PRNC - 162 VOLUME I

PUERTO RICO NUCLEAR CENTER

Aguirre Power Project
Environmental Studies 1972
Annual Report

PUERTO RICO NUCLEAR CENTER
AEC-UPR

OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT
NO. AT (40-1)-1833 FOR U S ATOMIC ENERGY COMMISSION

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Prepared for Puerto Rico Water Resources Authority
By the Staff of Puerto Rico Nuclear Center of the
University of Puerto Rico - March 1973

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PLANKTON OF JOBOS BAY

JOBOS BAY ANNUAL REPORT

Introduction

A series of fifty plankton samples have been taken at Jobos Bay in the time period from October 1971 to July 1972 and analyzed for species diversity, abundance, and distribution. Additional samples were taken to determine biomass. These are part of a continuing effort to establish environmental baseline data to monitor effects of the proposed power plants' operation on the Bay's ecosystems, as well as to determine whether it is permissable from an environmental standpoint to install a power plant complex in the Aguirre area at all. Information about the plankton communities found in coastal Caribbean waters is very limited, so this survey should also serve to add to that expanding field of knowledge.

Methods and Materials

Plankton samples were obtained in several ways. The majority were taken using plankton nets of mesh sizes 380 μ, 300 μ, 202 μ, and 60 μ, pulled behind 13 to 17 foot dories for 5 to 20 minutes. For uniformity, the nets were pulled at speeds to keep them 1 to 3 feet below the water surface. The samples were then preserved in 4% buffered formalin and taken back to the laboratory for analysis. A small flowmeter was suspended in the mouth of each 380 μ mesh net, volumes of water sampled estimated for the remaining nets used.

For counting organisms, aliquots of each sample were removed from a well-shaken container by means of 5cc, 10cc, or 20cc spoons and diluted into a squared Petri dish or a counting tray. All zooplankton in the subsamples were counted under 10 to 30 power magnification. Phytoplankton and zooplankton were identified using 30 to 400 power magnification.

A few plankton samples were obtained using a 2-quart bucket to pour surface water through a 60 μ net sieve (primarily for phytoplankton and microzooplankton). One sample, JB-25, was taken utilizing a hand held concentrator over the side of a boat as it journeyed through a shallow canal between heavily mangroved cays.

Biomass estimates were obtained in the following manner. Zooplankton was sampled using a 202 µ mesh net, animals (and incidental trash, phyto- and mannoplankton) transferred to bottles that were placed, without preservative, into an ice chest. Wet weights were determined as explained in the following. Phytoplankton and mannoplankton were sampled by using 2-quart buckets to fill a 5-gallon cubitainer. This was then first filtered through a 60 µ mesh sieve, with frequent washing off of captured material to eliminate clogging, to separate phytoplankton and then filtered through 0.45 µ membrane filters to separate mannoplankton. All samples were finally filtered through membrane filters that had been HCL treated. Initially the filters were wet with fresh water, a slight vacuum placed on them, then the sample poured through. Ten filters were weighed wet (following 15 seconds of vacuum) and their average used as the weight of a standard filter. The filtered samples were subjugated to an additional 20 seconds of vacuum following apparent dryness, then were weighed on a Mettler balance accurate to 0.01 gram.

Data

Jobos Bay has been divided arbitrarily into six sampling areas (see Fig. 1). The inner bay, area 1, has been largely ignored as the predicted current patterns should have little effect there. Most of the sampling effort has gone into area 2 (the intake area) and area 5 (the outfall area). Area 4, the Boca del Infierno and the area sheltered by the Cayos Caribe and Cayos Barca should be indicative of recruitment potential provided to the coastal areas directly adjacent to the power plant complex. Area 3 was sampled only in November, 1971 and then only because it is a break point for surface waters coming through the Boca del Infierno, and probably is the most unstable environment in the Bay, as well as the richest. Area 6 was sampled to determine a possible trend toward seaward drift from area 5 and anticipate recruitment problems associated with detrimental effects the heated effluent might have. Table 1 is a complete tabulation of plankton hauls analyzed to date and locates samples to area taken, giving date taken, time taken, and other parameters. Tables 2 - 7 list plankton concentrations according to: (a) number taken per minute towed (#/min), (b) number taken per cubic meter of water sampled (#/m^3), and (c) percentage of total catch that each plankter category constitutes (% total catch).

Composition of Plankton

Copepods are the most numerous members of the Jobos community. The calanoid Acartia tonsa is found in all aras sampled. A. lilljeborgii was captured in areas 2, 3, 4, and 5, A. spinata in areas 2, 3, and 5, A. longiremis in area 5. Temora turbinata is the second most common calanoid, occurring in all areas except number 3. Pseudodiaptomus cokeri is found in areas 3, 5, and 6.

Other calanoids which appear less commonly are Calanopia americana, Clansocalanus furcatus, Paracalanus crassirostris, P. aculeatus, Paracalanus sp., Labidocera scotti, and Labidocera sp.

The cyclopoids Oithona hebes, O. nana, and the harpacticoid Euterpina acutifrons also are found in the bay.

The sergestid Lucifer faxoni is present in all areas of the bay, Jaxea sp. in area 3, probably Jaxea nocturna.

Among the pelagic appendicularia (identified by Mr. César Flores of the Institute of Biology of the National Autonomoas University of Mexico, Mexico City, Mexico) Oikopleura dioica, O. parva, O. longicauda, and O. fusiformis f. cornutogastra are represented in Jobos Bay, as well as Fritillaria sp.

Chaetognaths of the genus Sagitta have been found in all areas of the bay. Sagitta hispida, S. enflata have been identified. Besides another Sagitta sp., Krohnitta subtilis is also present in Jobos Bay.

A cladoceran, Evadne sp., has been identified in areas 4, 5, and 6, and is probably E. tergestina.

Two species of mysids have been identified. Siriella chierchiae has been taken in areas 3, 5, and 6 (in area 6 during the day), while Mysidopsis sp. (kindly identified by Dr. Torleiv Brattegard of the Universitetet 1. Bergen in Norway as a new species he first found in Colombian coastal waters in 1971 and calls Mysidopsis C) was taken during a day time tow in area 4.

The only fish eggs to be identified positively are those of the anchovy Anchoa lamprotaenia and were found almost everywhere in the Bay. A less frequently found anchovy egg can be tentaively identified as *Anchoviella perfasciata*. Leptocephalis of *Megalops atlanticus* and *Elops saurus* have been identified.

There are seven polychaete species in Jobos Bay. *Platynereis* (*nereis*) *dumerilii* has been taken night lighting in area 5, and is the only one identified to date.

Two medusae have been identified as *Obelia* sp. and *Sarsia tubulosa*.

Tintinnopsis sp. and *Favella* sp. are tintinnids found in Jobos Bay, while *Tretomphalus bulloides* and *Globigerina* sp. are the only Forams found

Crustacea represent a very real identification problem due to the scarcity of suitable tropical keys. In addition to those mentioned earlier, the euphausid *Euphausiid furcilia*, the amphipod *Hyperia galba*, and larval stages of *Clibanarius* sp. *Synalpheus* sp., *Petrolisthes* sp., *Callinectes* sp., *Balanus eburneus*, and *Aratus pisonii* have been identified.

Phytoplankton and mannoplankton make up the bulk of the biomass at Jobos Bay. The following phytoplankton have been identified.

Amphiroa sp.
Amphiura sp.
Amphora laevis
Asterionella sp.
Bacteriastrum elegans
Biddulphia sp.
Centronella sp.
Ceratium extensum
Ceratium sp.
Chaetoceros decipiens
C. peruvianus
Chaetoceros sp. (2)
Coscinodiscus excentricus
Coscinodiscus sp.
Cymbella affinis
Dictyocha fibula
Gyrosigma sp.
Nitzchia sp.
Peridinium sp. (2)
Pleurosigma angulatum

Rhizosolenia setigera
Rhizosolenia sp.
Spirulina sp.
Skeletonema costatum
Thalassionema nitzschioides
Trichodesmium sp.

The following is a list of zooplankton identified to date in Jobos Bay.

Copepods	*Acartia tonsa*
	A. Lilljeborgii
	A. longiremis
	A. spinata
	Calanopia americana
	Clausocalanus furcatus
	Euterpina acutifrons
	Labidocera scotti
	Labidocera sp.
	Oithona hebes
	O. nana
	Paracalanus crassirostris
	P. aculeatus
	Paracalanus sp.
	Pseudodiaptomus cokeri
	Temora turbinata
Foraminifera	*Tretomphalus bulloides*
	Globigerina sp.
Tintinnids	*Tintinnopsis* sp. (2)
	Favella sp.
Cladocera	*Evadne tergestina*
Appendicularia	*Oikopleura dioica*
	O. fusiformis f. cornutogastra
	O. longicauda
	O. parva
	Fritillaria sp.
Chaetognatha	*Krohnitta subtilis*
	Sagitta enflata
	S. hispida
	Sagitta sp.

Fig. 1 Sampling Areas of Jobos Bay

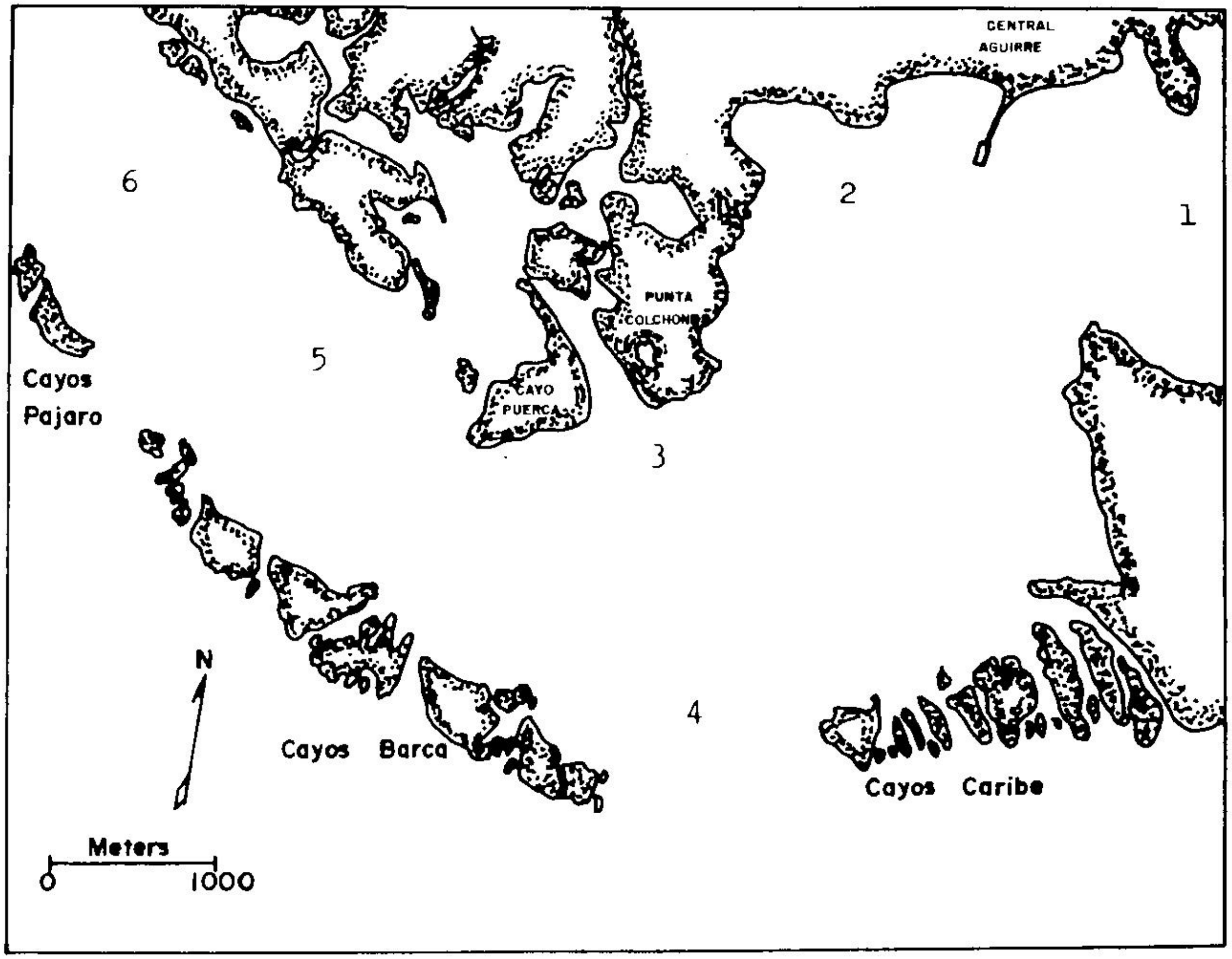

TABLE I

CHARACTERISTICS OF JOBOS BAY SAMPLES

Sample #	Area	Date	Time	Minutes Towed	# M^3 Sampled	Total Zooplankton #/min. towed	Total Zooplankton #/M^3	Net mesh size (u)	Type of sample
0	5	10-20-71	1635	10	58.3	280.0	47.9	380	tow
00	4	10-21-71	0945	10	62.8	93.0	15.0	380	tow
1	4	11- 9-71	1400	5	25.9	110.4	21.1	380	tow
2	3	11- 9-71	2215	5	30.1	548.8	91.0	380	tow
3	3	11-10-71	0845	5	44.3	1548.0	174.3	380	tow
4	6	11-10-71	1000	10	57.6	1077.0	186.7	380	tow
5	4	11-10-71	1310	5	13.7	102.0	37.3	380	tow
6	4	12- 8-71	1532	15	92.3	352.0	57.0	380	tow
7a	5	12- 8-71	1601	qualitative purposes				380	tow
7b	5	12- 8-71	1625	15	110.3	63.6	8.6	380	tow
8	5	12- 8-71	2303	15	69.8	464.0	99.6	380	tow
9	6	12- 8-71	1012	10	61.8	265.0	64.5	380	tow
10	5	12- 9-71	1036	15	72.9	54.0	11.1	380	tow
11	4	12- 9-71	1449	15	56.3	40.0	10.7	380	tow
12	2	12-13-71	1335	15	140.8	75.6	8.0	380	tow
13	1	12-13-71	1515	15	134.9	593.3	66.1	380	tow
14	5	1-27-72	1635	-	0.076	-	1842.2	60	grab
16	2	1-27-72	1830	qualitative purposes				380	tow
19	5	1-27-72	2307	10	101.5	1647.4	162.4	380	tow
21	2	1-28-72	0003	5	54.6	5592.0	512.1	380	tow
22	6	2- 3-72	1503	10	40.0	5960.0	1490.0	60	tow
23	6	2- 3-72	1520	10	40.0	2285.0	571.2	60	tow
24	5	2- 3-72	1620	-	0.057	-	4904.5	60	grab
25	5	2- 3-72	1640	qualitative purposes				60	grab
26	5	2- 3-72	1710	15	60.0	4021.3	781.7	60	grab
27	5	2- 3-72	1731	5	20.0	2680.0	670.0	60	tow
28	5	2- 4-72	0429	19	75.0	4799.7	1216.2	60	tow
29	5	2- 4-72	0458	5	20.0	17248.0	4312.0	60	tow
30	5	2- 4-72	1000	-	0.019	-		60	grab
31	2	2- 4-72	1030	20	80.0	1498.0	369.0	60	tow
32	2	2- 4-72	1100	5	20.0	476.0	119.0	60	tow
33	2	2- 4-72	1100	-	0.019	-		60	grab
34	2	2-15-72	2000	15					tow
35	5	2-16-72	0000	10					tow
36	2	2-16-72	0935	10					tow
37	2	2-16-72	1010	15					tow
38	4	4-25-72	1500	8	3.5	10.5	24.0	300	still tow
39	5	4-26-72	1100	10	75.0	44.7	5.7	300	tow
40	2	4-26-72	1130	10	75.0	40.0	5.3	300	tow
BB	5	5-25-72	0500	5	35.0	5399.3	771.5	202	tow
BC	2	5-26-72	1530	5	35.0	2292.0	327.4	202	tow
BD	5	5-26-72	1551	5	35.0	8784.0	1254.6	202	tow
BE	5	5-26-72	1609	5	40.0	1327.5	165.8	300	tow
CB	5	6-13-72	1717	5	40.0	756.7	94.6	300	tow
CC	5	6-13-72	1726	5	35.0	2683.2	383.2	202	tow
CD	2	6-13-72	1809	5	35.0	1658.9	237.1	202	tow
CE	2	6-13-72	1818	5	40.0	253.0	31.6	300	tow
CF	5	6-13-72	2235	5	40.0	2245.0	280.7	300	tow
CG	5	6-13-72	2250	5	35.0	2541.0	362.9	202	tow

TABLE 2

AREA I ZOOPLANKTON SUMMARY

	Station J B - 13			
	A	B	C	
Amphipods				
Appendicularia	1.6	0.2	0.3	
Bivalve				
Brachyura	125.0	13.	21.0	
Caridea	56.7	6.3	9.5	
Chaetognaths				
Cladocera				
Copepods	218.3	24.3	36.8	
Cumaceans				
Decapod larvae				
Euphausid				
Fish eggs (total)	11.6	1.4	1.8	
Anchovy eggs	3.3	0.4	0.5	
Fish larvae				
Foranis				
Gastropods				
Isopods				
Lucifer faxoni	23.3	2.6	4.0	
Medusae				
Mysids				
Nauplii (total)	46.7	5.2	7.9	
Copepod	-	-	-	
Cirrip	46.7	5.2	7.9	
Ostracods				
Penaeid	18.3	2.0	3.1	
Pleuteus larvae				
Polychaete				
Porcellanid	5.0	0.6	0.8	
Siphonophora	1.6	0.2	0.3	
Tintinnids				
Totals	593.3	66.1	100.0	

TABLE 3

AREA 2 ZOOPLANKTON SUMMARY

	Station 12			Station 21			Station 31			Station 32		
	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods	0.1	0.01	0.2				2.0	0.5	0.1			
Appendicularia	0.1	0.01	0.2	24	2.2	0.4				56.0	14.0	11.8
Bivalve										16.0	4.0	3.4
Brachyura	1.1	0.1	1.4	328	30.0	5.9	6.0	1.5	0.4	8.0	2.0	1.7
Caridean				56	5.1	1.0	20.0	5.0	1.3	4.0	1.0	0.8
Chaetognaths				512	46.9	9.3	4.0	1.0	0.3	12.0	3.0	2.5
Copepods	69.3	7.4	91.6	4160	381.0	74.4	1290.0	322.5	86.1	268.0	67.0	56.3
Decapod larvae	1.6	0.2	2.1	112	10.3	2.0	6.0	1.5	0.4			
Fish eggs (total)	1.0	0.1	1.2	112	10.3	2.0	28.0	7.0	1.9	8.0	2.0	1.7
Anchovy eggs	0.3	0.03	0.4				20.0	5.0	1.3	4.0	1.0	0.8
Fish larvae				72	6.6	1.3						
Isopods	0.1	0.01	0.2									
Lucifer faxoni	0.1	0.01	0.2	8	0.7	0.1						
Medusae				56	5.1	1.0				4.0	1.0	0.8
Nauplii (total)	1.9	0.2	2.5	96	8.8	1.7	110.0	27.5	7.3	96.0	24.0	20.2
Cirripede				96	8.3	1.7	110.0	27.5	7.3	96.0	24.0	20.2
Nemertineans										4.0	1.0	8.0
Ostracods							22.0	5.5	1.5			
Peneid larvae				8	0.7	0.1						
Polychaete larvae				24	2.2	0.4						
Porcellanid larvae	0.3	0.03	0.4	24	2.2	0.4	10.0	2.5	0.7			
Totals	79.6	8.07		5582	512.1		1480.0	369.0		476.0	119.0	

A: #/minutes towed B: #/M^3 sampled C: % of total catch

TABLE 3 (Cont.)

AREA 2 ZOOPLANKTON SUMMARY

	[illegible]			BC			CD			CE		
	A	B	C	A	B	C	A	B	C	A	B	C
Ascidian larvae				4.0	0.6	0.2						
Amphipods							5.3	0.8	0.3			
Appendicularia				192.0	27.4	8.4	651.9	93.1	39.3	75.9	9.5	30.0
Bivalve							5.3	0.8	0.3			
Brachyura	2.0	0.3	5.0	48.0	6.8	2.1	26.5	3.8	1.6	20.7	2.6	8.2
Caridea	1.0	0.1	2.5	16.0	2.3	0.7	15.9	2.3	1.0	16.1	2.0	6.4
Chaetognaths				12.0	1.7	0.5	5.3	0.3	0.3			
Cladocera												
Copepods	30.0	4.0	75.0	1612.0	230.3	70.3	259.7	37.1	15.6	36.8	4.6	14.6
Cumaceans												
Decapods												
Stomatopod lar.												
Euphausids												
Fish eggs (total)	6.0	0.8	15.0	72.0	10.3	3.2	37.1	5.3	2.3	29.9	3.7	11.8
Anchovy eggs	6.0	0.8	15.0	68.0	9.7	3.0	15.9	2.3	1.0	13.8	1.7	5.4
Fish larvae				24.0	3.4	1.0	10.6	1.5	0.6			
Foraminifers												
Gastropods				32.0	4.6	1.4	10.6	15.1	6.4			
Isopods										2.3	0.3	0.9
Lucifer faxoni				4.0	0.6	0.2						
Medusae												
Mysids				4.0	0.6	0.2						
Nauplii (total)	1.0	0.1	2.5	216.0	30.8	9.4	455.8	65.1	27.5	57.5	7.2	22.7
Copepod										2.3	0.3	0.9
Cirripede	1.0	0.1	2.5	216.0	30.8	9.4	455.8	65.1	27.5	55.2	6.9	21.8
Ostracods				32.0	4.6	1.4	53.0	7.6	3.2			
Penaeid				8.0	1.1	0.3	15.9	2.3	1.0	2.3	0.3	0.9
Pleuteus larvae				4.0	0.6	0.2						
Polychaete							10.6	1.5	0.6			
Porcellanid												
Siphonophora												
Tintinnids												
Unidentified				12.0	1.7	0.5				11.5	1.4	4.5
Totals	40.0	5.3	100.0	2292.0	327.4	100.0	1658.9	237.1	100.0	253.00	31.6	100.0

A = #/min. towed

TABLE 4

AREA 3 ZOOPLANKTON SUMMARY

	Station J B-2			Station J B-3		
	A	B	C	A	B	C
Amphipods	1.4	0.2	0.3			
Appendicularia	19.6	3.3	3.6	7.2	0.8	0.5
Bivalve						
Brachyura	9.8	1.6	1.8	532.8	60.6	34.4
Caridea						
Chaetognaths	9.8	1.6	1.8	28.8	3.2	1.9
Cladocera						
Copepods	476.0	79.1	86.7	770.4	86.3	49.8
Cumaceans						
Decapod larvae	22.4	3.7	4.1	129.6	14.6	8.4
Euphausid						
Fish eggs (total)	4.2	0.7	0.8	14.4	1.6	0.9
Anchovy eggs						
Fish larvae	1.4	0.2	0.3	3.6	0.4	0.2
Foranis						
Gastropods						
Isopods	1.4	0.2	0.3			
Lucifer faxoni	1.4	0.2	0.3	21.6	2.4*	1.4
Medusae						
Mysids	1.4	0.2	0.3			
Nauplii (total)				3.6	0.4	0.2
Copepod						
Cirripede						
Ostracods						
Penaeid						
Pleuteus larvae				10.8	1.2	0.7
Polychaete						
Porcellanid				25.2	2.8	1.6
Siphonophora						
Tintinnids						
Totals	548.8	91.0	100.0	1548.0	174.3	100.0

TABLE 5

AREA 4 ZOOPLANKTON SUMMARY

	JB - 00			JB - 1			JB - 5			JB - 6			JB - 11		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods							22.0	8.0	21.0				4.00	1.1	10.00
Appendicularia	40.0	6.4	43.1	22.8	4.4	19.2				19.33	2.9	11.0	1.33	0.4	3.34
Bivalve															
Brachyura	20.0	3.2	21.5	24.0	4.6	20.20	34.0	12.4	33.3	12.00	1.9	6.82	4.00	1.1	10.00
Caridea															
Chaetognaths				9.6	1.8	8.08	4.0	1.5	3.9	3.33	0.5	1.9			
Cladocera				10.8	2.1	9.09				0.4	0.1	0.7			
Copepods	13.0	2.1	14.1	19.2	3.7	16.2	4.0	1.5	4.0	108.00	17.6	61.4	8.00	2.1	20.00
Cumaceans															
Decapod larvae	2.5	0.4	2.7	8.4	1.6	7.07	4.0	1.5	3.9	14.00	2.3	8.0	13.33	3.5	33.33
Euphausid larvae															
Fish Eggs (total)	5.5	0.9	5.9	16.8	3.2	14.14				12.7	2.1	7.20	5.33	1.4	13.33
Anchovy eggs															
Fish larvae	0.5	0.1	0.5	1.2	0.2	1.01				4.7	0.8	2.7			
Foraminifera															
Gastropodo larvae							6.0	2.2	5.9						
Isopods															
<u>Lucifer faxoni</u>										0.7	0.1	0.4			
Medusae	0.5	0.1	0.5	1.2	0.2	1.01									
Mysids															
Nauplii (total)	0.5	0.1	0.5												
Copepods															
Cirripides															
Ostracod larvae							8.0	2.9	7.8						
Penaeid															
Pleuteus larvae	7.0	1.1	7.5	1.2	0.2	1.01									
Polychaete				1.2	0.2	1.01									
Porcellanid	0.5	0.1	0.5												
Siphonophora				2.4	0.5	2.03				0.7	0.1	0.4			
Tintinnids															
Brachiopod larvae							4.0	1.5	3.9						
Unidentified	3.0	0.5	3.2				16.0	5.8	15.7				4.0	1.1	10.0
Totals	93.0	15.0	100.0	118.8	22.9	100.0	102.0	37.3	100.0	176.0	28.4	100.0	40.00	10.7	100.0

A = #/min. towed B = #/M3 C = % of total catch

Majority of unidentified organisms in JB - 00 + 5 are worms.

TABLE 6

AREA 5 ZOOPLANKTON SUMMARY

	JB - 0			JB - 7b			JB - 8			JB - 10			JB - 14			JB - 19		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods							2.1	0.5	0.5							33.0	3.3	2.0
Appendicularia	1.6	0.3	0.6	2.0	0.3	3.2	57.6	12.4	12.4	3.7	0.8	6.9	N.A.	263.2	14.3	13.8	1.4	0.8
Ascidian larvae	0.8	0.1	0.3															
Bivalve larvae																		
Brachyura	206.4	35.4	73.6	13.3	1.8	21.1	30.9	6.6	6.7	11.5	2.4	21.3				74.2	7.3	4.5
Caridea																137.5	13.5	8.3
Chaetognaths	0.8	0.1	0.3				4.3	0.9	0.9	0.3	0.05	0.5				170.5	16.8	10.3
Cladocera							6.4	1.4	1.4	0.5	0.1	1.0						
Copepods	17.6	3.0	6.3	4.7	0.6	7.4	138.7	29.8	29.9	12.8	2.6	23.8	N.A.	1447.4	78.6	924.0	91.0	56.1
Cumaceans																		
Decapod larvae	30.4	5.2	10.9	16.0	2.2	25.3	60.0	12.8	12.9	5.1	1.0	9.4						
Euphausid larvae																2.8	0.3	0.2
Echinoderms																		
Fish eggs (total)	8.0	1.4	2.8	4.0	0.5	6.3	123.7	26.6	26.7	14.7	3.0	27.2				192.5	19.0	11.7
Anchovy eggs																		
Fish larvae	2.4	0.4	0.9	0.7	0.1	1.1	4.2	0.9	0.9	0.3	0.05	0.5						
Foraminifera																2.8	0.3	0.2
Gastropods																		
Isopods																		
Parasitic																		
Lucifer faxoni	12.0	2.0	4.3	2.0	0.3	3.2	4.3	0.9	0.9	0.8	0.2	0.1				41.2	4.1	2.5
Medusae				1.3	0.2	2.1				0.8	0.2	1.5						
Mysids							3.2	0.7	0.7									
Nauplii (total)				18.7	2.5	29.5	26.7	5.7	5.8	6.4	1.2	12.0				35.8	3.5	2.2
Copepods										2.7	0.5	5.0						
Cirripedes										0.5	0.1	1.0				35.8	3.5	2.2
Ostracods																		
Penaeid																16.5	1.6	1.0
Pleuteus larvae				0.7	0.1	1.1				0.3	0.05	0.5						
Polychaete							1.1	0.2	0.2				N.A.	131.6	7.1			
Porcellanid							1.1	0.2	0.2									
Siphonophora																		
Tintinnids																		
Unidentified																2.8	0.3	0.2
Totals	280.0	47.9	100.0	63.3	8.6	100.0	464.0	99.6	100.0	53.9	11.1	100.0	N.A.	1842.2	100.0	1647.4	162.4	100.0

A = #/min. towed B = #/M3 A = #/min. towed

TABLE 6

AREA ZOOPLANKTON SUMMARY

	JB - 24			JB - 26			JB - 27			JB - 28			JB - 29		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods							8.0	2.0	0.3	42.1	10.7	0.9	168.0	42.0	1.0
Appendicularia							80.0	20.0	3.0				72.0	16.0	0.4
Ascidian larvae							16.0	4.0	0.6	21.0	5.3	0.4	32.0	8.0	0.2
Bivalve larvae	N.A.	394.7	8.0				8.0	2.0	0.3	2.6	0.7	0.05	16.0	4.0	0.1
Brachyura	N.A.	196.5	4.0	66.7	16.7	2.1	32.0	6.0	1.2	42.1	10.7	0.9	152.0	38.0	0.9
Caridea				40.0	10.0	1.3	32.0	8.0	1.2	36.8	9.3	0.8	80.0	20.0	0.5
Chaetognaths				3.3	0.8	0.1	16.0	4.0	0.6	7.9	2.0	0.2	168.0	42.0	1.0
Cladocera															
Copepods	N.A.	1775.4	36.0	2530.0	632.5	80.9	1680.0	420.0	62.7	4473.7	1133.3	93.2	16000.0	4000.0	92.8
Cumaceans															
Decapod larvae							64.0	16.0	2.4				24.0	6.0	0.1
Euphausid larvae															
Fish eggs (total)				40.0	10.0	1.3	40.0	10.0	1.5	7.9	2.0	0.2	144.0	36.0	0.85
Anchovy eggs													8.0	2.0	0.35
Fish larvae							16.0	4.0	0.6				32.0	8.0	0.2
Foraminifera				6.7	1.7	0.2				10.5	2.7	0.2			
Gastropods	N.A.	593.0	12.0	20.0	5.0	0.6	96.0	24.0	3.6	23.7	6.0	0.5	16.0	4.0	0.1
Isopods															
Parasitic													16.0	4.0	0.1
<u>Lucifer faxoni</u>				23.3	5.8	0.7	8.0	2.0	0.3	10.5	2.7	0.2	56.0	14.0	0.3
Medusae							8.0	2.0	0.3						
Mysids				40.0	10.0	1.3				2.6	0.7	0.05	8.0	2.0	0.05
Nauplii (total)		1775.4	36.0	336.7	84.2	10.9	528.0	132.0	19.7	97.3	24.7	2.0	216.0	54.0	1.25
Copepods	N.A.	1578.9	32.0							10.5	2.7	0.2			
Cirripedes	N.A.	196.5	4.0				528.0	132.0	19.7	86.8	22.0	1.8	216.0	54.0	1.25
Ostracods				20.0	5.0	0.6				13.2	3.3	0.25	56.0	14.0	0.3
Penaeid							8.0	2.0	0.3	2.6	0.7	0.05	8.0	2.0	0.05
Pleuteus larvae							8.0	2.0	0.3						
Polychaete	N.A.	196.5	4.0				32.0	8.0	1.2	2.6	0.7	0.05			
Porcellanid															
Siphonophora															
Tintinnids															
Unidentified										2.6	0.7	0.05			
Total	N.A.	4904.5	100.0	3126.7	781.7	100.0	2680.0	670.0	100.0	4799.7	1216.2	100.0	17248.0	4312.0	100.0

A = #/min. towed C = % of total catch

TABLE 6

AREA ZOOPLANKTON SUMMARY

	JB-CB			JB-CC			JB-CF			JB-CG		
	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods							45.0	5.6	2.0	22.0	3.1	0.9
Appendicularia	165.6	20.7	21.9	801.6	114.5	29.8	15.0	1.9	0.7	852.5	121.8	33.5
Bivalve												
Brachyura	29.9	3.73	4.0	4.8	0.7	0.2	275.0	34.4	12.2	71.5	10.2	2.8
Caridea	29.9	3.73	4.0	28.8	4.1	1.1	1425.0	178.1	63.5	555.5	79.4	21.9
Chaetognaths				9.6	1.4	0.4	30.0	3.8	1.3	16.5	2.4	0.6
Cladocera												
Copepods	57.5	7.2	7.6	672.0	96.0	25.0	330.0	41.2	14.7	726.0	103.7	28.6
Cumaceans												
Decapods												
Euphausids												
Fish eggs (total)	163.3	10.50	21.3	52.8	7.5	2.0	75.0	9.4	3.3	60.5	8.6	2.4
Anchovy eggs	2.3	0.28	0.3									
Fish larvae				48.0	6.8	1.8	20.0	2.5	0.9	66.0	9.4	2.6
Foraminifers												
Gastropods	4.6	0.6	0.6	321.6	45.9	12.0				60.5	8.6	2.4
Isopods												
Lucifer faxoni	4.6	0.6	0.6	4.8	0.7	0.2	15.0	1.9	0.7	11.0	1.6	0.4
Medusae	9.2	1.15	1.2	24	3.4	0.9				11.0	1.6	0.4
Mysids				4.8	0.7	0.2						
Nauplii (total)	259.9	32.5	34.3	532.8	76.0	19.8	15.0	1.9	0.7	33	4.7	1.3
Copepods				48	6.8	1.8						
Cirripedes	259.9	32.5	34.3	484.8	69.2	18.0	15.0	1.9	0.7	33	4.7	1.3
Ostracods				38.4	5.5	1.4				22	3.1	0.9
Penaeid	11.5	1.43	1.5	14.4	2.1	0.6				11	1.6	0.4
Pleuteus larvae	2.3	0.3	0.3									
Polychaete	2.3	0.3	0.3	101.2	14.4	3.8				22	3.1	0.9
Porcellanid												
Siphonophora				9.6	1.4	0.4						
Tintinnids												
Unidentified	16.1	2.01	2.1	14.4	2.1	0.4						
Totals	756.7	94.51	100	2683.2	383.2	100	2245.0	280.7	100	2541	362.9	100

A = #/min. towed B = $\#/M^3$ C = % of total catch

TABLE 6

AREA ZOOPLANKTON SUMMARY

	39			BB			BD			BE		
	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods				13.0	1.8	0.2						
Appendicularia				4.4	0.6	0.1	60.0	8.6	0.7	31.5	3.9	2.4
Ascideans												
Bivalve												
Brachyura	19.2	2.6	43.1	120.2	17.2	2.2	60.0	8.6	0.7	32.0	4.0	2.1
Caridea	7.9	1.0	17.6	81.2	11.6	1.5	72.0	10.3	0.8	73.5	9.2	5.6
Chaetognaths	2.6	0.3	5.9	48.8	7.0	0.9	12.0	1.7	0.1			
Cladocera												
Copepods	1.8	0.2	3.9	4462.2	637.5	82.7	5916.0	845.1	67.4	385.0	48.1	29.2
Cumaceans				3.2	0.5							
Decapods												
Stomatopod lar.												
Euphausids												
Echinoderms				19.5	2.8	0.4						
Fish eggs (total)	6.1	0.8	13.7	42.2	6.0	0.8	936.0	133.7	10.6	605.5	75.7	45.9
Anchovy eggs										10.5	1.3	0.8
Fish larvae	0.9	0.1	2.0	36.0	5.1	0.6	24.0	3.4	0.3	3.5	0.4	0.3
Foraminifers												
Gastropods				19.5	2.8	0.4						
Isopods				3.2	0.5	0.05						
<u>Lucifer faxoni</u>	1.8	0.2	3.9	3.2	0.5	0.05						
Medusae				3.2	0.5	0.05	12.0	1.7	0.1			
Mysids				9.8	1.4	0.2	48.0	6.8	0.5			
Nauplii (total)	0.9	0.1	2.0	126.8	18.1	2.3	1032.0	147.4	11.8			
Copepods							12.0	1.7	0.1			
Cirripedes	0.9	0.1	2.0	126.8	18.1	2.3	1020.0	145.7	11.7	143.5	17.9	10.8
Ostracods				256.8	36.7	4.9	516.0	73.7	5.9	32.0	4.0	2.1
Penaeid	0.9	0.1	2.0	61.8+	8.8+	1.1+	36.0	5.1	0.4	17.5	2.2	1.3
Pleuteus larvae												
Polychaete				45.5	6.5	0.8	36.0	5.1	0.4	3.5	0.4	0.3
Porcellanid												
Siphonophora				9.8	1.4	0.2						
Trochophore larvae	2.6	0.3	5.9									
Tintinnids												
Unidentified												
Totals	44.7	5.7	100.0	5399.3	771.5	100.0	8784.0	1254.6	100.0	13.27.5	165.8	100.0

A = #/min. towed

+ = All of these were eggs

TABLE 6 (Cont.)

AREA 4 ZOOPLANKTON SUMMARY

	JB - 38		
	A	B	C
Bivalve larvae	2.6	6.0	25.0
Copepods	4.4	10.0	41.7
Gastropod larvae	3.5	8.0	33.3
Totals	10.5	24.0	100.0

Note: JB - 38 was taken in a very low flow rate area.

TABLE 7

AREA 6 ZOOPLANKTON SUMMARY

	JB - 4			JB - 9			JB - 22			JB - 22		
	A	B	C	A	B	C	A	B	C	A	B	C
Amphipods				1.7	0.4	0.6				5.0	1.2	0.2
Appendicularia	72.0	6.2	3.3	5.0	1.2	1.9	16.0	4.0	0.3	115.0	28.8	5.0
Ascidians	18.0	1.6	0.8									
Bivalve												
Brachiopod larvae	6.0	0.5	0.3									
Brachyura	222.0	19.2	10.3	16.7	4.0	6.3	8.0	2.0	0.1			
Caridea							4.0	1.0	0.1	5.0	1.2	0.2
Chaetognaths	630.0	54.6	29.2	1.7	0.4	0.6	32.0	8.0	0.5	30.0	7.5	1.3
Cladocera	24.0	2.1	1.1									
Copepods	744.0	64.5	34.5	178.3	43.3	67.3	5540.0	1385.0	93.4	2015.0	503.8	88.3
Cumaceans												
Decapod larvae	264.0	22.9	12.3	25.0	6.1	9.4	12.0	3.0	0.2			
Euphausids												
Fish eggs (total)	84.0	7.3	3.9	18.3	4.5	6.9	144.0	36.0	2.4	30.0	7.5	1.3
Anchovy eggs												
Fish larvae	24.0	2.1	1.1	3.3	0.8	1.3	4.0	1.0	0.1			
Foraminifera										5.0	1.2	0.2
Gastropods							12.0	3.0	0.2			
Isopods												
Lucifer				3.3	0.8	1.3						
Medusae												
Mysids				1.7	0.4	0.6						
Nauplii (total)		.		8.3	2.0	3.1	176.0	44.0	2.9	65.0	16.2	2.9
Copepod							20.0	5.0	0.3	20.0	5.0	0.9
Cirripede							156.0	39.0	2.6	45.0	11.2	2.0
Ostracods							8.0	2.0	0.1	15.0	3.8	0.6
Penaeid												
Pleuteus	12.0	1.0	0.6				4.0	1.0	0.1			
Polychaete	6.0	0.5	0.3									
Porcellanid	24.0	2.1	1.1									
Ptereopods												
Siphonophora	18.0	1.6	0.8									
Tintinnids												
Unidentified				1.7	0.4	0.6						
Totals	2154.0	186.7	100.0	265.0	64.5	100.0	5960.0	1490.0	100.0	2285.0	571.2	100.0

A: #/minutes towed B: #/M^3 sampled C: % of total catch

FORAMINIFERS FROM JOBOS BAY

REPORT NO. 5

GEORGE A. SEIGLIE

INTRODUCTION

The purpose of this paper is to describe the foraminiferal faunas of the samples taken at Jobos Bay on June 29, 1972 and September 29, 1972. The samples of June were taken on board of the R/V R.F. Palumbo and the samples of September were taken in a boat. Size analyses were made and calcium carbonate content was determined for samples of most of the stations of Jobos Bay.

The samples were taken with a Phleger corer and the top section (0-1cm) of the core and the section below it (1-2cm) were preserved separately in jars with 33% ethyl alcohol. Protoplasm of living foraminifers were strained with Bengal Rose in the laboratory in a sieve No. 230 U.S. standards.

SALINITIES AND TEMPERATURES

Table No. 8 shows salinities and temperatures, taken on June 9 and September 29, 1972. The minium temperature at Jobos Bay 24.5°C, was taken in March 1971 and the maximum 30.0°C taken in September 1972. Salinities taken in two years ranged from 35 ppt to 37 ppt.

The small changes in temperatures and salinities are not related apparently to changes in the foraminiferal assemblages.

SEDIMENTS

Table No. 7 shows the size analysis and calcium carbonate content of sediments of the stations of Jobos Bay. The analysis were made by Myriam Albino.

No relationship is evident comparing the sediments (Table No. 7) with the living foraminiferal assemblages (Table No. 9). However, this does not mean necessarily that there is any relationship between them. Sedimentation and foraminifers have obviously changed during the last years. Old and new sediments may have mixed and the relationships lost.

Changes in sedimentation have been observed in most of the bay. The amount of organic matter has increased and the amount of carbonate sediments decreased. The increase of organic matter is a consequence of the larger amount of mangrove or of the organic matter dumped by the sugar mill in the bay or both. The sediments in or close to the dumping areas of the sugar mill are composed mostly by organic matter. They suggest that pollution had an important role in the change of sedimentation.

A core of 2.50 meters of length was taken at Sta. 53 whose depth is about 15 meters. The bottom of the core is a yellowish muddy sand which contrasts in color with the remaining of the core. It indicates a small unconformity before the last raise of the sea level. Abundant organic matter is present several centimeters above the yellowish bottom of the core. This vegetal matter supplied by the mangroves was deposited in an environment shallower than the present one. The organic matter is absent or scarce in the middle part up to some centimeters from the top of the core, where it is abundant again. This station is at the entrance of the bay where a canal has been dredged. Concentration of organic matter in this station is a consequence of pollution.

LIVING FORAMINIFERAL FAUNAS

The absolute number of foraminifers per sample in the upper centimeter do not show significant differences among the stations.

Specific composition of living foraminiferal assemblages show, however, significant differences in the several areas of Jobos Bay.

Three foraminiferal biofacies were determined: 1) *Ammonia biofacies*, 2) *Fursenkoina* - *Ammonia* - *Florilus biofacies*, and 3) *Ammonia* - *Fursenkoina* with high specific diversity.

Ammonia biofacies

Ammonia catesbyana is the dominant species of this facies. It is present in four forms: *Ammonia catesbyana* forma *typica*, *A. catesbyana* forma *tepida*, *A.* Catesbyana high-spire form. *A. catesbyana* abnormal form. Characteristic forms of this highly variable foraminifer are present in several environments of Jobos Bay. Plate I shows scanning photographs of three of these forms. *Ammonia* biofacies is the shallowest biofacies and it has the lowest species diversity.

