CRUISE REPORT

W-67

Scientific Activities

St. Thomas - Bonaire - Belize - Miami

25 November 1982 - 5 January 1983

R/V Westward

Sea Education Association

Woods Hole, Massachusetts

SHIPBOARD DRAFT

PREFACE

This cruise report is intended to serve as an outline of the scientific research and academic program conducted on board the R/V Westward during her sixty-seventh cruise, which took place during the winter of 1982. Included are the abstracts from a series of projects that the students had defined prior to the cruise while taking the Shore Component in Woods Hole. Also reported herein are data which are being incorporated in the long-term studies of S.E.A. staff scientists and associated researchers. The bulk of this report was written at sea and is not intended to represent the final analysis or interpretation of data generated during this cruise.

R/V Westward cruise W-67 was one of the most productive oceanographic cruises in which I have participated. Much of the success of the cruise was due largely to an enthusiastic and skillful crew. Completion of all of the scientific goals was made possible by the tireless efforts of the staff and the cooperation between everyone.

I am particularly indebted and grateful to the Captain, Paul DeOrsay, for his help and interest in accomplishing our scientific objectives. In addition, I very much appreciated his continued support through port stops, especially helping to organize and drive a field trip through the wilder parts of Bonaire!

Paul was supported by three mates of extraordinary skill. Gregg Swanzey, Michael Mulhern and Peg Brandon brought to Westward considerable experience from other large sailing vessels, and their help throughout the cruise made completion of stations a pleasure. Our engineer, Dan Brashear, provided a constant source of advice for problems with

analytical equipment. In particular, special thanks are in order to Dan, as well as to Gregg, for the many hours of work that they put in when the hydrowinch broke down. Only through their efforts were we able to continue without a major disruption to the cruise. Finally, where would we have been without Malinda? As steward, she provided the ship with a constant stream of excellent food - her culinary skills are outstanding.

I was fortunate enough on this cruise to have three excellent assistant scientists. Don Levitan assumed much of the burden of gear maintenance and laboratory preparations, as well as providing a seemingly endless knowledge of marine invertebrates. Tim Slauson proved to be an effective teacher and scientist, bringing to Westward an interest in fishes, particularly sharks. His keen sense of humor and sharp wit kept spirits high and he provided much of the entertainment for our holiday festivities. Bob McLaughlin came to Westward with considerable experience in marine education. His strong commitment to teaching was evident, and his efforts in that direction were greatly appreciated by us all.

I offer my sincere thanks to all of these mentioned above and, most of all, to the Sea Semester students who contributed to a highly successful cruise!

Susan E. Humphris
Chief Scientist

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INTRODUCTION

This cruise report provides a record of the scientific research activities conducted during cruise 67 of the R/V Westward. This cruise, which was preceded by a rigorous six week course on shore, emphasized the application of theoretical concepts to the study of the ocean, and consisted of Oceanographic Laboratory I and II (Boston University course numbers NS-225 and NS-226).

The itinerary and cruise track (Table 1 and Figure 1) took us to both open ocean and nearshore sub-tropical marine environments and provided students with the opportunity to investigate a wide variety of oceanographic and marine biological problems.

Although a major theme for the cruise was multi-disciplinary studies of localized water masses in the Caribbean Sea, numerous other projects were completed. The bulk of this cruise report consists of the abstracts from student projects. These are generally arranged and divided into sections on a geographical basis, with the objectives of the research discussed in the Introduction to each section.

The positions for all oceanographic stations and scientific operations are listed in Appendices I and II, and shown in Figure 2. Information herein should not be excerpted or cited without the permission of the Chief Scientist.

Table 1. Itinerary of R/V Westward cruise W-67

	<u>Depart</u>	<u>Date</u>	<u>Arrive</u>	<u>Date</u>
Leg I	Charlotte Amalie, St. Thomas	11/25/82	Kralendijk, Bonaire	12/07/82
Leg II	Kralendijk, Bonaire	12/09/82	Belize City, Belize	12/21/82
	Belize City, Belize	12/24/82	Ramsay's Cay, Belize	12/24/82
Leg III	Ramsay's Cay, Belize	12/26/82	Miami	01/04/83

Figure 1. Cruise Track of the R/V Westward cruise W-67: 25 November 1982 - 5 January 1983.

Figure 2. Oceanographic stations conducted during cruise W-70.

Table 2. Ship's complement for R/V Westward cruise W-67

Nautical Staff

Paul B. DeOrsay	Captain
Gregg H. Swanzey	Chief Mate
Michael C. Mulhern	Second Mate
Peg E. Brandon	Third Mate
Daniel R. Brashear	Engineer
Malinda K. Jones	Steward

Scientific Staff

Susan E. Humphris	Chief Scientist
Don R. Levitan	Assistant Scientist
Tim P. Slauson	Assistant Scientist
Bob A. McLaughlin	Assistant Scientist

Students

Jennifer G. Blank, Stanford University, Senior, Geology
 Maria-Victoria Chattey, Johns Hopkins University, Junior, Oceanography
 Duff A. Dean, Connecticut College, Junior, Zoology
 Syma A. Ebbin, Williams College, Senior, Biology
 Susan J. Grinols, Skidmore College, Senior, Biology
 John H. Grosvenor, Jr., Bowdoin College, Senior, Economics
 Shannon B. Gunn, University of Tulsa, Junior, Chemical Engineering
 John R. Leazer, University of Miami, Junior, Liberal Arts
 James W. Long, Boston University, Senior, Biology
 Carolyn L. McConnell, Tulane University, Senior, Biology
 Jeffrey T. Melby, Cornell University, Junior, Geology
 Elizabeth J. Miller, Connecticut College, Senior, Psychology/
 Linguistics
 Richard P. Paczynski, Boston College, Junior, Universal Studies
 John R. Polisar, Cornell University, Junior, Fine Arts/Natural
 Resources
 William M. Pulliam, Stanford University, Senior, Biology
 Aaron S. Rachlin, University of Pennsylvania, Junior, Geology
 David W. Raible, Cornell University, Senior, Biology
 Karen K. Rasmussen, Carleton College, Junior, Geology
 Deborah L. Reinke, Colby College, Junior, Biology
 Christopher P. Sagovac, Cornell University, Junior, Mathematics
 Linn S. Speers, Connecticut College, Senior, Human Ecology
 Karen L. Susskind, Tufts University, Junior, Biopsychology
 Margaret C. Thompson, Smith College, B.S., Biology
 Monica H. Woelfel, Swarthmore College, Junior, Biology

ACADEMIC PROGRAM

Throughout the cruise, a 24-hour science watch was maintained by a member of the staff and three students. Their responsibilities included maintenance of the science log, completion of scientific stations, routine observations of oceanographic and meteorological parameters, and continuation of the scientific program in terms of analysis of samples and interpretation of data. In addition, time was made available for individual student instruction and work on their projects. The responsibilities of the students were increased gradually over the cruise, culminating in each student being designated Junior Science Watch Officer for two or three watches, during which they were responsible for the efficient running of the lab and the progress of the scientific program.

Formal instruction on a daily basis was provided in the form of lectures. Lecture topics, listed in Table 3, included principles behind sampling and analytical methodology, oceanographic characteristics of areas under study, and discussion of the on-going research activities. In addition, a collection of fauna and flora ("Feature Creatures") was assembled from a variety of marine environments in an attempt to familiarize the students with the life history and adaptations of important marine vertebrates, invertebrates, and plants.

Students were also required to complete a research project, either individually or as a small group. These projects were defined by the students during the shore component, with the presentation of a formal, written project proposal. The projects selected covered a variety of oceanographic topics. The work was completed while at sea, and written reports submitted before the end of the cruise. In addition,

a 10-minute presentation of each project and its results was given by each student. The abstracts of the papers comprise the bulk of this report.

Table 3. Oceanography Lectures During W-67

25 November	Scientific Objectives - Leg I	Susan Humphris
26 November	Measurement of temperature in the ocean	Susan Humphris
29 November	Geology of the Lesser Antilles and Caribbean	Susan Humphris
30 November	Circulation of the Caribbean Sea	Susan Humphris
1 December	Coral reef ecology	Don Levitan
2 December	Mangroves	Don Levitan
3 December	Spectrophotometric methods	Susan Humphris
6 December	Geology of Bonaire	Susan Humphris
7-9 December	Bonaire - field trip	Susan Humphris
10 December	Scientific objectives - Leg II	Susan Humphris
11 December	Planktonic marine invertebrates	Don Levitan
13 December	Larval ecology	Don Levitan
14 December	Fish schooling	Bob McLaughlin
15 December	Shark reproduction	Tim Slauson
16 December	EXAM	
17 December	The continental margin of Belize	Susan Humphris
20 December	Student seminars	
21 December	Student seminars	
22-26 December	Belize	
27 December	Scientific Objectives - Leg III	Susan Humphris
	Competition for space on hard substrates	Don Levitan
28 December	Student seminars	
29 December	Student seminars	
30 December	Dissection of <u>Carcharhinus falciformis</u>	Tim Slauson

Table 3 (continued).

2 January	EXAM
3 January	Student seminars
4 January	Cruise summary

STUDIES OF CIRCULATION IN THE CARIBBEAN SEA

The Caribbean is a marginal sea consisting of a series of five deep basins greater than 3000 m. in depth: Grenada, Venezuela, Columbia, Cayman, and Yucatan. These basins are separated by four major submarine rises that greatly influence the distribution and circulation of the deep water masses through the Caribbean.

The general flow of water in the upper layers of the Sea is from east to west, with inflow being mainly through the island passages along the northern and eastern borders of the Caribbean Sea, and outflow through the Yucatan Straits.

Two features of the surface flow were examined during W-67. A multidisciplinary study was carried out to identify and characterize the eddies that are sometimes formed to leeward of the Lesser Antilles. Physical, chemical and biological studies were completed to the west of St. Vincent, where the presence of eddies have previously been reported (e.g. Leming, 1971). The second study on surface flow concerned the little recognized source of water entering the Caribbean Sea from the Amazon River. Nineteen percent of all freshwater input into the world's ocean is discharged at the mouth of the Amazon (Ryther *et al.*, 1967). The influence of the river extends great distances offshore and traces of the water mass have been identified off Barbados and the Lesser Antilles (e.g. Kidd and Sander, 1979). On W-67, Susskind used chemical parameters to detect the presence of Amazon Water along a transect from St. Vincent to Bonaire, while others used phytoplankton indicator species as an additional line of evidence.

Beneath the surface layer, the water column in the Caribbean Sea is highly stratified, with several major water masses having been identified in the upper 1500 m. One problem that has been revealed from these studies, however, concerns the mass balance of Antarctic Intermediate Water (AAIW) entering and leaving the Caribbean Sea/Gulf of Mexico system. According to Worthington (1968), AAIW flows into the eastern Caribbean at a rate of 10 million m³/sec. As it flows westward,

it mixes with North Atlantic Deep Water flowing into the Caribbean through the northern passages between the Greater Antilles, and begins to lose its distinguishing characteristics. The volume of AAIW leaving the area through the Straits of Florida is about 3 million m³/sec. The problem, according to Worthington (1968) is that the quantity of North Atlantic Deep Water computed to be flowing into the system is insufficient to explain the observed dilution of AAIW.

During W-67, McConnell undertook a hydrographic study of three of the major passages through which AAIW is believed to enter the Caribbean in order to determine whether previous estimates of inflow were correct.

References

- Kidd, R. and F. Sander. 1979. Influence of Amazon River discharge on the marine production system off Barbados, West Indies. J. Mar. Res., 37:669-681.
- Leming, T.D. 1971. Eddies west of the southern Lesser Antilles. Symp. on Invest. and Resources of the Carib. Sea and Adjacent Regions. Curacao, 1968. UNESCO, Paris. pp. 113-120.
- Ryther, J.H., D.W. Manzel, and N. Corwin. 1967. Influence of the Amazon River outflow on the ecology of the western tropical Atlantic. I. Hydrography and nutrient chemistry. J. Mar. Res., 25:69-83.
- Worthington, L.V. 1968. Water circulation in the Caribbean Sea and its relationship to North Atlantic circulation. In: Symp. on Invest. and Resources of Carib. Sea and Adjacent Regions. Curacao, 1967. UNESCO, Paris. pp. 181-191.

i)

STUDY OF AN EDDY IN THE LEE OF ST. VINCENT

The location and multi-disciplinary study of an eddy in the lee of St. Vincent involved a group of six students in using a variety of oceanographic techniques. Initially, a zigzag cruise track, moving away from the island of St. Vincent was set up, passing through the regions where eddies had been detected previously (Figure 3). Physical, chemical and biological parameters were then measured at various stations along the cruise track. In addition, a station was placed in the St. Lucia-St. Vincent Passage so that the inflow into the Caribbean in this area could be characterized, and another station placed outside of the likely eddy region to represent the "typical" Caribbean water column.

