Cruise Report

W-43

Scientific Activities

St. Thomas - Guadeloupe - Jamaica - Key West

29 November 1978 - 10 January 1979

R/V WESTWARD

Sea Education Association

Woods Hole, Massachusetts

DRAFT COPY

Galistes sp.

"HOOTER"

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PREFACE

The objective of this cruise report is to compile the data collected by 23 undergraduate students, 3 staff scientists, and 4 visiting scholars on cruise W-43 of the R/V Westward. This compilation of data in one place can serve as a guide for future Westward cruises, as a data base for interpretation of results by scientists ashore, and as a teaching reference in the shore component of the Sea Semester program.

The report presents an overview of cruise W-43 with some preliminary interpretation of results. We conducted an array of individual projects, many of them focused on the study of island mass effects, and this report provides space to see how our diverse interests meshed. It is my particular hope that this experience on the Westward revealed to the students a realistic view of how the scientific method works even while a sense of awe and wonder at the natural world remained.

It was my pleasure to rely upon a fine crew and scientific staff. I thank Captain Wallace Stark for his cooperation and interest in the scientific program. The mates were skillful and helpful in getting the ship to perform the often arduous tasks we asked of her and at the essential art of finding out where we were. Carl Baum contributed a wealth of experience and first-hand knowledge of biological oceanography as well as an enlivening sense of humor. Sally Kaul brought an engaging interest in diverse fields -- from beach botany through marine mammals -- as well as the artistic talent that enlivens the pages of this report with her drawings. I appreciated greatly being able to lean on this strong staff.

We enjoyed the presence of 4 visiting scholars on this cruise. It was especially nice for me to be able to invite Dr. Ken Haines from the St. Croix Marine Station, where I did my thesis research, to participate in Leg I of this cruise. His warm interest in the program and the students was as highly appreciated as his scientific contribution. Two Ph.D. candidates, Dan Gibson and Larry Brand, brought their respective research interests to Legs II and III, thereby enlightening the students to the realities of graduate

school work. Dr. Diane Brousseau's study of gastropod larvae distribution on Leg III fit nicely into our theme of island mass effects. All three had experiences and approaches to life that enriched our enjoyment of them on the cruise.

This report was largely prepared at sea and is not meant to represent a final consideration of the data.

Mary Farmer
Chief Scientist

INTRODUCTION

This report is the result of the laboratory portion of Introduction to Marine Science (NS 225 at Boston University), which took place on cruise W-43 of the R/V Westward (figure 1). Ship's itinerary and compass point extremes are given in Table 1, and the ship's complement is listed in Table 2.

The academic program consisted of daily lectures and weekly quizzes by the staff. Student projects were supervised and resulted in final papers and seminars, the abstracts of which compose the main body of this cruise report.

Most of the scientific education on the cruise took place during science watch. Students on watch in the laboratory learned the operation of oceanographic equipment, the chemical and biological work-up of samples, and analysis of data, including statistical manipulation. Becoming familiar with specific organisms and proper maintenance of a scientific log were also part of the science watch.

Research conducted during W-43 partly represents ongoing work of individuals and agencies that have extended their assistance to our students. Scientific operations performed on W-43 are listed in Appendix I and data are given in Appendices II - V. Material reported here should not be excerpted or cited without written permission of the Chief Scientist.

Figure 1. Cruise track of R/V Westward cruise W-43. Itinerary in table 1.

Table 1. Itinerary and compass point extremes of R/V Westward cruise W-43

<u>Port</u>	<u>Arrival</u>	<u>Departure</u>
St. Thomas, U.S.V.I.	-	29 November 1978
Les Saintes, Guadeloupe	09 December 1978	11 December 1978
Montego Bay, Jamaica	23 December 1978	26 December 1978
Key West, Florida	10 January 1979	-

<u>Compass Point</u>	<u>Latitude (N)</u>	<u>Longitude (W)</u>
North	24°49'	84°32'
South	16°02'	61°47'
East	19°09'	59°43'
West	23°56'	87°10'

Table 2. Ship's complement for R/V Westward cruise W-13.

NAUTICAL STAFF

Wallace Stark, B.S. L.L.B.	Captain
Richard Ogus, B.S.	Chief Mate
Jeff Bolster, B.A.	Second Mate
Armin Elsaesser, B.S.	Third Mate
Pat Harren	Engineer
Sam Baxter	Steward

SCIENTIFIC STAFF

Carl Baum, B.S.	Scientist
Mary Farmer, Ph.D.	Chief Scientist
Sally Kaul, B.S.	Scientist

VISITING SCHOLARS

Larry Brand, Ph.D. Candidate (Leg III)	Woods Hole Oceanographic Institution
Diane Brousseau, Ph.D. (Leg III)	Fairfield University, Connecticut
Dan Gibson, Ph.D. Candidate (Leg II)	Marine Biological Laboratory, Woods Hole
Kenneth Haines, Ph.D. (Leg I)	University of Texas, St. Croix Marine Station

STUDENTS

Karen Alence	University of Vermont
Frank Apesecche	Cornell University, N.Y.
Frank Armour	Haworth, N.J. (on sabbatical)
Wayne Chimenti	Providence College, R.I.
Virginia Coy	Cornell College, Ia.
Lucinda (Cindy) Damon	Kenyon College, Ohio
Alice Dawson	University of California at Davis
Deborah Fenton	University of Delaware
Scott Frankel	Roger Williams College, R.I.
Ross Friedman	Seattle Central Community College, Wa.
David Goldsmith	Colby College, Me.
Diana Hews	Pomona College, Ca.
Steve Luce	Cornell University, N.Y.
Grace Koppelman	Colby College, Me.
Jerome (Jerry) Moles	Massasoit Community College, Ma.
Ken Potter	Carleton University, Ottawa, Ontario, Canada
Paul Rosenzweig	Haverford College, Pa.
Jodie Schlott	Cornell University, N.Y.
Tamsen (Tummy) Scott	University of Massachusetts at Amherst
Helen (Polly) Shaw	Cornell University, N.Y.
Ed Stumpf	College of Wooster, Ohio
Christina (Tina) Swanson	Cornell University, N.Y.
Brian Taras	University of Pennsylvania

RESEARCH AND OBSERVATIONS

W-43 PROGRAMS

The programs developed specifically for W-43 were: two island mass effect studies, Yucatan Channel studies, student research projects, and visiting investigator programs.

The island mass effect is the sum of physical, chemical, geological, and biological influences an island has, simply by its existence, on the water surrounding it. Island mass effect studies were conducted near Guadeloupe and Jamaica. Stations were established at intervals of approximately 20 miles on the windward and leeward sides of the islands (figure 2). The stations consisted of 1) a bathythermograph; 2) a hydrocast for temperature, salinity, oxygen, and silicates; 3) a step bongo tow whereby the bongo nets were towed at four depths for the Guadeloupe stations and at two depths for the Jamaica stations; 4) nanoplankton and neuston tows at the Guadeloupe stations; 5) light intensity measurements at the stations conducted during daylight. Standard methods were used to analyze the samples: silver nitrate titration for salinity, Winkler method for oxygen, Strickland and Parsons (1972)* for silicate, and volume displacement by filtration for zooplankton biomass. Ambient and underwater light intensities were measured with a Kahl Underwater Irradiometer.

Yucatan channel studies were designed with the approval of Dr. Kent A. Fanning (U. South Florida) to follow up on a study of circulation through the channel using dissolved silica as a water mass tracer (Carder, K. L. et. al. 1977. Deep Sea Res. 24: 1149-1160). Three hydrocast stations were done in the channel itself, one in the Yucatan Basin as a Caribbean control, and one in the Gulf of Mexico as a Gulf control.

* Strickland, J. D. H. and T. R. Parsons 1972. A practical handbook of seawater analysis. Bull. 167 (Ed. 2) Fish. Res. Bd. Can., Ottawa. 310 pp.

Figure 2. A. Island mass effect stations near Guadeloupe. B. Island mass effect stations around Jamaica. Station numbers in the text and appendices are prefixed with W43.

W-43 PROGRAMS, continued

Several students used data collected routinely from either the island mass effect stations or the Yucatan Channel studies for research projects in specific aspects of these studies (Armour, Rosenzweig, Coy, Apeseche, Stumpf, and Scott). Other student projects focused on biological questions in the Caribbean (Swanson, Fenton, Moles, Frankel, and Alence), and two projects were developed in the nautical science field (Potter and Luce). The remaining students studied subjects that are part of on-going SEA or cooperative programs (Goldsmith, Damon, Dawson, Koppelman, Chimenti, Friedman, and Hews).

The visiting investigator programs included collection of Trichodesmium (Haines) and dinoflagellates (Brand) for culture, examination of crustacea for cyanoblasts (Gibson), and biogeography of gastropod larvae, especially Strombus gigas, the Queen conch (Brousseau).

Other scientific operations exclusive of the long term studies were bathythermograph and surface temperature profiles. Data from all scientific operations are summarized in Appendix II.

ISLAND MASS EFFECTS

Ways in which islands affect the water surrounding them were examined in two cases: Guadeloupe, which is a relatively small island and one of a chain of islands that form an arc separating the Atlantic from the Caribbean, and Jamaica, which is larger than Guadeloupe but is located close to two even larger islands (figures 1 and 2).

It was expected that islands, by their presence, would interrupt current flow, resulting in eddies, mixing and local turbulence. The land mass should provide some nutrient input from river run-off and, where reefs are present, act as a nutrient trap, concentrating nutrients from the passing waters. The result of these effects should be an increase in productivity in nearby waters.

ISLAND MASS EFFECTS, continued

The stations established on this cruise were designed after asking whether island mass effects do exist in the Caribbean and, if so, how far do the effects extend.

The abstracts and summaries that follow present different aspects of the study.

Temperature: Profiles drawn from the bathythermograph data of the island mass effect stations show different effects on the water by Guadeloupe and Jamaica. The major feature of the Guadeloupe profile was mixing on the leeward (Caribbean) side of the island with a very stable temperature profile on the windward (Atlantic) side (figure 3A). The surface mixed layer was deeper in the Atlantic than in the Caribbean and isotherms, especially from 70°F and colder, were deeper in the Atlantic.

The major feature of the Jamaica profile was the rising of a thin subsurface inversion layer to the surface together with a decrease in temperature at any given depth in the water column (figure 3B). Such a profile suggests upwelling on the windward side of the island. Little evidence of mixing was seen leeward of the island, where the water was warmer than on the windward side.

