

OC467 Cruise Report
Draft 8/6/10

Voyage #467 of R/V *Oceanus* was the third of four cruises in 2010 organized to serve complementary scientific objectives of two different projects. The two projects are:

GOMTOX: Dynamics of *Alexandrium fundyense* distributions in the Gulf of Maine: an observational and modeling study of nearshore and offshore shellfish toxicity, vertical toxin flux, and bloom dynamics in a complex shelf sea – NOAA ECOHAB

Objectives:

Investigate *A. fundyense* bloom dynamics and the pathways that link this organism to toxicity in nearshore and offshore shellfish.

Investigate the vertical structure of *A. fundyense* blooms, vertical toxin flux, and linkage to toxicity in offshore shellfish.

Alexandrium population biology in the Gulf of Maine – Woods Hole Center for Oceans and Human Health – NSF/NIEHS¹

Objectives:

Sample genetic variability of *Alexandrium* subpopulations throughout the Gulf of Maine.

Measure changes in relative abundance of *Alexandrium* genotypes in space and time.

Objectives common to both projects include:

Assess hydrodynamic and hydrographic context for interpretation of *Alexandrium* spp. measurements.

Incorporate field observations into a suite of numerical models for hindcasting and forecasting applications.

The primary domain of interest is Georges Bank, where a large bloom of *A. fundyense* was observed in 2007 and shorter and less intense bloom occurred in 2008. The four cruises in 2010 are designed to (1) resolve the seasonal variation of the Georges Bank bloom, and (2) quantify its interannual variability.

A secondary objective was added to the 2010 cruises when the results of the fall 2009 cyst survey (OC440) revealed that cyst abundance offshore of mid-coast Maine is now higher than in all prior measurements, including those that preceded the severe blooms of 2005 and 2008. This field season thus offers an exceptional opportunity for testing the hypothesis that the magnitude

¹ http://www.whoi.edu/science/cohh/whcohh/projects/habs1_abstract.htm

of the bloom in the western Gulf of Maine and Southern New England is set by the abundance of cysts. We therefore must consider the possibility of redirecting some of this year's observational effort from Georges Bank to the Gulf of Maine. These choices will be informed by a number of factors, including real-time nowcasting and forecasting activities², as well as state agency toxicity monitoring efforts along the coasts of Maine, New Hampshire, and Massachusetts. If widespread toxicity appears along the coast, that would be consistent with the cyst hypothesis. However, if widespread toxicity does not appear, that would not necessarily be inconsistent with the hypothesis, as a large bloom could be present offshore. It is in this latter circumstance that diverting to the western Gulf of Maine would be most advantageous for hypothesis testing, insofar as confirming the absence of a large bloom would provide evidence for rejecting the hypothesis.

OC467 began with a survey of Georges Bank (Figure 1). Surface waters are virtually devoid of *Alexandrium* cells, with a non-zero finding at only one station. During the survey we occupied a pump station at the FDA shellfish monitoring site on Cultivator Shoal, despite a live count of zero in that location. Given the near-absence of *Alexandrium* on the bank, we decided not to occupy the final transect of the survey on the Northeast Peak in order to leave more time for our coastal survey.

With the GOMTOX Georges Bank surveys now completed, it is useful to assess what has been learned thus far. Data from this cruise suggest that termination of the Georges Bank *Alexandrium* bloom in 2010 took place at approximately the same time as in 2008—and both years exhibit what appears to be a seasonal bloom from May to August (Figure 2). Moreover, some clues to the striking interannual variability are beginning to emerge. Water mass analysis suggests that the times when *Alexandrium* was most abundant on Georges Bank (May, June 2007; June 2008), the water was relatively cold and salty. In contrast, low *Alexandrium* abundance was characterized by waters that were relatively warm and fresh. These warm and fresh anomalies have at least two potential origins. The drastic decline of the *Alexandrium* population from June to July 2008 was accompanied by a warm and fresh anomaly that was confined to near-surface waters (Figure 3, left hand panel). Analysis of the climatological mean temperature and salinity fields suggest an origin in the western Gulf of Maine (Figure 3, right hand panel). For the first two cruises in 2010, waters on Georges Bank were warmer and fresher than at the same time of year in 2008 (Figure 4 A,B): in late April / early May, the core Georges Bank water (4-8°C, 31.5-33.5 psu) was nearly 2°C warmer and perhaps 0.5 psu fresher in 2010 than 2008. During that time period, bank-wide *Alexandrium* abundance was lower in 2010 than in 2008 (Figure 2). As the water mass anomaly lessened in late June through early August 2010 (Figure 4 C,D), *Alexandrium* abundance were more similar to those present during that same time of year (bloom decline) in 2008 (Figure 2).

To first order, the GOMTOX findings are consistent with a “leaky incubator” model for *Alexandrium* populations on Georges Bank. When Georges Bank is relatively isolated from its surroundings (cold and salty), *Alexandrium* populations thrive. When large volumes of warm and fresh waters flow onto Georges Bank, two factors potentially hinder *Alexandrium* populations: (1) dilution of the Georges Bank population with low-*Alexandrium* water, and (2) inoculation with relatively low-nutrient water that is unfavorable for *Alexandrium* growth. We

² <http://omglnx3.meas.ncsu.edu/GOMTOX/2010forecast/>

will see if this straw-man conceptual model holds up to further scrutiny when the full data sets are in hand. It is ironic that this conceptual model runs counter to the original GOMTOX hypothesis, in which waters from the western Gulf of Maine were a source of *Alexandrium* to Georges Bank. The data suggest that the Georges Bank bloom is independent of the coastal Gulf of Maine (at least on seasonal time scales), and that connectivity between the western Gulf and Georges Bank is detrimental rather than beneficial to *Alexandrium* populations on the bank.

While in transit across the crest of Georges Bank, we encountered discolored waters that were brownish in hue. These areas were clearly discernible in visible satellite imagery (Figure 5A,B) and in underway fluorescence that peaked at station 28 (Figure 5C). Microscopic examination of surface samples taken in the discolored waters revealed abundant diatoms and detritus (Figure 5D).

The OC467 coastal survey consisted of a series of transects spanning from Cape Ann to Mt. Desert Island with an additional transect in the Bay of Fundy (Figure 1). Live counts indicate surface waters were virtually devoid of *Alexandrium* cells. Thus, from the point of view of documenting bloom termination, OC467 was a success. However, we must be careful not to over-interpret these surface data; a complete analysis will require thorough scrutiny of the subsurface samples.

A line of drifters was released across the Grand Manan Basin on the Bay of Fundy line (Figure 6; Appendix A, Table 3)³. Initial results indicate cyclonic circulation to be expected in a gyre overlying the basin. Hydrographic observations indicate the deep waters in the basin (Figure C28) are warmer and saltier than prior years, which would favor intensification of the gyre.

With the 2010 bloom season now apparently complete, we can begin to synthesize our findings. Model predictions of a larger-than-usual bloom in the western Gulf of Maine did not materialize in May and June (Figure 7). What factors prevented a large *A. fundyense* bloom from occurring? There was a distinct water mass anomaly in the deep and intermediate waters of the Gulf of Maine as compared with 2008 when the last major bloom took place (Figure 8). In early May, deep waters were more than one degree warmer, and Maine Intermediate Waters were a few tenths of a degree warmer and a few tenths of a psu fresher than during this same time period in 2008. Near surface waters in May 2010 were several degrees warmer than they were in May 2008. The deep and intermediate water mass anomalies persisted into late May / early June, and surface temperatures were 2-4°C warmer in 2010 than they were in 2008. As the water mass anomaly lessened in late June / early July (Figure 8C), the *Alexandrium* population in the western Gulf of Maine increased temporarily⁴ (Figure 7G), via local growth and/or advection from upstream. By late July / early August, the bloom had terminated (Figure 7H).

³ Also see <http://nefsc.noaa.gov/drifter>

⁴ Note that the Casco Bay line had very low concentrations, and it is possible this is due to temporal aliasing. The WGOM survey began with the Saco Bay line and proceeded south. Live counts contained a significant fraction of planozygotes, suggesting the bloom was beginning to terminate. It is possible that by the time R/V *Oceanus* returned to the Casco Bay line after sampling the Cape Ann and Boston lines, the cells may have already vacated surface waters.

The early-season water mass anomaly was accompanied by anomalies in the nutrient environment in the western Gulf of Maine. In early May, nitrate, phosphate, silicate, and ammonium were all lower in 2010 than in 2008 for depths greater than 50m (Figure 9). By late May / early June, the contrast in the nutrient environment lessened, such that there was no significant difference in nitrate, phosphate, and silicate profiles for 2010 vs. 2008 (Figure 10). However, ammonium concentrations in the upper 50m were significantly lower in 2010, which may have negatively impacted the growing conditions for *Alexandrium*.

Given the relatively low springtime nutrient concentrations in 2010, it is surprising that the spring phytoplankton bloom in April was the highest observed in the entire MODIS record, subsequently crashing to the lowest post-bloom condition in May (Figure 11). It may be that the higher stratification in 2010 induced by the water mass anomaly caused the bloom to be uninterrupted by mixing events, allowing it to reach a higher peak and more complete nutrient exhaustion, leading to anomalously low chlorophyll concentrations in the post-bloom period. In any case, it is clear that the late-springtime conditions that ensued were unfavorable for growth of the *A. fundyense* population.

It also appears that conditions were unfavorable for hydrodynamic transport of *A. fundyense* along the coast. Observations from NERACOOS buoys B, E, and I (Figures 12-15) reveal stalling of the coastal current in spring 2010 which was unprecedented in the last eight years of measurements. Next steps are to (1) compare the ADCP observations with drifter trajectories to see if they are consistent; (2) examine satellite imagery to see if the stalling reflects offshore turning of the coastal current; and (3) ascertain the extent to which the decrease in the coastal current be attributed to a change in the baroclinic circulation by compute dynamic height and geostrophic currents from hydrography.

What process might be driving the unusual conditions in the Gulf of Maine in 2010? Townsend et al. (2010) describe three major transport pathways for deep (>100m) water into the Gulf of Maine: warm slope water (WSW; warm, salty, high nitrate) and Labrador slope water (LSL; cold, fresh, low nitrate) flowing in through the Northeast Channel, and Labrador shelf water (LShW; cold, fresh, low nitrate) flowing in through the sill between Nova Scotia and Browns Bank. Temperature time-series from NERACOOS mooring M (Figure 16) indicate the arrival of a warm anomaly at depth (>125m) in mid-March that persisted through the end of the record (mid-June). Only a modest increase in salinity was associated with this warming (Figure 17), and thus this feature does not fit the classic form of a WSW intrusion. However, this water mass anomaly is qualitatively similar to the anomaly present in hydrographic observations from May and June 2010 (Figure 8 A,B), which show deep waters of the western Gulf of Maine having warmed by a similar amount with only a slight increase in salinity. This warming was associated with a decrease in nitrate (Figure 9), the opposite of what would be expected if this warm water had a WSW origin. Next steps are to (1) ascertain where a deep warm/slightly-salty/low nitrate water mass might have come from by interrogating the climatology; (2) determine how reliable is our inference about WGOM deep water variability based on the Jordan Basin mooring record by (A) plotting climatological T and S at 200m to evaluate the relationship between Jordan and Wilkinson basins; and (B) plotting the T/S characteristics from JB mooring data together with cruise data (Figure 8).

NERACOOS mooring M also reveals a freshening in the upper ocean that begins at approximately the same time as the warming at depth (Figures 16,17). Given that local fresh water discharge into the Gulf of Maine was about average in 2010 (Figure 18), the logical source of the freshening would be LShW. Thus, advection of this water mass into the western Gulf of Maine provides a qualitatively consistent explanation for the observed freshening of intermediate and near-surface waters in 2010 (Figure 8 A,B) and the associated decrease in nutrients (Figure 9).

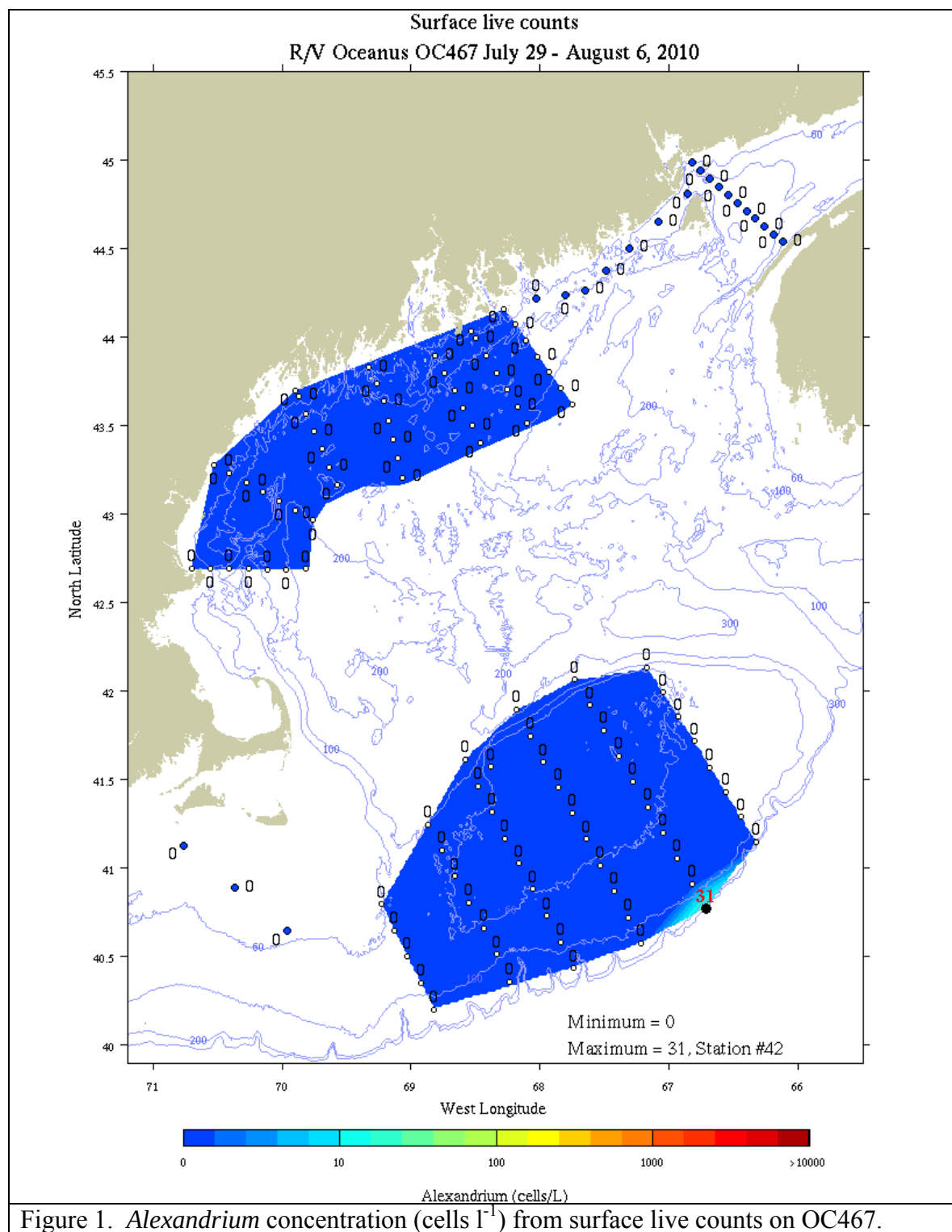


Figure 1. *Alexandrium* concentration (cells l^{-1}) from surface live counts on OC467.

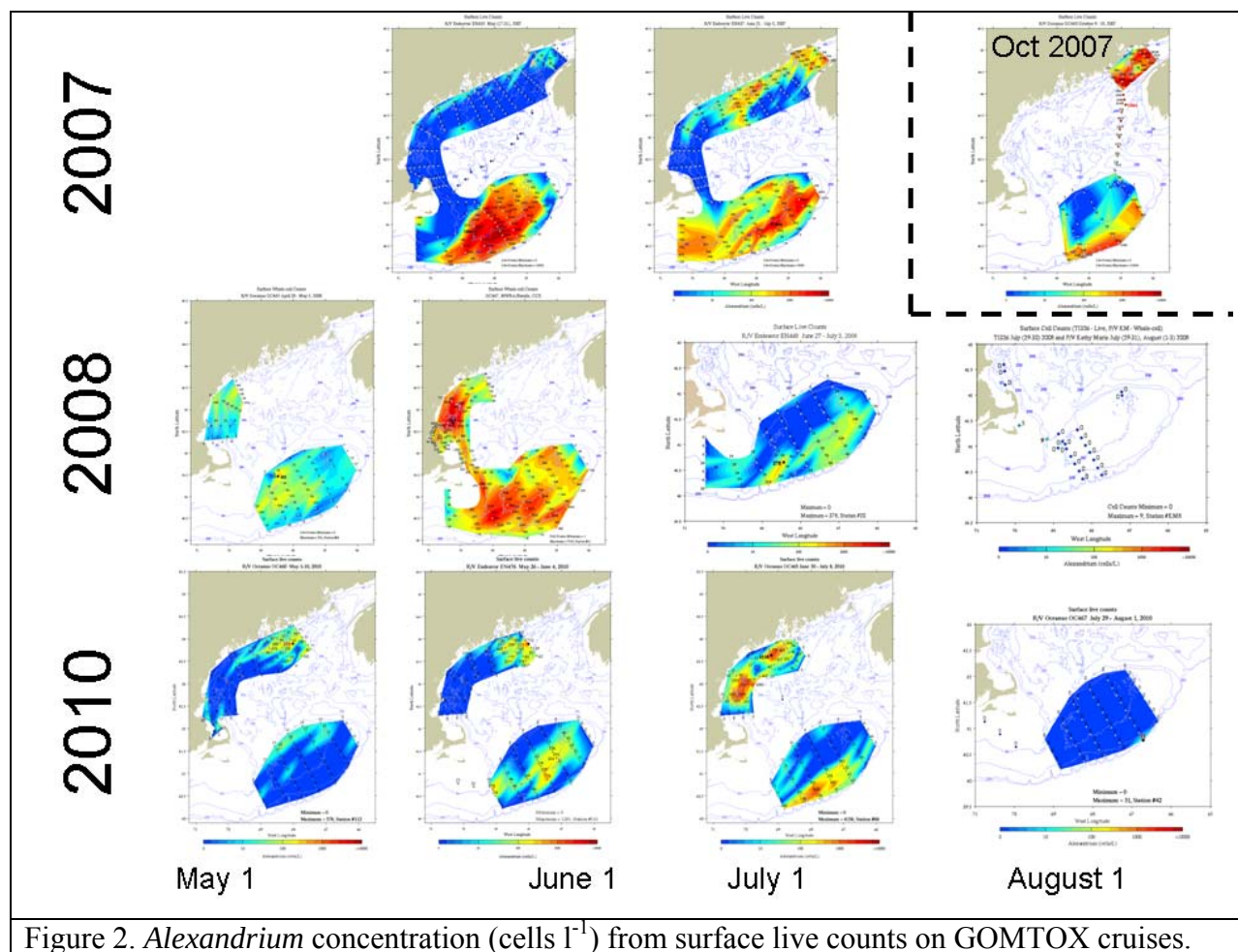


Figure 2. *Alexandrium* concentration (cells l^{-1}) from surface live counts on GOMTOX cruises.

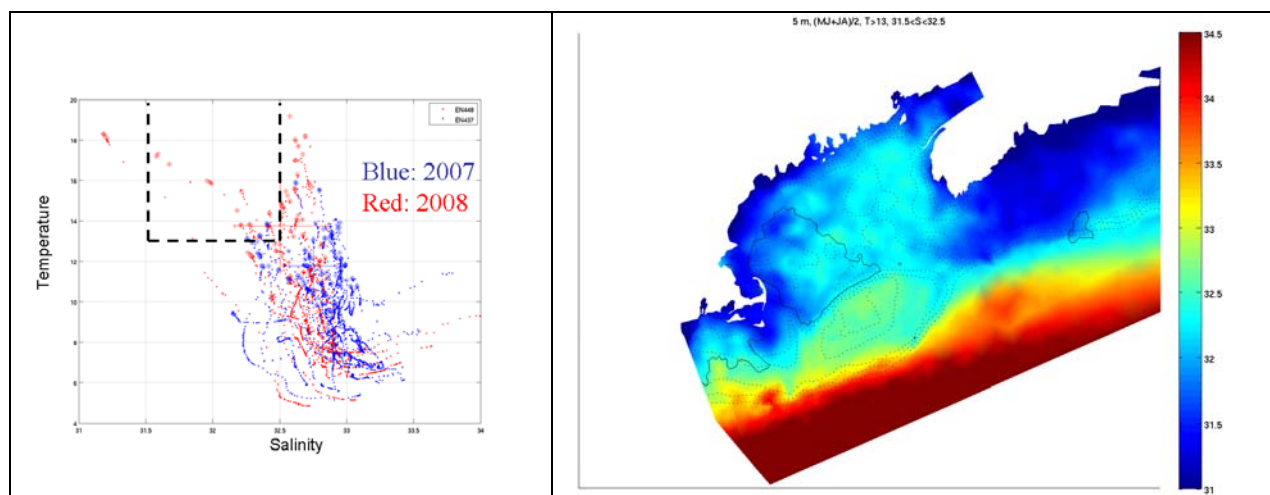
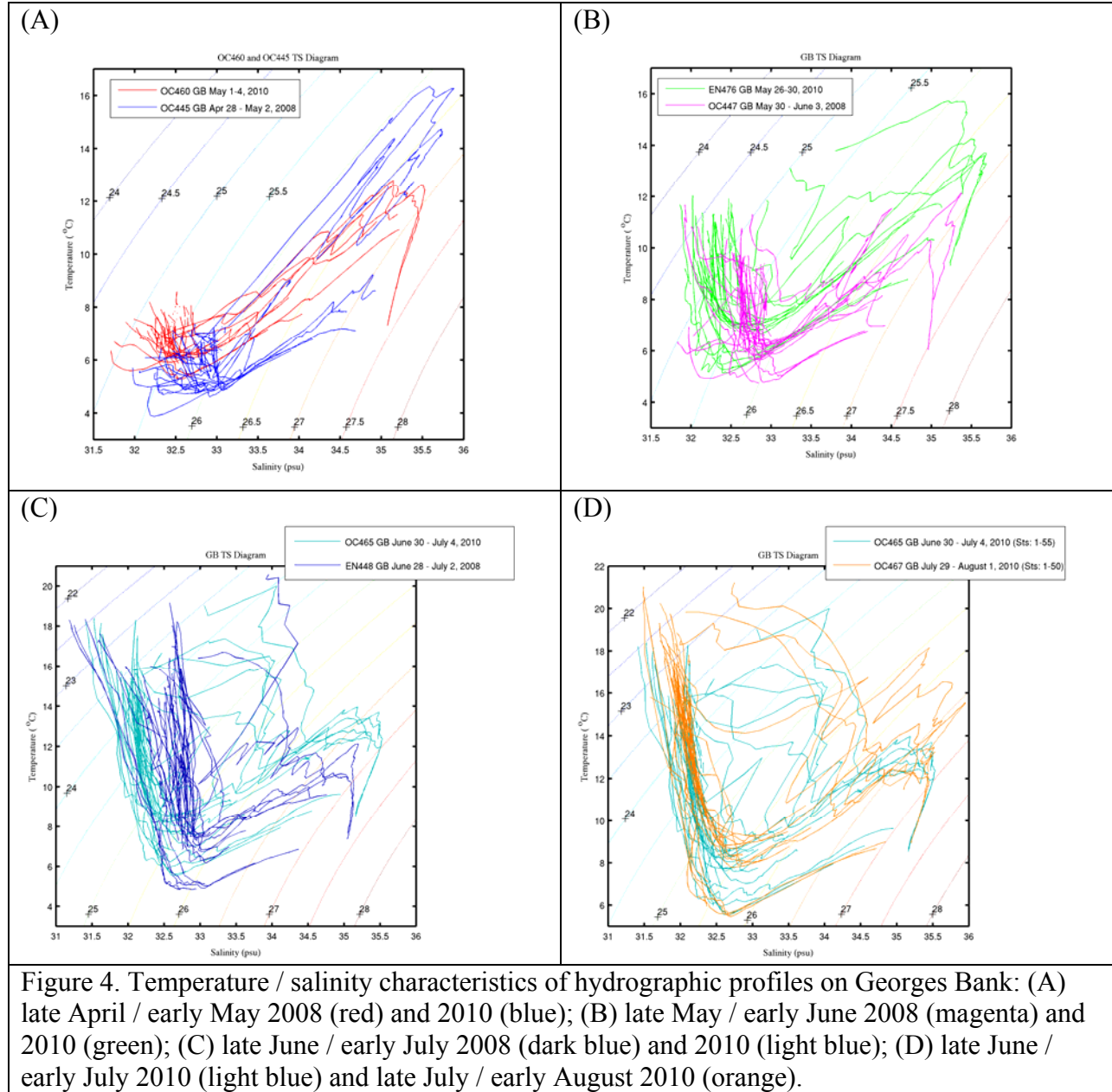
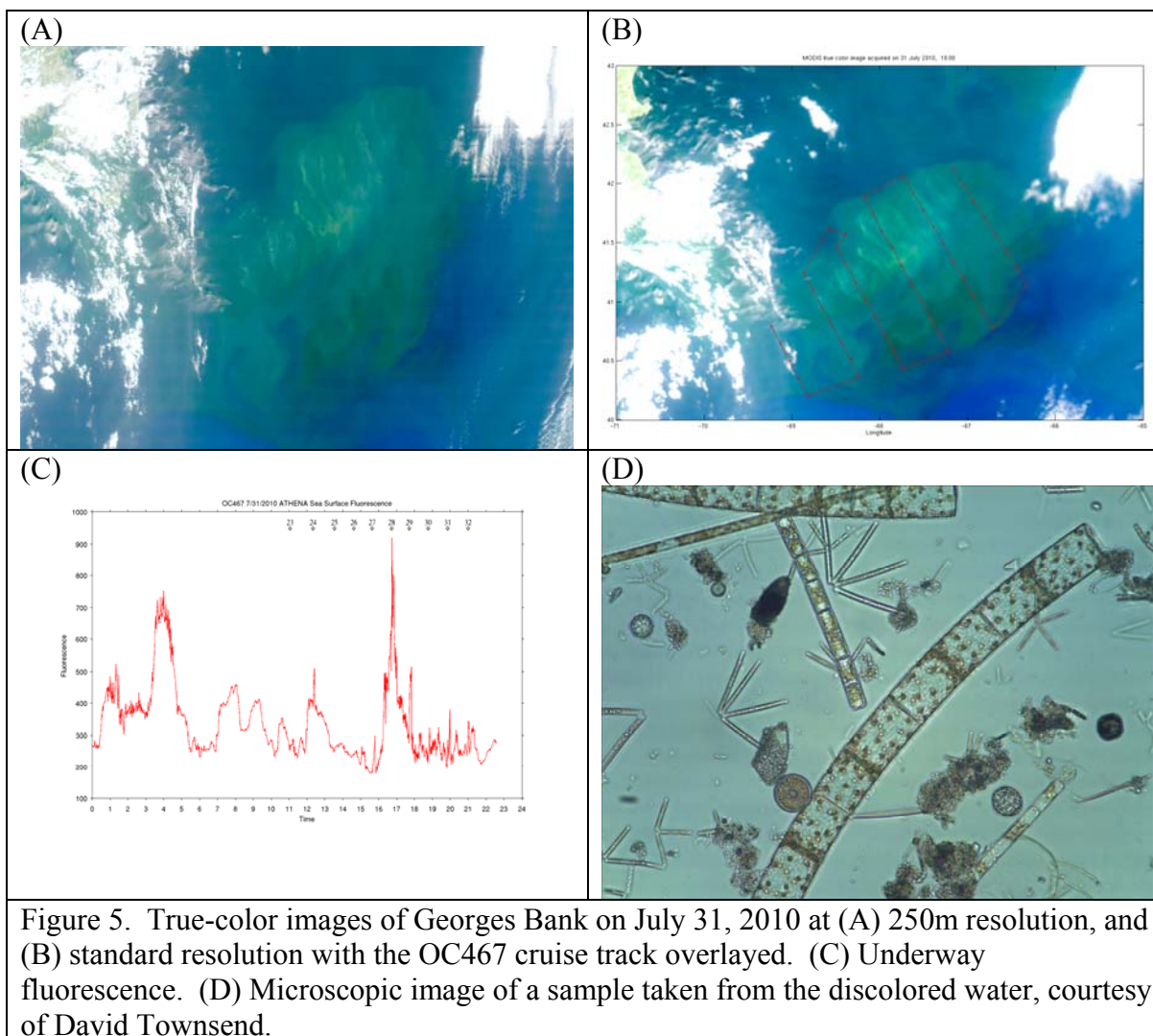


Figure 3. Left: Temperature / salinity characteristics of hydrographic profiles on Georges Bank during EN437 June 21 – July 5 2007 (blue) and EN448 June 27 – July 3 in 2008 (red). Right: Climatological mean salinity at 5m averaged between May-June and July-August. Solid contour indicates areas in which temperature exceeds 13°C and $31.5 < S < 32.5$ (water mass bounded by the dashed line in the left hand panel).





