Cruise Report
R/V OCEANUS Cruise 303
Georges Bank
6-23 May 1997

Acknowledgements

We gratefully acknowledge the very able assistance provided by the officers and crew of the R/V OCEANUS, WHOI's Shipboard Scientific Support Group, and several student volunteers. This report was prepared by Greg Lough, Lew Incze, Bob Campbell, Jeff Runge, Betsy Broughton, Marie Kiladis, Elaine Caldarone, Phil Alatalo, Maureen Taylor, and Jim Manning.. This cruise was sponsored by the National Science Foundation and the National Oceanic and Atmospheric Administration.

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Note: This document is available on-line at http://www.wh.whoi.edu/~jmanning/oc303.html.

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Purpose of the Cruise

The objectives of the cruise were to:

- (1) determine the distribution and abundance of larval and juvenile cod and haddock on the eastern flank of Georges Bank in relation to advective and dispersive processes, and
- (2) conduct site studies to determine their vertical distribution, diel variability, predator-prey relations, and biochemical content in relation to water column conditions.

Cruise Narrative

We remained in port on 6 May to insure that our MOCNESS sensors were functioning and the Video Plankton Recorder (VPR) attached independently to the MOCNESS frame was recording properly. And with the onset of gale force winds that night, it was decided to start out the next morning. The R/V OCEANUS left Woods Hole at 0915h DST, 7 May 1997.

We arrived at the first bongo station 86, 7 May 230 h DST, the eastern side of the Great South Channel below Little Georges, 75-m bottom depth, and continued eastward sampling the southern flank about every 10 miles between the 50- and 100-m isobaths (see Figure 1). Note that we continued numbering stations consecutively from the April OCEANUS 301 cruise. Larvae were sorted from both nets of the bongo for real-time estimates of abundance and preserved for biochemical analysis ashore. At station 95, our farthest eastern station was completed at 2003 h, 8 May. Generally less than 10 cod and haddock larvae were caught in the bongo tows. Haddock were more abundant than cod, and high numbers of recently-hatched haddock larvae were observed at station 95. There may have been a spawning aggregation on the southeastern part of Georges Bank, but we decided to focus our study on the western part of Georges to take advantage of the Schlitz/Brink moorings, designed to determine the amount of recirculation on western Georges. Also, larvae on the western part of Georges may be the same cohort that we studied in April (OC 301) that were some 50 miles to the east.

A more intensive grid of bongo stations was laid-out from about 67 30'W to 68 30'W longitude and from the 50- to 100-m isobaths. The 7 NW-SE transects were spaced 7 miles apart and bongo stations were every 5 miles on a transect. The first transect began with bongo station 96, 0018 h, 9 May. On transect 2, station 106, the first of 3 drifters, drifter 34, drogued at 30-m depth, was deployed at 1350 h, 40 57.4'N, 67 51.6'W, 59-m bottom depth. The second drifter 21 was deployed at station 107 at 1506 h, 40 52.6'N, 67 43.7'W, 65-m bottom depth. A third drifter was deployed at station 108 at 1700 h, 40 48.5', 67 41.6'W, 72-m bottom depth. The bongo grid was completed 2330 h 11 May with station 145. After a review of the survey results we steamed east to check out the three drifters deployed on transect 2 as possible time-series sites. At each drifter site a bongo-CTD Seabird tow was made to determine the water structure and plankton. Drifter 4, the farthest west was picked up at 0531 h 12 May, 40 47.2'N, 68 0.9'W. Arrived at drifter 1 at 0723 h, 40 49.6'N, 67 48.9'W and was left in place. Three stations (148-150) were made north of drifter 1 to define a frontal feature. We then went to drifter 6 (40 50.26'N, 67 35.55'W) at 1133 h, 12 May, found it had lost its holey sock, and retrieved it. We went back west to drifter 1 and did two bongo stations (152, 153) to determine where to place drifters for two contrasting sites within 10 miles of each other. Station 154 was designated as the shoaler site (57 m) within the cooler (6.5 C) part of the frontal band. Two drifters were set out at 1848 h and 1857 h 12 May, 40 5.9'N, 67 55.17'W: drifter 234 (13-m) and drifter 6 (30 m). We then steamed south to drifter 1, designated to be the deeper (67-m) station 155 on the warm side of the front (7.6 C), and deployed a 15-m drifter 200 at 2010 h 12 May 40 50.27'N, 67 47.21'W. We immediately began our time series operations with bongo-net hauls and plankton pump operations, followed by our first MOCNESS tow 137.

On 13 May, MOCNESS and plankton pump, bongo operations continued on station 155. *Calanus* were very abundant at this site, especially from 20 m, the base of the thermocline, to surface. Our day was highlighted with dozens of breaching whales feeding on surface schools of small mackerel/herring. At 2100 h we steamed north to station 154 making a SeaBird CTD transect between drifter stations 155 and 154. MOCNESS tows 140 and 141 and a plankton pump/CTD profile were completed by 1000 h 14 May. We returned to station 155 by 1120 h to continue plankton pump/bongo operations. On 15 May, 1630 h, we moved back to station 154, drifter 234 and resumed sampling operations. We searched for drifter 6 and found that it had lost its drogue some time within the previous 12 h, but stayed there to complete sampling. By early evening lightning storms were developing that interrupted MOCNESS operations. Drifter 6 was brought aboard at 2154 h, 15 May, 40 56.58'N, 67 54.75'W. Further sampling operations ceased because of the intense lightning/40-50 kt winds as the front was moving through the area. We then steamed to find drifter 234. We deployed a new drifter 1(b) at 0007 h, 16 May, to replace drifter 6 (33-m) at a position where it should have been in relation to the other drifters: 40 50.90'N, 67 55.10'W, 61-m bottom depth. The storm continued through the night and only a 1/4-m ^{2} MOCNESS (149) was completed by 0700h at this new drifter 1b. Winds 30 kt prevented further MOCNESS hauls so we decided to conduct a SeaBird CTD transect starting at 1040 h, north at CTD #89 (40 57.6'N, 68 04.9'W) at 44-m depth and working south sampling every 5 miles until 1430 h, CTD #93 (40 41.0'N, 67 46.0'W, 77-m bottom). We returned to station 155, drifter 4 at 1620 h and began pump/CTD operations. Operations ceased after 2200 h to ride out the 30 kt winds.

On the morning of 17 May, 0531 h another SeaBird transect was conducted across the frontal zone along 68 00 longitude until 0702 h, from 40 42.5'N (97) to 40 50.2'N (101). We then moved back to station 154, drifter 1, and completed MOCNESS tow 150 and a pump profile. By noon 17 May, we had moved to station 155, drifter 4, to begin pumping operations followed by MOCNESS tows 151 and 152, and another pumping profile completed before midnight.

After midnight, 18 May, our good luck ran out. The starboard boom ceased-up with MOCNESS tow 153 over the side, so this tow couldn't begin until 0237 h. During the tow the VPR didn't work, and there were net sequencing problems. Then, as the 1/4-m^2 MOCNESS was preparing to launch, the wire got stuck in the stern block and had to be cut. A leisurely Sunday morning breakfast was on order as the wire had to be re-terminated, which gave us time to consider the pros and cons of further sampling at this site. We all agreed we had had enough and steamed to pick up the shallow-tethered (13-m) drifters 234 and 200. We picked-up drifter 234 at 0946 h, 40 42.14'N, 68 03.0'W, 80-m bottom depth. Picked-up drifter 200 at 1015 h, 40 40.5'N, 68 2.6'W, 85-m bottom depth. A SeaBird cast were made at drifter site 200. We returned to station 155, drifter 4, at 1200 h and ended the final pump-CTD, bongo, ring-net operations for this time series at 1530 h. We then picked-up drifter 1 (station 154), which was within a half mile of drifter 4, at 1550 h, 40 41.9, 68 11.5'W, 77-m bottom depth. Drifter 1 was left on site for further monitoring as we steamed to station 171, 6 miles south of station 155.

Arrived at station 171 at 1430 h, 40 36.5'N, 68 08.0'W, 92-m bottom depth, and completed a ring net, 1-m^2 MOCNESS tow 154, and pump-CTD cast by 2130 h, 18 May. We then decided to make a SeaBird CTD transect along the Schlitz/Brink moorings, south to north from mooring 7 to 4. The transect began with station 172 near mooring 7 at 2304 h, 18 May,(40 32.0'N, 68 15.5'W) and ended with station 177 near mooring 4 at 0322 h, 19 May (40 52.5'N, 68 29.9'W). We then steamed east 11 miles to station 178, 40 50.5'N, 68 17.0'W, 50-m bottom depth, arriving at 1430 h. MOCNESS tow 155, a pump-CTD cast, and a ring net were made by 1130 h. Stations 171 and 178 were made to bracket the time-series station 155, drifter 4, going in waters shoaler and deeper than the tidal front (60-70 m) to check the water type and organisms.

Arrived back at the mooring transect at 1430 h, 19 May, a couple of Seabird CTD casts (stations 179 and 180) were made at 70- and 50-m isobaths to make sure we were on either side of the front. At station 180, drifters 6C (33 m) and 234B (13 m) were deployed at 1542 h, 40 44.6'N, 68 26.1'W, 55-m bottom depth. We then steamed a few miles south to deploy drifters 1C (33 m) and 200 (13 m) on station 181 at 1628 h, 40 40.4'N, 68 22.0'W, 70-m bottom depth. Operations commenced with a pump-ctd profile, followed with MOCNESS tow 156. Moved back north to station 180 and began MOCNESS tow 157 at 2330 h 19 May. After a pump-CTD and ring net we moved to a new station 182, about 5 miles north on the transect at 40 48.5'N, 68 28.5'W, 45-m bottom depth. A pump-CTD, MOCNESS tow 158 was completed by 0745 h 20 May. Station 180 began about 1020 h and ended at 1300 h. Station 181 began at 1500 h and ended with MOCNESS tow 160 at 2030 h. New station 183 was added south of 181 at 40 35.0'N, 68 20.0'W, 90-m bottom. Arrived at station 183 and began MOCNESS tow 161 at 2200 h, followed by a ring net and pump-CTD. Between 0248 h and

0450 h, 21 May, a SeaBird-CTD transect was made across the front on the western side of the moorings from south to north, station 184 (40 34.7'N, 68 30.1'W, 75 m) to station 187 (40 37.4, 68 33.8'W, 65 m). Additional steaming transects were made in the area to provide ADCP profiles and locate drifters. By 0816 h we returned to station 183 to complete daylight sampling operations for comparison with the previous nights. MOCNESS tow 162, a pump- CTD, ring net and bongo were completed by 1430 h, 21 May.

We then steamed north to station 180, arrived at 1530 h, 21 May, completed a bongo, ring net, pump-CTD and MOCNESS tow 162 by 2100 h. The final station 182 for pump-CTD and MOCNESS tow 164 was completed between 2300 h 21 May and 0214 h 22 May. Search for drifters began around 0330 h.

Drifter 6c was retrieved at 0515 h, 22 May, 40 42.19'N, 68 29.53'W, 60-m bottom; drifter 34 was retrieved at 0700 h, 40 31.7'N,68 38.3'W, 75-m bottom; drifter 1c was retrieved at 0740 h, 40 31.6'N,68 45.6'W, 71-m bottom; drifter 234 was retrieved at 0823 h, 40 37.21'N,68 42.70'W, 60-m bottom; drifter 2006 was retrieved at 0924 h, 40 31.32'N,68 49.31'W, 71-m bottom. As luck would have it, we were within 3 miles of the lost buoy "Y", from the Schlitz/Brink moorings, and recovered it without incident at 1041 h, 40 30.07'N,68 53.3'W, 70-m bottom. No instrumentation was attached to the short chain link. Marks on the buoy appeared to have been made by collision with a vessel.

