# Spring 2015 Update: Annual Condition of the Northeast Shelf Ecosystem

Produced by the Ecosystem Dynamics and Assessment Branch

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Northeast Fisheries Science Center

166 Water Street

Woods Hole MA 02543-1026

Phone: (508) 495-2000

# Spring 2015 Update: Conditions of the Northeast Shelf Ecosystem

## Summary


- Sea surface temperatures (SSTs) in the Northeast Shelf Large Marine Ecosystem during 2014 continue to be above average, though they represent a moderation in thermal conditions compared to the record highs observed in 2012.
- The Gulf of Maine and other northern segments of the ecosystem have remained warm compared to historical trends, more so than the Middle Atlantic Bight.
- The fall bloom on the Northeast Shelf was well developed covering a large area including Georges Bank and much of the Gulf of Maine.
- Warm water thermal habitats remain at high levels in 2014 despite a rebound in cold water habitats.
- The arrival of the fall thermal transition has gotten progressively later over the past two decades in all areas of the Northeast Shelf, with the most pronounced shift occurring in the northern parts of the ecosystem.
- The fall distribution of fish and invertebrate species sampled by the NEFSC is portrayed by kernel density plots and the assessments of species distributions using both along-shelf distance and depth. The dominant movement of species has been to the Northeast and into deeper water.
- Summer wind speed and direction has changed over time, thus impacting the movement of water masses and organisms in the ecosystem.


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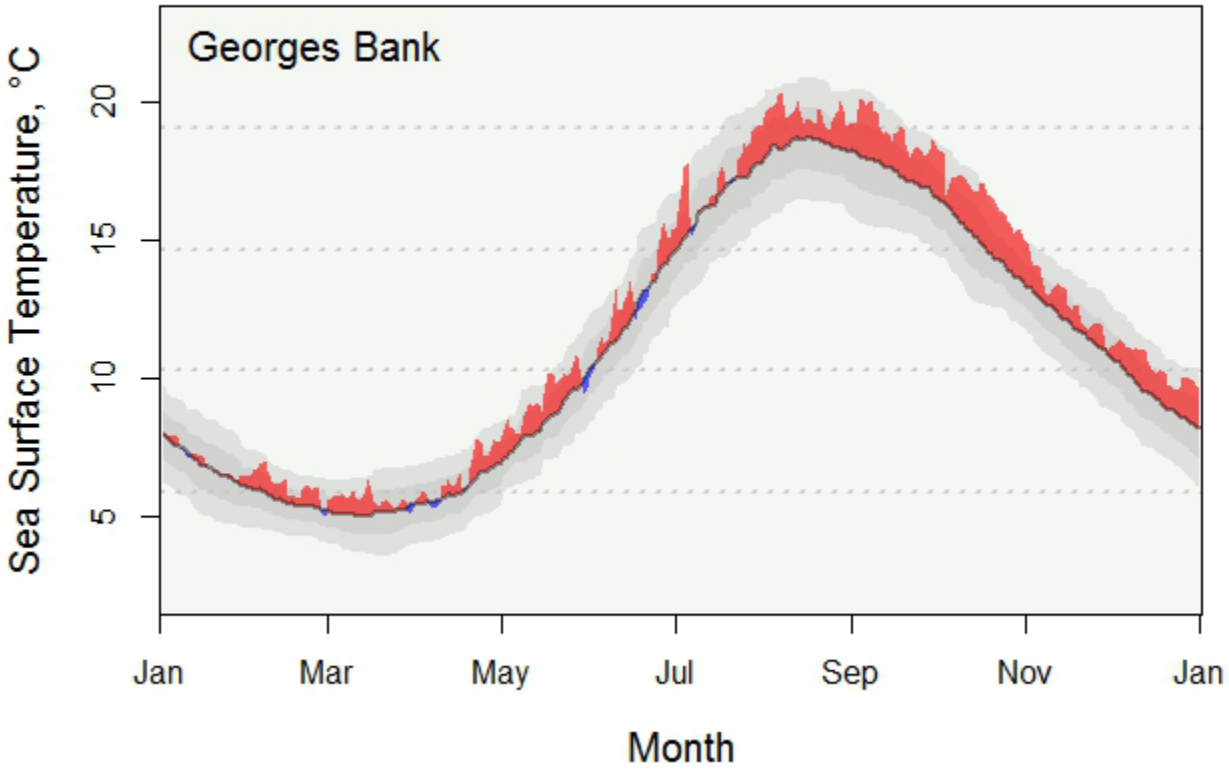
## Fall Sea Surface Temperature - Northeast Shelf Ecosystem

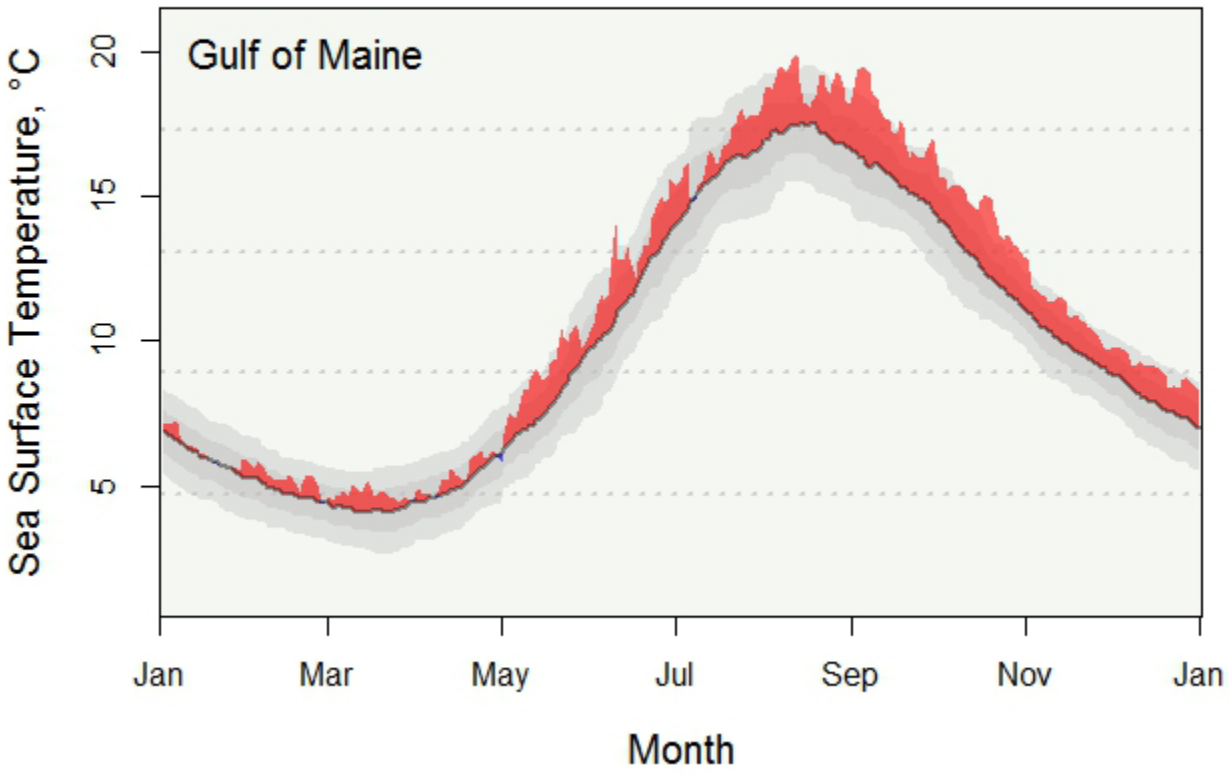
The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures (SSTs) during the fall of 2014 after a period of cooling in some parts of the ecosystem seen during spring.

In each 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. SSTs for 2014 that were above the mean are shown in red and below the mean in blue.

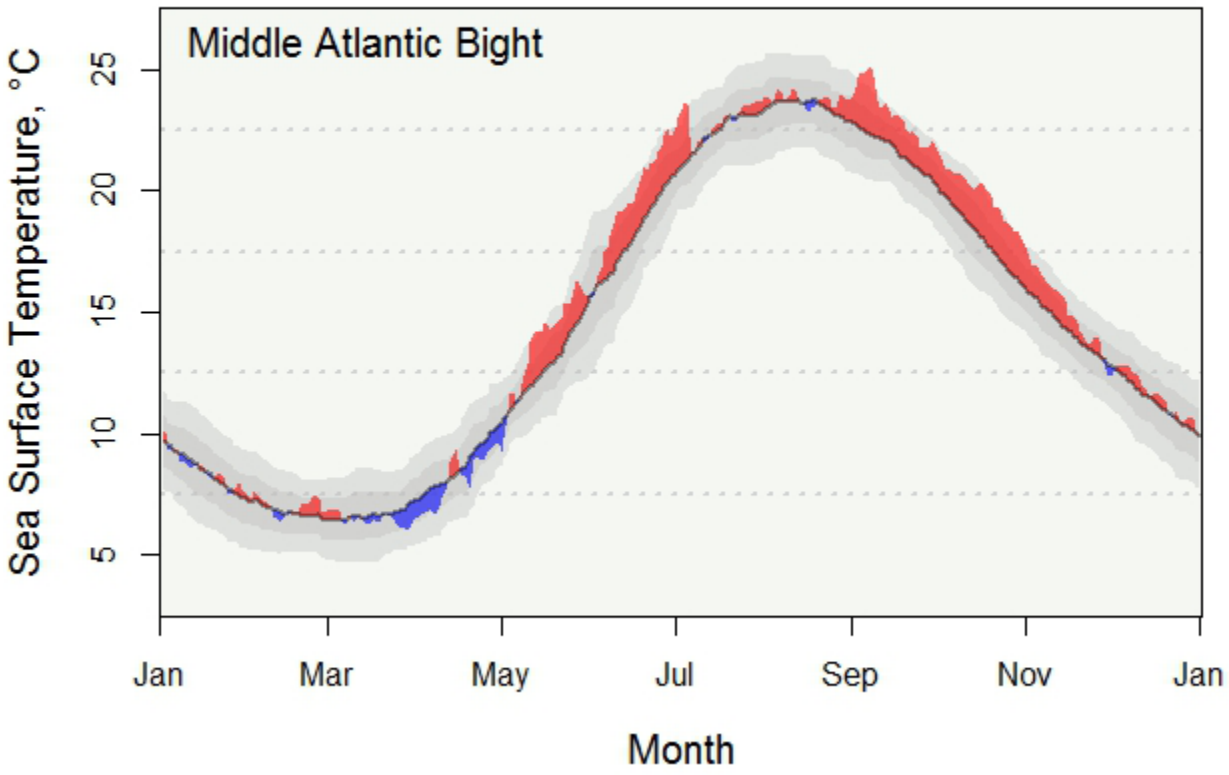
Though all areas show above average summer into fall temperatures, SSTs were well above the mean in the northern end of the ecosystem as seen in the Gulf of Maine, Georges Bank, and Scotian Shelf subareas. Many days were above the mean by more than two standard deviations in these areas. SSTs were at or below the long term means during last winter and into spring in the Middle Atlantic Bight and at the long term mean during the summer.



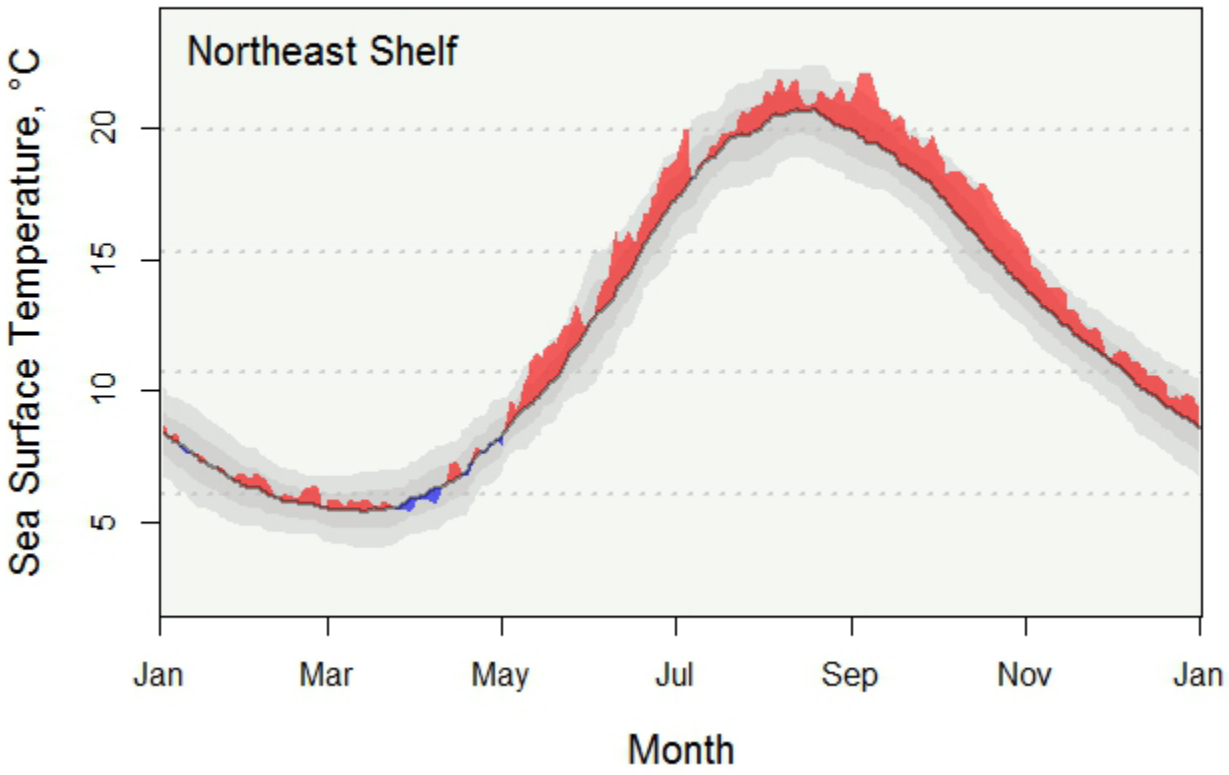

Georges Bank



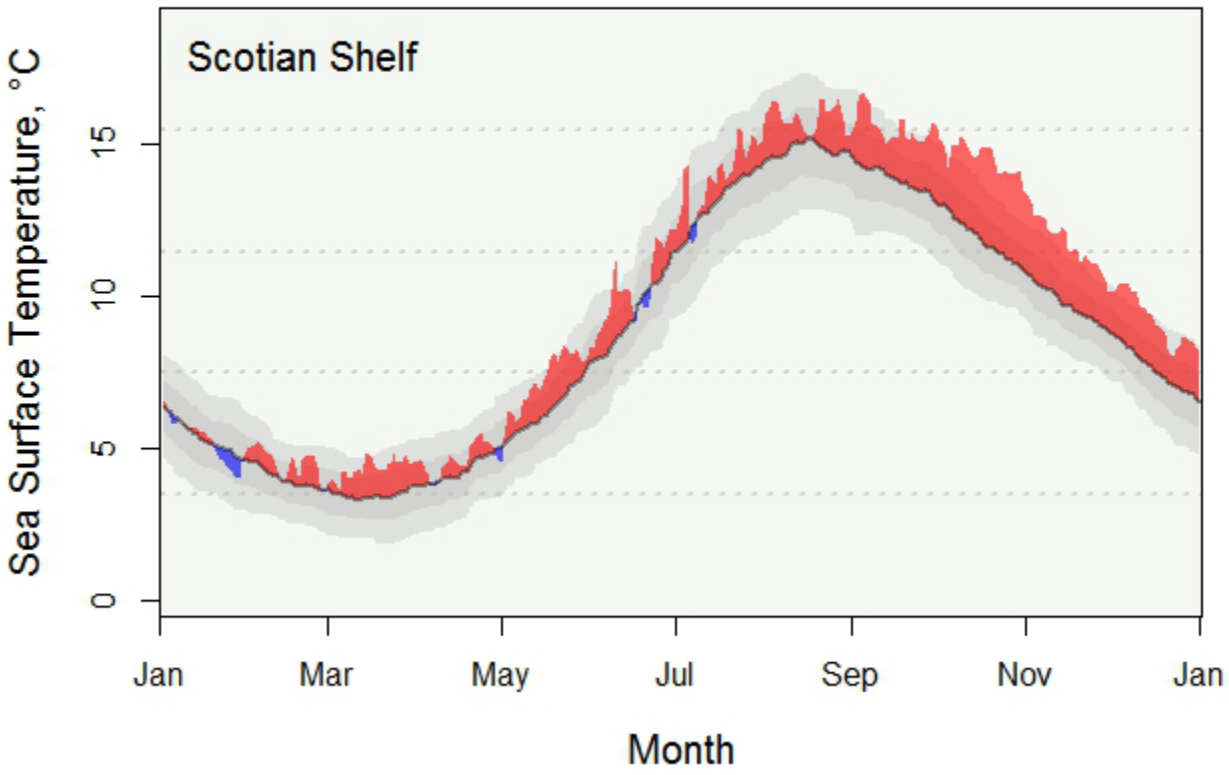

Gulf of Maine




Mid-Atlantic Bight




Northeast Shelf




Scotian Shelf

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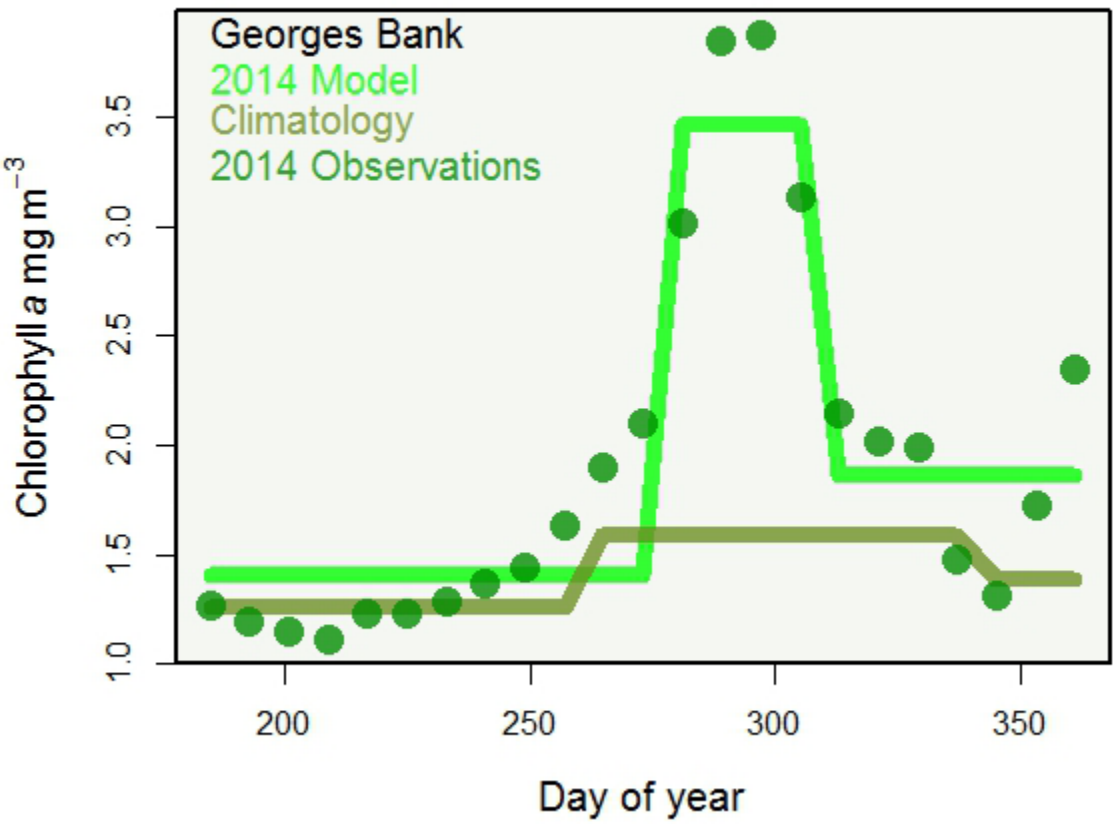
# Fall Bloom Development on the Northeast Shelf

There were well developed fall blooms detected in the Gulf of Maine and Georges Bank areas, though these blooms started later in the year than typical fall blooms and were of short duration.

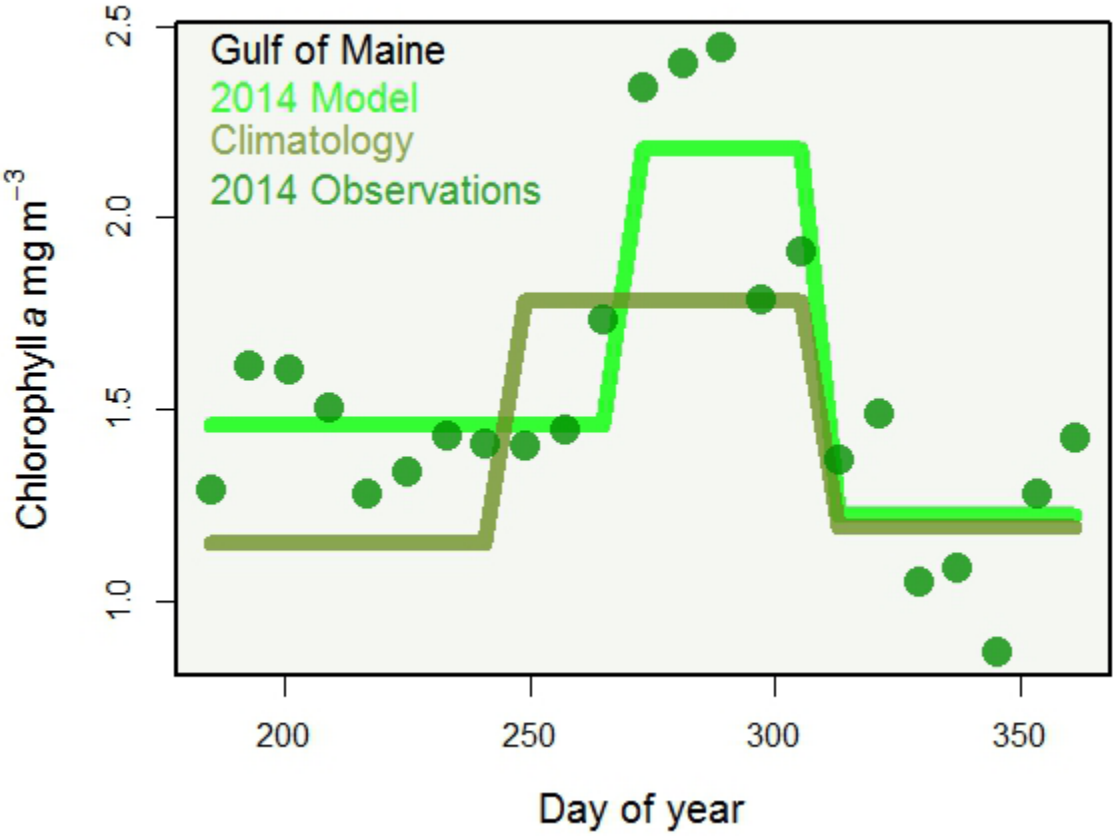
Bloom chlorophyll levels on Georges Bank were well above the climatological levels in excess of 3.5 mg m-3 for over two weeks.

The Scotian Shelf subregion, which typically has a fall bloom, had a highly variable pattern of chlorophyll concentrations.

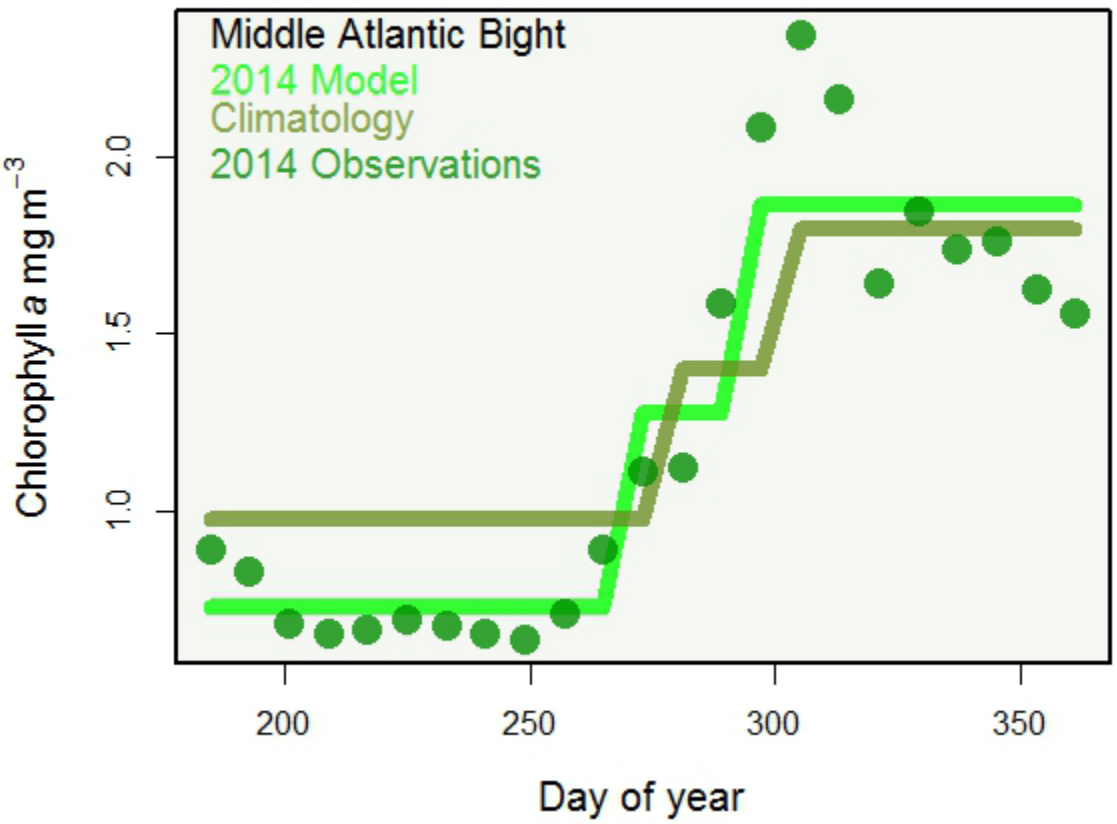
A distinct fall bloom is not typical of the Middle Atlantic Bight area, but a peak in chlorophyll can be seen in the data despite a failure to detect a bloom; this was also the case for the composite depiction of the bloom pattern for the Northeast Shelf.



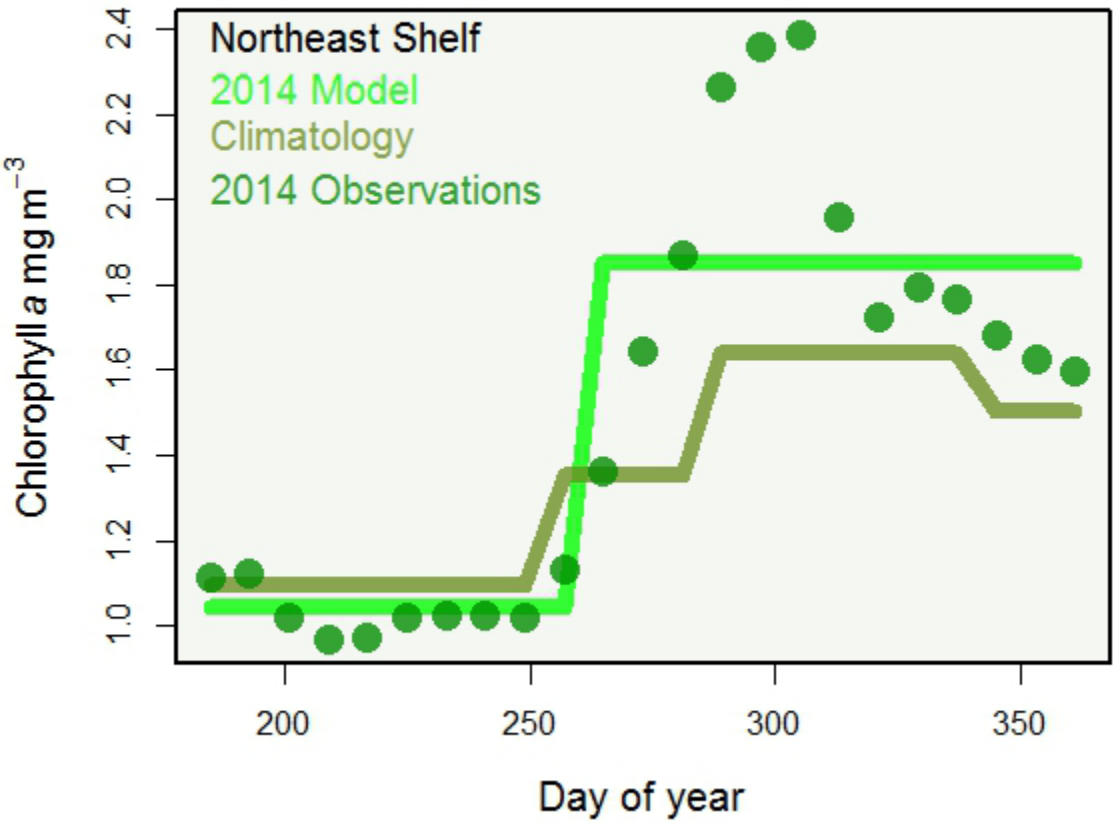

Georges Bank



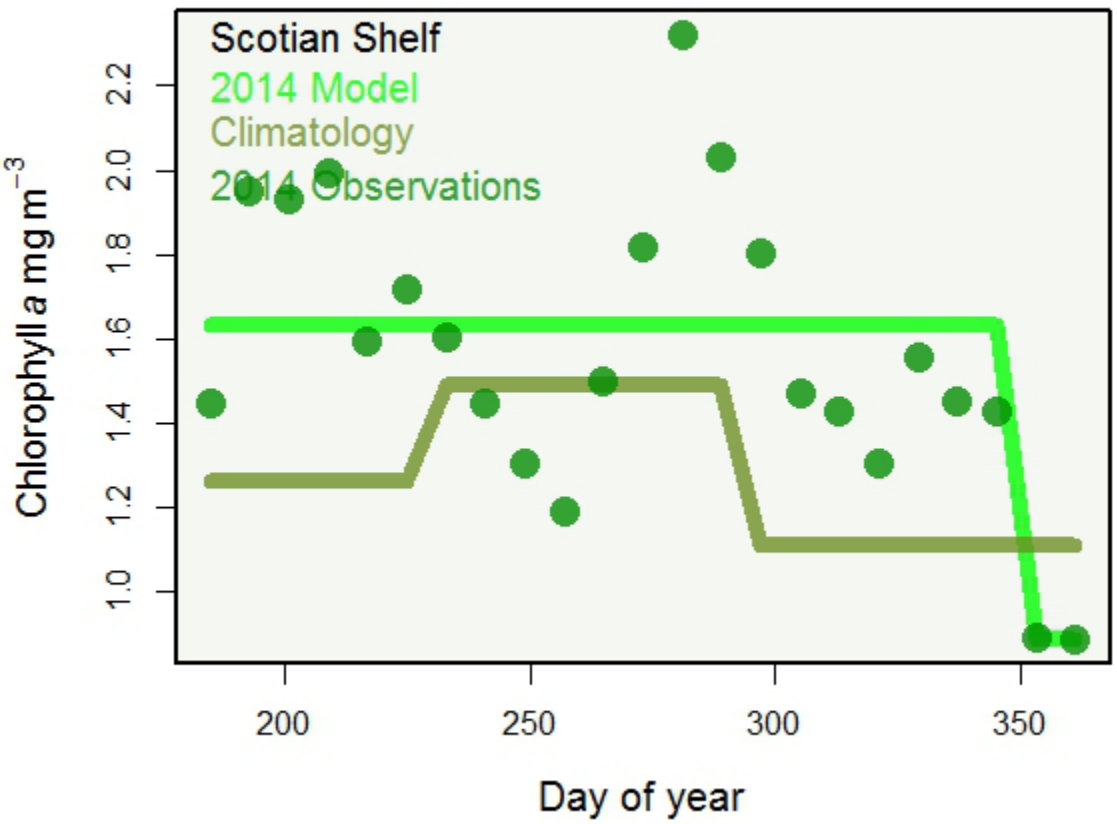

Gulf of Maine




Mid-Atlantic Bight




Northeast Shelf




Scotian Shelf

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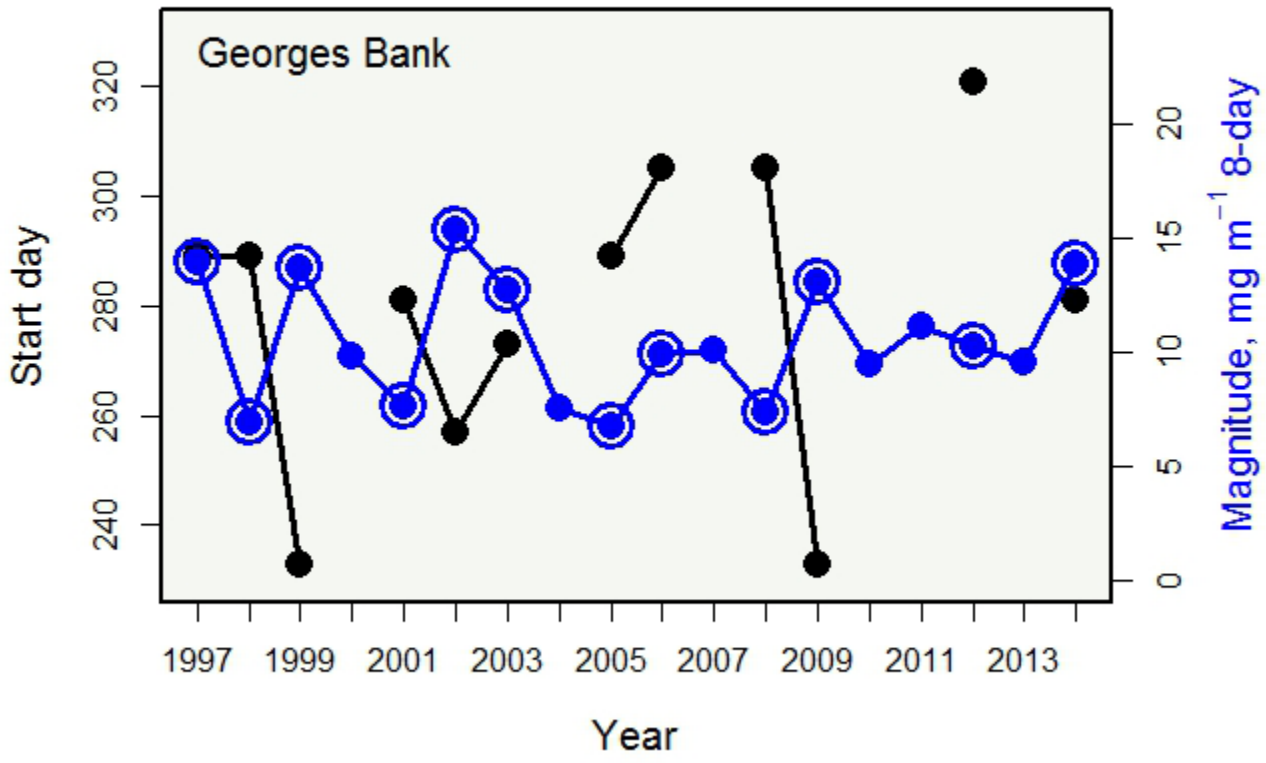
# Fall Bloom Start Day and Magnitude

