NOAA Undersea Research Program Fiscal Years 1979 and 1980 Report

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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

Research and Development Special Projects Office
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NOAA'S REGIONAL UNDERSEA RESEARCH PROGRAM—INTRODUCTION

NOAA was given the mandate to establish programs for the assessment, protection, development, and utilization of U.S. Coastal Zone resources. To address this mandate, NOAA's Manned Undersea Science and Technology (MUS&T) Office initiated, in 1977, the NOAA Undersea Laboratory System (NULS) program. Funds for the program were provided in the FY 1978 appropriation to NOAA for continuation of the Oceanlab Project; the Senate Appropriations Committee report of June 1977 stated that funds in the appropriation were to be used for "cooperative undersea programs, including habitats in shallow and intermediate depths."

The purpose of the program was, and is, to provide manned underwater facilities and research support to investigations of U.S. coastal marine environmental, biological, geological, and ecological problems. Initial program emphasis was on the provision of seafloor laboratories and the advanced technology needed for safe saturation-diving operations in support of scientific missions.

The first phase of the program was formulated in such a way as to permit a focusing of scientific interest on marine problems solvable by *in situ* research during the development, construction, and initial operation of a Mobile Underwater Laboratory System (Oceanlab), planned for the period 1977-82. The purpose of this phase of the program was to develop techniques, knowledge, and expertise in operations and safety which might later be used effectively in more complex advanced coastal and deeper water systems. In addition, undersea research was to be accomplished.

As discussed in more detail in the following section, this first phase was implemented by the establishment of the first regional cooperative undersea facility, then called NULS-1, operated for NOAA by the West Indies Laboratory of Fairleigh Dickinson University, and using the undersea habitat, *Hydrolab*.

The overall goals of the NULS program were to:

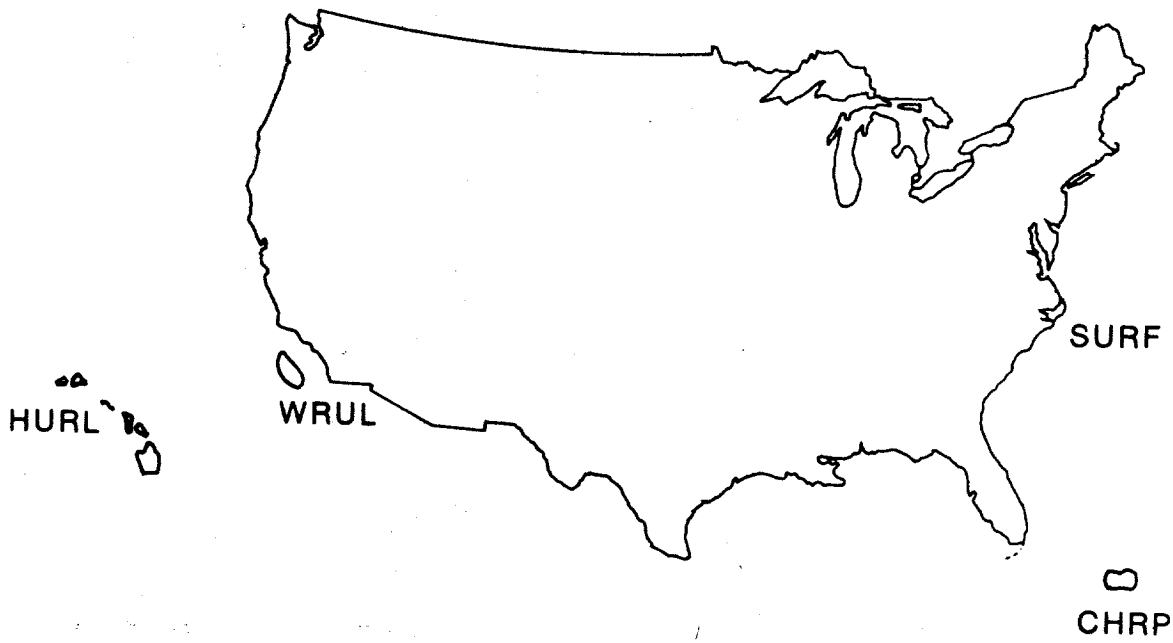
- Acquire basic scientific information about the marine ecology and environment applicable to conditions existing in U.S. coastal areas.
- Support research efforts requiring advanced underwater laboratories and saturation-diving operations in pursuit of solutions to marine environmental problems.
- Demonstrate that safe manned underwater operations can significantly enhance the ability of researchers to successfully complete selected tasks and that classical land-based laboratory scientific methods can be extended to the seafloor.
- Provide a mechanism to ensure continuity of effort and long-range funding for otherwise infeasible *in situ* research efforts.
- Provide the training and facilities to develop a cadre of scientific personnel proficient in the use of underwater laboratory systems and advanced underwater research techniques.

In September 1978, the Oceanlab Program was redirected. As part of the newly constituted program, NOAA decided that the cooperative underwater program should be expanded to provide, in several regions, undersea laboratories using different systems. "Letters of interest," indicating possible collaboration in establishing and maintaining regional laboratories and conducting scientific research programs using them, were solicited from over 400 academic institutions. Initially, it was contemplated that the second step in the program would consist of the establishment of a second undersea laboratory and program, tentatively called NULS-2. Fifteen positive responses were received. After screening, nine of these were selected as representing potentially viable candidates. The institutions that had submitted these nine were asked to develop detailed feasibility studies, setting forth the proposed facilities, the scientific programs envisaged, and means for operation and control. The nine feasibility studies were completed by March 1, 1979, and were evaluated by a panel of scientists and engineers experienced in undersea marine research.

Of the nine, three were selected as superior. These were submitted by the University of Hawaii, the University of Southern California, and the University of North Carolina at Wilmington. The evaluation criteria used by the panel emphasized not only the candidates' experience in undersea operations and past marine scientific activities, but also their proposed science programs and how well these programs related to the use of the facilities proposed.

Each of the three institutions was asked to submit a formal proposal discussing in detail the development and operation of the regional undersea research program. A second evaluation panel was set up consisting of engineers and scientists experienced in undersea operations, marine science programs, and NOAA's mission requirements. This panel reviewed the proposals in detail and provided recommendations on how the programs should be implemented.

In July 1980, separate contractual cooperative agreements were awarded to the three universities by NOAA, authorizing the implementation of their undersea facilities



Map showing respective locations of regional programs.

and programs. These programs and facilities, along with the ongoing *Hydrolab* program, are described in more detail in the following sections.

