Environmental Monitors on Lobster Traps

Phase II: Salinity

Final Report

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Abstract

In order to continue demonstrating their potential contribution to our regional ocean observing systems, local lobstermen secured Seabird Microcats to their gear in "Phase II" of the Environmental Monitors on Lobster Traps Project. The experiment was carried out as expected. Several lobstermen collected multi-month time series of salinity and temperature at fixed locations (Figure 1). Deep water (<1 meter above the bottom) salinity has never been recorded so extensively in the Gulf of Maine region. A total of 66 months of hourly data were collected in depths ranging from 55 to 210 meters. Average salinity ranged from near 32 to over 35 PSU. While many of the salinity records are uncertain due to potential fouling of the conductivity cell by fine-grain bottom sediment, the collaboration was generally successful. As found in all phases of the eMOLT project, the New England lobstermen are willing and able to assist in deploying oceanographic instrumentation.

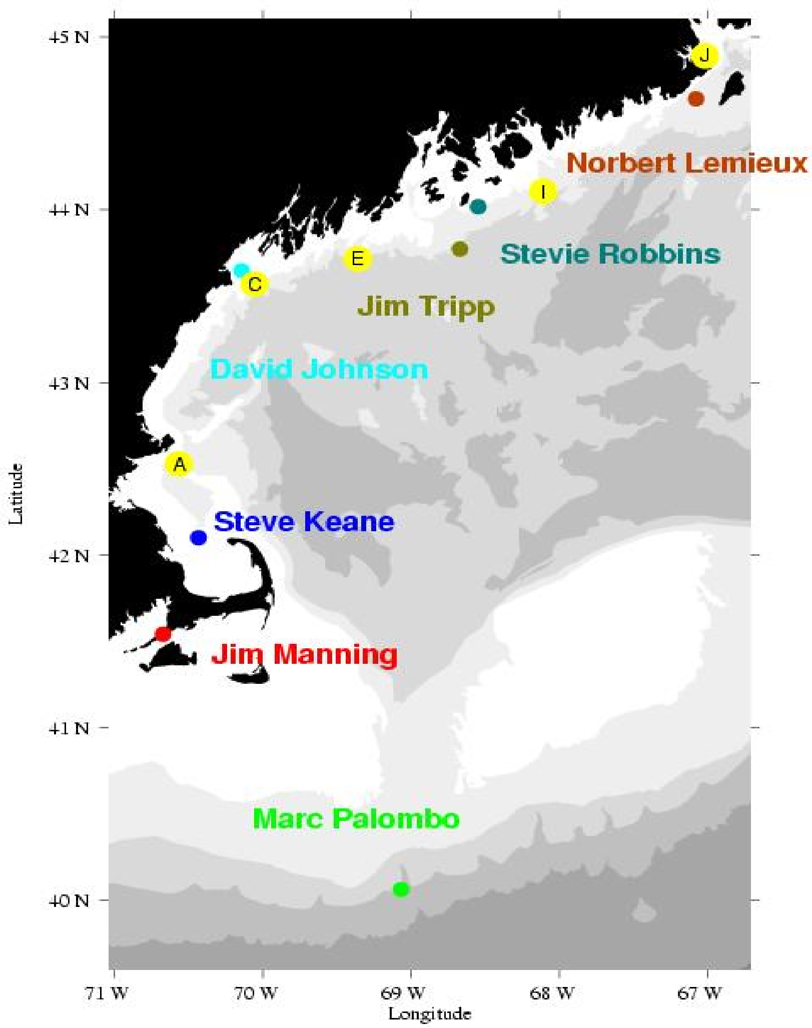

Figure 1. eMOLT salinity monitoring sites and the lobstermen who maintained them. GoMOOS moorings sites are posted as yellow dots.

Our methodology is described here in full and alternative protocol is suggested if similar projects are conducted in the future. The preliminary results are presented in tabular and graphical form along with in-depth analysis. Discussion of particular events at each monitoring site and comparisons with those from nearby Gulf of Maine Ocean Observing System (GoMOOS) moorings are included. Salinity is plotted along with concurrent measurements of temperature, wind, and river discharge.

Introduction

Given recent findings of source waters entering our region from the north, there is an obvious need to assess the influx of the fresher (low salinity) water mass as it is transported into and around the Gulf of Maine. Is there a detectable increase in the Canadian ice melt waters? Will climate change have a significant effect on the conditions of our coastal waters? For purposes of monitoring the influences of advective water masses, salinity is an effective tracer. Hence, as a natural extension of our Phase I temperature probe project funded in year 2000, we had proposed phase II: salinity.

Evidence of remote source waters affecting Gulf of Maine waters has been published (Loder et al., 2001; Smith et al., 2001; Bisagni et al, 1996; and Houghton and Fairbanks, 2001). These papers provide an indication of low-salinity episodes transported from north to south. Periods of low-salinity appear for several months at a time and can be tracked at several locations along the coast (Mountain and Taylor, 1998). The objective of eMOLT II was to extend this idea to include several sites within the Western Gulf of Maine. If this advective hypothesis holds true, empirical data alone may help in forecasting the arrival of these anomalous events at downstream locations. The effect of local river runoff also plays an important role in the interannual variability of salinity at many locations off the coast of Maine (Mountain and Manning, 1994; Geyer et al., 2004) and the inner Mid-Atlantic Bight (Manning, 1991). The challenge remains however in differentiating these advective influences from the heating/mixing processes that take place locally. Studies have found a near-equal contribution from each of these processes (Mountain and Jessen, 1987) .

The very interesting possibility of submarine freshwater discharges affecting the bottom water conditions around the gulf and, in particular, along the bathymetically complicated coast of Maine has recently been proposed. This phenomenon was not even considered as a potential influence to near-bottom salinity levels prior to the start of this project. While these point source inputs of fresh water certainly do **not** play a significant role in the overall variability of the gulf's salt budget, the possibility that they exist can not be ignored. This new hypothesis that nutrient-rich freshwater is injected into the near-bottom marine environment in certain geological formations along the coast of Maine is certainly intriguing and worth further investigation.

Project Objectives and Scientific Hypothesis

The two-fold objective of eMOLT Phase II was to a) demonstrate the concept of lobstermen contributing to the region's ocean observing system and b) investigate the scientific hypothesis that water masses can be detected and tracked along the western boundary of the Gulf of Maine.

Given accurate measurements of both temperature and salinity as tracers, we proposed to examine the advection of water masses through the area.

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Methods

On 24 April 2002, lobstermen Nick Lemieux, Jim Tripp, and Stevie Robbins III met with eMOLT administrators in Portland, Maine for training. The others, Marc Palombo, Steve Keane, and David Johnson, were trained separately. The following topics were covered over the course of a few hours:

- terminology (Microcat, SBE37SM, Seabird, etc)
- importance of salinity (ie motivation behind sampling)
- results of preliminary test deployments in Woods Hole
- care & maintenance of salinity probe
- water bottle sampling technique
- deployment/recovery strategy & timeline
- battery replacement and recalibration schedule

A multi-page web-served document "*User Manual for eMOLT Participants Deploying the SEABIRD SBE37sm Microcat Temperature and Salinity Probe*" was provided to each participant with complete instructions on the process from setting up the instrument to downloading data. The final chapter listed in detail "Who's responsible for what".

In addition to a Microcat (Figure 2), each lobstermen was equipped with a Niskin bottle and several glass sample bottles. The apparatus is used to capture samples of seawater at selected depths in the water column. The Lamotte units (see Figure 3) we purchase for $199/each are a 1-liter sampler of clear acrylic furnished with a 20 meter calibrated line and a lead collar which assures rapid descent and minimal drift. A brass messenger triggers a release mechanism to seal the sample chamber with two fitted rubber plungers at the desired sampling depth. The built-in side outlet and flexible tube allows for removal of the water sample. Most participants experimented with this instrument but, as discussed below, only a few actually made use of the unit as proposed. Ideally, samples are required along with any measure of salinity in order to calibrate the instrumentation and correct for offset/bias.

Figure 2. Seabird Microcat temperature and salinity sensor.

Seabird Microcats, setup to record hourly samples, were secured directly to traps. As pictured in Figure 4, the instrument was mounted horizontally in the bridge of the trap so that it rested a foot or more above the seabed. While each lobsterman secured the instrument in a slightly different fashion, the basic configuration was the same. The instruments were deployed for multiple months (see Table 1) and often hauled during normal fishing operations. Occasional hauls allowed for the inspection and a deck-hose rinsing of conductivity cells. In some cases, the instrument remained on the bottom for the entire deployment. Instruments were deployed in a variety of bottom habitats from sandy (highly energetic tidal flow) to deep muddy (relatively stagnant) environments.

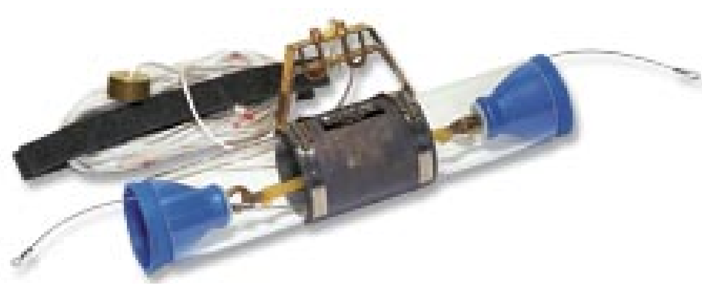


Figure 3. Lamotte water sampler used to acquire calibrations.

Figure 4. Microcat attached to the bridge of a lobster trap (photo by Norbert Lemieux).

Whenever it was convenient (such as prior to fish forums or lobstermen association meetings where both industry & science partners would be attending), the probes were hauled-in, detached, brought to shore, downloaded, and reinitialized. This occurred at least a few times for each participant, except in one case, where one continuous series was collected.

Data

The data was downloaded after each deployment and processed with a series of software routines:

Seabird:

- "Seaterm (ver 1.24) " pulls the data from the instrument
- "CNV37.exe (ver 1.5)" converts binary to ascii
- "derive (ver 4.249)" converts conductivity to salinity

MATLAB:

- "emolt.m" general raw-processing of eMOLT data types & produced ORACLE-ready data
- "sb2mat" called by emolt.m to process cnv file & return yearday, temp, and salinity
- "emolt_rawplot" called by emolt to make plots of raw data

Perl/ORACLE

- "sqlldr usrname/psword control=emolt_sensor.ctl" reads file generated by emolt.m & puts them in database
- allows only those temperature values less than 80 degF and salinity less than 37 PSU
- "serve1.cgi" CGI allows data extraction via the web according to user-selected site codes later replaced by alternative website applications at http://emolt.org

The data is now archived in NOAA/NEFSC ORACLE tables. The site information is stored in "emolt_site" while the data is stored in "emolt_sensor". While some haul information is stored in a "emolt_set" table, it is a limited collection and does not apply to the moorings that include salinity. No attempts were made to correlate salinity variability with haul counts.

