Cruise Report

W-36

Scientific Activities

Woods Hole - San Juan

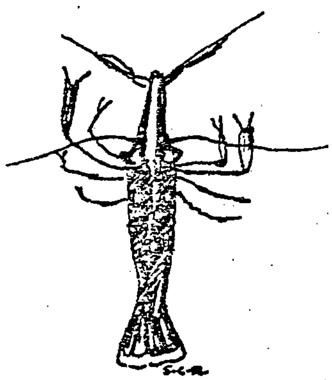
October 12 - November 23, 1977

R/V Westward

Sea Education Association

Woods Hole, Massachusetts

DRAFT COPY



Preface

This report is the outcome of a six-week cruise aboard the Research Vessel Westward that took twenty-three students across the western North Atlantic Ocean and the eastern Caribbean Sea. The pages that follow outline the structure of Introduction to Marine Science (NS 225 at Boston University) and abstract the research and project work which constitutes its framework.

Our objective, in addition, is to provide the students with an overview of what has been accomplished and the staff with a last opportunity to summarize observations or measurements whose significance requires reemphasis.

The scientific merit and sophistication of the student reports varies appreciably; in part this reflects the variable scientific content of their academic backgrounds. I find it interesting, however, that there are striking exceptions to this correlation.

In preparing this report at sea we are imparting to it limitations that time, library facilities and reflection could mitigate. On the other hand the students will soon disseminate across the Western Hemisphere and there will be no other opportunity.

Arthur G. Gaines, Jr.
Chief Scientist
November 23, 1977
off San Juan, Puerto Rico

Contents

Summary

This offering of Introduction to Marine Science was structured about Westward's transect of the Western North Atlantic Ocean and the Grenada Basin of the Caribbean Sea. The course included 30 lectures, 150 contact hours of supervised field and laboratory work, and an individual project for each student. The emphasis of the program reflects opportunities inherent to the ship's track and special skills of the staff, but subject matter treated on W-36 was broad and encompassed biological, chemical, physical and geological aspects of oceanography.

On leg 1, after very heavy weather which eliminated planned work on Gulf Stream eddies, five students collaborated on studies of the Sargassum community and constructed a trophic model. On this leg primary productivity, nutrient limitation, diversity and abundance of phytoplankton were studied. Twelve neuston samples were analysed for their content of tar balls, Sargassum weed, pelagic siphonophores and the marine insect, Halobates. Prior to our first port, Antigua, bathymetric and oceanographic observations were made at the charted position of Echo Bank, an open ocean "shoal" of questionable existence that we, also, did not find.

On legs 2 and 4 hydrographic stations were occupied in the Grenada Basin. Profiles of salinity, temperature, dissolved oxygen and phosphorus were used to identify water masses and zones of biological activity. At these stations students identified mesopelagic fishes from depths ranging to 1000 meters. Drogues were deployed to examine surface current shear; and sediments were taken by gravity corer for analysis ashore.

Students prepared species rosters of corals and fishes on leg 3 during three days at the Tobago Cays and immunological studies were conducted on species of sea urchins from the reef. Other projects here dealt with biological zonation and with the geology of a rampart island.

Throughout the cruise logs were kept on sightings of marine mammals, birds, squids, turtles ; on atmospheric transparency and certain meteorological events. The students continued long term SEA projects involving daily transmissions of weather observations, longlining and shark tagging and ichthyoplankton sampling. Further progress was made in developing methods to measure surface tension on uncontaminated seawater samples.

At port stops special opportunities were taken to study evidence of displacements of sea level and to examine plankton of tropical embayments.

The student project reports, abstracted below, were prepared at sea and submitted prior to our arrival in Puerto Rico, the terminal port for W-36.

Introduction

This offering of Introduction to Marine Science (Laboratory) followed the prescribed curricular criteria according to which lectures, supervised laboratory and field work ("science watch") and individual project work receive approximately equal emphasis. Among these areas individual participation, responsibility and research orientation vary nearly from one extreme to the other.

As is always the case the exact tone of the course is influenced by the special interests of the staff and students. On W-36 these included a relatively broad range of oceanographic topics as is evident from the contents of this report. Where possible we have taken advantage of professional and academic abilities of the ship's nautical staff, which have been unusual both in breadth and accessibility.

Research conducted during W-36 partly represents ongoing work of individuals and agencies that have extended their assistance to our students. Material reported here should not be excerpted or cited without written permission of the Chief Scientist.

Table 1. Outlined Itinerary W-36

Port	Arrival	Departure
Woods Hole	-	October 12
Antigua	October 30	November 3
Bequia	November 8	November 9
Tobago Cays	November 9	November 12
Bequia	November 12	November 14
St. Croix	November 21	November 22
San Juan	November 23	-

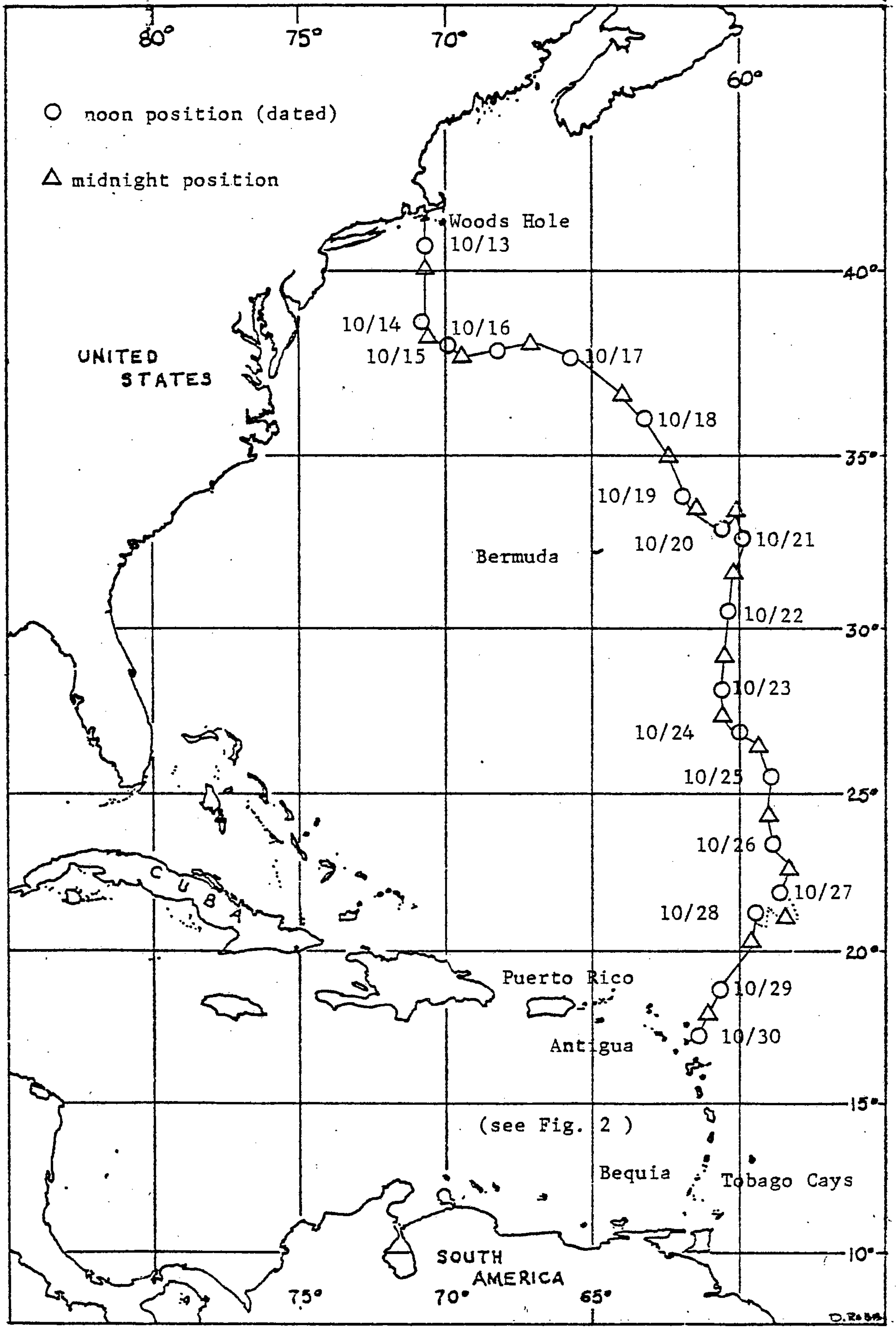


Fig. 1. W-36 Cruise track (see also Fig. 2).

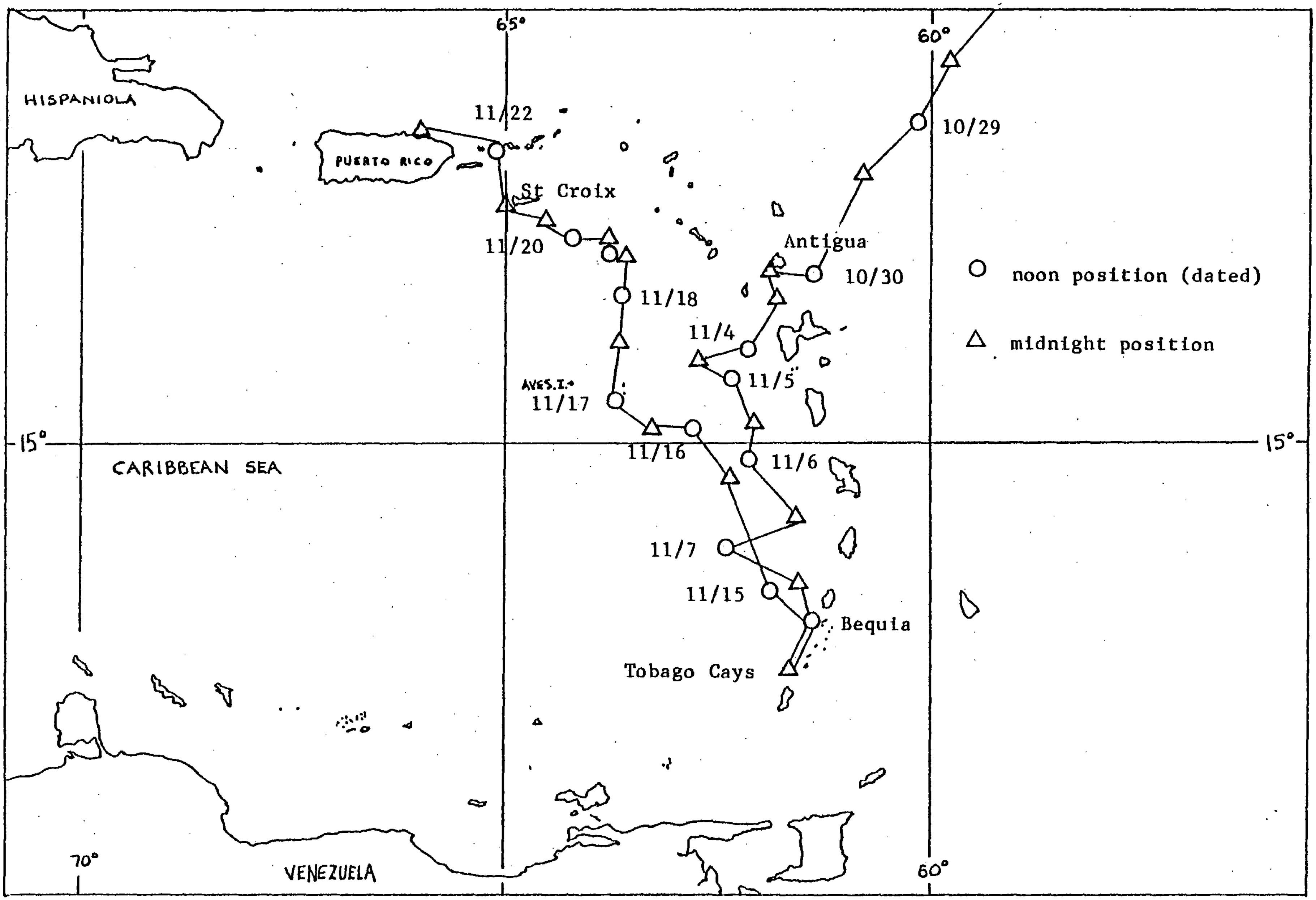


Fig. 2. W-36 Cruise track in the Caribbean Sea (see also Fig. 1).

Table 2. W-36 ship's complement.

Nautical Staff

Wallace C. Stark, J.D., M.M.	Captain
Rick Farrell, B.A.	Chief Mate
Carl M. Baum, B.S.	2nd Mate
Rod Oakes	3rd Mate
John Thompson, B.E.	Chief Engineer
Sally Kaul, B.S.	Steward

Scientific Staff

Mary Farmer, Ph.D.	Scientist-2
Arthur G. Gaines, Jr., Ph.D.	Chief Scientist
Paul Markowitz, B.S.	Scientist-3

Students	College	Home
Abigail (Gay) Alling	Middlebury College, Vt.	Mt. Kisco, N.Y.
Jean Champion	Boston U., Mass. (G)*	San Francisco, Calif.
Loralee Clark	St. Mary's College, Minn.	Coal City, Ill.
Christine Collins	Boston U., Mass.	Methuen, Mass.
Edward (Ned) Colt	Connecticut College, Conn.	Dedham, Mass.
Jeremy Cranston	Cornell U., N.Y.	Middletown, R.I.
Kimberly (Kim) Grane	College of Idaho, Idaho	Scottsdale, Ariz.
Robin Gross	Simmons College, Mass.	Malden, Mass.
Donald Huizenga	Colorado College, Colo.	Rochester, Minn.
Peter Lodge	U. of Rhode Island, R.I.	Providence, R.I.
John Mitchell	Northern Michigan U., Mich.	Spring Lake, Mich.
Carolyn Nielsen	Dennison U., Ohio	Cincinnati, Ohio
Dorinda (Rindy) Ostermann	Pomona College, Calif.	South Pasadena, Calif.
Susan Rechen	U. of Maryland, Md. (G)	Kensington, Md.
David Robb	Boston U., Mass.	McLean, Va.
Leslie Robinson	Oberlin College, Ohio	Milton, Mass.
Bruce Rumish	Adelphi U., N.Y.	Wantagh, N.Y.
Peter Schultheiss	St. Olaf College, ~~Wisc.~~ Minn.	Marshfield, Wis.
Martha Smythe	College of Charleston, S.C.	Charleston, S.C.
Mark Travis	Greenville College, Ill.	Kilbourne, Ill.
William (Biff) Umhau	Davidson College, N.C.	Chevy Chase, Md.

Students (cont'd)	College	Home
Brooks Wallin	Carleton College, Minn.	Edina, Minn.
Bonnie Wood	Wellsley College, Mass.	Morristown, N.J.

Visiting Scientist

Arnold J. Lande, M.D. The University of Texas (Leg 1 only)

* G= graduate

Academic Program

Lectures

Lectures included diverse subject material (Table 3) timed when possible to bear directly upon the ship's activities or location. This material formed the basis of weekly quizzes and a written final exam (Appendix 1). Lecture slots at the cruise end were filled by voluntary student seminars.

Science watch

A scheduled 24-hour science watch consisting of a staff scientist and two to three students was maintained while at sea. Activities during watch involved carrying out operations related to the scientific program (Table 4) and maintaining a complete science log. Watch time also provided a valuable opportunity for personal instruction, discussion of oceanographic subjects and individual project work. Unfilled minutes were commonly spent at microscopy. A practical examination based upon certain organisms collected during watch (Table 5) formed part of the final examination.

Shore visits

Laboratories and sites of scientific interest which were visited while in port included:

Government Chemistry Laboratory
Dunbar Hill, Antigua

Arawak Indian Village excavation
Antigua

St. Croix Marine Station
St. Croix, U.S.V.I.

Table 3. Lectures and seminars presented during W-36

Oct.	13	Gulf stream rings - physical, chemical and biological aspects	Gaines
	14	The bathythermograph	Gaines
	17	Artificial gills for human deep sea diving	Landé
	18	Phytoplankton diversity and abundance in shelf and Gulf Stream waters	Farmer
	19	Control of island fly populations using the sterile male technique	Markowitz
	20	The geochemical cycle of phosphorus	Farmer
	21	Neuston: the surface dwellers	Gaines
	24	Determination of dissolved oxygen	Gaines
	26	Ecology of the blue green alga <u>Trichodesmium</u> in the Sargasso Sea	Farmer
	27	The classification of fishes	Markowitz
	28	Artificial resuscitation: future possibilities	Landé
Nov.	2	Archaeological investigations of an Arawak Indian village, Antigua	Nickolson
	3	Water masses of the Caribbean	Farmer
	4	Fishes: skin and scales	Markowitz
	7	The hydrocast - outlined procedures	Gaines
	8	Determination of salinity using chlorinity titrations	Gaines
	10	Coral reef ecology	Markowitz
	11	Geology of coral reefs	Markowitz
	15	Determination of dissolved phosphorus	Gaines
	16	Measurement of ocean currents	Gaines
	17	Fish locomotion and musculature	*Champion
		Regional geology of the Caribbean	*Wallin
	18	Primary productivity of pelagic Sargassum	*Robinson
		Production of Sargassum in enriched medium	*Lodge
		The Sargassum nudibranch	*Travis
		Respiration rate of Sargassum fauna	*Nielsen
		A simple trophic model of the Sargassum community	*Gross
	21	Marine mammals:cetaceans	*Alling
		Littoral zonation in the Tobago Cays	*Wood
		Immunological studies on sea urchins	*Schultheiss

*Student seminars

Table 4. Sampling operations on W-36 involving general participation

Operation	Number performed
Bathythermographs	70
Phytoplankton tows	30
Neuston tows	12
Hydrocasts	5
Chemical determinations	
Dissolved oxygen	130
Salinity	57
Phosphate	62
Gravity cores	3
Longline sets	1
Weather observations and transmissions	58
Reef dive expeditions	7
Current drogues deployed	4
Isaacs-Kidd midwater trawls	4
Zooplankton bongo tows	5
Bathymetric surveying (fathometer)	210 miles

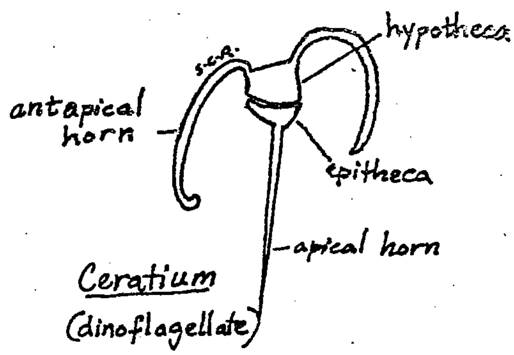
Table 5. Demonstration organisms for W-36.

Organism	Common name
Phylum cyanophyta	Blue-green algae
Trichodesmium sp.	Blue-green algae
Phylum pyrophyta	Fire algae
Ceratium sp.	Dinoflagellate
Phylum chlorophyta	Green algae
Halimeda tuna	Calcareous green algae
Phylum phaeophyta	Brown algae
Sargassum sp.	Pelagic algae
Phylum protozoa	One-celled animals
Stenosomella sp.	Tintinnid
Phylum coelenterata	Coelenterates
Acropora palmata	Elkhorn coral
Diploria sp.	Brain coral
Gorgonia flabellum	Sea fan
Millepora sp.	Fire coral
Siderastrea radians	Star coral
Porpita sp.	Bluebutton jelly fish
Phylum echinodermata	Echinoderms
Arbacia sp.	Common coral urchin
Diadema sp.	Spiny sea urchin
Eucidaris sp.	Slate pencil urchin
Phylum mollusca	Mollusks
Loligo sp.	Squid
Strombus sp.	Queen conch

(continued on next page)

Table 5 . (continued)

Organism	Common name
Phylum arthropoda	Arthropods
Halobates sp.	Marine insect
Labidocera sp.	Blue copepod
Portunus sayii	*Sargassum* crab
Phylum chordata	Vertebrates
Chaetodon sp.	Butterfly fish
Coryphaena hispurus	Dolphin fish
Cypselurus heterurus	Flying fish
Leptocephalus larvae	Eel larvae
Thalassoma sp.	Bluehead fish
Stenella coeruleoalba	Striped dolphin
Fregata magnificens	Frigate bird



Research, Collections and Observations

Cooperative Programs

Cooperative Ship Weather Observation Program (NOAA)

The R/V Westward is certified to gather weather observations for the U.S. National Oceanic and Atmospheric Administration in cooperation with an international weather program. The data, collected at 0600 and 1200 GMT, form part of a global grid for forecasting and satellite surface-truth purposes.

On W-36, 57 sets of observations were collected of which 50% were successfully transmitted. Of these, about 40% were copied by NMG, New Orleans, the remainder going to NMN, Portsmouth, Va., to which all transmissions were initially addressed. These observations (Table 6) also comprise a detailed meteorological record for W-36.

Shark tagging program (NMFS)

In cooperation with an ongoing study by the Narragansett Laboratory of the National Marine Fisheries Service, the R/V Westward carries out a program of capture, identification, characterization and tagging of sharks. The overall program aims to define the extensive movements of these organisms and to elucidate their natural history.

One longline was set during W-36 (Table 7) but owing to equipment failure it was not possible to tag any of the sharks. Part of the line was on the bottom as indicated by minor fouling.

The hooks were baited with half mackerel, which had been stored in salt for five weeks. Brine from the bait barrel was used for chumming.

