CRUISE REPORT

W-66

Scientific Activities

Woods Hole - Bermuda - Martinique - Bequia - St. Barts - St. Thomas

08 October - 19 November 1982

R/V Westward

Sea Education Association
Woods Hole, Massachusetts

SHIPBOARD DRAFT

PREFACE

The objective of this report is to compile the data collected on the sixty-sixth cruise of the research vessel Westward, which took place between 08 October and 19 November 1982. Included are the abstracts from student projects completed and written during the cruise. Also included are data being incorporated in the long-term studies of SEA staff scientists and associated researchers.

Cruise W-66 provided much of the material from which legends are born: a force 9 gale the first night out, storms severe enough to disable a crew member with seasickness and to cause an unscheduled port stop in Bermuda, slicing turkey on the galley deck, and so forth. Each participant undoubtedly has a favorite tale by now.

Yet the voyage was a scientific and educational cruise and a great deal of our scientific mission was accomplished. Despite delays in arriving at the specified site, and despite an unexpected slackening of trade winds, we were able to locate a frontal zone in the Sargasso Sea, do vertical migration and other studies in the North Equatorial Current, and hover off a lee shore (St. Lucia) for some delicate island mass effect transects. We did not prove or disprove the Gaia hypothesis that the Earth's processes, especially those in the ocean, act to maintain a state of homeostasis - no single cruise could do that - but we did uncover an active system of Air-Sea interaction. Upon analysis of the hydrocasts done in the Sargasso Sea and North Equatorial Current, a clear picture was seen between the erratic trade winds we experienced and the salinity maximum water we detected (see report by Allen and Farmer).

The skill of John Wigglesworth as captain, and his loving care of the Westward herself, were instrumental in the attainment of our goals. Chief Mate Phil Sacks and Mates Jim Millinger and Bill Hallstein oversaw the navigation and seamanship needed to run the often arduous oceanographic stations. In addition, Bill, a medical doctor, kept our small medical problems from becoming large ones. Engineer Jeff Wheeler was always ready to help anyone with questions about the engine room as well as with analytical instruments in the lab. The galley was run bravely by students and a bunk-ridden Lynn Blank during the stormy weather. With appreciation to Lynn for her effort while ill, we welcomed Priscilla (Cilla) Brooks in Bermuda to keep the galley running smoothly, and above all cheerfully, for the rest of the voyage.

Assistant Scientists Don Levitan, Arthur Allen, and Amy Stone ran the lab diligently even during those days we could not perform stations because of the weather. Don's expertise in ecology, Arthur's in physical oceanography, and Amy's in marine mammals and laboratory protocols provided a balance to the scientific program that is rarely experienced. This was the first cruise in which I did not stand a watch myself and I was glad to have the laboratory in such capable hands while I coordinated the stations and the academic program to accomplish the various goals of students and staff.

I wish to thank all participants, and especially the cheerful, hard-working students, for the invaluable contributions they made to the cruise.

Mary W. Farmer, Ph.D.
Chief Scientist
W-66

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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 NS225 at Boston University. The cruise track (figures 1 and 2) was designed to study the physical, chemical, and biological properties of the Sargasso Sea and North Equatorial Current, with special emphasis on boundaries between water masses and between land and sea. The ship's itinerary (table 1) permitted W-66 participants to examine volcanic islands and some tropical reef habitats in addition to the open ocean environment. Cruise participants are listed in table 2.

The major portion of research was accomplished through the design and execution of individual projects and through the continuation of long-term studies conducted by SEA. The projects were completed while the students were still aboard, and the abstracts of their reports comprise the bulk of this volume.

Research conducted during W-66 also represented the ongoing work of individuals and agencies that have extended their assistance to our students. Material reported here should not be excerpted or cited without written permission of the Chief Scientist.

Figure 1A. Cruise track for W-66 of the R/V Westward. Circles = noon position; squares = midnight position. See figure 1B for track within rectangle.

Figure 1B. Inset for figure 1A. Cruise track for W-66 in the region of the Lesser Antilles. Circles = noon position; squares = midnight position.

Figure 2A. Stations for cruise W-66.

Figure 2B. Stations in the region of the Lesser Antilles.

Table 1. Itinerary and port stops for cruise W-66

Port	Arrive	Depart
Woods Hole, Massachusetts	-	08 October 1982
St. Georges, Bermuda	05 October 1982	16 October 1982
Fort-de-France, Martinique	03 November 1982	05 November 1982
Bequia	08 November 1982	09 November 1982
St. Barthelemy (St. Barts)	13 November 1982	15 November 1982
St. Thomas, U.S.V.I.	19 November 1982	-

Table 2. Ship's complement for cruise W-66

Nautical Staff

John Wigglesworth, Ocean Operator	Captain
Philip A. Sacks , Ocean Operator	Chief Mate
James Millinger, Inland Operator	Second Mate
William Hallstein, M.D.	Third Mate
Jeff Wheeler	Chief Engineer
Lynn Blank, B.S. (First Leg)	Steward
Priscilla Brooks, B.S. (Remaining Legs)	Steward

Scientific Staff

Mary W. Farmer, Ph.D.	Chief Scientist
Don Levitan, M.S.	Assistant Scientist
Arthur Allen, M.S.	Assistant Scientist
Amy M. Stone, B.S.	Assistant Scientist

Students

Eric M. Aldrich, B.S., Hamilton College
 David D. Blaney, Sophomore, Williams College
 Nanette M. Brodeur, Junior, Connecticut College
 Douglas J. Burgoyne, Senior, Colgate University
 Susan J. Burt , Junior, Tufts University
 Nancy R. Chapin, Senior, Cornell University
 Meredith M. Chase, Senior, Dartmouth College
 Susan L. Decker, Junior, Tufts University
 Gregory P. DiLisio, Junior, Cornell University
 Hugh S. Ferguson, Junior, Bowdoin College
 Robert A. George, Junior, Middlebury College
 David S. Goldsmith, Junior, Oberlin College
 Randall J. Hanford, Senior, Boston College
 Paula M. Harris, Junior, Middlebury College
 Sarah J. Jordon, Junior, Colby College
 Hannah M. Keevil, Senior, Cornell University
 John R. Kelley, Junior, Georgetown University
 Heidi B. Lovett, Junior, Bates College
 Renee S. Mercaldo, Junior, Connecticut College
 N. Allyn Pistole, Junior, Cornell University
 Richard G. Robbins, Junior, Colgate University
 Karen L. Sundberg, Junior, Colby College
 Sarah DeW. Woodhouse, Junior, Colby College
 Jennifer A. Woodward, Senior, Pitzer College

SARGASSO SEA CONVERGENCE AND PHYSICAL OCEANOGRAPHY STUDIES

Introduction

The Sargasso Sea is the center of an oceanographic gyre bounded by the Gulf Stream and North Atlantic Drift on the west and north and by the Canary Current and North Equatorial Current on the east and south. It is a relatively quiet pool in the midst of an active current system. The Sargasso Sea is also bounded by predominately westerly winds in the north and by the easterly trade winds in the south. Because of these winds, the water of the Sargasso Sea may be envisioned as "piling up" near the center of the pool. Such an event may have several effects, one of which is a convergence, or meeting of two water types, along a rather narrow oceanic front. This convergence could mean that Northern Sargasso Sea water does not mix with Southern Sargasso Sea water and that the Sargasso Sea as a whole actually consists of two distinct bodies of water.

To search for such a front on cruise W-66, we conducted regular bathythermograph (BT) lowerings at approximately 10-nautical mile intervals until we saw a rather abrupt rise in the 70° F isotherm (figure 3A). We continued until the isotherm began to sink again, and then we reversed course and lowered the BT as quickly as we could, at approximately 1-nautical mile intervals. At the end of this section we began a 3-station hydrocast and phytoplankton tow transect with BTs between stations (figure 3 inset).

The "rapid" BT transect showed several patches of well mixed water (figure 3B), a characteristic of frontal systems. From the hydrographic section Robbins and George were able to calculate the direction and velocity of a geostrophic current through the front (figure 4), and Aldrich presented biological evidence of a vertical current (figure 5).

On a larger scale, the hydrographic section from 28° N to 14° N showed the formation and sinking of high salinity water, with a disruption probably related to a disruption in trade wind flow previous

to the disruption experiences on W-66 (figure 6). Also on this scale was seen some further evidence that the frontal region we studied really was a front, a convergence zone where 18° C water that had been formed in the Northern Sargasso Sea sank to deeper than 200m (figure 6).

That these physical features affected the organisms living in the Sargasso Sea and North Equatorial Current was seen in the studies reported in the section after this one.

Figure 3. Bathythermograph profiles (top left and bottom) across a front in the Sargasso Sea. Top left is profile of BTs 41 through 45 as shown on the cruise track in the top right inset. Bottom is profile of BTs 46 through 57, a "rapid transect," also shown in the inset. Depths are in feet, temperatures in degrees Fahrenheit.

Volume transport along the Sargasso Sea Convergence

Richard Robbins
Robert George

ABSTRACT

An oceanic front in the Sargasso Sea has been recognized for some time. A current flowing along the front has also been measured, although there are varying opinions on the depth and direction of the current. In this study we detected a subsurface density front in the Sargasso Sea to 27° N, $58^{\circ}20'$ W (figure 4). We located the front using BT profiles from bathythermographs spaced at 10-nautical mile intervals. The front was recrossed and a BT transect with approximately 1-nautical mile intervals was done. On the third crossing we took water samples and temperatures at specified depths with Nansen bottles at three stations. Using the geostrophic method we calculated a surface velocity of 110-120 cm/s to the southwest, based on zero velocity at 290 meters. Volume transport of this current was estimated to be $1.02 \text{ m}^3/\text{s}$.

Figure 4. A density front in the Sargasso Sea. Wavy lines indicate approximate width of the front. Circles and numbers preceded by an "S" indicate hydrocast and phytoplankton tow stations. Small numbers = bathythermograph lowerings. Arrows indicate direction and relative velocity of geostrophic flow, as calculated from station data.

Investigating a mid-Sargasso front using physical and biological water mass indicators

Eric M. Aldrich

Oceanic thermal fronts in the Sargasso Sea may be signs of a convergence zone, and Katz (1969) has hypothesized that at such a place vertical as well as horizontal currents are necessary to maintain a well-defined interface. He proposed a deep water "common mixed" zone at about 150 meters depth wherein sinking surface waters mix and flow away from the front. In the present study, physical (temperature and salinity), chemical (dissolved phosphate and silicate), and biological (radiolaria and foraminifera) features were examined in light of this model.

