Spring 2006 Update: Annual Condition of the Northeast Shelf Ecosystem

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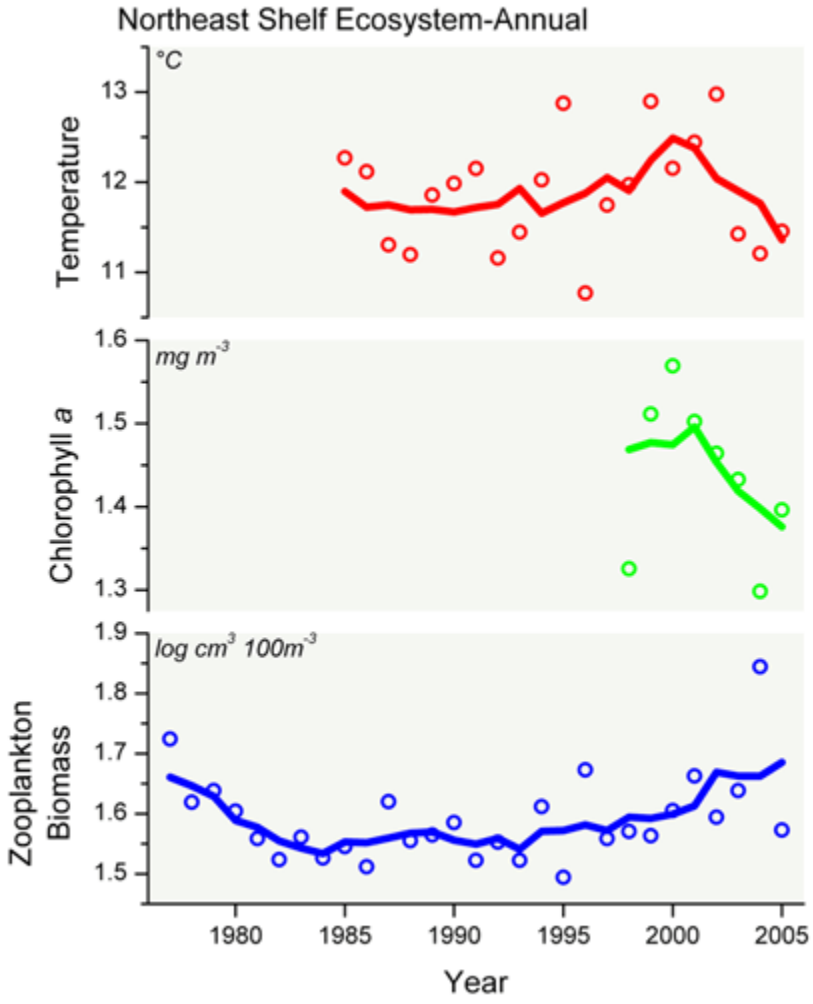
Spring 2006 Update: Annual Conditions



This advisory is an examination of satellite remote sensor and in situ survey data related to the plankton of the Northeast U.S. Shelf ecosystem. Specifically, we report on the sea surface temperature (SST), chlorophyll concentration, and zooplankton biomass. These are ecosystem wide environmental measurements. The results can best be interpreted with other physical and biological data to provide a complete description of the ecosystem.

Sea surface temperature and surface chlorophyll data exhibit a large amount of internal variability, but there is an indication in recent years of a cooling trend in shelf-wide SST and a reduction in surface chlorophyll. There was no appreciable trend in SST until the late 1990s, when temperatures began to increase. The data suggest a peak in SST around the year 2000, followed by a decreasing trend through 2005. Estimates of chlorophyll concentration are derived from remotely-sensed measurements made by the SeaWiFS sensor which began operation in September 1997. The available time series in chlorophyll mirrors SST, with a decline evident in recent years.

Data on total zooplankton abundance is available from 1977. There is also substantial internal variability in zooplankton biomass, as represented by a biovolume measurement, yet a long-term trend is apparent. Zooplankton biomass decreased

through the late-1970s, remained at relatively constant levels from about 1980-1995, and increased after 1995. Although these data suggest an overall increase in secondary production and a decrease in temperature and phytoplankton biomass, regional and temporal dynamics must be considered in the assessment of the entire ecosystem.

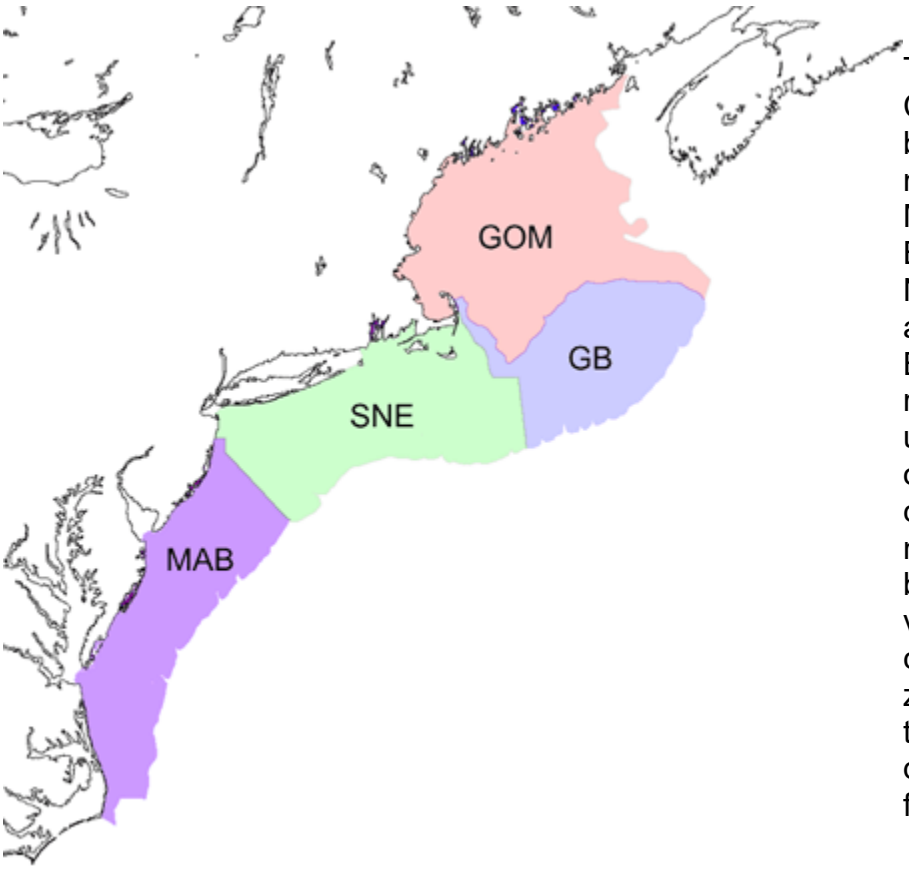
Data Sources

SST is derived from the Advanced Very-High Resolution Radiometer onboard the Polar Orbiting Environmental Satellite (AVHRR-POES) and represents the near-surface ocean temperature, not the temperature of the entire water column.

