NAFO Sci. Coun. Studies, 24: 125–141

Oceanographic Conditions of Georges Bank Spawning Grounds: 1992–94*

J. Manning
National Marine Fisheries Service, 166 Water Street
Woods Hole, MA 02543-1097, USA

Abstract

Oceanographic surveys were conducted on the southern flank of Georges Bank in the month of May for three consecutive years, 1992, 1993 and 1994, to investigate the physical environment of recently hatched cod and haddock larvae. Observations including a) anomalous wind events, b) advective water mass intrusions, c) highly resolved tidal fronts, and d) small-scale patchiness of acoustic backscatter and fluorescence are discussed. Attempts to follow larval patches around the tidal ellipse and to map the distribution of organisms relative to the moving water are described.

Key words: Environment, Georges Bank, hydrology, larvae, sampling

Introduction

In 1992, 1993 and 1994, oceanographic surveys were conducted in known fish spawning grounds of Georges Bank to examine stratification variability and its effect on larval fish survival. The surveys were carried out in late-spring, in the month of May, on the southern flank of Georges Bank. The first two years were funded by NOAA Climate and Global Change, Marine Ecosystem Response Program and the later year was funded by the US GLOBEC Program (Global Ecosystem Dynamics).

The objectives of these surveys were to test and inter-calibrate a variety of sampling systems for determining the distribution and abundance of larval fish and their planktonic prey in relation to hydrographic conditions. An additional objective was to test and evaluate different sampling strategies that could be used in future field operations.

The purpose of this manuscript is to provide a progress report and summary of data collected by the Woods Hole National Marine Fisheries Service (NMFS) scientists. Many other scientists (approximately 100) and institutions are involved. This report is intended for scientists outside the GLOBEC project as a brief overview of work in progress. Much of the text and figures are extracted from Manning *et al.*, MS 1994 and Taylor and Manning, MS 1994. The sampling systems are described and the data is summarized primarily in the form of contoured distributions. The discussion section is limited to brief notes on the significant unplanned observations of a) a wind event – i.e. anomalous wind events, b) the appearance of Scotian Shelf Water on Georges Bank – advective water mass intrusions, c) highly resolved tidal fronts, and d) small-scale structure of the fluorescence signal – i.e. small-scale patchiness of acoustic backscatter and fluorescence.

More recent information on Georges Bank studies may be found on the WWW: "http://globec.whoi.edu/globec.html."

Sampling Systems

Shipboard

The primary shipboard sampling systems used during this survey to accomplish the above objectives were:

MOCNESS: Multiple Opening/Closing Net and Environmental Sensing Systems with 1 m^2 (0.333 mm mesh nets) and 1/4 m^2 (0.064 mm mesh nets) mouth openings and each equipped with 9 nets and conductivity/temperature/depth measuring packages (identified as MOC1 and MOC1/4, respectively).

Seabird Electronics Seacat Model 19 CTD (*Profiler*): a conductivity, temperature, and depth measuring instrument with a sampling rate of 2 observations/second. During a bongo haul, the Profiler was attached above the bongo frame and towed double – obliquely through the water.

* Funding provided by NOAA's Climate and Global Change Program under the Marine Ecosystem Response Program and US GLOBEC under the Georges Bank Stratification Project.

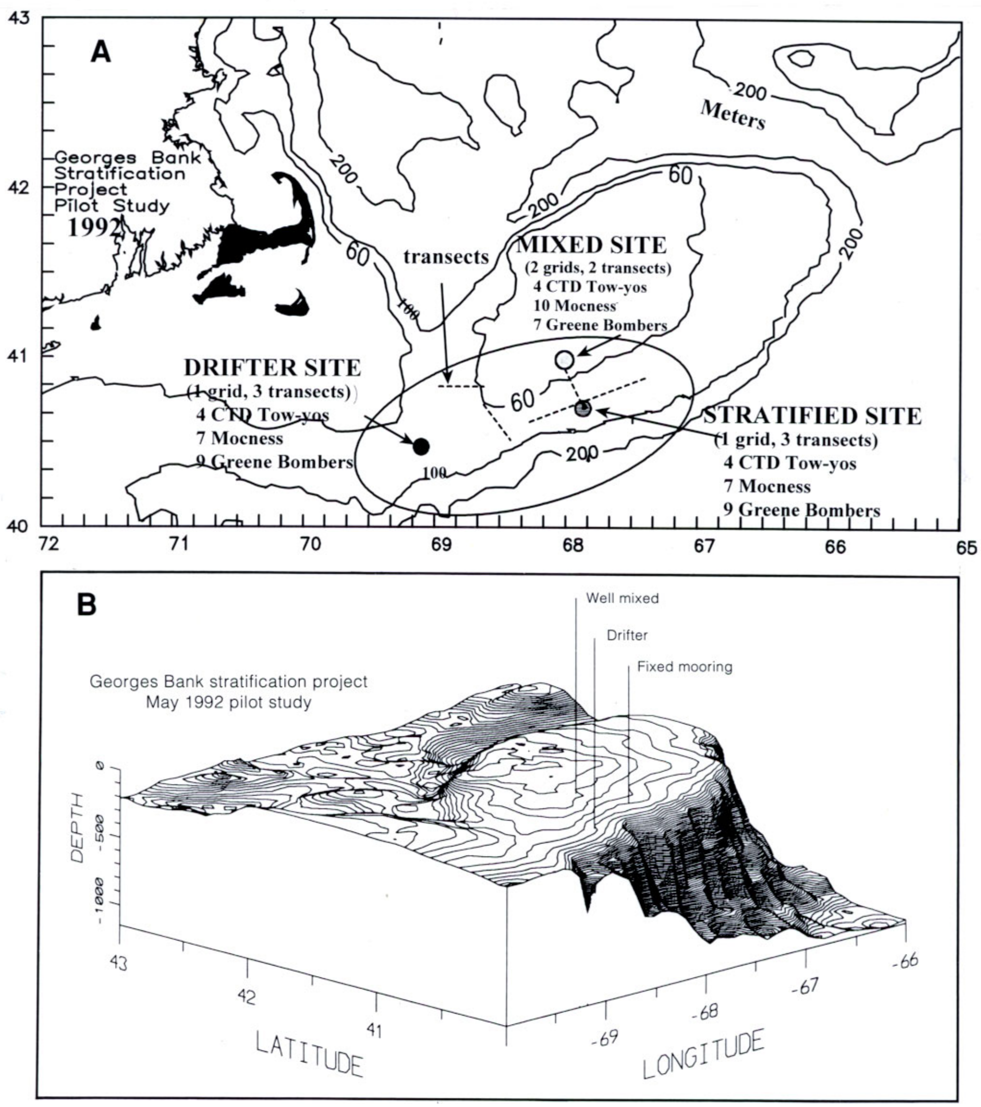

Fig. 1. (**A**) Station map of operations on the main leg of the *Albatross* cruise in the spring of 1992 and (**B**) a three-dimensional prospective of Fig. 1A.

MK5 CTD: a Conductivity/Temperature/Depth measuring system equipped with a fluorometer and rosette water sampler.

Near real time satellite: satellite derived SST was sent to the ship via radio transmission at 300 baud.

Mooring

A physical oceanographic mooring with instruments to measure temperature, salinity and current in the upper 50 m of the water column was deployed to monitor the vertical structure in the water column during the 1992 and 1993 survey periods.

Vector Averaging Current Meters (*VACM*): were attached at 15 m and 45 m to record current velocity and temperature 16 times per hour.

RBR Temperature Loggers (*TPODS*): single channel temperature loggers (model series XL-105) used in fixed mode of operation as part of the moored array. Temperature observations were recorded every 2 minutes of their deployment. Instruments were attached at 5, 25 and 35 m.

Seabird Electronics Seacat Model 16: internally recording temperature/conductivity instruments intended for fixed mooring operations. Instruments were attached at 1, 10, 20, 30, 40 and 50 m and recording every 2 minutes.

