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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 2015. 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, 2015 was characterized by warming, 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 2015, presumably a consequence of anomalously cold air temperatures that persisted over the northeastern United States during winter. The vigorous mixing led to the formation of an anomalously thick layer of intermediate water extending to the bottom of Wilkinson Basin the following spring. Finally, observations indicate that Gulf Stream water intruded onto the shelf in the Middle Atlantic Bight during late summer, leading to anomalous warming at the shelf break and in the upper 30 meters across the width of the shelf. Pycnocline gradients were enhanced and aligned with a shoreward protruding tongue of saline water. 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 Oceans and Climate 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 2015 led to the elimination of 2 of these 6 surveys, namely the February and August Ecosystem Monitoring (EcoMon) Surveys. In addition, ship scheduling constraints shifted sampling earlier than normal during the annual fall EcoMon Survey, with truncated sampling occurring in October rather than November, further collapsing seasonal coverage for the year. The result was that roughly half as many stations were occupied this year, comprehensively sampling just 2 of 4 seasons.

This document presents an annual summary of the 2015 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 5 different regions over the 3 bimonthly periods sampled. In the Middle Atlantic Bight, 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 Oceans and Climate 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

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

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 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 2015, hydrographic data were collected aboard the NOAA ships *Henry B. Bigelow* and *Gordon Gunter*, the R/V *Hugh R. Sharp*, and the charter vessel *Eagle Eye II* 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 was calculated based on comparisons between the CTD measured conductivity and salinometer results, and was applied to the CTD measured conductivity before conversion back 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 publicly available via anonymous ftp. Cruise reports were prepared for each survey listed in Table 1 and are available online. Readers are referred to the individual cruise reports for notes, property maps, and aggregate data specific to a particular survey.

This document is intended to provide a descriptive overview of the hydrographic sampling conducted in 2015 and to characterize the broadscale oceanographic conditions that were observed. The processed CTD data were sorted into 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 were produced from profile data falling within each bimonthly period. Surface fields include the shallowest observed temperature/salinity at each station that was also in the upper 5 m of the water column, while bottom maps include the deepest observation at each station that also fell within 10 m of the reported water depth. Average values were computed from the data within 5 subregions spanning the NEUS Continental Shelf to examine the spatial and temporal variability over broader areas of the shelf (Figure 1). Regional averages were computed for the bimonthly binned fields (Tables 2 and 3) and for individual cruises (Appendix Tables 1-5).

Anomalies were 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 Fisheries 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-Davis 1989). The anomalies presented here are defined as the difference between the observed 2015 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-Davis and Mountain (1990).

Finally, the temperature, salinity and volume of the shelf water in the Middle Atlantic Bight during 2015 were calculated and related this to the conditions observed during the MARMAP reference period. Following Mountain (2003), the shelf water mass was defined as water within the upper 100 m having salinity less than 34. For each survey in 2015, the area of a subregion was apportioned among its stations by an inverse distance-squared weighting. The shelf water volume at a given station was the thickness of the shelf water at the station multiplied by its apportioned area, and the total shelf water volume within the subregion was the sum of these products for all stations within the region. Similarly, the average temperature and salinity were 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 determined the volume-weighted average temperature and salinity. Anomalies in the property and volume of the shelf water mass were calculated relative to like variables derived from MARMAP hydrographic data, as described above. Hence, here regional anomalies were computed as the mathematical difference between regional averages, *not* an average of the anomalies computed for a given subregion.

RESULTS

Hydrographic Conditions in 2015

During 2015, hydrographic data were collected on 8 individual NEFSC cruises, amounting to 1244 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 2015 relative to previous years (Figure 2b). No sampling occurred during January-February due to the cancelation of the winter EcoMon survey. Only limited sampling occurred in July-August due to cancelation of the summer EcoMon. The fall EcoMon Survey, typically conducted in November, was shifted earlier to October. The earlier survey overlapped the final leg of the fall bottom trawl survey, leaving a significant gap in sampling coverage during fall. The results are a significant reduction in sampling during 2015, with only 3 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).

Relative to historical values, regional ocean temperatures across the NEUS shelf were warm during 2015 (Figure 3). Annually, waters were approximately 0.4-1.7°C warmer than normal in all locations, with the largest anomalies occurring in the Middle Atlantic Bight. 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 Middle Atlantic Bight. During winter, regional upper ocean temperatures were near normal to slightly colder than normal except in the southern Middle Atlantic Bight. Bottom waters were warm year round in the eastern Gulf of Maine, and near normal to slightly colder than normal in the western Gulf of Maine, particularly during spring (Figure 3).

Annually, surface waters were generally saltier than normal in 2015, particularly in the Middle Atlantic Bight (Figure 4). Large anomalies were observed during fall and spring in the Middle Atlantic Bight, where anomalies approached 1 salinity unit. By comparison, bottom waters were slightly saltier than normal everywhere except the western Gulf of Maine, where conditions were near normal. The total volume of shelf water in the Middle Atlantic Bight, defined as waters having salinity less than 34, was reduced significantly in 2015 relative to the MARMAP period, particularly in spring in the southern Middle Atlantic Bight and during summer/early fall throughout the Middle Atlantic Bight (Figure 5). While the shelf water mass was warmer than normal, reflective of broader regional conditions, its salinity remained near normal in the spring and summer 2015, particularly in the southern Middle Atlantic Bight (Figure 5). This suggests that the anomalously salty conditions observed in the Middle Atlantic Bight (Figure 4) indicate a different water mass moving into the region, consistent with a significant shoreward movement of the shelf/slope front, a feature marking the transition between colder/fresher shelf water onshore and warmer/saltier slope water offshore.

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 6-8). The bimonthly property maps show that regional warming observed in the southern Middle Atlantic Bight during March-April and in the northern Middle Atlantic Bight during May-June (Figure 3) was largely concentrated along the shelf edge, with colder temperatures observed along the inner shelf (Figure 6b). While enhanced warming is also observed along the shelf edge during September-October, warm conditions are observed throughout the water column across the entire NEUS shelf during this period (Figure 8b). The large regional salinity anomalies observed at the surface in the Middle Atlantic Bight (Figure 4) reflect the enhanced positive anomalies aligned with regions of warming extending shoreward from the shelf edge in the northern/southern Middle Atlantic Bight in fall/spring (Figures 6b and 8b).

As in previous years, the extreme temperature and salinity anomalies observed at the shelf edge during summer and fall were accompanied by a procession of Gulf Stream warm core rings whose interaction with the topography at the shelf break drove an incursion of warm and salty water onto the middle shelf (e.g., Fratantoni et al. 2015). In 2015, the largest temperature and salinity anomalies were observed in the upper 20 m over the mid shelf and throughout the water column over the shelf break and upper slope (Figure 9). Gradients in the seasonal thermocline were enhanced by the inundation and appear to support the shoreward protrusion of high salinity water. Salty intrusions along the seasonal pycnocline are not uncommon in this region, representing an important mechanism for promoting exchange across the shelf slope front and setting shelf water properties (Lentz 2003). The impingement of warm, saline Gulf Stream water at the shelf break and the shoreward intrusion of slope water also appear to have eroded the cold pool – a seasonal bottom-trapped feature formed when winter-cooled shelf water is isolated from the surface by summer heating (Figure 9). Both the cold pool and the shelf slope front serve as critical habitat for fisheries on the NEUS shelf (Sullivan et al. 2005; Miller et al. 2016).

Deep inflow through the Northeast Channel continues to be dominated by Warm Slope Water (Figure 10). Springtime temperature-salinity profiles indicate the presence of a pronounced Cold Intermediate Layer in the western Gulf of Maine during 2015, a mid-depth water mass formed seasonally as a product of convective mixing driven by winter cooling (Figure 11). In fact, the remnant winter water resident in the Cold Intermediate Layer extends to the bottom of Wilkinson Basin in the spring of 2015, confirming that robust convective mixing took place in the preceding winter (Figure 12). This is not surprising, considering the fact that air temperatures over the northeastern US were more than 2°C colder than normal in 2015 (Figure 13). 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 and should result in a thicker intermediate layer during spring, both potentially having an impact on the timing or intensity of spring phytoplankton blooms.

Basin-Scale Conditions in 2015

During 2015, surface air temperatures were colder than average (1981-2010) over the North American continent, Labrador Sea, and central North Atlantic during winter and warmer than average during summer and fall, suggesting a larger seasonal range in 2015 (Figure 13). Sea surface temperature (SST) mirrored these patterns, with cooler than average SST in the central basin and near shore along the NEUS shelf during winter/spring and enhanced warming over the NEUS shelf in summer and fall (Figure 14). On average, the magnitude of the surface warming is comparable to that observed in the 1950s, but unlike the 1950s, 2015 is characterized by an increased seasonal range with enhanced warming in summer and fall (Figure 15). This warming is consistent with Friedland and Hare’s (2007) demonstration 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 (Visbeck et al. 2003; Petrie 2007). The NAO index was positive during the winter of 2015, indicative of a deepening of the Icelandic low and a strengthening of the Azores high (Figure 16). 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 between strongly negative and strongly positive anomalies 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

- Observations indicate that the seasonal range in ocean temperatures on the NEUS shelf is increasing, mirroring seasonal trends in air temperatures over the region, with greater warming occurring in spring and fall
- An intrusion of Gulf Stream ring water in the Middle Atlantic Bight contributed to enhanced warming and salinification in late-summer/early-fall and probably led to warming and erosion of the Cold Pool
- Anomalously cold winter air temperatures over the Northeastern US contributed to deeper mixing and colder, fresher intermediate/bottom waters in the western Gulf of Maine
- 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

Fratantoni PS, Holzwarth-Davis TJ, Taylor MH. 2015. Description of hydrographic conditions on the Northeast US shelf during 2014. Northeast Fish Sci Cent Ref Doc. 15-21; 49 p.

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-Davis 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.

Lentz S. 2003. A climatology of salty intrusions over the continental shelf from Georges Bank to Cape Hatteras. J Geophys Res. 108(C10):3326; doi:10.1029/2003JC001859.

Miller A, Shepherd G, Fratantoni PS. 2016. Offshore habitat preference of migrating juvenile and adult black sea bass, *Centropristis striata,* and the relationship to year-class success. PLOS ONE. 11(1): e0147627. doi: 10.1371/journal.pone.0147627.

Mountain DG. 2003. Variability in the properties of Shelf Water in the Middle Atlantic Bight, 1977-1999. J Geophys Res. 108(C1): 3014; doi:10.1029/2001JC001044.

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

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

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.

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

Sullivan MC, Cowen RK, Steves BP. 2005. Evidence for atmosphere-ocean forcing of yellowtail flounder (*Limanda ferruginea*) recruitment in the Middle Atlantic Bight. Fish Oceanogr. 14: 386-399.

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.

Table 1. Listing of 2015 NOAA Northeast Fisheries Science Center cruises supported by the oceans and climate 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
HB1501	Spring Bottom Trawl	14 Mar - 7 May	Full Shelf	SBE-19+V2,SBE-911+	390
EY1501	Apex Predators Survey	4 Apr - 18 May	Southern MAB	SBE-19+	50
HB1502	EcoMon	19 May - 2 Jun	Full Shelf	SBE-19+V2,SBE-911+	167
S11501	Scallop Survey	28 May - 16 Jun	GB, GOM	SBE-911+	54
HB1503	AMAPPS - Marine Mammal	11 Jun - 1 Jul	GB, Offshore	SBE-19+,SBE-19+V2,SBE-911+	52
HB1505	Benthic Habitat Survey	13 - 20 Aug	Southern MAB	SBE-19+	22
HB1506	Fall Bottom Trawl	2 Sep - 5 Nov	Full Shelf	SBE-19+V2,SBE-911+	386
GU1506	EcoMon	12 - 25 Oct	MAB, GB	SBE-19+V2,SBE-911+	123

