Spring 2014 Update: Annual Condition of the Northeast Shelf Ecosystem

Produced by the Ecosystem Dynamics and Assessment Branch

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

Summary

- Sea surface temperatures (SSTs) in the Northeast Shelf Large Marine Ecosystem during 2013 represented a moderation of thermal conditions compared to the record highs observed in 2012. The moderation in temperature was not uniform over the ecosystem, with more cooling occurring in the southern part of the ecosystem.
- Bottom temperature collected during the most recent fall survey indicate that benthic thermal conditions in the Middle Atlantic Bight have cooled to below average and have remained above average in the Gulf of Maine.
- The fall bloom on the Northeast Shelf was poorly developed with the exception of some bloom activity in the Gulf of Maine; no fall bloom was detected on the Georges Bank.
- Despite the moderation in thermal conditions on the Shelf, warm water thermal habitats remained at high levels in 2013.
- The arrival of the fall thermal transition has gotten progressively later in all areas of the Northeast Shelf, with the most pronounced shift occurring in the northern part of the ecosystem. The shift in fall timing has delayed fall by nearly a month in some areas.
- An experimental forecasting data product suggests that sea surface temperature will remain above average through summer into fall.

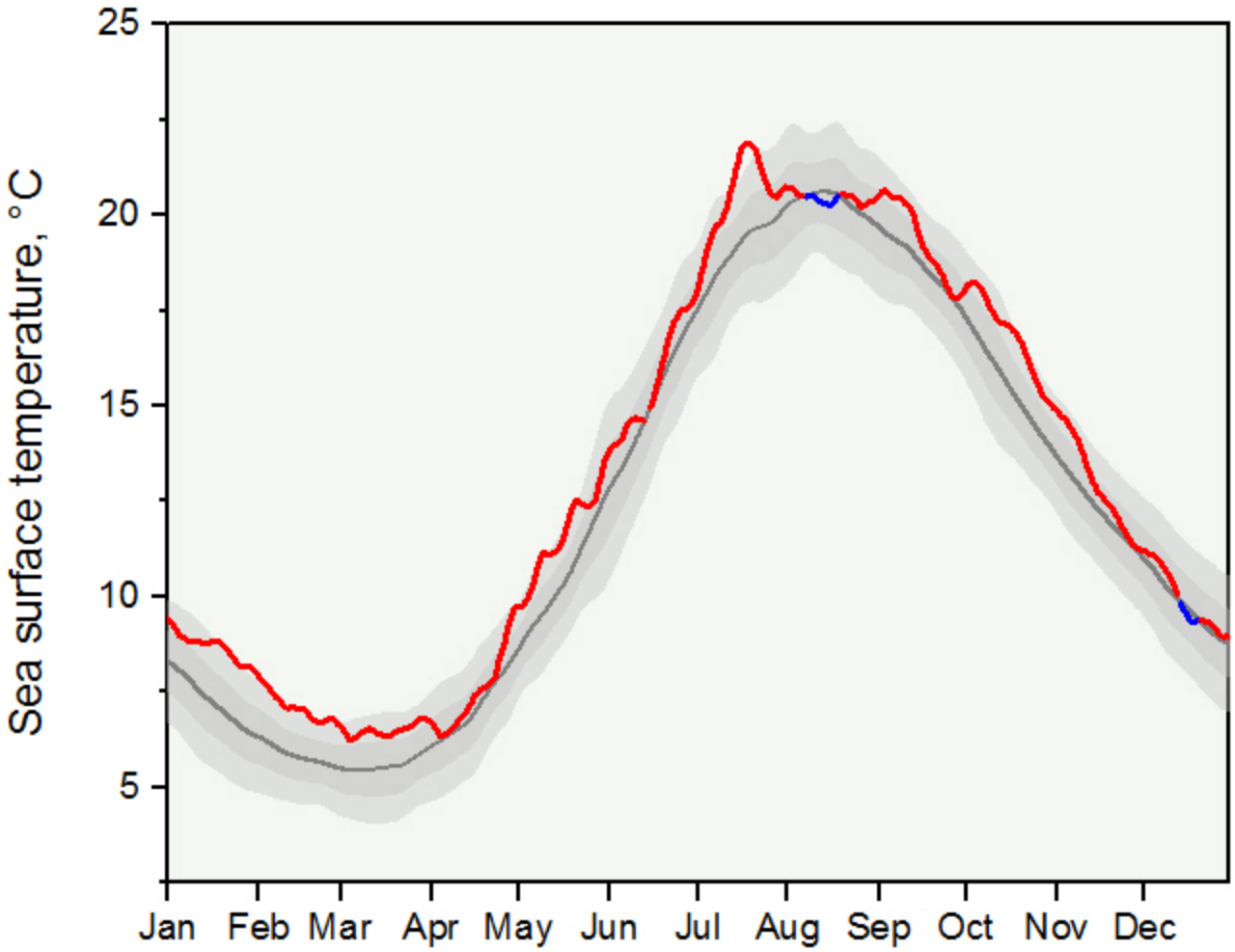
Data Sources

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



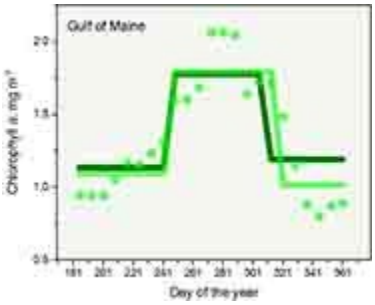
Sea surface temperature cycle

The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures (SSTs) during the fall of 2013, continuing the trend of above average temperatures seen during spring. In the graph, the long term mean SST is shown as a dark gray line with areas

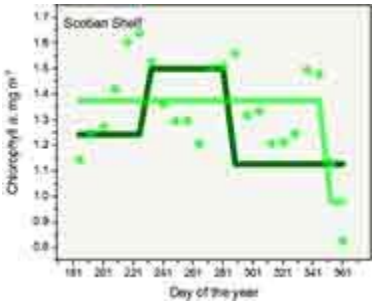
representing plus and minus one and two standard deviations of the mean as progressive shades of gray, respectively (see **figure**). In 2013, SSTs were all well above the mean and are shown in red. Some thermal moderation occurred during the middle of the summer when temperature fell below the long term mean and again during December.

Bloom Development on the Northeast Shelf

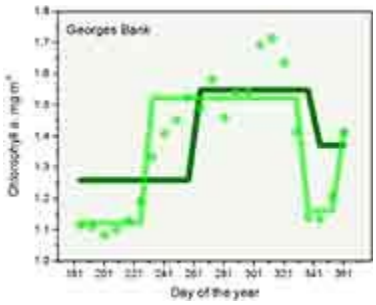
Though regions of the Northeast Shelf Large Marine Ecosystem often have fall bloom activity, the ecosystem as a whole does not typically have a fall bloom. The only region that produced a typical fall bloom pattern was the Gulf of Maine (see **figure**) where the 2013 fall bloom was nearly identical to the climatological fall bloom pattern. The Scotian Shelf region also tends to produce a distinct fall bloom, but the 2013 chlorophyll pattern did not show a fall bloom (see **figure**). Georges Bank has a more irregular pattern of fall bloom formation and though we observed a seasonal increase in chlorophyll concentration in 2013, this pattern exceeds the limits to what we considered to be a bloom versus a seasonal increase in chlorophyll (see **figure**). The low bloom productivity in fall is in contrast to the exceptionally high chlorophyll concentrations observed during the spring bloom.



