Crane

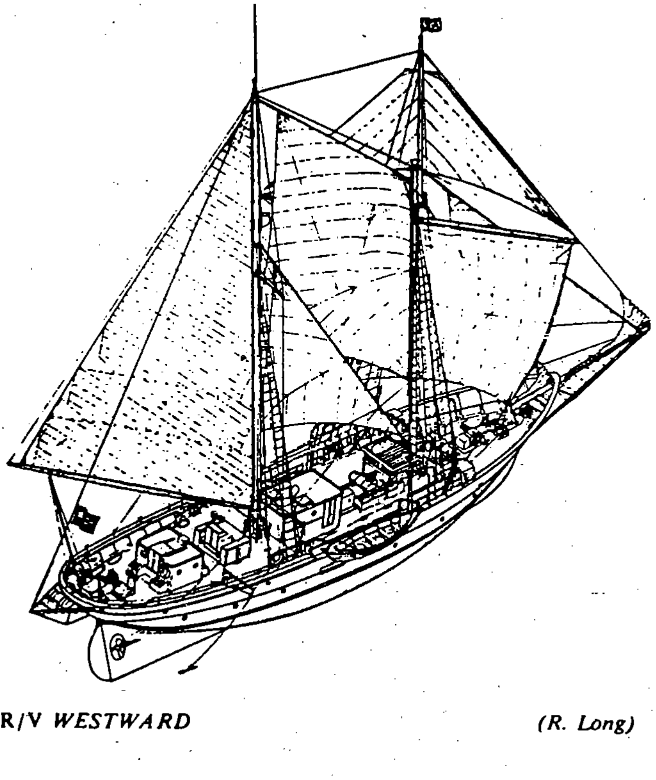
CRUISE REPORT

W-89

Scientific Activities
Undertaken Aboard
R/V Westward

Woods Hole - Ile St. Pierre - Lunenburg - Gloucester

19 July - 29 August 1986



R/V *WESTWARD* *(R. Long)*

Sea Education Association - Woods Hole, Massachusetts

Cruise Report

W-89

Scientific Activities

19 July - 29 August 1986

R/V *Westward*

Sea Education Association
Woods Hole, Massachusetts

DRAFT COPY

PREFACE

This Cruise Report is intended to serve as an outline of the scientific research activities and academic program conducted on board the R/V Westward during her eighty-ninth cruise, which took place in the summer of 1986. The bulk of this report consists of abstracts from projects defined by the students while taking the Shore Component in Woods Hole with emphasis on standardization of long-term studies of S.E.A. staff scientists and associated researchers.

The abstracts were written while at sea and are not intended to represent the final analysis or interpretation of data collected during W-89. However, it is important for the students to complete their projects while at sea and this process enables them to participate in the initial stages of analysis of data they helped to collect.

Through the diligent efforts of the staff on board R/V Westward cruise W-89, and the ambition of a highly motivated group of students, we were able to complete all the student projects and staff studies. Terry Hayward, as Westward's master, worked long and hard to extract the best possible oceanographic work from a challenging cruise track, especially in the fjord. I owe Terry special thanks for his interest, help, and support throughout the cruise.

In the operation of the vessel, Terry had the assistance of exceptionally skillful mates. Their enthusiasm for the science program and their dedication to teaching the finer points of ship handling and navigation allowed us to complete our stations efficiently and easily. I am very grateful for the help I received from Carol Hayward, Dick Waterhouse, and Beth Doxsee.

In addition to his duties as the ship's engineer, Ken Potter was invaluable in the maintenance and repair of several stubborn pieces of oceanographic gear. And the culinary skills of Albert Shahinian were outstanding! He facilitated a constant stream of delectable treats from the galley with considerable ease--and added immensely to the morale of the cruise.

I was fortunate on this cruise to have three fine assistant scientists: I owe them my great thanks for their enormous efforts in _Westward_'s laboratory. Steve Berkowitz, a veteran of a long-ago _Westward_ cruise, assumed much of the responsibility of the maintenance of the laboratory and was a much-appreciated stickler for methodological details. Greg DiLisio, a _Westward_ alum, made a welcome return after several years, and greatly added to the experience of the students by his unflappable enthusiasm for science. Craig Swatland, a _Westward_ alum of the Williams-Mystic Program, also brought enthusiasm and a conscientious approach to the safe handling of gear.

In addition to the ship's regular staff, Peter Stifel joined us for Leg I of cruise W-89. He helped us build a place to stow and use Jim Beach's highly appreciated computer. Despite crippling sea-sickness, Peter contributed greatly to our cruise with his philosophy, with his ability to teach and to spark our curiosity, and with his warm personality. We were delighted to meet up with him again in Maine when we conducted a special sail for visitors.

In the final analysis, however, I feel I owe special thanks to a superlative group of students. We could not have accomplished so much, and produced such consistent and high quality data without both their hard work and consideration for each other. I thank them all for making W-89 such an exciting and memorable cruise!

Mary W. Farmer
Chief Scientist, W-89

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INTRODUCTION

A. Research Program

This report is the product of the research conducted on R/V Westward cruise W-89 for the Sea Semester program. The cruise track (Fig. 1) was designed to permit collection of physical, chemical, sedimentological, and biological data from several major water masses in the North Atlantic Ocean including samples from continental shelf regions and the continental slope. The ship's itinerary, including intermediate ports of call (Table 1), permitted participants on W-89 access to several terrestrial and neritic habitats as well as the open ocean environment. Cruise participants are listed in Table 2.

Three themes were addressed during cruise W-89: standardization of long-term studies conducted by S.E.A. students and staff, multidisciplinary investigations of the water masses of the western North Atlantic, and shallow water benthic studies. Each of these themes is introduced in its own section. Introductory remarks are followed by abstracts of individual student projects, which make up a large portion of the report.

The positions of all oceanographic stations and scientific operations are listed in Appendix I and are shown in Figures 2-4. Data from the oceanographic stations are tabulated in the remaining appendices. Information reported herein may not be excerpted or cited without written permission of the Chief Scientist.

Table 1. ITINERARY OF R/V WESTWARD CRUISE W-89

	Arrive	Depart
Woods Hole, MA	--	19 July 1986
Ile St. Pierre	05 August 1986	07 August 1986
Grand Banks, Newfoundland*	07 August 1986	07 August 1986
Bay d'Espoir, Newfoundland	08 August 1986	10 August 1986
Sable Island, Nova Scotia	14 August 1986	14 August 1986
Lunenburg, Nova Scotia	18 August 1986	20 August 1986
Bar Harbor, ME	23 August 1986	23 August 1986
North Haven, ME	24 August 1986	25 August 1986
Gloucester, MA	29 August 1986	--

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*Customs clearance only

Table 2. SHIP'S COMPLEMENT ON R/V *WESTWARD* CRUISE W-89

Nautical Staff

Harold (Terry) A. Hayward	Captain
Carol S. Hayward	Chief Mate
Richard (Dick) E. Waterhouse	Second Mate
Elizabeth B. Doxsee	Third Mate
Kenneth J. Potter	Engineer
Albert J. Shahinian	Steward

Scientific Staff

Mary W. Farmer	Chief Scientist
Steven P. Berkowitz	Assistant Scientist
Gregory P. DiLisio	Assistant Scientist
Craig A. Swatland	Assistant Scientist

Visitor

Peter B. Stifel (Leg I)	University of Maryland

Students

James A. Beach, Middlebury College, Sophomore, Economics

Julie A. Bedford, Wheaton College, Sophomore, Biology

Patricia A. Brown, Rice University, Senior, Biology

Jeanette Fielden, Univ. of Texas/El Paso, Senior, Geophysics

Peter N. Fish, Vassar College, Junior, Biology

Timothy M. Hall, Trinity College, Senior, Urban Studies

Peter J. Hodum, Bowdoin College, Junior, Biology/Envir. Studies

Lianna L. Jarecki, Cornell University, Junior, Biology

Thomas A. Jarecki, Boston University, Junior, Philosophy

Kimberly A. Mason, Case Western Reserve U., Senior, Geology

Sophie Morse, University of Vermont, Sophomore, Envir. Studies

Margie Oleksiak, Wellesley College, Sophomore, Math/Philos.

