APPENDIX A

NURC-FDU

PROJECT SUMMARY REPORTS

1988 – 1990

[Converted to electronic form by Damon J. Gomez (NOAA/RSMAS) in 2002. Copy available at the NOAA Miami Regional Library. Minor editorial changes were made.]

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **AQUARIUS Habitat shakedown mission: Mission 88-A**

2. NOAA Research Category:

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Mr. Richard Berey
NURC-FDU

5. Institutions involved: Fairleigh Dickinson University, NASA-Ames Human Factors Laboratory

6. Co-Principal Investigator:

7. Participants:

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements:

10. Mission Period
Start: 11 January, 1988
End: 15 January, 1988

11. Operational Time
Number of excursions: 21
Total bottom time: 31 h

12. Operational Depth Range
Maximum: 65 feet
Average: 57 feet

13. Geographic Location: St. Croix, USVI

14. Outcome

As this was an internal mission which primarily addressed operational concerns, no reports or publications were forthcoming. The outcome was that the habitat proved fully operational and the staff received valuable training.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

Date prepared: 27 June, 1990

1. Project Title: **NOAA Diving Safety Board mission: Mission 88-B**

2. NOAA Research Category:

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Mr. Richard Rounds
NURC-FDU

5. Institutions involved: Fairleigh Dickinson University, NASA-Ames Human Factors Laboratory, NOAA, U.S. Navy

6. Co-Principal Investigator:

7. Participants: Aquanauts: Mr. Richard Rounds, Dr. Morgan Wells (DSB), Mr. Doug Smith (NASA), Dr. L. Nuckols.

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements:

10. Mission Period
Start: 20 January, 1988
End: 23 January, 1988

11. Operational Time
Number of excursions: 22
Total bottom time: 18 h

12. Operational Depth Range
Maximum: 120 feet
Average: 78 feet

13. Geographic Location: St. Croix, USVI

14. Outcome

Mission 88-B was internal. Accordingly, costs were not tracked as they were for science missions. No publications resulted, because no studies were performed. The mission had two objectives which were both achieved. The first objective was to obtain approval from NOAA's Diving Safety Board. Dr. Wells suggested a few small improvements which were implemented, but was quite pleased with the overall operation.

Approval for missions came soon after this saturation. The second objective was to ready the habitat and sea floor for Mission 88-1. The Gazebo was put in place, canyon markings were checked, and other vital tasks were performed which demonstrated a readiness for a two-week science saturation mission.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Primary productivity and nutrient fluxes of the benthic microflora of coral reef sediments: Mission 88-1**

2. Contract number: NA88AA-H-UR020

3. NOAA Research Category:

4. Principal Investigator: Dr. Thomas R. Fisher
Associate Professor
Horn Point Environmental
Labs U of Maryland - CEES
Cambridge, MD 21613

5. Institutions involved: University of Maryland

6. Co-Principal Investigator:

7. Participants: Dr. Larry Sandford, Dr. Leslie Smith-Morrill, Dr. Emily R. Peele, Mr. Robert D. Doyle, Mr. Michael Williams, Mr. Kim Glandon, Ms. Susan L. Pearce, Mr. Gary Baptist

8. Type of System/Facilities:
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Centrifuge, spectrophotometer, fluormeter, productivity chambers, oxygen microelectrodes, PAR light sensors, S4 current meter, H-3 Thymidine

10. Mission Period
Start: 6 February, 1988
End: 19 February, 1988

11. Operational Time
Number of excursions: 122
Total bottom time: 253 h 1 m

12. Operational Depth Range
Maximum: 70 feet
Average: 65 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: Yes, draft
    Due date: Past due

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $17,312

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries: T. Fisher, R. Doyle, L. Sanford
       Other: NSF support to L. Smith-Morrill, E. Peele

       Total:

    c. Total Co-funding and Matching Funds:

19. Reseach summary and results

Globally, coral reef environments represent only approximately 1 percent of the ocean's surface area. However, they are among the most productive marine habitats. Research on primary production has generally focused on the reefs themselves, while the surrounding calcareous sediments have been overlooked as an important source of organic material. This project was twofold in approach, and studied (1) the relative magnitudes of sedimenting organic matter out of the water-column versus net primary productivity (NPP) by the phytomicrobenthos inhabiting the sands of Salt River Canyon, and (2) the effects of physical disturbance, nutrient additions (NH_4, PO_4 and SiO_4) and grazer exclusion on the benthic NPP in the vicinity of Aquarius.

During the day, the benthic community actively photosynthesized and took up ammonium and phosphate, while at night, respiration occurred. NPP averaged 11 mmol O_2 m^{-2} d^{-1}, which corresponds to 110 mg O_2 m^{-2} d^{-1} assuming a PO_2 of 1.2. The microprofiles yielded an NPP of 24-48 mmol O_2 m^{-2} d^{-1} (240-480 mg O_2 m^{-2} d^{-1}). These rates represent 10-33 percent of the organic matter settling out of the water-column.

Physical disturbance was determined from data collected with InterOcean S4 current meters deployed on the western and eastern sides of the habitat. The effects of nutrient additions and the exclusion of grazers were tested on 4 x 4 m experimental plots. Sediment cores were collected from experimental and control plots and were analyzed for chlorophyll-a. A significant pattern of increasing algal biomass moving from the eastern side of the habitat towards the south and then west was found. This may be due to differences in wave energies, as higher wave energies and a rolling bedform were noted on the east. The exclusion of large grazers (fish and conch) had a significant positive effect on benthic biomass, while nutrient additions had no detectable effect. These data suggest that there is a photosynthetically active microphytobenthic community inhabiting the calcareous sands of Salt River Canyon that is nutrient-replete and heavily grazed by benthic organisms. The microphytobenthos influences the composition of the overlying water-column by acting as an effective trap of the dissolved inorganic N and P that diffuses from the porewaters of the sediment-column, as well as contributing to the availability of carbon to benthic grazers. This largely overlooked community may be the primary base of the benthic food chain leading to commercially important fisheries such as conch and demersal fish.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Oxygen dynamics and anaerobic metabolism in sediments of Salt River Canyon: Mission 88-2**

2. Contract number: NA88AA-H-UR020

3. NOAA Research Category: Biological Productivity and Living Resources

4. Principal Investigator: Dr. Gary M. King
University of Maine
Darling Marine Center
Walpole, ME 04573

5. Institutions involved: University of Maine (UMO), Michigan State University (MSU)

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Gary King (UMO), Dr. Rick G. Carlton (MSU), Mr. Richard F. Losee (UMO). Surface support staff: Mr. Mark Wells (UMO), Mr. Thomas Sawyer (UMO)

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Spectrophotometer, fluorometer, pH meter, balances, drying ovens, IBM and Mac computers, radioisotopes, acetylene and nitrogen gases, oxygen micro electrodes.

10. Mission Period
Start: 10 March, 1988
End: 18 March, 1988

11. Operational Time
Number of excursions: 68
Total bottom time: 90 h 30 m

12. Operational Depth Range
Maximum: 100 feet
Average: 71 feet
Total Bottom Time: 90 h 30 m

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: Yes
    Final: Yes
    Due date:

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $10,771.00

18. Principal Investigator Support/Co-Funding
    a. Organization: NSF to King and Carlton
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:
       Approximately $10,000, per Final Report

19. Research summary and results

In spite of the relative lack of data for oxic and anoxic processes in carbonate sediments, several studies have indicated that anaerobic metabolism plays in important role in benthic nutrient cycles. The distribution of oxygen and its concentration ultimately determine both the extent of anoxic processes as well as the oxidation of reduced metabolic end-products (e.g. hydrogen sulfide and ammonia). The oxygen content of sediment porewaters is itself determined by several factors including the oxygen content of the water column, diffusive and advective fluxes between the water column and sediments, and rates of benthic oxygen production (by micro- or macroalgae) and consumption. While such factors as these are important, rates of oxygen consumption are probably most significant since the other physiochemical variables are subject to less temporal or spatial variability. Rates of oxygen consumption are primarily affected by the availability of organic carbon arising from production in situ or from sedimentation.

Prior to the advent of oxygen microelectrodes, concentrations of porewater oxygen could not be determined either routinely or reliably. Rates of oxygen consumption were

analyzed using "flux box" or chamber methods, but these have been criticized because they do not accurately mimic in situ fluid flow phenomena at the sediment-water interface. As a result of these limitations, the oxygen status of sediments such as those associated with coral reefs has often been mistakenly evaluated on the basis of sediment color or oxidation-reduction potential. Positive "redox" potentials and the absence of blackening have been considered indicators of the presence of molecular oxygen. Oxygen microelectrodes have dramatically altered the understanding of benthic oxygen dynamics; oxygen is often limited to depths of only a few tens of millimeters or even less, regardless of sediment type or appearance. In fact, sediment redox potentials and coloration reflect much more complex aspects of sediment chemistry than oxygen distribution.

Given these considerations, the primary objectives of this project were to assess the distribution of oxygen and key anaerobic processes in the sediments of Salt River Canyon. These objectives were established for the following reasons: 1) oxygen depletion had been previously observed in the Canyon sediments within a depth of about 5-15 mm; 2) the work of others had suggested that anaerobic metabolism was important in carbonate sediments, even though such sediments generally appeared highly oxidized, and; 3) no data were available from the literature which provided a simultaneous analysis of oxygen profiles and anaerobic processes such as sulfate reduction and nitrogen fixation.

The use of microelectrodes during this saturation mission documented in a limited survey that oxygen could be substantially depleted, even in coarse-grained sediments with low organic carbon concentrations. These observations also suggested that anaerobic metabolism could have a substantial impact on macrofaunal activities as well as benthic-water column exchanges. In particular the formation of hydrogen sulfide could affect virtually all aspects of sediment metabolism and chemistry. Enhanced rates of nitrogen fixation, an anoxic process, could also affect benthic primary production and nutrient exchanges.