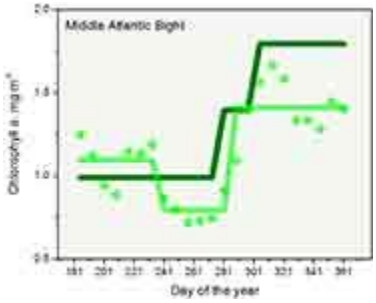
Gulf of Maine (GOM)



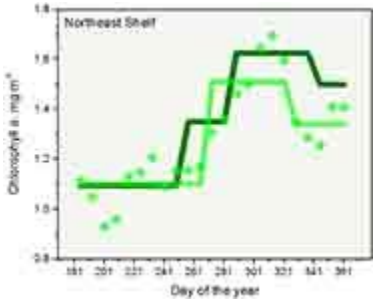
Scotian Shelf (SCS)



Georges Bank (GBK)



Middle Atlantic Bight (MAB)

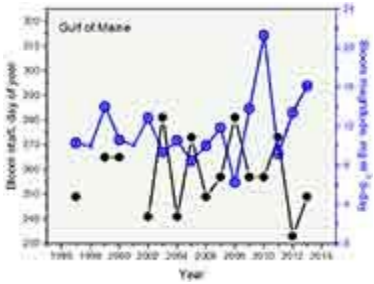


Northeast Shelf (NES)

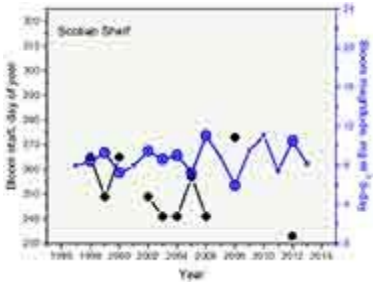
Bloom Start Day and Magnitude

Fall blooms have been most frequently detected in the Georges Bank, Gulf of Maine and Scotian Shelf regions, though that pattern of bloom frequency was not observed in 2013. The time series figures for these regions show the start day of detected blooms (black circles) and bloom magnitudes for both detected blooms (large blue circles) and climatological bloom magnitudes for years where a bloom was not detected (small blue circles).

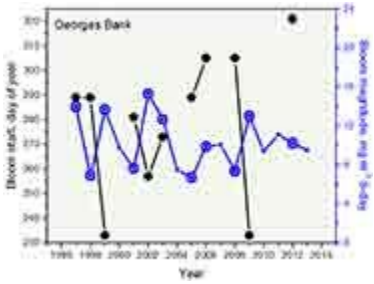
A bloom was detected in the Gulf of Maine and in the composite Northeast Shelf chlorophyll signal. In the other areas, Georges Bank, Scotian Shelf and the Middle Atlantic Bight, no fall bloom was detected. The 2013 Gulf of Maine fall bloom was relatively early and the second largest magnitude fall bloom in the time series.



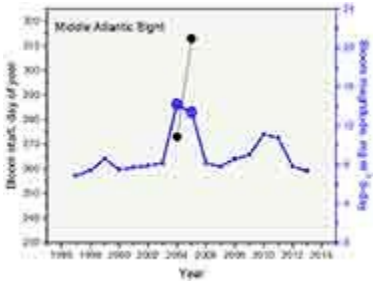
Gulf of Maine (GOM)



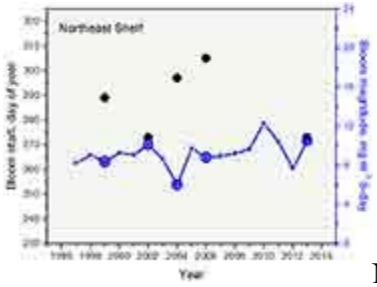
Scotian Shelf (SCS)



George Bank (GBK)



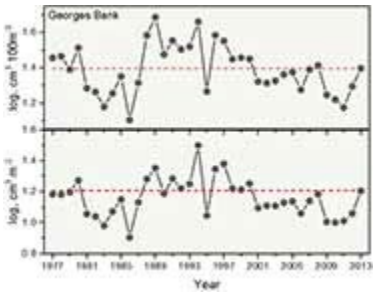
Middle Atlantic Bight (MAB)



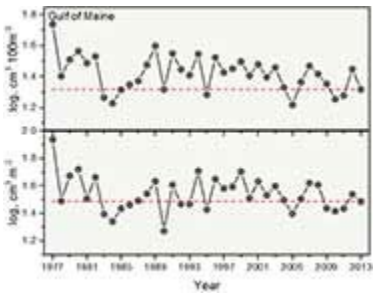
Northeast Shelf (NES)

Zooplankton Biomass

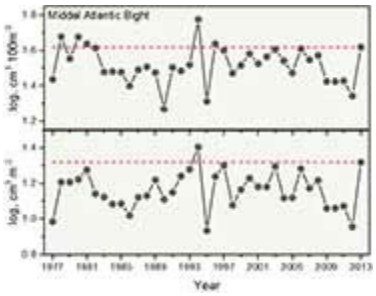
The biomass of zooplankton showed a range of response in different ecoregions of the Northeast Shelf during fall 2013. Zooplankon biomass is represented with two biovolume indices, a density index (cm3 100m-3) indicating the volume of zooplankton to a volume of seawater; and, a per area index (cm3 m-2) which provides an estimate of zooplankton volume throughout the water column for an area of the ocean surface. Middle Atlantic Bight and Scotian Shelf biovolumes (see figures) were slightly above average during fall 2013; wheras, the Gulf of Maine index was slightly below average. Biovolume was approximately at the time series average level on Georges Bank.



