R/V Albatross IV
AL9701 Cruise Report
January 13 - 20, 1997

Acknowledgements

The scientific party acknowledges and commends the officers and crew of the R/V ALBATROSS IV. We were able to complete much of the survey work due to their professionalism and dedication.

This report was prepared by John Sibunka, Maria Casas, Maureen Taylor, Antonie Chute, Jennifer Crain, and Lawrence Lougee with assistance from colleagues in the scientific party.

This cruise was sponsored by the national Science Foundation and the National Oceanographic and Atmospheric Administration.

TABLE OF CONTENTS

Purpose of the Cruise

Six broadscale surveys are part of the 1997 U.S. GLOBEC Georges Bank Program. These six broadscale surveys are conducted monthly from January to June to monitor the changing biological and physical status in the Georges Bank ecosystem. The first cruise in this series was aboard R/V ALBATROSS (AL 97-01, 13-20 January 1997). The principle objectives of the cruise were to:

(1) determine the distribution and abundance of the ichthyoplankton and zooplankton community on the Bank and in adjacent Gulf of Maine and slope waters. Emphasis was on target fish (eggs, larval and juvenile cod and haddock) and copepod species (all stages of *Calanus finmarchicus* and *Pseudocalanus* sp.) and their predators and prey.

(2) provide systematic collections of larval and juvenile cod and haddock for age and growth estimates.

(3) collect individuals of *Calanus* and the euphausiid, *Meganyctiphanes norvegica*, for population genetics studies.

(4) conduct a hydrographic survey of the Bank.

(5) map the Bank wide velocity field using an Acoustic Doppler Current Profiler (ADCP).

(6) deploy drifting buoys to make Lagrangian measurements of the currents.

In order to obtain uniform Bank-wide coverage, 40 predetermined "Standard stations" and 39 "Bongo stations" were scheduled for this survey. During this cruise 19 Standard stations were occupied. The entire Bank was surveyed, including the portion in Canadian waters (Figure 1).

The cruise was originally scheduled for 6 to 18 January. However, the first week of the scheduled cruise was lost due to persistent adverse weather conditions. As a result, both the North East Fisheries Science Center (NEFSC) and the Atlantic Marine Center (AMC) allowed the GLOBEC Georges Bank program additional vessel time for survey work. Another storm system was predicted to arrive in the survey area by the end of the second week of the scheduled cruise period (on or about 16 January). Because of survey time already lost, and the threat of another impending series of gale force weather systems, it was decided to limit the number of stations occupied. This was done as an attempt to ensure minimal coverage of the Georges's Bank survey area. This decision was made, with the consent of several GLOBEC broadscale project investigators, prior to departure on 13 January. The proposed coverage for this cruise would now be limited to stations with a priority 1 and 2 designation. In addition, it was decided that the new station #40 also be occupied. Deployment of the 10-m^2 MOCNESS sampler would only be made at priority #1 stations and at station #40, weather and sea conditions permitting.

The 40 Standard stations were assigned a priority code number (from 1-4) which reflected the equipment used on a given station. Priority stations assigned 1 or 2 were "full stations" with "high priority" , and stations assigned 3 or 4 were "partial stations" and designated "low priority". The intermediate Bongo stations were considered to have a lower priority (i.e. priority code number 5) than the 40 Standard stations.

At priority # 1 stations, an oblique plankton tow from surface to near bottom was made with a bongo sampler along with a Seabird real-time CTD attached to the towing wire. A large volume zooplankton pumping system was use to sample the water column. A Neil Brown Mark V CTD-fluorometer unit was used to characterize the water column. Niskin bottles attached to a rosette were used to collect water samples at selected depths for biological and chemical analysis. Water samples were collected on shipboard for chlorophyll-*a* and phaeopigment concentrations. Samples for phytoplankton species identification, cell count, and spatial distribution were taken for on shore analysis. Samples for microzooplankton were collected for both shipboard and post cruise processing. Water was also drawn for salinity determination and $H_2{}^{18}O/H_2{}^{16}O$ isotope concentration analysis. A 1-m^2 MOCNESS (Multiple Opening Closing Net Environmental Sampling System) was towed obliquely from surface to near bottom cycling twice to make vertically stratified collections of zooplankton with both 335µm mesh and 150µm mesh nets, and to make collections of fish larvae with 335 µm mesh nets. A 10-m^2 MOCNESS fitted with 3.0-mm mesh nets was towed obliquely from surface to near bottom to make vertically stratified collections of larger predators on target species. At priority # 2 stations, a bongo tow, a large volume zooplankton pumping system, a Neil Brown Mark V CTD cast, and 1-m^2 MOCNESS tow were made. At selected stations, the real-time CTD and a Niskin bottle cast were made for calibration purposes. A summary of sampling events that occurred during this cruise is in Appendix 1.

The ship's ADCP unit was used to make continuous measurements of the water current profile under the ship, in order to construct the current field over the whole Bank. This data will be used to help in the interpretation of all the other observations made on the cruise.

Cruise Narrative

In this section, reference made to station numbers refers to Standard station number.

6-8 January

Departure was canceled each day during this time period due to gale force west winds of 30 to 40 knots. The dockside time was utilized on setting up, checking out and securing the various types of scientific equipment on board.

9 January

The R/V ALBATROSS IV departed NEFSC Woods Hole, Massachusetts, at 1330 hrs. Sailing was scheduled for 1100 hrs, but was delayed in order to change a defective water pump on one of the ship's main engines. Weather conditions at the time of sailing had moderated to west winds of 10 to 15 knots at Woods Hole. The morning weather prediction was for a possible storm system developing during the night with accompanying gale force winds. As this storm was forecast to move quickly through the survey area, it was decided to sail. A fire and life boat drill was conducted shortly after departure. An updated weather forecast was obtained

late in the afternoon. The prediction was for a rapidly intensifying storm system to develop during the evening hours in our area of operation and continue through the next day. The winds for this storm were forecast to veer from the southeast to west and increase to 35 to 45 knots with gusts to 55 knots. The seas were expected to increase and build to 14 to 18 feet. Based on this forecast, it was decided to return to Woods Hole and wait out this storm. Arrived and docked at 1910 hrs.

10-11 January

The weather forecast for this time period was for gale force west winds. These winds were expected to diminish during 12 January. Departure was scheduled for 1600 hrs on 12 January. A snow storm developed during the morning of 11 January and deposited about four inches of snow at Woods Hole.