CARIBBEAN REGIONAL HYDROLAB PROGRAM

The first segment of the Regional Undersea Research Program to be implemented was the Caribbean Program, which is operated for NOAA by the West Indies Laboratory of Fairleigh Dickinson University. The centerpiece of the program is the seafloor habitat *Hydrolab*, which was purchased from its builder, Perry Oceanographics, Inc., of West Palm Beach, Fla., in 1977. The habitat was refurbished and placed on the ocean floor in the Salt River Canyon off the north central coast of St. Croix, U.S. Virgin Islands.

Description

Hydrolab is 4.88 m long and 2.44 m in diameter and is equipped to support four divers for as long as 14 days. It rests at a depth of 15.2 m, but aquanauts (saturated divers) using it have made excursion dives within Salt River Canyon to a maximum depth of 46 m.

During the period May 1, 1978, through August 10, 1980, the *Hydrolab* facility has supported 24 scientific projects, involving 56 investigator/aquanauts from 33 different organizations (mostly academic institutions).

The specific goals of the Caribbean Regional Hydrolab Program are to:

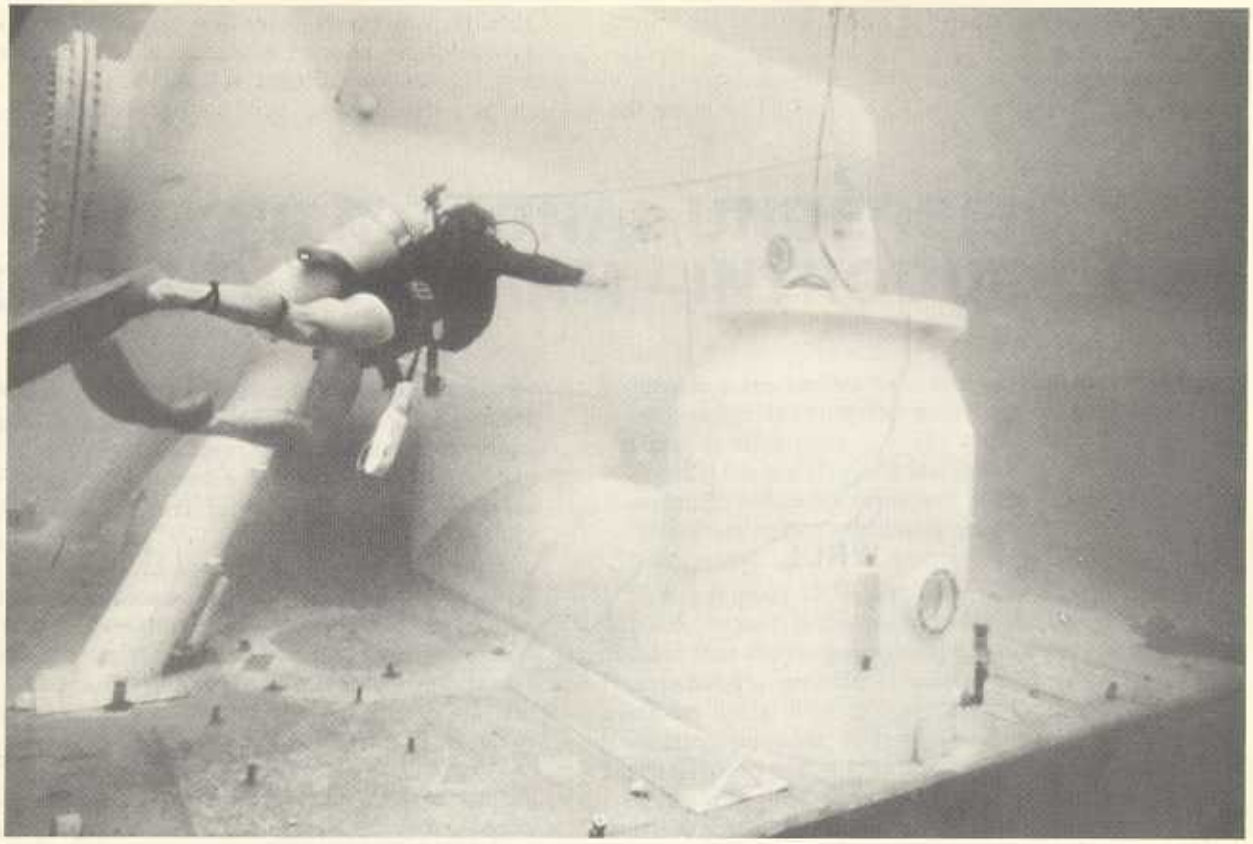
- Acquire, via *in situ* study, scientific information about the marine environment, in particular that prevailing in the Salt River Canyon and similar locations.
- Provide a national underwater facility for preliminary and advanced training of marine scientists in underwater research techniques and saturation diving.
- Develop new and improved underwater scientific research and engineering techniques, oceanographic instrumentation, and diving equipment.
- Provide a facility for the open-sea test and evaluation of underwater procedures tested in shore-based hyperbaric laboratories.

Although each of these objectives is being met in this program, the scientific research program is the *raison d'etre* for the program as a whole.

