Cruise Report

W-48

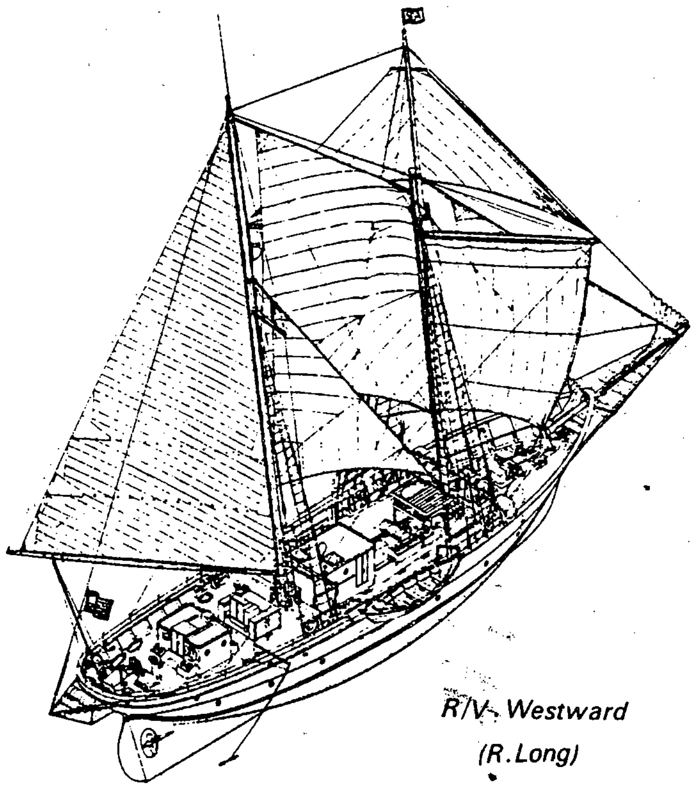
Scientific Activities

Undertaken Aboard

R/V Westward

Woods Hole - St. Thomas

10 October - 21 November 1979



R/V Westward
(R. Long)

Sea Education Association - Woods Hole, Massachusetts

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Woods Hole - Antigua - St. Lucia - Bequia - St. Thomas

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SHIPBOARD DRAFT

PREFACE

This Cruise Report is written in an attempt to accomplish two objectives. Firstly, and more importantly, it presents a brief outline of the scientific research completed aboard R/V Westward during W-48. Reports of the status of on-going projects and of the traditional academic program are presented. In addition, abstracts from the research projects of each student are included. Secondly, for those of us that participated, it represents the product of our efforts and contains a record of other events that were an important part of the trip, in particular the activities during port stops.

Once again, I owe special thanks to Abby Ames, who was in charge of the shipboard laboratory, and upon whom I was able to depend throughout the cruise. Her effectiveness and perseverance under the difficult working conditions at sea, and her cheerful attitude and enthusiasm were greatly appreciated by us all.

Rob Nawojchik, who participated as an Assistant Scientist, added a new field of interest to the cruise with his vast knowledge of ichthyology. The energy with which he pursued his interest and his enthusiasm for the subject, set an example for us all.

Two visiting scholars participated in different legs of this cruise. Dr. Roscoe Mason (M.D.) accompanied us for the open ocean leg from Woods Hole to Antigua. I am sure that the students and staff join me in thanking him for administering the occasional, necessary potion!!

Dr. Charles McClennen joined us in St. Lucia for the final leg of the cruise, during which he conducted side scan sonar observations. I am very grateful to him for the considerable amount of time he spent with the students, and for illustrating another aspect of oceanographic studies to us all.

During the cruise, I was able to rely upon the patience, skill, and enthusiasm of a fine Nautical Science staff. I am particularly indebted and grateful to the Captain, Rick Farrell, for his interest and cooperation in fulfilling the scientific objectives of the cruise. As for the rest of the staff, what else can I say but - "gre-e-e-e-at!!"

This report was composed at sea, and does not represent a detailed interpretation of the data. The limitations of the lack of library facilities and restricted time are clearly reflected in the contents. However, I feel that it is important for the students to be responsible for the completion of their projects while at sea, including writing up a report. The abstracts of these constitute the bulk of this report.

Susan E. Humphris

Chief Scientist

Cruise W-48

TABLE OF CONTENTS

INTRODUCTION

This cruise report provides a record of the scientific research activities conducted aboard the R/V Westward during the laboratory section of the Introduction to Marine Science course - NS 225 at Boston University.

The itinerary and ship's track for W-48 (Table 1 and Figures 1 and 2) took us to both open ocean and nearshore marine environments; these provided opportunities for individual student research projects in a variety of oceanographic fields.

Every effort was made to expose the students to all the different oceanographic operations of which the R/V Westward is capable. However, it is inevitable that the interests of both the SEA staff and the visiting scientists are clearly reflected in the emphasis placed on particular aspects of the program.

The part of this Cruise Report dealing with abstracts of student projects and research designed specifically for this cruise has been divided into sections on a geographical basis. The scientific objectives for each region are therefore presented in the Introduction to each section.

Research conducted during W-48 partly represents on-going work of individuals and agencies that have extended their assistance to our students. Material reported here should not be excerpted or cited without permission of the Chief Scientist.

TABLE 1 Itinerary of R/V Westward Cruise W-48

	Depart	Date	Arrive	Date
Leg 1	Woods Hole, Mass.	10 Oct. 1979	Antigua (English Harbor) W.I.	29 Oct. 1979
Leg 2	Antigua (English Harbor) W.I.	1 Nov. 1979	St. Lucia (Castries) W.I.	7 Nov. 1979
Leg 3	St. Lucia (Marigot Bay) W.I.	10 Nov. 1979	Bequia (Admiralty Bay) W.I.	11 Nov. 1979
	Bequia (Admiralty Bay) W.I.	13 Nov. 1979	Tobago Cays	13 Nov. 1979
	Tobago Cays	15 Nov. 1979	St. John[1] (Cruz Bay) U.S.V.I.	20 Nov. 1979
	Great St. James Island (Christmas Cove) U.S.V.I.	21 Nov. 1979	St. Thomas U.S.V.I.	21 Nov. 1979

[1] Entering and clearing customs only.

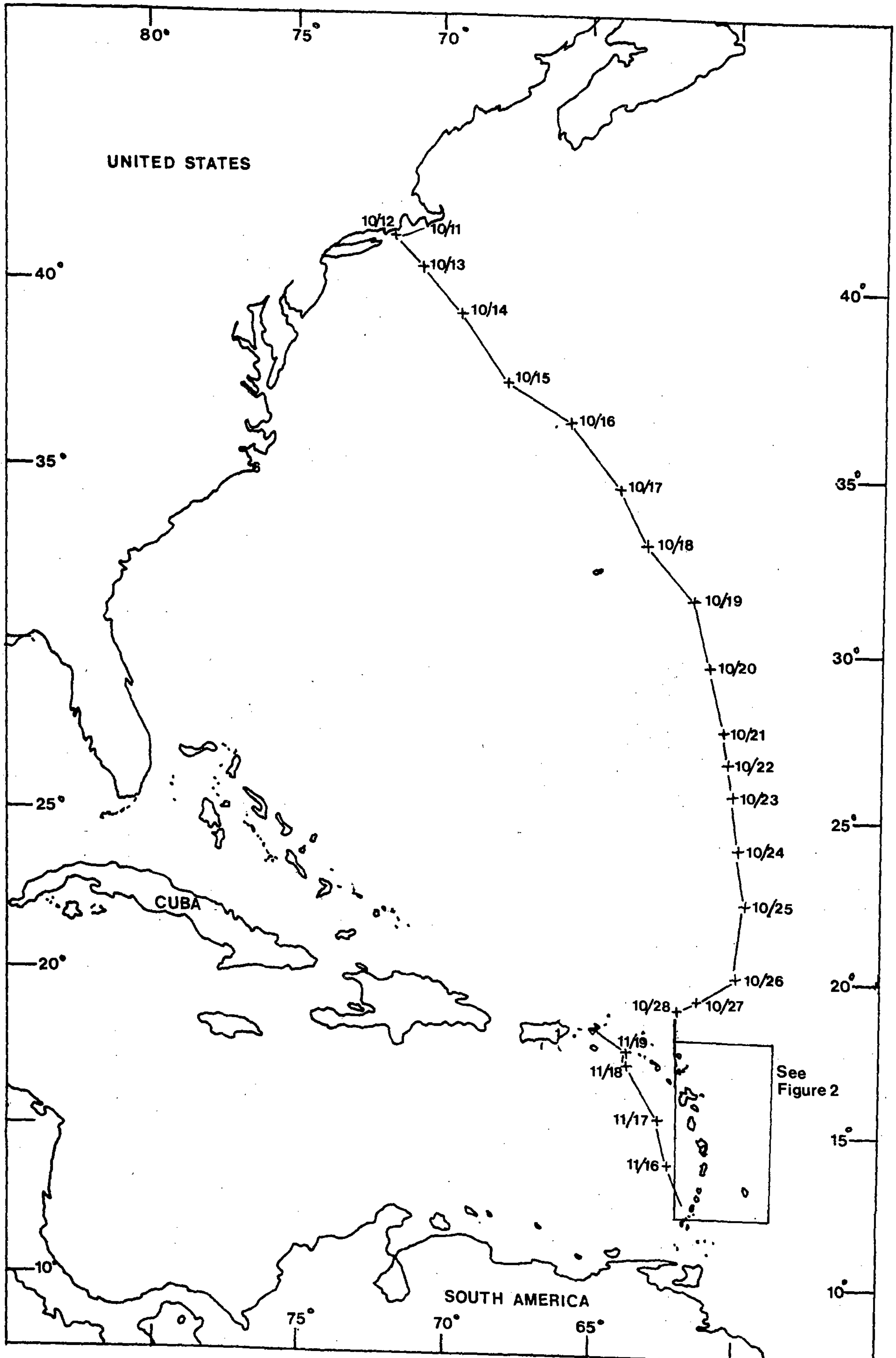


Fig. 1. North Atlantic cruise track of R/V Westward W-48 (dates indicate noon positions)

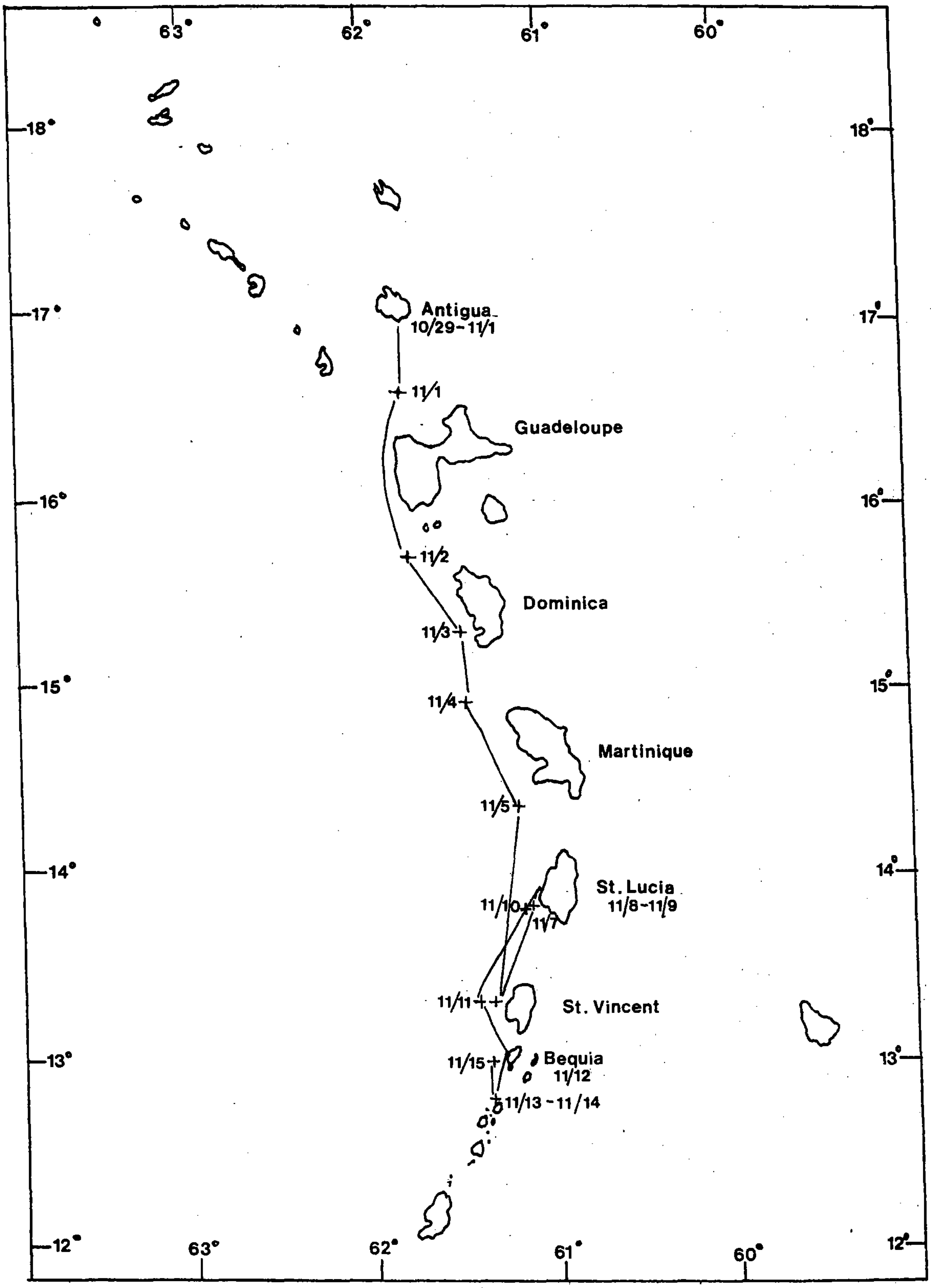


Fig. 2. Cruise track of R/V Westward in the Caribbean, W-48. (dates indicate noon positions)

TABLE 2. Ship's complement for R/V Westward Cruise W-48

Nautical Staff

Richard W. Farrell, Jr., B.A., Ocean Operator	Captain
Richard C. Ogus, B.S.	Chief Mate
Gregg H. Swanzey, B.S.	Second Mate
Tim Higbee	Third Mate
Gary Manter, A.M.S.	Chief Engineer
Susan Pilling, B.S. (Leg 1)	Steward
Sally Kaul, B.S. (Legs 2 and 3)	

Scientific Staff

Susan E. Humphris, Ph.D.	Chief Scientist
Melinda A. Ames, B.S.	Second Scientist
Robert Nawojchik, B.S.	Third Scientist

Visitors

Dr. Roscoe Mason (Leg 1)	Ship's Doctor
Mary Hutchison, B.A. (Leg 1)	
Charles E. McClennen, Ph.D. (Leg 3)	Colgate University

Students

Robin Bailey, Westminster College, Pa., Biology, Senior
Jan Beal, Cornell U., Ecology, B.S.
Peg Brandon, University of Rhode Island, Natural Resources, B.S.
Helen Edwards, University of Michigan, Microbiology, B.S.
Brenda Fogarty, University of Vermont, Biological Sciences, Senior
Rodman Getchell, University of New Hampshire, Microbiology, B.A.
Doug Goldhirsch, Colgate U., Geology, B.A.
Ned Grier, Davidson College, N.C., Economics, Senior
Andy Hadik, Keene State College, Earth Sciences, Senior
April Heitkamp, University of Vermont, English/Geology, Senior
Norm Livingston, Connecticut College, Botany, Junior

Students (continued)

Chris Lynch, Cornell U., History, Sophomore

Ann Magee, Wellesley College, Art History, Senior

Wendy Marks, University of Vermont, Education/Geology, Senior

Chris Nicholas, Cornell U., Physics, Junior

Lori Petitti, Regis College, Biology, Senior

Peggy Roesler, University of Miami, Biology, Senior

Tyler Sack, Wellesley, Sociology/Psychology, Junior

Donna Vallas, Williams College, Biology, Junior

Mary Jean Vickers, Reed College, Biology, Senior

Beth Walker, Connecticut College, Zoology/Anthropology, Junior

Chris West, Middlebury College, American Studies, Junior

Amy Wolff, Earlham College, Sophomore

Paige Wood, University of the South, TN, Biology, Senior

ACADEMIC PROGRAM

The Marine Science academic program aboard R/V *Westward* was composed of three areas of activity, each of which was given equal emphasis in the final evaluation.

1. Lectures

Lectures were given each weekday while at sea, and on occasion while in port; the topics covered are listed in Table 3. Many of them were related to sampling and analytical methodology, while others pertained to the on-going research activities, including those of the Visiting Scientist. Advantage was also taken of the opportunity to learn about subjects of particular interest in the ports we visited. For example, Desmond Nicholson of the Antigua Archaeological Society gave an extremely interesting lecture on the Arawak Indians, and organized a visit to see his collection of artifacts.

Information obtained during lectures and science watch was evaluated by means of a written examination (Appendix 1a).

2. Science watch

A 24-hour science watch was maintained throughout the cruise, and consisted of a member of the staff plus three students. Their responsibilities included maintenance of the science log, execution of scientific stations, and continuation of the scientific program in terms of analysis of samples and interpretation of data. In addition, laboratory and analytical techniques were learned, and time was also made available for individual student research projects, and personal instruction.

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 diversity of life in the ocean (Appendix 1b). This collection served as the basis for study of different phyla, and evalulation in this area was by means of a practical examination.

During the last two weeks of the cruise, one student each watch was designated Junior Science Watch Officer. He/she took over the responsibilities previously held by the staff scientist, and was responsible for the efficient running of the lab and the scientific program.

3. Individual research project

While in Woods Hole, each student was required to define a research project to be carried out on board *Westward*. Any subject could be chosen, the only constraints being that

i) the project should take advantage of the opportunities offered by the *Westward*

ii) it should be approached, executed, and written up in a scientific fashion.

The projects selected covered several fields of Marine Science, Nautical Science and Meteorology. Each student was requested to submit a written report before leaving the ship. The abstracts of these papers comprise the bulk of this Cruise Report. In addition, 10-minute presentations of the project and its results were given by each student.

TABLE 3. Lectures during W-48

T	11 October	Watch protocol; scientific activities for Leg 1	S. Humphris
F	12 October	The bathythermograph	A. Ames
M	15 October	Marine invertebrates I	R. Nawojchik
T	16 October	Marine invertebrates II	R. Nawojchik
W	17 October	The Gulf Stream	S. Humphris
T	18 October	Salinity and its determination	S. Humphris
F	19 October	Nansen bottles and reversing thermometers	A. Ames
M	22 October	Sargasso Sea - physical and chemical characteristics	S. Humphris
T	23 October	Sargasso Sea - the biological community	A. Ames
W	24 October	Oxygen determination - the Winkler method	S. Humphris
T	25 October	Ichthyology	R. Nawojchik
F	26 October	EXAM	
T	30 October	Archaeological findings in Antigua	D. Nicholson
T	1 November	Scientific research for Leg 2	S. Humphris
F	2 November	Spectrophotometric methods	S. Humphris
M	5 November	Geology of the Caribbean	S. Humphris & D. Goldhirsch
T	6 November	Identification of marine mammals	S. Pilling & R. Nawojchik
W	7 November	Introduction to the marine algae	A. Ames
S	10 November	The use of the side scan sonar	C. McClennen
T	13 November	Coral reef ecology	R. Nawojchik
T	15 November	Student seminars	
F	16 November	Student seminars	
S	17 November	Student seminars	
S	18 November	FINAL EXAM	
M	19 November	Student seminars	
T	20 November	Summary of side scan sonar work	C. McClennen

COOPERATIVE PROGRAMS

Cooperative Ship Weather Observation Program (NOAA)

Abby Ames

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. In addition, they provide ground truth information for comparison with satellite maps.

On average, our open ocean station data constitute the only observations in 144 sq. miles. On W-48, 55 sets of observations were compiled, of which 91% were successfully transmitted. Of these, 68% were copied by NMN, Portsmouth, Va., 31% by NMG, New Orleans, and 1% by NMC, San Francisco.

For our own purposes, these observations comprise a detailed sea surface and meteorological record for the cruise, and are available to anyone interested from the SEA office.

Shark Tagging Program (National Marine Fisheries Service)

Abby Ames

In cooperation with Dr. Jack Casey of the Narragansett Laboratory, National Marine Fisheries Service, the R/V Westward continues a long-lining project to catch, identify, characterize and tag sharks. The goal of this program is to discover migration patterns of certain species of sharks in the North Atlantic.

