

## Cruise Report

### R/V ENDEAVOR CRUISE EN259

#### to Georges Bank

10 Jan - 22 Jan 1995

#### Acknowledgements

This report was prepared by Edward Durbin, with inputs from all Principal Investigators. The contribution of Jeff Van Kuren, who maintained the event log during the cruise was greatly appreciated. We thank Jim Bisagni of the NOAA Remote Sensing Laboratory of Narragansett, RI for the satellite sea surface temperature images.

We gratefully acknowledge the excellent support provided by the Captain and the crew of the R/V Endeavor. The professional atmosphere enabled our research to be carried out smoothly and allowed the scientific party to achieve all of its goals and objectives.

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#### Introduction

EN259, which took place between January 10th and January 22nd, was the first of five US-GLOBEC zooplankton process cruises to be carried out during 1995. The major objectives of this cruise were to measure abundance, fine scale distribution, and feeding, growth, and reproductive rates of the target species of zooplankton, *Calanus finmarchicus*, and *Pseudocalanus* spp., at a series of four 24 hr stations in different hydrographic regimes on Georges Bank. In addition, since this cruise took place 3 weeks prior to the first broad scale survey cruise we carried out some bank wide CTD, MOCNESS sampling to provide information of the abundance and stage distribution of the target zooplankton species on Georges Bank and in adjacent Gulf of Maine (GOM) and slope waters. Groups participating in the cruise included:

- E. Durbin, J. Runge and A. Durbin: Zooplankton growth and reproduction.
- E. Durbin and A. Durbin: Zooplankton abundance and distribution from MOCNESS and pump sampling.
- D. Gifford and M. Sieracki: Zooplankton feeding, and water column chlorophyll a, nano- and microphytoplankton and nano- and microzooplankton.
- C. Davis and S. Gallagher: VPR studies of fine scale zooplankton distribution and hydrography.
- J. van Kuren: Visible and UV light modelling.

The cruise track and the locations of the CTD, MOCNESS, and plankton pump stations, and the VPR transects are shown in Figures 1-5. Surface salinities and temperatures at the CTD stations are shown in Figures 6 and 7. Figure 8 shows section data from VPR transect 13.

The R/V Endeavor left Narragansett at 12:00 on January 10th and proceeded to first station in the Great South Channel (GSC). The weather was fine and the seas were almost flat calm. We arrived at Station 1 in the GSC at 22:30 and proceeded to carry out CTD, MOC sampling and to collect live animals for experiments. The first CTD cast was not entirely successful because several of the GO-Flo bottles failed to trip. The same problem re-occurred on a second cast. Net tows with Stephane Plourde's 1m 333 net were then made for the collection of live animals. This was followed by a MOCNESS tow. In the live tow it was found that *Calanus* females dominated the population. A number of adult males were also observed while C5s constituted about 1/3 of the population. The MOCNESS tow was successful with no problems arising except for an offset on the pressure sensor. The depth sensor was

indicating 4.5 m when the net was at the surface. The MOC samples had great quantities of a large *Coscinodiscus* which left a scum on the bottom of our buckets. Despite the problems on board, the weather remained great with low winds, calm seas, and very cold air (about 33 F). Snow fell gently through the night.

Because of the time lost at this first station it was decided to forgo the night VPR transect between Station 1 and Station 2 and also to switch the order of the day activities by carrying out the VPR tow first (08:00 to 14:00), followed by the CTD, MOCNESS tows and pump cast in order to give the plankton people a rest.

At Station 2, the first 24 hr station, the GPS/ARGOS drifter was deployed around 08:00; the radar transponder was quite visible on the ship's radar but did not provide good distance information. The VPR went in the water around 10:12 and a surface tow was carried out around the drifter. Problems with the Goflos continued and Jan Szelag decided to make new lanyards for the bottles and to increase the tension on the rubber closing spring. Problems emerged at this station while making the live tows with the ring net because of the wire jumping out of the shieve. Apparently a new block is on order and will have to be in place before the first broad scale survey cruise. The net tow at this station was dominated by *Centropages typicus*. There were also large quantities of the large centric diatom *Coscinodiscus* still present at this station. While sorting live animals, we found that there was the lack of a sufficient ice making capacity on the ship, and had to freeze large blocks of ice and then break them up for use in experiments. More ice making capacity is needed for future cruises. A MOCNESS tow was then made after a birdsnest in the cable was untangled at the winch. This tow went smoothly as did the plankton pump cast which followed.

