Cruise Report

W-41

Scientific Activities

Woods Hole-Bermuda-Lunenburg-Boston

July 26 - September 6, 1978

R/V Westward

Sea Education Association

Woods Hole, Massachusetts

Introductory Preface

This report documents the scientific education and research programs undertaken on the 41st cruise of the R/V Westward under direction of Sea Education Association, Woods Hole, Mass. Primary among our purposes on this six week cruise was to give its twenty-three students a multidisciplinary exposure to oceanographic concepts and research techniques, drawing on the various backgrounds of the staff and the sampling equipment on board. To this end, students were offered a wide range of relevant lecture material and on watch instruction; they were required to participate as assistants in staff directed research, as well as accomplish a personal research project of their own design. This program thus comprises Boston University Course NS CLX 225, Introduction to Marine Science Laboratory.

Due to constraints on time, results of all research efforts are presented mainly in abstract form, the state of data reduction and interpretation remaining essentially as it existed at the end of the cruise. The main body of the report contains overviews of cooperative, in-house and visiting investigator research activities, accompanied by related student reports. Summaries of major stations, tabulated and graphed data, a cruise track and details of the academic program appear in appropriate sections and in appendices.

No cruise of this type would be a success without the aid of a talented supporting staff. It has been a genuine pleasure to work with Dr. Mary Farmer, Miss Molly Allison, and Miss Abigail Ames, all members of S.E.A.'s permanent scientific staff. Miss Patricia McGill, Mr. Edward Robb, and Mr. Timothy Ramage all made stimulating contributions as visiting investigators. The ship's nautical staff, notably her alternate captains, Mr. Jonathan Lucas and Mr. Richard Farrell, deserve special thanks for their cooperation and competent management of the cruise.

Research conducted on W-41 partly represents the ongoing work of individuals and agencies that have extended their assistance to our students. Material reported herein should not be excerpted or cited without the written permission of the Chief Scientist.

Carl M. Baum
Chief Scientist
September 25, 1978

Table of Contents

	(page)
Introductory Preface	1
Table of Contents	1
Cruise Itinerary	2
Cruise Track	3
Ship's Complement	4
Academic Program	5
 List of Lectures and Seminars	 6
Overview of Research and Study Activities	8
I. Cooperative Programs	8
A. Cooperative Ship's Weather Observation Program (NOAA)	8
B. Shark Tagging by Long Line (NMFS)	8
 II. In-House Research	 8
A. Zoogeography of Western North Atlantic Midwater Fauna	8
1) Distribution of Myctophid Genera (Rand)	9
2) Gulf Stream Edge Effect (Davis)	10
B. Diel Periodicity in the Western North Atlantic	11
1) Vertical Migration in Midwater Fish (Sanantz)	11
C. Distribution of Anguilliform Leptocephalus Larvae in the Western North Atlantic	13
1) Family Diversity in Anguilliform Leptocephalus Larvae (Hatch and Owen)	13
D. Distribution and Acoustics of Marine Mammals in the Western North Atlantic	14
1) Baleen Whale Distribution and Zooplankton Abundance (Deutsch)	14
2) Photographic Identification of Whales (Belisle)	16
3) History of Whaling (McAlpin)	17
4) Whaling Legislation (Letelier)	18
E. Investigations into the Neuston and <u>Sargassum</u> Communities	18
1) Neuston Fish Diversity (Ziewacz)	19
2) Morphological Adaptations in Neuston Fish (Thebault)	20
3) <u>Sargassum</u> Weed Standing Crop (LaParl)	21
4) <u>Sargassum</u> Macrofauna Diversity (Reese)	21
5) <u>Biology of the Sargassum Fish,</u> <u>Histrio histrio</u> (Baum)	22
F. Island Mass Effects on Phytoplankton Communities (Farmer)	24
G. Physical and Chemical Comparison of Major Water Masses in the Western North Atlantic	24
1) Temperature - Salinity Profiles (Howerton and Hodges)	24
2) Nutrient Profiles (Llewellyn and Robbins)	27
3) Secchi Disc and Submarine Photometry (Glasser)	28
4) Surface Temperature Effects on Weather (Morss)	29

Table of Contents (Cont.)

H. Miscellaneous Studies and Investigations	30
1) Coral Reef Fish Observations	30
2) Epibenthos of the Continental Shelf — Otter Trawls	30
3) Life Boat Navigation Technique (Gandrup and Valpey)	30
III. Visiting Investigators	30
A. Seabird Studies	30
1) Seabird Observations from Four Central Atlantic Water Masses (McGill)	31
2) Population Dynamics of Pelagic Birds (Rumage)	32
3) Effects of Water Mass Productivity on Seabird Diversity and Density (Steiner and Quintrell)	32
B. Pathology of Pelagic Fishes (Robb)	34
Appendices	
1) Summary Logs of Major Stations	35
2) The Biological Teaching Collection	39
3) Ship's Weather Observations	40
4) Marine Mammal Sightings	41
5) Coral Reef Fishes at Castle Rock, Bermuda	43
6) Otter Trawl Species Rosters	44
7) Hydrographic Data Log	45

W-41 Geographic Itinerary

26 July	depart Woods Hole
Leg I	800 miles
08-10 August	St. George's Harbor, Bermuda
Leg II	1100 miles
23-26 August	Lunenburg, Nova Scotia
Leg III	500 miles
06 September	arrive Boston
	Total miles: 2400

W 41 Cruise Track
Figure 1

W-41 Ship's Complement

Nautical Staff

Jonathan Lucas, M.M.	Captain
Richard Farrell, Licensed Ocean Operator	Relief Captain
Richard Ogus, Licensed Mate	Chief Mate
Ronald Harelstad, B.S.	2nd Mate
Gregg Swanzey, B.S.	3rd Mate
Gary Manter, Assoc. Arts	Chief Engineer
Gail Gryska, B.A.	Steward

Scientific Staff

Carl Baum, B.S.	Chief Scientist
Mary Farmer, Ph.D.	Assistant Scientist
Molly Allison, M.S.	Assistant Scientist
Abigail Ames, B.S.	Assistant Scientist

Visiting Investigators

Patricia McGill, M.S., Wildlife Science, Cornell University; (Woods Hole-Bermuda)

Edward Robb, D.V.M. Candidate, N.Y. State College of Veterinary Medicine at Cornell University; (Bermuda-Lunenburg, Nova Scotia)

Wm. Timothy Ramage III, M.S., Biol. Science, Boston University; (Bar Harbor, Maine-Boston)

Students

College

William Belisle	Boston University
Margaret Davis	Whitman College
Charles Deutsch	Cornell University, N.Y.
Bradley Gandrup	Univ. of Connecticut
Jenny Glasser	City College (C.U.N.Y.)
Jeffrey Hatch	Framingham State College
Patricia Hodges	Wellesley College
Todd Howerton	Goucher College
William LaParl	Boston University
Christian Letelier	American University
Janet Llewellyn	U. of Nebraska at Lincoln
John McAlpin	Oberlin College
Charles Morss	Connecticut College
Ralph Owen	U. of Massachusetts
Josie Quintrell	Colby College
Carl Rand	Occidental College
Dwight Reese	Boston University
Lisa Robbins	Vanderbilt University
Lena Sanentz	Harvard University
Carolyn Steiner	Oberlin College
Hervé Thebault	University of Grenoble
Marion Valpey	Wellesley College
Thomas Ziewacz	U. of Wisconsin

Academic Program

The academic program on W-41 consisted of a series of lectures and seminars, 150 hours on watch instruction and discussions, and independent student research projects. For grading purposes, students were evaluated according to their performance in the following three areas on an equal weight basis: 1) lecture and laboratory final testing*, 2) on-watch performance as research assistants, and 3) quality of individual research project effort.

Lecture material was designed and presented to coordinate with current research activities in the laboratory. The ship's scientific staff and visiting investigators contributed according to their own backgrounds and, during the final leg of the cruise, students delivered seminars based on their completed project work.

Three students per watch were assigned to the laboratory on a rotating 24 hour basis. Under the guidance of a member of the science staff, watch standers discussed, and received technical on-the-job training in the various sampling techniques, analyses, and data reduction processes involved in the research program. Time was also allotted to their personal project work and special interests.

Student project work commenced during the shore component in Woods Hole where they may avail themselves of the unique resources of an oceanographic community in the design of a testable project hypothesis. The continuing advice and constructive criticism of the staff aided each student in the execution of his project aboard ship. The students were nevertheless entirely responsible for the final products of their efforts, the abstracts of which appear in the following pages. The complete works are maintained on file at S.E.A.

During the course of the cruise, students were given the opportunity to visit the following places of educational interest ashore:

- 1) The Bermuda Biological Station, Bermuda
- 2) A coral reef dive, Bermuda
- 3) The Bermuda Marine Aquarium
- 4) The Lunenburg National Fisheries Museum (Currently under improvement) Lunenburg, Nova Scotia

* The laboratory final was based largely on knowledge of a biological teaching collection assembled during the cruise (see appendix 2.)

W-41 Marine Science Lecture Program

Staff Lectures

Research Objectives and Academic Responsibilities for W-41	Baum/Farmer
The Bathythermograph and Ocean Thermal Structure	Ames
Nansen Bottles and Reversing Thermometers	Ames
Titration Technique	Ames
Phytoplankton and Primary Productivity	Farmer
Fish Taxonomy and General Biology	Baum
Biology of Pelagic Birds	McGill
Coral Reef Ecology	Baum/Farmer
The Sargassum Weed Community	Allison
Zooplankton Taxonomy and Identification	Allison
Qualitative and Quantitative Analysis of a Zoo- plankton Tow	Baum
Mesopelagic Ecology	Baum
Identification of Great Whales and Some Common Dolphins	Allison
Fish Pathology	Robb
Long Line Technique and Shark Dissection	Baum
Marine Bioacoustics	Rumage

Student Seminars

Family Diversity fo Anguilliform Leptocephalus Larvae	Hatch/Owen
Diversity of Macrofaunal Associates in <u>Sargassum</u> Weed	Reese
Standing Crop of Pelagic <u>Sargassum</u> Weed and Tarball Concentrations	LaParl
Seabird Density and Diversity in Relation to Water Mass Productivity	Quintrell/Steiner

Student Seminars Cont.

Morphological Adaptations of Some Neuston Fishes	Thebault
Diversity of Fish in the Neuston Layer	Ziewacz
Distribution of Genera of the Midwater Fish Family Myctophidae	Rand
Vertical Migration of Mesopelagic Fishes	Sanentz
The Effect of Ecotones on Diversity, Biomass and Relative Size of Zooplankters	Davis
The Relationship between Summer Distribution of Baleen Whales and Zooplankton Abundance in Atlantic Coastal Waters	Deutsch
A Comparison of Temperature-Salinity Profiles from Several Water Masses	Howerton/Hodges
A Comparison of Nutrient Levels in Several Water Masses	Llewellyn/Robbins
Intercalibration of a Secchi Disc and Submarine Photometer	Glasser
The Effect of Surface Water Changes on Weather	Morss
International Whaling Legislation with Special Emphasis on Canada	Letelier
The History of Whaling with a Profile of the Canadian Industry	McAlpin
Technical Photography and Shipboard Film Development	Belisle
Experiments in Life Boat Navigation	Gandrup/Valpey

Overview of Research Activities

Research activities conducted during W-41 were divided into three categories: 1) cooperative research accomplished for outside agencies, 2) in-house research originated by S.E.A. staff members, and students under staff direction, and 3) short term programs conducted by visiting investigators (see appendix 1. for a summary of stations taken). The results of each are presented below in abstract form, together with tabulated and graphic data in a preliminary state of refinement. It will be noted that an effort has been made to integrate student project work with staff research in order that each party's interests be best served.