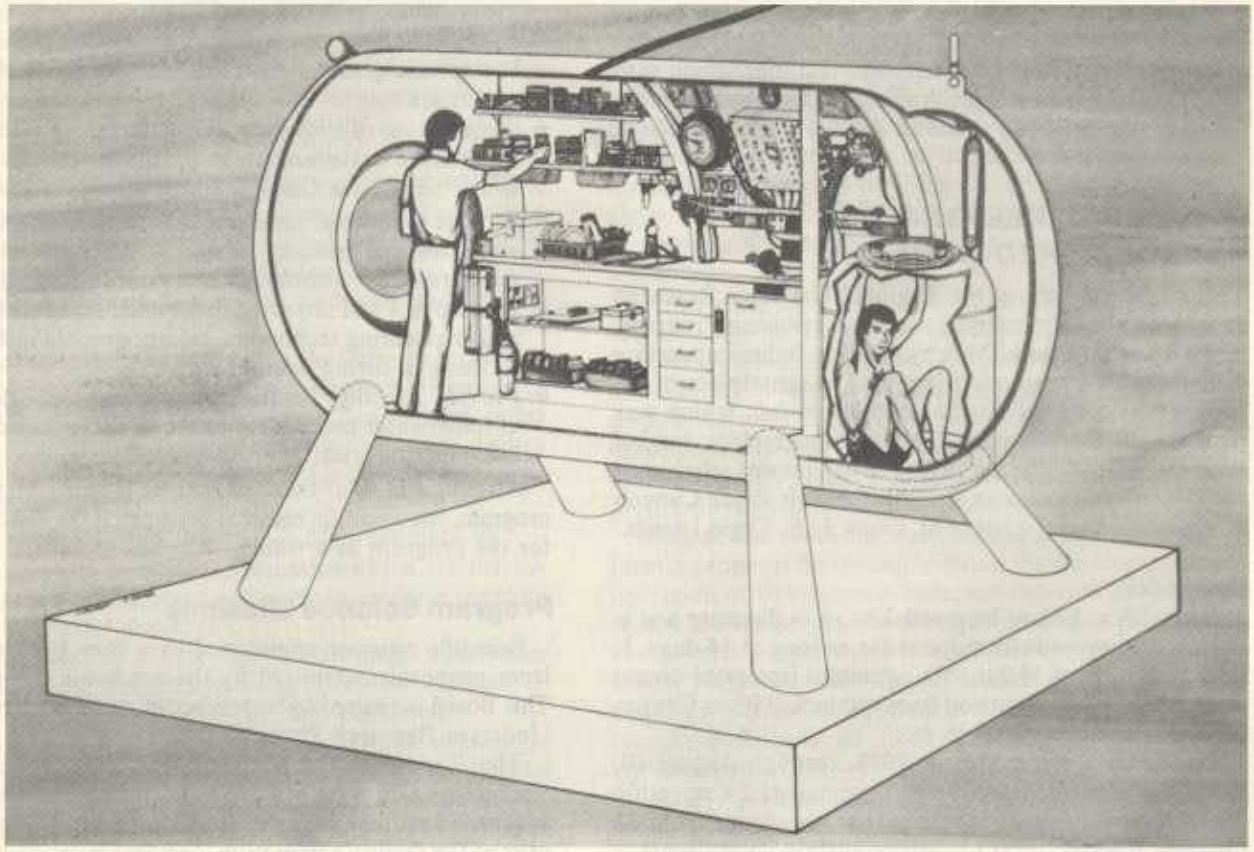
Program Science Missions

Scientific missions are selected by a Peer Review Board from proposals submitted by the academic community. This Board is chaired by a member of the staff of NOAA's Undersea Research Program Office.

The Report of the Manned Undersea Science and Technology Office for FY 1977 and 1978 lists the missions accomplished using *Hydrolab* during FY 1978, the first year of the facility's operation, and also gives abstracts of



Hydrolab located in Salt River marine canyon off St. Croix.



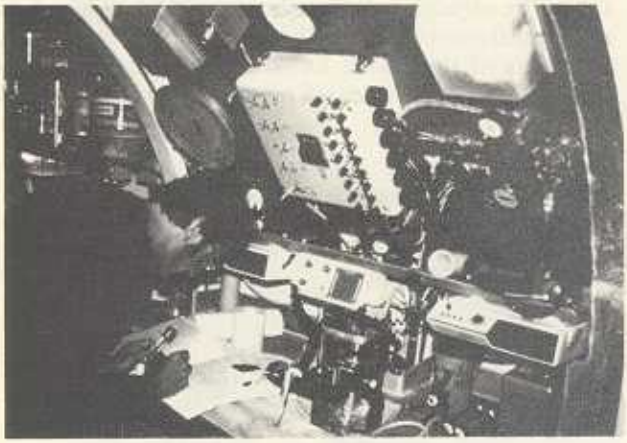
Artist's pictorial cutaway of inside of *Hydrolab*.

the results of nine scientific investigations accomplished in these missions.

Table 2, following, lists 16 scientific missions that were accomplished during FY 1979 and 1980. Following the table, the objectives, scientific personnel involved, and accomplishments of 15 of these missions are given in the abstracts of the Quick Look Reports required at the completion of each research mission at the *Hydrolab* site.

Table 2.—Virgin Islands Regional Program Hydrolab FY 1979-80 Scientific Missions

Investigating Institution	Date	Project
University of West Florida, Rutgers University	Oct 21-Nov 4 1978	Quantification of Reef Fishes
College of the Virgin Islands University of West Florida	Oct 22-Nov 4 1978	Oxygen Consumption of Reef Fishes During Quiescent Periods of Their Circadian Activity Cycles
West Indies Laboratory of Fairleigh-Dickinson Univeristy	Dec 12-18 1978	Sediment Transport Processes of Salt River Submarine Canyon, St. Croix, U.S. Virgin Islands
West Indies Laboratory of Fairleigh-Dickinson University	July 7-14 1979	The Settlement and Recruitment of Post-Larval Fishes into the Coral Reef Community
West Indies Laboratory of Fairleigh-Dickinson University	July 17-28 1979	Geologic Development of Salt River Submarine Canyon
University of Cincinnati University of Michigan	Aug 12-25 1979	The Comparative Feeding Behavior of Crinoids and Ophiuroids
University of Puerto Rico	Sep 15-27 1979	Manipulation of Large External Isopods on Brown and Blue Chromis
Department of Conservation and Cultural Affairs, USVI	Oct 1-11 1979	Optimum Yield for Virgin Islands Black Coral Fishery
West Indies Laboratory of Fairleigh-Dickinson University	Oct 16-24 1979	Structure of the Planktivorous Fish Community Along a Depth Gradient
University of California, Davis	Feb 9-16 1980	Social Behavior and Foraging Ecology of Caribbean Chaetodontids
Moss Landing Laboratories	Mar 24-Apr 6 1980	The Sources, Dispersal, and Utilization of Benthic Drifting Plants in the Salt River Submarine Canyon
State University of New York, Buffalo	Apr 17-23 1980	Resource Availability and Suspension Feeding by Gorgonians
College of the Virgin Islands	May 13-20 1980	In Situ Oxygen Consumption of Reef Fishes During Quiescence (Part II)
West Indies Laboratory of Fairleigh-Dickinson University	May 27-Jun 3 1980	Influence of Sediment Bioturbators on the Success of Seagrass Communities
University of Maryland	July 7-18 1980	An Experimental Analysis of Ecological Processes that Structure Fish and Invertebrate Reef Communities
Moss Landing Laboratories	July 27-Aug 9 1980	The Sources, Dispersal, and Utilization of Benthic Drifting Plants in the Salt River Submarine Canyon



Scientist at work in *Hydrolab*.

Collecting fish to measure their activity.

Quantification of Reef Fishes

Date: October 21—November 4, 1978

Purpose: Compare methods of quantifying reef fish populations (Report No. 78-8a).