Ammonia biofacies at Mar Negro Lagoon has been previously sampled (September 23, 1971; See Report No. 4). An *Ammonia* - *Cribroelphidium* assemblage was found at about 4 meters of depth. Dissolved oxygen was about 1.6 ppm. The sample of September 29, 1972, was taken at 2.5 meters of depth and the amount of dissolved oxygen 1.6 ppm. *Ammonia catesbyana* high-spire form constituted 99% of the fauna, all specimens are megalospheric and also some abnormal specimens occasionally occur. The dumping area of wastes of the sugar mill is now in an inlet at the entrance of the chain of small lagoons in the passage to Mar Negro lagoon. *Cribroelphidium poeyanum* has decreased in number of percentage (from 50% to 1%), and specific diversity is lower than before.

Ammonia biofacies at Sta. 44. This station is on the dumping area of the sugar mill prior to December 1971. Samples taken at this station on September 1971. Samples taken at this station on September 1971 contained in one sample two living Ammonia and in a second sample no living specimen was found. Dissolved oxygen was about 0.6 ppm. Empty foraminiferal tests were scarce worn and whitish indicating high acidity in the environment.

A sample taken at this station on September 29, 1972, contained an Ammonia biofacies consisting mostly in A. catesbyana high-spire form, and some specimens of A. catesbyana forma tepida.

Ammonia biofacies in other areas. A. catesbyana forma tepida is the dominant foraminifer at Sta. 29A (September 29, 1972) north of Cayo Puerca. The other abundant species are Fursenkoina pontoni and Florilus grateloupii. Samples of Stations 29 and 34, close to Sta. 29A, taken in 1971 contained similar assemblages, but with populations larger than in the sample taken in 1972.

Ammonia biofacies of Sta. 54 contained an assemblage similar to the one at Sta. 29A. Ammonia biofacies of Sta. 11 contained an assemblage with no one specimen of Fursenkoina or Florilus.

Ammonia biofacies south of Aguirre Plant, Sta. 24. A sample of this station was taken on March 19, 1971 (See Report No. 2). The dominant foraminifer (more than 90% of the fauna) consisted of A. catesbyana high-spire and abnormal forms. All specimens were megalospheric, many of them with an abnormally large proloculus. More than the 10% of the specimens were extremely abnormal.

A. catesbyana high-spire form with large abnormal proloculus constituted the 29% of the A. catesbyana population of Sta. Jf-24 (same locality as Js-24), in a sample taken in February, 1972. This is an indication of a decrease of stress conditions in relation to the sample taken in March 1972.

A sample was taken on September 29, 1972. One hundred seventy four specimens of Ammonia catesbyana were found: ten of them were A. catesbyana forma tepida, seventeen were A. catesbyana high-spire form and 59 were A. catesbyana forma typica. Many specimens of the forma typica were microspheric and some of them with strongly limbated sutures.

Ammonia infaunal biofacies. The second section of the cores (1 to 2 cm of the top) of all the stations of Jobos Bay were also preserved, but in most of the cases the fauna was to scarce to be significant, and distortion of the top of the core may have influenced the foraminiferal content. However, the second section of stations Ju-18A, Js-24, Js-29A and Ju-52 contained a relatively abundant fauna. The percentage and number of living Ammonia catesbyana were higher than in the top centimeter, (See Table No. 9). Ammonia catesbyana forma tepida was the dominant form in second centimeter of Stations Ju-18A and Js-29A. A. catesbyana high-spire form was the dominant form at Sta. Js-24. The second centimeter of Sta. Jm-24 shows an increase in the number and percentage of A. catesbyana.

On the other hand, Florilus grateloupii and Fursenkoina pontoni which are relatively abundant in the upper centimeter of Stations Ju-18A, Js-24, Js-29A and Ju-52 are absent or very scarce in the second centimeter.

These values indicate that Ammonia catesbyana is in part infaunal, but A. catesbyana forma typica with ornamented sutures is probably epifaunal. Florilus grateloupii and Fursenkoina pontoni are epifaunal. Other species are too scarce to be supported by statistics

Fursenkoina-Ammonia-Florilus Biofacies

The dominant foraminifer in most of the samples is Fursenkoina pontoni. Ammonia catesbyana forma typica or forma tepida are the only forms present in this biofacies. The third species in abundance is

Florilus grateloupii. This biofacies occurs in Stations: Ju-4, Ju-5, Ju-7, Ju-9, Ju-16 and Ju-17.

Samples of these stations had been previously taken in October, 1970 and in July, 1971. Ammonia catesbyana was the dominant foraminifer in all cases, and Fursenkoina and Florilus were scarce.

Ammonia-Fursenkoina biofacies

This biofacies includes the deepest stations of the study area (Station 46 to 52). The dominant species is Ammonia catesbyana forma typica. The second abundant species is Fursenkoina pontoni.

The highest species diversity correspond to this biofacies.

LIVING "PYRITIZED" FORAMINIFERS

Seiglie (1973, in press) reported living foraminifers with "pyrite" inside the test. Ammonia catesbyana forma tepida and forma typica constitutes about the ninety percent of the "pyritized" foraminifers in Mayaguez, Jobos and Guayanilla Bays. Table No. 10 shows the number of living "pyritized" foraminifers per station in Jobos Bay (June 1972). Ammonia catesbyana forma typica and tepida constitute the 86% of the "pyritized" foraminifers. It is the only abundant living foraminifer that has been frequently found "pyritized". Other abundant foraminifers, like Fursenkoina and Florilus, have been found only rarely "pyritized", this suggests that "pyrite" is formed only below the bottom surface.

DEAD FORAMINIFERAL ASSEMBLAGES

The dead assemblages of mollusks were reported for Mar Negro Lagoon. Their distribution in the lagoon does not show transportation of shells. Warme (1969) indicated that post mortem transportation in coastal lagoons occurs only in short distances and frequently empty shells are in situ. Transportation of foraminiferal tests covers also only short distances as is shown below.

Dead foraminiferal assemblages of Sta. 29A (3m of depth) are shown in Table No. 10. Comparison of these assemblages with the living ones shows three different faunas: two of them dead and the third one living.

The oldest one is a back reef assemblage with part of the fauna "glauconitized". The dominant foraminifers are Archaias angulatus (all the specimens are glauconitized) and Quinqueloculina lamarckiana (part of them glauconitized). The reef assemblage constitute the 28% of the total foraminiferal fauna in the upper centimeter and the 41% in the second centimeter. Growing mangroves and bottom vegetation obstruct the transportation of tests to Sta. 29A. Therefore, foraminiferal tests at this station are considered in situ or close to it.

Several species of Critroelphidium constitute the dominant group in the second dead assemblage. They constitute about the 30% in the two upper centimeters. The species of this genus, present in the dead assemblage, is never associated to Archaias angulatus in living assemblages. On the other hand, they constitute only the 5% of the living Ammonia assemblage. Living assemblages of the close Stations 29 and 34 (See Tables 1 and 2 of Report No. 2) contain only 5.4% and 1.7% respectively of specimens of this genus. Thus, Cribroelphidium assemblage is considered younger than the dead reef-assemblage and older than the living assemblage. The decrease in number of the populations of Cribroelphidium in Jobos Bay is observed comparing the tables of living and dead assemblages (Tables No. 1 and No. 2, Report No. 1). The scarcity of living specimens of Cribroelphidium in sediments can not be attributed to an algal habitat, because their percentage in living assemblages on algae are as low as in living assemblages on sediments. Living populations of Cribroelphidium in Mar Negro Lagoon, Stations 43 and 43B, (see Table No.5, Report No. 4) have decreased in number and percentage (50%) compared with the present populations (about 1%). The most recent change in relation to Mar Negro Lagoon is the effect of the dumping of wastes of the sugar mill as explained above. This faunal change suggests that the present scarcity of Cribroelphidium is caused by pollution, but more samples are necessary to support this assumption.

A core taken at Sta. Js-24 showed another significant dead assemblage. A living assemblage of this station in 1971 was constituted by Ammonia catesbyana high-spire form. Dead assemblages in the top centimeter are fairly similar to the living ones. The sediment was constituted by vegetal matter and mud. The sediments of the core, from 34 to 35 cm. were constituted by vegetal matter and Halimeda fragments. The foraminiferal assemblage was constituted mainly by the dominant species: *Cribroelphidium poeyanum*, *Astrononion* cf. *Halicum*, *Florilus grateloupii* and *Rotorbinella* cf. *murrayi*. No one specimen of *Ammonia catesbyana* was found. This is the oldest studied recent foraminiferal assemblage of the area, previous to the pollution of the bay.

SPECIES DIVERSITY

The formula of information function was used to measure species diversity. It is used by communication engineers to predict the name of the next letter in a message. It is considered a good measure of species diversity (McArthur and McArthur, 19 ; McArthur, 1965) and involves a certain measure of species equitability. It is expressed by:

$$H = \sum_{i=1}^{N} p_i \log_e p_i$$

When N is the total number of species in the sample and p_i the proportion between the number of specimens of the i^{th} species and the total number of specimens.

Table No. 11 shows the species diversity by information function. The three foraminiferal biofacies in the upper section described above are related to different set of values of the information function.

Ammonia biofacies. The values range from 0.06 to 1.76. The lowest value correspond to Sta. Js-43 in Mar Negro Lagoon. Species diversity in year 1971 at Sta 43 was 0.67, the present value (0.06) is probably as a consequence of the change of place of the dumping area of the sugar mill.

Fursenkoina-Ammonia-Florilus biofacies. Species diversity ranges from 1.29 to 2.19.

Ammonia-Fursenkoina biofacies, (Stations Ju 46 to Ju52). Species diversity ranges from 2.56 to 2.93.

Species diversity and fauna below the bottom surface. The foraminiferal fauna and the species diversity of the second section below the top of the core (1-2 cm) was determined in five stations (see Table No. 11). The species diversity of the second centimeter was lower than the one in the top centimeter in the five cases.

Species diversity change in the polluted area. The most polluted area of the bay in year 1970 and 1971 was the area south Aguirre Plant and the pier of Aguirre sugar mill (Stations 5, 17, 18 and 24). These values of species diversity compared to the present ones are given below:

	5 and 5A	17	18 and 18A	24
1970/71	2.15	1.38	1.18	0.25
Feb. 1972				
Sept. 1972	2.25	1.67	1.79	1.76

(Stations 5A and 5 and Stations 18 and 18A are close enough to compare the results). The recovery, after the dumping of wastes was removed from this area, is shown in the values above, as an increase in species diversity. Sta. 24 is located in the most polluted part of the area, the value 0.48 two months after the dumping area was removed indicate already a recovery. The species diversity in the section 34-35 cm. of the top of the core Sta. Js-24 is 2.45, which previous to the pollution of the area.

CONCLUSIONS

Four variants of Ammonia catesbyana are found at Jobos Bay. All these forms were described in the previous reports as Ammonia tepida variants. A. catesbyana forma tepida is a small form abundant under stress conditions in nature or in polluted environments. A. catesbyana forma typica, large, microspheric form with limbated sutures, it is frequent under normal environmental conditions and in mildly polluted waters. A. catesbyana high-spire form has a high spire and generally a large proloculus, it is common under strong stress environmental conditions and in strongly polluted waters. A. catesbyana abnormal form has a large and protruding proloculus, it is abundant in strongly polluted waters and scarce under strong stress environmental conditions, it is always associated to the high-spire form. Many intermediate forms between the high-spire and the abnormal forms occur in strongly polluted waters.

Samples taken in years 1970 and 1971 close to the piers of Aguirre Sugar Mill show dominance of two species foraminifers: Ammonia catesbyana forma tepida and Quinqueloculina rhodiensis abnormal form, small with smooth on weakly costate walls. Foraminiferal assemblages in samples taken in the same area, June 1972, after dumping of wastes was removed to another part of the bay, became dominated by Fursenkoina pontoni, Florilus grateloupi and Ammonia catesbyana. Mayaguez assemblage is similar but with A. catesbyana scarce or absent. The scarcity of Ammonia in Mayaguez Bay assemblages are probably a consequence on the open conditions of the Bay. The assemblage consisting mainly of Fursenkoina and Florilus is therefore considered to represent a lower degree of pollution than an assemblage consisting of Quinqueloculina rhodiensis abnormal form and Ammonia catesbyana forma tepida.

Species of Cribroelphidium are common in the dead assemblages of Jobos Bay, but they are scarce in the living ones. The decrease in the number of individuals of these species and the decrease in species diversity (by information function) are obviously due to an environmental change. The abundance of Cribroelphidium in Mar Negro Lagoon previous to the change of the dumping area and its present scarcity in that lagoon suggest that its scarcity in all the bay is due to pollution.

The lowest values of species diversity correspond to the *Ammonia* biofacies. The most polluted part of the bay corresponded to Sta. 24 which show three stages: 1) pre-pollution stage, with no one specimen of *Ammonia* and species diversity of 2.45; 2) polluted, with a population consisting mostly of megalospheric, deformed *Ammonia* and a species diversity of 0.25; 3) after pollution, with normal, microspheric *Ammonia* and species diversity of 1.76.

The biofacies of Sta. 29A has also changed, through three stages: 1) pre-pollution, reef-foraminiferal assemblage with *Archaias angulatus* and *Quinqueloculina lamarckiana*; 2) beginning of pollution with a dominant *Cribroelphidium* assemblage 3) pollution stage, with *Ammonia*-*Fursenkoina* assemblage.

In the foraminiferal faunas most polluted area of the bay, close to the piers of the sugar mill the foraminiferal faunas increased its species diversity since the dumping of wastes was removed from it.

PLATE 1

All figures, magnification X240

Fig. 1 Ammonia catesbyana deformed form with abnormal proloculus; type I-2; Sta. Jm-24.

Fig. 2 Ammonia catesbyana forma typica, low spire, microspheric, obique view; type II-2; Sta. Js-24.

Fig. 3,4. Ammonia catesbyana high-spire form, megalospheric; types III-2 and III-3 respectively; Sta. J-43.

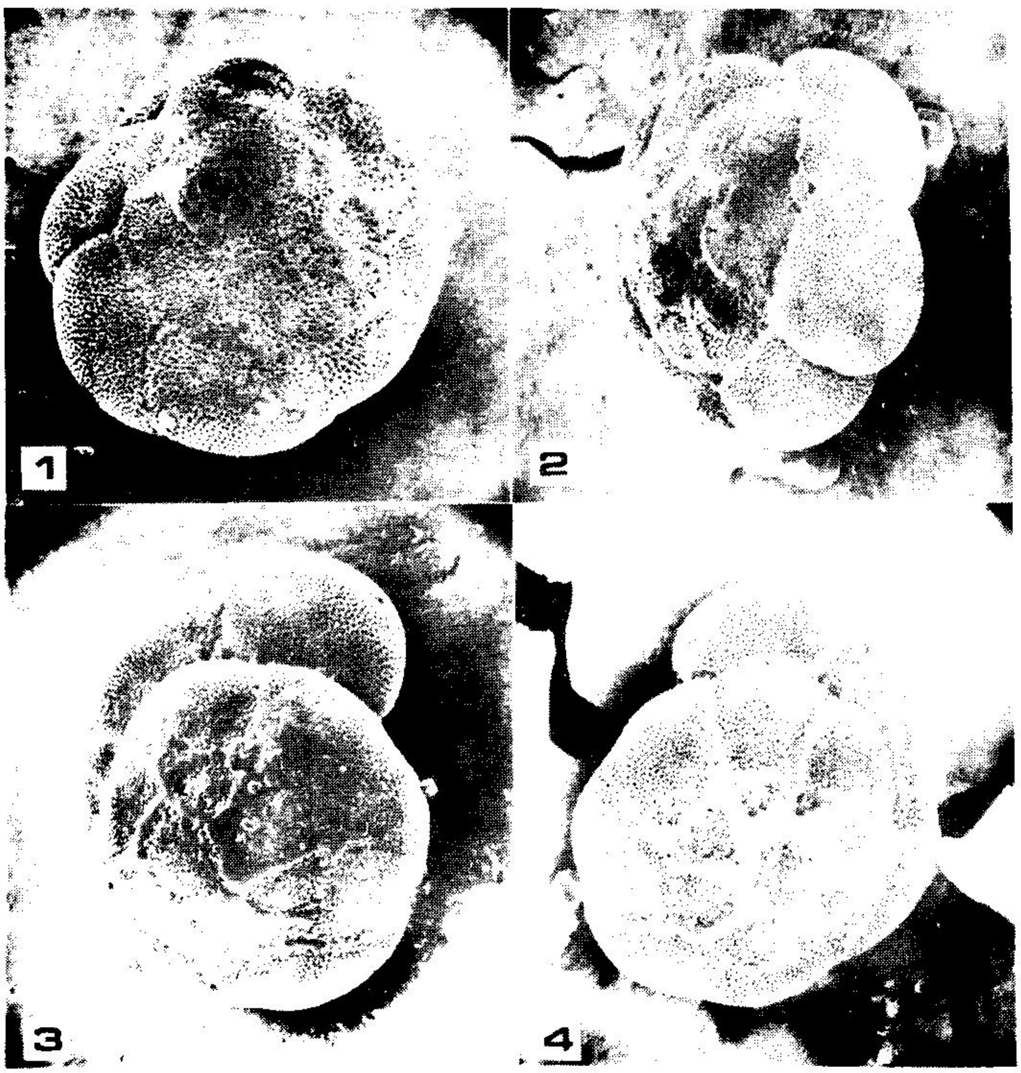

Table No. 7. Size analysis and calcium carbonate content of sediments in percent of dry sample.

Components	J-1	J-2	J-3	J-4	J-5 (1)	J-5 (3)	J-6	J-7	J-8	J-9	J-13	J-14	J-15
Gravel	20.0	7.9	7.3	8.1	0.0	1.6	0.0	3.7	0.2	1.2	0.5	0.0	0.8
Sand	8.5	17.4	12.8	18.9	6.2	4.5	9.5	17.4	6.4	9.2	5.1	4.9	33.7
Silt	26.8	38.8	30.0	34.8	41.3	10.1	57.7	39.4	59.2	68.5	69.2	59.1	47.6
Clay	44.7	35.9	49.0	38.2	52.5	83.8	32.8	39.6	34.2	21.1	25.1	36.1	17.9
$CaCO_3$	38.7	36.7	28.6	54.9	24.2	-	31.4	27.5	22.5	25.9	34.9	34.2	34.0

	J-16	J-17	Jg-17	J-18	Jg-18A	J-19	J-46	J-47	J-48	Jg-49	J-50	Jg-51	Jg-52	J-53
Gravel	0.0	0.1	0.0	1.0	0.0	0.1	2.8	4.6	0.2	11.9	0.1	37.1	28.4	2.7
Sand	8.0	2.0	10.4	2.7	6.6	18.3	4.1	8.8	4.4	21.5	14.7	24.1	37.9	31.1
Silt	54.9	44.9	35.7	14.5	44.0	41.5	56.4	53.2	53.9	44.1	31.3	23.8	16.4	48.8
Clay	37.1	53.0	53.9	81.8	50.0	4.8	36.8	33.5	41.5	22.4	53.9	15.1	17.3	17.5
$CaCO_3$	29.1	24.8	24.8	19.4	24.3	40.1	32.1	42.0	43.4	34.8	33.8	66.8	86.7	66.1

TABLE NO. 8

SALINITIES AND TEMPERATURES IN STATIONS OF JOBOS BAY JUNE 9, 1972, STATION: Ju, SEPTEMBER 29, 1972, STATIONS: Js

	Salinities, p.p.t.		Temperature °C	
Station	Surface	Bottom	Surface	Bottom
Ju- 4	36.20	36.57	29.4	29.3
Ju- 5A	35.82	36.62	29.2	28.2
Ju- 7	35.91	36.50	29.3	29.2
Ju- 9	35.95	36.52	29.2	29.2
Ju-11	35.60	35.61	28.5	28.4
Ju-16	35.90	36.69	29.2	29.0
Ju-17	35.90	36.54	29.3	29.3
Ju-18A	35.78	36.46	29.2	29.3
Ju-46	35.68	36.26	28.8	29.1
Ju-48	35.85	35.75	29.0	28.8
Ju-49	35.82	35.76	28.8	28.7
Ju-50	35.79	35.78	28.8	28.6
Ju-52	35.76	35.67	28.8	28.5
Js-24			29.5	
Js-29			29.5	
Js-37			30.0	
Js-43			28.8	28.5
Js-44			29.5	
Js-54			29.5	29.0

TABLE 9

NUMBER OF LIVING FORAMINIFERS PER STATION AT JOBOS BAY IN JUNE 9 (Ju) AND SEPTEMBER 29 (Js), 1972

	Ju-4 0-1 cm.	Ju-4 1-2 cm.	Ju-5A 0-1 cm.	Ju-7 0-1 cm.	Ju-9 0-1 cm.	Ju-11 0-1 cm.	Ju-16 0-1 cm.	Ju-17 0-1 cm.	Ju-18A 0-1 cm.	Ju-18A 1-2 cm.	Js-24 0-1 cm.
Acervulina inhaerens							1				
Ammobaculites directus								1			
A. exilis						3					
A. salsus											
Ammonia catesbyana f. typica											
A. catesbyana f. tepida											
A. catesbyana f. high spire											
A. catesbyana s.l.	11	5	43	10	48	18	32	16	6	15	174
A. parkinsohiana											
Amphistegina gibbosa											
Angulogerina sp.											
Articulina cf. pacifica						1					
Astrononion stelligera											2
Baggina philippinensis											
Bolivina pseudoplicata							1				
B. rhomboidalis						1					
B. variabilis							1				10
Brizalina inflata			1								
B. lowmani				1	5	1(2)					6(2)
B. sp.	1			1							3
B. striatula											10
Bulimina marginata			4		2		2		1	1	2
Buliminella elgantissima	1			1			1		5		1
Cancris sagra											
Cibicides sp. A.						1					
Cribroelphidium actvenum			2								
C. cariacoense											
C. discoidale							1				
C. poeyanum poeyanum			2		10	3(2)		1			16
C. poeyanum kugleri					2						
C. sp.					2	0				1	
Cyclogyra involvens			3			2	3			1	6
C. planorbis											
Discorbinella floridensis											
Discorbis? bulbosa								1			
Fissurina pellucida			2		2		3	1	1		2
Florilus grateloupii	7	1	12		3		23	18	10		16
Fursenkoina pontoni	25	1	21	10	12		27	20	52	1	12
Gaudryina pauperata									3		
Glabratella charlottensis											
Globocassidulina minuta									1	1	
Glomospira elongata			1								
G. cf. gordialis											4
Haplophragmoides cf. canariensis											
Hopkinsina milletti	1		3	1				1			
Lagena laevis							2	1			
Loxostomum porrectum					2						
Miliolinella subrotunda			2			2	2				6
Monalisydium politum											
Neoconorbina cf. orbicularis						1					
Nouria polymorphinoides											
Parvigenerina fusiformis				1	1		1				
Protoelphidium sp.			1(1)				2	1(1)			3
P. delicatulum											
Pseudonodosaria torrida							1				
P.								1			
Pyrgo elongata											
Quinqueloculina agglutinans											
Q. candeiana			2				1				
Q. lamarckiana			1(2)								
Q. poeyana			1(2)			3					
Q. rhodiensis						1					2
Q. sp. 1	2		11		3	2	5	1	6		6
Q. sp. 2	1		2		1		4				24
Q. sp. 3					2		2				
Q. sp. 4			1		2	1					
Q. sp.											
Q. subpoeyana									1		
R. caribensis									1		
R. nana	1								1		
R. scotti	1		1		1			1	14		
Rosalina floridana			1			24	1				2
Rotorbinella cf. murrayi											
R. sp. 1						9					
Saccammina cf. atlantica											
Sagrina cubana											
S. pulchella											
Sigmavirgulina tortuosa											
Sigmoilopsis arenata											
Siphogenerina duartei											

Table 9 cont'd.

	Ju-4 0-1 cm.	Ju-4 1-2 cm.	Ju-5A 0-1 cm.	Ju-7 0-1 cm.	Ju-9 0-1 cm.	Ju-11 0-1 cm.	Ju-16 0-1 cm.	Ju-17 0-1 cm.	Ju-18A 0-1 cm.	Ju-18A 1-2 cm.	Js-24 0-1 cm.
Siphotextularia cf. saulcyana											
Spirolina sp.											
Spiroloculina caduca											
Textularia fiterrei meningoi											
T. earlandi			1				1		7		2
T. sp.					1						
Tretomphatus bulloides						3					
Triloculina fit errei meningoi											
T. sidebottomi			1								
T. sp.			3		2						
T. trigonula						3					
Trochammina cf. advena											
T. discorbis				1			2				
T. cf. squamata											
	51	7	122	26	101	79	119	64	168	20	309

(1) Protoelphidium?
(2) Cf.

NUMBER OF LIVING FORAMINIFERS PER STATION AT JOBOS BAY IN JUNE 9 (Ju) AND SEPTEMBER 29 (Js), 1972

	Js-24 1-2 cm.	Js-29 0-1 cm.	Js-29 1-2 cm.	Js-43 0-1 cm.	Js-44 0-1 cm.	Ju-46 0-1 cm.	Ju-48 0-1 cm.	Ju-49 0-1 cm.	Ju-50 0-1 cm.	Ju-52 0-1 cm.	Ju-52 1-2 cm.
Acervulina inhaerens							1				
Ammobaculites directus						1	1				
A. exilis						1	1	1			
A. salsus									1(2)	1	
Ammonia catesbyana f. typica											
A. catesbyana f. tepida								14	16	16	
A. catesbyana f. high spire											
A. catesbyana s.l.	232	40	17	75	12	101	72				27
A. parkinsoniana											1
Amphistegina gibbosa									1		
Angulogerina sp.						1	2	1	1	2	2
Articulina cf. pacifica											
Astrononion stelligera			1								
Baggina philippinensis									1	1	
Bolivina pseudoplicata						4					
B. rhomboidalis											
B. variabilis						2				2	
Brizalina inflata											
B. lowmani						3(2)					5(2)
B. sp.	6				2	1				2	
B. striatula						4		4	2	3	
Bulimina marginata						5	3			1	
Buliminella elegantissima								1			
Cancris sagra										1	1
Cibicides, sp. A.										1	1
Cribroelphidium actvenum						1					3
C. cariacaense							14				
C. discoidale											1
C. poeyanum poeyanum	2(2)	4	3	1		8	4	3	5	2	1
C. poeyanum kugleri							5				
C. sp.	15					3			1		1
Cyclogyra involvens							14	1	5	1	
C. planorbis						3					
Discorbinella floridensis			1							2	
Discorbis? bulbosa							1			1	
Fissurina pellucida	1					3			1		
Florilus grateloupii		8				16	12	4	4	2	
Fursenkoina pontoni	2	12				34	4	5	8	1	1
Gaudryina pauperata											
Glabratella charlottensis							2				
Globocassidulina minuta							1	1			
Glomospira elongata							3				
G. cf. gordialis									2(2)		
Haplophragmoides cf. canariensis						1	2				
Hopkinsina milletti						2				2	
Lagena laevis						1		1			
Loxostomum porrectum							2		2(2)	1	1
Miliolinella subrotunda		2					1				
Monalisydium politum											1
Neoconorbina cf. orbicularis										1	1
Nouria polymorphinoides						3	11	5			
Parvigenerisa fusiformis						1	1				
Protoelphidium sp.							2			1	
P. delicatulum						6			1		
Pseudonodosaria torrida							3	2	2		
P.								2			
Pyrgo elongata											2
Quinqueloculina agglutinans							1(2)				
Q. candeiana							6		1		
Q. lamarckiana						2(2)	1				
Q. poeyana						2	2				
Q. rhodiensis											
Q. sp. 1	1	12			4	12	16	1	4		3
Q. sp. 2						2	16	2	1		
Q. sp. 3		2				16			1		3
Q. sp. 4							5				
Q. sp.						4	4		3	1	
Q. subpoeyana							6				
R. caribensis						1	1	2			
R. nana							1				
R. scotti		4				2					
Rosalina floridana						1	2		1		3
Rotorbinella cf. murrayi						3					
R. sp. 1								1			
Saccammina cf. atlantica							1				
Sagrina cubana						1					
S. pulchella						2	1				1
Sigmavirgulina tortuosa						1	1				
Sigmoilopsis arenata						2	2				
Siphogenerina duartei										1	

Table 9 cont'd.

	Js-24 1-2 cm.	Js-29 0-1 cm.	Js-29 1-2 cm.	Js-43 0-1 cm.	Js-44 0-1 cm.	Ju-46 0-1 cm.	Ju-48 0-1 cm.	Ju-49 0-1 cm.	Ju-50 0-1 cm.	Ju-52 0-1 cm.	Ju-52 1-2 cm.
Siphotextularia cf. saulcyana							1				
Spirolina sp.										1	
Spiroloculina caduca							2				
Textularia fiterrei meningoi											
T. earlandi							1				
T. sp.							2	1			
Tretomphatus bulloides						1					
Triloculina fiterrei meningoi								1		1	
T. sidebottomi											
T. sp.							2				
T. trigonula							7(2)		1		
Trochammina cf. advena						1	4		1	1	
T. discorbis									1		
T. cf. squamata								1			2
	259	84	22	76	18	258	247	55	67	50	63

(1) Protoelphidium?
(2) Cf.

TABLE 10

NUMBER OF LIVING "PYRITIZED" FORAMINIFERS PER STATION IN
JOBOS BAY, JUNE 9, 1972

	4 0-1cm	4 1-2cm	5A 0-1cm	7 0-1cm	9 0-1cm	11 0-1cm	17 0-1cm	18A 0-1cm	18A 1-2cm
Ammonia catesbyana	2	1	2	3	7	2	2	1	4
Brizalina sp.	1								
Cribroelphidium spp.		1			2				

	46 0-1cm	48 0-1cm	50 0-1cm
Ammonia catesbyana	5	5	
Baggina philippinensis			1
Brizalina sp.			
Cribroelphidium spp.		1	1
Quinqueloculina sp.	1	1	

TABLE NO. 11

SPECIES DIVERSITY BY THE FORMULA OF INFORMATION FUNCTION IN JOBOS BAY, JUNE 1972 AND SEPTEMBER 1972

Ju- 4, 0-1cm	1.29	Js-29A, 0-1cm	1.60
Ju- 4, 1-2cm	0.80	Js-29A, 1-2cm	0.76
Ju-5A, 0-1cm	2.25	Js-43, 0-1cm	0.06
Ju- 7, 0-1cm	1.75	Js-44, 0-1cm	0.84
Ju- 9, 0-1cm	2.00	Ju-46, 0-1cm	2.52
Ju-11, 0-1cm	2.19	Ju-48, 0-1cm	2.93
Ju-16, 0-1cm	2.19	Ju-49, 0-1cm	2.57
Ju-17, 0-1cm	1.67	Ju-50, 0-1cm	2.73
Ju-18A, 0-1cm	1.79	Ju-52, 0-1cm	2.69
Ju-18A, 1-2cm	0.97	Ju-52, 1-2cm	2.22
Js-24, 0-1cm	1.76	Js-54, 0-1cm	1.26
Js-24, 1-2cm	0.45		

PUERTO RICO NUCLEAR CENTER
RESEARCH REPORT ON
ALGAE OF JOBOS AND GUAYANILLA BAYS

Purpose:

During this three-month study, algae from Jobos Bay and from Guayanilla Bay were collected, identified, and then preserved. This investigation was undertaken for several purposes:

1. To compare the algae from a relatively unspoiled bay (Jobos) to those of a bay spoiled by chemical and thermal pollution from industries (Guayanilla).
2. Within Guayanilla Bay alone:
   a. To measure the effects of thermal pollution on algae, using stations at varying distances from the source of the hot effluent from the fossil fuel power plant.
   b. As part of baseline study before two new units are added to the power plant, so that changes over time can be studied.
3. At Jobos Bay alone:
   a. As part of a study to determine if a power plant should be built there.
   b. If the plant is to be built, as part of a baseline study for determination of the environmental impact of the proposed power plants on the marine life of the bay.
4. To build up a reference collection of herbarium sheets and slides for future investigators.
5. To add to the general scientific knowledge by contributing to the catalogue of Puerto Rico's marine flora (including hopes of finding previously unreported species or areas of distribution).

Procedure:

The investigation was conducted for three months, March 29 to June 30, 1972. Trips to the study areas for sampling were as follows:

March 29-30	Jobos Bay
April 5	Jobos Bay
April 11	Guayanilla Bay
April 25-26	Jobos Bay
May 5	Guayanilla Bay
May 11	(outside) Guayanilla Bay (A. Froelich and S. Kolehmainen, collectors)
May 30	Guayanilla Bay
May 30-June 1	Jobos Bay

Also, a trip to the Union Carbide Plant at Guayanilla was made on May 24 to observe their primary and secondary treatment of waste water, before returning it to the bay.

On these field expeditions, algae were collected from the benthic habitat by skin-diving, as well as from mangrove roots reached by the boat. The algae were placed in a 5% formalin-sea water solution and brought back to the lab for identification. Larger algae were mounted on herbarium paper as dry specimens, while slides were made of micro-algae. These specimens are maintained as a collection for future reference.

Results:

The data are listed in the voluminous tables included with this report. A list of all algae collected has been tabulated, with the numbered sequence corresponding to the numbers on the herbarium sheets and slides. This is intended as a key for the reference collection. The remainder of the data sheets are reports on each station, including the name, date sampled, location, description of site, and information on the algae as to the dominant species, the habitat, and the list of specimens by taxonomic groups: Chlorophyta, Rhodophyta, Phaeophyta, Cyanophyta, and Bacillariophyceae.

The results as to the distribution of species per station are tabulated on a chart, along with two maps plotting the stations and the number of species corresponding to each.

Before discussing the results in relation to the purposes, it is necessary to make some comments on the parameters for determining what is a "good" algal situation and what is a "bad" one. This is a prerequisite before value judgments can be placed on the determination of the effects of an environmental factor upon algae. Some sort of species diversity index, usually more elaborate than the actual raw number of species as used here, is currently popular in ecologic studies for use in environmental impact studies. Higher diversity is generally considered more desirable in terms of stable systems. However, as this parameter alone seems insufficient to the author, the number of species in each order of algae is included so that one may get a feeling for the kind of predominant algal group represented at each station. Also, in the descriptive write-up of each station, the dominant algal species are mentioned.

Moreover, a quantitative biomass parameter for the algae at each station would have been desirable because the number of species does not necessarily represent the abundance of algae. While a high number of species generally means a high biomass of algae (except in the case of having many species of crustose reds or of blue-greens), a lower number of species does not necessarily mean low biomass, but may only reflect the fact that one or two species are extremely dominant. Keeping these factors in mind, an interpretation of the results in relation to the purposes can be attempted.

1. Comparison of the two bays in general:

    The turtle grass beds at Jobos Bay have far more species than those at Guayanilla Bay; the dominant species at Jobos are the greens and the most numerous species fall in the red and green group with a high variety represented. The dominant species and the group with the highest number of species at Guayanilla are the red algae, mostly as small epiphytes on turtle grass blades. These may represent an indication of a more rapid absorption at the wave lengths of red light in Guayanilla. However, the healthy turtle grass station outside Guayanilla Bay's mouth has a variety of species in both the red and green groups.

    Regarding the mangrove stations, the number of species at some of the Guayanilla stations (M0, M10, M3-M4) are comparable to that at Jobos, while others (F, M7, M6, M5) fall short of Jobos in species diversity. These latter stations also show blue-greens and greens as the dominant groups while the healthy stations from both Jobos and Guayanilla show greens and reds as predominant.

The reef area (and Pta. Verraco rocky shoreline) outside Guayanilla Bay is relatively unpolluted and yields comparable numbers of species, with a predominance of reds, to the Jobos Bay reef stations.

In general, there are more brown alga at Jobos, except for outside Guayanilla Bay. Also, Jobos Bay stations generally exhibit the same number of species of blue-greens as those at Guayanilla, but the number of species from other groups is higher so the blue-greens have relatively less numerical importance. The blue-greens and some of the filamentous greens seem the best adapted to survive the pollution at Guayanilla, while the reds, calcareous greens, and browns seem to be eliminated.

2. Within Guayanilla Bay:

The turtle grass beds seem to exhibit low species diversity over the entire bay, both the control stations and the others. Based on temperature studies conducted by the Guayanilla Bay Project, TG1 = TG2 > TG3 > TG5 $\geq$ TG4; this temperature gradient does not seem to correlate with the number of species or type of groups represented. In fact, the two warmest stations have a few more species than the other three stations. The collections from these beds may not contain a very representative sampling since they are difficult to sample due to the water being too dirty and too shallow for snorkeling and too turbid to see the bottom well when wading and digging. Perhaps the effects of chemical pollution are the main factor here -- turbidity plus chemicals tend to be inhibitory of algae over a wide range of temperatures. At the turtle grass bed station outside the bay's mouth, a fair number of species was found, with reds predominating, indicating the pollution is not critical out this far.

A definite temperature effect on species number and type can be seen at the Guayanilla mangrove stations. Temperature-wise, F > M7 > M6 > M9 $\geq$ M5 > M3 + M4 > M0 related to distance from the source of hot effluent (plus the factor of topographic configuration and current direction). The corresponding total number of species is: F=3, M7=4 or 5, M6=3, M9=5, between

M3+M4=10, M10+5, and M0=17. Thus, there appears to be an inverse relationship between high temperatures and high number of species. Furthermore, regarding types of algae, the hotter stations have primarily blue-greens and secondarily greens, while the three coldest stations have primarily reds and secondarily greens. On mangrove roots, red algae seem to be the most vulnerable to higher temperatures and are eliminated early.

The reef (and rocky shore) outside the bay is also in a relatively less polluted area where the temperatures are normal or nearly so. Here the number and type of species seem to be comparable to Jobos.

3. At Jobos Bay:

Three environments, turtle grass beds, mangrove roots, and reefs (with the first and third overlapping), were sampled, plus two stations of mud bottom samples. These habitats support a rich variety of algal life.

Conclusions:

1. In regard to the parameters of total number of species, distribution of these species among the algal groups, and dominant species at each station, Jobos Bay far surpasses Guayanilla Bay in its complement of algae. Pollution at Guayanilla reduces the total number of species and transforms the dominant groups and dominant species to those of the blue-greens and filamentous greens.

2. In Guayanilla, higher temperatures are inversely related to diversity of species. However there is a reversal in dominance among species of the mangrove stations. This may be a synergistic effect of temperature, chemicals, and turbidity. There appears to be a positive correlation among the turtle grass stations. This may be due to chemical pollution and turbidity being the major limiting factors here. Addition of units to the power plant may increase temperatures even more, causing a shift in the healthy mangrove root stations toward the status of the present unhealthy ones.

3. Jobos Bay is a rich and complex set of communities. In this regard, the algal communities are of primary importance to the health and production of the area.

Regarding the proposed nuclear and fossil fuel plants, one must make a decision as to which course will have the most desirable long-range effects, both on the natural systems of the bay and on the quality as well as quantity of life of the human elements of the Puerto Rico ecosystem. Hindsight is better than foresight; it is difficult to predict what effects today's actions will produce tomorrow.

Remarks:

The value of this study is limited by factors: limited time of study (three months--April, May and June), omission of the planktonic algae, and by the limited availability of references. In this latter regard, much credit and thanks are to be given to Alida Ortiz and Dr. Luis Almodovar of the Marine Sciences Institute of the University of Puerto Rico for their assistance in identifying some of the specimens, particularly the red algae.

Chart of Distribution of Species by Algal Groups
and Total Number of Species Per Station

ALGAL GROUPS + NO. OF SPP.

STATION	CHLOROPHYTA	RHODOPHYTA	PHAEOPHYTA	CYANOPHYTA	TOTAL
Jobos Bay					
R-X	3	12	2	2	19*
R+TH-Y6	8	11	2	3	24
R+Th-Z	2	6	2	1	11
TH3	9	9	4		22
TH2	3	1		2	6
V			3		3
W	6	4	4		14
M14	7	5	5	1	18*
M15	4	4	1		9
M17	4	3		1	8*
M18	4	4		4	12*
M19					0
M20	2	1			3
M21	2	2		1	5
M22	3	13		3	19*
M23	1	4		1	6*
Guayanilla Bay					
B11	4	7			11 (washed up)
MO	7	8		2	17*
M10	5	8		2	15*
bet. M3+M4	4	6			10*
M5	1			4	5*
bet. M5+M6					0
M9	2			3	5

ALGAL GROUPS + NO. OF SPP.

STATIONS	CHLOROPHYTA	RHODOPHYTA	PHAEOPHYTA	CYANOPHYTA	TOTAL
Guayanilla Bay					
M6	2	1			3
M7	1 or 2			3	4 or 5*
F	1			2	3
TG1	1	4 or 5			5 or 6
TG2	1	2		1	4
TG3		1			1
TG4		1	1		2
TG5		3			3
TG-A	4	5			9
B	3	11	3		17
R-C	1	10	2		13

*diatoms present

SAMPLING STATIONS - JOBOS BAY

NAME	:	M19 DATE: 5/31 TOTAL: 0 spp.
LOCATION	:	Middle of the back (north) side of large Cayos de Barca
DESCRIPTION	:	Very shallow; in front is a turtle grass bed with underlying coral rubble; close to shore lies "quick sand" bottom (making site almost inaccessible); except for a few bryozoans, roots barren on mangroves at edge of water
ALGAE	:	none observed on 3 sample roots brought back; habitat mangrove roots.

SAMPLING STATIONS - JOBOS BAY

NAME : M20 DATE: 5/31 TOTAL: 3 spp.

LOCATION : Embayment on west side of Cayo Puerca, with a narrow channel running into cay

DESCRIPTION : At mouth of channel - clear, mud bottom with crab holes and _C. sertularoides_; channel 6' wide, a tunnel overhung with mangroves; featherduster worms, black and clear ascidians, pink sponges, bryozoans

ALGAE : dominated by _Caulerpa verticillata_ and _Spyridia filamentosa_; habitat on mangrove roots

1. _Chlorophyta_ 2 spp.

   Caulerpa verticillata 295

   C. racemosa 296

2. _Rhodophyta_ 1 sp.

   Spyridia filamentosa 297

SAMPLING STATIONS - JOBOS BAY

NAME : M21 DATE: 5/31 TOTAL: 5spp.

LOCATION : Northernmost tip of Cayo Puerca

DESCRIPTION : Mangrove point with prop roots at edge of water; oysters, sponges

ALGAE : dominantly Acanthophora spicifera and Lyngbya majuscula, also significant Caulerpa sertularoides, C. racemosa; habitat on mangrove root except: 307 epiphytic on 305

1. Chlorophyta 2 spp.

Caulerpa sertularoides 304

C. racemosa 306

2. Rhodophyta 2 spp.

Acanthophora spicifera 305

Spyridia filamentosa 308

3. Cyanophyta 1 sp.

Lyngbya majuscula 307

SAMPLING STATIONS - JOBOS BAY

NAME : M22 DATE: 5/31 TOTAL: 19 spp.*

LOCATION : East side of north tip of Cayo Puerca

DESCRIPTION : In wide channel between cays; black and orange ascidians, oysters, blue sponge, bryozoans

ALGAE : Many different types, dominantly Centroceros clavulatum, Heterosiphonia wurdemanni, Acanthophora spicifera, Spyridia filamentosa; habitat mangrove roots except 309-a epihytic on 309; 312-a to 312-e on 312; 313 also on 320; 317 epiphytic on 318 and 314; 315-a and 315-b on 315; 317-a to 317-d on 317; 320-a to 320-e on 320.