A temperature profile showed a bolus of mixed water at 130 to 180 meters depth (figure 3) to the south of the proposed front; this mixed water was highly saline (~ 36.69 ‰). Phosphate and silicate data concentrations were lower at front stations than at non-front stations. Radiolarian and foraminiferal populations were similar at the surface all across the front and were similar at depth from the Northern Sargasso Sea up to, but not including, the southernmost station of the front. At the front, but at no other place, those populations at the surface were similar to the ones at depth (figure 5). Taken together, these data (1) show mixing at depth characteristic of a front and (2) suggest a vertical current that could be explained either by the model of Katz (1969) or by the sinking-countercurrent model of Defant (1936).

Defant, A. 1936. Die Irophosphare, Deutsch Atl. Exped. "Meteor" 1925-27. Wiss. Erg. 6(1):289-411 (Berlin).

Katz, E.J. 1969. Further study of a front in the Sargasso Sea. Tellus. 21(2):259-269.

Figure 5. Descriptive cross-section of the density front. Hatched bars connect water samples with similar populations of microzooplankton. Arrows show proposed vertical circulation to account for the distribution of organisms.

The hydrographic section from 28° N to 14° N

Arthur Allen and Mary Farmer

An approximately meridional section along 57-60° W was conducted with a mechanical bathythermograph (BT) and Nansen bottle hydrocasts. The BTs were lowered to 200-250 meters at 4-hour intervals (approximately every 40 km); hydrocasts were done at more irregular intervals (stations 6, 8, 11-15, 18, 20-22, 24, 25, 28; figure 2). Temperature and salinity data from these stations were compared with a similar track of the R/V Atlantis summarized by Worthington (1976) (figure 6A).

The most clearly defined water mass was a salinity maximum layer that usually extends from 31° N to about 11° S, is centered at 50° W, and appears at a depth of 51-150m (Worthington 1976). This salinity maximum is directly related to trade wind behavior. The trade winds transport water vapor from the 30s north latitude south to the equatorial trough zone. There the vapor condenses, forms giant cumulonimbus clouds, and releases heat. This heat provides energy for the general circulation of the atmosphere. With condensation of water vapor comes rain and the formation of a low salinity surface water mass in the equatorial trough zone. Meanwhile, by removing water vapor from the central gyre, the trade winds have created a region where average precipitation is much less than evaporation and surface water of high salinity is formed. Salinity maximum water thus formed at the surface begins to sink and move south as more high salinity water forms.

The Atlantis section, made when trade winds were blowing steadily, shows high salinity water (10 parts per 100,000 higher than normal) extending from the surface in the Sargasso Sea south to 12° N, near Barbados (figure 6B). Maximal salinity (50 parts per 100,000 higher than normal) extended as far south as 18° N.

This year the high salinity layer was broken up at about 20° N, but a fragment continued further south and sank to deeper than 200m (figure 6C). Worthington (1976) has argued that when the trade winds fail the salinity maximum layer becomes patchy, that the trade winds are necessary for the generation of salinity maximum water. If this

Figure 6. A. Hydrographic sections of the R/V Westward (transect W) and of the R/V Atlantis (transect A) compared. B. Salinity anomaly from the R/V Atlantis. C. Salinity anomaly from the R/V Westward. Single-hatched contours in both transects represent an anomaly of +10 parts per 100,000. Cross-hatched contours = +50 parts per 100,000. Striped contours = -10 (exterior) and -50 (interior) parts per 100,000.

is true, then the gap at 20° N represented a cessation, or slacking, of the trade winds for a certain period of time, (It should be noted that the trade winds were far from steady on cruise W-66. Although the erratic behavior during the cruise was not directly seen in the hydrocast section, it is probable that a similar disruption had occurred earlier in the year.)

Fresher water is found at the surface from about 20-22° N through the rest of the section in both the Atlantis and the Westward sections (figure 6B and C). The layer was not as thick this year as it was in the Atlantis section. Such a difference may be due to the unsteadiness of the trade winds this year. Slack trade winds would bring less water vapor to the equatorial trough zone and would therefore create a smaller amount of low salinity water than would steady trade winds.

The temperature section showed a well-mixed layer of 60-75m over a sharp thermocline (figure 6D). Below the thermocline water was stratified. Between 22°10'N and 21°30'N was the first indication of a subsurface temperature maximum. This layer was warmer than 27.5° C and about 15m thick, centered at a depth of about 60m. In the BT section this layer extended as far south as 14° N but it was not always detected in the hydrocast section because of widely spaced bottles. In the hydrocast section the subsurface temperature maximum appears as two boluses. A third bolus of warm water occurred at about 17° N and was associated with the sinking salinity maximum layer (figure 6D).

Two possible thermal fronts are suggested by this section. The first is between stations 11 and 12, where the 27° C isotherm breaks the surface. Associated with this front, which is described in more detail by Robbins and George and by Aldrich in this report, are rises in the 20 through 25°C isotherms to the south, and a sinking of the 19°C isotherm to the north of the front. Also here the 18°C water that was formed in the Northern Sargasso Sea (Worthington 1976) sinks and begins to diminish in volume.

The second possible thermal front appears between stations 20 and 22, where the 28°C isotherm breaks the surface, and where the salinity maximum layer, associated with a deep warm water maximum, begins to

sink. From this latitude south, the thickness of the layers of water between 19° and 20°C is approximately the same as the thickness between 18° and 19°C. There is no "excess" 18°C water. Thus, we have reached the end of water formed in the Northern Sargasso Sea.

In summary, the hydrographic section showed the presence of salinity maximum water. This water formed at the surface between the latitudes 22 and 26°N this fall. It sank and moved south as more salinity maximum water was formed but at some point the formation of this water was interrupted, probably by a disruption of trade winds. The old salinity maximum water continued to flow south and eventually sank to deeper than 250m at a latitude of about 16°N. When the formation of new salinity maximum water resumed, it began to sink again but a layer of "normal" salinity water had already intruded between the old and new patches of high salinity water.

Meantime, low salinity water had been forming at the surface in the equatorial trough. Being relatively fresh, and light, it stayed at the surface and moved north as more low salinity water formed. An interruption in trade winds here is reflected not in patchiness but in a thinner layer than is seen in times of steady trade winds.

The thermal regime shows two transition zones. The first may mark a front between the Northern and Southern Sargasso Seas and the second may mark the end of the Sargasso Sea.

Worthington, L.V. 1976. On the North Atlantic circulation. Johns Hopkins University Press. Baltimore. 110 pp.

CHEMICAL AND BIOLOGICAL OCEANOGRAPHY STUDIES

Introduction

Temperature and salinity of the ocean define an organism's climate in the sea just as temperature and rainfall determine climate on land. In addition, nutrient supply and light intensity control the rate of primary production just as they do on land, where we usually think of fertility of the soil and day length as the controlling factors.

For some of the organisms studied on W-66, the temperature and salinity ranges of the water sampled were narrow enough to be considered one climate. Thus, for phytoplankton (primary producers) at the surface, silicate (a nutrient) concentration had important effects on the number and diversity of cells present but "climate" did not influence their distribution (Woodward and Sundberg). Likewise, for the total biomass of zooplankton (primary and secondary consumers) there was a correlation with oxygen concentration, but, again, no detectable influence of climate (Keevil).

For other organisms, however, climate exerted a crucial influence. Primary producers found within the thermocline, a region colder, darker, and usually more saline than the surface, were distinctly different species from those found at the surface (Brodeur). Chaetognaths, which are voracious predators, were markedly affected by climate: 4 species were restricted to North Equatorial Current water and 9 to coastal waters. Only one species was cosmopolitan, found in all waters studied (Lovett). Fish and fish larvae were affected by climate. Deep water fish did not migrate above the 10°C isotherm and few midwater fish migrated above the thermocline (Pistole). The species found in the Northern Sargasso Sea were different from those found in the Southern Sargasso Sea and these in turn were different from those in the North Equatorial Current (Blaney and Ferguson). The larvae of eels may be influenced by salinity in an interesting way. The largest of these were found in salinity maximum water. It has been suggested that the high salinity may act as a trigger to physiological processes that would enable an eel to begin its homeward migration (Chase).

Some biological studies of the important zooplankter, the euphausiid (in this case, genus Stylochieron) showed that food supply was important in maintaining a body density/length ratio (Burgoyne). This euphausiid vertically migrates but the environmental factor that triggers migration seemed to vary: in the Southern Sargasso the euphausiid seemed to be following a certain intensity of light whereas in the North Equatorial Current the controlling factor could not be determined but definitely was not light (Decker).

It is well known that coastal waters differ from open ocean waters and usually these differences seem to be related to factors other than temperature and salinity. Nutrients seem to be critical. Near the coast of a continent river runoff brings high concentrations of nutrients to the ocean, allowing high levels of primary productivity. Near islands an effect is also seen, although whether the effect is due to river runoff from such small land masses is still not settled. An alternative might be local upwelling, if the conditions are right. A small region near St. Lucia was studied for an "island mass effect" and because silicate seemed to be delivered to the surface from deeper Antarctic Intermediate Water, and for other reasons, it was proposed that local upwelling was important near St. Lucia (DiLisio).

A comparison between surface water phytoplankton diversity and nutrient concentrations in the North Atlantic Ocean

Jennifer Woodward
Karen Sundberg

ABSTRACT

Phytoplankton tows were done in the Sargasso Sea in the North Equatorial Current and off St. Lucia (Stations 1, 3, 10-13, 28, 29; figure 2). The number of organisms were counted and species were keyed out from a subsample for each station (table 3). Data indicated a general trend of increasing cell number and diversity corresponding to an increase in nutrient concentrations (figure 7). However, the relationship between diversity and silicate concentration was not demonstrated at the stations along the front (stations 11-13) nor for the northernmost station (station 1). Neither did the relationship between cell number and silicate concentration hold for that northernmost station. The general trend may be attributed to a symbiotic relationship between organisms in the low nutrient Sargasso Sea waters: as nutrient concentration increases, so would cell number but also species diversity because some species might require the presence of others for their own nutritional needs. Variations in the trend may be due to upwelling and convergence, which would change the concentration of nutrients and ultimately change species diversity.

Figure 7. Relationships between phytoplankton cell number, diversity, and silicate concentration. A. Cell number versus silicate. B. Diversity vs. silicate. Circled numbers = station numbers. Straight line = best fit by eye of the data.

