AL9705 Cruise Report

Acknowledgements

We appreciate and acknowledge the efforts and professionalism of the officers and crew of the ALBATROSS IV. Their dedication and cooperation made the success of this cruise possible.

This cruise was sponsored by the National Oceanographic and Atmospheric Administration and the National Science Foundation. This report was prepared by all members of the Scientific Party on this cruise (see Appendix A).

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PURPOSE OF THE CRUISE

The cruise aboard ALBATROSS IV (ALB-9705) was the fifth in a series of six Broad Scale surveys conducted monthly from January to June during 1997 to monitor the changing biological and physical status in the Georges Bank ecosystem. These six cruises are the third year of broad scale surveys conducted as part of the U.S. Globec Georges Bank Program. The personnel who participated in this cruise are listed in Appendix A.

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 is 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 and feeding habits.

(3) conduct a hydrographic survey of the Bank

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(4) conduct a survey of chlorophyll and nutrient levels on the Bank

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

(6) collect live animals for herring feeding experiments at the University of Rhode Island.

(7) to recover a GLOBEC broad scale mooring that had broken free.

SAMPLING OPERATIONS

The plan for the GLOBEC Broad Scale surveys is to accomplish the objectives above by sampling at a grid of 40 "standard station" locations which covers the entire bank (Figure 1a). The Broad Scale sampling protocol separates these 40 stations into two groups, full stations and partial stations. At the 20 full stations, a complete set of sampling operations is conducted. This involved a double-oblique bongo net tow, a CTD cast with rossette collection of water samples, a 1-m^2 MOCNESS (Multiple Opening Closing Net Environmental Sampling System , MOC-1) tow, a plankton pump cast and a 10-m^2 MOCNESS (MOC-10) tow. At the partial stations only the bongo tow, CTD cast and MOC-1 tow are done. Additional bongo net tows were made between the standard stations to

increase the sampling density for cod and haddock larvae. Current measurements also were collected continuously by a hull mounted 300 kHz Acoustic Doppler Current Profiler (ADCP).

Bongo tows were made with a 0.61-m frame fitted with paired 335 mm 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 or reduced due to adverse weather and sea conditions. A Seabird CTD was attached to the towing wire above the frame to monitor sampling depth in real time mode and to measure and record temperature and salinity. Once back on board, the 335 mm mesh nets were rinsed with seawater into a 335 mm mesh sieve. The contents of one sieve were preserved in 5% formalin and kept for ichthyoplankton species composition, abundance and distribution. The other sample was preserved in 95% ethanol and kept for age and growth analysis of larval fish. The same preservation procedure was followed as for the 1-m^2 MOCNESS.

At stations where the 1-m^2 MOCNESS system either was not towed or could not be used due to adverse weather conditions, a second bongo tow was made. This frame was fitted with both 335 mm mesh and 200 mm mesh nets. 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 except maximum tow depth was 500 m. Wire payout and retrieval rates were 50 m/min and 20 m/min respectively. The nets were each rinsed with seawater into a corresponding mesh sieve. The 200 mm mesh sample was retained for zooplankton species composition, abundance and distribution, and preserved in 10% formalin. The other sample (335 mm mesh) was kept for molecular population genetic analysis of the copepod, *Calanus finmarchicus*, and preserved in 95% ethanol. After 24 h of initial preservation, the alcohol was changed.

The 1-m^2 MOCNESS sampler was loaded with ten nets. Nets 1-4 were fitted with 150 mm mesh for the collection of older and larger copepodite and adult stages of the zooplankton. Nets 0, and 5-9 were fitted with 335 mm mesh for zooplankton (nets 0 and 5) and ichthyoplankton (nets 6-9) collection. Tows were double oblique from the surface to within 5 m from the bottom. The maximum tow depth for nets 0, 1 and 5 was 500 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 6-9, 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 mm mesh sieve, subsampled using a 2-L plankton sample splitter if the final biomass volume was too large for one quart jar, and then preserved in 10% formalin. Samples from nets 5-9 were sieved through 330 mm mesh sieve and preserved in 95% ethanol. After 24 h of initial preservation, the alcohol was changed. The used ethanol was retained for disposal or recycling ashore. At priority 1 and 2 stations and at station 40, 90-ml subsamples from the bottom and surface 150 mm mesh nets were removed and preserved in 10% formalin for Dr. C. Miller (OSU). At priority 1 and 2 stations, 90-ml subsamples from nets 2, 3, and 4 were removed and preserved in 95% ethanol. These samples were collected for Dr. A. Bucklin for population genetic studies to distinguish the *Pseudocalanus* species found on Georges Bank. At stations deeper than 150 m where C. Miller required subsamples for live analysis, the 1-m^2 MOCNESS was hauled out after the first oblique. Samples from nets 0-4 were collected and the MOCNESS was then immediately redeployed to complete the tow.

