Fall 2013 Update: Annual Condition of the Northeast Shelf Ecosystem

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Fall 2013 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 2013 moderated compared to the record high temperatures that occurred in 2012; however, temperatures remain above the long-term mean based on both contemporary satellites remote sensing data and ship-board measurements.
- This moderating effect 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 cooled to a greater extent.
- Spring survey hydrocast data shows that surface and bottom temperatures have moderated since 2012, but remain above average with bottom temperatures being influenced by water entering the ecosystem.
- In contrast to the 2012 Gulf of Maine spring bloom which was a long duration, intense bloom that started at the earliest recorded start date, the 2013 was the latest recorded bloom that was so poorly developed its extent was below detection limits. The bloom on Georges Bank was also relatively late and though it could be detected, it was a small bloom in terms of duration and intensity.
- Though not a regular feature in the Middle Atlantic Bight, a distinct spring bloom could be measured in 2013.
- An analysis of spring transition temperatures shows that there has been an abrupt shift in spring thermal phenology.
- 2013 spring zooplankton biomass on the Northeast Shelf was the lowest on record for the monitoring time series; the biomasses were lowest for the northern segments of the ecosystem and would appear to be related to the poorly developed spring bloom in the Gulf of Maine area
- The Northeast Shelf ecosystem continues to experience wide swings in physical conditions and biological responses that would appear to reflect great variation in the climate system impacting the ecosystem.

Data Sources

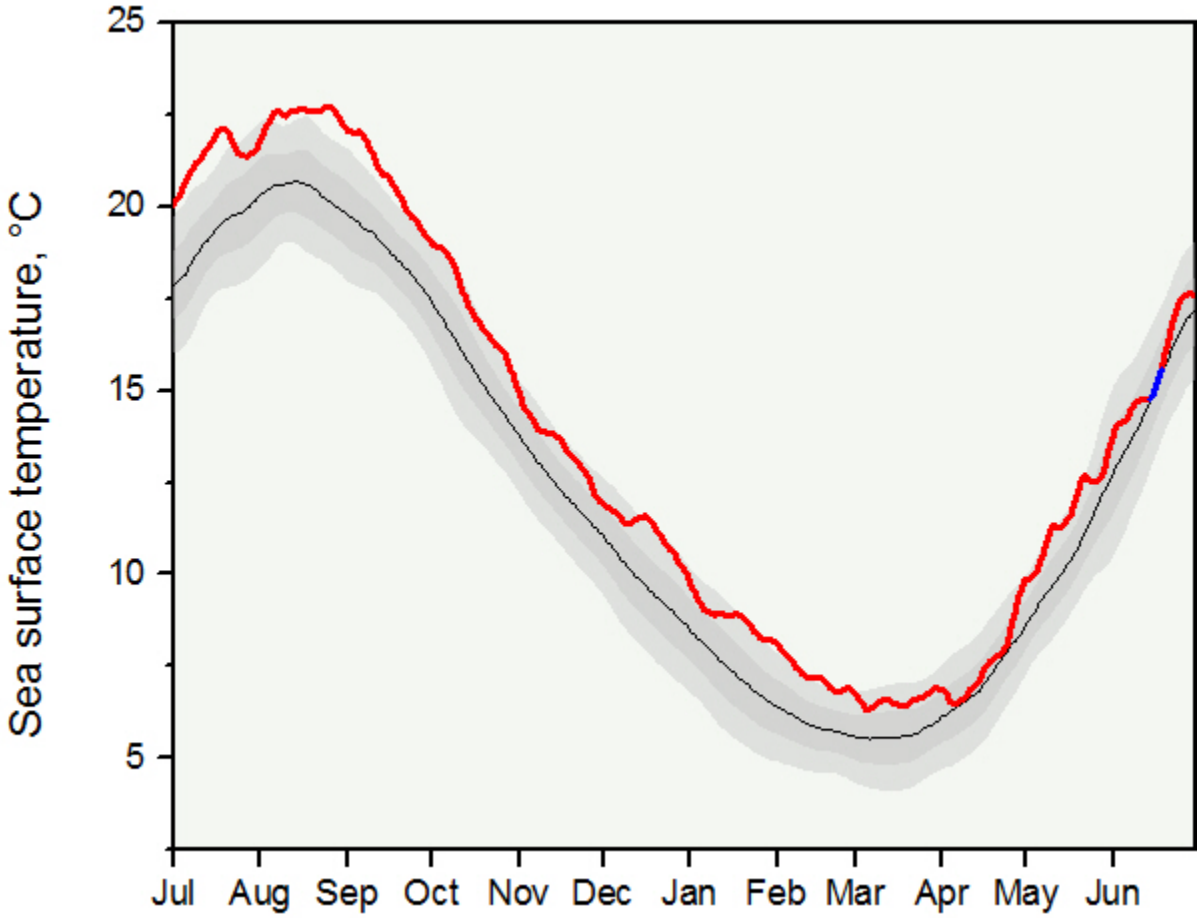
SST was derived by compositing data from three sources: the Advanced Very-High Resolution Radiometer onboard the Polar Orbiting Environmental Satellite (AVHRR-POES); the MODIS Terra sensor; and the MODIS Aqua sensor. The data represent the surface ocean temperature, not the temperature of the entire water column. 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



Sea surface temperature cycle

The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures during the spring of 2013 continuing the trend of above average temperatures seen during fall into winter seasons.

In the graph for the last half of 2012 and first half of 2013, 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**). Temperatures did go below the long-term mean during June.

SSTs below the long term mean are shown in blue, above the mean in red.

The warmest seasonal conditions during 2013 were found during January and February with periods of average temperature during April and again during June.

Bloom Development on the Northeast Shelf

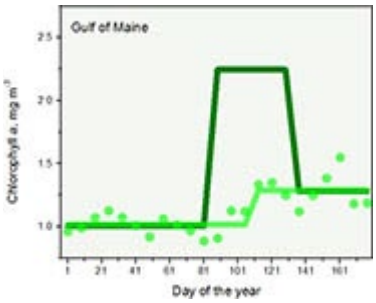
The spring bloom development in the ecoregions of the Northeast Shelf was atypical during 2013. Most regions of the Northeast Shelf Large Marine Ecosystem have a well developed spring phytoplankton bloom. The impact of the spring bloom will depend on multiple factors related to the timing and duration of the bloom and how productive the constituent phytoplankton species are over time.

The spring bloom for the Northeast Shelf ecosystem as a whole was poorly developed and did not meet the threshold conditions of our bloom detection algorithm to be detected (see **NES** figure; for this and following figures, dark green line is long-term mean bloom pattern, light green line 2013 bloom pattern, points are for 2013 data).