Table 3. Species of phytoplankton observed at the surface and beneath the mixed layer throughout the Sargasso Sea

Species	Northern Sargasso Sea						Front		Southern Sargasso Sea	
	Station No.:		1		3		10		11	
	deep	deep	deep	deep	surface	deep	surface	deep	surface	deep
DIATOMS										
<i>Asteromphalus heptactis</i>						+				
<i>Biddulphia sinensis</i>			+							
<i>Chaetoceros lunula</i>	+									+
<i>C. simplex</i>										
sp. A						+				
sp. B						+				+
sp. C	+									
<i>Coscinodiscus</i> sp. A	+	+						+		+
sp. B	+	+			+			+		
sp. C		+			+			+		
<i>Compylodiscus cribrus</i>	+	+			+					
<i>Eucampia greenlandica</i>										+
<i>Fragilaria</i> sp. A								+		
sp. B								+		
<i>Hemiaulus hauckii</i>		+							+	+
<i>Hyalodiscus stelliger</i>		+							+	
<i>Planktoniella sol</i>	+									
<i>Rhizosolenia acuminata</i>					+			+		
<i>R. alata</i>					+					
<i>R. castracanci</i>					+					+

(continued)

Table 3. (continued)

Species	Northern Sargasso Sea						Front		Southern Sargasso Sea	
	Station No.: 1		3		10		11		12	
	deep	deep	deep	deep	surface	deep	surface	deep	surface	deep
<i>Rhizosolenia robustus</i>		+		+		+				
<i>R. setigera</i>			+			+				
<i>R. shrubsolei</i>		+				+		+		+
<i>R. styliformis</i>			+			+				+
Unidentified diatoms										
A				+						
B		+								
C		+								
D				+						
DINOFLAGELLATES										
<i>Ceratium batakum</i>						+				
<i>C. caricense</i>		+		+		+				+
<i>C. contrarium</i>									+	
<i>C. declinatum</i>	+	+			+			+		
<i>C. digitatum</i>								+		
<i>C. gallicum</i>	+			+		+		+	+	
<i>C. gibberum</i>	+	+				+		+	+	
<i>C. gravidum</i>	+			+						
<i>C. intermedium</i>	+	+				+		+		+
<i>C. karsteni</i>				+				+		+
<i>C. longipes</i>										+
<i>C. lineatum</i>						+			+	

(continued)

Table 3. (continued)

Species	Northern Sargasso Sea						Front		Southern Sargasso Sea	
	Station No.:		1		3		11		12	
	1	2	deep	surface	deep	surface	deep	surface	deep	surface
<i>Ceratium longinium</i>						+				
<i>C. macroceros</i>								+		
<i>C. massiliense</i>								+		+
<i>C. paradoxides</i>	+							+		
<i>C. pentagonium</i>			+		+		+		+	
<i>C. platycorne</i>							+			
<i>C. ranipes</i>			+							
<i>C. reticulum</i>										+
<i>C. trichoceros</i>										+
<i>C. tripos</i>	+		+		+		+		+	+
<i>C. vultur</i>										
sp. A			+				+			
sp. B			+							
sp. C										+
<i>Ceterocorys horrida</i>			+				+			
<i>Gaussiaula minima</i>					+					
<i>Gymnodinium</i> sp.					+				+	
<i>Ornithocercus magnificus</i>					+		+		+	
<i>O. steini</i>	+		+		+		+		+	+
<i>O. thurni</i>	+			+				+		
<i>Peridinium diabolis</i>										
<i>P. divergens</i>										

Table 3. (continued)

Species	Northern Sargasso Sea						Front		Southern Sargasso Sea	
	1	3	10	11	12	13				
	deep	deep	surface	deep	surface	deep	surface	deep	surface	deep
<i>Peridinium fatulina</i>			+						+	
<i>P. grande</i>										+
<i>P. leonis</i>										
<i>P. oceanicum</i>		+								
<i>P. pendunculatum</i>										+
<i>P. steini</i>	+					+				
<i>Pyrocystis fusiformis</i>	+	+	+			+				
<i>P. hamulus</i> (var. <i>semicirculus</i>)		+				+				+
<i>P. noctiluca</i>	+	+	+			+				
<i>P. sp.</i>			+							+
<i>Pyrophacus stein</i>	+									
Unidentified dino-flagellate	+					+				
Silicoflagellate										+
<i>Trichodesmium sp.</i>	+	+	+	+	+	+	+	+	+	+
Phosphate, ug-at/l	0.47	0.18	0.00	0.13	0.07	0.03	0.03	0.07	0.00	0.00
Silicate, ug-at/l	6.2	6.4	2.8	5.0	0.9	0.2	0.4	0.3	0.8	0.7
Similarity (C/(A+B))	0.20	0.12	0.14	0.10	0.11				0.07	
No. species in common	7	6	6	5	4				2	

Phytoplankton diversity, density, and similarity between surface and thermocline

Nanette Brodeur

ABSTRACT

In this project phytoplankton diversity, density (cell number), and the similarity between the surface and the thermocline populations were compared in the Northern Sargasso Sea near Bermuda and in a convergence zone (density front, see Robbins and George, this paper).

Samples were collected using a phytoplankton net attached to a hydrocast wire, preserved with 5% formaldehyde in seawater, and then concentrated by siphoning off supernatant liquid. A CAT chamber was used for cell counts and species identification. At each station phosphate and silicate nutrient data were also obtained.

It was hypothesized that the thermocline had greater nutrients than the surface and therefore diversity would be lower in the thermocline. Diversity, however, fluctuated randomly between surface and thermocline, and the phosphate and silicate nutrient concentrations did not appear much greater within the thermocline (table 3).

The highest cell densities occurred within the surface populations and the lowest densities occurred within the thermocline, indicating perhaps that the light intensity was a limiting factor. One exception occurred at the front convergence zone (see Robbins and George, this report) where densities at both depths dropped to a low point; believed due to greater predation from a richer ensemble of organisms at a front.

Extremely low similarities were found between the stations at the two depths (table 3), indicating that conditions such as temperature, density, and light intensities differ enough between the depths to create two distinct niches for phytoplankton.

Vertical changes in oxygen concentrations as related to zooplankton biomass in the North Equatorial Current and off the Caribbean Islands

Holly Keevil

ABSTRACT

The purpose of this study was to compare oxygen concentrations to zooplankton biomass in (1) the North Equatorial Current (NEC) and (2) off the Caribbean islands. Special attention was paid to the zooplankton at the oxygen minimum layer located near the thermocline. From a BT etching, Nansen bottle and meter net depths were determined with the intent of sampling the surface water, the top of the thermocline, and the base of the thermocline. Oxygen concentrations were determined by the modified Winkler technique, and biomass was calculated for each meter net tow. It was found for both regions that oxygen concentrations were low at the surface, gradually increased to 100 meters, and decreased again around 200 meters (figure 8). Thus, an oxygen maximum was seen that coincided with the thermocline. In general, the oxygen curve was less variable in the NEC than off the islands; the surface oxygen concentration was not as high and the minimum not as low.

Zooplankton biomass decreased with a vertical decrease in oxygen level (figure 8C). The same relationship was seen horizontally; greater surface oxygen supported a higher biomass than did lower surface oxygen. The increase in oxygen at the thermocline illustrated that light must be penetrating deeper than the mixed layer, allowing for photosynthesis without the inhibiting effect direct sunlight has on the surface. Both zooplankton and phytoplankton therefore affected vertical oxygen concentration and areas of oxygen minima represented areas of increased respiration and decreased photosynthesis.

Figure 8. Oxygen profiles for two sets of stations (solid lines) compared with thermocline depths (dashed lines) and zooplankton biomass (bar graphs). A. North Equatorial Current. B. Windward of the Lesser Antilles. C. Zooplankton biomass as a function of O_2 concentration.

Chaetognatha used as water mass indicators in the North Equatorial Current and Caribbean

Heidi B. Lovett

ABSTRACT

Different species of the Phylum Chaetognatha, or arrowworms, have been shown to be good biological water mass indicators. The objective of this project was to determine whether chaetognaths found in the North Equatorial Current and the Caribbean could be water mass indicators. Samples were taken from six oblique meter net tows (stations 18, 20, 30, 31, 32, and 34; figure 2). Subsamples of chaetognaths were identified. Diversities and densities (number of chaetognaths/m³) were calculated as well as a temperature-salinity profile for each of the stations and species. Species A was the only species found to be cosmopolitan (figure 9). Species E, F, T and J were found to be indicators for the North Equatorial Current, while species B, C, D, G, H, K, I, P and Y were indicators for the coastal waters off of St. Lucia (figure 9). The species found at one particular station around St. Lucia are either due to small projections or fingers of different water masses or to spatial ecological niches in the environment.

Figure 9. Latitudinal distribution of chaetognath species. Species A was found at all stations but 31, species P and Y were found only at 31.

A new breeding ground for the European eel, Anguilla anguilla, and the possibility of a physiologically triggered migration

Meredith Chase

ABSTRACT

This study was designed to investigate the migration pattern of the larvae of the European eel, Anguilla anguilla, and to look for the spawning ground outlined by Schmidt. All plankton and neuston tows were examined for leptocephali (figure 10). The smallest leptocephali found were near Bermuda, and size increased as the Westward tracked away from that station, suggesting that the spawning ground was further north than Schmidt's data indicated. The largest leptocephali were found in the surface-salinity maximum zone (see Allen and Farmer, this report), suggesting that this area may trigger a metabolic rate change that initiates migration. A pattern of vertical migration was also demonstrated.

Schmidt, J. 1925. The breeding place of the eel. Ann. Rep. Smith. Inst. 1924. 279-316.

Figure 10. Eel larvae (leptocephali) stations shown with respect to Schmidt's spawning ground (hatched), the spawning ground proposed by this study (striped), major circulation features, and the area of maximum salinity of surface waters for this season.

A study of Stylocheiron, a euphausiid: the effect of length and phytoplankton abundance on Stylocheiron density

Douglas J. Burgoyne

ABSTRACT

The western North Atlantic Ocean is divided by the swift moving Gulf Stream. Shelf water tends to be cold and nutrient rich while Sargasso Sea water is warm and nutrient depleted. The Gulf Stream boundary is not fixed and there is mixing across it through the mechanism of warm and cold eddies. Organisms trapped in these eddies are placed under considerable stress and those swept off the shelf by a cold core ring eventually starve. The purpose of this project was to examine the density of euphausiids, an indication of starvation, in relation to phytoplankton abundance and particularly the number of diatoms. Samples were taken and analyzed to determine their density (g/ml); this was done for samples as a whole and for size classes within a sample. Phytoplankton data were collected from other projects; density was compared with size class, total phytoplankton abundance, and diatom concentration.

Three major relationships were revealed by this study. First, body density and length was directly correlated: larger euphausiids were more dense than smaller ones (figure 11A). This could be a source of error if organisms aren't sorted out by length. Secondly, the density of Stylocheiron was related to the phytoplankton abundance, suggesting that density could be used as an indicator of euphausiid starvation. Thirdly, density was closely related specifically to the diatom concentration, suggesting that diatoms are a major food source for euphausiids (figure 11B).