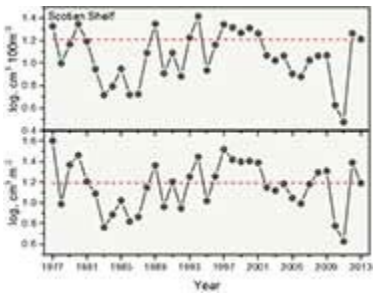
Georges Bank (GBK)



Gulf of Maine (GOM)



Middle Atlantic Bight (MAB)

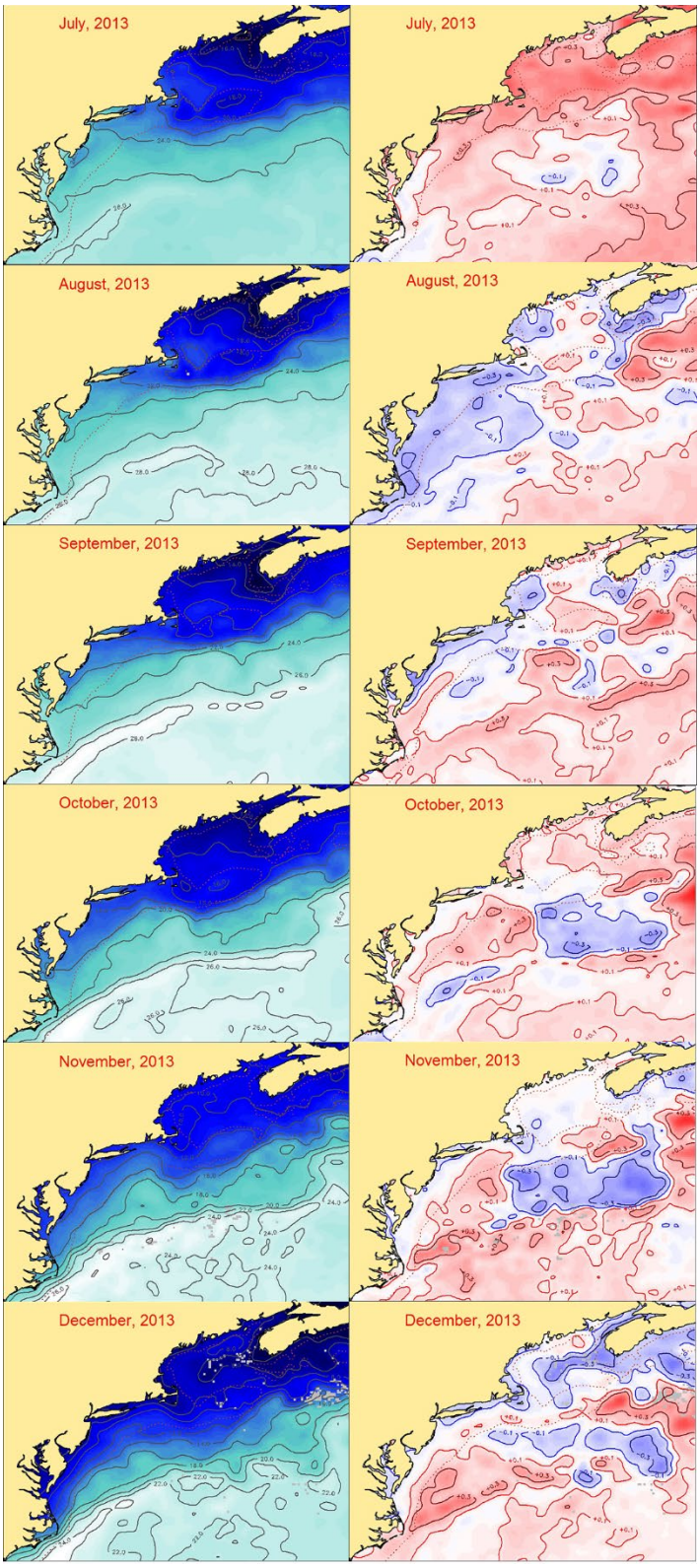


Scotian Shelf (SCS)

Sea Surface Temperature Distribution

Fall Sea Surface Temperature Distribution

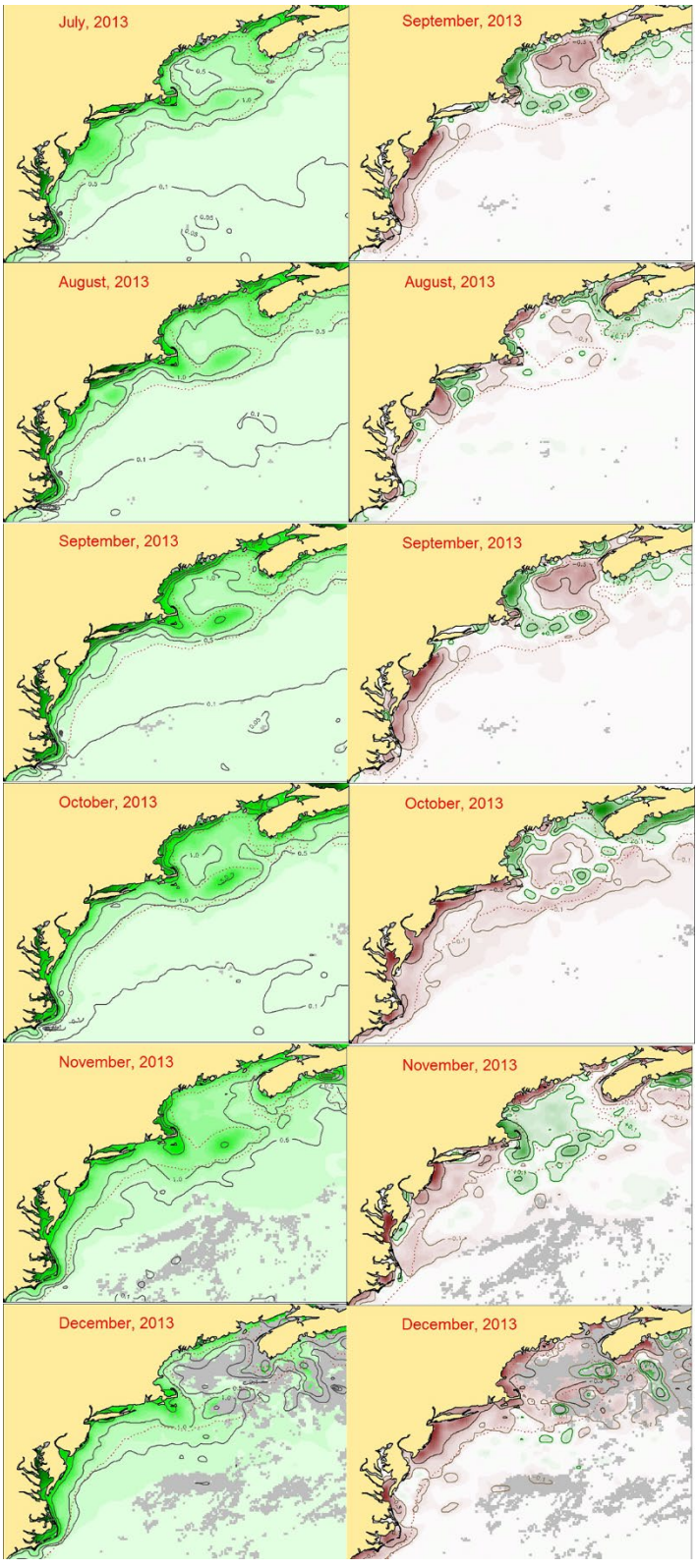
The progression of fall sea surface temperatures for the months of July through December are shown in the interactive figure below. SSTs appear as progressive shades of cyan to blue in the left hand icons. Anomalies of SST, those tending to exceed plus or minus one quarter of a standard deviation of 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 northern segment of shelf was generally above average temperature during July and August whereas the southern segment was below average. There was a mixed pattern of slightly above and below temperatures over the Shelf during September and October. Most of the ecosystem was above average temperature during November followed by below average conditions during December.