Table 6. Weather observations taken during W-36. Observations are given in international weather code.

Weather observations follow the code: (1) $99L_aL_aL_a$, (2) $Q_cL_oL_oL_oL_o$, (3) $YYGGd_w$, (4) Nddff, (5) VVwwW, (6) PPPTT, (7) $N_hC_LhC_mC_H$, (8) D_sv_sapp, (9) $0T_sT_sT_dT_d$, (10) $1T_wT_wT_w{}^tT$, (11) $3P_wP_wH_wH_w$, (12) $d_wd_wP_wH_wH_w$

99388	70704	14123	81410	96208	00322	43364	526//	00122	12207	30806	99///
99386	70706	15063	12515	98012	01018	13300	00001	05215	12089	30501	18505
99384	70702	15123	82130	97006	03517	85000	00125	05813	12133	30806	22806
99381	70692	16063	02613	98000	14820	00000	31290	05315	12300	30502	99504
99380	70693	16123	62108	98012	13622	21504	51005	05214	12322	30900	21701
99381	70672	17063	82250	92658	90022	87000	00753	0//22	1///5	31009	24918
99371	70667	17120	62435	48158	02621	62300	31220	06019	12656	30304	28088
99363	70637	18063	12520	98021	10221	12400	32213	05916	12456	30606	99///
99360	70632	18123	32619	98030	12523	32571	22211	05413	12504	30503	26606
99353	70626	19063	42205	98000	15824	42///	42400	00018	12451	30502	99///
99336	70614	20063	91813	97006	15026	9////	32609	00322	12527	30503	99///
99335	70608	20123	81815	97022	13726	82300	32707	05223	12701	30302	99///
99333	70604	21063	12615	98018	09825	13300	41603	05222	12570	399//	/////
99315	70608	22063	22501	99000	19823	/////	52403	05117	12450	30901	25602
99313	70601	22123	31603	97020	20724	11505	42210	05218	12534	399//	99///
99293	70604	23063	50803	97031	17224	11451	42712	05221	12608	39901	99///
99283	70605	23113	70810	98162	17025	63329	41108	05422	12693	30101	08502
99274	70605	24063	70608	98022	15525	733//	41611	05323	12706	30000	00000
99272	70601	24123	63501	99031	15926	38668	31218	05223	12711	30000	35501
99263	70595	25060	80000	98028	15526	73333	32618	05322	12751	30000	99/00
99243	70590	26063	60907	97022	15626	32430	42715	05222	12722	30501	12402
99238	70591	26123	40906	98025	15927	23401	41210	05123	12772	30501	09702
99223	70586	27063	51006	98022	14027	53400	41717	05123	12762	30101	12502
99220	70585	27123	61106	98028	15625	43430	41108	05523	12750	30101	12502
99212	70585	28063	40708	98021	14126	13410	71710	05223	12777	30101	12502
99212	70586	28123	50708	98025	15127	33305	41299	05024	12765	30201	08502
99199	70596	29063	81108	//022	13927	23407	52712	00023	12777	30201	12603
99193	70590	29123	21005	98022	14127	21418	52104	05126	12752	30101	10603
99179	70607	30063	71109	97251	12326	73400	52711	05225	12787	3////	09502
99173	70611	30123	51015	98016	12827	52470	42310	05025	12808	30302	10803
99165	70621	04063	31003	98030	08926	30580	31713	05423	12797	30000	11/01
99164	70622	04123	20003	99020	10528	12421	41208	00025	12823	30000	05601
99160	70623	05063	21203	98130	10327	22300	41802	00025	12747	30000	12501
99159	70625	05123	71102	98506	10526	78300	41407	05326	12827	39900	13501
99153	70620	06063	11402	99131	08827	13400	01702	01323	12762	30002	11501
99150	70620	06123	41310	98020	09128	21430	412//	00024	12801	30302	17403
99145	70621	07063	90712	97006	06325	9////	00613	05125	12658	30302	00000
99143	70623	07123	71114	78032	08528	18332	311//	00124	12783	30301	11502
99132	70613	08053	31506	96020	07627	32400	42000	00023	23788	3//01	15502
99133	70615	08123	30402	98020	08229	22478	00237	00229	12854	3////	04501
99129	70612	09123	60807	98031	10125	54470	41201	05426	12786	30201	14503
99126	70613	10063	30705	97018	10327	6////	00001	05224	12828	3//01	/////
99126	70613	10123	41104	99030	10128	32405	00211	00024	12833	30201	00/00
99126	70613	11063	10808	98000	09928	11400	00803	00124	12849	30201	00/00
99126	70613	12063	10804	98030	00928	11000	00400	00024	12813	30201	00/00
99126	70613	13123	40803	98020	09928	32401	00104	00025	12833	30201	00/00
99133	70615	15123	50901	97030	11825	28271	71217	05624	12840	399//	99/01
99143	70622	16063	11012	98020	13029	11500	72008	00223	12845	3////	99///
99151	70625	16133	21310	98020	15028	22400	00217	00125	12849	30301	12502
99152	70631	17063	11108	97020	13527	1/100	00804	00127	12808	3////	10///
99153	70633	17123	11012	98020	14628	11400	71/19	00024	12823	30201	15501
99161	70635	18063	30706	97018	12527	3////	81814	05525	12838	3//01	//5//
99164	70635	18123	11012	98020	12827	11400	81405	05124	12828	30201	08502
99173	70636	19063	10805	97020	10827	12311	00500	05224	12832	3////	/////
99173	70638	20063	71208	98031	10828	784//	71710	00127	12839	30401	/////
99174	70640	21123	61005	98515	10827	68400	71400	05124	12842	3////	05501
99178	70640	22123	70516	97162	10727	38430	82217	05125	12827	30504	/////

Table 7. W-36 longlining results

Position: Saba Bank, Caribbean Sea (16.7°N, 63.5°W)
Date: November 19, 1977
Time out: 0310 Time in: 1600 Time overboard: 12.8 hrs
Number of hooks: 67 Depth of set: 12-16 m
Bait: salted half mackerel

Catch	Size (m)	Sex	Remarks
Elasmobranchs			
Carcharinus falciformis (Silky)	1.3	-	Released alive
Galeocerdo cuvieri (Tiger)	1.3	M	Dissected (dead on capture)
G. cuvieri	3.0	F	Dead on release
G. cuvieri	0.7	-	Released alive
G. cuvieri	1.5	-	Dissected (dead on capture)
G. cuvieri	2.7	M	
G. cerratum (Nurse)	2.2	F	Released alive
C. obscurus (Dusky)	2.7	F	
Teleosts			
Epinephelus morio (Red grouper)	0.7		Served for dinner

Plankton studies (City College of CUNY)

Plankton tows were taken throughout the first leg of the cruise for water mass identification studies. Surface water samples were also taken for analysis ashore in connection with this study. Tows in the second and third legs of the cruise were taken to examine the relationship between island masses and the diversity and abundance of net plankton populations. Samples were preserved with buffered formalin and were returned to City College of CUNY for analysis.

Ichthyoplankton Neuston Sampling (NMFS)

Twelve neuston samples collected on W-36 (see p 42) and associated environmental data will be forwarded to the National Marine Fisheries Service, Miami, where the samples will be examined for fish eggs and larvae. This ongoing program aboard the Westward is part of the Marine Resources Monitoring Assessment and Prediction Program (MARMAP) of NOAA.

Invertebrate Immunology Study (Sidney Farber Cancer Inst)

S.E.A. students on W-36 continued work on a program designed by Dr. Carol Reinisch, Sidney Farber Cancer Institute (Harvard Medical School) to elucidate aspects of invertebrate immunology. The program takes advantage of the availability of live, healthy, invertebrates on most Westward cruises.

Immunologic Response in the Sea Urchins _Tripneustes ventricosus_, _Arbacia punctulata_, and _Eucidaris tribuloites_

Peter Schultheiss

Abstract: The existence of intraspecific and interspecific immunologic response is studied in vitro in the sea urchin species _Arbacia punctulata_, _Tripneustes ventricosus_, and _Eucidaris tribuloites_. Criteria for response was based on agglutination rates of crossed versus uncrossed coelomic fluids with consideration also given to coelomocyte counts. Results were inconclusive partially due to variable testing conditions aboard ship and apparent natural differences in in coelomocyte counts within each organism. Data pointed to possible immunologic response in crosses that involved _Eucidaris tribuloites_. The procedure was a modification of one contributed by Carol L. Reinisch, Harvard Medical School.

Allogenic Cell Growth of _Arbacia punctulata_

J.A. Champion

Abstract:

Cancer research, in an attempt to understand the immunologic response at a simple level, has turned to invertebrates. Allogenic cell challenge of _Arbacia punctulata_ was not recognized by _Arbacia_. It was concluded that they are phenotypically different.

Surface Tension Study (Tufts University)

Measurement of surface tension at sea poses serious problems using conventional equipment but is desirable because of the sensitivity of this property to modification during sample storage. Over several Westward cruises we have been attempting to determine the precision and accuracy of methods defined by Dr. Thomas Gibb of Tufts University.

Surface tension measurements at sea

William F. Umhau

Abstract

Surface tension measurements were made at sea using a differential bubble pressure tensiometer and the oil drop dispersion method of Adam. Tensiometer measurements had a precision as good as S.D. = 0.181 after some practice with the instrument. The oil dispersion method is inherently limited to give only rough values.

In-house programs on W-36

1. <u>Surface observations on the ocean and atmosphere</u>

Marine mammals

Gay Alling

Abstract

During the W-36 cruise, 19 cetacean sightings were recorded in the North Atlantic Ocean and the Caribbean Sea (Fig. 3,4; Table 8). These included two whale species (*Physeter catadon* and *Globicephala macrorhyncus*), six dolphin species (*Stenella plagiodon*, *S. coeruleoalba*, *S. longirostris*, *S. frontalis*, *Delphinus delphis* and *Tursiops truncatus*) and several unidentified dolphins.

The sightings were not evenly spread throughout the voyage but were clumped together with long stretches in between. Most cetaceans were found near passages between the Antilles islands.

Mixing occurred between two dolphin species as well as between dolphins and whales. The mixing included *S. coeruleoalba* with *S. plagiodon*; *D. delphis* with *S. frontalis*; and *G. macrochyncus* with *T. truncatus*. On three occasions sharks were seen trailing closely behind cetacean pods, an observation which has not to my knowledge been recorded in the literature.

Sea turtles

Edward A. Colt

Abstract

A watch was maintained over 2,700 miles for marine Testudinata. Only two sightings were made and both were in harbors (Table 9). This paucity of sightings suggests a small turtle population. That the two observations made took place in harbors may show the turtle leaving natural feeding grounds (e.g., reefs) and heading for those created by man.

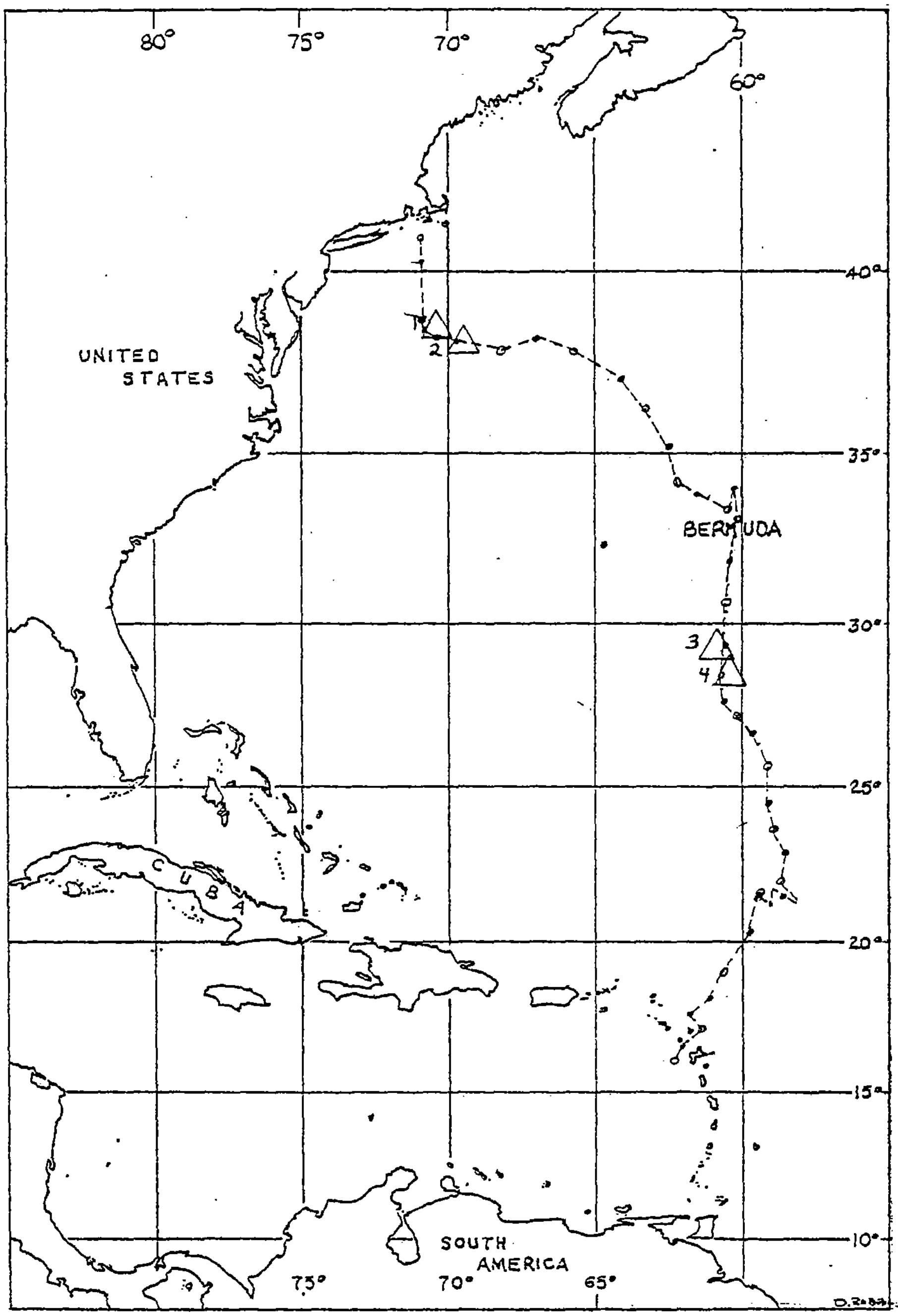


Figure 3. Marine mammal sightings along cruise track of leg 1, W-36.

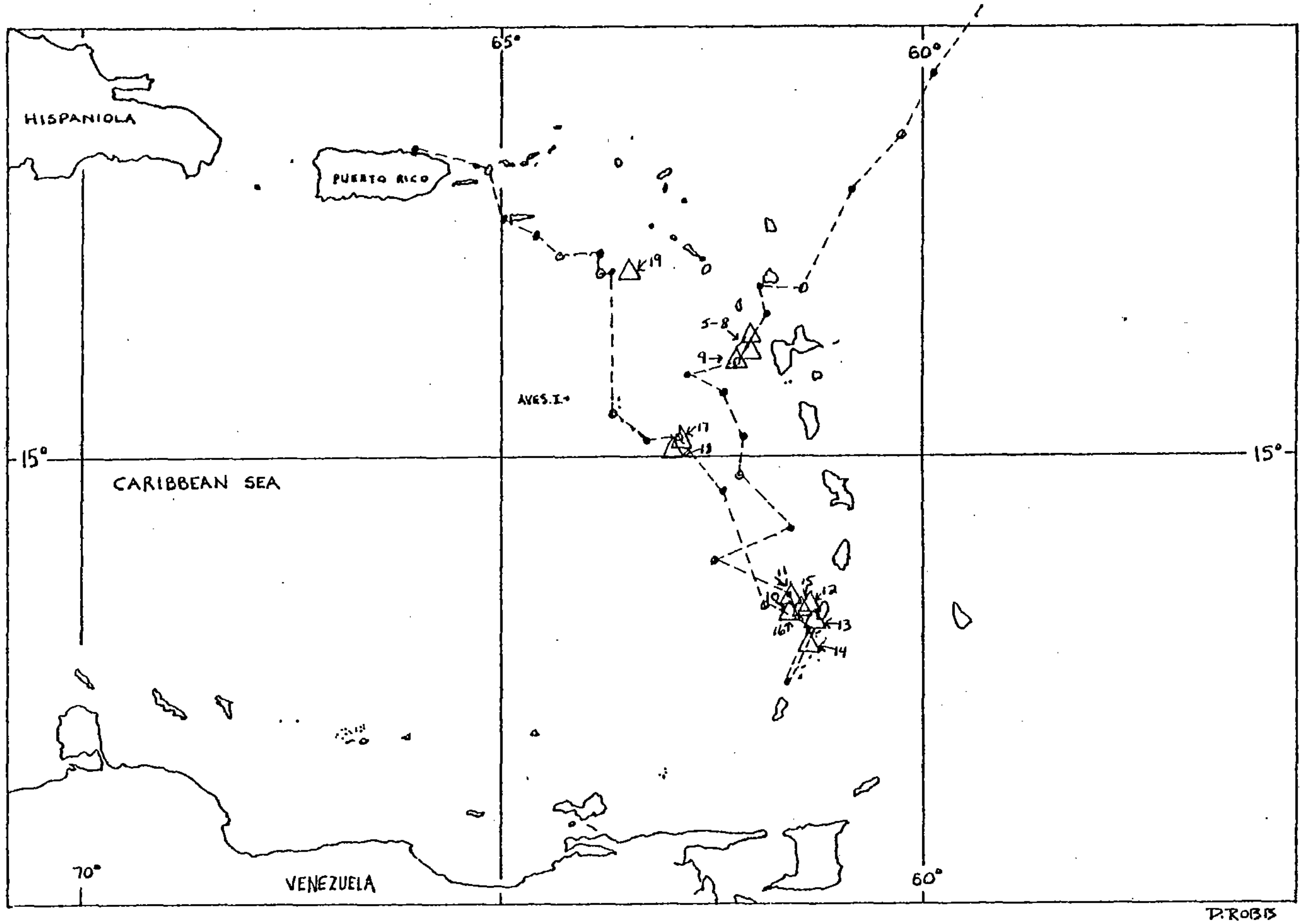


Figure 4. Marine mammal sightings along cruise track of legs 2 and 3, W-36.

Table 8. Marine mammal sightings during cruise W-36

	Marine mammal	ID	#	Size	Date	Time	N Lat.	W Long.	Mode	Speed	Direction	Position	Sharks
1	*Stenella plagiodon*	2	50	5	10/16	1230	$38^{\circ}35'$	$70^{\circ}15'$	H/T	5-10	E-W	Bow	
2	*S. coeruleoalba*	2	18	6	10/17	0630	$38^{\circ}04'$	$69^{\circ}20'$	sail	6	N-S	Bow	
	S. plagiodon	3	1	8									
3	*Delphinus delphinus*	2	30	6	10/23	0945	$29^{\circ}25'$	$60^{\circ}28'$	sail	5-10	N-S	Bow	
	S. frontalis	3	4	6									
4	Unidentified dolphin	-	10	6	10/23	2330	$23^{\circ}25'$	$60^{\circ}18'$	sail	3	N-S	Bow	
5	*Globicephala macrorhynchus*	3	3	15	11/4	0600	$16^{\circ}18'$	$62^{\circ}06'$	sail	3-6	W-E	Abeam	
6	*G. macrorhynchus*	2	15	12	11/4	0645	$15^{\circ}17'$	$62^{\circ}06'$	sail	3-6	S-N	Abeam	**
	Unidentified dolphins	-	6	-									
7	*Tursiops truncatus*	3	8	8	11/4	0715	$16^{\circ}16'$	$62^{\circ}06'$	sail	6	W-E	Bow	
8	*T. truncatus*	2	13	8	11/4	1000	$15^{\circ}13'$	$62^{\circ}07'$	sail	2-6	W-E+N-S	*	
9	*S. longirostris*	2	40	6	11/4	1800	$16^{\circ}03'$	$62^{\circ}11'$	H/T	6	N-S	Bow	
10	Unidentified dolphin	-	4	-	11/8	0600	$13^{\circ}12'$	$61^{\circ}29'$	sail	5	N-S	--	
11	Unidentified dolphin	-	7	6	11/8	0920	$13^{\circ}18'$	$61^{\circ}29'$	sail	5	S-N	Abeam	
12	*Physeter catodon*	2	4	30-40	11/8	1020	$13^{\circ}15'$	$61^{\circ}22'$	sail	8	E-W	Abeam	
13	*P. catodon*	2	6	40	11/9	0845	$13^{\circ}06'$	$61^{\circ}18'$	sail	5	S-N	Port+Stbd	
14	*T. truncatus*	2	10	10	11/12	1340	$12^{\circ}56'$	$61^{\circ}18'$	sail	6	E-W	Abeam	**
	G. macrorhynchus	2	2	12									
15	Unidentified dolphins	-	6	6	11/15	0500	$13^{\circ}10'$	$61^{\circ}20'$	sail	4	N-S	Abeam	
16	*Stenella frontalis*	2	18	6	11/15	0900	$13^{\circ}20'$	$61^{\circ}29'$	sail	2	SW-NE	*	**
17	Unidentified dolphins	-	20	6	11/16	1300	$15^{\circ}08'$	$62^{\circ}50'$	sail	6	N-S	Abeam	
18	Unidentified dolphins	-	4	6	11/16	1615	$15^{\circ}07'$	$62^{\circ}58'$	sail	6	N-S	Stern	
19	Unidentified dolphins	-	-	-	11/18	2100	$17^{\circ}02'$	$63^{\circ}32'$	sail	-	-	Abeam	

Key: Quality of ID
1 = excellent, no chance of mistake
2 = good, high probability of correct ID
3 = fair, distance or conditions somewhat marginal

*Surrounded ship
**Shark present

Table 9. Turtle sightings.

