Cruise Report

R/V ENDEAVOR Cruise 296 to Georges Bank

4 - 16 March 1997

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Acknowledgements

This report was prpepared by the Chief Scientist, with contributions from all Scientific Investigators. Jeffrey Merrell complied the Event Log. We are grateful for the continuing support of Captain Thomas Tyler and the crew of R.V. *Endeavor*.

The research was sponsored by the National Science Foundation. All data contained within the report are to be considered preliminary.

OBJECTIVES OF THE CRUISE

EN296 was the first of three vital rates process cruises fielded by the U.S.-GLOBEC program during 1997. The overall focus of the cruise was to examine vital physiological rates of the target species of copepods and larval fish in the context of retention, exchange and loss in on-Bank versus off-Bank waters. Three separate PI groups led by Scott Gallager, Dian Gifford, and Karen Wishner participated in the cruise. Scientific efforts on the cruise focused on four general areas. Specific objectives and the responsible investigators were:

(1) Hydrography (D. Gifford and M. Sieracki). The hydrographic component collected CTD profiles using the ship's SeaBird instrument package. Discrete samples were collected for analysis of size-fractionated chlorophyll, nanoplankton and microplankton.

(2) Zooplankton and Optics (K. Wishner and P. Donaghay). Distribution and transport of target zooplankton species in source and on-Bank waters. Zooplankton were collected using a 1-m MOCNESS interfaced with a SaFire multispectral fluorometer to identify water types by optical characteristics.

(3) Naupliar feeding (D. Gifford and M. Sieracki). Feeding of naupliar stages of *Calanus finmarchicus* in source versus on-Bank waters. Because experiments ultimately require lab-reared nauplii, the focus of this first of three cruises was to collect female brood stock.

(4) Larval fish feeding (S. Gallager and H. Yamazaki). Feeding of larval cod, *Gadus morhua*, in source versus on-Bank waters. Data collected included larval feeding rates on microzooplankton and estimates of larval condition and survivorship. The primary method was short-term drifter incubations.

The cruise plan was to work at 4 pairs of stations (Figure 1; Table 1; Table 2): (1) the Great South Channel / northern edge of Bank; (2) Georges Basin / Northeast peak; (3) Bank crest / Southern flank; and (4) within / without Scotian Shelf cold plume, if present. A typical on-station work plan for the cruise is shown in Table 3.

Table 1. EN296 Target station descriptions.

Station Number	Location	Time (h)	Comments
1	Georges Basin	36-48	Off Bank pair with NEP
2	Northeast Peak	36-48	On Bank pair with G Basin; Off-plume pair with Plume
3	SS Cold Plume	36-48	In-plume pair with NEP
4	Southern Flank	36-48	Pair with Crest
5	Crest	36-48	Pair with S. Flank; On-Bank pair with N. Edge/GSC
6	GSC/N. Edge	36-48	Off-Bank pair with Crest

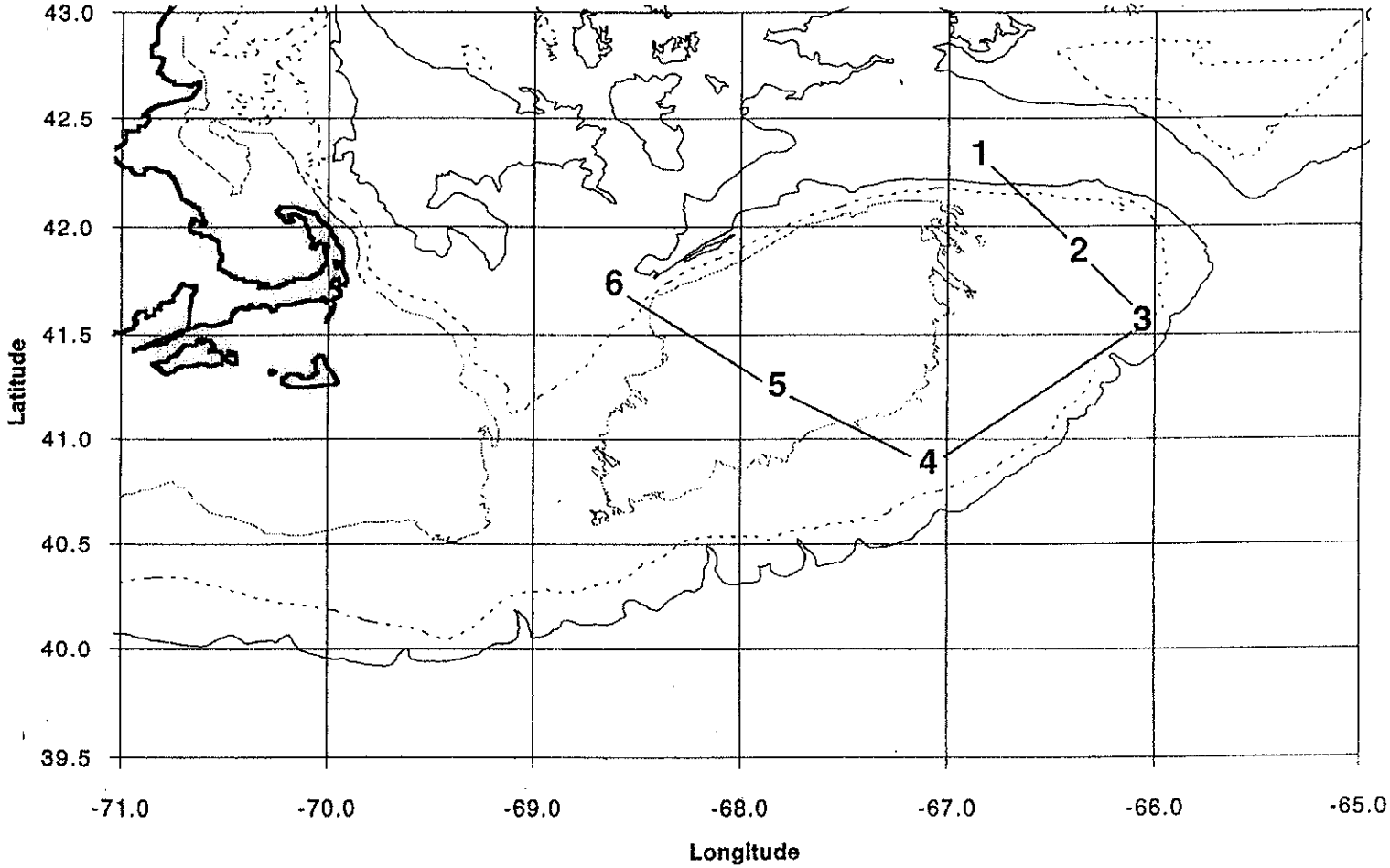

Figure 1. Station locations for EN 296

Table 2. EN296 Target station locations.