Data was posted on the emolt.org website within a few days of downloading. Plots were generated and posted on the individual's website under "Results from the Field" as well as the "What's New" site. Data was served through the Distributed Oceanographic Data System (DODS) and accessible by the Gulf of Maine Ocean Observing System. GoMOOS provided an internet mapping service where users can click on zones in order to select particular eMOLT mooring datasets, view their approximate positions relative to other moorings, and view time series plots.

The basic mooring information is listed in Table 1 below. More than 66 months of data were collected in depths ranging from 55 to 210 meters (See Figure 5). The range of values observed at each site were within those expected from historical records but the margin of error is difficult to quantify given the similarity of real oceanographic events and those potentially due to cell contamination (see discussion below). Figure 5 is presented in order to depict the relative time periods each sensor was deployed.

A complete description of the database protocol and strategies is presented in the Phase III "eMOLT Database Management Final Report" submitted earlier this year and posted on the emolt.org site under "updates/reports".

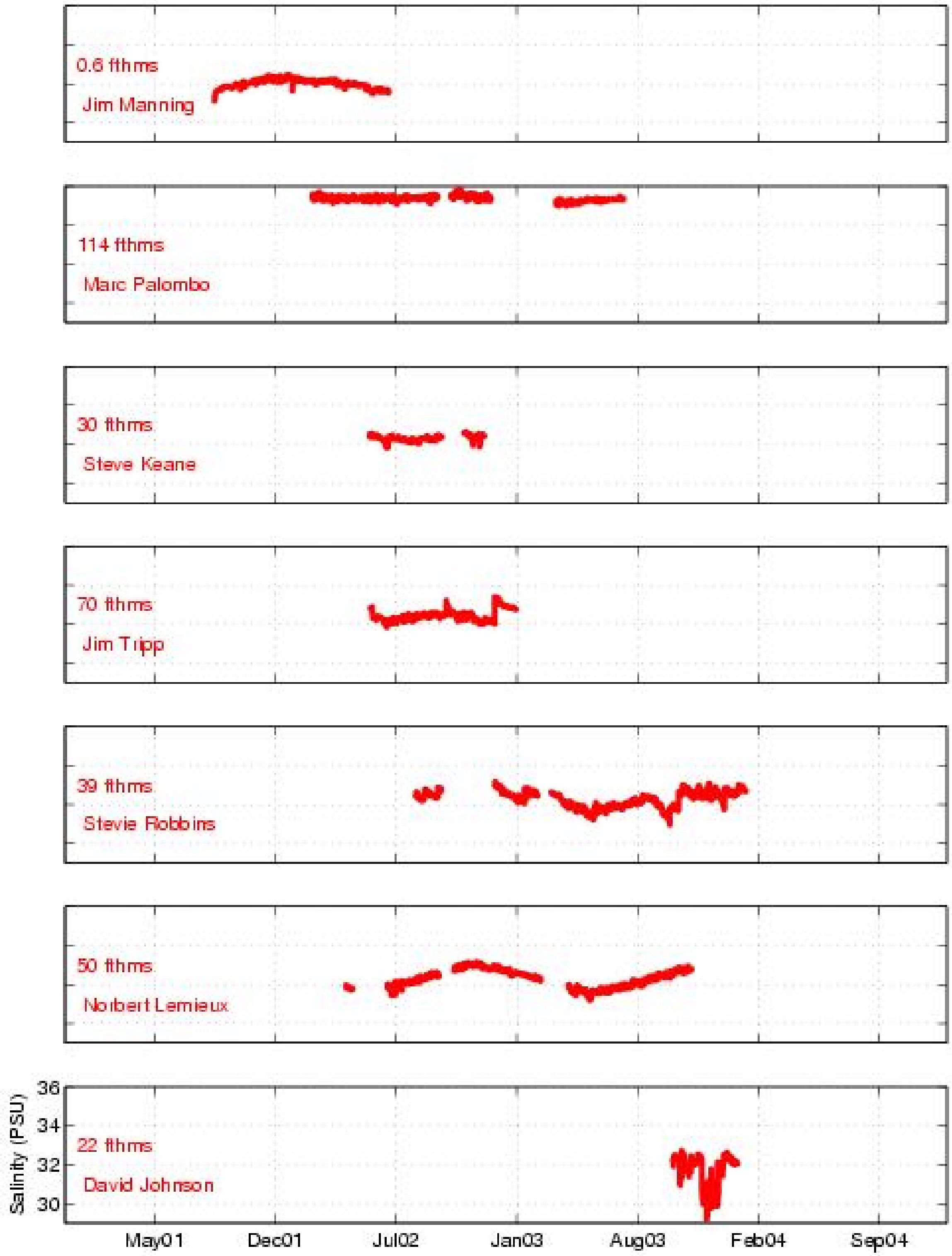


Figure 5. Time series of salinity as collected at eMOLT sites 2001-2004. Note the y-axis scale is consistent w/bottom panel.

Results and Conclusions

Initial tests were conducted in Woods Hole (WH02) starting in late 2001. Most sensors were first deployed by late 2002 and the last were recovered in early 2004. Note the consistent salinity scale is posted in the lowermost panel of Figure 5, ranging from 32 to 35 PSU. Except for Marc Palombo's salty record (>35 PSU, 2nd panel from the top) from the Hydrographer Canyon on the shelf edge and Dave Johnson's fresher record (<32, bottommost panel) near the river outfalls, most records fall within the range of 33 and 34. In order to depict the details associated with these series, each is plotted individually in Figures 10-16 along with the associated wind and temperature records. Results from each probe location is presented separately below. Each record is compared to the Microcat records on nearby GoMOOS moorings. GoMOOS mooring sites are denoted by the yellow dots in Figure 1.

Table 1. Mooring location and site information

Site	**Region**	**Lobstermen**	**Latitude**	**Longitude**	**Depth(ftm)**	**Depth(m)**	**#months****	**Association**	**Ave**	**Std**	**Min**	**Max**
TA15	Hydrographer's Canyon	Marc Palombo	4003.75	6904.00	115	210	12.1	AOLA	35.37	.12	34.98	35.86
NL01	Downeast	Norbert Lemieux	4438.55	6702.03	50	91	14.7	DELA	32.29	.45	31.18	33.15
DJ02	Casco Bay	David Johnson	4338.84	7008.57	22	40	3.5	MeLA	31.77	.75	29.18	32.74
SK01	Mass Bay	Steve Keane	4306.00	7026.00	30	55	5.7	MaLA	32.30	.14	31.81	32.64
RS01	mid-coast shallow	Stevie Robbins III	4401.00	6832.80	39	71	14.8	DELA	32.54	.20	32.06	33.18
JT04	mid-coast deep	Jim Tripp	4346.30	6840.20	70	128	8.4	MeLA	32.46	.28	31.83	33.40
WHAQ*	Woods Hole	Jim Manning	4132.50	7040.30	1	2	7.3	NOAA	32.08	.21	30.47	32.49
Total							66.5					

* test site
** time series collected at hourly rates

Hydrographer's Canyon

The first lobsterman to deploy a Microcat on his trap was Marc Palombo. Marc was the first and probably the most active participant in the eMOLT project in general with temperature series collected nearly a decade ago. He has a total of 139 well-documented mooring deployments. He fishes in a very dynamic area affected by a combination of shelfedge processes. While his temperature series will be presented in the final report of the temperature project, a brief summary and analysis of his salinity records are as follows. As depicted in the 7-day running average salinity in Figure 6, typical salinities in this region are greater than 35 PSU but are significantly modulated by tides, winds, and especially the offshore influence of Gulf Stream ring passages. The event on Oct 2002 (Figure 7) was subsequently observed at other sites located to the southwest of Palombo's and, as indicated in Figure 8, propagated to the Mid-Atlantic Bight in November and December. It is difficult to make estimates of ring propagation speeds from these records since the instruments often observe perturbations of the shelfslope front rather than the ring itself. As depicted in Figure 7, for example, locations marked by black dots are affected by episodic "streamers" or eddies spawned from eddies. The shelf-slope front is often detectable at these deep sites in the form of temperature and salinity oscillations.

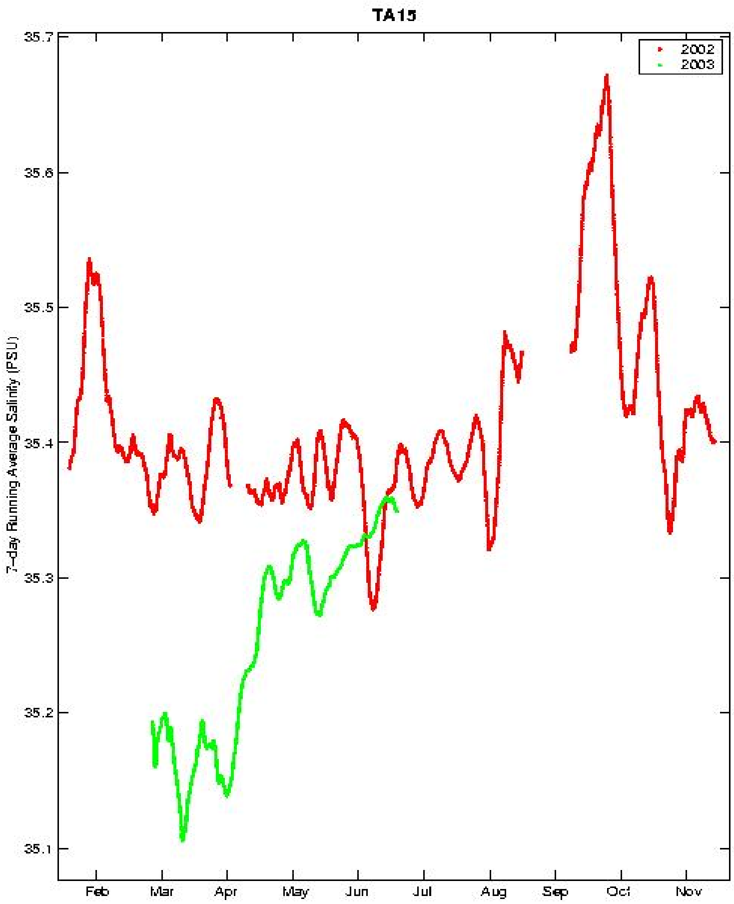


Figure 6. Time series of salinity as collected by Marc Palombo in Hydrographer's Canyon.

Some of the temperature sites document tidal variations of several degrees. Figure 9 depicts a moderate case of a few degrees and a few tenths of a PSU. We can determine from this figure, for example, the front was in the vicinity of this probe for a few days centered around 07/08, was advected away, and then reappeared on 07/14. In other words, the presence or absence of the front at anyone location can be determined by the tidal variability of both temperature and salinity.