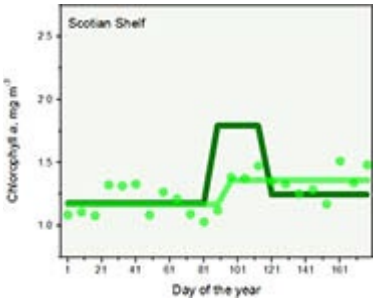
Likewise, a bloom could not be detected in the Gulf of Maine or Scotian Shelf ecoregions (see **GOM** and **SCS** figures). In both areas a transition from low to high chlorophyll was detected which could be interpreted as the beginning of a bloom; however, these transitions were relative late and were not matched with a high to low transition.

Blooms were detected on Georges Bank and in the Middle Atlantic Bight (see **GBK** and **MAB** figures). The Georges Bank bloom was relatively late and a small dimension bloom compared to previous bloom patterns.

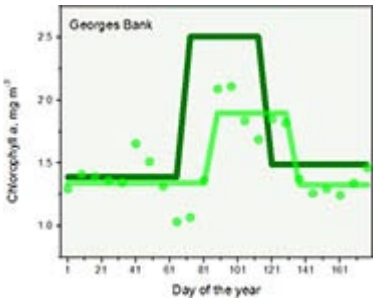
The Middle Atlantic Bight area usually does not have a discrete, detectable spring bloom; however, in 2013 a large spring bloom occurred in the area. This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.



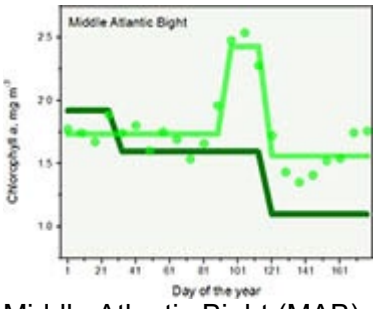
Gulf of Maine (GOM)



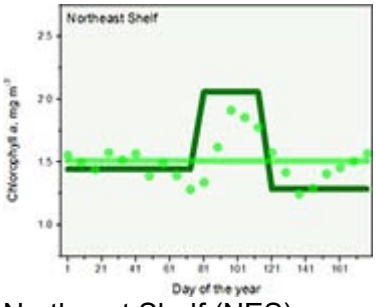
Scotian Shelf (SCS)



Georges Bank (GBK)



Middle Atlantic Bight (MAB)



Northeast Shelf (NES)

Bloom Start Day and Magnitude

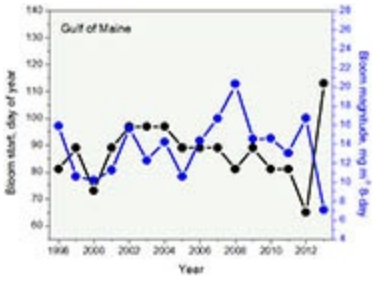
The spring bloom typically starts earlier in the more southern segments of the Northeast Shelf LME.

In 2013, no bloom start date could be detected for the Northeast Shelf as a whole and bloom magnitude based on a climatological bloom period was lower than recent years (see **NES** figure). Spring bloom magnitude is one measure of bloom dimension and is calculated as the sum of chlorophyll concentrations during the bloom period.

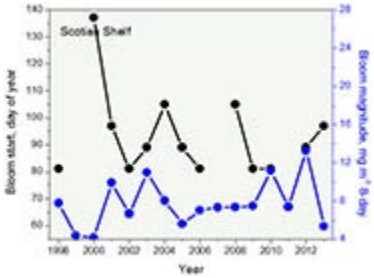
A more dramatic change in bloom dynamics occurred in the Gulf of Maine where bloom start day went from the earliest recorded bloom start in 2012 to the latest recorded start in 2013 (see **GOM** figure). The Gulf of Maine bloom magnitude was the lowest of the time series.

The 2013 Georges Bank and Scotian shelf blooms were also relatively late and small dimension blooms, but not to the extent seen in the Gulf of Maine (see **GBK** and **SCS** figures).

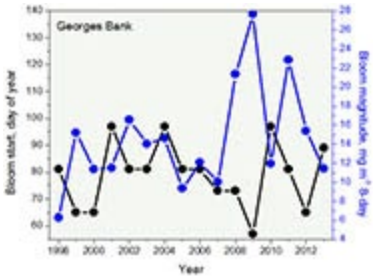
Finally, the Middle Atlantic Bight bloom started at around day 100, but since so few spring bloom have been detected in this area, it is hard to assess the significance of the this particular bloom start (see **MAB** figure). This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.



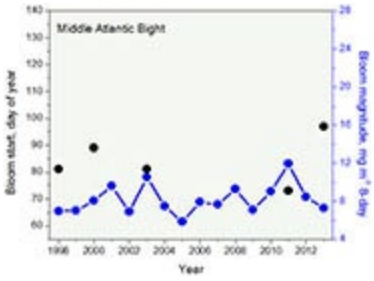
Gulf of Maine (GOM)



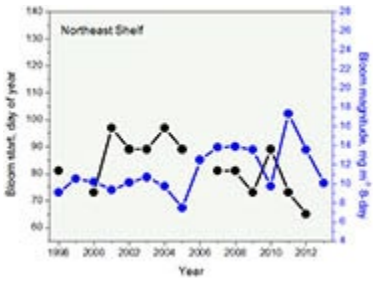
Scotian Shelf (SCS)



George Bank (GBK)



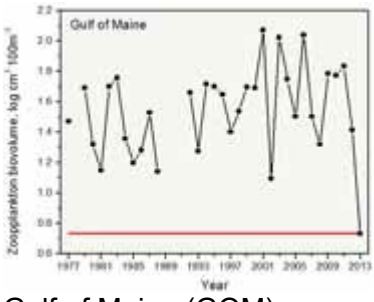
Middle Atlantic Bight (MAB)



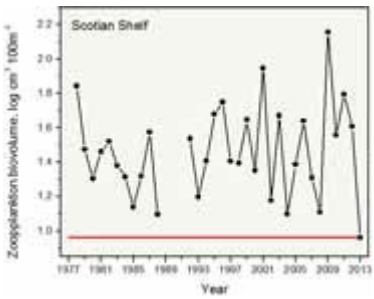
Northeast Shelf (NES)

Zooplankton Biomass

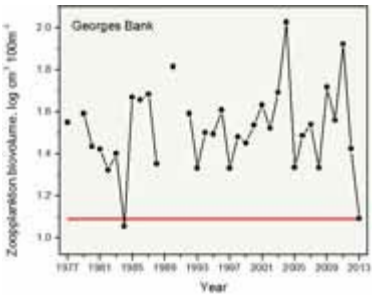
The biomass of zooplankton was the lowest on record for the Northeast Shelf ecosystem as a whole and for the northern ecoregions of the ecosystem in particular in spring 2013. The March-April zooplankton biovolume was approximately log 0.9 cm3 100m-3 over the extent of the Northeast Shelf, which is the lowest value in the time series (see **NES** figure). Previous low values occurred in the late 1970s and early 1980s, but we believe these low values are in part due to the balance of sampling between months over the spring period. The Middle Atlantic Bight biovolume, which is based on March data, was among the lower values for the time series (see **MAB** figure). The biovolumes in the Gulf of Maine and Scotian Shelf ecoregions were record low values (see **GOM** and **SCS** figures), whereas the Georges Bank 2013 biovolume was the second lowest in the time series (see **GBK** figure). The Gulf of Maine, Georges Bank and Scotian Shelf biovolumes are based on April data. The absence of a well developed spring bloom over the Gulf of Maine and Georges Bank areas would appear to be the proximal cause of these low zooplankton biomasses.