After the pump sample we were no longer getting a radar return from the drifter with any consistency so we decided to pick it up and check it. Finding it in the dark with snow squalls passing was difficult without radar but we were fortunate and were able to locate and retrieve it. The transponder mast had broken and was floating in the water attached by a tag line. We repaired the mast and redeployed the drifter after attaching a life jacket flasher. The wind at this point had picked up with sleet flying horizontally and the VPR group decided it was too rough to deploy the VPR so the drifter was recovered, taking three passes (in the driving sleet and rain) and we proceeded to Station 3.

We arrived at Station 3 on Thursday morning January 12th. Forecasts were for 30-35 kt winds. We carried out a CTD cast and MOCNESS tow at this station, cruised south to Beardsley drifter site 1, released it, and proceeded to Station 4 (the 2nd 24 hr station), arriving there at 13:30.

On arriving at this station we made a CTD hydro cast (goflo bottles still hanging up), Jeff van Kuren did a light cast, and then we made a MOC tow. The net release hung up on this tow so we tried again. This second tow was successful but when we retrieved it the down net (net 0) had 'blown' with a large tear extending along much of the net. Fortunately the two upcast nets were OK. The pump was next, followed by net hauls for live animals. These were dominated by *Centropages typicus* with relatively few *Calanus* and even fewer *Pseudocalanus*. The seas remained relatively calm although it was cloudy and rained for much of the morning.

CTD profiles at Stations 1-4 showed that Station 1 and Station 2 were very similar with salinities of around 33.29. Those at Station 3 and Station 4, which were on the shallower regions of the bank were a little lower at 33.19.

Friday 13th. 07:00. Partly sunny and warm (50 F). Winds about 18 kts. We made a daytime CTD cast at Station 4, carried out a VPR grid, then deployed Beardsley drifters 2, 3, and 5 while steaming to Station 5 on the northeast peak, the third 24 hr station. The VPR was deployed first when we arrived at Station 5 (around 23:00) but the cable jumped off the shieve at the traction head and was damaged. It had to be re-terminated.

Saturday 14th was beautiful, warm, sunny morning. At 07:00 we made a CTD cast followed by a MOCNESS tow and a pump cast. We found the wire out and wire speed indicator was not working on winch 1 (CTD winch) while making the cast. Jan Szelag and Jack Buss worked on it later in the morning. We then made net tows for live animals. We found mostly adult female *Calanus* with few C5s. There were also many adult males and many *Centropages typicus*. The VPR people were still working on re-terminating their cable. Jan was trying to fix the Inmarsat (it hadn't worked properly since the beginning of the cruise). The VPR cable was finally finished around 19:00 and it was put in the water for a grid at Station 5. Everything went well and they finished around 00:30 on the 15th.

We arrived at Station 6 on Sunday 15th at 02:40. It was a beautiful, warm (52 F), cloudless night with a gentle breeze and a bright moon. We did a CTD cast and a MOCNESS tow. There were no problems with either and things seem to be going much better. After this station the VPR group carried out a transect from the edge of the bank to Station 7 in Georges Basin.

While we were doing a CTD profile at Station 7 (300m), the cable jumped a sheave in the winch when about 180m was out. The cause appears to be the unevenness with which the cable was wound on the drum with the cable staying in valleys as the level wind and sheave moved away from it. Jack was able to get the cable back on the sheave and the cast was completed. This problem with the winch needs to be fixed.

At this station (Station 7) there was a layer of colder, less salty Scotian Shelf water in the surface 20m (Figures 12 and 13). There were a lot of Pteropods near the surface. Scott Gallagher and Phil Alatalo set up some swimming behavior experiments with these animals. At the surface the proportion of adult female *Calanus* was probably smaller than at the on-Bank stations. At depth (>100m) C5s dominated. These were probably resting animals.

The VPR group then did a 3 hr transect towards Station 8 and then we steamed the rest of the way to the station arriving around 20:00. The wind was picking up at this time and 25-35kt winds were predicted for Monday and Tuesday. At Station 8 we did a CTD, a MOCNESS tow and a VPR tow onto the bank towards the next station (Station 9).

We arrived at Station 9 on Monday morning 03:00. The moon was full, the temperature a surprising 55 degrees, and the wind not too strong. A CTD cast and MOC tow were made. There were fewer *Calanus* than at Station 7 and much less phytoplankton in the MOC nets than at previous bank stations. After this station the VPR group made a tow away from Station 9 towards the next station on the Bank (Station 11).