1. Chlorophyta 3 spp.

Rhizoclonium kochianum (cf. Kerneri) 312-a 317-c, 320-a

Enteromorpha chaetomorphoides 312-b, 315-a 319, 320-c

Caulerpa racemosa 318

2. Rhodophyta 13 spp.

Bostrychia tenella 309

Centroceros clavulatum 310, 312-d

Polysiphonia ferulacea 311

Polysiphonia sp. 312-c, 320-b

Heterosiphonia wurdemanni 312, 315

Acanthophora _spicifera_ 314

Pterocladia sp. 317

Griffithsia _globulifera_ 317

Ceramium _fastigiatum_ 317-a

Callithamnion _byssoides_ 317-b

Goniotrichum _alsidii_ 320-d

Erythrotrichea _carnea_ 320-e

Spyridia _filamentosa_ 320

4. Cyanophyta 3 spp.

Nostoc sp. or _Anabaena_ sp. 313

Lyngbya _majuscula_ 316, 319

unidentified _colonial_ blue-gree alga 309-a

5. Bacillariophyceae*

diatoms present 312-e, 315-b, 317-d, 319-a

SAMPLING STATIONS - JOBOS BAY

NAME : M23 DATE: 5/31 TOTAL: 6 spp.*

LOCATION : Channel between 2 long fingers of the shoreline peninsula north of Cayo Puerca.

DESCRIPTION : Wide mouth bordered by mangroves with prop roots; oysters, tree oysters, black and orange ascidians, barnacles

ALGAE : Dominantly Caulerpa sertularoides, Acanthophora spicifera, Lyngbya majuscula; habitat mangrove roots except: 299 epiphytic on 298, 300 and 301 on 298.5, 299-a and 299-b on 299

1. Chlorophyta — 1 sp.

Caulerpa sertularoides 298

2. Rhodophyta — 4 spp.

Acanthophora spicifera 298.5

Pterocladia sp. 299

Erythotrichea carnea 299-a

Spyridia filamentosa 301.5

2. Cyanophyta — 1 sp.

Lyngbya majuscula 300, 301

5. Bacillariophyceae*

diatoms present 299-b, 300-a

SAMPLING STATIONS - JOBOS BAY

NAME : R-X DATE: 4/5 TOTAL: 19 spp.*

LOCATION : Coral reef on Cayos Caribes side (east) of Boca del Infierno

DESCRIPTION : 10' deep, fairly murky; large coral heads, Acropora palmata, gorgonians, etc.

ALGAE : A few algae visible, commonest is Dictyoptens delicatula, also small coral epiphytes and Amphiroa rigida; habitat on bottom or in crevices except: 47's on coral, 49a to i epiphytic on 49, 50-a and 50-b on 50, 52 on 50, 52-a on 52, 110 floating

1. Chlorophyta 3 spp.

Cladophora sp. 47E

Halimeda opuntia 48

Bryopsis pennata 49

2. Rhodophyta 12 spp.

Champia parvula 47C

Melobesia membranacea 49-g, 52-a

Polysiphonia sp., 47E-a, 49-f

Ceramium fastigiatum 49-a, 50-a

Erythrotrichia carnea 49-c, 50-b

Acrochaetium sp. 49-d

Erythrocladia subintegra 49-e

Amphiroa rigida 50

Peyssonnelia rubra 47A, 47D

Gelidium corneum 47B

Gelidiella acerosa 52

unidentified red alga 49-b

3. *Phaeophyta* 2 spp.

Dictyopens delicatula 51

Sargassum fluitans 110

4. *Cyanophyta* 2 spp.

microcoleus lyngbyensis 47E-b

Lyngbya confervoides 49-h

5. *Bacillariophyceae**

diatoms present 49-i

SAMPLING STATIONS - JOBOS BAY

NAME : R+TH-Y DATE: 4/5 TOTAL: 24 spp.

LOCATION : In front of (south of) Cayo Puerca shore

DESCRIPTION : Very shallow, 1/2-3' deep, clear; old fringing reef with some active coral sites, smaller heads, Acropora palmata, turtle grass beds with sand composed of Halimeda plates

ALGAE : Many algae, dominated by Penicillus capitatus Halimeda spp., Udotea flabellum, Avrainvillea rawsoni, Amphiroa spp.; habitat on bottom except: 53's on coral; 64-a epiphytic on 64, 69's on turtle grass and Udotea, 70-a and 70-b on 70

1. Chlorophyta 8 spp.

Halimeda opuntia 55

H. tuna 59

Caulerpa racemosa 55.5, 58, 62

C. sertularoides 57

Udotea flabellum 56

Penicillus capitatus 63

Avrainvillea rawsoni 60

unidentified green alga 69-d

2. Rhodophyta 11 spp.

crustose corallinaceous alga 53A

branding corallinaceous alga 53B

Amphiroa tribulus 54

A. fragilissima 61A

SAMPLING STATIONS - JOBOS BAY

NAME : R+TH-Z DATE: 4/25 TOTAL: 11 spp.

LOCATION : Northwest end of Cayo de Pájaros

DESCRIPTION : 3-5' deep, fairly clear; "lagoon" back-reef area behind reef flat; spaced large gorgonians, corals, sandy areas, with turtle grass beds in shallower parts; Diadema present

ALGAE : Not extremely rich in algae, dominated by Penicillus capitatus and Laurencia obtusa; habitat on sandy bottom except 113 on hard substrate, 111 floating, 117, 118, 119's, 120's epiphytic on turtle grass

1. Chlorophyta 2 spp.

Penicillus capitatus 112

Dictyosphaeria cavernosa 113

2. Rhodophyta 6 spp.

Amphiroa rigida 114

Laurencia obtusa 116

Ceramium sp. 119-a

C. strictum 117

Melobesia membranacea 119-b, 120A, 120B

unidentified red alga 115

3. Phaeophyta 2 spp.

Sargassum natans 111

Dictyota sp. 118

4. Cyanophyta 1 sp.

Lyngbya majuscula 119

SAMPLING STATIONS - JOBOS BAY

NAME : TH3 DATE: 3/29 TOTAL: 22 spp.

LOCATION : Behind (north of) Cayos de Barca

DESCRIPTION : 3-5' deep, clearwater; sandy bottom; live turtle grass beds (*Thalassia testudinum*); many sea urchins (white species and *Diadema*), a few conchs

ALGAE : Many calcareous algae, predominantly *Halimeda* spp., *Penicillus capitatus*, and *Udotea flabellum*, contributing to sand particles; *Laurencia* spp., *Amphiroa* spp. also significant; habitat on bottom except: 1-a epiphytic on 1, 5-a on 5, 7 on 6, 19 and 20 on sea pen, 23 on 22, 24's on turtle grass, 21 floating

1. *Chlorophyta* 9 spp.

Caulerpa cupressoides 1

C. taxifolia 2

C. racemosa 11

Halimeda opuntia 3, 22A, 26

H. tuna 22B

Ernodesmis verticillata 5

Penicillus capitatus 13A

Udotea flabellum 13B

Valonia ventricosa 20

2. *Rhodophyta* 9 spp.

Melobesia membranacea 1-a, 5-a, 24

Laurencia obtusa 6

L. poitei 12

Laurencia sp. 9,23

Polysiphonia ferulacea 7

Amphiroa rigida 10

A. fragilissima 25

Jania sp. 4

Ceramium byssoideum 24-a

Callithamnion sp. 24-b

3. *Phaeophyta* 4 spp.

Dictyota divaricata 19

D. cervicornis 8, 19

Sargassum natans 21

S. fluitans 21

SAMPLING STATIONS - JOBOS BAY

NAME : TH2 DATE: 3/30 TOTAL: 6 spp.

LOCATION : In front of (south of) mangrove peninsula to the west of Cayo Puerca, across from opening between Cayos de Pájaros and de Barca

DESCRIPTION : 1/2-2' deep, clear water; dominated by turtle grass and manatee grass (*Syringodium filiforme*); sandy bottom

ALGAE : Predominantly *Penicillus capitatus* and *Halimeda opuntia* (underlying grass beds); turtle grass epiphytes like *Melobesia membranacea* and blue-greens fairly common habitat on bottom except: 16, 17, 18 on turtle grass

1. *Chlorophyta* 3 spp.

   Halimeda opuntia 14

   H. tuna 14

   Penicillus capitatus 15

2. *Rhodophyta* 1 sp.

   Melobesia membranacea 17

4. *Cyanophyta* 2 spp.

   Lyngbya sp. 16

   Nostoc sp. or *Anabaena* sp. 18

SAMPLING STATIONS - GUAYANILLA BAY

NAME	: M9 DATE: 4/11 TOTAL: 5 spp.
LOCATION	:: Channel on north side of Tallaboa Poniente
DESCRIPTION	: Murky, fairly shallow; narrow channel overhung by mangroves leading to stagnant pool surrounded by mangroves with prop roots, old sunken logs, etc.
ALGAE	: little algae; by far; dominated by _Caulerpa verticillata_; habitat mangrove roots and partly submerged logs

1. Chlorophyta 2 spp.

   Caulerpa verticillata 97

   Vaucheria sp. 99

4. Cyanophyta 3 spp.

   Lyngbya majuscula 98, 99-a

   Nostoc sp. or _Anabaena_ sp. 99-b

   Microcoleus sp. 99-c

SAMPLING STATIONS - GUAYANILLA BAY

NAME	:	Between M5 and M6 DATE: 5/5, 5/30 TOTAL: 0 spp.
LOCATION	:	Southwest corner of effluent side of bay
DESCRIPTION	:	Mangrove roots at edge of water; tar or oil layer covering on roots; dead tree oyster shells; little if any fauna
ALGAE	:	Very little if any

SAMPLING STATIONS - GUAYANILLA BAY

NAME	:	M7 DATE: 4/11, 5/5, 5/9 TOTAL: 4 or 5 spp.*
LOCATION	:	Point across from effluent from power plant
DESCRIPTION	:	Murky, shallow, mangroves with roots in water, dead or unhealthy (show signs of stress as very thin long prop roots hanging down); dead tree oyster shells; a few hermit crabs, old shells, isopods in barnacle shells
ALGAE	:	Little algae; 4/11-only algae observed was diatomaceous slime on bark of roots; 5/5 and 5/9 large masses of slime (*Rhizoclonium*) floating on surface and streaming out in current path; habitat mangrove roots

1. *Chlorophyta* 1 or 2 spp.

   Rhizoclonium kochianum (cf. *kerneri*) 186

   R. kerneri 204

SAMPLING STATIONS - GUAYANILLA BAY

NAME : M5 DATE: 4/11, 5/5, 5/30 TOTAL: 5 spp.*

LOCATION : On south side of channel leading into effluent bay (on peninsular arm on north side of Tallaboa Poniente)

DESCRIPTION : Shallow, murky; "pile" of dead mangroves and mangroves (both live and dead) with roots at edge of water; some crabs

ALGAE : Little except for Caulerpa verticillata and blue-greens mixed with diatoms

1. Chlorophyta 1 sp.

Caulerpa verticillata 179, 267

4. Cyanophyta 4 spp.

Lyngbya majuscula 100

Nostoc sp. or Anabaena sp. 180

Spirulina subsalsa 268

unidentified blue-green alga 100

5. Bacillariophyceae*

diatoms present 100, 268

SAMPLING STATIONS - GUAYANILLA BAY

NAME	:	M6 DATE: 5/5 TOTAL: 3 spp.
LOCATION	:	East of effluent along mangrove shore
DESCRIPTION	:	Fairly shallow, murky; mangroves with roots at edge of water; mangroves not too healthy
ALGAE	:	Little algae, except for one big glob of *Enteromorpha Clathrata*; habitat mangrove roots.

1. *Chlorophyta* 2 spp.

   Enteromorpha clathrata 175

   Enteromorpha sp. 177

2. Rhodophyta 1 sp.

   unidentified red alga 176

SAMPLING STATIONS - JOBOS BAY

NAME : M14 DATE: 3/29 and 5/31 TOTAL: 18 spp.*

LOCATION : Embayment on west side of Cayo Puerca

DESCRIPTION : 3-4' deep, murky; red mangroves (Rhizophora mangle) with prop roots at edge of water; oysters uppermost, barnacles, ascidians (black, orange, clear), featherduster worms

ALGAE : mainly Acanthophora spicifera, Caulerpa racemosa, and Giffordia mitchellae with Rhizoclonium; also important (from 5/31) Giffordia rallsiae and Lyngbya majuscula; habitat on mangrove roots except: 37, 38 some of 277 epiphytic on 276, 278 on 276 and 281, 279's around stalk of 281.

1. Chlorophyta 7 spp.

Caulerpa racemosa 27, 276

C. sertularoides 35

C. verticillata 282

Enteromorpha chaetomorphoides 36B, 40-a, 44, 45, 46

Chaetomorpha gracilis 44

Rhizoclonium kochianum (cf. Kerneri) 36B, 44

Cladophora sp. 44, 45, 46

2. Rhodophyta 5 spp.

Acanthophora spicifera 39, 281

Spyridia filamentosa 40, 277

Ceramium fastigiatum 44

Polysiphonia sp. 44

Callithamnion byssoides 278

3. Phaeophyta 5 spp.

Giffordia mitchellae 36A, 36B, 43, 44, 45, 46

G. rallsiae 279

Sargassum natans 37

S. fluitans 37, 38

Dictyota indica 41

4. Cyanophyta 1 sp.

Lyngbya majuscula 36B, 40-b, 42, 43-a, 44, 279-a, 280

5. Bacillariophyceae*

diatoms present 36B, 44, 46

SAMPLING STATIONS - JOBOS BAY

NAME : M15 DATE: 3/29 and 5/31 TOTAL: 9 spp.

LOCATION : On northwest knob of island directly north of Cayo Puerca

DESCRIPTION : 3-4' deep, murky; red mangroves with prop roots at edge of water; rich fauna (esp. 5/31) including oysters, ascidians (black, orange, clear), barnacles, worms, isopods, sponges, bryozoans

ALGAE : less than M14 on 3/29, but fairly abundant on 5/31; 3/29 - dominated by Caulerpa verticillata, C. racemosa, and blue-green algae zone; 5/31 dominated by Acanthophora spicifera, C. racemosa, and Spyridia filamentosa; habitat on mangrove roots.

1. Chlorophyta 4 spp.

Caulerpa racemosa 27, 272

C. verticillata 28

Chaetomorpha linum 29

Bryopsis pennata 275

2. Rhodophyta 4 spp.

Gracilaria verrucosa 30,31

Acanthophora spicifera 32, 271

Spyridia filamentosa 273

Bostrychia tenella 274

3. Phaeophyta 1 sp.

<u>Dictyota</u> <u>cervicornis</u> 33

SAMPLING STATIONS - JOBOS BAY

NAME : M18 DATES: 4/25 and 5/31 TOTAL: 12 spp.*

LOCATION : Channel behind reef between 2 large islands of Cayos de Barca

DESCRIPTION : 7' deep, very clear; mangroves with prop roots surrounding channel with an island in the middle toward the reefward end; bottom scoured barren except for coral rubble and sea urchins, especially Diadema; roots generally sparsely populated

ALGAE : a few types, as Caulerpa racemosa, C. sertularoides; Callithamnion byssoides mixed with blue-green slime like Microcoleus sp. pronounced; habitat on mangrove roots

1. Chlorophyta 4 spp.

Caulerpa sertularoides 121

C. racemosa 122

Vaucheria dichotoma 126, 129

Cladophora sp. 124-a

2. Rhodophyta 4 spp.

Callithamnion byssoides 124, 302

Ceramium byssoideum 126-a

C. fastigiatum 129-a

Amphiroa fragilissima 127

4. Cyanophyta 4 spp.

Microcoleus sp. 124-c. 125, 302-a, 303

Lyngbya majuscula 124-e, 302-b

Nostoc sp. or Anabaena sp. 123

Oscillatoria sp. 124-d

5. Bacillariophyceae*

diatoms present 124-b

SAMPLING STATIONS - JOBOS BAY

NAME : M17 DATE: 5/31 TOTAL: 8 spp.*

LOCATION : Channel between island directly north of Cayo Puerca and Pta. Colchones

DESCRIPTION : Mangrove with prop roots bordering channel 25' wide; very rich fauna - tree oysters, barnacles, flatworms, isopods, clams, orange ascidians, featherduster worms

ALGAE : Many algae particularly Halimeda opuntia, Caulerpa taxifolia, C. racemosa, C. verticillata, Acanthophora spicifera, Pterocladia sp.; habitat on mangrove root except: 283 also on tunicate; 286 epiphytic on 283 + 285; 290 on 291; 287 on 283, 285, 289, 288 on 285; 293 also on 291.

1. Chlorophyta 4 spp.

Halimeda opuntia 283, 291

Caulerpa taxifolia 284

C. racemosa 289, 292

C. verticillata 286, 290

2. Rhodophyta 3 spp.

Acanthophora spicifera 285, 293

Pterocladia 287, 294

Spyridia filamentosa 288

3. Cyanophyta 1 sp.

Microcoleus sp. 287-a

4. Bacillariophyceae*

diatoms present 287-b

SAMPLING STATIONS - JOBOS BAY

NAME : V DATE: 5/31 TOTAL: 3 spp.

LOCATION : Grab sample 400 yds. behind (north of) Cayos de Barca on proposed outflow line

DESCRIPTION : mud bottom, 8 meters deep; little fauna

ALGAE : 3 species of Dictyota only; habitat on mud bottom

1. Phaeophyta 3 spp.

Dictyota bartayresii 269

D. divaricata 270

D. cervicornis 270

SAMPLING STATIONS - GUAYANILLA BAY

NAME : B11 DATE: 5/5 TOTAL: 11 spp. (washed up)

LOCATION : Playa Guayanilla

DESCRIPTION : Specimens washed up on dirty sandy beach and in shallow water wash, or on old beach-wood; angiosperm Halophila engelmannii present

ALGAE : a variety; dominantly Gracilaria spp., Spyridia aculeata, Acanthophora spicifera, Enteromorpha flexuosa; habitat washed up from other areas except: 153 and 160 growing on beach wood.

1. Chlorophyta 4 spp.

Enteromorpha flexuosa 153

Caulerpa prolifera 157

Ulva fasciata 158

Rhizoclonium kochianum (cf. Kerneri) 160

2. Rhodophyta 7 spp.

Gracilaria verrucosa 150

G. foliifera 155

Agardhiella tenera 151

Ceramium strictum 152

Acanthophora spicifera 154

Hypnea musciformis 156

Spyridia aculeata 159

SAMPLING STATIONS - GUAYANILLA BAY

NAME ; MO (control) Date: 4/11, 5/5, 5/30
TOTAL: 17 spp.*

LOCATION : At patch of mangroves on north side of Y-dock (incurrent side of power plant)

DESCRIPTION : very shallow, murky to fairly clear; mangroves with prop roots at edge of water; white colonial and black ascidians; also a small very shallow side pool with clear water and mud bottom.

ALGAE : A variety; 4/11 dominated by *Caulerpa racemosa* and *Acanthophora spicifera*; 5/5 *C. verticillata*, *C. sertularoides*, and *Centroceros clavulatum* also significant; 5/30 *Bryopsis pennata* also important; habitat on mangrove roots except: 163 on mud bottom of pool; 167 and 168 epiphytic on animal (on slide 167); 170 on tunicate; 170-a on 170; 173's on 171; 174A-a on 174; 174B-a and 174B-b on 174

1. *Chlorophyta* 7 spp.

Caulerpa racemosa 102, 103, 164, 171

C. verticillata 172

C. sertularoides 163

Halimeda opuntia 161

Bryopsis pennata 170, 265

Vaucheria sp. 66a

Rhizoclonium kochianum (cf. *kerneri*) 166, 168-b

2. Rhodophyta 8 spp.

Acanthophora spicifera 101, 165, 169

Centroceros clavulatum 162

Callithamnion byssoides 168, 173, 174B-a, 266

Polysiphonia sp. #1 and sp. #2 174A

Polysiphonia ferulacea 174B

Erythrotrichia carnea 173-a, 174B-b

Gelidium sp. 168-a

4. Cyanophyta 2 spp.

Lyngbya majuscula 173-b

Microcoleus lyngbyensis 173-c

5. Bacillariophyceae*

diatoms present 167, 168-c, 170-a, 173-d, 174A-a

SAMPLING STATIONS - GUAYANILLA BAY

NAME : M 10 DATE: 4/11 TOTAL: 15 spp.*

LOCATION : Small island in bay Cayo Mata

DESCRIPTION : 1/2-1' deep, clear; west side inlet-sandy bottom, clear shallow pool with shells, surrounded by mangroves; east side inlet-fairly sandy bottom next to mangroves with turtle grass bed just seaward.

ALGAE : Many types, predominantly Ulva lactuca, Centroceros clavulatum, Caulerpa taxifolia, C. racemosa, Gracilaria spp., Enteromorpha flexulosa; habitual mangrove roots except: 76 on sandy bottom of pool; 78 on floating stick, 86-a on 86.

1. Chlorophyta 5 ssp.

Ulva lactuca 76

U. fasciata 89

Enteromorpha flexuosa 78, 84

Caulerpa racemosa 79

C. taxifolia 80

2. Rhodophyta 8 spp.

Gracilaria verrucosa 75

G. mammilaris 82

G. foliifera 88

Centroceros clavulatum 77

Agardhiella tenera 81

Hypnea musciformis 83

H. cervicornis 85

Acanthophora spicifera 87

4. Cyanophyta 2 spp

Lyngbya sp. 86

L. majuscula 86

5. Bacillariophyceae*

diatoms present 86-a

SAMPLING STATIONS - GUAYANILLA BAY

NAME : F DATE: 5/9 TOTAL: 3 spp.

LOCATION : Outflow right where hot effluent current from power plant comes out under bridge.

DESCRIPTION : A corrugated metal wall and rocks form the edge of land impinged upon by water; some crabs, snails, barnacles

ALGAE : little algae except blue-green mats and Enteromorpha clatharata habit.

1. Chlorophyta 1 sp.

   Enteromorpha clatharata 207

4. Cyanophyta 2 spp.

   Microcoleus sp. 208, 209

   unidentified filamentous blue-green algae 209

SAMPLING STATIONS - GUAYANILLA BAY

NAME : TG1 DATE: 5/5 and 5/9 TOTAL: 5 or 6 spp.

LOCATION : South of mouth to effluent bay

DESCRIPTION : Very shallow, 1-2'; turtle grass bed on coral rubble bottom with much organic matter

ALGAE : fair amount-mainly Hypnea cervicornis and Acanthophora spicifera, but few epiphytes on blades; habitat on bottom except: 184 and 212's epiphytic on turtle grass blades.

1. Chlorophyta 1 sp.

Enteromorpha chaetomorphoides 212-a

2. Rhodophyta 4 or 5 spp.

Acanthophora spicifera 182, 210

Hypnea cervicornis 183, 211

Melobesia membranacea 184, 212

Ceramium byssoideum 185

Ceramium sp. 212-b

SAMPLING STATIONS - GUAYANILLA BAY

NAME : TG2 DATE: 5/9 TOTAL: 4 spp.

LOCATION : West of mouth to effluent bay

DESCRIPTION : Shallow; turtle grass bed

ALGAE : Little algae; habitat-as epiphytes on turtle grass blades

1. Chlorophyta 1 sp.

Enteromorpha sp. 215

2. Rhodophyta 2 spp.

Melobesia membranacea 214

Ceramium sp. 215

4. Cyanophyta 1 sp.

Lyngbya majuscula 215

SAMPLING STATIONS - GUAYANILLA BAY

NAME	:	TG3 DATE: 5/9 TOTAL: 1 sp.
LOCATION	:	East of Cayo Mata
DESCRIPTION	:	Very shallow; turtle grass bed on coral rubble with calcareous sand and organic matter
ALGAE	:	Little algae; habitat epiphytic on turtle grass blades

2. Rhodophyta 1 sp.

Melobesia membranancea 213

SAMPLING STATIONS - (OUTSIDE) GUAYANILLA BAY

NAME : TG-A DATE: 5/11 TOTAL: 9 spp.

LOCATION : Behind a reef - Arrecife Guayanilla

DESCRIPTION : Some turtle grass, manatee grass; sand bottom

ALGAE : A variety; (of specimens brought back) dominantly Agardhiella, Spyridia filamentosa, Hypnea musciformis; habitat on bottom except: 224 epiphytic on 223; 226 on 225; 248 and 249 on turtle grass blade

1. Chlorophyta 4 spp.

Ulva fasciata 221

Cladophora fascicularis 226, 248

Enteromorpha chaetamorphoides 226

Enteromorpha sp. 249

2. Rhodophyta 5 spp.

Agardhiella ramossissima 222

Gracilaria domingensis 223

Hypnea musciformis 224, 246

Spyridia filamentosa 225

S. aculeata 247

SAMPLING STATIONS - (OUTSIDE) GUAYANILLA BAY

NAME : B DATE: 5/11 TOTAL: 17 spp.

LOCATION : Punta Verraco - south shore

DESCRIPTION : Beach rocks along shore

ALGAE : Great variety; (of specimens brought back) dominantly Laurencia papillosa, Spyridia aculeata, Sargassum polyceratium, Padina; habitat on rocks except: 229 also on 228, 242-a and 242-b on 242

1. Chlorophyta 3 spp.

Caulerpa racemosa 233

C. sertularoides 234

Chaetomorpha media 239

2. Rhodophyta 11 spp.

Laurencia papillosa 228

Hypnea musciformis 229

Hypnea cornuta 245

Coelothrix irregularis 230

Spyridia aculeata 231, 240, 242

Gracilaria mammilaris 237

G. verrucosa 238

Centroceros clavulatum 240, 241, 242-b, 243

Gonitrichum asidii 242-a

Herposiphonia secunda 244

Amphiroa fragilissima 244-a

3. *Phaeophyta* 3 spp.

Sargassum polyceratium 227

Dictyopteris delicatula 232

Padina sanctae-erucis 236

SAMPLING STATIONS - (OUTSIDE) GUAYANILLA BAY

NAME : R-C DATE: 5/11 TOTAL: 13 spp.

LOCATION : On Arrecife Guayanilla - reef area

DESCRIPTION : Shallower part of reef plus deep hole (part submarine canyon - 90') to the west; angiosperm Halophila present

ALGAE : A variety; (from specimens brought back) dominantly Wrangelia argus and Callithamnion byssoides; Dictyota indica and Dictyopteris delicatula also significant; habitat at bottom of deep hole except: 259, 260, 261, 262 from sandy reef area

1. Chlorophyta 1 sp.

Ulva fasciata 251

2. Rhodophyta 10 spp.

Spyridia aculeata 252

S. filamentosa 253

Hypnea musciformis 254

Gracilaria verrucosa 255

G. mammilaris 256

Wrangelia argus 259

Agardhiella tenera 250

Callithamnion byssoides 260

Amphiroa fragilissima 261

Gelidium sp. 262

H	S	No.	Name
	x	18	Nostoc sp. or Anabaena sp.
x		19	Dictyota divaricata Lamouroux Dictyota cervicornis Kützing
x		20	Valonia ventricosa T. Agardh
x		21	Sargassum natans (Linn.) J. Meyen Sargassum fluitans Børgesen
x		22A	Halimeda opuntia (Linn.) Lamouroux H.o. F. tribola (Dec.) Barton
x		22B	Halimeda tuna (Ellis + Sol.) Lamouroux
x		23	Laurencia sp. Lamouroux
	x	24 24-a 24-b	Melobesia membranacea (Esper) Lamouroux Ceramium byssoideum Harvey Callithamnion sp. Lyngbye
x		25	Amphiroa fragilissima (Linn.) Lamouroux
x		26	Halimeda opuntia (Linn.) Lamouroux
x		27	Caulerpa racemosa (Forssk) J. Agardh V. occidentalis (J.Ag. Børgesen
x	x	28	Caulerpa verticillata J. Agardh
x	x	29	Chaetomorpha linum (Müll.) Kützing
x	x	30	Gracilaria verrucosa (Huds.) Papenfuss
x		31	Gracilaria verrucosa (Huds.) Papentuss
x		32	Acanthophora spicifera (Vahl) Børgesen
x		33	Dictyota cervicornis Kützing
x		35	Caulerpa sertularoides (Gmel.) Howe
x	x	36A	Giffordia mitchellae (Harv.) Hamel
x	x	36B	Enteromorpha chaetomorphoides Børgesen Rhizoclonium Kochianum (cf. Kerneri) Kützing

H	S	No.	Name
			Giffordia mitchellae (Harv.) Hamel Lyngbya majuscula (Dillw.) Harvey diatoms (e.g., Cymbella)
x		37	Sargassum natans (Linn.) J.Meyen
x			Sargassum fluitans Børgesen
x		38	Sargassum fluitans Børgesen
x		39	Acanthophora spicifera (Vahl) Børgesen
x	x	40	Spyridia filamentosa (Wulf.) Harvey
		40-a	Enteromorpha chaetomorphoides Børgesen
		40-b	Lyngbya majuscula (Dillw.) Harvey
x		41	Dictyota indica Sonder in Kützing
x	x	42	Lyngbya majuscula (Dillw.) Harvey
	x	43	Giffordia mitchellae (Harv.) Hamel
		43-a	Lyngbya majuscula (Dillw.) Harvey
	x	44	Chaetomorpha gracilis Kützing
			Cladophora sp. Kützing
			Rhizoclonium Kochianum (cf. Kerneri) Kützing
			Lyngbya majuscula (Dillw.) Harvey
			Enteromorpha Chaetomorphoides Børgesen
			Ceramium fastigiatum (Roth) Harvey
			Giffordia mitchellae (Harv.) Hamel
			Polysiphonia sp. Greville
	x	45	Giffordia mitchellae (Harv.) Hamel
			Enteromorpha chaetomorphoides Børgesen
			Cladophora sp. Kützing

H	S	No.	Name
x	x	46	Enteromorpha chaetomorphoides Børgesen
			Cladophora sp. Kützing
			Giffordia mitchellae (Harv.) Hamel
			diatoms (e.g., Cymbella)
	x	47A	Peyssonnelia rubra (Grev.) J. Agardh
	x	47B	Gelidium corneum (Huds.) Lamouroux
	x	47C	Champia parvula (C. Ag.) Harvey
	x	47D	Peyssonnelia rubra (Grev.) J. Agardh
	x	47E	Cladophora sp. Kützing
		47E-a	Polysiphonia sp. Greville
		47E-b	Microcoleus lyngbyensis
x		48	Halimeda opuntia (Linn.) Lamouroux
x	x	49	Bryopsis pennata Lamoroux
		49-a	Ceramium fastigiatum (Roth) Harvey
		49-b	Unidentified red alga
		49-c	Erythrotrichia carnea (Dillw.) J. Agardh
		49-d	Acrochaetium sp. Nägeli
		49-e	Erythrocladia subintegra Rosenvinge
		49-f	Polysiphonia sp. Greville
		49-g	Melobesia membranacea (Esper) Lamouroux
		49-h	Lyngbya confervoides C. Agardh
		49-i	diatoms (e.g., Licmophora, Striatella, Fragilaria)
x		50	Amphiroa rigida Lamouroux v. antillana Børgesen

H	S	No.	Name
		50-a	Ceramium fastigiatum (Roth) Harvey
		50-b	Erythrotrichea carnea (Dillw.) J. Agardh
xq	x	51	Dictyopteris delicatula Lamouroux
	x	52	Gelidiella acerosa (Forssk.) Feldman + Hamel
		52-a	Melobesia membranacea (Esper) Lamouroux
		53A	Crustose alga of family Corallinaceae, subfamily Melobesieae
		53B	Branching alga of family Corallinaceae, subfamily Melobesieae
x		54	Amphiroa tribulus (Ellis + Sol.) Lamouroux
x		55	Halimeda opuntia (Linn.) Lamouroux
x		55.5	Caulerpa racemosa (Forssk.) J. Agardh V. urifera (Turn.) Weber-van Bosse
x		56	Udotea flabellum (Ellis + Sol.) Lamouroux
x		57	Caulerpa Sertularoides (Gmel.) Howe
x		58	Caulerpa racemosa (Forssk.) J. Agardh V. uvifera (Turn.) Weber-van Bosse
x		59	Halimeda tuna (Ellis + Sol.) Lamouroux
x		60	Avrainvillea rawsoni (Dickie) Howe
x		61A	Amphiroa fragilissima (Linn.) Lamouroux
x		61B	Amphiroa rigida Lamouroux v. antillana Børgesen
x		62	Caulerpa racemosa (Forssk.) J. Agardh V. uvifera (Turn.) Weber-van Bosse
x		63	Penicillus capitatus Lamarck
	x	64	Amphiroa fragilissima (Linn.) Lamouroux
		64-a	Callithamnion byssoides Arnott in Hooker

H	S	No.	Name
x		65	Laurencia obtusa (Huds.) Lamouroux
x		66	Coelothrix irregularis (Harv.) Børgesen
x		67	Dictyota dichotoma (Huds.) Lamouroux
x	x	68	Nostoc sp. or Anabaena sp.
	x	69	Melobesia membranacea (Esper) Lamouroux
		69-a	Nostoc sp. or Anabaena sp.
		69-b	Lyngbya majuscula (Dillw.) Harvey
		69-c	Giffordia mitchellae (Harv.) Hame
		69-d	unidentified green alga
x	x	70	Lyngbya sp. Agardh
		70-a	diatoms (e.g., Licmophora)
		70-b	Goniotrichum alsidii (Zanard.) Howe
x		71	unidentified red alga
x		75	Gracilaria verrucosa (Huds.) papenfuss
x		76	Ulva lactuca Linnaeus
x	x	77	Centroceros clavulatum (C. Ag.) Montagne
x	x	78	Enteromorpha flexuosa (Wulf.) J. Agardh
x		79	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) Taylor
x		80	Caulerpa taxifolia (Vahl) C. Agardh
x		81	Agardhiella tenera (J. Ag.) Schmitz
		82	Gracilaria mammilaris (Mont.) Howe
x		83	Hypnea musciformis (Wulf.) Lamouroux
x	x	84	Enteromorpha flexuosa (Wulf.) J. Agardh

H	S	No.	Name
x	x	85	Hypnea cervicornis J. Ag.
x	x	86	Lyngbya sp. Agardh
			Lyngbya majuscula (Dillw.) Harvey
		86-a	diatoms (e.g., Biddulphia, Melosira, Grammatophora, naviculoid type
		87	Acanthophora spicifera (vahl) Børgesen
x		88	Gracilaria foliifera (Forssk.) Børgesen
x		89	Ulva fasciata Delile
x		90	Caulerpa verticillata J. Agardh
x		91	Caulerpa sertularoides (Gmel.) Howe
x		92	Gracilaria verrucosa (Huds.) Papenfuss
x		93	Acanthophora spicifera (Vahl)
x		94	Hypnea cervicornis J. Agardh
x		95	Caulerpa racemosa (Forssk.) J. Agradh V. macrophysa (Kütz.) Taylor
		96	diatoms (e.g., Cymbella)
x		97	Caulerpa verticillata J. Agardh
x	x	98	Lyngbya majuscula (Dillw.) Harvey
x	x	99	Vaucheria sp. De Candolle
		99-a	Lyngbya majuscula (Dillw.) Harvey
		99-b	Nostoc sp. or Anabaena sp.
		99-c	Microcoleus sp. Desmazieres
x		100	diatoms (e.g., naviculoid, type centric, Melosira, Pleurosigma)
			Lyngbya majuscula (Dillw.) Harvey
			unidentified blue gree alga

H	S	No.	Name
x		101	Acanthophora spicifera (Vahl) Børgesen
x		102	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) J. Agardh
x		103	Caulerpa racemosa (Forsk.) J. Agardh
	x	104	unidentified blue-gree alga
			diatoms (e.g., nariculoid type, Licmorphora)
x		110	Sargassum fluitans Børgesen
x		111	Sargassum natans (Linn.) J. Meyen
x		112	Penicillus capitatus Lamarck
x	x	113	Dictyosphaeria cavernosa (Forssk.) Børgesen
x		114	Amphiroa rigida Lamouroux v. antillana Børgesen
x		115	unidentified red alga
x	x	116	Laurencia obtusa (Huds.) Lamouroux
x	x	117	Ceramium strictum (Kütz.) Harvey
x		118	Dictyota sp. Lamouroux
x	x	119	Lyngbya majuscula (Dillw.) Harvey
		119-a	Ceramium sp. Roth
		119-b	Melobesia membranacea (Ezper) Lamouroux
	x	120A	Melobesia membranacea (Esper) Lamouroux
		120B	Melobesia membranacea (Esper) Lamouroux
x		121	Caulerpa sertularoides (Gmel.) Howe
x		122	Caulerpa racemosa (Forssk.) J. Agardh V. occidentalis (J. Ag.) Børgesen
x	x	123	Nostoc sp. or Anabaena sp.
x	x	124	Callithamnion byssoides Arnott in Hooker

H	S	No.	Name
		124-a	Cladophora sp. Kützing
		124-b	diatoms (e.g., naviculoid-type Synedra)
		124-c	Microcoleus sp. Desmazieres
		124-d	Oscillatoria sp. Vaucher
		124-e	Lyngbya majuscula (Dillw.) Harvey
	x	125	Microcoleus sp. Desmazieres
x	x	126	Vaucheria dichotoma (Linn.) C. Agardh
		126-a	Ceramium byssoideum Harvey
x	x	127	Amphiroa fragilissima (Linn.) Lamouroux
x	x	129	Vaucheria dichotoma (Linn.) C. Agardh
		129-a	Ceramium fastigiatum (Roth) Harvey
x		130	Halimeda incrassata (Ellis) Lamouroux
x		131	Caulerpa prolifera (Forssk) Lamouroux
x		132	Caulerpa sertularoides (Gmel.) Howe
x		133	Acanthophora spicifera (Vahl) Børgesen
x		134	Hypnea spinella (C. Ag.) Kützing
x		135	Acetabularia crenulata Lamoroux
		136	Sargassum natans (Linn.) J. Meyen
x		137	Dictyota cervicornis Kützing
x	x	138	Chaetomorpha gracilis Kützing
x		139	Hyphea musciformis (Wulf.) Lamouroux
x		140	Dictyota divaricata Lamouroux
x		141	Dictyota divaricata Lamouroux
x		142	Dictyota bartayresii Lamouroux

H	S	No.	Name
x	x	143	unidentified green alga
x		144	Dictyota divaricata Lamouroux
x	x	145	Chaetomorpha gracilis Kützing
		146	Dictyota bartayresii Lamouroux
	x	147	Callithamnion byssoides Arnot in Hooker
x		150	Gracilaria verrucosa (Huds.) Papenfuss
x		151	Agardhiella tenera (J. Ag.) Schimtz
x	x	152	Ceramium strictum (Kütz.) Harvey
x		153	Entermorpha flexuosa (Wulf.) J. Agardh
		154	Acanthophora spicifera (Vahl) Børgesen
x		155	Gracilaria foliifera (Forssk.) Børgesen
x		156	Hypnea musciformis (Wulf.) Lamouroux
		157	Caulerpa prolifera (Forssk.) Lamouroux
x		158	Ulva fasciata Delile
x	x	159	Spyridia aculeata (Schimp.) Kützin
		160	Rhizoclonium Kochianum (cf. Kerneri) Kützing
x		161	Halimeda opuntia (linn.) Lamouroux
x	x	162	Centroceros clavulatum (C. Ag.) Montagne
x		163	Caulerpa sertularoides (Gmel.) Howe
x		164	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kutz.) Taylor
		165	Acanthophora spicifera (Vahl) Børgesen
	x	166	Rhizoclonium kochianum (cf. Kerneri) Kützing
	x	167	diatoms (e.g. Licmophora, naviculoid type, etc.)
x	x	168	Callithamnion byssoides Arnott in Hooker

H	S	No.	Name
		168-a	Gelidium sp. Lamouroux
		168-b	Rhizoclonium Kochianum (cf. Kerneri) Kützing
		168-c	diatoms (e.g., Licmophora)
		169	Acanthophora spicifera (Vahl) Børgesen
x	x	170	Bryopsis pennata Lamouroux
		170-a	diatoms (e.g., Licmophora)
x		171	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) Taylor
		172	Caulerpa verticillata J. Agardh
	x	173	Callithamnion byssoides Arnott in Hooker
		173-a	Erithrotrichia carnea (Dillw.) J. Agardh
		173-b	Lyngbya majuscula (Dillw.) Harvey
		173-c	Microcoleus lyngbyensis
		173-d	diatoms (e.g., centric, melosira)
x	x	174A	Polysiphonia sp. #1 Greville
			Polysiphonia sp. #2 Greville
		174A-a	diatoms (Nitschia-type)
	x	174B	Polysiphonia ferulacea Suhr
		174B-a	Callithamnion byssoides Arnott in Hooker
		174B-b	Erythrotrichia carnea (Dillw.) J. Agardh
x		175	Enteromorpha clathrata (Roth) J. Agardh
	x	176	unidentified red alga
	x	177	Enteromorpha sp. Link
		179	Caulerpa verticillata J. Agardh
	x	180	Nostoc sp. or Anabaena sp.

