a report for yr O 971-7

Sea Grant Program

University of Hawaii Honolulu, Hawaii 9682

CONTENTS

SEA GRANT PROGRAM
A Report for Year 04 1971-72

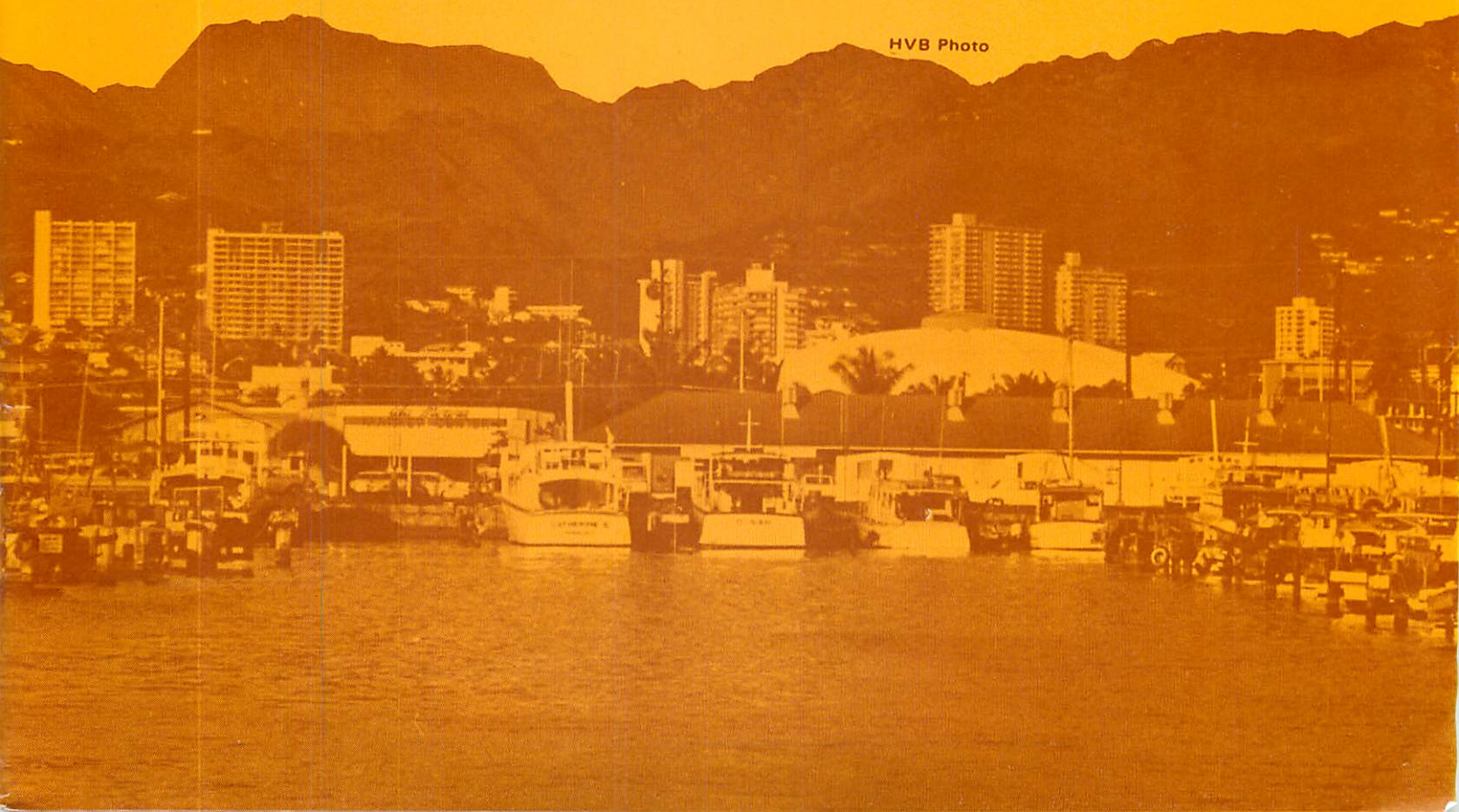
Jack R. Davidson, Director

Miscellaneous Report
UNIHI-SEAGRANT-MR-74-02
January 1974

This report describes Sea Grant Program activities during the period September 1, 1971 through August 31, 1972 which were supported by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 2-35243. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

Front cover photo courtesy of Paul Henning

INTRODUCTION



HVB Photo

INTRODUCTION

In 1969 the State of Hawaii undertook to spell out the state's concerns with ocean resources. The research and development and policies and programs needed to accomplish the goals which had been identified to promote these concerns were published as *Hawaii and the Sea.* Important legislation designed to place the state firmly on a course leading to the realization of the full potential of its ocean heritage followed in 1970.

> There is need for a planned and concerted effort to explore and develop to their fullest potential the vast, under-utilized resources of the Pacific Ocean. In view of its mid-Pacific location, unique oceanographic environment, and other advantages, Hawaii can take the lead in fostering the development of the ocean's resources, consistent with state and national goals of economic growth, international development assistance, and cooperation with neighbors in the Pacific Basin . . . **Senate Bill 1157-70, Fifth Legislature of the State of Hawaii, 1970.**

In 1968 the University of Hawaii, together with five other selected marine institutions received its first Sea Grant institutional award. The young Sea Grant Program figured prominently in *Hawaii and the Sea* and the ensuing legislation provided for state support for the Sea Grant Director and an Advisory Services Coordinator.

Impetus for general marine resource development at the state level was provided in the 1970 Legislative Session by establishment of the Office of coordinator of Marine Affairs with the Governor's Office and the position of Dean of Marine Programs at the University.

The sweeping language of Senate Bill 1157-70, which focused the state's concern for ocean resources, also described the focus of the University of Hawaii Sea Grant Programs.

With a sound vote of confidence from the National Sea Grant Office in the form of significantly increased funding which approaches $1.3 million in Year 04, the University of Hawaii was able to expand the scope of its Sea Grant Program to encompass many of the issues underscored as vital in *Hawaii and the Sea* and provides for the framework required for future qualification as a Sea Grant College. The multi-discipline, multi-directional research, educational, and advisory program developed in Year 04 provides the means for finding and adopting solutions, knowledge, methods and technologies which will permit Hawaii to eventually realize the benefits of its oceanic location.

Research programs in Year 04 sought answers to questions in:

*Aquaculture
*Fisheries
*Coastal Environmental Management
*Human Performance in the Sea
*Ocean Bottom Resources and Ocean Engineering

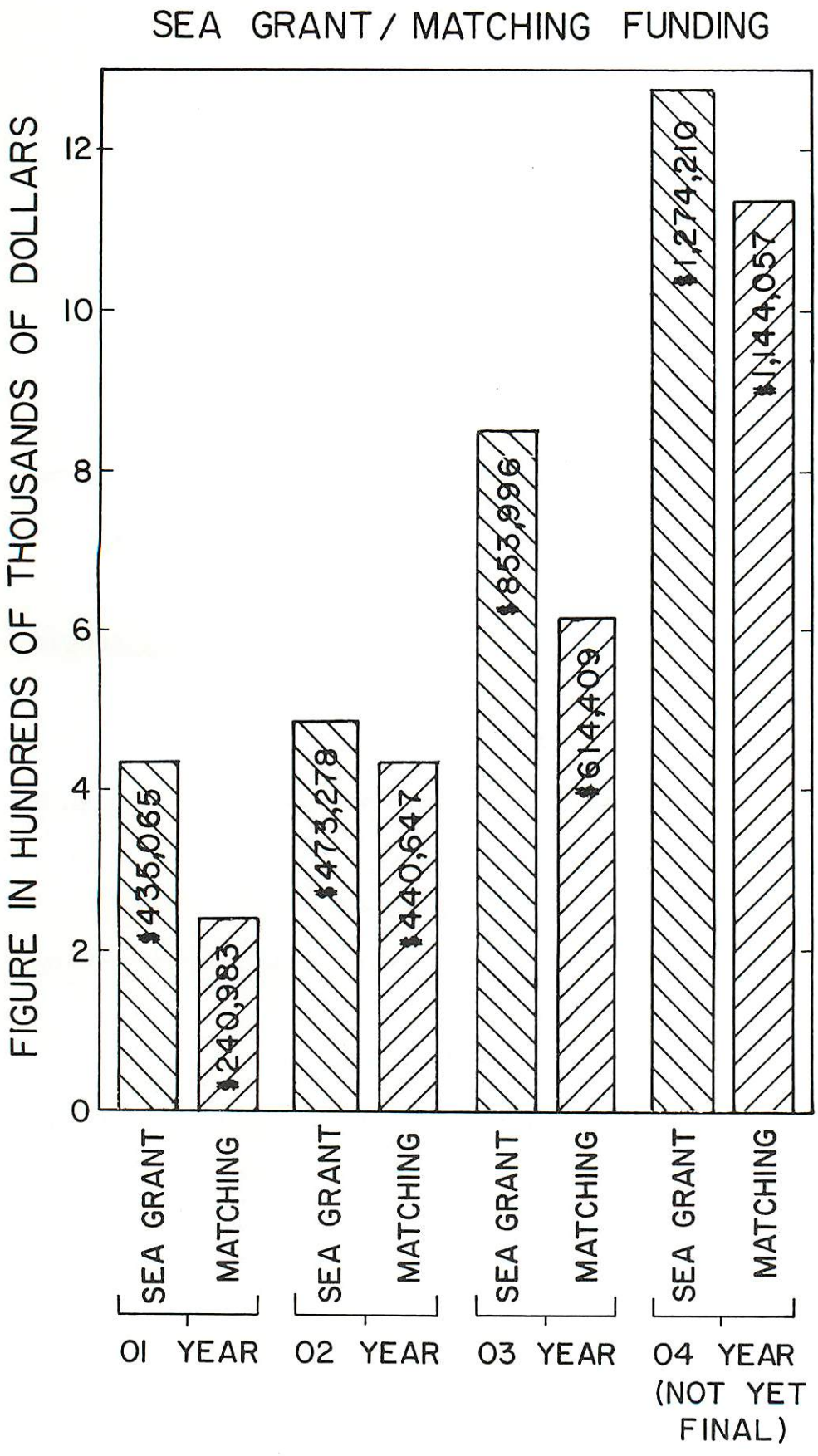
Increased funds in Year 05 permitted the organization of two vital components of the overall program, Sea Grant Advisory Services and Publications Office. These provide for the crucial activities of information dissemination and establishment of feedback channels.

As indicated in the graph below, from a plateau reached during Years 01 and 02, the funding level nearly tripled in Year 04 within a scant two years of operation. Of particular significance is the high level of matching state funds which the Program has enjoyed, far in excess of the required 2:1. This indicates the potential for program expansion in Hawaii.

The tabulation shown below of funding allocations by the four broad categories of Sea Grant functions – education, research, advisory services, and program management – indicates a drastic drop in funding earmarked for education in Year 04 in spite of the higher funding level. The rise in allocation for Advisory Services reflects the establishment of the Advisory Services and Publications components.

FUND ALLOCATION BY CATEGORY

	Years 01-03		Year 04	
	Sea Grant	Matching	Sea Grant	Matching
		Education		
Amount allocated	$ 114,695.86	$ 96,820.00	$ 53,616.19	$ 43,193.00
Percent of total allocation	6.61%	7.43%	4.21%	3.78%
		Research		
Amount allocated	$1,502,382.25	$1,176,593.95	$1,079,579.88	$1,024,847.45
Percent of total allocation	86.54%	90.30%	84.72%	89.58%
		Advisory Services		
Amount allocated	$ 63,304.80	$ 15,353.00	$ 88,911.43	$ 20,420.00
Percent of total allocation	3.65%	1.18%	6.98%	1.78%
		Program Management		
Amount allocated	$ 55,746.49	$ 14,286.00	$ 52,102.41	$ 55,597.00
Percent of total allocation	3.21%	1.10%	4.09%	4.86%
Totals	$1,736,129.40	$1,303,052.95	$1,274,209.91	$1,144,057.45


SEA GRANT / MATCHING FUNDING
FIGURE IN HUNDREDS OF THOUSANDS OF DOLLARS
0
2
4
6
8
10
12
$435,065
$240,983
$473,278
$440,647
$853,996
$614,409
$1,274,210
$1,144,057
SEA GRANT
MATCHING
SEA GRANT
MATCHING
SEA GRANT
MATCHING
SEA GRANT
MATCHING
01 YEAR
02 YEAR
03 YEAR
04 YEAR (NOT YET FINAL)

YEAR 04 SUPPORTING ORGANIZATIONS AND PERSONNEL

GOVERNMENTAL

City and County of Honolulu, State of Hawaii
County of Hawaii, State of Hawaii
County of Kauai, State of Hawaii
Department of Health, State of Hawaii
Department of Land and Natural Resources, State of Hawaii
Department of Planning and Economic Development, State of Hawaii
Department of Transportation, State of Hawaii
Gilbert and Ellice Islands Colony Government
Government of American Samoa
Hawaii Civil Air Patrol
National Marine Fisheries Service, Honolulu Office
Office of Environmental Quality Control
Office of the Marine Affairs Coordinator, State of Hawaii
PASGAP (Pacific Sea Grant Advisory Program)
Philippines Fisheries Commission
Trust Territories
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Naval Undersea Center (Kaneohe)

ACADEMIC

Bishop Museum
University of Guam
University of Hawaii, Hilo College
University of Hawaii, Leeward Community College
University of Washington

INDUSTRIAL

Alexander and Baldwin, Inc.
Amfac (American Factors)

C. Brewer and Company
Cement and Concrete Products Industry of Hawaii
Control Data Corporation
Dillingham Corporation
Fish Farms Hawaii
Gaspro, Inc.
HC&D
Hawaii Dredging
Hawaii Welding
Hawaiian Tuna Packers
Informatics, Inc.
Jakus
Jorgensen Steel
Kentron Hawaii
Kilauea Plantation Co.
Makai Range, Inc.
Mardela Company
Marine Colloids, Inc.
Maui Divers, Inc.
McBryde Plantation Co.
Ocean Resources, Inc.
Oceanic Insitute
Van Camp Sea Food Company