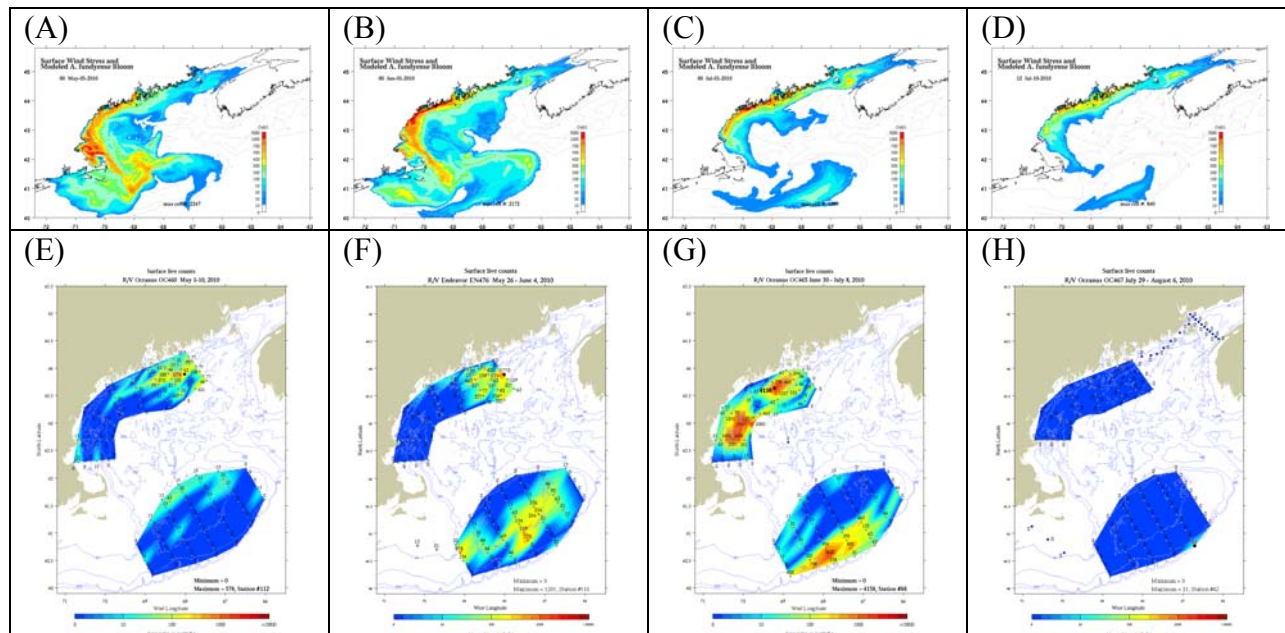
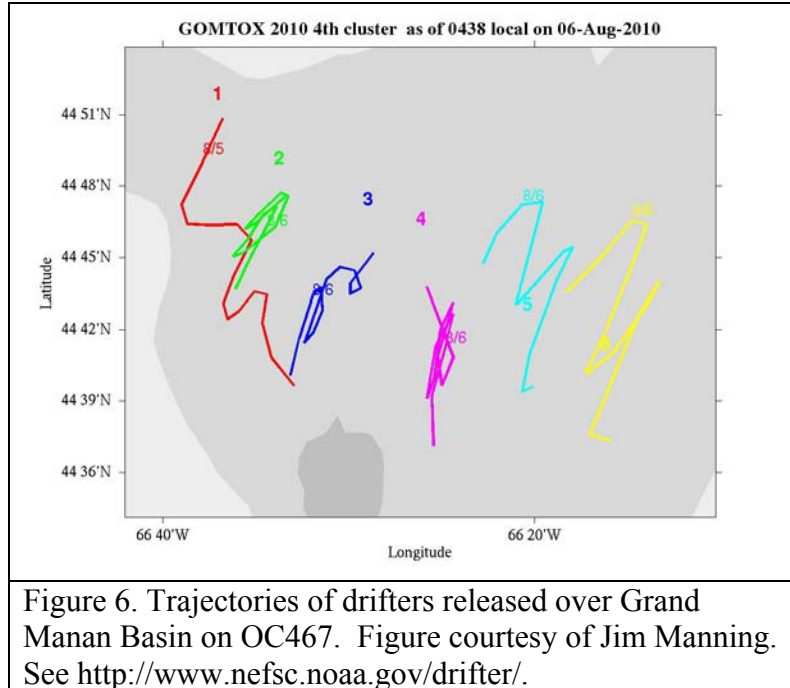


Figure 7. Top row: *A. fundyense* model predictions for (A) May 5, (B) June 1, (C) July 1, (D) July 10. For a complete description of the forecast system and 2010 results, see <http://omglx3.meas.ncsu.edu/GOMTOX/2010forecast/>. Bottom row: *A. fundyense* live counts in 2010: (E) early May; (F) late May / early June; (G) late June / early July; (H) late July / early August.

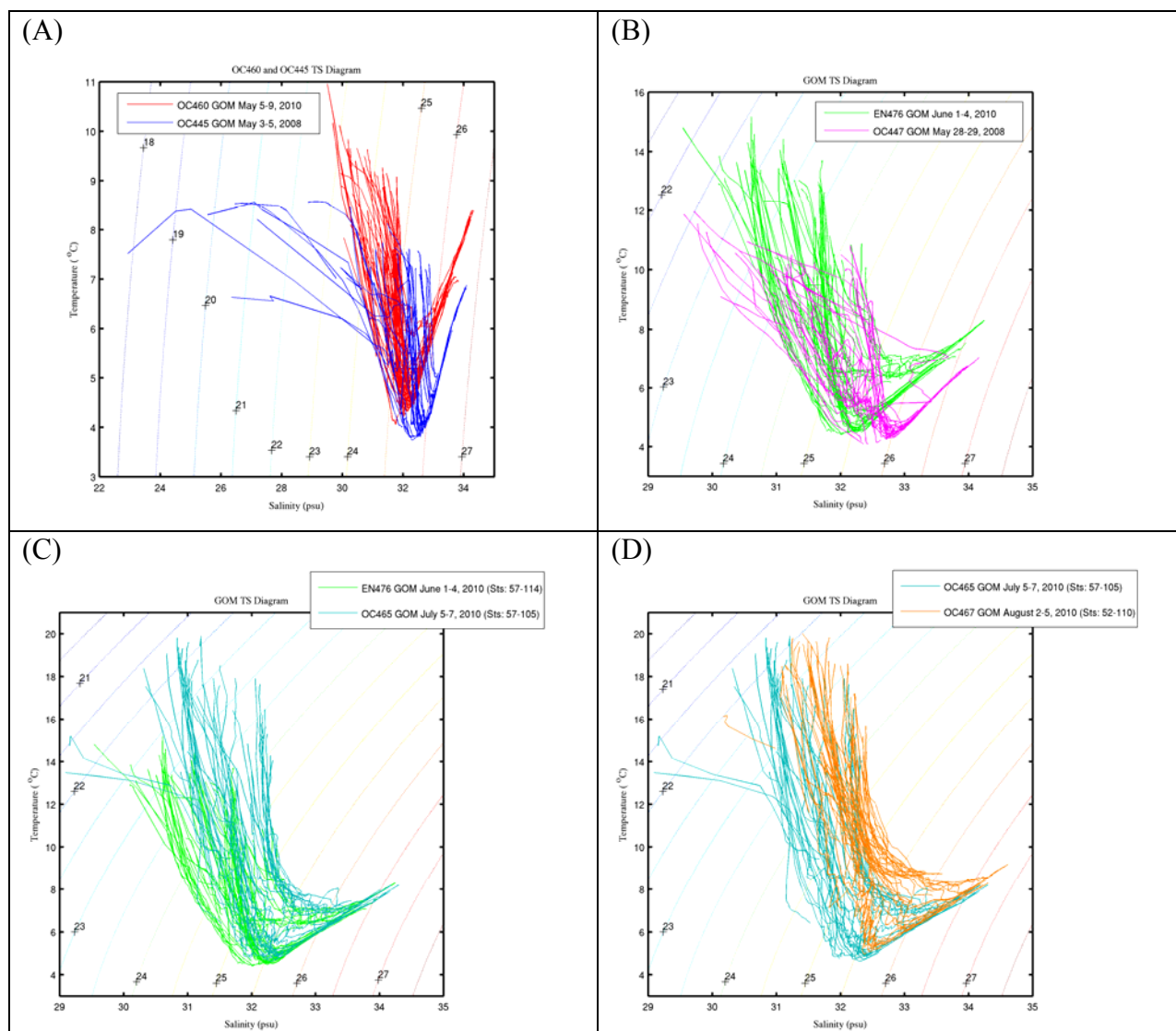


Figure 8. Temperature / salinity characteristics of hydrographic profiles in the Gulf of Maine: (A) late April / early May 2008 (blue) and 2010 (red); (B) late May / early June 2008 (magenta) and 2010 (green); (C) late June / early July 2008 (dark blue) and 2010 (light blue); (D) late June / early July 2010 (light blue) and late July / early August 2010 (orange).

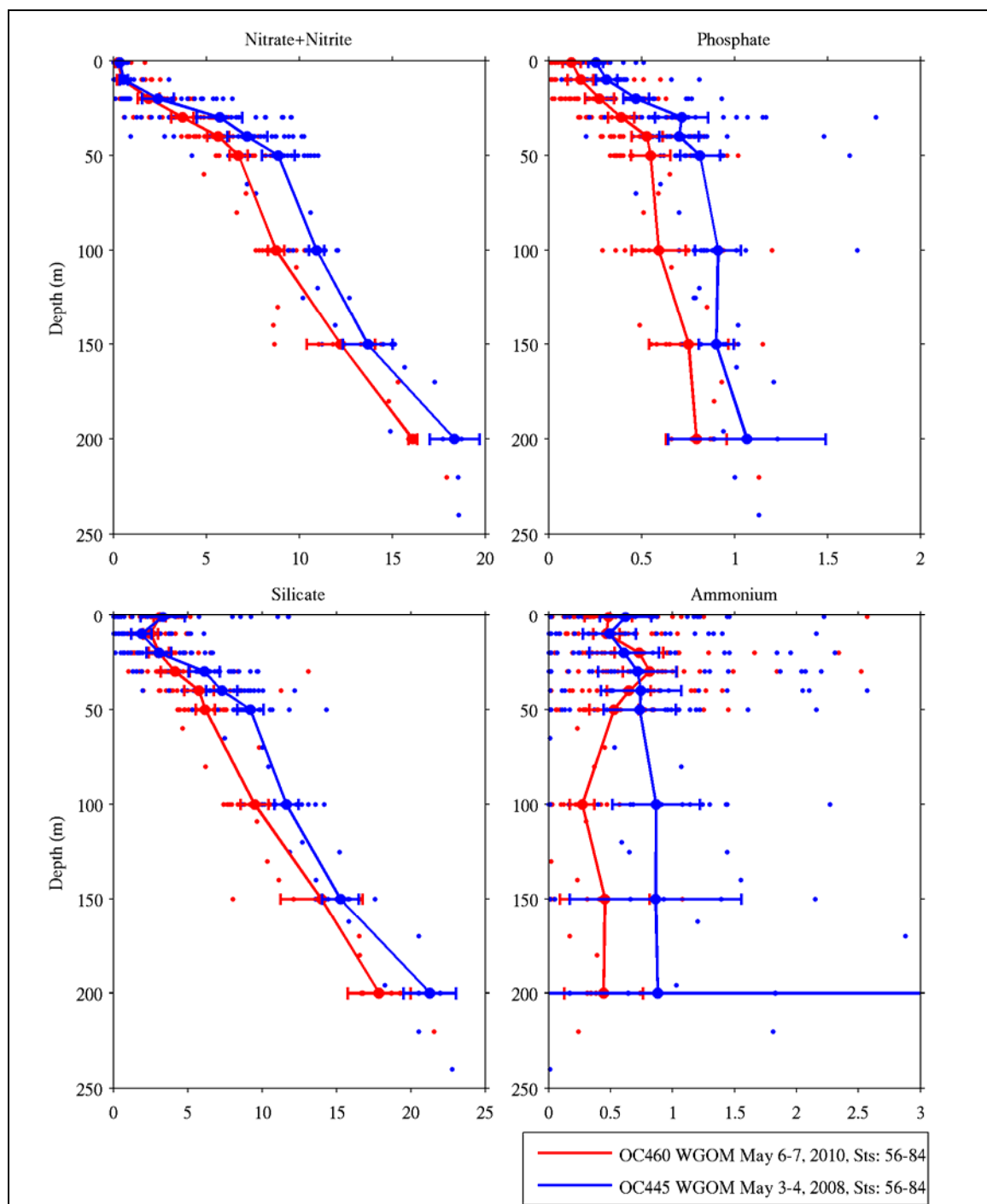


Figure 9. Profiles of nitrate+nitrite, phosphate, silicate, and ammonium in the western Gulf of Maine for early May 2008 (blue) and 2010 (red). Individual data points are indicated by small dots; solid lines depict mean profiles with 95% confidence intervals. Source: Dave Townsend and Maura Thomas.

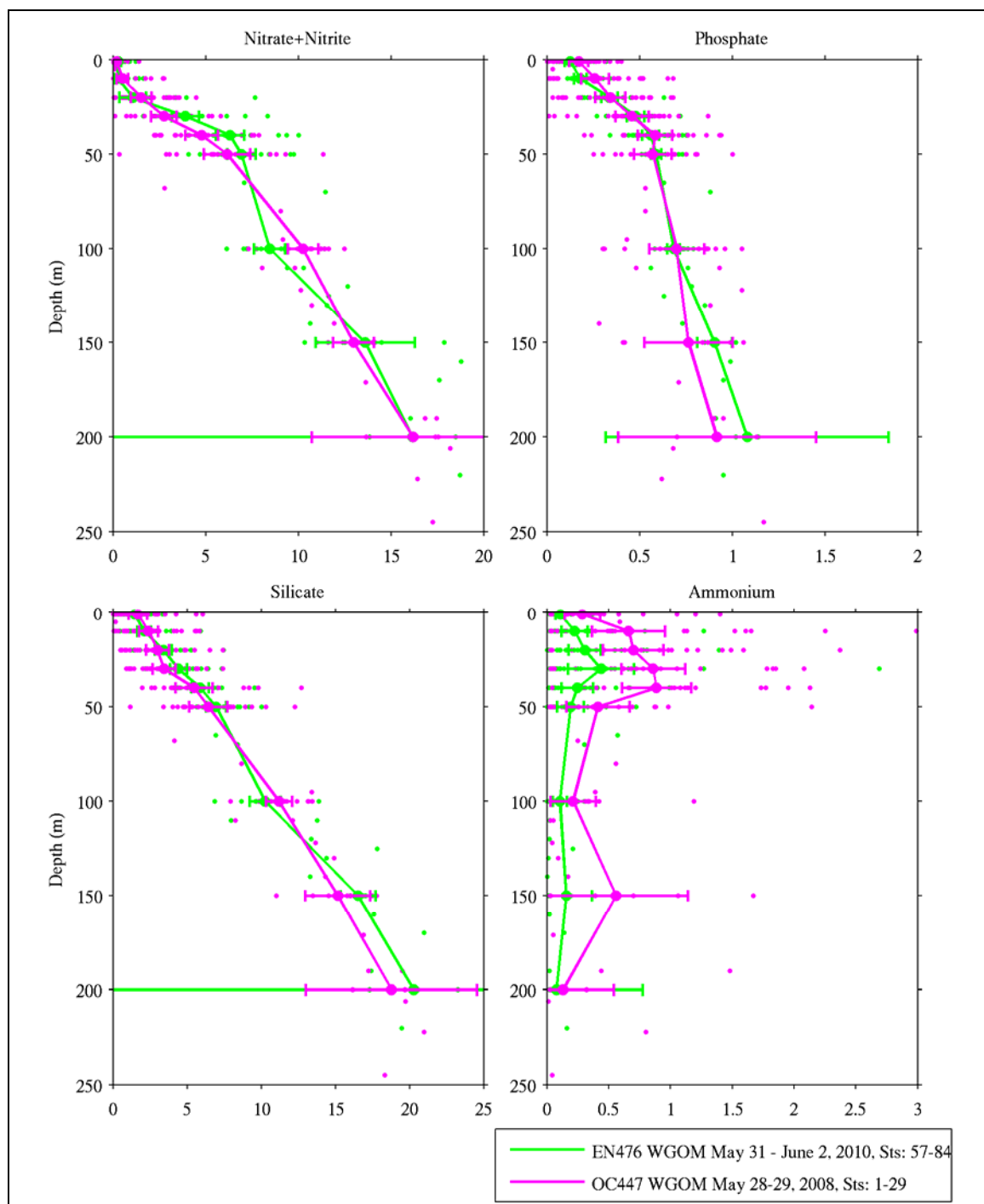
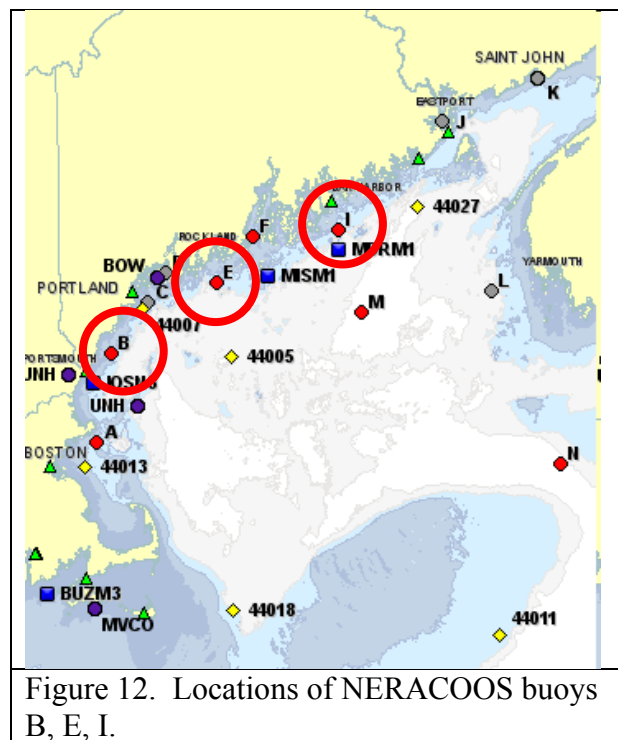
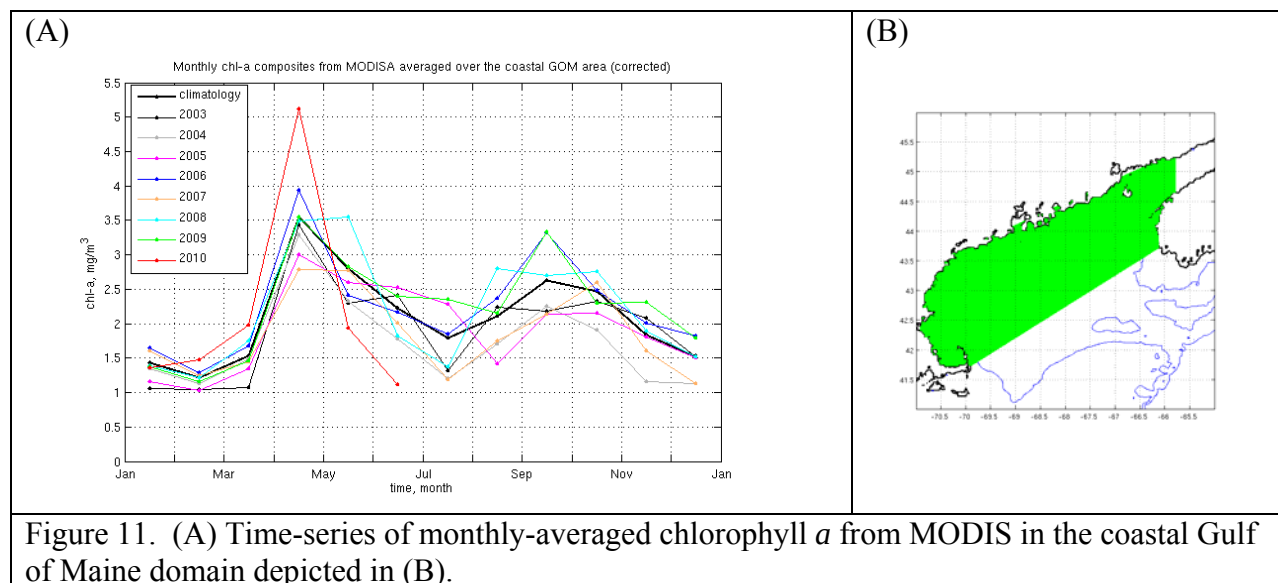


Figure 10. Profiles of nitrate+nitrite, phosphate, silicate, and ammonium in the western Gulf of Maine for late May 2008 (magenta) and late May / early June 2010 (green). Individual data points are indicated by small dots; solid lines depict mean profiles with 95% confidence intervals. Source: Dave Townsend and Maura Thomas.



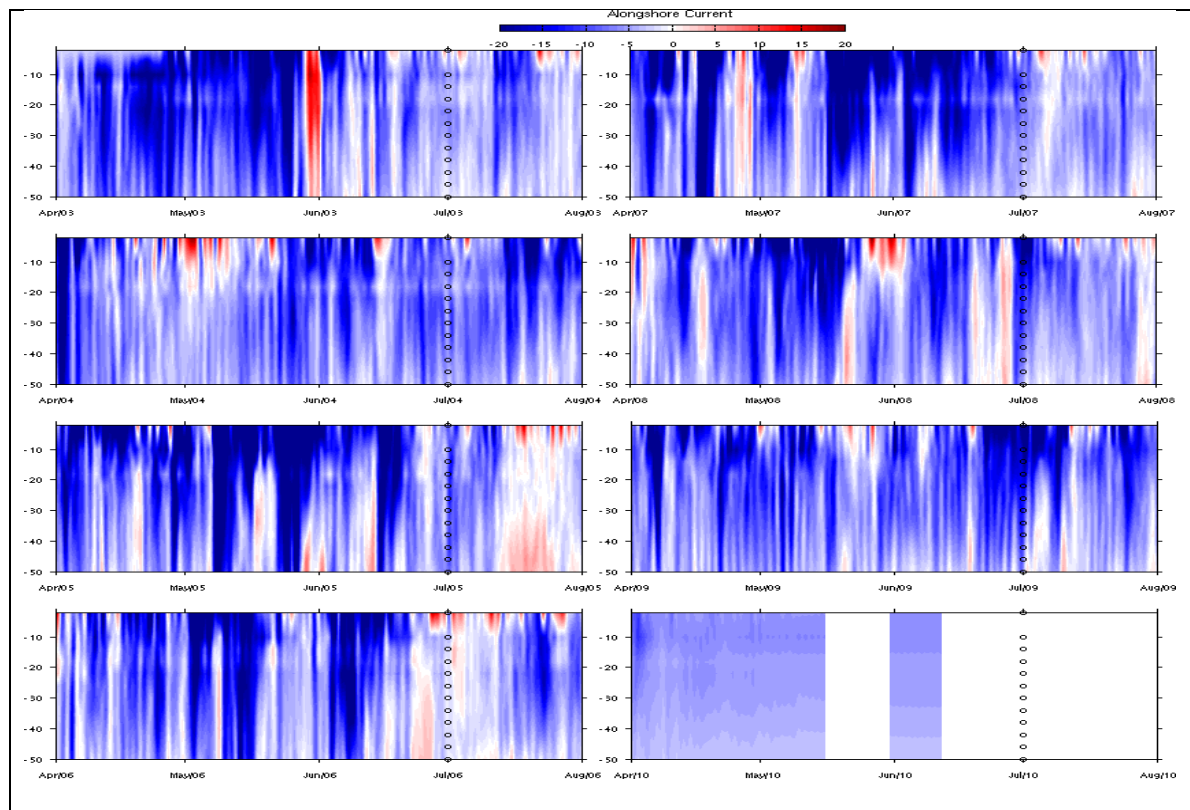
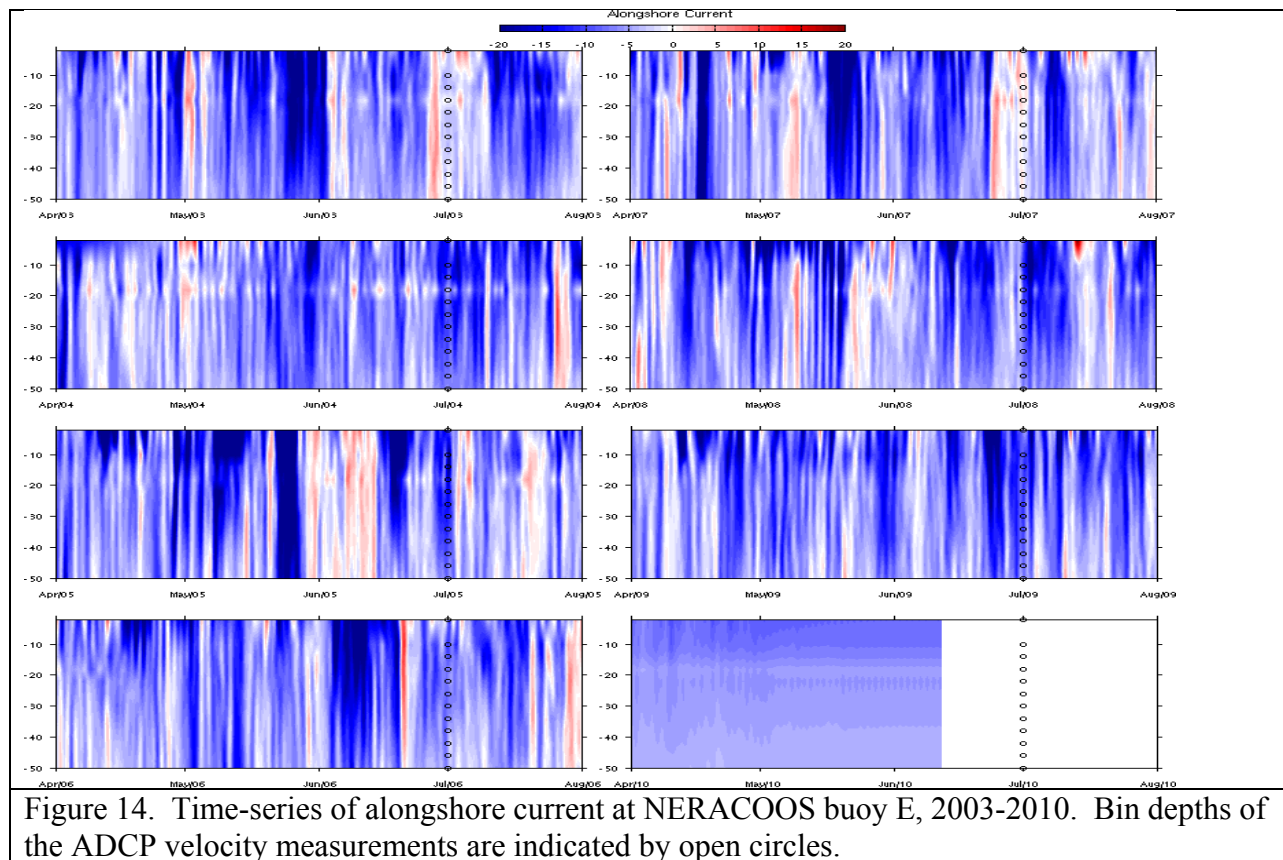


Figure 13. Time-series of alongshore current at NERACOOS buoy B, 2003-2010. Bin depths of the ADCP velocity measurements are indicated by open circles.