Daily synoptic views of surface concentrations of chlorophyll a are derived from the Sea-viewing Wide Field of View Sensors (SeaWiFS) ocean color sensor onboard the SeaStar spacecraft. Chlorophyll a is considered to be an index of the amount of phytoplankton biomass present in the water.

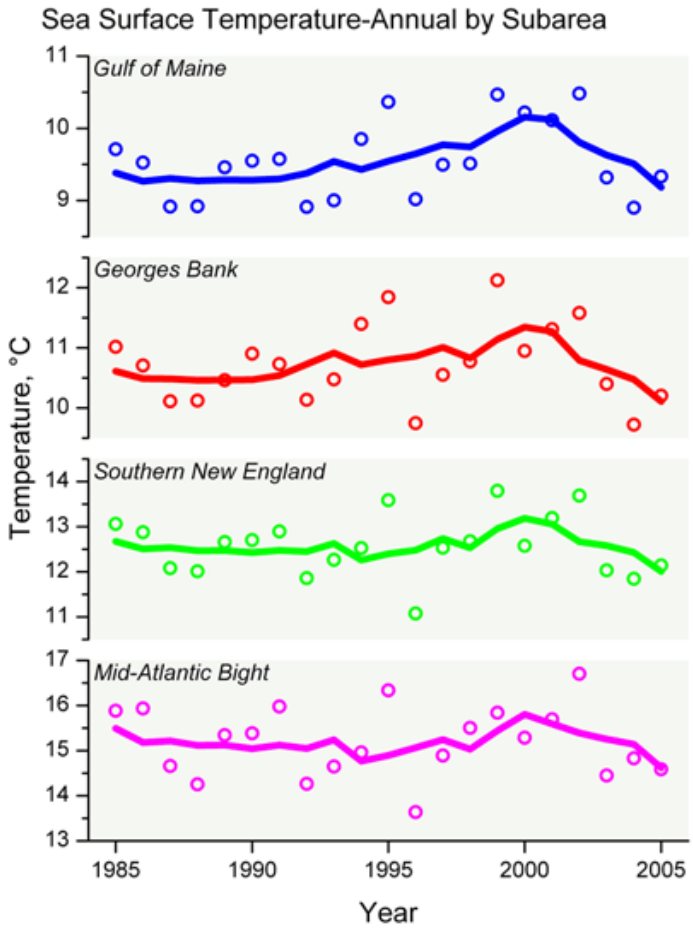
Zooplankton biomass is derived from shipboard surveys of the Northeast U.S. Shelf ecosystem - these small animals link the energy produced through primary production to higher trophic levels. From 1977-1987, the MArine Resources Monitoring, Assessment, & Prediction (MARMAP) program conducted intensive surveys from Cape Hatteras, North Carolina to Nova Scotia. These efforts continued at a reduced level through the 1990s and are ongoing today. Currently, 30 plankton samples are taken 6 times a year in each of the four ecosystem subareas: Mid-Atlantic Bight, Southern New England, Georges Bank, and Gulf of Maine (resulting in approximately 720 measures of zooplankton biomass annually).

Annual Conditions on the Northeast Shelf Ecosystem by Subareas



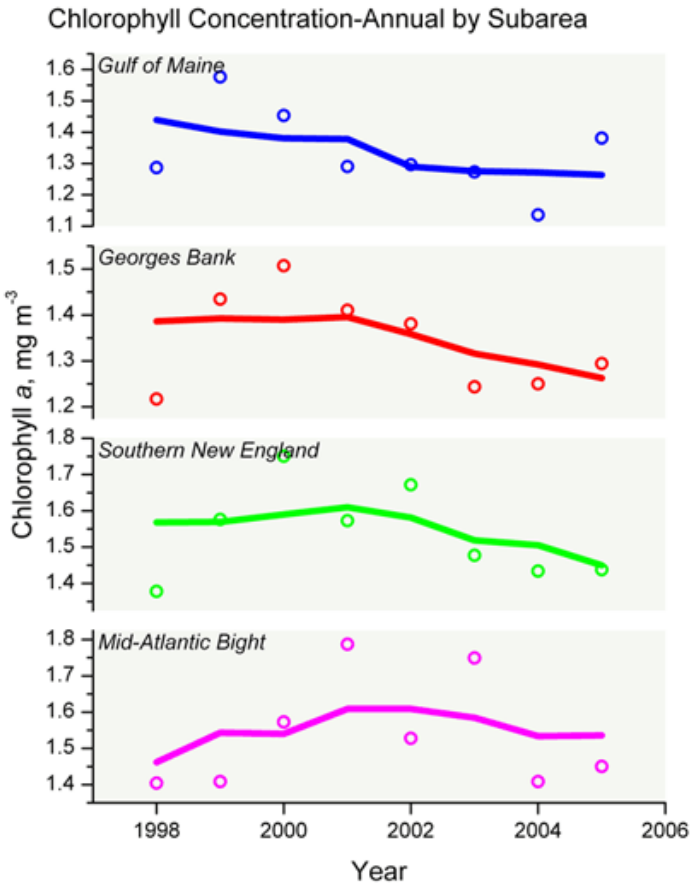
The Northeast Continental Shelf can be divided into four major subareas: Gulf of Maine (GOM), Georges Bank (GB), Southern New England (SNE) and the Middle Atlantic Bight (MAB), which reflect different underlying oceanographic conditions and fishery management boundaries. The variations in SST, chlorophyll, and zooplankton biomass in these four subareas are described in the following sections.