SERVICES

S. L. Gaines
M. Dale Green
James Leslie
Steven B. Ribakoff
James M. Smith
University of Hawaii Aquanauts

RESEARCH

Status of Research Projects Funded During Year 04

Research Project	new	continuing	completed
aquaculture			
production of food colloids from tropical marine algae		X	
seaweed agronomy	X		
algal food for aquatic organisms		X	
tropical animal aquaculture		X	
pond culture of brine shrimp	X		
ecological investigations of fish eggs and larvae	X		
fisheries			
further exploration and development of a tuna bait resource			X
pre-management study of tuna bait resources, hawaii and the trust territory (palau)	X		
a new trapping technique for menpachi	X		X
new food processing and products from hawaiian marine life		X	
coastal environment management			
law of coastal zone management	X		
economic and institutional aspects of multiple uses in hawaii's coastal zone	X		
quality of coastal waters		X	
shoreline surveillance	X		X
sand recovery		X	
beach and surf parameters	X		
succession and stimulation of successcion on denuded coral reef substrates		X	
life in the sea			
human performance in the sea: physiological and medical factors		X	
improvement and continued operation of a four atmosphere hyperbaric facility		X	
ocean bottom resources			
ecology of precious corals and the development of precious coral fisheries in hawaii		X	
manganese resources			X
other			
biological study of pala lagoon, american samoa	X		X
floating community design	X		

List of Projects and Principal Investigators

aquaculture	
production of food colloids from tropical marine algae	maxwell s. doty
seaweed agronomy	maxwell s. doty
algal food for aquatic organisms	maxwell s. doty
tropical animal aquaculture	philip helfrich
pond culture of brine shrimp	philip helfrich
ecological investigations of fish eggs and larvae	john m. miller
fisheries	
further exploration and development of a tuna bait resource	wayne j. baldwin
pre-management study of tuna bait resources, hawaii and the trust territory (palau)	garth i. murphy
a new trapping technique for menpachi	e. donald stevens
new food processing and products from hawaiian marine life	francisco s. hing
coastal environment management	
law of coastal zone management	john p. craven george sheets v. carl bloede
economic and institutional aspects of multiple uses in hawaii's coastal zone	chennat gopalakrishnan
quality of coastal waters	l. stephen lau
shoreline surveillance	ralph moberly, jr.
sand recovery	robert q. palmer
beach and surf parameters	frans gerritsen
succession and stimulation of succession on denuded coral reef substrates	keith e. chave
life in the sea	
human performance in the sea: physiological and medical factors	suk ki hong terence o. moore
improvement and continued operation of a four atmosphere hyperbaric facility	john t. o'brien
ocean bottom resources	
ecology of precious corals and the development of precious coral fisheries in hawaii	richard w. grigg
manganese resources	james e. andrews
other	
biological study of pala lagoon, american samoa	philip helfrich
floating community design	john p. craven

PROFITABLE FARMS RESULT FROM PLANT AQUACULTURE STUDIES

As wild supplies of *Eucheuma* seaweeds fall far short of US industrial needs, pilot farms set up by this Sea Grant marine agronomy project have begun producing high-quality crops at a cost that should assure a good profit . . .

The average American would probably balk at the idea of eating seaweed, yet chances are he consumes a substantial amount of it during his lifetime without realizing that he's doing it. When he was an infant, it was in the commercially prepared formula his mother fed him. As a teenager, it was in those extra-thick chocolate malts he loved. And as a hurried, harried adult, the instant breakfast he gulps down as he dashes off to work contains it. Many of his other favorite foods—ice cream, puddings, whipped desserts—add to his seaweed consumption. Seaweed is also an ingredient in inks, paints, toothpaste, insect sprays, shampoos, and cosmetics. And treatment of an ulcer or a bone graft might well include a seaweed-based product.

The versatile seaweed - derivative which has such wide commercial use is carrageenan, an industrial colloid or stabilizing agent that makes emulsions possible. Irish moss supplies much carrageenan. It is also obtained from tropical seaweeds, such as those in the genus *Eucheuma*, which are harvested from wild stands mainly in the Philippines and Indonesia. US industry is presently seeking a 20-fold increase in the available supply. The food industry alone needs 10 to 20 times more carrageenan than the 3000 to 4000 dry tons of *Eucheuma* as well as the harvesting of other wild seaweeds which reach the world market annually can provide.

The potential profitability of farming the various *Eucheuma* species was established after in-the-field investigations by this project. In the Northern Sulu Sea, for example, a section of Panagatan Bay, an area of considerably less than one square kilometer, yielded twenty-five dry weight tons of *Eucheuma*, indicating a live weight of several kilograms per square meter. And estimates are that the world market might pay as much as $350 per ton if the product were clean, rewashed, dried, and composed of compatible species. Two types of carrageenan, known as "kappa" and "iota" are produced from *Eucheuma*. The harvest brings the best price when the seaweed is sorted into kappa or iota-producing species.

The prospects for controlled harvesting of wild crops, using various conservation methods to ensure a continuing supply at a given location, were investigated by the project. This course appeared impractical for a number of reasons ranging from seasonal weather and water conditions in the growing areas to local customs that regard such wild harvests as belonging to anyone who wants to take them.

After many months of research and experimentation, several pilot farms were established, in cooperation with industry, in the Philippines and Indonesia.

Of the various methods of planting *Eucheuma* tried, the most successful was found to be lashing the "seed" *Eucheuma* to the mesh intersections of specially developed nets and putting it below low-tide levels and a half meter off the bottom. When the seed plants were placed on the bottom, most were quickly eaten by sea urchins and other sea-bottom creatures.

Because of the need for considerable supervision and management, the pilot plants have overhead costs far higher than should be necessary later when *Eucheuma*-farming routines and procedures become well established. Even under present pilot production, which is only two-thirds of what is expected to be realized later as methods are improved, the figures indicate profitability for the pilot farms, based on a price of $250 per ton. (In times of scarcity recently, small amounts have brought as much as $400 a ton.) It is believed that eventually *Eucheuma* farming will provide more than three times the dollar return per square meter that sugar raising brings.

An illustrated and detailed report on the results obtained to date by this project has been published entitled, *Eucheuma Farming for Carrageenan,* Sea Grant Advisory Report UNIHI-SEAGRANT-AR-73-02.

While the major emphasis in the tropical marine agronomy area focused on *Eucheuma* farming during Year 04, two other lines of research were also being conducted. One involved investigation of various algal foods to feed marine organisms, particularly creatures being raised by aquaculture. The other was a study of various possible uses for local Hawaiian seaweeds.

Work in all these areas will continue into Year 05 by Sea Grant.

TEAM APPROACH ADVANCES AQUACULTURE IN FIVE AREAS

Successful commercial rearing of ocean fish, shrimp, and turtles – including breeding in captivity and control of diseases -- moves several steps closer to reality as a result of this continuing project . . .

A basic form of aquaculture has existed in Hawaii for centuries. Over 200 large fish ponds, many built by constructing lava rock walls along a reef, have been identified by the Bishop Museum. These ponds served mainly to trap young fish and hold them until they grew to a size suitable for eating. It was an effective means of having fish available when they were needed and of making sure they would be fresh when eaten. But the early Hawaiian fishpond tenders had no more control over their charges than did a primitive land farmer who trapped young animals in the wild and simply kept them penned up, foraging for themselves until he was ready to use them.

In contrast to this method, the Sea Grant aquaculture project at the University of Hawaii has adopted a team approach with the aim of placing aquaculture on the same scientific footing as the most modern controlled "mass production" methods for raising poultry.

This project began, in Sea Grant Year 01 in Hawaii, as three separate animal aquaculture projects: one to raise finned ocean fish, one to be concerned with mollusks such as clams, limpets and octopus, and the third to deal with crustaceans, primarily, shrimp and crabs. Last year the three projects were merged into one and the team approach adopted.

In this approach, the marine biologists at the Hawaii Institute of Marine Biology, where the project is headquartered, work closely with specialists in animal nutrition, animal diseases, chemistry, behavioral psychology, microbiology, and agricultural and ocean engineering.

The project established ten major objectives. These include determining which creatures, either native or introduced to Hawaii, are best suited to aquaculture, finding ways to induce breeding in captivity, learning the techniques needed to raise larval organisms to juvenile size (generally, the larval stages present the most problems for aquaculturists), improving the methods of feeding, controlling diseases, developing efficient enclosures for raising various

kinds of marine creatures, developing commercially marketable aquaculture crops, and testing and developing aquaculture inputs to recreational fisheries.

During this past year, in accordance with recommendations of the 1972 NOAA Aquaculture Survey and the University of Hawaii Sea Grant Advisory Committee, work on several species was phased out or de-emphasized and efforts were concentrated on more promising species.

Two new creatures were added during the year to the list of animals under study by the project. One was the green sea turtle *(Chelonia mydas)*. There is a great demand for products from sea turtles, including the meat, shell, eggs, leather, and oil, and natural stocks are being depleted by unrestrained fishing. Another was the giant Malaysian prawn *(Macrobrachium rosenbergii)*. Commercial culturing of these prawns has already been achieved in Hawaii, thanks to extenseive work at the State Division of Fish and Game, but further work was needed on the development of feeds.

The project's efforts have been organized into five major areas of concern: ecology, reproductive biology, nutrition, disease, and facilities engineering. Progress was made in all areas during the year and following are some of the highlights in each.

ECOLOGY

One of the fish most studied by this project is a Hawaiian species of the jack family, locally known as "omaka" *(Caranx mate)*, a popular food and sport fish. Techniques which have been developed for rearing omaka through the difficult larval stage have been successfully replicated. Types and concentrations of antibiotics to maximize survival of both embryonic and larval forms of omaka have been determined. An "energy budget" has been constructed for the larvae during its critical developmental period. The best survival conditions for omaka eggs and larvae, based on zones of tolerance for variations in water temperature and salinity, have been studied. It is anticipated that the techniques developed for this species will be applicable to many other local species.

REPRODUCTIVE BIOLOGY

The spawning seasons of the omaka and of another popular Hawaiian food and sport fish, the "moi" *(Polydactylus sexfilis)*, have been

determined by field studies. Investigations of the metabolic requirements for ovarian maturation of a local ocean shrimp species, *Penaeus marginatus*, have also been carried out. This type of information is needed before these species can be induced to spawn in the laboratory and under the controlled conditions of scientific aquaculture.

NUTRITION

An important step in the development of preparing artificial rations for marine species has been the finding of suitable "binders" to hold food pellets together in the water so that food is not lost and decaying bits of feed do not pollute the rearing waters. Diets consisting of different ingredients, have been evaluated for their protein and energy-producing ability and the growth rates they induce in shrimps, prawns, and sea turtles.

A taste attractant has been found which stimulates the goatfish, *Mullidae*, to feed on artificial food and the monitoring of the fish's responses to various odors and tastes have been started. If ways can be found to attract aquaculture animals to artificial rations, problems of feeding would be simplified.

DISEASES

For the first time anywhere, a cell line, or continuous culture of fish cell tissues (kept alive in a heavy "nutrient soup") has been established from the larval stage of the omaka. This cell line, or continuing culture, is a unique and valuable tool in studying any viruses that might occur in fish being raised under intensive cultivation, since viruses only survive in living tissues. It is also of great value for assessing virus transfer in the food chain, even to the potential human consumer.

FACILITIES ENGINEERING

Prototype versions of several different structures, for intensive culture of popular ocean shrimp species have been designed and constructed. Raceways with multi-storied shrimp production trays and stacked pans using shallow water levels have been built and tested. The object of these designs is to make mass production of shrimp possible in limited space by bringing ample oxygen-bearing water to the creatures while carrying off metabolic wastes and uneaten food. Without a way of doing this, it would be impossible to keep the shrimp alive, much less healthy and growing, at high densities. Another innovation, a raft for cage culture that will be rotated by wind

power, is being designed.

This project in animal aquaculture was funded for continuation into Year 05 and is projected to run through Year 09.

A NEW INDUSTRY — AND PERHAPS A NEW PROTEIN SOURCE

An uncontaminated supply of live food for aquaculture . . . a profitable, non-polluting industry for a remote Pacific atoll — and perhaps an important new source of cheap protein food for humans. All this from Sea Grant work with one of nature's odder creatures . . .

The brine shrimp *(Artemia salina)* is one of the few creatures that can live in water considerably saltier than normal seawater. Not only does it live in such hypersaline water—it thrives, flourishes, and reproduces rapidly in this rather private ecological niche. Only two weeks after hatching, *Artemia* reaches sexual maturity, producing some 200 offspring every five days during its six-month to one-year life span.

This prolific creature plays a vital part in modern aquaculture and is an important live food supply for many aquarium hobbyists, because the dried eggs of the brine shrimp can be stored in cans for long periods. When dumped into water, these eggs soon hatch into tiny living creatures which serve as the live food that so many fishes must have, at least at certain periods of their lives, to survive. Without the live food that brine shrimp provide, most aquaculture projects would prove much more difficult, if not impossible. Brine shrimp come mainly from the San Francisco and Salt Lake City areas but these supplies have become somewhat contaminated by pesticides and alternate sources of supply are desired.

Beside the brine shrimp's usefulness to fish raisers, it has another characteristic that could prove quite valuable to a world faced with increasing demands for sources of animal protein. Brine shrimp eat algae, and convert these tiny sea plants into brine shrimp flesh and structure at a remarkable efficiency rate of as high as 79 percent! A conversion rate of 50 percent – with two pounds of algae producing one pound of brine shrimp -- could almost certainly be depended

upon. Brine shrimp are a good protein source, safely edible, and with no excessively salty taste. Some remote tribes are known to eat them and the response to an experimental shrimp tempura prepared from frozen brine shrimp was quite favorable.

Christmas Island, lying some 1160 miles due south of Oahu, appears an ideal place to raise the creatures. It has the largest land mass (124 square miles) of any atoll in the world. Much of this area contains some 500 shallow, highly saline lakes that previously contributed nothing to the inhabitants of the Gilbert and Ellice Islands (of which Christmas Island is a part) who are plagued with the problems of a too-dense population forced to depend on limited phosphate deposits and copra plantations for a cash economy.

The Government of the Gilbert and Ellice Island Colony reacted favorably to the idea of seeing whether brine shrimp production would be commercially feasible on Christmas Island. The project was started by Sea Grant in 1970, in cooperation with three private companies.

Researchers found that *Artemia* could indeed be raised successfully on Christmas Island. Detailed studies of the algal food eaten by the brine shrimp were conducted, fertilizer needs were determined, and a series of seven interconnected lakes was chosen as a likely first production site. The recommended plan is to concentrate first on producing brine shrimp eggs, with fresh frozen and possibly freeze-dried adult *Artemia* as by-products.

An economic study was made, based on producing 10,000 gallons of brine shrimp eggs the first year, 20,000 the second, and 30,000 in the third year. This admittedly rough calculation predicted a net profit after the third year of operation.

Two potential investors as well as the Government of the Gilbert and Ellice Island Colony are interested in the project. Meetings will be held sometime during 1973 to work out detailes for the establishment of a new and non-polluting industry for Christmas Island -- brine shrimp raising – that could also possibly provide a new source of low-cost animal protein food for hungry humans.

This project was completed in Year 04.