H	S	No.	Name
	x	181	Melobesia membranacea (Esper) Lamouroux
		182	Acanthophora spicifera (Vahl) Børgesen
x		183	Hypnea cervicornis J. Agardh
		184	Melobesia membranacea (Esper) Lamouroux
	x	185	Ceramium byssoideum Harvey
x	x	186	Rhizoclonium kochianum (cf. Kerneri) Kützing
x		190	Caulerpa sertularoides (Gmel.) Howe
x		191	Caulerpa racemosa (Linn.) Lamouroux V. occidentalis (J. Agardh) Børgesen V. macrophysa (Kütz.) Taylor
x	x	192	Polysiphonia sp. #3 Greville
	x	193	Caulerpa verticillata J. Agardh
		194	Acanthophora spicifera (Vahl) Børgesen
x		195	Caulerpa racemosa (Linn.) Lamouroux
x	x	196	Callithamnion byssoides Arnott in Hooker
x	x	197	Polysiphonia sp. #1 Greville
x		198	Caulerpa sertularoides (Gmel.) Howe
		199	Caulerpa racemosa (Linn.) Lamouroux
		200	Caulerpa verticillata J. Agardh
		201	Acanthophora spicifera (Vahl) Børgesen
		202	Callithamnion byssoides Arnott in Hooker
	x	203	Rhizoclonium kochianum (cf. kerneri) Kützing
	x	204	Rhizoclonium kerneri Stockmayer
		204-a	diatoms (e.g., Licmophora)
	x	205	Microcoleus sp. Desmazieres
	x	206	Spirulina subsalsa Oersted

H	S	No.	Name
x	x	207	*Enteromorpha clathrata* (Roth) J. Agardh
	x	208	*Microcoleus* sp. Desmazieres
	x	209	*Microcoleus* sp. Desmazieres
			unidentified filamentous blue-green alga
		210	*Acanthophora spicifera* (Vahl) Børgesen
		211	*Hypnea cervicornis* J. Agardh
	x	212	*Melobesia membranacea* (Esper) Lamouroux
		212-a	*Enteromorpha chaetomorphoides* Børgesen
		212-b	*Ceramium* sp. Roth
	x	213	*Melobesia membranacea* (Esper) Lamouroux
	x	214	*Melobesia membranacea* (Esper) Lamouroux
	x	215	*Enteromorpha* sp. Link
			Ceramium sp. Roth
			Lyngbya majuscula (Dillw.) Harvey
x	x	216	*Hypnea cervicornis* J. Agardh
		216-a	*Ceramium byssoideum* Harvey
		217	*Melobesia membranacea* (Esper) Lamouroux
		218	*Melobesia membranacea* (Esper) Lamouroux
	x	219	*Sphacelania furcigera* Kützing
x		221	*Ulva fasciata* Delile
x		222	*Agardhiella ramosissima* (Harv.) Kylin
x		223	*Gracilaria domingensis* Sander
x		224	*Hypnea musciformis* (Wulf.) Lamouroux
x	x	225	*Spyridia filamentosa* (Wulf.) Harvey
	x	226	*Cladophora fascicularis* (Mert.) Kützing
			Enteromorpha chaetomorphoides Børgesen

H	S	No.	Name
x		227	Sargassum polyceratium Montagne
x		228	Laurencia papillosa (Forssk.) Greville
x		229	Hypnea musciformis (Wulf.) Lamouroux
x	x	230	Coelothrix irregularis (Harv.) Børgesen
x	x	231	Spyridia aculeata (Schimper) Kützing V. hypneoides J. Agardh
x		232	Dictyopteris delicatula Lamouroux
x		233	Caulerpa racemosa (Forssk.) J. Agardh V. uvifera (Turn.) Weber-Ban Bosse
x		234	Caulerpa sertularoides (Gmel.) Howe
x	x	236	Padina sanctae-crucis Børgesen
x	x	237	Gracilaria mammilaris (Mont.) Howe
x		238	Gracilaria verrucosa (Huds.) Papenfuss
x	x	239	Chaetomorpha media (C.Ag.) Kützing
	x	240	Spyridia aculeata (Schimper) Kützing
			Centroceros clavulatum (C.Ag.) Montagne
x	x	241	Centroceros clavulatum (C.Ag.) Montagne
x	x	242	Spyridia aculeata (Schimp.) Kützing
		242-a	Goniotrichum alsidii (Zanard.) Howe
		242-b	Centroceros clavulatum (C.Ag.) Montagne
	x	243	Centroceros clavulatum (C.Ag.) Montagne
	x	244	Herposiphonia secunda (C.Ag.) Ambronn
		244-a	Amphiroa fragilissima (Linn.) Lamouroux
	x	245	Hypnea cornuta (Lamour.) J. Agardh
x		246	Hypnea musciformis (Wulf.) Lamouroux
x	x	247	Spyridia aculeata (Schimper) Kützing V. hypneoides J. Agardh

H	S	No.	Name
x	x	248	Cladophora fascicularis (Mert.) Kützing
x	x	249	Enteromorpha sp. Link
x		250	Agardhiella tenera (J.Ag.) Schmitz
x		251	Ulva fasciata Delile
x	x	252	Spyridia aculeata (Schimper) Kützing V. hypneoides J. Agardh
x	x	253	Spyridia filamentosa (Wulf.) Harvey
x	x	254	Hypnea musciformis (Wulf.) Lamouroux
x		255	Gracilaria verrucosa (Huds.) Papenfuss
x		256	Gracilaria mammilaris (Mont.) Howe
x		257	Dictyopteris delicatula Lamouroux
x		258	Dictyota indica Sonder in Kützing
x	x	259	Wrangelia argus Montagne
x		260	Callithamnion byssoides Arnott in Hooker
		261	Amphiroa fragilissima (Linn.) Lamouroux
	x	262	Gelidium sp. Lamouroux
		265	Bryopsis pennata Lamouroux
	x	266	Callithamnion byssoides Arnott in Hooker
		266-a	Vaucheria sp. De Candolle
		267	Caulerpa verticillata J. Agardh
	x	268	Spirulina subsalsa Oersted
			diatoms (e.g., naviculoid type)
x		269	Dictyota bartayresii Lamouroux
x		270	Dictyota divaricata Lamouroux
			Dictyota cervicornis Kützing
		271	Acanthophora spicifera (Vahl) Børgesen

H	S	No.	Name
x		272	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) Taylor
x	x	273	Spyridia filamentosa (Wulf.) Harvey
		274	Bostrychia tenella (Vahl.) J. Agardh
x		275	Bryopsis pennata Lamouroux
x		276	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) Taylor
x		277	Spyridia filamentosa (Wulf.) Harvey
x	x	278	Callithamnion byssoides Arnott in Hooker
x	x	279	Giffordia rallsiae (Vick.) Taylor
		279-a	Lyngbya majuscula (Dillw.) Harvey
x	x	280	Lyngbya majuscula (Dillw.) Harvey
		281	Acanthophora spicifera (Vahl) Børgesen
		282	Caulerpa verticillata J. Agardh
x		283	Halimeda opuntia (Linn.) Lamouroux F. triloba (Dec.) Barton
x		284	Caulerpa taxifolia (Vahl) C. Agardh
		285	Acanthophora spicifera (Vahl) Børgesen
		286	Caulerpa verticillata J. Agardh
x	x	287	Pterocladia sp. J. Agaardh
		287-a	Microcoleus sp. Desmazieres
		287-b	diatoms (e.g., Grammatophora, pennate)
		288	Spyridia filamentosa (Wulf.) Harvey
x		289	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kütz.) Taylor
		290	Caulerpa verticillata J. Agardh
x		291	Halimeda opuntia (Linn.) Lamouroux F. triloba (Dec.) Barton

H	S	No.	Name
x		292	*Caulerpa racemosa* (Forssk.) J. Agardh V. *macrophysa* (Kütz.) Taylor
		293	*Acanthophora spicifera* (Vahl) Børgesen
		294	*Pterocladia* sp. J. Agardh
		295	*Caulerpa verticillata* J. Agardh
x		296	*Caulerpa racemosa* (Forssk.) J. Agardh V. *macrophysa* (Kütz.) Taylor
x		297	*Spyridia filamentosa* (Wulf.) Harvey
x		298	*Caulerpa sertularoides* (Gmel.) Howe
		298.5	*Acanthophora spicifera* (Vahl) Børgesen
x	x	299	*Pterocladia* sp. J. Agardh
		299-a	*Erythrotrichia carnea* (Dillw) J. Agardh
		299-b	diatoms (e.g., *Licmophora*, pennate)
x	x	300	*Lyngbya majuscula* (Dillw.) Harvey
		300-a	diatoms (*Biddulphia*, stellate)
x	x	301	*Lyngbya majuscula* (Dillw.) Harvey
		301.5	*Spyridia filamentosa* (Wulf.) Harvey
x	x	302	*Callithamnion byssoides* Arnott *in* Hooker
		302-a	*Microcoleus* sp. Desmazieres
		302-b	*Lyngbya majuscula* (Dillw.) Harvey
x	x	303	*Microcoleus* sp. Desmazieres
x		304	*Caulerpa sertularoides* (Gmel.) Howe
		305	*Acanthophora spicifera* (Vahl) Børgesen
x		306	*Caulerpa racemosa* (Forssk.) J. Agardh V. *macrophysa* (Kütz.) Taylor
x	x	307	*Lyngbya majuscula* (Dillw.) Harvey
		308	*Spyridia filamentosa* (Wulf.) Harvey

H	S	No.	Name
x	x	309	Bostrychia tenella (Vahl) J. Agardh
		309-a	unidentified colonial blue-green alga
x	x	310	Centroceros clavulatum (C. Ag.) Montagne
x	x	311	Polysiphonia ferulacea Suhr
x	x	312	Heterosiphonia wurdemanni (Bail.) Falkenberg
		312-a	Rhizoclonium kochianum (cf. Kerneri) Kützing
		312-b	Enteromorpha chaetomorphoides Børgesen
		312-c	Polysiphonia sp. Greville
		312-d	Centroceros clavulatum (C. Ag.) Montagne
		312-e	diatoms (e.g., pennate, Melosira, Synedra)
x	x	313	Nostoc sp. or Anabaena sp.
		314	Acanthophora spicifera (Vahl) Børgesen
	x	315	Heterosiphonia wurdemanni (Bail) Falkengberg
		315-a	Enteromorpha chaetamorphoides Børgesen
		315-b	diatoms (e.g., Melosira, Synedra)
x	x	316	Lyngbya majuscula (Dillw.) Harvey
		316-a	diatoms (e.g., naviculoid type)
x	x	317	Pterocladia sp. J. Agardh
			Griffithsia globulifera Harvey
		317-a	Ceramium fastigiatum (Roth) Harvey
		317-b	Callithamnion Byssoides Arnott in Hooker
		317-c	Rhizoclonium kochianum (cf. Kerneri) Kützing
		317-d	diatoms (e.g., naviculoid type, Cymbella, Synedra)
x		318	Caulerpa racemosa (Forssk.) J. Agardh V. macrophysa (Kutz.) Taylor
x	x	319	Enteromorpha chaetomorphoides Børgesen

H	S	No.	Name
			Lynbya majuscula (Dillw.) Harvey
		319-a	diatoms (e.g., *Melosira*, *Cymbella*, pennak centric)
x	x	320	*Spyridia filamentosa* (Wulf.) Harvey
		320-a	*Rhizoclonium kochianum* (cf. Kerneri) Kützing
		320-b	*Polysiphonia* sp. Greville
		320-c	*Enteromorpha chaetomorphoides* Børgesen
		320-d	*Goniotrichum alsidii* (Zanard.) Howe
		320-e	*Erythrotrichea carnea* (Dillw.) J. Agardh

Discussion:

The biomass of Thalassia beds was somewhat lower in the Inner Bay and Mid Bay than in the Aguirre Ship Canal. No definite explanation for this can be given, but it could be that the high turbidity in the Inner Bay and Mid Bay may have been limiting the productivity of Thalassia. Thalassia-eating organisms such as parrotfishes and sea urchins, Lytechinus variegatus and Tripneustes esculentus were not more common in the Inner Bay and Mid Bay areas than in the Ship Canal, thus predation cannot account for the differences in biomass.

The average biomass of Thalassia was 10.9 kg wet weight/m^2 in July - August. Using this figure for the whole area of turtle grass (261 hectares) in Jobos Bay (Figure 6), the total biomass of Thalassia was 2.8 x 10^7 kg wet weight. The total biomass of benthic macro plants was in order of 3 x 10^7 kg wet weight.

Unlike in Jamaica (Jackson, 1972), mollusks did not make the overwhelming proportion of the biomass except at station 8. Codakia orbicularis, which was the most important species in the biomass of macroinvertebrates in Jamaica, was quite unimportant in Jobos Bay. There was no one species of mollusk that was found in great numbers or that made up a significant proportion of the biomass at all stations in Jobos Bay. Neither was there any other single species of other phyla that was dominant in several stations. The number of species of mollusks in Thalassia beds in Jobos Bay is higher than that of Jamaican Thalassia beds reported by Jackson (1972). He also states that the greater biomass was correlated with low diversity in Jamaican Thalassia beds. This was true for station 8 in Jobos Bay, but not for the other stations.

Summary:

1. Total area of Thalassia beds in Jobos Bay from the Inner Bay in the east to the longitude 66° 16' W in the Aguirre Ship Canal was 261 hectares.

2. The maximum depth of Thalassia beds was directly related to the clearness of the water.

3. The biomass of Thalassia and other benthic macroplants was highest in the Ship Canal. The average

biomass of Thalassia was 10.9 kg wet weight per square meter and the total biomass in the whole bay 2.8×10^7 kg wet weight in July - August, 1972.

4. No single species of invertebrates was dominant in the biomass. The most important phyla were Mollusca, Annelida, Porifera and Chordata (Ascidiacea). The biomass of invertebrates varied from 0.21 to 2.0 kg wet weight per square meter in July - August, 1972. The average biomass of macroinvertebrates was 660 g wet weight per square meter or 1.7×10^6 kg wet weight for the whole Thalassia area.

5. The highest number of species of benthic organisms did not coincide with the lowest biomass. The highest number of species was in the Aguirre Ship Canal. The number of macro-algae and invertebrates species was about one hundred in the Ship Canal, while in the Inner Bay and Mid Bay there were only half as many.

6. Very little resemblance was found between the Thalassia beds in Jobos Bay and in Jamaica (see Jackson, 1972) in terms of species composition or biomass of macroinvertebrates.

REFERENCES

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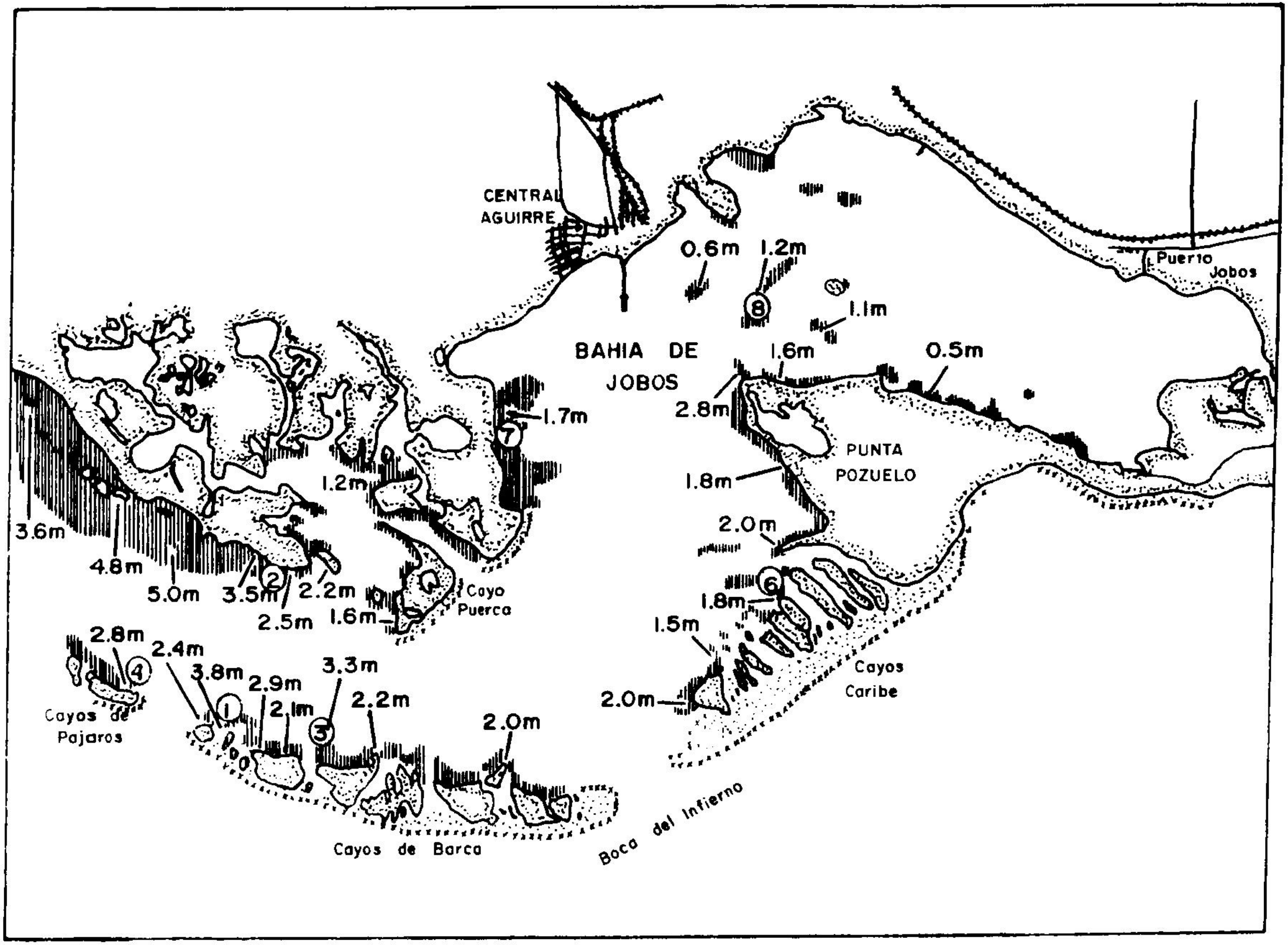

Figure 6 The distribution of Thalassia beds in Jobos Bay. The location of sampling stations for the biomass and species diversity are shown as well as the maximum depth of Thalassia beds at different parts of Jobos Bay.

TABLE 1A BIOMASS OF THALASSIA AND OTHER MARINE PLANTS AT DIFFERENT STATIONS IN JOBOS BAY.

THALASSIA BIOMASS — WET WEIGHT

STATION	DATE	OLD LEAVES	NEW LEAVES	SHEATHING	RHIZOMES	VERTICAL SHOOTS	ROOTS	TOTAL THALASSIA
TH #1	7/31/72	208	1720	3795	3705	1448	3785	14660
TH #2	8/1/72	148	805	3590	2538	1335	4213	12630
TH #3	7/31/72	75	1258	2778	2678	2030	3263	12080
TH #4	8/1/72	578	1080	2145	1335	945	2003	8090
TH #7	7/31/72	1238	1935	1278	1278	500	1558	7790
TH #8	7/31/72	193	1420	2013	2315	638	3618	10200

THALASSIA BIOMASS — DRY WEIGHT g/m^2

STATION	DATE	OLD LEAVES	NEW LEAVES	SHEATHING	RHIZOMES	VERTICAL SHOOTS	ROOTS	TOTAL THALASSIA
TH #1	7/31/72	47.7	174.2	474.9	709.5	285.2	555.5	2247
TH #2	8/1/72	26.7	89.9	415.5	423.0	292.5	297.8	1545
TH #3	7/31/72	33.2	86.3	319.8	404.0	298.2	312.1	1454
TH #4	8/1/71	77.1	76.4	156.5	308.4	124.4	213.6	956
TH #7	7/31/72	120.9	161.4	95.2	203.0	90.4	199.9	871
TH #8	7/31/72	22.2	158.3	240.6	451.5	129.6	462.9	1465

TABLE 1B BIOMASS OF THALASSIA AND OTHER MARINE PLANTS AT DIFFERENT STATIONS IN JOBOS BAY

BIOMASS OF OTHER PLANTS

WET WEIGHT

STATION	DATE	SYRINGODIUM FILIFORME	HALIMEDA SP.	PENICILLUS CAPITATUS	VALONIA VENTRICOSA	ENTEROMORPHA SP.	TOTAL BIOMASS OF PLANTS
TH #1	7/31/72	213	1238		25		16,140
TH #2	8/1/72	47.5					12,680
TH #3	7/31/72		1048				13,130
TH #4	8/1/72	1760		2.5		2.5	9,850
TH #7	7/31/72						7,790
TH #8	7/31/72						10,200

BIOMASS OF OTHER PLANTS

DRY WEIGHT

g/m^2

STATION	DATE	SYRINGODIUM FILIFORME	HALIMEDA SP.	PENICILLUS CAPITATUS	VALONIA VENTRICOSA	ENTEROMORPHA SP.	TOTAL BIOMASS OF PLANTS
TH #1	7/31/72	40.3	634		0.5		2,922
TH #2	8/1/72	7.78					1,553
TH #3	7/31/72		527				1,981
TH #4	8/1/72	217		.78		0.1	1,274
TH #7	7/31/72						871
TH #8	7/31/72						1,465

TABLE 2

BIOMASS OF *THALASSIA* IN MARCH 1972 IN JOBOS BAY

Station	Date	*Thalassia* total g/m^2 wet weight	*Thalassia* total g/m^2 dry weight
Th #1	3/01/72	4,650	570
Th #2	3/01/72 3/30/72	9,750	1,200
Th #3	3/01/72 3/30/72	5,320	1,020
Th #6	3/01/72	7,370	990
Th #7	3/01/72	6,380	1,000
Th #8	3/1/72	8,460	1,470

TABLE 3

BIOMASS OF BENTHIC INVERTEBRATES IN *THALASSIA* BEDS
IN JOBOS BAY DURING JULY AND AUGUST 1972

Values are given as grams wet weight per square meter.

	1	2	3	4	7	8
INVERTEBRATES						
Porifera						
Collyspongia sp.						2.5
Chondrilla nucula		20				
Geodia gibberosa	3.5	87.5				
Ircinia sp.		80				
COELENTERATA						
Anthozoa						
Unident. Actinia						133.8
ANNELIDA						
Polychaeta						
Arabella opalina	0.5					
Ammotrypane fimbrata						0.5
Leodice sp.	1.3					10
Leodice unifrons	5.6					
Lumbrinereis sp.	0.6	0.25				0.25
Nereis antillensis					1.3	0.25
Nereis sp.		30.5			2.5	12.8
Protis torguata	1.0					
Sabellastarte magnifica	12.5					
Scolops cirratus						2.5
Syllis sp.						2.5
Terebella sp.		37.5	2.5			
Unident.	120	42.5	1.3		12.5	

TABLE 3 (cont'd.)

	1	2	3	4	7	8
SIPUNCULIDA						
Unident.	15.0	31.3			15.0	0.75
MOLLUSCA						
Gastropoda						
Bulla striata				77.5		
Cerithium sp.				35		
Cerithium algicola					40.	
Crepidula glauca					2.5	1.25
Diodora cayenensis	27.5					
Engina sp.	2.5					
Engoniophos unicinctus					37.5	
Modulus modulus				20	7.5	1.25
Murex brevifrons						1.25
Smaragdia viridis		2.5				
Tegula fasciata	65		22.5			
Turbo castanea		90			5.0	25
Bivalvia						
Arca imbricata			85			
Barbatia domingensis				12.5		
Brachidontes exustus					12.5	1518
Chione cancellata					368	158
Codakia orbicularis		7.5				
Codakia orbiculata						3.0
Corbula contracta						1.25
Crassinella lunulata				1.25		
Musculus lateralis			2.5			
Sphenia antillensis						0.25

TABLE 3 (cont'd.)

	1	2	3	4	7	8
ARTHROPODA						
Crustacea						
Cirripeda						
Balanus eburneus						1.25
Amphipoda					13.8	
Isopoda						
Cirolana parva	5.1					
Decapoda						
Macrura						
Alpheidea sp.	1.25	15	2.5			
Thor sp.	1.25					
Brachyura						
Micropanope sp.	10					
Microphrys bicornutus	37.5					
Mithrax sculptus		22.5	10	25		
Panopeus bermudensis	2.5					2.5
Panopeus bockei						7.5
Panopeus occidentalis		10				
Pinnixa sp.			2.5			
Anomura						
Clibanarius antillensis	2.5		2.5			
Petrolisthes polita						10

TABLE 3 (cont'd.)

	1	2	3	4	7	8
Anomura						
Coenobita clypeatus			5.0			
Pagurus miamensis					1.3	
BRYOZOA						
Vittaticella sp.						0.5
ECHINODERMATA						
Echinoidae						
Lytechinus variegatus			50			
Ophiuroidea						
Amphiuridae sp.	2.0	2.5				2.5
Ophiothrix angulata						
Ophioderma sp.			5.0	42.5		
Ophiophramus sp.	1.25					
Holothurioidea						
Holothuria spp.		40				
Chirodota rotifera		12.5				
CHORDATA						
Ascidiacea						
Herdmania momus			87.5			
Polycarpa obtecta						75
Pyura vittata		10				
Trididemnum savignii					2.5	
Total biomass	318.4	542.1	278.8	213.8	521.9	1974.4

TABLE 5

THE SPECIES OF DIFFERENT ORGANISMS FOUND IN THE THALASSIA BEDS IN JOBOS BAY

	Stations 1	2	3	4	6	7	8
ALGAE							
Cyanophyta							
Lyngbya sp.		x			x		
Nostoc sp.		x				x	x
Oscillatoria sp.							x
Chlorophyta							
Acetabularia sp.						x	
Avrainvillea nigricans	x		x				
Caulerpa cupressoides	x	x	x		x	x	x
Caulerpa racemosa v. *macrophysa*	x		x			x	x
Caulerpa sertularioides	x						
Caulerpa taxifolia	x		x				
Dictyospheria cavernosa			x				
Ernodesmis verticillata			x				
Halimeda incrassata	x						
Halimeda opuntia	x	x	x		x	x	x
Halimeda tuna	x	x	x				
Penicillus capitatus	x	x	x	x	x	x	x
Udotea flabellum	x		x	x		x	
Valonia ventricosa	x	x	x			x	

	Stations						
	1	2	3	4	6	7	8
ALGAE							
Phaeophyta							
Dictyota bartayresii							x
Dictyota cervicornis		x	x	x	x		x
Dictyota divaricata	x	x	x		x	x	x
Dictyota sp.				x			
Sargassum fluitans		x	x				
Sargassum natans	x	x	x				
Rhodophyta							
Amphiroa fragilissima	x		x	x		x	
Amphiroa rigida	x	x	x			x	
Amphiroa sp.	x				x		
Callithamnion byssoides			x			x	
Ceramium byssoideum			x				
Champia parvula						x	
Jania sp.			x				
Laurencia obtusa	x		x			x	
Laurencia poitei	x		x				
Lomentaria sp.		x	x				
Melobesia membranacea		x	x				
Polysiphonia ferulacea	x		x				
INVERTEBRATES							
Porifera							
Callyspongia sp.			x				x
Callyspongia vaginalis		x					
Chondrilla nucula	x	x	x			x	x

	Stations						
	1	2	3	4	6	7	8
INVERTEBRATES							
Porifera (cont'd.)							
Geodia gibberosa	x						
Haliclona rubens	x	x	x				
Halisarca sp.	x	x	x				
Iotrochota birofulata		x					
Ircinia strobilina	x	x	x			x	
Mycale sp.		x					
Tedania ignis		x					
Unident.		x					
COELENTERATA							
Hydrozoa							
Hydroidea				x			
Millepora alcicornis	x		x	x			
Anthozoa							
Acrophora cervicornis	x						
Bartolomea angulata	x			x			x
Bolocervides (anemone)	x	x	x	x	x	x	x
Briareum asbestinum	x						
Cladocora arbuscula		x	x	x			
Condylactis gigantea	x		x			x	
Manicina areolata	x	x	x	x		x	
Porites asteroides		x					
Porites porites		x	x	x			
Pseudoterogorgia sp.	x	x	x	x			
Sideastrea radians				x			
Stoichactis helianthus				x			

	Stations						
	1	2	3	4	6	7	8
PLATHELMINTHES							
Turbellaria, Unident.	x						
NEMERTEA							
Unidentified				x	x		
ANNELIDA							
Polychaeta							
Ammotrypane fimbrata		x					x
Aphroditus elongatus				x			
Cirratulus sp.				x			
Groniadidae sp.				x			
Hermenia verrucosa		x					
Leodice culebra			x				
Leodice rubra			x				
Leodice sp.	x	x	x	x			
Leodice unifrons	x	x					
Lepidonotus sp.	x						
Lumbrinereis sp.		x					x
Nainereis sp.		x					
Nereis dumerilii	x	x					
Nereis sp.		x					x
Paraxiothea torguata	x	x					
Polynoidae sp.	x			x			
Protis torguata	x						
Sabella melanostigma	x	x	x			x	x
Sabellastarte magnifica	x	x	x			x	x
Scoloplos sp.		x					
Spirobranchus giganteus	x						
Terebella sp.	x			x			

	Stations						
	1	2	3	4	6	7	8
SIPUNCULIDA, Unident.	x	x		x		x	x
MOLLUSCA							
Amphineura							
Acanthochitona pygmaea	x			x			
Acanthochitona spiculosa				x			
Ischnochitona sp.				x			
Gastropoda							
Anachis pulchella		x					x
Astraea caelata							x
Astraea phoebia		x					
Bulla occidentalis			x				
Bulla striata				x			
Cassis tuberosa			x				
Cerithidea sp.	x	x		x			
Cerithium algicola		x		x		x	x
Cerithium eburneum	x	x			x		
Cerithium literatum		x	x	x			
Colubraria swifti	x						
Columbella mercatoria				x			
Conus spurius		x					
Crassispira fuscescens			x				x
Crepidula aculeata	x	x					
Crepidula convexa		x					x
Crepidula glauca		x				x	x
Crepidula plana	x						x
Diodora arcuata		x					
Diodora cayenensis	x						
Diodora dyseni		x					

	Stations						
	1	2	3	4	6	7	8
MOLLUSCA							
Gastropoda (cont'd)							
Diodora minuta		x					
Engina sp.	x						
Engoniophos quadalupensis			x				x
Engoniophos unicinctus				x		x	
Fasciolaria tulipa		x	x				x
Jaspidella jaspidea			x				
Leucozonia nassa		x	x				
Littorina nebulosa	x						
Littorina ziczac	x						
Lucapinella limatula			x				
Modulus carchedonius	x	x	x	x			
Modulus modulus	x	x	x	x		x	x
Murex breyifrons	x		x				x
Murex pomum		x	x				
Nassarius vibex						x	
Neritina virginea						x	
Nitidella sp.							x
Nudibranchia, Unident.			x	x			
Smaragdia viridis		x					
Strombus gallus	x		x				
Strombus gigas			x	x			
Strombus pugilis			x				
Tegula fasciata	x	x	x	x			
Turbo castanea	x	x		x		x	x
Turritella variegata							x
Vasum muricatum			x	x			

	Stations						
	1	2	3	4	6	7	8
MOLLUSCA							
Bivalvia							
Anadara notabilis		x	x				
Arca imbricata	x		x				
Arca seticostata	x						
Arca transversa	x						
Atrina seminuda			x				
Barbatia cancellaria	x						
Barbatia domingensis	x			x			
Brachidontes citrinus				x			
Brachidontes exustus				x		x	x
Chama macrophylla		x					
Chione cancellata				x	x	x	x
Codakia orbicularis		x	x		x		
Codakia orbiculata	x						x
Codakia pectinella	x						x
Corbula contracta							x
Crassinella lunulata			x	x			
Diplodonta punctata						x	
Lioberus castaneus			x				
Musculus lateralis			x				
Papyridea soleniformis	x						
Pinctada radiata			x				
Pinna carnea	x	x	x				
Pteria colymbus		x	x				
Sphenia antillensis							x
Tagelus divisus						x	
Cephalopoda							
Octopus sp.			x				

	Stations						
	1	2	3	4	6	7	8
ARTHROPODA							
Crustacea							
Cirripeda							
Balanus amphitrite var. *pallidus*							x
Balanus eburneus							x
Isopoda							
Cirolana parva	x		x				
Paracerceis sp.	x		x	x			
Sphaerosoma walkeri							x
Unident.			x				
Decapoda							
Macrura							
Alpheidea sp.	x	x	x				
Alpheus normanni		x					
Palaemon northropi	x						
Periclimenes sp.		x					
Synalpheus frizmüllerii			x				
Synalpheus sp.	x						x
Thor sp.	x	x					
Brachyura							
Dardanus venosus				x			
Epialtus sp.	x						

	1	2	3	4	6	7	8
ARTHROPODA							
Brachyura							
Hexapanopeus caribbaeus	x						
Hypoconcha sabulosa	x	x					
Micropanope sp.	x						
Microphrys bicornutus	x						
Mithrax coryphe				x			
Mithrax forceps		x	x				
Mithrax hispidus	x						
Mithrax sculptus	x	x	x	x			
Panopeus bermudensis	x						x
Panopeus boekei		x					x
Panopeus herbstii		x	x	x			
Panopeus occidentalis	x	x					x
Pelia mutica		x					
Pinnixa sp.			x				
Stenorhynchus seticornis		x					
Anomura							
Calcinus tibicen	x	x		x			
Callianassa sp.			x	x			
Clibanarius antillensis	x	x	x		x		
Clibanarius tricolor							x
Coenobita clypeatus			x				
Pagurus marshi				x			
Petrolisthes galathinus		x					
Petrolisthes polita							x
Petrolisthes marginatus	x						

	Stations						
	1	2	3	4	6	7	8
ARTHROPODA							
Stomatopoda							
Gonodactylus oerstedii	x	x		x			
Hemisquilla brasiliensis			x				
BRYOZOA							
Crisia sp.		x					
Vittaticella sp.							x
ECHINODERMATA							
Asteroidea							
Echinaster sentus						x	
Oreaster reticulatus	x		x		x		
Echinoidea							
Diadema antillarum	x	x	x	x	x		
Lytechinus variegatus	x	x	x		x	x	x
Tripneustes esculentus			x				x
Ophiuroidea							
Amphiura sp.	x	x					x
Amphiura stimpsonii		x					
Ophiactis savignyi		x					
Ophiocantha biclintata		x					
Ophiocoma echinata	x	x					
Ophioderma appressum		x					

	Stations						
	1	2	3	4	6	7	8
ECHINODERMATA							
Ophiuroidea							
Ophioderma brevicavdum			x				
Ophioderma guttatum		x					
Ophioderma sp.		x	x	x			
Ophiophragmus sp.	x						
Ophiothrix angulata	x	x	x	x			x
Ophiothrix oerstedii			x				
Holothurioidea							
Chirodota rotifera		x					
Holothuria arenicola		x					
Holothuria grisea				x			
Ludwigothuria mexicana		x	x		x		x
CHORDATA							
Ascidiacca							
Amaroucium bermudae		x					
Ascidia interrupta	x		x				
Ascidia nigra			x				x
Botryllus planus		x	x			x	x
Didemnum candidum		x				x	
Herdmania momus	x	x	x				x
Microcosmus exasperatus	x						x
Microcosmus helleri	x	x	x				
Molgula occidentalis	x	x	x	x			x
Perophora viridis	x	x	x	x	x	x	x
Polycarpa obtecta			x	x			x
Polycitor olivaceus		x					

	Stations 1	2	3	4	6	7	8
CHORDATA							
Ascidiacea							
Pyura vittata	x	x	x				
Rhodosoma turcicum							x
Styela plicata			x				
Symplegma viride							x
Trididemnun savignii							x

ECOLOGY OF SESSILE AND FREE-LIVING ORGANISMS ON MANGROVE ROOTS IN JOBOS BAY

by

Seppo Kolehmainen

INTRODUCTION

The ecology of mangrove trees and organisms living inside and behind the mangrove swamps on the mud flats have been studied widely (Davis, 1940; Gill and Tomlinson, 1969; Golley et al., 1962; Verwey, 1930; Walsh, 1967), but practically no studies have been made concerning the species diversity, biomass, and the ecological factors controlling the populations of organisms living on the mangrove roots. Mollusks and algae are the only groups that have been studied a little in this respect. Mattox (1949) has studied the ecology of mangrove oysters *Crassostrea rhizophorae* in Puerto Rican mangroves and Robertson (1959) the mollusk fauna of Bahamian mangroves. Warner (1967) reported the life history of a mangrove crab, *Aratus pisonii*. Biebl (1962) and Almodovar (1964) have studied the species of algae on the mangrove roots of Puerto Rico.

In Puerto Rico all phyla of algae and eleven phyla of macro invertebrates live on the mangrove roots. This community provides food and shelter to many economically important species of fish, crustacea and shell fish.

The organisms on the aerial roots of the red mangrove, *Rhizophora mangle*, are more sensitive to pollution than the trees themselves. In Guayanilla Bay, in a thermally altered area, the diversity of species living on mangrove roots is inversely related to the water temperatures above 34° C (Kolehmainen and Morgan, 1972). It was, therefore, felt that the ecology of the root communities had to be studied in order to be able to predict the impact of power plants on the mangrove ecosystem as a whole.

SAMPLING STATIONS AND METHODS

The mangrove root communities in Jobos Bay show enormous variations in the species composition and biomass. The reasons for this are generally unknown, but it seems that salinity, temperature, food availability, wave action, depth and pollution are important factors controlling the mangrove root communities.

Eight sampling stations were selected to represent different types of mangrove root communities around the proposed intake and discharge areas of the cooling water for the power plants. Station 11 was north of Cayo Puerca at the end of a cove that has received effluents from the settling ponds of Central Aguirre (Figure 7). This area used to be badly polluted with dissolved organic compounds that utilized all oxygen from the water. Part of the mangroves in this area were killed by the pollution and all of them showed signs of stress which could be seen from an unusually large number of aerial roots. Since spring 1972 this area has not been receiving waste from the sugar mill. Even months after the dumping of sugar mill effluents was stopped, this area was anoxic on the bottom and producing H_2S and CH_4 that bubbled continuously to the surface. After the sugar mill settling ponds were used as fill areas for dredging near the power plant site, the overflow from this fill area entered the mangroves near station 11. This water was almost clear and saturated with oxygen. As a result of this overflow water the conditions at station 11 were improved remarkably. Water, even on the bottom, was no longer anoxic and the production of reduced compounds was ceased.

Water at this station was about 0.5 meters deep at the edge of the mangroves. The sediments were very soft mud. The overflow from the settling ponds created a weak current toward the south. Maximum water temperatures were between 31 - 31.5° C. in the summer.

Station 12 was south of station 11, at the mouth of the embayment where the pelican rookery is located. This station was somewhat affected by the pollution from the sugar mill settling ponds, but no damage to the mangrove trees could be seen. Water here was low in oxygen, but not anoxic. Currents were sluggish, created mainly by tidal flushing. The color of the water in this area was dark brown and, consequently, the surface temperatures got quite high: from 31.5 to 32° C. in an afternoon in summer. Water at the edge of the mangroves was about 0.8 meters deep. Sediments were soft mud.

Station 15 was at the northern side of a mangrove island just north of Cayo Puerca. This station was not affected by the pollution. Water here was light brown and saturated with oxygen. Currents were sluggish and the maximum temperatures from 31 to 31.5° C. on the surface. Water was from 0.8 to 1 meter deep at the edge of the mangroves. The sediments were mud and in places there was turtle grass growing next to the mangroves.

Station 13 was at the northern tip of Cayo Puerca in a narrow channel between Cayo Puerca and the mangrove island just north of it. Water here was always clear and well saturated with oxygen. Currents were slow, but there were some swells and wave action at this station while the previous stations did not have any water movement caused by swells or waves. Station 13 had maximum temperatures up to 31.5° C. Sediments here were mud, and turtle grass was found here and there close to the mangroves. Water was about 0.8 meters deep.

Station 14 was at the southwestern side of Cayo Puerca. This area was protected both from the wave action and swells. Water was clear, well oxygenated and about 0.7 meters deep. Summer temperatures rose up to 31.5° C. on the surface. Sediments were mud.

Station 5 was on the northern shore of Aguirre Navigational Canal on a peninsula west of Cayo Puerca. This station was exposed to the wave action and swells. Water was well saturated with oxygen and currents were moderate. Sediments at this station were silt and fine sand. Water was shallow, between 0.3 and 0.5 meters. Temperatures up to 31° C. were observed on the surface in the summer.

Station 7 was on the south side of the Aguirre Navigational Canal at Cayos de Barca. This station was exposed to the wave action and the swells in the Navigational Canal. Water was well saturated with oxygen and clear. Summer temperatures up to 31° C. were measured on the surface. Currents were moderate and flowing to the west. Water was shallow between 0.2 and 0.5 meters deep. Sediments were mud.

Station 3 was located on the east shore of Punta Colchones in the Mid Bay. This station was exposed to the wave action and swells, but it was somewhat protected by a wide shallow turtle grass bed in front of it. Water at this station was light brown, well oxygenized. There was a weak southerly current passing by the station. At times of strong winds the water was silty. Water temperatures rose up to 31.5°C.

in the summer. Water at this station was 0.7 meter deep and the sediments were mud.

Samples were collected twice. The first time was in September 1971 and the second time in July - August, 1972. The first collecting involved cutting 30 cm sections of ten roots from the mean sea level down. The species, genera or phyla were identified and the biomass of each of them measured. The results are given in the Aguirre Power Project Environmental Studies 1971 Annual Report, PRNC-153, pp. 34-43. This study uncovered so many interesting aspects of the mangrove root communities that a more thorough investigation was undertaken.

In the second sampling whole mangrove roots were collected by cutting them at the mean high water level, which coincides with the uppermost sessile organisms on the roots. The roots were carefully surrounded with a 0.5 mm mesh net before lifting them out of the water. This way all the free swimming crustaceans and fish were recovered. Three to six randomly chosen roots were collected at each station.

The roots were placed into large polyethylene bags and transported into the laboratory in an ice chest. In the laboratory the roots were cut into 10 cm sections from the upper tide level down. The organisms in each section were separated, identified and the wet weight of each species was recorded. Because of the vertical zonation of organisms, the biomass is given per root instead of per unit length of root.

RESULTS

Species composition:

The number of species at different stations varied considerably (Table 1). Station 5 had the lowest number, or 27 species, and stations 4, 12 and 13 had the highest numbers, or 78 - 83. The total number of species collected at all stations was 168. They divided between the phyla as follows:

Cyanophyta	4
Chlorophyta	15
Phaeophyta	6
Rhodophyta	16
	41

Porifera	8
Coelenterata	2
Platyhelminthes	1
Annelida	14
Mollusca	24
Crustacea	41
Bryozoa	3
Echinodermata	3
Chordata	22
	118

At stations 4, 5, 7 and 12 crustaceans had the highest number of species of all phyla and at station 3 and 11 chordata (Ascidiacea) had more species than any other phylum (Table 1). At stations 13 and 5 there were as many species of ascidians as crustaceans. Station 13 had the most species of algae.

Species diversity is expressed only as number of species because there are so many encrusting algae, sponges, bryozoans and colonial ascidians that it would be impossible to use number of individuals as species diversity indices. The list of species found is given in Table 2.

BIOMASS

Biomass varied even more than species composition between different stations (Table 3). Station 5 had the lowest biomass, 12.7 g wet weight per root, while station 15 had the highest, 569 g. All the stations along the Aguirre Navigational Canal, 4, 5 and 7, had a low biomass compared to the stations inside mangrove areas in the coves and channels, stations 12, 13 and 15. Station 11 had a low biomass which, together with the types of species present, indicated that this station still had not recovered completely from the pollution. There was, however, an increase in the biomass and in the number of species present from the first sampling in September 1971.

Ascidians made the major contribution to the biomass at stations 3, 12, 13 and 15 (Table 3). Algae were the major phylum at station 7, mollusks at station 4 and cirripeds at stations 5 and 11. Sponges were an important phylum at stations 11 and 13 and polychaetes at station 3. Outside station 4, mollusks had a large biomass only at station 13. Biomasses of different species are given in Table 4.

VERTICAL ZONATION AND ECOLOGY OF MANGROVE ROOT COMMUNITY

The organisms living on the mangrove roots showed a distinct vertical zonation caused by the preference of each type of organism to the light, space and temperature, and by the competition. Algae were growing mainly on the upper part of the root, the maximum biomass being in just below the intertidal zone. The distribution of algae biomass showed a preference of algae to the sunlight (Figure 8). Sponges, *Tedania ignis* and *Ircinia strobilina*, lived below the intertidal zone and were not able to survive an exposure to the direct sunlight and air. *Callyspongia* spp. and especially *Halisarca* sp. were also found at the tip of the root.

The distribution of polychaetes reflected two different types of living habits. Species living in calcarous tubes, like *Pomatostegus stellatus*, were found in the intertidal zone while species dwelling in mud tubes (*Cirratulus* spp.) and pliable tubes (Sabellaridae) live below the intertidal zone. Worms living in calcarous tubes can close the tube with an operculum and thus survive long exposures to direct sunlight and air. Polychaetes did not usually live close to the tip of the root.

Molluscs as a group did not have a distinct zone on the post to live, but different species were found in special zones. The mangrove oyster, *Crassostrea rhizophorae*, grew throughout the intertidal zone, but not usually below it. Tree oysters, *Isognomon alatus*, grew in a zone just below the mangrove oysters. A mussel, *Brachidontes exustus*, grew intermittently with the tree oyster. Other bivalves were only found occasionally on the mangrove roots. Of the gastropods a periwinkle, *Littorina angulifera*, lived on the roots above the surface. Other gastropods occupied all levels below the intertidal zone. Many small gastropods lived in the bundles of algae. *Murex brevifrons*, a dril, preyed on mangrove oysters and other molluscs living on the mangrove roots.

Cirripeds had a zonation too. *Chthamalus stellatus* and *C. fragilis* lived in the upper part of intertidal zone while Balanus amphitrite and B. eburneus occupied all the space from there on down. In the middle part of the root there usually was a large number of dead Balanus shells.

