



Manned Undersea Science and Technology Fiscal Years 1977 and 1978 Report

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U.S. DEPARTMENT OF COMMERCE

Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration

Richard A. Frank, Administrator

Office of Ocean Engineering

Steven N. Anastasion, Director

The Charles Stark Draper Laboratories (CSDL) provided technical support with the system design areas and the user mission-related work.

In December 1977, the contract efforts were directed to reevaluate and update the Phase I study in response to congressional and Department of Commerce queries.

Based on surveys made by NOAA and CSDL on scientific user requirements, scale models of the Oceanlab laboratory facilities were made and minimum laboratory size and configuration requirements identified, and a baseline laboratory developed. Optimum system configurations were developed and compared, one being a surface-support independent autonomous submersible and the other a surface-supported undersea mobile habitat.

Using these improved configurations, detailed comparative cost analysis and mission effectiveness studies were done with respect to the various capabilities and design parameters.* In July 1978 NOAA began a review of the entire Oceanlab Program. As a result of this review, it was decided that NOAA should continue a program of development and use of various technological means for supporting undersea research.

In order to provide for the widest scientific community interest and use, it was decided not to implement a single undersea system, but instead to support and stimulate "man-in-the-sea" technology for ocean research. The program was redirected in September 1978 to include:

- Continuing examination of manned undersea facility requirements with close interactions with the science community.
- Analyses of existing U.S. undersea facilities and systems.
- Developments of requirements for advanced-capability systems and technologies.
- Expansion of NOAA's cooperative underwater laboratory program on a regional basis using a number of different systems.

These items will comprise a 2-year effort resulting in the identification of undersea technological program areas requiring new capabilities and facilities. From here, either existing systems can be modified and updated or new ones implemented to meet the scientific requirements.

Cooperative National Manned Underwater Laboratory Regional Program

In the House of Representatives Appropriations Committee report of May 1977, which discussed the FY 1978 appropriation of \$3,750,000 to NOAA for the continuation of the Oceanlab Project, it was stated that the funds were also to be used for "cooperative habitat

*The final results were published under Department of Commerce Contract No. 7-35252, Oceanlab Comparative Concept, Cost and Effectiveness Studies of Alternate Oceanlab Systems, 31 July 1978, based on General Electric Document No. 78SDR2243 dated 30 June 1978.

programs." The corresponding Senate report of June 1977 stated that the funds were also for "cooperative undersea programs, including habitats in shallow and intermediate depths necessary to develop safety and expertise in future Oceanlab operations."

Therefore, NOAA initiated a cooperative national manned underwater laboratory regional program in 1977. The purpose of this program 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 is on the provision of sea-floor laboratories and the advanced technology needed for safe science saturation diving operations.

The overall goals of the programs include:

1. Acquire basic scientific information about the marine ecology and environment applicable to conditions existing in U.S. coastal areas.
2. Provide solutions to marine environmental problems through the support of research efforts requiring advanced underwater laboratories and saturation diving operations.
3. Demonstrate that safe manned underwater operations can greatly enhance researchers' ability to successfully complete selected types of tasks, and that certain classical land-based laboratory scientific methods can successfully be extended to the sea floor.
4. Provide a mechanism to ensure continuity of effort and long-range funding for otherwise unfeasible in-situ research efforts.
5. 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.

Hydro-Lab Regional Program

The first phase of the cooperative regional programs took place in St. Croix, U.S. Virgin Islands, using the former *Hydro-Lab* as the first undersea habitat facility.

In 1977 NOAA purchased *Hydro-Lab* from its builder, Perry Oceanographics, Inc. After a thorough refurbishing, it was placed on the ocean floor at St. Croix, U.S. Virgin Islands, off the north central coast as the head of Salt River submarine canyon (Figure 7).

Hydro-Lab, 4.88 m (16 ft) long and 2.44 m (8 ft) in diameter, sits on the ocean floor and is equipped (in its refurbished state) to support four divers for as long as 14 days. Its key advantages over surface-supported diving and other research techniques are:

- Its fixed location allows for laying out a permanent grid of study areas, an especially important factor in statistical analyses of population densities.
- Less time and energy are wasted in surfacing and diving during limited research time.