SEEKING THE SECRETS OF PROTECTING HAWAII'S NEARSHORE FISH

Realistic shoreline planning calls for a knowledge of what happens to various fishes when water quality changes. Researchers working on the question found they first had to learn how to identify the larval forms of several *hundred species* . . .

The building boom that hit Hawaii in recent years is changing not only its skyline but also its shoreline. And major changes along the shore seem to trigger changes in the nearshore waters.

These changes could well have serious adverse effects on the nearshore fish populations of Hawaii and, perhaps, even on many of the fish species that, as adults, live far out from shore. (The nursery areas for the larval and tiny juvenile forms of many species of deepwater fish have long been known, or believed, to be in shallow, nearshore waters.)

Even though the adults of some species might not seem to be affected by changes on the development along the shoreline, this is no guarantee that the larval and post-larval forms of these fish might not be seriously disturbed, reducing or even eliminating these types in future years. Virtually every endeavor that attempted to raise marine creatures has discovered that the larval forms are extremely delicate and die off rapidly if conditions are not just exactly right.

In Year 04, this project was initiated to learn what effects various man-made "stresses" on the nearshore ocean environment could have on Hawaiian fish populations. The information obtained would be extremely useful to those charged with the responsibility of managing the state's shoreline areas and the inshore fisheries which have a value of at least a million dollars a year to the state.

Prior to the start of this project, less that 5 percent of the 580 known species of Hawaiian fish had their larvae described so that they could be identified. And since different species often seem to have different environmental requirements, the ability to identify egg and larval forms is essential to any research seeking to discover what effects environmental changes have on those species.

Much of the early work, therefore, was devoted to collecting and identifying larvae. Approximately 300 collections of fish larvae were made during the year, off the islands of Oahu, Kauai, Maui, and Lanai. It was often necessary to culture the larvae until they reached an identifiable juvenile stage. By the end of the first year, 210 kinds of larvae were identified. Although this is less than half of the Hawaiian species, the ones that were identified included most of the common inshore larvae. For example, 89 percent of the larvae that had been taken off the island of Kauai could not be identified.

Inshore areas from which larvae were collected ranged from pristine areas to harbors and sewage outfalls. As had been expected, both the numbers of species and individual creatures were generally significantly lower in areas under stress by man's activities.

In addition to fish larvae, zooplankton samples were also taken. Zooplankton are the food of virtually every marine animal at some stage in its life history and includes the larval stages of all the commercially important invertebrates, such as crabs, clams, and shrimp. Like the fish larvae, these also generally were more adversely affected by man-caused stresses than the adults of their species.

Studies were also made in Kaneohe Bay on Oahu. The northern sector of the bay is fairly close to a natural state and the southern sector is under heavy stress by man. Some types of larvae are more prevalent in the northern waters, but other species seemed to do much better in the stressed southern area. Unfortunately, few of the latter were species presently considered "valuable" to man.

This project will be continued in Year 05.

Fisheries

SEEKING NEW SPECIES OF BAIT FOR HAWAII'S TUNA FISHERY

Two promising species, theadfin shad and sharpnose mollie, have been identified . . .

The traditional live baitfish used by Hawaii's pole-and-line commercial skipjack tuna is nehu *(Stolephorus purpureus)*. Up to 30 or 40 percent of the fisherman's total working time must be spent in catching this increasingly scare baitfish. Once caught, it is difficult to keep the nehu alive in shipboard baitwells for more than three or four days. Nehu mortality in captivity is estimated at about 25 percent per day. Because of

the absolute necessity of the bait being alive when used, it is not possible for Hawaiian skipjack tuna vessels to travel far from home.

During Year 04, two species were investigated as a possible subsitute for nehu: the threadfin shad *(Dorosoma petenese)* and the sharpnose mollie *(poecilia sphenops).* Both species have shown ability to attract tuna, are hardy, and appear amenable to pond rearing. Studes were made in several areas. Although early attempts to spawn shad were successful, attempts made during Year 04 were unsuccessful for reasons as yet unknown. Feasibility of pond rearing the mollies for both commercal and recreational fishing bait appears excellent.

For Year 05 this project will merge into the large animal aquaculture project.

A PRE-MANAGEMENT STUDY OF IMPORTANT TUNA BAIT RESOURCES

Supply of "nehu" is a limiting factor to the skipjack tuna fisheries in Hawaii and Palau . . .

Almost all of the commercial fishing for skipjack tuna in both the Hawaiian Islands and in Palau, Pacific Trust Territories, employ the live-bait, pole-and-line method. In both of these fisheries, the live bait used almost exclusively is a species of anchovy *(Stolephorus purpureus)* known locally as "nehu."

In Hawaii, there is a pressing need to expand the dwindling supply of bait for the existing tuna fleet, while in Palau there is pressure to expand the existing fleet from 11 to possibly 18 vessels. To meet bait supply needs for the increased fleet in Palau, considerably more nehu than is now being used would be required.

This project studied the ecology and population biology of nehu in Hawaii and Palau via two concurrent studies. Information gained from these studies will be used to establish proper practices for managing the tuna bait resources in the two areas to avoid their depletion. Much information has been gathered in both areas, but the data has not yet been

analyzed by the end of Year 04.

The studies will be continued in Year 05.

FISHTRAPS: THE WAY TO CATCH MENPACHI?

An attempt to develop a suitable technique to trap menpachi . . .

A type of inshore fish, known in Hawaii as menpachi *(Myripristis)*, is a good market fish, but is seldom caught on a commercial scale because of the unsuitability of the available techniques and equipment. Menpachi have been taken illegally by chloroxing (poisoning the water with a bleach) or legally by netting, which is difficult and a poor economic venture. There are some 400 small-boat fishermen in Hawaii who make a significant part of their income catching inshore fish. The problem this project addressed was the devising of a technique for taking menpachi in commercial numbers to benefit fishermen and to better use a potential foodfish resource.

Two types of traps for taking menpachi were designed and developed. Preliminary field tests indicated that there were some basic difficulties in the designs of the traps which made them difficult to handle and menpachi appeared to be a fish not easily trapped.

This project was terminated at the end of Year 04.

FOOD USES OF LOCAL FISH RESOURCES STUDIED

Fish sausages and ways of freezing table fish to preserve its quality were key areas of focus for this project . . .

In July 1968, to bolster the declining local fishing industry, the state of Hawaii and the local fishing industry provided money for the "Hawaiian Fish Product Development" project which had a two-fold thrust. One of them focused on new food uses for unused or under-used species of fishes. The other concentrated on new methods of

processing fish that would keep it both edible and appealing for relatively long periods of time so that the common "feast or famine" situation that prevails in the table-fish market situation locally could be leveled out to the benefit of both fishermen and consumers. Initial Sea Grant support to study methods of processing skipjack tuna was given in Sea Grant Year 02. At the early stages, much effort went into developing new ways of preparing fish that would appeal to local appetites and tastes. Fish hams and sausages, using popular local food fish, met with good initial reception.

Year 04 largely concentrated on various processing treatments of skipjack tuna. Interestingly enough, the quality of the fish was affected in the same way by either slow freezing or quick freezing. Using either method, during the first month, the frozen fish deteriorated somewhat in quality, that is, the muscle tissue of the fish lost some of its water holding capacity. However, after this initial deterioration, there was no further downgrading of quality for up to three months. When ground fish was heated there was a quality loss at temperatures between 30°C and 60°C. Above 65°C, changes in quality were relatively small. Freeze drying did not alter the quality of fish muscle tissue.

HVB Photo

Preliminary methods of freezing and storing fresh fish for "sashimi," a Japanese delicacy, were also explored.

This project was terminated in Year 04.

Coastal Environment Management

STUDYING THE LAWS OF THE COASTAL ZONE RELATED TO HAWAII

The state of Hawaii can be classified a coastal zone, a condition which requires wise planning . . .

Hawaii's extensive shoreline is equal to about one-half the total open-sea shoreline of the 48 contiguous states. And Hawaii is presently the only state with statewide land use planning as an official policy under the state's Land Use Law. It is believed that federal laws relating to the coastal zone may cause problems in Hawaii because of the island state's unique geographic situation. This project is examining ways to make the clearest possible detailed statement of the present situation in coastal zone law with particular reference to Hawaii's unique conditions.

During Year 04 the studies concentrated on legal regimes which would permit the state of Hawaii to manage conservation and utilization of the resources of the Hawaiian archipelago. A paper was produced on this subject. Three other papers focused on: (a) the resources of the Hawaiian archipelago as related to current legal regimes; (b) criminal jurisdiction in the Hawaiian archipelago; and (c) community and government legal awareness of the legal problems of the archipelago.

These studies on various legal aspects of the coastal zone will be continued for further research and evaluation into Year 05.

COASTAL ZONE PROJECT PUBLISHES SEVERAL REPORTS

Spheres of influence of Hawaii's all-important coastal zone are being examined from the standpoint of county, state, and federal involvement . . .

The pressures of different uses on Hawaii's shoreline have increased dramatically in recent years. Growth has occurred in a haphazard manner. Recent conservation legislation has called for a setback of construction from the shoreline but the law is surrounded by controversy because the rationale behind the practice of establishing setback limits is not clear and there appears to be a need to re-examine the whole issue of coastal zones. This project was funded by Sea Grant beginning in Year 04 to examine both the economic and institutional aspects of multiple uses of Hawaii's coastal zone.

As a first step an exhaustive survey of federal agencies active in Hawaii's coastal environment was undertaken and completed. A report describing current federal interest, jurisdiction, and activities in Hawaii's coastal zone was prepared for publication early in Year 05, under the title, *Spheres of Influence in Hawaii's Coastal Zone: Federal Agency Involvement.*

A comprehensive study of state and county agency involvement was also launched and is nearing completion. Questionnaires were prepared and sent to nearly 500 industrial concerns engaged in activities along Oahu's shoreline. A report on institutional aspects of coastal zone management in Hawaii was presented at the annual meeting of the Western Regional Science Association; another report on the same general topic is scheduled for publication by the *American Journal of Economics and Sociology.*

This important project will be continued in Year 05.

AN IN-DEPTH STUDY OF THE QUALITY OF HAWAII'S COASTAL WATERS

It was found that even pristine waters exceeded nutrient levels set in the state's Water Quality Standards . . .

How do factors such as pesticides, heavy metals, chemicals and nutrients affect the quality of Hawaii's coastal waters? What do they do to the waters themselves, to the sediments, and to the plant and animal life in the waters? This project, planned in Year 03 and activated in Year 04, is a major effort to answer these questions. It is a multi-disciplinary study directed to the overall objective of identifying not only physical and chemical factors, such as nutrients and pesticides, but of also identifying and evaluating the social, political, economic, institutional, educational, scientific, and technological factors which either help or hinder the protection and restoration of coastal water environments in Hawaii. The results of the first year's work have been detailed in a 214-page technical report, entitled *The Quality of Coastal Waters: First Annual Progress Report.* Also during Year 04, five special Project Bulletins brought pertinent information developed by the project to the community.

While space does not permit reproducing the detailed findings contained in the comprehensive report, certain findings are of enough interest to merit mention here. Some heavy metals were found to be present in significant concentrations in Hawaiian soils and sediments, possibly because of the volcanic origin of the island chain. Herbicides used in agriculture were not detected in coastal waters. When discharge of sugar mill wastes into the ocean was halted on Kauai, recovery of the waters from the effects of the previously discharged wastes was rapid. Another finding was that nutrients in seawater exceeded existing standards even in pristine waters. The import of these findings has led to requests from the State Health Department, which has cooperated fully in this project, for assistance in revising and up-dating the state's Water Quality.

This project, considered to be of major importance, was funded for continuation into Year 05.

A SURVEILLANCE OF HAWAII'S SANDY SHORELINES

Information gained by this program will be of great use in planning for use of Hawaii shorelines . . .

Back in 1962 and 1963, a seasonal program of measurement was undertaken on some 90 beaches on the six major Hawaiian islands. This program provided most of the physical information for the state's shoreline plan and is a basis for this project. Prior to the start of this project, there was no overall program of shoreline surveillance for several years in Hawaii, although specific areas where erosion was a problem were sometimes surveyed. Sixty beaches were surveyed in Sea Grant Year 04; for 33 of these, the volume of sand and the width of the beach could be compared with earlier measurements to indicate trends of erosion over the last ten years. The west coast of Oahu was found to have been quite stable since 1963. The north and east coasts, however, have several coastal segments undergoing erosion, for example, Kailua and Mokuleia; whereas, Waimea has accreted or gained sand. On Maui some of the beaches formerly having severe erosion problems now seem to be stabilized, whereas Kihei and Honokohau still are being cut back. Because the island of Hawaii has only one beach that seems to be eroding, survey efforts were concentrated on beaches on Oahu, Kauai, Molokai, and Maui.

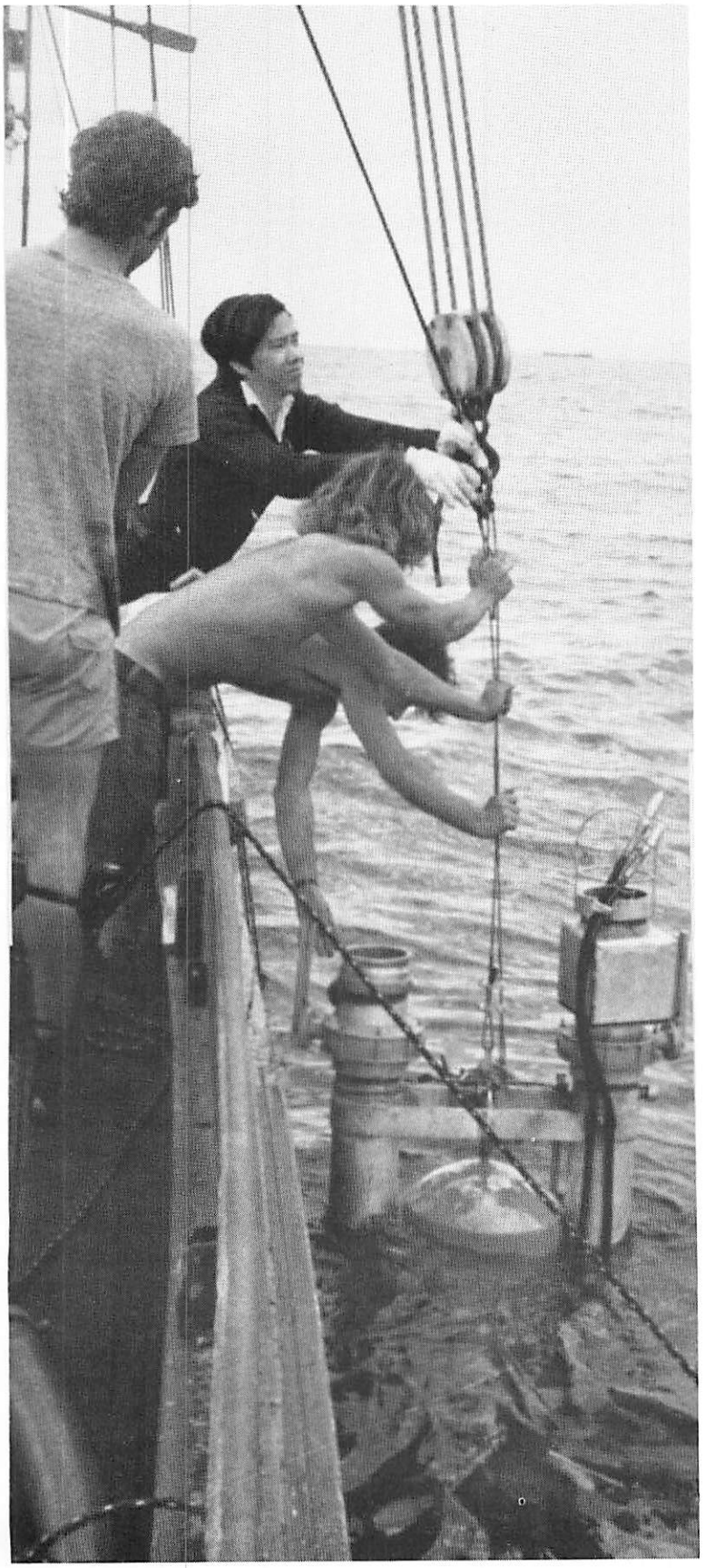
Under this project, a report entitled, *Hawaiian Shallow Marine Sand Inventory*, was re-issued, and at the end of Year 04 a report, *Erosion and Accretion of Selected Hawaiian Beaches, 1962 - 1972*, based on the project's work, was published.

