NOAA Technical Memorandum OAR NURP-1

CHEMICAL ECOLOGY AND DISTRIBUTION OF SPONGES IN THE SALT RIVER CANYON, ST. CROIX, U.S.V.I.

Rockville, Md.
April 1984

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / Office of Oceanic and Atmospheric Research

NOAA TECHNICAL MEMORANDUMS

NOAA's Office of Undersea Research

The National Oceanic and Atmospheric Administration's Office of Undersea Research, through the NOAA Undersea Laboratory System (NULS) begun in 1977, has provided manned underwater facilities and other research support for investigations of coastal marine environments including biological, geological, and ecological problems. There are currently five National Undersea Research Facilities which operate under cooperative agreements between universities and NOAA. The facilities are located at: the West Indies Laboratory of Fairleigh Dickinson University, the University of North Carolina at Wilmington, the University of Connecticut at Avery Point, the University of Southern California at the Catalina Marine Science Center, and the University of Hawaii at Makapuu Point on Oahu.

NOAA's Undersea Research Program funds scientists to conduct research at these facilities which is in line with NOAA's research needs and priorities in the areas of: (1) fisheries, (2) marine pollution, (3) sea floor properties and processes, and (4) ocean services.

Since its inception, NOAA also has encouraged and supported the use of submersibles to perform in-situ underwater observations and data gathering. Many shallow-water submersible missions have been supported by the Undersea Research Program, including the Johnson Sea-Link, the Nekton-Gamma, and the Mermaid, as well as deep-water missions using the Alvin. Submersible program goals are to support research from NOAA's major program elements, and the submersible needs of the Sea Grant College system.

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Nancy McKeever Targett
Skidway Institute of Oceanography
P.O. Box 13687
Savannah, Georgia 31516

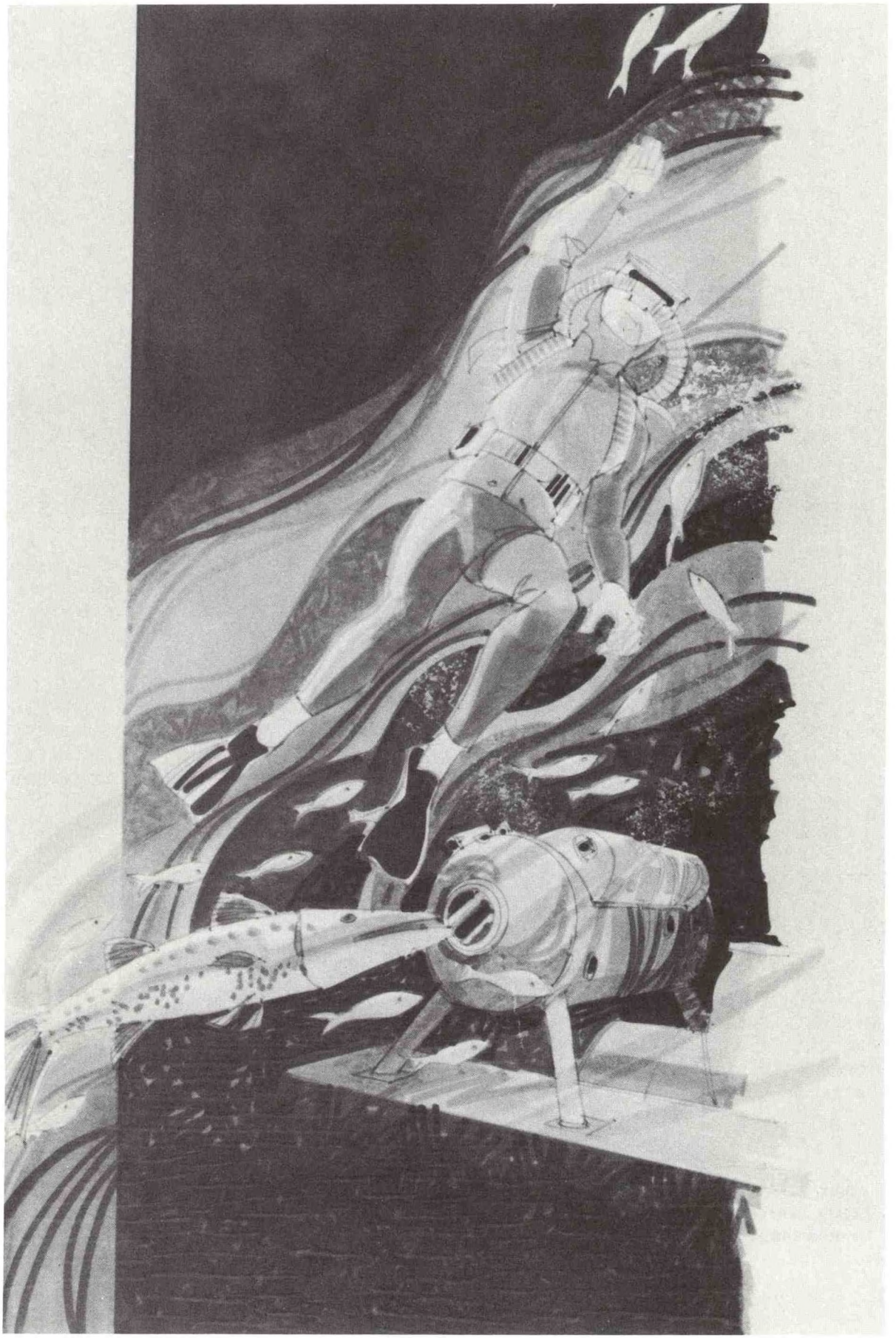
George P. Schmahl
University of Georgia
Athens, Georgia 30602