With the remaining time we decided to do SeaBird-CTD transects along the Schlitz/Brink moorings starting with mooring 2, heading east to mooring 3 and 4. A new transect started at mooring 4 and ran southwest to mooring 9 and farther on the same bearing. At 1253 h, 22 May we arrived at station 188 (mooring 2), 40 51.20'N,68 49.11'W. There was no superstructure on the surface float, nor was there any on buoy 3, and appeared to have been unscrewed, since there were no apparent markings upon close inspection. We arrived at mooring 4 (station 192) at 1530 h, 40 51.70'N,68 30.29 and every thing was intact. We then steamed on the second transect towards mooring 9, completing stations 193 and 194. Arrived at mooring 9 (Station 195), 40 41.93'N,68 40.48'W, at 1645 h an found the tower missing in the same way as the other 2 moorings. Notified Coast Guard of moorings as navigational hazzards. Station 195 was completed at 1646 h, 22 May and we headed for Woods Hole. Arrived at Woods Hole 0915 h, 23 May 1997.

Individual Reports

Physical Oceanography (J. Manning)

Drifter Deployments

As in our previous cruise (OC301), one dozen GPS/ARGOS/VHF drifter deployments were made on OC303. The times and positions of each deployment is given in the cruise narrative above and again in the eventlog. Here we discuss the results of each of three clusters. The first cluster (Figure 5) consisted of three instruments deployed in a cross-bank line along the 2nd bongo transect. The three drifters (34, 21, and 36) all had 30m tethers and were deployed in 59, 65, and 72 meter water, respectively. After a few tidal cycles, the three drifters tended to converge towards the tidal front and spread-out alongbank. Drifter 36 lost its drogue part way through the deployment.

As explained in the cruise narrative, a second cluster (Figure 6) of drifters were deployed on 12 May with two drifters 234a (13m) and 6b (33m) on the onbank side of the tidal front and two drifters 200a (13m) and 1a (still 33m) on the off bank side. The results were similar to the first cluster in that the drifters tended to converge towards the front. The drogue on drifter 6b let go. One of the drifters (4b) was left in the water and fortunately drifted into our final cluster experiment further to the west. This third and final cluster (Figure 7) was again two pairs of drifters with a deep and shallow drogue on either side of the tidal front. The deeper drifter on the onbank side (6c) held its position relative to the other three (36c,1c, and 200b) which moved quickly along isobath towards the west-southwest and joined with 4b which had apparently traveled along the tidal front jet from the east.

Shipboard Sensors

One minute interpolated values of shipboard sensor data were loaded into a MATLAB routine for range and delta checks and then plotted in Figures 6 (salinity) and Figure 7 (temperature). Note that the salinity records appeared to be good at the start of the cruise (~31.3 PSU) but then suddenly filled with primarily "dropouts". The peak values in the record may be savagable with some filtering but all was lost after 17 May. The seasurface temperature (upper line in Figure 7) looks reasonable until 17 May (see scale on right of figure). There was a general warming of the surface waters of approximately 1 C in the first week of the cruise. The air temperature record shows peaks on 13 and 16 May. In the case of the meteorological sensors, the 5-minute interpolated values look reasonable (see Figure 8 barometric pressure and short wave radiation). Unfortunately, as is often the case with shipboard anemometer records, the wind data is virtually unusable. With the speed and direction of both the wind and ship varying so much especially in heavy seas, it is very difficult to obtain an accurate estimate of the wind. Consequently, the nearby NOAA buoy records are plotted in Figure 9. Buoy (44011) is stationed approximately 100 miles east of the study area but provides an adequate index of the local wind events.

RDI Acoustic Doppler Current Profilers were on board, one operating at 150kHz and the other at 300 kHz. Post-processing of these records has just begun at the time of this writing. A routine to convert the RDI raw data to MATLAB formatted data called BB2MAT has been used to extract velocities. Error checking and quality control of the data needs to be conducted prior to data plotting and release.

Hydrography

A total of 154 CTD casts were conducted including 132 Seabird Profiler casts (Model 19) and 22 Seabird CTD (Model 9/11) cast with a rossette. Most of the 9/11 deployments were actually a series of several up/down cast. In addition, Seabird temperature (Model 3) and conductivity (Model 4) sensors were mounted on all 27 MOCNESS hauls.

The Profiler was attached to the wire just above the bongo-net frame. These cast were double oblique through the water column except for a few vertical cast taken with water bottle samples. The vertical cast were taken for calibration purposes and, since the salinometer difference was less than 0.01 PSU, no salt correction was applied to these data. While the main purpose of these deployments on the bongo hauls is to have a measure of depth (pressure) in real time, significant hydrographic information is gathered. Post-processing of this data was conducted by Maureen Taylor (see Figures 10, 11, , 12, 13, and 14). A total of 7 cross-bank sections were conducted with five or more stations per section. The cross-bank vertical sections of the temperature and salinity are shown in Figures 15 and 16, respectively, for the fine-scale grid study. A more detailed picture of the second of transect #2 is shown in 17

After the fine-scale bongo grid, Seabird 9/11 cast were conducted a few times during the day and a few cast during the night. All cast included measurements from a fluorometer and a transmissometer in addition to the standard CTD variables. While real time display and post-station hardcopy plots of each cast depicted fairly clean and useful data, each cast needed careful hand editing and post-processing especially for the near-surface values. There were typical problems associated with the near-surface values of salinity in particular when the CTD failed to equilibrate or the pump did not turn on until after the package was lowered into the water column. This results in artificial values that are difficult to filter objectively from the real data especially in cases of heavy seas where the instrument is oscillating through the near-surface layer. Nevertheless, the processed data is now posted on the GLOBEC homepage under "PROCESS|1997|NMFS_CTDSB". The individual profiles are displayed for temperature and salinity in Figure 18, and fluoresence and transmission in Figure 19.

The evolution of water-mass structure at drifter station 155 is depicted in Figure 20 for the period of 13-18 May. Eight Model 911 casts at this station (numbers posted at the top of the temperature contour) show the pynocline present at ~25-m depth with approximately 0.3 sigma-t gradient. Except for the very slight mixing of the surface layer due to wind on the afternoon of 16 May, the structure remained fairly constant at this drifter station 155.

The most significant hydrographic observation in the analysis of the data thus far is the presence of two bands of relatively cold/fresh water (possibly remnant Scotian Shelf Water) along the southern flank. One band was apparently aligned and advected with the tidal front and the other was just inside the shelf/slope front. The offbank band was often found as subsurface minimums at bongo/ctd stations 109,113,125,129, and 138. This two-band structure is best depicted in Figure 15, but was visible in most of the satellite imagery from the cruise period (see, for example, Figure 21 and Figure 22. This same feature had been observed on the previous cruise (OC301) and in other years (1995) after episodes of Scotian Shelf crossovers had occurred.

Ichtho-Zooplankton Studies

Bongo-net Survey (G.Lough, E.Broughton, M.Kiladis)

Bongo tows were made with a 61-cm frame fitted with 0.333-mm and 0.505-mm mesh nets using standard MARMAP procedures; i.e., double-oblique from surface to within 5 m of the bottom. A SeaBird CTD (Model 19) was attached to the towing wire above the bongo to monitor sampling depth in real time and to record temperature and salinity. Both net samples were sorted at sea to provide counts on the number of cod and haddock eggs and larvae. Larvae from the bongo-net samples were frozed for biochemical analyses ashore. The initial bongo survey of 10 stations (86-95), 10 miles apart, covered the southern flank of Georges Bank between the 50- and 100-m isobaths during 7-8 May (Figure 2). Few haddock (1-7 per tow) and fewer cod (1-4 per tow) were caught on these stations until station 95, the most eastern site where up to 36 recently- hatched haddock and 7 cod larvae were collected. New spawning was reported on the northeast part of Georges by the previous broadscale cruise OCEANUS 302; so it seems likely that recently- hatched larvae were advected to the southeast part of Georges Bank. Older larvae on the western part of Georges were probably advected there from the southeast as observed in April (OCEANUS 301). A fine-scale grid of stations (50) was conducted on the southern flank between about 67 30' and 68 30' during the period of 9-11 May (Figure 10). Seven transects were made 7 miles apart between the 50-m and 100-m isobaths. On each transect bongo stations were 5 miles apart. Few gadid eggs were found on the survey. Larvae were found (Figure 23) at all but a few stations; their modal size was 6-7 mm SL. Larval catches were typically less than 10 per net (note: Figure 23 includes both .333-mm and .505-mm nets). Haddock larvae were generally more abundant than cod and found more at stations 60 m and shoaler. Highest number of both cod (7-11) and haddock (16-17) caught in the 0.333-mm net was at station 136 on the southwest part of Little Georges, 55-m bottom depth. Larval catches were significantly low or absent at stations located along the 70-m isobath and deeper. Also, the percentage of *Calanus* in the samples usually was greater than 70% in water deeper than 70 m and less than 50% in waters shoaler. The distribution of hydroids (provided by Barbara Sullivan and Jason Williams at URI) was similar (Figure 24). Water type and associated organisms appeared to be different on either side of a front along the 70-m isobath. Based on this survey, the time-series sites were selected at the frontal region near the 70-m isobath where *Calanus* and larval fish were sufficiently abundant to conduct feeding and growth experiments. The sites were to be located to the east on transect 2 or 3 where the drifters were presently, which would allow us to follow them for 5-7 days and not be advected into the Great South Channel.

Table 1. Bongo samples taken for analysis

Mesh size (mm)	0.333	0.505
Number of jars	79	72
COD- Caldarone	105	89
HADDOCK- Caldarone	262	241
Calanus, CIV- Campbell	454	
LH SCULPIN - Incze	1	

MOCNESS Sampling (G.Lough, E.Broughton, M.Kiladis)

The 1-m^2 MOCNESS with nine 0.333-mm mesh nets was used to sample larval fish and larger zooplankton. New sensors on the 1-m^2 MOCNESS (light, transmission, fluorometry) worked this cruise. A Video Plankton recorder (VPR) also was attached to the MOCNESS frame to record fine-scale zooplankton during the tow. Results of the VPR recordings are discussed below. The 1/4-m^2 MOCNESS with nine 0.064-mm nets was used to sample the smaller plankton such as copepod nauplii. The tow profile for these two nets was nominally 10-m strata within 5 m of the bottom; extra nets were used for special collections. The 1-m^2 MOCNESS nets typcally sampled for 5 minutes to filter about 200 m^3 of water; the 1/4-m^2 MOCNESS nets for 2-3 minutes to filter about 30 m^3. Following a drifter as the station marker, the MOCNESS sampling strategy was to make four tows every 24 hours; 0700, 1200, 1700, and 2400 h. The one night tow at 2400h was fully sorted for fish larvae, which were frozen for biochemical analysis. The early morning, midday, and late afternoon tows were preserved in formalin for gut content analysis; any extra nets were used for biochemical specimens. In between MOCNESS tows and CTD-pumping, other special sampling was conducted for zooplankton demography, rearing and experimental feeding studies.

The distribution of all 1/4m^2 taken during the cruise is plotted in Figure 31 and all 1-m^2 MOCNESS is plotted in Figure 32. Eleven MOCNESS tows (137-139, 142-146, 151-153) were made following drifter station 155, off-shore of the tidal front, and six MOCNESS tows (140-141, 147-150) were made following drifter station 154, on-shore of the front. Two larval fish vertical profiles are shown here for station 155 in Figure 25, and for station 154 in Figure 26. MOCNESS 143 (Fig. 25) was made on the off-shore side of the tidal front where there was a weak thermocline (5.6-6.8 ^oC) near 15 m depth. Cod and haddock larvae were most abundant in the surface 20 m, and haddock, which were more abundant, had maximum density at 10-20 m, the thermocline depth. In contrast, MOCNESS 150 (Fig. 26) made on the on-shore side of the tidal front, shows larvae to be distributed throughout the water column, with a slight middepth increase in abundance near 30 m, corresponding with the 1 ^{o}C change in water temperature. It is unclear how this vertical distribution of larvae is related to the tidal-front structure. The available length frequencies for the two stations are shown in Figure 27. The range of larval length, 5-11 mm, was similar for both cod and haddock and at both stations. More larvae were available for station 155, the off-shore station; haddock had a length mode of 6 mm, and cod, 7 mm. There did not appear to be a pronounced modal length at the on-shore station 154.

