Spring 2009 Update: Annual Condition of the Northeast Shelf Ecosystem

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Spring 2009 Update: Summary of Conditions of the Northeast Shelf Ecosystem

Summary

- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem during the second half of 2008 moderated from the warming trend of the first half of the year.
- Problems with the SeaWiFS ocean color sensing satellite make the 2008 chlorophyll data used in this report provisional. Despite the provisional nature of the data, it is clear that there were exceptional spring and fall phytoplankton blooms on the Northeast Shelf. The fall bloom was initiated early with bloom activity in the Middle Atlantic Bight. In 2008, chlorophyll a concentrations, which are an indication of primary productivity, were among the highest observed in the satellite data time series.
- Zooplankton biomass levels were average or above during most of the year.
- The contribution of krill (euphausiids) to the diet of herring has been shown to be episodic and appears related to fall phytoplankton blooms.
- Students from regional schools contributed to efforts to measure ocean currents by constructing drifter buoys. These buoys provide data for direct measurement of currents and to evaluate circulation models.
- Analyses of sea surface temperature over the past 26 years suggest that the critical transitional thermal habitat of the Northeast Shelf ecosystem has been constricted by changes in temperature conditions.
- In 2008, selected subregions of Northeast Shelf ecosystem experienced both extremely high monthly summer SSTs and extremely low winter SSTs, based on historical data dating back to 1854.

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 SeaWiFS sensor was out of service during most of the first half of 2008. The data sources were combined to represent trends in chlorophyll *a* during 2008; however, there are known discrepancies between the two sensors so these data should be considered provisional until an upcoming data reprocessing can be

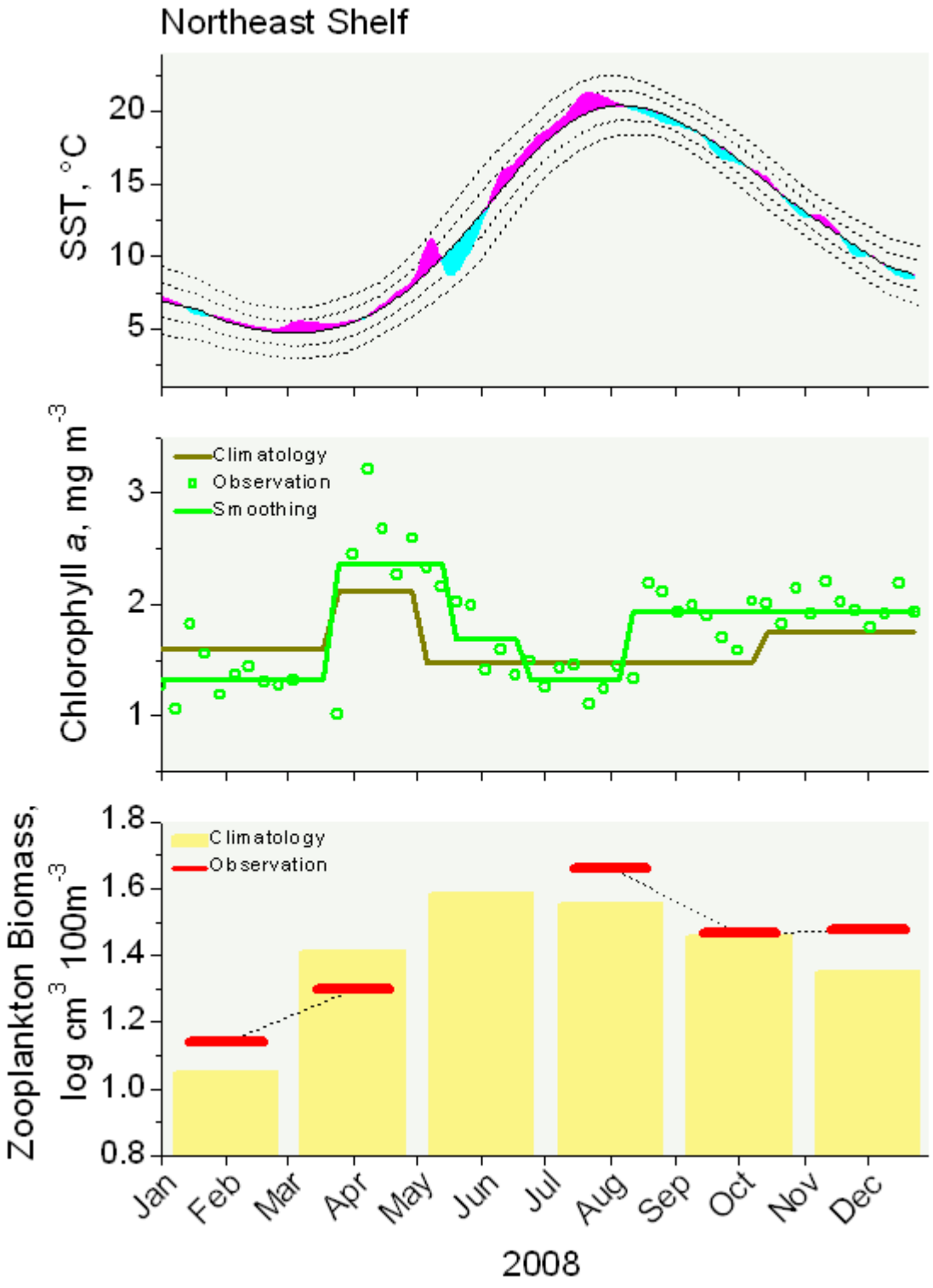
completed. Chlorophyll *a* is considered a proxy of phytoplankton biomass present in the near-surface water.
Zooplankton biomass was derived from shipboard surveys of the U.S. Northeast Shelf ecosystem. Zooplankton provide the link from primary producers to higher trophic levels. From 1977-1987, the 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.