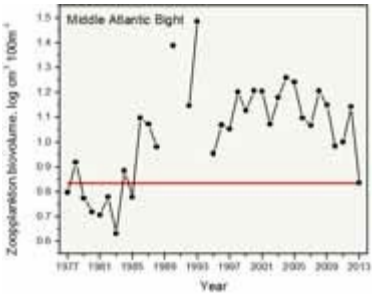
Gulf of Maine (GOM)



Scotian Shelf (SCS)



Georges Bank (GBK)



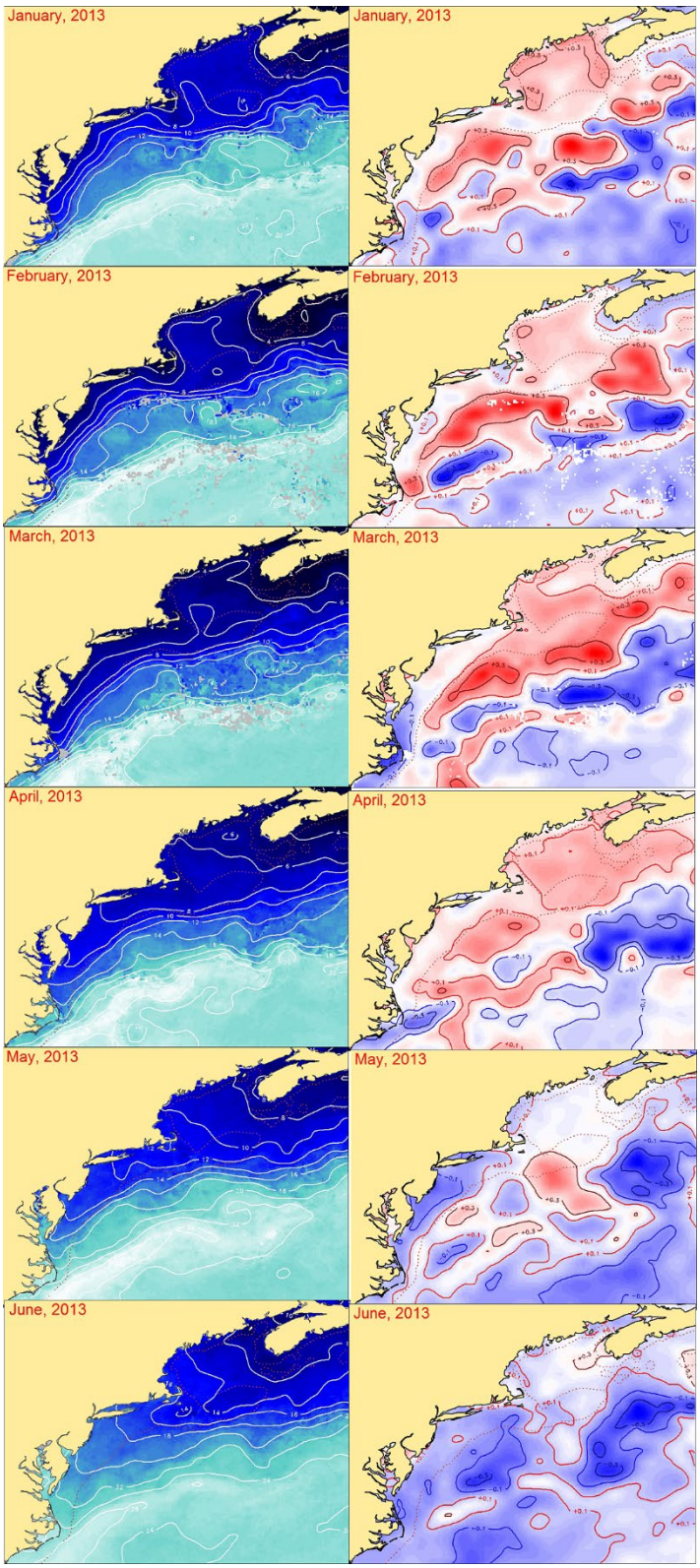
Middle Atlantic Bight (MAB)

Northeast Shelf (NES)

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 top row of 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 second row 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 above average temperature for the first four months of the year as reflected in the distribution white areas and light red 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