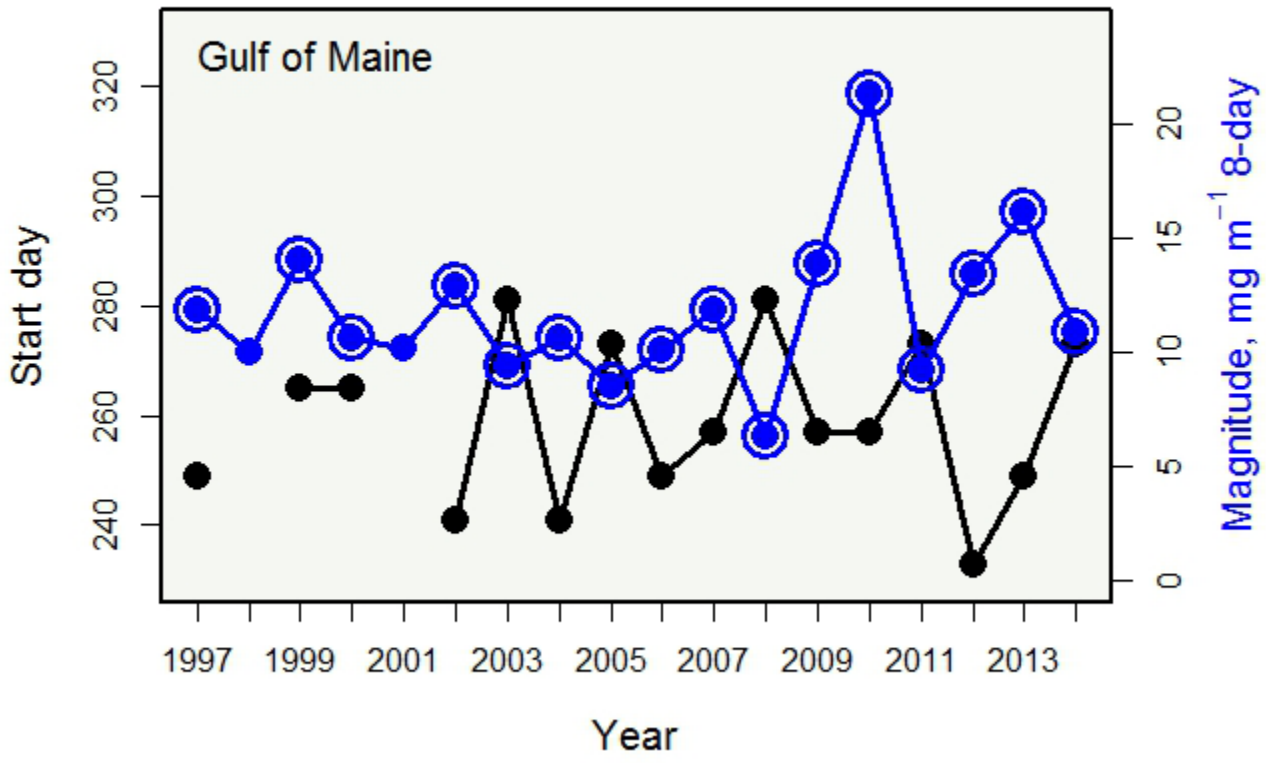
Fall blooms have been most frequently detected in the Georges Bank, Gulf of Maine and Scotian Shelf regions. In 2014, blooms were detected in Georges Bank and Gulf of Maine only.

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).

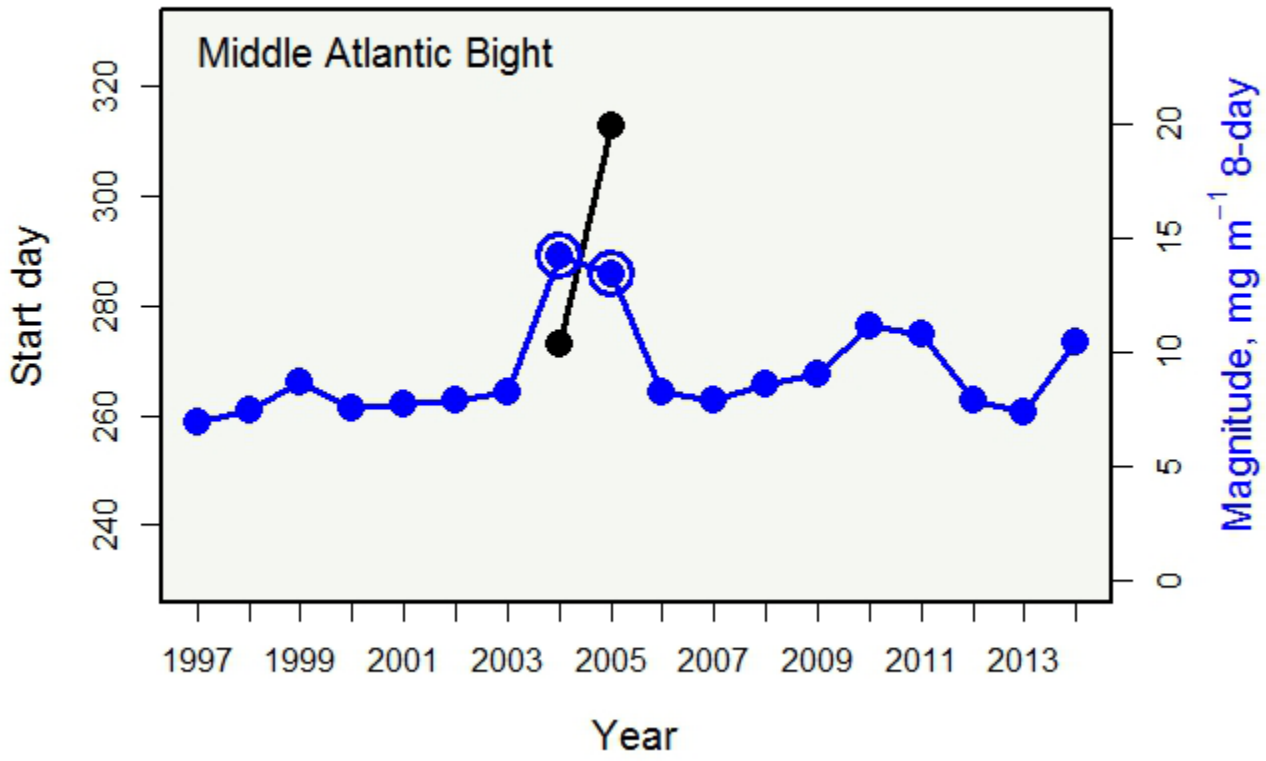
The Georges Bank bloom was among the largest bloom in terms of the bloom magnitude index; however, it was a not a particularly early bloom. The Gulf of Maine bloom was an average bloom both in terms of size and timing.



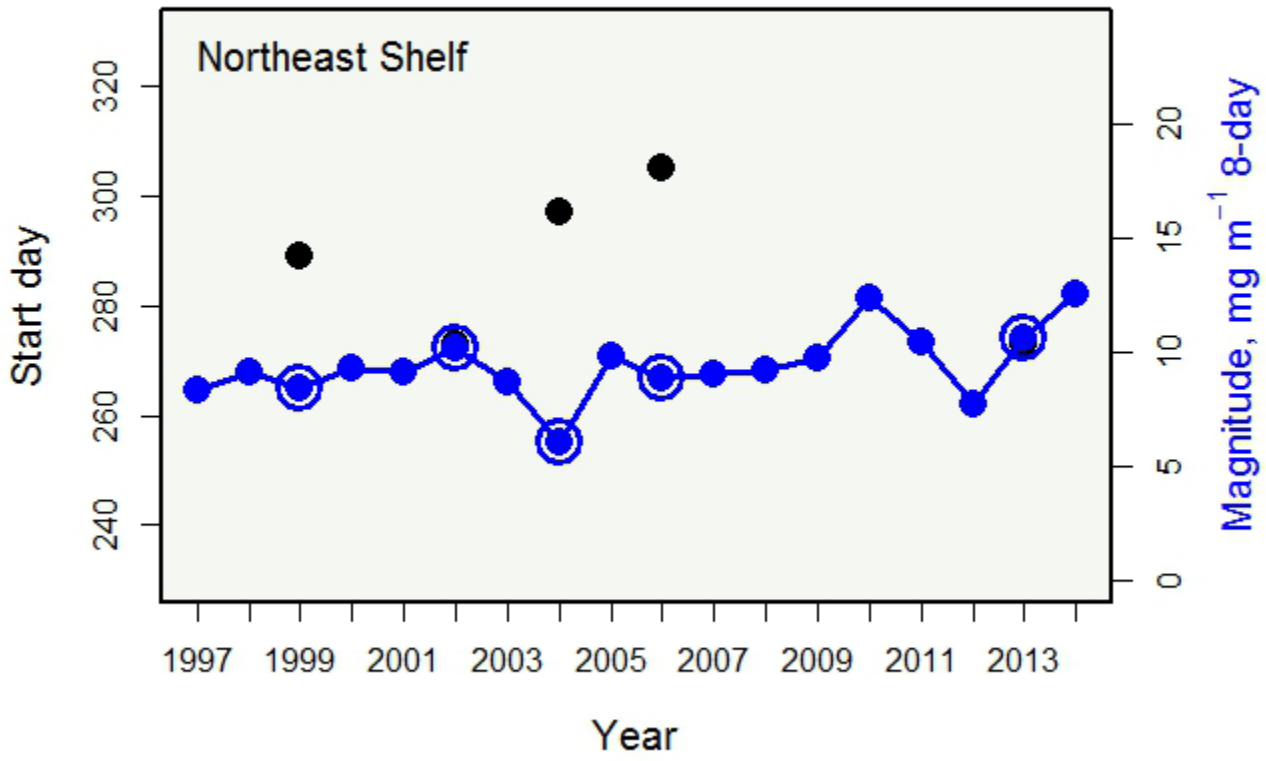

Georges Bank



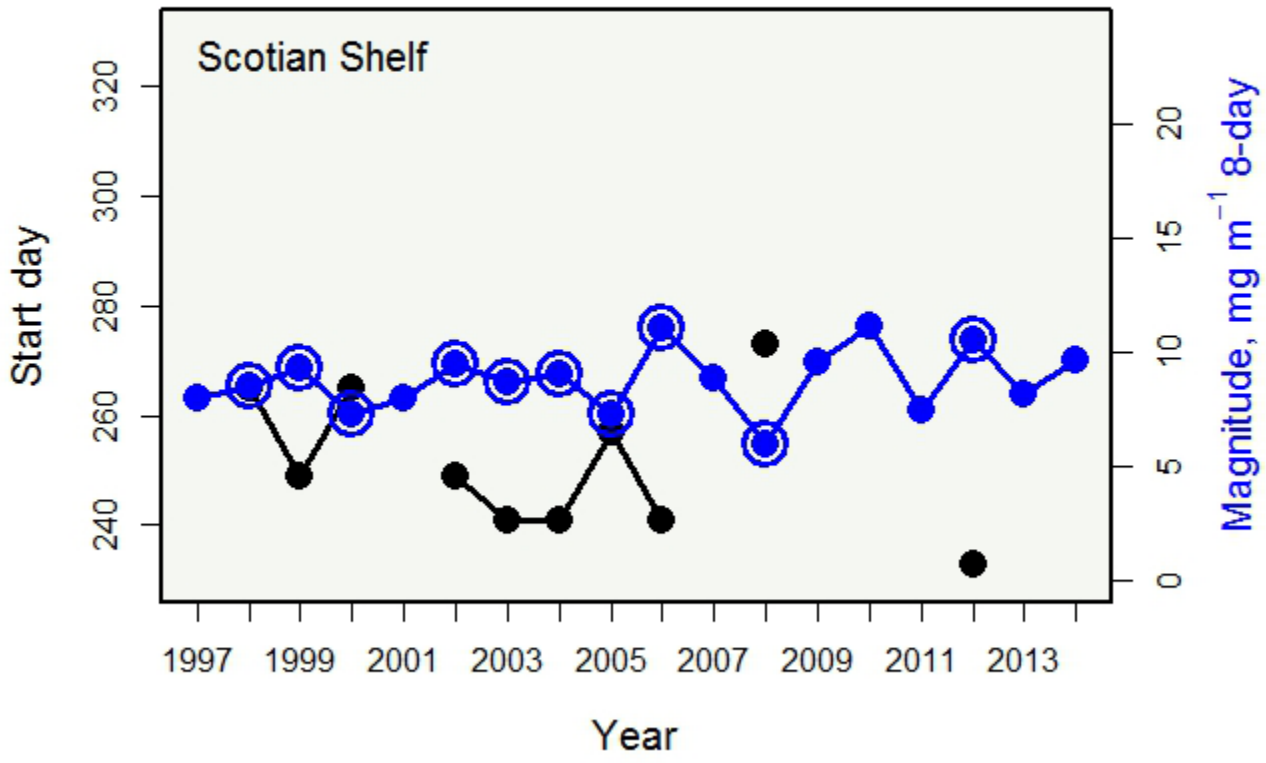

Gulf of Maine




Mid-Atlantic Bight




Northeast Shelf




Scotian Shelf

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# Spring Sea Surface Temperature Distribution

## Fall Sea Surface Temperature Distribution

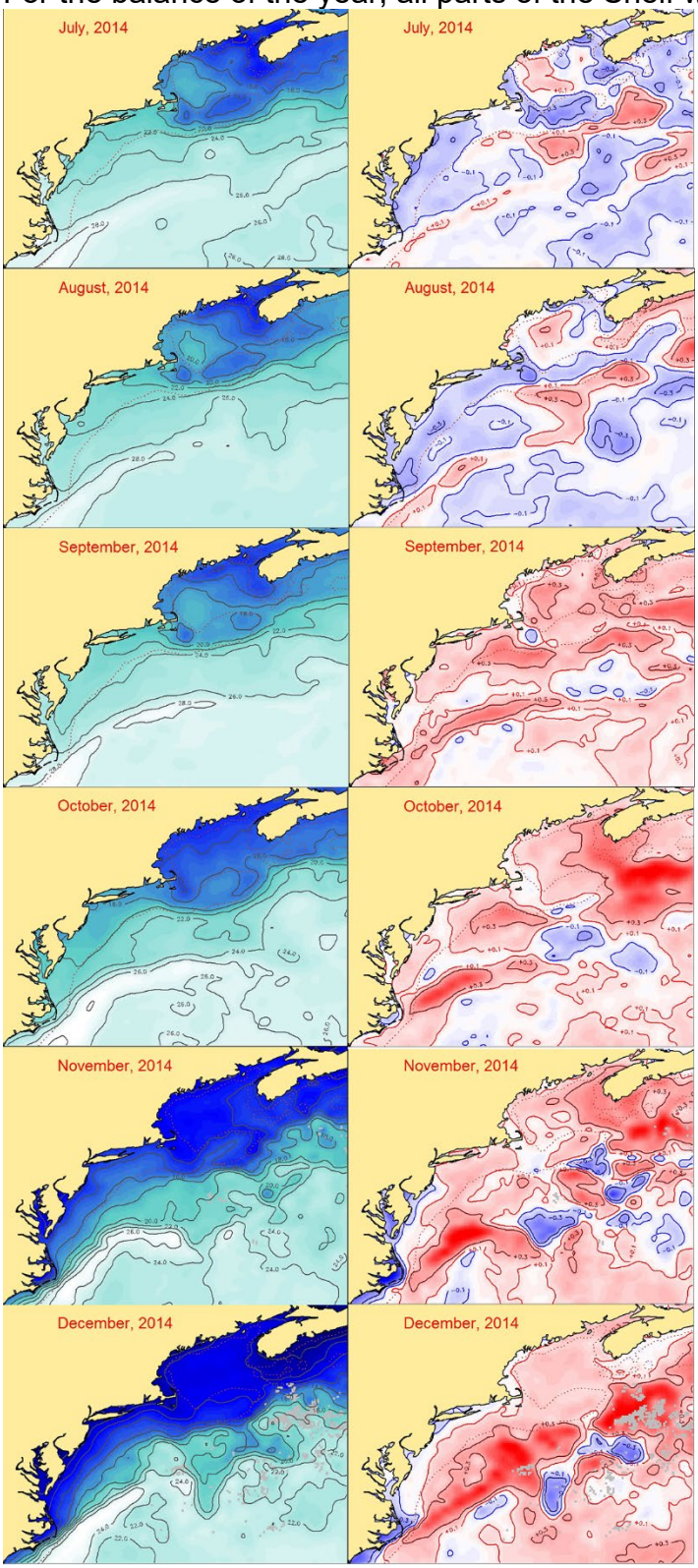
The progression of fall sea surface temperatures for the months of July through December are shown in the interactive figure.

SSTs appear as progressive shades of cyan to blue in the top 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 bottom 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 Northeast Shelf was generally below average temperature during July and August with the exception of some warmer temperatures in the Gulf of Maine area.

For the balance of the year, all parts of the Shelf were above average temperature.



# Spring Chlorophyll Distribution

## Fall Chlorophyll Distribution

The progression of fall chlorophyll concentrations for the months of July through December are shown in the interactive figure.

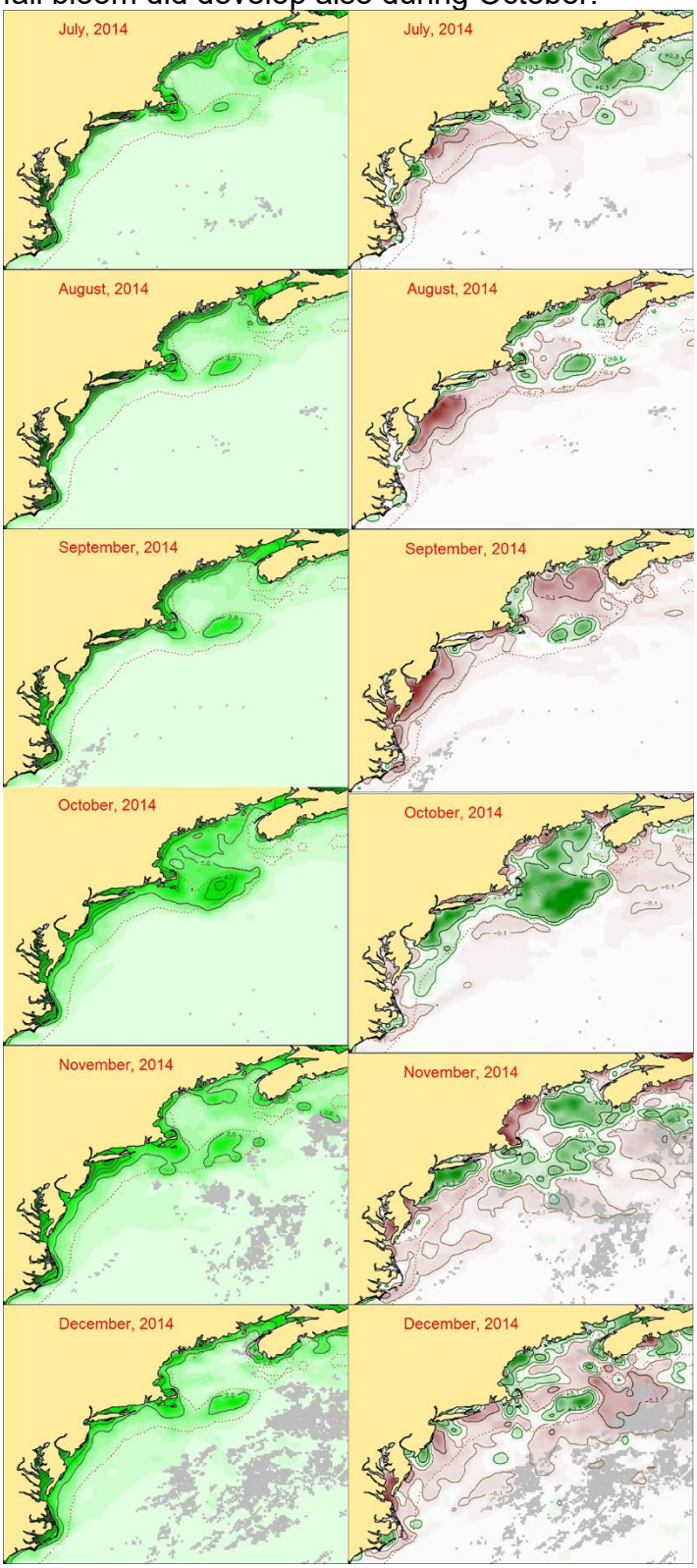
Chlorophyll concentrations appear as progressive shades of green in the top icons. Anomalies of chlorophyll concentration, those tending to exceed plus or minus one quarter of a standard deviation of the overall concentration for the field, are in the bottom set of icons.

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 large fall bloom developed later in the season during October in an area covering the Georges Bank and most of the Gulf of Maine.

More localized bloom activity can also be seen over parts of Georges Bank in the months before the main bloom.

There was no summer bloom in the Middle Atlantic Bight, as seen in some years, but a fall bloom did develop also during October.



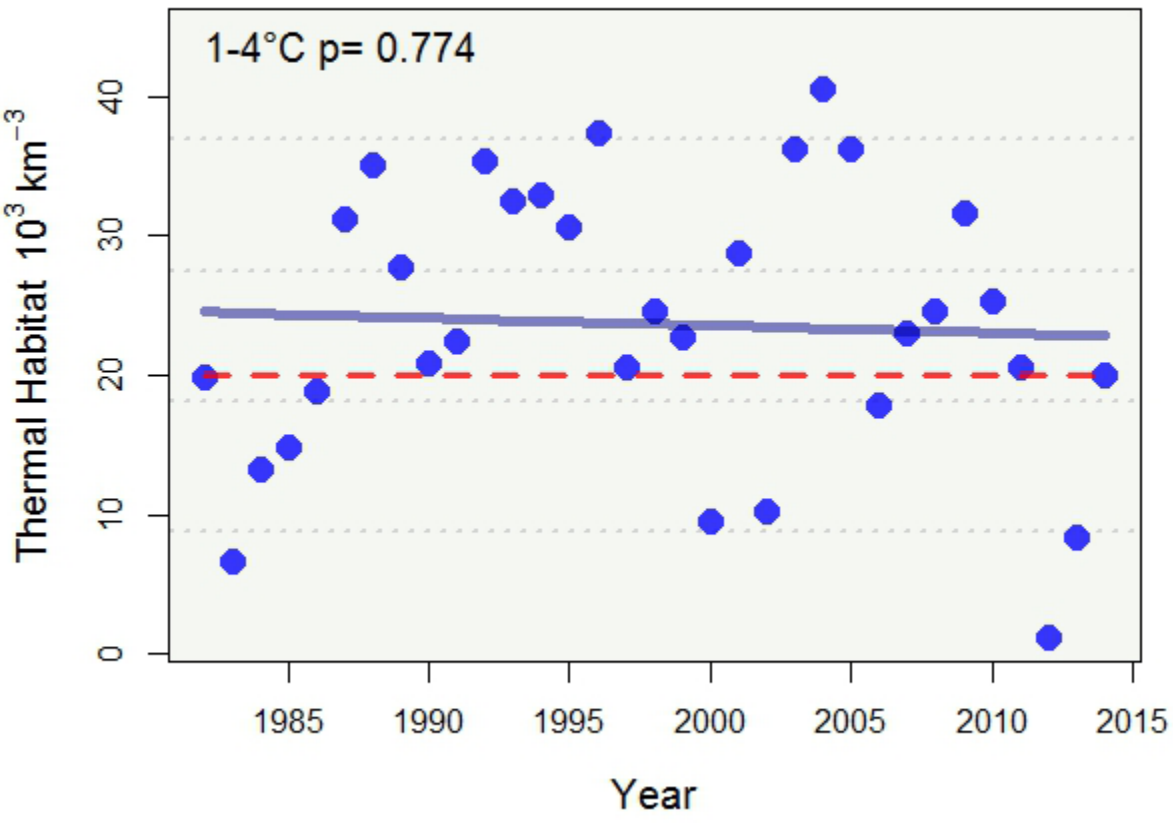
# Ecosystem Shift in Thermal Habitat

Temperature affects the behavior and physiology of marine organisms, thus it is a key determinant of habitat within the ecosystem.

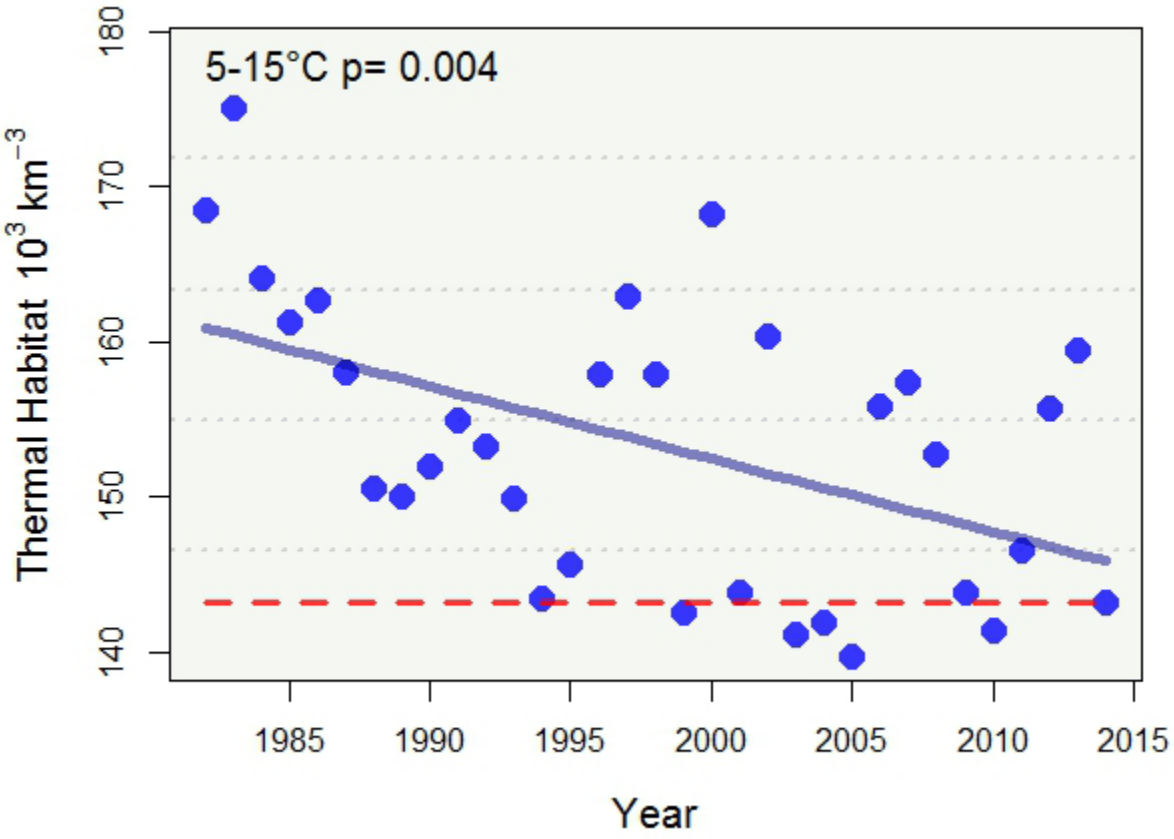
The area of cold water habitats (1-4°C) show no time series trend despite extremely low values in recent years.

Cold water habitats in 2014 were approximately 20,000 km2 (2014 value marked over the time series with dashed red line, linear trend shown with blue line, regression model significance shown in upper left of figures).