Date	Time	Location	Species	Remarks
11/13	1100	Admiralty Bay, Bequia	*Chelone mydas*	Identification based on coloration and carapacial form. Wave height = 15 cm. Depth = 10 m. Sand bottom.
11/22	0900	Frederiksted, St. Croix, U.S.V.I.	---	Wave height = 10 cm. Depth = 12 m. Sand bottom.

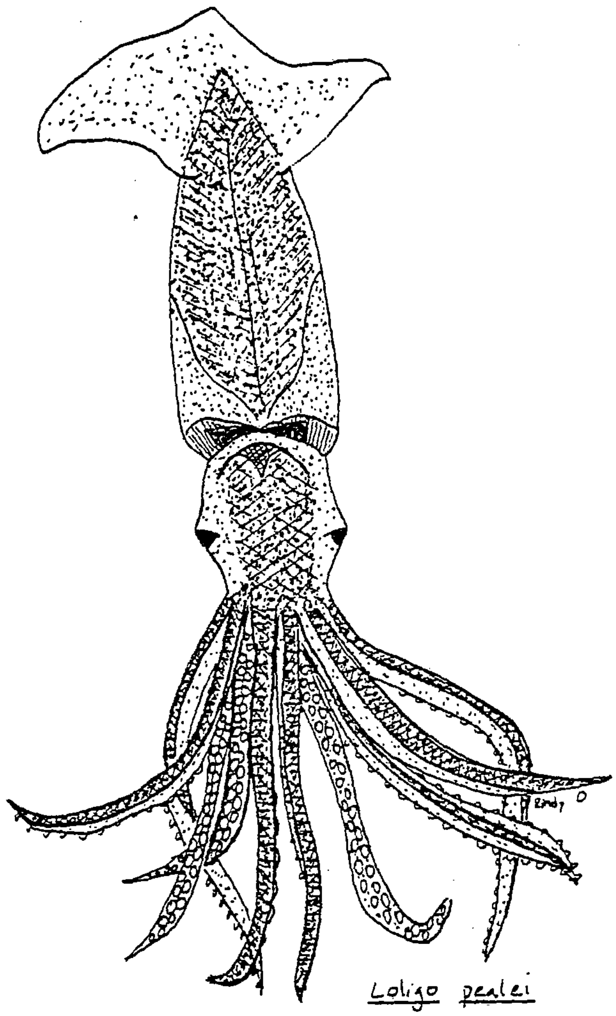
Squid

The distribution of squid species in the Western North Atlantic and eastern Caribbean Sea

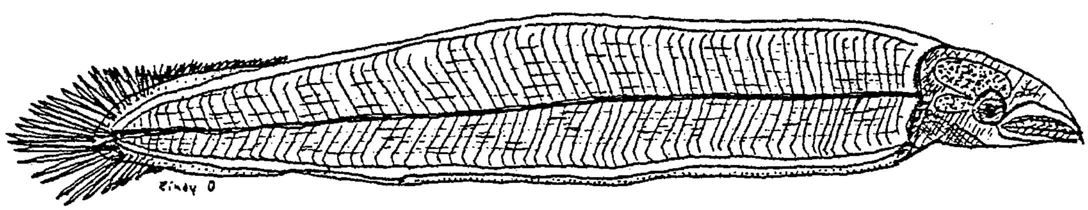
Christine Collins

Abstract

The recent interest in squid as an underexploited fishery raises the need for better definition of the distribution of these cephalopods. Seventy-three squids of six species were captured or observed on W-36 (table 10). Considerably more individuals probably could have been taken using more appropriate sampling gear.



<u>Loligo pealei</u>



Leptocephalus larvae of the eel <u>Anguilla rostrata</u>

Table 10. Squid distribution on W-36.

Species	#	Capture Method	Location	Remarks
Loligo pealei	61	NT #2*	60.4W,33.3N	Larvae
Illex illecebrosus (?)	5	NT #2	60.4W,33.3N	
Unidentified	3	NT #3	60.2W,32.5N	Sample lost
Onychoteuthis banksi	1	IKMT**	62.9W,15.1N	
Loligo pealei	1	Dip net	61.3W,13.0N	Anchored in Admiralty Bay, attracted to ship's lights
Ommatreiphes pteropus	1	---	62.2W,14.5N	Hove to, attracted to ship's lights
Sepioteuthes sepioidea (?)	1	---	61.4W,12.6N	Sighted while snorkeling at Tobago Cays

*Neuston tow

**Isaacs-Kidd Midwater Trawl

Birds

W-36 bird log with an emphasis on North Atlantic sightings

Loralee Clark

Abstract

A bird log was kept throughout the sea component. A total of 46 species were observed, including 21 species of land birds, 12 species of shore birds and 13 species of sea birds (Fig.5 and Table 11). The North Atlantic sightings included more warbler sightings than any other species

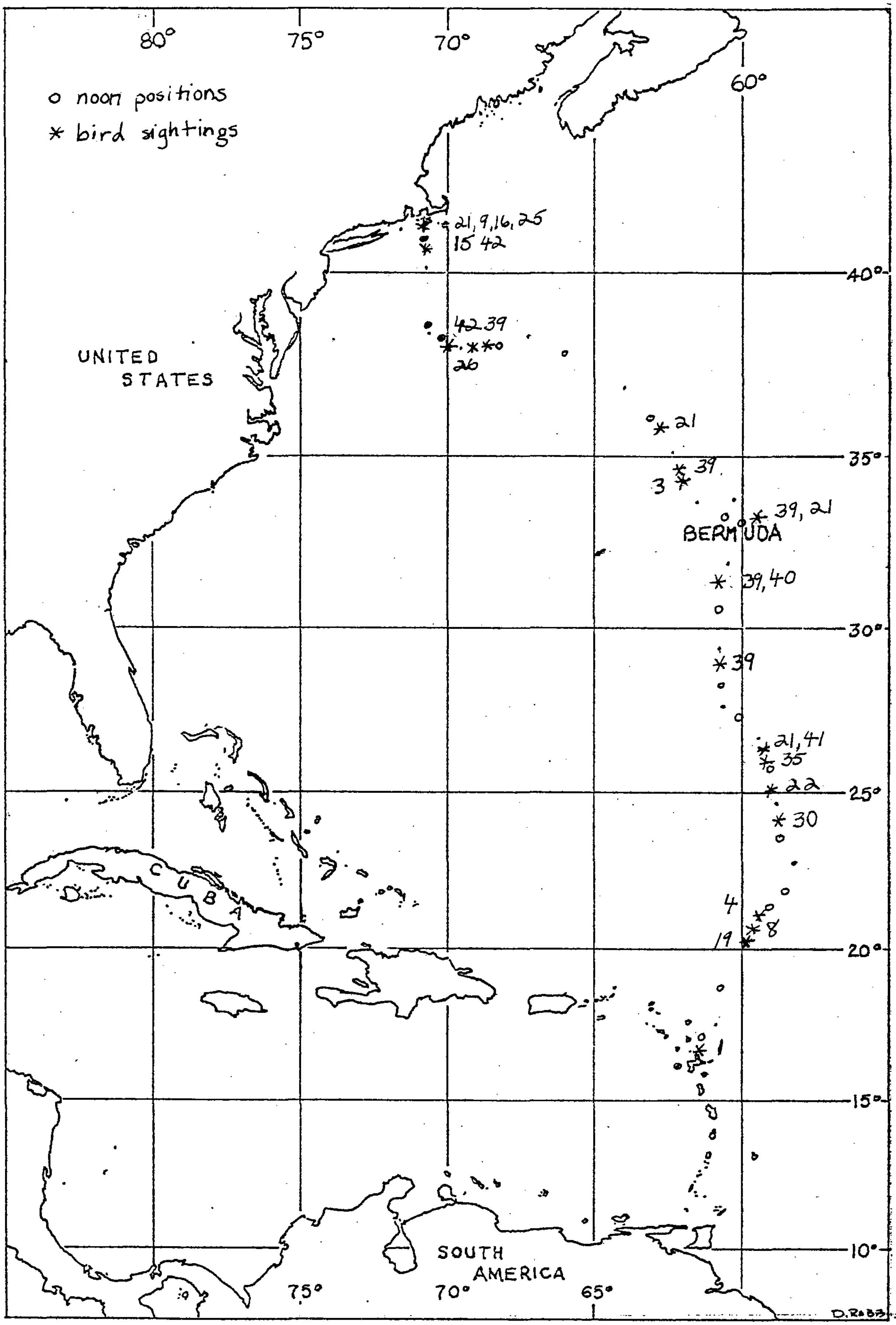


Fig. 5. North Atlantic bird sightings. See also Table 11.

Table 11. Birds observed on W-36

	Species	Land	Shore	Sea	Bermuda*
1.	sooty shearwater			x	F
2.	leach's petrel			x	F
3.	wilson's petrel			x	F
4.	white-tailed tropic-bird			x	B
5.	brown pelican		x		A
6.	blue-faced booby			x	
7.	red-footed booby			x	
8.	brown booby			x	A
9.	double-crested cormorant		x		F
10.	frigate bird		x		F
11.	American egret		x		F
12.	cattle egret		x		F
13.	yellow-crowned night heron		x		F
14.	great blue heron		x		F
15.	canada goose		x		F
16.	black duck		x		F
17.	spotted sandpiper		x		F
18.	sandpiper species		x		
19.	parasitic jaeger			x	F
20.	pomarine jaeger			x	F
21.	herring gull		x		F
22.	common tern			x	B
23.	royal tern			x	F
24.	sooty tern			x	A
25.	tern species			x	
26.	mourning dove	x			R
27.	large dove species	x			
28.	ground dove	x			B
29.	mangrove cuckoo	x			
30.	nighthawk	x			F
31.	Antillean crested hummingbird	x			
32.	hummingbird species	x			
33.	gray kingbird	x			A
34.	rusty-tailed flycatcher	x			
35.	belted kingfisher	x			F
36.	barn swallow	x			F
37.	swallow	x			
38.	tropical mockingbird	x			
39.	warbler	x			
40.	magnolia warbler	x			F
41.	blackpoll warbler	x			F
42.	hooded warbler	x			F
43.	carib grackle	x			
44.	bananaquit	x			
45.	black-faced grassquit	x			
46.	small dark finch	x			
47.	yellow-bellied seedeater	x			

*(F=frequent or regular, B=breeding, A=rare or occasional, R=resident.)

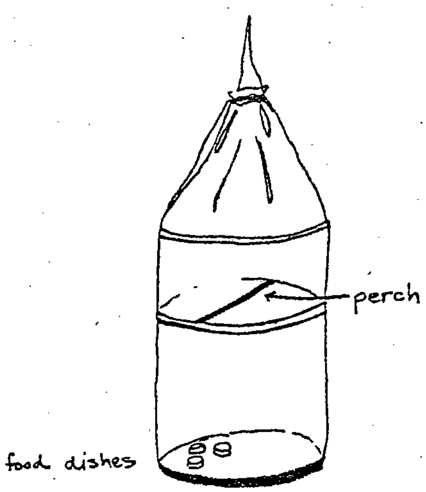
including oceanic ones. Warblers were occasionally seen in small flocks, which were not observed for other species. The abundance could be explained by their use of the fall northwest winds in southerly migration. All birds observed in the North Atlantic are listed as occurring in Bermuda by Wingate (1973). Sightings included a tagged immature herring gull.

Observations on the mortality of land birds at sea

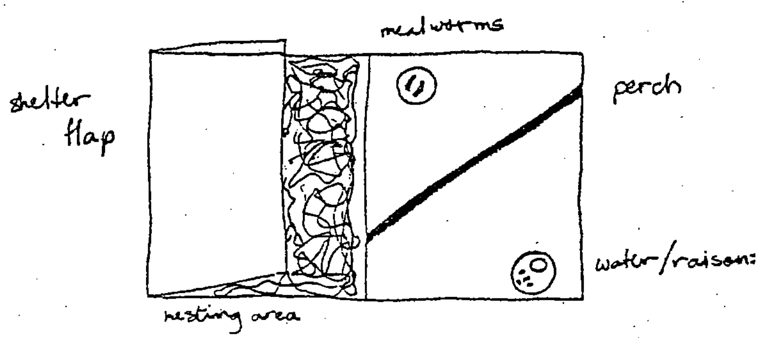
Loralee Clark

Abstract

Three migrating warblers alighting on deck were caged and offered mealworms, soaked raisins, fresh water, bird seed, and canned dogfood. For two birds accepting food, water was taken preferentially, followed by mealworms and water-soaked raisins, in that order. The other foods were ignored. All caged birds died about 24 hours later, no matter how well they seemed to have adjusted and what they consumed. A black-poll warbler learned to use an open deck feeding station.



Bird cage

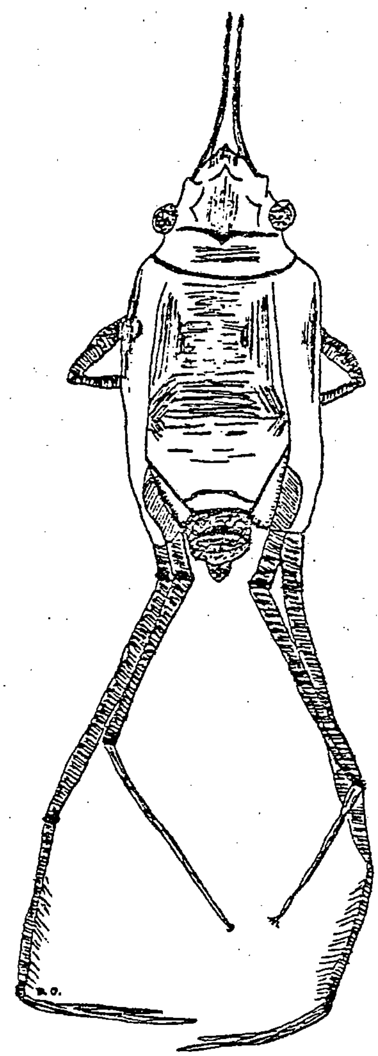


Feeding station

The change in sky transparency with change of latitude as determined by star magnitude observations

Martha Smythe

Sky transparency, an indication of the degree to which radiation enters the earth's atmosphere, was evaluated from latitude 40°N to 13°N. The faintest visible star in each of ten constellations was recorded, using the Skalnate Pleso Atlas of the Heavens for identification and magnitude. The results demonstrated greater sky transparency in the southern latitudes than in the northern latitudes, taking into consideration the important effect of moonlight and weather conditions on transparency and on this method of estimating transparency.



Halobates micans

Other observations - annotated excerpts from the science log.

Date	Time	Position	Observation
10/16	2110	38.1N,67.5W	St. Elmo's Fire observed during squall. It appeared as a pale glow of blue light, of varying intensity, around the radio antenna and lasted for 15 to 20 minutes. St. Elmo's Fire is a luminous discharge of electricity normally associated with pointed objects and results from a difference in electrical potential between the ship and the air. The phenomenon is sometimes visible as a spray of light. St. Elmo's Fire was reported again several hours later.*
10/16	2300	38.2N,67.4W	Ship hove to. Peak of North Atlantic gale. Wind force 9 (44 kt), gusting 10 (52 kt). Beaufort 10 seas (22 ft).
10/20	2300	33.5N,60.2W	St. Elmo's Fire visible on radio antenna. Ship hove to.
10/23	0745	28.6N,60.6W	Waterspouts bearing 183°, approximately two miles. Waterspouts typically form below a cumulus cloud and may have cyclonic or anticyclonic rotation. They appear as a dark narrow cone tapering downward from the base of the cloud. The dark appearance is a result of condensation in the moist air around the low pressure center. Although we did not witness it, some waterspouts spin seawater upward causing an inverted cone to rise from the ocean surface.*
10/23	1125	28.2N,60.5W	Monarch butterfly lands on ship. Nearest land ca 300 miles.
10/23	1228	26.6N,59.8W	Large rafts of Sargassum weed.
10/24	2300	30.5N,59.7W	Beaufort force 0 conditions. No swell. Full moon on cumulonimbus development around horizon.
11/3	1736	17.2N,61.8W	The green flash observed by six students as the sun's upper limb set below the horizon under distant stratocumulus clouds. Although its

*by Don Huizenga

(continued)

Other observations (continued)

Date	Time	Position	Observation
			existence is doubted by some sailors who have spent years at sea, one student witnessed the phenomenon the first time he looked for it. The color results from atmospheric diffraction of the sun's light into a color spectrum. Blue is absorbed by the atmosphere and the eye detects a flash of the next color in the spectrum -- green. The green flash is also visible at sunrise but more difficult to observe because passage of the sun's upper limb above the horizon must be anticipated precisely.*
11/4	1925	16.1N,62.3W	Intense lightning disply over Guadeloupe in isolated cumulonimbus development above the island. No moon, clear sky.
11/12	0455	12.6N,61.4W	Artificial satellite observed. Orbit crossed Orion's Belt in southward direction.
11/16	1045	15.1N,62.8W	Large tree (<u>ca</u> 20 m long) observed floating to starboard. No leaves evident. Abundant vegetative debris fouled by marine organisms observed over next 12 hours.
11/18	1735	16.7N,63.5W	The green flash observed under low distant stratocumulus clouds.
11/20	1120	17.4N,64.3W	Saba Bank. Large numbers of jellyfish (<u>Aurelia</u>) observed over large area. Estimated at 3 X 10^4 per Km^2. Typically 20 cm in diameter.

23 Oct. 1977 Sargasso Sea Waterspout

2. Leg 1. Western North Atlantic Studies

Observations on Gulf Stream rings

Bruce Rumish

Abstract

Gulf Stream rings are mesoscale ocean circulation features of broad oceanographic interest. They result when meanders in the Gulf Stream pinch off forming a rotating mass of slope or Sargasso Sea water enclosed by a ring of Gulf Stream water. Cold core eddies, containing New England slope water, occur south of the Stream, rotate in a cyclonic sense and move southward and then southwestward until they are reabsorbed by the Gulf Stream.

Their biological interest stems from the fact that eddies contain an isolated mass of water and its associated biota. Rings constitute a large scale invasion of one oceanic community into another. As the rings age they appear to experience a physical, chemical and biological evolution which promises to provide insight into a number of oceanographic questions.

The configuration of the Gulf Stream and distribution of rings was monitored for several weeks prior to the departure of W-36 using the Ocean Frontal analyses of the U.S. Naval Oceanographic Office. The proposed cruise track (Fig. 6), transecting a well defined eddy formed during the week of September 21, was based upon the forecasted position.

The actual cruise track for this portion of W-36 was influenced by a force 9 gale which made adherence to the proposed track difficult. In the end it was decided to cancel this portion of the proposed work. Prior to its termination the bathythermograph survey delineated the north wall of the Stream (Fig. 7).

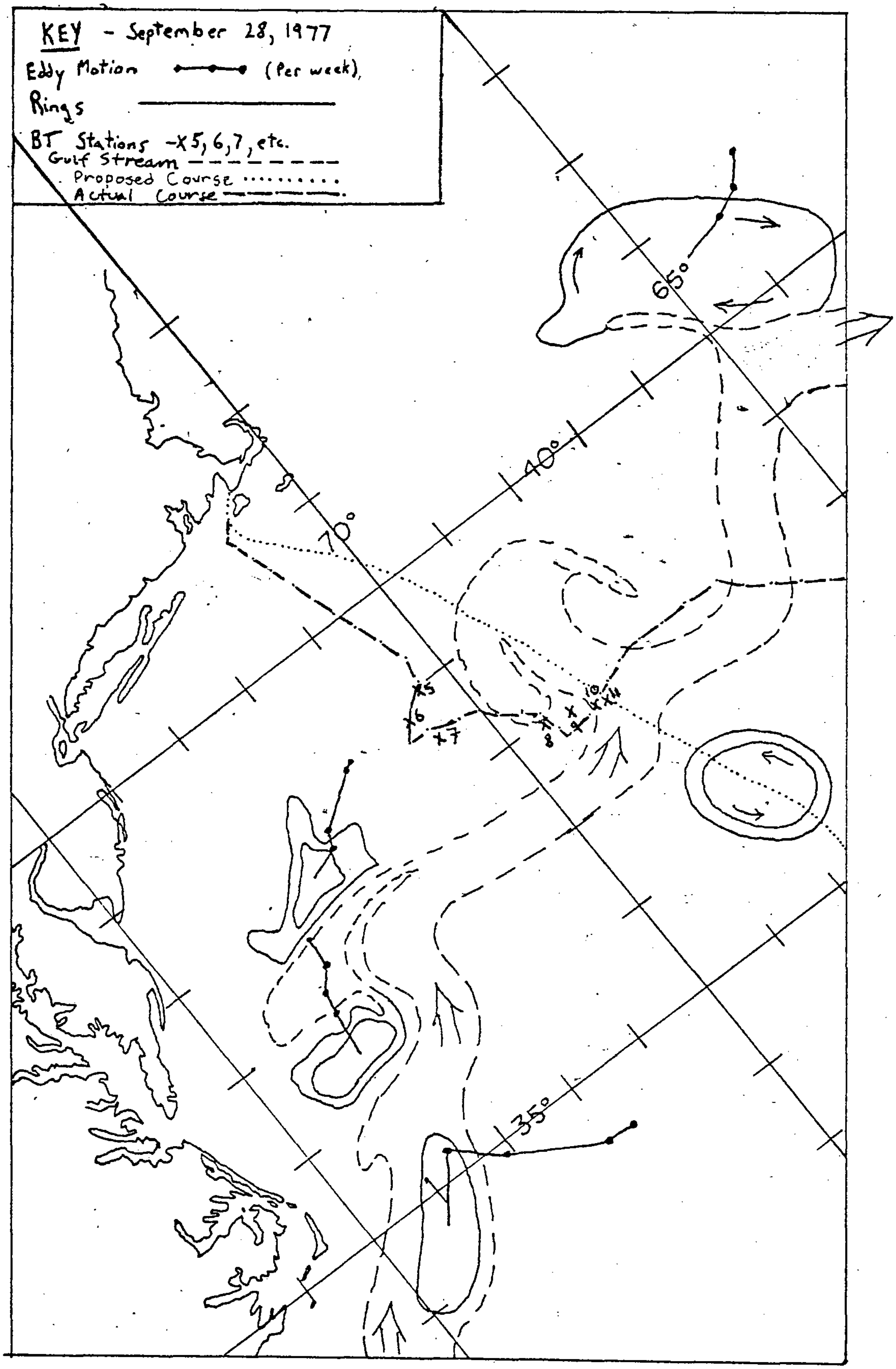


Fig. 6. Location of Gulf Stream and eddies (modified from U.S. Naval Oceanographic Office , Ocean Frontal analysis).