A variety of sites were examined during this mission, including areas colonized by patchy, but common algal films. In conjunction with these studies, several aspects of sediment and porewater chemistry (e.g. chlorophyll contents, acid volatile and chromium reducible sulfur [pyrite] sulfate, and sulfide) were examined. The distribution of oxygen within the ripple fields that are a common feature of Salt River Canyon was measured, and parallel analyses were made of boundary layer flows at these sites using "skin friction" sensors provided through collaboration with Dr. G. Gust, University of South Florida. Other studies of fluid flow were conducted using a dye and video recorder.

Oxygen penetrated to sediment depths generally no more than 5-10 mm, with occasional penetration to greater depths related to turbulence in the water column. Oxygen

supersaturation at the sediment-water interface or at depths of a few millimeters was the result of active benthic photosynthesis. Anoxic conditions usually prevailed at sediment depths greater than 10 mm. The highest rates of sulfate reduction typically occurred between 10-30 mm. Sulfate reduction rates were positively correlated with surface algal films. Similar trends were observed for the distribution of solid phase reduced sulfur species and for nitrogen fixation. Both sediment data and an analysis of detritus-associated nitrogen fixation indicated that nitrogen fixation was probably limited by the distribution of oxygen.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **The energetics of sediment removal and zooplankton feeding in Caribbean reef-bulilding corals: Mission 88-3**

2. NOAA Research Category: Coastal Oceanic and Estuarine Pocesses and Biological Productivity and Living Resources

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Dr. James W. Porter
Professor of Zoology
University of Georgia
Athens, GA 30602

5. Institutions involved: University of Georgia

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. James W. Porter, Mr. Charles Keith, Mr. RayJakubczak, Mr. Scott Eckert, Mr. Glenn Taylor (NURC/FDU). Surface support staff: Mr. Steve Bird, Ms. Karen Eckert, Mr. Hany Abdul-Salam, Ms. Valerie Morgan.

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Underwater respirometers, plankton pumping and filtering system

10. Mission Period
Start: 11 April, 1988
End: 30 April, 1988

11. Operational Time
Number of excursions: 62
Total bottom time: 167 h 29 m

12. Operational Depth Range
Maximum: 110 feet
Average: 76 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: Yes
    Final: Yes
    Due date:

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $23,082

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds: None

19. Research summary and results

The scientific research conducted from the habitat during this mission included six major studies.

Throughout the Caribbean during 1987 and 1988, as many as 40 percent of all corals turned white, a phenomenon called "bleaching." Studies from Aquarius revealed that this discoloration was due to a loss of the symbiotic zooxanthellae as well as a reduction in the major photosynthetic pigment, chlorophyll. Bleached coral specimens had significantly reduced photosynthetic capacities relative to unbleached specimens of the same species, and hence lower Production/Respiration (P/R) ratios. Reduced P/R ratios are reliable indicators of stress. Stable isotope analyses of the Carbon-13/Carbon-12 ratio in the skeletons corroborated this physiological assessment of stress. Analyses of the stable isotope ratios of Oxygen-16/Oxygen-18 also revealed that bleached coral specimens experienced abnormally elevated temperatures relative to unbleached specimens. This is the first identification of the cause of coral bleaching. The fossil record will be surveyed to see if the stable isotope signal for bleaching has occured previously. The bleaching response seen to elevated temperatures also suggests that if global warming proceeds unabated, this kind of stress to reefs may become more frequent.

Corals expand at night and contract during the day in response to light. Investigations of the neurophysiology of photoreception in corals revealed, for the first time for the phylum Cnidaria, that this light response is neuronally mediated. Surprisingly, the light response is transmitted by receptors that are totally distinct from tactile receptors. Two pathways were identified that control light-induced contraction: a nicotinic cholinergic pathway that stimulates contraction, and a muscarinic cholinergic pathway that inhibits contraction. Although the ubiquitous photopigment rhodopsin mediates photoreception in all organisms known, no evidence for this pigment was found in corals.

A newly designed plankton pump was used to filter massive amounts of water from the reef through a plankton net located on a boat above the dive site. The collection cone of the siphon was carefully positioned by divers, allowing for a precise determination of planktonic abundance. Results showed that nocturnal hourly plankton density varied from 1.7 to 15.7 mg dry wt meter^{-3}. The results demonstrated with statistical confidence that there are two peaks in plankton abundance, the first occurring at 1900 (military hours) and the second at 0500 hours. Further, there was no significant difference between the plankton abundance at 1 m above the reef compared to either 17 m or 30 m. Coral reef zooplankton represents a fairly nutritious food source with an elemental composition for freeze-dried samples of 17.8 percent carbon, 2.7 percent hydrogen, and 2.9 percent nitrogen.

In a parallel study on zooplankton feeding by the coral, *Montastraea cavernosa,* the success with which this coral species fed on reef zooplankton was measured by taking stomach samples throughout the night. The stomach contents were counted and the nutritional value of this material estimated. The amount of carbon supplied from photosynthesis was measured simultaneously by an in situ respirometer. *M. cavernosa* captures a mean of 21.6 ug dry wt polyp^{-1}hr^{-1} at night at 17 m depth, and 16.4 ug dry wt polyp^{-1}hr^{-1} at 30 m. These data show that 24 percent of *M. cavernosa's* basal metabolic requirement is met by zooplankton feeding at 17 m and 27 percent at 30 m. Photosynthesis can supply an additional 65 percent of the required carbon at 17 m and 60 percent at 30 m, for a total of 89 percent and 87 percent respectively, of the carbon required for survival supplied by these two forms of feeding (photosynthesis + zooplankton capture) at 17 and 30 m. This is the first complete energy budget for any coral reef invertebrate.

The metabolic cost of zooplankton feeding (the energy required for tentacle expansion, nematocyst discharge, etc.) was also measured by comparing the respiration rate of corals in the absence of, and in the presence of, zooplanktonic prey. Coral respiration rates increase by 35 percent in the presence of zooplankton. Models of coral photosynthesis and respiration require estimates of respiration during the daytime. Recent

models suggest that photosynthesis stimulates respiration during daylight. If this is true, it would require a higher estimate for diurnal respiration. Information here, however, suggests that plankton-feeding also stimulates respiration. Since plankton capture occurs only at night, nocturnal rates and diurnal rates are probably comparable.

The energetic cost of clearing sediments was measured in special chambers that allowed the simultaneous recording of coral respiration rates and sediment removal rates. Eight species of Caribbean corals were tested: *Acropora cervicornis, Porites porites, Porites astreoides, Agaricia agaricites, Montastraea annularis, Diploria strigosa, Meandrina meandrites, and Isophyllastraea rigida.* Gravity removed most of the sediment, especially from the branching corals. However, metabolic energy had to be expended, especially among the flatter coral species, to remove the the remaining sediment. Using sedimentation rates similar to those found naturally in the submarine canyon where Aquarius is located, it was shown that all Caribbean corals tested, except *D. strigosa*, raised their respiration rate during sediment clearing. Respiration increased from as little as 7.1 percent in *D. strigosa* to as much as 57.8 percent in *A. cervicornis*. All species, except P. porites, also exhibited significantly lower photosynthetic rates. Declines in photosynthesis ranged from as little as 0.0 percent in *P. porites* to as much 70.2 percent for *M. meandrites*. The combined stress of elevated respiration rates and reduced photosynthetic rates lowered the P/R ratio to values significantly below one. Such low P/R values do not occur naturally for any of these species at this depth. The energetic cost of clearing sediments (discounting the weight removed by gravity during the first minute) was highest for *A. cervicornis*, which removed only 2.2 grams of sediment for every calorie expended; and lowest for *M. meandrites*, which on average was able to remove 16.9 grams of sediment for every calorie expended. M. meandrites was also superior at removing the coarsest sediment sizes (particles 500, 250, or 125 microns in diameter). All coral species tested were equally adroit at removing particles in the 63 micron size range due to the fact that they all employed mucus to clear these particles. Long term exposure to sedimentation significantly modified the photosynthetic characteristics of *M. annularis*, as witnessed by reductions in the maximum photosynthetic rate, the compensation point, the break point, and alpha for chronically sediment-stressed specimens of this species.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Patterns and processes structuring tropical algal communities along a depth gradient: The dynamic roles of productivity and herbivory: Mission 88-4**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Dr. Robert S. Steneck
University of Maine
Darling Marine Center
Walpole, ME 04573

5. Institutions involved: University of Maine

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Robert S. Steneck, Mr. Rick Wahle, Ms. Cathy Phister, Mr. Kirt Moody, Mr. Lawrence Woodams (NURC-FDU). Surface support staff: Ms. Sally Hacker, Mr. David Low.

8. Type of System/Facilities
Aquarius Undersea Habitat:
Wet Diving:

9. Special Equipment Requirements: Time-lapse movie camera

10. Mission Period
Start: 19 May, 1988
End: 28 May, 1988

11. Operational Time
Number of excursions: 66
Total bottom time: 166 h 13 m

12. Operational Depth Range
Maximum: 150 feet
Average: 102 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: Yes
    Final: No
    Due date: Past due

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $12,528.00

18. Principal Investigator Support/Co-Funding
    a. Organization: NSF to R. Steneck
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries: from above NSF grant for C. Pfister and to purchase dive gear
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

Coral reefs are remarkably diverse and apparently unstable communities. The 1983 - 1984 die-off of the major grazing urchin, *Diadema antillarum*, resulted in an increase in macroalgal abundance in many regions throughout the Caribbean. Data collected between 1977 and 1982 provided a quantitative record of algal communities in St. Croix prior to the die-off, and provided the opportunity to asses the impact of this single herbivore species on algal community structure. Specifically, data collected during Hydrolab Mission 82-6 was used for comparison with results obtained during this Aquarius Mission.

Rates of primary productivity and herbivory (from all sources) on coral substrata covered with algae along identical transects used in 1982 were determined. Measurements were made using an in situ biomass harvest technique and a regrowth technique. The frequency and intensity of herbivore-induced disturbance from fishes along this gradient were determined using time lapse movies (units in, number of bites $meter^{-2}$ $hour^{-1}$ for each species of herbivorous fish). Biomass accumulation rates were also compared on plates suspended in the water column away from the reef (to avoid fish grazing) with those attached to the benthos (normal fish grazing) to quantify rates of herbivore induced disturbance (units of grams dry mass lost to grazer $meter^{-2}$ day^{-1}).