This project was terminated in Year 04.

A NEW, LOW-COST METHOD OF RECOVERING OFFSHORE SAND

Specially designed for Hawaii's needs, it's an ecologically sound system that doesn't cloud the water with sediment . . .

The existing methods for hauling up underwater sand require sizeable ships or barges, large crews, and costly equipment. They need to operate at a large scale, on large deposits, to pay off. They have difficulty operating in



rough seas. When they do operate, they may rip up reefs, often smother coral, and interfere with other animal and plant life. Even if the environmental damage caused by the existing sand recovery system had been acceptable for use in Hawaii, but which has not, the cost of these large sand-recovery systems made them uneconomical for Hawaii's limited sand markets.

A search for a method of offshore sand recovery compatible with Hawaii's economic needs, environmental concerns, and often-rough waters was instituted in the first year of Sea Grant in Hawaii.

By Year 03 two distinct methods had been developed and were ocean-tested with half-size models. One system, called the "buried intake field," was primarily for returning eroded sand back to beaches from thin deposits at a low rate. The second system, known as the "sand cratering" system, was for use with thick deposits of offshore sand. The latter system consists of a self-burrowing suction head which is jetted to the bottom of the sand deposit from where the sand is sucked out. This system could supply sand for beach replenishment at a slow rate, or provide sand at a rapid rate for beach

building or construction use.

The cratering system is designed to operate in rough seas from a small (60-foot) vessel with minimum crew requirements. Since a large volume of sand can be removed from a single crater and because the head can operate when buried, no maneuvering of the vessel is required. Most important, it protects the reef environment from turbidity, sedimentation, and physical damage.

Ocean tests of half-size models of both systems, during Year 03, showed that they had a common, and potentially serious, problem. Their intake ports would clog from bits of coral and other fragments in the sand. Since the sand cratering system was not as seriously affected by clogging, and beause it offered greater potential, a decision was made to concentrate on this system during the year being reported.

A considerable amount of time was devoted to finding ways to cope with the particles of coral, shell, and rock that would gather at the intake and eventually choke it off.

The idea that seemed most promising was to crush the particles being drawn in so that they would freely pass up the suction pipe. A roller crusher powered by a hydraulic motor was designed and built. A second half-scale model of the cratering system, designed to permit gravity feed of the crusher, was also constructed. This new system with the crusher was named the "Submarine Sand Recovery System" (SSRS).

Tests were conducted with the new SSRS early in 1972. About 35 cubic yards were pumped, from a depth of 40 feet, at a rate of 7 yards per hour, with no interruption in flow. A crater about 7 feet deep by 23 feet across was formed. This crater was subsequently filled in by wave action and more sand was pumped from the same area.

Two dredging specialists from the U.S. Army Corps of Engineers inspected the system in March 1972, and gave it favorable comments.

In the spring of 1972 the half-size model, with its 3-inch pipes, was scaled up and construction drawings completed for the full size prototype SSRS, which would employ 6-inch pipes. (Indications are that the 6-inch size is optimum.)

Additional support subsystems for the SSRS were designed, built and

ocean-tested. including a "variable buoyancy lifting device" that will enable divers to move and replace the suction head on the bottom.

Construction of the full-size prototype SSRS began in late June 1972. Completion was scheduled for late October, and ocean testing the following month.

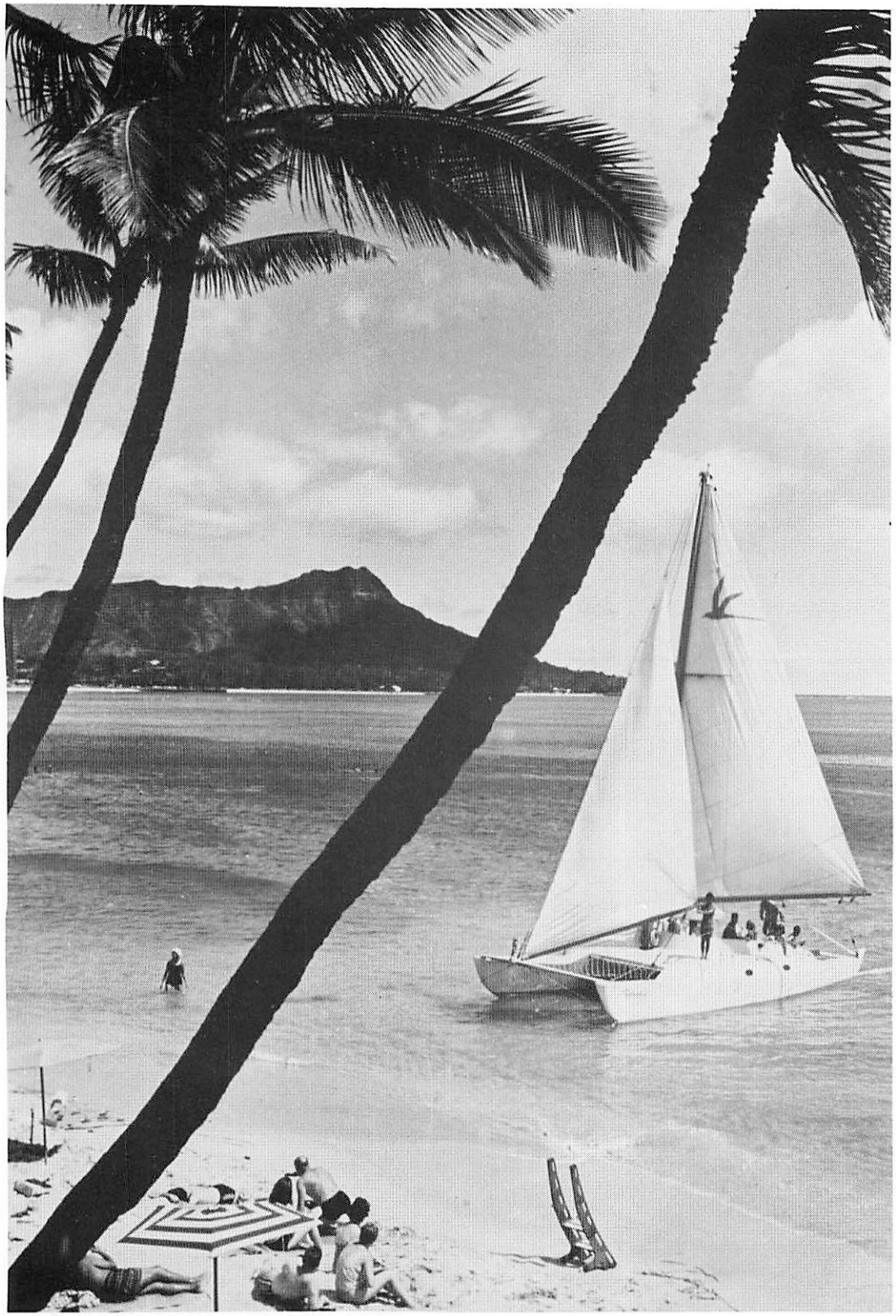
The project will be continued by Sea Grant in Year 05.

LEARNING HOW TO PROTECT ONE OF HAWAII'S MOST VALUABLE ASSETS

Special monitoring equipment will provide data needed to understand the dynamics of wind and wave and how they affect beaches . . .

Because beaches are one of the greatest attractions for Hawaii's important tourist industry, they are also among Hawaii's major economic assets. But use of the beaches is not limited to tourists; in fact, local residents probably use Hawaii's beaches more than do tourists. And surfing sites are another important asset, providing recreation for an estimated 50,000 to 60,000 surfers as well as being the site for countless tourist photographs.

This project will provide a basis for practical recommendations for the protection and stability of Hawaiian beaches and surfing areas. Beach problems in Hawaii have been investigated by various agencies in the past, but additional basic investigations are required to obtain a thorough understanding of the processes of wind and waves at work recently in the Hawaiian coastal environment. Such a basic approach to beach and surf problems has become possible through the use of the specialized measuring equipment now available. During Year 04, the areas selected for study were Waikiki Beach on Oahu's southern shore and Haleiwa Beach on its northern shore. Water circulation patterns were studied with dye-marker experiments. Ranges were established in reference to existing landmarks and regular beach profile surveys were conducted. Waves were monitored by recording devices at the 50-foot depth and in



HVB Photo

the surf zone. The studies have already contributed to a better understanding of the forces at work in the nearshore environment and a detailed annual report entitled *Beach and Surf Parameters* has been issued.

The project was funded for further research and investigation in Year 05.

NEW ATLAS HOLDS DATA ON WORLD'S MOST-STUDIED REEF SYSTEM

A team of Hawaii scientists spent three full years measuring and monitoring the reefs in Oahu's Kaneohe Bay, and ecosystem under stress . . .

While coral reefs can be deadly enemies to unwary seamen who stray or are storm-driven onto their shipwrecking upper edges, reefs are the best of friends to those who dwell on tropic islands. They blunt the fury of waves that come smashing shoreward from the ocean's broad reaches and save beaches and shores from being ravaged away by erosion. Their numberless holes, caves, and crevices provide essential shelter from marine predators to countless tasty sea creatures -- so that they can grow and thrive and eventually become food for man. If the reefs are barrier reefs -- not directly connected to the shore as are fringing reefs -- they provide a breakwater to shelter the lagoon that forms between reef and shore. Often reefs have even created the very ground that the atoll-dwellers of the South Pacific live upon. And if the island with the reefs is a modernized, urbanized one like Hawaii's Oahu, the reefs also provide fascinating, mind-soothing relaxation for thousands of skin and SCUBA divers.

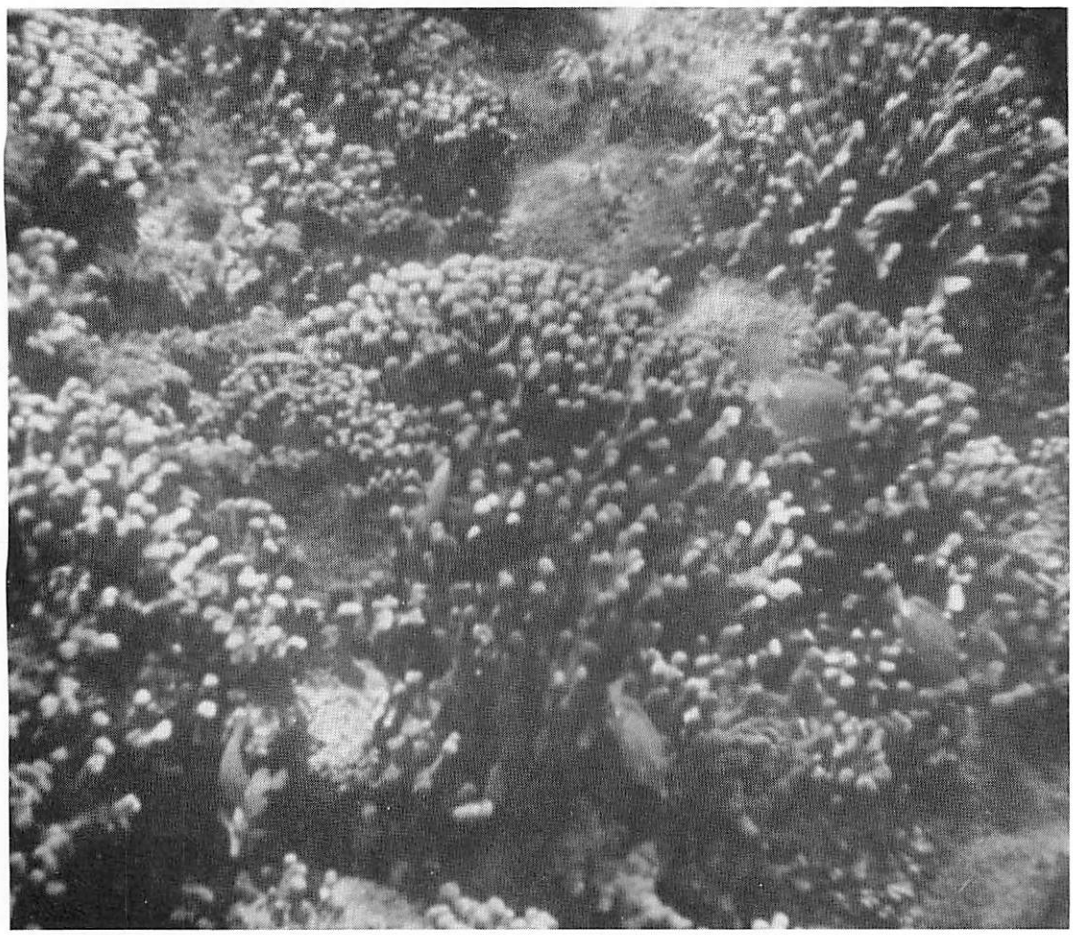
Yet for all their importance in the marine environment, until this Sea Grant project was launched in Year 01, no comprehensive study had ever been made of an entire reef system that sought to answer three important questions:

1) How does a reef community function normally to build reefs?