At the end of the cruise, a series of day and night paired 1-m^2 MOCNESS tow (156-164) were made at the Schlitz/Brink moorings to cover both sides of the tidal front at the southwest corner of Georges Bank (see Figure 32).

Special Collections (E.Broughton, E.Caldarone, L.Buckley)

Samples for biochemical and age analysis were taken from 58 0.333-mm mesh, 61-cm bongo nets, 51 0.505-mm mesh, 61-cm bongo nets, and 23 0.333-mm mesh 1-m^2 MOCNESS hauls. All samples were rinsed from the nets using minimal seawater pressure and transferred to buckets containing ice packs. Plankton from nets that were not to be sorted was preserved immediately using 4% buffered formaldehyde in seawater. Plankton samples sorted for fish or invertebrates were picked in seawater filled translucent sorting trays on ice covered light tables. Every effort was made to keep samples cold during processing to delay decomposition. Plankton remaining after removal of samples was preserved with 4% buffered formaldehyde and sea water.

Larval fish collected for Caldarone/Buckley were video taped using a Zeiss Stemi SV6 stereomicroscope outrigged with an MTI CCD72 black and white video camera, then individually frozen in liquid nitrogen. The video images will be used to collect morphometric data. The data will be used to determine the nutritional condition and growth rate of the individual fish.

Larval fish collected for B.Burns were measured to the nearest 0.01 mm SL using Optimas image analysis software connected to a Zeiss Stemi SV6 stereomicroscope, equiped with a Hitachi HV-C20 color video camera. These fish will have their age determined by otolith microstructure analysis. A total of 192 cod and 503 haddock were collected from bongo tows conducted at 66 stations. Individual cod and haddock were collected, videotaped. and placed in liquid nitrogen. A total of 159 cod and 603 haddock were collected from 23 1-m^2 MOCNESS tows. The larvae will be analyzed for their RNA, DNA, and protein content, and length. The data will be used to determine the growth rate and nutritional condition of the individual fish. A comparison will be made of fish taken from the different sites and at discrete depths.

Table 2. MOCNESS samples taken for analysis

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                                             1-m2  MOCNESS SAMPLES
Net Number 0 1 2 3 4 5 6 7 8
Number of jars 35 26 25 26 32 48 62 67 29
COD - Caldarone 4 10 11 11 5 18 15 59 27
HADDOCK - Cald 34 18 15 36 31 81 51 211 105
COD - Burns 4        4
HADDOCK - Burns 17       26 37

                                             1/4-m2  MOCNESS SAMPLES
Net Number 0 1 2 3 4 5 6 7 8
Number of jars 0 5 5 5 5 6 5 3 2
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Larval Fish Prey Field (L. Incze, B. Novak)

This cruise was a continuation of work begun during Cruise OC301 in April this year to describe potential prey available to larval cod and haddock at various times of day and under different hydrographic conditions and shelf locations. We used the same pump system (ca. 350 l/min on deck) and mesh size (40 um) described for the earlier cruise except that we modified the subsampling system to provide 15-19 l/min instead of the previous 8-10 l/min. This enabled us to reduce sampling time to 2 minutes per depth to get the desired sample volume. Sampling depths were 60, 50, 40, 35, 30, 25, 20, 15, 10 and 5 m with occassionally deeper (up to 75 m) and shallower (usually 2 m) samples.

We averaged 36.2 l per sample (sd = 3.2 l) on this cruise and obtained 188 samples from 20 stations. This included a series of samples taken at the two original drifters #155 (7 profiles from 5/13-5/18) and 154 (1 profile each on 5/14 and 5/17). Prey sampling with the pump was focussed to match locations and times of larval fish sampling. This accounts for most of the imbalance in number of profiles at the two stations. Weather and convergence of drifters after the first 1.5 d also contributed to the small number of profiles at #154. After the drifter series was completed, we profiled the deeper and shallower portions of the bank at positions orthogonal to the isobaths at the final drifter positions to sample what should more clearly have been mid-flank and inner bank stations (stations 171 and 178, respectively). These will be used to compare with the converged (frontal) drifters that we had been studying for the previous week. The final phase of the cruise from 20-22 May concentrated on across-shelf sampling at the mooring line near the southwest corner of the bank, again coupling pump with larval fish sampling (station 180: 3 profiles; 181: 2 profiles; 182: 1 profile; 183: 3 profiles).

In addition to the above samples (40 um mesh net, formalin-preserved), we collected Niskin water bottle samples and preserved 200 ml whole water with Lugol's preservative at the following stations: 3 profiles at station 155; 2 at station 154 and 1 each at stations 171 and 178. Sampling depths were 50, 40, 30, 20, 10 and 5 m.

The video camera on the 1-m^2 MOCNESS and the fine mesh (60 um) on the 1/4 m MOC will provide cross-calibrations of methods with pump estimates. In addition, larger zooplankton from the pump samples will be compared with 1-m^2 MOCNESS samples at selected stations. Pump samples are of intermediate resolution for depth and volume between the nets and the camera.

VPR-MOCNESS Activities (G.Lough)

The Video Plankton Recorder, an underwater imaging video microscope, was mounted above the net opening on the 1-m^2 MOCNESS. This particular system was held in four underwater housings and consisted of a Hi-8 Video Camcorder interfaced with a Tattletale Computer Software, a single high-magnification camera, a strobe, and a standard MOCNESS battery pack. Operation was independent of the MOCNESS. Field of view for the high magnification camera was 5 mm by 4 mm. Recordings were later dubbed to SVHS tape format together with time code. Recordings were made for all 1-m^2 tows with the exception of haul 153. All in-focus images will be identified to the lowest taxon possible. A total of 22 tapes will be analyzed and contribute to prey field composition data.

Calanus Vital Rate Studies (R.Campbell, J.Runge)

A bongo survey was conducted for the first five days of the cruise (7 - 12 May) to map the fish larvae and *Calanus* distributions along the southern flank of the bank. This survey was used to select two stations later in the cruise for comparative time series measurements, and one of these stations was chosen for the *Calanus* recruitment-mortality study.

Calanus abundances were greatest at stations located in water greater than about 70 m and decreased towards the shallower stations. At the shallow stations (<50 m) *Calanus* were only approximately 30% of the total copepod abundances, other copepods included *Pseudocalanus*, *Centropages*, and *Temora*. In the shallow regions the biomass was dominated by hydroids, and there was a very great amount of phytoplankton, either *Phaeocystis* sp. or *Chaetoceros socialis*, which coated the nets with a brown slime. As we moved into deeper water we found that the biomass of hydroids and phytoplankton decreased and the proportion of *Calanus* increased to greater than 90% of the total copepod numbers, with some *Pseudocalanus* and *Metridia* also present. We did not observe a clear demarcation between these regions but rather a gradual change, and the depth range over which this change occurred was dependent on the stage of the tide.

During the entire cruise, at most stations on the southern flank, *Calanus* life stages were dominated by stages C3 and C4. There were usually good numbers of C5s present, and C1s and C2s, at times, were also abundant. However, there were few adults and naupliar stages observed on the southern flank during the cruise. At most stations it appeared that the number of adult males were equal to or greater than the number of females, which generally are much more abundant than males. In the early part of the cruise some late stage *Calanus* nauplii were observed, but by mid-cruise very few *Calanus* nauplii were present. Even in the *Calanus* rich regions there were very few nauplii, and of those present the majority were other species.

On 12 May two drifter stations located more than 10 miles apart on either side of the tidal mixing front were selected for time series measurements. Stations 154 and 155 were located on the shallow and deeper sides, respectively, of the front. The shallow site had a mix of different copepods including *Calanus*, *Pseudocalanus*, *Centropages*, and *Temora*. There were some hydroids and phytoplankton but not as much as at shallower stations. In contrast, station 155 contained more than 90% *Calanus*, some *Pseudocalanus* and *Metridia*, no hydroids, and no phytoplankton that slimed the nets. We chose station 155 to conduct the recruitment-mortality study.

At Sta. 155, as at Sta. 154, two drifters were deployed, one drogued at 15 m and the other at 30 m. We chose to conduct all of our sampling at Sta. 155 at the deeper drogued drifter. Five replicate vertically integrated pump samples and three oblique bongo tows were taken each day for estimation of daily abundance of *Calanus* life stages beginning on the night of 12 May and continuing through 18 May. In addition, *Calanus* egg production measurements were made daily, and naupliar development rates and copepodite development and growth rates were determined several times at the station during this period.

During the six day time series both sets of drifters from Stas. 154 and 155 converged at the frontal region. Initially, the 30 m drogued drifters were deployed more than 10 miles apart, but by the time they were picked up 6 days later they were separated by only 1/4 mile. During the six day deployment the deep drifter at Sta. 155 remained at approximately the same isobath (70 m) and moved in a southwest direction. However, even though the depth did not change there was a substantial change in the biota.

Initially, at Sta. 155 more than 90% of the copepods in the .333-mm net were *Calanus*. For the first two days the *Calanus* were so abundant that the bongo hauls had to be split prior to preservation. On the 13th, the *Calanus* were found to be near the surface (10 - 20 m) in very great abundance based on observations from the MOCNESS tow. There were huge schools of small fish, possibly herring or mackerel, boiling at the surface which appeared to be feeding on this *Calanus* layer. The fish schools in turn were being fed upon by numerous humpback, fin, pilot and possibly sei/minke whales. Estimates of the number of larger whales (humpbacks, fins, sei/minke) that were observed around the ship ranged between 20 and 40. On the 14th, we collected only about 25% of the *Calanus* biomass that was collected on the previous day, but *Calanus* was still the dominant copepod. Also, there were no fish schools or whales observed. There was a thermocline present at 25 m and the *Calanus* were located above this in the surface. At this time we noticed that all the drifters appeared to be converging at the front. By the 15th, more phytoplankton was accumulating in the nets, and by the 16th *Calanus* was no longer the dominant copepod. At this time, *Pseudocalanus*, *Calanus*, and *Metridia* were equally abundant, and some *Centropages* and *Temora* were also present. There was a significant amount of phytoplankton, which appeared to be *Chaetoceros socialis*, coating the nets. These phytoplankton colonies were also observed in the surface by the VPR. Other phytoplankton present included *Coscinodiscus, Ceratium*, various chain forming diatoms, and an unidentified green ball approx. 0.2 - 0.4 mm in diameter. By the 18th, the final day, the phytoplankton had increased in abundance and *Psuedocalanus* was the most numerous copepod.

C. finmarchicus recruitment

C. finmarchicus egg production rates varied between 2 (Sta. 183, 21 May) and 38 (Sta. 142, 11 May) eggs female-1d-1 (Table 3). The median egg laying rate was 25 eggs female-1d-1. The two low rates at stations 171 and 183 are consistent with 1995 broadscale observations, which showed a low reproductive index for females on the southern edge of the flank. At the drifter station, egg production on the first day was 5 eggs female-1d-1 (Sta. 155-A, 13 May), but subsequently varied between 23 and 28 eggs female-1d-1 (14-18 May). The significantly lower rate on 13 May may be associated with the dramatic change in abundance of *Calanus* that was previously noted. Hatching success of eggs, determined for the first 7 egg production observations (Table 4), varied between 62 and 80% (mean: 69.8%).

Table 3. Summary of *Calanus* egg production measurements, 24 h incubation immediately after capture: mean egg production rate and standard error (n = number of individual females), mean clutch size and standard error (n = number of clutches)

Station	Date	EP Rate (eggs fem-1d-1)	S.E. (n)	Clutch size	S.E. (n)
94	8/5	11.7	3.5 (40)	42.4	6.1 (11)
107	9/5	21.5	4.5 (40)	43.2	8.6 (20)
123	10/5	28.1	6.2 (40)	51.2	11.3 (22)
142	11/5	38.0	7.2 (20)	58.5	5.1 (13)
155-A	13/5	5.0	2.2 (40)	33.5	7.9 (6)
155-B	14/5	26.7	4.1 (40)	34.4	4.4 (31)
155-C	15/5	33.5	5.1 (39)	39.6	4.0 (33)
155-D	17/5	22.8	4.0 (40)	45.5	3.4 (20)
155-E	18/5	28.5	6.1 (29)	47.6	6.9 (18)
171	18/5	4.9	2.8 (30)	29.2	12.9 (5)
178	19/5	25.9	5.9 (30)	55.4	6.3 (14)
181	20/5	25.0	4.4 (40)	45.2	4.6 (22)
183	21/5	2.1	1.3 (40)	28.0	7.2 (3)

Table 4. Results of egg viability experiments to date. ParthNv dish refers to eggs that were clearly parthenogenic (opaque, no membrane) or non-viable (irregular shape) in dish during counting. Mean hatch success refers to results of incubations of lots of 50 mixed eggs. Total hatch success (1-ParthNV dish) * hatch success.