Plates had biomass accumulation rates roughly equivalent to those observed in 1982. Long-spined sea urchin densities had decreased by an order of magnitude since 1982. However, herbivorous fishes are no less abundant since 1982. The *Thalassia* seagrass bioassay technique recorded much higher levels of grazing in 1988 than in 1982. Patterns of algal biomass showed an increase in biomass at 120 feet in 1982, whereas that increase seemed to occur at 150 feet in 1987. It is possible that parrotfish may now be somewhat released from competition from urchins along the gradient measured and have extended there foraging range to greater depths accordingly.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Effect of water movement on zooplankton feeding by corals: Mission 88-5**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Dr. Kenneth P. Sebens
Marine Science Center
Northeastern University
Nahant, MA 01908

5. Institutions involved: Northeastern University

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Kenneth P. Sebens, Dr. Amy Johnson, Ms. Robin Allmon, Mr. Steven Zamojski, Mr. Douglas Kesling (NURC-FDU). Surface support staff: Mr. Edward J. Maney, Mr. Tim Loher, Ms. Laura Savina.

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: IBM computer, Li-cor irradiance meter,S4 current meter, thermister flowmeters, movie cameras, video camera.

10. Mission Period
Start: 14 July, 1988
End: 28 July, 1988

11. Operational Time
Number of excursions: 122
Total bottom time: 278 h 35 m

12. Operational Depth Range
Maximum: 150 feet
Average: 70 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual:
    Final: Yes
    Due date:

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $27,930

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds: None

19. Research summary and results

Coral reefs comprise a variety of microhabitats, each with a characteristic pattern of water movement. Variation in flow microhabitat is expected to influence the distribution and abundance of suspension feeders, such as the corals that compose such a reef. This project was the first to concurrently measure prey capture success and water flow over reef corals; the effect of water movement on several aspects of the feeding biology of corals was measured. A second part of this project measured small scale water flow around corals in the field and conducted experiments on expansion and contraction behavior and feeding during several diel cycles. A self-contained underwater thermistor flowmeter with a 2 mm spatial resolution was constructed.

Water flow was measured concurrently with wave heights at eight depths along the forereef slope in Salt River Canyon. The greatest flow occurred on the shallow forereef at 6 m depth, where oscillatory wave-induced flow reached speeds well over 50 cm s^{-1}. From 6 m to at least 15 m depth, flow decreased and was primarily bidirectional. Below 15 m depth, flow decreased even further to approximately one tenth of that experienced by shallow corals, and flow was unidirectional.

Prey capture by corals was altered by changes in flow, and plankton capture by corals with different morphologies was affected in radically different ways by increasing flow. Tentacle size and colony shape, and the resulting modification of flow, influenced the relationship of flow to feeding success in these corals. Such relationships may account for differences in distribution of corals of different morphologies. In transect surveys from 7 to 45 m depths, branching and mounding corals with tentacular feeding modes were most common in the shallow forereef habitats, and plating corals with small polyps (mucus feeders) were ubiquitous in the deeper zones.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

Date prepared: 27 June, 1990

1. Project Title: **Field measurement of diffusional boundary layers and turbulent enhancement in scleractinain reef corals: Mission 88-6**

2. NOAA Research Category: Coastal Oceanic and Estuarine Processes

3. Contract Number: NA88AA-H-UR020

4. Principal Investigator: Dr. Mark R. Patterson
University of California, Davis
Division of Environmental Science
Davis, CA 95616

5. Institutions involved: University of California at Davis

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Mark Patterson, Dr. Laurie Sanderson, Mr. Wm. Stephen Price, Mr. Mchael Savarese, Ms. Christine ASlexander, Mr. Michael Herko (NURC-FDU). Surface support staff: Mr. Todd Hopkins, Mr Stephen Wing.

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements:

10. Mission Period
Start: August 15, 1988
End: September 3, 1988

11. Operational Time
Number of excursions: 83
Total bottom time: 216 h 42 m

12. Operational Depth Range
Maximum: 150 feet
Average: 67 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual:
    Final: No
    Due date: Past due

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $9600.00

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

Many sessile marine invertebrates depend on forced convection of seawater to deliver particulate food, dissolved nutrients, and respiratory gases. Previous work with passive suspension feeding cnidarians, including NOAA Hydrolab Missions 84-7 and 85-7, has shown that the state of flow in the boundary layer over the organism is the most important determinant of food particle and gas flux. The theory of mass transfer has been under-utilized in the analysis of convection mediated gas flux in aquatic invertebrates. This project investigated how flow modulates exchange processes in several species of reef cnidarians through experiments using gas microelectrodes, heated model organism analogs, and field morphometry. This work complements laboratory experiments conducted at UC Davis utilizing recirculating flow respirometry, cell layer organism analogs, and diffusional boundary layer mapping in a laboratory flume.

The goals of this study included: 1) an understanding of the effects of organism size, geometry, and spacing on the Sherwood/Reynolds number relationship, 2) measurement of the frequency of diffusional boundary layer limitation and turbulent enhancement effects in real turbulent flows in shallow subtidal reef habitats, 3) testing of diffusional similarity models as a scheme for understanding the allometry of polyp geometry in reef cnidarians, and 4) investigation of microelectrode diffusional boundary

layer mapping as a physiological probe for areal exchange coefficients and their relationship with animal structure and the momentum boundary layer. The results of this gas exchange study will give insights into uptake of dissolved organic matter and some aspects of osmoregulation, and will be useful to workers interested in estimating primary and secondary productivity in marine habitats. This work also has application to the study of fouling communities, coral reef ecology, and near-shore benthic processes.

Recirculating convection metabolism chambers were deployed from the habitat and used to vary the flow over the reef-frame building corals *Montastrea annularis* and *Acropora cervicornis*, which both have a very different morphology and biology. A Macintosh Plus computer using a LCD display was used within the habitat to control flow in the chambers and dump data from the Licor LI-1000 datalogger. Every available position in the Aquarius Science Buss No. 2 was used to bring data from oxygen and light sensors and the chamber pumps. Convection over the two species in the chamber experiments was varied in such a manner as to allow calculation of the Sherwood/Reynolds number relationship, which gives insight into the mass transfer as a function of size, shape, and orientation of the coral. Surface scientists made determinations of coral biomass, including polyp number, surface area, nitrogen, and chlorophyll-a concentration. In addition, an experiment was performed with two colonies of *M. annularis* using the mitochondrial membrane blocking agent, 2,4-dinitrophenol to determine if physiological stress due to flow, with its attendant elevated cellular ADP levels, could account for the increased metabolism seen in the chamber experiments.

While the data collected has not been analyzed carefully (over 1 Megabyte of raw data was collected in this part of the mission), by "eye- balling" the raw numbers, it appears that *A. cervicornis* shows a similar response to flow and photosynthesis, increased respiration. The mitochondrial poisoning experiment also appears to have yielded negative results, eliminating a persistent criticism about flow-mediated metabolic effects in general.

Some novel measurements of light regimes in and around coral polyps were made during the mission using a fiber optic irradiance meter. Using a micromanipulator attached to a magnetic stand attached to a heavy steel plate, irradiance transects around and into coral polyps were made, likely the first such measurements made in situ. A preliminary scan of the data indicates that (1) light fields around different coral morphologies may be quite different at the microscale level, and (2) there is no evidence that space irradiance increases due to scattering inside coral tissues, a phenomenon which has been observed in terrestrial plants; more measurements are needed in situ, with a probe of smaller diameter, to eliminate the possibility of the existence of this interesting phenomenon.

A heated model with thin film temperature indicating liquid crystal "skin" was deployed in a variety of microhabitats on the reef to characterize small scale differences in mixing which may be important in regulating the metabolism of invertebrates. Eight temperatures on the surface of the model were sensed using thermistors and recorded electronically on an audio tape. The liquid crystal skin also showed qualitative differences in the flow patterns around the model in different habitats. Radical differences in mixing are seen between the West Wall, East Slope way station area, and the vicinity of the habitat, based on a quick view of the raw data collected (c. 500 kbytes).

A fluorescein dye sampler was used to characterize small-scale patterns of mixing around coral polyps in the following species of coral which have radically different morphologies: *M. cavernosa* (mount), *Meandrina meandrites* (plate), and *Porites porites* (fingers). Differences in mixing experienced by polyps in upstream/downstream and top/bottom locations of a colony were measured in situ at the East Slope and in the vicinity of the habitat. These measurements allow more insight into the flow over and around coral polyps than single point measurements of flow speed, since the device exploits the fact that replicate measurements show the variability in the local eddies that are being shed by the polyps and the colony itself as the wind-driven wave period overhead changes.

Diffusional boundary layers over one colony of *Diploria clivosa* were measured in the vicinity of the habitat using an oxygen microelectrode attached to a 33 m coaxial cable which allowed use of a picoammeter in the entry lock. A micromanipulator was used to control the placement of the probe in situ. The depth of diffusional boundry layer seems to be on the order of 300-600 micra in wave driven flow over this species. Oxygen transect measurements were made into the tentacular tissue of this species, showing essentially constant oxygen values in the tissues.

An extensive series of coral polyp morphometric measurements were made photographically at night to allow the testing of some predictions on polyp allometry made by a mathematical model developed for a "diffusionally similar series" of polyps.