Drifters

Loran-C Marker Buoy: these instruments, manufactured by Seimac Limited and loaned for the study by Art Allen of USCG Research and

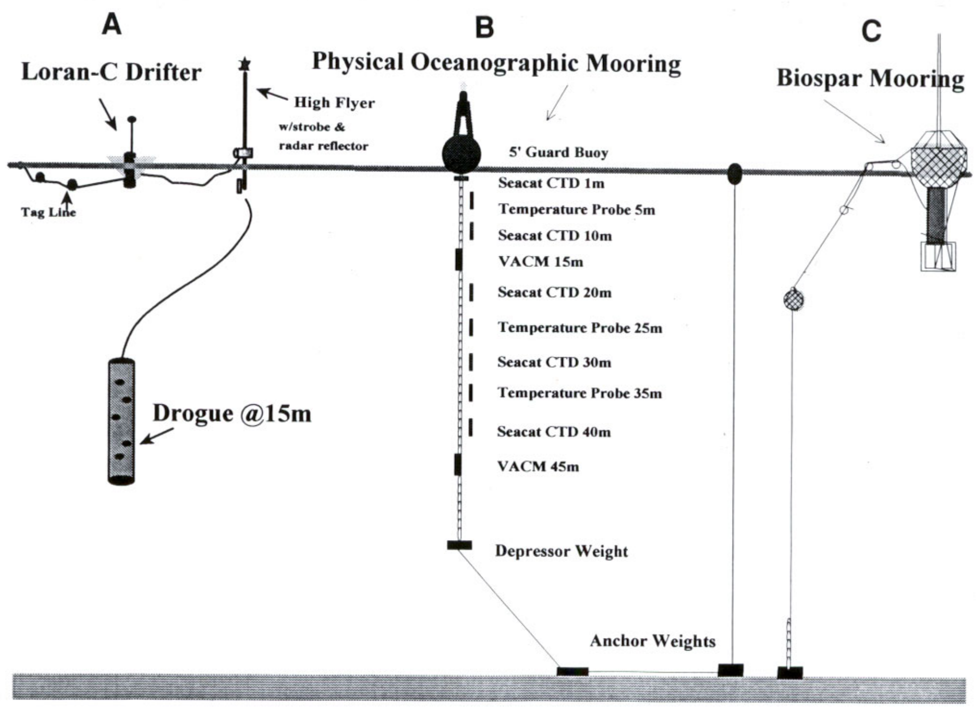

Fig. 2. Loran-C Marker Buoy Drifter (**A**) and mooring (**B** and **C**) configuration in May 1992.

Development Lab, received Loran radio signals at a user defined setting (the setting used was 30 minutes) and transmitted the time delays *via* VHF radio to the ship in both 1992 and 1993.

GPS/VHF/ARGOS drifters: these instruments, manufactured by Brightwaters Instrument Systems, received both GPS and ARGOS positions and relayed the fixes via VHF in 1994.

Methods

Sampling operations

During the first three days of the Albatross cruises in 1992, 1993 and 1994, a survey was conducted to locate cod and haddock larvae on the southern flank of Georges Bank and to provide an initial indication of the hydrographic conditions in the region. A bongo-net (61 cm dia., 0.333 mm and 0.505 mm nets) equipped with a Seabird CTD profiler was used on approximately 30 stations (5–10 mile spacing) between the 50 and 100 m isobaths.

From the survey information a site was chosen for deployment of the physical oceanographic mooring, the BIOSPAR mooring[1], and the drifters (Fig. 1 and Fig. 2). This site (at approximately 80 m bottom depth) was selected to be in the region of the bank which characteristically has a stratified water column. It is identified as the stratified site (S). A second site (at approximately 50 m depth) was selected in the characteristically well-mixed, shallow portion of the bank nearest to the site S. This site is referred to as the mixed site (M).

After deployment of the moorings, drifters were deployed near the site S. The drifters consisted of the surface canister with electronics tethered to a 6 m long holey sock drogue at 10 m depth. The vessel had a VHF receiving unit to keep track of the buoy position. The drifters formed a third site, the drifting site (D) which was expected to drift southwest away from the site S during the course of the study.

At the three sites two different sampling schemes were conducted. The first was called a "site transect" which extended from 2 miles south to two miles north of the site (essentially across the isobath). A MOC1 tow was made starting at the southern end and towed toward the site. After it was completed the vessel returned to the southern end of the transect and a CTD Tow-Yo was made along the 4 miles section at 2.5 knots with profiles every 5 minutes (approximately 0.2 mile spacing). The Greene Bomber (a dual beam acoustic system operated by WHOI personnel) was towed during both MOC1 and Tow-Yo. On some occasions a MOC1/4 tow was made at the completion of the Tow-Yo. In some cases the transects were conducted jointly

[1] The BIOSPAR (Bioacoustic Sensing Platform and Relay) is aa dual-beam biological echo sounder and satellite and radio communications system mounted on a spar buoy. This instrument was deployed by WHOI personnel.

with R/V *Endeavor* (1992) and both R/V *Delaware II* and R/V *Columbus Iselin* (1994) for inter-comparison of systems on the two vessels and for a more complete sampling of the water column by the full suite of available instrument systems.

The second sampling operation conducted in 1992 was the fine scale "grids". These were attempts to survey a square mile of ocean in a Lagrangian sense. In other words, our objective was to map the physical and biological variables relative to the moving water mass assuming a slab like advection over a 3–4 hours of the tidal cycle. The sampling was conducted on nominally 6 transects that were one mile long and 0.2 miles apart. In some cases, R/V *Endeavour* simultaneously ran grid lines offset by 0.1 miles from the *Albatross IV* grid so that the combined effort sampled the square mile of water with a transect spacing of 0.1 miles. The movement of the water during the sampling had to be taken into account in order to sample the intended parcel of water. The tidal currents are often greater than 50 cm per sec and, over the 4 hours required to conduct the sampling, would displace the parcel of water a distance three to four times greater than the size of the square. To compensate for movement during the sampling, a drifting buoy (with drogue at 10 m) was used as a reference marker and all grid lines were positioned relative to the drifter at the time the lines were run. The Greene Bomber was deployed on all grid lines. A MOC1 tow was conducted on the first and last lines. A CTD Tow-Yo was conducted on the second through fifth lines with profiles every 3 minutes (for an approximate along-track spacing of 200 m). Four grids were completed by *Albatross*, three of which were conducted with *Endeavour*.

In order to reference the position of samples relative to the moving parcel of water the following procedure, as suggested by Captain Dean Smehil, was used on Grid Nos. 4 and 5. The proposed one mile grid pattern was drawn on the *Albatross IV* radar screen with a grease pen. The ship was simply steered such that the signal from the drifters radar reflector traced out the pattern on the screen.

The approximate location of the three sites and a summary of the operations conducted at each site in the first year, 1992, is shown in Fig. 1.

Some "longer transects" of observations also were occupied. These included two Tow-Yo transects with the Greene Bomber between the site S and M, with CTD profiles every kilometre. An along isobath transect of CTD stations every 5 miles was occupied from 25 miles northeast to 20 miles southeast of the site S. In some cases transects also were occupied near the western end of Georges Bank and across the eastern side of Great South Channel. These transects included sampling by MOC1, Greene Bomber and the MK5 CTD.

Processing operations

MOCNESS and most bongo samples from most cruises have now been sorted and identified for fish larvae, eggs and zooplankton. Fish larvae were measured to the nearest tenth millimetre and all lengths were converted to live lengths using Bolz and Lough (1983) algorithm.

Copepods and fish eggs from selected MOCNESS hauls have also now been staged according to life history traits. Depth distributions were plotted using total numbers, although means and standard deviations have now been calculated for each haul. Weighted mean depth was calculated for fish eggs and larvae using the following formula:

$$\text{wmd} = \sum\text{product}/\sum\text{density}$$

where $\sum$product = mid-point of depth interval × density of specimens. When more than one depth profile was performed during a haul, each depth profile was considered be either an up or down haul. Separate sets of analyses were performed for each type of haul (i.e. up or down). Day and night distributions have been calculated for selected MOCNESS hauls at stratified, drifter, and mixed sites. Density distributions of fish eggs and larvae have been calculated using MOCNESS volume data.

The Seabird PROFILER (CTD) records were bin-averaged to 1 m using Seabird 'BINAVG' software. Corrections were applied after calibration with Niskin bottle samples. Seabird PROFILER data was contoured at sea using Golden Software's SURFER routines.

The Neal Brown Mark V CTD was deployed a total of 470 times over the three years. The General Oceanic software "CTDPOST" was used to generate 1 m bin averages. Corrections were applied after calibration with Niskin bottle samples. In order to merge position, water depth and other "header" information with the pressure, temperature, salinity and fluorometry, several processing steps were developed.