Rockville, Md.
April 1984

UNITED STATES
DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

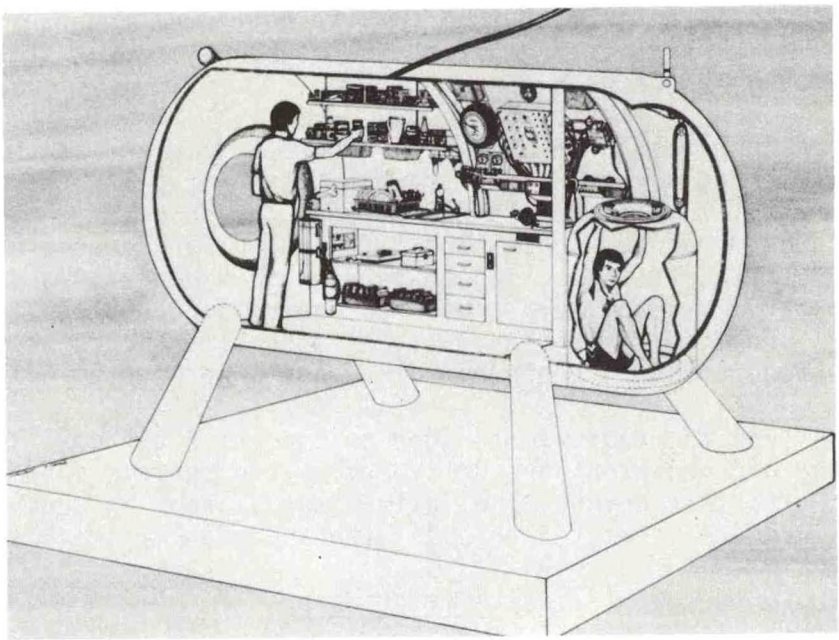
National Oceanic and
Atmospheric Administration
John V. Byrne, Administrator

Office of Oceanic and
Atmospheric Research
Joseph O. Fletcher
Assistant Administrator



NOAA'S NATIONAL UNDERSEA RESEARCH PROGRAM AT WEST INDIES LABORATORY OF FAIRLEIGH DICKINSON UNIVERSITY

THE HYDROLAB SATURATION HABITAT



The National Oceanic and Atmospheric Administration (NOAA) has a legislative mandate to establish programs for the assessment, protection, development, and utilization of U.S. coastal zone resources. In addressing this mandate, NOAA's Office of Undersea Research has initiated the National Undersea Research Program. This program will provide the facilities needed to aid in solving the U.S. coastal marine environmental problems of national significance through the use of underwater laboratories and saturation diving techniques. While this National Program represents a renewed dedication to underwater scientific research, it is, in effect, the next major step in a long series of manned underwater investigations sponsored by NOAA.

Oceanographic research has shown that certain types of data relating to the marine environment cannot be obtained by using exclusively surface-oriented research methodology. As a result of extensive experience in manned underwater operations, NOAA has established the seafloor laboratory system, Hydrolab, as a national facility on St. Croix, U.S. Virgin Islands. Hydrolab is managed and operated by the West Indies Laboratory of Fairleigh Dickinson University.

Equipment Description

The Hydrolab underwater habitat was designed and constructed in the mid-1960s by Perry Submarine Builders of Florida. Early in its career, it was used as an educational facility by Florida Atlantic University and later was moved

to Freeport, Grand Bahama Island, for scientific operations. Following its distinguished service in Freeport, it was purchased by NOAA, refurbished, and moved to St. Croix for use with the National Undersea Research Program. American Bureau of Shipping interim class certification was obtained in June of 1979.

Hydrolab consists of a cylindrical chamber, 16 feet long by 8 feet in diameter with a double-lock entrance trunk 30 inches in diameter by 48 inches high located at one end (24" diameter hatch openings). A transfer tunnel 10 feet long by 3 feet in diameter leads from the bottom of the habitat out to one side and is sealed closed at the far end. This tunnel houses some equipment but remaining space can be used for storage.

The habitat contains three 6'4" x 24" bunks (two of which convert to a couch), a sink with cold, hot, and ultra-hot fresh water, trash compactor, single-burner hot plate, air conditioner/heater, fresh water shower, communications, normal and emergency lights, and life support and decompression equipment. There are seven viewports, one of which is 3 feet in diameter and located at one end of the habitat. Ground fault protected convenience outlets for 110 VAC, 15 amp service are provided. Emergency batteries provide lights, communication, and CO_2 removal equipment in the event of a main power system failure.

Excursions from the habitat are done on special SCUBA gear supplied by Hydrolab. Tanks and equipment are delivered by the surface support team to underwater sites in the canyon. The maximum normal working depth limit is 130'. Special excursions are permitted to 150' with approval of the Operations Director.

Site Description

The habitat is situated at a depth of 51 fsw (15 m) in the Salt River marine canyon on the north side of St. Croix approximately 1/2 mile off-shore. The canyon head at the barrier reef fronting the Salt River Estuary, cuts northnorthwest for 450 m across the narrow St. Croix shelf, and extends downward to a depth of 3500 m where it joins the Christiansted Canyon.

For more information about the Hydrolab saturation system, call the Science Director at (809) 778-1608.

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ABSTRACT

The purpose of mission 83-3 was threefold:

1. Chemical ecology studies
2. Distribution and abundance studies
3. Histocompatability studies

For the chemical ecology studies an *in situ* chemical sampling apparatus was built to detect organic chemicals in the water surrounding six sponge species: *Haliclona rubens*, *Ectyoplasia ferox*, *Iricinia strobilina*, *Agelas conifera*, *Plakortis zygompha* and *Xestospongia muta*. Organic compounds were detected from water surrounding all six species. However, only compounds from water surrounding *H. rubens* and *P. zygompha* indicated a possible match with metabolites actually extracted from the sponges. In an assay testing for bleaching/necrosis of the deep water scleractinian *Agaricia lamarcki* when in direct contact with sponge tissue, *P. zygompha* caused the most dramatic effect. Organic extracts from *P. zygompha* which were coated onto synthetic sponges and placed in direct contact with a coral also caused a bleaching/necrotic effect.

Distribution and abundance studies sampled sponges along three transects, each in a distinct reef zone. Seventy five sponge species were recorded in the 60 m^2 sampled. The average percent surface area covered per transect was 20-30%.

Histocompatability studies were carried out using a recently developed histocompatability bioassay of clonal identity to determine the extent of phenotypic variation within natural clones of the marine sponge *Aplysina cauliformis*. A genetic basis is suggested for a polymorphism of *A. cauliformis*.

Introduction

Sessile organisms on coral reefs must effectively deal with competition for space and food and adopt defense mechanisms to minimize predation and fouling by epibenthos. Sponges are remarkable because they lack both specialized organs and behaviors, and yet are successful in an environment where such adaptions are commonplace. Their success apparently depends on adaptations that can be effected at a cellular level of organization. Spicules and tough fibrous skeletal materials probably render sponges unpalatable to most predators (Randall and Hartman, 1968). But, sponges are also rich in secondary compounds, organic compounds that are not part of the general biochemical array found in most organisms. Secondary compounds may protect sponges from predation, and perhaps serve as allelochemicals in competition and prevention of fouling.