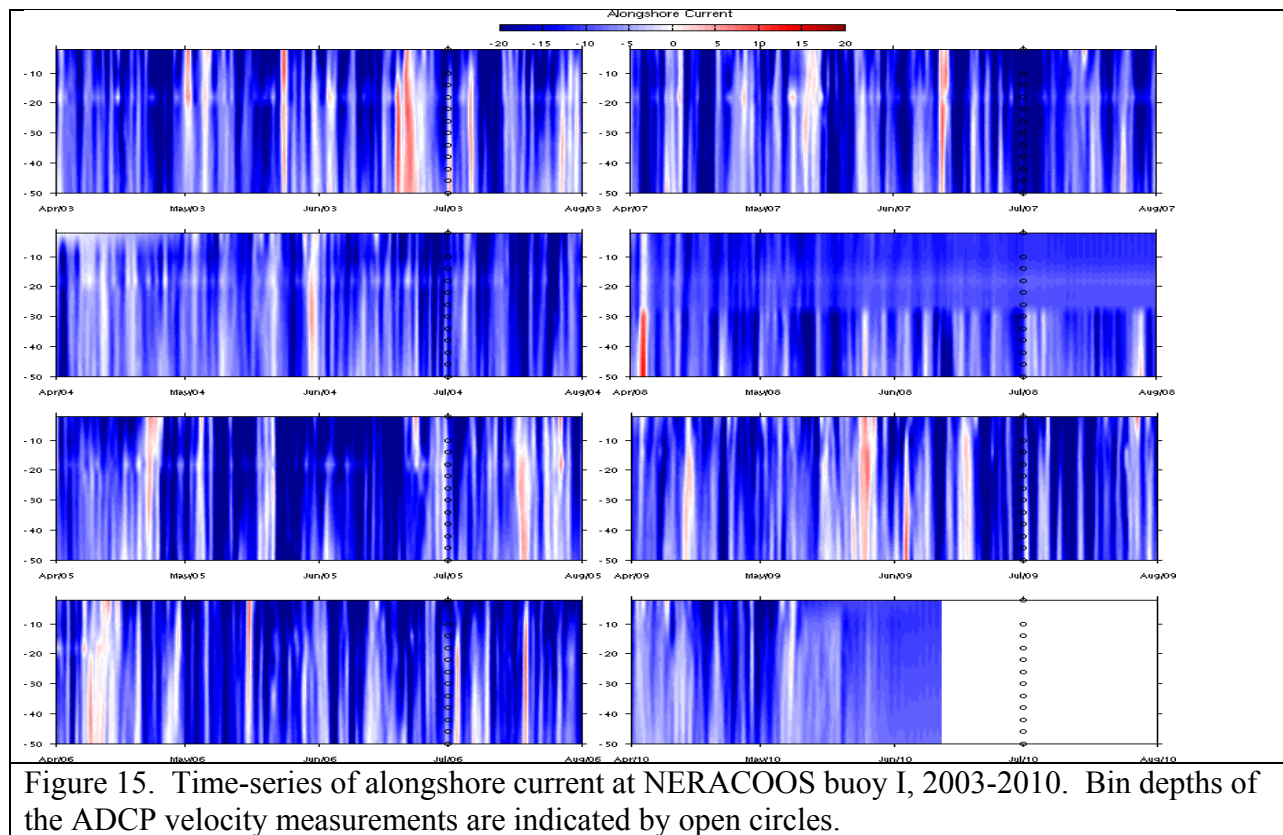


Figure 15. Time-series of alongshore current at NERACOOS buoy I, 2003-2010. Bin depths of the ADCP velocity measurements are indicated by open circles.

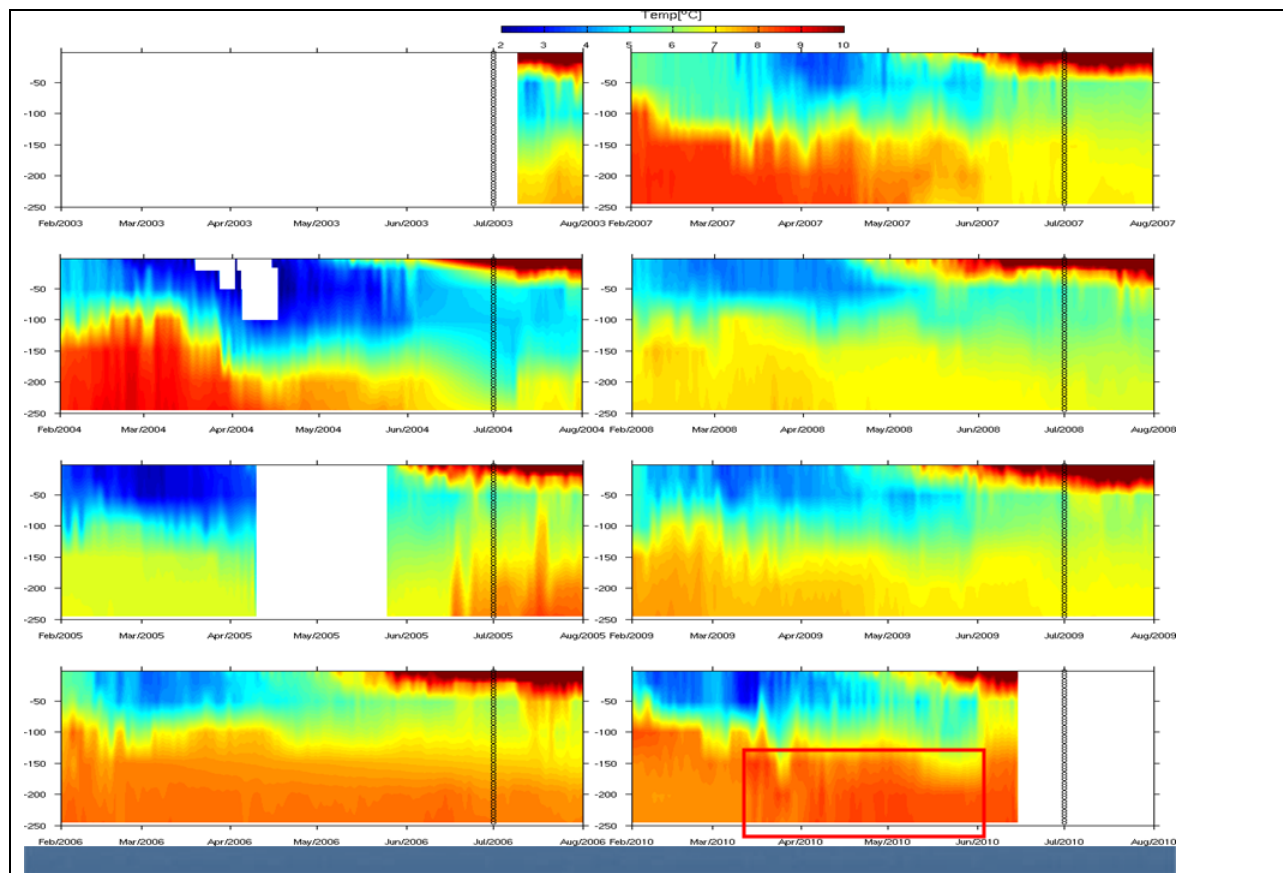


Figure 16. Time-series of temperature at NERACOOS buoy M, 2003-2010. Depths of temperature measurements are indicated by open circles. Red rectangle in 2010 indicates the time period of the warm water mass anomaly discussed in the text.

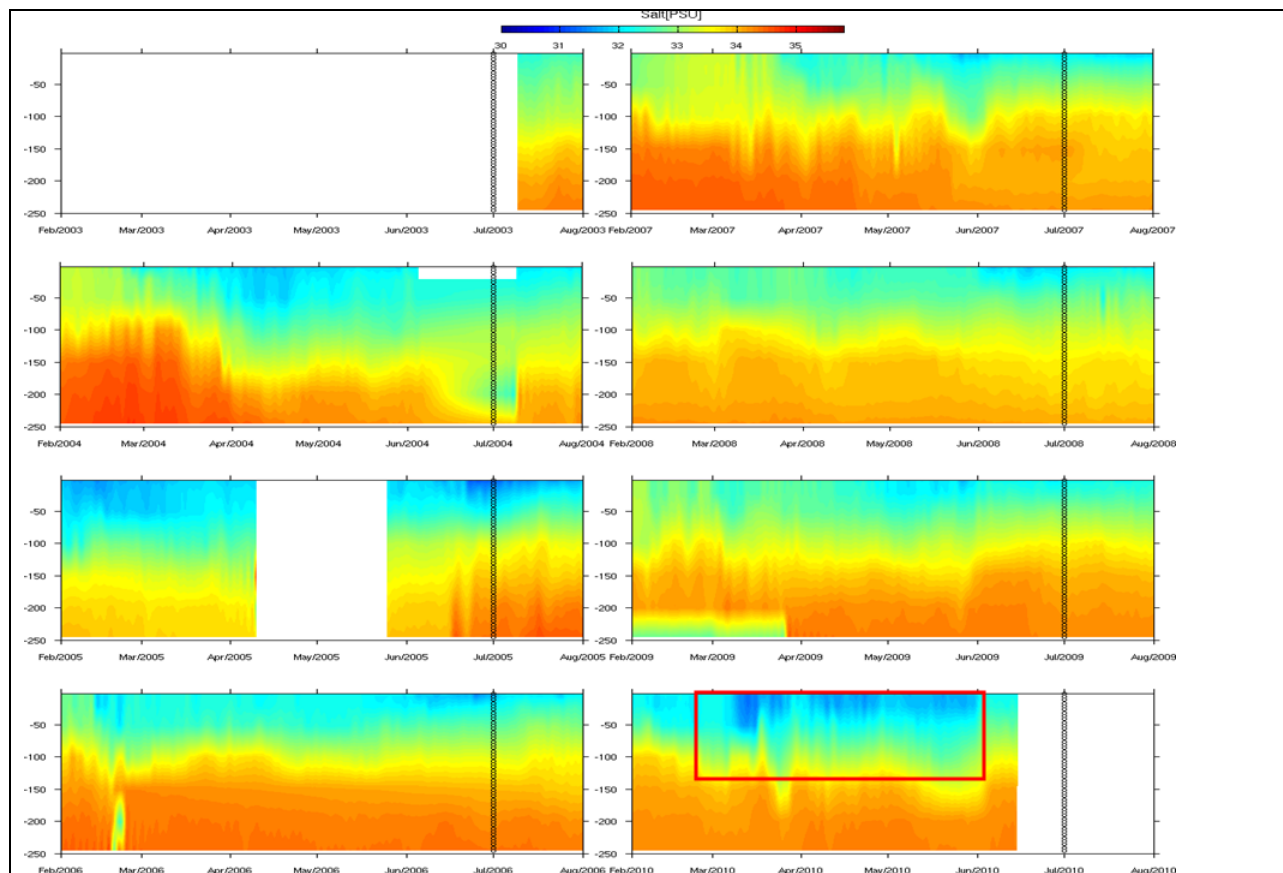


Figure 17. Time-series of salinity at NERACOOS buoy M, 2003-2010. Depths of conductivity measurements are indicated by open circles. Red rectangle in 2010 indicates the time period of the upper ocean salinity anomaly discussed in the text.

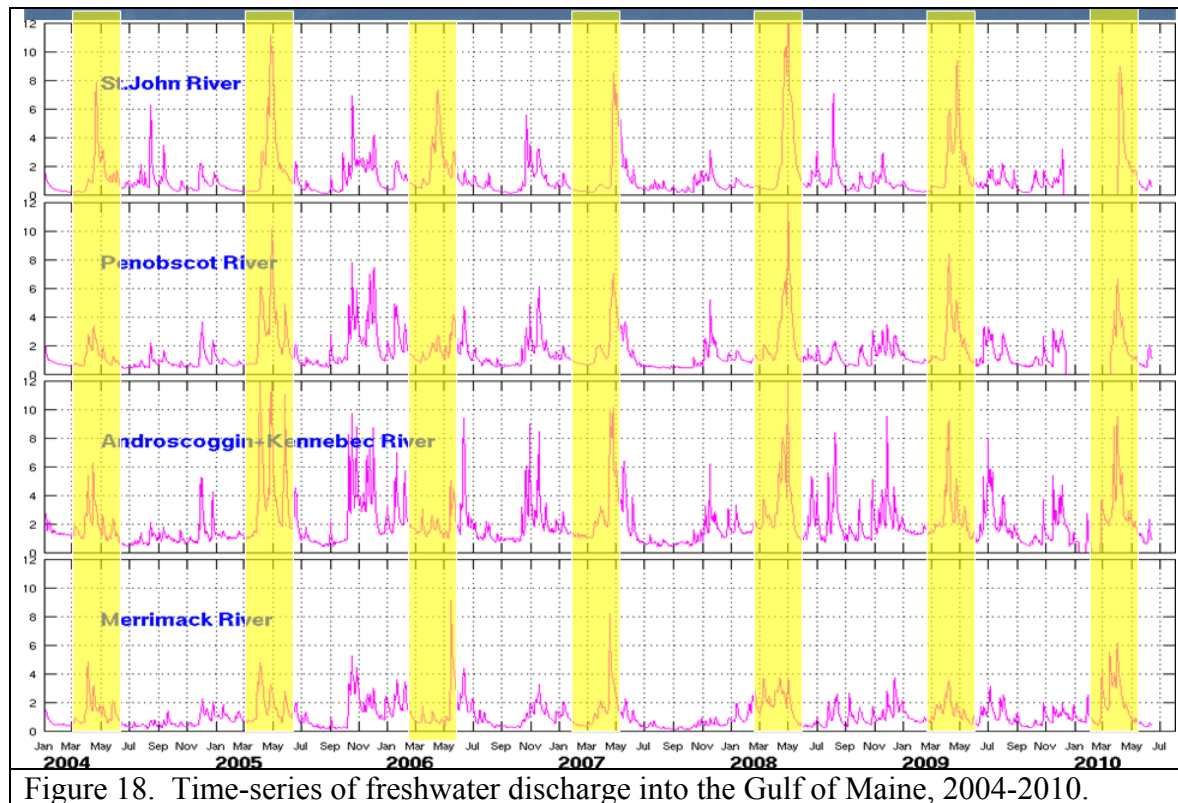


Figure 18. Time-series of freshwater discharge into the Gulf of Maine, 2004-2010.

References

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- Li, Y., He, R., McGillicuddy, D.J., Anderson, D.M. and Keafer, B.A., 2009. Investigation of the 2006 *Alexandrium fundyense* Bloom in the Gulf of Maine: In situ Observations and Numerical Modeling. *Continental Shelf Research*, 29: 2069-2082.
- Townsend, D.W., Rebeck, N.D., Thomas, M.A., Karp-Boss, L. and Gettings, R.M., 2010. A changing nutrient regime in the Gulf of Maine. *Continental Shelf Research*, 30(7): 820-832.

Appendix A: Measurements made on OC467

Underway measurements

- a. Acoustic Doppler Current Profiler
- b. Meteorological sensors

Core hydrographic measurements

- a. CTD (pressure, temperature, salinity, oxygen, fluorescence, beam attenuation, PAR)
- b. *Alexandrium* cell counts: 1, 10, 20, 30, 40, 50m plus 250/near bottom
- c. Nutrients: standard depths plus 100, 150, 200, 250m

Water budget:

Bottle #	Depth	Live	Spare	Whole Cell	SHA	Nuts/Chl	Pseuds	total
1	1			2	2	1.0	1.0	7.0
2	1	10						10
3	1		10					10
4	10			2	2	1.0	1.0*	7.0
5	20			2	2	1.0	1.0*	7.0
6	30			2	2	1.0	1.0*	7.0
7	40			2	2	1.0	1.0*	7.0
8	50			2	2	1.0	1.0*	7.0
9	100					1.0		1.0
10	150					1.0		1.0
11	200					1.0		1.0
12	250 / near bottom					1.0		1.0

Af water- For Whole Cell (WC) and Sandwich Hybridization (SHA) – 4 liters collected total and 20 µm sieved and split between the two assays.

4L/depth combined/split x 6 depths=6 WC tubes&6 filters/station (6 hole-manifold #1 loaded once)

Pseuds – At each station: 1) 125 ml whole water will be filtered for *Pseud* SHA onto 0.45µm Duropore filters; 2) 125ml whole water will be filtered for ARISA samples onto 0.45µm Isopore HA filters (as in 2008); 3) 125 ml whole water will be filtered for Domoic Acid onto 0.45µm Isopore HA filters. SHA filters will be frozen in LN2 Dewar

3 filters and cryo-vials/station will be needed. Use a 3-hole manifold—Note that the Pseud SHA filter and the ARISA/DA filters are the same pore size, but not the same material. Do not mix up the filter types.

*A vertical profile of *Pseuds* will be sampled at 4-6 selected stations with high abundance, in different hydrographic regimes as conditions permit. Same procedure as above but repeat for all 6 std depths.

A Domoic Acid “calibration” station will also be done at selected stations—details TBD.

Opportunistic samples– a spare 10L live sample will be available for multiple purposes; e.g., culturing of *Pseuds* and/or *Alexandrium*, life cycle stage samples, and possibly microsatellite analysis of *Alexandrium* populations. Additional opportunistic samples may be taken in areas of high *Alexandrium* and/or *Pseud* abundance.

Toxin size fractionation – Turner

Pump profiles were carried out at selected locations. Sampling depths were chosen to coincide as closely as possible with hydrographic sampling and sediment trap measurements. Pump deployments are summarized in Table 2.

	Date	Time (local)	Latitude	Longitude	Station	Live Count
1	Jul 30		41 34.3 N	68 23.0 W	FDA shellfish time-series site Cultivator Shoal, CTD 14p	0
2	Aug 2		43 01.0 N	69 53.6 W	Outer Saco Bay line, CTD64p	0
3	Aug 3		43 42.4 N	68 40.3 W	Rockland line CTD83p	0
4	Aug 4		44 58.9 N	66 49.1W	Wolves CTD100p	0

Table 2. Pump stations.

Drifters

ID	Mon	Day	Year	Time GMT	Lon	Lat	Drogue depth(m)	Station Number
108440671	8	4	2010	2339	66 45.3 W	44 56.2 N	15	BOF2D
108440672	8	5	2010	0023	66 36.3W	44 50.4 N	15	BOF2E
108440673	8	5	2010	0052	66 32.4 W	44 47.9 N	15	BOF2F
108440674	8	5	2010	0156	66 23.8 W	44 42.5 N	15	BOF2G
108440675	8	5	2010	0225	66 19.8 W	44 40.1 N	15	BOF2H
108440676	8	5	2010	0310	66 18.3 W	44 39.2 N	15	BOF2I

Table 3: Summary of drifter releases in the Bay of Fundy. For more information see <http://nefsc.noaa.gov/drifter>.

Microbial community structure and bacterial abundance – Amaral-Zettler and Murphy

OC467 #1 – CTD14 – Georges Bank Cultivator Shoal – *Alexandrium* live count = 0

7/30/10 41 34.3 N / 68 23.0 W

Sfc (1),(2)

10m (1),(2)

20m (1),(2)

OC467 #2 – CTD64 – Outer Saco Bay transect– *Alexandrium* live count = 0

8/2/10 43 01.0 N / 69 53.6 W

Sfc (1),(2)

10m (1),(2)

20m (1),(2)

OC467 #3 – CTD67p – Rockland transect – *Alexandrium* live count = 0

8/3/10 42 43 42.4 N / 68 40.3 W

Sfc (1),(2)

10m (1),(2)

20m (1),(2)

OC467 #4 – CTD100p – The Wolves – *Alexandrium* live count = 0

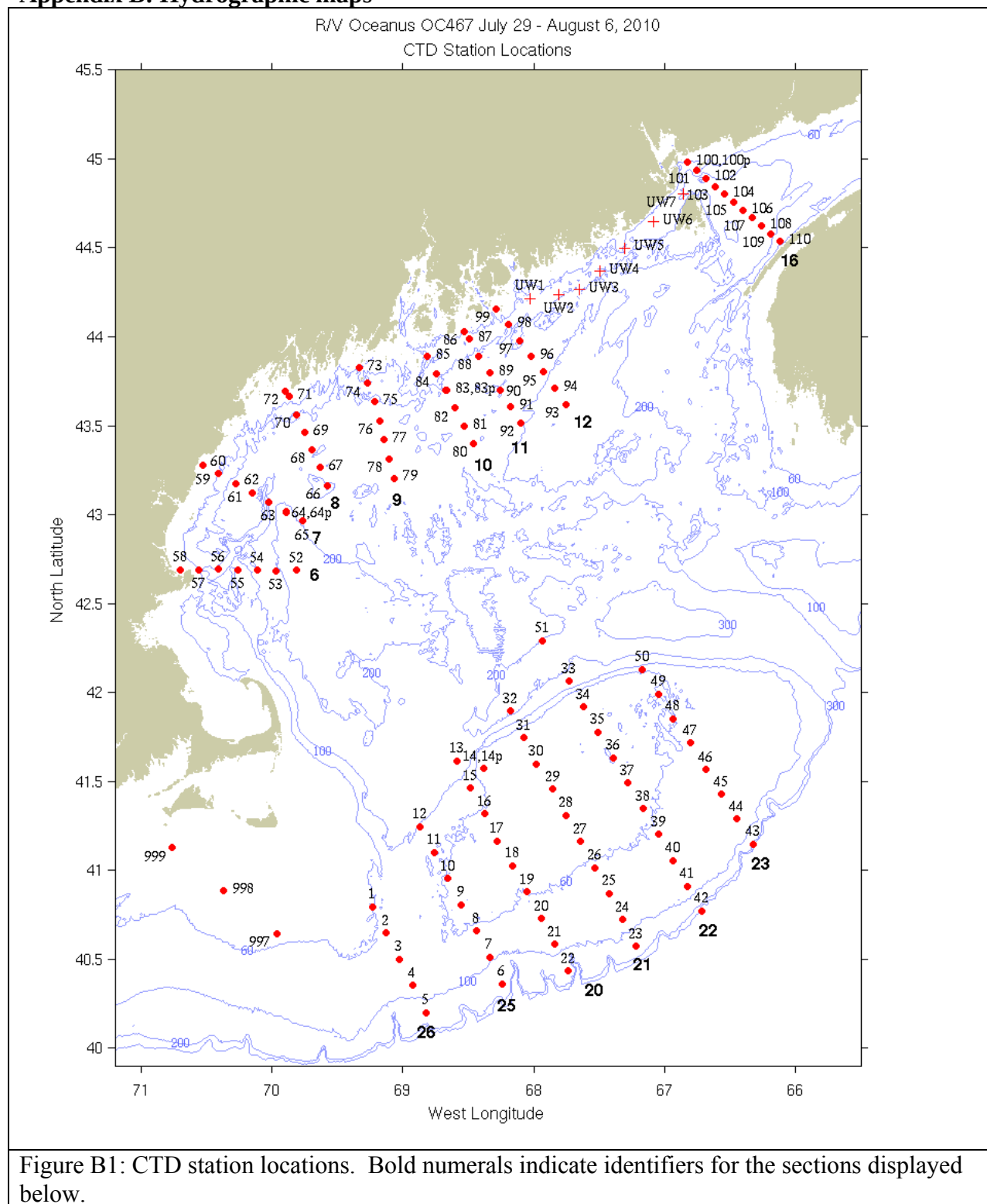
8/4/10 44 58.9 N / 66 49.1 W

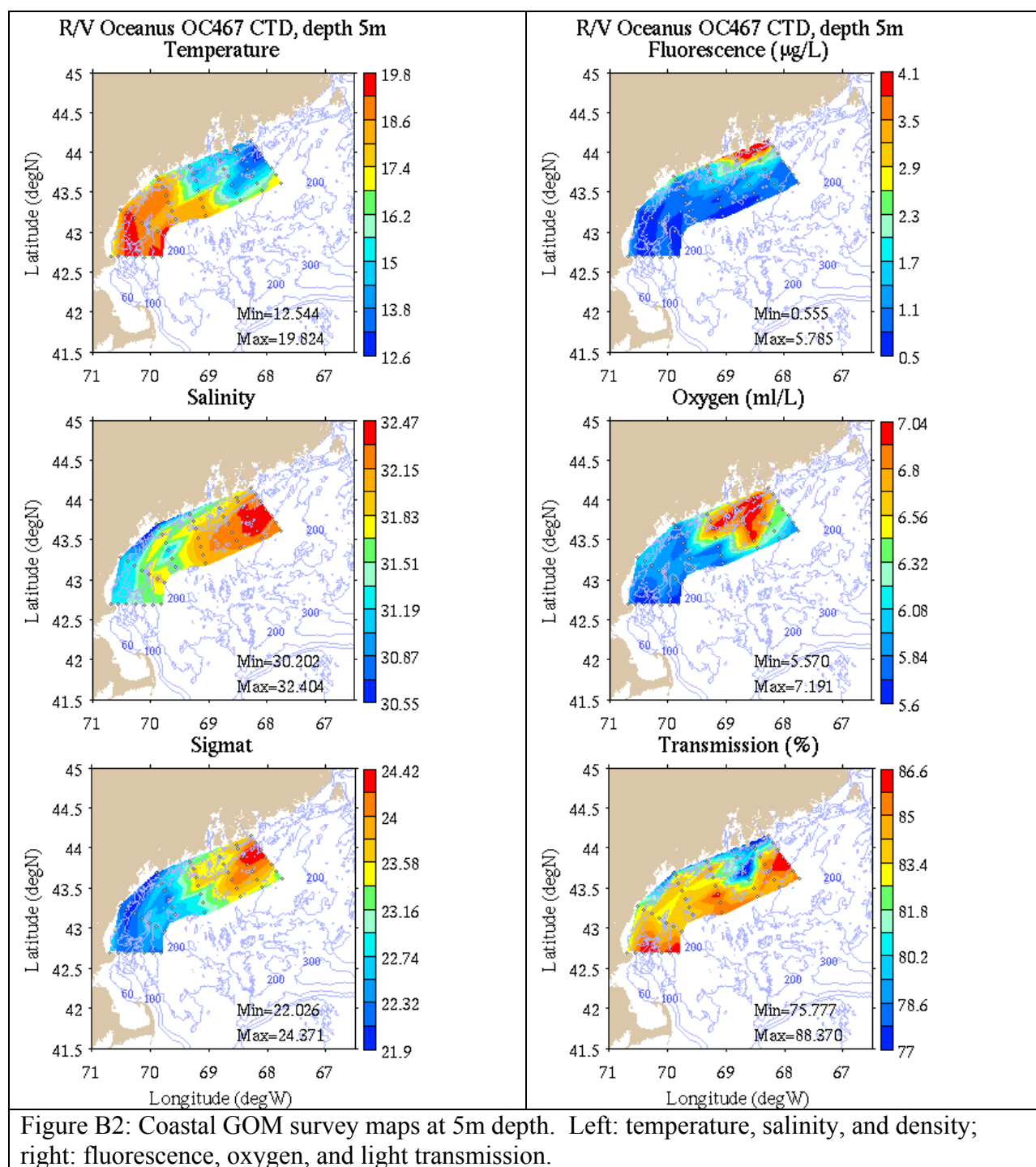
Sfc (1),(2)