July, 2013
July, 2013
August, 2013
August, 2013
September, 2013
September, 2013
October, 2013
October, 2013
November, 2013
November, 2013
December, 2013
December, 2013

Chlorophyll Distribution

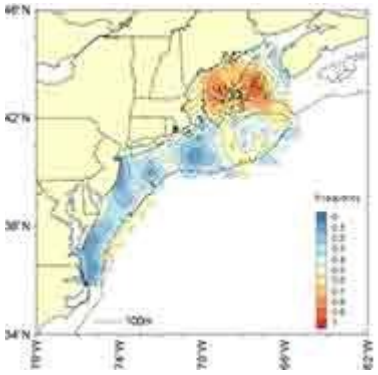
Fall Chlorophyll Distribution

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. A localized summer bloom occurred off the New Jersey coast during July; this bloom feature has been occurring more often in recent years marked by a large dimension bloom in 2011. Fall bloom in the Gulf of Maine was well developed in the western portion of the Gulf by September. The fall bloom on Georges Bank was not strongly developed and appeared to be limited to a series of smaller bloom centers arrayed across the Bank.


July, 2013
September, 2013
August, 2013
August, 2013
September, 2013
September, 2013
October, 2013
October, 2013
November, 2013
November, 2013
December, 2013
December, 2013

Bloom Spatial Dynamics

The fall bloom is a production feature that varies in size and frequency in different parts of the ecosystem. A discernible fall bloom develops during most years in the Gulf of Maine. The red tones in the frequency map indicates that most parts of the Gulf of Maine has a fall bloom frequency in excess of 0.7, indicating that in 7 out of 10 years a fall bloom can be detected. In contrast, the Middle Atlantic Bight has frequencies typically less the 0.3, indicate that a discernible bloom is a rare event. Georges Bank represents an intermediate area with fall blooms having a frequency of occurrence of approximately 0.5, essentially a coin toss. The contrast between years with and without a bloom is emerging as an important ecological driver, which is particularly important on Georges Bank. The dimensions of the fall bloom vary throughout the ecosystem. Here, the fall bloom is characterized as bloom magnitude, or the sum of the chlorophyll concentrations during the bloom period. Bloom magnitudes are highest close to the coastline reflecting the trend of higher chlorophyll concentrations found there and a localized peak in bloom magnitude on the northern flank of Georges Bank. The fall bloom starts earlier in the year in the northern part of the Gulf of Maine and begin progressively later in the year in the southern part of the ecosystem.