The Desmospongiae are the most common, widespread, and diverse class of sponges, comprising ca. 95% of the sponge population on coral reefs. The chemistry of this class has received much attention, and in the past few years over 100 different species have been investigated for secondary metabolites. About 200 new molecules, most with unique structures have been identified (Minale, 1979). From the morass of information, patterns of chemical distribution are being established (Cimino *et al.*, 1975; Minale *et al.*, 1975; Minale, 1978; Wells, 1979). For example, dibromotyrosine derived compounds seem to be confined to the family Verongidae and the closely related genus *Ianthella*. The family Spongidae appears to be a major producer

of furanoterpenes. Certain other genera (Agelas, Phakellia, and Axinella) contain bromopyrrole derivatives.

Although the presence of usual metabolites has been documented and linked to specific families or genera, little is known about the function of these secondary metabolites, many of which are present in significant concentrations (4-8% of the crude extract) (Wells, 1979). Few fish species in coral reef areas intentionally consume sponges even though sponges are abundant (Randall, 1967; Randall and Hartman, 1968). A relatively high percentage of exposed sponge species and some cryptic sponge species from the Great Barrier Reef are toxic in a bioassay (Bakus, 1981). This led Bakus to hypothesize that toxicity in coral reef organisms is correlated with a sessile and slow moving habit and that dominant sessile species are more likely to use toxicity as a defense. Sessile organisms are also remarkably free of fouling from epizooic and epiphytic organisms. Fresh tissue sections and extracts of many sponge species show pronounced antibiotic and cytotoxic activity (Burkholder, 1973; Faulkner, 1977). In the space limited, highly competitive coral reef environment, some sponge species produce necrosis in corals if the two invertebrates are in contact (Bryan, 1973; Jackson and Buss, 1975).

Specific associations between sponges and other invertebrates have also been observed. For example, the spicules of two subspecies of the sponge Pleraplysilla spinifera are identical and the subspecies show only slight morphological differences, yet one subspecies grows in association with the coelenterate Paramuricea camaleon, the other does not. Chemical analysis show that these two P. spinifera subspecies contain different chemical patterns (Cimino, 1977), and it has been suggested that these differences may

be responsible for the association of only one of the two Pleraplysilla subspecies with Paramuricea. Another example is the association between the dorid nudibranch Diaulula sandiegensis, and the sponge Haliclona permoliis. Elvin (1976) has shown that Dianula can locate Haliclona, its preferred food, by chemotaxis.

To better understand the potential role of unusual sponge secondary metabolites in chemical ecological interactions, it is necessary to establish the nature of the compounds and their concentrations in the seawater surrounding the sponges. Coll et al. (1982) isolated 4 unusual secondary metabolites from the water surrounding 2 species of soft coral. These same secondary metabolites have been isolated in laboratory work-ups of crude extracts obtained from the 2 soft coral species. For many sponge species the chemical nature of secondary metabolites separated from sponges in the laboratory is already available in the natural products literature. Using an adaptation of the method and apparatus developed by Coll et al. (1982) for soft corals, we examined the waters surrounding six sponge species.

The objectives were three fold:

1. Develop and test an in situ chemical sampling apparatus for sponges.

2. Determine whether sponges released secondary metabolites into their surrounding water.

3. Test sponge organic extracts for evidence of allelochemicals (i.e. attractants, antifoulants, etc.).

Site Description

The chemical ecology work was conducted primarily on the east wall north west of the tank drop site in 60-100' of water. The area consisted of a gently sloping rubble bottom which lead to a near vertical wall. One sponge species not found on the east wall was sampled at the juncture of the A line and west wall 50 foot contour line.

Techniques

The method and apparatus that Coll et al. (1982) developed for work on soft corals have been adapted to extract organic sponge exudates from seawater (Figure 1). In this method the organism is surrounded by an incomplete enclosure of ca. 25 l volume which does not totally isolate the organism from its surrounding environment but slows the rapid dilution of exudates. A submersible, battery operated series 5012A-P Deep-Sea Impeller Pump samples the water within the enclosure and provides the force necessary to pull water through 6 reverse phase sep pak absorption columns contained in a rosette. The apparatus is used to sample each sponge for one hour. Background levels of dissolved organic compounds present in the water are assessed by replicating the sampling procedure in the same location immediately following sampling of each specimen, but without a specimen in the enclosure. At the conclusion of each experiment sep pak cartridges were removed and transported to the surface.

Samples 1 through 8 were chemically processed immediately upon reaching the surface. Each sep pak cartridge was eluted sequentially with 20 ml of