I. Cooperative Programs

A. Ship's Weather Observations Program (NOAA)

When underway offshore, the R/V Westward routinely gathers weather observations for the National Oceanic and Atmospheric Administration in conjunction with international weather and surface-truth programs. Synoptic data is collected and transmitted to U.S. Coast Guard shore stations at 0600 and 1200 GMT daily.

Thirty-two sets of synoptic observations were recorded on W-41 and appear in Appendix 3. The rate of successful transmission was approximately 50%. Unsuccessful attempts were accounted for by shipboard radio failures, poor transmission conditions, and unexplained failures to answer on the part of the Coast Guard.

B. Shark Tagging by Long Line (NMFS)

This program is conducted in cooperation with Dr. Jack Casey at the National Marine Fisheries Service, Narragansett Lab, R.I. Sharks are captured on long lines stretching one half to one mile in length and consisting of 50-100 baited hooks. Captured sharks are tagged after ascertaining identity, sex, length and unusual characteristics. This study endeavors to elaborate upon the suspected migratory habits of certain species.

Two eighty-hook longlines were set at two fathoms in the Gulf of Maine on W-41: one at Cashes Ledge (43°03'N, 68°20'W) and a second at Stellwagon Bank (42°31'N, 70°20'W). Frozen 12-inch mackerel were used as bait. In all, 35 male blue sharks, Prionace glauca, ranging in overall length from three to nine feet (mean = 5.8 ft), were captured; 33 were tagged live and released. Of the two that expired, one seven foot specimen was dissected as a demonstration for students. No internal abnormalities were noted.

II. In-House Research

A. Zoogeography of the Midwater Fauna of the Western North Atlantic

As a part of an ongoing study following the work of Dr. Richard

Overview of Research Activities (cont.)

Backus et al., of Woods Hole Oceanographic Institute, six Isaacs-Kidd midwater trawls were conducted along the W-41 cruise track in order to provide material for investigating variations in the faunal assemblages between adjacent water masses. Carl Rand examined lantern fishes of the family Myctophidae to test the Gulf Stream as a faunal boundary between North American Slope and Sargasso Waters. Margaret Davis examined the relative diversity, density, biomass and size of Midwater Zooplankton collected at the Gulf Stream edge to look for ecotone effects. As with previous cruises, the midwater fish samples will require further work ashore before results can be critically analyzed in light of Backus et al.'s findings.

1) Distribution of Genera of the Family Myctophidae in Slope Water, Gulf Stream and North Sargasso Sea (Carl Rand)

Abstract

The distribution of genera of the family Myctophidae (Teleostei) was investigated to determine faunistic differences between the Slope Water, Gulf Stream and North Sargasso Sea water masses. This analysis of lanternfish distribution was carried out in conjunction with biological and hydrological sampling aimed at characterizing these three water masses. Results were compared to those obtained by Backus et al. Specimens were collected during a series of oblique, nocturnal Isaacs-Kidd midwater trawls at depths ranging from 600 meters to the surface and identified at the generic level. North Sargasso Sea and Slope Water were found to be faunistically distinct environments; the Gulf Stream, which acts as a boundary between the two, contains genera common to both. Additionally, Slope Water and North Sargasso Sea share similar diversity indices (1.36 and 1.21 respectively) while the diversity index of the Gulf Stream is reasonably higher (2.34). (See Table 1.)

Table 1. Distribution and biomass of myctophid genera

Genera	Slope Water		Gulf Stream		North Sargasso Sea	
	N	M	N	M	N	M
<u>Benthosema</u>	13	- 4.57	2	-0.07		
<u>Ceratoscopelus</u>	2	- 0.09	2	-0.53	3	0.30
<u>Diaphus</u>	1	0.18	1	0.04	1	1.90
<u>Gonichthys</u>	2	- 0.09	1	0.18		
<u>Hygophum</u>			1	0.04	1	0.38
<u>Lampanyctus</u>			5	0.85		
<u>Lobianchia</u>	1	0.14			1	0.08
<u>Symbolophorus</u>			1	0.04		
Total	19	5.07	13	1.78	6	2.66
No. of Genera	5		7		4	
Diversity Index	1.36		2.34		1.21	

N = number of individuals
M = biomass in ml/hr of tow

Overview of Research Activities (cont.)

2) The Effect of Ecotones on Diversity, Biomass and Relative Size of Zooplankton in the North Atlantic (Margaret Davis)

Abstract

The convergence of distinct communities produces a transition area known as an ecotone characterized by an environment intermediate between that of each of the overlapping regions. High population density and diversity have been associated with these zones due to the presence of organisms from the bordering regions as well as those specifically adapted to ecotones (Odum, 1953). A relative increase in size has also been noted when observing ecotonal water masses in the North Atlantic (Baum, personal communication).

Six Isaacs-Kidd midwater trawl samples were analyzed from regions bordering the Gulf Stream and within the Sargasso Sea and Slope waters. Total biomass was measured in number of animals per hour of towing time, and diversity was found using the index $D = S-1/\ln N$. A random sample of euphausiids was measured from each station to determine the presence of gigantism.

Relatively high diversity and population density were noted in two samples taken within or near the ecotones along the northern and southern walls of the Gulf Stream. One sample taken within the Sargasso Sea yielded comparatively low biomass and diversity as well as a relatively small size of euphausiids, while a sample taken from Slope waters produced opposite results, yet lower than those seen in the ecotone. The first sample, taken along the southern edge of the Gulf Stream gave poor results which may indicate an error in judging the position of the ecotone at that time. (See Table 2.)

Table 2. Edge effect reflected in biomass, number of kinds and diversity of organisms, and average size of euphausiids in six IKMTS

IKMT Number	Total Biomass (# individuals per hour towing)	# of Kinds of Organisms	Diversity	Ave. Size of Euphausiids (cm)	Location of Tow
1	338.00	9	0.859	1.220	Gulf Stream South Edge
2	1823.90	11	1.330	1.600	Sargasso Sea
3	472.12	9	1.290	0.880	Bermuda
4	632.25	7	0.930	0.700	Gulf Stream South Edge
5	3710.35	13	1.460	1.725	Gulf Stream North Edge
6	1247.69	9	1.120	0.750	No. American Slope Water
Total Average Size = 1.14 cm					

Overview of Research Activities (cont.)

B. Diel Periodicity in the Western North Atlantic

Two diel (24 hour) stations were conducted on W-41 and modeled after those developed by Farmer and Baum (W-40 Cruise Report). Each station consisted of four sets each of the following operations spaced at six hour intervals around the clock: 1) a bathythermograph to 900 ft. 2) a hydrocast with bottles at 0, thermocline, 200 and 400 meters, 3) a submarine photometer (Kahl 268WA310 Irradiometer) reading to 25 meters (daylight), and 4) a concurrent multiple-net zooplankton tow sampling at thermocline, 200 and 400 meters. Vertical and temporal regimes for temperature, salinity, dissolved oxygen, phosphate and nitrate were derived for each station from the nansen bottles; coefficients of incident light extinction and compensation depths (one per cent light depth) were derived from the photometer data; and the net samples were analyzed for biomass (volume displacement) of dominant taxonomic groups of zooplankton and mesopelagic fish.

This complex station constitutes an effective tool for characterizing and comparing water masses with respect to the dynamic activity of their physical, chemical and biological properties, thus providing a broader picture than would be obtained from a single sampling. Of particular interest to this cruise was the quantitative picture of vertical migration in midwater fauna provided (in relation to changing and static physical and chemical parameters.) Further, the diel activity of a warm core eddy located 180 miles south of Cape Cod on 29 July 1978 (38°33'N, 70°08'W) was compared to that of its hypothetical parent waters in the Sargasso Sea at the southern edge of the Gulf Stream 360 miles to the East (37°47'N, 62°35'W). Together with hydrographic data collected in the vicinity of these sites, the pair of diel stations provided a means of measuring the state of decay of the warm core eddy by degree of similarity in all respects to parent and present surrounding waters. Additional stations on subsequent cruises will further elucidate this picture.

Preliminary chemical and physical data for the diel stations can be located in The Hydrographic Data Log (Appendix 7.). Figure 2 depicts the diel vertical migration of midwater fauna in relation to changing chemical and physical factors. Lena Sanentz examined the vertical migratory behavior of three families of midwater fish. Various other aspects are dealt with in part by student reports in later sections.

1) Mesopelagic Fishes in the Western North Atlantic — Vertical Migration (Lena Sanentz)

Abstract

In order to measure vertical migration, two meter nets and a bongo net were used to collect samples of mesopelagic fishes from depths of 20-75, 200 and 400 meters respectively, at four stations during a 24 hour period. Two water masses were sampled: a warm core eddy (38°22'N, 70°08'W), and Sargasso Sea (37°45'N, 62°33'W). Biomass was measured by volume displacement of fish per cubic meter water filtered in the nets.

Figure 2. Diel activity of midwater fish and total zooplankton (biomass), light intensity, phosphate-phosphorus (PO_4-P), and dissolved oxygen (O_2) in two water masses: a warm core eddy and the Sargasso Sea. Four sampling sets at even intervals in 24 hours.

Overview of Research Activities (cont.)

The night catches per unit volume filtered were larger than the day catches at depths of 20-75 meters, while the day catches per unit volume were larger than the night catches at depths of 200-400 meters. The daytime increase at greater depths, and the night-time increase in shallower waters was used as an estimate of vertical migration. Night-time increase in surface waters exceeded daytime increase at higher depths. Differences in vertical migratory behavior at the familial level are indicated by the dominance of Myctophids above 200 meters, and Gonostomatids below 200 meters in night tows. On a comparative basis, the eddy fish followed the normal pattern of post-sunset and predawn rises, while the Sargasso Sea fish exhibited only a prolonged morning rise. This difference could be accounted for by the overall greater standing crop of fish in the eddy waters, but remains largely unexplained for lack of sufficient data. (See Figure 2.)

C. Distribution of Anguilliform Leptocephalus Larvae in the Western North Atlantic

This work involved a series of five stations (see Appendix 1) each consisting of a bathythermograph, a hydrocast to 400 meters and a zooplankton tow stepped at 100, 75, 50 and 25 meters. Larvae collected in these tows and all other tows were identified and correlated with bathymetric and geographic parameters. Family diversity of leptocephalus larvae collected along the cruise track was the subject of a study by Ralph Owen and Jeff Hatch.

Particular attention was paid to larvae of the American and European freshwater eels, Anguilla sp., the object of a study initiated by Dr J.H.W. Hain, formerly of S.E.A. This species is believed to spawn in the Sargasso Sea southwest of Bermuda, with subsequent migration of the larvae back to the adult habitat in fresh water systems of coastal North America and North Europe. It is hoped that a more detailed picture of the location of the spawning area and nature of the migration in these eels will be gained from this research. Results will be made available to Dr. Hain.

1) A Study of Family Diversity in Anguilliform Leptocephalus Larvae in the Western North Atlantic (Hatch and Owen)

Abstract

Family diversity of anguilliformes leptocephali was measured along the cruise track of W-41. Specimens were taken using the multiple net towing technique devised on W-41 (meter net at 26 meters; meter net at 200 meters; Bongo net at 400 meters) and from various IKMT and Neuston tows. The cruise track was divided into two communities to facilitate diversity analysis: North of the Gulf Stream and South of the Gulf Stream (including the Gulf Stream and the Sargasso Sea area). Sixty-nine specimens of anguilliform leptocephali from 10 families were taken at probable depths of 0-100 meters during the hours 2100 to 0300. The greatest diversity was shown north of the Gulf Stream (5.41 vs. 3.26 south of Stream). The most abundant families were Muraenidae (28 individuals), Anguillidae (12),

Overview of Research Activities (cont.)

and Synphobranchidae (12). Anguillidae showed an average size of 4.5cm near Bermuda and up to 6.0 cm near Sable Island, N.S., supporting the theory that Anguilla spawn in the Sargasso Sea area. Muraenidae as well as all the other families were found above the 15°C isotherm and the 36‰ isohaline as expected. All leptocephali were found at depths above 150 m (estimated from towing data). (See Table 3.)