The percent composition of krill (euphausiids) in the diet of Atlantic herring was derived using data in the NEFSC Food Habits Database, collected from ship-based fishery independent surveys of the U.S. Northeast Shelf ecosystem.

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.

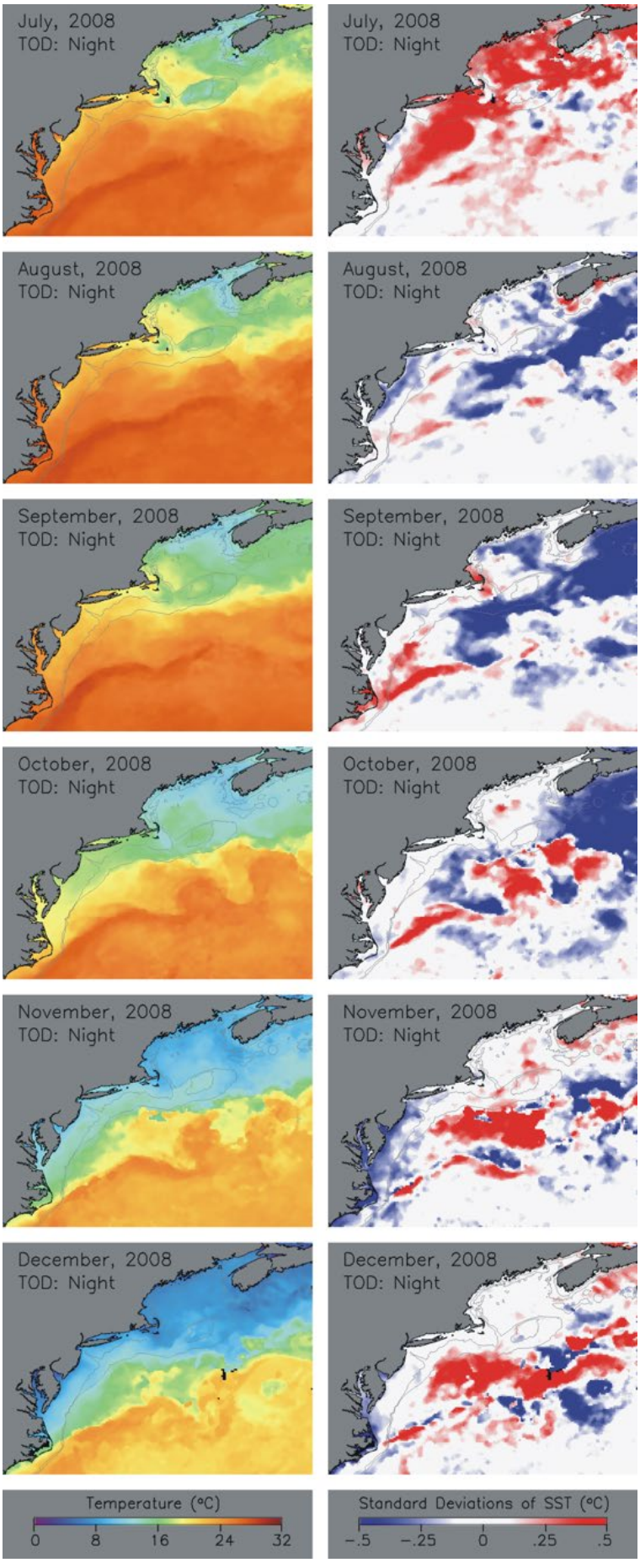
Fall Conditions of the Northeast Shelf Ecosystem