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 500 m. The same depth strata were sampled as with the 1-m^2 MOCNESS. The winch rate for retrieval varied between 5 and 20 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 mm 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 suction end, fitted with a 1.7-L Niskin bottle cut in half lengthwise, to the boom wire. The boom winch meter block was zeroed at the surface and the wire out reading was used to determine the depth of the cast. 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 75 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 mm mesh nets, sieved through a 30 mm mesh sieve and preserved in 10% formalin. Sampling depths were from the maximum depth to 36 m, 36-11 m, and from 11 m to surface. Before samples were collected, water was diverted from the net and the hose was allowed to flush for 60 seconds. This assured that the zooplankton from the desired strata was obtained. Once at the surface, the intake section was held just below the surface for 60 s. This allowed the water to pass completely through the hose. Wire retrieval rate was approximately 4 m/min. This rate was used to obtain volumes of 500 L per 5 m depth interval sampled.

To collect live animals for the herring feeding experiments at URI paired bongo nets, using the 335 mm mesh size fitted with a cod end, were hauled vertically through the water column. This haul was made at Station 38 after all other standard station operations were completed. The net was attached to the winch wire together with a 45 kg ball beneath the bongo frame to depress the sampler. The array was lowered to a maximum depth of 40 meters and retrieved at approximately 5 m/min for a total haul time of 10 minutes. The animals were gently poured into two 50 gallon trash cans lined with plastic liners and filled with seawater.

The primary hydrographic data 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. In addition 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 MK5 was deployed with 10 bottles on the rosette and samples were collected for various investigators. On each MK5 cast, samples were to be collected for chlorophyll/nutrient analysis (see Individual Report section below), for oxygen isotope analysis by R. Houghton (LDGO) and a sample was taken at the bottom for calibrating the instrument's conductivity data. At selected "full" standard stations water samples were collected for micro-zooplankton analysis for S. Gallager (WHOI). Surface samples for phytoplankton species composition were collected for J. O'Reilly (NMFS) at the "full" standard stations.

Equipment notes:

All systems functioned well during the cruise with only minor occasional problems. The MOCNESS system initially repeatedly reported a non-fatal error during data acquisition. This was traced to the problems with the navigation data coming from the ship's computer system. The logging of navigation data by the MOCNESS program was deactivated and the error did not re-occur.

On consecutive station 11 (the bongo tow between standard stations 6 and 7) the electrical termination on the boom wire needed to be redone. One of the wires had broken. The wire was soldered and re-wrapped to be water proof.

On standard station 16 the flow meter on the MOC-10 failed. The gearing had become stuck and the shaft did not turn. The meter from the MOC-1 was then used on both the MOC-1 and MOC-10. The stuck flow meter was adjusted and reinstalled for standard station 17. It again became stuck on standard station 20. A successful repair to the meter was made by Chief Engineer John Hurder and the meter functioned properly from standard station 27 to the end of the cruise.

On standard station 20 a hydraulic line to the CTD winch leaked and hydraulic fluid spilled into the water while the CTD instrument was in the water. The instrument was retrieved through the slick of fluid, possibly contaminating the water bottles on the rosette. The CTD instrument and frame were washed with detergent and rinsed. The sampling bottles were repeatedly washed and soaked in detergent and rinsed. Four bottles were replaced with spares, and these new bottles were used at the primary sampling depths. On two stations paired samples were taken in both a clean spare bottle and a washed bottle to allow confirmation that no residual effect remained.

On standard station 34 the termination on the boom failed during the deployment of the MOC-1 system. The termination fitting slipped off the wire and the MOC-1 frame was lost. The termination being used was a mechanical termination, not the poured termination that had characteristically been used with the MOCNESS system. [a post-cruise note: the MOC-1 was recovered on the next cruise of ALBATROSS IV through a recover effort which used a flat net with a chain sweep to trawl the area. After ten hours of trawling the MOC-1 was recovered in quite good condition.]

CRUISE NARRATIVE

The cruise departed Woods Hole at 2020 on Monday, May 19. The watch schedule was set for the 0600-1400, 1400-1800, 1800-2200, 2200-0600 ('8,4,4,8'). This was a break from the traditional '6 and 6' schedule used on ALBATROSS IV. The vessel arrived at the first station at 0600 on May 20. No significant problems were encountered and the routine of sampling operations was quickly established. Many in the scientific party had been on 10 or more of the Broad Scale survey cruises, and efficient team work occurred without direction. The weather throughout the cruise was quite good, with winds rarely above 20 kts. No time was lost due to weather.