Table 3. Lengths of anguillid leptocephali reflecting increased size in higher latitudes

Station	Date	#Specimen	Mean Length	Latitude
Eel #3	8/04	2	5.2 cm	34°09'N
Eel #2	8/01	5	4.5 cm	36°56'N
IKMT 4	8/15	1	4.7 cm	38°18'N
Diel #1, Set 1	7/29	1	4.8 cm	38°33'N
IKMT 5	8/17	1	5.6 cm	40°07'N
IKMT 6	8/18	1	6.0 cm	42°59'N

D. The Distribution and Acoustics of Marine Mammals in the Western North Atlantic

As a part of a continuing program, all marine mammal sightings were recorded along with pertinent behavioral and geographic data (see Appendix 4). In addition, an intensive whale watch with two lookouts aloft was kept during daylight hours on Leg III, while transiting known summer feeding grounds of great whales in the Scotian and New England coastal waters. Most notable was the sighting of a pod of Sperm whales, of mixed ages, numbering no less than 15 individuals, just south of the Gulf Stream main axis.

Eight acoustic stations were conducted with a recording hydrophone in association with major sightings or suspected presences (see Appendix 1). The only vocalizations detected and recorded came from the above mentioned sperm whales. The combined sighting and acoustic data will be made available to interested parties: notably Dr. H. Winn of the University of Rhode Island, Dr. Steven Katona and Mr. Scott Kraus of the College of the Atlantic, and Dr. J.H.W. Hain.

Charles Deutsch investigated the relationship between whale populations and zooplankton abundance. Bill Belisle documented sightings photographically and devised a process for the color slide film development aboard ship. John McAlpin and Chris Latelier researched the related topics of whaling industry history and legislation.

1) The Relationship Between Summer Distribution of Baleen Whales and Zooplankton Abundance in the Waters off Nova Scotia and in the Gulf of Maine (Deutsch)

Abstract

Zooplankton is the primary food source for most species of baleen

Table 4

The Relationship between the Local Summer Distribution of Baleen Whales and
Zooplankton Abundance in the Waters off Nova Scotia and in the Gulf of Maine

Plankton Tow # per Whale Census	1	2	3	4	5	6	7	8
WATER MASS	Continental Slope Break	Scotian Shelf Break	Gully off Sable Is. N.S.	Coastal (St. Margaret's Bay, N.S.)	Baccaro Bank	100 fathom curve — West of Brown's Bank	Casher Ledge	Stellwagen Bank
Census Period Index (mile-hours)	34.0	49.0	31.7	32.6	38.1	49.0	37.9	—
PLANKTON Biomass (ml/m ³ X10 ⁻³)	9.25	3.5	38.3	219	524	53.6	138	271
Major Organisms	Diverse: Euphausiids, Chaetognaths	Euphausiids	Copepods	Copepods, some Ctenophores & Chaetognaths	Copepods (Ctenophores, Amphipods)	Ctenophores (Jellyfish, Euphausiids)	Copepods	Copepods Ctenophores
# Baleen Whales observed during Census	0	0	0	0	15-19	1	1	10-12
Depth (M)	2500	240	410	50	100	200	150	84
Surface Temp. (°C)	23.3	20.0	19.5	16.1	14.2	15.8	19.7	18.1
Beaufort Force of Wind	4	3	4	3.3	2	1	0	4

Overview of Research Activities (cont.)

whales during the summer feeding season. The relationship between the local distribution of mysticete whales and the abundance of zooplankton was studied on the continental shelf off Nova Scotia and in the Gulf of Maine. Simultaneous plankton tows and ten-mile long whale censuses were taken at eight locations along the cruise track. Zooplankton biomass was determined by the volume displacement technique, and it was used as an index of the relative productivity of the water mass. No whales were observed in the low productivity localities, whereas large aggregations of these animals--including seis, fins, and humpbacks--were found in the two areas which had the greatest zooplankton biomass. The plankton samples from the productive waters were composed primarily of copepods. The populations of baleen whales seemed to be locally distributed over the highly productive offshore banks. (See Table 4.)

2) Photographic Identification of Individual Humpback Whales in the Western North Atlantic (Belisle)

Abstract

Photographs of marine biota found along the cruise track of Westward, W-41, were taken using 35 mm still camera and various wide-angle, close-up, and telephoto lenses.

Plate 1. Humpback whale sighted 3 September 1978, on Stellwagon Bank

Overview of Research Activities (cont.)

Immediate access to photographs was provided by an on-board color slide developing station which yielded results comparable to commercial quality development techniques. Standard Kodak chemicals were used to develop Ektachrome slides in E-6 chemistry.

An attempt to identify individual whales by tail fluke markings met with partial success by yielding a photograph of a humpback whale which may have been previously identified. Tail fluke markings in humpbacks are distinctive enough to identify individuals of the species, and are compiled in a photographic guide, (Katona et al, 1977). This information will be sent to Dr. Katona at the College of the Atlantic. (See Plate 1.)

3) The History of Whaling with a Profile of the Canadian Industry (McAlpin)

Abstract

The overexploitation of the world's wild stocks of animals can be exemplified by a description of man's mismanagement of the whaling industry. Beyond the leviathan's awesome totality, it has no natural enemies in its environment except man, who has taken to the seas with such vigor that the whale stocks are in serious decline.

For centuries the whale has captured the imagination of men, and has become an intricate part of their superstitions, mythology, and folklore, though until recently man's efforts at capturing whales have been far removed from scientific-factual knowledge of its life history and behavior.

The whaling industry has experienced many changes since its inception in the 11-12th century with the Basques, who set a precedent for the history of whaling--the total decimation of an entire local population with the subsequent migration of the whalers to new slaughtering grounds.

The Dutch-dominated arctic whaling of the 17-18th century was eventually abandoned because of the scarcity of whales. The pelagic efforts of New Englanders seeking the riches of the sperm whale flourished, until a chain of events, including the discovery of crude petroleum and the Civil War, crumbled that industry into an irreparable state.

The modern age of whaling is characterized by many new inventions and has evolved into a computerized, technologically dependent industry. The awesome efficiency of the giant factory ships and their associated killer ships have revolutionized the industry and if whaling were allowed to continue unchecked, would inevitably spell catastrophe for the already depleted stocks of many species.

International legislation is currently negotiating reasonable quotas and maximum sustainable yields of the wild stocks, in an effort to rejuvenate or at least prolong an industry that has pursued a pattern of exploitation while ignoring scientific knowledge of the whale.

Overview of Research Activities (cont.)

Historically, the Canadian industry was a shore-based enterprise, though at its inception the pelagic trend of the 18th century was carried on by a band of Nantucket whalers imported to Dartmouth, Nova Scotia. Modern Canadian whaling ended in 1972 on a controversial note, as the men who lost their jobs were outraged as they felt the closing of their station at Blandford, Nova Scotia was for purely political-public sentiment reasons, rather than a necessity in closing because of any real threat to the population stocks of whales.

4) International Whaling Legislation from 1908 to 1978; with Special Emphasis on Canada (Letelier)

Abstract

Legislation pertaining to whales was traced in the international sphere from 1908 until the present in part I, while Canadian legislation was dealt with more on a contemporary basis from about 1969 until the present in part II.

In the case of International whaling, early attempts at legislation were discussed and finally special emphasis was given to the International Whaling Commission, I.W.C., beginning in 1946. Topics that were dealt with included: the modern factory ship, Paul Savagin's warning in 1910, countries which initially joined the I.W.C. as well as those that never did, problems with the implementation of I.W.C. policy including the tragedy of the blue whale unit (B.W.U.), Japanese and Soviet public boycotts, the gestation period of whales, the U.S. proposal for a ten year moratorium on commercial whaling and the current Endangered Species Act under which all whale product imports have been banned, the accepted Australian proposal which replaced the blue whale unit as a management scheme dividing all stocks of whales into one of three categories in an effort to insure the most rapid possible restoration of depleted stocks, and finally some mention of the increasing grey whale stock.

In regard to Canadian whaling legislation, three Canadian whaling reports to the I.W.C. were investigated. These were the 23rd (1969-1971), 24th (1973) and 27th (1975-1976) reports to the Commission. Attention was given to the Canadian Arctic Eskimo and his bowhead hunt, scientific work carried on by Canada, Fisheries Minister Davis's Communique on Canada's ban on commercial whaling, mention of a new Canadian Committee on Whales and Whaling and of the Canadian harp seal, and finally a Canadian policies trend analysis.

E. Investigations into the Neuston and Sargassum Communities

A subject of ongoing interest aboard Westward has been the neuston organisms and their relationship to the surface layer in which they dwell. On this cruise, Tom Ziewacz examined variations in neuston fish diversity between day and night, and between adjacent water masses; Hervé Thebault sought to identify morphological adaptations unique to the neuston environment. The standard neuston net (1.0 X 0.5 M) was modified with a stabilizer plane and weighted bridle in order to increase effective towing speed from two to five knots and thus improve catch rates.

Overview of Research Activities (cont.)

A related subject of continuing study aboard Westward has been the ecology of the pelagic Sargassum weed entrained within the North Atlantic gyre (Sargasso Sea) and the organisms that associate with it. This unique association resembles a comparable benthic community and is thought to have evolved from the displacement of ancestral organisms with the weed fragments that drifted from an original shore environment and subsequently established a pelagic existence.

On this cruise Bill LaParl undertook a determination of the standing crop of Sargassum weed as well as pelagic tar ball concentrations utilizing neuston tow samples; Dwight Reese examined the relationship between weed mass and age, and the diversity and density of macrofaunal associates using dip net samples. Also reported below are the abstracted collective results of observations made on the biology and behavior of the Sargassum fish, Histrio histrio. Two separate mating pairs, in addition to numerous single specimens, were captured by dip net and maintained successfully in the ship's aquariums during W-37, 40 and 41. The interactions between these fish, the weed and its other associated fauna not only afforded a unique teaching aid in fish biology, but also provided considerable insight into the trophic relationships within the Sargassum community, which is the ultimate focus of these studies.

On completion of W-41, a mating pair of Sargassum fish, each measuring approximately 12 cm, were presented to the Boston Aquarium for display and study at that facility.

1) Biomass+Diversity of Fish in the Neuston Layer (Ziewacz)

Abstract

Diversity and biomass of fish in the neuston layer were measured during a transect from Woods Hole to Bermuda and Bermuda to Nova Scotia. A total of twenty hour-long tows with a net 0.5 x 1.0 meters were done during the cruise. Species were identified or given an arbitrary designation to facilitate the calculation of diversity. Diversity was calculated using $d = s-1 / \ln N$, where S is the number of species per tow and N the number of individuals per tow. Biomass in ml/m^2 was also calculated for each tow. Diversity was the highest (3.40), while biomass was the lowest (0.4×10^{-3}), per tow near Bermuda—the result of the presence of large numbers of juveniles. Biomass was highest (8.0) while diversity was low (0.57) in the Warm Core Eddy and Slope Water because of an increase in the number of a few types of individuals taken in these more fertile water masses. Night-time catches generally had a greater biomass and diversity than comparable day-time catches, due to the arrival of vertical migrators at the surface. The boundaries between adjacent water masses also exhibited relative increases in biomass and diversity. (See Table 5.)

Table 5. Neuston tow collections: number of individuals and species, diversity, biomass (ml/m^2), size ranges, and color patterns of fishes; Sargassum weed and tar concentrations.