Annual Sea Surface Temperature



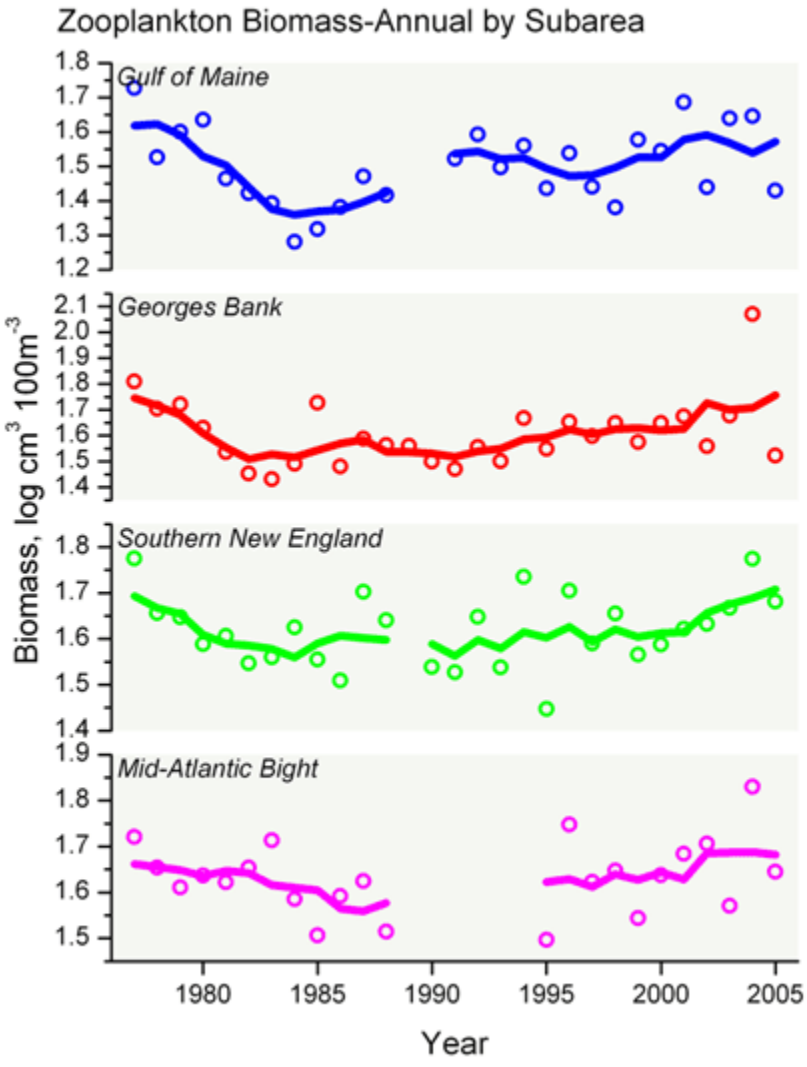
The four shelf subareas show similar temporal trends in SST; however, the temperature levels between subareas are different. SST in the GOM averaged 9.6°C over the period whereas temperature in the MAB averaged 15.2°C; the SSTs on GB and in SNE were intermediate between these values. Though all four subareas show an increase in temperature around the year 2000 and a subsequent decrease during the past five years, the relative magnitude of the change is greatest in the GOM and on GB. The 2000 peak in the temperature represents a 10% increase over SSTs at the beginning of the time series in the GOM whereas it only represents a 4% increase in the MAB. Despite these regional differences in average surface temperature, the general trend in SST, as assessed by satellite sensors for the whole shelf, is representative of the Northeast Shelf Ecosystem.

Annual Chlorophyll



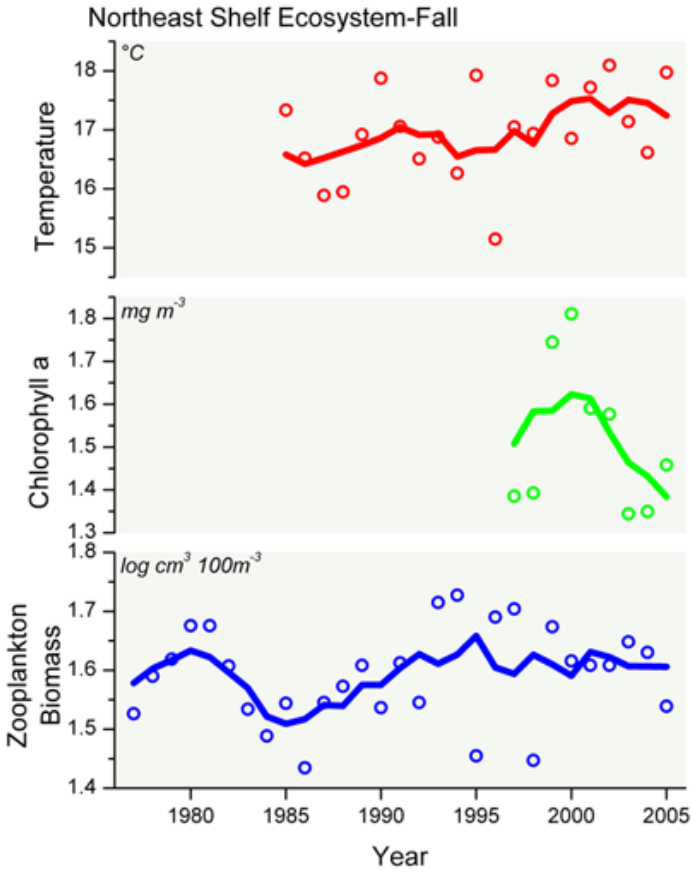
From examination of temporal trends in satellite derived surface chlorophyll for the past eight years, it is evident that there is a high degree of year-to-year variability in the shelfwide chlorophyll index in each of the four subareas. Although this time series of observations is relatively short, the trends for GOM, GB and SNE are similar, showing a down-trend during the past 3 years, whereas the trend in the MAB indicates an increase from 1998 to 2000, followed by lower values during the most recent two years. MAB appears to exhibit the greatest inter-annual variability and GB the least.