After standard station 7 recent positions were received by e-mail for the GLOBEC broad scale mooring which had broken free. The mooring had drifted from near standard station 16 southwestward to be approaching standard station 8. J. Irish was contacted by satellite phone to provide the most recent positions in order to plan a recovery. Within an hour positions were received that were only a few hours old and indicated that the mooring was less than 30 km from standard station 8. After completing standard station 8 sampling operations were suspended and a search for the mooring begun. As the vessel steamed toward the expected mooring location - determined by dead reckoning - the flashing light on the mooring was observed at a distance of about 3 km. The mooring was recovered with no problems. The mooring consisted of the top float, an ADCP unit, a bio-optical package and one pair of temperature/conductivity sensors. The mooring line had parted about two meters below the bio-optical package, which was about 10 m below the surface float. Sampling operations were then resumed at the bongo station between standard stations 8 and 9 (consecutive station 16).

A list of the sampling operations and other events on the cruise is presented in Appendix B.

INDIVIDUAL REPORTS

Station numbers referred to in the following reports are standard station numbers (figure 1a), unless otherwise noted.

Hydrography

(Maureen Taylor and David Mountain)

The SBE19 Profiler and the MK5 data were post-processed at sea. The Profiler data were processed using the Seabird manufactured software: DATCNV, 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.

Figure 1b shows the locations of the MK5 casts made the bank - wide survey, identified by the consecutive cast number. 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 hydro-graphic data set as a reference. The anomaly distributions are shown in figures 4-6. The distributions of surface and bottom measured fluorescence are shown in figure 7. Profiles of each MK5 CTD cast with a compressed listing of the preliminary data are found in Appendix C.

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 8. 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) was also calculated and compared against the expected values. Similar to other Broad Scale surveys, all four regions were at least 0.3 fresher than the expected salinity values. Scotian Shelf water was observed in varying degree at standard stations 8, 16, 17, 22, 24, 25, and 39. Scotian Shelf water

was not observed on the Bank during the May Broad Scale survey ALB9605. The volume average temperature anomaly for the northwest region was approximately 0.75C warmer than the temperature anomalies for the rest of the Bank.

Relatively warm and fresh water was observed in the northwest region of the Bank. Salinity < 31.5 occurred in the upper 15 meters of the water column at standard station 38. The surface temperature and salinity distribution figures show a horizontal gradient in the northwest region that extends toward the typically homogenous center of the Bank. The contoured distributions suggest the encroachment of water from the Gulf of Maine extended further into the shallow central region of the Bank than has characteristically been observed.

Seasonal temperature and density stratification was established along the southern flank of the Bank. For example, the temperature and density difference from the surface to 25 meters at standard station #9 was approximately 3.4C and 0.75 sigma-t units respectively. Vertically well-mixed conditions existed at this station during the previous Broad Scale survey in May.

A preliminary comparison of the MK5 fluorescence data (in volts) with the total chlorophyll-a (mg/m^3) was made for the samples that were read at sea. The R^2 for the data that had been analyzed by cruise completion was approximately 0.78.

Phytoplankton Chlorophyll, Nutrients and Light Attenuation Studies

(David W. Townsend, Jiandong Xu and Robert Stessel)

Overview: The purpose of this GLOBEC project is to investigate the idea that the growth and production of zooplankton and fish on Georges Bank are limited by the amount of nutrients (especially nitrogen) that is brought onto the Bank from the nutrient-rich, deeper waters around the Bank's edges (cf. Townsend and Pettigrew, 1997). Thus, we are collecting water samples on four of the six broadscale cruises (February to May) to analyze for a suite of nutrients and phytoplankton biomass. The sampling period is chosen to bracket the winter-to-early summer transition, during which time the winter nutrient levels become depleted over much of the Bank. During this cruise, water samples were collected for analyses of:

¸ dissolved inorganic nutrients (NO_3+NO_2, NH_4, SiO_4, PO_4);

¸ dissolved organic nitrogen and phosphorus;

¸ particulate organic carbon, nitrogen and phosphorus, and

¸ phytoplankton chlorophyll a and phaeophytin

Methods: Water collections were made at various depths at all of the regular hydrographic stations (Stations 1 - 40) sampled during the May 1997 broad scale survey cruise aboard *R/V Albatross*, using the 1.7 liter Niskin bottles mounted on the rosette sampler. Additional near-surface water samples were collected at positions between the regular stations (Stations numbered >40) using a Kimmerer Bottle to sample a depth of approximately 2m. In order to place the spring phytoplankton bloom into proper context, we also measured the vertical attenuation of photosynthetically active radiation (PAR).