	STATION LOCATIONS	
Station Number	Latitude (°N)	Longitude (°W)
1	42° 25' N	67° 70' W
2	41° 51' N	66° 30' W
3	41° 25' N	65° 58' W
4	40° 56' N	67° 20'W
5	41° 21' N	67° 42' W
6	41° 43'N	68° 33' W

Table 3. On-Station work plan.

Time (h)	**Activity**
0600	CTD/hydrographic profile
0700	Zooplankton net tows
0800	Larval fish drifter
0900	"
1000	"
1100	"
1200	MOCNESS (day)
1300	"
1400	"
1500	"
1600	"
1700	"
1800	Zooplankton net tows
1900	CTD
2000	MOCNESS (night)
2100	"
2200	"
2300	"
2400	"
0100	"

CRUISE NARRATIVE

R.V. *Endeavor* sailed from U.S. Navy Pier 2 at Newport, RI at 1110 hours on Tuesday, 4 March 1997, following a delay for delivery of an ARGOS control box for the Gallager group. Fire and lifeboat drill was conducted at 1300 hours.

We arrived at Station 1 in Georges Basin at 1000 hours on Wednesday, 5 March. Activities commenced with a CTD cast, followed by a wire test of the MOCNESS system. Richard Limeburner's drifters were deployed at 1350 and 1355. At approximately 1430, with a major ocean storm forecast, *Endeavor* set sail for Portland, ME under relatively calm conditions, arriving at 0430 on Thursday, 6 March. While the storm raged, all hands enjoyed the pleasures of Portland including excellent food, world class art, and numerous microbreweries. During this period, our sister ship, R.V. *Oceanus*, also on Georges Bank but too distant to run for shore, reported 65 knot winds and 35 foot seas.

With the storm abating, we departed Portland at 1230 hours on Friday, 7 March, arriving back at Station 1 in Georges Basin on Saturday, 8 March at 0600 under overcast skies with light snow. Activities began with a CTD cast, which showed the water column to mixed to 50 m. Two vertical tows with a 335 um ring net revealed that female *Calanus* were abundant at the station. A larval cod drifter experiment was deployed at 0817 hours and retrieved approximately 3 hours later. A noon CTD cast was done followed by a MOCNESS deployment. Vertical net tows, a CTD cast and nightime MOCNESS deployment were done beginning at 1809 hours and ending at 2100 hours.

We departed for Station 2 on the Northeast Peak at 2220 hours, arriving at 0110 hours on Sunday, 9 March. Because of increasing weather, the ship hove to until 1415 hours. Activities resumed with a CTD cast, which showed the water column to be mixed to the bottom. Zooplankton net tows were followed by a larval cod drifter deployment. A nighttime CTD cast followed by a MOCNESS deployment began at 2023 hours and ended at 2120 hours. On Monday, 10 March a CTD cast at 0810 was followed by a MOCNESS deployment and zooplankton net tows. A CTD/light cast was done at 1235, followed by deployment of a larval cod drifter at 1338 and drifter retrieval at 1630. We sailed for Station 3, the Scotian Shelf cold plume, at 1700 hours.

The cold plume was present in satellite images collected before the cruise, which showed 1-2 °C sea surface temperature within the plume, in contrast to 4-5 °C Georges Bank water (Figure 2). Because of overcast skies, no new satellite images were available during the cruise, and we were unable to get an updated location for the plume. We did a transect through the area where the cold water was last seen, monitoring sea surface temperature and salinity on the ship's environmental sensing system. However, the transect was done during an intense storm, and we did not encounter any obvious manifestation of the plume. There was a short sequence (probably less than 1 km wide) of slightly lower sea surface temperature and salinity (3.8 °C and 31.9386 ‰ salinity compared to 4.2 degrees C and

32.06 ‰ salinity at station 2) near 41° 33.19 N; 66° 10.00 W. The transition to and from these seasurface values was relatively gradual, not sharp as if crossing a front. In retrospect, this was probably the remnant of the cold plume which had been mixed with warmer saltier water by the storm.

We continued on through the area of the last satellite image showing the to a deeper location at 41° 16.29 N; 65° 47.19 to rewind the MOCNESS wire, which had bad wraps. Further attempts to return to the presumed cold plume region and to find a stronger signal of it were rebuffed by the high winds and seas, so we steamed to Station 4 on the Southern Flank, arriving at approximately noon on Tuesday, 11 March. Deck operations began at 1230 hours with a CTD cast, zooplankton net tows and a larval cod drifter deployment. The CTD data showed a well mixed water column. Net twos and bottles samples revealed a bloom of *Phaeocystis pouchettii* . A nighttime MOCNESS was done at 1930. On Wednesday 12 March, science activities began with a CTD cast at 0700, followed by a daytime MOCNESS tow, a CTD/light cast, and zooplankton net tows. A larval cod drifter was deployed at 1300 and retrieved approximately 3 hours later, after which we set course for Station 5 on the bank crest, arriving at 2300 hours.

We spent Thursday , 13 March hove to because of weather, resuming deck operations on Friday, 14 March at 0700 hours. Science operations began at 0715 hours with a CTD cast, followed by zooplankton net tows and a MOCNESS deployment at 0830 hours. The CTD data showed a well mixed water column, and net tows again revealed a *Phaeocystis* bloom. We then steamed to Station 6 in the Great South Channel, arriving at approximately 1200 hours. A CTD cast , zooplankton net tows, and daytime MOCNESS deployment began at 1230 hours. The water column was mixed to approximately 135 m, and stratified below that depth. A second pair of CTD and MOCNESS deployments was done at 1430 hours, followed by a larval cod drifter deployment at 1714 hours. Following retrieval of the drifter, we hove to because of deteriorating sea conditions. Richard Limeburner's ARGOS drifters were deployed at 2100 hours, giving the Chief Scientist and associates an unanticipated salt water shower on the 01 deck. We hove to for the night, doing a final CTD and zooplankton net tow at 0930 on Saturday, 15 March. With another ocean storm approaching, *Endeavor* set sail for Newport, RI at 1030 hours, arriving on Sunday, 16 March at 0940 hours.

PRINCIPAL INVESTIGATOR REPORTS:

Hydrography: Dian Gifford , Mike Sieracki , Jeff Merrell and Ming Wah Wong

CTD data. Hydrographic data were collected using the ship's CTD instrument package, which includes a Sea Bird 911 CTD, Sea Tech fluorometer, Sea Tech-25 Transmissometer, and oxygen sensor. The package is equipped with 10-L Teflon lined Go-flo bottles for collection of discrete water samples.

