Spring 2012 Update: Annual Condition of the Northeast Shelf Ecosystem

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Spring 2012 Update: Summary of Conditions of the Northeast Shelf Ecosystem

Summary

- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem were above average during the second half of 2011 continuing the trend of warm conditions found during the first half of the year.
- There were exceptionally robust spring phytoplankton blooms on the Northeast Shelf; however, the fall bloom was not distinct enough to be measured as an event. Clearly there were multiple regional blooms in the second half of the year, most notably a summer bloom in the Middle Atlantic Bight.
- Zooplankton biomass levels were above average for the first half of the year and below average for the second half.
- Key climate drivers related to thermal conditions on Northeast Shelf were at extreme index levels, which were associated with the warm conditions observed on the Shelf in both short and long time series.
- Core thermal habitats were at a low level in 2011 caused by warming conditions that were not uniform across the ecosystem.

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.

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.

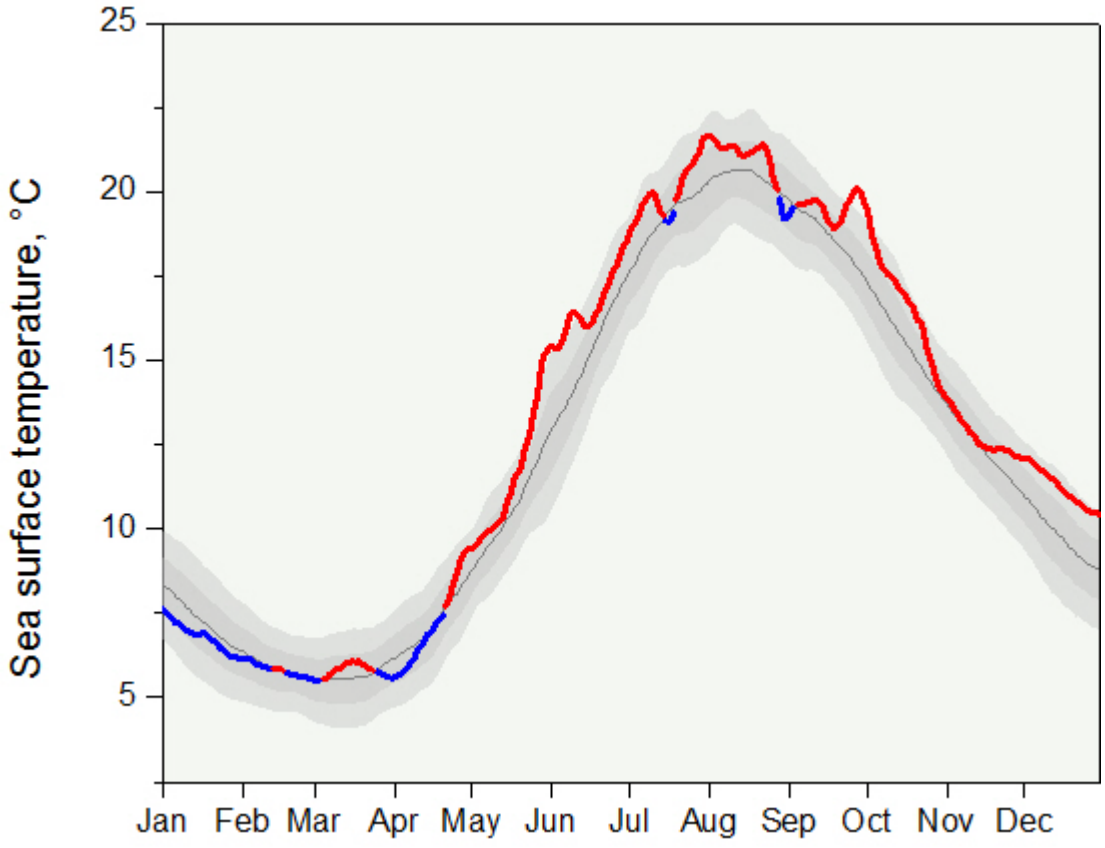
Zooplankton biomass was derived from shipboard surveys of the U.S. Northeast Shelf ecosystem. Zooplankton provide the link from primary producers to higher trophic levels. From 1977-1987, the MArine Resources Monitoring, Assessment, & Prediction (MARMAP) program conducted intensive surveys from Cape 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.

Thermal habitats were computed using the NOAA Optimum Interpolation 1/4 Degree Daily Sea Surface Temperature Analysis.