Station	Date	Part dish	Mean hatch success(%)	S.E. (n)	Total hatch success (%)
94	8/5	0.04	62	2.7 (5)	60
107	9/5	0.03	69	2.0 (5)	67
123	10/5	0.03	65	2.8 (5)	63
142	11/5	0.01	74	2.5 (5)	73
155-A	13/5	0.01	80	6.1 (5)	79
155-B	14/5	0.02	68	11.9 (5)	67
155-C	15/5	0.02	71	5.2 (5)	70
155-D	17/5	0.03			
155-E	18/5	0.03			
171	18/5	0.12			
178	19/5	0.01			
181	20/5	0.01			
183	21/5	0.01			

Naupliar development

Development rates of *Calanus* naupliar stages were determined in triplicate on-deck 100 liter mesocosms. The mesocosms were placed inside a water bath where temperature was controlled with circulating surface sea water. The mesocosms were filled with prescreened (0.10 mm) water pumped from 2 meters depth with a diaphram pump. Nauplii were collected with a 0.150 mm net and gently screened through a 0.20 mm nitex mesh that was immersed in a bucket of surface water to remove older stages. A portion of the resulting 0.15 to 0.20 mm size fraction, a cohort consisting of mainly N4 and N5 *Calanus* nauplii, was added to the mesocosms to give a density of less than 2000 nauplii per tank. The development of the cohort was monitored daily for 3 days by sampling the tanks for stage abundances. Chlorophyll a concentrations were also monitored. The copepods were preserved in 4% formaldehyde for later stage identification and enumeration. The changes in stage abundances over time will enable us to calculate development rates.

Three experiments were conducted during the cruise at Stas. 94, 155, and 181 beginning on 8 May, 13 May, and 19 May respectively. Several attempts were made to conduct additional experiments at the drifter station (Sta. 155), but too few *Calanus* nauplii were present. In all the experiments *Pseudocalanus* early copepodites were the most abundant copepod stages present in the tanks. At Sta. 94, *Calanus* nauplii were 25% of the total copepod numbers in the tanks, but at Stas. 155 and 181 they were less than 5%.

Copepodite development and growth

Both development and growth (carbon and nitrogen) rates of *Calanus* copepodite stages were determined. Copepodites of a specific stage were sorted (unanesthetized) from a live net tow under a dissecting microscope, incubated in 8 l polycarbonate bottles filled with ambient surface water or ambient water enriched with phytoplankton cultures (Tetraselmis sp. and Heterocapsa triquetra) and placed in a water bath (temperature controlled with circulating surface sea water). Measurements were taken for initial size (length, and carbon and nitrogen content), and final size measurements (noting any molting that had occurred for development rate calculations) were made after a two day incubation. The enriched treatment was used to determine if development and/or growth rates were food limited and as such, could be enhanced with the addition of the mixed phytoplankton diet.

Three separate experiments were conducted at Sta. 155, and one each at Sta. 123 and Sta. 181 (Table 5). At this time, the carbon and nitrogen growth calculations have not been completed. Development rates were faster in May than during the April cruise, where development rates were generally below 50% of the maximum rates. The May development rates were still some what below the maximum rates achieved in the laboratory, except for the one experiment with C2s. The increased development rates coincided with increased food concentrations in terms of Chlorophyll a(Figure 24). Chlorophyll a concentrations during the April cruise were less than 1 microg/l.

Table 5. Results of *Calanus* copepodite development rate experiments. The proportion of the maximum development rate (corrected for incubation temperature) achieved for each stage and treatment in a given experiment are shown. Values represent means of 3 replicate bottles.

Stage	Treatment	Sta. 123 10-May	Sta. 155 13-May	Sta. 155 16-May	Sta. 155 17-May	Sta. 181 20-May
C2	Ambient	1.09				
C3	Ambient	0.75	0.69			
C3	Enriched	0.68				
C4	Ambient	0.67	0.67	0.97	0.28	
C4	Enriched	0.62	0.73	0.79	0.63	

Size and condition measurements At Sta. 155, *Calanus* C1 through adult were collected with live net hauls (0.15 mm) for size (length, carbon, and nitrogen) and condition (RNA/DNA ratio) measurements. Copepods, under anesthetic (MS222), were sorted from the net haul using a dissecting microscope, their images recorded with a video system for later length measurements, and then placed in either a tin boat and dried over desiccant for carbon and nitrogen analysis or put into cryotubes and frozen in liquid nitrogen for RNA/DNA determinations. In addition, size and condition measurements were made on *Calanus* C4s during four separate transects across the tidal mixing front on the southern flank.

Appendix. I. Event Log

EVENT#	INSTRU	CAST	STA	MTH	DAY	GMT	S/E	LAT	LON	WDEP	SDEP	PI(S)	
oc12797.1	BongoSB	1	86	5	7	2301	s	4034.7	6830.3	75	70	Lough	
oc12797.2	BongoSB	1	86	5	7	2313	e	4035.0	6830.4	75	70	Lough	
oc12897.1	BongoSB	2	87	5	8	140	s	4040.4	6829.4	62	58	Lough	
oc12897.2	BongoSB	2	87	5	8	146	e	4039.8	6829.3	62	58	Lough	
oc12897.3	BongoSB	3	88	5	8	424	s	4050.3	6815.2	50	44	Lough	
oc12897.4	BongoSB	3	88	5	8	435	e	4049.7	6815.4	50	44	Lough	
oc12897.5	BongoSB	4	89	5	8	611	s	4043.0	6806.8	77	73	Lough	
oc12897.6	BongoSB	4	89	5	8	620	e	4042.3	6807.2	77	73	Lough	
oc12897.7	BongoSB	5	90	5	8	813	s	4037.0	6801.9	91	85	Lough	
oc12897.8	BongoSB	5	90	5	8	826	e	4037.0	6801.9	89	85	Lough	
oc12897.9	BongoSB	6	91	5	8	1020	s	4044.2	6752.2	74	69	Lough	
oc12897.10	BongoSB	6	91	5	8	1031	e	4044.3	6752.8	75	69	Lough	
oc12897.11	BongoSB	7	92	5	8	1229	s	4037.8	6742.1	78	75	Lough	
oc12897.12	BongoSB	7	92	5	8	1241	e	4037.4	6742.5	78	75	Lough	
oc12897.13	ZPN	1	94	5	8	1319	s	4051.5	6726.2	85	50	Campbell	mesocosm #4
oc12897.14	ZPN	1	94	5	8	1327	e	4051.3	6726.1	85	50	Campbell	
oc12897.15	ZPN	2	94	5	8	1331	s	4051.2	6726.1	85	70	Runge	Calanus egg
oc12897.16	ZPN	2	94	5	8	1340	e	4050.8	6726.1	85	70	Runge	
oc12897.17	BongoSB	8	93	5	8	1444	s	4045.0	6731.4	86	82	Lough	
oc12897.18	BongoSB	8	93	5	8	1459	e	4044.6	6731.8	86	82	Lough	
oc12897.19	BongoSB	9	94	5	8	1648	s	4052.8	6725.7	82	77	Lough	
oc12897.20	BongoSB	9	94	5	8	1700	e	4052.0	6726.2	83	77	Lough	
oc12897.21	BongoSB	10	95	5	8	2103	s	4058.7	6715.1	77	73	Lough	

