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STUDIES OF THE NATURAL HISTORY OF THE CARIBBEAN REGION: VOL. 75, 2000

A REVISION OF THE SHALLOW-WATER AZOOXANTHELLATE SCLERACTINIA OF THE WESTERN ATLANTIC

by

STEPHEN D. CAIRNS*

ABSTRACT

CAIRNS, S. D., 2000. A revision of the shallow-water azooxanthellate Scleractinia of the western Atlantic. *Studies Nat. Hist. Caribbean Region 75*, Amsterdam, 2000: 1-231.

This paper constitutes the second of a two part revision of the western Atlantic azooxanthellate Scleractinia – this part addressing the taxonomy and distribution of the 73 species known to occur at depths shallower than 183 m within the tropical and warm temperate realm. Of this number, 27 species occur exclusively shallower than 183 m; these are fully described, figured, and mapped. The remaining 46 species are also known to occur at depths greater than 183 m, most of those species treated more fully in part 1 (CAIRNS 1979). Lists are also provided of the azooxanthellate species that occur exclusively deeper than 183 m (56 species) as well as the western Atlantic zooxanthellate fauna (65 species), resulting in the first comprehensive list of all 192 western Atlantic scleractinian species. In the western Atlantic there are approximately twice as many azooxanthellate as zooxanthellate species. One species, *Tubastraea coccinea* is considered to be introduced; its distribution and chronology of its possible dispersal are mapped and discussed.

Approximately 6900 specimens (1100 lots) were examined, collected from over 550 stations. Additional records of all but three of the 73 species are reported herein. Ten species and one subspecies are described as new; ten new combinations are suggested.

Among the 73 shallow-water species several patterns of distribution were discerned: widespread insular and continental, primarily insular, primarily continental, endemic to Brazil, and endemic to the Carolinian Province. The most common pattern, shared by 18 species, was a distribution that includes the entire tropical western Atlantic as well as the northern warm temperate region in the northern Gulf of Mexico and/or southeast coast of the US, these 'eurythermic tropical' species usually extending no farther than 34°30' to 35°00'N. Among the 27 exclusively shallow-water azooxanthellates, the percentage of species endemic to the western Atlantic (85%) and the amphi-Atlantic component (11%) were considerably higher and lower, respectively, than those components for the deeper water azooxanthellates, but virtually identical to that of the western Atlantic zooxanthellate corals.

Key words: **Scleractinia, azooxanthellate, Caribbean, western Atlantic, taxonomy, biogeography**.

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INTRODUCTION

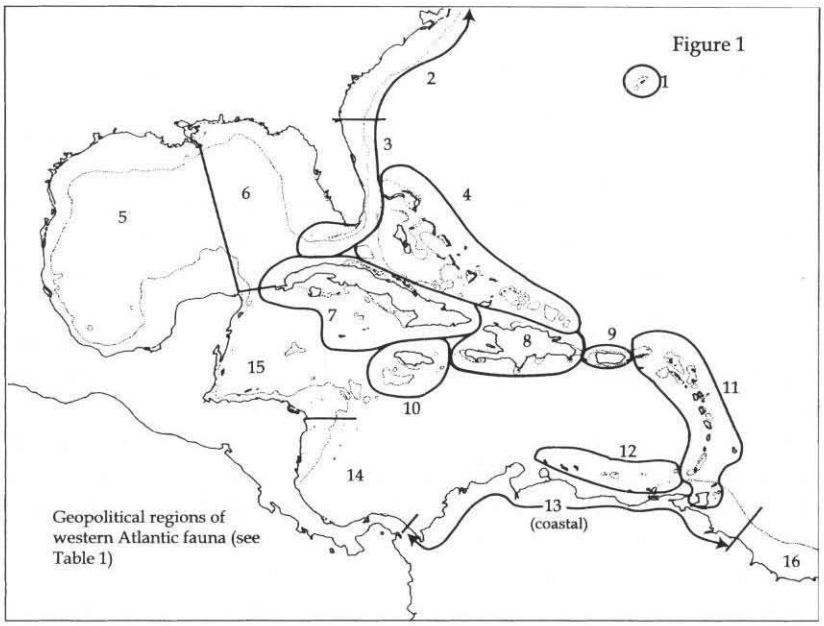
In 1979, I (CAIRNS 1979) published a revision of the deep-water azooxanthellate Scleractinia of the tropical western Atlantic, consisting of an account of 88 species. It had always been my intention to publish the complementary text, which would treat the shallow-water azooxanthellate species from the same region; however, specimens were less available for such a comprehensive treatment until extensive collections were made by the BLM/MMS and various other independent expeditions and collectors (see Station List). Now, two decades later, I submit the second and final part of the revision of the western Atlantic azooxanthellate corals.

The coverage for this revision includes all azooxanthellate species that have all or part of their bathymetric range shallower than 183 m and that occur in the tropical and/or warm temperate regions of the western Atlantic. Altogether 73 species are treated, 43 of which are more thoroughly discussed in previously published papers (CAIRNS 1977a-b, 1978a, 1979; see Table 1 and Fig. 1), most of which have bathymetric ranges that are shallow but also exceed 183 m; the remaining 30 are fully described herein. Despite the overlap of 43 species, all 73 shallow-water species are included herein so that this paper can be considered comprehensive for the shallow-water fauna. Another 56 azooxanthellate species (Appendix 1) occur in waters exclusively deeper than 183 m, which brings the total number of western Atlantic azooxanthellates to 129 species.

Historical Resume: A history of the literature on western Atlantic azooxanthellate corals, including both deep and shallow-water species, was given by CAIRNS (1979) and will not be repeated here, except to update several significant papers published after 1979.

In his revision of the Scleractinia of Cuba, ZLATARSKI (1982) included the redescriptions and illustrations of six shallow-water azooxanthellate species from that country. His descriptions, synonymies, and ecological notes were extensive; however, one of the six species, *Caryophyllia smithi*, is herein reidentified as *Caryophyllia crypta* and *Coenocyathus caribbeana*. Five of these six species were also reported and illustrated by CAIRNS (1982b) from Belize.

The most significant addition to this fauna was the report on shallow-water ahermatypic corals from Trinidad by HUBBARD & WELLS (1986). These



authors reported 19 coral species, including one new species, from northwestern Trinidad and the islands between Trinidad and Península de Paria, Venezuela, called Dragon's Mouths. One of these 19 species is now considered hermatypic and another four have been synonymized with other species, which reduces the number of azooxanthellates reported from this region to 14. As HUBBARD & WELLS (1986) explained, this area is environmentally atypical, being strongly influenced by riverine discharge and thus having seasonal variation in salinity, as well as high turbidity and low light penetration. Although these conditions tend to inhibit the growth of reef corals, azooxanthellates are common and, indeed, seem to flourish. For instance, in this region, two species (*Astrangia solitaria* and *Colangia immersa*) reach a calicular size maximum; two others (*Thalamophyllia riisei* and *Eguchipsammia cornucopia*) have unusually prolific branching; one species (*Cladocora debilis*) has an unusual, sympodial branching pattern; and *Rhizopsammia maculata* occurs without black pigment. Furthermore, several species (*e.g., Madracis myriaster* and *Javania cailetti*) are found at unusually shallow depths in this region. Most of these specimens are deposited at the

USNM and the peculiarities mentioned above are discussed in the species accounts.

Building on two earlier papers that listed the azooxanthellate coral fauna from the Gulf of Mexico (CAIRNS 1977b, 1978a), additional records and a summary of all azooxanthellate species were reported by VIADA & CAIRNS (1987) and CAIRNS *et al.* (1994) from the six subdivisions of the Gulf.

A very detailed account of one species, *Astrangia poculata*, was published by PETERS *et al.* (1988), including a redescription, complete synonymy, neotype designation, illustrations, and discussions of ecology and nomenclatural history.

CAIRNS *et al.* (1991) listed all scleractinian species that occur off North America at depths shallower than 200 m, including 51 species from the western Atlantic. Common names were given for some species.

Finally, in a beautifully illustrated field guide, HUMANN (1993) included colour, *in situ* photographs of 15 shallow-water azooxanthellate species, including three described as new species herein. Many of the illustrated specimens are deposited at the USNM. HUMANN provided common names for all the corals he illustrated.

There have been many more references to shallow-water western Atlantic azooxanthellate corals in the literature, but usually as parts of larger revisions or checklists on reef corals from various regions. These citations are listed in the synonymies of each species as well as in the References section.

MATERIAL AND METHODS

Material: This study is based on the examination of approximately 6900 coralla divided into 1100 lots that were collected from over 550 stations, including 54 vessels or programs (see Station List), and several hundred additional sites not listed as stations from throughout the western Atlantic. Additional records are reported herein for all but three of the 73 shallow-water azooxanthellate species, those being: *Caryophyllia zopyros, C. barbadensis,* and *Gardineria paradoxa.* The three most commonly collected species were *Astrangia poculata, Balanophyllia floridana,* and *Phyllangia americana americana.*

The largest source of new records for the study originated with the var-

ious programs of the BLM/MMS. Other significant contributions included specimens collected by the U.S. Fish & Wildlife Service vessels; RSMAS, University of Miami; the Johnson-Sea-Link (HBOI); and from the Discovery Bay Lab, Jamaica, the latter donated to the USNM by JOHN W. WELLS. There were many more sources of material, as listed in the Station List and in the New Records section of each species.