Chlorophyll. Seawater was collected using 10-L teflon-lined Go-flo bottles mounted on the CTD rosette. Water was drained into opaque brown 1-L bottles immediately after collection and refrigerated until processed. Samples were collected onto filters within one hour of water collection. In areas where the water column was well mixed, water was collected from the top, middle and bottom of the water column. When the water column was stratified, water was collected from the top, middles and bottom of the water column as well as around the hydrographic features of interest. Samples were prepared for total, <20 um, and <5 um chlorophyll and phaeopigment. Samples for total pigments consisted of bulk seawater. Samples for < 20 um and < 5 um pigments were passed gently through clean Nitex meshes of appropriate porosity and the filtrate retained for analysis. Three replicate 50-ml samples of each size fraction were collected onto 25 mm GF/F filters, placed into 5 ml of 90% acetone in a capped test tube, and extracted in the freezer for 24 hours prior to analysis. Samples were read on a Turner Designs Model 10 fluorometer before and after acidification with 10% HCl (Parsons et al., 1984).

Nanoplankton Abundance and Biomass. Samples for nanoplankton abundance and biomass were collected from the Go-flo rosette. Nanoplankton abundance, size and trophic structure and biomass are being measured to determine the role of nanoplankton in the diet of *Calanus*. Samples were collected from three copepod grazing experiments and 5 vertical bottle casts for nanoplankton (cells 2 - 20 um) analysis by flow and imaging cytometry. Slides were prepared for image analysis using epifluorescence microscopy methods and samples for flow cytometry were fixed and frozen (liquid N_2). The majority of slides and samples will be analyzed back at the lab. An example analysis that was done at sea is shown (see Table 4 and Figure 3) for a sample collected at Station 2 on the northeast peak at 20 m. Cell were quite low (total nanoplankton, 400 per ml). The lack of vertical water column structure and the recent high winds, mean that the cells could be mixing well below the compensation depth at this station, providing little production to support more biomass. The community was dominated by small flagellates, both phototrophic and heterotrophic. Few large microzooplankton (ciliates and heterotrophic dinoflagellates), diatoms, or phototrophic dinoflagellates were seen.

Microplankton abundance and biomass. Samples for microplankton abundance and biomass were collected from CTD casts using the Go-flo rosette. Water was preserved with 10% (v/v) acid Lugol's solution and stored in the dark pending analysis by inverted microscopy at the home laboratory.

Naupliar Feeding: Dian Gifford, Mike Sieracki, Jeff Merrell and Ming Wah Wong

The objective of the research is to compare feeding rates and the diets *of Calanus finmarchicus* naupliar stages N3-N6 in source versus on-Bank waters. In this first of three vital rates process cruises , our primary goal was to collect *Calanus* broodstock in order to

rear nauplii fin the home laboratory or experiments on subsequent cruises. We also performed feeding experiments with female *C. finmarchicus* in source and on-Bank waters.

Nanoplankton Abundance and Biomass. Samples were collected from experimental treatment bottles for nanoplankton (cells 2 - 20 um) analysis by flow and imaging cytometry. Slides were prepared for image analysis using epifluorescence microscopy methods and samples for flow cytometry were fixed and frozen in liquid nitrogen. The majority of slides and samples are analyzed at the home laboratory.

Microplankton abundance and biomass. Samples for microplankton abundance and biomass were collected from experimental treatment bottles. Water was preserved with 10% (v/v) acid Lugol's solution and stored in the dark pending analysis by inverted microscopy at the home laboratory.

Zooplankton and Optics: Karen Wishner, Mike Twardowski, Jim Sullivan and Mary Rapien

Our focus on this cruise was to measure inputs and losses of zooplankton associated with episodic features and different water masses on and near Georges Bank. We interfaced a MOCNESS 1 m2 net system with 2 bio-optical instruments, a WET Labs SaFire and ac-9, using a WET Labs MODAPS as a central data acquisition and archiving system. The SaFire measures 2-D spectral DOM fluorescence at a subset of wavelengths within the total 96 excitation/emission pairs, and the ac-9 measures spectral total absorption and attenuation, or dissolved absorption when a prefilter is attached to the intake. The combination of these optical signatures should allow us to identify water types with a high degree of differentiation and to track subtle features over time. We intend to determine how closely zooplankton are associated with particular water masses (described hydrographically and bio-optically) by sampling with the MOCNESS / SaFire / ac-9 system day and night at source locations just off Georges Bank, on the Bank itself, and within episodic features of opportunity. One set of day and night tows uses standard depth strata, and additional tows use depth strata determined on the basis of the bio-optical signature.

Although the system worked on deck and when submerged from the GSO dock, it did not work during its first sea test at station 1 on 3/5/97. This problem was tracked down and successfully solved during the unanticipated port stop in Portland (3/6/97), which was done to avoid a major storm. The time in port allowed us to repeatedly dip the net into the water off the ship next to the dock (in calm conditions) and track down the problem without the conflicting requirements of other sampling needs and the pressure of lost time on station. It turned out that one part of the instrument had to be electrically isolated from the rest of the instrument. Dave Nelson (marine tech) was instrumental in the solution of this problem. Before we left Portland after the storm, the MOCNESS was working

successfully on the deck and in the water. The SaFire successfully detected DOM spectral fluorescence in the water. The ac-9 successfully measured total absorption and attenuation coefficients, but, with a 0.2um prefilter attached to measure dissolved absorption, the flow cells of the instrument cavitated and a bubble-free reading was never obtained. We have observed this before in surface waters, and have been able to pressurize the flow cells and purge all bubbles only when the ac-9 is deployed to a depth of at least 10 meters. As a result, we were optimistic that dissolved absorption coefficients could be obtained at our proposed field stations.

Day and night vertically-stratified tows were taken at stations 1 (Georges Basin), 2 (the northeast peak), 4 (the southern flank), 5 (crest, day only), and 6 (Great South Channel, day only, plus second day tow to examine interesting bio-optical structure). Depth strata varied with the station, with broader deep strata at the deep stations and 10 m strata near the surface. High winds and rough seas limited sampling opportunities, as the ship spent probably over 50% of the cruise hove to for weather. Also, cloudy conditions prevented any useful satellite images from being obtained between Feb. 24 and March 14, virtually the entire cruise. Lack of updated feature locations and high winds, which limited course selection and ship speed, eliminated most of the feature-chasing possibilities.

Zooplankton Results. The following notes are based on visual observations of whole samples fresh from the nets and will obviously be modified by the direct counts later in the lab.