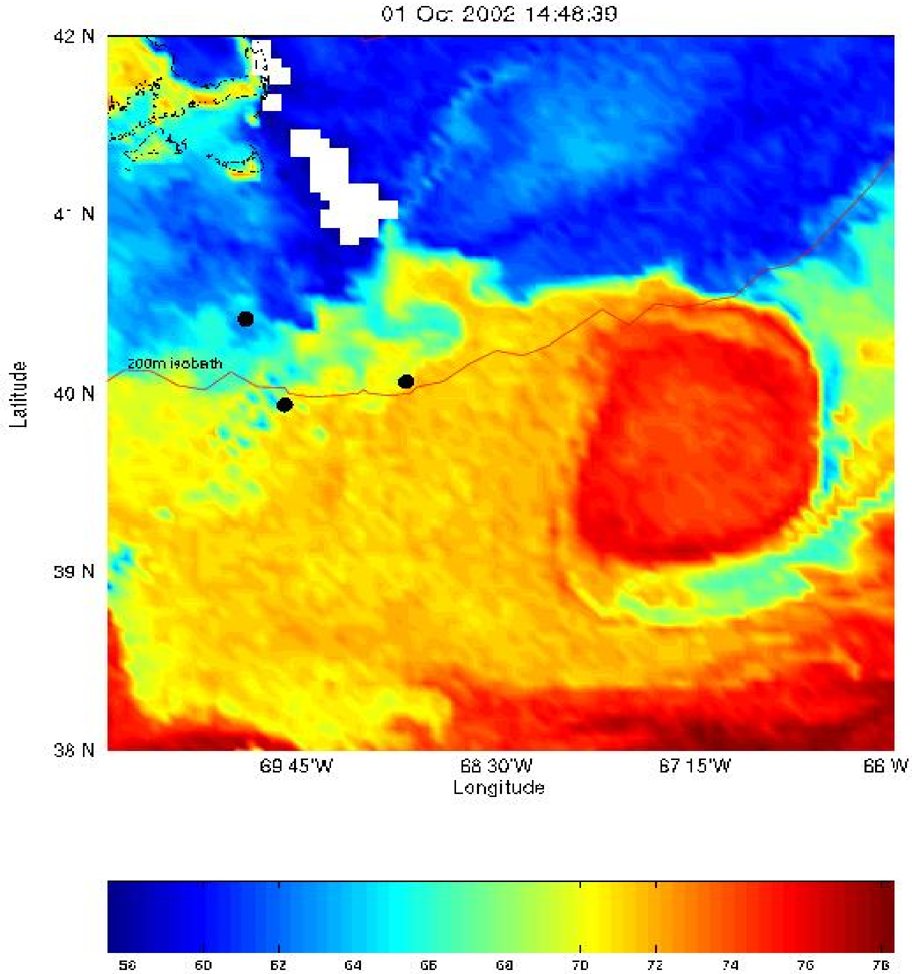


Figure 7. Satellite-inferred seasurface temperature image for 1 Oct 2002 depicting lobster trap locations (black dots).

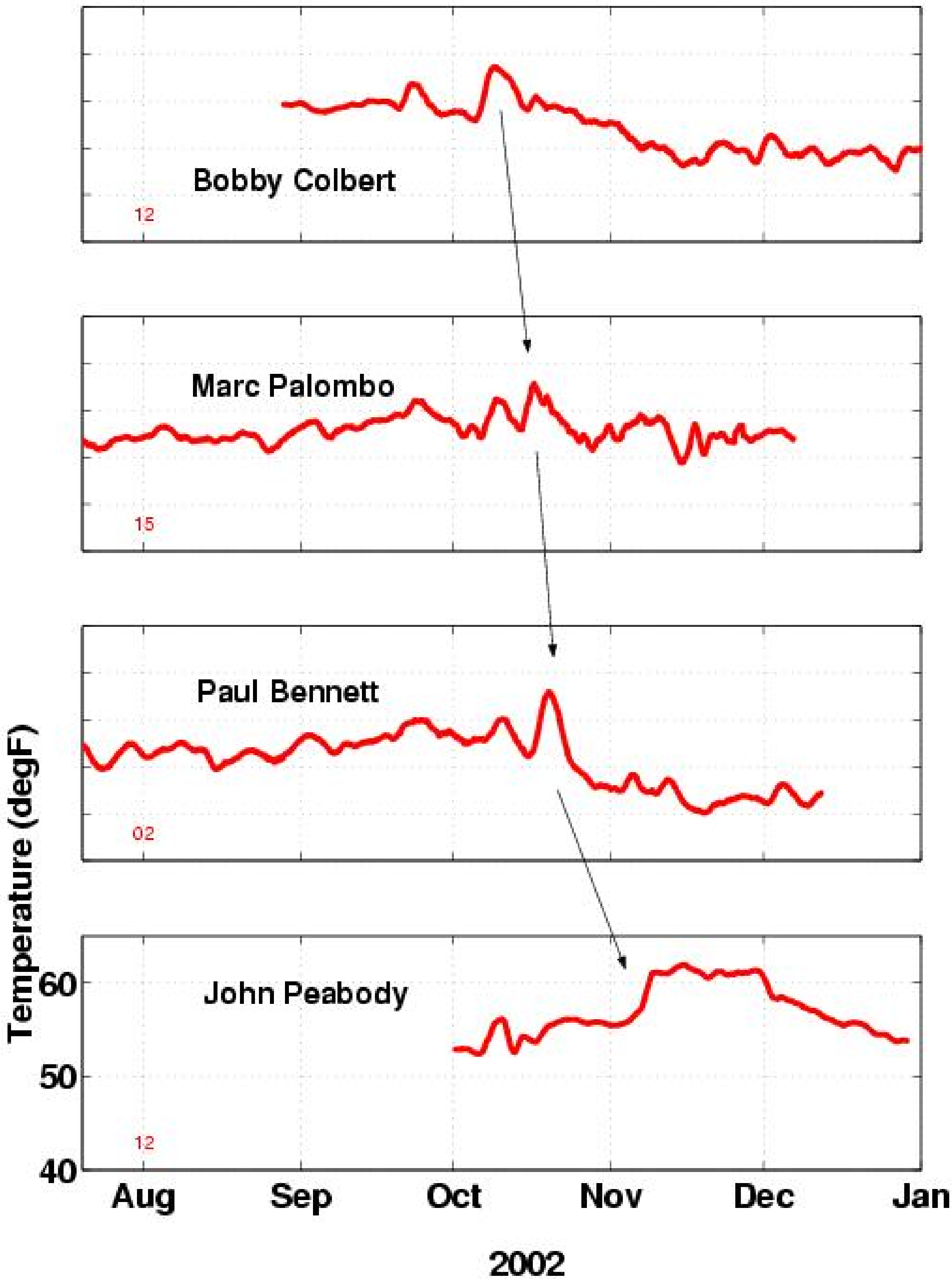
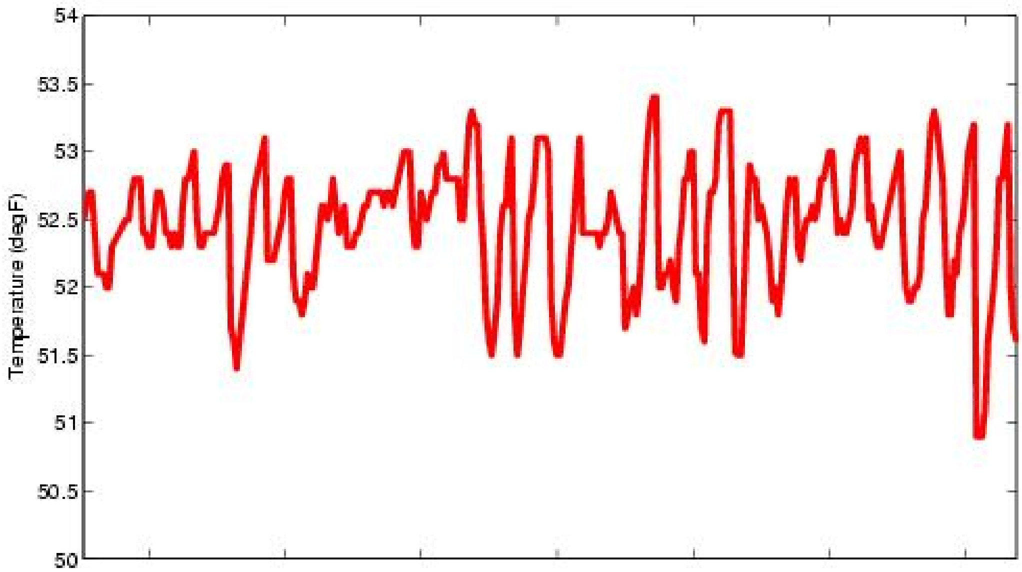


Figure 8. Time series of temperature depicting the migration of warm core ring events passing successive trap locations.



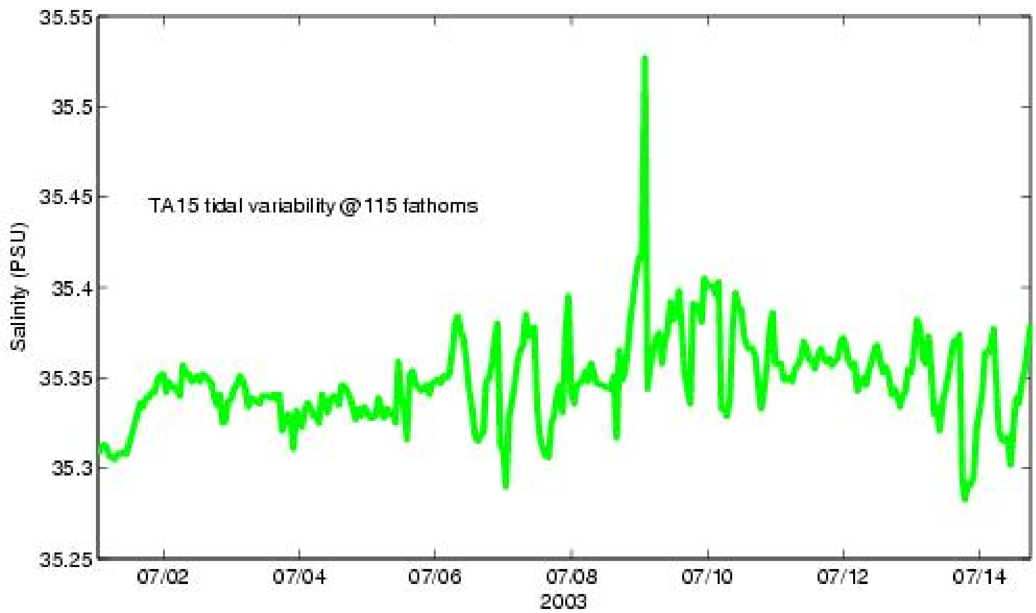


Figure 9. Tidal variability in temperature (top panel) and salinity (bottom panel) as captured at Marc Palombo's site in the Hydrographers Canyon.

Mass Bay

Steve Keane's deployments in Mass Bay provided data through the summer (Figure 10) and fall (Figure 11) of 2002. As seen at the 50m Microcat on the upstream GoMOOS mooring "A", SK01 recorded a gradual freshening in May through most of June. In late June, these deep sensors were apparently capped off from the surface waters as stratification took effect. Both T & S held fairly steady through July with small intermittent variations, possibly due to oscillations in the wind (top panel) before a gradual increase in August and September. Steve obtained two water samples during this first deployment on 27 June and 10 October. There is a large discrepancy in the first sample (~0.3PSU) that is likely due to a number of factors. (see discussion below).