Early in the cruise, a whitetip shark, *Pterolamiops longimanus*, was caught on a fishing line and tagged. This shark and his companion circled the ship and bait for 40 minutes and provided us all with a unique opportunity to observe shark behavior.

Later, a longline was set on Saba Bank. Whole squid were used as bait, and forty hooks set. The line fished from sunset to sunrise. Two female sharks were caught and tagged - *Carcharhinus obscurus*, the dusky shark, and *Galeocerdo cuvieri*, the tiger shark.

The Distribution of Eel Larvae

Brenda Fogarty

ABSTRACT

Numerous zooplankton tows of various mesh size, at varying depths, in both daylight and night time were done on W-48 and inspected for leptocephalus. A total of 96 Anguilliformes were collected and identified to the family level. Approximately 70% of the Anguilliformes were of the family Muraenidae. Geographical zonation and temperature preferences by certain families were seen. Muraenidae were widely dispersed but were only found in a narrow temperature range. Of the samples collected 92% of the larvae were found at night which suggests that the Anguilliformes may be vertical migrators. These samples will be sent to Dr. J. Hain for further studies.

LONG TERM INTERNAL PROGRAMS

Neuston Studies

Abby Ames

For more than two years, Westward cruises have routinely carried out neuston tows and certain shipboard analyses of the catch. During W-48, twenty neuston tows were conducted and analysed for their contents of tarballs, Sargassum weed, and the marine insect Halobates micans. The results are shown in Table 4, and positions of stations are shown in Fig. 3.

Tar

Tar balls are thought to originate from crude oil lost during tanker washings (Butler et al. 1973. Bermuda Biol. Sta. Spec. Pub. 10). Lighter hydrocarbons evaporate, but the heavier hydrocarbons tend to concentrate into floating balls, which have a residence time of between 6 months and 10 years.

On W-48 we saw lower concentrations of tar, compared with similar cruises in 1977 and 1978. The maximum concentration encountered was at station W48-N13 in the Guadeloupe Passage.

Sargassum weed

Sargassum weed is a primary producer and is of particular interest to us in the long-term study of trophic dynamics in the Sargasso Sea. Considering data from only the interior part of the Sargasso Sea (Stations N1-10), the mean standing crop of Sargassum was 92.0 $mg.m^{-2}$ (S.D. = 89.1; range 261.7). This is very similar to values obtained on W-36 (73.8 $mg.m^{-2}$) and on W-42 (58.8 $mg.m^{-2}$). The abundance of Sargassum weed decreased dramatically south of station W48-N10.

Halobates

Halobates micans, a water strider, is the only one of 750,000 species of insects that spends its entire life cycle at sea. The mean abundance of 7000 km^{-2} is not significantly different from those observed on previous cruises to this area, although a lot of variability between tows was noted.

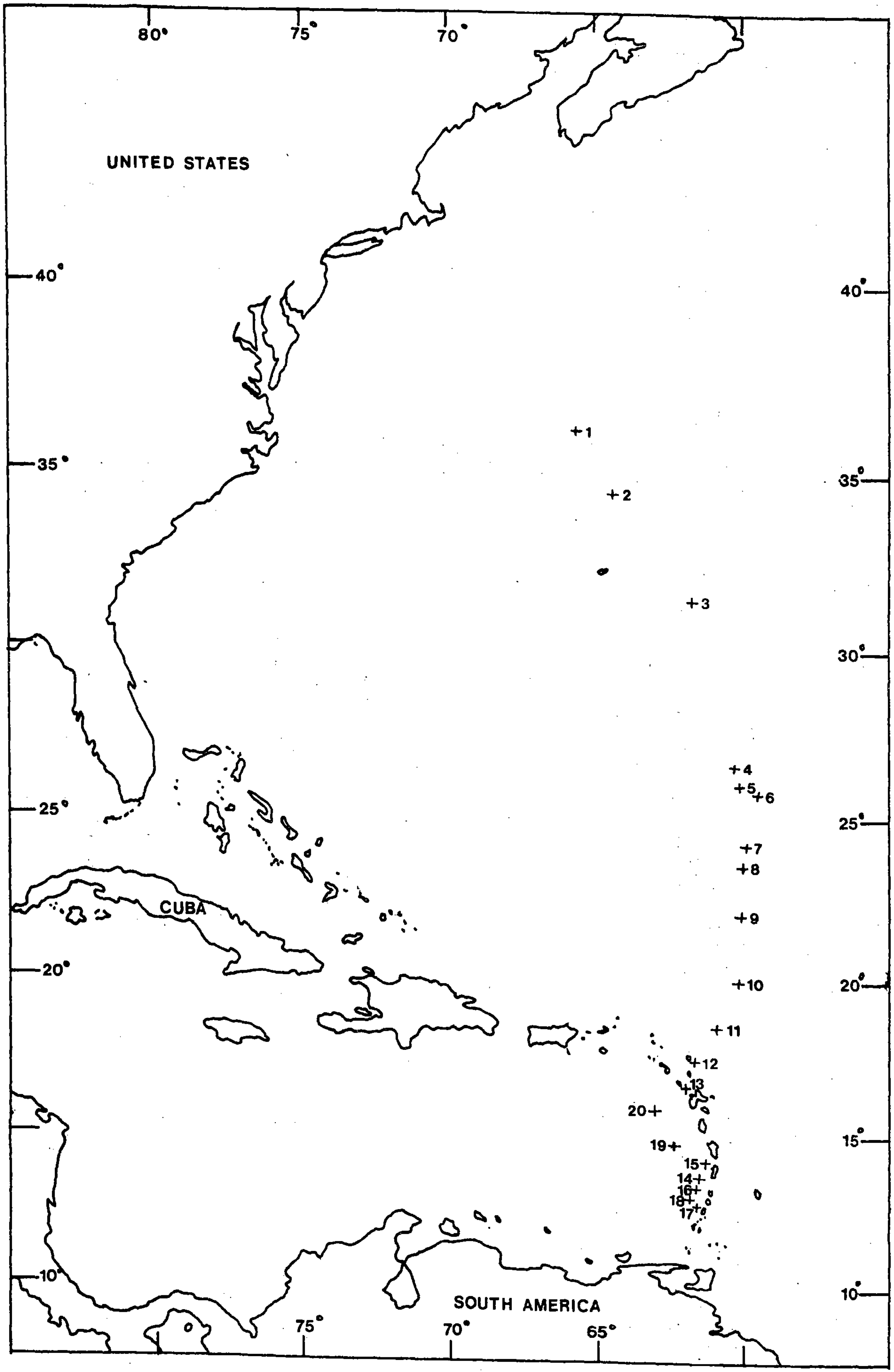


Fig. 3. Locations of neuston tows, cruise W-48.

Table 4. Summary of W-48 Neuston Tow Results

Calculated concentrations are based on an area filtered of 1853 m^2/tow (2.0 kts. for 30 mins)

Tow #	Date	Time (hrs)	Position N	Position W	Tarballs $10^{-3}g.m^{-2}$	Sargassum $10^{-3}g.wet\ wt.m^{-2}$	Halobates $10^3/km^2$
W48-N1	10/16	1145	36°24'	65°17'	5.9	26.9	0
W48-N2	10/17	1205	34°44'	64°04'	trace	17.6	0
W48-N3	10/18	1105	31°31'	61°04'	1.1	160.3	0.5
W48-N4	10/22	1130	26°31'	59°58'	1.1	261.7	1.1
W48-N5	10/22	2020	25°58'	59°46'	2.7	59.4	16.2
W48-N6	10/23	1145	25°41'	58°58'	1.1	50.7	10.8
W48-N7	10/24	1145	24°10'	59°24'	<1.1	31.3	4.3
W48-N8	10/24	2020	23°24'	59°25'	0.5	212.1	9.7
W48-N9	10/25	2000	21°50'	59°30'	0.5	6.5	13.0
W48-N10	10/26	1152	19°58'	59°34'	2.6	93.6	4.3
W48-N11	10/27	1220	18°05'	60°20'	0.5	1.1	5.4
W48-N12	10/28	1200	17°31'	61°42'	1.1	0.0	23.2
W48-N13	11/1	1130	16°40'	61°45'	10.8	0.0	1.6
W48-N14	11/6	2155	13°34'	61°13'	0.0	0.0	3.8
W48-N15	11/7	1310	13°52'	61°07'	1.5	0.0	7.6
W48-N16	11/10	1930	13°22'	61°15'	<0.5	0.0	15.1
W48-N17	11/15	1130	12°41'	61°24'	0.2	0.4	3.8
W48-N18	11/15	2015	13°11'	61°31'	0.0	0.0	20.0
W48-N19	11/16	2010	14°22'	62°17'	0.0	0.0	3.2
W48-N20	11/20	2010	15°43'	62°51'	0.8	0.2	1.1
Mean					1.7	46.1	7.2
Standard deviation					2.6	77.3	7.0
Range					10.8	261.7	23.2

Geg. 205

Ornithological Survey of the Atlantic Ocean and Caribbean Sea

Peg Roesler

ABSTRACT

An ornithological survey was taken during W-48 beginning at 39°20' N latitude, 69°30' W longitude. Bird sightings were correlated to potentially influential environmental factors including wind force and its direction relative to the land, phytoplankton biomass measured as settled volume, and marine vertebrate sightings (mammals and fish). The distribution of terrestrial birds was observed to be dominated by the wind force and direction in relation to the land and their migration routes. Marine bird distribution is dependent on marine life for food; few were seen in the relatively unproductive Sargasso Sea. However, in the Caribbean, flocks of marine birds flying close to the water were associated with whales, dolphins, and schools of large fish, presumably both seeking related food sources. Data are presented in Tables 5 and 6, and the positions of sightings are shown, and compared with previous cruises, in Figures 4 and 5.

TABLE 5. ORNITHOLOGICAL SURVEY W-48 ATLANTIC OCEAN PASSAGE

Date	Position	Common Name	Latin Name	Number	Habitat	Wind Direction	Beaufort Force	Transect Number
10/14/79	39°20'N 69°30'W	Yellow-shafted Flicker	Colaptes auratus	2	Arboreal Migrant	North Squalls	5	1
		Myrtle Warbler	Dendroica coronata	1	Terrestrial Migrant	"		2
		White-throated sparrow	Zonotrichia albicollis	1	"	"		3
		Vesper sparrow	Pooecetes gramineus	1	"	"		4
		Eastern meadowlark	Sturnella magna	1	Pastoral Migrant(?)	"		5
10/15/79	37°17'N 67° 0'W	Song sparrow	Melospiza melodia	1	Terrestrial Migrant	NNW	5	6
10/16/79	36°24'N 65°17'W	Herring Gull (Im.)	Larus argentatus	1	Coastal	WNW	4	7
	35°43'N 64°57'W	Herring Gull	"	2	"	W	4	7
10/17/79	35° 4'N 64°25'W	White-tailed Tropic birds	Phaethon lepturus	1	Oceanic	E drizzles	2	8
	34°54'N 64°14'W	Pine Warbler	Dendroica pinus	1	Arboreal Migrant	ENE	2	9

TABLE 5. (continued) ORNITHOLOGICAL SURVEY W-48 ATLANTIC OCEAN PASSAGE

Date	Position	Common Name	Latin Name	Number	Habitat	Wind Direction	Beaufort Force	Transect Number
10/17/79	34°36'N 63°50'W	Herring Gull	Larus argentatus	1	Coastal	ENE	3	7
10/19/79	32° 0'N 61°21'W	White-tailed Tropic Bird	Phaethon leptarus	1	Oceanic	ENE	5	8
10/21/79	27°42'N 60°11'W	American Redstart	Setophaga ruticilla	1	Terrestrial Migrant	NE Squalls	5	10
	"	Least Tern	Sterna albifrons	1	Shore	"		11
	27°30'N 60°20'W	Herring Gull	Larus argentatus	1	Coastal	E Squalls	5	7
10/22/79	26°N 60°20'W	Barn Swallow	Hirundo rustica	1	Pastoral Migrant	W	1	12
10/24/79	24°38'N 59°16'W	Barn Swallow	"	2	Pastoral Migrant	SSW Squalls	5	12
	"	Prothonotary Warbler	Protonotaria citrea	1	Terrestrial Migrant	"	5	13
	24°11'N 59°24'W	Common tern	Sterna hirundo	1	Coastal	SSW	3	14

TABLE 5 (continued) ORNITHOLOGICAL SURVEY W-48 ATLANTIC OCEAN PASSAGE

Date	Position	Common Name	Latin Name	Number	Habitat	Wind Direction	Beaufort Force	Transect Number
10/25/79	22°06'N 59°38'W	Blue-faced Booby	_Sula dactylatra_	1	Winters on ocean	SSE	2	15
		Barn Swallow	_Hirundo rustica_	1		"	2	12
10/26/79	20°32'N 59°30'W	Barn Swallow	"	1		SE	1	12
		Common tern	_Sterno hirundo_	1	Coastal	SE	1	14
10/27/79	18°49'N 59°60'W	Common egret	_Casmerodius albus_	1		SE	3	16
	17°35'N 60°15'W	Least tern	_Sterna albifrons_	1	Coastal	SE	4	11
10/28/79	17°31'N 60°41'W	Yellow warbler	_Dendroica petechia_	1	Arboreal	SE	3	17

Key to Figures 4 and 5.

Bird species are designated by numbers found in 'transect number' column In Tables 5 and 6.

Bird type

□	Terrestrial
o	Pelagic
△	Coastal

Cruise number of sighting

11	(heavy lettering)	W-48	(this report)
11	(italics)	W-42	(1978)
11	(circled number)	W-36	(1977)

Number of birds sighted

1	- no letter
2	- denoted by the letter A
3-5	- denoted by the letter B
up to 10	- C
>10	- D

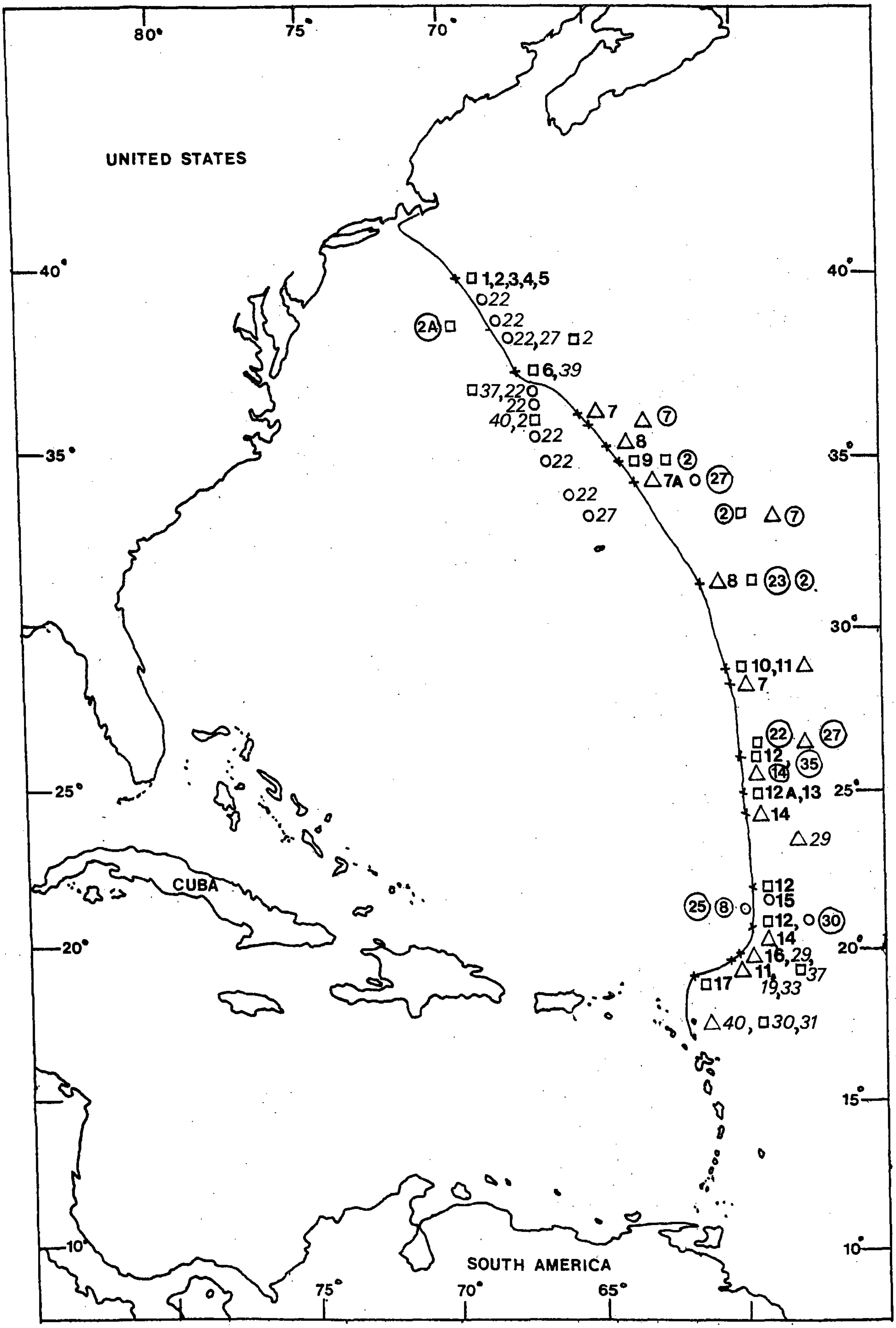


Fig. 4. Species and types of birds seen during North Atlantic Ocean passages of cruises W-36 (1977), W-42 (1978), and -48 (1979).