The Lagrangian coordinates for the grid paths were calculated differently for different grids, depending on whether we a) were near the mooring, b) were near the drifter and c) used the "grease pen" technique. This 'XY' current position file (where x are y are in kms relative to the start of the operation) along with that of the ship position file became input to a FORTRAN routine 'LAGRD.EXE' to obtain the back calculated Lagrangian positions.

A data acquisition system called the Scientific Computing System (SCS) developed by engineers at Atlantic Marine Center (AMC) was in its first year of operation on the April 1992 survey on Albatross. It provides the scientists with continuous records of position, ship speed/direction, wind speed/direction, air temperature, and several other variables.

Satellite SST records as transmitted from shore were run through an ADD_POSN for a routine that merged temperatures with geographic grid points and then contoured then with SURFER at sea.

Results

Physical oceanography

The physical oceanographic program consisted of 1) deploying a mooring to measure the water column structure during the course of the study, 2) deploying drifters to track for repeated sampling of the same water parcel, and 3) CTD profiles to measure the water column structure in connection with the other sampling programs on the cruise. Results are presented in that order.

1) **Mooring**

The physical oceanographic mooring shown in Fig. 2B was deployed in 1992 and 1993. It contained 2 VACM current meters, 6 SEACAT conductivity/temperature recorders and 3 Branker temperature recorders. The deployment and recovery of the mooring were accomplished successfully except for the loss of one SEACAT recorder in 1992.

The hourly averaged time series from 1992 of detided velocity from the two VACM records and the shipmounted anemometer are presented in Fig. 3. The temporal evolution of the water column structure as measured by the mooring is contoured in Fig. 4 including resultant wind speed in the top panel. Similar contouring of the 1993 mooring was not possible due to the episodic impingement of slope water into the mooring area.

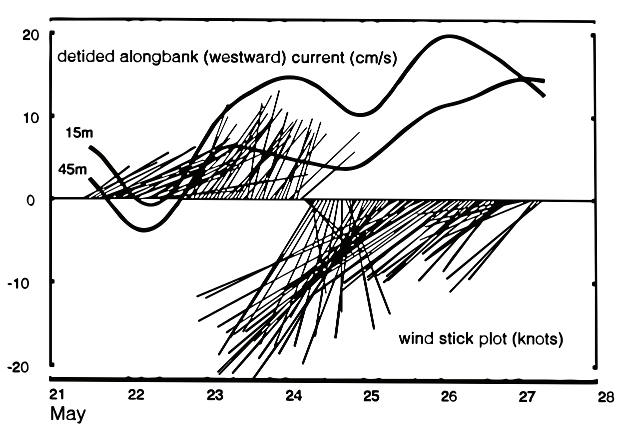

Fig. 3. Time series of wind (shipboard anemometer) and current (VACMs).

2) **Drifters**

As depicted in Fig. 5, the quality of the Loran-C Buoy fixes in 1992 was variable but sufficient for general tracking. The buoy drifted about 100 km to the west-southwest in 7 days (15 cm per sec), essentially along the isobaths. In 1994, the drogue drifter was deployed on three occasions, twice in the stratified area and once in the well-mixed water (Fig. 6). The ship and drifter positions, displayed on a laptop screen, were used to guide the ships track during MOCNESS hauls. The results were satisfactory as most of the MOCNESS hauls intersected the drifter track at about their mid-point. Two of the drifter tracks at Stratified Site I and Mixed Site performed as expected in the bank's circulation having a 10 km semidiurnal tidal excursion and a southwestward mean drift along isobaths of about 12 cm per sec (10 km per day). However, on Stratified Site II, 22–23 May, the expected tidal excursion was observed but there was little mean drift. The difference was most likely due to changes in the wind pattern during the cruise.

3) **CTD**

The temperature, salinity and fluorescence data collected by the CTD systems showed considerable structure, in both the along isobath and cross isobath directions, and significant interannual variability. The SEABIRD surface salinity for the April 1992 Albatross cruise is contoured in Fig. 7. The SEABIRD bottom temperature for both bongo surveys Albatross, May and April (II) are presented in Fig. 8 respectively. The most significant oceanographic observations was the presence of a cold (<3°), fresh (<32 PSU) water in 1992 (see discussion below) and a warm (>13°C), salty (>34 PSU) water impinging on the bank in the southwestern corner of the survey in 1994 (Fig. 8).

Two Tow-Yo sections conducted in 1993 demonstrate the difference in water column structure as a function of tidal phase (Fig. 9). Two Tow-Yo sections were also conducted during an off-bank phase of the tide in the early hours of 24 May 1994. In Fig. 10, the most notable feature is the relatively high values of fluorescence near the tidal front and distributed throughout the water column.

Grid study figures begin with a summary of cruise tracks (Fig. 11) followed by detailed tracks of grid #1 in Fig. 12.

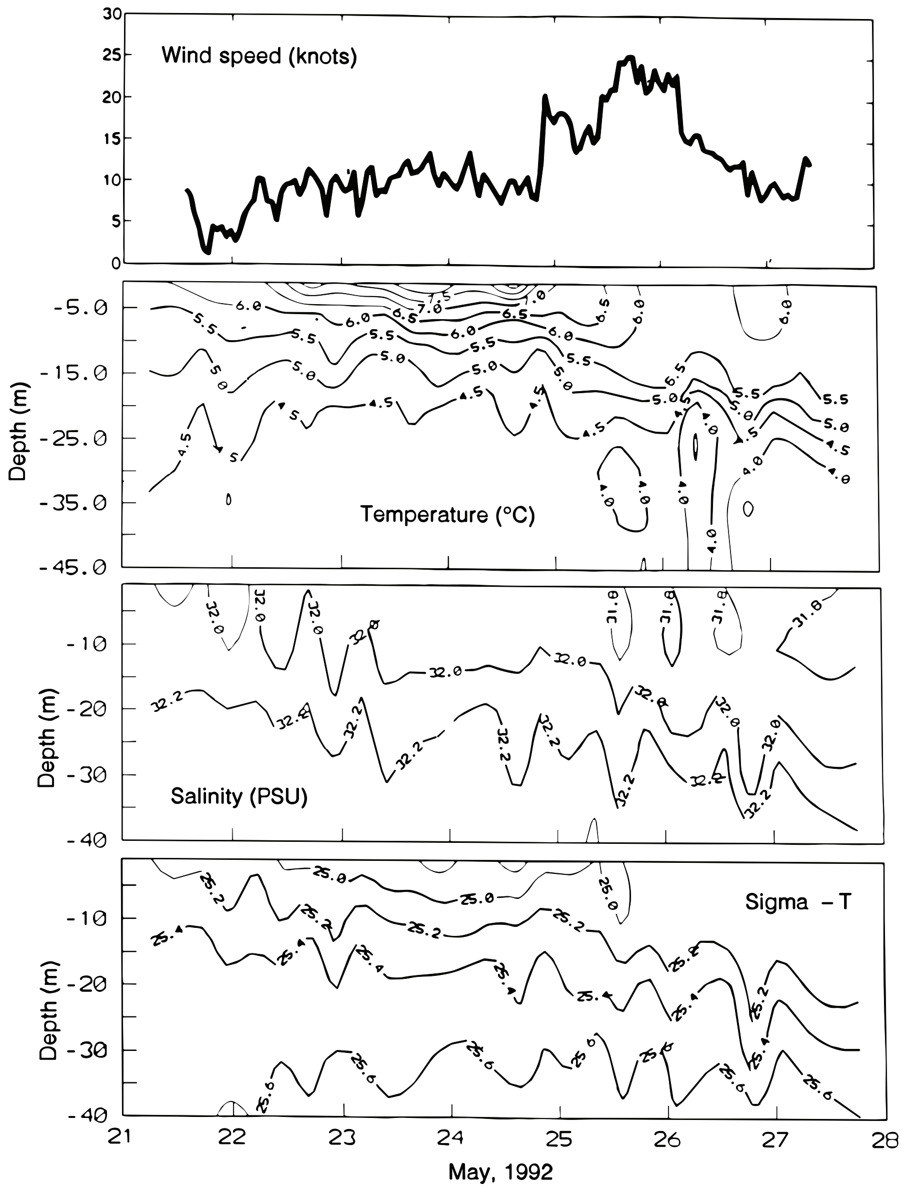

Fig. 4. Evolution of water column structure as measured by the mooring. Wind speed is depicted in the top panel above the contoured structure of temperature, salinity and density in the lower 3 panels.