Methods: As mentioned in the Introduction, this paper is meant as much as possible to serve as a complement, not a repetition, of my earlier paper (CAIRNS 1979) on the deep-water azooxanthellates; however, all species that have a bathymetric range shallower than 183 m are included herein. Thus, for the 43 species that occur in both papers, a reduced treatment is given herein, including only an updated (post 1979) synonymy, and a diagnosis (not a description); type deposition, type locality, and distributional maps are omitted.

Otherwise, synonymies are made as complete as possible, including occurrence in checklists (annotated as 'listed'). In order to clarify what previously published material was examined by the author, the following convention was used (see MATTHEWS 1973). Three symbols are used in the synonymies, which always precede the year of publication:

*, means that this entry represents the original description of a validly described species under the terms of the ICZN (1985);

v*, means that I have examined the type series of this species; and

v., means that I have examined this/these nontype specimens and agree that they belong in this synonymy. The letter 'v' is Latin for *vidimus* (we have seen). This convention is not used for publications written by myself, as it is obvious that I have seen specimens that I have previously reported.

In the 'New Records' sections, the station number is followed by the number of specimens examined, followed by the museum of deposition and its catalog number, if any. Most newly designated types are deposited at the USNM.

183 m (instead of 200 m) was chosen as the maximal lower limit for a species to be included in this paper. This still maintains a complete coverage of all western Atlantic azooxanthellates, as none has a range exclusively between 183 and 200 m, and omits species such as *Fungiacyathus symmetricus*, which has a range of 183-1664 m, and thus is not considered as part

of the shallow-water fauna. In order to avoid erroneous depth ranges for species as a result of bathymetrically wide-ranging trawls, a 'confirmed' depth range is employed in this paper, which is defined as the deepest shallow to the shallowest deep component of all trawls considered. For instance, if a species was trawled at a station indicating a range of 20-300 m and again at a station indicating 250-500 m, the confirmed depth range would be 250-300 m, a conservative estimate of the true depth of capture range.

In some cases the corallum was dyed black with cloth dye and recoated with sublimed ammonium chloride in order to improve contrast for conventional photography.

Several azooxanthellate species listed by CAIRNS (1979: Tables 1, 4) as occurring in shallow water are not included in this report for various reasons. For instance, *Tethocyathus cylindraceus* was listed by CAIRNS (1979) as occurring at 155-649 m. POURTALÈS (1874) even reported it from Cabo Frio at 64 m, but his identification was based on a dead specimen and was equivocal; that specimen has not subsequently been located at MCZ and was not subsequently reported by POURTALÈS (1880a) at that depth range. The 155 m record originates from BL-296 (POURTALÈS 1880a), which CAIRNS (1979) stated was not *T. cylindraceus*. Therefore the shallowest records of this species is 100-200 fms (=183-366 m) for the syntypes (POURTALÈS 1868) and 183 m from Barbados (POURTALÈS 1874), and thus it is not included in this report. Similar upward revisions of the minimum depth range have been made to *Desmophyllum striatum*, *Madrepora oculata*, and *Thalamophyllia gombergi*, details of the changes included herein under the discussion of congenerics. *Desmophyllum dianthus* is not included because it occurs shallower than 183 m only in the cold temperate region. *Madracis formosa* is herein considered to be zooxanthellate (FENNER 1993b) as is *Agaricia cailleti* (FENNER, *pers. comm.* 1997). Finally, *Oculina varicosa* appears to be a facultative zooxanthellate (REED 1980) and the status of *O. valenciennesi* is uncertain. Neither are included herein.

Since 1979, four species of exclusively deep-water azooxanthellates can be added to the western Atlantic fauna. Although not an integral part of this paper, they are included in the calculations of faunistic affinities in the zoogeographic analysis. One of these species is *Caryophyllia sarsiae* Zibrowius, 1974, five specimens herein reported from off Bermuda at 1097-1200 m (Figs. 69, 71; USNM 76307, 80473). CAIRNS (1995a) considered that

species to be a junior synonym of *C. diomedeae* Marenzeller, 1904, with a circumtropical/temperate distribution at 245-2200 m. One specimen (Figs. 85-86; USNM 62523) of a second species, *Premocyathus dentiformis* (Alcock, 1902), is herein reported from P-876 (off St. Vincent, Lesser Antilles, 231-258 m). It is otherwise known from the tropical western Pacific at 115-757 m (CAIRNS & ZIBROWIUS 1997). The third species, *Polymyces wellsi* Cairns, 1991, is reported from three stations (P-586, USNM 98948; O-11225, USNM 98949, Figs. 174-175; and Eastward-36259, University of California, Santa Cruz), including off the Bahamas; off Havana, Cuba; and off Nicaragua at depths of 549-1682 m. This species is otherwise known to be cosmopolitan in tropical and temperate waters at 355-1165 m (CAIRNS & ZIBROWIUS 1997). Finally, *Cryptotrochus carolinensis* was described by CAIRNS (1988), a species known only from off North Carolina at 320-338 m.

LIST OF ABBREVIATIONS

VESSELS AND EXPEDITIONS:

Alb	U. S. Fish Commission Steamer Albatross
ASLAR	Atlantic Slope and Rise Studies (a BLM/MMS program)
B-A DS	Barbados-Antigua Expedition of 1918 (Dredging Station)
BL	U. S. Coast Survey Steamer Blake
BLM	Bureau of Land Management, U. S. Department of Interior
CI	R/V Columbus Iselin
CSA	Continental Shelf Associates, Jupiter, Florida
DBL	Discovery Bay Lab, Jamaica
EJ	Ed Joyce station
FH	U.S. Fish Commission Steamer Fish Hawk
G	R/V Gerda
Gos	R/V Gosnold
GS	R/V Gilliss
IOSP	Instituto Oceanographico da Universidad de São Paulo
JS	Johnson Smithsonian Deep-Sea Expedition, Yacht Caroline (1933)
JSL	Johnson-Sea-Link
LGL	LGL Ecological Research Associates, Bryan, TX
LMRS	South Atlantic Outer Continental Shelf Living Marine Resources Study (a BLM/MMS program)
MMS	Mineral Management System, U. S. Department of Interior (previously called the Bureau of Land Management)
NEEB	New England Environmental Benchmark Program (a BLM/MMS program)
O	M/V, R/V Oregon and R/V Oregon II
OCS	Outer Continental Shelf (a BLM/MMS program)
P	R/V Pillsbury
SB	M/V, R/V Silver Bay
SOFLA	Southwest Florida Shelf Ecosystem Study (a BLM/MMS program)
TAMU	Texas A & M University (R/V Alaminos)
USGS	United States Geological Survey
WB	N/Oc Wladimir Besnard

MUSEUMS:

BM	The Natural History Museum (formerly the British Museum (Natural History), London
FSBC I	Florida State Board of Conservation Identification number (now the Florida Department of Environmental Protection)
HBOI	Harbor Branch Oceanographic Institution, Fort Pierce, FL
IRCZM	Indian River Coastal River Museum, Fort Pierce, FL (associated with the HBOI)
MCZ	Museum of Comparative Zoology, Harvard, MA
MNHN	Muséum National d'Histoire Naturelle, Paris
MNRJ	Museu Nacional/Universidade Federal do Rio de Janeiro

NMC	National Museum of Canada, Ottawa
RMNH	Nationaal Natuurhistorische Museum Naturalis (formerly Rijksmuseum van Natuurlijke Histoire), Leiden
ROM	Royal Ontario Museum, Toronto
RSMAS	Rosenstiel School of Marine and Atmospheric Science, University of Miami, FL (specimen cataloged in Invertebrate Museum prefaced with UMML)
SME	Station Marine d'Endoume, Marseille
SMNH	Swedish Museum of Natural History, Stockholm
TU	Tulane University, New Orleans, LA
UCSC	University of California, Santa Cruz
USNM	United States National Museum (now named the National Museum of Natural History), Smithsonian Institution, Washington, D.C.
YPM	Yale Peabody Museum, New Haven CT

MORPHOLOGICAL AND MISCELLANEOUS TERMS:

BP	Before present
CD	Calicular diameter
GCD	Greater calicular diameter
HT:GCD	Ratio of height to greater calicular diameter of a solitary corallum
ICZN	International Commission of Zoological Nomenclature
LCD	Lesser calicular diameter
PD	Pedicel diameter
PD:GCD	Ratio of pedicel diameter to greater calicular diameter
Sx, Cx, Px	Septa, costae, or pali (respectively) of cycle designated by numerical subscript
Sx > Sy	In the context of a septal formula, indicates that septa of cycle x are wider than septa of cycle y.
v.	In the context of a synonymy, indicates that I have examined these specimens (literally *vidimus*).
*	In the context of a synonymy, indicates that this entry represents the original description of a validly described species (see MATTHEWS 1973).