The Northeast Shelf Large Marine Ecosystem experienced minor fluctuations in sea surface temperatures (SSTs) during the fall of 2008. In contrast to the warmer than average conditions recorded during the first half of the year, SSTs during the second half the year were generally close to the long term mean, with exception of July. July SSTs were above the long term average across much of the shelf. The high level of phytoplankton biomass (represented by the high

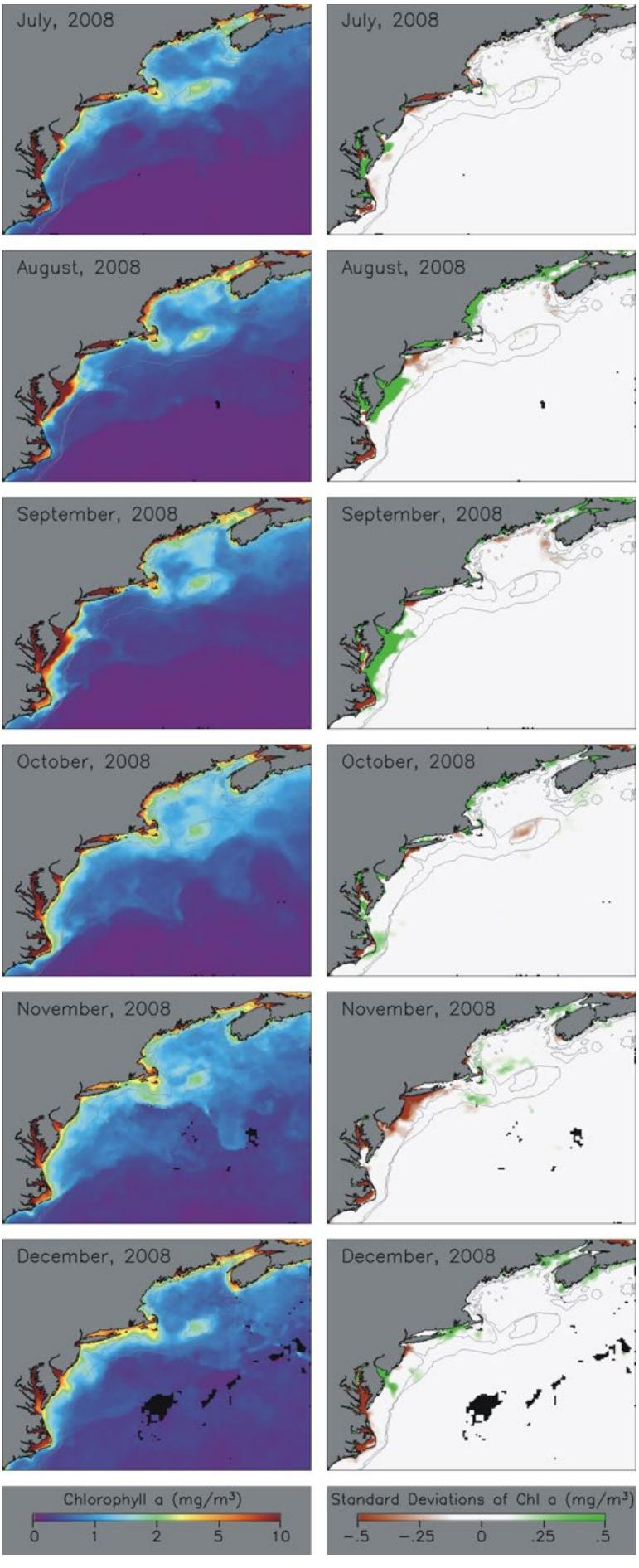
chlorophyll *a* concentrations in the adjacent figure) observed in the first half of 2008 also continued into the second half of the year. Integrated estimates of chlorophyll concentration were at high levels by late summer, some 1-2 months in advance of the typical time frame that fall blooms usually develop on the shelf. This analysis was based on the level 3 chlorophyll data products which are due for revision; though the estimated chlorophyll concentrations may change, it is not expected that the revision will alter the observed trends or change the view that 2008 was a highly productive year. Zooplankton biomasses were at or above average throughout the summer and fall of 2008.