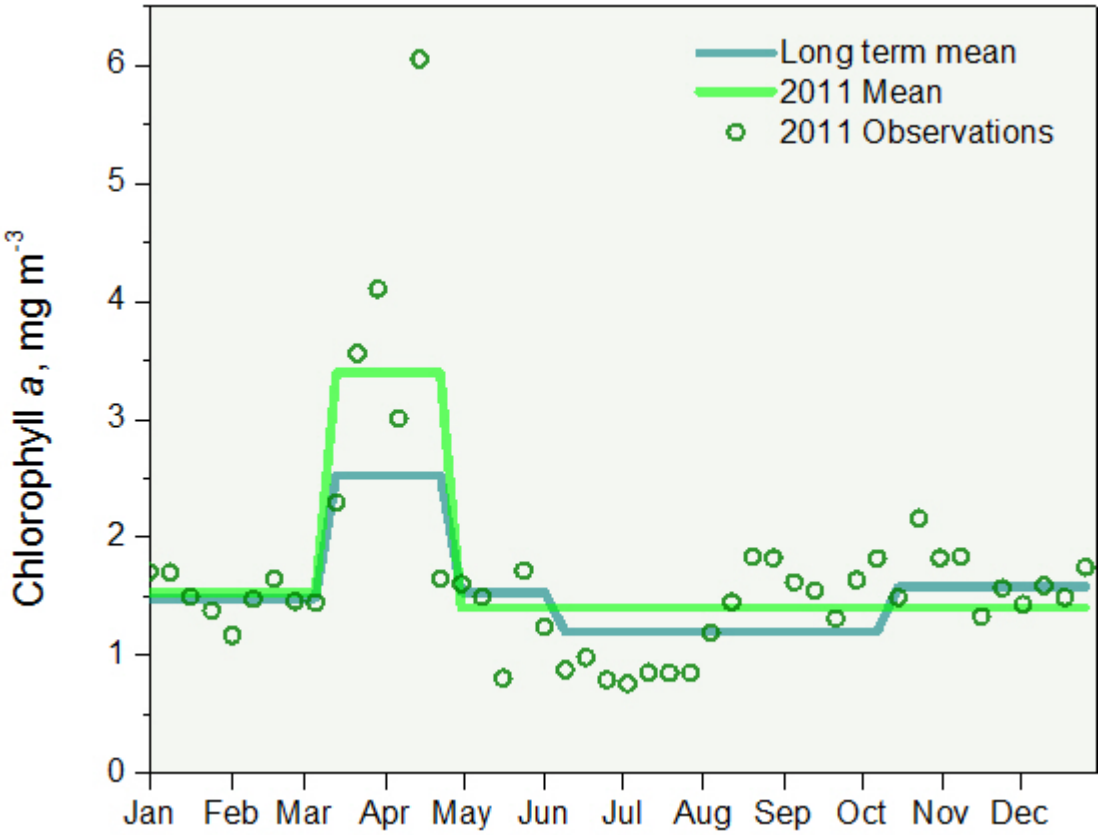
Long term SSTs were extracted from the Extended Reconstructed Sea Surface Temperature (ERSST, version 3) dataset. This dataset is based on the temperature compilation of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) SST dataset, and contains reconstructed SST fields (obtained by interpolation) in regions with sparse data.

Sea Surface Temperature



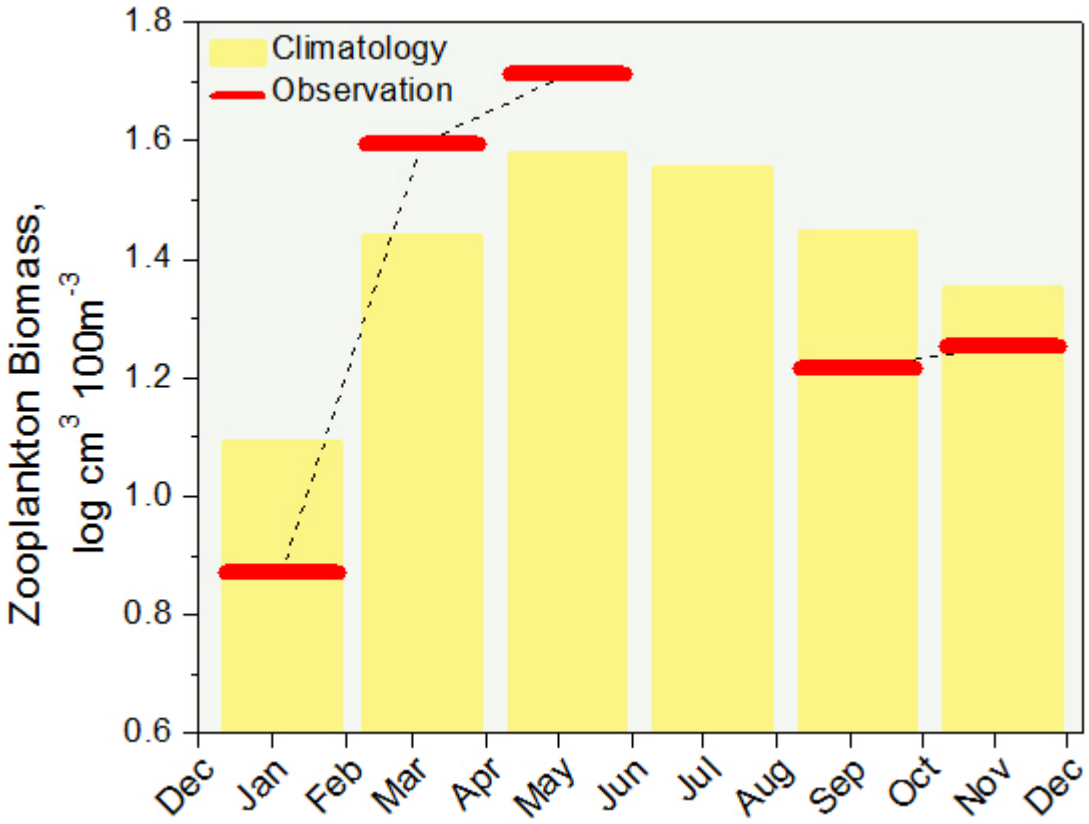
The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures (SSTs) during the fall of 2011 continuing the trend of above average temperatures seen during spring into summer seasons. In the graph, the long term mean SST is shown as a dark gray line with areas representing plus and minus one and two standard deviations of the mean as progressive shades of gray, respectively. SSTs below the long term mean are shown in blue, above the mean in red. The warmest seasonal conditions during 2011 were found during December.

Chlorophyll Concentration



Though regions of the Northeast Shelf Large Marine Ecosystem often have fall bloom activity, the ecosystem as a whole does not typically have a fall bloom. This depiction of long term trend in chlorophyll concentration is restricted to the data coming from the MODIS Aqua sensor only because of bias between the data from this sensor and the historical data from the SeaWiFS sensor. Though not sufficient to register as a distinct bloom during fall of 2011, there were two distinct peaks in chlorophyll during late summer and fall. Chlorophyll concentrations were more closely aligned to the long term mean at the end of the year.