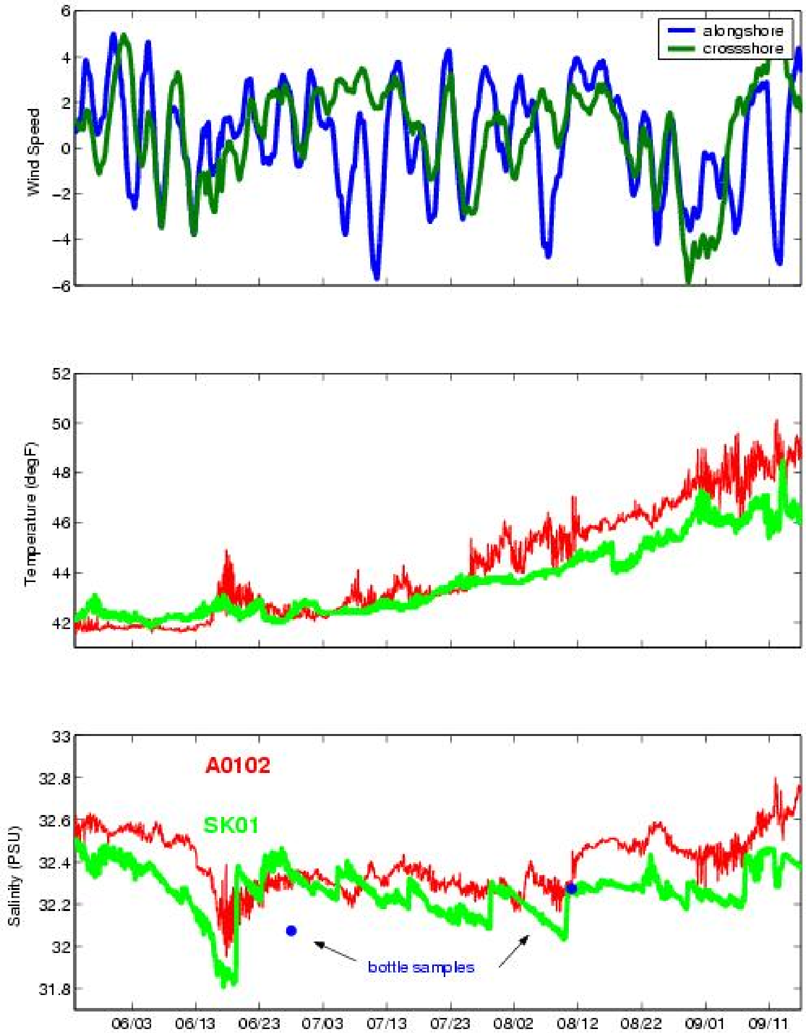


Figure 10. Steve Keene's time series of temperature (top) and salinity (bottom) during the summer of 2002 in Mass Bay with GoMOOS mooring "A" records depicted in red.

An interesting pair of events occurred during the fall deployment (Figure 11) on the 7th and 17th of November. Drops in salinity of nearly 1/2 PSU occurred suddenly and held steady of a few days. Given that there was not a concurrent change in temperature, these events are a prime example of potential fouling by small grains of mud or sand in the conductivity cell. While there is the possibility of downwelling events causing the relatively fresh coastal waters of Plymouth to be forced to the deep, one expects a corresponding rise in the temperature signal that clearly did not occur.

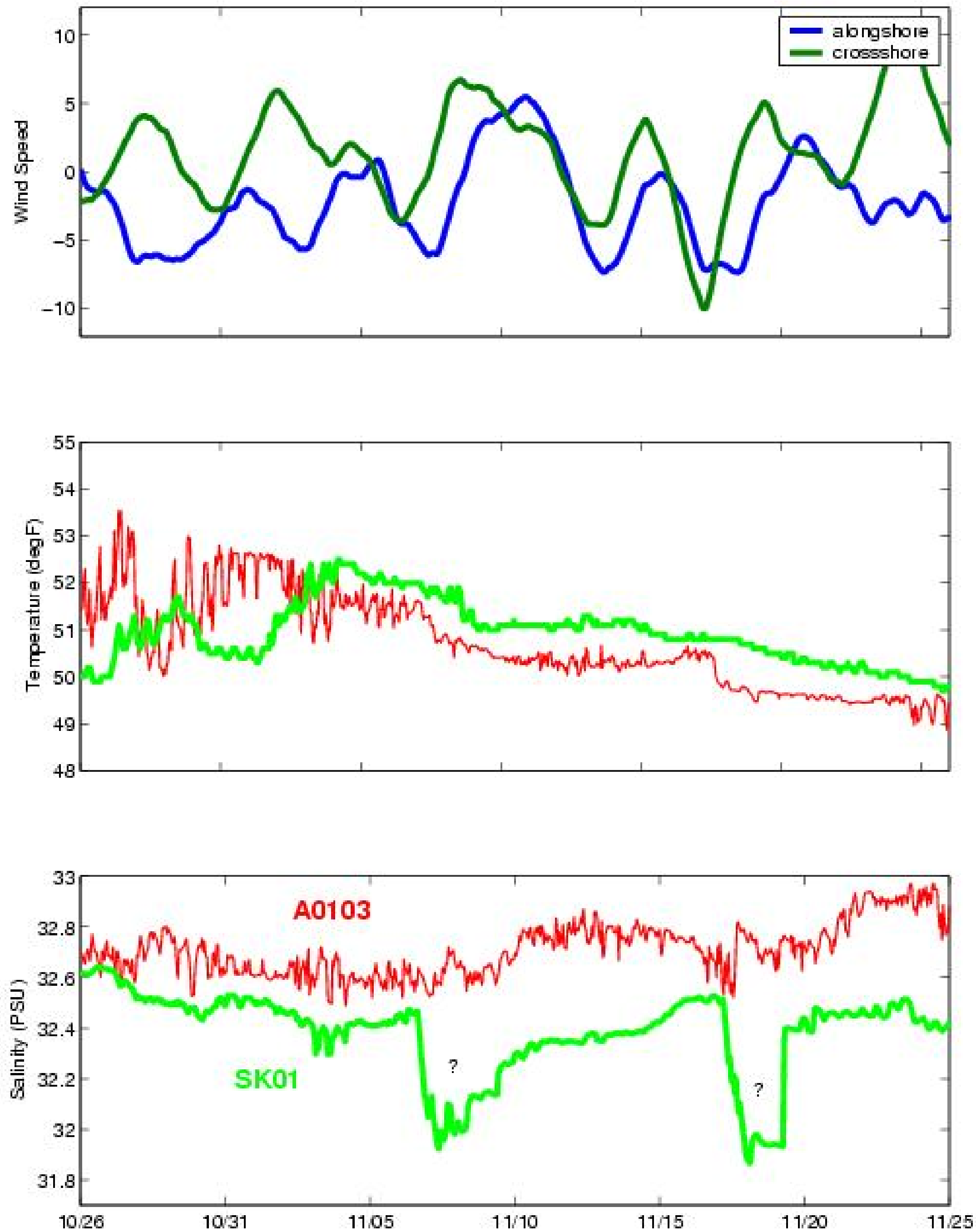


Figure 11. Same as Figure 10 but for a different time period (Fall 2002).

Casco Bay

Dave Johnson was the last participant to deploy a probe. His short record is perhaps the most interesting but the most difficult to explain. His was obtained in a very dynamic, almost-estuarine, environment just outside Casco Bay. As discussed in more detail below, initial looks at the erratic data concluded possible contamination of the conductivity cell but further examination and comparison with nearby GoMOOS records suggest there is at least some chance that the episodic events are real phenomenon associated with river plume dynamics. Visual inspection of the Kennebec River discharge (data downloaded from USGS, the Forks gage), depicts a few small events during the fall but no consistent coherence with salinity at either the GoMOOS mooring "C0204" or the eMOLT site "DJ02". The sudden drops in the former in December could potentially be the result of the relatively large discharge earlier that month. Further conclusions on this dataset will be possible after the U Maine Orono moorings, deployed at the mouth of Casco Bay during this time, are recovered and processed.

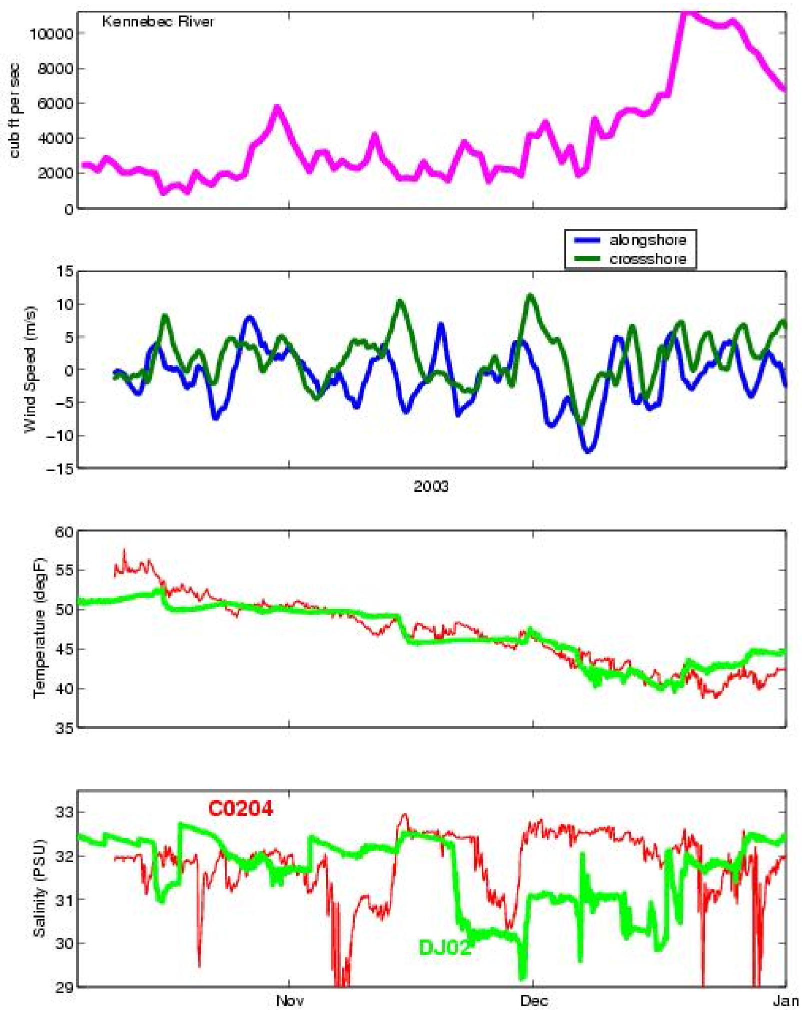


Figure 12. Time series of river discharge (top), wind (2nd), temperature (3rd), and salinity (bottom) for Casco Bay in the Fall of 2003.

Deep Mid-Coast

Jim Tripp fishes the deep waters beyond Matinicus Island. His is the most suspect of all records Figure 13). The decline in salinity in August 2002 (relative to the 50m record at GoMOOS buoy E) and the abrupt increase of 1.5 PSU in December are probably due to sediment particles or biofouling of the conductivity cell followed by a flushing.