Figure 11. A. Relationship between Stylocheiron density (wet weight/vol) and body length. Data from two stations shown. B. Relationship between Stylocheiron density and number of diatoms in the water.

Vertical migration of krill: An "illuminating" subject

Susan Decker

ABSTRACT

The vertical migration of euphausiids, a 24-hour cycle of swimming toward the surface during the night and into the depths during the day, remains unexplained. This behavior alone suggests that light could be the mechanism by which they migrate.

This project was carried out in the Southern Sargasso Sea and the North Equatorial Current. My intent was to show that euphausiids (Stylocheiron) would migrate according to the level of turbidity since light intensity beneath the surface is directly controlled by weather and turbidity. Plankton nets were towed at 5, 100, and 160 meters for 30 minutes; a flow meter was used to calculate the water volume sampled. The euphausiid, Stylochieron, was sorted and counted from a subsample preserved in 10% formaldehyde. The total number of Stylochieron counted was multiplied by 25 (to represent the full 400 ml sample) and then divided by the water volume sampled to get the concentration of euphausiids in number/meter³. The nets were towed four times a day for each set of stations: noon, dusk, midnight, and dawn. Light intensities and isolumes were calculated by combining Secchi Disk readings with those of the surface irradiator.

At stations in the Southern Sargasso Sea, Stylochieron seemed to migrate with the 0.04 uW/cm² isolume whereas in the North Equatorial Current their migration did not seem to be directly related to any particular isolume (figure 12). These differences may have been related to water mass difference, food supply, or other environmental factors not tested.

Figure 12. Number of euphausiids found at three depths at different times of day for two sets of stations, in the Southern Sargasso Sea (top), and in the North Equatorial Current (bottom). Dashed lines are isolumines in $\mu W/cm^2$.

Diurnal vertical migration of mesopelagic fish in the Sargasso Sea and North Equatorial Current

Nancy Allyn Pistole

ABSTRACT

Two aspects of diurnal vertical migration of mesopelagic fish in the Sargasso Sea and North Equatorial Current were examined. Meter net tows were taken at night and during the day at depths of 5, 50, 100, and 160 meters. A significantly greater number of fishes were found at night than during the day. Most fish were caught at night at the 100-meter level, corresponding to the top of the thermocline rather than at the 5-meter level, where the greatest density of a food source (euphausiids) was found (figure 13).

A deep meter net tow was also done at 800, 900, 1000 meters. The 10° isotherm which marks the bottom of the Sargasso Sea water mass was found at 850 meters. The species were compared between the deep tows and surface tows. Of the 30 species identified, only 5 were common to both the surface and deep water layers (table 2). This is evidence to support Haffner's (1952) hypothesis that deep-water fish show vertical migration but do not cross the boundaries of water masses.

Haffner, R.E. 1952. Zoogeography of the Bathypelagic Fish Chauliodus. Syst. Zool. 1, 113-133.

Figure 13. The percentage of midwater fish caught at night on cruise W-66 (circles), compared with that reported by Bachus (1969) (triangles), the percentage of euphausiids, a potential food item (squares), and with the mixed layer/thermocline boundary (hatched area).

Table 4. Mesopelagic fish caught on W-66, listed by family and tabulated

<u>Family</u>	<u>Genus/Species</u>	Depth (m)	<u>Day*</u>		
			60	100	160
Astronesthidae	(unidentified)				
Bregmacerotidae	(unidentified)				4
Sternoptychidae	<u>Sternoptyx diaphana</u>				
	<u>Argyropelecus hemigymnus</u>				
Alepocephalidae	<u>Xenodermichthys copei</u>				
Melanostomiatidae	<u>Eustomias schnidti</u>				
Myctophidae	<u>Benthosema glaciele</u>				
	<u>Notolychnus valdiviae</u>				
	<u>Myctophum</u> (unknown)				
	<u>Mychotophum selenops</u>				
	<u>Lampadena</u> (unknown)				
	<u>Lobianchia dofleini</u>				
	<u>Lampanictus macadonaldi</u>				
	<u>Lampanictus alatus</u>				
	<u>Diaphus</u> (unknown)				
	<u>Hygophum reinhardtii</u>				
	<u>Hygophym taaningi</u>				
	(unidentified - mangled)			1	
Dirismidae	(unidentified)				
Neosopelidae	(unidentified)				
Gonostomatidae	<u>Bonapartia pedaliota</u>				
	<u>Vinciguerrria attenuatta</u>				
	<u>Margrethia obtusirostra</u>				
	<u>Margrethia</u> (unknown)				1
	<u>Yarella blackfordi</u>				
	<u>Pollichthys</u> (unknown)				
	<u>Soneda pauchilampa</u>				1
	<u>Valenciennellus tripunciulatus</u>				
	(unidentified - mangled)		1		
Paralepididae	<u>Macroparalepis</u> (unknown)		—	—	—
	TOTAL		1	1	6

*Data compiled by N. A. Pistole

**Data compiled by D. Blaney and H. Ferguson

by time of day, depth of net towed, and station number

Night*				Dusk*			Station No. **							
5	50	100	160	800	900	1000	1	3	14	15	16	18	20	22
				1		1		2						
		1							3		1	1		
				3				3						
				1	2	4		7						
						1		1						
	1						1							
			3	13	11	1		35		3				
	3	5	4		5	2	3	7		7			2	
	1													
		1					1					1		
			4							4				
		1												
			1		3			3		1				
		2	5			2	3			5				
			1									1		
5	13	15	4			3	13	3		1		9	1	
		1										1		
								1						
						1		1						
				7	9	5		21						
				40	64	48		152						
				3	1			4						
					1			1						
		1										1		
	2						2					1		
						1		25						
											1			
—	—	—	—	1	—	—	—	2	—	—	—	—	—	—
5	20	27	22	69	96	69	22	267	4	22	2	17	1	0
							North.			South.			N. Eq.	
							Sarg.			Sarg.			Curr.	
							Sea			Sea				

Patterns of zoogeography of mesopelagic fish in the Sargasso Sea
and North Equatorial Current

David Blaney
Hugh Ferguson

ABSTRACT

Eight stations (1, 3, 14-16, 18, 20, 22; figure 2) were sampled for mesopelagic fish to study their distribution in the Northern Sargasso Sea (2 stations), Southern Sargasso Sea (3 stations), and North Equatorial Current (3 stations). There was a low similarity (14% species in common) between the Northern Sargasso Sea and the North Equatorial Current; the Southern Sargasso Sea had a 37% similarity with the Northern Sargasso Sea and 41% similarity with the North Equatorial Current (table 4). These data suggest that the Southern Sargasso Sea may act as a barrier between the Northern Sargasso Sea and the North Equatorial Current. There was a positive relationship between the number of fish caught and the volume of other zooplankton in the net (potential food supply) except at station 3, where the tows were much deeper than elsewhere (figure 14). Juveniles tended to congregate at different depths from the adults.

Figure 14. Biomass of zooplankton (potential food) (white bar) compared with number of mesopelagic fish caught at each station (hatched bar).

An upwelling mechanism to explain the island mass effect found
at St. Lucia

Gregory DiLisio

ABSTRACT

This study was conducted to examine the island mass effect at St. Lucia by describing physical characteristics of the bathymetry and water column and by showing that upwelling rather than river runoff could cause increased productivity of the plankton, particularly diatoms, radiolarians, silicoflagellates, and euphausiids. An underwater peninsula or hump between the 20 fm and 100 fm contours was chosen as the locus of a sampling grid (figure 15). This was an ideal local feature for studying both inshore/offshore and upstream/downstream effects of upwelling. Nansen bottles, BTs, meter nets, a phytoplankton net, and a sediment scoop were deployed to obtain the required data.

The data supported an upwelling mechanism (figure 16) whereby nutrient rich, relatively fresh, cold Antarctic Intermediate Water (AAIW) is upwelled as it flows from east to west past St. Lucia into the Caribbean. Locally, at the hump, currents flow NE - SW, hit the hump and some upwelling occurs. There was good evidence for the upwelling in the silicate data, which increased rather than decreased near the surface. There was little evidence of river runoff or of silica dissolution from the sediment as silicate sources, but silicate in adjacent AAIW water was a sufficient source. Silica sinks could be marine organisms, detritus fallout, and outgoing currents. Temperature data showed input to the mixed layer as deep as 120m at the hump/ the mixed layer and the water mass below it could be mapped from inshore to offshore (figure 16). A lowering of the mixed layer at the hump was very good evidence of upwelling.

An open-ocean species of euphausiid was found at the hump in shallow water. The best explanation for its presence is that it was passively upwelled along with AAIW. The combined silica, temperature, and euphausiid data lend probability to the upwelling mechanism as a cause for the island mass effect. Little to no evidence was found to give

credibility to river runoff as a source of increased production near St. Lucia.

Figure 15. Station grid for island mass effect study off St. Lucia. Squares = hydrostation; circles = sediment scoop; diamonds = BT

Figure 16. A model of circulation off St. Lucia showing upwelling, river runoff, the thermocline, and silica sources and sinks.

METHODOLOGICAL STUDIES

Two studies were done to aid in the practical execution of laboratory procedures. A key to crustaceans, a significant component of zooplankton, was written (Jordan and Harris), and a manual of the use of oceanographic gear was compiled (Burt).

KEY TO CRUSTACEANS

Sarah Jordan and Polly Harris

A key from Subphylum Crustacea down to Orders was put together using sources available on the R/V Westward. The completed key, along with a glossary and a summary key (figure 17) will be available for use on future cruises.

The information to construct this key was obtained by taking notes from sources found in the lab. To organize the data, notes were taken in table form with various members of a group (class, subclass, superorder, or order) along the vertical axis and characteristics along the horizontal axis (eyes, carapace, appendages, etc.). To organize the key, a series of steps with two choices of characteristics at each was made. Each choice led to another step that differentiated another characteristic or led to distinguishing a certain class, subclass, superorder, or order. The key was divided into sections for each division (class, subclass, etc.). For the final section on orders, some useful characteristics such as habitat, size, feeding, and common name were given along with a general diagram of that order. To make a glossary, unfamiliar terms encountered during the research were listed and their definitions found. The summary key was made by listing the Crustacean classification in one column with a small diagram in the second column, and a few distinguishing characteristics in the third column. This compacted key will be useful as a quick reference to someone using a microscope or working in the lab.

