# Fall 2009 Update: Annual Condition of the Northeast Shelf Ecosystem

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# Fall 2009 Update: Summary of Conditions of the Northeast Shelf Ecosystem

## Summary


- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem during the first half of 2009 continued to be moderate following the trend from the second half of 2008.
- Problems with the SeaWiFS ocean color sensing satellite make the 2009 chlorophyll data used in this report provisional. Despite the provisional nature of the data, it is clear that there was an exceptional spring phytoplankton bloom on the Northeast Shelf focused in the western Gulf of Maine and Southern New England.
- Zooplankton biomass levels were average or above during the first half of 2009
- The 2009 spring phytoplankton blooms on Georges Bank and in the Gulf of Maine began in the same late February and early March time frames as last year. However, the blooms peaked in a later time frame reflecting longer duration blooms.
- Spring bloom timing appears to be in part affected by the progression of spring SSTs in the region, suggesting a linkage between thermal conditions and water column structure.
- A newly developed method to detect phytoplankton biomass fronts offers a tool to understand the relationship between phytoplankton production and fisheries.
- Analysis of recent data confirms that the zooplankton community structure on Georges Bank shifted into a new state in the early 2000's


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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.

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. The data sources were combined to represent trends in chlorophyll *a* during 2008 and 2009;

however, there are known discrepancies between the two sensors so these data should be considered provisional until an upcoming data reprocessing can be completed. 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.

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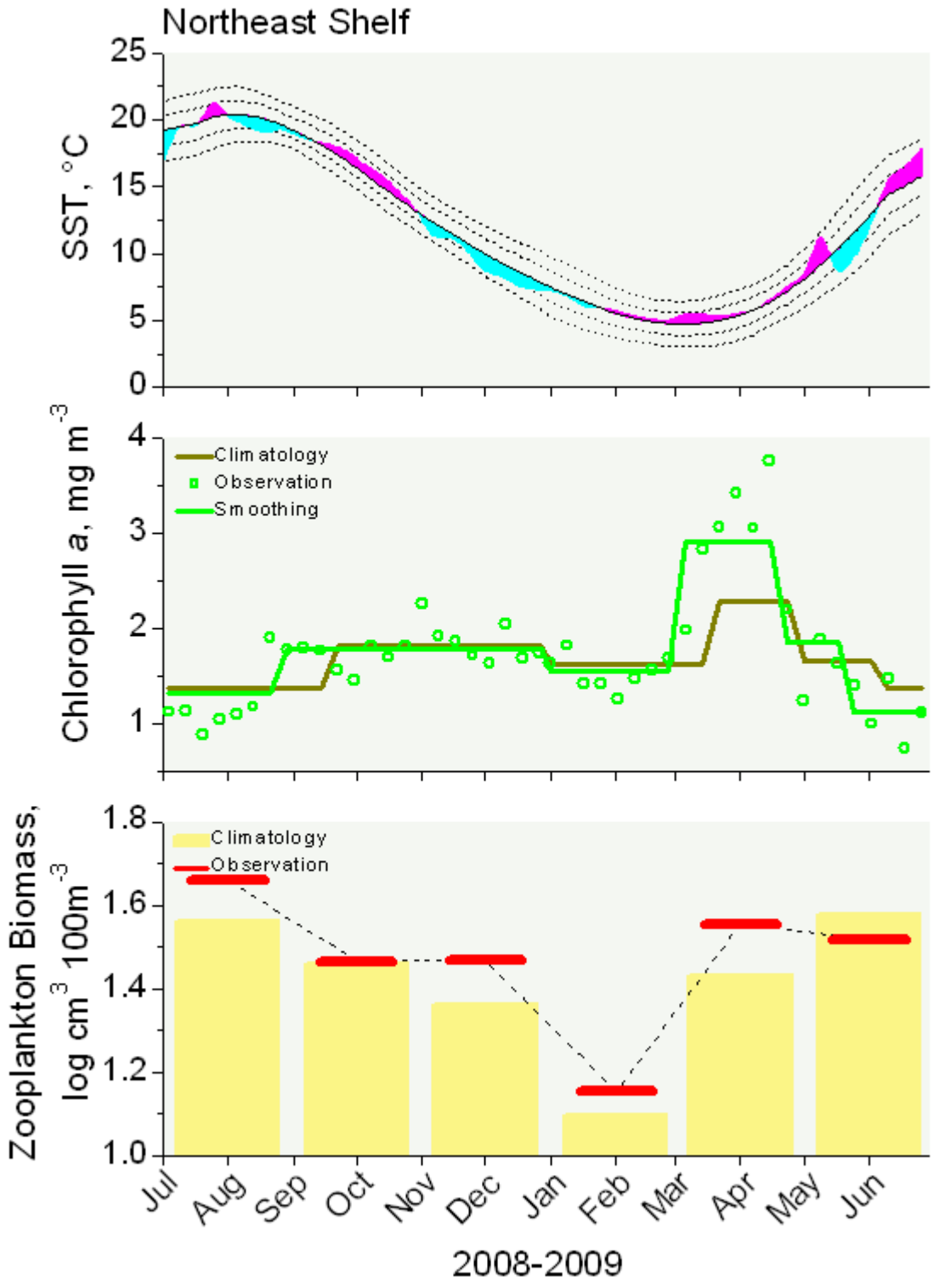
# Conditions on the Northeast Shelf Ecosystem