12 January

The morning weather forecast predicted continued gale force west winds into13 January, but with diminishing winds late in the evening of that day. Departure was canaled for today and rescheduled for 1000 hrs on 13 January.

13 January

The R/V ALBATROSS IV departed NEFSC Woods Hole, Massachusetts, at 1015 hrs. The weather conditions at Woods Hole were clear with sunny skies and northwest winds of 20 to 30 knots. Gale force winds were still present over the offshore waters, but these winds were predicted to diminish to northwest 20 to 30 knots during the evening hours. At 1045 hrs, the ship was stopped in sheltered waters in order to deploy the 1-m^2 MOCNESS and the Neil Brown Mark V CTD for a test check to ensure correct operation of these systems. Both preformed without fault and the ship resumed its course and speed to the survey area.

14 January

Survey activity began on 0015 hrs at station # 3, the first station occupied this cruise. Stations # 4 and 7 were also completed. Weather and sea conditions during this time were an overcast sky with a west wind of 15 to 20 knots and a moderate ground swell sea state. At station # 7 the Seabird CTD system malfunctioned during the down cast of the bongo plankton tow. Retows were attempted and aborted. During the down cast , the Seabird software program on the accompanying computer used to monitor the cast either "locked up" on the computer or the active program would exit out to the DOS prompt. A second Seabird CTD unit was deployed with similar results. A different computer for monitoring the cast was used and another version of the Seabird software program was installed and used without solving the problem. The final bongo tow at this station only obtained a maximum sampling depth of 130 meters before the Seabird system malfunctioned. Subsequent analysis of this problem during the next few stations revealed that the first and second Seabird CTD unit used were both defective. A third Seabird CTD unit was used on a subsequent station (# 16) and operated correctly.

15 January

Completed stations # 9, 12, 13, 16, and 17. Weather conditions during this time was for a southwest wind of 15 to 20 knots and an overcast sky. On station # 16, the ship temporarily lost the FERRUPS electronic power system during the Neil Brown Mark V CTD cast. As the CTD was being retrieved at this time and data was already collected during the down cast, no recast was made. In addition to the loss of electric power to all the computers on line at the time the FERRUPS system went down, the ship's SCS data system was also disrupted and temporarily inoperative. The SCS system was reset by the Electronic Technicians, however there was no SCS input available during the 1-m^2 MOCNESS tow. The Electronic Technicians determined that the cause of the FERRUPS power lose was due to an overload on this system. This overload was probably caused by a refrigerator being used for scientific purposes and plugged into the FERRUPS system. The compressor for the refrigerator activated at the same time when something else demanded power and tripped the circuit breaker. The refrigerator was plugged into the ship's regular AC power system.

The weather forecast for the next day was for possible gale winds for the survey area and continued gale winds into the following day. Based on this weather forecast, it was decided not to deploy the 10-m^2 MOCNESS system at this station (# 10). This decision was made with the intent to utilize the present good weather to occupy as many stations before the ship would have to suspend operations for adverse weather. On station # 17, during the Pacer high-volume pump cast, a section of submersible hose broke near one of its end fittings. The needed repair was made by personnel from the engine department and a second cast was made.

16 January

Completed stations # 18, 20 and 23. Weather conditions deteriorated during the day with a south wind increasing to a steady 30 knots with higher gusts by the end of the 1200-1800 hrs watch. This wind was accompanied by rain and an increase in sea state. Upon deployment of the drifter at station # 23, survey operations were suspended and the ship secured for adverse weather. On station # 18, several nets on the 10-m^2 MOCNESS were repaired. These nets were separating where the mesh is sewn to the net collar and repairs were made by the scientific party. Similar repairs had to be made to these nets after the completion of previous 10-m^2 MOCNESS tows this cruise. At the completion of the 1-m^2 MOCNESS tow on station # 20, one of the net bar release wires was found to be severely chafed and in need of repair. This was accomplished by cutting off the release wire from the lowest net bar on the frame (this wire on the bottom bar of net # 0 is not used) and substituting it for the damaged wire. Repairs were made by both the scientists and personnel from the deck department on watch.

17 January

Ship secured and jogging. Weather conditions were gale force winds throughout the day. By early morning the wind direction shifted from south to west and increased to 30 to 45 knots with higher gusts along with a substantial increase in sea state. The air temperature dropped to below freezing; frequent and intense snow squalls occurred throughout this time. The ship's superstructure was accumulating a layer of skin ice. During the night of 16-17 January, the ship jogged to station # 39 and arrived at about 0800 hrs. Because of the existing weather and sea conditions scientific sampling was not possible. It was decided to delete this station and slowly jog to station # 27. The feasibility of working station # 27 was more likely as it is located in the shallower waters of 68 meters verses the 214 meters depth at station # 39. During the 1200-1800 watch, the monitor for the computer used along with the Neil Brown Mark V CTD came loose from its secured position and was damaged when it hit the deck. The Electronic Technicians supplied another unit for use. A full fifty-five gallon drum of ethanol, which was secured in the holding rack near the starboard rail on the main deck, was damaged by a sea or seas. Most of the ethanol leaked out of the drum and was lost.

18 January

Completed stations # 27, 29, 30 and 40. By 0130 hrs the ship was at station # 27 and the weather conditions had moderated to allow survey operations to resume. The air temperature at this time was still below freezing, and all the equipment on deck became coated with ice. The fastening on the end fitting to a section of the submersible hose for the Pacer high-volume pump was damaged. Repair was made by personnel from the engine department and the cast redone. During station activity on # 27, a clog occurred in the sea water drain pipe in the port scientific laboratory and an overflow occurred before the sea water was secured. Personnel from the engine department needed to disconnect a section of drain pipe to free the clog. On station # 29, a five gallon container of gasoline was crushed by the port side leg of the stern gantry. The gantry was being raised to deploy the 10-m^2 MOCNESS. A sea coming aboard over the stern during the previous storm must have pushed this container from its secured place on deck aft of the gantry to under the gantry leg. The gasoline spilled onto the main deck which was already coated with ice and slush. The decks were cleaned and the 10-m^2 MOCNESS set. The flowmeter on the 10-m^2 MOCNESS was reported to have stopped working by the scientist monitoring the computer for the cast and the 10-m^2 MOCNESS brought back aboard. A shaft in the flowmeter was found to have come loose in its mount. The necessary repair was made by personnel from the engine department, and a retow was completed. After the tow, several of the nets on the 10-m^2 MOCNESS were found to be damaged; repairs were made by the scientific party. Weather conditions again began to deteriorate while on station # 40. The winds from the north had increased to 25+ knots, the seas began to increase, the air temperature dropped to -5.0 Celsius, it began to snow and the ship was again subjected to icing on deck and its superstructure. Because of these conditions, it was decided not to deploy the 10-m^2 MOCNESS at this station.