Figure 7.—*Hydro-Lab* on Ocean Bottom off St. Croix, U.S. Virgin Islands

The specific goals of the *Hydro-Lab* system program are to:

- Acquire, via in-situ study, scientific information about the marine environment of U.S. coastal and tropical marine environments.
- 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 biomedical and diving procedures tested in shore-base hyperbaric laboratories.

The MUS&T Office is responsible for overall management of the *Hydro-Lab* program. These responsibilities include:

- Final review and approval of all safety and operational aspects of the program.

- Coordination and integration of the scientific program.

Fairleigh Dickinson University's (FDU) West Indies Laboratory (WIL), acting under NOAA Grant No. 04-8-1401-6, is responsible for the operation and maintenance of the underwater laboratory system and associated shore support facilities as well as the development of safety and operating procedures to meet NOAA requirements.

A discussion of the science mission projects accomplished using *Hydro-Lab* is given in the Marine Science Applications section of this report. Development of the second phase of the program began in April 1978 with the solicitation for "letters of interest," from over 400 academic institutions in a second regional cooperative manned undersea research program. Fifteen responses were received which in turn were evaluated by a screening group. Nine were selected as viable candidates and were asked to develop detailed feasibility studies. These final feasibility studies will be completed in FY 1979. They will in turn be evaluated by a panel of scientists and engineers experienced in undersea marine research. Further development of the next regional cooperative underwater research programs is planned to begin in FY 1980.

HYDRO-LAB REGIONAL PROGRAM SCIENCE MISSIONS

Extensive research, sponsored by NOAA and other agencies, is being conducted in U.S. coastal waters on a wide range of environmental problems of national significance. As a part of this ongoing research effort, NOAA initiated a cooperative national manned underwater laboratory regional program designed to provide facilities (underwater laboratories) and technical support to these scientific missions, with the *Hydro-Lab* at St. Croix as the first step*.

The first announcement of opportunity for science missions using saturation diving was sent to the U.S. science community in November 1977. Thirty-one indications of interest were received prior to the first peer review meeting in February 1978. Fourteen proposals were reviewed at this meeting and nine proposals accepted.

The second peer review meeting was held in August 1978. Eleven proposals were reviewed at this meeting and eight proposals accepted. Eight missions were completed in 1978 during which twelve science projects were conducted. These missions are summarized in Table 22. Those science projects completed in FY 1978 (through September 30, 1978) are discussed in the following paragraphs. At the end of 1978 the *Hydro-Lab* habitat was removed from the sea floor for refurbishment and American Bureau of Shipping classification.

Following are concise descriptions of the scientific missions undertaken in the *Hydro-Lab* habitat during FY 1978. The reports are presented chronologically. The specific location for all missions is Salt River Canyon, St. Croix, U.S. Virgin Islands (see Figure 21).

*A grant was awarded by NOAA to Fairleigh Dickinson University's West Indies Laboratory at St. Croix, U.S. Virgin Islands, to provide the support to operate the *Hydro-Lab*.

Comparative Study of Chaetodontid Foraging Patterns

Date: May 25-June 2, 1978

Purpose: Obtain quantitative behavioral, distribution, and feeding data for some chaetodontid and pomacanthid fishes as part of a larger comparative study of the niche dimensions and overlap among species in these families between relatively comparable reef communities in the Caribbean and Indo-West Pacific.

Participants: U. of Guam—Charles Birkeland, Principal Investigator, and Steve Neudecker

Accomplishments: A microscopic examination of the stomach contents of fishes was done to provide verification of the field observations on foraging behavior. Individual fish were observed for 5-minute intervals to obtain samples of feeding habits. Several individuals, each of *Chaetodon capistratus* and *Prognathodes aculeatus*, were observed near the transects at 15.2- and 30.5 m (50- and 100-ft) depths along the east and west canyon walls during both morning and late afternoon. It was found that, despite traditional conceptions of fish feeding patterns in the Caribbean, one of the species studied fed predominantly on scleractinian corals.

The Role of Light in Nocturnal/Diurnal Changeover Patterns of Certain Coral Reef Fishes

Date: June 10-17, 1978

Purpose: Test the hypothesis that fish respond directly to light intensity each time they enter or leave their shelters.