Biology

1) Bongo surveys

During the initial Bongo surveys, few month-old cod were collected in shoal waters on the southeast part; however, a broad area of haddock and cod larvae was located on the southwest part from the shoals to the 90 m isobath, centered near 68°00'W. The abundance of larvae was relatively low; less than 6 larvae per Bongo-net haul was typical (Fig. 13). Larval haddock were about four times as abundant as cod. Most larvae were recently hatched, 4–5 mm. Both cod and haddock were a few weeks older, 5–8 mm, and more abundant in the shoal water <60 m depth. In 1992, the patch of larvae was located farther to the southwest (40–70 miles) than expected from previous year's surveys conducted in the last half of May. Perhaps the cold band of water observed in April that moved onto the southern edge of Georges Bank had displaced eggs and larvae southwestward and more onto the shoals. The cold water (<4°C) also may have retarded development

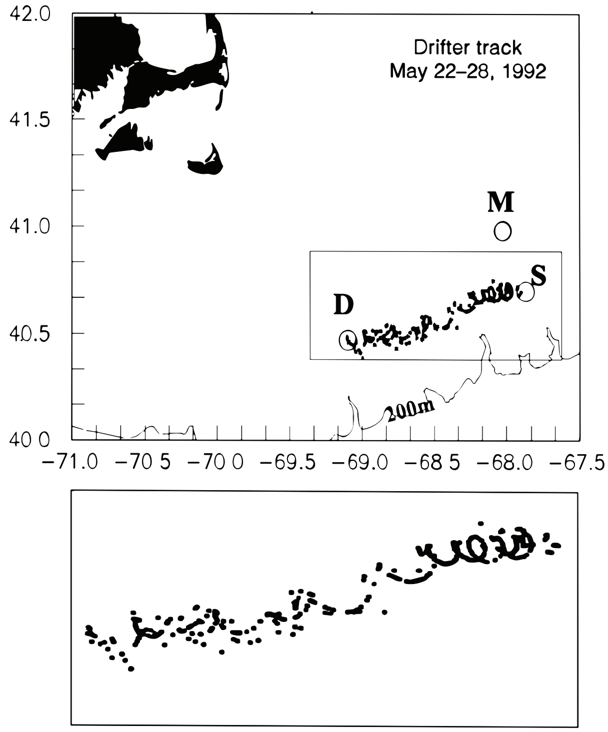

Fig. 5. Drifter track (1992) including an blown-up version in lower panel.

and induced high mortality of the eggs and larvae in the year.

In 1994, a patch of larval haddock was located from the Bongo-net grid of 42 stations on the southern flank of Georges Bank.The larval patch, identified by haul catches greater than 4, was about 15 x 30 miles in extent, centered on the 70 m isobath. Highest catches were in the range of 10–20 per haul. A few (1–7) cod larvae were caught on most stations, but showed no identifiable patch. The size of cod and haddock larvae ranged from recently hatched to 14–19 mm and the modal size appeared to be 7–8 mm.

2) MOCNESS hauls

A total of 103 MOCNESS hauls were made over the three years. In 1992 seven hauls were made at the drifter site (D), 8 at the stratified site (S), and 10 hauls at the mixed site. Few cod or haddock larvae were collected at the stratified-water sites; most larvae were collected at the mixed site in water <50 m bottom depth. The MOCNESS vertical profiles indicated that cod and haddock larvae were distributed broadly through the water column, generally more abundant towards the bottom. Haddock larvae were

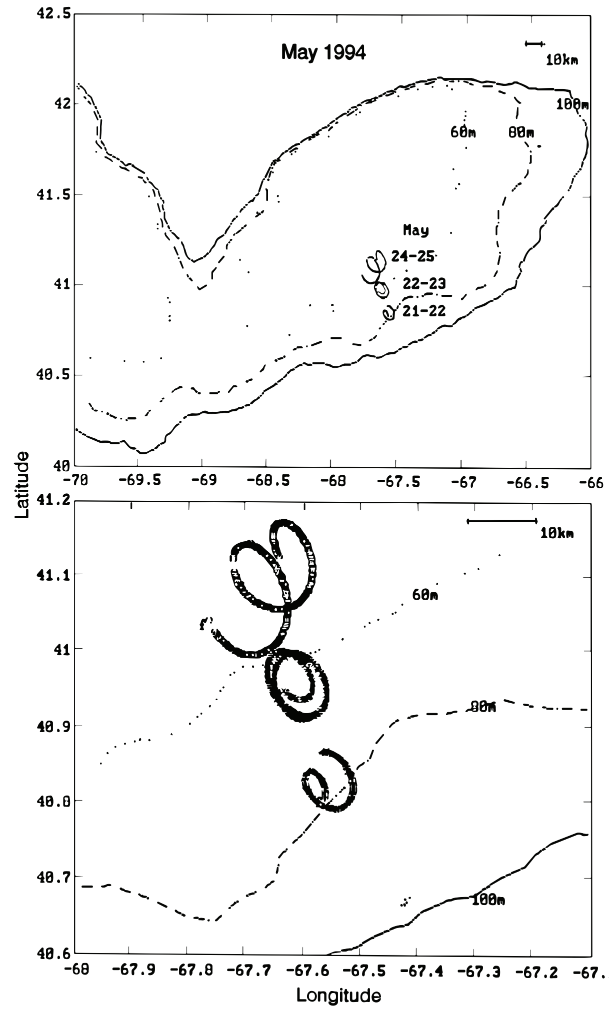

Fig. 6. Drifter track (1994) including an blown-up version in lower panel.

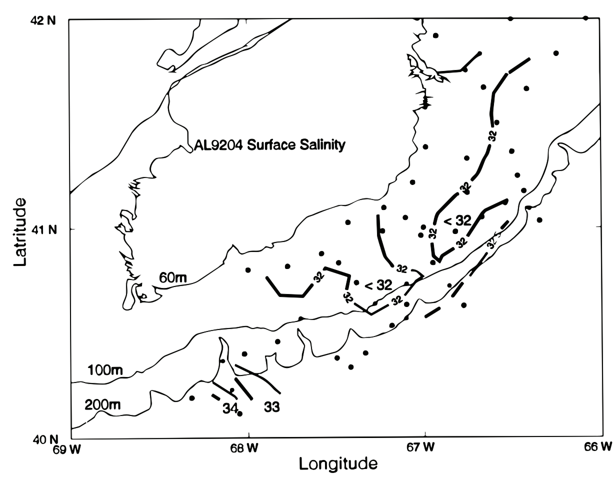

Fig. 7. Surface salinity (5 m) as measured by SEABIRD CTD stations (dots) indicating the band of Scotian Shelf Water along the shelf edge of Georges Bank.