19 January

Completed stations # 34 and 36. Weather and sea conditions during the 0000-0600 watch were windy with rough seas; the air temperature was below freezing. The ship was reduced in speed because of sea state and to minimize icing. The ship jogged to the position of 41 50' North,

67 41' West to deploy a drifter, then proceeded to station # 34. When the ship arrived on station # 34, the winds had decreased to 15 to 20 knots from the northwest and the sea state had moderated. The air temperature was -7.5 Celsius. The sea water intake hose for the Pacer high-volume pump broke into two pieces when attempting to deploy for a cast. The hose was brittle as a result of the freezing air temperature. The repair was made by the scientific party and the cast redone. During the pumping operation on station # 36, the motor on the pump finally started with the assistance from an engineer. The difficulty was attributed to the cold air temperature.

20 January

Completed station # 38 at 0215 hrs with the deployment of the last drifter. As this was the last station for this cruise, the ship began its return run to Woods Hole. The scientific party utilized the time dismantling the MOCNESS samplers and packing scientific equipment and supplies. The weather forecast predicted another gale system to develop by the end of the day. During the 0600-1200 watch, the winds had increased to 25 to 28 knots from the southwest, and the sea were again beginning to increase. R/V ALBATROSS IV arrived at NEFSC Woods Hole, Massachusetts, dock at 1045 hrs and completed cruise AL 97-01.

Individual Reports

Hydrography

(Maureen Taylor and Marie Kiladis)

Objectives:

The primary hydrographic data presented here were collected using a Neil Brown Mark V CTD instrument (MK5), which provides measurements of pressure, temperature, conductivity, fluorescence and light transmission. The MK5 records at a rate of 16 observations per second, and is equipped with a rosette for collecting water samples at selected depths.

Operations:

Bongo hauls were made at each of the stations occupied. A Seabird Electronics Seacat model 19 profiling instrument (SBE19 Profiler) was used on each bongo tow to provide depth information during the tow. Pressure, temperature, and salinity observations are recorded twice per second by the Profiler.

The following is a list of the CTD data collected with each of the sampling systems used on the cruise:

Instrument	# of Casts
MK5	19
MK5 calibration	17
SBE19/Bongo	19
SBE19 calibration	3

The MK5 was deployed with 6 bottles on the rosette and samples were collected for several investigators. After each cast, 400 mls were immediately siphoned out of two Niskins (bottom and mid-depth) for observations of micro-zooplankton swimming behavior (S. Gallagher and L. Louggee, WHOI). Samples were collected for $H_2{}^{18}O/H_2{}^{16}O$ oxygen isotope concentration analysis at selected depths for R. Houghton (LDGO) and a sample was taken at the bottom for calibrating the instrument's conductivity data. Total chlorophyll samples were filtered from three depths: bottom, 20 meters, and surface. These samples were frozen for later analysis ashore since there was not a fluorometer available during this cruise. Surface samples for phytoplankton species composition were collected and preserved for J. O'Reilly (NMFS).

Parameter	# of Samples Taken
Oxygen isotope	74
Micro-zooplankton	34
Chlorophyll	150
Species composition	18

Data:

The SBE19 Profiler and the MK5 data were post-processed at sea. The Profiler data were processed using the Seabird manufactured software: DATCNV, FILTER, ALIGNCTD, BINAVG, DERIVE, ASCIIOUT to produce 1 decibar averaged ASCII files. The raw MK5 data files were processed using the manufacturer's software CTDPOST in order to identify bad data scans by "first differencing." The latter program flags any data where the difference between sequential scans of each variable exceed some preset limit. The "Smart Editor" within CTDPOST was then used to interpolate over the flagged values. The cleaned raw data were converted into pressure averaged, pressure centered 1 decibar files using algorithms provided by R. Millard of WHOI, which had been adapted for use with the MK5.

The transmissometer data during all of the MK5 CTD casts completed seemed very erratic and the values seemed too low for the "expected" winter conditions. The lenses were cleaned and the electrical connections were double-checked, but no cause for these low values was discovered during the cruise. The sensor will be shipped away for diagnostics upon return to Woods Hole. Prior to this cruise, the time constant on the fluorometer was changed from three seconds down to a 1 second time constant by switching a jumper on the receiver electronics circuit board. As was expected, there was noticeably more "scatter" in the raw fluorescence signal.

At Standard station #7 (consecutive station #3), we experience some trouble with the Seabird CTD systems losing signal after about 120 meters. The bongo/SB haul was repeated with two different CTD units, software versions, and computers. It is now suspected that the bulkhead connectors on these CTD units may have leaked causing the intermittent loss of signal under pressure. After a third SB CTD was put on-line, we did not experience any more problems.

Figure 1 shows the consecutive and Standard station locations occupied during the bank - wide survey (priority #1 and #2 stations only). The surface and bottom temperature and salinity distributions are shown in Figures 2 - 3. Surface and bottom anomalies of temperature and salinity as well as a stratification index (sigma-t difference from the surface to 30 meters) were calculated using the NMFS MARMAP hydrographic data set as a reference. The anomaly distributions are shown in Figures 4-6. Profiles of each MK5 CTD cast with a compressed listing of the data are shown in appendix 1.

Very little stratification was observed during the survey and the Bank as a whole was well mixed. The surface and bottom salinity anomaly distributions (Figure 5) showed that the Bank was 0.5 - 0.7 psu fresher than the MARMAP reference. This is consistent with what had been observed on Georges Bank during the previous NMFS/NEFSC Fall Bottom Trawl survey. Scotian shelf water was observed at only one station (Standard station 25, MK5 cast #12) with the top 50 meters having salinity less than 32 psu and temperature less than 5C.