Tow #	Position	Time	# individuals	# species	Diversity	Biomass	Counter Shading Color	Shading Patterns	Weed Camouflage	Other	$\frac{\text{Sargassum}}{\text{Weed}} (\times 10^{-2} \text{ g}/\text{m}^2)$ Concentrations	Tarball ($\times 10^{-3} \text{ g}/\text{m}^2$) Concentrations
1	warm core eddy	2130	35	3	0.57	8.0	34	1	—	—	1.433	—
2	Gulf Stream	1730	12	9	3.23	0.5	3	5	4	—	1.538	—
3	Gulf Stream	1430	8	5	1.92	0.8	5	1	3	—	4.964	12.140
4	Sargasso	0500	21	9	2.63	2.2	18	3	—	—	1.096	5.397
5	Sea	0030	46	5	1.04	2.7	30	1	2	—	2.382	<1.140
6	↓	1830	7	4	1.54	0.5	4	2	1	—	4.984	9.251
7	↓	1330	8	5	1.92	0.4	4	2	2	—	6.122	—
8	↓	2300	118	10	1.89	3.1	84	8	26	—	4.047	4.945
9	Bermuda	1930	23	8	2.23	0.5	19	2	2	—	1.527	<1.340
10	↓	0800	500	7	0.97	—	493	4	3	—	3.221	19.550
11	↓	1400	115	6	1.05	0.5	112	2	1	—	3.022	4.430
12	↓	1930	19	11	3.40	0.4	9	4	6	—	21.240	4.857
13	↓	0200	69	13	2.84	0.9	31	19	19	—	0.222	3.444
14	Sargasso	1400	19	8	2.38	0.5	18	1	—	—	12.450	1.904
15	Sea	2200	57	10	2.23	2.4	36	6	15	—	5.963	5.189
16	↓	2130	31	6	1.46	1.1	21	3	7	—	2.391	3.103
17	Gulf Stream	1500	19	6	1.70	3.1	1	14	4	—	5.818	<0.498
18	Slope	0230	80	7	1.37	2.9	30	38	12	—	9.594	1.686
19		1430	0	1	—	0.5	—	3	—	—	—	1.559
20		2100	45	4	0.79	1.9	41	—	4	—	—	—

% of total fish in various size ranges: 5-9mm - 6%, 11-14mm - 27%,
15-19mm - 35%, 20-24mm - 6%, 25-29mm - 6%, 30-34mm - 6%,
35-44mm - 6%, 45-114mm - 8%.

2) Aspects of the Biology of Some Neuston Fishes of the Western North Atlantic--Morphological Adaptations (Thbault)

Abstract

The neuston layer of the ocean (0-50 cm) contains a unique biotope with specific conditions involving high solar radiations, diurnal changes in sea temperature, high oxygen and low nutrient levels. The neuston fishes should present morphological adaptations to this habitat at a statistical level. In this study the colour and size (measured by the total length) were observed. For colour, three patterns were expected according to the idea of possible camouflage adaptations: countershading pattern (blue or green on top, silver on sides and below), Sargassum weed-like (white, yellow, and

Overview of Research Activities (cont.)

brown mottled), and any other colour (with no evidence of colour adaptations to the neuston layer). For size, the hypothetical expectation was that nanism (unusually short length) would be observed in the neuston fauna (Hartman, Jurger 1970).

Twenty tows, equally distributed through the 24-hour cycle, (for a total time of 17 hours and 30 minutes, covering a surface area filtered of 15 ha) were taken along Legs I and II. 1223 specimens were caught. Among them 81% exhibited the counter-shading pattern and 9% the Sargassum weed camouflage. The other 10% contained juveniles whose pigmentation process had just started, and tropical reef fishes which keep the colour adaptation specific to that habitat.

For the size range, 62% of the fishes were found in the class 10-20 mm and 91.5% between 5 and 45 mm.

Most of the specimens observed showed colour adaptations appropriate to the neuston environment. Concerning the size range, the judgement is rather intuitive because the limits of nanism are poorly defined without any element of comparison. The observed lengths, however, appeared to be smaller than the average for the families concerned as listed in the literature. Some distortion may occur with the catch of numerous juveniles of very small size, which alters the relative abundance in these size classes, especially by day and around the island of Bermuda. (See Table 5)

3) The Standing Crop of Pelagic Sargassum Weed (LaParl)

Abstract

The standing crop of pelagic Sargassum weed for the western North Atlantic along the W41 cruise track was determined to find if the average standing crop is relatively constant. A 1 X 0.5 meter neuston net was used to perform twenty surface tows averaging one hour each. The Sargassum weed was weighed wet and in most cases the associated tar balls were collected and weighed.

Based on results from data collected on previous Westward cruises the expected average standing crop was $7.02 \times 10^{-2} \text{ g/m}^2$. Results yielded an average standing crop of $7.789 \times 10^{-2} \text{ g/m}^2$, and an average tar ball distribution of $5.027 \times 10^{-3} \text{ g/m}^2$. The average standing crop of pelagic Sargassum is therefore suggested to be relatively constant. There was no basis for comparison of the tar ball data on board for this area. (See Table 5)

4) Diversity of Macrofauna Associated with Pelagic Sargassum

(Reese)

Abstract

Sargassum weed was collected by dipnet from ten sites in the

Overview of Research Activities (Cont.)

Sargasso Sea and the Gulf Stream on a transect from Cape Cod to Bermuda and thence to Nova Scotia. The macrofauna were collected from the weed. The ten samples contained fourteen species and seventy five individuals. Diversity of species was calculated using the index $D = (S - 1)/(\ln N)$. Diversity varied geographically; there appeared to be an area of low diversity in the Sargasso Sea, with high diversity occurring north in the Gulf Stream and south near Bermuda. There was a rough relationship observed between diversity and the age of weed, as measured by the amount of encrustation. This relationship was directly proportional at lower encrustation levels, and became inversely proportional at encrustation levels higher than 50%. No correlation was found between surface temperature or biomass of the weed samples and macrofaunal diversity. There was no correlation between the number of individuals and the biomass of the weed. (See Figure 3)

Figure 3. Rough relationship between diversity of macrofaunal Sargassum associates, and per cent encrustation of weed and latitude

5) Observations on the Biology of the Sargassum fish, Histrio histrio (Baum)

Abstract

Eighteen Sargassum fish, Histrio histrio, ranging 1 to 12 cm in approximate length, were captured in association with Sargassum weed samples dip netted from the Sargasso and Caribbean Seas during cruises W 37, 40 and 41. Highlights of subsequent study of their

Overview of Research Activities (Cont.)

biology in shipboard aquariums are as follows:

- a) Two specimens measuring approximately 12 cm in standard length were captured in one 60 gm clump of weed and later proved to be a mating pair. The fact that the female was not ready to spawn (marked by distension of the abdomen) at the time of capture, in addition to their continued coexistence (over two months) in a five gallon aquarium, indicated the possibility of long term pairing of mates without the deterrence of cannibalism or individual territorial defense generally associated with this species.
- b) A total of 16 spawnings between two mating pairs were partially or completely observed. Time intervals between spawning ranged from three to 15 days and appeared to be inversely proportional to food availability. The spawn is delivered in the form of a gelatinous, scrolled sheath or raft after a brief convulsive motion oriented at the surface. This is followed immediately by dispersal of the sperm around the raft by the male. Total eggs per raft were estimated at between 3.2 and 4.0×10^6 , with a mean egg size of 0.5 mm. Spawning related behavior commenced approximately 24 hours prior to actual fertilization of the eggs, and culminated consistently at 1700 - 1900 local time. Elements of apparent courtship involved close attention and physical contact paid by the male to the female for the duration of the 24 hour period, but no elaborate display language or other ritualized behavior were observed.
- c) Female specimens were markedly more aggressive in feeding than males, presumably to support the metabolic demands of egg production.
- d) Observed prey capture strategies were energy conservative, utilizing surprise from camouflaged concealment and short stalking sorties in lieu of extended search and chase activity.
- e) Sexual dimorphism has been tentatively established based on external features of coloration (white dotted ocelli on the lateral surfaces of the male; none such on the female), relative dorsal spine length, and ventral tassel size. Dissection of one male specimen has provisionally confirmed this
- f) Two specimens became conditioned to associate approach of an aquarium net with feeding in three trials within less than 24 hours.
- g) Six parasitic copepods, penella exocoeti, were removed from their attachments on the external body surfaces of one of the mating pairs. This resulted in inflamed lesions which healed within approximately one month.
- h) Specimens over approximately 4 cm in length exhibited a transition in preference from keeping station in aquarium weed clumps to residing on or near the aquarium bottom.
- i) Food items readily consumed included juvenile jacks (Caranx), Sargassum pipe and file fish species, Sargassum crustations (small shrimps and crabs), and their own kind.

Overview of Research Activities (Cont.)

F. Island Mass Effects on Phytoplankton Communities (Farmer)

Phytoplankton populations in tropical waters are generally sparse, due primarily to low nutrient concentrations. Tropical islands, however, may be a source of nutrients, and thus enhance the growth of phytoplankton in surrounding waters. On W 41, ten phytoplankton tows were taken with a 0.25 meter, 60-micron mesh net on a transect approaching and circumnavigating the island of Bermuda. Samples will be thoroughly examined ashore for correlation between phytoplankton biomass and distance from land based on the above premise. Preliminary analysis by students aboard ship did not reveal the expected relationship. Dinoflagellates of the genus Ceratium were dominant in most samples. Microzooplankton appeared more numerous than phytoplankton in every sample. It is probable that nanoplankton too small to be collected in this net account for the most numerous phytoplankton in these waters. Further studies with whole water samples will be done to ascertain what if any role oceanic nanoplankton play in island mass effects on phytoplankton populations.

G. Physical and Chemical Comparisons of Water Masses

The Westward transited five distinct water masses in the course of W 41: North American coastal and slope waters, a warm core eddy, the Gulf Stream, and the Sargasso Sea. The combined sum of hydrographic data collected in them provided several students with the opportunity to make comparative studies of vertical and horizontal profiles of physical and chemical characteristics, as well as other physical effects. Todd Howerton and Patricia Hodges examined temperature and salinity profiles; similarly, Janet Llewellyn and Lisa Robbins looked at nutrients. Jenny Glasser made a first attempt at intercalibrating a secchi disc and a submarine photometer. The effects of surficial thermal fronts in water masses on weather was the subject of Charles Morss' project. Bathythermograph profiles of the epipelagic zone for transects of the warm core eddy and the Gulf Stream are presented in Figure 4.

1) A Comparison of Temperature-Salinity Profiles of New England Atlantic and Scotian Slope, Warm Core Eddy, and Sargasso Sea Waters

(Howerton and Hodges)

Abstract

Water masses encountered on W41 were compared using temperature-salinity diagrams and temperature-salinity vs depth curves. In particular, New England Atlantic slope and shelf, warm core eddy and Sargasso Sea, and warm core eddy and slope waters were contrasted.

Nansen bottles and reversing thermometers were used to obtain water samples and temperatures at target depths of 0, thermocline, 100, 200, and 400 meters. Computations of actual depths of sampling based on unprotected thermometer readings proved unreliable. Therefore, depth values are based on wire angle calculations. Salinity

Figure 4. Bathythermograph profiles of warm core eddy and Gulf Stream (N-S) transects conducted on W41

Overview of Research Activities (Cont.)

was determined by silver nitrate titration.

Results supported expectations in the warm core eddy comparisons; the eddy bore most resemblance to the Scotian slope water into which it originated, and showed remnant characteristics of Sargasso Sea water. Results from the remaining hydrocasts were somewhat inconclusive. New England Atlantic slope water was colder and less saline than the Scotian slope. This was unexpected, yet explained by the influence of the Gulf Stream which moves north during late summer. New England Atlantic shelf water was less saline than neighboring slope water and had a more uniform temperature profile, due to river runoff and vertical mixing, respectively. (See Figure 5)

Figure 5 Exemplary temperature - salinity diagrams for U.S. slope water (2), a warm core eddy (4), the Sargasso Sea (13), and Scotian slope water (14)

Overview of Research Activities (Cont.)