Annual Zooplankton



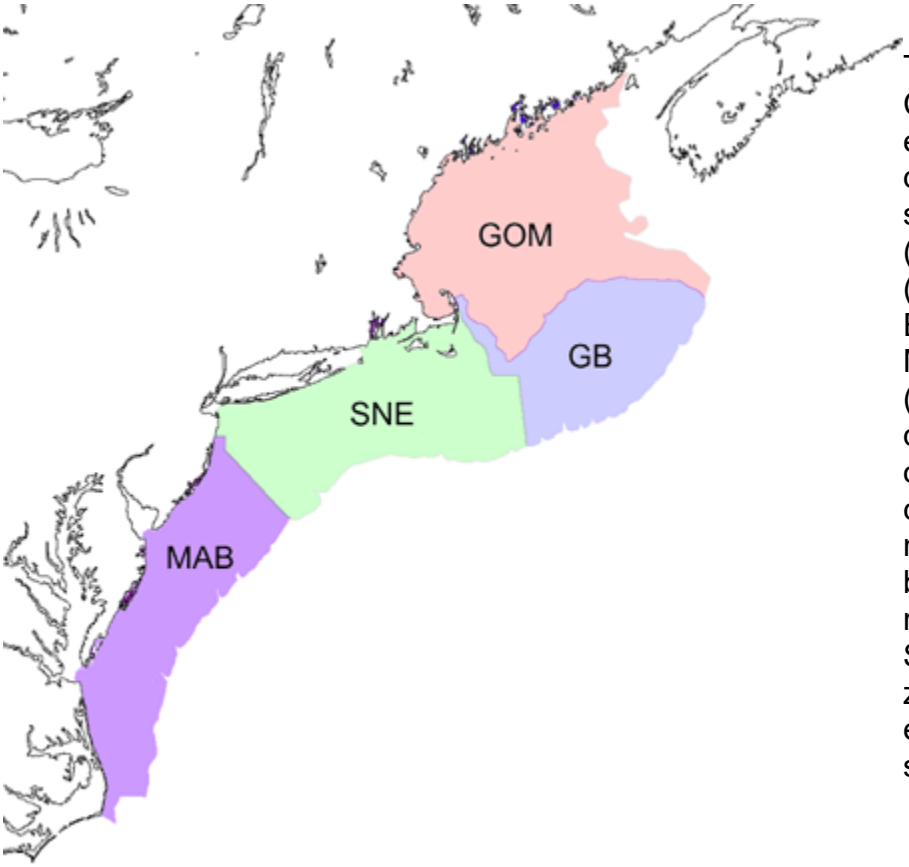
The general trends in zooplankton biomass in all four shelf subareas resemble the shelf-wide average; however, the dynamic pattern of change in biomass level and internal variability in survey results are dramatically different among subareas. The northern subareas, GOM and GB, show a more conservative pattern of interannual change in biomass, suggesting zooplankton are responding to conservative forcing parameters and are well estimated. Zooplankton biomass in SNE and MAB vary widely year to year, which we believe reflects the dynamic nature of the circulation system affecting zooplankton in the region. Generally zooplankton appear to have declined during the early 1980s and have since slowly increased in biomass level. However, this pattern of decline is not the same among the subareas. On GB and in the GOM the decline in zooplankton was most pronounced in the 1980s, resulting in a relative decrease of nearly 50% in zooplankton biomass levels. The biomass in both subareas increased to levels close to 1970s high period between 2000 and 2005. The relative decline in SNE and MAB was more on the order of 20%. Similarly, the recent increase in zooplankton differs in magnitude among subareas. The increase from 2000 to 2005 in the MAB is on the order of 25%, where is SNE the increase in on the order of 10%.

Fall Conditions on the Northeast Shelf Ecosystem



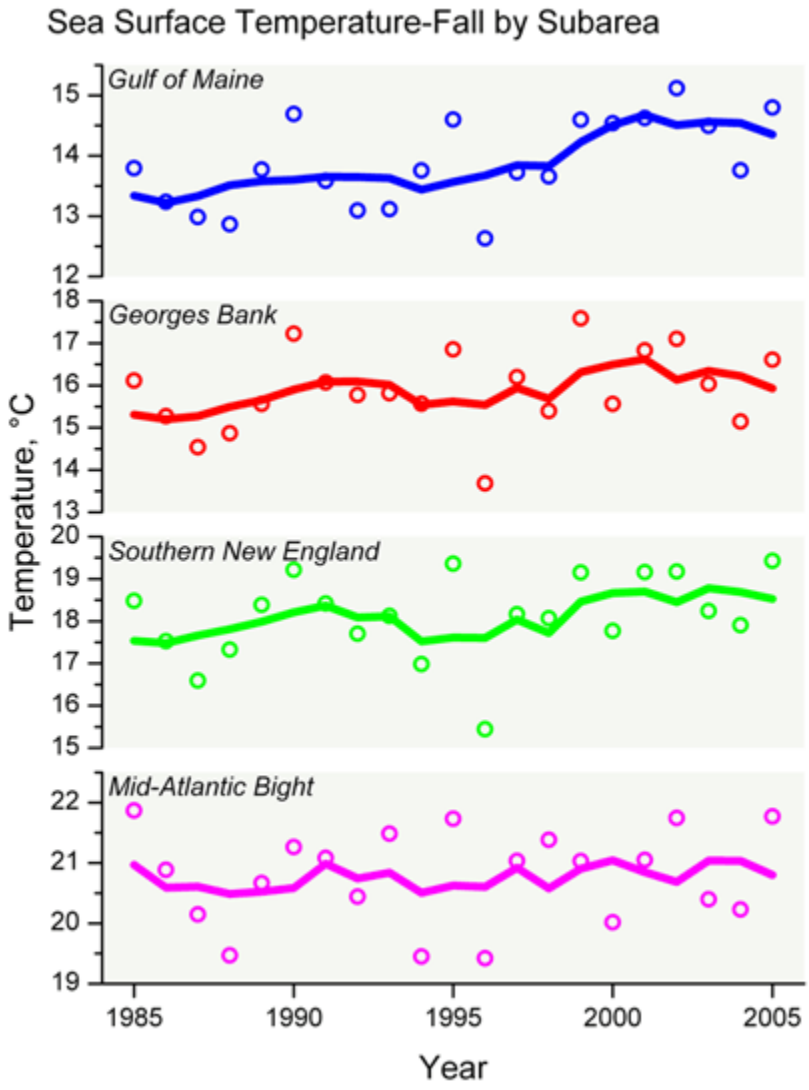
If we consider only the time trend of SST during the fall season then a different pattern emerges from the annual trend in SST for the entire shelf system. Whereas the annual mean suggests surface waters have cooled during the past few years, the fall SST data indicate a continuation of the warming trend that began in the 1990s. Fall chlorophyll levels are slightly higher than the annual mean reflecting the seasonally of fall blooms in some areas. The fall bloom pattern appears to be in synchrony with the overall time series pattern of chlorophyll levels on the shelf. Fall zooplankton biomass suggests a different pattern of decline and increase in zooplankton communities; the decline in zooplankton biomass of the mid 1980s appears to be a more localized event. The recent increase in annual zooplankton abundance is also not seen in the fall, indicating important seasonal dynamics affecting the annual pattern.