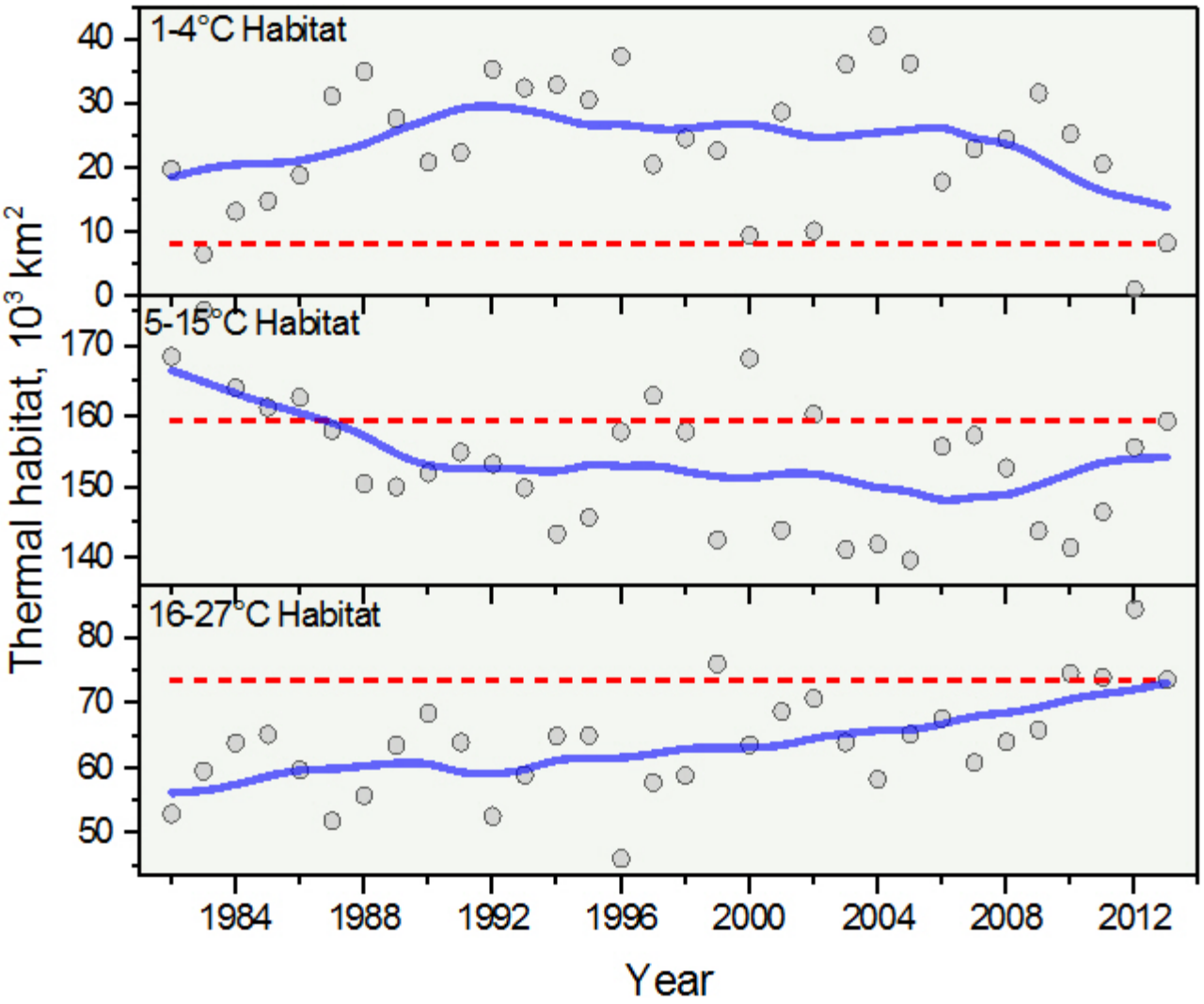


Bloom frequency

Bloom magnitude

Bloom start day

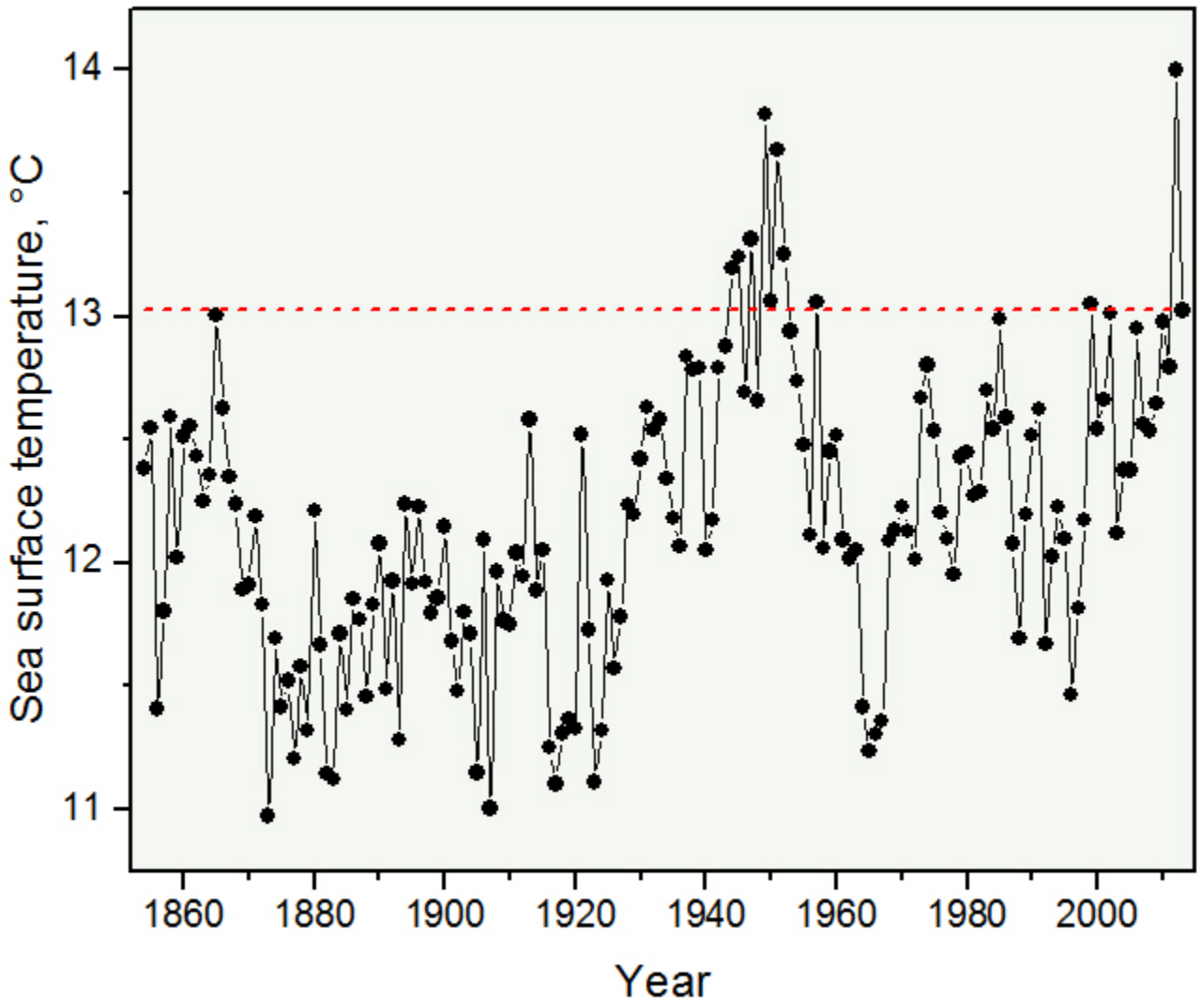
Ecosystem Shift in Thermal Habitat



Ecosystem shift in thermal habitat

Temperature affects the behavior and physiology of marine organisms, thus it is a key determinant of habitat within the ecosystem. Thermal habitats shifted dramatically in 2012 reflecting the record warming that occurred last year. The 2013 thermal habitats reflect the thermal moderation seen during the year; however, the ecosystem remains relatively warm. Cold water habitats (1-4°C) had remained relatively stable over time despite an overall trend of warming in the ecosystem. The 2013 cold water habitat (2013 value marked over the time series with dashed red line) increased to nearly 10,000 km^2 after virtually disappearing during last year. Cool water habitats (5-15°C) were slightly above average at a level of nearly 160,000 km^2. Warm water habitats (16-27°C) remained among the highest levels in the time series at over 70,000 km^2 in 2013. The simultaneously cooling and warming affecting the ecosystem in recent decades, actuated by Labrador Current, ended abruptly in 2012 signaling the potential start of a new environmental regime.

Long-Term Temperature Trends for the Northeast Shelf Ecosystem



Temperature trends

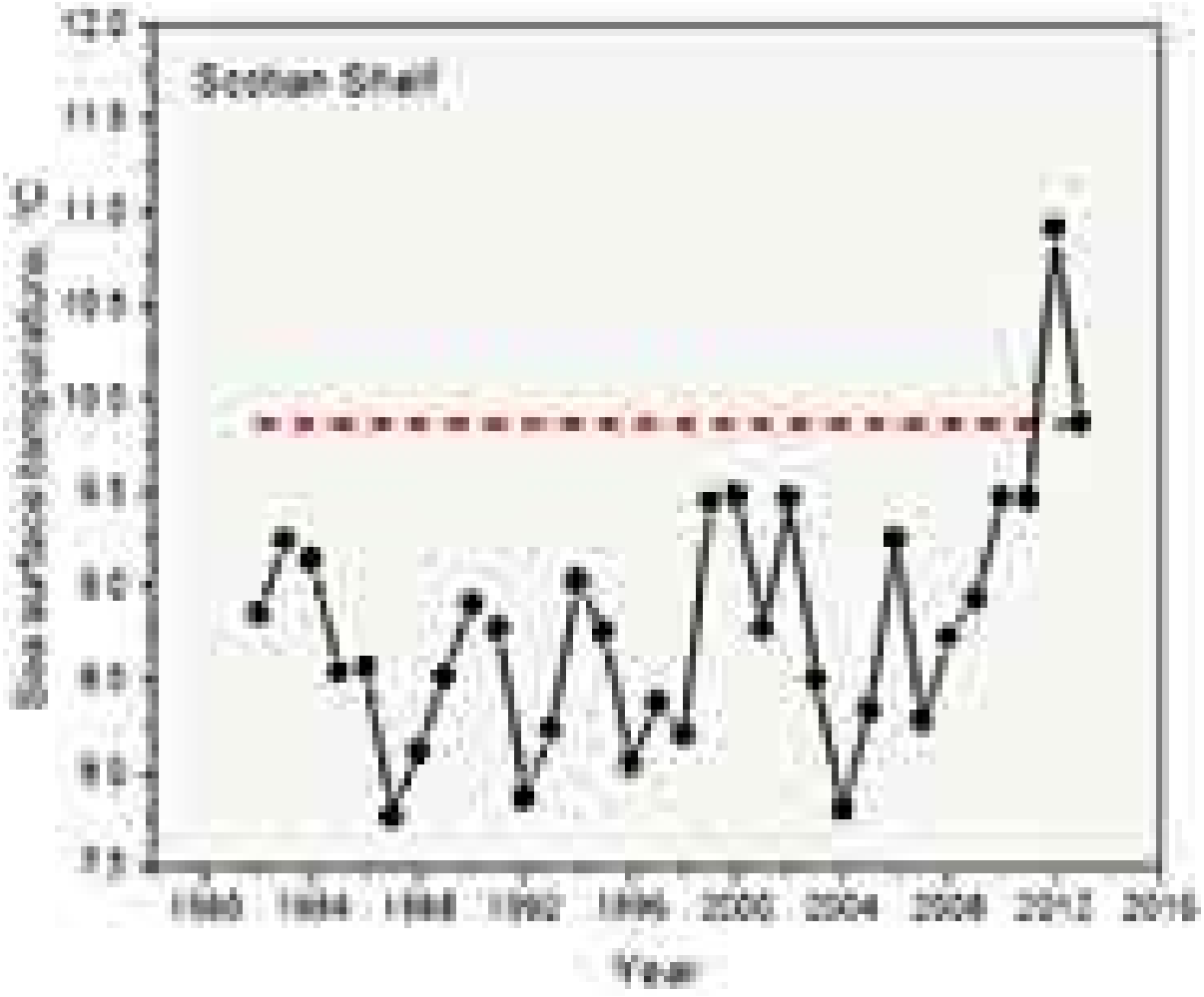
The Northeast Shelf Ecosystem was at a record high SST in 2012, the 2013 mean level (2013 value marked over the time series with dashed red line) was more in line with the temperature trend established over recent decades. The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854. The temperature decrease in 2013 was among the highest absolute jumps in temperature seen in the time series, in contrast to the positive jump in temperature last year that exceeded 1°C.