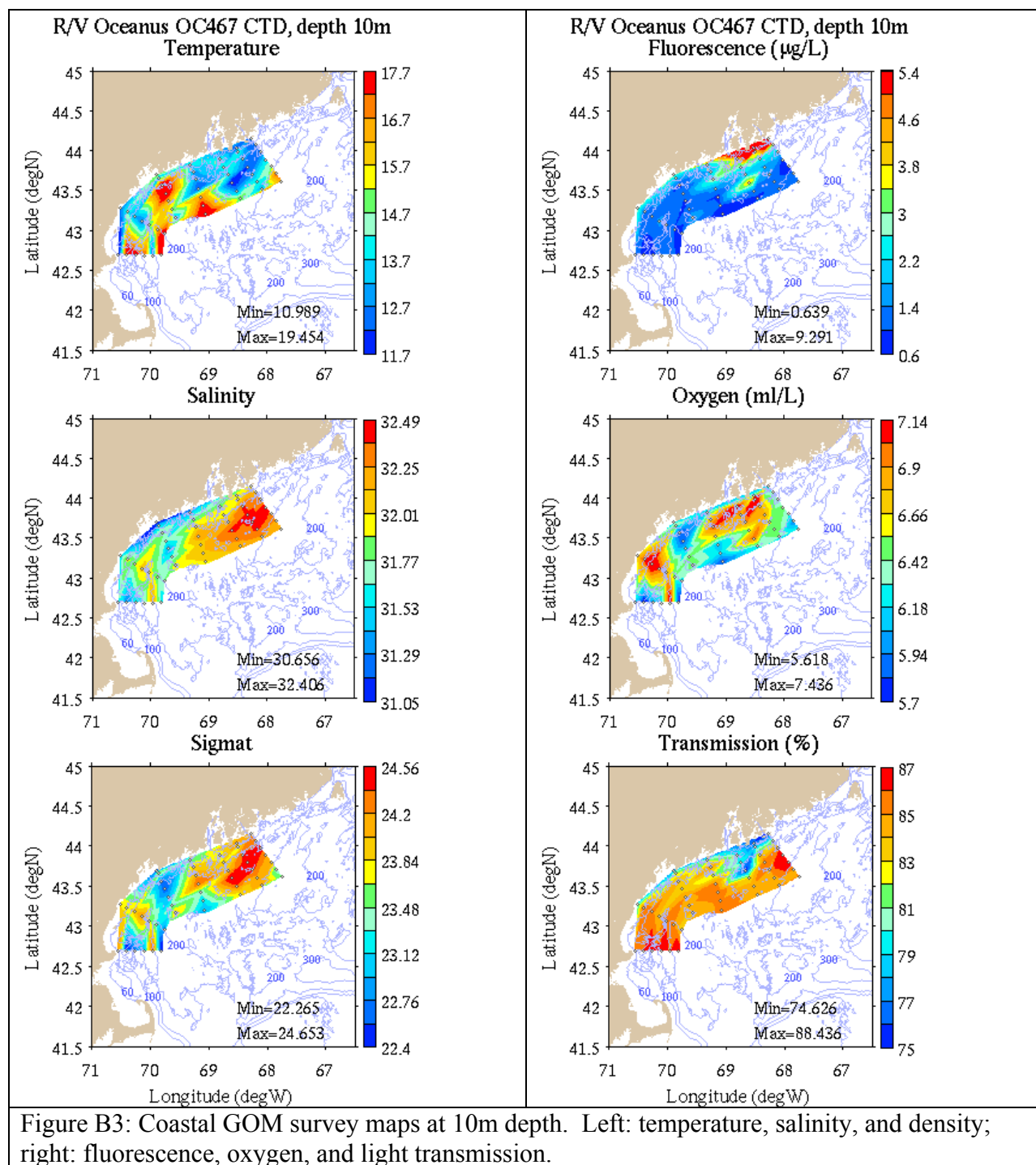
10m (1),(2)

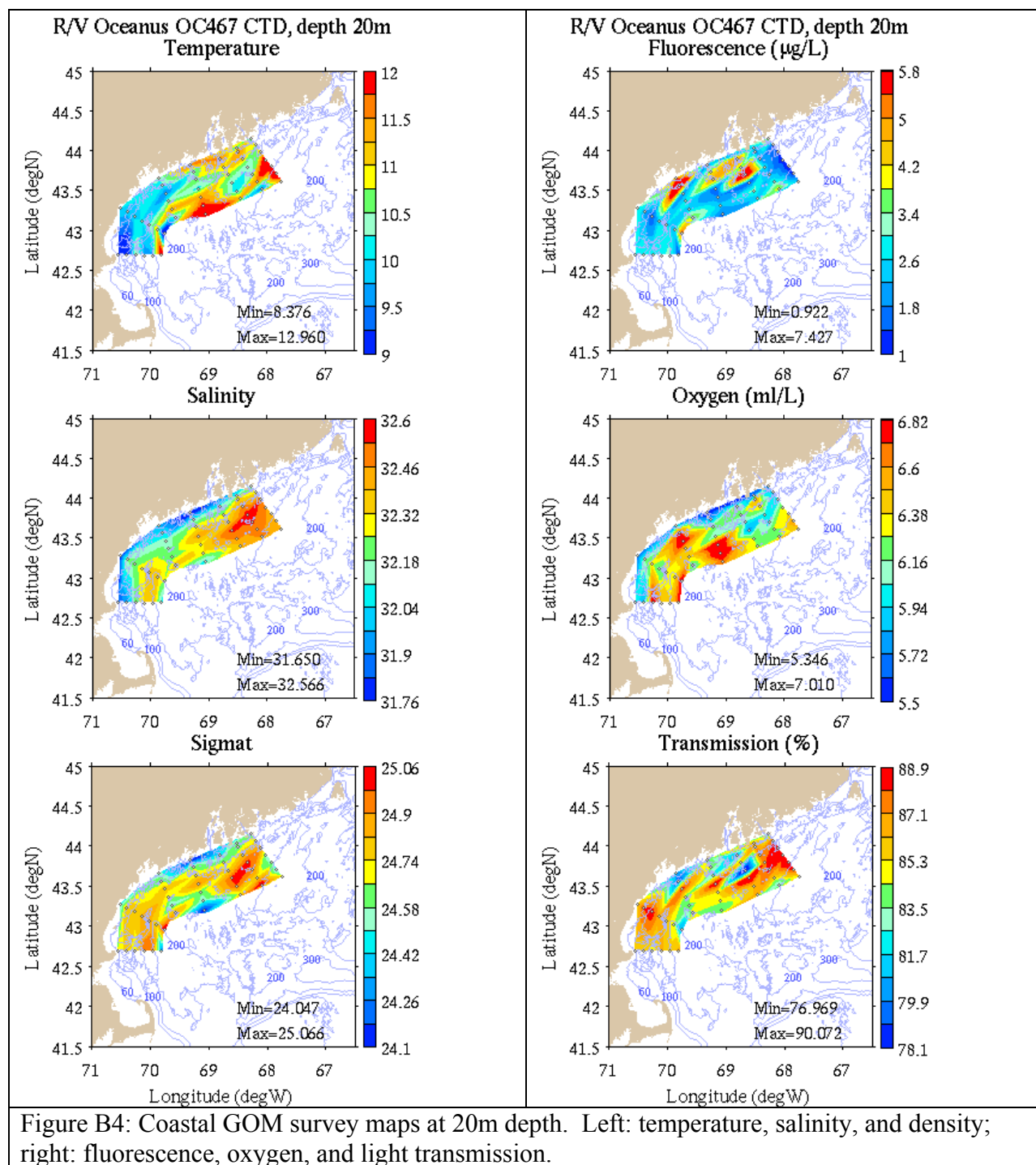
20m (1),(2)

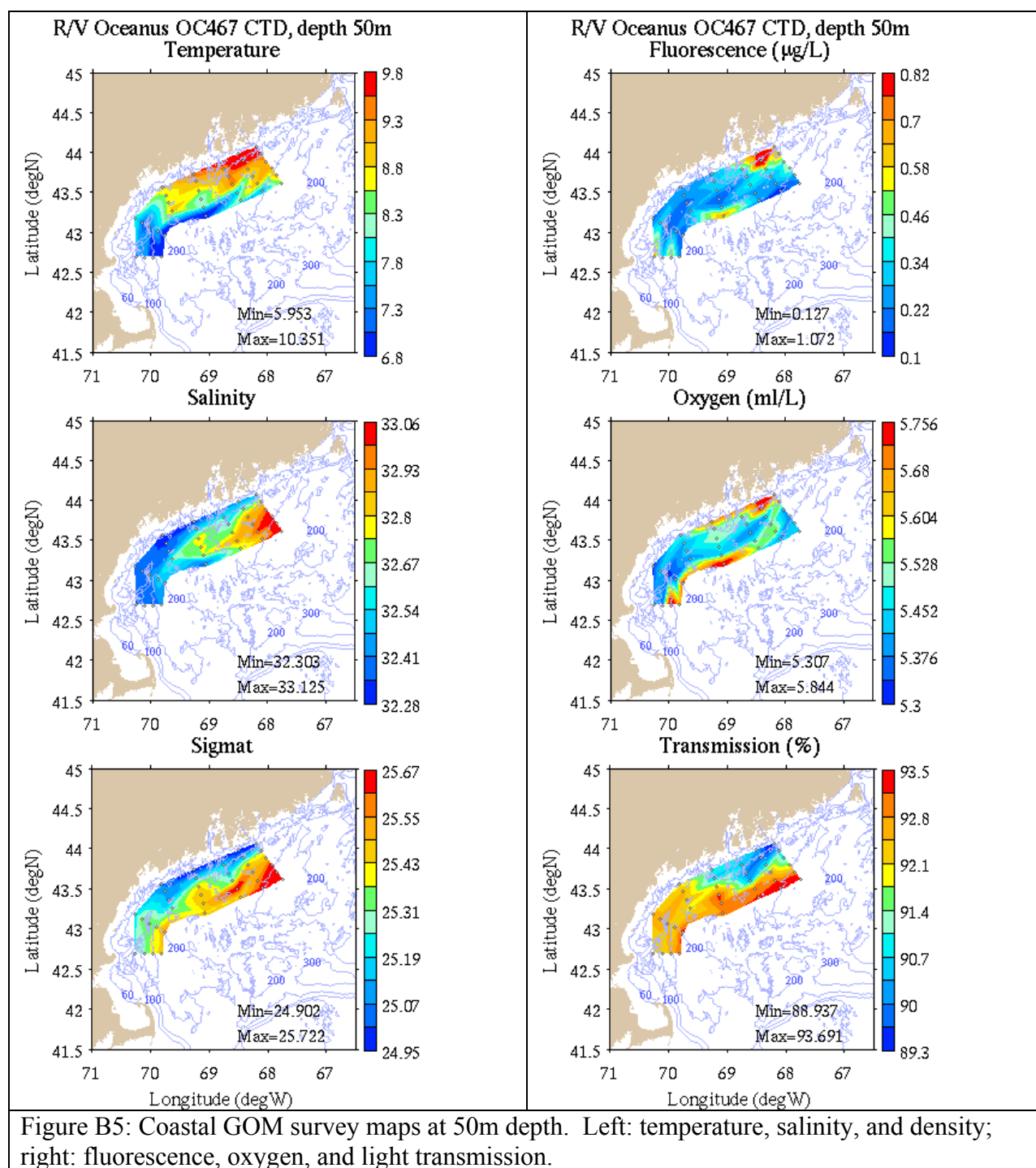
Appendix B: Hydrographic maps

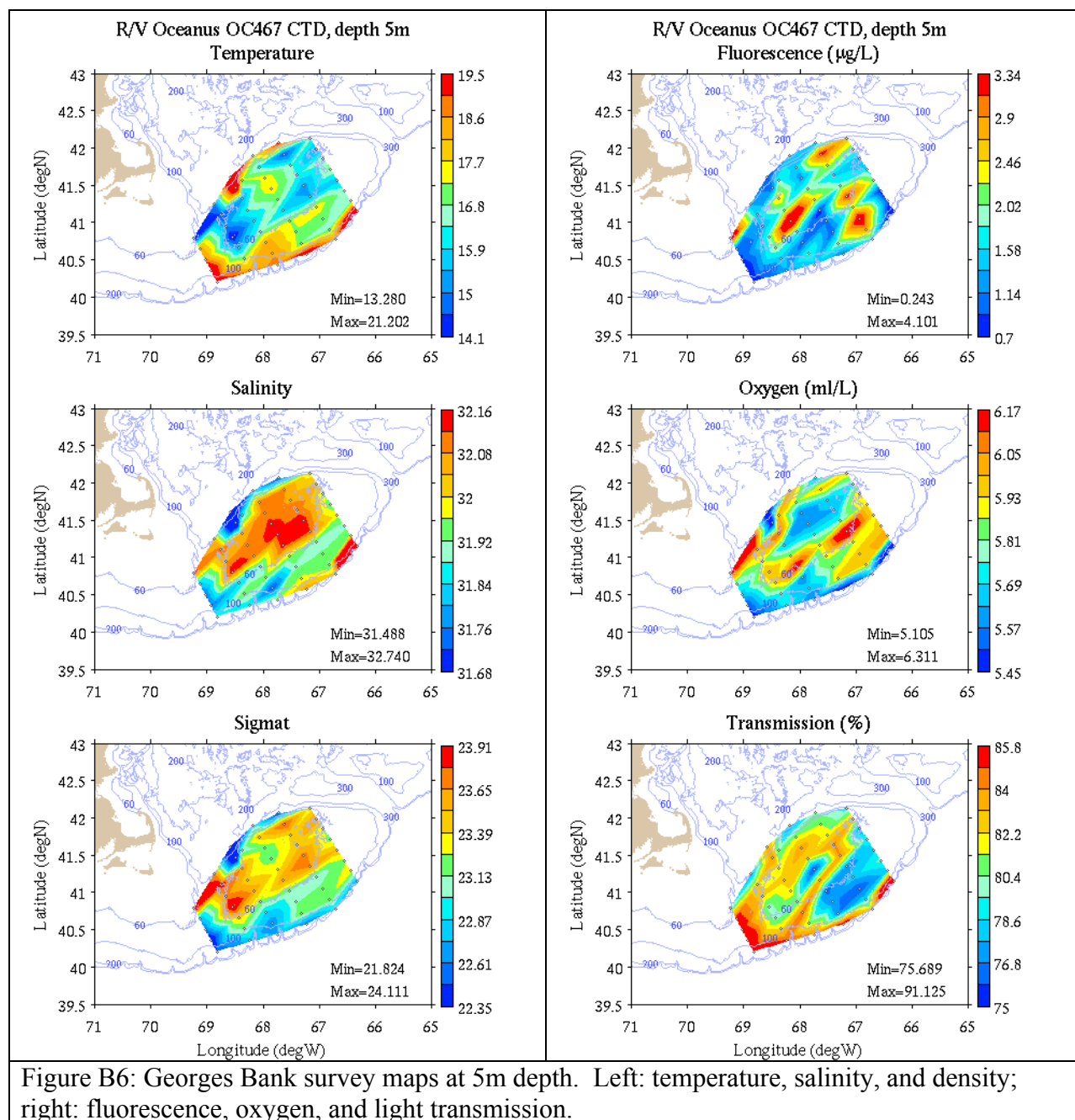












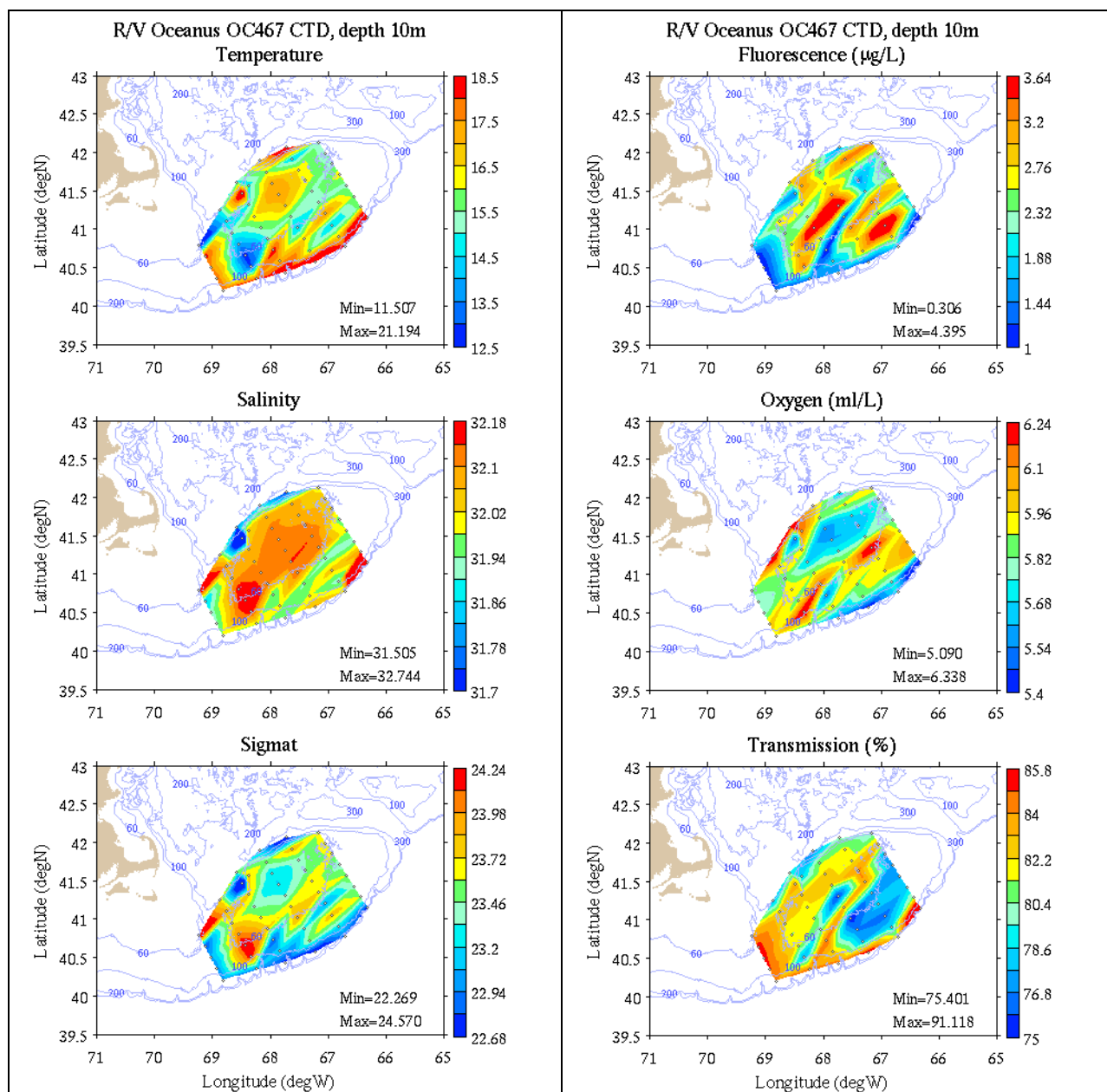


Figure B7: Georges Bank survey maps at 10m depth. Left: temperature, salinity, and density; right: fluorescence, oxygen, and light transmission.

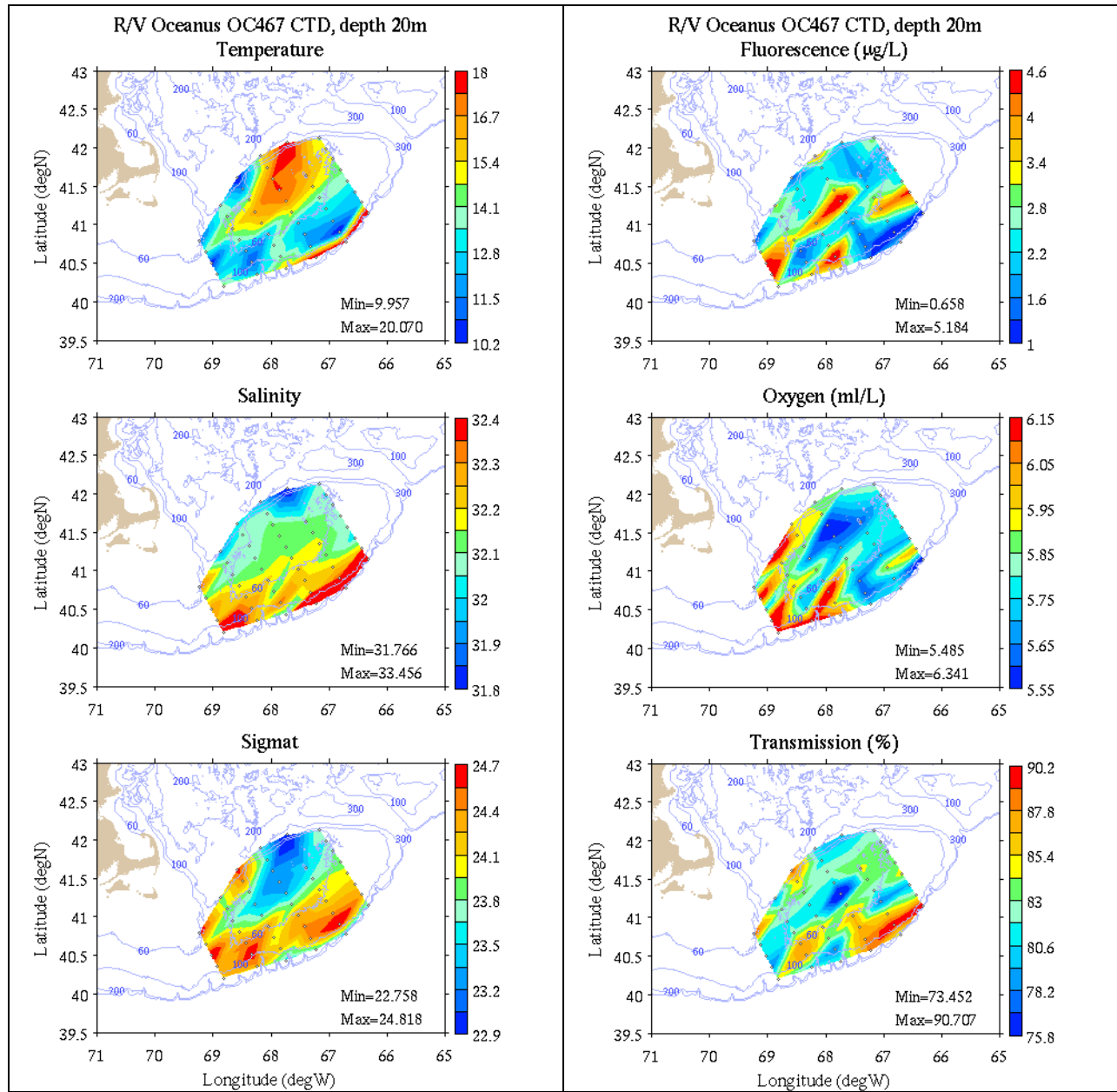


Figure B8: Georges Bank survey maps at 20m depth. Left: temperature, salinity, and density; right: fluorescence, oxygen, and light transmission.

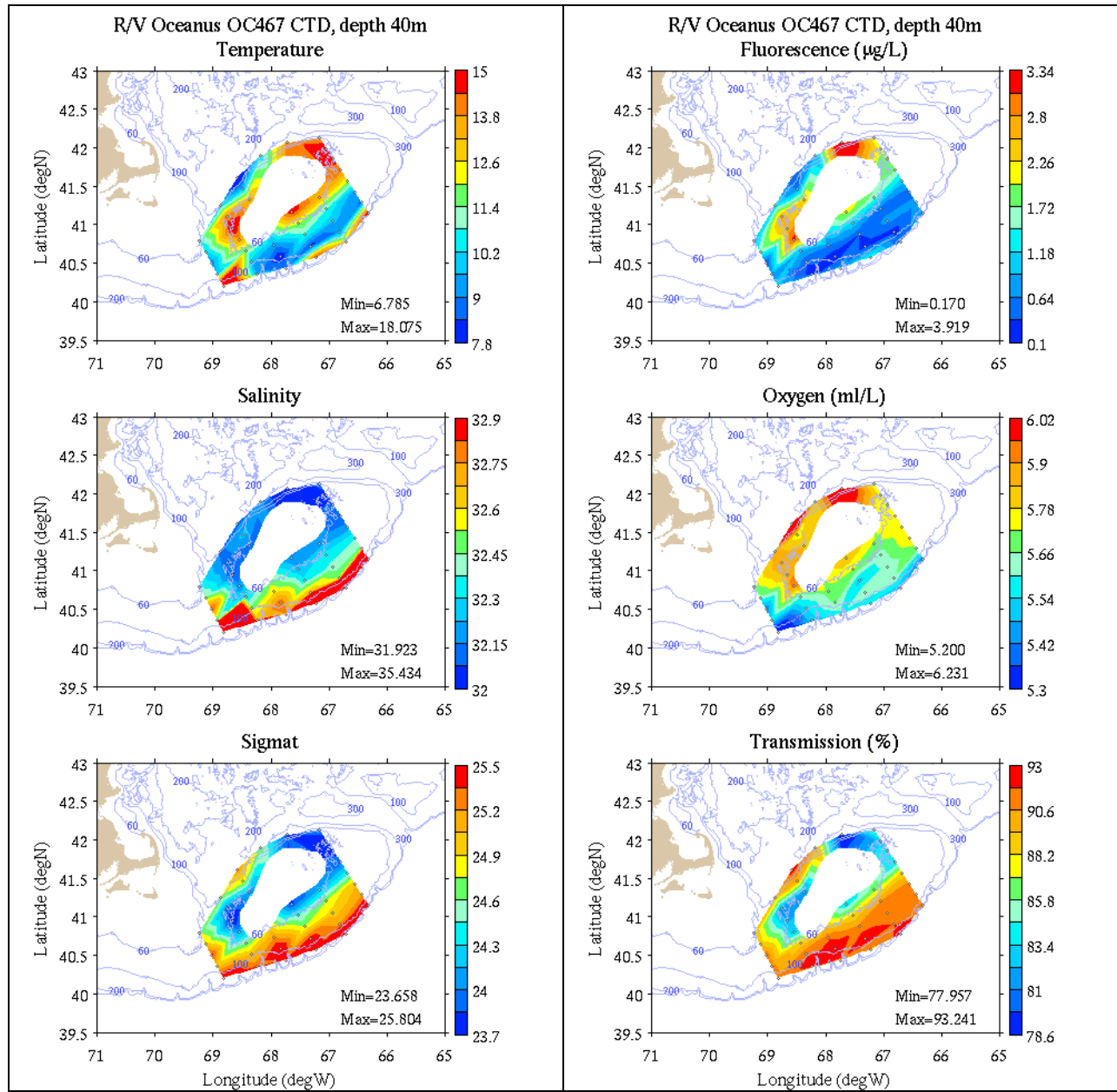


Figure B9: Georges Bank survey maps at 40m depth. Left: temperature, salinity, and density; right: fluorescence, oxygen, and light transmission.