STATION LIST

Station	*Latitude	*Longitude	Depth (m)	Date
		Akaroa		
92	10°20'20"S	36°10'25"W	21	3 IX 1965
		U.S.F.S. Albatross (Alb)		
2120	11 07 00 N	62 14 30 W	134	30 I 1884
2142	9 30 15	76 20 30	77	25 III 1884
2146	9 32 00	79 54 30	62	2 IV 1884
2152	4 km NW of Havana Light		702	30 IV 1884
2157	23 10 00	82 21 00	57	30 IV 1884
2160	23 10 31	82 20 37	305	"
2161	23 10 36	82 20 28	267	"
2167	23 10 40	82 20 30	368	1 V 1884
2280	35 21 00	75 21 30	29	19 X 1884
2285	35 21 25	75 24 25	24	"
2313	32 53 00	77 53 00	181	5 I 1885
2316	24 25 30	81 47 45	91	15 I 1885
2317	24 25 45	81 46 45	82	"
2318	24 25 45	81 46 00	82	"
2319	23 10 22	82 20 06	245	17 I 1885
2320	23 10 39	82 18 48	238	"
2321	23 10 54	82 18 00	421	"
2322	23 10 54	82 17 45	210	"
2327	23 11 45	82 17 54	333	"
2330	23 10 15	82 19 15	221	"
2331	23 10 31	82 19 55	209	"
2336	23 10 48	82 18 52	287	19 I 1885
2338	23 11 00	82 20 00	346	19 I 1885
2354	20 59 30	86 23 45	238	22 I 1885
2374	29 11 30	85 29 00	48	7 II 1885
2386	29 15 00	88 06 00	110	4 IV 1885
2387	29 24 00	88 04 00	59	"
2388	29 24 30	88 01 00	64	"
2394	28 38 30	87 02 00	768	13 IV 1885
2405	28 45 00	85 02 00	55	15 IV 1885
2406	28 46 00	84 49 00	48	"
2407	28 47 30	84 37 00	44	"
2412	26 18 30	83 08 45	49	19 IV 1885
2414	25 04 30	82 59 15	48	"
2596	35 08 30	75 10 00	90	17 X 1885
2617	33 37 30	77 36 30	26	20 X 1885
2619	33 38 00	77 36 00	27	"
2639	25 04 50	80 15 10	102	9 V 1886

Station	*Latitude	*Longitude	Depth (m)	Date
2640	25 05 00	80 15 00	102	"
2641	25 11 30	80 10 00	110	"
2651	24 02 00	77 12 45	177	13 V 1886
2762	23 08 00	41 34 00	108	30 XII 1886
		M/V Aleutian Bounty		
83-165	26 30'N	84 50'W	640	12 XI 1983
		R/V Alvin		
761-F27	27 04.0'N	79 18.8'W	611	29 V 1977
762-F13	27 03.1	79 19.3	620	30 V 1977
764-F17	26 54.8	79 09.6	452	1 VI 1977
846	26 25.7	77 52.1	785	3 XI 1978
1268	40 13.3	67 36.9	1809	?
1270	40 21.7	67 40.0	933	19 IX 1982
1335	27 05	79 40	620	21 II 1984
		Alpha Helix		
16	12 30'18"N	70 02'42"W	30	26 VI 1977
		Anton Dohrn		
6392	30 49'N	79 49'W	400-425	?
		ASLAR		
Gyre 4	40 50'42"N	68 00'12"W	67	13 V 1983
Gyre 15	32 10 14	76 42 50	1900-2020	18 IX 1985
Oceanus 1	41 13 00	67 15 18	55	9 XI 1981
		Atlantis		
20-28	St. Paul Rocks, Atlantic		205-225	19 III 1966
		Barbados-Antigua Expedition of 1918 (B-A DS)		
3	Pelican Id., Barbados		137-146	15 V 1918
4	"		201	"
9	"		183	16 V 1918
10	"		196	"
32	off Payne's Bay Church, Barbados		91	21 V 1918
34	S.E. of Hastings, Barbados		146-164	23 V 1918
45	Pelican Id., Barbados		164-182	25 V 1918
59	W. of Telegraph Sta., Barbados		157	30 V 1918
65	Payne's Bay Church, Barbados		91	31 V 1918
		U.S.C.G.S. Blake (BL)		
2	23 14'N	82 55'W	1472	1878
155	16 41 54	62 13 24	161	16 I 1879
203	14 28 50	64 05 40	176	10 II 1879
247	12 05 25	61 47 15	311	25 II 1879
296	13 05 24	59 38 45	155	10 III 1879

Station	*Latitude	*Longitude	Depth (m)	Date
		BLM (1974)		
17	29 37'N	87 27'W	66	1974
18	29 33	87 24	82	"
19	29 27	87 25	82	"
22	29 50	86 26	82	"
33	29 38	86 11	69	"
		BLM, James Island Area Block		
198-2	32 46'28.70"N	78 51'41.65"W	32-33	
380-3	32 33 59.80	78 33 49.62	97-102	
380-4	32 33 57.83	78 34 15.61	72-79	
380-7	32 34 23.23	78 34 47.63	60-63	
380-11	32 34 39.56	78 34 08.53	96-98	
380-19	32 35 33.34	78 34 23.93	64-69	
463-4	32 30 37.36	78 49 01.67	46-49	
463-5	32 30 13.41	78 49 27.65	47	
463-6	32 30 31.53	78 49 21.41	47-48	
463-7	32 28 58.77	78 48 35.79	57-58	
463-11	32 29 51.84	78 51 22.57	50-54	
463-14	32 29 06.89	78 50 13.34	50-51	
463-16	32 29 17.19	78 49 29.73	49	
463-18	32 29 26.64	78 49 12.73	49	
463-19	32 29 43.17	78 48 55.21	51	
463-20	32 30 11.32	78 48 01.01	48	
463-21	32 30 05.35	79 48 28.17	50	
I-2A	32 46	78 51	95-98	
I-11	32 34	78 34	96-98	
		BLM, LMRS		
O-S01	31 31'48"N	79 44'42"W	54	9 III 1981
O-S03	30 26 12	80 12 18	61	11 III 1980
O-S05	33 48 42	76 34 12	102	14 V 1981
O-S06	32 29 24	78 49 42	49	3 XI 1981
I-579	31 32 12	79 44 06	61	8 III 1980
I-580	30 26 54	80 12 06	60	10 III 1980
I-S05	34 24 00	76 35 06	24	13 VIII 1981
MS-03	30 54 00	80 36 18	35	22 VIII 1980
MS-04	33 31 48	77 24 36	28	12 VIII 1981
MS-06	32 48 36	78 39 36	34	6 V 1981
		BLM, NEEB		
24	40 35'17"N	67 11'15"W	121	9 V 1977
27	40 27 17	67 31 36	140	7 V 1977

Station	*Latitude	*Longitude	Depth (m)	Date
		BLM, OCS		
A1	39 14'42"N	72 42'18"W	91	3 XI 1975
A2	39 21 36	72 31 00	128	"
F1	38 44 00	73 14 42	85	1 VI 1977
F2	38 44 18	73 09 12	110	"
F4	38 44 12	73 02 36	206	10 II 1977
K5	38 01 36	73 53 48	151	12 III 1976
L4	37 08 06	74 36 54	97	4 VIII 1977
L5	37 06 06	74 33 26	180-200	22 III 1976
4C	31 45 26	80 29 03	20	24 II 1977
5B	31 12 00	81 07 59	11	21 II 1977
5C	31 08 00	80 49 57	19	25 II 1977
6H	30 22 56	79 56 52	320	2 IX 1977
		BLM, SOFLA		
1	26 45.77'N	82 43.11'W	25	28 X 1980
3	26 45.86	83 21.44	50	29 X 1980
7	26 16.82	82 44.02	32	6 XI 1980
9	26 16.83	83 23.81	60	5 XI 1980
10	26 16.73	83 42.82	71	3 XI 1980
11	26 16.72	83 46.82	83	4 XI 1980
13	25 45.93	82 09.35	22	8 XI 1980
15	25 45.89	82 31.62	34	9 XI 1980
17	25 45.58	83 20.23	59	15 XI 1980
23	25 16.89	83 37.79	77	17 XI 1980
27	24 47.77	83 08.02	54	20 XI 1980
29	24 47.59	83 41.19	67	21 XI 1980
30	24 47.42	83 51.15	76	21 XI 1980
32	26 16.67	84 04.08	137	25 VII 1981
35	25 44.84	84 21.03	159	26 VII 1981
36	25 16.83	83 57.35	127	2 VIII 1981
38	25 16.50	84 14.77	159	2 VIII 1981
39	24 47.16	83 55.36	152	3 VIII 1981
44	26 17.87	82 12.62	13	5 XII 1982
45	26 03.18	82 08.45	17	6 XII 1982
51	25 17.67	81 48.00	16	8 XII 1982
52	25 17.80	81 39.80	14	3 VI 1983
55	24 36.17	82 41.97	27	25 III 1985
		R/V Chain (Cruise 35)		
35-15	St. Paul Rocks, Atlantic Ocean		291	13 IV 1963
35-16	"	"	110-146	13 IV 1963
35-20	?	?	?	?
35-35	7-8°N	54-58°W	?	28 IV 1963
35-36	8 10.5	57 40	104	28 IV 1963
35-38	8 08	57 52.5	110	"
35-39	8 08	57 52	101	"
35-43	8 53	59 04	?	29 IV 1963