Because of weather conditions, only a single light cast was made, at CTD station 21. A LiCor underwater spherical quantum sensor and deck-mounted cosine quantum sensor were used to compare the underwater light field as a function of depth corrected to coincident surface irradiance. Data will be presented at a later date.

Samples for dissolved inorganic nutrients and chlorophyll were collected at all regular stations and at in-between stations (at 2 m). Water samples for DIN were filtered through 0.45 mm Millipore cellulose acetate membrane filters, and the samples were frozen in 20ml polyethylene scintillation vials by first placing the vials in a seawater-ice bath for about 10 minutes. Samples will be analyzed on shore following the cruise using a Technicon II AutoAnalyzer, and reported later, as will all the various nutrient measurements. Water samples (50 mls) for dissolved organic nitrogen, and total dissolved phosphorus were collected at 2 depths (2 and 20m) at each of the main stations and frozen as described above. These samples will be analyzed ashore using a modification of the method of Valderrama (1981). Samples for particulate organic carbon and nitrogen were collected by filtering 500 mls from 2 depths (2 and 20m) at each of the main stations onto pre-combusted, pre-ashed GF/F glass fiber filters, which were frozen for analysis ashore. The filters will be fumed with HCl to remove inorganic carbon, and analyzed using a Control Equipment Model 240-XA CHN analyzer (Parsons *et al.*, 1984). Samples for particulate phosphorus were collected as for PON (but 200 mls were filtered) and frozen at sea. Laboratory analyses will involve digesting the sample in acidic persulfate and then analyzing for dissolved orthophosphate.

Phytoplankton chlorophyll *a* and phaeopigments were measured on discrete water samples collected at all stations and determined fluorometrically (Parsons *et al.*, 1984). The extracted chlorophyll measurements involved collecting 100ml from bottle samples taken at depths selected to correspond to "interesting" features revealed in the *in situ* fluorometer CTD cast. Samples were filtered onto GF/F filters, extracted in 90% acetone in a freezer for at least 6 hours, and analyzed at sea using a Turner Model 10 fluorometer.

Unusually high values of both chlorophyll *a* and phaeopigments were observed, and prompted a post-cruise recalibration of the Turner Model 10 fluorometer (against pure chlorophyll *a* from Sigma Chemical). The calibration confirmed the high values (see results presented in Table 1), which we expect are likely the result of our not having pre-screened the water samples (e.g., through a 200 mm mesh nitex screen) as is commonly done in order to remove larger zooplankton. In addition to removing the larger zooplankton, pre-screening also removes a significant fraction of the chain-forming diatoms commonly encountered in productive coastal waters, which we wanted to capture, thus we intentionally did not pre-screen the samples prior to extracting in acetone.

Preliminary Results of Zooplankton Findings.

(Maria Casas, Alyce Jacquet, James Pierson and Amy Lapolla)

Zooplankton from the 1-m^2 MOCNESS samples from nets 0-4, and all pump samples will be identified, staged, and enumerated at the University of Rhode Island, Graduate School of Oceanography.

Preliminary observations during this cruise showed that *Calanus finmarchicus* was present in significant numbers at most stations

on the Bank. All stages were seen, but older ones were the most common. Adult females, however, were not very abundant. *Pseudocalanus* spp. was also prominent with a greater proportion of adult females. *Temora longicornis* was extremely abundant, being present at almost all stations, but more so on the crest and shallower areas. *Centropages hamatus* and *Centropages typicus* followed a similar pattern as *T. longicornis* in both abundance and distribution. Other copepod species present in smaller numbers were *Calanus hyperboreus*, *Metridia lucens*, *Euchaeta* spp., *Aetideus armatus*, *Euchirella rostrata*, and *Pleuromamma* spp. *Oithona* spp. was not seen in as great abundance as they have been seen in the past.

Hydroids (Clytia spp.) were encountered in great numbers at the shallower stations on the crest and along the southern flank. Phaeocystis occupied similar locations but their abundance was not as great. Other dominant non-copepod species found in moderate to high abundances during this cruise were chaetognaths, amphipods, ctenophores, shelled pteropods, shrimps, euphausiids and cumaceans.

Following are general observations on the plankton assemblage made at each of the stations during this cruise using net 0 (surface to bottom - 335mm) on the 1-m^2 MOCNESS and the Bongo hauls (mesh size 200mm) that were used to replace the MOCNESS from station 30 onwards.

Station 1 *Phaeocystis* was very abundant at this station with a moderate number of the shelled pteropod, *Limacina*, and the chaetognath, *Sagitta elegans*. The most abundant copepod was *Centropages typicus*. There was a moderate number of *Calanus finmarchicus* (stages C4 and older), and moderate numbers of older stages of *Pseudocalanus* spp. In addition, *Temora longicornis* was fairly abundant.