Hydrography: Vertical temperature and salinity profiles showed fresher water at the surface than at depth at all stations. The more saline water was closer to the surface on the leeward than the windward side of Guadeloupe (figure 4). Silicate and oxygen concentrations showed greater variability on the leeward than windward side of Guadeloupe (figure 4), suggesting turbulent mixing, corresponding to the bathythermograph profiles.

The high salinity layer was deeper on both sides of Jamaica (100-200 m) than off the leeward side of Guadeloupe (50-150 m) (figure 5). The oxygen profiles were more variable off the leeward than the windward side of Jamaica (figure 5). Since there was no evidence of mixing leeward of Jamaica, this variability was most likely related to biological patchiness or some factor other than mixing.

Figure 3. Temperature profiles to the windward and leeward of Guadeloupe (A) and of Jamaica (B). Profiles are east-west and data were collected at stations shown in figure 2. Surface temperatures are at the top of each section: all temperatures in degrees Farenheit.

Figure 4. Hydrographic features to the windward and leeward of Guadeloupe. Profiles read from east to west, and each block represents a station shown in figure 2A.

Figure 5. Hydrographic features to the windward and leeward of Jamaica. Profiles read from east to west, and each block represents a station shown in figure 2B.

ISLAND MASS EFFECTS, continued

Zooplankton Concentration: Total biomass of zooplankton was considered to indicate approximately the level of productivity of the water column at a given station. Estimates of zooplankton biomass were done by filtering the organisms captured by one bongo net, towed in steps at 200, 150 and 50 meters, onto a glass fiber filter to remove interstitial water from between the organisms. (The organisms from the other bongo net were kept for taxonomic examination.) The animals were then added to a known volume of seawater, and the new volume was recorded. The difference between the new and original volumes was called the volume displacement.

When volume displacement was plotted against distance from Guadeloupe, two trends were seen (figure 6): One trend was a consistently greater zooplankton biomass at night than during the day, presumably because of vertical migration. The other trend was a tendency for the biomass to increase as land was approached. The correlation between the log of zooplankton biomass and distance from land was $r = -0.916$ ($p = 0.01$) for nighttime samples. The correlation for daytime samples ($r = -0.792$) was not significant, perhaps because of the low numbers of samples (three).

The data are suggestive of an increase in productivity near Guadeloupe.

The following student projects are consistent with these findings.

Figure 6. Concentration of zooplankton biomass, by volume displacement, with respect to distance from Guadeloupe. Triangles = daytime samples; circles = nighttime samples. Bottom curve fits triangles and top curve fits circles by a linear regression performed on the log of zooplankton concentration as a function of distance from land.

The Island Mass Effect on Light Penetration and Photosynthetic Production

Franklin B. Armour

Abstract. Data were collected with a Kahlsico Model 268 WA 310 Irradiometer to study possible effects of an island mass on the attenuation coefficient (k) of light intensity and the resulting changes in primary productivity. Light units were in mW cm^{-2} and gross photosynthetic production was estimated from the following equation.

$$P_g = 0.84 I_d (1 + 0.105 I_d)^{-1} \text{ mg C mg chl}^{-1} \text{ hr}^{-1}$$

The four stations that could be analyzed for island mass effect were stations 25 and 27 on the windward side and stations 30 and 32 on the leeward side of Guadeloupe. Although k values showed little effect on underwater light intensity by nearness to the island (table 3), calculated production was higher at the stations near the island (27 and 30) than at stations away from the island (25 and 32) (figure 7). Also stations to the lee of the island (30 and 32) showed distinctly greater calculated production than stations to the windward.

Figure 7. Calculated primary productivity as a function of light intensity at 4 stations around Guadeloupe. Stations W43-25 and W43-27 were windward and stations W43-30 and W43-32 were leeward of Guadeloupe. Production was calculated from the equation $P_g = 0.84 I_d (1 + 0.105 I_d)^{-1}$ where P_g = gross production and I_d = light intensity in mW cm^{-2} at the specified depth.

Table 3. Attenuation coefficients for stations near Guadeloupe.

Depth of reading (m)	Station: Distance from land (m):	k (mW cm ⁻² m ⁻¹)			
		25 80	27 40	30 20	32 60
1		0.49	-	0.81	0.65
3		0.31	0.81	0.40	0.42
5		0.29	0.33	0.26	0.31
10		0.16	0.17	0.14	0.21
15		0.10	0.03	0.12	0.11
20		0.08	0.09	0.07	0.11
25		0.07	0.09	0.10	0.09

Silicate as a Water Mass Indicator

Ginnie Coy

Abstract. The intent of this study was to examine two aspects of silicate concentration in the water column. The first aspect focused on the effect of island mass on silicate concentration. The second aspect used silicate concentrations to determine water circulation in the Yucatan Strait. Island mass effect was seen more distinctly on the leeward than the windward sides and was characterized by 1) a wide range of silicate concentration in the surface layer due to river runoff and uneven circulation patterns and 2) a silicate minimum layer beneath the mixed layer possibly due to uptake by microzooplankton or diatoms growing at very low light intensity (figure 4).

Results of studies in the Yucatan Strait support the conclusions by Carder et al. (1977) * regarding circulation in the area and are presented in the section under Caribbean Studies. Continued emphasis should be placed on the importance of silicate concentration in relation to water mass in future studies.

* Carder, K. L., K. A. Fanning, P. R. Betzer, and V. Maynard. 1977. Dissolved silica and the circulation in the Yucatan Strait and deep eastern Gulf of Mexico. Deep Sea Res. 24: 1149 - 1160.

A Study of Possible Upwelling off the Leeward Coast of Guadeloupe

Frank Apeseche

Abstract. The purpose of this study was to determine whether a possible upwelling zone exists off the leeward side of Guadeloupe. To investigate this matter, four hydrostations were taken along a transect perpendicular to the shore (figure 2). At each station water samples were collected at specific depths to 200 m and were analyzed for temperature, salinity, density, phosphate and silicate. Results suggest that phosphate and silicate concentrations at the three stations closest to shore were influenced by island runoff. The furthest station off the coast might have been in an upwelling zone because phosphate and silicate concentrations varied by only 0 and 1.16 $\mu\text{g-at l}^{-1}$, respectively, over the top 100 m while these concentrations varied by as much as 0.02 and 2.7 $\mu\text{g-at l}^{-1}$, respectively, at the other stations.

Spiny Lobster Larvae Dispersion in the North Atlantic, Caribbean
and Gulf of Mexico

E. Stumpf and T. Scott

Abstract. The phyllosoma larvae of the spiny lobster, Panulirus argus, were collected from plankton tows in the Sargasso Sea and during island transects of Guadeloupe and Jamaica. Thirty-seven tows yielded 176 larvae in the Sargasso Sea ($21^{\circ}10'N$, $60^{\circ}16'W$) and 7% from the Guadeloupe and Jamaican areas (figure 8). Because of small sample size, it was not possible to conclude whether larval concentrations increased approaching land. The study did show vertical migration by the larvae. The larvae were also carried long distances by currents.

Figure 8. Larval distribution of *Panulirus argus* according to distance from land and molting stage. A 24-hour station in the Sargasso Sea yielded a total of 176 larvae in four tows with an average stage of stage 6.

CARIBBEAN STUDIES

The Caribbean Sea encompasses 4 large and 3 small basins with an average depth of 4400 m. The basins are separated by ridges approximately 1000-1500 m deep. It is bounded by the Greater and Lesser Antilles island arc on the north and east and by the Central and South American continent on the west and south. Oceanographic studies in the Caribbean included hydrographic samplings of certain basins and biological studies of two reefs in the island arc complex.

Hydrography: Permanent features of vertical salinity profiles of Caribbean basins include 1) surface water, 2) Subtropical Underwater (SUW, core at 50-200 m), 3) Sub Antarctic Intermediate Water (SAIW at 700-850 m) and 4) North Atlantic Deep Water (DW at 1800-2500 m) (Gordon 1966)*. Waters between the cores are mixtures, and the distinction between cores become less pronounced as the water flows from east to west through the Caribbean.

Deep hydrocasts were taken in the Venezuela Basin (W43-33), Columbia Basin (W43-35), Yucatan Basin (W43-48) and in an unnamed depression off Jamaica that we called the "Jamaica Well" (W43-40). Our profiles were consistent with the permanent features (figure 9). Temperature declined steadily throughout the top 1000 m and then remained constant to the deepest depth sampled (2411 m). Salinities showed probable seasonal variations superimposed on the permanent features. The depth of the salinity maximum coincided with SUW and salinity minimum with SAIW, but the variability between stations was rather high. An increase in salinity between 1200 and 1600 m in the Venezuela basin (W43-33) could not be explained.

* Gordon, A. 1966. Caribbean sea oceanography, in Fairbridge, R. W. (Ed.): The encyclopedia of oceanography. Reinhold Publishing Corporation. New York. pp 175-181.

Figure 9. Hydrographic stations in the Caribbean. Station numbers increase from east (Venezuela Basin) to west (Yucatan Basin). The oxygen profile was compared with station 160 of Metcalf, W.G., M.C. Stalcup, and M. Zeranovic. 1973. Hydrographic station data, Caribbean Sea, Knorr Cruise 25. WHOI-73-10, Technical Report.

CARIBBEAN STUDIES, continued

An oxygen profile at the Jamaica Well (W43-40) showed features similar to those found by Metcalf and associates (1973, *ibid*) at a similar latitude, except our values were consistently somewhat higher than theirs. The oxygen minimum layer here coincided with the salinity minimum layer of SAIW. Oxygen in the North Atlantic DW was higher than at the surface.

Overall, hydrographic studies of the basins suggest a great deal of variability in the top 1000 m of the water column while deeper water became less saline with distance away from the Atlantic Ocean.

The two student projects that follow examine aspects of circulation in the Caribbean.

Circulation through the Yucatan Strait

Ginnie Coy and Mary Farmer

Abstract. Carder and associates (1977)* reported that dissolved silica concentration in water deeper than 1250 m are greater in the Gulf of Mexico than in the Caribbean. This information enabled them to use silica as a natural tracer of the circulation patterns through the Yucatan Strait.

Data were collected on this cruise to study whether the patterns reported by Carder et al. still showed up. Five hydrocasts were taken: a Caribbean station (W43-48), a Gulf of Mexico station (W43-57) and three stations in the Yucatan Strait (W43-40 through 52) (figure 10).

Silicate analyses showed the expected decrease in concentration below 1250 at the Caribbean Station (figure 11). The most westerly station in the strait showed Caribbean water to approximately 1600 m and then Gulf water beneath it. Other stations in the strait were too shallow to show the circulation pattern clearly. The Gulf station showed a low silicate concentration at 1400 m, suggesting that Caribbean water had been carried to this point.