Station	*Latitude	*Longitude	Depth (m)	Date
		Circé		
25	29 20.3'N	87 45.9'W	100	
27-1	29 20.3	87 45.8	112	
27-2	29 20.3	87 45.8	112	
28-1	29 20.3	87 45.9	104	
28-2	29 20.3	87 45.9	104	
28-3	29 20.3	87 45.9	104	
29	29 19.8	87 46.4	107	
30-1	29 19.8	87 46.5	107	
31-2	29 19.8	87 46.5	107	
81-3	28 39.8	89 49.6	?	
83-1-F	28 32.8	89 55.6	?	
		R/V Columbus Iselin (CI)		
158	23 30'24"N	76 55'36"W	1317	5 II 1974
		M/V Combat		
90	28 52'N	80 05'W	119	3 IX 1956
283	32 56	78 06	91	19 IV 1957
384	34 54	75 25	137	17 VI 1957
457	25 19	80 07	119	26 VII 1957
		CSA		
1331-1	29 18'N	88 21'W	?	14 X 1991
1347-1	29 52	87 14	67	1991
1347-2	29 56	87 04	73	"
		CSA, Pinnacle site		
2	29 26.6'N	87 36.5'W	69-81	12 V 1997
4	29 19.7	87 46.1	95-107	17 V 1997
7	29 15.4	88 20.3	70-88	16 V 1997
9	29 14.3	88 19.6	89-96	16 V 1997
		R/V Delaware II		
004	27 40.1'N	80 13.5'W	18	18 V 1984
008	27 49.9	80 02.3	46	"
010	27 20	79 58	92	20 IV 1983
012	27 20	80 01	46	20 IV 1983
023	27 40	79 59	64	21 IV 1983
029	27 50	80 00	64	"
062	28 41	80 03	64	20 V 1983
067	28 41	80 03	86-91	33 IV 1983
074	29 19.8	80 29.9	33	21 V 1984
075	29 19.4	80 17.7	46	"
121	30 40	80 06	92	26 IV 1983
126	30 31	80 10	64	"
131	30 20	80 14	64-66	27 IV 1983
132	30 20	80 12	92	"

Station	*Latitude	*Longitude	Depth (m)	Date
137	30 10	80 14	91	27 IV 1983
138	30 11	80 15	64	27 IV 1983
140	30 00	80 20	48	27 IV 1983
		R/V Eastward		
10868	29 —'N	80 —'W	70-82	?
10881	28 18 54	79 59 00	75-78	1969
10892	28 02 00	79 59 30	68-72	?
19483	18 28 30	77 23 36	100-220	1972
19497	Discovery Bay, Jamaica		200	1972
26533	27 28.2	78 57.8	?	?
30174	19 24.5	81 20.2	1050-1125	10VII 1976
30176	19 24.4	81 16.7	600-1250	"
30178	19 25.4	81 22.5	585-600	11 VII 1976
34957	30 50.7	79 30.3	790	1979
35941	38 07.8	73 48.4	116-312	?
35948	38 06.9	73 50.1	670-790	4 V 1979
35985	40 11.8	68 07.9	755-930	1979
35992	40 16.0	68 06.6	630-1175	19 V 1979
36023	40 22.8	67 39.4	430-613	25 V 1979
36259	27 30.6	78 02.2	1115	1981
		EJ (=R/V Hernan Cortez II)		
77-136	27 56'N	84 48'W	192	?
81-8	26 54	84 32	53	21 IV 1981
81-9	26 28	84 42	228-236	22 IV 1981
81-20	26 51	84 35	178-186	24 IV 1981
81-21	27 01	84 41	199-207	"
81-22	27 07	84 49	239-247	"
81-24	27 49	84 21	148-162	25 IV 1981
81-29	27 31	84 31	126-136	"
		Endeavor		
1	22 33'07"N	74 46'10"W	70-600	6 XI 1986
		Explorer		
1b	16 39'N	82 50'W	274	11 III 1960
		U.S.F.C.S. Fish Hawk (FH)		
134	Puerto Rico		?	I 1899
770	Narragansett Bay, R.I.		15	6 VIII 1880
775	"		15-22	"
842	"		15	31 VIII 1880
957	Buzzard's Bay, MA		11	26 VIII 1881
958	"		9	26 VIII 1881
1237	Block Id. Sound, R.I.		37	30 VIII 1887
1686	Long Id. Sound, CT		29	9 IX 1892

Station	*Latitude	*Longitude	Depth (m)	Date
7106	Anclote Keys, FL		23	28 III 1901
7123	26 33	83 10	51	2 IV 1901
7282	24 21 15	81 52 15	199	19 II 1902
7516	off Fowey Rocks Light, FL		91	30 III 1903
8339	37 15 05	76 04 40	46	22 X 1915
8371	37 03 18	75 58 12	14	3 XII 1915
8499	36 57 06	75 59 56	23	22 IV 1916
8592	36 56 37	75 58 38	19	18 VII 1916
8595	36 57 02	76 00 26	22	25 VII 1916
8596	36 58 53	76 00 22	14	25 VII 1916
8602	37 17 01	76 14 14	10	26 VII 1916
8826	Chesapeake Bay, MD		46	8 VII 1920
8827	"		18	9 VII 1920
		R/V Gerda (G)		
304	25 26'N	79 23'W	796	23 V 1964
602	25 05	80 14	95	15 IV 1965
694	26 28	78 40	622-695	21 VII 1965
701	26 29	78 40	274-311	22 VII 1965
702	26 29	78 40	73-219	22 VII 1965
703	26 29	78 40	27-165	"
704	26 29	78 40	274-366	"
725	26 01	79 10	143-210	3 VIII 1965
849	25 54	79 59	256	2 VIII 1967
882	21 12	86 20	64-73	9 IX 1967
899	20 57	86 34	40-165	10 IX 1967
956	20 50	86 30	46-183	29 I 1968
983	24 05	80 20	216	5 III 1968
984	24 05	80 20	155-230	"
985	24 06	80 12	37-201	"
986	24 05	80 19	137-241	"
1002	27 19	80 01	38-59	21 V 1968
1003	27 18	80 02	46-48	"
1086	24 21.5	82 26.7	59-60	26 IV 1969
1246	23 57.7	80 28.6	?	11 III 1970
		R/V Gilliss (GS)		
74-04-94	36 39'48"N	74 36'30"W	77-87	21 XI 1974
75-08-95	36 41 12	74 41 30	105-135	20 IX 1975
		R/V Gilliss (GS Geology)		
5	24 22'N	80 50'W	247-265	
44	24 26	80 45	145-266	
71-5	24 48.5	80 26.5	90-150	
71-6	24 41	80 33	155-188	

Station	*Latitude	*Longitude	Depth (m)	Date
		R/V Gosnold (Gos)		
39	off Pt. Morant, Jamaica		200-300	18 III 1967
112/27	17 55'N	76 05'W	400-480	13 II 1968
112/78	17 21	78 19	700	23 II 1968
1456	33 49.6	77 30.0	27	19 V 1964
1481	32 20.0	79 46.1	25	21 V 1964
1483	32 20.0	80 13.5	13	21 V 1964
1494	30 59.5	80 59.8	19	"
1503	30 19.8	81 15.0	12	22 V 1964
1504	30 15.3	81 19.6	15	"
1507	29 59.0	81 02.3	22	"
1508	30 00.0	81 15.0	19	"
1509	29 50.1	81 13.9	17	"
1510	29 49.9	80 59.5	22	23 V 1964
1514	29 46.0	81 12.5	39	"
1521	29 00.0	80 39.0	19	"
1533	28 20.9	80 00.5	78	24 V 1964
1535	28 09.8	80 11.0	32	"
1539	28 00.5	80 20.0	22	25 V 1964
1540	28 00.0	80 11.4	32	"
1541	28 00.1	80 00.1	66	"
1564	25 08.5	80 11.9	105	28 V 1964
1575	24 25.1	82 00.1	74	31 V 1964
1588	24 39.4	80 37.3	207	1 VI 1964
1620	27 10.0	80 00.0	72	4 VI 1964
1624	27 30.0	80 01.5	56	"
1643	29 01.0	79 40.3	822	5 VI 1964
1647	29 41.5	79 43.6	727	6 VI 1964
1686	30 00.0	80 45.5	36	11 VI 1964
1688	29 20.0	80 45.1	24	"
1689	29 09.4	80 44.1	24	"
1716	29 39.9	80 14.7	76	13 VI 1964
1738	30 31.2	79 52.0	480	14 VI 1964
1769	31 59.1	78 45.0	386	17 VI 1964
1774	32 20.0	79 00.0	85	18 VI 1964
1857	34 18.7	76 00.1	85	26 VI 1964
1860	34 37.0	75 44.4	66	"
1863	34 51.0	75 31.0	86	"
1866	35 03.0	75 18.0	85	27 VI 1964
2027	38 39.9	74 45.2	26	2 VIII 1964
2349	29 28.7	76 59.4	1098	21 VIII 1965
2366	28 29.0	79 00.0	895	24 VIII 1965
2439	29 28.7	76 59.4	1098	21 VIII 1965
2452	27 23.8	79 29.3	695	14 IX 1965
		Grampus		
5118	26 30'00"N	83 55'00"W	108	23 III 1889