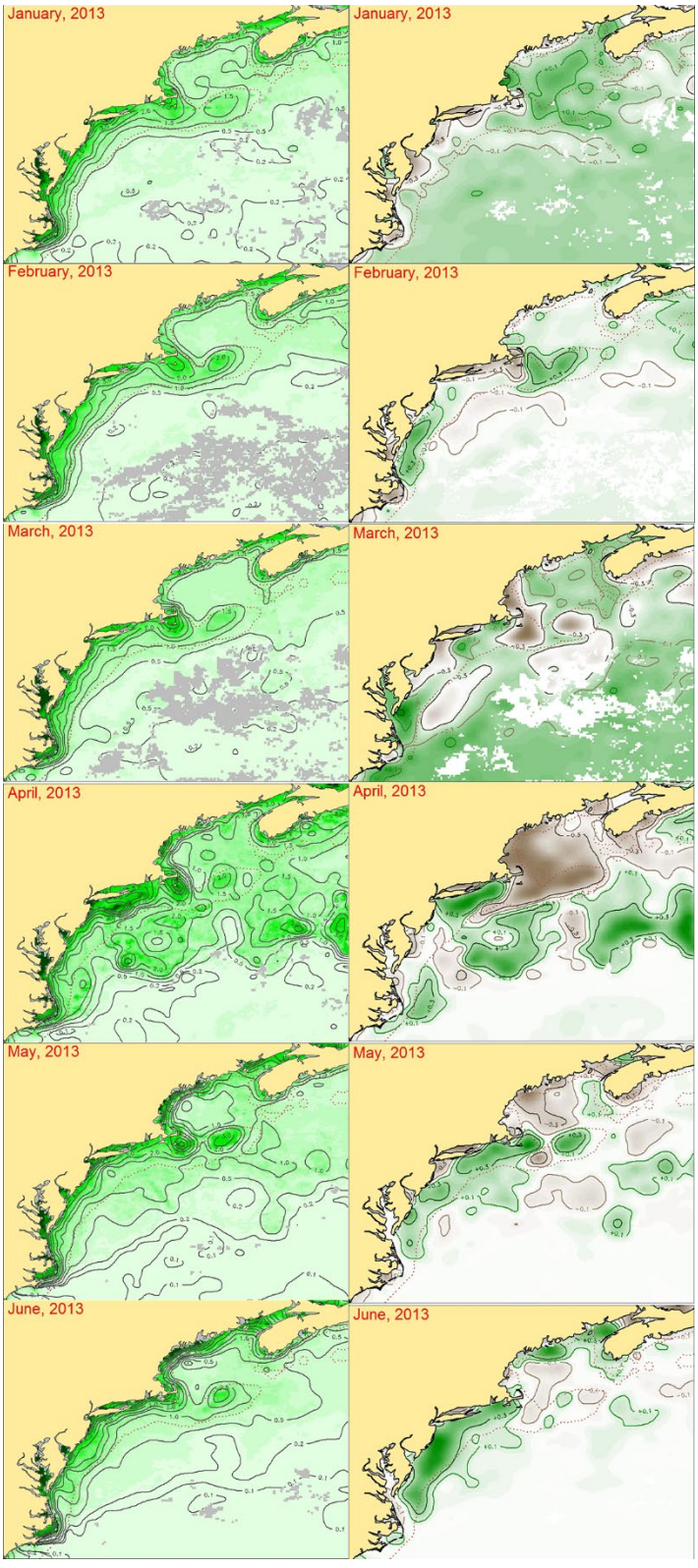


and June the shelf was largely at mean temperatures or slightly below average in the Middle Atlantic Bight.

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 top row of 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 second row of icons. The most striking feature in the spatial analysis of chlorophyll concentration is the distribution of chlorophyll in April. April is typically when the spring bloom is at its peak in the Gulf of Maine and on Georges Bank; the deep brown tones in the anomaly map indicates these areas were well below average. During the same month, the coast along Long Island appears deep green indicating a strong spring bloom in this area, which is not typically associated with a spring bloom of that intensity. There were also localized areas of elevated chlorophyll concentration in non-bloom months as well, for example in the Nantucket Shoals during February and in the Middle Atlantic Bight during June.


January, 2013
January, 2013
February, 2013
February, 2013
March, 2013
March, 2013
April, 2013
April, 2013
May, 2013
May, 2013
June, 2013
June, 2013

Bloom Spatial Dynamics

The ocean color satellite data time series now offers the ability to characterize 16 years of spring bloom activity. Spring bloom frequency, start day and bloom magnitude were derived from 0.5° longitude-latitude gridded data based on the blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.

The interior Gulf of Maine is the only region of the Northeast Shelf that has a consistent spring bloom as part of its production cycle (see **frequency figure**). Most of this area had bloom frequencies in excess of 0.8 or 80%.

Blooms were detected progressively less frequently on Georges Bank with the southern flank of the Bank having bloom frequencies of approximately 60-70%.

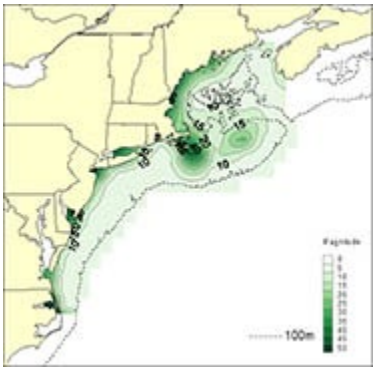
The main-interior portion of the Middle Atlantic Bight, the northern Gulf of Maine, and parts of the Scotian Shelf had bloom frequencies of less than 30%. The spring bloom starts earliest over the Nantucket Shoals area typically at around day 70 or something during March (see **start day figure**).

The spring bloom tends to start later on Georges Bank beginning some two weeks later during the end of March or early April. The bloom is progressively later in the northern Gulf of Maine typically starting well into April.

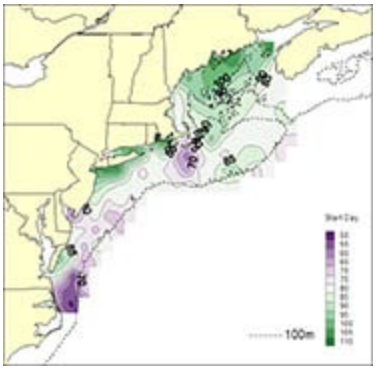
The location of the earliest blooms, Nantucket Shoals, is also where the greatest magnitude blooms occur (see **magnitude figure**).

High magnitude blooms also occur on the northern flank Georges Bank.