[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 in 2015 for the 5 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	Temp	Anomaly	SDV1	SDV2	Flag	#obs	Temp	Anomaly	SDV1	SDV2	Flag
							January-February						
GOME													
GOMW													
GB													
MABN													
MABS													
							March-April						
GOME	108	15	4.49	-0.40	0.23	0.68	0	18	7.99	0.39	0.36	0.85	0
GOMW	114	49	5.71	0.01	0.18	0.53	0	48	5.12	-0.11	0.14	0.55	0
GB	104	54	5.83	0.37	0.19	1.10	0	56	6.52	0.50	0.19	0.96	0
MABN	92	52	4.61	-0.33	0.23	1.23	0	52	5.80	-0.32	0.26	1.63	0
MABS	81	91	8.11	1.68	0.20	4.00	0	91	7.07	0.19	0.23	1.70	0
							May-June						
GOME	143	44	7.96	0.40	0.15	1.05	0	44	7.64	0.62	0.17	0.67	0
GOMW	142	48	9.11	0.38	0.16	1.55	0	50	5.43	0.09	0.14	0.87	0
GB	154	80	10.98	1.09	0.16	2.24	0	77	8.50	0.67	0.15	1.09	0
MABN	143	24	12.47	1.74	0.36	2.27	0	24	8.07	0.09	0.43	2.11	0
MABS	141	44	15.33	1.04	0.27	1.65	0	41	8.95	0.32	0.33	1.36	0
							July-August						
GOME													
GOMW													
GB													
MABN													
MABS	227	21	25.48	1.19	1.78	0.47	1	21	14.56	0.26	1.86	1.35	1
							September-October						
GOME	290	25	13.80	1.25	0.18	0.69	0	35	9.41	0.95	0.21	1.21	0
GOMW	296	38	12.84	0.86	0.17	0.47	0	49	7.18	0.28	0.13	0.82	0
GB	287	84	16.69	1.91	0.15	2.11	0	101	14.36	1.90	0.15	1.99	0
MABN	273	52	20.42	2.45	0.23	1.50	0	68	15.30	2.83	0.23	2.04	0
MABS	261	97	23.98	2.44	0.19	1.23	0	117	15.71	2.26	0.21	3.53	0
							November-December						
GOME	305	1	10.91	0.57	0.72		1	2	10.69	2.00	0.78		1
GOMW	307	12	11.49	1.07	1.07	0.43	1	18	8.43	0.33	0.27	0.84	0
GB													
MABN													
MABS													

"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 in 2015 for the 5 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	108	15	32.30	-0.23	0.14	0.24	0	18	34.53	0.14	0.07	0.41	0
GOMW	114	49	32.88	0.32	0.08	0.27	0	48	33.37	-0.11	0.05	0.29	0
GB	104	54	33.07	0.07	0.07	0.43	0	56	33.62	0.22	0.06	0.31	0
MABN	92	52	33.17	0.31	0.10	0.41	0	52	33.68	0.07	0.09	0.43	0
MABS	81	91	34.14	0.98	0.11	0.75	0	91	34.38	0.57	0.08	0.36	0
May-June													
GOME	143	44	32.08	-0.29	0.08	1.14	0	44	34.13	0.13	0.05	0.35	0
GOMW	142	47	32.23	0.07	0.07	0.48	0	50	33.23	-0.02	0.05	0.27	0
GB	154	79	33.02	0.12	0.05	0.81	0	77	33.46	0.23	0.05	0.36	0
MABN	143	24	32.6979	0.2501	0.16	0.77	0	24	33.83	0.39	0.13	0.40	0
MABS	141	44	33.1508	0.9005	0.16	0.73	0	41	33.6726	0.2249	0.11	0.33	0
July-August													
GOME													
GOMW													
GB													
MABN													
MABS	227	21	32.19	0.38	1.10	0.32	1	21	33.19	0.03	0.68	0.32	1
September-October													
GOME	291	21	32.90	0.25	0.11	0.15	0	35	34.59	0.09	0.05	0.22	0
GOMW	296	35	32.63	0.13	0.08	0.13	0	48	33.64	-0.08	0.04	0.31	0
GB	287	75	33.49	0.72	0.05	0.91	0	101	33.70	0.53	0.05	0.69	0
MABN	272	43	33.78	0.91	0.11	0.62	0	68	33.96	0.41	0.08	0.56	0
MABS	261	95	32.97	0.67	0.12	0.72	0	116	33.76	0.24	0.07	0.75	0
November-December													
GOME	305	1	33.02	0.01	0.35		1	2	33.66	-0.16	0.37		1
GOMW	307	12	32.69	0.02	0.46	0.32	1	18	33.41	0.11	0.09	0.27	0
GB													
MABN													
MABS													

"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.

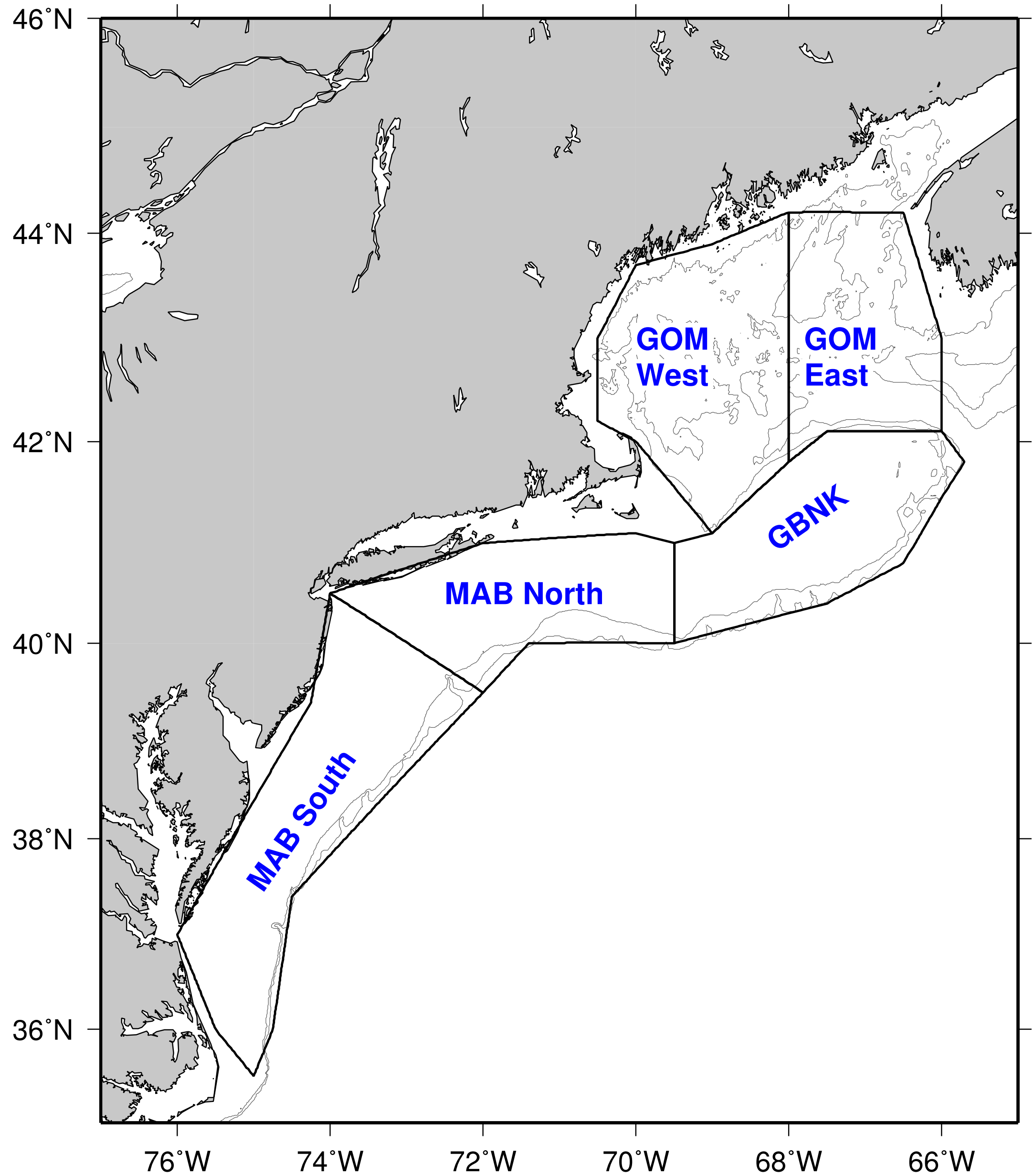


Figure 1. Regional designations used in the description of 2015 oceanographic conditions on the Northeast US Continental Shelf. The 100 m and 200 m isobaths are also shown. MAB = Middle Atlantic Bight; GBNK = Georges Bank; GOM = Gulf of Maine.

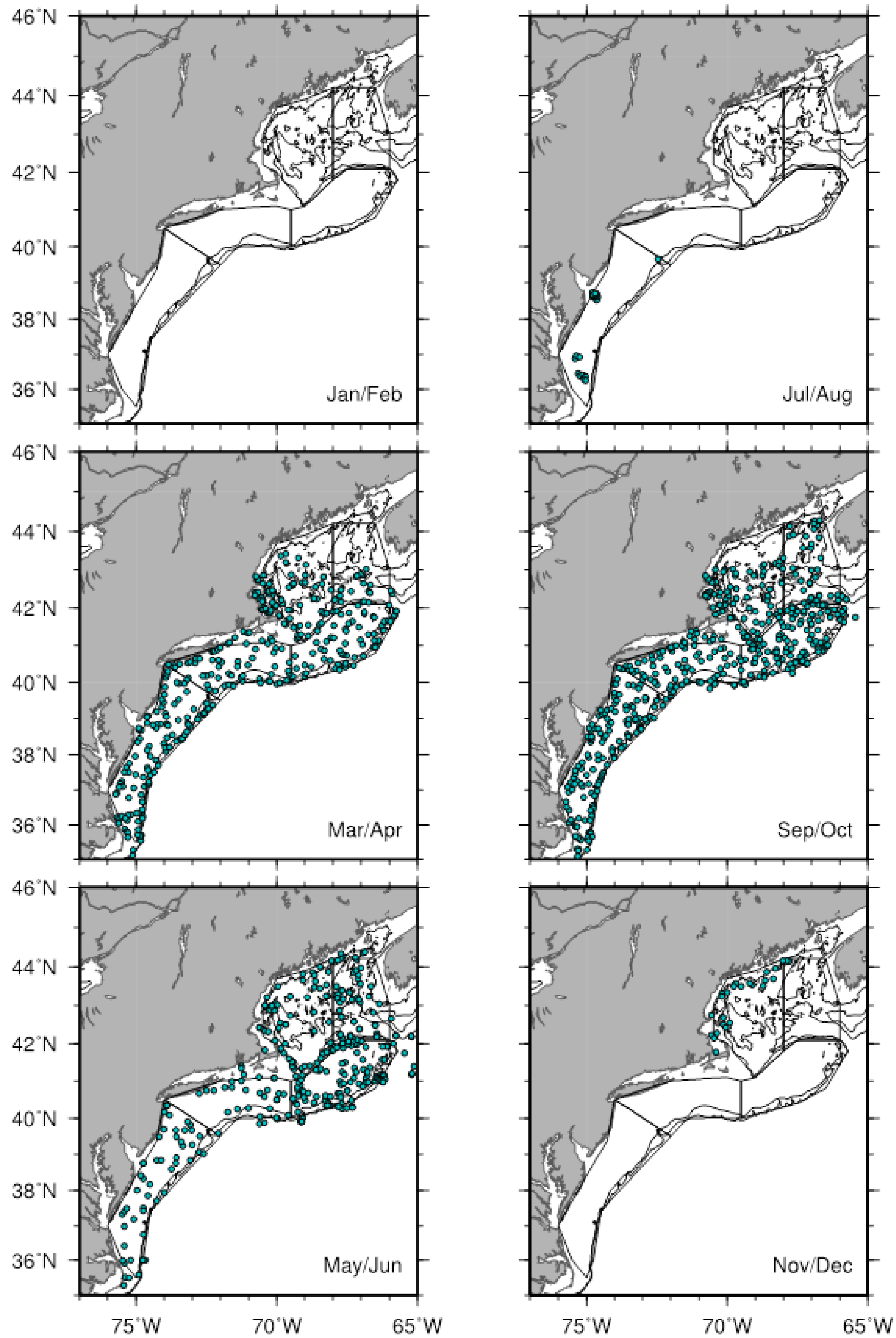


Figure 2a. Bimonthly distribution of hydrographic stations used in the description of 2015 oceanographic conditions on the Northeast US Continental Shelf. Regional boundaries used in the analysis are also shown. Contours correspond with the 100- and 200-m isobaths.