Finally, some flow data were gathered deep on the reef at 150 feet. This environment is a transition area between hermatypic corals, dead coral, antipatharians and whip gorgonians. It is at these depths that diffusional boundary layers are most apt to be important in regulating reef metabolism. Flows at these depths are rarely measured; however, the InterOcean S4 current meter was utilized to gather data at this depth which will be useful in making predictions based on chamber manipulations.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Field studies of the roles of spatial scale and boundary-layer flow regime in active habitat selection by settling larvae: Preliminary sampling. Project Number 88-7**

2. NOAA Research Category:

3. Contract Number: CANCELLED

4. Principal Investigator:
Dr. Cheryl Ann Butman
Assistant Scientist
Ocean Engineering Department
Woods Hole Oceanographic Inst.
Woods Hole, MA 02543

5. Institutions involved: Woods Hole Oceanographic Institution

6. Co-Principal Investigator:

7. Participants:

8. Type of System/Facilities
   Wet Diving

9. Special Equipment Requirements:

10. Mission Period
    Start:
    End:

11. Operational Time
    Transit days:
    Number of operational days:
    Number of dives:
    Total bottom time:

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **An observational and survey study of crew compostion and member satisfaction in subsea habitats:**

2. NOAA Research Category:

3. Contract Number: Special Project

4. Principal Investigator:
Dr. H. Clayton Foushee
Crew Research and Space
Human Factors Branch
NASA-Ames Res. Center
MS 239-15
Moffet Field, CA 94035

5. Institutions involved: NASA-Ames, University of Texas at Austin (UTA)

6. Co-Principal Investigators:
Dr. Barbara Kanki
Crew Research and Space
Human Factors Branch
NASA-Ames Res. Center
MS 239-15
Moffet Field, CA 94035

Dr. Robert L. Hlemreich
Department of Psychology
University of Texas, Austin
Austin, TX 78713

7. Participants: Study consists of observation of other approved habitat projects. On-site participation by Mr. Douglas Smith, San Jose State University Foundation, Santa Barbara, CA 93108.

8. Type of System/Facilities
AQUARIUS undersea habitat

9. Special Equipment Requirements:

10. Mission Period
Start: 1 January, 1988
End: 31 December, 89

11. Operational Time
Number of dives:
Total bottom time:

12. Operational Depth Range
    Maximum:
    Minimum:

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file

    Quick Look: No
    Annual: Yes
    Final: No
    Due date:

16. Publications

    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: none

18. Principal Investigator Support/Co-Funding

    a. Organization:
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds

    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

19. Research results and summary

The major focus of this program is to examine the effect of personality factors on crew performance in isolated and confined environments. Since the habitat configuration, habitat size, number of crew, work tasks, and surrounding hostile environment closely parallel that of an orbiting space station, NASA feels that the fidelity of this environment can closely duplicate operational conditions in space (excluding, of course, microgravity and mission duration).

Methodology closely follows an ongoing study which uses volunteer airline pilots who fly a three day scenario in the full fidelity simulator at NASA-Ames. The aquanaut participants are asked to complete surveys prior to, during and post saturation. In addition to

the primary study of crew performance, other performance variables, such as traffic flow, the use of space in the habitat, and communications patterns are also studied by remote television observation. At all times the privacy of the individuals is assured. The data are sent to the University of Texas for computerized reduction and the results are sent to NASA-Ames for interpretation.

The goals of this program are to provide both NASA and NOAA with guidelines for crew selection and training. These guidelines are already in use in many of the major airlines, the Air Force, and the astronaut training program at NASA Johnson Space Center in Houston.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Chemical and structural defenses of Caribbean gorgonians: Pattern and Process over a depth gradient: Mission 89-1**

2. NOAA Research Categories: Biological Productivity and Living Resources and Ocean Services

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator:
Dr. C. Drew Harvell
Ecology and Systematics
Corson Hall
Cornell University
Ithaca, NY 14853

5. Institutions involved: Cornell University (CU), Scripps Institution of Oceanography (SIO), Northeastern University (NU)

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. C. Drew Harvell (CU), Ms. Julia Miles (NU), Mr. Josh Nowlis (CU), Mr. Brian Helmuth (CU), Mr. George Bruno, Mr. Doug Kesling (NURC-FDU). Surface support staff: Dr. Charles Greene (CU), Ms. Jenifer Ruesink (CU), Ms. Jordan West (CU), Dr. William Fenical (SIO).

8. Type of System/Facilities
   Aquarius Undersea Habitat
   Wet Diving

9. Special Equipment Requirements: Underwater respirometers, data-logger, underwater video camera, analytical balance, Li-Cor irradiance meter.

10. Mission Period
    Start: 15 January, 1989
    End: 25 January, 1989

11. Operational Time
    Number of excursions: 85
    Total bottom time: 193 h 22 m

12. Operational Depth Range
    Maximum: 100 feet
    Average: 69 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: 31 July, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $40,443.50

18. Principal Investigator Support/Co-Funding
    a. Organization: Hatch and NSF
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

Despite a decade of intense research by chemists and pharmaceutical companies that have focused on bioactive compounds from gorgonians (soft corals), no studies have explored the qualitative or quantitative variation in chemistry of a single species from different habitat types. The two gorgonian species utilized in this study possess compounds that are of known biomedical significance. The primary compounds isolated from the study organism, briareins, are highly bioactive and are potent anti-inflammatory, antiviral, and insecticide agents with good potential for biomedical and agrichemical applications. The ecological function of these compounds is not clear, though, several compounds from one of these study organisms are extremely deterrent to potential predators, fish. Work conducted both during saturation and from the surface throughout 1989, and in January 1990, included: analysis of the structural and chemical defenses of

gorgonians from shallow and deep water; measurements of productivity throughout the day for shallow and deep water colonies; reciprocal transplants of shallow and deep water colonies to assess environmental and genetic components that determine colony morphology and chemistry; and genetic analysis, by electrophoresis, of shallow and deep water populations.

Preliminary results suggest that briareins from gorgonians collected in St. Croix are different than from elsewhere in the Caribbean. Also, reciprocal transplants in St. Croix demonstrated phenotypic plasticity in a suite of morphological characters, i.e. gorgonian morphology depends strongly on environmental effects, rather than genetic effects.

The density of predators, density of gorgonians, the number of interspecific contacts and diel expansions and contraction behavior of *Briareum* and *Erythropodium* were assessed on shallow and deep transects. The abundance of invertebrate predators declined sharply from 35 to 80 and 100 feet. Fishes were not markedly more abundant at 35 than 80 feet, but declined sharply at 120 and 150 feet. *Briareum*, and to a lesser extent *Erythropodium*, showed a much higher frequency of wounds in shallow than deeper water. An assessment of wound recovery rates is in progress. It seems clear that pressure from predators is more intense in shallow water, but the regeneration results will allow comparison of the consequences of predation at various depths. Observations and video tapes were made that confirmed a number of fish as gorgonian predators; fish not previously known to eat gorgonians included the grey angelfish, the scrawled filefish and the spotted filefish. In predator preference tests, *Cyphoma* (a snail) prefer deep to shallow colonies (42/69 were for deep colonies).

Gorgonians have both chemical and structural defenses against predators and competitors. The chemistry of Briareum colonies is complex, but is dominated by 5 compounds tentatively identified as Briareins A-E. Colonies collected from shallow and deep reefs in St. Croix did not vary qualitatively as measured by thin layer chromatography, although the secondary compounds do vary with depth in the Bahamas. Quantitative assessment is in progress by High Pressure Liquid Chromatography at Scripps and Cornell. The population genetics of Briareum is also under investigation utilizing electrophoresis: parts of 20 shallow and 20 deep colonies were collected for this purpose.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Effects of animal disturbance on microbiological processes in sediments of Salt River Canyon: Mission 89-2**

2. NOAA Research Categories: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Gary M. King
Associate Professor
Darling Marine Center
Walpole, ME 04573

5. Institutions involved: University of Maine (UM), Michigan State University (MS), University of Aarhus, Denmark (UA)

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Gary King (UM), Dr. Rick G. Carlton (MS), Mr. T. Sawyer (UM), Ms. R. Irving (UM), Mr. J. Brinch-Iversen (UA), Mr. Chris Bourne (NURC-FDU). Surface support staff: Dr. T.H. Blackburn (UA), Dr. R. Findlay (UM).

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Underwater video camera tethered to habitat, Li-Cor irradiance sensor, Zenith computer in habitat, fume hood installed in habitat, radioisotopes (35S-sulphate), centrifuge, Milli-Q water system, analytical balance, oxygen microelectrodes.

10. Mission Period
Start: 17 March, 1989
End: 27 March, 1989

11. Operational Time
Number of excursions: 85
Total bottom time: 132 h 3 m

12. Operational Depth Range
    Maximum: 150 feet
    Average: SCUBA 82 feet
    EXO 60 feet
    HOOKAH 60 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: Yes
    Final: No
    Due date: 31 July, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $17,220

18. Principal Investigator Support/Co-Funding
    a. Organization: NSF
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds
    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

Physical disturbances at the water sediment interface, as occur by the feeding activities of swimming and burrowing organisms, are an important factor regulating benthic microbial processes such as photosynthesis, nitrogen fixation, and sulfate reduction. Work conducted from the Aquarius investigated benthic microbial processes in sediments by measuring oxygen, nitrogen, and sulfur dynamics, and water currents at the water sediment interface. Microbial biomass and community structure were also determined. High productivity in coral reef environments, which occurs in waters of low nutrient concentration, depends on processes that tightly couple the cycling of nutrients between the sediments and the overlying water. This research characterized, through time-course studies, how benthic systems respond to physical disturbances (in this study stingray pits

were investigated), and ultimately how disturbances affect productivity and nutrient cycling in benthic systems.

Although differences in microbial biomass between ray pit and undisturbed sediments suggests a significant impact of ray feeding on benthic microbial processes, analyses of oxygen uptake suggest a more complicated picture. Oxygen uptake was analyzed using both a small, static chamber method for comparative purposes and larger, mixed chambers to provide more accurate estimates. After deploying the chambers, samples were removed by syringe at a fixed interval and returned to the habitat for processing by a Winkler titration. The initial steps in this method were performed in the habitat and the final on the surface. In both cases, there were no consistent differences in rates of oxygen uptake between disturbed and undisturbed sediments. Rates of uptake varied between about 16-23 mmol oxygen m^{-2} day^{-1}. In addition, depth profiles of oxygen concentrations obtained by using microelectrodes in situ were similar in pits and adjacent sediments. This was particularly notable since biomass differed significantly for at least 48 hr after pit formation. One plausible explanation for this may be that the exposure of anoxic sediments containing sulfides resulted in a chemical (and possible microbial) oxygen demand in the ray pits which offset the decreased biomass. In addition, the microflora of the ray pits may have had a higher rate of uptake per unit biomass. Higher rates of uptake may have been coupled with increased growth rates and could explain in part the relatively rapid increase in biomass after 48 hr. Post-mission processing of samples for sulfide contents and rates of sulfide reduction may provide further clarification of the oxygen results and the role of sulfide oxidation.