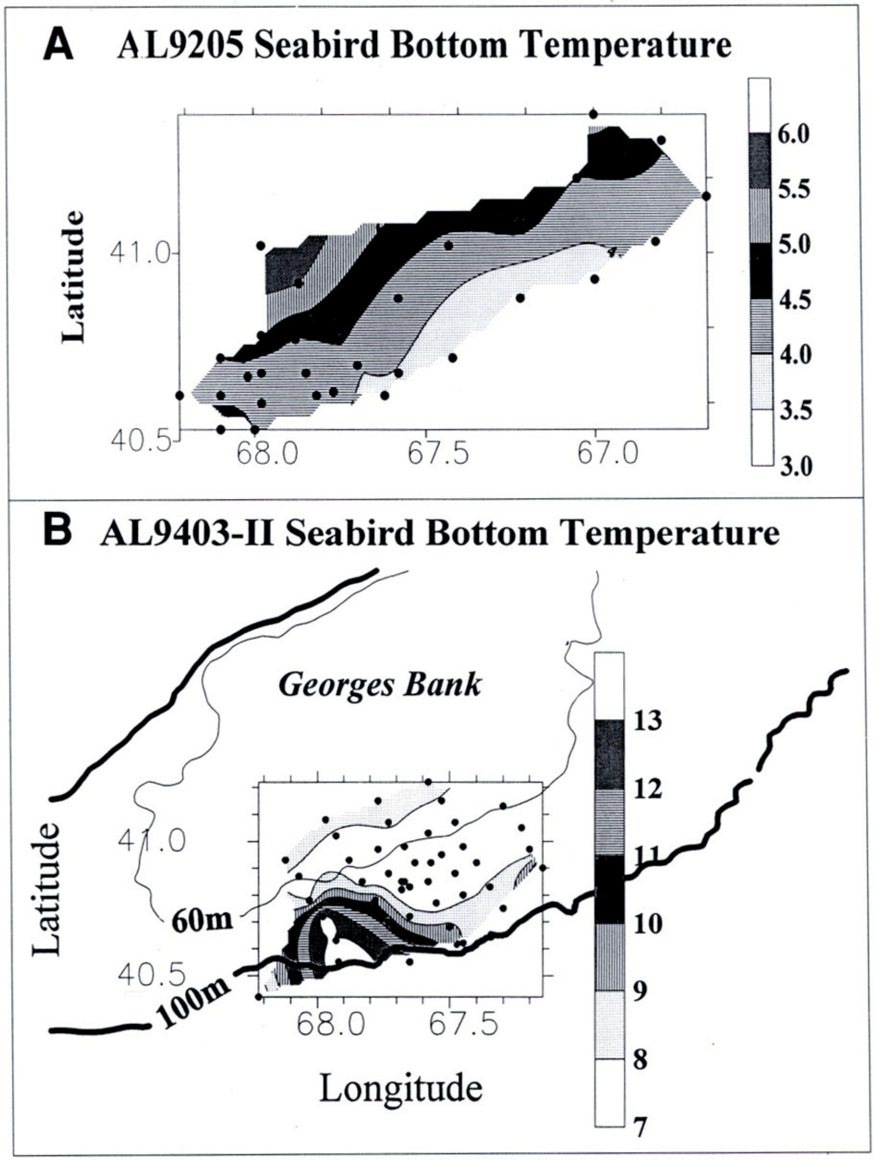

Fig. 8. Bottom temperature measured with CTD stations in mid-May (**A**) 1992 and (**B**) 1994 in the same general area. Note the difference in temperature scale and the opposite cross-bank gradient.

collected in greater numbers at depths deeper than 20 m in several hauls. Zooplankton abundance generally appeared to be highest in the upper 40 m of the water column. The copepod *Calanus finmarchicus* dominated the zooplankton hauls in stratified waters.

Along the transect occupied at the western end of the survey region (68°20'W) five MOC1 hauls were made simultaneously with the Greene Bomber. Haddock and cod larvae (7–8 mm mode) were collected at the shallowest stations. Their abundance and vertical distribution was similar to the previous three site study. On the transect across the eastern side of the Great South Channel three MOC1 hauls were made from 50–80 m bottom depth. Older haddock and cod larvae (6–11 mm) were collected in all hauls. The general distribution pattern of larvae observed during the cruise was consistent with the recirculation of some fraction of larvae on the eastern side of the Great South Channel.

In 1992, a total of 182 cod and 189 haddock larvae were collected with the 1M MOCNESS and frozen for biochemical studies. All but 2 cod

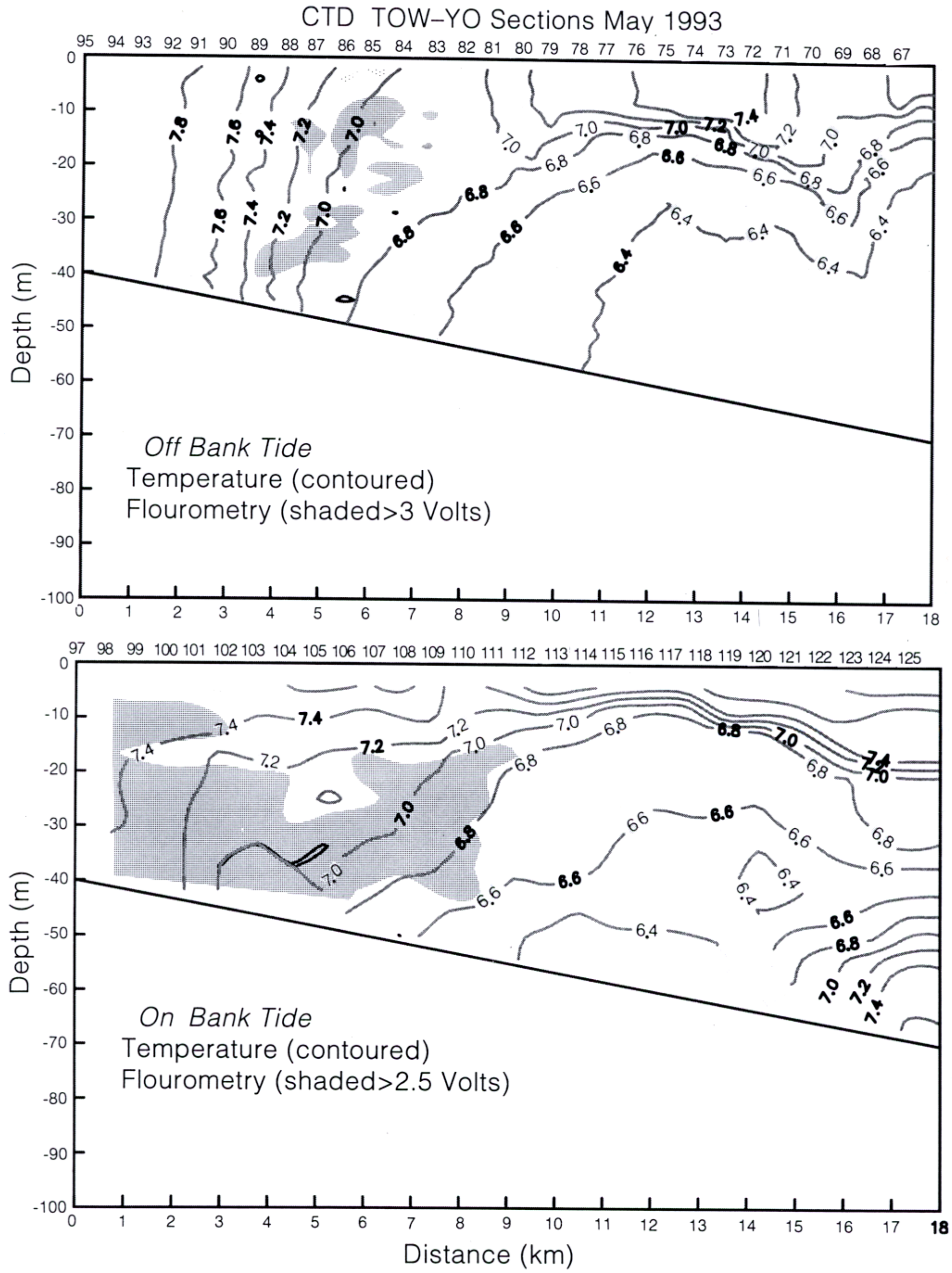

Fig. 9. Two across-bank Tow-Yo transects during two different phases of the tide in 1993 demonstrating the dispersal of the fluorescence front on the on-bank phase.

and 7 haddock came from the shoal or transect sites. Larvae were sampled from a total of 11 MOC1 hauls representing both day and night tows. Larvae were sampled from both integrated and discrete depth nets. The majority of gadid larvae were frozen on petri dishes in the ship's freezer. Other samples were frozen in liquid nitrogen. These samples will be analyzed for RNA and DNA content using an automated fluorescence procedure. We will attempt to sample otoliths from these larvae. Standard length will either be measured directly or estimated from DNA content.