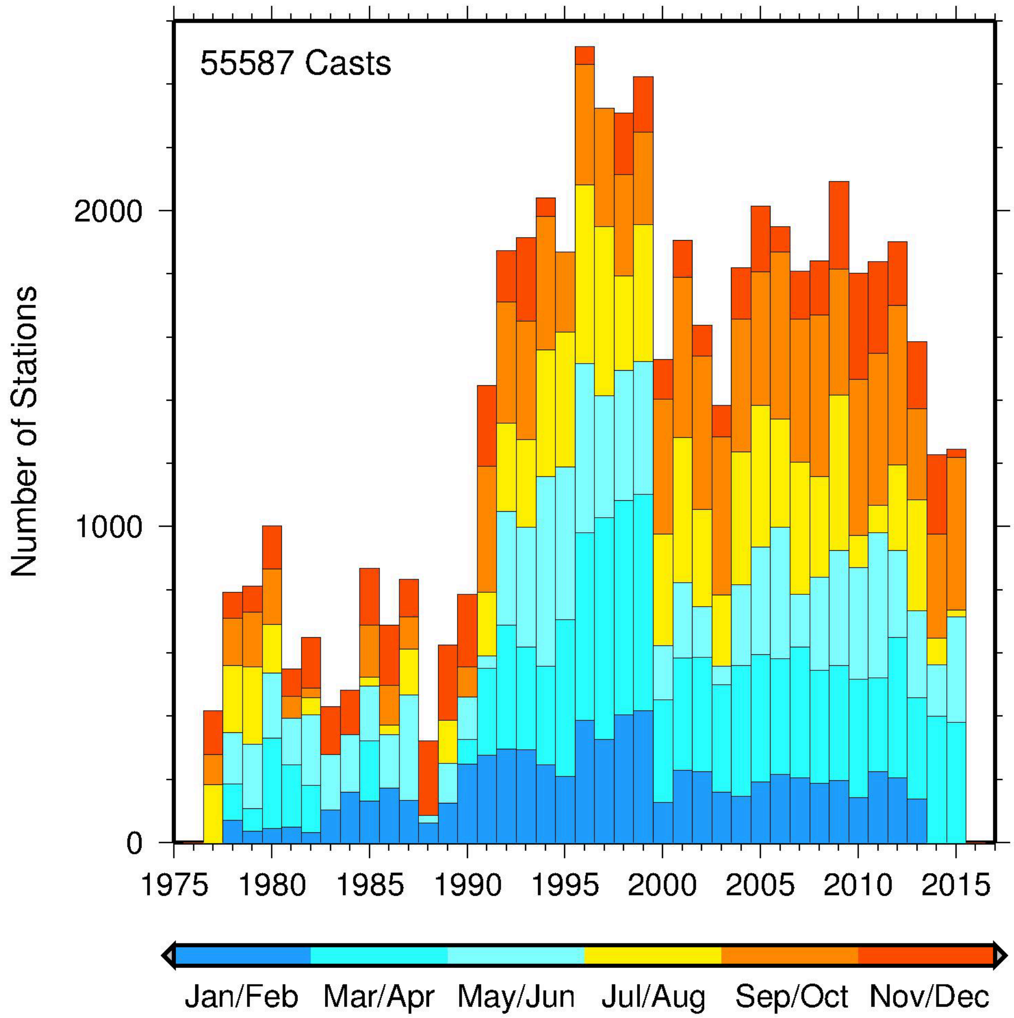


Figure 2b. Histogram of the number of hydrographic stations occupied on Northeast Fisheries Science Center surveys in a given year, color-coded by bimonthly period.

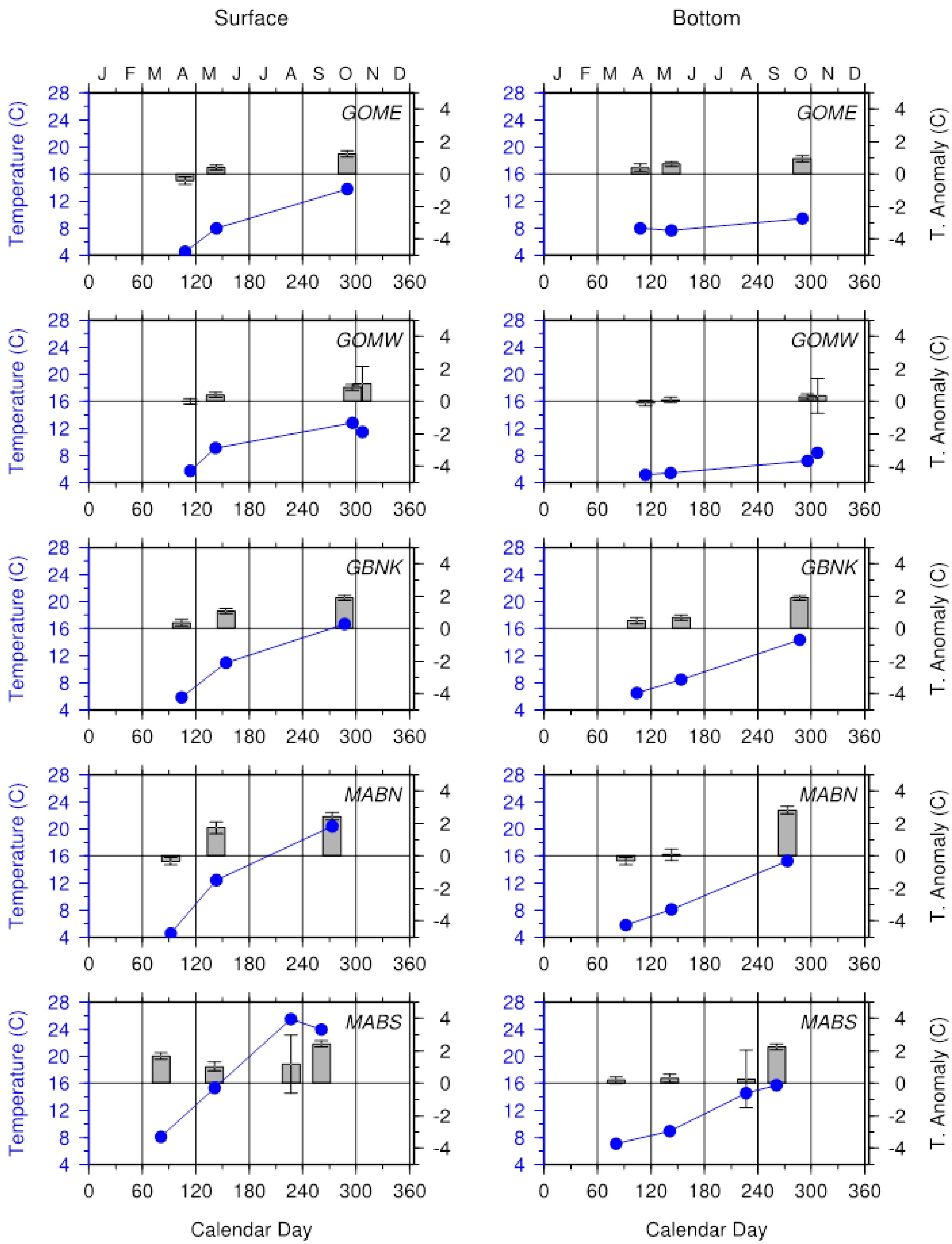


Figure 3. Time series of the 2015 regional surface (left) and bottom (right) temperatures (blue) and anomalies (bars) as a function of calendar day. Error bars are indicated for the anomaly estimates. GOME = Gulf of Maine east; GOMW = Gulf of Maine west; GBNK = Georges Bank; MABN = Middle Atlantic Bight north; MABS = Middle Atlantic Bight south.

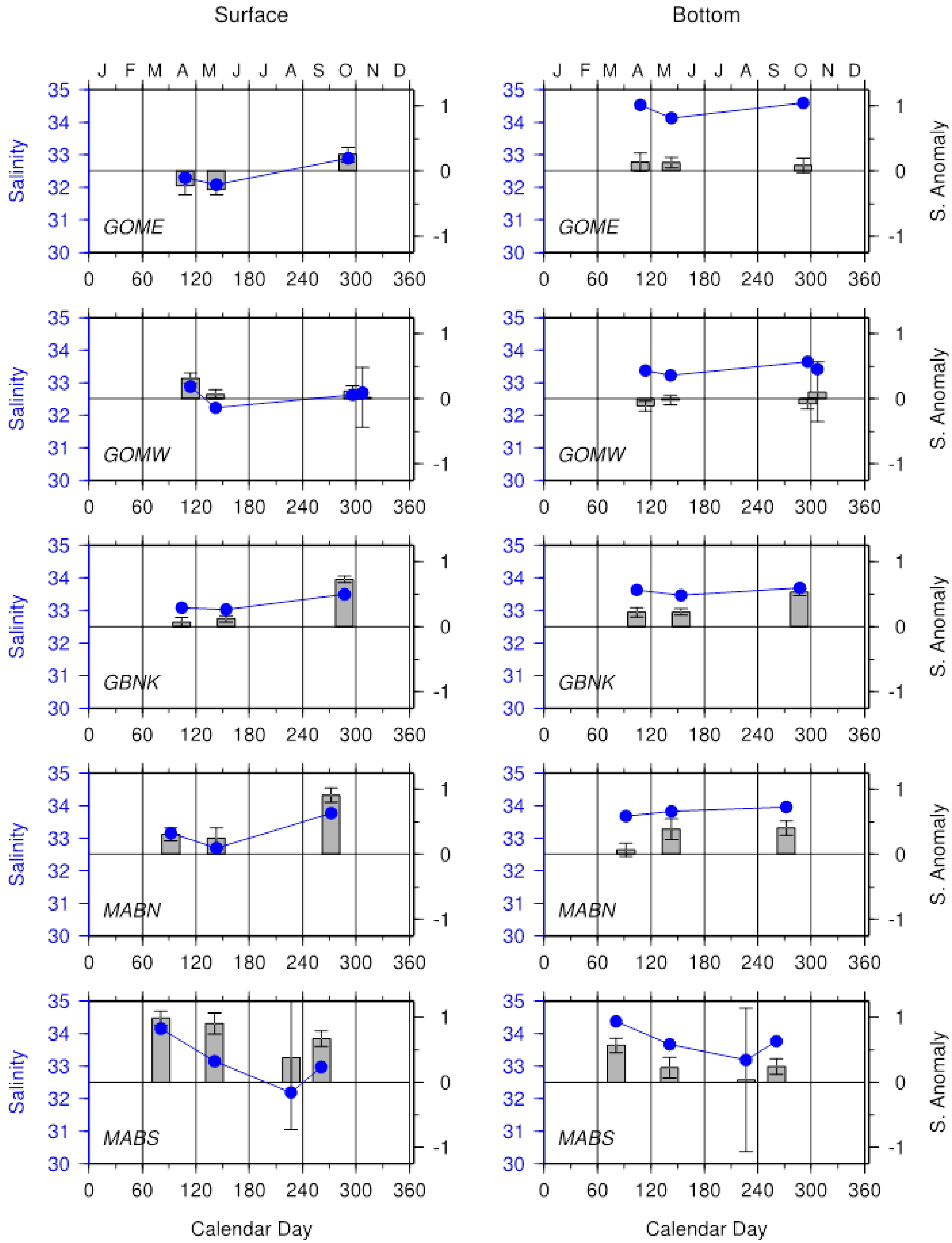


Figure 4. Time series of the 2015 regional surface (left) and bottom (right) salinities (blue) and anomalies (bars) as a function of calendar day. Error bars are indicated for the anomaly estimates. GOME = Gulf of Maine east; GOMW = Gulf of Maine west; GBNK = Georges Bank; MABN = Middle Atlantic Bight north; MABS = Middle Atlantic Bight south.

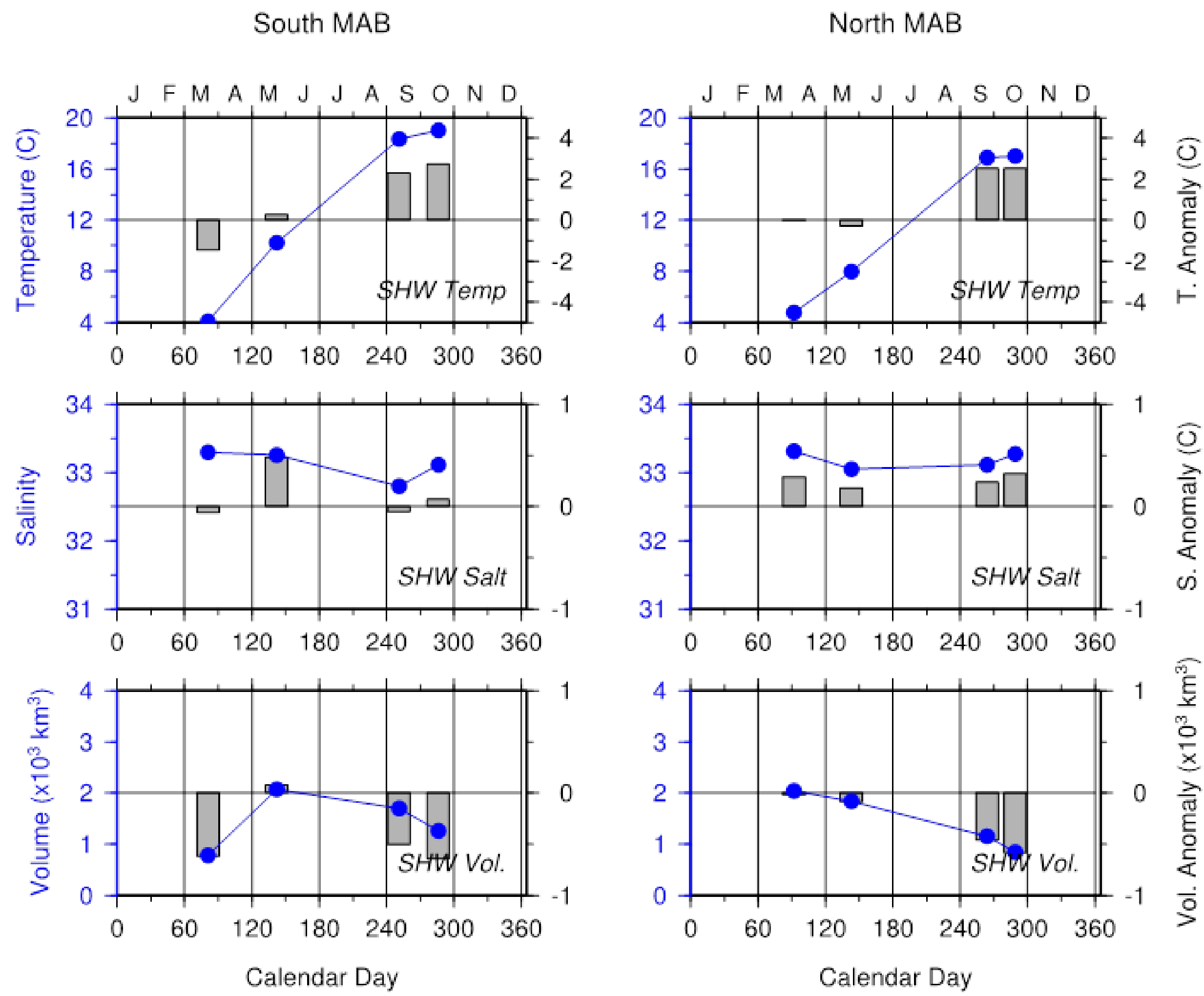


Figure 5. Time series of the 2015 regional shelf water (SHW) temperature, salinity, and volume as a function of calendar day shown in blue for the southern (left) and northern (right) Middle Atlantic Bight. The vertical bars show the corresponding shelf water anomalies.