Georges Basin (station 1) was stratified with different zooplankton layers at different depths. During the day, euphausiids and copepods were dominant at depth (125-220 m), amphipods in mid-depths (75-100 m), and copepods and phytoplankton at upper depths. At night the euphausiids occurred form 125 m to the surface, copepods and chaetognaths were the dominant taxa at depth, and naked and shelled pteropods were prominent from 100-200 m and 20-50 m. The upper samples contained mostly euphausiids, copepods, amphipods, pteropods, and ctenophores. The northeast peak (station 2) was well-mixed to the bottom with much suspended sand caught with the plankton at all depths (50 m to the surface). Prominant zooplankton included ctenophores, amphipods, and chaetognaths. The southern flank (station 4) was also well-mixed to depth. A massive *Phaeocystis* bloom was the dominant item in the zooplankton nets from all depths (50 m to the surface); ctenophores, amphipods, and chaetognaths were the most visible zooplankton. Day and night samples appeared similar (no obvious vertical migration) at both stations 2 and 4. The crest station (5) samples were dominated again by *Phaeocystis*; ctenophores and larval hake were also present. At the Great South Channel station (6) within a tidal jet moving about 30 cm/sec northeast (but virtually still a few hours later), we completed two tows, a standard vertically-stratified daytime tow and a second day tow to tow-yo in and out of the bottom boundary layer at about 140-160 m, which had interesting optical structure (see later section). Samples within the bottom layer included pteropods (*Limacina*), euphausiids, and copepods, while amphipods and copepods dominated the middle layers.

Abundant near-monospecific *Calanus* concentrations occurred only in the upper 10 m and ctenophores were also common here. Weather deteriorated by nighttime canceling a night tow.

Optics Results. At station 1 (3/8), DOM spectral fluorescence was measured and spectral dissolved absorption was obtained on the upcast after the attenuation channel flow cell pressurized. The peak in DOM fluorescence was at an EX:EM pair of 265:490 throughout the water column. DOM fluorescence peaked in the surface mixed layer (40-50 meters deep) and decreased with depth in a stairstep fashion mimicking the hydrographic structure. Dissolved absorption followed the same pattern very closely. Subtle spectral fluorescence shifts were observed in the raw, real-time data during the upcast, indicating that the composition of the DOM pool may have changed with depth. We realized during these casts that a pressure transducer installed in the SaFire would be of great value in pinpointing the exact depths at which changes in DOM fluorescence were occurring; using the MOCNESS pressure transducer is not appropriate for the high resolution required.

At stations 2 (3/9-3/10), 4 (3/11-3/12), and 5 (3/14), the water columns were well-mixed, as evidenced by the hydrographic casts and the optics. The DOM 2-D fluorescence spectra at each station were nearly identical, with slightly higher values at station 2. At station 5 (35 meters total depth) there were suspended sediments throughout the water column, visible in net tows from all depths and in the greenish hue of the surface water. The ac-9 had a newly attached prefilter for the station 2 casts, but the flow cells never cleared and dissolved absorptions were not obtained. As a result, the prefilter was removed and total absorption and attenuation were measured for the casts at stations 4 and 5.

At station 6 (3/14), the water column was well-mixed down to about 135 meters, where there was a strong stairstep in temperature, salinity, DOM fluorescence, and total attenuation. From the real-time fluorescence data, we observed a small DOM fluorescence peak present within the interface, and then a decrease in the bottom boundary layer. Total attenuation clearly increased through the interface, with several peaks in the bottom layer. In a second tow, the MOCNESS was deployed in a tow-yo pattern through the optical interface with multiple nets triggered below it, in it, and above it. Below the interface, the optics and the hydrography gave the impression of several interleaving layers, in some cases unstable with respect to density. We interpret these observations as evidence of active mixing in the bottom of the water column. A clear distinction in faunal diversity and abundances was also observed above, below, and within the interface (see above).

The Cold Plume. We had hoped to sample the Scotian Shelf water (the cold plume), which was clearly present in satellite images from before the cruise, with a temperature of 1-2 degrees C in contrast to the Georges Bank water at 4 - 5 degrees C. However, no clear images were received during the cruise so we could not get an updated location. Our transect through the area of the presumed cold water plume (from station 2 to 3, which was supposed to be within the cold plume) was done during a major storm (35 kt winds, high

seas). We did not encounter an obvious manifestation of the plume, although a brief region (probably less than 1 km wide) of slightly lower seasurface temperature and salinity (3.8 degrees C and 31.9386 ‰ salinity compared to 4.2 degrees C and 32.06 ‰ salinity at station 2) was observed near 41 33.19 N 66 10.00 W. The transition to and from these seasurface values was relatively gradual, not sharp as if crossing a front. In retrospect, this was probably the remnant of the cold plume which had been mixed with deeper warmer saltier water by the stormy weather. We continued on through the area of the satellite image showing the plume (which was not apparent any longer at the sea surface) to a deeper location (over 1000 m, sea surface temperature 6.3 degrees C and salinity 32.8693 ‰) to rewind the MOCNESS wire, which had bad wraps. Our attempts to return to the presumed cold plume region and to find a stronger signal of it were rebuffed by the high winds and seas (and the lack of a recent satellite image to tell us if we were close), so we headed off to station 4.

Feeding Studies on Larval Cod: Jeff Van Keuren, Linda Davis, Phil Alatalo and David Zimmer.

The overall focus of this research effort, headed by Dr. Scott Gallager, WHOI, is to investigate how variations in light and turbulence influence the feeding success of young larval cod. The objectives of our participation on GLOBEC cruise EN296 included documentation of the influence of different levels of spectrally- appropriate in situ light on the ability of larval cod to capture prey items, vertical and diel characterization of the spectral light regime useful to these animals, and characterization of spatial and temporal changes in the motility patterns and size distribution of microzooplankton populations on and around Georges Bank during the period of early development of cod larvae.

Six successful drifter incubation deployments were completed during this cruise. Deployments were made in the Northeast Peak region of Georges Bank where these fish are known to spawn in the late winter/early spring of the year, along the southern flank of Georges Bank where these young larvae are passively advected by the currents, and at a third site on the western flank of Georges Bank in the vicinity of the Great South Channel. During each drifter deployment, animals were placed within replicate incubation chambers at depths ranging from the surface to 40m and allowed to feed on natural and enhanced levels of natural prey items. Immediately following each incubation, the uptake of fluorescent-labeled microzooplankton and copepod nauplii by each larval cod was quantified using computer-aided image analysis routines.

Although final analysis of the data from these drifter deployments will require further lab analysis following completion of this and the follow-on cruise in April, preliminary results from this cruise suggest that feeding of larval cod on natural and enhanced levels of natural food assemblages is inhibited during daylight hours in the near surface waters at this time of year in the three regions of Georges Bank visited. The near surface feeding rates were

consistently lower than comparable rates measured at greater depths. These pattern of these results appears to confirm previous modeling work by J. Van Keuren and preliminary measurements by S. Gallager.