Sea Surface Temperature Distribution


July, 2008
TOD: Night
July, 2008
TOD: Night
August, 2008
TOD: Night
August, 2008
TOD: Night
September, 2008
TOD: Night
September, 2008
TOD: Night
October, 2008
TOD: Night
October, 2008
TOD: Night
November, 2008
TOD: Night
November, 2008
TOD: Night
December, 2008
TOD: Night
December, 2008
TOD: Night
Temperature (°C)
0
8
16
24
32
Standard Deviations of SST (°C)
−.5
−.25
0
.25
.5

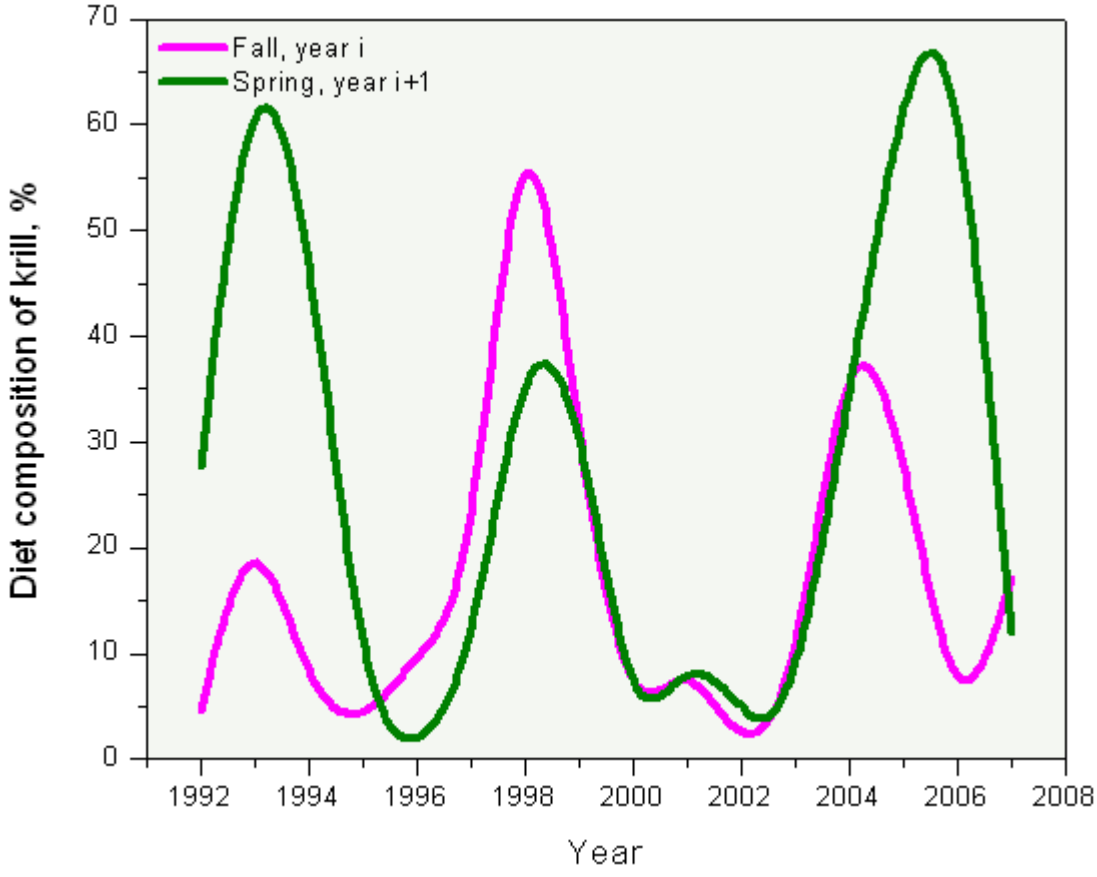
The progression of fall sea surface temperatures (SSTs) during the months of July through December are shown in the left hand set of panels. Higher SSTs appear as warm shades whereas low SSTs appear as cool shades. The right hand set of panels show SST anomalies, those tending to exceed plus or minus one quarter of a standard deviation of the overall SST for the field. The anomaly figures highlight above (red shades) and below (blue shades) average SSTs in a given area. Above average spring SSTs extended into July in the Gulf of Maine, on Georges Bank and throughout much of the Middle Atlantic Bight. These warmer than average conditions diminished in August and thereafter SSTs remained at average levels through the remainder of the year. Only some light tones of blue and red appear on the Northeast Shelf during these months. Offshore patches of warming and cooling are typically due warm and cold core rings associated with the Gulf Stream. The Scotian Shelf, which is a source of water for the Northeast Shelf, was very cool this past fall. Inflows of Scotian Shelf water may have contributed to a moderation of SSTs in the Gulf of Maine.

