Fall 2014 Update: Annual Condition of the Northeast Shelf Ecosystem

Produced by the Ecosystem Dynamics and Assessment Branch

Published by Northeast Fisheries Science Center

October 14, 2014

Northeast Fisheries Science Center

166 Water Street

Woods Hole MA 02543-1026

Phone: (508) 495-2000

Fall 2014 Update: Summary of Conditions for the Northeast Shelf Ecosystem

Summary

- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem during the first half of 2014 continued to moderate compared to the record high temperatures that occurred in 2012; however, temperatures remain above the long-term mean based on both contemporary satellite remote-sensing data and ship-board measurements.
- This moderating effect in temperature was not uniform over the ecosystem. The northern ecoregions of the Gulf of Maine and Georges Bank remained relatively warm whereas the Middle Atlantic Bight has cooled to a greater extent.
- Spring survey hydrocast data indicate that surface and bottom temperatures remain above average over most of the region, although temperatures are moderated relative to the past few years. There is some evidence of cooling in the central Middle Atlantic Bight.
- The spring bloom on Georges Bank was of average size and timing, which was in contrast to the Gulf of Maine spring bloom, which was poorly developed and below detection limits.
- Spring thermal transition dates for 2014 continue to be among the earliest dates recorded over the past three decades.
- Projections for spring and fall thermal transition dates over the next 75 years suggest a shift in timing of 3-4 weeks, resulting in an increase in length of summer by approximately two months.
- The distribution of fish and invertebrate species sampled by the NEFSC bottom trawl survey have changed; utilizing data through the spring 2014 survey, kernel density plots and the assessments of species distributions both along- and across-shelf show mixed distribution movements over time

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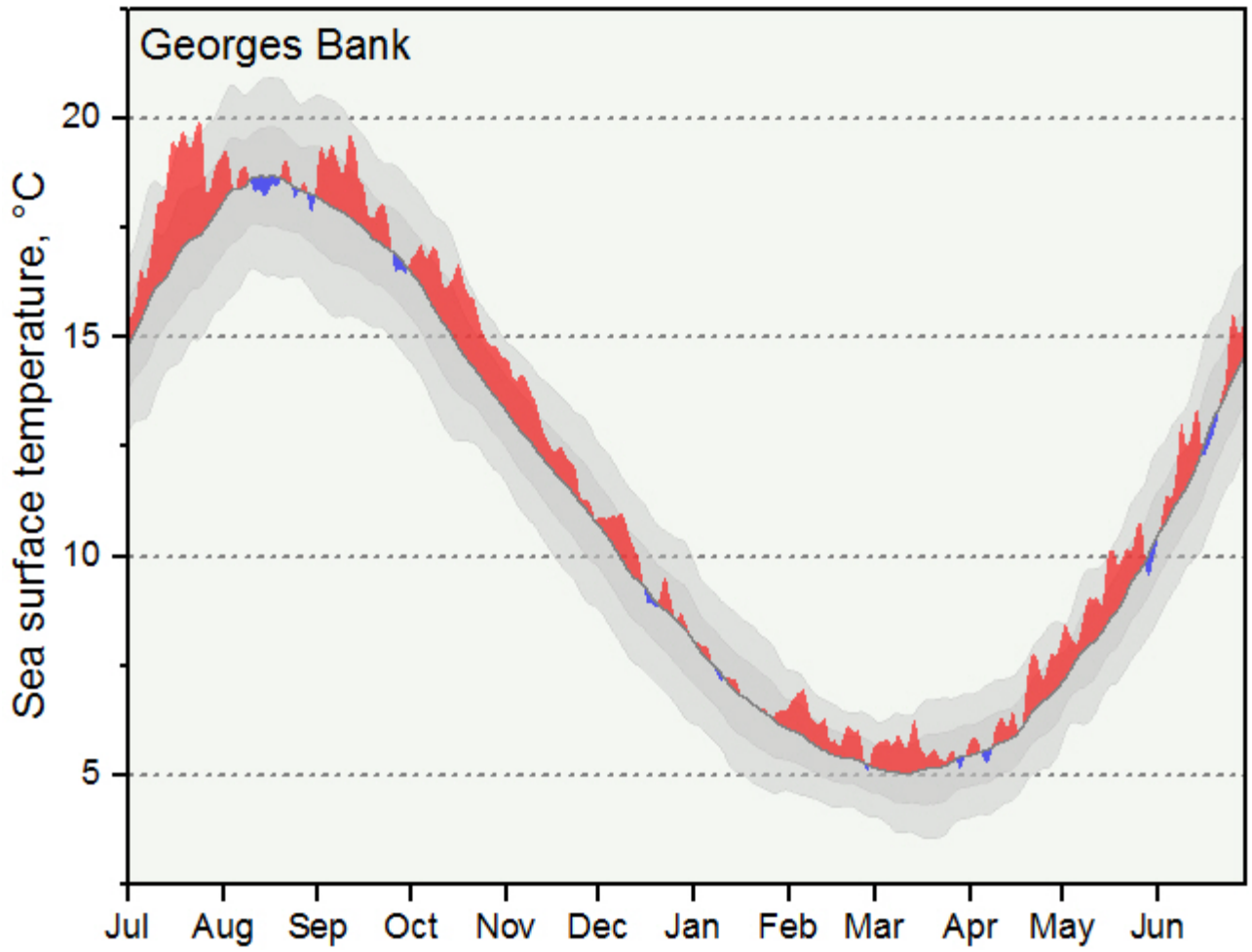
Data Sources

SST was derived by compositing data from three sources: the Advanced Very-High Resolution Radiometer onboard the Polar Orbiting Environmental Satellite (AVHRR-POES); the MODIS Terra sensor; and the MODIS Aqua sensor. The data represent the surface ocean temperature, not the temperature of the entire water column. Long term SSTs were extracted from the Extended Reconstructed Sea Surface Temperature (ERSST, version 3) dataset. This dataset is based on the temperature compilation of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) SST dataset, and contains reconstructed SST fields (obtained by interpolation) in regions with sparse data. Temperatures from the survey were taken from hydrocasts made during the bottom trawl survey and EcoMon cruises on the Northeast shelf.

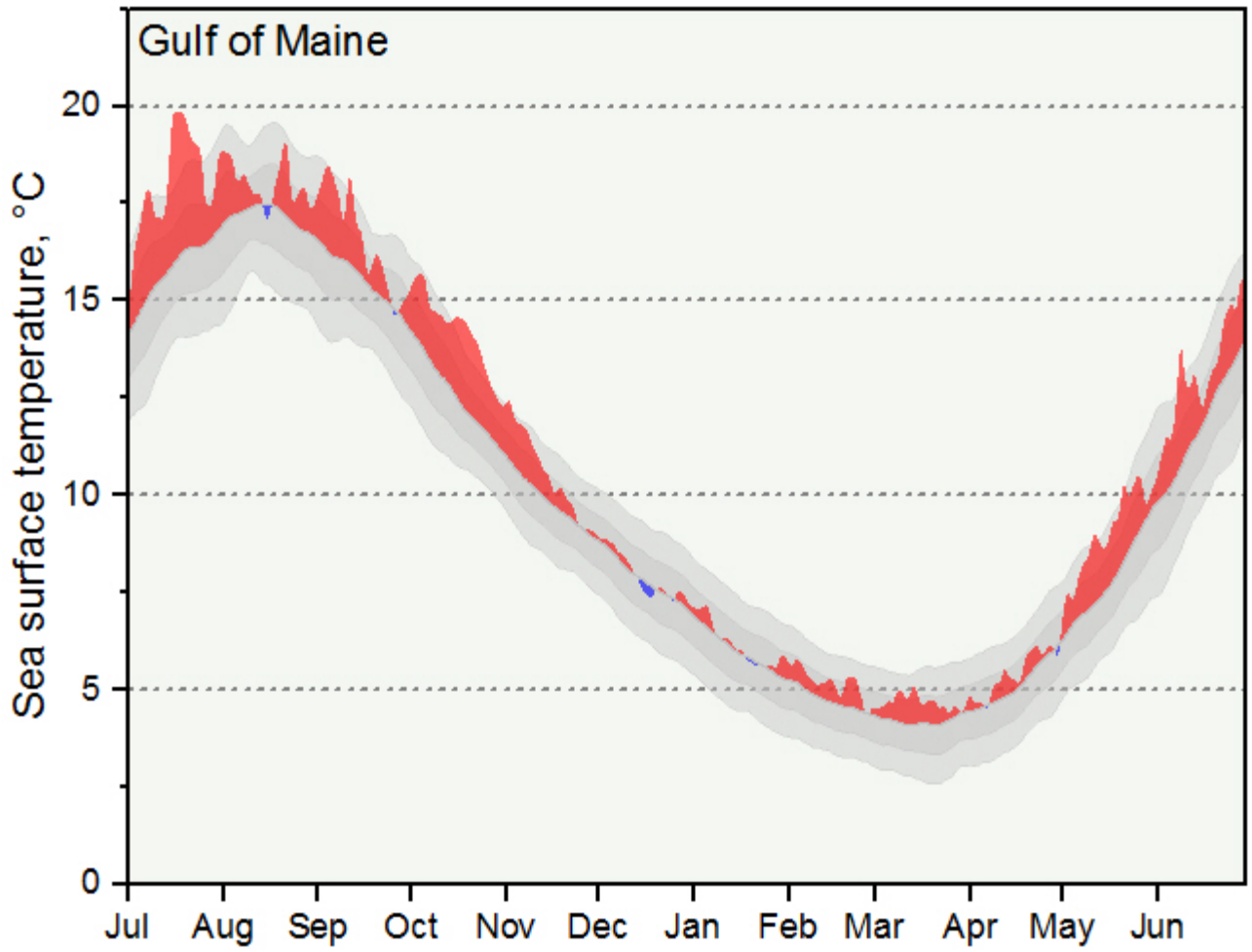
Synoptic views of surface concentrations of chlorophyll *a* were derived from the Sea-viewing Wide Field of View Sensor (SeaWiFS) and the Moderate Resolution Imaging Spectroradiomater on the Aqua satellite (MODIS-Aqua). Data from these ocean color sensors were obtained from the NASA Ocean Biology Processing Group. Chlorophyll *a* is considered a proxy of phytoplankton biomass present in the near-surface water.
Zooplankton biomass was derived from shipboard surveys of the U.S. Northeast Shelf ecosystem. Zooplankton provide the link from primary producers to higher trophic levels. From 1977-1987, the MArine Resources Monitoring, Assessment, & Prediction (MARMAP) program conducted intensive surveys from Cape Hatteras, North Carolina to Nova Scotia. These efforts continued at a reduced level through the 1990s and are ongoing today as the Ecosystem Monitoring program (EcoMon). Currently, 30 plankton samples are taken 6 times a year in each of four ecosystem subareas: Middle Atlantic Bight, Southern New England, Georges Bank, and the Gulf of Maine (resulting in approximately 720 zooplankton biomass samples annually). Zooplankton are identified to the lowest taxonomic level possible, resulting in taxon specific data on abundance and distribution.

Sea Surface Temperature

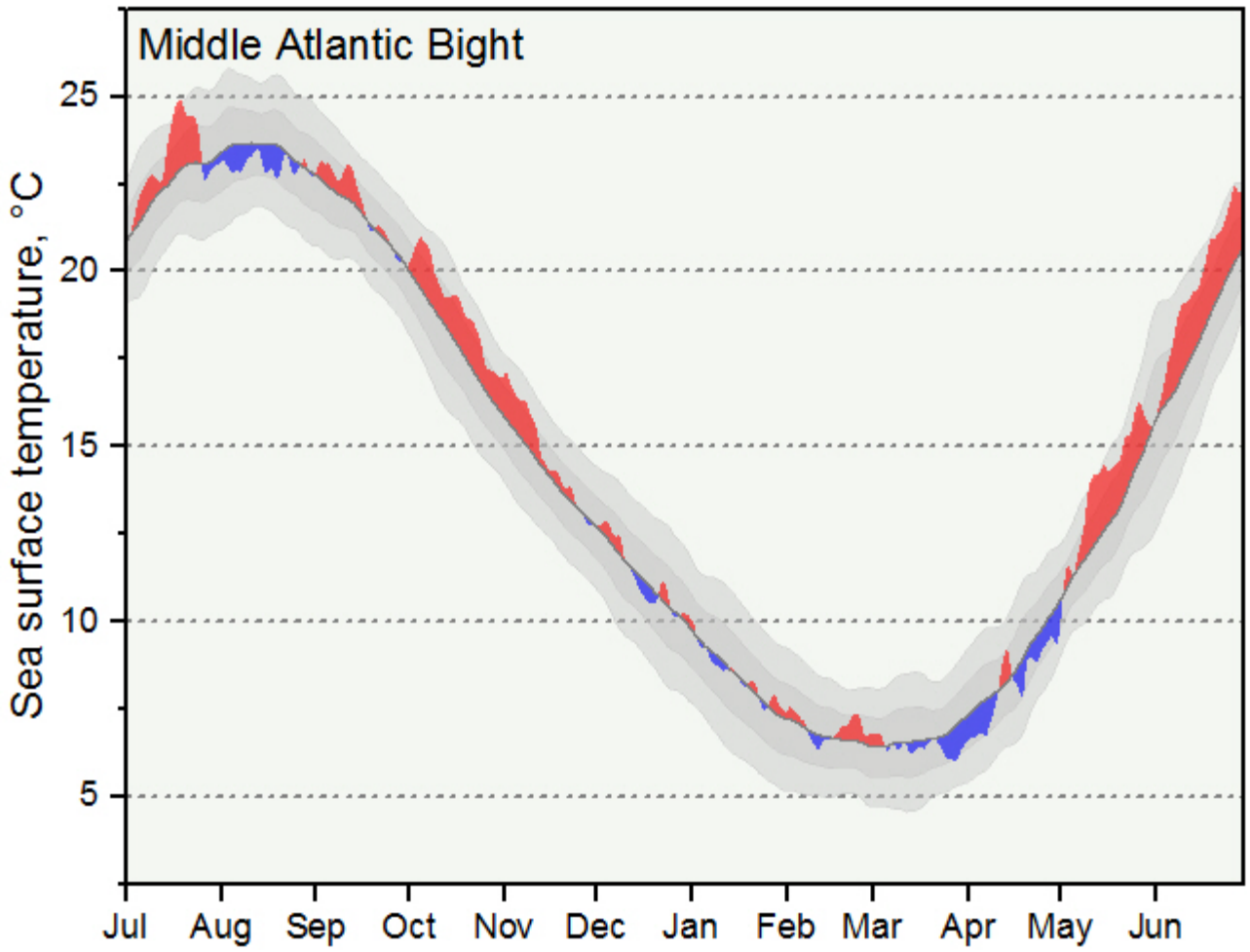
The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures during the spring of 2014 continuing the trend of above average temperatures seen during fall into winter seasons. In the graph spanning the last half of 2013 and first half of 2014, the long-term mean SST is shown as a dark gray line with areas representing plus and minus one and two standard deviations of the mean as progressive shades of gray, respectively (see figure). SSTs below the long term mean are shown in blue, above the mean in red. The warmest seasonal conditions during the first half of 2014 were found during May into June, below average conditions were limited to the Middle Atlantic Bight in April into May.