Replicate samples have been sent to Kent Fanning of U. of South Florida for analysis.

* Carder et al. Ibid.

Figure 10. Hydrocast stations for silicate profiles through the Yucatan Strait (W43-50 through 52), in the Caribbean (W43-48) and the Gulf of Mexico (W43-57). Station positions are listed in the appendix. Silicate data is shown in figure 11.

Figure 11. Silicate profiles from the Yucatan Strait and nearby stations. Station positions are shown in figure 10.

Density Determination for Water Masses and Mixing Layers

Paul S. Rosenzweig

Abstract: The purpose of this study was to examine some of the circulatory patterns of the Caribbean waters. The study fell into two convenient parts: examination of large scale circulatory and of small scale circulatory patterns. In the large scale study an attempt was made to trace Atlantic water into the Caribbean Sea. In the small scale study vertical mixing patterns to the windward and leeward of Guadeloupe and Jamaica were examined.

In each case water masses were traced by their similarities in temperature, salinity and density. The temperatures were determined from reversing thermometers lowered to specific depths at 21 stations. The salinity was found by titration with silver nitrate. The density was then determined from a graph of temperature versus salinity.

In the small scale study vertical mixing was definitely found on the leeward side of Guadeloupe, and possibly on the leeward side of Jamaica. There was no vertical water motion on the windward side of either island. In the large scale study Atlantic water was found only in the Venezuela Basin, but apparently not in Colombian Basin or in a deep well northeast of Jamaica.

W-43 PROGRAMS, continued

CARIBBEAN STUDIES, continued

Biological Studies. The only marine insect known is Halobates, a water strider. Its habitat is the air-sea interface, where it can sit on the sea surface without breaking the molecular tension of water because of its long appendages.

Halobates organisms were collected in several neuston tows and were sent to Dr. Michael Ivie of the College of the Virgin Islands, St. Thomas, for further study.

The next five student projects concern other biological aspects of the Caribbean studies.

Chaetognaths as Water Mass Indicators

Tina Swanson

Abstract. Certain species of the phylum Chaetognatha have been found to be excellent indicators of water mass in the North Atlantic.

R/V Westward's cruise track took us through four different water masses, and Chaetognaths were collected in each. Physical characteristics were used to distinguish between the different water masses, arrow worms were identified to species, and a relationship between species and water mass was sought. Five species, all of the genus Sagitta, were found to be restricted in their distribution and thus could be considered indicator species (table 4). Two were found only in the Sargasso Sea, North Equatorial Current and windward coastal water (species D and E), the other three only in the leeward coastal water and the Caribbean.

Table 4. Proportion of total chaetognaths seen in each water mass sampled on W-43

Species	Percent of Total Chaetognaths				
	Sargasso Sea	North Equatorial Current	Coastal Windward	Coastal Leeward	Caribbean Sea
<u>Sagitta</u> sp.A	50	50	43.9	41.4	45.8
<u>S.</u> sp.B	-	-	-	3.4	16.7
<u>S.</u> sp.C	12.9	17.7	12.2	-	20.8
<u>S.</u> sp.D	4.8	6.5	9.8	-	-
<u>S.</u> sp.E	6.5	4.8	-	-	-
<u>S.</u> sp.F	3.2	-	-	3.4	-
<u>S.</u> sp.G	8.1	9.7	2.4	10.3	-
<u>S.</u> sp.H	-	-	-	10.3	-
<u>S.</u> sp.I	-	-	-	6.9	-
<u>Krohnitta</u> sp.A	11.3	11.3	31.7	13.8	8.3
<u>K.</u> sp.B	1.6	-	-	10.3	4.2
<u>Heterokronia</u> sp.	1.6	-	-	-	4.2

A Comparative Study of the Jamaican Coral Reef

Deb Fenton

Abstract. The coral reef has long been known as a highly productive ecological area with great diversity in its species population. The study of the pattern of growth of this diverse coral population has undergone much research in the past. Twenty years ago, T.F. Goreau* divided the Jamaican coral reef into a series of zones based on the bottom topography of the reef itself and by the dominant corals selective for each area. He then studies each zone in detail and set up a graph depicting each zone and which specific coral species were found there. The present study was restricted to a 33 m² transect within one zone to observe the changes in the species population over the past twenty years. The zone was transected by setting out a line perpendicular to the shoreline across the reef itself, delineating the specific area to be observed. Coral species were observed along this line only. By comparison with the data of Goreau, brain corals (family Faviidae) seemed to have decreased in relative abundance while other species, such as Millepora complanata (stinging coral), increased dramatically (table 5). This type of change might have been related to the construction of a series of jetties along the shoreline, which inhibited the water circulation in the reef itself and retarded the maximum possible coral growth. These conditions might also explain the high population of stinging coral, which seems to favor this type of environment.

* Goreau, T. F. 1958. The ecology of Jamaican reef corals.
Ecology. 40: 67-90.

Table 5. Coral species found in a 33m² transect off the coast of Jamaica. Numbers represent the relative abundance of the species found in that transect.

Coral	Common Name	Goreau (1959)	Fenton (1978)
<u>Acropora cervicornis</u>	staghorn	.02	.03
<u> palmata</u>	elkhorn	.31	.09
<u> prolifera</u>	fused staghorn	.02	0
<u>Agaricia agaricites</u>	leaf	.08	.27
<u> fragilis</u>	fragile leaf	.02	.015
<u>Siderea radians</u>	rough starlet	.05	.015
<u> siderea</u>	smooth starlet	.02	.015
<u>Porites porites</u>	club finger	.02	.09
<u> astreoides</u>	finger	.02	.045
<u>Favia fragum</u>	golfbay	.02	.015
<u>Diploria divosa</u>	knobby brain	.05	.015
<u> strigosa</u>	smooth brain	.10	.03
<u> labyrinthi-</u> <u> formis</u>	grooved brain	.05	.015
<u>Colpophyllia natans</u>	giant brain	.02	.015
<u>Montastraea annularis</u>	mountainous star	.02	.03
<u>Millipora alcicomis</u>	encrusting stinging	0	.17
<u> complanata</u>	leafy stinging	.10	0
Total # colonies		38	66

Light and Dark Ambient Environments with Sea Anemones

Jerome B. Moles

Abstract. The behavior of three families of sea anemones, Actinidae, Stiochactiidae, and Phymanthidae were observed under aquarium conditions, and their response to different stimuli were tested.

The major objective in a series of experiments was to test and observe the anemones' preference to light and dark ambient environments and reactions when tentacle contact was made between different anemones. One half of a five gallon tank was darkened with black construction paper, the other half remained uncovered. Contact between anemone tentacles was observed when anemones from families Stiochactiidae, Actinidae and Phymanthidae were placed in close proximity to each other. It was noted that anemones, especially the Stiochactiid, showed a definite tendency to move toward the light side of the aquarium. A green tentacle was removed from the Stiochactiid and found to contain symbiotic algae. The movement exhibited was probably a response to the needs of symbiotic algae. When tentacle contact between the Stiochactiid and the Actinid was made, an immediate response (aversion and contraction) occurred. It is assumed that a chemical reaction and nemotocyst discharge occurred when contact took place.

Tropical Algae Herbarium

Scott Frankel

Abstract. Tropical algae were collected at Baie de Pontpierre, Isle des Saintes, and Montego Bay, Jamaica, to construct an herbarium. Ten specimens were preserved from each area, and observations were made on zonation. Chlorophyta extended throughout the zones at both sites while Rhodophyta and Phaeophyta occurred only in the deeper water. Calcareious algae were prominent and proved to be difficult specimens to preserve with standard herbarium techniques.

Sargassum fluitans and Plumularia setaceoides

SARGASSUM WEED and HYDROIDS

Seaweed Palatability

Karen Alence

Abstract. The palatability of seaweed was tested by serving cooked dishes containing Sargassum polyceratum. During four trial meals, all persons aboard the R/V Westward cruise W-43 were offered identical aliquots of the seaweed dish along with several non-seaweed dishes. Each taster was asked to rate the palatability of the seaweed dish on a scale of 1 - 10, as well as to rate a designated non-seaweed dish at that meal on the same scale.

The average rating of the Sargassum dishes were 7.55, 7.88, 7.96, and 5.05. The average rating of the designated non-seaweed dishes were, respectively, 6.35, 5.31, 3.04, and 7.64. The results indicate a positive inclination towards seaweed palatability and evoke questions for further investigation on this subject.

W-43 PROGRAMS, continued

Navigation Studies. Two student projects on W-43 investigated aspects of nautical science.

Current Observations based on Set and Drift of the Research Vessel

Ken Potter

Abstract. Current observations were taken in the North Equatorial Current, Sargasso Sea, and Caribbean Currents, using the traditional method of determining set and drift of a vessel by its deviation from dead reckoning positions. Wind observation indicated that wind driven currents could be accounted for by set but not by drift.

An Evaluation of Chichester's Method of Determining Longitude without Time
Steve Luce

Abstract. This study was designed to evaluate the ease and accuracy of Sir Francis Chichester's method of determining longitude without time.

A series of consecutive sextant sights were taken of the moon and sun or star and graphed out to find the most accurate ones. These sights were then reduced and plotted using guessed-at times either side of the approximate time. Latitude was determined by LAN, a polaris sight, or a timed celestial fix. Results showed that simultaneous sightings were not necessary for the method to work as long as the time difference was preserved between the sights during reduction. Five minutes on either side of the approximate time of sight was found to be more suitable than Chichester's suggested thirty minutes. Chichester's method has several problems with accuracy. The method is extremely latitude sensitive, one minute of error in latitude generally resulting in eleven or more miles of error in longitude. The time of the lunar cycle is also important. The times of greatest change in declination (half moon) are essential for valid sights; phases of low change in declination are nearly valueless for this method. Extremely accurate sextant altitudes are necessary for good results. It is also probable that more accurate tables (to the nearest 0.1 minute) would improve the accuracy of the method.

Although there are many problems and sources of error with Chichester's method, it can be used to find a reasonably close position by a very careful navigator under good conditions.

W-43 PROGRAMS, continued

VISITING INVESTIGATOR PROGRAMS

Leg I: St. Thomas to Les Saintes.

Dr. K. C. Haines collected samples of the blue-green algae, Trichodesmium, and subjected them to a matrix of culture medium and culture container conditions. Initial data showed more variability between colonies of Trichodesmium than between culture conditions. Dr. Haines took surviving cultures to the U. of Texas St. Croix Marine Station for follow-up studies.

Leg II: Les Saintes to Montego Bay, Jamaica.