Appendix C: Vertical sections.

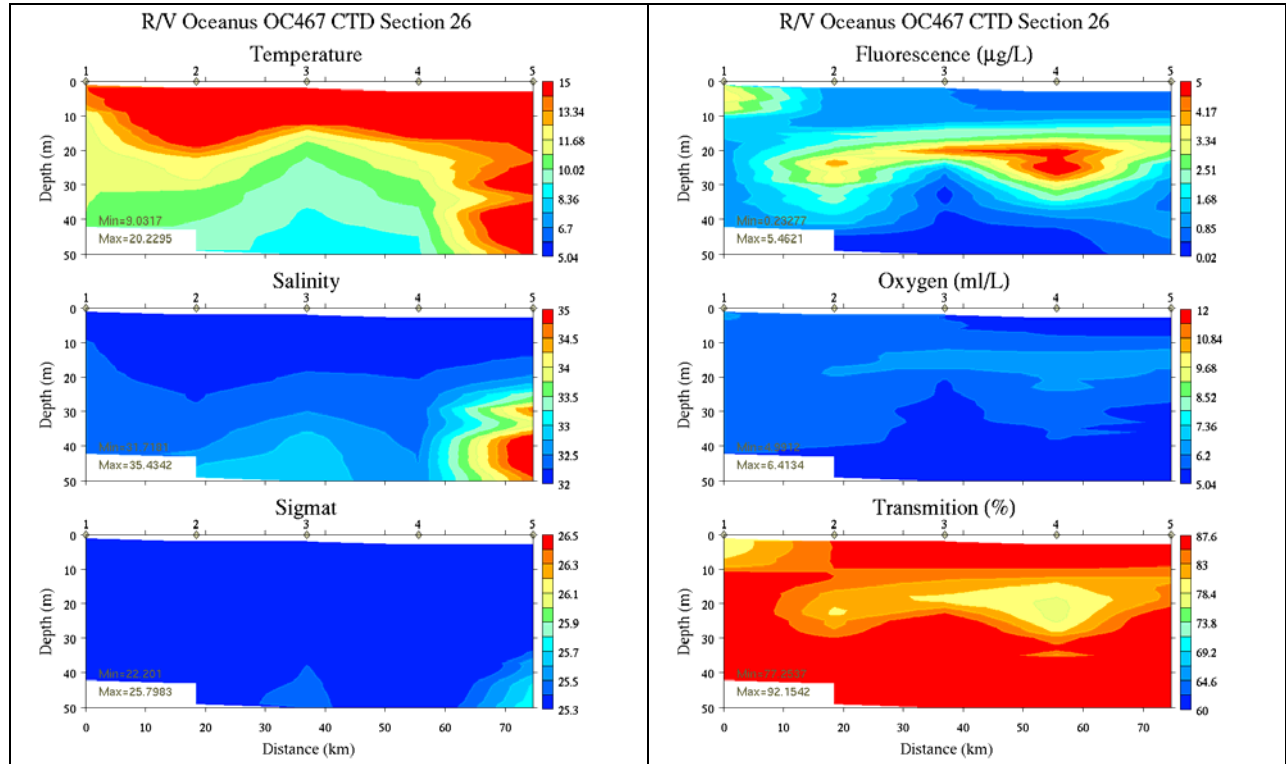
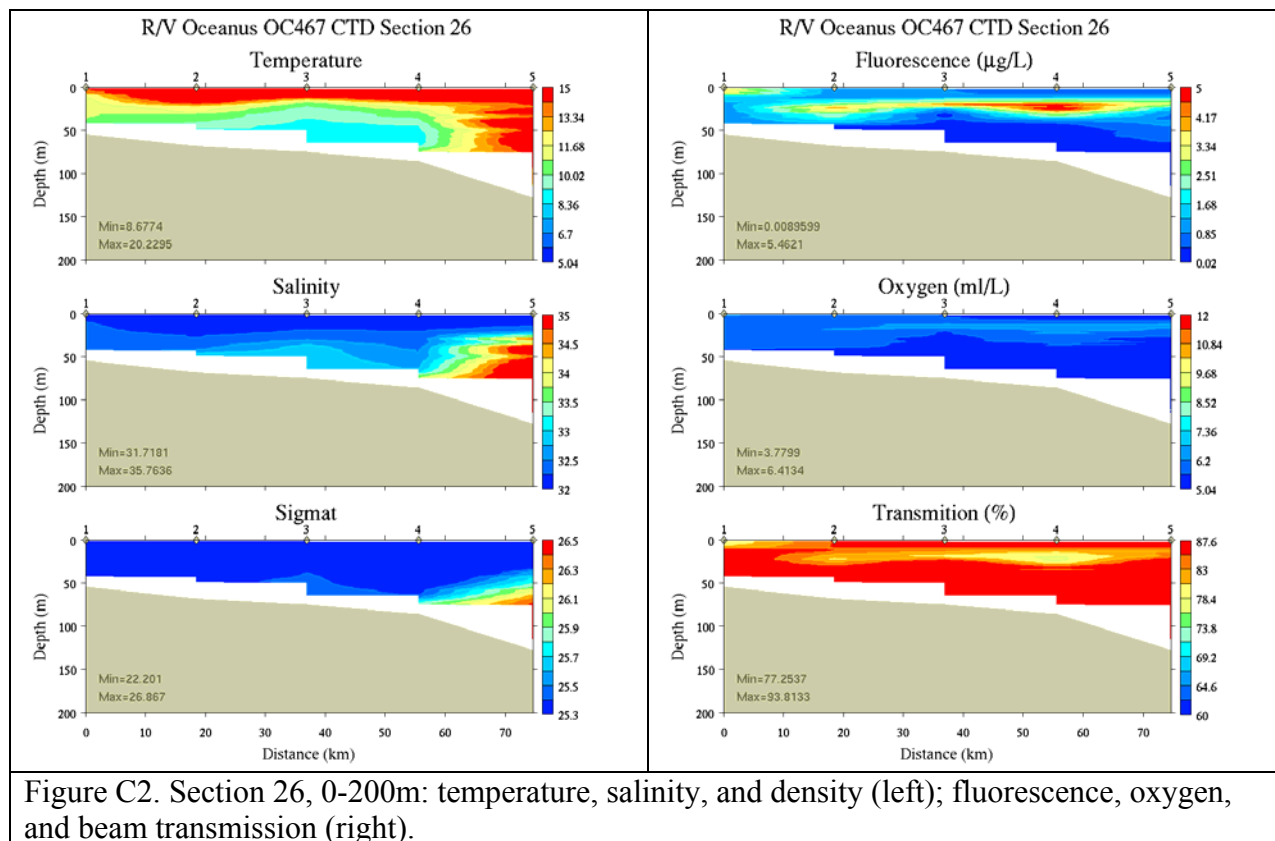


Figure C1. Section 26, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).



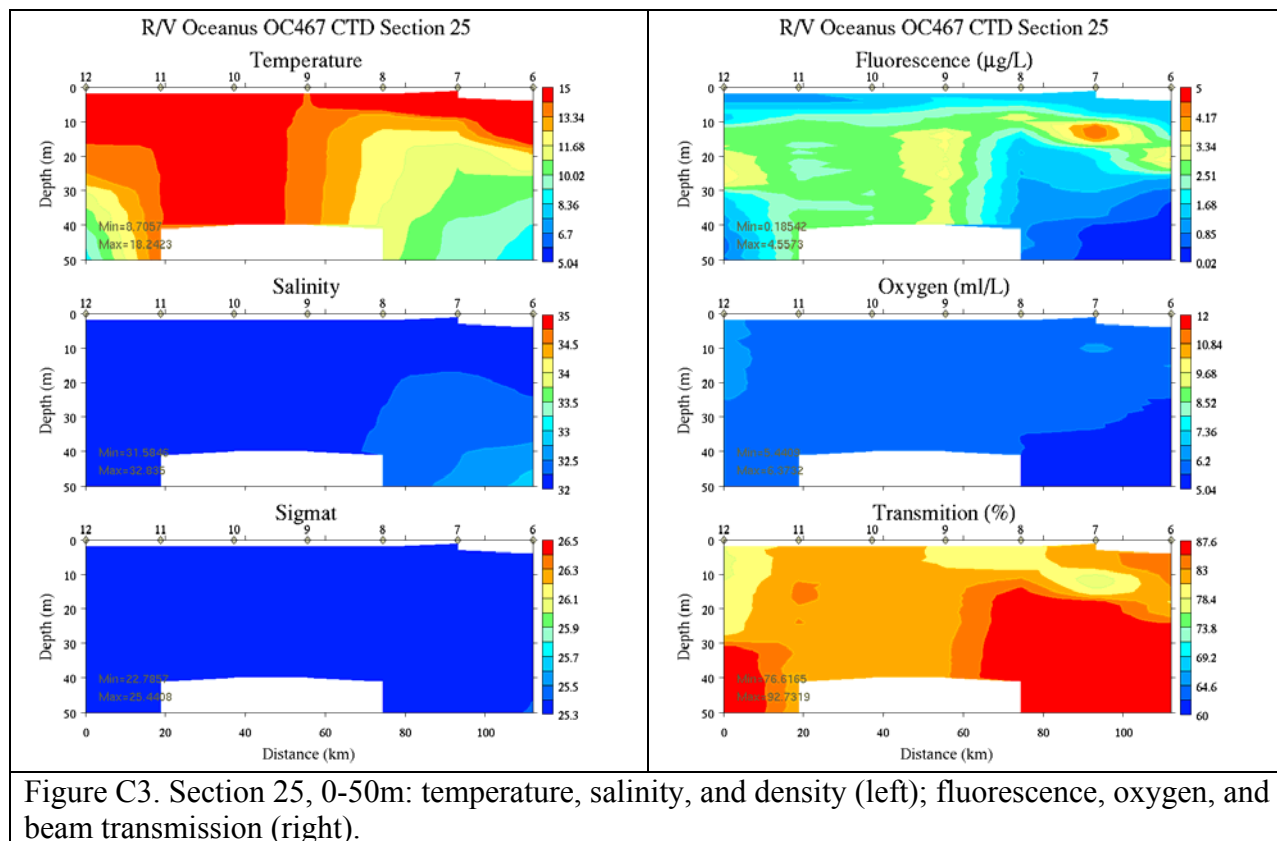
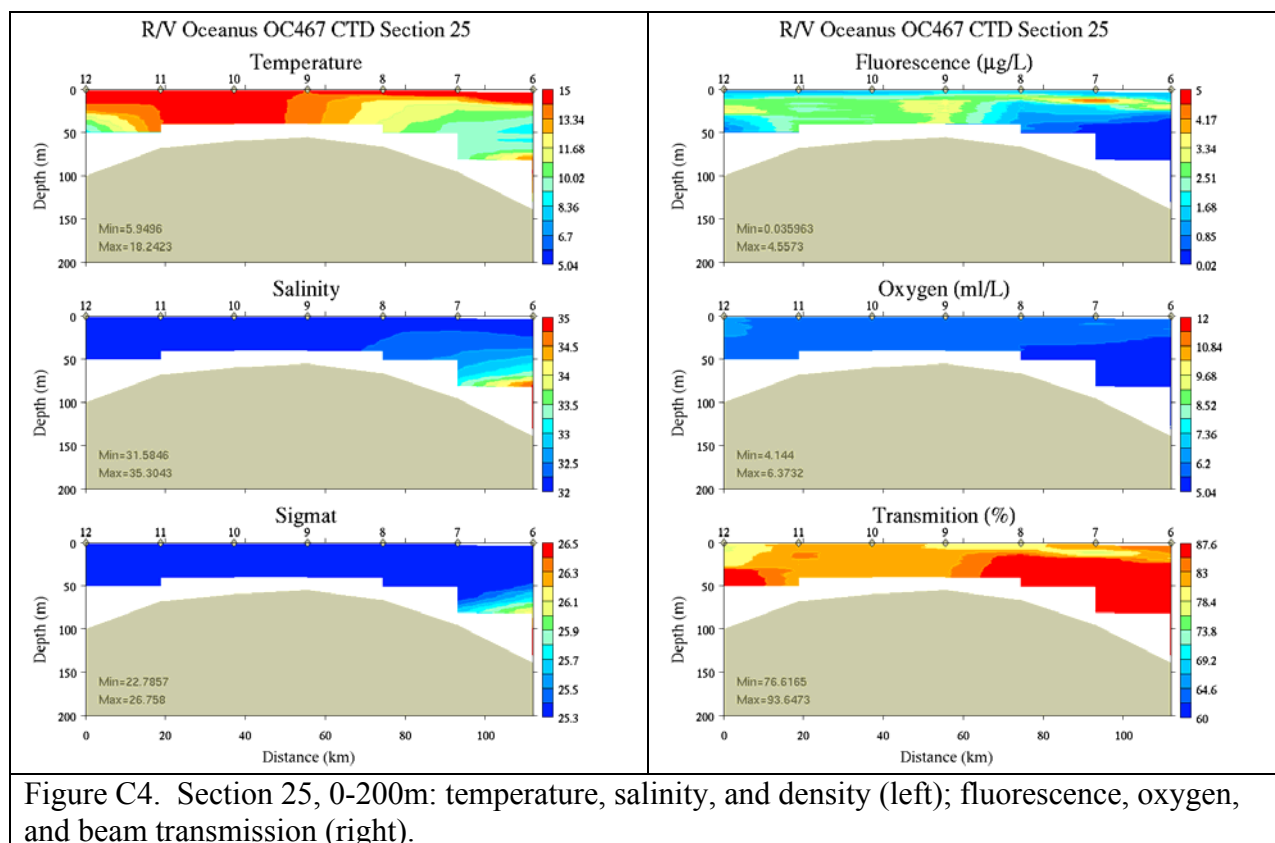
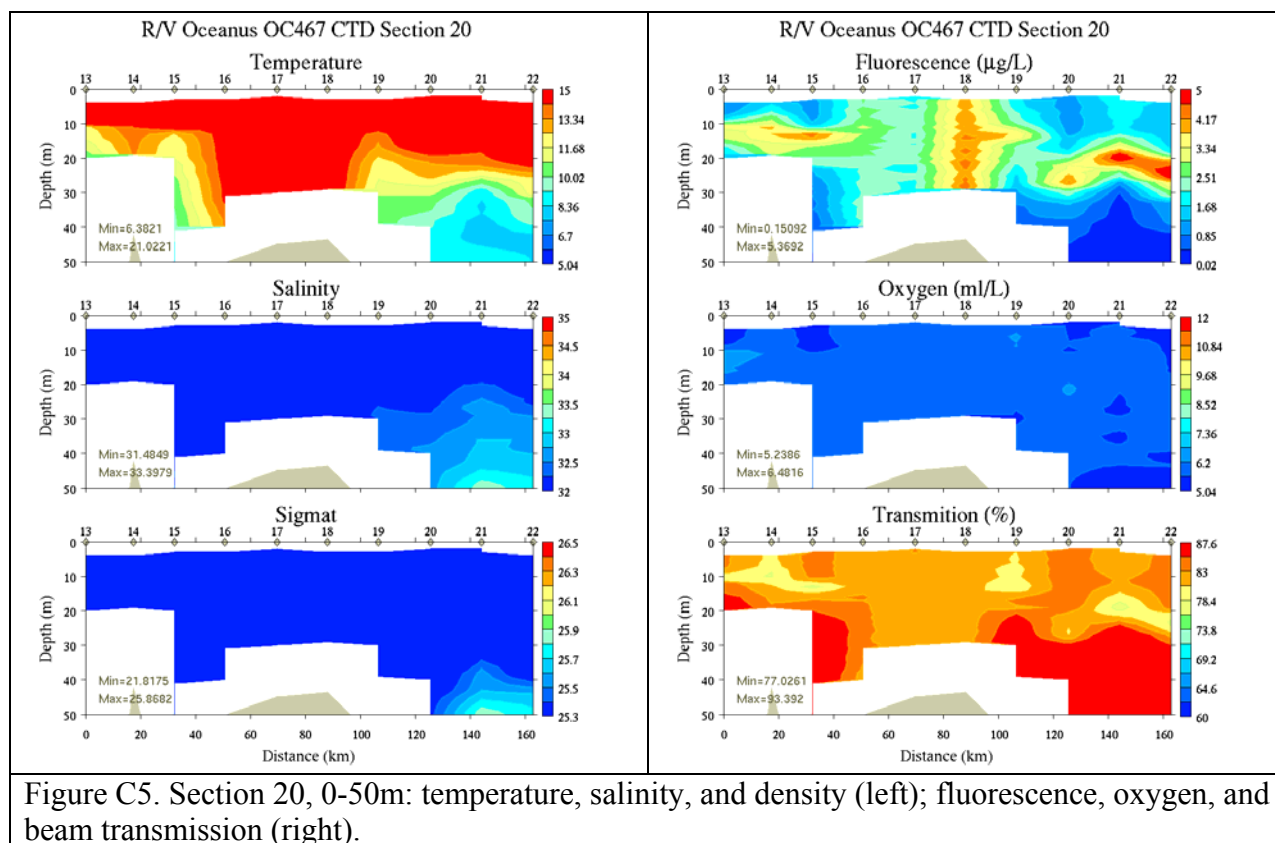
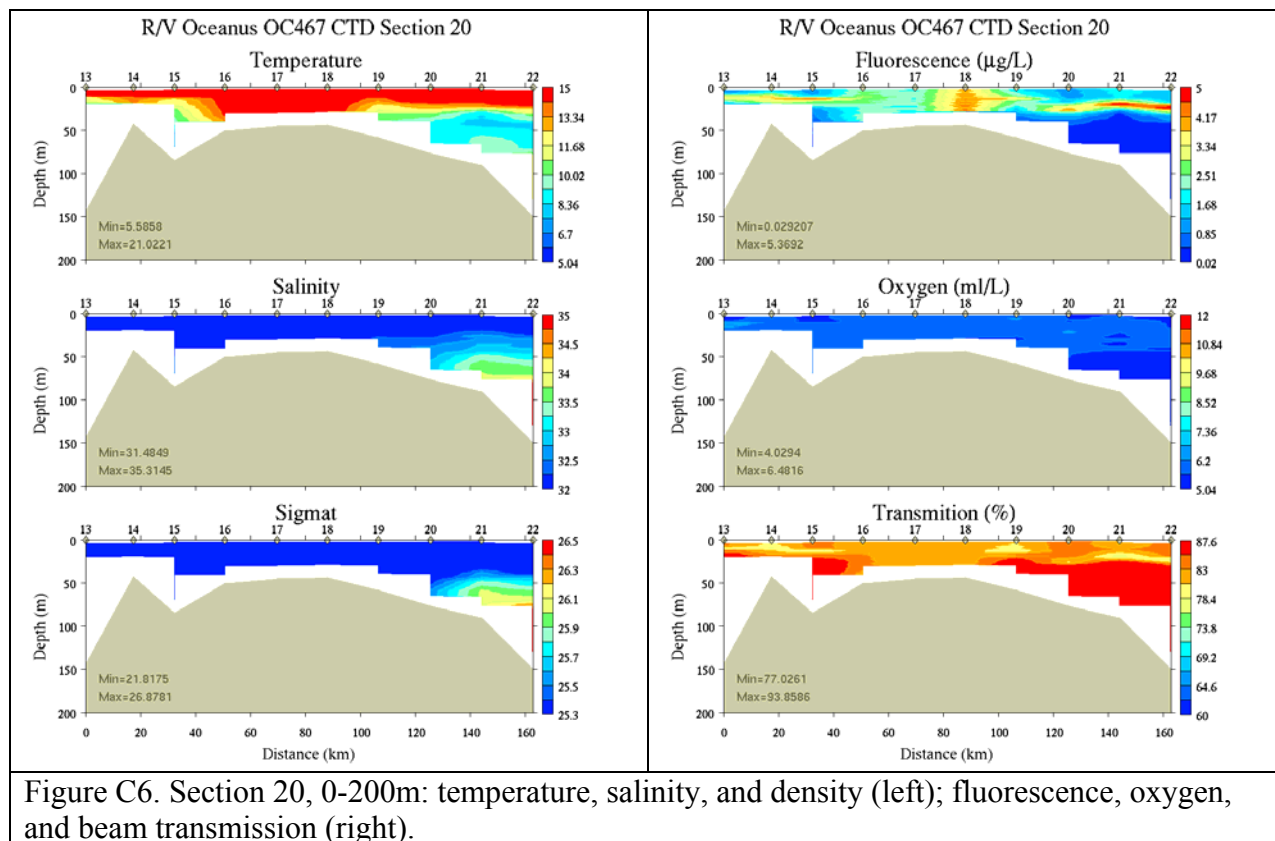


Figure C3. Section 25, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).