We then steamed to the release site of Beardsley's drifter 4, let it go, and continued to Station 11, the 4th 24 hr station, arriving there in late afternoon. The day was very pleasant with sunny skies and warm, but there was a large swell from the SW. At this station there

were very few zooplankton and almost no *Calanus*. *Centropages typicus* was still the dominant. Because of the seas it was not possible to deploy the VPR, so we decided to use the time to run a hydro line from the crest mooring (Station 4), through the southern flank mooring, to Station 12 on the slope. This took place during the night of the 16th and 17th. We arrived at Station 12 around 09:00 and did a CTD. The seas were still quite rough with 15-20 ft waves. Because of the possibility of ripping nets out with the surge of the ship we omitted the MOC tow.

After this we steamed east along the flank to the start of a VPR transect across the bank in a location similar to the one run on the R/V Columbus Iselin in 1994. The seas were still quite rough during the steam and we had to tack to the east to avoid being beam on to the seas while steaming. This put us further into the slope water when we reached the end of the line so we decided to do a deep CTD cast (2500 m) starting around 19:00 to straighten out the cable winding on the winch. We then made a MOC tow to 400 m to sample the deep *Calanus* layer in slope water reported by Wiebe et al. There were *Calanus* C5s in the deep sample (400-100m), but the abundance was very low compared with what we had seen in deep water in the GOM. The wind had gone around to the north during the evening and the seas calmed down somewhat so the VPR transect was started. A fisherman's long line was snagged during the first profile but this was cleared and the tow continued. During the early morning hours the wind picked up from the NE and by morning was blowing 25 kts with seas too rough for any VPR or CTD work. As a result we spent Wednesday slowly jogging waiting for the weather to ameliorate. Winds were predicted to remain high for 24 hrs.

Wednesday evening. The winds and seas calmed down enough to deploy the VPR. We steamed back to where the VPR transect was broken off and continued it, getting the VPR in the water around 24:00.

Thursday morning, 19th. The seas have calmed down a little further. The VPR is going well. A CTD, MOC, and net tow (0-100m) at Station 17 were next after this line was completed. There were many *Calanus* at all depths. Both C5s and C6 females were present at the surface but very few adult males. At depth there were mostly C5s. Interestingly, there appeared to be more adult males than females in this sample.

While we steamed to Station 18 Scott re-terminated the VPR cable because the outer sheath of the cable was loosening. He, Jack and Cabell were afraid that one of the strands would break and jam in the sheave. Because this was going to take a while we decided to do a CTD hydro line between Station 18 and Station 19 first for Dian, then return along the line with the VPR hoping that it would be done by then. Everything went well and this line was completed around 07:00. We then steamed to Station 20, the beginning of a second transect from the bank into the GOM. The weather was good with 15-20 kt winds and seas not too uncomfortable. The MOC sample at this shallow station came up full of sand even though the net did not go closer than 7 m off the bottom. There were very few *Calanus* at this station. As we sampled, however, the winds picked up and after the work at the station was finished Captain Tyler was reluctant to start a VPR transect. We decided to steam to Station 21 to sample there. The VPR people remembered at this point that they still had to intercalibrate the CTD and VPR so this was carried out in deeper water halfway to St 21.

As we approached Station 21 the wind picked up and by the time we arrived at the station it was blowing so hard and the seas were so high that we were unable to do a MOC tow or a pump cast, and only did a CTD and live tows. We spent time after this carrying out tows to collect live zooplankton for mackerel feeding experiments. By this time the wind was blowing around 30 kts and it was raining heavily, a wild night. After much discussion about whether to leave early and head back to Narragansett, or to stay out and hope that the weather got better on Saturday, we decided to head down to Station 1 and hang out there until Saturday morning when the wind was predicted to go around to the south and the seas die down to 8-9 ft. We hoped that under these conditions we would be able to sample Station 1 and carry out a VPR tow between Station 1 and Station 2.

By the time we had returned to Station 1 the wind had gone around to the south and the seas had died down enough for the VPR to go in the water. A VPR transect from St 1 to a location east of Station 2 was begun at 03:00 and ended at 10:00. We then returned to Station 1 and carried out a CTD, light, and pump cast, and a MOCNESS and live net tow finishing up around 15:30.

Overall, despite a few problems which occurred, everything went very well on this cruise. We had gone to sea expecting to lose many days to weather and to be chipping ice off the deck. Instead, we were blessed with very favorable unseasonal weather, losing very little time because of it. As a result we were able to accomplish everything we set out to do and more. The crew were extremely helpful and pleasant to work with (as we have come to expect on the Endeavor) making the trip much more enjoyable.

Scientifically, much was accomplished. The presence of actively reproducing populations of *Calanus* both on the bank and in the GOM was, perhaps, rather surprising. However, there remained large numbers of resting C5 animals at depth in the GOM, particularly in Georges Basin which will probably continue to seed the bank as the winter progresses. We must have been sampling the *Calanus* populations near the beginning of their annual cycle because of the relatively large number of males compared with females in the deep populations. The abundance of *Centropages typicus* and the presence of reproduction in this population was also surprising as was the relative scarcity of *Pseudocalanus*.