2) Nutrient Levels on the Atlantic Shelf and Slope, a Warm Core Eddy, the Sargasso Sea, and the Scotian Shelf (Llewellyn and Robbins)

Abstract

Water samples were collected from fourteen hydrocast stations on the Atlantic shelf, slope, a warm core eddy, the Sargasso Sea, and Scotian slope along a transect from Woods Hole, Massachusetts, to Bermuda, and from Bermuda to Lunenburg, Nova Scotia. Each station consisted of an average of four nansen bottles sampled to a maximum depth of 400 meters. Water samples were analyzed for phosphate, nitrate and oxygen concentrations using Hach Kits (Kit NI 14 for nitrates and kit PO 19 for phosphates were under evaluation for use aboard Westward) and the Winkler method.

Theoretically, collection of data in the summer months shows low nutrient levels in the surface waters due to depletion by the spring phytoplankton bloom. These layers remain depleted throughout the summer due to lack of substantial vertical mixing. The Sargasso Sea was expected to show lower nutrient levels than the shelf and slope waters. In addition, inverse correlations between oxygen and nutrient concentrations, as well as oxygen concentrations and temperature were expected.

Figure 6. Exemplary vertical profiles for phosphate - phosphorus ($\text{PO}_4 - \text{P}$) and dissolved O_2 in U.S. slope water (2), a warm core eddy (4), the Sargasso Sea (13), and Scotian slope water (14)

Overview of Research Activities (Cont.)

The data showed the general trend of relatively lower nutrient concentrations in the surface waters with marked increases below the thermocline. In addition, extremely low nutrient levels were evident in the Sargasso Sea in comparison to the Atlantic shelf and slope. Diurnal fluctuations of nutrient levels were noted in the warm core eddy. Lastly, inverse correlations between oxygen and nutrient concentrations, and oxygen and temperature prevailed at nearly all stations. Hach Kit measurement of nutrients at these low levels required standardization with known solutions to bring readings within realistic ranges. (See Figure 6)

3)A Comparison of Extinction Coefficient Measurements Taken with a Secchi Disc and a Submarine Photometer (Glasser)

Abstract

The transparency of sea water is controlled by the inherent scattering and absorption nature of the water molecules, the presence of dissolved colored substances, and the presence of suspended particulate matter. The secchi disc depth, the depth of disappearance of this disc, is an indicator of transparency. The submarine photometer (Kahl Mod 268 WA 310 Irradiometer) readings were used as a standard. The percentage of total incident light at any depth was designated %I. The coefficient of extinction (k) is the rate of decrease of downward radiation. The formula used for photometer readings was $k = (\ln I_0 - \ln I_d)/d$, where I_0 = ambient light intensity, I_d = light intensity at any depth, and d = actual depth of sub-surface photo cell. For the secchi disc measurements, $k = 1.7/d$, where d is the length of secchi disc line out at disappearance. The values

Table 6. Comparison of % light intensities (%I) and coefficients of extinction (k) derived from Secchi disc and submarine photometer measurements

Station	Date	Time	actual secchi depth	secchi wire angle	% I at secchi depth	% I derived by photometer	% difference	secchi k	photometer k	% difference
1	7/30/78	0823	10.61	45°	10.70	9.35	12.6	.149	.200	25.5
2	7/30/78	1525	18.61	40°	12.38	1.50	87.6	.091	.200	54.5
3	8/02/78	1030	22.28	50°	9.07	4.90	46.0	.060	.110	45.5
4	8/02/78	1640	34.03	15°	17.32	1.00	94.2	.050	.075	33.3
5	8/06/78	1500	33.86	30°	14.88	2.00	86.6	.050	.080	37.5
6	8/07/78	1015	19.01	45°	10.77	3.50	67.5	.089	.160	44.4
7	8/07/78	1700	26.61	45°	10.64	0.35	96.7	.064	.220	70.9
8	8/14/78	1345	23.57	45°	10.74	4.50	58.1	.072	.270	46.6
9	8/15/78	0800	31.00	0°	18.21	3.50	80.8	.055	.099	44.4

Overview of Research Activities (Cont.)

for %I extrapolated from secchi disc depths were consistently higher, and for k consistently lower, than those derived for equivalent depths using the photometer. Calculating the per cent difference between the secchi and photometer values gave results ranging from 12.6 to 96.7% for %I, and from 25.5 to 70.9% for k. The secchi depth %I values were directly affected by the wire angle of the secchi line. The %I at a line angle of 0° was 18.21, and at a line angle of 50° , 9.07. It is evident that the secchi disc formula for calculating k requires an additional factor to allow for wire angle of the line. Another possible factor would be sea state, but there was insufficient data to measure its effect. (See Table 6)

4) The Effect of Surface Thermal Changes on Weather in the Western North Atlantic (Morss)

Abstract

The effect of surface temperature changes on the air masses above them was studied. Since the sea has a relatively simpler surface than land masses, features affecting the air above the sea were easy to isolate. A graph showing water and atmospheric conditions was maintained from July 27 to Aug. 21, as Westward tracked from Woods Hole to Bermuda, and thence to Sable Island, Nova Scotia. This graph revealed two related water and air masses: a semitropical Sargasso Sea system and a cool slope and coastal system. The most interesting features were the stationary fronts that lie at the Gulf Stream and warm core eddy edges. Radar plots and drawings were used to study individual squalls, while a weatherfax machine gave information on large scale systems. Overall, there was strong evidence that surface contrasts play an important role in controlling the weather on a large and small scale basis. (See Figure 7)

Figure 7. NOAA satellite analysis depicting standing cold front at southern edge of Gulf Stream

Overview of Research Activities (Cont.)

H. Miscellaneous Studies and Observations

1) A roster of coral reef fishes sighted on a diving field trip to Castle Rock on the island of Bermuda is presented in Appendix 5. These sighting rosters will be maintained on a visit to visit basis in order to monitor any noteworthy changes in the indigenous reef fish populations.

2) Three otter trawls were taken at selected sites off the U.S. and Scotian coast in order to demonstrate the epibenthic fauna to the students. Long term monitoring on a seasonal and annual basis will provide information on changes in these communities. (See Appendix 6 for species rosters)

3) Two students, Marion Valpey and Brad Gandrup, conducted a study not strictly related to marine science, but nevertheless of a technical nature. The results of their investigation into the accuracy of life boat navigation techniques are presented below.

Abstract

Experiments in Life Boat Navigation (Valpey and Gandrup)

The objective of this study was to test some of the techniques involved in life boat navigation and thereby gain a working knowledge of their practical application and relative value. The tests were made using methods of varying degrees of sophistication and this information was compared with Westward's own navigational data. The experiments included: the use of a chip log and Dutchman's log, and the ship's compass for two DR plots; declination by approximation; longitude by stimulus; and altitude measurements of celestial bodies using the life boat sextants (Ebbco - plastic) and two primitive astrolabes.

Results showed the chip and Dutchman's logs to vary in accuracy by as much as four knots according to the ship's point of sail, though this was partially attributed to faulty methodology. Approximated declinations proved accurate to within 10.6'. The plastic sextant and longitude by stimulus were nearly as reliable, being in error on the average by 10.4' and 17.0', respectively. The astrolabes, though functionally accurate to approximately one degree of arc, are still deemed much more valuable than nothing at all. Results with all the tools and techniques showed that accuracy improved substantially with practice.

III. Visiting Investigator Programs

A. Seabird Observations

Two separate visiting ornithologists, Miss Patricia McGill and

Overview of Research Activities (Cont.)

Mr Timothy Ramage, accompanied Westward on W 41, Legs I and III, respectively. Their reports on seabird observations, together with that of students, Josie Quintrell and Carolyn Steiner, appear below.

1) Bird Observations from Four Western North Atlantic Water Masses (McGill)

Abstract

During cruise W 41 of R/V Westward from Woods Hole to St. George, Bermuda (July 27 to Aug. 8, 1978), bird observations were recorded during 15 minute periods spaced throughout the day. There were at least five and up to 14 observation periods per day, for a total of 108. Each daylight hour was sampled between five and nine times. During each observation period the following information was recorded: species and number of birds, direction of travel and general behavior; sea and weather conditions, barometric pressure, surface water temperature, water depth, and location of the ship. In addition to observations during hourly periods, all other casual bird observations were recorded.

An attempt was made to make adequate samples of birds found in all water masses crossed by the ship. The ship spent different amounts of time in different water masses, and the number of observations reflects this: continental shelf and slope waters - 29 observation periods in 59 hours; warm core eddy - 20 periods in 36 hours; Gulf Stream - 5 periods in 14 hours; and Sargasso Sea - 53 periods in 171 hours.

Preliminary analysis of the data indicates that the water masses are characterized to some extent by the birds found there. The most common birds of the shelf and slope waters were the Greater Shearwater and Wilson's Petrel. Both Herring and Great Black-backed Gulls were also seen in this area, although they disappeared after the first 12 hours. Petrels did not appear until after this initial period. While the most common bird of the warm core eddy was again Wilson's Petrel, shearwaters were rarely seen in this area. Gulf Stream waters, on the other hand, were characterized by shearwaters, primarily Greater, but also Cory's, Audubon's and Sooty. At one time a congregation of 75 to 100 shearwaters was seen. The Sargasso Sea showed a striking difference in local birds seen. Three shearwaters were seen in the first few hours. Following that, only White-tailed Tropicbirds were seen.

Further analysis of these data will attempt to correlate bird distributions with water depth, time of day, distance from shore and weather conditions. It appears that water masses may have indicator bird species. Closer analysis of these data and repeated data collection on similar cruises may lead to more refined conclusions.

Overview of Research Activities (Cont.)

2) Population Dynamics of Pelagic Birds (Rumage)

Abstract

The study conducted on W 41 is part of a long term project on seabird ecology. The aim of the research effort is to test potential correlations of meteorological data, productivity levels and distance from land with intra- (based on age class) and inter-specific diversity and abundance.

Preliminary results from W 41 demonstrate a sharp demarcation between coastal-marine (i.e. Herring Gull) and true pelagic (i.e. Greater Shearwater) species based on water mass parameters. Those species that could be aged by plumage had a bimodal distribution pattern with a significantly higher proportion of subadults found in the intermediate water zones, areas of relatively low productivity and inside the 50 fathom contour, than in more productive areas.

The stage of wing molt in Greater Shearwaters was recorded, as were different modes of prey catching behavior exhibited by that species. Behavioral interactions of rafting Greater Shearwaters were noted and their vocalizations recorded.

3) Diversity and Population Density of Pelagic Birds as They Relate to Water Mass Productivity (Quintrell and Steiner)

Abstract

This study focused on the relationship between the productivity of water masses and pelagic bird diversity and population density. Highly productive waters would be expected to support communities of greater density and diversity than in waters of relatively low productivity.

Bird watches were conducted for a total of an hour per day in four fifteen minute intervals. The number of individuals and species, and the ship's position were recorded for each sighting. Productivity data in the form of biomass of neuston fish and sub-surface zooplankton were collected from other student's projects. A relatively high diversity and dense populations of pelagic birds characterized the waters north of the Gulf Stream, in contrast to sparse populations and low diversity found in the Sargasso Sea. Although bird populations showed a general increase in density and diversity with proximity to continental land masses, it was not possible to distinguish the direct effects of productivity on these birds. This may be attributed to the lack of precise coincidence between sighting periods and productivity sampling. (See Table 7)

Table 7.