Fall Conditions on the Northeast Shelf by Subarea



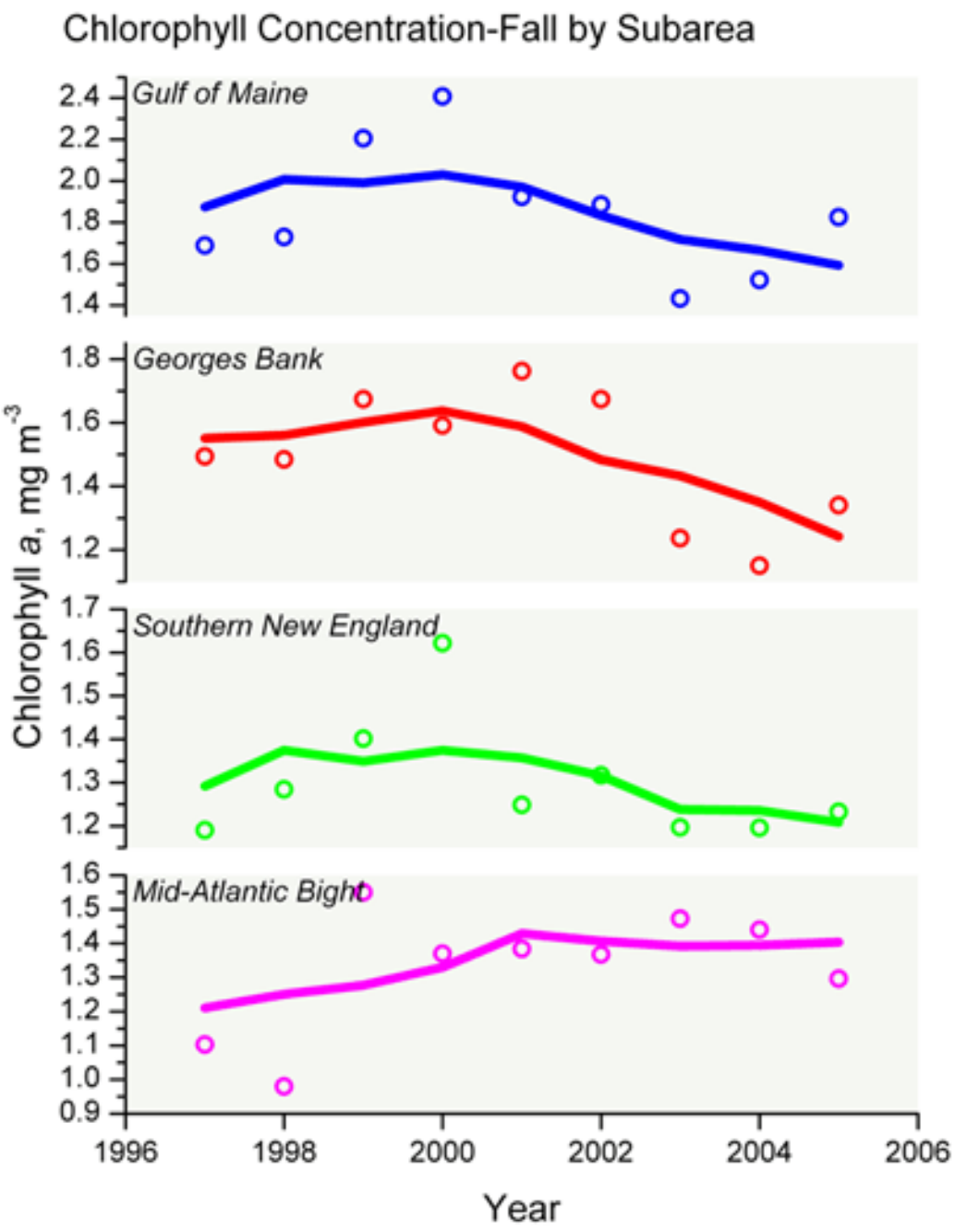
The Northeast Continental Shelf ecosystem can be divided into four major subareas: Gulf of Maine (GOM), Georges Bank (GB), Southern New England (SNE) and the Middle Atlantic Bight (MAB), which reflect different underlying oceanographic conditions and fishery management boundaries. The regional variation in SST, chlorophyll, and zooplankton biomass is evaluated by these subareas.

Fall Sea Surface Temperature



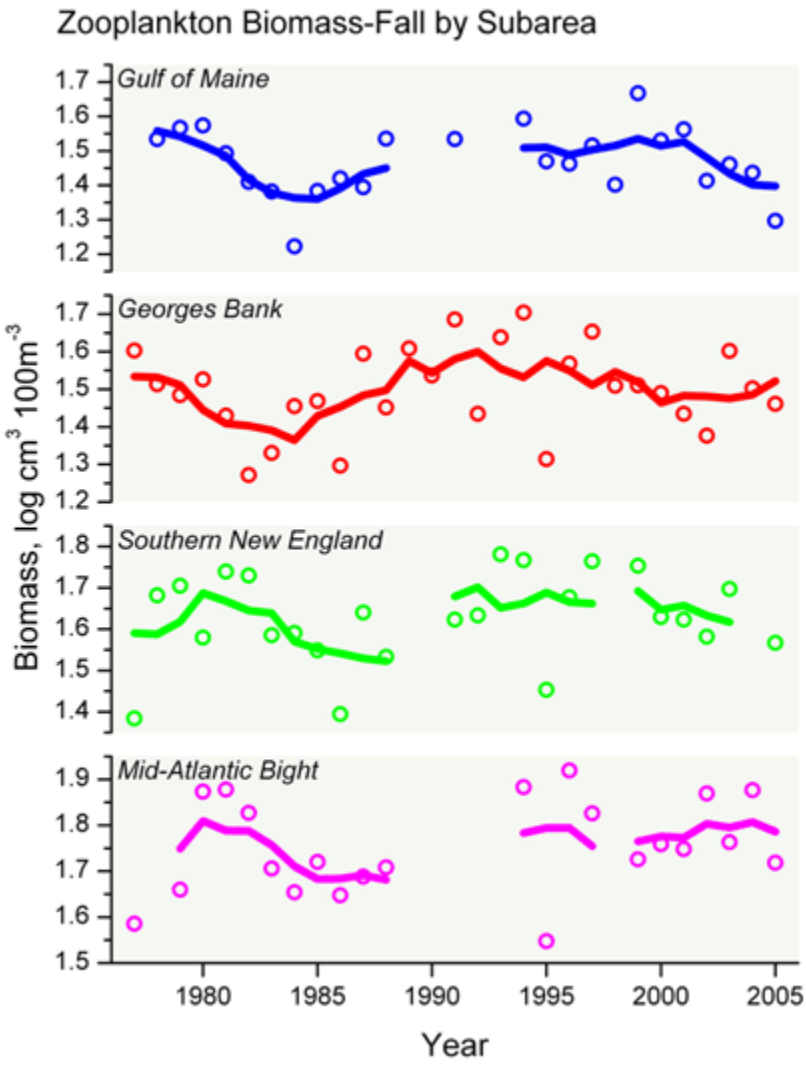
The increase in fall SST is most pronounced in the northern subareas of the shelf. The GOM has gone through a 1.5°C increase in fall SST over the past 20 years. It is not clear there has been any significant shift in temperature in the MAB.