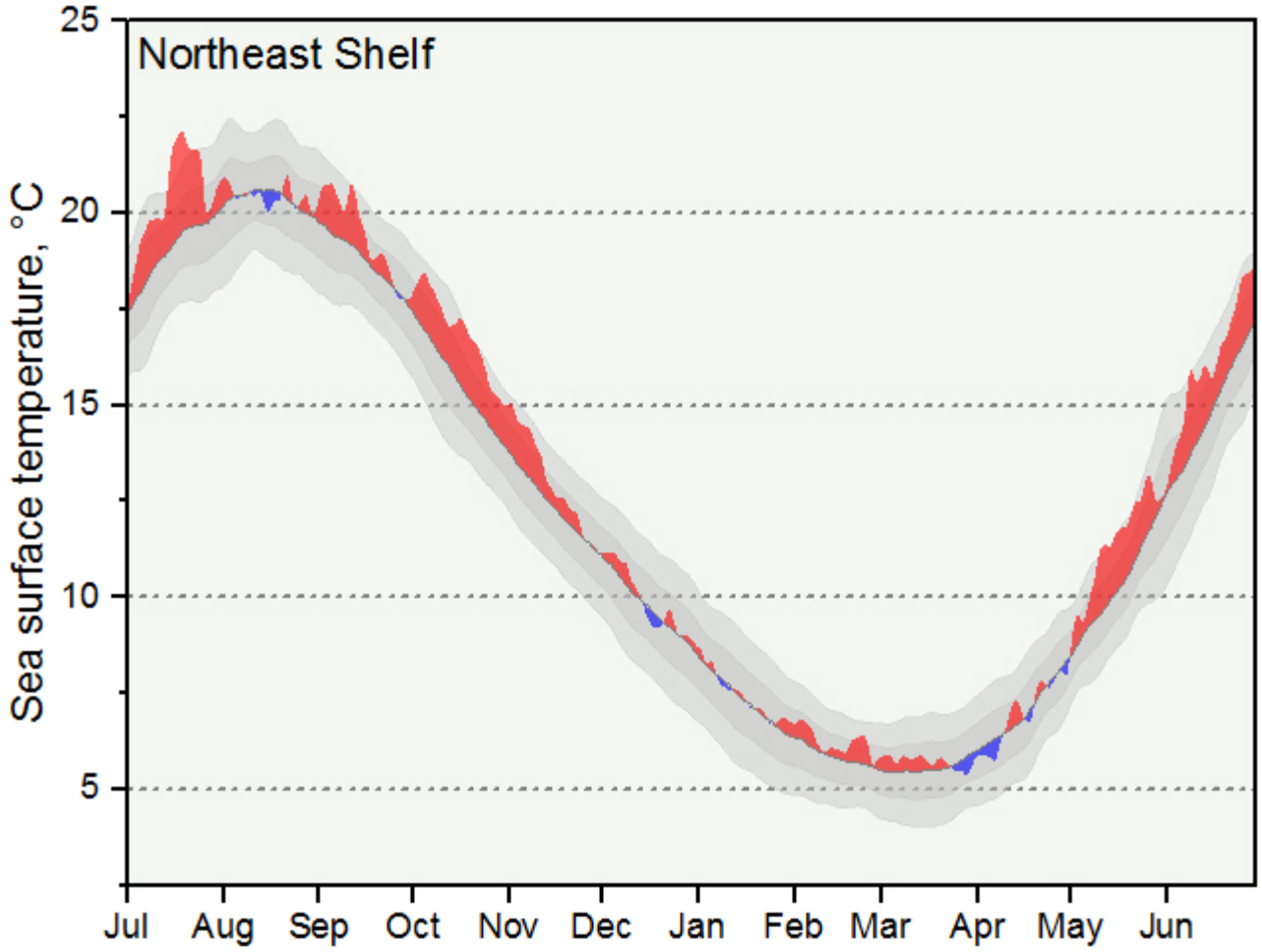
Georges Bank



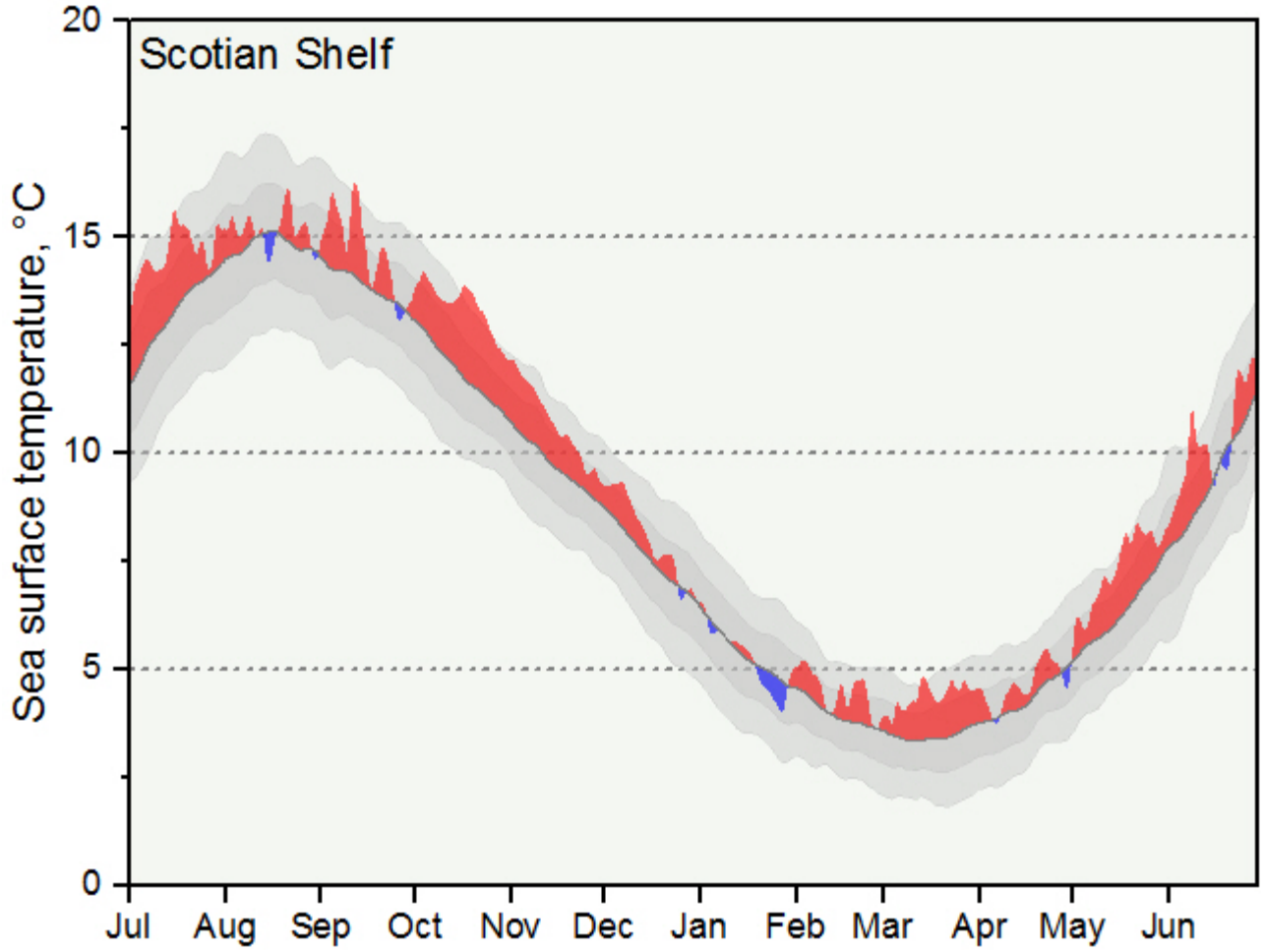
Gulf of Maine



Middle Atlantic Bight



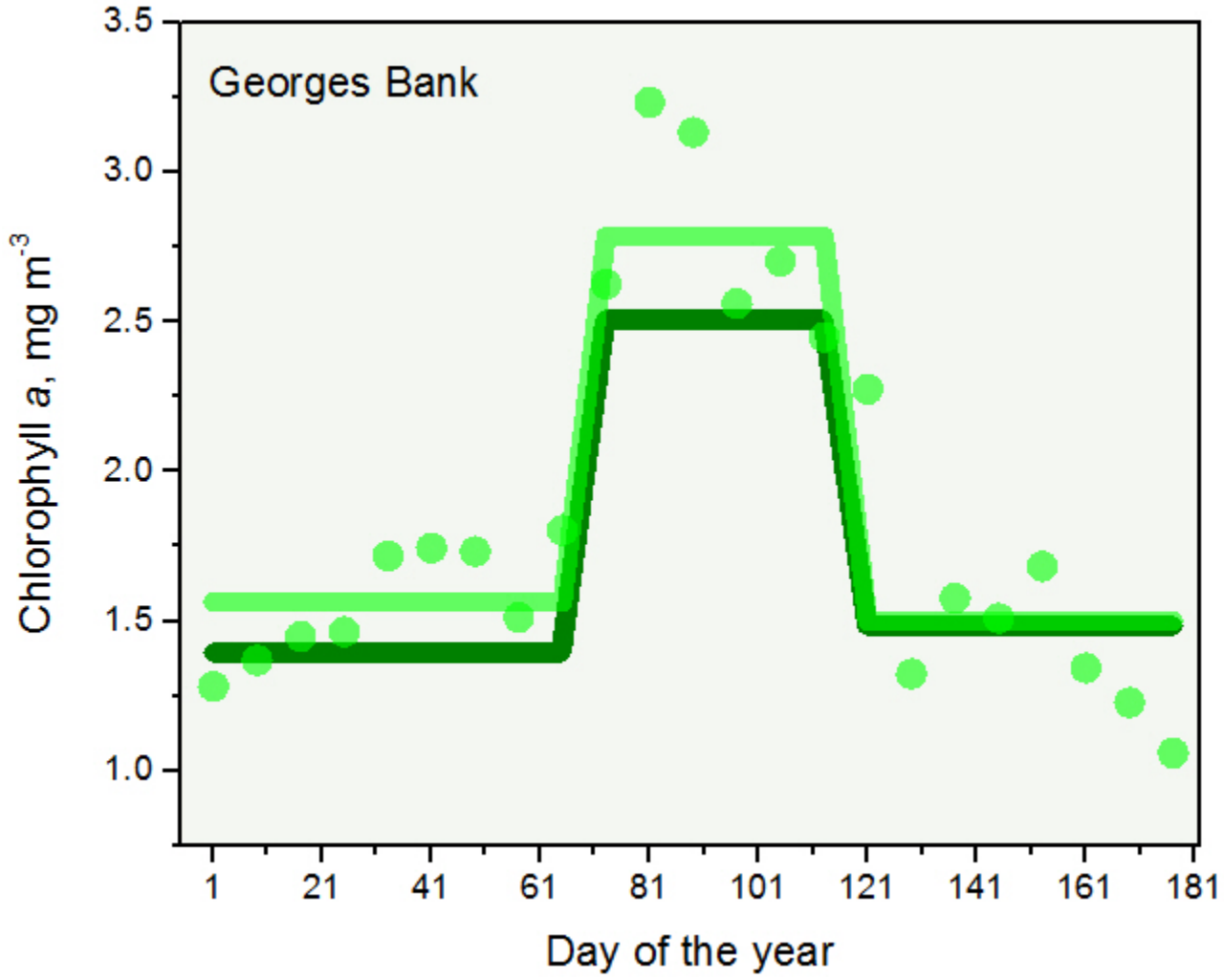
Northeast Shelf



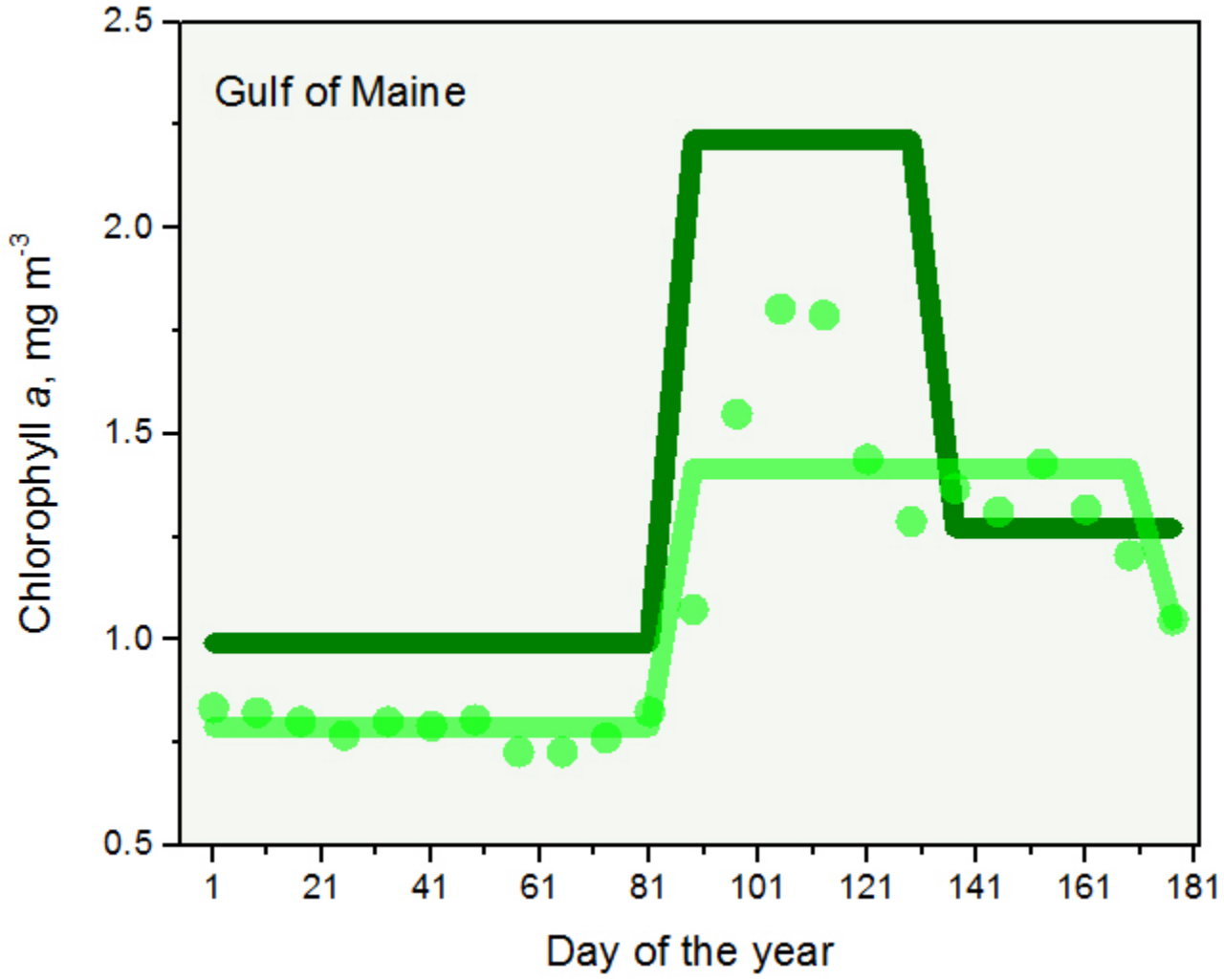
Scotian Shelf

Bloom on the Northeast Shelf

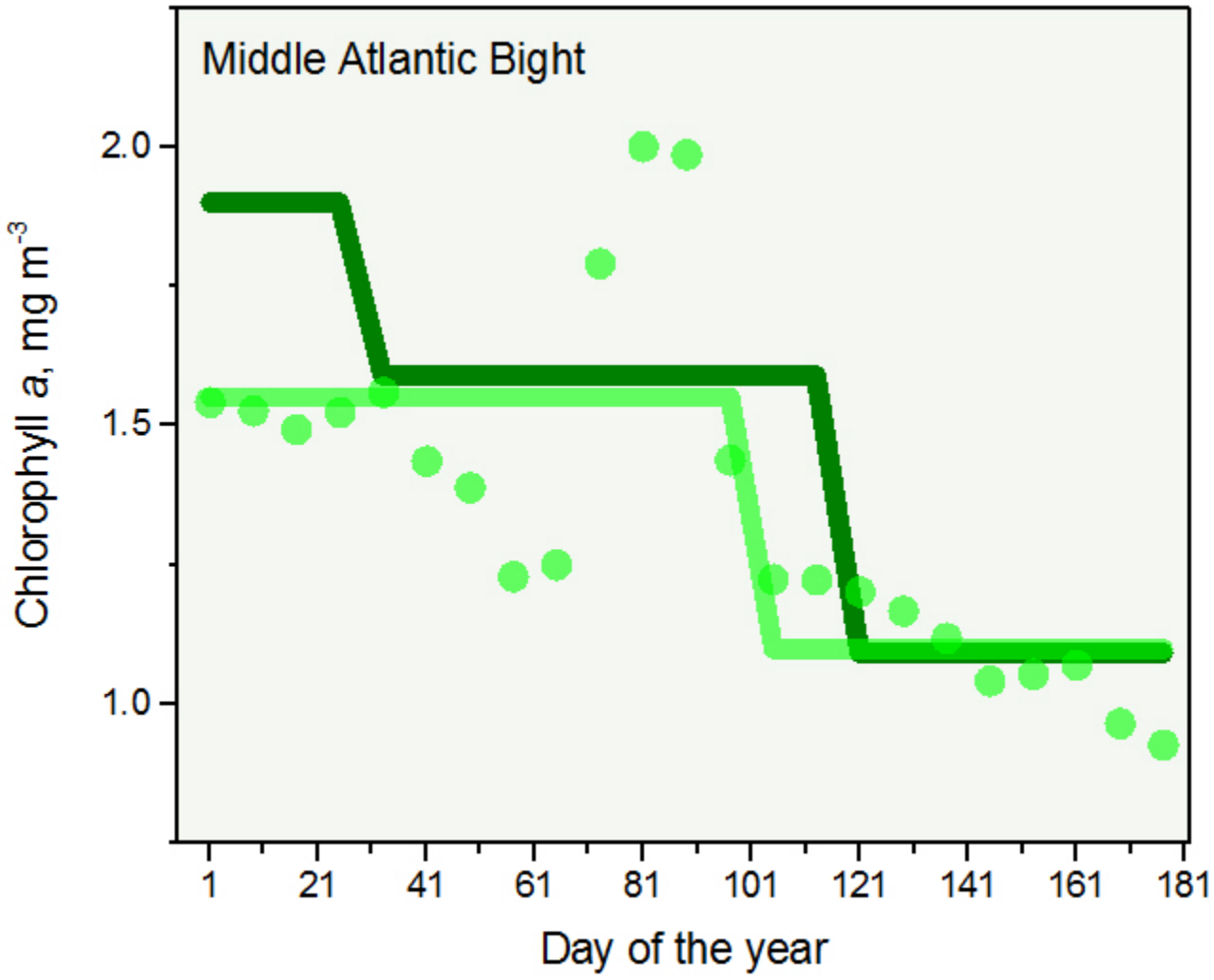
Most regions of the Northeast Shelf Large Marine Ecosystem have a well developed spring phytoplankton bloom. The impact of the spring bloom will depend on multiple factors related to the time and duration of the bloom and how productive the constituent phytoplankton species are over time. The spring bloom for the Northeast Shelf ecosystem as a whole suggested the bloom was early and short lived in composite (see NES figure, for this and figures for ecoregions, dark green line is long-term mean bloom pattern, light green line 2014 bloom pattern, points are for 2014 data). A bloom could not be detected in the Gulf of Maine and Middle Atlantic Bight. In the GOM a bloom start transition from low to high chlorophyll was detected which could be interpreted as the beginning of a bloom; however, this transition was not matched with a high to low transition. The Middle Atlantic Bight area usually does not have a discrete, detectable spring bloom. A robust bloom was detected on Georges Bank and a smaller bloom was seen in the Scotian Shelf ecoregion. This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.