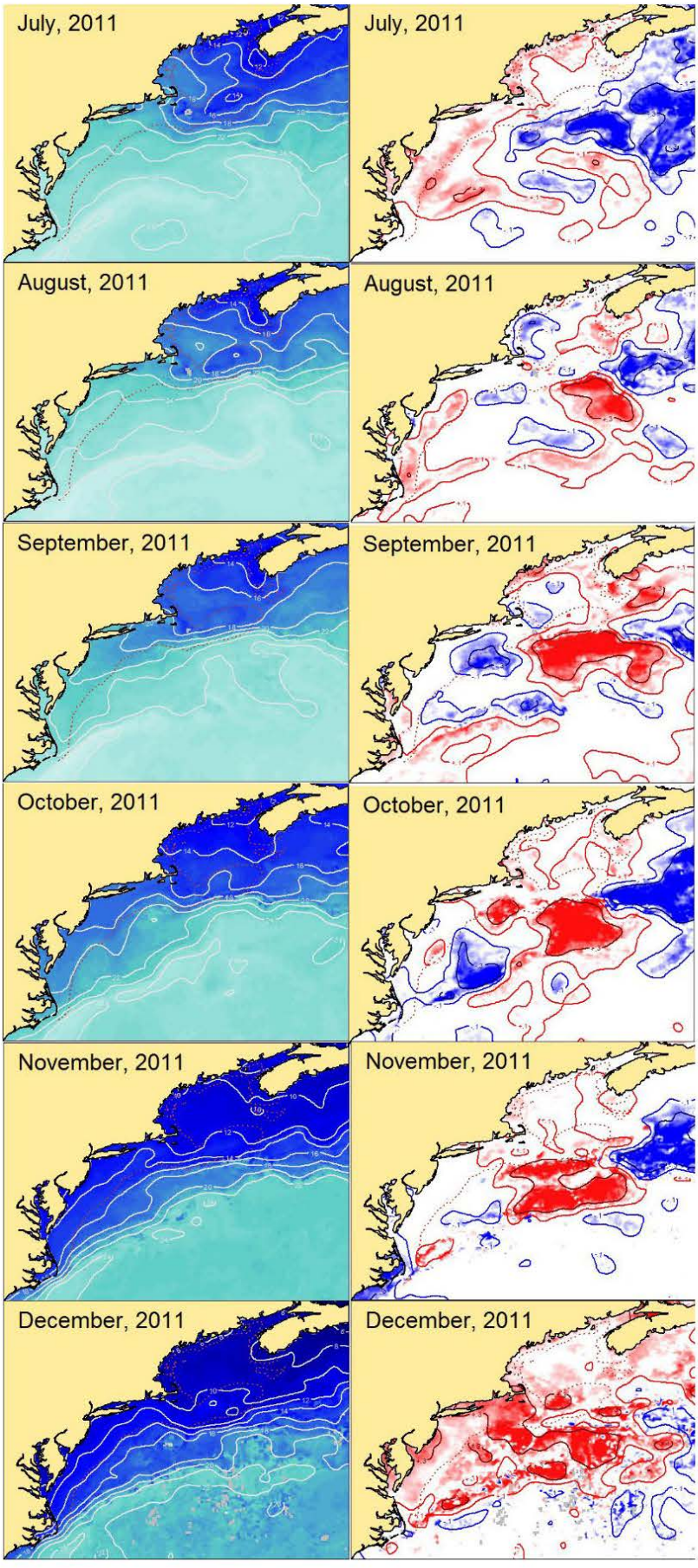
Zooplankton Biomass



The biomass of zooplankton was available for the September-October and November-December periods. Unlike the trend seen during spring of zooplankton biomass well above the long term mean, fall zooplankton biomass was well below the long term mean.