Mar/Apr, 2015

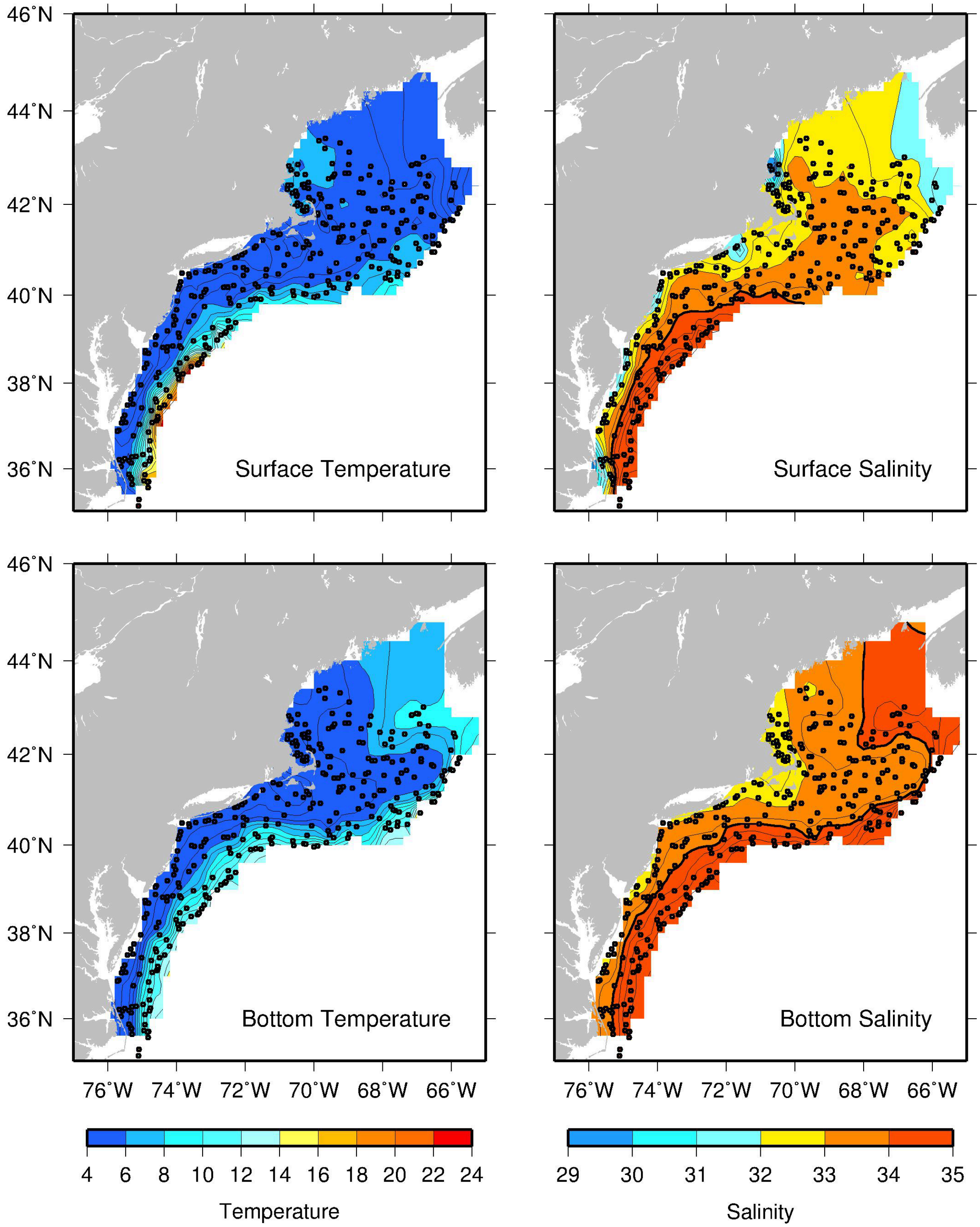


Figure 6a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during March-April 2015. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

Mar/Apr, 2015

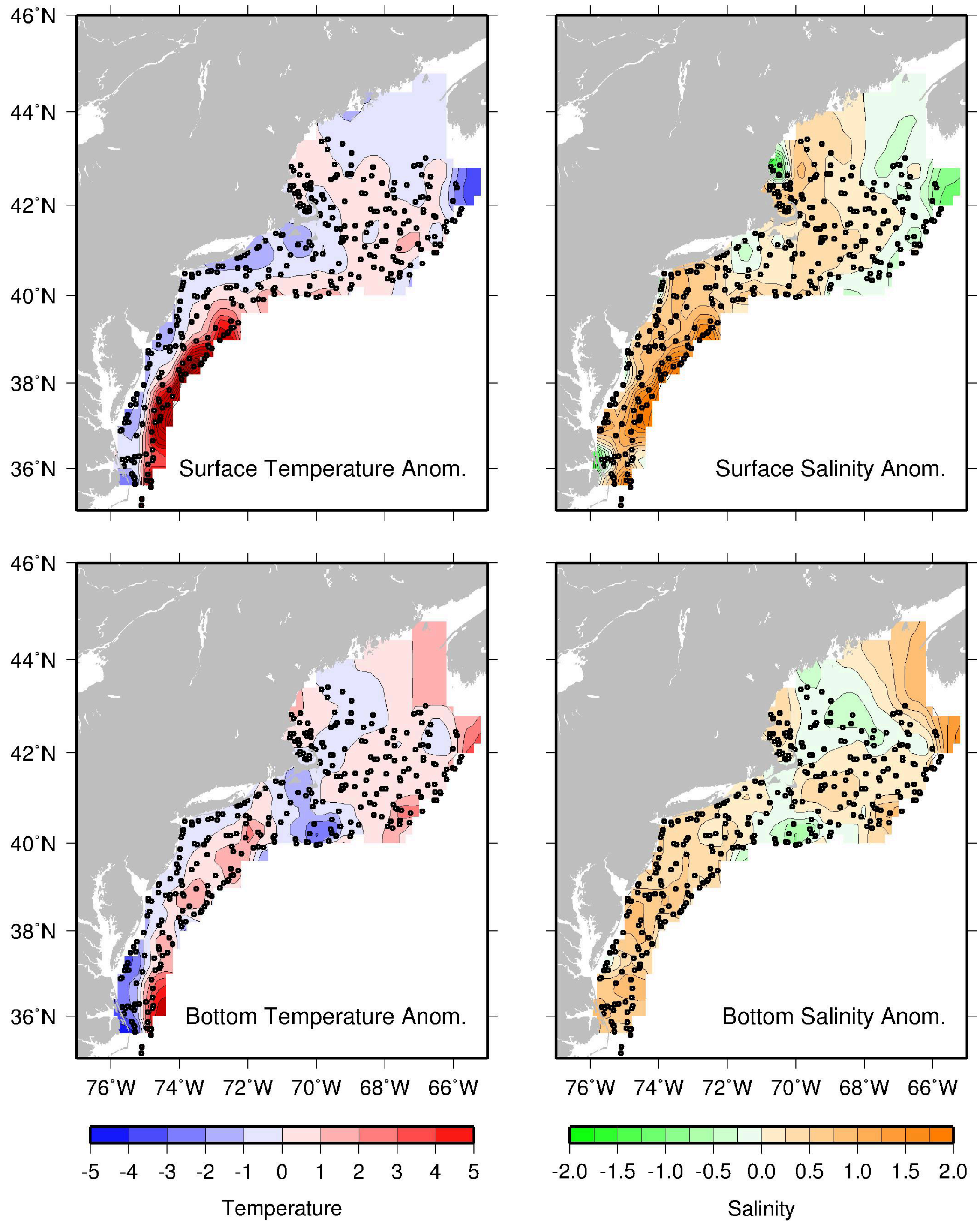


Figure 6b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during March-April 2015. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

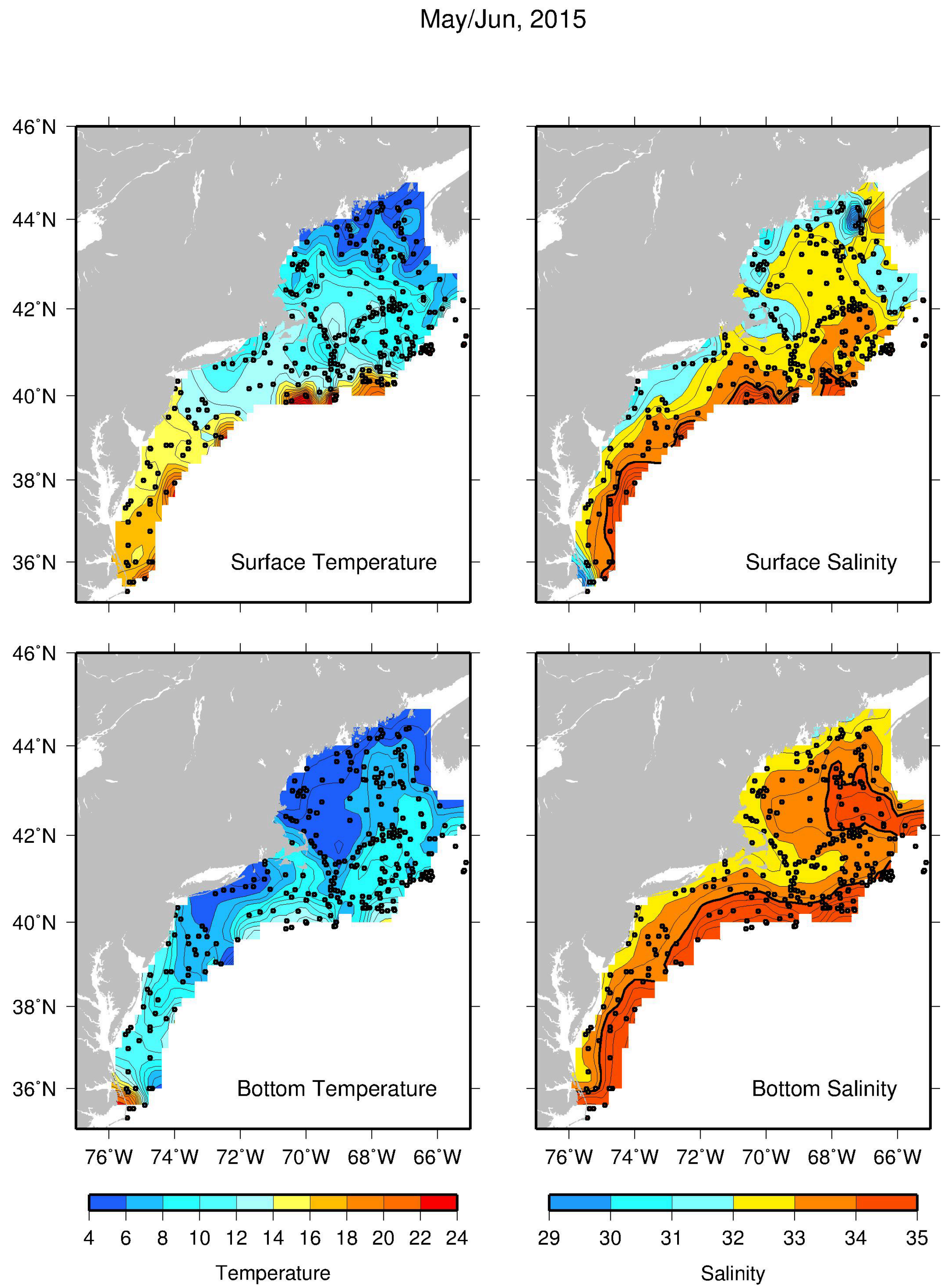


Figure 7a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during May-June 2015. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