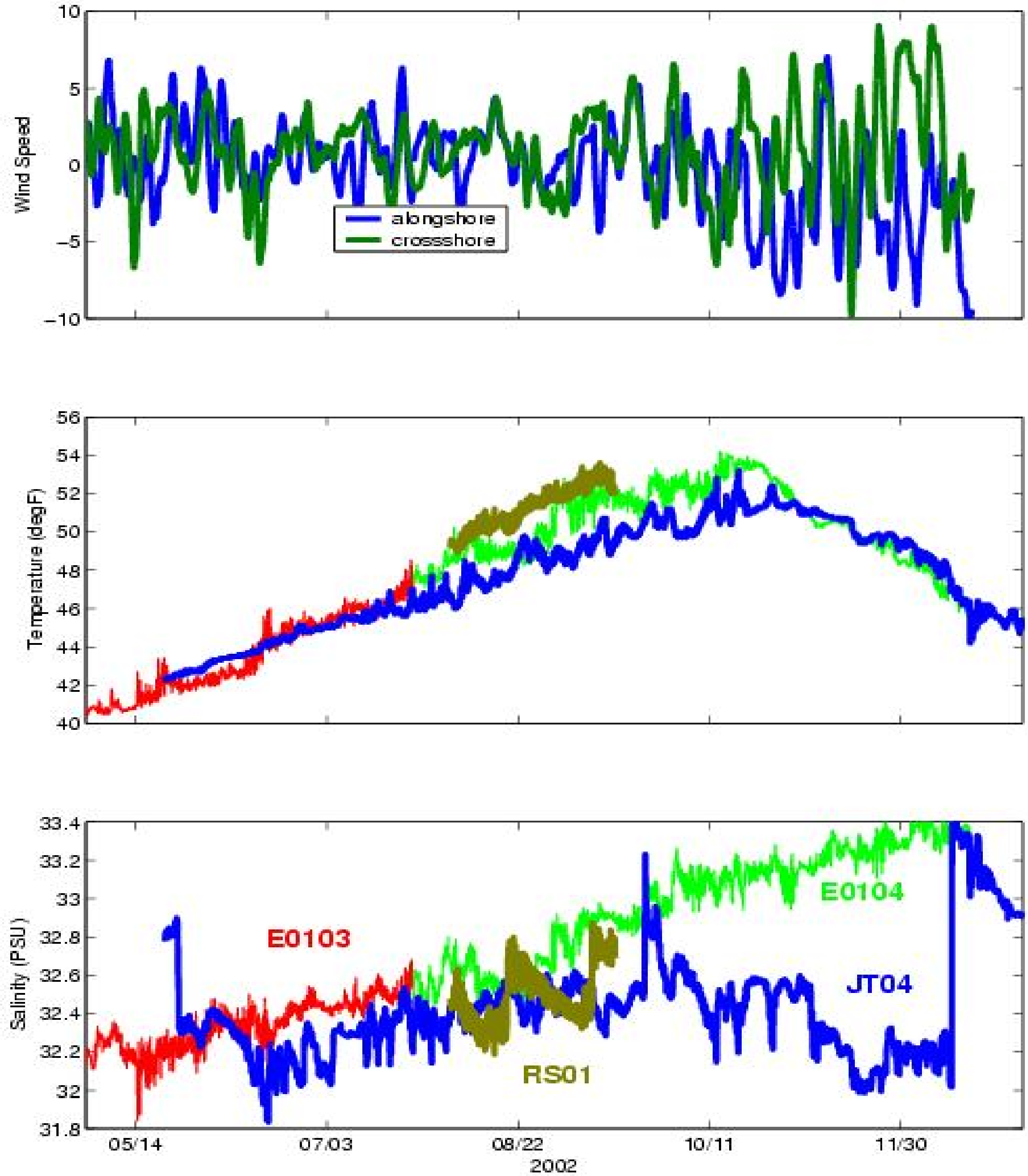


Figure 13. Jim Tripps and Stevie Robbins temperature (middle panel) and salinity (bottom panel) records from spring-fall 2002 with GoMOOS mooring "E" records included. The top panel depicts the wind speeds at mooring E.

Shallow Mid-Coast

Stevie Robbins III, out of Stonington Me, obtained a short record in the summer of 2002 (see "RS01" line in Figure 13) and then one of the longest time series for most of 2003. The latter, when plotted against GoMOOS Buoy I (Figure 14), indicates the salinity record is often nearly a full PSU less than the 50m record from the GoMOOS mooring. While we might expect a variation in salinity as the core of the WMCC passes overhead, the temperature record should depict a change as well. We are again left with doubt as to the validity of these values. The abrupt increases in salinity during the Fall 2003 are more likely due to flushing of the conductivity cell by either natural currents or participant hauling. Unfortunately, a detailed log of exactly when the instrument was hauled is not always available.

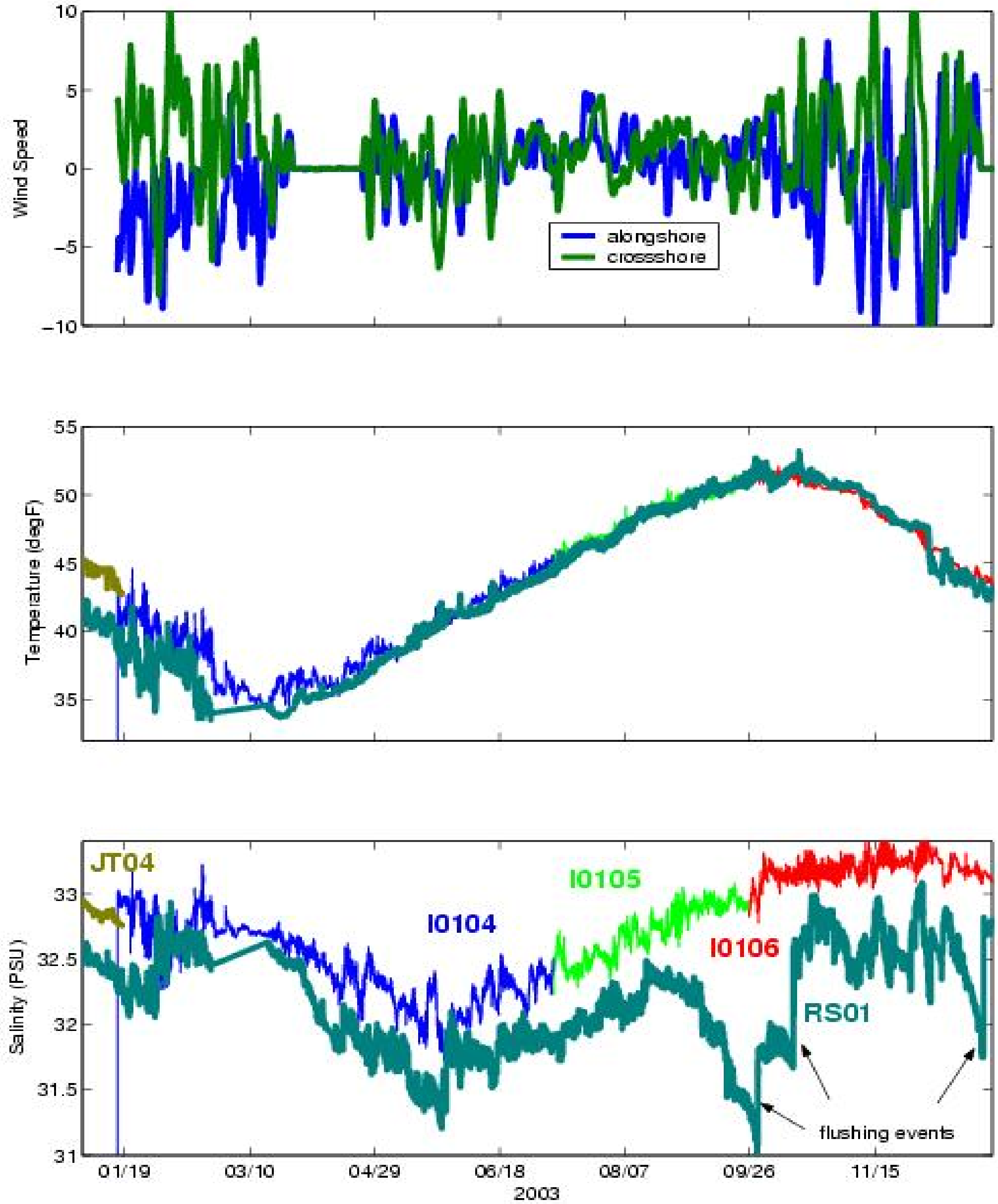


Figure 14. Stevie Robbins records with GoMOOS mooring "I" overlaid.

Downeast

Norbert Lemieux and his son Nick also provided a long series. Since it is such a long time series, 2002 and 2003 are plotted separately in Figure 15 and 16, respectively. The first year is plotted against the records from mooring "I" downstream. According to preliminary results of the eMOLT drifter project, the typical transit time between NL01 and mooring I is often less than a week.

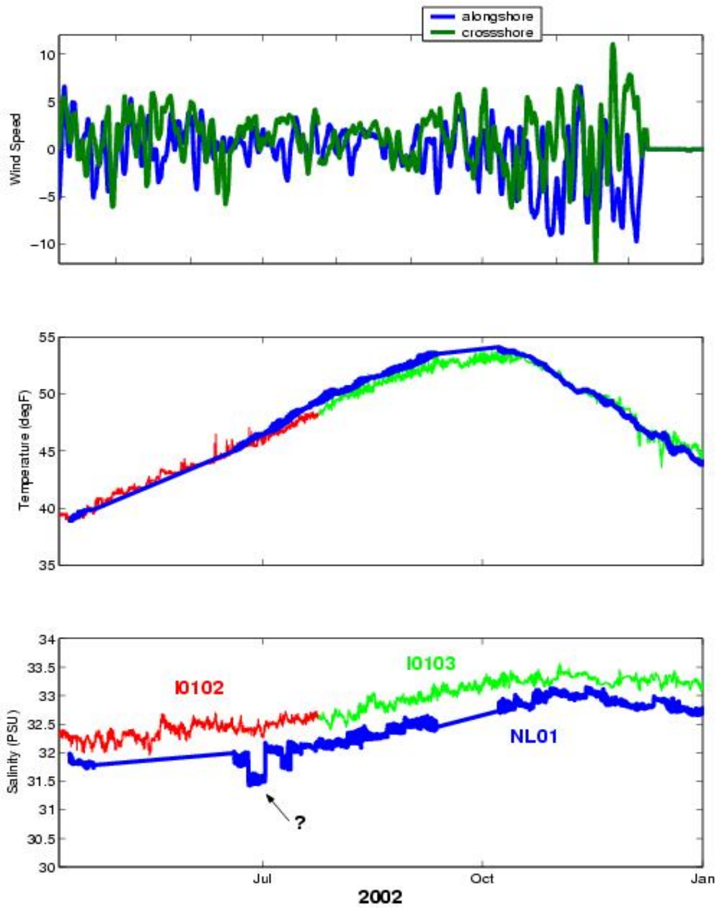


Figure 15. Norbert Lemeiux's records from 2002 with wind at mooring "I" in the top panel.