Additional insights into the nature of the microbial biomass in canyon sediments will be available after sample processing in Maine. This effort will involve analyses of the qualitative and quantitative fatty acid composition of the lipid phosphates. Information from these fatty acid "signatures" will be used to assess the major types of microbes present in the sediment and changes that occurred as a result of disturbances.

Two additional microbial processes were also measured. Both of these, sulfate reduction and nitrogen fixation, are sensitive to local redox conditions and substrate availability. They should provide an indication of the extent to which the surface sediments of ray pits undergo transitions in redox status. Sulfate reduction was determined by collecting the 0-2 cm interval of ray pit and adjacent sediments in cut-off 5 cc syringes. These were returned to the habitat and injected with a solution of radioactive sulfate (35S-sulfate). After an incubation for 6-12 hr, the reduction of sulfate was terminated by injecting a solution of zinc acetate. The syringe cores were then sent to the surface and frozen. After returning to Denmark, the samples will be processed by a distillation

technique which allows quantification of the conversion of radiolabelled sulfate to sulfide and estimation of the total mass of sulfides. The work in the habitat with isotope was again facilitated by the fume hood which provided a confined work space. While using isotope in the habitat, all standard safety procedures were followed: isotope was stored in a sealed, marked container and segregated from other materials; absorbent bench paper, disposable gloves, separate syringes and pipets were used for handling; swipe surveys were performed daily; solid wastes were collected separately; no liquid wastes were generated.

Nitrogen fixation was analyzed by collecting syringe cores as above. After returning to the habitat, the syringe cores were injected with a solution of acetylene-saturated seawater. This solution was prepared by generating acetylene from calcium carbide and then bubbling a volume of seawater vigorously for 1-15 min. The carbide was sent from the surface in sealed serum bottles and the bubbling conducted outside the habitat with a diver on EXO or SCUBA. After incubation of the syringe cores for about 12 hr, a solution of ammonical silver nitrate was injected to terminate the reaction and to precipitate dissolved acetylene. The sediments in the syringe cores were then transferred to blood collection tubes which were sealed. Gas phases samples of these tubes will be analyzed for ethylene (an index of nitrogen fixation) after return to Denmark. The original plan to analyze samples in the habitat using a portable gas chromatograph was not feasible since the detector lacked the necessary sensitivity. This problem was due to the hyperbaric conditions of the habitat, but may be rectified for future uses by modifying the instrument to allow operation of the analytical column at temperatures above ambient.

The potential significance of ray feeding disturbances in the canyon was estimated by monitoring transects throughout the canyon. From these data, it was possible to calculate the approximate surface area represented by ray pits. Values were generally between about 2-10 percent of the total area with the higher numbers occurring in sandy sediments and the lower within Halophila beds. While these percentages seem relatively small, the turnover of pits from a recognizable to a non-distinct feature means that actual percentages on a yearly basis are much higher. Thus ray feeding may have a biogeochemical impact comparable to the sediment infauna. This impact would result from the redistribution of sediments, the exposure of reduced sulfidic sediments to oxygenated water, and changes in the sediment microflora among others.

Oxygen dynamics were examined in disturbed and undisturbed sediments at numerous depths under various conditions of light intensity and velocity of overlying water (see figure demonstrating velocities near the sediment -water interface). Two approaches were used. The first consisted of enclosing small area (ca. 700 cm^2) of sediment within clear acrylic domes and monitoring changes in oxygen concentration through time. The

second method utilized polarographic oxygen-sensitive microelectrodes for direct measurement of oxygen concentration in situ and in core samples brought into the habitat. Preliminary analyses of the data have revealed that very large amounts of oxygen are produced photosynthetically in sediments colonized by either microalgae or Halophila. However, these same sites consume sufficient oxygen during darkness to become anoxic. At depths exceeding 80 ft in Salt River Canyon, algal oxygen production does not exceed the demand by the sediment microbial community with the result that oxygen concentration at the sediment-water interface is well below saturation. Another early conclusion is that oxygen dynamics inside and outside ray pits appear to be similar in deep areas of the Canyon, while obvious differences occur shallower.

In addition to work on feeding disturbances and oxygen dynamics, the dynamics of microbial processes were studied in local seagrass beds within the canyon and in the shallower waters of Sugar and Triton Bay. Diurnal studies were conducted to determine the behavior of porewater nutrients (e.g. ammonia), microbial activities (e.g. sulfate reduction and oxygen uptake), and nutrient exchanges across the sediment-water interface. These analyses involved the *Halophila* beds located between about 70-90 ft in the canyon, *Thallassia* beds in Triton Bay and a *Syringodium* bed near the entrance to Sugar Bay. While most of the samples will be processed post-mission, it is quite evident from the ammonia data generated on site that there are significant shifts in porewater nutrients which presumably reflect plant activity. In contrast, no trends were detected in microbial biomass. Changes in oxygen uptake (or production) were as expected for a system with a photosynthetic component. A much more thorough characterization of the three types of seagrass beds will be available after samples are analyzed for additional nutrient concentrations and rates of sulfate reduction, denitrification, and nitrogen fixation.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Salt River Submarine Canyon long-term ecological monitoring program: Standardization of methods for Virgin Islands coastal ecosystems: Mission 89-3**

2. NOAA Research Categories: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Mary Lou Coulston
Caribbean Research Institute
University of the Virgin Islands
St. Thomas, USVI 00802

5. Institutions involved: University of the Virgin Islands (UVI), VI Government Department of Planning and Natural Resources (DPNR), National Park Service (NPS)

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Mary Lou Coulston (UVI), Mrs. Marcia Taylor (DPNR), Ms. Robin Simms (DPNR), Ms. Charlotte Linville (UVI), Ms. Zandy Hillis (NPS), Mr. Oriel Hewlett (UVI), Mr. Michael Herko (NURC-FDU). Surface support staff: Mr. Neil Coulston.

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Underwater video camera, underwater drill and hydraulics, underwater cameras and quadrapod system.

10. Mission Period
Start: 10 April, 1989
End: 24 April, 1989

11. Operational Time

Number of excursions:	101	
Total bottom time:	SCUBA	264 h 16 m
	HOOKAH	4 h 31 m

12. Operational Depth Range

Maximum:	120 feet	
Average:	SCUBA	88 feet
	HOOKAH	58 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: 31 June, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $13,505

18. Principal Investigator Support/Co-Funding
    a. Organization:
    Status:
    Period:
    Amount:

    b. Matching Funds
    Salaries: $9528 (7 individuals for 3 weeks)
    Other: $300 (instrument calibration)
    Total:

    c. Total Co-funding and Matching Funds: $1228.00

19. Research summary and results

An environmental monitoring program was established in Salt River Submarine Canyon by local governmental agencies. Linear transects, permanently marked photo-quadrants and video surveys were conducted throughout the canyon.

Results from this mission are particularly noteworthy and immediate due to Hurricane Hugo. Using the photoquadrat and transect data a quantitative pre- and post-Hurricane Hugo environmental assessment was conducted. Data analysis includes usage of a digitizing system with photographs and video to determine storm induced changes in species richness, percent cover, and relative abundance of the benthic community. Results are not yet available.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **The trophic impact of deposit and suspension-feeding ophiuroids on recruitment of other coral reef organisms: A feasibility study: Mission 89-4 [Training Mission]**

2. NOAA Research Categories: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator:
Dr. Jeremy Woodley
University of the West Indies
Discovery Bay Marine Laboratory
P.O. Box 35
Discovery Bay, Jamaica, WI

5. Institutions involved: University of the West Indies (UWI), Smithsonian Institution (SI), University of the Virgin Islands (UVI), NOAA: NURP and NURC-FDU.

6. Co-Principal Investigator:
Dr. Richard B. Aronson
Smithsonian Institution
Dept. of inv. Zoology, NMNH
Washington, DC 20560

7. Participants: Aquanauts: Dr. Jeremy Woodley (UWI), Dr. Richard B. Aronson (SI), Dr. Steven L. Miller (NURC-FDU), Ms. Charlotte Linville (UVI), Mr. Gregory Stone (NURP), Mr. Richard Berey (NURC-FDU).

8. Type of System/Facilities
   Aquarius Undersea Habitat
   Wet Diving

9. Special Equipment Requirements: Underwater video camera tethered to habitat, underwater cameras and quadrapod system.

10. Mission Period
    Start: 16 June, 1989
    End: 20 June, 1989

11. Operational Time
    Number of excursions: 46
    Total bottom time: SCUBA 117 h 14 m
    EXO 3 h 56 m

12. Operational Depth Range:
    Maximum: 120 feet
    Average: SCUBA 72 feet
    EXO 59 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: Not applicable for training mission
    Final: Not applicable for training mission
    Due date:

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $4882.00 to UWI, $410.00 to G. Stone

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

This mission was organized as a Training Mission for a Caribbean-based scientist, Dr. Woodley. A preliminary investigation was made of the abundance of ophiuroids (e.g., brittle-stars and basket-stars) and a test of remote video monitoring by red-light illumination during the night was successfully conducted. Brittle stars are known to feed on suspended particles, and basket-stars in particular have been shown to capture zooplankton larger than 0.5 mm, including fish larvae. Drs. Woodley and Aronson's research addresses the role of these organisms at the benthic-pelegic interface, particularly with respect to recruitment processes in marine organisms. Brittle-star abundance was low and their distribution patchy, so the ten quadrats at each location probable do not adequately characterize the sites. However, a trend is apparent with increasing abundance and diversity from deep to

shallow station (130 feet, 90 feet, 50 feet). Mean density at the 50 foot station was approximately 30 per meter square. In all, 127 individuals from 12 species were sampled: half of the species are known to suspension feed, constituting 65 percent of all individuals. The rarity of basket-stars in the Canyon may reflect high levels of predation by fishes. The possible relationship between predator abundance and basket-star abundance requires further attention. Results of the ophiuroid surveys provided baseline data for a post-Hugo survey conducted by Dr. Aronson.