Station 2 These were very "clean" samples, as almost no phytoplankton was present. The majority of the copepods were *C. finmarchicus* and *Pseudocalanus*, mostly C4 and older. Other copepods were *Metridia lucens*, *T. longicornis* and *C. typicus*. Lower numbers of Pteropods and Chaetognaths were also seen.

Station 3 The abundance of *C. finmarchicus* gave these sample the "strawberry daiquiri" look. There was an absence of *Centropages* spp., but a few *Pseudocalanus* and *T. longicornis* were seen. A few hyperid amphipods and pteropods were also at this station.

Station 4 Hydroid City! And chaetognaths are also very abundant. The copepod mix at this station are *C. typicus* and *C. hamatus*, *T. longicornis*, and *Pseudocalanus*, in order of abundance. Very few *C. finmarchicus* were present, mostly C4 and C5.

Stations 5 and 6 Hydroids were absent from these stations. A moderate number of shelled pteropods were present. The copepods were mostly a mix of *C. finmarchicus* (many C2 & C3), *Pseudocalanus* and *T. longicornis*. Very few *Centropages* were seen here.

Station 7 At this station there wasn't much in the way of plankton in the water column. A few hyperid amphipods, chaetognaths, and euphausiids were seen. A mix of *Rhincalanus* spp., Aetideus *armatus*, *T. longicornis*, *M. lucens*, *C. finmarchicus*, and *Pseudocalanus* were present, but in very small numbers.

Station 8 *Phaeocystis* was moderately abundant here, as were shelled pteropods. The majority of the copepods was made up by *T. longicornis*, followed by *Pseudocalanus* (C3 and older), and very few *C. finmarchicus* (C3 and older).

Station 9 Moderate numbers of *Phaeocystis* and chaetognaths were seen. Lesser numbers of *T. longicornis* were present than in the previous station. Moderate numbers of *C. finmarchicus* (C3 and older) and *C. typicus* were here.

Station 10 Many chaetognaths were present at this station with a smaller number of barnacle cyprids. The copepods were represented by large numbers of *T. longicornis*, *C. typicus* and *Pseudocalanus*. A lesser number of *C. finmarchicus* was seen, mostly older stages than C3.

Station 11 Fair number of hydroids and *Phaeocystis*, together with some chaetognaths. The majority of the copepods was composed of *C. typicus* and *C. hamatus*, *T. longicornis* and *Pseudocalanus*. Very few *C. finmarchicus*.

Station 12 Many hydroids present at with station. Also a mix of cumaceans, shrimps and crab zoea. The bulk of the copepod mix was similar to station 11.

Station 13 Hydroid City!!! Same copepod mix as in station 12.

Station 14 Absence of hydroids at this station. Instead *Phaeocystis* appears together with some chaetognaths, shelled pteropods and mysids. The most abundant copepods were *Pseudocalanus* and *T. longicornis*. Some *C. finmarchicus* were present, stages C2 and older.

Station 15 Again *Phaeocystis* was in abundance here, with more shelled pteropods than in the previous station. Same copepod mix as in station 14, but more *C. finmarchicus* were seen, mostly older stages.

Station 16 No phytoplankton in the samples. The copepod mix was an abundance of *C. finmarchicus* (C5's), with moderate numbers of *Euchaeta spp.*, *M. lucens*, *Euchirella rostrata*, and *Pleuromamma* spp. Euphausiids and chaetognaths were also seen in moderate numbers.

Station 17 Almost all *C. finmarchicus* older stages, but some C1 and C2's. Mixed in with *Calanus* are some *Pseudocalanus*, and a few *T. longicornis*. The rest of the zooplankton is made up of hyperid amphipods, and chaetognaths.

Station 18 Phytoplankton is abundant again, including *Phaeocystis*. Hydroids are making their presence again. *C. finmarchicus* is moderately abundant (all stages). There are also moderate numbers of *Pseudocalanus*, *T. longicornis* and *Centropages* spp. Some mysids and chaetognaths were also seen.

Station 19 Hydroid city again. Fewer numbers of *C. finmarchicus* that at station 18. The rest are the usual Bank mix of copepods. Balance of the plankton are polychaetes, crab zoea, mysids and chaetognaths.

Station 20 *Coscinodiscus* and hydroids dominate the plankton. The rest of the plankton is a Georges Bank mix. A little of everything.

Station 21 *Coscinodiscus*, shelled pteropods and chaetognaths are here in moderate numbers. Mostly older stages of *C. finmarchicus* and *Pseudocalanus* are in abundance, with a few *T. longicornis*.

Station 22 Mostly *C. finmarchicus* at this station with many adult females (not seen before on this cruise). Also a few *M. lucens*, *Pseudocalanus* and *T. longicornis* were seen. Hyperid amphipods were also abundant.