The abstracts that follow show the range of parameters measured during this study. In summary, an eddy was located about 30 nm west of St. Vincent (stations B and D) where mixing of inflow water (characterized by station A) and Caribbean water (characterized by station C) was observed. The eddy exhibited higher biomass than the surrounding waters and phytoplankton species composition indicated vertical mixing of different water masses inside the eddy.

Water mixing to the west of the island of St. Vincent
Christopher P. Sagovac

ABSTRACT

The presence of eddies behind the island of St. Vincent was first suggested by Ingham and Mahnken (1966), and later investigated by Leming (1971). He proposed that the eddies were generated as a result of horizontal shear of Atlantic water flowing into the Caribbean through the St. Lucia Channel. The purpose of this project was to establish the presence of an eddy to leeward of St. Vincent, and to establish the type and degree of mixing taking place.

BT transects and hydrostations were conducted in the lee of St. Vincent (Figure 3). An eddy was located thirty nautical miles to the west of the island. It exhibited a steepened thermocline and isothermal depression to about 85 m. Mixing of Atlantic water, characterized by station A, and Caribbean Water, characterized by station C, was evident in the eddy.

References

- Ingham, M.C. and Mahnken, C.V. 1966. Turbulence and productivity near St. Vincent Island, B.W.I. A preliminary report. Carib. J. Sci., 3-4,
- Leming, T.D. 1971. Eddies west of the southern Lesser Antilles. Symp. on Invest. and Resources of the Carib. Sea & Adjacent Regions. Curacao, 1968. UNESCO, Paris. pp. 113-120.

Eddy chemistry west of the St. Lucia-St. Vincent Channel

Jen G. Blank

ABSTRACT

Five hydrographic stations (Figure 3) to a depth at 300 m. were made west of the St. Lucia-St. Vincent Channel to measure the variations in water column chemistry associated with cyclonic eddies in the lee of St. Vincent (Leming, 1971). Analyses of temperature, salinity, dissolved oxygen, phosphate, and silicate (Appendix IIIC and Fig. 4), indicated that vertical mixing was occurring at stations B, D and E with regenerated nutrients being returned to the surface layers. Stations A and C showed stratified water columns indicative of regions outside an eddy.

Reference

- Leming, T.D. 1971. Eddies west of the southern Lesser Antilles.
In: Symp. on Investigations and Resources of the Caribbean
Sea and Adjacent Regions. Curacao, Nov. 1968. UNESCO, Paris.
pp. 113-120.

Figure 4. Vertical profiles of T, S, O₂, phosphate and silicate at hydrostations inside and outside the eddy.

Estimation of gross photosynthesis in the eddy behind St. Vincent

Shannon B. Gunn

ABSTRACT

The objective of this study was to estimate gross photosynthesis in the eddy and the surrounding waters in the lee of St. Vincent by two different methods. Parsons' method (1977) depends on an empirical equation based entirely on the attenuation coefficient of light in the water column. The other method (Ryther and Yentsch, 1970) takes into account maximum daily radiation and chlorophyll a concentrations.

Four stations (Figure 3) were conducted consisting of irradiation measurements and collection of water samples for fluorometric analysis of chlorophyll a, and gross photosynthesis was calculated. Station H-10 showed higher gross productivity, suggesting it was located inside the eddy.

The two methods used agreed reasonably well, but the Ryther and Yentsch (1970) equation was preferred as it took into account two of the variables affecting photosynthesis.

References

- Parsons, T.R. and Takahashi, M. 1977. Biological Oceanographic Processes. Pergamon Press, New York, 332 pp.
- Ryther, J.H. and Yentsch, C. 1970. Estimation of phytoplankton in the ocean from chlorophyll and light data. J. Mar. Res., 281-286.

Phytoplankton used as biological indicators of the presence of an eddy west of St. Vincent

Monica H. Woelfel

ABSTRACT

Speciation of phytoplankton has been used as a means of indicating the presence of certain water masses, vertical mixing, and the influence of the neritic environment (Wood, 1971). During W-67, phytoplankton indicator species were used to investigate the presence and location of an eddy to the west of St. Vincent. Hour long tows using three phytoplankton nets at 5, 60 and 90 meters depth were carried out at four stations (stations A, B, C, and E on Figure 3), and the results of the analyses are shown in Table 4. Station A, located in a passage, shows the influence of the N. Equatorial current with some vertical mixing, and is therefore believed to be outside an eddy. Stations B and E, both of which showed high phytoplankton biomass, contained species indicative of vertical mixing of several different water masses, including Amazon water at station E. This, together with the physical and chemical data available, suggests that both are influenced by eddies. Station C was outside the eddy and probably represented a typical Caribbean phytoplankton assemblage.

Reference

- Wood, E.J.F. 1971. Phytoplankton distribution in the Caribbean region. In: Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions, Curacao, Nov. 1968. UNESCO, Paris. pp. 399-410.

Table 4. Species of phytoplankton observed at eddy stations

Stations (as in Fig. 3)	A			B			C			E		
	5m	60m	90m	5m	60m	90m	5m	60m	90m	5m	60m	90m
I. Indicators *(see below)												
1. <u>Planktoniella sol</u>	x											
2. <u>Navicula membranaceae</u>				x	x	x					x	
3. <u>Hemiaulus hauckii</u>			x	x	x	x				x		
4. <u>Ceratium declinatum</u>					x							
5. <u>Leptocylindrus danicus</u>							x			x		
6. <u>Discophaera tubifer</u>											x	
7. <u>Synedra</u> sp.				x								
8. <u>Nitzschia</u> sp.			x									
II. Diatoms												
1. <u>Bacterosira</u> sp.			x			x			x	x		
2. <u>Biddulphia</u> sp.		x	x	x	x	x	x					
3. <u>Ceratualina bergonii</u>									x	x		
4. <u>Chaetoceros</u> sp.					x							
5. <u>Detonula</u> sp.	x										x	
6. <u>Guinardia</u> sp.												
7. <u>Leptocylindrus minimus</u>										x		
8. <u>Mesocera polymorpha</u>					x							
9. <u>Paralia sulcata</u>									x			
10. <u>Phormidian</u> sp.												x
11. <u>Rhizosolenia</u> sp.											x	
III. Dinoflagellates												
1. <u>Ceratium</u> sp.	x	x		x	x	x	x			x		x
2. <u>Glenodinium</u> sp.		x										
3. <u>Gymnodinium</u> sp.							x	x				
4. <u>Ornithocerus</u> sp.	x				x					x		
5. <u>Oxytoxum</u> sp.						x						
6. <u>Peridinium</u> sp.			x	x			x				x	
7. <u>Pyrocystis</u> sp.											x	
IV. Cyanophyta												
1. <u>Anabaena</u> sp.	x											
2. <u>Aphanizomenon</u> sp.							x					
3. <u>Coelosphaerium</u> sp.								x			x	
4. <u>Lyngbya</u> sp.							x		x			
5. <u>Nodularia</u> sp.		x										
6. <u>Oscillatoria</u> sp.			x				x	x		x	x	x
7. <u>Pelagothrix</u> sp.												

Table 4 (continued).

	A			B			C			E		
	5m	60m	90m	5m	60m	90m	5m	60m	90m	5m	60m	90m
V. Chlorophyta												
1. <u>Ankistrodesmus</u> sp.			x									
2. <u>Botryococcus</u> sp.		x										
3. <u>Hyalotheca</u> sp.							x					
4. <u>Microspora</u> sp.		x		x		x				x		x
5. <u>Sirogonium</u> sp.												x
6. <u>Zygnema</u> sp.							x		x			
VI. Mastigophora												
1. <u>Chlamydomonas</u> sp.	x											
2. <u>Dictyocha</u> sp.							x					x
3. <u>Distephanus</u> sp.		x										x
4. <u>Phaeocystis</u> sp.			x									

* Indicators

- 1, 4, 6 - vertical mixing
- 2, 7 - neritic influence, with possible vertical mixing
- 3 - influence of N Equatorial Current
- 5 - presence of Amazon water; neritic influence
- 8 - influence of Sub-tropical Underwater

Investigation of zooplankton populations in the eddy behind St. Vincent
Maria-Victoria Chattey

ABSTRACT

A series of oblique meter net tows were carried out at five stations (Figure 3) to investigate the influence of an eddy system on the abundance and diversity of zooplankton.

Biomass was shown to range from a high of 6.85 mL/100m³ at Station B to 2.15 mL/100m³ at Station C. Individuals from 13 main orders were counted and the results are shown in Table 5 and Figure 5, Station B exhibited the highest diversity (Shannon-Weaver index of 1.97) which was probably due to mixing of several different water masses within the eddy.

Table 5. Composition of zooplankton found during eddy study

Taxonomic Order	Stations (as in Figure 3)				
	A	B	C	D	E
Anguilliformes (eel larvae)	1.30	0.50	-	1.20	-
Decapoda	18.80	18.00	7.25	4.80	3.60
Euphausiacea	7.60	12.10	2.00	2.40	0.30
Amphipoda	2.40	2.00	0.65	0.60	0.30
Stomatopoda	0.40	1.80	0.20	-	0.90
Mysidacea	2.40	15.30	2.30	1.70	2.60
Errantia (sub class)	0.30	0.50	-	0.40	0.90
Chaetognatha (phylum)	8.50	3.90	17.60	17.30	15.10
Chordata (phylum)	3.20	2.70	0.90	1.30	0.60
Thecosomata	2.30	3.00	1.10	2.60	0.30
Calanoida	50.60	34.50	65.10	65.40	74.30
Harpacticoida	1.40	4.60	1.10	1.10	1.60
Cyclopoida	0.80	1.10	1.80	1.20	1.00
# of Org. counted	310	394	441	522	382

Figure 5. Composition of zooplankton at stations A-E in the eddy study.

Mesopelagic fish populations in the eddy behind St. Vincent

William M. Pulliam

ABSTRACT

Mesopelagic organisms spend most of their lives at depths below the levels of primary production in the ocean. However, they depend on surface productivity for food, and consequently variations in surface productivity should be reflected in the mesopelagic zone.

This research examined the effects of small scale changes in surface productivity on mesopelagic fish by investigating variations across an eddy behind St. Vincent, where surface productivity is increased by turbulence and mixing. Six oblique multi-net tows were conducted - five near St. Vincent inside and outside the eddy (Figure 3), and one away from coastal influences chosen to represent Caribbean fauna (St. W67-33 at 14°53'N x 75°50'W). Total fish biomass was determined by volume displacement and all identified to species (Table 6).

The elevated surface production in the eddy had no discernible effect on the abundance and biomass of mesopelagic fish. The samples from within the eddy immediately west of the island showed a greater species diversity than those from other stations. This may be due to a mixing of the Atlantic and Caribbean faunas which meet along the Antilles arc. Hence, this suggests that the mesopelagic fauna is not significantly affected by small-scale near-surface features, such as eddies.