Dr. Miller, as part of NURC-FDU funded research with Dr. M. Dennis Hanisak (Harbor Branch Oceanographic Institution), conducted a preliminary survey of nutrient availability in deep reef environments. This research project, *Nutrient relations of coral reef algae*, addresses the general question of whether algal productivity on reefs is nutrient limited. Despite low ambient nutrient concentrations found in coral reef environments, many sources of nutrient input exist. Although these inputs are responsible for the net production within a reef, nutrient additions to a reef are difficult to detect. The primary objectives of this program are to determine the spatial and temporal variability in nutrient availability within St. Croix reef environments and to determine experimentally whether turf algae and other seaweeds can exploit transient pulses of nutrients.

This project was initiated in 1989 as a surface-based program. Preliminary data was to be used to help design and better plan for an Aquarius mission in 1990 (subject to additional peer review). Samples collected during this Aquarius mission were destroyed just prior to analysis, by Hurricane Hugo. The NURC-FDU autoanalyzer and WIL analytical lab were also damaged by the storm.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Ultraviolet light and its effect on reef-building corals: Mission 89-5**

2. NOAA Research Categories: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Gerard M. Wellington
Associate Professor
Biology Department
University of Houston
Houston, TX 77204-5513

5. Institutions involved: University of Houston (UH), University of California, Santa Barbara (UCSB), Fairleigh Dickinson University/West Indies Lab (WIL).

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Gerard Wellington (UH), Mr. Daniel Gleason (UH/WIL), Mr. Bruce Lock Rogers (UCSB), Mr. Eric Graham (UH), Mr. Doug Kesling (NURC-FDU). Surface support staff: Ms. Michelle Woodbury (WIL), Mr. Michael McCormack (UH).

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Ultraviolet light sensors and data loggers, ultraviolet lamps in underwater housings, S4 current meter, computer, spectrophotometer, muffle furnace, analytical balance, drying oven, centrifuge, underwater cameras.

10. Mission Period
Start: 17 July, 1989
End: 27 July, 1989

11. Operational Time
Number of excursions: 71
Total bottom time: SCUBA 249 h 2 m

12. Operational Depth Range
Maximum: 130 feet
Average: SCUBA 88 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: 27 January, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $24,824.00

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

The detrimental effects of ultraviolet (UV) radiation on marine organisms has only recently been recognized. This is partly a result of the difficulty in measuring this short wavelength high energy light. Previous studies suggest the UV light may be an important physical parameter affecting the distribution and abundances of reef-building corals; these observations are particularly relevant in regard to recent coral bleaching events throughout the Caribbean (bleaching has occurred extensively in Jamaica again this past summer, and to a lesser amount at other Caribbean sites). The objectives of this project were to systematically quantify the natural flux of ultraviolet-a (320-400 nm) and ultraviolet-b (280-320 nm) from the sea surface to a depth of 24 m. Experimental manipulations of corals were conducted to test the hypothesis that unusually high levels of UV radiation penetration, associated with calm clear water conditions, causes coral bleaching.

All environmental parameters were monitored and experimental manipulations were conducted at the far east end to the canyon just beyond the east slope tank rack. Three sets of International Light UV-A and B sensors with peak detections at 365 nm (50 percent

range: 330-375 nm) and 285 nm (50 percent range: 265-31 0 nm), respectively, were deployed. Ultraviolet levels were monitored along the depth gradient by placing one pair of sensors at the surface, one at 11 m, and one at 24 m. The sensors at the surface and 11 m were interfaced with a data logger located on a boat moored directly above the site, while at 24 m they were attached to a data logger deployed in an underwater housing. Various water column parameters were measured to evaluate their influence on UV penetrance. Suspended organics and inorganics were determined twice daily at 1, 10, 20, and 24 m by filtering 5 liter water samples through 0.3 um glass fiber filters. Phytoplankton abundances were extrapolated from measures of photosynthetic pigments (i.e., chlorophylls-a, -b, and -c and carotenoids) extracted from each sample. In addition, qualitative observations were made on sea surface conditions since surface deflection of UV light may be significant in rough seas. The above observations and analyses were carried out by two surface support personnel.

Spectroline mediumwave (peak of 1800 uW/ cm^2 of 302 nm at 15 cm) and longwave (peak of 1750 uW/cm^2 of 365 nm at 30 cm) UV lamps enclosed in PVC housings that had one face composed of UV transparent acrylic, were lowered to a depth of 24 m. These lamps were used to irradiate small colonies (100 cm^2) of *Montastrea annularis* and *Agaricia agaricites* at levels above the ambient levels recorded over a two day period. Ten colonies of each species were used in each of the three treatments. These colonies were collected from the surrounding reef along the 24 m contour line, positioned under the lights at appropriate distances and affixed to the substrate with epoxy. In addition, ten colonies of each species were tagged in situ to act as controls. All the colonies were photographed on the first day of exposure to the UV lamps and at the end of the experiment seven days later. The purpose of the short term experiment was to determine the level of irrradiance that induces stress as indicated by the loss of zooxanthellae (bleaching).

In addition to the short term experiments, long term (4-6 months) manipulations were set up to determine response and adaptability of corals to increase in UV light. Corals from 27 m were transplanted to 22, 19, and 16 m, representing a range of exposures above ambient levels at 27 m. Again, colonies of *Montastrea annularis* and *Agaricia agaricites* of approximately 100 cm^2 in size were used. All corals used in this experiment were collected outside the bounds of the canyon to minimize the impact within.

Corals were then transported to the appropriate depths and cemented to the substrate with underwater epoxy. Three treatments were employed at each depth: 1) exposures to ambient UV light (no cover), 2) UV block (acrylic cover that filters UV-A and -B), and 3) exposure to ambient light, but with control for the effects of the cover in treatment 2 (quartz

glass cover). At each depth, seven replicates of treatments 1 and 2 and two replicates of treatment 3 were established. Comparing results from treatment 1 and 2 will measure the effects of enhanced UV light and any "cover effects." These "cover effects" will be factored out by comparing the results of treatments 1 and 3. Assays for measuring responses to elevated UV levels will be loss of zooxanthellae, colony death, changes in mitotic indices, differences in concentrations of UV blocking pigments, and differences in growth rates (based on initial skeletal growth line established with the vital stain).

Although water clarity was not ideal during the course of our mission (high sediment loads occurred during most days) both UV-A and -B were still detectable down to 24 m. As an example of an average day during the saturation, the maximum UV-A levels at 11 and 24 m were 18.5 and 4 percent of that seen at the surface, respectively. In contrast, UV-B at 11 and 24 m was 6 and <1 percent of that at the surface. During the period of peak irradiance, the intensity of UV-A reaching the surface of the water was approximately 14 times that of UV-B. This relationship did not hold along the depth gradient (UV-A was 43 and 105 times the level of UV-B at 11 and 24 m, respectively) suggesting that the extinction curves through the sea water differ or the wavelengths are differentially affected by water column parameters. Thus, monitoring water column characteristics in quantifying UV flux is important because curves indicate that there is not a perfect correlation between UV-A irradiance at the surface and that reaching to 24 m. Parameters which are likely to be most significant are currently being evaluated.

The short-term UV enhancement experiments are also undergoing continual evaluation. At the close of the mission (and 4 days following saturation), no significant change in color was detected among the experimental corals compared to the controls.

Regarding the long term transplant experiments, no signs of bleaching were observed as of six days after the mission. This was not unexpected, negative responses might be expected within two to three weeks after the experiments began. These responses will be measured in terms of colony appearance (degree of bleaching) and zooxanthellae densities acquired by subsampling tissues. By allowing colonies to recover an estimate of adaptability (i.e., percent of corals surviving specific levels of exposure to UV). Considering the increased UV levels to which transplanted colonies are being exposed is possible, it is highly unlikely that bleaching will not occur in at least the 16 m treatment.

In conclusion, these data indicate that both UV-A and -B can penetrate to depths greater than 24 m, even under less than ideal conditions. At present the UV conditions that may have caused the bleaching event are not known. These experiments would have been virtually impossible to initiate without the use of the Aquarius habitat.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Adaptive selection of local habitat and passive movement of larvae as factors influencingcomposition of assemblages of fishes on coral reefs: Mission 89-6a**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator:
Dr. John P. Ebersole
Associate Professor
Univ. of Massachusetts/Boston
Harbor Campus
Boston, MA 02125-3393

5. Institutions involved: University of Massachusetts/Boston (UM), New England Aquarium (NEA), University of Florida/Gainesville (UF), University of Georgia (UG), Virgin Islands Government Fisheries Department (VI).

6. Co-Principal Investigator:
Dr. Les Kaufman
Curator/Senior Scientist
New England Aquarium
Boston, MA 02110-3309

7. Participants: Aquanauts: Dr. Les Kaufman (NEA), Dr. Carole McIvor (UF), Ms. Holly Martel (NEA), Mr. Jim Beets (VI), Dr. Gene Helfman (UG), Mr. Glenn Taylor (NURC-FDU). Surface support staff: Dr. John Ebersole (UM), Mr. John Sisson (UM), Ms. Susan Saucerman (UG), Mr. Paul Sackley(NEA).