Kimberley L. O'Sullivan, Middlebury College, Senior, Bio/Psych

Adam T. Perlin, Skidmore College, Junior, Bio/Chem

Deborah Poor, Univ. of Pennsylvania, Senior, Envir. Studies

Kitty Quejada, San Francisco State U., Senior, Marine Biology

Helen M. Rozwadowski, Williams College, Junior, Bio/Eng

Charles A. Schick, Boston College, Junior, Biology

Cynthia R. Smith, Middlebury College, Sophomore, Biology

Ellen L. Steinberg, Wellesley College, Sophomore, Art

D. Hannah Taylor, Harvard University, Junior, Anthropology

Cheryl L. Watts, Westminster College, Senior, Biology

Mark A. Williams, Univ. of Rhode Island, Sophomore, Ocean/Chem

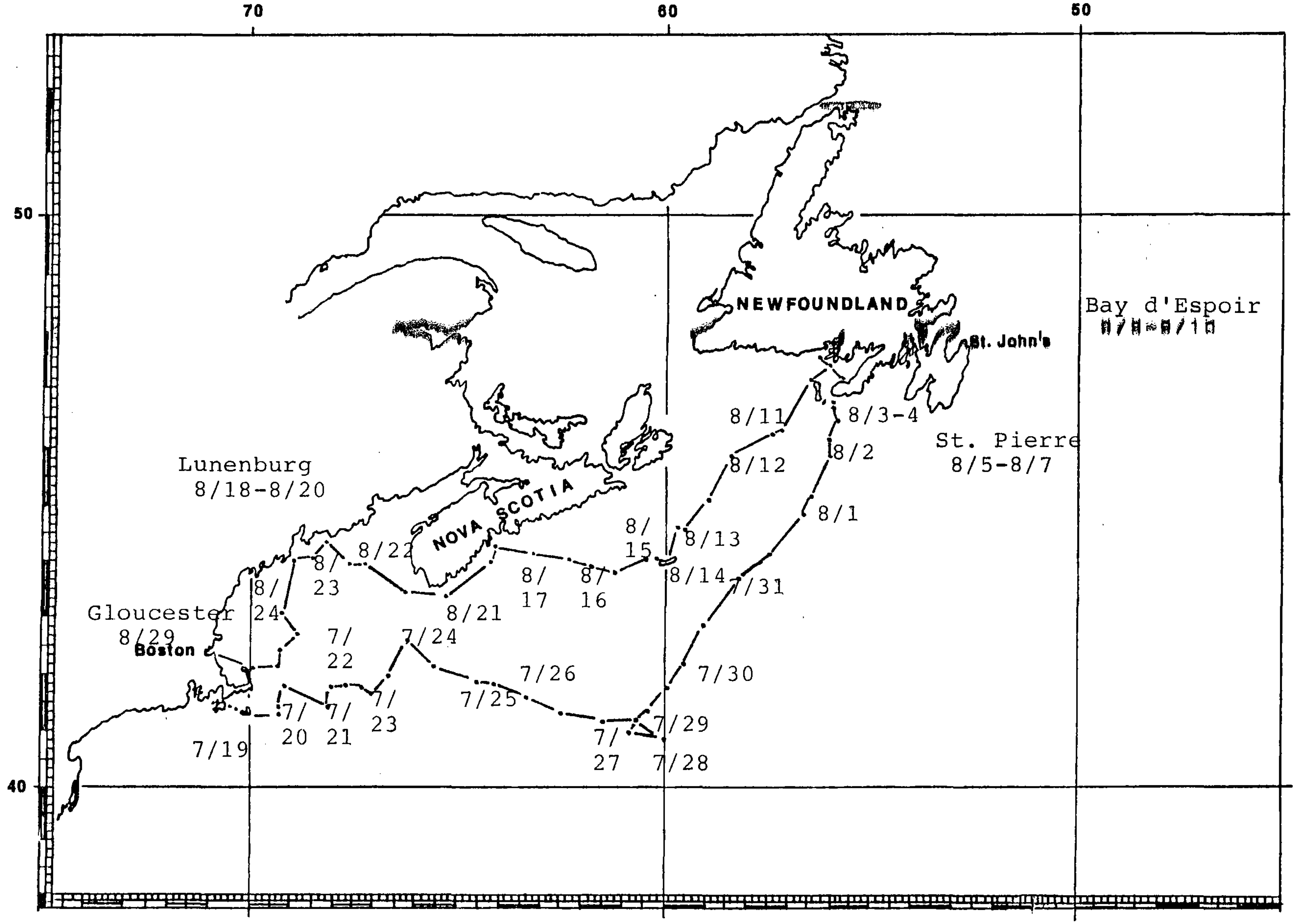

Figure 1. Cruise track of the R/V Westward, cruise W-89. Noon and midnight positions. Dates given by the noon position.

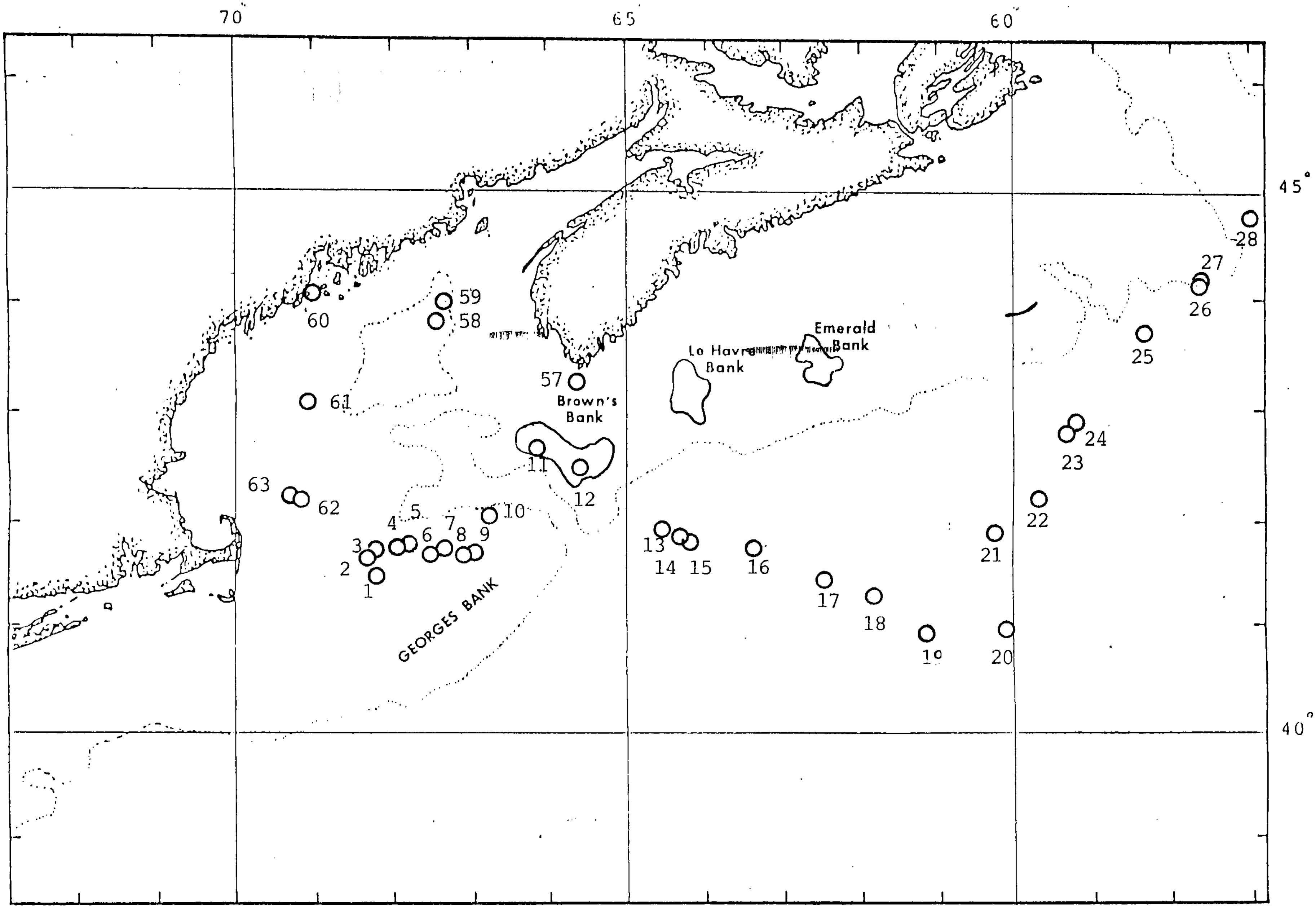

Figure 2. Oceanographic stations performed on cruise W-89 of the R/V *Westward*. Southern section.

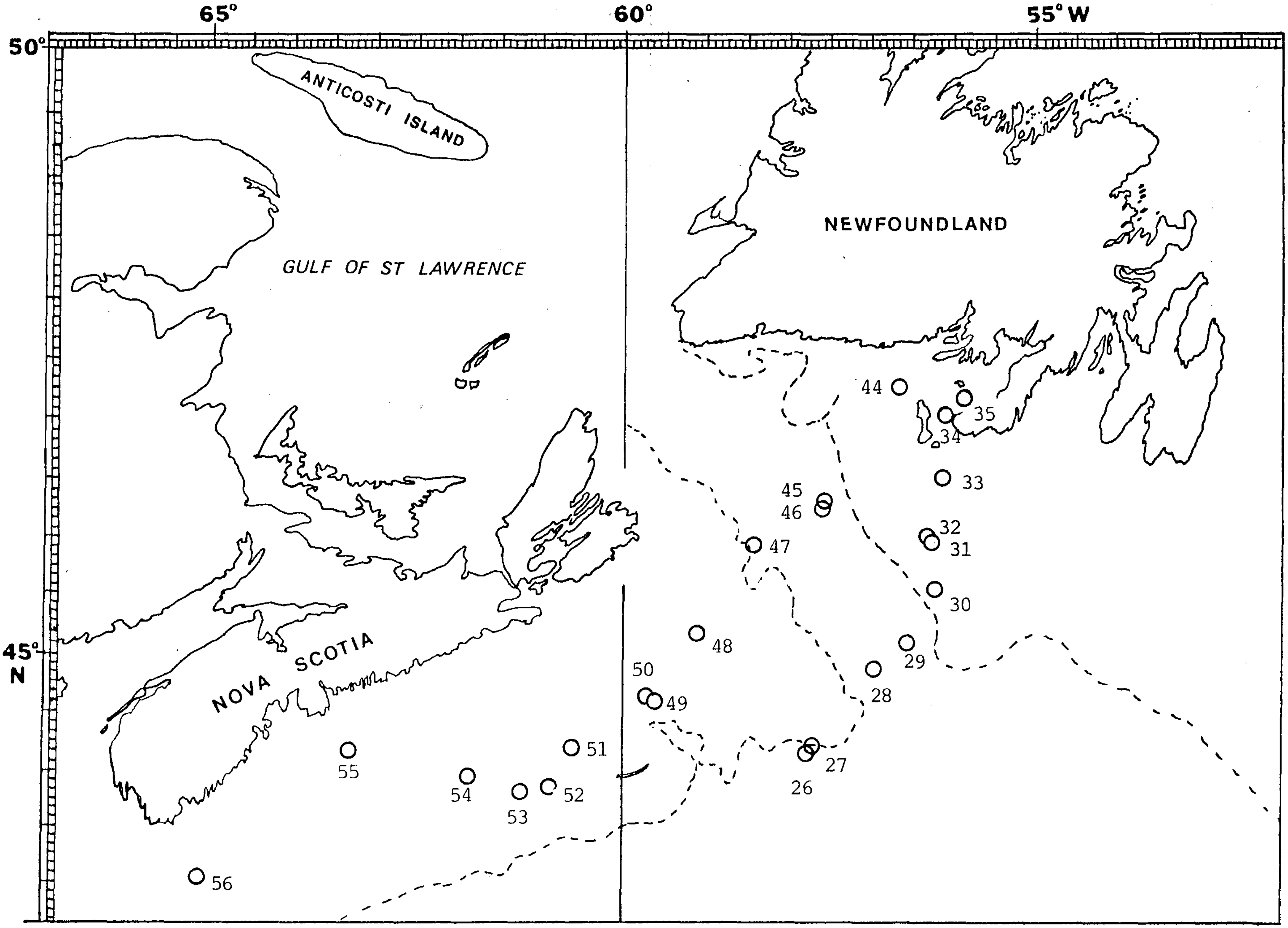

Figure 3. Oceanographic stations performed on cruise W-89 of the R/V Westward. Northern section. Stations 37-43 given in Fig. 4.