Participants: University of West Florida:
Stephen A. Bortone,
Principal Investigator
Rutgers University: R.W. Hastings
University of West Florida: D. Siegel
University of West Florida: R.J. Bolton

Accomplishments: Two 100-meter transects were laid out running north to south, one each along the east and west walls of the Salt River Canyon. Each transect was marked off in 10-meter intervals. The methods used were the following: *Quadrate*: Stations were established at 10 m intervals along each transect. The diver would count and estimate the size of each individual fish which entered an imaginary 2x2x2 meter cube. *Random Swim*: Each diver would swim randomly but slowly in the vicinity of the transect and record species seen in a 50-minute sampling period. *Transect*: Two divers positioned themselves on either side of the origin and the transect line. The divers would then swim along the transect and record the number of each species seen. There were three approaches to photography. (1) *Movie (Cinetransect)*: A super 8 mm movie camera with day-night film was utilized. One diver would swim at a leisurely pace for 50 m while exposing 2.75 minutes of movie film, aiming on the transect line. This was done during both day and night. (2) *Movie (Turret)*: Again, a super 8 mm movie camera was employed. A diver would expose film while slowly panning in a circular fashion (clockwise) for 2 minutes (360°). Each transect was exposed at each end and center of the study area during daylight. (3) *Still Photography*: A diver would expose four frames of ASA-64 Kodachrome film in each of four compass directions. Each transect consisted of ten stations with four frames each. Preliminary findings indicate that each of the methods contributes a specific and necessary amount of information on the population level of reef fishes. The random-swim technique was the easiest to employ and probably the least sensitive to error. It became very obvious at the outset that any method that requires a diver to count fishes has a great amount of potential error inherent in it. It may be reasonable to see that, once the relative species abundance has been discerned, some effort may be made toward standardizing the population figures to absolute abundance levels. A prior assumption concerning photographic techniques seems to be invalid in our opinion. It is doubtful that even the most careful analysis will correct for a diver's *in situ* ability to identify fish. This study has reinforced some assumptions made in certain collecting techniques. The preliminary analysis indicates that some method which permits the diver to inspect all areas of the reef is essential to comparing reefs on the basis of their fish populations. Methods which restrict the observations of divers significantly underestimate the species diversity levels of reefs. Future attempts will be made to combine both quantitative and qualitative methodology to make efficient use of the type of information each of these provides.

Oxygen Consumption of Reef Fishes During Quiescent Periods of their Circadian Activity Cycles

Date: October 22—November 4, 1978

Purpose: Measure oxygen consumption of reef fishes (Report No. 78-8b).

Participants: College of the Virgin Islands:
Paul Winkler, Principal Investigator
University of West Florida:
R. I. Bolton, Jr.

Accomplishments: The standard or resting metabolic rate of fishes has proven difficult to measure under laboratory conditions. Fishes unaccustomed to visual restrictions, particularly during active segments of diel behavioral rhythms, tend to elevate oxygen consumption through spontaneous random and directed movement. The introduction of the fish, then, into an enclosure with water of a strange chemical milieu, would significantly increase the metabolic rate above basal levels. The decreased handling, transport, and acclimation procedures made available by field measurements, and the assurance of water with a familiar chemical milieu, temperature, and pressure, would

perhaps lend itself to a more accurate measure of standard metabolism. Oxygen consumption of diurnally active and nocturnally active fishes was measured using their corresponding quiescent periods. Fishes were captured and placed in the respirometer several hours before measurements were begun. Oxygen consumption was calculated. At the conclusion of the test, fishes were removed, preserved, and weighed. Water samples were analyzed for dissolved oxygen by the Winkler Method. Data for the bicolor damselfish (*Eupomacentrus partitus*) show a weight-oxygen consumption regression. Respiration values for larger fish are similar to those reported in the literature for tropical species. However, the data for smaller fish are not as well correlated. In general, cardinal fishes demonstrate a much higher level of awareness and activity during quiescent periods than diurnally active species. Individual variation among cardinal fishes appears to be quite high and, at this point, unpredictable.

Sediment Transport Processes of Salt River Submarine Canyon St. Croix, U.S. Virgin Islands

Date: December 12-18, 1978

Purpose: To determine sediment transport processes (Report No. 78-9)

Participants: West Indies Laboratory
Fairleigh Dickinson University: Dennis K. Hubbard,
Principal Investigator
Fairleigh Dickinson University: J. Sadd
Fairleigh Dickinson University:
H. Tonnemacher
University of Sydney, Australia: C. Phips

Accomplishments: Sixteen short-core (15-cm) sediment samples were taken from the canyon floor to determine the nature of the canyon fill. The coarsest sand occurred near the base of the west wall, confirming that this low trough was a zone of higher current activity. Other statistical parameters showed little systematic variation and no trends are readily apparent at this time. Measurements were also made to characterize wall "roughness." The data show that there are systematic changes in wall roughness along either wall, from wall to wall, and with depth. In general, the west wall is more irregular than the east with the majority of the wall roughness being confined to the upper transect. Experiments were also set up to measure directly the sediment transport rates during both storm and nonstorm conditions. Eight sediment traps were attached to the canyon walls at various sites to collect the sediment entering the canyon from the adjacent shelf. On the canyon floor, four bedload traps were buried at a depth of 30 m along the excursion limit line. As part of an ongoing West Indies Laboratory study in Salt River Canyon, five sediment tracer experiments were monitored before, during, and/or after the mission. At each site, sand was removed, washed, dried, and impregnated with a fluorescent material. The sediment was then reintroduced and allowed to move for a given length of time. The data from these experiments will be used to calculate daily transport values for the east and west canyon walls and the canyon floor. Based on these data, daily and annual transport rates will be calculated and a sediment transport model constructed. While analysis is incomplete, some conclusions can be made. First, the major areas of transport certainly vary from storm to nonstorm conditions. During nonstorm conditions, most of the sediment introduced to the canyon comes down the west wall. Furthermore, sediment appears to be stored in the canyon during nonstorm conditions. In contrast, during storms most of the sediment is introduced over the east wall in response to the dominant northeast swell and seas. Storm surges are dominant movers of sediment in Salt River Canyon. During storm conditions (5 to 14 days per year, on the average), 11,000 to 35,000 kg are introduced to the canyon and moved seaward through its axis. During the other 351 to 360 days of the year, only twice that amount is moved. The data seem to support our premise that storm events are extremely important and should be closely observed.