Table 6. Total number and species of mesopelagic fish caught during the eddy study

Station #	W67-17	W67-19	W67-20	W67-22	W67-25	W67-33
Family Gonostomatidae						
<u>Pollichthys mauli</u>	-	-	-	-	-	1
<u>Vinciguerrria nimbaria</u>	-	2	-	-	2	1
<u>Gonostoma elongatum</u>	-	2	-	2	2	1
<u>Cyclothone microdon</u>	-	-	-	-	-	1
<u>Cyclothone sp.</u>	-	-	1	-	-	-
<u>Bonapartia pedaliota</u>	-	-	-	-	-	1
<u>Valencienellus tripunctulatus</u>	-	1	1	-	-	-
Family Sternoptychidae						
<u>Argyropelecus acculeatus</u>	-	1	-	-	-	-
Family Astronesthidae						
<u>Astronesthid sp.</u>	-	1	-	1	1	-
Family Melanostomiatidae						
<u>Eustomias sp.</u>	-	-	-	-	-	1
<u>Leptostomias gladiator</u>	-	-	1	-	-	-
Family Myctophidae						
<u>Myctophum asperum</u>	-	-	-	-	-	1
<u>Myctophum obtusirostre</u>	-	1	-	-	-	-
<u>Diaphus splendidus</u>	-	-	1	1	2	1
<u>D. brachycephalus</u>	-	1	-	1	-	-
<u>D. problematicus</u>	-	-	1	1	-	-
<u>D. termophilus</u>	-	-	-	-	-	1
<u>Lepidophanes guentheri</u>	1	7	5	14	18	18
<u>Lobianchia gemellari</u>	-	1	2	-	-	-
<u>Ceratoscopelus warmingii</u>	-	-	1	-	1	-
<u>Notolychnus valdiviae</u>	-	10	4	3	2	5
<u>Benthosoma suborbitale</u>	-	-	-	-	3	-
<u>Lampadena luminosa</u>	-	-	-	-	1	1
<u>Bolinichthys supralateralis</u>	-	-	-	-	-	4
Total Fish	1	27	17	23	32	37
Total Species	1	10	9	7	9	13
Species diversity						
Shannon-Weaver index	0	1.84	1.95	1.33	1.56	1.84
Simpson's index	0	0.78	0.82	0.60	0.66	0.73

The influence of Amazon River water on the salinity and silicate concentrations in the Caribbean Sea

Karen Susskind

ABSTRACT

Amazon water has been shown to significantly affect the chemical and biological characteristics of waters in the region of the Caribbean Sea (e.g. Calef and Grice, 1967; Froelich et al., 1978; Kidd and Sander, 1979). Pathways of Amazon River water were investigated using salinity and nutrient chemistry. Surface salinities were taken from approximately 13°N 63°W to Bonaire (Figure 6). Hydrocasts were completed when low surface salinities were encountered, and the results of chemical analyses presented in Appendix IIIId. Three lenses of low salinity surface water were encountered, as shown in Figure 7, located at 12°44'N x 63°47'W, 12°50'N x 67°04'W, and 12°18'N x 67°49'W. Salinity and silicate data (Figure 8) indicated that this surface water mass extended to a depth of 50-60 m. and was characterized by salinities of less than 35.5 ‰ and silicate concentrations of 2-4 µM/L. This suggests the presence of Amazon water at these locations, which was confirmed by the presence of Amazon River phytoplankton indicator species.

References

- Calef, G.W. and Grice, G.D. 1967. Influence of the Amazon River outflow on the ecology of the western tropical Atlantic.
II. Zooplankton abundance, copepod distribution, with remarks on the fauna of low salinity areas. *J. Mar. Res.*, 25, 84-94.
- Froelich, P.N., Atwood, D.K. and Giese, G.S. 1978. Influence of Amazon River discharge on surface salinity and dissolved silicate concentration in the Caribbean Sea. *Deep Sea Res.*, 25, 735-744.
- Kidd, R. and Sander, F. 1979. Influence of Amazon River discharge on the marine production system off Barbados, West Indies. *J. Mar. Res.*, 37, 669-681.

Figure 6. Transect and station locations used in the Amazon Water study.

Figure 7. Surface salinities along the transect from St. Vincent - Bonaire
(track shown in Figure 6).

Figure 8. Vertical profiles of chemical parameters for hydrocasts conducted for the Amazon Water study.

Indicator plankton species for Amazon Water

Tim Slauson and 'C' Watch

The presence of lenses of Amazon water in the Caribbean Sea has been found to be detectable by their distinctive salinities, silicate concentrations, and phytoplankton species. Certain species of diatoms and dinoflagellates are thought to be associated with water masses of low salinity from Amazon River discharge (Wood, 1968; Lawson and Maybaum, 1982).

Near-surface phytoplankton tows were conducted simultaneously with the hydrostations discussed by Susskind (W67-25, W67-26, W67-27). Three subsamples were taken from each station and phytoplankton counted: the results of the abundance and identification of Amazon indicator species are presented in Table 7. Evidence was found at all three stations of at least one Amazon species being present in the water column. In addition, Woelfel in her eddy study also found Amazon indicator species at two stations. These findings therefore are in agreement with those of Susskind, and suggest that lenses of Amazon water enter the eastern Caribbean and can be traced by both chemical and biological parameters.

References

- Lawson, J. and H. Maybaum (1982). The influx of Amazon River water into the Caribbean Sea. S.E.A. Cruise Report W-61, p. 23.
- Wood, E. 1968. Phytoplankton distribution in the Caribbean region. Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions, Curacao, Netherlands Antilles, Nov. 1968. UNESCO, Paris, 1971. pp. 399-410.

Table 7. Phytoplankton found at three stations in Southern Caribbean
(Station locations in Figures 3 and 6; values are % of total counts)

Phytoplankton species	S T A T I O N				
	W67-21	W67-23	W67-25	W67-26	W67-27
Non-Amazonian Species			98	97	97
Amazonian Species			2	3	3
<u>Ceratium declinatum</u>	-	-	-	1	1
<u>Ceratium macroceros</u>	-	-	-	-	2
<u>Leptocylindrus danicus</u>	1*	1*	-	1	-
<u>Pyrophacus horologicum</u>	-	-	-	1	-
<u>Thalassiothrix nitzchoides</u>	-	-	2	-	-

* from study by Woelfel, found at 5 m.

Volumetric transport of Antarctic Intermediate Water through the passages of the Lesser Antilles

Carolyn L. McConnell

ABSTRACT

A major problem in our understanding of the circulation of the Caribbean Sea concerns the mass balance of Antarctic Intermediate Water. According to Worthington (1968), AAIW flows into the eastern Caribbean at a rate of 10 million m^3/sec , but only 3 million m^3/sec can be accounted for exiting through the Florida Straits.

The purpose of this study was to investigate the transport of AAIW through three passages in the Lesser Antilles. Hydrographic stations were conducted to leeward of the sills across the Dominica, St. Lucia, and St. Vincent Passages (Figure 9). Temperature, salinity, dissolved oxygen and silicate concentrations were determined (Appendix IIIb) and used as indicators of AAIW. Profiles of these parameters (Figures 10 and 11) suggested that the water mass was flowing into the eastern Caribbean at depths of 750-900 m. Using previous estimates of water velocity (Gordon, 1967), a total volume transport of AAIW for these three passages was calculated to be 1.1 million m^3/sec . Estimating flow through the Windward and Anegada Passages and assuming the same depth range for AAIW in these passages, the total volume transport of AAIW into the Caribbean Sea was calculated to be about 4.5 million m^3/sec . This figure comes much closer to the estimate of outflow through the Yucatan Straits, and hence accounting for circulation of AAIW in the Caribbean.

References

- Gordon, A.L. 1967. Circulation of the Caribbean Sea. J. Geophys. Res. 72, 6207-6213.
- Worthington, L.V. 1968. Water circulation in the Caribbean Sea and its relationship to North Atlantic circulation. In: Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions. Curacao, 1967. UNESCO, Paris. pp. 181-191.

Figure 9. Hydrographic stations conducted for AAIW study.

Figure 10. Vertical profiles of T, S, O_2 , and silicate in the passages of the Lesser Antilles.

Figure 11. Vertical profiles of temperature, salinity, oxygen, and dissolved silicate
in the passages of the Lesser Antilles (continued)

c) ST. LUCIA - ST. VINCENT PASSAGE

BANK STUDIES

1. SABA BANK

Saba Bank is an isolated shoal area located at 17°25'N, 63°30'W, about 5 km southwest of the volcanic island of Saba. It is a completely submerged platform 20-30 m. below sea level that covers 1300 sq. km. The only previous work in the area was a geological reconnaissance survey (MacIntyre *et al.*, 1975) which indicated minimal reef development with sediments rich in residual material derived from late Cenozoic bedrock.

The W-67 cruise track traversed Saba Bank, and so the opportunity was taken to make a bathymetric profile and collect sediment samples. Figures 12 and 13 show the transect line and the profile obtained. The platform rose very sharply from a depth of about 950 m. up to 36 m. on the northern edge and, although the Bank was fairly flat, it gradually increased in height to a depth of 19 m. at the southern edge. There was also a distinct shelf-edge ridge on the southern side.

Analysis of the sediment samples suggested that Saba Bank is covered dominantly by carbonate sediments ranging in size from gravel to fine sand. Skeletal, grains of coral, Halimeda, molluscs and foraminifera made up most of the carbonates. The sediment also contained between 2 - 5% non-carbonate material consisting mostly of volcanic glass and minerals. The sediments exhibited a wide range of size and sorting with no distinct pattern of variation across the Bank.

Reference

MacIntyre, I.G., D.J.J. Kinsman, and R.C. German. 1975. Geological reconnaissance survey of Saba Bank, Caribbean Sea. *Carib. J. Sci.*, 15, 11-15.

Figure 12. Transect across Saba Bank.
(Soundings in fathoms)

Figure 13. Bathymetric profile across Saba Bank.

2. ROSALIND BANK

Rosalind Bank is a shoal area, located about 16°30'N x 80°20'W, which forms part of the Nicaragua Rise. The origin of the Rise is unknown, although it has been suggested that it was formed during the early Mesozoic due to rifting and separation of the American-Afro-European continental plates (Arden, 1969).

Although the Rosalind Bank has not been previously studied, another shoal - Pedro Bank - which lies about 100 miles to the north-east has been found to have a granodiorite basement overlain by about 2000 m. of tertiary carbonates (Uchupi, 1975). It is believed that shortly after the formation of Pedro Bank subsidence began and has continued with reefal accumulation on top of the bank keeping pace with subsidence.

During W-67, both geological and biological studies were carried out on Rosalind Bank. The objective of the geological study was to obtain a bathymetric profile across the Bank and to collect surface sediment samples in order to investigate its structure and present sediment composition. The biological study was designed to test the hypothesis that a shoal area surrounded by deep water might result in a localized area of higher productivity due either to upwelling on the Bank or to vertical mixing of nutrients released from the sediments.

References

- Arden, D.D. 1969. Geological history of the Nicaraguan Rise. Trans. Gulf. Coast Assoc. Geol. Soc., 19, 295-309.
- Uchupi, E. 1975. Physiography of the Gulf of Mexico and Caribbean Sea. In: Nairn, A.E.M. and F.G. Stehli: The Ocean Basins Margins, Vol. 3, pp. 1-64.

i) A geological investigation of Rosalind Bank

Jeff Melby
Karen Rasmussen

ABSTRACT

The Rosalind Bank is a shoal area about 63 miles long and 35 miles wide which forms part of the Nicaragua Rise. This study was conducted to investigate the topography and surface sediment composition of the Bank in order to gain an understanding of the origin of the Bank.

A transect was made across the Rosalind Bank (Figure 14) using a continuously recording echo sounder and collecting sediment samples, with a Fisher scoop or sediment grab. Analyses of grain size, as well as composition, were completed.

The bathymetric profile (Figure 15) indicated that the bank consists of steep sides with a relatively flat top which slopes to the west. There also appears to be some evidence of at least four terraces, although small scale topographic relief obscures this to some extent. The sediments (Figure 16) are well sorted and are composed almost exclusively of carbonates, such as Halimeda plates, foraminifera and corals. This suggests that for a portion of its history, the Rosalind Bank had an active shallow water, coral reef community, although today it appears to be characterized by patches of soft coral in a more barren, fine-grain carbonate sediment.

Figure 14. Location of transect and stations on Rosalind Bank.

Figure 15. Bathymetric profile across Rosalind Bank (transect shown in Figure 14).

Figure 16. Analyses of grain size distribution of sediments from Rosalind Bank.

ii) Circulation and biomass on Rosalind Bank

Jim W. Long

ABSTRACT

A study was conducted to investigate whether circulation around and on Rosalind Bank - a small shoal which constitutes part of the Nicaragua Rise - gives rise to a local area of more productive water over the Bank.

Bathythermographs, hydrostations and zooplankton tows were conducted on and in the vicinity of Rosalind Bank (Figure 14). Measurements and analyses included T, S, O₂, PO₄³⁻ and biomass. Biomass measurements indicated that zooplankton were more abundant over the Bank (biomass of 1.99 mL/m³) compared with the nearby pelagic zone (biomass of 0.34 mL/m³). The profiles obtained from hydrocasts (Appendix IIIe and Figure 17) indicated some mixing over the Bank, with higher levels of phosphate being present.