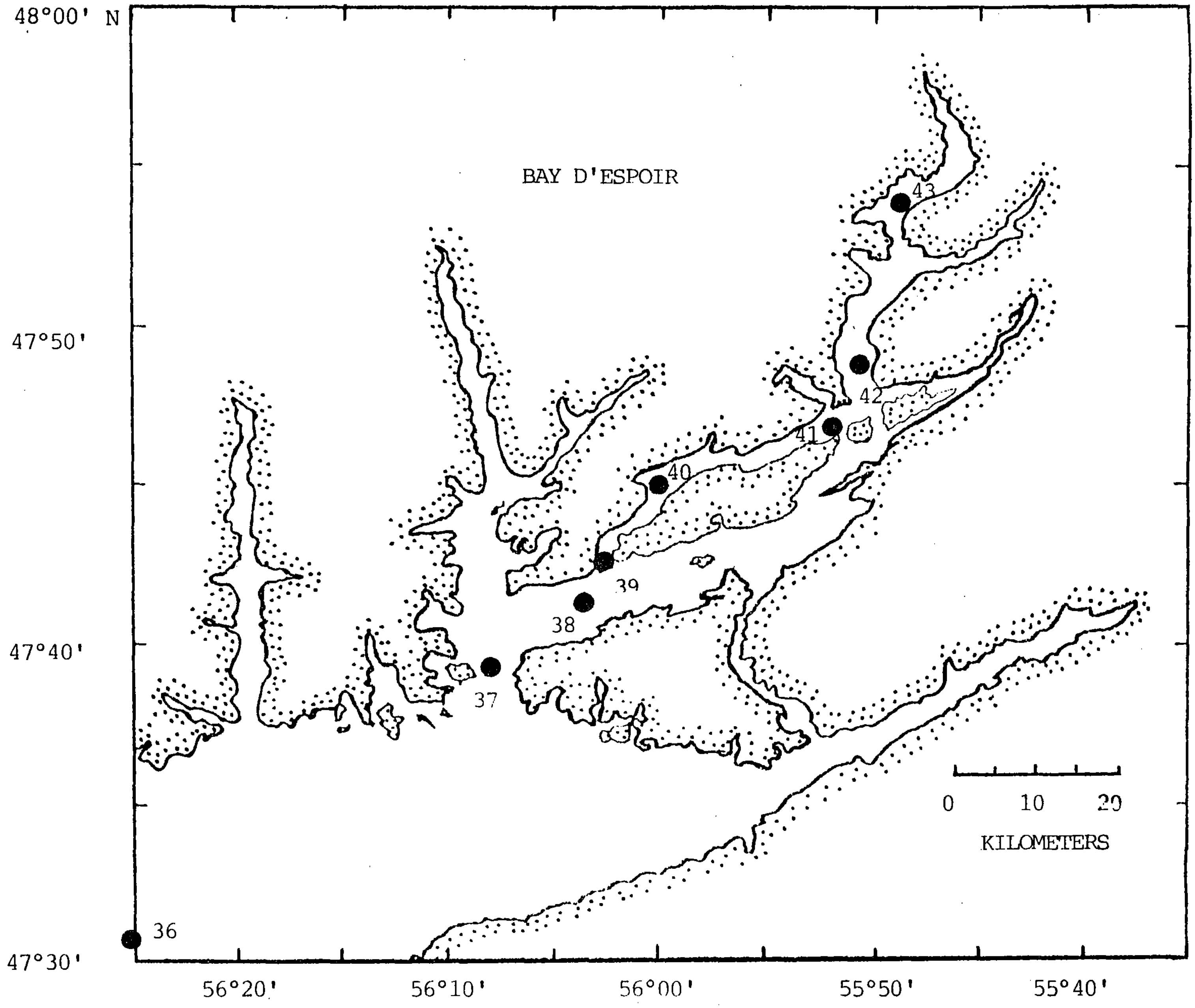

Figure 4. Oceanographic stations performed in Bay d'Espoir, Newfoundland.

B. Academic Program

Throughout the six week period covered by R/V Westward cruise W-89 a 24-hour science watch was maintained by teams of three students and one member of the science staff. During science watch students were instructed in the use of gear and scientific procedures spanning many aspects of physical, chemical, geological, and biological oceanography. Instruction was provided in the form of oceanographic and marine biological research, which was conducted either for individual projects or the work of S.E.A. staff or long-term cooperative programs. Routine meteorological and oceanic observations were made and weather data were transmitted during science watches. During the last two weeks of the cruise, students were sufficiently familiar with scientific procedures to operate activities of the laboratory without major direction from the marine science staff.

Formal instruction on a daily basis was provided in the form of lectures given by the marine science staff. Lecture topics were designed to cover aspects of science not readily gained from laboratory experience. In addition to lecture material, a small museum of organisms called "Feature Creatures" was developed during the cruise to familiarize students with the life history and adaptation of important marine vertebrates, invertebrates, and plants.

Oceanographic studies fell into three categories: (1) Each student took to sea a well-planned project which could be completed during the cruise. These projects were chosen by the students and completed as independent research. A short seminar at the end of the cruise was given by each student to summarize their findings. (2) Two projects, designed by the science staff, were completed to demonstrate or test particular oceanographic principles. These cruise projects required the participation of all student crew members in data gathering, sample processing, and data reduction. The project designed by G. DiLisio is included here and the report is on file at the S.E.A. office. (3) Several long-term projects are being conducted by S.E.A. staff members and associated organizations. Many of the student projects were centered around these topics. The data from these studies will be kept in the oceanographic data bank now being established at S.E.A.

Every oceanographic station was made for the purpose of actual research and no sample was taken solely for the purpose of demonstration. In this way, students were given the opportunity to learn from meaningful participation in actual research activities.

LONG-TERM S.E.A. STUDIES

Introduction

Since 1977 scientists at S.E.A. have been collecting data on the substances and organisms that float at the sea surface. These include pelagic tar and *Sargassum* weed, the seaweed that gave the Sargasso Sea its name. In 1982 we began to analyze other seaweeds, especially in northern waters, and within the past two years we have added analysis of plastic particles to our repertoire. We have periodically monitored the pH of precipitation--rain or fog--as well. Finally, for several years we have been cooperating with Tim Rumage of the Rhode Island School of Design to provide data on sightings of seabirds and of marine mammals.

The neuston tows on W-89 yielded only one sample of *Sargassum* weed (Appendix IV) whereas 11 of the 34 tows contained the rocky intertidal seaweed, *Ascophyllum*, and 3 of these tows also contained a related seaweed, *Fucus* sp. Our students were interested in the biological fate of these weeds ripped away from their natural habitat: Rozwadowski and Steinberg found some evidence that salinity, but not temperature, affects pigmentation of the floating weed. *Ascophyllum* appeared to be very hardy and was able to photosynthesize at very low light intensities (L. Jarechi).

Tar was present in 25 of the 34 neuston tows; it apparently had been dispersed rapidly by wind and currents (Taylor and Poor). Plastic was present in 23 tows, also. Most of it was in the manufactured, rather than raw, form (Hall).

The pH of rain and fog was low this year, ranging from 4.2-4.8 (Morse). "Normal" rain has a pH of 5.2; the weather systems experienced on W-89 apparently originated in, or passed through, the acid rain belt of the northeastern United States before moving out to sea.

Forty-five species of birds were sighted in 10-minute transects along the cruise track of W-89 (Appendix VI), including several species of song bird and even a ruby-throated hummingbird! Atlantic White-sided Dolphins were seen feeding once during the cruise; they were accompanied by a high concentration of seabirds (Brown and Hodum). Other cetaceans were seen mostly at the edges of bottom features--the edge of Georges Bank and the edge of the continental shelf (Fielden), but it was not possible to photograph them successfully (T. Jarechi).

A STUDY OF CONDITION, DISTRIBUTION, AND MORPHOLOGY OF ASCOPHYLLUM IN NORTHWEST ATLANTIC WATERS

Helen Rozwadowski and Ellen Steinberg

Abstract

This project was a survey of the condition, distribution, and morphology of Ascophyllum in Northwest Atlantic waters. Samples were collected through routine neuston tows along the cruise track and one dip net sample was taken in Bay D'Espoir. Seventeen of 34 neuston tows contained Ascophyllum. At each station, surface salinity, surface temperature, and lateral distance from shore was measured. With this information, distribution and morphological differences were analyzed. Distribution of biomass was not affected by temperature or salinity, did seem to be affected by lateral distance from shore, and was definitely acted upon by currents. The condition of the weed varied in terms of pigmentation, decay, and the presence of epiphytes and receptacles. Temperature did not seem to affect morphological condition. Salinities of 33-35 parts per thousand, however, yielded the greenest Ascophyllum, and as salinity levels dropped, the weed became browner and more varied in pigmentation.

Ascophyllum grows naturally in the rocky intertidal zones where pigments are adapted to a low light environment. When the weed breaks away and floats on the surface of the ocean, the fucoxanthin pigments may become unnecessary and fade. These ideas are still hypothetical and need to be tested.