Satellite SST Trends for the Northeast Shelf Ecosystem

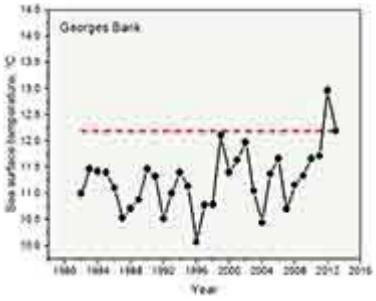
The SST conditions for 2012 were the warmest recorded in the satellite remote sensing data series. The NES SST was in excess of 13°C in 2013 (2013 values marked over the time series with dashed red lines), which was less than the record level set in 2012, but was still the second warmest temperature in the time series. The temperature moderation was not uniform over the

ecosystem. Temperature for 2013 was second highest in the time series for the Gulf of Maine, Scotian Shelf and Georges Bank; however, the lower 2013 temperatures in the Middle Atlantic Bight were exceeded by the temperatures in five other years. The temperature moderation was more pronounced in the southern part of the ecosystem compared to the northern part.

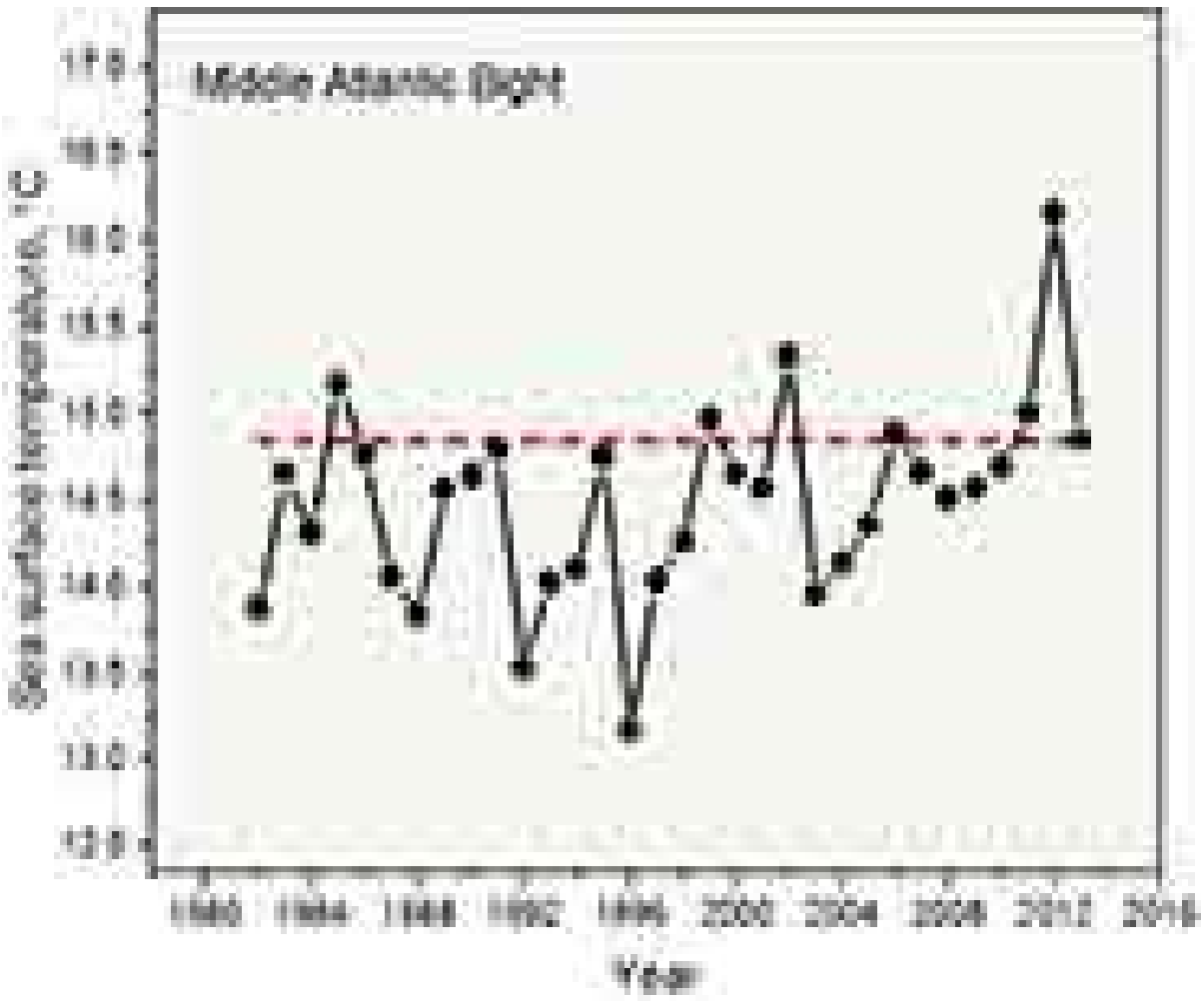
Gulf of Maine (GOM)