Bloom frequency

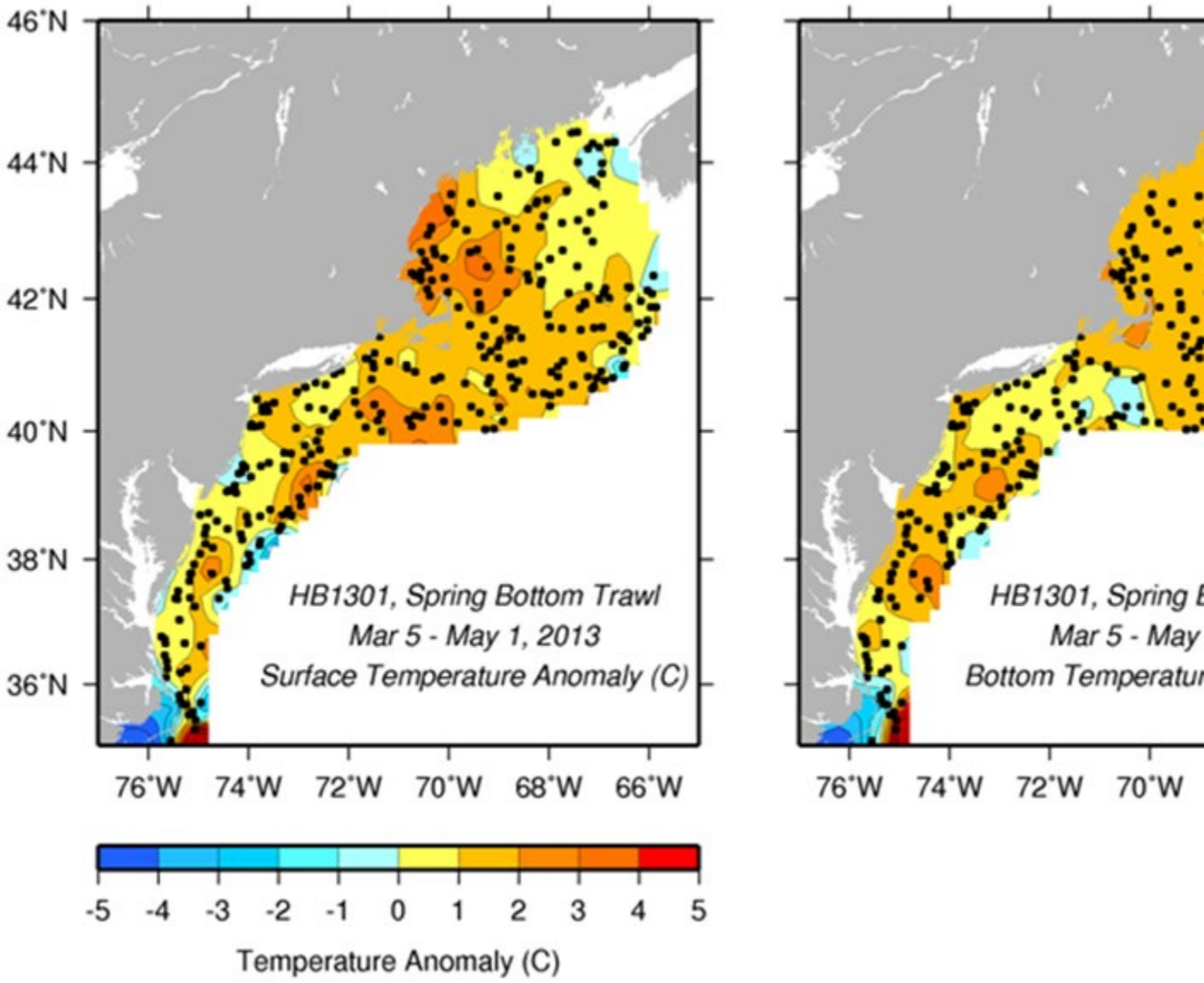


Bloom magnitude



Bloom start day

Temperature from Spring Survey



Temperature anomalies

Warming continues to dominate surface ocean temperatures across the northeast U.S. shelf relative to average values (1977-1987), although warming has moderated since the extremes observed in 2012. Regionally, surface temperature anomalies were highest in the western Gulf of Maine, the northern Middle Atlantic Bight and over Georges Bank, exceeding average values by 1.5-3°C at the surface. This surface-warming pattern extended to the bottom throughout the region, where average bottom temperatures ranged between 0.5-1.7°C warmer over the entire northeast U.S. shelf, with the warmest anomalies found in the western Gulf of Maine, over Georges Bank and in the southern Middle Atlantic Bight. Bottom temperatures in the deep basins of the eastern Gulf of Maine were also warmer, with anomalies exceeding 1°C in Jordan Basin and slightly less in the Northeast Channel and Georges Basin. Here, bottom waters are

largely insulated from surface forcing, so that temperature trends typically reflect changes in the composition of slope waters entering through Northeast Channel.

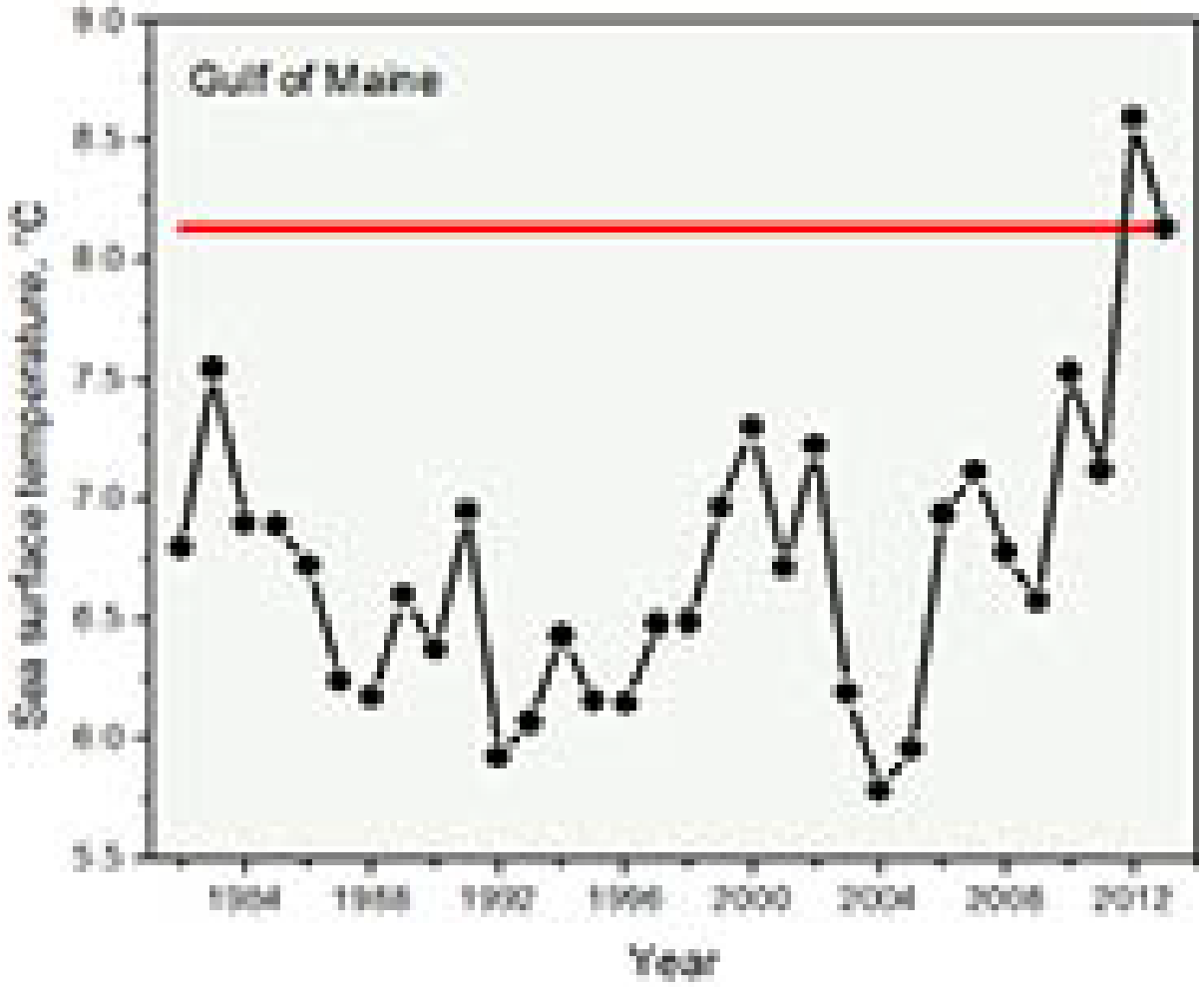
Satellite SST for First Half Year

The SST conditions for the first half of 2013 were amongst the warmest recorded in the satellite remote sensing data series for some parts of the ecosystem.