Unfortunately, the time period during which storms occur was later than usual in 1978, and did not coincide with the "time-window" set for the mission. Because the storms did not occur as anticipated, the mission was used to determine base-line data for the Canyon and to set up experimental traps to be monitored by surface-based divers during later storms. An attempt will be made to schedule a mission at a later date during a storm period.

The Settlement and Recruitment of Postlarval Fishes into the Coral Reef Community

Date: July 7-14, 1979

Purpose: Observe colonization of reefs by postlarval fish to describe the events of settlement and determine their role in shaping the eventual composition of the developing fish community (Report No. 79-1)

Participants: Fairleigh Dickinson University
West Indies Laboratory: John C. Ogden,
Principal Investigator
West Indies Laboratory: S. Miller
Cornell University:
W. McFarland and N. Wolf
University of Washington: M. J. Shulman
University of Massachusetts:
J. P. Ebersole

Accomplishments: Thirty artificial reefs were constructed on the sand floor of the Salt River Canyon at three different times: June 7, June 22, and July 7. Adult damselfish (*Eupomacentrus variabilis* or *E. leucostictus*) were transplanted to replicates of each time series. The reefs were monitored twice weekly prior to and several times daily during the mission. A transect on the east wall of the Salt River Canyon was also investigated for larval fish during the mission. Observations were made of interactions between settling postlarval fish, resident damselfish, and transient predators. Transfers of various species onto reefs were carried out to examine the effect of one species

on another. Preliminary results have indicated that interactions between postlarval fish are important in determining where fish will settle and the chances of their survival (e.g., presence of juvenile snappers (*Lutjanus mahogoni* and *L. buccanela*) prevents the settlement of postlarval grunts (Family *Pomadasyidae*)). Adult territorial fish also affect recruitment (e.g., adult damselfish lowered recruitment of surgeonfish (*Acanthurus bahianus* and *A. chirurgus*). The presence of an established fish community decreases recruitment of postlarval fish. Older reefs had significantly fewer settling fish than reefs that had just been built. Plankton tows were conducted at surface and midwater levels while aquanauts made tows at 2-3 meters above the canyon floor at regular intervals throughout the day and night. These established that there was an increase in the number of larval fish in surface and midwater plankton during the night, with a peak about an hour before dawn. An initial impression is that postlarval fish first appear on reefs at dawn.

Geologic Development of Salt River Canyon

Date: July 17-28, 1979

Purpose: To study the geologic development of Salt River Submarine Canyon by obtaining cores from horizontal holes drilled into the reef walls (Report 79-2)

Participants: Fairleigh Dickinson University
West Indies Laboratory:
Dennis K. Hubbard,
Principal Investigator
West Indies Laboratory: S. McGowan
West Indies Laboratory: H. Tonnemacher
University of Texas: J. Sadd

Accomplishments: The principal objective of this mission was to accomplish the drilling of a number of holes horizontally into the reef wall of Salt River Canyon, a process previously considered impossible, to obtain material which might throw light on the geologic development of the Canyon. Drilling operations ran in two-man shifts. During the 6 days of the saturation mission, four holes were drilled in the west wall. Total length of core penetration was over 13.7 m with an average recovery rate of 50 percent (this means that of the 13.7 m of core, half was solid rock and half was either sand, rubble, or void space in the wall). The deepest hole penetrated 5.4 m into the wall. This is the first time any extensive horizontal drilling of this type has been attempted, and one of the holes represents the deepest lateral penetration into deep reef framework on record. The cores have been split in half and the core-logging is underway. Samples have been sent to the University of Texas for radiocarbon dating. The preliminary results are speculative at this point. The wall was highly porous and the voids well-connected. The short-term turbid plume was observed on various occasions to emerge at sites away from the drilling operation. If it was easier for the turbid water to pass through the wall and emerge elsewhere than to return to the drill hole, then a free and open pore network is indicated. The coral samples collected were remarkably fresh. If they are Pleistocene in age (say 120,000 years b.p.), then this preservation is noteworthy. If they are Holocene (20,000-30,000 years b.p.), then one of the holes drilled records the thickest accumulation of Holocene material found to date.

The Comparative Feeding Behavior of Crinoids and Ophiuroids

Date: August 12-25, 1979

Purpose: Make repeated samplings of echinoderm food preferences and ambient supply of suspended food material. Document the crinoid distribution in the area, study the possible cause of their cryptic behavior, and make comparative samplings of nocturnally emergent plankton from various reef substrata (Report No. 79-3)

Participants: University of Cincinnati: David L. Meyer,
Principal Investigator
University of Cincinnati: G. A. Minnery
Smithsonian Institution: C. G. Messing
University of Michigan: L. H. Somers

Accomplishments: The color patterns, living habitats, morphology, and depth distribution of four crinoids (*Nemaster rubiginosa, Nemaster discoida, Comactinia echinoptera* and an additional color form belonging to the genus *Nemaster*) were examined on the east and west walls of the Salt River submarine canyon. The three Nemaster species were sampled for gut contents in order to determine their feeding preferences. An ambient plankton sampling was taken concurrently with 64 micron mesh net. Insufficient numbers of crinoids at the site prevented the taking of a series of nocturnal feeding samples which would have enabled the times of maximum feeding activity to be documented. Data was collected for this population on the degree of nocturnal emergence, which appeared to be slight. The cryptic behavior of these crinoids was also observed. Two individuals of the yellow-tipped

Securing Crinoid for predator study.

Nemaster were attached to fiberglass screening covering a weighted plexiglass tray during the day. The tray was left in the open in the natural habitat, preventing the crinoids from crawling back into the normal semicryptic living position. Insufficient numbers of suspension feeding ophiuroids were found to compare to crinoids on the basis of feeding behavior and diet preferences. A single adult basket-star (*Astrophyton nuricatum*) was found on a night excursion along the west wall, but this individual was not in the normal feeding posture. A few juvenile basket-stars were also observed. Despite the abundance of sponges in the study area, the ophiuroid *Ophiothrix suensonii* was not common. A few individuals associated with the tube sponges were found along the west wall. The nocturnal suspension feeding ophiuroid *Ophiopsila* was found but is not common. The nocturnal emergence of demersal plankton from interstices of the reef may influence the day-night differences in feeding behavior of reef-dwelling suspension feeders. Because the crinoid study site was located 350 m from the underwater laboratory, the plankton sampling was conducted in closer proximity to the laboratory. Four traps (each covering 0.25 m x 0.25 m) were used to sample plankton emerging from several types of substrata (coral, sand, rubble, and *Halphila* grass on sand). Samples from these substrata were obtained over a variety of sampling periods, day and night. The samples will be analyzed in the laboratory and compared to results obtained from other reef areas.