TABLE 6. ORNITHOLOGICAL SURVEY W-48 CARIBBEAN SEA

Date	Position	Common Name	Scientific Name	Number	Habitat	Transect Number
10/29/79-11/1/79	English Harbor, Antigua	Magnificent Frigate Bird	Fregata magnificens	4	Pelagic	18
		Brown Pelican	Pelecanus occidentalis	3	Coastal	19
		Gannet	Morus bassanus	1	Winters on oceans	20
		Common tern	Sterna hirundo	Flock	Coastal	14
11/1/79	16°22.5'N 61°53'W	Laughing Gull	Larus atricilla	1	Coastal	21
11/3/79	15°17.7'N 61°27.4'W	Unidentified Tern	Family Laridae Sub F. Sterninae	2	Coastal	14
		Frigate Bird	Fregata magnificens	1	Pelagic	18
11/4/79	15°N 61°27'W	Frigate Bird	"	1	Pelagic	18
	14°57'N 61°24'W	Shearwater	Puffinus sp.	Flock 15-20	Pelagic	22
11/5/79	14°37'N 61°12'W	Audubon's Shearwater	Puffinus lherminieri	10	Pelagic	22
		Greater Shearwater	Puffins gravis	3	Pelagic	23
		Magnolia Warbler	Dendroica magnolia	1	Terrestrial	24
11/6/79	13°15'N 61°20'W	No I.D.	--	Flock	Marine	
	13°23'N 61°20'W	Shearwaters	Puffinus sp.	Flock	Pelagic	22
	13°34.2N 61°08.8W	Least tern	Sterna albifrons	1	Coastal	11

TABLE 6 (continued) ORNITHOLOGICAL SURVEY W-48 CARIBBEAN SEA

Date	Position	Common Name	Scientific Name	Number	Habitat	Transect Number
11/7/79	61°11'W 13°36'N	Sooty tern	Sterna fuscata	4	Coastal	25
	13°52'N 61°7.4'W	Tern - Unidentified	Sub F. Sterninae	1	Coastal	14
11/10/79		Magnificent Frigate Bird	Fregata magnificens	2	Pelagic	18
11/10/79		Magnificent Frigate Bird	Fregata magnificens	1	Pelagic	18
11/11/79	13°38'N 61°30'W	No I.D.		10-12	Coastal or Pelagic	
	13°16'N 61°17'W	Common egret	Casmerodius albus	2	Coastal	16
	13°15'N 61°17'W	Caspian tern	Hydroprogne caspia	1	Coastal	26
	13°04.5'N 61°13.4'W	Frigate bird	Fregata magnificens	1	Pelagic	18
	"	Gull unidentified	Family: Laridae	2	Coastal	7
		Greater Shearwater	Puffins gravis	3	Pelagic	22
		Unidentified tern	Family: Sterninae	2	Coastal	14
	13°N 61°13'W	Brown Boobies	Sula leucogaster	7-8 flocks	Coastal	27
		Greater Shearwater	Puffins gravis	3	Pelagic	22
11/14/79		Frigate bird	Fregata magnificens	2	Pelagic	18

TABLE 6 ORNITHOLOGICAL SURVEY W-48 CARIBBEAN SEA
(continued)

Date	Position	Common Name	Scientific Name	Number	Habitat	Transect Number
11/14/79		Frigate bird	*Fregata magnificens*	Flock 12	Pelagic	18
		Frigate bird	"	4	"	18
11/15/79	12°53'N 61°30'W	Tern Unidentified	Family: *Sterninae*	2	Coastal	14
	13°01.3'N 61°34'W	Shearwater Unidentified	*Puffinus* sp.	3 Flocks (~ 60)	Pelagic	22
		Frigate bird	*Fregata magnificens*	1	Pelagic	18

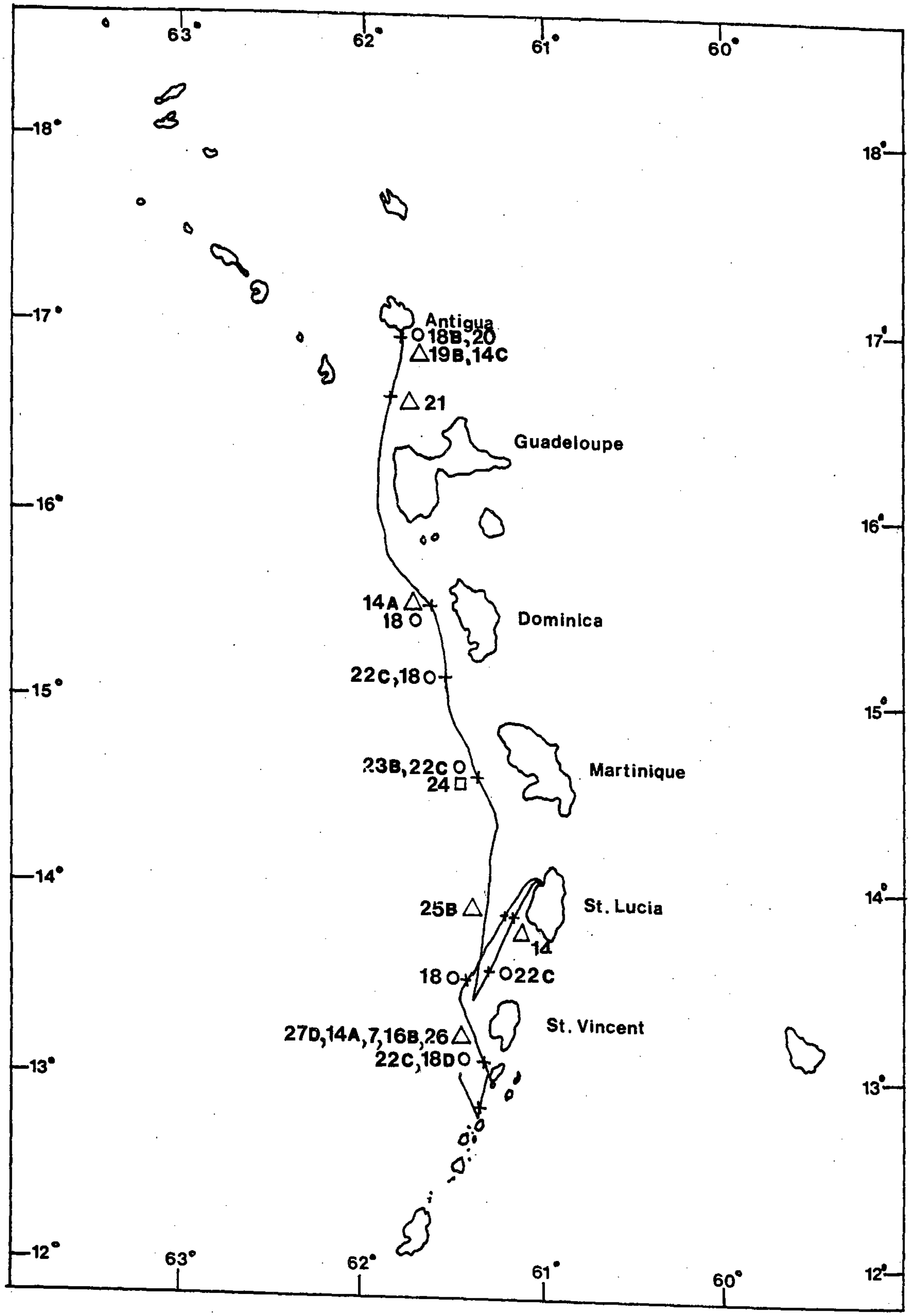


Fig. 5. Birds seen during the Caribbean passage during W-48.

SARGASSO SEA STUDIES

Introduction

The Sargasso Sea represents the center of an asymmetrical anti-cyclonic gyre in the North Atlantic, and is composed of a mass of warm, saline water, extending to a depth of about 200m. It is bounded on the western and northern sides by the Gulf Stream and North Atlantic Drift, and on the eastern side by the ill-defined Canary Current. To the south lies the Antilles current, which is derived from the Northern Equatorial Current.

For several years we have been examining productivity, biomass, species diversity, and feeding relationships of the community associated with Sargassum weed, in an effort to collect enough data to produce a simple trophic model. Aspects of this work were continued by students during W-48. In addition, various aspects of circulation within and around the Sargasso Sea were studied. The abstracts that follow represent individual research projects undertaken by students.

A. PHYSICAL STUDIES

A Transect of the Gulf Stream Between 38°08'N 68°07'W and 37°16'N 67°16'W

Christopher W. Lynch

ABSTRACT

A study was undertaken to determine the temperature structure of the upper 300 meters of the Gulf Stream between 38°08'N 68°07'W and 37°16'N 67°16'W on 15 October, 1979 (Figure 6). Using the Ocean Frontal Analysis to estimate the Stream's position, stations (taking bathythermograph and bucket thermometer readings) were begun on the northern boundary of the current and continued at 5 nautical mile intervals across the Stream. The temperature transect (Figure 7) obtained defined part of the northern wall of the Gulf Stream, with its sharp temperature gradient. The southern extent of the current was less well-defined, due to the similarity in temperature between the Gulf Stream and the waters of the Sargasso Sea. It was also determined that the Gulf Stream was positioned 2.5 to 4 nautical miles further north, at this time, than indicated by the Ocean Frontal Analysis.

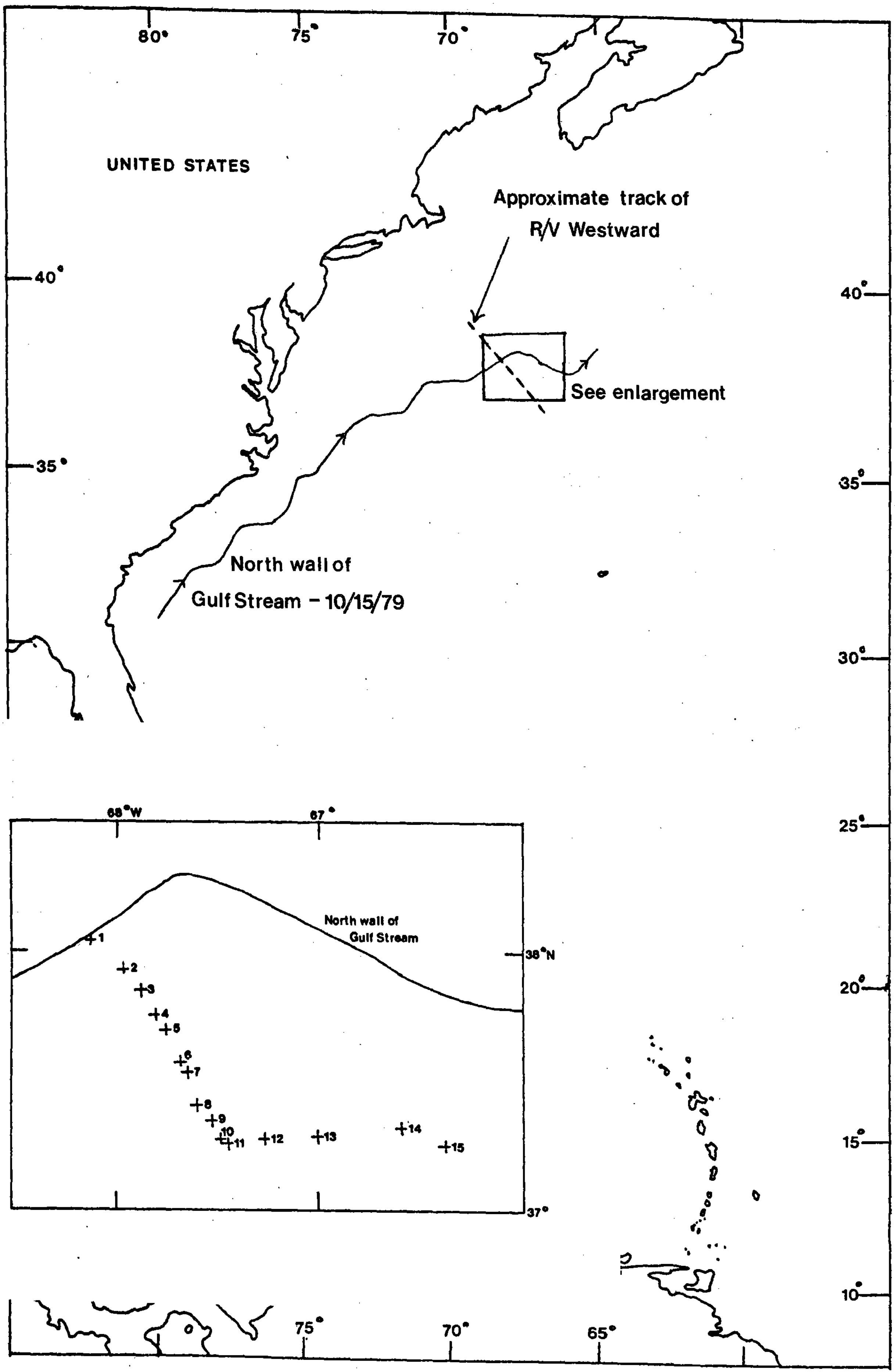


Fig. 6 . Position of crossing of the Gulf Stream, and location of the north wall of the Gulf Stream estimated from Ocean Frontal Analysis.

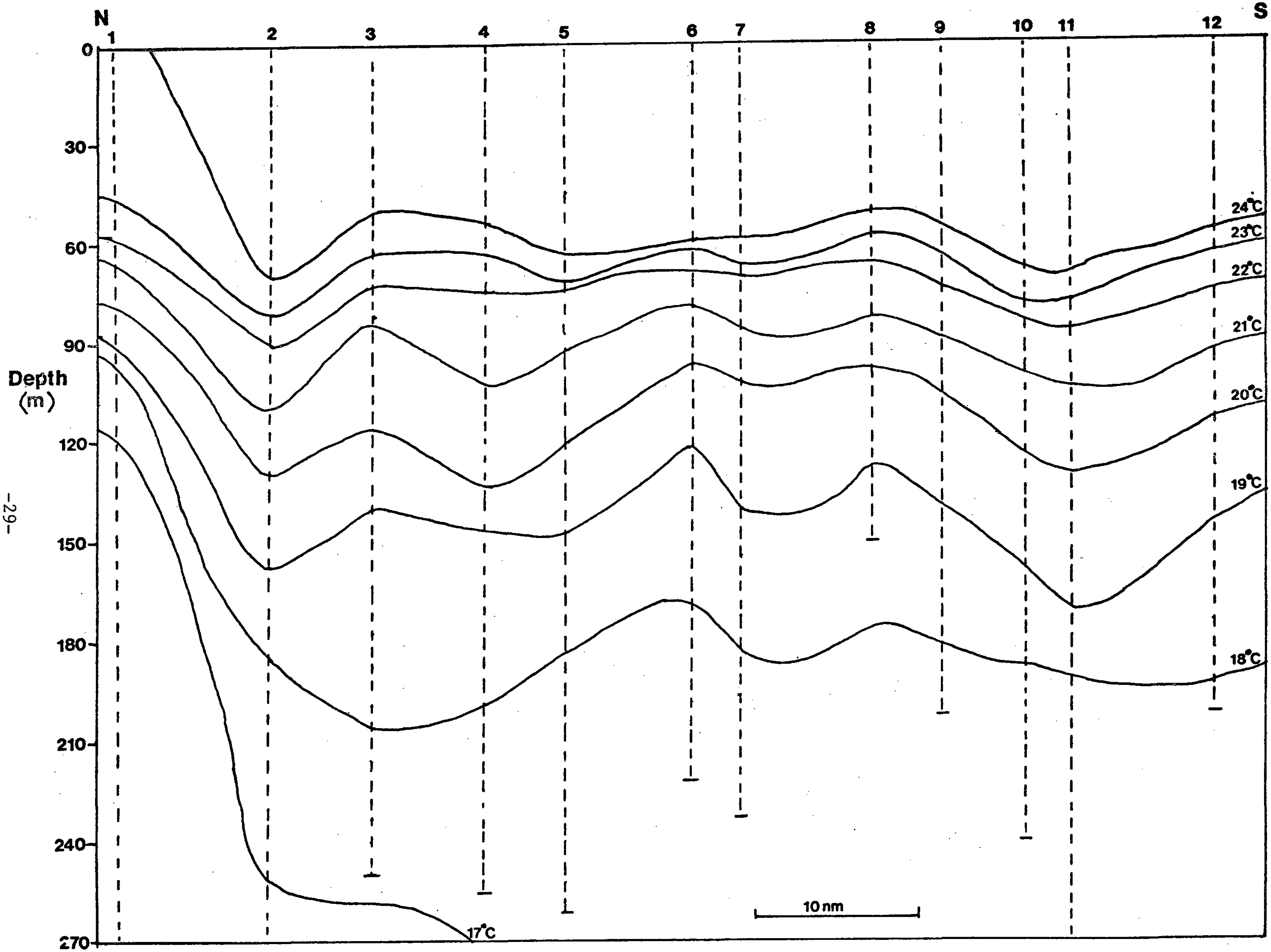


Fig. 7. Temperature profile across the north wall of the Gulf Stream (position in Fig. 6)

Geostrophic Velocities in Currents of the Sargasso Sea

Chris Nicholas

ABSTRACT

Hydrocasts were taken at five locations across the Sargasso Sea in order to calculate current flow using the geostrophic model. The density distribution was calculated from temperature and salinity data, and showed a gradient from approximately 27°N latitude, decreasing in a southerly direction. Velocities were calculated to be less than 2 kts. at the surface, decreasing with depth.

Thermal Fronts of the North Atlantic Subtropical Convergence

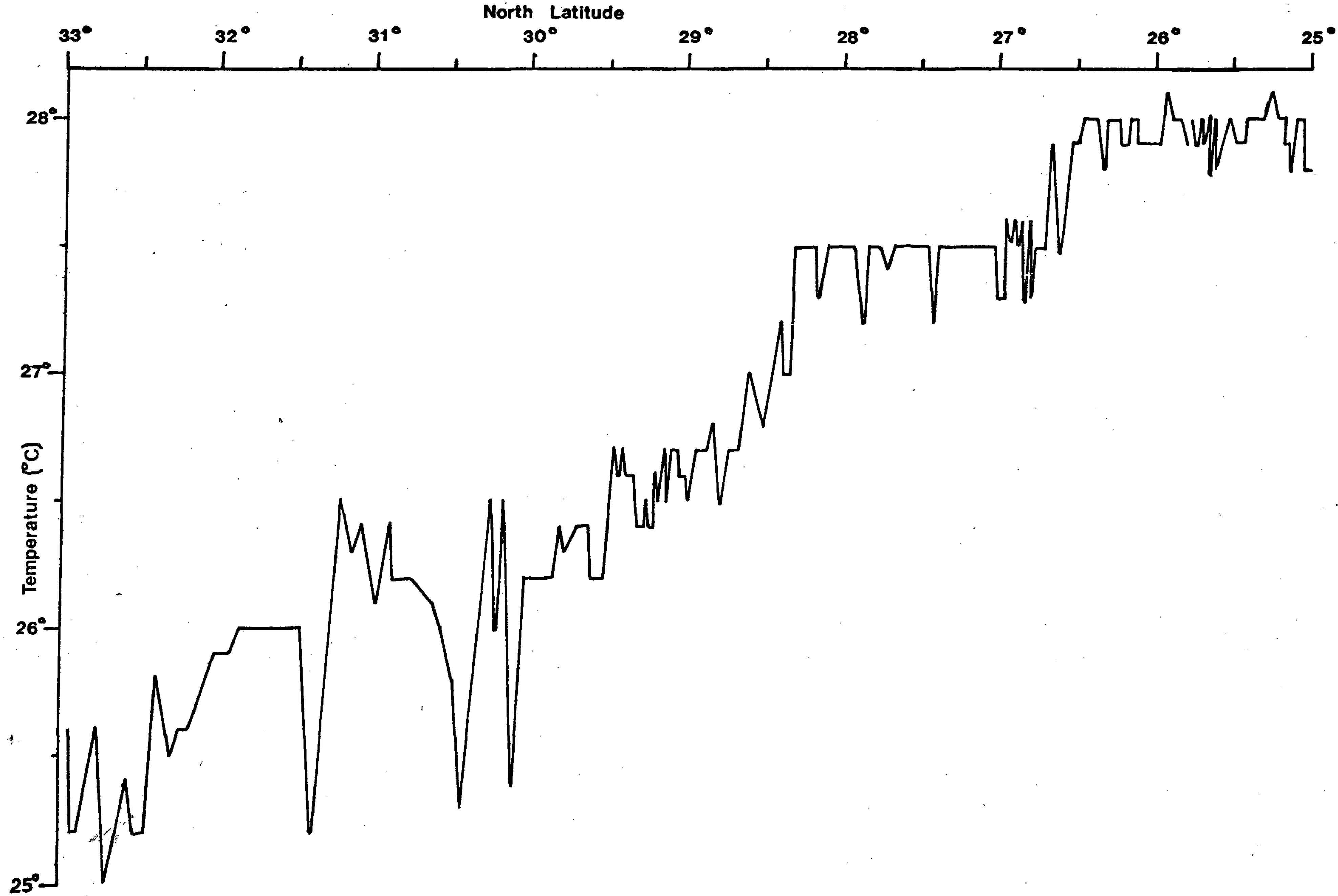
Wendelyn W. Marks

ABSTRACT

Thermal fronts, which form between 25°-30°N in the Sargasso Sea, are the result of the convergence of the westerly winds and the easterly trades. They are characterized by changes in temperature of 1° C or more over a distance of 10 km. or less, which is due to a wedge of warmer southern waters over the cooler northern waters (Voorhis and Schroeder, 1976). On October 17th and 20th, two thermal fronts were located in the Sargasso Sea between 31.5° north and 30° north and 60° west. Hourly surface temperatures were taken from the ship to locate the fronts. Both fronts extended 10 n.mi., the first with a temperature range from 25.2° C to 26.5° C, the second with a range from 25.3° C to 26.5° C. Because the temperature changes were not recognized as thermal fronts until we were too far south to return, further data are not available. Surface temperature readings are shown in Fig. 8.

Voorhis, A.D. and Schroeder, E.H. 1976. The influence of deep mesoscale eddies on sea surface temperature in the North Atlantic Subtropical Convergence. J. Phys. Oceanogr., 6, 953.

Fig. 8. Surface temperature observations along the cruise track in the Sargass Sea.



B. BIOLOGICAL STUDIES

Primary productivity in the Sargasso Sea

Mary Jean Vickers

ABSTRACT

Measurements of primary productivity of surface water at different latitudes in the Sargasso Sea were made using the light and dark bottle method. Although net productivity at all stations was low, a trend of higher production in the more northern stations was observed. Due to possible zooplankton contamination in the samples, primary productivity may be higher than measured in these experiments.

An Ecological Study of Diatoms in the Sargasso Sea

Helen Edwards

ABSTRACT

A study of diatoms in the Sargasso Sea was conducted to determine what genera were present and which were more plentiful compared with previous studies. Five samples of diatoms were collected using a phytoplankton net approximately every three degrees of latitude from 37°36'N to 25°34'N. Samples were then analyzed for diatom content. *Navicula* was determined to be the most widespread genus, being found everywhere that diatoms were found. Other genera found included *Biddulphia*, *Rhizoselenia*, *Chaetoceros*, *Coscinodiscus*, *Asterionella*, *Mitzschia*, and *Bacterioasteria*. One sample contained no diatoms. Data compared well with a similar study done March 1979, on *Westward* and with a previous extensive study (Riley, 1957). A notable exception was that *Navicula* was not listed as an indigenous species and is now the most widespread. A seasonal change was expected but not observed in relation to the Spring study.