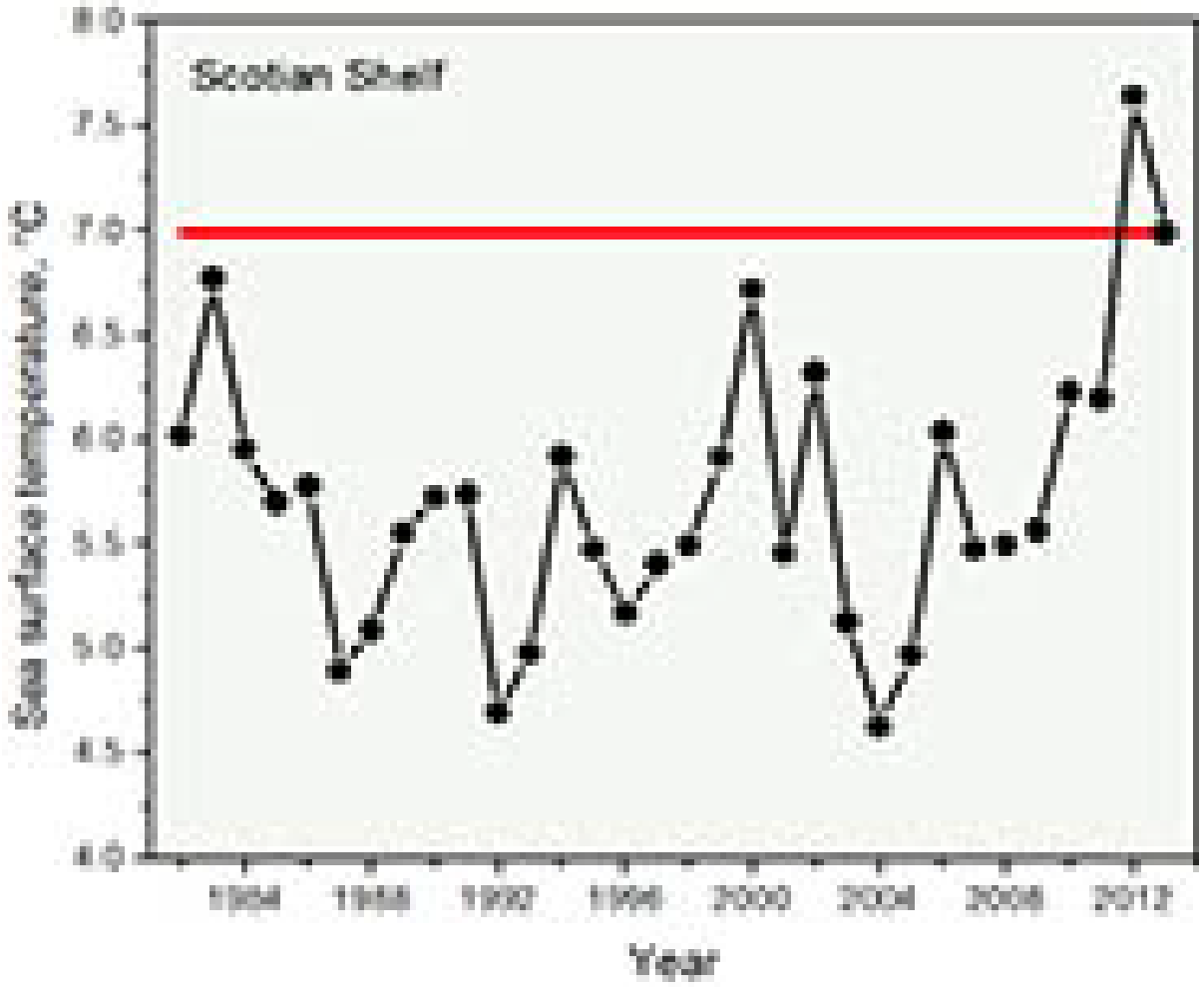
The SST for the Northeast Shelf as a whole declined in excess of 1°C in 2013, which made it the third warmest in the time series and well above the long-term mean (see **NES** figure).

The first half SST in the Gulf of Maine, Georges Bank and the Scotian Shelf went down less than a degree centigrade from last year making 2013 the second warmest year in the time series in these areas (see **GOM**, **GBK**, and **SCS** figures).

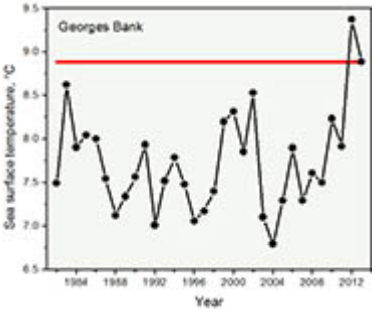
The Middle Atlantic Bight SST declined by nearly 2°C, making it only the ninth warmest year and only slightly above the long-term mean (see **MAB** figure).



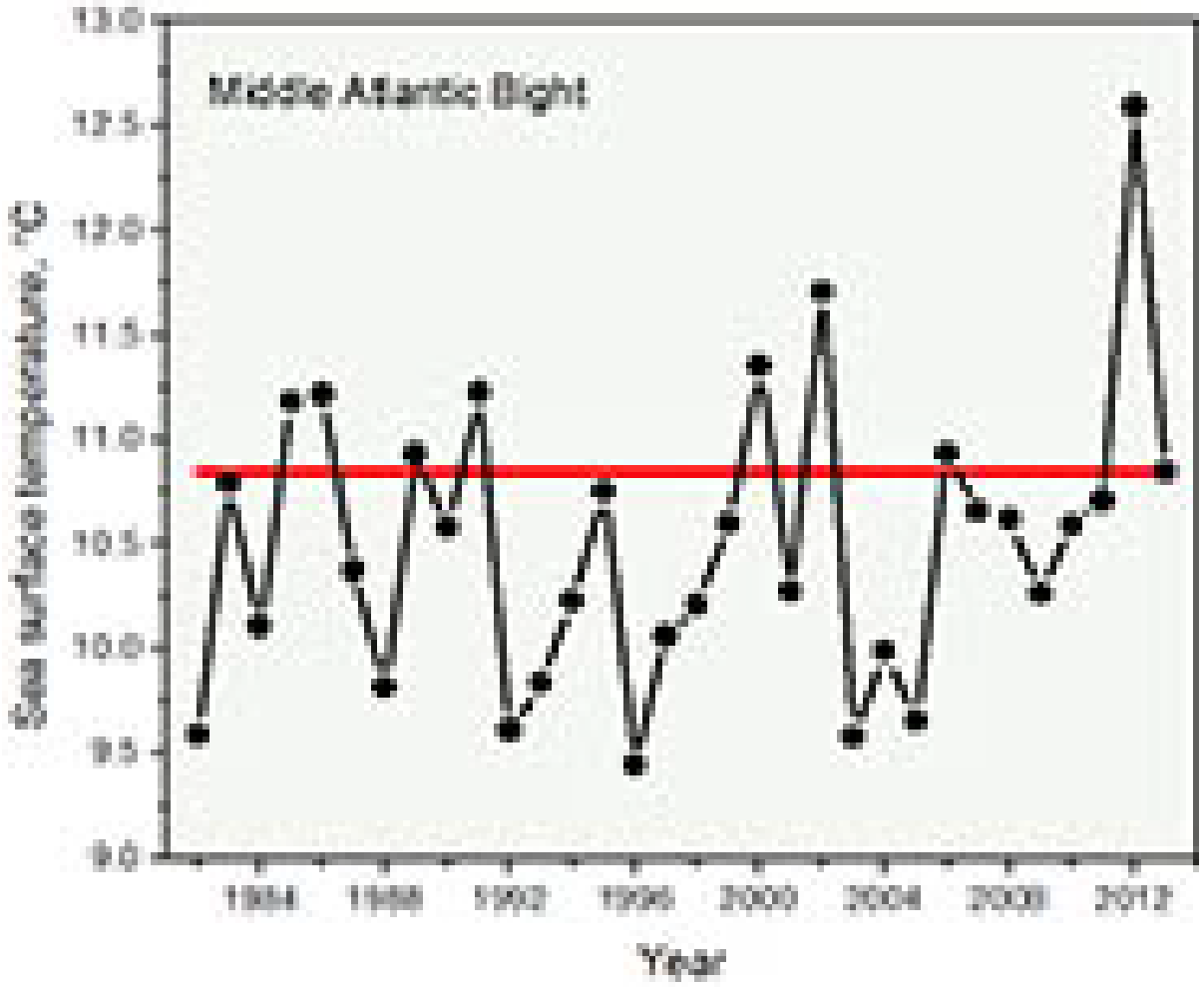
Gulf of Maine (GOM)