While we can not expect the conditions at the two sites to be exactly the same due to the differences in the depths of sensors and the distances from river plumes, we see that, despite their alongshelf separation distance, they are very similar nevertheless. The temperature is the same within a few degrees and the salinity is slightly saltier at mooring I downstream. While the temperature peaks in late September the salinity peaked later in October. Plotted against GoMOOS mooring "J" during mid-2003 (Figure 16), the record indicates slightly cooler and saltier conditions off the coast of Cutler relative to that measure at 10m near shore. There is a chance that the two slight depressions in salinity on spring 2003 at "NL01" may have been the result of the two large drops in salinity as measured about a week previous at J. Without other mooring data to substantiate this possibility, we are left to the uncertainty again in the lobster trap readings.

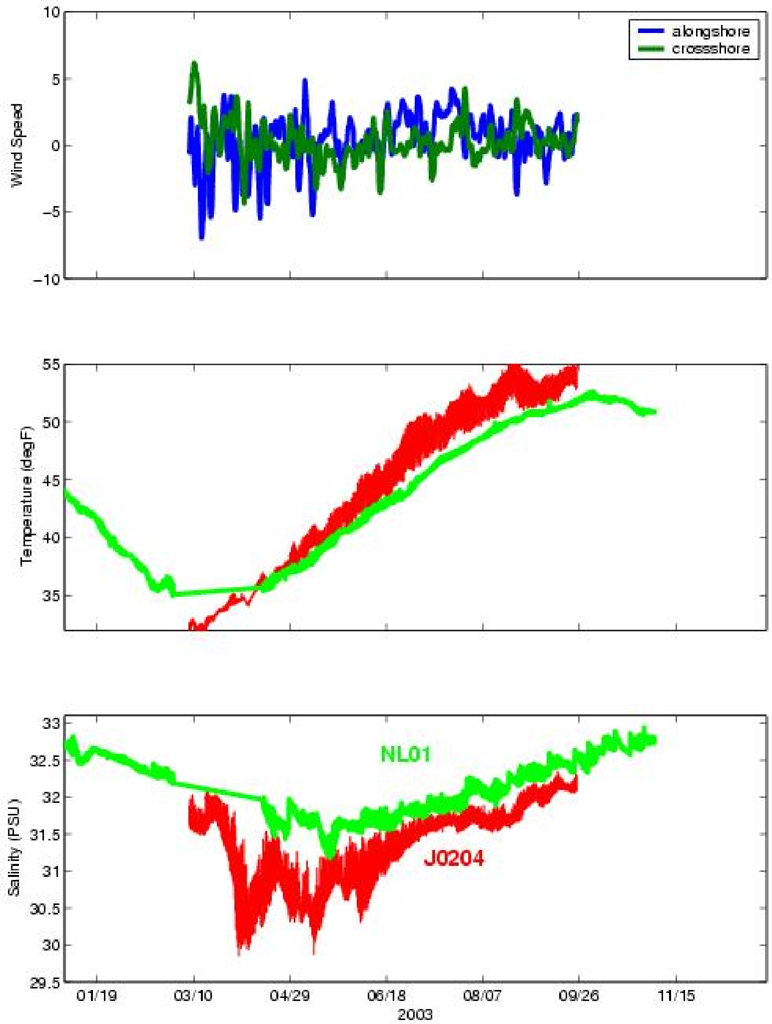


Figure 16. Norbert Lemieux's records in 2003 with GoMOOS mooring "J" records overlaid.

Woods Hole

Preliminary instrument tests were conducted in Woods Hole during in 2001 and 2002 before any were distributed to lobstermen. The initial tests were discouraging due to problem with fouling in Woods Hole Harbor. As previously discovered by others (Taylor, 1992), hanging a conductivity sensor off the dock in the inner harbor results in contaminated data probably due to the prevalence of motor oil and other effluents. This was not only a problem with Seabird Microcats but also with other instrumentation such as the YSI model deployed simultaneously (Figure 17).

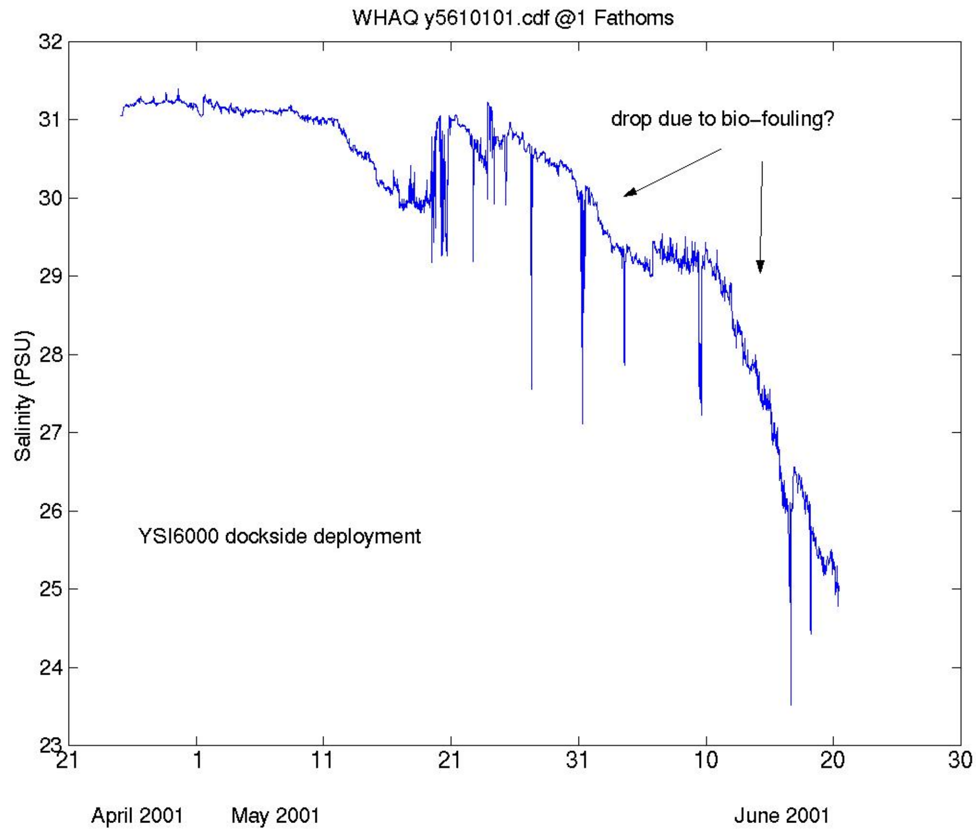


Figure 17. YSI instrument salinity dockside records from Spring 2001.

After these initial tests, the Microcat was deployed in the NEFSC Aquarium tanks for a lengthy examination. As noted in Figure 18 , water samples were taken on a near-weekly basis to test the accuracy of the electronic sample. Satisfactory results were obtained. It is interesting to note the gradual increase of salinity documented in early Winter. The rapid drop in mid-January was likely due to the aquarium personnel deciding to dump a load of warm water from the fresh water tap into the tank. After these initial tests, the instrument was deployed for nearly a year which resulted in what may be the longest hourly salinity record from Woods Hole Harbor (Figure 19).

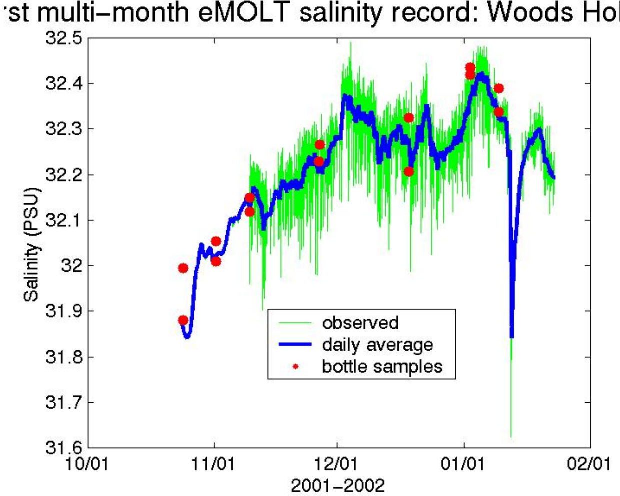


Figure 18. Seabird Microcat test deployment in Woods Hole Aquarium with calibration samples (red dots) overlaid.

This seasonal cycle during 2001 and 2002 is less obvious in the subsequent months of 2003 when only an occasional Niskin sample was obtained off the dock (Figure 20). A total of 79 bottle samples were taken on time periods ranging from a week to a month by submerging a Niskin bottle mid-way through the water column (being careful not to disturb the bottom sediment) and releasing a messenger to trip the mechanism. This bottle data extended the electronic record through most of 2003. In several cases, samples were taken both off the dock and inside the aquarium where harbor water is pumped. The differences between the two sets were not consistent and likely less than the error associated with the method of comparison.

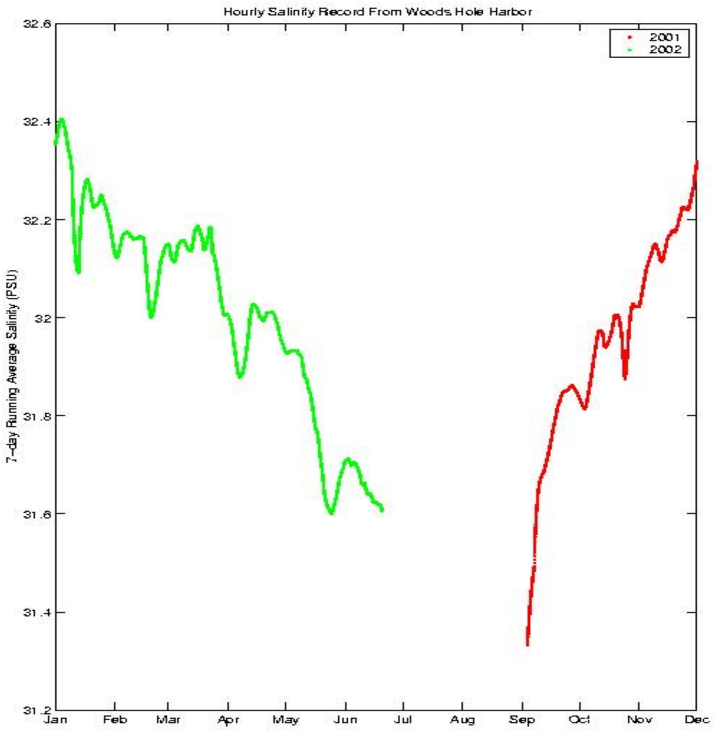


Figure 19. Weekly averaged salinity record from Woods Hole in 2001-2002.

In order to investigate the longterm character of salinity in Woods Hole Harbor, historical data from Woods Hole Lightship was obtained from Kathy Elder (WHOI) and plotted along with the salinity data collected at the NEFSC Milford Aquarium over a period of a few decades (Figure 21). The seasonal cycles are given in Figure 22 . It is clear from Figure 22 that the Milford site is a brackish estuarine environment typically at around 25 PSU with minimum salinities as expected in April and maximum in late October. Both these datasets were entered into the eMOLT database along with many other longterm temperature series at various state, government, and commercial institutions. The draft write up of this ancillary project is posted at http://www.nefsc.noaa.gov/epd/ocean/MainPage/whwt/newt.html.