Riley, G. 1957. Phytoplankton of the North Central Sargasso Sea. Limnol. Oceanogr., 2, 252-270.

Zooplankton of the Sargasso Sea

Paige Wood

ABSTRACT

The distribution of zooplankton in the Sargasso Sea was investigated at six stations, in a transect from the center to the southern boundary current. Measurements of the settled volume indicated that the biomass was greater in the Antilles current (up to 5.0 ml/m^3 water) and coastal water near Bermuda (0.3 ml/m^3 water) than in the central Sargasso Sea (up to 0.2 ml/m^3 water).

GRENADA BASIN STUDIES

Introduction

The Caribbean Sea can be divided into three basins: the Colombia Basin in the west, the Venezuela Basin, and the smaller Grenada Basin, which lies behind the Lesser Antilles. Each of these basins is separated from the others by ridges, which directly affect the water structure. The water is highly stratified in the upper 1200 meters, with weak stratification between 1200 and 2000 m., and nearly homogeneous conditions below 2000 m.

The passages in the Lesser Antilles, through which much of the Caribbean water enters, have sill depths of less than 1200 m, which means that deep and bottom waters do not penetrate into the Caribbean between these islands. Renewal of deep and bottom waters must therefore occur through the passages in the Greater Antilles, excluding the Yucatan Straits, even though they are less that 200 m. deep.

Many questions still remain concerning the general circulation of the Caribbean. Stalcup and Metcalf (1972) have suggested that the Grenada, St. Vincent and St. Lucia Passages are the main sources of upper water to the eastern Caribbean. Eddies have been detected to the west of these passages, but their origin is not yet fully understood (Leming, 1971). At greater depths, Antarctic Intermediate Water (AAIW), which originates in high latitudes but can be traced in a diluted form as far north as the Tropic of Cancer, flows through the deeper passages into the Grenada Basin. Worthington (1971) has estimated that about 10×16^6 m^3/sec of AAIW should be flowing westward in the eastern Caribbean. However, it appears that not enough North Atlantic Deep Water enters the Caribbean to mix with the AAIW to reduce its flow to the 3×10^6 m^3/sec that is observed in the Florida Straits. Hence the distribution and volume of AAIW in the Caribbean is still an important question. In the deep and bottom waters, the major unresolved problem is the rate of renewal of these waters and by what process this may occur (Wust, 1964; Worthington, 1971).

On W-48, a study was begun to investigate the distribution and chemical characteristics of water masses down to a maximum depth of 2000 m. in the eastern Caribbean. A series of hydrostations were carried out in the passages between the islands of the Lesser Antilles in order to determine the characteristics of the water flowing over the sills. In addition, a series of hydrocasts were made on the western side of the Grenada Basin in an attempt to study the water mass distribution and characterize the water column on the eastern side of the Aves Ridge. The locations of the stations are shown in Fig. 9 , and the data for all the hydrocasts are presented in Appendix II. The analysis of the data given here is only preliminary, and hopefully can be combined with similar data from the Venezuela and Colombia Basins to be collected on future cruises.

Other projects were completed in the Grenada Basin. The distribution of marine life, in relation to productivity of the water, was studied near St. Vincent; a 24-hour station was carried out in order to look at vertical migration; microbiological experiments were also done. Abstracts of these student projects are included in this section. In addition, side scan sonar track lines were run in the lee of St. Lucia and St. Vincent, and as we approached Tobago Cays.

Hydrography of the Grenada Basin

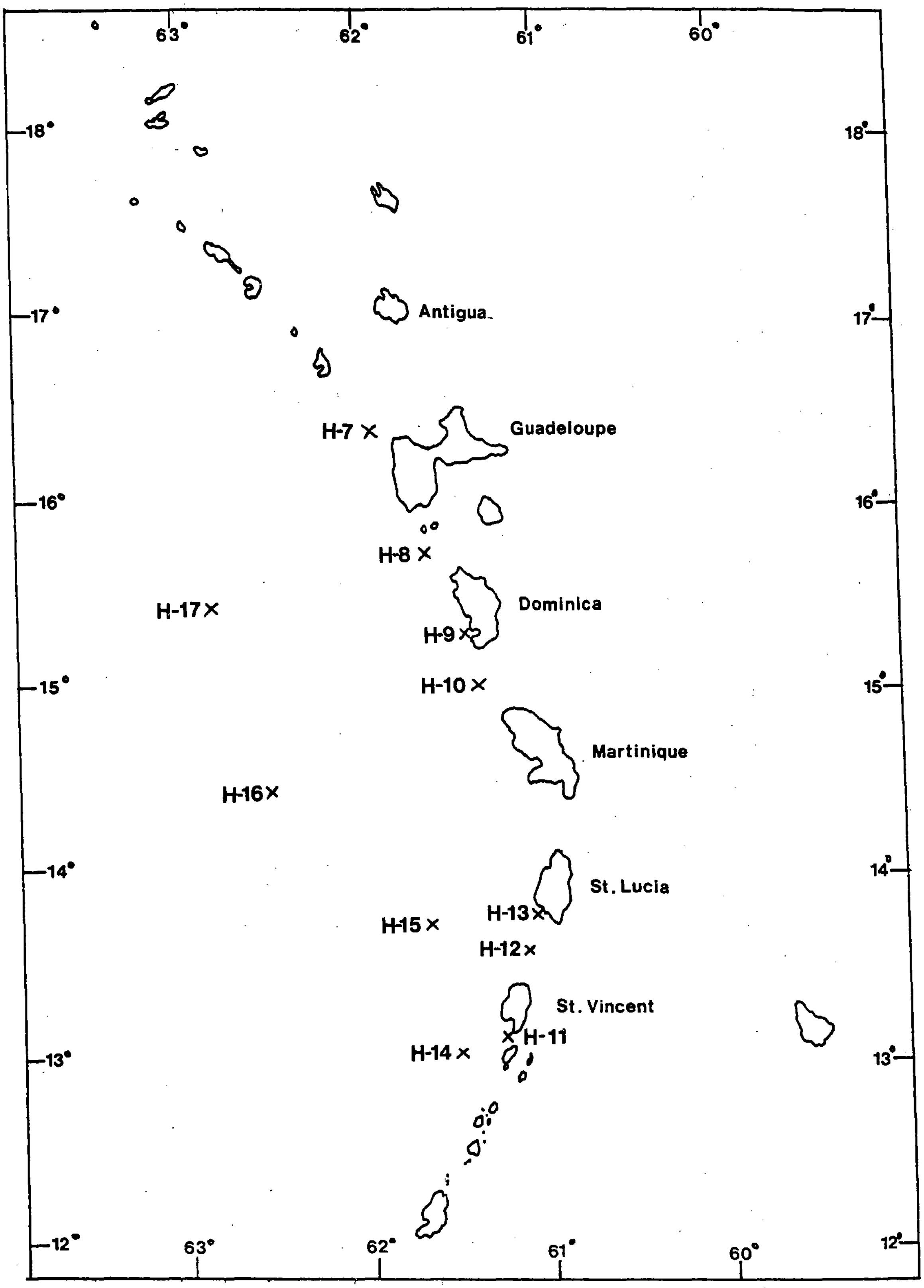
a) Temperature (Fig. 10)

In all the stations, a surface mixed layer with a temperature between 27.0 and 29.5° C, extends down to a depth of up to 90 m. Beneath this, temperature decreases with depth, reaching 4.20° C at 1750 m, the deepest sample recovered. Of those investigated, the major passages with sill depths deep enough to allow penetration of large amounts of AAIW, the core of which has been defined as the 6° C isotherm (Worthington, 1971), are those between St. Vincent and Bequia, St. Vincent and St. Lucia, and between Martinique and Dominica.

b) Salinity (Fig. 11)

An interesting surface feature seen in the most southerly stations is a tongue of water with very low salinity at the surface. This may

Fig. 9.   Locations of hydrostations in the Grenada Basin.



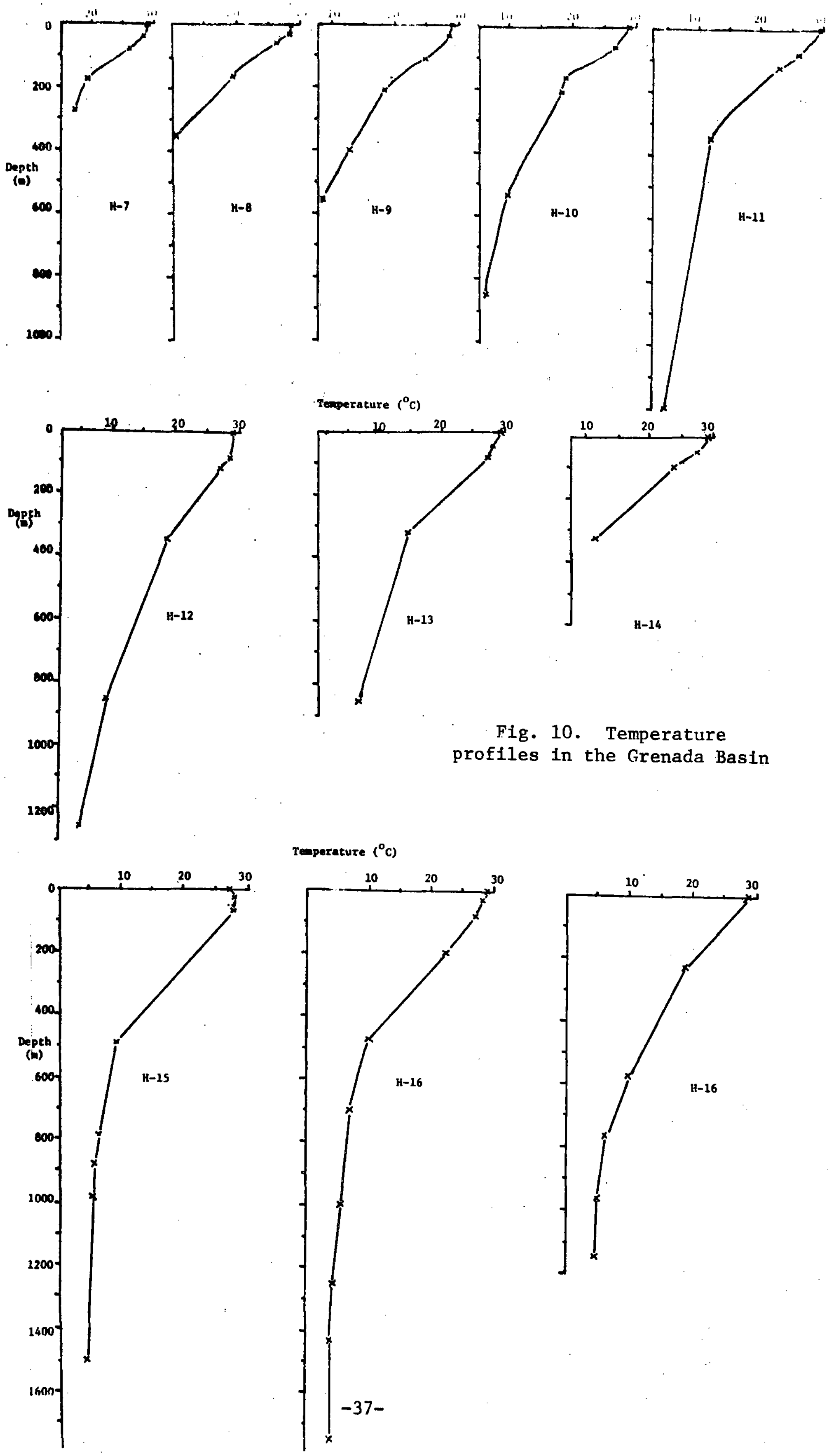


Fig. 10. Temperature profiles in the Grenada Basin

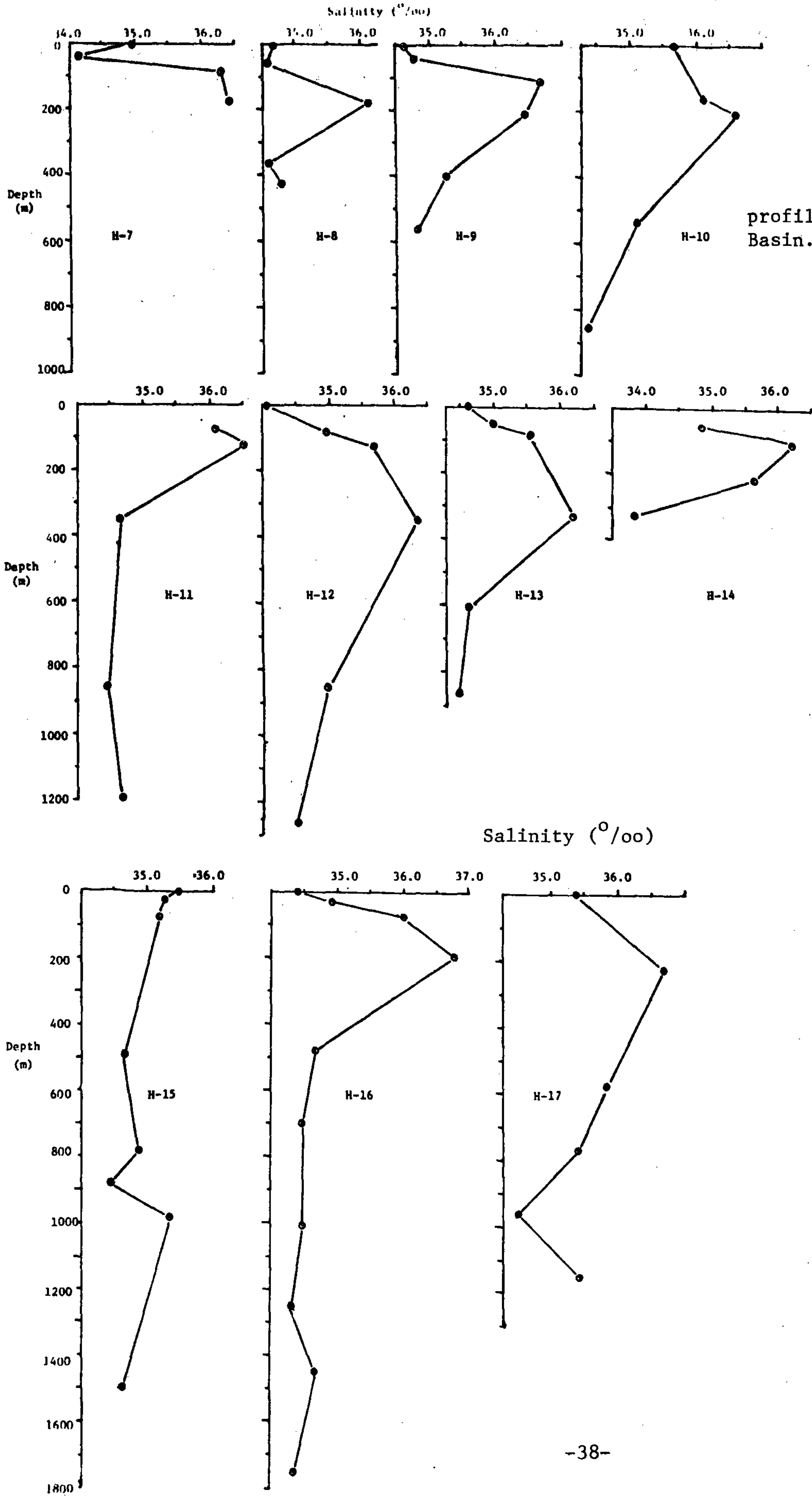


Fig. 11. Salinity profiles in the Grenada Basin.

be indicative of entrainment of fresh water from the major rivers along a portion of the South American coast (Orinoco and Amazon), into the northward flowing currents.

The most noticeable feature in these profiles is the salinity maximum that occurs at a depth of 100-200 m. In the most southerly stations (H-11 and H-14), this water mass exhibits a maximum at about 100 m, where salinity reaches values of 36.50 $^{o}/oo$. In the passage between St. Lucia and St. Vincent (H-12 and H-13), the salinity maximum covers a greater depth range, but reaches salinities of only 36.35 $^{o}/oo$. In the northern passages, the core of this water mass again lies between 100 and 200 m. This water mass is the Subtropical Underwater (or salinity maximum water in the terminology of Worthington [1976]), which results from the excess of evaporation over precipitation in the trade wind region. This produces denser water that converges, sinks and flows as a tongue of saline water. Below the maximum, the salinity, in general, shows a gradual decrease with depth.

c) Dissolved oxygen (Fig. 12)

The dissolved oxygen content of the mixed layer, which extends to a depth of up to 100 m, varies between 4.60 and 4.90 ml/l. The concentration then decreases with depth to a minimum at depths of about 500-700 m. Dissolved oxygen contents at these depths can be as low as 2.75 ml/l. This minimum is possibly related to the presence of Tropical Atlantic Central Water, as distinguished by Morrison (1977). The deeper hydrostations show that below this, the oxygen content of the water increases, due to the presence of North Atlantic Deep Water (NADW) at greater depths.

d) Dissolved silicate (Fig. 13)

The surface layer is depleted in dissolved silicate throughout the Grenada Basin, with concentrations of less than 3 μM/L. In those profiles where there are sufficient data, a decrease in silicate content is seen to a depth of between 50 and 150 m, where a minimum of approximately 1 μM/L. is observed.

Silicate concentrations then increase with depth to the high values associated with AAIW. This water mass is particularly well defined in