Amphipods lived mainly among algae, sponges and cirripeds, but some species were found in the branchial sacks of large ascidians. Isopods were found in dead Balanus shells. Usually there was one individual of each sex in the same shell, but sometimes there would be several individuals in one Balanus shell.

Caridean shrimp were found among algae and in dead shells of the bivalves. Young individuals of the spiny lobster, Panulirus argus, were found occasionally crawling on the roots. Brachyuran crabs were usually more concentrated among algae, sponges and ascidians. Aratus pisonii, however, usually climbed on the root above the surface and Pachygrapsus transversus stayed in the intertidal zone. Microphrys bicornutus always had a layer of one or several species of colonial ascidians covering the carapace, thus making this sedentary crab very difficult to distinguish from the ascidians growing on the roots. The mangrove crab, Goniopsis cruentata, mainly lived further inside in the mangrove swamp, above and below the surface. Petrolisthes polita was the most common Anomuran crab. This species swimmed and crawled on the roots below the intertidal zone. Hermit crabs were found occasionally.

Two bryozoans were found on most mangrove roots. A species of Crisia, a branching bryozoan, occupied the root below the intertidal zone. Schizoporella errata, an encrusting bryozoan, was usually found near the tip of the root.

Ophiuroids were occasionally found on the roots. The most common of them, Ophiothrix angulata, lived among the algae, sponges and ascidians.

Ascidians were the most important animals on mangrove roots. Colonial ascidians Botryllus planus, Symplegma viride, Didemnum candidum, Trididenmun savignii, and Polyclinum constellatum seemed to prefer the zone just below the intertidal zone or the tip of the root, while simple ascidians, Ascidia spp., Microcosmus spp., Molgula occidentalis, Styela spp., Pyura vittata and Polycarpa obtecta were found mainly in the lower parts of the root. Clavelina picta and Ecteinascidia turbinata grew in the middle part of the root. A tiny branching species, Perophora viridis was an early settler, but poor competitor, thus it is found on the lowest part of the intertidal zone and at the tip of the root or, if space was available, on the shells of tree oysters.

Two species of fish were also found living on the roots inside of algae and dead bivalve shells. They were a blenny, Hippoleurochilus aequipinnus, and a goby, Coryphopterus glaucofraenum.

The maximum biomass of all organisms was between 30 and 60 centimeters below the mean water level.

DISCUSSION

The number of species on the mangrove roots was highest at station 12, which was characterized by almost stagnant water and no wave action. Stations 5 and 7 along Aguirre Navigational Channel had the lowest number of species. Water was shallow at these stations and the wave action was strong. Station 5 had the strongest wave action and swells because the prevailing winds were from the southeast. This station also had the least number of species on the roots. Station 11 had the second lowest number of species which indicated that this station had probably not yet recovered from the pollution. Algae found on the roots in Jobos were different from those reported by Biebl (1962) in La Parguera, but the same species were found as were reported by Almodovar (1964) in Jobos Bay. Many species of invertebrates found in the Jobos Bay area were the same as those reported by Mattox (1949) for the mangrove roots in Boqueron Bay. Mattox listed only 36 species or genera, while the total number of invertebrates on mangrove roots in Jobos Bay was 123. The mollusc fauna outside of Littorina angulifera and Isognomon alatus appeared to be completely different from that of Bahamian mangroves as reported by Robertson (1959).

The species of algae were more numerous in Jobos than in Guayanilla mangroves (see Kolehmainen and Morgan (1972), and the sections on mangrove communities in Guayanilla Bay in this report), but the species of invertebrates were practically the same. The mangrove roots in Guayanilla Bay had considerably more species of macroinvertebrates.

The biomass of organisms on the roots varied from 12.7 to

563 g wet weight per root. The lowest biomass was at station 5, which also had the lowest number of species. Station 15 had the highest biomass and station 13 had almost as high a biomass. In general stations with strong wave action had a low biomass while the stations in protected quiet places inside the mangrove coves and channels had a high biomass. Station 11 was an exception. A low biomass at this station indicated the effects of the previously polluted situation. The major species there were Balanus amphitrite var. pallidus and Balanus eburneus. These species were poor competitors and, therefore, were able to maintain a large biomass only in unfavorable ecological conditions where less tolerant species could not survive. A high biomass of cirripeds indicated usually a hypersaline, excessively hot or polluted condition. In Guayanilla Bay in the thermally altered cove, Balanus amphitrite var. pallida and Balanus eburneus were the dominant species in temperatures above 38° C. (see Kolehmainen and Morgan (1972) and the sections on mangrove root communities in Guayanilla Bay in this report).

At station 5 Balanus spp. were the major species, but their biomass was very low, which illustrates that the environmental conditions at station 5 did not resemble those of station 11. At stations 5 and 7 major parts of the root surface were not occupied by any organisms. The reason for this and the low biomass at these stations could be that the wave action and swells produced an unfavorable condition for sessile organisms. Another possible explanation is that mangrove root communities reach a maximum diversity and biomass only in places where there is enough suitable food. The most luxurious growth of the root communities was usually found inside or at the edge of large mangrove areas. This could indicate that suitable food for these sessile organisms was produced only in the mangrove swamp. This was not, however, always the case because in Guayanilla Bay some of the best root colonies were found in places where the whole mangrove stand was less than 0.1 hectares (Kolehmainen and Morgan, 1972). On the other hand, in Biscayne Bay and Card Sound the author has seen areas that had a mangrove swamp hundreds of meters deep and still there were almost no sessile organisms growing on the roots of red mangroves at the water front. One factor was common for most of the unpolluted mangrove areas that have poorly developed root communities. The water was less than 0.5 meter deep. Figure 8 shows that the most biomass was concentrated between 30 and 60 cm below the mean water level. Shallowness may, therefore, be one limiting factor.

The number of species and biomass were not directly correlated, but behaved independently. In the material from Jobos Bay the lowest number of species was found at station 5 where the biomass was also the lowest. Station 11 which had a moderate biomass had the second lowest number of species. At this station pollution was limiting the number of species, but some of these few species were able to attain a fair biomass. Guayanilla Bay is a good example of how pollution enables a few species to produce a large biomass in a low species diversity area. In temperatures between 35 and 37.5° C. two species, Isognomon alatus and Balanus amphitrite var. pallidus had a higher biomass than organisms on mangrove roots in high diversity areas. (Kolehmainen and Morgan, 1972. Also see the section on mangrove root communities in Guayanilla Bay in this report.) In general the highest species diversity was found inside the mangrove swamps in channels, embayments and coves in Jobos Bay. However, this was not a rule in Guayanilla, as discussed earlier.

Vertical zonation of species on mangrove roots is caused by several ecological factors: the settling speed and the growth rate of the species, the hardiness of the species to temperature and exposure to air, the growth rate and length of the mangrove root.

According to Gill and Tomlinson (1969), the aerial roots of red mangrove grow on the average of 3 mm per day and the growing region exceeds 20 cm. This means that it takes about nine months for a root to grow from the surface level down to 80 cm below the surface. In Jobos Bay the biomass of sessile and free-living organisms on mangrove roots was 290 g on the average. Assuming a 3 mm/day growth rate of the root the net production of organisms living on mangrove roots would be several hundred grams per year on young roots.

Balanus spp. and Crassostrea were the first settlers on the root when the tip of the root submerged. The next species to settle was Pomatostegus stellatus. These species were dominant as long as the root did not extend below the intertidal zone. Below the intertidal zone the competition increased when bryozoans, algae and ascidians covered the first settlers. Balanus spp. and Crassostrea *rhizophorae* were eventually smothered and they died. Since *Balanus* spp. were the first settlers, they kept occupying the growing tip. *Crassostrea*, however, did not settle on the root below the *intertidal* zone.

When the root accumulated more biomass, it became heavier, which caused the root to sink at the same time as it kept growing at the tip. New space was, therefore, created for *Balanus* and *Crassostrea* to settle at the surface. Even though these species were killed below the intertidal zone they were able to maintain their populations on the upper part of the root. Dead shells of *Balanus* and *Crassostrea* found below the intertidal zone on the root support the hypothesis that the root sinks besides growing within the 20 cm zone at the tip. Encrusting bryozoans were one of the first settlers below the intertidal zone. Since they were poor competitors they were killed soon. The only zone where encrusting bryozoans were found alive on most roots was near the tip.

After the roots had a layer of algae, sponges and ascidians there was ample space for polychaetes to attach their tubes. At this stage the roots attracted a multitude of free living crustaceans (isopods, amphipods, shrimp and crabs) and ophiuroids because of the food and shelter that the root community offered.

The interaction between different invertebrates on mangrove roots is completely unknown. Parasitism, commensalism and symbiosis are all probably present in this complicated community. Different niches have to be really closely spaced because most of the animals in the community are filter feeders.

THE IMPACT OF THE POWER PLANTS ON MANGROVE ROOT COMMUNITIES

The direct impact of the two fossil fuel power plants on the mangroves will be limited to the construction of the discharge canal. The construction will destroy 37 acres of mangroves, but about 5 acres are expected to be replanted in the fill area. The proposed route of the canal will destroy the least area of mangroves of all the possible routes because this was used as one of the criteria in selecting the location of the discharge canal. A flushing ditch was proposed to be constructed at the edge of the east side of the canal, from the embayment that has the pelican rookery to the Aguirre Navigational Channel. This ditch will maintain the tidal flushing of the above mentioned embayment and replace part of the lost water line that is the most productive part of the mangroves.

The discharge canal will divide the mangrove swamp into two separate areas, but this is not expected to have any adverse effects on the mangroves because the tidal flushing is maintained on the east side and no changes are anticipated in the water current situation in the Mar Negro area itself. The blocking of the narrow channel between Cayo Puerca and Punta Colchones will cut off the supply of water that flows in this channel. The current studies show, however, that the net flow through this channel is negligible. The physical separation of the mangroves in Mar Negro from the mangroves on Punta Colchones is not expected to have any effect on the mangroves or the mangrove root communities because both areas are much larger than needed to maintain a fully functional mangrove ecosystem.

Studies in Guayanilla Bay show that the elevated temperatures have no effect on composition of species or biomass in mangrove root communities below 34° C. (see Kolehmainen and Morgan (1972) and also see the section on mangrove root communities in Guayanilla Bay in this report). The temperatures in the mangrove areas in the Aguirre Ship Canal will not be increased more than 0.5° C. above ambient or from 31 to 31.5° C. during the warmest season. This small an increase in the temperature is not expected to have any adverse effects on the mangrove root communities or on the mangrove trees themselves.

Siltation and turbidity can seriously affect mangrove root communities, but it is not likely that these two adverse factors will endanger the mangrove root communities in the Aguirre Ship Canal. The slight increase in siltation and turbidity introduced by the cooling water in the Navigational Channel will be diluted about ten times by the entrainment water in the Navigational Channel before the plume reaches the mangroves. The root communities living now along the Navigational Channel have adapted to living in high turbidity water because they are exposed to strong wave action and swells. Therefore, siltation or turbidity conditions are not expected to endanger mangrove root communities along the Aguirre Navigational Channel.

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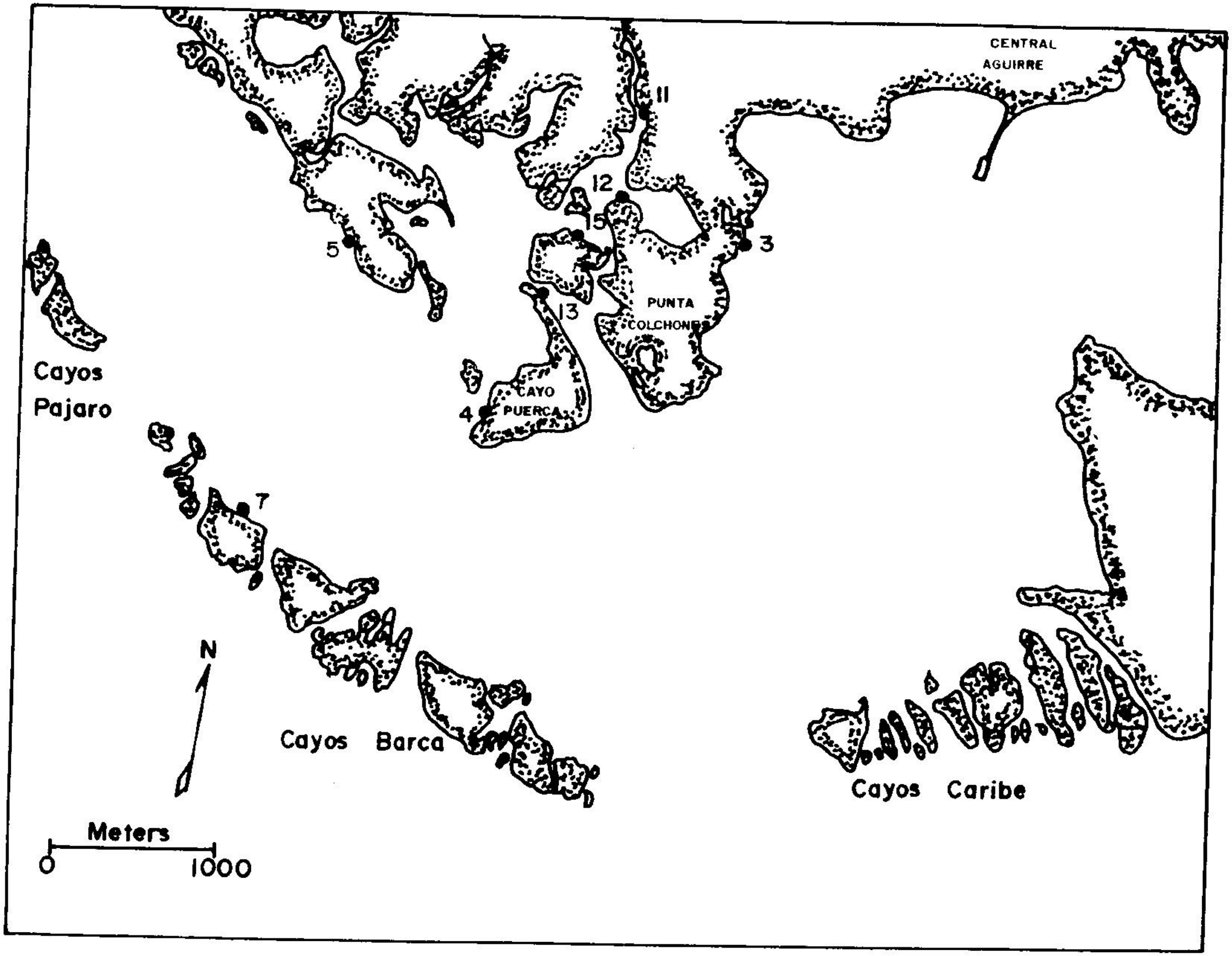

Figure 7. Location of the Mangrove stations studied.

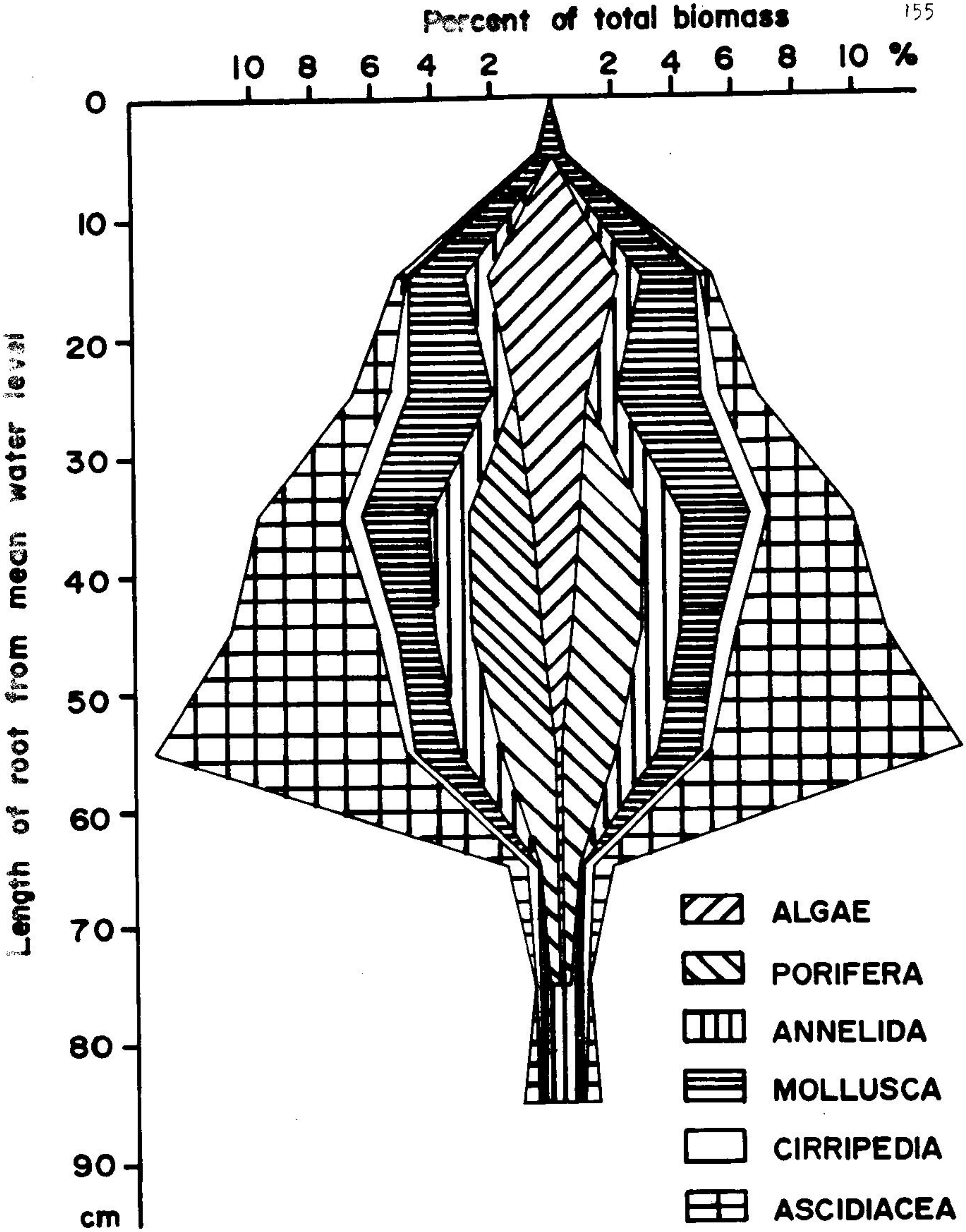

Figure 8. Vertical distribution of different organisms on the mangrove roots at Stations #12 &#13.

TABLE I

THE NUMBER OF DIFFERENT SPECIES IN EACH PHYLUM ON THE MANGROVE ROOTS IN JOBOS BAY

Phylum	Stations							
	3	4	5	7	11	12	13	15
Cyanophyta	1	1			2	2	2	
Chlorophyta	3	7	4	11	3	8	5	5
Phaeophyta		5	1	1	2	2	2	2
Rhodophyta	3	5	1	4	1	6	13	4
Total Algae	7	18	6	16	8	18	22	11
Porifera	6	3	2	1	2	5	4	3
Coelentarata	3	1	1	2		2	3	3
Platyhelminthes	1					1	1	1
Annelida	10	7	1	4	5	6	6	6
Mollusca	7	11	2	3	1	10	7	12
Arthropoda	15	21	9	13	11	23	16	15
Bryozoa	1	2	2	1	1	3	2	2
Echinodermata	2	2				2	1	1
Chordata (Ascidiacea)	18	12	4	10	14	14	16	14
Total invertebrates	63	59	21	34	34	66	56	57
Total species	70	77	27	50	42	84	78	68

TABLE 2

SPECIES LIVING ON THE MANGROVE ROOTS AT DIFFERENT STATION

	3	4	5	7	11	12	13	15
ALGAE								
Cyanophyta								
Lyngbya majuscula		x					x	
Lyngbya sp.	x				x	x		
Nostoc sp.							x	
Oscillatoria sp.					x	x		
Chlorophyta								
Caulerpa cupressoides		x		x				x
Caulerpa mexicana				x				
Caulerpa racemosa	x	x				x	x	
Caulerpa sertularioides		x	x		x	x	x	x
Caulerpa taxifolia				x		x		
Caulerpa verticillata				x	x	x		x
Chaetomorpha gracilis		x	x	x		x		
Chaetomorpha sp.						x		
Cladophora sp.	x	x	x	x	x	x	x	x
Enteromorpha chaetomorphoides		x					x	
Enteromorpha intestinalis				x				
Halimeda opuntia				x				
Penicillus capitatus				x				
Rhizoclonium kochianum		x					x	
Valonia ventricosa				x				

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
ALGAE								
Phaeophyta								
Dictyota bartayresii		x	x	x		x		
Dictyota cervicornis	x				x		x	x
Dictyota divaricata					x	x		x
Dictyota indica		x					x	
Giffordia mitchellae		x						
Giffordia rallsiae								
Rhodophyta								
Acanthophora spicifera	x	x	x	x		x	x	x
Amphiroa fragilissima				x				
Bostrychia tenella							x	
Callithmnion byssoides		x				x	x	
Centroceras clavulatum						x	x	
Ceramium fastigiatum		x					x	
Erythrotrichia carnea							x	
Gonitrichum alsidii							x	
Gracilaria sp.				x				x
Griffithsia globulifera							x	
Heterosiphonia wurdemanni						x	x	
Polysiphonia ferulacea	x					x	x	
Polysiphonia sp.	x	x			x	x	x	
Pterocladia sp.							x	
Spyridia aculeata								x
Spyridia filamentosa		x				x	x	
INVERTEBRATES								
Porifera								
Callyspongia vaginalis	x	x						x

TABLE 2 (cont'd.)	3	4	5	7	11	12	13	15
Porifera								
Chondrilla nucula	x					x	x	
Halichondria sp.								
Halisarca sp.	x		x	x	x	x		
Ircinia strobilina	x	x				x	x	x
Mycale sp.					x		x	
Tedania ignis	x	x	x			x	x	x
Terpies sp.						x		
COELENTERATA								
Anthozoa								
Bartholomea annulata		x		x		x	x	x
Erythropodium caribaeorum			x	x			x	x
PLATYHELMINTHES								
Turbellaria Unident.	x					x	x	x
ANNELIDA								
Polychaeta								
Cirratulus sp.		x					x	x
Leodice sp.		x		x	x	x		x
Lumbrinereis sp.	x							
Marphysa sanguinea	x							
Nereis sp.	x	x			x	x		x
Podarke guanica	x							
Pomatostegus stellatus	x	x	x	x	x	x	x	x
Sabella melanostigma	x	x		x	x	x	x	x
Sabella alba	x						x	
Sabellastarte magnifica		x		x		x	x	x
Syllis prolifera	x							
Syllis sp.	x							
Terebella annulifilis					x	x	x	
Terebella sp.	x	x						

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
MOLLUSCA								
Amphineura								
Chiton, Unident.	x							x
Gastropoda								
Bulla striata						x		
Crepidula aculeata		x						
Crepidula convexa								x
Crepidula glauca						x	x	x
Diodora arcuata		x						
Diodora cayenensis		x				x		x
Diodora sayi						x		
Leucozonia nassa							x	
Littorina angulifera	x	x	x	x		x	x	
Murex brevifrons		x						x
Petaloconchus erectus		x						
Thais haemastoma	x							
Bivalvia								
Brachidontes exustus	x	x		x	x	x	x	x
Brachidontes citrinus								x
Chione cancellata				x				x
Chione granulata						x		
Corbula caribae								x
Crassostrea rhizophorea		x	x			x	x	x
Isognomon alatus	x	x				x	x	
Modiolus americana								x
Musculus lateralis	x						x	x

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
MOLLUSCA								
Bivalvia								
Ostrea equestris	x							
Pinctada radiata		x				x		x
Plicatula gibbosa		x						

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
ANTHROPODA								
Crustacea								
Cirripeda								
Balanus amphitrite var. pallidus	x	x	x	x	x	x	x	x
Balanus eburneus	x	x	x	x	x	x	x	x
Chthamalus fragilis	x						x	
Chthamalus stellatus var. communis			x	x		x		
Amphipoda, Unident.	x	x		x	x	x	x	x
Isopoda								
Cirolana parva	x					x	x	
Excorallana quadricornis	x		x		x	x	x	x
Excorallana sexticornis	x				x	x	x	x
Excorallana tricornis					x	x		
Excorallana sp.	x	x				x	x	x
Sphaerosoma walkeri				x		x		
Decapoda								
Macrura								
Gnathophyllum americanum		x						
Latrecutes fucorum		x						
Palaemon northropi				x				
Panulirus argus		x						

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
Decapoda								
Macrura								
Periclimenes americanus						x		
Synalpheus frizmüllerii		x						x
Synalpheus minus						x		
Synalpheus townsendi								x
Synalpheus sp.	x	x				x	x	
Brachyura								
Aratus pisonii		x			x	x		
Cronius ruber					x			
Gonipsis cruentata	x	x	x	x	x	x	x	x
Hexapanopeus caribbaeus		x						x
Hexapanopeus hemphillii							x	
Hypoconcha nicholsoni		x		x				
Hypoconcha sabulosa						x		
Microphrys bicornutus	x	x	x	x		x	x	x
Mithrax coryphe			x					
Mithrax forceps		x				x		
Mithrax hispidus		x					x	x
Mithrax sculptus				x				
Pachygrapsus transversus	x	x	x	x	x	x	x	x
Panopeus bermudensis	x					x		x
Panopeus harttii	x					x		
Pilumnus dasypodus		x					x	
Podochela grossipes		x						
Sternorhynchus seticornis		x		x				
Anomura								
Clibanarius antillensis			x					
Pagurus marshi				x				
Petrolisthes polita	x	x			x	x	x	x

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
BRYOZOA								
Crisia sp.		x	x	x	x	x	x	x
Savigniella lafontii						x		
Schizoporella errata	x		x	x			x	x
ECHINODERMATA								
Ophiuroidea								
Amphiuridae sp.						x	x	x
Ophiothrix angulata	x	x				x	x	x
Ophiothrix oerstedii	x					x		
CHORDATA								
Ascidiacea								
Ascidia curvata	x				x		x	x
Ascidia interrupta	x				x			x
Ascidia nigra	x	x		x	x	x		x
Botryllus planus	x	x	x		x	x	x	x
Clavelina picta	x				x	x	x	x
Didemnum candidum	x						x	
Diplosoma macdonaldi	x					x	x	
Distaplia bermudensis							x	
Ecteinascidia turbinata	x	x			x	x	x	x
Herdmania momus		x	x	x	x	x		
Microcosmus exasperatus	x	x		x	x	x	x	x
Microcosmus helleri				x				
Molgula occidentalis	x	x		x	x	x	x	x
Perophora viridis	x		x	x	x	x	x	x
Polycarpa obtecta	x			x	x			x
Polyclinum constellatum		x				x		

TABLE 2 (cont'd.)

	3	4	5	7	11	12	13	15
Ascidiacea								
Pyura vittata	x	x			x		x	
Rhodosoma turcicum	x						x	x
Styela partita	x	x		x	x	x	x	x
Styela plicata	x	x			x	x	x	x
Symplegma viride	x	x	x	x		x	x	x
Trididemnum savignii	x	x		x		x	x	

TABLE 3

THE BIOMASS OF MAJOR GROUPS OF ORGANISMS ON
MANGROVE ROOTS IN JOBOS BAY

Weights are given in grams wet weight per root.

	3	4	5	7	11	12	13	15
Algae	15.2	22.2	3.5	18.9	17.3	76.7	16.1	46.6
Porifera	15.2	7.6	0.6	0.1	45.3	0.5	120.5	63.4
Annelida	56.8	7.5	0.6	0.4	21.0	71.5	33.5	13.1
Mollusca	15.3	65.5	0.2	0.4	12.8	32.5	136.7	40.6
Cirripedia	43.4	7.5	5.0	6.0	70.5	31.8	19.3	44.7
Chordata	257.3	62.7	0.8	14.7	25.6	129.4	233.4	194.5

TABLE 4

BIOMASS OF DIFFERENT SPECIES LIVING ON THE MANGROVE ROOTS
(The weight is given as grams wet weight per root.)

	3	4	5	7	11	12	13	15
ALGAE								
Cyanophyta								
Lyngbya majuscula		0.6						
Lyngbya sp.	0.1				4.8	4.1		
Nostoc sp.							0.3	
Oscillatoria sp.					0.3	3.2		
Total Cyanophyta	0.1	0.6			5.1	7.3	0.3	
Chlorophyta								
Caulerpa cupressoides		1.0						
Caulerpa racemosa								4.5
v. macrophysa	4.8	8.4						8.4
Caulerpa sertularioides			0.1			6.4	1.8	11.6
Caulerpa taxifolia				0.3				
Chaetomorpha gracilis		0.5	1.4	0.8		47.3		
Cladophora sp.	0.1		1.9	4.5	0.2	8.3	0.5	0.6
Enteromorpha chaetomorphoides							0.3	
Enteromorpha sp.	1.1		0.1	0.2		1.5		
Halimeda opuntia				0.1				
Total Chlorophyta	6.1	9.9	3.5	5.9	0.2	69.4	2.6	25.1
Rhodophyta								
Dictyota bartauresii		1.2		0.1				
Dictyota cervicornis		8.0						
Total Phaeophyta		9.2		0.1				

TABLE 4 (cont'd.)

	3	4	5	7	11	12	13	15
ALGAE								
Rhodophyta								
Acanthophora spicifera	8.7	2.5		1.5			2.2	21.5
Ceramium fastigiatum							10.5	
Polysiphonia ferulacea	0.3							
Polysiphonia sp.					12.0		0.5	
Unident.				11.1				
Total Rhodophyta	9.0	2.5		12.6	12.0		13.2	21.5
INVERTEBRATES								
Porifera								
Callyspongia vaginalis	4.9	0.8						2.6
Chondrilla nucula	0.3						0.1	
Halichondria sp.	0.2							
Halisarca sp.	0.1		0.1	0.1	1.3	0.1		
Ircinia strobilina	0.8	1.3				0.3	5.0	8.4
Mycale sp.					44.0		1.2	
Tedania ignis	8.9	5.4	0.5			0.1	114.2	52.4
Total Porifera	15.2	7.5	0.6	0.1	45.3	0.5	120.5	63.4
COELENTERATA								
Actinia unident.	0.4							
Bartolomea annulata		0.1		0.5		1.5	0.2	1.2
Erythropodium caribaeorum			0.1	0.1			0.1	1.1
Hydroidea unident.	0.8							
Total Coelenterata	1.2	0.1	0.1	0.6		1.5	0.3	2.3
Platyhelminthes								
Turbellaria Unident.	0.1					0.5	.3	[illegible]

TABLE 4 (cont'd.)

	3	4	5	7	11	12	13	15
ANNELIDA								
Polychaeta								
Cirratulus sp.		0.1					5.9	3.2
Leodice sp.	1.7	0.2		0.1	1.0	2.8		1.8
Lumbrinereis sp.	1.2							
Marphysa sanguinea	0.1	0.1						
Nereis sp.	1.1	0.4			0.2	4.0		1.0
Podarke guanica	0.1							
Pomatostegus stellatus	9.5	2.3	0.6	0.1	13.2	17.6	16.3	2.0
Sabella alba	0.1						0.3	
Sabella melanostigma	42.7	3.8		0.1	6.5	40.4	6.0	5.1
Sabellastarte magnifica		0.6		0.1		8.1	4.2	
Syllis prolifera	0.1							
Syllis sp.	0.1							
Terebella annulifilis					0.1	4.2	0.8	
Terebella sp.	0.1	0.1						
Total Polychaeta	56.8	7.6	0.6	0.3	21.0	71.5	33.5	13.1
MOLLUSCA								
Amphineura								
Chiton unident.	0.1							
Gastropoda								
Crepidula aculeata		0.1						
Crepidula glauca							0.1	0.6
Diodora cayenensis		0.1				0.2		1.9
Leucozonia nassa							0.1	
Littorina angulifera	0.3	0.2	0.2	0.3		0.4	0.2	
Murex brevifrons		1.1						

TABLE 4 (cont'd.)

	3	4	5	7	11	12	13	15
MOLLUSCA								
Gastropoda								
Nudibranchia	0.1							
Petalocunchus crectus		0.2						
Total Gastropoda	0.4	1.7	0.2	0.3		0.6	0.4	2.5
Bivalvia								
Brachidontes exustus	14.1	1.1		0.1	12.8	29.4	74.0	36.6
Chione cancellata								0.1
Chione granulata						1.2		
Corbula caribaea								0.1
Crassostrea rhizophorae		26.2					36.2	1.2
Musculus lateralis	0.1						0.3	0.1
Ostrea equestris	0.7							
Isognomon alatus		36.5				1.3	25.8	
Total Bivalvia	14.9	63.8		0.1	12.8	31.9	136.3	38.1
ANTHROPODA								
Crustacea								
Cirripedia								
Balanus amphitrite *v. pallidus*	42.5	4.4	0.8	0.1	57.9	21.6	14.1	39.7
Balanus eburneus	0.8	3.1			12.6	10.2	5.1	5.0
Chthamalus fragilis	0.1						0.1	
Chthamalus stellatus *v. communis*			4.2	5.9				
Total Cirripedia	43.4	7.5	5.0	6.0	70.5	31.8	19.3	44.7
Amphipoda, unident.	1.0	1.2		0.1	1.0			0.5

TABLE 4 (cont'd.)

	3	4	5	7	11	12	13	15
ARTHROPODA								
Isopoda								
Cirolana parva	0.1					0.4	0.2	
Excorallana quadricornis	0.5		0.1		1.5	1.2	0.1	0.3
Excorallana sexticornis	1.5				1.3	0.6	0.1	0.05
Excorallana sp.							0.2	0.1
Excorallana tricornis					0.4			
Total Isopoda	2.1		0.1		3.2	2.2	0.6	0.45
Decapoda								
Macrura								
Periclimenes americanus						0.1		
Synalpheus fritzmuelleri		0.1						0.1
Synalpheus townsendi								0.1
Synalpheus sp.	0.2	0.2				0.1	0.4	
Total Macrura	0.2	0.3				0.2	0.4	0.2
Brachyura								
Aratus pisonii		0.4			0.2	0.4		
Cronius ruber					0.5			
Hexapanopeus caribbaeus		0.1						
Hexapanopeus hemphillii							0.4	
Microphrys bicornutus	0.1		0.2	0.1		1.8	3.1	
Mithrax coryphe			0.8					
Mithrax hispidus							0.6	0.2
Pachygrapsus transversus	0.3	0.3	0.1	0.2	0.4		0.4	0.1
Panopeus bermudensis	0.9	1.2				1.7		0.5
Panopeus hartii	0.3	0.4				0.8	0.3	
Pilumnus dasypodus		0.2					0.7	
Total Brachyura	1.6	2.1	1.1	0.3	1.1	4.7	5.5	0.8

TABLE 4 (cont'd.)

	3	4	5	7	11	12	13	15
ANTHROPODA								
Anomura								
Clibanarius antillensis			0.1					
Petrolisthes polita	1.8	3.2			0.2	5.8	1.5	1.6
Total Anomura	1.8	3.2	0.1		0.2	5.8	1.5	1.6
BRYOZOA								
Crisia sp.		0.1	0.1	0.1	2.4	4.6	0.1	0.7
Savignyella lafontii						0.7		
Schizoporella errata	1.5	0.2	0.1				0.2	2.1
Total Bryozoa	1.5	0.3	0.2	0.1	2.4	5.3	0.3	2.8
ECHINODERMATA								
Ophiuroidea								
Amphiuridae sp.		0.1						
Ophiothrix angulata	0.3	0.4				0.6	0.1	0.6
Ophiothrix oerstedii	0.1							
Total Ophiuroidea	0.4	0.5				0.6	0.1	0.6
CHORDATA								
Ascidiacea								
Ascidia curvata	1.2						3.0	
Ascidia interrupta	0.4				1.2			
Ascidia nigra	25.7	4.8			8.6	5.1		
Botryllus planus	0.9	0.1	0.4		4.1	1.2	0.2	
Clavelina picta	1.4				0.2	0.2	43.0	168.0
Didemnum candidum							44.7	
Diplosoma macdonaldi	0.3						10.8	

INTRODUCTION

Jobos Bay and the Aguirre Ship Channel are protected from the action of strong Caribbean waves by a barrier of coral and mangrove cays. This barrier is broken up into four groups of Cays: Cayos Caribes, Cayos de Barca, Cayos de Pajaros, and Cayo Morrillo. The cays consist primarily of coral reefs on the windward side, with mangroves growing behind the reef, and turtle grass communities growing on the calm leeward side. In some places, small channels and lagoons are formed among the mangroves. These communities, like the mangroves and turtle grass beds inside the bay, depend for their existence on the protection from wave action that the coral reefs provide.

Coral reefs are climax communities. They are among the most complex and diverse communities in the marine environment. The corals themselves are important as primary producers and as providers of shelter for the many other reef organisms. Coral reefs are ares of high productivity in what are considered to be low-productivity tropical waters. Many commercially valuable fish and invertebrates live or come to feed on the reef. It is generally considered that the living coral reefs around Puerto Rico are mostly a thin veneer of coral growing on relict limestone structures. Thus, the corals are in part responsible for preventing the older structures from being gradually eroded away by wave action. Because of these considerations, the presence and preservation of the coral on the reefs outside of Jobos Bay is important for the preservation of the integrity of the bay itself.

To understand how various environmental factors may affect the stability of the reef community, it is first necessary to know the organisms present and the interactions among them. The following biological survey of the fauna and flora of the coral reefs of Jobos Bay is being undertaken for this purpose. Ten stations were chosen in order to represent the diversity of the reefs of Jobos Bay. At each station data was collected to study the reef zonation patterns, species composition, species diversity and standing crop. The stations and their locations are the following: (Fig. 9).

STATION 1 - Outside of Cayos Caribes. This station has fairly clear water. There is little influence from

Jobos Bay on this area.

STATION 2 - East end of Boca del Infierno (Cayos Caribes side).

STATION 3 - West end of Boca del Infierno (Cayos de Barca side). Both stations 2 and 3 have turbid water. The current created by water entering the bay stirs up sediments causing siltation to occur on the reefs. The reefs do not extend as deep and there is less coral life.

STATION 4 - Outside of middle of Cayos de Barca. This station has clear water with little influence from the bay.

STATION 5 - West end of Cayos de Barca.

STATION 6 - East end of Cayos de Pajaros. These two stations have murky water which is laden with silt from Jobos Bay. These stations are in the area that the warm water plume might affect.

STATION 7 - Outside Cayos de Pajaros - This area and the next two stations are also affected by Jobos Bay water.

STATION 8 - West end of Cayos de Pajaros.

STATION 9 - East end of Cayo Morrillo.

STATION 10 - Fringing reef off Cayo de Puerca and Punta Colchones. This is the only reef area inside the Bay. It lies directly opposite Boca del Infierno and receives the onslaught of the waves entering the Bay. This is probably the reason why the reef has been able to form inside the Bay.

MATERIALS AND METHODS

Sampling methods were geared to collect descriptive and quantitative data. Three methods were used, all involving the use of scuba diving:

1. Transects: A nylon line marked at 1 m intervals was used to make transects extending from as close

to the reef flat as safe swimming allowed, to the beginning of the reef fore-slope. The transect usually covered a distance of 75 to 125 meters. Data from the first few transects were recorded on plexiglass plates, on which all corals and major cover organisms (such as sponges and gorgonians) along each meter interval were noted and recorded. Later transects were recorded photographically, but only every third meter was photographed. The transect data was used to describe the reef zonation and structure and to determine species dominance among the main cover organisms.

2. Measured Quadrats: Two meter by two meter areas were marked off with heavy stakes and nylon lines or with a metal rod frame. The plots were then divided into 1/4 m^2 grids. The areas covered by each species of coral and other important organisms were recorded on a plexiglass plate or on film. The resulting diagrams or photographs were used to calculate percentages of bottom coverage, and dominance and species diversity among the major encrusting organisms.

3. Collected Quadrats: 1/4 m^2 areas of the above quadrats were collected in their entirety. Crowbars and knives were used to remove sections of the reef rock which contained encrusting and boring organisms. The samples were immediately placed into large plastic bags, held next to the collecting site by a second diver, in order to ensure that none of the small free-living organisms such as crabs and brittle stars could escape. The samples were stored in plastic buckets and refrigerated on their way back to the laboratory where they were sorted into phylogenetic groups, weighed and preserved for later identification. Corals were weighed and their surface area estimated. Pieces of pre-weighed and measured coral were dried at 110°C., reweighed, subjected to Clorox digestion, dried and weighed again to estimate the amount of living animal and plant material present. The pieces of coral rubble which remained after most of the encrusting and boring organisms had been removed were similarly treated to estimate the amount of non-removable material [illegible] the bryozoans,

boring sponges, calcareous algae, and boring worms) still remaining. A factor was calculated from this and used to calculate the amount of organics in the total rubble sample. This total is listed in the biomass estimates as "miscellaneous."

In the case of station 10, three clumps of material were collected and labeled samples 10A, 10B, and 10C. The narrowness and relief of the reef there made it very difficult to collect quadrat samples. For this reason, no transect data was collected for this area.

Total biomass estimates were derived by tracing the area covered by coral reefs from a standard USCGS map, cutting out and weighing the tracings and multiplying the estimated area by the average of the biomass estimates computed from the collected quadrats data.

Only the corals, gorgonians, mollusks, crustaceans and echinoderms were classified to genus and species level. The classification of the sponges, annelids (present in very large numbers), sipunculids and other worm-like organisms was not attempted. I wish to acknowledge and thank Mr. Carlos Carrera, Department of Marine Sciences, University of Puerto Rico, for his help in classifying the brittle stars.

RESULTS

To this writing, data has been collected for Stations 1, 2, 3, 4, 5, 7 and 10. Stations 1 - 7 are from the outer reefs; Station 10 is from the Cayo de Puerca area. The outer reefs can be divided into five life zones: the shallow reef flat, the Millepora-Palythoa zone, the Acropora zone, the buttress zone, and the reef fore-slope. In addition, there is the lagoon-back reef habitat on the leeward sides of the reefs. Since usually only one sample was collected at each station, and samples were not always collected in the same reef zone, quadrat data for all five zones of each station have not yet been collected. The samples were distributed as follows:

Station #	Zone of Measured Quadrat	Zone Collected Quadrat
1	-	Upper *Acropora*
2	-	Middle *Acropora*
3	-	Lagoon-Back Reef
4	Upper *Acropora* Lower *Acropora* and Buttress	Buttress; reef flat
5	Lagoon-back reef	Lagoon-back reef
7	Fore-slope	Buttress

A. Description of Reef Zones:

The outer reefs of Jobos Bay can be divided into five zones (landward to seaward): (Fig. 10).

1. *Reef flat*: This is a shallow area of sand and rubble that lies behind the reef front and between the reef and the mangroves growing on the cays. In some places, it deepens to form small channels and lagoons between the mangrove stands. The depth of this zone (exclusive of the latter channels) varies from a few inches to around three feet during high tide. There is a very strong current rushing over the area.

   This zone is characterized by sturdy encrusting and small branching corals such as *Porites astreoides* and *P. porites*. Others, such as *Favia fragum*, *Agaricia agaricites*, and *Siderastrea radians*, are common to a lesser degree. The black sea urchin, *Diadema antillarum* occurs in large quantities and is second only to the corals in numbers. Other sea urchins such as *Trypneustes esculentus* and *Brissopsis elongata* are also very common. Encrusting zoantharians such as *Palythoa* and *Zoanthus* are responsible for around 5 - 10% of the bottom coverage. The corals provide another 30% bottom coverage. The remainder of the surface is coarse sand and coral rubble.