Station	*Latitude	*Longitude	Depth (m)	Date
		R/V Hernan Cortez		
D	27 37'N	83 58'W	55	11 VIII 1966
L	26 24	83 22	55	13 XI 1966
		Hidalgo		
316	16 04'48"N	82 57'06"W	37	29 VII 1962
319	16 21 12	82 44 24	48	30 VII 1962
334	16 04 12	81 36 00	37	31 VII 1962
		CSS Hudson		
3A	12 29'N	61 13'W	439-549	17 III 1968
4B	12 23	61 20	297-423	"
		Wagenaar Hummelinck		
1334	Caracas Baai, Curaçao		10	9 II 1955
1442	off Barbados		100	19 II 1964
1443	off Barbados		200	"
		IOSP		
1	24 20'S	44 40'W	130	19 V 1962
		JS (R/V Caroline) Johnson-Smithsonian Deep-Sea Expedition		
16	18 33'45"N	66 15'00"W	732-1097	30 I 1933
52	18 30 30	66 04 05	366-548	2 II 1933
99	18 40	64 56	329-366	3 III 1933
		JSL-I (Johnson-Sea Link)		
1037	26 43.3'N	79 01.2W	194	17 V 1981
1200	27 49.0	79 57.5	88	3 VI 1982
1277	23 58.2	74 26.4	243	9 X 1982
1332	26 14.8	77 37.7	66	12 IV 1983
1334	26 25.0	77 47.3	243	14 IV 1983
1354	Grand Bahama Id., Bahamas		376-378	13 VI 1983
1355	26 41.8	79 01.3	231-301	"
1357	26 42.92	79 00.72	244-309	14 VI 1983
1360	26 40.49	79 00.42	272-313	16 VI 1983
1495	24 01	74 34	309	20 X 1983
1500	24 02.75	74 32.53	391-527	22 X 1983
1504	24 04.6	74 33.1	323-353	24 X 1983
1910	26 27	78 43	411	28 X 1986
2064	27 46.8	91 33.1	366	16 VI 1987
2317	18 24.71	75 03.0	266	12 X 1988
2582	27 55.29	91 29.04	188	4 IX 1989
2585	27 44.37	91 07.54	129-144	5 IX 1989
2586	27 44.09	91 07.20	183	6 IX 1989
2590	27 48.31	91 33.70	252-263	8 IX 1989
2591	27 48.35	91 33.34	?	IX 1989

Station	*Latitude	*Longitude	Depth (m)	Date
3659	25 23.07	77 51.50	180-190	14 II 1994
3660	25 23.08	77 51.13	77	15 II 1994
		JSL-II (Johnson-Sea-Link)		
809	25 36.2'N	76 44.5'W	409-482	10 IV 1984
816	25 23.7	77 54.5	231-412	14 IV 1984
1519	26 28.86	78 49.57	564	8 XI 1987
1720	13 15.82	59 40.43	226	10 IV 1989
1724	13 02.75	59 38.60	174	12 IV 1989
1736	13 14.90	59 39.20	74	19 IV 1989
1845	16 10.00	61 49.13	234	10 V 1989
3005	26 38.3	78 57.80	249	24 X 1997
3104	29 50.93	87 16.55	67	28 VIII 1991
		LGL		
E2-2	28 16.78'N	86 14.77'W	622	18 V 1985
WC-6	27 42.3	91 32.9	543-783	10 VI 1985
		Nekton (gamma)		
232	Discovery Bay, Jamaica		166	?
244	"		274	4 IX 1972
		Oregon (O)		
933	27 36'N	83 18'W	37	18 III 1954
1493	20 40	93 20	1833	14 IV 1956
1494	29 15	88 30	110	3 V 1956
2075	1 57	48 15	48	17 XI 1957
2727	26 13	82 10	17	3 II 1960
3210	29 50	87 08	121	8 II 1961
3147	30 13.5	88 13	13	23 XI 1960
3480	29 23	88 35	57	30 I 1962
3494	29 33	88 24	48	5 II 1962
3568	14 14	81 59	183-366	21 V 1962
3603	12 16	82 54	27-37	2 VI 1962
3621	16 00	81 09	219-254	6 VI 1962
3704	28 54	88 46	402	12 VIII 1962
4216	0 15'S	46 45	27	8 III 1963
4225	0 18	44 23	182	9 III 1963
4227	1 24'S	43 11	73	10 III 1963
4228	2 02'S	43 17	51	"
4231	1 50'S	42 43	65	"
4393	12 32	71 04	84	25 IX 1963
4394	12 37	71 10	119	"
4398	12 46	70 41	201	26 IX 1963
4459	10 50	66 58	97	13 X 1963
4461	10 50	66 55	97	"
4832	14 16	80 27	220-238	12 V 1964

Station	*Latitude	*Longitude	Depth (m)	Date
4904	10 00	76 05	146-183	28 V 1964
5016	13 05	59 40	146-183	20 IX 1964
5033	11 06	62 40	54	23 IX 1964
5398	17 53	77 50	40-48	18 V 1965
5442	20 20	69 59	11-20	31 V 1965
5648	12 27	69 51	229	2 X 1965
5683	12 31	71 41	82	9 X 1965
5696	12 05	72 13	33	12 X 1965
5699	12 13	72 25	68	12 X 1965
5737	9 37	79 03	66	19 X 1965
11225	12 35	82 16	549	27 X 1970
11705	30 26	79 44	640	19 I 1972
22084	18 24.2	75 02.8	421-519	12 VII 1977
23271	0 30'S	46 23	37	6 XII 1977
24237	17 49.5	66 08.8	311-457	28 VII 1978
24238	17 49.7	66 07.8	503-567	28 VII 1978
		Pelican		
116-5	26 31.5'N	96 26.0'W	95	4 II 1939
117-1	26 30.0	96 26.0	91	5 II 1939
167-5	27 41.0	80 07.5	29	17 I 1940
169-7	28 24.5	80 03.0	64	18 I 1940
177-10	30 56.0	81 00.5	18	26 I 1940
180-5	31 53 3	80 34 3	27	2 II 1940
182-6	32 06 0	79 14 0	110	4 II 1940
204-3	28 59.0	80 04.0	91-183	29 III 1940
209-5	29 00.5	80 41.5	16	5 IV 1940
		R/V Pillsbury (P)		
112	32 08'N	79 16'W	70-95	28 VII 1964
199	27 59	79 20	311-329	11 VIII 1964
236	5 20	4 45'E	101-128	12 V 1965
330	9 37.5	78 54	64-128	8 VII 1966
365	9 31.3	76 15.4	56-58	13 VII 1966
366	9 31	75 59	33-37	"
372	9 45	76 12	82-101	"
389	9 53.8	75 50.9	51-70	15 VII 1966
392	9 45.1	76 09.1	75-79	16 VII 1966
399	9 01.3	76 40.2	119-179	17 VII 1966
405	8 49.2	77 21.2	92-93	17 VII 1966
417	9 24.8	78 12.7	51	19 VII 1966
419	9 28.3	78 20.7	51-55	"
435	9 08.5	80 29.5	37-48	20 VII 1966
439	8 51.3	81 08.3	18-22	"
444	8 57.5	81 31	73	21 VII 1966
584	21 02	86 24	347-353	23 V 1967
592	21 00	86 23	174-348	15 III 1968

Station	*Latitude	*Longitude	Depth (m)	Date
595	21 08.5	86 27	33-586	"
596	21 04	86 22	46-420	"
619	15 56	87 34	18-64	20 III 1968
623	16 00	86 08	42-55	21 III 1968
624	15 59.5	86 05.5	35-37	"
625	15 59.5	86 02.5	27-37	"
629	15 58.2	86 09.0	40	"
650	6 07	52 19	84-91	8 VII 1968
658	7 10	53 36	126-135	9 VII 1968
671	7 07	55 08	64	11 VII 1968
684	7 19	56 51	55-59	14 VII 1968
686	7 00	57 08	26-27	15 VII 1968
691	8 25	58 08	82-88	"
705	10 45	62 00	77-86	18 VII 1968
707	11 21	62 21	78	19 VII 1968
708	11 24.7	62 40.5	70-73	"
709	11 08.8	62 46.1	46	"
710	10 47.4	62 55.0	46-48	"
711	10 48	63 13	46-51	"
712	11 08	63 18	24-27	"
717	11 21	64 10	64	20 VII 1968
718	11 22.5	64 08.6	60	"
727	10 20	65 02	64	21 VII 1968
728	10 22.5	65 23	80	21 VII 1968
734	11 01.8	65 34.2	60-68	22 VII 1968
736	10 57	65 52	70-155	"
737	10 44	66 07	60-73	22 VII 1968
745	11 57.9	66 50	64-66	24 VII 1968
749	10 37.0	67 57.9	59	25 VII 1968
758	11 42.2	69 40	15-18	27 VII 1968
759	12 09	69 49	35-37	"
761	11 52	70 22	35	"
768	12 33.4	71 10.8	64-68	28 VII 1968
769	12 31	71 41	143-146	"
773	12 17	72 15	60-64	29 VII 1968
775	12 05	72 38.5	79-82	"
778	11 46.5	72 48.0	9	30 VII 1968
835	9 36	60 10	48	30 VI 1969
838	10 32	60 23	93-115	"
840	10 40.5	60 37.5	29-37	1 VII 1969
841	10 49.5	60 29	55-68	"
857	12 23.5	61 21.6	9-348	3 VII 1969
874	13 11.2	61 05.3	156	6 VII 1969
876	13 13.9	61 04.7	231-258	"
887	14 09.0	60 56.7	18	7 VII 1969
913	14 53.8	61 04.9	46-48	10 VII 1969
924	15 13.0	60 56.9	68-69	14 VII 1969