8. Type of System/Facilities
   Aquarius Undersea Habitat
   Wet Diving

9. Special Equipment Requirements: Compressed air for plankton samplers,light traps for plankton.

10. Mission Period
    Start:
    End:

11. Operational Time
    Number of excursions: 91
    Total bottom time: SCUBA 247 h 25 m
    HOOKAH 3 h 38 m

12. Operational Depth Range
    Maximum: 135 feet
    Average: SCUBA 82 feet
    HOOKAH 52 feet

13. Geographic Location: St. Croix, USVI

14. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: February, 1990

15. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

16. NURC-FDU Cost: $26,095.00

17. Principal Investigator Support/Co-Funding
    a. Organization:
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds
    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

The composition of coral reef fish communities can be influenced by passive movement of larval fishes, or by the active processes of habitat selection and post-settlement mortality. Drs. Ebersole and Kaufman in a Hydrolab mission discovered that the east and west walls of Salt River Canyon differed in species composition. While the canyon walls are close enough to recruit from the same pelagic larval pool, somehow the two walls end up with different assemblages of adults. These investigators conducted studies to determine whether this faunal differentiation occurs due to passive movement of larval fishes, active selection of habitat by larvae, or differential losses and gains of juveniles in different habitats. Dr. Ebersole and Mr. James Beets (Ph.D. candidate, University of Georgia and Department of Fisheries, VI Government) repeated their pre-Hurricane Hugo fish censuses in November, 1989.

Results of these studies suggest that faunal differences between the two walls identified in 1981 were equally evident in 1989. These include the relatively depauperate and cryptic nature of species observed over gorgonian/rubble habitat on the East Slope versus brightly colored species on the West Wall, and presence of sand-associated species on the East Slope. There were, however, profound differences between the 1981 and 1989 censuses. The 1989 census curves took longer to level off and revealed a higher number of species than the 1981 censuses, for both walls. Furthermore, in 1981 the East Slope produced consistently fewer species than the West Wall; in 1989 the two habitats exhibited equivalent species diversity, although each habitat hosted 24 species which were sighted during censuses only on that wall. Analyses of larval samples are not complete.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Effects of ontogeny and refuge quality on threat-sensitivity in recently-recruited coral reef fishes: Mission 89-6b**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator:
Dr. Gene S. Helfman
Associate Professor
Department of Zoology
University of Georgia
Athens, GA 30602

5. Institutions involved: University of Massachusetts/Boston (UM), New England Aquarium (NEA), University of Florida/Gainesville (UF), University of Georgia (UG), Virgin Islands Government Fisheries Department (VI).

6. Co-Principal Investigator:

7. Participants: Aquanauts: Dr. Les Kaufman (NEA), Dr. Carole McIvor (UF), Ms. Holly Martel (NEA), Mr. Jim Beets (VI), Dr. Gene Helfman (UG), Mr. Glenn Taylor (NURC-FDU). Surface support staff: Dr. John Ebersole (UM), Mr. John Sisson (UM), Ms. Susan Saucerman (UG), Mr. Paul Sackley (NEA).

8. Type of System/Facilities
   Aquarius Undersea Habitat
   Wet Diving

9. Special Equipment Requirements: Motorized device for driving resin-coated fish.

10. Mission Period
    Start:
    End:

11. Operational Time
    Number of excursions: 91
    Total bottom time: SCUBA 247 h 25 m
    HOOKAH 3 h 38 m

12. Operational Depth Range
    Maximum: 135 feet
    Average: SCUBA 82 feet
    HOOKAH 52 feet

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: February, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $6,415.00

18. Principal Investigator Support/Co-Funding
    a. Organization:
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds
    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

The ability to avoid predators strongly influences larval fish recruitment on coral reefs. Actual avoidance behaviors of recruits and ontogenetic differences in avoidance ability were studied as part of this project. By presenting predator models (resin-coated fish) to recently recruited fish and older fish graded responses to predatory threat ("threat-sensitivity") were compared. Refuge quality in the form of hard versus soft coral was also correlated with threat-sensitivity. Results from these studies conducted by Dr. Helfman will help identify behavioral traits that determine successful recruitment in coral reef fish.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Spatial resolution and taphonomic gradients in accumulating molluscan remains, Salt River, St. Croix: Postponed due to Hurricane Hugo**

2. NOAA Research Category: Pathways and Fates of Materials in the Ocean

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator:
Dr. Arnold I. Miller
Assistant Professor
Department of Geology
University of Cincinnati
Cincinnati, Ohio 45221

5. Institutions involved: University of Cincinnati (UC), Miami University (MU), University of Rochester (UR), Fairleigh Dickinson University/West Indies Lab (WIL).

6. Co-Principal Investigator:

7. Participants: Dr. Arnold Miller (UC), Dr. Mark R. Boardman (MU), Ms. Karla Parsons (UR/WIL).

8. Type of System/Facilities
   Aquarius Undersea Habitat: Mission postponed
   Wet Diving

9. Special Equipment Requirements: Vibrocore powered by diesel motor at surface.

10. Mission Period
    Start: Postponed due to Hugo, project was initiated in August from the surface using SCUBA.
    End:

11. Operational Time
    Number of excursions:
    Total bottom time:

12. Operational Depth Range
    Maximum:
    Average:

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Not applicable
    Annual: No
    Final: No
    Due date: 15 March, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $24,735

18. Principal Investigator Support/Co-Funding
    a. Organization:
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds
    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

The purpose of this project was to evaluate and quantify gradients in the effects of transport on the distributions, abundances, and physical conditions of accumulating molluscan skeletal material in Salt River Submarine Canyon and adjacent areas. To this end, the molluscan content of vibrocores and bulk samples were collected at regular intervals along sampling transects in the canyon (cancelled due to Hugo), adjacent shelf areas, and estuary. Spatial patterns in collected data were analyzed using multivariate statistical techniques. Preliminary work carried out just prior to Hurricane Hugo was expanded post-Hugo as part of an NSF quick response grant. Sufficient data were collected from surface-based operations to meet many objectives of this project, especially considering the pre- and post-Hugo assessment.

As part of the assessment of transport and spatial variability among accumulated molluscan skeletal remains in the Salt River area, a series of airlifted molluscan samples were collected at 30 m intervals along a 1020 m transect just prior to Hurricane Hugo. The passage of the hurricane provided an excellent opportunity to directly measure distribution

changes in subfossil accumulations associated with a major storm. Because it is now recognized that much of the fossil and sedimentary rock records were deposited in association with storms and other catastrophic events, such data are of substantial interest to geologists and paleobiologists.

The post-Hugo objective was to duplicate the earlier sampling program, in order to provide post-storm data that would be directly comparable to that collected before Hugo (funding for this return trip was provided by NSF). Two buoys that were placed along the transect during the earlier sampling remained in place during the hurricane, and were encountered during resampling. The presence of these buoys helped substantially in relocation of the original transect. Three primary tasks, identical to those in the earlier work, were conducted at each station: 1) a molluscan sample was airlifted, 2) a sediment sample was collected, and 3) bottom vegetation, if present, was censused.

The first task provided the primary molluscan data for distributional analyses and evaluation of the physical condition of the skeletal material. The second and third tasks provided subsidiary environmental data that permit determination of the degree to which shells were indigenous to the subenvironments in which they were found. In this case, they also provided a direct reading of any changes to the benthic environment associated with Hurricane Hugo.

Laboratory analyses of the pre-Hugo data are ongoing but it is already clear that these data exhibit excellent spatial resolution and well-defined variability directly associated with environmental transitions along the transect. As many as five to six distinct molluscan assemblages/communities can be recognized among the skeletal remains preserved along the transect. Thus, the pre-storm data are clearly of sufficient quality to serve as a baseline for an analysis of post-storm changes.

Although the post-storm sampling was completed, laboratory analyses of these data have not yet begun. Nevertheless, observations made during sampling permit a preliminary "read" of changes associated with the hurricane. Clearly, there was no wholesale reorganization of either environments or molluscan skeletal distributions in Sugar/Salt River Bay. The series of environments and molluscan assemblages that could be recognized laterally along the transect prior to the storm remained relatively intact. At the same time, there are indications that local changes did take place. For example, in the southernmost molluscan samples, there is evidence of a post-storm enrichment in oyster shells belonging to species that lived on nearby mangrove roots. Similarly, the northern area of the transect, near the reef, shows evidence of disturbance. Whether these and other changes are demonstrably reflected in the data, thereby leaving some sort of post-storm signature in molluscan remains, must await laboratory and quantitative analysis.

One pre-storm sample was collected near the habitat. To round out the post-storm comparison, a post-storm sample was also collected at this site; it appears that the contents of the pre- and post-storm samples differ substantially.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **In situ studies of the distribution, behavior and community ecology of zooplankton, micronekton and benthos at a deep-sea station near St.Croix, USVI: Project 89-9**

2. NOAA Research Category: Ocean Lithosphere and Mineral Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Laurence P. Madin
Woods Hole Oceanographic Inst.
Woods Hole, MA 02543

5. Participants and Institutions involved:

Dr. Laurence P. Madin	Woods Hole Oceanographic Institution
Dr. Jelle Atema	Boston University Marine Program
Dr. Thomas Bailey	Harbor Branch Oceanographic Institution
Dr. Gary Owen	Harbor Branch Oceanographic Institution
Dr. Marsh J.Youngbluth	Harbor Branch Oceanographic Institution
Mr. Kim Reisenbichler	Monterey Bay Aquarium Research Institute
Dr. Bruce H. Robinson	Monterey Bay Aquarium Research Institute
Mrs. Peggy Hamner	University of California, Los Angeles
Dr. William M. Hamner	University of California, Los Angeles
Richard Malatesta	University of Connecticut
Dr. Robert B. Whitlatch	University of Connecticut
Dr. Michael Land	University of Sussex, UK
Dr. Justin Marshall	University of Sussex, UK
Dr. Frank Carey	Woods Hole Oceanographic Institution
Dr. Carol Diebel	Woods Hole Oceanographic Institution
Dr. J. Frederick Grassle	Woods Hole Oceanographic Institution
Dr. Russ Peters	Woods Hole Oceanographic Institution
Rose Petracca	Woods Hole Oceanographic Institution
Dr. Paul Snelgrove	Woods Hole Oceanographic Institution
Dr. Jenny Purcell	Woods Hole Oceanographic Institution

8. Type of System/Facilities
Johnson Sea-Link
R.V. Edwin Link

9. Special Equipment Requirements: Midwater platform with an array of oceanographic equipment

10. Mission Period
Start: 3 May, 1989
End: 4 June, 1989

11. Operational Time
    Number of excursions:
    Total bottom time:

12. Operational Depth Range
    Maximum:
    Average:

13. Geographic Location: St. Croix, USVI

14. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: 1 January, 1989

15. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

16. NURC-FDU Cost:

17. Principal Investigator Support/Co-Funding

a. Organization:	b. PI Support/Matching Funds
Status:	Salaries:
Period:	Other:
Amount:	Total:

    c. Total Co-funding and Matching Funds:

18. Research summary and results

This project was a multidisciplinary program of deep-sea in situ research that relocated from the Bermuda to St. Croix in 1989 for its second year of operation. The investigators continued research begun in 1987 in Bermuda, using manned submersibles. Better operating conditions in St. Croix included improved weather and sea conditions for submersible operations in the lee of the island, as St. Croix is a higher island than Bermuda. Logistical support and managerial assistance of NURC-FDU were other factors which led to the move to St. Croix. The Principal Investigators and project summaries are listed below.