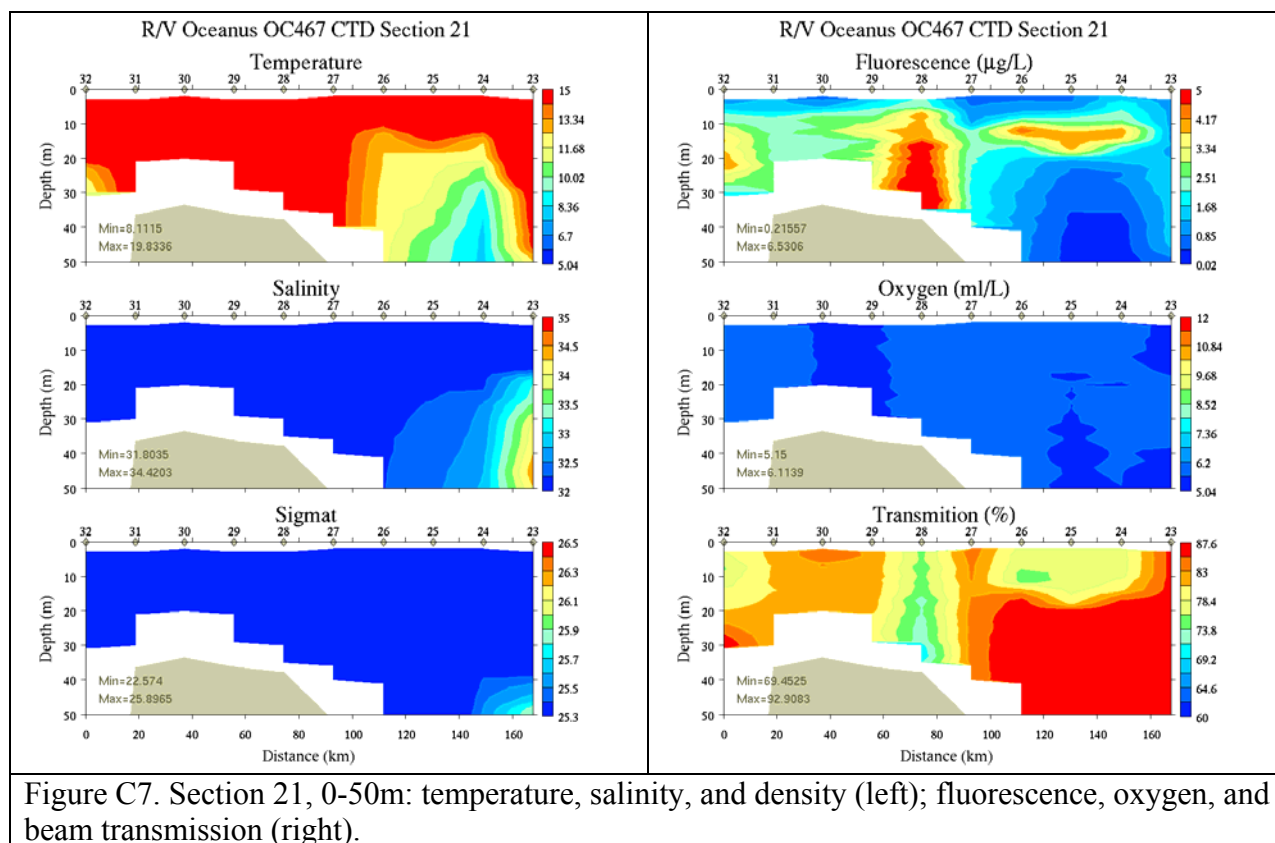


Figure C7. Section 21, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

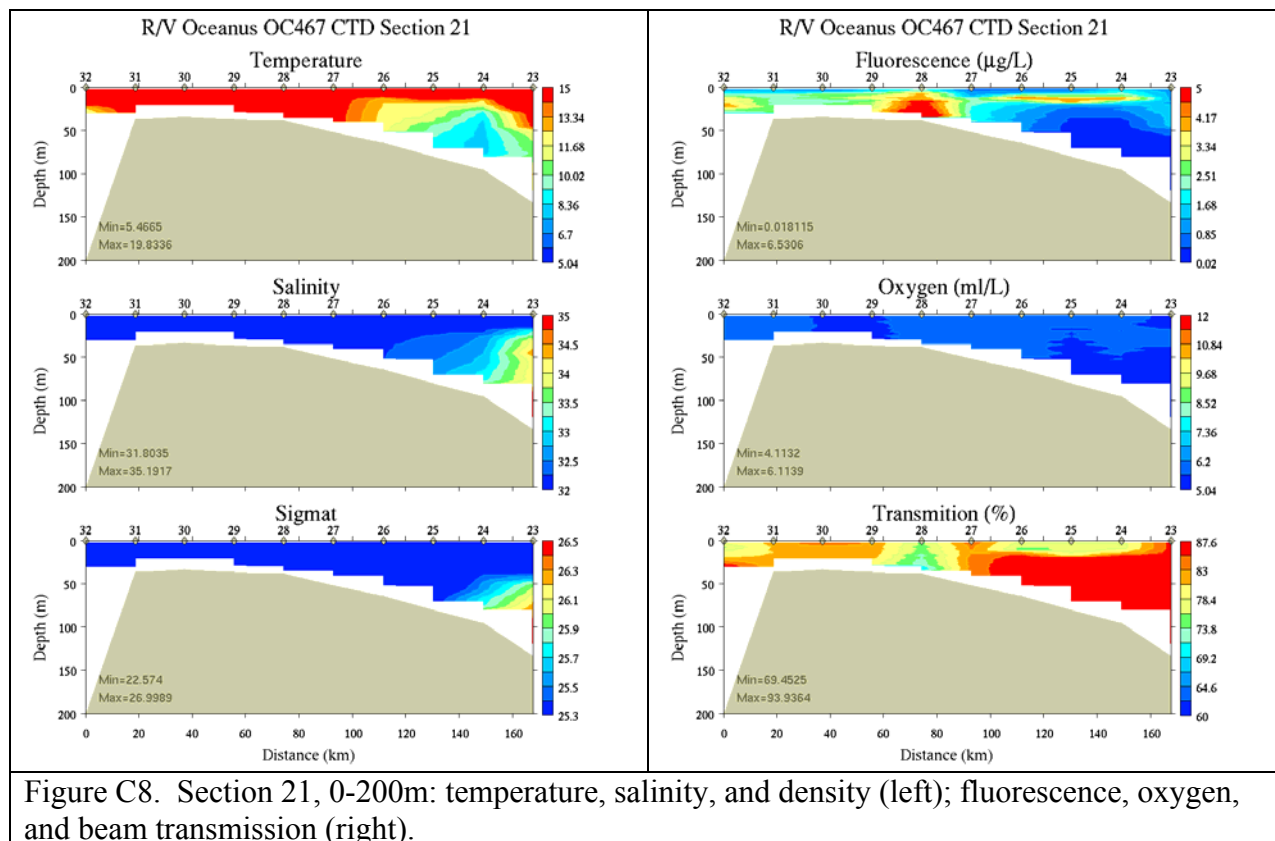


Figure C8. Section 21, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

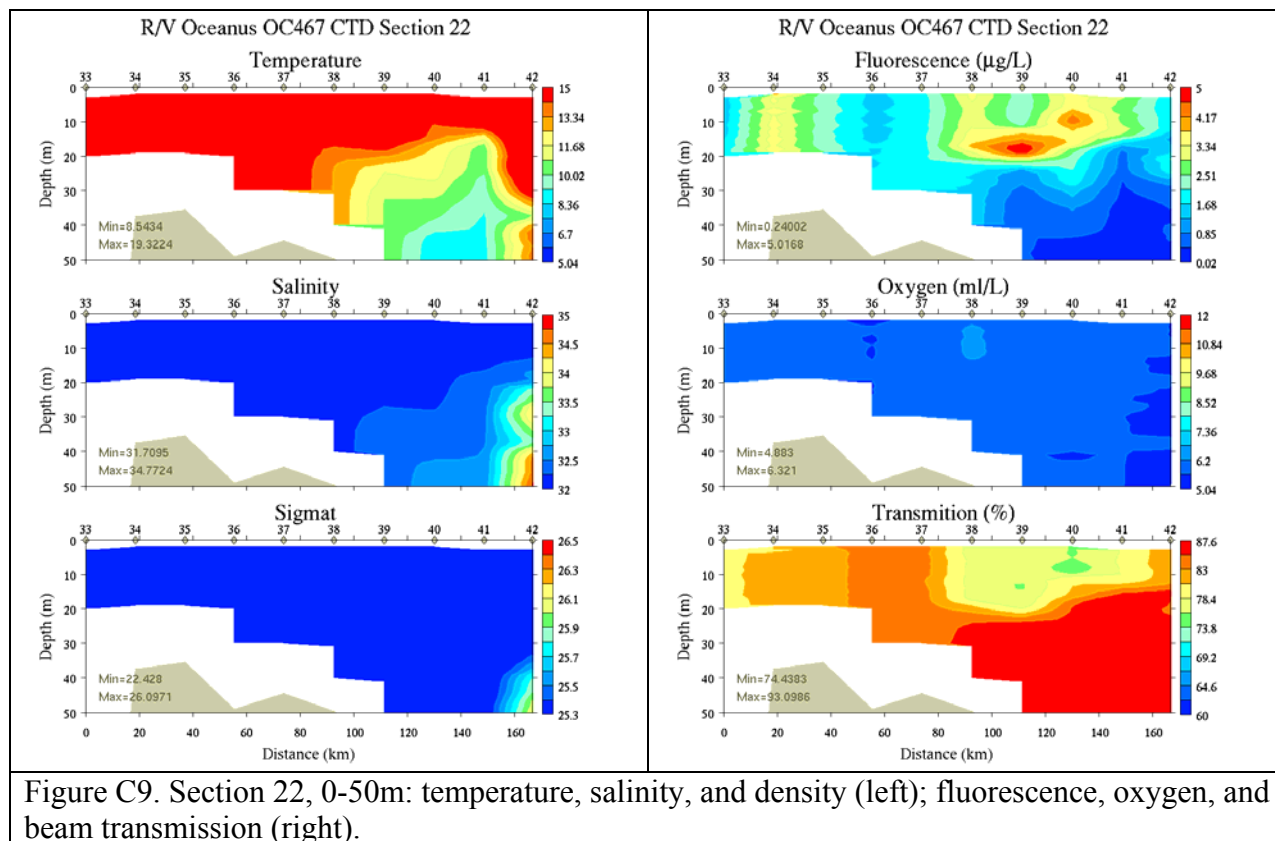


Figure C9. Section 22, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

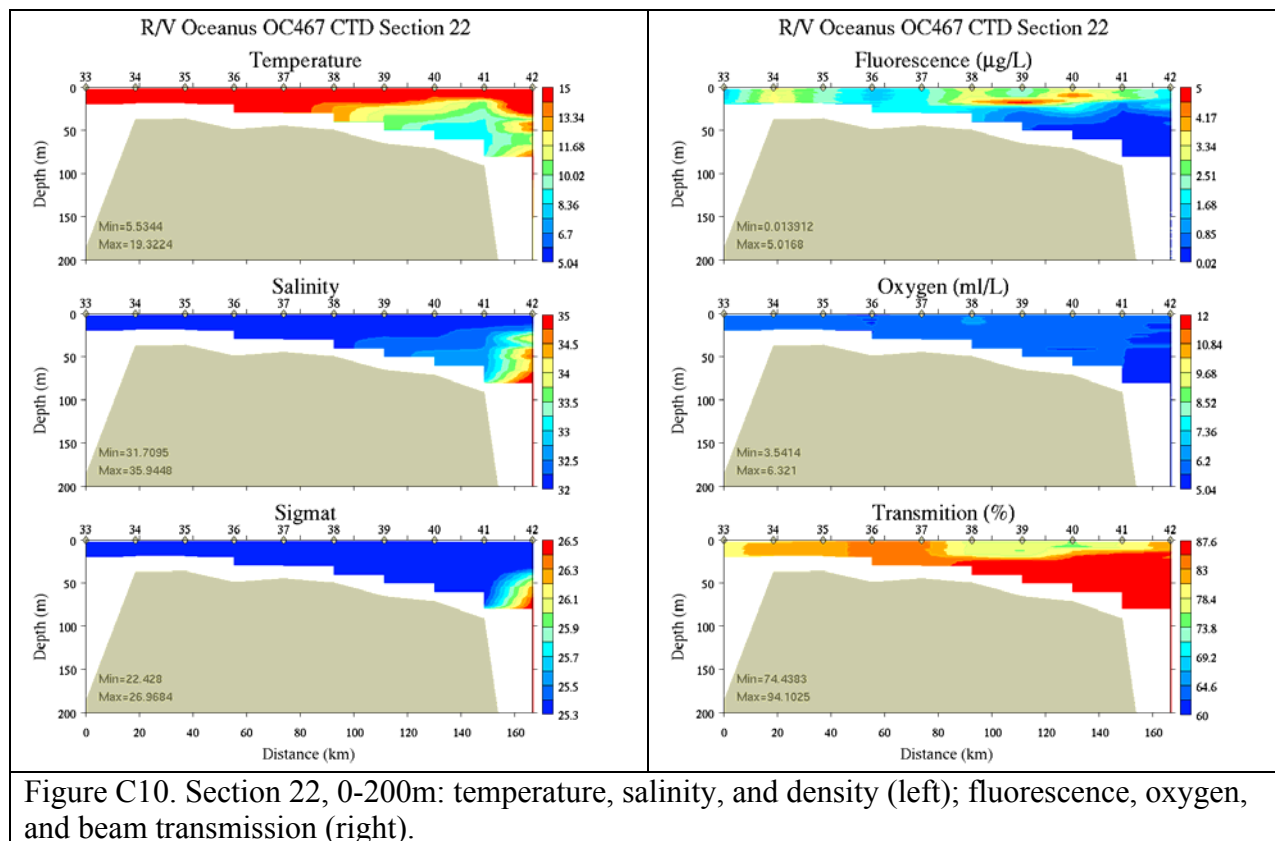


Figure C10. Section 22, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

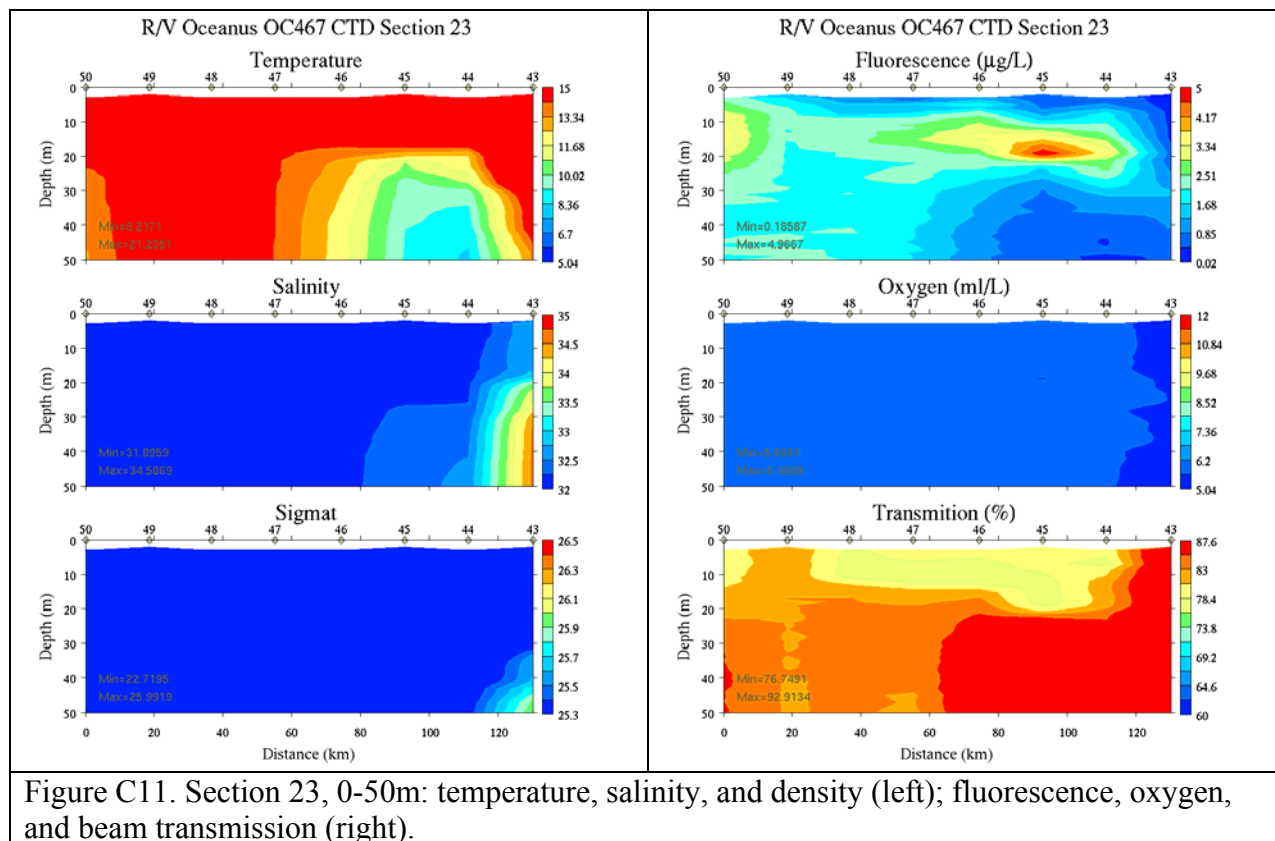
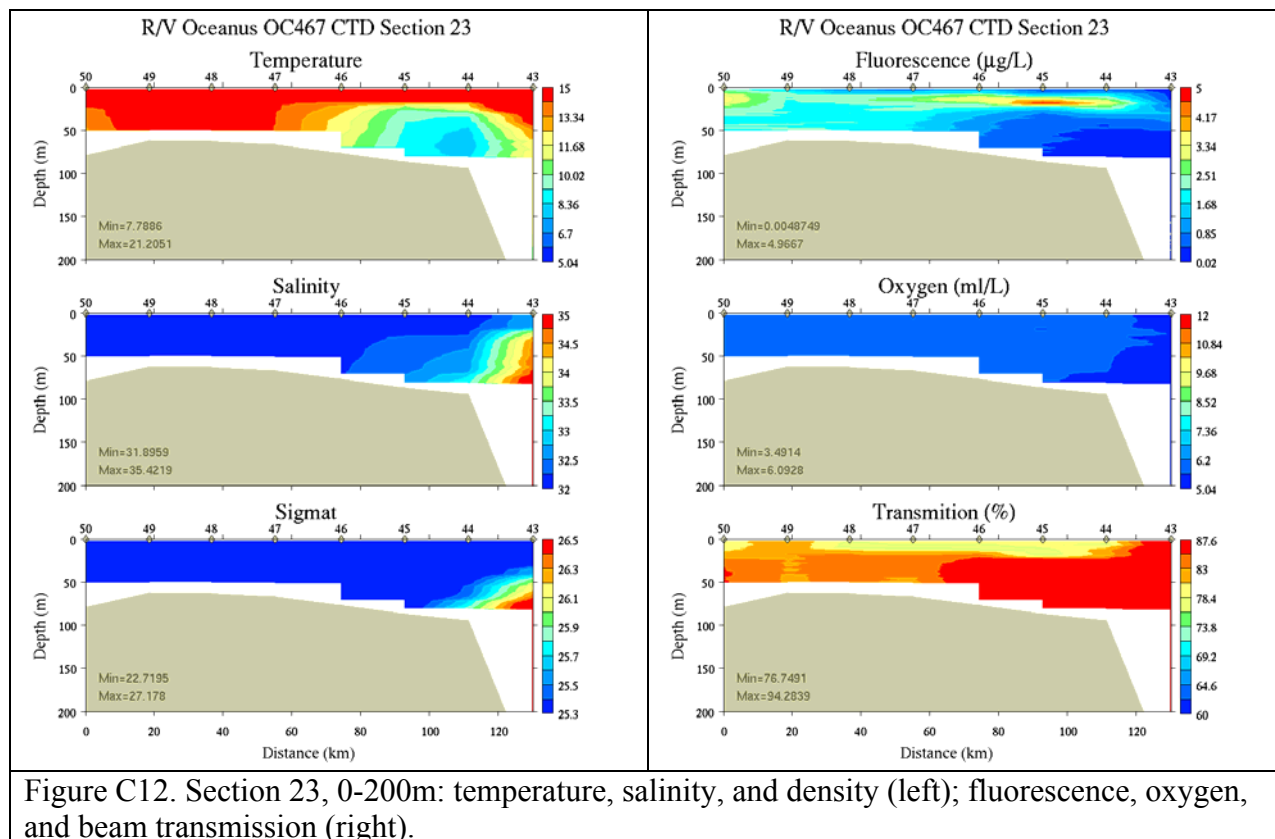


Figure C11. Section 23, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).



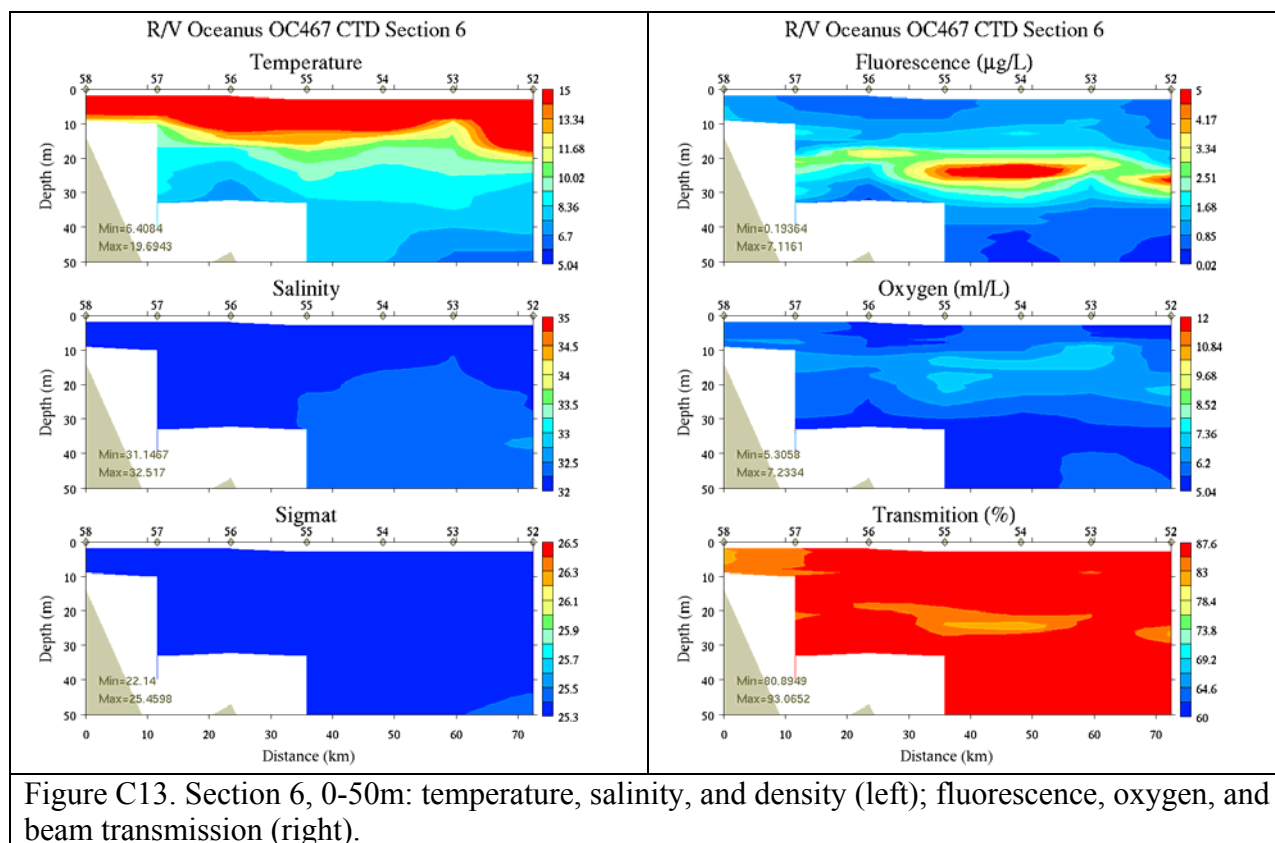


Figure C13. Section 6, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

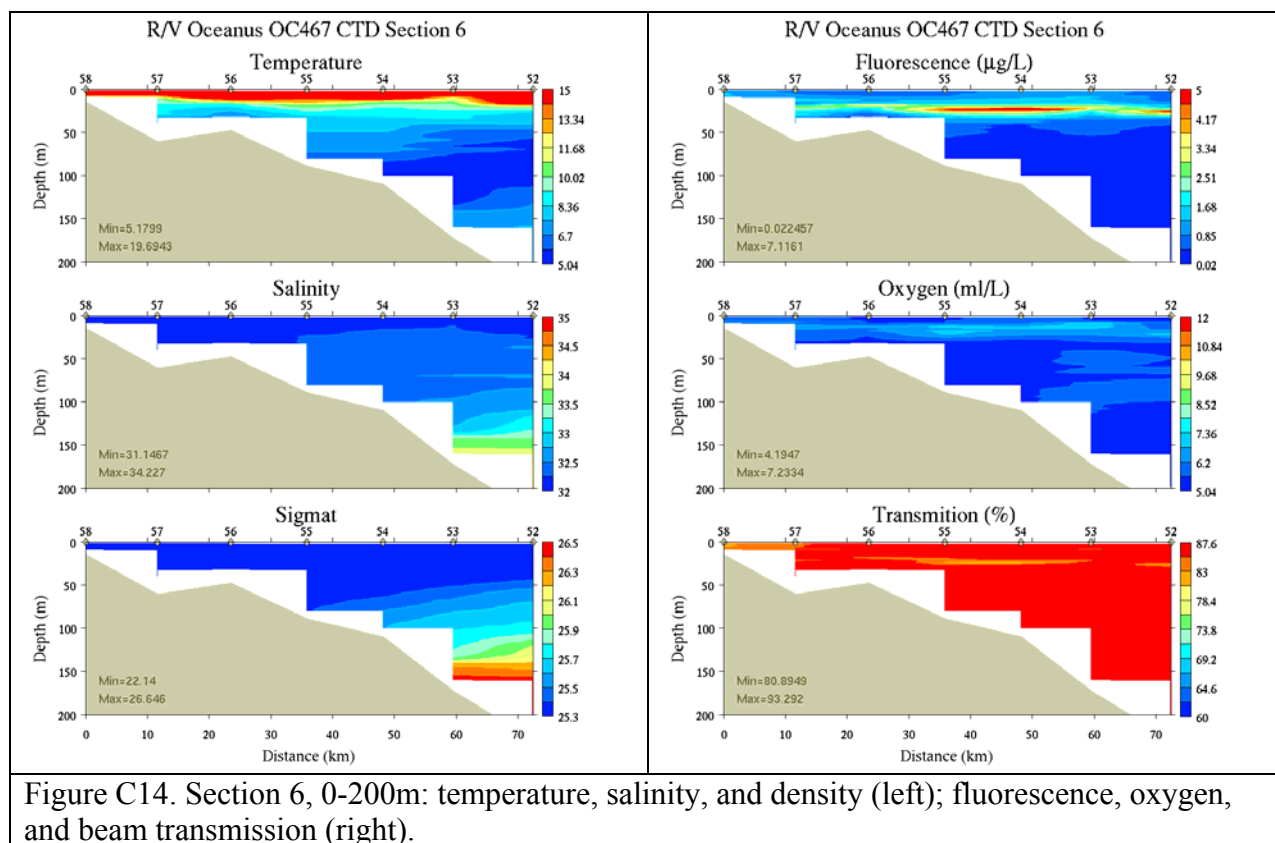
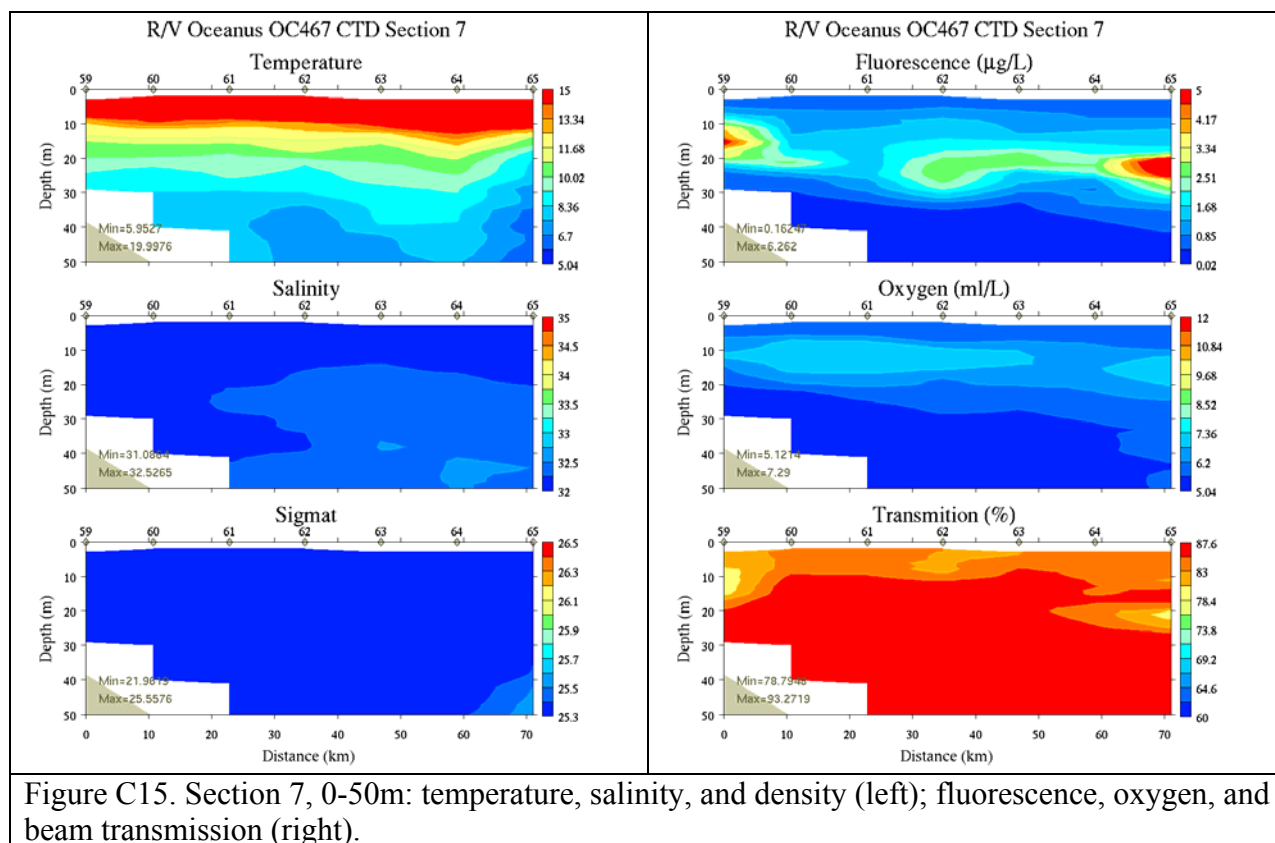


Figure C14. Section 6, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).