Photographic study of research site at *Hydrolab*.

Manipulation of Large External Isopods (Genus Anilocra) on Brown and Blue Chromis

Date: September 15-27, 1979

Purpose: Transfer the large, external isopod *Anilocra* (which occurs under the eye of the brown chromis *Chromis multilineatus*, and the blue chromis *Chromis cyanea*) from infested brown chromis to noninfested brown and blue chromis. This method is new and has only been previously tested in aquaria (Report No. 79-4)

Participants: University of Puerto Rico: Ernest H. Williams, Principal Investigator
University of Puerto Rico: J. J. Kimmel
University of Puerto Rico: R. Waldner
University of Puerto Rico: L. B. Williams

Accomplishments: Uninfested brown and blue chromis were collected from an experimental reef at storage depth with quinaldine. Brown chromis infested with isopods were also collected at storage depth with quinaldine from the west wall of the canyon. Fishes were held individually in plastic aquarium bags inside dive bags on the tank rack for no more than 2 hours before transfers. The uninfested fishes were removed from plastic bags in an aquarium. They were then tagged in one or more areas just beneath the scales with an injection of acrylic paint, and held in contact with an isopod from a donor fish in the appropriate location (beneath one eye) until the isopod attached. They were then placed in a plastic bag, suspended in a dive bag for no more than 1 hour, returned to the experimental reef, and released into the field. The donor fishes were released in the areas in which they were initially collected. In the first 2 days, 15 brown and 13 blue chromis isopod transfers were released in the experimental area. During days four and five, five brown and five blue chromis and four blue and two brown chromis transfers, respectively, were released in the area of the experimental reef. During the final observations at the end of day six, 14 of the brown and 14 of the blue chromis were observed from the 22 brown and blue chromis released.

Transferring isopods between fishes was successfully accomplished during the study. Infested individuals were observed in the field throughout the study. The new method promises to be a very useful device for studying parasitism of marine fishes.

Optimum Yield for Virgin Islands Black Coral Fishery

Date: October 1-11, 1979

Purpose: Provide data on black coral growth and mortality to be used in the preparation of an optimum yield estimation for the Virgin Islands Black Coral resource (Report No. 79-5)

Participants: V. I. Department of Conservation and Cultural Affairs: David A. Olsen, Principal Investigator
V. I. Department of Conservation and Cultural Affairs: K. Turbe
Pressure Limited: B. Friedman

Accomplishments: 300 black coral colonies of two species were observed. They ranged in size from 0.5 mm to 47 mm basal diameter. The length and the width of 100 colonies were measured. The initial plotting of the data indicates that there may be size classes which may represent year classes. These data will also permit an initial estimate of the growth rate equation. Over 95 percent of the colonies in the areas of study were measured on the east slope and west walls. These areas consisted of approximately 130 meters of slope/wall area and were north of the standard excursion areas. The colony density will be estimated from

the standard figures of the area. During a followup mission, coral colonies will be remeasured, estimates of recruitment figured, and mortality calculated.

Structure of the Planktivorous Fish Community Along a Depth Gradient

Date: October 16-24, 1979

Purpose: To study the structure of the planktivorous fish community along a depth gradient (Report No. 79-6)

Participants: West Indies Laboratory
Fairleigh Dickinson University:
W. B. Gladfelter, Principal Investigator
Goucher College: W. S. Johnson,
Co-Principal Investigator
National Institutes of Health:
Jeffery Davidson

Accomplishments: The plankton feeding fishes (*Clepticus, Chromis cyanea, multilineata, C. insulata* and *Eupomacentrus partitus*) were investigated along three 50 m transects at a study area located along the east wall of the Salt River Submarine Canyon. These transects were located along the 15.2, 30.5, 100 and 45.7 m depth contours. The number and locations of these fishes were recorded in five excursions. A diver-towed plankton net was used to collect plankton along the same transect. Ten specimens were collected for further study. The results were preliminary requiring more definitive fish and plankton identifications.

Social Behavior and Foraging Ecology of Caribbean Chaetodontids

Date: February 9-16, 1980

Purpose: To obtain quantitative, behavioral, distribution, reproductive, and foraging data for certain Caribbean Chaetodontids and other fishes (Report No. 80-1)

Participants: University of California—Davis:
Steve Neudecker, Principal Investigator
University of California:—Davis:
W. J. Hamilton
Harvard University: P. S. Lobel

Accomplishments: The four 100-meter transects on the east slope and west wall of Salt River Canyon, established during NULS Mission 1 (1978), were sampled for a comparison of chaetodontid distribution, abundance, and foraging patterns. Abundance of chaetodontids and pomacanthids was measured by divers swimming along the transect lines and counting all relevant species seen within 1 meter to either side and within 2 meters above the transect. As in 1978, *Chaetodon capistratus* and *C. aculeatus* were the most abundant chaetodontid fishes. *Chaetodontid striatus* was counted on the east slope transect during this mission and not previously. *Chaetodon sedentarius* was observed only twice and did not occur in any transect survey. For a dietary comparison to the data taken in 1978, six individuals of *Chaetodon capistratus* and *C. aculeatus* were observed at each transect. Foraging behavior and prey selection were quantified by following individuals for 5-minute periods and consecutively tallying the number of bites on each prey item. Individual fish were not followed over successive 5-minute periods.

During evening crepuscular observations on the east slope, several pairs of *Hypoplectrus guttavarius* (shy Hamlet) were found spawning regularly in the vicinity of the east slope tank drop site. Observations of fishes at dusk have revealed that a majority of reef fishes spawn at this time. Hamlets spawn in pairs, above a towering structure. Such orientation may be advantageous to fish because it enables the adults to remain close to refuge (if a predator attacks), and puts the eggs relatively high into the water, out of the grasp of benthic dwelling planktivores. The crepuscular period is the general time of peak predation by reef piscivores and fishes exposed at this time risk higher mortality than at other times. However, at this time, eggs released in the water column have a low risk of mortality, since by dusk most reef planktivores have descended to the reef for the night and any remaining active may be quickly satiated. The relative influence of predators upon spawning reef fishes was also investigated. Several pairs of *H. guttavarius* were selected for study, and a baseline on their natural spawning activity was obtained for each pair. The following data were recorded: the time of each spawning clasp; the location and structure (coral, gorgonian, etc.) over which spawning occurred; height over the structure and height over the bottom where spawning occurred; and the movements of the spawning pair. The aquanauts then acted like potential predators by not allowing the pairs to spawn (each time fish attempted to spawn, a diver rushed in). The fish have two alternative reactions: they may cease spawning (which is the reaction of certain pomacanthids), or they may continue to attempt spawning regardless of the risk.