oc12897.22	BongoSB	10	95	5	8	2119	e	4058.6	6716.6	78	73	Lough	
oc12997.1	BongoSB	11	96	5	9	18	s	4037.9	6724.9	98	94	Lough	
oc12997.2	BongoSB	11	96	5	9	26	e	4037.7	6724.9	98	94	Lough	
oc12997.3	BongoSB	12	97	5	9	136	s	4042.4	6728.0	92	88	Lough	
oc12997.4	BongoSB	12	97	5	9	156	e	4041.7	6727.4	92	88	Lough	
oc12997.5	BongoSB	13	98	5	9	315	s	4046.8	6731.0	85	82	Lough	
oc12997.6	BongoSB	13	98	5	9	325	e	4046.4	6730.6	85	82	Lough	
oc12997.7	BongoSB	14	99	5	9	448	s	4051.3	6734.0	76	73	Lough	
oc12997.8	BongoSB	14	99	5	9	502	e	4050.7	6733.5	76	73	Lough	
oc12997.9	BongoSB	15	100	5	9	621	s	4055.2	6736.5	70	66	Lough	
oc12997.10	BongoSB	15	100	5	9	632	e	4054.7	6736.3	70	66	Lough	
oc12997.11	BongoSB	16	101	5	9	741	s	4059.8	6738.9	64	60	Lough	
oc12997.12	BongoSB	16	101	5	9	750	e	4059.6	6739.1	64	60	Lough	
oc12997.13	BongoSB	17	102	5	9	840	s	4105.0	6742.7	47	43	Lough	
oc12997.14	BongoSB	17	102	5	9	848	e	4104.7	6743.0	49	43	Lough	
oc12997.15	BongoSB	18	103	5	9	932	s	4108.9	6745.3	43	39	Lough	
oc12997.16	BongoSB	18	103	5	9	941	e	4108.7	6745.6	45	39	Lough	
oc12997.17	BongoSB	19	104	5	9	1102	s	4106.0	6753.4	50	46	Lough	
oc12997.18	BongoSB	19	104	5	9	1109	e	4105.9	6753.5	50	46	Lough	
oc12997.19	BongoSB	21	106	5	9	1318	s	4057.0	6752.5	57	52	Lough	
oc12997.20	BongoSB	21	106	5	9	1327	e	4057.1	6752.0	57	52	Lough	
oc12997.21	Drifter	4a	146	5	9	1350	s	4057.4	6751.6	57	33	Manning	Deployment
oc12997.22	BongoSB	20	105	5	9	1408	s	4101.9	6750.9	50	46	Lough	
oc12997.23	BongoSB	20	105	5	9	1415	e	4102.0	6750.5	50	46	Lough	
oc12997.24	BongoSB	22	107	5	9	1444	s	4052.4	6744.8	65	60	Lough	
oc12997.25	BongoSB	22	107	5	9	1456	e	4052.5	6744.0	65	60	Lough	
oc12997.26	Drifter	1a	107	5	9	1506	s	4052.6	6743.7	65	33	Manning	Deployment
oc12997.27	ZPN	3	107	5	9	1514	s	4052.6	6743.2	70	55	Runge	egg produc
oc12997.28	ZPN	3	107	5	9	1520	e	4052.6	6743.2	70	55	Campbell	
oc12997.29	Drifter	6a	108	5	9	1700	s	4048.5	6741.6	72	33	Manning	Deployment
oc12997.30	BongoSB	23	108	5	9	1711	s	4048.5	6741.6	72	67	Lough	
oc12997.31	BongoSB	23	108	5	9	1720	e	4048.3	6740.7	70	67	Lough	
oc12997.32	BongoSB	24	109	5	9	1832	s	4043.5	6739.0	77	73	Lough	
oc12997.33	BongoSB	24	109	5	9	1841	e	4043.2	6738.7	77	73	Lough	
oc12997.34	BongoSB	25	110	5	9	1943	s	4039.5	6736.4	87	85	Lough	
oc12997.35	BongoSB	25	110	5	9	1956	e	4039.2	6736.0	87	85	Lough	
oc13097.39	BongoSB	26	111	5	9	2133	s	4035.1	6733.5	101	97	Lough	
oc13097.40	BongoSB	26	111	5	9	2147	e	4034.8	6733.3	104	97	Lough	
oc12997.36	BongoSB	27	112	5	9	2330	s	4031.9	6742.2	134	137	Lough	
oc12997.37	BongoSB	27	112	5	9	2352	e	4031.8	6743.2	500	+137	Lough	
oc13097.1	BongoSB	28	113	5	10	50	s	4036.4	6745.1	85	80	Lough	
oc13097.2	BongoSB	28	113	5	10	107	e	4036.2	6745.7	85	80	Lough	
oc13097.3	BongoSB	29	114	5	10	152	s	4040.4	6747.6	79	76	Lough	
oc13097.4	BongoSB	29	114	5	10	206	e	4040.1	6747.9	79	76	Lough	
oc13097.5	BongoSB	30	115	5	10	321	s	4044.9	6750.4	73	69	Lough	
oc13097.6	BongoSB	30	115	5	10	332	e	4044.5	6750.4	73	69	Lough	
oc13097.7	BongoSB	31	116	5	10	442	s	4049.4	6753.5	68	65	Lough	
oc13097.8	BongoSB	31	116	5	10	454	e	4048.1	6754.1	68	65	Lough	
oc13097.9	BongoSB	32	117	5	10	609	s	4053.9	6756.6	58	55	Lough	
oc13097.10	BongoSB	32	117	5	10	619	e	4053.1	6756.8	58	55	Lough	
oc13097.11	BongoSB	33	118	5	10	737	s	4058.4	6759.0	54	50	Lough	
oc13097.12	BongoSB	33	118	5	10	749	e	4057.9	6759.4	54	50	Lough	
oc13097.13	BongoSB	34	119	5	10	915	s	4103.0	6802.4	43	38	Lough	
oc13097.14	BongoSB	34	119	5	10	927	e	4102.7	6803.4	42	38	Lough	
oc13097.15	BongoSB	35	120	5	10	1045	s	4159.6	6810.0	45	42	Lough	
oc13097.16	BongoSB	35	120	5	10	1055	e	4159.6	6810.7	45	42	Lough	
oc13097.17	BongoSB	36	121	5	10	1205	s	4055.3	6807.5	59	56	Lough	
oc13097.18	BongoSB	36	121	5	10	1218	e	4055.2	6807.9	59	56	Lough	
oc13097.19	BongoSB	37	122	5	10	1317	s	4050.9	6804.8	62	59	Lough	
oc13097.20	BongoSB	37	122	5	10	1327	e	4050.6	6804.7	62	59	Lough	
oc13097.21	BongoSB	38	123	5	10	1412	s	4046.4	6801.4	71	70	Lough	
oc13097.22	BongoSB	38	123	5	10	1422	e	4046.2	6801.1	71	70	Lough	
oc13097.23	BongoSB	39	123	5	10	1425	s	4046.2	6801.0	71		Lough	
oc13097.24	BongoSB	39	123	5	10	1435	e	4046.0	6800.7	71		Lough	
oc13097.25	ZPN	4	123	5	10	1443	s	4045.9	6800.4	72	50	Campbell	growth exp
oc13097.26	ZPN	4	123	5	10	1450	e	4045.9	6800.4	72	50	Campbell	
oc13097.27	ZPN	5	123	5	10	1452	s	4045.9	6800.2	72	65	Runge	egg produc
oc13097.28	ZPN	5	123	5	10	1459	e	4045.9	6800.2	72	65	Runge	
oc13097.29	ZPN	6	141	5	10	1620	e	4032.9	6823.6	92	85	Runge	
oc13097.30	BongoSB	40	124	5	10	1626	s	4041.9	6759.0	83	78	Lough	
oc13097.31	BongoSB	40	124	5	10	1638	s	4041.0	6759.2	83	78	Lough	
oc13097.32	BongoSB	41	125	5	10	1754	s	4037.3	6756.1	89	89	Lough	
oc13097.33	BongoSB	41	125	5	10	1805	s	4036.6	6756.1	90	90	Lough	
oc13097.34	ZPN	7	142	5	10	1857	e	4036.1	6825.7	65	55	Runge	
oc13097.35	BongoSB	42	126	5	10	1913	s	4032.9	6753.5	100	95	Lough	
oc13097.36	BongoSB	42	126	5	10	1928	s	4032.1	6753.5	99	95	Lough	
oc13097.37	BongoSB	43	127	5	10	2054	s	4029.8	6802.0	121	116	Lough	
oc13097.38	BongoSB	43	127	5	10	2110	s	4029.4	6802.0	124	116	Lough	
oc13097.41	BongoSB	44	128	5	10	2223	s	4034.8	6804.6	98	91	Lough	
oc13097.42	BongoSB	44	128	5	10	2240	s	4035.3	6804.4	94	91	Lough	
oc13097.43	BongoSB	45	129	5	10	2328	s	4039.0	6807.5	88	83	Lough	
oc13097.44	BongoSB	45	129	5	10	2340	s	4039.7	6807.9	85	83	Lough	
oc13197.1	BongoSB	46	130	5	11	30	s	4043.5	6810.1	74	68	Lough	
oc13197.2	BongoSB	46	130	5	11	43	s	4043.2	6810.4	74	68	Lough	
oc13197.3	BongoSB	47	131	5	11	219	s	4048.5	6813.1	51	48	Lough	
oc13197.4	BongoSB	47	131	5	11	229	s	4048.6	6813.4	51	48	Lough	
oc13197.5	BongoSB	48	132	5	11	345	s	4051.7	6816.0	47	43	Lough	
oc13197.6	BongoSB	48	132	5	11	357	s	4051.2	6816.0	47	43	Lough	
oc13197.7	BongoSB	49	133	5	11	521	s	4056.3	6818.5	48	42	Lough	
oc13197.8	BongoSB	49	133	5	11	529	s	4055.7	6818.4	48	42	Lough	
oc13197.9	BongoSB	50	134	5	11	640	s	4053.4	6826.5	52	47	Lough	

oc13197.10	BongoSB	50	134	5	11	654	s	4052.5	6826.7	52	47	Lough	
oc13197.11	BongoSB	51	135	5	11	744	s	4049.4	6824.0	49	45	Lough	
oc13197.12	BongoSB	51	135	5	11	754	s	4048.5	6824.1	49	45	Lough	
oc13197.13	BongoSB	52	136	5	11	937	s	4044.5	6821.1	58	54	Lough	
oc13197.14	BongoSB	52	136	5	11	948	s	4044.2	6820.7	58	54	Lough	
oc13197.15	BongoSB	53	137	5	11	1051	s	4040.5	6818.1	73	70	Lough	
oc13197.16	BongoSB	53	137	5	11	1103	s	4040.2	6818.1	73	70	Lough	
oc13197.17	BongoSB	54	138	5	11	1219	s	4036.0	6815.3	93	89	Lough	
oc13197.18	BongoSB	54	138	5	11	1236	s	4035.7	6815.0	93	89	Lough	
oc13197.19	BongoSB	55	139	5	11	1324	s	4031.4	6812.5	105	101	Lough	
oc13197.20	BongoSB	55	139	5	11	1343	s	4031.0	6812.1	105	101	Lough	
oc13197.21	BongoSB	56	140	5	11	1502	s	4028.4	6820.6	100	98	Lough	
oc13197.22	BongoSB	56	140	5	11	1515	s	4028.0	6820.8	100	98	Lough	
oc13197.23	BongoSB	57	141	5	11	1604	s	4032.9	6823.6	92	88	Lough	
oc13197.24	ZPN	6	141	5	11	1604	s	4032.9	6823.6	92	85	Runge	
oc13197.25	BongoSB	57	141	5	11	1620	s	4032.1	6823.5	93	88	Lough	
oc13197.26	BongoSB	58	142	5	11	1827	s	4037.4	6826.0	74	68	Lough	
oc13197.27	BongoSB	58	142	5	11	1842	s	4036.5	6826.1	76	68	Lough	
oc13197.28	ZPN	7	142	5	11	1851	s	4036.3	6825.9	65	55	Runge	
oc13197.29	BongoSB	59	143	5	11	2056	s	4041.8	6829.1	60	57	Lough	
oc13197.30	BongoSB	59	143	5	11	2107	s	4041.1	6829.3	64	57	Lough	
oc13197.31	BongoSB	60	144	5	11	2217	s	4046.0	6832.1	57	50	Lough	
oc13197.32	BongoSB	60	144	5	11	2217	s	4045.6	6832.4	51	50	Lough	
oc13197.33	BongoSB	61	145	5	11	2330	s	4050.4	6834.6	58	53	Lough	
oc13197.34	BongoSB	61	145	5	11	2340	s	4050.2	6834.8	58	53	Lough	
oc13297.1	Drifter	4a	146	5	12	523	s	4047.3	6801.0	70	33	Manning	Recovery
oc13297.2	BongoSB	62	146	5	12	631	s	4047.2	6800.9	71	67	Lough	
oc13297.3	BongoSB	62	146	5	12	645	s	4046.5	6801.1	71	67	Lough	
oc13297.4	BongoSB	63	147	5	12	723	s	4049.6	6748.9	68	64	Lough	
oc13297.5	BongoSB	63	147	5	12	735	s	4049.1	6749.1	68	64	Lough	
oc13297.6	BongoSB	64	148	5	12	836	s	4051.7	6749.8	65	62	Lough	
oc13297.7	BongoSB	64	148	5	12	845	s	4051.5	6749.9	65	62	Lough	
oc13297.8	BongoSB	65	149	5	12	905	s	4054.4	6750.1	63	60	Lough	
oc13297.9	BongoSB	65	149	5	12	912	s	4054.3	6750.1	63	60	Lough	
oc13297.10	BongoSB	66	150	5	12	932	s	4057.0	6751.0	58	55	Lough	
oc13297.11	BongoSB	66	150	5	12	939	s	4056.9	6750.9	58	55	Lough	
oc13297.12	Drifter	6a		5	12	1133	s	4050.4	6735.9	74	33	Manning	Recovery
oc13297.13	BongoSB	67	151	5	12	1139	s	4050.4	6736.0	74	70	Lough	
oc13297.14	BongoSB	67	151	5	12	1150	s	4050.1	6736.3	74	70	Lough	
oc13297.15	BongoSB	68	152	5	12	1426	s	4051.0	6752.4	67	64	Lough	
oc13297.16	BongoSB	68	152	5	12	1436	s	4050.8	6752.3	67	64	Lough	
oc13297.17	Drifter	234a	154	5	12	1440	s	4056.6	6755.0	57	13	Manning	Deployment
oc13297.18	Drifter	6b	154	5	12	1445	s	4056.6	6755.0	57	33	Manning	Deployment
oc13297.19	Drifter	200a	155	5	12	1610	s	4050.4	6747.4	67	13	Manning	Deployment
oc13297.20	BongoSB	69	153	5	12	1616	s	4054.7	6754.2	60	56	Lough	
oc13297.21	BongoSB	69	153	5	12	1626	s	4054.3	6753.7	60	56	Lough	
oc13297.22	BongoSB	70	154	5	12	1741	s	4057.4	6755.5	57	52	Lough	
oc13297.23	BongoSB	70	154	5	12	1751	s	4057.9	6754.7	58	52	Lough	
oc13297.24	BongoSB	71	155	5	12	2016	s	4050.4	6747.3	67	63	Lough	
oc13297.25	BongoSB	71	155	5	12	2031	s	4050.0	6746.3	68	63	Lough	
oc13297.26	BongoSB	72	155	5	12	2036	s	4049.9	6746.0	65	61	Lough	
oc13297.27	BongoSB	72	155	5	12	2047	s	4049.6	6745.3	69	61	Lough	
oc13297.28	BongoSB	73	155	5	12	2116	s	4049.0	6744.0	70	63	Lough	
oc13297.29	BongoSB	73	155	5	12	2127	s	4048.7	6743.3	67	63	Lough	
oc13397.1	MOC1	137	155	5	13	216	s	4049.7	6748.2	68	60	Lough	
oc13397.2	MOC1	137	155	5	13	254	e	4049.6	6746.9	67	60	Lough	
oc13397.3	MOC1	138	155	5	13	910	s	4048.7	6747.2	69	60	Lough	
oc13397.4	MOC1	138	155	5	13	1019	e	4046.9	6745.6	67	60	Lough	
oc13397.5	Pump/CTD	2	155	5	13	1130	s	4048.7	6747.8	70	60	Campb/Inzce	Pump 75
oc13397.6	Pump/CTD	2	155	5	13	1343	e	4051.1	6748.0	63	60	Campb/Incze	
oc13397.7	BongoSB	74	155	5	13	1415		4050.3	6749.5	67	64	Durbin	
oc13397.8	BongoSB	74	155	5	13	1426		4050.2	6748.7	67	64	Durbin	
oc13397.9	BongoSB	75	155	5	13	1443		4050.2	6748.2	69	65	Durbin	
oc13397.10	BongoSB	75	155	5	13	1453		4050.2	6747.9	69	65	Durbin	
oc13397.11	BongoSB	76	155	5	13	1458		4050.1	6747.5	69	65	Durbin	
oc13397.12	BongoSB	76	155	5	13	1508		4050	6747.1	69	65	Durbin	
oc13397.13	ZPN	8	155	5	13	1547	s	4052.1	6749.4	61	40	Campbell	growth expe
oc13397.14	ZPN	8	155	5	13	1553	e	4052.2	6749.3	61	40	Campbell	
oc13397.15	ZPN	9	155	5	13	1556	s	4052.3	6749.4	61	50	Runge	egg product
oc13397.16	ZPN	9	155	5	13	1605	e	4052.3	6749.2	61	50	Runge	
oc13397.17	MOC1	139	155	5	13	1701	s	4053.0	6748.2	63	60	Lough	
oc13397.18	MOC1	139	155	5	13	1815	e	4053.1	6744.4	67	60	Lough	
oc13397.19	SeabrCTD	77	156	5	13	2222	s	4043.5	6744.6	72	68	Manning	
oc13397.20	SeabrCTD	77	156	5	13	2228	e	4043.4	6744.7	73	68	Manning	
oc13397.21	SeabrCTD	78	157	5	13	2246	s	4045.5	6746.4	70	66	Manning	
oc13397.22	SeabrCTD	78	157	5	13	2252	e	4045.5	6746.5	70	66	Manning	
oc13397.23	SeabrCTD	79	158	5	13	2308	s	4047.7	6748.2	70	66	Manning	
oc13397.24	SeabrCTD	79	158	5	13	2315	e	4047.6	6748.4	70	66	Manning	
oc13397.25	SeabrCTD	80	159	5	13	2332	s	4049.7	6749.9	67	64	Manning	
oc13397.26	SeabrCTD	80	159	5	13	2339	e	4049.8	6750.0	67	64	Manning	
oc13497.1	SeabrCTD	81	160	5	14	0	s	4051.4	6752.5	65	62	Manning	
oc13497.2	SeabrCTD	81	160	5	14	7	e	4051.4	6752.7	65	62	Manning	
oc13497.3	SeabrCTD	82	154	5	14	29	s	4052.8	6754.6	65	62	Manning	
oc13497.4	SeabrCTD	82	154	5	14	36	e	4052.8	6754.8	65	62	Manning	
oc13497.5	MOC1	140	154	5	14	56	s	4052.8	6754.9	64	50	Lough	
oc13497.6	MOC1	140	154	5	14	144	e	4052.8	6754.9	64	50	Lough	
oc13497.7	MOC1	141	154	5	14	540	s	4055.6	6756.1	58	50	Lough	
oc13497.8	MOC1	141	154	5	14	615	e	4055.6	6756.1	58	50	Lough	
oc13497.9	Pump/CTD	3	154	5	14	804	s	4054.4	6754.2	60	60	Incze	Pump 76
oc13497.10	Pump/CTD	3	154	5	14	907	e	4053.3	6753.3	62	60	Camp/Incze	