Mr. Dan Gibson collected scarlet prawns and analyzed slides of their hemolymph to look for cyanoblasts, which he has found in horseshoe crabs. Two of the prawns were gravid females, and he took the larvae to the Marine Biological Laboratory, Woods Hole, for follow-up work.

Leg III: Montego Bay, Jamaica, to Key West, Florida.

Mr. Larry Brand collected nannoplankton samples to culture coccoliths and dinoflagellates for studies of genetic variability within populations. He took cultures to Woods Hole Oceanographic Institution for analysis.

Dr. Diane Brousseau filed the following report on her study of gastropod larval distribution.

Gastropod Larval Distribution

A total of 18 zooplankton samples were presorted on shipboard, and the larval gastropods were removed and preserved in 10% buffered formalin. Samples were collected using a Bongo Net (330 and 500 mesh size) towed at a maximum depth of 200 m. The following locations were sampled:

W43-23	Echo Bank	(Lat. 21°10'; Long. 60°16')
W43-24	Echo Bank	(Lat. 17°52'; Long. 59°36')
W43-25	Guadeloupe TR-1	(Lat. 16°40'; Long. 60°00')
W43-26	Guadeloupe TR-2	(Lat. 16°31'; Long. 60°20')
W43-27	Guadeloupe TR-3	(Lat. 16°21'; Long. 60°36')
W43-28	Guadeloupe TR-4	(Lat. 16°16'; Long. 61°08')
W43-29	Guadeloupe TR-5	(Lat. 16°02'; Long. 61°48')
W43-30	Guadeloupe TR-6	(Lat. 16°10'; Long. 62°14')
W43-31	Guadeloupe TR-7	(Lat. 16°17'; Long. 62°28')
W43-32	Guadeloupe TR-8	(Lat. 16°17'; Long. 62°58')
W43-37	Jamaica TR-1	(Lat. 17°43'; Long. 74°58')
W43-38	Jamaica TR-2	(Lat. 17°51'; Long. 75°26')
W43-39	Jamaica TR-3	(Lat. 17°56'; Long. 75°46')
W43-41	Jamaica TR-4	(Lat. 18°04'; Long. 76°07')
W43-42	Jamaica TR-5	(Lat. 18°19'; Long. 78°30')
W43-43	Jamaica TR-6	(Lat. 18°25'; Long. 78°51')
W43-44	Jamaica TR-7	(Lat. 18°21'; Long. 79°20')
W43-45	Jamaica TR-8	(Lat. 18°29'; Long. 79°38')

These sites represent eight stations to the windward of Guadeloupe (GTR-1 to GTR-4) and Jamaica (JTR-1 to JTR-4) and eight stations to the leeward of these islands (GTR-5 to GTR-8; JTR-5 to JTR-8), thereby providing the opportunity to study island mass effects on larval dispersion of benthic gastropods. Special consideration will be given to the distribution patterns of the three common West Indian species of strombid conches, Strombus gigas, S. costatus and S. pugilus since it is known that larvae of some marine gastropods (esp. of the Families Cymatiidae, Tonnidae, Cassidae and Muricidae) are capable of long-distance dispersal.

LONG-TERM PROGRAMS

S E A PROGRAMS

Surface Observations.

A 24-hour watch was maintained to record notable natural phenomena on the open sea. Special attention was paid to marine mammals, birds, evidence of pollution, and meteorological events. Student projects were devoted to birds and surface tar incidence.

Marine Mammals

Sally Kaul, Assistant Scientist

Observations of numbers, behavior, and location of marine mammals were recorded on W-43 as part of an on-going in-house project of the Sea Education Association. Twelve sightings were recorded, including at least four species and 102 individuals (table 6). The four species, all in the dolphin family (Delphinidae), included Stenella frontalis, Delphinus delphis, Stenella coeruleoalba, and Grampus griseus (figure 12).

Schools of flying fish and/or flocks of birds were observed simultaneously with the dolphins at five sightings. There is no apparent explanation for the lack of any whale sightings previously seen on similar Westward cruises.

Stenella plagiodon — Atlantic Spotted

Stenella frontalis — Bridled Dolphin

Delphinus delphis — Saddleback Dolphin

Grampus griseus — Grampus

Figure 12.
Marine mammals sighted on W-43.

Table 6. Marine mammals sighted on cruise W-43

SIGHTING	MARINE MAMMAL	ID QUALITY	#	SIZE(ft.)	DATE	TIME	N. LAT	W. LONG	FISH	BIRDS	POSITION
1.	unidentified dolphins	-	1	-	12-8	1030	16°25'	60°40'			ABEAM
2.	unidentified dolphins	-	12-15	-	12-12	0615	16°05'	62°00'	X		BOW
3.	unidentified dolphins	-	6-7	-	12-12	1326	16°12'	62°15'	X	X	BOW
4.	unidentified dolphins	-	4		12-13	2105	16°12'	63°35'			BOW
5.	<u>Stenella frontalis</u>	2	6	6	12-17	0625	16°49'	70°47'		X	BOW
6.	unidentified dolphins	-	6 ⁺	5	12-19	0520	17°07'	74°08'	X	X	BOW
7.	<u>Delphinus delphis</u>	2	2	5	12-26	1545	18°19'	78°51'			BOW
8.	<u>delphis</u>	1	25-30	6-8	12-30	1800	19°35'	84°11'			BOW
	<u>coeruleoalba</u>	3	3-5	6-8	12-30	1800	19°35'	84°11'			ABEAM
9.	<u>delphis</u>	2	12-15	6-8	1-2	0730	22°00'	85°53'			BOW & ABEAM
10.	unidentified dolphins	-	-	-	1-4	1400	22°30'	86°35'		X	ABEAM
11.	<u>delphis</u>	1	6	5	1-6	0815	24°15'	86°20'			BOW
12.	<u>Grampus griseus</u>	1	5	9-11	1-7	1242	24°65'	84°18'			ABEAM & BOW

Yucatan Channel "Norther"

Armin Elsaesser, Navigator

After many days of fine, predictable Trade Wind Zone weather, we experienced our first "norther" on Westward on January 2, 1979. Changes in barometric pressure, wind direction and force followed the classic pattern of the invasion of Cold Continental Polar Air into a Tropical area (table 7).

Early indications of an advancing cold front were apparent on the Weatherfax maps of December 31. An extensive cold air mass was steadily progressing southeastward from the upper midwest. Its movement was slowed briefly by an auxiliary low pressure cell which subsequently moved east and finally offshore at the Virginia Capes. By January the effects of the front had reached into the Southeastern states.

On Tuesday morning, January 2, the signs of the advancing norther were evident. Westward had arrived at the second hydrostation in the Yucatan Channel and sampling procedures were underway. At midnight the winds were just south of east and veering slowly to the south, always a sure sign in the tropics of an approaching cold front at this time of year. Wind was a light Force 3 and barometric pressure was falling. The warm, stable air was being displaced and lifted by the denser, cooler air of this massive frontal system.

The morning weather map confirmed movement of the front to mid-Florida with the westernmost branch just northwest of the Yucatan Channel. Indeed, by 0800 the barometer showed a slight rise. Wind was Force 3, now west - southwest, and cloud cover was 60% low cumulus.

The hydrographic station was complete by noon and was followed shortly by a sudden increase in wind velocity to Force 6 out of the north-northwest. Cloud cover was 100% cumulo-nimbus; low, dark threatening scud. The wind continued to veer and increase accompanied by an even barometer. By 1800 it was apparent that the front had passed. Barometric pressure rose rapidly along with wind velocities to Force 8 and a wind shift to NXE. Westward lay

battened down and hove-to in the Yucatan Channel.

The intense and extensive high pressure cell lost its southeast momentum and began to move eastward to form a series of cells over northern Florida. The effect was a continued flow of cold, unstable air over western Cuba bringing high winds and low, heavy cloudiness. Westward remained hove-to the following day in northeast winds varying from Force 7-9 and 10'-15' seas.

Finally, by early Thursday morning the wind and sea conditions began to moderate slightly, enough at least for Westward to get underway. Wind and sea conditions remained heavy and made progress slow. However, rising temperatures and gradually clearing skies indicated the air mass was assuming tropical characteristics and stabilizing. The effects of this system were reported as far south as Panama beginning what appears to be a permanent and predictable feature of the Gulf, Mid and Western Caribbean, intense and frequent winter "northers".

Table 7. Weather data during the Yucatan Channel "Norther"

	<u>Tuesday 1/2/79</u>			<u>Wednesday 1/3/79</u>			<u>Thursday 1/4/79</u>
<u>TIME</u>	<u>PRESSURE</u>	<u>WIND DIR</u>	<u>/FORCE</u>	<u>PRESSURE</u>	<u>WIND DIR</u>	<u>/FORCE</u>	<u>PRESSURE: Steady</u>
0000	30.00	ESE	3	30.24	NNE	8	<u>WIND: 7-8</u>
0200	29.98	SE		30.26		9	<u>DIR: NE</u>
0400	29.96	SWXS		30.24			
0600	29.96			30.25		7	
0800	30.02	WSW		30.29			
1000	30.05	W		30.35			
1200	30.07	NNW	6	30.34		8	
1400	30.04	N	7	30.30	NE		
1600	30.04		8	30.29			
1800	30.14	NXE		30.29		7	
2000	30.20	NNE		30.31			
2200	30.25	NNE		30.35		8	

Relative Increase in Pelagic Tar in the Caribbean Sea

David M. Goldsmith

Abstract. Pelagic tar was sampled with a neuston net at nine stations across the Caribbean. Wet weight of samples was compared with weights obtained in two previous studies of the same area (Jeffrey 1972 and Round 1978).^{*} An increase in weight of tar per square meter of water was seen at all stations except one, when compared with the previous studies. Mean weight per square meter was seven times as great as was found in 1973 and had doubled since 1978. The increase was assumed to be related to an increase in petroleum activity within the Caribbean.

^{*} Jeffrey, L. M. 1972. Pelagic tar distribution in the Gulf of Mexico and Caribbean Sea. Texas A & M University.

Round, P. 1978. Distribution of tarballs in relation to proximity of shipping lanes. Cruise Report W-37 of the R/V Westward.

Dissolved Oxygen Concentrations in Oceanic Surface Waters Containing
Varied Amounts of Pelagic Tar

Jodie Schlott

Abstract. Pelagic tar samples from neuston tows done on R/V Westward cruise W-43 were incubated in oceanic surface water to determine oxygen consumption during a six-hour incubation period. Standard oxygen titrations yielded results supporting the hypothesis that tar balls are involved with oxygen consumption. A negative correlation (coefficient ($r = -0.885$)) was found between oxygen content and weight of tar. Oxygen consumption (O_2 ml/l/gm tar/hr) was calculated as 0.13. This rate points to possible competition for oxygen between the tar and zooplankton within the immediate area of the tar. Although an exact reason for oxygen consumption was not developed, it was assumed to be related to the bacterial and other organisms dwelling in and on the tar itself. Because the oxygen bottles were incubated in the dark, chemo-oxidation, dependent on the sunlight, should have been retarded if present at all.