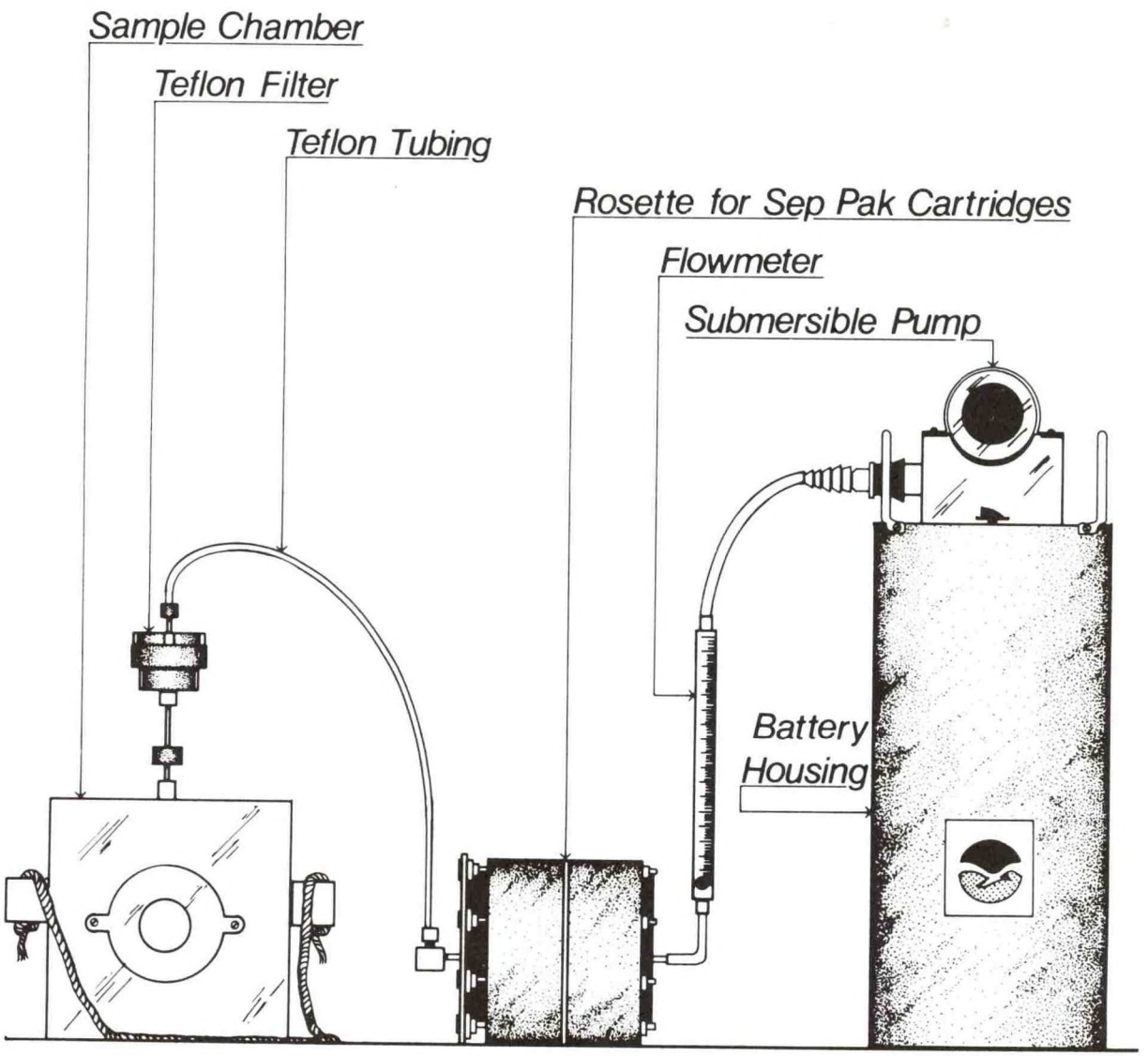

Figure 1. In situ sampling apparatus.

high purity methanol, ethyl acetate and chloroform. Eluents for each sep pak from a single run were combined and reduced to small volumes on a hot plate.

Small pieces of sponge tissue were extracted with 1:1 methanol:chloroform, the filtrate decanted and the volume reduced on a hot plate. When only water and organic residues remained the extract was partitioned with ethyl acetate. The ethyl acetate layer was decanted and dried. Thin layer chromatography comparisons were made between sep pak eluents and sponge tissue extracts. These proved inconclusive.

Because of the harsh methods used to evaporate the eluent and extracts down to manageable volumes it was possible that the potentially sensitive compounds were decomposing or evaporating. Therefore, after 8 runs we discontinued on-site lab extractions and began freezing sep paks and sponge tissue for return to Skidaway and a gentler work-up schedule.

The assay for allelochemicals which would have utilized the extracts on synthetic sponges was necessarily deleted. In its place a coral necrosis/bleaching assay tested sponge tissue placed in direct contact with the deep water scleractinian Agaricia lamarcki.

After workup at Skidaway follow-up tests utilizing the synthetic sponge assay were carried out on one extract. Synthetic cellulose sponges were coated on one side with sponge organic extract and placed in direct contact with the scleractinian Agaricia agaricites found commonly in the Florida Keys.

Results

Thin Layer Chromatography (TLC) of eluents from sep paks through which sponge water had been filtered indicated the presence of organics in water

surrounding each of the six sponge species sampled: Haliclona rubens, Plakortis zygompha, Agelas conifera, Ectyoplasia ferox, Ircinia strobilina and Xestospongia muta. However, only with H. rubens and P. zygompha did the TLC R_f values indicate a possible match between organics in the water column and those actually in the organisms' crude extracts.

Bleaching/necrosis assays (Table 1) showed that H. rubens had no effect on A. lamarcki at 24 hrs, Plakortis zygompha on the other hand, caused a marked bleaching/necrotic effect on the coral at 24 hrs (Figure 2). Organic extracts of P. zygompha coated onto synthetic sponges also caused bleaching/necrosis (Figure 3). High resolution 'H nuclear magnetic resonance (400 MHz) indicated the presence of similar organic components from water surrounding both intact and wounded specimens of P. zygompha. The 'H NMR was inconclusive regarding their presence in crude extracts of P. zygompha.

Discussion

Plakortis zygompha produced the most dramatic bleaching/necrotic effect in 24 hrs. Other sponge species (e.g., Verongula sp. and Agelas conifera) did not bleach the coral thus indicating that mechanical irritation and pressure were not responsible for the effect observed with P. zygompha. Coral bleaching was not as dramatic with the extract coated synthetic sponge as with the natural sponge, however this preliminary work was not quantitative. In addition, the synthetic sponge tests were undertaken in the Florida Keys following chemical workup for P. zygompha at Skidaway. Agaricia lamarcki was not readily accessible at the Florida Keys site and so the related Agaricia agaricites was used. This change in coral species may also contribute

TABLE 1

HYDROLAB 83-3 BLEACHING/NECROSIS ASSAY

SPONGE	NO. SAMPLES FOR WHICH DATA RECORDED	NECROSIS AT 24 HRS.*
Verongia longissima	4	+
Haliclona rubens	5	-
Agelas conifera	2	-
Ectyoplasia ferox	6	+
Verongula sp.	3	-
Plakortis zygompha	7	+