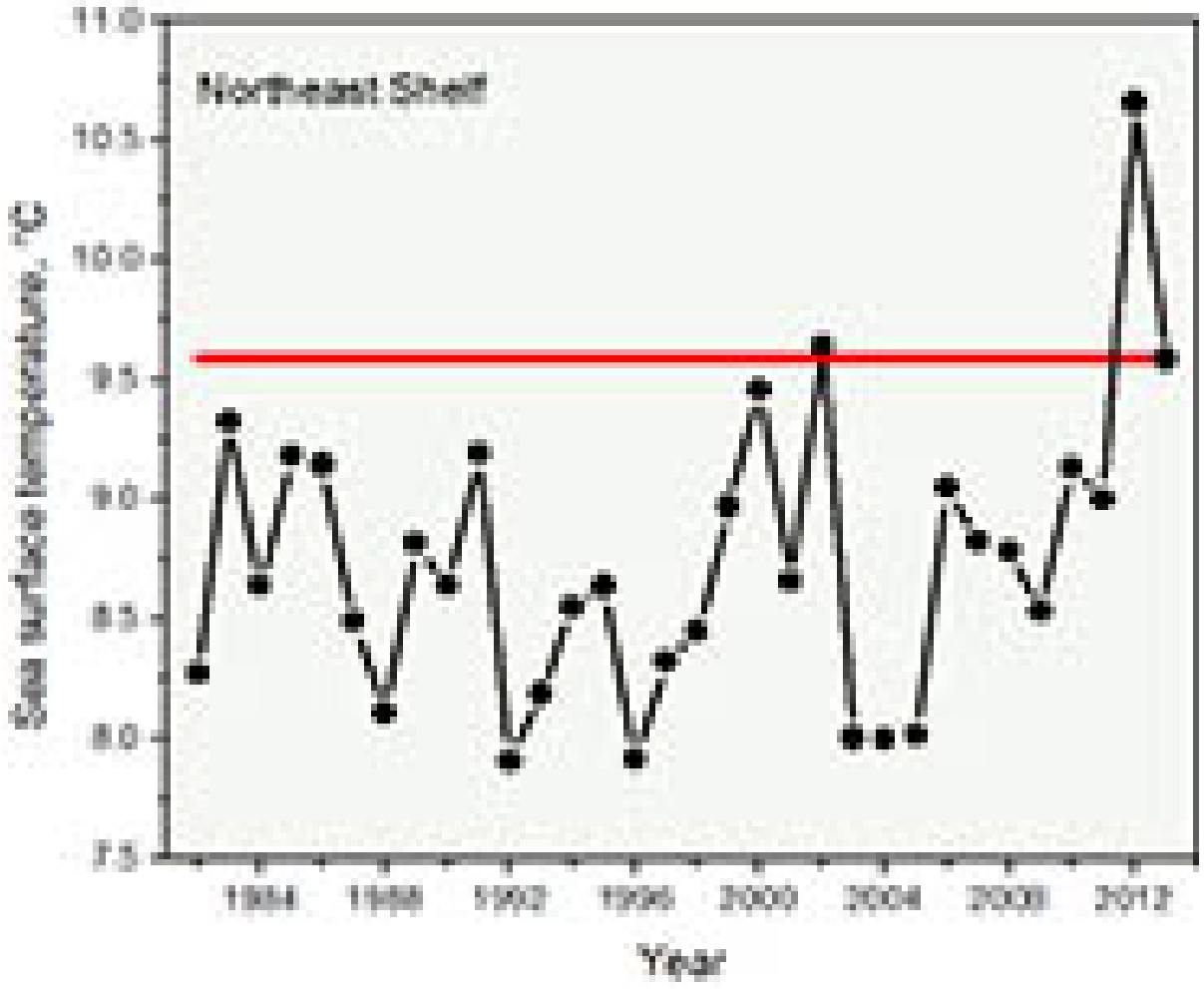
Scotian Shelf (SCS)



Georges Bank (GBK)