2) What happens when a reef community is disrupted or destroyed by natural or man-caused processes?

3) And perhaps most important of all, how can a reef community be stimulated to recover at a faster than normal rate from a destructive event?

The coral reef environment is among the most complex of marine environments in terms of biological, geological, chemical, and physical factors. Answers to the three questions required close and continued monitoring and study by scientists in several disciplines. The University of Hawaii's Institute of Marine Biology is exceptionally well located to conduct such a reef study,



as it is situated on a small island in Kaneohe Bay, and some of the reef areas are but a few steps away.

The project involved several phases of study. One part was concerned with coral transplantations to evaluate causes of coral growth and death. Another phase studied the growth of algae. The contents of reef fish stomachs and intestines were examined to determine what they eat in order to establish the position of each species in the food web or chain. The physical energy of waves pounding on the reef was also studied.

Some 350 locations were established around the bay to measure various factors.

As the study progressed over the first three years, it was discovered that what was being studied was not simply a reef complex, but a reef complex strongly affected by outside factors, such as two major sewer outfalls at the southern end of the bay and soil runoffs from construction projects on the slopes surrounding the bay. The northern portions of Kaneohe Bay and its reefs are relatively unpolluted, as opposed to the more strongly stressed southern areas.

During Year 04, almost all of the activity of the project was aimed at compiling the data and preparing a detailed atlas entitled, *Atlas of Kaneohe Bay: A Reef Ecosystem Under Stress,* which will be published in Year 05. The atlas has 128 pages, including 65 charts and illustrations. The information gathered in the detailed surveys is given, along with explanatory material on the history of the bay, the purposes of the study, and a chapter concerning the stresses and influences brought to the bay and its reefs by man.

This project will be continued in Year 05.

Life in the Sea

10-DAY EXPERIMENT PUTS SIX DIVERS AT 500-FOOT DEPTH FOR 2 DAYS

Sea Grant-sponsored "dry dive" shows ways to combat excessive loss of body heat and other problems plaguing divers who work long periods deep beneath the sea . . .

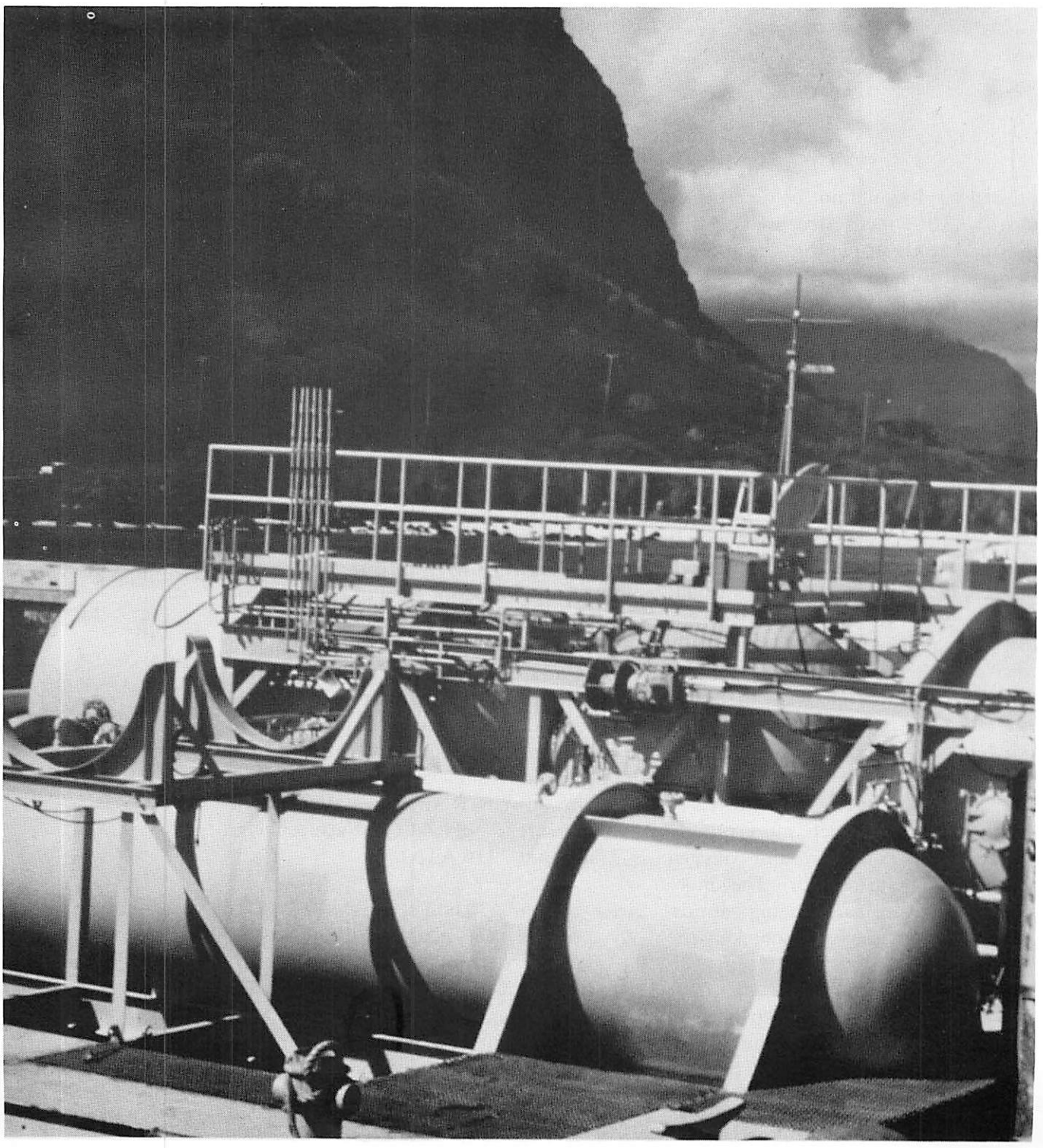
Armed with modern techniques and technology, such as saturation diving, variable helium-oxygen breathing mixtures, undersea habitats, and multi-unit diving systems with elevator-like transfer capsules that carry men down to their working depth in a dry atmosphere, divers have been penetrating deeper and deeper into the ocean's depths. The 1000-foot mark has been passed in the open ocean. Simulated "dry dives" in hyperbaric chambers that reproduce the pressures of the ocean depths have placed men successfully at the 2000-foot level for a short time. Six men have lived and worked for three days in an open-to-the-ocean habitat placed 516 feet beneath the surface. The limits to this penetration do not yet appear to have been reached.

But although the sea's depths have not yet placed limits on how far down divers can penetrate or on how long they can stay down, the pressures that increase with every foot of descent have definitely – and sometimes severely – limited the physical and even mental efficiency and effectiveness of deep divers.

Since Sea Grant Year 01 at the University of Hawaii, this "Human Performance in the Sea" project has been working to more clearly define and understand the various limits imposed upon divers, so that measures may be taken to counter these limits and bring performance as close as possible to sea-level standards.

One of the major factors interfering with efficient performance on deep divers has been excessive loss of body heat. There are a series of factors leading to this heat loss at depth, which can be explained as follows. Even in quite shallow water (10 feet, for example) a diver cannot expand his chest against the water pressure to inhale unless the air he is breathing is at the same pressure as the surrounding water. This equal outward pressure negates the inward pressure of the water column. As the diver goes deeper, the equal outward pressure of the breathing gases in his lungs also keeps him form being squeezed flat.

Down to about 150 feet, divers can safely breathe compressed air. Below that depth problems occur. The nitrogen in compressed surface air begins to seriously intoxicate the diver. This problem cannot be overcome by breathing pure oxygen on deep dives; below 50 feet the pressure makes pure oxygen toxic and eventually lethal. Even if there were no problem from the nitrogen in com-



pressed air, it could not be used below about 300 feet. Because of the pressure at these depths, the oxygen in normal surface air becomes as toxic as pure oxygen is below 50 feet.

The best answer to this problem, so far, has been a mixture of helium and oxygen for breathing on deep dives with the percentage of oxygen being steadily reduced as the diver descends. (Because pressurizing a gas forces more molecules of that gas into a given volume, at 600 feet a mix with 2 percent oxygen contains enough oxygen molecules to properly sustain human life.) As the percentage of oxygen is reduced as a diver descends, the percentage of helium in the mixture must, of course, be increased. And this is where the heat loss problem comes in on a deep dive.

Helium molecules tend to carry away body heat much more rapidly than do the nitrogen and oxygen molecules in surface air. The more helium in the surrounding atmosphere, the greater and quicker the body heat loss.

After months of planning experiments and checking the normal physical parameters of the six volunteers who would be pressurized in this study during Year 04, the actual experiment got under way in January 1972. It was to be a "dry dive" -- meaning that although the interior of Makai Range's sealed undersea habitat, AEGIR, would be pressurized to equal a depth of 500 feet, the habitat would remain on the surface, not submerged to that depth.

The six subjects (three from Makai Range; three from the University) entered the habitat and were sealed from the outside. Interior pressure of surrounding breathing gases was increased slowly, until on the second day the 500-foot level of pressure was reached. The men inside were under exactly the same pressure-atmosphere conditions they would have encountered if the habitat had been 500 feet down in the ocean with the bottom hatch open. At that depth the men were subjected to sixteen times the normal surface atmospheric pressure, or "16 atmospheres absolute" (16 ATA).

After 43 hours at the 16 ATA pressure, the long slow process of gradual decompression began, easing off the pressure slowly to avoid such dangers as the "bends." It was not until a full ten days after the men were first pressurized in the habitat that the top hatch was opened and the six emerged into the sunlight.

In addition to the heat loss problem, three other areas had been studied during the pressurization dive:

1) The nutritional and metabolic requirements of saturation diving.

2) Fluid balance and kidney function.

3) Sensory and motor function impairment caused by exposure to high pressure of inert gases, such as helium or nitrogen.

Objectives of the research were reached in all four areas. Body heat losses were documented according to the various ways heat escapes from the human body, such as by breathing, and through specific areas of skin. Recommendations can now be made for countering the heat drain experienced by divers. Food requirements cannot be established as a function of depth and work load. During the first three days of the dive, the divers went into "negative fluid balance" which affected their hearts and work efficiency. The researchers learned the causes and can recommend appropriate measures. And much information was obtained relating to sensory and motor function problems which should be useful in making divers healthier and more efficient.

A number of other lines of research were also followed during the year, including the determining of oxygen conservation during breath-hold diving, documenting how the divers regulate the pulmonary ventilation during the exercise, documenting the time for recovery from exercise in cold water, identifying several common drugs which could cause problems when used by divers, and defining a physiological "marker" for individual susceptibility to becoming "intoxicated" by nitrogen. The researchers also participated in the NAUI diving course for physicians and diving instructors and published eleven manuscripts in the scientific literature.

Makai Range contributed considerable support to this research and the State of Hawaii, through the State Marine Affairs Coordinator, contributed $55,000 over and above required matching-fund support for Sea Grant projects.

Another Sea Grant project, closely related to this "human performance" project, called for the improvement and maintenance of a large "diving tank" at the University's Look Laboratory of Ocean Engineering

which could be used for various in-water experiments with divers. In this tank, 40 feet high by 30 feet in diameter, pressures in either air or water to a depth of 100 feet can be reproduced. Work is almost completed on a special lock for 4 ATA hyperbaric facility.

The facilities project was merged into the overall human performance project and both projects will be continued in Year 05.

Ocean Bottom Resources

JEWELS THAT GROW ON THE SEA FLOOR

Beautiful pink and black corals form the basis of an expanding precious coral jewelry industry in Hawaii. Before this project, all pink coral had to be imported. Now new jobs have been created and a new type of coral jewelry is being introduced . . .

The popularity of jewelry fashioned from shaped and polished pink and black corals is on the rise in Hawaii. Tourists and residents alike prize coral jewelry as a beautiful and long-lasting souvenir of the sea. So much so, in fact, that present retail sales in Hawaii are estimated at $4 million annually, $1.7 million in black corals and $2.3 million in pink.

The raw black corals used by Hawaii's jewelry fabricators are harvested by divers from depths near 200 feet off the island of Maui. When this project was inaugurated, there was no commercial harvesting of pink corals in Hawaii. The pink corals, which are even more prized than the black, are found at much greater depths, growing on substrates from 1200 to 1500 feet beneath the surface. All of the pink corals used by Hawaii fabricators were purchased

from Japanese sources, under conditions that did not assure an ample supply from year to year. Most of the imported pink corals were taken from banks north of Midway Island that is regarded as being geographically part of the long Hawaiian Island chain by crude dredging methods that destroy far more of the corals than they recover.

One important reason for the establishment of a precious coral project was to investigate a bed of pink coral that was known to exist near Oahu's Makapuu Point. In

addition, project personnel surveyed other beds near Hawaii and determined the extent of the beds, and tried to compute a rate at which the corals could be harvested to allow them to replace themselves, so that the supply would not be depleted. Another important goal was to develop methods of harvesting that were both non-destructive and selective, so that all corals not ready for harvesting would be allowed to continue their growth.

The Makapuu bed was carefully surveyed and sustained-yield harvest rates determined. A method of harvesting the coral by means of a mechanical arm mounted on a submersible was developed.

To date three new beds of pink corals have been discovered and preliminary surveys made. Last year, in addition to the required one-third matching funds, the project obtained $45,000 from the Marine Affairs Coordinator of the State of Hawaii, and some $65,000 worth of support from Makai Range, Inc. These funds provided ten days of sea time with the Makai Range research submersible, STAR II.

During Year 04, the project started and completed growth studies of black corals, began an investigation of the legal status of both pink and black corals, and initiated studies of marine creatures found near pink corals, which identified eleven new species.

Two Sea Grant Advisory Reports on precious corals have been published; two more papers are in preparation.

The greatest success of the project so far, from an economic standpoint, lies in the fact that since January 1972, Makai Range has been commercially harvesting via the STAR II submersible, and successfully marketing pink corals from the Makapuu bed using the selective harvesting methods developed by this project.

New types of gold and bamboo corals were discovered by the project in the Makapuu bed. Gold coral jewelry has been developed and introduced to the Hawaii market on a trial basis. Early results indicate that it will be well received.

The creation of at least ten new jobs in the Hawaii coral jewelry industry can be attributed to this project. It has also greatly reduced the need to import raw pink corals, which sell for around $50 a pound.

This precious coral project will be continued in Year 05 by Sea Grant.

MANGANESE NODULE PROJECT SPARKS MUCH INTEREST AND ACTIVITY

A German research group and an international consortium have worked with this manganese resource project which also inspired a state-sponsored international conference . . .