W-41 Bird Sightings

Common Name	Scientific Name	No.
<u>Shelf and Slope Water</u>		
Audubon shearwater	<u>Puffinus lherminieri</u>	100+
Cory's shearwater	<u>Puffinus diomedea</u>	2
greater shearwater	<u>Puffinus gravis</u>	138+
shearwater, probably sooty	<u>Puffinus griseus</u>	2
shearwater	unidentified	355+
greater black-backed gull	<u>Larus marinus</u>	66
herring gull	<u>Larus argentatus</u>	144+
gulls	unidentified	107+
Leach's petrel	<u>Oceanodroma leucorhoa</u>	1
Wilson petrel	<u>Oceanites oceanicus</u>	74
petrel	unidentified	111+
Cape May warbler	<u>Dendroica tigrina</u>	2
yellow-throated warbler	<u>Dendroica dominica</u>	1
warbler	unidentified	2
tern	unidentified	2
<u>Warm Core Eddy</u>		
Audubon shearwater	<u>Puffinus lherminieri</u>	2
greater shearwater	<u>Puffinus gravis</u>	1
Wilson petrel	<u>Oceanites oceanicus</u>	11
yellow warbler	<u>Dendroica petechia</u>	1
<u>Gulf Stream</u>		
Audubon shearwater	<u>Puffinus lherminieri</u>	15+
Cory's shearwater	<u>Puffinus diomedea</u>	29+
greater shearwater	<u>Puffinus gravis</u>	120+
sooty shearwater	<u>Puffinus griseus</u>	2+
shearwater	unidentified	20
Leach's petrel	<u>Oceanodroma leucorhoa</u>	2
Wilson petrel	<u>Oceanites oceanicus</u>	9
petrel	unidentified	5
white-tailed tropicbird	<u>Phaethon lepturus</u>	1
cedar waxwing	<u>Bombycilla cedrorum</u>	1
<u>Sargasso Sea</u>		
Cory's shearwater	<u>Puffinus diomedea</u>	1
greater shearwater	<u>Puffinus gravis</u>	7
shearwater	unidentified	1
herring gull	<u>Larus argentatus</u>	1
barn swallow	<u>Hirundo rustica</u>	7
rough-winged swallow	<u>Stelgidopteryx ruficollis</u>	1
Cape May warbler	<u>Dendroica tigrina</u>	6
white-tailed tropicbird	<u>Phaethon lepturus</u>	24+

Overview of Research Activities (Cont.)

B. Fish Pathology Studies

A visiting veterinary student, Mr. Edward Robb, made use of the various fishes collected during Leg II of W 41 in order to investigate the extent of pathological conditions in these pelagic forms. His report follows.

1) Pathology of Some Pelagic Fishes Collected in the Western North Atlantic (Robb)

Through a combination of otter trawls, Isaacs-Kidd midwater trawls, and trolling, various pelagic fishes were collected for observation of gross pathological lesions (ulcers, fin rot, lymphocystis, cauliflower disease, black spot, reversal and skeletal abnormalities). Necropsies of the following species were initiated: Histrio histrio, myctophidae (two species), Thunnus thynnus, Myoxocephalus octodecemspinosus, Hippoglossoides plattessoides, Limanda ferruginea, and Raja radiata. Parasitic copepods, trematodes, and cestodes were routinely found. Other tissues were fixed in formalin for histopathological study on shore.

Appendix 1

Summary Logs of Major Stations

Operation	#	Date	Time	Depth	Lat (N)	Long (W)	Notes
Hydrocasts	1	28 July	1200	100 M	40°06'	69°51'	
	2	29 July	0000	400 M	39°49'	69°40'	
	3	29 July	2040	400 M	38°33'	70°08'	Diel Sta. 1-1
	4	30 July	0207	400 M	38°33'	70°08'	Diel Sta. 1-2
	5	30 July	0812	400 M	38°31'	70°11'	Diel Sta. 1-3
	6	30 July	1430	400 M	38°33'	70°08'	Diel Sta. 1-4
	7	1 Aug	2020	200 M	36°56'	66°25'	Eel Sta.
	8	4 Aug	2143	400 M	34°00'	66°31'	Eel Sta.
	9	11 Aug	2115	400 M	34°07'	64°33'	Eel Sta.
	10	14 Aug	1355	400 M	37°47'	62°35'	Diel Sta. 2-1
	11	14 Aug	2016	400 M	37°43'	62°29'	Diel Sta. 2-2
	12	15 Aug	0206	400 M	37°42'	62°33'	Diel Sta. 2-3
	13	15 Aug	0806	400 M	37°46'	62°36'	Diel Sta. 2-4
	14	17 Aug	2035	400 M	41°38'	61°42'	Eel Sta.
Isaacs-Kidd Midwater Trawls (IKMT)	1	31 July	2233	600 M	37°32'	68°07'	
	2	2 Aug	2005	600 M	36°02'	66°00'	
	3	10 Aug	2138	600 M	32°34'	64°33'	
	4	15 Aug	0035	600 M	38°18'	62°22'	
	5	16 Aug	2250	600 M	40°07'	61°51'	
	6	18 Aug	2130	600 M	42°59'	60°32'	
Diel Stations	1	29 July	2000	400 M	38°33'	70°08'	
		to 30 July	1800				
	2	14 Aug	1400	400 M	37°47'	62°35'	
		to 15 Aug	1100				
Eel Stations	1	29 July	0240	T	39°45'	69°35'	
	2	1 Aug	2135	100 M	36°56'	66°25'	
	3	4 Aug	2300	(Nets)	34°09'	66°31'	
	4	11 Aug	2255	I	34°14'	64°27'	
	5	17 Aug	2140	I	41°38'	61°45'	
Neuston Tows	1	30 July	2122		38°27'	70°07'	
	2	31 July	1715		37°46'	68°36'	
	3	1 Aug	1420		37°01'	66°54'	
	4	2 Aug	0455		36°47'	66°05'	
	5	4 Aug	0027		34°30'	66°31'	
	6	4 Aug	1810		34°10'	66°19'	
	7	5 Aug	1315		34°09'	66°08'	
	8	6 Aug	2240		33°58'	66°38'	
	9	6 Aug	1910		32°46'	64°59'	
	10	7 Aug	0753		32°38'	64°43'	
	11	7 Aug	1340		32°18'	65°22'	
	12	7 Aug	1930		32°09'	64°49'	
	13	8 Aug	0150		32°19'	64°38'	
	14	12 Aug	1352		35°00'	64°31'	

(Summary Logs of Major Stations Cont.)

Operation	#	Date	Time	Depth	Lat (N)	Long (W)	Notes
Neuston	15	12 Aug	2200		35°19'	64°32'	
Tows	16	13 Aug	2110		36°56'	63°57'	
(cont.)	17	16 Aug	1500		39°24'	61°35'	
	18	17 Aug	0215		40°16'	61°56'	
	19	17 Aug	1410		41°10'	61°51'	
	20	19 Aug	2100		43°50'	59°35'	
Phytoplankton	1	27 July	1717	 Surface 	41°02'	71°01'	
Tows	2	30 July	1505		38°30'	70°11'	
	3	2 Aug	1112		36°28'	65°55'	
	4	4 Aug	0027		34°30'	66°31'	
	5	6 Aug	0630		33°29'	65°31'	
	6	6 Aug	1450		32°59'	65°01'	
	7	7 Aug	1040		32°30'	64°55'	
	8	7 Aug	1600		32°05'	65°03'	
	9	7 Aug	2222		32°13'	64°41'	
	10	10 Aug	2005		32°34'	64°33'	
Submarine	1	30 July	0823	25 M	38°31'	70°11'	 Calibrate Secchi Disc
Photometer	2	30 July	1525	25 M	38°33'	70°08'	
	3	2 Aug	1030	25 M	36°28'	65°55'	
	4	2 Aug	1640	25 M	36°13'	65°58'	
	5	6 Aug	1500	25 M	32°58'	65°01'	
	6	7 Aug	1015	25 M	32°30'	64°55'	
	7	7 Aug	1700	25 M	32°06'	65°03'	
	8	14 Aug	1345	25 M	37°46'	62°37'	
	9	15 Aug	0800	25 M	37°46'	62°36'	
Acoustic	1	15 Aug	1107		37°45'	62°30'	Negative ¹
Stations	2	16 Aug	1400		39°19'	62°05'	Positive ²
	3	1 Sept	1945-2045		42°46'	69°16'	Negative
	4	1 Sept	2130-2210		42°42'	69°18'	Negative
	5	2 Sept	0505		-	-	Negative
	6	2 Sept	0850-1220		42°41'	69°20'	Negative
	7	3 Sept	0200-0250		42°46'	70°11'	Negative
	8	4 Sept	1340-1401		42°66'	70°25'	Negative
¹ Pilot Whales; recorder failed							
² Sperm Whales							
Otter	1	28 July	1715	160 M	39°57'	69°41'	AA
Trawls	2	20 Aug	1535	31 fm	44°07'	59°34'	
	3	22 Aug	1420	35 fm	44°34'	63°60'	CAM
Long	1	31 Aug	1930		43°03'	68°20'	
Lines	to 1	Sept	0940				
	2	4 Sept	0300-1050		42°31'	70°20'	
Bottom	1	2 Sept	1315	100 M	42°44'	69°15'	Demonstration
Grab							

(Summary Logs of Major Stations Cont.)

Operation	#	Date	Time	Depth (ft) of Thermocline	T _s °C	Lat (N)	Long (W)
Bathythermo-graphs	1	28 July	1100	30	20.4	40°06'	69°51'
	2	29 July	0036	50	21.7	39°47'	69°39'
	3	29 July	0650	15	21.8	39°39'	69°41'
	4	29 July	0835	60	24.8	39°26'	69°49'
	5	29 July	1024	50	24.0	39°17'	69°55'
	6	29 July	1153	40	24.5	39°10'	70°00'
	7	29 July	1505	30/150	24.7	38°52'	70°04'
	8	29 July	1800	40/155	24.7	38°33'	70°08'
	9	29 July	1920	40	24.8	38°33'	70°08'
	10	30 July	0112	70	24.5	38°32'	70°08'
	11	30 July	0700	80	24.5	38°31'	70°11'
	12	30 July	1330	70	24.5	38°30'	70°12'
	13	30 July	2205	60	23.6	38°22'	70°02'
	14	31 July	0045	40	23.5	38°18'	69°56'
	15	31 July	0304	40/100	23.5	38°15'	69°46'
	16	31 July	0505	60	23.7	38°15'	69°39'
	17	31 July	0715	60	24.9	38°08'	69°29'
	18	31 July	0915	20/40	25.3	38°02'	69°19'
	19	31 July	1215	80	24.8	37°56'	69°08'
	20	31 July	1430	150	26.9	37°43'	68°56'
	21	31 July	1725	100	28.9	37°46'	68°36'
	22	31 July	1917	140	29.0	37°41'	68°23'
	23	31 July	2140	115	28.6	37°30'	68°09'
	24	1 Aug	0250	80	28.0	37°32'	68°07'
	25	1 Aug	0500	100	29.7	37°22'	67°51'
	26	1 Aug	0810	80	26.2	37°19'	67°32'
	27	1 Aug	0955	80	26.7	37°15'	67°23'
	28	1 Aug	1920	80	28.4	36°56'	66°30'
	29	2 Aug	0210	140	28.3	36°53'	66°22'
	30	2 Aug	1210	100	28.4	36°28'	65°55'
	31	3 Aug	0015	90	26.9	35°57'	66°06'
	32	3 Aug	1200	145	27.0	35°19'	66°24'
	33	4 Aug	0045	60	26.9	34°40'	66°31'
	34	4 Aug	1213	100	26.9	34°14'	67°20'
	35	4 Aug	2000	105	26.9	34°09'	66°30'
	36	5 Aug	1200	60	27.0	34°09'	66°08'
	37	6 Aug	0336	100	27.0	33°41'	65°43'
	38	6 Aug	1330	80	27.0	33°00'	65°06'
	39	7 Aug	0010	60	—	32°42'	64°53'
	40	7 Aug	1200	115	27.2	32°37'	64°56'
	41	8 Aug	0030	100	27.1	32°15'	64°41'
	42	10 Aug	2020	95	27.3	32°34'	64°33'
	43	11 Aug	1307	115	27.4	33°07'	64°38'
	44	11 Aug	2030	100-120	27.1	34°06'	64°33'
	45	12 Aug	1200	110	28.1	34°48'	64°31'
	46	13 Aug	0005	120	28.1	35°26'	64°14'
	47	13 Aug	1315	100	27.3	36°02'	64°11'
	48	14 Aug	0000	120	28.3	37°09'	63°50'
	49	14 Aug	0725	200	28.2	37°44'	63°35'
	50	14 Aug	1010	220	28.1	37°45'	63°10'

(Summary Logs of Major Stations Cont.)