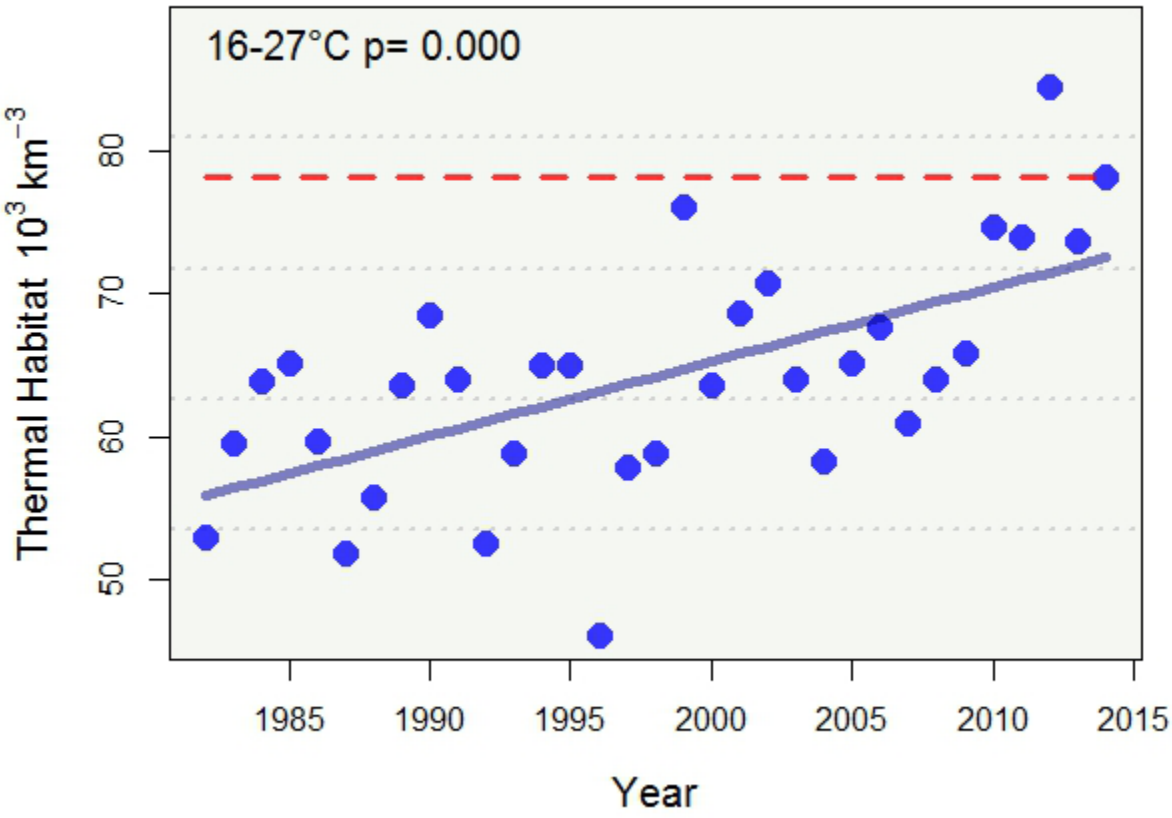
Cool water habitats (5-15°C) show a negative trend over time declining on the order of 20,000 km2 , which is matched by a corresponding increase in warm water habitats (16-27°C).




Cold water habitats




Cool water habitats




Warm water habitats

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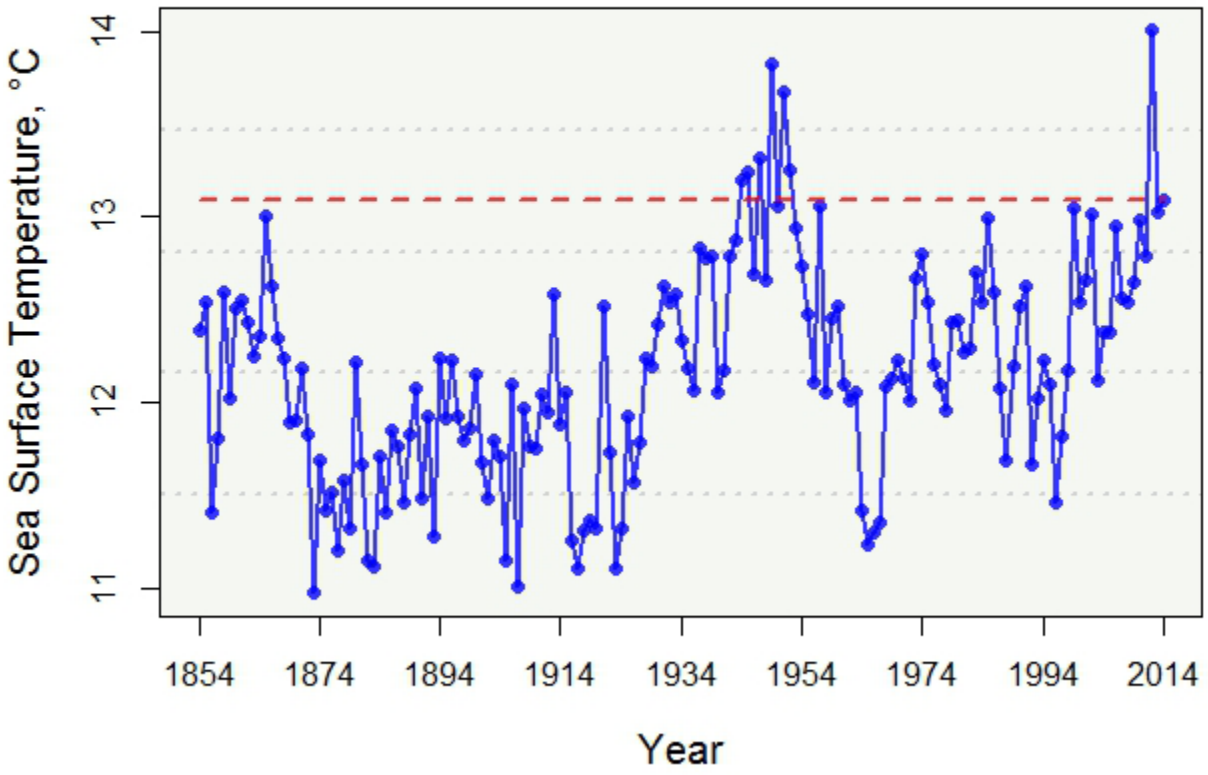
# Long-Term Temperature Trends for the Northeast Shelf Ecosystem




Long-term temperature trends

The Northeast Shelf Ecosystem was at a record high SST in 2012, the 2014 mean level (2014 value marked over the time series with dashed red line) was slightly higher than the 2013 value.

The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854.

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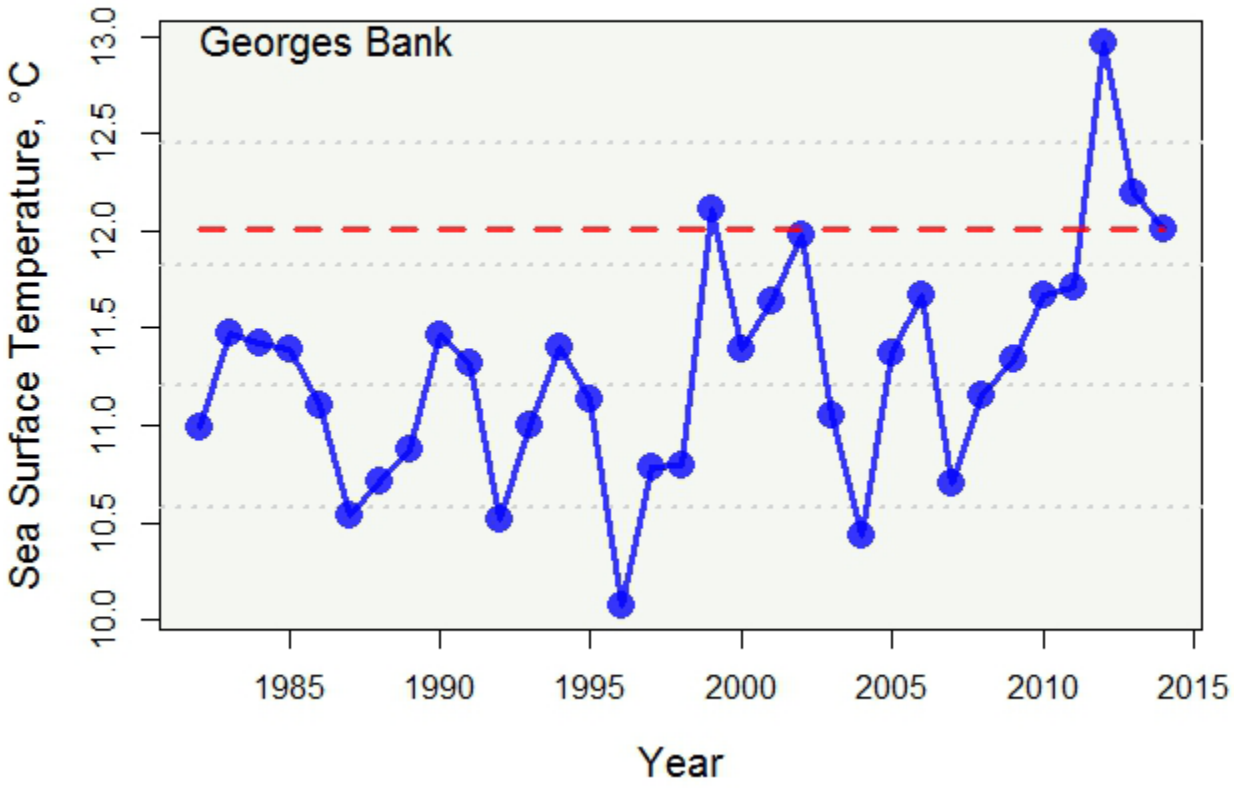
# Satellite SST Trends for the Northeast Shelf Ecosystem

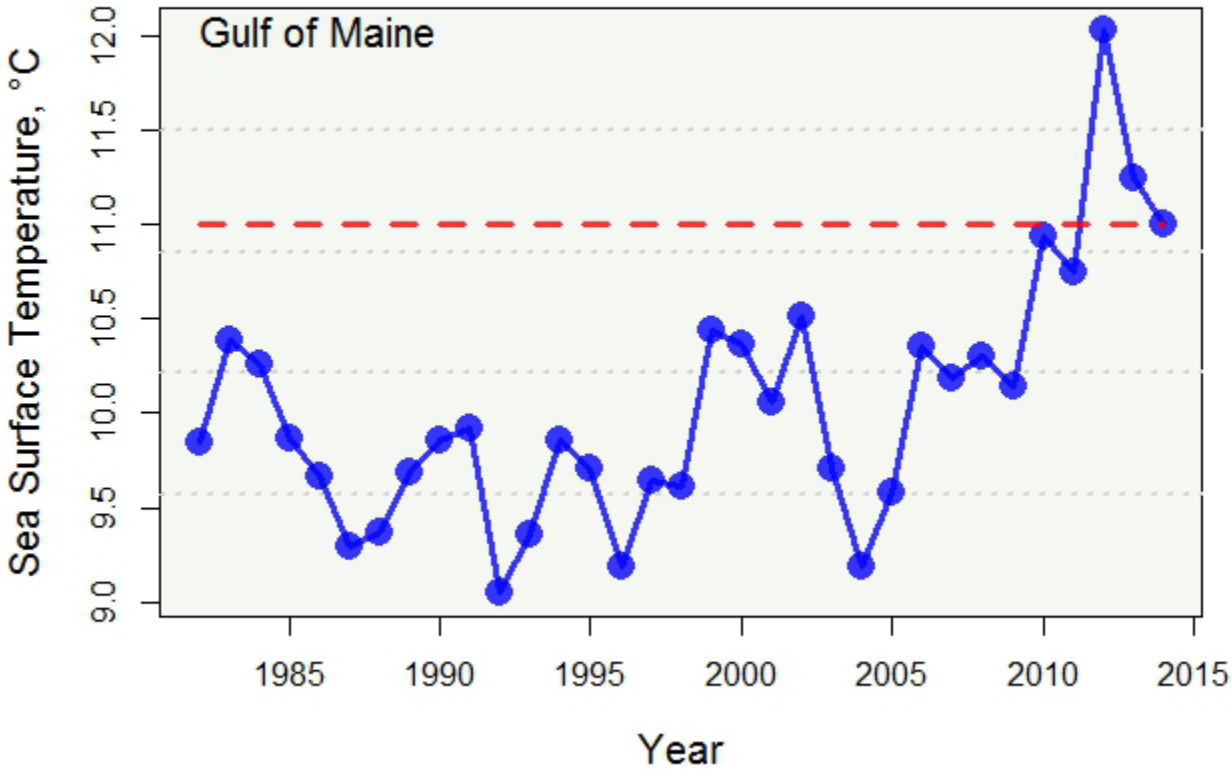
The SST conditions for 2014 were among the warmest recorded in the satellite remote sensing data series.

The NES SST was in excess of 13°C in 2014 (2014 values marked over the time series with dashed red lines), which was less than the record level set in 2012, but well above average for the ecosystem.

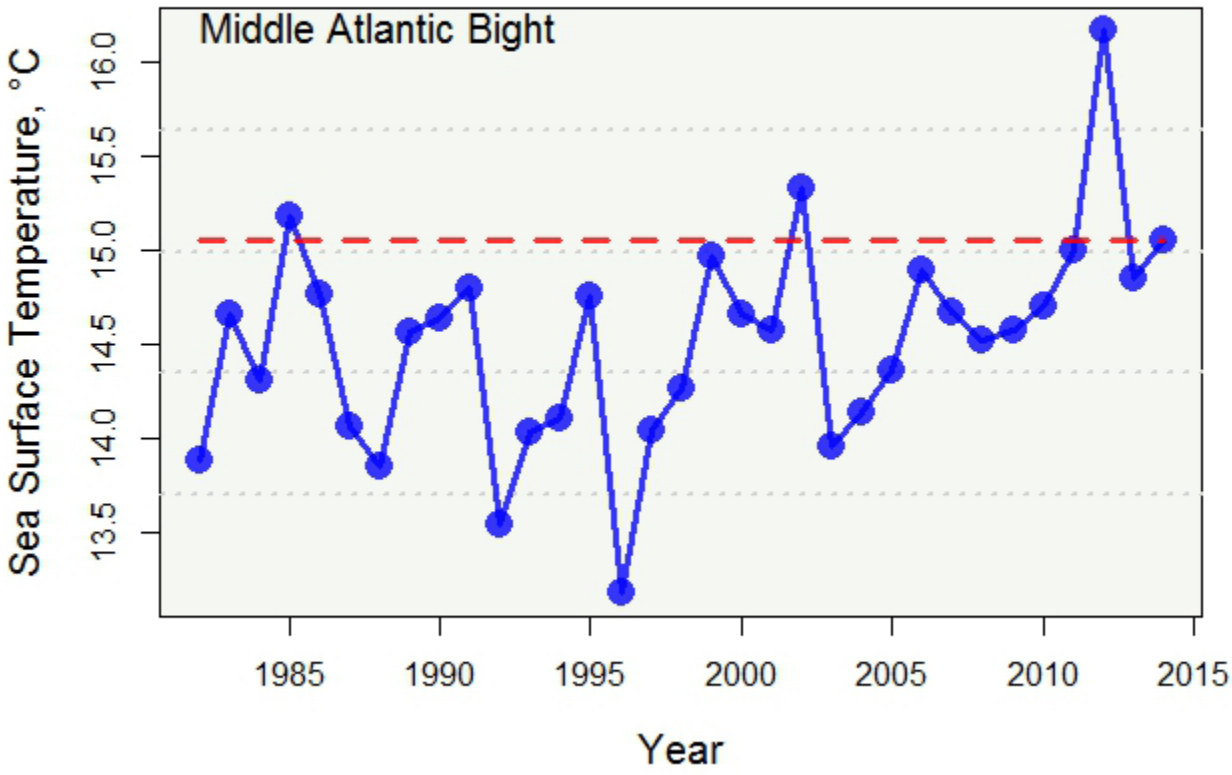
Temperatures continue to be well above average in the northern subregions of the ecosystem, Gulf of Maine, Scotian Shelf and Georges Bank; and, closer to the long-term mean in the Middle Atlantic Bight.



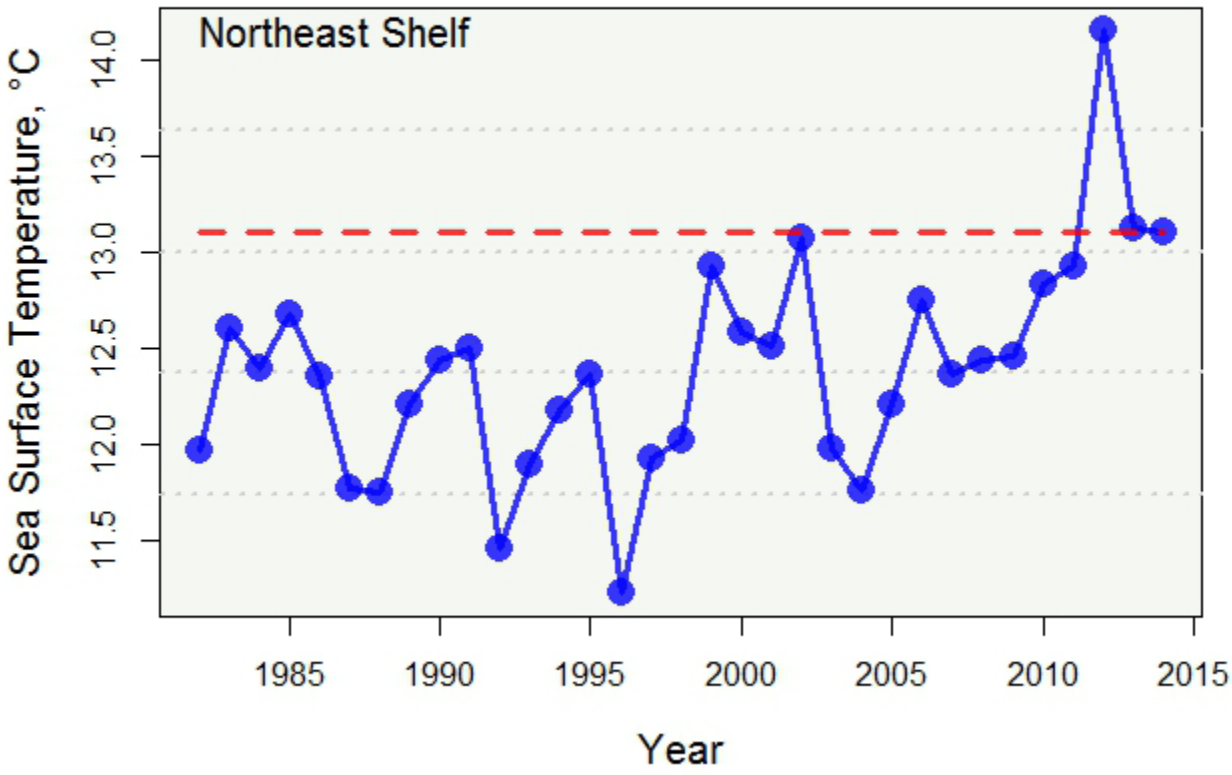

Georges Bank



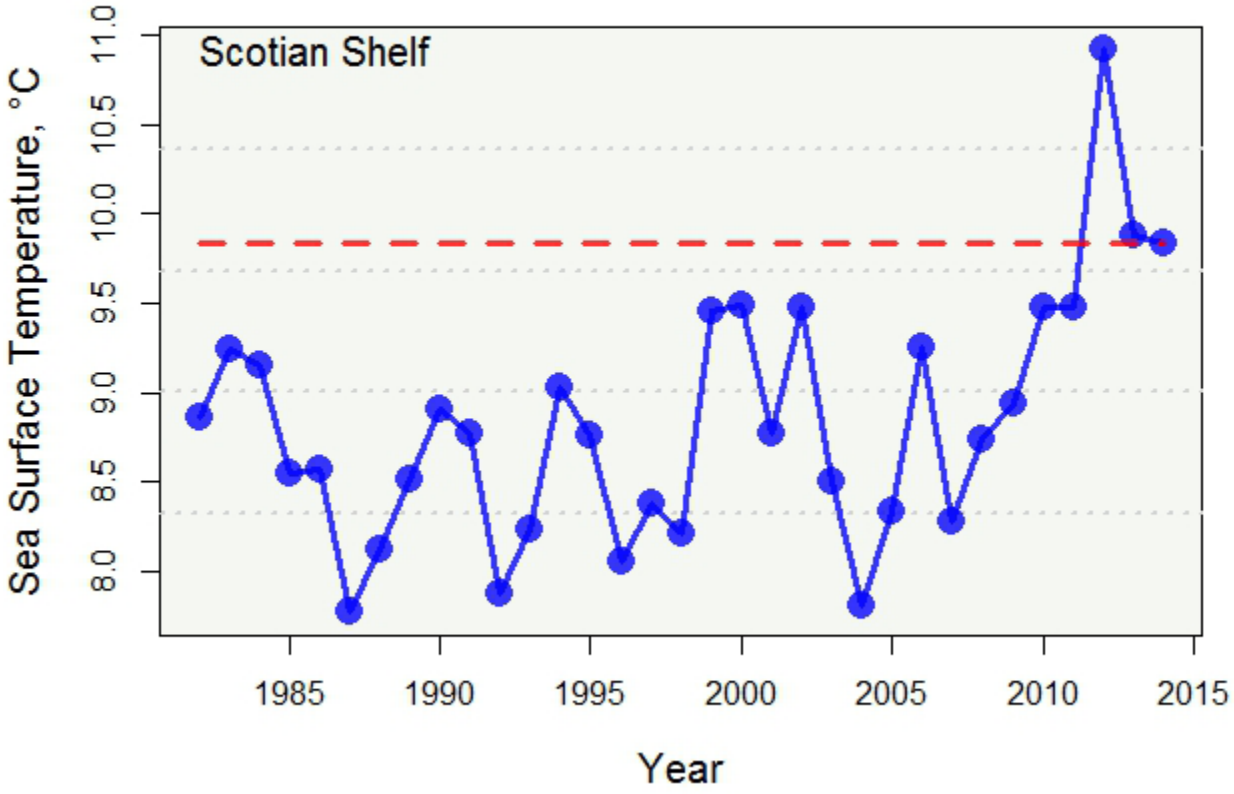

Gulf of Maine




Middle Atlantic Bight




Northeast Shelf




Scotian Shelf

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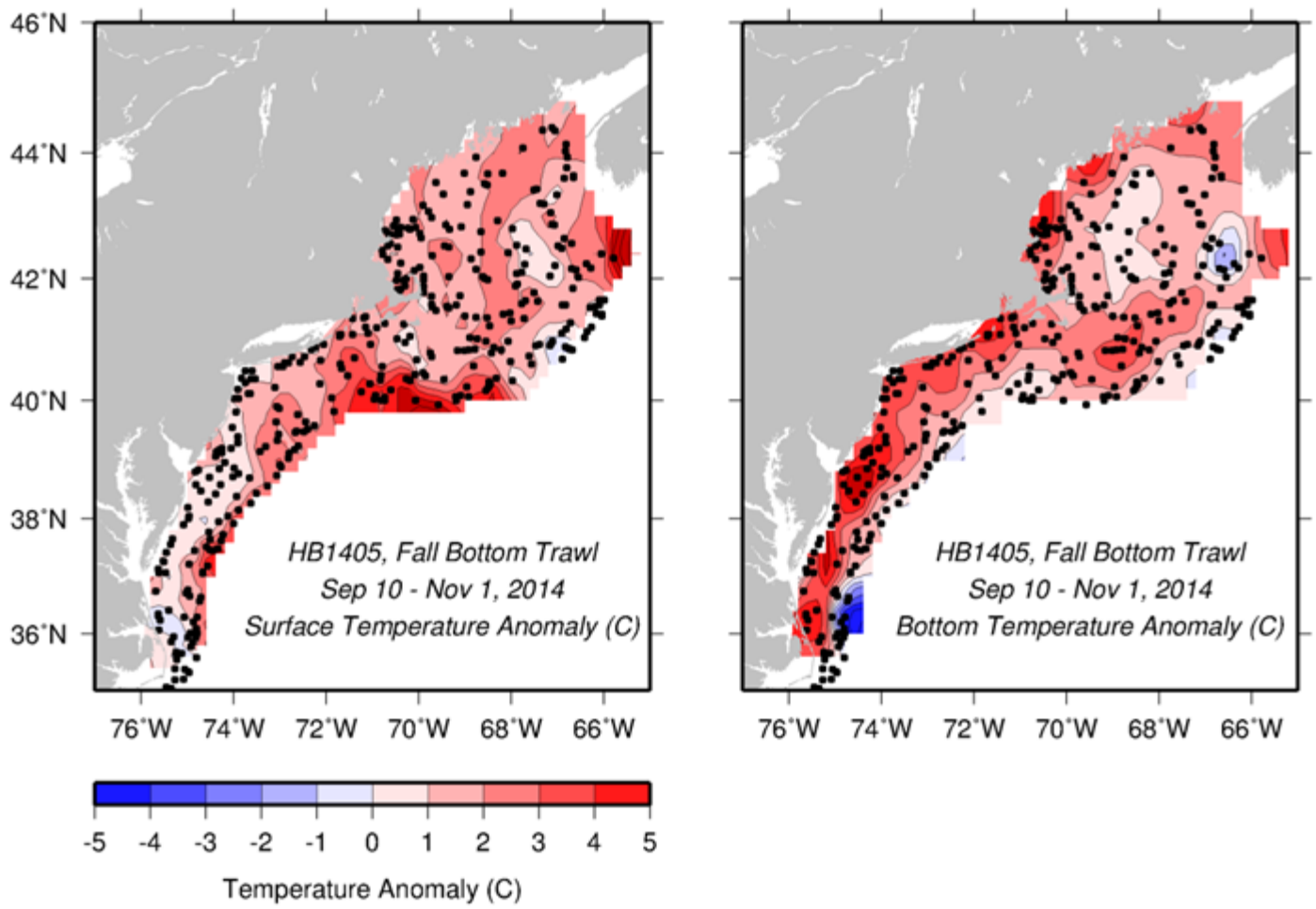
# Fall Temperature from the Survey




Fall bottom temperature anomalies

During fall, ocean temperatures were warmer than average across the entire northeast U.S. shelf at both the surface and near the bottom (relative to 1977-1987).

Surface ocean temperature anomalies were in the range of 1-3°C over most of the shelf, but exceeded 3°C along the mid- to outer shelf south of New England. Bottom waters also experienced significant warming in fall 2014, with the largest anomalies located in the shallow waters near shore and over shallow banks.

Along the mid-shelf in the Middle Atlantic Bight, waters were over 2°C warmer near the bottom. This is an area normally occupied by the “cold pool”, a seasonal bottom-trapped feature formed when winter-cooled shelf water is isolated from the surface by summer heating. However, observations indicate that this feature was virtually non-existent in 2014.

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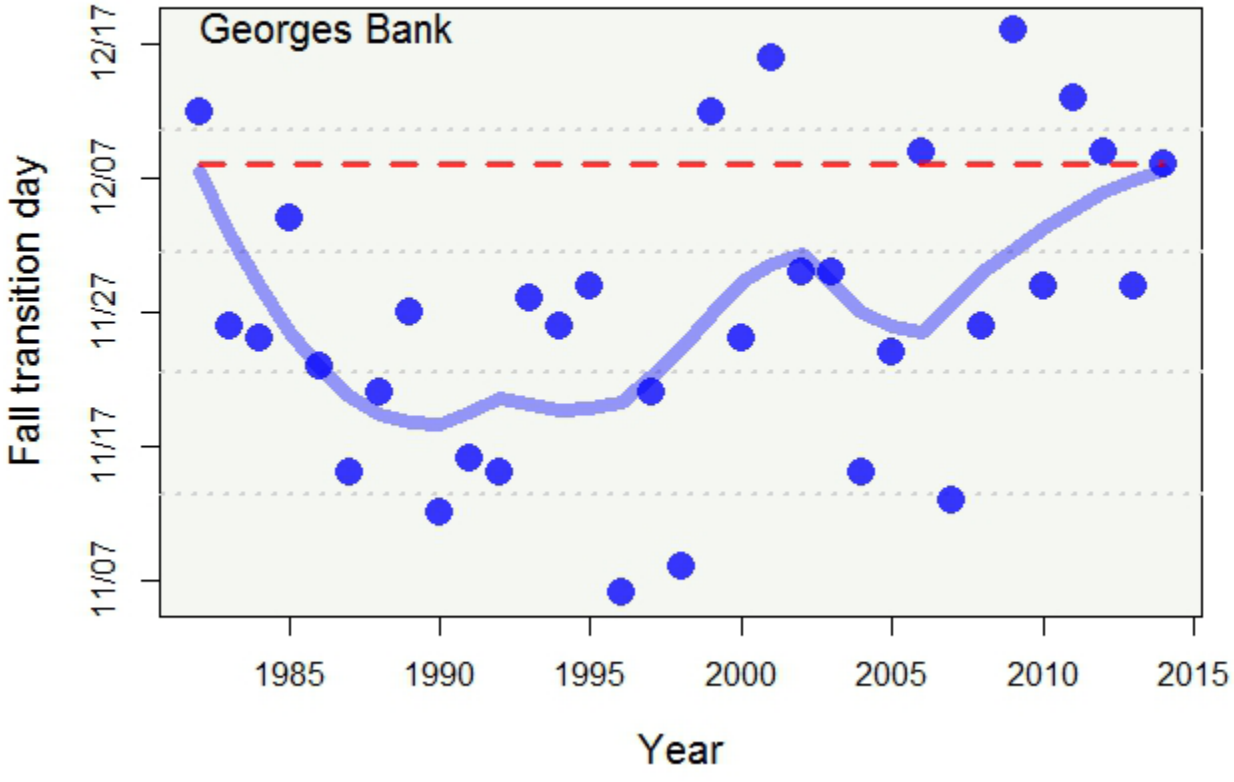
# Fall Thermal Transition Date

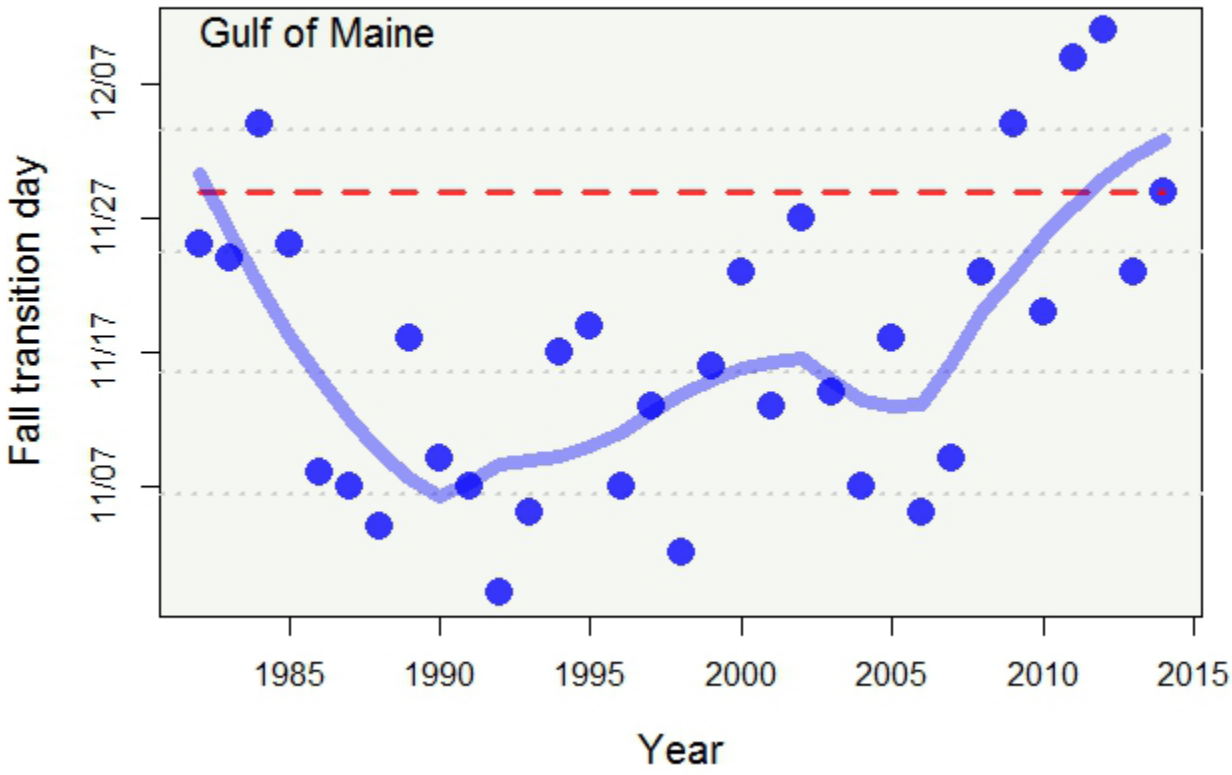
Phenology is the climate influence related to the timing between plant and animal production cycles. Many marine organisms time their reproductive cycles to best utilize seasonal phytoplankton blooms, like the spring and fall blooms, and in turn temperature plays a role in the development of these blooms.