The volume average temperature and salinity of the upper 30 meters were calculated for the Bank as a whole and for the four sub-regions shown in Figure 7. These values are compared with characteristic values that have been calculated from the MARMAP data set for the same areas and calendar days. The volume of Georges Bank water (salinity < 34 psu) was also calculated and compared against the expected values. All four regions of the Bank were at least 0.5 fresher than the expected values for mid-January. The northwest region was the only area that was warmer than expected (approx. 0.35^0C). The southeast region was both fresher (0.50 psu) and cooler (0.40 ^{0}C) than the expected conditions.

Microzooplankton Analysis. The Importance of Microzooplankton in the Diet of Newly Hatched Cod Larvae: Broad-scale Studies of Prey Abundance.

(Scott Gallager, Philip Alatalo and Ladd Lougee)

One objective of this study is to characterize seasonal changes in the potential prey field for newly hatched cod larvae with respect to prey motility patterns and the prey size spectrum.

Prey Size, Abundance and Motility Experiments:

Purpose:

To observe, record and analyze motility patterns and size spectrum of available prey from three locations in the water column- near bottom, pycnocline, and upper well-mixed area at all broad- scale stations from January through June.

General Procedure:

Water samples are collected from the near bottom, and pycnocline areas of the water column using Go-Flo bottles on the Neil Brown Mark V CTD. Surface samples are collected with a plastic bucket. Go-Flo bottle samples are collected by gently siphoning from the top of the bottle instead of the normal port so that microplankton are not disrupted. Two-hundred ml tissue culture flasks are filled after being dipped in soapy water and air dried to prevent fogging. To further prevent fogging as well as maintain a constant low temperature, the flasks are transferred to an incubator at 5 C immediately after filling.

Each flask, in turn, is placed in a holder across from a B/W high-res Pulnix camera fitted with a 50 mm macrolens and directly in front of a fiber optic ring illuminator fitted with a far-red filter. This apparatus is suspended within the incubator by bungee cord to reduce vibration produced by the ship. Recordings are made using a Panasonic AG1980 video recorder with SVHS formatted cassettes, a Panasonic TR-124MA Video Monitor, and a timing device for a period of 15 minutes for each sample. The flask is then replaced with the next sample and recordings continue. The field of view is set to ~10 mm.

Each priority 1 station of cruise AL9701 was analyzed; samples were recorded and preserved in 10% Lugols. Station # 40 as well as all priority 2 stations, with the exception of stations # 27 and # 39, were sampled and recorded but not preserved in Lugols.

Post cruise processing:

Motility patterns will be analyzed with the Motion Analysis EV system. The final output will be particle size distribution and a motility spectra associated with each particle. This will be compared with species composition in the microzooplankton fraction preserved in Lugols.

Zooplankton and Ichthyoplankton studies based on Bongo and MOCNESS tows.

(John Sibunka, Maria Casas and Antonie Chute)

Objectives:

(1) Principle objectives of the ichthyoplankton group in the broadscale part of the U.S. GLOBEC Georges Bank Program were to study the composition of the larval fish community on Georges Bank, to define larval fish distribution across the Bank and within the water column, to determine those factors which influence their vertical distribution, and to determine bank-wide versus "Patch-Study" mortality and growth rates. Emphasis in this study is on cod and haddock larvae along with their predators and prey. This study also includes larval distribution and abundance, and age and growth determination. These objectives were implemented through use of bongo net and MOCNESS to make the animal collections. To subsample from 1-m^2 MOCNESS hauls for population genetic studies on *Pseudocalanus* spp. at the University of New Hampshire.

(2) The primary objective of the zooplankton group was to carry out a bank-wide area survey of Georges Bank to determine the distribution, abundance, and stage composition of the target species *Calanus finmarchicus* and *Pseudocalanus* spp. A second objective was to identify and quantify, the occurrence of the more abundant non-target species to describe the biological environment occupied by the target species. These objectives were implemented by using the 1-m^2 MOCNESS, (a vertically discrete, multiple opening and closing net system) to sample the larger copepodite stages of the zooplankton, and a submersible pump system to sample the naupliar stages.

In addition to these objectives, the zooplankton group was responsible for the following:

(a) To carry out a series of ring nets tows to collect *Calanus finmarchicus* naupiar stage N5 if present, for RNA/DNA analysis at the University of Rhode Island.

(b) To subsample from the 1-m^2 MOCNESS hauls for population genetic studies on *Pseudocalanus* spp. for Dr. A. Bucklin at the University of New Hampshire.

(c) To carry out a series of surface net tows at each geographic corner of Georges Bank for Dr. P. Hargraves at the University of Rhode Island/Graduate School of Oceanography for an ongoing phytoplankton study.

Methods:

Bongo tows were made with a 0.61-m frame fitted with paired 335 µm mesh nets. A 45 kg ball was attached beneath the bongo frame to depress the sampler. Digital flow meters were suspended in the mouth of each net to determine the volume of water filtered. Tows were made according to standard MARMAP procedures, (i.e., oblique from surface to within five meters of bottom or to a maximum depth of 200 m while maintaining a constant wire angle throughout the tow). Wire payout and retrieval rates were 50 m/min and 20 m/min respectively. These rates were reduced in shallow water (<60 m) to obtain a minimum of a five minute tow. A Seabird CTD was attached to the towing wire above the bongo to monitor sampling depth in real time mode and to measure and record temperature and salinity. Once back on board, the 335 µm mesh nets were each rinsed with seawater into a 335 µm mesh sieve. The contents of one sieve was preserved in 4% formalin and kept for ichthyoplankton species composition, abundance and distribution. The other sample was kept for age and growth analysis of any larval fish collected and preserved in 95% ethanol. The same preservation procedure was followed as for the 1-m^2 MOCNESS.