Distribution and Behavior of Pelagic Birds in the Caribbean

Alice Dawson

Abstract. Oceanic bird distribution is a relatively unknown field because of the vast area of ocean to be studied and the small number of observers on the ocean. To contribute data concerning distribution and behavior of pelagic birds, 10-minute watches and spot sightings were conducted during the Caribbean portion of R/V Westward cruise W-43. Gulls, kittiwakes, broown boobies, brown noddys, frigatebirds, white terns, cattle egrets, Audubon's shearwaters, and petrels were observed (figure 13). The boobies and petrels were seen only within large flocks. Members of all species except boobies, petrels, and frigatebirds were seen searching for food singly. The number of birds observed appeared to vary with productivity of the waters and intensity of wind. Species distribution data coincided with already existing distribution data.

Figure 13. Birds seen along the cruise track of W-43.

Seabird Scarcity in the Caribbean

Cindy Damon

Abstract. Sea birds were tabulated in relation to distance from land during the month of December as the R/V Westward traveled through the northern Caribbean. The Caribbean was assumed to be a conducive seabird habitat year-round, and at least 20 species were expected to be seen. 15-minute stations were held from December 15 through January 1, initially at one predetermined time. After December 26 the times of stations were varied to test a secondary hypothesis that time day could be a factor in the dearth of bird sightings thus far. The number of birds sighted increased, but it appeared completely random. Nine identified species were sighted in total and several species were located out of their assumed flight range, probably due to storm activity (figure 14). A total of 14 birds were sighted during stations. It was concluded that one 15-minute station per day in the Caribbean provides insufficient data to make statistically accurate observations.

Migrating Land Birds Seen at Sea

Polly Shaw

Abstract. Three purple martins were observed aboard R/V Westward at latitude 16°N and longitude 64°W during December Of 1978. Previously no satisfactory Antillean record for any martin had been found for the month of November or December, according to one author.

It is well known that land birds migrate south during the winter, but their method of navigation still remains a puzzle. Theories of land bird navigation were examined in an attempt to explain the sightings of these birds in the Caribbean. Satellite weather maps showed storm activity that seemed to be correlated with these sightings at sea.

Figure 14. Birds seen as a function of distance from land. Stations consisted of predetermined 15-minute observation periods and were held between December 15, 1978, and January 1, 1979. Between station sightings were recorded after December 26.

Midwater Fauna.

Isaacs-Kidd Midwater Trawls (IKMT) and neuston tows are routinely done on cruises of the Westward to study the zoogeography of midwater fish. Two reports follow.

Neuston Fishes of Two Island Mass Transects

Carl Baum, Assistant Scientist

Abstract. Four sets of neuston tows, totaling 16 in all, were conducted at 20-mile intervals along windward and leeward transects of Guadeloupe and Jamaica to coincide with other extensive sampling designed to determine the effect of island masses on the properties of surrounding waters. The net employed was a standard 0.505 mm mesh attached to a 0.5 X 1.0 m frame, and was towed an average 33 minutes at 4 knots. A total of 600 fishes were collected and identified to at least the familial level.

Members of the mesopelagic family Myctophidae, primarily Myctophum sp., constituted 19% of the total catch. These fishes comprised between 0 and 20% of day catches, and between 24 and 92% of night catches, thus conforming to expected patterns of diurnal vertical migration. However, the response in their numbers due to changes in water properties proximal to island masses is not clear from these data for lack of experimental control over the effect of near shore bottom topography on their migrations.

Eleven epipelagic and shore fish families were represented in their young adult, and meroplanktonic larval and juvenile forms. These included: Belontiidae, Hemirhamphidae, Exocoetidae, Syngnathidae, Mugilidae, Coryphaenidae, Carangidae, Echeineidae, Stomateidae, Balistidae, and Diodontidae. Exact relative percentages of these families cannot be stated with confidence due to considerable mutilation of identifying factors. The number of families

per catch ranged accordingly from two to > 10 . Hypothetically, the numbers of these neuston fishes should increase with proximity to an island mass in response to spawning input by shore species, as well as the overall higher biological productivity supported by runoff, upwelling, and general turbulence associated with the island. More specifically, a negative correlation between quantity of fishes per tow and distance from land was expected. Inspection of Table 8 shows the Guadeloupe data suggest this relationship, although not strongly; the Jamaican data contradict the hypothesis with weak positive coefficients of correlation. The relatively high magnitude of correlation observed to windward sides of Guadeloupe (-0.60) as compared to leeward (-0.23) was unexpected due to predicted higher productivity and larval entrainment in the turbulence to leeward. The 90% confidence intervals for these correlation coefficients are poor though, and the statistical validity of these results is limited by the small sample population size. Patchiness, an undetected misalignment of the transects with prevailing current axes, and insufficient sampling may account for lack of agreement between predicted and experimental results.

An interesting qualitative observation made, but not clearly reflected in these data, was a trend from many, relatively small/young specimens to fewer, relatively large/old specimens in catches from the eastern to the western extremes of the sampling range. Possible explanations for this trend include progressive aging and predation on the downstream course from the east to west end of the Caribbean, as well as an increase in the quantity of surface weed providing suitable habitat for the larger associates of floating material.

Table 8. Results of 16 neuston tows conducted along windward and leeward transects of Guadeloupe and Jamaica.

	Station Number	Time	Distance from Island (nm)	Number of Surface Fishes (s)	Number of Meso-pelagic Fishes	Total Fishes	Correlation Coefficient (s vs. nm)	90% Confidence Intervals	Mesopelagic Fishes as % of Total
Guadeloupe	Windward Approach	25 2030-2104	80	16	5	21			24
		26 0340-0410	60	9	18	27	- 0.60	- 0.94	67
		27 1130-1207	40	10	0	10		to	0
		28 2010-2040	20	33	21	54		+ 0.53	39
	Leeward Departure	29 0718-0748	20	149	1	150		- 0.87	1
		30 1658-1745	40	71	0	71	- 0.23	- 0.87	0
		31 0324-0355	60	3	4	7		to	57
		32 1223-1253	80	133	0	133		+ 0.73	0
	Subtotal		269 min.	424	49	473			16
Jamaica	Windward Approach	37 0236-0306	80	1	5	6		- 0.73	83
		38 1120-1155	60	27	1	28	+ 0.23	- 0.73	4
		39 2227-2305	40	1	11	12		to	92
		41 2113-2143	20	2	6	8		+ 0.87	75
	Leeward Departure	42 1605-1645	20	4	1	5		- 0.77	20
		43 2355-0030	40	11	21	32	+ 0.13	- 0.77	66
		44 1102-1132	60	12	0	12		to	0
		45 1835-1905	80	5	19	24		+ 0.84	79
	Subtotal		228 min.	63	64	127			50
	Total		497 min.	487	113	600			19

Geographical Distribution of Myctophidae

Grace F. Koppelman

Abstract. The purpose of this project was to investigate the geographical distribution of the family Myctophidae in the Caribbean Sea and the Atlantic north of the Antilles to determine the distribution pattern and compare it with the "Tropical" pattern found there by Backus et. al. (1977)* Tows were made at seven stations A station at Echo Bank with two more stations just southeast of Echo Bank comprised the Atlantic tows. A series of tows in the Caribbean included the Venezuelan Basin, the Columbian Basin, some Jamaican transects, and the area south of the Cayman Islands. A neuston net, a Bongo net, and an Isaacs Kidd Midwater Trawl were used to sample the surface, 200 to 50 m, and 450 to 100 m, respectively. Myctophids were keyed out to genus. The genera were assigned a relative percent of the total population and were compared to the tropical community composition reported by Backus et al. (1977).

Several genera were found to have very close percentages in both studies. Some genera were not found at all in this study, due probably to insufficient sampling. Several genera were found in much smaller or much larger percentages in this study. These differences may be due to patchiness and insufficient sampling.

* Backus, R. H., J. E. Craddock, R. L. Haedrich, and B. H. Robison. 1977. Atlantic mesopelagic zoogeography, in Fishes of the Western North Atlantic, Memoir I, part 7, Yale University, Sears Foundation for Marine Research.

Echo Bank.

The charted location of Echo Bank is $21^{\circ}08' \text{ N}$; $58^{\circ}42' \text{ W}$ on Hydrographic Office Chart 120. The site was reported to be 34 fathoms deep in 1837 and as shallow in 1946. No other verified sounding of shallow water has been made. The R/V Westward has returned to the reported position twice before W-43 in an attempt to find shoaling.

On W-43 the location sounded was at the same latitude, but at a longitude west of the charted site ($21^{\circ}08' \text{ N}$; $60^{\circ}16' \text{ W}$). A 24-hour station was conducted around that position for two purposes: 1) to take soundings and 2) to study vertical migration of zooplankton.

The track followed during the 24-hour station is shown in figure 16. The fathometer was run for up to 15 minutes at a time along each leg of each triangle. No indication of water more shallow than 100 fathoms was seen. Each triangle represents 1) Northwest corner = position for beginning of the station; hydrocast and nanoplankton tows were done while the ship was hove-to and drifting from the northwest to southeast; 2) Southern tip = position for beginning of simultaneous net tows; tows were done at approximately 3 knots toward the northeast; 3) return of ship to beginning of station. Results of vertical migration studies done at this station are given in the following student project abstract.

Diurnal Vertical Migration of Copepods

Brian Taras

Abstract. Diurnal vertical migration is a phenomenon in which zooplankton and other organisms, such as midwater fish, migrate vertically through the water column. The purpose of this study was to observe vertical migration in copepods and to examine the relationship of pigmentation to depth in the water column. Also, I hoped to trace the migratory patterns of the differently pigmented copepods. Data was collected by simultaneously towing four nets at various depths for two hours at six-hour intervals during a 24-hour station. The copepods from each tow were counted and examined for type of pigmentation. The number of copepods ranged from 10 in some samples to 600 in others, a sixty-fold difference. The greatest numbers occurred in deep, nighttime tows, and the fewest numbers occurred in shallow, daytime tows. The copepods were divided into three groups; transparent, pigmented, and copepods with chromatophores. Each group exhibited characteristic migratory patterns and lived at certain depths (figure 17). Also, while the transparent copepods exhibited a slight vertical migration, the pigmented copepods accounted for most of the mass vertical migration in the water column.