Surface temperature, chlorophyll and zooplankton biomass values are shown from July 2008 to June 2009.The Northeast Shelf Large Marine Ecosystem experienced minor fluctuations in sea surface temperatures during the first half of 2009. There was a transient warming event followed by a cooling event during May into June. Over the past year, SSTs tended to track average conditions. The first half of 2009 was however

marked by a large spring bloom event, repeating the pattern in bloom development observed last year. The spring bloom developed earlier than usual and had much higher chlorophyll concentrations than the long term mean. Zooplankton biomass levels were at average or slightly elevated levels, perhaps reflecting the higher primary productivity levels in the ecosystem over recent years

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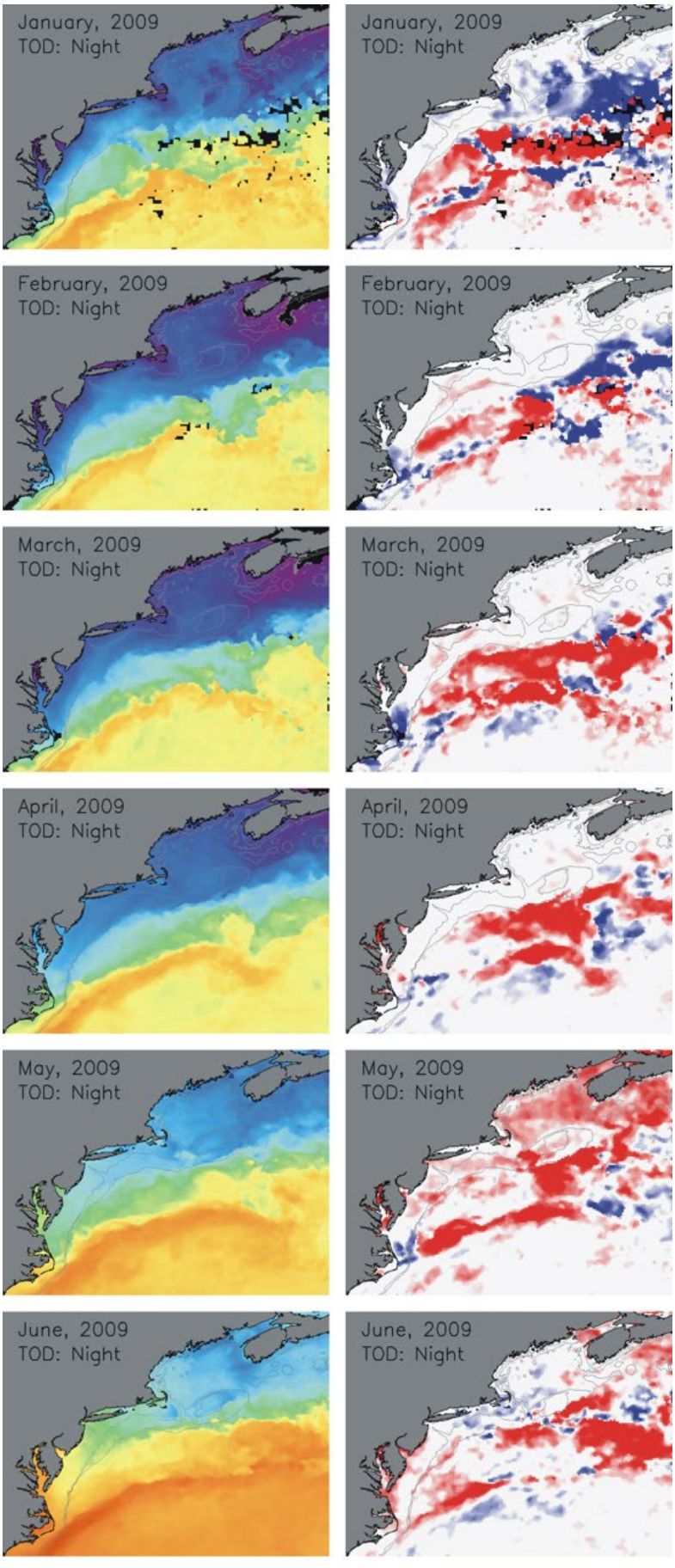
## Sea Surface Temperature Distribution