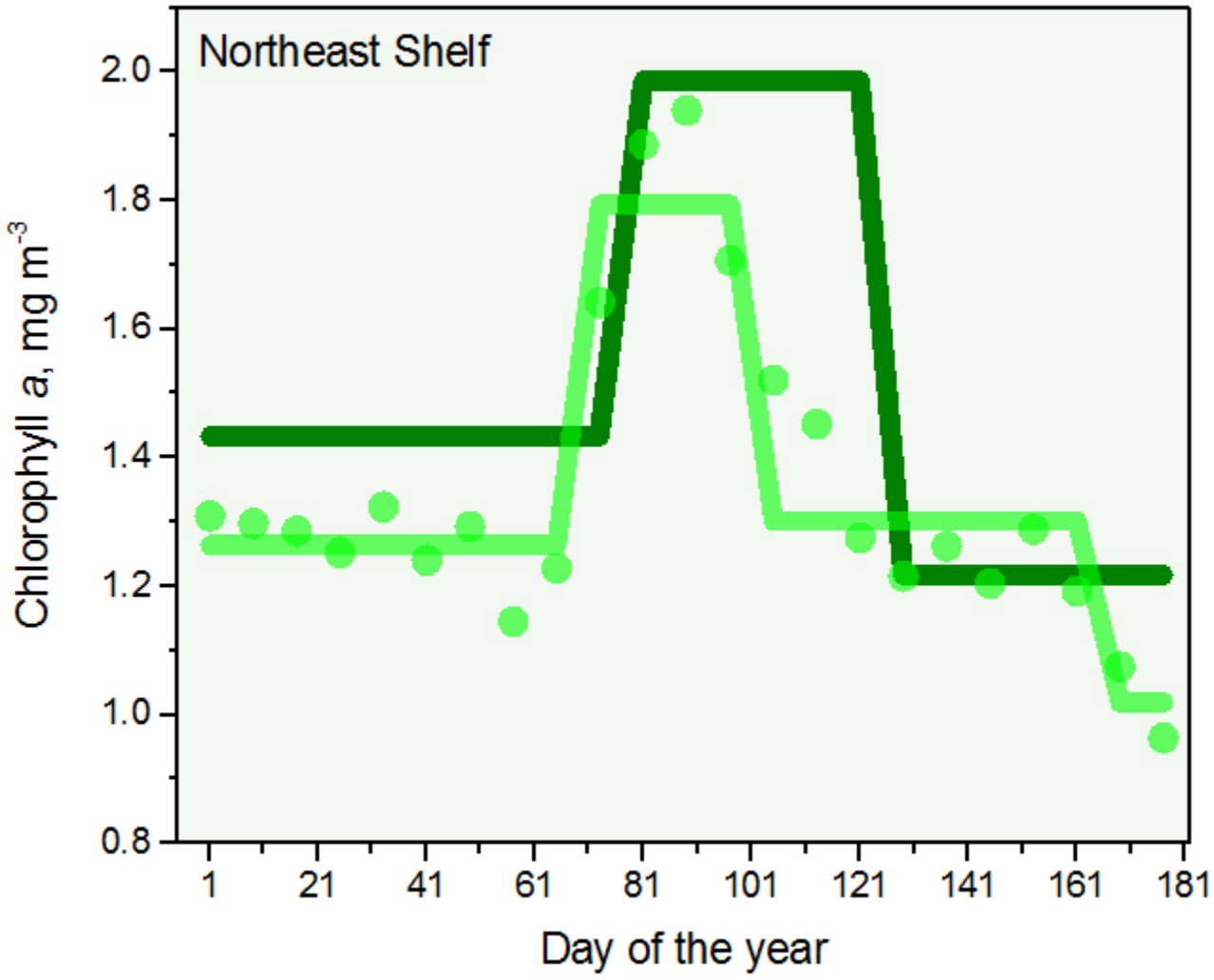
Georges Bank



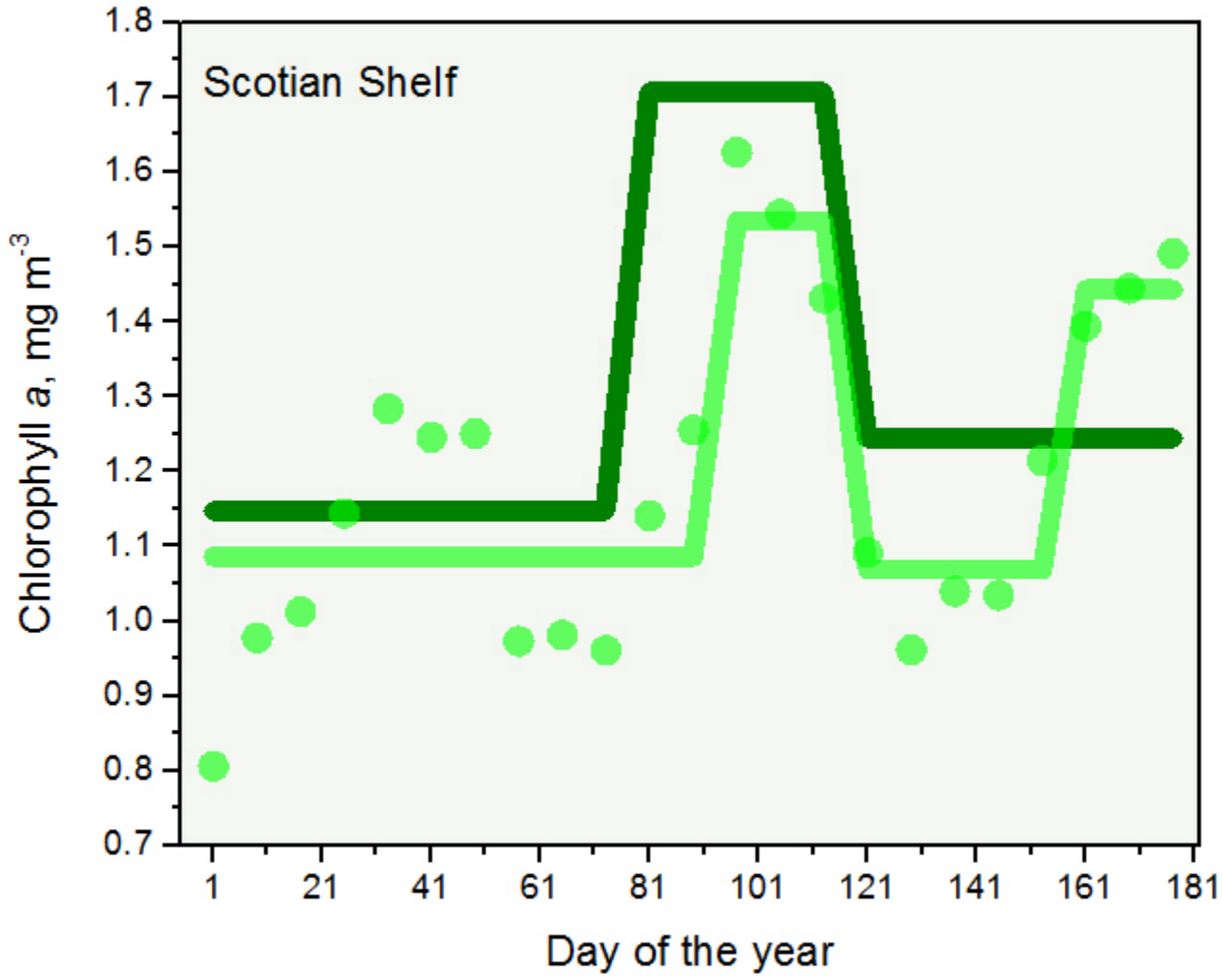
Gulf of Maine



Middle Atlantic Bight



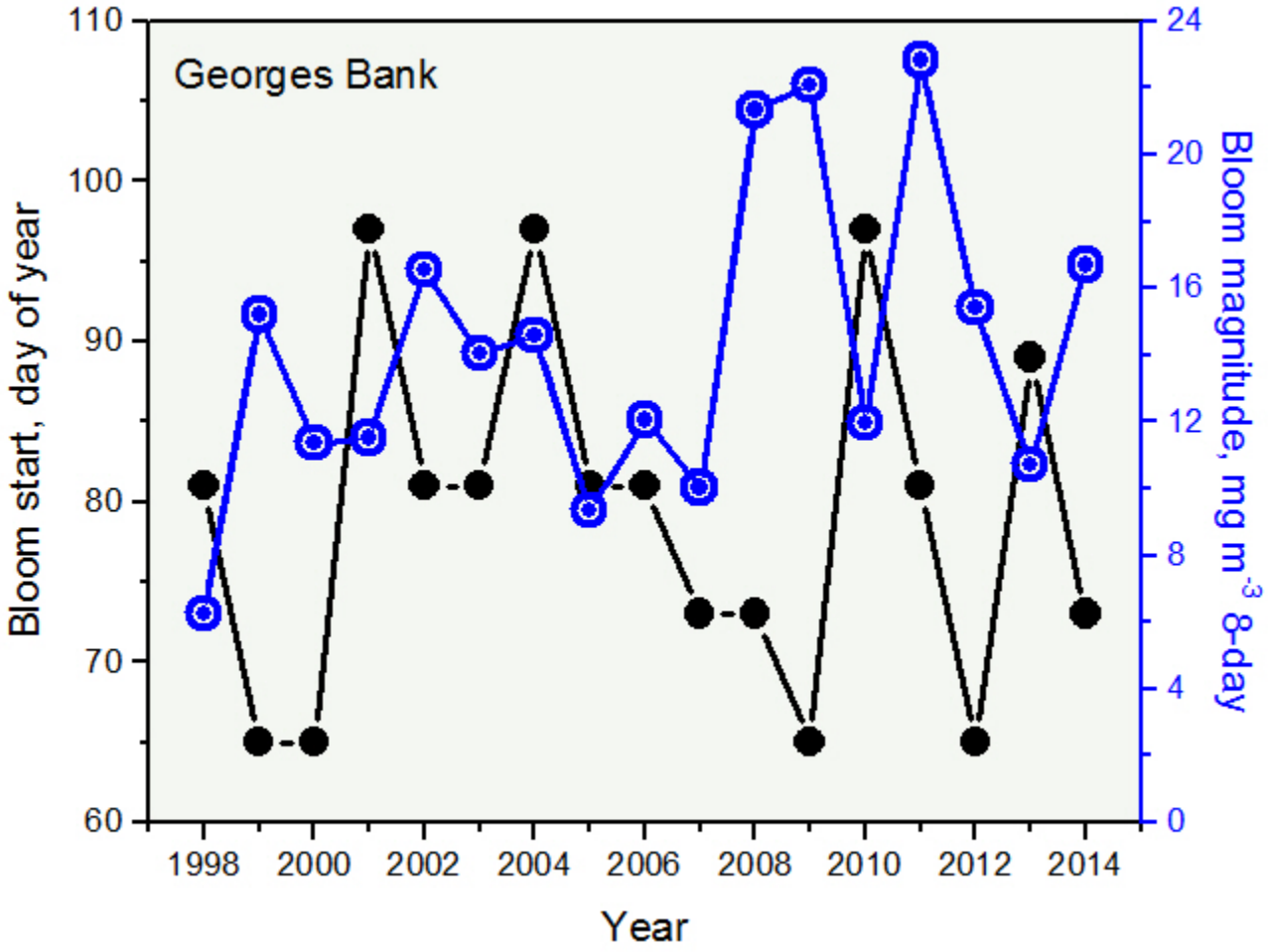
Northeast Shelf



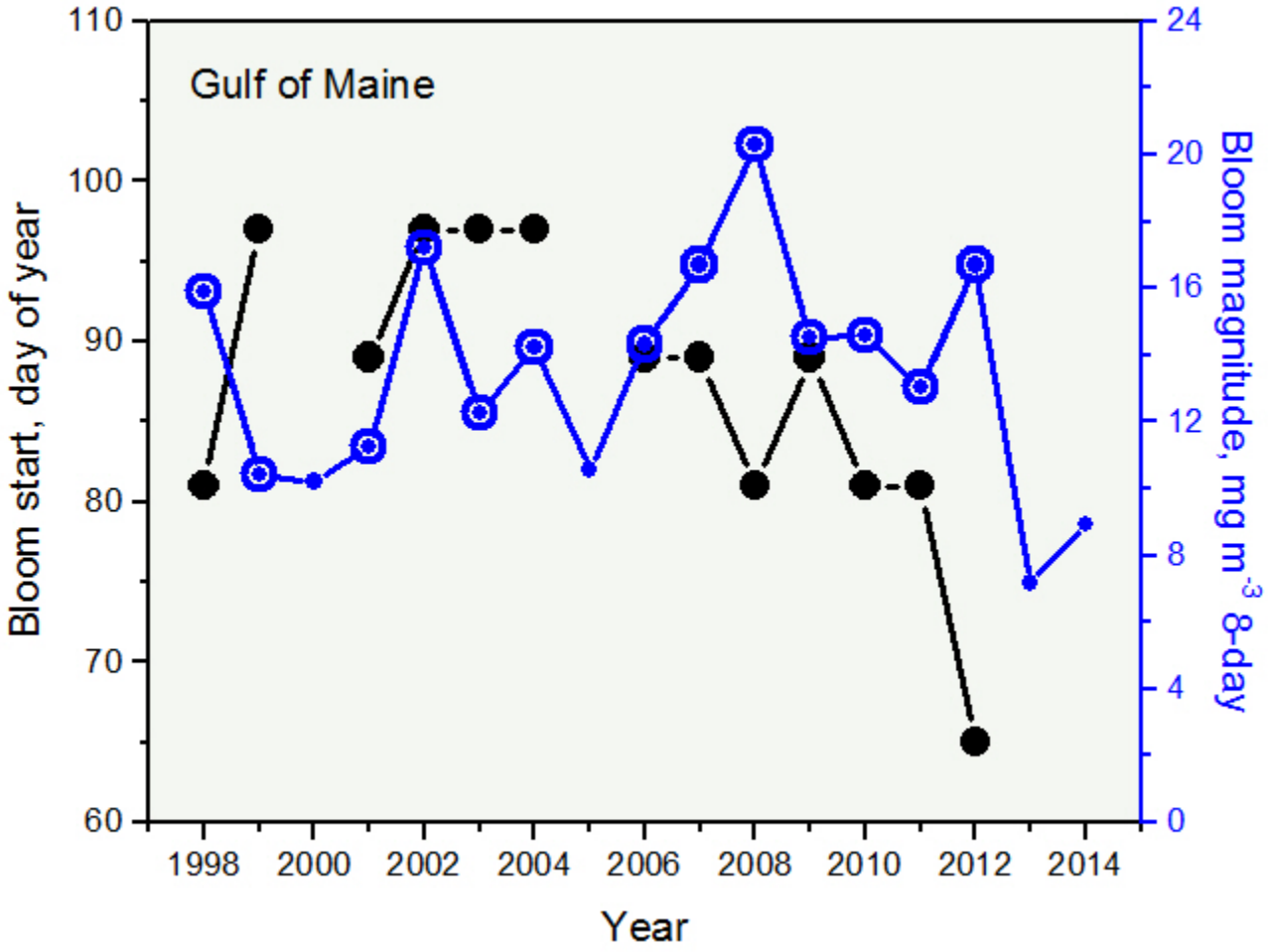
Scotian Shelf

Bloom Start Day and Magnitude

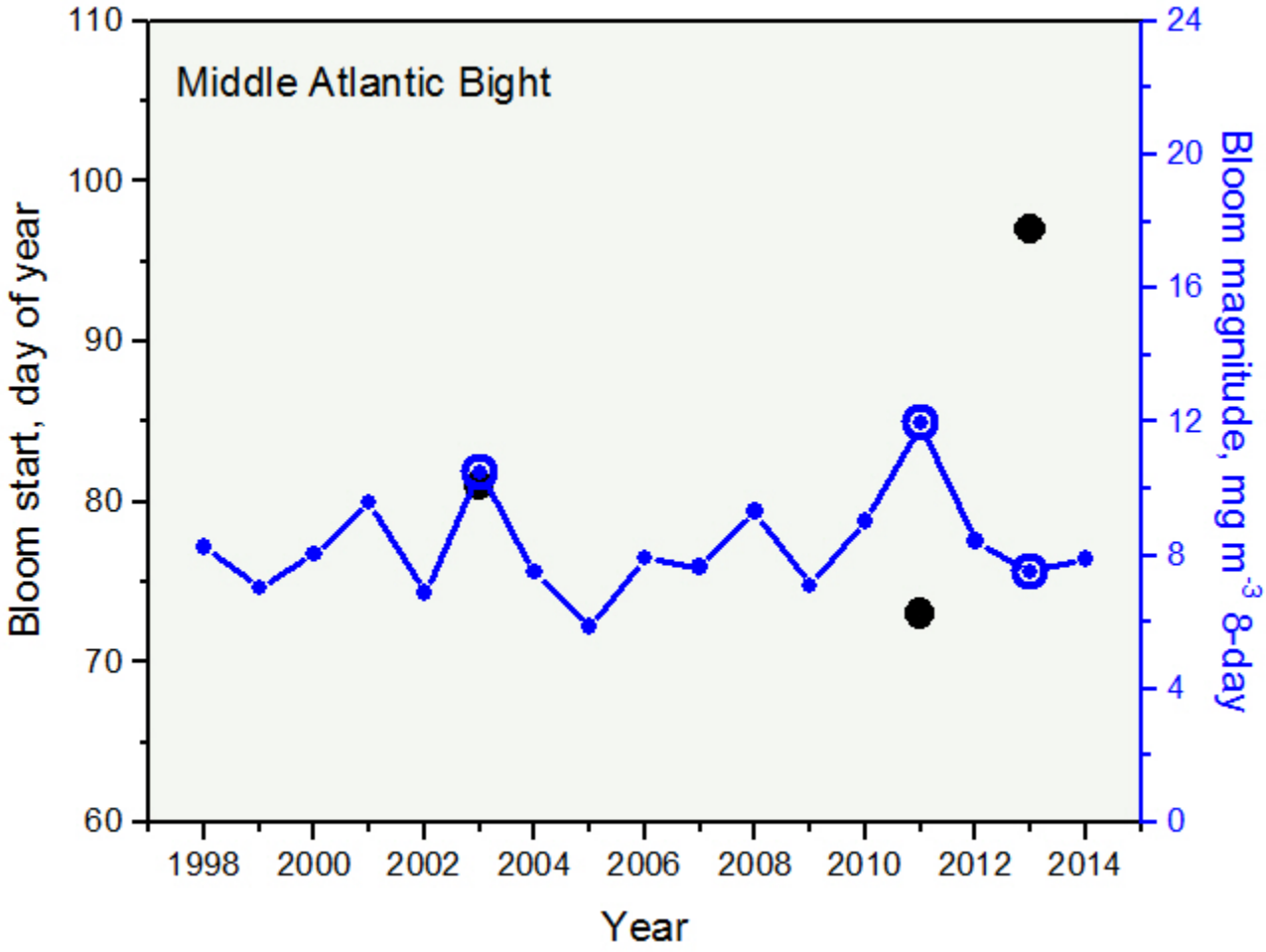
The spring bloom typically starts earlier in the more southern segments of the Northeast Shelf LME. In 2014, the Northeast Shelf composite bloom start was mid-March, which was consistent with the bloom start on Georges Bank and earlier than the start date for the Scotian shelf which was the first week of April. Since blooms were not detected in the Gulf of Maine or Middle Atlantic Bight, no start dates are estimated. Spring bloom magnitude is one measure of bloom dimension and is calculated as the sum of chlorophyll concentrations during the bloom period. For the areas with detected blooms, the Georges Bank bloom had a slightly above average bloom magnitude whereas the Scotian Shelf bloom was smallest magnitude bloom detected in the region time series. This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.


Georges Bank
Bloom start, day of year
Bloom magnitude, mg m-3 8-day
Year
110
100
90
80
70
60
24
20
16
12
8
4
0
1998
2000
2002
2004
2006
2008
2010
2012
2014

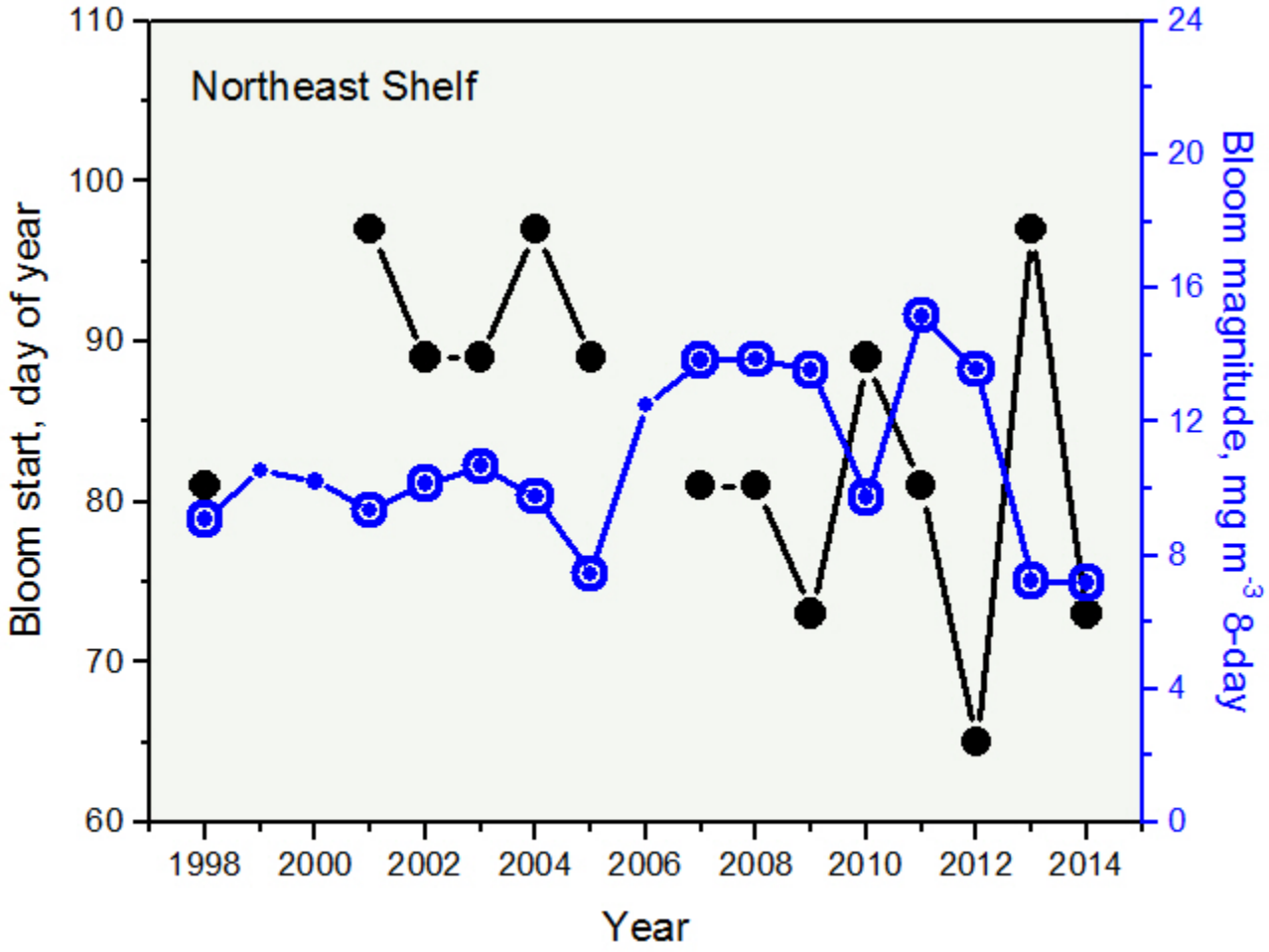
George Bank



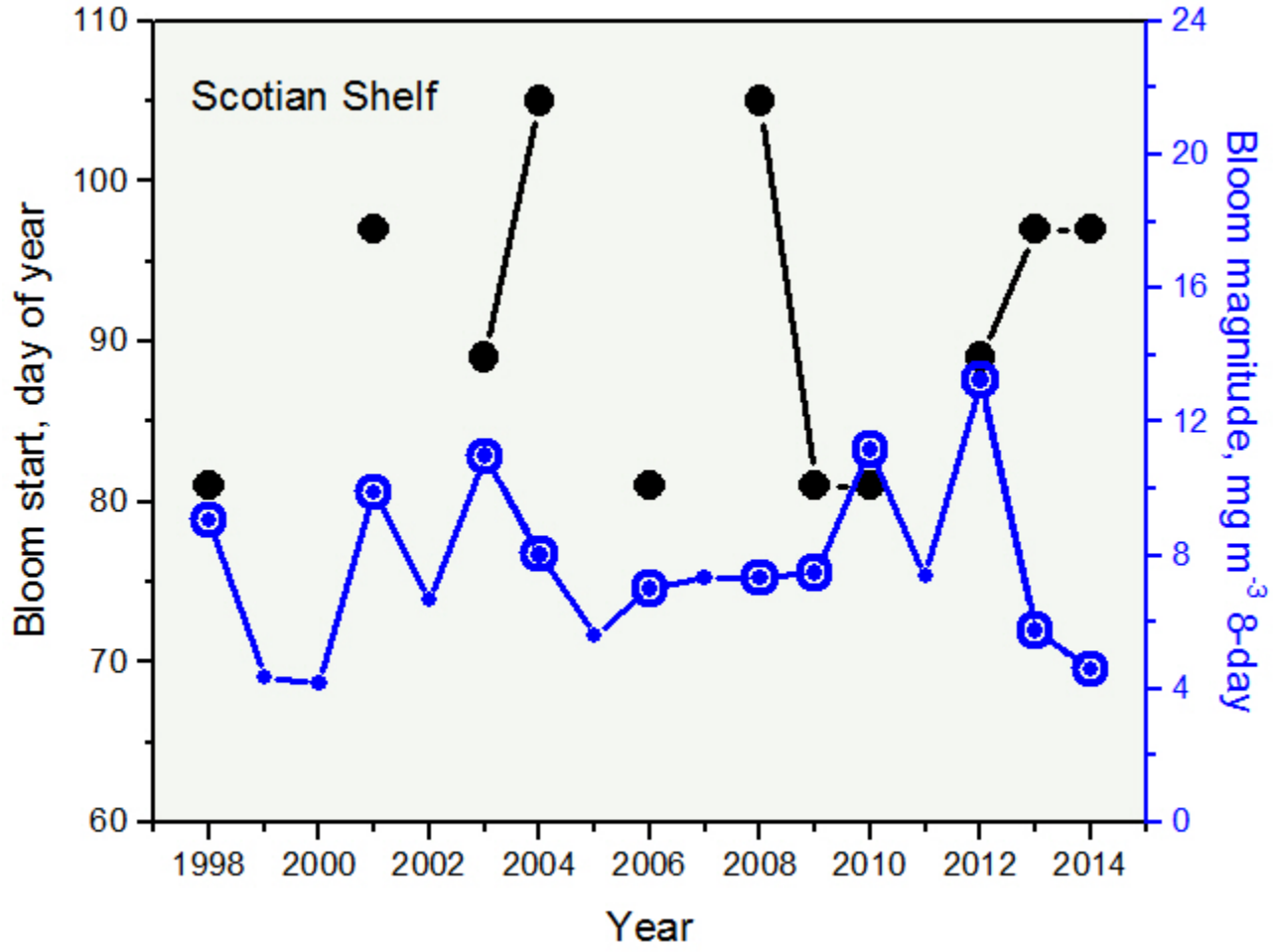
Gulf of Maine



Middle Atlantic Bight



Northeast Shelf

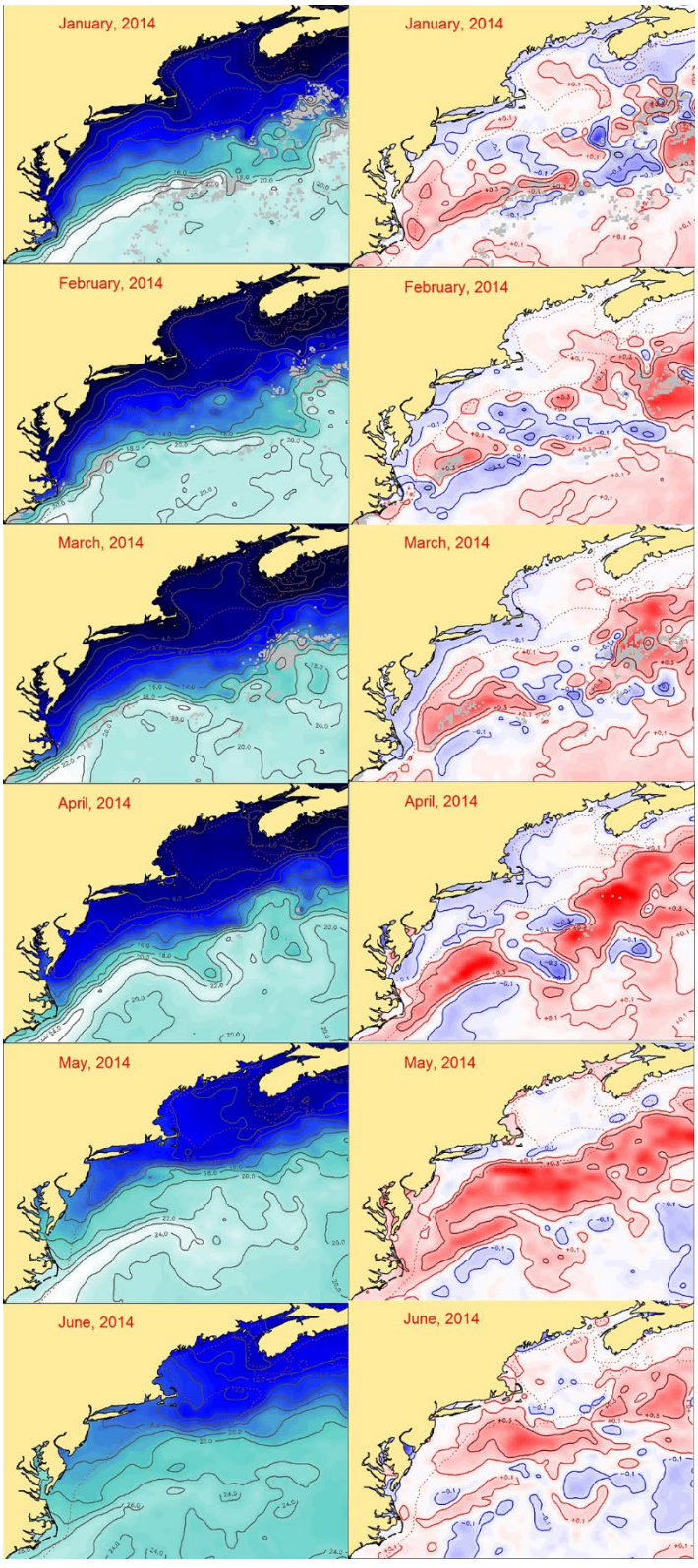


Scotian Shelf

Sea Surface Temperature Distribution

Spring Sea Surface Temperature Distribution

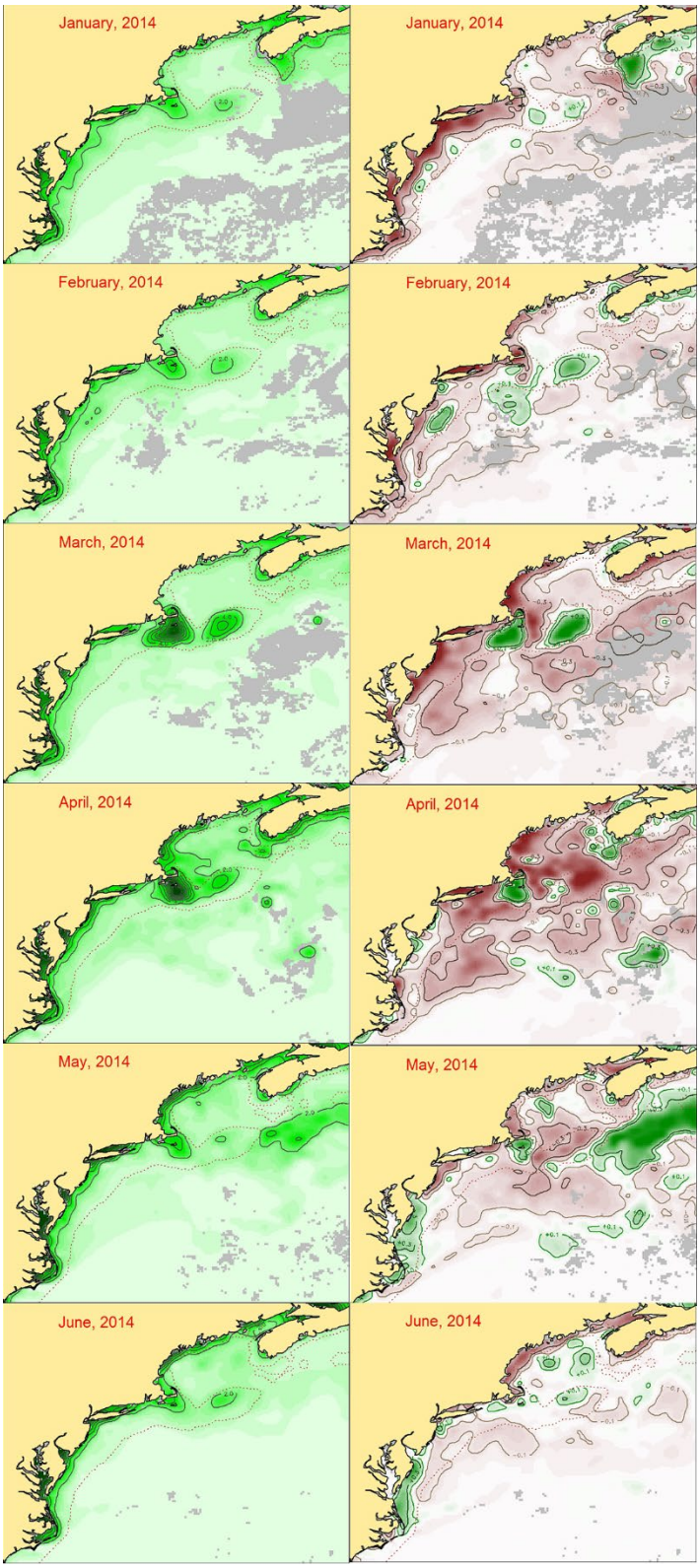
The progression of spring sea surface temperatures for the months of January through June is shown in the interactive figure. SSTs appear as progressive shades of cyan to blue in the left hand icons. Anomalies of SST, those tending to exceed plus or minus one quarter of a standard deviation of the overall SST for the field, are in the right hand set of icons. This type of anomaly tends to highlight high SSTs in an area, the red shades, and low SSTs in an area, the blue shades. The Northeast Shelf was generally near or slightly below average temperature for the first four months of the year as reflected in the distribution white areas and light blue tones in the anomaly maps. The seaward extent beyond the shelf break front was a shifting pattern of cold and warm anomalies most likely associated with movement of the Gulf Stream. By May and June the shelf was largely at mean temperatures or slightly below average in the Middle Atlantic Bight and in parts of the Gulf of Maine.



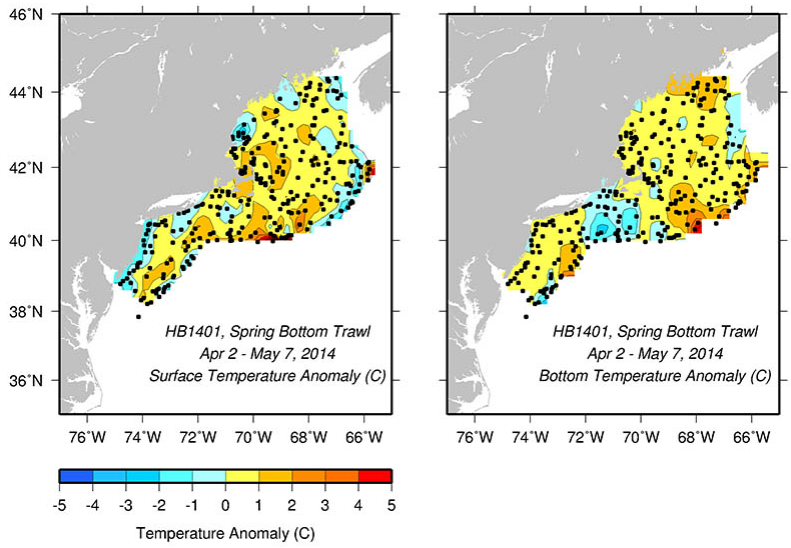
Chlorophyll Distribution

Spring Chlorophyll Distribution

The progression of spring chlorophyll concentrations for the months of January through June are shown in the interactive figure. Chlorophyll concentrations appear as progressive shades of green in the left hand icons. Anomalies of chlorophyll concentration, those tending to exceed plus or minus one quarter of a standard deviation of the overall concentration for the field, are in the right hand set of icons. The most striking feature in the spatial analysis of chlorophyll concentration is the distribution of chlorophyll in March where we see above average chlorophyll concentrations on Nantucket Shoals and on Georges Bank. April is typically when the spring bloom is at its peak in the Gulf of Maine and on Georges Bank; however, in 2014 the deep brown tones in the anomaly map indicates these areas were well below average. There was no distinct spring bloom event in the Middle Atlantic Bight.