In 1994, thirty seven hauls were made on the stratified sites and 16 hauls on the mixed site. A single 10 m^2 MOCNESS haul was made at Stratified Site II and the Mixed Site, and since no pelagic juvenile cod or haddock were caught, this sampler was not used further. Most

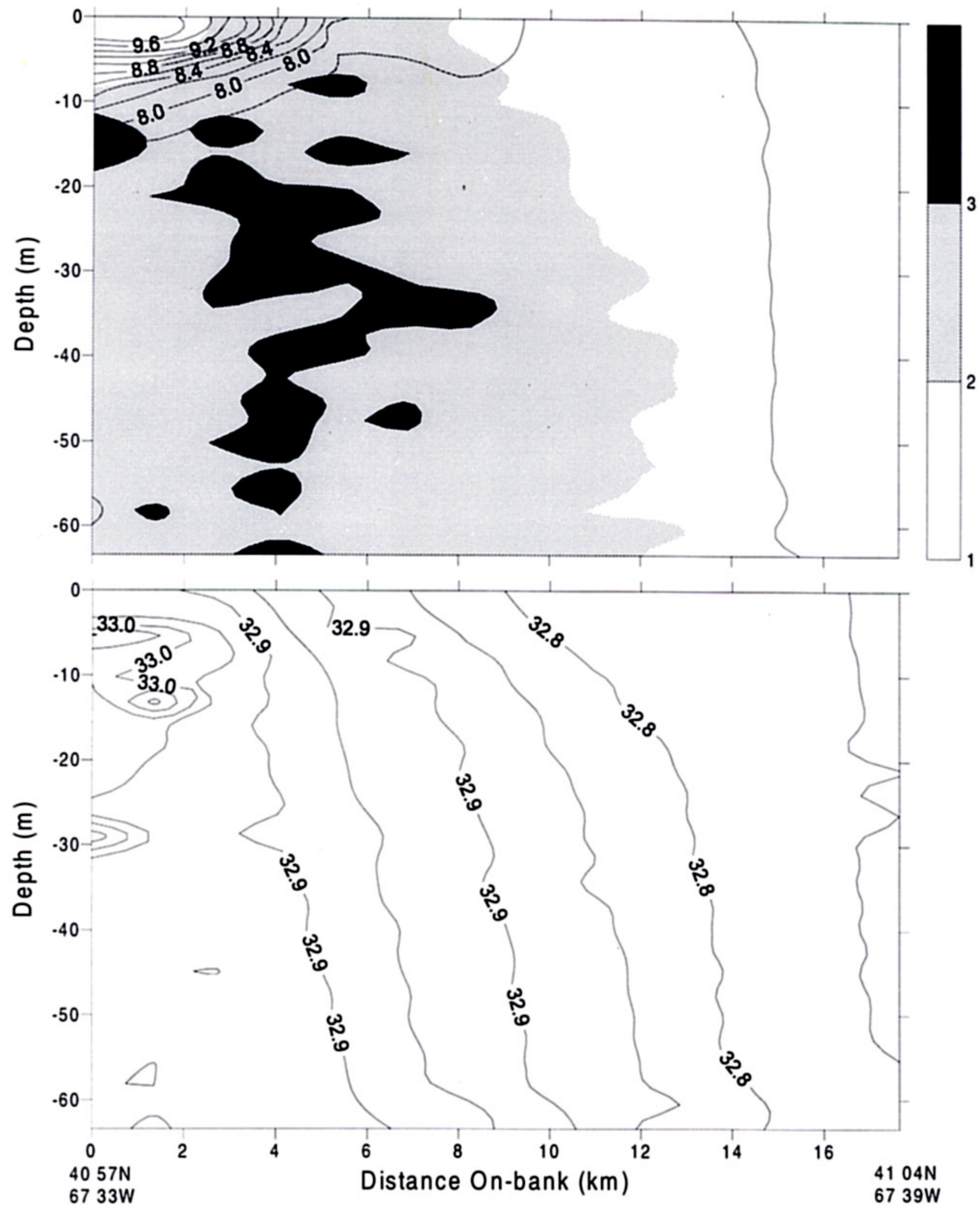

Fig. 10. One across-bank Tow-Yo transect in 1994 demonstrating the fluorescence front.

1 m^2 MOCNESS hauls had replicate profiles so that one profile-set of samples could be used for picking larval fish for biochemical analysis. Yellowtail flounder (*Hippoglossoides platessoides*) were much more abundant than haddock and cod larvae. A total of 2 512 larvae were frozen (1 072 haddock, 236 cod, 1 204 yellowtail), and 1 803 larvae preserved in alcohol (219 haddock, 56 cod, 1 522 yellowtail) for otolith analysis. Because of the variability observed in the vertical distribution of larval fish, it was difficult to generalize patterns until all the samples are fully processed.

Discussion

Most of our survey went as planned, and we were fortunate to encounter some interesting phenomena. A very brief description of these unplanned observations are discussed here. Detailed analyses of anomalous oceanographic features and the biological consequences are intended in forthcoming papers.

Scotian shelf washover

The temperature and salinity data on a number of transects in 1992 indicated the presence of low temperature (<4°C) and low salinity (<32.00 PSU)

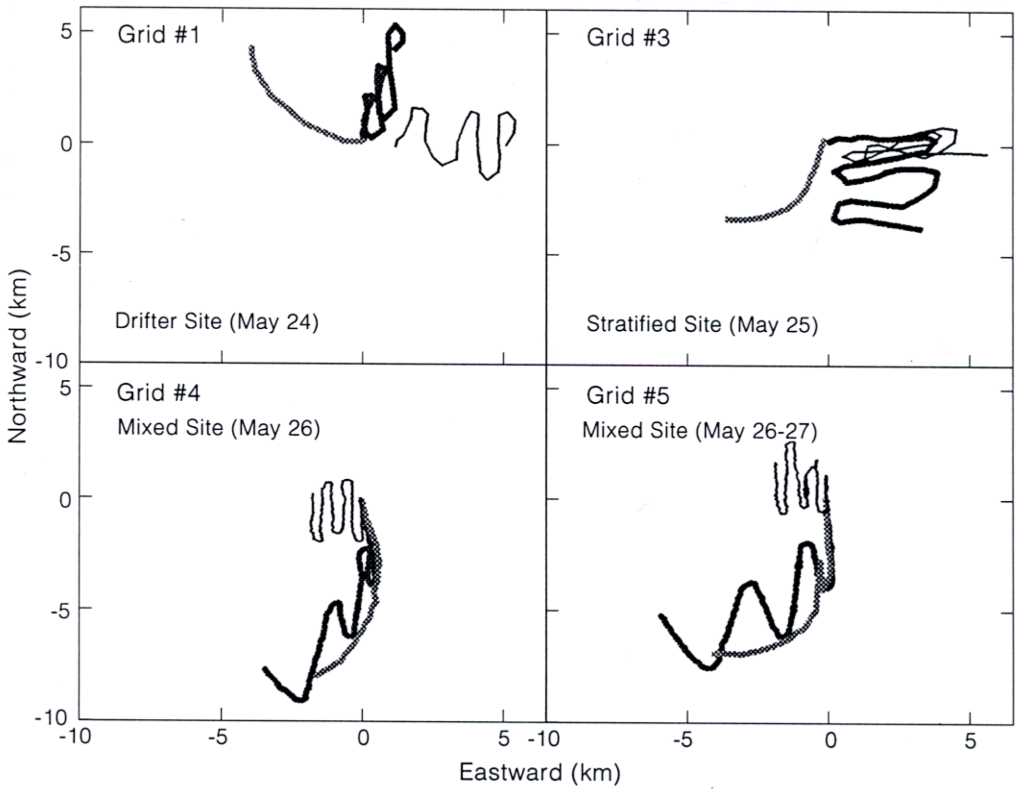

Fig. 11. Summary of the grid operations including drifter track (gray line), ship track (thick black line), and the track relative to moving drifter (thin line).