AN INVESTIGATION OF GROWTH, RESPIRATION, AND DETERIORATION OF ASCOPHYLLUM NODOSUM IN CONTINENTAL SHELF AND SLOPE WATERS FROM CAPE COD TO NEWFOUNDLAND

Lianna Jarecki

Abstract

Ascophyllum was sampled by neuston tows at twelve-hour intervals; it was present in 17 of 32 neuston tows, and sample weights ranged from 0.2 grams to 191.44 grams. Respiration rate was estimated by incubating bottles with and without Ascophyllum for predetermined amounts of time and by measuring changes in oxygen concentration using the Winkler titration method. Measurements were taken every six hours for 42 hours and then again at 66 hours. Respiration rate showed a cyclic pattern paralleling the day/night cycle for the first 30 hours. Over longer periods of time the respiration rate probably decreased as oxygen concentration decreased, but the experiment was not continued long enough to observe long-term effects. Ascophyllum was able to photosynthesize both in very low light intensities and in a very basic seawater environment with moderate light intensities.

For the decay analysis, the rate of phosphate increase was measured. Samples were treated similarly to those for respiration analysis, but the samples were taken every two days over a six day period. Rate of phosphate release increased very slowly initially, but after 48 hours of incubation, it rose sharply. Its peak, at 96 hours measured 0.87ug-at /hr. The rate

was low initially because the algae was healthy, but as it ran out of oxygen it began to release phosphates. The study set guidelines for *Westward* students doing further physiological studies on pelagic seaweed, and it raised interesting questions about the physiology of pelagic *Ascophyllum* and its importance to the oceanic ecosystem in the northwest Atlantic Ocean.

THE DISTRIBUTION AND FATE OF PELAGIC TAR IN THE NORTHWEST ATLANTIC FROM CAPE COD TO NEWFOUNDLAND

D. Hannah Taylor and Deborah Poor

Abstract

This study was designed to investigate the correlation between pelagic tar and oil industry activities at sea, and the distribution of tar in the water column as it relates to tar's residence time in the ocean. Tar was collected throughout our cruise track via neuston tows, Nansen bottle hydrocasts, and one sediment grab. It was then analyzed for concentration per surface area and for locale in the water column. Age was assigned by color and texture. Tanker ports, routes, and bilge pumping areas were charted as were wind and current patterns. Wind and current activities seem to provide a rapid dispersal mechanism for tar which results in pervasive distribution of random amounts of it throughout our oceans. Tar is also an indicator of the more tragic oil pollution problem.

A PILOT STUDY OF PELAGIC SURFACE PLASTIC IN THE NORTHWEST ATLANTIC

Timothy Hall

Abstract

Thirty-four neuston tows were analyzed to determine the frequency and distribution of plastic in the area of the Northwest Atlantic between Cape Cod and Newfoundland. Plastic was found in 23 of these 34 tows, and was then measured and categorized by type and form. The original intent of this study was to verify plastics research north of Cape Cod as a valid subject for research by future _Westward_ students. It was also intended to determine if plastic spherules and disks were evident in these waters where no obvious source of such pollution exists. This type of plastic was found to a small degree, supporting the original hypothesis of plastics outliving the effects of circulation, thus having a ubiquitous presence. Plastics in general were found across the entire cruise-track. This is a clear indication that this study should be continued. As a long-term _Westward_ study the change in the amount of plastics in this area could be studied.

ACID AND SULFATE ANALYSES OF RAIN AND FOG BETWEEN CAPE COD AND NEWFOUNDLAND

Sophie Morse

Abstract

During the last three decades acid rain has become an increasing problem throughout Northeastern North America, Europe, and Scandinavia. Acidity of rain in the Northeastern United States and Southeastern Canada has increased from average pH values of 4.6 to 4.1, increasing the threat to the environment in affected areas and raising concern in both countries. The rise in acidity has been correlated with the rise in sulfate and nitrate emissions from industry and the burning of fossil fuels. Sulfates and nitrates form acid when combined with oxygen and water vapor in the atmosphere.

Seven samples were taken between Newfoundland and Cape Cod showing acidic values between 4.2 and 4.8. Two of the three fog samples had pH values of 4.2 and the third had a pH of 4.8. The rain samples showed values of 4.2, two with 4.5, and one with 4.8. These values indicated a trend of higher acidity in fog than in rain. Only one sample contained sulfate, which due to careless analyses was unquantified.

The two unexpected readings for fog and rain which contradicted the trend in their relative acidities were attributed to local conditions and weather phenomena. The sulfate reading could have been due to emissions from <u>Westward</u> and remained an exception to the sulfate readings for the remaining samples.

It has been accepted by many scientists that acid rainfall in New England area is due to emissions from the Great Lakes Region being transported by prevailing westerly winds to the area and depositing its pollutants in precipitation. From Westward's weatherfax machine it was possible to obtain irregular prognoses of these high-altitude winds which aided in assessing the general source of the precipitation that was sampled.

CETACEAN AND SEABIRD ASSEMBLAGES IN THE NORTHWEST ATLANTIC

Patricia Brown and Peter Hodum

Abstract

The intent of this study was to examine the possible correlation between increased localized concentrations of seabirds and the presence of cetaceans. Along the cruise track of W-89, we investigated the associations between seabirds and cetaceans as influenced by prey selection and feeding methods of seabirds.

Thirty separate bird transects, consisting of three consecutive 10-minute observations, were conducted to obtain an indication of birds in the area as well as their behaviors. When cetaceans were sighted, a separate bird count of associated seabirds was performed. Species and number of individuals of seabirds and cetaceans and their respective behaviors were noted.

All sightings and regular transects were recorded on standard "Whale/Dolphin Sighting Records" and "Seabird Mapping Schemes" respectively. Data were collected along the entire cruise track.

Of the 26 sightings along the cruise track, only one sighting involved feeding cetaceans--Atlantic White-sided Dolphins were the representative. This was also the only sighting that had associated seabirds. Although this single association data point cannot be used to form any conclusions, it is supportive of the hypothesis; the concentrations of seabirds in the assemblage was considerably higher than the average

concentrations of seabirds on Georges Bank as indicated by standard daily bird transects. The species composition of the associated birds, which exhibited feeding behavior, primarily Greater and Sooty Shearwaters, also yielded expected results because of the similarity in diet of the shearwaters and dolphins. The data, including sightings of both baleen and toothed cetaceans, did substantiate the null hypothesis that seabirds do not associate with non-feeding cetaceans.

A STUDY OF THE RELATIONSHIP BETWEEN CETACEAN SIGHTINGS AND WATER DEPTH

Jeanette Fielden

Abstract

The purpose of the study was to investigate the possible correlation between water depth and location of sightings. Additionally this report will contribute data towards long-term cetacean studies.

Observations were made along the cruise track from July 19 to August 18, 1986. All sightings were recorded on a standard whale/dolphin sighting card. The majority of sightings occurred between 41N x 68W on the eastern edge of Georges Bank. A few sightings occurred off the edge of the continental shelf.

PHOTOGRAPHIC TECHNIQUE ABOARD R/V *WESTWARD*: AN ATTEMPT AT PHOTO-IDENTIFICATION OF HUMPBACK WHALES FOUND ALONG THE CRUISE TRACK OF W-89

Thomas A. Jarecki

Abstract

Migratory patterns, reproduction, and social structure of cetaceans, although they have been studied in depth, are still relatively unknown. This project was designed to compare photographs of Humpback whales taken and processed on board to field catalogues showing known individuals. These data would aid in the study of migratory patterns of Humpbacks.

Although there were 23 sightings over the course of the cruise, none of the sightings contained any Humpback whales. Additionally, many of the sightings were poor due to weather conditions. For these reasons, the only data obtained were the tables and figure accompanying this report, which will serve as a database from which R/V *Westward* can contribute to cetacean studies. A detailed description of the methods of photography on board a moving ship was formulated.

It is hoped that from using both the database started and the manual of photographic technique produced, future R/V *Westward* photographers can be well informed of what is required before they go to sea.

WATER MASS STUDIES

Introduction

At the ocean's surface, solar radiation heats water and water evaporates and precipitates. These processes give seawater its temperature and salinity characteristics, which stay with a water mass as it sinks and moves through the ocean depths. Water masses of the western North Atlantic originated from many surface sources: the Labrador Sea, the Gulf of St. Lawrence, the Gulf Stream system, and the continental shelf and slope.

Particular attention was paid to a fjord in Newfoundland, Bay d'Espoir (pronounced Bay Despair), on W-89. Water masses from the continental slope and the Labrador Current find their way up this long, narrow inlet, where they meet fresh water running off Newfoundland. A massive hydroelectric plant has been installed at the head of Bay d'Espoir and in recent years scientists from S.E.A. have become interested in the effects of this hydroelectric plant on the natural circulation patterns of Bay d'Espoir.

On W-89 saline water was found at the surface at the head of the fjord, whereas just downstream of the head,water was quite fresh (Beach and Schick). Further, silicate concentrations were higher at the head of the fjord than downstream (Smith). Such surprising data, which suggests the possibility of upwelling of continental slope water at this location, needs further investigation.

Water masses in the Gulf of Maine were closely studied by Assistant Scientist Greg DiLisio. Coastal water near Nova Scotia was affected by upwelling in some areas and by tidal circulation in others. Analysis of deep water showed that Scotian Slope water penetrates far north into the Gulf of Maine.

Water masses influence the biology of a region, and the remaining water mass studies investigated this effect. A warm core ring off the continental slope was less productive than the fjord (Watts), and the fjord was less productive than shelf and slope water (Oleksiak). Both pteropods (small gastropods called sea butterflies) and chaetognaths (arrow worms) were severely restricted by temperature and salinity. Five pteropod and four chaetognath species were found only in the warm core ring (O'Sullivan and Quejada). Midwater fish were also affected by water masses, and one species appeared to have been carried by the warm core ring into continental slope water (Bedford and Fish). The midwater fish species Benthosema glaciale, by contrast, was present in three different water masses and its abundance was related to its food supply (Perlin).