Upwelling was not indicated from the BT information, and consequently it is suggested that high levels of productivity are maintained in the water column over the Bank by vertical mixing of nutrients regenerated from the sediments.

Figure 17. Variations in chemical parameters down the water column
on and off Rosalind Bank.

a) Station W67-36 H-28

b) Station W67-38 H-30

c) Station W67-40 H-31

VERTICAL MIGRATION STUDIES

Diurnal vertical migration (DVM) has been a known phenomenon of oceanic organisms for a long time. Many theories have been proposed as to the advantage of this behavior. However, one factor they respond to appears to be the amount of ambient light which penetrates to different ocean depths during changes of daylight and weather conditions (Boden and Kampa, 1967).

Phytoplankton exhibit reverse migration, i.e. moving up in the water column and dispersing during the day, and returning to deeper water during the night. This pattern is believed to be a phototactic response designed to optimize the light level required for photosynthesis (e.g. Staker and Bruno, 1980).

The basic migration pattern of zooplankton and mesopelagic fishes is an ascent to shallower levels during the evening and then descent back to their resting levels as light starts penetrating into the water column. Although light is widely accepted as the migrating and controlling factor for this migration, there is still considerable controversy about the way in which organisms interpret the light stimulus.

During W-67, three students focussed their attention on different aspects of migration. A 24-hour station was conducted during which samples were collected from a variety of depths at regular intervals. Thompson investigated the migration patterns of phytoplankton, using chlorophyll a concentration as an indicator of phytoplankton abundance. Reinke studied the relation between pigmentation and DVM patterns in copepods testing the hypothesis that copepods should exhibit different migration patterns so as to maximize the advantages of their various pigments.

Finally, mesopelagic fishes were collected by Grinols, whose objective was to determine whether they migrate in response to hunger by observing their migration depths with reference to their food source, and also by looking at stomach contents. The abstracts from these three projects follow.

The diurnal vertical migration of phytoplankton in the Caribbean Sea
Margaret C. Thompson

ABSTRACT

Phytoplankton migrate to the surface during the day, and return to deeper water at night. This migratory pattern is believed to be primarily a phototactic response to optimize lighting conditions for photosynthesis (e.g. Staker & Bruno, 1980). During W-67, a study was made of the changes in the vertical distribution of phytoplankton over a 24-hour period. Water samples were collected in Nansen bottles from 0-90 meters at 15 meter intervals four times during the day at 15°22'N x 70°40'W. Chlorophyll concentration was used as an indicator of phytoplankton abundance, and was determined photometrically.

Variations in the vertical distribution of the phytoplankton throughout the day were observed (Figure 18). The phytoplankton were dispersed during the night, and then appeared to congregate near the surface during the early morning. Two distinct chlorophyll maxima appeared during the day, centered at about 15 and 60 m. Just after sunset the phytoplankton appeared to disperse. The two maxima observed represent two independently migrating groups, which may be composed of different species of phytoplankton.

Reference

Staker, R.D. and Bruno, S.F. 1980. Diurnal vertical migration in marine phytoplankton. *Botanica Marina*, 23, 167-172.

Figure 18. Vertical profiles of chlorophyll a in the water column in a twenty-four hour period.

Vertical distribution and migration of copepods according to pigmentation
Deborah L. Reinke

ABSTRACT

Diurnal vertical migration is a common phenomenon in all marine groups with planktonic representatives. Many theories have been proposed as to the advantage of this behavior; however, one factor they respond to appears to be the light intensity (e.g. Boden and Kampa, 1967). This project was designed to investigate the distribution of variously pigmented copepods, since they should exhibit different migration patterns in order to maximize their biological advantages of distribution throughout the water column. Five nets were towed at various depths for 1½ hours, four times during a 24-hour period at 15°22'Nx77°40'W. Biomass was measured by volume displacement, and the samples analyzed for the quantities of variously colored copepods (Figure 19). Red copepods were found to migrate most extensively, showing highest abundances at the surface at sunset. Blue copepods were found to generally inhabit the surface waters above 5 m., with possible downward dispersion around noon at times of highest ambient light intensity. Transparent and black-striped copepods both showed uniform distribution in the water column at midnight, and a migration pattern reversed to that of the red copepods. These data therefore indicate that copepods exhibiting different pigmentation also show variation in their distribution and patterns of diurnal vertical migration.

Reference

- Boden, B.P. and Kampa, E.M. 1967. The influence of natural light on the vertical migration of an animal community at sea. Symp. Zool. Soc. Lond., 19, 15-26.

Figure 19. Distribution of variously pigmented copepods during a
twenty-four period.

The vertical migration of mesopelagic fish
Sue Grinols

ABSTRACT

Mesopelagic fishes of the Families Gonostomatidae and Myctophidae migrate vertically through the water column in a diurnal pattern. This study was designed to determine whether the fishes follow their food source during migration, and also whether there is any correlation of migration with hunger, as indicated by their stomach contents.

Five nets were towed at different depths for about 1½ hours four times during a 24-hour period at 15°22'N x 77°40'W. Biomass was measured, and mesopelagic fish identified and dissected for stomach contents. A correlation between zooplankton biomass and numbers of mesopelagic fishes during daily vertical migration was observed (Figure 20). However, stomach content analyses indicated no relation to depth, suggesting that hunger may not be an important stimulus for diurnal vertical migration.

Figure 20. Kite diagrams showing the relation between biomass and mesopelagic fishes at various times over a twenty-four hour period.

SHORE-BASED STUDIES

i) BONAIRE

The island of Bonaire in the Netherland Antilles forms part of the Aruba - La Blanquilla chain - a series of small islands running E-W on the Venezuelan borderland. This borderland is part of a broad orogenic belt of Mesozoic and younger rocks at the boundary of the Caribbean with the South American plate.

Historically, Bonaire, Aruba and Curacao formed part of a volcanic arc situated on the leading edge of a tectonic plate. In the late Cretaceous, this island arc collided with the continental margin of South America. A southward-dipping Benioff zone developed and island arc volcanism continued until about 55 myr. B.P. Since then, the area has been very stable, and deposition of limestones during a period of slow tectonic uplift and changes in sea level during the Ice Age has continued.

Consequently, the geology of Bonaire, which is only 256 sq. km. in area with a maximum relief of 243 m., is characterized by both volcanic material and carbonate terraces (Figure 21). The distribution of Plio-Pleistocene carbonates indicates that the island consisted of two topographically high volcanic areas when deposition of the carbonates first started: Brandaris in the north, and a smaller peak to the east of Kralendijk. Lithologically, the island consists of five main units. The Washikemba Formation consists of a thick sequence of volcanic arc material, with eruptions being mainly submarine through the greater part of the succession. The four lithologic units above this Formation are comprised mainly of depositional materials. The upper unit of Neogene and Quaternary limestones indicates a rise of the islands or a change in sea level of about 200 m. This is seen in the series of terraces along both the windward and leeward sides of the island, in which many corals are preserved in their growing positions.

Bonaire also displays a unique flora and fauna in both its terrestrial and marine environments. It is characterized by a semi-arid climate, with an annual rainfall of between 340-680 mm, and exhibits cacti, mangrove swamps, and hypersaline ponds (saliñas). It is perhaps most

Simplified Geologic Map of BONAIRE

- FIGURE 21

(from Beets et al, 1977)

well known for its spectacular reefs, pink flamingos (Phoenicopterus ruber), iguanas, and Bonairean parrots (Amazona barbadensis rothschildi).

A field trip was made to the northern end of the island where a 13,500 acre game preserve - Washington Park - is maintained. In addition, the salinas provided topics for two student projects: one concerned with the macrophytes, and the other with the relation between salinity and zooplankton species composition. Two other students also took advantage of the presence of coral reefs to begin a comparative study of coral zonation and sponge distribution between the fringing reef of Bonaire and the back reef area of Ramsay's Cay, Belize.

Reference

- Beets, D.J., H.J. MacGillavry and G. Klaver. 1977. Cretaceous and Early Tertiary of Bonaire. In: Guide to the Field Excursions on Curacao, Bonaire, and Aruba, Netherlands Antilles. G.UA Papers of Geology, Series 1, No. 10.

Distribution trends of aquatic macrophytes in the salinas of Bonaire, NA
Syma Ebbin

ABSTRACT

Diversity and abundance of aquatic macrophytes were investigated in relation to the salinities of three salinas on Bonaire (Figure 21) in an attempt to determine whether macrophyte diversity decreased with increasing salinity (i.e. a physically controlled environment), and whether abundance increases as a result of reduced interspecific competition in the higher salinity ranges. Thirty-meter transects were laid out in each salina, and the macrophytes studied in quadrats at intervals of about six meters (Table 8).

Diversity and abundance were both found to decrease with increasing salinity. Salina Lac, with a salinity averaging 35.58 ‰ showed the highest abundance of algae and also the greatest diversity of species. In contrast, Salina Funchi, with a salinity of 173 ‰ contained no aquatic macrophytes. This suggests that salinity affects macrophyte species diversity by increasing the stress until no algal colonization is possible. However, the concurrent increase in abundance due to decreased competition was not observed. The stress inherent in a highly saline environment and also the wide variations in salinity known to occur in these areas are probably important factors in the observed decrease in both abundance and species diversity of aquatic macrophytes in the salinas of Bonaire.

Table 8. Macrophytes found in three salinas on Bonaire

1. <u>Salina Lac</u>	Av. Salinity = 35.58 ‰
a) <u>Aquatic</u>	b) <u>Terrestrial</u>
<u>Acanthophora spicifera</u>	<u>Rhizophora mangle</u>
<u>Thalassia testudinum</u>	<u>Avicennia germinans</u>
<u>Halimeda opuntia</u>	<u>Sesuvium portulacastrum</u>
<u>Cladophora sp.</u>	<u>Sesuvium virginicus</u>
<u>Rhizoclonium kernerii</u>	<u>Tournefortia gnaphalodes</u>
2. <u>Pekelmeer Natural Salina</u>	Av. Salinity = 40.91 ‰
a) <u>Aquatic</u>	b) <u>Terrestrial</u>
<u>Acetabularia crenulata</u>	<u>Batis maritima</u>
<u>Dictyosphaeria cavernosa</u>	<u>Conocarpus erectus</u>
<u>Champia parvula</u>	<u>Fimbristylis spathacea</u>
<u>Cladophoropsis membranacea</u>	
3. <u>Salina Funchi</u>	Av. Salinity = 173 ‰
a) <u>Aquatic</u>	b) <u>Terrestrial</u>
None	<u>Sporolobus virginicus</u>
	<u>Sesuvium portulacastrum</u>
	<u>Opuntia curassavica</u>
	<u>Acacia tortuosa</u>
	<u>Tournefortia gnaphalodes</u>

Salinity and its relation to numbers of animal species in the hypersaline ponds on Bonaire, N.A.

Aaron S. Rachlin

ABSTRACT

Three salinas on the island of Bonaire (Figure 21) were studied in order to determine whether there is a correlation between animal species diversity and salinity. The zooplankton at Salina Funchi was almost completely dominated by the brine shrimp, Artemia salina, while at Pekelmeer and Salina Lac thirty and twenty-three species of zooplankton respectively were identified. The results obtained suggest that the number of animal species found in the hypersaline ponds on Bonaire is inversely proportional to the salinity.

ii) BELIZE

Belize is a small country bordered to the north by Mexico, and to the west and south by Guatemala. Its greatest length is 174 miles and it is only 68 miles wide. The country and its continental shelf are divided into two major geographic provinces. The mainland terrain south of Belize City is mountainous. The Maya Mountains are a mass of folded and faulted Paleozoic metasediments with maximum elevation of about 100 m. To the north of Belize City, the mainland is flat-lying limestones with no elevation greater than 65 m.

The continental shelf varies between 10-30 miles in width and is terminated abruptly to the east by an escarpment down to depths greater than 3000 m., on which an extensive fringing and barrier reef system is developed. During the glacial periods, the whole of the Belize continental shelf was exposed. River valleys and drainage channels were cut into the shelf at that time. In fact, the Belize Deep Water Channel which cuts through the barrier reef is thought to be such a drainage line. Apart from cutting channels, the whole area was subject to karst erosion which formed irregular concave surfaces. Consequently, the continental shelf of Belize is characterized by relict drainage patterns and karst topography.