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 occurrence of 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 (blue line is time series smoother, red dashed line marks 2014 data).

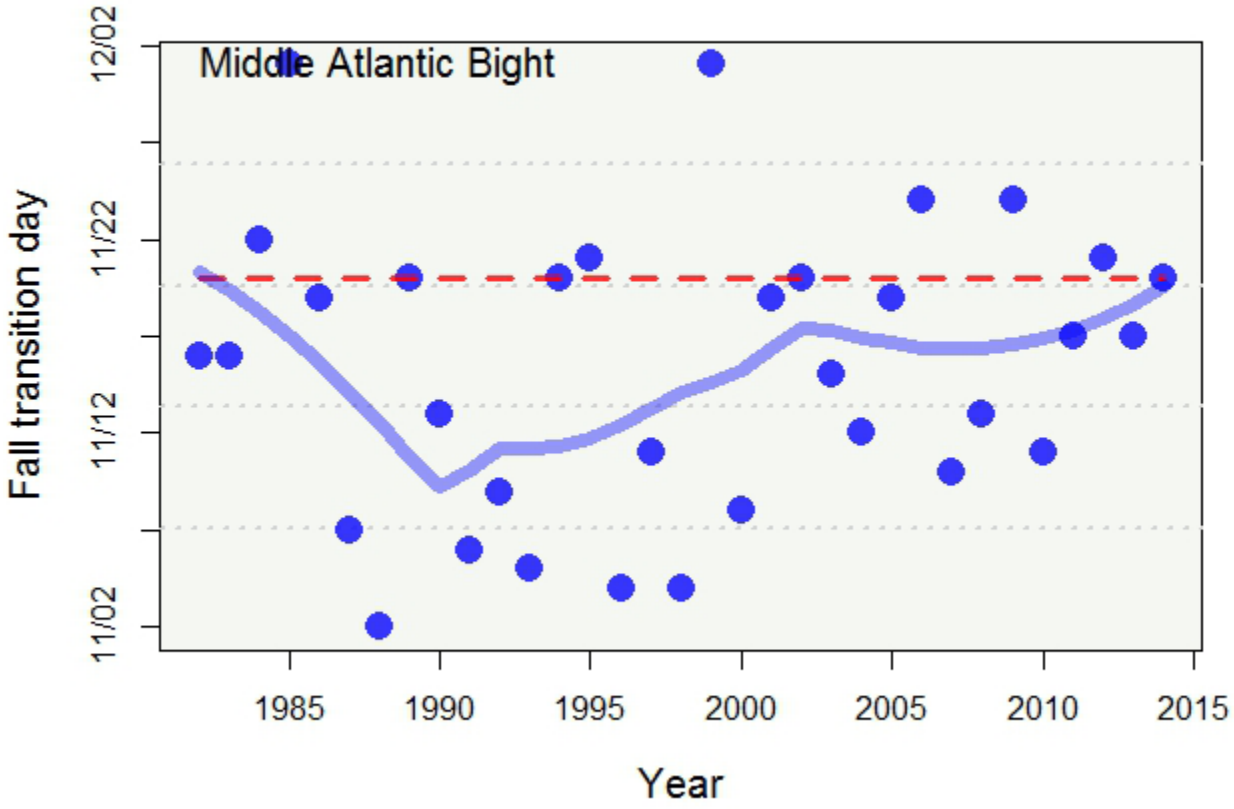
The transition has shifted by nearly a month in the northern part of the ecosystem as seen in the data for the Scotian Shelf where the transition date was around November 20 during the 1980s and is now close to December 20. The shift at the southern end of the ecosystem was not as large. The seasonal shift fall transition in the Middle Atlantic Bight was more on the order of one week.



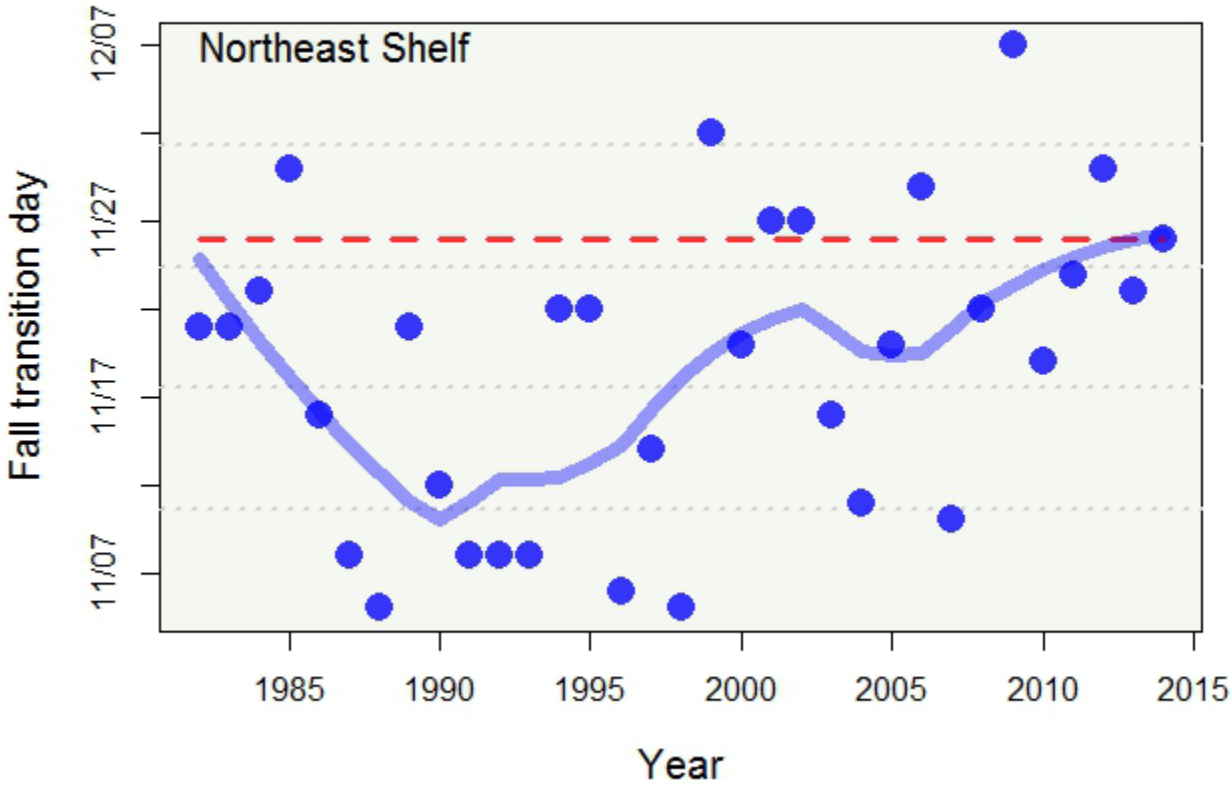

Georges Bank



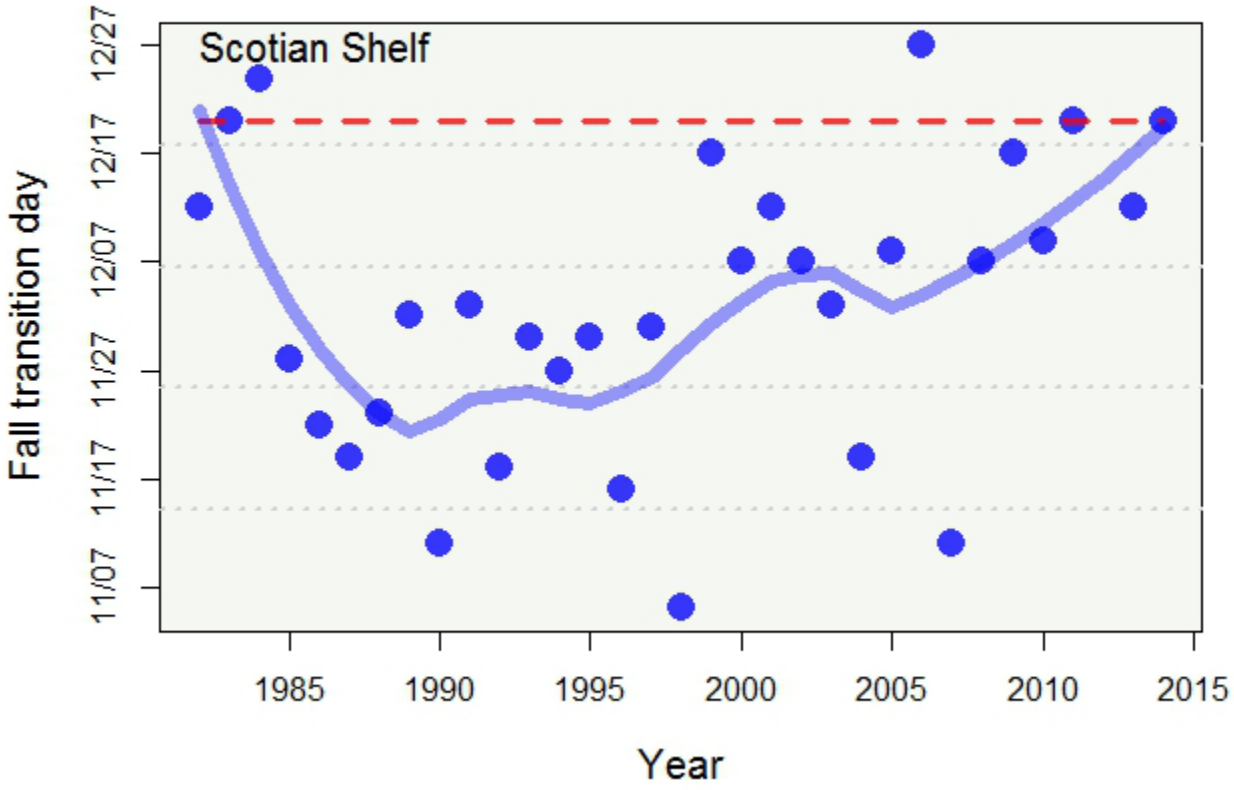

Gulf of Maine




Mid-Atlantic Bight




Northeast Shelf




Scotian Shelf

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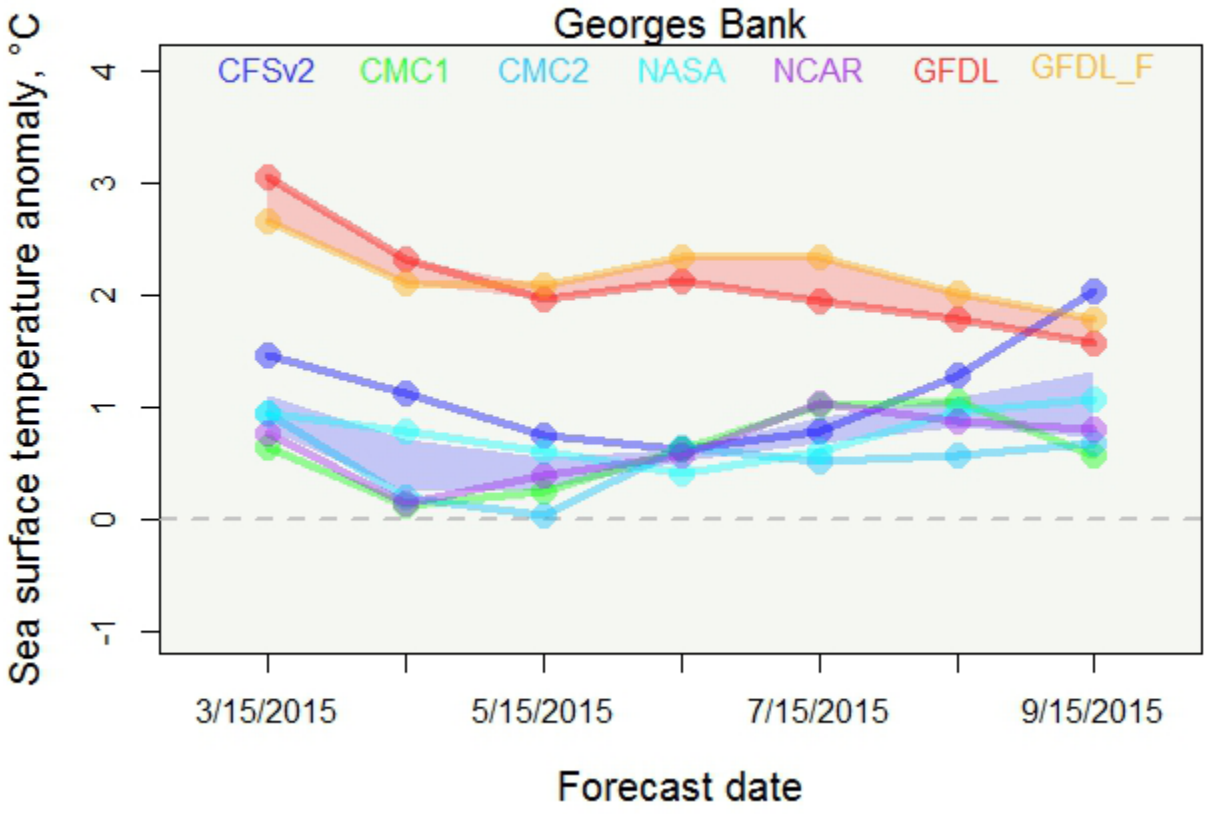
# Ecosystem Forecast - Experimental Data Product

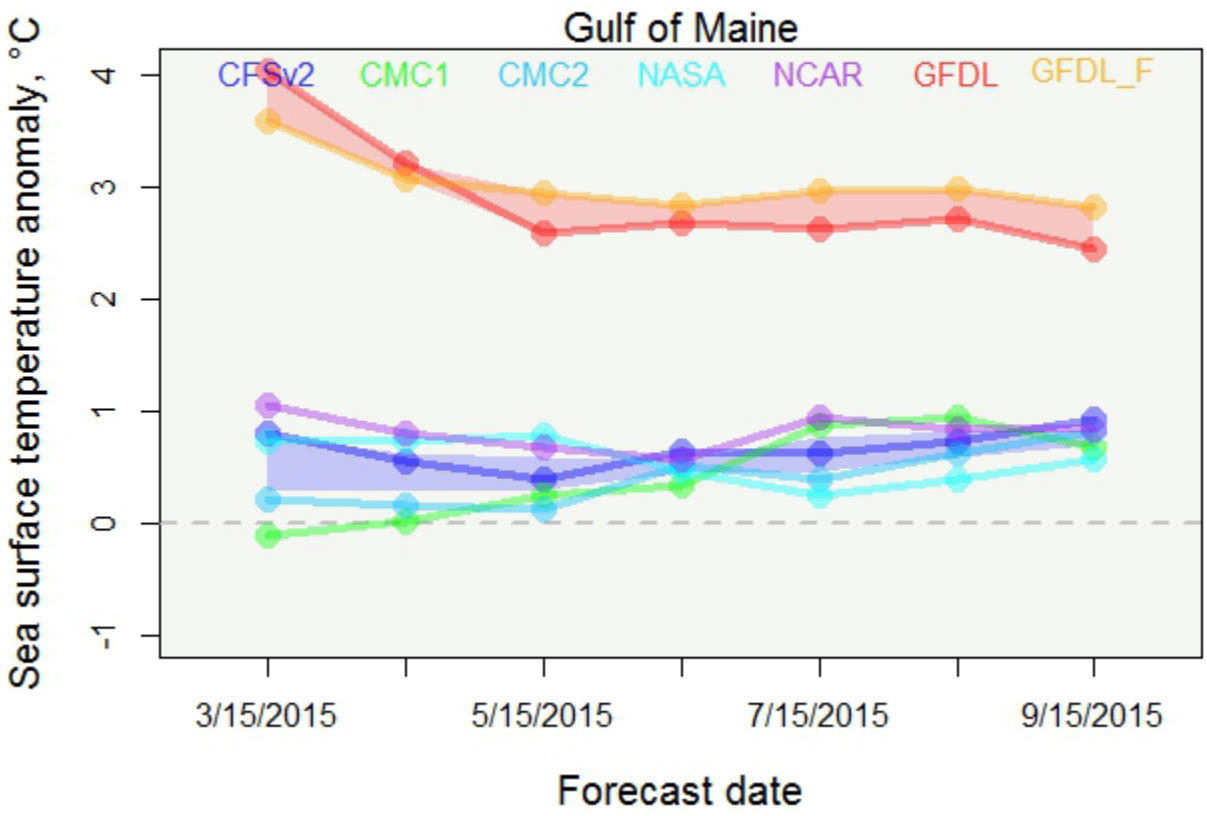
As weather and earth system models have improved, monthly forecasts over seasonal scales ranging up to seven months in advance have improved in quality. For each of the ecoregions of the Northeast Shelf, forecasts from an ensemble of seven forecast models are provided starting with the forecast estimates for March 2015 and ending in September 2015.

There was model agreement in the forecasts for the Middle Atlantic Bight suggesting that sea surface temperature will rebound in the coming months to an ensemble means of approximately 0.5°C above average. In the Northern subareas there was less model agreement; in particular, forecast estimates from the GFDL models diverged from other models in the ensemble.

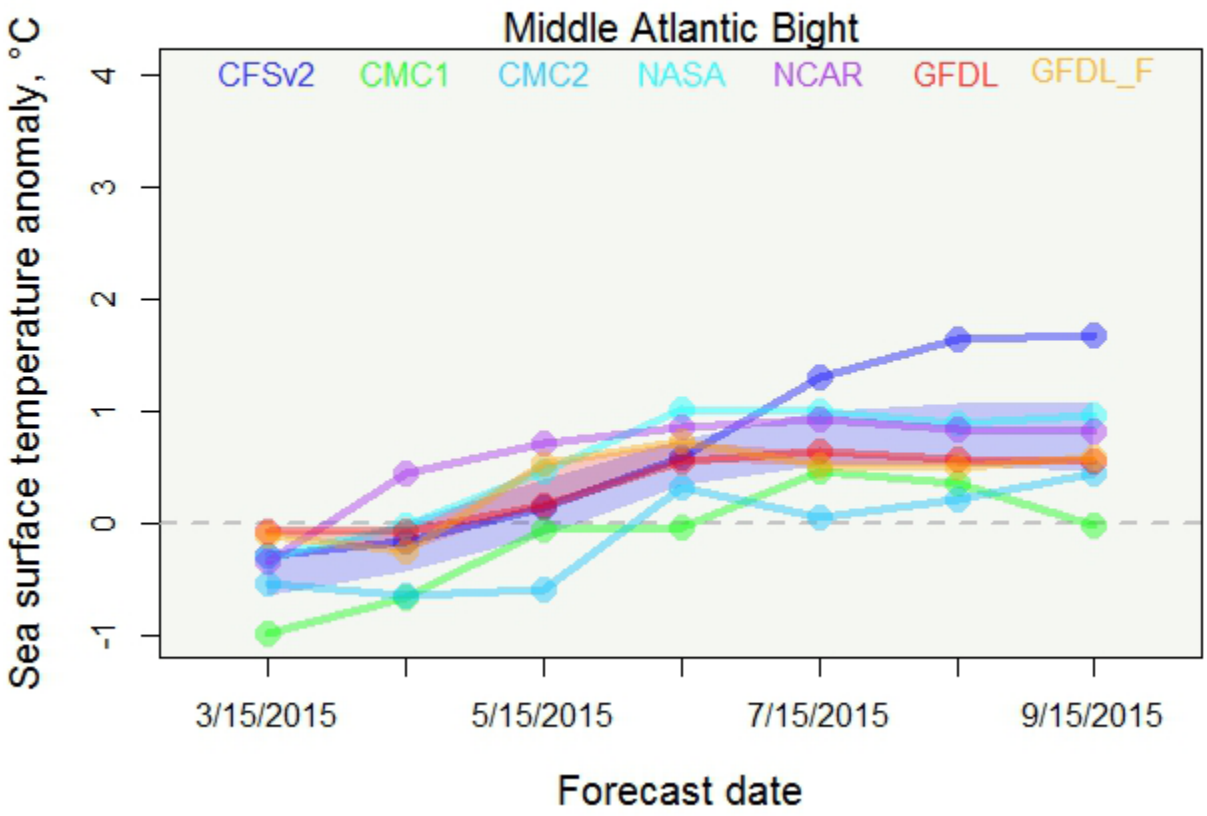
Despite poor model agreement, all the forecasts suggest above average temperatures for these areas at a level likely approaching 1.0°C.



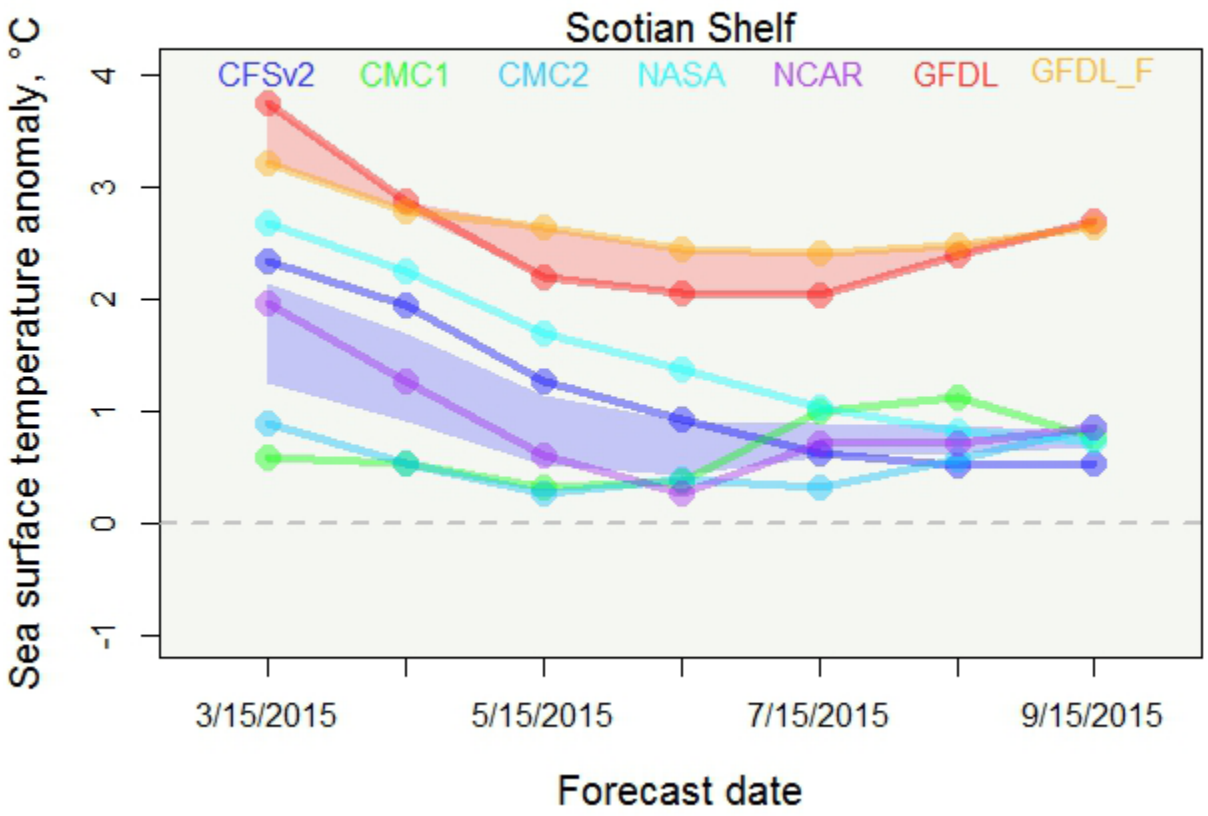

Georges Bank




Gulf of Maine




Middle Atlantic Bight




Scotian Shelf

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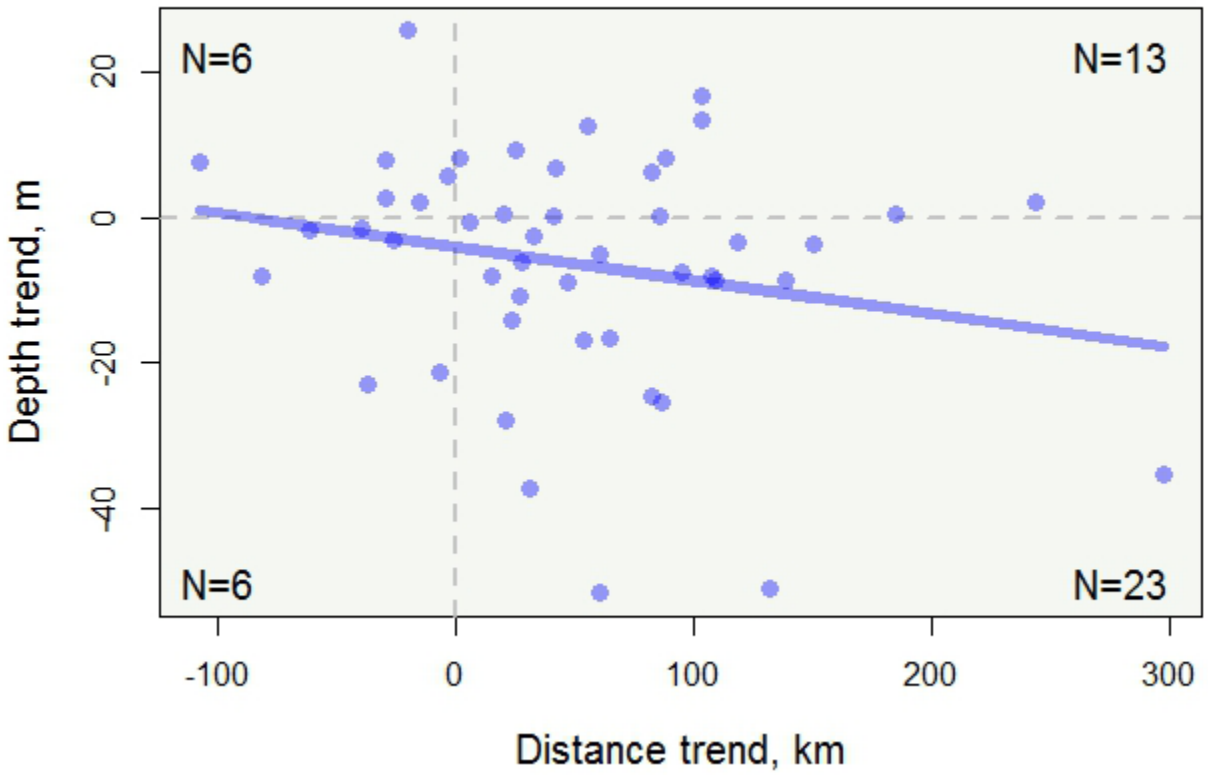
# Trends in Fall Species Distribution




Along shelf trend

The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades. Individual species has shifted distribution due to a number of reasons and these shifts can be characterized in a number of different ways. Two metrics that have been used to characterize distribution on the NE Shelf include:

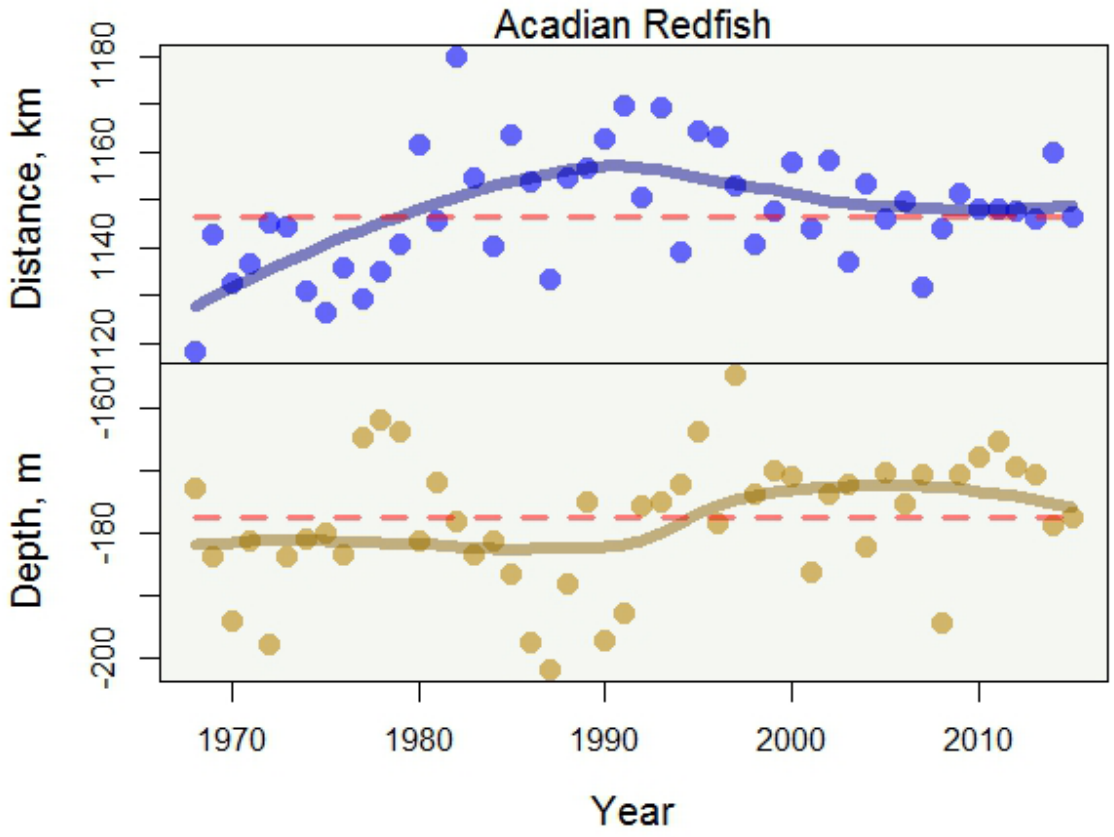
1. the position in the ecosystem along an axis oriented from the southwest to the northeast referred to as the along shelf distance; and,
2. the depth of occurrence

*NOTE: In the previous Advisory characterizing spring distribution, along shelf position was calculated in respect to a bathymetric path, thus along shelf distances used here are not the same quantity; and, a cross shelf quantity was calculated that is not part of the current assessment.*
Along shelf distances range from 0 to 1360, which relates to positions along the axis from the origin in southwest to northeast in kilometer units. Depth ranges from 0 to -260, which relates to depth of occurrence in meters.