Participants: Sarah Lawrence College—Raymond D. Clarke; Fordham U.—George Dale

Accomplishments: Technical—Two recording hydrophotometers were designed and constructed specifically for this project. These instruments were capable of

**Table 22—Cooperative National Regional Underwater Laboratory Program
Hydro-Lab FY 1978 Science Projects (through Sept. 30, 1978)**

Investigating Institution	Dates (1978)	Project
University of Guam	May 25-June 2	Tropical Fish Feeding Patterns
Sarah Lawrence College Fordham University	June 10-17	Coral Reef Fish Reactions to Light
American Museum of Natural History	June 10-17	Colonization Behavior of Coral Reef Fishes
University of Puerto Rico	July 24-31	Diurnal Changes in Distribution and Abundance of Herbivorous Fishes
Department of Agriculture, Puerto Rico	July 24-31	Diurnal Changes in Distribution and Abundance of Carnivorous Fishes
University of Texas	September 1-7	Reaction of Squid and Octopus to Variations in Light Levels
University of Puerto Rico	September 18-25	Spawning of Western Atlantic Reef Fishes and Coral Distribution in the Salt River Canyon

recording light levels three orders of magnitude lower than the minimum level observable by the unaided human eye. *Scientific*—The experimenters used artificial lighting to illuminate the study reef just prior to the normal evening changeover in fish assemblage from diurnal to nocturnal. The lighting seemed to delay the changeover but not prevent it. When the reef was darkened prematurely by the experimenters, many of the changes associated with evening changeover were initiated.

One of the striking features observed was the rapidity with which the diurnal assemblage of fish was replaced by the nocturnal assemblage (18 minutes) and vice versa (15 minutes). This replacement did not include a quiescent period, as some experimenters have reported; on the contrary, there was a period when the nocturnal and diurnal fishes were intermixed over the reef. For the first time, light intensity measurements showed a correlation between light intensity and a predictable sequence of changeover events, supporting the theory that nocturnal fishes use light intensity as a cue for the onset of changeover behavior. The diurnal fish seem to be less dependent on light intensity, though it may still be important in controlling activity patterns.

Regulatory Mechanisms in Coral Reef Fish Communities

Date: June 10-17, 1978

Purpose: Determine whether habitat selection is a function primarily of size or of species-specific advantages.

Participants: American Museum of Natural History—C. Lavett Smith, James C. Tyler

Accomplishments: After preliminary censusing of five separate reef patches, selected individuals representing six species of fish (four gobies, two blennies) were removed from their habitats. Subsequent observations revealed that none of the spinyhead blennies—which have a very specialized habitat in abandoned worm tubes—were replaced. Areas from which less specialized fishes were removed, however, were filled within 3 days. The rate of recolonization is apparently influenced by the availability of recruits that have recently transformed from the pelagic larval stage. Therefore, there should be a strong seasonal effect on recolonization patterns.