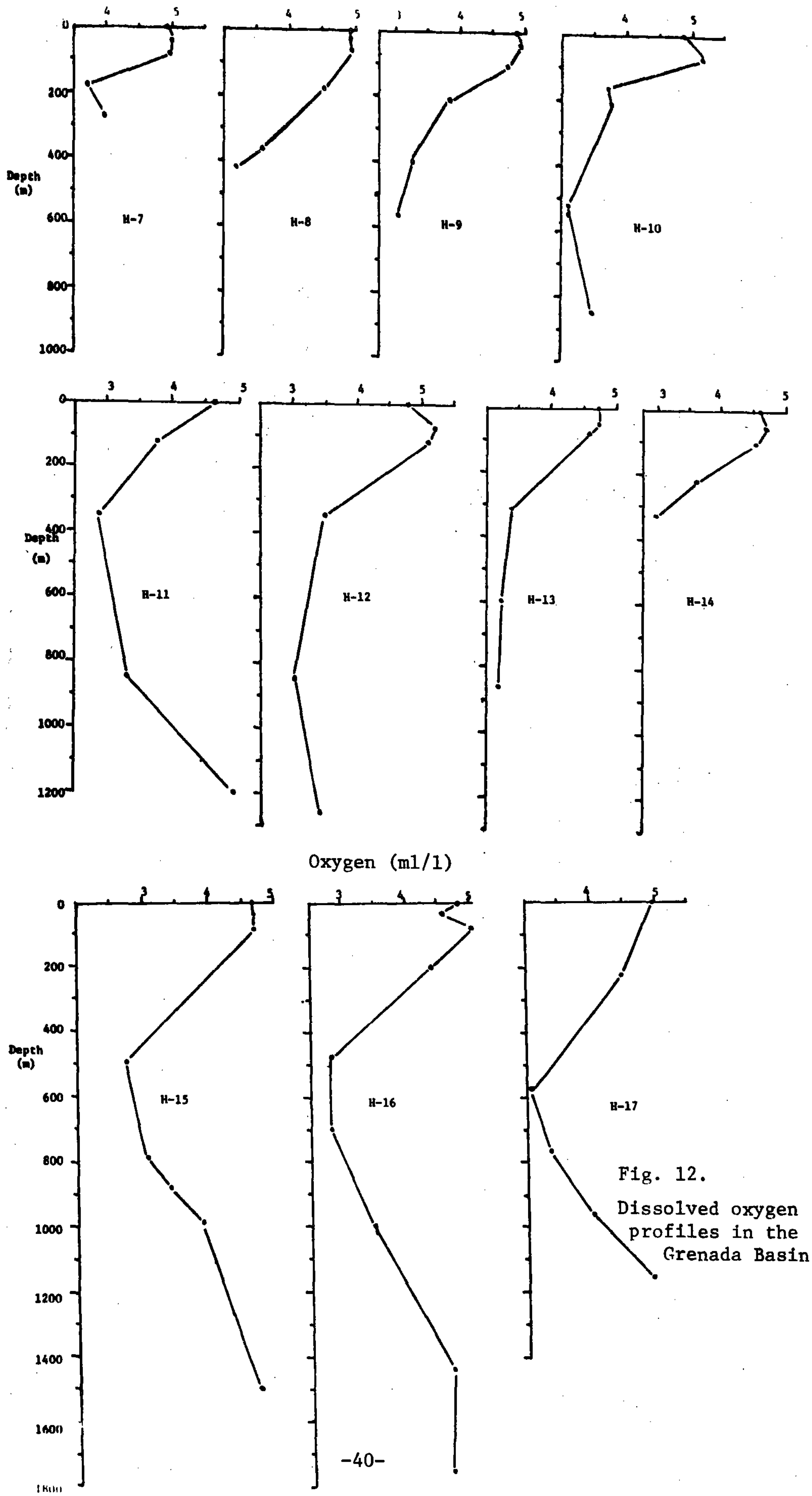


Fig. 12.
Dissolved oxygen profiles in the Grenada Basin

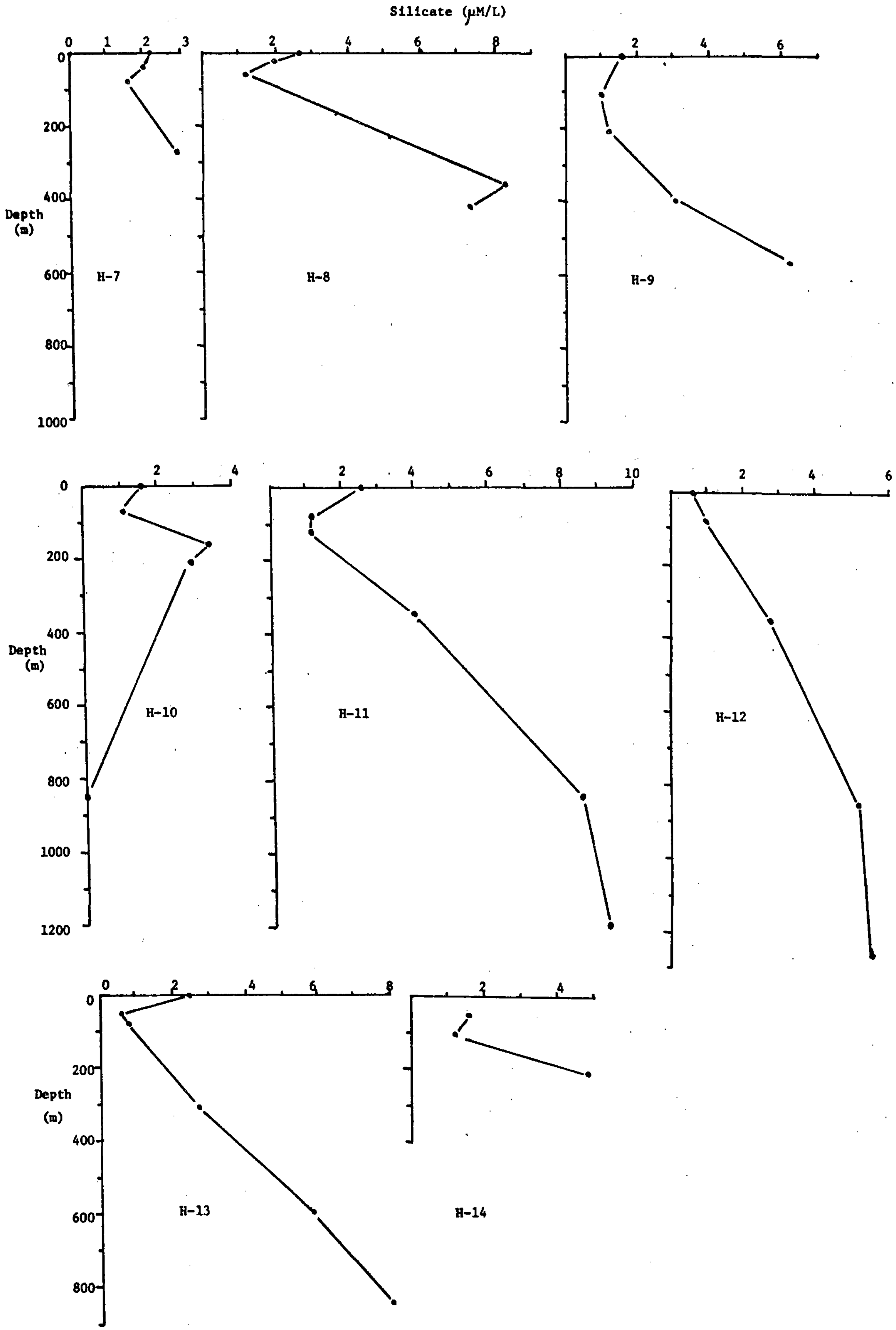


Fig. 13 Silicate concentrations at hydrostations in the Grenada Basin.

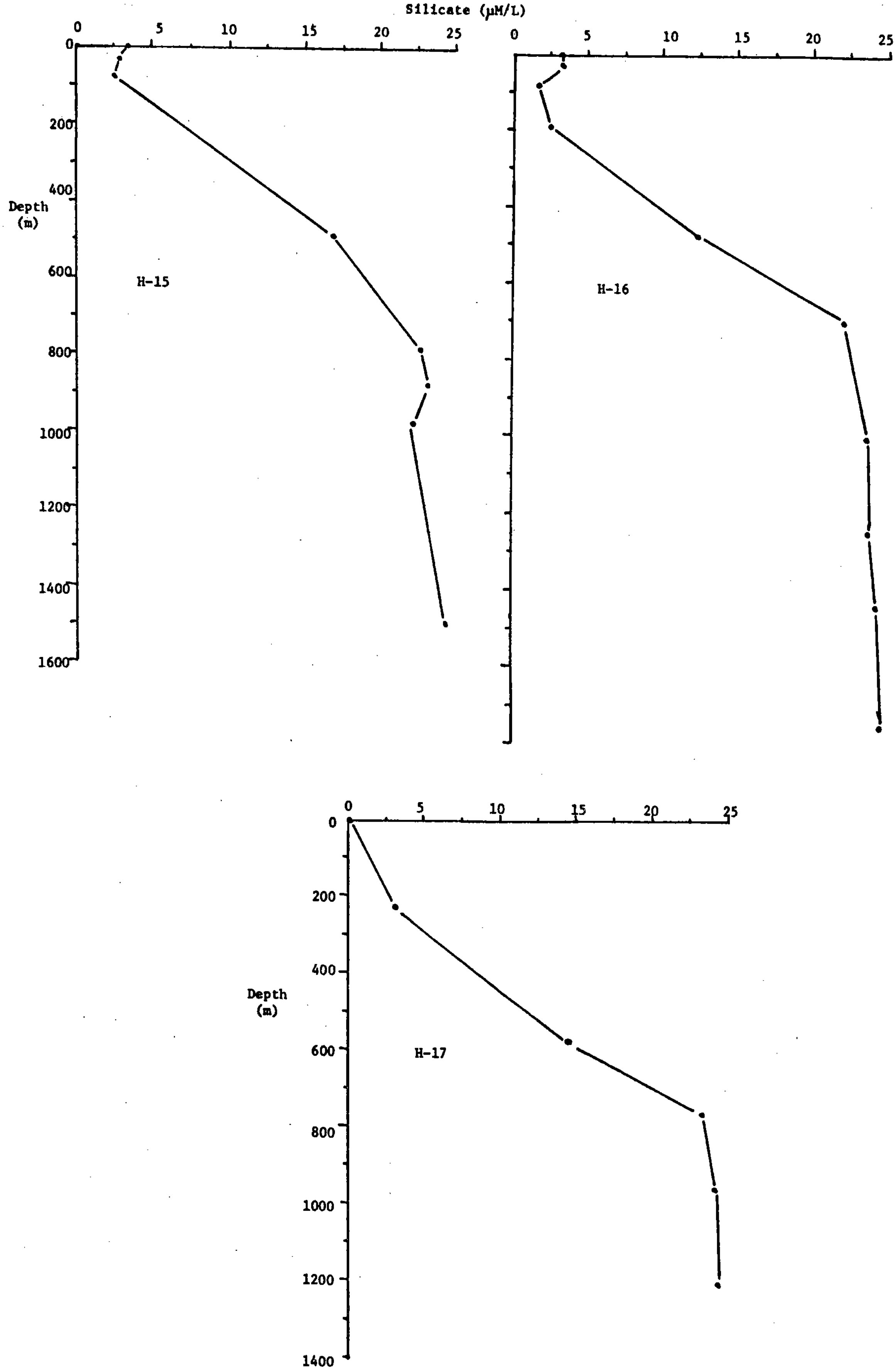


Fig. 13 (continued) Silicate concentrations in the Grenada Basin.

the stations on the western side of the Grenada Basin, where silicate contents greater than 20 uM/L are seen. The core of AAIW is well illustrated at station H-15, where a relative maximum is seen between 800-1000m. The increase in silicate concentration with depth is also seen in some of the deeper passages, although the concentrations are not as high. This may be the result of mixing due to turbulence as the water passes over the sills.

e) Phosphate (Fig. 14)

Phosphate also exhibits a depleted surface layer about 100m thick, with concentrations of less than 1 uM/L. Below this depth, on the western side of the basin, there is an increase in phosphate content to a depth of 700-900m, where a maximum concentration of 2.5 uM/L associated with AAIW, is reached. In the deeper layers, phosphate levels tend to decrease. In the passages between the islands, an increase in phosphate with depth is seen -- this is particularly pronounced in the passage between St. Lucia and St. Vincent.

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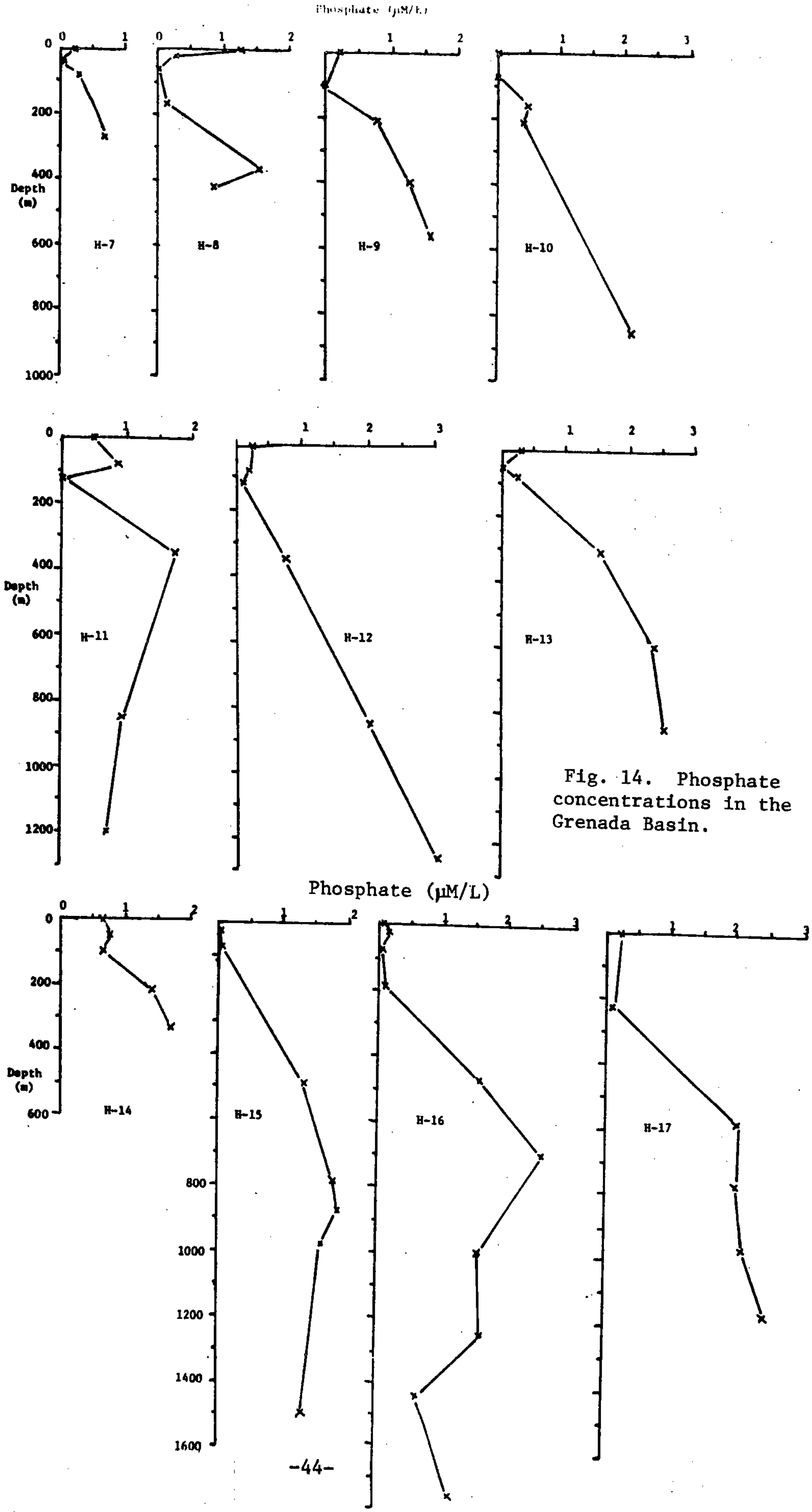


Fig. 14. Phosphate concentrations in the Grenada Basin.

Relating high nutrient levels around the St. Lucia - St. Vincent Passage to higher productivity, in particular fish and mammal sightings

Christopher West

ABSTRACT

The relation between high productivity and the characteristics of the water entering the Caribbean Sea through the St. Lucia - St. Vincent Passage was studied. Three station locations across this passage were compared with a fourth station on the western side of Dominica. The water mass was identified by its higher temperature, and was shown to have high nutrient concentrations, specifically phosphorus. Meter net tows indicated a higher biomass in this area, which correlated with the larger numbers of fish, mammal and bird sightings associated with this water mass.

Diurnal Vertical Migration of Copepods in the Grenada Basin

Donna Vallas

ABSTRACT

Diurnal vertical migration refers to the vertical movement of zooplankton and some mid-water fish through the water column on a daily cycle. The organisms descend during the day and ascend at night. Although light intensity seems to be a major factor of this migration, other studies have correlated this phenomenon with available food sources, gravity, metabolic energy efficiencies, and isolumes.

Five multi-net tows were conducted at a twenty-four hour station in the lee of Dominica. The nets were set at depths of 10, 150, and 300 meters. An estimated total biomass was determined by settled volume, and copepods of different pigments were counted to determine whether pigmentation was related to vertical distribution and migration. A diurnal vertical migratory pattern was observed for the total biomass, and a study of the vertical distribution according to pigment showed that red copepods were the dominant variety at all depths. They were most abundant, however, at the surface where transparent individuals were absent. This may be related to the ability of the red pigmented copepods to withstand greater light intensities (Hairston, 1976). Significant numbers of transparent individuals were found at greater depths. Although vertical distribution seemed to correlate with pigmentation, no correlation between coloration and vertical migratory patterns was discernible (Figure 15).

Hairston, N.G. 1976. Photoprotection by carotenoid pigments in copepods. Proc. Nat. Acad. Sci., 73, 971.

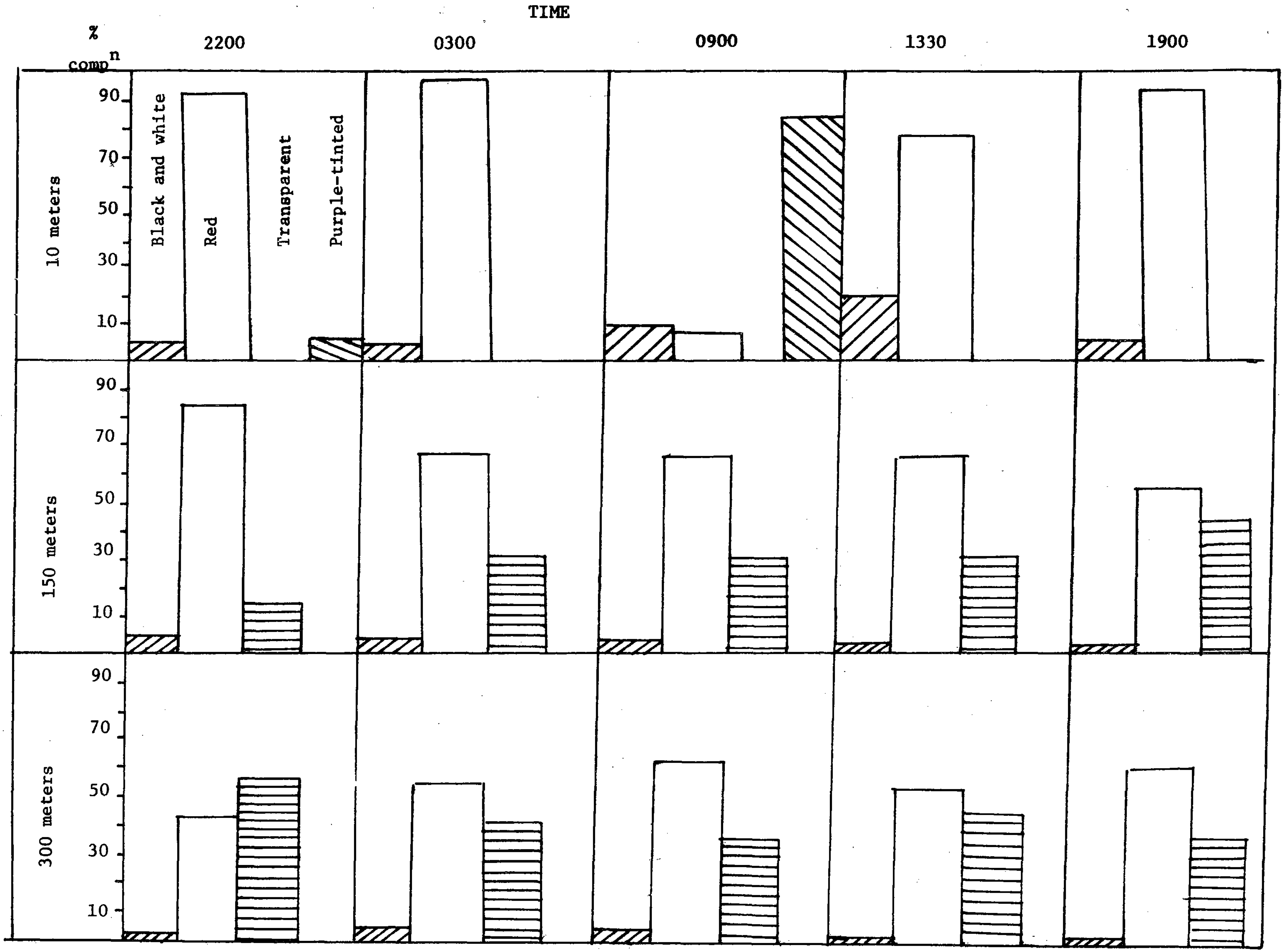


Fig. 15. Percentage composition of copepods by pigment with respect to time and depth.

Nutrient Regeneration

Robin Bailey

ABSTRACT

The objective of this experiment was to determine the quantitative rate of phosphate and ammonia regeneration by zooplankton. This rate is important in terms of availability of limiting nutrients for phytoplankton productivity due to nutrient recycling in surface waters. The method used in this study consisted of the collection of zooplankton, placement of the specimens in a container of water with known nutrient concentration, collection of periodic water samples from the container and analysis of the samples with a spectrophotometer. The data obtained demonstrated a qualitative increase in phosphate concentration with time.

A Bacteriological Investigation in the Grenada Basin

Rodman G. Getchell

ABSTRACT

During the cruise of R/V Westward in the Grenada Basin, plate counts on Zobell's Medium 2216E were taken from 24 water samples during a 24-hour station on November 2 and 3, 1979 to study the vertical distribution of bacteria and their correlation with temperature, salinity, oxygen, ammonium, and phosphate concentrations. The highest bacterial numbers were found just above the thermocline in 30 m depth (Fig. 16). High phosphate and ammonium concentrations were also found in this area (Fig. 17). No direct influence of oxygen concentration or salinity on bacterial numbers existed.