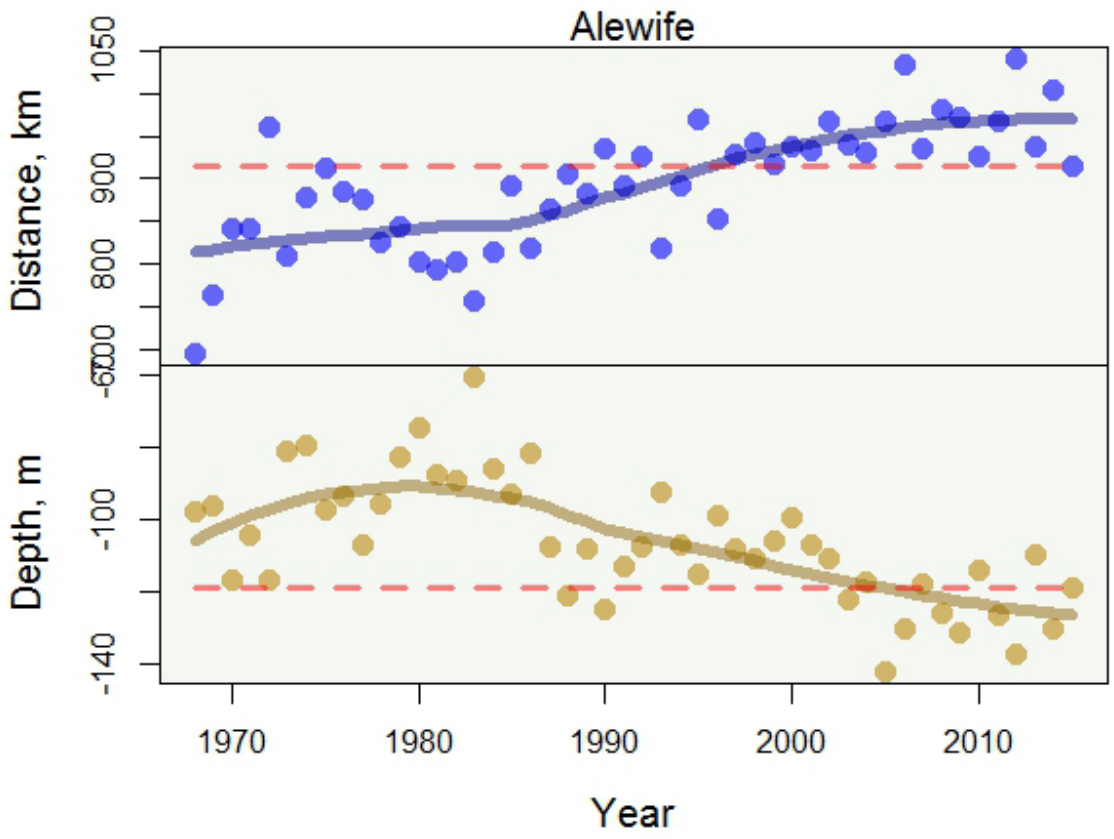
The table below shows the species analyzed; click on a species name to see the along and depth distribution trends. For each species, a linear trend for along shelf distance

and depth was computed based on the period 1968-2014 (see **figure**). Most species have moved to the Northeast and into deeper water (N=23) followed by species moving the Northeast and into shallower water (N=13). Twelve species distributions have along shelf trends to the Southwest equally divided between species going into deep and shallow water.

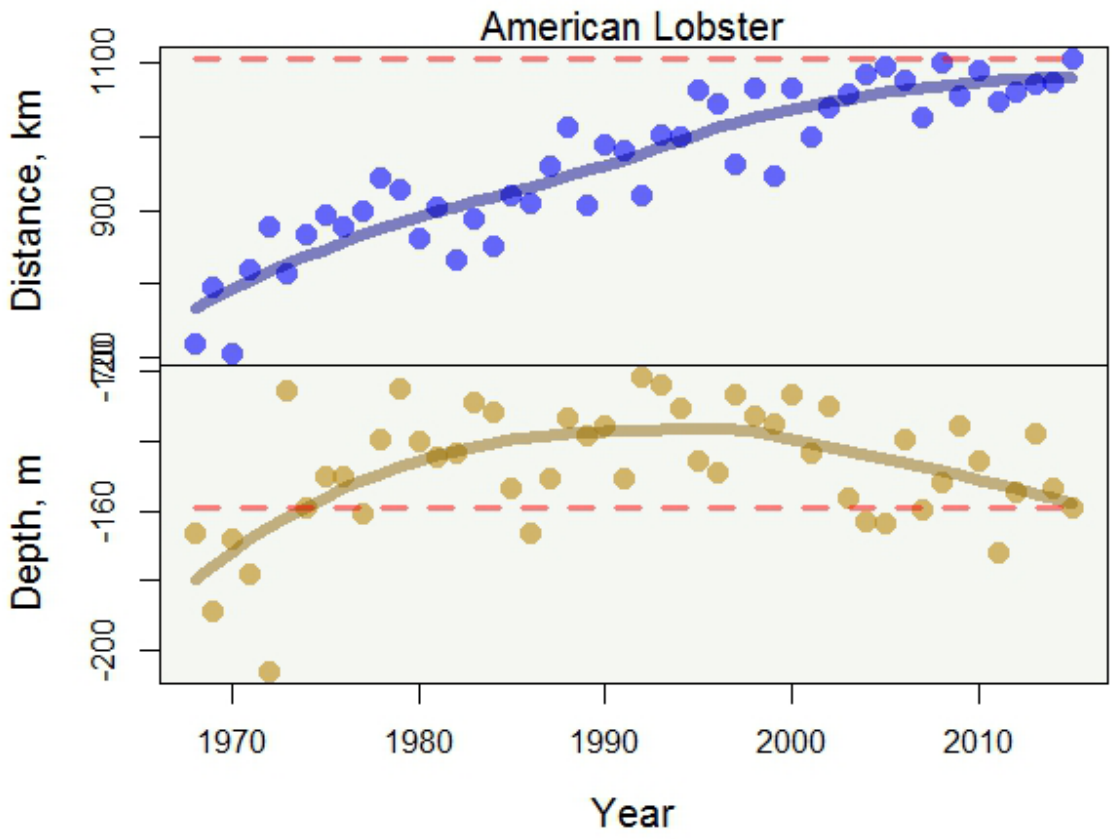
- **Acadian Redfish**



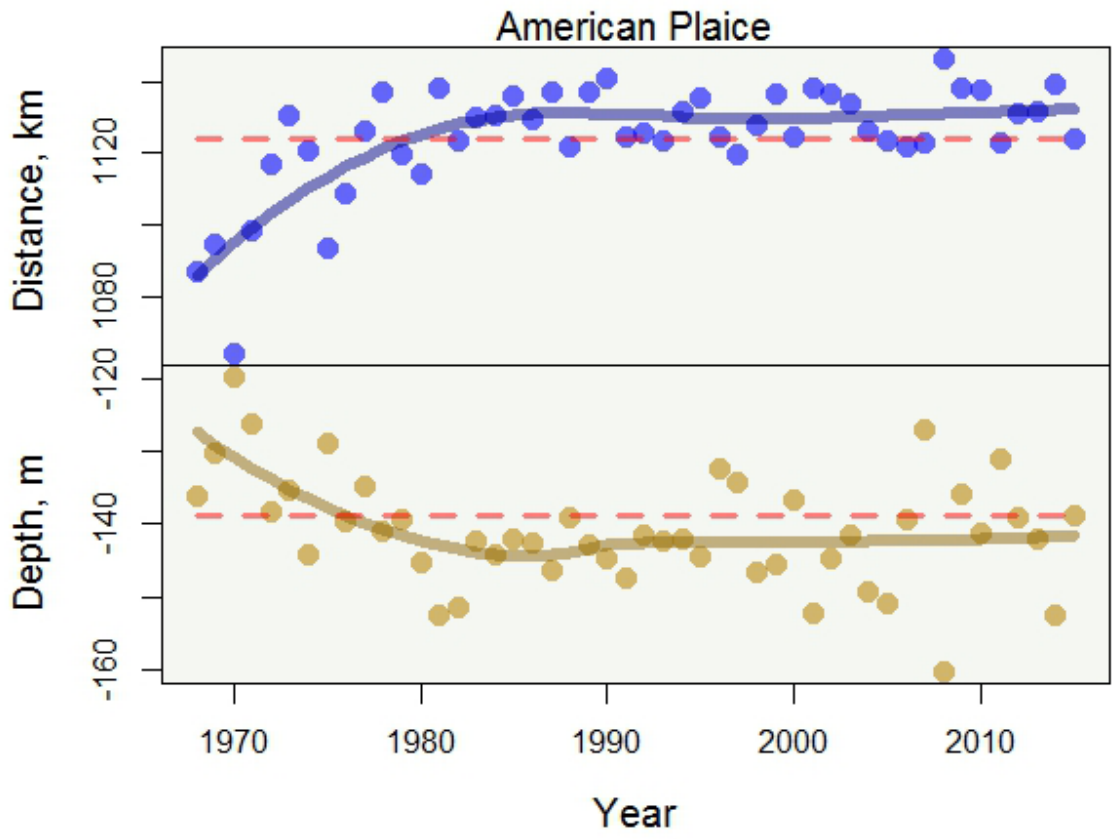
- **Alewife**


Alewife
Distance, km
1050
900
800
-6000
Depth, m
-100
-140
1970
1980
1990
2000
2010
Year