COMPACT KEY TO CRUSTACEANS

PHYLUM ARTHROPODA

SUBPHYLUM CRUSTACEA

I CLASS COPEPODA

A ORDER CYCLOPOIDA

PLANKTONIC & BENTHIC
ONE TO SEVERAL mm
NO CARAPACE
2nd ANTENNA UNIRAMOUS

B ORDER CALANOIDA

PRIMARILY PLANKTONIC
ONE TO SEVERAL mm
NO CARAPACE
2nd ANTENNA BIRAMOUS
PRINCIPLE POINT BETWEEN 6th & 7th
SEGMENT/5th LEG ON LAST MEIOSOME
SEGMENT

C ORDER HARPACTICOIDA

PRIMARILY BENTHIC
ONE TO SEVERAL mm
PRINCIPLE POINT BETWEEN 5th & 6th
SEGMENT/5th LEG ON 1st SEGMENT
OF URSOME

II CLASS CEPHALOCARIDA

NO CARAPACE
NO EYE
LESS THAN 4 mm

III CLASS OSTEOCARIDA

A ORDER CLADOPODA

BIVALVED CARAPACE
NO THORACIC APPENDAGES

B ORDER PLATYPODA

BIVALVED CARAPACE
ONE PAIR THORACIC APPENDAGES

C ORDER POLDOPODA

BIVALVED CARAPACE
2 PAIR THORACIC APPENDAGES
2nd ANTENNA UNIRAMOUS

IV CLASS MALACOSTRACA

A SUBCLASS LEPTOSTRACA

1 ORDER NEBALIACEA

UNHINGED, BUT BIVALVED CARAPACE
8 THORACIC APPENDAGES

B SUBCLASS EUMALACOSTRACA

1 SUPERORDER EUCARIDA

a ORDER DECAPODA

CARAPACE FUSED WITH ALL THORACIC
APPENDAGES
3mm TO SEVERAL METERS
TEN APPENDAGES
SOME PELAGIC, SOME BURROW
FIRST 3 PAIRS THORACIC APPS. ARE
SPECIALIZED MAXILLIPEDS

b ORDER EUPHALSACEA

CARAPACE FUSED WITH ALL SEGMENTS
ALL THORACIC APPS. UNSPECIALIZED

2 SUPERORDER HETEROCARIDA

a ORDER STomatopoda

RIDGES ON CARAPACE & SEGMENTS
5-35 cm

3 SUPERORDER PERICARIDA

a ORDER TANAIDACEA

1-2 mm
STALKED EYES
2nd THORACIC LEGS WITH PINCERS

b ORDER MYSIDACEA

AVERAGE 1.5-3 cm
STALKED EYES
2nd THORACIC LEGS UNSPECIALIZED

c ORDER CUMACEA

AVERAGE 1.5-3 cm
SESSILE EYES
CARAPACE

d ORDER ISPODA

SESSILE EYE
FLATTENED TOP TO BOTTOM

e ORDER AMEHIPODA

SESSILE EYES
FLATTENED SIDE TO SIDE
LESS THAN 0.5 mm

V CLASS MYSIDOCARIDA

LONG THIN CARAPACE
4 OR 5 THORACIC APPENDAGES

VI CLASS BRANCHIURA

3-12 mm
CIRCULAR CARAPACE
4 OR 5 THORACIC SEGMENTS

VII CLASS CIRRIPEdia

A ORDER THORACIA

COVERED WITH CALCAREOUS PLATES
4-6 PAIRS APPENDAGES
ADULTS USUALLY ATTACHED TO SUBSTRATE

Figure 17. Summary key for the "Key to Crustaceans" compiled from references on the R/V Westward.

An oceanographic equipment manual for the R/V Westward

Susan Burt

ABSTRACT

A notebook of hydrographic and biological equipment used on the R/V Westward was compiled. Each of the fourteen instruments has a schematic diagram, general description, operation instructions and specifications (figure 18). Appropriate data sheets are included for some of the equipment as well. The manual serves as an educational tool for future SEA students as well as visiting scientists, specifically in the familiarization of the oceanographic equipment available aboard the vessel.

SPECIFICATIONS

SIZE: 55 cm long

SAMPLING AREA: 1.25 Capacity

WEIGHT, UNLADEN: Approximately 15 lbs

WINCH: #1 Hydrowinch

MANPOWER REQUIRED: Three: winch operator + 2 deck men

RECOMMENDED SPEEDS:

LOWERING: 50 m/min RETRIEVAL: 100 m/min

TOWING: 0° Wire angle-hove to

WIRE-OUT/METER DEPTH: As desired

SUGGESTED FISHING TIME:

SPECIAL COMMENTS: Messenger travels at 200 m/min at 0°-30° wire angle. Keep bottles in upright position at all times when transporting them. Be sure to check prior preparations.

PROBLEMS PRESENTED AND SUGGESTED SOLUTIONS:

Figure 18. Sample sheet from the "R/V Westward Oceanographic Equipment Manual".

LONG-TERM STUDIES

Currently three long-term distribution studies are being conducted under the auspices of SEA staff and associates. (1) neuston studies for pelagic tar and Sargassum weed distribution are coordinated by SEA staff; (2) marine mammal and pelagic bird studies are supervised by Timothy Rumage, III, Curator, Natural History Museum, RISD; (3) the distribution of the phyllosoma larvae of spiny lobsters is being studied by Mary Farmer, Staff Scientist.

In each of these areas individual research projects were conducted on W-66. (1) An examination of the relationship between the floating tar caught in neuston nets and the amount of tar suspended in the water column showed a surprisingly high amount of tar beneath the thermocline and an undetermined relationship between suspended and floating tar concentration (Hanford). The organisms that live on the floating tar were found to undergo succession and a food web was proposed for the system (Woodhouse). Many of the organisms found on tarballs have been known for years as organisms that encrust Sargassum weed. These organisms were most abundant on weed found around 30° N on this cruise, although the reason for this abundance could not be determined (Kelley). Motile organisms such as fish and crabs are also members of the Sargassum community. The diversity of these organisms decreased with an increase in salinity but this finding may have been coincidental since diversity could also have decreased for biological reasons (Mercaldo). The only marine insect, Halobates micans, is also caught in the neuston net and on this cruise it was shown that the speed of towing the net affected how many Halobates were caught (Chapin).

(2) Few marine mammals are usually seen on the usual cruise track of the Westward in the fall and 1982 was no exception. Cetaceans were sighted six times, mostly near islands. At least three of the sightings were the first reported by the Westward for the region, and one sighting might suggest migration time between winter and summer ground for the harbor porpoise (Stone).

(3) One of the perplexing problems of spiny lobster larvae dispersal is whether larvae leaving a region such as Florida or the Bahamas can be carried, during its 8-11 month larval life, all the way around the Sargasso Sea and back to the habitat of the adults. Although the problem was not solved this cruise, a large haul of larvae near the Echo Bank region suggested that the trip was at least feasible. Three other possibilities were also suggested as possible reasons for the presence of these larvae at this place (Goldsmith).

The distribution of suspended particulate tar found in the water column in the Northern Sargasso Sea and its relation to surface tar

Randy Hanford

ABSTRACT

The relationship between the concentration of tar balls found in the surface water and particulate tar found suspended at different depths in the water column in the Northern Sargasso Sea was observed on W-66 aboard the research vessel Westward. Neuston tows were used to sample the surface tar balls and Nansen bottle hydrocasts were used to sample the particulate tar suspended in the water column. A high concentration of suspended tar was present within the thermocline and an even higher concentration was found at 300m. The weight of tar found in neuston tows was generally related to the concentrations of suspended tar (figure 19) but more data are needed, especially from deeper within the water column, to determine whether surface and suspended tar concentrations are directly proportional.

Figure 19. Particulate tar concentrations at the surface (black bar), compared with concentrations suspended in the water column. Suspended tar was determined two ways: total number of tar particles (hatched bar) and volume of tar (white bar).

A study of community succession and structure on pelagic tar

Sarah Woodhouse

ABSTRACT

Over the past decade pelagic tar concentration in the Sargasso Sea has been increasing (Butler et al., 1973). This study was designed to examine the organisms that inhabit pelagic tarballs. Tarballs were collected throughout the Sargasso Sea, and the organisms found on them were recorded. The consistency of the tar was used as a measure of age to demonstrate a pattern of the distribution of organisms. Youngest tarballs had no organisms, the next age was highly diverse, and the oldest tarballs showed a reduction in diversity. Small tarballs supported an abundance of polychaete worms whereas large ones had none of that species; the goose barnacle Lepas and the Spirorbis worm were present on large, but not small, tarballs (figure 20A). The data support a model of ecological succession derived from a food web that has plankton and detritus at the base and Spirorbis as top predator (figure 20B).

DISTRIBUTION OF ORGANISMS ON SARGASSUM

Species

	A	B	C	D	E	F	G	H	I	J	K
consistency: hard	74	25- 50%	1	8						3	2
0-200 mm ²	72		1	15		7	2			4	17
consistency: semisoft		5- 50%	3	8	2	7	2	1	3	3	10
200-400 mm ²	2										
consistency: sticky											
400 mm ²			3	1	2			1	3	1	4

- A: Polychaete tubeworm
 B: Diplosoma gelatinosum
 C: Membranipora tuberculata
 D: Anemone
 E: Flatworm
 F: Gonothyra gracilllis
 G: Campanulani volubilis
 H: Lepas anatifera
 I: Spirobis corrugatus
 J: Unidentified hydroid
 K: filamentous strand

TARBALL FOOD WEB

Figure 20. A. Organisms found on tar balls, arranged by age (sticky = young; hard = old) and by surface area (mm²). B. Hypothetical food web for organisms living on tar balls.

Northern and southern distribution of Sargassum epibionts in the Sargasso Sea

John R. Kelley

ABSTRACTS

A study was undertaken to examine any differences in the distribution of epibionts living on Sargassum in the Northern and the Southern regions of the Sargasso Sea. The epibionts present on Sargassum have been noted and studied a great deal, but a comparison of percent coverage and diversity between different regions of the Sargasso Sea has not been done.

Sargassum samples were obtained by neuston tows and dip netting at seven stations (1, 2, 4, 6-0; see figure 2) across a transect of the Sargasso Sea from 33°59'N to 27°40'N. Leaves, bladders, and stems were examined. The northern station was dominated by Clytia noloformis and the southern station by Spirorbis corrugatus and various species of hydrozoans (figure 21).

The percent coverage for stems, bladders, and leaves was very high, around 30 N (station 6). A convergence zone has been reported in this region, but the reason for a relationship between that physical factor and the high percent cover was not immediately obvious.

Figure 21. Percentage of encrusting species found on leaves, stems, and bladders of Sargassum weed in the northern (stations 1 and 2) and southern (stations 4, 6-9) Sargasso Sea. Species key: A = *Clytia noliiformis*, hydrozoan. B. *Diplosoma gelatinosum*, tunicate. C = *Membranipora tuberculata*, bryozoan. D. *Plumularia setaceoides*, hydrozoan. F. *Spirorbis corrugatus*, polychaete. G. *Sertularia inflata*, hydrozoan. H. *S. gracilis*, hydrozoan.