Temperature from Spring Survey

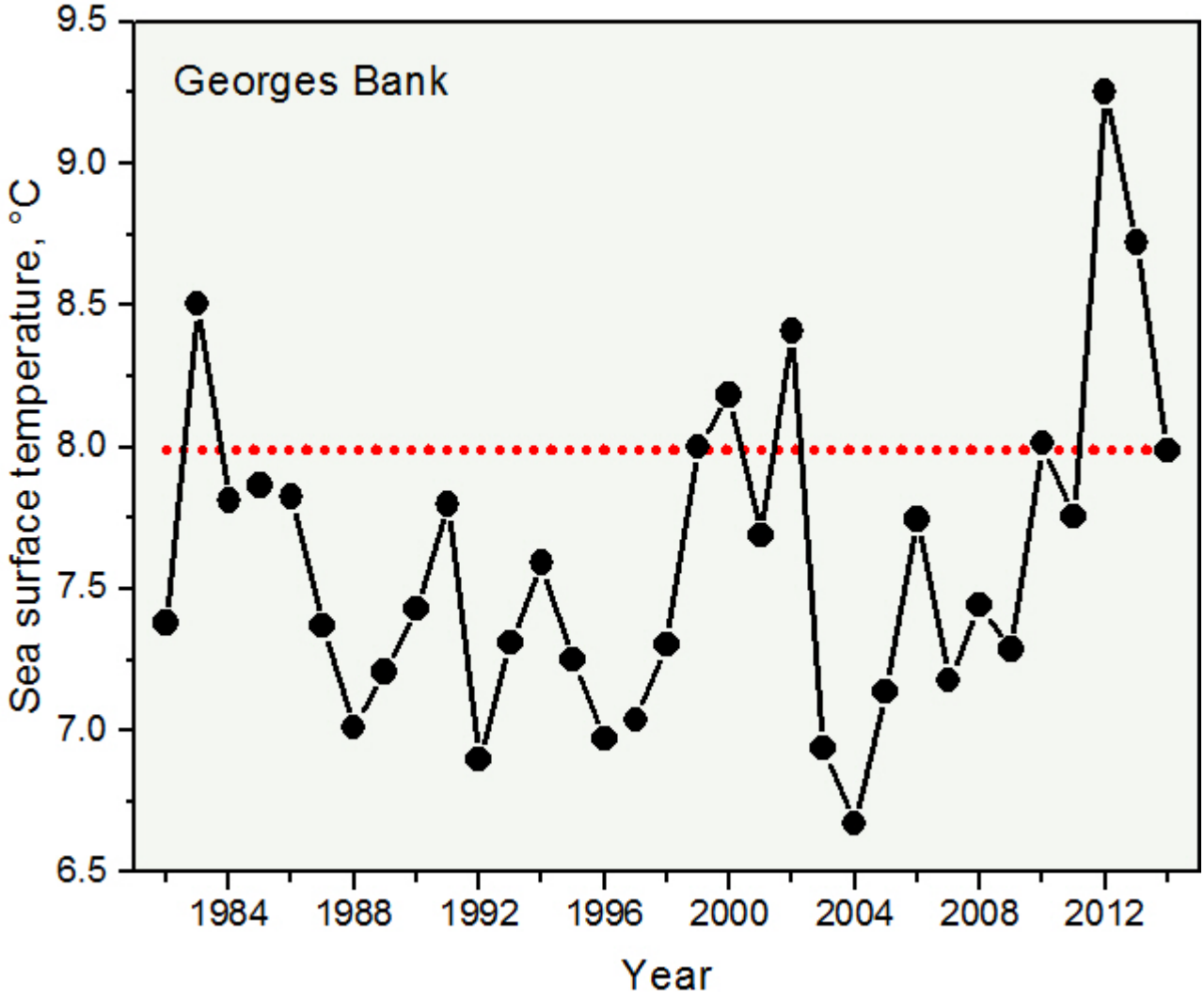


Spring survey temperature trends

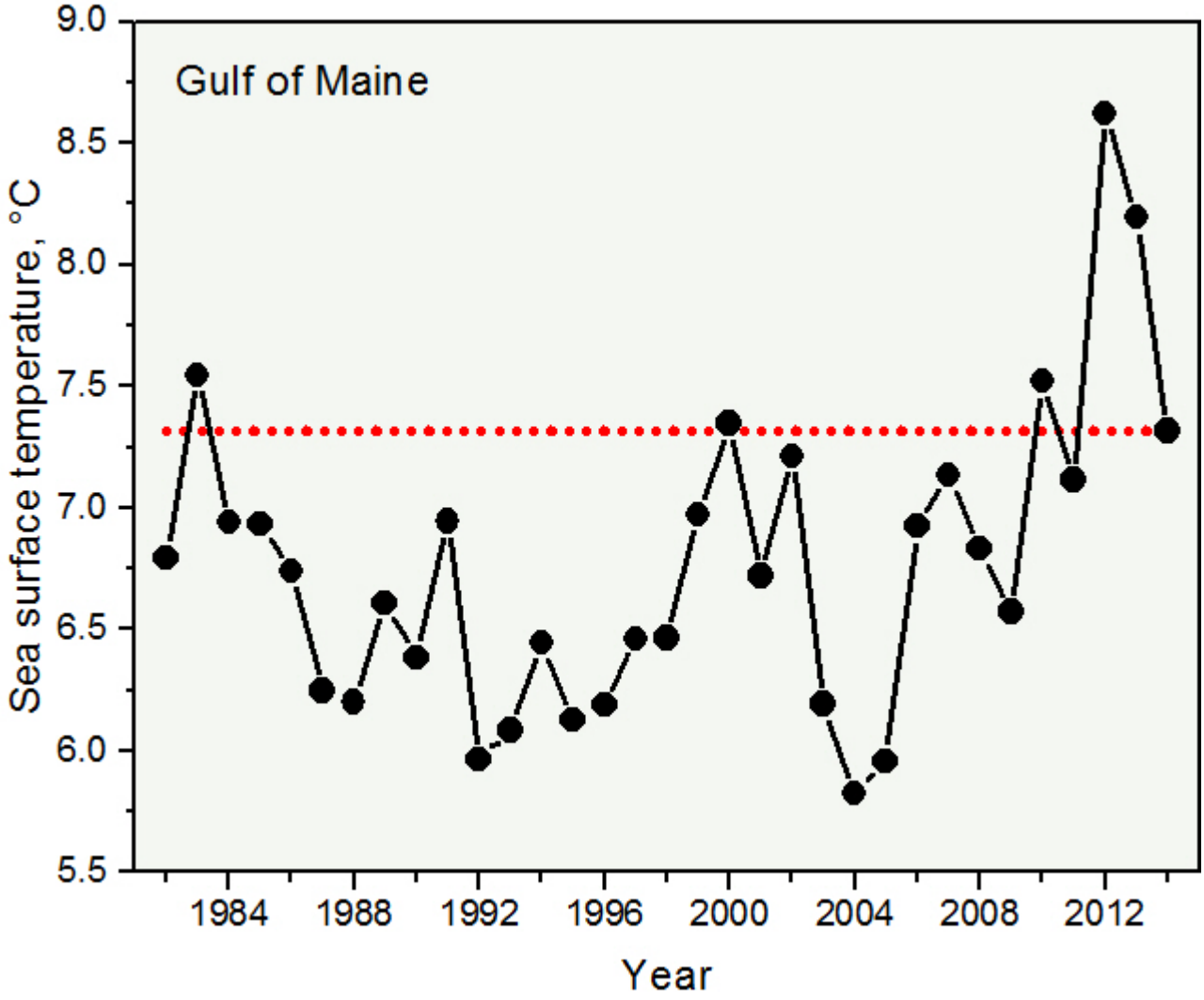
During spring, ocean temperatures were generally warmer than average across the majority of the northeast U.S. shelf at both the surface and near the bottom (relative to 1977-1987). Overall, warming continues to moderate relative to the extremes observed in 2012, with surface ocean temperature anomalies only exceeding 1°C within isolated regions across the shelf. A band of cooler surface temperatures were observed near shore along the coast of Long Island and southwest of Hudson Canyon. A similar feature was noted in shipboard data from the preceding fall. While this coastally trapped feature does not extend to the bottom, bottom temperatures were colder than average across the entire shelf south of Rhode Island and Cape Cod. Elsewhere, bottom waters are predominantly warmer than average, although anomalies are reduced relative to near-bottom conditions the preceding fall.

Satellite SST for First Half Year

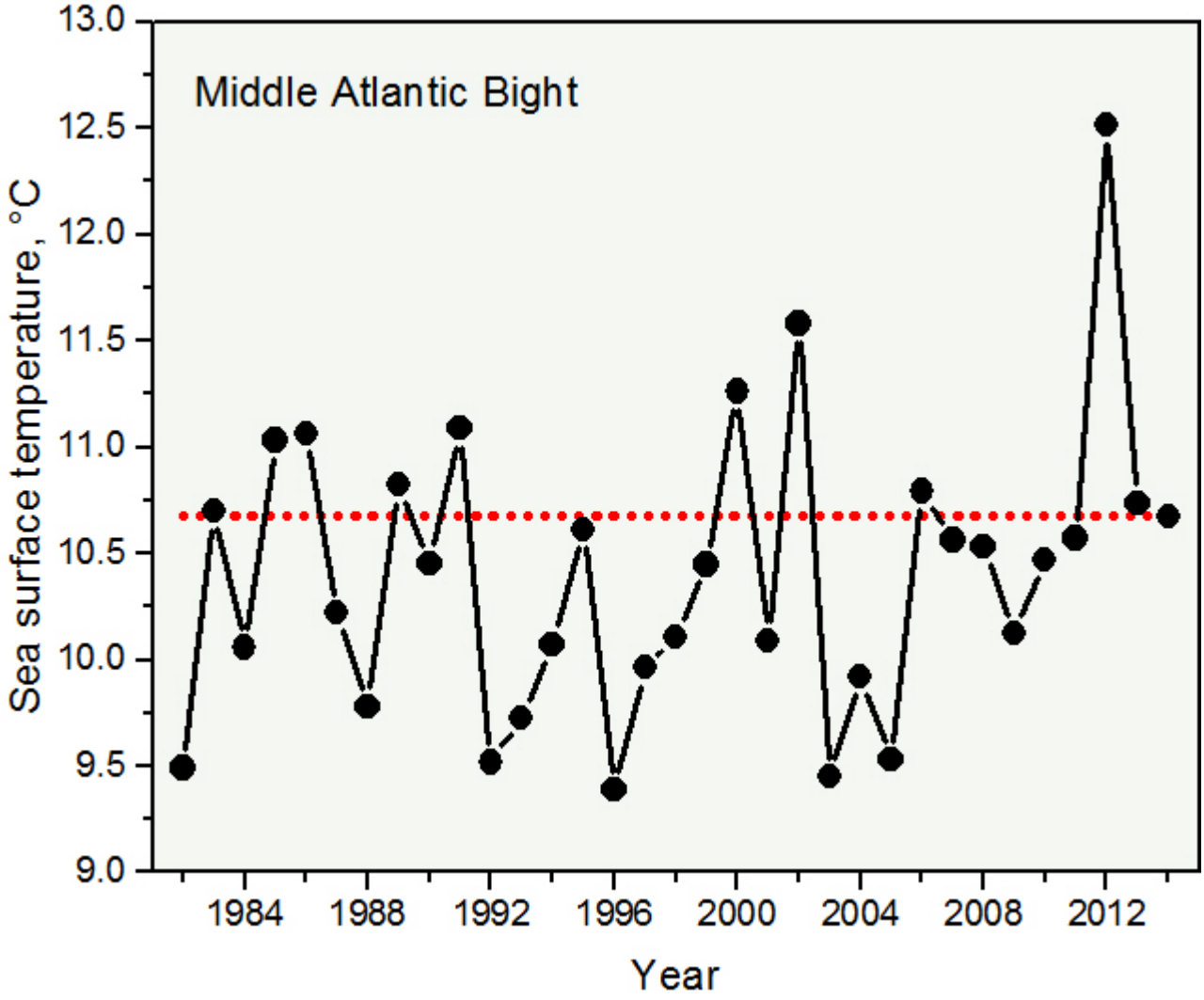
The OISTT sea surface temperature data is based on satellite measurements and provides high spatial and temporal resolution depictions of temperature trends. The SST conditions for the first half of 2014 were amongst the warmest recorded in the satellite remote sensing data series for some parts of the ecosystem. The SST for the Northeast Shelf as a whole declined in excess of 1.5°C from the record high temperature recorded in 2012 (see NES figure). The first half SST in the Gulf of Maine, Georges Bank and the Scotian Shelf went down in on the order of a half degree centigrade from last year, thus well below the record levels of 2012, 2014 spring temperature were still above average (see GOM, GBK and SCS figures). The Middle Atlantic Bight SST is nearly unchanged from last year.