Operation	#	Date	Time	Depth of Thermocline (ft)	T _s °C	Lat (N)	Long (W)
Bathythermo- graphs (cont.)	51	14 Aug	1200	160	28.4	37°46'	62°42'
	52	14 Aug	1300	160	28.5	37°46'	62°37'
	53	14 Aug	1950	160	28.4	37°44'	62°31'
	54	15 Aug	0105	160	28.4	37°43'	62°34'
	55	15 Aug	0710	240	28.5	37°46'	62°38'
	56	15 Aug	1210	180	28.5	37°44'	62°29'
	57	15 Aug	1410	140	28.5	37°41'	62°28'
	58	15 Aug	1700	180	28.5	37°37'	62°27'
	59	15 Aug	1910	200	28.4	37°54'	62°26'
	60	15 Aug	2100	220	28.3	38°04'	62°24'
	61	16 Aug	0000	250	28.4	38°18'	62°22'
	62	16 Aug	0427	260	28.4	38°24'	62°17'
	63	16 Aug	0615	260	28.4	38°35'	62°07'
	64	16 Aug	0800	220	28.0	38°46'	61°57'
	65	16 Aug	1020	180	28.3	39°00'	61°58'
	66	16 Aug	1300	140	29.7	39°12'	61°46'
	67	16 Aug	1505	150	29.0	39°24'	61°35'
	68	16 Aug	1715	120	28.3	39°27'	61°38'
	69	16 Aug	1842	100	25.6	39°41'	61°44'
	70	16 Aug	2145	95	25.5	39°57'	61°48'
	71	17 Aug	0245	260	25.1	40°16'	61°56'
	72	17 Aug	0510	50/125	24.5	40°30'	61°56'
	73	17 Aug	1200	55	24.1	41°26'	61°32'
	74	17 Aug	1900	120	24.1	41°26'	61°32'
	75	18 Aug	1200	65	23.2	42°27'	60°49'
	76	19 Aug	0105	65	22.4	43°00'	60°32'
	77	19 Aug	1215	60	20.3	43°29'	59°47'

Appendix 2

W-41 Biological Teaching Collection

Organism	Common Name	Source
Phylum Arthropoda		
<u>Eupagurus bernhardus</u>	hermit crab	Continental Shelf
<u>Acanthephyra purpurea</u>	scarlet prawn	warm core eddy
<u>Phronima sp.</u>	amphipod	Gulf Stream
<u>Palinurus sp.</u>	spiny lobster larvae	Gulf Stream
<u>Lepas hilli</u>	gooseneck barnacle	drifting bottle
<u>Halobates micans</u>	water strider	Neuston
<u>Euphausia hemigibba</u>	krill	Sargasso Sea
Phylum Chaetognatha		
<u>Sagitta elegans</u>	arrow worm	cosmopolitan
Phylum Chordata		
<u>Paraxeno mystax</u>	eel larvae	warm core eddy
<u>Pyrosoma atlanticum</u>	tunicate	Sargasso Sea
<u>Histrio histrio</u>	Sargassum fish	Sargasso Sea
<u>Physeter catodon</u>	sperm whale	Gulf Stream edge
<u>Thalia democratica</u>	salp	Slope water
<u>Ceratoscopelus sp.</u>	lantern fish	Western North Atlantic
<u>Puffinus gravis</u>	greater shearwater	north of Gulf Stream
Phylum Coelenterata		
<u>Hippopodius hippopus</u>	siphonophore bracts	warm core eddy
Phylum Ctenophora		
<u>Pleurobrachia pileus</u>	comb jelly	No. American coastal waters
Phylum Cyanophyta		
<u>Trichodesmium sp.</u>	bluegreen algae	Gulf Stream
Phylum Mollusca		
<u>Calliteuthis reversa</u>	pelagic squid	warm core eddy
<u>Pterotrachea coronata</u>	heteropod	warm core eddy
<u>Cavolina trispinosa</u>	pteropod	Sargasso Sea
Division Phaeophycophyta		
<u>Sargassum fluitans</u>	Sargassum or Gulf weed	Sargasso Sea
Phylum Platyhelminthes		
<u>Dactylogyrus sp.</u>	parasitic worm	bluefin tuna gills

Appendix 3. W-41 Ship's weather observations

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 T	3P _w P _w H _w H _w	d _w d _w P _w H _w H _w
99408	70736	28063	11911	98020	11522	10000	32201	00422	12013	3////	////
99403	70699	28123	62309	97030	10723	65141	41206	00722	11995	30201	22702
99380	70700	29123	12604	98030	11924	12500	51400	05022	12475	30303	25702
99369	70665	02043	2////	98600	24027	91111	51400	0//26	12835	3////	////
99369	70665	02063	41707	98030	23927	422//	21400	05124	12894	3//01	////
99359	70661	03063	20905	99020	25226	////	51705	05124	12696	3//00	////
99357	70664	03123	11010	99030	24527	12200	41305	00124	12672	30201	15402
99345	70665	04063	11221	99000	22926	11200	41101	00024	12688	3//02	////
99342	70665	04123	21413	98180	23527	22362	41109	00026	12702	30202	11054
99341	70661	05063	12005	99020	26427	122//	51403	00024	12680	3////	////
99341	70666	05123	21408	99020	27327	21300	31220	00225	12698	30201	18302
99338	70658	06063	11405	99020	27827	11000	42009	05024	12720	3////	////
99335	70655	06123	40712	99030	27428	41400	31208	00224	12710	30301	08502
99332	70646	11123	73312	98152	22527	57661	81400	00024	12735	30201	01502
99335	70643	12063	61402	99299	21526	497//	81003	05223	12710	30000	99502
99344	70643	12123	62604	99018	22026	28379	81105	05023	12695	30301	27102
99355	70643	13063	12604	99000	21428	1/3//	81403	05024	12831	3//01	////
99359	70643	13123	72507	98501	21928	7849/	00106	05025	12820	30301	25602
99373	70638	14063	82724	97182	18326	873//	82717	05325	12793	3////	27/04
99377	70635	14123	81820	97632	17826	873//	22000	05125	12821	30302	22703
99388	70620	16123	10502	99050	20026	11480	82108	05520	12830	30101	06501
99403	70619	17003	03102	99011	17725	00900	81708	00123	12515	30000	99501
99405	70620	17173	13203	98010	17525	00001	81021	00224	12391	30000	19701
99418	70612	18063	42507	98031	15524	00979	11807	00324	12349	30301	25501
99430	70602	19063	82507	97022	13123	862//	11004	00422	12147	3////	25501
99438	70595	20063	11008	98010	16019	16400	11702	00116	11936	30201	21502
99440	70596	20123	70915	98031	15519	65218	11705	00118	11958	30201	09503
99444	70608	21063	80815	98022	13220	864//	62708	00219	11913	3//02	09/03
99423	70663	28063	03210	99020	21116	00900	61208	00113	11560	30101	99501
99423	70665	28123	10105	98020	22217	00018	31210	00315	11560	39901	24501
99433	70675	29063	91615	94216	09917	8////	71753	00315	11580	3//02	////
99426	70692	02063	12793	97001	20819	1////	00203	00218	11845	3//01	////

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 temp.; 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 temp. difference; T_d = dew point; T_w = sea temp.; ^tT = tenths of air temp.; P_w and H_w = wind wave period and height; d_w = swell direction.

Appendix 4.

W-41 Marine Mammal Sightings

Date	Time	Lat (N)	Long (W)	Sighting/ I.D./ No's.
27 July	1640	41° 02'	71° 01'	Three blows: unidentified, 1.
29 July	1126	39° 10'	70° 01'	Bottlenose dolphins: <u>Tursiops truncatus</u> , 6.
30 July	0645	38° 33'	70° 08'	Saddlebacks; <u>Delphinus delphis</u> , 50.
1 Aug	1600	38° 54'	66° 49'	Dolphins: unidentified, 3-4.
15 Aug	1107	37° 45'	62° 30'	Pilot whale: <u>Globicephala melaena</u> , 1-2.
16 Aug	1400	39° 19'	62° 05'*	Sperm whale: <u>Physeter catodon</u> , 15.
18 Aug	0735	42° 05'	61° 04'	Bottlenose dolphins: <u>Tursiops truncatus</u> , 15-20.
18 Aug	1405	42° 41'	60° 51'	Striped dolphins: <u>Stenella coeruleoalba</u> , 10 ⁺ .
18 Aug	1630	42° 44'	60° 55'	Dolphins: unidentified, approx. 50.
19 Aug	1040	43° 23'	59° 52'	Sperm whale: <u>Physeter catodon</u> , 1.
19 Aug	1105			Possible Right whale: unidentified, 1.
19 Aug	1518	42° 44'	60° 55'	Striped dolphins: <u>Stenella coeruleoalba</u> , 3.
19 Aug	1940	43° 41'	59° 38'	Pilot whales: <u>Globicephala melaena</u> , 5-6.
20 Aug	0715	43° 59'	59° 10'	Pilot whales: <u>Globicephala melaena</u> , 4.
20 Aug	0730	43° 59'	59° 11'	Striped dolphins: <u>Stenella coeruleoalba</u> , 30-40.
22 Aug	1025	44° 25'	63° 59'	Striped dolphins: <u>Stenella coeruleoalba</u> , 2.
22 Aug	1410	44° 34'	64° 00'	Dolphin: unidentified, 1.
26 Aug	1720	43° 58'	64° 16'	Possible Pilot whales: <u>Globicephala melaena</u> , 3.
27 Aug	0720	43° 01'	64° 39'	Whale: unidentified, 1.
27 Aug	0740	42° 60'	64° 40'	Whale: unidentified, 1-2.
27 Aug	0835	42° 38'	64° 40'	Possible Pilot whales: <u>Globicephala melaena</u> , 10 ⁺ .
27 Aug	0940	42° 57'	64° 41'	Whale: unidentified, 1.
27 Aug	0950	42° 57'	64° 41'	Whale: unidentified, 1.
27 Aug	1000	42° 57'	64° 41'	Whale: unidentified, 1.
27 Aug	1011	42° 57'	64° 41'	Whales: unidentified, 3.
27 Aug	1015	42° 57'	64° 41'	Whales: unidentified, 3.
27 Aug	1024	42° 57'	64° 41'	Possible Finback whales: <u>Balaenoptera physalus</u> , 4 ⁺ .
27 Aug	1026	42° 57'	64° 41'	Possible Finback whale: <u>Balaenoptera physalus</u> , 1.
27 Aug	1115	42° 54'	65° 56'	Whale: unidentified, 1.
27 Aug	1130	42° 54'	65° 56'	Whale: unidentified, 1.
27 Aug	1140	42° 54'	65° 56'	Whale: unidentified, 1.
27 Aug	1150	42° 54'	65° 56'	Whales: unidentified, 1-2.
27 Aug	1158	42° 54'	65° 56'	Probably Fin whale: <u>Balaenoptera physalus</u> , 1.
27 Aug	1203	42° 54'	65° 56'	Whale: unidentified, 1.
27 Aug	1210	42° 53'	65° 56'	Whale: unidentified, 1.
27 Aug	1215	42° 53'	65° 56'	Whale: unidentified, 1.
27 Aug	1230	42° 53'	65° 56'	Whale: unidentified, 1.
27 Aug	1440	42° 52'	65° 04'	Whale: unidentified, 1.
28 Aug	0540	42° 18'	66° 16'	Possible dolphins: unidentified, 3.

(W-41 Marine Mammal Sightings Cont.)