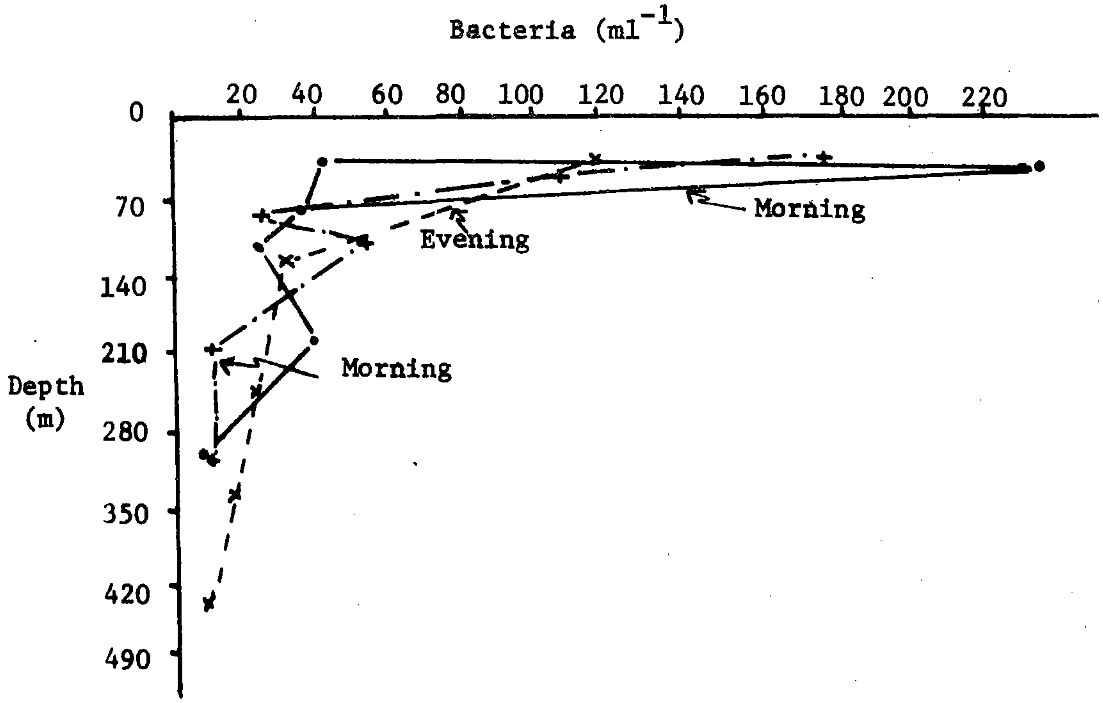


Fig. 16 Bacterial counts in the water column .

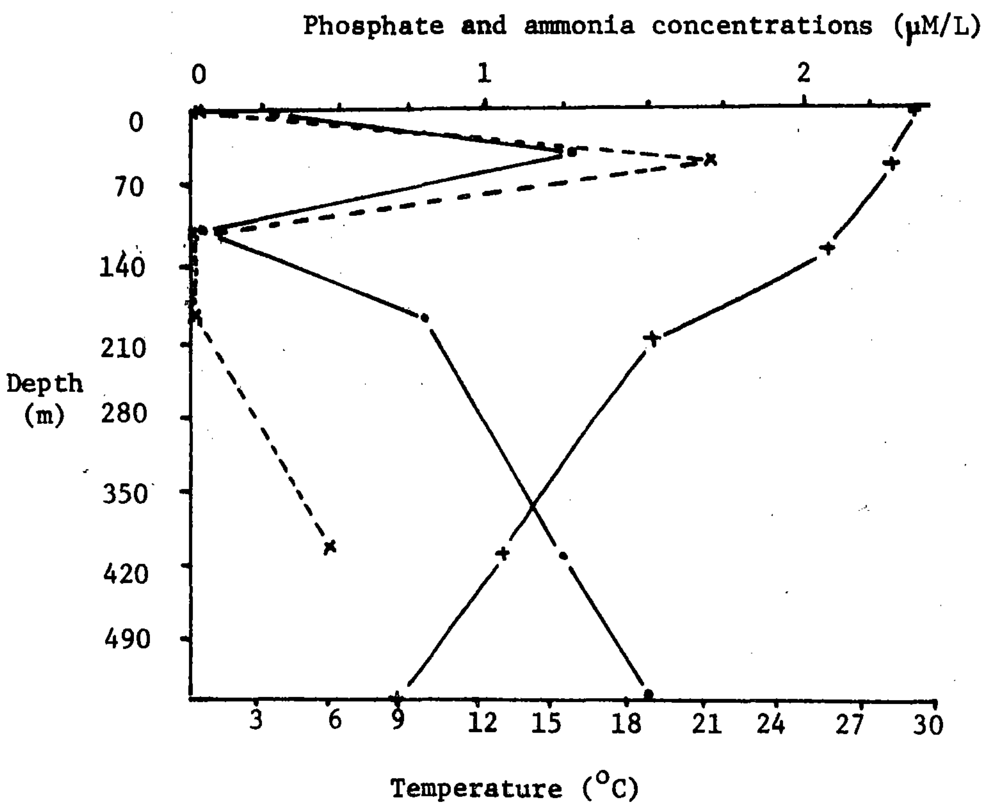


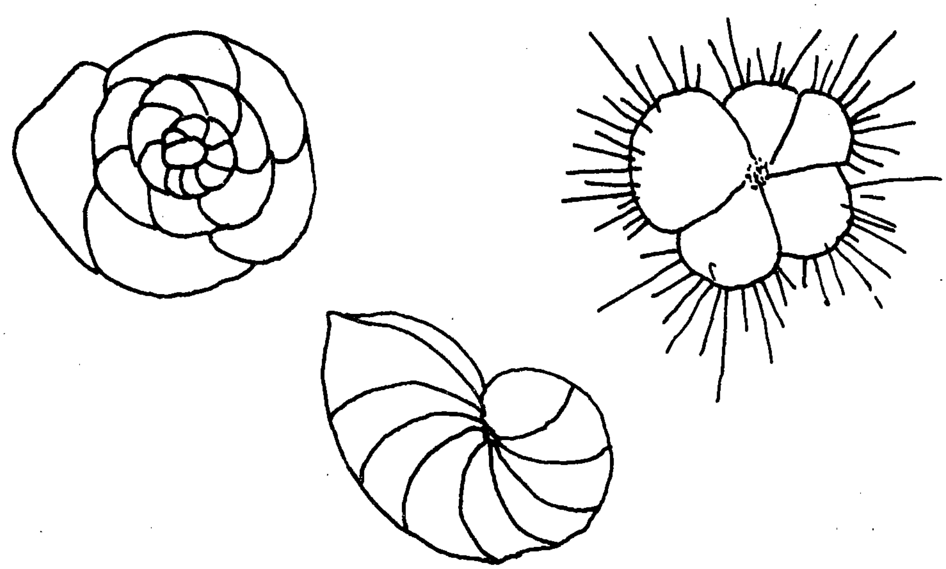
Fig. 17 Temperature and dissolved nutrients in the water column.

Foraminifera in four Caribbean anchorages

Douglas Goldhirsch

ABSTRACT

Phytoplankton tows and bottom grabs were taken in four Caribbean anchorages in order to study the distribution of foraminifera. Several benthic forms were found and put into groupings; no planktonic forms were seen. A change in both type and size was recognized for the southern stations, and it was postulated that the change may be related to the nature of the anchorage, rather than latitude.



PRELIMINARY REPORT OF SIDE SCAN SURVEY ALONG THE WESTERN SHORES OF ST. LUCIA, ST. VINCENT, AND CANOUAN

Charles E. McClennen
Colgate University
Hamilton, New York 13346

November 1979

Introduction

Side scan sonar provides useful data on seafloor topography, texture, and composition. It is commonly used in shallower shelf waters where a short cable is sufficient to tow the transducer fish near the bottom. The proposed W-48 cruise plan of R/V *Westward* along the Lesser Antilles and the loan of an EDO side scan sonar system from the United States Geological Survey, Office of Marine Geology, Woods Hole, Mass. provided an opportunity to survey in an area previously unsampled by such a technique. Of particular scientific interest is the morphology and depth of submarine terraces, valleys, and volcanic as well as reef deposits. Previous bathymetric studies have identified submerged terraces from many places in the world including other portions of the Caribbean Sea, with 20 m, 35 m, and 72 m being prominent depths.

Methods

The side scan sonar fish was towed at depths of 8 to 20 m as the ship speed varied between 0 and 4 knots. Most of the data was collected at close to 2 knots with the fish at about 15 m below the surface. Navigational fixes were generally taken at half hour intervals by using multiple bearings on prominent land features. With the shore between 1/4 and 1/2 mile away the fixes were sufficient to get location along the coast at about 1 mile intervals. Course changes were not recorded with sufficient accuracy to plot a more accurate cruise track. The data reduction consisted of sketching the depth profile and side scan features along the ship track overlayed next to the mapped land physiography. The depth of each distinct valley, peak, terrace and notch was recorded and tabulated for each of the three islands. Also the rock type and age was noted as reported by Briden et al. (1979).

Results

St. Lucia was surveyed from Pilari Pt., just south of Marigot Bay, to Beaumont Pt., just south of the Pitons at Soufrière, from 0800 to 1400 on the 10th of November, 1979, a distance of about 9 miles. The terraces found mostly at 35m and 72m made up 50 to 75% of the track surveyed while valleys and peaks made up most of the rest and clustered at 50 to 105m and 80 to 250+m respectively. The terraces were found north of Soufrière Bay, with essentially unterraced irregular sea bed to the south around Petit and Gros Pitons. The prominent marine valleys correlated with the higher order streams draining the land to the north and the bays along the coast. Lower order streams typify the southern section of St. Lucia. A surface banding with nearly parallel dark and light stripes at a few meter spacing, was noted in the valley bottoms and walls as well as the slopes of the peaks, suggestive of the eroded tuff bedding exposed in cliffs along the island.

St. Vincent was surveyed from Larikai Pt. on the northwest to Kingstown Bay on the south from 0925 to 1405 on the 11th of November, a distance of about 13 miles. Irregular unterraced bathymetry typifies the record north of Wallilabu Bay whereas terraces make up 75% of the record to the south. The terraces are mostly between 50 and 100m in depth and the valleys bottomed at depths greater than 170m. The peaks are mostly between 40 and 90m. In the north the bays match the location of the major deeps and there are only low order streams on land so no major stream valleys were noted offshore. To the south the higher order streams displayed a fairly good fit to the valleys in the terraces. As off St. Lucia, surface banding was noted in some valley bottoms and along the walls of valleys and peaks.

The western Canouan platform was surveyed to midway between Mayreau Island and Channel Rock from 1130 to 1415 on the 13th of November over a distance of about 6 miles. The shallow (30m) flat region showed subdued relief. While the northern portion of the record was uniformly dark, the southern portion showed considerable textural contrast. Both dark and light patches formed local deeps and local highs of 2 to 4m relief.

The elevated dark patches cast clear shadows on the records. Generally the equidimensional patches measured 10 to several 10's of meters in diameter. Linear features called sand waves had crestal spacing of about 10 to 15m and longer sand stringers had 30 to 100m spacing and extended up to 250m along individual crests. The crests of the sand stringers were generally light in color over a darker trough or bed. These linear features were best developed to the west and south of Canouan Island.

Discussion

The terraces are best developed on the older portions of St. Lucia and St. Vincent in the more easily eroded units. Andesite pyroclastics of St. Lucia just north of Soufrière have a K-Ar age of 2.2 MY. To the south the mixed dacites, andesite lava and dacite pyroclastics have been dated as young as 0.26 MY (Briden et al. 1979) and a major ash producing event from St. Lucia is dated at 80,000 YBP in a 150,000 to 50,000 YBP period of activity (Huang et al. 1977). St. Vincent in contrast has post Pleistocene and young (0.36, 0.69, 1.18, and 1.33 MYBP) flows and scoria to the north of Wallilabu Bay and older (1.16 and 1.65 MYBP) lava and tuff to the south where the terraces are well developed (Briden et al. 1979). On both of the islands the older areas have more mature drainage networks illustrated by the higher order streams on land and the terraces offshore. The younger areas have only immature streams with low order networks. Correspondingly there are only poorly developed terraces to no terraces in the youthful sections. The 72m terrace may have formed in the Early Wisconsin (110,000 YBP) as reported by Johnson (1978) for the reefs of New Guinea. Sigurdsson (personal comm. 1979) also mentioned a 72m terrace on Kick-em Jenny, a submarine volcano located just north of Granada.

The sand waves and sand stringers seem to be caused by the divergence of flow of the east to west currents on the west side of Canouan Island. In this locality it is logical for the carbonate sands to be deposited as the current velocity decreases. The location and orientation are consistent with this concept. The smaller elevated patches are presumed to be coraline reef material. Perhaps the depressions are caused by current erosion, reduced reef development, or solution during subaerial exposure at times of lowered sea level.

Clearly there is potential for more data collection to clarify some of the ideas mentioned above. However, this preliminary survey has shown the existence of many geologically significant features along this section of the Lesser Antilles.

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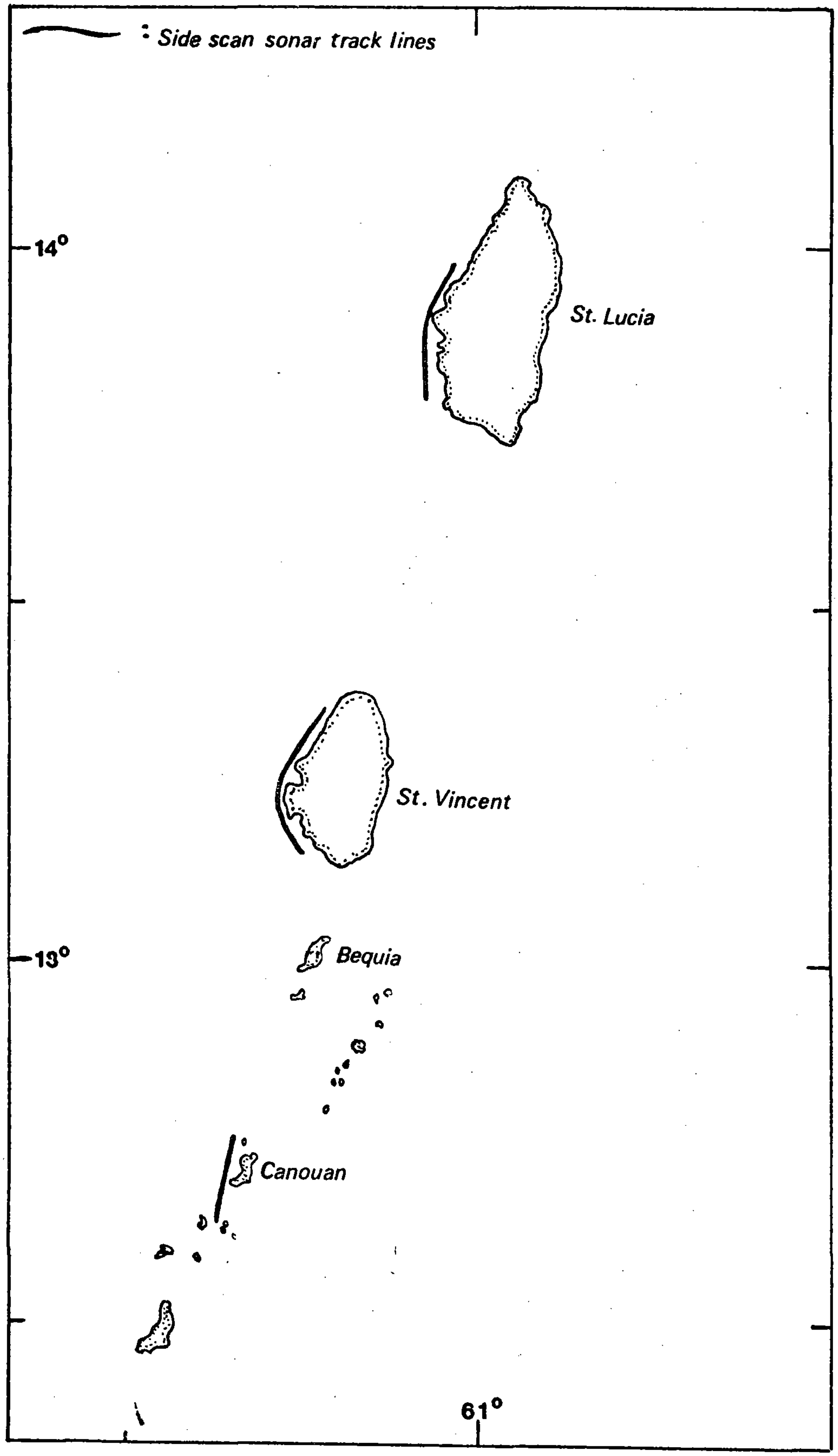


Fig. 18. Locations of side-scan sonar track lines.

Side scan sonar studies in the lee of St. Lucia and St. Vincent

Norman Livingston

ABSTRACT

A comparison of the ocean floor topography was made approximately 1/4 mile off of the west coast of St. Vincent and St. Lucia. Visual observations and the side scan sonar were used to study the continuation of the land topography seaward. A difference in depth between the submarine terraces of St. Lucia and St. Vincent was observed, the St. Lucia terraces being deeper. This may be due to differences in the isostatic readjustment of the two islands.

PELAGIC FISH STUDIES

Pelagic Fish Survey — Robert Nawojchik

Fish comprise the most successful vertebrate group in the marine environment. Studies of these organisms during oceanographic voyages greatly aid our knowledge of their distribution, life history, and ecology. During W-48, pelagic fish were collected with the use of fishing lines, long line, neuston tows, meter net tows, dip net, and an Isaacs-Kidd Midwater Trawl. Over twenty families were sampled, often with several species and many individuals represented. Table 7 lists the families of fish collected, with representative species included. However, not all fish were keyed out to species, and thus only the genus or family name is noted. Larval fish went basically unidentified. However, larval stages of several families in the order Anguilliformes were collected and identified, and are discussed in another section of this cruise report.

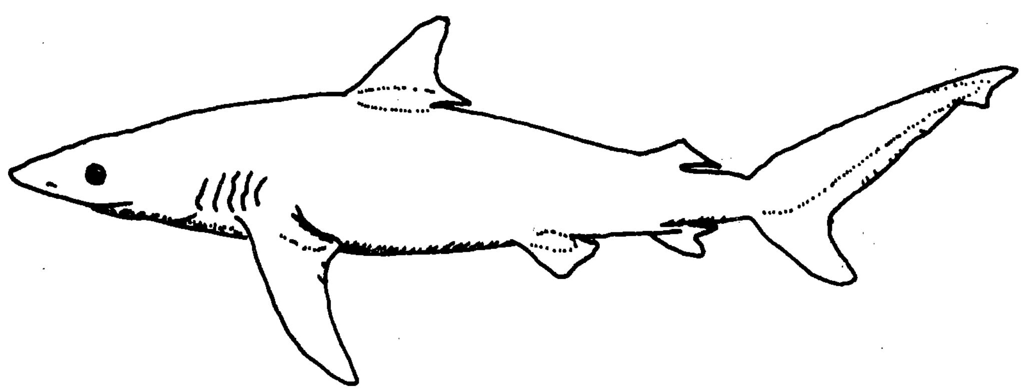


TABLE 7

Family Carcharhinidae	grey sharks
Carcharhinus maou	oceanic whitetip shark
Carcharhinus obscurus	dusky shark
Galeocerdo cuvieri	tiger shark
Family Myctophidae	lanternfishes
Myctophum sp.	lanternfish
Family Stomiatidae	deepsea scaly dragonfishes
Stomias sp.	scaly dragonfish
Family Sternoptychidae	deepsea hatchetfishes
Sternoptyx sp.	hatchetfish
Family Exocoetidae	flyingfish
Exocoetus obtusirostris	oceanic 2-wing flyingfish
Hirundichthys affinis	fourwing flyingfish
Family Hemiramphidae	halfbeaks
Hemiramphus brasiliensis	ballyhoo
Family Syngnathidae	pipefish and seahorses
Syngnathus pelagicus	Sargassum pipefish
Family Belonidae	needlefish
Tylosurus crocodilus	houndfish
Family Sphyraenidae	barracudas
Sphyraena barracuda	great barracuda
Family Echeneidae	remoras
Remora remora	remora
Family Coryphaenidae	dolphinfishes
Coryphaena hippurus	dolphinfish
Family Scombridae	tunas and mackerals
Acanthocybrium solandri	wahoo
Thunnus atlanticus	blackfin tuna
Family Carangidae	jacks and pompanos
Caranx sp.	pompano
Naucrates ductor	pilotfish

TABLE 7 (continued)

Family Balistidae	triggerfish
Xanthichthys ringens	Sargassum triggerfish
Canthidermis sufflamen	ocean triggerfish
Family Diodontidae	porcupinefish
Diodon holocanthus	balloonfish
Family Moncanthidae	filefish
Aluterus scriptus	scrawled filefish

Larval fish: including Exocoetidae, Xiphiidae, and Angulliformes (leptocephali)

Stomach contents of pelagic teleosts

Janice Beal

ABSTRACT

Seven pelagic teleosts, representing the families Coryphaenidae, Scombridae, Exocoetidae, and Carangidae, were caught during W-48 and their stomach contents examined. Fish remains, crustaceans, squid, and pteropods were common food items. A food web was con structed and distribution charted. Generalizations were difficult with the little data and the variety of fish examined.