January, 2009
TOD: Night
January, 2009
TOD: Night
February, 2009
TOD: Night
February, 2009
TOD: Night
March, 2009
TOD: Night
March, 2009
TOD: Night
April, 2009
TOD: Night
April, 2009
TOD: Night
May, 2009
TOD: Night
May, 2009
TOD: Night
June, 2009
TOD: Night
June, 2009
TOD: Night
Temperature (°C)
0
8
16
24
32
Standard Deviations of SST (°C)
−.5
−.25
0
.25
.5

The progression of spring sea surface temperatures for the months of January through June are shown in the left hand set of panels. Higher SSTs appear as warm shades whereas low SSTs appear as cool shades. The right hand set of panels show exceptional anomalies of SST, those tending to exceed plus or minus one quarter of a standard deviation of the overall SST for the field. 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 progression of spring warming was generally at average levels for most of the Northeast Shelf with the exception of warm conditions that were established during May. This warming took place over much of the shelf, but as indicated by the pink tones, it was not a pattern of strong or consistent warming. By June there was some indication that the mid shelf region had actually cooled, most likely related to shifting weather patterns in the region.

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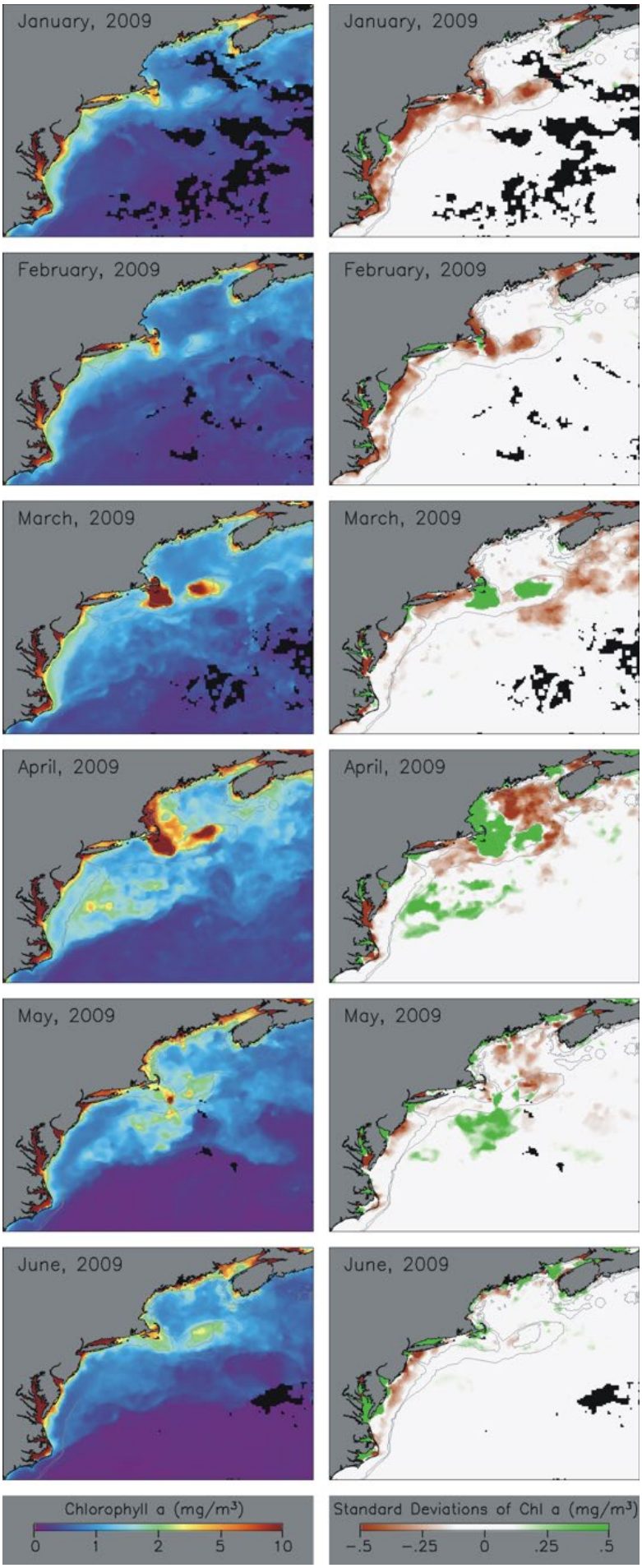
## Chlorophyll Distribution