* + = necrosis

\- = no necrosis

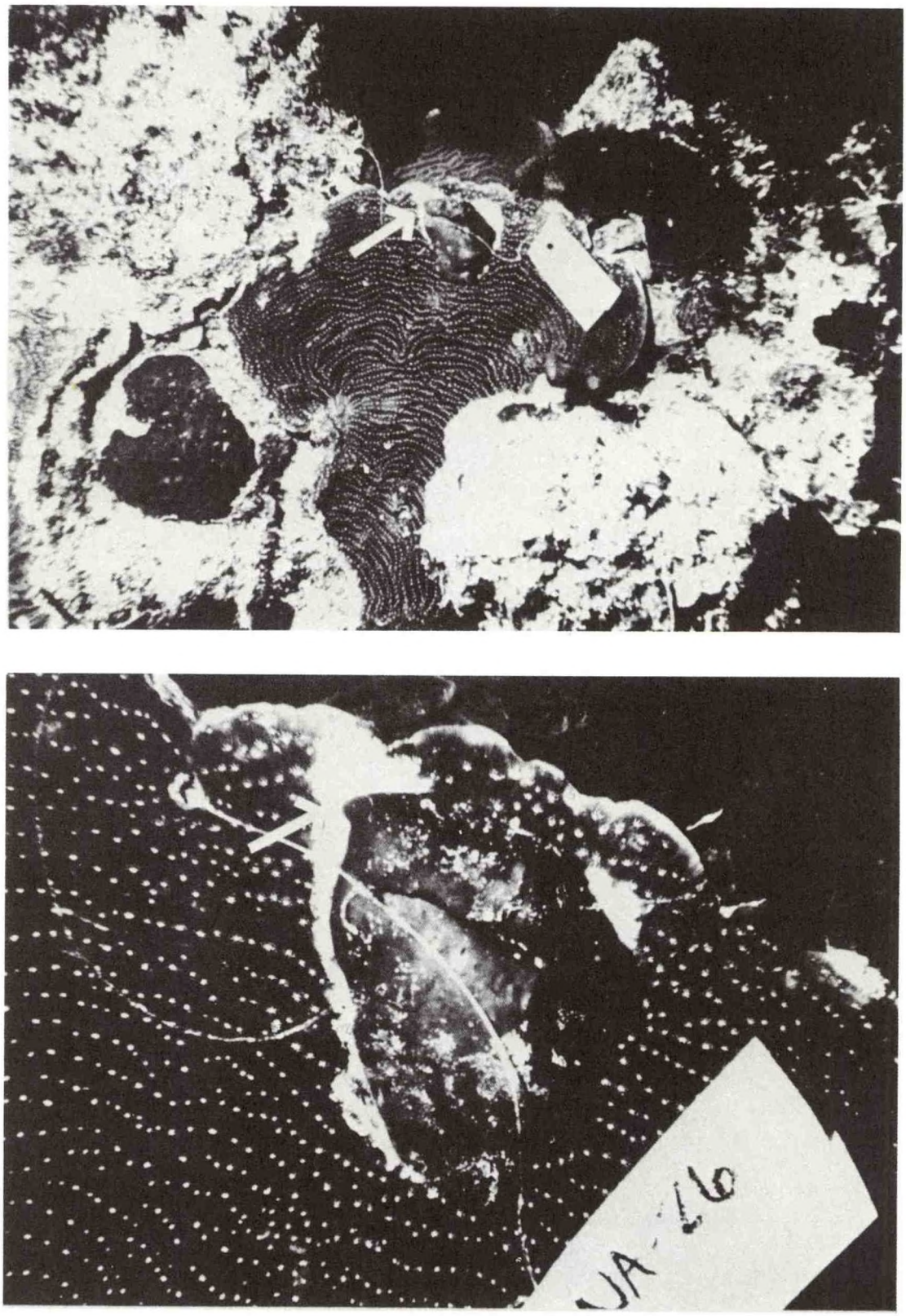

Figure 2.--Contact between Plakortis zygompha and Agaricia lamarcki produces bleaching and necrosis of the A. lamarcki tissue. Contact experiment shows area of bleaching (arrow) after 24 hours (top). Close-up of the interaction is also shown (bottom).

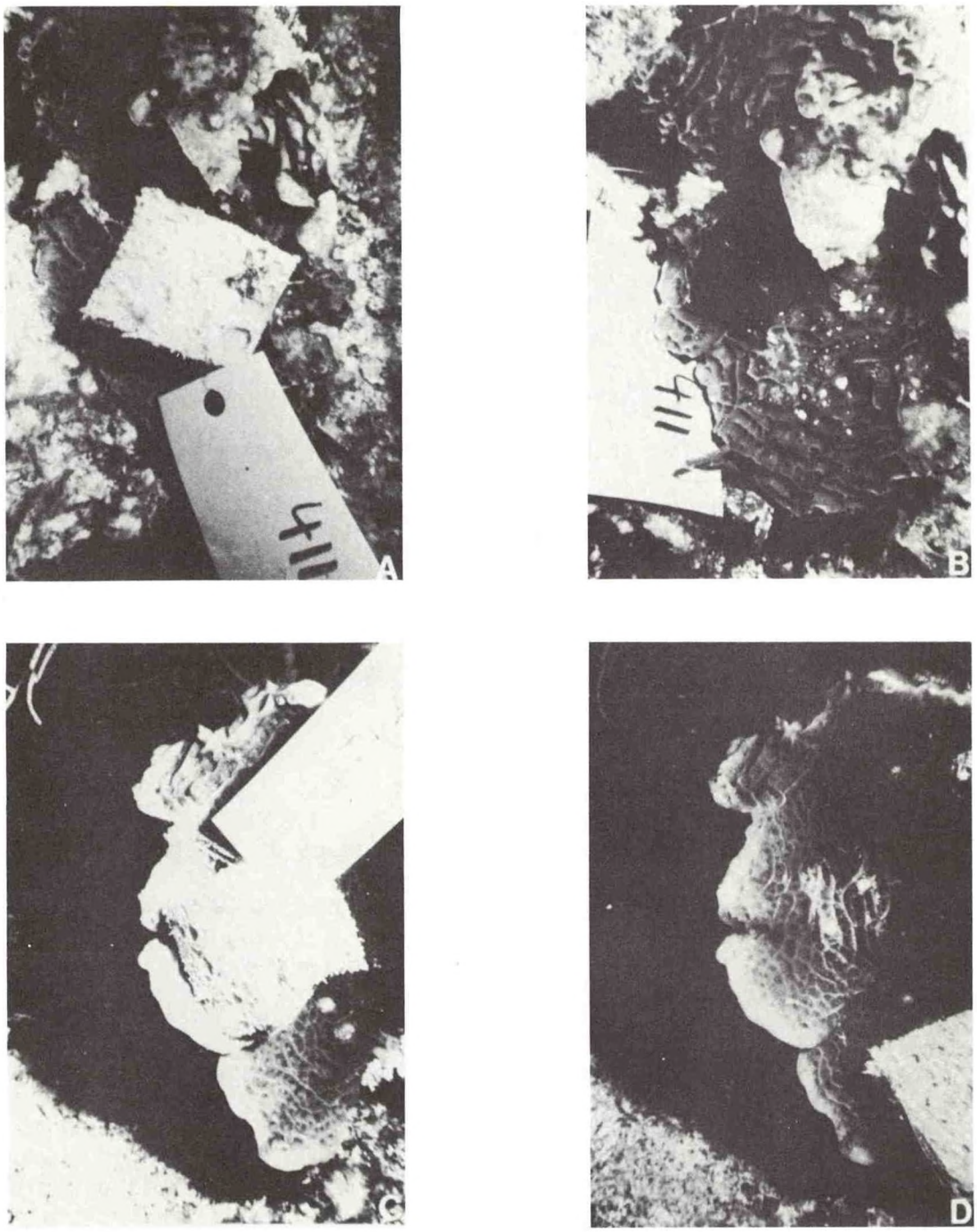

Figure 3.--Control (A-B) and experimental (C-D) pads tied to Agaricia agaricites at time = 0 (A, C) and after 24 hours (B, D). Control pads were soaked in ether before submersion; experimental pads were soaked with organic extracts of the sponge Plakortis zygompha prior to submersion. Note that neither the mechanical irritation of the pad attachment, nor the presence of the solvent caused bleaching under the control pad after 24 hours (B). The zone under the Plakortis pad (D), however, demonstrates that organic extracts of this sponge can reproduce the bleaching/necrosis response seen in nature (Figure 1).

