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ABSTRACT

Hydrographic observations from 8 surveys spanning the Northeast US Continental Shelf are combined into a descriptive overview of the broadscale oceanographic conditions observed during 2014. Temperature and salinity observations are combined into 6 bimonthly time periods to maximize both the spatial coverage of the data and its temporal resolution during the year. Maps of near-surface and near-bottom property distributions are presented for each bimonthly period, and time series of regional average properties are discussed for 5 geographic regions spanning the shelf: western Gulf of Maine, eastern Gulf of Maine, Georges Bank, and northern and southern Middle Atlantic Bight. Overall, 2014 was characterized by continued warming throughout the water column, an increase in the seasonal range of temperature and generally more saline conditions across the region. Deep (slope) waters entering the Gulf of Maine were warmer and saltier than average and their temperature and salinity suggest a subtropical source. Mixed layers in the western Gulf of Maine were anomalously deep during the winter of 2014, presumably a consequence of colder than average air temperatures that persisted over the northeastern United States during winter. The vigorous mixing led to the formation of a thicker layer of cold intermediate water the following spring. Finally, observations reveal a significant intrusion of Gulf Stream water in the Middle Atlantic Bight during late summer. The intrusion encompassed the width of the shelf, leading to profound changes in the water mass distributions. Such episodic events have the potential to cause significant changes in the ecosystem, including changes in nutrient loading on the shelf, the seasonal elimination of critical habitats such as the cold pool and shelf-slope front, disruption of seasonal migration cues, and an increase in the concentration of offshore larval fish on the shelf.

INTRODUCTION

The Northeast Fisheries Science Center (NEFSC) conducts multiple surveys on the Northeast US (NEUS) Continental Shelf each year in support of its ongoing mission to monitor the shelf ecosystem and assess how its components influence the distribution, abundance, and productivity of living marine resources. In support of this mission, the NEFSC's Oceanography Branch provides conductivity, temperature and depth (CTD) instruments to all NEFSC cruises for the measurement of water column profiles of temperature and salinity. In addition to providing oceanographic context to specific field programs, these data contribute to a growing database of historical measurements that are used to monitor seasonal and interannual variability in the water properties on the NEUS Continental Shelf.

In addition to more regionally focused surveys, the NEFSC conducts multiple shelf-wide surveys every year. The broadscale surveys collect hydrographic measurements at hundreds of randomly stratified stations spanning the shelf from Cape Hatteras, North Carolina, through the Gulf of Maine. Typically, the NEFSC completes 6 full-shelf hydrographic surveys per year – the minimum required to resolve the dominant seasonal cycle in this region. However, budget cuts in 2014 led to the elimination of 2 of these 6 surveys and ship maintenance issues led to truncation of the remaining surveys. The result was that roughly half as many stations were occupied this year, comprehensively sampling just 2 of 4 seasons.

Here we present an annual summary of the 2014 observations, including surface and bottom distributions of temperature and salinity and their anomalies computed relative to a consistent reference period. In addition, regional average values of temperature and salinity and their anomalies are computed for five different regions over 6 bimonthly periods. In the Middle Atlantic Bight (MAB), the volume and properties of shelf water are specifically examined. Finally, a summary of basin-scale oceanographic and atmospheric conditions provides context to the *in situ* hydrographic observations.

DATA AND METHODS

The Oceanography Branch provides CTD instrumentation and support to all NEFSC programs requesting this service. Training in instrument maintenance and operation, including deployment, data acquisition, recovery, and preliminary processing, is provided as needed prior to sailing. On NEFSC surveys, CTD instruments are typically deployed in 1 of 2 modes:

(1) During a bongo net tow, a SBE-19+ SEACAT[1] CTD instrument is mounted on the conducting wire above the bongo frame and data are collected as a double oblique profile with the ship steaming at approximately 2 knots. The sensors are not soaked at the surface prior to descent during bongo tows, rendering the upper 30 m or more of the downcast unreliable. For this reason, the upcast profile data are routinely processed as the primary data for each station.

(2) During a non-net cast, either a SBE-19+ SEACAT CTD is mounted vertically on the wire or a SBE-9+ is deployed on a rosette frame with a carousel water sampling

[1] Reference to trade names does not imply endorsement by any collaborating agency or government.

system (SBE32) and up to 11 Niskin water-sampling bottles. In either configuration, the CTD is oriented so that the intake is exposed to new water as it is lowered, so the downcast profiles are routinely processed as the primary data for each station. The CTD sensors are soaked for 1 min at the surface prior to descent to allow for sensor equilibration and for the circulation pump to turn on. In SBE-9+ deployments, water samples are often collected at discrete depths using the Niskin bottles. The water samples are captured on the upcast in order to avoid leakage and sample contamination, which can occur as the pressure increases with depth. Following community protocols, the CTD package is stopped for 30 sec at each sample depth before a bottle is closed in order to allow the package wake to dissipate, the bottles to flush and the surrounding water to equilibrate. The CTD remains stopped for another 10-15 sec after the bottle trip is confirmed to allow time for closure and to collect CTD data for comparison with the water sample data. Water samples are processed ashore for nutrients and carbonate chemistry, described elsewhere.

In 2014, hydrographic data were collected aboard the NOAA ships *Henry B. Bigelow*, *Gordon Gunter* and *Pisces* and the R/V *Hugh R. Sharp* using a combination of Seabird Electronics SBE-19+ SEACAT profilers and SBE 9/11 CTD units (Table 1). All raw CTD profile data were processed ashore, using standard Seabird Electronics software to produce 1-decibar averaged profiles. Water samples were collected twice daily at sea during vertical casts. Following each cruise, these samples were analyzed using a Guildline AutoSal laboratory salinometer to provide quality control for the CTD salinity data. Following manufacturer recommended procedures, a slope correction is calculated based on comparisons between the CTD measured conductivity and salinometer results and is applied to the CTD measured conductivity before conversion to salinity. Vertical density profiles were examined for inversions due to bad conductivity or temperature readings and/or sensor misalignment. Egregious cases were replaced with a flag value. The processed hydrographic data were loaded into ORACLE database tables and made publically available via anonymous ftp (ftp://ftp.nefsc.noaa.gov/pub/hydro). Cruise reports have been prepared for each survey listed in Table 1 and are available online at http://www.nefsc.noaa.gov/epd/oceanography/. Readers are referred to the individual cruise reports for notes, property maps and aggregate data specific to a particular survey.

Here we aim to provide a descriptive overview of the hydrographic sampling that was conducted in 2014 and to characterize the broadscale oceanographic conditions that were observed. The processed CTD data have been sorted into six 2-month time bins to maximize both the spatial coverage of the data and its temporal resolution. Maps of near-surface and near-bottom temperature and salinity have been produced from profile data falling within each bimonthly period. Surface fields include the shallowest observed temperature/salinity at each station that is also in the upper 5 m of the water column, while bottom maps include the deepest observation at each station that also falls within 10 m of the reported water depth. Average values have been computed from the data within five subregions spanning the NEUS Continental Shelf to examine the spatial and temporal variability over broader areas of the shelf (Figure 1). Regional averages have been computed for the bimonthly binned fields (Tables 2 and 3) and for individual cruises (Appendix Tables 1-5).

Anomalies have been calculated at each station relative to a standard reference period (1977-1987) to characterize variability that is not related to seasonal forcing. During this period the NOAA National Marine Fisheries Service (NMFS) Marine Resources Monitoring and Prediction (MARMAP) program repeatedly occupied stations spanning the entire NEUS Continental Shelf so that an annual cycle could be constructed for water properties across all regions of the shelf (Mountain et al. 2004; Mountain and Holzwarth 1989). The anomalies presented here are defined as the difference between the observed 2014 value at individual stations and the expected value for each location and time of year based on this reference period. Similarly, regional anomalies are the area-weighted average of these anomalies within a given domain. The methods used and an explanation of uncertainties is presented in Holzwarth and Mountain (1990).

Finally, we calculate the temperature, salinity and volume of the shelf water in the MAB during 2014 and relate this to the conditions observed during the MARMAP reference period. Following Mountain (2003), the shelf water mass is defined as water within the upper 100 m having salinity less than 34. For each survey in 2014, the area of a subregion was apportioned among its stations by an inverse distance-squared weighting. The shelf water volume at a given station is the thickness of the shelf water at the station multiplied by its apportioned area, and the total shelf water volume within the subregion is the sum of these products for all stations within the region. Similarly, the average temperature and salinity was calculated in the shelf water layer at each station and multiplied by the total shelf water volume for that station. The sum of these products over all stations within a given subregion divided by the total shelf water volume for the region determines the volume-weighted average temperature and salinity. Anomalies in the property and volume of the shelf water mass are calculated relative to like variables derived from MARMAP hydrographic data, as described above. Hence, regional anomalies are computed as the mathematical difference between regional averages, <u>not</u> an average of the anomalies computed for a given subregion.

RESULTS

Hydrographic Conditions in 2014

During 2014, hydrographic data were collected on 8 individual NEFSC cruises, amounting to 1228 profiles of temperature and salinity (Table 1). Despite the bimonthly binning of observations, significant gaps remain in several of the bimonthly periods shown in Figure 2a. This reflects an overall reduction in stations occupied in 2014 relative to previous years (Figure 2b). No sampling occurred during January-February and only limited sampling occurred in July-August, due to truncated vessel schedules in February and cancelation of the August Ecosystem Monitoring (EcoMon) survey. The impact is that critical periods coinciding with the seasonal extremes in ocean temperatures were not sampled. Further, the cancelation of the May EcoMon survey resulted in poor coverage during May-June. Mechanical problems on the NOAA Ship *Henry B. Bigelow* led to lost sea days during the Spring Trawl Survey and truncated coverage in the southern MAB during March-April. Finally, the gap in station coverage in the eastern Gulf of Maine during September-October results from a misalignment between this bimonthly period and the fall bottom trawl survey that began in September, sampling first in the southern MAB. Together, these lost sea days led to a significant reduction in sampling during 2014 with only 2 broadscale surveys sampling the entire shelf and a critical loss of seasonal resolution. The large gaps in station coverage preclude the calculation of a true area-weighted regional average surface/bottom temperature and salinity in several regions (Tables 2 and 3; Figures 3 and 4). These cases are flagged in Tables 2 and 3 and the reader should keep them in mind when interpreting results.

Relative to historical values, regional ocean temperatures across the NEUS shelf were uniformly warm during 2014 (Figure 3). Annually, waters were approximately 1°C warmer than normal everywhere. Of the seasons sampled, warming was most pronounced during late summer/early fall, with regional temperature anomalies exceeding 2°C all the way to the bottom in the MAB. Correspondingly, bottom waters were warm over the entire region, with temperatures exceeding historical values year round in the Gulf of Maine and on Georges Bank (Figure 3).

Annually, surface waters were saltier than normal in 2014, particularly in the MAB. The largest regional salinity anomalies were observed during fall when anomalies exceeded 1 salinity unit in the MAB (Figure 4), coincident with the period of enhanced warming (Figure 3). By comparison, bottom waters were near normal in the Gulf of Maine and saltier than normal on Georges Bank and in the MAB. The total volume of shelf water in the MAB, defined as waters having salinity less than 34, was reduced significantly in 2014 relative to the MARMAP period, particularly in late summer/early fall (Figure 5). This reduction in volume suggests that the shelf/slope front was shifted inshore during this period, a ubiquitous feature that marks the transition between colder/fresher shelf water onshore and warmer/saltier slope water offshore. While the shelf water mass was warmer than normal, reflective of broader regional conditions, its salinity remained near normal during 2014 (Figure 5). This observation suggests that the anomalously salty conditions observed in the MAB are reflective of a different water mass moving into the region, consistent with a significant shoreward movement of the shelf/slope front.

Bimonthly surface and bottom property distribution maps reveal details related to the regional averages in Figures 3 and 4, although temporal continuity suffers from reduced sampling (Figures 6-9). While regionally surface waters were generally warm in winter/spring and summer/fall, warming was strongest during September-October along the shelf edge at the surface, and near shore and over shallow banks at the bottom (Figure 8b). By November/December this widespread warming observed at the surface had abated, but enhanced warming persisted at the bottom along the mid-shelf in the northern MAB (Figure 9b). Similarly, large regional salinity anomalies observed in the MAB during September/October (Figure 4) are reflective of a swath of positive anomalies extending from the shelf edge toward shore between Cape Cod MA and Cape Hatteras NC (Figure 8b). During this period, nearshore waters just offshore of Long Island NY were more than 1.5 salinity units saltier than normal.

The extreme temperature and salinity anomalies observed during summer and fall were presumably caused by a procession of Gulf Stream warm core rings, whose interaction with the topography at the shelf break drove an incursion of Gulf Stream water onto the inner shelf between spring and fall of this year (e.g., Zhang et al. 2015). The conditions are indicative of a significant intrusion that inundated the shelf with the largest anomalies occurring at the surface, ultimately moving the 34 isohaline, typically aligned with the shelf slope front, 100 km inshore of its climatological position and rendering the shelf slope front unidentifiable in a composite cross-shelf section (Figure 10a). Salinity over the mid-shelf was more than 5 standard deviations higher than the long-term mean, while temperature was more than 2 standard deviations higher (Figure 10b). Anomalies were largest over the Cold Pool (a seasonal bottom-trapped feature formed when winter-cooled shelf water is isolated from the surface by summer heating), which was virtually eliminated by the inundation event (Figure 10). Beginning in October, the Cold Pool typically breaks down with the onset of vertical mixing induced by fall cooling and storm activity. In this process, warm surface waters are mixed down, gradually warming the pool of colder winter water at the bottom. In 2014, both the Cold Pool and overlying waters were much warmer than normal, so it is not surprising that warm anomalies persisted at the bottom in November/December when this erosion process would be taking place (Figure 9b).

The influence of Gulf Stream meanders and warm core rings was also episodically observed in the Northeast Channel during fall (Figure 11-13), while outside of these periods Warm Slope Waters dominated the deep inflow to the Gulf of Maine (Figure 11). Springtime temperature-salinity profiles indicate the presence of a thicker Cold Intermediate Layer in the western Gulf of Maine in spring 2014. This layer is a mid-depth water mass characterized by its temperature minimum, formed seasonally as a product of convective mixing driven by winter cooling (Figure 13). A thicker Cold Intermediate Layer suggests that robust convective mixing took place in the preceding winter leading to deep mixed layers. Correspondingly, winter mixed layers during 2014 were 4 times as deep and 2°C colder than those observed in 2012 (Figure 14). The differences are understandable, considering winter air temperatures over the NEUS were more than 3°C colder in 2014 compared with 2012 (Figure 15). Cold/dry winds blowing off the continental land mass will lead to more efficient evaporative cooling in the western Gulf of Maine and deeper convective mixing. In general, deeper vertical mixing has greater potential to tap into nutrient rich slope water at depth, while the thicker intermediate layer that results creates a larger reservoir for trapping sinking biologically fixed carbon and nitrogen. Together these processes play an important role in nutrient dynamics in the Gulf of Maine, with the potential to influence primary production in the region.

Basin-Scale Conditions in 2014

During 2014, surface air temperatures were generally colder than average (1981-2010) over the North American continent and central North Atlantic, particularly in winter and spring. Conversely, air temperatures were warmer than average over the NEUS Continental Shelf, with enhanced anomalies in summer and fall suggesting a larger seasonal range (Figure 16). Sea surface temperature (SST) mirrored these patterns, with cooler than average SST in the central basin, warmer than average SST along the NEUS shelf year round and enhanced warming over the NEUS shelf in summer and fall (Figure 17). On average, the magnitude of the surface warming was comparable to that observed in the 1950s but, unlike the 1950s, 2014 was characterized by an increased seasonal range with enhanced warming in summer and fall (Figure 18). This observation is consistent with Friedland and Hare (2007), who demonstrated that the difference between the summer maximum SST and the winter minimum SST on the NEUS shelf has been increasing since 1980.

It has been suggested that an index measuring the atmospheric sea level pressure difference between Iceland and the Azores is a reliable indicator of atmospheric conditions and oceanic response in the North Atlantic. The so-called North Atlantic Oscillation (NAO) has been related (with lags) to the intensity, frequency, and pathway of storms crossing the North Atlantic; the intensity of westerly winds; the depth of convection and amount of sea ice in the Labrador Basin; the temperature and salinity of waters on the Canadian and US continental shelves; and the position of the north wall of the Gulf Stream (e.g., Visbeck et al. 2003; Petrie 2007). The NAO index was positive during the winter of 2014, indicative of a deepening of the Icelandic low and a strengthening of the Azores high (Figure 19). A positive NAO is typically associated with stronger northwesterly winds over the shelves, warmer bottom waters in the Gulf of Maine, a northward shift in the Gulf Stream, and a predominance of Warm Slope Water in the Northeast Channel (Petrie 2007; Mountain 2012; Joyce et al. 2000). Distinct from earlier periods (prior to 2000), the index continues to fluctuate on shorter time scales, remaining in one phase for no more than 1-2 years; this undoubtedly complicates the response in the ocean, particularly for those processes that involve the propagation of anomalies or adjustments over multiple years.