January, 2009
January, 2009
February, 2009
February, 2009
March, 2009
March, 2009
April, 2009
April, 2009
May, 2009
May, 2009
June, 2009
June, 2009
Chlorophyll a (mg/m³)
0
1
2
5
10
Standard Deviations of Chl a (mg/m³)
−.5
−.25
0
.25
.5

The progression of spring chlorophyll concentrations for the months of January through June are shown in the left hand set of panels. Higher chlorophyll concentrations appear as warm shades whereas low concentrations appear as cool shades. The right hand set of panels show exceptional anomalies of chlorophyll concentration, those tending to exceed plus or minus one quarter of a standard deviation of the overall concentration for the field. This type of anomaly tends to highlight strong blooms in an area, the green shades, and weak blooms in an area, the brown shades. With the provisional nature of these data, it would be imprudent to make definitive inferences on the intensity of regional bloom activity on the shelf. There appears to be an exceptional phytoplankton bloom in the contiguous region of Massachusetts Bay and Nantucket Shoals. This region often blooms in advance of the other northern subregions of the Northeast Shelf and often with greater intensity. The location of high chlorophyll levels off the shelf during May suggests some portion of shelf productivity is exported from the ecosystem.

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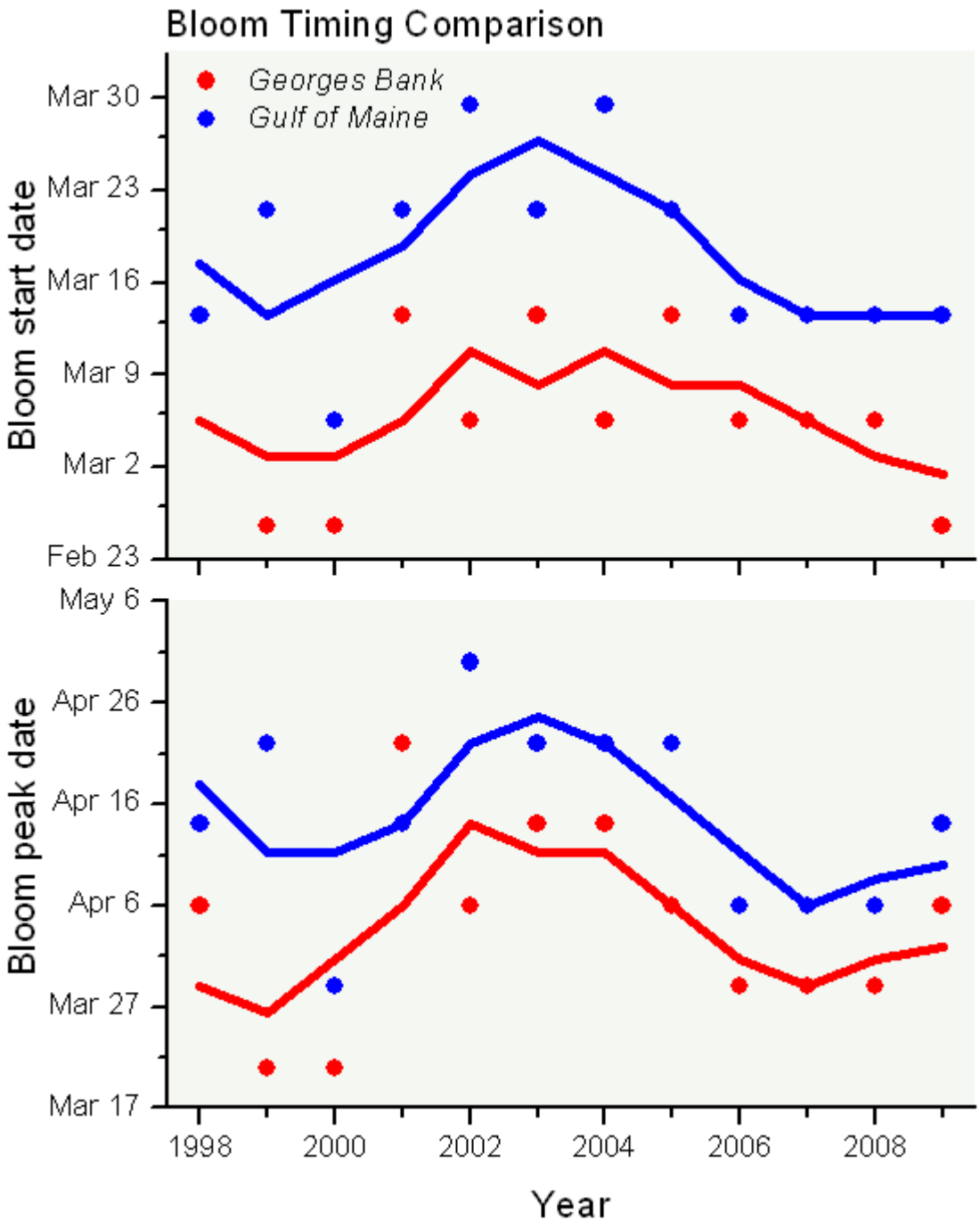
## Spring Bloom Timing