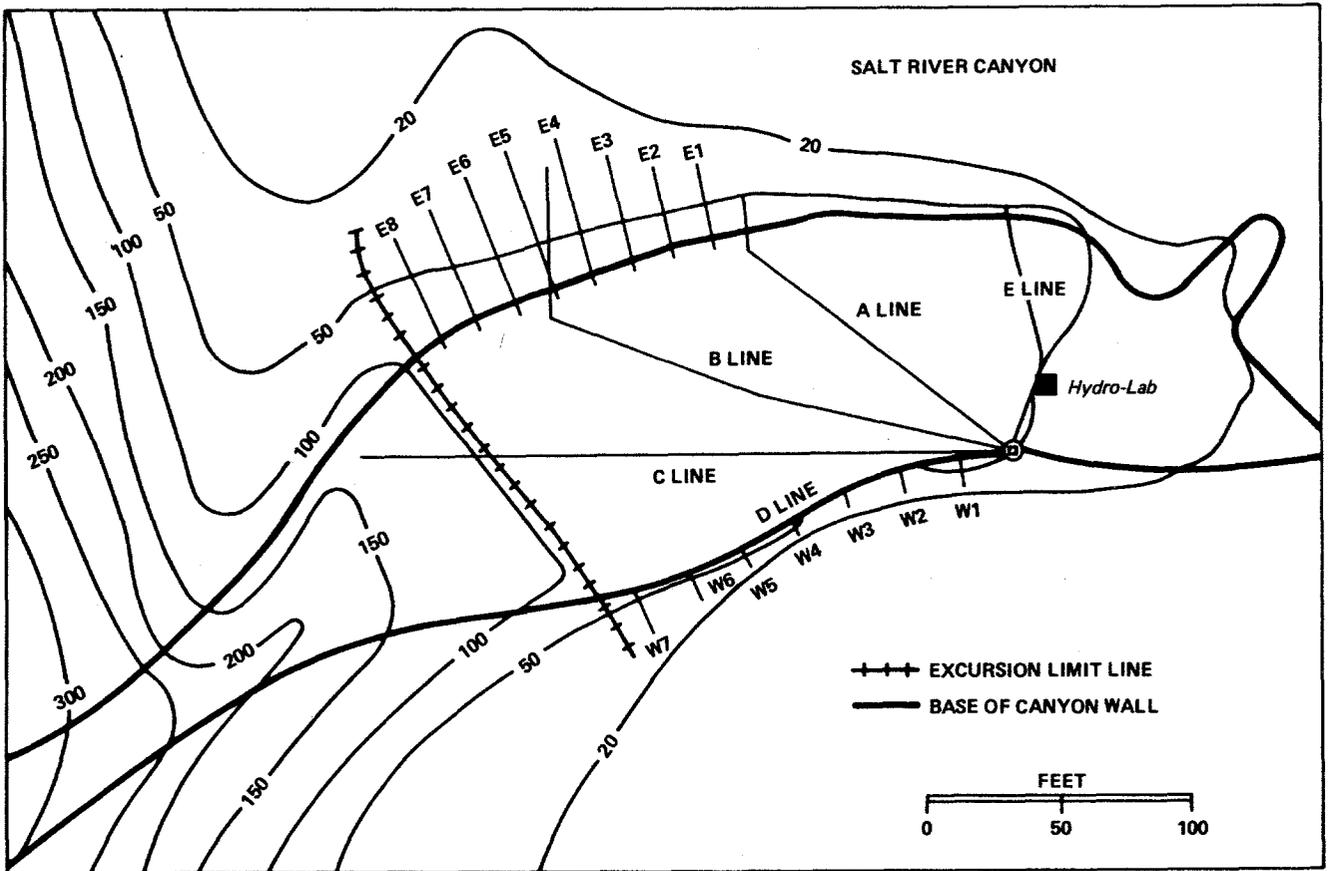


Figure 21.—Transect Location Map for *Hydro-Lab* Scientific Missions

Diel and Depth Variation in the Population Densities of Herbivorous Fishes

Date: July 24-31, 1978

Purpose: Determine the variation in the population densities of herbivorous fishes in relation to food resources and depth along the east and west walls of the Salt River Canyon.

Participants: U. of Puerto Rico—Ileana E. Clavijo, Principal Investigator

Accomplishments: The results of the study show that species diversity and abundance of herbivorous fishes decreases with increasing depth. Three families of herbivorous fishes were represented in the canyon: damselfishes, surgeonfishes, and parrotfishes. The parrotfish, *Sparisoma aurofrenatum*, was most abundant on the east wall at depths of 15 m. The surgeonfish, *Acanthurus bahianus*, was more abundant on the east wall than the west wall; the opposite was true of the closely related doctorfish, *A. chirurgus*. These two species have nearly identical diets; the differences may be due to competitive exclusion or habitat preference. The parrotfishes observed appeared not to utilize the food resources on the canyon walls.

Herbivorous fishes, especially species in the family *Scaridae*, are not limited to shallow depths in their distribution. The abundance of scarids decreases with increasing depth due mainly to the decrease in the quantity rather than the quality of plant foods. Certain migratory species utilize deeper areas for shelter rather than for feeding.

Diel and Depth Variation in Population Densities of Commercially Important Carnivorous Fishes

Date: July 24-31, 1978

Purpose: Investigate population densities of commercially important carnivorous fishes along the walls of the Salt River Canyon. Examine variations in densities over depth and time of day.

Participants: Commercial Fisheries Laboratory, Dept. of Agriculture of Puerto Rico—Deborah Arneson, Principal Investigator, and University of Puerto Rico—Linda Meiklejohn

Accomplishments: Thirty-seven species of fishes were recorded from eleven families. Each of the following families contributed more than 10 percent of the total number of fishes recorded for each wall (east = 275, west = 540): *Lutjanidae* (snappers), *Serranidae* (groupers), *Pomadasyidae* (grunts), *Mullidae* (goat fishes), and *Carangidae* (jacks).