SUMMARY

- Despite anomalously cold winter air temperatures over the NEUS, ocean temperatures continue to be anomalously warm and more saline at the surface and bottom.
- Cold and dry winter air temperatures over the NEUS contributed to deeper mixed layers and a well-developed thicker cold intermediate layer in the western Gulf of Maine.
- Observations indicate that the seasonal range in ocean temperatures on the NEUS shelf is increasing, mirroring the seasonal trends in air temperatures over the region, with greater warming occurring in spring and fall.
- An intrusion of Gulf Stream water in the MAB during late summer/early fall led to extreme changes in the water mass distributions on the shelf, including the elimination of the Cold Pool and disruption of the shelf slope front.
- Slope waters entering the Gulf of Maine through the Northeast Channel were anomalously warm and salty, consistent with the properties characteristic of warm slope water derived from subtropical origins.

REFERENCES CITED

Armi L, Bray NA. 1982. A standard analytic curve of potential temperature versus salinity for the Western North Atlantic. J Phys Oceanogr. 12: 384-387.

Friedland K, Hare, J. 2007. Long-term trends and regime shifts in sea surface temperature on the continental shelf of the northeast United States. Continent Shelf Res. 27, 2313-2328.

Holzwarth TJ, Mountain DG. 1990. Surface and bottom temperature distributions from the Northeast Fisheries Center spring and fall bottom trawl survey program, 1963-1987. Northeast Fish Sci Cent Ref Doc. 90-03; 62 p.

Hurrell JW. 1995. Decadal trends in the North Atlantic Oscillation and relationships to regional temperature and precipitation. Science. 269: 676-679.

Joyce TM, Deser C, Spall MA. 2000. The relationship between decadal variability of Subtropical Mode Water and the North Atlantic Oscillation. J Climate. 13: 2550-2569.

Mountain DG, Holzwarth TJ. 1989. Surface and bottom temperature distribution for the Northeast Continental Shelf. NOAA Tech Memo NMFS-F/NEC-73; 55 p.

Mountain DG. 2003. Variability in the properties of Shelf Water in the Middle Atlantic Bight, 1977-1999. J Geophys Res. 108: 3014; doi:10.1029/2001JC001044, (14-)1-11.

Mountain DG, Taylor MH, Bascuñán C. 2004. Revised procedures for calculating regional average water properties for Northeast Fisheries Science Center cruises. Northeast Fish Sci Cent Ref Doc. 04-08; 53 p.

Mountain DM. 2012. Labrador slope water entering the Gulf of Maine – Response to the North Atlantic Oscillation. Continent Shelf Res. 47: 150-155.

Northeast Regional Climate Center. Seasonal climate summary tables. Cornell University [cited 2014 June 23]. Available at: http://www.nrcc.cornell.edu/.

Petrie B. 2007. Does the North Atlantic Oscillation affect hydrographic properties on the Canadian Atlantic Continental Shelf? Atmos-Ocean. 45: 141-151.

Taylor MH, Mountain DG. 2009. The influence of surface layer salinity on wintertime convection in Wilkinson Basin, Gulf of Maine. Continent Shelf Res. 29, 433-444.

Visbeck M, Chassignet EP, Curry R, Delworth T, Dickson B, Krahmann G. 2003. The oceans's response to North Atlantic Osciallation variability. In: Hurrell J, Kushner Y, Ottersen G, Visbeck M, editors. The North Atlantic Oscillation: Climatic Significance and Environmental Impact. Washington [DC]: American Geophysical Union, Geophys Mono. 134; p 113-145.

Zhang WG, Gawarkiewicz GG. 2015. A direct intrusion of Gulf Stream water onto the Mid-Atlantic Bight Continental Shelf. Submitted to Nature Geoscience.

Table 1. Listing of 2014 NOAA Northeast Fisheries Science Center cruises supported by the Oceanography Branch, where EcoMon refers to Ecosystem Monitoring Surveys and AMAPPS refers to the Atlantic Marine Assessment Program for Protected Species.

Cruise	Program	Dates	Region(s)[1]	Gear	Casts
GU1401	EcoMon	1 - 8 Mar	GB, GOM	SBE-19+V2,SBE-911+	73
GU1402	AMAPPS	11 Mar - 26 Apr	MAB, Offshore	SBE-19+,SBE-19+V2,SBE-911+	193
HB1401	Spring Bottom Trawl	2 Apr - 31 May	MAB,GB,GOM	SBE-19+V2	297
S11401	Scallop Survey	1 - 24 Jul	GB	SBE-911+	70
HB1403	AMAPPS	25 - 30 July	MABN,Offshore	SBE-19+,SBE-911+	15
S11402	N. Right Whale	4 - 15 Sep	GOMW, GB, Offshore	SBE-19+,SBE-911+	32
HB1405	Fall Bottom Trawl	10 Sep - 13 Nov	Full Shelf	SBE-19+V2,SBE-911+	371
PC1405	EcoMon	3 - 18 Nov	Full Shelf	SBE-19+V2,SBE-911+	177

[1] Regional Abbreviation:
GOM=Gulf of Maine
GB=Georges Bank
MAB=Mid Atlantic Bight

Table 2. Regional average surface and bottom temperature values computed from CTD data that were sorted into six 2-month time periods for the 5 regions of the Northeast US Continental: Gulf of Maine east (GOME); Gulf of Maine west (GOMW); Georges Bank (GB); Middle Atlantic Bight north (MABN); and Middle Atlantic Bight south (MABS).

		SURFACE						BOTTOM					
Region	CD	#obs	Temp	Anomaly	SDV1	SDV2	Flag	#obs	Temp	Anomaly	SDV1	SDV2	Flag
							January-February						
GOME													
GOMW													
GB													
MABN													
MABS													
							March-April						
GOME	64	16	4.13	0.31	0.25	0.79	0	14	7.57	0.43	0.44	1.52	0
GOMW	72	17	4.61	0.15	0.25	0.50	0	11	5.60	0.76	0.28	0.93	0
GB	77	52	5.85	0.81	0.21	1.25	0	43	6.02	0.56	0.18	1.04	0
MABN	99	103	5.76	0.45	0.17	0.83	0	100	5.64	-0.19	0.19	1.29	0
MABS	90	124	7.63	0.32	0.17	1.39	0	113	7.51	0.21	0.22	0.68	0
							May-June						
GOME	135	38	7.17	0.32	0.15	0.58	0	35	7.83	0.56	0.19	0.87	0
GOMW	141	48	9.02	0.47	0.15	0.94	0	47	5.63	0.43	0.13	0.57	0
GB	130	45	7.80	0.57	0.21	1.52	0	44	7.82	1.04	0.21	1.10	0
MABN													
MABS													
							July-August						
GOME	200	5	16.99	3.01	0.81	1.93	1	5	8.40	-1.02	0.82	2.82	1
GOMW	200	6	15.10	0.04	1.06	0.40	1	8	8.47	1.58	1.03	1.53	1
GB	195	41	14.86	0.49	0.25	1.38	0	39	11.38	1.61	0.25	1.39	0
MABN	198	5	15.90	-0.10	1.61	1.65	1	5	11.48	3.29	2.03	0.99	1
MABS	183	5	23.66	2.33	1.56	0.71	1	4	8.18	1.11	1.71	2.67	1
							September-October						
GOME	287	11	15.67	2.37	0.86	0.59	1	9	9.64	0.69	0.86	2.03	1
GOMW	286	33	15.24	2.37	0.19	0.86	0	25	7.30	0.74	0.17	0.71	0
GB	283	69	16.82	1.68	0.18	1.30	0	66	14.05	1.85	0.17	1.25	0
MABN	273	46	20.17	2.24	0.25	1.44	0	47	15.14	2.20	0.28	1.46	0
MABS	263	106	22.89	1.36	0.18	1.11	0	105	16.69	2.81	0.22	2.39	0
							November-December						
GOME	312	46	12.35	1.50	0.14	0.86	0	45	9.81	1.48	0.18	1.00	0
GOMW	313	48	11.49	1.23	0.18	0.49	0	48	9.07	1.76	0.15	1.13	0
GB	310	37	13.86	0.64	0.24	1.37	0	37	13.05	0.81	0.23	1.16	0
MABN	317	19	14.17	0.52	0.38	0.91	0	19	14.55	1.70	0.46	1.50	0
MABS	320	37	15.36	1.05	0.30	0.68	0	43	15.24	1.39	0.34	1.32	0

"Region", the geographic region of the northeast continental shelf: "CD", the calendar mid-date of all the stations within a region for a time period: "#obs", the number of observations included in each average: "Temp", the areal average temperature: "Anomaly", the areal average temperature anomalies: "SDV1",the standard deviation associated with the average temperature anomaly: "SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived: "Flag", a value of "1" indicates that a true areal average could not be calculated due to poor station coverage. The areal averages listed were derived from a simple average of the observations within the region.

Table 3. Regional average surface and bottom salinity values computed from CTD data that were sorted into six 2-month time periods for the five regions of the Northeast US Continental Shelf: Gulf of Maine east (GOME); Gulf of Maine west (GOMW); Georges Bank (GB); Middle Atlantic Bight north (MABN); and Middle Atlantic Bight south (MABS).

		SURFACE						BOTTOM					
Region	CD	#obs	Salt	Anomaly	SDV1	SDV2	Flag	#obs	Salt	Anomaly	SDV1	SDV2	Flag
							January-February						
GOME													
GOMW													
GB													
MABN													
MABS													
							March-April						
GOME	64	16	32.55	-0.02	0.14	0.38	0	14	34.04	-0.03	0.13	0.62	0
GOMW	72	17	32.96	0.09	0.11	0.23	0	11	33.36	0.00	0.08	0.24	0
GB	77	52	33.17	0.17	0.07	0.47	0	43	33.41	0.15	0.06	0.36	0
MABN	99	102	32.78	0.05	0.08	0.32	0	100	33.22	-0.15	0.07	0.40	0
MABS	90	124	33.79	0.65	0.10	0.53	0	113	34.03	0.20	0.08	0.34	0
							May-June						
GOME	135	38	32.55	0.13	0.08	0.22	0	35	34.11	-0.03	0.04	0.29	0
GOMW	141	48	32.38	0.11	0.06	0.37	0	47	33.25	-0.10	0.04	0.20	0
GB	130	45	33.02	0.10	0.07	0.59	0	44	33.56	0.27	0.07	0.35	0
MABN													
MABS													
							July-August						
GOME	200	5	32.34	-0.16	0.33	0.17	1	5	33.05	0.19	0.30	0.24	1
GOMW	200	6	32.56	0.44	0.35	0.56	1	8	32.83	0.01	0.32	0.26	1
GB	195	40	32.92	0.15	0.08	0.40	0	39	33.35	0.39	0.08	0.46	0
MABN	198	5	32.20	-0.44	0.48	0.17	1	5	33.77	0.55	0.72	0.64	1
MABS	183	3	31.66	-0.41	0.76	0.65	1	4	33.49	0.43	0.60	0.74	1
							September-October						
GOME	287	11	32.79	0.21	0.36	0.26	1	9	34.14	0.25	0.26	0.17	1
GOMW	286	33	32.35	-0.08	0.08	0.21	0	25	33.87	0.10	0.05	0.27	0
GB	283	69	33.08	0.28	0.06	0.53	0	66	33.59	0.21	0.06	0.32	0
MABN	273	46	33.92	1.22	0.11	0.81	0	47	33.93	0.33	0.09	0.52	0
MABS	263	106	33.15	0.81	0.10	1.13	0	105	33.51	-0.20	0.08	0.68	0
							November-December						
GOME	312	46	33.08	0.40	0.07	0.38	0	45	34.74	0.30	0.05	0.38	0
GOMW	313	48	33.05	0.36	0.07	0.27	0	48	33.63	0.15	0.05	0.28	0
GB	310	37	32.98	0.14	0.08	0.47	0	37	33.38	0.16	0.08	0.33	0
MABN	317	19	33.21	0.14	0.16	0.59	0	19	34.20	0.45	0.15	0.56	0
MABS	320	37	33.84	0.76	0.16	0.41	0	43	34.17	0.60	0.12	0.48	0

"Region", the geographic region of the northeast continental shelf: "CD", the calendar mid-date of all the stations within a region for a time period: "#obs", the number of observations included in each average: "Salt", the areal average salinity: "Anomaly", the areal average salinity anomalies: "SDV1",the standard deviation associated with the average salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
"Flag", a value of "1" indicates that a true areal average could not be calculated due to poor station coverage. The areal averages listed were derived from a simple average of the observations within the region.

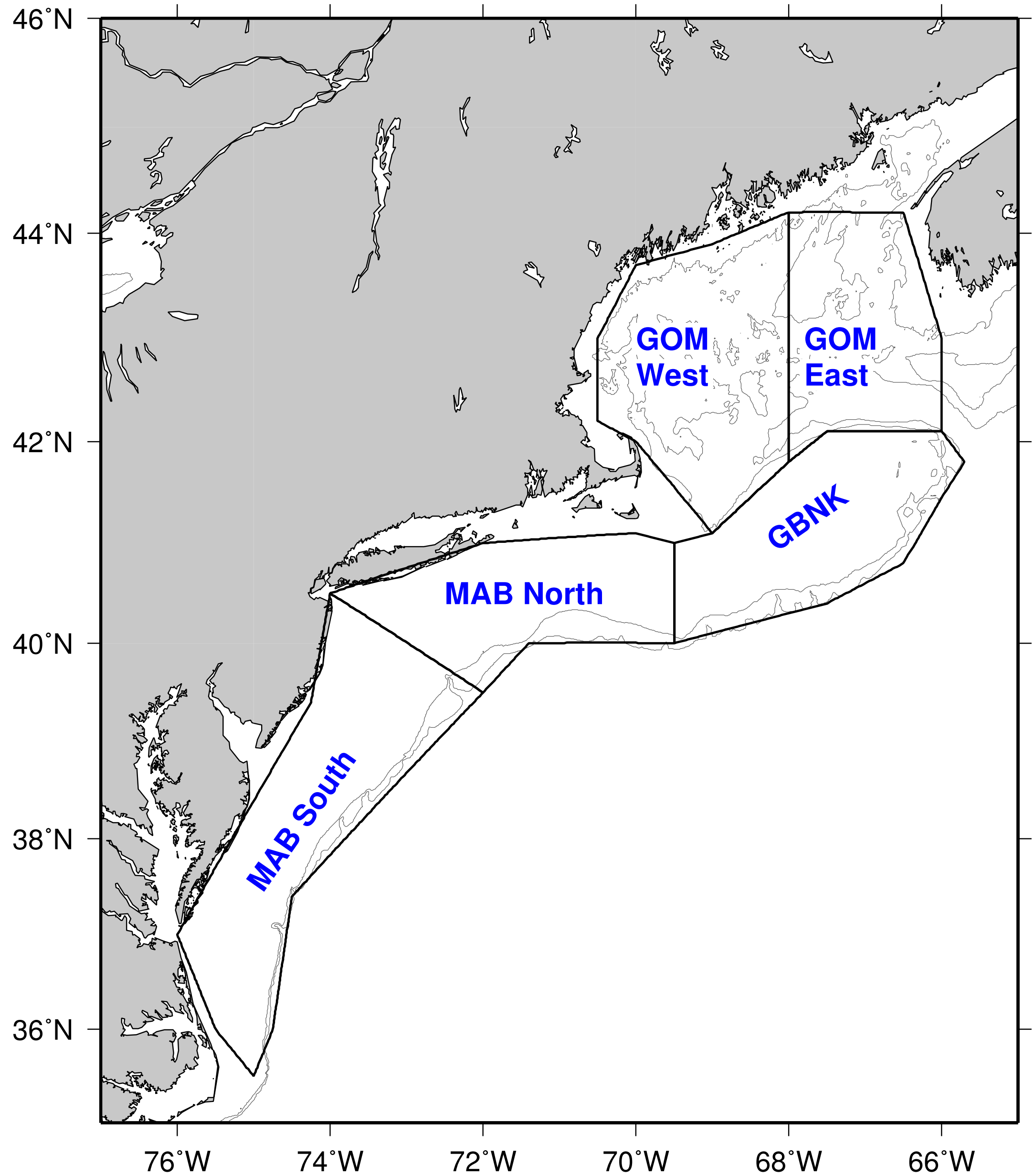

Figure 1. Regional designations used in the description of 2014 oceanographic conditions on the Northeast US Continental Shelf. The 100 m and 200 m isobaths are also shown. MAB = Middle Atlantic Bight; GBNK = Georges Bank; GOM = Gulf of Maine.