The large number of VPR transects which were carried out provided quite good coverage around the bank and should provide a valuable 'winter' picture of the plankton and of the hydrography.

An initial examination of the hydrography shows a layer of lower salinity water at the surface to the north of the bank at Station 7 and on the southern flank (Figures 5, 6 and 9). This salinity was lower than surface salinities in the southern GOM at Station 1 and in the shallow regions on the crest of the bank. Satellite images of sea surface temperature (Figure 7) suggest that this water is from the Scotian Shelf or the slope waters adjacent to the shelf.

## Individual PI Reports

### A. Egg production of dominant copepods species on Georges Bank. (S. Plourde & J.A. Runge)

#### Objectives

1. To measure egg production rates of the dominant copepod species on Georges Bank.
2. To compare egg production rates, mortality and recruitment rates of the dominant copepod species in different regions of

Georges Bank and adjacent waters.

3. To determine the reproductive state of the *Calanus finmarchicus* female population.
4. To estimate degree of food limitation of *C. finmarchicus* females on Georges Bank.

## Methods

*Calanus finmarchicus*: *In situ* egg production rates were measured following same methods used on Cruise CI9407. Females were caught with a 1-m diameter 333  $\mu$ m mesh sized plankton net towed obliquely from depths ranging between 50-100 m and the surface. Forty females were quickly sorted within 1 hr after being caught. Individual females were incubated in filtered sea water (FSW) in petri dishes for 24 h at 6-7 °C under a 12:12 light cycle. Eggs were counted and removed each 8 hrs to prevent cannibalism and then preserved for future egg viability and quality assessment. At some stations, when time was limiting or weather too rough, females were individually incubated in 45 ml flasks and then both eggs and animal preserved in the container at the end of incubation period.

The level of food limitation was evaluated by measuring the time taken for females kept in enriched FSW to reach maximal egg laying rates. Animals were incubated (5 ind. container<sup>-1</sup>) in 1.2 l egg separator cylinders immersed in 2 l beakers filled with FSW enriched with superabundant concentration of *Tetraselmis* sp. For each experiment there were five replicate containers. Egg separators and females were transferred in new beakers containing fresh medium each 24 hrs.

Other copepod species: Egg laying measurements of other copepod species were made with 45-ml flask method.

## Results and Discussion

Egg production was measured at Station 1 (Great South Channel), Station 2 (South Western Flank), Station 4 (central shallow region), Station 5 (Northeast Peak), Station 7, Station 17 and Station 21 (Georges Basin). At Station 11 (Southern flank), we were not able to set up an experiment because of the low *Calanus* female abundance at this station. Eggs and females at Station 7 were preserved and will be counted after the cruise.

The results were quite surprising. *Calanus finmarchicus* females laid eggs at c.a. 20 eggs f<sup>-1</sup> d<sup>-1</sup> at stations in Great South Channel (Station 1, Station 2), and in Georges Basin (Station 17, Station 21). In comparison egg production rates were c.a. 32 eggs f<sup>-1</sup> d<sup>-1</sup> at Station 4 and Station 5. At first 4 stations, about 55-60% of females laid eggs whereas between 70 and 86% of the animals produced at least 1 clutch at other stations. Clutch sizes were nearly the same among stations, ranging between 30 to 40 eggs per spawning event.

Were egg production rates food limited?

*Calanus finmarchicus*: Based on CHN analysis of *Calanus* females caught during first leg of the CI9407 Cruise carried out in May and June 1994 (104 g female<sup>-1</sup>), and assuming an egg carbon content of 0.23 g, the females were laying eggs at 4.4% body C day<sup>-1</sup> at the Great South Channel and Georges Basin stations and 7.0% body C day<sup>-1</sup> at the Georges Bank stations. This implies that Georges Bank females were laying eggs at maximal rates at the prevailing surface water temperatures (c.a. 7-8 °C). The results of the long-term egg production experiments support this conclusion. In these experiments females that had received a superabundant food supply showed no increase in egg production rates over those observed for animals incubated in *in situ* food levels. Additionally, we observed gut pigments in more than 70% of animals sorted. Data provided by Ted Durbin's gut pigment measurements, CHN and RNA/DNA analyses, and the grazing experiments made by Dian Gifford will help us to answer this question. The lower egg laying rates measured at Great South Channel and Georges Basin stations might be explained by presence of newly molted and fertilized females which had ascended from deep water and were not ready to produce eggs.