The results of this experiment will enable contrasting between the reproductive behavior of Hamlets and that of other reef fishes. It will also provide an experimental evaluation of the response of Hamlets to predators.

The Sources, Dispersal, and Utilization of Benthic Drifting Plants in the Salt River Submarine Canyon

Date: March 24—April 6, 1980

Purpose: Determine the sources, export and dispersal of shallow, near-shore benthic vegetation to deeper, offshore areas via the Salt River Submarine Canyon. Also determine the role of the drift accumulating on the canyon floor (additional habitat or food for demersal organisms) (Report No. 80-2)

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Accomplishments: Little research has focused on the interactions between shallow coastal lagoons, nearby offshore reefs, and deeper waters. Submarine canyons may be important in the drifts of seagrasses and seaweeds from the shallow lagoon areas to deeper water. The drift material's role as an energy and habitat source must be determined in order to understand the coral reef ecosystem. Tropical seagrass beds and their associated seaweeds are among the most productive systems in the world, but it is not known how much of this productivity reaches the surrounding waters in forms readily used by the resident fauna. If this transport is significant, shore developments and other human influences on tropical lagoonal systems could have unpredicted consequences in the adjacent coral reef and deeper habitats.

Several methods were used, including vegetation surveys, drift studies, tagging experiments, and a survey of organisms utilizing the drift. Surface divers explored the Salt River Bay, the coral reef at the mouth of the bay, and the head waters of the submarine canyon to identify the possible drift vegetation sources to the submarine canyon area. Bottom drifters were set in several locations at the beginning of the mission in order to monitor possible avenues of drift dispersal. Surface divers set 150 drifters in the lagoon, the main channel, and at the head of the canyon. Habitat divers set the remaining 50 in the main axis of the canyon. Repeated sightings of these drifters were monitored to detect bottom currents and to suggest probable movement patterns of drift plants. Seven drift collecting nets were placed in and around the canyon to collect drift seaweed and seagrasses. Four of these were placed and sampled daily by the aquanauts. The remaining three were placed at the head of the canyon by surface divers and checked daily. Plants and animals in the net samples were sorted, identified, weighed, and enumerated. Species composition of drift algae is valuable in assessing the most likely source of the drift. Naturally occurring clumps of drift plants in the canyon were also collected, sorted, identified, weighed, and enumerated at the shore-based laboratory. Numerous transects within the canyon were taken to assess the distribution and abundance of drift plants and their potential associates and/or grazers.

A preliminary assessment of the role played by drift in the life history of its occupants was conducted. Information on animals in net drift and drift clumps suggests further investigations to be carried out in the second phase of the project (e.g., actual utilization of the drift).

Resource Availability and Suspension Feeding by Gorgonians

Date: April 17-23, 1980

Purpose: Determine whether gorgonians are capable of suspension feeding and the abundance and nature of particulate matter naturally available on the reef of Salt River Canyon (Report No. 80-3)

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Accomplishments: The reef fauna of the east slope of Salt River Canyon is dominated by gorgonian soft corals. This domination can be related to the water quality (particulate rich), resuspension rate, and current. However, the autoecology of these species is not well known. Suspension feeding is of particular interest as gorgonians are almost incapable of capturing zooplankton. Like the reef corals, gorgonians also obtain nutrition from their algal symbionts, but it is likely that energetic and micronutrient requirements must be met through some additional mode of nutrition. The comparison of gross primary production and suspension feeding between species from shallow- and deep-water habitats is therefore of use in determining whether deep water and light species have adapted to their environments via photoadaptation or changes in particulate feeding. The work accomplished can be divided into three components: characterization of particulate resources, suspension feeding experiments, and measurement of photosynthetic rates. The greatest effort was directed at the first two components.

Resource availability will be determined from day and night water samples collected at 15.2 m and 27.4 m on each of the 5 days of experiments, with hand-held Niskin bottles. Samples were taken to determine particulate weight, chlorophyll, Carbon-Hydrogen-Nitrogen (C:H:N) composition, and the presence and abundance of mucous flocs and of proteinaceous particles. Additional samples were preserved to determine bacterial density and dissolved organic content. Zooplankton abundances also were measured and collections designed to provide a broad overview of zooplankton availability. Water and zooplankton samples do not characterize the temporal pattern of resource availability, and the water samples may not represent an "average" condition. Samples are, however, intended as an initial characterization of resource availability which may be useful in a comparative sense.

Feeding experiments were designed to measure capabilities for filtering unbound particles and mucus from the water column. The feeding capabilities of two *Plexaura spp.* were compared (one was most abundant in 24-30 m, and the other at 15.2 m, and both were among the dominant species at their respective depths). Branch tips from each of the species were clipped from a colony and reciprocal transplants made between 27.4 m and 16.8 m sites. During the experiment, the branch tips were enclosed in a plexiglass chamber providing natural light and natural water movement via oscillations of the flexible side walls. Ten-liter and 1.5-liter chambers were used. The colonies' behavior remained normal in the chamber. Hydrated sephadex heads were injected into the 10 liter chamber and colonies allowed to feed for 10 minutes. They were then placed in plastic bags and immediately preserved by injecting formalin. The colonies were tested in pairs (one from each species and four replicate experiments per site). Particle feeding experiments were conducted at both sites at approximately 1030 hours and at the shallow site at

2130 hours. Mucus feeding experiments were conducted using alcian blue stained mucus from *Porites spp.* as a prey item. At each site three branch tips of the "native" species were placed in the 1.5 liter chamber and the particles injected. Two replicate experiments were conducted at each site. In all, 112 feeding experiments were conducted. Polyps from each of the 260 branch tips collected will be examined for the presence, abundance, and size of food particles.

Photosynthetic rates were determined by measuring oxygen flux of groups of three branch tips enclosed in the 1.5-liter chambers. Initial and final 50 ml water samples were removed from each chamber and dissolved oxygen measured on the surface. Light was simultaneously monitored using Liquantum flux sensors. At the 27.4 m site, readings were integrated over the entire experimental period and an average determined. Spot readings were taken with a meter at the shallow site spot. Measures of afternoon net primary production and light level were made on each of 4 days.