Fall Chlorophyll



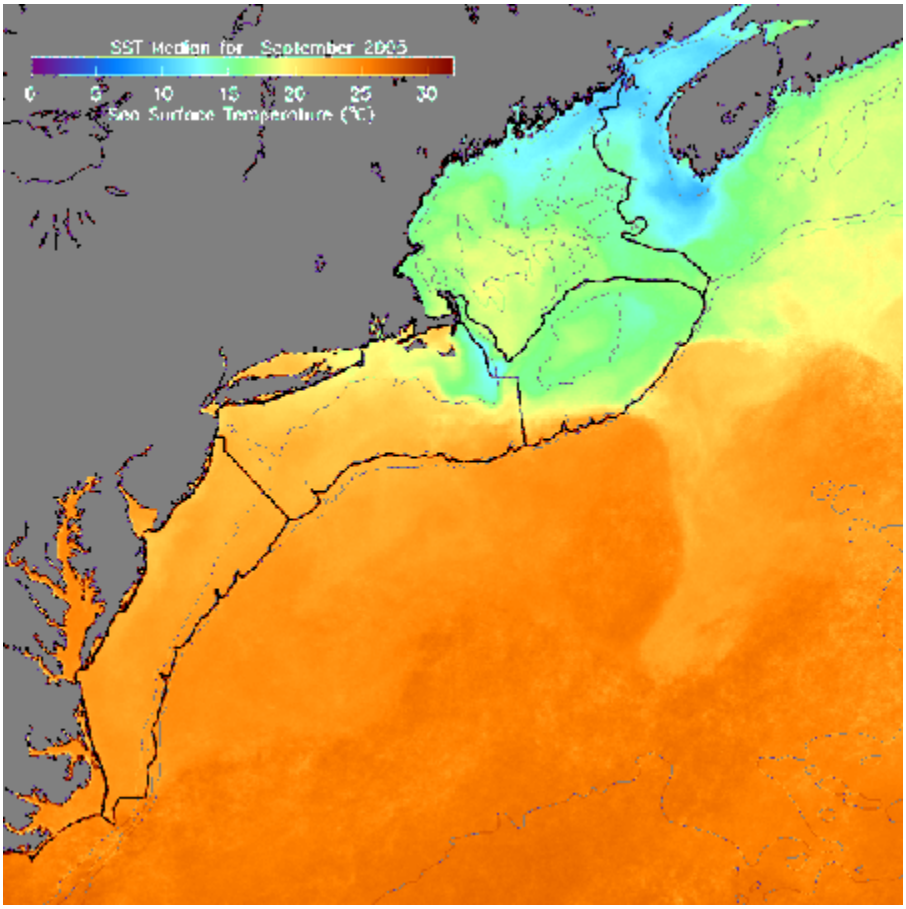
Fall chlorophyll concentrations have decreased in the GOM and on GB while they have increased in the MAB. The magnitude of the decline in the two northern subareas is significant and on the order of 25% when comparing the peak years to the last three years of the time series.