In prior advisories, spring bloom start and peak dates for the Gulf of Maine and George Bank areas were computed using a computer algorithm that analyzed daily chlorophyll data at fine spatial resolution. The problems with ocean color sensors this past year has made the necessary data unavailable to repeat these analyses. Instead, bloom start and peak were estimated by partitioning the production cycle based in the 8-day chlorophyll data. This approach yields comparable data to the previous assessment and in some cases appears to provide more accurate results. The bloom on Georges Bank precedes the bloom in the Gulf of Maine by approximately a week in most years. The

2009 spring bloom began around February 26 on Georges Bank and around March 14 in the Gulf of Maine. The bloom peaked around April 2 and 10 for Georges Bank and the Gulf of Maine, respectively. After a period of five years during which the spring bloom started later, the 2009 bloom occurred earlier, similar to the spring blooms at the beginning of the time series.

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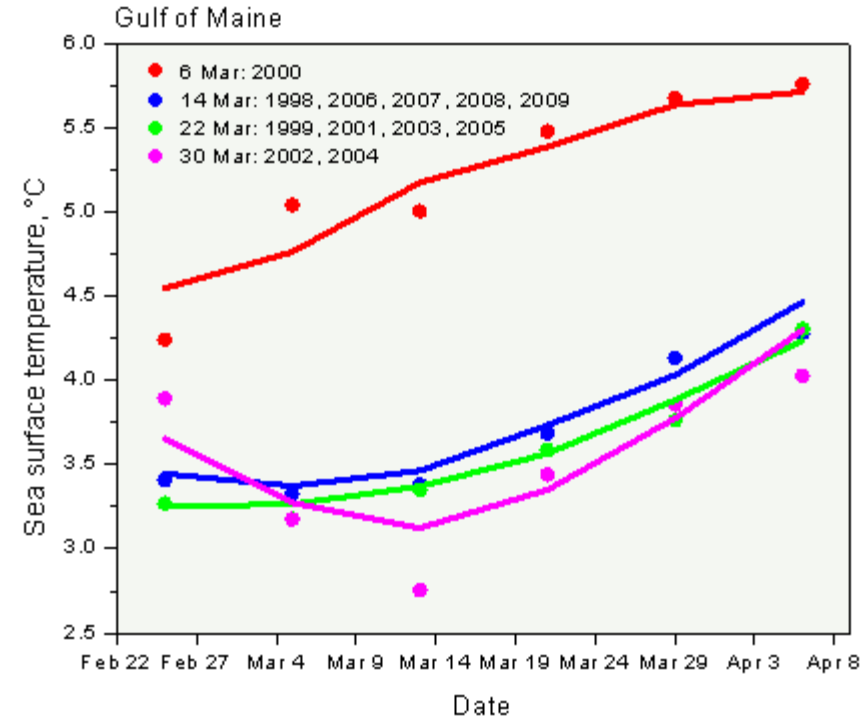
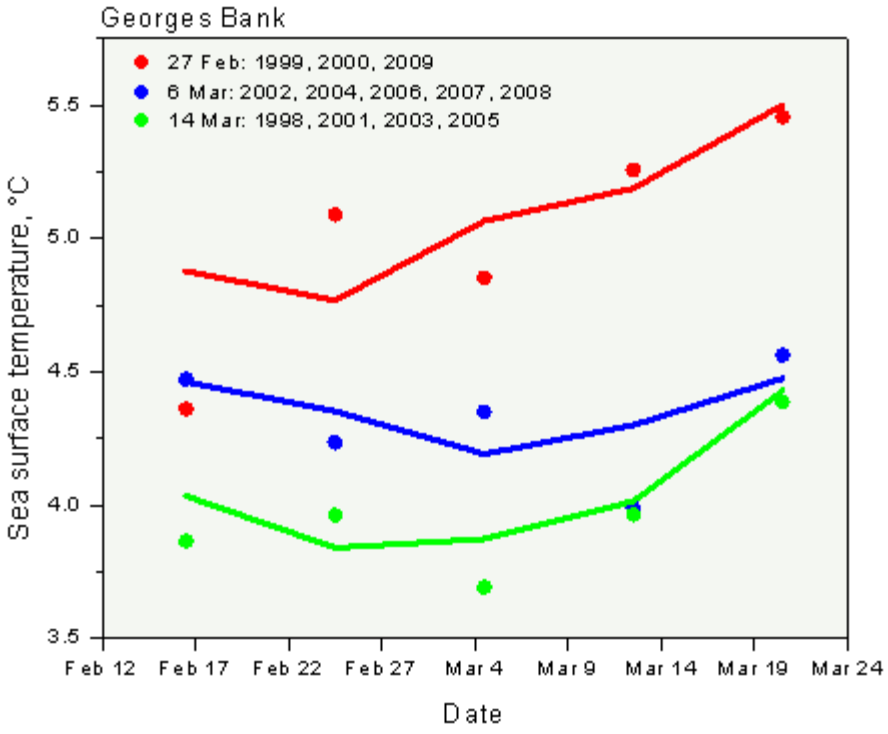
## Temperature Effects on the Spring Bloom