No marked egg production was expected at this time of year. Generally, it is believed that the *C. finmarchicus* overwintering population of diapausing stages CIV and CV should molt, mate and start to reproduce later in the season (late February, early March). The presence of *C. finmarchicus* females, which dominated in proportion to CVs in the population at the shallow stations visited, may be explained in 2 different ways: (1) a proportion of population stayed and grew slowly in surface waters throughout summer and autumn months and/or (2) females molted early from CV overwintering stock. The first statement is supported by observations made by Durbin's working group in Gulf of Maine: they noted CVs in surface waters in November. But these could also have been animals which had recently ascended to the surface at that time and started feeding. The second suggestion should also be considered as a high number of *C. finmarchicus* males were observed in deep water in Georges Basin, indicating onset of mating and the reproductive season. This might explain lower egg laying rates measured at Great South Channel and Georges Basin stations: newly molted and fertilized females ascended from deep water layer and weren't quite ready eggs, needing to feed a few more days to get benefit of primary production.

Other copepod species: *Centropages typicus* and *Metridia lucens* females were also relatively numerous at nearly all of the stations. Several females showed developed gonads, indicating active egg laying. At Station 11 located on the Southern Flank of the Bank, some *C. hamatus* were also seen in the live tow catch. Egg laying experiments were carried out at Stations 2, 4, 11 and 20 with *C. typicus*. Eggs and females were preserved and have to be counted to obtain reproductive rates. This reproductive activity was quite surprising since the active reproductive period for this species is considered to be during summer-autumn period. At Station 17, *M. lucens* females laid eggs at c.a. 5-6 eggs f<sup>-1</sup> d<sup>-1</sup>.

## B. Zooplankton Abundance, Physiological Condition, and Growth Rates (E. Durbin, A. Durbin, R. Campbell, P. Garrahan, G. Teegarden)

Objectives:

1. To determine the abundance and stage composition of target zooplankton species (*Calanus finmarchicus* and

*Pseudocalanus* spp.) on Georges Bank through a series of MOC-1 transects over different parts of the Bank (see map), and plankton pump samples at the 24 hr experimental sites.

2. To determine the size (length, carbon, nitrogen) and condition (condition factor, RNA/DNA ratio) of *Calanus* over the Bank, and whether the C5s and C6s are resting or feeding.
3. To determine the molting rate of *Calanus* C5s to C6s, whether this rate varied spatially over the bank, and whether this rate could be enhanced with added phytoplankton.

The location of the MOC-1 stations are shown in Figure 3. We used 150 m mesh nets on the MOCNESS and sampled over same standard depth ranges as to be used in the Broad Scale surveys. The new frame and software performed very well. The only problem was that a number of the 150 m nets blew out. This appeared to be due to weak construction in the lower corner in the mouth of the nets since this was the location of the tear in each case. In addition to this MOCNESS sampling, we sampled with the plankton pump at each of the 24 hr experimental sites (Figure 4), collecting samples on a 50 m mesh net which quantitatively retains all of the nauplii of the target species of copepods. Samples were collected at 5m depth intervals down to 60 m and pooled over the same depth ranges as the MOCNESS samples. At the first two 24 hr stations we deployed our GPS/ARGOS drifter which was drogued at 7 m so that the VPR group could use its position to lay out their grids. A radar transponder was mounted on the drifter to help locate its position since we did not have a ARGOS deck receiver. Unfortunately, when we went to download the GPS positions after retrieving the drifter we found that no data had been recorded. We decided not to deploy the drifter at any further stations until this problem was resolved.

We chose to process samples and set up experiments at the first station (Station 1) in the Gulf of Maine (GOM), rather than at the first 24 hr station (Station 2) on the edge of Georges Bank. At this station (Station 1) *Centropages typicus* was the numerically dominant copepod with large numbers of *Calanus* also present. *Pseudocalanus* spp. were very rare. All copepodite stages of *Centropages* appeared to be present. However, we were surprised to find that most of the *Calanus* in the surface layer had already molted to the adult stage. Adult females predominated but males were also abundant. At depth, however there were still large numbers of resting C5s. Because of the abundance of adult females we were unable to sort enough C5s for a molting rate experiment. C5s and C6 females from the surface were sorted for carbon and nitrogen, and RNA/DNA. As individuals were sorted for RNA/DNA we noted whether they had food in their guts or not and found that most of them did. We also measured gut pigments of C6 females and found a mean value of 4.07 ng pigment copepod<sup>-1</sup>. These values are not high but indicate a moderate level of feeding. These observations indicate that most, if not all, of the *Calanus* in the surface layer are actively feeding and growing, rather than in the resting stage as expected. Stephane Plourde found that about half of the *Calanus* females were laying eggs (see his report). Observations on fine mesh phytoplankton net tows (35 m) collected on the bank at Station 5 revealed the presence of both *Calanus* and *Centropages* nauplii, with *Calanus* stages up to C1 being observed. These observations indicate actively growing and reproducing populations. The abundance of *Calanus* males suggests that we were present soon after the molt of C5s to the adult stage.