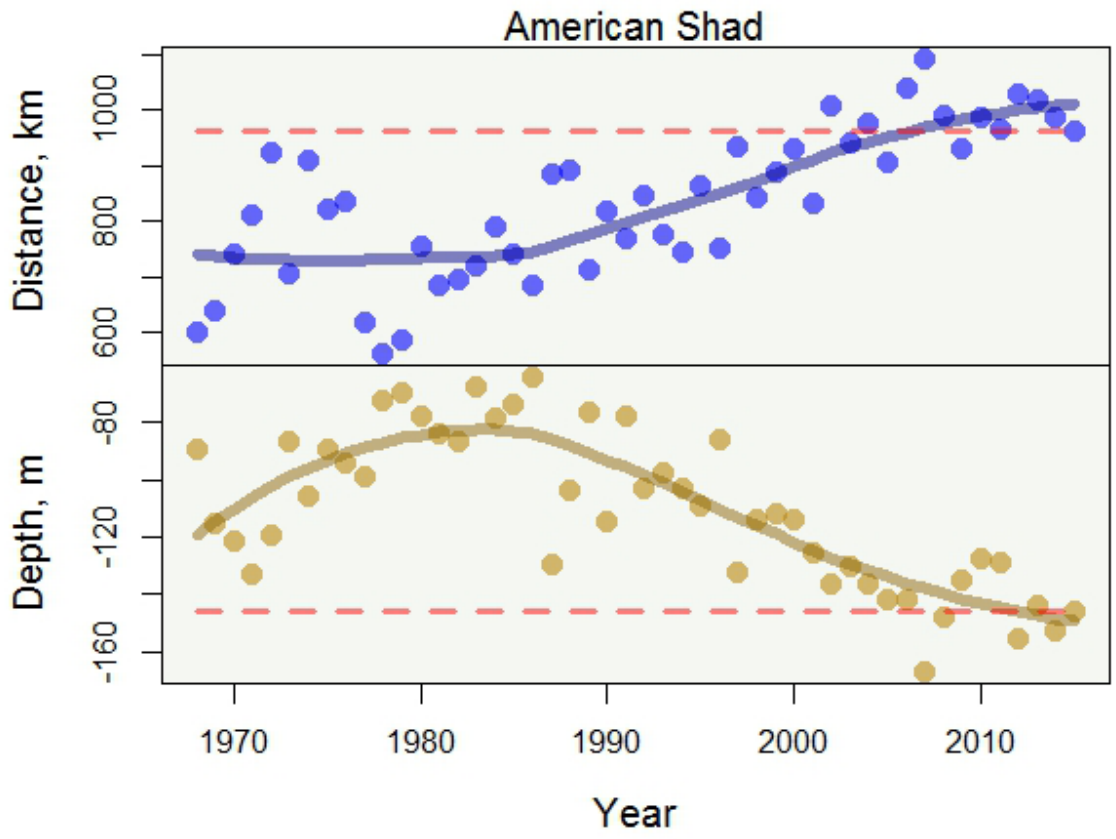
- **American Lobster**



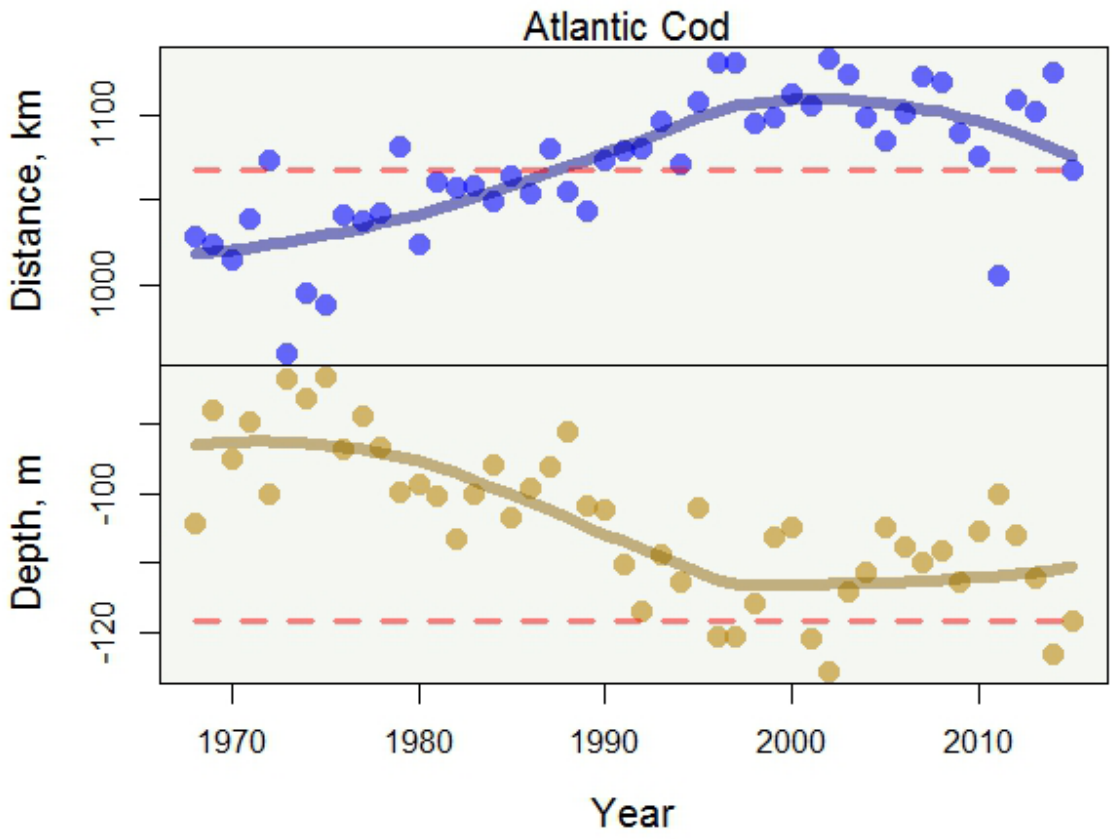
- **American Plaice**



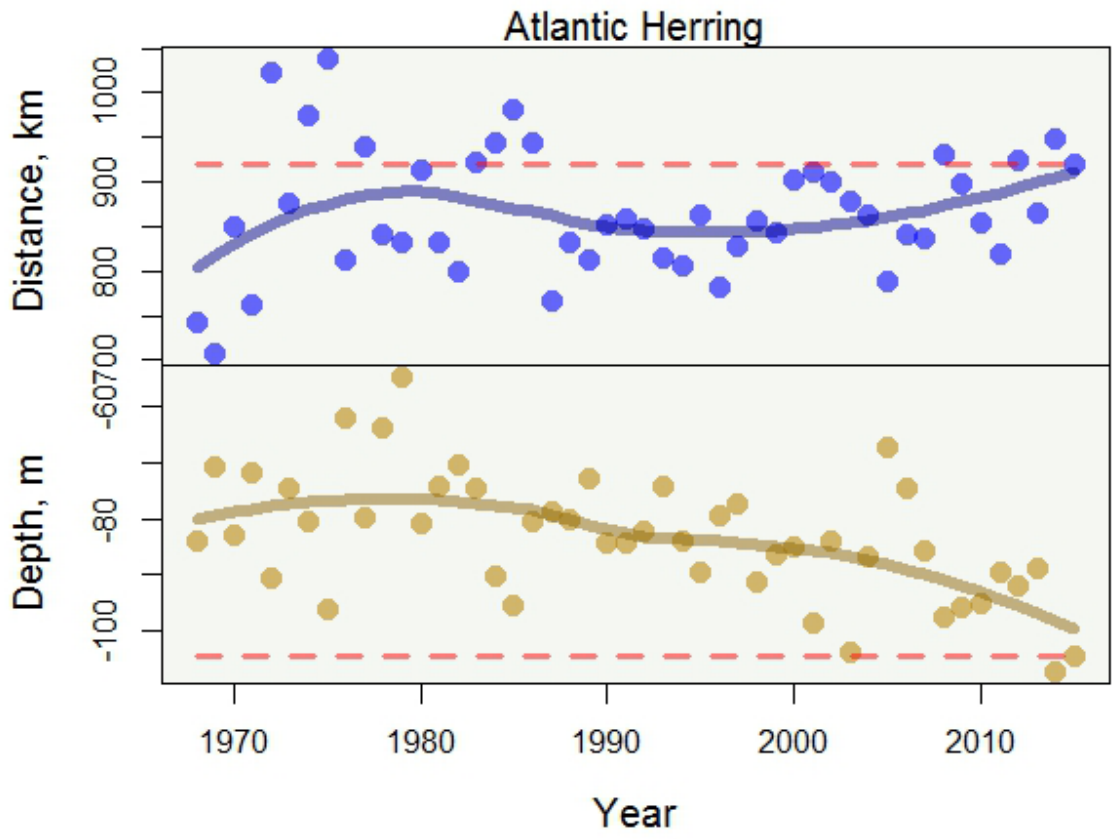
- **American Shad**



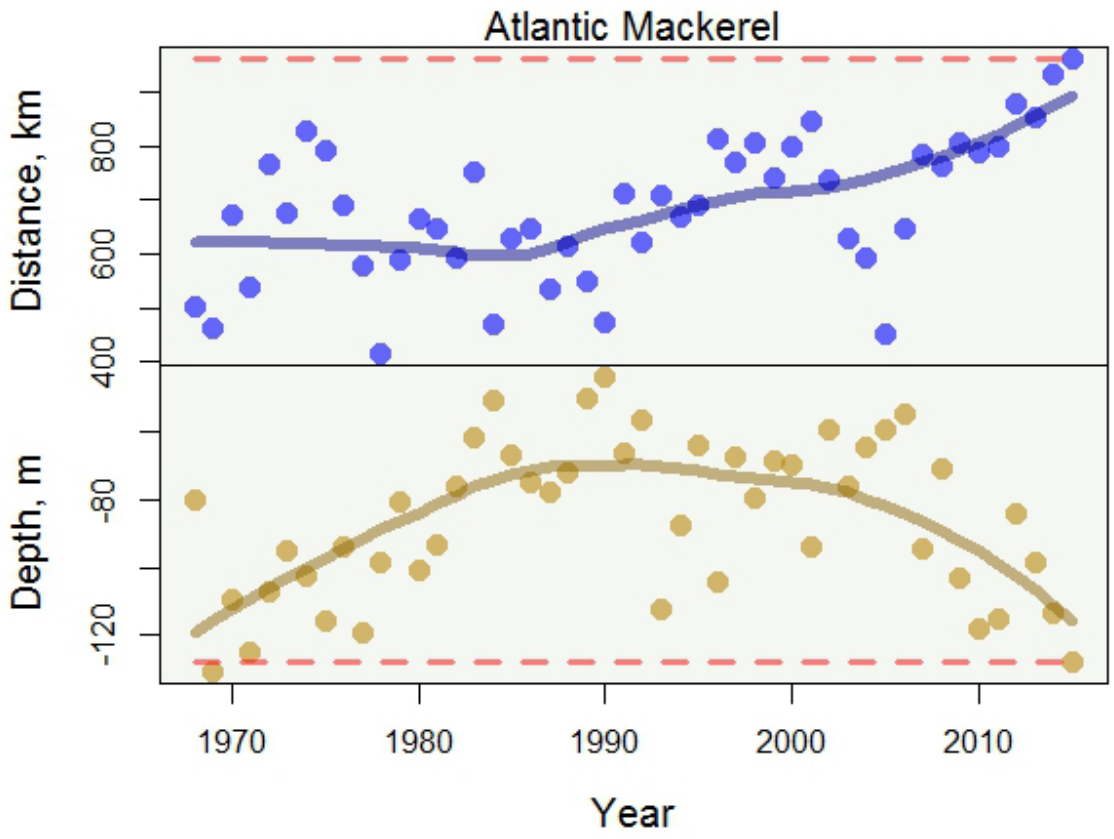
- **Atlantic Cod**



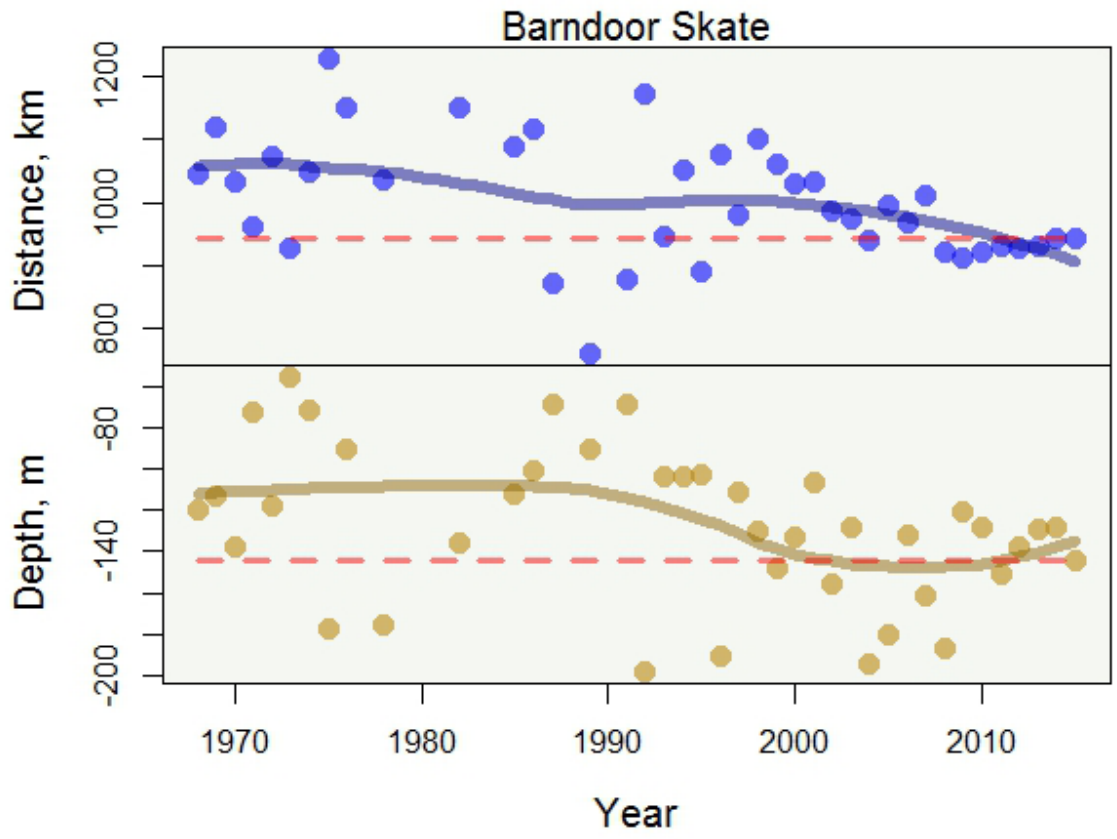
- **Atlantic Herring**



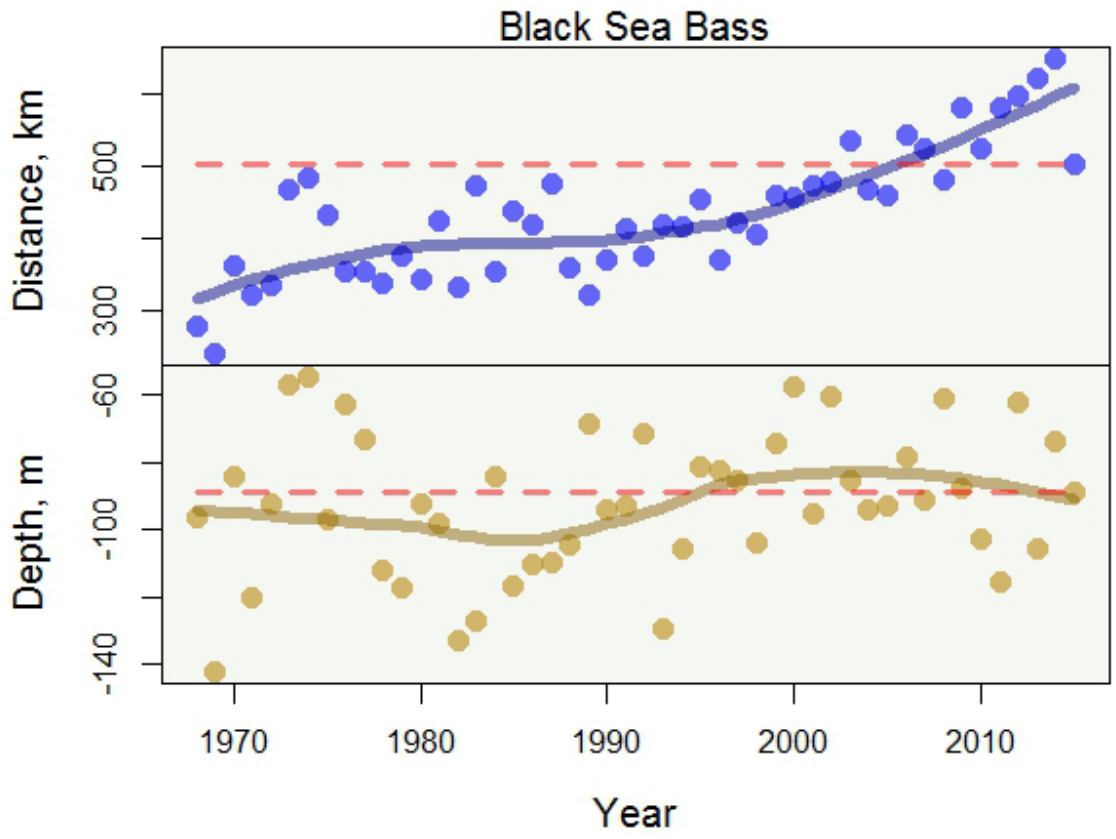
- **Atlantic Mackerel**



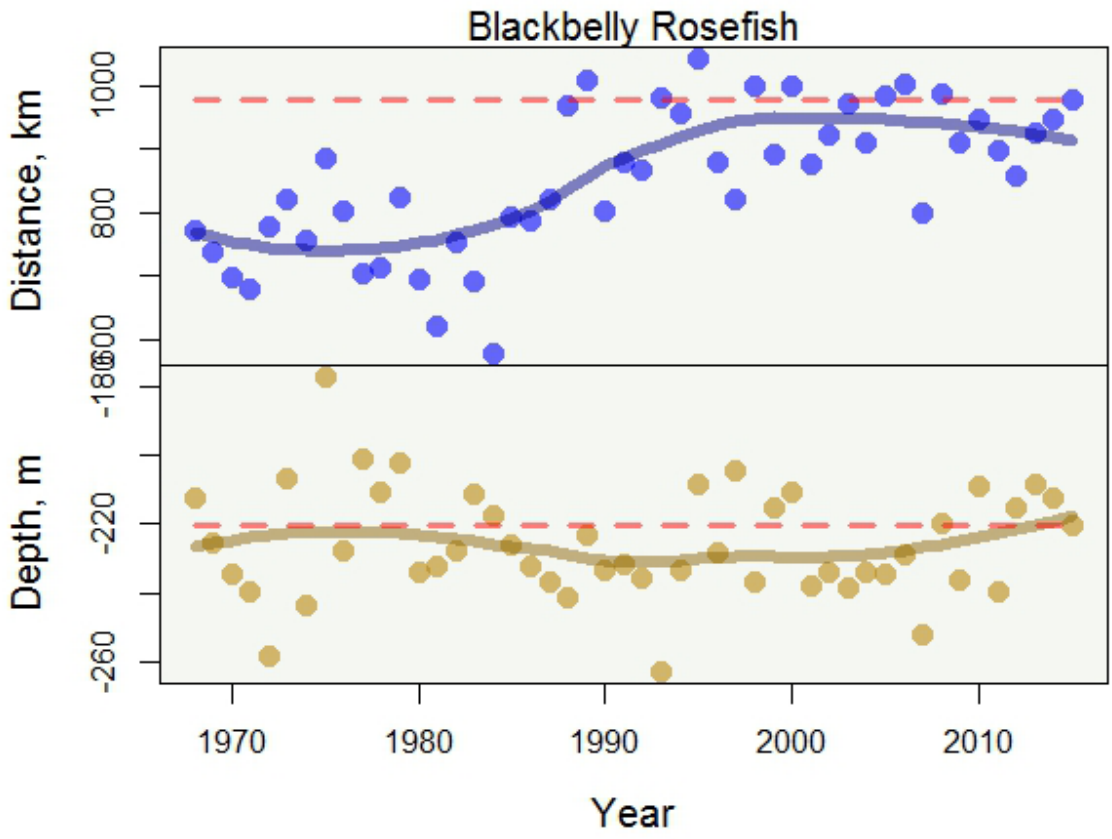
- **Barndoor Skate**



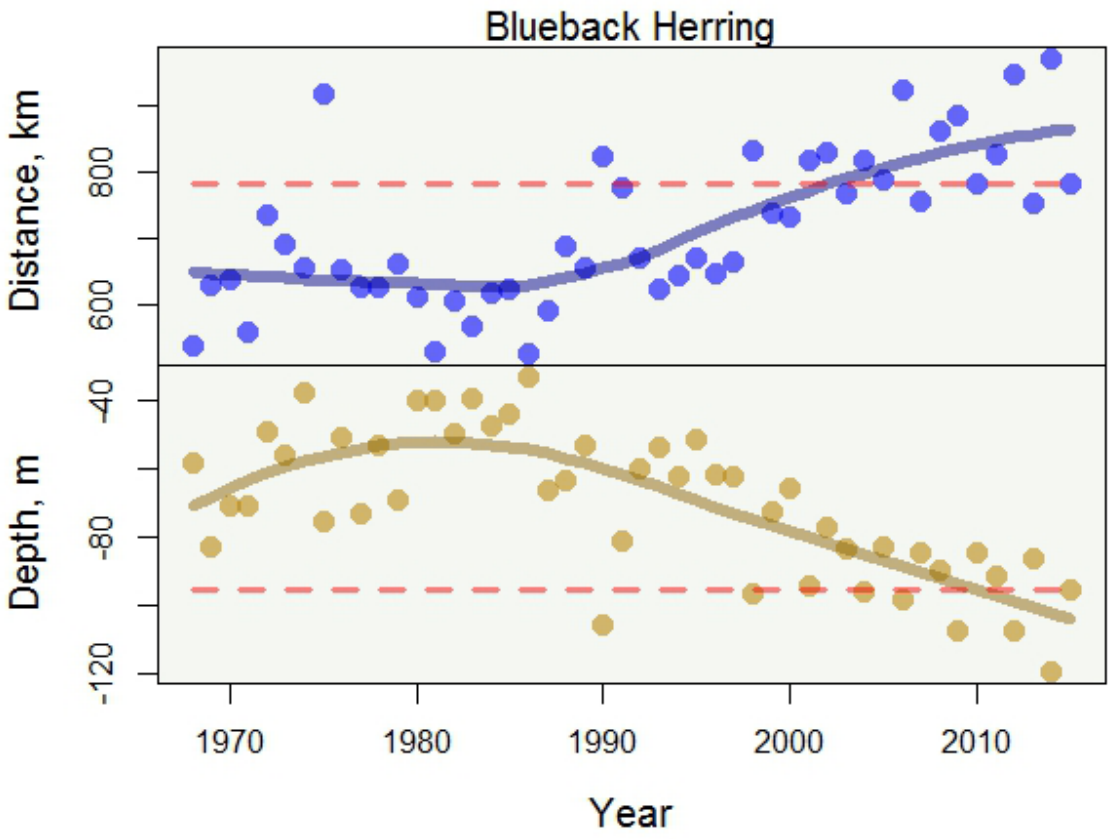
- **Black Sea Bass**



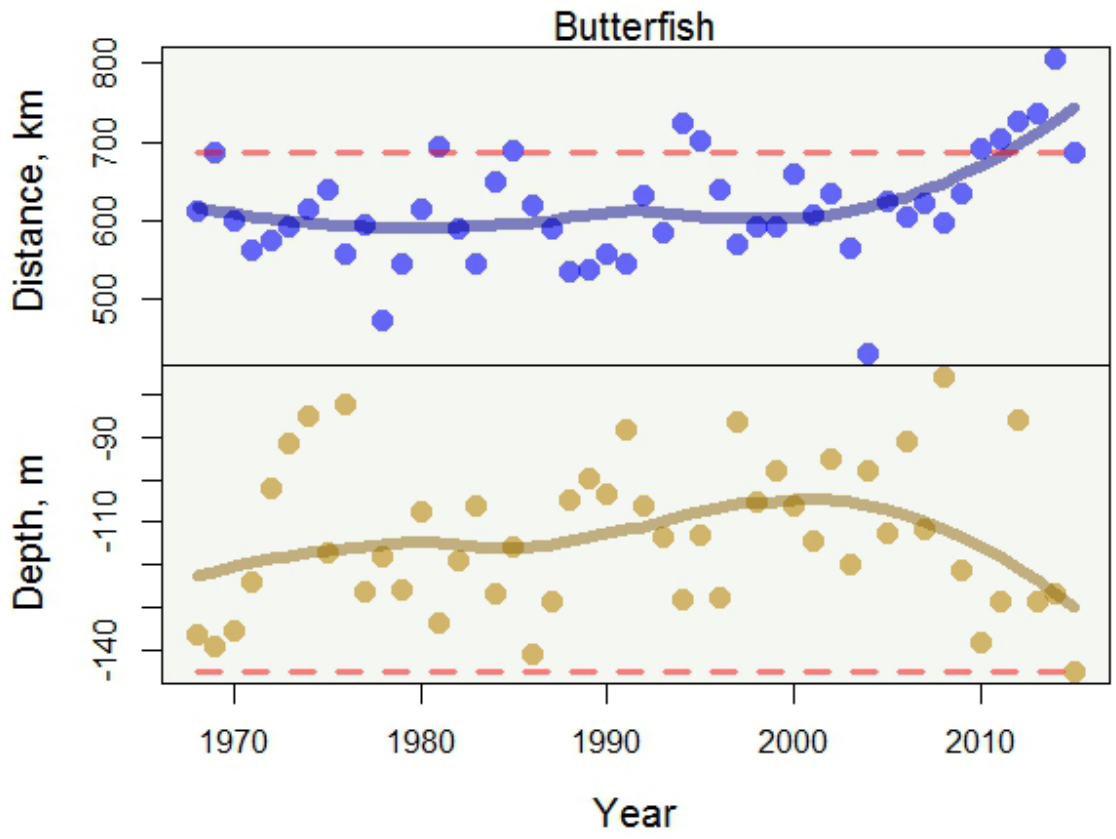
- **Blackbelly Rosefish**



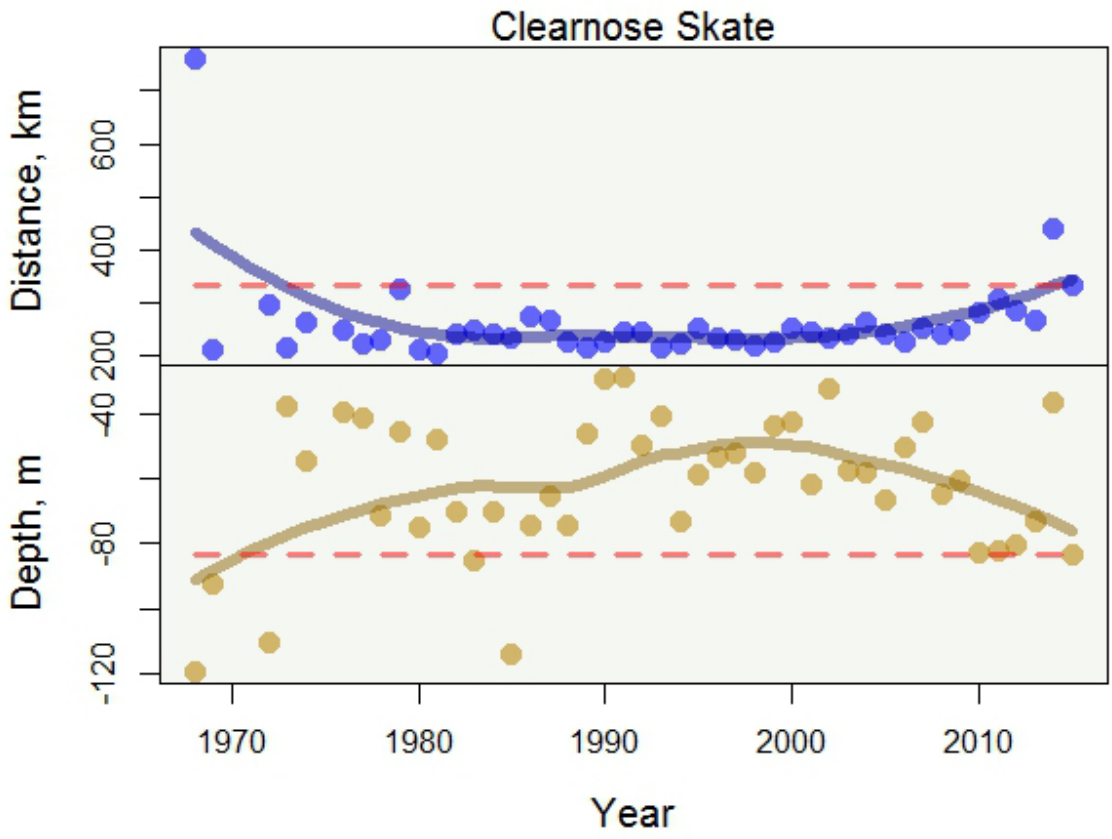
- **Blueback Herring**



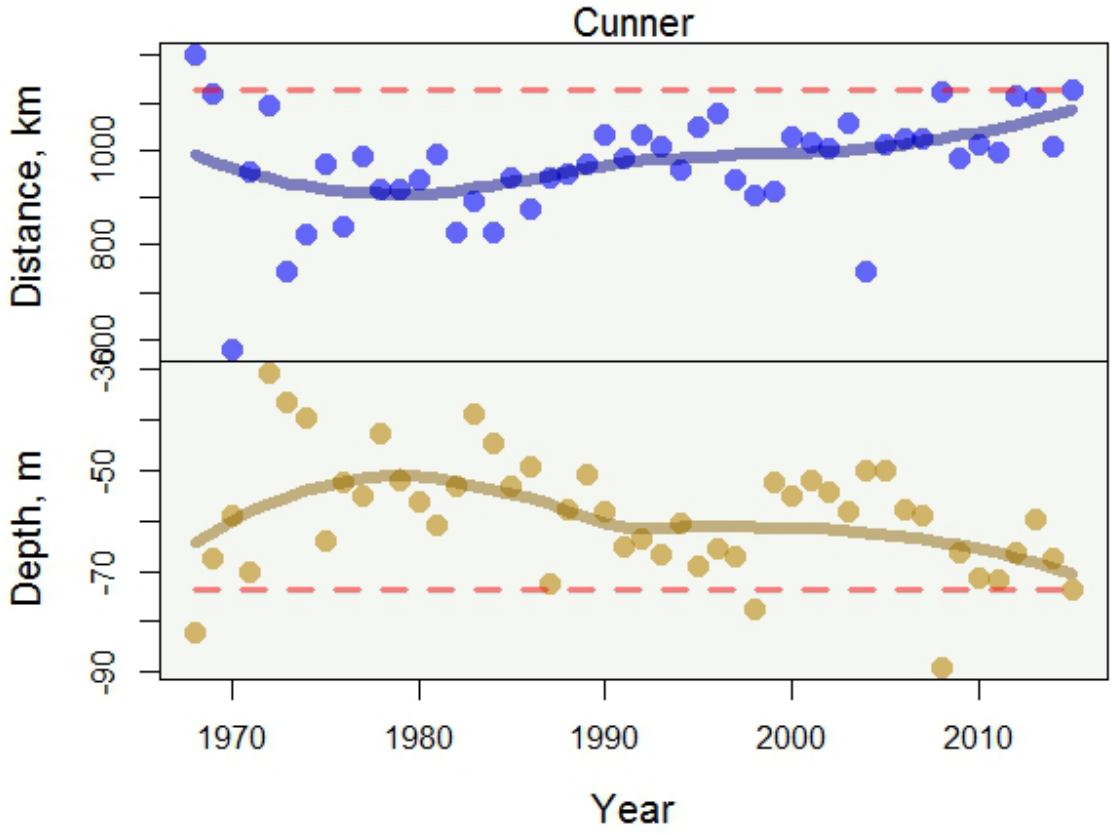
- **Butterfish**


Butterfish
Distance, km
500
600
700
800
Depth, m
-140
-110
-90
1970
1980
1990
2000
2010
Year

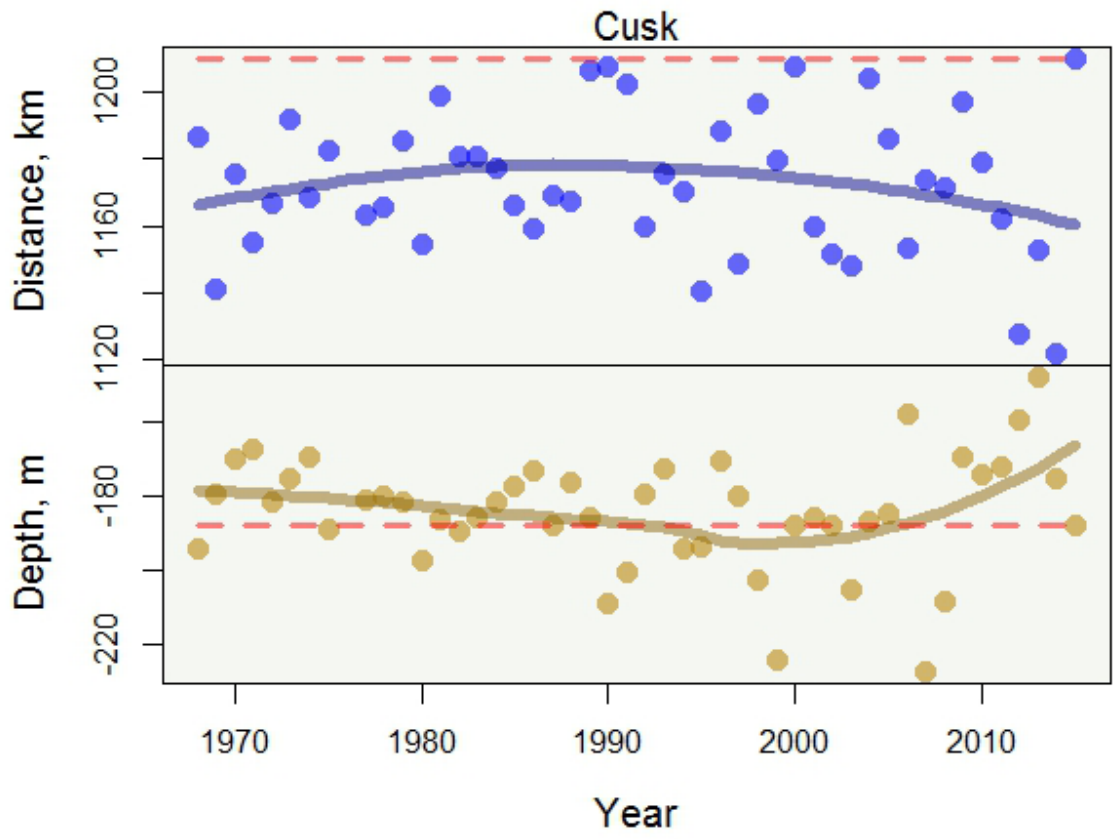
- **Clearnose Skate**



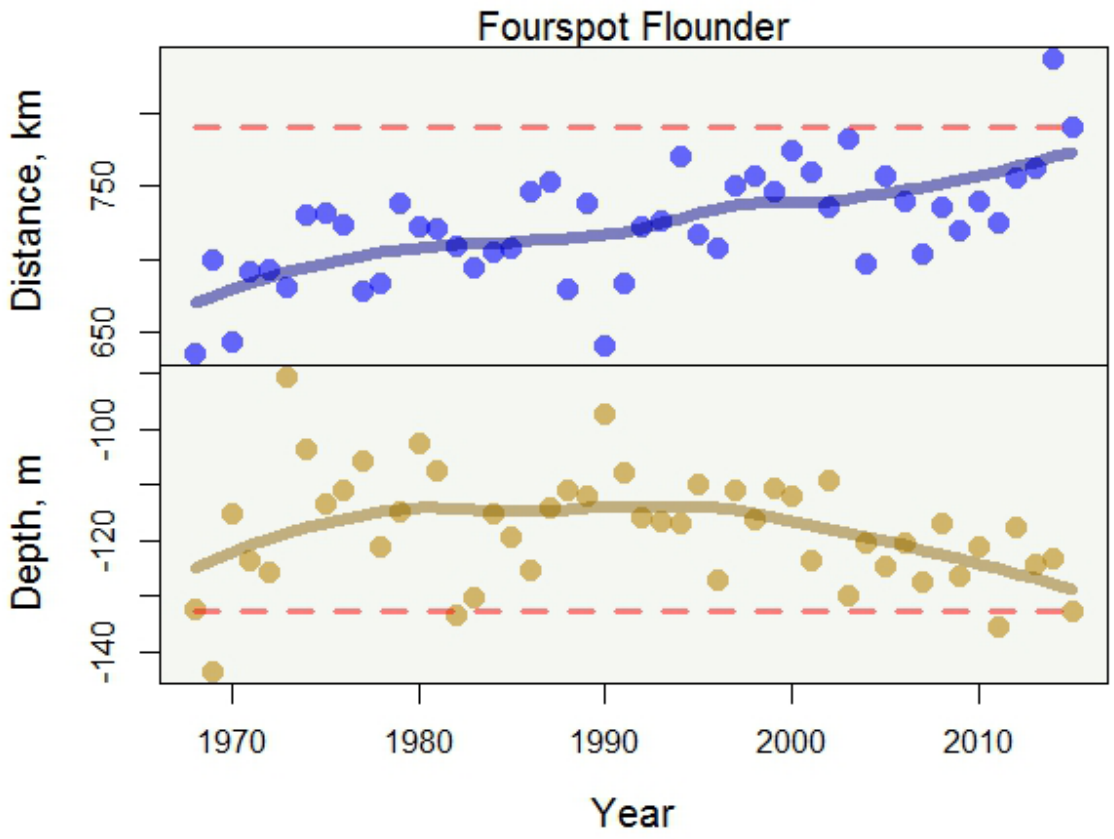
- **Cunner**


Cunner
Distance, km
1000
800
-3000
Depth, m
-50
-70
-90
1970
1980
1990
2000
2010
Year

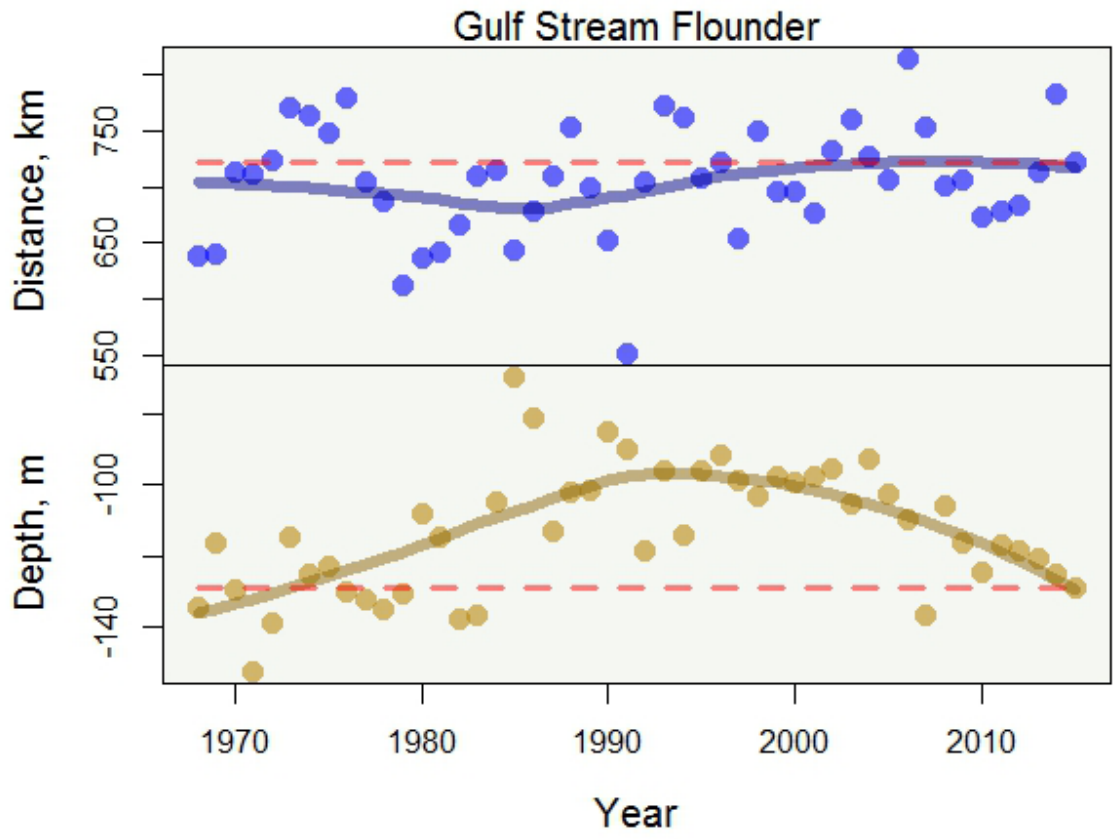
- **Cusk**


Cusk
Distance, km
1200
1160
1120
Depth, m
-180
-220
1970
1980
1990
2000
2010
Year

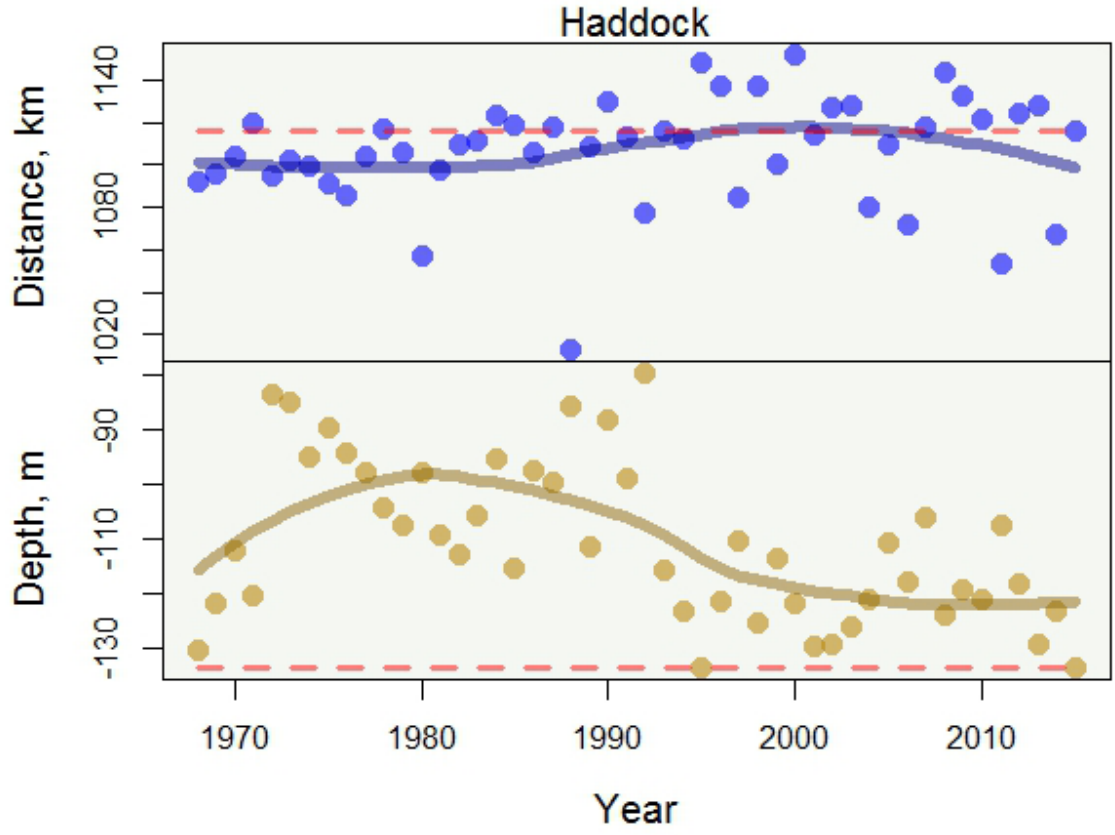
- **Fourspot Flounder**



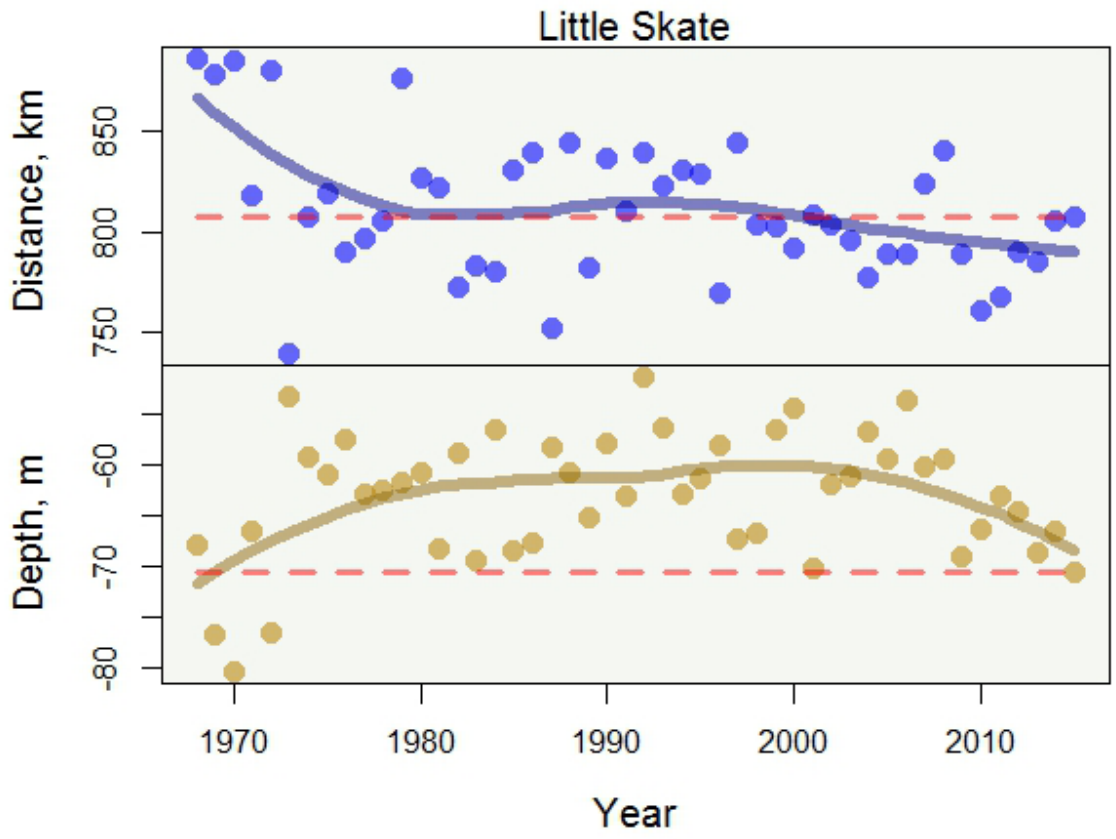
- **Gulf Stream Flounder**



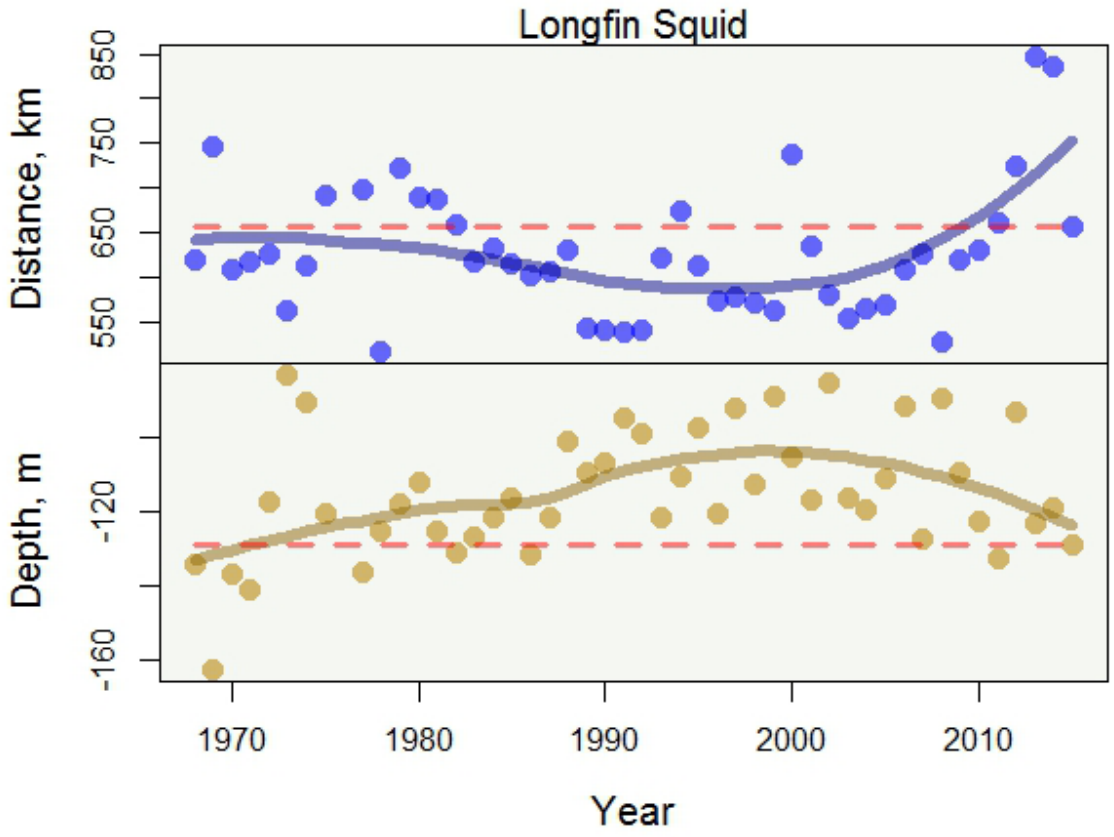
- **Haddock**


Haddock
Distance, km
1140
1080
1020
Depth, m
-90
-110
-130
1970
1980
1990
2000
2010
Year