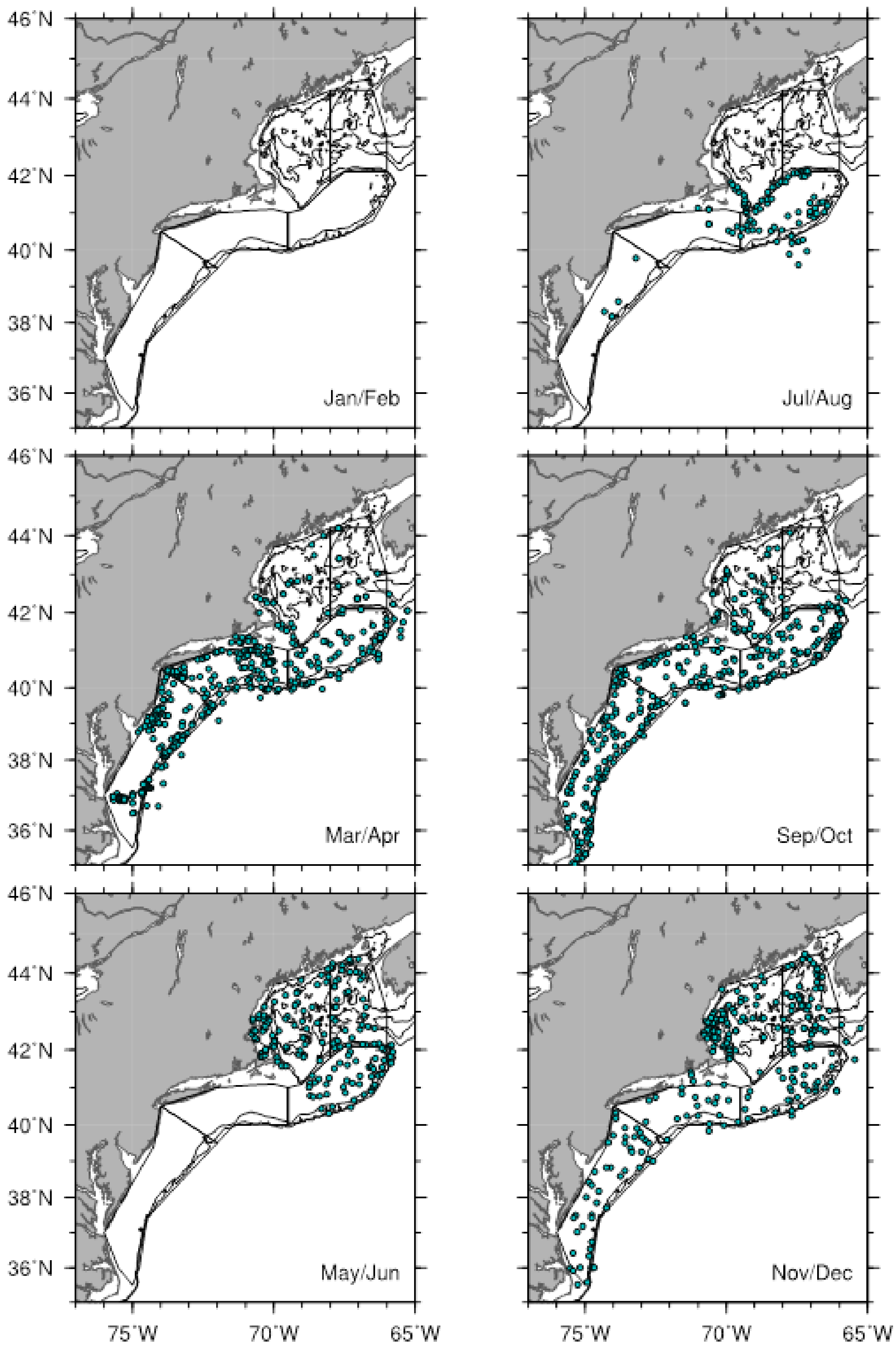

Figure 2a. Bimonthly distribution of hydrographic stations used in the description of 2014 oceanographic conditions on the Northeast US Continental Shelf. Regional boundaries used in the analysis are also shown. Contours correspond with the 100- and 200-m isobaths.

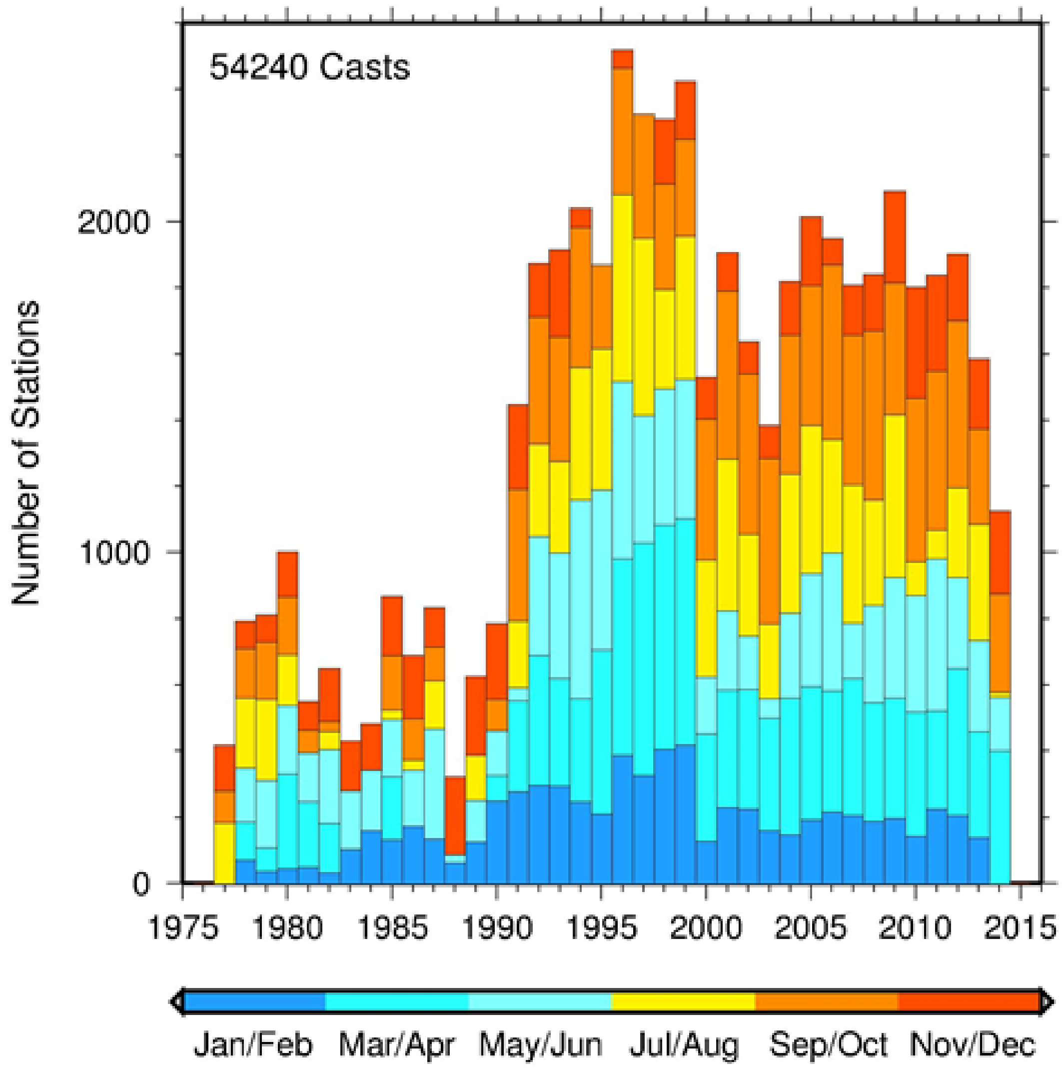

Figure 2b. Histogram of the number of hydrographic stations occupied on Northeast Fisheries Science Center surveys in a given year, color-coded by bimonthly period.

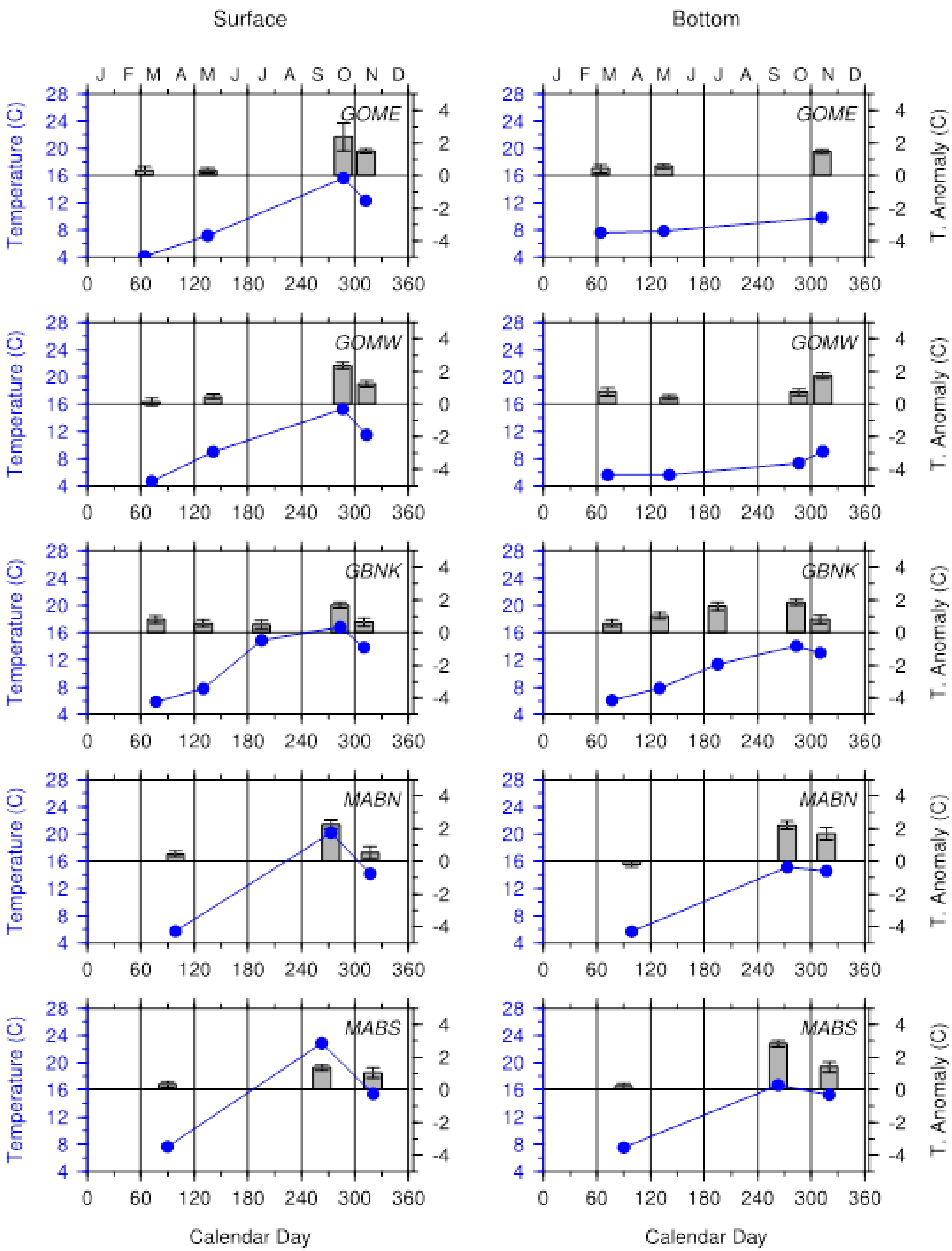

Figure 3. Time series of the 2014 regional surface (left) and bottom (right) temperatures (blue) and anomalies (bars) as a function of calendar day. Error bars are indicated for the anomaly estimates. GOME = Gulf of Maine east; GOMW = Gulf of Maine west; GBNK = Georges Bank; MABN = Middle Atlantic Bight north; MABS = Middle Atlantic Bight south.

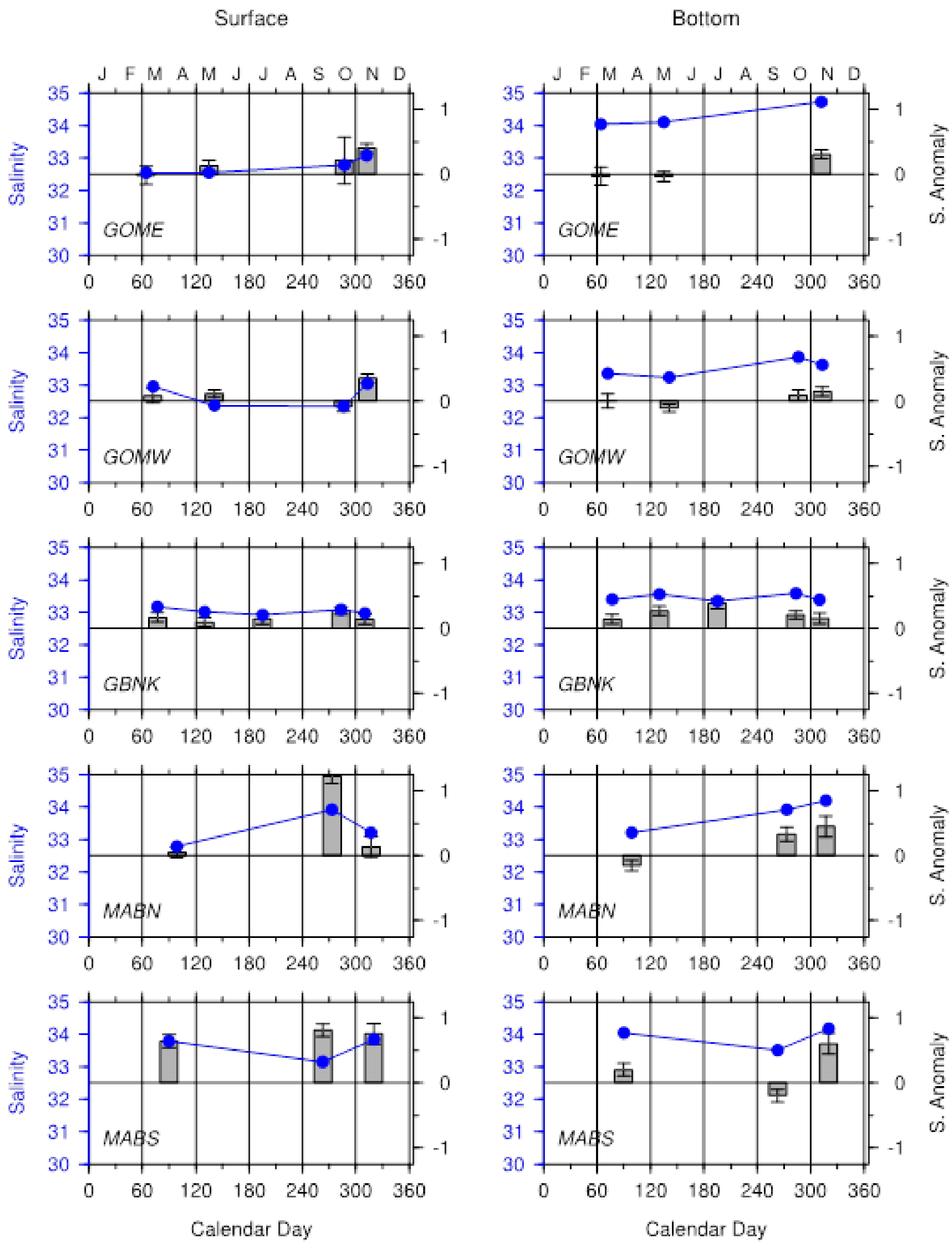

Figure 4. Time series of the 2014 regional surface (left) and bottom (right) salinities (blue) and anomalies (bars) as a function of calendar day. Error bars are indicated for the anomaly estimates. GOME = Gulf of Maine east; GOMW = Gulf of Maine west; GBNK = Georges Bank; MABN = Middle Atlantic Bight north; MABS = Middle Atlantic Bight south.

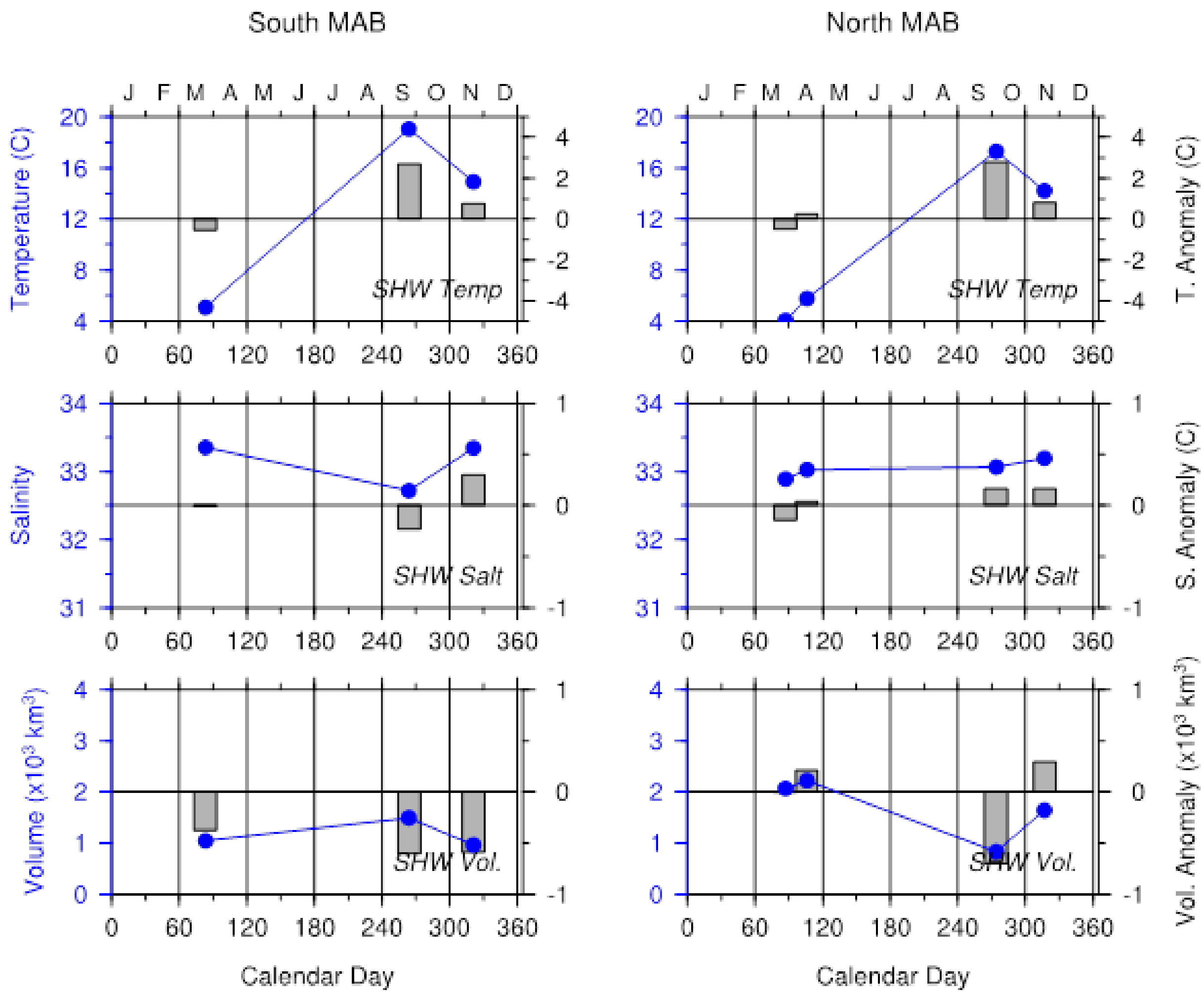

Figure 5. Time series of the 2014 regional shelf water (SHW) temperature, salinity, and volume as a function of calendar day shown in blue for the southern (left) and northern (right) Middle Atlantic Bight. The vertical bars show the corresponding shelf water anomalies.