Figure 17. Copepod vertical distribution at a 24-hour station in the Sargasso Sea (Echo Bank). Each bar represents a different group of coepods: white bar = transparent (non-pigmented) coepods; diagonal stripes = orange pigmented coepods; horizontal stripes = coepods with discrete chromatophores. Percent incidence of each group was based on the total number of coepods in a subsample. Stippled bars = the sum of midwater fish and scarlet prawns taken as a percent of total fish and decapods in a subsample.

LONG-TERM PROGRAMS, continued

COOPERATIVE PROGRAMS

Weather Observations (NOAA).

Weather observations were carried out twice daily when the ship was more than 40 miles from land. Observations were successfully transmitted 24 out of 54 attempts, and all written records have been sent to the National Weather Service, NOAA, AOML, Miami, Florida. Data collected are reported in Appendix IV.

Shark Longlining/Tagging (NMFS).

The Westward cooperates with the National Marine Fisheries Service in a program to discover and explain the migratory habits of certain sharks in the North Atlantic. All data are sent to the Narragansett Laboratory, NOAA, NMFS, Rhode Island. The two student projects that were based on this operation follow.

A Study of Caribbean Sharks for Size Grouping

Wayne Chimenti

Abstract. The purpose of this experiment was to study sharks in the Caribbean by longlining to examine the hypothesis that sharks of the same size will group together. Tagging was planned as well in cooperation with the National Marine Fisheries Service for a study of the migratory pattern of blue sharks. One longline was set (19°N , 83°W) and no sharks were caught. A second longline could not be done because of storm conditions. Possible causes for the lack of sharks on the first longline were that the bait (beef) was inappropriate and that the site was too far from land to attract sharks of the area, which are largely reef sharks.

Shark Habitats

Ross Friedman

Abstract. It was my purpose to collect data on shark habitats in relation to depth, water temperature and distance off land. The sharks would be caught by longlining at preset depths and locations. Studies have suggested shark habitats to be in surface waters close to productive shores.

One longline was set over Mysteriosa Bank in the northwest Caribbean during Westward cruise W-43. Stew beef was used as bait due to the lack of the preferred trash fish for bait. No sharks were caught. To accurately make a habitat study, two or more longlines should be set, using the same bait, at stations with equal bottom depth, but at varying distance from land.

Eel Larvae Distribution (J. Hain, U.R.I.)

The Westward has collected eel larvae for three years under the supervision of Dr. James H. W. Hain to study the distribution of the American eel larvae, Anguilla rostrata. Data collected are sent to Dr. Hain for analysis. The following student project was based on this long-term study.

Eel Larvae Distribution

Diana K. Hews

Abstract. The distribution of eel larvae in relation to various spatial and temporal factors was studied. Individuals were collected using oblique and stepped bongo tows to 200 meters, meter net to 100 m and Isaacs-Kidd Midwater trawl to depths of 400 m. Specimens were preserved in buffered 10% formalin for identification. Data suggests that there might be an inverse correlation between number of individuals caught and distance from shore. The relationship from the Guadeloupe Island transect was more apparent than those from Jamaica. There also seemed to be a correlation between the numbers of individuals caught and the depth of the water column from which the samples were collected. There was no correlation between proximity to midnight and number of samples collected. None of these trends were significant, probably because of small sample size.

Of special interest was this set of data viewed in consideration of the larval distribution of the American eel, Anguilla rostrata. It was hoped that leptocephali of this species would be collected and thus be able to determine the actual location of spawning and depth, both of which are still undetermined. Aspects of A. rostrata larval distribution are discussed.

APPENDIX I

Summary Log of Stations Done on Cruise W-43

Station	Date	Time	Lat (N)	Long (W)	Operation	Notes
W43-1	12-1-78	1200	20°30'	65°00'	Bathylthermo-graph (BT)	
W43-2		1325			BT	
W43-3		1415			BT	
W43-4		1600			BT	
W43-5		1635			BT	
W43-6		1800			BT	
W43-7		1900			BT	
W43-8		2050			BT	
W43-9	12-2-78	0000	21°36'	64°36'	BT	
W43-10		0210			BT	
W43-11		0415			BT	
W43-12		0600			BT	
W43-13		0745			BT	
W43-14		0935			BT	
W43-15		1125			BT	
W43-16		1325			BT	
W43-17		1500	21°47'	62°10'	Hydrocast, Nannoplankton, Light Intensity, Bongo Tow	
W43-18		2325	21°47'	62°35'	BT	
W43-19	12-3-78	0115			BT	
W43-20		0308			BT	
W43-21		0432			BT	
W43-22		1030	21°50'	61°44'	BT, Hydrocast, Nannoplankton, Light Intensity, Bongo Tow	
W43-23A	12-4-78	1800	21°10'	60°16'	BT, Hydrocast, Nannoplankton, Neuston, Meter #1, Meter #2 Bongo Tow	Echo Bank
W43-23B	12-5-78	0000			Replicate of 23A	Diel. Sta 1
W43-23C		0600			Replicate of 23B	Diel. Sta 2
W43-23D		1210			Replicate of 23C	Diel. Sta 3
W43-24	12-7-78	0000	17°52'	59°36'	BT, Hydrocast, Nannoplankton, Bongo	Diel. Sta 4
W43-25		1600	16°40'	60°00'	BT, Hydrocast, Light Intensity, Nannoplankton, Bongo, Neuston	Guadeloupe Transect Sta. 1

APPENDIX I, continued

<u>Station</u>	<u>Date</u>	<u>Time</u>	<u>Lat (N)</u>	<u>Long (W)</u>	<u>Operation</u>	<u>Notes</u>
W43-26		2250	16°31'	60°20'	BT, Hydrocast, Nannoplankton, Bongo Tow, Neuston	Guad. Sta. 2
W43-27	12-8-78	0630	16°21'	60°36'	BT, Hydrocast, Light Intensity, Nannoplankton, Bongo, Neuston	Guad. Sta. 3
W43-28		1608	16°16'	61°08'	BT, Hydrocast, Nannoplankton, Bongo, Neuston	Guad. Sta. 4
W43-29	12-12-78	0326	16°02'	61°48'	BT, Hydrocast, Nannoplankton, Bongo, Neuston	Guad. Sta. 5
W43-30		1215	16°10'	62°14'	BT, Hydrocast, Nannoplankton, Bongo, Neuston	Guad. Sta. 6
W43-31		2224	16°17'	62°28'	BT, Hydrocast, Nannoplankton, Bongo, Neuston	Guad. Sta. 7
W43-32	12-13-78	0725	16°17'	62°58'	BT, Hydrocast, Nannoplankton, Bongo, Neuston, Light Intensity	Guad. Sta. 8
W43-33	12-16-78	1300	16°35'	69°26'	Hydrocast	Venezuela Basin
W43-34	12-17-78	1700	16°50'	71°53'	BT, IKMT	
W43-35	12-18-78	0830	16°54'	73°04'	BT, Hydrocast	Columbia Basin
W43-36		1710	16°51'	73°26'	IKMT	
W43-37	12-19-78	2215	17°43'	74°58'	BT, Hydrocast, Bongo, Neuston	Jamaica Transect Sta. 1
W43-38A	12-20-78	0000	17°44'	74°59'	BT, Hydrocast, Bongo, Neuston	Jam. Sta. 2A
W43-38B		0740	17°50'	75°26'	BT, Hydrocast, Light, Bongo, Neuston	Jam. Sta. 2B
W43-39		1755	17°56'	75°46'	BT, Hydrocast, Bongo, Neuston,	Jam. Sta. 3

APPENDIX I, continued

<u>Station</u>	<u>Date</u>	<u>Time</u>	<u>Lat (N)</u>	<u>Long (W)</u>	<u>Operation</u>	<u>Notes</u>
W43-40	12-21-78	0140	18°07'	75°47'	Deep Hydrocast	Jamaica "Well"
W43-41		1645	18°04'	76°07'	BT, Hydrocast, Neuston, Bongo	Jam. Sta. 4
W43-42	12-26-78	1130	18°19'	78°30'	BT, Hydrocast, Bongo, Neuston	Jam. Sta. 5
W43-43		1925	18°25'	78°51'	BT, Hydrocast, Bongo, Neuston	Jam. Sta. 6
W43-44	12-27-78	0630	18°25'	79°20'	BT, Hydrocast, Bongo, Neuston	Jam. Sta. 7
W43-45		1400	18°29'	79°38'	BT, Hydrocast, Bongo, Neuston	Jam. Sta. 8
W43-46	12-28-78	2001	18°43'	82°11'	IKMT	
W43-47	12-30-78	0327	18°55'	83°50'	Longline	
W43-48	12-31-78	0300	20°24'	84°07'	Deep Hydrocast	Yucatan Basin
W43-49		1635	20°21'	84°08'	Neuston	
W43-50	1-1-79	1900	21°40'	85°33'	Deep Hydrocast	Yucatan Channel
W43-51	1-2-79	0625	22°00'	85°53'	Deep Hydrocast	"
W43-52	1-4-79	1540	22°20'	86°18'	Hydrocast	"
W43-53	1-6-79	2008			BT	
W43-54		2216			BT	
W43-55	1-7-79	0000	24°44'	84°58'	BT	
W43-56		0140			BT	
W43-57		0530	24°49'	84°32'	BT and Hydrocast	Gulf of Mexico
W43-58		1218	24°54'	84°20'	BT	Control