to the difference observed. Sponges of the genus Plakortis contain numerous unusual secondary metabolites such as cyclic peroxides and aromatic lactones (Faulkner et al., 1978; Stierle and Faulkner, 1980). Plakortis zygompha specifically, contains (z)-7-methyl-4-octen-3-one and several derivatives of 3-hydroxymethyl-4-pentenoic acid (Faulkner and Ravi, 1980).

Initial test results indicate that an organic component of the sponge is responsible for the observed bleaching/necrotic effect, however, the nature of the organic component(s) which caused the effect is still unknown.

The lack of correlation between organics found in water surrounding the sponge and in the sponge extract for 4 of the 6 species tested could indicate that they do not release secondary metabolites, that the metabolites are labile and rapidly change upon being released, or that the metabolites are present at concentrations below levels measured with the current technique.

DISTRIBUTION AND ABUNDANCE

Introduction

Sponges are an obvious and important component of the benthic community on coral reefs (Reutzler, 1978), yet due to a confused taxonomy and the difficulty in biomass determination, they have been largely neglected in ecological studies. The numerical importance of sponges has been documented for a few specialized reef areas, such as tunnels (Logan, 1982) or beneath overhanging foliaceous corals (Jackson and Winston, 1982). However, quantitative assessments of whole community sponge abundance and distribution in open reef areas are few (Alcolado 1979, Wilkinson, 1982). Sponges have

been shown to be important in competitive interactions for space with corals and other benthic fauna on coral reefs (Vicente, 1978), and some have evolved allelochemical mechanisms to enhance their competitive edge (Jackson and Buss, 1975, Sullivan et al., 1983). As the main purpose of this project was to investigate chemically-mediated interactions in the ecology of sponges, it was deemed necessary that the abundance and occurrence of sponge species be documented, so that the relevance of such interactions could be assessed. It would also provide needed distributional records for sponge species near the present Hydrolab site.

Site Description

Initial surveys identified the major reef zones of interest in the study area. Three zones were selected: West Wall (60'), East Slope Pinnacle (80') and the East Slope Rubble area (60'). The West Wall is steep, often vertical and provided with some overhangs and caves. The East Slope Pinnacle is also steep, although not as vertical as the West Wall, with high surface relief. The East slope Rubble zone is more gently sloping and comprised primarily of cobble stones and loose sediment.

Techniques

Analyses of community composition, distribution and abundance of the sponge fauna in Salt River Canyon was carried out using a line transect/1m^2 quadrat technique. A 100 meter transect line was established along the specified depth contour within each of the identified zones. One meter square quadrats were sampled at five meter intervals along the transect line (20

m^2 total) in which each macro epibenthic sponge was identified and enumerated. Two measures of abundance were recorded: 1) number of individuals and 2) area coverage using a modified phyto-sociological technique adapted from Braun Blanquet (Scheer, 1978). Percent surface area covered by each sponge species in each quadrat was estimated into classes where + = < 1%, 1 = 1-5%, 2 = 5-10%, 3 = 10-25%, 4 = 25-50%, 5 = 50-75% and 6 = 75-100%. Each entry consisted of two numbers separated by a decimal point, where the first represented the number of individuals and the second the percent cover class estimate.

Because the intraspecific variability in size of coral reef sponges makes number of individuals a quantity of limited usefulness, an additional method of abundance measurement was required. The number of individuals is, however, the most straightforward measure of abundance and is the statistic which is most readliy comparable with other studies of this type. It also must be noted that the cover class estimate used in this study is mainly for relative comparisons between sites and should not be interpreted to represent absolute cover values. The technique is such that subjective classification is required, especially of those species which lie near the boundaries of the cover class groups, which could lead to high error variation around the actual values. It is used here only to provide information on biomass differences that could not be shown using number of individuals alone. The use, application and limitations of such semi-quantitative techniques are discussed in Mueller-Dombois and Ellenberg (1974).

Sponges were identified by use of the commonly available written descriptions. Taxonomic organization, for the most part, follows that given by Wiedenmayer (1977). Some species could not be identified using the available

literature or their names could only be inferred from incomplete accounts. Errors in identification are the responsibility of the author (G.P.S.) - tissue specimens for most of the questionable species are available in his personal collection.

Mean number of species and individuals and average percent cover was calculated per square meter for each of the reef zones. The midpoint of the percent cover class estimated was used for cover calculations. Diversity was measured by the Shannon information function (H') (where $H' = -\sum_{i=1}^{n} p_i \ln p_i$, p_i = the proportion of total individuals displayed by each species), and Margalef's diversity measure D (where D = n-1/ln N, n = # of species, N = # of individuals). Evenness (J) was also calculated (J = H'/ln n, n = # of species). The similarity of the transects was investigated by pairwise comparisons of sites using similarity indices. Two measures were calculated: the Jaccard Index (Jac = C/A+B-C, C = # of species in common, A = # of species in transect #1, B = # of species in transect #2) which weights similarity by the presence or absence of species and the Percent Similarity Index ($PS = \sum_{i=1}^{n} \min (p_{iA}, p_{iB})$, p_{iA} = percent of total for species i in transect #1, p_{iB} = percent of total for species i in transect #2), which takes individual species abundance into account.