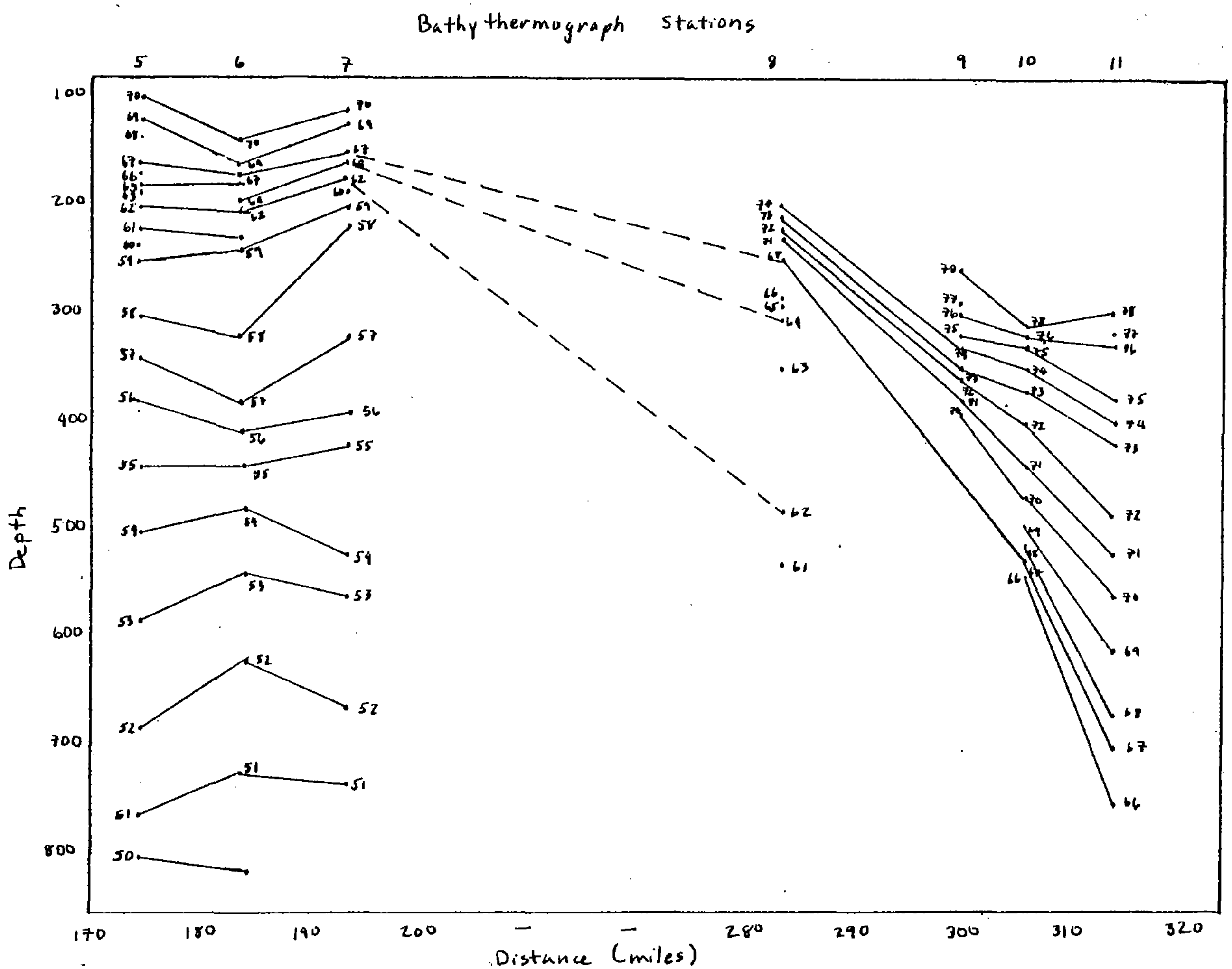


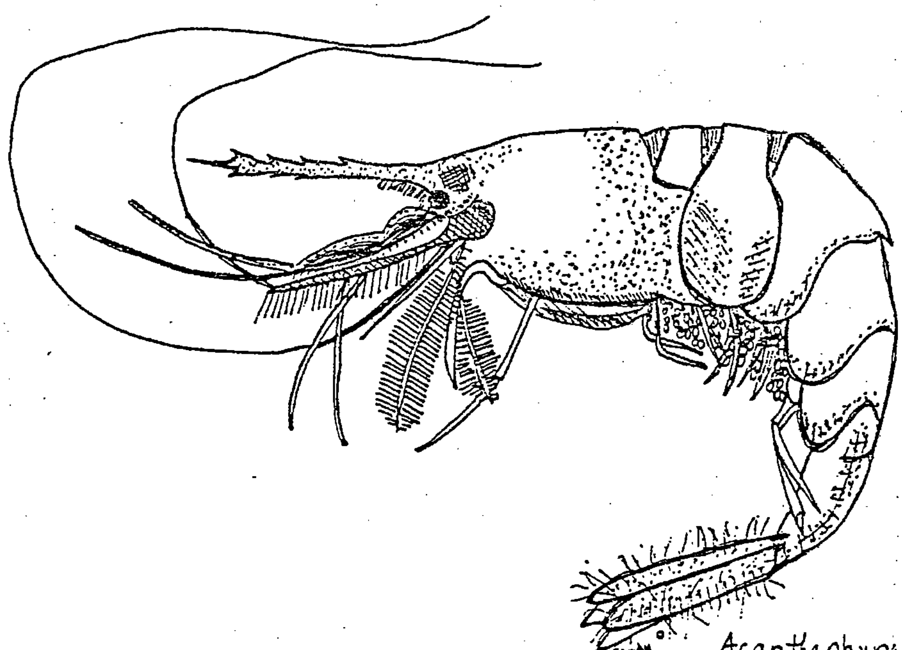
Fig. 7. Temperature surfaces associated with a transect of the north wall of the Gulf Stream. W-36.

Phytoplankton Studies

Phytoplankton enrichment: Critical nutrients

Susan Rechen

Abstract: Small-sized plankton of the Atlantic and Caribbean Sea not ordinarily collected in plankton tows were examined for response to nutrients critical to growth. Portions of surface bucket samples were enriched with h/2 culture medium minus one nutrient (nitrate, phosphate, ammonia, or silicate) and compared with total medium and unenriched controls. Only flagellates appeared in Sargasso Sea cultures, perhaps as a late autumn bloom. In the Atlantic (near Antigua) and the Caribbean (Tobago Cays) cultures appeared several coastal and bottom-type diatoms, where silicate levels seemed to be high enough for unenriched diatom growth. In the Antiguan sample nitrate appeared to be limiting to growth and possibly so in Tobago Cays, where phosphate (used by zooxanthellae in coral organisms and by benthic algae) was limiting. In both areas unenriched seawater nutrient levels were too low to support growth in culture tubes.



Acanthephyra sp.

Floristic demarcation of the north wall of the Gulf Stream

Mary Farmer and Susan Rechen

Abstract

Plankton at the surface of the north wall of the Gulf Stream were compared with plankton from the continental shelf and the Sargasso Sea. *Trichodesmium* and dinoflagellates characterized the phytoplankton of the Gulf Stream and the Sargasso Sea (Table 12). Diatoms were not seen in the Gulf Stream sample where nutrients were presumed to be low, and they were abundant on the shelf where nutrient concentrations were probably high. The data suggest that phytoplankton from the Gulf Stream may be a seed population for the Sargasso Sea while phytoplankton from the shelf msy not affect the Gulf Stream population, or vice versa.

Primary productivity of net and nannoplankton of the Sargasso Sea

Rindy Ostermann

Abstract: An attempt was made to calculate the productivity of net and nannoplankton as fractioned communities. The productivity levels of surface samples collected at two stations in the Sargasso Sea produced results that indicated even the combined producitvity level of the phytoplankton was too low to be measured using the Winkler titration method. A third station concentrating the raw sample 10.2 times produced similiar results to the previous two stations.

Table 12. Phytoplankton Species Collected from the Continental Shelf to the Sargasso Sea, October 1977

Species	Shelf	Gulf Stream	Sargasso Sea	
	40°55' N 70°50' W	37°46' N 68°07' W	30°37' N 60°25' W	27°04' N 60°04' W
DIATOMS				
Biddulphia sp.	+			
Coscinodiscus sp.*	+			
*Leptocylindricus**	+			+
DINOFLAGELLATES				
Ceratium tripos	+			
C. fusus	+	+	+	
C. contrarium		+	+	
C. setatum				+
Ornithocercus sp.		+		+
Ceratocorys sp.			+	
Goniaulax sp.			+	
G. minita				+
Pyrocystis sp.			+	+
BLUE-GREEN ALGAE				
Trichodesmium sp.		+	+	+

**Coscinodiscus* and *Leptocylindricus* were about equal in abundance in the shelf water sample. Their total concentration was $58 \times 10^3 \cdot m^{-3}$. See table for concentrations of Gulf Stream organisms.

The *Sargassum* Community

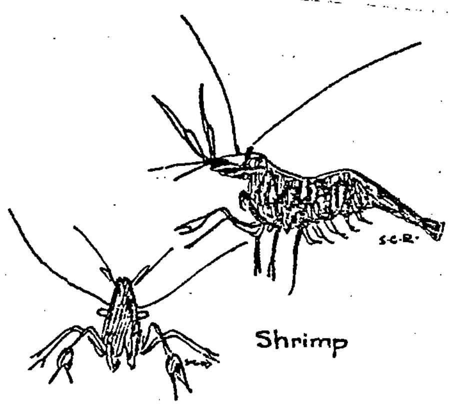
Introduction

Carolyn Nielsen

The *Sargassum* community includes over 100 species of organisms linked through their dependence on the floating brown alga, *Sargassum*. Pelagic *Sargassum* weed occurs as drifting accumulations in the Sargasso Sea, whose exact boundaries change with movements of the currents that define its limits but which generally lies between 20°-40° N latitude and 30°-70° W longitude.

This drifting community is sometimes referred to as a displaced benthic community since it resembles rocky shore communities associated with other species of brown algae in which the attached seaweed provides both shelter and nutrition.

One objective of W-36 has been to quantitatively describe the trophic interaction of the *Sargassum* community and to generate a model of this unique association of organisms.



Shrimp

Primary productivity of pelagic Sargassum

Leslie Robinson

Abstract

Primary productivity studies on pelagic *Sargassum* weed collected in the central Sargasso Sea indicate a net productivity of 1.97 mg C/g/hr (=57 mg C/m^2/yr), a gross productivity of 2.80 mg C/g/hr (=131 mg C/m^2/yr) and a respiration rate of -0.83 mg C/g/hr (=-78 mg C/m^2/yr) on a dry weight basis . These low rates are generally consistent with published values (see Tables 13 and 14).

Table 13. Results of productivity measurements on pelagic *Sargassum* (mg C/g dry weight *Sargassum*/hr).

Incubation duration(hr)	Productivity Net	Productivity Gross	Respiration
Study I. Position 60 30'W, 30 20'N; incubation T=27.7 -31.8 C; sea surface T=27.2; t_0=1037, t_f=1637.			
2	1.42	2.49	-1.07
4	1.12	1.99	-0.87
6	1.63	2.61	-0.98
Study II. Position 59 19'W, 25 28.5'N; incubation T=28.3°C sea surface T=27.7°C; t_0=0905, t_f=1505.			
3	2.98	3.35	-0.56
6	2.68	3.36	-0.60
Mean(mg C/g/ hr)	1.97(σ=0.87)	2.80(σ=.98)	-0.83(σ= .26)
(mg C/g/day)	14.4	33.6	-19.9
(gm C/m^2/yr)	56.5	131.0	-77.8

Table 14. Comparison of productivity measurements with certain published values (mg C (g Sargassum)$^{-1}$ hr^{-1})

	Carpenter & Cox (1974)	This study
Net	0.48 (σ=0.31)	1.97 (σ=0.87)
Gross	0.69(σ=0.28)	2.80 (σ=0.97)
Respiration	-0.19	-0.83 (σ=0.26)

Production of pelagic Sargassum in enriched medium

Peter Lodge

Abstract

Nutrients were added to Sargasso Sea water to investigate whether the Sargassum weed is limited by low nutrient levels in its natural environment. Net productivity levels of samples enriched with "h/2" medium decreased to 0.025 ml $O_2 \cdot g^{-1} \cdot hr^{-1}$ or by about one order of magnitude relative to unenriched samples. Although respiration was unaffected, photosynthesis decreased sharply. Possible explanations are discussed.

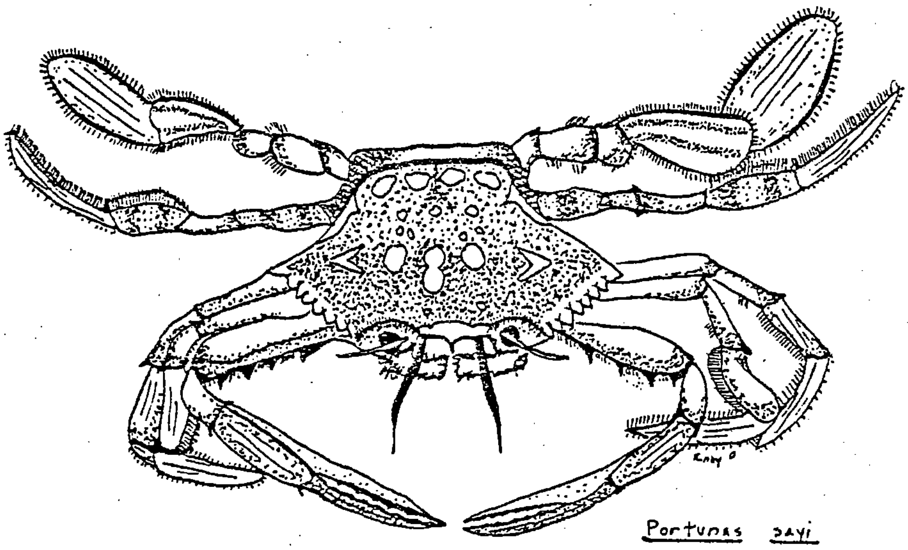
Respiration determinations on macrofaunal species found on pelagic Sargassum

Carolyn Nielsen

Abstract

Macrofauna associated with Sargassum weed was collected, identified and subjected to respiration studies. Four decapod species, two crabs and two shrimp dominated the assemblage.

Respiration rates varied appreciably among species. Expressed in ml $O_2 \cdot g^{-1} \cdot hr^{-1}$ ($\pm$ 1 S.D.) they were: <u>Planes</u>, 2.6 $\pm$ 0.7; <u>Leander</u>, 0.7 $\pm$ 0.5; <u>Latreutes</u>, 9.8 $\pm$ 10.3; <u>Portunus</u>, 3.5, on a dry weight basis. However, the energy drain upon the <u>Sargassum</u> by each of the decapod populations was fairly uniform at an average value of 0.18 $\pm$ 0.05 ml O_2·kg <u>Sargassum</u>$^{-1}$·hr^{-1}.



Portunus sayi

Absence of an expected species; the Sargassum Nudibranch Scyllaea pelagica.

Mark A. Travis

Abstract

The nudibranch Scyllaea pelagica can be expected to be a common member of the Sargassum community. Research proposed involved a determination of the role of S. pelagica in the trophic dynamics of the Sargassum community.

Twelve Neuston tows, 20 kg of Sargassum raft and occasional dip net samples of Sargassum were examined for S. pelagica. The entire taxonomic group of the species was missing from our samples. Absence of nudibranch may have resulted from the youthfullness and apparent low diversity of organisms in the Sargassum. (Refer to Gross, this paper)

A simple trophic model of the Sargassum community

Robin Gross

Abstract

The biomass and respiration rates of organisms associated with 3 kg (dry weight) of Sargassum weed collected in the southern Sargasso Sea were used to construct a simple trophic model of this community. The results indicate a positive net productivity for the community, with macrofauna amounting to only 0.25 percent of the Sargassum in terms of biomass and consuming only 0.34 percent of its gross productivity. If important constituents of the community were not missed, this implies a rapidly growing algal population.

Neuston studies

Introduction

As an interface between two very different media, the sea surface has a number of interesting properties that give it special oceanographic interest. Many organisms show adaptations that reflect use of the sea surface. Furthermore, as a sharp density interface it is especially susceptible to contamination.

Twelve neuston tows were made on W-36 (Fig. 8) using a 0.505 mm mesh, rectangular mouth net, 1 m wide and 0.5 m high. The net was towed 20-30 minutes at 2-3 kts. The contents of these tows were examined for certain natural and anthopogenic constituents (Table 15).

DISTRIBUTION AND ABUNDANCE OF THE SIPHONOPHORE PORPITA

Kimberly A. Grane

ABSTRACT

Current studies of the siphonophore Porpita are limited. Using neuston sampling techniques, the highest concentration of specimens has been found at 23° N 60° W in the Sargasso Sea. However, at any one station, the density of Porpita per square meter filtered was less than one organism. Reasons for such extremely low values are speculated as resulting from low nutrient and productivity levels.

The physical characteristics of Porpita aid in their identification. The brilliant blue coloration of the dorsal surface, and the presence of specific, specialized zooid members on the ventral surface are distinguishing features. Several specimens varied from the documented accounts, and these unusual forms were identified tentatively as Porpita. Further investigations into the taxonomy of these samples is necessary.

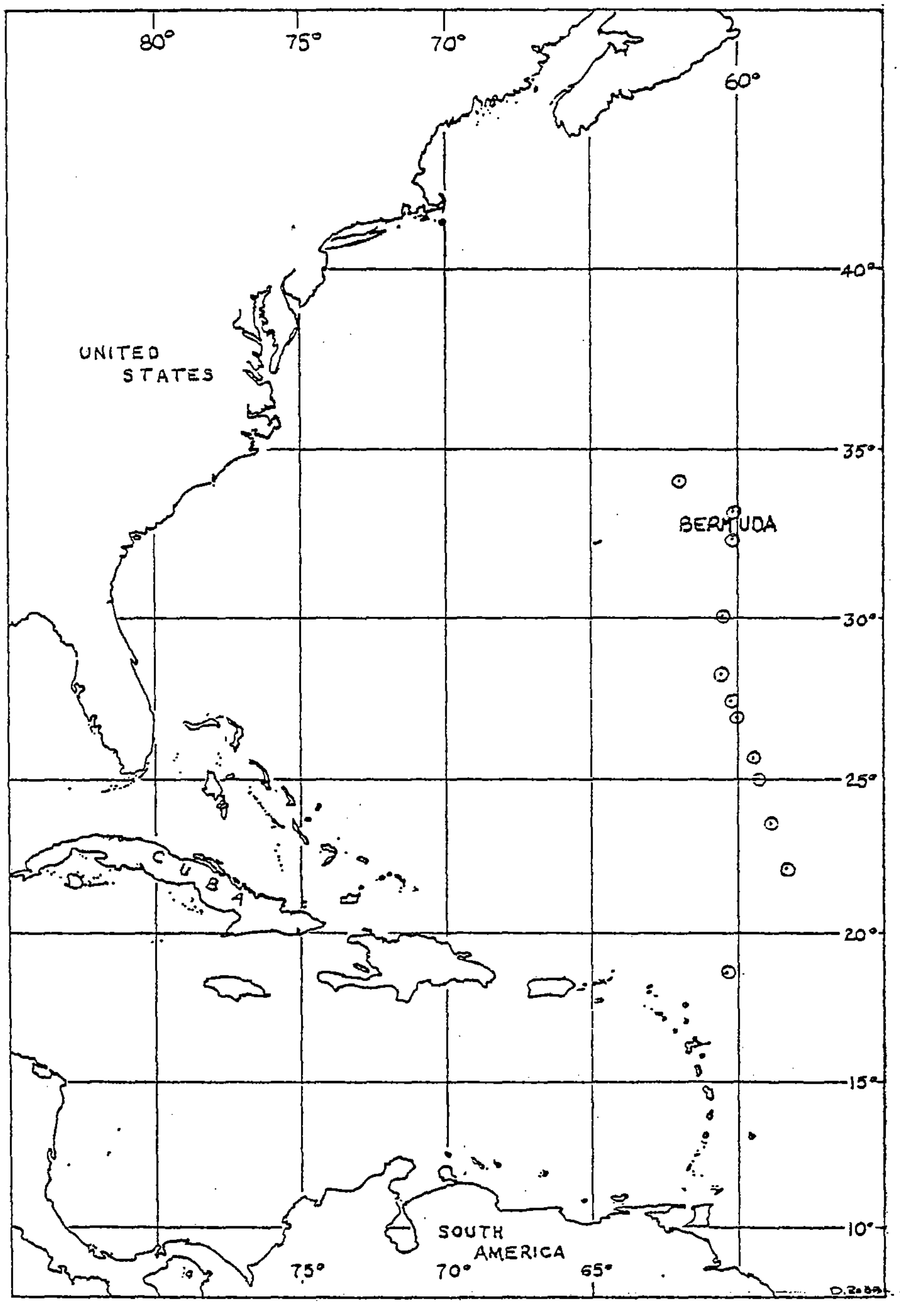


Fig. 8. Neuston stations occupied on leg 1 of W-36.