A second objective of our group was to further document the vertical and diel light regime available to these young cod larvae for feeding. Using information discovered by J. Van Keuren, WHOI, and Dr. Ferenc Harosi, MBL, in a separate ongoing microspectrophotometry study, we obtained spectral light filters closely matched to the spectral response of the eyes of young cod larvae. These special filters were employed during this cruise to document the vertical attenuation of this spectrally-appropriate light at the site of each drifter deployment. Another sensor equipped with a matched filter was used to continuously monitor the amount of this light available at the ocean surface under varying meteorological and astronomical conditions. This information will be used in the final analysis of the these drifter incubations as well as to provide primary data for ongoing individual-based modeling work being conducted in conjunction with Dr. Francisco Werner, UNC.

A third objective of our group was to continue our characterization of the spatial and temporal changes in the motility patterns and size distribution of microzooplankton populations on and around Georges Bank. Surface and/or CTD samples were taken at each station and filmed in tissue culture flasks using a gimbaled microscope-video system. Samples of food abundances used within each larval cod deployment were also videotaped before and after each deployment. While size spectrum analysis and motility patterns will be analyzed in the laboratory, shipboard observations showed very little motility at most stations. Microzooplankton tended to be small while diatoms and the dinoflagellate *Ceratium* sp. were prevalent at all stations. Station 4, Southern Flank yielded the highest numbers of microzooplankton, often with medium-sized microzooplankton exhibiting "darting-like" motion. Station 5, the well-mixed Crest of the Bank was sampled after high gales and showed higher numbers of small microzooplankton. Station 1 and 2, Georges Basin and Northeast Peak respectively, had relatively low abundance of microzooplankton. The Great South Channel, Station 6, yielded high abundances of small microzooplankton at the surface, while very fine particles were observed at depths exceeding 130 m. *Phaeocystis* colonies were present at both the Bank Crest and the Great South Channel stations.

Science Personnel

Dian Gifford	University of Rhode Island	Chief Scientist
Philip Alatalo	Woods Hole Oceanographic Institution	Scientist
Linda Davis	Woods Hole Oceanographic Institution	Scientist
Leah Feinberg	University of Connecticut	Graduate Student
Jeffrey Merrell	University of Rhode Island	Scientist
David Nelson	University of Rhode Island	Marine Technician
Mary Rapien	University of Rhode Island	Scientist
Michael Sieracki	Bigelow Laboratory for Ocean Science	Scientist
James Sullivan	University of Rhode Island	Graduate Student
Michael Twardowski	University of Rhode Island	Graduate Student
Jeffrey Van Keuren	Woods Hole Oceanographic Institution	Postdoctoral Scientist
Karen Wishner	University of Rhode Island	Scientist
Ming Wah Wong	Bigelow Laboratory for Ocean Science	Scientist
David Zimmer	State University of New York	Scientist

Ship's Personnel

Thomas Tyler	Master
Steve Vetra	Chief Mate
Dick Foley	Second Mate
Bill Appleton	Chief Engineer
Jim Cobleigh	Engineer
Tim Varney	Engineer
Jack Buss	Boatswain
Dave Rocha	Able Seaman
Glenn Prouty	Able Seaman
Ron Regnier	Able Seaman
Dan Butler	Steward
Brian Miller	Messman

Appendix 1. EN296 Event Log.