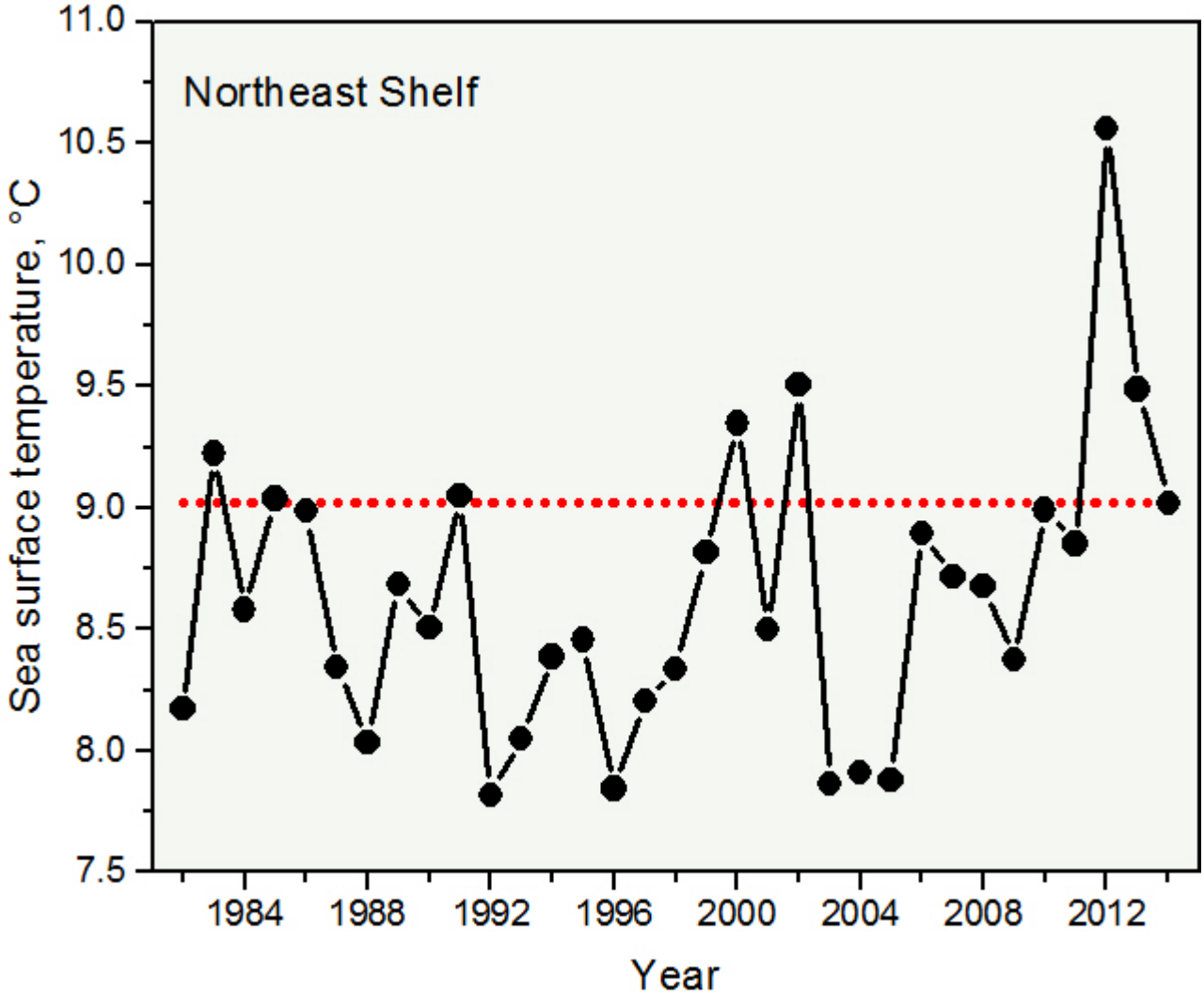
Georges Bank



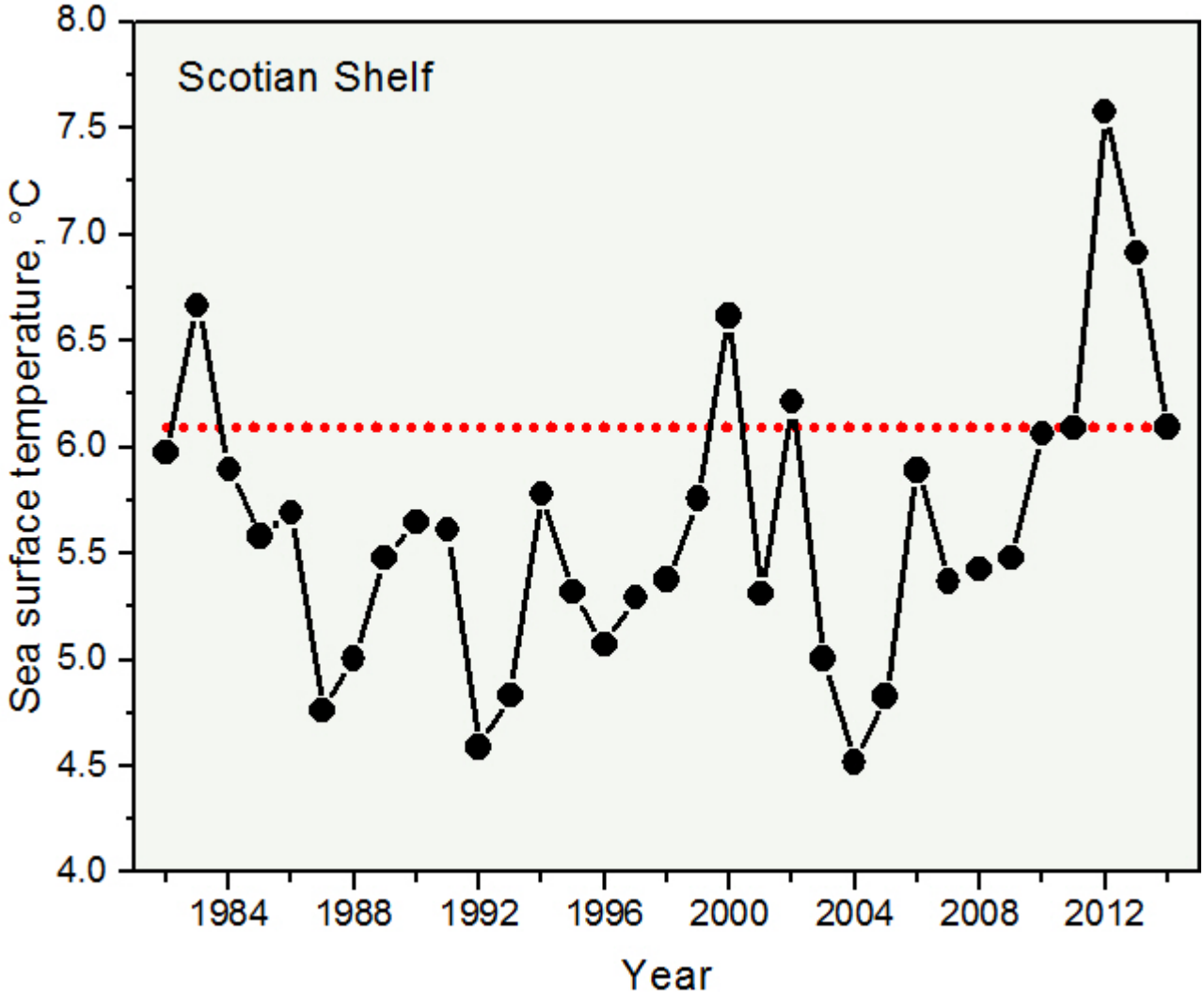
Gulf of Maine



Middle Atlantic Bight



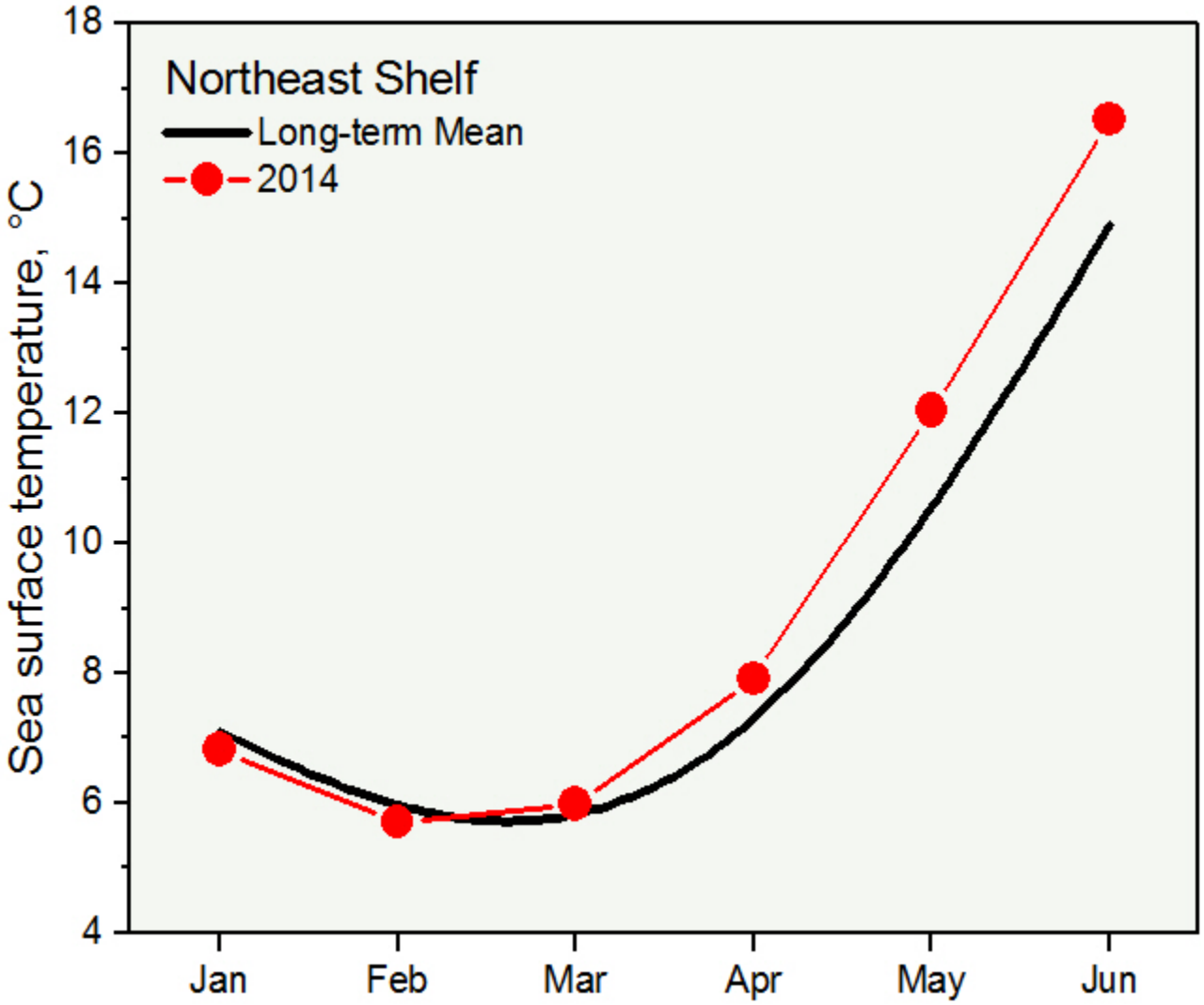
Northeast Shelf



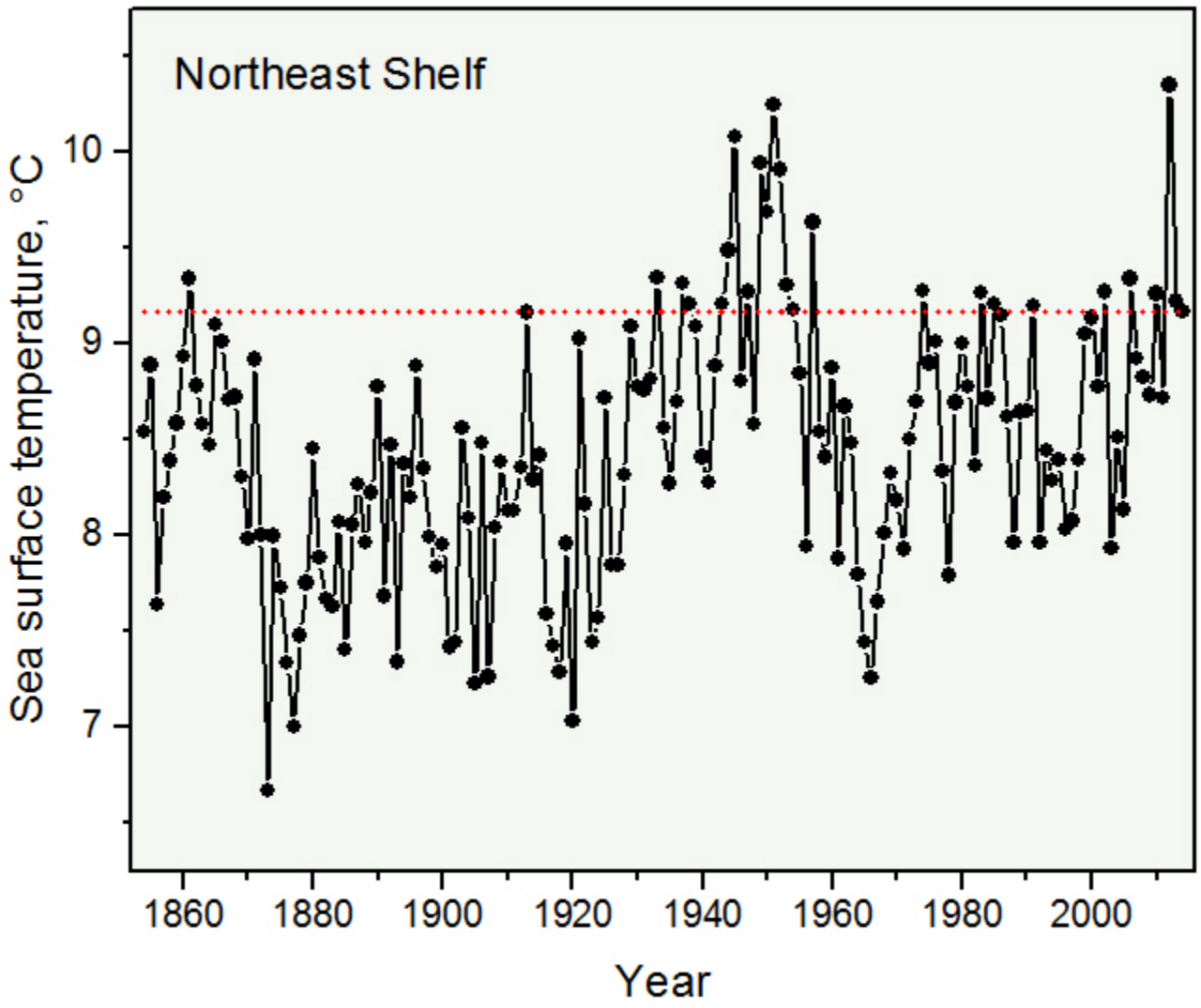
Scotian Shelf

Extended Reconstruction SST for First Half Year

The ERSST temperature time series provide a low resolution depiction of sea surface temperature on the Northeast Shelf since the 1850s and is based on historical shipboard measures and augmented with other data in recent years. The SST conditions for the first half of 2014 reflected cooler winter temperature conditions on the shelf and rapid warming in late spring as compared to the long term record (see Figure for first months of the year). The NES SST was in excess of 9°C in 2014, which is still above the long-term average of approximate 8.5°C, and is more typical of temperatures measured in recent decades (see Figure of SST time series), which are generally below the sea surface temperatures seen during the warm period of the late 1940s and early 1950s.



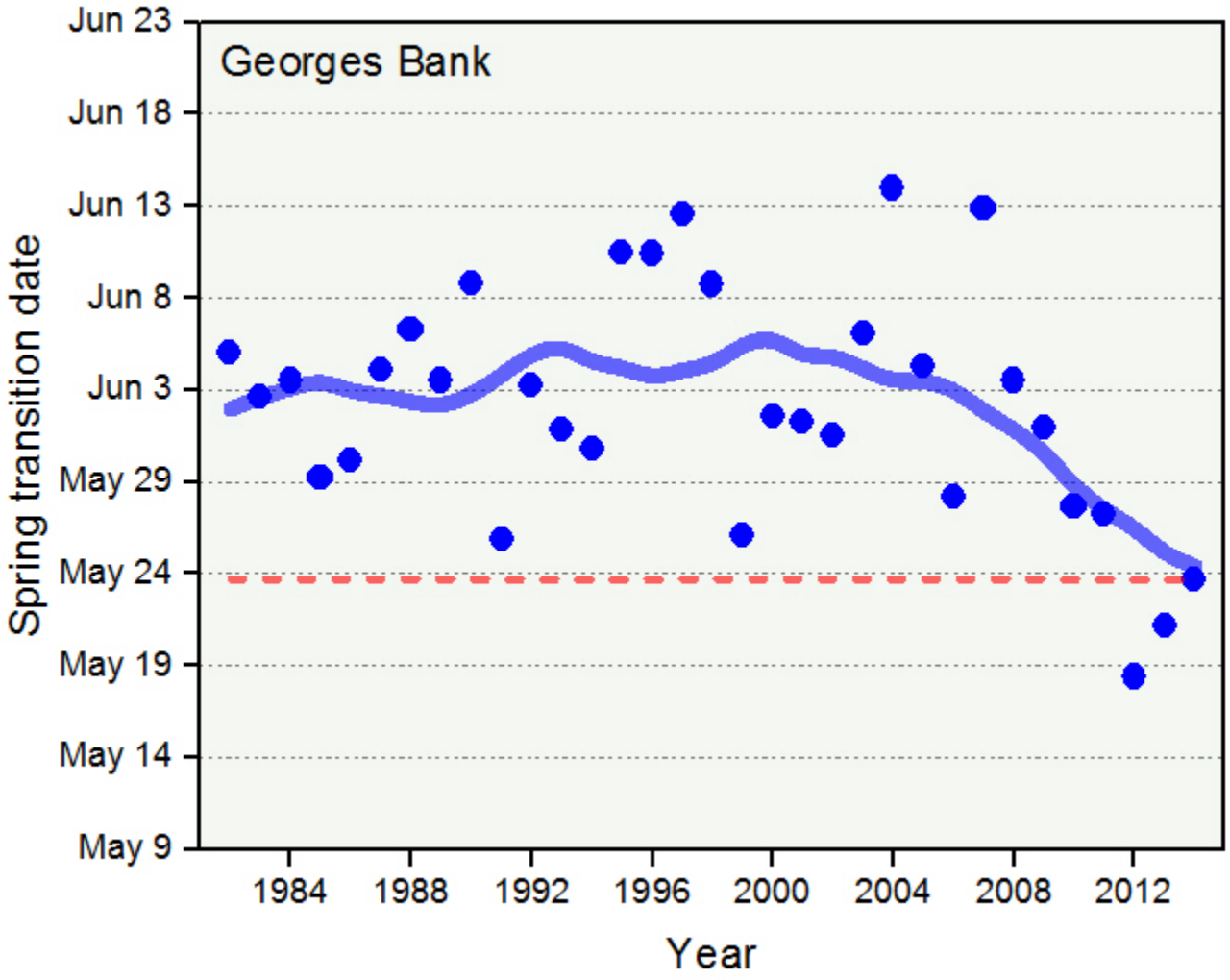
First months 2014



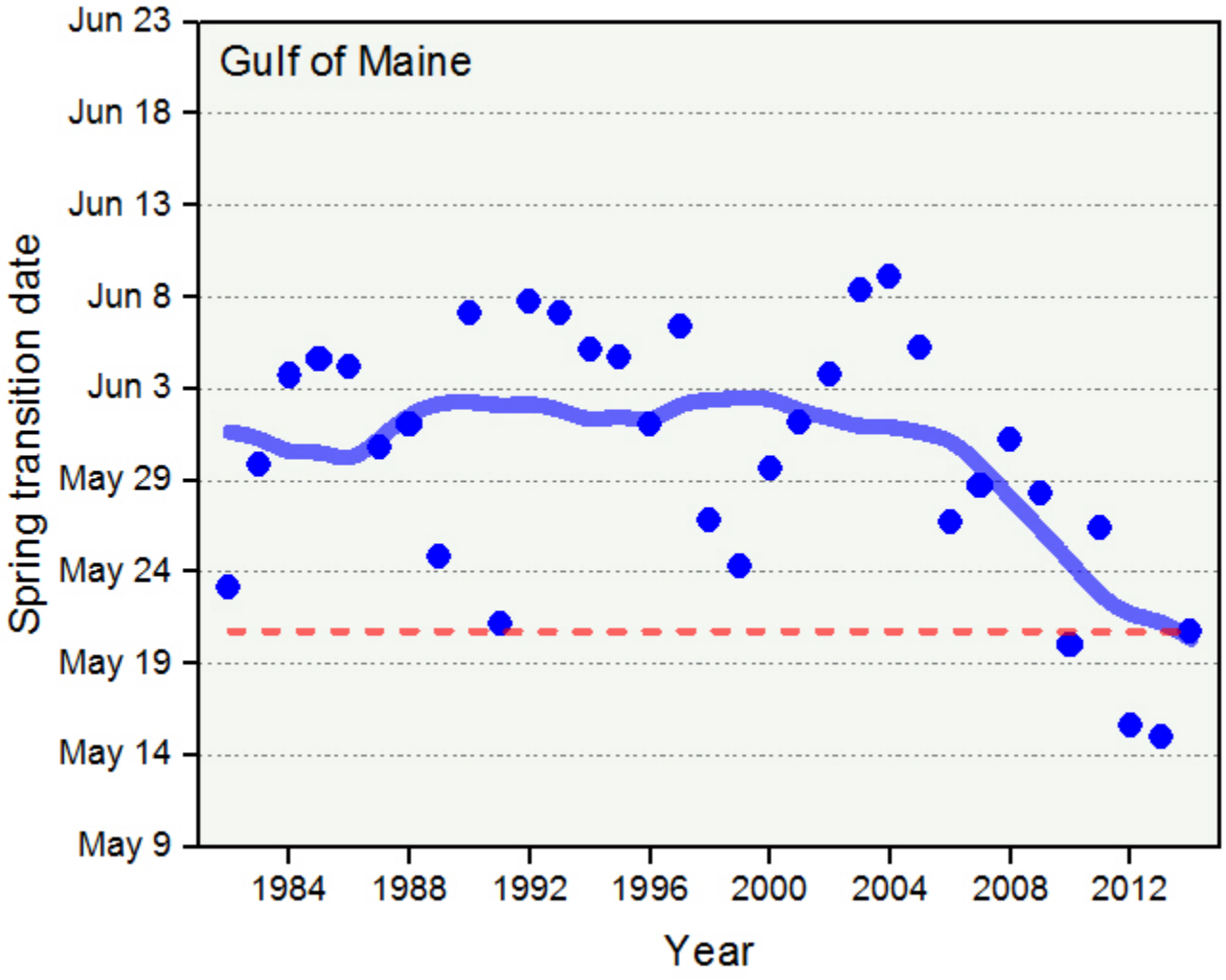
SST Time series

Thermal Transition Date

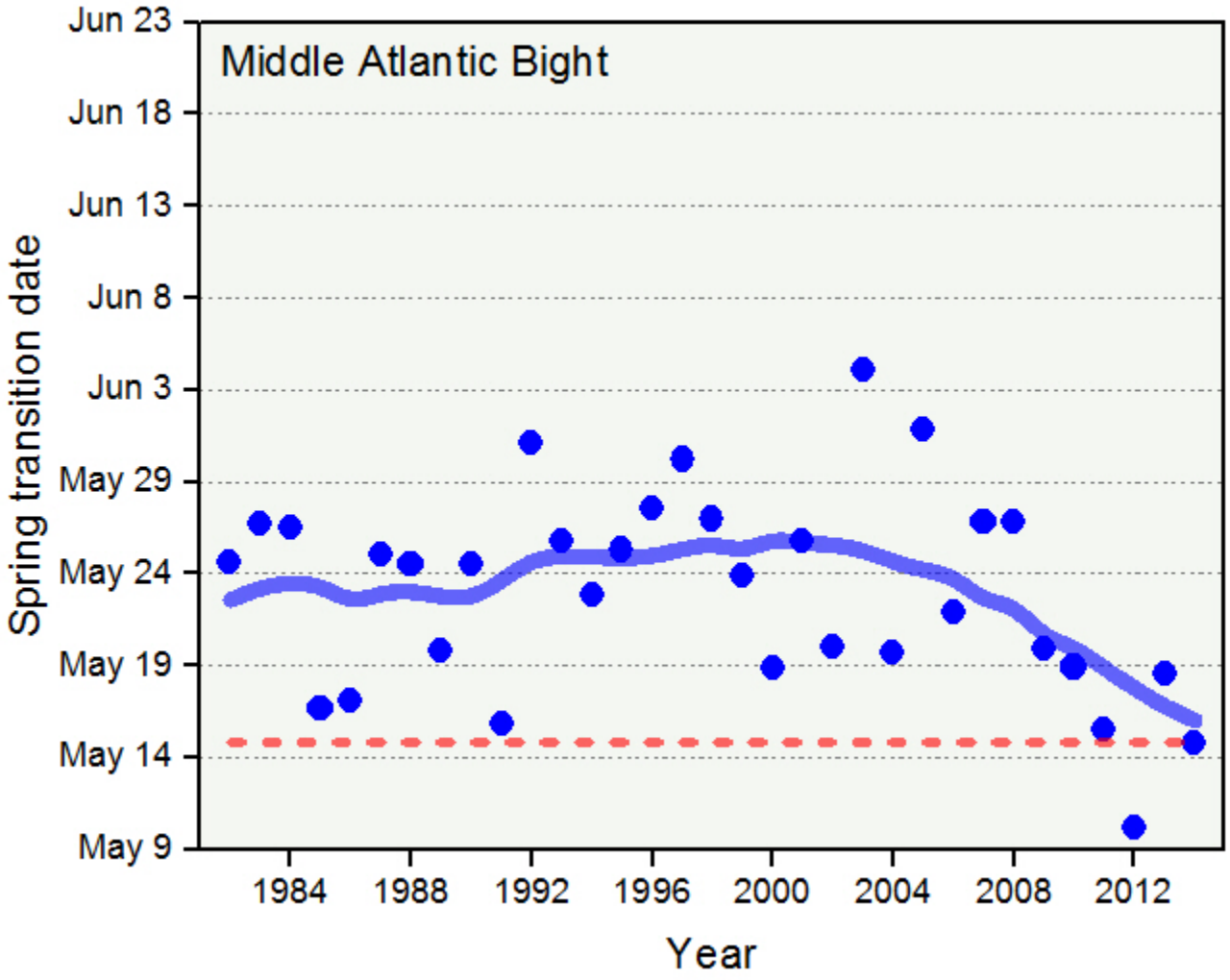
Phenology is the climate influence on the timing between plant and animal production cycles. Many marine organisms time their reproductive cycles to best utilize seasonal phytoplankton blooms, like the spring bloom, and in turn temperature plays a role in the development of the spring bloom. One measure to characterize the change in the timing of thermal forcing is the date of arrival of a spring transition temperature, which will vary by region and is meant to mark the average temperature between winter and summer. The date of arrival of the spring thermal transition temperature has been relative constant since 1982 to approximately 2006 for the Northeast Shelf as a whole and its constituent ecoregions (see figure). Since 2006, spring transition date has advanced on the order of two weeks. The 2014 spring transition dates are among the earliest in the data time series.