2. *The Millepora-Palythoa Zone* is the breaker zone. This is the zone of highest wave energy and water movement. The dominant organisms in this zone are mostly small colonies of *Acropora palmata*, large

stands of the hydrocoral Millepora complanta and two encrusting coelenterates, the zoanthid Palythoa caribaea and the gorgonian Erythropodium caribaeorum, which cover most of the rubble in the area. Various species of red calcareous algae, Gonolithon and Lithothamnion, commonly grow on the sides of and between the corals. Diadema antillarum is also evident in large quantities. Samples have not been collected in this zone because of the difficulties of working in this area of breaking waves and overwhelming quantities of sea urchins and fire-coral.

3. Acropora Zone: This zone extends from the bottom edge of the Millepora-Palythoa Zone for about 30 - 45 m seaward. Medium sized Acropora palmata and large Gorgonia colonies are characteristic, along with large pieces of rubble which in many cases are encrusted with Porites astreoides, Palythoa caribaea, the gorgonian Erythropodium caribaeorum, and various sponges such as Chondrilla nucula. The depth of this zone varies from 4 - 20 feet. The sizes of the A. palmata, G. flabellum and G. ventalina colonies increase with depth. At the shallow end of the zone, there are few corals other than A. palmata growing and only about 39% of the bottom is covered with living organisms. Fig.11 shows how a typical $4m^2$ of reef bottom would appear in the upper Acropora zone. At the deeper end of the zone, where there are more encrusting corals like Montastrea annularis, Diploria clivosa, Siderastrea siderea and Porites astreoides, and more gorgonians, the bottom coverage is 49% (Fig. 12). The polychaete, Hermodice carunculata was commonly found feeding on A. palmata and M. complanata in this zone.

4. Buttress Zone: This is an area of high relief due to the presence of very large Acropora palmata colonies and to large buttresses covered with many different corals and organisms. The depth varies in this zone from 5 feet at the crest of a buttress, to depressions between the buttresses of 15-25 feet deep. This appears to be a fairly rich area with many reef fish and invertebrates. The buttress zone, with all its canyons, tunnels, and towering coral heads, provides a great variety of

habitats for reef organisms. Fig.13 displays a $4m^2$ example of the crest of a buttress, 7 feet from the surface, with a bottom coverage of 63%.

5. Reef fore-slope: Beyond the varied relief of the buttress zone, the reef flattens out and slopes down to its base. The slope varies, being gradual down to around 35 to 45 feet and then dropping off steeply to a depth of 60 feet. The width of the slope varies from reef to reef, being wider off Cayos Caribes and narrower off Cayos de Pajaros. The gradually sloping portion of the zone is covered with encrusting corals such as *Montastrea annularis*, *M. cavernosa*, *Siderastrea siderea*, *Diploria labyrinthiformis*, and *Porites astreoides*. *Isophyllia multiflora*, *Isophyllastrea rigida*, *Mycetophllia lamarckiana*, and *Mussa angulosa* are very common between the heads of encrusting corals. In some areas there are channels cut through the reef slope, (relic buttress and groove formations from a lowered stand of sea level, 8-12 thousand years ago), which end at the reef base. Many sponges grow on the vertical walls of these grooves. *Agaricia agaricites* is the predominant coral.

From the break in slope down to the base of the reef there is little living coral. The lower parts of the steep slope are silted over. Dead colonies of *Montastrea* and *Porites*, covered with silt, can be recognized. In one such area long whip-like gorgonians, *Ellisella* sp., were found growing.

Gorgonians are very abundant on the reef fore-slope especially in the gradually sloping region where they sometimes make up 50% of the bottom cover. But there are few of them on the steep slope. Fig.14 is a diagrammatic representation of the bottom coverage of a $4m^2$ area of the upper fore-slope.

The lagoon-back reef refers to a different type of coral habitat. It is found on the protected and deepening lee-ward back sides and ends of bank reefs. In Jobos Bay, this habitat type is found in the passes between the chains of cays, e.g., Boca del Infierno. Depth varies from 15-25 feet. The bottom is usually hard with some sand over it. There are occasional clumps of coral (*Montastrea annularis*, *Siderastrea siderea* and *Diploria labyrinthiformis*) with

Gorgonia flabellum, various sponges and other reef organisms associated with them. Gorgonians are very abundant in these areas, either growing on the clumps or separately in the sandy areas. Fig.15 shows a $4m^2$ section of bottom from the pass between Cayos de Barca and Cayos de Pajaros. A similar type habitat is found in the shallow lee of reefs, in the end zones. There the bottom is shallower (3-6 ft.) and siltier. Most of the coral is Siderastrea radians, and the gorgonians Pseudoterogorgia americana and P. acerosa are the most abundant (Fig.16).

The formerly described zones are present on all three sets of outer reefs studied (Cayos Caribes, Cayos de Barca and Cayos de Pajaros). There are differences in the relative extension and development of the five zones between the three reefs, but these are probably a reflection of the differences in the base structures on which the reefs have grown. In general, the differences between zones of the same reef are greater than the differences between the same zones on different reefs.

The only reef present within the bay is a small reef growing on the southeast side of Cayo Puerca and Punta Colchones. There is very little living coral on this reef, which is only a few meters wide and is between 1-5 feet deep. It is bounded to the lee by a Thalassia bed and mangroves, and to the windward side by a sand and silt area with some Thalassia. Living coral is found only on the edge of the reef (Siderastrea radians) or forming a few large boulders growing within a couple of feet of the reef itself (Montastrea annularis). Other corals present are Millepora alcicornis, Acropora cervicornis (both indicative of quiet waters with good circulation), Favia fragum, Agaricia agaricites, Diploria spp., Isophyllia multiflora and Porites astreoides. No Porites porites was seen although its presence would be expected. Palythoa is very abundant and so is Erythropodium, to a lesser extent. Gorgonians are present in fair quantities a few feet from the reef. There are many back reef species present such as Stoichactis helianthus and Sabellastarte magnifica, and many algae such as Caulerpa sertularioides and Halimeda sp., which cover extensive areas of the reef. Red calcareous algae are also very abundant. Only two young colonies of Acropora palmata were observed.

The reef seems to be the remains of a former Porites reef. The flat area between the edge of the reef and the mangroves is undermined and tunneled and appears as if it were once a

An attempt was made to rank the commonness of the various cover-organisms. This was done by noting the presence or absence of a given species for each meter interval of each transect. The organism which had the most number of occurrences in a particular transect was ranked number 1, and so forth down the line. Later, the ranks received by each species in each transect were added together. The cover-organism receiving the highest total rank was deemed to be the most common and so forth. The results from this analysis on 6 transects are presented in Table 5. The elkhorn coral, Acropora palmata was the overall most common species. This was to be expected because most of the transects started at the outer edge of the Millepora-Palythoa zone and continued in most cases only until the upper edge of the buttress zone, (in Station 2 there was only a narrow buttress zone and a short steep fore-slope after a broad Acropora zone). Because of this, the Acropora zone made up around two-thirds of the transects. Gorgonians, (specifically the branching forms) which are relatively abundant in all reef zones, were the second most common group. It is interesting to note that the two most common organisms have branching growth forms. The success of branched forms is probably due to the fact that they can outgrow the heavier massive, encrusting forms and over-shadow them, therefore being more successful in the competition for space. Notice that most of the other organisms classified as cover-organisms are massive and encrusting in growth form, (Table 5, right column). These types are important to the reef because they are the ones responsible for protecting the reef structure from mechanical erosion and chemical dissolution.

It is interesting to note that Montastrea annularis, which is considered the main reef builder in the Caribbean, (Goreau, 1959; Stoddart, 1969) is only ranked 10th on the Jobos reefs. The abundance of the various cover-organisms varies with reef zone. The percentage of cover provided by each species in $4m^2$ measured quadrats for the different reef zones is presented in Table 6. At the bottom of the column for each sample is the total bottom coverage provided by the organisms in that quadrat (calculated from Figs.11 - 15.

The diversity of the cover organisms of each quadrat was calculated using an index of diversity which takes into account both the number of species and individuals, and the distribution of the individuals among the species. The index, based on information theory, is known as the Shannon index (Shannon, 1948) and is given by the equation:

$$(1)\quad H' = -P_i \log P_i \text{ information units}$$

but can be calculated by an easier method (Lloyd, 1967) using:

$$(2)\quad H' = \frac{c}{N}(N \log N - n_i \log n_i) \text{ information units}$$

where c is a scale factor for converting from logarithms base 10 to other bases (in this case, base e was used, c = 2.302585, and the results are expressed in "nits"), N is the total number of individuals and n_i is the number of individuals in species i where i = 1, 2, ... S. S is the total number of species present. P in equation (1) is the proportion of n_i to N. H'/H' max is called the Pielou evenness index (Pielou, 1966). The maximum H' value for a given sample would occur if the individuals were divided evenly among the species. In that case

$$(3)\quad H'_{max} = S\left(\frac{1}{S} \log_e \frac{1}{S}\right) = \log_e S$$

so that H'/H' max would equal to 1 for samples with perfectly even distribution and equal to 0 for samples where all the individuals are of one species. The percentage of bottom cover was used instead of the number of individuals in the case of the cover-organisms. Both indexes (H' and H'/H max are useful for comparing the various quadrat samples. But it should be remembered that since there is no universal criteria as to how much difference there should be between diversity indexes before they are significantly different, the user will be compelled to make decisions, on this respect, based on experience with the assemblage studied.

The percentage of bottom coverage is an indication of the successfulness of organisms in colonizing an area. It probably also reflects the stability of an area, e.g., a high stability area would have a high percent bottom coverage. There appears to be a trend of higher percents bottom coverage and higher diversity of cover organisms with increasing water depth. The stability of deeper areas is higher since wave action is not as strongly felt and there is less variation in temperature and salinity than in shallow areas. The deepest zone, the fore-slope, as expected, had the highest diversity. (Fig.14). But the highest bottom coverage was found for the buttress zone. The buttress zone sample was taken from the crest of a buttress where the conditions encountered were similar to those found in the Millepora-Palythoa zone. The three organisms responsible for the majority of the coverage were Millepora, Palythoa and sponges, all of which are encrusting. The crest of the buttress is, then, similar to the Millepora-Palythoa zone in that the few organisms which have successfully adapted to it have been able to occupy almost all of the available space. The lagoon-back reef which is intermediate in depth and in stability has both fairly high coverage and high diversity. The diversity and percent coverage is lowest for the Acropora zone, an extremely unstable zone, which is frequently destroyed by storms and hurricanes.

A sample taken near the bottom of a buttress would most probably result in the highest cover and diversity. The reason for the increase of diversity and coverage with depth is because more species of corals can survive in the less turbulent water of the buttress, reef slope and lagoon-back reef zones, so that they can take advantage of all the available light for photosynthesis. The depth at which light penetration decreases below the limit for rapid coral settlement and growth could be called the reef compensation depth. In the shallower waters of the Acropora zone, only the few corals and other organisms that can withstand the large waves and bottom scour will do well, inspite of the increased light supply: therefore, lower diversity and bottom cover (more organisms will be destroyed by wave action in this area). However, in the Millepora-Palythoa zone and the reef flat, there are species which are specialized for strong currents and do not receive as much pounding from the waves. The rapid water currents in this area bring a constant fresh supply of nutrients from the rest of the reef. Thus, these factors result in areas of high productivity and bottom coverage although not necessarily of high diversity.

Examination of the coverage percentages for the various cover species in Table 6 shows us how the importance of the species varies with its location on the reef. Gorgonians are most common in the back reef-lagoon area, where less wave action will pull fewer colonies free from the substrate. Erythropodium, an encrusting gorgonian, is most abundant where it gets plenty of circulation and light, but not too much wave action, i.e., in the lower Acropora zone. Acropora palmata which needs a lot of circulation, and is of course, the most abundant species in the zone named after it, is not present at all on the deeper reef-slope. A. cervicornis was found only on the deeper reef-slope, therefore, it does not enter into competition with its congener. The massive corals are mostly present in the deeper zones. Algae are of very little importance on the reefs. The large numbers of herbivorous fish present in the daytime probably consume the algae faster than they can grow.

III Biomass Estimates:

Biomass (also known as the standing crop) is a measure of the biological material present in an area. The biomass estimates from the ten samples studied are presented in Table 8 broken down into various phylogenetic categories. The last category, "Miscellaneous," takes into account the organic material present in the substrate as well as encrusting material, (both plant and animal) that could not be separated from the substrate. Also included are small amounts of biomass from other phylogenetic groups which were not considered important enough to be listed separately. The non-living organic material present in (or on) the substrate is included because this material is important as food for the many detrital and filter feeders on the reef and is an important part of the reef's energy cycle.

In this work, it is expressed as grams wet weight per 1/4 square meter. The wet weights of each catagory were not converted to one meter square units because of the heterogeneity of the reef environment. Larger sample sizes would have been better for statistical purposes, but the increased amount of material would have been impossible to handle. The total biomass for each sample area was converted to wet weight/m^2 because it was considered that although the composition of the biomass may vary from spot to spot, the total biomass present per area should be fairly constant.

In stations 1 through 7, 1/4 m^2 samples were collected. However, the areas collected were less than 1/4 m^2 for samples 10A, 10B, and 10C. In the last line of Table 8, the ratio of the total biomass to the weight of the remaining substrate is shown for comparison. This ratio relates the amount of biomass collected with the third dimension of the area sampled. A flat area with no rubble will have less substrate weight than another area which has a large amount of rubble accumulated on it, and therefore, more surface area. The Cayo Puerca stations (10) have much more living material per amount of substrate than the outer reef stations. Notice also that the distribution of the biomass among the various phylogenetic groups is different from that of the outer reef stations. Algae are more important here than in the outer stations. Also the bulk of the biomass is found in the Miscellaneous category. There is probably a lot of detrital material, accumulating in the crevices of the reef, coming both from the mangrove and _Thalassia_ communities behind the reef and from the bay itself. Much less flushing occurs on this inner reef than on the outer reefs.

Of the other stations, sample 4B seems to be the richest in standing crop. It was taken on the reef flat, and as can be seen, corals are the major component of the biomass. The corals present however, were mainly of 3 species (_Porites porites_, _P. astreoides_ and _Agaricia agaricites_) so that coral diversity was low even though biomass was high. *Diadema antillarum* was the next most abundant organism in sample 4B. Notice that the ratio of biomass to substrate material is lower than that of many of the other stations. This is probably because the large amount of rubble found in this zone is not very stable in position, and not many organisms get a chance to attach to it. The next zone in biomass is the buttress zone, where samples 4A and 7 were taken. Sponges and coelenterates (but not necessarily scleractinian corals) were the most abundant animals. As can be seen in Table 8, the other groups such as crustaceans and mollusks made only very small contributions to the biomass of these or any other of the samples. The lagoon-back reef environment is the next in biomass, (Stations 3 and 5). In sample 3, the majority of the biomass was made up of several different species of sea urchins and the total biomass is much lower than for sample 5. Sponges and coelenterates are, again, the dominant organisms in sample No. 5. The difference between the two samples in this zone results from the patchiness of the habitat. Coral, sponge and gorgonian clumps are sparsely sprinkled among a hard and bare or silty bottom. The richness of the sample will depend on the proportion of clump to bare surface included in the sample. The *Acropora* zone was the poorest in biomass of all the zones studied. The samples, however, were biased in that large *Acropora palmata* colonies were avoided when the quadrat was being implaced because of the extremely problematical situation of having to detach the colonies from the bottom and transport them to the surface.

No samples were collected from the reef fore-slope nor from the *Millepora-Palythoa* zones. I would expect the fore-slope to be intermediate between the buttress and back-reef lagoon habitats, with corals being the major biomass contributer. The *Millepora-Palythoa* zone should be fairly similar to the reef-flat and upper buttress zone, but with less biomass and even less diversity of corals and associated organisms.

IV. Trophic Levels:

In any natural community there exist relationships between the various organisms based on their feeding habits. Plants produce food from solar energy; herbivorous fish, crabs, etc. eat the plants; larger fish, crabs, mollusks eat the herbivores, and so on, forming a complex food web. The organisms at any given feeding level, or trophic level, can be lumped together so that one can speak of primary producers, herbivores, primary carnivores, secondary carnivores and so on. Table 9 shows the data from Table 8 broken down into the various trophic levels. Corals and other coelenterates were considered primary producers, because of their zooxanthellae, herbivores because of the nutrition they derive from the zooxanthellae (Muscatine and Cernichiari, 1969), and carnivores because they capture and feed on zooplankton. The wet weights arrived at for the coelenterates were divided into the three categories as follows: 2/3 of the weight was assumed to be zooxanthellae based on estimates made by Odum and Odum (1955); the remaining 1/3 of the weight was arbitrarily distributed 1/2 and 1/2 among the herbivorous and carnivorous categories since no good quantitative data exists for coelenterate nutrition. "Miscellaneous" was divided 2/3 to the primary producers and 1/3 to the herbivorous group, since there seemed to be more combined detrital and plant material than animal material. The detrital material is included with the primary producers since it is a source of food for non-carnivorous detrital and filter feeders (which were included with the herbivores). The animal portion was considered to be herbivorous because it consisted mostly of sponges, bryozoans and small tube worms, which are mainly filter feeders and non-predatory. Mollusks and crustaceans were arbitrarily assigned 1/2 and 1/2 to herbivores and carnivores since both modes of feeding occur in each group and not enough information is available to determine which species is in which category. It is generally expected that the lower trophic levels have a higher biomass than the trophic levels above them so that one should obtain a pyramid if the biomass of the trophic levels were arranged in a block diagram. Figure 9 shows the data from Table 9 expressed in the form of biomass pyramids, where the bottom levels includes both the primary producers and detritus, the middle levels the herbivores, filter feeders and detritus feeders and the upper levels, all of the carnivores. It must be pointed out that only the bottom dwelling and sessile organisms are included in this data, and that no attempt has been made to quantify the contributions to the various levels made by the phytoplankton, the zooplankton, the fish and by bacteria, forams and other microorganisms. Therefore, these diagrams are not representative of the true energy balance nor of the complete food chain of the reef ecosystem, but only of the macrobenthic fauna and flora. The category "Other" includes the 1/3 of Miscellaneous (Table 8) plus filter and detrital feeders, crustaceans and mollusks when they were not abundant enough to be listed separately. The various sample stations in Fig. 17 have been arranged by the reef zone where each sample was collected.

It can be seen in Figs. 17A and 17B that all samples except for Station 3 resulted in pyramid shaped, trophic level diagrams. The major biomass contributors in Station 3, as mentioned earlier, are various species of sea urchins which are herbivorous in food habit. A possible explanation for the predominance of herbivores in this sample is that the urchins, which are nocturnal feeders, tend to clump in the daytime anywhere there are good hiding places. So, although they were collected in a given area, their grazing range extends over a much larger area.

All diagrams were drawn to the same scale. From the diagrams, the differences in total biomass as well as their distribution among the trophic levels, are evident. Zooxanthellae make up the major portion of the primary producers of the outer reefs (Fig. 17A) where almost no algae were found. However, algae are the important producers in the inner reef samples of Station 10 (Fig. 17B) where zooxanthellae no longer play a major role. Other than the coelenterates and algae, only the sponges and echinoderms make major contributions to the standing crop. The annelids, crustaceans, mollusks, ascidians, and other invertebrates, although numerous in individuals, were usually very small in size so that they were not a significant part of the reef biomass.

The average of the biomass estimates for each trophic level of Stations 1 through 7 (the outer reef stations) is shown in Fig.17C. The average of all ten samples is shown in Fig.17D. The shape of these two pyramids are fairly similar but the ratio of carnivores to herbivores decreases when one averages in the Cayo Puerca samples. This indicates fewer carnivores for the inner reefs than for the outer reefs, and possibly a higher efficiency of energy transfer on the outer reefs. These ratios of 35% and 26% are very high compared to the estimate of 8% arrived at by Odum and Odum (1955) for a Pacific reef flat.

It was calculated that there are approximately 3.44 km^2 of coral reef in Jobos Bay. The average of all the biomass estimates results in a standing crop of 3.84 kg wet weight/m^2. This results in an estimate of 3.8×10^6 kg wet weight/km^2 or a total of 13.2×10^6 kgs of wet weight living material on the Jobos Bay reefs.

DISCUSSION

The results obtained for the stations sampled so far give us an idea of the structure and composition of the reef communities of Jobos Bay. The species list, species diversity, and biomass estimates are sufficient, though not complete, records of the organisms found on the Jobos Bay reefs. They will be most useful five or ten years from now to study the effects of the power plants, or any other man or naturally induced change, on the reefs' ecology.

But they are not sufficient to determine the inter-relationships between the organisms that make up the system. Several observations and conclusions can be made, however, which may be useful in understanding and making predictions on the effects which the operation of power plants may have on the reef ecosystem.

Structurally, the Jobos reefs are different in zonation characteristics from other coral reefs studied off the south coast of Puerto Rico (specifically, the La Parguera and Guayanilla reefs). The buttress zone is absent, and the *Acropora* zone is much richer in coral life, on most of the La Parguera reefs. In addition, there are extensive gorgonian flats between the *Acropora* zone and the break in slope of the fore-slope, which are not found on the Jobos reefs except for Cayos Caribes. the reef fore-slope on most of the La Parguera reefs is much narrower, and usually goes deeper than the Jobos reefs. In general there is not as much marine life apparent on the Jobos reefs as on the La Parguera reefs. The Guayanilla reef, which is mostly devoid of coral, probably due to waste chemicals in the water, has a very wide Acropora zone (without any living A. palmata), gorgonian flats, and a buttress zone of sorts, but no fore-slope was found. Structurally, the Jobos reefs are most similar to the fringing reefs off the north coast of Jamaica (Goreau, 1959). In general there are fewer coral species found in Jobos Bay than on other Caribbean reefs (Goreau and Wells, 1967; Smith, 1969; Roos, 1971). But this is true for the only other Puerto Rican reefs studied (Almy and Carrion, 1963; Pressick, 1970). It is yet to be shown whether there is a real paucity of corals in Puerto Rico or whether the fewer species found is due to the relatively less work done on the Puerto Rican corals.

Unfortunately most studies of coral reefs in the Caribbean have been limited only to looking at the coral components (Goreau, 1959; Roos, 1964; Kissling, 1965), and when the invertebrates associated with the reefs have been looked at, the studies have not been quantitative (Storr, 1964; Lewis, 1960; Glynn, 1964). Therefore, there is no way to compare the diversity of the Jobos Bay reefs associations with other coral reefs at the present time.

A close look at the trophic diagrams in Fig. 17will show us that the reef community depends quite heavily on the zooxanthellae from the coelenterates for its support. The coral-zooxanthellae association enters the reef food web in many places. As a primary producer, it is a source of food for other organisms higher up in the food chain. Other animals may benefit from the corals by eating the corals directly, by feeding on the mucus strands that the corals produce, or by absorbing dissolved organic materials such as sugars and lipids that the corals release. Fig. 10 shows very generally the types of interactions the coral-zooxanthellae association has among itself and with the rest of the reef complex. The phytoplankton and macro-algae components are included in the diagram, although they are not as important to the reef community as the zooxanthellae. In general, algae and phytoplankton are in competition with the zooxanthellae containing coelenterates. The macro-algae and corals are in fierce competition for growing surfaces. Selective grazing by the many herbivorous reef fish give the corals a definite advantage over the algae. The phytoplankton compete with the corals for light. If too many phytoplankters are present in the water column, they will cloud the water making conditions unfavorable for the corals. Therefore, the two groups of primary producers are, in a sense, mutually excluding. Anything which will alter the quality of the water surrounding the reefs, especially by increasing the nutrients and favoring high phytoplankton productivity will cause unfavorable conditions for the corals. Such a situation would decrease the corals competitive advantage for settling space over the macroalgae. It is yet to be seen how well the algae and phytoplankton could fill the corals' niches on the reef. Guayanilla reef, where there is less than 1% bottom coverage by living coral, is an example of a reef where the coral components have been killed off and replaced to a certain extent by algae. No quadrat samples were collected there, but a subjective opinion, after examining a few sites carefully, was that there is very little diversity present on Guayanilla reef. Reef fish were scarce. Only a few of the expected invertebrates were found by the usually very productive overturning of cobbles. Brittle stars and sea urchins (Diadema) were in apparent over-abundance, probably due to lessened competition and predation, and to ample supplies of algae.

It is not known what effects the discharge from the power plants will have on the water quality. Both increased water clarity and increased phytoplankton productivity have been postulated. Clearer water cannot but help the reef community, but high productivity may well upset the ecological balance among the primary producers.

The major preoccupation about the effects of the power plants on the Jobos Bay Marine communities, is that the heated water from the discharge channel will have adverse physiological effects on many of the marine organisms. Unfortunately for everyone, very little data on the upper thermal limits of tropical marine organisms is available. Table 10 is a list of upper thermal limits compiled from the literature. Although there seems to be a reasonable amount of data for the corals and gorgonians, it must be pointed out that those experiments were done a long time ago, and that Mayer's (1914, 1918) experimental techniques would not be acceptable today. Most of his experiments were on short term exposure to raised temperature. In our case (except for plankton caught in the entrainment process), the effects of long term exposure are more important. How will the elevated temperatures affect the organisms growth, behavior, reproduction and ability to cope with other fluctuating environmental variables? How will it affect larval settlement and survival?

Most of the temperatures cited in Table 10 are well above the temperatures predicted to reach the outer reefs. The highest temperature recorded in Boca del Infierno was 30^{o} C during September, 1970. That temperature is probably representative of the maximum water temperature on all the outer reefs. The temperatures on the back reefs and reef flats will probably be a degree or so higher (31^{o} C). The water temperature of the warm water plume is predicted to be 1.7^{o} C higher than the surrounding bay waters at the time it hits the reefs (PRNC, 1971). The resulting water temperature of 31.7^{o} C to 32.7^{o} C is within the reported tolerance limits of all the organisms in Table 10. A. palmata would be exposed to 31.7^{o} C water during the warmest part of the year which is only 0.3^{o} C below its reported tolerance, and this is the dominant coral of the Jobos Bay reefs.

There is evidence from studies on Hawaiian corals, (Jokiel, 1972) that temperatures of 30^{o} C to 32^{o} C were lethal to some corals over a period of time. However, Hawaiian water temperatures are lower than those of Puerto Rico. Mayer (1914) found that although Caribbean corals survived higher temperatures for a short time, at around 30^{o} - 33^{o} C they lost much of their mobility and ability to capture food. Two other studies on Hawaiian corals showed that the rate of $CaCO_3$ deposition (growth) increased with rising temperature to an optimum temperature of 27^{o} C and decreased sharply with further temperature increases (Clausen, 1971), and that the same pattern is found for respiration and photosynthesis rates (Coles, 1972). These studies need to be repeated on Caribbean species of corals and gorgonians before we can make reasonable assurances that no damage will be done to our coral reef systems.

In summary, it was shown that the coral - zooxanthellae association is the most important primary producer on the Jobos Bay reefs at this time. It is intimately linked into the reef food web. Factors which could upset the energy balance on the reef are increased phytoplankton productivity and algal growth, and raised temperatures, both of which could reduce the coelenterates' survival and productivity. Without more physiological data on temperature effects, no conclusions can be made as to whether the power plants will have a detrimental effect on the Jobos coral communities. I believe, however, that other factors in water quality, such as waste chemicals and increased productivity, will be more harmful to the reef ecosystem than the 1.7° C. increase in water temperature.

Note added in editing:

The following dry weight biomass relationships were not included in the report originally because data were collected only for the first four stations. However, since some of the reviewers requested these data, the following values are offered so that approximate dry weight values can be calculated for the rest of the stations.

Relationship between dry wt. and wet wt. biomass estimates

Station No.	% Dry Wt. of Wet Wt.
1	54
2	47
3	45
4A	46
Average	48

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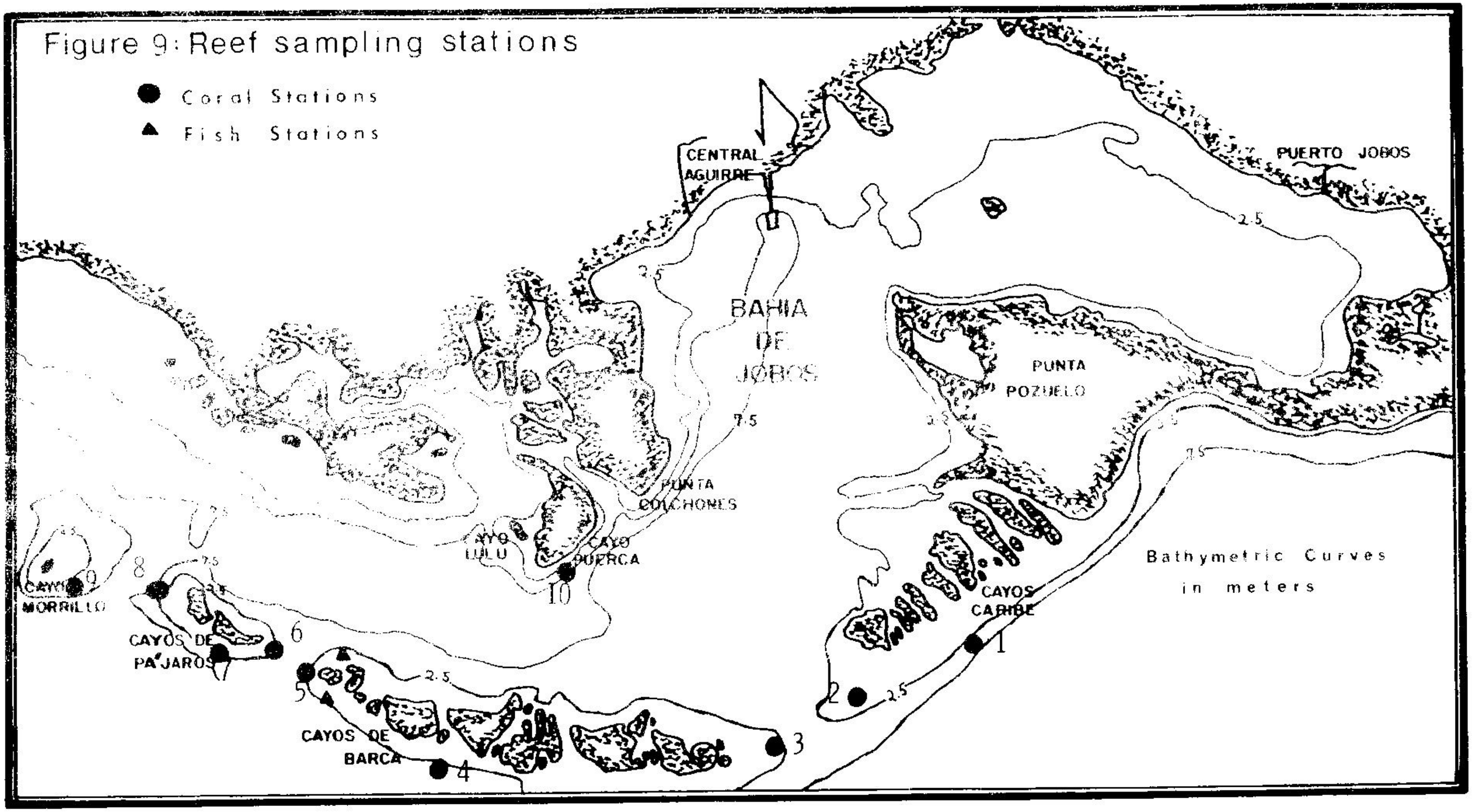


Figure 9: Reef sampling stations

Legend for Figures 10,11,12,13,14,15
and 16.

Porites porites
Mycetophllia lamarckiana
Acropora cervicornis
Acropora palmata
Agaricia agaricites
Diploria clivosa
Erythropodium caribaeorum
Favia fragum
Gorgonian
Isophyllia multifora
Millepora complanata
Montastrea annularis
Palythoa sp.
Porites astreoides
Siderastrea siderea
Sponge
Montastrea cavernosa
Gorgonia flabellum
Briareum asbestinum
Diadema antillarum
Chondrilla nucula
Meandrina meandrites

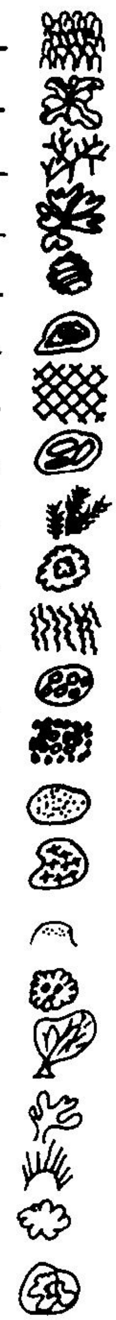


Figure 10 *Diagramatic representation of the coral zonation of Jobos Bay reefs.*

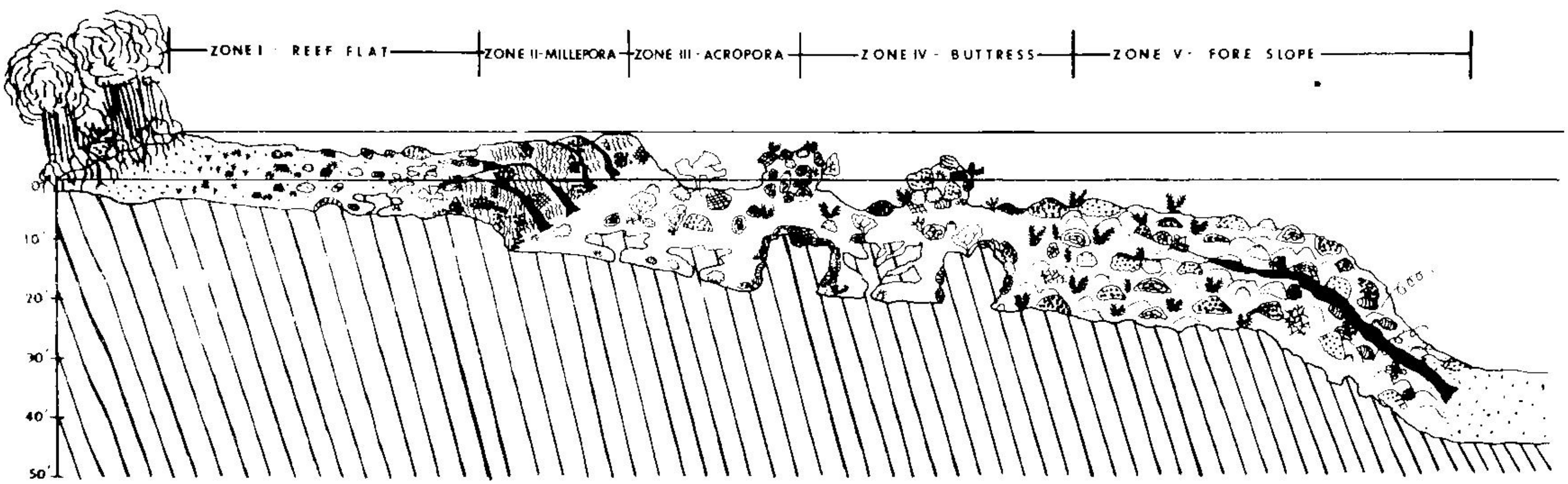


Figure 11: Diagramatic representation of a $4m^2$ area from the upper <u>Acropora – Gorgonia</u> zone, Sta. 4

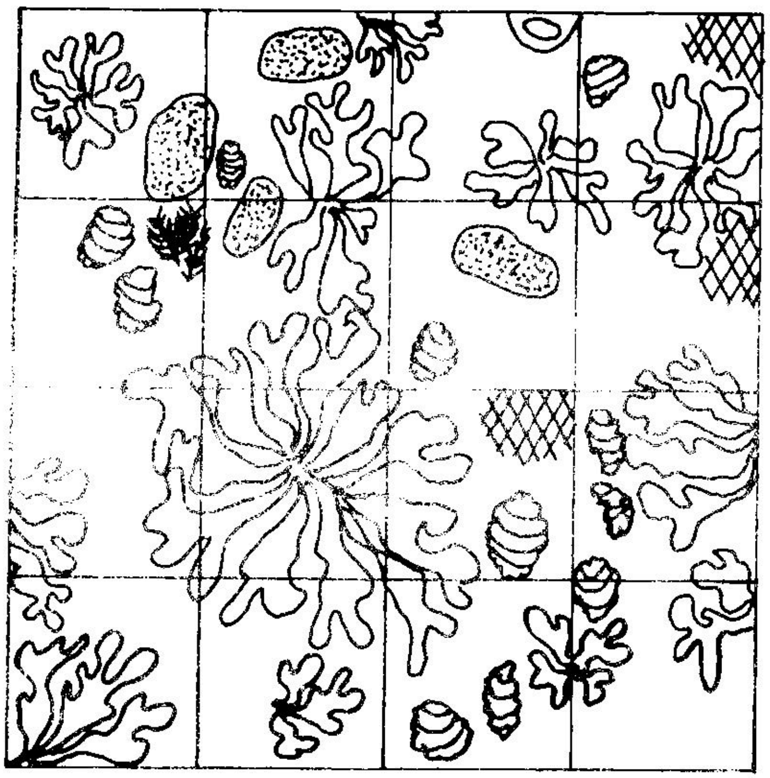


Figure 12 : Diagramatic representation of a $4m^2$ area from the lower <u>Acropora – Gorgonia</u> zone, Sta. 4

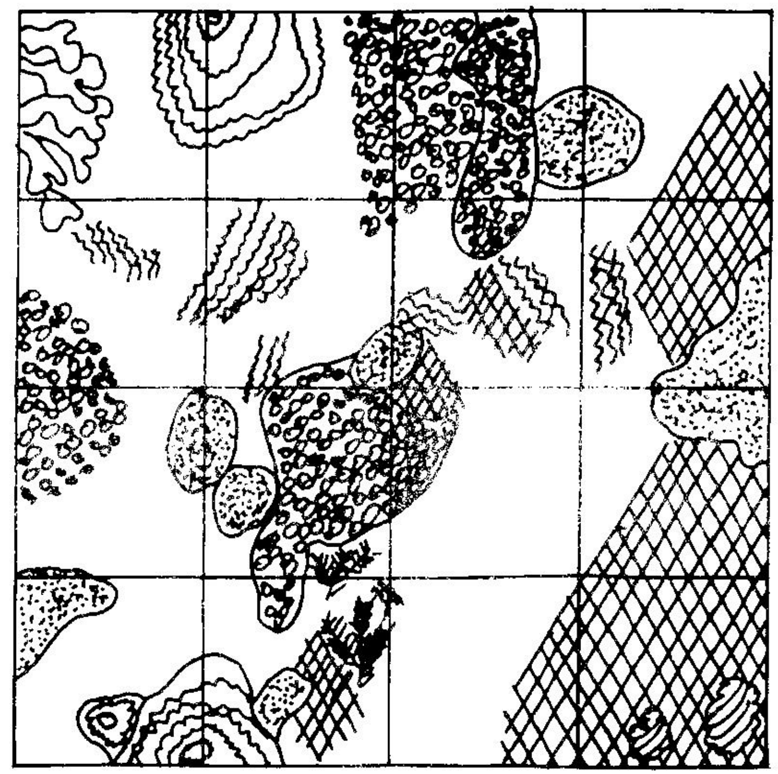


Figure 13 Diagramatic representation of a $4m^2$ area from the top of a buttress, Sta. 4

Figure 14 Diagramatic representation of a $4m^2$ area from the upper fore-slope, Sta. 7

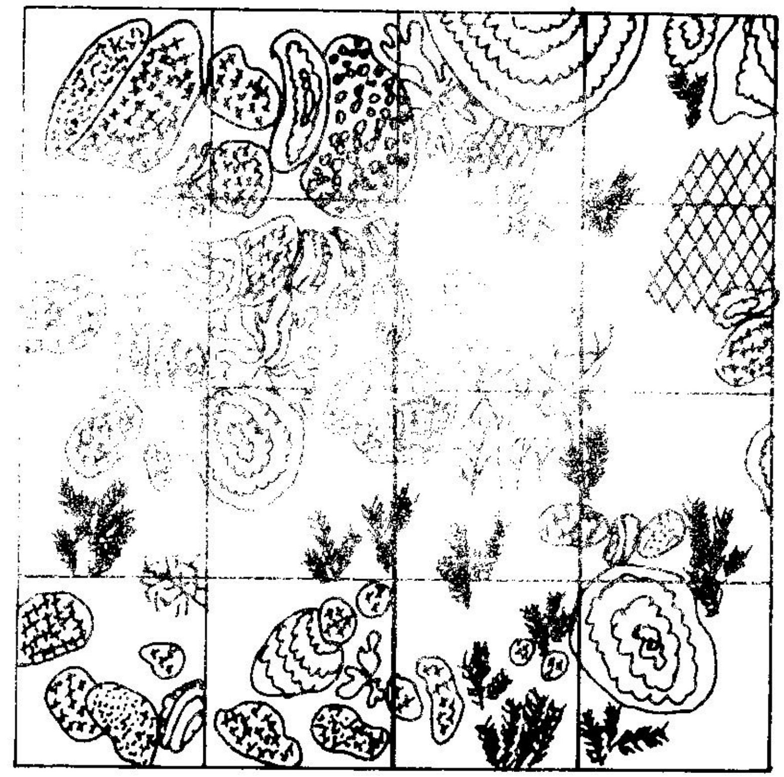


Figure 15 : Diagramatic representation of a $4m^2$ area from the pass between Cayos de Barca and Cayos de Pajaros, Sta·5

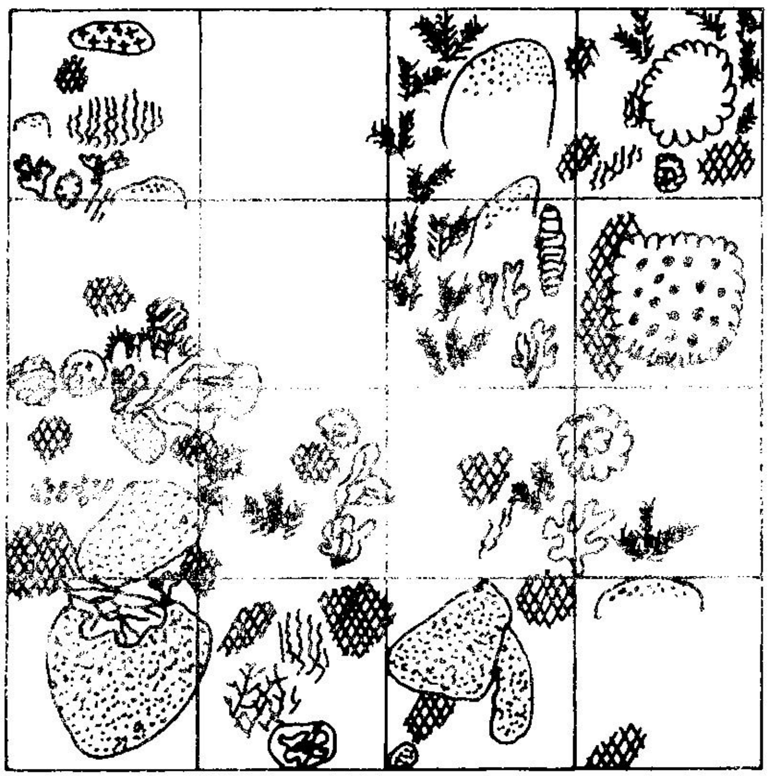


Figure 16: Diagramatic representation of a $4m^2$ area from the back reef, west end of Cayos de Pajaros, Sta· 8