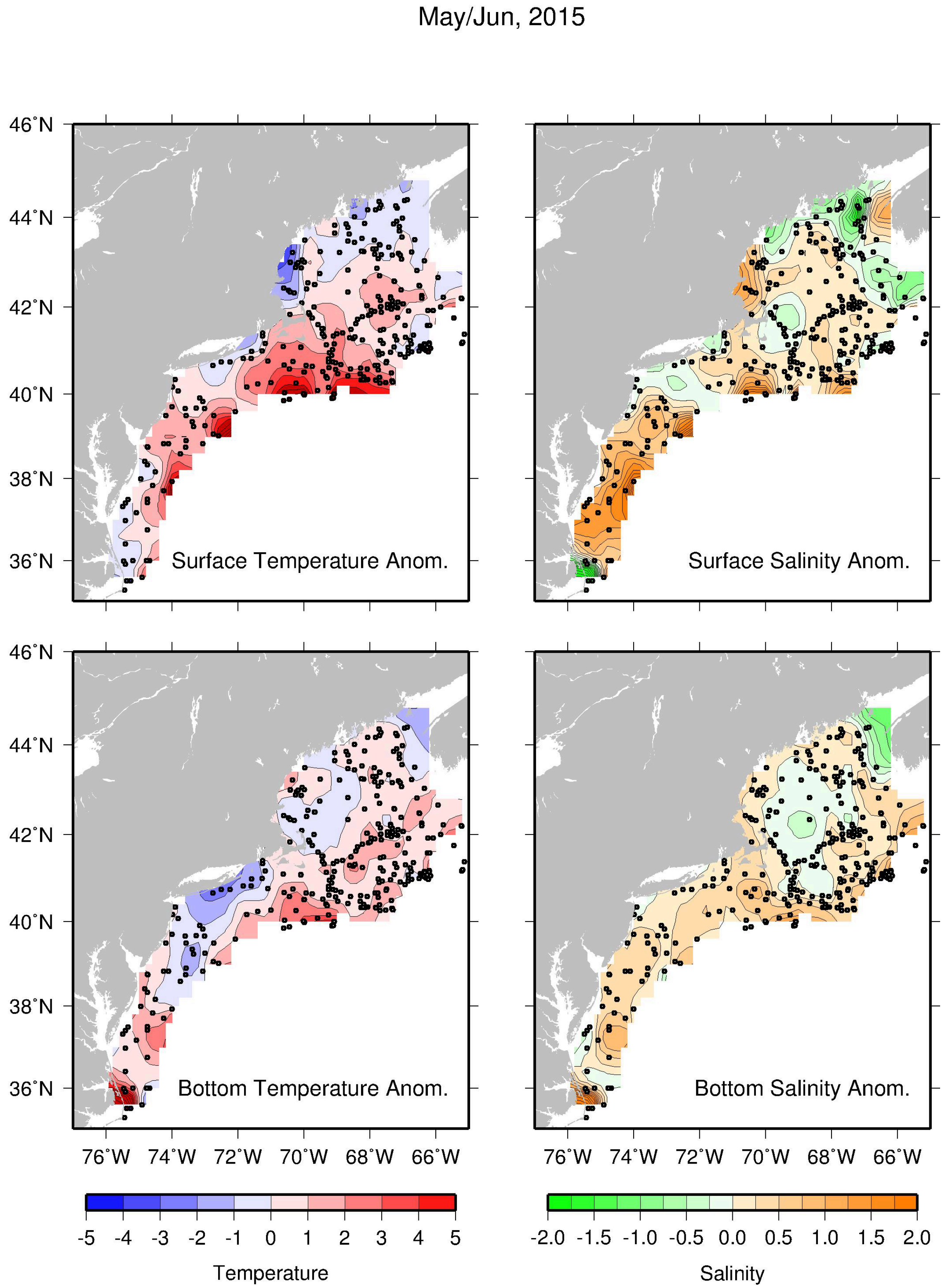


Figure 7b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during May-June 2015. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

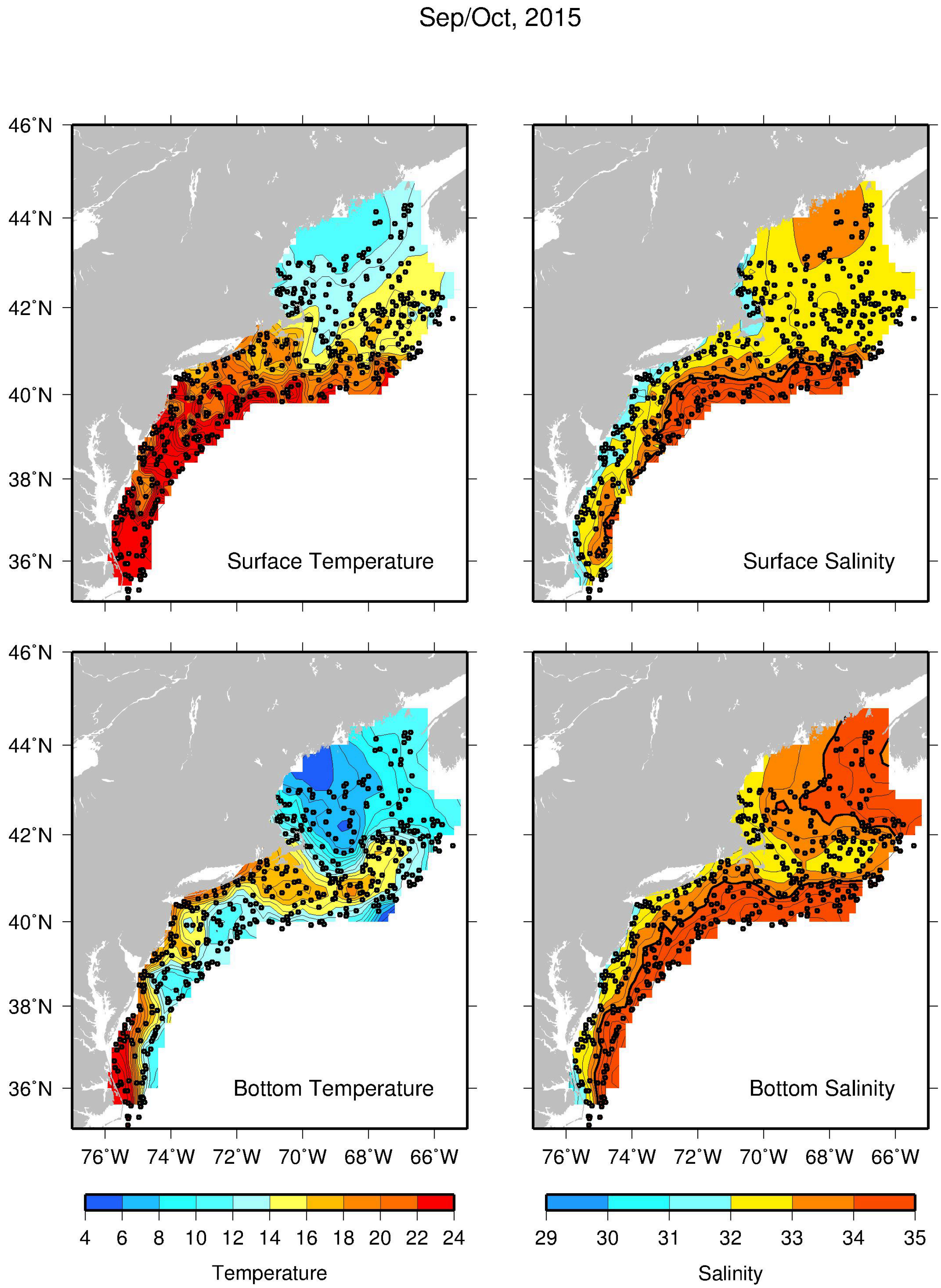


Figure 8a. Near-surface (top) and near-bottom (bottom) temperature (left) and salinity (right) distributions on the Northeast US Continental Shelf during September-October 2015. Temperature and salinity are contoured in increments of 1ºC and 0.5, respectively. The 34 isohaline is denoted by the heavier contour.

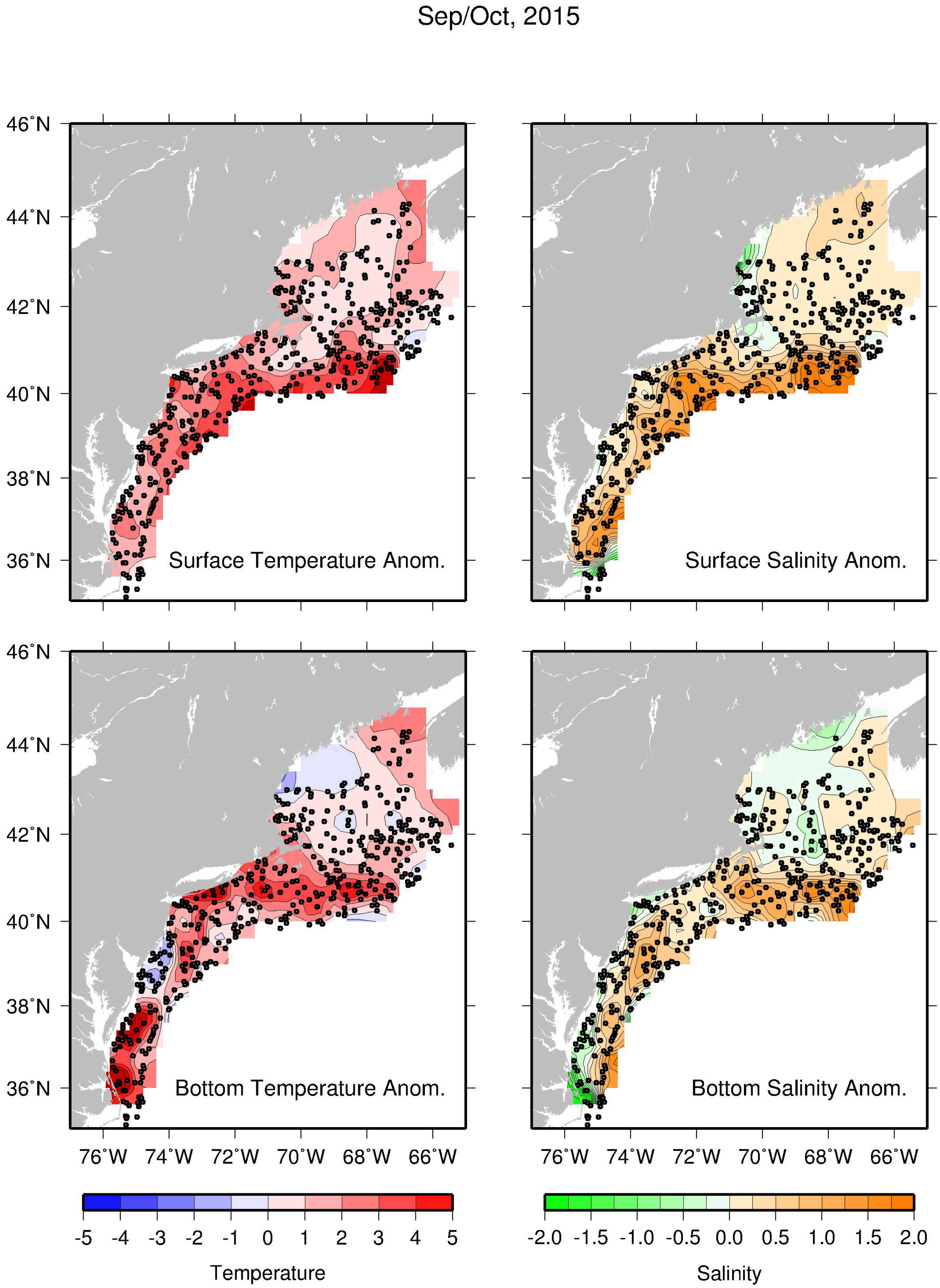


Figure 8b. Near-surface and near-bottom temperature anomaly (left) and salinity anomaly (right) distributions on the Northeast US Continental Shelf during September-October 2015. Temperature and salinity anomaly are contoured in increments of 1ºC and 0.5, respectively.