Station	*Latitude	*Longitude	Depth (m)	Date
931	15 31.2	61 12.3	146-494	15 VII 1969
935	15 36.5	61 18.8	33-38	"
944	16 33.0	61 37.0	360-421	17 VII 1969
969	17 27.8	61 41.1	69-339	20 VII 1969
991	18 47	64 46.8	205-380	23 VII 1969
1143	20 54.5	73 28.2	110-220	13 I 1970
1191	17 41	75 41	33	2 VII 1970
1196	17 27.5	75 57	26	3 VII 1970
1202	17 51.1	76 23.8	18	4 VII 1970
1220	17 35.9	77 21.8	24-27	6 VII 1970
1242	18 27.6	77 56.9	1	9 VII 1970
1273	17 51.6	71 39.2	9-18	18 VII 1970
1294	18 15.2	70 58.3	48-49	20 VII 1970
1302	?	?	35	21 VII 1970
1303	18 21	69 14.3	170-176	"
1330	11 51.2	83 26.6	24	28 I 1971
1335	12 28.9	83 04.8	27	"
1336	12 42	82 47	38-46	29 I 1971
1360	15 23.2	82 19.3	18	1 II 1971
1362	15 36	83 04	24	"
1368	16 03.2	85 12	117-124	2 II 1971
1369	16 07	85 38	55-57	2 II 1971
1384	19 45	67 00	7919-7956	6 VII 1971
1395	18 21.3	69 12.6	165-167	10 VII 1971
1411	20 18	69 13	27-183	18 VII 1971
		N/OC Almirante Saldanha		
1743	01 12'00"S	43 54'05"W	55	4 XI 1967
		R/V Silver Bay (SB)		
37	29 15'N	85 31'W	66	14 VII 1957
48	29 00	85 31	42-55	15 VII 1957
331	29 15	88 16	128-137	26 III 1958
437	23 37	87 58	91-121	18 V 1958
961	20 02	91 58	48	28 I 1959
1125	20 04	91 50	48	?
1515	33 37	76 49.3	15-16	11 XII 1959
1571	29 03	80 15.5	42-46	21 I 1960
1634	35 02	75 26	55-59	23 II 1960
1697	34 01	76 51	33	29 II 1960
1698	34 03.5	76 44	37	"
1710	34 36	76 35	13-14	2 III 1960
1788	32 01	79 24	64-82	14 III 1960
1789	32 01.5	79 14.5	101-128	"
1902	28 53.5	80 09	64	17 IV 1960
1952	28 05.5	80 11.5	29-30	20 IV 1960
1956	28 02.5	80 08	37	"

Station	*Latitude	*Longitude	Depth (m)	Date
1959	27 49.5	79 58.5	91	"
1970	28 25	80 01	91	23 IV 1960
1999	28 27	80 13	37	25 IV 1960
2008	28 13.5	80 02.5	59-73	"
2009	28 15	80 02	73	"
2010	28 17.5	80 01.5	62-75	"
2020	28 22.5	80 02	75-82	26 IV 1960
2061	29 36.5	80 23	40	30 IV 1960
2368	29 16.5	80 04	384	2 V 1960
2405	24 31.5	81 13	137	27 X 1960
2412	24 31.5	81 26.5	64	26 X 1960
2425	24 24	81 59	137	29 X 1960
2432	24 27	83 04	73	30 X 1960
2446	24 08	80 09.5	40-183	3 XI 1960
2447	24 00.5	80 25	165-229	"
2462	23 37	79 34	366-412	6 XI 1960
2523	28 53	80 05	90	15 XI 1960
2547	33 11	77 26	49-104	7 XII 1960
2813	34 35	75 53	42-46	1 III 1961
3033	28 28	80 10	40-43	25 IV 1961
3147	28 47	80 09	55	9 V 1961
3191	29 14.5	80 15.5	60	8 VII 1961
3266	28 22.5	80 07	48	13 VII 1961
3278	28 04	80 02.5	62-64	14 VII 1961
3284	27 55	80 03	55	15 VII 1961
3407	27 52	80 07	37	22 IX 1961
3467	27 27	79 00	229-274	25 X 1961
3494	23 36	75 25	183-366	3 XI 1961
4122	35 08	75 08	73-91	6 VI 1962
4195	34 05	77 18	26	2 VIII 1962
4215	29 58	80 08	366-384	22 VIII 1962
4228	29 14	80 03	366	24 VIII 1962
4419	29 09	80 12	66-73	5 X 1962
4420	29 09	80 10	73-97	"
4428	29 14	80 50	18-20	6 X 1962
5107	27 59	80 01	73	28 IX 1963
		TAMU		
76-68-II-1	27 54'53"N	93 26'50'W	100	11 X 1976
		Triton		
553-56	off Palm Beach, FL		183	5 VI 1951
		USGS		
VIII-A-1B	27 57.1'N	91 57.6'W	99	11 IV 1976
VIII-A-2	27 52.4	91 50.9	175	"
VIII-A-3	27 49.5	91 53.8	114	"
IX-1	27 54.5	93 18.0	61	21 IV 1976

Station	*Latitude	*Longitude	Depth (m)	Date
		USGS-AE-9701		
42	29 26.50'N	87 41.42'W	73	8 VIII 1997
67	29 26.43	87 34.63	70	10 VIII 1997
77	29 24.36	87 59.53	75-77	12 VIII 1997
		Vema		
15-1	31 54'N	79 05'W	413	29 X 1958
16-65	46 45	56 22	42	9 IX 1960
		N/OC Wladimir Besnard (WB)		
2	24 09'S	43 59'W	160	22 VII 1969
6	23 22 S	44 23	46	"
302	23 14 S	?	49	*16 II 1968*
318	25 15 S	44 00	180	7 II 1969
379	23 59 S	44 07	130	22 VII 1969
413	33 40 S	51 46	78	31 X 1968
5148	24 14 S	44 32	134	?
5192	24 13.2 S	44 24.8	180	20 VII 1987
5366	24 22.30 S	44 18	240	12 VIII 1988

* All latitudes are N unless otherwise indicated; all longitudes are W unless otherwise indicated.

ZOOGEOGRAPHY

Patterns of Distribution: Among the 73 shallow-water species considered in this revision, several patterns of distribution occur within the western Atlantic (Table 1, column 21; Table 2); however, eight species were not included in the analysis because of a paucity of records (pattern 0).

For the purpose of this analysis, the marine zoogeographic regions and provinces defined by BRIGGS (1974) are adopted, realizing that the boundaries to any province may be highly variable depending on season, current pattern, depth of occurrence, and kind of organism being analyzed. BRIGGS (1974) placed the three northern boundaries of the tropical western Atlantic region at Cape Kennedy (=Cape Canaveral) on the east Florida coast, Cape Romano on the western Florida coast, and Cape Rojo on the Mexican coast. The southern boundary was placed at Cabo Frio, Brazil. Only two shallow-water azooxanthellate species occur throughout this entire realm (Tables 1-2: pattern 1A), which includes both insular and continental coasts, the distribution of *Astrangia solitaria* being almost exactly concordant with this region (Fig. 15). The most common pattern followed by shallow-water azooxanthellate corals (pattern 1B) consists of being widespread throughout the western Atlantic tropics but also extending to varying degrees into the northern warm temperate region in the Gulf of Mexico and southeastern United States. Eighteen of these 'eurythermic tropical' species are listed in Table 1, 10 of which extend to both the northern Gulf of Mexico and southeast coast of the US, and eight of which extend only into the northern Gulf of Mexico. According to BRIGGS, this pattern is not uncommon among tropical organisms between Cape Kennedy and Cape Hatteras, the eurythermic tropical species generally occurring offshore, the temperate species being inshore, this pattern being reinforced by the offshore, northward-following Antilles Current and Gulf Stream. Among the ten species that extend up the coast, most (7 of 10) have their northern range between 34°30'N and 35°08'N (Onslow Bay to Cape Hatteras, NC), which would appear to be not only a boundary for inshore warm temperate but also for the offshore tropical eurythermic fauna (CERAME-VIVAS & GRAY 1966). Another distributional pattern, represented by only four taxa (pattern 1C), consists of species that are widespread throughout the Caribbean, but are not known from the Brazilian Province or from the northern warm temperate region. *Colangia im-*

TABLE 1. –Geopolitical Distribution (see FIG. 1) of the 73 Shallow-Water (0-183 m) Western Atlantic Azooxanthellate Scleractinia