This pattern of large numbers of *Centropages typicus* and a dominance of *Calanus* by adult stages seen at Station 1 was also observed at most stations on the bank as well, and samples were processed at each of the 24 hr stations as described above.

At Station 7 in Georges Basin larger numbers of *Calanus* C5s were observed at the surface and these were sorted for a molting rate experiment. For this experiment 60 C5s were put into six 5 gal polycarbonate carboys with either ambient water collected from 20m depth, or ambient water enriched with lab cultures of *Tetraselmis* and *Thalassiosira weissflogii*. These were incubated in a water bath cooled with surface water on deck. Pairs of carboys were taken down at two day intervals and the stages present determined. The lengths of the copepods were then recorded and then they were frozen for RNA/DNA.

*Calanus* was moderately abundant in the shallower regions of Georges Bank, at Station 5 on the NE peak and at Station 7 in Georges Basin. However, at Station 11 adjacent to the mooring on the southern flank, there were very few *Calanus*. This water was of lower salinity than water on the crest or in the GOM suggesting an origin from the Scotian Shelf.

### **C. Phytoplankton and Protozoa in the Diets of Copepods and Larval Cod on Georges Bank. (Scott Gallager, Phil Alatalo)**

The overall objectives of this study are the following:

1. To examine grazing by newly hatched cod larvae on natural assemblages of microzooplankton.
2. To determine growth and survival rates of larvae fed prey assemblages collected at different depths.
3. To characterize seasonal changes in the potential prey field for newly hatched cod larvae with respect to prey motility patterns and size spectrum.

During this cruise, we addressed objective 3 only. All objectives will be addressed in subsequent process cruises in February-March, and April. The working hypothesis for the study was the following: The microzooplankton assemblage will be both quantitatively and qualitatively different between the geographic locations and depths in the water column and thus will influence larval cod grazing and growth differentially. Newly hatched cod larvae should graze exclusively on microzooplankton between 50 and 100 m in diameter whose motility patterns are relatively continuous rather than erratic.

#### **Prey Motility Experiments:**

Fourteen hours of video information were recorded on motility patterns and particle size composition in the water column at various depths following collection both invasively (Go Flow port sample) and relatively non-invasively (bucket from the surface or siphon from Go Flow bottle). Prey motility patterns will be digitized and characterized with our Motion Analysis System back at Woods Hole and compared with capture success for cod larvae foraging on natural assemblages of prey. Seasonal changes in the prey field numbers, size spectra, and motility patterns should indicate when cod larvae are most likely to survive in the field.

#### Procedure:

Water samples were collected from the surface and on occasion from depth with 10 l Go Flow bottles. Samples were also collected from the surface with a bucket over the side. Go Flow samples were either collected from the port as usual, or to test the idea that microplankton are disturbed by this procedure, by siphoning from the bottle through the air port. 200 ml tissue culture flasks were filled with the sample and placed into a refrigerator.

A BW high-res Pulnix camera was fitted with a 50 mm macro lens and mounted on a frame across from a fiber optic ring illuminator. The entire apparatus was suspended by bungee cord to reduce vibration produced by the ship. Recordings were made on SVHS medium for a period of 15-30 min for each sample. The flask was then replaced with the next sample and recordings continued. The field of view was set to 23 mm (scale bar at the beginning of each tape).

Post cruise processing: Upon returning to WH, 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.

#### Tape Log

Date	Station	Depth
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1	11 95	1 surface
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1	11 95	2 surface
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1	12 95	4 surface
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		38 m
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1	15 95	7 surface
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		20 m
--	--	------

1	16 95	11 surface
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		14 m
--	--	------

1	17 95 B4	surface
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		45 m
--	--	------

		11 surface
--	--	------------

		65 m
--	--	------

		13 surface
--	--	------------

		45 m
--	--	------

		75 m
--	--	------

		16a surface
--	--	-------------

		127 m
--	--	-------

		2090 m
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#### Pteropod Studies

In addition to the microzooplankton motility study described above, we were able to record swimming and sinking activity of the pteropod *Limacina retroversa* under a variety of food conditions. Variables quantified from the video tapes were vertical swimming speed, sinking speed, time spent swimming vs sinking, and beat frequency of the parapodia as a function of shell size.