Station 23 The samples were full of copepod molts! In between this mix there were a few *C. finmarchicus*, and a mix of the usual copepods.

Station 24 Most abundant were *C. finmarchicus* and *Pseudocalanus* older stages, but not too many adults. Clean samples, phytoplankton not a problem at this station.

Station 39 and 25 The same composition as station 24, except quite a few *C. hyperboreus* were present.

Station 26 Small (1-2cm) orange jellyfish very abundant. The zooplankton component was made up of *Pseudocalanus*, *C. finmarchicus*, *M. lucens*, *T. longicornis*, and *Centropages* spp. Phytoplankton was absent.

Station 27 and 28 Hydroids were again abundant at this station, together with chaetognaths and a moderate number of shrimps. The dominant copepod was *Pseudocalanus* (older stages). *C. finmarchicus* were few in number, stage C3 and older, few females. Also *C. typicus* and *T. longicornis* were present in moderate numbers.

Station 29 Almost all *C. finmarchicus*, a mix of all stages, but older ones were most prevalent. Mixed in the sample were also *M. lucens*, *Euchirella rostrata*, and *Pseudocalanus*.

Station 30 Moderate number of hydroids, some *Coscinodiscus*, and chaetognaths. The smaller components of the copepods were present at this station: *C. typicus*, *T. longicornis*, *Pseudocalanus*, and a few younger stages of *C. finmarchicus*.

Station 40 Similar to station 29.

Station 31 Many *C. finmarchicus* and *Pseudocalanus* nauplii were seen at this station, together with *Calanus* C1's. the balance of the copepods were a mix of *T. longicornis* and *C. hamatus*. Some *Coscinodiscus* was present in the samples.

Station 32 *Coscinodiscus* present at this station. *C. hamatus* was very abundant, as were *Pseudocalanus* and *T. longicornis*. *C. finmarchicus* was almost totally absent from the sample.

Station 33 A bank mix of copepods. Small numbers of *C. finmarchicus* C1's were seen as well as older stages. *Pseudocalanus* was more abundant. Many nauplii of both species. Very few *C. typicus* and *T. longicornis* were in the sample.

Station 34 *C. finmarchicus* was the most abundant copepod (mostly C5's). Smaller numbers of *Pseudocalanus* were present. Some *Coscinodiscus* were still seen in the samples.

Station 36 A this shallow station, many polychaetes, bivalves, and some shelled pteropods were seen. Also smaller number of hydroids, *Coscinodiscus* and crab zoea were here. *C. finmarchicus* was present in extremely small numbers. The balance of copepods were the smaller sized *Pseudocalanus,*and *Centropages* spp.

Station 37 Similar to station 36, but more *Coscinodiscus* seen.

Station 38 Mostly C. finmarchicus present here in great abundance. All stages from C1 to adult were seen, but the majority were C5's.

Preliminary Summary of Ichthyoplankton Findings.

(Antonie Chute, J. Sibunka and Alyse Weiner)

Despite the impediment to visibility caused by dense phytoplankton, observations of preserved ichthyoplankton samples were steadfastly carried out for the duration of the cruise. As usual, jarred samples from bongo nets A and B and $1m^2$ MOCNESS nets 6 through 9 were examined for the presence of fish eggs and larvae. Although far from precise due to the aforementioned physical consistency of the catch, these observations provide useful "quick and dirty" information regarding abundance and distribution.

Herring (*Clupea harengus*) and **sand lance** (*Ammodytes* sp.): These early-spawned larvae that dominated the catches in the beginning the year have all but grown out of the range of our nets. Less than 25 sand lance larvae were captured (on the eastern portion of the Bank, average length 31mm), and no herring larvae were evident in the samples.

Cod (*Gadus morhua*): Cod larvae were observed consistently but in low numbers (never more than 4 per station) in samples from the north, northwest and central portions of the bank. All but a few were between 12 and 26mm. Earlier this year, in March, the cod larvae were located on the southern flank. In April, they were located primarily on the western side. Following this pattern, the larvae seem to have been carried clockwise toward the northeast this month. This same pattern of clockwise motion of the main concentration of cod larvae was also evident in 1996.

Haddock (*Melanogrammus aeglefinus*): Haddock larvae were captured on the southern, southwestern and western areas of the Bank in numbers comparable to the cod larvae. All haddock larvae observed were between 6 and 12mm in length. Since haddock are known to spawn later than cod, these larvae may be "upstream" of cod in regard to both position on the Bank and physical development, occupying the same size range and distribution that the cod larvae did a month or two ago.