Chlorophyll Distribution


July, 2008
July, 2008
August, 2008
August, 2008
September, 2008
September, 2008
October, 2008
October, 2008
November, 2008
November, 2008
December, 2008
December, 2008
Chlorophyll a (mg/m3)
0
1
2
5
10
Standard Deviations of Chl a (mg/m3)
−.5
−.25
0
.25
.5

The progression of fall chlorophyll *a* concentrations during the months of July through December are shown in the left hand set of panels. Higher chlorophyll a 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. The anomalies highlight strong blooms in an area (i.e., the green shades) as well as significantly below-average concentrations (i.e., the brown shades). Given the provisional nature of these data, it would be imprudent to make definitive inferences on the intensity of regional bloom activity on the shelf. However, the only exceptional phytoplankton bloom appeared to be localized in the Middle Atlantic Bight during August and September. It is likely that this bloom contributed to the apparent early onset of fall bloom activity. In most other areas of the Shelf, phytoplankton bloom levels were near the long-term mean.

Krill Predation by Atlantic Herring



Krill (Family: Euphausiidae) are an important food web component within the U.S. Northeast Shelf ecosystem, but are relatively understudied. Euphausiids are principal prey of Atlantic herring (*Clupea harengus*), often accounting for greater than 60% (by weight) of the diet of herring in some years. The importance of this prey appears to vary inter-annually, which may be related to oceanographic processes. In general, increases in percent diet composition of krill

during spring lag behind those of the previous fall. This may be a response to oceanographic conditions--particularly to the timing of fall blooms