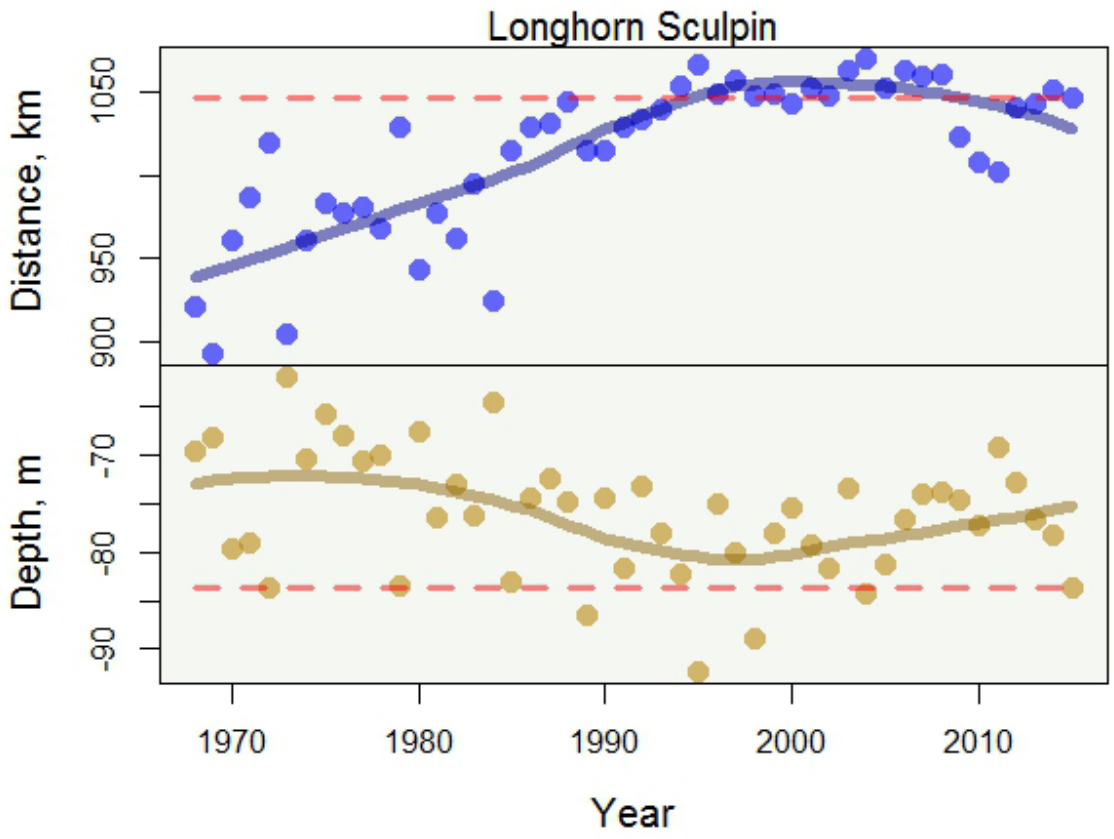
- **Little Skate**



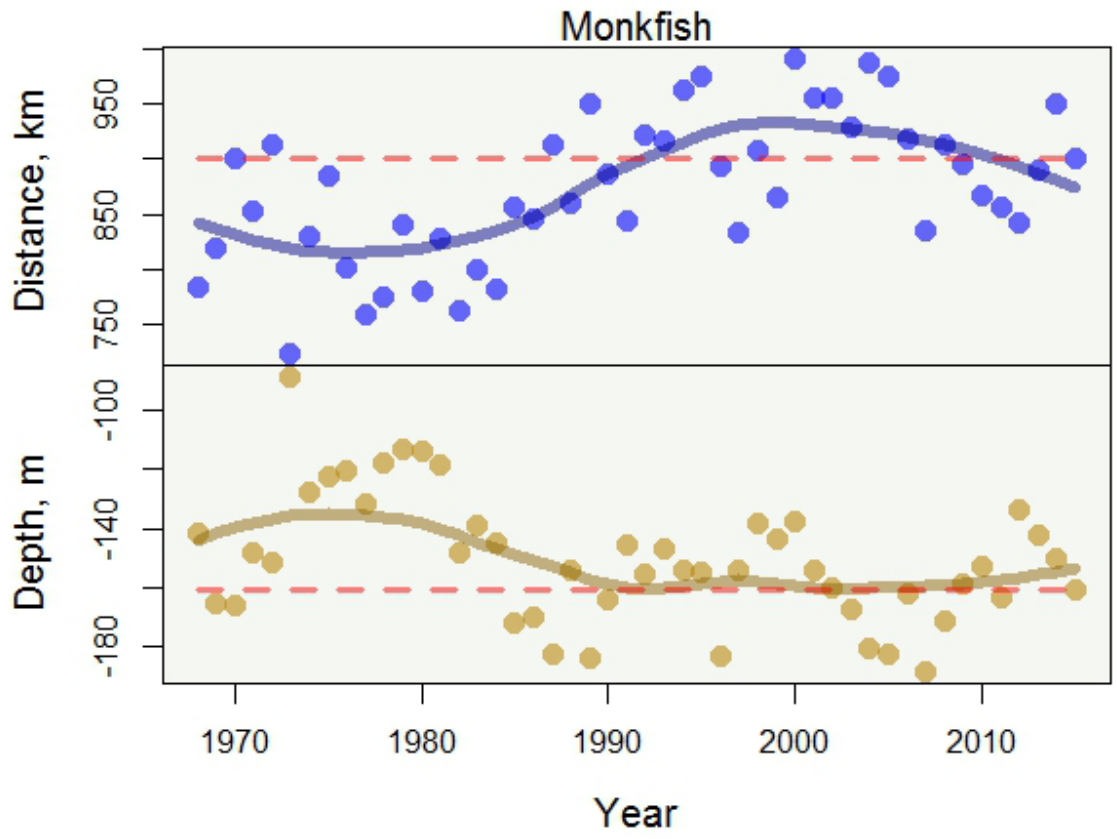
- **Longfin Squid**



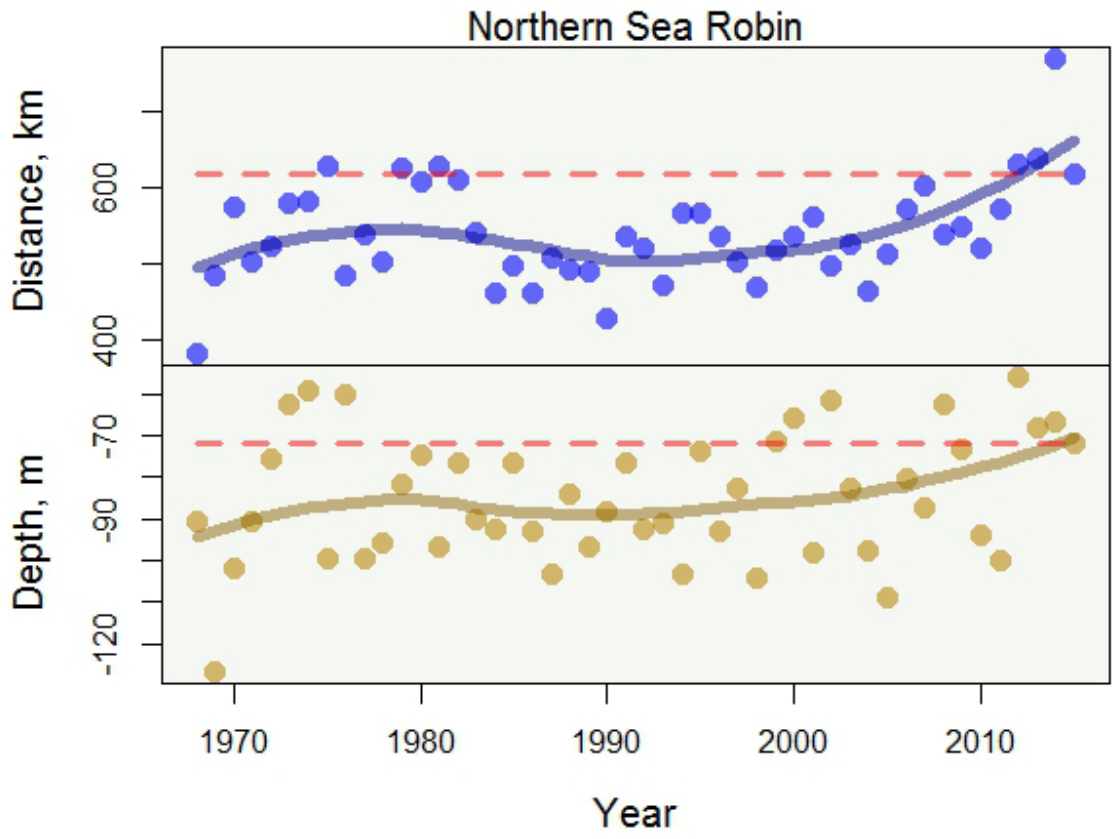
- **Longhorn Sculpin**



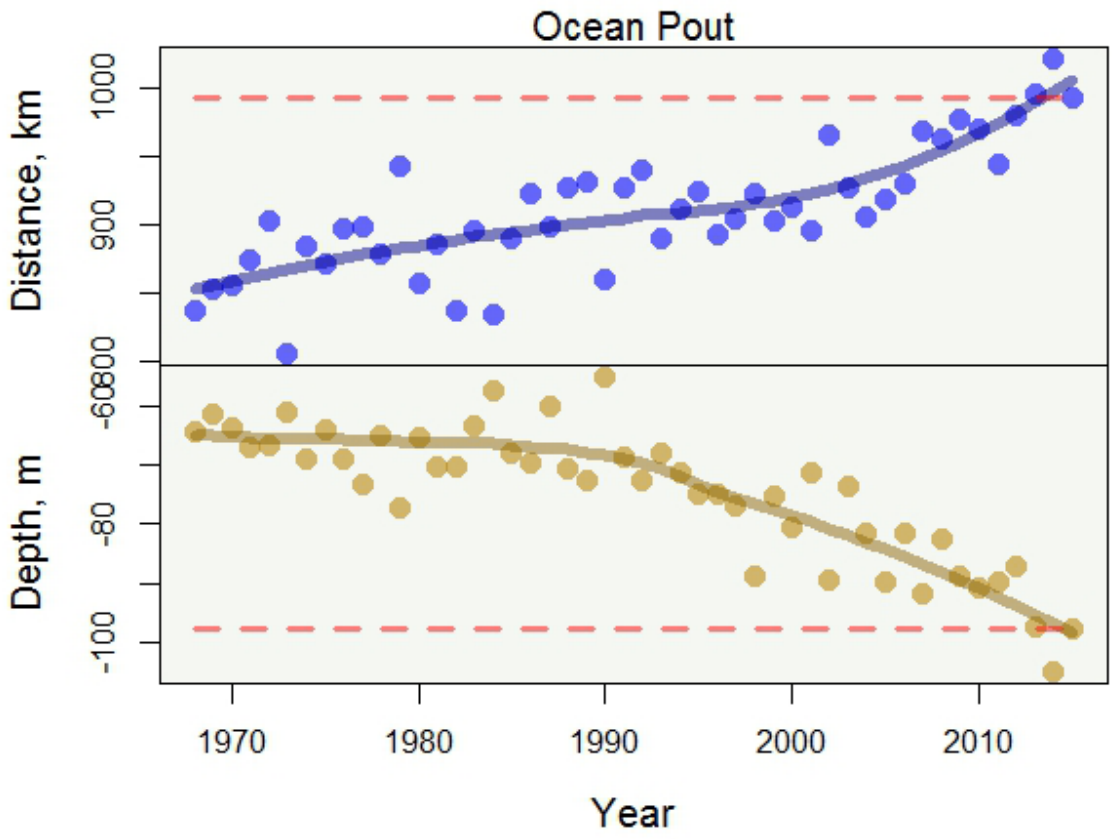
- **Monkfish**


Monkfish
Distance, km
950
850
750
Depth, m
-100
-140
-180
1970
1980
1990
2000
2010
Year

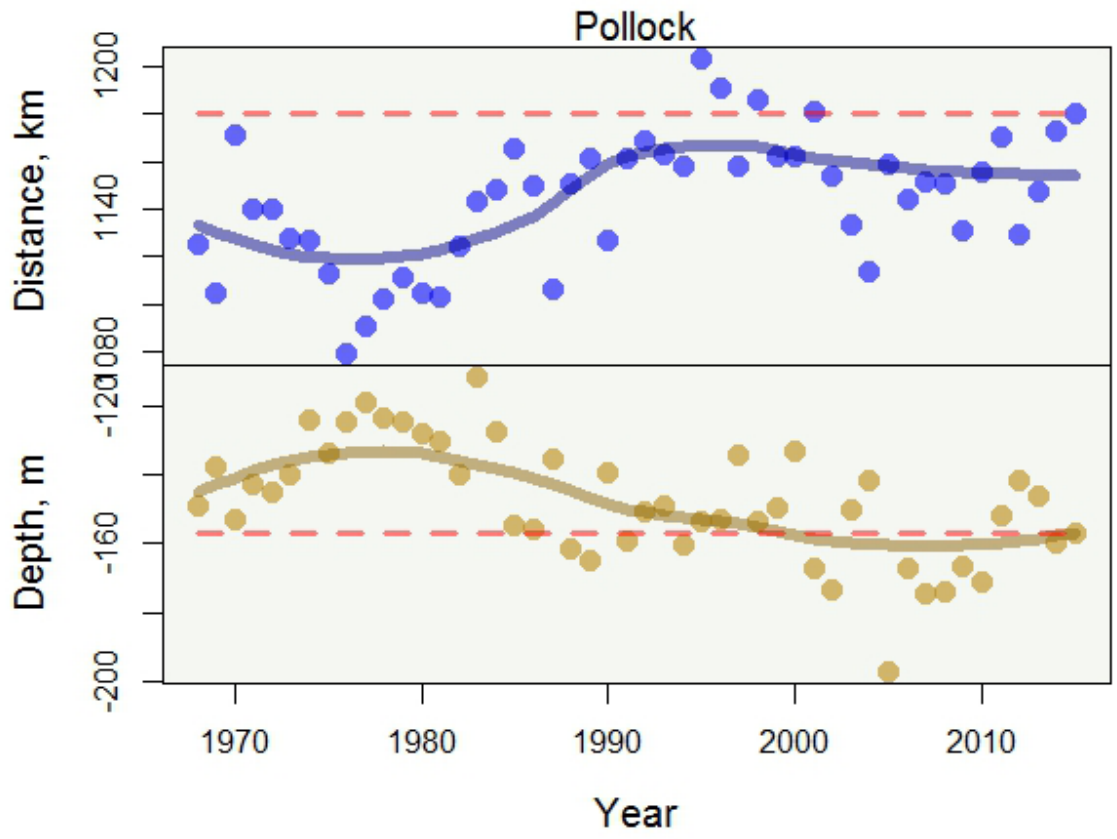
- **Northern Sea Robin**



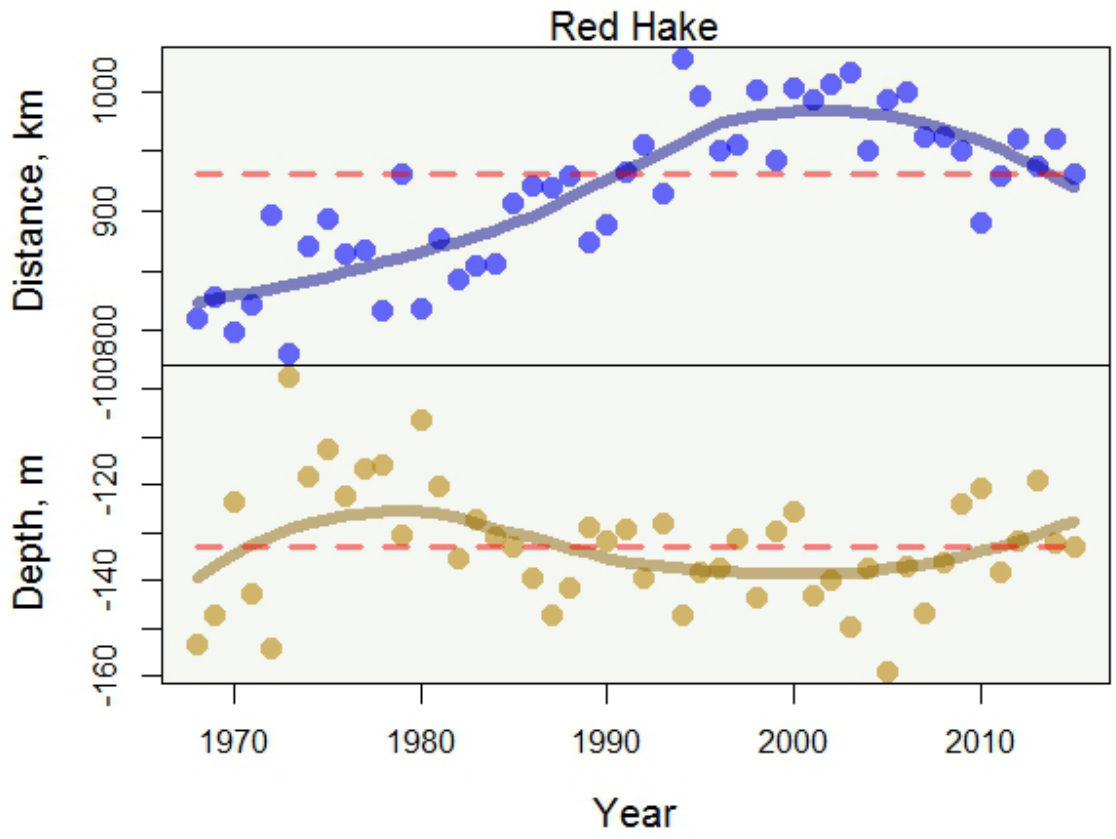
- **Ocean Pout**


Ocean Pout
Distance, km
1000
900
800
Depth, m
-60
-80
-100
1970
1980
1990
2000
2010
Year

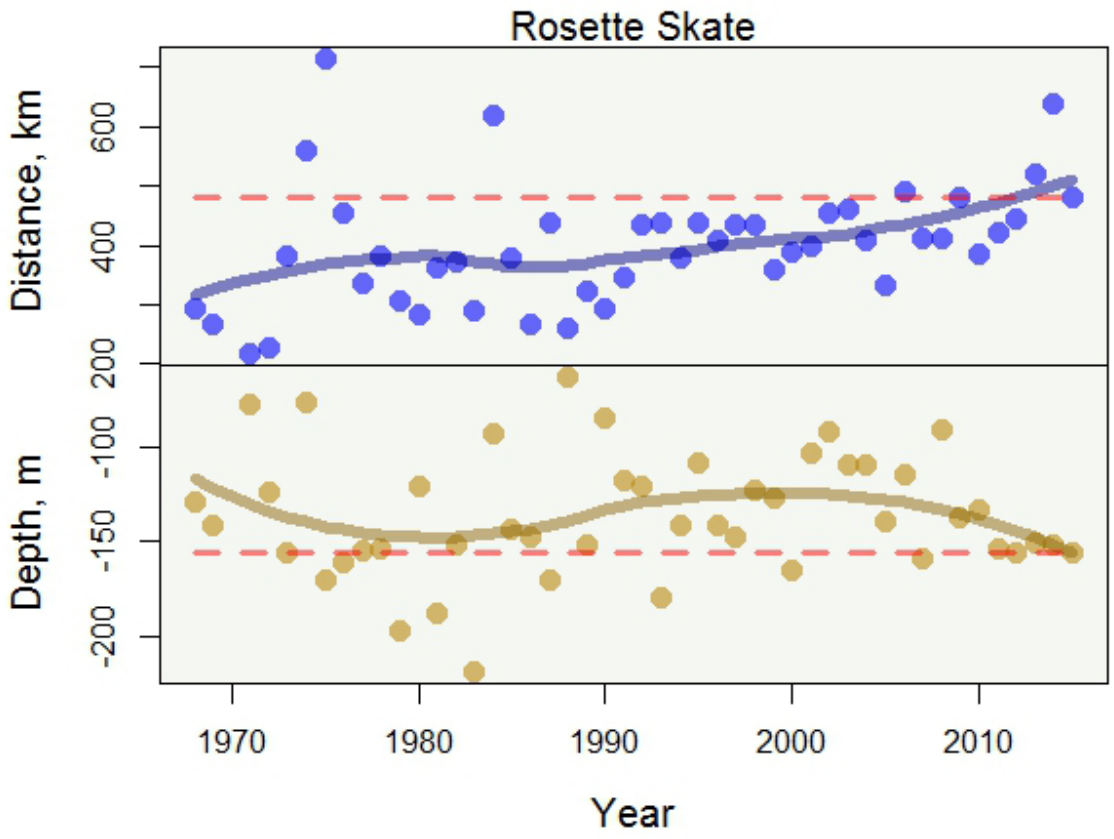
- **Pollock**


Pollock
Distance, km
1200
1140
1080
Depth, m
-120
-160
-200
1970
1980
1990
2000
2010
Year

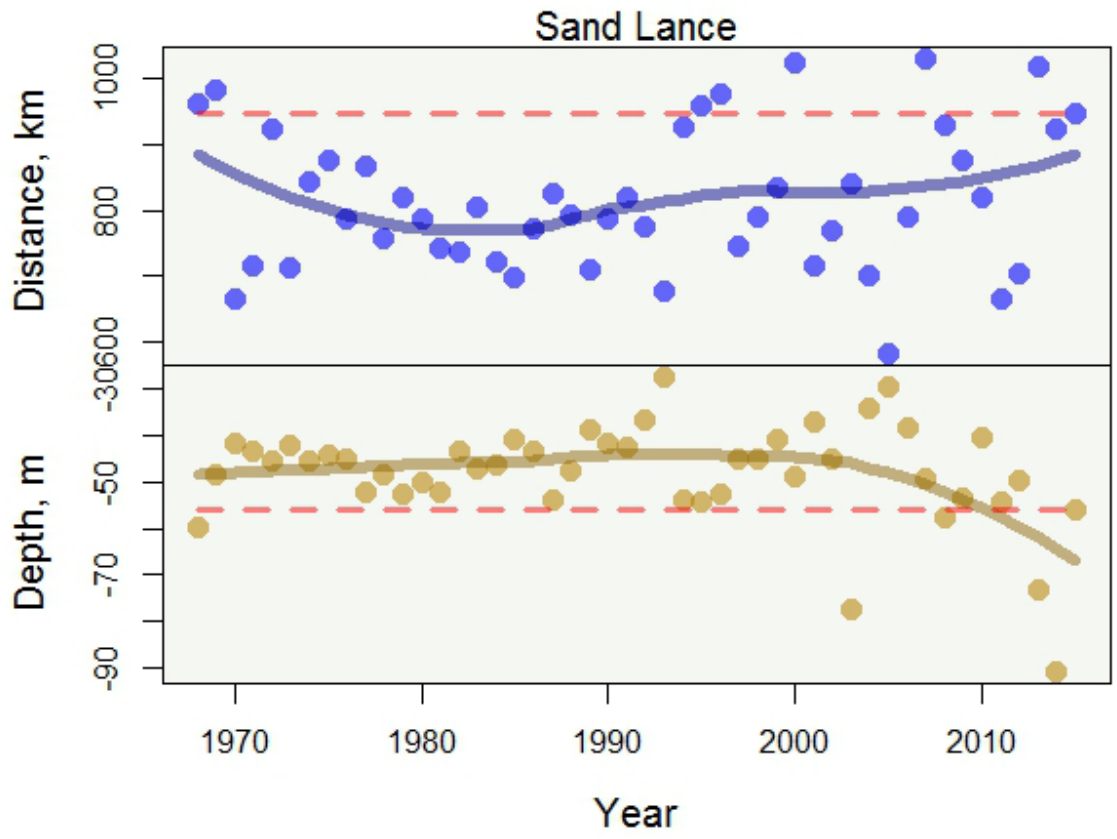
- **Red Hake**


Red Hake
Distance, km
1000
900
800
Depth, m
-100
-120
-140
-160
1970
1980
1990
2000
2010
Year

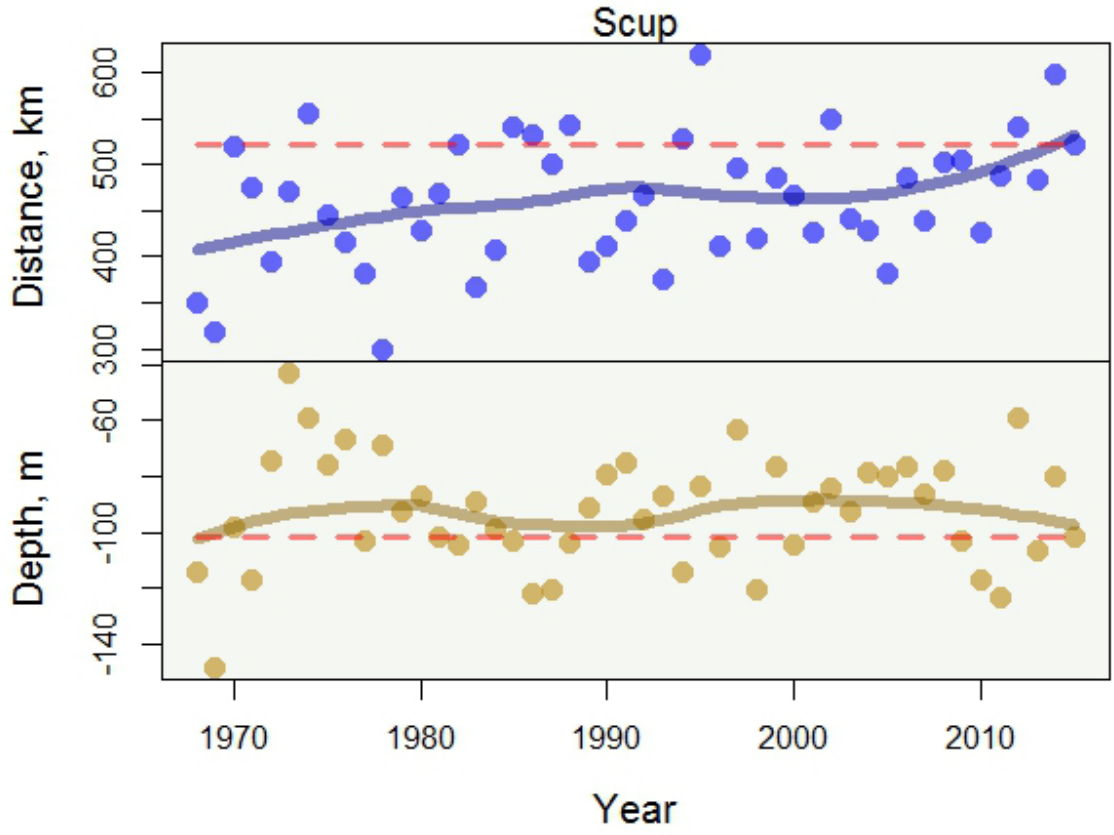
- **Rosette Skate**



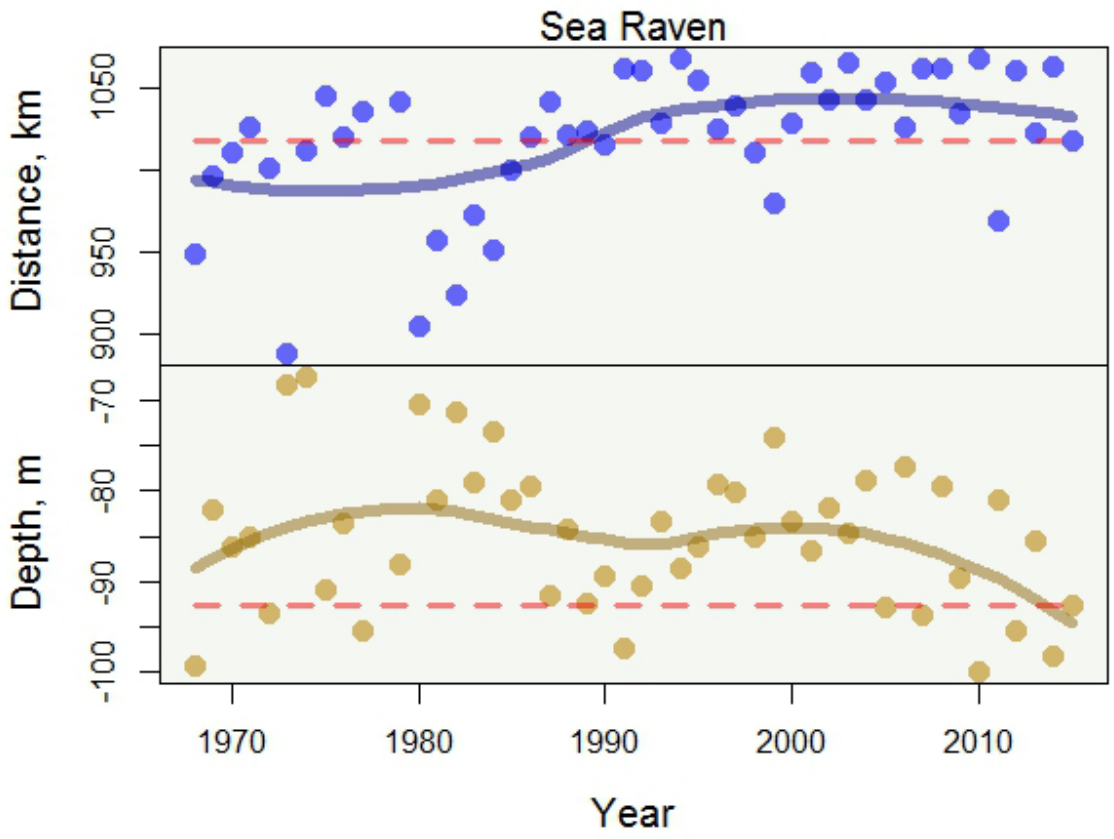
- **Sand Lance**


Sand Lance
Distance, km
1000
800
-30600
Depth, m
-50
-70
-90
1970
1980
1990
2000
2010
Year

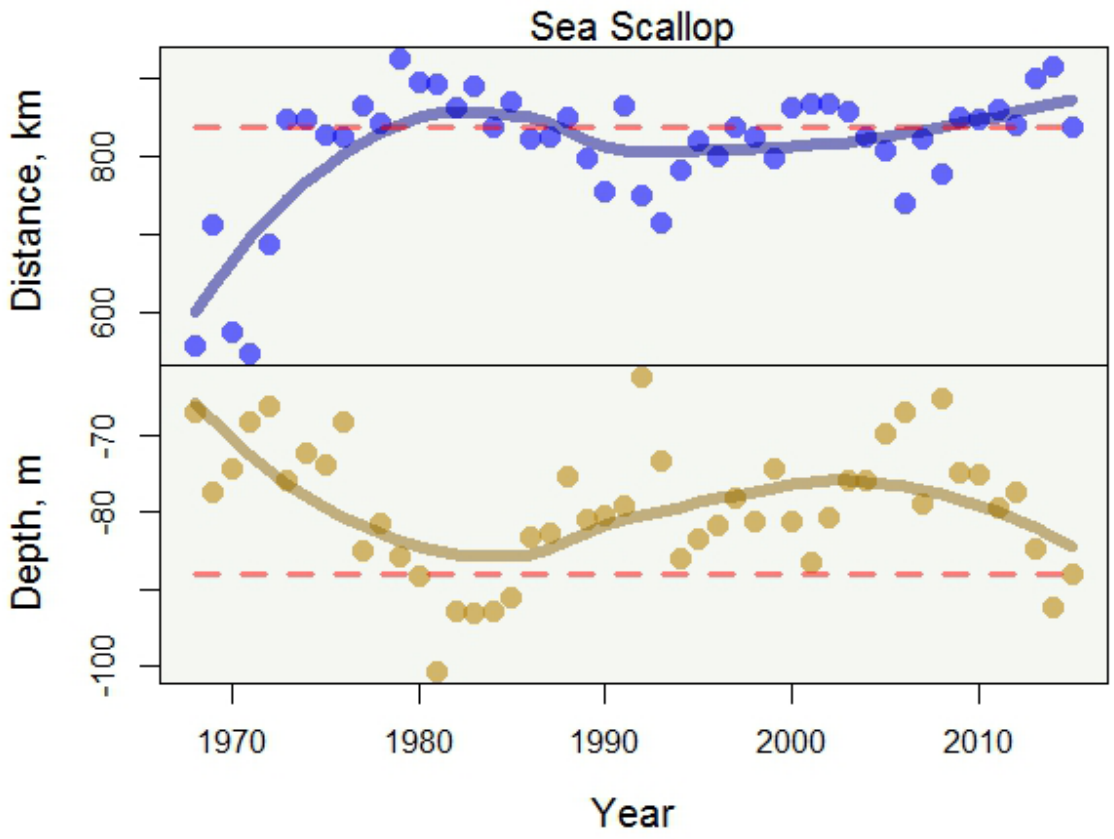
- **Scup**


Scup
Distance, km
600
500
400
300
Depth, m
-60
-100
-140
1970
1980
1990
2000
2010
Year

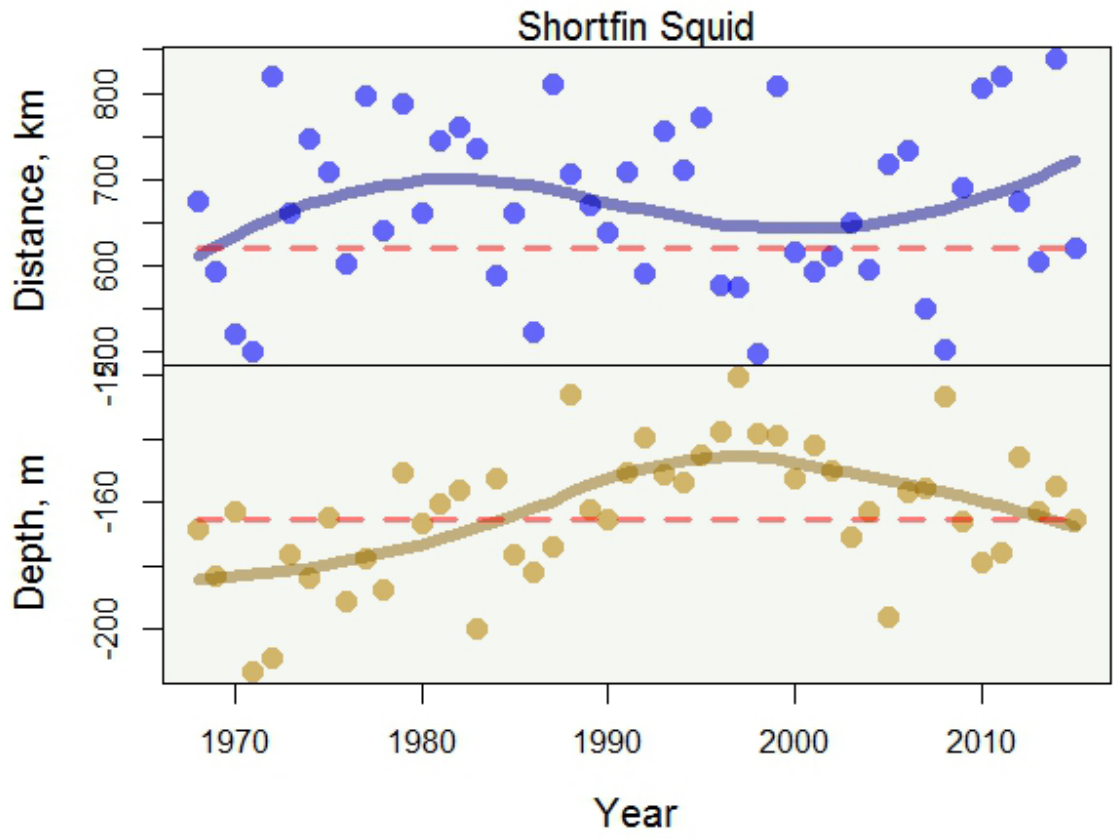
- **Sea Raven**


Sea Raven
Distance, km
1050
950
900
Depth, m
-70
-80
-90
-100
1970
1980
1990
2000
2010
Year