Table 15. Summarized results of neuston tows

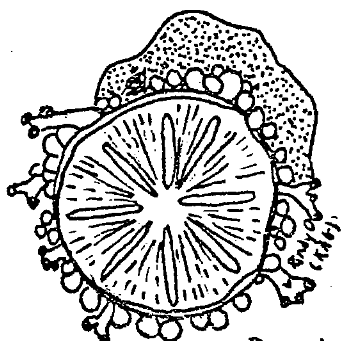
Station #	Date	Position	Time	Duration (min)	T_s (°C)	Area Sampled ($X10^{-3}$ km^2)	BT#	Wet Weight Sargassum (kg· km^{-2})	Tar Balls (kg· km^{-2})	Halobates (1000 km^{-2})	Porpita (1000 km^{-2})
1	10/19	34.02N,62.05W	1505	20	25.7	1.7	22	28	7.6	1.2	0
2	10/20	33.35N,60.23W	1755	20	--	1.2	26	220	21	22	0
3	10/21	32.48N,60.23W	1755	20	--	1.1	--	21	15	12	0
4	10/22	30.12N,60.42W	1505	32	--	1.9	--	12	17	0	0
5	10/23	28.20N,60.55W	1139	24	--	1.9	--	190	2.6	0	0
6	10/23	27.50N,60.30W	1810	21	27.0	1.4	--	31	4.3	0	0.72
7	10/24	27.11N,60.12W	1250	32	27.2	1.5	31a	27	1.7	2.7	2.0
8	10/25	25.62N,59.37W	0642	29	27.3	2.2	31b	0	1.9	--	1.3
9	10/25	25.00N,59.16W	1715	30	27.7	1.9	--	180	46	1.6	0
10	10/26	23.53N,59.03W	1220	32	27.9	1.3	33	29	1.1	8.5	5.4
11	10/27	22.15N,58.66W	0603	30	27.3	1.9	34	0.27	1.4	0	4.3
12	10/29	18.68N,60.48W	1513	30	27.9	1.9	60	0	0	0	0
		Mean			27.3	1.6		67	11.4	3.9	1.1
		Range			2.2	1.1		220	46	21	5.4

The standing crop of pelagic Sargassum in the Sargasso Sea

Leslie Robinson

Abstract

The standing crop of pelagic Sargassum determined from 12 neuston tows transecting the Sargasso Sea averaged 7.09×10^{-2} g wet weight$\cdot$m^{-2}. This value is one to two orders of magnitude lower than published values but is believed to accurately represent the area transected.



Porpita sp.

The search for Echo Bank

Introduction

Echo Bank is a shoal of questionable existence in the tropical North Atlantic. It is shown on Hydrographic Office Chart 120, a single, isolated 34-fathom sounding surrounded by water nearly 3000 fathoms deep. The shoal bears the code "PD" or "position doubtful" as its existence is based on only two reports -- one in 1837 and one in 1946. The basis of these reports, i.e., the nature of the sounding, is not known to us.

Dr. Howard Winn of the University of Rhode Island believes sightings of colored water near Echo Bank from airplanes may tie this mystery to another seemingly unrelated one -- the breeding ground of the American eel, Anguilla rostrata. Winn suggests that massive "shoals" of eels congregating for spawning could explain sightings of "bottom" in water of oceanic depth. Eels could also be responsible for midwater sonar reflectors.

Soundings

As our course took us near Echo Bank on W-36 we spent a day studying this area. Figure9 shows the ship's track and identified scientific stations. Our course came within about two miles of the geographic center of the Bank and at no time did we detect bottom. The ship's fathomother, though not suitable for oceanographic purposes, was left on the 0-100 fathom (0-200 m) range and no bottom trace was evident. Midwater reflectors at 30-31 fathoms (60-62 m) were detected for a few miles at the site of BT #50. However, BT casts here and elsewhere extending to depths between 125 and 140 fathoms (250-275 m) did not hit bottom. A 250-fathom (500 m) hydrocast ten miles from the reported center of the bank did not encounter the sea floor.

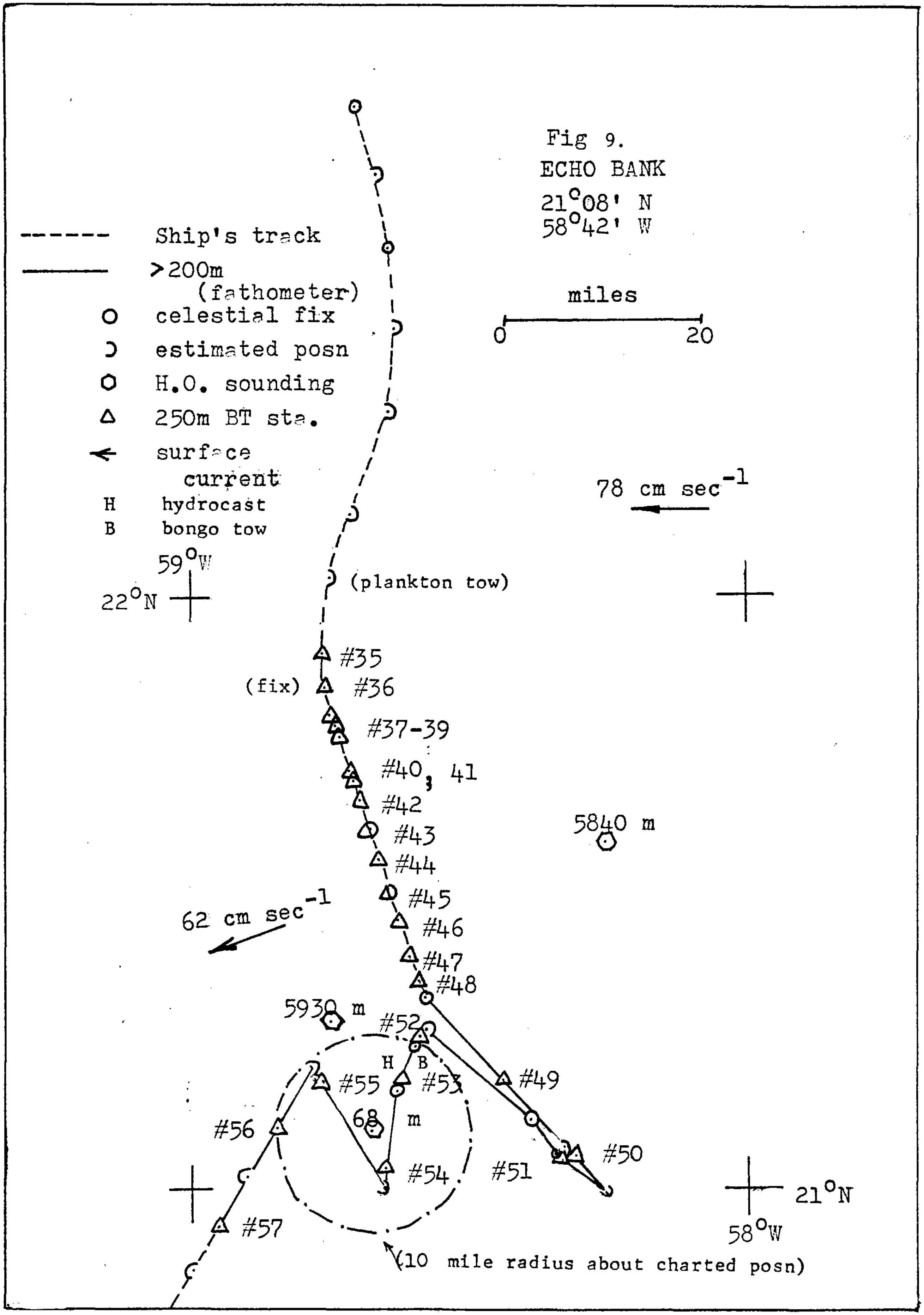


Fig 9.
ECHO BANK
21°08' N
58°42' W
Ship's track
>200m (fathometer)
celestial fix
estimated posn
H.O. sounding
250m BT sta.
surface current
H hydrocast
B bongo tow
miles
0
20
78 cm sec-1
59°W
22°N
(plankton tow)
#35
(fix)
#36
#37-39
#40, 41
#42
#43
#44
#45
#46
#47
#48
5840 m
62 cm sec-1
5930 m
#52
H
B
#55
#53
#49
68 m
#56
#50
#54
#51
21°N
58°W
#57
(10 mile radius about charted posn)

According to Sverdrup, Johnson and Fleming (1942, p.22) volcanic islands can have slopes as great as 50°. A seamount in the plotted position of Echo Bank, which resulted in soundings shown on H.O. chart 120, could have a slope as little as 14°. Furthermore if Echo Bank had a slope of 50° we would not have detected it unless we passed virtually directly over it.

From the transect shown in Fig.9 , our sounding range and the H.O. sounding of 68 m, a probability of 0.9 can be calculated that we would have detected Echo Bank if it is five miles wide and within ± 10 miles of its reported position. If the Bank were only 2.5 miles wide the probability is only 0.6 that we would have detected it. From our work, therefore, we conclude that if Echo Bank exists as a geological feature it is probably smaller than five miles in diameter. Future bathymetric transects should be spaced accordingly.

Hydrography

We examined the hydrography of this area to look for structure that could bear on midwater sonar reflectors. The subsurface temperature maximum at 30 m in this hydrocast in fact extended from 15 m to 67 m as delineated on BT numbers 52 and 53 and coincided with a minor oxygen minimum (Table 16).

Table 16. Hydrography of the ocean near Echo Bank

Depth (Wire Out; m)	Temperature (°C)	Salinity (°/oo)	Dissolved oxygen ($ml \cdot l^{-1}$)
0	27.4	34.97	4.00
30	28.4	36.48	3.63
100	23.6	36.79	4.32
200	20.0	36.67	3.81
300	18.3	36.62	3.26
400	16.8	36.31	3.19
500	14.8	35.77	3.19

A salinity maximum, presumably associated with Subtropical Underwater, was detected at 100 meters (50 fathoms).

Plankton

A 0.505 mm mesh "bongo" net was step towed for half hour periods at 50m and 25m depths. Cursory examination of the catch revealed a conspicuous fraction of larval fishes, including flatfish and small leptocephalus larvae, and larval decapods. Also evident were siphonophore nectophores, foraminifera, radiolarians and anthomedusae. Chauliodontid and Myctophid midwater fishes were also present (see Mitchell, in this report).

Plankton taken in a one hour #20 mesh surface tow do not reflect a shallow water biota (Table 17). The plankton appears to represent a transition from Sargasso Sea types to Caribbean Sea types in our study. There were no plankton unique to the Echo Bank area in this catch. It should be pointed out, however, that this plankton tow was taken 60 miles cross current from the charted position of Echo Bank and the results may not apply to this study.

Conclusions

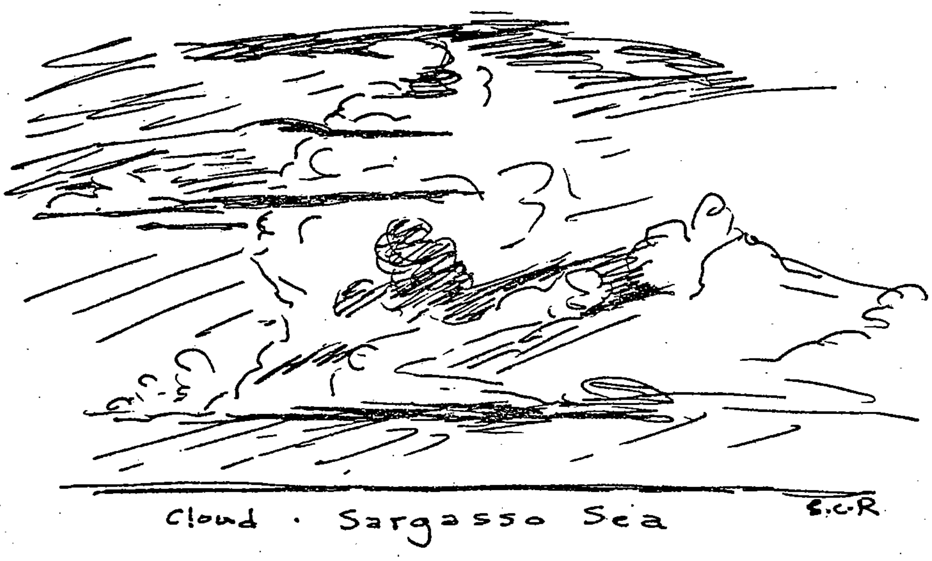
Our observations of the Echo Bank area suggest the "bank" is probably smaller than 5 miles in diameter if it exists as a geographic feature at all. From the slopes of volcanic islands elsewhere it is entirely possible that we could have missed detecting Echo Bank if it is small. On the other hand, midwater reflectors in this part of the ocean, possibly related to the zooplankton and the temperature-salinity structure here, could be misinterpreted as shoal water on an echo sounder.

A watch maintained aloft for parts of this portion of the cruise reported

Table 17. Composition of netplankton tows from four stations in the Atlantic and the Caribbean, cruise W-36

Organism	Position			
	N: 37°46' W: 68°07'	27°04' 60°04'	22°09' 58°39'	16°56' 61°43'
	Gulf Stream	Sargasso Sea	Echo Bank	Caribbean Sea
PHYTOPLANKTON				
Diatoms				
<u>Coscinodiscus</u> sp.				+
<u>Eucampia</u> sp.			+	
<u>Leptocylincricus</u> sp.		+		
<u>Rhizoselenia</u> sp.			+	
Dinoflagellates				
<u>Ceratium</u> sp.	+	+	+	+
<u>Ceratocoryx</u> sp.			+	+
<u>Goniaulax</u> sp.		+	+	
<u>Gymnodinium</u> sp.				+
<u>Ornithocercus</u> sp.	+	+	+	+
<u>Pyrocystis</u> sp.		+	+	+
<u>Pyrophaceus</u> sp.				+
Cyanophytes				
<u>Trichodesmium</u> sp.	+	+	+	+
MICROZOOPLANKTON				
Foramnifera	+		+	+
Radiolarians	+	+	+	+
Tintinnids		+	+	+
MACROZOOPLANKTON				
Copepods				
Calanoid	+	+	+	+
Cyclopoid	+		+	+
Harpactacoid	+		+	+
Appendicularians				+
Chaetognaths	+		+	+
Pteropods				+
Polychaetes				+
LARVAL FORMS				
Copepod nauplii	+		+	+
Crustacean zoea			+	+
Gastropod larvae	+	+	+	+
Bivalve larvae	+			+
Polychaete larvae			+	+
Eggs (?)			+	+

no evidence of discolored water other than drifting patches of Sargassum weed.



3. Studies at Antigua, West Indies

Plankton observations in English Harbor, Antigua

Mary Farmer, Rindy Ostermann and Bonnie Wood

Embayments along the southern coast of Antigua have a conspicuously high turbidity relative to oceanic water. Transparency at inshore stations averaged 3.2m (Secchi depth) while values exceeding 30m were recorded immediately offshore. In harbors used by the yachting and hotel industries, such as English Harbor, it is sometimes presumed that the turbidity is related to water pollution. At the request of Mr. Desmond Nicholson we examined samples from English Harbor and from a physiographically similar basin nearby (Indian Creek) which, however, is not extensively used by man. The results of the study (Appendix 6) will be sent to Mr Nicholson and are outlined below.

Water transparency was low at all inshore stations and appears to result from a very high standing crop of zooplankton. We found no evidence that turbidity in these cases is related to pollution. Dissolved oxygen was uniformly high in surface water. The uptake rate of oxygen by samples of natural water was variable and it can only be said that the rate was less than 0.5 ml $L^{-1}day^{-1}$ at all stations. The unique occurrence of the dinoflagellate, Dinophysis, in English Harbor may represent natural variability among inshore sites or it may indicate a response to sewage unput.

The very low phytoplankton and zooplankton standing crops we observed offshore are typical of the tropical ocean. Low phytoplankton levels inshore may result from intense grazing by the abundant zooplankton found there. Overall, the composition of the zooplankton inshore suggests the embayments are productive nursery grounds for diverse species of animals (see Fig. 10; Tables 18-20).

Table 18. Measured and calculated characteristics of Falmouth Harbour, English Harbour and Indian Creek, Antigua

	English Harbour inner	English Harbour outer	Falmouth Harbour	Indian Creek	Offshore
Station #	3	4	2	1	5
Date sampled	11/3 (0600)	11/3 (1200)	11/2 (1800)	11/2 (1630)	11/3 (1600)
Plankton sample #	3	-	2	1	4
Salinity ($\pm$ 0.1°/oo)	32.2-34.0	-	-	-	34.2
Temperature ($\pm$ 1° C)	27.6 (0750)	28.5 (1225)	-	-	27.8 (1720)
Boats anchored	ca 90	ca 10	-	0	0
Dissolved oxygen surface ($\pm$ 0.05 ml/L	3.9	4.0	3.9	3.9	4.0
BOD Oxygen uptake rate (ml O_2/L/day)	<0.5	<0.5	<0.5	<0.5	<0.5
Flushing time (days)	16.2		15.4	24.8	-
Transparency (Secchi depth, M $\pm$ 10%)	3.0	5.5	3.0	1.3	30.0

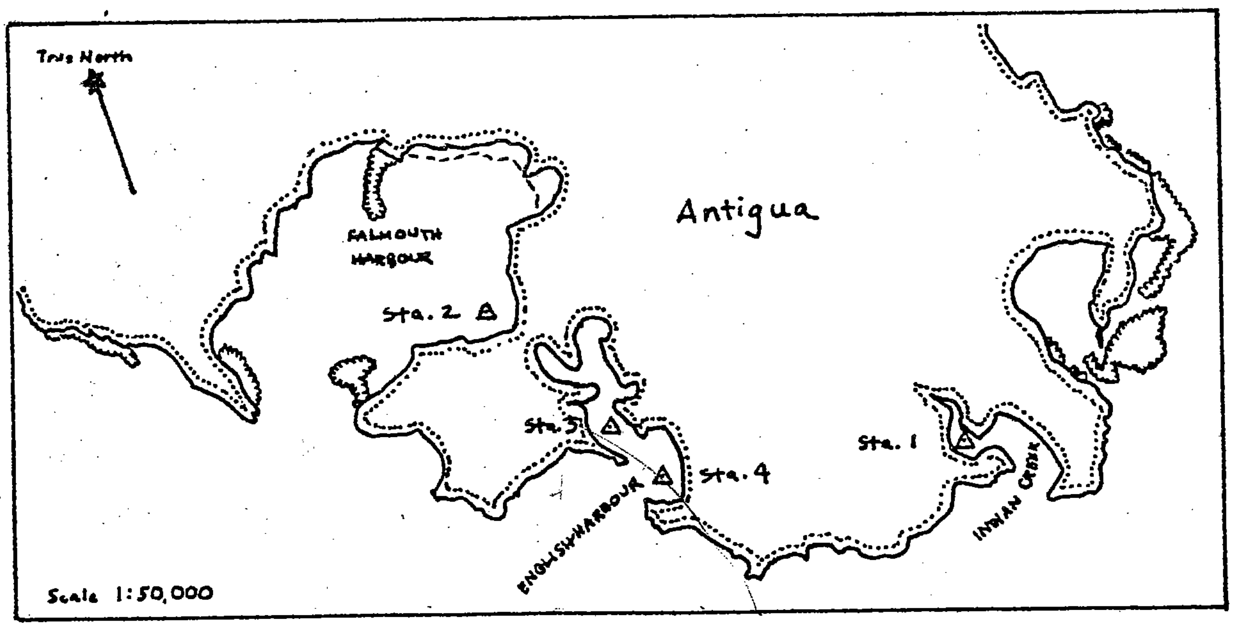


Fig. 10. Stations sampled in embayments of Antigua.