Diversity of motile macrofauna associated with pelagic Sargassum weed

Renee Mercaldo

ABSTRACT

Sargassum weed was collected during seven neuston tows taken along the surface (stations 2, 4-0; figure 3). Fourteen species and 315 individuals of motile macrofauna were found and identified (table 5). Diversity was calculated using Margalef's formula:

$$D = \frac{(S - 1)}{\ln N}, \text{ where } S = \text{number of species and} \\ N = \text{number of organisms.}$$

Low diversity was observed overall and seemed to decrease moving both south. Diversity also decreased with a rise in salinity. No correlation could be detected between diversity and volume displacement (a measure of biomass) or between diversity and temperature. The low diversity found in this study may be attributed to several factors including seasonal succession, reproductive and larval cycles, size and age of the weed, migration and island biogeography.

Table 5 Species of motile macrofauna, their biomass and diversity, associated with Sargassum

List of Macrofauna	Station No.						
	2	4	5	6	7	8	9
<u>Chaetognatha</u>	3	0	0	0	0	0	0
<u>Doto pygmaea</u>	0	0	0	0	0	0	0
<u>Flatworm</u>	11	0	0	0	0	0	0
<u>Hippolyte coerulescens</u>	0	6	0	0	0	0	0
<u>H. zostericola</u>	1	7	0	0	0	0	0
<u>Latreutes fucorum</u>	8	37	0	0	0	5	1
<u>L. tenuicornis</u>	1	13	0	0	0	6	3
<u>Litiopa melanostoma</u>	0	0	0	1	0	0	0
<u>Planes minutes</u> (adult)	2	0	3	4	2	3	4
<u>P. minutes</u> (larvae)	1	0	29	0	36	0	107
<u>Platynereis coccinea</u>	0	0	0	0	0	1	0
<u>P. dumerillii</u>	1	1	0	1	0	1	0
<u>Portunus sayi</u>	0	0	1	0	0	1	1
<u>P. spinimanus</u>	0	0	0	0	0	1	0
Total # of organisms	28	65	33	6	38	18	127
Total # of species	8	6	3	3	2	7	5
Volume displacement, ml/100g weed	19	0.079	53	36	57	5.7	12
Diversity Index, D	2.1	1.2	0.6	1.1	0.28	0.35	0.83

The effect of neuston net tow speed and light (day vs. night) on the capture rate of Halobates micans (Hemiptera, Gerridae) in the North Atlantic Ocean

Nancy R. Chapin

ABSTRACT

The capture rate of the marine insect Halobates micans was examined by sampling with a neuston net under a variety of sea states, tow speeds, and lighting conditions. Four types of tows were compared: slow speed daytime tows, fast speed daytime, slow night, and fast night. Each of the four groups contained three or more neuston tows, giving a total of sixteen sample sites at 15 stations. All tows lasted 30 minutes, and the number of Halobates per 1000m² was calculated in order to compare tows with different distances.

Fast tow speeds (~4 knots) captured more Halobates than did slow tow speeds (~2 knots), both at night and during the day (figure 22). The hypothesis that the insect sees the net in time to avoid it was not supported in this study. If that were true, then more insects should be captured at night than during the daytime, and here more insects were captured during the day (figure 22).

Figure 22. Effect of tow speed and light (day vs. night) on number of Halobates captured in a neuston net. White bar = all Halobates; hatched bar = adults only.

Cetacean sightings on cruise W-66

Amy M. Stone

Marine mammals were sighted six times on W-66, all near islands in the Caribbean Sea, with the exception of a pilot whale seen on 23 October at the density front in the Sargasso Sea (figure 23). These two regions - the front and coastal Caribbean water - represent areas of relatively high productivity surrounded by barren, unproductive water. While the migratory routes for most North Atlantic cetacean species have not been determined, we do know that the Caribbean Sea is the major wintering ground for the species that migrate south in the fall.

The identifications (table 6) for all but the Tursiops are tentative, particularly for the first two sightings. The animal seen very briefly at the front was believed to have been a short fin pilot whale, Globicephala macrorhynchus, due to the presence of a sharply falcate fin and dark body color. The whales seen on 02 November were originally identified as pilot whales, a decision based on body size and dark color. However, further analysis of fin shape and swimming profile indicated that they were more likely Risso's dolphins, Grampus gireus. The characteristic gray color of the adults and the dorsal scars were not observed, making this identification somewhat suspect.

The dolphins riding the bow wave on 06 November were one of two species in the genus Stenella, S. longirostris or S. coeruleoalba, and were most likely Spinner dolphins, S. longirostris. This decision was based on the gradual color changes of dark to white from dorsal to ventral surfaces (as opposed to the distinct stripes of S. coeruleoalba), the presence of white on the beak, their small size, and the fact that Spinner dolphins are more likely to be found in coastal waters than the striped dolphins. However, none of the characteristic leaping and spinning behavior of Spinners was observed.

This sighting does not correspond with data collected on previous Westward cruises; according to Rumage*, the only Stenella species sighted in the 13°N x 61°W block have been of Bridled dolphins, S. frontalis, or possibly Atlantic Spotted dolphins, S. plagiodon (figure 24).

Rumage, T. 1981. Marine mammal sightings, W-60. W-60 Cruise Report. Sea Education Association.

There was insufficient light at 0130 on 12 November to identify the dolphins riding the bow wave. The animals sighted later that day were identified as Bottlenose dolphins, Tursiops truncatus, based on their gray color on the dorsum gradually changing to white on the belly, and their short beaks. They rode the bow wave for quite awhile, giving us a good chance to make a positive identification.

The dolphins seen on 16 November were again T. truncatus. It is interesting to note that the only previous sighting of Tursiops on a fall cruise occurred at the beginning of W-60, when they were seen much farther north, east of the New Jersey shore. It is possible that the Tursiops seen on W-60 were migrating south to the Caribbean, while those seen on W-66 had already reached their wintering grounds a month later in the year. Another interesting point is that on both W-60 and on the fall trip of 1977, Saddleback dolphins, Delphinus delphus, were sighted southeast of Bermuda. Westward passed through the same area on W-66 (close to the convergence zone) and one pilot whale was seen, but no Delphinus were sighted.

Table 6. Cetaceans sighted on W-66

<u>Date</u>	<u>Time</u>	<u>Position</u>	<u>Number</u>	<u>Species</u>
23 Oct.	0657	27°25N, 58°25W	1	<u>Globicephala macrorhyncus</u>
02 Nov.	1545	14°29N, 61°11W	1 or 2	<u>Grampus griseus</u>
06 Nov.	0600	13°52N, 61°19W	12	<u>Stenella longirostris</u> or <u>Stenella coruleoalba</u>
12 Nov.	0130	17°01N, 62°10W	10	unidentified dolphins
12 Nov.	0700	17°13N, 62°18W	12	<u>Tursiops truncatus</u>
16 Nov.	1750	18°09N, 63°50W	8-10	<u>Tursiops truncatus</u>

Figure 23. Locations of sightings of marine mammals on cruise W-66.

Figure 24. Sightings of marine mammals near Caribbean islands on cruise W-66 (triangle) compared with sightings on W-60 (circle). Key to species given in figure 23.

Recruitment of Panulirus argus larvae in the Echo Bank region of the North Atlantic

David Goldsmith

ABSTRACT

The phyllosoma larvae of the spiny lobster, Panulirus argus, were collected from neuston tows and meter net tows as the R/V Westward crossed the Sargasso Sea. The larvae were then counted and staged in hopes of determining migration patterns. Over 200 larvae were captured, 154 of these in one 5-meter net tow which took place in a region of the southern Sargasso near Echo Bank (figure 25). Three hypotheses were proposed to explain the extraordinary number of larvae captured at this station. The first was that a local population of spiny lobster is found in the Echo Bank region. The second was that the larvae were recruited from Bermuda along an interior gyre of the Sargasso Sea. The third was that the larvae were recruited from Africa along the North Equatorial current. Evidence was presented both in support of and opposed to each of the hypotheses. It seems possible that a combination can be used to explain our findings.

Figure 25. Distribution of spiny lobster larvae across the Sargasso Sea and North Equatorial Current. Numbers represent total number of larvae caught per station on cruise W-66 (circle) and on past cruises (triangle). Arrows show possible path of migration from Bermuda (small) and the direction of flow of the North Equatorial Current (wide).

COOPERATIVE SHIP WEATHER OBSERVATION PROGRAM (NOAA)

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

On W-66, 36 complete sets of meteorological data were collected, of which 14 were successfully transmitted to the Coast Guard Station in Portsmouth, Virginia, 3 to the station in New Orleans, Louisiana, and 19 did not get through.

APPENDICES

Appendix I:

W-66 Station Summary

Station No.	Date	Time Begun	Latitude (N)	Longitude (W)	Baththermograph	Secchi disc	Hydrocast (6 bottle)	Hydrocast (12 bottle)	Neuston tow	Phytoplankton (single)	Phytoplankton (multi-net)	Zooplankton (single)	Zooplankton (multi-net)	Sediment scoop	Other (specify)
W66-1	13 Oct 82	1620	33° 56'	65° 34'	✓		✓				✓		✓		
W66-2	14 Oct 82	2200	32° 18'	64° 40'	✓		✓		✓						
W66-3	17 Oct 82	1210	32° 17'	64° 18'	✓	✓		✓		✓			✓		
W66-4	18 Oct 82	1345	31° 52'	62° 05'					✓						
W66-5	20 Oct 82	0020	29° 51'	60° 22'					✓						
W66-6	20 Oct 82	0110	29° 21'	60° 41'	✓	✓	✓		✓						
W66-7	21 Oct 82	0000	28° 12'	60° 47'					✓						
W66-8	21 Oct 82	1200	27° 48'	60° 08'	✓		✓		✓						
W66-9	22 Oct 82	0046	27° 40'	59° 54'					✓						
W66-10	22 Oct 82	1710	27° 56'	58° 20'	✓	✓	✓				✓				
W66-11	23 Oct 82	0840	27° 25'	58° 25'	✓		✓				✓				
W66-12	23 Oct 82	1130	27° 21'	58° 22'	✓		✓				✓				
W66-13	23 Oct 82	1635	27° 12'	58° 33'	✓		✓				✓				
W66-14	26 Oct 82	1205	21° 29'	57° 12'	✓		✓						✓		
W66-15	27 Oct 82	0005	20° 15'	57° 10'	✓		✓						✓		
W66-16	27 Oct 82	0600	20° 12'	57° 11'	✓		✓						✓		
W66-17	27 Oct 82	1200	19° 35'	57° 35'					✓						
W66-18	27 Oct 82	1745	19° 20'	57° 45'	✓		✓						✓		
W66-19	28 Oct 82	0000	19° 00'	58° 50'					✓						
W66-20	28 Oct 82	1200	18° 10'	58° 15'	✓		✓						✓		
W66-21	29 Oct 82	0005	17° 34'	58° 48'	✓		✓						✓		
W66-22	29 Oct 82	0557	17° 02'	58° 56'	✓		✓						✓		
W66-23	29 Oct 82	1200	16° 37'	59° 01'					✓						T,S,N*
W66-24	29 Oct 82	1800	16° 07'	59° 08'	✓		✓						✓		
W66-25	30 Oct 82	0100	15° 38'	59° 23'					✓						T,S,N*
W66-26	30 Oct 82	1210	15° 02'	59° 52'											O/C**
W66-27	30 Oct 82	1930	14° 39'	59° 55'		✓									O/C**
W66-28	31 Oct 82	1235	14° 08'	60° 27'	✓			✓		✓					
W66-29	01 Nov 82	0720	13° 44.6'	60° 49.8'	✓	✓	✓			✓			✓		
W66-30	01 Nov 82	1053	13° 44.4'	60° 52.9'	✓	✓	✓			✓		✓			
W66-31	01 Nov 82	1227	13° 46.2'	60° 52.8'	✓		✓			✓		✓		✓	