oc13497.11	Pump/CTD	4	155	5	14	1125	s	4048.0	6748.6	66	60	Camp/Incze	Pump 77
oc13497.12	Pump/CTD	4	155	5	14	1231	e	4047.4	6750.1	64	60	Camp/Incze	
oc13497.13	BongoSB	83	155	5	14	1436	s	4048.6	6752.4	70	65	Durbin	
oc13497.14	BongoSB	83	155	5	14	1449	e	4048.3	6752.3	70	65	Durbin	
oc13497.15	BongoSB	84	155	5	14	1457	s	4048.1	6752.3	69	65	Durbin	
oc13497.16	BongoSB	84	155	5	14	1457	e	4048.1	6752.3	69	65	Durbin	
oc13497.17	BongoSB	85	155	5	14	1513	s	4047.7	6752.5	69	65	Durbin	
oc13497.18	BongoSB	85	155	5	14	1525	e	4047.5	6752.5	69	65	Durbin	
oc13497.19	ZPN	10	155	5	14	1600	s	4050.5	6750.9	66	50	Durbin	RNA/DNA ana
oc13497.20	ZPN	10	155	5	14	1606	e	4050.5	6750.9	66	50	Durbin	
oc13497.21	ZPN	11	155	5	14	1613	s	4050.6	6750.9	66	40	Runge	egg product
oc13497.22	ZPN	11	155	5	14	1619	e	4050.6	6750.9	66	40	Runge	
oc13497.23	MOC1/4	142	155	5	14	1740	s	4050.7	6750.8	69	60	Lough	
oc13497.24	MOC1/4	142	155	5	14	1811	e	4049.8	6750.6	69	60	Lough	
oc13497.25	MOC1	143	155	5	14	1906	s	4052.9	6749.4	66	60	Lough	
oc13497.26	MOC1	143	155	5	14	2025	e	4050.2	6749.0	67	60	Lough	
oc13497.27	Pump/CTD	5	155	5	14	2120	s	4050.7	6747.7	68	60	Incze/M	Pump 78
oc13497.28	Pump/CTD	5	155	5	14	2221	e	4050.3	6746.8	68	60	Incze/M	
oc13597.1	MOC1	144	155	5	15	30	s	4048.3	6748.0	70	60	Lough	
oc13597.2	MOC1	144	155	5	15	126	e	4048.3	6748.0	67	60	Lough	
oc13597.3	MOC1/4	145	155	5	15	608	s	4052.3	6752.0	62	60	Lough	
oc13597.4	MOC1/4	145	155	5	15	631	e	4051.6	6752.0	64	60	Lough	
oc13597.5	MOC1	146	155	5	15	908	s	4050.1	6750.8	68	60	Lough	
oc13597.6	MOC1	146	155	5	15	1037	e	4047.7	6748.7	68	60	Lough	
oc13597.7	Drifter	1a	155	5	15	1115	s	4048.5	6751.7	70	33	Manning	Recovery
oc13597.8	Drifter	4b	155	5	15	1117	s	4048.5	6751.7	70	33	Manning	Deployment
oc13597.9	Pump/CTD	6	155	5	15	1145	s	4048.3	6751.9	70	60	Incze/Camp	Pump 79
oc13597.10	Pump/CTD	6	155	5	15	1320	e	4049.2	6752.6	70	60	Incze/Camp	
oc13597.11	BongoSB	86	155	5	15	1418	s	4048.2	6753.7	72	68	Durbin	
oc13597.12	BongoSB	86	155	5	15	1433	e	4048.2	6753.3	72	68	Durbin	
oc13597.13	BongoSB	87	155	5	15	1437	s	4048.1	6753.1	71	65	Durbin	
oc13597.14	BongoSB	87	155	5	15	1451	e	4048.0	6752.7	71	65	Durbin	
oc13597.15	BongoSB	88	155	5	15	1454	s	4048.0	6752.5	69	65	Durbin	
oc13597.16	BongoSB	88	155	5	15	1510	e	4047.8	6752.0	69	65	Durbin	
oc13597.17	ZPN	12	155	5	15	1605	s	4049.7	6755.9	65	50	Runge	egg product
oc13597.18	ZPN	12	155	5	15	1610	e	4049.7	6755.9	65	50	Runge	
oc13597.19	ZPN	13	155	5	15	1612	s	4049.7	6755.9	65	50	Campbell	mesocosm 15
oc13597.20	ZPN	13	155	5	15	1618	e	4049.8	6755.9	65	50	Campbell	
oc13597.21	ZPN	14	155	5	15	1621	s	4049.9	6755.9	65	50	Campbell	mesocosm 10
oc13597.22	ZPN	14	155	5	15	1627	e	4050.1	6755.9	65	50	Campbell	
oc13597.23	MOC1/4	147	154	5	15	1740	s	4057.2	6759.9	52	40	Lough	
oc13597.24	MOC1/4	147	154	5	15	1812	e	4056.1	6759.6	52	40	Lough	
oc13597.25	MOC1	148	154	5	15	1900	s	4058.7	6758.2	57	50	Lough	
oc13597.26	MOC1	148	154	5	15	2016	e	4057.1	6755.6	58	50	Lough	
oc13697.1	Drifter	6b	154	5	16	7	s	4050.9	6755.1	61	33	Manning	Recovery
oc13697.2	Drifter	1b	154	5	16	8	s	4050.9	6755.1	61	33	Manning	Deployment
oc13697.3	MOC1/4	149	154	5	16	557	s	4052.7	6800.3	53	40	Lough	
oc13697.4	MOC1/4	149	154	5	16	627	e	4052.7	6759.0	53	40	Lough	
oc13697.5	SeabrCTD	89	161	5	16	1039	s	4057.6	6804.9	44	40	Manning	
oc13697.6	SeabrCTD	89	161	5	16	1045	e	4057.3	6804.9	43	40	Manning	
oc13697.7	SeabrCTD	90	162	5	16	1129	s	4053.6	6800.3	49	45	Manning	
oc13697.8	SeabrCTD	90	162	5	16	1135	e	4053.4	6800.3	49	45	Manning	
oc13697.9	SeabrCTD	91	163	5	16	1217	s	4049.4	6755.5	70	66	Manning	
oc13697.10	SeabrCTD	91	163	5	16	1230	e	4049.3	6755.3	70	66	Manning	
oc13697.11	SeabrCTD	92	164	5	16	1320	s	4045.1	6750.7	75	70	Manning	
oc13697.12	SeabrCTD	92	164	5	16	1329	e	4045.0	6750.6	75	70	Manning	
oc13697.13	SeabrCTD	93	165	5	16	1412	s	4041.0	6746.0	77	71	Manning	
oc13697.14	SeabrCTD	93	165	5	16	1424	e	4040.8	6745.9	77	71	Manning	
oc13697.15	Pump/CTD	7	155	5	16	1650	s	4047.2	6759.6	72	60	Incze/Camp	Pump 80
oc13697.16	Pump/CTD	7	155	5	16	1826	e	4046.7	6759.0	72	60	Incze/Camp	
oc13697.17	BongoSB	94	155	5	16	1922	s	4046.1	6759.5	70	65		
oc13697.18	BongoSB	94	155	5	16	1933	e	4045.6	6759.3	73	65		
oc13697.19	BongoSB	95	155	5	16	1940	s	4045.3	6759.3	76	70		
oc13697.20	BongoSB	95	155	5	16	1951	e	4044.9	6759.2	77	70		
oc13697.21	BongoSB	96	155	5	16	1957	s	4044.7	6759.2	77	73		
oc13697.22	BongoSB	96	155	5	16	2011	e	4044.3	6759.0	77	73		
oc13697.23	ZPN	15	155	5	16	2125	s	4048.7	6757.9	69	50	Campbell	Growth #6
oc13697.24	ZPN	15	155	5	16	2130	e	4048.7	6757.9	69	50	Campbell	
oc13797.1	BongoSB	97	166	5	17	531	s	4042.5	6800.2	81	78	Manning	
oc13797.2	BongoSB	97	166	5	17	536	e	4042.4	6800.2	81	78	Manning	
oc13797.3	BongoSB	98	167	5	17	549	s	4043.7	6800.2	77	73	Manning	
oc13797.4	BongoSB	98	167	5	17	553	e	4043.8	6800.2	77	73	Manning	
oc13797.5	BongoSB	99	168	5	17	609	s	4045.7	6800.2	73	72	Manning	
oc13797.6	BongoSB	99	168	5	17	616	e	4045.7	6800.1	73	72	Manning	
oc13797.7	BongoSB	100	169	5	17	631	s	4047.8	6800.3	70	67	Manning	
oc13797.8	BongoSB	100	169	5	17	638	e	4047.9	6800.3	70	67	Manning	
oc13797.9	BongoSB	101	170	5	17	655	s	4050.2	6800.5	66	62	Manning	
oc13797.10	BongoSB	101	170	5	17	702	e	4050.3	6800.4	66	62	Manning	
oc13797.11	MOC1	150	154	5	17	843	s	4049.3	6802.7	63	60	Lough	
oc13797.12	MOC1	150	154	5	17	1011	e	4046.2	6802.0	72	60	Lough	
oc13797.13	Pump/CTD	8	154	5	17	1102	s	4047.7	6801.0	70	60	Incze	Pump 81
oc13797.14	Pump/CTD	8	154	5	17	1222	e	4046.9	6759.8	70	60	Incze	
oc13797.15	Pump/CTD	9	155	5	17	1257	s	4044.8	6801.0	75	50	Incze	Pump 82
oc13797.16	Pump/CTD	9	155	5	17	1403	e	4044.6	6800.6	75	50	Incze	
oc13797.17	BongoSB	102	155	5	17	1440	s	4043.9	6802.5	77	72		
oc13797.18	BongoSB	102	155	5	17	1453	e	4043.6	6802.5	77	72		
oc13797.19	BongoSB	103	155	5	17	1458	s	4043.4	6802.5	77	73		
oc13797.20	BongoSB	103	155	5	17	1511	e	4043.0	6802.5	77	73		
oc13797.21	BongoSB	104	155	5	17	1515	s	4042.9	6802.5	78	73		
oc13797.22	BongoSB	104	155	5	17	1529	e	4042.5	6802.5	78	73		
oc13797.23	ZPN	16	155	5	17	1550	s	4044.1	6803.6	77	70	Runge	egg product