With the possible exception of the "floating city" project (described elsewhere in this report), no Sea Grant project at the University of Hawaii has attracted as much attention, interest, and cooperative work as has this investigation of the ferromanganese resources of the ocean bottom.

There has been much cooperation and exchange of information with the Valdivia Research Group, representing both the West German government and Metallgeschellschaft A.G. and Preussag A.G., of Frankfurt, Germany. Investigators on this Sea Grant project have made short cruises aboard the R/V VALDIVIA with the German research group which has established a base in Hawaii's Foreign Trade Zone. An international consortium formed by Dr. John Mero of Ocean Resources, Inc. has also worked with the project. University of Hawaii scientists aboard the University research vessel KANA KEOKI, along with scientists from the Centre National pour l'Exploitation des Oceans, Brest, France, worked with the consortium at the end of Year 04 on ocean tests of a *continuous line bucket* deepsea mining system developed by Commander Yoshio Masuda of the Japan Maritime Safety Force. The system was tested aboard the Japanese ship KYOKUYU MARU NO. 2. The Mero consortium has applied to the state of Hawaii for prospecting and mining rights.

Hawaii's Department of Planning and Economic Development has established an ad hoc manganese resources committee to investigate the various ways that the state might benefit from the considerable manganese resources discovered in the channels between some of the major islands by investigators on this project. The director of the state's Center for Science Policy and Technology Assessment has been asked to

devote a considerable amount of his time to manganese resources.

Originally, this project was to do a general study of the composition of manganese nodules of the deep Pacific. When it was discovered that cores taken from near the Hawaiian island of Kauai contained evidence of manganese enrichment, mid-way during Sea Grant Year 02, the project was redirected to explore the extent of manganese deposits near the major Hawaiian islands and to determine the economic importance of such deposits.

During Year 04 manganese deposits near Hawaii were sampled in four reconnaissance cruises aboard the R/V TERITU. These deposits, which are in the form of crusts or "pavements", rather than nodules, are located at depths of less than 400 to over 2400 meters off the east and south coasts of Kauai, the west coast of Oahu, and the east and west coasts of Niihau. Other manganese deposits have been found off Necker and Brooks Banks in waters about 400 meters deep. These discoveries extend the known areas of manganese enrichment mapped in Year 03 by seven-fold, two-thirds of which are in shallower water than deposits previously reported. One such deposit is located near Barber's Point, an industrial area at the southwest tip of Oahu.

From all indications, the deposits have commercial potential. The metals most sought after from manganese deposits at the present time are copper, nickel, and cobalt, although many other minerals are found in such deposits (e.g., iron, manganese, titanium and zinc).

Additional work has followed on the deepsea deposits south of Hawaii. A second international conference was held in July 1973, to review the results of German, University of Hawaii, and other US work in the area.

Except for some funds for environmental monitoring, Sea Grant support was withdrawn from the project at the end of Year 04, on the assumption that other sources, such as industry and the state, would continue funding for this important research.

Other

PREDICTING THE EFFECTS OF DREDGING SHALLOW TROPICAL LAGOONS

Deeper and wider does not always mean that there will be an improvement to mother nature's handiwork . . .

Few studies have been made of the effects of dredging in tropical waters.
50 This project came into being when a proposal was made to dredge shallow Pala Lagoon on Tutuila Island, American Samoa to provide a channel and turning basin for small boats and to permit additional recreational use of the lagoon. Pala Lagoon has a mean depth of only 1.5 centimeters. A party of nine investigators spent a week at the lagoon, studying current systems, phytoplankton productivity, abundance and distribution of bacteria in the waters, and numerous other factors. The study showed that the dredging would not notably increase internal circulation in the lagoon, except near the entrance. In fact, the dredging may result in less effective tidal dilution of the lagoon waters. And, because there is leaching of domestic sewage into part of the lagoon, the investigators' preliminary report concluded that the dredging "is not expected to improve the microbial quality of the lagoon."

A final report on the investigation was in preparation at the end of Year 04 when the project was concluded.

A FLOATING CITY TO SOLVE URBAN PROBLEMS

Can the ocean's vast three-dimensional space relieve the modern city's dual problems of congestion and sprawl? Preliminary socio-economic studes said, "Yes—so this project began working on the engineering practicalities . . .

The ideal city is compact and convenient, with activities centralized and everything necessary for a good life only a short distance away. New York City, in its pre-automotive days, was like this. But today's cities, as they grow, face increasing problems of both central core congestion and ever-outward-extending urban sprawl.

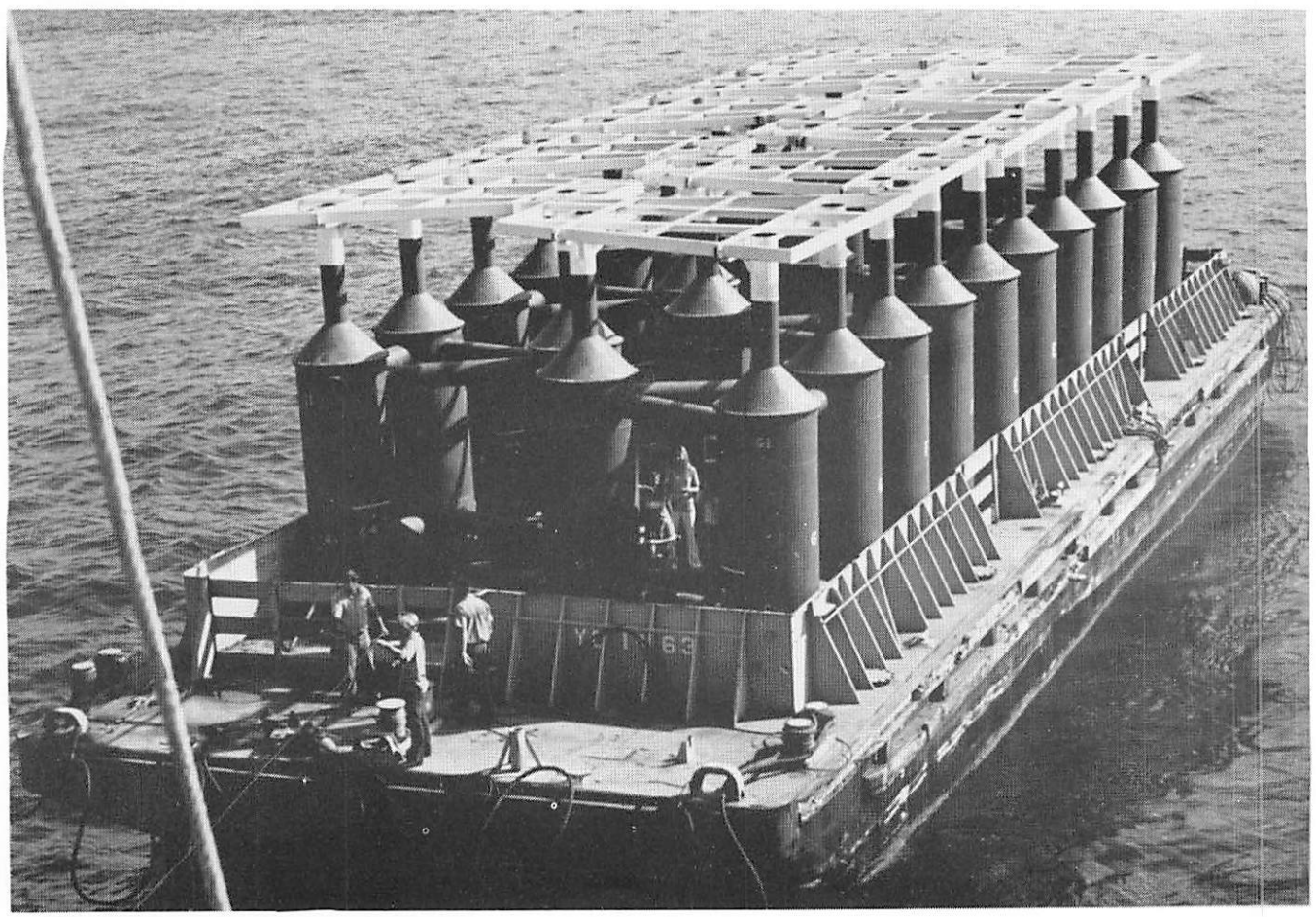
Such cities are not compact, neither are they convenient or comfortable. Land-based "solutions" have intensified the problems, not solved them. More high-rise construction results in more congestion; moving suburbs further outward increases sprawl and lengthens supply and support lines, thus lessening efficiency. But for the large number of cities located on a sea coast, there may be a sea-based solution.

Land may be saved from further encroachment (and perhaps even return some to open-space uses) by moving many activities out to sea on large stable floating platforms. The advantages are both numberous and compelling.

The entire sea surface is a self-maintaining highway for the lowest-cost of all forms of transportation, so that people and supplies can readily move between the land city and the floating platforms with minimum cost and difficulty. Because such stable platforms would have large volumes and areas of useable space beneath the waterline, activities and complexes placed on such platforms could be made truly three dimensional and the need for long horizontal movements of people and goods in space-consuming, air-polluting autos and trucks will be eliminated. When rebuilding or "urban renewal" becomes necessary, the affected sections could be floated away for replacement or recycling.

Already plans are well under way along several areas of the East Coast of the United States to build floating power plants at sea. But these will be on shallow-draft barges floating behind the shelter of man-made breakwaters; the concept of the basic platform developed in Hawaii is quite different and extremely practical.

The Hawaii concept is founded on two basic facts concerning the ocean: the sea's surface is seldom calm, usually ranging from mildly rough to wildly tempestuous and, although the surface of the sea is often heaving and churning, the action of waves decreases with depth, extending not much farther below sea level than above it.



These facts are being utilized more and more by offshore drilling operations of the oil industry, which is increasingly turning to what are called, "semi-submersible" rigs for exploratory drilling at sea. The working areas of these rigs are above the reach of wave action, and the rigs are kept afloat by large pontoons placed well below the turbulent surface. The result is a remarkably stable working platform even in extremely rough seas. (Such rigs are now being built to operate even in areas where 100-foot waves often occur such as in the North Sea.

Hawaii's "floating community" concept calls for platforms that would measure 370 feet from main deck to the bottom of the flotation pontoons, ballasted so that the main deck would ride forty feet above mean sea level. To minimize surface wave action on the structure, the flotation pontoons would have long narrow necks that go through the wave-action area. The 120-foot long neck of the pontoons would be 38 feet in diameter at the upper end, widening out to 80 feet at the lower end. The lower 80-foot portion would measure 250 feet from top to bottom.

Although a great deal of theoretical investigation work was done on such areas as hydrostatic and hydrodynamic behavior of the core ring of the floating platform and its components, the most visible manifestation of the work performed during Year 04 was the 1:20 scale model that was built. This model consists of ten modules with three pontoons each. It is 50 feet in diameter when assembled into a circle, 17.5 feet high, and weighs 50 tons dry and 150 tons when ballasted with water. Fabrication was begun in February and completed in mid-April 1972. Most of the labor was done by volunteer workers with much material and equipment donated by local firms. On May 6 the model was loaded aboard a Navy barge and taken to Oahu's Kaneohe Bay by the Navy for in-water assembly and testing. The natural waves occurring in Kaneohe Bay correspond well to the 1:20 scale of the model, making the bay the ideal testing site.

No structures were placed atop the model's basic deck or platform, as the model is to be used for various engineering tests. A detailed 46-page "First Annual Report" on the project was published in August 1972, giving far more data and details on the project than are possible here. Of great significance is the large amount of support given the project by various institutions, individuals, and agencies. With Sea Grant support at $85,000 for Year 04, the value of all support as computed in the project's "First Annual Report" is $391,932.89.

Because of the great potential of such a floating community concept for relieving urban congestion in coastal cities, and the increasing need for such relief, the project was funded for further investigation and research in Year 05.

ADVISORY

During Year 04, a small but effective Seat Grant Publications Office was developed and a capable science editor employed. The primary function of the unit is to edit and handle the technical production requirements for Sea Grant reports. A list of Sea Grant publications issued in Year 04 appears on page 59. Since July 1971, the Sea Grant Publications staff has written and produced a monthly Sea Grant Newsletter covering major marine developments in the University and marine community at large. The office also provided technical services and displays for symposia and workshops.

Advisory Services agreed to provide technical guidance and produce three units of a marine atlas for the state of Hawaii: a book on common Hawaiian reef fish and compendia of bays, anchorages, and harbors and marine mineral resources in the state.

Sea Grant Advisory Specialists played a significant role in bringing experts in animal science together with marine biologists to strengthen the Sea Grant aquaculture reserach program, cooperated in assessing the economic feasibility of current developments in aquaculture, and provided help in developing brine shrimp production on Christmas Island as a viable commercial enterprise.

Commercial fishermen were assisted in the handling of live bait and problems and means of providing assistance to small-boat fishermen were examined by Advisory Specialists, particularly on the outer islands. Other advisory efforts were aimed at improving and handling fish and processing fish products.

The Environmental Center joined with the Sea Grant Advisory Services in providing liaison in coastal environmental matters between the university and the community, including governmental agencies. Using the output of the Sea Grant coastal environment program, the Center conducted an active program of reviewing and advising legislative committees on proposed coastal environmental legislation. Relying heavily on Sea Grant input, it reviewed and advised the State Office of Environmental Quality Control on environmental impact statements of federal and state agencies and the Department of Health on the sanction of proposed zones of mixing in

coastal waters. The Center calls on Sea Grant project personnel as speakers for meetings, conferences, seminars, and symposia dealing with environmental problems and to serve as members on task forces for the Office of Environmental Quality Control, such as those on Keehi Lagoon and Pearl Harbor.

Advisory services were extended to shoreline residents and others concerned with developing and maintaining attractive and functional vegetation cover under Hawaiian shoreline conditions through reports and public workshops. A workshop on the state's sand resources established goals and industry support for next year's program in inventorying offshore sand deposits and developing systems for economical mining of these deposits.

A series of films and public service information releases on diving safety were developed. A preliminary look at diving safety legislation was begun in Year 04. The diving safety message is being carried on commercial TV and a feature on ETV was devoted to air embolism, bends, and shallow-water blackout.

While advisory services in all program areas were strongly supported and many activities were initiated, another vital role was the analysis of local needs and development of a plan to service these needs. In this regard, the Oregon State Advisory Services Workshop was an immense help. From that meeting came the realization the Hawaii's marine development is as complex as that of any other state and the plan developed for the coming years must be multi-faceted.

COOPERATIVE REPORTS
Advisory Reports

Information Sheets

Project Bulletin No. 1. *Quality of Coastal Waters Project Bulletin.* 1972. (UH Water Resources Research Center.) Feb.