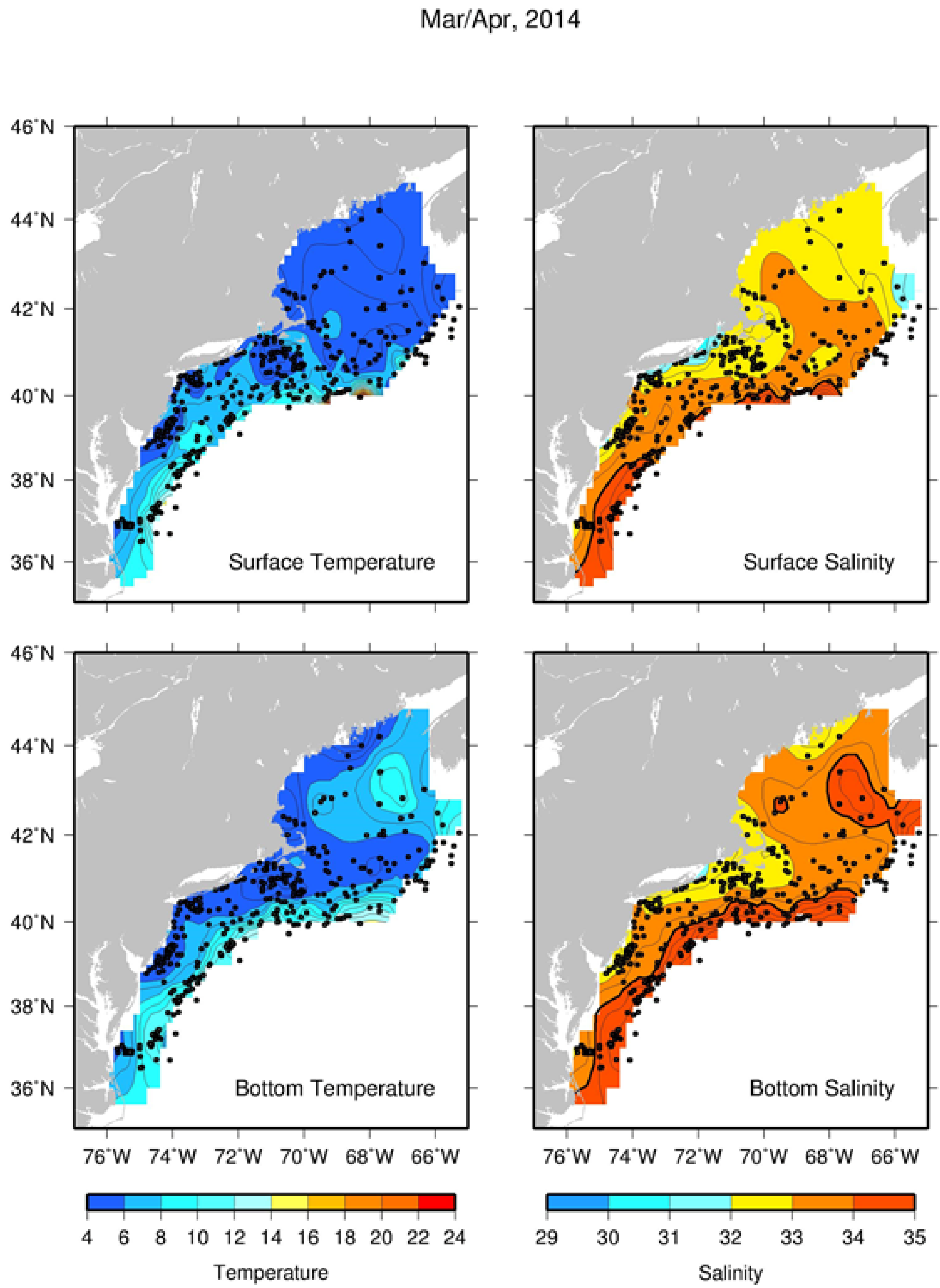

Figure 6a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during March-April 2014. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

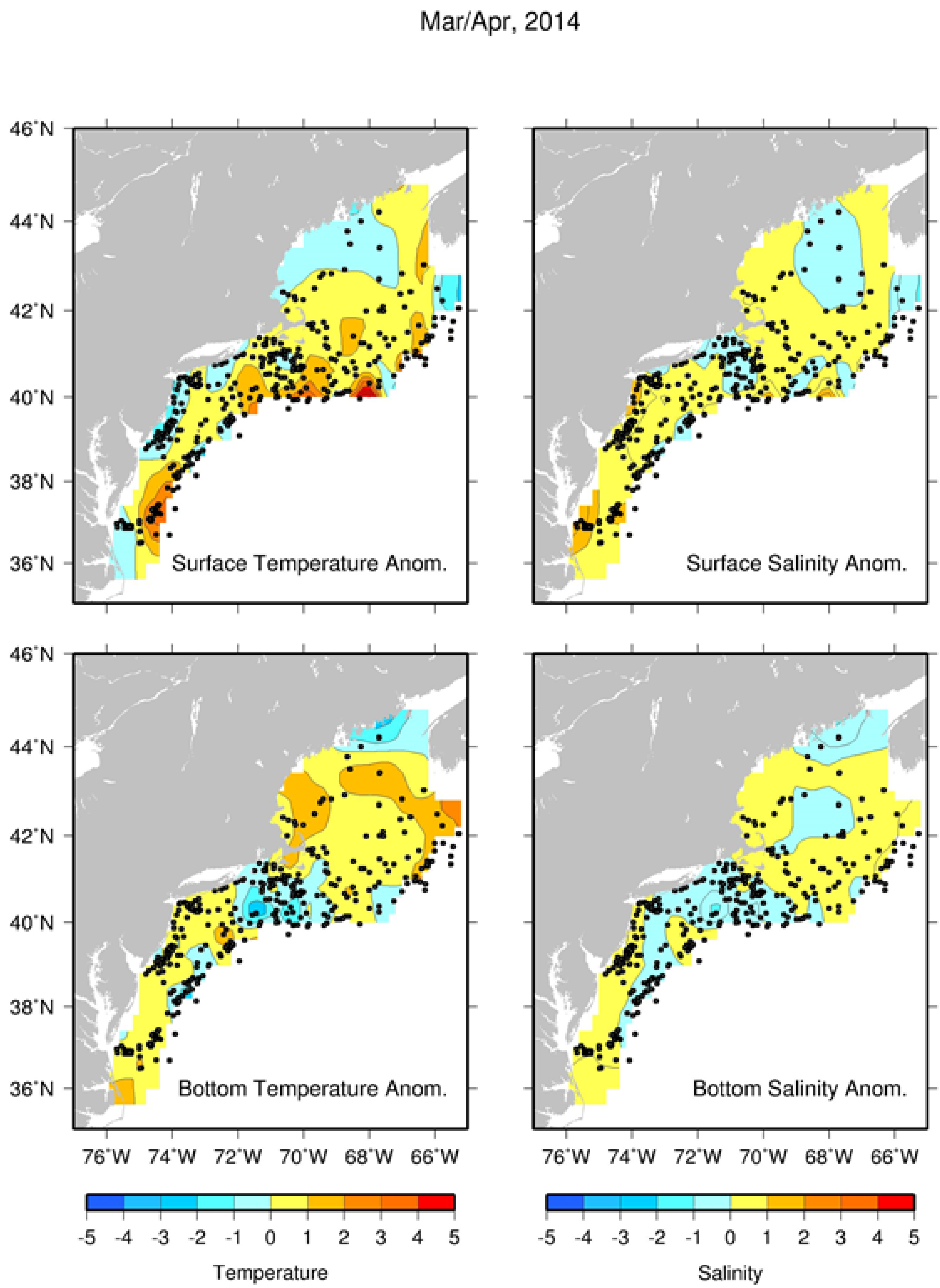

Figure 6b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during March-April 2014. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

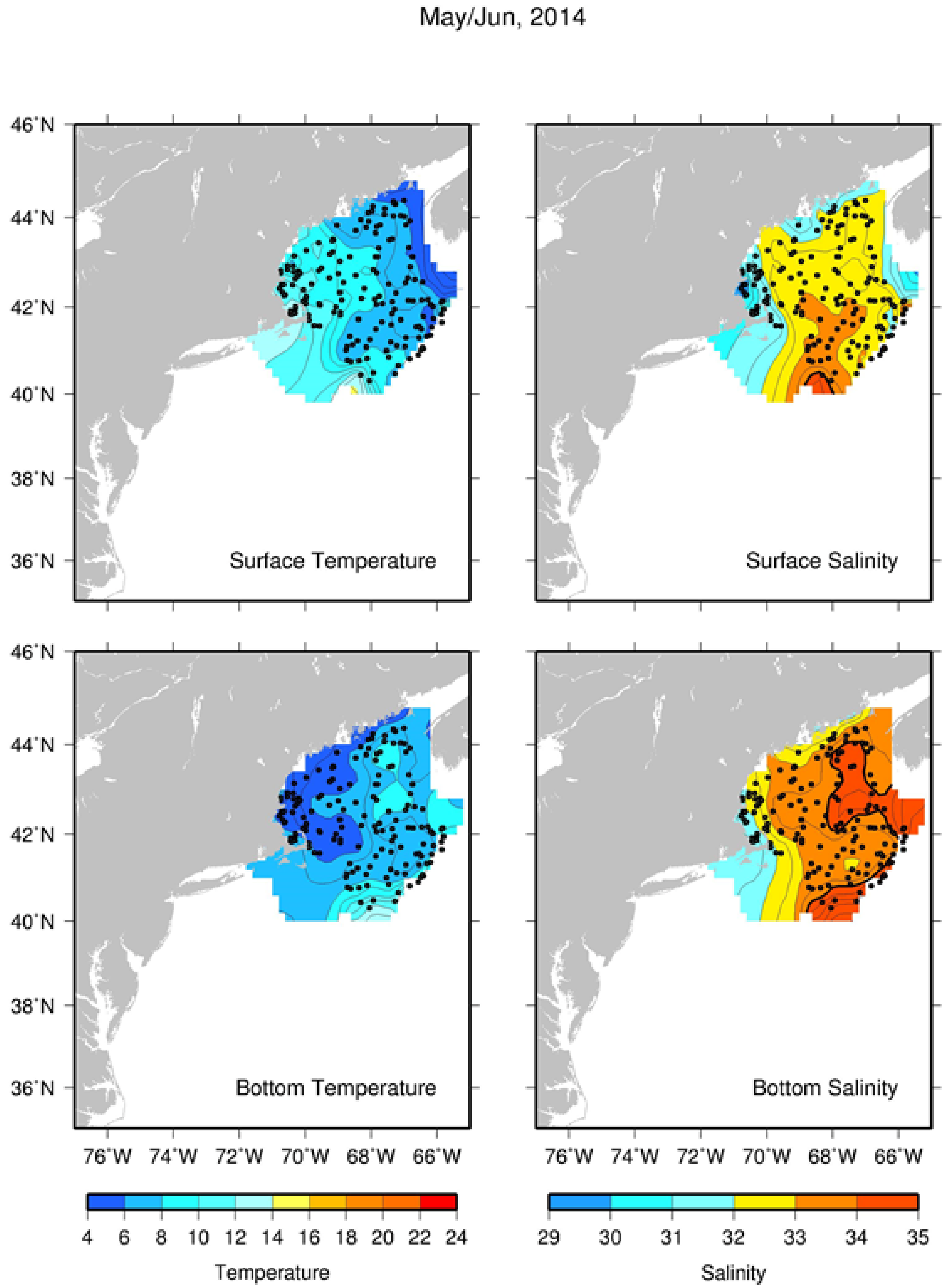

Figure 7a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during May-June 2014. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

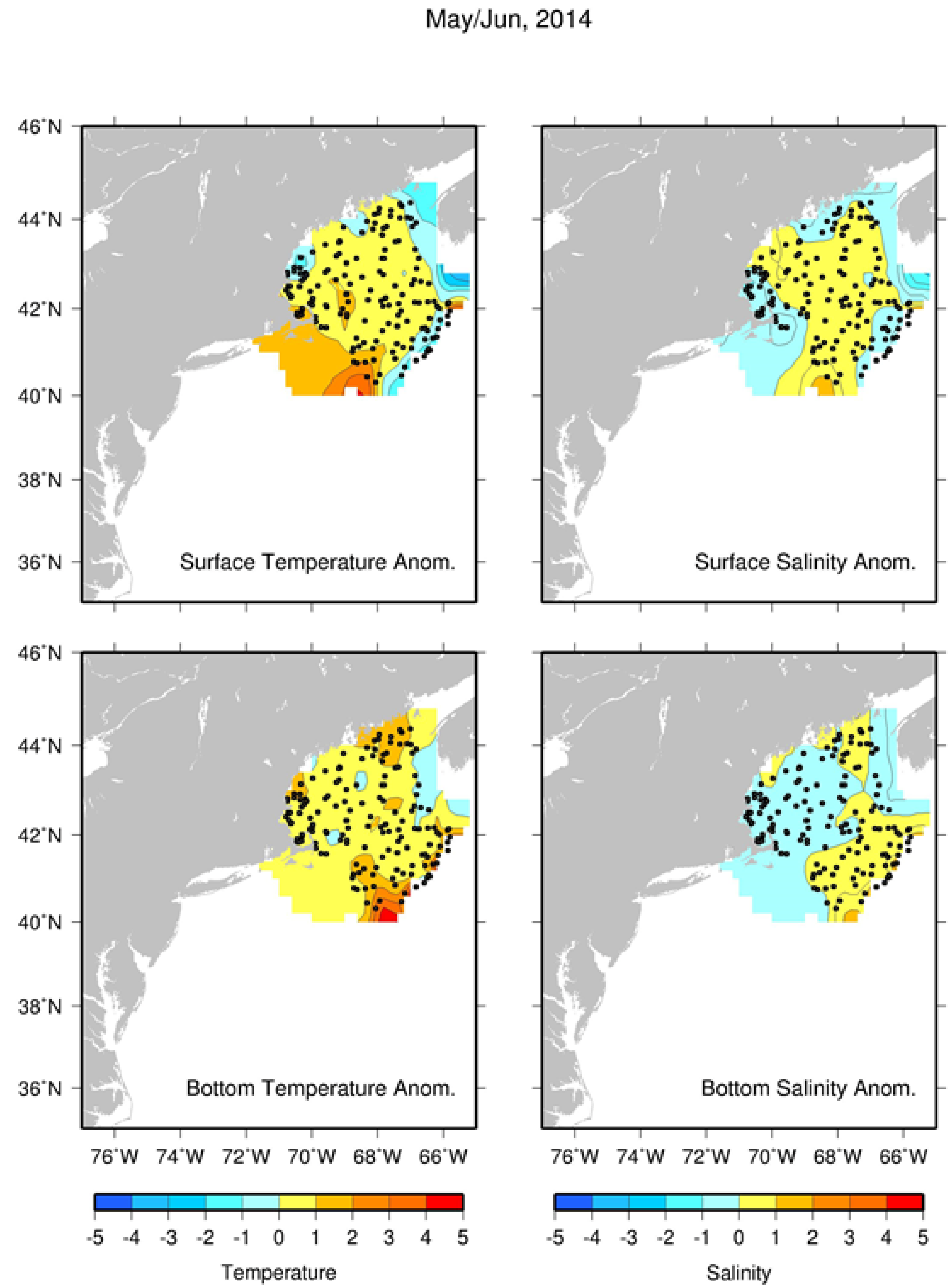

Figure 7b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during May-June 2014. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