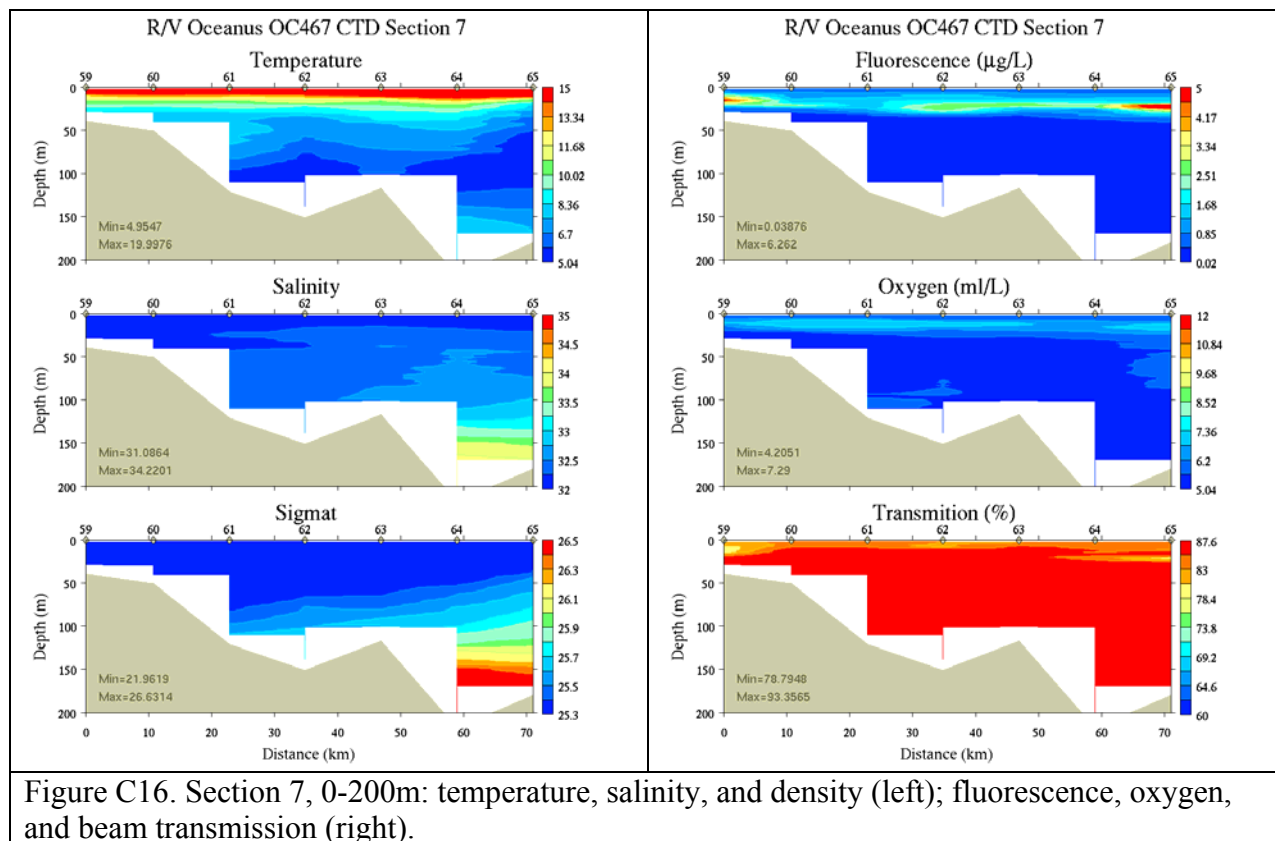
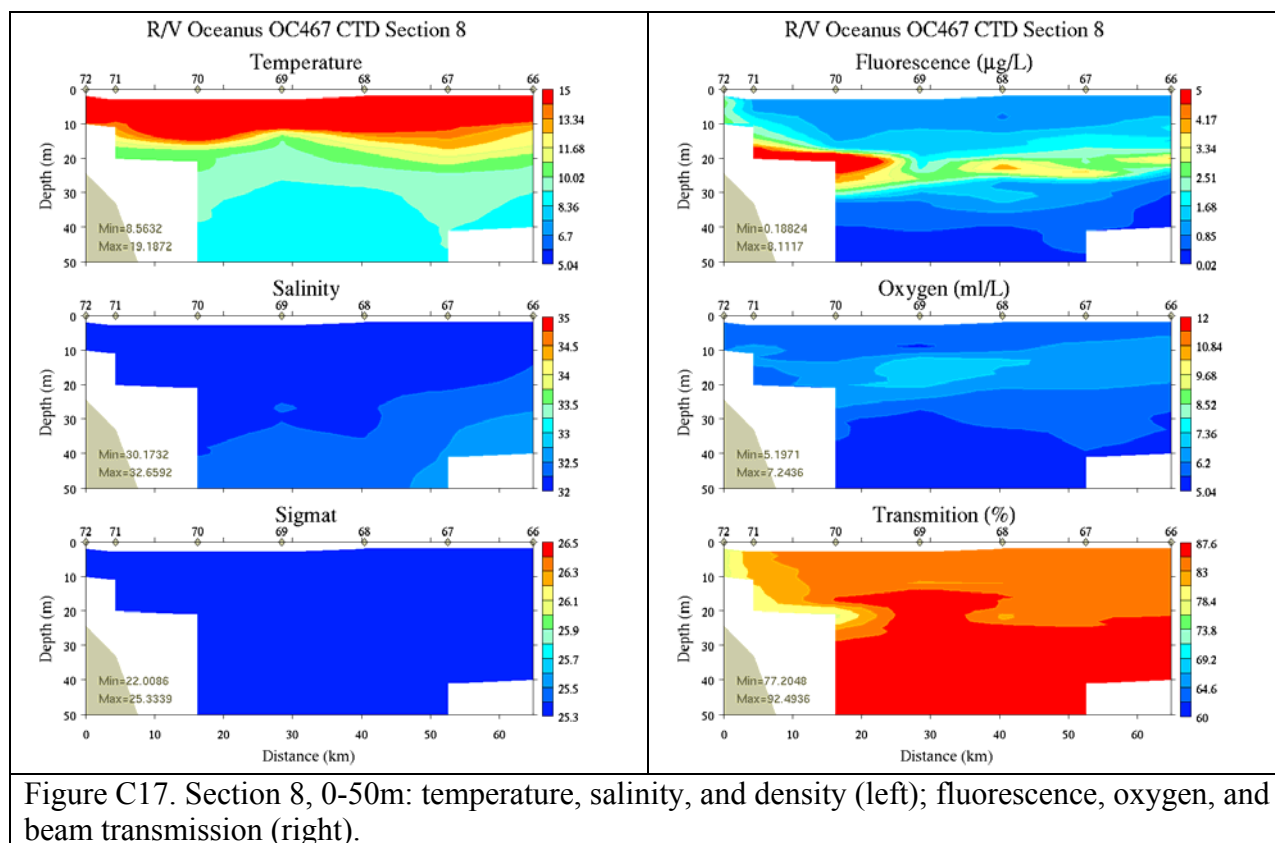


Figure C16. Section 7, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).



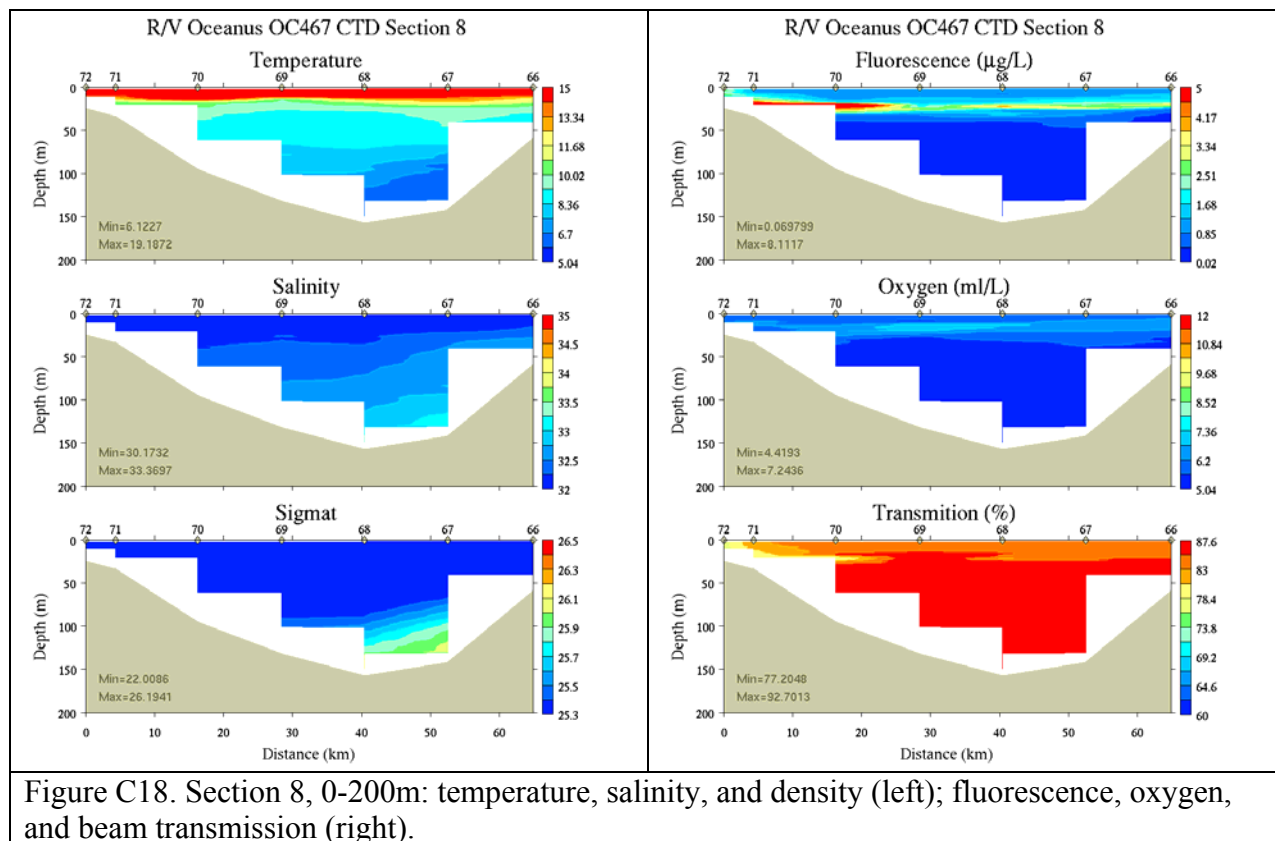


Figure C18. Section 8, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

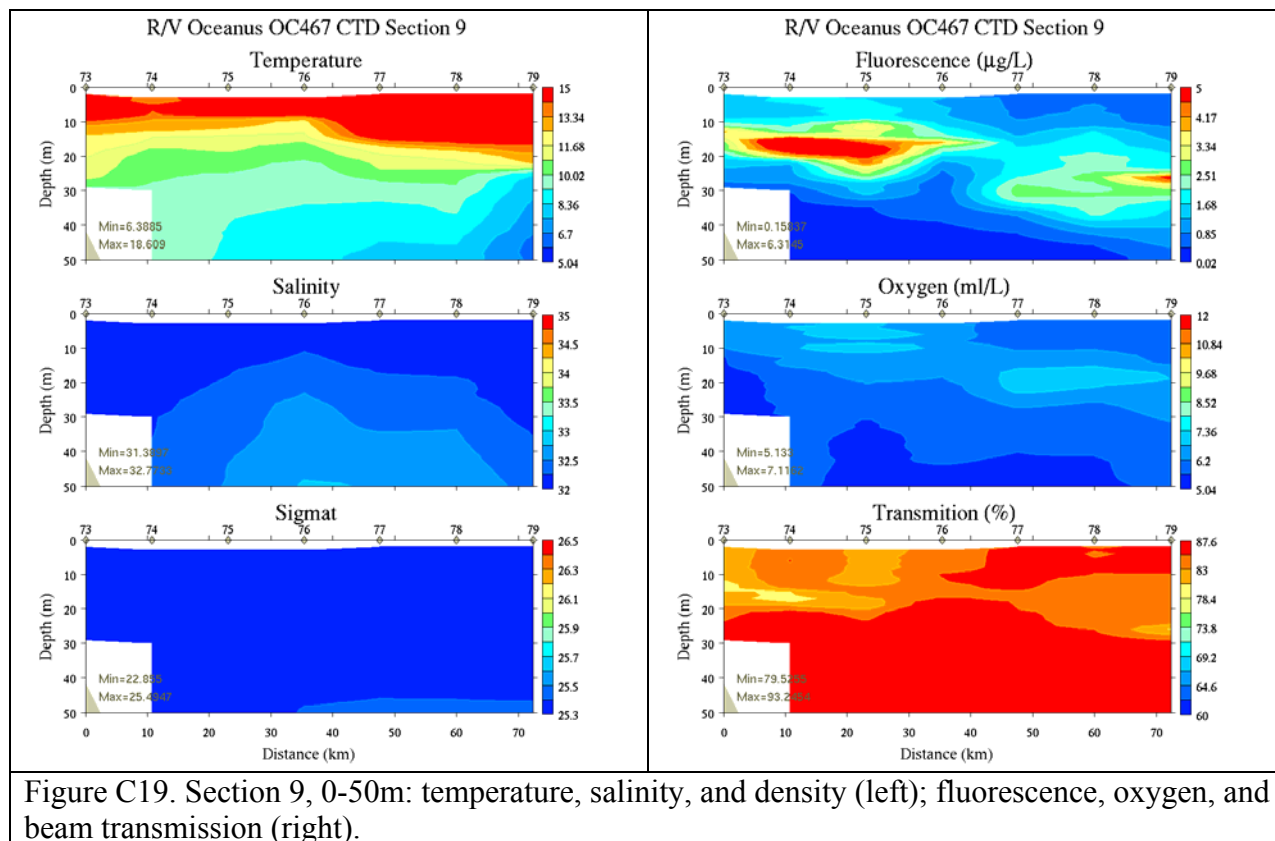
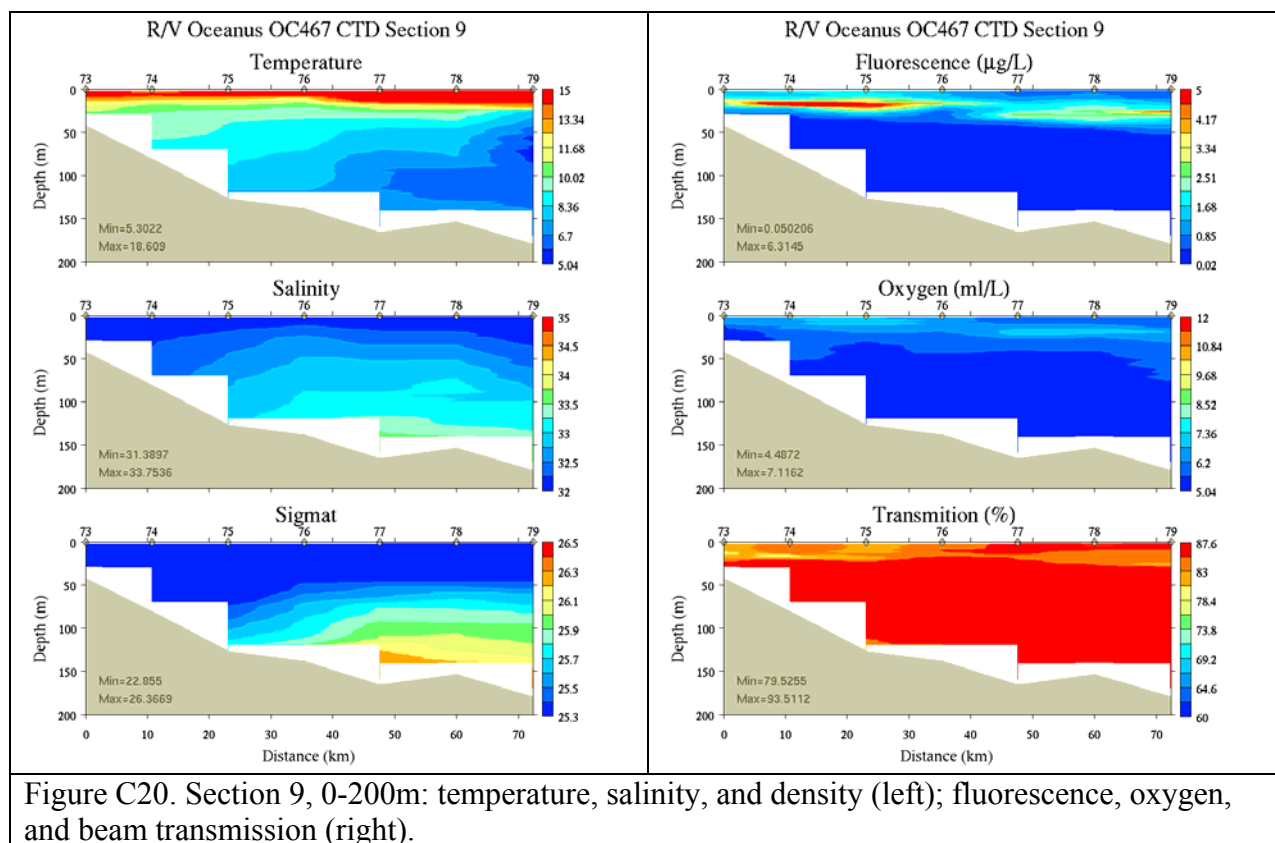


Figure C19. Section 9, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).



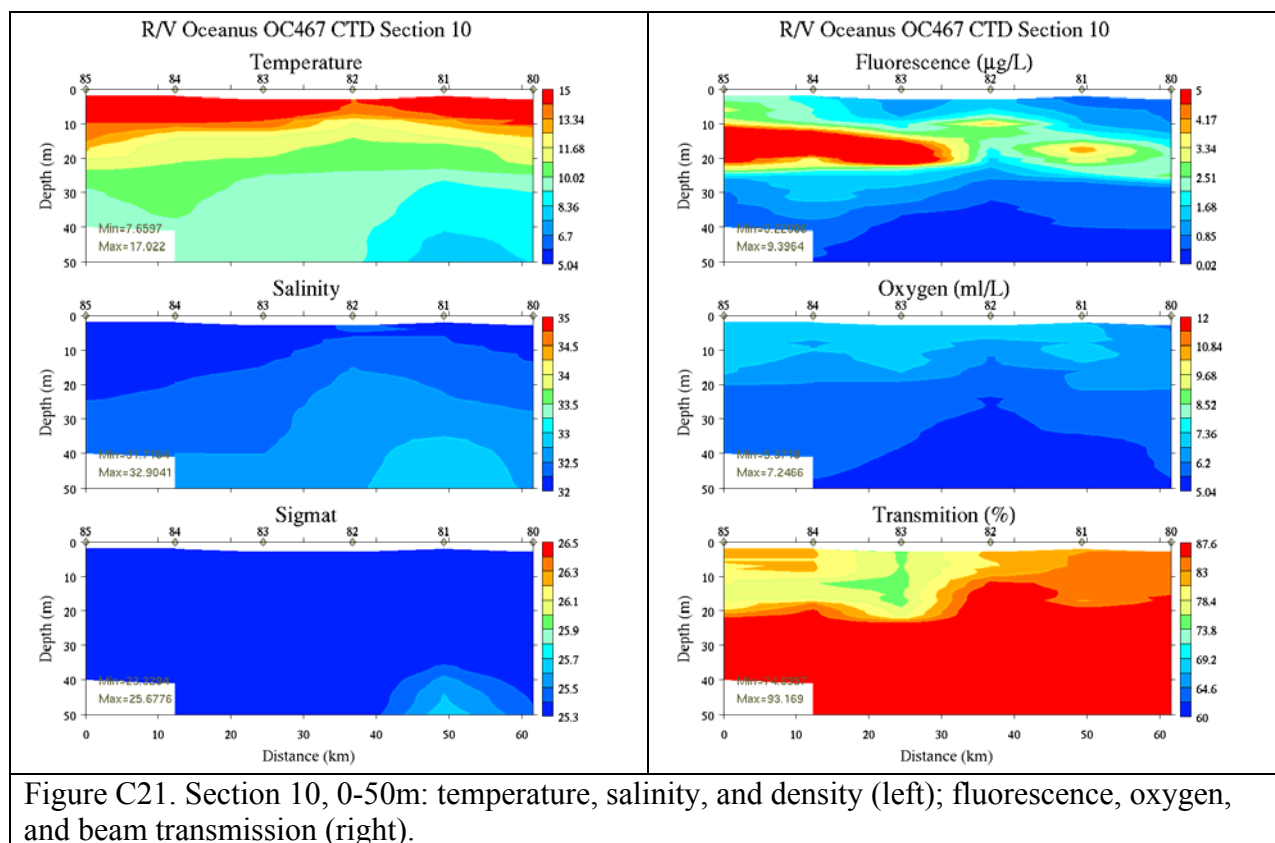


Figure C21. Section 10, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

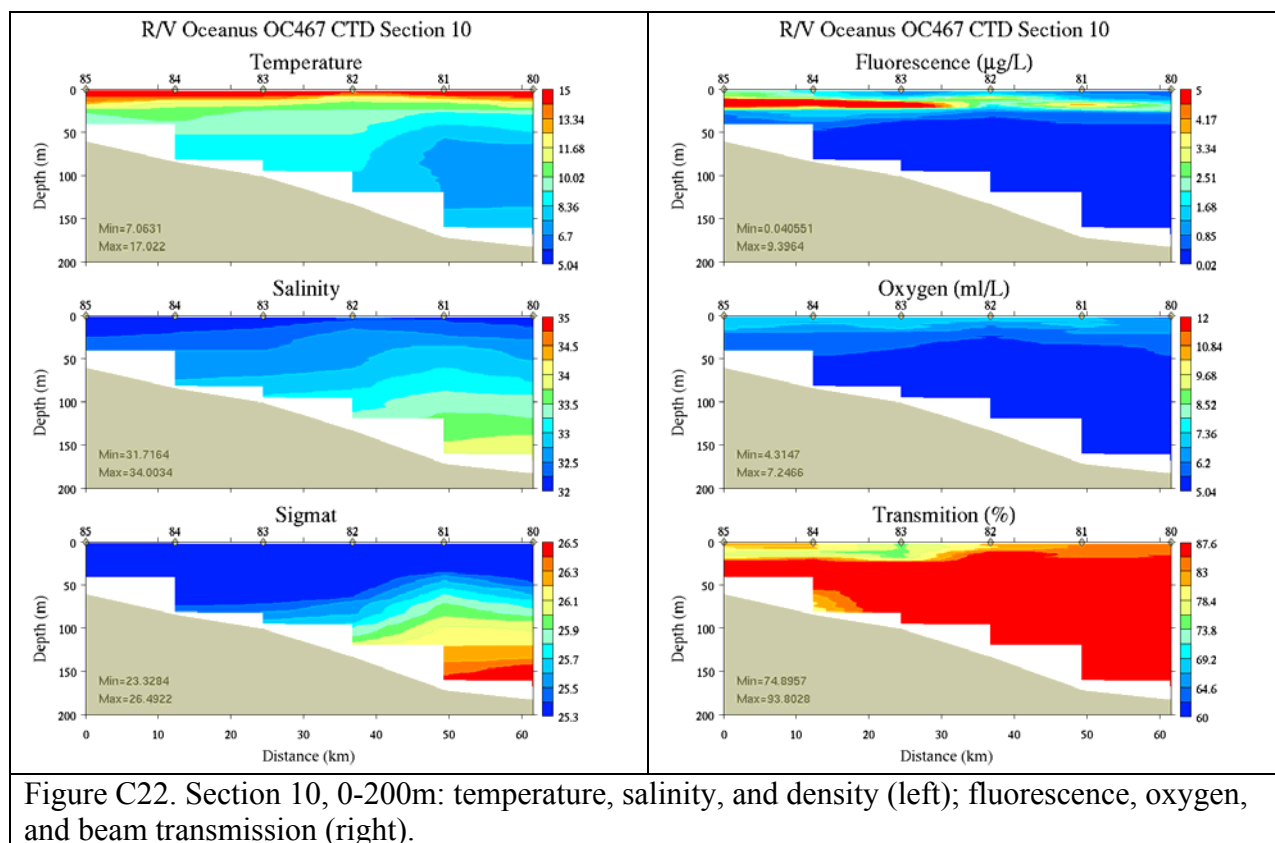
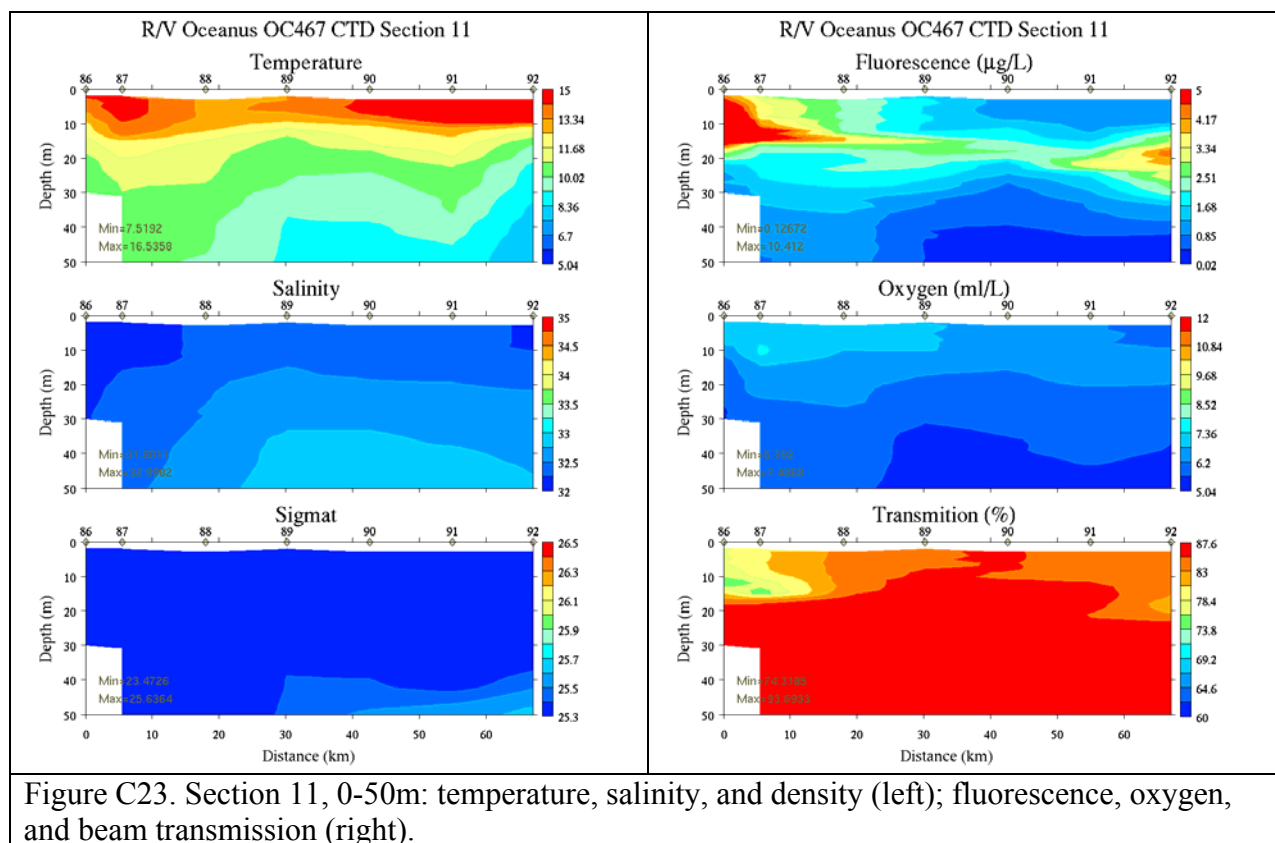
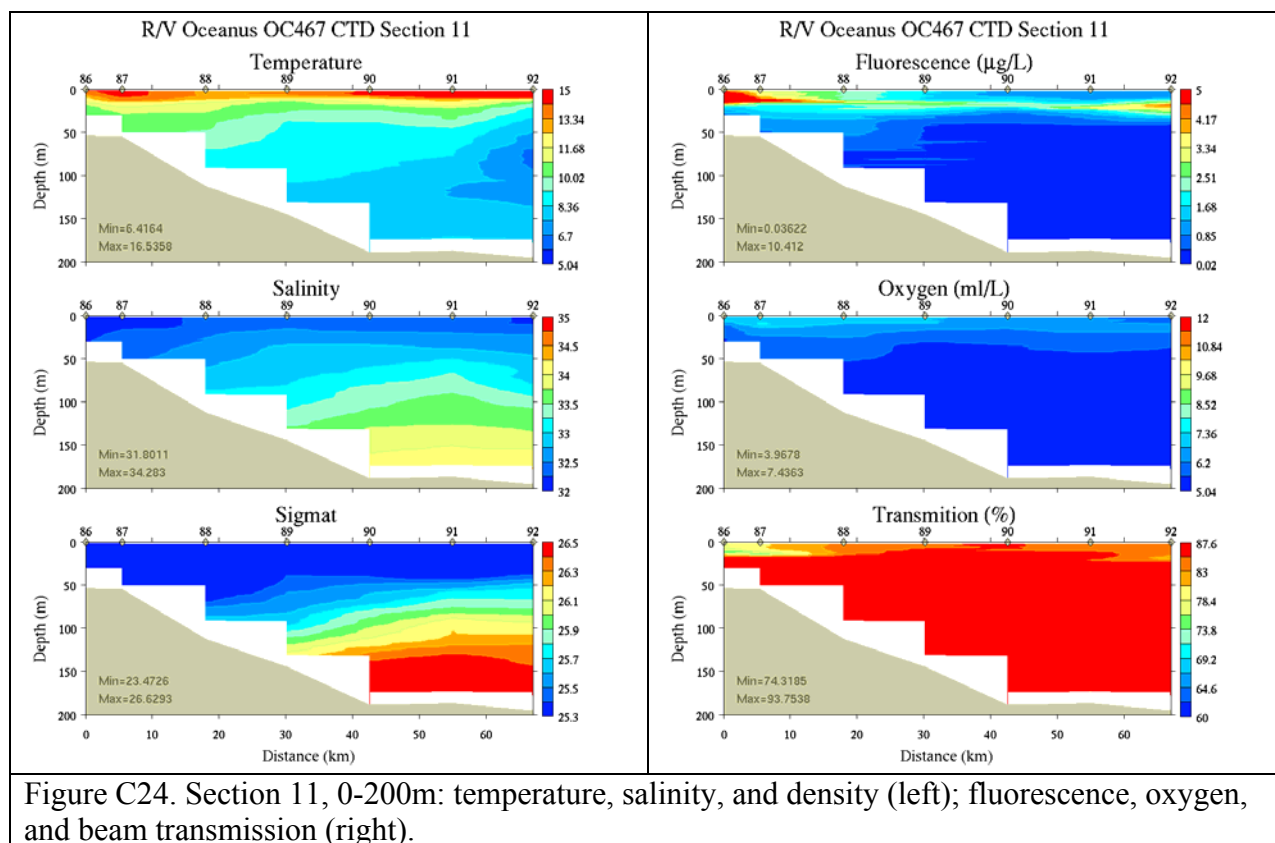
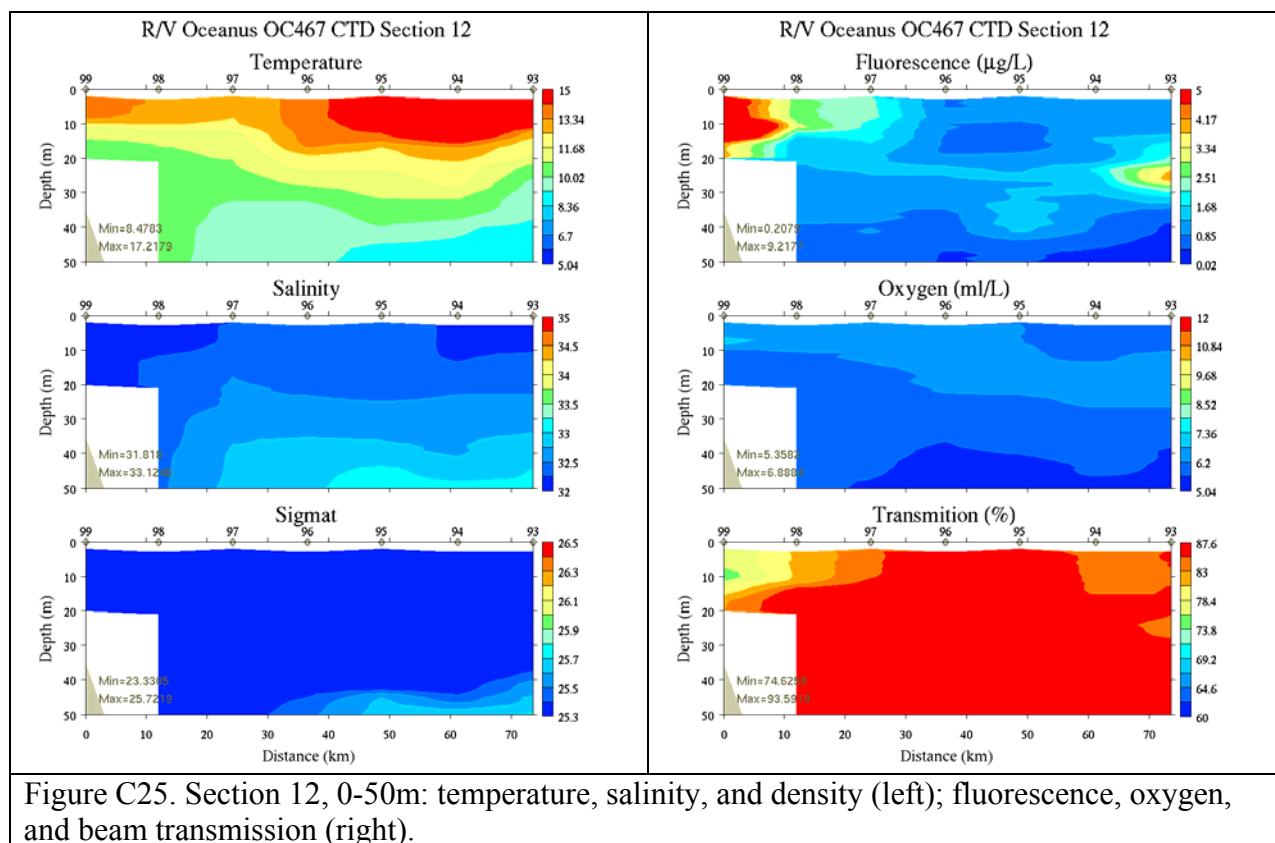
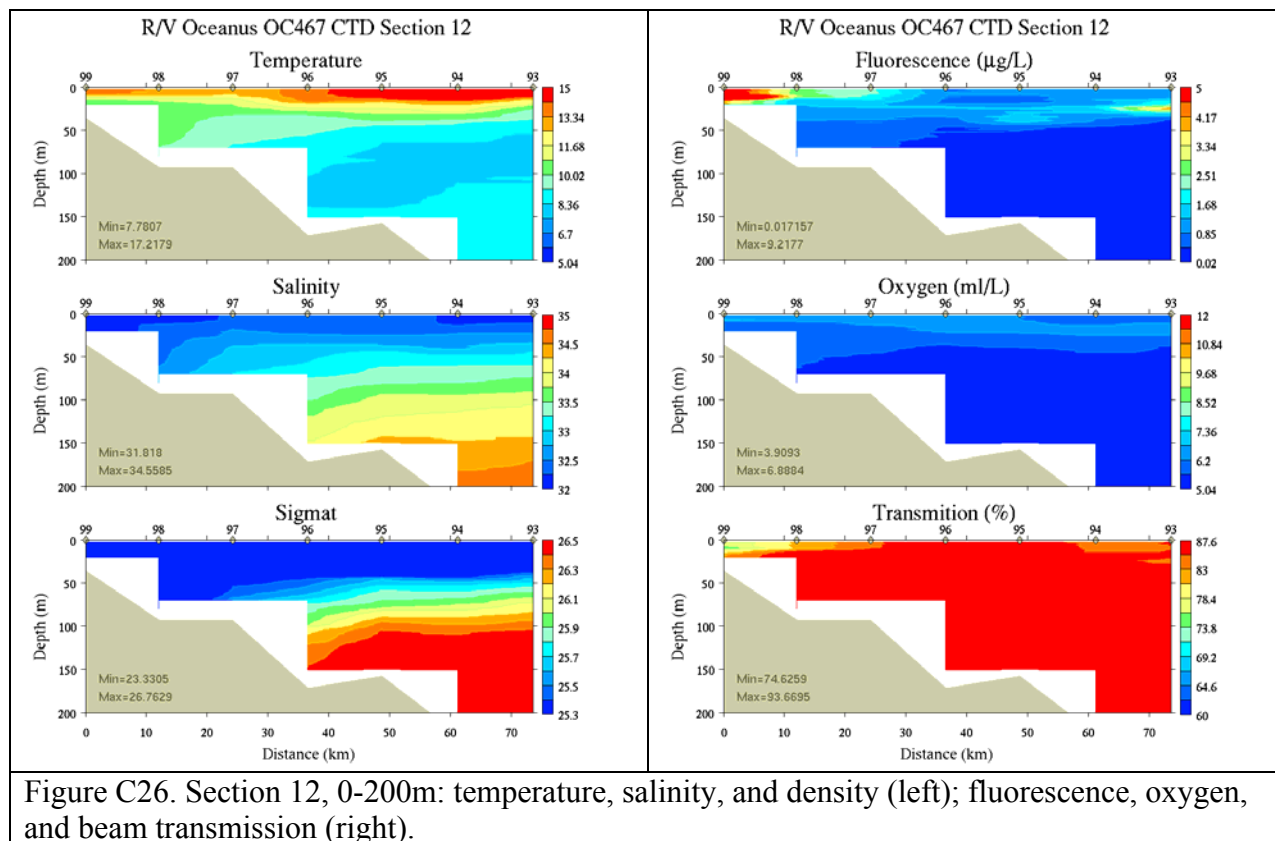