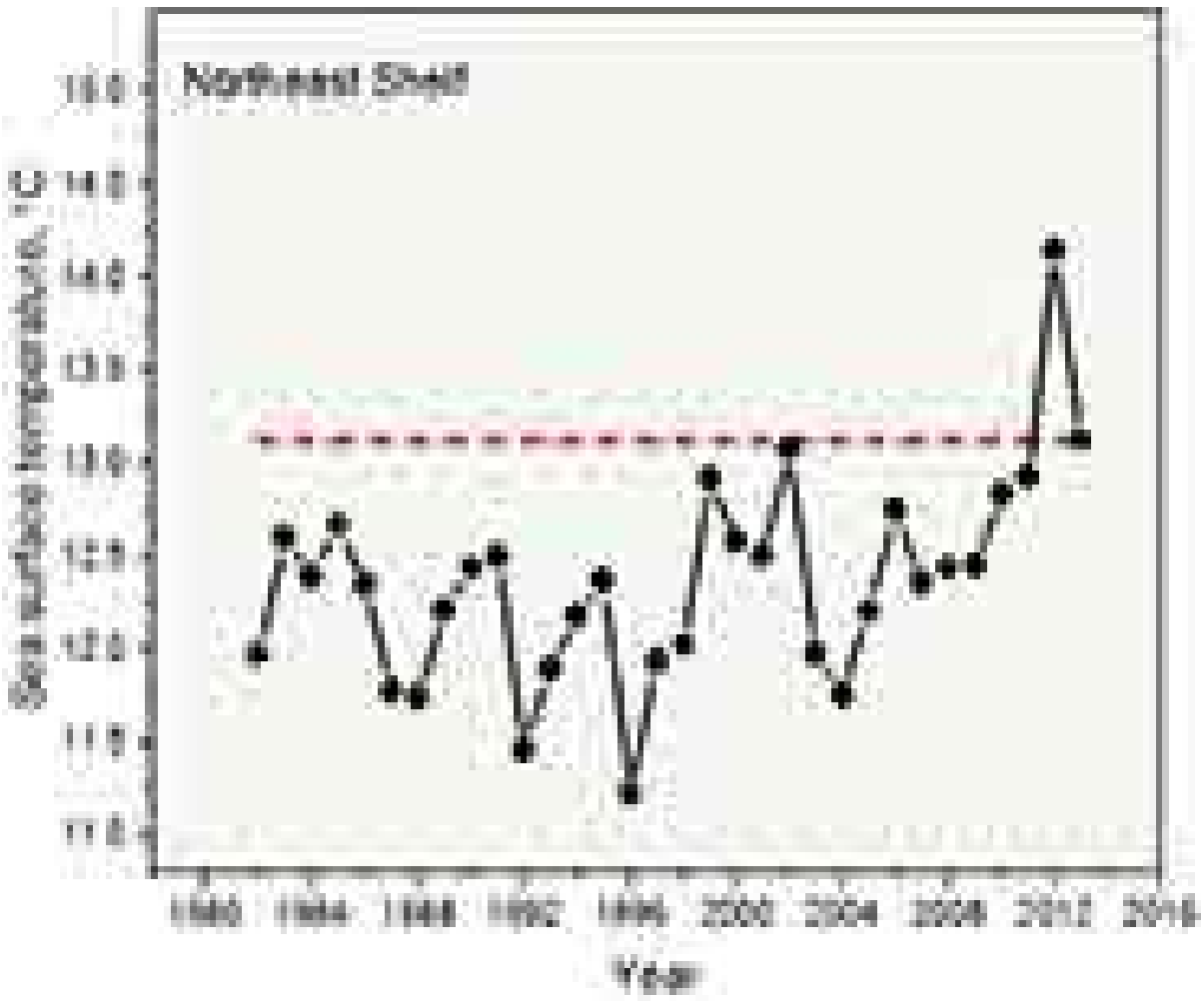
Scotian Shelf (SCS)



Georges Bank (GBK)

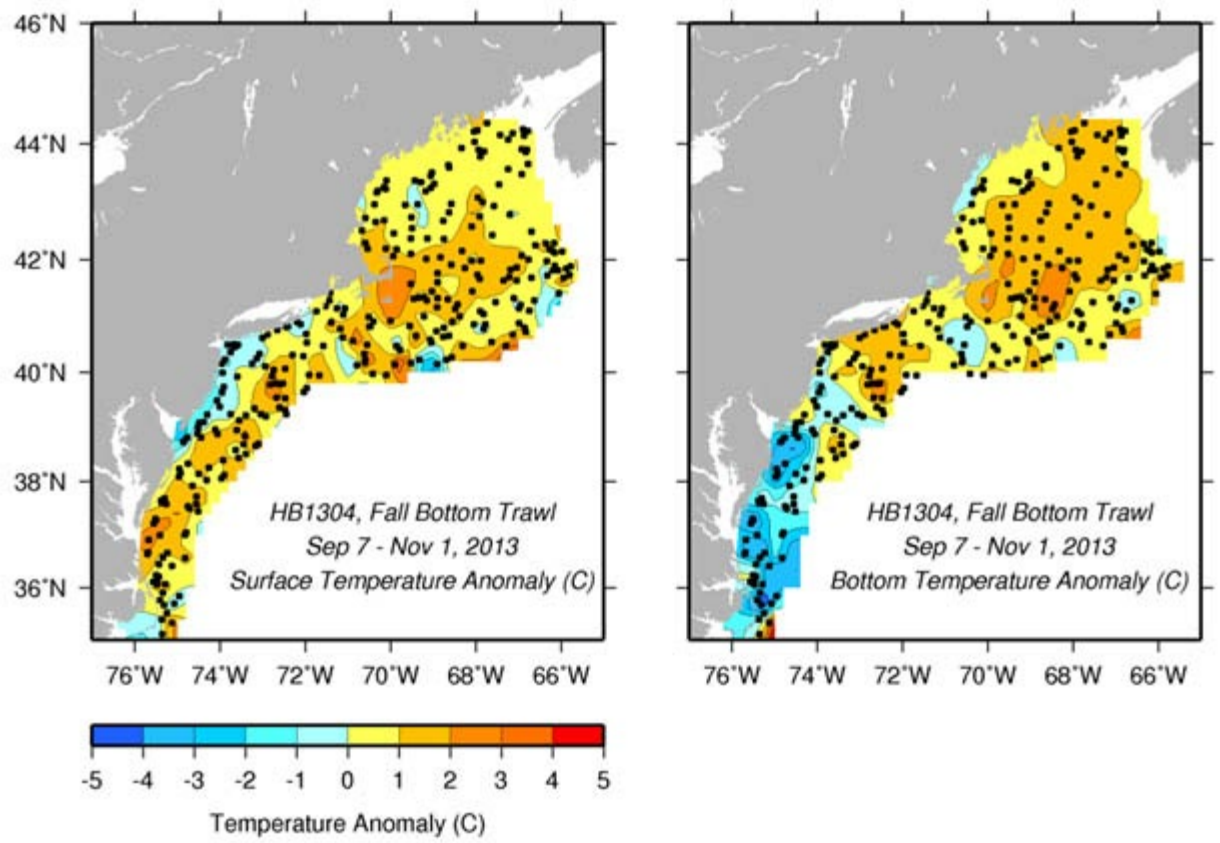


Middle Atlantic Bight (MAB)



Northeast Shelf (NES)