Date	Time	Lat (W)	Long (W)	Sighting/ I.D./ No's.
28 Aug	1205	42°45'	66°51'	Whale: unidentified, 1.
28 Aug	1545	42°42'	66°43'	Whales: unidentified, 2.
28 Aug	1730	42°45'	66°52'	Atlantic White-sided dolphins: <u>Lagenorhynchus acutus</u> , 12.
31 Aug	0720	44°15'	68°10'	Probable Minke whale: <u>Balaenoptera acutorostrata</u> , 1.
31 Aug	1015	44°01'	68°05'	Probable Minke whale: <u>Balaenoptera acutorostrata</u> , 1.
31 Aug	1055	43°56'	68°07'	Possible Harbor porpoises: <u>Phocoena phocoena</u> , 2-3.
31 Aug	1240	43°49'	68°07'	Possible Minke whale: <u>Balaenoptera acutorostrata</u> , 1.
31 Aug	1700	43°18'	68°16'	Atlantic White-Sided dolphins: <u>Lagenorhynchus acutus</u> , 30 ⁺ .
1 Sept	1340	42°54'	68°45'	Atlantic White-Sided dolphins: <u>Lagenorhynchus acutus</u> , 20-30 ⁺ .
1 Sept	1445	42°52'	68°54'	Dolphins: unidentified, 30-40.
1 Sept	1537	42°52'	68°56'	Probable Minke whale: <u>Balaenoptera acutorostrata</u> , 1.
3 Sept	1505	42°39'	70°31'	Whales: unidentified.
3 Sept	1520	42°39'	70°31'	Whale: unidentified.
3 Sept	1525	42°39'	70°31'	Whales: unidentified.
3 Sept	1655	42°35'	70°25'	Humpback whale + one other species: <u>Megaptera novaeangliae</u> , 2.
3 Sept	1707	42°35'	70°25'	Humpback whale: <u>Megaptera novaeangliae</u> , 1.
3 Sept	1712	42°35'	70°25'	Humpback whale, 1.
3 Sept	1720	42°35'	70°25'	Blows, unidentified.
3 Sept	1725	42°35'	70°25'	Blows, unidentified.
3 Sept	1732	42°35'	70°25'	Blows, unidentified.
3 Sept	1745	42°35'	70°25'	Blows, unidentified.
3 Sept	1800	42°35'	70°25'	Blows, unidentified.
3 Sept	1804	42°35'	70°25'	Blow, unidentified.
3 Sept	1808	42°35'	70°25'	Blow, unidentified.
3 Sept	1815	42°35'	70°25'	Blow, unidentified.
3 Sept	1829-1854	42°20'	70°11'	Whales: unidentified, 4.
4 Sept	1320	42°66'	70°25'	Whales: unidentified, 11.

Appendix 5

Coral Reef Fishes Sighted at Castle Rock, Bermuda August 10, 1978

Common Name	Scientific Name	Relative Sighting Frequency
purple mouth moray	<u>Gymnothorax vicinus</u>	1
fairy basslet	<u>Gramma lareto</u>	1
Jew fish	<u>Epinephelus itajata</u>	1
blue striped grunt	<u>Haemulon sp.</u>	1
pork fish	<u>Anisotremus virginicus</u>	2
goat fish	<u>Pseudupeneus sp.</u>	1
silver porgy	<u>Diplodus argenteus</u>	1
peacock flounder	<u>Bothus lunatus</u>	1
blue head wrasse	<u>Thalassoma bifasciatum</u>	3
angelfish, queen	<u>Holacanthus ciliaris</u>	3
angelfish, blue	<u>Holacanthus bermudensis</u> (Goode)	3
queen triggerfish	<u>Balistes vetula</u> (Linnaeus)	2
blue tang	<u>Acanthurus coeruleus</u>	2
smooth trunk fish	<u>Lactophrys triqueter</u>	4
spotted trunk fish	<u>Lactophrys bicaudalis</u> (Linnaeus)	1
jolthead porgy	<u>Calamus bajonado</u>	2
sergeant major	<u>Abudefduf saxatilis</u>	7
cocoa damselfish	<u>Eupomacentrus variabilis</u>	1
stoplight parrotfish	<u>Sparisoma viride</u>	4
red band parrotfish	<u>Sparisoma aurofrenatum</u> (Valenciennes)	1
Molly Miller	<u>Blennius cristatus</u> (Linnaeus)	1
grey snapper	<u>Lutjanus griseus</u>	1
butterfly fish	<u>Chaetodon sp.</u>	1
queen parrotfish	<u>Scarus vetula</u>	1
blue parrotfish	<u>Scarus coeruleus</u>	2
French grunt	<u>Haemulon flavolineatum</u>	1
four-eye butterfly fish	<u>Chaetodon capistratus</u>	1
longsnout butterfly fish	<u>Prognathodes aculeatus</u>	1
razorfish	<u>Hemipteronotus sp.</u>	1
rainbow parrotfish	<u>Scarus guacamaia</u>	1

Appendix 6.

W-41 Otter Trawl Species Rosters & Diversities

Trawl #	Name	No.	Length/Wt.
28 July 78	leopard skate	<u>Raja garmani</u>	1 13 oz
39°57'N	spotted hake	<u>Urophycis regius</u>	2 28 oz
69°41'W	four spotted flounder	<u>Paralichthys oblongus</u>	12 94 oz
	armored sea robin	<u>Peristedion miniatum</u>	1 8 oz
(1)	goosefish	<u>Lophius americanus</u>	1 104 oz
	hermit crab	<u>Eupagurus bernhardus</u>	1
	crab	<u>Cancer borealis</u>	22
	lobster	<u>Homarus americanus</u>	2
	shrimp	<u>Munida valida</u>	21
	starfish	<u>Henricia genus</u>	5
	starfish	<u>Leptychaster arcticus</u>	17
	starfish	<u>Ctenodiscus arcticus</u>	3

Diversity Index = 6.15

20 Aug 78	thorny skate	<u>Raja radiata</u>	1 30 oz
44°34'N	long horn sculpon	<u>Myoxocephalus octodecemspinosus</u>	1 8 oz
59°34'W	yellow tail flounder	<u>Limanda ferruginea</u>	6 48 oz
	American plaice	<u>Hyppoglossoides platessoides</u>	15 104 oz
(2)	skate egg cases		11
	hermit crab	<u>Pagurus bernhardus</u>	2
	purple sun star	<u>Solaster endeca</u>	1
	basket star	<u>Gorgonocephalus arcticus</u>	3
	cushion star	<u>Hippasteria phrygiana</u>	1
	blood stars	<u>Asterias vulgaris</u>	7
	starfish, others		2
	grey brittle stars and		53
	black-striped brittle star	<u>Ophioderma sp.</u>	2
	red striped brittle star	<u>Ophiopholis aculeata</u>	4
	brittle star others		2
	orange striped sea cucumbers	<u>Cucumaria frondosa</u>	159
	sand dollar	<u>Echinarachnius parma</u>	80
	sea urchin	<u>Strongylocentrotus drobachiensis</u>	9

Diversity Index = 5.49

22 Aug 78	American plaice	<u>Hyppoglossoides platessoides</u>	340 12-40 cm
44°34'N	skate	unidentified	2
64°00'W	starfish	<u>Asterias sp.</u>	130
	brittle star	unidentified	21
(3)	purple sun star	<u>Solaster endeca</u> (Linnaeus)	2
	golden bordered star		35
	sea cucumber	<u>Leptosynapta sp.</u>	

Diversity Index = 1.84

Appendix 7

W-41 Hydrographic Data Log

Sta #	Date d/m	Time	Position		Depth (M)	Temp. °C	Salinity ‰	O ₂ ppm	PO ₄ -P μg-aT/L	NO ₃ -N μg-aT/L
			Lat (N)	Long (W)						
1	28 July	1200	40°06'	69°51'	0	20.31	34.04	5.26	.0286	14.29
					13	19.85	34.09	5.40	.0536	2.86
					36	8.86	32.79	5.88	.0203	2.86
					66	8.10	33.85	5.60	.0286	0.71
					100	9.05	35.29	4.68	—	—
2	29 July	0000	39°49'	69°40'	0	21.71	33.83	5.04	.0225	0.36
					100	15.02	37.27	3.99	.0162	2.14
					200	10.48	33.85	3.37	.0950	13.57
					300	8.38	36.05	3.29	.0455	17.14
					400	6.52	34.90	4.20	.0455	10.00
3	29 July	2040	38°33'	70°08'	0	24.73	36.79	4.88	.0286	0.00
					26	22.96	36.05	4.88	.0620	0.00
					200	13.93	35.71	3.45	.0781	6.43
4	30 July	0207	38°33'	70°08'	0	24.53	35.47	4.64	.0039	0.00
					27	22.68	33.90	5.15	.0390	0.00
					200	12.29	35.59	3.50	.0370	42.86
					400	7.96	35.04	3.42	.0039	7.80
5	30 July	0812	38°31'	70°11'	0	23.96	35.21	4.63	.0740	7.14
					30	23.12	36.36	4.79	.0330	0
					200	13.4	35.91	3.58	.0580	.71
					400	8.39	35.09	3.42	.0870	12.46
6	30 July	1430	38°33'	70°08'	0	24.62	28.61	5.10	.000	.71
					21	23.38	—	5.12	.0245	0.00
					200	12.38	25.77	3.66	.0290	11.79
					400	7.75	29.91	3.66	.0330	7.86
7	1 Aug	2020	36°56'	66°25'	0	28.48	34.25	5.73	.0094	0.00
					40	27.62	32.41	6.03	.0039	.71
					100	23.50	31.75	4.79	.0329	0.00
					200	19.21	26.15	3.47	.0203	1.50
8	4 Aug	2145	34°00'	66°31'	0	26.90	36.13	5.98	.0240	0.00
					40	22.66	36.54	7.15	.0203	2.14
					110	18.63	36.44	6.85	.0162	0.00
					200	18.14	36.65	6.18	—	—
					400	17.33	—	5.71	—	—
9	11 Aug	2115	34°07'	64°33'	0	27.14	35.30	2.69	.000	0.00
					120	18.48	35.50	3.12	.035	0.00
					200	18.19	35.38	3.27	.000	0.00
					400	17.93	35.50	3.35	.000	0.00

(W-41 Hydrographic Data Log Cont.)

Sta #	Date d/m	Time	Position		Depth (M)	Temp. °C	Salinity °/oo	O ₂ ppm	PO ₄ -P	NO ₃ -N
			Lat (N)	Long (W)					µg-aT/L	µg-aT/L
10	14 Aug	1355	37°47'	62°35'	0	28.55	35.09	4.27	.0245	1.07
					55	28.59	35.17	4.21	.0039	0.00
					200	24.98	—	3.86	—	—
					400	19.34	35.42	3.64	.0203	3.21
11	14 Aug	2016	37°43'	62°29'	0	28.52	35.32	4.20	.0290	0.00
					55	—	35.30	4.21	.0703	1.43
					200	25.66	35.55	3.90	.0162	1.43
					400	19.94	35.67	4.21	.0290	2.86
12	15 Aug	0206	37°42'	62°33'	0	28.52	35.11	4.30	.0000	1.43
					55	30.07	35.05	4.35	—	—
					200	23.12	35.71	3.80	.0300	2.14
					400	18.56	35.57	4.29	.0200	1.43
13	15 Aug	0806	37°46'	62°36'	0	28.55	35.30	3.99	.0710	1.80
					75	28.23	35.25	3.92	.1500	0.71
					200	22.89	35.94	4.12	—	1.07
					400	18.45	35.30	4.49	.0710	4.30
14	17 Aug	2035	41°38'	61°42'	0	23.98	33.94	4.72	.0330	1.43
					40	17.99	34.59	5.47	.0039	0.00
					100	15.43	34.92	5.24	.0203	5.70
					200	12.76	34.79	6.61	.0290	3.57
					400	8.51	32.60	5.87	.0162	10.20