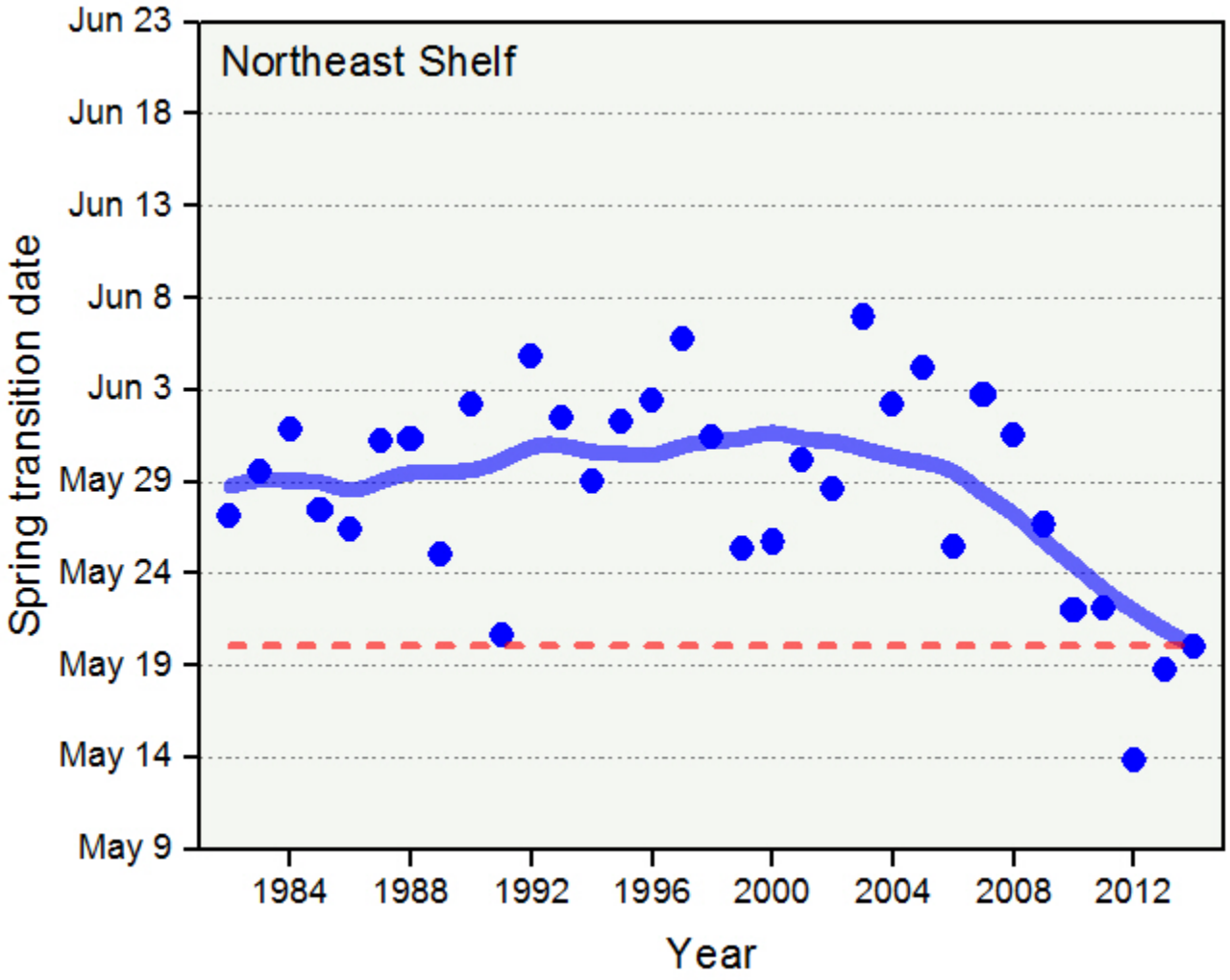
Georges Bank



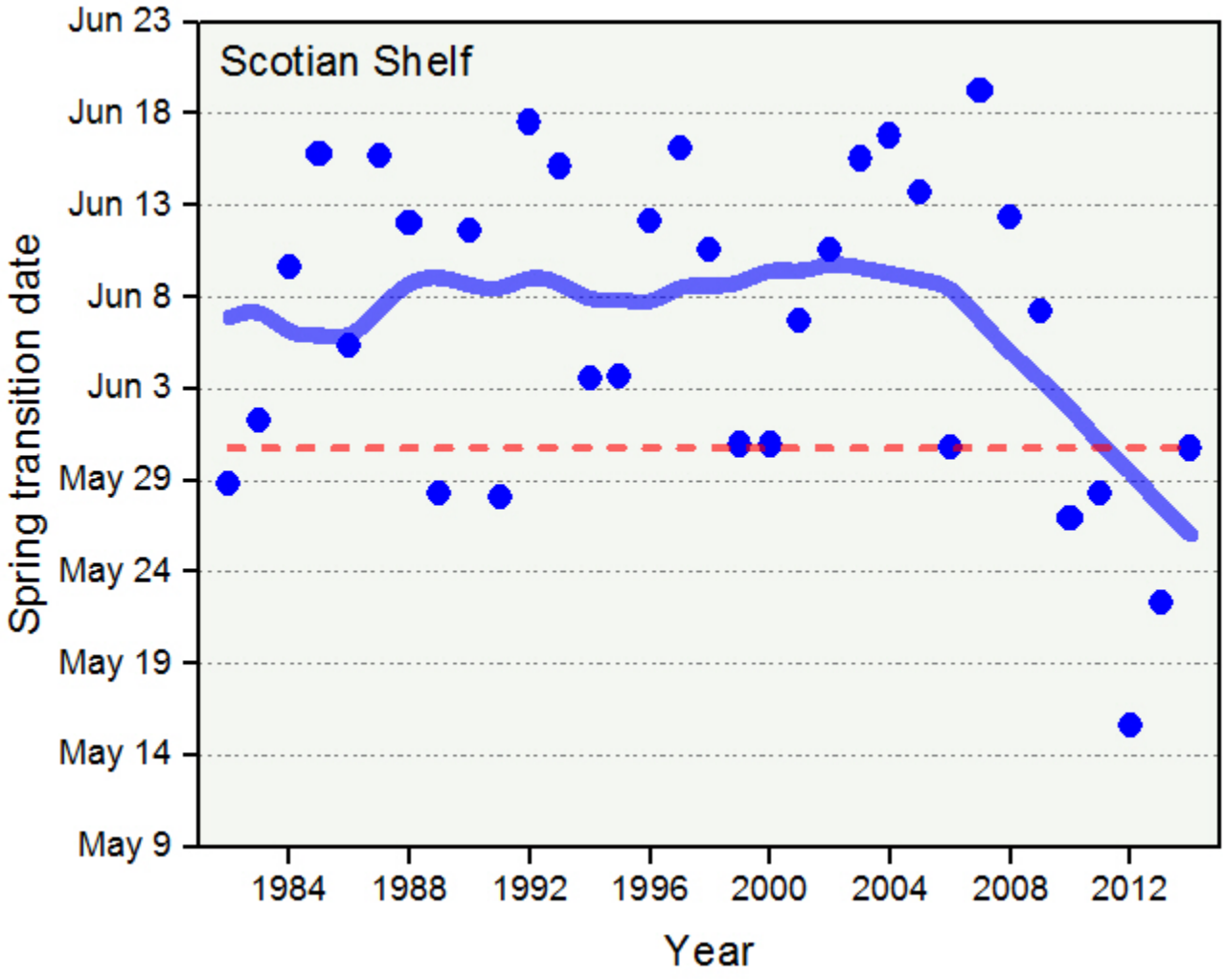
Gulf of Maine



Middle Atlantic Bight



Northeast Shelf

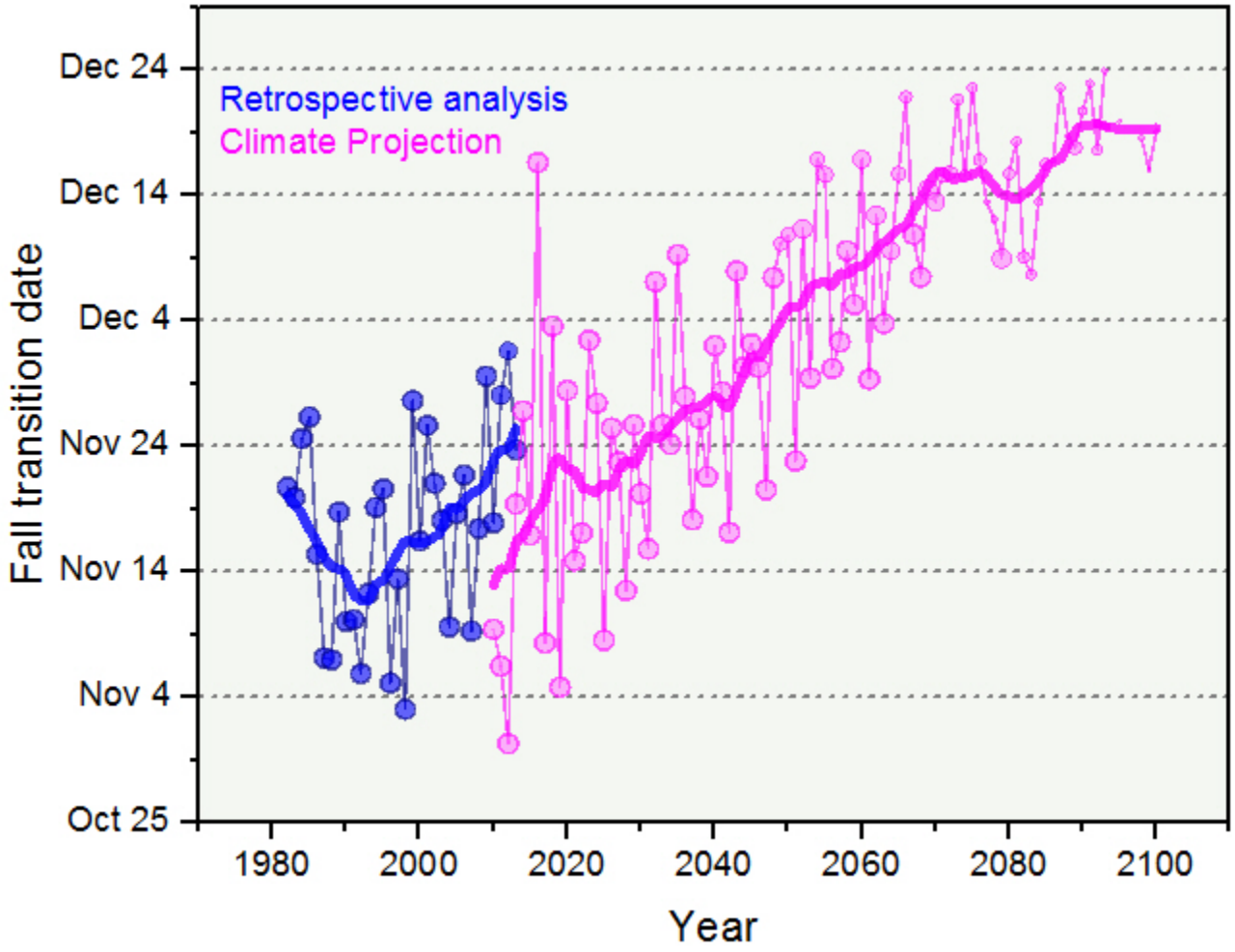


Scotian Shelf

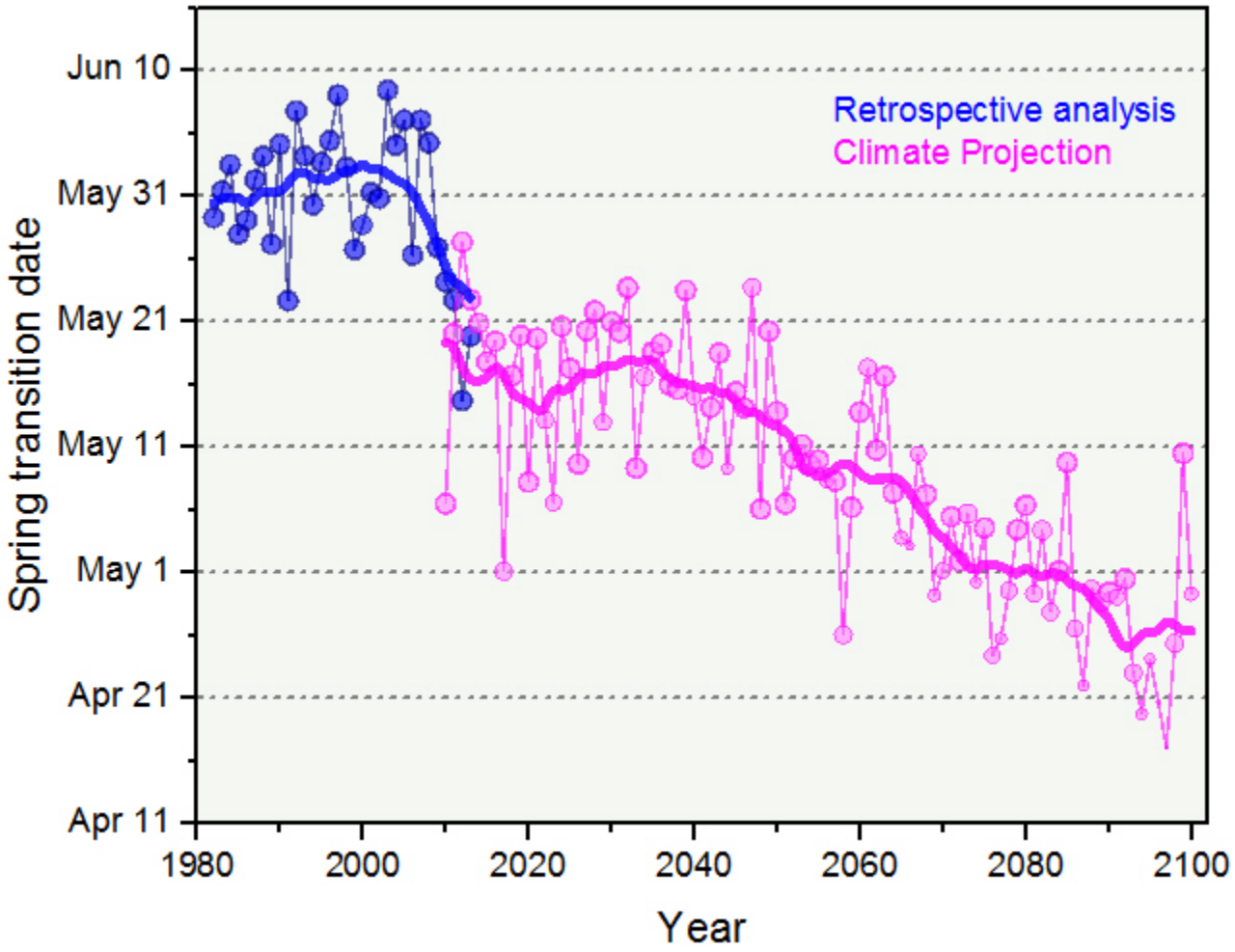
Long-Term Projection of Thermal Transitions and Length of Summer

With the expectation of increased temperature in future decades, other aspects other Northeast Shelf thermal regime are also likely to change. Using a climate projection provided by the Canadian Centre for Climate Modelling and Analysis, estimates of spring and fall thermal transition date and the length of the summer portion of the year were made to the year 2100. The model scenario used was the RCP8.5 case, which had been intended to represent the upper level of climate change forcing but is rapidly becoming a more likely case. The analysis was done on the spatial extent represented by the full Northeast Shelf large marine ecosystem for a base period of 1982 to 2013 (shown in blue); model projections based on the same transition temperature go from 2006 to 2100 (shown in magenta). The spring transition that is currently identified as mid-May is likely to shift on the order of three week to early April. The fall transition has the potential to shift slight more than the spring transition from a current date of

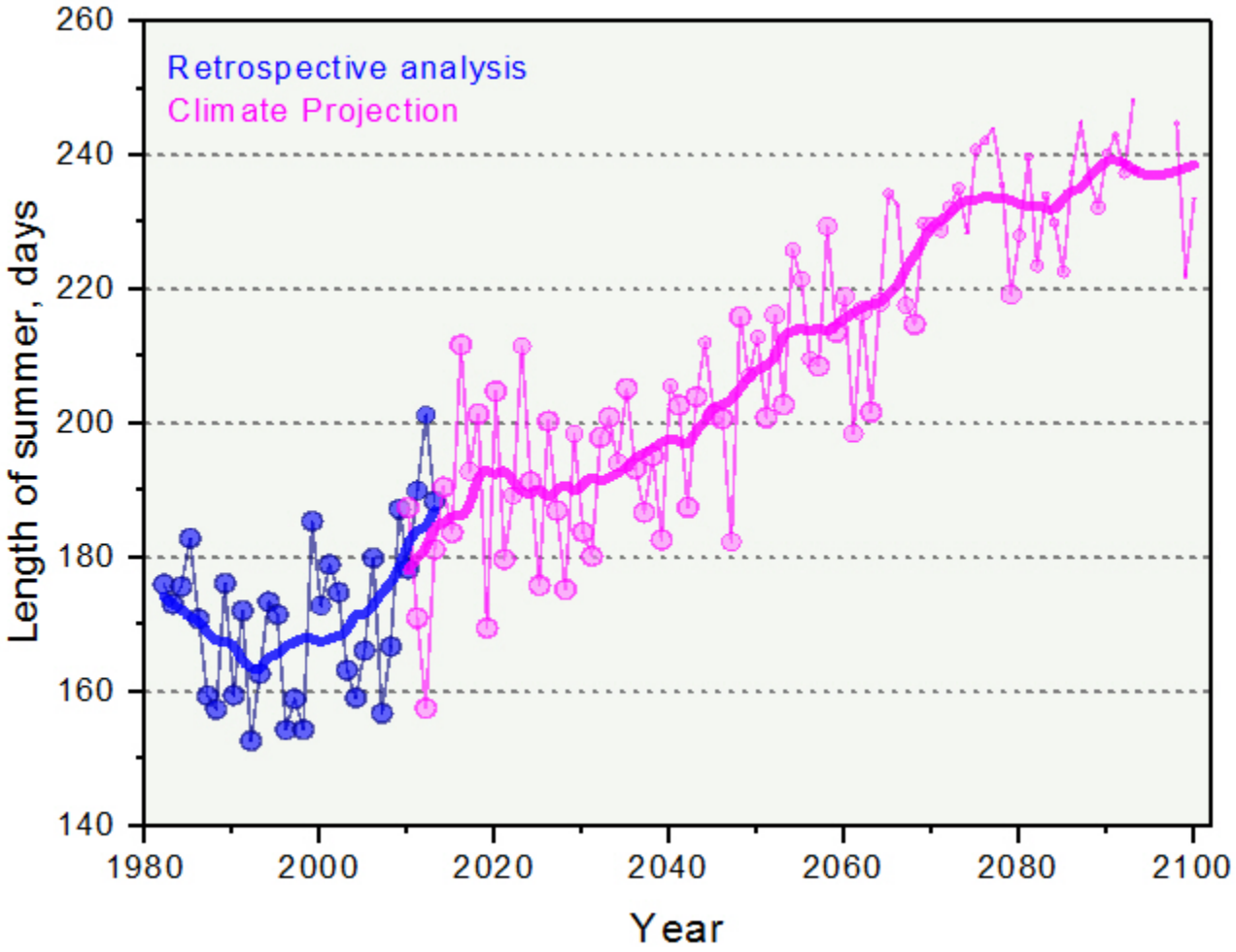
around mid-November to well into December. The consequences of these complementary shifts are that the length of the summer portion of the year, based on the contemporary transition temperature, will increase by approximately two months.



Fall transition date



Spring transition date

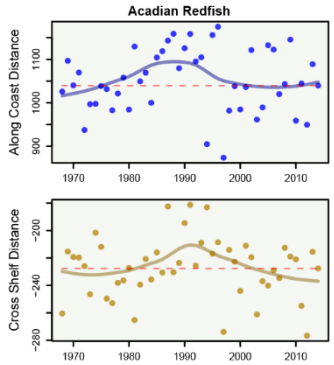


Length of summer

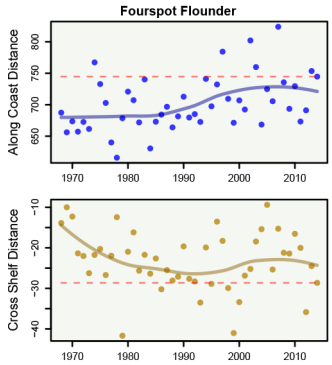
Trends in Spring Species Distribution

The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades. Individual species has shifted distribution due to a number of reasons and these shifts can be characterized in a number of different ways. Two metrics that have been used to characterize distribution on the NE Shelf include: 1) the position in the ecosystem along an axis oriented from the southwest to the northeast referred to as the along shelf distance; and, 2) the position across the continental shelf from the coastline referred to as the cross shelf distance. Along shelf distances range from 0 to 1300, which relate to positions along the axis from the southwest to northeast, respectively. Cross shelf distance range from 0 to -300, which relate to positions along an east-west axis from the coastline to offshore, respectively. The table below shows the species analyzed; click on a species name to see the along and cross-shelf distribution trends.