Summary of Bathythermograph Data

Station	Date	Time	Lat.	Long.	Depth of Mixed Layer	
					(ft.)	(m)
W43-1	12-1-78	1211	20°30'	65°00'	220	67.06
W43-2	12-1-78	1325			240	73.15
W43-3	12-1-78	1415			220	67.06
W43-4	12-1-78	1600			220	67.06
W43-5	12-1-78	1635			220	67.06
W43-6	12-1-78	1800			250	76.2
W43-7	12-1-78	1930			240	73.15
W43-8	12-1-78	2050			270	82.3
W43-9	12-1-78	0005	21°36'	64°36'	240	73.15
W43-10	12-2-78	0215			220	67.06
W43-11	12-2-78	0415			225	68.58
W43-12	12-2-78	0600			210	64.00
W43-13	12-2-78	0745			240	73.15
W43-14	12-2-78	0935			265	80.77
W43-15	12-2-78	1125			240	73.15
W43-16	12-2-78	1312			210	64.00
W43-18	12-2-78	2335	21°47'	63°10'	240	73.15
W43-19	12-2-78	0115	21°47'	62°35'	245	74.68
W43-20	12-3-78	0308			220	67.06
W43-21	12-3-78	0432	21°50'	61°44'	180	54.86
W43-22	12-3-78	1030			215	65.53
W43-23A	12-4-78	1815	21°10'	60°16'	240	73.15
W43-23B	12-5-78	0005	21°09'	60°15'	300	91.44
W43-23C	12-5-78	0600			320	97.54
W43-23D	12-5-78	1210	21°23'	60°00'	300	91.44
W43-24	12-7-78	0010			180	54.86
W43-25	12-7-78	1605	16°40'	60°00'	210	64.01
W43-26	12-7-78	2205	16°31'	60°20'	210	64.01
W43-27	12-8-78	0630	16°21'	60°36'	230	70.10
W43-28	12-8-78	1608	16°16'	61°08'	230	70.10
W43-29	12-12-78	0326	16°02.2	61°47.6	220	67.06
W43-30	12-12-78	1215	16°10'	62°14.5	220	67.06
W43-31	12-12-78	2224	16°17'	62°28'	220	67.06
W43-32	12-13-78	0725	16°17.5	62°58'	145	44.20
W43-34	12-17-78	1700	16°50'	71°53'	290	88.39
W43-35	12-18-78	0815	16°54'	73°04'	385	117.35
W43-36	12-18-78	1710			390	118.87
W43-37	12-19-78	2215	17°43'	74°58'	340	103.63
W43-38A	12-20-78	0600	17°50'	75°18'	300	91.44
W43-38B	12-20-78	0740	17°50'	75°26'	280	85.34
W43-39	12-20-78	1755	17°56'	75°45.5	340	103.63
W43-41	12-21-78	1645	18°03'	76°06'	240	73.14
W43-42	12-26-78	1200	18°19'	78°30'	310	93.0
W43-43	12-26-78	1925	18°25.1'	78°50.9'	320	104.9
W43-44	12-27-78	0607	18°21'	79°20'	380	115.82
W43-45	12-27-78	1359	18°29.5	79°38'	320	97.54
W43-48	12-31-78	0730	20°26'	84°3'	370	112.78
W43-50	1-1-79	2315	21°40'	85°33'	340	103.63
W43-51	1-2-79	1000	22°00'	85°53'	305	91.5
W43-52	1-4-79	1440	22°19.5'	86°18.5'	130	39.62
W43-53	1-6-79	2008	24°45.5'	85°30'	360	109.73
W43-54	1-6-79	2216	24°48.5'	84°20'	280	85.34
W43-55	1-7-79	0000	24°43'	84°57'	240	73.15
W43-56	1-7-79	0140	24°47'	84°49'	150	45.72
W43-57	1-7-79	0330	24°49'	84°32'	120	36.58
W43-58	1-7-79	1218	24°54'	84°10'	60	18.29
W43-59	1-7-79	1415	24°54'	84°12'	100	30.48

APPENDIX III

Summary of hydrographic data.

Station	Assumed Depth	(m) Calc. Depth	T ^o C	S‰	Jt	O ₂ (ml.l ⁻¹)	SiO ₄ (mg-at l ⁻¹)	Zoopl. (ml m ⁻³) 10 ⁻⁴
W43-17	0	0	27.09	33.27*		4.76		
	50	51	26.90	34.86*		4.26		
	100	102	23.55	36.46*		-		
	200	205	19.33	34.07*		4.28		
W43-22	0	3	26.96	35.915	23.2	4.76		
	50	50	26.88	36.838	24.3	4.77		
	100	100	23.12	37.043	25.5	5.12		
	200	200	18.93	36.099	25.9	4.76		
W43-23	0	0	26.56	34.87*		4.80		
A	70	73	27.31	35.67*		4.80		
	100	104	27.52	37.26*		4.70		
	200	208	20.90	36.46*		4.50		
W43-23	0	0	-	37.26*		-		
B	70	68	27.12	36.46*		5.00		
	100	97	27.52	35.67*		4.80		
	200	194	22.00	37.26*		4.40		
W43-23	0	0	26.78	35.67*		4.71		
C	100	94	27.56	37.26*		5.00		
	200	173	22.01	37.26*		4.60		
W43-23	0	0	26.78	36.46*		4.30		
D	70	66	26.84	37.26*		5.10		
	100	95	27.09	35.67*		4.80		
	200	183	21.04	35.67*		4.90		
W43-24	0	0	27.18	34.721	22.5	4.81		33.8
	60	59	27.95	36.650	23.6	5.00		
	100	99	24.17	36.695	24.8	5.21		
	200	190	18.95	36.283	26.1	4.54		
W43-25	0	0	27.45	35.610	23.0	4.80	2.07	63.2
	70	63	26.63	36.715	24.2	5.06	1.81	
	100	90	25.91	36.568	24.2	4.96	0.79	
	200	179	20.57	36.551	25.8	3.89	1.33	
W43-26	0	0	27.39	35.405	22.9	4.74	2.49	159.5
430°	70	61	27.50	35.610	23.1	4.79	2.00	
	100	85	26.07	36.766	24.1	5.03	0.95	
	200	172	21.31	36.633	25.7	4.85	0.79	
W43-27	0	0	27.53	35.134	22.7	4.69	1.81	45.7
	70	62	27.55	35.088	22.6	4.76	1.78	
	100	89	26.18	35.869	23.7	4.178	1.41	
	200	168	20.71	36.558	25.5	4.14	2.25	
W43-28	0	0	27.58	35.594	23.0	4.69	2.36	161.0
	70	68	27.41	36.053	23.4	4.93	1.34	
	100	97	26.26	36.374	23.9	4.97	1.12	
	200	184	20.66	36.374	25.8	4.17	0.86	
W43-29	0	0	27.21	35.405	22.7	4.87	2.55	143.7
	80	85	25.49	36.145	24.0	4.65	2.60	
	100	106	24.56	37.042	25.0	4.74	0.98	
W43-30	0	0	27.38	34.905	22.5	4.80	2.09	43.3
	57	54	27.35	36.019	23.4	4.83	2.00	
	100	94	27.14	36.329	23.7	4.75	0.97	

Summary of hydrographic data.

Station	Assumed Depth	(m) Calc. Depth	$T^{\circ}C$	S‰	Jt	O_2 (ml.l ⁻¹)	SiO ₄ (mg-at l ⁻¹)	Zoopl. (ml m ⁻³) 10 ⁻⁴
W43-31	200	188	19.66	36.283	25.8	3.16	2.07	110.4
	0	0	27.10	34.859	22.6	4.90	3.61	
	60	64	27.12	36.512	23.8	5.06	3.48	
	100	106	24.94	36.742	24.6	4.72	0.64	
W43-32	200	191	18.86	36.283	26.1	4.10	1.56	41.0
	0	0	27.09	34.813	22.6	4.81	1.98	
	50	52	27.05	36.565	23.0	4.83	0.55	
	100	104	24.10	36.329	23.9	4.47	0.70	
W43-33	200	192	19.74	36.329	25.1	4.26	16.21	
	0	0	27.27	35.061	27.6		15.19	
	150	102	25.32	36.269	25.2		1.50	
	300	205	19.08	36.118	25.7		1.45	
	500	341	14.60	35.326	26.2		4.12	
	750	528	10.26	34.947	26.7		13.41	
	1000	704	6.55	34.571	27.1		23.81	
	1200	1094	-	34.533	-		24.03	
	1400	1277	4.38	34.911	27.6		20.39	
	1600	1459	4.29	34.835	27.6		24.40	
	1800	1642	4.21	34.445	27.4		24.42	
	2000	1824	4.13	34.533	27.5		24.64	
	2200	2006	4.09	34.609	27.8		24.66	
	0	1	27.42	34.655	22.2			
	150	69	27.70	34.914	22.4			
	300	137	23.59	34.951	23.7			
W43-35	500	229	19.04	35.839	23.6			
	750	344	-	35.385	-			
	1000	458	10.62	34.581	26.3			
	1200	990	4.95	34.396	27.1			
	1400	1155	4.60	34.581	27.2			
	1600	1320	4.40	34.396	27.2			
	1800	1485	4.27	34.478	27.4			
	0	1	27.64	34.919	22.5	4.78		
	100	78	27.66	35.617	23.0	4.62		
	200	157	20.75	35.727	25.1	4.57		
W43-37	400	313	15.54	31.807	23.5	3.84		
	0	1	27.60	34.951	22.5	4.90		
	100	82	27.47	35.543	22.9	4.74		
	200	164	20.78	35.987	25.4	4.16		
W43-38	400	328	15.24	35.400	26.3	3.60		
	0	1	27.56	35.096	22.6	4.99		
	130	99	24.38	35.141	23.6	4.86		
	200	164	20.82	35.980	25.0	4.69		
W43-39	400	328	15.35	35.494	26.4	4.14		
	0	1	27.66	34.743	22.4	4.66		
	80	76	26.64	35.847	23.5	4.70		
	200	190	21.04	35.980	25.1	4.40		
W43-41	400	363	15.87	34.258	25.4	4.05		
	0	1	27.47	35.025	22.6	4.59		
	200	177	21.12	35.987	25.3	4.42		
	400	354	15.99	35.273	26.2	3.59		
W43-40	600	531	12.07	35.494	27.1	3.50		

Summary of hydrographic data.