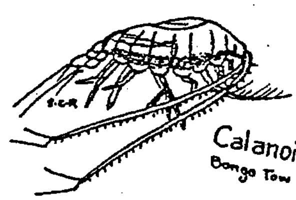
Table 19. Concentration of phytoplankton (x $10^3 \cdot m^{-3}$) in three shore locations and one coastal site, Antigua

Organism	Indian Creek	Falmouth Harbour	English Harbour	Coastal Water
Diatoms				
Asterionella sp.		1.10		
Chaetoceros sp.		.37		
Coscinodiscus sp.		.73	1.47	0.020
Leptocylindricus sp.	.37			
Navicula sp.		.37		
Rhabdomema sp.		.73		
Rhizoselenia sp.	.37	.73	.37	
Diatom A	.37	.37		
Dinoflagellates				
Ceratium (3 sp.)				0.452
Ceratocoryx sp.				0.393
Dinophysis sp.			3.30	
Gymnodinium sp.				0.020
Ornithocercus sp.			.37	0.059
Peridinium sp.			.37	
Pyrocystis sp.		.37		0.059
Pyrophaceus sp.				0.020
Blue-Green Algae				
Trichodesmium sp.				2.396
Total Phytoplankton	1.11	4.77	5.88	3.419

Ceratium extensum (tropical oceanic species) · Needlelike form, when horizontal, retards sinking. (sample P-4)

Table 20. Concentration of zooplankton (x $10^3 \cdot m^{-3}$) in three shore locations and one coastal site, Antigua

Organism	Indian Creek	Falmouth Harbour	English Harbour	Coastal Water
Microzooplankton				
Foramnifera (2 sp.)		4.03	5.50	0.098
Radiolarians (3 sp.)				0.589
Tintinnids (3 sp.)	16.13	.37		0.098
Macrozooplankton				
Adults				
Copepods				
Calanoid	45.47	65.27	98.87	1.355
Cyclopoid (<u>Corycaeus</u> <u>sp</u>)		1.47	0.73	1.316
Harpactacoid			1.83	0.020
Anthomedusae		.37		
Appendicularians		1.83	5.13	0.039
Chaethgnaths				0.176
Pterpods				0.078
Polychaetes (<u>Tomopteris sp.</u>)				0.039
Subtotal	61.60	73.34	107.06	3.808
Larvae				
Copepod nauplii + metanauplii	26.40	17.23	8.80	0.157
Other crustacean larvae + zoea	11.00	1.10	2.20	0.059
Gastropod larvae	3.30	9.90	4.40	0.059
Lamellibranch larvae	.73	4.77	14.30	0.039
Polychaete larvae	.37		.37	0.059
Ascidian larvae			.37	
Unidentified eggs			2.20	0.020
Subtotal	41.40	33.00	32.64	0.393
Total Zooplankton	103.40	106.34	139.70	4.201



Calanoid copepod
Bongo Tow W36-H1

Evidence for sea-level change on the Antigua-Barbuda insular platform.

Jeremy Cranston

Abstract Observations were undertaken on W-36 of R/V Westward to determine if there was any evidence of sea-level change in the Lesser Antilles island arc. Findings from the Antigua-Barbuda insular platform, in the form of raised wave-cut benches in the hillsides of Antigua and submerged coastal features (Fig 11) suggest that the relative sea-level has changed at least three times, inclusive of the present level. For certain of the submerged coastal features the magnitude of the change is within accepted limits for eustatic fluctuation, but some features are outside these limits and cannot be explained without invoking tectonic forces. These features are not explainable purely by either eustatic change or tectonic movement. Instead, there appears to be a combination of these two forces at work. The features would seem to confirm the existance of major tectonic forces operating in this region where the Caribbean plate over-rides the North American plate. Observations made in areas other than the Antigua-Barbuda platform, during W-36, were not conclusive enough to be considered.

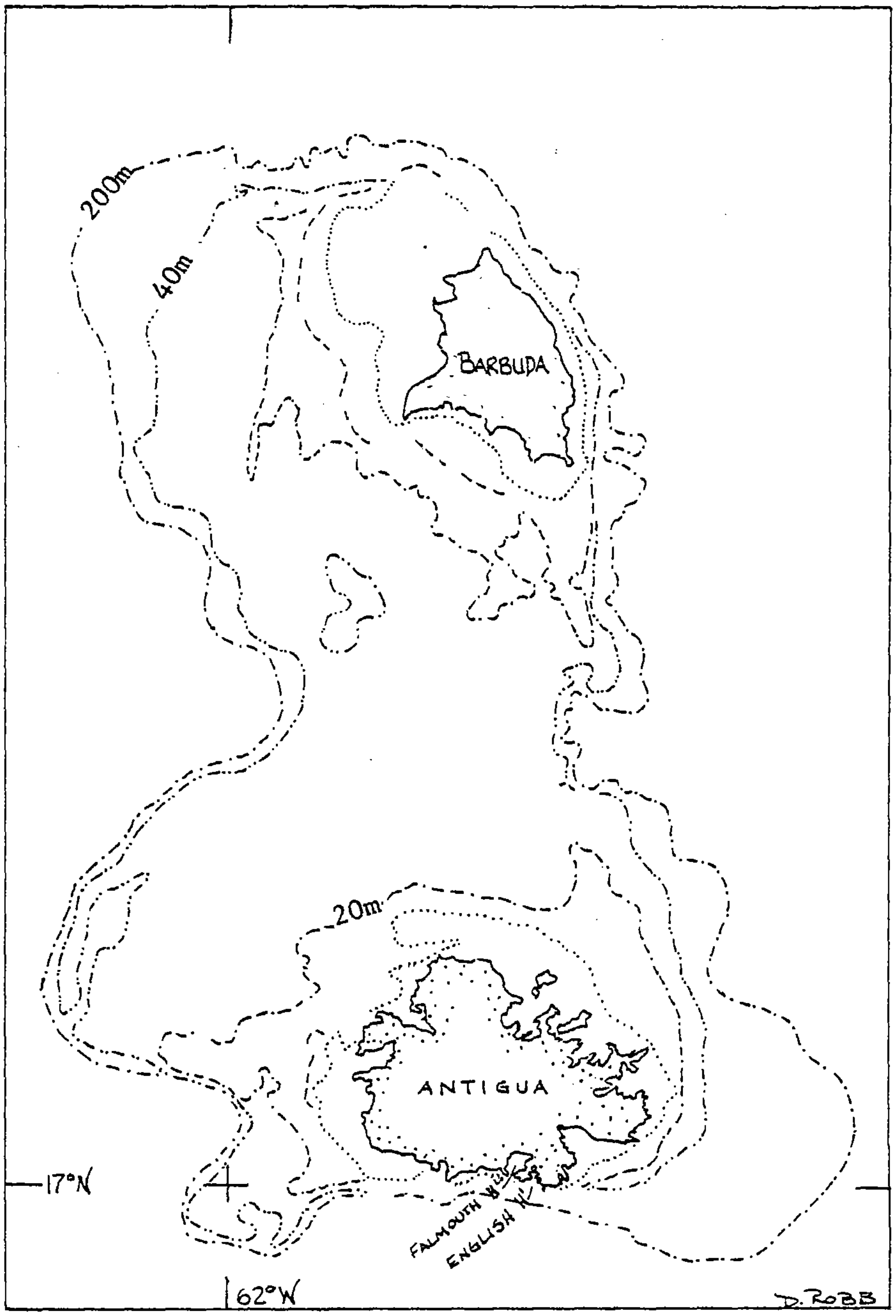


Fig 11. The Antigua-Barbuda insular platform. Some of its submerged topography may have formed under subaerial conditions (from Admiralty Chart # 955).

Caribbean bird observations

Loralee Clark

Abstract A bird log was kept throughout the Caribbean legs of W-36 (Table 21 ; Fig. 12). Observations on Antigua, Bequia and the Grenadine islands suggest no major differences among the avifauna of these islands. At sea in the Caribbean swallows seemed to replace warblers of the North Atlantic as a land species commonly encountered. Similarly, boobies occurred where we had seen gulls in the Atlantic. Three flocks of more than 100 sea birds were observed in the Caribbean whereas flocks were not seen in the Atlantic. The carcass of a small bird was found in the stomach of a tiger shark.

Table 21.Caribbean Bird Observations

	Species	Sea	Antigua	Tobago Cay	Bequia	Aves
1.	Wilson's petrel	x				
	brown pelican		x	x	x	
3.	blue faced booby	x				
4.	red-footed booby	x				
5.	brown booby (sula leucogaster)	x		x	x	
6.	frigate bird	x	x	x	x	x
7.	American egret	x				
8.	great blue heron	x				
	yellow crowned night heron			x		
	cattle egret		x			
	spotted sandpiper			x		
	sandpiper species		x			
13.	parasitic jaeger	x				x
14.	pomarine jaeger	x				
15.	common tern	x				
	royal tern		x			
	sooty tern	x				x
	tern species	x	x	x		x
	ground dove		x	x		
	large dove species		x	x		
	Antillean crested hummingbird			x		
	hummingbird species		x		x	
	gray kingbird		x			
	rusty-tailed flycatcher			x		
	tropical mockingbird			x	x	
26.	barn swallow	x		x		
	blackpoll warbler			x		
	warbler species		x			
	carib grackle		x	x	x	
	bananaquit		x	x	x	
	black faced grassquit			x	x	
	small dark finch			x	x	
33.	white tailed tropic bird	x				
	mangrove cuckoo				x	
	yellow-bellied seedeater*				x	
	flycatcher/pewee sp.				x	

* possible

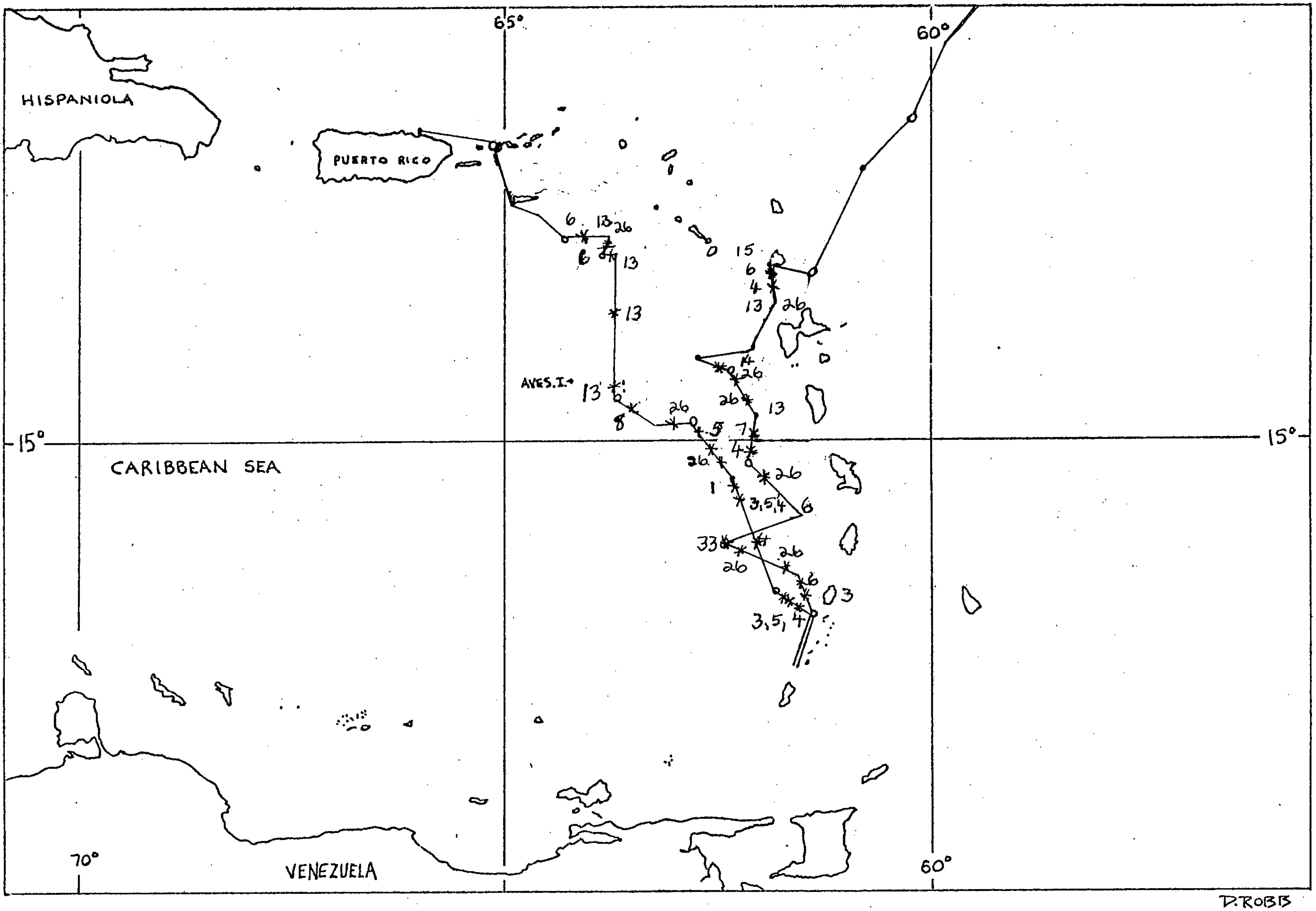


Fig. 12. Caribbean bird sightings (see also Table 21)

4. Legs 2 and 4. Oceanographic observations on the Grenada Basin

The Grenada Basin is one of the minor basins of the Caribbean mediterranean. It lies between the Aves Ridge and the Antilles island arc and can be represented as a closed contour at 2000 meters depth (Figure 13). The surface current here, an extension of the North Equatorial and Antilles current, flows to the west and northwest. This and deeper water enters the basin through passages between the islands.

Hydrography

On W-36 we carried out four hydrostations in the Grenada Basin to examine its water masses; at each station Isaacs-Kidd midwater trawls and plankton tows were also conducted. The temperature profiles (Figure 14) revealed a shallow surface layer never exceeding 70 meters which was characterized by isothermal conditions or by a subsurface temperature maximum. Beneath this a single thermocline showing only minor deviations from exponential decrease extended throughout the water column sampled.

The salinity maximum detected at 200 meters at all stations identifies Subtropical Underwater formed in the North Atlantic. The deeper salinity minimum, between 600-800 meters, results from Antarctic Intermediate water which evidently has free access to this basin through several channels. The oxygen minimum, generally found just above this water mass, is the result of dynamic processes of supply (including atmospheric diffusion, surface mixing, photosynthesis and upward mixing of oxygen rich deeper waters) and consumption (mainly respiration). The phosphorus maximum associated with the oxygen minimum reflects the mutual implication of these elements in

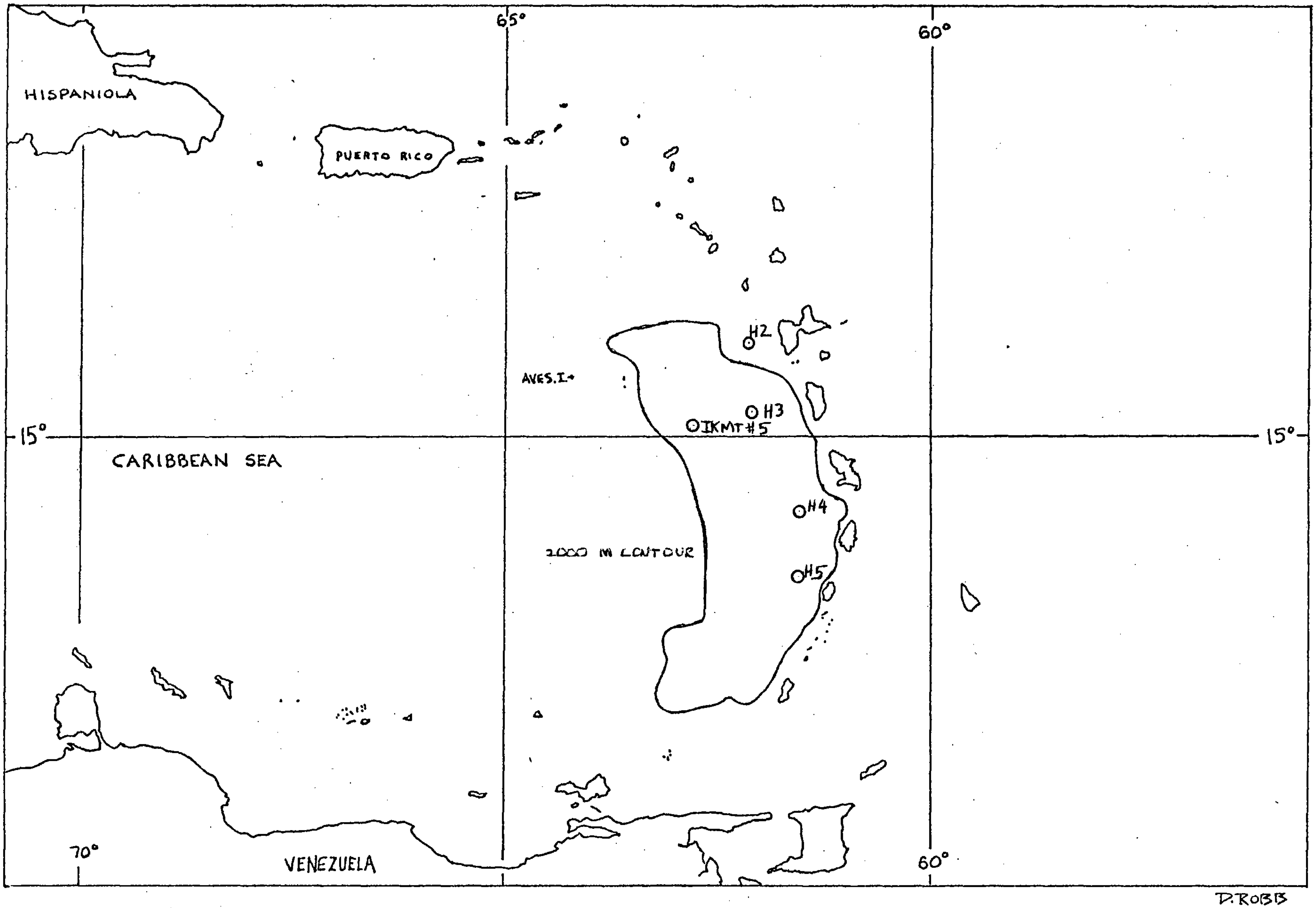


Fig. 13. Hydrographic and midwater trawl stations in the Grenada Basin.

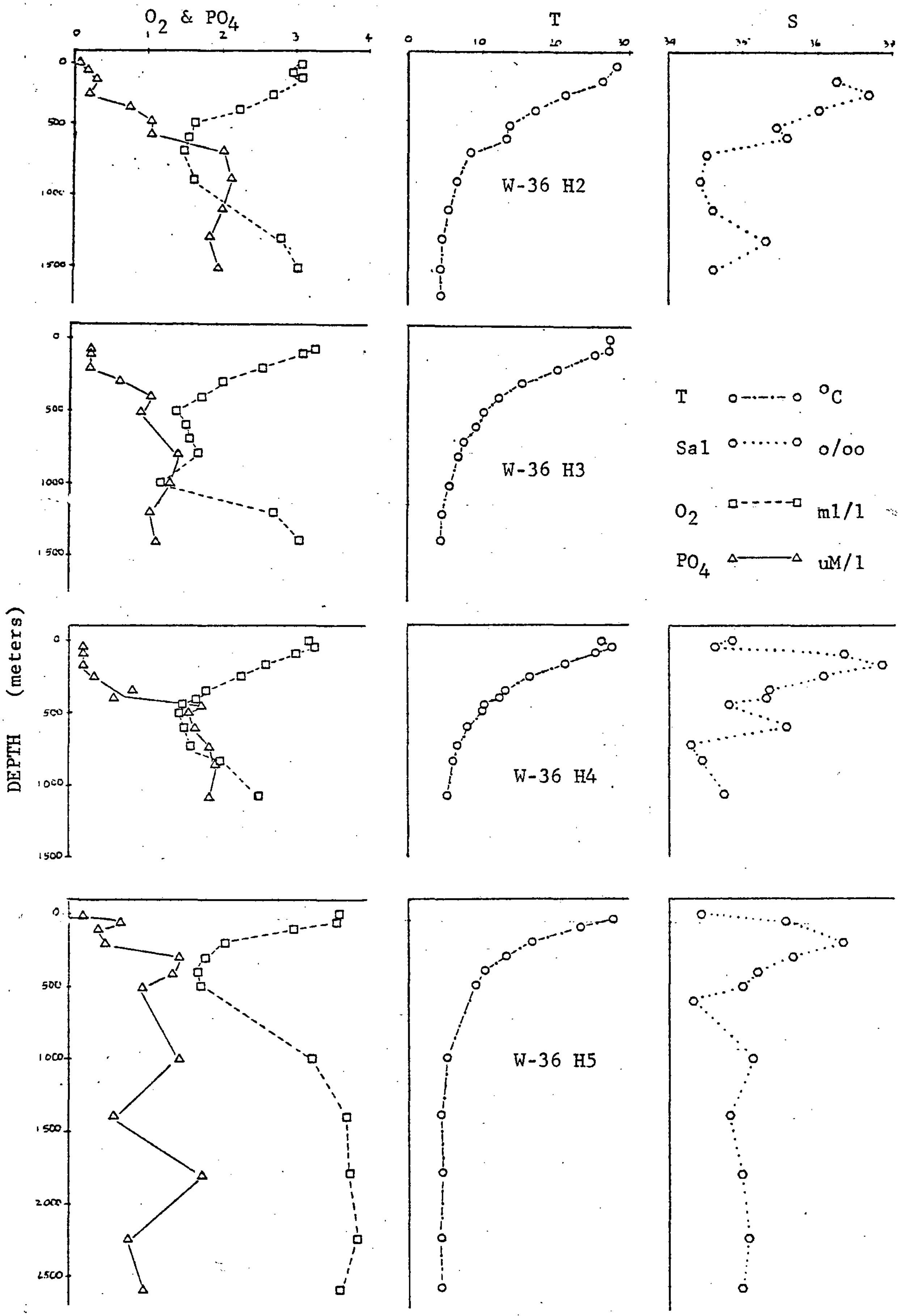


Fig. 14. Results of hydrographic observations in the Grenada Basin.