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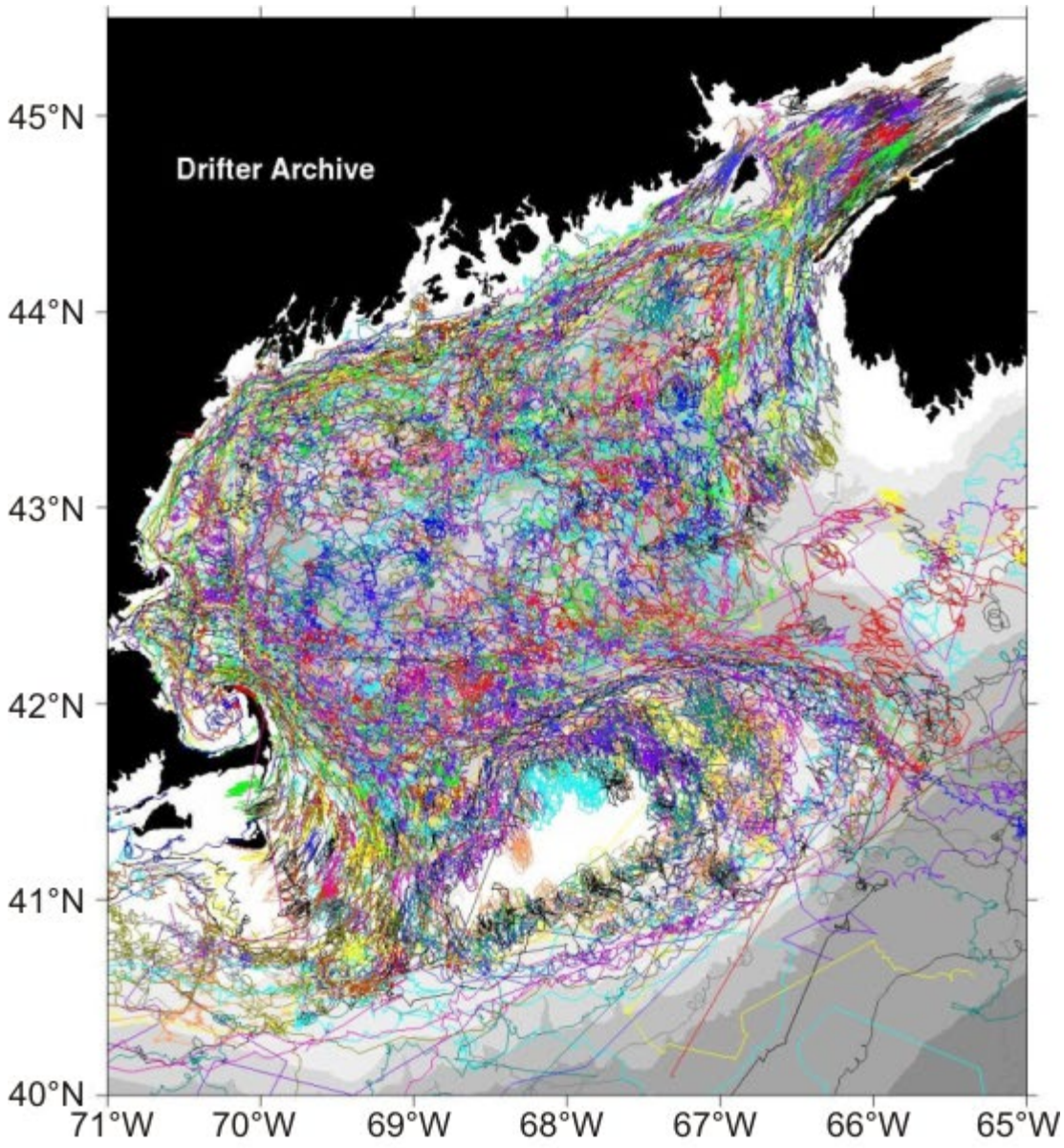