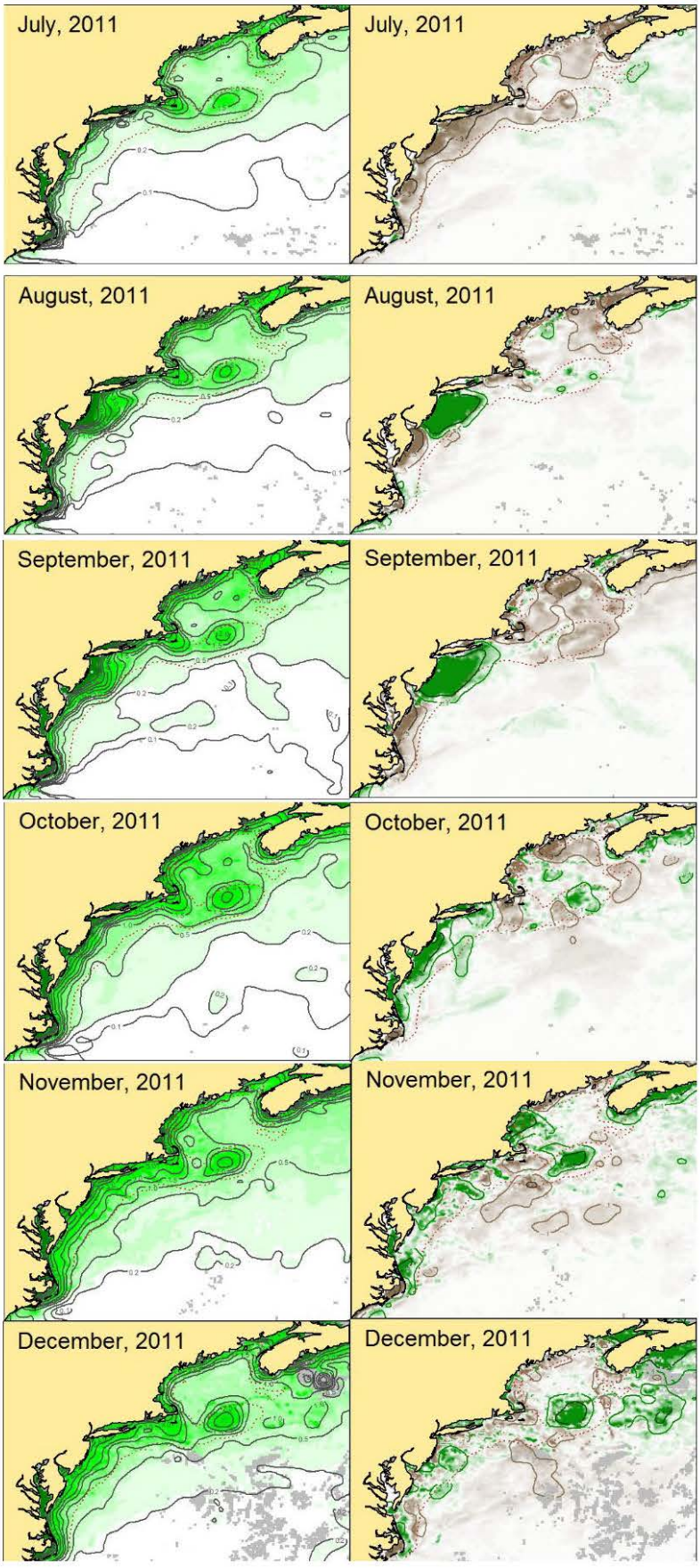
Sea Surface Temperature Distribution

The progression of fall sea surface temperatures for the months of July through December are shown in the interactive figure below. 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 shelf was generally above average during July, however, an area of cooling developed in the Middle Atlantic Bight during August and September, which may have been indicative of summer upwelling. The ecosystem remained at moderate conditions for the rest of the fall and showed sign of significant warming by December.

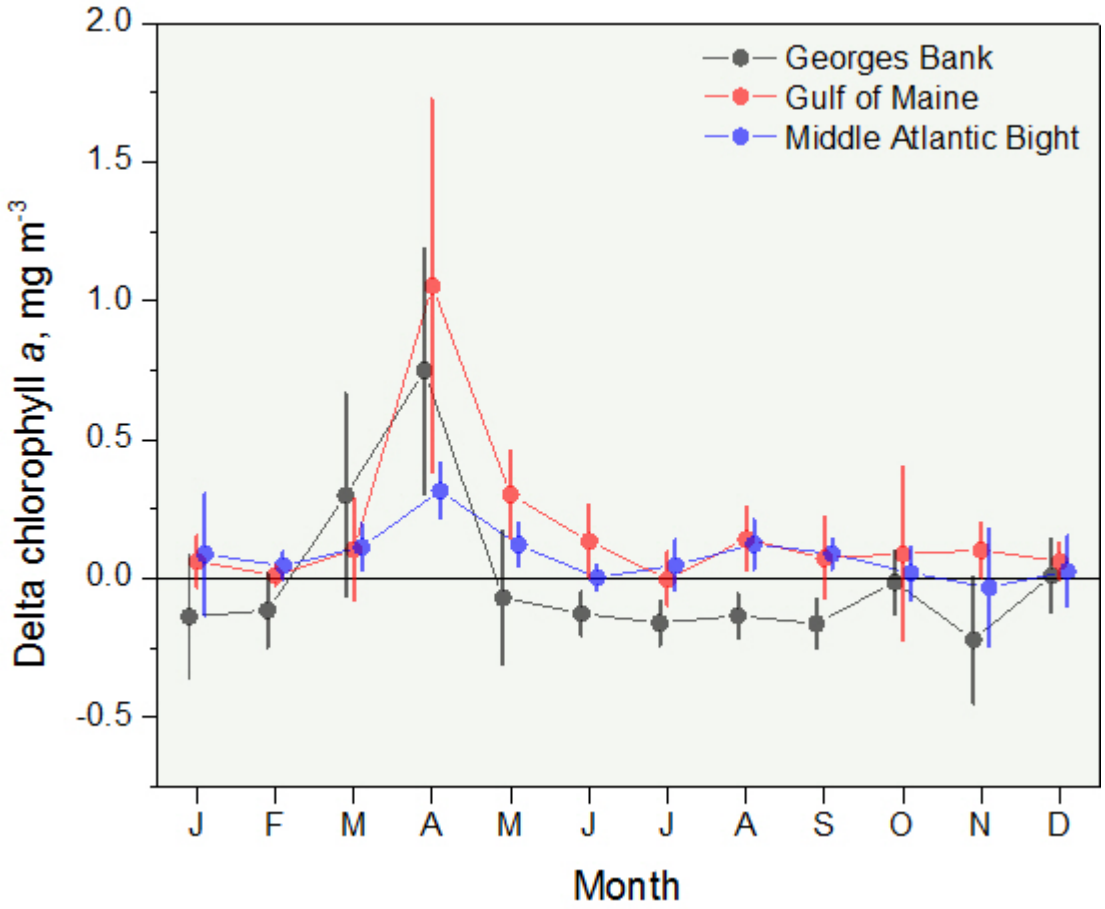

July, 2011
July, 2011
August, 2011
August, 2011
September, 2011
September, 2011
October, 2011
October, 2011
November, 2011
November, 2011
December, 2011
December, 2011

Chlorophyll Distribution

The progression of fall chlorophyll concentrations for the months of July through December are shown in the interactive figure below. 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. This type of anomaly tends to highlight strong blooms in an area, the green shades, and weak blooms in an area, the brown shades. Chlorophyll concentrations were below average over nearly all the shelf ecosystem during July. From August into September, a bloom event dominated the Middle Atlantic Bight that extended along most of the New Jersey coast to Long Island and offshore to the shelf break. The bloom dissipated by October with some remnant chlorophyll evident off the Delaware Bay. By November and into December there would appear to have been a bloom on Georges Bank.