The 1-m^2 MOCNESS sampler was loaded with ten nets. Nets 1-4 were fitted with 150 µm mesh for the collection of older and larger copepodite and adult stages of the zooplankton. Nets 0, and 5-8 were fitted with 335 µm mesh for zooplankton (nets 0 and 5) and ichthyoplankton (nets 6-8) collection. Tows were double oblique from the surface to within 5 m from the bottom. The standard GLOBEC protocol is to sample to a maximum depth of 500m, however, during this cruise there was only sufficient wire on the winch to allow a maximum sampling depth of ~350 m. The maximum tow depth for nets 0, 1 and 5 was 350 m, and for net 6 was 200 m(if net 5 was sampled deeper than 200 m, it was returned up to 200 m and closed). Winch rates for nets 0-5 were 15 m/min and for nets 6-8, 10 m/min. The depth strata sampled were 0-15 m, 15-40 m, 40-100 m, and >100 ,m. The first (#0) and sixth (#5) nets were integrated hauls. For shallow stations, with only 2 or 3 of the depth strata, not all nets were fished. The contents of nets 0-4 were sieved through 150 µm mesh, split using a plankton sample splitter if the final volume was too large, then preserved in 10% formalin. Samples from nets 5-8 were sieved through 335 µm mesh and preserved in 95% ethanol. After 24 h of initial preservation, the alcohol was changed. At all 1 and 2 priority Standard stations, 90-ml subsamples were taken from nets 2-4 for the *Pseudocalanus* spp. population genetic study (A. Bucklin, Univ. of New Hampshire) and preserved in 95% ethanol. In addition, at these same stations additional 90-ml subsamples were taken from nets 1-4 for C. Miller's study correlating the *Calanus finmarchicus* male to female sex change occurring at maturation, and preserved in 10% formalin. Subsamples were also taken from net 5 for C. Miller's study and preserved in 95% ethanol.

The 10-m^2 MOCNESS was loaded with five 3.0 mm mesh nets. Tows were oblique from surface to ~10 m from bottom or a maximum depth of 350 m. The same depth strata were sampled as with the 1-m^2 MOCNESS. The winch rate for retrieval varied between 5 and 15 m/min depending on the depth stratum. The slow winch rates were used in order to filter at least 4,000-5,000 m^3 of water per depth stratum sampled. A stepped oblique tow profile during retrieval was used to achieve this, if needed. Catches were sieved through a 335 µm mesh, and preserved in 10% formalin.

The Pacer high-volume pump was used to collect nauplii and younger, smaller copepodite stages of zooplankton. The intake hose was deployed off the port side by connecting the intake hose to a 1.7-L Niskin bottle cut in half lengthwise, and attached to the winch wire. Cast depth was monitored by use of the meter block on the boom winch. Two 45 kg weights were used to depress the array. Three 30-m sections of 7 cm diameter hose were connected to the pump, allowing the intake hose to attain a maximum depth of approximately 70 m. At shallow stations, the intake hose nozzle was lowered to 3-5 meters off the bottom. Three integrated depth samples were collected with 35 µm mesh nets, sieved through a 30 µm mesh and preserved in 10% formalin. Sampling depths were from the maximum depth to 36 m, 36-12 m, and from 12 m to surface. Before samples were collected, water was diverted from going into the net and was allowed to flush for 60 s. This assured that the zooplankton from the desired strata was obtained. The hose was again flushed at the surface for 60 s. This allowed the water to pass completely through the hose. Wire retrieval rate was approximately 4-5 m/min. This rate was used to obtain volumes of 500 L per 5 m depth interval sampled.

To collect *Calanus finmarchicus* nauplii for the RNA/DNA experiments, a vertical haul was carried out using a 1-meter diameter ring net fitted with 100 µm mesh. These hauls were completed at Standard stations # 12, 20, 29, and 38. The net was attached to the winch wire with a book clamp together with a 45-kg weight. This array was lowered to a depth of 60 meters and retrieved at approximately 4 m/min. The animals caught in the cod end were gently poured into a 5-gallon plastic bucket. A few hundred mls from this bucket were collected in several plastic beakers and kept on ice at all times. The contents of these beakers were poured through a 100 µm mesh and rinsed into another beaker using MS-222 solution to anesthetize the animals and kept on ice while the nauplii picking was being completed.

Phytoplankton collections for species composition were made at each corner of the Bank (Standard stations # 3, 23, 27, and 34). Tows were made with a 29-cm ring net fitted with a 20µm mesh net. The net was fished at the surface for 5 min at a vessel speed of 1.5 kts. After the tow the net was rinsed with sea water and the sample preserved in 5% formalin.

Samples Collected by the Zooplankton and Ichthyoplankton Groups:

Gear Tows Number of Samples

1. Bongo nets, 0.61-m 19 tows 19 preserved, 5% formalin

335-µm mesh 19 preserved, EtOH

2. MOCNESS, 1-m^2 19 tows

150-µm mesh 62 preserved, 10% formalin

335-µm mesh 19 preserved, 10% formalin

335-µm mesh 82 preserved, EtOH

3. MOCNESS, 10-m^2 8 tows 34 preserved, 10% formalin

3.0-mm mesh

4. Pump 18 profiles 53 preserved, 10% formalin

335-µm mesh

Preliminary Summary of Zooplankton Findings.

(Maria Casas, Alyce Jacquet, James Pierson and Dorothy Schriber)

Observations of zooplankton species composition were made at most Standard stations sampled during this cruise. These observations were made from the net 0 (335 µm mesh), 1-m^2 MOCNESS, samples unless otherwise stated.

Station 3

Centropages typicus was the most abundant copepod with some *C. hamatus* mixed in. Some *Calanus finmarchicus* and *Metridia lucens* were also present. Amphipods and Ctenophores were abundant with a moderate amount of Pteropods.

Station 4

The copepod composition was similar to station 3. In addition, the chaetognath, *Sagitta elegans* was very abundant.

Station 7

Similar copepod composition. Many Euphausiids present in samples.

Stations 9, 12, 13

C. typicus again the most abundant copepod, in addition to a Bank mix of *C. hamatus*, *Temora longicornis*, *C. finmarchicus*, *M. lucens*, and *Pseudocalanus* spp.

Station 16

The copepod *Euchaeta* spp. was very abundant, as was *M. lucens*. Euphausiids and amphipods made up the remainder of the sample.

Stations 17, 18, 20, 23, 27, 30

C. typicus most abundant at all these southern flank/Northeast Peak stations. A moderate mix of Bank copepods such as *C. hamatus*, *T. longicornis*, *C. finmarchicus*, *M. lucens*, and *Pseudocalanus* spp. were also collected. Chaetognaths and Ctenophores continued to be present in most samples.

Station 25

Mostly *C. finmarchicus* and *M. lucens*, some *Centropages* spp.