Belize is best known for its barrier reef which runs north-south, and is believed to be the longest continuous barrier reef system in the Atlantic and Caribbean. The reefs appear to be built on fault-controlled ridges and platforms, the formation of which may have been associated with the evolution of the Cayman Trench. The entire length of the reef is skirted by small sandy cays and coral heads. The cays typically are composed of either accumulations of unconsolidated and consolidated carbonates of biological origin (e.g. coral, calcareous algae, etc.) with coconut (Cocos nucifera) being the dominant flora, or of concentrations of the red mangrove, Rhizophora mangle, growing in shoal areas, sometimes with no dry land.

During W-67, Ramsay's Cay was visited. This was a mangrove-sand cay with a small lagoon in the center in which red mangroves were growing.

The leeward sub-tidal zone consisted mainly of grasses, algae and sponges with small patch reefs offshore. These back reefs provided areas for two projects involving comparative work with the reefs of Bonaire.

Coral reef zonation in fringe and back reefs

David Raible

ABSTRACT

Differences between a fringe reef near Bonaire and a back reef area near Ramsay's Cay, Belize, were examined. Species composition was recorded along a line transect by quadrat sampling and flowmeter and phosphate measurements were recorded. Analysis of species composition (Figure 22) showed sediment-hardy species that prefer low current and sunlight were prevalent at the barrier back reef, while species needing greater currents were dominant at the fringe reef. The fringe reef had greater diversity and greater general frequencies of species than the back reef area, and coral composed a greater percentage of ground cover. Species zonation was observed at each area: an Acropora palmata zone, mixed zone, Acropora cervicornis zone, Porites zones, and Diploria zone were observed at the fringe reef; the back reef had a defined Porites zone and soft coral zone. Differences between the two areas were determined to be due to different selection pressures, particularly sedimentation, current, and light intensities.

Figure 22. Comparison of coral species abundances on the back reef of Belize with a fringe reef in Bonaire

Sponges in competition with corals

John Leazer

ABSTRACT

A study was made of sponges at a fringe reef off Bonaire, Netherland Antilles, and a back reef off Belize in order to investigate the interaction between corals and sponges. Types of competition and species interaction were recorded along a line transect by quadrat sampling at 5 m. intervals.

The type of competition that dominated was sponge overgrowing coral. Few boring sponges, which are known to be a main cause of coral destruction, were observed.

LONG-TERM AND COOPERATIVE PROGRAMS

1. NEUSTON STUDIES

Since 1977, scientists have been gathering data on the distribution of pelagic tar, Sargassum species, and the marine water strider, Halobates micans. Manuscripts are in review or in preparation on all of these topics. During W-67, twenty-nine neuston tows were completed; the results are presented in Table 9. In addition, the distributions of tar, Sargassum and Halobates provided topics for student projects. Each of these will be discussed below.

a) Tar

Tarballs are believed to originate from both natural oil seepage and crude oil lost as a result of transport vessels "washing" their tanks at sea. The light hydrocarbons evaporate leaving the heavier fraction to concentrate into floating balls. With time, it is believed that these balls sink through the water column.

During W-67, students continued our studies on surface tar distribution (Speers) and also extended this study to start investigating the distribution of suspended tar in the water column.

Table 9. Summary of neuston data collected on R/V Westward cruise W-67
(calculations based on towing for 30 mins at 2 kts,
i.e. 1853 m²/tow)

<u>Station</u>	<u>Date</u>	<u>Time</u> (hrs)	<u>Position</u>		<u>Tarballs</u> (mg/m ²)	<u>Sargassum</u> (mg/m ²)	<u>Halobates</u> (No/1000m ²)
			<u>N</u>	<u>W</u>			
W67-1	11/26/82	0031	17°53'	64°28'	< 0.1	2.7	3.2
W67-2	11/26/82	1224	17°30'	63°48'	< 0.1	1.1	0.5
W67-8	11/27/82	0100	16°55'	63°07'	< 0.1	0.5	1.1
W67-9	11/27/82	1214	16°02'	62°26'	0.1	0	0
W67-28	12/10/82	1337	12°52'	69°58'	< 0.1	0	5.4
*W67-29	12/11/82	0000	13°14'	71°05'	0	0	7.0
W67-30	12/11/82	1340	13°47'	72°30'	< 0.1	0	0
*W67-31	12/12/82	0016	13°52'	73°38'	0	0	31.3
W67-32	12/12/82	1346	14°39'	74°52'	0	0	0
*W67-33	12/13/82	0102	14°53'	75°50'	< 0.1	0	4.6
W67-34	12/13/82	1949	15°08'	76°45'	2.5	0	-
W67-36	12/16/82	1555	16°31'	79°54'	0.5	0.6	0.5
*W67-37	12/17/82	0031	16°37'	79°56'	0.2	6.7	5.1
W67-43	12/19/82	1327	17°20'	84°07'	0.5	0	0.5
*W67-44	12/20/82	0030	17°12'	85°16'	10.3	0.5	13.0
W67-45	12/20/82	1338	17°20'	86°22'	0.4	1.1	1.1
*W67-47	12/21/82	0015	17°18'	87°04'	41.0	0.4	11.1
*W67-48	12/27/82	0013	18°16'	87°40'	13.1	0.6	1.3
W67-49	12/28/82	1430	20°11'	86°48'	0.1	-	0
W67-53	12/29/82	1717	21°34'	85°57'	2.4	0	1.6
W67-54	12/29/82	0059	22°00'	85°36'	0.3	24.3	7.0
W67-56	12/30/82	1335	22°55'	85°31'	0	1.1	0
W67-57	12/31/82	0000	23°36'	85°09'	0.3	32.4	1.1
W67-58	12/31/82	1355	24°11'	84°47'	1.3	22.7	0
W67-59	01/01/83	0009	24°33'	84°47'	9.7	313.0	1.1
W67-60	01/01/83	1237	24°11'	84°23'	< 0.1	trace	2.2
W67-61	01/02/83	0032	24°20'	83°39'	< 0.1	3.5	2.2
W67-62	01/02/83	1200	24°27'	83°15'	0	75.6	11.3
W67-63	01/03/83	1333	24°18'	81°14'	< 0.1	0.2	0.6

(* Net towed at 4 kts for 30 mins - i.e. 3706 m²/tow)

The concentration and distribution of pelagic surface tar in the Caribbean
Linn D. Speers

ABSTRACT

Within the last fifteen to twenty years, there has been a notable increase in surface tar found in neuston net samples. Studies show that this increase in tar is due to the increase of tanker traffic throughout the Caribbean. Oil from these ships is discharged into the ocean during procedures of deballasting and bilge cleaning.

A survey of pelagic surface tar was conducted to investigate the concentration and distribution of tarry aggregates throughout the Caribbean. Neuston tows were done across the Caribbean and tar concentrations were determined (Table 9). It was found that regions of heavy tanker traffic such as northwest of Lake Maracaibo, north of the Panama Canal, and the Yucatan Straits consistently showed greater concentrations of tar (Figure 23). The concentration of tar shows a general trend of increasing down current and exhibited greatest concentration in the Yucatan Straits.

A survey of the distribution of particulate tar in relation to density structure in the Caribbean Sea

Rich Paczynski

Duff Dean

ABSTRACT

Twelve hydrocasts were taken across the Caribbean Sea (Figure 24) in order to examine the distribution of suspended particulate tar within the water column, particularly in relation to the pycnocline. Density structure was calculated from analyses of salinity and temperature. The water samples were filtered on to 0.45 μ gridded filter papers for counting and size determinations. The weight of tar per liter was then calculated from the estimated diameter and shape of each particle using an equation proposed by Morris et al (1977).

In eight out of the twelve stations, there was a pronounced increase in the concentration of particulate tar at the pycnocline (Figure 25). Increased concentrations were also observed at the surface and at depths approaching 500 m. This suggests that the sinking rate of the tar through the water column is decreased at the pycnocline. Since the increased residence time of the tar at these levels would correspond to a greater "exposure time" for the biota of this region, an understanding of such settling processes may be of considerable importance in assessment of the effects of oil pollution to the marine environment.

Reference

- Morris, B.F., J.N. Butler, T.D. Sleeter and J. Cadwallader. 1977. Particulate hydrocarbon material in ocean waters. Rapp. et Proces-Verbaux des Reunion: Cons. Perm. Int. pour l'Explor. de la Mer, 171, 55-60.

Figure 24. Station locations for the particulate tar study.

Figure 25. Typical profiles of particulate tar in the water column.

b) Sargassum weed

Sargassum weed is a primary producer and is of particular interest to us in a long-term study of its distribution. The highest level of Sargassum weed were encountered in the Yucatan and Florida Straits, and on the western side of the Caribbean, which is in agreement with our previous findings (W-61 Cruise Report).

Another aspect of the weed of interest is its associated community. We have been involved in a study of the trophodynamics and succession of the Sargassum community and one student project continued this work.

Species diversity and the succession of epiphytes on Sargassum weed
John Grosvenor

ABSTRACT

Many studies have provided evidence of ecological succession of epiphytes on a variety of marine algae (e.g. Ryland, 1974; Stebbing, 1972). In this study, the epiphytes on three species of Sargassum weed (S. filipendula, S. vulgare, and S. fluitans) were studied in order to investigate species diversity and succession of epiphytes.

Clumps of weed, collected by neuston tows or with dip nets, were divided into age zones primarily of color difference and the maturity of the different parts of the gulfweed. Diversity of epiphytes was low on all three species of Sargassum and in their different age zones. In addition, diversity appeared to increase with time or with ageing of the weed. Hydroids were found to inhabit the newer portions of the plant, while encrusting organisms, such as bryozoans, preferred the older parts of the plant.

References

- Ryland, J.S. 1974. Observations on some epibionts of gulfweed, Sargassum natans. J. Exp. Bio. and Ecology, 14, 17-25.
- Stebbing, A.R.D. 1972. Preferential settlement of a bryozoan and serpulid larvae on the younger parts of Laminaria fronds. J. Mar. Biol. Assoc. U.K., 52, 765-772.

c) Project Halobates

John Polisar

ABSTRACT

Halobates, the only insects known to spend their entire life cycle at sea, are known to lay their eggs on debris floating at the surface of the ocean (e.g. Cheng, 1973). Consequently, a correlation might be expected between the abundance of Halobates and the presence of surface debris.

Six four-knot neuston tows were conducted at midnight in the southern Caribbean Sea. Halobates abundance and concentration and composition of surface debris were estimated. The location of stations together with the results for all neuston tows are listed in Table 9. No correlation was found between numbers of Halobates and surface debris concentrations, although a positive correlation was indicated between Halobates and the concentration of surface debris other than Sargassum weed. This suggests that perhaps Halobates avoid Sargassum weed, possibly because of predation by the community of organisms associated with the weed.

Reference

Cheng, L. 1973. Halobates, Oceanog. Mar. Biol. Rev., 11, 223-225.

2. DISTRIBUTION OF MARINE BIRDS

Bob McLaughlin and 'A' Watch

In cooperation with Timothy Ramage of the Rhode Island School of Design, a formal bird count system has been developed and instituted to provide quantitative data for analysis of bird distribution, feeding, and migration patterns. R/V Westward cruise W-67 continued this research by conducting daily half-hour bird counts at 0900 and 1400 hours. Data are summarized in Appendix IV and Figures 26 and 27. During 43 bird watches throughout the cruise, twice as many birds were sighted within 40 miles of land than farther than 40 miles. The three major species sighted - Jaegers, Boobies, and Gulls - were predominant on different legs of the cruise. Boobies were the major type seen west of the Lesser Antilles. They follow shoals of fish along the coasts of these islands, which explains their abundance in the area. Jaegers and gulls were the two most common types from the coast of Belize up through the Florida Straits. The gulls were primarily a small subspecies of the laughing gulls common on the east coast of the United States. Their winter range includes the Gulf of Mexico and the Caribbean Sea. Jaegers were also common with the gulls because they harass them for food. Jaegers do not exhibit distinctive migration patterns - their distribution is determined mostly by abundant food sources and is therefore in direct correlation with gull populations.

Key for Figures 26 and 27

O - no birds
B - booby
Bb - brown booby
Br - red-footed booby
Bf - blue-footed booby
Tb - tropic-bird
J - jaeger
T - tern
ST - sooty tern
Sw - swallow
H - heron
F - frigate-bird
G - gull
E - egret
U - unidentified species

Figure 26. Distribution of bird sightings near the Lesser Antilles

Figure 27. Bird sightings distribution in the Caribbean Sea.