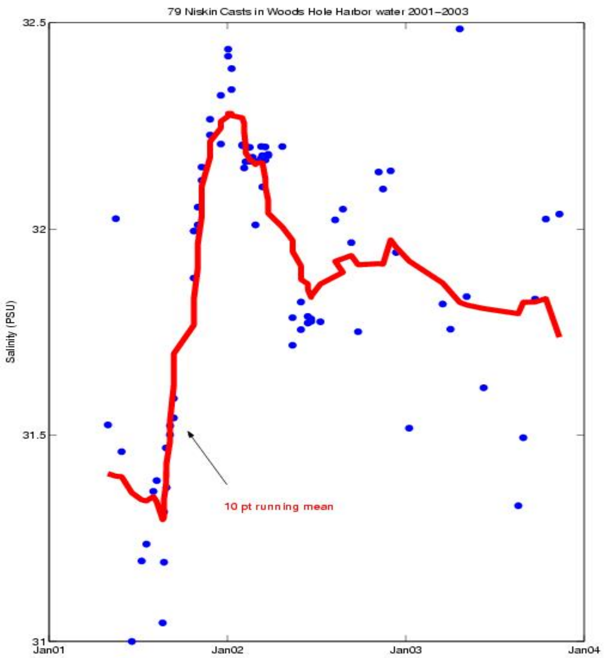


Figure 20. Water sample salinity as measured off the NMFS dock in Woods Hole 2001-2004.

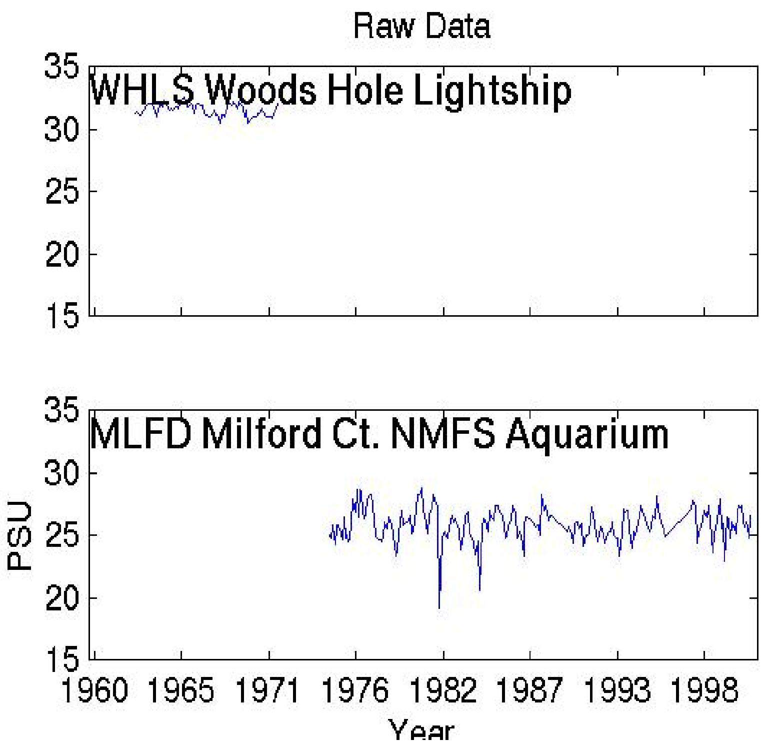


Figure 21. Salinity as measured over multiple years in Woods Hole, Ma, (top) and Milford, Ct. (bottom).

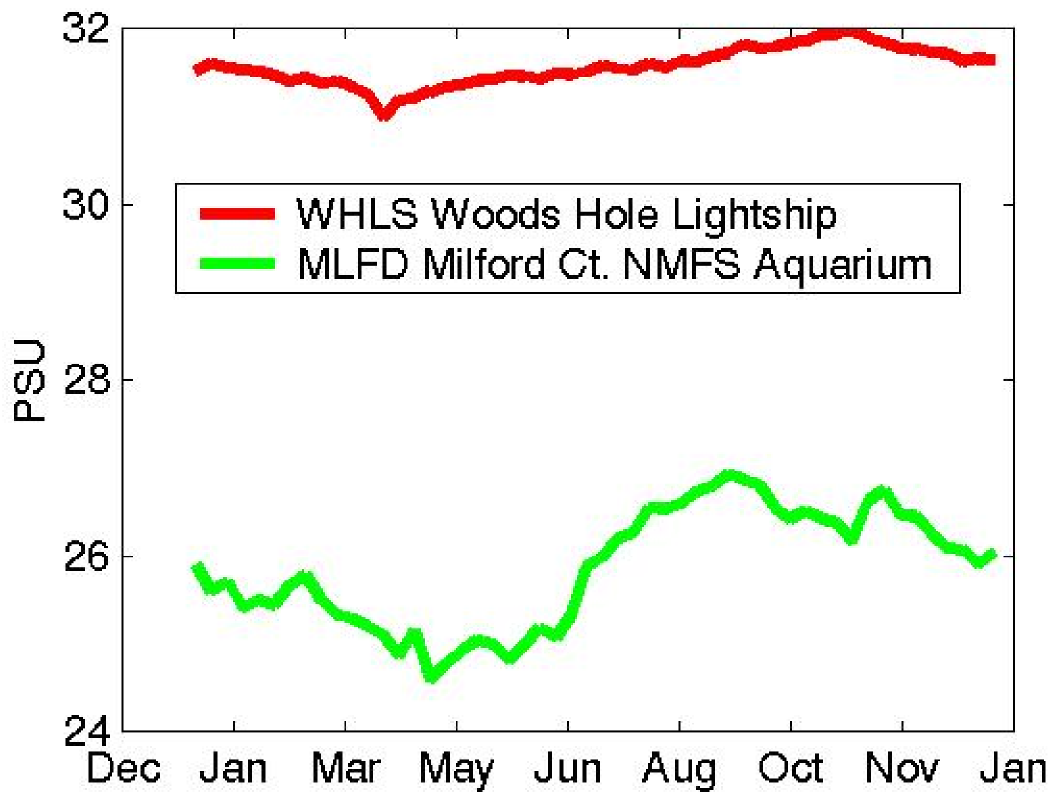


Figure 22. Seasonal cycle derived from data depicted in previous figure.

Discussion

One of the most serious failings of the eMOLT II project was in obtaining adequate water samples. The original objective of obtaining near-monthly calibration samples with a Niskin bottle turned out to be unrealistic for a variety of reasons. The units purchased were adequate for the operation except that, in some cases, the lead line was not long enough. In these cases it was necessary for the participant to add line to the tether. This was a particular problem in the case of Palombo's where the water depth exceeds a few hundred meters. It was physically difficult to deploy the unit at this site and the time involved with such an operation was economically unfeasible. In this case, and especially in the case of Norbert Lemieux's, the tidal velocity was so extreme that bottle was not weighted sufficiently to easily get to the bottom. In cases of muddy bottom (Johnson and Keane), the bottle samples were too easily fouled due to sediment resuspension. The difficulty of getting a "near-bottom" sample without disturbing the sediment was not considered in the original protocol. While the lead line was incrementally marked, future studies will need to have a well-marked maximum extension that is appropriate for the particular site at a particular slack tide.

If lobstermen are to obtain water samples, alternative protocols need to be developed. The protocol could be radically modified, for example, to take "near-surface" samples instead. This would require a conscious effort on the part of the participants. In this scenario, the participant would take water samples on an opportunistic schedule whenever they happen to be hauling a sensor in calm seas and when the instrument was scheduled for its hourly sample. The salinity sensor would need to be hauled up just below the surface (preferably in view) while the Niskin is deployed as close as possible in time with the scheduled electronic sample.

Another alternative to allow for undisturbed near-bottom samples would be to deploy the trap (with the salinity sensor installed) along with a traditional Niskin bottle permanently attached to taunt mooring line a meter or two above the trap. This "taunt mooring line" would be distinct from the normal mooring line and have its own flotation but would only be recoverable in low tide situations. The lobstermen could then take advantage of low tide situations during a scheduled electronic sample by dropping a messenger down the taunt line to trip the Niskin bottle. The trawl is hauled, the sample is drawn, the Niskin bottle is reset, and the entire mooring is redeployed. There are, however, potential problems with this alternative. In tidally-dominated environments this configuration would cause buoy lines to wrap around the taunt-mooring line. In these cases, the taunt-mooring line would need to be deployed separately, like a traditional subsurface mooring and possibly marked with a set of "surface guard buoys". The other difficulty with permanent Niskin bottles is that any biological growth along the line would prevent the messenger from properly descending through the water column.

It was necessary to look closely at potential contamination of conductivity cells by fine grain sediments or fouling. Initial looks at the most uncertain of all the records, site DJ02, indicated it may have been fouled. This preliminary conclusion was based on the fact that a) the record was highly variable, b) the temperature did not seem to vary along with the salinity, c) unlike other sites, the instrument was not hauled during routine fishing operations (hauling would tend to provide occasional flushing of the cell) and d) the lobsterman reported the site as "muddy". A closer look however indicates that , given the location of the probe at the mouth of Casco Bay in relative shallow water, the "highly variable" time series may have resulted from real estuarine processes. After looking at the near-surface salinity records of the nearby GoMOOS Buoy C, the type of variation observed at DJ02 does not seem that implausible. In that location, for example, drops of nearly 2 PSU were observed to occur, for example, in mid-November over the course of a few hours. While the episodic events at DJ02 are not coherent with those at Buoy C (they are located in very different regions of Casco Bay), the degree and frequency at which they occur, are similar (see the bottommost panel of Figure 12).

The episodic variability at the other eMOLT sites were not nearly as dramatic as at DJ02. In the Fall of 2002, for example, the variations at three eMOLT sites were similar in magnitude to those observed at the GoMOOS site "I" (see Figure 23) except that the tidal variations are apparently more pronounced near the bottom. Note that changes in the near-bottom conditions **are** likely to be more abrupt than the changes that occur in the upper water column due to the structure of the near-bottom front being more vertical. While the halocline lies relatively horizontal in the water column, the orientation of the isohalines is altered by the bottom-boundary layer to be vertical. This is often referred to as the "foot-of-the-front". This mechanism is especially plausible the case of Stevie Robbins' (71m) where the probe may be located nearby a persistent tidal front. It appears that the sensor was exposed to some edge of the frontal gradients throughout the series. Is it possible that the axis of the front was perturbed, for example, on 08/20 (and again on 09/10) where the probe may have been exposed to the opposite side of the front? Notice that these abrupt changes occurred when the tidal variation was greatest. Again, without adequate calibration samples at critical times in the record, the question remains unanswered. In hindsight, a pair of instruments deployed by each lobstermen either in the same location or at slightly different depths would have helped resolve the problem. Having instruments in depths differing by ~5 meters, say, would help determine the speed of front translation.