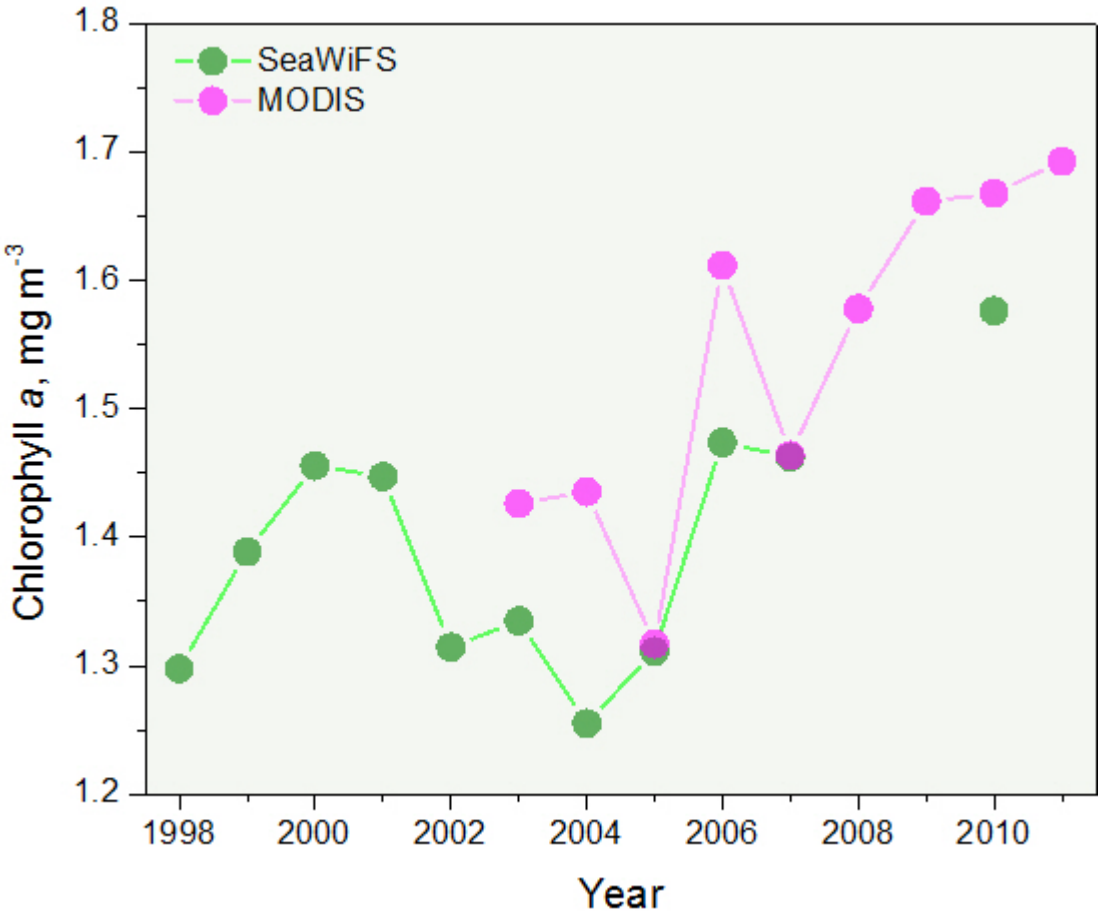

July, 2011
July, 2011
August, 2011
August, 2011
September, 2011
September, 2011
October, 2011
October, 2011
November, 2011
November, 2011
December, 2011
December, 2011

Comparison of SeaWiFS and MODIS Aqua Sensors



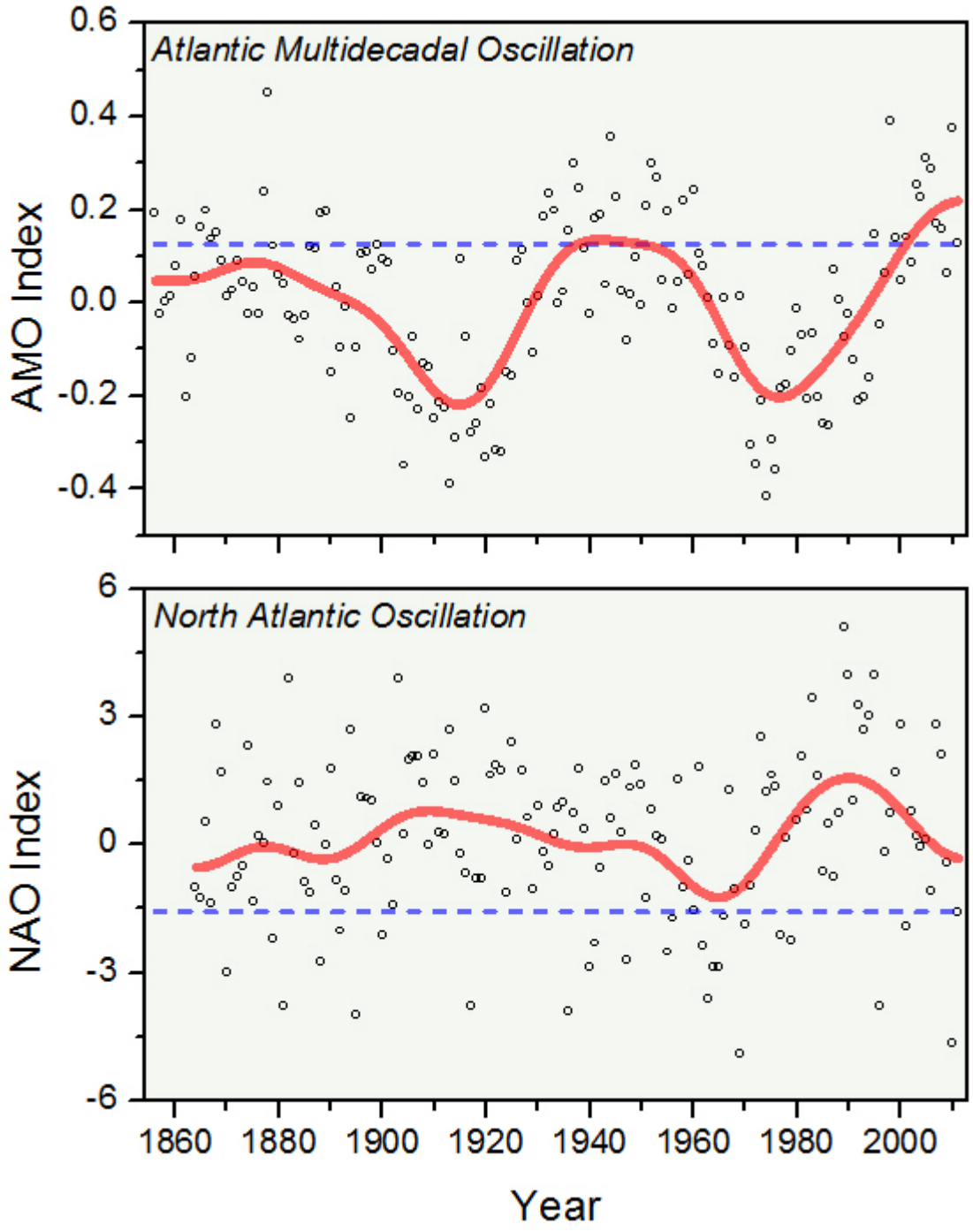
The satellite derived chlorophyll concentrations used to characterize the primary production of the Northeast Shelf LME comes from the SeaWiFS and MODIS Aqua sensors. The SeaWiFS sensor ceased to function in 2010 and overlapped the data coming from the MODIS sensor for nine years. During this time, the two sensors yielded simultaneous estimates of chlorophyll concentration with bias between the two sensors varying both seasonally and spatially. For estimates of chlorophyll concentrations for the same regions over the same time frame, a delta chlorophyll statistic (MODIS-SeaWiFS estimate) shows that in all three production units areas of the Northeast Shelf ecosystem, MODIS data provided higher estimates of spring bloom chlorophyll than SeaWiFS based on high positive delta values for April. The bias was greatest in the Gulf of Maine and lowest in the Middle Atlantic Bight. During the rest of the year MODIS estimates were slight higher in the Gulf of Maine and Middle Atlantic Bight, and lower on Georges Bank. The MODIS data was recently reprocessed to improve calibrations to observed data on a global scales, however, regional scale biases still exist.