Phytoplankton blooms are initiated by a complex set of physical and biological conditions that vary from year to year. In some instances blooms are initiated by thermal conditions related to how the progression of warming influences the vertical structure of

the water column. The physical structure of the water column can also be influenced by weather and wind, so in some instances blooms may fail to develop or be delayed if there is variation in wind driven mixing. In addition to physical conditions, phytoplankton blooms are influenced by the availability of nutrients and zooplankton grazing; phytoplankton growth is dependent on a suite of limiting nutrients in the water column and even minor changes to zooplankton communities are often sufficient to control phytoplankton blooms. The figures show the progression of SSTs associated with the bloom start dates in the Gulf of Maine and Georges Bank. The earliest bloom start date in the Gulf Maine was estimated at March 6 and was only observed in 2000. This early start date was associated with the warmest SST conditions. Later blooms in the Gulf of Maine with start dates of March 14, 22 and 30 were associated with cooler SST conditions. The latest start date of March 30 appears to be associated with the coldest conditions during mid-March. The pattern of association between thermal conditions and bloom start is more developed on Georges Bank; early to late bloom starts are associated with progressively cooler SST conditions on the Bank. From these data, it would appear that bloom start is at least in part associated with the progression of spring warming in these areas of the Shelf Ecosystem.

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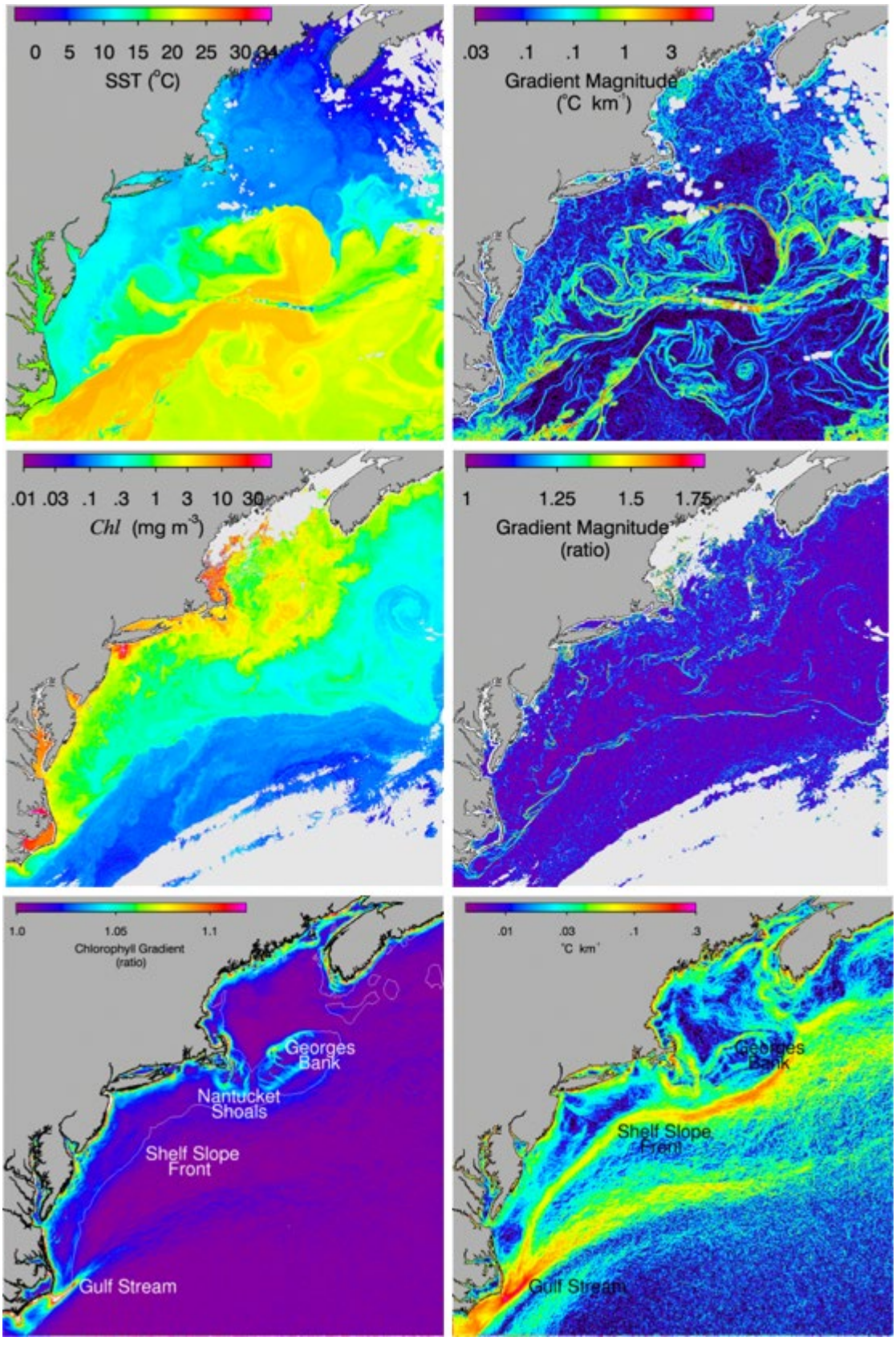
# Phytoplankton and Fronts


0 5 10 15 20 25 30 34
SST (°C)
.03 .1 .1 1 3
Gradient Magnitude