(continued)

W-66 Station Summary (continued)

Station No.	Date	Time Begun	Latitude (N)	Longitude (W)	Baththermograph	Secchi disc	Hydrocast (6 bottle)	Hydrocast (12 bottle)	Neuston tow	Phytoplankton (single)	Phytoplankton (multi-net)	Zooplankton (single)	Zooplankton (multi-net)	Sediment scoop	Other (specify)
W66-32	01 Nov 82	1440	13° 48.8'	60° 53.5'	✓	✓	✓			✓		✓		✓	
W66-33	01 Nov 82	1715	13° 45.7'	60° 50.6'	✓		✓			✓					
W66-34	01 Nov 82	2120	13° 47.2'	60° 51.7'	✓		✓			✓		✓			
W66-35	02 Nov 82	0053	13° 49.7'	60° 51.8'	✓		✓			✓			✓		
W66-36	05 Nov 82	2010	13° 47.4'	60° 49.3'										✓	T*
W66-37	05 Nov 82	2056	14° 08'	61° 03'	✓		✓		✓				✓		
W66-38	06 Nov 82	0415	13° 59.9'	61° 03'										✓	
W66-39	06 Nov 82	1145	13° 27'	61° 10'	✓		✓		✓				✓		
W66-40	06 Nov 82	1900	13° 13'	61° 18'										✓	
W66-41	07 Nov 82	1015	12° 46'	61° 25'					✓						
W66-42	10 Nov 82	1245	14° 43'	61° 29'			✓		✓						
W66-43	11 Nov 82	1030	15° 37'	61° 57'	✓	✓	✓						✓		
W66-44	12 Nov 82	1100	17° 00'	62° 15'	✓	✓	✓						✓		

*T=Surface temperature

S=Surface salinity

N=Surface nutrients (phosphate, silicate)

**O/C=opening/closing net system

Appendix II. Bathythermograph Summary

BT #	Date	Time	Ts °C	Latitude(N)	Longitude(W)
1	11 Oct 82	1139	22.0	37 51.6	69 47.2
2	11 Oct 82	1342	23.8	39 39.9	69 40.7
3	11 Oct 82	1515	25.3	37 30	69 38.5
4	11 Oct 82	1400	23.2	37 22	69 38.5
5	13 Oct 82	0845	24.9	34 22	66 11
6	13 Oct 82	1155	25.1	34 06	65 57
7	13 Oct 82	1535	25.0	33 56	66 37
8	14 Oct 82	0341	24.4	33 40	65 14
9	14 Oct 82	0810	25.0	33 19	65 08
10	14 Oct 82	1340	25.2	32 51	64 49
11	14 Oct 82	1606	25.8	32 35	64 39
12	14 Oct 82	2102	25.2	32 15	64 36
13	17 Oct 82	1116	25.5	32 21	64 29
14	17 Oct 82	2345	25.1	32 16	63 40
15	18 Oct 82	0345	25.1	32 14	63 23
16	18 Oct 82	0900	24.9	32 08	62 56
17	18 Oct 82	1740	25.0	31 38	62 00
18	18 Oct 82	2000	25.1	31 33	61 47
19	18 Oct 82	2110	24.8	31 27	61 36
20	18 Oct 82	2250	25.0	31 20	61 20
21	19 Oct 82	0100	25.0	31 23	61 01
22	19 Oct 82	0330	25.3	31 09	61 05
23	19 Oct 82	0945	25.2	30 53	60 49
24	19 Oct 82	1400	25.1	30 30	60 45
25	19 Oct 82	1745	25.2	30 12	60 34
26	20 Oct 82	0700	26.0	29 25	59 53
27	20 Oct 82	1410	26.1	28 54	60 36
28	20 Oct 82	1850	26.5	28 33	60 44
29	21 Oct 82	0145	26.5	28 12	60 47
30	21 Oct 82	0400	26.5	27 47	60 48
31	21 Oct 82	0749	26.8	27 40	60 50
32	21 Oct 82	0958	26.6	27 53	60 45
33	21 Oct 82	1400	26.7	27 54	60 34
34	21 Oct 82	1800	26.5	27 57	60 22
35	21 Oct 82	2020	26.5	27 50	60 14
36	22 Oct 82	0015	26.8	27 42	59 56
37	22 Oct 82	0406	26.8	27 39	59 37
38	22 Oct 82	0727	26.7	27 48	58 23
39	22 Oct 82	1145	26.9	27 43	58 51
40	22 Oct 82	1415	26.8	27 52	58 52
41	22 Oct 82	1948	27.1	27 56	58 20
42	22 Oct 82	2212	27.0	27 43	58 24
43	23 Oct 82	0010	27.1	27 31	58 29
44	23 Oct 82	0245	27.0	27 19	58 29
45	23 Oct 82	0329	27.1	27 10	58 20
46	23 Oct 82	0426	27.0	"R A P I D T R A N S E C T"	
47	23 Oct 82	0436	26.9	"	
48	23 Oct 82	0446	27.0	"	
49	23 Oct 82	0457	26.9	"	

Appendix II. (continued)

BT #	Date	Time	Ts °C	Latitude(N)	Longitude(W)
50	23 Oct 82	0507	26.9	"R A P I D	T R A N S E C T"
51	23 Oct 82	0517	27.0	"	"
52	23 Oct 82	0529	27.0	"	"
53	23 Oct 82	0543	26.8	"	"
54	23 Oct 82	0553	26.8	"	"
55	23 Oct 82	0601	26.9	"	"
56	23 Oct 82	0610	26.9	"	"
57	23 Oct 82	0624	26.8	"	"
58	23 Oct 82	1014	27.0	"	"
59	23 Oct 82	1440	27.2	27 17	58 25
60	23 Oct 82	1529	27.2	27 12	58 29
61	23 Oct 82	1745	27.1	27 12	58 33
62	23 Oct 82	1928	27.0	27 20	58 30
63	23 Oct 82	2304	27.0	26 50	58 30
64	24 Oct 82	0310	27.0	26 35	58 20
65	24 Oct 82	0711	27.0	26 15	58 20
66	24 Oct 82	1104	27.5	25 46	58 28
67	24 Oct 82	1310	27.4	25 43	58 20
68	24 Oct 82	1500	27.5	25 35	58 19
69	24 Oct 82	2130	27.2	25 17	58 32
70	24 Oct 82	2370	27.0	25 11	58 26
71	25 Oct 82	0305	27.2	24 47	58 16
72	25 Oct 82	0700	27.5	24 29	58 06
73	25 Oct 82	1100	27.3	24 10	58 00
74	25 Oct 82	1504	27.5	23 59	57 37
75	25 Oct 82	1710	27.3	23 33	57 25
76	25 Oct 82	2300	26.8	23.25	57 21
77	26 Oct 82	0347	27.2	22.37	57 07
78	26 Oct 82	0700	27.0	22 10	57 00
79	26 Oct 82	1135	27.2	21 30	57 10
80	26 Oct 82	1730	27.8	21 10	57 10
81	26 Oct 82	1917	27.5	20 56	57 13
82	26 Oct 82	2330	27.3	20 21	57 09
83	27 Oct 82	0545	27.5	20 12	57 11
84	27 Oct 82	1130	27.7	19 46	57 35
85	27 Oct 82	1500	27.8	19 32	57 38
86	27 Oct 82	1730	27.7	19 20	57 45
87	27 Oct 82	2310	27.5	19 07	57 51
88	28 Oct 82	0300	27.5	18 46	57 57
89	28 Oct 82	0705	27.6	18 30	58 04
90	28 Oct 82	1200	27.8	18 10	58 15
91	28 Oct 82	1530	27.8	18 10	58 10
92	28 Oct 82	1915	27.7	18 05	58 20
93	29 Oct 82	0000	27.8	17 34	58 43
94	29 Oct 82	0340	27.8	17 18	58 51
95	29 Oct 82	0532	27.9		
96	29 Oct 82	1100	28.1	16 49	58 59
97	29 Oct 82	1513	28.1	16 24	59 06
98	29 Oct 82	1745	28.1	16 07	59 08

Appendix II. (continued)

<u>BT #</u>	<u>Date</u>	<u>Time</u>	<u>Ts °C</u>	<u>Latitude(N)</u>	<u>Longitude(W)</u>
99	29 Oct 82	2308	27.8	15 45	59 20
100	30 Oct 82	0318	27.9	15 25	59 32
101	30 Oct 82	2135	28.0	14 39	59 55
102	30 Oct 82	2315	27.9	14 29	59 58
103	31 Oct 82	0315	28.0	14 07	60 12
104	1 Nov 82	0710	28.0	13 56	60 49
105	1 Nov 82	1001	28.0	13 43	60 50
106	1 Nov 82	1100	28.1	14 44	60 53
107	1 Nov 82	1330	28.2	13 46	60 53
108	1 Nov 82	2100	28.0	13 47	60 51
109	1 Nov 82	2205	28.0	13 47	60 51
110	2 Nov 82	0035	28.0	13 48	60 50
111	5 Nov 82	2035	28.0		
112	5 Nov 82		28.0		
113	6 Nov 82	0415	27.8		
114	6 Nov 82	1121	28.0		