Shelfwide Chlorophyll Concentration



The integrated mean annual chlorophyll concentration for the Northeast Shelf Ecosystem is represented as separate time series for both the SeaWiFS and MODIS sensors. The estimate of mean annual chlorophyll concentration for 2011 continues the trend of high values that started in 2009, with the caution that MODIS estimates appear to be biased higher than SeaWiFS data.

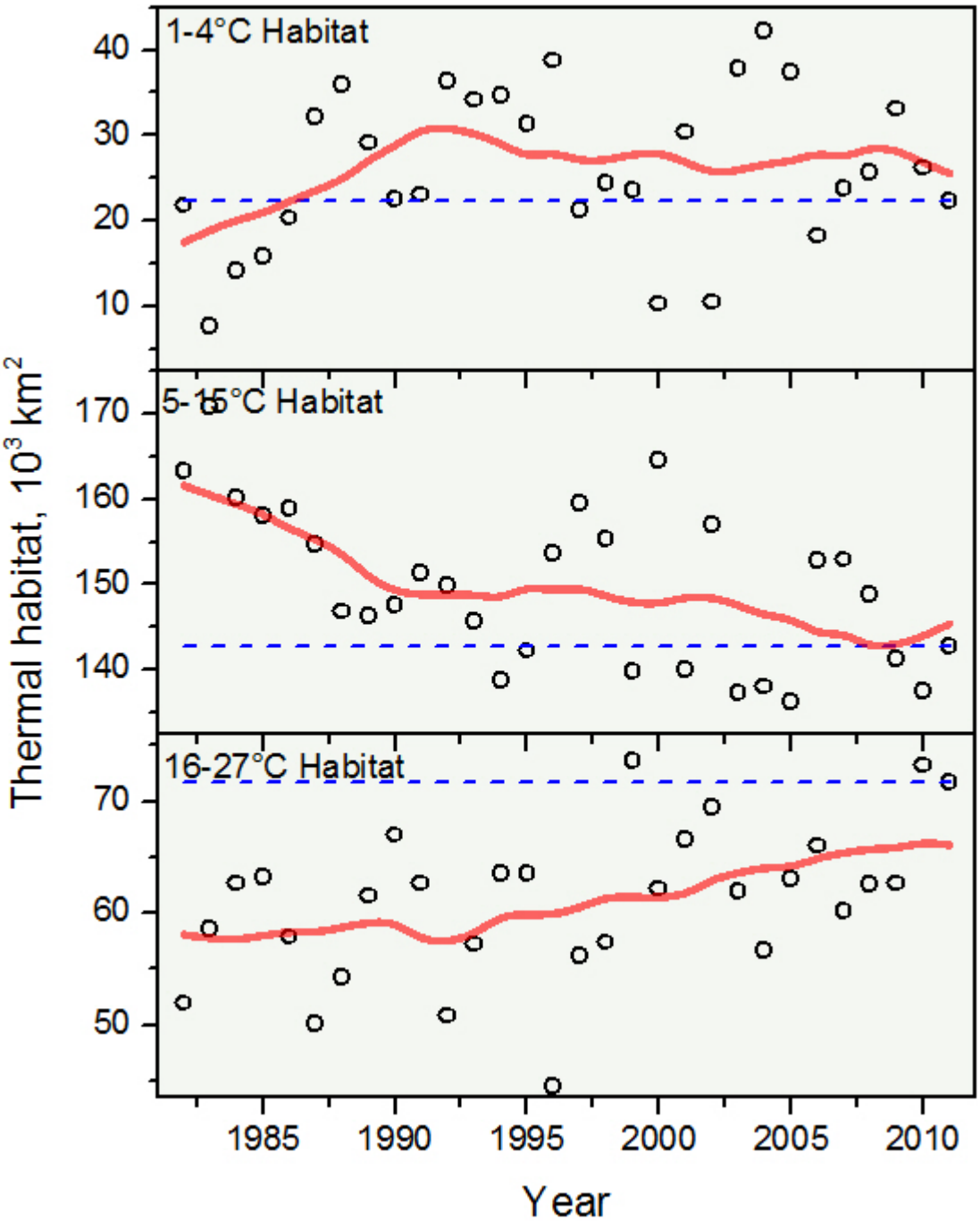
Key Climate Drivers



Two key climate drivers affecting the oceanography of the Northeast Shelf Ecosystem are the Atlantic Multidecadal Oscillation (AMO) and the North Atlantic Oscillation (NAO). Multidecadal patterns in sea surface temperature (SST) in the North Atlantic are represented by the Atlantic Multidecadal Oscillation (AMO) index, which has been linked to the poleward shifts of fish distributions on the northeast U.S. shelf. The AMO has been in a warm phase (positive) since 1997, a trend that continues with the 2011 level (marked in the time series with the dashed blue line). The warm phase is expected to continue for the next 10-20 years. This (NAO) index has been related to key oceanographic and ecological processes in the Northern hemisphere and