oc13797.24	ZPN	16	155	5	17	1556	e	4044.3	6803.6	77	70	Runge	
oc13797.25	ZPN	17	155	5	17	1557	s	4044.3	6803.6	77	70	Campbell	growth #7
oc13797.26	ZPN	17	155	5	17	1603	e	4044.5	6803.6	77	70	Campbell	
oc13797.27	MOC1/4	151	155	5	17	1632	s	4044.6	6803.7	77	70	Lough	
oc13797.28	MOC1/4	151	155	5	17	1709	e	4044.3	6805.3	75	70	Lough	
oc13797.29	MOC1	152	155	5	17	1819	s	4046.4	6805.6	67	60	Lough	
oc13797.30	MOC1	152	155	5	17	1936	e	4045.1	6805.5	72	60	Lough	
oc13797.31	Pump/CTD	10	155	5	17	2034	s	4047.3	6805.2	65	50	Incze	Pump 83
oc13797.32	Pump/CTD	10	155	5	17	2145	e	4047.4	6803.7	65	50	Incze	
oc13897.1	MOC1	153	155	5	18	237	s	4043.4	6805.3	77	60	Lough	
oc13897.2	MOC1	153	155	5	18	339	e	4041.4	6806.8	81	60	Lough	
oc13897.3	Drifter	234a	154	5	18	946	s	4042.1	6803.0	80	13	Manning	Recovery
oc13897.4	Drifter	200a	155	5	18	1015	s	4040.5	6802.6	85	13	Manning	Recovery
oc13897.5	BongoSB	105	155	5	18	1101		4040.5	6802.5	85	81	Lough	
oc13897.6	BongoSB	105	155	5	18	1108		4040.4	6802.5	85	81	Lough	
oc13897.7	Pump/CTD	11	155	5	18	1215	s	4044.4	6809.6	70	50	Camp/Incze	Pump 84
oc13897.8	Pump/CTD	11	155	5	18	1332	e	4042.7	6808.8	72	50	Campbell/Incze	
oc13897.9	BongoSB	106	155	5	18	1402		4042.5	6810.1	76	71	Lough	
oc13897.10	BongoSB	106	155	5	18	1418		4042.7	6810.7	76	71	Lough	
oc13897.11	BongoSB	107	155	5	18	1425		4041.8	6811.0	77	73	Lough	
oc13897.12	BongoSB	107	155	5	18	1437		4041.4	6811.4	77	73	Lough	
oc13897.13	BongoSB	108	155	5	18	1442		4041.3	6811.6	78	73	Lough	
oc13897.14	BongoSB	108	155	5	18	1456		4040.9	6812.1	78	73	Lough	
oc13897.15	ZPN	18	155	5	18	1515	s	4041.7	6811.2	72	60	Runge/Camp	egg product
oc13897.16	ZPN	18	155	5	18	1520	e	4041.6	6811.3	72	60	Runge/Camp	
oc13897.17	Drifter	1b	154	5	18	1550	s	4041.4	6811.4	79	33	Manning	Recovery
oc13897.18	ZPN	19	171	5	18	1635	s	4036.5	6808.1	95	85	Runge/Camp	egg product
oc13897.19	ZPN	19	171	5	18	1644	e	4036.5	6808.1	95	85	Runge/Camp	
oc13897.20	MOC1	154	171	5	18	1707	s	4037.0	6806.9	93	80	Lough	
oc13897.21	MOC1	154	171	5	18	1851	e	4035.6	6810.4	95	80	Lough	
oc13897.22	Pump/CTD	12	171	5	18	1941	s	4036.7	6807.7	93	50	Camp/Incze	Pump 85
oc13897.23	Pump/CTD	12	171	5	18	2120	e	4037.3	6806.2	91	50	Campbell/Incze	
oc13897.24	Seabird	109	172	5	18	2304		4031.2	6816.7	97	95	Lough	
oc13897.25	Seabird	109	172	5	18	2313		4031.1	6816.4	97	95	Lough	
oc13997.1	Seabird	110	173	5	19	32		4038.2	6819.8	78	73	Lough	
oc13997.2	Seabird	110	173	5	19	40		4038.2	6819.7	78	73	Lough	
oc13997.3	Seabird	111	174	5	19	103		4040.7	6821.7	67	65	Lough	
oc13997.4	Seabird	111	174	5	19	111		4040.5	6821.7	67	65	Lough	
oc13997.5	Seabird	112	175	5	19	141		4042.8	6823.6	59	58	Lough	
oc13997.6	Seabird	112	175	5	19	149		4042.7	6823.6	59	58	Lough	
oc13997.7	Seabird	113	176	5	19	219		4046	6825.1	54	50	Lough	
oc13997.8	Seabird	113	176	5	19	226		4045.9	6825.1	54	50	Lough	
oc13997.9	Seabird	114	177	5	19	316		4052.5	6830.0	42	39	Lough	
oc13997.10	Seabird	114	177	5	19	322		4052.6	6830.2	42	39	Lough	
oc13997.11	MOC1	155	178	5	19	500	s	4050.2	6816.8	50	40	Lough	
oc13997.12	MOC1	155	178	5	19	547	e	4050.0	6816.8	49	40	Lough	
oc13997.13	Pump/CTD	13	178	5	19	1000	s	4050.5	6817.0	48	43	Camp/Incze	Pump 86
oc13997.14	Pump/CTD	13	178	5	19	1114	e	4051.4	6815.0	54	43	Camp/Incze	
oc13997.15	ZPN	20	178	5	19	1132	s	4051.4	6814.5	49	40	Runge/Camp	egg product
oc13997.16	ZPN	20	178	5	19	1136	e	4051.4	6814.5	49	40	Runge/Camp	
oc13997.17	Seabird	115	179	5	19	1430		4040.4	6821.8	70	66	Lough	
oc13997.18	Seabird	115	179	5	19	1439		4040.4	6821.7	70	66	Lough	
oc13997.19	Seabird	116	180	5	19	1531		4044.6	6826.0	55	52	Lough	
oc13997.20	Seabird	116	180	5	19	1539		4044.6	6826.1	55	52	Lough	
oc13997.21	Drifter	6c	180	5	19	1542	s	4044.6	6826.1	55	33	Manning	Deployment
oc13997.22	Drifter	234b	180	5	19	1545	s	4044.6	6826.1	55	13	Manning	Deployment
oc13997.23	Drifter	1c	181	5	19	1628	s	4040.4	6822.0	70	33	Manning	Deployment
oc13997.24	Drifter	200b	181	5	19	1631	s	4040.4	6822.0	70	13	Manning	Deployment
oc13997.25	Pump/CTD	14	181	5	19	1700	e	4040.5	6822.2	70	60	Camp/Incze	
oc13997.26	Pump/CTD	14	181	5	19	1700	s	4040.5	6822.2	70	60	Camp/In	Pump 87
oc13997.27	ZPN	21	181	5	19	1901	s	4040.6	6821.9	68	50	Campbell	Pete'sMess
oc13997.28	ZPN	21	181	5	19	1906	e	4040.6	6821.9	68	50	Campbell	
oc13997.29	MOC1	156	181	5	19	1939	s	4041.1	6821.6	68	60	Lough	trouble
oc13997.30	MOC1	156	181	5	19	2111	e	4039.4	6822.5	72	60	Lough	
oc13997.31	MOC1	157	180	5	19	2330	s	4045.0	6826.0	58	50	Lough	
oc14097.1	MOC1	157	180	5	20	59	e	4043.6	6823.1	60	50	Lough	
oc14097.2	Pump/CTD	15	180	5	20	207	s	4044.4	6825.8	50	40	Camp/Incze	Pump 88
oc14097.3	Pump/CTD	15	180	5	20	316	e	4043.5	6826.1	50	40	Camp/Incze	
oc14097.4	Pump/CTD	16	182	5	20	446	s	4048.5	6828.4	60	50	Incze	Pump 89
oc14097.5	MOC1	158	182	5	20	637	s	4050.2	6828.2	45	50	Lough	
oc14097.6	MOC1	158	182	5	20	733	e	4049.8	6828.8	61	50	Lough	
oc14097.7	MOC1	159	180	5	20	1027	s	4045.4	6825.3	55	50	Lough	
oc14097.8	Pump/CTD	16	182	5	20	1101	e	4049.3	6829.3	54	50	Incze	
oc14097.9	MOC1	159	180	5	20	1159	e	4042.8	6826.1	60	50	Lough	
oc14097.10	Pump/CTD	17	180	5	20	1252	s	4044.5	6825.5	60	50	Incze	Pump 90
oc14097.11	Pump/CTD	17	180	5	20	1342	e	4043.8	6824.6	61	50	Incze	
oc14097.12	Pump/CTD	18	181	5	20	1446	s	4040.2	6821.8	65	50	Incze	Pump 91
oc14097.13	Pump/CTD	18	181	5	20	1536	e	4039.5	6822.0	68	50	Incze	
oc14097.14	ZPN	22	181	5	20	1554	s	4039.2	6822.1	73	55	Runge	Egg Product
oc14097.15	ZPN	22	181	5	20	1600	e	4039.2	6822.2	73	55	Runge	
oc14097.16	ZPN	23	181	5	20	1603	s	4039.1	6822.2	73	55	Campbell	
oc14097.17	ZPN	23	181	5	20	1608	e	4039.1	6822.2	73	55	Campbell	
oc14097.18	MOC1	160	181	5	20	1712	s	4041.7	6821.5	67	60	Lough	
oc14097.19	MOC1	160	181	5	20	1840	e	4040.2	6824.8	67	60	Lough	
oc14097.20	MOC1	161	183	5	20	2159	s	4035.7	6820.4	87	80	Lough	
oc14097.21	MOC1	161	183	5	20	2349	e	4032.6	6818.3	97	80	Lough	
oc14197.1	Pump/CTD	19	183	5	21	39	s	4034.9	6819.9	85	55	Incze	Pump 92
oc14197.2	Pump/CTD	19	183	5	21	126	e	4034.6	6818.9	87	55	Incze	
oc14197.3	Seabird	117	184	5	21	248		4034.7	6830.1	75	70	Lough	
oc14197.4	Seabird	117	184	5	21	258		4034.5	6830.2	75	70	Lough	