eventno	Instr	cast#	Stn#	Sta_std	L Mth	O Day	C A L hhmm	s/e	Lat	Lon	Water Depth	Cast Depth	PI	Region	Comments	Lat(decimal)	Lon(decimal)	TimeZone	GMT HHMM
en6497.1	SeabirdCT	1	1	0	3	5	1023	s	4214.29	6648.04	248	220	Gifford	Georges Basin		42.238	-66.801	5	1523
en6497.2	SeabirdCT	1	1	0	3	5	1102	e	4214.29	6648.04	248	220	Gifford	Georges Basin		42.238	-66.801	5	1602
en6497.3	Cable (wi	1	1	0	3	5	1215	s	4213.87	6646.37	235		Wishner	Georges Basin		42.231	-66.773	5	1715
en6497.4	Cable (wi	1	1	0	3	5	1216	e	4213.87	6646.37	235		Wishner	Georges Basin		42.231	-66.773	5	1716
en6497.5	MOC1	101	1	0	3	5	1330	s	4213.87	6646.37	257		Wishner	Georges Basin		42.231	-66.773	5	1830
en6497.6	MOC1	101	1	0	3	5	1340	e	4213.87	6646.37	257		Wishner	Georges Basin		42.231	-66.773	5	1840
en6497.7	Drifter	1	1	0	3	5	1350	s	4215.29	6649.08	248		Umeburner	Georges Basin		42.255	-66.818	5	1850
en6497.8	Drifter	1	1	0	3	5	1351	e	4215.29	6649.08	246		Limeburner	Georges Basin		42.255	-66.818	5	1851
en6497.9	Drifter	2	1	0	3	5	1400	s	4215.29	6649.08	246		Limeburner	Georges Basin		42.255	-66.818	5	1900
en6497.10	Drifter	2	1	0	3	5	1401	e	4215.29	6649.08	246		Umeburner	Georges Basin		42.255	-66.818	5	1901
en6797.1	SeabirdCT	2	1	0	3	8	618	s	4214.79	6648.41	250	220	Gifford	Georges Basin		42.247	-66.807	5	1118
en6797.2	SeabirdCT	2	1	0	3	8	652	e	4214.79	6648.41	250	220	Gifford	Georges Basin		42.247	-66.807	5	1152
en6797.3	ZPN	1	1	0	3	8	746	s	4214.79	6648.41	250	70	Gifford	Georges Basin		42.247	-66.807	5	1246
en6797.4	ZPN	1	1	0	3	8	752	e	4214.79	6648.41	250	70	Gifford	Georges Basin		42.247	-66.807	5	1252
en6797.5	ZPN	2	1	0	3	8	755	s	4214.79	6648.41	250	70	Gifford	Georges Basin		42.247	-66.807	5	1255
en6797.6	ZPN	2	1	0	3	8	801	e	4214.79	6648.41	250	70	Gifford	Georges Basin		42.247	-66.807	5	1301
en6797.7	Cod Drifte	1	1	0	3	8	816	s	4215.24	6648.91	262	20	Gallager	Georges Basin		42.254	-66.815	5	1316
en6797.8	Cod Drifte	1	1	0	3	8	1112	e	4216.76	6649.52	262	20	Gallager	Georges Basin		42.279	-66.825	5	1612
en6797.9	SeabirdCT	3	1	0	3	8	1207	s	4214.97	6647.00	250	200	Gifford	Georges Basin		42.250	-66.783	5	1707
en6797.10	SeabirdCT	3	1	0	3	8	1226	e	4214.97	6647.00	250	200	Gifford	Georges Basin		42.250	-66.783	5	1726
en6797.11	MOC1	102	1	0	3	8	1248	s	4215.18	6646.03	258	222	Wishner	Georges Basin		42.253	-66.767	5	1748
en6797.12	MOC1	102	1	0	3	8	1404	e	4214.11	6642.06	256	222	Wishner	Georges Basin		42.235	-66.701	5	1904
en6797.13	ZPN	3	1	0	3	8	1809	s	4214.97	6647.00	250	70	Gifford	Georges Basin		42.250	-66.783	5	2309
en6797.14	ZPN	3	1	0	3	8	1825	e	4214.97	6647.00	250	70	Gifford	Georges Basin		42.250	-66.783	5	2325
en6797.15	Seabird C	4	1	0	3	8	1843	s	4215.68	6648.65	260	225	Gifford	Georges Basin		42.261	-66.811	5	2343
en6797.16	Seabird C	4	1	0	3	8	1904	e	4215.68	6648.65	260	225	Gifford	Georges Basin		42.261	-66.811	5	0004
en6797.17	MOC1	103	1	0	3	8	1930	s	4215.60	6648.66	267	229	Wishner	Georges Basin		42.260	-66.811	5	0030
en6797.18	MOC1	103	1	0	3	8	2042	e	4214.57	6647.82	267	229	Wishner	Georges Basin		42.243	-66.797	5	0142
en6897.1	SeabirdCT	5	2	0	3	9	1432	s	4150.24	6629.54	78	76	Gifford	NE Peak		41.837	-66.492	5	1932
en6897.2	SeabirdCT	5	2	0	3	9	1449	e	4150.24	6629.54	78	76	Gifford	NE Peak		41.837	-66.492	5	1949
en6897.3	ZPN	4	2	0	3	9	1514	s	4150.24	6629.54	78	60	Gifford	NE Peak		41.837	-66.492	5	2014
en6897.4	ZPN	4	2	0	3	9	1527	e	4150.24	6629.54	78	60	Gifford	NE Peak		41.837	-66.492	5	2027
en6897.5	Cod Drifte	2	2	0	3	9	1601	s	4149.44	6630.35	74	30	Gallager	NE Peak		41.824	-66.506	5	2101
en6897.6	Cod Drifte	2	2	0	3	9	1915	e	4147.95	6635.37	74	30	Gallager	NE Peak		41.799	-66.590	5	0015
en6897.7	SeabirdCT	6	2	0	3	9	2011	s	4151.29	6630.45	77	72	Wishner	NE Peak		41.855	-66.508	5	0111
en6897.8	SeabirdCT	6	2	0	3	9	2023	e	4151.29	6630.45	77	72	Wishner	NE Peak		41.855	-66.508	5	0123
en6897.9	MOC1	104	2	0	3	9	2048	s	4151.08	6630.02	78	58	Wishner	NE Peak		41.851	-66.500	5	0148
en6897.10	MOC1	104	2	0	3	9	2120	e	4151.08	6630.02	78	58	Wishner	NE Peak		41.851	-66.500	5	0220
en6997.1	SeabirdCT	7	2	0	3	10	810	s	4151.01	6630.07	79	58	Wishner	NE Peak		41.850	-66.501	5	1310
en6997.2	SeabirdCT	7	2	0	3	10	824	e	4151.01	6630.07	79	58	Wishner	NE Peak		41.850	-66.501	5	1324
en6997.3	MOC1	105	2	0	3	10	844	s	4151.67	6600.47	79	59	Wishner	NE Peak		41.861	-66.008	5	1344
en6997.4	MOC1	105	2	0	3	10	908	e	4151.67	6600.47	79	59	Wishner	NE Peak		41.861	-66.008	5	1409
en6997.5	ZPN	6	2	0	3	10	1055	s	4150.48	6630.00	76	60	Gifford	NE Peak		41.841	-66.500	5	1555
en6997.6	ZPN	6	2	0	3	10	1105	e	4150.48	6630.00	76	60	Gifford	NE Peak		41.841	-66.500	5	1605