is associated with alternate states of wind and weather in regions associated with the North Atlantic Basin. Since 1972, the NAO has primarily been in a positive state, although one-year reversals to a negative state have occurred. Changes in the NAO have been linked to changes in plankton community composition in the North Atlantic, reflecting changes in both the distribution and abundance of warm and cold-temperate species. In 2011, the winter NAO index was moderately negative (marked in the time series with the dashed blue line).

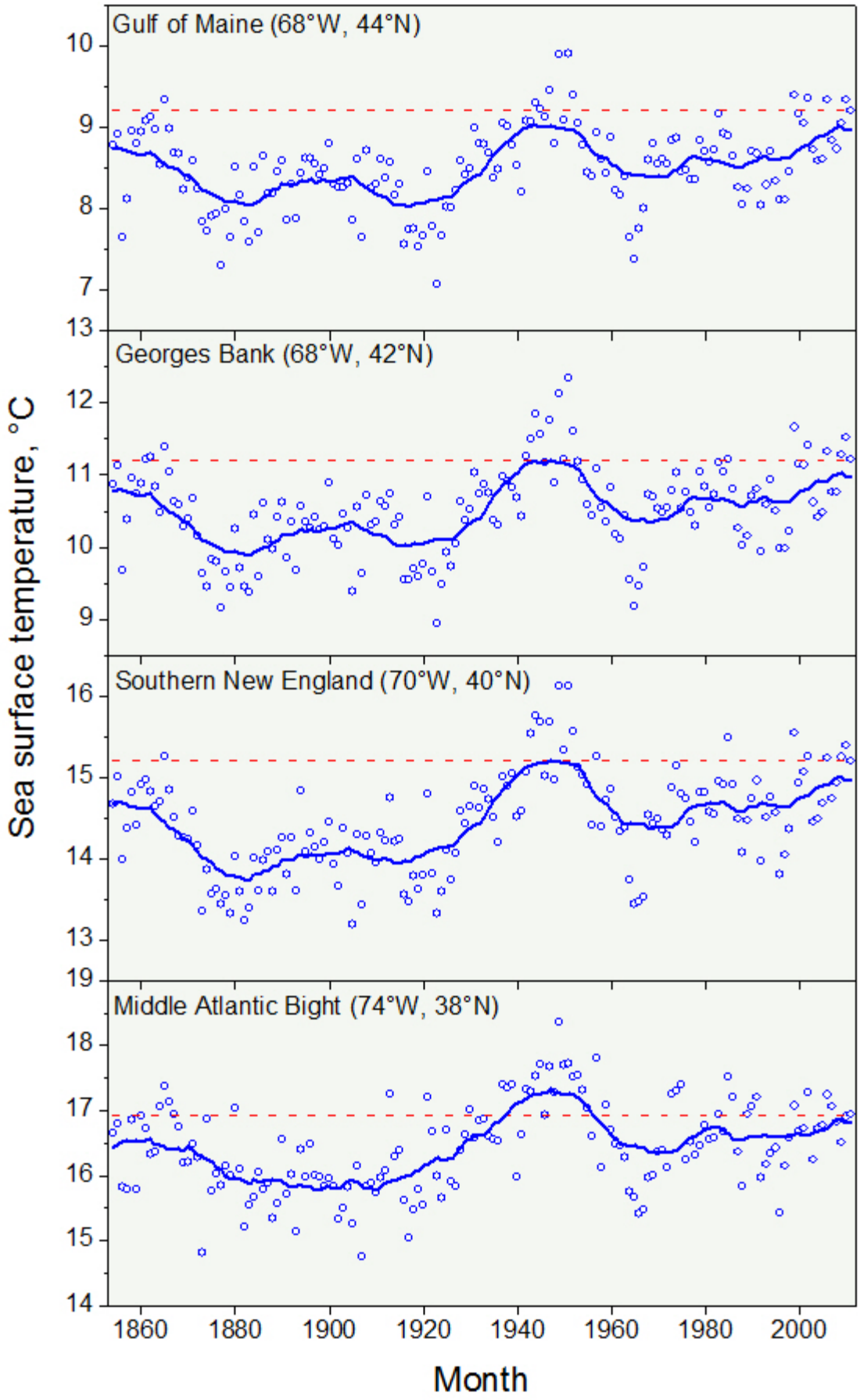
Ecosystem Shift in Thermal Habitat



Temperature is one of the most important factors defining the habitat of marine organisms. Thermal conditions affect the growth and development of fish and shellfish, and differentially affect the survival of different life stages. Recent analyses of the amount of surface thermal habitat on the Northeast Shelf over the past 30 years reveal a trend of constriction of the core thermal habitats of the Northeast Shelf ecosystem. Core thermal habitats represent year round habitats ranging from 5 to 15°C, whereas peripheral thermal habitats are only available during parts of the years, i.e. the winter and summer. Core thermal habitats have been declining over time (see figure), with the 2011 estimate of approximate 143,000 km2 being one of the lower values in the time series (marked by blue dashed line). The ecosystem appears to have been