- Dr. Thomas Bailey and Dr. Marsh J. Youngbluth (both from Harbor Branch Oceanographic Institution) conducted midwater respiration studies with animals collected at depths from 600-1000 meters; data were recorded for 35 animals.

- Dr. J. Frederick Grassle, with three graduate students and technicians, (Harbor Branch Oceanographic Institution) conducted benthic experiments that included: faunal survey and sampling studies; sediment analyses; colonization and successional studies with organic loading manipulations; deployment of emergent traps, and sediment traps. Dr. Grassle described the cruise as "near flawless."

- Dr. William M. Hamner (University of California, Los Angeles) tested a 3-dimensional video system to record, in situ, movements of planktonic animals; velocities and swimming directions were recorded for several phyla. Also, a new aquarium, designed to hold undamaged animals collected with the submersible, was successfully tested.

- Dr. Laurence P. Madin (Woods Hole Oceanographic Institution), Dr. Jelle Atema (Boston University Marine Program) and two graduate students deployed a midwater platform to investigate the near-bottom community, record physical oceanographic data and to measure concentration gradients in "odor plumes" by micro-electrodes.

- Dr. Bruce H. Robinson (Monterey Bay Aquarium Research Institute) and a graduate student successfully conducted 30 transects with an ISIT low-light camera as part of their bioluminescence studies. These data will contribute to an overall analysis of bioluminescence potential and its relationships to midwater community structure. The mechanism of light production and its associated anti-predator behavior was also studied using a benthopelagic holothurian. This is only the second time that the actual function of bioluminescence for a deep sea species has been observed and investigated in situ.

- Dr. Robert B. Whitlatch (University of Connecticut) and a graduate student examined the feeding biology of deep-sea deposit feeding invertebrates, studied bioturbational processes, and discerned feeding responses of benthic invertebrates in organic enrichment experiments.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Quantification of fish reproductive activity using a passive acoustic method: Mission postponed due to Hurricane Hugo**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-URO020

4. Principal Investigator:
Dr. Phillip S. Lobel
Associate Scientist
Biology Department
Woods Hole Oceanographic Inst.
Woods Hole, MA 02543

5. Institutions involved: Woods Hole Oceanographic Institution (WHOI).

6. Co-Principal Investigator:

7. Participants: Dr. Tundi Agardi (WHOI)

8. Type of System/Facilities
   Aquarius Undersea Habitat
   Wet Diving

9. Special Equipment Requirements: Current meters, underwater video cameras, shore-based radiotelemetry data acquisition, hydrophone radiotelemetry moorings, computers.

10. Mission Period
    Start: Not yet scheduled
    End:

11. Operational Time
    Number of excursions:
    Total bottom time:

12. Operational Depth Range
    Maximum:
    Average:

13. Geographic Location:

14. Latitude/Longitude:

15. Reports on file

    Quick Look: Yes
    Annual: No
    Final: No
    Due date:

16. Publications

    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $35,080.00

18. Principal Investigator Support/Co-Funding

    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **The effect of water movement on zooplankton capture by corals: Mission postponed due to Hurricane Hugo**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Kenneth P. Sebens
   Professor and Director
   Northeastern University
   Nahant Marine Science Center
   East Point
   Nahant, MA 01908

5. Institutions involved: Northeastern University (NU)

6. Co-Principal Investigator:

7. Participants: Dr. Kenneth Sebens, Dr. Amy S. Johnson, and seven others.

8. Type of System/Facilities
   Aquarius Undersea Habitat: Mission postponed
   Wet Diving

9. Special Equipment Requirements: Computer in habitat, Li-Cor irradiance meter, S4 current meter, thermistor flowmeters, underwater video cameras, analytical balance.

10. Mission Period
    Start: Postponed due to Hugo
    End:

11. Operational Time
    Number of excursions:
    Total bottom time:

12. Operational Depth Range
    Maximum:
    Average:

13. Geographic Location:

14. Latitude/Longitude:

15. Reports on file

    Quick Look:
    Annual:
    Final:
    Due date:

16. Publications

    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $39,598.00

18. Principal Investigator Support/Co-Funding

    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds

       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Porewater measurements of reef flank diagenesis and hydrology: Mission scheduled for 1990, postponed due to Hurricane Hugo**

2. NOAA Research Category: Ocean Lithosphere and Mineral Resources

3. Contract Number: No contract

4. Principal Investigator:
Dr. Francis J. Sansone
Associate Professor
Oceanography Department
Hawaii Instit. of Geophysics
University of Hawaii
1000 Pope Road
Honolulu, HI 96822

5. Institutions involved: University of Hawaii,

6. Co-Principal Investigator:

7. Participants: Dr. Francis J. Sansone

8. Type of System/Facilities
Aquarius Undersea Habitat
Wet Diving

9. Special Equipment Requirements: Autoanalyzer for ammonium, nitrate, nitrite, o-phosphate and silica analyses, compressed air for drill, liquid nitrogen.

10. Mission Period
Start: To be scheduled at new site
End:

11. Operational Time

Number of excursions:
Total bottom time:

12. Operational Depth Range

Maximum:
Average:

13. Geographic Location:

14. Latitude/Longitude:

15. Reports on file

    Quick Look:
    Annual:
    Final:
    Due date:

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $12,955.00

18. Principal Investigator Support/Co-Funding

    a. Organization:
    Status:
    Period:
    Amount:

    b. PI Support/Matching Funds

    Salaries:
    Other:
    Total:

    c. Total Co-funding and Matching Funds:

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **The evolution of mating systems and fertilization rates in hermaphroditic fishes: Aquarius Mission 90-1, conducted as a surface-based project due to Hurricane Hugo.**

2. NOAA Research Category: Biological Productivity and Living Resources

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. Christopher W. Petersen
NATO Postdoctoral Fellow
Friday Harbor Laboratories
620 University Road
Friday Harbor, WA 98250

5. Institutions involved: University of Washington,
Smithsonian Tropical Research Institute

6. Co-Principal Investigator:

7. Participants: Dr. Chris Petersen and three others

8. Type of System/Facilities
Aquarius Undersea Habitat: Mission cancelled by PI and modified to work as a surface-based program
Wet Diving

9. Special Equipment Requirements:

10. Mission Period
Start: Cancelled by PI, surface-based work began in January, 1990
End: February, 1990

11. Operational Time
Number of excursions:
Total bottom time:

12. Operational Depth Range
Maximum:
Average:

13. Geographic Location: St. Croix, USVI

14. Latitude/Longitude:

15. Reports on file
    Quick Look: Yes
    Annual: No
    Final: No
    Due date: 15 August, 1990

16. Publications
    Refereed paper:
    Non-refereed paper:
    Non-refereed abstract:

17. NURC-FDU Cost: $12,921

18. Principal Investigator Support/Co-Funding
    a. Organization:
       Status:
       Period:
       Amount:

    b. PI Support/Matching Funds
       Salaries:
       Other:
       Total:

    c. Total Co-funding and Matching Funds:

19. Research summary and results

The past decade has seen the elucidation of mating patterns for most of the shallow water species of simultaneously hermaphroditic reef fishes; three types of mating systems exist, serial monogamy, permanent monogamy and harem polygyny. Data generated in these studies will be used to test current theory on the evolutionary stability of hermaphroditism, the evolution of cooperation, and the role of aggression in determining sex allocation pattern and mating system evolution. This work has direct implications on population productivity, and indirectly supplies data that are necessary to estimate larval mortality of reef-based fish populations. In general, these studies are relevant to aspects of reproductive biology and larval ecology of reef fishes.

There were three goals of this work: 1) to develop a technique to measure fertilization rates in spawns where eggs are released into the water column and then fertilized, 2) to compare different types of spawns within a species [done in conjunction with Dr. Robert R. Warner at the University of California at Santa Barbara] and 3) to examine interspecific patterns of fertilization rate. Preliminary results suggest that in some species that release sperm into the water column ability to fertilize eggs declines rapidly

with time; after 30 seconds few sperm are capable of fertilizing eggs. Estimates of fertilization rates under different water conditions require further statistical analysis.

NOAA National Undersea Research Center
Fairleigh Dickinson University
Project Summary Report

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Date prepared: 27 June, 1990

1. Project Title: **Seafloor processes associated with potential accumulation and effects of particles reaching the seafloor from deep-water sludge disposal.**

2. NOAA Research Category: Biological Productivity and Living Resources, Fate of Materials in the Ocean

3. Contract Number: NA88AA-D-UR020

4. Principal Investigator: Dr. J. Frederick Grassle
Rutgers University

5. Institutions involved: Rutgers University, US Geological Survey, U. Mass-Boston, Woods Hole Oceanographic Institution, University of Rhode Island

6. Co-Principal Investigator:

7. Participants: 20 scientists

8. Type of System/Facilities
DSRV ALVIN

9. Special Equipment Requirements:

10. Mission Period
Start: 15 September, 1989
End: 26 September, 1989

11. Operational Time
Number of dives: 7

12. Operational Depth Range
Maximum:
Average:

13. Geographic Location: SDWD-106 municipal sludge dump site south of Hudson Canyon off New Jersey

14. Latitude/Longitude:

15. Reports on file
Quick Look: Yes
Annual: No
Final: No
Due date: 27 March, 1990