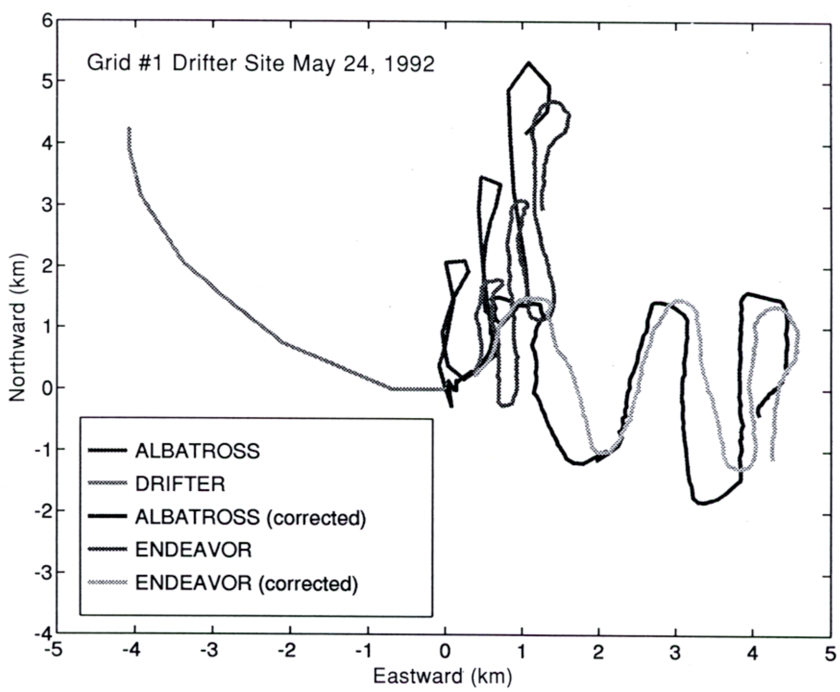

Fig. 12. Grid paths in both geographic and Lagrangian coordinates.

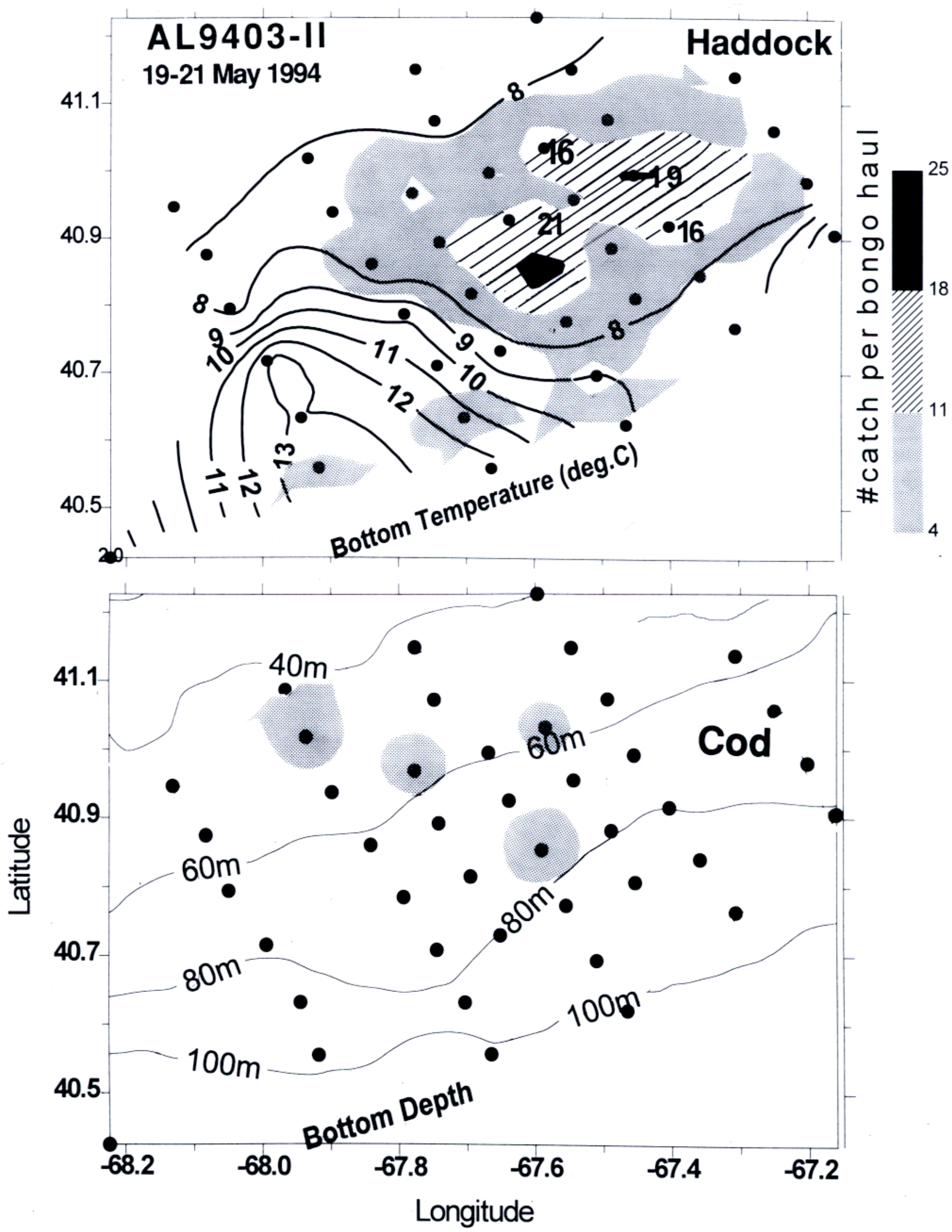

Fig. 13. Catch-per-tow in bongo survey 1994 for haddock (top) and cod (bottom).

in small patches or layers in the water column. This was believed to be a remnant of a large influx of Scotian Shelf Water (SSW) onto eastern Georges Bank, which was observed in satellite images from March through June 1992 and confirmed by shipboard observations on the R/V *Albatross* in early-May. NOAA buoy 44011 SST sensor also recorded unusually cold water from late-March through to the end of May. The cause of this feature, as reported by Rusham *et. al.*, (1994) and Bisagni *et al.*, (1995), may have been the unusually large St. Lawrence River runoff in the spring of 1991. The thickness of the lens as defined by the 32 ppt isohaline varied in both the cross and along-isobath directions (Fig. 14). The influx and continued presence of SSW may have important implications for the plankton communities in the bank, both by the unusually cold temperatures and by a westward displacement of the water on the southern flank of the bank.

May 25 wind event

A slight warming period over a few days from 22 May through mid-day of 24 May resulted in a build up in stratification in the vicinity of the mooring

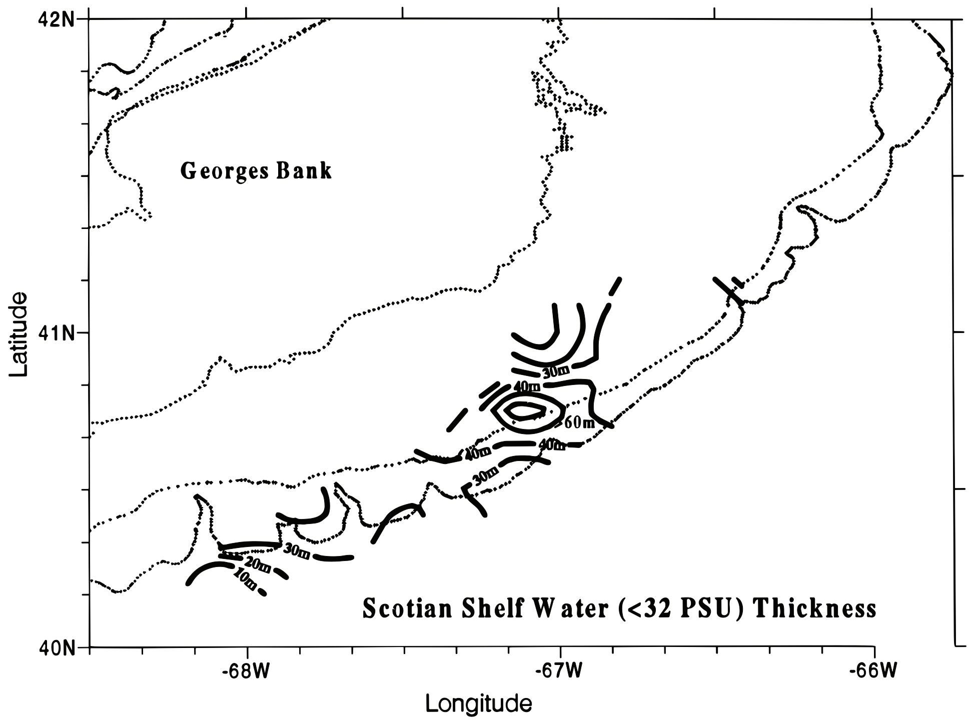

Fig. 14. Scotian Shelf Water lens thickness contour.

site of approximately 4°C temperature gradient in the top 20 m of the water column (Fig. 4). This was followed by a period of strong northeasterly winds on late-day of 24 May Fig. 3 contributing to mixing of the upper water column (Fig. 4), as well as unusually fast westward drift of the surface waters (Fig. 5). This observation supports the hypothesis that the onset of stratification on Georges Bank in late-spring is not a steady seasonal process but rather an intermittent addition of the sun's heat interrupted by occasional 2–3 day wind events. Examination of the NOAA Buoy 44011 wind record for the entire month of May 1992 revealed at least three other events occurred with magnitudes similar to that observed on 24 and 25 May. Superimposed on these wind-driven cycles were the semi-diurnal advections of both the tidal front and the shelf-slope front. The former advection was clearly evident in the 1992 mooring record, as seen by the oscillating isopycnals in the bottom panel of Fig. 4 and, as will be demonstrated in the 1993 data report (Taylor and Manning, MS 1994), the intrusion of slope water is possible in the lower portion of the southern flank water column.