Metazoan parasites of pelagic fish

Lori Petitti

ABSTRACT

Fish caught by various methods during W-48 were examined both internally and externally for metozoan parasites. Of the three dolphin fish, *Coryphaena hippurus*, the largest contained no parasites, while the other two contained stirgeoid Trematodes in the gut. In addition, one was also lost to Nematodes. A wahoo *Acanthocybium solandri* caught in the Sargasso Sea contained Trematodes of the family Bucephalidae. Crustacea of the family Cymothoidae were found in the gills of a blue runner, *Caranx crysos*. Calculations made on incidence and intensity of infestation/infection indicated that internal parasites were most abundant with the highest number being those of Trematodes.

SHORE-BASED STUDIES

1. Antigua

The Arawak Indians

(from lectures and a tour of Dow's Hill Archaeological Workshop, by Desmond Nicholson).

Antigua was inhabited by various Indian tribes before it was discovered by Christopher Columbus in 1493. The first of these tribes, all of which migrated from the Orinoco Basin in South America, was the Ciboney; they inhabited Antigua around 500 B.C. The Arawaks originated near Saladero, Venezuela, and inhabited Antigua from 190-1000 A.D., until they were exterminated by the Caribs, who occupied the islands when the Spaniards arrived.

In 1973, Yale University and the Antigua Archaeological Society systematically excavated the site of an Arawak village at Indian Creek. This work recovered a large number of Arawak artifacts - shards of ceramics, food relics, and implements made of bone, shell and stone. A complete human skeleton was also found.

The decoration on their pottery suggests that there were at least two groups of Arawaks who inhabited Antigua. The earlier one painted simple designs in white paint on a red background. The later group incised the designs on the the pottery. Further cultural evolution and the Ellenoid influence from the Greater Antilles is also well illustrated in their ceramics.

Oceanographic Observations on Antigua

Abby Ames

Our surveys of English Harbor and Indian Creek constitute the third in a series of studies to compare the embayment of Indian Creek, which drains mostly uninhabited land, with the yachting center of English Harbor, in order to observe the possible consequences of anthropogenic activity.

The oxygen content in English Harbor surface water showed little fluctuation compared with Indian Creek (Figs. 19 and 20). The greater variation in Indian Creek is probably a function of biological activity. Salinity showed a predictable horizontal gradient being less distinct in Indian Creek (δ 2‰) than in English Harbor (δ3%o). This difference is due to the different volumes of fresh water input. Tank Bay appears to be a major source of fresh water for the Harbor.

Nutrient concentrations observed were higher than previously reported. PO_4 and NH_3 were higher in Indian Creek, which suggests that English Harbor is not being excessively polluted by yacht activity. In fact, the high PO_4 concentration in Indian Creek and its decrease seaward suggests that this high concentration is derived from the surrounding grazeland.

In accordance with last year's data (W-42, see also W-36) light was absorbed more rapidly in English Harbor than in Indian Creek. Extrapolated compensation depths (Figure 21) were 8.5m and 20.0m respectviely. This agrees with the plankton analysis of English Harbor and Indian Creek. English Harbor had 10x more biomass than Indian Creek. Inner English Harbor (Tank Bay) had only two planktonic constituents - silicoflagellates like <u>Biocea</u> sp., and nauplii larva. Outer Harbor (Freeman's Bay) was significantly more diverse, being dominated by zooplankton gastropods, ostracods, copepods. In contrast, the sample from Indian Creek was mostly phytoplankton and plant material with zooplankton conspicuously absent - perhaps fed upon by the schools of herring present.

The greater productivity in English Harbor recorded by Gaines and Farmer (W-36) correlates well with the relatively impaired light transmission of the water; these two environmental parameters usually have an inverse relation. Also, the high productivity of English Harbor may explain why the nutrients were low. One would expect nutrients to be high in a yacht center due to boat discharge, i.e. more nutrients available. Perhaps the anthropogenic input of nutrients has so increased productivity, and hence nutrient utilization-fixation, that the net nutrient concentration in English Harbor is less than Indian Creek.

Sediments of Nelson's Dockyard in English Harbor could be characterised as fine sand (85% 250um - 150um) with major constituents being igenous rock fragments from weathering. The high concentration of large particles (large relative to other harbor and embayment samples taken on the cruise) was surprising, and suggests a relatively high energy regime.

An addition to previous data was the drift bottle survey (Fig. 22) which recorded surface velocities of 12m/min - 3m/min. Barclay Point (fort) was definitely a point of impact and erosion from prevailing swells separating littoral currents from inner harbor flow. Freeman's Bay proved to be an area of lower velocity and consequent deposition. The distinct E-W direction of bottle movement may be attributed to wind driven circulation of surface water, which apparently dominated the N-S tidal flushing during our measurements.

Fig. 19 Salinity and dissolved oxygen data for English Harbor.

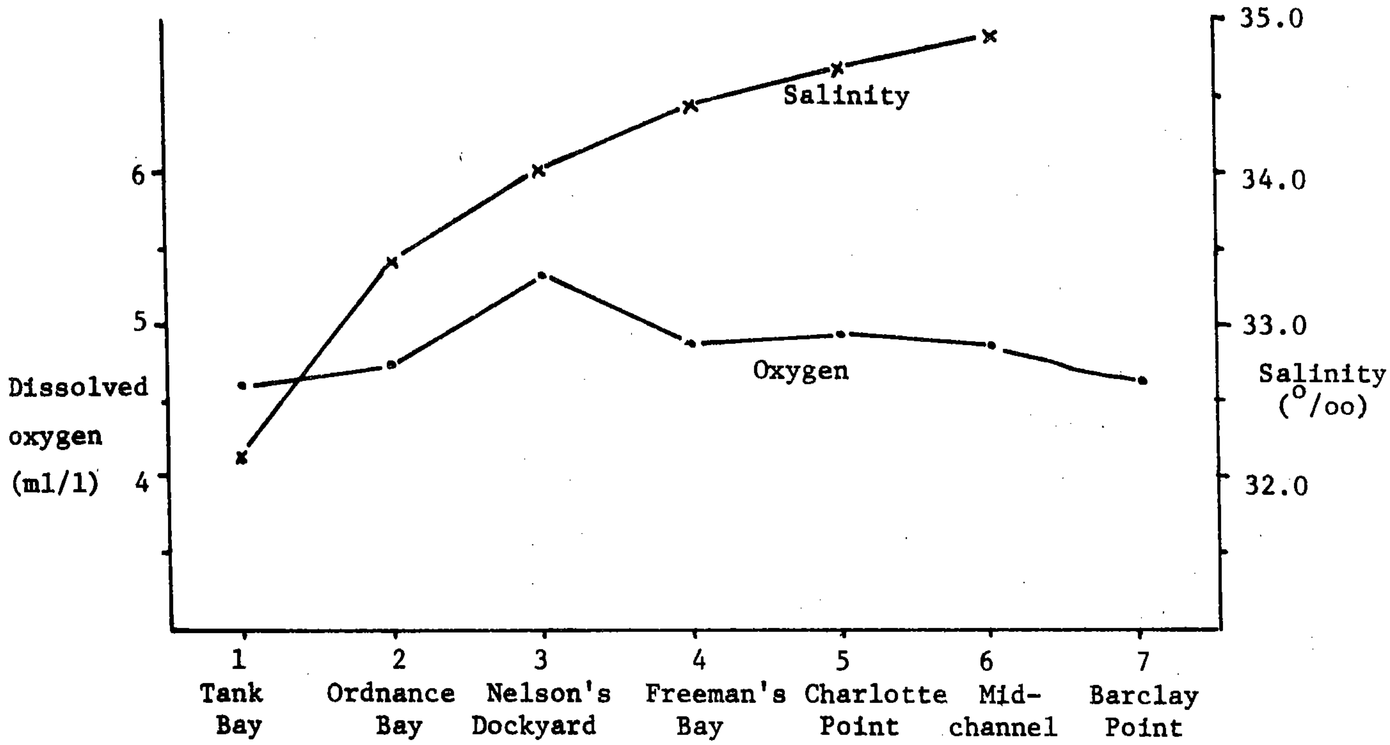


Fig. 20. Salinity and dissolved oxygen data for Indian Creek.

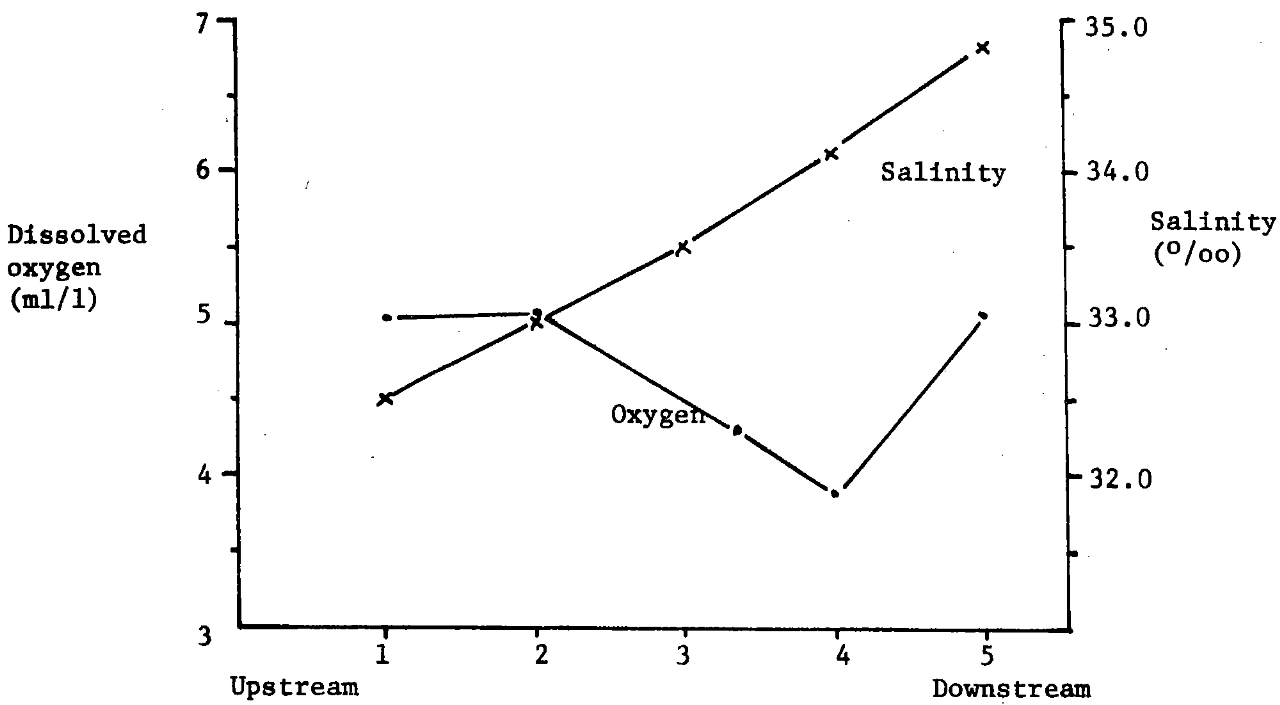


Fig. 21. Light attenuation at English Harbor and Indian Creek.

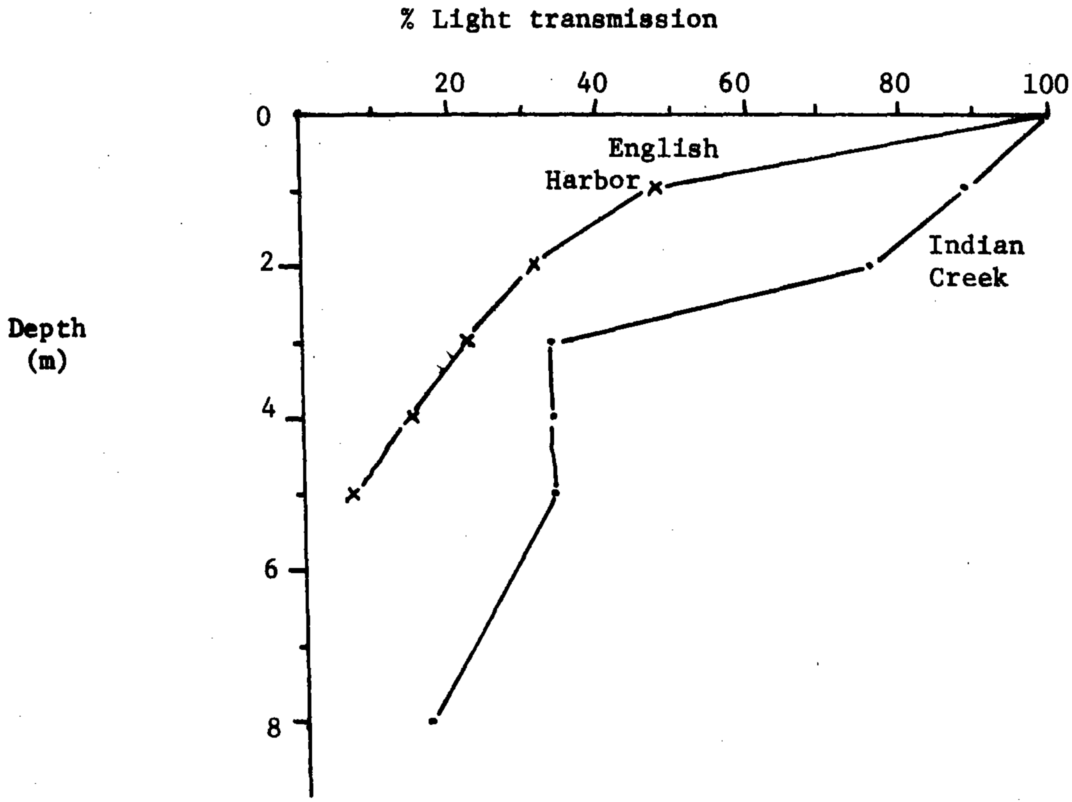
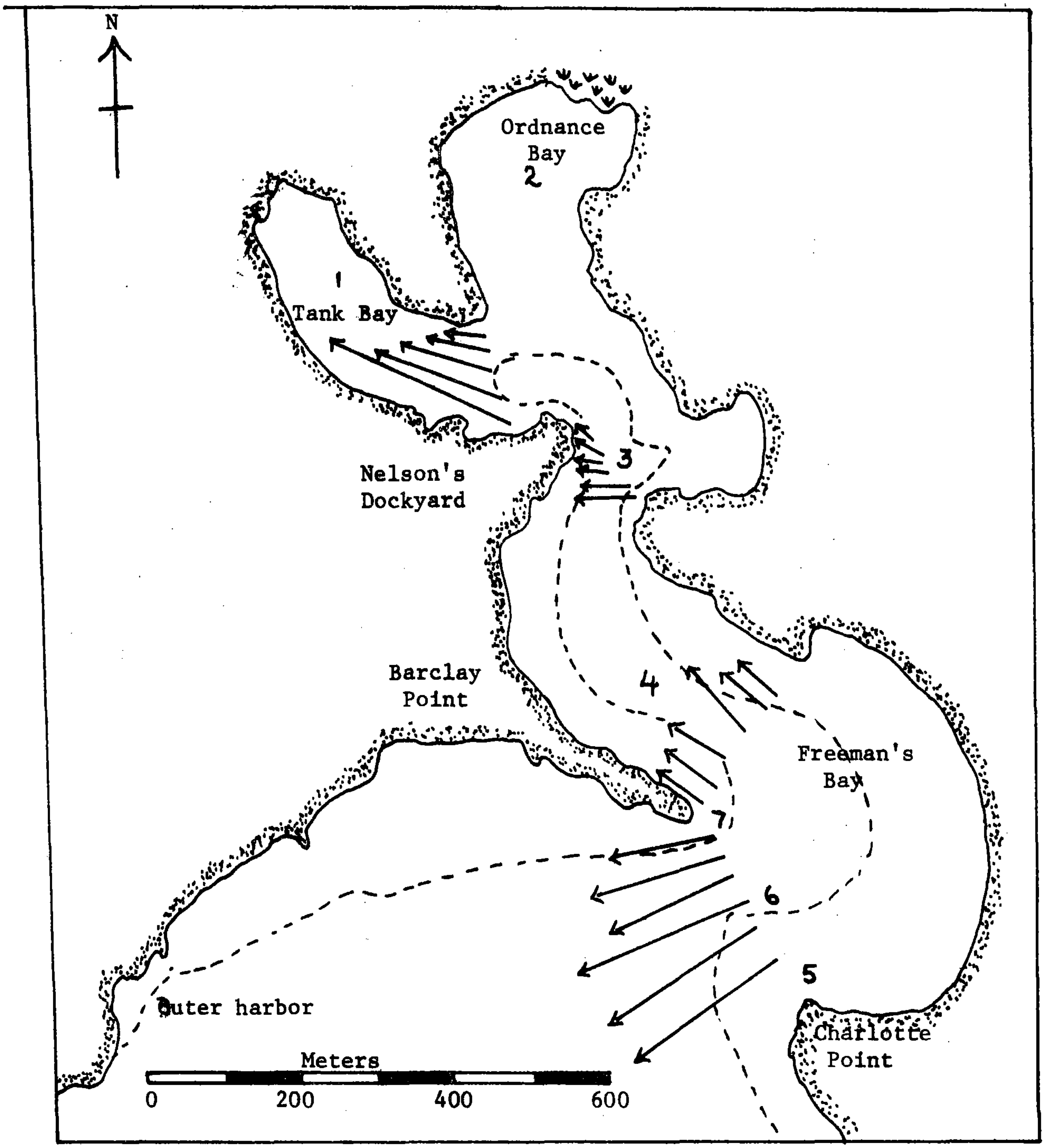


Fig. 22. English Harbor, Antigua: station locations and surface drift patterns.



2. St. Lucia

The Geology of the Soufrière Volcanic Center, St. Lucia

The Lesser Antilles represent an active island arc being produced by subduction of the Atlantic plate to the east beneath the Caribbean plate. This results in a specific rock sequence - the "calc-alkaline" suite - which is typical of the highly explosive island arc volcanism.

During W-48, a field trip was taken to visit the Soufrière region of St. Lucia in order to illustrate the major geological and structural features associated with volcanic activity in this area. The Soufrière region is the youngest volcanic center on the island, and its main structure is a caldera about 4 miles in diameter. It was formed more than 40,000 years ago at the end of a period of extremely violent volcanic activity. After the caldera had collapsed, eruptions continued and built domes and craters on the caldera floor; they also carried pumice blocks and ash for distances of up to eight miles beyond the caldera rim (Tomblin, 1965).

The history of the region can be divided into four main phases of volcanic activity, as delineated in Table 8. The earliest known rocks in this region were the basalt lava flows, which were subsequently eroded and weathered to depths of 10 m. During the second phase, a group of stratovolcanoes were built up from eruptions of andesite lava flows and pyroclasts. A series of eruptions of pumice then took place, probably from a new vent within the site of the ultimate caldera, and together they removed an estimated 1.8 cubic miles of material from a sub-surface reservoir. Further pumice flows removed more material, and were followed by caldera collapse involving subsidence of about 800 feet.

During the final phase of activity, andesite and dacite domes were formed within the caldera. The Pitons represent such domes from which the marginal talus has been almost completely removed by erosion.

Present-day activity on St. Lucia is restricted to the emission of steam and other gases at Sulphur Springs. These springs were visited and provided a most impressive sight of solfataric activity. The pools of water give the impression of boiling due to steam which blasts through the water, producing fountains. Sulphur, gypsum, and many minerals containing trace elements are continuously being deposited from these springs.