Station 29

Many *C. typicus* and *C. finmarchicus* C5's. The diatoms *Coscinodiscus* and *Ceratium* were abundant.

Station 40

Many *C. finmarchicus* C5's and *Centropages* spp. Net 1 fished within a distinctive layer of *Euchaeta*. Chaetognaths and Euphausiids again present.

Preliminary Summary of Ichthyoplankton Findings.

(Antonie Chute, John Sibunka, Alyce Weiner and Joseph Kane)

The samples collected at the 19 GLOBEC broadscale stations from both the bongo, 1-m^2 MOCNESS and 10-m^2 MOCNESS were examined on shipboard for the presence of fish eggs and larvae. The samples were preserved, and observed while in the jar with the aid of a magnifying glass. This was done in an attempt to obtain a qualitative estimate of abundance, distribution, and size range of ichthyoplankton on Georges Bank. The following observations are based on examination of samples in the jars following preservation. The formalin-preserved samples are clearer, and delicate eggs are less likely to collapse as those preserved in ethanol.

Cod(*Gadus morhua*) and/or Pollock(*Pollachius virens*):

Cod/pollock larvae were observed in very low numbers (less than 5 larvae per station, more commonly only one or two) at 10 out of 19 stations, representing every area of the Bank except the Northeast Peak. The four specimens found in the 10-m^2 MOCNESS samples ranged from 16 to 30mm, and the approximately 20 larvae observed in the 1-m^2 MOCNESS samples ranged from 6 to 15mm. The smallest cod/pollock (6-9mm) were collected at stations # 3, 7, 9 and 17, located along the southern edge of the Bank. The other stations where cod/pollock larvae were collected were located towards the central and northwest portions of the Bank. At these stations, the larvae were consistently larger, with a size range of 10-30mm. Omitting the 10-m^2 MOCNESS catches, the range would be 10-20mm. No cod/pollock larvae were observed in the samples from the Northeast Peak area, where the highest concentration of gadid-sized eggs was noted. It is likely that some of the larvae noted as cod/pollock were in fact pollock, due to the apparent lack of pigment at the end of the tail (caudal peduncle pigment is diagnostic for cod larvae) and to the large size of some of the specimens collected. It would be unusual to find cod larvae in the 16-30mm range at this time of year, whereas adult pollock are known to spawn earlier than cod and the larvae could presumably have grown to 30mm if hatched in the autumn.

Atlantic herring (*Clupea harengus*):

Herring larvae were observed in samples collected at 7 of the 19 stations occupied. With the exception of station # 40 on the northern edge, all the stations where herring larvae were found represent the central portion of the Bank. The larvae collected were quite large (from 17 to 50mm) and easy to see and count in the samples. There was not a distinct difference in size occurrence of larvae between stations. As was noted for the cod/pollock larvae above, no herring larvae were observed in the samples collected on the Northeast Peak. A total of 75 herring larvae were counted in the combined samples from station # 36, and # 29 from the combined samples collected at station # 3. Both of these stations are located on the western portion of Georges Bank. At the remaining stations where herring larvae were taken, they were less abundant (less than17 larvae in the combined samples for the station), and mostly caught in the 10-m^2 MOCNESS.

Sand lance (*Ammodytes* sp.):

Sand lance larvae are normally abundant on Georges Bank this time of year, and they were observed in catches from 15 out of the 19 stations occupied. Sand lance larvae were distributed across the entire Bank, with the largest concentration of larvae (estimated to be in the thousands per sample jar) found at stations # 9, 12, and 13. These stations are located on the central portion of Georges Bank, across the edge of the shoals. The sand lance larvae collected ranged from 8 to 30mm in length. The highest densities of larvae, at stations # 9, 12 and 13, also represented the smallest larvae. This may suggest a localized hatching event, or concentration of the larvae due to physical factors.

Eggs:

Cod/haddock/pollock eggs were found at 14 out of 19 stations occupied. This suggests that spawning has commenced on the Bank. Most of these large gadoid eggs were concentrated in the area of the Northeast Peak, typical for this time of year on Georges Bank. The numbers of these eggs collected at stations on the central portion of Georges Bank and in the Gulf of Maine were small, less than 10 eggs per station. The largest catch, estimated to be in the thousands of eggs per sample jar, occurred on the Northeast Peak at station # 23. No cod/pollock larvae were observed in the Northeast Peak samples where gadid-sized egg concentrations were highest. Slightly higher egg concentrations (100 eggs in the combined samples) were also found at stations # 4 and 36, which are adjacent to each other and located on the western side of the Bank. The scarcity of cod/pollock larvae coupled with the modest concentration of gadid-sized eggs on the Northeast Peak suggests that cod spawning is just getting under way. During the January cruise in 1996 (EN-276), only one gadid larva was found, and gadid eggs did not appear to be as abundant as they were in 1997.

Miscellaneous Fish Larvae:

The following fish larvae were also identified in the ichthyoplankton samples collected during this broadscale survey.

1.Snailfish *Liparis* sp.

2. Lantern fish Myctophidae

3. Pearlside Paralepididae

4. Sculpins *Myoxocephalus* sp.

5. Unidentified elvers Anguilliformes

6. Unidentified leptocephalus larvae Anguilliformes

Preliminary Summary of the 10-m^2 MOCNESS samples.

(Antonie Chute and Maria Casas)

The 10-m^2 MOCNESS was deployed 8 times during the cruise, mostly on the southern and western areas of the Bank. Only one haul, station # 29, which is essentially Gulf of Maine, represents the northern part of the Bank. Most individual net catches were small (usually contained easily in a single quart jar) and lacked variety, with Ctenophores, Euphausiids and several species of Decapod shrimp making up most of the biomass. Below are brief summaries of catches per station, based on observations of preserved, jarred samples.

<u>Standard Station 3, Haul 1</u>

200 Ctenophores

Decapod shrimp

Polychaete worms

Small Euphausiids (12mm)

Atlantic herring larvae (*Clupea harengus*)

<u>Standard Station 7, Haul 2</u>

2 gallon jugs of Euphausiids

Hyperiid amphipods

10 Ctenophores

Shell-less Pteropods (*Clione* sp.)

<u>Standard Station 9, Haul 3</u>

Decapod shrimp

20 Ctenophores

Snailfish (*Liparis* sp.) larvae

Atlantic herring larvae

Polychaete worms

Small flatfish (*Scopthalmus aquosus*?)