Project Bulletin No. 2. *Detergent Phosphates in Hawaii.* 1972. (UH Water Resources Research Center.) March.

Project Bulletin No. 3. Dugan, Gordon L. 1972. *Receiving Water Quality Criteria Concepts.* (UH Water Resources Research Center.) April.

Project Bulletin No. 4. Cox, Doak C. 1972. *A Definition: Best Practicable Treatment or Control in Hawaii Water Quality Standards.* (UH Water Resources Research Center.) May.

Project Bulletin No. 5. *A Summary: Quality of Coastal Waters Progress Report.* 1972. (UH Water Resources Research Center.) Nov.

Project Bulletin No. 6. Klemmer, Howard and Samuel N. Luoma. 1973. *Mercury Levels in Marine Biota.* (UH Water Resources Research Center.) Jan. NTIS Accession Number COM-73-10508.

Project Bulletin No. 7. Young, Reginald H.F. 1972. *Bacterial Indicators of Water Quality.* (UH Water Resources Research Center.) Dec.

Technical Reports

SEAGRANT 69-1. Moberly, Ralph Jr. and J. Frisbee Campbell. 1969. *Hawaiian Shallow Marine Sand Inventory Part 1. Introduction and Part 2. Ahu o Laka Sand Deposit, Kaneohe Bay, Oahu.* Also HIG-69-10. NSF Sea Grant Program Grant No. GH-28. 24 pp., 13 figs., 1 table, 2 plates.(UH Hawaii Institute of Geophysics) June. o.p. NTIS Accession Number PB 186 134. (Re-issued: Aug. 1972)

SEAGRANT 69-2. Ho, Francis P. and Lynn A. Sherretz. 1969. *A Preliminary Study of Ocean Waves in the Hawaiian Area.* Also HIG-69-16. NSF Sea Grant Program Grant No. GH-28 and ESSA Contract No. E-106-69(N). 36 pp., 4 figs., 1 table. (UH Hawaii Institute of Geophysics) Aug. o.p. NTIS Accession Number PB 186 363. (Re-issued: Aug. 1972)

UNIHI-SEAGRANT-TR-71-03. Coulbourn, William T. 1971. *Sedimentology of Kahana Bay, Oahu, Hawaii.* Also HIG-71-14. National Sea Grant Program Grant. No. GH-93. 141 pp., 57 figs., 1 table, 4 plates, 5 Appen dices. (UH Hawaii Institute of Geophysics) Dec. o.p. NTIS Accession Number COM-72-10235.

UNIHI-SEAGRANT-TR-72-02. Campbell, J.F. 1972. *Erosion and Accretion*
60 *of Selected Hawaiian Beaches, 1962-1972.* Also HIG-72-20. Sea Grant Program Institutional Grant No. 2-35243. 30 pp., 6 figs., 10 tables. (UH Hawaii Institute of Geophysics) Nov. NTIS Accession Number COM-73-10321.

Miscellaneous Reports

Gopalakrishnan, C., Ed. 1971. *Directory of Marine-Related Activities in the State of Hawaii: 1971.* 63 pp.

UNIHI-SEAGRANT-72-01. Water Resources Research Center. *The Quality of Coastal Waters: First Annual Progress Report.* 1972. Also WRRC Technical Report No. 60. National Sea Grant Program Institutional Grant No. 2-35243. 213 pp., 48 figs., 65 tables, Appendice A-C. (UH Water Resources Research Center) Sept. NTIS Accession Number COM-73-10144.

Craven, John P. and Joe A. Hanson. 1972. *Hawaii's Floating City Development Program: First Annual Report - Fiscal Year 1972.* National Sea Grant Program Grant No. 2-35243. University of Hawaii and the Oceanic Institute. 46 pp. Aug. NTIS Accession Number COM-72-11482.

Journal Contributions

Hing, Francisco S., Nora Yu-Ang Tang, and Catherine G. Cavaletto. 1972.

"Stability of Fish Sausage at Low Temperature Storage". Reprinted from *Journal of Food Science* 37:191-194. NTIS Accession Number COM-72-11414.

Rivers, Jerry B., James E. Pearson, and Cynthia D. Shultz. 1972. "Total and Organic Mercury in Marine Fish". Reprinted from *Bulletin of Environmental Contamination & Toxicology* 8(5):257-266. NTIS Accession Number COM-73-10446.

Hanna, Joel M. and Suk Ki Hong. 1972. "Critical Water Temperature and Effective Insulation in Scuba Divers in Hawaii". Reprinted from *Journal of Applied Physiology* 33(6):770-773.

SEA GRANT REPORTS

Advisory Reports

UNIHI-SEAGRANT-AR-72-01. Ahsan, Abu Ekram, John L. Ball, Jr., and Jack R. Davidson. 1972. *Costs and Earnings of Tuna Vessels in Hawaii.* Sea Grant Program Institutional Grant No. 2-35243. 22 pp. 2 figs., 14 tables. July. NTIS Accession Number COM-73-10063.

Miscellaneous Reports

UNIHI-SEAGRANT-MS-71-01A. Baldwin, W.J., J.W. Struhsaker, and G. Akiyama. 1971. *Longer Life for Nehu.* (Translated into Japanese by Mr. Seiyei Wakukawa) Prepared under the National Science Foundation Sea Grant Program and the State of Hawaii Fisheries Research Program. 24 pp. Aug. NTIS Accession Number COM-73-10121.

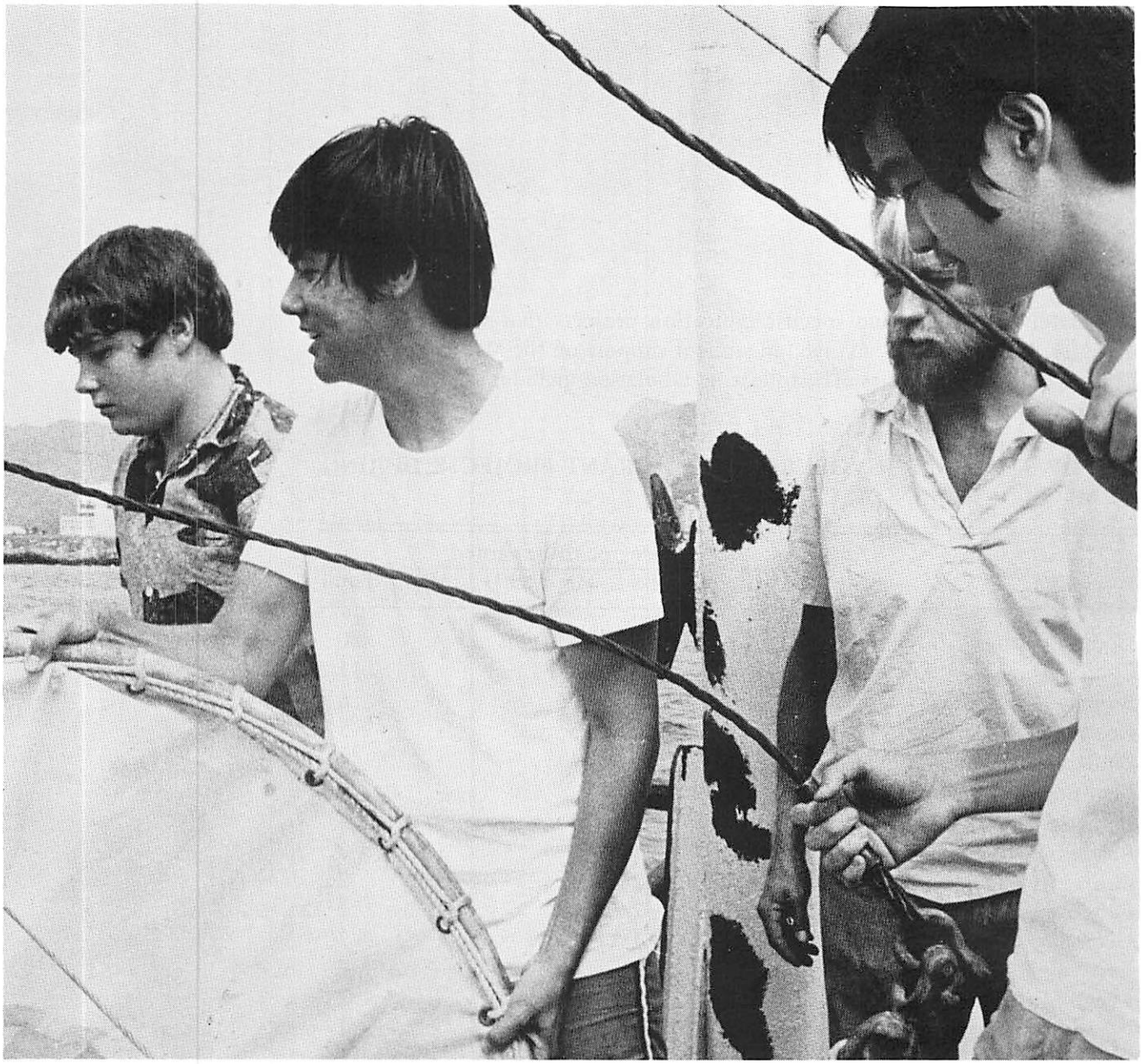
EDUCATION

Status of Education Projects

Research Project	new	continuing	completed
marine option program	X		
marine technician training program		X	
formation of a marine pathology teaching collection		X	

List of Projects and Principal Investigators

marine option program	barry h. hill
marine technician training program	john benson
formation of a marine pathology teaching collection	albert c. smith



Of the 84 students supported by Sea Grant, a suprisingly large number are graduate students. Some 63 percent of all students supported are graduate students, but only 38 percent are in oceanography. Of the graduate students, 83 percent are candidates for Master's degrees and 17 percent (including the MD candidate) are doctoral candidates.

Master of Science degrees were awarded to four Sea Grant supported students: one in oceanography and three in ocean engineering. Two of the three ocean engineers are employed by a Honolulu-based engineering consultant firm and the U.S. Corps of Engineers. The other enlisted in the U.S. Navy and is currently assigned to the U.S. Naval Civil Engineering Laboratory. The oceanography student matriculated to the University of California at Berkeley.

In addition to the two specific education projects that were funded in Year 04, Sea Grant was involved in student support on the Manoa campus as part of its other activities. The following tabulation includes students on the Manoa campus only.

NO. OF STUDENTS INVOLVED IN SEA GRANT PROJECTS DURING YEAR 04 AT MANOA CAMPUS

Discipline	Degree to be earned						
	UG	G	BS	MS	PhD	MD	Total
Oceanography	-	20	-	18	2	-	20
Zoology	5	7	5	7	-	-	11
Biology	6	-	6	-	-	-	6
Ocean Engineering	-	5	-	5	-	-	5
Biological Oceanography	-	4	-	4	-	-	4
Civil Engineering	2	-	2	-	-	-	2
Food Science	1	3	1	3	-	-	4
Business Administration	1	1	1	1	-	-	2
Dental Hygiene	2	-	2	-	-	-	2
Economics	2	-	2	-	-	-	2
Geology	1	1	1	1	-	-	2
Law	2	-	2	-	-	-	2
Urban Studies	-	2	-	1	1	-	2
Agricultural Economics	-	1	-	-	-	-	1
Animal Sciences	-	1	-	1	-	-	1
Botany	-	1	-	-	1	-	1
Chemistry	3	-	3	-	-	-	2
Education	1	-	1	-	-	-	1
Liberal Arts	2	-	2	-	-	-	1
Microbiology	-	1	-	1	-	-	1
Nursing	1	-	1	-	-	-	1
Soil Science	-	1	-	-	1	-	1
Pre-law	1	-	1	-	-	-	1
Physiology	-	4	-	1	3	-	4
Accounting	1	-	1	-	-	-	1
Medicine	-	1	-	-	-	1	1
TOTAL	31	53	31	44	8	1	84

ANY STUDENT CAN LEARN ABOUT THE OCEAN

The University of Hawaii is one place where a student doesn't have to be a postgraduate specialist to get really involved with the sea – thanks to the unique Sea Grant "Marine Option Program"...

There are some 8 million undergraduate and graduate students enrolled in American colleges and universities these days. However, only a tiny percentage of the students are being taugh anything about the ocean. These are the 2 or 3 thousand who are studying to become ocean scientists and ocean engineers. Almost all of the rest will leave college with no more formal knowledge of the ocean than they had when they entered high school despite the fact that the world is over 70 percent ocean and that the US is bounded by far more ocean than land.

Many young people who don't want to make a career of ocean science or technology do have an interest in the sea, but the opportunities to pursue this interest as part of their formal educations are rare. In high school, they are generally told that they should "take oceanography in college." At the college level, they almost always find they need a basic four-year degree (generally in science) before they can begin to study oceanography. Seldom if ever can an undergraduate student combine studies leading toward any land-oriented career with courses and activites concerning his or her interest in the ocean.

Even at such an ocean-surrounded school as the University of Hawaii, this was the case until six months before the start of Sea Grant Year 04, when a new idea in providing ocean education and experiences to undergraduates was launched under a University Innovations Grant. Sea Grant very quickly became a major sponsor of the new concept, beginning in the latter half of Year 03.

The Marine Option Program or MOP, as it is called, is designed to supplement, rather than supplant, a student's major course of studies. To earn a Marine Option Program certificate, the student must take twelve credit hours of ocean-related courses, including six hours of studies related both to the marine environment and to the student's degree major.

Several interdisciplinary courses have been created especially for MOP students, although others may also enroll in the classes. A single such course might include marine biology, marine

technology, ocean law, and sea economics, taught to a group ranging from engineers to pre-law and liberal arts majors. As Dr. John Craven, Dean of Marine Programs, has said about this aspect of MOP, "The ocean is not a subject -- it is a place. Therefore, every discipline can be included."

But academic studies is only one phase of the Marine Option Program. Each MOP student must acquire a marine skill relating to his or her interests. Although SCUBA diving instruction leading to a NAUI certification is offered to all MOP students, SCUBA proficiency is not regarded as one of the acceptable marine skills under the program; rather it is considered a valuable tool for operating in the marine environment. Within MOP a marine intern program has been established to assist students in the acquiring of those marine skills that might require expensive special equipment, special training, travel, or extensive time at sea.

MOP students are encouraged to interact actively with the ocean. A sailing course is only one option available. One student organized snorkeling instruction and guided tours in Oahu's beautiful Hanauma Bay for the benefit of people who had never observed underwater creatures first hand. Students have helped run experiments with dolphins and have learned to care for various marine mammals, becoming involved even to the extent of making a meal of the fishes fed to the marine mammals. Others have organized clubs among high school students interested in the ocean. Two MOP interns acted as crew members and assistants to scientists on a three-month cruise aboard the University research vessel KANA KEOKI.