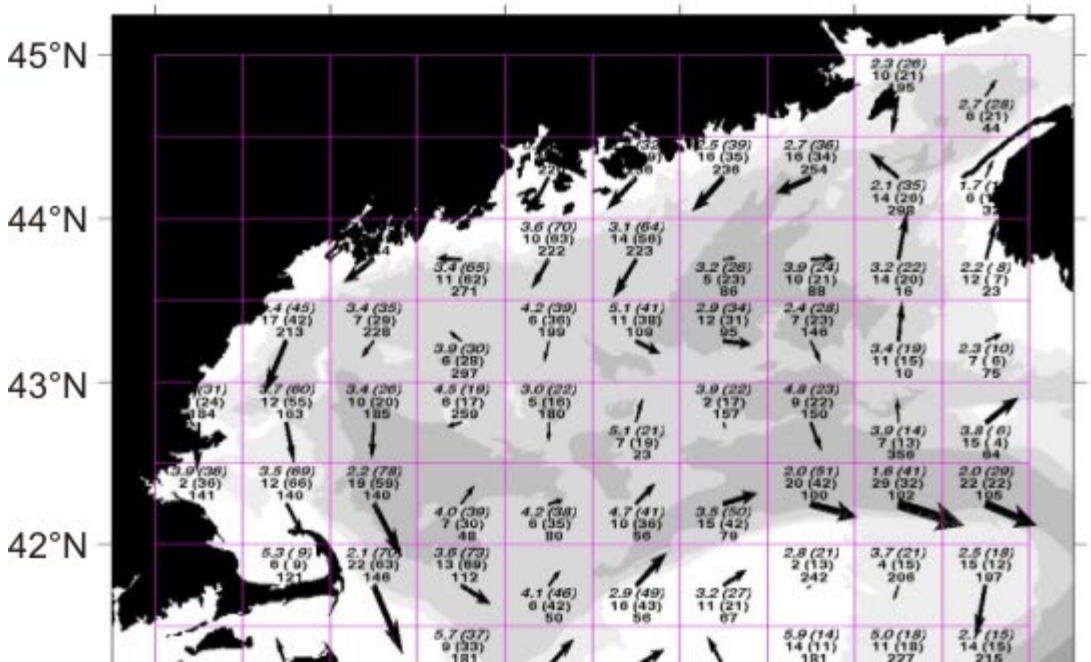
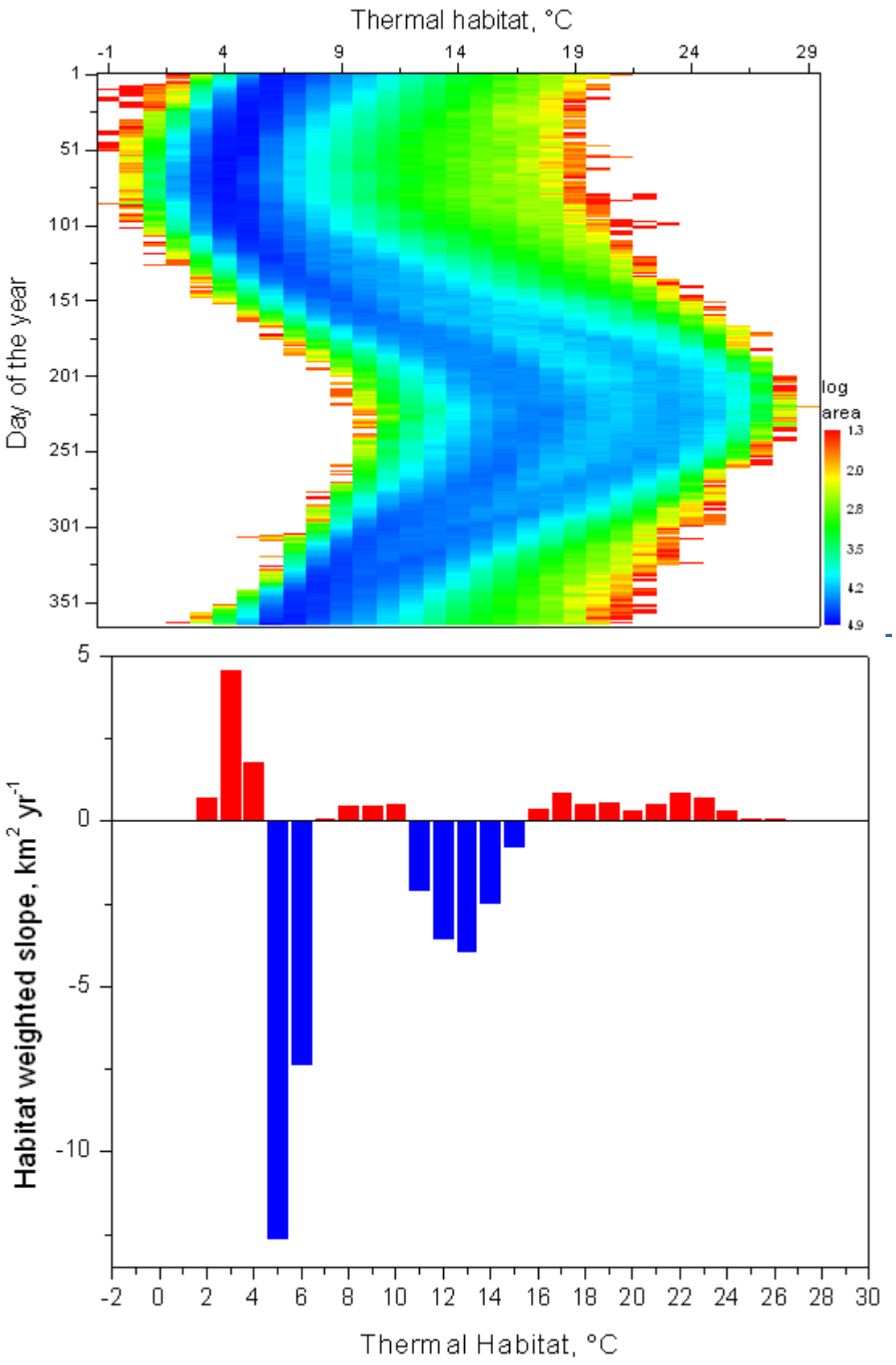
Drifter Measure Currents