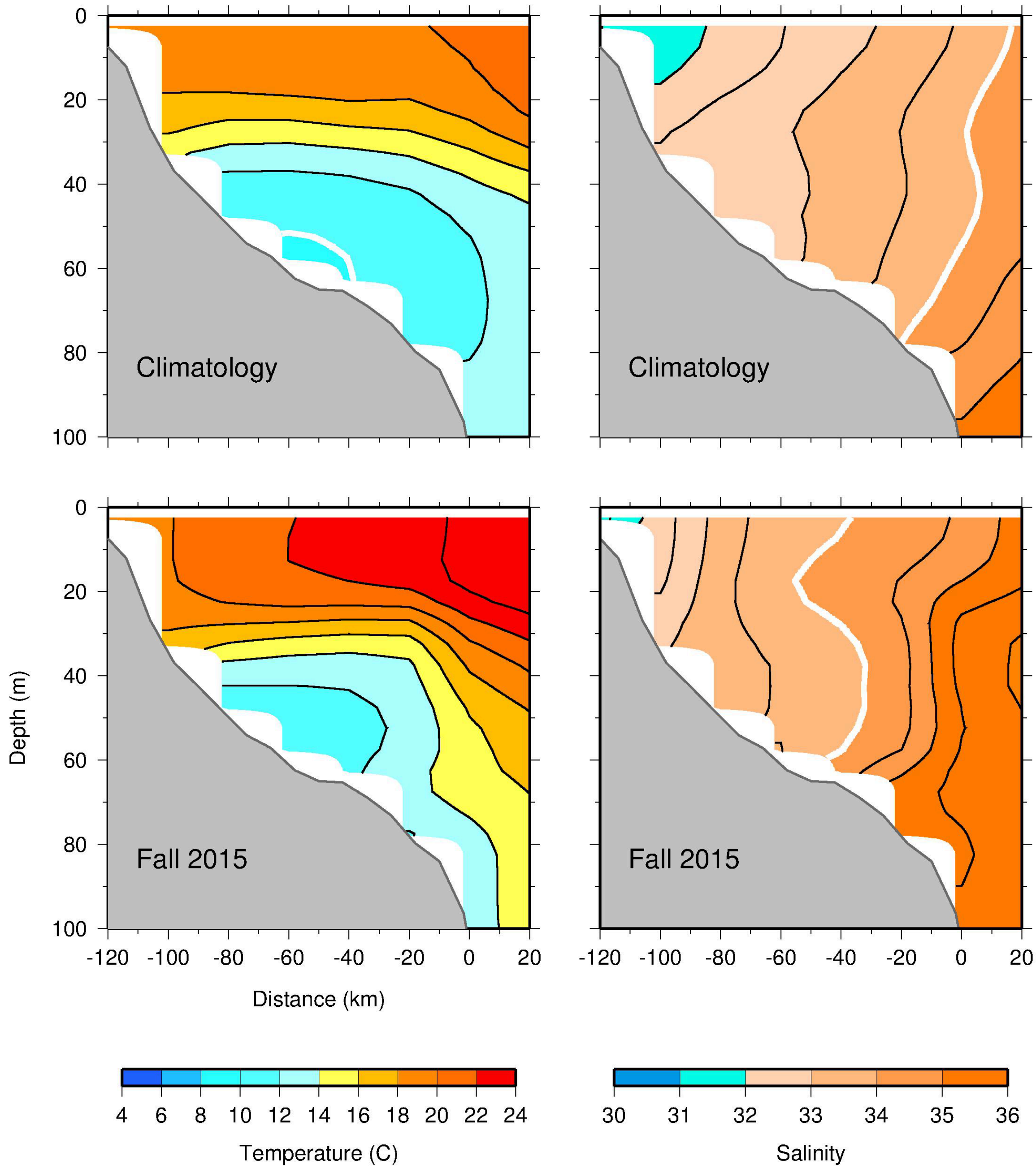


Figure 9. Vertical sections of temperature (left) and salinity (right) crossing the Northeast US Continental Shelf in the Middle Atlantic Bight. The top panels show the climatological average for September spanning the years 1981-2010. The bottom panels show the synoptic mean section for September 2015. 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.

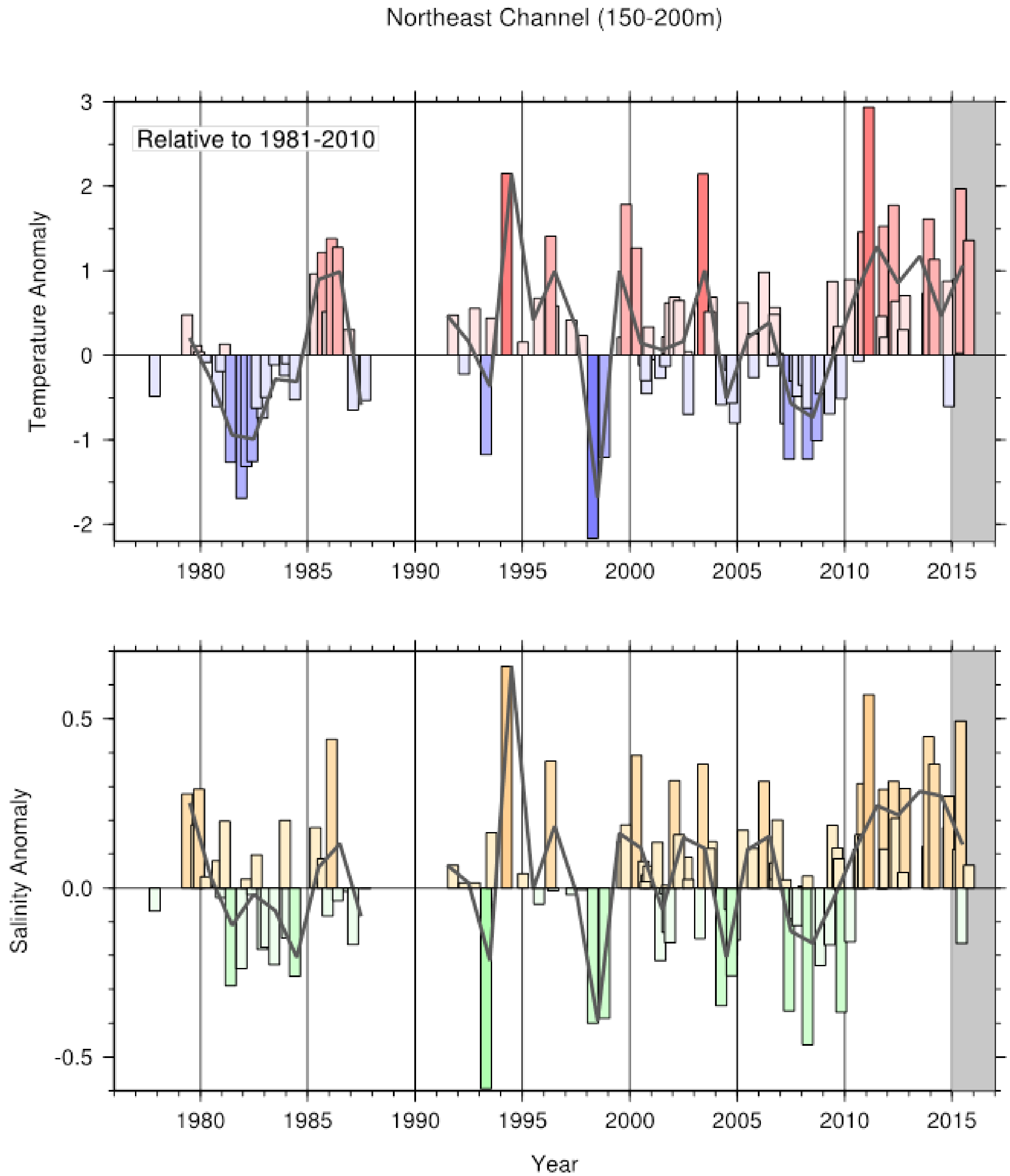


Figure 10. Time series of temperature and salinity anomaly in the deep Northeast Channel. Each bar represents a volume-weighted average of all observations from a single survey collected between 150-200 meters in the Northeast Channel. The grey curve shows the annual average anomaly time series. Positive values are warmer and saltier than the long-term mean calculated for 1981-2010. The gray shading highlights sampling done in 2015.

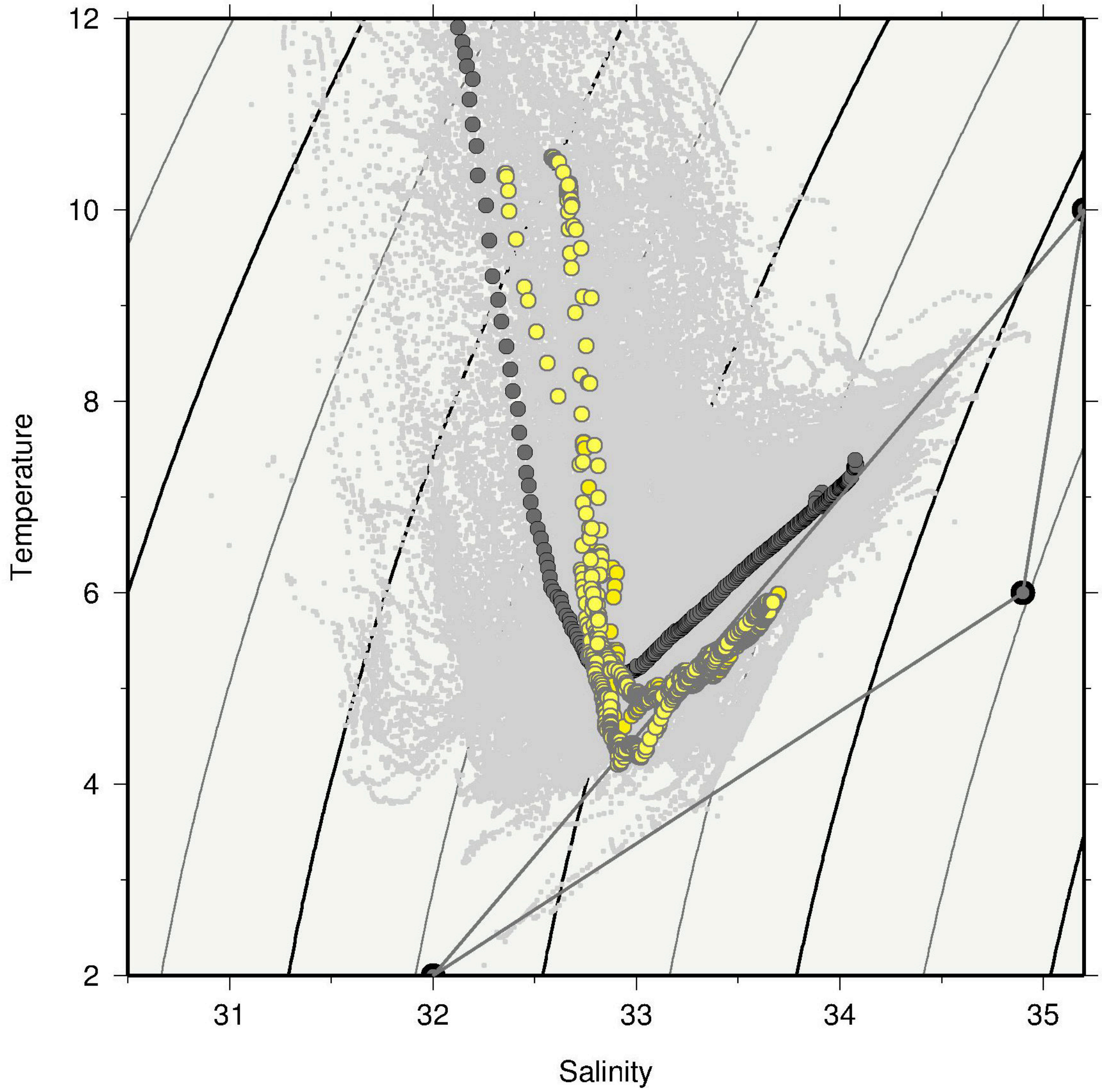


Figure 11. Temperature-salinity diagram showing water properties in Wilkinson Basin in the western Gulf of Maine. All observations from spring 2015 (yellow) are shown along with the spring climatological average profile (1981-2010, dark gray). The lightest gray dots show the historical range encompassed by observations from the reference period, 1981-2010.