Swimming speeds ranged from 12 to 30 mm s<sup>-1</sup> while sinking speeds were higher at 15 to 40 mm s<sup>-1</sup>. A positive relationship existed between both swimming and sinking speed and shell length. Beat frequency of the parapodia for actively swimming pteropods as inversely related to shell size ranging from about 19 Hz in small pteropods and 12 Hz in the largest recorded. When hovering, beat frequency fell to 5 to 6 Hz.

A complete analysis of the functional morphology of feeding and locomotion is planned using the recordings made at sea along with others obtained from pteropods returned to the laboratory for culture. Data from these studies will provide behavioral information necessary to explain the patchy distributions in time and space often associated with this pelagic mollusk on and around Georges Bank.

#### D. Ingestion of phytoplankton, nanozooplankton and microzooplankton by *Calanus finmarchicus*. (Dian Gifford and Mike Sieracki)

##### Objectives:

1. To measure ingestion rates of *C. finmarchicus* and

2. To characterize the potential prey field of *C. finmarchicus* by measuring the vertical distributions of size fractionated chlorophyll a, nanozooplankton and microzooplankton.

We performed feeding experiments with adult female *C. finmarchicus* at two 24 hr drifter stations, Station 4, located on the bank crest and Station 5, located on the northeast peak. When the data are analyzed ashore we will have ingestion rates of *C. finmarchicus* on three size fractions of chlorophyll a, on selected groups of nano- and microphytoplankton taxa, and on major nano- and microzooplankton taxa. To characterize the copepods potential prey field we collected 120 samples for chlorophyll, nanozooplankton and microzooplankton from Go-Flo bottles in conjunction with CTD casts at 19 stations including the hydroline between Stations 4 and 12. Preliminary analysis of epifluorescence samples showed that large diatoms were abundant and included *Coscinodiscus*, *Thalassionema* and *Chaetoceros* species. In general, chlorophyll greater than 20  $\mu\text{m}$  constituted at least 50% of the total chlorophyll. Our impression is that the phototroph to heterotroph ratio in the nano (2 - 20  $\mu\text{m}$ ) and micro (20 - 200  $\mu\text{m}$ ) size categories is higher than we observed in May/June 1994.

#### **E. Video Plankton Recorder Studies (Cabell Davis and Scott Gallager)**

We conducted 13 Video Plankton Recorder (VPR) tows on Georges Bank and across its boundaries (Figures 8 -20) to determine the vertical and horizontal distributions of plankton taxa and detritus on scales from microns to tens of kilometers. The VPR was towed from surface to bottom at a ship's speed of 4 knots. The video was preprocessed on board in real time to extract in-focus images of zooplankton taxa as well as large phytoplankton taxa and detritus and store them to disk as TIFF files. Images from VPR tow 7 were analysed on shipboard using a point-and-click user interface to select taxa and measure organism size.

The first tow was made near the drifter at Station 2 on the western edge of the bank north east of the Great South Channel (see Cruise event log for position and time of the tows). A single double oblique haul was made at the end of which the ship's UPS failed and we had to restart the VPR computer acquisition system. Once restarted we towed the VPR horizontally at the surface. The ancillary sensor package (i.e., MOCNESS electronics) was not working properly and pressure and conductivity readings were incorrect.

VPR 2 was done at Station 4 in the mixed area and was conducted in two parts; a short test tow made at the surface confirmed that the ancillary sensor package was not functioning properly, so the sensor package was replaced. The VPR then was towed along a 4 km grid centered on the drifter beginning at 21:38 local time. The grid described an inward square spiral around the drifter in order for the ship to always turn to starboard to keep the tow cable away from the ship's propeller (the VPR was towed on the starboard side using the crane boom.) During the middle of this tow, a strand of the cable's armour broke and this strand had to be cut and taped to complete the tow.

VPR 3 was a daytime grid following the drifter at Station 4. At the end of VPR 3, after recovery of the drifter, it was found that the drifter was not recording GPS perhaps due to interference with the transponder attached to the drifter's antenna. In addition, the transponder was not useful for tracking the drifter on the ship's radar (as was its intended purpose), because the transponder transmits a series of signals in response to the ship's radar. It was ambiguous as to which radar return actually corresponded to the drifter itself. Since, as determined during the May cruise on R/V Iselin (CI9407), a high-flyer with radar reflector is inadequate in rough seas, it is recommended that a shipboard receiver be used in real time to determine the drifter's GPS position. The grid then could be followed using a notebook computer which plots in real time, the ship's position relative to that of drifter.