VERTICAL MIXING IN THE FJORDS OF BAY D'ESPOIR, NEWFOUNDLAND

Jim Beach and Charles Schick

Abstract

The vertical mixing of the Bay d'Espoir is analyzed through use of hydrocast data and water analysis data. Salinities, temperatures and densities were calculated and graphed and general trends of the bay were observed. The fresher and warmer surface water was seen as a separate layer of about ten meters depth. Beneath this layer is the Labrador Current, flowing into the bay. The flow of the Labrador Current over the Copper Head Sill at the division between the outer and inner part of the bay, is clearly seen.

Interesting data is revealed at the head of the bay as water of a greater salinity and density (about 35 parts per thousand, and 1.256 sigma-t) is found to rest above the Labrador Current layer (about 30-33 parts per thousand, and 1.242 sigma-t). A hypothesis of this being some Modified Slope Water (at a depth of about 200 meters), seen in the outer basin at great depths, that has entered the fjord and upwelled at the head, where topographical conditions induce upwelling. Data from other students indicates the presence of this Modified Slope Water within the inner bay.

PHOSPHATE AND SILICATE ANALYSES OF A NEWFOUNDLAND FJORD AND A WARM CORE RING

Cynthia R. Smith

Abstract

This study was undertaken in an attempt to look at the potential for primary productivity and also to characterize the water masses to determine how much mixing may be occurring. Samples were taken from hydrocasts from two stations in each region for temperature, salinities, and phosphate and oxygen concentrations.

Our warm core ring was very shallow (50m) and as such it was easy to see where the slope water invaded and mixed with the warmer, more saline ring water. At the mouth of the fjord, the waters of Hermitage Bay met but did not mix with the waters of Bay D'Espoir. At the head of the fjord, an extraordinarily high concentration of silicate supports the hypothesis that upwelling may be occurring in a region previously thought to be quite static in terms of vertical mixing.

TIDAL MIXING OF SCOTIAN SHELF WATER AND UPWELLING OF GULF OF MAINE INTERMEDIATE WATER BETWEEN CAPE SABLE AND YARMOUTH, NOVA SCOTIA, MID-AUGUST 1986

Gregory Paul DiLisio

Abstract

Strong tidal current oscillation occurs off the convex southwestern coast of Nova Scotia. One model states tidal currents rounding the Yarmouth-Cape Sable coast will experience centrifugal force balanced by onshore drift of bottom water. We tested this model integrating bathythermograph, hydrocast, and surface observations of temperature, salinity, and silica. Upwelling of Gulf of Maine Intermediate Water appeared to affect coastal water off Yarmouth whereas tidal mixing of stratified Scotian Shelf Water appeared to create the water mass off Cape Sable.

A hydrocast in the deep waters of the Western Gulf of Maine revealed the penetration of warm, saline bottom water, which inflows through the Northeast Channel at depths >200 m and moves north into Jordan Basin and west into Wilkinson Basin. The data indicate this Scotian Slope Water exists as far north in the Jordan Basin as *Westward*'s transect.

A STUDY OF PHYTOPLANKTON SPECIES DIVERSITY, PRIMARY PRODUCTIVITY, AND NUTRIENT CONTENT OF SURFACE WATERS FROM CAPE COD TO NEWFOUNDLAND

Cheryl L. Watts

Abstract

During the W-89 cruise from Cape Cod to Newfoundland several bodies of water were sampled for their nutrient content, primary productivity, and phytoplankton species diversity: the continental shelf and slope, a warm core ring, and fjord. It was expected that areas of high nutrient content and high productivity (shelf regions and the fjord) would have low species diversity and a low ratio of diatoms to dinoflagellets. It was expected that areas of low nutrient content and low productivity (slope water and warm core ring) would have a high species and a low ratio of diatoms to dinoflagellets.

The warm core ring was less productive, more diverse, had relatively fewer diatoms, and a lower silicate concentration than the fjord. These data are consistent with the expected results when the sources of error are taken into consideration.

The other water masses lacked a full compliment of data; but it was possible to infer that slope water showed an oligotrophic trend of low productivity and high diversity and that shelf regions showed an eutrophic trend of high productivity low species diversity.

THE POTENTIAL OF FISHERIES DEVELOPMENT IN CANADIAN FJORDS BASED ON PRODUCTIVITY ANALYSES

Margie Oleksiak

Abstract

The purpose of this project was to determine the suitability of developing Canadian fjords into successful fisheries by comparing their potential productivity with the productivity of shelf water, slope water, and warm core ring water. Since shelf water is already successfully fished, a comparable productivity value for shelf water and fjord water would indicate the fjord's potential as a successful fishery.

To determine the potential productivity of these water bodies, I measured photosynthesis using the light/dark bottle incubations and the Winkler method for oxygen titrations. Net photosynthesis for water from Brown's Bank was 383.51 mg C/m^3.hr, for slope water 13.01, and for fjord water 0.00. Chlorophyll a was filtered from these water bodies and its concentrations measured. The chlorophyll in ug/l was 1093 from Brown's Bank, 577 from St. Pierre Bank, 566 from slope water, 205 from fjord water, and 127 from warm core ring water. Using these results and secchi disk depths, I calculated the mg C/day m^2 to be 135 in slope water and 2.83 in fjord water.

High chlorophyll content indicates high productivity. Therefore, the low chlorophyll content in the fjord indicates low productivity. This low productivity is substantiated by the much lower carbon content in the fjord water as compared with the slope water as well as by the fact that net photosynthesis in the fjord is zero. These results suggest that the Canadian fjords are not likely sites for fisheries development.

SHELLED PTEROPODS AND CHAETOGNATHS AS BIOLOGICAL WATER MASS INDICATORS IN THE NORTH WEST ATLANTIC

Kimberley Lloyd O'Sullivan and Maria Imelda A. Quejada

Abstract

Pteropods and chaetognaths have been recognized in the past as biological water mass indicators. These two organisms from the zooplankton community were collected from seven stations along the Northwest Atlantic using horizontal and oblique meter net tows, in order to see whether species diversity and abundance indicates different water masses. The distinct qualities of the continental slope, fjord, warm core ring, and other water masses of the Northwest Atlantic provide an ideal cross-section of different water types to study.

Temperature and salinity were very restrictive in the distribution of species. In both pteropods and chaetognaths, species diversity and abundance of organisms were found to decrease in cooler and less saline water.

Positive identification of all ten pteropod species and 9 of the 11 chaetognath species in the warm core ring. Four chaetognath species (*Sagitta hexaptera*, *S. fowleri*, *S. bipunctata*, and *S. serratodentata*) and 5 pteropod species, (*Cuvierna columnella*, *Clio pyrimidata*, *Creseis acicula*, *Diacria trispinosa* and *Atlanta fusca*) were unique to the warm core ring. Fewer species and organisms were found in the slope water and fjord stations. This may be due to their preference for deeper and warmer waters. Only *Sagitta elegans* was found to survive extremes in both temperature and salinity.

DISTRIBUTION OF MYCTOPHIDAE ACROSS A WARM CORE RING AND SURROUNDING SLOPE WATERS

Julie Bedford and Peter Fish

Abstract

Myctophids are widely distributed and abundant mesopelagic fish which are easily distinguished by species-specific photophores. Thus they are excellent indicators of various water masses. Consequently, myctophids were valuable for the identification of the water masses found along the W-89 cruise track between Cape Cod and Newfoundland. Specifically, a warm core ring and the surrounding slope waters were studied.

Seven stations (four outside the ring, one in the transition zone, and two in the ring) were used to collect myctophids. Myctophids were sorted, identified, and catalogued. A temperature/salinity diagram, a station map, tables, and diversity-similarity indices were formulated.

More than 60 individuals were caught and identified. A total of seven species were found. Most notable was the tropical-subtropical species specimen, _Ceratascope warmingii_, known to be carried into the North Atlantic slope waters by Gulf Stream eddies, suggesting that the ring we encountered was an aged and dissipating one across which there was an exchange of tropical and temperate Myctophid species.

THE ZOOPLANKTON BIOMASS-MYCTOPHID CONNECTION

Adam Perlin

Abstract

The intent of this study was to determine a correlation between zooplankton biomass and the presence of mesopelagic fish in the hopes of shedding some light on the causative agents of vertical migration patterns of these fish. An ideal species of Myctophidae was sought; one that was present in different water masses. By doing so the variables of behavioral idiosyncrasies between species could be eliminated. The use of a single species also allowed for an estimate of fish biomass and standardization of number present relative to size. Samples were collected using fixed meter net and oblique meter net tows. Benthosema glaciale was found in three different water masses making it the subject of investigation. In each of the water masses the number of fish showed a correlation to the amount of biomass present; the greater the biomass the greater the number of fish. It should be noted that the fish were taken at different depths giving indication of a correlation between the vertical level of the fish and biomass.

BENTHIC STUDIES

Introduction

Two projects were devoted to sampling the bottom. Mason found a relationship between sediment type and the organisms that live there, and Williams showed that most of the fish sampled by the *Westward*'s otter trawl were small and young.

THE INFLUENCE OF SUBSTRATUM ON BENTHOS FROM GEORGES BANK, ST. PIERRE'S BANK, BAY d'ESPOIR, AND SABLE ISLAND

Kimberly Mason

Abstract

The purpose of this study was to investigate the relationship between epifaunal and infaunal invertebrate benthos (macrofauna) as related to the grain size of the substratum on/in which they are found. Significant characteristics of each organism was recorded to see if there was also a relationship between their feeding habits and mobility (or lack of) and the substrate on which they were found. A Shipek Grab was used to collect sediments and then the rock dredge was deployed to retrieve the benthos. Three hundred and twenty organisms were collected at the 5 stations. Sediments ranged from mud to cobbles (less than 0.064mm to greater than 64mm). A relationship was found between the organisms characteristic substrate, their mobility, and feeding habits and the substratum on which they were found.

FISH DIVERSITY IN OTTER TRAWL CATCHES ALONG THE NORTHWEST ATLANTIC CONTINENTAL SHELF

Mark A. Williams

Abstract

To standardize the study of benthic fishes aboard the R/V *Westward*, the vessel's otter trawl was put to use off of Georges Bank and Sable Island Bank. Environmental factors such as depth, temperature, and sediment type play a role in the abundance and variation of species.