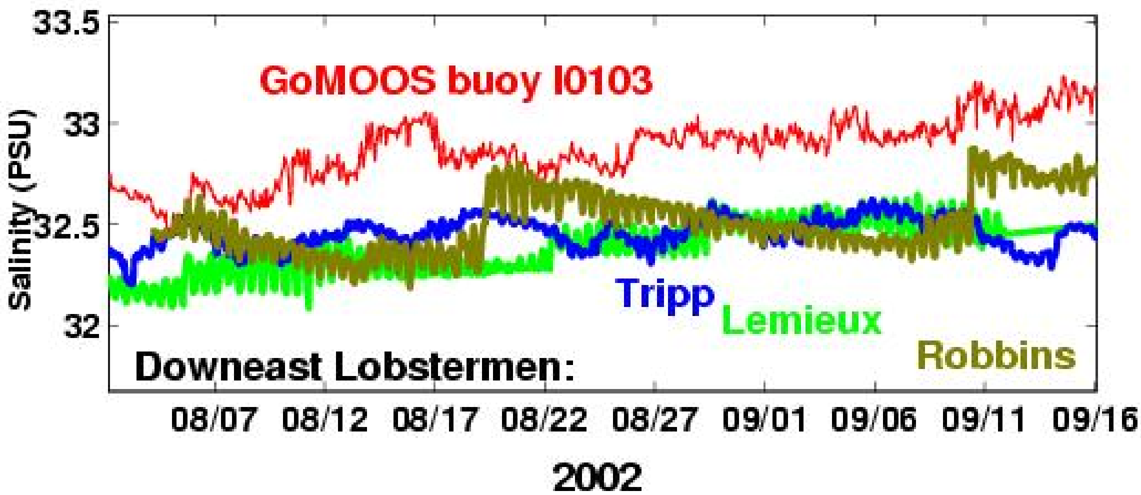


Figure 23. Example overlay of lobsterman-obtained salinity records along with those from GoMOOS mooring "I".

It should be noted that none of the sensors were visibly fouled on recovery. Participants were trained to visually inspect the condition of the cell and note any obvious fouling. Nothing was noted. The units were all returned in good conditions with conductivity cells clean and free of particles. While the cell may appear free of particles (Figure 24), even the slightest film or temporary alteration of the geometry can apparently bias the conductivity reading. The cells may have been partially blocked while moored and then flushed during the hauling operation.

Figure 24. Photo of Microcat conductivity cell.

As noted in the previous paragraph, all Microcats were shipped to Seabird (except for the one lost) to get refurbished after eMOLT deployments. All units were calibrated "as received", cleaned, replatinized, and calibrated again (In Steve Keane's case, unit 130, replatinizing was not necessary). The results of this operation are documented in Table 2 below. Salinity drifts of this order are not insignificant. Variations of nearly 0.005 PSU per month are small (approximately 1/10th the natural variation due to seasonal change in this area) but values of ~0.05 per **year** are close to the magnitude associated with interannual changes. The drift Seabird notes for these instruments is in the same order of magnitude as those of other instruments we have deployed in the past. Instruments that are typically turned-around on a bi-annual basis have drifts on the order of 0.001 PSU/month. These values are often dependent on the depth of the instrument in the water column with those in the deep being less fouled. Nevertheless, if this experiment is planned again in the future, it will be imperative to schedule a recalibration and cleaning of instruments more frequently than the annual rate. The advantage of lobstermen-deployed moorings is the regular opportunity to inspect and clean/flush the instrument. An accurate log of cleaning operations must be kept. Since the focus of this pilot project was on shorter term variations and the fouling appeared to be intermittent, no corrections were applied to the archived data.

Table 2. Results of "as received" Microcat calibration by Seabird Electronics.

Site	Serial#	Drift in salinity (PSU/mth)	PSU/year	Drift in temperature (degC/year)
TA15	126	-0.0039	0.0468	+0.00017
RS01	127	-0.0041	0.0492	+0.00072
NL01	128	-0.0034	0.0408	+0.00064
JT04	129	not recovered		
SK01	130	-0.0008	0.0096	+0.00004
DJ02	935	-0.0027	0.0324	+0.00024

Partnerships

The fishermen-scientist partnership was especially successful. Having met with each participant in-person on multiple occasions and had multiple phone conversations, the science party benefitted greatly from the industry's input. In particular, the expectations of what is and is not possible was continuously adjusted with each communication. The logistics of taking a water samples given the equipment supplied, for example, was often discussed. The fishermen expressed genuine interest in the project and conducted the operations in a cooperative manner. The fishermen took on the challenge of rigging the Microcat to their respective traps with no help from the science party. Given their expertise in these sorts of gear adaptations, they showed their own ingenuity. In one case, the fishermen took photos of his solution to the problem so that they could be shared with others (see Figure 4). Norbert Lemeiux, an engineer prior to being a lobstermen, independently set about designing a Niskin-bottle-retrieving mechanism (fashioned after a fishing rod) to allow easier water sampling. While the apparatus was never actively used in this study, the unit can be implemented and revised in the future.

Collaboration with other projects

In order to come to a better understanding of this potential-fouling problem, an experiment is underway at the time of this writing in the northeast portion of Casco Bay. The marine science studies of Dr. Ed Laine and his students at Bowdoin College have led to an investigation of near-bottom salinity affter several class trips where Conductivity, Temperature, and Depth (CTDs) casts observed lower than expected levels of near-bottom salinity near particular sites in "Quahog Bay". Hearing this curiosity led Manning to visit Laine during the fall of 2003 at Bowdoin. After some discussion and subsequent visits, a plan was devised to deploy the eMOLT Microcats at this location to test a) the problem of sediment interference and b) potential existence of submarine freshwater discharges. After the Microcats were returned to Seabird for cleaning, calibration, and replatinizing, two of them were mounted on an old CTD Rosette cage (obtained from the

WHOI surplus). One is mounted to rest 20cm above the bottom (similar to a lobster trap mounting) and the other is 1 meter above the bottom (Figure 25). The units were securely fitted to the cage with the help of the Bowdoin machine shop and deployed in approximately 10 meters of water with the help of MER associates on 22 July 2004. The recovery is planned for late September 2004. While eMOLT funded the instrument refurbishment, Bowdoin (Laine et al) funded the new batteries, rigging, and deployment. Bowdoin has also conducted a series near-weekly of CTD casts for calibration purposes. Being a geologist, Laine is interested in the possibility of submarine discharges occurring at particular geological formations. If the discharge is confirmed at this location, investigations at other similar structures will likely be made in the future.

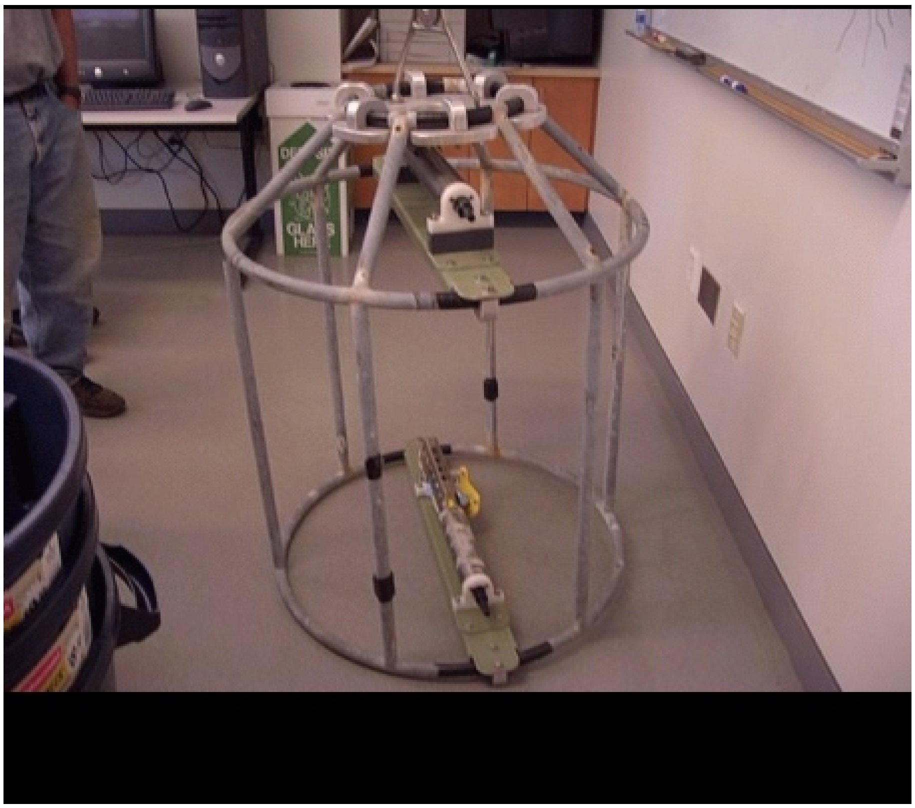


Figure 25. Photo of Microcat frame used in Quohog Bay experiment with instruments mounted on both the top and bottom.

Another successful collaboration to come out of this project is the eMOLT-GoMOOS connection. Manning has visited the GoMOOS office in Portland several times. Farrey is an active member of their board of directors. The eMOLT administrators have used their conference rooms on multiple occasions for meetings. In some cases, eMOLT participants (actual fishermen) have joined us at the GoMOOS offices to provide input/feedback to the website designers/programmers. Given that fishermen are one of the primary users of the GoMOOS website, the eMOLT network of these individuals can help contribute ideas in internet data display and mapping utilities.

Further discussions on partnerships and collaborations may be found in the eMOLT annual reports.

Impacts on end-users

One could say that NOAA is the primary "end-user" of the eMOLT project. As they prepare for the implementation of a nation-wide ocean observing system (OOS), they will begin with an integration of existing observational networks. What better place to begin than with the individuals who already spend their days at sea, have the biggest stake in preserving the resource, and are the most knowledgeable of the local waters? If NOAA intends to invest in the future of our coast, these individuals need to be recognized, recruited, and supported for their efforts. NOAA needs to look towards the many organizations of fishermen such as local lobstermen associations. GoMOOS, a prime example of a regional OOS, has done well in this respect by catering to the industry's need. They have been present at many of the forums where fishermen congregate, have listened to their needs, and have recognized eMOLT as a means to supplement the data they collect.

We could also say that the general public is an "end-user" of the eMOLT Phase II. Since salinity is so expensive and hard to measure, it has not received the attention historically that it might deserve. Fishermen often complain the water is "too hot" or "too cold". It is hoped that in the future, partly because of preliminary investigations by eMOLT, some might note instead that "we had a particularly large influx of less-saline Scotian Shelf water into the Eastern Maine Coastal Current this year" or "there was apparently a persistent Gulf Stream ring outside the NE Channel that provided a salty influx all the way into the Wilkensen Basin".

Presentations

A total of 74 presentations were made on eMOLT progress at various meetings, forums, conferences over the course of this project phase (see "Training Sessions and Meetings" link under the emolt.org main page for a full list often including agenda/minutes). While very little of the subject presented at these functions focused on the **salinity** phase of eMOLT, the point was made often to the general public that temperature was not the only important physical variable in the ocean.

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