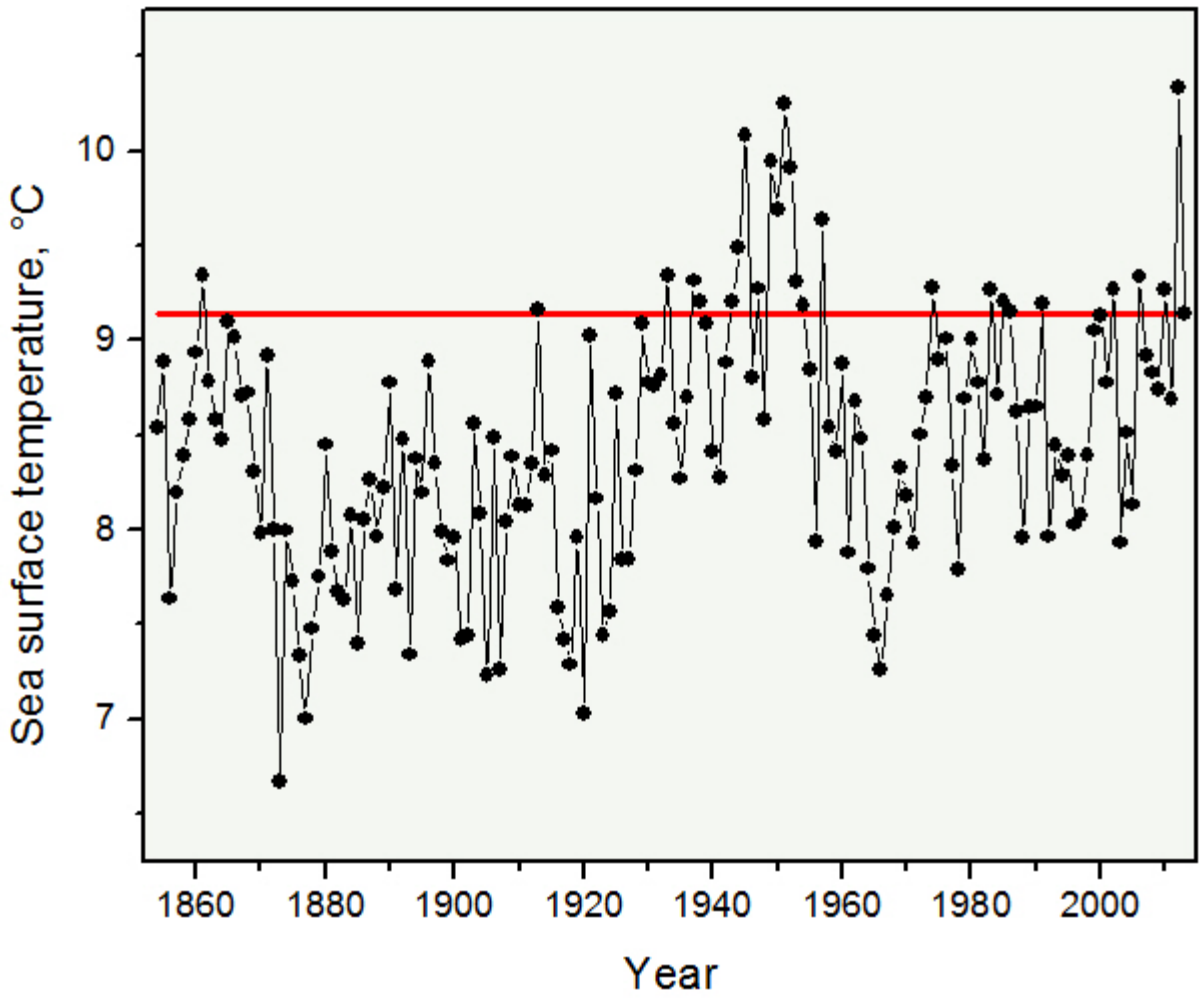


Middle Atlantic Bight (MAB)



Northeast Shelf (NES)

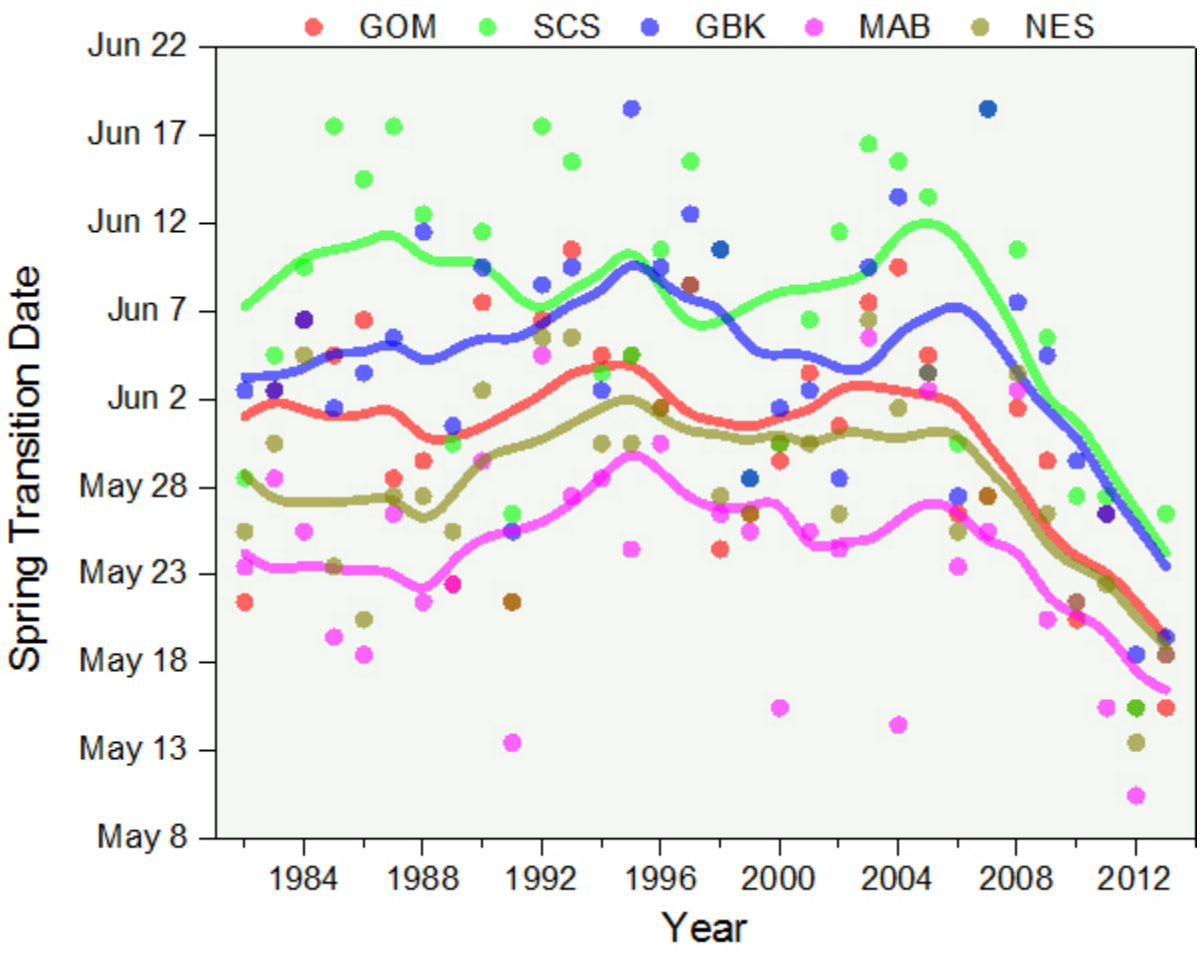
Extended Reconstruction SST for First Half Year



The SST conditions for the first half of 2013 reflected cooler temperature conditions on the shelf as compared to the record warm conditions recorded in 2012.

The NES SST was in excess of 9°C in 2013, 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**), which are generally below the sea surface temperatures seen during the warm period of the late 1940s and early 1950s.

Thermal Transition Date



Spring thermal transition date.