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	•Depth (m)
**Madracis asperula*					x	x	x		x		x	x	x	x	x	x	x		**X**	?	1B	24-311
**M. brueggemanni*					x	x					x		x	x			**X**				3B	51-130
M. myriaster	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					1B	20-1220
**M. pharensis* f. *pharensis*				x	x	x	x	x		x	x		x	x	x		x		**X**	x	1B	11-333
**Astrangia solitaria*	x		x	x	x		x	x	x	x	**X**	x	x	x	x		x				1A	0-51
**A. rathbuni*																x	**X**				4	?-90
**A. poculata*		**X**	x		x	x			?		?								?		5	0-263
Madrepora carolina	x	x	**X**	x	x	x	x	x		x	x			x	x			x			1B	53-801
**Oculina tenella*			**X**			x															5	25-159
Caryophyllia berteriana			x	x	x	x	x		x	x	**X**	x		x	x	x					1B	99-1033
C. horologium					x	**X**															5	55-175
**C. crypta*			**X**				x			x	x	x	x	x	x						1C	12-183
C. antillarum				x			x	x			**X**										2A	150-730
C. zopyros							x			x	**X**										2A	73-618
C. barbadensis					x						**X**						?				0	129-249
Premocyathus cornuformis		x	**X**	x		x	x			x	x	x			x		x		x	?	2B	137-931
**Coenocyathus humanni*			**X**																		0	21
**C. caribbeana*				x	?		x			x	x	**X**			x						1C	5-100
C. parvulus				x	x	x	**X**			x	x		x		x		x				2B	97-399
**C. goreaui*		**X**							x												0	2-6
Trochocyathus rawsonii		x	x	x	x	**X**	x	x	x	x	**X**		x	x	x	x	x			?	1B	55-700
**T. laboreli*																	**X**				4	130-240

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	•Depth (m)
Paracyathus pulchellus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		**X**		1B	17-250
**Polycyathus senegalensis*		x	x			x					x		x			x			**X**		3B	12-143
**P. mayae*				**X**			x	x		x	x				x						2A	137-309
**Cladocora debilis*		x	x			x							x	x	x		x	x	**X**		3B	32-480
Deltocyathus calcar	x	x	x	x	x	x	x	x	x	x	**X**	x	x	x	x	x	x				1B	81-675
**D. halianthus*																	**X**				4	46-130
Thalamophyllia riisei				x	x	x	x			x	**X**			x	x	x					1B	4-914
Lophelia pertusa	x	x	x	x	x	x			x	x	x		x				x		**X**	x	1B	146-1200
Dasmosmilia lymani		x	**X**			x						x				x			x	x	3B	37-366
D. variegata			**X**			x						x					x		x	x	2B	*110-421*
Oxysmilia rotundifolia	x	x		x	x	x	x	x	x		x	x	x	x		x					1B	46-640
**Colangia immersa*		x		**X**			x	x	x	x	x	x		x	x						1C	0.5-347
**C. jamaicaensis*										**X**					x						0	10-20
**C. multipalifera*										**X**											0	20
**Phyllangia americana americana*	x	x	x	x	x	x	x		x	x	**X**	x	x	x	x		x				1B	0-53
**P. pequegnatae*	**X**				x	x															5	48-112
**Rhizosmilia maculata*		x	x				x		x	x	x	x	x	x	x		**X**				1A	0.5-508
R. gerdae				**X**			x		x		x										2A	123-549
Phacelocyathus flos				x		x	**X**	x	x	x	x			x	x	x	x				2B	20-355
Anomocora fecunda				**X**		x	x	x		x	x	x	x	x	x		x	x	x		1B	37-640
A. prolifera		x	**X**	x	x	x					x	x	x			x			x		3C	30-329
A. marchadi				x								x	x						**X**	x	3B	35-229
Coenosmilia arbuscula				x	x	x	x		x		**X**	x	x	x	x	x					1B	74-622

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	•Depth (m)
Pourtalosmilia conferta																						
	X	x			x	x											x	x			3D	55-191
Deltocyathoides stimpsonii																						
		x	**X**		x	x	x				x						x		x		2B	110-553
**Sphenotrochus auritus*																						
																x	**X**				4	15-64
**S. lindstroemi*																						
											x		x			**X**					1D	22-78
**S. andrewianus moorei*																						
		x	x			**X**															5	9-42
Flabellum floridanum																						
			x	x	x	**X**															5	80-366
Javania cailleti																						
		x	x	x	x	x	x	x		x	**X**		x	x	x	x	x		x	x	1B	30-1809
Polymyces fragilis																						
		x	**X**	x	x	x	x				x		x	x	x		x				1B	75-822
Guynia annulata																						
	x			x	x	x	x	x		x	x	x		x	x	x			**X**	x	1B	30-653
Schizocyathus fissilis																						
			x	x	x	x	x		x		**X**	x		+	x				x		2B	88-640
Stenocyathus vermiformis																						
		x	**X**	x	x	x	x				x						x	x	x	x	2B	165-835
Gardineria paradoxa																						
			X							x	x				x					x	2A	91-700
**G. simplex*																						
			x				**X**	x		x	x				x						2A	46-241
G. minor																						
			x	x			x	x		**X**	x	x	x	x	x						1C	2-146
Balanophyllia floridana																						
		x	**X**			x	x				x			x					x		3C	13-220
B. cyathoides																						
			x				**X**				x				x						2A	45-494
B. palifera																						
			x	x			**X**			x	x				x						2B	53-708
B. dineta																						
											x	x	**X**			x	x				1D	27-274
B. caribbeana																						
											X	x	x								1D	33-86
B. pittieri																						
							x						x	**X**	x						3A	40-96
**Leptopsammia trinitatis*																						
											X				x						0	15-40
Eguchipsammia cornucopia																						
		X	x			x	x	+			x	x	x		x				x		3C	91-300
**E. strigosa*																						
		x									x		**X**								3B	25-77

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	•Depth (m)
E. gaditana	x			x	x	x	x			x	x		x		x	x		x	**X**	x	3B	97-505
**Rhizopsammia bermudensis*	**X**																				0	8-12
R. goesi				x		x					**X**		x		x		?				1B	4.5-119
Cladopsammia manuelensis			x	x	x	x	x								x		x		**X**		3D	70-366
**Tubastraea coccinea*				x			x		x	x	x	x	x	x					x	**X**	0	0.3-37
	12	24	31	41	33	41	41	18	18	31	51	26	32	28	38	20	27	6	22	11		

1 Bermuda
2 Northeast coast of US (north of Florida: 30°48'N)
3 Eastern Florida and Florida Keys
4 Bahamas
5 Western Gulf of Mexico (boundary between eastern and western Gulf considered as a line from Mississippi Delta to northeastern tip of Yucatan Peninsula
6 Eastern Gulf of Mexico (southeastern border of Gulf considered as longitude 83°30'W between Cuba and Florida Keys; southwestern border the shortest line between Cuba and Yucatan Peninsula
7 Cuba and Cayman Islands
8 Hispaniola
9 Puerto Rico
10 Jamaica
11 Windward Group of Lesser Antilles (Virgin Islands to Trinidad)
12 Leeward Group of Lesser Antilles (from Los Testigos to Aruba)
13 Northern coast of South America (Venezuela and Colombia)
14 Southwestern Caribbean (Atlantic coastal regions of Panama, Costa Rica, Nicaragua (to 15°N)
15 Northwestern Caribbean (Atlantic coastal regions of Honduras, Guatemala, Belize, and Mexico to northern tip of Yucatan Peninsula)
16 Guianas/Suriname (Guyana, Suriname, French Guiana)
17 Brazil
18 St. Peter and Paul Rocks
19 Eastern Atlantic
20 Indo-Pacific
21 Distribution Pattern (see text)

\+ denotes a fossil occurrence; bold capital **X** denotes region of type locality of species.
* denotes the 30 species that were not previously treated in detail by Cairns (1977a-b, 1978a, 1979) and are thus fully discussed in this paper.
• depth range for western Atlantic records only.

TABLE 2. – Distributional Patterns of the 73 Western Atlantic Shallow-Water Azooxanthellate Scleractinia. Eight species have no discernable pattern and are not included.

1. Widespread (insular and continental)
   A. Tropical Western Atlantic (Caribbean, Antillean and Brazilian Provinces): 2 species
   B. Tropical Western Atlantic and Carolinian warm temperate Province (eurythermic tropical): 18 species.
   C. Caribbean: 4 species.
   D. Southeastern Caribbean: 3 species.
2. Primarily Insular ("Antillean Province")
   A. Exclusively Antillean: 7 species.
   B. Antillean and Brazilian Province and warm temperate Carolinian Province (eurythermic tropical): 8 species.
3. Primarily Continental ("Caribbean Province")
   A. Southwestern Caribbean: 1 species
   B. Southern Caribbean and warm temperate Carolinian Province (eurythermic tropical): 7 species
   C. Southern Caribbean, Carolinian Province, and southern Lesser Antilles: 3 species
   D. Bi-temperate: 2 species
4. Endemic to Brazilian Province: 4 species
5. Endemic to warm temperate Carolinian Province: 6 species

mersa and *Gardineria minor* are excellent examples of this pattern (Fig. 6). Another three species (pattern 1D) have a distribution characteristic of both insular and continental coasts in the southeastern Caribbean and northeastern coast of South America.