(°C km⁻¹)
.01 .03 .1 .3 1 3 10 30
Chl (mg m⁻³)
1 1.25 1.5 1.75
Gradient Magnitude
(ratio)
1.0 1.05 1.1
Chlorophyll Gradient
(ratio)
Georges Bank
Nantucket Shoals
Shelf Slope Front
Gulf Stream
.01 .03 .1 .3
°C km⁻¹
Georges Bank
Shelf Slope Front
Gulf Stream

Enhanced primary and secondary productivity is often associated with oceanic fronts. While sea surface temperature fronts are well documented, the location, frequency and strength of chlorophyll fronts are virtually unknown. SST frontal structure occurs in both shelf and oceanic waters (SST image from May 3, 2001, top left panel and associated thermal fronts, top right panel). Chlorophyll fronts are often distinct from thermal fronts with greater intensity fronts more often seen in inshore areas (chlorophyll image from October 14, 2000, middle left panel, with associated chlorophyll fronts, middle right panel). Using satellite data from several high-resolution ocean color and thermal sensors (SeaWiFS, MODIS-Aqua and MODIS-Terra) a climatology of chlorophyll and SST fronts in the Northeast U.S. Continental Shelf Large Marine Ecosystem was produced with a new front detection algorithm. The chlorophyll and SST frontal climatologies document spatial, seasonal and interannual variability of a variety of fronts in this region (mean chlorophyll, bottom left panel, and SST, bottom right panel, gradients). The SST fronts are associated with western boundary currents (Gulf Stream Front), water mass boundaries (Shelf-Slope Front), and tidal mixing including fronts around Georges Bank, Nantucket Shoals, and the Eastern Gulf of Maine. The chlorophyll and SST fronts provide an enhanced remotely-sensed product at synoptic, seasonal and annual scales that have the potential to describe oceanographic processes and environmental factors that are relevant to fisheries research and management.