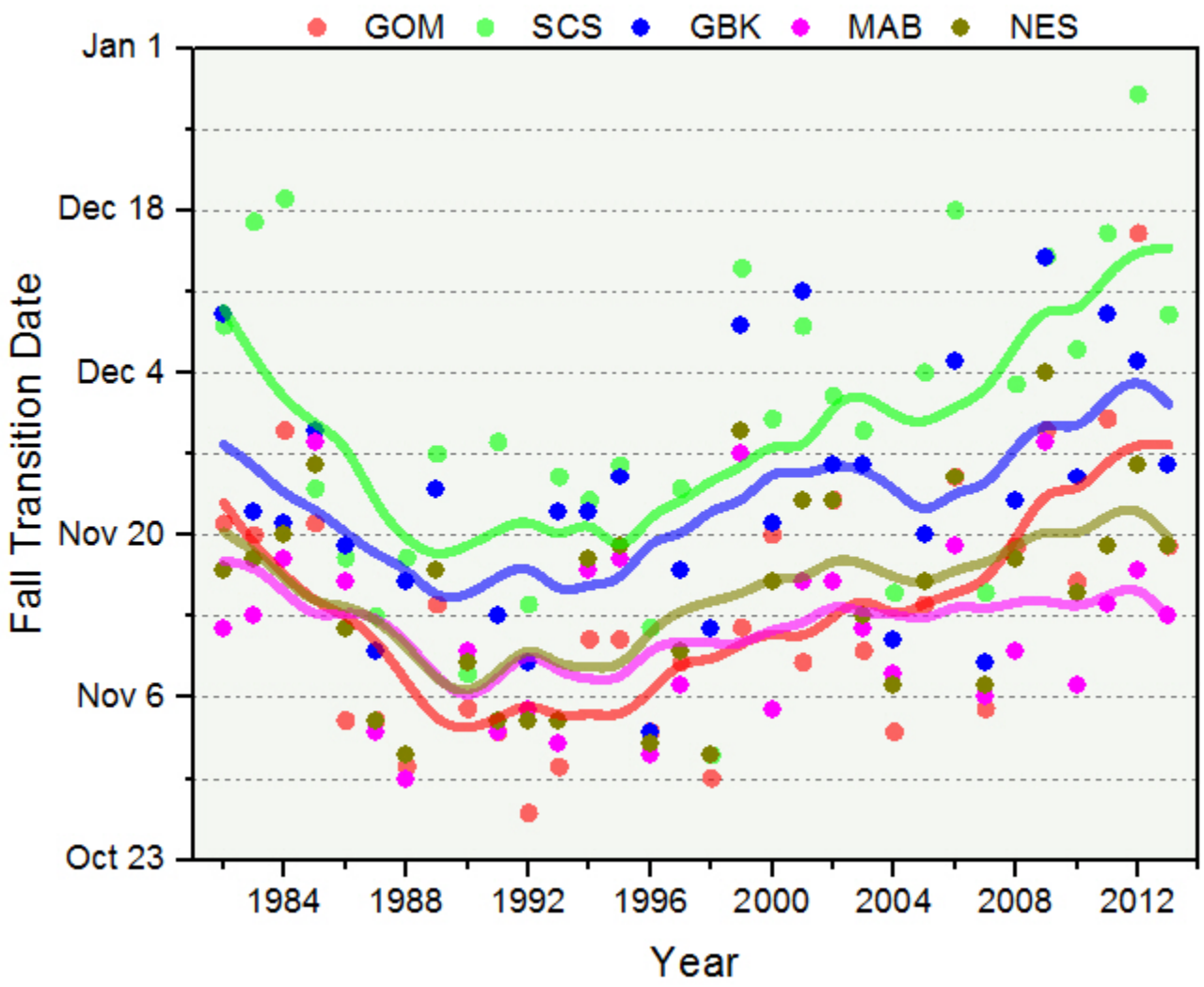
Temperature from Fall Survey



Fall survey temperature trends

The Northeast Shelf Ecosystem was at a record high SST in 2012, the 2013 mean level (2013 value marked over the time series with dashed red line) was more in line with the temperature trend established over recent decades. The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854. The temperature decrease in 2013 was among the highest absolute jumps in temperature seen in the time series, in contrast to the positive jump in temperature last year that exceeded 1°C.

Thermal Transition Date

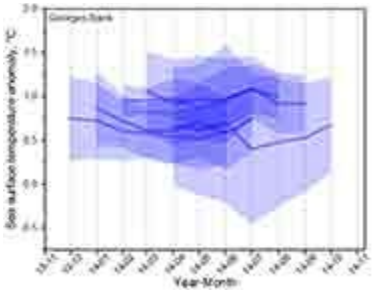


Fall thermal transition date.

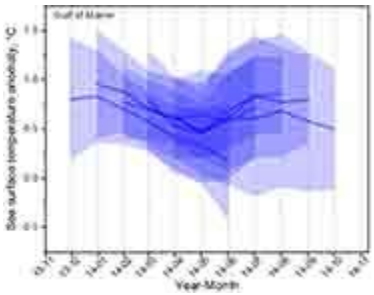
Phenology is the climate influence on the timing between plant and animal production cycles. Many marine organisms time their reproductive cycles to best utilize seasonal phytoplankton blooms, like the spring and fall blooms, and in turn temperature plays a role in the development of these blooms. One measure to characterize the change in the timing of thermal forcing is the date of arrival of a fall transition temperature, which will vary by region and is meant to mark the average temperature between summer and winter. The date of arrival of the fall thermal transition temperature has reflected progressively later fall seasonal conditions over the past few decades (see **figure**). The transition has shifted by nearly a month in the northern part of the ecosystem as seen in the data for the Scotian Shelf where the transition date was around November 20 during the 1980s and is now close to December 20. The shift at the southern end of the ecosystem was not as large. The seasonal shift fall transition in the Middle Atlantic Bight was more on the order of one week.

Ecosystem Forecast-Experimental Data Product

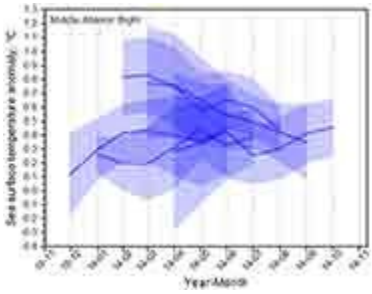
As weather and earth system models have improved, monthly forecasts over seasonal scales ranging up to seven months in advance have improved in quality. For each of the ecoregions of the Northeast Shelf, five sequential forecasts are overlaid to provide a depiction of the overall direction of the forecast 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 Gulf of Maine forecast that suggests temperature will be about 1°C above average through the fall. There is poor agreement of successive forecasts for the Georges Bank area suggesting the forecast direction has shifted with successive forecasts.



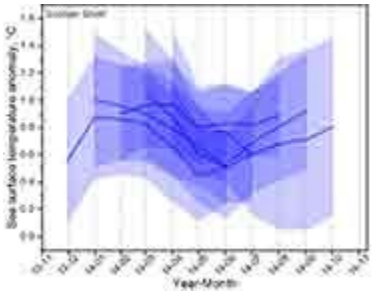
Georges Bank



Gulf of Maine



Mid Atlantic Bight



Scotian Shelf