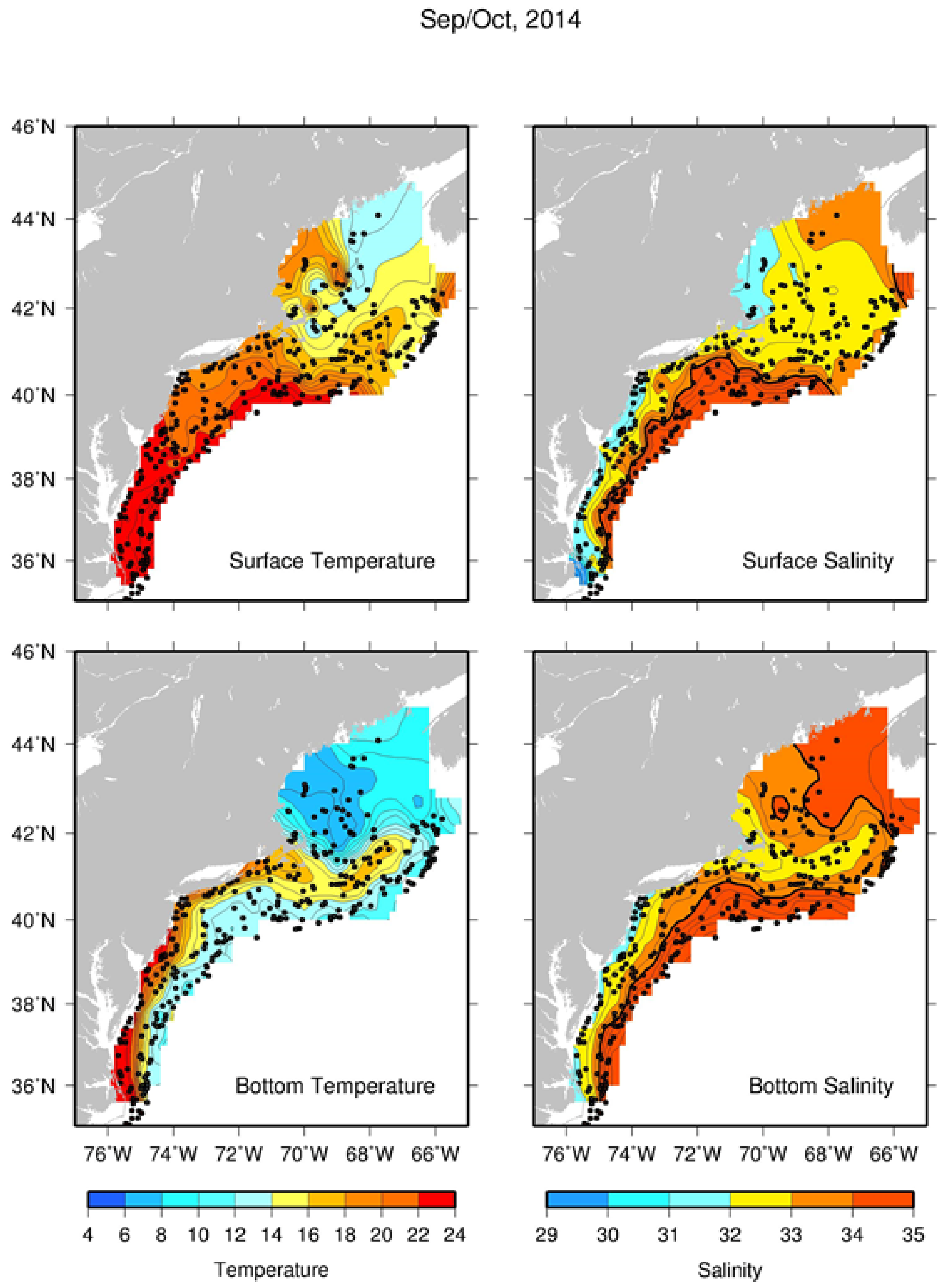

Figure 8a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during September-October 2014. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

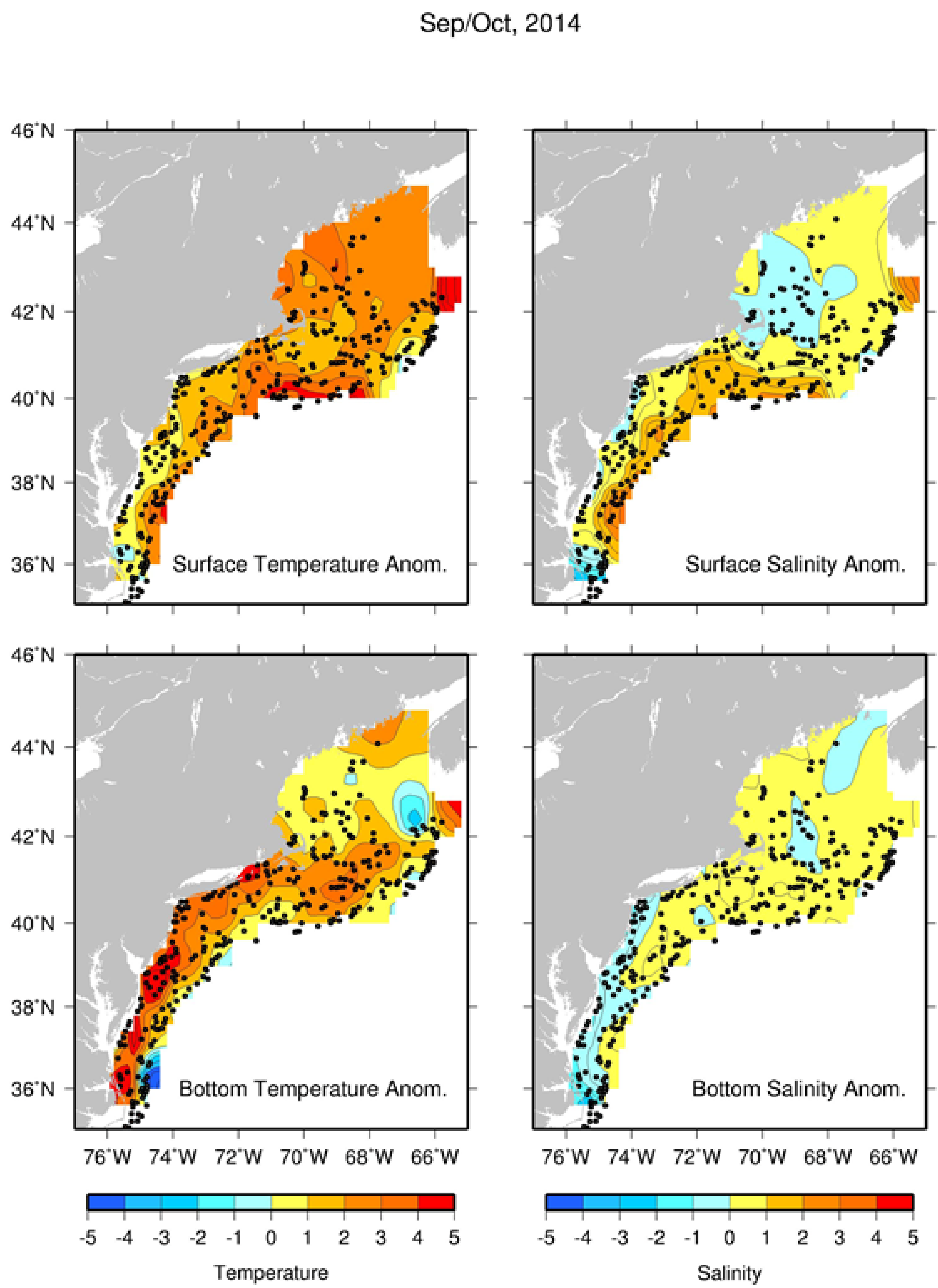

Figure 8b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during September-October 2014. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

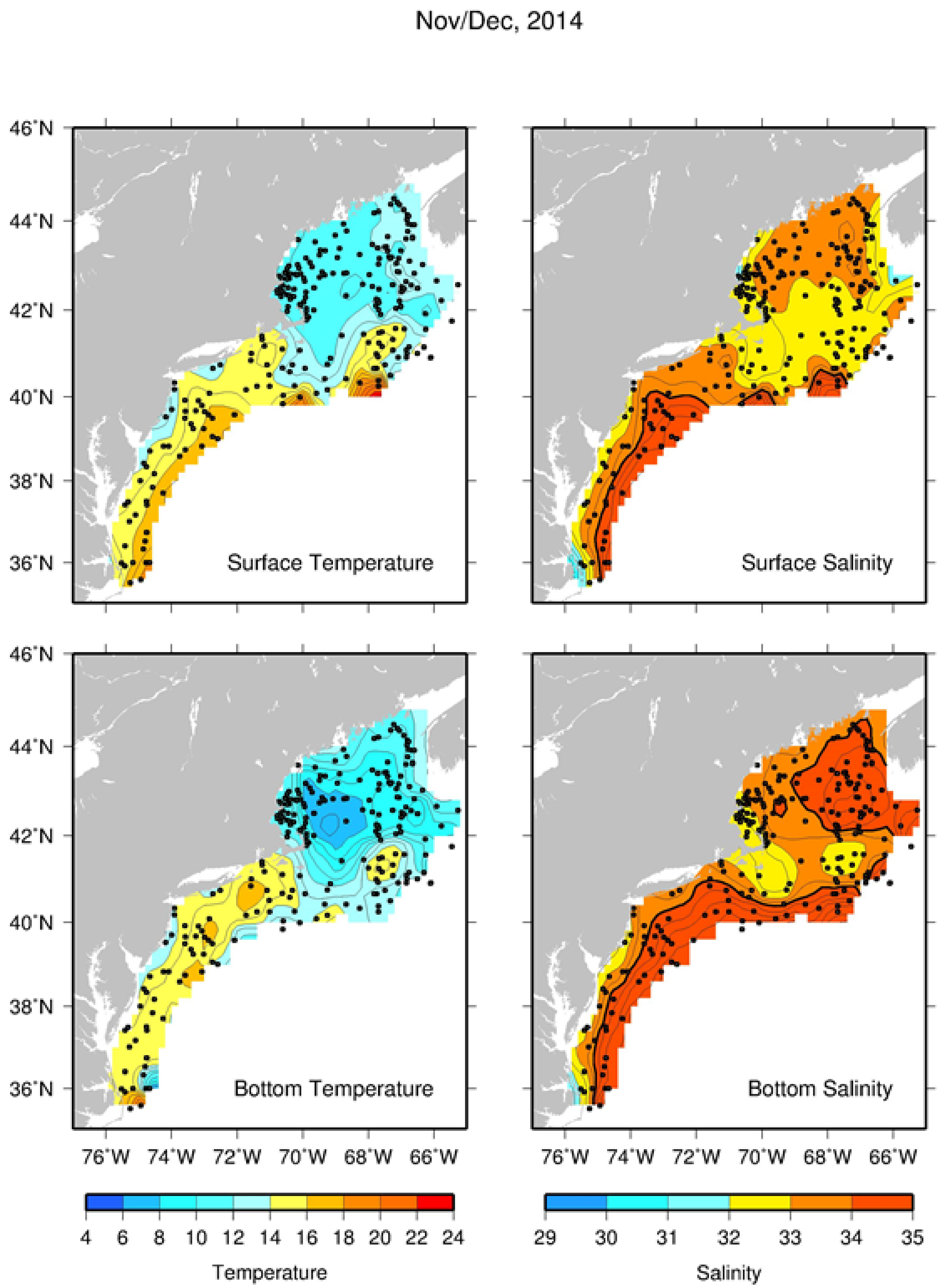

Figure 9a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during November-December 2014. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

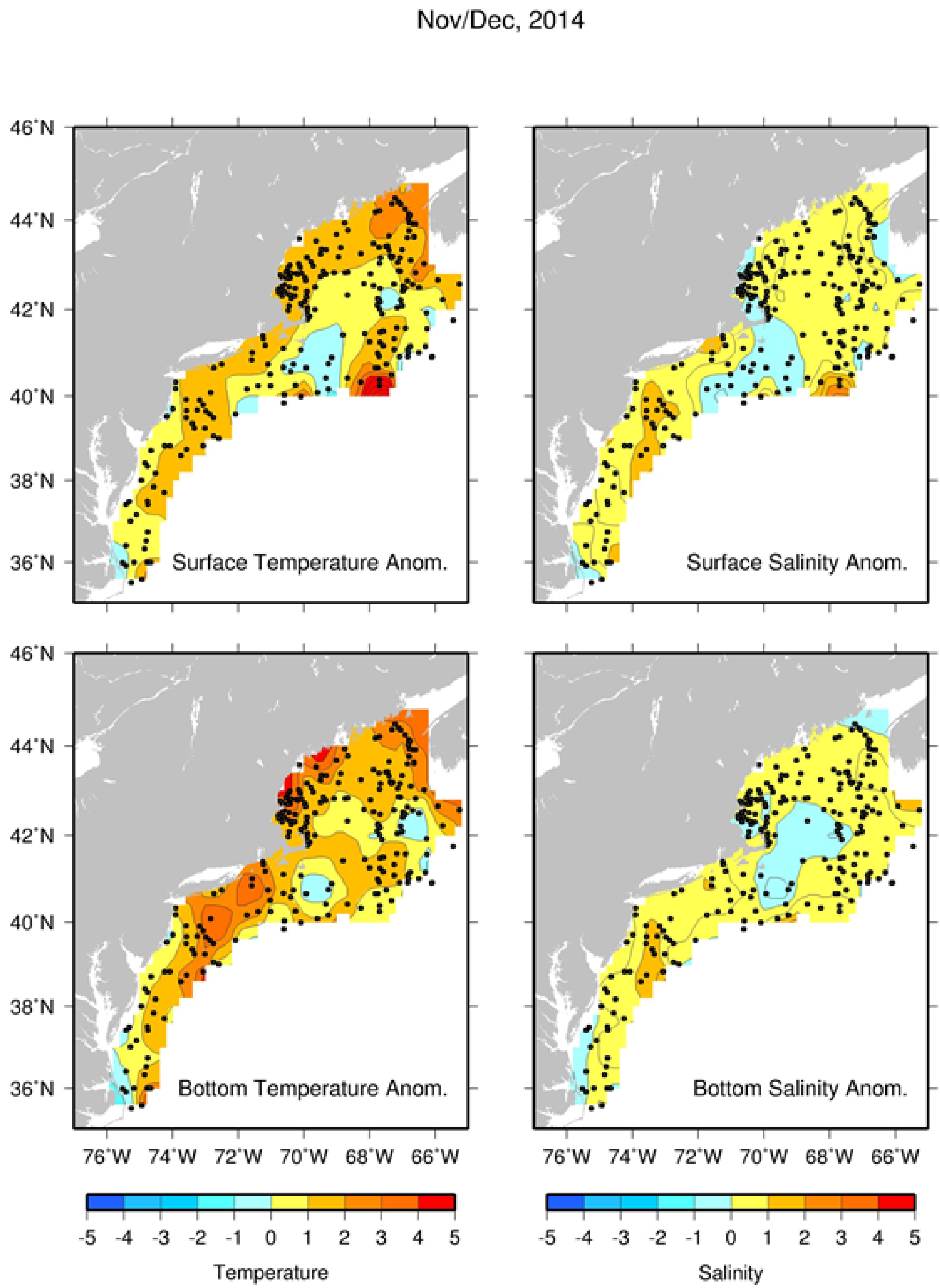

Figure 9b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during November-December 2014. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