Results

A total of 75 species of sponges were sampled on the three transects. Eleven other species were observed in the transect zones but not within sampled quadrats bringing the total to 86 species. A list of the species observed, organized by taxonomic order, is given in Table 2. The number of

TABLE 2

LIST OF SPECIES OBSERVED

	EAST RUBBLE*			EAST PINNACLE*			WEST WALL*		
	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's
Order: KERATOSA									
Ircinia felix (=fasciculata)	7	.50	5	2	.05	2	2	.30	2
I. strobilina				10	1.125	7	2	.05	2
Ircinia sp. (dendroides?)				2	.025	1			
Aplysina cauliformis (=Verongia longissima)	29	1.425	12	1	.15	1	12	.80	7
Aplysina archeri							5	.675	3
A. lacunosa				1	.15	1	8	1.30	8
Aiolochroia crassa (massive finger form) = Dendrospongia crassa Pseudoceratina crassa Ianthella ardis Ianthella basta				29	3.725	11	13	1.90	8
A. crassa (tube form)	4	.60	4	10	1.275	7	3	.45	3
Aplysinidae sp.(tube)				7	1.925	5	3	.30	2
Verongula rigida				3	.75	2			
Aplysilla sulfurea	2	.30	2						
Smenospongia aurea	16	1.25	10	1	.15	1	27	1.875	12
Dysidea etherea	1	.025	1	1	.025	1	3	.15	1
Keratosa	1	.15	1				1	.15	1
OTHERS:									
Verongula gigantea				X					
Eurypongia rosea				X			X		
Fasciospongia cerebreformis		X							

*For Each Zone:
1st Column: Number of Individuals
2nd Column: Percent Cover (of entire transect)
3rd Column: Number of Quadrats Species Appeared In (out of 20)

	EAST RUBBLE			EAST PINNACLE			WEST WALL		
	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's
Order: HAPLOSCLERIDA									
Amphimedon compressa (=Haliclona rubens)	10	.825	8	38	1.90	12	22	1.80	9
Haliclona molitba	7	.075	3	4	.20	3			
Amphimedon complanata(?)				8	.175	7	26	.40	11
Callyspongia vaginalis	2	.30	2						
Niphates digitalis	1	.15	1	10	1.875	8	10	.70	8
N. erecta (=Gelloides ramosa)				10	.60	9	7	.80	7
N. amorpha	5	.50	5				8	.575	8
Cribrochalina vasculum	3	.30	2	3	.90	3			
Xestospongia muta	4	.10	4	6	.975	5	3	.325	3
Siphonodictyon siphonum				1	.025	1			
Oceanapia sp. (fistulosa?)				2	.525	2			
Foliolina peltata				2	.15	1			
Haliclona sp. (pink tube)							1	.025	1
OTHERS:									
Callyspongia tenerrima				X					
Xestospongia tierneyi		X		X					

	EAST RUBBLE			EAST PINNACLE			WEST WALL		
	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's
Order: POECILOSCLERIDA									
Ulosa reutzleri (=hispida)	16	.25	10	36	.45	13	9	.125	5
Agelas sceptrum							2	.15	1
A. conifera	2	.15	1	8	1.625	6	8	.975	5
A. clathrodes				6	.50	5			
A. dispar				1	.15	1			
A. sp. #1	2	.175	2				6	.50	5
A. sp. #2				8	.425	7	3	.30	2
Didiscus sp.	1	.15	1	2	.05	2	17	1.50	7
Thalysias sp.	1	.025	1						
Neofibularia nolitangere	1	.025	1						
Monanchora sp. (barbadensis) (?)	1	.15	1	20	.35	14	11	.65	7
Mycale laevis							5	.45	3
Poecilosclerida sp.	59	2.475	19						
Desmapsamma anchorata	1	.025	1						
Order: HALICONDRIIDA									
Halichondria sp.	36	2.775	11				4	.925	4
Halichondriida sp.	2	.175	2						
OTHERS:									
Iotrochota birotulata				X					
Microciona spinosa				X					
Pandoras acanthiofolium				X					
Mycale horridus (=angulosa)				X					

	EAST RUBBLE			EAST PINNACLE			WEST WALL		
	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's
Order: AXINELLIDA									
Pseudaxinella lunaecharta	2	.175	2						
Teichaxinella morchella							2	.025	1
Homaxinella rudis	3	.175	2						
Axinellidae sp.				2	.025	1			
Ectyoplasia ferox (=Hemecyton ferox)				34	2.775	10	3	.30	2
Order: HADROMERIDA									
Timea mixta	7	.10	4	1	.025	1			
Spheciospongia vesparium	1	.025							
Cliona deletrix				2	.30	2	7	.60	5
Cliona sp. #1 (yellow)	1	.025	1				1	.025	1
Cliona sp. #2 (blue)	1	.15	1						
Spirastrella cunctatrix				5	.325	3	7	1.00	6
Spirastrella coccinea	1	.15	1						
Order: CHORISTIDA									
Erylus formosus	3	.45	3	2	.175	2			
Geodia gibberosa							2	.15	1
Geodia neptuni	1	.15	1						
Cinachyra kuekenthali	1	.15	1	4	.45	3	6	.625	5
Cinachyra alloclada	4	.30	2						
Chondrilla nucula							4	.15	1
Chondrosia reneformis							1	.15	1
OTHERS:									
Anthosigmella varians	X			X					
Placospongia carinata	X								

	EAST RUBBLE			EAST PINNACLE			WEST WALL		
	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's	# Inds.	% Cover	# Q's
Order: HOMOSCLEROPHORA									
Plakortis sp. #1	4	.35	4	90	2.025	16	38	2.50	15
Plakortis sp. #2				2	.15	1			
CLASS CALCAREA									
Clathrina coriacea				1	.025	1			
OTHERS (unidentified)									
Orange (sediment tolerant)(Jaspis sp.?)	84	5.575	20				6	.70	4
Red encrusting	3	.075	3				7	.35	4
Orange encrusting	3	.45	3						
Black massive encrusting				10	1.425	5	1	.15	1
Hard green branch				1	.15	1			
Orange #1	1	.025	1	1	.15	1	7	.65	6
Black encrusting #2							1	.15	12
Yellow							1	.025	1
Green							3	.05	2
Massive convoluted							1	.375	1

individuals, average percent cover over the entire samples transect and the number of quadrats in which the species occurred (out of a possible 20) are also tabulated. Various community statistics for the three transect zones are given in Table 3.

The West Wall (WW) transect exhibited the greatest number of species with 45; the other two transects each combined 41 species. However, the greatest number of individuals observed occurred in the East Slope Pinnacle (ESP) zone, while the least number was recorded from the WW. The WW transect also showed the highest evenness (equitability) value while the East Slope Rubble (ESR) zone had the least. These facts were reflected in the Shannon and Margalef diversity indices; the WW displayed the highest diversity values, followed by the ESP and the ESR zones respectively. The average percent surface area covered per transect ranged from 21-30%. (Note high error variation associated with these values - see "Techniques"), with the highest value being obtained on the ESP zone and the lowest on the ESR zone.