Yellowtail flounder/American plaice: (*Limanda ferruginea*/*Hippoglossoides platessoides*): Since the small larvae of these two flatfish are difficult to tell apart without the aid of a microscope, we combined them into one category. They were found in samples

from every area of the Bank except the Northeast Peak, and ranged from 6 to 13mm in length. The largest catches (generally more than 5 larvae per station) occurred on the central portion of the bank along the 60m isobath.

Cod/haddock/pollock eggs: In contrast to the high density of gadid-sized eggs observed on the Northeast Peak earlier in the season, diminished numbers of cod/haddock/pollock eggs were observed in samples from all over the bank with no particular area of concentration evident. Only a few eggs per jar were observed at most stations.

Miscellaneous larvae: The following larave were also identified in the ichthyoplankton samples:

Sea snails (*Liparis* sp.)

Witch flounder (*Glyptocephalus cynoglossus*)

Atlantic mackerel (*Scomber scombrus*)

Lanternfish (family Myctophidae)

Ocean pout (family Zoarcidae)

10-m^2 MOCNESS - Preliminary Ichthyoplankton Results

(Antonie Chute and John Sibunka)

The 10-m^2 MOCNESS was deployed 20 times during the cruise. Below are brief summaries of catches per station, based on observations of preserved, jarred samples. The catches are listed in descending order of biomass.

Standard Station 3, Haul 1

Several gallons of ctenophores (*Pleurobrachia* type)

Naked pteropods

Standard station 4, Haul 2

Decapod shrimp (*Crangon*)

Isopods

Polychaetes

Hydroids

Standard station 7, Haul 3

Several quarts of hyperiid amphipods

Standard Station 9, Haul 4

Ctenophores

A few amphipods

Standard Station 12, Haul 5

Small samples of:

Hay

Weeds

Feathers

Bugs

Seaweed

Marsh grass

Station 13, Haul 6

Several gallons of hyperiid amphipods

A few jellyfish

Isopods

Euphausiids

Station 16, Haul 7

Hyperiid amphipods

Euphausiids

Chaetognaths

Jellyfish

A few myctophids

Station 17, Haul 8

Decapod shrimp

Hyperiid amphipods

Ctenophores (*Beroe* type)

Ctenophores (*Pleurobrachia* type)

Jellyfish

Unidentified leptocephalus larva

Standard Station 18, Haul 9

Isopods

Decapod shrimp

Hyperiid amphipods

Station 20, Haul 10

Several gallons of ctenophores (*Pleurobrachia* type)

Hydroids

Standard Station 23, Haul 11

Decapod shrimp

Hyperiid amphipods

Isopods

Ctenophores (*Pleurobrachia* type)

Standard Station 39, Haul 12

Several gallons of euphausiids

Ctenophores (*Beroe* type)

Ctenophores (*Pleurobrachia* type)

Hyperiid amphipods

Standard Station 25 Haul 13

(Very small samples)

Ctenophores (*Pleurobrachia* type)

Hyperiid amphipods

Naked pteropods

Jellyfish

Large *Euchaeta* copepods

Standard station 27, Haul 14

Several gallons of ctenophores (*Pleurobrachia* type)

Isopods

Decapod shrimp

Hydroids

Standard Station 29, Haul 15

Large caridean shrimp

Hyperiid amphipods

Euchaeta copepods

Chaetognaths

Myctophids

Standard Station 30, Haul 16

Many Lion's Mane-type Jellyfish

Ctenophores (*Pleurobrachia* type)

Standard Station 40, Haul 17

Several gallons of euphausiids

Standard Station 34, Haul 18

Euphausiids

Naked pteropods

Hyperiid amphipods

Extremely small ctenophores (both *Beroe* and *Pleurobrachia* types)

Jellyfish

Standard Station 36, Haul 19

Jellyfish

Decapod shrimp (*Crangon*)

Standard Station 38, Haul 20

Euphausiids

Hyperiid amphipods

Naked pteropods

Copepod Life History Studies

Jennifer Crain/Charles B. Miller, Oregon State University

Calanus 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 MOC-1 nets on this and subsequent BroadScale cruises. On AL9705, we collected subsamples (90/600ml) at standard stations 3, 4, 7, 9, 12, 13, 16, 17, 18, 20, 22, 23, 25, 39, 27, 29, 30, 40, 34, 35, 36 and 38 for analysis of first antennal setation patterns.

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 have been cryopreserving adult male and female *Calanus*. Very few adult *Calanus* were found this month, so none were frozen in liquid nitrogen. Ethanol-preserved subsamples from MOC-1 net 5 (90/400ml) taken at standard stations 3, 4, 7, 9, 12, 17, 18, 20, 23, 24, 25, 39, 27, 29, 30, 40, 34, 35 and 36 will be used to augment samples from previous cruises for biochemical analyses.