Five stations were performed, two on Georges Bank and three on Sable Island Bank. From all five stations 17 different species were found and a total of 207 fish were collected. The predominant species were yellowtail flounders, silver hake, longhorn sculpin, and skates (round, smooth, winter, thorny). The average length of all species was between 20-30 cm. The largest fish brought up was a winter skate measuring 92 cm and the smallest fish was a 9 cm yellowtail flounder. On the whole, the fish were on the young side with sizes ranging mainly from small to medium. The larger ones were found at Georges Bank.

APPENDICES

APPENDIX I.

STATIONS CONDUCTED ON W-89

Station No.	Date	Time Begun	Latitude (N)	Longitude (W)	Bathythermograph	Secchi disc	Hydrocast (6 bottle)	Hydrocast (12 bottle)	Neuston tow	Phytoplankton (single)	Phytoplankton (multi-net)	Zooplankton (single)	Zooplankton (multi-net)	Sediment scoop	Other (specify)
1	07/21/86	1030	41°31'	68°12'										x	x rock dredge
2	07/21/86	1416	41°40'	68°17'					x						
3	07/21/86	2206	41°49'	78°13'					x						
4	07/22/86	0904	41°53'	67°52'	x	x	x			x					
5	07/22/86	1206	41°55'	67°45'					x						
6	07/22/86	1630	41°48'	67°34'											x otter trawl
7	07/23/86	0025	41°51'	67°22'					x						
8	07/23/86	0800	41°43'	67°04'			x			x					x sed. grab rock drg
9	07/23/86	1648	41°49'	66°57'											x otter trawl
10	07/24/86	0040	42°05'	66°46'					x						
11	07/24/86	1316	42°43'	66°10'	x	x	x			x					
12	07/25/86	0030	42°27'	65°35'					x						
13	07/25/86	1203	42°59'	64°42'					x						
14	07/25/86	1655	41°54'	64°24'	x	x	x			x			x		
15	07/26/86	0004	41°53'	64°16'					x						
16	07/26/86	0950	41°42'	63°27'	x	x	x		x	x					
17	07/27/86	0033	41°23'	62°30'					x						
18	07/27/86	1030	41°15'	61°43'	x	x		x					x		
19	07/28/86	0800	40°55'	61°05'		x		x		x			x		
20	07/28/86	1846	40°58'	60°02'									x		
21	07/29/86	0045	41°54'	60°08'					x						
22	07/30/86	1123	42°15'	59°44'		x	x		x						
23	07/30/86	2203	42°52'	59°24'					x						
24	07/31/86	1120	42°58'	59°20'			x					x			
25	07/31/86	1200	43°44'	58°24'					x						
26	07/31/86	2210	44°08'	57°44'					x						
27	08/01/86	0020	44°12'	57°44'			x					x			
28	08/01/86	1200	44°51'	56°58'					x						
29	08/01/86	2200	45°06'	56°37'					x						
30	08/02/86	1005	45°31'	56°11'			x		x	x					x sediment grab
31	08/03/86	0000	45°53'	56°18'					x						

Station No.	Date	Time Begun	Latitude (N)	Longitude (W)	Bathythermograph	Secchi disc	Hydrocast (6 bottle)	Hydrocast (12 bottle)	Neuston tow	Phytoplankton (single)	Phytoplankton (multi-net)	Zooplankton (single)	Zooplankton (multi-net)	Sediment scoop	Other (specify)
32	08/03/86	1716	46°03'	56°18'					x						
33	08/04/86	0011	46°31'	56°07'					x						
34	08/07/86	0017	47°04'	56°07'					x						
35	08/07/86	1205	47°09'	55°51'	x				x						
36	08/07/86	2200	47°37'	56°27'				x	x			x			
37	08/08/86	0939	47°40'	56°08'	x	x		x	x	x					
38	08/08/86	1355	47°42'	56°03'	x		x								
39	08/08/86	1515	47°43'	56°02'	x	x	x								
40	08/08/86	1800	47°46'	55°55'	x	x	x								
41	08/08/86	2115	47°47'	55°52'	x		x					x			
42	08/09/86	0955	47°49'	55°51'	x	x	x			x					
43	08/10/86	0755	47°54'	55°48'	x	x	x			x					sedi. grab x rock dredge
44	08/11/86	0001	47°17'	56°38'					x						
45	08/11/86	1930	46°18'	56°37'			x								
46	08/11/86	0000	46°15'	57°40'					x						
47	08/12/86	1200	45°55'	58°30'					x						
48	08/13/86	0000	45°10'	59°07'					x						
49	08/13/86	0835	44°34'	59°35'	x	x									sedi. grab rock dredge 2 otter trawl
50	08/14/86	0010	44°37'	59°42'					x						
51	08/15/86	2317	44°11'	60°37'					x						
52	08/16/86	0400	43°52'	60°54'	x										otter trawl
53	08/16/86	1200	43°52'	61°18'					x						
54	08/17/86	0000	43°56'	61°55'					x						
55	08/17/86	2338	44°09'	63°18'					x						
56	08/21/86	0910	43°34'	65°05'	x	x	x			x					
57	08/21/86	1717	43°16'	65°39'	x	x	x			x					
58	08/22/86	1156	44°01'	67°17'					x						
59	08/22/86	1430	43°53'	67°24'			x								
60	08/24/86	1400	44°05'	69°00'					x						
61	08/26/86	0005	43°08'	69°08'					x						
62	08/26/86	1215	42°14'	69°15'					x						
63	08/26/86	1325	42°12'	69°15'		x	x								

APPENDIX II.

BATHYTHERMOGRAPH LOCATIONS FOR CRUISE W-89

BT Number	Date	Latitude (oN)	Longitude (oW)	Surface Temperature
001	21JUL86	41o30.5'	68o12.7'	14.8
002	22JUL86	41o52.2'	67o51.8'	13.3
003	23JUL86	41o41.7'	67o01.8'	13.0
004	24JUL86	42o08.9'	66o42.2'	15.2
005	24JUL86	42o11.6'	66o39.3'	15.9
006	24JUL86	42o13.0'	66o37.4'	14.9
007	24JUL86	42o14.1'	66o34.1'	15.6
008	24JUL86	42o15.0'	66o31.3'	15.7
009	24JUL86	41o15.9'	66o28.2'	15.3
010	24JUL86	42o20.4'	66o23.0'	15.6
011	24JUL86	42o24.0'	66o19.3'	16.1
012	24JUL87	42o30.3'	66o19.3'	15.6
013	24JUL86	42o33.4'	66o15.1'	16.2
014	24JUL86	42o40.4'	66o11.5'	15.3
015	24JUL86	42o44.0'	66o09.7'	14.6
016	25JUL86	41o52.8'	64o24.8'	18.6
017	26JUL86	41o42.4'	63o27.3'	19.8
018	26JUL86	41o33.0'	62o51.7'	23.8
019	26JUL86	41o28.7'	62o42.4'	23.5
020	26JUL86	41o27.0'	62o38.5'	21.1
021	26JUL86	41o24.4'	62o32.3'	21.2
022	27JUL86	41o22.0'	62o26.2'	20.8
023	27JUL86	41o19.8'	62o19.0'	22.4
024	27JUL86	41o17.9'	62o11.2'	21.8
025	27JUL86	41o16.3'	61o58.0'	22.8
026	27JUL86	41o16.0'	61o51.5'	23.1
027	27JUL86	41o15.4'	61o45.2'	22.4
028	27JUL86	41o14.3'	61o36.9'	24.1
029	27JUL86	41o03.2'	61o15.0'	24.0
030	27JUL86	41o05.0'	61o05.0'	24.1
031	27JUL86	61o00.0'	41o10.0'	24.6
032	27JUL86	41o15.0'	61o00.0'	23.0
033	27JUL86	41o15.0'	60o59.0'	22.4
034	28JUL86	41o16.0'	60o45.0'	21.8
035	28JUL86	41.14.0'	60o45.0'	21.5
036	28JUL86	41o10.0'	60o47.0'	22.0
037	28JUL86	41o05.0'	60o49.0'	20.1
038	28JUL86	41o04.0'	60o54.0'	22.6
039	28JUL86	41o00.0'	60o57.0'	23.9
040	28JUL86	40o50.0'	60o50.0'	24.2
041	29JUL86	41o26.5'	60o42.5'	21.8
042	30JUL86	41o37.3'	60o22.3'	21.6
043	30JUL86	43o22.8'	59o47.5'	21.2
044	30JUL86	42o45.3'	59o30.8'	15.7
045	31JUL86	43o03.6'	59o13.5'	16.8
046	31JUL86	43o21.5'	58o49.4'	16.8
047	31JUL86	43o39.0'	58o31.0'	16.9