For total number of fishes, there appeared to be no statistically significant differences over time or depth or between most of the transect areas. Bottom type seemed to be the most important factor influencing numbers of fishes.

Response of Squids to Night Lights and Reef Behavior of Octopuses

Date: September 1-7, 1978

Purpose: Study the behavior and ecology of cephalopods; determine the behavioral responses of squids to various night lighting schemes, and evaluate the role of the octopus as a prominent night predator.

Participants: U. of Texas—Roger Hanlon and Raymond Hixon

Accomplishments: Four squid species were attracted to night lights set up by the experimenters. Observations of their behavior near the underwater lamp indicated that all species were attracted individually and not as a school, and that they did not subsequently group together. They seemed to be in a dazed or mesmerized state (see Figure 22).

The Salt River Canyon does not support as large an octopus population as other reef areas observed in the Caribbean. Three species of benthic octopuses were present in the area; all three are nocturnal. Two of the species were found only in the restricted habitat characterized by cobble-filled tributaries with slope angles of approximately 15 to 20 degrees. Various aspects of their hunting and movement patterns were observed. During the dive, several octopuses were collected for laboratory observation. One larval species was collected and taken to the U. of Texas for rearing. If successful, it will be a first, and the experimenters will be able to determine what this animal looks like as an adult, something unknown throughout 40 years of investigation of that species.

Spawning of Western Atlantic Reef Fishes

Date: September 18-25, 1978

Purpose: (1) Investigate the occurrence and duration of spawning by western Atlantic marine shore fishes. (2) Determine behavior and movement of various species before, during, and after spawning. (3) Collect eggs of selected species for larval rearing.

Participants: U. of Puerto Rico—Patrick Colin, Principal Investigator, A. Charles Arneson, and Ralf Boulon, Jr.

Accomplishments: Definite spawning was observed for seven species of fishes, all in a limited area within 100 m of the east wall "tank drop" area. Potential courtship was observed in several other species, but no definite spawning was observed.

Observations were made at various locations and times of day, with emphasis on the late afternoon period. With dawn representing 0% day and sunset representing 100% day, the most intensive observations were made during the period from 80-100% day, and then extending to 2.5% night (using the same system). This relative day length (RD_L) measurement system is useful for comparison with similar observations at different locations and different times of year.

During the dive, 52 definite spawning events were observed. Results correlated well with those gathered by