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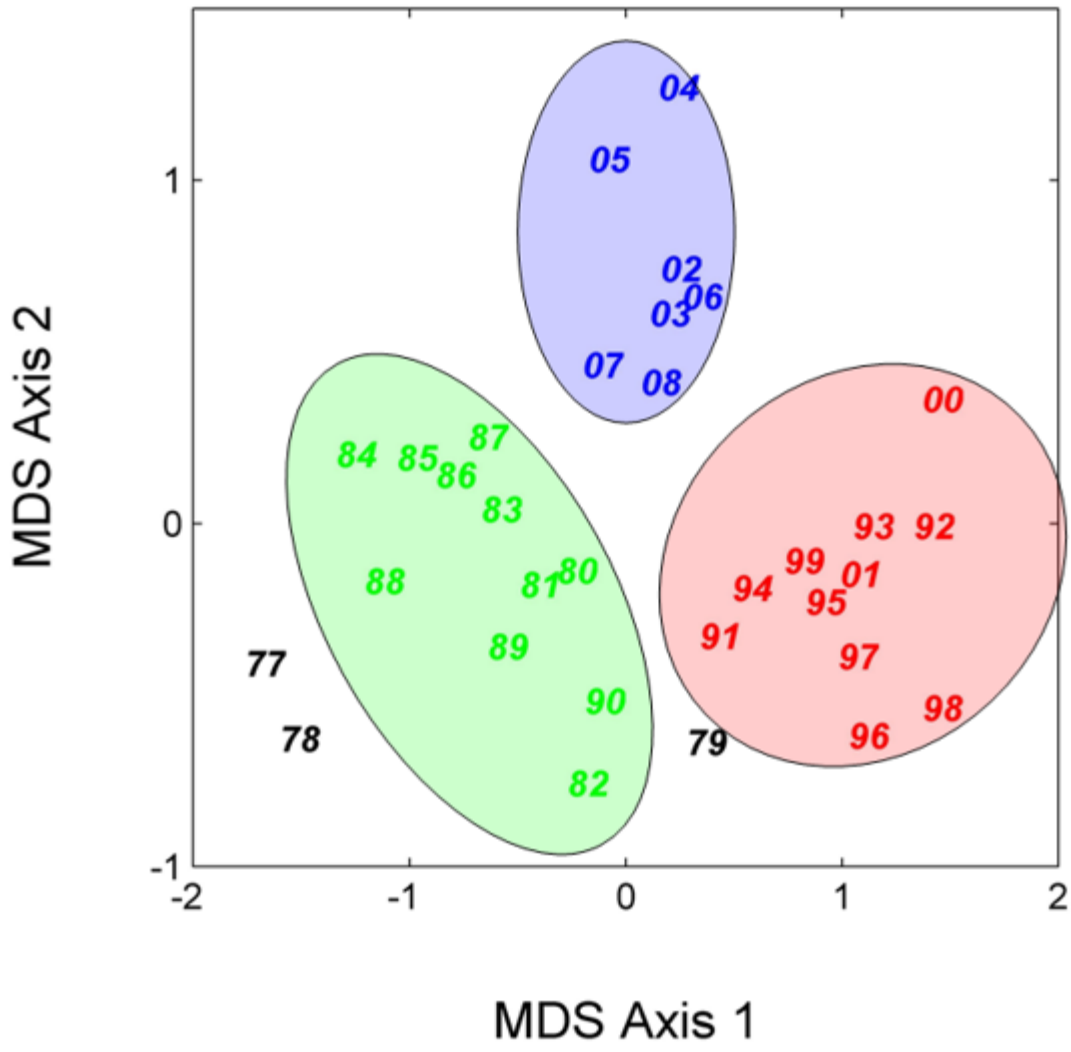
# Georges Bank Zooplankton Community Shift




An update of a study by Kane (2007, ICES J. Mar. Sci. 64: 909–919) demonstrates that the copepod community on Georges Bank entered a new state in the early 2000's. The initial study included data through 2004. An addition of four more years of data through 2008 confirms that a transition in zooplankton community structure occurred in the early 2000's. This represents the third distinct community since zooplankton monitoring was initiated on the northeast U.S. shelf in the late 1970's. The shift in community structure from the 1980's to the 1990's was related to an overall increase in copepod numbers and a relatively greater increase in smaller copepods (e.g., *Centropgaes hamatus* and *typicus*) compared to larger copepods (e.g., *Calanus finmarchicus*). The community shift in the early 2000's was associated with a decrease in smaller-bodied species and little change in larger-bodied species. These changes in zooplankton community structure have implications for higher trophic levels, but the specific consequences are under investigation. The figure shows an ordination of zooplankton species from 1977-2008. Points that are close together in the ordination represent years in which the zooplankton species composition was similar. Points that are far apart represent years in which the zooplankton species composition was different.