BT Number	Date	Latitude (oN)	Longitude (oW)	Surface Temperature
048	31JUL86	43o56.0'	58o08.7'	15.7
049	31JUL86	44o01.6'	57o54.5'	15.5
050	31JUL86	44o10.0'	57o42.3'	14.8
051	01AUG86	44o18.0'	57o41.3'	15.3
052	01AUG86	44o37.7'	57o15.9'	14.3
053	01AUG86	44o47.9'	57o03.0'	13.6
054	01AUG86	44o52.3'	56o53.7'	14.6
055	01AUG86	44o56.0'	56o46.1'	14.2
056	01AUG86	44o58.9'	56o40.8'	14.0
057	01AUG86	45o03.2'	56o38.3'	14.0
058	01AUG86	45o07.5'	56o36.0'	14.1
059	02AUG86	45o12.0'	56o32.0'	14.4
060	02AUG86	45o16.3'	56o28.9'	14.8
061	02AUG86	45o22.8'	56o22.4'	13.6
062	02AUG86	45o27.4'	56o15.4'	13.3
063	02AUG86	45o29.2'	56o12.7'	12.9
064	02AUG86	45o36.7'	56o17.0'	13.9
066	07AUG86	47o11.2'	55o54.5'	15.9
067	07AUG86	47o16.4'	56o03.5'	16.4
068	09AUG86	47o24.5'	56o12.1'	15.3
069	07AUG86	47o27.1'	56o13.9'	14.8
070	07AUG86	47o29.2'	56o16.0'	14.5
071	07AUG86	47o32.8'	56o23.9'	15.6
072	08AUG86	47o31.0'	56o12.0'	14.5
073	05AUG86	47o38.0'	56o07.5'	16.2
074	08AUG86	47o41.9'	56o03.2'	16.7
075	08AUG86	47o43.0'	56o02.5'	17.2
076	08AUG86	47o45.6'	55o55.1'	18.7
077	08AUG86	47o46.6'	55o57.5'	20.0
078	09AUG86	47o49.2'	55o50.5'	19.1
079	10AUG86	46o53.0'	55o48.5'	18.2
080	11AUG86	46o24.0'	57o24.0'	15.3
081	11AUG86	46o30.2'	57o23.8'	15.2
082	11AUG86	46o27.1'	57o31.0'	15.4
083	11AUG86	46o30.0'	57o15.0'	15.2
084	11AUG86	46o15.0'	57o04.0'	15.6
085	12AUG86	46o10.0'	57o40.2'	15.6
086	12AUG86	46o12.4'	57o50.8'	15.2
087	12AUG86	46o10.0'	58o02.0'	15.0
088	12AUG86	45o58.0'	58o18.1'	16.1
089	12AUG86	45o52.0'	58o49.0'	16.3
090	13AUG86	44o34.0'	59o34.5'	17.8
091	16AUG86	43o52.7'	60o54.3'	18.5
092	21AUG86	43o38.0'	64o52.5'	18.2
093	21AUG86	43o36.0'	65o01.0'	17.7
094	21AUG86	43o32.0'	65o08.0'	19.0
095	21AUG86	43o23.5'	65o20.8'	18.8
096	21AUG86	43o19.9'	65o28.4'	18.0
097	21AUG86	43o17.6'	65o33.4'	16.5
098	21AUG86	43o15.9'	65o38.1'	13.0
099	21AUG86	43o15.1'	65o39.3'	13.9

BT Number	Date	Latitude (oN)	Longitude (oW)	Surface Temperature
100	21AUG86	43o17.0'	66o00.8'	10.5
101	21AUG86	43o28.8'	66o14.2'	10.7
102	22AUG86	43o37.1'	66o30.4'	11.6
103	22AUG86	43o39.3'	66o45.9'	13.9
104	22AUG86	43o42.4'	66o57.2'	14.5
105	22AUG86	43o47.4'	67o08.6'	16.1
106	22AUG86	43o54.4'	67o15.1'	15.3
107	22AUG86	44o01.1'	67o16.1'	14.0
108	22AUG86	43o59.0'	67o21.0'	14.1
109	22AUG86	43o53.2'	67o25.2'	14.5
110	22AUG86	43o58.1'	67o33.2'	14.0
111	23AUG86	44o02.0'	67o43.7'	14.4
112	23AUG86	44o05.1'	67o57.1'	13.6
113	23AUG86	44o07.1'	67o58.8'	12.8
114	25AUG86	43o27.5'	68o53.5'	13.6
115	25AUG86	43.14.1'	69o02.8'	14.3
116	26AUG86	43o05.5'	69o10.5'	16.1
117	26AUG86	43o52.3'	69o33.0'	17.2
118	26AUG86	42o24.0'	69o22.5'	18.3
119	26AUG86	44o12.5'	69o14.5'	18.8
120	26AUG86	44o11.2'	69o31.1'	18.3
121	26AUG86	42o09.2'	69o43.5'	17.8
122	26AUG86	42o10.0'	69o55.2'	16.4

APPENDIX III.

SUMMARY OF HYDROCAST DATA, CRUISE W-89

Station No.	Depth (m)	Temperature (oC)	Salinity (o/oo)	Oxygen (ml/l)	Silicate (ug-at/l)	Description
W89-04	0	12.75	32.821	--	--	Georges Bank
	11	12.12	32.837	--	--	
	14	12.04	--	--	--	
	20	11.93	--	--	--	
	31	11.84	--	--	--	
	39	11.77	32.839	--	--	
W89-08	0	12.72	32.688	--	--	Georges Bank
	11	12.59	32.715	--	--	
	26	12.53	32.709	--	--	
	30	12.54	32.691	--	--	
	40	12.69	32.685	--	--	
	56	12.56	32.700	--	--	
W89-11	0	13.26	35.635	5.44	--	Brown's Bank
	14	9.80	35.980	5.33	--	
	25	8.67	32.839	5.51	--	
	30	8.73	32.745	4.62	--	
	36	8.76	32.782	0.23	--	
	57	8.72	32.780	0.04	--	
W89-14	0	18.03	32.839	--	--	Continental Slope
	74	9.82	34.109	5.72	--	
	131	12.58	35.384	--	--	
	207	12.12	35.384	--	--	
	288	9.47	35.305	--	--	
	382	7.43	35.030	5.06	--	
W89-16	0	19.25	33.586	5.92	--	Continental Slope
	75	17.13	35.786	5.82	--	
	102	13.78	35.577	5.45	--	
	154	13.62	35.600	6.22	--	
	195	12.57	35.532	4.88	--	
	301	10.40	35.322	4.32	--	
W89-18	0	--	35.450	--	--	Continental Slope
	20	21.50	35.370	--	--	
	42	19.70	35.728	--	--	
	75	16.55	35.827	--	--	
	110	14.55	35.658	--	--	
	152	13.55	35.634	--	--	
	201	13.60	35.689	--	--	
	364	8.97	35.135	--	--	

Station No.	Depth (m)	Temperature (oC)	Salinity (o/oo)	Oxygen (ml/l)	Silicate (ug-at/l)	Description
W89-19	0	24.11	35.250	5.61	--	Warm-core ring
	51	21.70	35.880	5.91	--	
	71	15.81	35.740	5.07	--	
	111	14.14	35.680	5.15	--	
	172	13.85	35.640	5.27	--	
	190	13.09	35.590	4.04	--	
W89-22	0	20.32	34.768	--	--	Continental Slope
	85	16.07	35.311	--	--	
	177	13.78	35.827	--	--	
	246	12.26	35.626	--	--	
	330	--	35.279	--	--	
	417	7.50	35.009	--	--	
W89-24	0	16.07	31.793	--	--	Continental Slope
	33	10.53	32.547	--	--	
	61	7.18	33.615	--	--	
	112	9.53	34.722	--	--	
	200	--	34.286	--	--	
	325	7.19	35.075	--	--	
W89-27	0	14.13	--	--	--	Continental Slope
	18	7.74	--	--	--	
	22	2.08	--	--	--	
	88	5.43	--	--	--	
	166	7.46	--	--	--	
	286	7.63	--	--	--	
W89-30	0	13.06	31.840	6.20	--	St. Pierre Bank
	10	11.94	31.890	6.30	--	
	20	10.24	31.835	6.40	--	
	30	2.75	32.222	6.70	--	
	40	1.99	32.340	5.50	--	
	55	1.86	32.307	6.40	--	
W89-36	0	13.98	30.818	--	--	Laurentian Channel
	5	11.56	31.360	--	--	
	10	9.64	31.662	--	--	
	25	4.28	32.036	--	--	
	56	1.61	31.914	--	--	
	103	0.44	32.494	--	--	
	129	1.12	32.868	--	--	
	150	--	--	--	--	
	219	16.12	--	--	--	

Station No.	Depth (m)	Temperature (oC)	Salinity (o/oo)	Oxygen (ml/l)	Silicate (ug-at/l)	Description
W89-37	0	15.92	27.325	6.15	1.020	Entrance to Bay d'Espoir
	5	3.78	29.361	5.30	1.020	
	10	9.54	31.085	6.61	1.020	
	20	1.90	32.059	7.42	1.030	
	62	1.17	32.200	6.88	1.030	
	95	0.83	32.426	6.77	1.030	
	138	1.10	32.947	6.16	1.030	
	146	2.39	33.232	7.30	1.030	
	223	5.91	34.358	4.21	1.030	
W89-38	0	16.34	25.587	--	1.020	Lampidoes Passage - Copper Sill
	10	9.48	30.870	--	1.020	
	20	1.45	32.023	--	1.030	
	40	0.95	31.972	--	1.030	
	60	0.67	32.242	--	1.030	
	110	0.48	32.477	--	1.030	
W89-39	0	13.72	25.518	--	1.020	Lampidoes Passage - Copper Sill
	10	6.87	30.952	--	1.020	
	20	2.19	31.522	--	1.030	
	40	0.88	32.079	--	1.030	
	63	0.81	31.981	--	1.030	
	149	0.45	32.114	--	1.030	
W89-40	0	16.30	18.435	--	1.010	Lampidoes Passage
	10	6.96	31.010	--	1.020	
	20	2.73	31.283	--	1.020	
	43	0.82	32.209	--	1.030	
	73	0.71	31.990	--	1.030	
	110	0.48	32.382	--	1.030	
W89-41	0	16.00	17.952	--	1.010	Bay d'Espoir
	10	0.67	30.411	--	1.020	
	20	2.40	31.111	--	1.020	
	40	1.08	31.901	--	1.030	
	56	0.99	31.975	--	1.030	
	118	0.78	32.027	--	1.030	
W89-42	0	18.88	4.400	7.30	1.000	St. Albans
	10	5.67	30.212	6.88	1.020	
	23	2.00	31.249	7.13	1.020	
	43	0.85	31.973	6.50	1.030	
	65	0.78	32.089	6.74	1.030	
	103	0.74	32.138	7.11	1.030	

Station No.	Depth (m)	Temperature (oC)	Salinity (o/oo)	Oxygen (ml/l)	Silicate (ug-at/l)	Description
W89-43	0	18.31	35.654	6.65	1.030	Head of Bay d'Espoir
	10	4.05	30.599	8.18	1.020	
	20	2.13	31.273	5.99	1.020	
	30	1.68	31.593	7.06	1.030	
	40	1.78	31.574	6.97	1.030	
	50	1.40	--	--	--	
W89-45	0	--	31.730	--	--	Laurentian Channel
	50	--	31.296	--	--	
	100	--	31.819	--	--	
	200	6.64	34.058	--	--	
	302	6.44	34.884	--	--	
	400	5.61	35.000	--	--	
W89-56	0	17.34	30.703	--	--	Scotian Shelf
	5	17.14	32.840	--	--	
	10	14.83	30.988	--	--	
	21	7.46	31.870	--	--	
	29	4.82	31.540	--	--	
	37	3.91	31.023	--	--	
W89-57	0	12.71	31.393	--	--	Scotian Shelf
	10	12.26	31.426	--	--	
	19	12.04	31.748	--	--	
	28	11.27	31.604	--	--	
	32	10.54	31.718	--	--	
	36	10.03	32.039	--	--	
W89-59	0	13.68	32.706	--	--	Jordan Basin Gulf of Maine
	44	10.13	32.855	--	--	
	102	8.78	33.824	--	--	
	151	7.57	34.006	--	--	
	199	8.04	34.311	--	--	
W89-63	0	18.41	32.227	--	--	Coast, Gulf of Maine
	15	17.87	32.213	--	--	
	40	10.15	32.883	--	--	
	90	5.78	33.137	--	--	
	140	5.65	33.241	--	--	
	190	6.20	33.647	--	--	

APPENDIX IV.