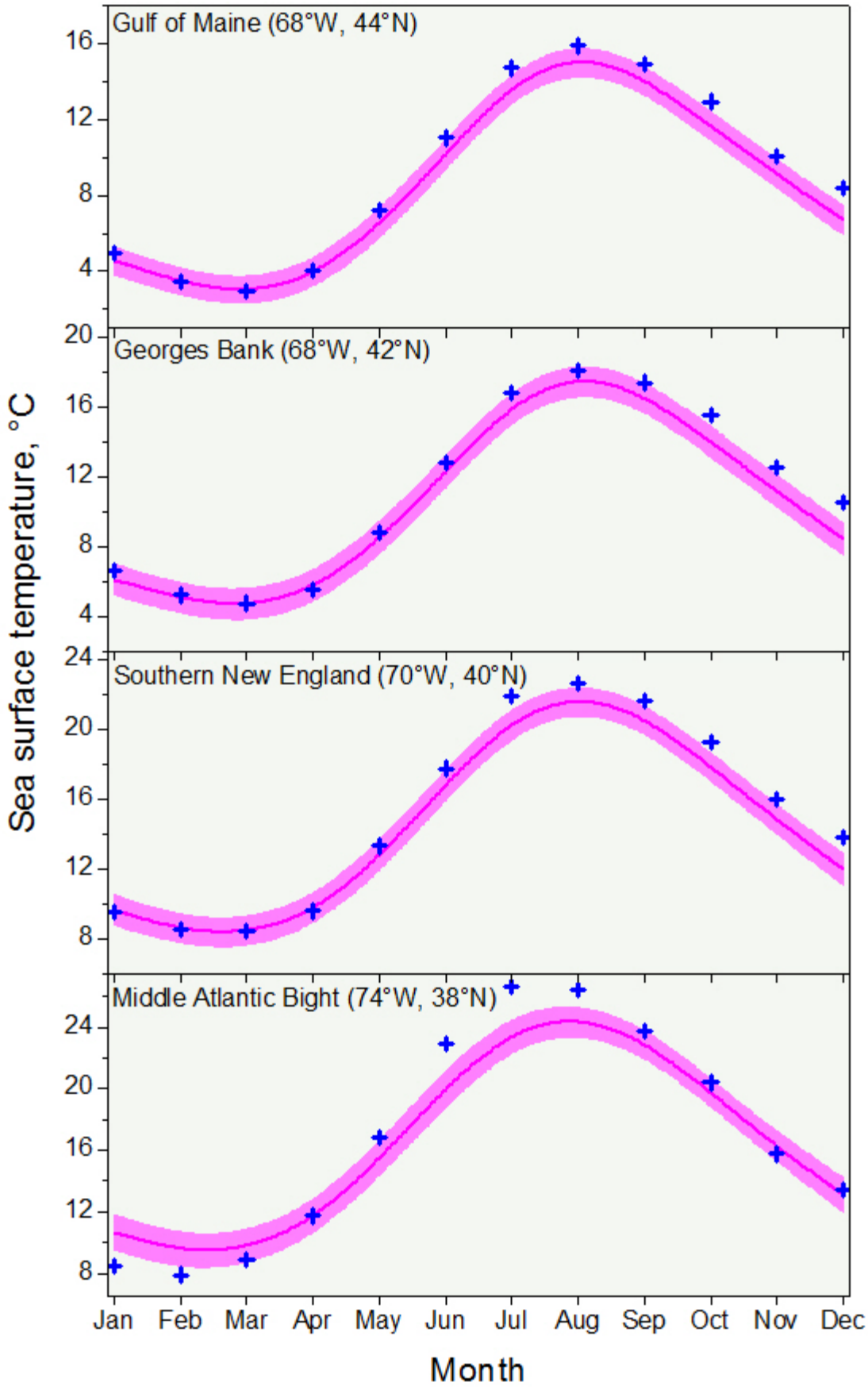
affected simultaneously by both cooling and warming effects; cooling was most likely actuated by inputs from the Labrador Current and warming by increased temperatures observed in the Middle Atlantic Bight.

Long Term Temperature Trends


Gulf of Maine (68°W, 44°N)
Georges Bank (68°W, 42°N)
Southern New England (70°W, 40°N)
Middle Atlantic Bight (74°W, 38°N)
Sea surface temperature, °C
Month
10
9
8
7
13
12
11
10
9
16
15
14
13
19
18
17
16
15
14
1860
1880
1900
1920
1940
1960
1980
2000

The Northeast Shelf Ecosystem continues its warming trend and in many areas is approaching the record high levels the system experienced during the 1940s and 1950s. The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854. Monthly mean SSTs in 2011 in four subregions of the ecosystem (Gulf of Maine, Georges Bank, Southern New England, and the Middle Atlantic Bight) were compared to long term trends in SST (dashed magenta line marks 2011, blue line is smoothed trend). The northern subareas of the ecosystem were well above the recent trends in the data and amongst the highest values in the time series, whereas the annual mean 2011 SST for the Middle Atlantic Bight was essentially equal to the trend.

Long Term Monthly Temperature Trends


Gulf of Maine (68°W, 44°N)
Georges Bank (68°W, 42°N)
Southern New England (70°W, 40°N)
Middle Atlantic Bight (74°W, 38°N)
Sea surface temperature, °C
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

All subregions of the shelf ecosystem showed warmer than average summer temperatures and generally average winter temperatures with the exception of the Middle Atlantic Bight, which had below average winter temperature in 2011. The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854. Monthly mean SSTs in 2011 in four subregions (Gulf of Maine, Georges Bank, Southern New England, and the Middle Atlantic Bight) were compared to long term means bounded by confidence bands (magenta line in light magenta region, respectively). In 2011, monthly SSTs for the Gulf of Maine were close to the long-term average early in the year, but were above average during the spring and summer months. A similar pattern can be seen in the monthly temperature data for Georges Bank and Southern New England. In the Middle Atlantic Bight subregion, winter temperatures were below average while summer temperature, in particular the temperature for June and July, were significantly above the long term mean. These data underscore how thermal properties within the ecosystem are not uniform.