3. DISTRIBUTION OF MARINE MAMMALS

Parameters of productivity relative to the study of cetaceans

B. Miller

ABSTRACT

The distribution and behavior of marine mammals is poorly understood and has been the subject of a long-term study in cooperation with Tim Ramage of the Rhode Island School of Design.

Cetacean sightings during W-67 were examined to determine whether a correlation exists between observations of marine mammals and various parameters indicative of high productivity, such as zooplankton biomass, bird sightings and proximity to land. Fifteen sightings of marine mammals were made and are listed in Table 10. A large number of the sightings occurred among the Lesser Antilles and all of them, with one exception, were within 60 nm. of land. Biomass determinations were found to show the least correlation with observations, probably due to patchiness of zooplankton. Bird counts correlated well with sightings (Figure 28) with an average of 10.4 birds seen on days of mammals sightings, and only 0.61 birds observed during daily bird counts when no cetaceans were observed.

Quality: 1-excellent
2-probable
3-poor

Table 10. Cetaceans sighted during R/V Westward cruise W-67

Date	Time	Latitude (N)	Longitude (W)	Species	Quality of ID	Approx. Number	Activity
11/28/82	2300	14°51'	61°22'	Spinner dolphins	2	5-6	bow riding, breaching
11/29/82	0945	14°17'	61°00'	Humpbacks, Minke	2	3	fluking, blowing in distance
11/30/82	0930	13°25'	61°12'	Spinner dolphins	1	7	bouncing briefly
12/01/82	0600	13°46'	61°24'	Unident. dolphins	-	6-8	bowriding, breaching
12/02/82	1545	13°14'	61°37'	Saddlebacks, and Striped dolphins	3	30-50	swimming past
12/05/82	1730	12°50'	66°00'	Striped dolphins	2	8	bow riding
12/10/82	1750	12°51'	69°58'	Bottlenosed dolphins	1	5-7	bow riding
12/19/82	1500	17°20'	83°13'	Unident. dolphins	-	10	swimming south
12/20/82	1630	17°20'	86°21'	Grampus or pilot whale	3	1-3	swam toward us, then away
12/21/82	1300	17°28'	88°10'	Unident. dolphins		3-4	in Belize Harbor close to us - rose only to breathe
12/22/82	1115	"	"	"	"	"	"
12/23/82	1320	"	"	"	"	"	breaching, spinning in distance
12/27/82	1615	18°15'	87°30'	Saddle backs and spotted dolphins	1	40-50	bow riding, breaching (20 m)
01/02/83	1055	24°26'	83°19'	Unident. whales		1-2	diving, breaching
01/03/83	1805	24°27'	80°31'	Bottlenosed dolphins	1	5-6	breaching, leaping past

Figure 28. Correlation between number of birds seen and marine mammal sightings.

4. DISTRIBUTION OF SPINY LOBSTER PHYLLOSOMA

Phyllosoma are the large, flattened larval forms of various tropical and subtropical lobster species, the distribution and dispersal of which are being examined by SEA Staff Scientist, Dr. Mary Farmer. Table 11 contains a list of the stations at which spiny lobster larvae were collected.

In addition, a series of spiny lobster larvae stations were conducted in the Yucatan Strait (Stations 50, 51, 52, 54, and 55, Figure 2). These consisted of a hydrocast to 200 m. followed by an oblique zooplankton tow. Results of the hydrocast are given in Appendix III. Spiny lobster larvae were recovered at three of these stations, as shown in Table 11. These have been given to Dr. Farmer for further study.

Table 11. Stations at which spiny lobster larvae were collected
during cruise W-67

<u>Station #</u>	<u>Date</u>	<u>Location</u>		<u>Collection Mode</u>	<u>Number</u>
		<u>N</u>	<u>W</u>		
W67-17	11/30/82	13°44'	61°16'	Oblique meter net tow	2
W67-19	12/02/82	13°12'	61°36'	"	2
W67-20	12/03/82	13°19'	62°00'	"	4
W67-30	12/11/82	13°47'	72°30'	Neuston tow	1
W67-33	12/13/82	14°53'	75°50'	Oblique meter net tow	6
				Neuston tow	1
W67-35	12/14/82	15°22'	77°40'	Oblique meter net tow	1
W67-50	12/28/82	20°30'	86°29'	"	1
W67-51	12/29/82	21°07'	86°08'	"	2
W67-55	12/30/82	22°31'	85°39'	"	1

5. DISTRIBUTION OF EEL LARVAE

Bob McLaughlin and 'A' Watch

Little is known about the dispersion and distribution of eel larvae, in particular of the American eel, Anguilla rostrata. During W-67, all net tows were examined for the presence of larvae, and were found in 18 tows, listed in Table 12. A total of 108 leptocephali were collected, with the greatest concentration being found in the lee of the Lesser Antilles. All the samples have been returned to SEA for further study.

Table 12. Stations at which eel larvae were collected during W-67

<u>Station</u>	<u>Date</u>	<u>Position</u>		<u>Collection Method</u>	<u>Number</u>
		<u>N</u>	<u>W</u>		
W67-17	11/30/82	13°44'	61°16'	Oblique net tow to 600 m.	6
W67-19	12/02/82	13°12'	61°36'	"	13
				Oblique net tow to 100 m.	6
W67-20	12/03/82	13°19'	62°00'	"	11
W67-22	12/03/82	13°13'	62°48'	Oblique net tow to 600 m.	6
				Oblique net tow to 100 m.	1
W67-25	12/04/82	12°44'	63°47'	Oblique net tow to 600 m.	6
W67-29	12/11/82	13°14'	71°05'	Neuston	21
W67-31	12/12/82	13°52'	73°38'	Neuston	1
W67-33	12/13/82	14°53'	75°50'	Neuston	12
				Oblique net tow to 600 m.	10
W67-37	12/17/82	16°37'	79°56'	Neuston	1
W67-44	12/20/82	17°12'	85°16'	Neuston	1
W67-46	12/20/82	17°23'	86°34'	Oblique net tow to 100 m.	2
W67-47	12/21/82	17°18'	87°04'	Neuston	5
W67-48	12/27/82	18°16'	87°40'	Neuston	2
W67-50	12/28/82	20°30'	86°29'	Oblique to 200 m.	2
W67-54	12/29/82	22°00'	85°36'	Oblique net tow to 200 m.	1

6. COOPERATIVE SHIP WEATHER OBSERVATION PROGRAM (NOAA)

The R/V Westward is certified to gather weather observations for the U.S. National Weather Service (NOAA). The data, which are collected twice daily at 0600 and 1200 GMT are transmitted to Coast Guard Stations ashore, and constitute part of a global weather observation network.

On W-67, 45 sets of observations were compiled, of which 70% were successfully transmitted; mainly to NMN, Portsmouth, VA.

APPENDICES

APPENDIX I

Oceanographic stations during Westward cruise W-67

<u>Station</u>	<u>Date</u>	<u>Latitude</u> (N)	<u>Longitude</u> (W)	<u>Operations</u>	<u>Comments</u>
W67-1	11/26/82	17°53'	64°28'	Neuston tow	
W67-2	11/26/82	17°30'	63°48'	Neuston tow	
W67-3	11/26/82	17°23'	63°49'	Fisher Scoop	Saba Bank
W67-4	11/26/82	17°21'	63°44'	Fisher Scoop	Saba Bank
W67-5	11/26/82	17°17'	63°41'	Fisher Scoop	Saba Bank
W67-6	11/26/82	17°14'	63°35'	Fisher Scoop	Saba Bank
W67-7	11/26/82	17°13'	63°35'	Fisher Scoop	Saba Bank
W67-8	11/27/82	16°55'	63°07'	Neuston tow	
W67-9	11/27/82	16°02'	62°26'	Hydrocast (H-1) Neuston tow	
W67-10	11/28/82	15°07'	61°25'	Hydrocast (H-2)	Dominica- Martinique Passage
W67-11	11/28/82	14°51'	61°22'	Hydrocast (H-3)	"
W67-12	11/29/82	14°20'	61°10'	Hydrocast (H-4)	Martinique- St. Lucia Passage
W67-13	11/29/82	14°11'	61°13'	Hydrocast (H-5)	"
W67-14	11/30/82	13°40'	61°05'	Hydrocast (H-6)	St. Lucia- St. Vincent Passage
W67-15	11/30/82	13°25'	61°12'	Hydrocast (H-7)	"
W67-16	11/30/82	13°26'	61°12'	Hydrocast (H-8) Irradiameter	"
W67-17	11/30/82	13°44'	61°16'	Multi-net phytoplankton tow Hydrostation (H-9) Zooplankton tow Mesopelagic multi-net tow	"
W67-18	12/02/82	13°31'	61°24'	Hydrocast (H-10) Irradiameter	"
W67-19	12/02/82	13°12'	61°36'	Multi-net phytoplankton tow Hydrostation (H-11) Zooplankton tow Mesopelagic multi-net tow	Lee of St. Vincent

APPENDIX I (continued)

<u>Station</u>	<u>Date</u>	<u>Latitude</u> (N)	<u>Longitude</u> (W)	<u>Operations</u>	<u>Comments</u>
W67-20	12/03/82	13° 19'	62° 00'	Mesopelagic multi-net tow	Lee of St. Vincent
W67-21	12/03/82	13° 40'	62° 35'	Hydrocast (H-12) Irradiameter Multi-net phytoplankton tow Hydrocast (H-13) Zooplankton tow	"
W67-22	12/03/82	13° 13'	62° 48'	Hydrocast (H-14) Zooplankton tow Mesopelagic multi-net tow	
W67-23	12/04/82	12° 44'	63° 07'	Multi-net phytoplankton tow Hydrocast (H-15)	
W67-24	12/04/82	12° 44'	63° 07'	Zooplankton tow	"
W67-25	12/04/82	12° 44'	63° 47'	Phytoplankton tow Hydrocast (H-16) Mesopelagic multi-net tow	S.E. Caribbean
W67-26	12/06/82	12° 50'	67° 04'	Hydrocast (H-17) Phytoplankton tow	
W67-27	12/06/82	12° 18'	67° 49'	Hydrocast (H-18) Phytoplankton tow	
W67-28	12/10/82	12° 52'	69° 58'	Hydrocast (H-19) Neuston tow	Southern Central Caribbean
W67-29	12/11/82	13° 14'	71° 05'	Neuston tow	
W67-30	12/11/82	13° 47'	72° 30'	Hydrocast (H-20) Neuston tow	"
W67-31	12/12/82	13° 52'	73° 38'	Neuston tow	
W67-32	12/12/82	14° 39'	74° 52'	Hydrocast (H-21) Neuston tow	
W67-33	12/12- 12/13/82	14° 53'	75° 50'	Mesopelagic multi-net tow Hydrocast (H-22) Neuston tow	
W67-34	12/13/82	15° 08'	76° 45'	Hydrocast (H-23) Neuston tow	

APPENDIX I (continued)

<u>Station</u>	<u>Date</u>	<u>Latitude</u> (N)	<u>Longitude</u> (W)	<u>Operations</u>	<u>Comments</u>
W67-35	12/13- 12/14/82	15°22'	77°40'	24-hour station Hydrocasts (H-24-27) Multi-net tows	
W67-36	12/16/82	16°31'	79°54'	Hydrocast (H-28 & 29) Zooplankton tow Neuston tow	
W67-37	12/17/82	16°37'	79°56'	Neuston tow	Rosalind Bank
W67-38	12/17/82	16°30'	80°15'	Hydrocast (H-30) Fisher scoop Rock dredge	"
W67-39	12/17/82	16°23'	80°22'	Sediment grab Fisher scoop	"
W67-40	12/17/82	16°31'	80°37'	Hydrocast (H-31) Zooplankton tow	"
W67-41	12/17/82	16°33'	80°52'	Fisher scoop	"
W67-42	12/17/82	16°33'	80°53'	Sediment grab	"
W67-43	12/19/82	17°20'	84°07'	Hydrocast (H-32) Neuston tow	Western Caribbean
W67-44	12/20/82	17°12'	85°16'	Neuston tow	"
W67-45	12/20/82	17°20'	86°22'	Hydrocast (H-33) Neuston tow	"
W67-46	12/20/82	17°23'	86°34'	Zooplankton tow	
W67-47	12/21/82	17°18'	87°04'	Neuston tow	
W67-48	12/27/82	18°16'	87°40'	Neuston tow	
W67-49	12/28/82	20°11'	86°48'	Hydrocast (H-34) Neuston tow	
W67-50	12/28/82	20°30'	86°29'	Hydrocast (H-35) Zooplankton tow	
W67-51	12/29/82	21°07'	86°08'	Hydrocast (H-36) Zooplankton tow	Yucatan Strait
W67-52	12/29/82	21°34'	85°57'	Hydrocast (H-37) Zooplankton tow	"
W67-53	12/29/82	21°34'	85°57'	Hydrocast (H-38) Neuston tow	"
W67-54	12/29/82	22°00'	85°36'	Hydrocast (H-39) Zooplankton tow Neuston tow	"