Standard Station 12 Haul 4

Hundreds of very small Ctenophores

Atlantic herring larvae

Hyperiid amphipods

Decapod shrimp

Cod/pollock larva (*Gadus morhua* or *Pollachius vireos*)

Standard Station 18, Haul 5

250 Ctenophores

Hyperiid amphipods

Decapod shrimp

Atlantic herring larvae

2 cod/pollock larvae

Isopods

Liparis sp. larva

Standard Station 29, Haul 6

2 gallon jugs large caridean shrimp

Ctenophores

Hyperiid amphipods

Shell-less Pteropods

Lanternfish

Standard Station 36, Haul 7

250 Ctenophores

Euphausiids

Decapod shrimp

Atlantic herring larvae

Cod/pollock larva

Standard Station 38, Haul 8

3 gallon jugs of Ctenophores

Euphausiids

Hyperiid amphipods

Siphonophore bells

Large Decapod shrimp

Population dynamics and Lipid Studies of *Calanus finmarchicus*.

(Jennifer Crain and Charles B. Miller)

Objectives:

Renewed support for the OSU (Oregon State University)-based contribution to the GLOBEC broadscale program is focused on a continuation of our examinations of life history patterns of *Calanus finmarchicus* on Georges Bank. Our projects fall into four major categories:

(1) Continued analysis of the frequency and environmental correlates of the apparent sex reversal of genetic male *Calanus.* Our research will include correlation with fecundity data being gathered by Jeff Runge and proposed use of molecular methods to determine the genetic sex of individuals.

(2) Continued examination of jaw morphology as a diapause signature in fifth copepodites. This will be correlated with lipid storage and gonad development. Jaw morphology will also be used as an indicator of age-within-stage of all copepodite stages.

(3) Analysis of fat storage by fifth copepodites. We will use images captured at sea and C. Miller's new algorithm for calculating oil sac volumes in conjunction with gas chromatography.

(4) A substantial contribution to the GLOBEC modelling effort using "individual vector models", being developed by C. Miller during his six month sabbatical in Nice, France.

Male to female sex reversal: the quadrithek story continues:

There is a large body of evidence supporting the hypothesis that genetic male copepods of the family Calanidae have a point in their development at which they can "choose" to develop as functional females, and that this "choice" is triggered by some unknown environmental signal. Laboratory rearing studies and field-generated sex ratios support this. The signature of females resulting from this change is a male setal pattern on the first antenna. Fleminger (1985) saw this pattern in females of a number of calanid species, and called them "quadritheks" because they (like males) have four setae on some of the segments in contrast to normal, or "trithek", females, which have only three. We have found definite seasonal trends in the proportions of quadritheks in our Georges Bank samples from 1994, 1995 and 1996. The same trend has been seen by colleagues (Svensen and Tande) in Norway. We will continue to monitor this trend using formalin-preserved subsamples from the 150 micron 1-m^2 MOCNESS nets on this and subsequent broadscale cruises. On this cruise, we collected subsamples (90/600ml) at Standard stations # 3, 4, 7, 9, 12, 13, 16, 17, 18, 20, 25, 27, 29, 30, 40, 34, 36 and 38.

We hope that we will be able to determine the underlying genetic sex of individual *Calanus* and correlate the quadrithek antennal morphology with genetic maleness. We will try to tackle this problem by analysis of DNA fragment lengths, which are expected to be different in X and Y chromosomes, and searching for highly multiple repeat sequences characteristic of sex chromosomes. For these analyses, we are cryopreserving adult male and female *Calanus*. On this cruise, adults were sorted from our subsamples and frozen live in liquid nitrogen from stations # 3, 7, 12, 16, 18, 29 and 38. Ethanol-preserved subsamples from 1-m^2 MOCNESS net 5 (90/400ml) taken at Standard stations # 3, 4, 7, 9, 12, 13, 16, 17, 18, 20, 23, 25, 27, 29, 30, 40, 34, 36 and 38 will also be used.

The question of relative egg outputs of normal (trithek) females versus sex-changed genetic males (quadritheks) and implications for individual reproductive success will be addressed by correlations between fecundity data gathered by Jeff Runge and analysis of antennal morphology for each specimen. There are some intriguing questions left to be answered regarding the impact of sex reversal on *Calanus* population dynamics. We are trying, by examination of broadscale subsamples and cooperative efforts with other PI's, to piece the whole story together.

Jaw morphology as an indicator of age-within-stage and diapause:

We have been analyzing jaw facies of fifth copepodites to determine the fractions of their stocks that are A) entering the copepodite resting stage typical of this species, and B) preparing for immediate maturation. Copepodites of the A group retain the postmolt facies, a large hemocoele extension into the mandibular gnathobase, which looks like a bubble. Copepodites of the B group quickly lose this 'bubble'. We are dissecting and examining the jaws of individuals from the formalin-preserved subsamples listed above to determine the proportions of animals in each group. Additionally, we are correlating jaw stage data with gonad development and oil sac volume, both indicators of whether a copepodite is halting or proceeding with development to maturity.

Jaw staging is also an indicator of an individual's age-within-stage. As the animal progresses through each stage, the jaw facies pass through recognizable postmolt, late postmolt, intermolt and tooth formation phases. Preliminary analyses of jaw phases of individual second through fifth copepodites from 1995 broadscale subsamples have yielded some interesting results with respect to the population dynamics of *Calanus* on Georges Bank. The formalin-preserved subsamples listed above will be used for continuation of this effort.

Lipid analyses : total storage volume and composition:

We are studying the large store of oily wax which *C. finmarchicus* secretes into a tubular sac in the prosome of the fifth copepodite stage, prior to either maturation or rest. Actually, all copepodite stages have such sacs and accumulate some oil. The main question under study in 1997 is the areal and seasonal variation in quantities of oil in C5. Oil is quantified by an integration of the projected area of the oil sac in video pictures and approximate conversion to oil volume, using image analysis and an algorithm recently worked out by C. Miller for calculating an accurate volume estimate from the area. On AL9701, sets of video recordings were taken at Standard stations # 3, 7, 12, 16, 18, 29 and 38. Fifth copepodites are recorded in groups of five, then cryopreserved for gas

chromatographic analysis of fatty acid and fatty alcohol components.

Collections for Genetic Studies.