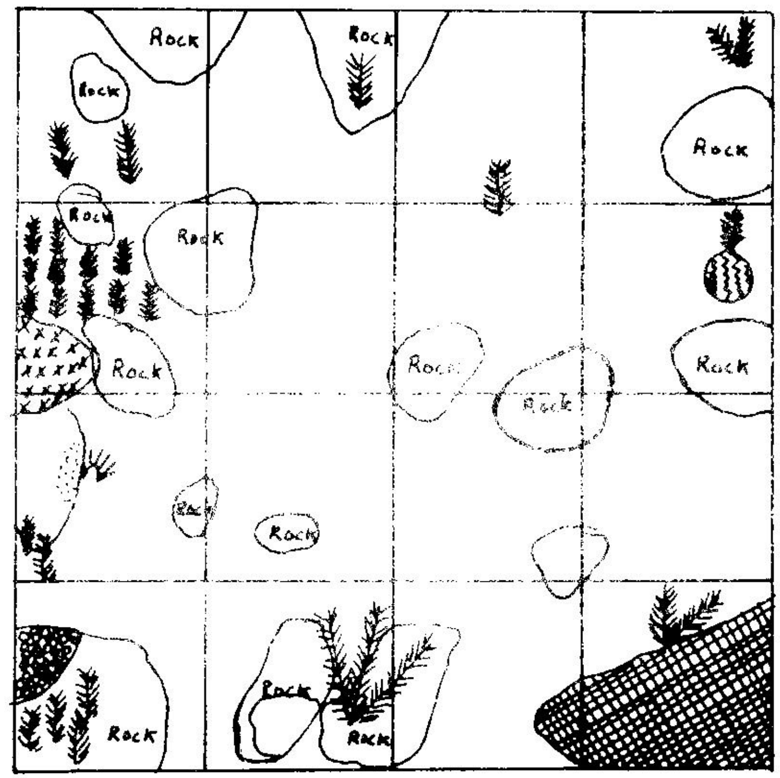
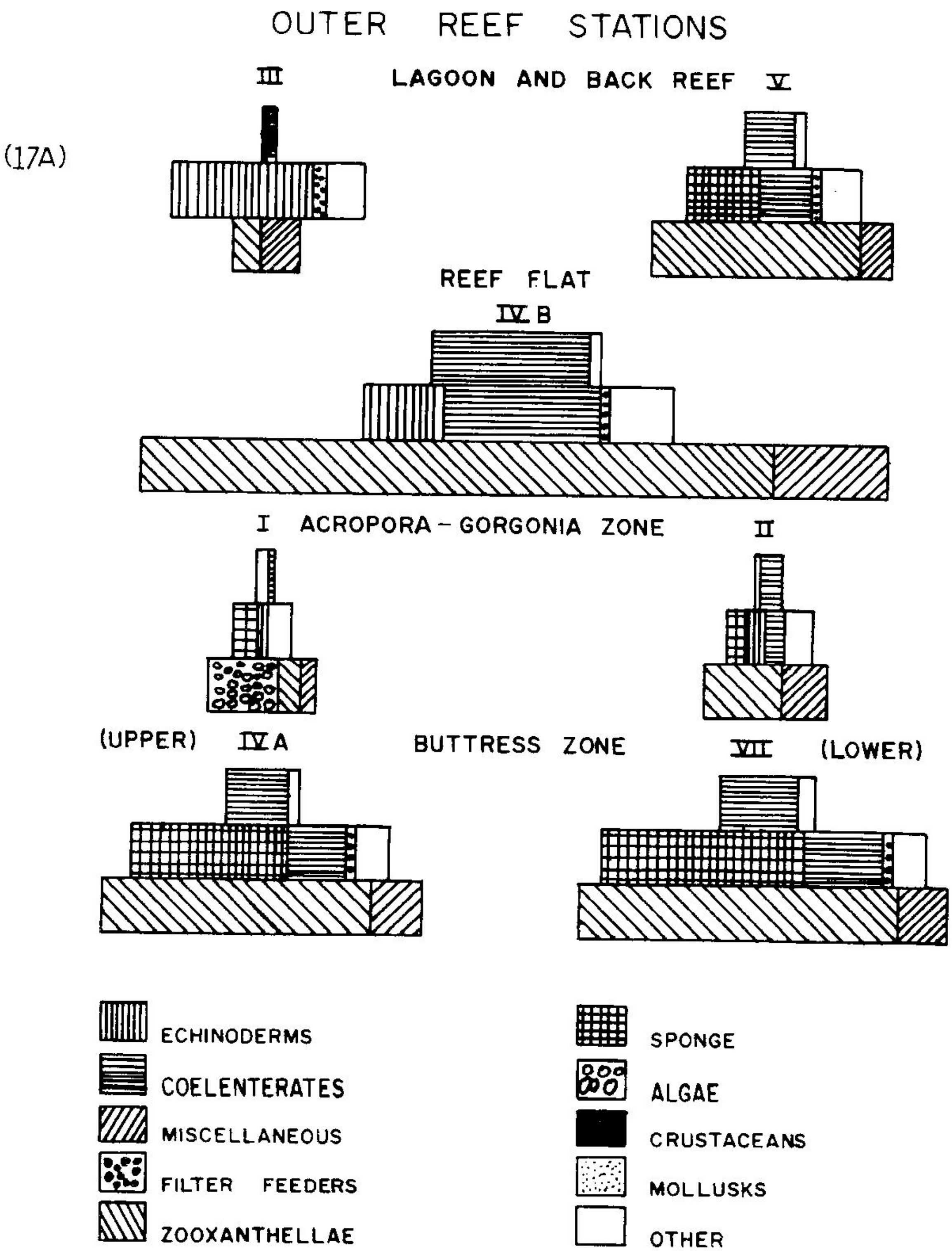
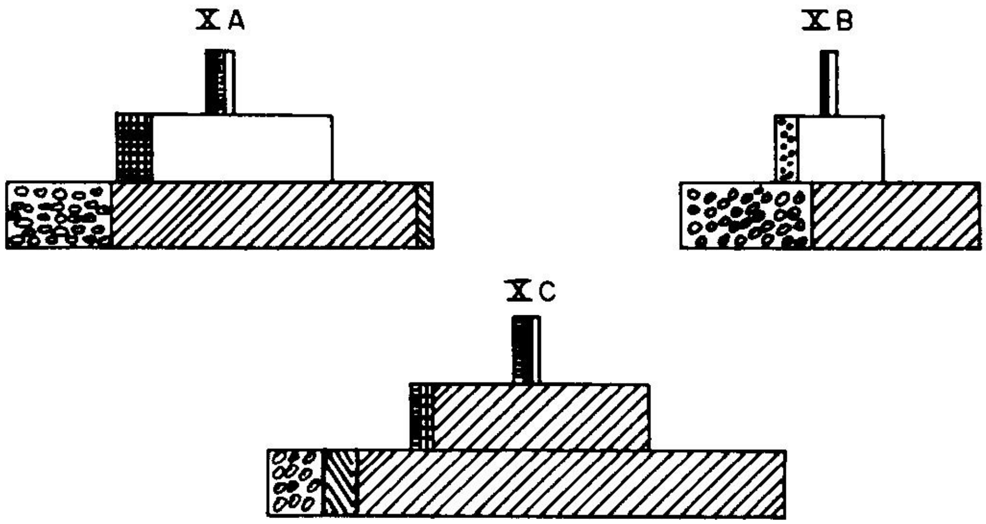


Figure 17: Biomass pyramids of biomass per 1/4 m^2 arranged by reef zone. See text for explanation.



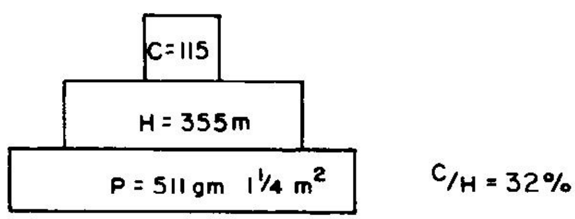
CAYOS DE PUERCA STATIONS

(17B)



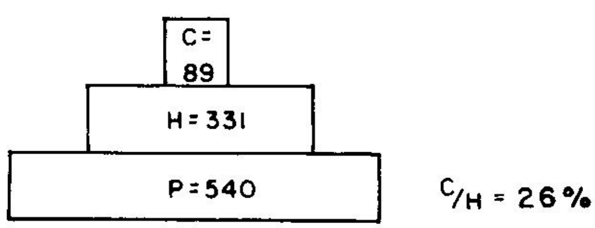
AVERAGE OF STATIONS I – VII

(17C)



AVERAGE OF ALL STATIONS

(17D)



C = Carnivores
H = Herbivores
P = Primary Producers

Figure 18: Generalized scheme for energy flow in a coral reef community.

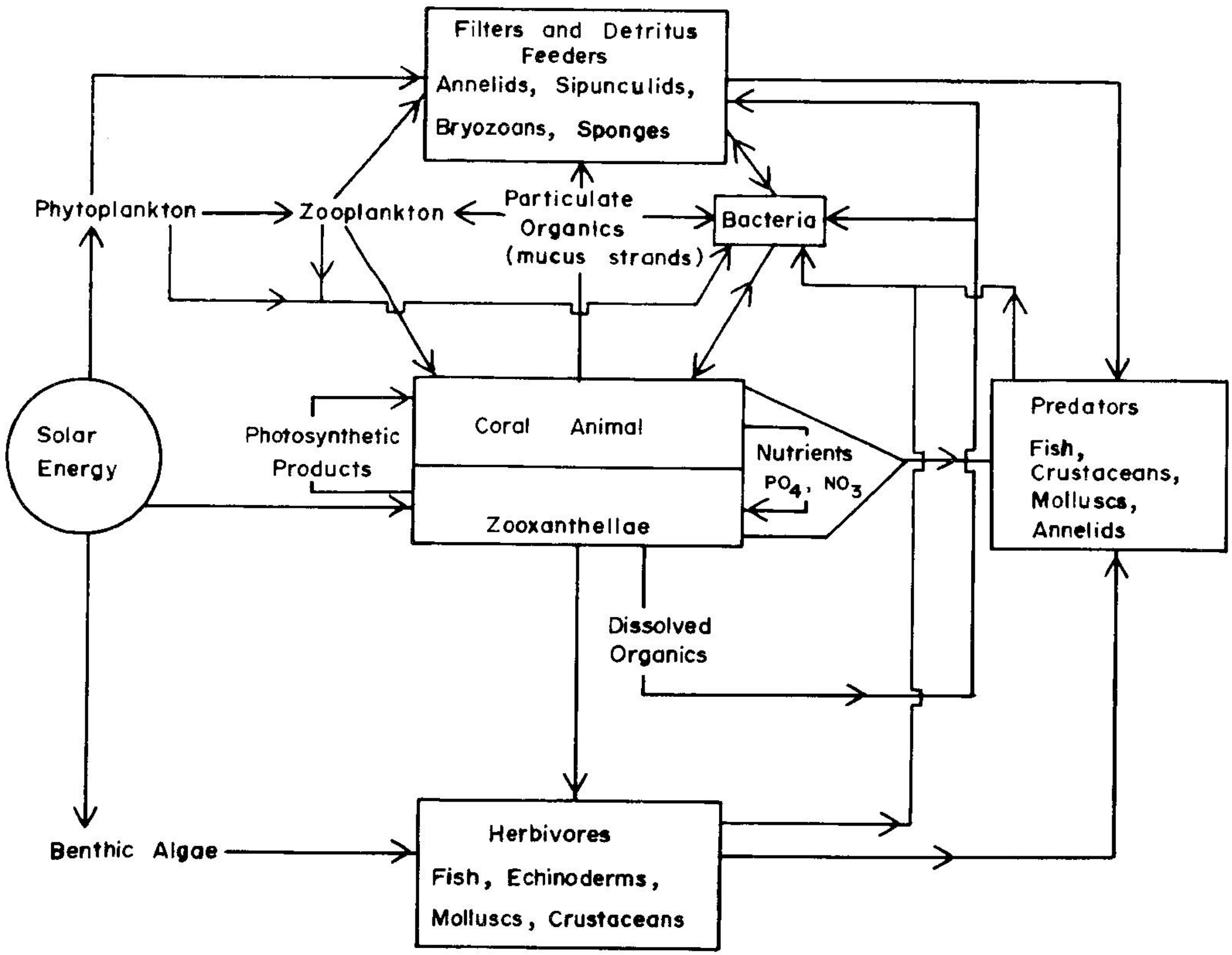


TABLE 1

Mollusks, Crustaceans and Ophiuroids Identified from Collected Quadrat Samples.

Numbers in columns under Station numbers are the numbers of individuals of the given species found at that Station. The crustaceans from Stations 1, 2, and 3 were not completely identified, so that only an X is present if a given species was found at these stations. This also applies for Station 3 of the ophiuroids.

	1	2	3	4A	4B	5	7	10A	10B	10C
Mollusca										
Amphineura										
Acanthochitona spiculosa		1								
Calloplax janeirensis					1			1		
Chiton squamosus								1		
Ischnochiton limaciformis			1		1					
Ischnochiton papillosus					1	1				
Ischnochiton sp.						1				
Gastropoda										
Diodora listeri	1	1						1		
Diodora variegata									1	
Diodora arcuata									1	
Diodora dysoni									1	
Lucapinella limatula	1									
Fissurella nodosa								1		
Fissurella angusta								1		
Fissurella nimbosa										1
Fissurella barbadensis										1
Acmaea spp.	1				1		1	1		
Tegula fasciata					1					
Astraea caelata		1		1						
Astraea tuber								1		
Tricolia adamsi				1						
Heliacus cylindricus				6						
Modulus modulus							1			
Modulus sp.						1				
Cerithium algicola						1				
Balcis intermedia					1					
Calyptraea centralis								3		
Crepidula aculeata						1		1		
Cyphoma gibbosum						1				
Natica canrena									1	
Drupa nodulosa			2							
Risomurex roseus		2								
Thais rustica	1						4			
Coralliophila caribaea	1			1	4	2	3			
Coralliophila aberrans							1			
Anachis sparsa								1		
Mitrella nitens								1		

Table 1 (cont.)

STATION	1	2	3	4A	4B	5	7	10A	10B	10C
Gastropoda										
Bailya intricata						1				
Engina turbinellas								1		
Cantharus sp.							1			
Leucozonia nassa									1	
Leucozonia ocellata								1		
Latirus infundibulum										
Hyalina albolineata					1					
Crassispira nigrescens							1			
Clathrodrillia melonesiana				1			1		1	
unknown sp.					1					
nudibranch					1					
Bivalvia										
Arca zebra									1	
Arca imbricata				1						
Barbatia domingensis	14	2	9	6	3	8	2	2	1	1
Barbatia cancellaria		5		1	1			1		1
Barbatia candida	5			1						
Barbatia tenera						1		4		
Barbatia sp.							1			
Arcopsis adamsi	1									
Brachidontes exustus						1				
Amygdalum sp.							3			
Musculus lateralis				1						
Lioberus castaneus			1							
Lithophaga nigra	2	5		4			4			1
Lithophaga antillarum							4			
Gregariella coralliophaga		1								
Isognomon alatus	1									
Isognomon radiatus	16	4	1	2	3	1		3		1
Isognomon bicolor				1						1
Pinctada radiata						1				
Ostrea equestris								1		
Coralliophaga coralliophaga				1						
Diplodonta notata									1	
Codakia pectinella									1	
Chama sarda									1	
Chama florida		1								
Papyridea soleniformis						1				
Papyridea simisulcata						1				
Petricola lapicida			1							
Tellina aequistriata										1
Asaphis deflorata			1							
Sphenia antillensis				2		1				
Gastrochaena hians				5		1				
Spengleria rostrata				2		1				
Lyonsia beana									1	
Cyathodonta semirugosa										1

Table 1 (cont.)

STATION	1	2	3	4A	4B	5	7	10A	10B	10C
Class Crustacea										
Order Stomapoda										
Gonodactylus oerstedii	X				2	2	1	4	5	
Order Isopoda										
Cirolana parva					2	6	6			1
Cirolana sp.					1					
Eurydice littoralis										1
Excorallana antillensis								1		
Paracerceis caudata								2	2	
Unid. isopods				11						
Order Amphipoda										
Unid. amphipods				24						
Lysianassa sp.									7	9
Stenothoe crenulata								6		
Order Decapoda, Macrura										
Synalpheus minus				1						
Synalpheus townsendi				6						
Synalpheus longicarpus				6		8	5	8	6	6
Synalpheus fritzmulleri				1	4					2
Synalpheus sp.	X				16	1				
Alpheus armillatus				2						
Alpheus formosus					1					
Alpheopsis trigonus							7			
Leptalpheus forceps							2			
Leptalpheus sp.							1			
Ogyrides occidentalis				1	14			1	1	
Upogebia affinis						1				
Order Decapoda, Anomura										
Pachycheles pilosus	X			2					1	2
Pachycheles serrata						1				
Petrolisthes amoenus					1					
Petrolisthes sp.			X							1
Calcinus tibecen				2	5					
Pagusistes sericeus					1					
Unid. pagurid								1		
Order Decapoda, Brachyura										
Epialtus longisiostris				1						
Mithrax pleuracanthus				4			3			
Mithrax hispidus				3						
Mithrax coryphe			X	1				1		
Mithrax sculptus					4					
Mithrax forceps						3		1		
Mithrax juv.				7		1				
Microphys bicornutus					1				2	
Macrocoeloma trispinosum									1	

Table 1 (cont.)

STATION	1	2	3	4A	4B	5	7	10A	10B	10C
Order Decapoda, Brachyura										
Paraliomera longimana								6		11
Platypodea spectabilis				5						
Panopeus occidentalis									1	
Micropanope nuttingi				1						
Pilumnus sayi			X		1	2				
Pilumnus dasypodus								3		
Pilumnus caribeus									2	
Domecia hispida				2	2					
Neopanopeus texana									2	
Unidentified Xanthid						2		1		
Tetraplax quadridentata				1						
Panoplax depressa				1						
Pinnixa sp.						1				
Pachygrapsus gracilis										
Percnon gibbesi				1						
Osachila antillensis						2				1
Unident. cancrid				1						
Ophiuroidea										
Ophiactis savignyi	3			15	5	10		15	40	15
Amphipholis pachylactera								1		
Amphipholis squamatus								5	3	
Ophiothrix bachyactis		6		8						
Ophiothrix angulata	3			13	1	3	1	2	2	
Ophiothrix orstedii			X	2	1		1	1		
Ophionereis reticulata						1				
Ophiocoma echinata	2	1	X		2	1	4			
Ophiocoma pumila	6			1						
Ophiocoma riisei	2									
Ophiopsila riisei						1				
Ophioderma brevicaudum	1				11				1	
Ophioderma appresum					1					
Ophiozona impressa	1			1						
Ophiomyxa flaccida					1					

TABLE 2

Other Organisms Identified in the Collected Quadrat Samples.

Only presence or absence of the species is indicated.

STATION	1	2	3	4A	4B	5	7	10A	10B	10C
Coelenterata										
Class Hydrozoa										
Millepora alcicornis				X						
Class Anthozoa, Hexacorallia										
Zoanthus pulchellus								X	X	X
Palythoa caribaea		X		X						
Unid. anemones		X					X	X		X
Stoichactis helianthus					X					
Astrangia solitaria	X	X		X			X	X		X
Agaricia agaricites		X		X	X	X	X	X		
Siderastrea radians					X	X				
Porites porites	X				X		X			
Porites astreoides		X	X		X	X	X			X
Favia fragum		X			X	X				
Manicina areolata						X				
Mycetophyllia lamarckiana							X			
Isophyllia sinuosa						X				
Isophyllia multiflora						X	X			
Class Anthozoa, Octocorallia										
Erythropodium caribaeorum		X				X	X			
Briareum asbestinum				X		X	X			
Muriceopsis flavida			X			X	X			
Eunicea mammosa			X							
Eunicea knighti						X				
Plexaura homomalla							X			
Pseudoplexaura flagellosa							X			
Gorgonia ventalina						X				
Pterogorgia citrina								X		
Pseudopterogorgia hummlincki						X				
Porifera										
Geodia gibberosa	X			X						
Chondrilla nucula	X			X						
Aplysilla sp.			X	X						
Cliona sp.				X		X				
Clathrina sp.				X						
Microciona sp.						X				
Callyspongia sp.						X				
Iotrochota sp.						X				
Tethya sp.						X				
Halisarca sp.										

Table 2 (cont.)

STATION	1	2	3	4A	4B	5	7	10A	10B	10C
Echiuroidea										
Thallasema sp.						X				
Sipunculida										
Goldfingia sp.		X	X	X	X		X	X	X	X
Ectoprocta										
Steginoporella magnilabris						X				
Rynchozoon verruculatum						X	X			
Gemelliporidra sp.							X			
Echinodemata, Class Echinoidea										
Echinometra viridis		X	X					X		
Trypneustes esculentus			X							
Diadema antillarum				X	X					
Lytechinus variegatus					X					
Brissopsis elongata					X					
Chordata										
Subphylum Urochordata										
Aphidium bermudae				X						
Pyura vittata				X		X	X		X	
Diplosoma macdonaldi						X				
Amaroucium bermudae								X		
Ascidia sydneiensis									X	
Cystodytes dellechiajei							X		X	
Echinochlinum verrilli							X			
Botrylus planus							X			
Fam. Dideninidae, unident.							X			
Subphylum Vertebrata										
Class Osteichthyes										
Labrisomus gobio					X					
Acanthemblemaria aspera							X			
Gobiosoma dilepsis							X			
Algae										
Dictyota sp.	X		X							
Halimeda opuntia	X							X		X
Valonia ventricosa							X			
Amphiroa tribuloides										X
Amphiroa fragilis							X			
Amphiroa sp.		X				X		X		
Jania sp.		X				X		X	X	
Lithothamnion sp.							X	X		
Coelotrix irregularis									X	

TABLE 3

Reef Fish Collected in Poisoning Stations.

Fish were killed with Rotenone. Specimens in A were from a non-de-limited area. Specimens in B were collected within a $56m^2$ area which was closed off with a 100 ft. gill net.

A. Cayos de Barca, Acropora Zone, S.W. end:

Adioryx vexillarius
Myripristis jacobus
Scorpaenodes caribbaeus
Chromis multilineata
Thalassoma bifasciatum
Ophioblennius atlanticus
Labrisomus guppyi

B. Cayos de Barca, Back Reef, S.W. end:

Gymnothorax moringa
Aulostomus maculatus
Epinephelus adscensionis
Apogon maculatus
A. quadrisquamatus
Haemulon sciurus
Eupomacentrus leucostictus
Thalassoma bifasciatum
Sparisoma radians
Scarus guacamaia
Ophioblennius atlanticus
Entomacrodus nigricans
Labrisomus nuchipinnis
L. bucciferus
Malacoctenus gilli
M. macropus
Enneanectes boehlkei
Ginsburgellus novemlineatus
Acanthurus bahianus

TABLE 4

Sight Records of Organisms on Jobos Bay Reefs

Algae
Caulerpa sp.

Porifera
Ircinia strobilina
Pellina carbonaria

Coelenterates
Millepora complanata
Stylaster roseus
Acropora palmata
A. cervicornis
A. prolifera
Diploria labyrinthiformis
D. clivosa
D. strigosa
Montastrea annularis
M. cavernosa
Siderastrea siderea
Eusmilia fastigiata
Mussa angulosa
Colpophyllia natans
C. amaranthus
Meandrina meandrites
Dendrophyllia cilindricus
Dichocoenia stokesii
Zoanthus sociatus
Condylactis gigantia
Bundosoma sp.
Bartholomea annulata
Cerianthus sp.
Gorgonia flabellum
Pseudopterogorgia americana
P. acerosa
P. blanquillensis
Plexaura flexuosa
Eunicea asperula
Pseudoplexaura porosa
Plexaurella fusifera

Annelids
Hermodice carunculata
Eupolymia nebulosa
Pomastegus stellatus
Spirobranchus giganteus

Mollusks
Lima lima
L. scabra
Chama macerophylla
Charonia variegata

Crustaceans
Panulirus argus
Porcellana sayana
Petrochirus diogenes
Grapsus sp.
Stenorynchus seticornis
Stenopus hispidus

Urochordates
Clavelina oblonga

Fish
Holocentrus ascensionis
Sphyraena barracuda
Epinephelus guttatus
E. striatus
Caranx ruber
Lutjanus jocu
L. synagris
Ocyurus chrysuriis
Haemulon chrysargyreum
Calamus sp.
Eqguetus acuminatus
Chaetodon capistratus
C. striatus
Pomacanthus arcuatus
Holacanthus tricolor
H. ciliaris
Eupomacentrus fuscus
E. partitus
Microsphathodon chrysurus
Abudefduf saxatilis
Chromis cyanea
Halichoeres spp.
Sparisoma viride
Scarus retula
Acanthurus coeruleus
A. chirurgus
Balistes vetula
Lactophyrys triqueter

TABLE 5

RANK OF MAIN COVERING ORGANISMS

Rank	Organism	Type of Organism	Type of Growth
1	*Acropora palmata*	coral	branching
2	Gorgonians	-	branching
3	*Porites astreoides*	coral	massive
4	*Millepora complanata*	hydrocoral	encrusting and branching
5	*Palythoa caribaea*	zoanthid	encrusting
6	*Erythropodium caribaeorum*	gorgonian	encrusting
7	*Diploria* spp.	coral	massive
8	Sponges	-	encrusting and branching
9	*Siderastrea* spp.	coral	massive
10	*Montastrea* spp.	coral	massive
11	*Favia fragum*	coral	small colonies
12	*Agaricia agarieites*	coral	small colonies
13	Algae	-	encrusting
14	*Acropora cervicornis*	coral	branching
15	*Isophyllia multiflora*	coral	massive
16	*Porites porites*	coral	branching
17	*Cerianthus* sp.	cerianthid anemone	burrowing
18	*Manicina areolata*	coral	small colonies

TABLE 8

Biomass Estimates for Jobos Bay Reef Stations
Biomass expressed as gm wet weight/¼m^2

STATIONS	1	2	3	4A	4B	5	7	10A*	10B*	10C*
Algae	119.8	2.8	1.2	27.2	2.6	2.4	5.2	151.9	188.9	80.5
Sponges	43.8	41.1	1.7	274.5	9.6	133.5	358.1	49.2	7.0	17.3
Coelenterates:										
Corals	61.7	105.4	45.0	26.0	1686.1	182.7	470.4	0.5	0	75.2
Gorgonians and others	0	106.1	29.2	649.6	13.1	382.1	381.9	26.7	1.1	1.9
Annelids	0.9	4.4	2.2	8.6	7.0	9.4	26.0	7.5	2.6	2.0
Mollusks	31.0	13.5	7.8	10.1	9.0	20.5	15.6	23.8	13.7	14.9
Crustaceans	2.1	3.5	1.7	5.9	9.3	3.0	3.0	18.7	10.2	12.8
Sipunculids	0	3.4	0.1	1.5	10.9	1.2	2.9	2.4	1.6	0.4
Bryozoans	+	+	+	0.5	+	4.7	2.8	+	+	+
Echinoderms:										
Ophiuroids	15.6	3.4	53.0	2.7	22.2	3.4	3.7	14.0	4.2	0.2
Others	0	23.9	197.7	11.5	119.8	0	0.1	0.3	0	0
Tunicates	0	0	25.7	4.0	0	3.8	3.8	0.1	9.4	0
Miscellaneous°	50.3	113.6	107.5	138.6	300.1	151.6	122.7	681.8	377.3	945.0
TOTAL	325.2	421.1	472.8	1160.7	2187.7	897.6	1396.2	969.9	614.4	1151.1
Times four = m^2	1300.8	1684.4	1891.2	4642.8	8750.8	3590.4	5584.8	3879.6	2457.6	4604.4
gm biomass/kg of reef material brought to lab	-	143	90	222	145	-	227	427	563	328

* Samples were not an entire 1/4 m^2, but small, easily removed units of the reef.

\+ Bryozoans might have been present, but they were not separated from the substrate and weighed for all the samples. The unseparated material would be included in miscellaneous.

° Factor for calculating these values were (in gm/gm substrate): 0.02 for Sta. 3,4A,B,5&7; 0.038 Sta. 2; 0.3 Sta.10A; 0.34 Sta. 10B; 0.27 Sta.10C. See Methods section for more detail.

TABLE 9

Biomass of Organisms Arranged by Trophic Level

Numbers are grams wet weight per 1/4 m^2. See text for explanation.

STATIONS	1	2	3	4A	4B	5	7	10A	10B	10C
Primary Producers and Detritus:										
Algae	119.8	2.8	1.2	27.2	2.6	2.4	5.2	151.9	188.9	80.5
2/3 Coral Wt.	41.0	70.3	30.3	17.3	1124.1	121.8	313.6	0.3	0	50.1
2/3 Other Coelenterate	0	70.7	19.5	433.1	8.7	254.7	254.6	17.8	0.7	1.3
2/3 miscellaneous	33.5	75.7	71.7	92.4	200.1	101.1	81.8	454.5	251.5	630.0
Detritus Total	194.3	219.5	122.4	570.0	1335.5	480.0	655.2	624.5	441.1	761.9
Herbivores:										
Sponges	43.8	41.1	1.7	274.5	9.6	133.5	358.1	49.2	7.0	17.3
1/6 Coral wt.	10.3	17.6	7.5	4.3	281.0	30.5	78.4	0.1	0	12.5
1/6 Other Coelenterate	0	17.7	4.9	108.3	2.2	63.7	63.6	4.5	0.2	0.3
1/2 Annelid	0.5	2.2	1.1	4.3	3.5	4.7	13.0	3.8	1.3	1.0
1/2 Mollusks	15.5	6.8	3.9	5.0	4.5	10.3	7.8	11.9	6.9	7.5
Echinoderms	15.6	27.3	250.7	14.2	142.0	3.4	3.8	14.3	4.2	0.2
Tunicates	0	0	25.7	4.0	0	3.8	3.8	0.1	9.4	0
Bryozoans	0	0	0	0.5	0	4.7	2.8	0	0	0
Sipunculids	0	3.4	0.1	1.5	10.9	1.2	2.9	2.4	1.6	0.4
1/3 miscellaneous	16.8	37.9	35.8	46.2	100.0	50.5	40.9	227.3	125.8	315.0
Total	102.5	154.0	331.4	462.8	553.7	306.3	575.1	313.6	156.4	354.2
Carnivores:										
1/6 Corals	10.3	17.6	7.5	4.3	281.0	30.5	78.4	0.1	0	12.5
1/6 Other Coelenterates	0	17.7	4.9	108.3	2.2	63.7	63.6	4.5	0.2	0.3
1/2 Annelids	0.5	2.2	1.1	4.3	3.5	4.7	13.0	3.8	1.3	1.0
1/2 Molluscs	15.5	6.8	3.9	5.0	4.5	10.3	7.8	11.9	6.9	7.5
Crustaceans	2.1	3.5	1.7	5.9	9.3	3.0	3.0	18.7	10.2	12.8
Total	28.4	47.8	19.1	127.8	300.5	112.2	165.8	39.0	18.6	34.1

TABLE 10

List of Upper Thermal Limits Compiled from the Literature

ORGANISM	UPPER THERMAL LIMIT °C	LOCATION STUDIED	REFERENCE
+Diadema antillarum	37.4-37.6	Florida	Mayer, 1914*
Larvae of Eunice fucata	42.7	"	
+Lytechinus variegatus	37.7	"	
Ophioderma brevispina	37.7	Jamaica	
+Ophioderma opressa	37.7	"	
Cassiopea frondosa	38.3	Florida	
Aurelia aurita	36.4	"	
+Siderastrea radians	38.5	"	
+S. siderea	38.3	"	
+Diploria labyrinthiformis	36.7	"	
+D. clivosa	38.2	"	
Manicina mayori	37.8	"	
+Porites furcata	37.2	"	
+P. astreoides	37.7	"	
+P. clavaria	37.7	"	
+Favia frugum	37.2	"	
+Montastrea annularis	36.8	"	
+M. cavernosa	<37.3	"	
+Agaricia sp.	35.9	"	
+Isophyllia sinuosa	36.7	"	
+Isophyllastrea rigida	35.9	"	
+Oculina diffusa	36.4	"	
+Acropora cervicornis	35.8	"	
+A. palmata	35.8	"	
+Eusmilia fastigiata	36.4	"	
Lepas fascicularis	42.3	"	
Pennaria tiarella	34.7	Jamaica	
+Acropora cervicornis	34.7	Florida	Mayer, 1918*
+Montastrea annularis	35.6	"	
+Porites astreoides	35.8	"	
+P. clavaria	36.4	"	
+Diploria labyrinthiformis	36.8	"	
+Porites furcata	36.8	"	
+Favia fragum	37.0	"	
+Siderastrea radians	38.2	"	
+Briareum asbestinum	38.2	Florida	Cary, 1918*
Eunicea calyculata	34.5	"	
Eunicea tourneforti	35.0	"	
+Plexaura flexuosa	35.0	"	
+P. homomalla	35.0	"	
+Pseudoplexaura porosa	34.5	"	

Table 10 (cont.)

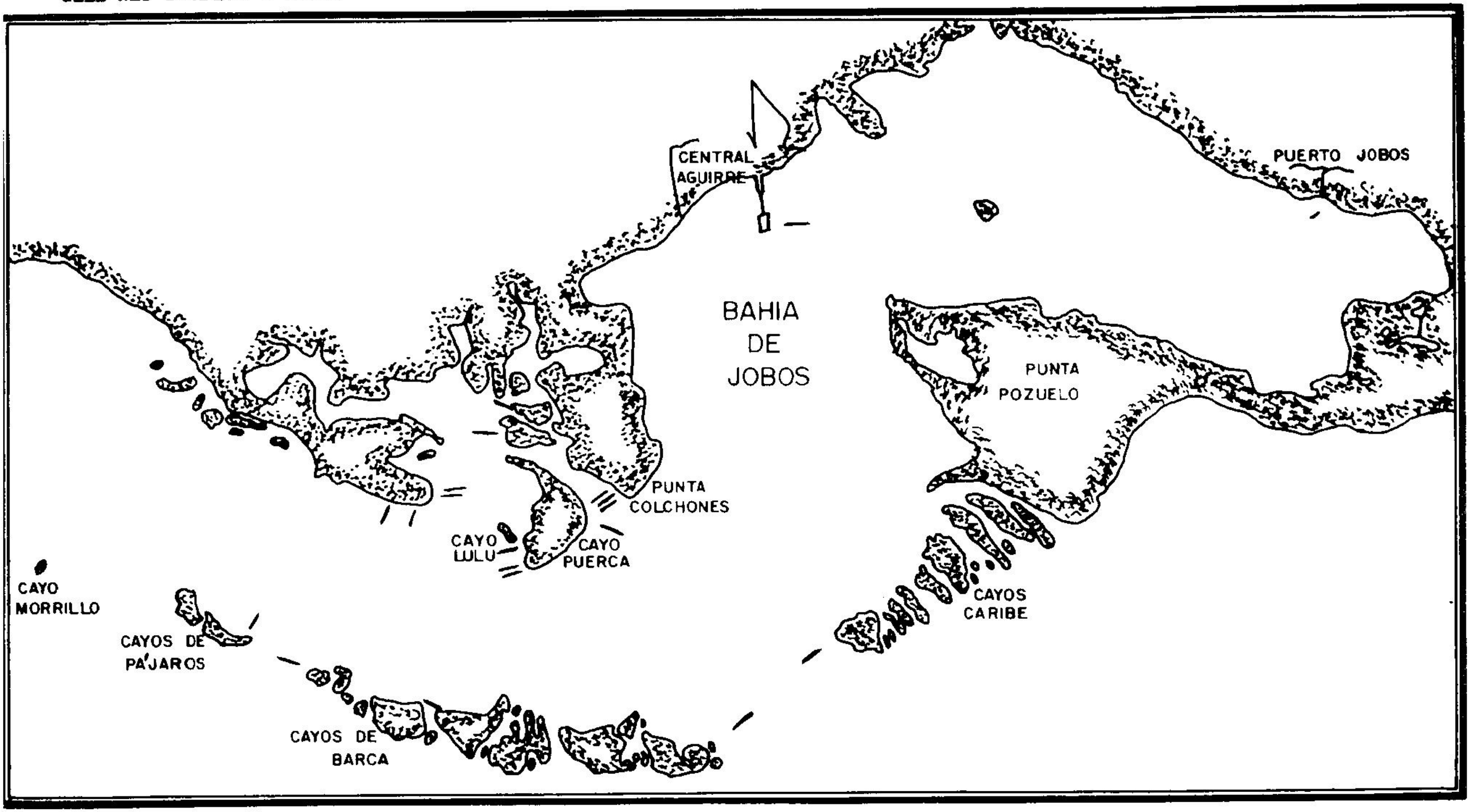
ORGANISM	UPPER THERMAL LIMIT °C	LOCATION STUDIED	REFERENCE
Plexaurella dichotoma	35.0	Florida	Cary, 1918* (cont.)
P. sp.	35.0	"	
+*Gorgonia flabellum*	37.0	"	
+*Pseudopterogorgia acerosa*	37.0	"	
Muriceopsis sulphurea	37.5	"	
+*Pterogorgia anceps*	37.5	"	
Ophioderma brevispinum	36	-	Orr, 1955
°*Callinectes sapidus* eggs	29	-	Sandoz & Rogers, 1944
Pagurus Longicarpus	36	Florida	Fraenkel, 1960
Corals	> 30	Hawaii	Jokiel, 1972
°*Chthamalus fragilis*	52.5	Trinidad	Southward, 1962
°*Balanus amphitrite*	46.2	"	
B. tintinnobulum	45.0	"	
Tetraclita radiata	47.0	"	
°*T. squamosa*	49.5	"	
°*B. eburneus*	47.5	France	
+*Acropora sp.*	32	West Indies	Kinsman, 1964
Other Corals	36	"	
+*Lima scabra*	33	Puerto Rico	Read, 1967
+*Ophiothrix oestedii*	37.5-38.0	Florida	Singletary, 1971
+*Ophiothrix angulata*	37.5-38.0	"	
+*Ophiopsila riisei*	39.3-40.0	"	
+*Ophiocoma echinata*	39.3-39.8	"	

* Taxonomic names in reference article changed to those in common use today.

\+ Organisms which have been found on Jobos Bay Reefs.

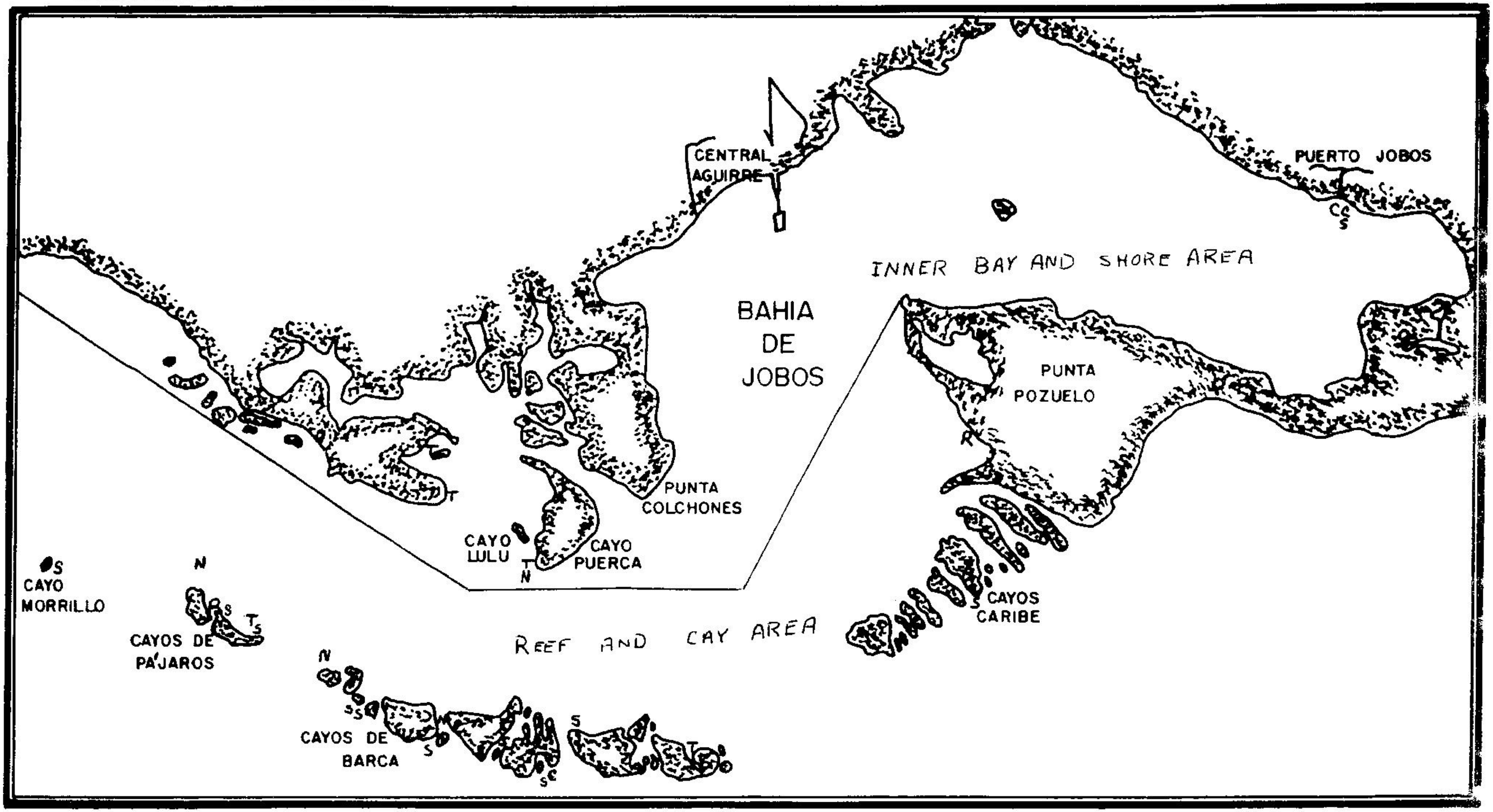
° Organisms found elsewhere in Jobos Bay.