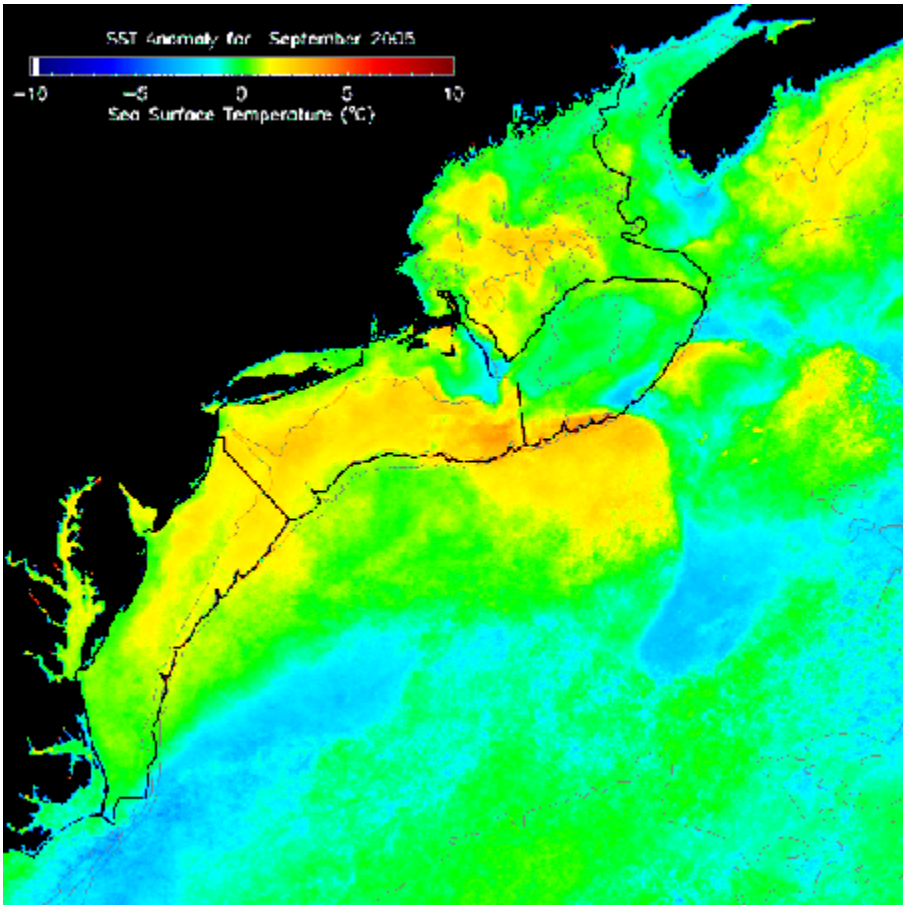
Fall Zooplankton



During September and October, zooplankton biomass is greatest in the MAB and least in the GOM and GB. Zooplankton biomass was near peak through the mid-1990s, but a gradual decline in biomass started in about 2000. Data from the 2005 autumn Groundfish Trawl Survey, which was completed in early November, provides further evidence for an ecosystem-wide decline in fall zooplankton biomass; biomass values estimated from three of the ecosystem subareas were the lowest observed since 2000. Regional declines in fall zooplankton coupled with regional increases in annual zooplankton indicate important regional dynamics affect the shelf-wide annual patterns.

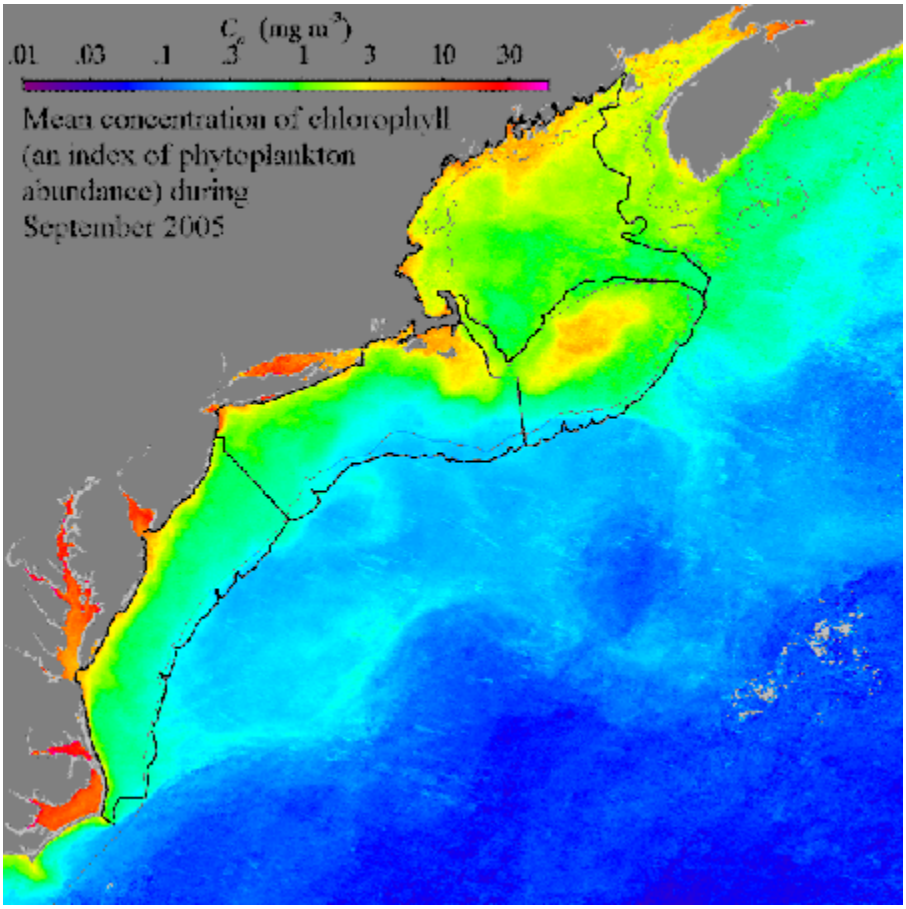
Fall Sea Surface Temperature Distribution