Small scale fluorescence structure

The structure of the fluorescence, assumed to be an indicator of chlorophyll-a abundance, showed a patchy distribution that in many instances were associated with similar structures in the temperature and salinity distributions. There was often a subsurface maximum, especially for the those cast in the stratified area (see, for example, Fig. 15), but there were horizontal gradients as well. Much of the future analysis on this data set will be estimating the length scales of these patches. This requires remapping these parameters in a Lagrangian reference frame. One such study already in progress (Wiebe *et al.*, 1994) relates the acoustic properties of these patches to other physical and biological parameters.

Conclusions

While these cruises were meant to be "pilot studies" and instrument "test", a large volume of data was collected to allow inter-comparison of the net, towed-acoustic, CTD, and moored systems under a variety of conditions. The joint operations with three other vessels also should allow inter-comparison with the video, acoustic and pumping systems. The ability to determine the three dimensional distribution of the organisms in relation to hydrographic conditions on relatively short space scales is believed to be very important to the objectives of the US GLOBEC field study. The observations made on these cruises potentially provide a significant contribution to our knowledge of the

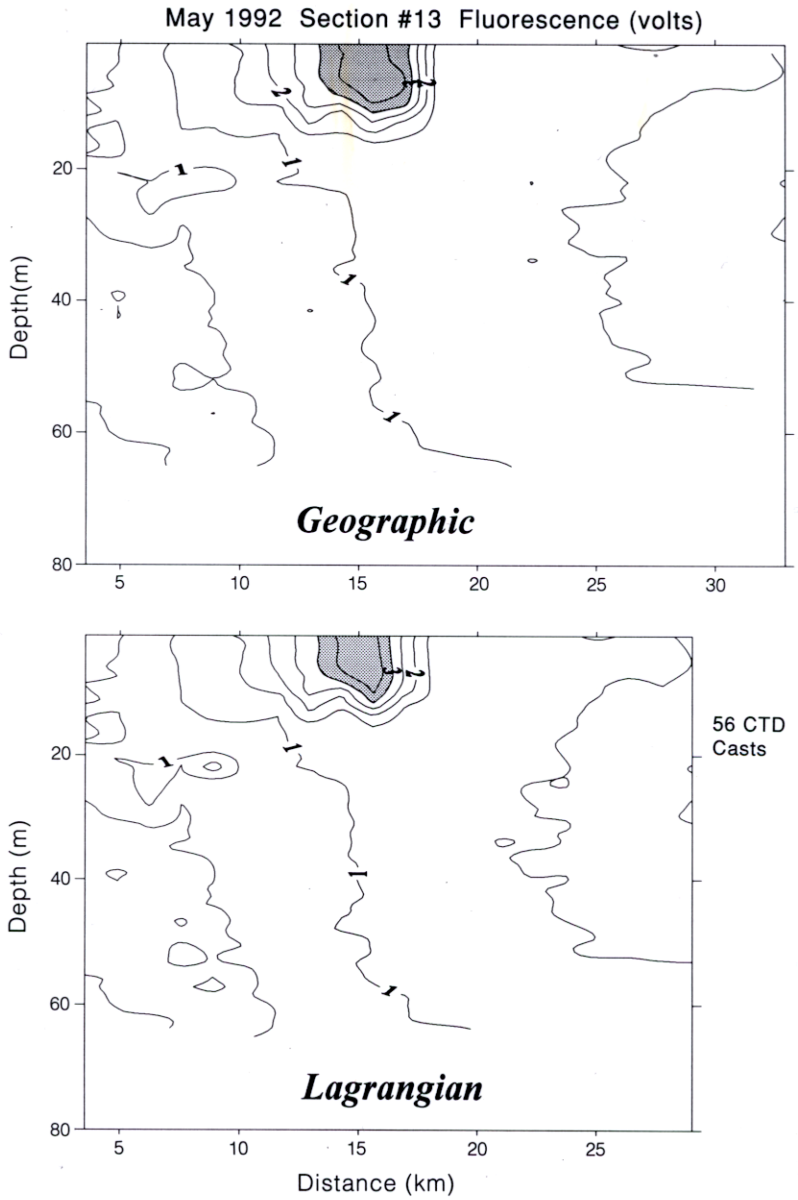

Fig. 15. Difference in small scale fluorescence structure in geographic *vs* Lagrangian (relative to moving water) reference frame.

system. The ability to map a small parcel of water that is being advected by the strong tidal currents on Georges Bank is a significant challenge but we have made great progress in that effort. The "grid" studies in particular provide for the first time an opportunity to conduct a inter-discinplary investigation of sub-mesoscale dynamics on the southern flank of Georges Bank.

References

BISAGNI, J., R. BEARDSLEY, C. RUSHAM, J. MANNING, and W. WILLIAMS. 1996. Interannual sea surface temperature variability on the southern flank of Georges Bank: spring 1992 and 1993. *Deep Sea Research*, (in prep).

BOLZ, G. R., and R. LOUGH. 1983. Growth of larval Atlantic cod, *Gadus morhua*, and haddock, *Melanogrammus aeglefinus*, on Georges Bank, spring 1981. *Fish. Bull. U. S.*, **81**(4): 827–836.

MANNING, J. P., T. HOLZWARTH-DAVIS, M. TAYLOR, T. ROTUNNO, D. MOUNTAIN, and G. LOUGH. MS 1994. Georges Bank stratification study: MS 1992 data report. *NEFSC Woods Hole Lab. Ref. Doc. No.*, 94–096.

RUSHAM, C., J. BISAGNI, J. MANNING, W. WILLIAMS, and R. BEARDSLEY. 1994. Interannual sea surface temperature variability on the southern flank of Georges Bank: spring 1992 and 1993. *EOS*, **75**(3), 67 p.

TAYLOR, M., and J. MANNING. MS 1995. Georges Bank stratification project: 1993 data report. *NEFSC Woods Hole Lab. Ref. Doc*., No. 95-12.

WIEBE, P. H., D. MOUNTAIN, C. GREENE, G. LOUGH, S. KAARVEDT, J. MANNING, J. DAWSON, L. MARTIN, and N. COPLEY. 1996. Acoustical study of the spatial distribution of plankton on Georges Bank. *Deep Sea Res*., (in prep.).

Discussions

Question: How do you hope to follow the patch and how long do you expect to follow that patch?

Response: The drifters are deployed to simulate the advection of the patch but we do not know how long the so called patch holds together. In spring of 1995, we will have the opportunity to conduct follow-up bongo surveys to remap the larval distribution week after week.

Question: How successful have you been in finding a "patch" and how big are they?

Response: We found distributions similar to that displayed in Figure 13 (no overhead available), but this kind of survey does not allow us to make good estimate of the spatial scales since our spacing is so large (several kms).

Question: What type of tide do you have, M^2, and, if so does that tide change day-to-day?

Response: Yes, the M^2 is the dominant tide but we expect to see variation due to the change of moon phase during the 2-weeks we sample.

Question: When did this Scotian Shelf event occur?

Answer: The first satellite evidence (clear images) shows it coming across the NE channel as early as January, being offshore the bank and the later squeezed up onto the bank in late-April and non-existent in early-June.

Comment: 1. OPEN I conducted very similar studies on the Scotian Shelf. They found smaller scales of patches and were able to follow those patches for about 20 days with the help of "data assimilation".

Comment: 2. Yes, I have talked with Keith Thompson of Dalhousie about these methods and yes, it would be ideal to have that system on board to incorporate modelling forecasts with data.