Appendix III. Summary of Hydrocast Data

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (°/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-1	0	Surface	25.0	-	-	0.30	
	70	72	21.12	36.211	5.16	0.18	
	100	97	19.37	36.488	5.00	-	
	200	183	17.91	36.460	4.88	0.47	
	600	537	13.31	36.705	4.45	1.18	
	800	679	9.67	35.997	3.61	2.22	
W66-2	0	Surface	25.4	36.278			
	25	-	25.49	-			
	50	40	25.47	-			
	100	84	22.61	-			
	150	123	20.42	-			
	200	161	19.10	-			
W66-3	0	Surface	25.37	36.226	4.76	0.05	6.3
	25	36	25.30	36.183	4.77	0.13	7.5
	50	55	25.33	36.195	4.78	0.11	4.5
	75	-	22.88	36.120	4.59	0.006	4.9
	100	-	20.82	36.547	4.54	0.18	6.4
	125	114	19.93	36.464	4.73	0.07	5.3
	200	197	18.62	36.488	-	0.07	6.3
	400	383	17.63	36.385	5.00	0.20	5.8
	600	567	16.13	36.060	4.48	0.77	7.1
	800	789	11.62	36.437	3.97	0.88	12.4
	1000	925	8.13	36.044	4.20	1.24	17.5
	1200	-	5.84	35.024	5.14	1.03	17.9
W66-4	Bucket	Surface	25.0	36.162			
W66-6	0	Surface	26.12	36.631			
	25	31	26.97	36.782			
	50	48	25.66	36.222			
	100	96	19.66	36.561			
	200	201	17.91	36.422			
	300	241	17.39	36.347			

Appendix III. (continued)

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (o/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-7	Bucket	Surface	26.6	36.685		0.07	
W66-8	0	Surface	25.58	36.721			
	25	26	26.40	36.797			
	50	46	26.39	36.795			
	100	116	21.58	36.569			
	200	171	18.35	36.504			
	300	-	17.64	36.355		0.18	3.5
W66-9	Bucket	Surface	26.7	36.714		0.35	0.3
W66-10	0	Surface	27.0	36.571		0	2.8
	25	-	27.76	36.543		0.11	4.0
	50	44	26.43	36.761		0.13	5.3
	100	86	21.12	36.511		0.11	2.0
	200	182	18.57	36.404		0.13	5.0
	300	302	17.88	36.341		0.43	4.8
W66-11	0	Surface	26.93	36.476		0.07	0.9
	25	42	26.86	36.454		0	0
	50	62	24.67	36.547		0	0
	100	105	22.31	36.592		0	0
	200	-	18.95	36.382		0.03	0.2
	300	-	18.53	36.325		0.07	0.4
W66-12	0	Surface	27.16	36.559		0.03	0.4
	25	30	26.99	36.535		0.006	0.4
	50	76	23.43	36.495		0.006	1.0
	100	126	20.30	36.551		0.05	0.3
	200	222	18.24	36.361		0.07	0.3
	300	-	17.70	36.282		0.18	0.2

Appendix III. (continued)

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (o/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-13	0	Surface	27.16	36.683	-	-	0.8
	25	30	26.97	36.653	-	-	0.7
	50	54	24.92	36.584	-	-	0
	100	101	21.20	36.689	-	-	0.7
	200	191	18.60	36.451	-	-	0.9
	300	-	17.86	36.403	-	-	1.3
W66-14	0	Surface	27.33	35.003	-	-	-
	40	41	27.48	35.042	4.93	-	4.93
	60	62	27.73	37.042	5.25	-	5.25
	100	103	25.27	37.105	5.40	-	5.40
	150	147	23.38	37.127	4.84	-	4.84
	200	187	21.76	37.050	4.47	-	4.47
W66-15	0	Surface	27.46	34.972	4.38	-	4.38
	66	48	27.65	35.196	-	-	-
	100	119	24.56	36.954	-	-	-
	130	125	23.81	37.032	-	-	-
	160	151	23.27	37.056	-	-	-
	200	174	21.96	36.904	-	-	-
W66-16	0	Surface	27.39	34.805	4.76	-	4.76
	62	24	27.11	36.608	5.34	-	5.34
	100	100	24.47	36.802	5.12	-	5.12
	130	112	23.92	37.103	4.75	-	4.75
	160	145	23.02	37.003	4.84	-	4.84
	200	199	20.32	36.729	4.04	-	4.04
W66-18	0	Surface	27.66	34.719	-	-	-
	63	33	26.45	-	5.04	-	5.04
	100	114	24.83	36.927	4.93	-	4.93
	130	132	23.89	36.949	4.85	-	4.85
	160	156	22.85	36.923	4.69	-	4.69
	200	191	21.36	36.872	4.12	-	4.12
W66-19	Bucket	Surface	27.5	34.530	-	0.07	0.4

Appendix III. (continued)

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (°/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-20	0	Surface	27.60	34.719	4.74		
	70	74	27.74	36.924	5.13		
	100	104	24.63	36.602	4.70		
	130	128	23.49	37.022	4.55		
	160	-	22.43	36.971	4.42		
	200	202	20.07	36.677	4.27		
W66-21	0	Surface	27.74	34.621	4.53		
	50	58	27.13	36.278	4.68		
	100	105	24.61	36.854	4.49		
	160	160	21.21	36.661	3.66		
	200	194	18.82	36.347	3.70		
	300	333	16.04	36.023	4.00		
W66-22	0	Surface	27.97	35.054			
	65	67	27.00	36.799			
	100	96	25.04	36.933			
	160	-	26.57	37.057			
	200	210	19.95	36.716	3.92		
	300	299	16.80	36.366	4.35		
W66-23	Bucket	Surface	21.1	34.744	-	0.09	0.9
W66-24	0	Surface	27.97	34.856			
	65	-	26.97	36.028			
	100	95	26.31	36.174			
	160	134	24.60	36.767			
	200	162	23.59	36.979			
	300	257	17.88	37.083			
W66-25	Bucket	Surface	27.9	34.741	-	0.24	
W66-28	0	Surface	28.00	34.633			3.4
	25	-	27.03 (?)	34.969			3.4
	50	-	27.21	36.155			1.4
	75	71	26.12	36.569			1.4

Appendix III. (continued)

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (o/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-28 (cont.)	100	89	25.36	36.626			1.2
	150	143	23.00	36.860			1.2
	200	164	20.23	36.591			5.1
	400	321	12.92	35.396			9.1
	600	524	8.82	35.011			17.9
	800	645	6.91	34.535			25.9
	1000	748	5.62	34.443			30.6
	1200	1004	5.30	34.771			28.6
W66-20	0	Surface	-	34.487			4.2
	25	-	28.26	34.495			3.2
	50	49	28.07	35.797			2.7
	100	86	25.19	36.650			1.4
	150	138	23.31	36.832			1.1
	200	191	19.59	36.410			2.6
W66-30	0	Surface	28.02	34.728			5.3
	20	22	27.95	34.733			3.8
	25	50	27.92	35.245			4.0
	30	58	27.53	35.739			3.6
W66-31	0	Surface	28.06	34.137			0.4
	10	10	28.09	-			0.5
	20	16	28.06	34.913			0.7
	30	28	28.02	34.909			
W66-32	0	Surface	28.15	34.692			1.3
	10	6	28.12	34.705			0.6
	20	21	27.98	34.763			1.3
W66-33	0	Surface	27.97	34.814			10.9
	15	10	28.02	34.768			9.9
	25	14	27.98	34.872			7.0
	35	31	27.98	34.998			6.8

Appendix III. (continued)

Station	Assumed depth(m)	Calculated depth(m)	Temperature (°C)	Salinity (°/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-34	0	Surface	27.92	34.739			4.1
	25	22	27.99	34.754			3.6
	40	51	27.97	34.874			3.3
	60	71	26.39	36.591			1.3
W66-35	0	Surface	27.92	34.737			7.7
	25	29	27.96	35.344			7.4
	50	44	28.06	36.846			
	100	98	26.25	36.465			5.1
	150	119	24.09	36.296			3.9
	200	144	19.87	36.597			6.1
W66-37	0	Surface	27.83	35.022			
	65	44	27.86	35.523			
	100	80	26.52	36.643			
	185	124	20.30	36.634			
	230	185	19.27	36.545			
	300	251	16.03	36.116			
W66-38	Bucket	Surface	27.8	35.887			
W66-39	0	Surface	27.83	35.731			
	85	84	25.91	36.535			
	100	87	25.27	36.825			
	185	171	17.66	36.425			
	230	-	17.06	36.338			
	300	283	14.53	36.331			
W66-42	0	Surface	28.24	36.699			
	20	21	27.87	34.709			
	40	-	26.34	35.781			
	60	66	27.01	36.374			
	80	-	26.49	36.594			
	100	98	25.49	36.820			

Appendix III. (continued)

Station	Assumed depth (m)	Calculated depth (m)	Temperature (°C)	Salinity (°/oo)	Dissolved oxygen (ml/l)	Phosphate (ug-at/l)	Silicate (ug-at/l)
W66-43	0	Surface	28.19	34.937			
	20	16	28.00	34.802			
	40	-	26.82	34.632			
	60	64	27.75	31.912			
	80	84	26.82	36.381			
	100	109	25.91	36.596			
W66-44	0	Surface	27.828	34.791			
	30	20	28.007	35.025			
	65	66	27.256	36.509			
	75	-	26.269	36.571			
	85	83	25.648	36.704			
	100	114	24.997	36.430			

Appendix IV. Neuston tow summary

Station	Date	Latitude (N)	Longitude (W)	Time Towed (min)	Speed of Ship (Kts)	Sargassum (g)	Tar (g)	Halobates (No.)
W66-2	14 Oct 82	32°18'	64°40'	30	2	121	-	1
W66-4	18 Oct 82	31°52'	62°05'	30	2	240	1.94	0
W66-5	20 Oct 82	29°51'	60°22'	30	2	72	-	2
W66-6	20 Oct 82	29°21'	60°41'	30	2	47.5	4.34	0
W66-7	21 Oct 82	28°12'	60°47'	30	2	30	-	1
W66-8	21 Oct 82	27°48'	60°08'	31	1.6	315	2.12	0
W66-9	22 Oct 82	27°40'	59°54'	29	1.2	190	-	-
W66-17	27 Oct 82	19°35'	57°35'	31	3.0	negligible	-	24
W66-19	28 Oct 82	19°00'	58°50'	30	5.7	"	-	37
W66-23	29 Oct 82	16°37'	59°01'	30	5-5.5	"	-	36
W66-25	30 Oct 82	15°38'	59°23'	33	5.5	"	-	59
W66-37	06 Nov 82	14°08'	61°03'	30	5	"	-	7
W66-39	06 Nov 82	13°26'	61°10'	30	5	"	-	2
W66-41	07 Nov 82	12°46'	61°25'	30	4.4	"	-	51
W66-42	10 Nov 82	14°43'	61°29'	30	5	"	-	23
"	"	14°50'	61°28'	30	1.2	"	-	9

avg 63.5
avg 1.525