GILL NET SAMPLES - NIGHT



MAP 2

MISCELLANEOUS COLLECTIONS



R= Rotenone stations N= Nightlight & handline T= Traps C= Cast net S= Seine & dipnet

MAP 3

VASCULAR PLANT AND DETRITUS FOOD WEB
JOBOS INNER BAY

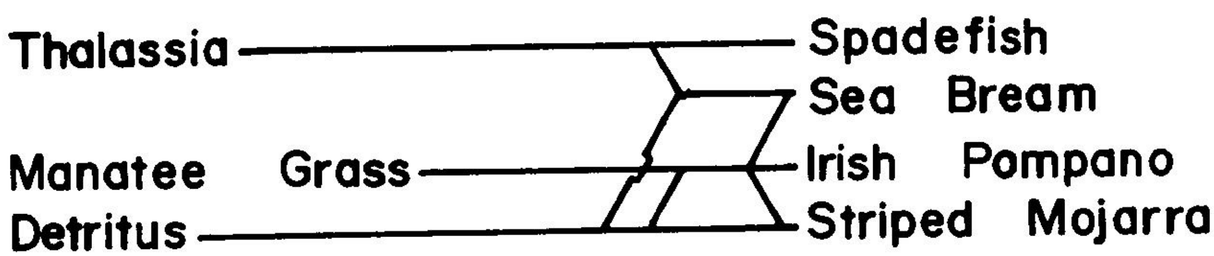


FIGURE 19

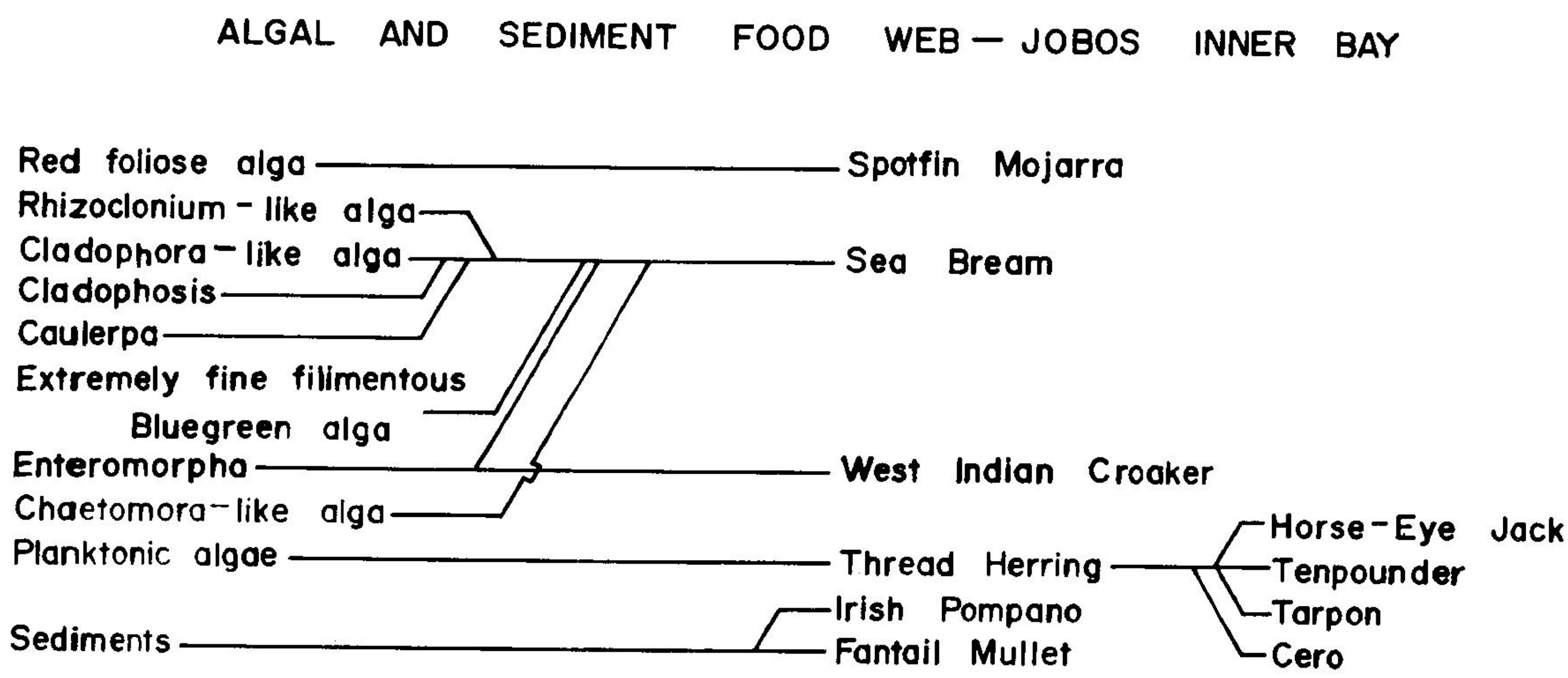

ALGAL AND SEDIMENT FOOD WEB — JOBOS INNER BAY
Red foliose alga
Rhizoclonium - like alga
Cladophora - like alga
Cladophosis
Caulerpa
Extremely fine filimentous
Bluegreen alga
Enteromorpha
Chaetomora - like alga
Planktonic algae
Sediments
Spotfin Mojarra
Sea Bream
West Indian Croaker
Thread Herring
Irish Pompano
Fantail Mullet
Horse-Eye Jack
Tenpounder
Tarpon
Cero

FIGURE 20

ZOOPLANKTON AND MISCELLANEOUS FOOD WEB — JOBOS INNER BAY

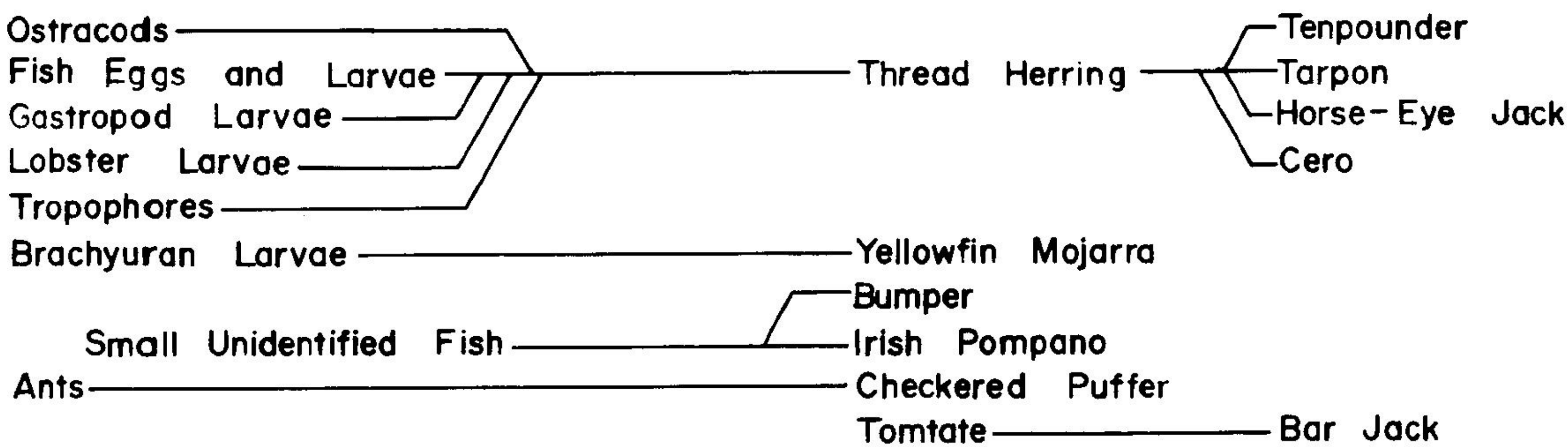


FIGURE 21

BENTHIC CONSUMER FOOD WEB — JOBOS INNER BAY

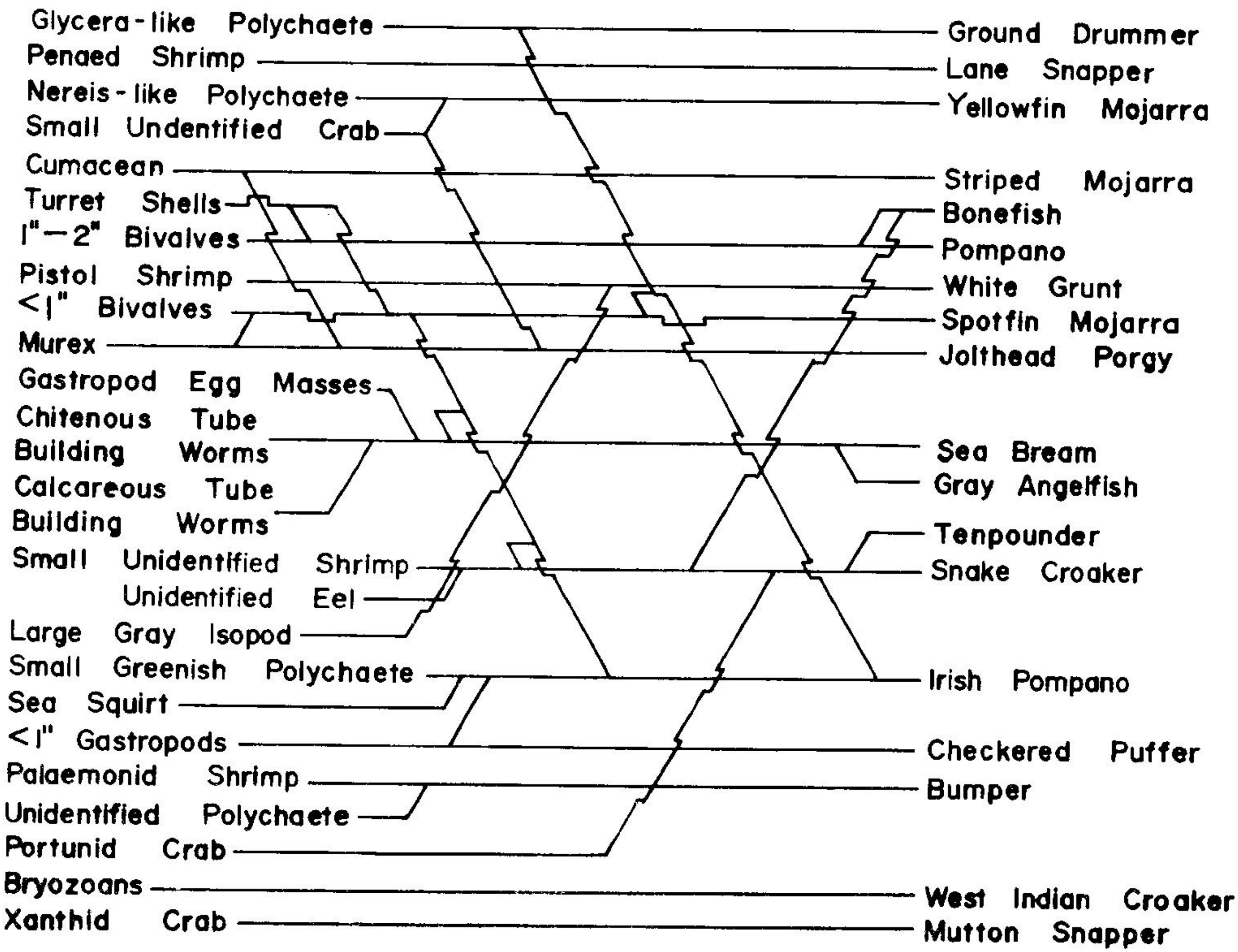


FIGURE 22

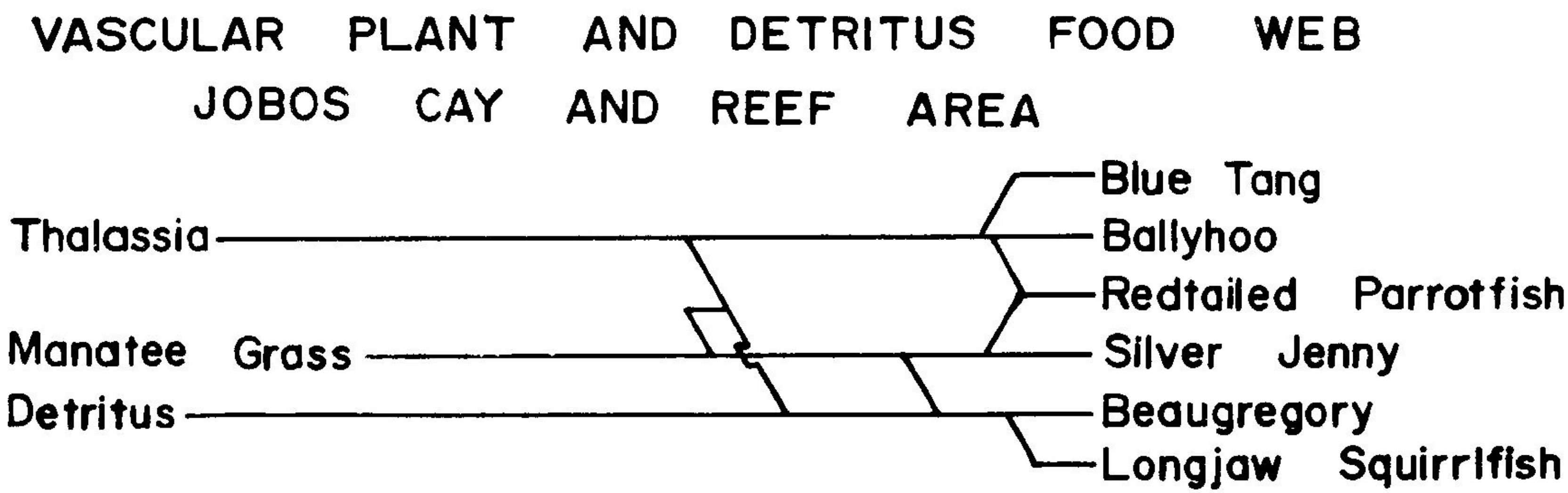

VASCULAR PLANT AND DETRITUS FOOD WEB
JOBOS CAY AND REEF AREA
Thalassia
Manatee Grass
Detritus
Blue Tang
Ballyhoo
Redtailed Parrotfish
Silver Jenny
Beaugregory
Longjaw Squirrlfish

FIGURE 23

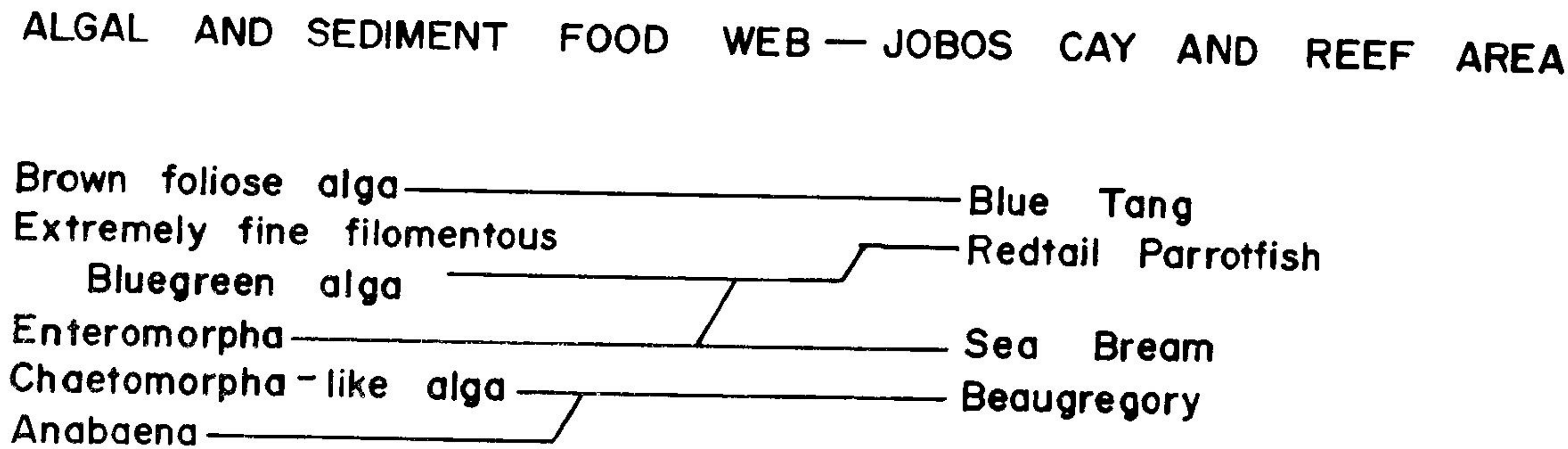

ALGAL AND SEDIMENT FOOD WEB — JOBOS CAY AND REEF AREA
Brown foliose alga
Extremely fine filomentous Bluegreen alga
Enteromorpha
Chaetomorpha - like alga
Anabaena
Blue Tang
Redtail Parrotfish
Sea Bream
Beaugregory

FIGURE 24

ZOOPLANKTON AND MISCELLANEOUS FOOD WEB — JOBOS CAY AND REEF AREA

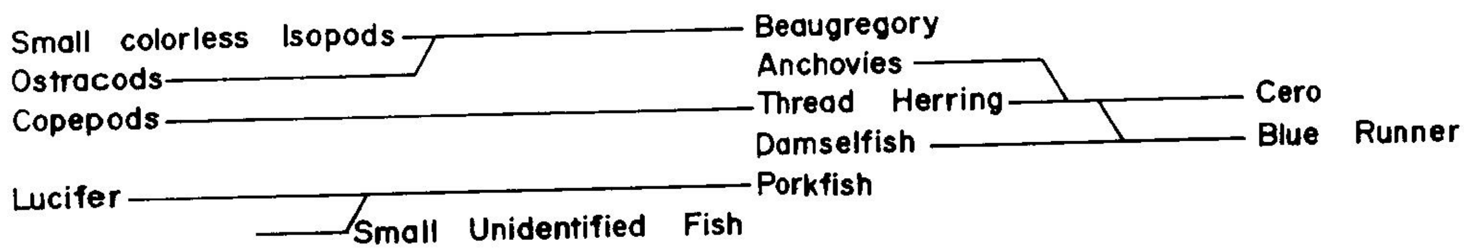


FIGURE 25

BENTHIC CONSUMER FOOD WEB — JOBOS CAY AND REEF AREA

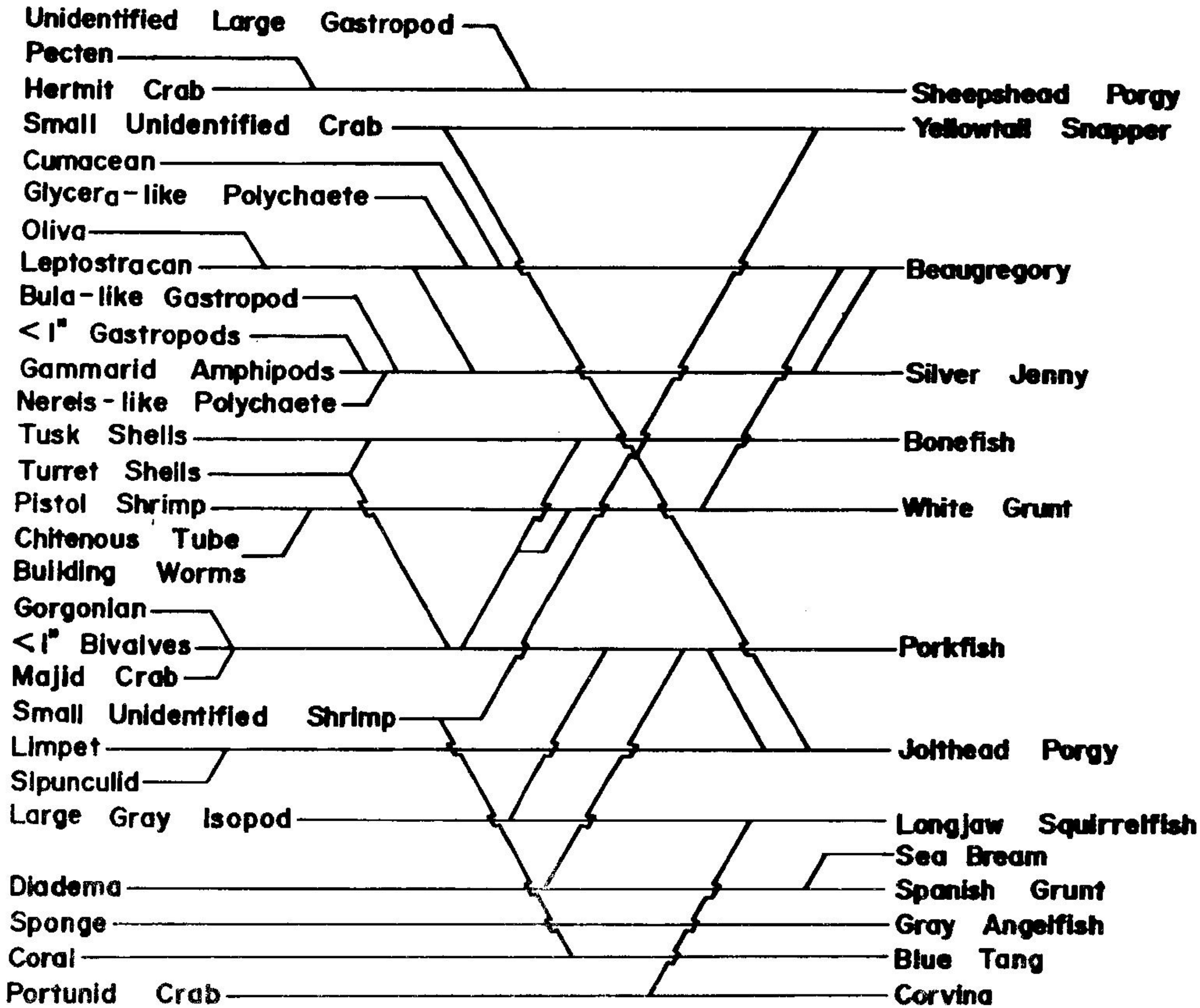


FIGURE 26

TABLE 1

Fishes of Jobos Bay and Aguirre Ship Channel

FAMILY	SPECIES	*HABITAT
ORECTOLOBIDAE		
	+*Ginglymostoma cirratum* - Nurse Shark	C, TG, R
CARCHARHINIDAE		
	+*Galeocerdo cuvieri* - Tiger Shark	C, TG, R
	Negaprion brevirostris - Lemon Shark	B, R
SPHYRNIDAE		
	Sphyrna lewini - Scalloped Hammerhead	O, I
DASYATIDAE		
	Dasyatis americana - Southern Stingray	O, I
MYLIOBATIDAE		
	Aetobatus narinari - Spotted Eagle Ray	O, I
ELOPIDAE		
	Elops saurus - Tenpounder	O, I
MEGALOPIDAE		
	Megalops atlanticus - Tarpon	O, I
ALBULIDAE		
	Albula vulpes - Bonefish	O, C, TG, I, R
MURAENIDAE		
	Gymnothorax moringa - Spotted Moray	TG, R
	Gymnothorax sp. - Moray	TG, R
	Muraena miliaris - Goldentail Moray	TG, R
OPHICHTHIDAE		
	Ahlia egmontis - Key Worm Eel	TG, R
	Myrophis punctatus - Speckled Worm Eel	TG, R

Table 1 cont'd.

FAMILY	SPECIES	* HABITAT
CLUPEIDAE		
	Harengula humeralis - Redeared Sardine	TC, R
	Opisthonema oglinum - Thread Herring	P, R, I
	Sardinella anchovia - False Sardine	P, R
ENGRAULIDAE		
	Anchoa lamprotaena - Longnose Anchovy	TC, R
SYNODONTIDAE		
	Synodus foetans - Inshore Lizardfish	O, I
	Synodus intermedius - Sand Diver	O, I
GOBIESOCIDAE		
	Acyrtops beryllius - Emerald clingfish	TG, R
ATENNARIIDAE		
	Histrio histrio - Sargassumfish	P
OPHIDIIDAE		
	Ogilbia sp.	TG, R
CARAPIDAE		
	Carapus bermudensis - Pearlfish	TG, I
EXOCOETIDAE		
	Hemiramphus brasiliensis - Ballyhoo	P, R
	Hyporhamphus unifasciatus - Halfbeak	P, I
BELONIDAE		
	Strongylura marina - Atlantic Needlefish	O, I

Table 1 cont'd.

FAMILY	SPECIES	HABITAT*
	Tylosaurus raphidoma - Houndfish	TC, R
ATHERINIDAE		
	Atherinomorus stipes - Hardhead Silverside	M, B, R
HOLOCENTRIDAE		
	Holocentrus ascensionis - Longjaw Squirrelfish	TG, R
AULOSTOMIDAE		
	†*Aulostomus maculatus* - Trumpet Fish	C, R
SYNGNATHIDAE		
	Corythoichthys brachycephalus - Crested Pipefish	M, R
	Syngnathus dunckeri - Pugnose pipefish	TC, R
	Syngnathus elucens - Shortfin Pipefish	TG, R
	Syngnathus pelagicus - Sargassum Pipefish	P, R
	Syngnathus rousseau - Caribbean Pipefish	TG, R
CENTROPOMIDAE		
	Centropomus ensiferus - Swordspine Snook	O, I
SERRANIDAE		
	†*Epinephelus striatus* - Nassau Grouper	C, TG, R
GRAMMISTIDAE		
	Rypticus saponaceus - Soapfish	TG, R
APOGONIDAE		
	Astrapogon puncticulatus - Punctate cardinalfish	TG, I

Table 1 cont'd.

FAMILY	SPECIES	* HABITAT
ECHENEIDAE		
	Echeneis naucrates - Sharksucker	P, I, R
CARANGIDAE		
	Caranx fuscus - Blue Runner	P, I
	Caranx hippos - Crevalle Jack	P, TG, I
	Caranx latus - Horse-Eye Jack	P, I
	Caranx ruber - Bar Jack	P, R
	Chloroscombrus chrysurus - Bumper	P, TG, R, I
	Oligoplites saurus - Leather Jack	P, TG, I
	Selene vomer - Lookdown	P, I
	Trachinotus carolinus - Pompano	O, I
	†*Trachinotus falcatus* - Permit	TG, I
	Vomer setapinnis - Moonfish	O, I
	Carangidae - Unidentified	P
LUTJANIDAE		
	Lutjanus analis - Mutton Snapper	TG, I
	Lutjanus apodus - Schoolmaster	O, R
	Lutjanus Griseus - Gray Snapper	M, TC, TG, R
	Lutjanus synagris - Lane Snapper	O, R, I
	Ocyurus chrysurus - Yellowtail Snapper	O, C, R, I
LOBOTIDAE		
	Lobotes surinamensis - Tripletail	P
GERRIDAE		
	Diapterus olisthostomus - Irish Pompano	O, TG, M, I
	Diapterus rhombeus - Rhomboid Mojarra	O, TG, I

Table 1 cont'd

FAMILY	SPECIES	HABITAT*
GERRIDAE	*Eucinostomus argenteus* - Spotfin Mojarra	TG, B, I
	Eucinostomus gula - Silver Jenny	TC, M, R
	Eucinostomus jonesii - Slender Mojarra	B, O, TG, R, I
	† *Eucinostomus lefroyi* - Mottled Mojarra	TG
	Eucinostomus melanopterus - Española	TG, R
	Eugerres plumieri - Plumer's Mojarra	O, I
	Gerres cinereus - Yellowfin Mojarra	O, TG, I
POMADASYIDAE		
	Anisotremus virginicus - Porkfish	O, C, R
	Haemulon aurolineatum - Tomtate	O, TC, R, I
	Haemulon chrysargyreum - Smallmouth Grunt	TC, R
	Haemulon flavolineatum - French Grunt	TC, R
	Haemulon macrostomum - Spanish Grunt	C, R
	Haemulon melanurum - Cottonwick	M, R
	Haemulon plumieri - White Grunt	O, TC, C, R, I
	Haemulon sciurus - Bluestriped Grunt	TC, M, C, R, I
SPARIDAE		
	Archosargus rhomboidalis - Sea bream	O, TG, M, I, R
	Calamus bajonado - Jolthead Porgy	O, C, R,
	Calamus penni - Sheepshead Porgy	O, R

Table 1 cont'd.

FAMILY	SPECIES	* HABITAT
SCIAENIDAE		
	Bairdiella ronchus - Ground Drummer	O, I
	Corvula sanctiluciae - St. Lucian Corvina	TG, O, I
	Cyanoscion jamaicensis - Sea Trout	O, R
	Micropogon furnieri - West Indian Croaker	O, I
	Ophioscion adustus - Snake Croaker	O, I
EPHIPPIDAE		
	Chaetodipterus faber - Spadefish	TG, I
CHAETODONTIDAE		
	Chaetodon capistratus - Four-Eyed Butterflyfish	TC, M, C, R
	†Holocanthus ciliaris - Queen Angelfish	C, R
	Pomacanthus arcuatus - Gray Angelfish	C, O, R, I
	†Pomacanthus paru - French Angelfish	C,R
POMACENTRIDAE		
	Abudefduf saxatilis - Sargeant Major	C, B, M, TC, R
	Eupomacentris leucostictus - Beaugregory	TC, B, TG, C, R
MUGILIDAE		
	Mugil curema - White Mullet	P, O, I
	Mugil trichodon - Fantail Mullet	P, O, I
SPHYRAENIDAE		
	Sphyraena barracuda - Great Barracuda	P, M, TC, R
	Sphyraena guachancho - Barracudina	P, O, I

Table 1 cont'd.

FAMILY	SPECIES	* HABITAT
POLYNEMIDAE		
	Polydactylus virginicus - Barbudo	O, TG, I
LABRIDAE		
	†Bodianus rufus - Spanish Hogfish	C, R
	Doranotus megalepis - Dwarf Wrasse	TG, R
	†Lachnolaimus maximus - Hogfish	R
	†Thalassoma bifasciatus - Bluehead	R
SCARIDAE		
	†Scarus sp. - Parrotfish	C, TG, R
	Sparisoma chrysopterum - Redtail Parrotfish	TG, B, TC, R, I
	Sparisoma radians - Bucktooth Parrotfish	B, R
	Sparisoma rubripinne - Yellowtail Parrotfish	B, R
BLENIIDAE		
	Entomacrodus nigricans - Pearl blenny	B, R
CLINIDAE		
	Acanthemblemaria aspera - Roughhead blenny	B, R
	Labrisomus guppyi - Mimic blenny	B, R
	Labrisomus nuchipinnis - Hairy blenny	B, R
	Malacoctenus aurolineatus - Goldline blenny	TG, R
	Malacoctenus erdmani - Imitator blenny	TG, B, R
	Malacoctenus gilli - Dusky blenny	B, R

Table 1 cont'd.

FAMILY	SPECIES	HABITAT*
CLINIDAE		
	Malacoctenus macropus - Rosy blenny	C, R
	Paraclinus fasciatus - Banded blenny	B, C, R
	Stathmonotus stahli - Eelgrass blenny	C, R
GOBIIDAE		
	Bathygobius curacao - Notchtongue goby	B, R
	Bathygobius soporator - Frillfin goby	B, R
	Gobionellus boleosoma - Darter goby	B, O, TC, R
	Gobiosoma dilepis - Orangeside goby	B, TG, R
ACANTHURIDAE		
	Acanthurus bahianus - Oceanic surgeonfish	TC, R
	Acanthurus chirurgus - Doctorfish	B, R
	Acanthurus coeruleus - Blue Tang	B, O, C, R
TRICHIURIDAE		
	Trichiurus lepturus - Cutlass Fish	O, I
SCOMBRIDAE		
	Scomberomorus maculatus - Spanish Mackerel	P, R
	Scomberomorus regalis - Cero	P, I, R
STROMATEIDAE		
	Peprillus paru - Harvestfish	P, R
	Stromateidae - unidentified	P
SOLEIDAE		
	Achirus sp. - Sole	O, I
	Gymnachirus nudus - Naked Sole	TC, R

Table 1 cont'd.

FAMILY	SPECIES	HABITAT*
BALISTIDAE		
	†*Balistes vetula* - Queen Triggerfish	C, R
	Stephanolepis setifer - Pigmy filefish	TG, R
OSTRACIONTIDAE		
	†*Acanthostracion* sp. - Cowfish	C, TG, R
	Lactophrys trigonus - Trunkfish	C, TG, R
TETRAODONTIDAE		
	Canthogaster rostrata - Sharpnosed Puffer	TC, R
	Sphoeroides testudineus - Checkered Puffer	O, TG, I, R
DIODONTIDAE		
	†*Diodon hystrix* - Porcupine fish	C, TG, R

* Habitat symbols: B = Reef Backflats; TC = Tide Channels; C = Coral; M = Mangrove; TG = Turtle grass; O = Open Mud or Sand Bottom; P = Pelagic. R - Reef and Cay Area, I - Bay and Shore area.

† indicates fish reported for Jobos bay which were not examined and verified by F. D. Martin.

TABLE 2

Breeding condition by date of fishes from Jobos Bay

SEPTEMBER 1971

CARANGIDAE

Selene vomer - Lookdown

21 cm - Ovaries large

LUTJANIDAE

Lutjanus apodus - Schoolmaster

36 cm - Enlarged testes

GERRIDAE

Diapterus olisthostomus - Irish Pompano

25 1/2 cm - Testes enlarged

POMADASYIDAE

Haemulon plumieri - White Grunt

20 cm - Ovaries enlarged

SPARIDAE

Archosargus rhomboidalis - Sea Bream

19 cm - Enlarged testes

NOVEMBER 1971

MEGALOPIDAE

Megalops atlanticus - Tarpon

50 cm, 1.8 kg. - Testes much enlarged.

SCIAENIDAE

Micropogon furnieri - West Indian Croaker

30.1 cm, 0.712 kg. - Ovaries much enlarged.

Table 2 cont'd.

DECEMBER 1971

GERRIDAE

Diapterus olisthostomus - Irish Pompano

20 1/2 cm, 284 grams - Enlarged ovaries

POMADASYIDAE

Anisotremus virginicus - Porkfish

19.5 cm, 208 grams - Ovaries enlarged

Haemulon macrostomum - Spanish Grunt

25 cm, 581 grams - Testes slightly enlarged.

SPHYRAENIDAE

Sphyraena guachancho - Barracudina

39 cm, 514 grams - Ovaries enlarged

FEBRUARY 1972

EXOCOETIDAE

Hyporhaphus unifasciatus - Halfbeak

One with ripe eggs.

SPARIDAE

Archosargus rhomboidalis - Sea Bream

20 cm, 312 grams - Well developed eggs.

18.2 cm - Ovaries enlarged.

SCIAENIDAE

Bairdiella ronchus - Ground Drummer

17.9 cm - Ovaries enlarged

Table 2 cont'd.

SCIAENIDAE

Ophioscion adustus - Snake Croaker

31 cm, 567 grams - Ovaries enlarged but egg size small.

38 1/2 cm, 333 grams - Testes greatly enlarged.

26.4 cm - Ripe ovaries

27 cm - Ripe ovaries

MARCH 1972

SCIAENIDAE

Cyanoscion jamaicensis - Sea Trout

13.2 cm - Enlarged testes

APRIL 1972

ATHERINIDAE

Atherinomorus stipes - Hardhead Silverside

4.5 cm - Mature eggs

5 cm - Mature eggs

MAY 1972

CLUPEIDAE

Opisthonema oglinum - Thread Herring

15.4 cm - Testes greatly enlarged.

12.2 cm - Hugely enlarged testes.

14.7 cm - Ovaries slightly enlarged.

12.9 cm - Very enlarged testes.

15.0 cm - Ovaries slightly enlarged.

15.3 cm - Enlarged testes.

Table 2 cont'd.

SCIAENIDAE

Ophioscion adustus - Snake Croaker

32 cm - Ovaries slightly enlarged.

SPHYRAENIDAE

Sphyraena barracuda - Great Barracuda

41 cm - Ovaries slightly enlarged.

JUNE 1972

OPHIDIIDAE

Ogilbia sp.

Most ♀♀ taken were pregnant.

MAMMALS OF JOBOS BAY - 1971-72

F. Douglas Martin

Two species of marine mammal, the manatee (Trichechus manatus) and the bottlenose dolphin (Tursiops truncatus) have been sighted in Jobos Bay during 1971 - 72. The accompanying map has the sighting localities marked and are as follows:

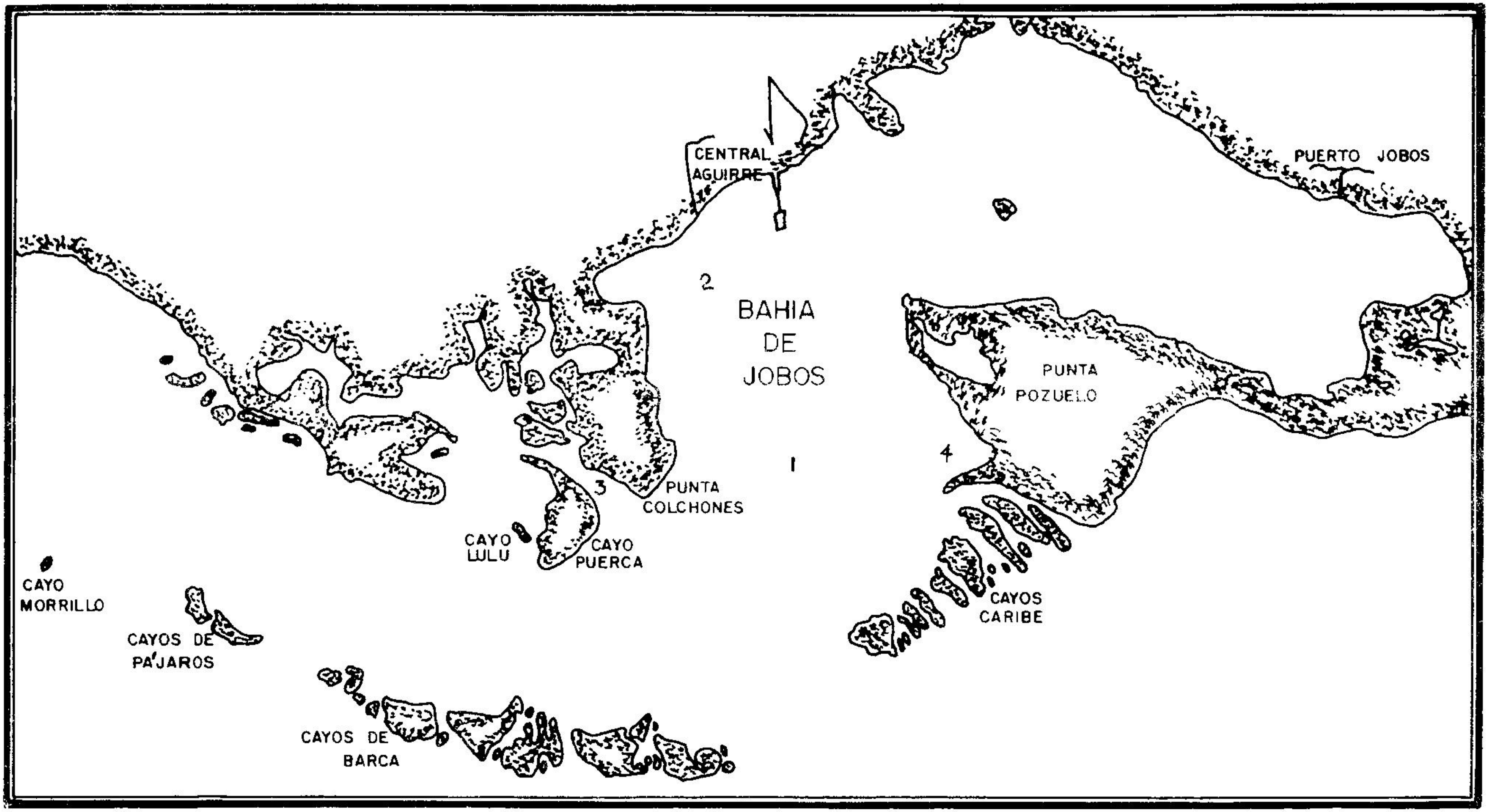
1. Tursiops truncatus - 29 Dec. 1971. One individual sighted at about 1430.

2. Tursiops truncatus - 1 March 1972. One individual sighted several times or a small school. Sighted at about 1030.

3. Trichechus manatus - 25 May 1972. One individual. Sighted at about 0645.

4. Trichechus manatus - 13 June 1972. One individual. Sighted at about 0845.

The only other non-domestic mammal seen at Jobos Bay has been the Norway rat, Rattus norvegicus. Populations are known to occur on Cayo Caribe 3, Cayos de Barca 6, 8 and 12, Cayos de Pajaros E. and W. and Cayo Puerca.


CENTRAL
AGUIRRE
PUERTO JOBOS
2
BAHIA
DE
JOBOS
1
PUNTA
POZUELO
4
PUNTA
COLCHONES
3
CAYO
LULU
CAYO
PUERCA
CAYOS
CARIBE
CAYO
MORRILLO
CAYOS DE
PÁJAROS
CAYOS DE
BARCA

MAP 4

BIRD FAUNA OF JOBOS BAY: 1972 CENSUS

The bird fauna of Jobos Bay is relatively varied even though the total species diversity is low. Many winter species are migrants from the north. The plant site has few birds but the off-shore cayos and the mangrove areas have 20-25 species additional.

A maximum species diversity of about 30 species per 1,000 individuals observed have been counted. Of these, several are uncommon and two, the Osprey and the Brown Pelican are considered endangered species for the U.S. mainland. The Brown Pelican in Puerto Rico is not noticeably decreasing in numbers but Ospreys are rare.

No major feeding or rookery areas are in the path of the canal. A transient disturbance in the rookery at the end of Rookery Bay may be noted when construction activity passes nearby but once the construction is ended, all areas should return to normal.

1972 SUMMER BIRD CENSUS I

Location: Jobos Bay area
Weather: Cloudy and breezy   Date: 12 June 1972
Observer: James A. McCandless   Time: 1430 to 1830

Pelicans	7	Ruddy Turnstones	2
Little Blue Heron	5	Black-necked Stilts	2
Green Heron	1	Royal Terns	2
Cattle Egrets	300	Sandwich Terns	4
Common Egrets	4	Ground Dove	1
Clapper Rails	5 h	Yellow Warblers	12 7h

Location: Mangrove island from Punta Rodeo to Punta Pozuelo
Weather: Rain showers with intervals of sunshine
Date: 13 June 1972
Time: 800 to 1200

Pelicans	3	Mangrove Cuckoos	5 3h
Little Blue Heron	4	Green Mango Hummingbird	1
Cattle Egrets	200	Gray Kingbird	1
Louisiana Heron	1	Lesser Antillean Pewee	1
Clapper Rails	9 h	Pearly-eyed Thrashers	3
Wilson's Plover	2	Bananaquits	5
Pectoral Sandpiper	1	Black-and-wjote Warblers	5
White-winged Dove	1	Yellow Warblers	25 15h
Mourning Doves	2 h	Grackles	10 5h
Ground Doves	6 3h	Black-faced Grassquits	20

Location: Jobos Bay area   Date: 13 June 1972
Weather: Overcast with rain   Time: 1445 to 1900

Pelicans	6	Royal Terns	3
Little Blue Herons	5	Sandwich Terns	7
Cattle Egrets	300	Ground Doves	3
Osprey	1	Common Night Hawks	2
Clapper Rails	10 h	Gray Kingbirds	2 h
Black-necked Stilt	1	Yellow Warblers	20 16h

Total species observed: 28   Individuals 1,010

Notes: Brush fires have recently swept the Punta Pozuelo area. We note the apparent absence of Great Blue Herons as opposed to the Winter count of 23.

KEY: h heard only

SUMMER BIRD CENSUS II

Location: Jobos Bay area; especially Punta Pozuelo
Weather: Clear
Observer: James A. McCandless
Date: 20 July 1972
Time: 1400 to 1800

Pelicans	6	Zenaida Dove	1
Green Herons	2	White-winged Doves	3 2h
Little Blue Herons	3	Ground Doves	2
Cattle Egrets	42	Common Night Hawk	3
Common Egrets	3	Green Mango Hummingbird	1
Louisiana Herons	2	Bananaquits	3
Clapper Rails	3h	Yellow Warblers	4
Black-bellied Plovers	5	Grackles	3
Spotted Sandpiper	1	Black-faced Grassquit	1
Peep	3		

Date: 21 July 1972
Time: 0700 to 1000

Pelicans	4	Gray Kingbird	1h
Green Heron	1	Stolid Flycatcher	2h
Little Blue Heron	2	Pearly-eyed Thrasher	1
Cattle Egrets	80	Cave Swallows	4
Louisiana Heron	1	Bananaquits	4
Clapper Rails	4h	Yellow Warblers	18 9h
White-winged Doves	2h	Grackles	2
Mangrove Cuckoo	1h		

Number of species observed: 24 Individuals: 218

NOTICE