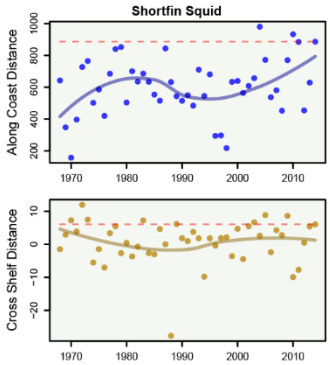
Acadian Redfish



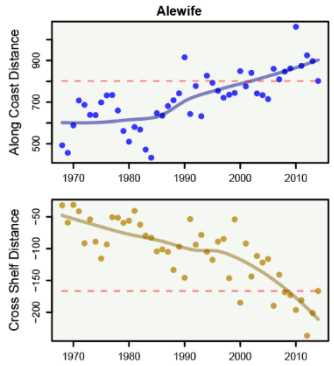
Fourspot Flounder



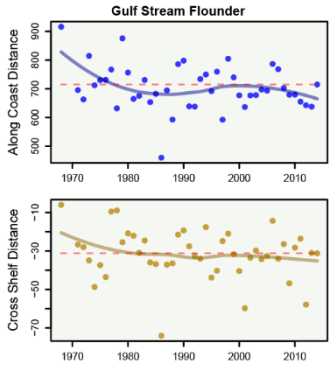
Shortfin Squid



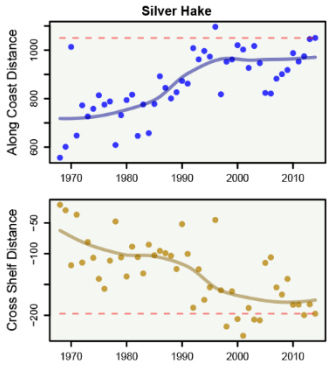
Alewife



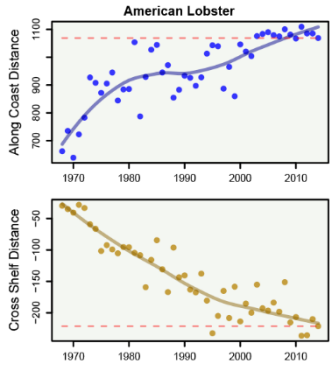
Gulf Stream Flounder



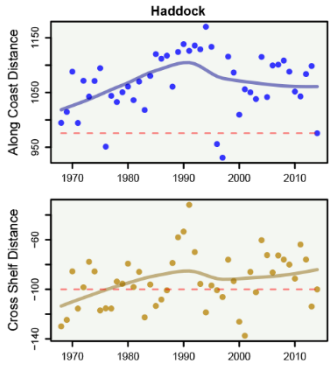
Silver Hake



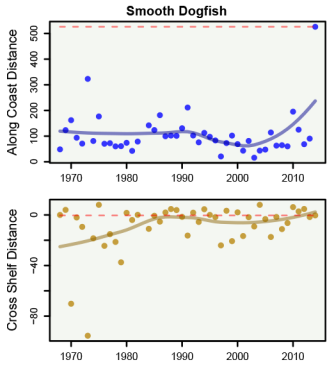
American Lobster



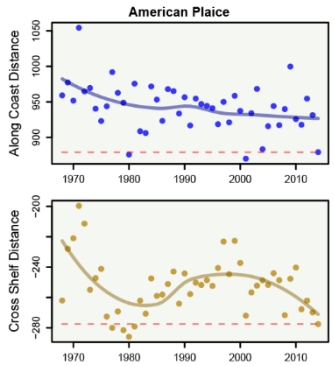
Haddock



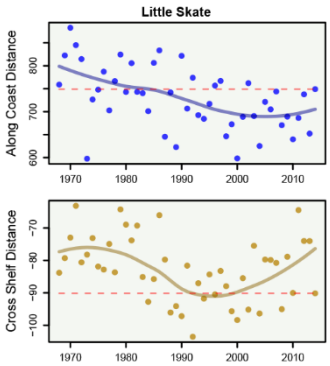
Smooth Dogfish



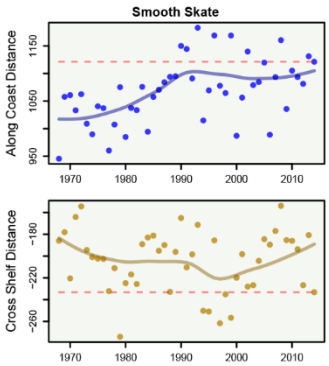
American Plaice



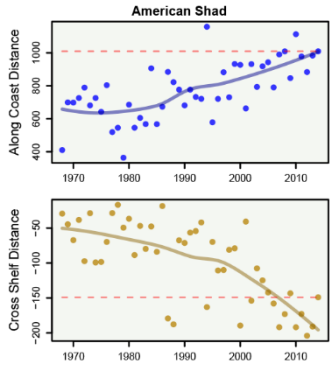
Little Skate



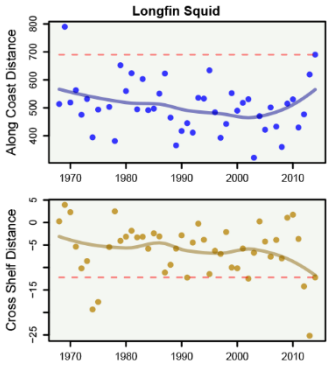
Smooth Skate



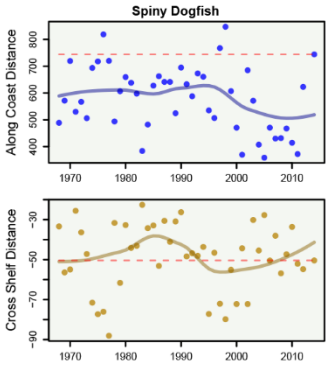
American Shad



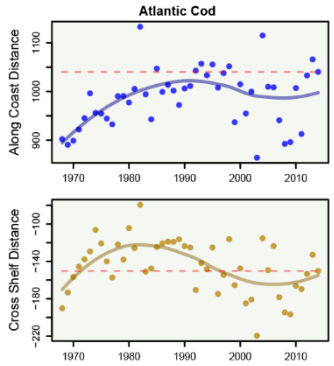
Longfin Squid



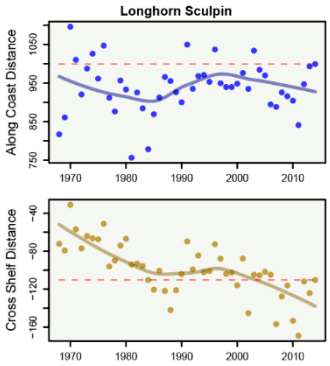
Spiny Dogfish



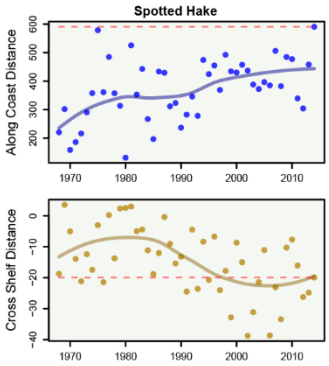
Atlantic Cod



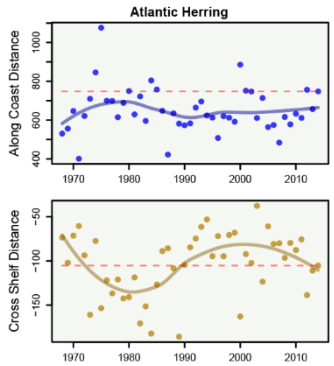
Longhorn Sculpin



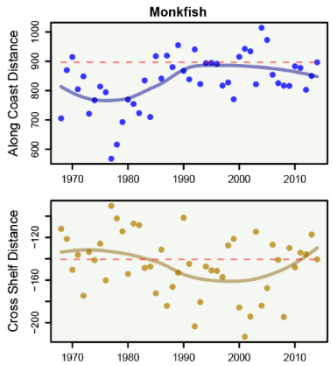
Spotted Hake



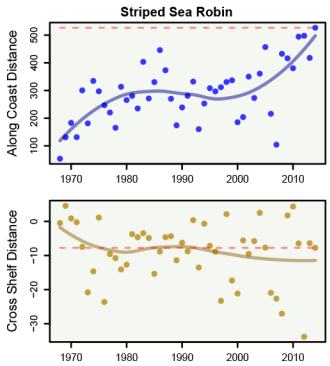
Atlantic Herring



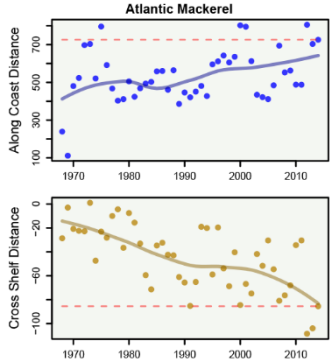
Monkfish



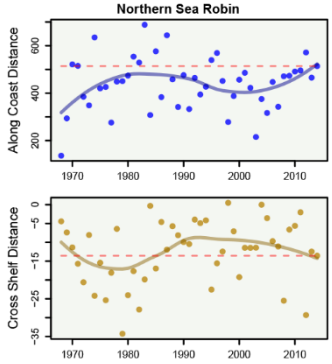
Striped Sea Robin



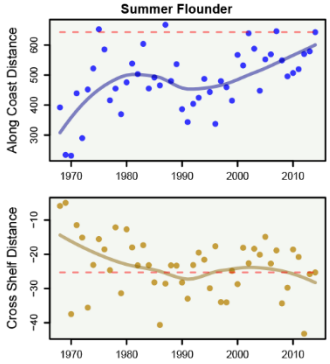
Atlantic Mackerel



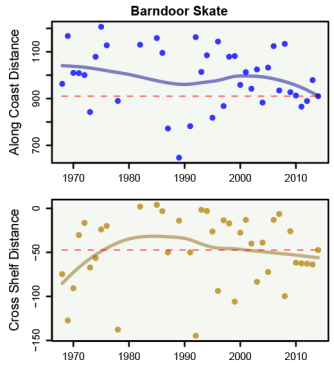
Northern Sea Robin



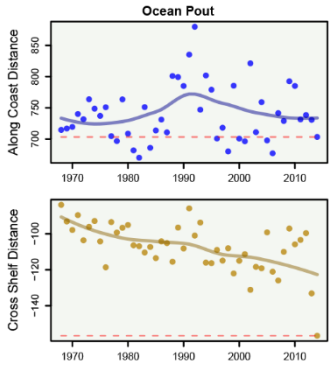
Summer Flounder



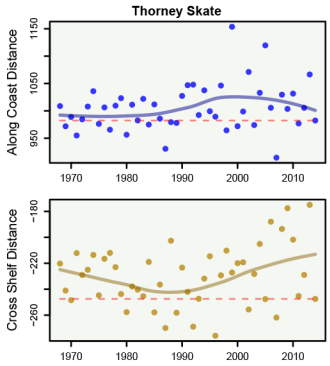
Barndoor Skate



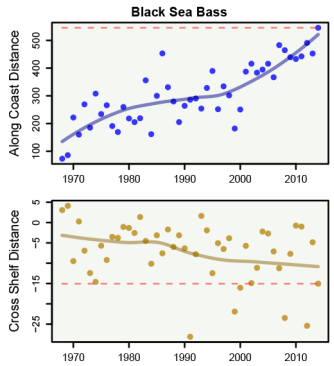
Ocean Pout



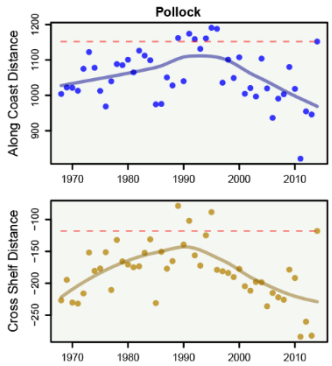
Thorney Skate



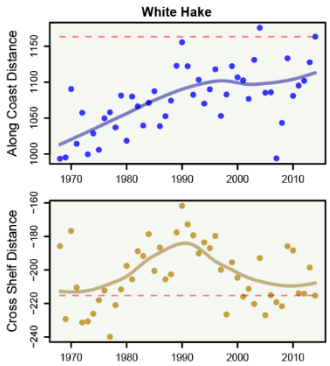
Black Sea Bass



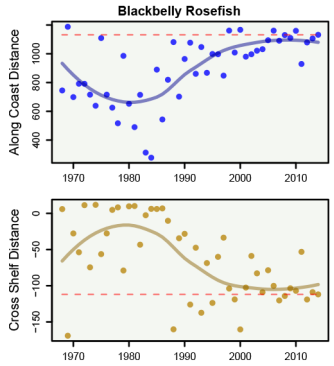
Pollock



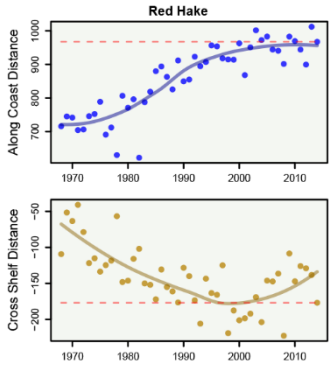
White Hake



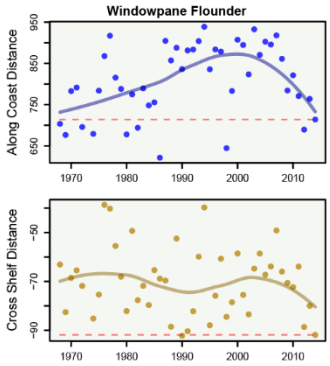
Blackbelly Rosefish



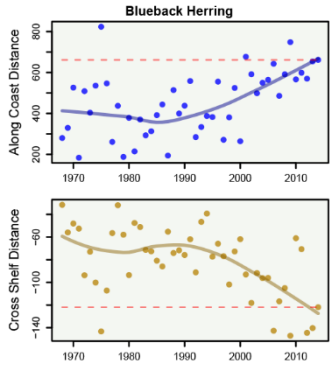
Red Hake



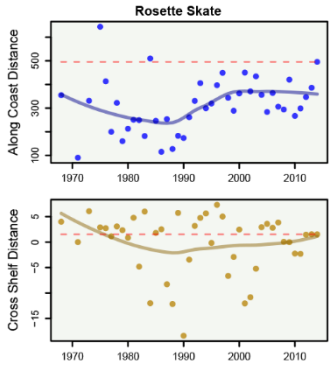
Windowpane Flounder



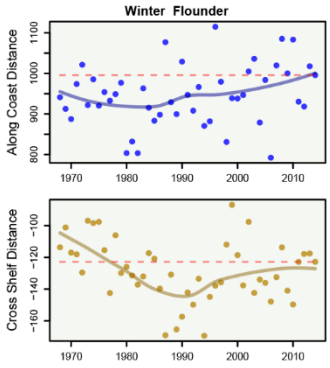
Blueback Herring



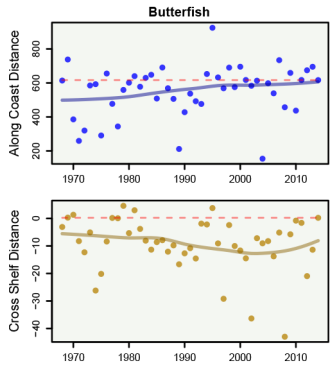
Rosette Skate



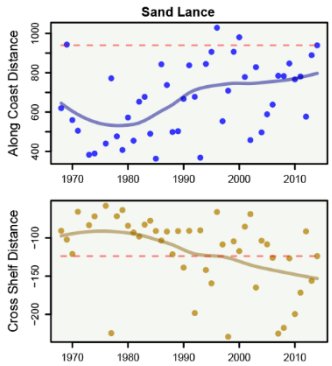
Winter Flounder



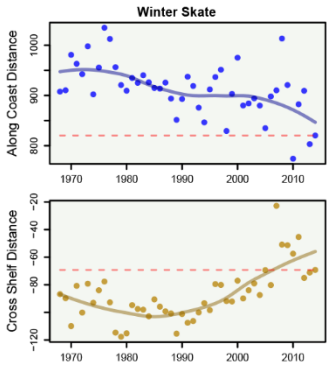
Butterfish



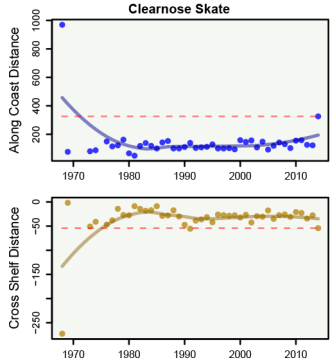
Sand Lance



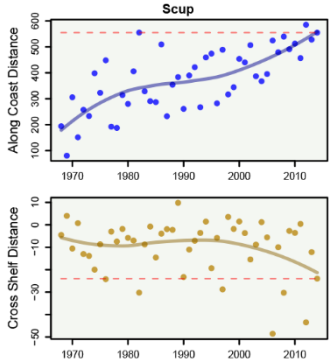
Winter Skate



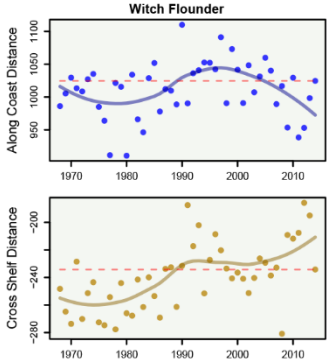
Clearnose Skate



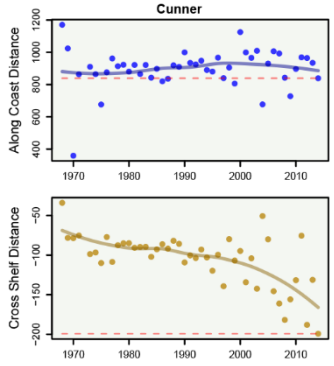
Scup



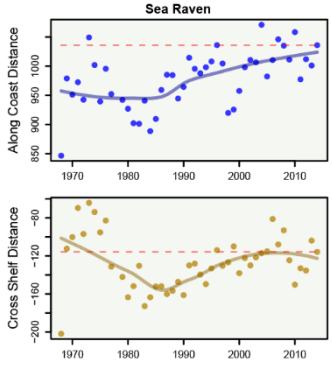
Witch Flounder



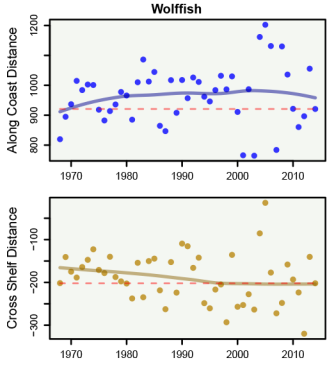
Cunner



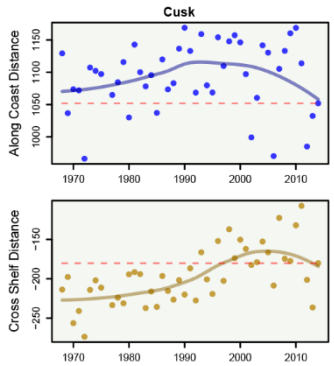
Sea Raven



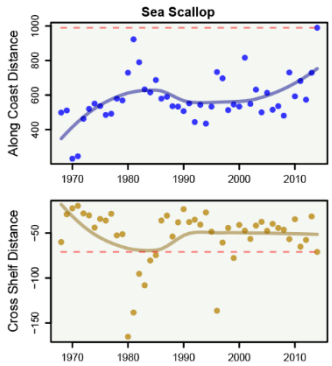
Wolffish



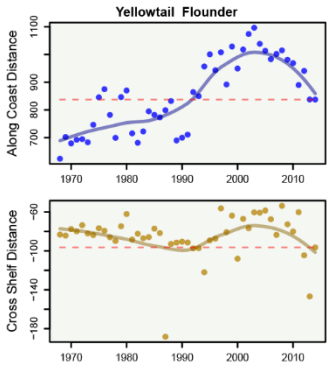
Cusk



Sea Scallop



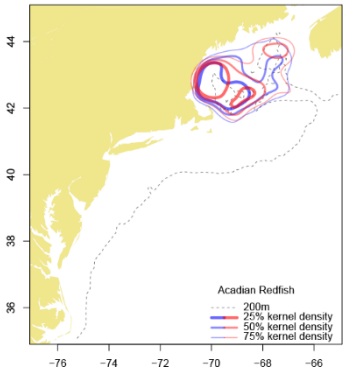
Yellowtail Flounder



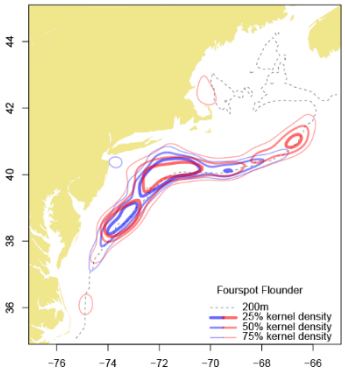
Kernel Density Plots of Spring Species Distribution

The habitats used by species of the Northeast Shelf ecosystem have changed over recent decades. Species have moved in response to a complex set of factors resulting in changes in distribution in respect to latitude and depth, among a number of habitat indicators. Kernel density plots provide a way of characterizing where a species is distributed by defining an area with an associated probability that a species will be found there. We compared the kernel densities for three probability levels between two time periods. The three probably levels were 25, 50, and 75% kernel densities; the 25% kernel defines the core area of the distribution whereas the 75% defines the broader use of the ecosystem. The two time periods were a base distribution period based on species distribution during the 1970s (shown as blue kernel densities) and a contemporary distribution period based on the last three years (2012-2014) for the spring survey (shown as red kernel densities). The table below shows the species analyzed; click on a species name to see kernel density plots.