SUMMARY OF NEUSTON DATA, CRUISE W-89

Station No.	Date	Time	Latitude (oN)	Longitude (oW)	Sargassum (g/1000 m2)	Fucus (g/1000 m2)	Asco-phyllum (g/1000 m2)	Tar (mg/ 1000 m2)	Plastic (cm2/tow)
W89-02	21JUL86	1416	41o39.2'	68o17.2'	--	--	--	--	--
W89-03	21JUL86	2206	41o49.3'	68o12.6'	--	--	1.08	--	24.00
W89-05	22JUL86	1204	41o55.1'	67o44.7'	--	--	4.40	--	--
W89-07	23JUL86	0025	41o51.2'	67o21.7'	--	--	1.84	--	--
W89-10	24JUL86	0047	42o04.7'	66o46.1'	--	--	191.44	5.40	19.00
W89-12	25JUL86	0046	42o26.9'	65o34.9'	--	--	190.00	5.60	16.00
W89-13	25JUL86	1203	41o59.3'	64o41.7'	--	--	1.10	2.50	0.25
W89-15	26JUL86	0004	41o53.9'	64o16.4'	--	--	--	--	--
W89-16	26JUL86	1132	41o41.4'	63o28.9'	--	--	3.22	--	--
W89-17	27JUL86	0033	41o23.5'	62o30.3'	--	--	--	0.34	4.50
W89-21	30JUL87	0045	41o54.3'	60o08.0'	--	--	--	--	--
W89-22	30JUL86	1320	42o15.0'	59o44.0'	50.00	--	--	5.00	0.00
W89-23	30JUL86	2203	42o52.4'	59o24.2'	--	--	--	5.80	0.35
W89-25	31JUL86	1200	43o44.2'	58o24.0'	--	--	--	4.30	36.00
W89-26	31JUL86	2210	44o08.3'	57o44.4'	--	--	--	2.10	0.60
W89-28	01AUG86	1200	44o51.2'	56o58.2'	--	--	0.29	4.90	--
W89-29	01AUG86	2200	45o05.6'	56o37.0'	--	--	--	4.30	0.16
W89-30	02AUG86	1344	45o31.7'	56o11.8'	--	--	--	0.15	--
W89-31	03AUG86	1200	45o52.3'	57o17.8'	--	--	--	3.70	0.50
W89-32	03AUG86	1216	46o03.0'	56o18.8'	--	--	--	2.20	17.00
W89-33	04AUG86	0011	46o31.3'	56o07.1'	--	1.71	11.09	33.80	--
W89-34	07AUG86	0017	47o03.6'	56o07.0'	--	14.95	1.46	2.90	1.00
W89-35	07AUG86	1205	47o09.2'	55o51.2'	--	1.00	2.00	0.78	0.25
W89-36	07AUG86	0112	47o30.7'	56o28.0'	--	--	--	0.47	2.00
W89-37	08AUG86	1217	47o37.9'	56o07.5'	--	--	--	--	--
W89-44	11AUG86	0001	47o17.0'	56o37.6'	--	--	--	3.00	8.00
W89-46	12AUG86	0000	46o15'	57o40'	--	--	--	8.30	--
W89-47	12AUG86	1200	45o55'	58o30'	--	--	--	1.30	1.00
W89-48	13AUG86	0000	45o09.5	59o07'	--	--	--	11.00	--
W89-50	14AUG86	0010	44o36.3'	59o41.9'	--	--	--	1.70	6.00
W89-51	15AUG86	2317	44o11'	60o37'	--	--	--	--	--
W89-53	16AUG86	1200	43o51.7'	61o17.8'	--	--	--	1.30	10.00
W89-54	17AUG86	0015	43o56.1'	61o54.9'	--	--	--	--	4.00
W89-55	17AUG86	2338	44o09.3'	63o18.0'	--	--	--	--	--
W89-58	22AUG86	1156	44o01.0'	67o17.2'	--	--	--	--	--
W89-62	26AUG86	1215	42o14.3'	69o14.7'	--	--	--	--	--
W89-60	24AUG86	1357	44o05'	69o00'	--	--	--	--	--
W89-61	26AUG86	0005	43o07.6'	69o08.3'	--	--	--	--	--

APPENDIX V

SUMMARY OF METER NET TOW DATA, W-89

Station No.	Latitude (oN)	Longitude (oW)	Date	Time In	Time Out	Depth of Tow (m)	Biomass Volume (ml/tow)
W89-14	41o54.2'	64o24.5'	25JUL86	2014	2129	200	126
--	--	--		2023	2118	100	88
--	--	--		2033	2105	10	3
W89-18	41o16.6'	61o41.9'	27JUL86	1235	1345	200	50
--	--	--		1244	1337	100	50
--	--	--		1253	1325	10	15
W89-19	40o54.7'	61o00.9'	28JUL86	1223	1404	400	260
--	--	--		1239	1346	200	40
--	--	--		1245	1334	100	70
--	--	--		1254	1325	10	90
W89-20	40o57.9'	61o01.7'	28JUL86	1846	2045	400	175
--	--	--		1910	2025	200	180
--	--	--		1919	2013	100	50
--	--	--		1933	2002	10	120
W89-24	42o58.9'	59o19.2'	30JUL86	0102	0133	100	115
W89-27	44o12.2'	57o44.4'	31JUL86	0213	0241	100	0
W89-36	47o32.1'	56o26.7'	07AUG86	2339	2355	100	100
W89-41	47o46.6'	55o51.5'	08AUG86	2227	2240	50	30

APPENDIX VI.

BIRDS SEEN IN 10-MINUTE TRANSECTS ALONG THE CRUISE TRACK OF W-89

Classification	Number Seen
Order Procellariiformes:	
Leach's Storm Petrel (*Oceanodroma lencorhoa*)	15
Wilson's Storm Petrel (*Oceanites oceanicus*)	406
Greater Shearwater (*Puffinus gravis*)	1390
Sooty Shearwater (*Puffinus grisens*)	168
Northern Fulmar (*Fulmarus glacialis*)	5
Order Gaviiformes:	
Common Loon (*Gavia immer*)	1*
Order Pelccaniformes:	
Northern Gannet (*Morus bassanus*)	5-10*
Great Cormorant (*Phalacrocorax carbo*)	2*
Double-er Cormorant (*Phalacrocorax auritus*)	8
Order Anseriformes:	
Am. Black Duck (*Anas rubripes*)	3*
Red-Breasted Merganser (*Merqus serrator*)	2*
Common Eider (*Somateria mollissima*)	315
Order Falconiformes:	
Bald Eagle (*Haliacetus leucocephalus*)	3*
Osprey (*Pandion haliaetus*)	10-15*
Order Charadriiformes:	
Ruddy Turnstone (*Arenaria interpres*)	1*
Sanderling (*Calidris alba*)	4*
Northern Phalarope (*Lobipes lobatus*)	10-15*
Parasitic Jacger (*Stercorarius parasiticus*)	1
Skua (*Catharacta sp.*)	8*
Great Black-backed Gull (*Larus marinus*)	63
Herring Gull (*Larus argentatus*)	61
Ring-billed Gull (*Larus delawarensis*)	NC
Bonaparte's Gull (*Larus philadelphia*)	1
Black-legged Kittiwake (*Rissa tridactyla*)	1
Common Tern (*Sterna hirundo*)	6 at least
Arctic Tern (*Sterna paradisaea*)	3 were Arctic
Black Guillemot (*Cepphus grylle*)	4
Atlantic Puffin (*Fratercula arctica*)	10
Order Columbiformes:	
Pigeon (*Columba livia*)	NC*
Mourning Dove (*Zenaida macroura*)	NC*

Classification	Number Seen
Order Apodiformes:	
Ruby-thr. Hummingbird (*Archilochus colubris*)	1*
Order Passeriformes:	
Barn Swallow (*Hirundo rustica*)	NC*
Tree Swallow (*Iridoprocne bicolor*)	NC*
Blue Jay (*Cyanocitta cristata*)	NC*
American Crow (*Corvus brachyrhynchos*)	NC*
American Robin (*Turdus migratorius*)	NC*
European Starling (*Sturnus vulgaris*)	NC*
Yellow Warbler (*Dendroica petechia*)	NC*
House Sparrow (*Passer domesticus*)	NC*
Common Grackle (*Quiscalus quiscula*)	NC*
Northern Cardinal (*Cardinalis cardinalis*)	NC*
Bobolink (*Dolichonyx oryzivorus*)	1*
Ipswich Sparrow (*Passerculus sandwichensis*)	NC (100's)*
Song Sparrow (*Melospiza melodia*)	NC*
Oriole sp. (?)	1*

NC = not counted

* = not seen during transects