en6997.7	SeabirdCT	8	2	0	3	10	1223	s	4150.4	6629.8	74	40	Gallager	NE Peak		41.840	-66.497	5	1723
en6997.8	SeabirdCT	8	2	0	3	10	1241	e	4150.40	6629.80	74	40	Gallager	NE Peak		41.840	-66.497	5	1741
en6997.9	Cod Drifte	3	2	0	3	10	1338	s	4150.97	6630.38	75	40	Gallager	NE Peak		41.850	-66.506	5	1838
en6997.10	Cod Drifte	3	2	0	3	10	1635	e	4145.63	6627.68	75	40	Gallager	NE Peak		41.761	-66.461	5	2135
en7097.1	SeabirdCT	9	4	0	3	11	1235	s	4056.46	6719.73	79	60	Gifford	S. Flank		40.941	-67.329	5	1735
en7097.2	SeabirdCT	9	4	0	3	11	1246	e	4056.46	6719.73	79	60	Gifford	S. Flank		40.941	-67.329	5	1746
en7097.3	ZPN	7	4	0	3	11	1306	s	4056.46	6719.73	79	60	Gifford	S. Flank		40.941	-67.329	5	1806
en7097.4	ZPN	7	4	0	3	11	1320	e	4056.46	6719.73	79	60	Gifford	S. Flank		40.941	-67.329	5	1820
en7097.5	Cod Drifte	4	4	0	3	11	1403	s	4055.69	6719.26	80	40	Gallager	S. Flank		40.928	-67.321	5	1903
en7097.6	Cod Drifte	4	4	0	3	11	1658	e	4052.58	6717.83	80	40	Gallager	S. Flank		40.876	-67.297	5	2158
en7097.7	SeabirdCT	10	4	0	3	11	1858	s	4055.93	6720.12	80	71	Wishner	S. Flank		40.932	-67.335	5	2358
en7097.8	SeabirdCT	10	4	0	3	11	1911	e	4055.95	6720.15	80	71	Wishner	S. Flank		40.933	-67.336	5	0011
en7097.9	MOC1	106	4	0	3	11	1931	s	4056.16	6720.59	79	64	Wishner	S. Flank		40.936	-67.343	5	0031
en7097.10	MOC1	106	4	0	3	11	2001	e	4057.10	6721.97	77	64	Wishner	S. Flank		40.952	-67.366	5	0101
en7197.1	SeabirdCT	11	4	0	3	12	707	s	4055.92	6720.03	78	60	Wishner	S. Flank		40.932	-67.334	5	1207
en7197.2	SeabirdCT	11	4	0	3	12	720	e	4055.92	6720.03	78	60	Wishner	S. Flank		40.932	-67.334	5	1220
en7197.3	MOC1	107	4	0	3	12	818	s	4056.19	6720.05	79	67	Wishner	S. Flank		40.937	-67.334	5	1318
en7197.4	MOC1	107	4	0	3	12	840	e	4056.68	6720.20	79	67	Wishner	S. Flank		40.946	-67.337	5	1340
en7197.5	SeabirdCT	12	4	0	3	12	1107	s	4101.91	6722.62	75	40	Gallager	S. Flank		41.032	-67.377	5	1607
en7197.6	SeabirdCT	12	4	0	3	12	1123	e	4101.91	6722.62	75	40	Gallager	S. Flank		41.032	-67.377	5	1623
en7197.7	ZPN	8	4	0	3	12	1200	s	4056.07	6720.33	79	60	Gifford	S. Flank		40.935	-67.339	5	1700
en7197.9	Cod Drifte	5	4	0	3	12	1308	s	4056.30	6721.14	75	40	Gallager	S. Flank		40.938	-67.352	5	1808
en7197.10	Cod Drifte	5	4	0	3	12	1619	e	4053.80	6717.86	75	40	Gallager	S. Flank		40.887	-67.298	5	2119
en7397.1	SeabirdCT	13	5	0	3	14	717	s	4120.56	6741.88	36	25	Gifford	Crest		41.343	-67.698	5	1217
en7397.2	SeabirdCT	13	5	0	3	14	728	e	4120.56	6741.88	36	25	Gifford	Crest		41.343	-67.698	5	1228
en7397.3	ZPN	9	5	0	3	14	747	s	4120.56	6741.88	36	25	Gifford	Crest		41.343	-67.698	5	1247
en7397.4	ZPN	9	5	0	3	14	803	e	4120.56	6741.88	36	25	Gifford	Crest		41.343	-67.698	5	1303
en7397.5	MOC1	108	5	0	3	14	816	s	4119.73	6743.38	37	33	Wishner	Crest		41.329	-67.723	5	1316
en7397.6	MOC1	108	5	0	3	14	837	e	4119.77	6744.31	36	33	Wishner	Crest		41.330	-67.739	5	1337
en7397.7	ZPN	10	6	0	3	14	1251	s	4142.92	6832.99	177	50	Gifford	GSChannel		41.715	-68.550	5	1751
en7397.8	ZPN	10	6	0	3	14	1303	e	4142.92	6832.99	177	50	Gifford	GSChannel		41.715	-68.550	5	1803
en7397.9	MOC1	109	6	0	3	14	1328	s	4143.00	6833.04	173	156	Wishner	GSChannel		41.717	-68.551	5	1828
en7397.10	MOC1	109	6	0	3	14	1431	e	4141.63	6834.46	156	156	Wishner	GSChannel		41.694	-68.574	5	1931
en7397.11	SeabirdCT	14	6	0	3	14	1510	s	4142.99	6832.97	173	160	Wishner	GSChannel		41.717	-68.550	5	2010
en7397.12	SeabirdCT	14	6	0	3	14	1537	e	4142.99	6832.97	173	160	Wishner	GSChannel		41.717	-68.550	5	2037
en7397.13	MOC1	110	6	0	3	14	1545	s	4143.26	6832.50	171	159	Wishner	GSChannel		41.721	-68.542	5	2045
en7397.14	MOC1	110	6	0	3	14	1711	e	4142.32	6828.74	185	159	Wishner	GSChannel		41.705	-68.479	5	2211
en7397.15	Cod Drifte	6	6	0	3	14	1714	s	4142.28	6828.40	187	40	Gallager	GSChannel		41.705	-68.473	5	2214
en7397.16	Cod Drifte	6	6	0	3	14	2033	e	4142.96	6828.31	187	40	Gallager	GSChannel		41.716	-68.472	5	0133
en7397.17	Drifter	3	6	0	3	14	2100	s	4142.80	6833.75	177		Limeburner	GSChannel		41.713	-68.563	5	0200
en7397.18	Drifter	3	6	0	3	14	2101	e	4142.80	6833.75	177		Limeburner	GSChannel		41.713	-68.563	5	0201
en7397.19	Drifter	4	6	0	3	14	2120	s	4142.8	6833.75	177		Limeburner	GSChannel		41.713	-68.563	5	0220
en7397.20	Drifter	4	6	0	3	14	2121	e	4142.80	6833.75	177		Limeburner	GSChannel		41.713	-68.563	5	0221
en7497.1	SeabirdCT	15	6	0	3	15	906	s	4042.88	6832.85	170	40	Gallager	GSChannel		40.715	-68.548	5	1406
en7497.2	SeabirdCT	15	6	0	3	15	931	e	4142.17	6832.92	170	40	Gallager	GSChannel		41.703	-68.549	5	1431
en7497.3	ZPN	1	6	0	3	15	950	s	4141.19	6832.97	170	150	Gallager	GSChannel		41.687	-68.550	5	1450
en7497.4	ZPN	1	6	0	3	15	1025	e	4141.02	6833.10	170	150	Gallager	GSChannel		41.684	-68.552	5	1525