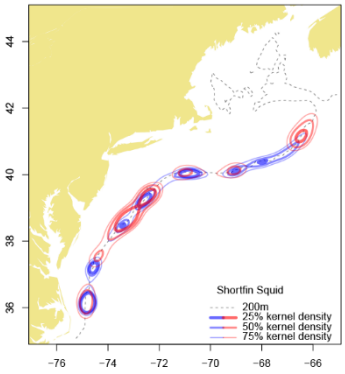
Acadian Redfish



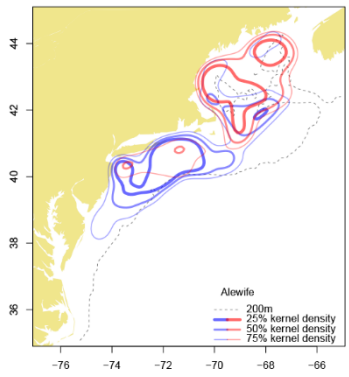
Fourspot Flounder



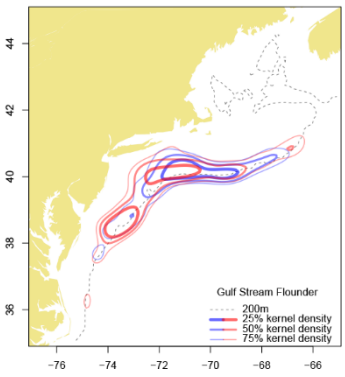
Shortfin Squid



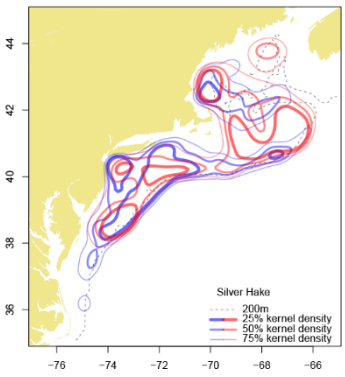
Alewife



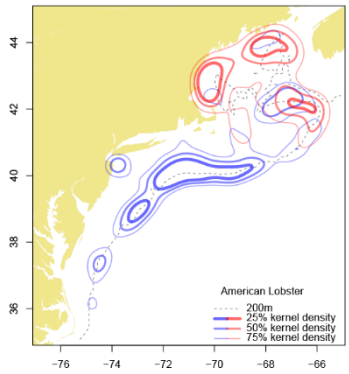
Gulf Stream Flounder



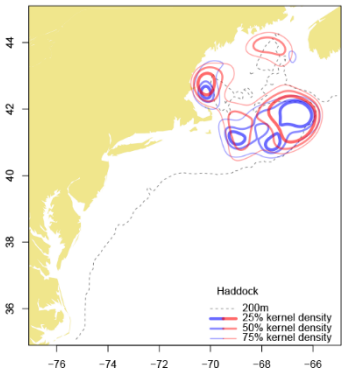
Silver Hake



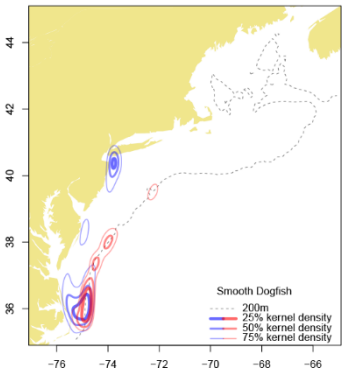
American Lobster



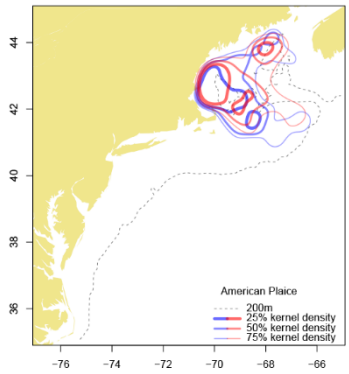
Haddock



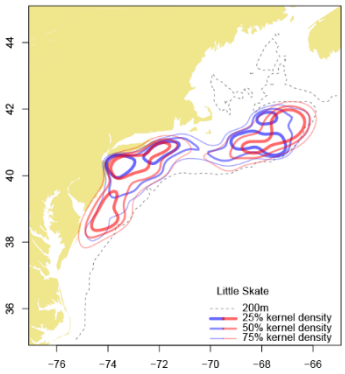
Smooth Dogfish



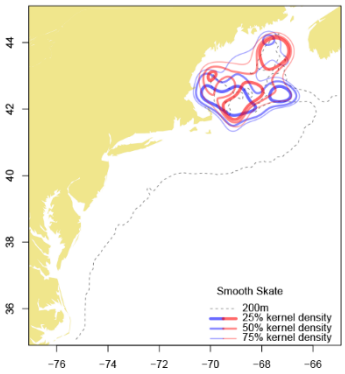
American Plaice



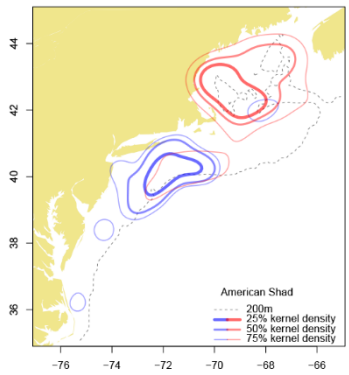
Little Skate



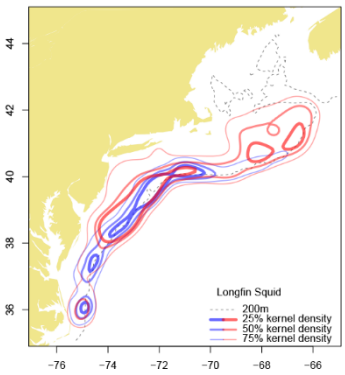
Smooth Skate



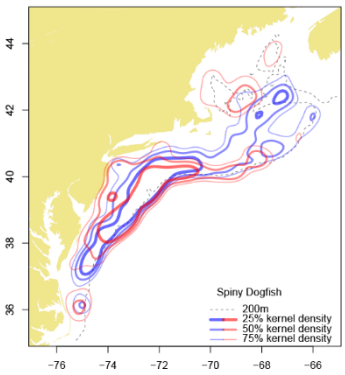
American Shad



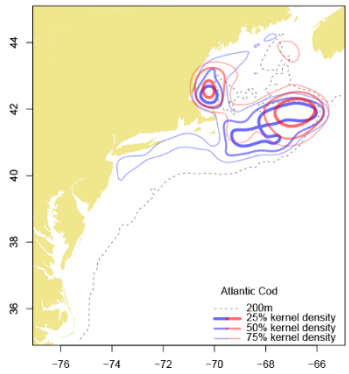
Longfin Squid



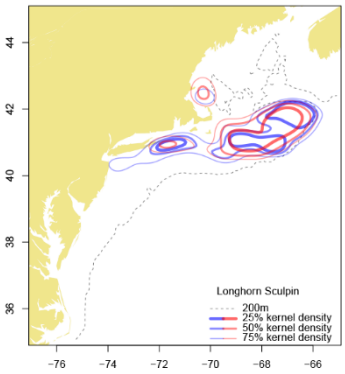
Spiny Dogfish



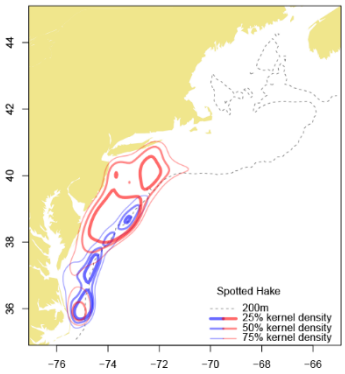
Atlantic Cod



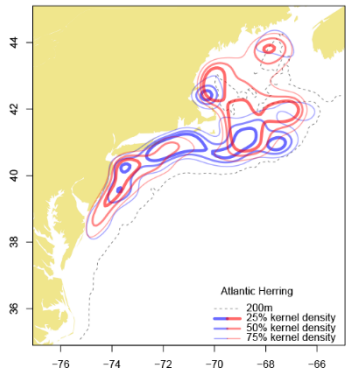
Longhorn Sculpin



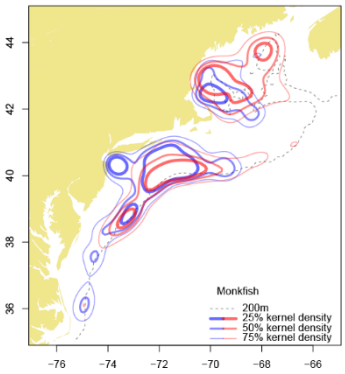
Spotted Hake



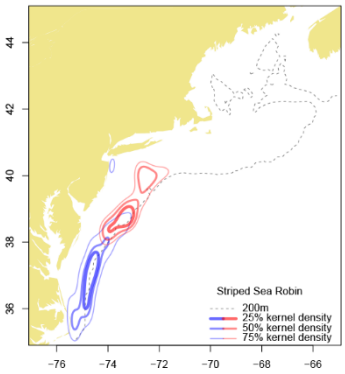
Atlantic Herring



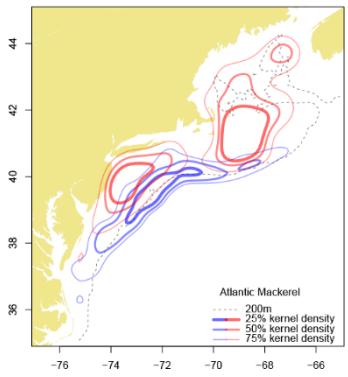
Monkfish



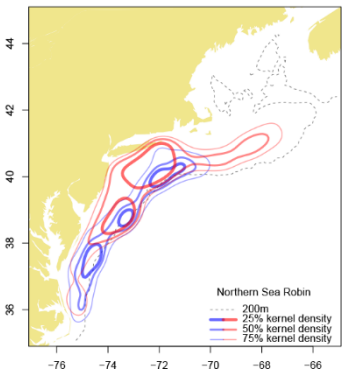
Striped Sea Robin



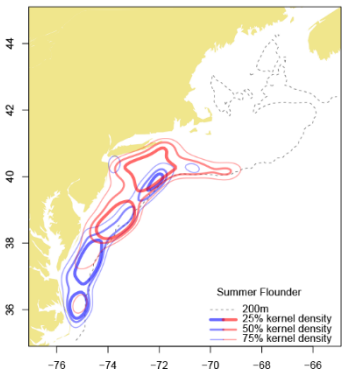
Atlantic Mackerel



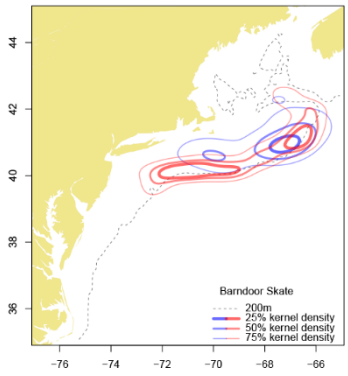
Northern Sea Robin



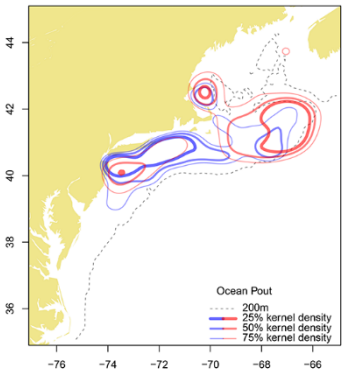
Summer Flounder



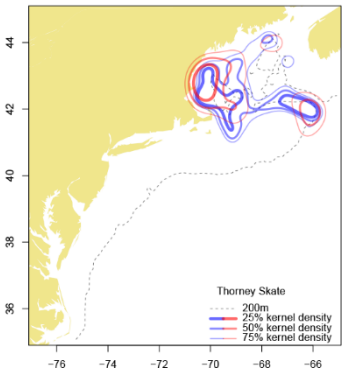
Barndoor Skate



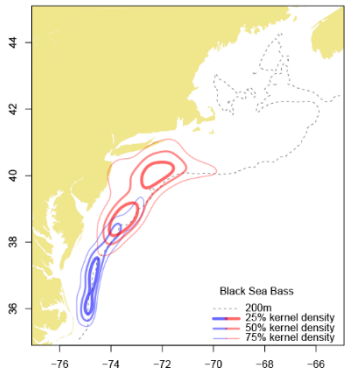
Ocean Pout



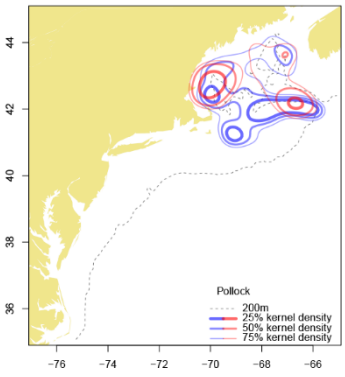
Thorney Skate



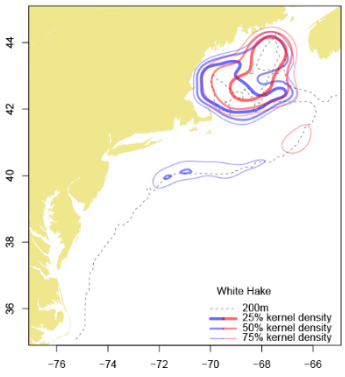
Black Sea Bass



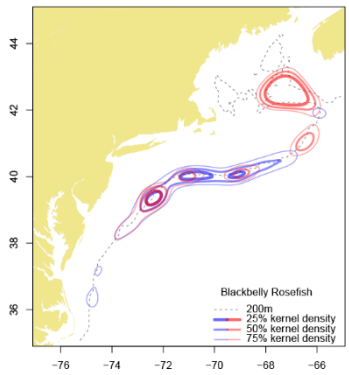
Pollock



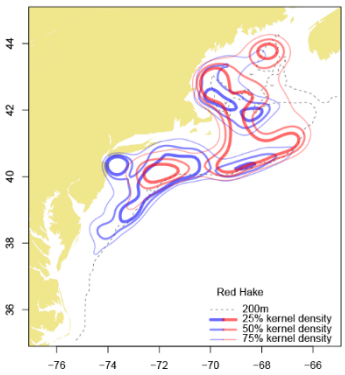
White Hake



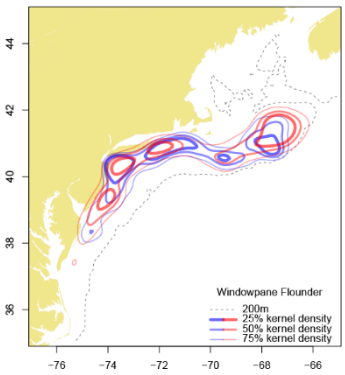
Blackbelly Rosefish



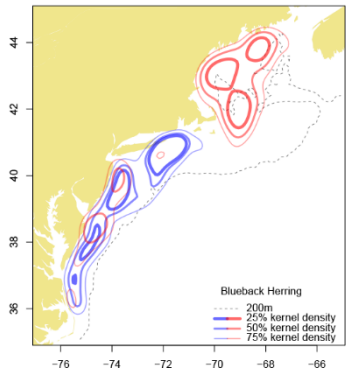
Red Hake



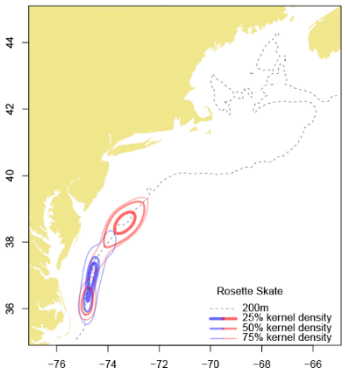
Windowpane Flounder



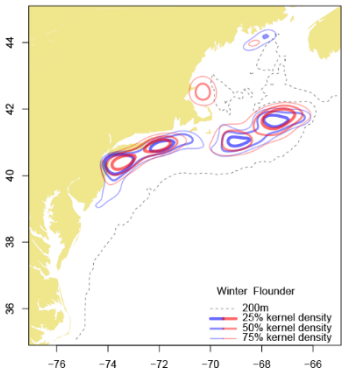
Blueback Herring



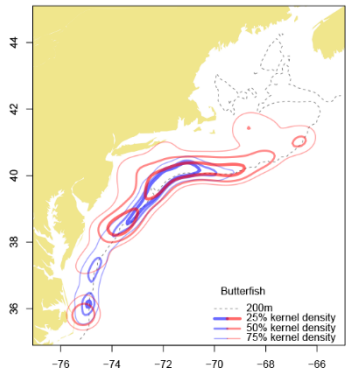
Rosette Skate



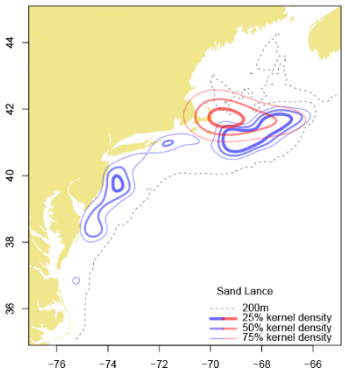
Winter Flounder



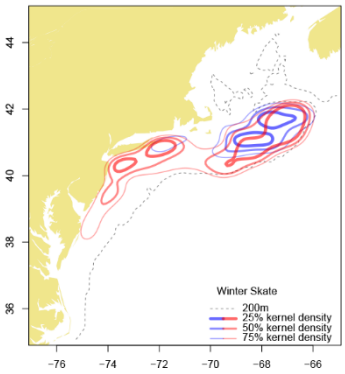
Butterfish



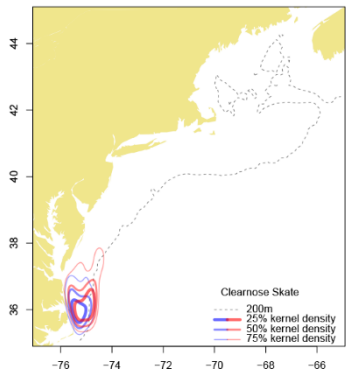
Sand Lance



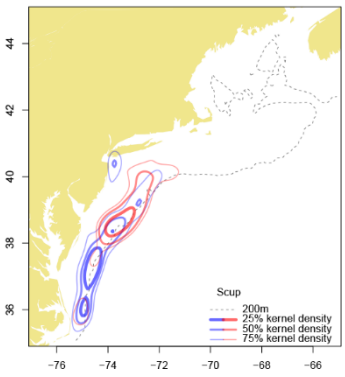
Winter Skate



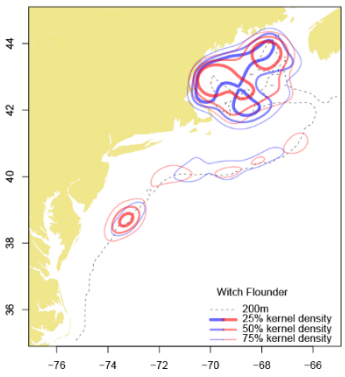
Clearnose Skate



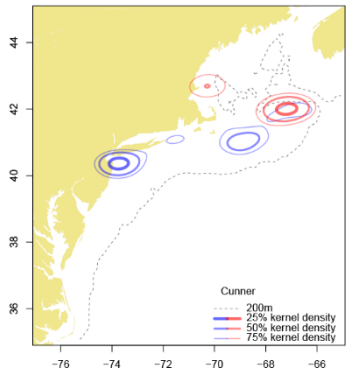
Scup



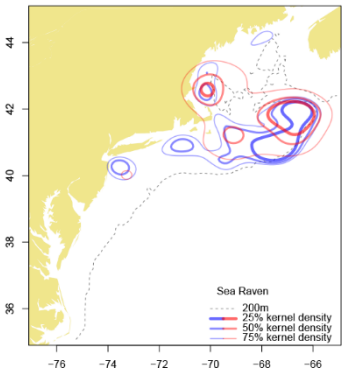
Witch Flounder



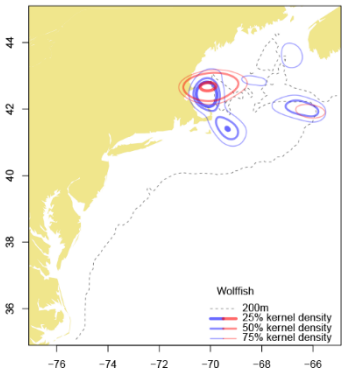
Cunner



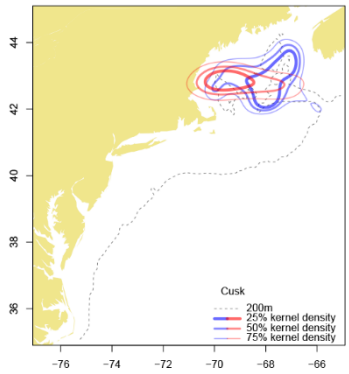
Sea Raven



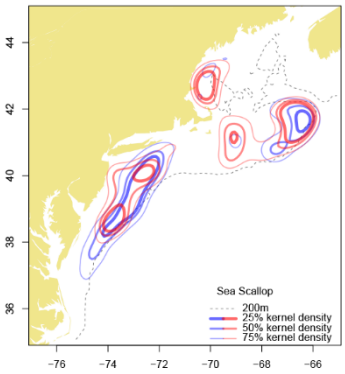
Wolffish



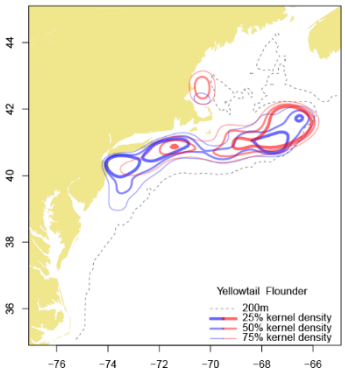
Cusk



Sea Scallop



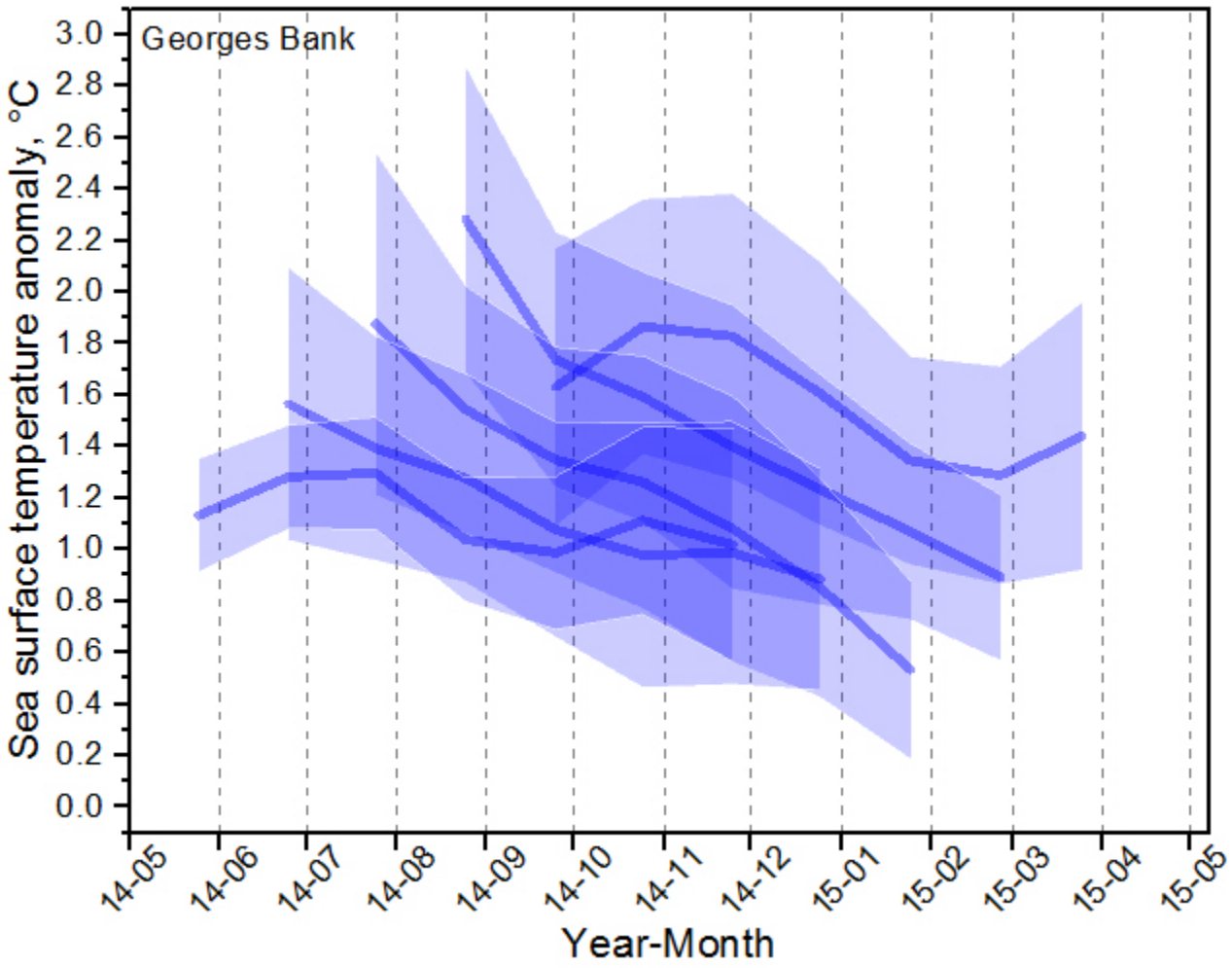
Yellowtail Flounder



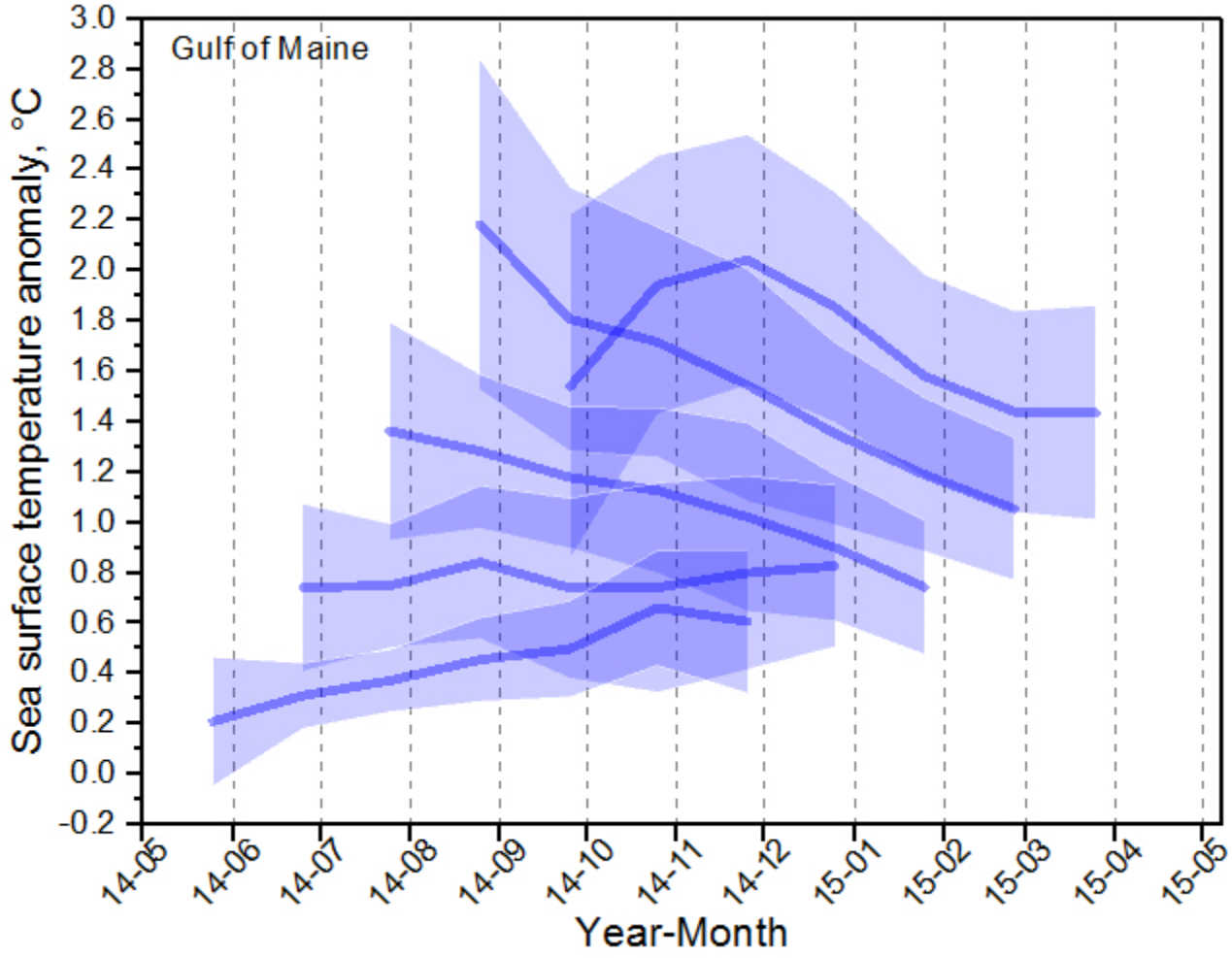
Sea Surface Temperature Forecast

For each of the ecoregions of the Northeast Shelf, five sequential forecasts are overlaid to provide a depiction of the overall direction of the forecast by area and a measure of the agreement between successive forecasts. Each forecast is represented by a line and an error fan of one standard error of the forecast ensemble mean. The forecast plots are made with transparent coloring so overlap or agreement is shown as darker tones. The best model and forecast agreement can be seen in the Middle Atlantic Bight that suggests temperature will be

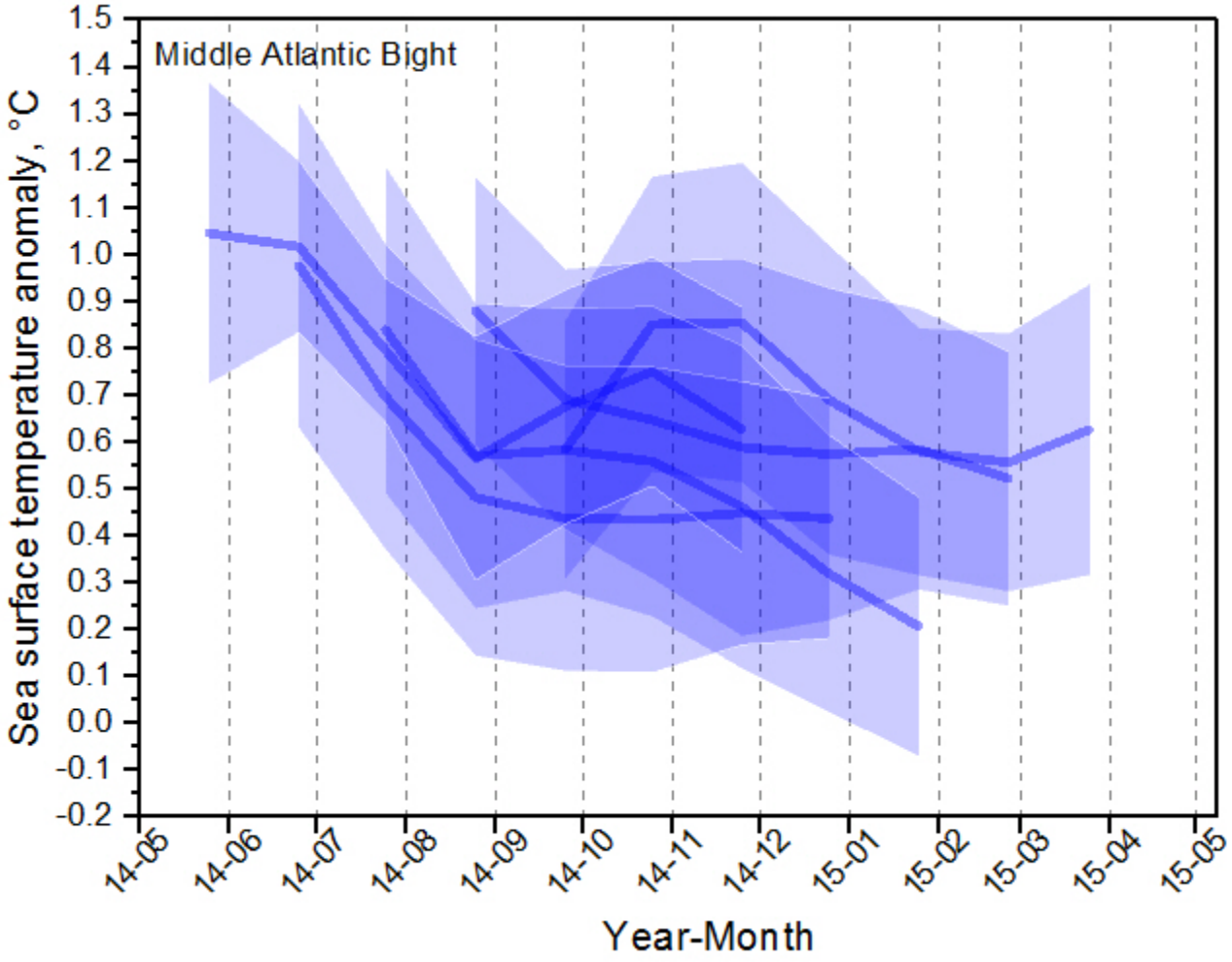
about 0.5°C above average through the early winter period. There is poor agreement of successive forecasts for the Georges Bank and Gulf of Maine areas suggesting the forecast direction has shifted with successive forecasts.



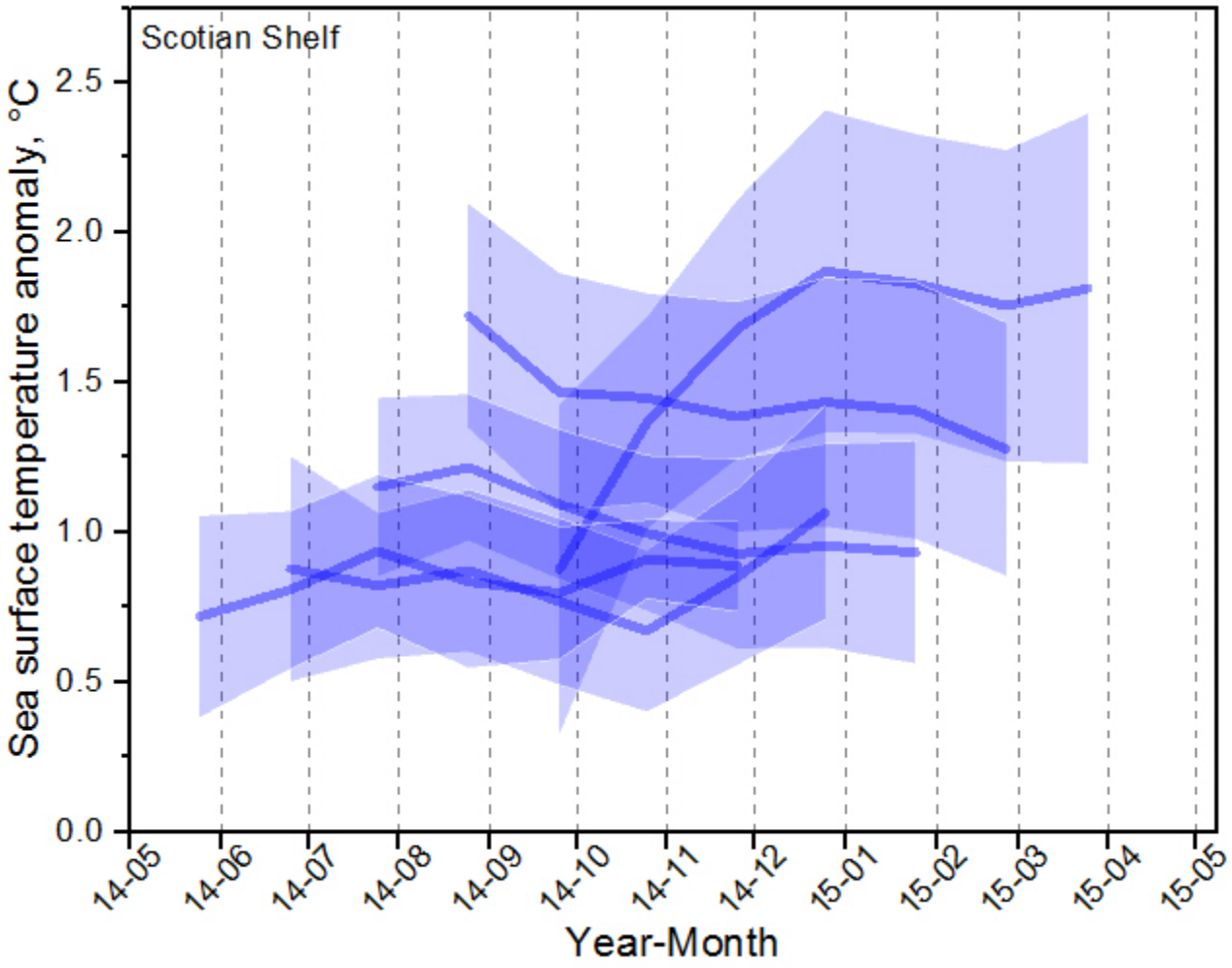
Georges Bank



Gulf of Maine



Middle Atlantic Bight



Scotian Shelf