APPENDIX I (continued)

<u>Station</u>	<u>Date</u>	<u>Latitude</u> (N)	<u>Longitude</u> (W)	<u>Operations</u>	<u>Comments</u>
W67-55	12/30/82	22° 31'	85° 39'	Hydrocast (H-40) Zooplankton tow	Yucatan Strait
W67-56	12/30/82	22° 55'	85° 31'	Neuston tow	
W67-57	12/31/82	23° 36'	85° 09'	Neuston tow	
W67-58	12/31/82	24° 11'	84° 47'	Hydrocast (H-41) Neuston tow	
W67-59	01/01/83	24° 33'	84° 47'	Neuston tow	
W67-60	01/01/83	24° 11'	84° 23'	Neuston tow	Florida Straits
W67-61	01/02/83	24° 20'	83° 39'	Neuston tow	"
W67-62	01/02/83	24° 27'	83° 15'	Neuston tow	
W67-63	01/03/83	24° 18'	81° 14'	Hydrocast (H-42) Neuston tow	

APPENDIX II

Bathythermograph stations completed during W-67

BT #	Date	Location		Surface Temperature	
		(°N)	(°W)	(°C)	(°F)
1	11/27/82	16°02'	62°26'	27.8	82.0
2	11/30/82	13°44'	61°19'	27.5	81.5
3	12/02/82	13°34'	61°24'	27.5	81.5
4	12/02/82	13°31'	61°24'	27.5	81.5
5	12/02/82	13°25'	61°30'	27.5	81.5
6	12/02/82	13°16'	61°38'	27.7	81.8
7	12/02/82	13°16'	61°40'	27.7	81.8
8	12/02/82	13°13'	61°40'	27.6	81.6
9	12/02/82	13°15'	61°47'	27.6	81.6
10	12/02/82	13°15'	61°48'	27.6	81.6
11	12/03/82	13°17'	61°53'	27.5	81.5
12	12/03/82	13°19'	62°00'	27.8	82.0
13	12/03/82	13°22'	62°06'	27.6	81.6
13A	12/03/82	13°24'	62°13'	27.6	81.6
14	12/03/82	13°30'	62°22'	27.6	81.6
15	12/03/82	13°40'	62°35'	27.5	81.5
16	12/03/82	13°34'	62°41'	27.5	81.5
17	12/03/82	13°29'	62°45'	27.8	82.0
18	12/03/82	13°22'	62°52'	27.2	80.9
19	12/03/82	13°16'	62°58'	27.2	80.9
20	12/04/82	13°06'	62°52'	27.3	81.1
21	12/04/82	13°00'	62°57'	27.4	81.3
22	12/04/82	12°55'	63°00'	27.4	81.3
23	12/04/82	12°51'	63°04'	27.5	81.5
24	12/11/82	13°47'	72°30'	25.9	78.7
25	12/12/82	14°37'	74°52'	26.5	79.7
26	12/13/82	15°08'	76°45'	27.8	82.0
27	12/16/82	16°31'	79°54'	27.6	81.6
28	12/16/82	16°29'	79°57'	27.2	80.9
29	12/17/82	16°37'	79°57'	26.9	80.5

APPENDIX II (continued)

<u>BT #</u>	<u>Date</u>	<u>Location</u>		<u>Surface Temperature</u>	
		(°N)	(°W)	(°C)	(°F)
30	12/17/82	16°23'	80°03'	27.0	80.6
31	12/17/82	16°24'	80°09'	27.2	80.9
32	12/17/82	16°24'	80°13'	27.1	80.7
33	12/17/82	16°33'	80°53'	27.0	80.6
34	12/19/82	17°20'	84°07'	26.8	80.2
35	12/20/82	17°20'	86°22'	26.8	80.2
36	12/28/82	20°08'	86°47'	26.7	80.0
37	12/28/82	20°30'	86°29'	26.9	80.5
38	12/29/82	21°07'	86°09'	26.4	79.5
39	12/29/82	21°34'	85°57'	26.5	79.7
40	12/29/82	22°00'	85°36'	26.3	79.3
41	12/30/82	22°31'	85°34'	25.8	78.4
42	12/31/82	24°11'	84°47'	24.5	76.1
43	01/03/83	24°18'	84°14'	25.2	77.9

APPENDIX III

Summary of hydrographic data from Westward cruise W-67

a) Hydrocasts completed for particulate tar studies

Station: W67-9 H-1
Position: 16°02'N 62°26'W

Depths (m)	0	58	110	165	208	297	430
Temperature (°C)	27.8	28.26	25.44	23.13	19.11	15.38	10.55
Salinity (°/oo)	34.906	35.422	36.080	36.735	36.991	36.783	36.187

Station: W67-28 H-19
Position: 12°52'N 69°58'W

Depths (m)	0	28	39	77	104	130	343
Temperature (°C)	27.2	27.05	27.13	25.23	22.87	20.48	11.77
Salinity (°/oo)	35.818	35.838	35.962	36.833	35.029	36.713	35.406

Station: W67-30 H-20
Position: 13°47'N 72°30'W

Depths (m)	0	96	129	136	164	318	492
Temperature (°C)	26.1	24.37	21.86	20.10	17.66	13.81	8.98
Salinity (°/oo)	36.773	36.816	36.856	36.741	36.331	35.785	35.029

Station: W67-32 H-21
Position: 14°39'N 74°52'W

Depths (m)	0	92	115	136	156	235	366
Temperature (°C)	27.2	24.98	23.68	21.98	20.16	16.70	11.92
Salinity (°/oo)	36.151	36.134	36.916	36.848	36.725	36.345	35.445

Station: W67-33 H-22
Position: 14°53'N 75°50'W

Depths (m)	0	25	45	65	75	97	
Temperature (°C)	27.22	27.27	27.22	27.22	26.84	25.51	
Salinity (°/oo)	35.821	35.968	-	36.007	36.345	-	

Station: W67-34 H-23
Position: 15°08'N 76°45'W

Depths (m)	0	50	75	105	258	332	503
Temperature (°C)	27.8	27.67	27.69	27.68	17.99	14.97	9.94
Salinity (°/oo)	-	35.467	35.256	35.175	36.356	35.917	35.194

APPENDIX III (continued)

Station: W67-36 H-29
Position: 16°31'N 79°34'W

Depths (m)	0	90	154	188	235	352	566
Temperature (°C)	27.6	27.50	24.99	22.74	20.02	16.31	10.72
Salinity (‰)	35.470	35.561	36.644	36.808	36.674	36.137	35.220

Station: W67-43 H-32
Position: 17°20'N 84°07'W

Depths (m)	0	38	65	82	113	153	484
Temperature (°C)	27.0	27.20	27.21	27.11	24.28	20.59	9.65
Salinity (‰)	35.961	35.954	36.009	36.064	36.717	36.756	35.145

Station: W67-45 H-33
Position: 17°20'N 86°22'W

Depths (m)	0	45	75	112	143	347	570
Temperature (°C)	27.3	27.10	26.95	23.99	20.70	14.01	8.45
Salinity (‰)	35.711	35.701	36.387	36.808	36.796	35.886	35.039

Station: W67-49 H-34
Position: 20°11'N 86°48'W

Depths (m)	0	42	70	92	135	192	561
Temperature (°C)	26.8	26.84	26.84	25.50	22.74	19.03	8.71
Salinity (‰)	35.880	-	36.211	36.603	36.853	36.596	35.022

Station: W67-53 H-38
Position: 21°34'N 85°57'W

Depths (m)	0	55	98	123	139	164	551
Temperature (°C)	26.8	26.84	26.33	24.12	22.57	21.02	10.61
Salinity (‰)	36.006	36.008	36.851	36.790	36.834	36.801	35.346

Station: W67-63 H-42
Position: 24°18'N 81°14'W

Depths (m)	0	25	45	60	85	105	150
Temperature (°C)		26.59	26.02	24.83	24.51	23.04	19.32
Salinity (‰)	35.997	35.787	36.308	36.231	36.272	36.604	36.586

APPENDIX III (continued)

b) Hydrocasts completed for AAIW study

<u>Depth</u> (m)	<u>Temp</u> (°C)	<u>Salinity</u> (°/oo)	<u>Dissolved</u> <u>Oxygen</u> (mL/L)	<u>Silicate</u> (µM/L)
Station: W67-10 H-2				
Position: 15°07'N 61°25'W				
146	18.77	35.815	3.17	-
441	11.29	35.408	3.01	-
590	8.29	34.988	3.00	-
731	6.61	34.880	3.00	-
874	5.69	34.850	3.57	-
920	5.42	34.933	3.17	-
Station: W67-11 H-3				
Position: 14°51'N 61°22'W				
502	9.22	35.098	3.00	-
639	7.15	34.840	3.10	-
740	6.64	34.830	3.06	-
752	6.47	34.811	3.07	-
870	6.40	34.843	3.05	-
999	5.02	34.908	3.93	-
Station: W67-12 H-4				
Position: 14°20'N 61°10'W				
346	12.72	35.559	3.23	9.4
436	10.98	35.298	3.02	10.9
480	10.18	35.211	2.86	11.7
491	9.70	35.124	2.81	13.0
614	8.10	34.976	2.96	13.6
714	6.86	34.852	2.95	17.0
Station: W67-13 H-5				
Position: 14°11'N 61°13'W				
901	5.60	34.776	3.65	19.9
1043	4.70	34.985	4.21	21.0
1140	4.48	34.994	4.56	-
1229	4.39	35.028	4.52	21.9
1404	4.30	35.043	4.59	24.6
1593	4.19	35.057	4.44	25.2

APPENDIX III (continued)

<u>Depth</u> (m)	<u>Temp</u> (°C)	<u>Salinity</u> (‰)	<u>Dissolved Oxygen</u> (mL/L)	<u>Silicate</u> (μM/L)
Station: W67-14 H-6				
Position: 13°40'N 61°05'W				
606	7.54	34.807	3.17	16.0
760	6.54	34.799	3.04	18.6
890	5.59	34.776	2.87	19.2
900	5.67	34.823	-	19.6
1040	4.92	34.912	4.32	22.5
1187	4.52	34.953	4.44	21.2
Station: W67-15 H-7				
Position: 13°25'N 61°12'W				
861	5.61	34.986	3.58	19.3
1045	4.72	34.966	4.31	19.8
1142	4.48	34.969	4.22	20.2
1230	4.37	34.982	4.12	21.2
1374	4.36	34.985	4.12	22.0
1540	3.85	34.994	4.53	29.8

APPENDIX III (continued)

c) Hydrocasts completed for eddy study

<u>Depth</u> (m)	<u>Temp</u> (°C)	<u>Salinity</u> (‰)	<u>Dissolved</u> <u>Oxygen</u> (mL/L)	<u>Phosphate</u> (μM/L)	<u>Silicate</u> (μM/L)
Station: W67-17 H-9					
Position: 13°44'N 61°16'W					
0	27.4	35.732	4.71	b.d.	1.4
55	27.30	36.473	4.20	0.42	1.5
77	26.29	36.834	4.54	b.d.	1.1
116	24.76	-	3.72	0.38	0.9
158	21.92	36.963	3.59	0.42	1.6
184	19.38	36.582	3.01	0.46	2.6
257	15.39	36.031	3.22	0.99	6.0

Station: W67-19 H-11					
Position: 13°12'N 61°36'W					
0	27.7	-	4.79	b.d.	1.6
45	27.59	-	4.67	b.d.	3.5
68	25.01	-	4.22	b.d.	2.3
87	23.73	36.876	4.02	0.05	2.2
138	18.66	36.571	3.56	0.36	4.0
198	16.10	36.159	3.34	0.45	5.1
313	12.29	35.551	2.98	0.88	-