Despite the range of values observed, no significant differences between the three zones could be detected by a one way ANOVA for number of species/m^2, number of individuals/m^2 or percent cover/m^2 ($p > .05$ in all cases). However, a pairwise comparison of the ESR and ESP areas did indicate a significant difference in percent cover/m^2 (t-test, $p < .01$). All other pairwise comparisons of sites for each of the three parameters did not show any significant differences.

The Jaccard similarity index ranged from .288 to .394 and the Percent Similarity index ranged from .173 to .458 (Table 3), indicating low similarity between the three sample sites in community composition. The highest simi-

TABLE 3

COMMUNITY STATISTICS FOR SAMPLE TRANSECTS

	# Species	# Individuals	Mean Sp/m^2 (S.D.)	Mean $Inds/m^2$ (S.D.)	Mean % Cover (S.D.)	Shannon H'	J	D
East Slope Rubble	41	335	7.95 (2.64)	16.75 (4.33)	21.55 (6.71)	2.685	.718	7.052
East Slope Pinnacle	41	387	9.25 (2.75)	19.35 (7.98)	29.58 (10.68)	2.871	.773	7.049
West Wall	45	321	9.80 (3.50)	16.05 (7.26)	26.025 (12.31)	3.391	.876	8.317

Total = 75 Species on Transects 86 Total Seen

	ESR	ESP	WW
ESR	-	.1728	.2708
ESP	.2879	-	.4583
WW	.3382	.3939	-
	Jaccard		

% Similarity

Similarity matrix for sample transets. Jaccard values are to the left of the diagonal, percent similarity values are to the right of the diagonal.

larity values for both indices were recorded between the ESP and WW sites, while the least values were obtained between the ESP and ESR zones.

Discussion

It is obvious that the Porifera is a highly diverse and important component of the benthic reef fauna in Salt River Canyon. The fact that 75 species were encountered in only 60 square meters of sampled area indicates the quantitative significance of the sponge community. Eighty-two species were described by Wiedenmayer (1977) from exhaustive collections in the Western Bahamas; and transect data, although not directly comparable to the present study, is given for various habitat types of that region. The only published directly comparable data from the Caribbean is that of Alcolado (1979) who studied the sponge fauna on a reef profile in Cuba. While the total number of species found in his study is not given, his fore reef station (#5) compared favorably with the present study, although the number of m^2 sampled was slightly greater and spread out over less total area in that study. He found 47 species with 15 individuals/m^2 in Cuba compared to 45 species, 16 individuals/m^2 (West Wall) in Salt River Canyon. The diversity and abundance was higher in the present study than that observed on similarly sampled transects in the Dry Tortugas, Florida, where 32 species with 12.7 individuals/m^2 were found at Pulaski Reef (Schmahl and Tilmant, in prep.).

The fact that no significant differences were found among the three reef sites in either species/m^2, individuals/m^2 or % of cover/m^2 by a one way ANOVA indicates that, in general, sponges are itilizing the available benthic space in approximatedly the same degree among the sample zones. This is

interesting, for the three areas were substantially different in the nature and orientation of the substrate, exposure to currents, degree of sedimentation and community composition (as indicated by similarity indices). The significance of this finding is unclear, but attests to the fact that sponges are able to adapt to a broad range of ecological situations so that their contribution to the entire community is similar in different types of habitats. More quantitative data is needed.

The ESR zone seemed to be subject to high levels of sediment loading. Increased sediments can interfere with the pumping action of some sponges (Gerrodette and Fleshig, 1979), but other sponges can withstand high sediment areas. The two most common sponge species in the ESR zone were sediment tolerant, both of which are as yet unidentified. One is an orange sponge (Jaspis sp.?) which grows covered with sediment except for its oscular openings, and the other is a black encrusting Poecilosclerid which incorporates much sand and debris within its tissues. These two species were not found to any extent in the other two zones and caused the slightly lower diversity and evenness values and lower similarity compared with the other two sites.

It was of interest also to note the occurrence of competitive interactions in which sponges were involved. The following interactions were observed in the immediate transect areas (not necessarily within sampled quadrats) and were not quantified further. The species listed first in each pair seemed to be the dominant competitor in terms of overgrowth capability.

Ectyoplasia ferox - Montastrea cavernosa (coral) (2 separate observations)

E. ferox - large gorgonian

Halichondria sp. - Millepora alcicornis (hydrozoan)

H. sp. - *Agaricia* sp. (coral)

H. sp. - *Plexaura homomalla* (gorgonian)

Anthosigmella varians - *Diploria clivosa* (coral)

A. varians - *Palythoa* sp. (zoanthid)

Encrusting green colonial ascidian - *Aplysina cauliformis*

Desmapsamma anchorata - *A. cauliformis*

Chondrilla nucula - *Porites porites*

Plakortis sp. #1 - *Agaricia* sp. (coral)

In all but one case (colonial ascidian) the sponges involved in the observed interactions seemed to be the dominant competitor. Although these data were not systematically quantified, it does provide observational evidence that sponges are important in competitive interactions among the benthic fauna on coral reefs.

Another observation made during this Hydrolab project was the occurrence of predation by fishes on sponges. Because of the high spicule content and presence of noxious chemicals, sponges are not fed upon heavily except by a few specialized fishes (Randall and Hartman, 1968). Two species of fish were observed to feed on sponges in Salt River Canyon, both of which were typified as sponge feeders by Randall and Hartman (1968). The first, the whitespotted filefish, (*Cantherhines macrocerus*) was observed feeding (several bites) on *Callyspongia plicifera*. The second observation involved two large french angel fish (*Pomacanthus paru*) and the unidentified orange sponge (*Jaspis* sp.?) which was extremely common in the East Slope Rubble zone. The fish did not feed, however, until a piece of the sponge had been removed as a voucher specimen. The surface of this sponge is heavily encrusted with calcareous

sediment and debris; once this outer covering was removed, the bright orange interior was exposed upon which the fish fed continuously (numerous bites) for approximately five minutes. The high sediment content of the outer layer of this sponge might act as a deterrent to predation and may contribute to its restricted distribution.

HISTOCOMPATABILITY

The data derived from the histocompatability work done out of Hydrolab has been combined with data from some other work done at the Discovery Bay Lab in Jamaica. It forms the basis for a paper (by J.E. Neigel and G.P. Schmahl which has been submitted to a scientific journal.

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