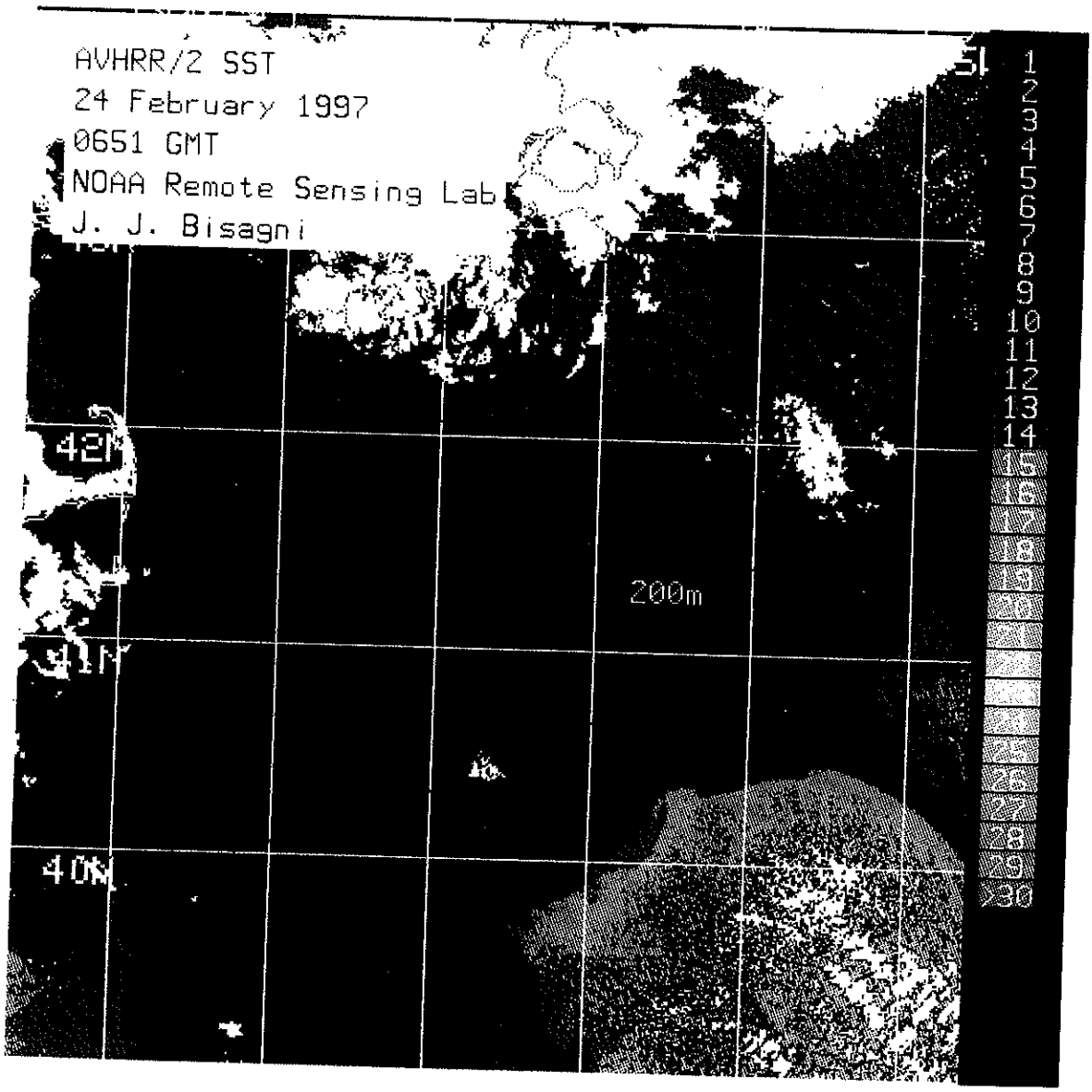

Figure 2. Pre cruise Sea Surface Temperature map. Note Scotian Shelf cold plume on Northeast Peak.

	Cell Type	Mean cell biomass fgC/cell	Abundance N/ml	Biomass ugC/L
Phototrophic nanoplankton (misc.)	PNAN	31848	75	2.40
Cryptophytes	CRYPTO	18795	118	2.22
	DIATOM	22038	33	0.72
Phototrophic dinoflagellates	PDINO	239880	8	1.81
Heterotrophic nanoplankton (misc.)	HNAN	13313	98	1.30
Heterotrophic dinoflagellates	HDINO	59993	38	2.26
Leucocryptos-type hetero. flagellate	POINTED ENDS	59142	8	0.45
	CILIATE	0	0	0.00
Choanoflagellates	CHOANO	12727	25	0.32
	Total phototrophic		233	7.14
	Total heterotrophic		168	4.33
	P/H Biomass Ratio =		1.650	

Table 4. Taxonomic distribution of nanoplankton abundance and biomass at Station 2.

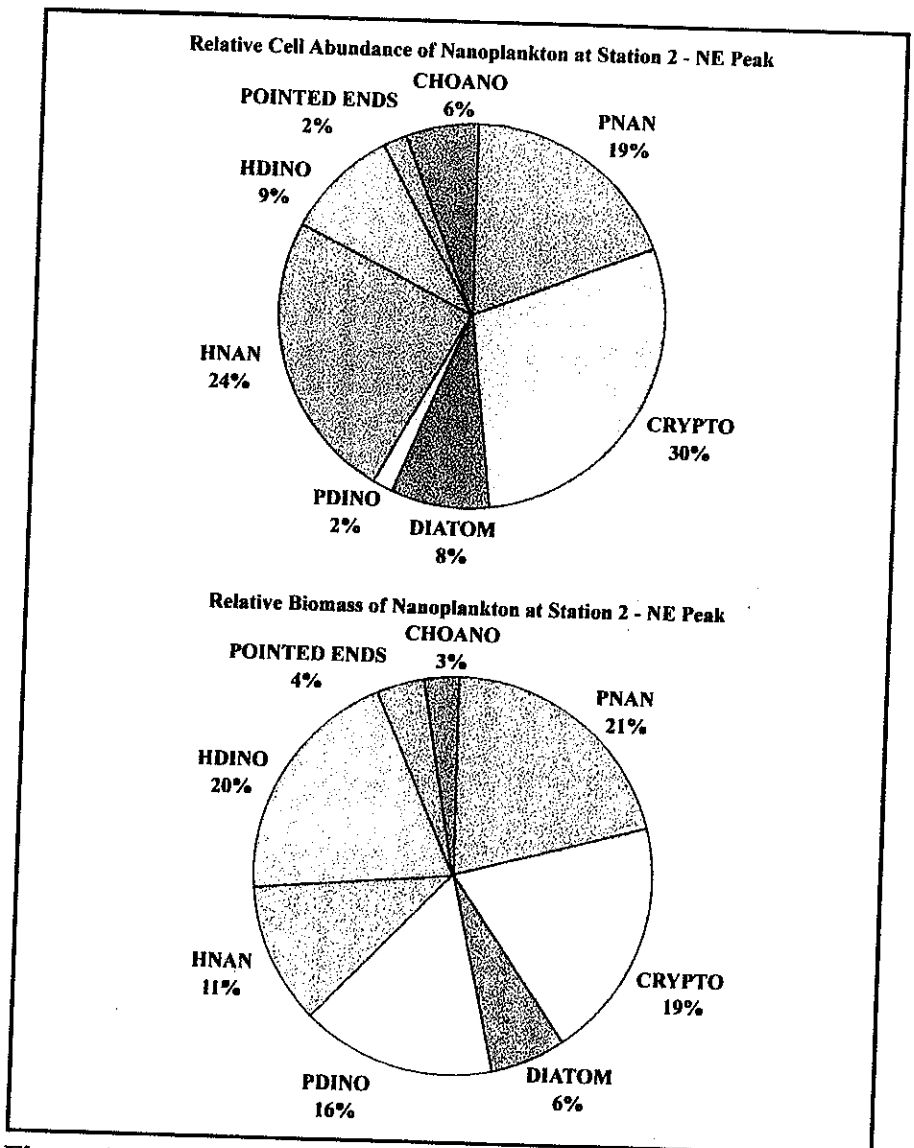

Figure 3. Relative nanoplankton cell abundance and biomass at Station 2.