VPR 4 was made on the northeast peak of Georges Bank at Station 5 at night. At the beginning of this tow, while deploying, the cable jumped the sheave at the traction head destroying 2-3 m of outer cable armour. This required retermination of the cable, a six hour task. We then conducted a long (45 min) surface deployment to determine scales of horizontal patchiness. Since the drifter tracking was no longer possible, we then towed the VPR along a cross pattern centered on Station 5, roughly tangential and orthogonal to the 80 m isobath. The first leg of the cross began 6 km NW of Station 5 and continued 12 km towards the SW. At this point, we towed towards the W to a point 6 km SW of Station 5 and then towed NE 12 km. Spurious values were noticed in the bottom depth data supplied by the ship's speed/bottom logging system (EDO). Although the display on the bridge was steady, the data supplied to us via the serial line in the 01 lab was somewhat erratic.

VPR 5 was started in the early morning (0500) at Station 7b on the northern edge (100 m) and towed towards the N. Many pteropods were observed. After 4 double oblique hauls a fiber optic termination broke inside the winch drum and we retrieved the VPR and switched to a different fiber in the junction box on the VPR bypassing the broken one in the winch.

VPR 6 was a 3 hr tow made towards Station 8, starting at Station 7. Four double oblique hauls were made, each to about 190 m. Many large siphonophores were observed.

VPR 7 was started at Station 8 in the Northeast channel, and the VPR was towed for 3 hr westward towards Station 9 on the edge of the bank (100 m). Many euphausiids were observed.

VPR 8 was a 2 hr early morning (0500-0700) tow transect from Station 9 towards Station 11.

VPR 9 was the first 5 hrs of a transect across Georges Bank from the Slope Water to the Gulf of Maine. VPR 9 was aborted after the bridge felt the weather would become too rough for retrieval.

VPR 10 was a 17 hr continuation of the cross-bank transect begun with VPR 9. The weather had settled down enough to redeploy the VPR and we restarted the transect at the same position that VPR 9 ended. The transect ended in the Gulf of Maine. After this tow we again reterminated the frayed cable.

VPR 11 was a 5 hr transect across the northern edge of the bank between Stations 18 and 19.

VPR 12 was a 45 min calibration with the ship's CTD in which both instruments were held at 15 m on the northern edge of the bank at Station 20a.

VPR 13 was a 7 hr transect across the western edge of the bank north of the Great South channel on a line between Stations 1 and

2.

In general, despite a few obstacles which were overcome, the cruise was highly successful for us. We achieved all of our objectives and obtained data from all important regions on the bank and around its edges. The data supplied to us from the ship on bottom depth, GPS, and ship speed required two separate serial lines rather than being available via the network or sail loop. For real time drifter tracking acquisition of GPS data from the drifter and the ship is needed in real time, so a shipboard receiver for the drifter is needed. The armour on the cable we used became loosened by the angle of the cable through the sheave on the boom and also perhaps by the traction head itself. A better wire angle and lighter block are needed for subsequent cruises.

#### **F. Characterization of ultra-violet and visible light regimes on Georges Bank (Jeff Van Kuren)**

The objective for this cruise was to collect data to characterize the ultra-violet (UV) and visible light regimes encountered by organisms living on Georges Bank during this season. Light profiles for four narrow band UV channels (308nm, 320nm, 340nm, 380nm) as well as broad-band PAR (400-700nm) were taken at sites extending from the center of the bank (Station 4) to stations well off the bank (Stations 1,7). Surface irradiance values for each of these five wavebands were also logged continuously throughout most of the cruise using a deck-mounted, matched sensor. These daytime surface irradiance measurements were complemented by broadband twilight and nocturnal light records generated by a logging photo-multiplier based system. These surface irradiance measurements and sub-surface profiles will be combined to generate UV and visible, multi-dimensional fields of subsurface light. The resultant light fields will ultimately be compared to organism distributions generated by whole-water samples, net samples, and acoustic profiles (ADCP) to evaluate dose levels of these spectral bands received by the organisms at various depths. The UV component of this work is being done in conjunction with Dr. Al Hanson, GSO, URI.

#### **APPENDIX 1: EN259 EVENT LOG**

The event log can be [found here](#).

Instrument abbreviations:

NB CTD: Neil Brown Mk III CTD

ZPN: Net hauls for live zooplankton

MOC1: 1m2 MOCNESS: Multiple opening-closing net and environmental sensing system

DFT: ARGOS Drifter

ZPP/NB CT: Zooplankton pump deployed on the Neil Brown Mk III CTD

BDFT: R. Beardsley's ARGOS drifter

PAR/UV: Cast to measure photosynthetically active radiation and UV light

VPR: Video plankton recorder

PPN: Phytoplankton net haul

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*Last modified: June 24, 1998*