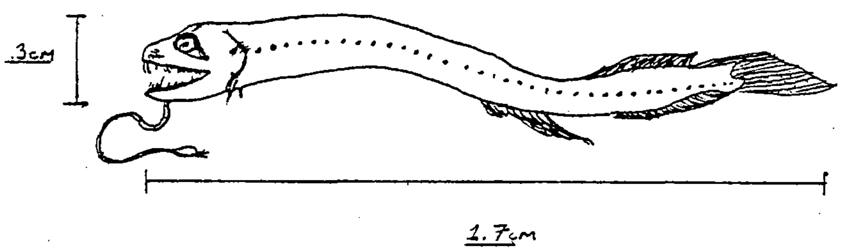
biological activities.

The deepest water in the Grenada Basin is of North Atlantic origin and enters either sporatically or continuously. Evidence to support the former contention might be seen at station W36-H4 (Figure 14) where a decrease in oxygen occured between 2200 meters and 2600 meters which suggests consumption without continuous resupply. Obviously considerably more evidence is necessary to reach a conclusion on this matter.

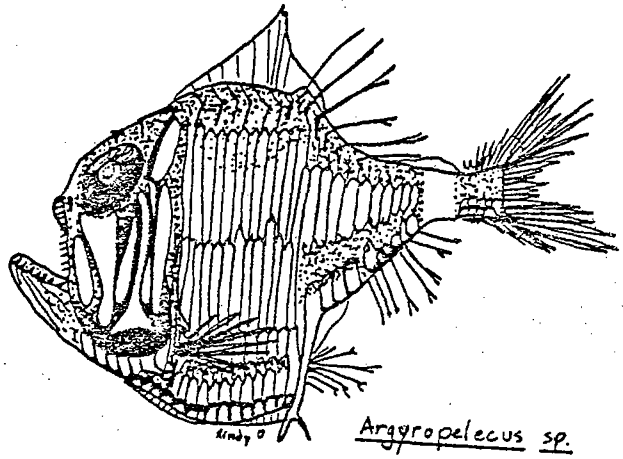
Distribution and identification of mesopelagic fishes in the Caribbean (Grenada Basin).

John F. Mitchell

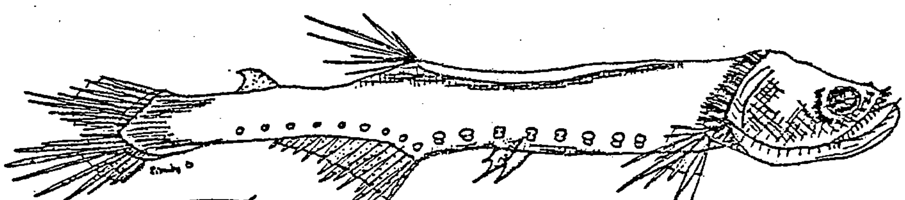
Isaacs-Kidd midwater trawls and zooplankton tows at six stations in the Atlantic and Eastern Caribbean were examined for their content of mesopelagic fishes. 67% of the species collected agreed with the faunal assemblage of Bachus (1970) for the Caribbean Sea. The remaining 33% corresponded with the Southern Sargasso and lesser Antilles assemblages. The numbers of each species captured was related to depth and time of the tow. In all, the fishes collected included 2 Chauliodontids (4 individuals), 9 Myctophids (77 individuals), 8 Gonostomids (19 individuals), 2 Stomids (5 individuals) and 1 Sternoptychtid (3 individuals).



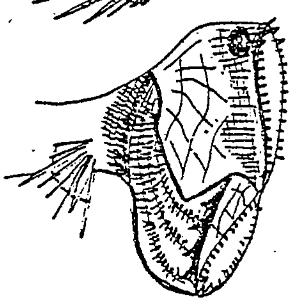
Stomias boa



Argyropelecus sp.



Gonostoma elelongatum

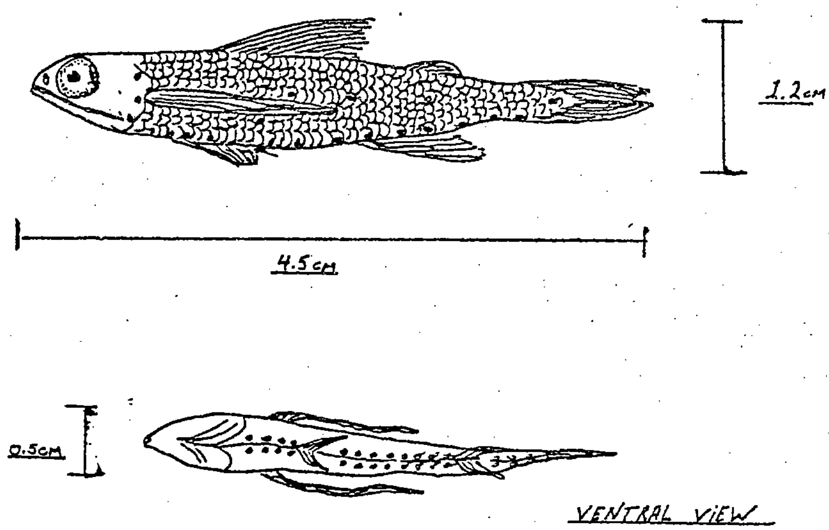


Water Transport Across the Aves Ridge

By David Robb
November 21, 1977

The intent of this study was to examine the surface and sub-surface currents on the West side of the Aves Ridge. We wanted to measure the set, drift, and volume of water transported at several different depths. To do so, four deep sea drogues were released at the same position at depths of 2m (surface), 25m, 50m, and 100 meters below the surface, and allowed to drift for about one hour. From the positions at recovery, relative set, drift, and volume of water transported for each layer of water was calculated.

From the results of the surface drogue, it can be shown that the predominate Westerly current is driven by the Easterly winds. The deviation from the wind direction recorded by the deeper drogues was due to wind shear. No sub-surface countercurrent was measured.



LAMPANYCTUS GÜNTHERI

Sediment Studies—Caribbean

Brooks Wallin

Abstract:

Hydrostation H-2

S ediments dredged from 1600 meters depth southwest of Guadeloupe were subject o preliminary onboard analysis by microscope. Fine-grained sub-angular vitreous particles were unexpectedly discovered in the sediment. Their concentration was less than 1% and hardness approximately equal to or greater than 7 on the Mohs Scale. Conchoidal fracture and other properties strongly suggest their composition to be quartz. I expect the question of their origin will be resolved with further post cruise studies. One possibility is that they represent wind-blown volcanically produced glass. The remainder of the sediment was a buff-brown calcareous clay of unknown composition.

Aves Ridge

Two sediment gravity cores were attempted in proximity to the central Caribbean island of Isla Aves. At 67 and 222 meters depth respectively, only living and dead coral fragments were recovered. This observation is of value in itself. Dead coral found well out of the euphotic zone in 222 meters of water indicates conditions of fairly rapid submergence. This would seem to be consistent with modern plate theories concerning the Aves Swell. Further analysis of the corals is planned.

Saba Bank

South of Saba Bank at a depth of 1290 meters a full gravity core was successfully taken. The composition of this core was pteropod-globigerina ooze with a significant fraction of black sub-angular mafic particles. Transparent vitreous sub-angular to sub-rounded particles were also present, similar to those found in the sample southwest of Guadeloupe. Again the sample was calcareous and the major clay component undetermineable. Additional analyses are planned onshore with more sophisticated equipment. These questions, as well as quantative description of the sediments will be undertaken there. Because the dark mafic minerals permeate the core, it is an initial hypothesis that volcanic activity has been prevalent and continuous in the late history of the islands.

5. Tobago Cays: studies on a fringing reef complex

A number of biological and geological studies were carried out between November 9 and 12 in the Tobago Cays. After a preliminary reconnoitering of the area three sites were selected for further study. These areas, designated as "A", "B" and "C" on Figure 15 are described in detail on the following pages.

The preliminary survey showed the passage between Petit Rameau and Petit Bateau islands and the shallows east and south of Petit Bateau (Figure 15) to have a barren and aparently mobile sandy bottom. Visibility was about 10 to 25 feet. Evidence of intensive biological reworking was abundant in the form of hills and depressions and small holes in the sand but only a few fishes were seen here. A single patch of Thalassia occurs near the small island east of Petit Bateau.

The east face of Horseshoe Reef is similiar to area A (Figure 15) in its fauna and geology but was farther from our anchorage, out of sight from the ship and more exposed to waves. Beneath about 25 feet depth visibility improved but this generally exceeded comfortable sustained snorkeling depth. Although not shown in Figure 15 another reef lies a mile or more offshore from Horseshoe Reef. This reef was not explored as it was not readily accessible to us but it may have been a more spectacular diving site.

At the time of our visit a small fisherman's camp on Petit Bateau was occupied by a dozen men who sold spiney lobsters and fish. About 6-8 pleasure craft were anchored in the area. Otherwise these small islands were uninhabited.

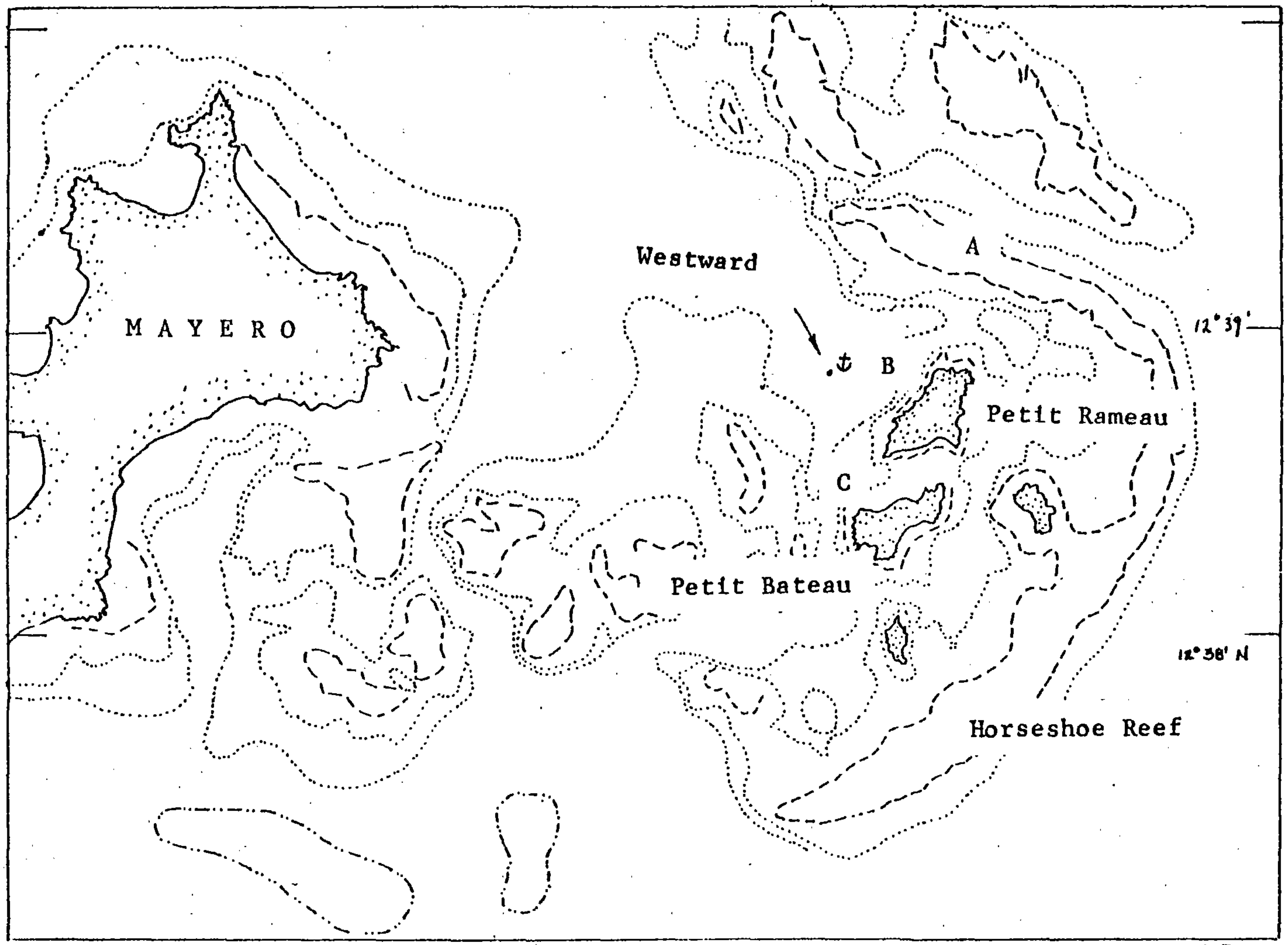


Fig. 15. The Tobago Cays.

Studies of the Reefs of the Tobago Cays

By Paul Markowitz
Bruce Rumish

Upon our arrival at Tobago Cays, on November 9, 1977, dive teams were organized to survey the structures and fauna of the offshore reef and the rocky beach (. A and B in Fig 15). The next day a team was sent to the sandy beach on Petit Bateau (C, Fig 15), and observations were continued at each site for the 3 days we remained. The diving conditions were uniform throughout our stay. There was much suspended particulate matter in the water restricting visibility to 15 to 30 feet. The current at the offshore reef was the strongest encountered at the three sities, all moving in a SW direction.

The offshore reef is hook shaped, extending from the NW portion of Petit Rameau Isand. The reef stratum ranged from 6 - 15 feet below the surface and the semi-enclosed portion dropped off severly to approximately 60 feet. The stratum is composed of the carbonate secretions of former reeforganisms. A current of ½ knot was recorded coming from the NE, but we were later informed that the prevailing current is NW, explaining the curved growth of the reef to the NW.

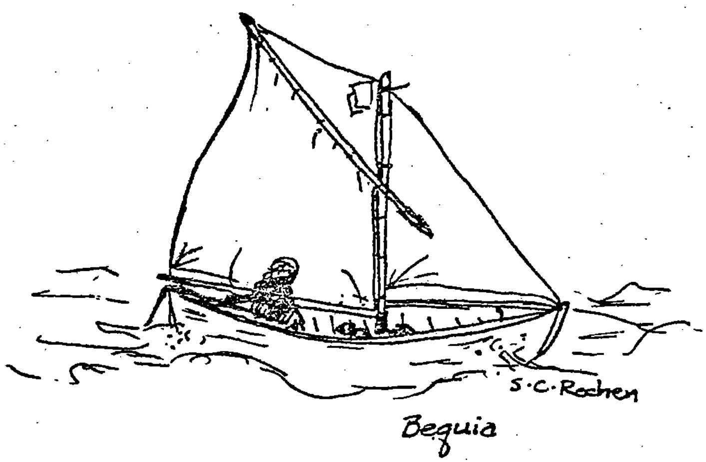
Table 22 lists the species of corals seen at the reef. The reef surface was sandy, a thin layer covering debris and bare spots. Overall, the reef seemed not to be in a productive state with many bare spots and moderate diversity of the corals. Acropora palmata was by far the most abundant species, growing in large patches and as solitary colonies. Brain corals, both large and small, were sparse and widely separated. Fire coral was relatively abundant, seen mostly in the shallowest areas. Soft corals, such as Sea fans and Sea whips were also relatively abundant.

Table 22.- Corals of the Tobago Cays Reefs

Name	Observed at Site		
Stony Corals	B Rocky beach	C Sandy beach	A Reef
Family Acroporidae			X
Acropora cervicornis - Staghorn			
Acropora palmata - Elkhorn Coral	X	X	X
Agariciidae			
Agaricia fragilis - Hat Coral		X	
Siderasteidae			
Siderastrea radians - Starlet	X		
Poritidae			
Porites porites - Clubbed finger	X	X	X
Porites furcata - Finger Coral			X
Porites astreoides - Finger Coral	X		
Faviidae			
Diploria clivosa - Brain Coral			X
Diploria labyrinthyformes - Brain	X	X	X
Diploria strigosa - Common Brain	X	X	X
Manicina areolata - Common Rose	X	X	X
Montastrea annularis - Common Star	X	X	X
Solenastrea bournoni - Star Coral	X	X	X
Mussidae			
Mussa angulosa - Large Flower	X		
Soft Corals			
Family Plexauridae			
Plexaura homomalla - Black Sea Rod	X	X	X
Plexaurella dichotoma - Double forked plexaurella	X	X	X

Table 22. (cont.)

	Rocky Beach B	Sandy Beach C	Reef A
Gorgoniidae			
<u>Gorgonia</u> <u>flabellum</u> - Venus fan	X	X	X
<u>Gorgonia</u> <u>ventalina</u> - Common sea whip	X	X	X
<u>Pterogorgia</u> <u>citrina</u> - Yellow Sea whip	X	X	X
<u>Pseudotperogorgia</u> <u>americana</u> - Slimy Sea Plume	X	X	X
<u>False Corals</u>			
Milliporidae			
<u>Millipora</u> <u>alcicornis</u> - Stinging Coral	X	X	X



The fish community was quite diverse (Table 23). Invertebrates were noted, although not charted. Among the invertebrates seen were echinoderms (brittle stars - Genus Ophiocoma), sea cucumbers, sea urchins (genus Diadema and Arabacia), serpullid worms, bristle worms, sponges of many types growing on the underside of the dead coral, many conch, and ctenophores floating with the current.

The rocky beach on Petit Rameau (Figure 16) was composed of weathered corals, gastropod shells, and weathered volcanic rocks. The majority of the rocks were weathered to red and green colors.

Just off the beach was an area of sand and pebbles two meters wide. Beyond this area the major component of the inner shore substratum was dead coral, this zone extended to twenty meters offshore. Growing on the dead coral was a zone of several large patches of Acropora palmata, and Porites porites was dominant towards the deeper edge. Near the outer end of the Porites porites was scattered growths of Gorgonias and Faviidae. As we swam farther out, the coral became scarcer as sand became the predominant bottom feature. Scattered sparsely in the sandy bottom was Diploria strigosa and large boulders of Montastrea annularis. The sponge Ircina was also growing in this area. Northward along the fringing reef, the major corals were Porites porites and Millipora. The area to the south was largely dead coral, with a few scattered colonies of Montastrea. Table 22 lists the many corals of this area.

There was a wide diversity of fauna. The invertebrates included squid, brittle stars, West Indian top snails, and sea unchins. There were also ctenophores floating in the water. Table 23 lists the fishes observed at this reef.

Table 23. - Fishes of the Tobago Cays Reefs

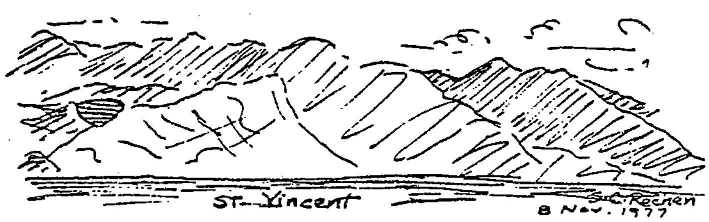
Name	Observed at site Rocky beach B	 Sandy beach C	 Reef A
Family - Synodontidae - Lizardfish			
Synodus foetens - Inshore Lizardfish	X	X	X
Synodus saurus - Blue stripe "	X	X	X
Holocentridae - Squirrelfish & Soldierfish			
Hocentrus escensionis - Longjaw squirrelfish	X	X	X
Hocentrus rufus - Squirrelfish	X	X	X
Myripristis jacobus - Blackbar soldierfish		X	
Aulostomidae - Trumpetfish			
Aulostomous maculatus - Trumpetfish	X	X	X
Fistubridae - Cornetfishes			
Fistularia tabacaria - Cornetfish	X		X
Bothidae - Lefteye flounders			
Bothus lunatus - Peacock flounder	X		
Priacanthidae - Bigeyes			
Priacanthus arenatus - Bigeye		X	
Lutjanidae - Snappers			
Ocyurus chrysurus - Yellowtail snapper	X		
Carangidae - Jacks, Scads, Pompanos			
Caranx latus - Horseeye jack	X		
Pomadasyidae - Grunts			
Haemulon flavineatum - French grunt		X	X
Haemulon chrysorgyreum - Smallmouth grunt		X	X
Anisotremus virginicus - Porkfish	X	X	

Table 23. (cont).