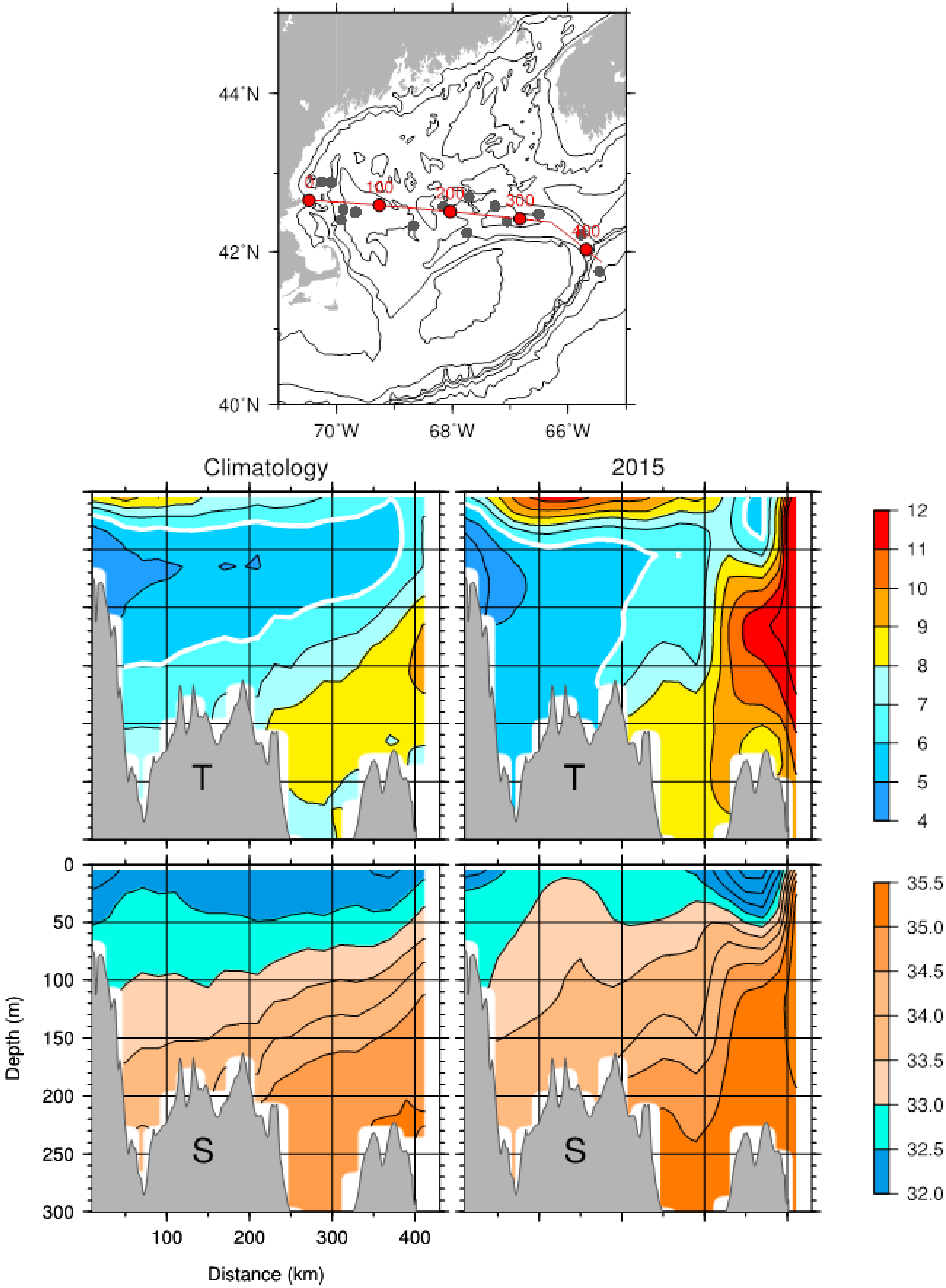


Figure 12. Vertical sections of temperature (top) and salinity (bottom) crossing the Gulf of Maine along a zonal transect shown in the map. The left panels show the climatological average for May spanning the years 1981-2010. The right panels show the synoptic mean section for May 2015. The heavy white contour highlights the 6°C isotherm as an indicator of the boundary of the Cold Intermediate Layer. Along-transect distances and the May 2015 station distribution are shown on the map for reference.

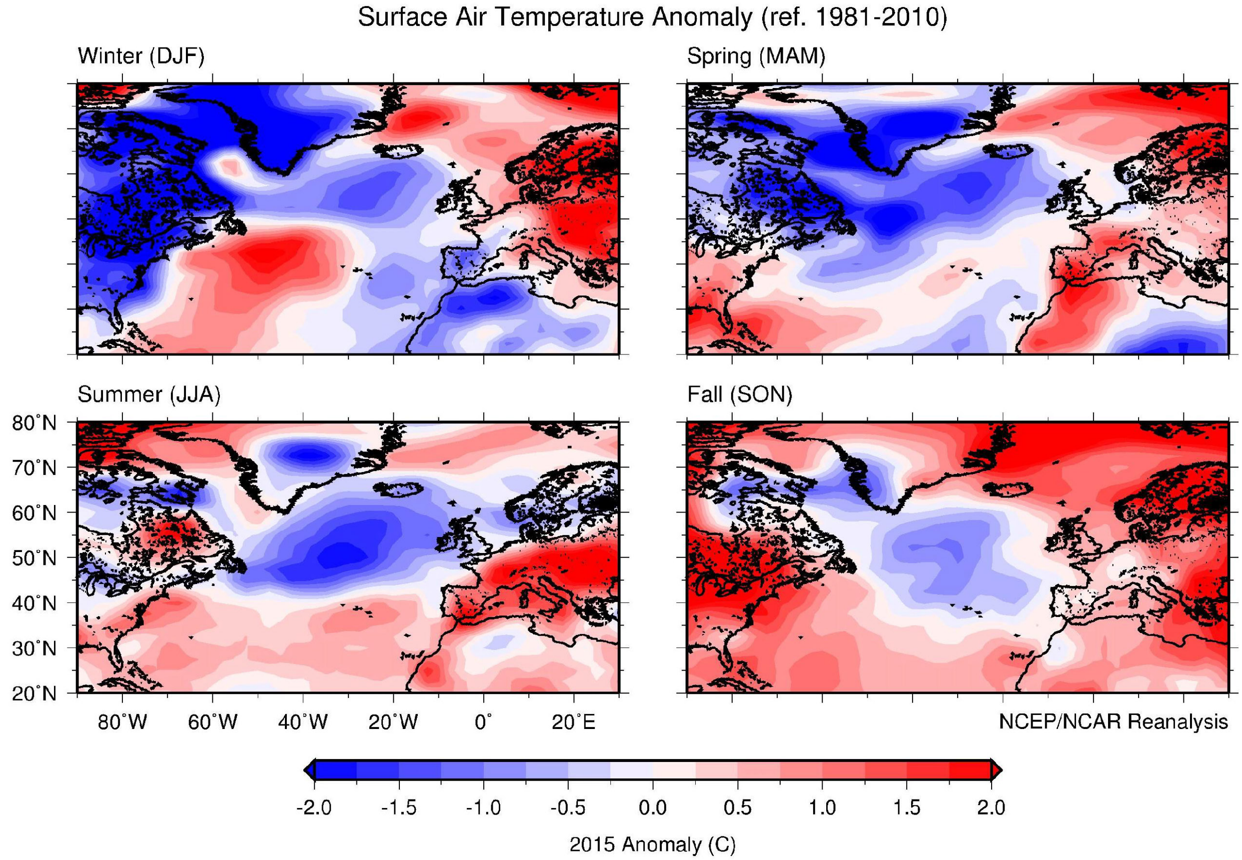


Figure 13. Surface air temperature anomaly on the Northeast US Continental Shelf derived from the NCEP/NCAR Reanalysis product. Seasons are made up of 3-month periods: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov). Positive anomalies correspond to warming in 2015 relative to the reference period (1981-2010).

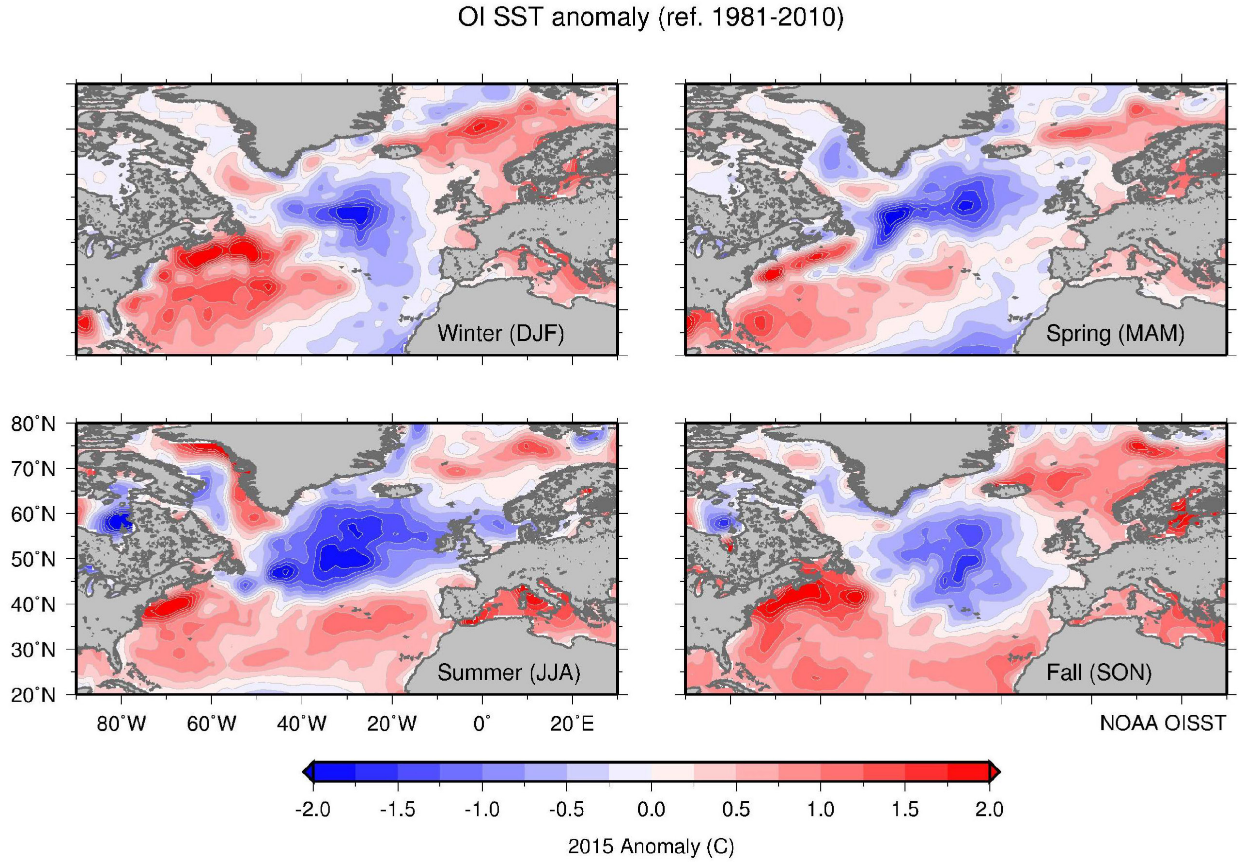
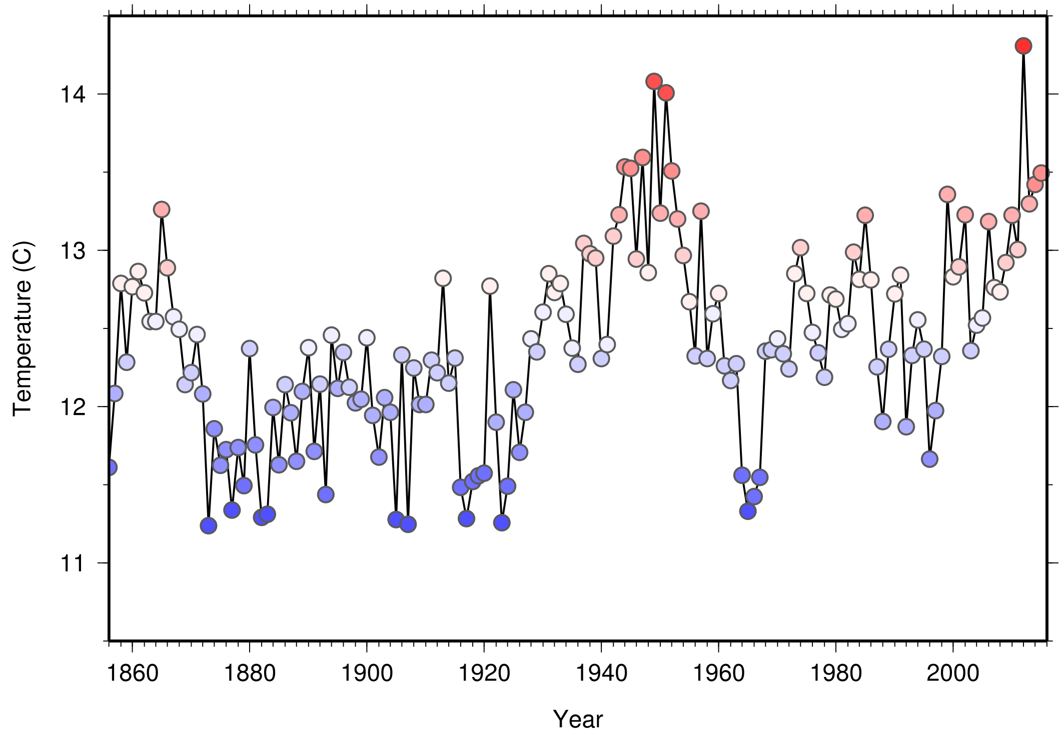


Figure 14. Sea surface temperature (SST) anomaly on the Northeast US Continental Shelf. derived from NOAA's Optimum Interpolation (OI) SST product. Seasons are made up of 3-month periods: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov). Positive anomalies correspond to warming in 2015 relative to the reference period (1981-2010).