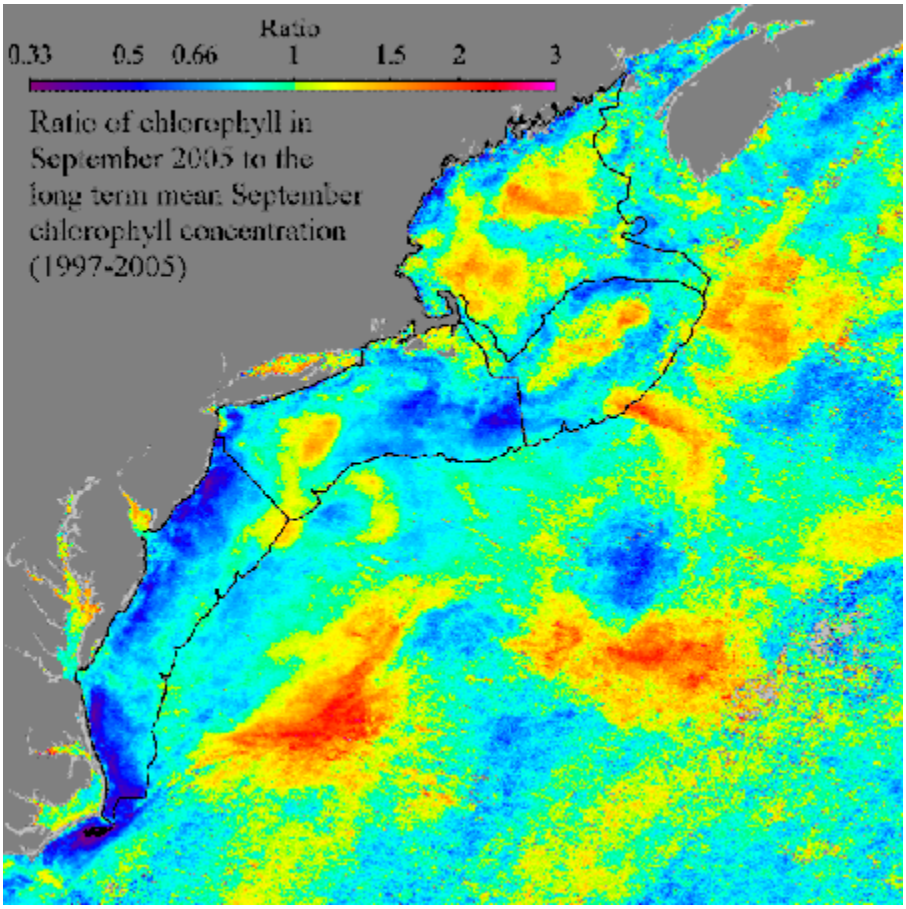




The distribution of sea surface temperature (SST) throughout the Northeast Shelf ecosystem during September 2005 shows a clear separation between the warmer waters in the Southern New England (SNE) / Mid-Atlantic Bight (MAB) subareas, and the cooler surface waters to the north, over Georges Bank and throughout the Gulf of Maine (GOM) ***(see upper map figure showing the distribution of sea surface temperature in degrees Celsius).*** The warm waters of the MAB continental shelf and over the western GOM water suggest conditions typical of late summer where the water column is vertically stratified. In contrast, the cooler surface waters over Nantucket Shoals, parts of Georges Bank, and along the Maine and Nova Scotia coasts reflect the typical conditions of strong tidal mixing and weak vertical thermal stratification throughout the summer. The departures of SSTs during September 2005 from the long-term September mean are shown as a temperature-anomaly map (***see lower anomaly map, also in units of degrees Celsius***). Surface waters in the western GOM (over Wilkinson Basin), offshore of Georges Bank, on the SNE shelf and most of the MAB shelf were about 2-3 degrees warmer during September 2005 than average. SSTs over much of Georges Bank and the northern GOM were similar to the long term mean. SSTs over the broad axis of the Gulf Stream during September 2005 are a few degrees cooler than the mean SST based on the 15-year (1985-1999) climatology, though further investigation will be required to determine whether this is significant to the fish and fisheries of the Northeast Shelf ecosystem.

Fall Chlorophyll Distribution

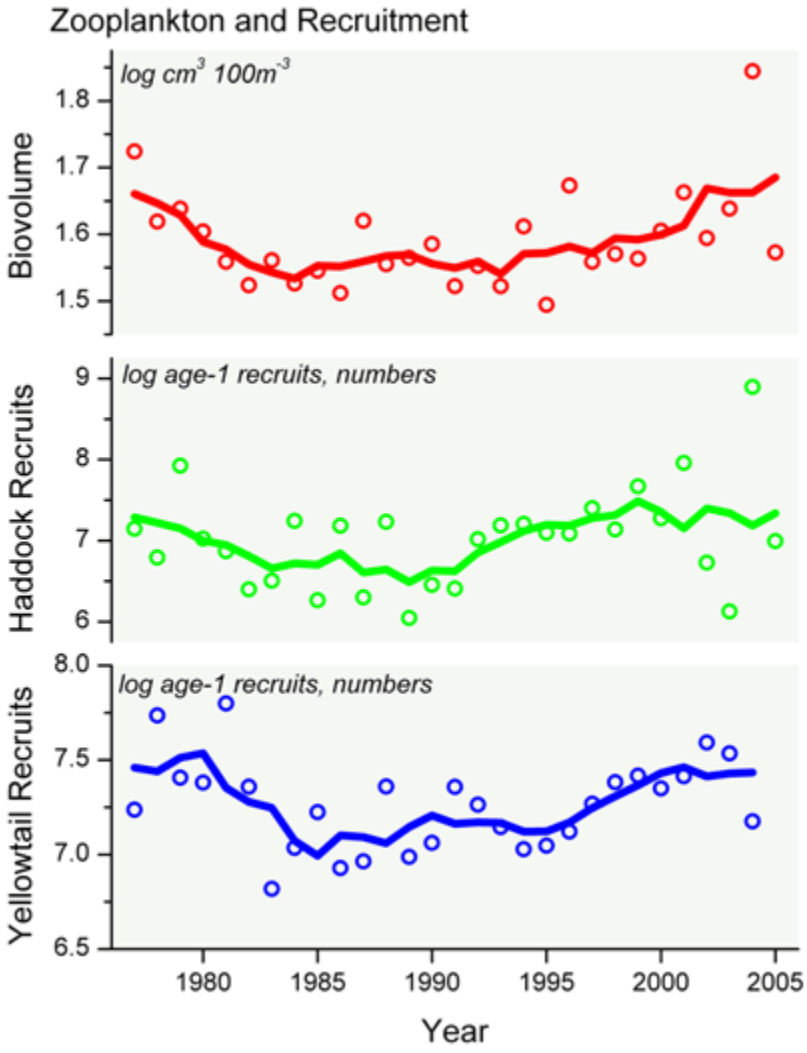




A general pattern is evident where chlorophyll concentration is greatest in continental shelf waters, intermediate over the deeper slope water, and lowest in the vicinity of the Gulf Stream and Sargasso Sea (***see upper map figure showing concentration of chlorophyll during September 2005 from Cape Hatteras to Nova Scotia***). High levels of chlorophyll occur in the tidally mixed central areas of Georges Bank and Nantucket Shoals, and in the Middle Atlantic Bight estuaries and coastal waters enriched by estuarine plumes. The high chlorophyll values (3-8 mg m-3) in the northern Gulf of Maine indicate that fall bloom is underway during September. The same geographic range is used to illustrate how chlorophyll conditions during September 2005 compare with the average values for this month, where the average is computed from September data from 1997 through 2005 (***see lower map figure showing ratio of chlorophyll concentration***). The ratio of September 2005 chlorophyll to the 9-year September mean chlorophyll indicates that throughout much of the inner Middle Atlantic Bight shelf chlorophyll concentrations during September, 2005 were below (2/3rds to1/2) the levels typically observed in surface water during September (1997-2005) whereas in the deeper waters of the Gulf of Maine and over the southern flank of Georges Bank chlorophyll concentrations during September 2005 were relatively greater than those typically observed during September. In the nearshore areas, the phytoplankton fall bloom usually starts in September and peaks during October. These recent data from September 2005 suggest that while the fall bloom is underway it is somewhat diminished relative to other years, and serve to highlight the significant

internal and spatial variability of primary production throughout the Northeast Shelf ecosystem.

Potential Linkages to Recruitment



Recruitment of fish stocks is a complex process dependant on both spawning stock size and environmental factors. For a number of stocks, environmental factors appear to be contributing to higher recruitment via transport mechanisms and the role of feeding opportunities for early life stages. The potential role of these and other factors are being explored for stocks on Georges Bank where we have seen improved recruitment over the past decade while zooplankton populations of the Northeast Shelf ecosystem have also increased. The indication of important regional and seasonal dynamics means that temporal and spatially-explicit examinations of zooplankton are required to further examine the link between lower-trophic level production and fisheries production.