	B	C	A
Scianidae - Drums and Croakers			
Equetus puntatus - Spotted Drum	X		X
Equetus lancelatus - Jackknife fish		X	
Mullidae - Goatfish			
Mulloidichthyes martinicus - yellow goatfish	X	X	
Pseudupeneus maculatus - Spotted goatfish	X	X	
Balistridae - Triggerfish and Filefish			
Canthidermis sufflamen - Oceantrigger	X		
Serranidae - Sea basses			
Cephalopholis fulva - Coney	X		X
Chaetodontidae - Angelfish & Butterfly			
Holocanthus tricolor - Rock beauty	X	X	X
Holocanthus ciliaris - Queen angel	X	X	X
Holocanthus bermudensis - Blue angel	X	X	
Chaetodon capistratus - Foureye butterfly fish		X	X
Chaetodon striatus - Banded butterfly		X	X
Pomacentridae - Damselfish			
Eupomacentrus dorsopunicans - Dusky damselfish	X	X	X
Eupomacentrus portitus - Bicolor damsel	X		
Eupomacentrus planifrons - Three spotted	X	X	
Eupomacentrus levcostictus - Beaugregory			X
Microspathodon chrysurus - Yellowtail damselfish	X	X	X
Abudefduf saxatilis - sargeant major	X	X	X
Abudefduf taurus - Night sargeant	X	X	X
Chromis cyanea - Blue chromis			
Labridae - Wrasses			
Thalasoma bifasciatum - Bluehead	X	X	X
Halochoeres maculipinna - Clown wrasse	X		
Halochoeres garnoti - Yellowhead wrasse	X		X
Halochoeres radiatus - Puddingwife	X	X	X
Halochoeres poeyi - Blackear wrasse	X		

Table 23. (cont.)

	B	C	A
Scaridae - Parrotfishes			
Scarus retula - Queen parrot	X	X	X
Scarus taeniopterus - Princess parrot	X	X	
Scarus guacamia - Rainbow parrot	X		
Sparisoma rubripinne - Yellowtail parrot			X
Sparisoma viride - Stoplight parrot	X	X	X
Sparisoma chrysopterum - Redtail parrot	X		X
Aconthuridae - Surgeonfish			
Acanthurus coerulus - Blue tang	X	X	X
Acanthurus chirurgus - Doctorfish	X	X	X
Acanthurus bahianus - Ocean surgeon	X	X	X
Ostraciidae - Trunkfish			
Lactophyrus triqueter - Smooth trunkfish		X	X
Lactophyrus bicaudalis - Spotted trunkfish	X	X	X
Ephippidae - Spadefish			
Chaetodipterus faber - Altantic spadefish	X		
Clinidae - Clinids			
Hemiemblemaria simulus - Wrasse blenny			X
Ophichthidae - Snake eels & worm eels			
Myrichthys oculatus - Goldspotted eels	X	X	
Belonidae - Needlefishes			
Tylosurus crocodilus - Houndfish	X	X	



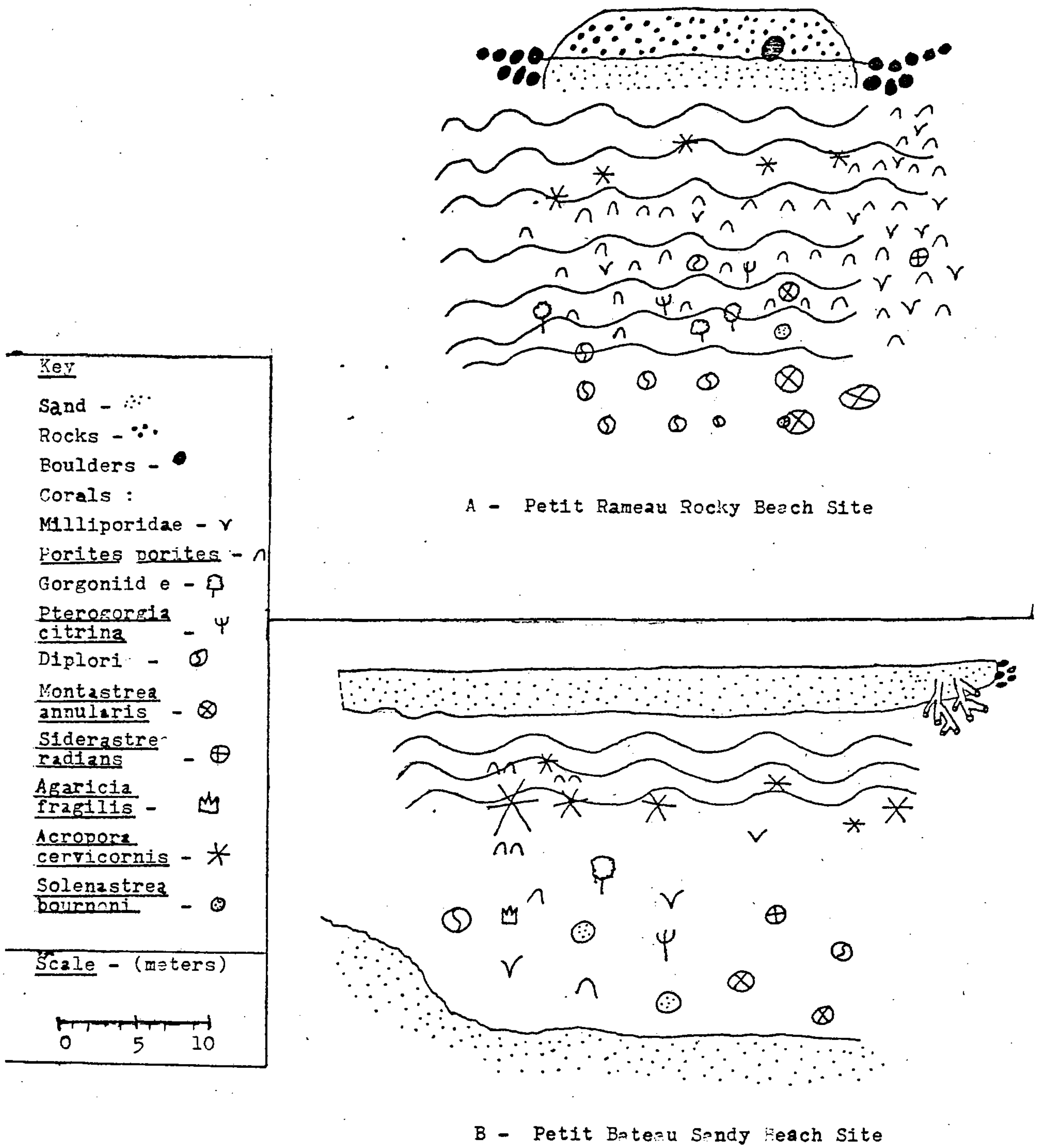


Fig. 16. Benthic transects at A) Petit Rameau and B) Petit Bateau Tobago Cays, W-36.

The sandy beach area was generally sheltered (Figure 16), the shore composed of carbonate sand. The reef ranged from 0.5 m to 7.0 meters in depth and extended to 20 meters from the beach. The reef top was covered with a layer of sand except for the area inshore of the _Acropora palmata_ zone, which was sand, rock, and littered with dead coral. This zone, however exhibited limited coral growth. The coral beyond the _Acropora palmata_ zone was scattered and varied, but mostly _Diploria._ Table 22 lists the corals at this site. Interspersed with the _Acropora_ was _Porites._ Sponges were scattered in the the deeper area of the reef. The reef ended at twenty meters offshore, the bottom becoming quite sandy.

The fauna included octupus, squid, a swarm of mysids, chaetognaths, ctenophores, clams, bristle worms, and the same urchins observed on the offshore reef and rocky beach. Sponges, brown algae, _Halimeda,_ and enteromorphs were noted. The fish population is listed in table 23.

Biological Zonation at Petit Rameau

Bonnie Wood

Abstract:

Observations at Site B on Petit Rameau showed that there is biological zonation on its rocks. There were six zones, A through G, extending from dry rock to rock which was constantly underwater but before coral growth began. Littorina and other gastropods inhabited the drier rock, and chitons and algae favored the wetter. In toto there were seven animal species observed and seven alga species, with a wide region of myxophyceans. The zonation at Petit Rameau generally corresponded to a worldwide pattern.

The Geology of Petit Tabac

Brooks Wallin

ABSTRACT

During W-36 Petit Tabac, an island associated with the Tobago Cay Reef Complex, was the focus of a general geological study. The island's perimeters were mapped, its topography and dominant vegetation noted, and its relationship to surrounding features studied. Petit Tabac is a typical rampart island (Fig.17) feature. The island is composed of coralline material derived from the reefs presumably to windward of it. Because of the persistence of a stable island form, we infer that the environmental conditions in the area do not exhibit a great deal of variance. Hopefully the information gathered for the study will be of future use in detecting landform and vegetative change in the years to come.

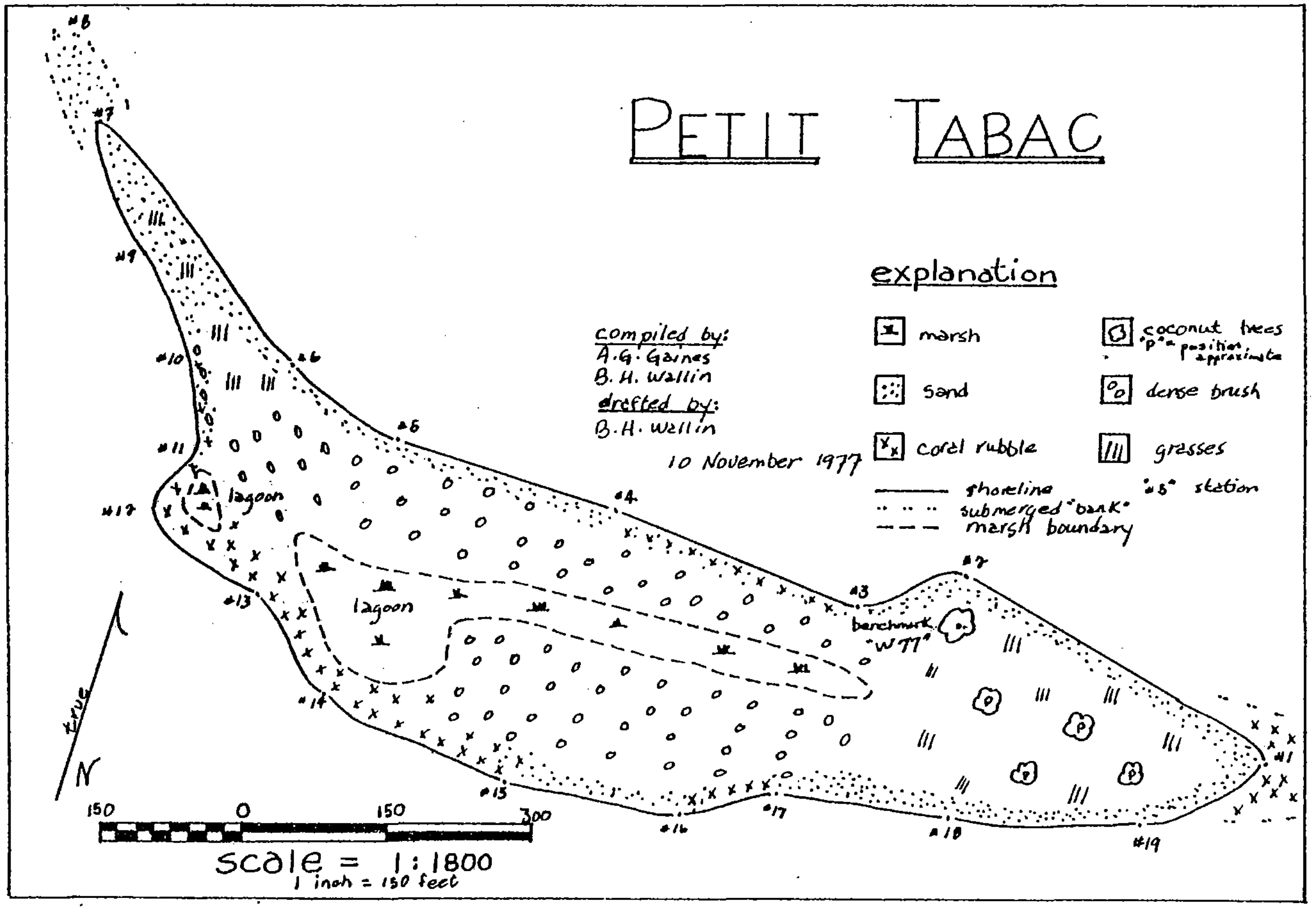
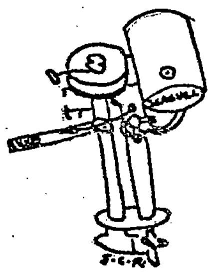


Fig. 17. Field survey of Petit Tobac, Tobago Cays, a rampart island. W-36.

Appendices



Appendix 1

Final Examination Questions (W-36)

1. Discuss the modifications of form, behavior and life style we have seen that represent organisms adaptations to or use of the ocean surface. Give specific examples.

2. Discuss the similarities of the coral reef system and the Sargassum weed system.

3. Explain briefly the following data from a hydrocast:

Depth (m)	Temperature (^oC) protected	unprotected	Salinity $^o/oo$	Oxygen ml/L	Phosphorus µM/L
0	28.0	28.0	34.28	4.2	0.2
50	28.0	28.4	34.28	4.2	0.2
100	29.0	29.8	35.02	4.8	0.1
200	25.0	26.7	34.90	4.2	0.2
400	18.0	21.3	30.00	4.0	0.8
800	10.0	16.7	33.80	3.0	1.8
1200	8.0	18.0	34.00	3.8	1.6
1600	6.0	19.3	35.00	3.8	1.6

4. List the major hydrographic features of the Sargasso Sea; discuss briefly how these affect the biological oceanography of the Sargasso Sea.

Appendix 2

Phytoplankton Tow Log (W-36)

Tow#	Date	Time In	Minutes Towed	Flow Meter Counts	Secci Disc	Latitude	Longitude
1	10/13	1437	11	5961	9m	40°55'N	70°50'W
2	10/14	1754	14	7658	7m	38°35'N	70°42'W
3	10/16	1416	21	9401	13.5m	37°46'N	68°52'W
4	10/19	1404	56	5973?	>23m	34°01'N	62°03'W
5	10/22	0938	88	47670	>23m	30°37'N	60°25'W
6 +	10/24	1345	30	8899	-	27°04'N	60°04'W
7 +	10/27	0559	33	56598	>23m	22°09'N	58°39'W
8	10/28	0617	55	½m net	-	21°10'N	58°38'W
9 +	10/29	1359	61	28062	>25m	18°42'N	60°16'W
10 +	10/30	0758	65	23393	>23m	17°19'N	61°09'W
11	10/30	1205	42	6211	>23m	17°00'N	61°23'W
12 +	10/30	1505	28	1999	>23m	17°00'N	61°31'W
13 +	11/3	1548	95	6185	30m	16°56'N	61°43'W
14 +	11/3	2037	46	389	-	16°42'N	61°56'W
15 +	11/4	0116	75	18401	-	16°29'N	62°06'W
16 +	11/4	1623	81	1032	34m	16°04'N	62°11'W
17 +	11/5	1833	60	2928	-	15°21'N	62°03'W
18 +	11/6	1321	90	6658	29m	14°27'N	62°12'W
19 +	11/7	0810	39	-	28m	13°17'N	61°29'W
20	11/16	1304	88	8373	>44m	15°08'N	62°51'W
21	11/16	2337	142	11149	-	15°14'N	63°10'W
22	11/17	1549	51	3340	-	15°39'N	63°39'W
23	11/18	0030	60	2478	-	16°12'N	63°34'W
24	11/18	0832	81	3314	35.5m	16°40'N	63°26'W
25	11/19	1050	47	333	Demonstration only		
26	11/20	1400	30	547	"	"	
A1	11/2	1630	5	249	1.3m	Indian Creek	
A2	11/2	1800	5	-	3.0m	Falmouth Harbour	
A3	11/3	1800	5	-	3.0m	English Harbour-inner	
A4	11/3	0600	*	-	5.5m	English Harbour-outer	

*250 quart bucket sample

#+ Nutrient sample taken - see nutrient log

Appendix 3
Bathythermograph Log (W-36)

BT#	Date	Local Time	Latitude	Longitude	Surface Temp. (°C)
1	10/13	2445	40°55'N	70°50'W	14.5
2	10/13	1625	40°42'N	70°47'W	16.0
3	10/13	1800	40°34'N	70°43'W	15.5
4	10/13	2020	40°11'N	70°37'W	16.7
5	10/14	0900	38°52'N	70°30'W	21.1
6	10/14	1300	38°48'N	70°43'W	21.5
7	10/14	1520	38°45'N	70°46'W	21.4
8	10/16	0725	38°02'N	69°19'W	23.2
9	10/16	0920	39°57'N	69°11'W	25.5
10	10/16	1055	37°49'N	68°52'W	27.3
11	10/16	1215	37°48'N	68°34'W	26.1
12	10/17	0850	37°54'N	66°14'W	25.0
13	10/17	1115	37°45'N	65°14'W	24.5
14	10/17	1340	37°33'N	65°28'W	24.3
15	10/17	1725	37°15'N	63°00'W	25.0
16	10/17	2100	36°57'N	64°47'W	25.0
17	10/18	0200	36°34'N	64°06'W	24.5
18	10/18	0415	36°24'N	63°52'W	24.7
19	10/18	0720	33°02'N	63°40'W	25.5
20	10/18	0950	36°06'N	63°27'W	25.4
21	10/18	1245	36°00'N	63°14'W	25.5
22	10/18	1700	35°35'N	62°56'W	25.7
23	10/19	1925	33°55'N	61°52'W	25.5
24	10/20	0630	33°30'N	60°49'W	26.2
25	10/20	0915	33°24'N	60°36'W	26.0
26	10/20	1500	33°19'N	60°19'W	25.3
27	10/21	0715	32°58'N	60°24'W	24.9
28	10/21	1130	32°36'N	60°24'W	24.9
29	10/22	0950	30°37'N	60°26'W	25.8
30	10/22	1400	30°17'N	60°25'W	25.8
31a	10/24	0945	27°06'N	60°07'W	27.4
31b	10/25	0545	25°47'N	59°24'W	27.3
32	10/25	2210	24°35'N	59°06'W	27.5
33	10/26	0950	23°38'N	59°03'W	27.5
34	10/27	0615	22°10'N	58°40'W	27.3
35	10/27	1130	21°52'N	58°46'W	27.8
36	10/27	1200	21°54'N	58°43'W	28.0
37	10/27	1230	21°47'N	58°45'W	28.0
38	10/27	1300	21°44'N	58°44'W	28.0
39	10/27	1330	21°42'N	58°43'W	28.0
40	10/27	1345	21°41'N	58°43'W	27.9

(continued)

Bathythermograph Log continued

41	10/27	1400	21°38'N	58°42'W	27.9
42	10/27	1430	21°35'N	58°40'W	27.9
43	10/27	1500	21°32'N	58°37'W	27.8
44	10/27	1530	21°29'N	58°35'W	27.5
45	10/27	1600	21°27'N	58°34'W	27.5
46	10/27	1630	21°23'N	58°31'W	27.5
47	10/27	1700	21°19'N	58°29'W	27.7
48	10/27	1730	21°17'N	58°27'W	27.5
49	10/27	1950	21°11'N	58°26'W	29.0
50	10/27	2130	21°07'N	58°24'W	27.5
51	10/27	2300	21°04'N	58°20'W	27.5
52	10/28	0300	21°13'N	58°36'W	27.4
53	10/28	0640	21°10'N	58°42'W	27.5
54	10/28	0900	21°02'N	58°40'W	28.0
55	10/28	1130	21°13'N	58°47'W	27.8
56	10/28	1310	21°10'N	58°50'W	27.8
57	10/28	1500	20°55'N	58°57'W	27.5
58a	10/28	1710	20°44'N	59°06'W	27.6
58b	10/28	2100	20°34'N	59°12'W	27.5
59	10/29	1000	19°10'N	60°06'W	27.6
60	10/29	1410	18°41'N	60°29'W	27.9
61	10/30	0840	Stylus failure		
62	11/3	2030	16°46'N	61°53'W	27.8
63	11/4	0125	16°29'N	62°06'W	27.9
64	11/4	1625	16°04'N	62°12'W	28.8
65	11/5	1720	15°26'N	62°08'W	27.6
66	11/6	1330	14°28'N	62°12'W	28.3
67	11/7	0136	14°20'N	62°29'W	26.5
68	11/8	0205	13°18'N	61°30'W	27.5
69	11/8	0750	13°22'N	61°26'W	28.5
70	11/16	1500	15°06'N	62°51'W	28.3

Appendix 4

Neuston Log

Tow#	Date	Time Start	Time Finish	Minutes Towed	Log Start	Log Finish	Position
1	10/19	1505	1525	20	703.4	704.4	62°03'W 34°01'N
2	10/20	1755	1815	20	0.77 miles		60°14'W 32°22'N
3	10/21	1755	1815	20	881.2	881.8	60°14'W 32°29'N
4	10/22	1505	1537	32	015.0	016.0	60°25'W 30°07'N
5	10/23	1139	1203	24	016.2	017.2	60°33'W 28°12'N
6	10/23	1810	1831	21	043.8	044.5	60°18'W 27°30'N
7	10/24	1250	1322	32	195.6	196.4	60°07'W 27°06'N
8	10/25	0642	0711	29	084.3	085.5	59°22'W 25°37'N
9	10/25	1715	1745	30	ass. 1 mile		59°09'W 25°00'N
10	10/26	1220	1252	32	414.5	415.2	59°02'W 23°32'N
11	10/27	0603	0633	30	taffrail out		58°39'W 22°09'N
12	10/29	1513	1543	30	817.5	817.5	60°30'W 18°49'N