Figure C22. Section 10, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).









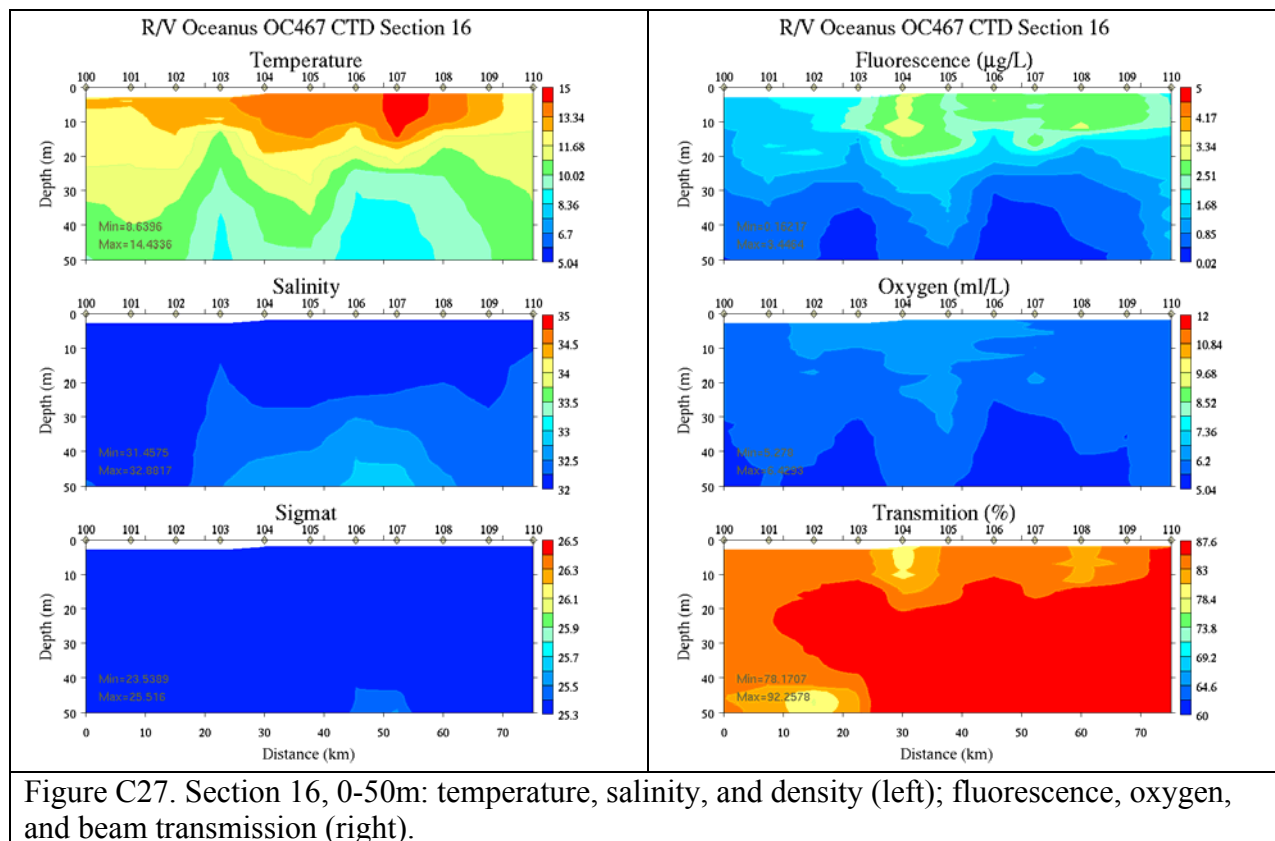


Figure C27. Section 16, 0-50m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

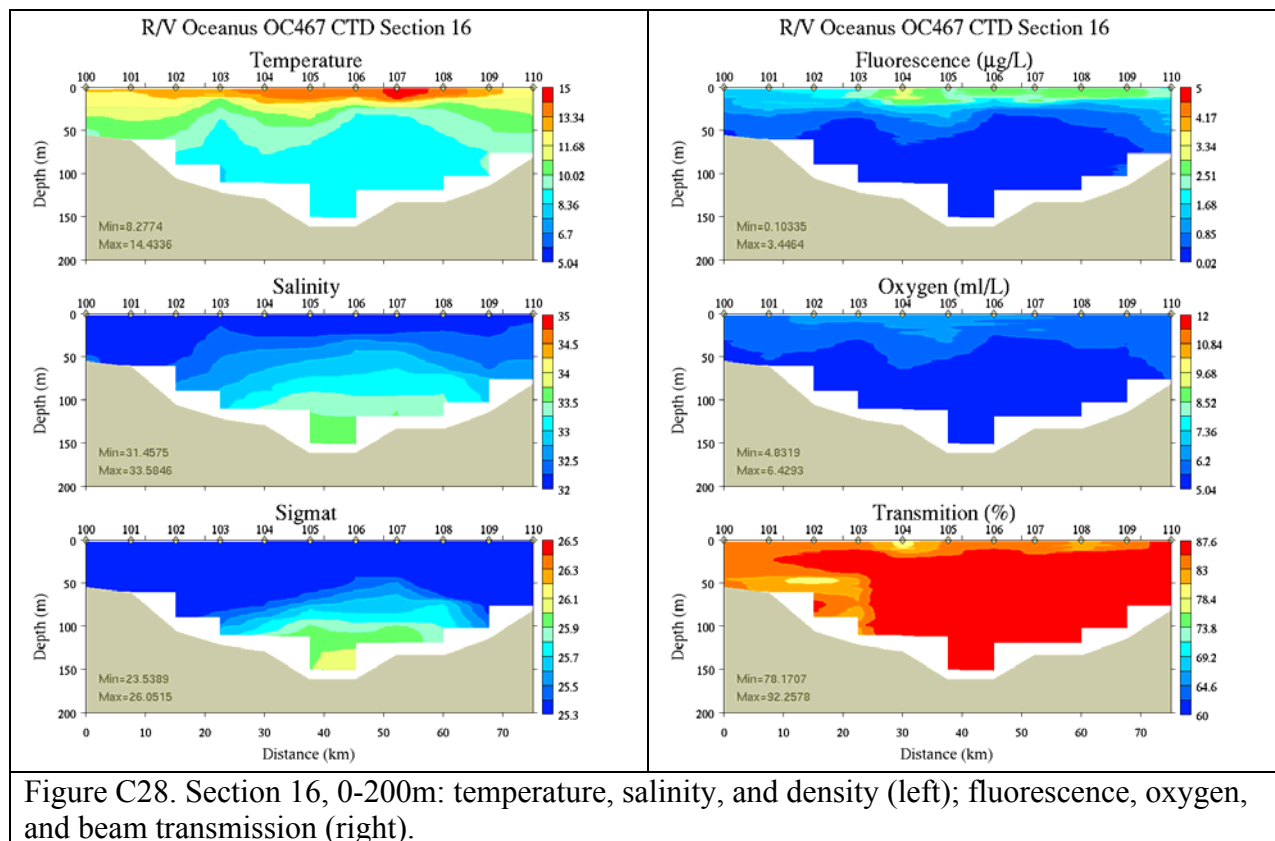
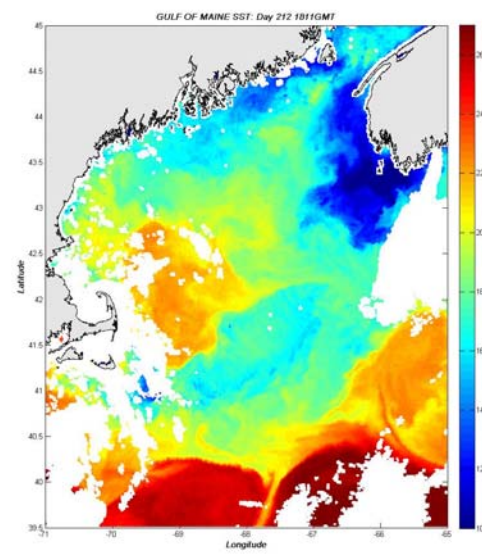
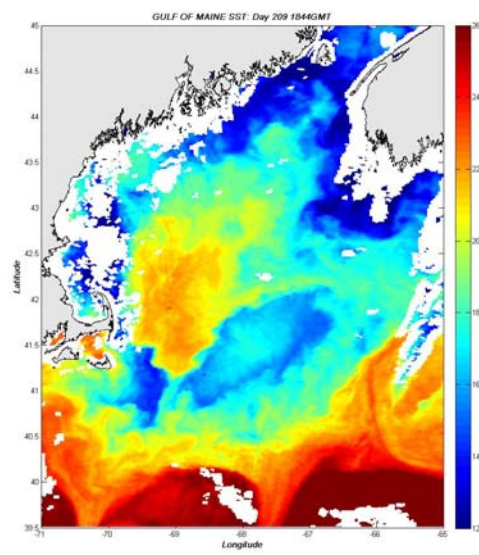
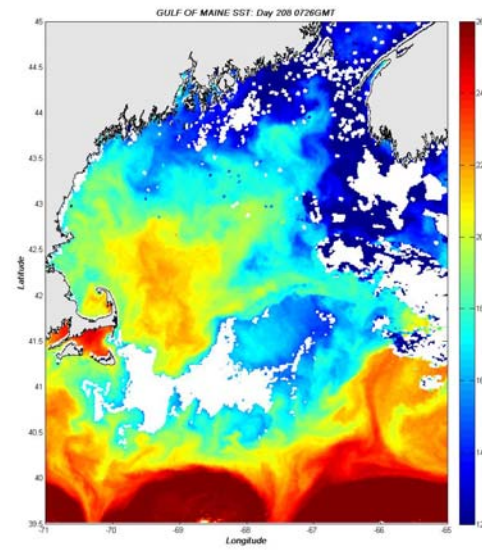
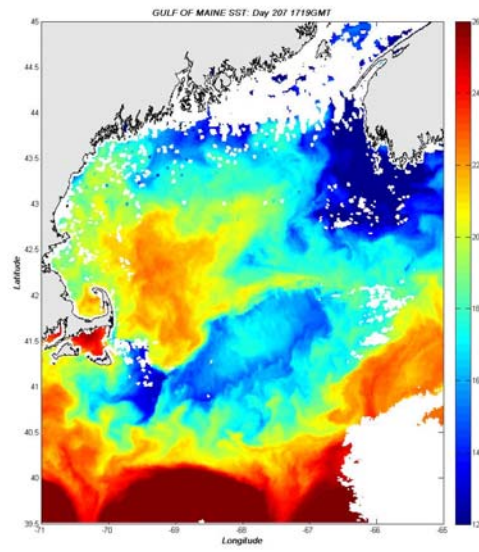
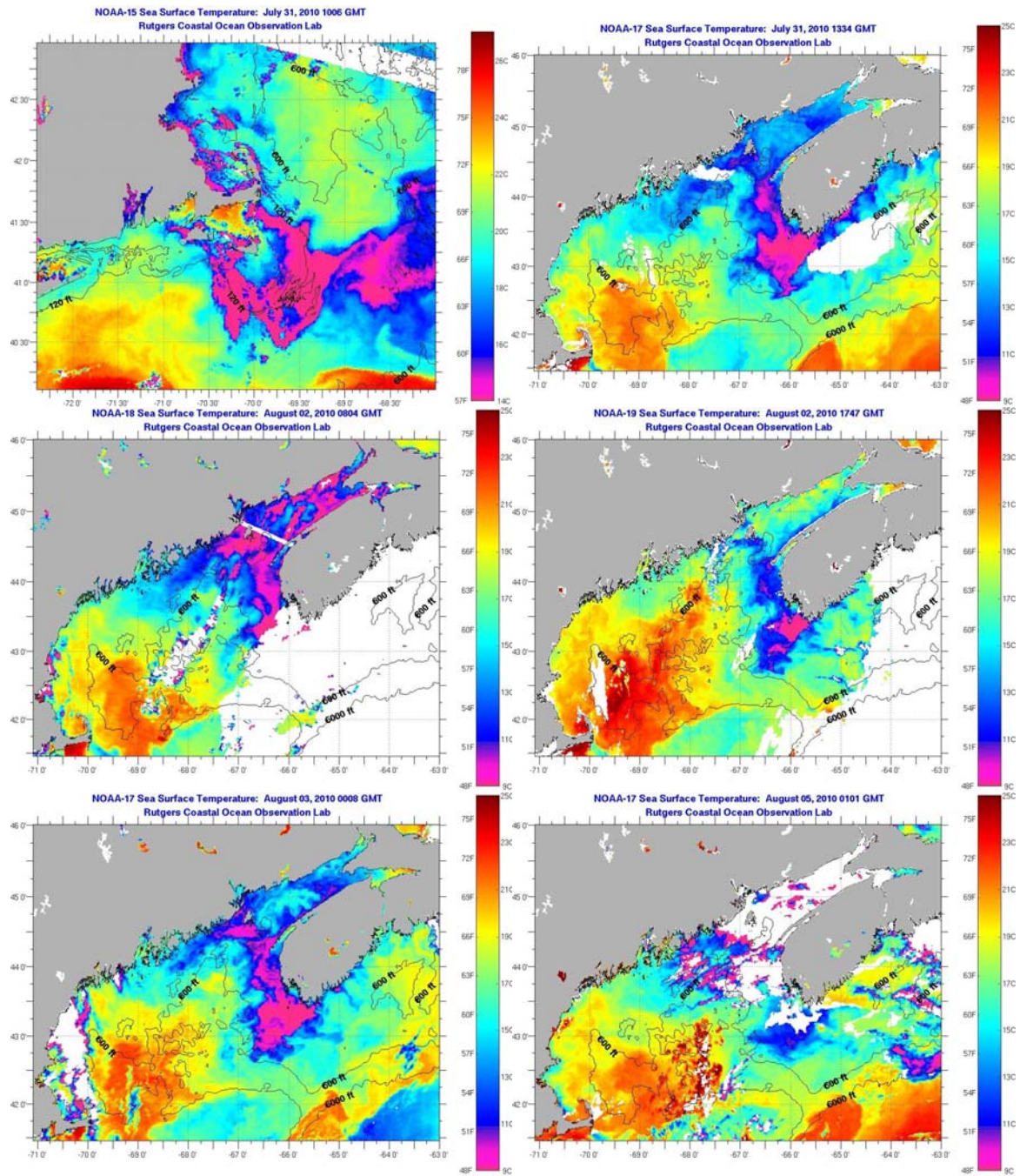
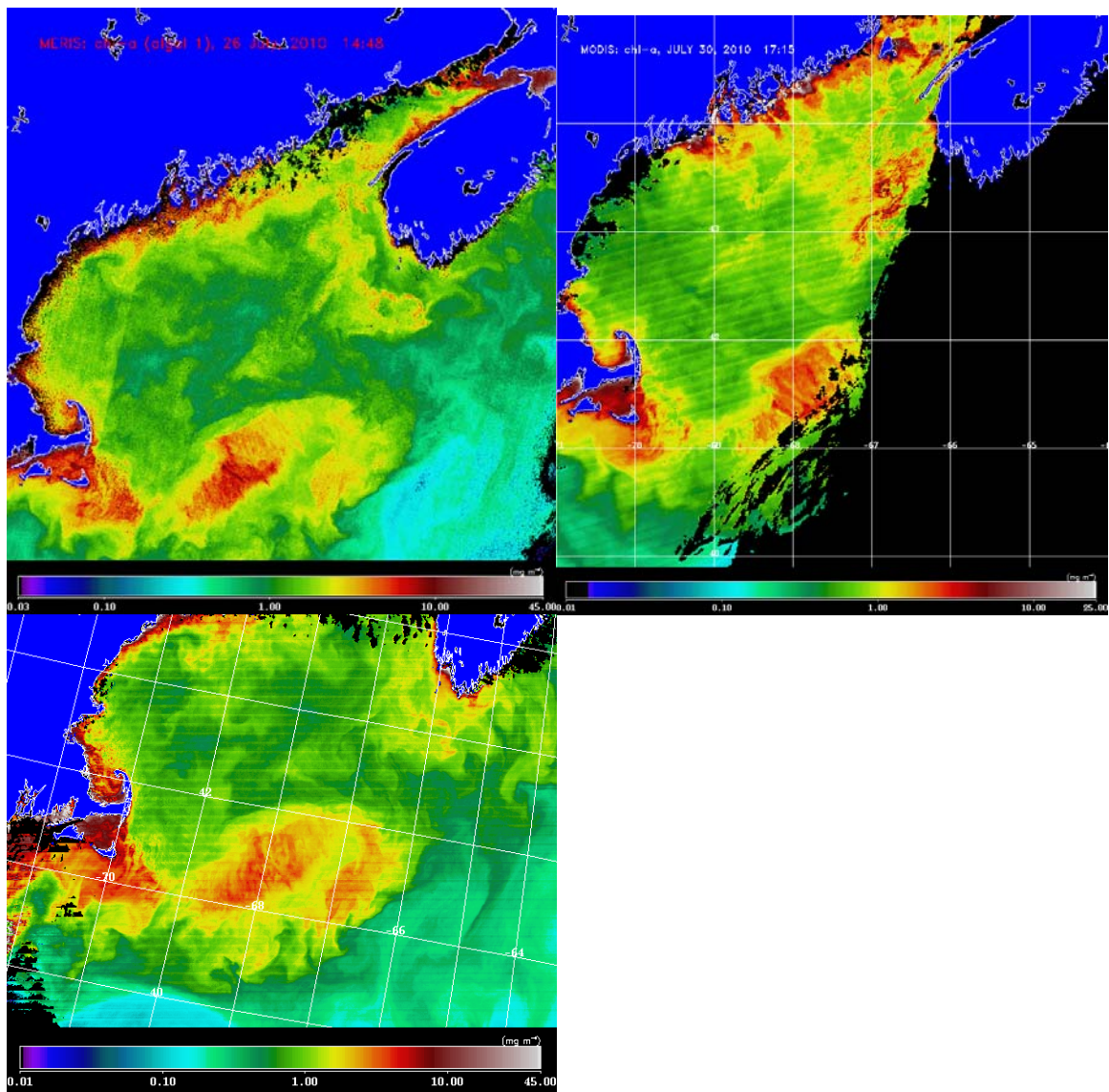


Figure C28. Section 16, 0-200m: temperature, salinity, and density (left); fluorescence, oxygen, and beam transmission (right).

Appendix D: Satellite imagery







Appendix E: CTD Salinity Calibrations

-To be added-

Appendix F: Personnel

McGillicuddy	Dennis	WHOI
Keafer	Bruce	WHOI
Norton	Kerry	WHOI
*Scarlott	Nicholas	NEU
*Meskill	Robert	NEU
Kosnyrev	Olga	WHOI
Smith	Keston	WHOI
Townsend	Dave	UMe
Thomas	Maura	UMe
*Neary	Mark	UMe
Haughwout	MaryLee	NOAA
*Handy	Sara	FDA
*Petitpas	Chrissy	UMassD
*Milligan	Peter	UMassD
Turner	Jeff	UMassD
*Knapp	Stacy	UMe
Karp-Boss	Lee	UMe

*Student/postdoc

Watch number	1	2	3
4 on / 8 off	8-12	12-4	4-8
1. CTD Operator	Mark	Keston	Stacy
2. Cell Counter	Bruce*	Kerry#*	Chrissy*
3. Nutrient sampler	Dave#	Lee	Maura#
4. Water sampler	Olga#	Bob#	Sara
5. Water sampler	MaryLee	Nick	Peter#
6. Water sampler			Jeff

* Wetlab chief

CTD slip line handlers