TABLE 8 <u>Summary of the history of volcanic events in the Soufrière region, St. Lucia</u>

(adapted from Tomblin, 1965)

PHASE	EVENT	ROCK TYPE	SPECIAL FEATURES
		DACITE DOMES	Nine other lava domes
4.	Post-caldera effusion and eruption	DACITE DOMES	Petit Piton and Gros Piton lava domes
* * * * * CALDERA COLLAPSE * * * *			
3.	Eruptions leading to caldera collapse	ANDESITE PUMICE	
- - - DISCONFORMITY (erosion and weathering) - - - - -			
2.	Growth of stratovolcanoes	ANDESITE	
- - - DISCONFORMITY (erosion and weathering) - - - - -			
1.	Effusion of lava flows	BASALT	

Tomblin, J.F. 1968. The Geology of the Soufrière volcanic centre, St. Lucia. In: Saunders, J.B. (ed): Trans. 4th Caribbean Geological Conference, 1965, p. 367.

Hot Springs and Helium Isotopes.

During the field trip in St. Lucia, a series of gas and water samples were collected from the Sulphur Springs for Dr. W. Jenkins of Woods Hole Oceanographic Institution, who will use them for measurement of helium isotopes.

Helium exists as two isotopes - ^{4}He, which constitutes about 99.9999% of all helium, and a lighter isotope, ^{3}He, which makes up the remaining fraction. ^{4}He atoms are produced by the radioactive decay of uranium and thorium in the interior of the earth. This helium is released into the oceans by volcanic activity at oceanic spreading centres. However, significant amounts of ^{3}He are not being produced, which means that any ^{3}He escaping from the earth must have been trapped there when the earth was formed. Island arc volcanism, such as that of the Lesser Antilles, provides a mechanism of volatile transport from the mantle. Hence, helium isotope measurements in such areas provide a means of determining whether the earth is still losing volatiles from its interior. Previous studies of hot springs associated with island arc provinces in the Pacific (Baskov *et al*. 1973; Craig *et al*. 1978) have found high $^{3}He/^{4}He$ ratios, indicating that degassing of the interior is still occurring. No comparable data have as yet been published for the Atlantic.

Such measurements also have some bearing on the origin of the rocks that characterize island arcs. If they result from melting of the subducted oceanic plate, then the helium in these rocks would be different from that which would be associated with rocks resulting from melting of pure mantle material. Previous work in the Pacific (Craig et al. 1978) has indicated that it is unlikely that the island arc rocks have formed by remelting of the subducted oceanic crust. However, whether this is true of all island arcs is as yet unknown.

Baskov, Y., Vetshteyu, V., Surikov, S., Tolstikhin, I., Malyuk, G. and Mishina, T. 1973. Isotopic composition of H, O, C, Ar and He in hot springs and gases in the Kurile-Kamchatka volcanic region as indicators of formation conditions, Geochem. Int., 130-138.

Craig, H., Lupton, J.E. and Horibe, Y. 1978. A mantle helium component in circum-Pacific volcanic gases: Hakone, the Marianas, and Mt. Lassen. Adv. Earth Planet. Sci., 3, 3-16.

3. Tobago Cays

Coral Reef Studies

Robert Nawojchik

Coral reef ecosystems are found in tropical environments and are characterized by their high productivity and great diversity. The reefs provide the potential for many studies, and, being along the track of W-48, were of special interest to the Westward's scientific program. Reef-type environments were encountered at the following locations: English Harbor, Antigua; Marigot Bay, St. Lucia; Tobago Cays, the Grenadine Islands; and Christmas Cove, St. Thomas. However, the Tobago Cays was the only site for specific, intensive reef studies.

Many organisms were observed at the Tobago Cays. The reef was very rich in both invertebrate and fish life. Many of the species were common to the other reefs mentioned, but many others were not. Observations were made while snorkeling and different sections of the reef were examined, ranging from the offshore patch reef to the more inshore fringing reef. An informal survey yielded the invertebrates and fish listed in Tables 8 and 9 , respectively. Fish were identified to species, while the invertebrates were identified to the most specific taxonomic group possible.

Coral species zonation in relation to light intensity

April Ellen Heitkamp

ABSTRACT

A study was done of the Tobago Cays coral reef to determine the extent and nature of vertical zonation of species in relation to a change in light intensity with depth. The data suggested that there was no linear zonation of species but that each coral species can be expected to exhibit a characteristic growth pattern in correlation with light intensity differences.

TABLE 8

Phylum Porifera	
various species, mostly class Demospongiae	
Phylum Cnidaria	
Class Hydrozoa	
Millepora squarrosa	square fire coral
Millepora complanata	leafy fire coral
Millepora alcicornis	encrusting fire coral
Class Anthozoa	
Subclass Zoantharia	
Acropora palmata	elkhorn coral
Acropora cervicornis	staghorn coral
Montastrea annularis	star coral
Dichocoenia stokesii	star coral
Porites porites	finger coral
Diploria strigosa	smooth brain coral
Diploria labyrinthiformis	grooved brain coral
Subclass Alcyonaria	
Briareum asbestinum	corky sea fingers
Plexaura flexuosa	sea rod
Gorgonia ventalina	common sea fan
Phylum Ctenophora	
Class Tentaculata	
Order Lobata	comb-jellies
Phylum Annelida	
Class Polychaeta	
Family Phyllodocidae	crawling polychaetes
Family Sabellidae	fanworms
Family Serpulidae	feather-duster worms
Phylum Mollusca	
Class Polyplacophora	chitons
Class Gastropoda	
Nerita peloronta	bleeding tooth
Strombus gigas	pink conch
Phylum Arthropoda	
Class Crustacea	
Panulirus argus	spiny lobster
Stenorhynchus seticornis	arrow crab
several species of crabs	
Phylum Echinodermata	
Class Echinoidea	
Diadema antillarum	long spined urchin
Arbacia punctulata	purple-spined sea urchin
Tripneustes ventricosus	sea egg
Lytechinus variegatus	green urchin
Mellita sexiesperforata	six-hole urchin

TABLE 9

Scientific Name	Common Name
Haemulon sciurus	bluestriped grunt
Pseudupeneus maculatus	spotted goatfish
Holacanthus tricolor	rock beauty
Chaetodon capistratus	foureye butterflyfish
Chaetodon striatus	banded butterflyfish
Microspathodon chrysurus	yellowtail damselfish
Pomacentrus partitus	bicolor damselfish
Abudefduf saxatilis	sergeant major
Bodianus rufus	spanish hogfish
Thalassoma bifasciatum	bluehead wrasse
Halichoeres garnoti	yellowhead wrasse
Sparisoma viride	stoplight parrotfish
Holocentrus rufus	squirrelfish
Priacanthus cruentatus	glasseye
Sphyraena barracuda	great barracuda
Acanthurus coeruleus	blue tang
Acanthurus bahianus	ocean surgeon
Cantherhines pullus	orange spotted filefish
Aluterus scriptus	scrawled filefish
Lactophrys triqueter	smooth trunkfish
Synodus foetens	inshore lizardfish
Aulostomus maculatus	trumpetfish
Gobiosoma oceanops	neon goby
Ophioblennius atlanticus	redlip blenny
Tylosurus crocodilus	houndfish
Hemiramphus brasiliensis	ballyhoo
Myrichthys oculatus	gold spotted snake eel
Epinephelus fulva	coney

The Re-mapping of Petit Tabac

Andrew L. Hadik

ABSTRACT

During anchorage in the Tobago Cays Reef Complex, the re-mapping of Petit Tabac Island was attempted. This island is situated in an area of strong currents and occasional severe tropical storms, and because of its ephemeral nature (coral debris and sand), could experience some changes in shape. A survey completed two years ago (W-36) provided a comparison. The re-mapping attempt was unsuccessful for several reasons, one of which was that pacing proved to be too inaccurate because of the variable topography. Even though the attempt was unsuccessful, several changes in the shore topography since the first survey were noted.

The sediments of Petit Tabac

Margaret Brandon

ABSTRACT

Sediment samples were collected from the shoreline of Petit Tabac, a small rampart island in the Tobago Cays, and analyzed with the dry sieve method. The results were compared with those from a similar study done during W-36 in 1977 to determine if the sediment distribution had changed. It was found that the distribution had changed significantly, with the windward side of the island being composed of large coral boulders and the leeward side of homogeneous sized (250 micron) coralline sands. The margins of these islands are highly susceptible to alteration due to seasonal changes in wave patterns or heavy storms.

IMMUNOLOGY EXPERIMENT

Defense responses in the sea urchin
Beth Walker

ABSTRACT

An attempt was made to study defense mechanisms in sea urchins. Coelomic fluid from one species was injected into other species and the reaction observed. The response was measured in terms of clumped and single coelomocytes at two intervals after injection of the donor cells. A general trend of defense response was seen, the most dramatic occurring when a solution of sea anemone tentacle was used as an antigen. This suggests that sea urchins do distinguish between self and non-self on the species level, although the defense reaction is probably reduced within the family.

METEOROLOGICAL AND NAUTICAL SCIENCE STUDIES

A study and correlation of local weather observations and Marinefax weather map printouts aboard the R/V Westward

Amy Wolff

ABSTRACT

The aim of this project was to determine the correlation between the observed local weather and Marinefax weather map printouts received aboard R/V Westward in an attempt to judge the usefulness of the Marinefax for weather prediction. Maps were collected and local data recorded and charted for ten consecutive days; these two sets of data were then interpreted and compared. Results indicate that Marinefax weather maps are reliable when predicting general weather trends such as relative barometric pressure and trends in wind speed and direction. Correlations were not as good when considering more specific information such as barometric pressure measurements, specific wind speeds and directions, and chance of precipitation.

Magnetic deviation of the standard compass

Tyler Sack

ABSTRACT

There is a compass on the Westward that is meant to be used as a standard compass. This would allow sights to be made directly across the compass with the use of an azimuth circle to obtain accurate bearings. As of now it has not been used because the deviation has never been determined. The magnetic deviation of the standard compass was studied by taking azimuths of the sun and Polaris with the aid of an azimuth circle. The calculations were done with the use of the Ho 229 Sight Reduction Tables for Mariners, the Nautical Almanac for the year 1979, and the calculator method cited in Bowditch, The American Practical Navigator. Maximum easterly deviation was found to be 28.1°E on magnetic heading 304.8°, and maximum westerly deviation to be 28.1°W on magnetic heading 004.7°. A graph of the magnetic deviation was produced, a copy of which was left on Westward for future reference.

Westward - factors that affect her sailing abilities

Ned Grier

ABSTRACT

The relationship between *Westward*'s speed through the water and several major variables was the concern of this project. The variables were: 1) wind velocity, 2) sails set, and 3) point of sail. A major assumption was that as wind velocity increased into the higher forces, *Westward*'s speed would increase at a decreasing rate. This was found true for close and beam reaching, but not for broad reaching. Two other interests were the speed increases caused by setting the genoa, and speed increases caused by setting the mainsail and jibtopsail.* Data was collected from *Westward*'s log book; wind velocity was measured in forces, ship's speed was averaged for several hours and recorded in knots. "Sails set" was simply noted and recorded from the right side of the log book. Points of sail considered were close reach, beam reach, and broad reach.

*Setting the genoa caused *Westward*'s speed to increase 15% to 20% in different force winds; setting the main and jibtopsail caused a 13% to 40% increase in ship's speeds.

Desalination processes and their effect on the growth of vegetables

Ann Magee

ABSTRACT

The effectiveness of evaporation and condensation of seawater as a desalination process for a water supply to grow vegetables was studied. Two of the experiments were supplemented with seaweed which was used as fertilizer. The largest number of healthy seedlings grew in the control, which was watered with deionized water. The seaweed proved to be ineffective as a fertilizer. These experiments were instrumental in illustrating the problems involved in trying to grow plants in an arid area limited by funds and technology.

APPENDIX 1

A. Final Examination

1. a) Marine mammals and pelagic fish have co-evolved some adaptations to their common environment. Discuss some of these adaptations, and also some differences between the two groups.

   b) Fish are the only vertebrate group that exhibit phosphorescence. Discuss the sources of phosphorescence, and the advantages conferred upon the organisms that have it.

2. A ship carrying a cargo of low-level radioactive wastes has sunk near an island whose economy depends heavily on fishing. You are asked to take Westward and carry out an environmental study to determine how the fisheries around the island may be affected by this accident. Discuss what samples and measurements you would need to take, and how they would help you assess the problem.

3. The Lesser Antilles represent volcanism associated with subduction. Describe some of the features characteristic of this type of volcanism, with particular reference to the islands visited, and discuss how the islands might be related to larger scale plate tectonics.

4. Two different marine environments encountered on W-48 were the coral reef and the pelagic.

   a) Discuss some differences between pelagic fish and coral reef fish. Such discussion may include anatomy and physiology, coloration, behavior and ecology.

   b) Discuss major differences between pelagic invertebrates and reef invertebrates, using organisms you have seen as examples.

5. The importance of nutrient concentrations in determining the productivity has become evident during this cruise. For 1 nutrient, discuss briefly:

   a) the analytical technique

   b) factors affecting its distribution in the water column

   c) the relation between its concentration and productivity of the water masses we have encountered on the cruise

6. As a result of this cruise, your views of the biological, physical and chemical characteristics of the oceans have probably changed. Imagine you are asked to give a <u>scientific</u> talk at your college about an aspect of the marine environment that was previously unexpected by you.
Write a short summary of your lecture describing this feature in rigorous scientific terms, and explaining why it is of interest to you.

B. MARINE FAUNA AND FLORA USED AS A BASIS FOR PRACTICAL EXAM

Phylum Protozoa	
Homotrema rubum	foraminifera
Phylum Mollusca	
Herse (cuvierina) columnella *Carolina* sp.	pteropod
Calliteuthis reversa	pelagic squid
Acanthopleura sp.	chiton
Phylum Ctenophora	
Pleurobrachia pileus	comb jelly
Phylum Chaetognatha	
Sagitta sp.	arrow worm
Phylum Echinodermata	
Diadema antillarum	long spined, black sea urchin
Phylum Bryozoan (Ectoprocta)	
Membranipora sp.	encrusting bryozoan
Phylum Porifera	
Halidoma rubens	red sponge
Callyspongia vaginales	tube sponge
Phylum Coelenterata (Cnidaria)	
Bunodoscoma covernata	warty sea anemone
Phylum Arthropoda	
Halobates micans	water strider
Stenorhynchus seticornis	arrow crab
Systellapsis debilis	scarlet prawn
Panulirus larva	spiny lobster larva
Copepods	

Phylum Chordata	
<u>Coryphaena hippurus</u>	dolphin fish
<u>Myctophum</u> sp.	lantern fish
<u>Sparisoma vividi</u>	stop light parrot fish
<u>Fregata magnificens</u>	magnificent frigate bird
Leptocephala	eel larvae
Phylum Cyanophyta	
<u>Trichodesmium</u>	Blue-green algae
Phylum Chlorophyta	
<u>Halimeda</u> sp.	calcareous green algae
Phylum Chrysophyta	
<u>Skeletonema</u> sp.	diatom
Phylum Phaeophyta	
<u>Sargassum fluitans/natans</u>	Sargassum gulf-weed

APPENDIX II

Hydrocast data from the Grenada Basin

Station #	Location	Depth (m)	T (°C)	S (°/oo)	O_2 (mL/L)	Phosphate (μM/L)	Ammonia (μM/L)	Silicate (μM/L)
W-48 H-7	16°22.5'N	0	29.44	35.00	4.93	0.2	BD*	2.2
	61°52.5'W	40	28.52	34.14	5.02	0.1	0.20	2.0
		80	26.47	36.34	4.98	0.3	0.45	1.6
		172	19.48	36.42	3.73	-	-	-
		273	17.64	-	3.98	0.7	BD	2.9
W-48 H-8	15°45.4'N	0	28.67	34.70	4.99	1.26	BD	2.6
	61°43.3'W	25	28.53	-	4.93	0.26	BD	1.9
		60	26.33	34.52	4.96	BD	BD	1.2
		171	19.68	36.11	4.51	0.13	-	-
		365	10.48	34.58	3.59	1.54	BD	8.3
		420	-	34.78	3.19	0.85	BD	7.4
W-48 H-9	15°17.6'N	0	29.33	34.58	4.89	0.24	BD	1.6
	61°27.5'W	40	28.70	34.74	4.95	-	-	-
		110	24.97	36.66	4.73	BD	BD	1.0
		210	18.50	36.42	3.85	0.78	BD	1.3
		400	12.97	35.24	3.26	1.30	0.40	3.1
		563	8.86	34.82	3.04	1.59	-	6.2
W-48 H-10	15°00.0'N	0	28.87	35.74	4.85	BD	BD	1.6
	61°25.5'W	70	26.80	-	5.15	BD	BD	1.1
		167	18.80	36.17	3.72	0.50	-	3.4
		210	18.48	36.59	3.78	0.42	BD	2.9
		537	9.89	35.09	3.12	-	-	-
		850	6.46	34.39	3.48	2.21	0.15	BD

Hydrocast data from the Grenada Basin

Station #	Location	Depth (m)	T (°C)	S (°/oo)	O_2 (mL/L)	Phosphate (μM/L)	Ammonia (μM/L)	Silicate (μM/L)
W-48 H-11	13°15.1'N	0	29.58	32.63	4.76	0.45	0.35	-
	61°20.1'W	80	26.04	36.09	-	0.88	1.54	1.2
		120	22.94	36.50	3.77	BD	0.81	1.2
		350	11.84	34.62	2.90	1.75	BD	4.0
		850	-	34.49	3.35	0.97	0.05	8.5
		1200	4.53	34.69	4.96	0.74	BD	9.2
W-48 H-12	13°34.2'N	0	29.07	34.05	4.75	0.25	BD	0.6
	61°08.8'W	80	28.45	34.95	5.18	0.21	0.1	1.0
		120	27.13	35.64	5.09	0.11	BD	-
		350	18.59	36.35	3.47	0.76	0.37	2.8
		850	9.97	34.99	3.00	2.00	BD	5.2
		1260	5.88	34.50	3.39	3.00	BD	5.6
W-48 H-13	13°46.3'N	0	29.05	34.70	4.70	0.28	BD	2.4
	61°65.0'W	55	28.16	34.99	4.70	BD	-	0.6
		78	27.51	35.47	4.61	0.28	0.10	0.8
		313	14.55	36.19	3.39	1.53	0.10	2.7
		598	-	34.61	3.24	2.38	0.15	5.8
		855	6.42	34.46	3.20	2.50	1.65	8.0
W-48 H-14	13°04.3'N	0	29.04	32.05	4.60	0.65	-	-
	61°13.4'W	55	27.51	34.80	4.70	0.75	BD	1.6
		104	23.88	36.22	4.51	0.65	BD	1.2
		217	-	35.64	3.58	1.40	0.15	4.8
		328	11.92	33.84	2.97	1.70	BD	-

Hydrocast data from the Grenada Basin

Station #	Location	Depth (m)	T (°C)	S (°/oo)	O_2 (mL/L)	Phosphate (μM/L	Ammonia (μM/L)	Silicate (μM/L)
W-48 H-15	13°49.0'N	0	28.67	35.47	4.66	-	0.39	3.4
	61°37.0'W	30	28.79	35.23	4.66	0.05	0.36	2.9
		76	27.87	35.28	4.67	0.05	BD	2.6
		489	9.42	34.65	2.75	1.35	0.63	16.8
		789	6.53	34.87	3.04	1.75	0.58	22.6
		880	5.84	34.46	3.39	1.83	0.41	23.0
		979	5.47	35.36	3.91	1.60	0.42	22.0
		1500	4.58	34.59	4.75	1.30	0.04	24.2
W-48 H-16	14°50.0'N	0	28.68	34.34	4.83	0.06	0.10	3.1
	62°36.0'W	30	28.35	34.90	4.57	0.17	0.10	3.2
		80	27.02	36.04	5.09	0.05	BD	1.6
		197	22.32	36.72	4.39	0.07	BD	2.4
		478	10.19	34.64	2.83	1.57	0.75	12.1
		700	7.04	34.47	2.84	2.52	1.03	22.0
		1000	5.89	34.49	3.54	1.57	BD	23.4
		1250	4.66	34.30	-	1.65	1.20	23.4
		1432	4.34	34.68	4.73	0.65	0.90	24.0
		1750	4.20	34.39	4.70	1.22	1.20	24.4
W-48 H-17	15°45.0'N	0	28.73	34.35	4.99	0.22	0.20	BD
	62°51.0'W	228	18.53	35.67	4.48	0.12	0.10	3.1
		572	9.87	34.79	3.07	2.00	BD	14.4
		765	6.23	34.37	3.39	2.00	0.97	23.2
		960	5.43	33.50	4.03	2.10	0.18	24.0
		1153	4.73	34.37	4.90	2.41	0.20	24.2

* - below detection