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.

Copepodite jaw morphology - an indicator of diapause and age-within-stage:

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 which looks like a transparent bubble reaching up toward the teeth of the mandibular gnathobase. Copepodites of the B group also have this 'bubble' for a short period following molting, but it begins retracting toward the base very quickly as the animal fills its new exoskeleton. We are dissecting and examining the jaws of individuals from the formalin-preserved subsamples listed above to determine the proportions of animals in this jaw phase. Additional correlations of jaw stage data with gonad development and oil sac volume, both indicators of whether a copepodite is halting or proceeding with development to maturity are being made to differentiate between the groups.

Observations of lipid volumes as seen on images captured (see below) showed that there were many fifth copepodites with large volumes of stored oil, especially at the deeper stations. These animals were still active, but quite possibly were preparing for diapause. Developing gonads were seen only in animals with smaller oil sacs.

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. Rate of progression through this series of jaw phases may be variable, possibly related to feeding or starvation history. Preliminary analyses of jaw phases of individual second through fifth copepodites from 1995 and 1996 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 Charlie for calculating an accurate volume estimate from the area.

On AL9705, sets of video recordings were taken at standard stations 3, 9, 12, 16, 20, 22, 39, 29, and 40. It is necessary to have undamaged, healthy individuals for these images. The animals caught in some of the deeper (longer) MOC-1 hauls on the previous cruise were dead or dying by the time they were sorted from the nets, and could not be used. To circumvent this problem, interrupted MOC hauls were made at the deeper stations on this cruise (16, 39, 29, and 40), rinsing the first five nets (0-4) before redeploying for the rest of the tow. These hauls yielded strong, healthy fifth copepodites for images. Each image recorded was of a group of five fifth copepodites. Each group was then cryopreserved for gas chromatographic analysis of fatty acid and fatty alcohol components.

SUMMARY OF OPERATIONS AND SAMPLES COLLECTED

The following is a list of the data and samples collected during CTD operations:

Instrument # Casts

MK5 40

SBE19/Bongo 86

SBE19 Calibration 8

Parameter # Samples

MK5 conductivity calibration 40

Oxygen isotope 144

Micro-zooplankton 18

Species Composition 18

The following is a list of the samples Collected by the Zooplankton and Ichthyoplankton Groups:

Gear Tows Number of Samples

1. Bongo nets, 0.61-m 86 tows

335 mm mesh 78 preserved, 5% formalin

335 mm mesh 86 preserved, EtOH

200 mm mesh 8 preserved, 10% formalin

2. MOCNESS, 1-m^2 32 tows

150 mm mesh 99 preserved, 10% formalin

335 mm mesh 32 preserved, 10% formalin

335 mm mesh 131 preserved, EtOH

3. MOCNESS, 10-m^2 20 tows 82 preserved, 10% formalin

3.0-mm mesh

4. Pump 19 profiles 56 preserved, 10% formalin

30 mm mesh

References:

Parsons, T.R., Y. Maita and C.M. Lalli. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis* . Pergamon, Oxford. 173 pp.

Townsend, D.W. and N.R. Pettigrew. 1997. Nutrient limitation of secondary production on Georges Bank. *J. Plankton Res.* 19(2): 221-235.

Valderrama, J.C. 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. *Marine Chemistry* 10: 109-122.

APPENDIX A

Officers and Crew of the ALBATROSS IV

CO CDR Derek Sutton
XO LCDR Michael Abbot
OPS LT Denise Gruccio
NAV LT Philip Gruccio
CME John Hurder
1AE Chuck Hersey
2AE Grady Abney
CB Kenneth Rondeau
LF Antonio Alvernaz
SF Antonio Vieira
SF Antonio Romao
F Anthime Burnette
F Douglas Roberts
CS Jerome Nelson
GVA Ernest Foster
RET Robert Yates

Scientific Party

David Mountain (Chief Scientist) NMFS, Woods Hole, MA
Maureen Taylor NMFS, Woods Hole, MA
Antonie Chute NMFS, Narragansett, RI
John Sibunka NMFS, Sandy Hook, NJ
Alyce Weiner NMFS, Sandy Hook, NJ
Jennifer Crain OSU, Corvallis, OR
Maria Casas URI, Narragansett, RI
Jamie Pierson URI, Narragansett, RI
Alyce Jaquet URI, Narragansett, RI
Melissa Miller URI, Narragansett, RI
Amy Lapola URI, Narragansett, RI
Jiandong Xu UM, Orono, ME
Robert Stessel UM, Orono, ME
Carollyn Carrington HU, Hampton, VA

APPENDIX B

The event log for cruise AL97-05 is available on-line .