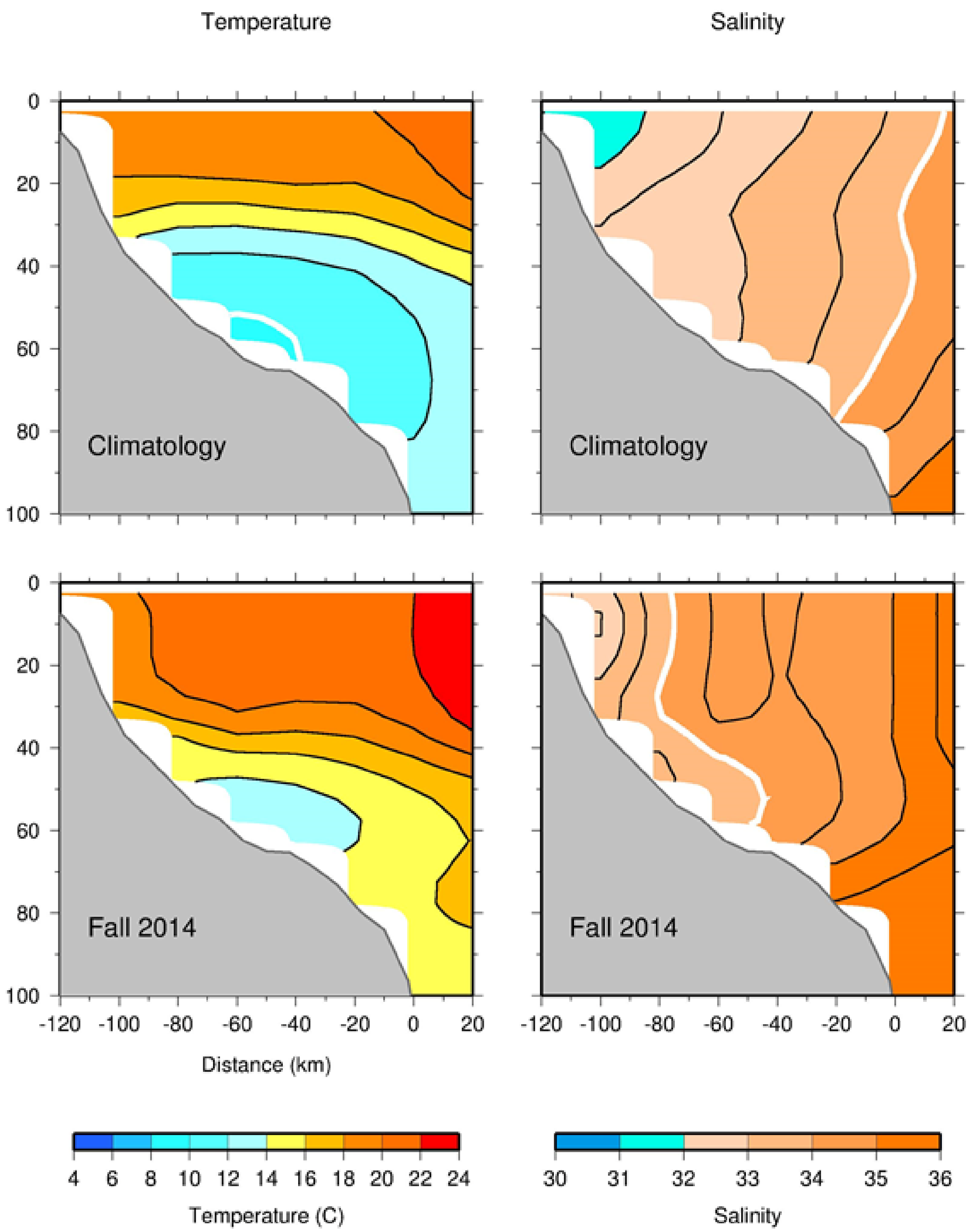

Figure 10a. Vertical sections of temperature (left) and salinity (right) crossing the Northeast US Continental Shelf in the Middle Atlantic Bight. The top panels show the climatological average for September spanning the years 1981-2010. The bottom panels show the synoptic mean section for September 2014. The heavy white contour highlights the 10°C isotherm as an indicator of the boundary of the cold pool and the 34 isohaline typically aligned with the shelf-slope front.

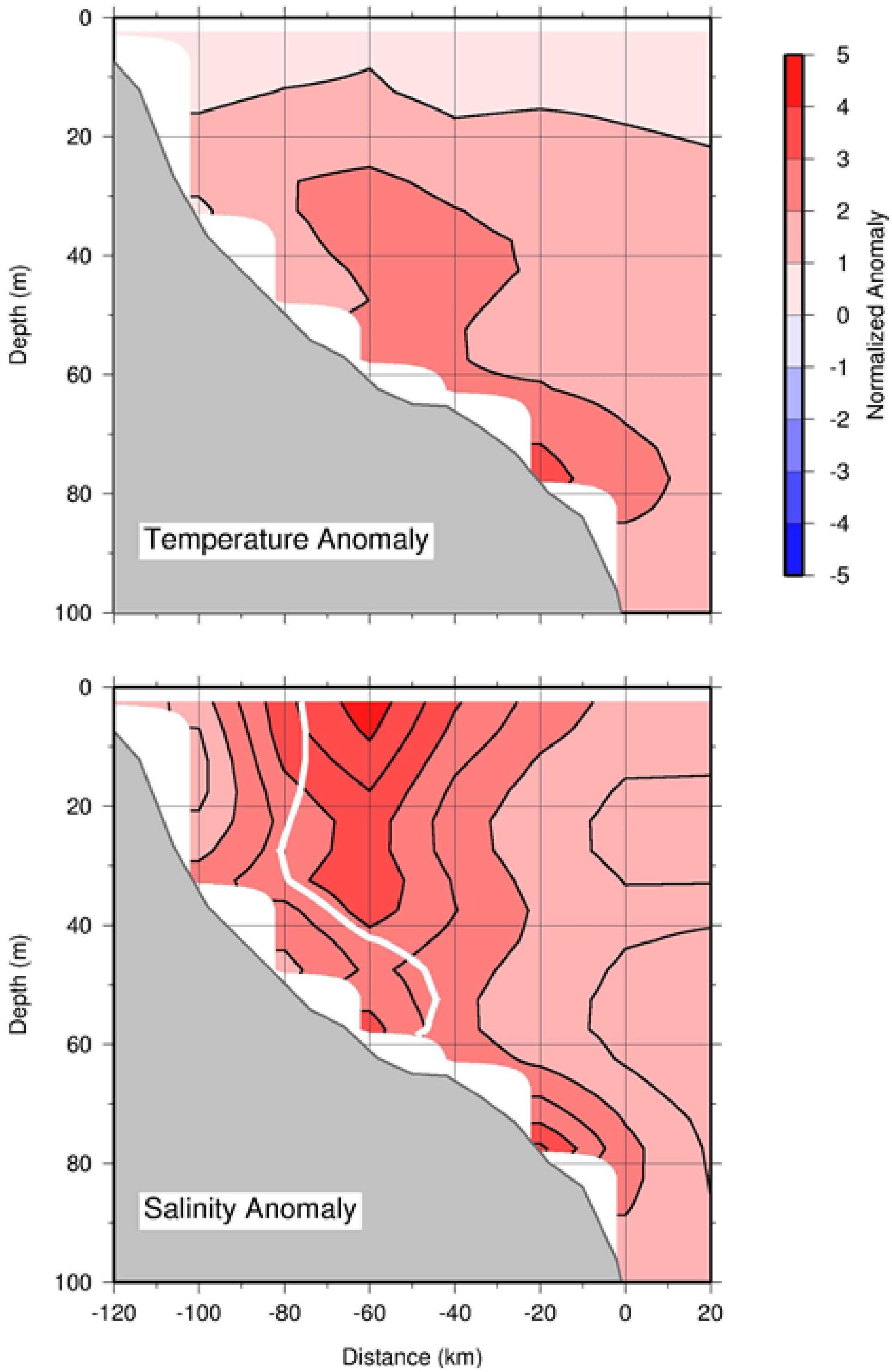

Figure 10b. Temperature (top panel) and salinity (bottom panel) anomalies on the Northeast US Continental Shelf associated with the vertical sections shown in Figure 10a. Positive anomalies correspond to warmer or more saline conditions in 2014 relative to the reference period (1981-2010). Anomalies have been normalized by the standard deviation of the temperature (salinity) over the reference period.

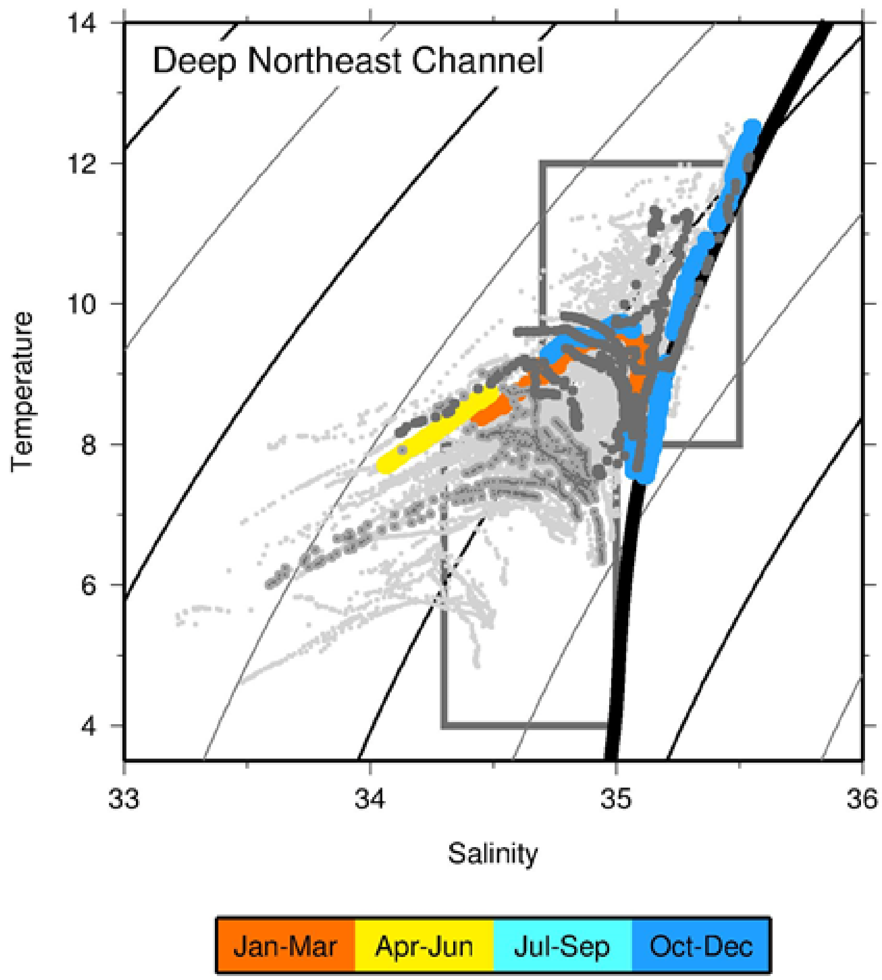

Figure 11. Temperature-salinity diagram showing water properties of the deep inflow to the Gulf of Maine, taken from 150-200 m depth in the Northeast Channel. Observations from 2014 (colored), 2012 (darkest gray), and 2008 (medium gray) are shown. The lightest gray dots show the historical range encompassing 1981-2010. The heavy black curve is the standard T-S curve constructed by Armi and Bray (1982) for western North Atlantic Central Water, which we take to be representative of Gulf Stream water. The two boxes outline the range of temperature and salinity typically attributed to Warm Slope Water (warmer/saltier) and Labrador Slope Water (colder/fresher).

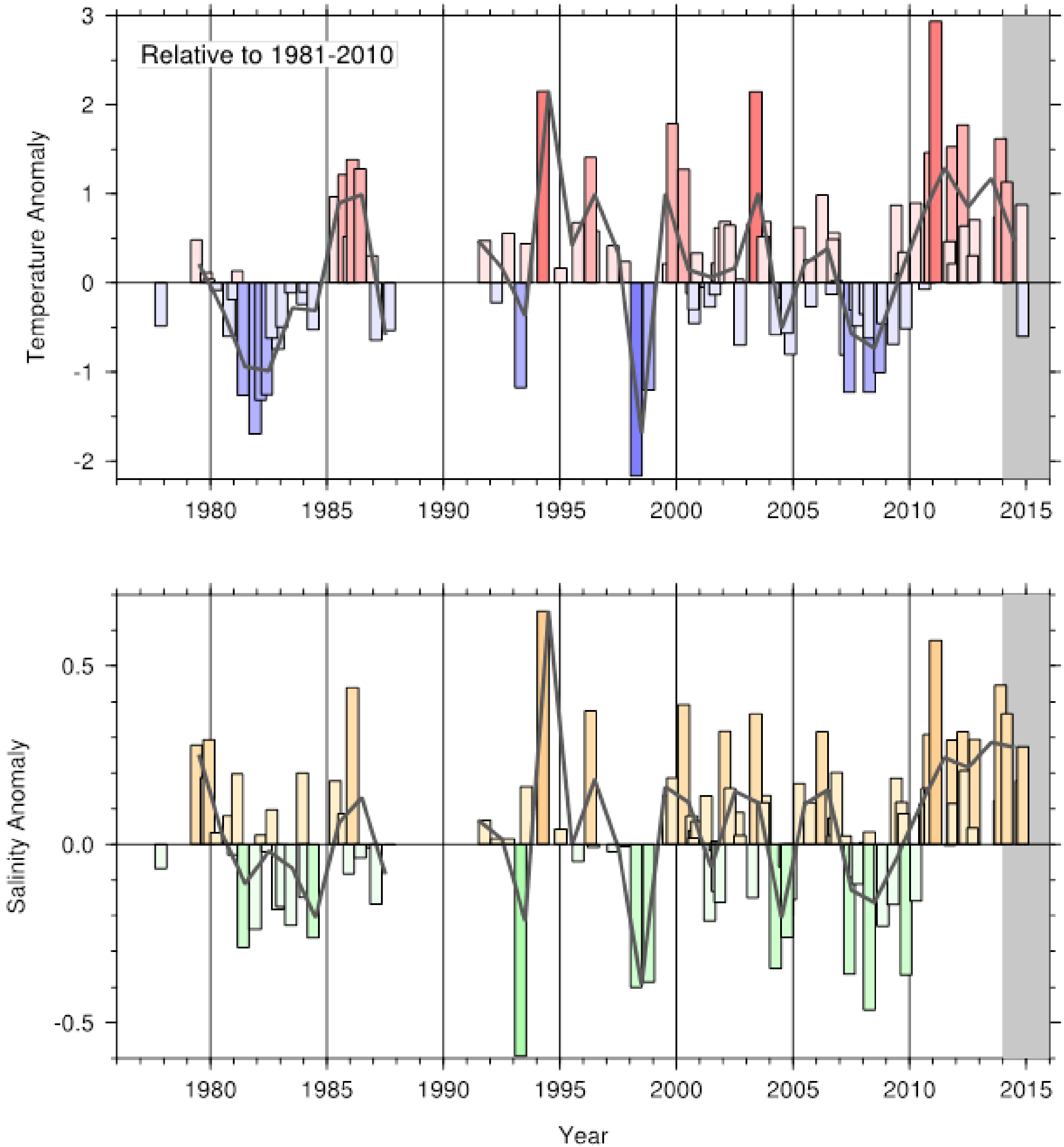

Figure 12. Time series of temperature and salinity anomaly in the deep Northeast Channel. Each bar represents a volume-weighted average of all observations from a single survey collected between 150-200 meters in the Northeast Channel. The grey curve shows the annual average anomaly time series. Positive values are warmer and saltier than the long-term mean calculated for 1981-2010. The gray shading highlights sampling done in 2014.

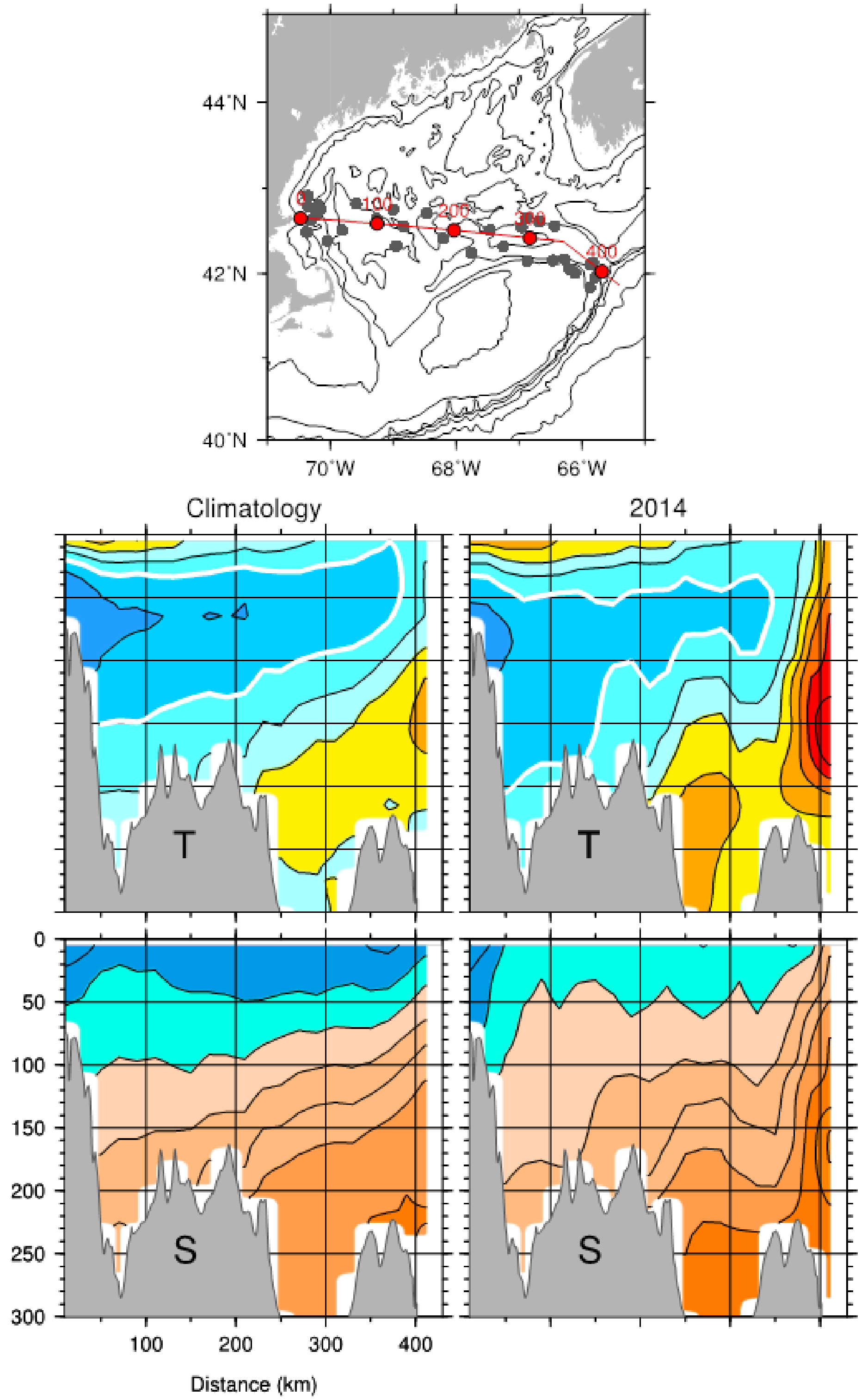

Figure 13. Vertical sections of temperature (top) and salinity (bottom) crossing the Gulf of Maine along a zonal transect shown in the map. The left panels show the climatological average for May spanning the years 1981-2010. The bottom panels show the synoptic mean section for May 2014. The heavy white contour highlights the 6°C isotherm as an indicator of the boundary of the Cold Intermediate Layer. Along-transect distances and the May 2014 station distribution are shown on the map for reference.