Seven species (pattern 2A) have their distributions confined primarily to insular coasts, *i.e.,* the Greater and Lesser Antilles and often Arrowsmith Bank, Yucatan Channel, but are not found in the Leeward Group of islands off the coast of Venezuela (Aruba to Los Testigos) or Trinidad and Tobago. This distribution has been called the West Indian Province by BRIGGS (1974) and the Antillean region by BAYER (1961) and CAIRNS (1979). An example of this distribution is that of *Caryophyllia antillarum*, or *Polycyathus mayae* (Fig. 4), when Arrowsmith Bank is included. Another eight species (pattern 2B) have a similar insular distribution but also extend south into the Brazilian Province as well as north into the warm temperate region, like the eurythermic widespread species of pattern 1B. Three of the eight species occur both in the northern Gulf of Mexico and southeastern US (*e.g., Deltocyathoides stimpsonii*), whereas five extend only to the Gulf of Mexico (*e.g., Caryophyllia parvula).*

A third class of distributions appear to be restricted to continental margins. One species, *Balanophyllia pittieri,* is confined to the continental mar-

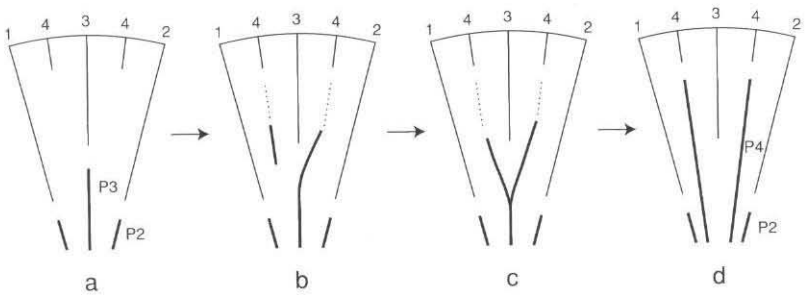


FIGURE 2. Diagrams illustrating the ontogenetic arrangement of paliform lobes (bold lines: P2, P3, P4) within one half-system of a *Colangia multipalifera*. Numbers 1-4 denote septal cycles; dotted lines represent a loose trabecular connection between a paliform lobe and its adjacent septum.

gin of the southwestern Caribbean (pattern 3A; Fig. 9), its distribution coming closest to matching the 'Caribbean Province' as defined by BRIGGS (1974). That province extends from Cape Rojo, Mexico to the Orinoco Delta, Venezuela, as well as including the southeastern coast of Florida, which produces a curiously disjunct nature to the province. Another seven species (pattern 3B) have this basic Caribbean continental pattern but also extend southward into the Brazilian Province and northward into the warm temperate Carolinian Province. Among these seven eurythermic tropical species, three extend to the northern Gulf of Mexico and along the southeastern US coast (*e.g., Cladocora debilis*, Fig. 18), two extend only into the northern Gulf of Mexico (*e.g., Anomocora marchadi*), and two extend only along the southeastern US coast (e.g., *Eguchipsammia stigosa*, Fig. 10). Because the western Caribbean is poorly known and distributional records few, this pattern of distribution (3B) often appears to be disjunct. Of the five eurythermic tropical species that extend up the southeastern US coast, four terminate between 34°30'N and 36°00'N (between Cape Lookout and Cape Hatteras, NC). Another three species (pattern 3C)have essentially the same distribution as pattern 3B, but in addition having several records in the southern Lesser Antilles. A fourth continental pattern (3D: bitemperate) consists of two species that appear to have disjunct distributions in both the northern and southern warm temperate regions.

BRIGGS (1974) defined the tropical Brazilian Province as extending from the Orinoco to Cabo Frio, Brazil. Three shallow-water azooxanthellate

TABLE 3. – Faunal Affinities of the Tropical/Warm Temperate Western Atlantic Azooxanthellate Scleractinia

	Exclusively 0-183 m (N=27 species)	Transitional (N=46 species)	Exclusively over 183 m (N=56 species)	TOTAL (N=129 spec.)
Endemic to Western Atlantic	23 (85%)	25 (54%)	32 (57%)	80 (62%)
Amphi-Atlantic	*3 (11%)	13 (28%)	9 (16%)	25 (19%)
Western Atlantic and W. Pacific	0	0	**5 (9%)	5 (4%)
Cosmopolitan, but not E. Pacific	0	5 (11%)	***4 (7%)	9 (7%)
Cosmopolitan in tropical and temperate seas	****1 (4%)	3 (7%)	6 (11%)	10 (8%)

* Includes two subspecies representing western Atlantic occurrence: *Phyllangia americana americana* and *Sphenotrochus andrewianus moorei*.

** Includes two subspecies representing western Atlantic occurrence: *Fungiacyathus pusillus pusillus* and *Anthemiphyllia patera patera*.

*** Includes one subspecies representing tropical/warm temperate occurrence: *Caryophyllia ambrosia caribbeana*.

**** *Tubastraea coccinea* considered to be an introduced species.

species are endemic to this province (pattern 4), representing 7.5% (3/40 species) of the shallow-water species known from this province.

BRIGGS (1974) defined the disjunct warm temperate Carolinian Province as extending from Cape Rojo, Mexico to Cape Romano, Florida in the Gulf of Mexico, and Cape Kennedy, Florida to Cape Hatteras, North Carolina. Six shallow-water azooxanthellate species are endemic to this province, representing 13% (6/47) of the shallow-water species that are known from this province. Three of these species occur both in warm temperate Gulf of Mexico and southeastern US and three are only known from the Gulf of Mexico. The distribution of one of the former species, *Astrangia poculata*, also extends well into the cold temperate region (Fig. 3)

Faunistic Affinities: In 1979, I (CAIRNS 1979: 205-208, Table 5) analyzed the relationship of the bathymetric ranges of western Atlantic coral species to the size of their geographic distributions, showing a strong correlation of greater depth to greater bathymetric distribution. This analysis is recalculated herein based on a greater number of species and certain refinements in methodology (Table 3). In 1979 the azooxanthellate were divided into two groups: those species occurring exclusively shallower than 200 m, and those occurring deeper than 200 m but which might also occur shallower than 200 at their shallowest. However, in this analysis, the 129 species of azooxanthellate Scleractinia known from the tropical-tem-

perate western Atlantic are divided into three categories: species found exclusively shallower than 200 m (27 species), those 'transitional' species that cross the 200 m boundary (46 species), and those found exclusively deeper than 200 m (56 species). It is the 73 species of the first and second categories that constitute the basis for this paper, but the exclusively deep-water species are reconsidered for comparison. Another 16 species and one subspecies of azooxanthellate Scleractinia are known from the cold temperate north and southwestern Atlantic (CAIRNS 1979: Tables 2-3), but these are not considered in this analysis.

The number of exclusively shallow-water species (see Tables 1, 3), *i.e.*, 27, is coincidentally the same number used in 1979 for the earlier analysis, despite the fact that only 17 species are in common between these two lists. Some of the species in the original list of 27 are now considered to be zooxanthellate (*i.e., Madracis formosa, Agaricia cailleti*) and others have been transferred to the transitional group, the deficit replaced by the description of new species. As Table 3 indicates, the shallow-water azooxanthellate fauna is highly endemic (85%), with a small Amphi-Atlantic component (11%), and one cosmopolitan species, *Tubastraea coccinea*. It is noteworthy that two of the three amphi-Atlantic species (*Phyllangia americana americana* and *Sphenotrochus andrewianus moorei*) are considered to be subspecies, each subspecies being restricted to one side of the Atlantic. This percentage affinity is extremely similar to that of the western Atlantic zooxanthellate corals (CAIRNS 1979: table 5), which, of course, are also restricted to shallow water. And if *Tubastraea coccinea* is removed from the analysis on the basis that it is probably an introduced species, the percentage affinities of the shallow water azooxanthellates and zooxanthellates are identical.

When the 102 deeper-water azooxanthellate species are considered, the western Atlantic endemic component decreases to 54-57% and the amphi-Atlantic component increases to 16-28% (Table 3). There is also a 16-18% component of cosmopolitan species. The three cosmopolitan species in the transitional group are *Madracis pharensis, Lophelia pertusa,* and *Javania cailleti*; and the five cosmopolitan (except for eastern Pacific) species are: *Dasmosmilia lymani, D. marchadi, Guynia annulata, Stenocyathus vermiformis,* and *Eguchipsammia gaditana.*

Among the 56 species of exclusively deep-water species (Appendix 1 and Table 3), there is an additional category consisting of a disjunct distribution in the western Atlantic and the western Pacific shared with five

species, two of which are considered subspecies: *Fungiacyathus pusillus pusillus* (subspecies *pacificus*, Cairns 1995 in the Pacific); *Anthemiphyllia patera patera* (subspecies *costata* Cairns, 1999, in the Pacific); *Stephanocyathus (O.) coronatus* Pourtalès, 1867; *Premocyathus dentiformis* (Alcock, 1902); and *Crispatotrochus sp. cf. C. cornu* (Moseley, 1881). Otherwise, the transitional and exclusively deep-water groups have fairly similar affinities.

In addition to the 129 azooxanthellate species known from the western Atlantic, there an additional 65 zooxanthellate species (Appendix 2), which include four facultative species capable of being either zooxanthellate of zooxanthellate (*i.e., Astrangia poculata, Madracis pharensis, Oculina varicosa,* and *O. diffusa*), the first two of which are included in the list of 129 azooxanthellates. Thus, the total number of scleractinian corals known from the tropical-warm temperate western Atlantic is 192. This almost perfect 2:1 ratio of azooxanthellate to zooxanthellate species is atypical in that worldwide there is essentially the same number of species (*i.e.*, 669 *vs* 655, respectively; CAIRNS, HOEKSEMA, VAN DER LAND, 1999) of both ecological categories. Viewed from a different perspective, the western Atlantic azooxanthellate species constitute 20% of the known worldwide azooxanthellate fauna; the western Atlantic zooxanthellates, 10% of the known worldwide zooxanthellate fauna; and the entire western Atlantic scleractinian fauna represents 15% of the known scleractinian fauna.