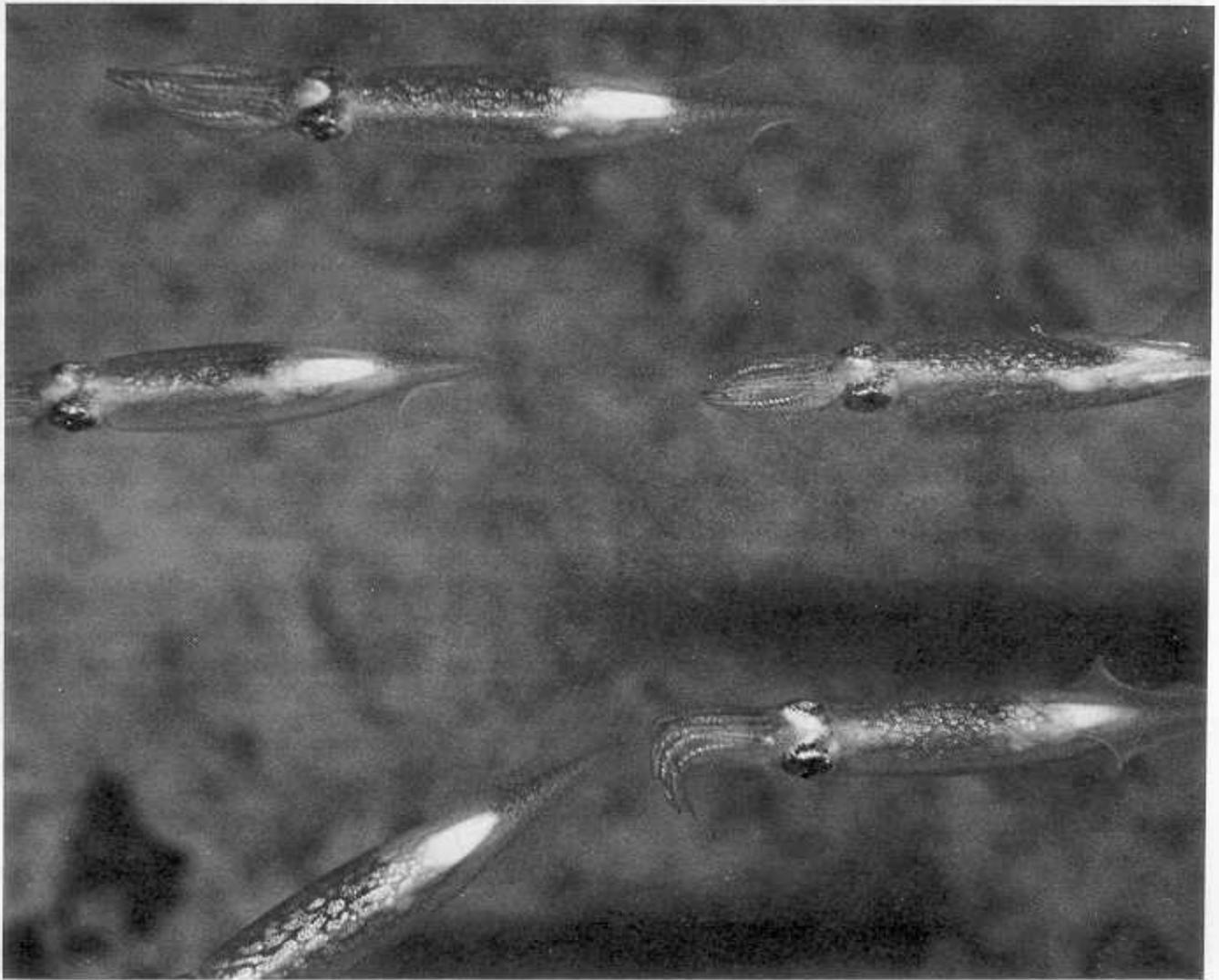


Figure 22.—School of Squid (*Loligo plei*) under a night-light station

Principal Investigator Colin in Puerto Rico. In addition, the ability to observe complete courtship and spawning cycles confirmed many of the preliminary but untested hypotheses based on segmented observations of each cycle on a number of different dives.

Several relatively uncommon marine invertebrates were found in the west wall area. These included the small lobster *Palimurellus gundlachi* and various slipper lobsters. The lobster *Justitia* was particularly common in reef caves outside the excursion limit line on the east wall.

Coral Distribution in the Salt River Canyon

Date: September 18-25, 1978

Purpose: Determine the gross distribution of scleractinian corals on the walls of the Salt River Canyon, and compare the coral distributions of the east and west walls.

Participants: U. of Puerto Rico—Patrick Colin, Principal Investigator, A. Charles Arneson, and Ralf Boulon, Jr.

Accomplishments: Percentage of coral cover was tabulated for the most abundant species along with total distance photographed. A list of coral species was compiled from observations made during excursions. The east and west walls of the canyon differ markedly in percentage of coral cover; this may be due to the differences in substrate and vertical profile. The east wall exhibited a change in coral distributions which appears to be related to the change in vertical profile and substrate characteristics. The west wall was fairly uniform in coral coverage, with an increase in its outer portions due to the increased abundance of large, platelike *Agaricia* species on the deeper portions of the wall. A relatively high number of Western Atlantic hermatypic corals (at least 26) and some of the more common shallow water ahermatypic corals were found in the canyon.

Comparison of Mediterranean and Caribbean Benthonic Biological Systems

Date: October 9-16, 1978

Purpose: (1) Study the ocean-floor behavior of two current-oriented plankton nets; compare samples every 6 hours. (2) Study growth of different species of *Caulerpale* (algae) and the increase of thalles by first making 12 plantings in 1-m² areas and then harvesting one planting per month. (3) Measure the oxygen consumption and

production on a selected area to study the metabolism rate of certain species and subsystems.

Participants: U. of Nice (France)—Prof. Raymond Vaissiere, Principal Investigator, Dr. Alexandre Meinesy, and Dr. Claude Falconetti; U. of Liege (Belgium)—Dr. Daniel Bay

Accomplishments: The investigators are still analyzing their results, which are expected to be published in mid-1979.