A number of MOP students utilized their SCUBA diving skills to lay underwater pipelines to supply seawater to the University's new Pacific Biomedical Research Center. Another group of MOP students obtained a grant from the National Science Foundation for an undersea study to provide a baseline to monitor environmental changes which could be caused by a sewage outfall. Many have assisted scientists at the Hawaii Institute of Marine Biology with a wide variety of tasks. One MOP student made a study of hovercraft and hydrofoils in connection with a study of marine mass transit for Oahu and he has written articles on the subject. Still another MOP project introduced about 700 high school students to working oceanography during the year via

cruises on one of the University's research vessels.

The Marine Option Program will publish a detailed report of their activities.

The Program has been funded for Year 05.

FILLING A VITAL NEED FOR HAWAII'S MARINE COMMUNITY

Neither ocean science nor ocean industry can function without skilled marine technicians -- and Hawaii was facing a serious shortage of these indispensible experts . . .

The United States does a marvelous job of producing highly educated marine scientists and engineers. In academic year 1971-72 there were some 130 colleges and universities offering graduate or undergraduate degree programs in ocean science and engineering. At the same time, there were barely 20 institutions training marine technicians to support their efforts. Yet without the aid of skilled technicians, trained in the special problems of coping with the marine environment, the carrying out of modern ocean projects is seldom possible.

Although Hawaii is a major oceanographic center, as recently as 1969, there was no program of any kind in the state for training marine technicians and support personnel. That year, a Sea Grant survey showed the Hawaii's marine community would need from 20 to 30 additional marine technicians each year. In September of 1970, a Sea Grant supported Marine Technician Training Program was instituted at Leeward Community College on Oahu, a part of the University of Hawaii system.

The program has a remarkable degree of flexibility, from the standpoint of a prospective marine technician. The basic course of instruction is a two-year curriculum, with both theoretical and "practical" instruction, leading to an Associate of Science degree. Courses in this program include chemistry, oceanography, marine biology, seamanship, oceanographic techniques, basic electricity and electronics, SCUBA diving, welding,

and physics, to name a representative selection. If the prospective student isn't interested in the degree, but wants to learn certain job-required skills, there is a special "certificate" program that can be adapted to his needs. On the other hand, the graduate of the two-year program can transfer over half of his credits into the University program, if he wants to go on for a four-year degree and possibly graduate work.

During Year 04, the number of courses of instruction increased from 18 to 30. Enrollment during the year totaled 85; five students completed requirements for the A.S. degree; all were employed upon graduation.

Community interest and participation in the program increased during the year. One evidence was the donation of a $20,000 diesel powered fishing vessel to the program.

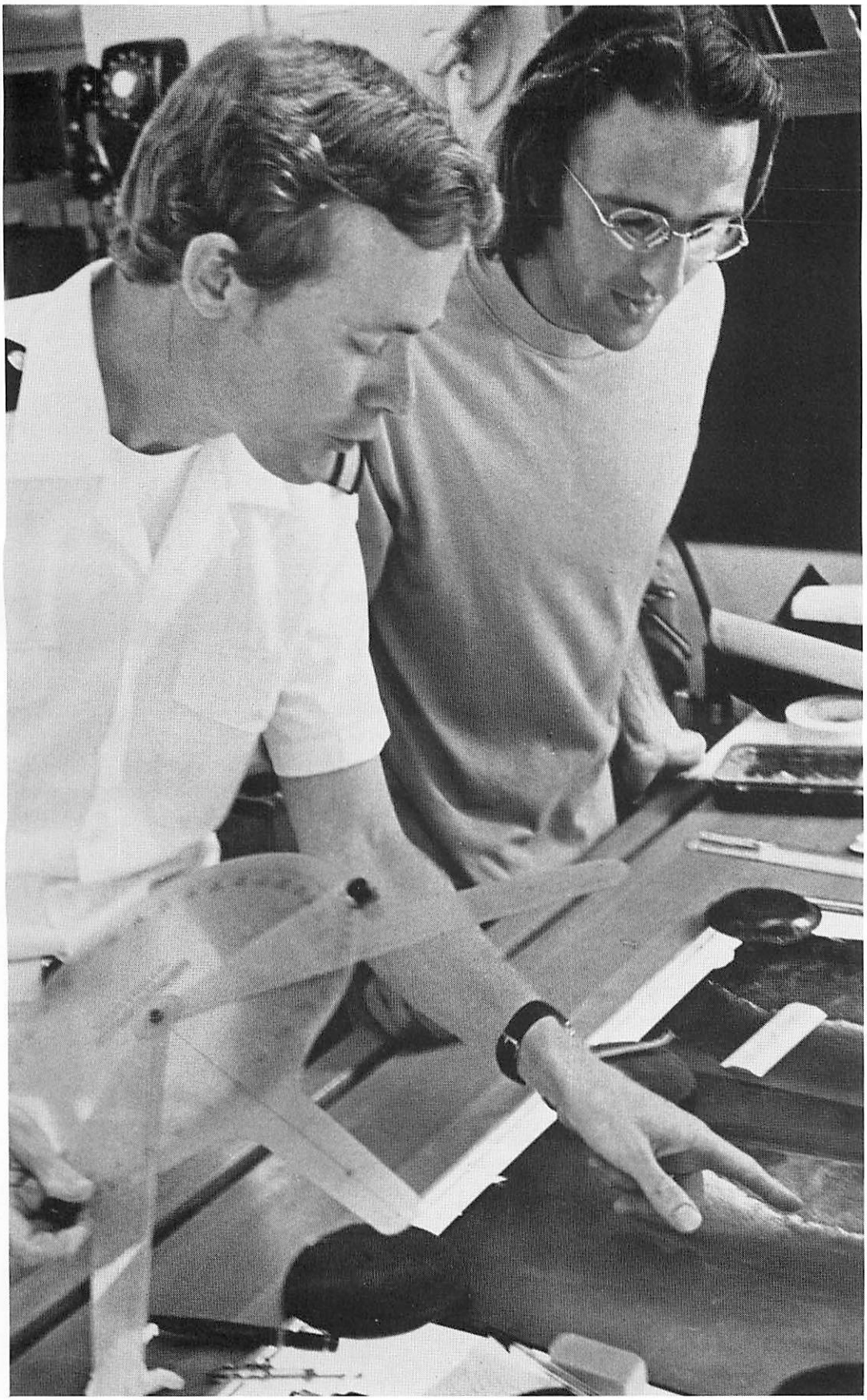
The Marine Affairs Coordinator of the State of Hawaii took a special interest in the program and made available $20,000, which, with the cooperation of the National Marine Fisheries Service, enabled students in the program to gain at-sea experience during the summer of 1972 aboard the CHARLES H. GILBERT, a 123-foot fisheries research vessel.

From June 5 through September 1, daily cruises were made aboard the GILBERT. A total of 28 students served aboard the ship: six of them for the entire time and the rest for 15-day periods. In addition to instruction in shipboard procedures, students received instruction and practical experience in live-bait tuna fishing (as done commercially in Hawaii) and in electronic tracking of deepsea fish. Cruises lasting from a week to ten days were made to Kona, Hawaii for marlin tracking, to Niihau for catching marlin, and to Maui and Hawaii for additional instruction in piloting, celestial navigation, and offshore watch standing.

A survey made during April 1972 showed that 21 students had obtained full-time employment and 13 had obtained part-time employment, all in ocean-related jobs. The information is tabulated in the table.

The total community contribution, or matching fund support, for the training program more than tripled from $20,000 to $63,000, sound evidence of the importance the marine community of Hawaii places in this program.

This project will be continued in Year 05.



EMPLOYMENT OF STUDENTS IN MARINE TECHNICIAN TRAINING PROGRAM: YEAR 04

	Employment Part-time	Employment Full-time
T. H. Davis Marine Division	-	1
Sea Gems Hawaii	-	1
Fishing vessel MOKIHANA	-	2
Model Cities	-	1
Hawaiian Tug & Barge	-	1
Charter boat ALLURE	-	1
Pearl Harbor Naval Shipyard	-	2
McWayne Marine Supply	-	1
Charter boat CALIFORNIA	-	1
Dan's Dive Shop	-	1
Hawaii Institute of Marine Biology		
at Eniwetok	-	2
at Kaneohe	1	1
Robert's Marine, Ltd.	-	1
National Marine Fisheries Service	7	1
Sunn Low Tom & Hara	-	1
United States Air Force	-	1
Pan Pacific Laboratories	3	-
Honolulu Zoo	1	-
Look Laboratory	1	-
Geolabs Hawaii, Inc.	-	1
Fishing vessel TAIHAE MARU	-	1
TOTAL	13	21

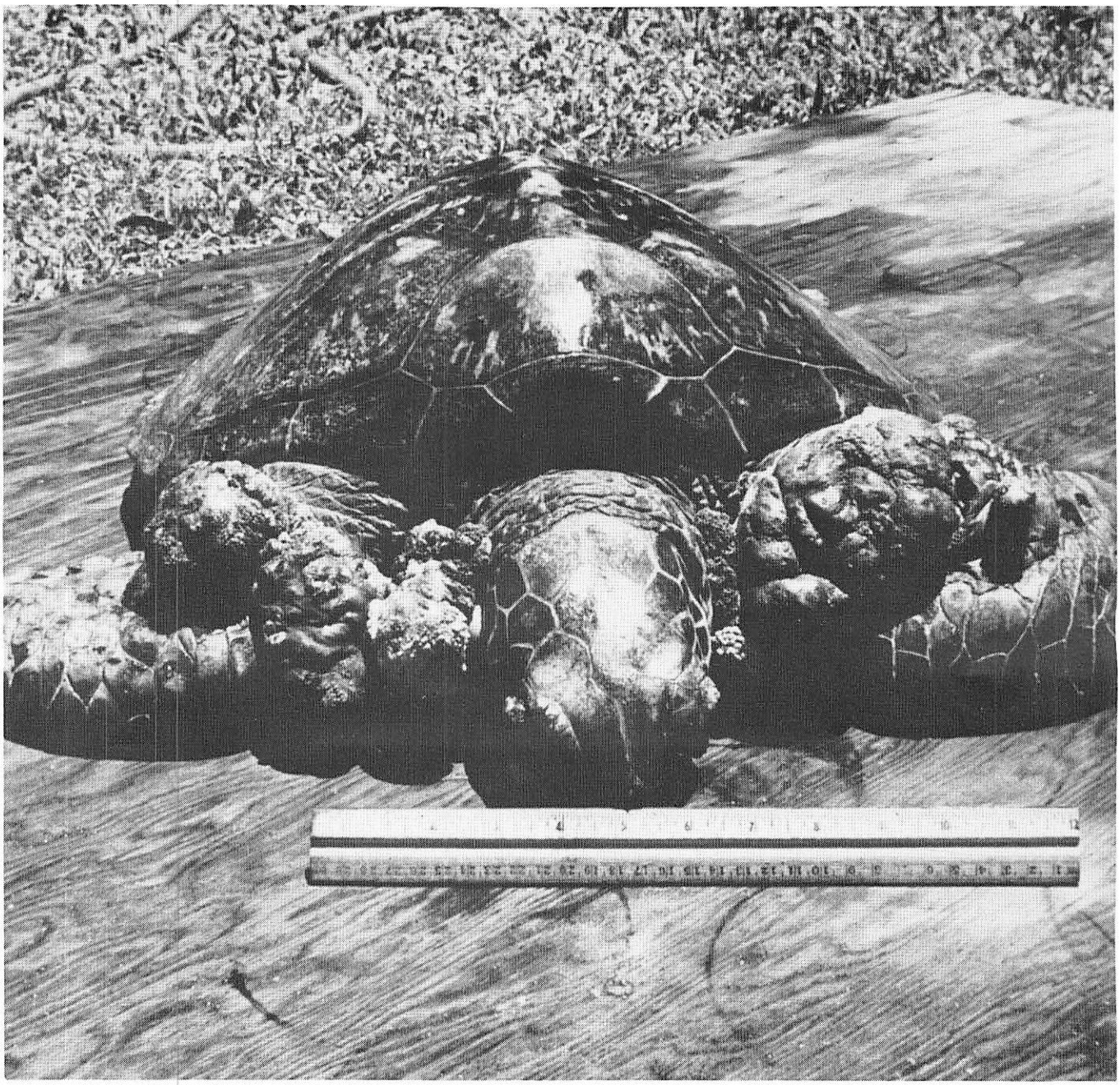
HOW CAN YOU IDENTIFY SICK FISH — BEFORE THEY BECOME A DEAD FISH?

Diseases are a major problem for aquaculturists and the problem grows in importance with the increasing need for protein from the sea. This project started the important task of gathering samples and creating a course of instruction . . .

In the open ocean, the process of natural selection generally prevents sick fish from spreading their disease throughout the school. The diseased ones, unable to keep up with the school, usually lag behind and are probably devoured by predators. But when fish are kept in confined areas, such as aqaculture enclosures, the sick ones remain close to the healthy, and the illness has a chance to spread. The stress of confinement probably also contributes an increased susceptibility to disease.

In many cases there are obvious indications that something is wrong with certain of the creatures, such as peculiar behavior or abnormal color, weight, or shape. But sometimes it is simply not possible, at least with present knowledge, to recognize from external signs that there is trouble internally. More than one aquaculturist has received his first indication that his creatures were harboring a disease when he found them all dead. Studies in this area may provide new indicators of health of marine creature that could solve the problem of diseases of marine animals. And even when there are recognizable external signs of pathology, there is need for a comprehensive knowledge of just what the signs indicate. This project was established to help meet this growing need for the ability to recognize indicators of health of marine animals and the proper materials to provide instruction in marine pathology.

During this past year (the project's second) much progress was made. Pathological marine specimens were acquired from Hawaii, California, Florida, Eniwetok, and elsewhere. Ten sets of slides of basic pathological lesions in marine animals were assembled. A marine pathology laboratory was set up at the University of Hawaii's Hilo College, and an undergraduate student trained in its operation. Following this, the first courses in marine pathology ever presented at the University of Hawaii were given, at both the Hilo and Manoa campuses. These courses were presented a year earlier than originally planned.



In addition, the first draft of a book on marine pathology was completed. Three articles on the same subject are currently being considered for publication by scientific journals. A "Super 8" movie film depicting the underwater autopsy of a sea cucumber was produced. The Principal Investigator also received funding from the Puerto Rico Inter-National Undersea Laboratory for a marine pathology project, and prepared a major part of the scientific section in a proposal to the National Institutes of Health for a biomedical award to conduct research on cancer and marine animals. The proposal was funded for $520,000 over a 5-year period; it is the largest single grant ever awarded to the University of Hawaii at Hilo.

This project was funded by Sea Grant for Year 05.