Station	Assumed Depth	(m) Calc. Depth	T°C	S‰	Jt	O ₂ (ml.l ⁻¹)	SiO ₄ (mg-at l ⁻¹)	Zoopl. (ml m ⁻³) 10 ⁻⁴
	800	708	8.02	33.949	26.7	3.07		
	1200	1062	4.93	34.081	27.0	4.94		
	1500	1419	4.42	34.214	27.1	5.31		
	1700	1629	4.23	34.214	27.1	5.72		
	1900	1820	4.18	35.406	28.0	5.50		
	2100	2024	4.11	36.023	28.0	5.04		
	2300	2203	4.14	33.923	27.2	5.48		
	2500	2411	4.17	34.214	27.1	5.53		
W43-42	0			34.920	-	4.74		
	100			35.586	-	4.73		
	200			36.202	-	4.47		
	400			35.230	-	4.66		
W43-43	0	1	27.97	35.586	22.9			
	100	88	27.92	35.586	22.9	4.59		
	200	176	23.65	36.355	24.8	4.46		
	400	352	16.81	36.163	26.5	4.11		
W43-44	0	1	27.68	35.509	23.0	4.33		
	130	86	26.23	35.932	23.6	4.66		
	250	166	21.03	36.278	25.8	4.68		
	400	266	-	35.509	-	4.78		
W43-45	0	1	27.70	35.162	22.5	4.91		
	100	77	27.70	35.162	22.5	4.74		
	200	153	24.41	36.200	24.4	4.57		
	400	355	18.08	35.701	25.8	4.33		
W43-48	0	0	27.06	35.240	-	3.27		
	150	140	-	35.471	-	3.27		
	300	281	19.67	36.086	-	5.27		
	500	468	14.65	35.355		6.06		
	750	716	8.70	34.201		18.36		
	1000	954	5.68	34.086		23.40		
	1200	1286	4.52	34.259		22.81		
	1400	1236	4.39	34.202		23.05		
	1600	1412	4.19	34.278		21.42		
	1800	1589	4.18	34.124		20.30		
	2000	1765	4.20	34.239		19.16		
	2200	1942	4.16	34.316		17.85		
	850	264	-	34.86		16.79		
	1600	496	15.72	35.415		4.73		
	1800	558	11.82	34.855		8.97		Pretripped
	2000	775	8.51	34.451		18.57		
	2200	852	6.40	34.297		23.14		
W43-50	0	0	27.45	36.635		1.68		
	150	160	23.9	36.030		1.24		
	300	321	18.15	36.010		3.21		
	500	534.6	13.03	34.878		9.10		
	750	799.9	7.67	35.998		21.51		
	1000	1066	5.21	35.403		24.07		
	1200	1178	4.74	-		24.05		
	1400	1374	4.34	-		23.94		
	1600	1570	4.25	34.804		21.99		
	1800	1766	4.24	34.229		23.39		
	2000	1963	4.18	-		-		Hit
	2200	2159	-	-		-		Bottom

Summary of hydrographic data.

Station	Assumed Depth	(m) Calc. Depth	T ⁰ C	S‰	Jt	O ₂ (ml.l ⁻¹)	SiO ₄ (mg-at l ⁻¹)	Zoopl. (ml m ⁻³) 10 ⁻⁴
W43-51	0	4.87	27.38	35.221		2.76		
	200	139	23.20	34.385		1.69		
	400	278.7	18.12	35.790		3.12		
	600	418	14.34	35.680		7.67		
	800	487	11.47	35.610		12.78		
	1000	608.6	8.96	33.099		17.43		
	1100	793.2	7.01	34.307		21.18		
	1300	926.0	5.80	34.562		24.24		
	1400	997	5.41	34.565		23.82		
	1500	1078	4.90	34.326		23.91		
	1600	1150.2	4.59	34.804		24.07		
W43-52	0	0	26.54	36.000		1.79		
	50	47	26.43	35.880		1.91		
	100	95	22.40	36.240		2.98		
	200	189	17.65	36.210		4.19		
	300	287	13.34	35.670		9.82		
	400	401.5	10.74	35.341		13.37		
W43-57	1400	1047		35.012		23.40		
	1600	1160		34.622		24.28		
	1800	1263		34.562		24.18		
	2000	1426		35.131		22.18		

APPENDIX W-43 Ship's Weather Observations
IV

99L _a L _a L _a	Q _c L _o L _o L _o	YYGGi _w	Nddff	VVwwW	PPPTT	N _h C _L hC _M C _H	D _s v _s app	OT _s T _s T _d T _d	1T _w T _w T _w T _w	3P _w P _w H _w H _w	d _w d _w P _w H _w H _w
99202	76510	01123	40815	98038	15927	32480	81309	00023	12710	30301	07805
99214	76131	02063	20810	98020	17726	2/4//	21603	00023	12648	3////	////
99217	76390	02123	30811	98030	18827	31400	21114	00224	12698	30101	08503
99218	76350	03063	20710	99131	18826	21300	22603	00123	12681	3////	////
99218	70620	03123	40915	98021	19226	3333/	21211	05123	12707	30301	09603
99217	70611	04063	10915	98010	18526	1/3//	21708	05222	12680	30301	09603
99214	76050	04123	60915	98801	18925	5334/	31400	00323	12679	30301	07704
99202	76000	06063	21210	97258	17626	1/3//	42303	00225	12690	3////	////
99195	70598	06123	11115	98011	18227	133//	32017	00123	12695	30301	09603
99173	70593	07123	21011	98018	17927	12442	42209	00024	12720	30201	09703
99163	70643	14063	40412	98020	15526	333//	62400	00123	12738	30301	27602
99163	70648	14123	10910	98020	14927	113//	61209	00123	12728	30301	08503
99162	70668	15063	20910	98020	15427	216//	62710	00024	12733	30201	07602
99163	70666	15123	20910	98030	15227	2248/	61306	00023	12723	30101	08703
99163	76815	16063	50816	99021	16227	4244/	62002	00024	12730	30201	08702
99165	76890	16123	40713	99031	16227	726//	62013	00124	12730	30202	09502
99168	70708	17123	20813	99030	16026	2346/	62213	05223	12730	30202	09702
99168	70722	18063	00805	99030	15626	00000	61001	05123	12759	30101	11602
99169	70729	18123	50805	99031	14926	42410	61107	05123	12739	30201	09702
99168	70739	19063	30813	99030	14827	314//	72602	05024	12753	30201	10602
99179	70731	20123	20802	99031	15026	1344/	62209	05223	12732	30000	01602
99179	70759	21063	30508	99600	14526	13430	11707	05123	12749	3//01	05602
99183	70763	22063	82204	98808	16125	863//	72400	05522	12740	3////	////
99183	70767	23123	21404	98036	15426	136/9	72400	05323	12750	30100	15602
99183	70789	27063	00205	98021	14525	00000	71109	05523	12795	3////	////
99186	70806	28063	11407	99020	12926	11400	61706	05123	12759	3//01	076//
99184	70805	28123	21607	99030	13926	21300	61502	05222	12755	30201	14602
99183	70821	29063	11402	99020	13226	1////	00107	05222	12745	3////	////
99185	70824	29120	00000	99050	13426	00000	62202	05223	12742	30000	16402
99185	70835	30063	00707	99050	15027	0////	61400	05323	12730	3////	07501
99189	70838	30123	10905	99030	15027	114//	00503	05123	12740	30101	10801
99203	70840	31063	10518	99020	16827	113//	82003	05124	12740	3////	////
99203	70841	31123	70926	97601	16025	775//	00503	05325	12759	30101	09604
99219	70847	01063	80520	98215	16126	873//	71706	05223	12731	3////	05/06
99212	70853	01123	51312	98011	15328	3343/	61502	00223	12731	30201	11804
99211	70857	02063	90130	97026	240//	////	00709	0////	1////	3//08	006//
99220	70856	03123	80435	95026	24920	77200	00210	06317	12731	3//08	02910
99221	70857	03183	80335	98022	27819	872//	00802	06416	12698	3//08	02708
99221	70857	04003	80730	98022	26121	874//	00203	06217	12723	3////	05808
99222	70857	04063	50230	98022	27521	573//	00014	06018	12655	3////	02707
99225	70862	04123	80430	98022	27521	834//	61206	06116	12662	3//03	04606
99223	70865	04183	70525	98022	26023	775//	31515	05420	12599	30202	04605
99225	70865	05003	80430	98022	24723	873//	71501	05521	12627	30202	04705
99230	70869	05063	80525	98022	25722	873//	71003	05821	12657	3////	04705
99233	70872	05123	80225	98022	24024	873//	71500	05323	12570	3////	07805
99240	70872	05183	70522	98012	25023	723//	82812	05521	12659	30301	05605
99241	70870	06063	11116	98011	21823	11400	32718	05521	12647	3////	////
99241	70863	06123	30920	98011	20023	31400	22710	05420	12609	30302	09604
99243	70865	06183	31420	98010	20525	31300	21710	05221	12620	30501	10602
99247	70858	07003	70918	99031	18024	32430	21605	05420	12623	3//01	12604
99247	70899	07063	41120	98031	17924	413//	21611	05322	12604	3//02	09504
99249	70843	07123	21524	99010	17925	214//	31000	00322	12350	30302	13603
99246	70835	07183	11308	99020	16524	00/10	22514	05023	12475	30302	13603

Key: L_aL_aL_a = latitude in degrees and tenths; Q_c = quadrant of globe; L_oL_oL_o = longitude in degrees and tenths; YY = day of month; GG = Greenwich mean time; i_w = wind indicator; N = total cloud amount; dd = wind direction; ff = wind speed; VV = visibility; ww = present weather; W = past weather; PPP = sea level pressure; TT = air temperature; N_h = amount of lowest clouds; C_L = type of low cloud; h = height of lowest clouds; C_M = type of middle cloud; C_H = type of high cloud; D_s = course of ship; v_s = speed of ship; a = character of pressure change; pp = amount of pressure change; T_s = air-sea temperature difference; T_d = dew point; T_w = sea temperature; ^tT = tenths of air temperature; P_w and H_w = wind wave period and height; d_w = swell direction.

APPENDIX V

Biological Teaching Collection

Organism	Common Name	Source
Phylum Cyanophyta		
Order Hormogonales		Surface -
<u>Trichodesmium</u> sp.	Blue-green algae	Nannoplankton tow
Phylum Phaeophyta		
Order Fucales		Surface -
<u>Sargassum natans</u>	<u>Sargassum</u> weed	Neuston net tow
Phylum coelenterata		
Class Scyphozoa		Surface -
<u>Aurelia</u> sp.	Common jelly fish	Neuston net tow
Phylum Mollusca		
Class Gastropoda		0 - 200 m -
<u>Carinaria lamarcki</u>	Pelagic heteropod	Bongo net tow
Phylum Arthropoda		
Class Crustacea		100 m -
Copepod spp.	Copepods	meter net
<u>Systellaspis debilis</u>	Scarlet prawn	0 - 400 m - IKMT
Class Insecta		Surface -
<u>Halobates micans</u>	Water strider	Neuston net tow
Phylum Annelida		
Class Polychaeta		50 - 200 m -
<u>Tomopteris</u> sp.	Pelagic bristle worm	Bongo net tow
Phylum Chaetognatha		50 - 200 m -
<u>Sagitta</u> sp.	Arrow worm	Bongo net tow
Phylum Chordata		
Class Thaliacea		
<u>Pyrosoma atlanticum</u>	Pelagic tunicate	0 - 400 m - IKMT
Class Osteichthys		50-200 m
<u>Ophichthidae</u> spp.	Eel larvae	Bongo net tow
<u>Lepidophanes</u> sp.	Myctophid, lantern fish	0-500 m IKMT
Class Mammalia		
<u>Stenella frontalis</u>	Bridled dolphin	Surface
Class Aves		
<u>Sula leucogaster</u>	Brown booby	Air