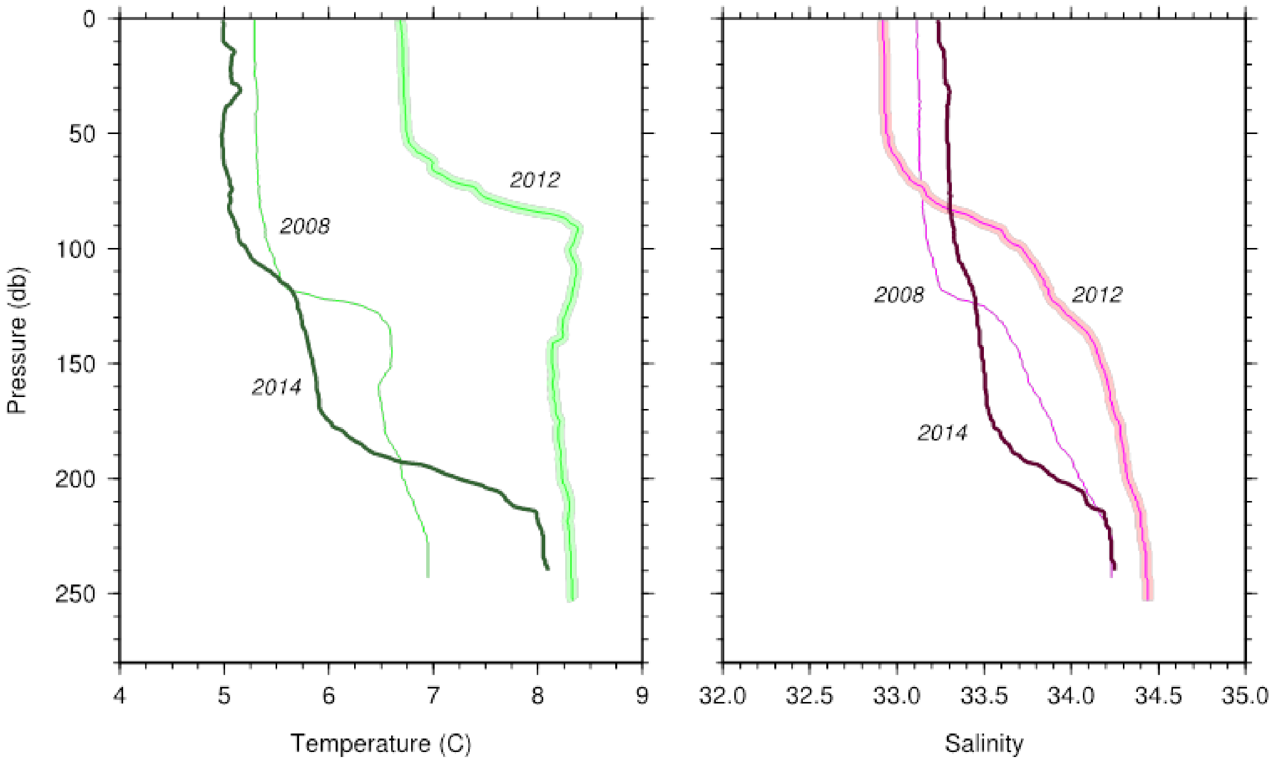

Figure 14. Average vertical profiles of temperature (left) and salinity (right) collected at a fixed station in Wilkinson Basin in the western Gulf of Maine. Profiles are shown from February 2008, 2012, and 2014.

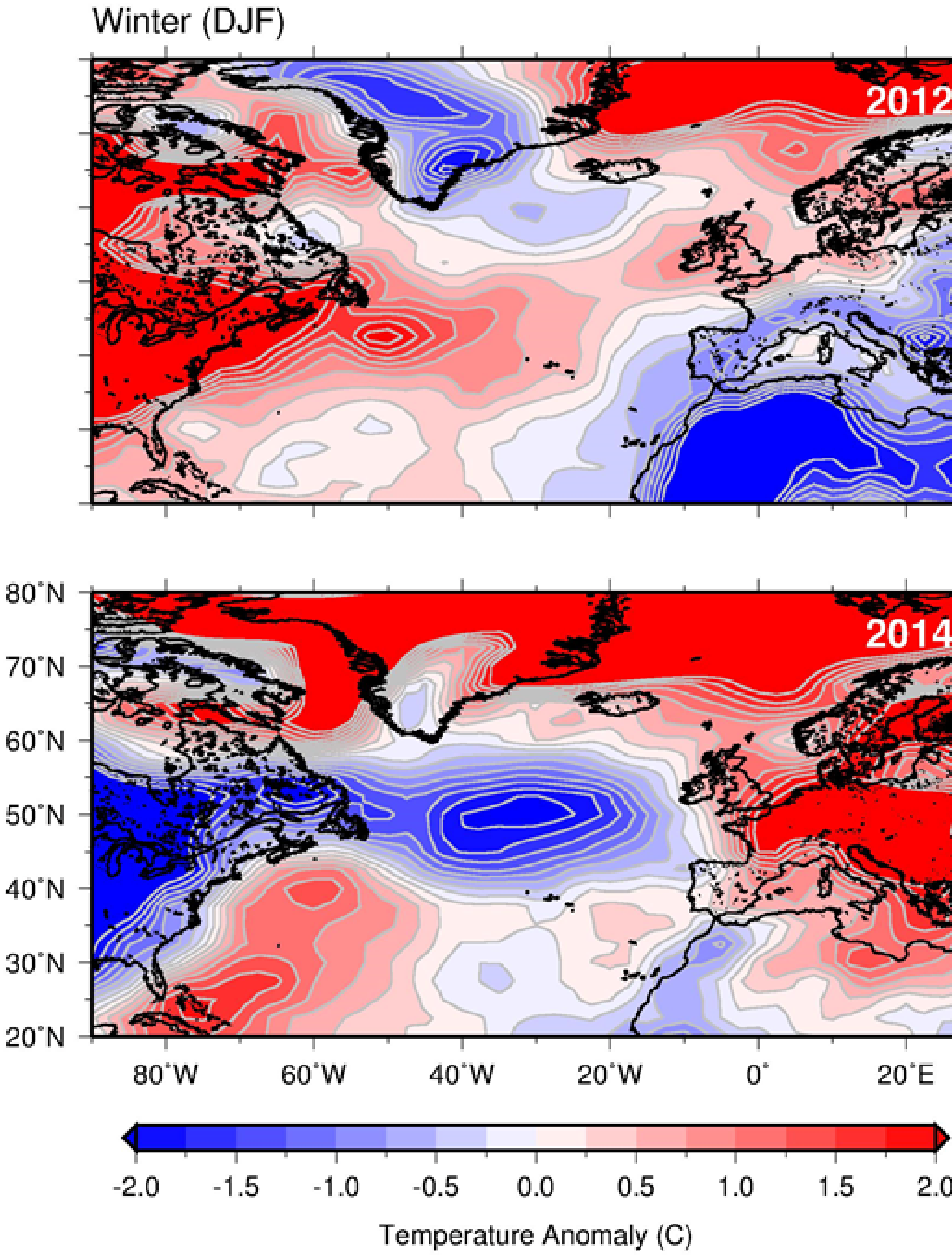

Figure 15. Winter (Dec-Feb) surface air temperature anomaly for 2012 (top) and 2014 (bottom) as derived from the NCEP/NCAR Reanalysis product (http://www.esrl.noaa.gov/psd/data/composites/day/). Positive anomalies correspond to warming relative to the reference period (1981-2010).

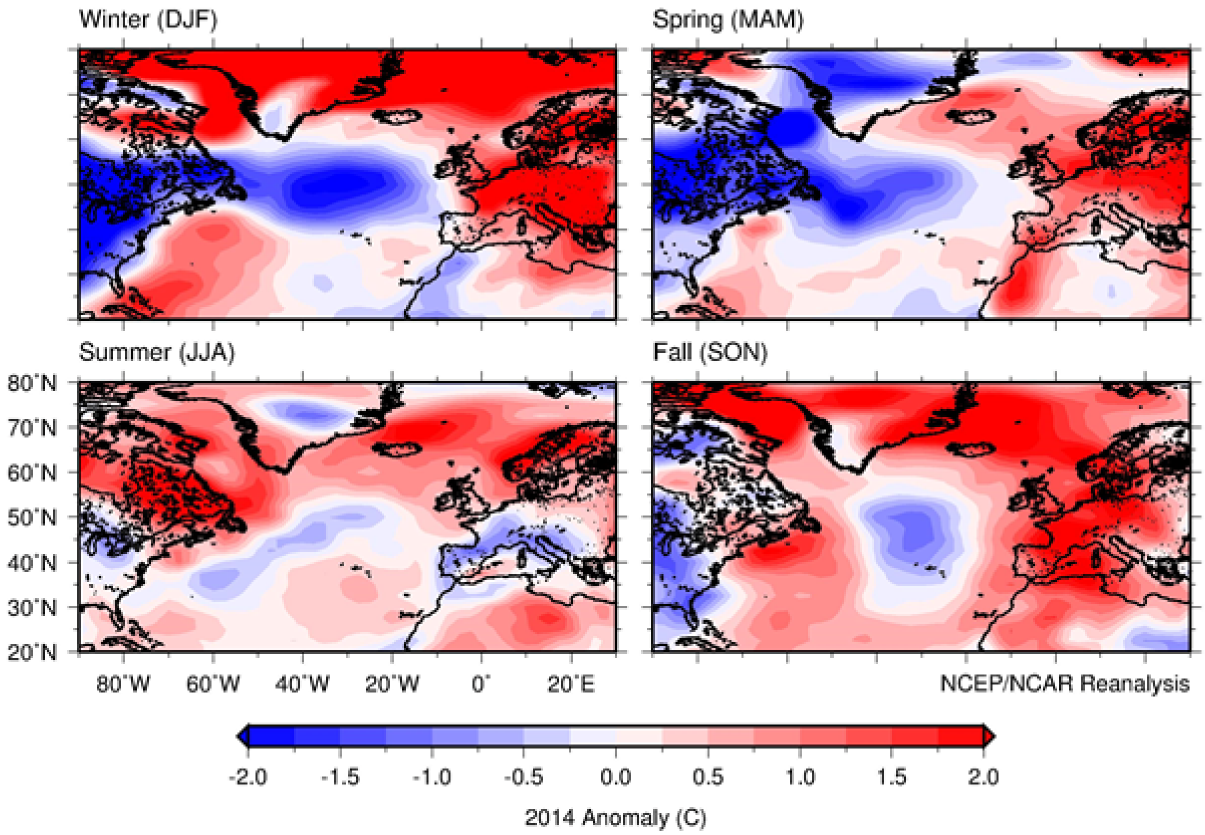

Figure 16. Surface air temperature anomaly derived from the NCEP/NCAR Reanalysis product (http://www.esrl.noaa.gov/psd/data/composites/day/). Seasons are made up of 3-month periods: winter(Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov). Positive anomalies correspond to warming in 2014 relative to the reference period (1981-2010).

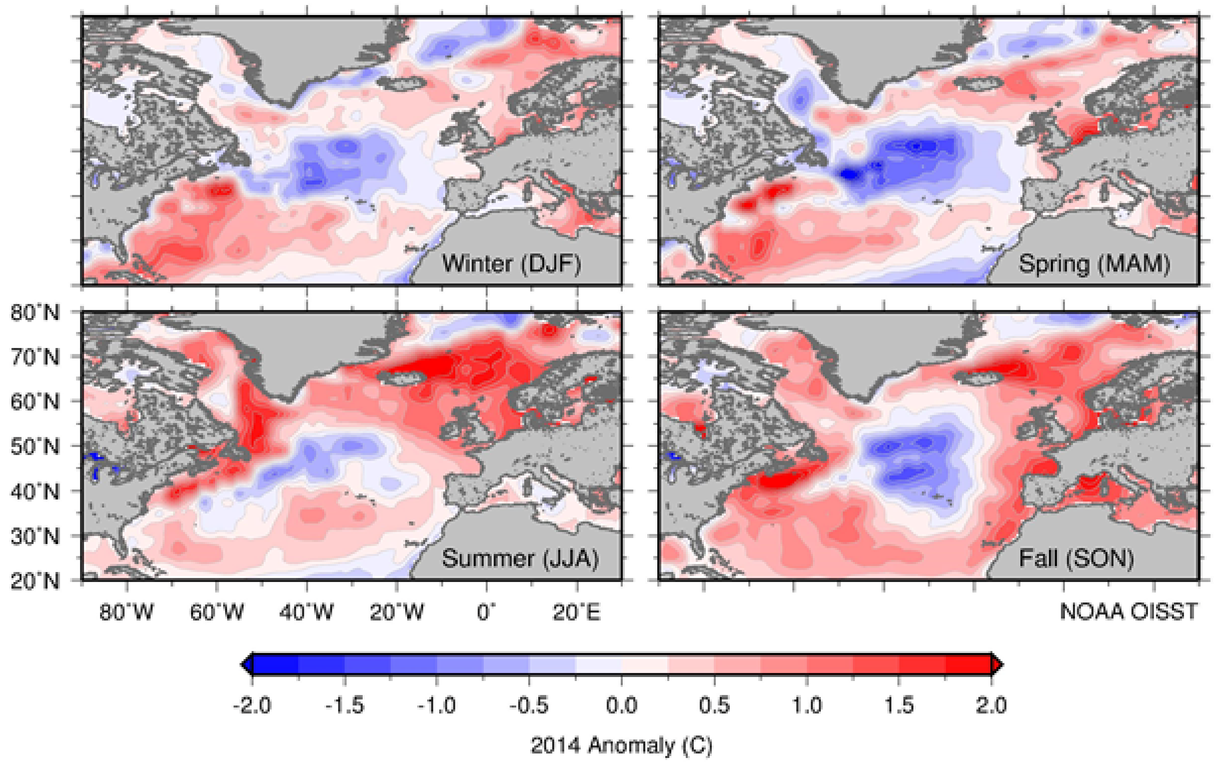

Figure 17. Sea surface temperature (SST) anomaly derived from NOAA's Optimum Interpolation (OI) SST product (http://www.esrl.noaa.gov/psd/data/gridded/data.noaa.oisst.v2.html). Seasons are made up of 3-month periods: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov). Positive anomalies correspond to warming in 2014 relative to the reference period (1981-2010).