Station: W67-21 H-13					
Position: 13°40'N 62°35'W					
0	27.7	35.401	4.47	0.60	2.7
55	27.69	35.681	4.65	b.d.	1.7
80	26.10	36.528	3.71	0.50	1.1
117	23.37	36.769	4.05	0.40	1.2
132	20.02	36.535	3.45	0.13	2.2
207	16.92	36.162	3.30	0.52	1.7
305	13.32	35.551	3.11	0.68	5.7

APPENDIX III (continued)

<u>Depth</u> (m)	<u>Temp</u> (°C)	<u>Salinity</u> (‰)	<u>Dissolved</u> <u>Oxygen</u> (mL/L)	<u>Phosphate</u> (μM/L)	<u>Silicate</u> (μM/L)
Station: W67-22 H-14					
Position: 13° 13'N 62° 48'W					
0	27.3	35.220	4.57	0.26	2.0
41	27.34	36.199	4.56	0.12	1.1
70	25.31	36.622	4.01	0.05	1.6
83	23.36	36.820	3.83	0.25	1.4
144	20.09	36.709	3.54	0.20	2.8
173	17.43	36.282	3.22	0.50	2.7
272	14.29	35.792	3.31	0.72	6.2
Station: W67-23 H-15					
Position: 12° 44'N 63° 07'W					
0	27.8	34.642	4.71	0.17	3.5
46	27.79	36.064	4.73	0.10	1.4
65	27.49	35.851	4.64	b.d.	1.1
99	26.03	36.511	4.15	b.d.	1.2
136	20.85	36.840	3.64	0.20	-
181	16.66	36.294	3.23	0.45	4.1
280	12.89	35.658	3.22	0.65	4.1

APPENDIX III (continued)

d) Hydrocasts completed for Amazon Water study

<u>Depth</u> (m)	<u>Temp</u> (°C)	<u>Salinity</u> (‰)	<u>Dissolved Oxygen</u> (mL/L)	<u>Silicate</u> (µM/L)
Station: W67-25 H-16				
Position: 12° 44'N 63° 47'W				
3	27.44	35.130	4.52	3.3
29	27.46	35.037	4.52	2.4
50	27.58	35.566	4.56	2.3
68	27.60	35.728	4.61	2.2
72	26.15	36.446	4.40	2.0
81	25.33	36.778	4.24	0.9
Station: W67-26 H-17				
Position: 12° 50'N 67° 04'W				
2	27.40	34.899	4.60	3.0
27	27.38	34.752	4.43	2.4
46	27.11	35.516	4.22	1.4
62	27.16	35.993	4.36	1.0
76	25.76	36.755	4.51	0.8
92	24.48	36.892	4.27	0.9
Station: W67-27 H-18				
Position: 12° 18'N 67° 49'W				
0	27.6	34.763	4.45	3.9
18	27.59	34.771	4.52	1.6
39	27.51	35.146	4.64	2.7
54	27.29	35.577	4.53	1.8
66	26.58	36.569	4.44	2.7
86	24.29	36.922	3.98	0.3

APPENDIX III (continued)

e) Hydrocasts completed for Rosalind Bank study

<u>Depth</u> <u>(m)</u>	<u>Temp</u> <u>(°C)</u>	<u>Salinity</u> <u>(‰)</u>	<u>Dissolved</u> <u>Oxygen</u> <u>(mL/L)</u>	<u>Phosphate</u> <u>(µM/L)</u>
Station: W67-36 H-28				
Position: 16°31'N 79°54'W				
0	27.6	35.558	4.67	0.20
62	27.45	35.512	5.60	b.d.
150	27.47	35.624	4.17	0.10
207	22.44	36.793	4.36	0.28
320	17.20	36.333	4.29	0.75
415	14.88	35.212	3.30	1.13
469	11.11	35.319	2.42	9.13

APPENDIX III (continued)

Depth (m)	Temp (°C)	Salinity (°/oo)	Dissolved Oxygen (mL/L)	Phosphate (µM/L)
Station: W67-38 H-30				
Position: 16°30'N 80°15'W				
0	27.5	35.484	4.65	0.28
23	27.46	35.601	5.47	0.48
46	27.50	35.580	5.56	0.05
92	27.31	35.798	5.18	0.30
144	26.71	36.165	4.47	0.10
190	20.68	36.716	4.42	0.61
231	17.47	36.365	4.38	1.65
Station: W67-40 H-31				
Position: 16°31'N 80°37'W				
0	27.76	35.886	4.16	0.05
4	27.68	35.472	4.76	0.64
8	27.66	35.884	4.67	0.10
12	27.58	35.909	4.50	0.75
14	27.64	35.494	4.64	b.d.
18	27.61	35.453	4.41	0.43

APPENDIX III (continued)

f) Hydrocasts completed for spiny lobster larva studies

Station: W67-50 H-35

Position: 20°30'N 86°29'W

Depth(m)	0	28	49	102	151	193
Temp (°C)	26.87	26.91	26.91	25.06	20.83	18.54
Salinity (‰)	35.923	35.949	35.951	36.646	36.768	36.567

Station: W67-51 H-36

Position: 21°07'N 86°08'W

Depth(m)	0	28	53	104	146	194
Temp (°C)	26.82	26.88	26.89	24.84	20.73	18.04
Salinity (‰)	35.910	35.928	35.976	36.658	36.784	36.454

Station: W67-65 H-37

Position: 21°34'N 85°57'W

Depth(m)	0	27	52	103	152	199
Temp (°C)	26.90	26.86	26.84	26.36	21.25	18.73
Salinity (‰)	35.962	35.931	35.962	36.776	36.782	36.694

Station: W67-54 H-39

Position: 22°00'N 85°36'W

Depth(m)	0	30	64	98	163	218
Temp (°C)	26.91	26.90	26.84	25.44	21.72	19.02
Salinity (‰)	35.879	35.845	35.870	36.489	36.739	36.614

Station: W67-55 H-40

Position: 22°31'N 85°39'W

Depth(m)	0	31	61	100	166	200
Temp (°C)	26.82	26.84	26.84	25.73	22.26	19.57
Salinity (‰)	35.742	35.747	35.762	36.379	36.530	36.540

APPENDIX IV

Bird counts made during R/V Westward cruise W-67

(*indicates incidental sighting)

Date	Time	Latitude (N)	Longitude (W)	Species (common name)	Number
11/25/82	1422	18° 10'	64° 50'	Booby sp.	2
11/26/82	0758*	17° 06'	64° 00'	M. Frigatebird	1
	0829*	"	"	Booby sp.	1
	0957*	"	"	Pomarine Jaeger	1
	0902	17° 40'	64° 05'	Jaeger sp.	1
				A. Shearwater	1
	1315*	17° 23'	63° 48'	Sooty tern	1
	1432	17° 27'	63° 54'		0
	1800*	17° 13'	63° 35'	Booby sp.	1
11/27/82	0918	16° 19'	62° 34'	Brown Booby	5
				unident. sp.	1
11/28/82	0859	15° 07'	61° 42'		0
	1341	15° 09'	61° 45'	W-T, Tropicbird	2
				Brown Booby	1
	1713	15° 02'	61° 29'		0
11/30/82	1424	13° 31'	61° 14'	unident. sp.	1
12/01/82	0930	14° 07'	61° 28'		0
	1432	14° 14'	61° 30'		0
12/02/82	0910	14° 15'	61° 16'	unident. sp.	1
	1404	13° 27'	61° 27'	Brown Booby	2
				unident. sp.	25-30
				Red-foot booby	1
12/03/82	0745*	13° 30'	62° 03'	Pomarine Jaeger	4
	0859	13° 22'	62° 13'		0
	1700*	13° 20'	62° 31'	sooty terns	20
				Booby sp.	5
				Barn swallow	2
12/04/82	0800*	12° 55'	63° 00'	Great Blue Heron	1
12/05/82	1006	12° 43'	65° 02'	Black-foot Booby	1
	1520	12° 46'	65° 56'	Booby sp.	3
				unident. sp.	1

APPENDIX IV (continued)

Date	Time	Latitude (N)	Longitude (W)	Species (common name)	Number
12/06/82	0918	12°40'	67°40'	Booby sp.	1
				Red-foot booby	1
	1417	12°20'	67°55'	Brown booby	4
				Red-foot booby	1
12/09/82	1800	12°10'	68°17'	unident. sp.	1
12/10/82	0915	12°40'	69°60'	Sooty terns	2
	1528	12°49'	70°02'	Brown booby	1
12/11/82	0732	13°31'	72°04'	Brown booby	2
	0806*	13°46'	72°31'	Barn swallow	1
	0908*	13°46'	72°31'	Snowy egrets	3
	1448	13°49'	72°34'		0
12/12/82	0909	14°34'	74°33'	Tern	1
	1125*	14°34'	74°43'	Brown booby	1
12/12/81	1525	14°39'	74°52'	Jaeger	1
12/13/82	0855	15°06'	76°26'		0
	1516	15°13'	76°56'	Swallow sp.	1
12/14/82	0845	15°08'	77°32'	Tern sp.	1
12/15/82	1400	16°17'	78°28'	Brown booby	1
12/16/82	0904	16°18'	79°48'	m. frigatebird	1
12/17/82	1506	16°29'	80°30'		0
12/18/82	1417	17°17'	82°16'		0
12/19/82	0900	17°20'	83°59'	Brown booby	3
				B.f. booby	1
				gull sp.	1
				unident. sp.	1
	1430	17°11'	84°10'		0
12/20/82	0853	17°18'	85°58'	Laughing gull	1
				Gull sp.	1
12/21/82	1044	17°15'	87°57'		0
12/26/82	1007	17°22'	88°05'	m. frigatebird	1
	1502	17°42'	87°50'		0

APPENDIX IV (continued)

Date	Time	Latitude (N)	Longitude (W)	Species (common name)	Number
12/27/82	0902	18° 12'	87° 31'	Snowy egret	1
				Laughing gull	1
	1420	18° 23'	87° 06'		0
	1830*	18° 24'	87° 30'	Brown booby	1
12/28/82	0857	19° 46'	87° 00'	m. frigatebird	3
	1707	20° 01'	87° 47'	Gull sp.	1
12/29/82	0755*	21° 07'	86° 08'	m. frigatebird	1
	0952- 1215	21° 34'	85° 57'	Laughing gull	6
12/31/82	0855	24° 11'	84° 49'	Gull sp.	3
01/01/83	0758*	24° 19'	84° 39'	Laughing gull	1
	1500	24° 29'	84° 19'	Gull sp.	1
				Jaeger	2
				unident. sp.	1
	1815*	24° 24'	85° 03'	Sand. tern	1
01/02/83	0830*	24° 27'	83° 15'	Sand. tern	1
	1350	24° 28'	83° 09'	Laughing gull	8
				Pom. jaeger	3
				r.b. gull	3

APPENDIX V

The Twelve Days of Christmas

On the first day of Christmas
My Captain gave to me,
A sextant and a time tick

On the second
Two dolphins diving

On the third
Three hours of sleep

On the fourth
Four lowers set

On the fifth
Five meals a day!

On the sixth
Six Nansen bottles

On the seventh
Seven shining sisters

On the eighth
Eight second showers

On the ninth
Nine knives a-munging

On the tenth
Ten running fixes

APPENDIX V (continued)

On the eleventh
Eleven D.O.'s waiting

On the twelfth
Twelve weeks of joy.

Another Day in Paradise

(to the tune of Greensleeves)

What place is this they call paradise,
Where the sun never studies
And our tans are dyin'.

Where everyday we go downstairs,
While the ship's a-pitchin'
We clean the kitchen!

This, this is W-67
Where you key out algae from three to seven.

You, you ask yourself why
You're scrubbing heads while dawn is nigh.

We waltz with mung
It's quite a feat,
And without mung this song's incomplete.

Dawn Watch

(to the tune of 9 to 5)

Roll out of bed
And stumble to the head,
Crawl up to deck
And do a boat check.
It's watch again
See the dawning of the day.

Relieve the helm and spin the boat around,
Get on track and prepare to tack,
It's dawn watch day
On deck from 3 to 7.

Chorus

Scrubbing 4 to 5
Really makes you feel alive,
Get the soles squeegee clean
And give the head a sheen,
Want to catch some Z's
But not time for that afloat,
Never a free moment
Aboard this crazy boat!

Nine to ten
Munging on field day
Sure does put the ship
In a better way.
Malinda pops on by
And gives a sugar high
I swear sometimes I'm going to
Double both my thighs!