It is essential for understanding variations in the winter production of zooplankton on the Bank as well a knowledge of the origin or sources of the target species *Calanus finmarchicus*, and *Pseudocalanus* sp. as well as the Spring zooplankton bloom. Individuals are believed to come onto the Bank from the Gulf of Maine, Gulf of St. Lawrence, Scotian Shelf, and possibility the Slope Water. However, it is impossible to define through the morphology of the individuals where zooplankton currently found on the Bank originated. Consequently, population genetics studies of *Calanus, Pseudocalanus*, and several other species (e.g. the euphausiid, *Meganyctiphanes norvegica*) are being conducted at the University of New Hampshire by A. Bucklin. This in an effort to identify viable genes to characterize dispersal patterns and to provide a genetic basis upon which to gauge Bank production as a function of recruitment source populations. An attempt to distinguish between the morphologically similar *Pseudocalanus* species found year round on the Bank (e.g. *molutoni* and *newmani*) is also being developed, as well as genetic based analysis of their Bank circulation patterns and dispersal pathways. The work mentioned above is tied directly to other efforts to identify water sources and losses for the Bank, as well as circulation and exchange processes across the Bank boundaries. On this cruise, samples were collected at every station for genetic studies with net #5 on the 1-m^2 MOCNESS. At selected stations, 90 ml subsamples from the bottom and surface 1-m^2 MOCNESS with 150-µm mesh nets were taken. All samples were preserved in 95% ethyl alcohol which was changed during the first 24 hr period after collection.

Drifter Deployments.

As part of the physical oceanographic studies of the current structure and circulation on Georges Bank being conducted by R. Beardsley and R. Limeburner, GLOBEC Drifter Buoys are deployed at strategic locations periodically throughout the year to track the Lagrangian flow from the point of deployment. This drifter is constructed with a holey sock drogue (a Dacron cylinder 90 cm diameter by 3 m tall with 5 circular hoop stays) at the bottom connected by either a 10 m or a 40 m cable to a small float (18 cm diameter) which in turn is connected by about 2.6 m of cable to a larger spherical surface float (about 32 cm diameter). The surface float contains a sea surface temperature sensor, a GPS receiver, and an ARGOS satellite transmitter. Temperature, time, and position data are transmitted periodically to shore through the ARGOS telemetry system. On this cruise, six drifters were deployed.

Shipboard ADCP (Acoustic Doppler Current Profiler) Measurements.

The flow field over Georges Bank is driven by a complex set of forces. A primary factor is the strong semidiurnal tides which dominate the high frequency variability (<1cpd) of the currents. Tidal rectification gives rise to a persistent subinertial clockwise circulation over the Bank. This circulation process can be substantially modified by the frequent storms common to the area, changes in the stratification of the Bank. and interactions with currents generated by offshore circulation features (i.e. Warm-Core Rings).

The Acoustic Doppler Current Profiler is one of the instruments being used to study the circulation process on the Bank by J. Candela and C. Flagg. Water current measurements were obtained using a 150 kHz RDI ADCP continuously during the entire cruise. The transducers were mounted on the hull of the ship (5 m below the surface with a heading offset (OH) of -1.5). The instrument was programmed to measure the current profile under the ship with a vertical resolution of 2 m, from 10 m depth to about 10 m from the bottom or up to a depth of about 120 m, which ever was shallower at a given location. The current profiles were generated by 60 s data averages. Transformation to geographical North and East current components was preformed using real time gyro information fed into the ADCP from the ship's navigation instrumentation. Also fed to the instrument was real time GPS positioning which was stored directly in the minute average profile data files. The ADCP measures currents with respect to the ship. To obtain the water current with respect to the ocean bottom, the ship's motion needs to be removed from the current observations. The ship's motion will be removed using the bottom track (BT) velocity measured by the ADCP. Depending upon sea conditions, the ADCP can preform this operation in water depths shallower than 200 to 230 m. When the BT is lost, accurate navigation will be used to remove the ship's velocity from the current.

The ADCP data collected on this cruise will be post-processed at Woods Hole Oceanographic Institution by Candela and Flagg.

Personnel List

Scientific

Name Title Organization

1. John Sibunka Chief Scientist NMFS/NEFSC, Sandy Hook, NJ

2. Alyse Weiner Biol. Sci. Technician NMFS/NEFSC, Sandy Hook, NJ

3. Joseph Kane Fishery Biologist NMFS/NEFSC, Narragansett, RI

4. Antonie Chute Biol. Sci. Technician NMFS/NEFSC, Narragansett, RI

5. Maria Casas Research Associate URI/GSO, Narragansett, RI

6. Alyce Jacquet Biol. Sci. Technician URI/GSO, Narragansett, RI

7. Dorothy Schriber Biol. Sci. Technician URI/GSO, Narragansett, RI

8. James Pierson Biol. Sci. Technician URI/GSO, Narragansett, RI

9. Maureen Taylor Hydrographer NMFS/NEFSC, Woods Hole, MA

10. Marie Kiladis Hydrographer NMFS/NEFSC, Woods Hole, MA

11. Jennifer Crain Biol. Sci. Technician OSU, Corvallis, OR

12. Lawrence Lougee Scientist WHOI, Woods Hole, MA

13 Peter Clarke Student Massachusetts Maritime Academy

ALBATROSS IV Officers and Crew

1. John Moakley Commanding Officer

2. Michael Abbott Executive Officer

3. Denise Gruccioa Operations Officer

4. Joel Michalski Navigation Officer

5. Kevin Cruse Chief Engineer

6. John Hurder First Assistant Engineer

7. Chuck Hersey Second Assistant Engineer

8. Grady Abney Third Assistant Engineer

9. Dusty Pittnam Junior Engineer

10. Orlando Thompson Utility Man

11. Kenneth Rondeau Chief Boatswain

12. Tony Alvernaz Lead Fisherman

13. Tony Viera Skilled Fisherman

14. Tony Roma Skilled Fisherman

15. Anthime Brunette Fisherman

16. Douglas Roberts Fisherman

17. Richard Whitehead Chief Steward

18. Jerome Nelson Chief Cook

19. Robert Yates Electronics Technician

20. Neal Lynch Electronics Technician

Appendix 1. Data inventory - List of Underway and station Activities.

Appendix 2. CTD Plots and Compressed Listings Of the Data.