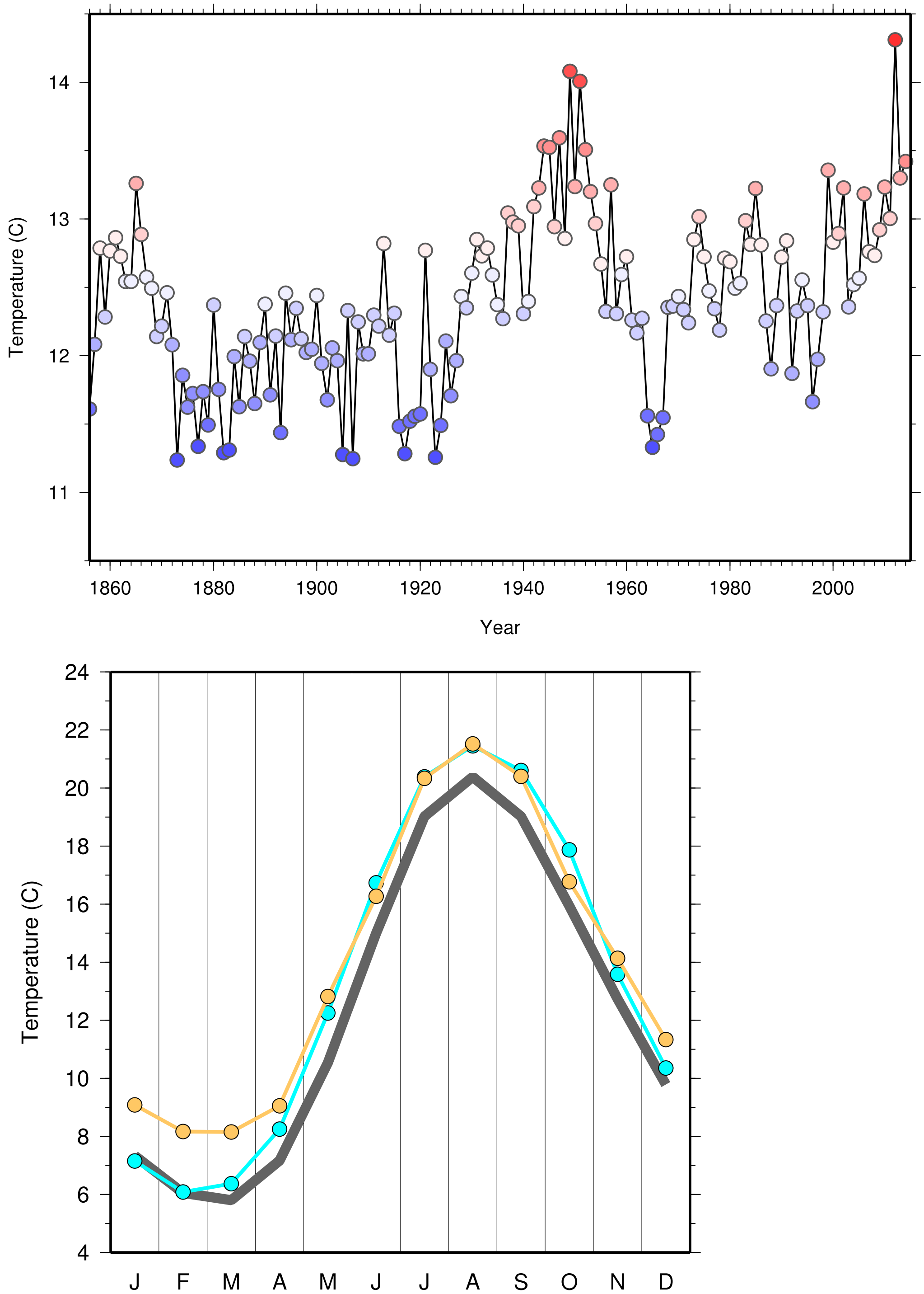

Figure 18. (top) Regional average annual sea surface temperature for the Northeast US (NEUS) Continental Shelf region calculated from NOAA's extended reconstructed sea surface temperature product (http://www.esrl.noaa.gov/psd/data/gridded/data.noaa.ersst.html). Regional average monthly mean SST for the NEUS shelf for 2014 (cyan), 1951 (orange) and 1981-2010 (gray) calculated from the same product.

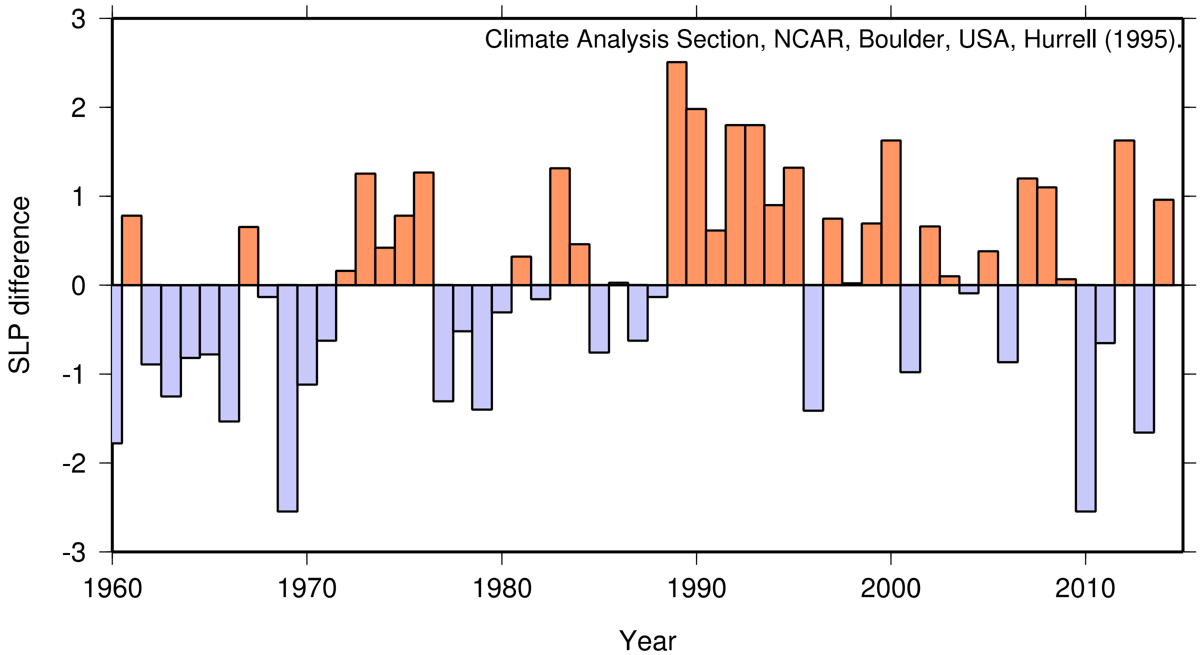

Figure 19. North Atlantic Oscillation index computed from principal component analysis of sea level pressure in the North Atlantic (see Hurrell, 1995).

Table A1. Regional average temperature and salinity calculated from hydrographic observations collected by individual Northeast Fisheries Science Center surveys in the eastern Gulf of Maine (boundary defined in Figure 1). Average values incorporating less than 10 observations are shown in gray. Average values are not reported for regions containing less than 5 observations.

Gulf of Maine East

Cruise	CD	#obs	Surface Temp	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Temp	Anomaly	SDV1	SDV2	Flag
GU1401	64	16	4.20	0.29	0.26	1.59	1	14	7.31	0.15	0.28	2.38	1
GU1402													
HB1401	135	37	6.97	0.06	0.18	0.86	0	35	7.77	0.53	0.19	0.80	0
S11401	200	5	16.99	3.01	0.81	1.93	1	5	8.40	-1.02	0.82	2.82	1
HB1403													
S11402													
HB1405	306	34	13.03	1.65	0.15	0.79	0	34	9.77	1.34	0.20	1.25	0
PC1405	315	21	12.07	1.51	0.20	0.90	0	20	9.84	1.57	0.26	1.06	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
GU1401	64	16	32.59	0.01	0.19	0.66	1	14	33.95	-0.13	0.15	0.84	1
GU1402													
HB1401	135	37	32.50	0.05	0.13	0.39	0	35	34.08	-0.04	0.09	0.34	0
S11401	200	5	32.34	-0.16	0.33	0.17	1	5	33.05	0.19	0.30	0.24	1
HB1403													
S11402													
HB1405	306	34	33.13	0.44	0.08	0.41	0	34	34.73	0.32	0.05	0.42	0
PC1405	315	21	33.00	0.35	0.11	0.29	0	20	34.64	0.27	0.07	0.24	0

"Cruise", the code name for a cruise:
CD, the calendar mid-date of all the stations within a region for that cruise:
"#obs", the number of observations included in each average:
"Temp", the areal average temperature: "Salt", the areal average salinity:
Anomaly, the areal average temperature or salinity anomaly:
"SDV1",the standard deviation associated with the average temperature or salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
Flag, a value of "1" indicates that a true areal average could not be calculated due to poor station coverage.
The areal averages listed were derived from a simple average of the observations within the region.

Table A2. Regional average temperature and salinity values calculated from hydrographic observations collected by individual Northeast Fisheries Science Center surveys in the western Gulf of Maine (boundary defined in Figure 1). Average values incorporating less than 10 observations are shown in gray. Average values are not reported for regions containing less than 5 observations.

Gulf of Maine West

Cruise	CD	#obs	Surface Temp	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Temp	Anomaly	SDV1	SDV2	Flag
GU1401	66	16	4.36	0.05	0.27	1.36	1	14	5.88	0.89	0.26	1.90	1
GU1402													
HB1401	139	52	8.78	0.38	0.15	0.93	0	51	5.79	0.50	0.13	0.59	0
S11401	200	6	15.10	0.04	1.06	0.40	1	8	8.47	1.58	1.03	1.53	1
HB1403													
S11402	254	10	18.81	2.98	1.12	1.21	1						
HB1405	307	52	12.64	1.82	0.15	0.45	0	52	8.38	1.31	0.13	1.26	0
PC1405	313	19	11.41	1.00	0.28	0.50	0	19	8.75	1.67	0.21	0.86	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
GU1401	66	16	32.99	0.06	0.19	0.58	1	14	33.47	0.11	0.15	0.60	1
GU1402													
HB1401	139	52	32.41	0.14	0.10	0.48	0	51	33.27	-0.08	0.07	0.27	0
S11401	200	6	32.56	0.44	0.35	0.56	1	8	32.83	0.01	0.32	0.26	1
HB1403													
S11402	254	10	31.76	-0.10	0.53	0.19	1						
HB1405	307	52	32.81	0.15	0.07	0.35	0	52	33.68	0.11	0.04	0.27	0
PC1405	313	19	33.07	0.35	0.11	0.26	0	19	33.73	0.12	0.07	0.31	0

"Cruise", the code name for a cruise:
CD, the calendar mid-date of all the stations within a region for that cruise:
"#obs", the number of observations included in each average:
"Temp", the areal average temperature: "Salt", the areal average salinity:
Anomaly, the areal average temperature or salinity anomaly:
"SDV1",the standard deviation associated with the average temperature or salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
Flag, a value of "1" indicates that a true areal average could not be calculated due to poor station coverage.
The areal averages listed were derived from a simple average of the observations within the region.

Table A3. Regional average temperature and salinity calculated from hydrographic observations collected by individual Northeast Fisheries Science Center surveys in the Georges Bank area (boundary defined in Figure 1). Average values incorporating less than 10 observations are shown in gray. Average values are not reported for regions containing less than 5 observations.

Georges Bank

Cruise	CD	#obs	Surface Temp	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Temp	Anomaly	SDV1	SDV2	Flag
GU1401	62	33	5.16	0.65	0.19	0.76	1	28	5.45	0.55	0.19	1.01	1
GU1402	110	12	7.86	1.68	0.38	4.41	1						
HB1401	127	51	7.70	0.73	0.15	1.75	0	40	6.82	0.59	0.18	0.97	0
S11401	195	39	14.60	0.42	0.24	1.38	0	39	11.38	1.60	0.25	1.39	0
HB1403													
S11402	250	9	18.56	2.38	1.21	0.82	1	6	11.66	1.66	1.66	1.96	1
HB1405	288	61	16.45	1.53	0.19	1.32	0	61	14.10	1.85	0.18	1.18	0
PC1405	310	36	13.87	0.65	0.24	1.39	0	36	13.06	0.81	0.23	1.16	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
GU1401	62	33	33.08	0.11	0.11	0.33	1	28	33.24	0.14	0.11	0.30	1
GU1402	110	12	33.49	0.44	0.25	1.58	1						
HB1401	127	51	33.04	0.09	0.09	0.58	0	40	33.22	0.19	0.11	0.36	0
S11401	195	39	32.87	0.14	0.07	0.40	0	39	33.35	0.39	0.08	0.46	0
HB1403													
S11402	250	9	32.83	0.10	0.49	0.39	1	6	34.54	0.60	0.62	0.46	1
HB1405	288	61	33.09	0.29	0.06	0.54	0	61	33.54	0.18	0.06	0.28	0
PC1405	310	36	32.98	0.14	0.08	0.48	0	36	33.38	0.16	0.08	0.33	0

"Cruise", the code name for a cruise:
CD, the calendar mid-date of all the stations within a region for that cruise:
"#obs", the number of observations included in each average:
"Temp", the areal average temperature: "Salt", the areal average salinity:
Anomaly, the areal average temperature or salinity anomaly:
"SDV1",the standard deviation associated with the average temperature or salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
Flag, a value of "1" indicates that a true areal average could not be calculated due to poor station coverage.
The areal averages listed were derived from a simple average of the observations within the region.

Table A4. Regional average temperature and salinity calculated from hydrographic observations collected by individual Northeast Fisheries Science Center surveys in the northern Middle Atlantic Bight (boundary defined in Figure 1). Average values incorporating less than 10 observations are shown in gray. Average values are not reported for regions containing less than 5 observations.

Northern Mid Atlantic Bight

Cruise	CD	#obs	Surface Temp	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Temp	Anomaly	SDV1	SDV2	Flag
GU1401													
GU1402	88	55	4.31	0.20	0.16	1.45	1	51	3.70	-0.50	0.17	1.82	1
HB1401	106	51	6.55	0.64	0.18	1.56	0	41	5.62	-0.45	0.23	1.61	0
S11401													
HB1403													
S11402													
HB1405	273	45	20.12	2.25	0.26	1.46	0	46	15.17	2.20	0.28	1.46	0
PC1405	317	19	14.17	0.52	0.38	0.90	0	19	14.55	1.70	0.46	1.50	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
GU1401													
GU1402	88	55	32.72	0.05	0.11	0.53	1	51	32.87	-0.05	0.11	0.59	1
HB1401	106	51	32.82	0.10	0.12	0.51	0	41	33.02	-0.37	0.13	0.58	0
S11401													
HB1403													
S11402													
HB1405	273	45	33.91	1.22	0.12	0.81	0	46	33.91	0.33	0.09	0.52	0
PC1405	317	19	33.21	0.14	0.16	0.59	0	19	34.20	0.45	0.15	0.56	0

"Cruise", the code name for a cruise:
CD, the calendar mid-date of all the stations within a region for that cruise:
"#obs", the number of observations included in each average:
"Temp", the areal average temperature: "Salt", the areal average salinity:
Anomaly, the areal average temperature or salinity anomaly:
"SDV1",the standard deviation associated with the average temperature or salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
Flag, a value of "1" indicates that a true areal average could not be calculated due to poor station coverage.
The areal averages listed were derived from a simple average of the observations within the region.

Table A5. Regional average temperature and salinity calculated from hydrographic observations collected by individual Northeast Fisheries Science Center surveys in the southern Middle Atlantic Bight (boundary defined in Figure 1). Average values incorporating less than 10 observations are shown in gray. Average values are not reported for regions containing less than 5 observations.

Southern Mid Atlantic Bight

Cruise	CD	#obs	Surface Temp	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Temp	Anomaly	SDV1	SDV2	Flag
GU1401													
GU1402	83	88	7.75	0.07	0.15	1.14	1	52	5.85	0.37	0.19	0.77	1
HB1401	102	48	7.47	0.06	0.20	1.45	1	32	6.37	0.14	0.24	1.06	1
S11401	183	5	23.56	2.23	1.56	0.73	1						
HB1403													
S11402													
HB1405	263	105	22.86	1.36	0.18	1.12	0	104	16.75	2.83	0.22	2.40	0
PC1405	320	37	15.36	1.05	0.30	0.68	0	43	15.24	1.39	0.34	1.32	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
GU1401													
GU1402	83	88	34.01	0.69	0.11	0.44	1	52	33.54	0.39	0.12	0.35	1
HB1401	102	48	33.31	0.40	0.14	0.56	1	32	33.39	0.19	0.15	0.51	1
S11401	183	5	32.21	0.09	0.77	0.97	1						
HB1403													
S11402													
HB1405	263	105	33.16	0.82	0.10	1.13	0	104	33.52	-0.20	0.08	0.68	0
PC1405	320	37	33.84	0.76	0.16	0.41	0	43	34.18	0.60	0.12	0.48	0

"Cruise", the code name for a cruise:
CD, the calendar mid-date of all the stations within a region for that cruise:
"#obs", the number of observations included in each average:
"Temp", the areal average temperature: "Salt", the areal average salinity:
Anomaly, the areal average temperature or salinity anomaly:
"SDV1",the standard deviation associated with the average temperature or salinity anomaly:
"SDV2", the standard deviation of the individual anomalies from which the average anomaly was derived:
Flag, a value of "1" indicates that a true areal average could not be calculated due to poor station coverage.
The areal averages listed were derived from a simple average of the observations within the region.

Table A6. Temperature, salinity and volume of the shelf water in the Middle Atlantic Bight during 2014. The shelf water is defined as water within the upper 100 meters having salinity less than 34. MABN = Middle Atlantic Bight north; MABS = Middle Atlantic Bight south.

CD	Temp	Temp. Anomaly	Salt	Salt Anomaly	SHW Temp	SHW T. Anom	SHW Salt	SHW S. Anom	SHW Volume	SHW Vol. Anomaly
MABN										
87	4.10	-1.54	32.89	-0.44	4.10	-0.49	32.89	-0.14	2067.62	-2.26
106	6.41	-0.09	33.24	-0.02	5.81	0.25	33.02	0.04	2217.85	209.31
274	18.29	3.34	34.43	0.80	17.32	2.80	33.06	0.16	833.94	-700.63
317	15.09	1.06	33.92	0.20	14.22	0.81	33.19	0.16	1646.75	288.05
MABS										
83	8.98	1.03	34.44	0.56	5.10	-0.55	33.35	-0.01	1040.26	-378.38
264	18.59	2.18	34.11	0.58	19.05	2.71	32.72	-0.23	1495.39	-606.67
321	15.91	1.77	34.41	0.41	14.92	0.75	33.34	0.30	958.81	-590.26

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