In Situ Oxygen Consumption of Reef Fishes During Quiescence

Date: May 13-20, 1980

Purpose: Monitor the oxygen consumption of reef fishes during quiescence (Report No. 80-4)

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Accomplishments: The oxygen consumption of bicolored damselfish *(Eupomacentrus partitus)*, a diurnally active reef resident, and various cardinal-fishes, nocturnally active residents, was measured by "sealed-vessel" respirometry during periods of quiescent behavior. Glass and plastic aquaria of various sizes with glass tops were used as respirometers, weighted with gravel, and supplied with plastic shelters in the larger damselfish tanks. Fish were collected while they were active and held in respirometers fitted with netting for 7 to 10 hours prior to testing. At the beginning of quiescence, the netting was replaced with weighted glass tops. Fishes were then run for 10 to 13 hours at which time water samples were taken from the respirometers by the evacuation of air from standard BOD bottles. Dissolved oxygen was measured with a YSI model 544 oxygen meter. Preliminary laboratory studies amply demonstrated the superiority of this method over the originally proposed "flow-through" system, which significantly raised the metabolism of laboratory fish. The long incubation times and larger respirometers used in this study allowed the fishes to "settle down" in their containers and perhaps, therefore, approach a measure of standard (resting) metabolism. In general, the respirometers functioned properly (i.e., fishes removed oxygen from the water according to their size). However, a larger damselfish respirometer without a plastic shelter (thus exposing the fish) consistently produced abnormally high metabolic rates. This was caused by piscivorous predators striking at the metabolism chamber. The situation was corrected using adequate shelter, and the metabolic rates declined. Sampling methods were improved, as was the reliability of the oxygen meter. During the study, a source of water with a predictable oxygen content was used to calibrate the meter.

Influence of Sediment Bioturbators on the Success of Seagrass Communities

Date: May 27—June 3, 1980

Purpose: Determine the influence of sediment bioturbators (specifically ghost shrimp of the genus *Callianassa*) on the grass beds and sediments in Salt River Canyon (Report No. 80-5)

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Accomplishments: Density surveys (10 m x 10 m) were performed at four depths from 15.2 m to 38.1 m. *Callianassa* were found to be patchily distributed. Two common *Callianassa* types were identified: mound builders (assumed to be *C. rathbunae*, or *C. quadracuta*) and hole dwellers (identified as *C. longiventris*).

Plankton collections were made during the day and at night to determine the diurnal behavioral patterns and distribution of larval *Callianassa*. In addition, emergent larval traps were placed over *Callianassa* mounds and the contents collected at three equal periods during the night for four nights centering on the full moon (the presumed period of larval release).

Burrow morphologies were analyzed by pouring fiberglass resin into open burrows and extracting the hardened resin. Burrows are shown to consist of surface-oriented tubes connected to subsurface chambers. The function of these chambers remains unknown.

An Experimental Analysis of Ecological Processes That Structure Fish and Invertebrate Reef Communities

Date: July 7-18, 1980

Purpose: Establish experimental reefs to be colonized by fish and invertebrates, census early fish colonists of these reefs, and sample plankton providing stock for recruitment to reefs in this environment (Report No. 80-6)

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Accomplishments: Fifteen artificial reefs were established along a 150-meter transect along the east wall of Salt River Canyon. The reefs were 10 meters apart and 10

Construction of artificial reefs for fish colonization studies.

meters west of the rubble along the east wall. Reefs for fish colonization were constructed of cinder blocks aged in seawater and held in place by rebars. Artificial reefs were established for invertebrates by placing pieces of normal coral rubble (sun dried in order to provide unoccupied space for settling cryptic organisms) at a given reef site. The artificial reef was established by impaling each piece of rubble on a short rebar. In addition, four small houses made of ceramic clay and plexiglass were around each piece of rubble, thus allowing the observation of the invertebrates settling in the holes of these houses through the plexiglass base. Three experimental conditions were established among the shallow reefs: five (Type A) reefs were constructed of both cinder blocks and sites for invertebrate colonization (rubble, ceramic houses); five (Type B) reefs provided only sites for fish (cinder blocks); and five (Type C) reefs were comprised of only sites for invertebrates (coral, rubble, ceramic houses). The reefs were placed in an A,B,C,A etc., sequence along the transect. Five artificial reefs were also constructed for fish and invertebrates (cinder blocks, coral rubble, ceramic houses) along the 33.5 m depth contour across the mouth of the Salt River Canyon. These reefs were initiated 20 meters west of the east wall, and placed 10 meters apart. Five Type A reefs were constructed in very shallow water (6 m), using surface diving techniques on the back reef of Salt River Canyon as a control for the deeper sites.

Ten pieces of naturally occurring coral rubble were collected along the east wall adjacent to each artificial reef containing sites for colonization by invertebrates. Ten pieces were also collected along the east wall, adjacent to the reefs at 33.5 m. These pieces of coral rubble were isolated in plastic bags and sent to the surface. Each piece was then chiseled into fine pieces and sieved so that all cryptic fauna could be preserved, recovered, and quantitatively analyzed. These measurements will provide a control for seasonal effects and indicate which cryptic species are available to colonize the artificial reef. On three separate nights, one plankton sample was collected near the light of the habitat and two samples were taken away from the habitat and near the artificial reef sites along the 18.3 m transect.

This study will provide the first comprehensive analysis of colonization of fish and invertebrates at deep 33.5 m, moderate 18.3 m, and shallow 6 m sites. The patterns of colonization and variations in the resultant community structure will be identified in detail during the next two missions. This fauna is almost totally different in species composition from that found in very shallow habitats. The assemblage undoubtedly contains undescribed species and probably undescribed genera. All of these samples will be identified and quantified, with the help of Smithsonian specialists for certain taxa.

HAWAIIAN UNDERSEA RESEARCH LABORATORY PROGRAM (HURL)

As the second segment of NOAA's regional undersea research program, the University of Hawaii is developing a regional undersea program for the Pacific region that is centered in Hawaii and capitalizes on existing Hawaiian facilities, organizations, and programs. Among the organizations involved are: the Hawaii Institute of Geophysics, Hawaii Institute of Marine Biology, the Bishop Museum, the Waikiki Aquarium, Sea Life Park, Oceanic Institute, Brigham Young University, the Community Colleges, State of Hawaii Fish and Game, National Marine Fisheries, Hawaii National Energy Laboratory (OTEC), University of Hawaii, Naval Underseas Center, Look Laboratory, and the Army Corps of Engineers. The program will include research missions of marine scientists on a national basis.

The scientific objectives of the HURL program are closely alined with those of NOAA. At the University of Hawaii, research is dominated by marine-related projects, with the State actively supporting programs in aquaculture, fisheries management, OTEC, and marine resource utilization. The four areas of research priorities are categorized