oc14197.5	Seabird	118	185	5	21	357		4040.3	6834.6	59	55	Lough	
oc14197.6	Seabird	118	185	5	21	406		4040.1	6834.6	59	55	Lough	
oc14197.7	Seabird	119	186	5	21	426		4038.4	6834.0	60	56	Lough	
oc14197.8	Seabird	119	186	5	21	433		4038.2	6834.1	60	56	Lough	
oc14197.9	Seabird	120	187	5	21	443		4037.4	6833.8	65	60	Lough	
oc14197.10	Seabird	120	187	5	21	450		4037.3	6833.9	65	60	Lough	
oc14197.11	MOC1	162	183	5	21	908	s	4035.2	6820.2	89	80	Lough	
oc14197.12	MOC1	162	183	5	21	1058	e	4032.5	6820.8	96	80	Lough	
oc14197.13	Pump/CTD	20	183	5	21	1210	s	4034.8	6819.8	90	65	Incze	Pump 93
oc14197.14	Pump/CTD	20	183	5	21	1210	e	4034.8	6819.8	90	65	Incze	
oc14197.15	ZPN	24	183	5	21	1320	s	4035.0	6819.9	93	65	Runge	Egg Product
oc14197.16	ZPN	24	183	5	21	1326	e	4034.8	6819.9	93	65	Runge	
oc14197.17	ZPN	25	183	5	21	1333	s	4034.6	6819.8	93	50	Campbell	Pteropods
oc14197.18	ZPN	25	183	5	21	1340	e	4034.4	6819.7	93	50	Campbell	
oc14197.19	BongoSB	121	183	5	21	1402		4033.7	6819.3	94	91	Lough	
oc14197.20	BongoSB	121	183	5	21	1420		4033.1	6819.8	94	91	Lough	
oc14197.21	BongoSB	122	180	5	21	1548		4044.5	6826.2	60	56	Lough	
oc14197.22	BongoSB	122	180	5	21	1606		4043.8	6826.8	60	56	Lough	
oc14197.23	BongoSB	123	180	5	21	1616		4043.5	6827.1	58	53	Lough	
oc14197.24	BongoSB	123	180	5	21	1623		4043.2	6827.4	60	53	Lough	
oc14197.25	ZPN	26	180	5	21	1643	s	4044.7	6826.3	58	50	Campbell	RNA/DNA CN
oc14197.26	ZPN	26	180	5	21	1649	e	4044.6	6826.2	58	50	Campbell	
oc14197.27	Pump/CTD	21	180	5	21	1703	s	4044.4	6826.3	52	52	Incze	Pump 94
oc14197.28	Pump/CTD	21	180	5	21	1748	e	4044.1	6826.5	52	52	Incze	
oc14197.29	MOC1	163	180	5	21	1934	s	4045.2	6824.2	56	40	Lough	
oc14197.30	MOC1	163	180	5	21	2055	e	4046.1	6827.9	59	40	Lough	
oc14297.1	Pump/CTD	22	182	5	22	12	s	4048.5	6828.5	60	50	Incze	Pump 95
oc14197.2	Pump/CTD	22	182	5	21	52	e	4048.0	6826.8	60	50	Incze	
oc14297.3	MOC1	164	182	5	22	124	s	4048.0	6828.2	55	40	Lough	
oc14297.4	MOC1	164	182	5	22	214	e	4044.9	6827.7	54	40	Lough	
oc14297.5	Drifter	6c	180	5	22	515	e	4042.2	6829.5	60	33	Manning	Recovery
oc14297.6	Drifter	4b	155	5	22	700	e	4031.7	6838.3	75	33	Manning	Recovery
oc14297.7	Drifter	1c	181	5	22	740	e	4031.6	6845.6	71	33	Manning	Recovery
oc14297.8	Drifter	234b	180	5	22	823	e	4037.2	6842.7	60	13	Manning	Recovery
oc14297.9	Drifter	200b	181	5	22	924	e	4031.3	6849.3	71	13	Manning	Recovery
oc14297.10	Seabird	124	188	5	22	1303	s	4051.1	6848.5	67	64	Lough	
oc14297.11	Seabird	124	188	5	22	1314	e	4051.0	6848.2	67	64	Lough	
oc14297.12	Seabird	125	189	5	22	1335	s	4051.3	6844.6	67	63	Lough	
oc14297.13	Seabird	125	189	5	22	1344	e	4051.1	6844.3	67	63	Lough	
oc14297.14	Seabird	126	190	5	22	1406	s	4051.6	6839.7	60	57	Lough	
oc14297.15	Seabird	126	190	5	22	1415	e	4051.4	6839.4	60	57	Lough	
oc14297.16	Seabird	127	191	5	22	1452	s	4051.9	6835.1	56	54	Lough	
oc14297.17	Seabird	127	191	5	22	1500	e	4051.6	6834.9	56	54	Lough	
oc14297.18	Seabird	128	192	5	22	1522	s	4051.9	6830.4	52	51	Lough	
oc14297.19	Seabird	128	192	5	22	1530	e	4051.6	6830.2	52	51	Lough	
oc14297.20	Seabird	129	193	5	22	1555	s	4048.5	6834.1	57	54	Lough	
oc14297.21	Seabird	129	193	5	22	1600	e	4048.2	6834.1	56	54	Lough	
oc14297.22	Seabird	130	194	5	22	1620	s	4045.3	6837.4	57	54	Lough	
oc14297.23	Seabird	130	194	5	22	1624	e	4045.1	6837.5	59	54	Lough	
oc14297.24	Seabird	131	195	5	22	1646	s	4042.1	6840.4	64	61	Lough	
oc14297.25	Seabird	131	195	5	22	1651	e	4041.8	6840.5	64	61	Lough	
oc14297.26	Seabird	132	196	5	22	1753	s	4033.3	6849.0	66	64	Lough	
oc14297.27	Seabird	132	196	5	22	1757	e	4033.3	6849.0	66	64	Lough	
oc14297.28	ZPN	27	196	5	22	1805	s	4033.3	6849.0	69	60	Campbell	Live Animals
oc14297.29	ZPN	27	196	5	22	1811	e	4033.3	6849.0	69	60	Campbell	

Appendix II. List of Personnel

Dr. R. Gregory Lough, NOAA, Ch. Scientist
Mr. James P. Manning, NOAA
Ms. Elizabeth A. Broughton, NOAA
Ms. Marie E. Kiladis, NOAA
Ms. Nancy J. McHugh, NOAA
Ms. Elaine M. Caldarone, NOAA
Ms. Jeanne M. Burns, NOAA
Mr. Michael S. Morss, University of Rhode Island
Dr. Robert G. Campbell, University of Rhode Island
Mr. Peter Garrahan, University of Rhode Island
Ms. Milissa Wagner, University of Rhode Island
Mr. Pierre Joly, Institut Maurice-Lamontagne
Ms. Luciene Chenard, Institut Maurice-Lamontagne
Dr. Lewis S. Incze, Bigelow Laboratory for Ocean Science
Ms. Elizabeth Novak, Bigelow Laboratory for Ocean Science
Ms. Kate L. Pickle, Maine Maritime Academy
Ms. Laura J. Sharpe, Maine Maritime Academy
Mr. Clifford Heil, Maine Maritime Academy

Appendix III. Maps of Haul Locations

Figures 30-35 depict the geographic location of each haul or cast. Figure 30, for example, shows the position of each zooplankton net tow. The remaining figures give positions for Seabird 911 cast , 1/4-m^2 MOCNESS hauls, 1-m^2 MOCNESS hauls, Bongo hauls conducted subsequent to the grid surveys, and and the extra Seabird 19 cast.

Appendix IV. List of Figures with captions

Figure 1. OC303 Cruise track.

Figure 2. Four phases of cruise track/operations including intial bongo survey (6-8 May), fine-scale bongo survey (9-11 May), drifter following at stations 154 & 155 (12-17 May), and excursions in the vicinity of the mooring line (18-22 May).

Figure 3. Summary of drifter tracks during OC303: cluster 1. The three drifters (33m drogues) were deployed across bank and converged to be along-bank.

Figure 4. Summary of drifter tracks during OC303: cluster 2. Four drifters, two on either side of the tidal front, converged towards the front. The shallow (13m) pair moved quickly towards the southwest.

Figure 5. Summary of drifter tracks during OC303: cluster 3. Four drifters (similar to cluster 2) were deployed. The deeper (33m) on the onbank side of the tidal front was retained while the others moved quickly towards the southwest and met with drifter 4b.

Figure 6. Raw salinity record from OCEANUS SAIL system. Note the frequent dropouts.

Figure 7. Raw data from hull mounted thermistors. Air temperature is the lower line with scale on the left and seasurface temp is the upper line with scale on the right axis.

Figure 8. Barometric pressure and short wave radiation.

Figure 9. Wind as observed at nearby NOAA buoy 44011.

Figure 10. Station numbers for fine-scale bongo grid.

Figure 11. Surface (top) and bottom (bottom) temperature from Seabird model 19 on the fine scale bongo grid.

Figure 12. Surface (top) and bottom (bottom) temperature anomaly from Seabird model 19 on the fine scale bongo grid.

Figure 13. Surface (top) and bottom (bottom) salinity from Seabird model 19 on the fine scale bongo grid.

Figure 14. Surface (top) and bottom (bottom) salinity anomaly from Seabird model 19 on the fine scale bongo grid.

Figure 15. Temperature cross-sections during the fine-scale bongo grid.

Figure 16. Salinity cross-sections during the fine-scale bongo grid.

Figure 17. Detail cross-section #2 during the fine-scale bongo grid including temperature, salinity, and sigma-t (sta 104-111).

Figure 18. Temperature and salinity profiles for individual SEABIRD Model 911 cast.

Figure 19. Fluoresence and transmisometer profiles for individual SEABIRD Model 911 cast.

Figure 20. Time series of water column structure observed at drifting site 155 including wind and air temp (from NOAA buoy 11), temperature and sigmat contours from 8 CTD casts, and index of stratification.

Figure 21. Satellite seasurface temperature image for 11 May 1997 showing a) the cruise track of fine-scale grid and b) bands of remnant Scotian Shelf-like water (2-4 C). The large feature off-bank is a Gulf Stream Ring.

Figure 22. A series of three satellite images 8-24 May showing the evolution of the Gulf Stream Ring activity on the off-bank edge of the study area.

Figure 23. Unstandardized bongo net hauls (No./Haul). Note the circle size is linearly dependent on the relative catch and those with zero catch are denoted with x's. These are the sum of the two nets 0.333 and 0.505mm.

Figure 24. Hydranths/m^3 from bongo net hauls. Note the circle size is logarithymically dependent on the relative catch and those with zero catch are denoted with x's. Data was supplied by Barabara Sullivan and Jason Williams of URI.

Figure 25. Vertical distribution of cod and haddock larvae and temperature profile from station 155, off-shore of the tidal front, 1-m^2 MOCNESS 143: 14 May 1997, 1906-2025 h DST, 67-m bottom depth.

Figure 26. Vertical distribution of cod and haddock larvae and temperature profile from station 154, on-shore of the tidal front, 1-m^2 MOCNESS 150: 17 May 1997, 0843-1011 h DST, 63-72-m bottom depth.

Figure 27. Length frequencies of cod and haddock from station 155, off-shore of the tidal front, and station 154. on-shore of the tidal front.

Figure 28. Chlorophyll a vertical profiles during the time series (13-18 May) at the drifter station 155.

Figure 29. Map of zooplankton net tow locations.

Figure 30. Map of Seabird 911 cast locations.

Figure 31. Map of 1/4-m^2 MOCNESS haul locations.

Figure 32. Map of 1-m^2 MOCNESS haul locations.

Figure 33. Map of Bongo haul locations (conducted subsequent to the grid surveys).

Figure 34. Map of the extra Seabird 19 cast locations.