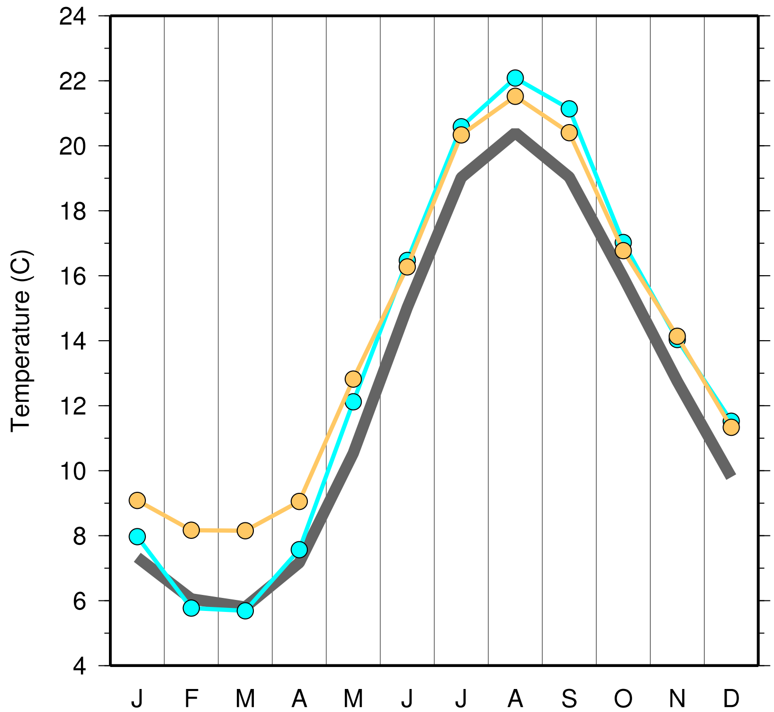


Figure 15. (Top) Regional average annual Sea Surface Temperature (SST) for the Northeast US (NEUS) Continental Shelf region calculated from NOAA's extended reconstructed sea surface temperature product. Regional average monthly mean SST for the NEUS shelf for 2015 (cyan), 1951 (orange) and 1981-2010 (gray) calculated from the same product.

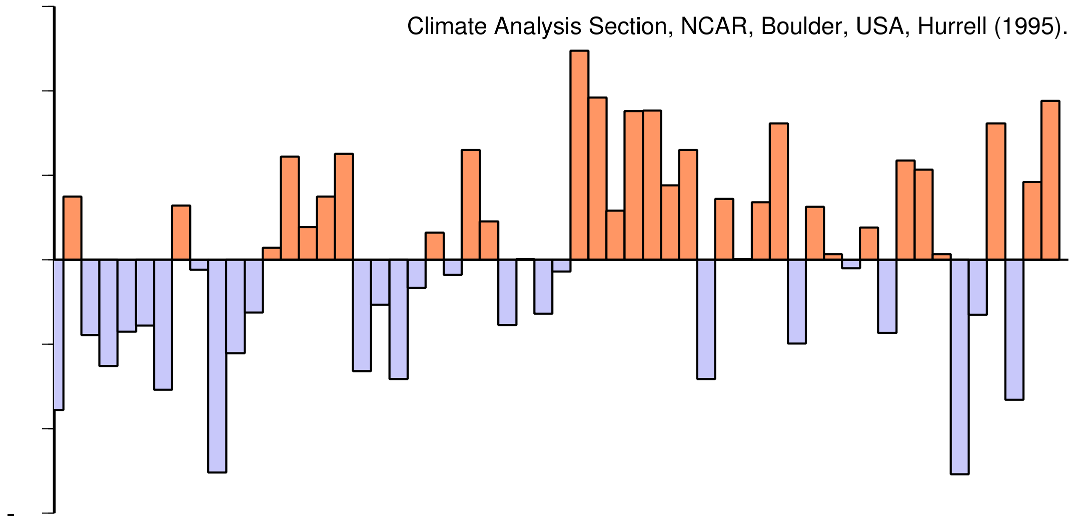


Figure 16. North Atlantic Oscillation index computed from principal component analysis of sea level pressure in the North Atlantic (see Hurrell 1995) from 1960-2015.

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) in 2015. 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
EY1501													
HB1505													
HB1501	116	36	5.19	-0.22	0.15	0.62	0	33	7.49	0.38	0.20	0.80	0
HB1502	150	22	8.45	0.30	0.21	1.09	0	18	7.85	0.77	0.27	0.67	0
S11501	157	5	9.95	0.11	0.84	0.42	1	5	7.10				1
HB1503	165	6	12.26	2.00	0.87	0.50	1	6	8.56	0.75	0.86	0.13	1
HB1506	292	40	13.61	1.20	0.13	0.59	0	38	9.41	0.97	0.21	1.19	0
GU1506													1

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1505													
HB1501	116	36	32.17	-0.30	0.08	1.24	0	33	34.15	0.04	0.05	0.37	0
HB1502	150	22	32.25	-0.08	0.12	0.35	0	18	34.32	0.24	0.08	0.39	0
S11501	157	5	32.89	0.20	0.33	0.12	1	5	33.21				1
HB1503	165	6	32.55	0.02	0.37	0.15	1	6	34.55	0.12	0.22	0.14	1
HB1506	292	40	32.92	0.26	0.08	0.15	0	38	34.60	0.09	0.05	0.22	0
GU1506													

"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) in 2015. 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
EY1501													
HB1505													
HB1501	117	70	5.84	0.08	0.13	0.84	0	68	5.09	0.00	0.12	0.68	0
HB1502	152	21	10.10	0.07	0.25	2.00	0	20	5.51	-0.19	0.21	0.64	0
S11501	158	6	10.73	-0.14	1.04	0.91	1	7	6.64	0.43	1.02	0.96	1
HB1503	163	4	13.43	2.05	1.00	0.34	1	3	5.78	0.65	0.63	1.18	1
GU1506	293	15	13.23	0.89	1.11	0.46	1	12	8.17	0.04	0.97	1.05	1
HB1506	300	58	12.44	0.98	0.14	0.48	0	57	7.45	0.32	0.12	0.77	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1505													
HB1501	117	70	32.66	0.20	0.06	0.49	0	68	33.30	-0.04	0.04	0.30	0
HB1502	152	21	32.30	0.22	0.10	0.39	0	20	33.36	-0.08	0.07	0.23	0
S11501	158	6	32.41	0.04	0.39	0.44	1	7	32.85	0.01	0.35	0.17	1
HB1503	163	4	32.15	-0.17	0.37	0.15	1	3	33.61	0.15	0.27	0.48	1
GU1506	293	15	32.41	0.08	0.49	0.16	1	12	33.13	-0.16	0.30	0.31	1
HB1506	300	58	32.69	0.09	0.06	0.21	0	57	33.64	-0.02	0.04	0.30	0
EY1501													

"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) in 2015. 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
EY1501													
HB1505													
HB1501	105	57	5.80	0.27	0.19	1.11	0	57	6.55	0.50	0.19	0.98	0
HB1502	148	37	9.64	0.43	0.24	1.18	0	35	8.62	0.77	0.22	1.07	0
S11501	161	33	11.32	0.83	0.27	1.70	0	33	8.41	0.14	0.23	0.91	0
HB1503	174	12	16.98	3.58	0.53	3.63	0	9	8.79	1.77	0.58	1.08	0
HB1506	282	64	17.87	2.69	0.18	2.18	0	62	14.58	2.06	0.19	2.16	0
GU1506	295	38	15.37	1.20	0.24	1.50	0	39	14.14	1.84	0.23	1.70	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1505													
HB1501	105	57	33.07	0.06	0.06	0.45	0	57	33.63	0.23	0.06	0.32	0
HB1502	148	37	32.84	-0.10	0.08	0.52	0	35	33.52	0.29	0.08	0.29	0
S11501	161	33	32.98	0.12	0.08	0.52	0	33	33.22	0.10	0.08	0.30	0
HB1503	174	12	34.02	1.03	0.19	1.37	0	9	34.38	0.55	0.21	0.67	0
HB1506	282	64	33.73	0.94	0.06	0.97	0	62	33.83	0.59	0.06	0.73	0
GU1506	295	38	33.16	0.41	0.07	0.60	0	39	33.47	0.46	0.07	0.62	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) in 2015. 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

			Surface						Bottom				
Cruise	CD	#obs	Temp	Anomaly	SDV1	SDV2	Flag	#obs	Temp	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1505													
HB1501	93	52	4.61	-0.38	0.23	1.24	0	52	5.80	-0.34	0.26	1.64	0
HB1502	143	22	12.14	1.37	0.37	1.71	0	22	8.12	0.06	0.44	2.14	0
S11501	148	2	13.56	3.79	1.42		1	2	8.94	1.43	1.93		1
HB1503	176												1
HB1506	265	51	21.58	2.92	0.24	1.33	0	50	14.56	2.17	0.28	1.69	0
GU1506	289	20	17.97	1.71	0.36	1.32	0	20	16.47	3.82	0.37	2.33	0

			Surface						Bottom				
Cruise	CD	#obs	Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Salinity	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1505													
HB1501	93	52	33.17	0.32	0.10	0.41	0	52	33.68	0.07	0.09	0.43	0
HB1502	143	22	32.63	0.19	0.16	0.55	0	22	33.84	0.40	0.13	0.37	0
S11501	148	2	33.01	0.29	0.44	NaN	1	2	33.87	0.58	0.65		1
HB1503	176												1
HB1506	265	51	33.64	0.97	0.10	0.66	0	50	33.85	0.30	0.09	0.46	0
GU1506	289	20	33.72	0.80	0.16	0.65	0	20	34.37	0.68	0.13	0.61	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) in 2015. 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
EY1501													
HB1503													
S11501													
HB1501	82	96	8.28	1.75	0.19	4.05	0	91	7.07	0.16	0.23	1.71	0
HB1502	142	44	15.32	0.85	0.27	1.65	0	42	8.96	0.29	0.33	1.33	0
HB1505	228	21	25.48	1.19	1.78	0.47	1	21	14.56	0.17	1.86	1.33	1
HB1506	252	94	25.73	3.04	0.19	1.06	0	91	14.74	1.47	0.23	3.58	0
GU1506	287	28	19.69	1.36	0.34	1.34	0	25	18.36	4.08	0.45	2.61	0

Cruise	CD	#obs	Surface Salinity	Anomaly	SDV1	SDV2	Flag	#obs	Bottom Salinity	Anomaly	SDV1	SDV2	Flag
EY1501													
HB1503													
S11501													
HB1501	82	96	34.18	1.01	0.11	0.75	0	91	34.38	0.57	0.08	0.36	0
HB1502	142	44	33.15	0.91	0.16	0.73	0	42	33.67	0.23	0.11	0.33	0
HB1505	228	21	32.19	0.37	1.10	0.32	1	21	33.19	0.03	0.68	0.32	1
HB1506	252	94	32.74	0.55	0.11	0.74	0	91	33.61	0.03	0.08	0.63	0
GU1506	287	28	33.41	0.86	0.22	0.73	0	25	34.07	0.80	0.17	0.69	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 2015. 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					
92	5.63	-0.19	33.56	0.25	4.77	-0.02	33.31	0.29	2036.86	-18.61
143	9.27	0.29	33.65	0.44	7.98	-0.29	33.05	0.18	1835.56	-86.56
264	18.16	3.36	34.40	0.81	16.89	2.51	33.11	0.24	1156.70	-459.06
289	17.83	2.87	34.32	0.64	17.00	2.52	33.27	0.32	846.76	-584.17
					MABS					
81	9.67	1.74	34.85	0.95	4.07	-1.49	33.30	-0.06	779.65	-622.39
142	11.38	0.95	33.91	0.52	10.25	0.28	33.26	0.48	2067.57	75.33
251	18.32	1.92	34.08	0.65	18.32	2.31	32.80	-0.05	1694.38	-505.39
286	19.05	3.11	34.23	0.51	19.01	2.73	33.11	0.07	1256.17	-643.96

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