Drifter Archive
45°N
44°N
43°N
42°N
41°N
40°N
71°W
70°W
69°W
68°W
67°W
66°W
65°W


45°N
44°N
43°N
42°N

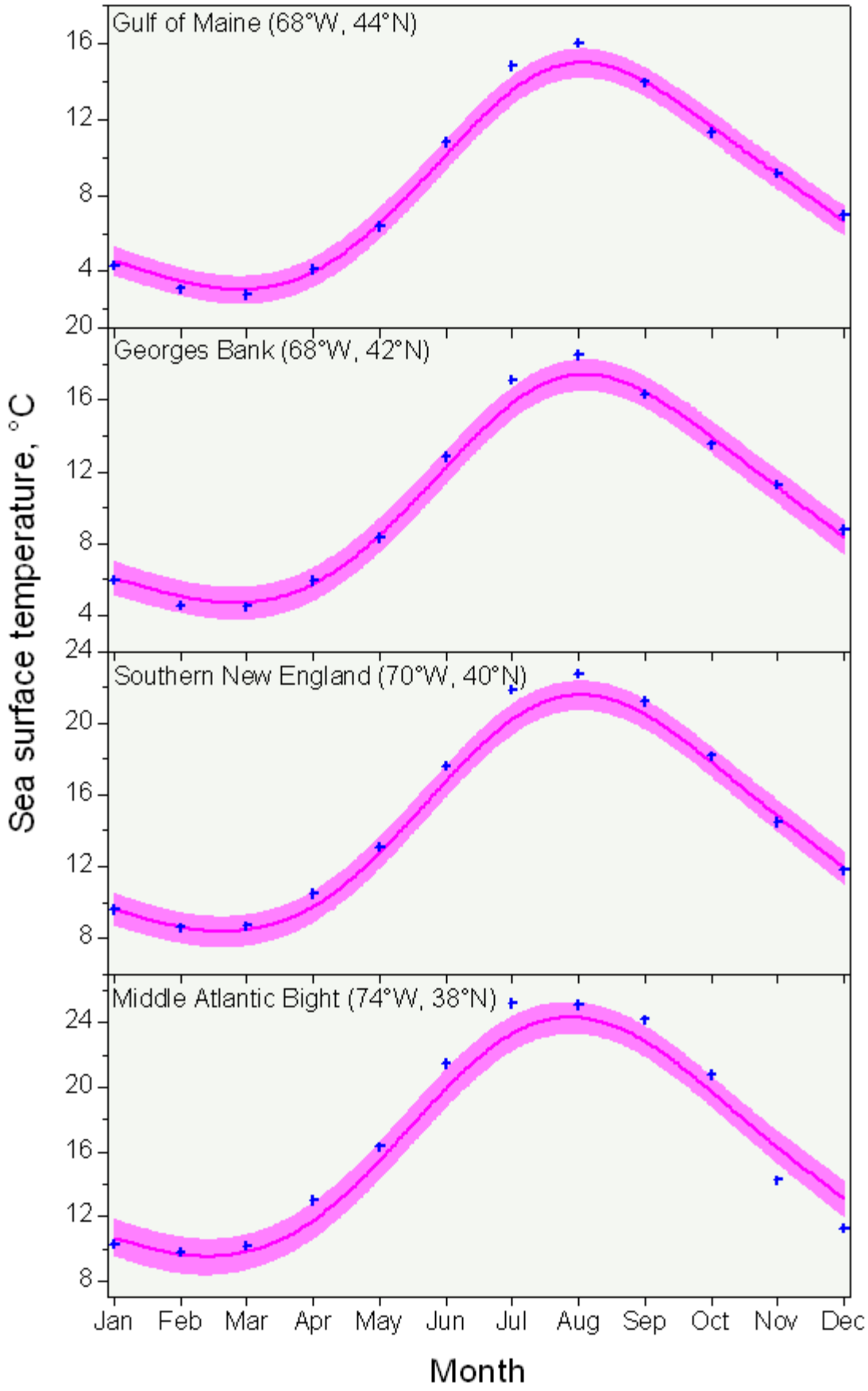
Since spring 2004, dozens of student-built satellite-tracked drifters have been deployed in the Gulf of Maine. These drifters increased the number of drifters released in the Gulf of Maine by fourfold. Data from the entire set of drifter releases in the Gulf of Maine (top panel) have been analyzed to developed statistics on surface water circulation patterns in the Gulf of Maine (bottom panel). Residence times in days (*italic*) and low-frequency speed (cm/s) and direction (degrees True) were estimated for 10o cells where data were available. The number of observations (nobs) appears in parentheses after each statistic. While the mean flow is aligned with historical observations, much more detailed information now exists in each region. For example, it is now apparent that grid cells in the Great South Channel have more than doubled the residence times of those directly east of Cape Cod. Similarly, there are regions in the middle of the Gulf where residence times are twice as great as those off the coast of Downeast Maine. Some regions are flow-through systems and some are stagnant. The drifter archive is now served through **http://www.nefsc.noaa.gov/epd/ocean/MainPage**, the NEFSC Oceanography website, and, according to NOAA IOOS conventions, through the Opensource Project for Network Data Access Protocol (OpeNDAP).

Ecosystem Shift in Thermal Habitat


Thermal habitat, °C
-1
4
9
14
19
24
29
1
51
101
151
201
251
301
351
Day of the year
log
area
1.3
2.0
2.8
3.5
4.2
4.9
5
0
-5
-10
Habitat weighted slope, km2 yr-1
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Thermal Habitat, °C

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 26 years reveal a trend of constricting thermal habitat ranges. Although certain thermal habitats are present year round (for example, 14°C thermal habitat is present on all days of the year (see top figure)), extreme thermal habitats (such as 5°C or 24°C habitats) are only available during short durations, i.e. the winter and summer, respectively. Coldest and warmest habitats have been increasing in recent years, whereas the main transitional habitats that account for most of the thermal habitat on the shelf have been declining (see bottom figure). Hence, the thermal habitats most utilized by marine organisms on the shelf have been constricted by changes in temperature conditions.

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

The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854. Monthly mean SSTs in 2008 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 2008, monthly SSTs for the Gulf of Maine were close to the long-term average in most months, with the most notable exception being the July and August SSTs, which were well above average. The duration of summer warming increased in the southern segments of the ecosystem, with above average SSTs observed in the Middle Atlantic Bight subregion from June to September. The Bight also had below average SSTs in November and December 2008, unlike areas to the north.