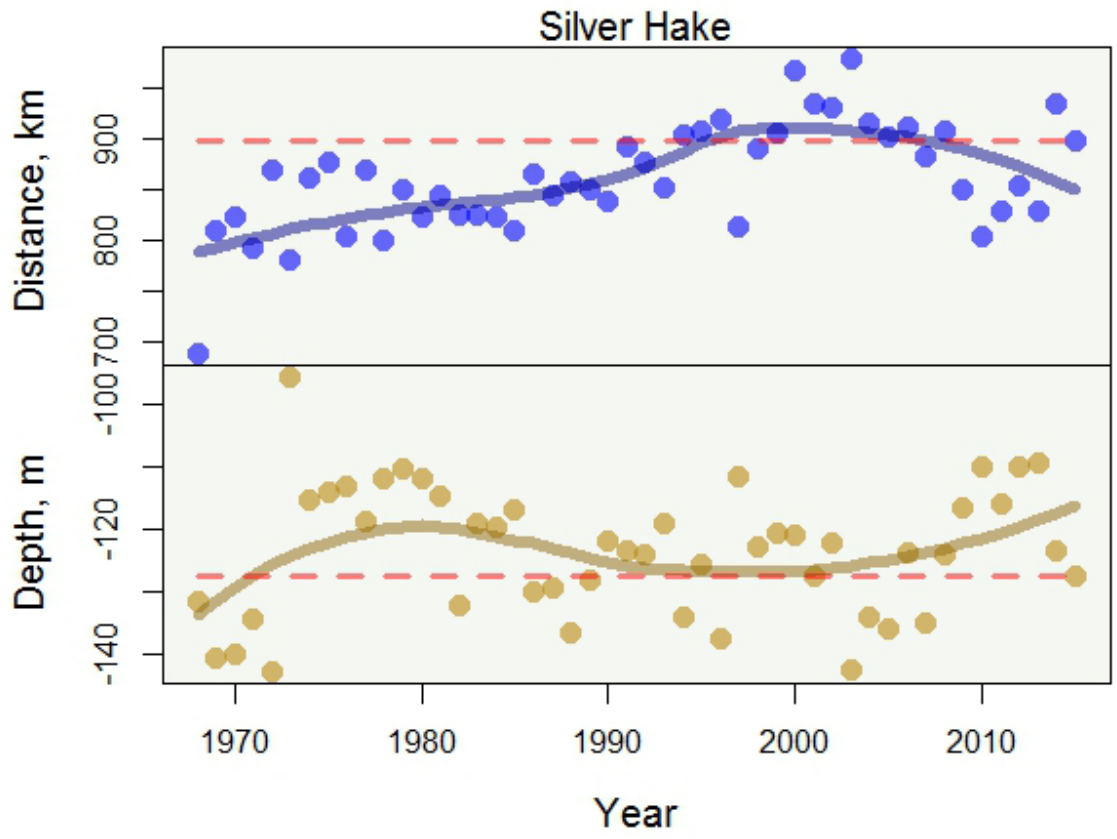
- **Sea Scallop**


Sea Scallop
Distance, km
800
600
Depth, m
-70
-80
-100
1970
1980
1990
2000
2010
Year

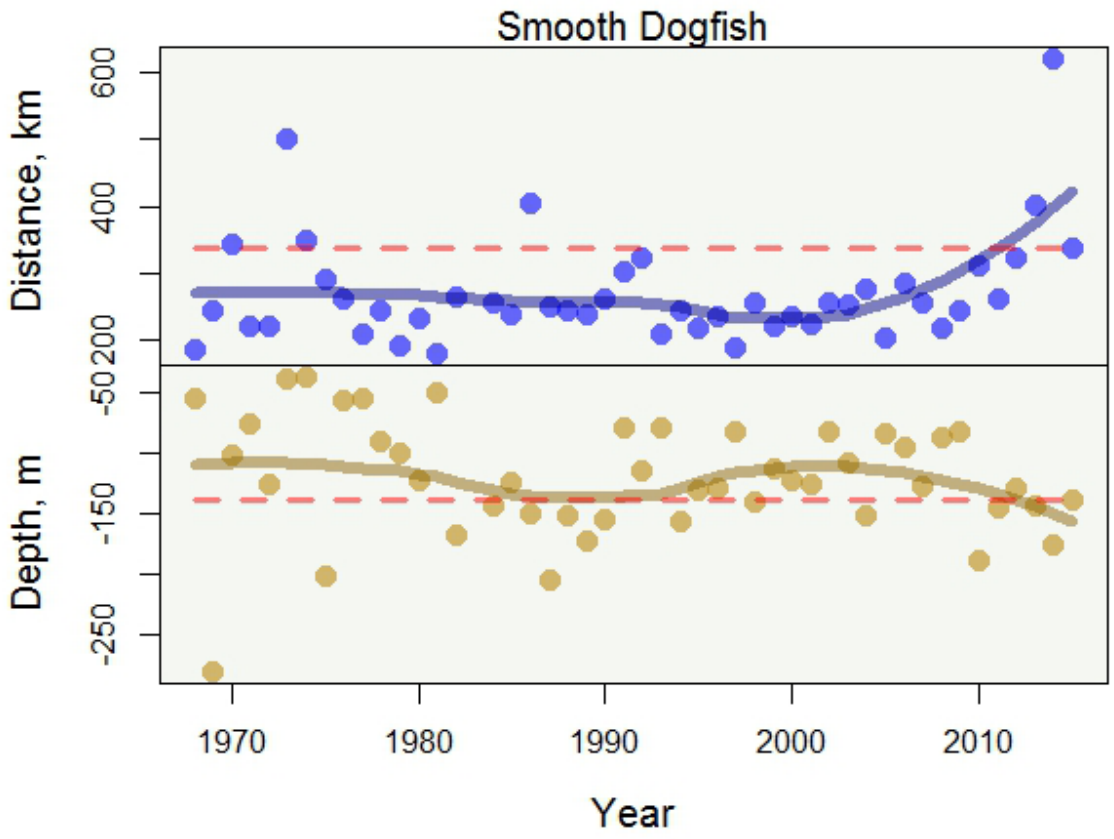
- **Shortfin Squid**



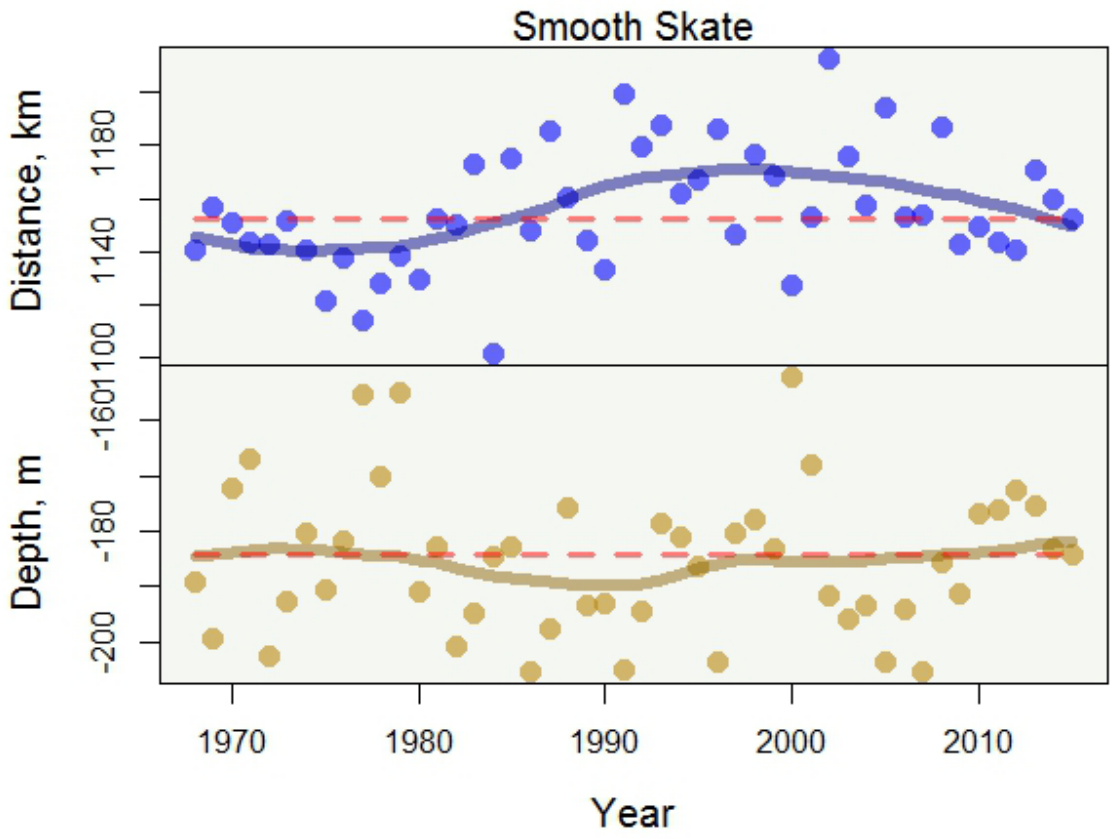
- **Silver Hake**


Silver Hake
Distance, km
900
800
700
Depth, m
-100
-120
-140
1970
1980
1990
2000
2010
Year

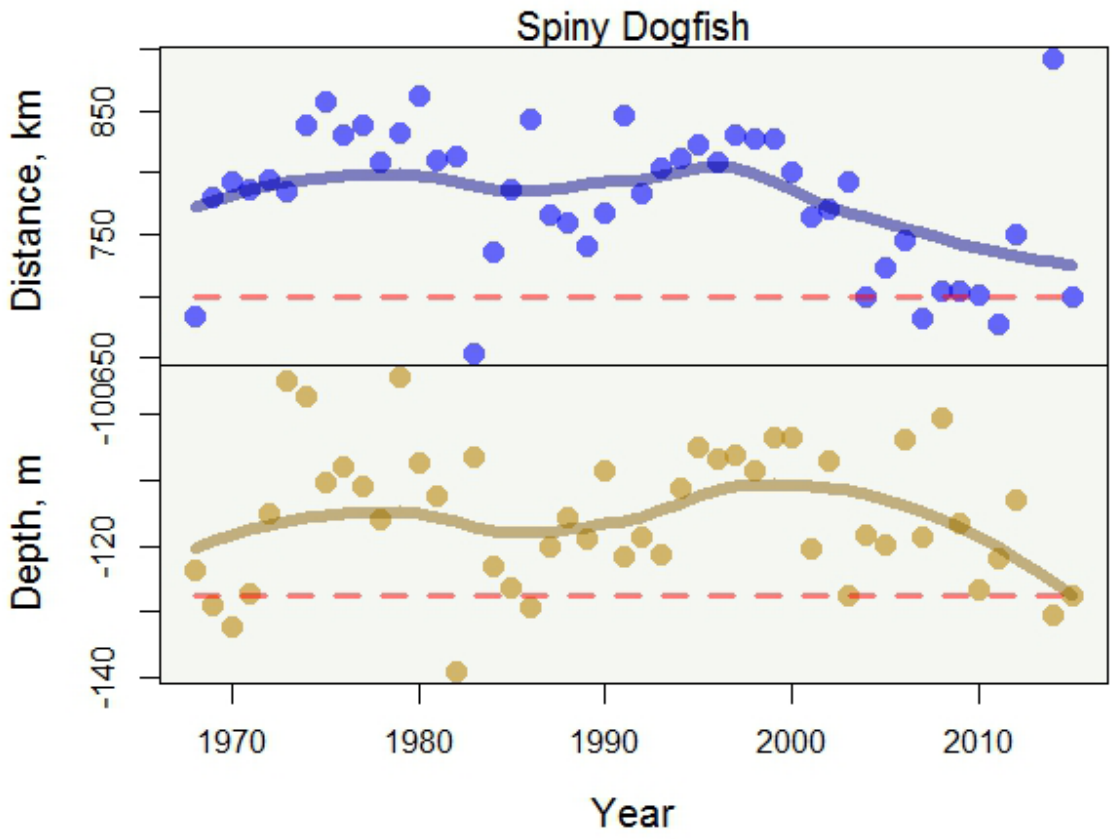
- **Smooth Dogfish**



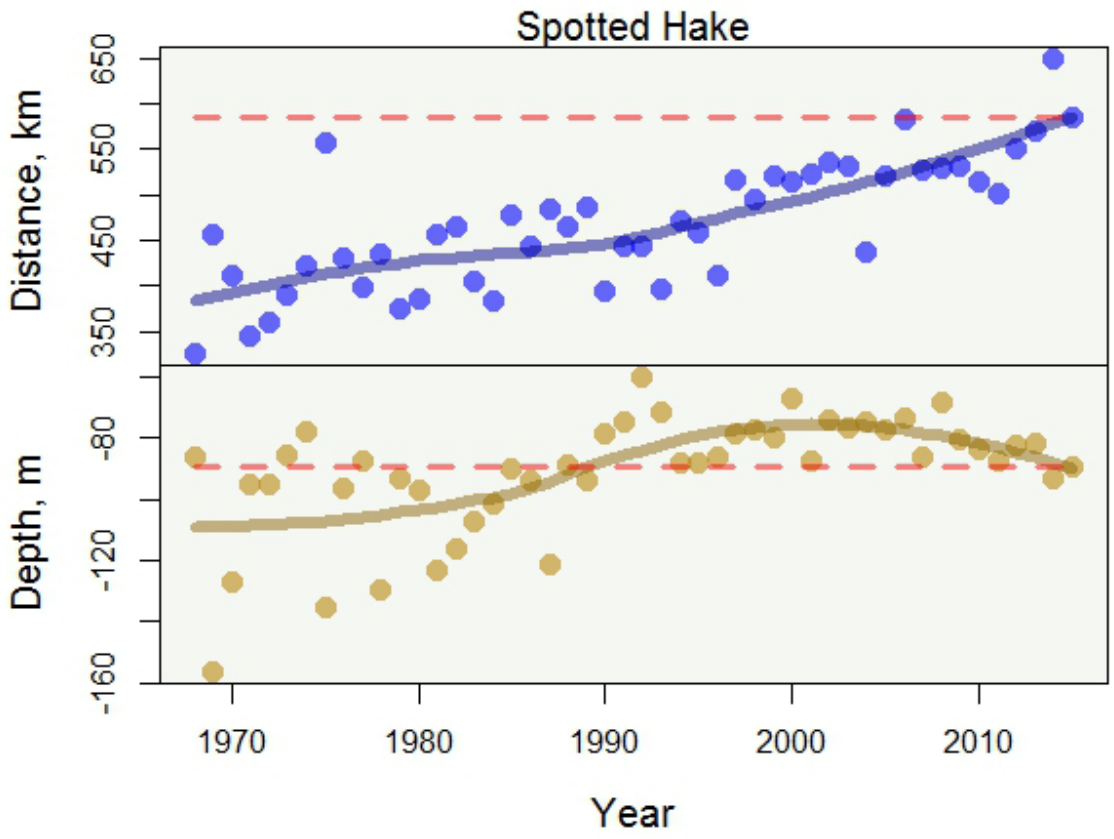
- **Smooth Skate**



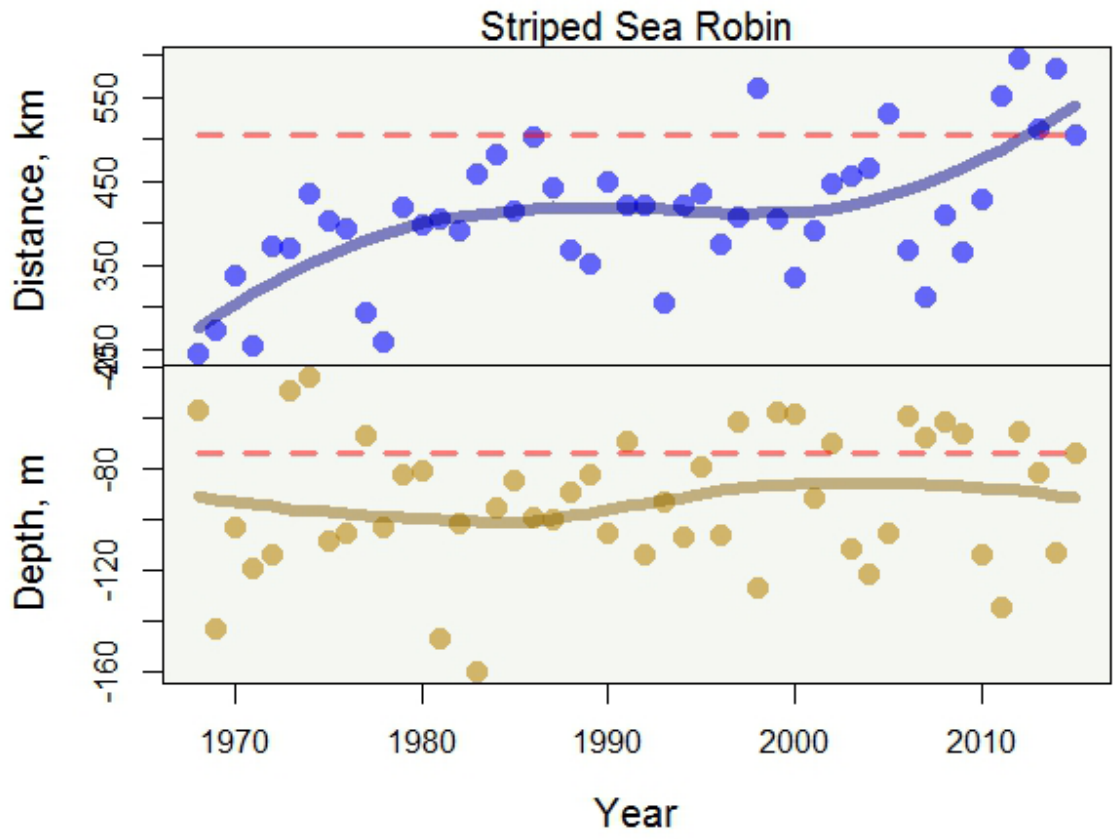
- **Spiny Dogfish**



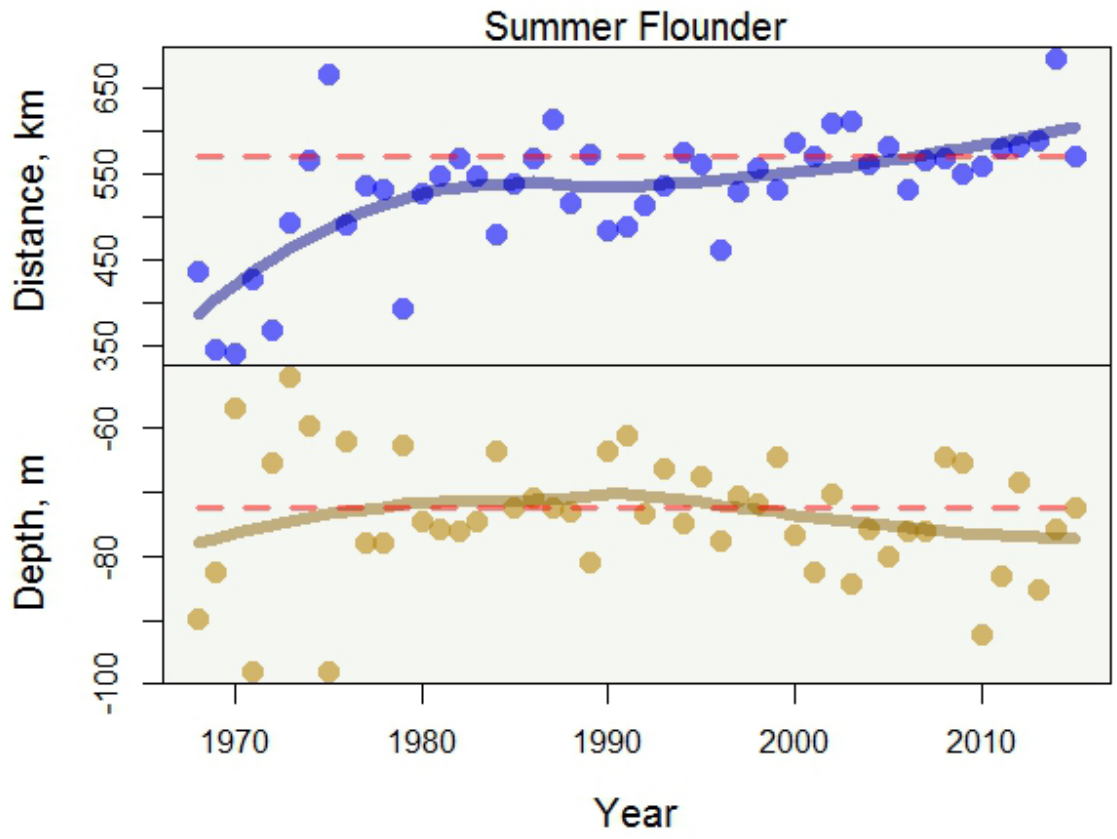
- **Spotted Hake**



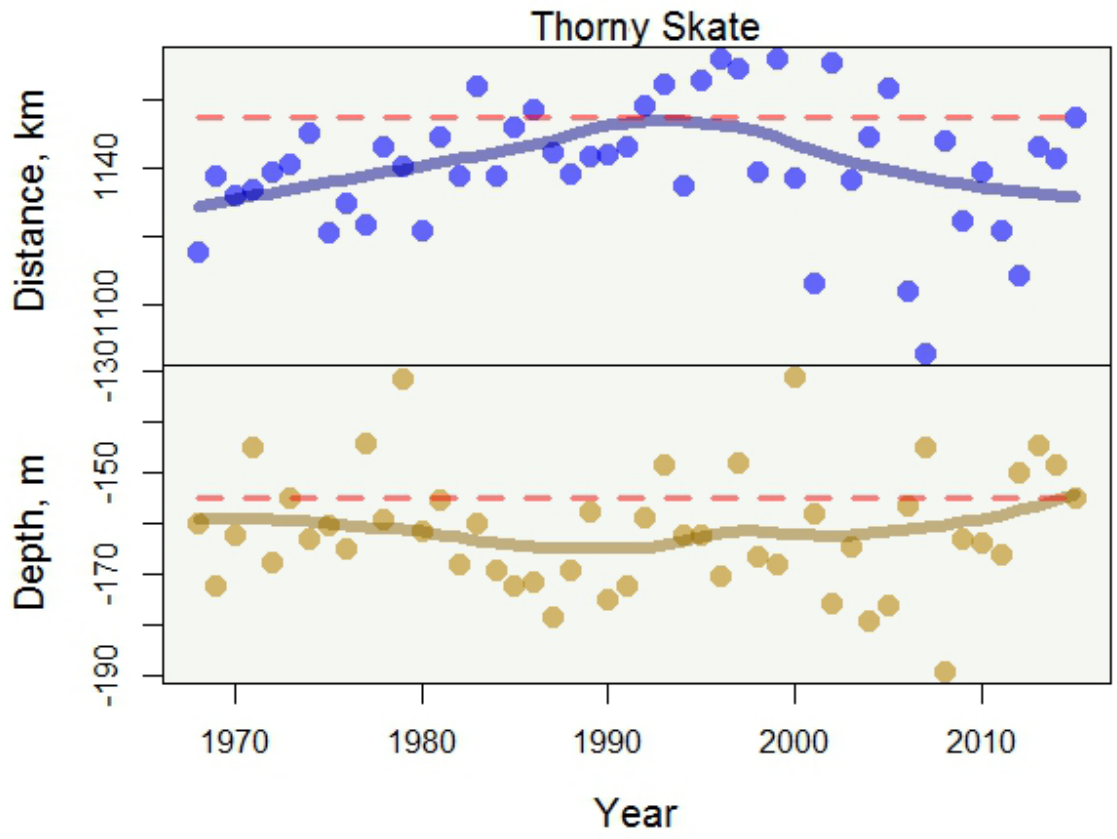
- **Striped Sea Robin**



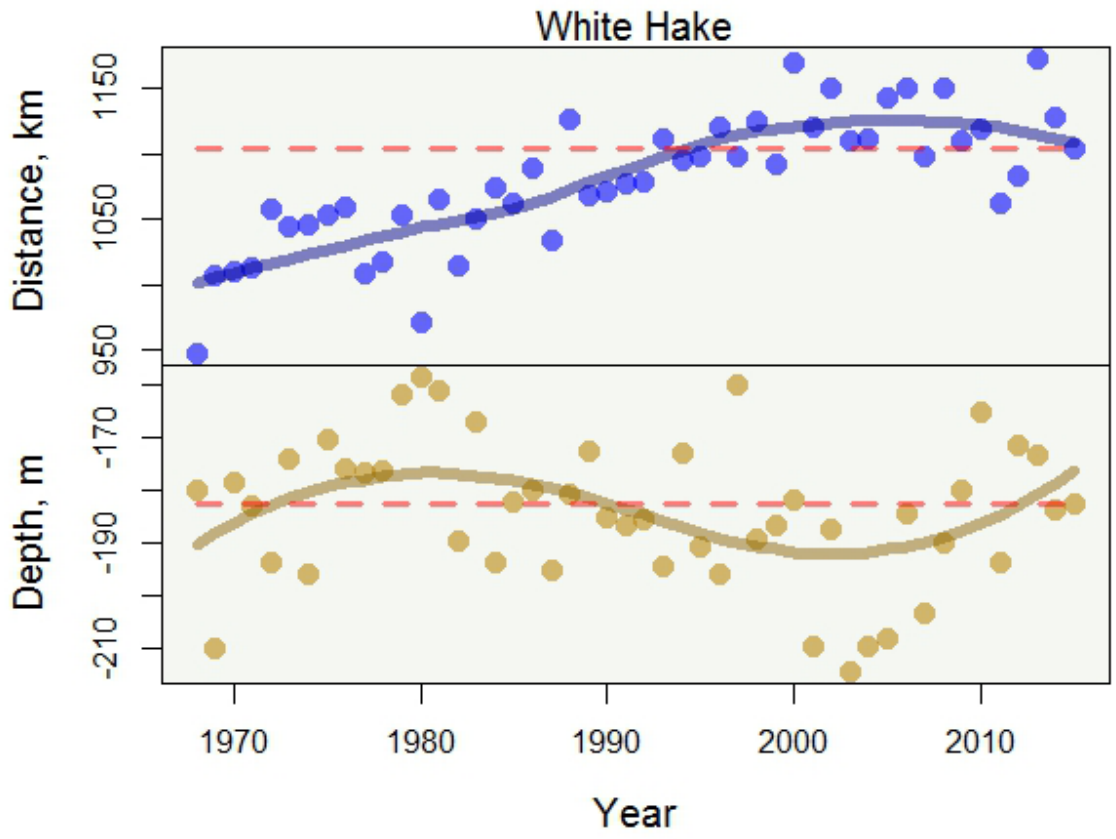
- **Summer Flounder**



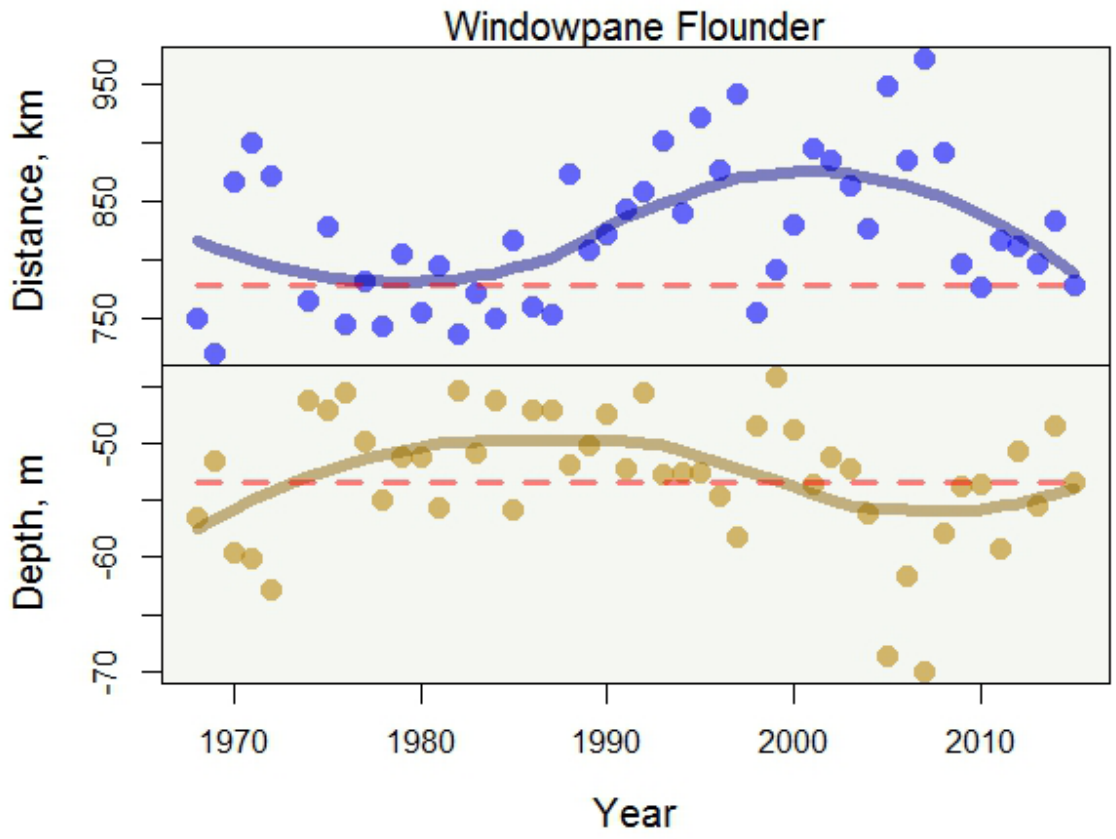
- **Thorny Skate**



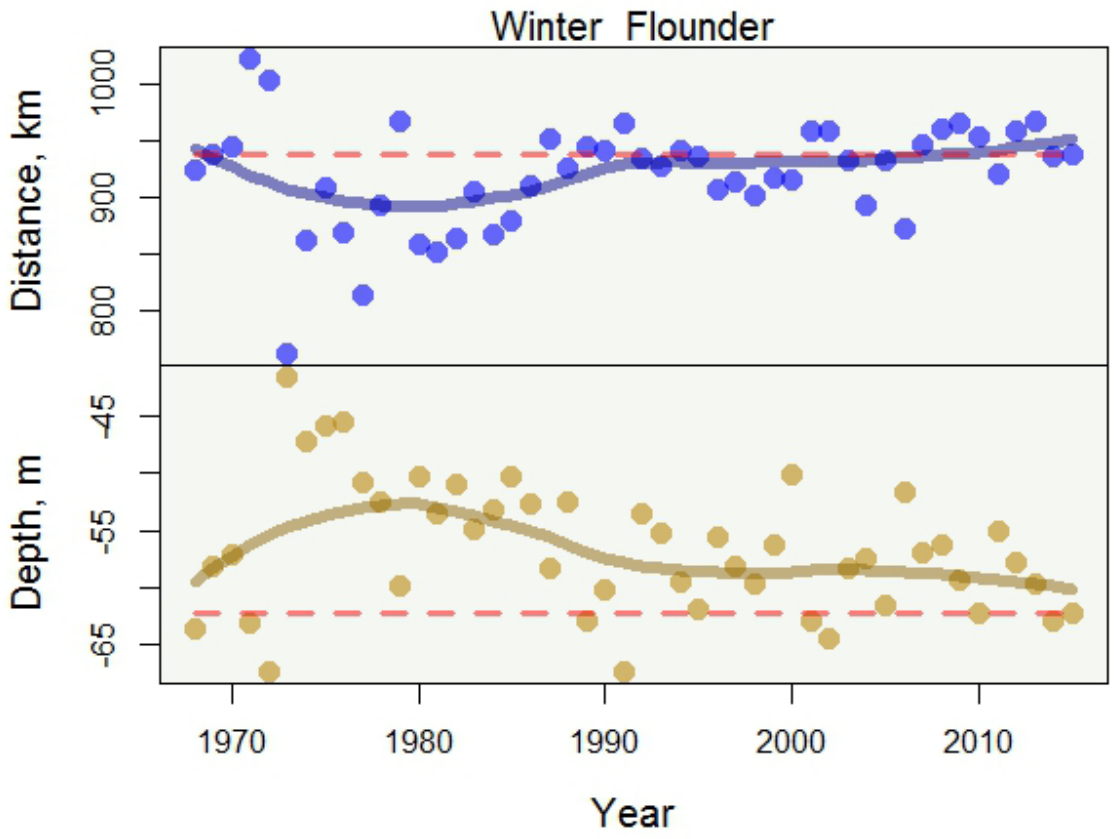
- **White Hake**


White Hake
Distance, km
1150
1050
950
Depth, m
-170
-190
-210
1970
1980
1990
2000
2010
Year

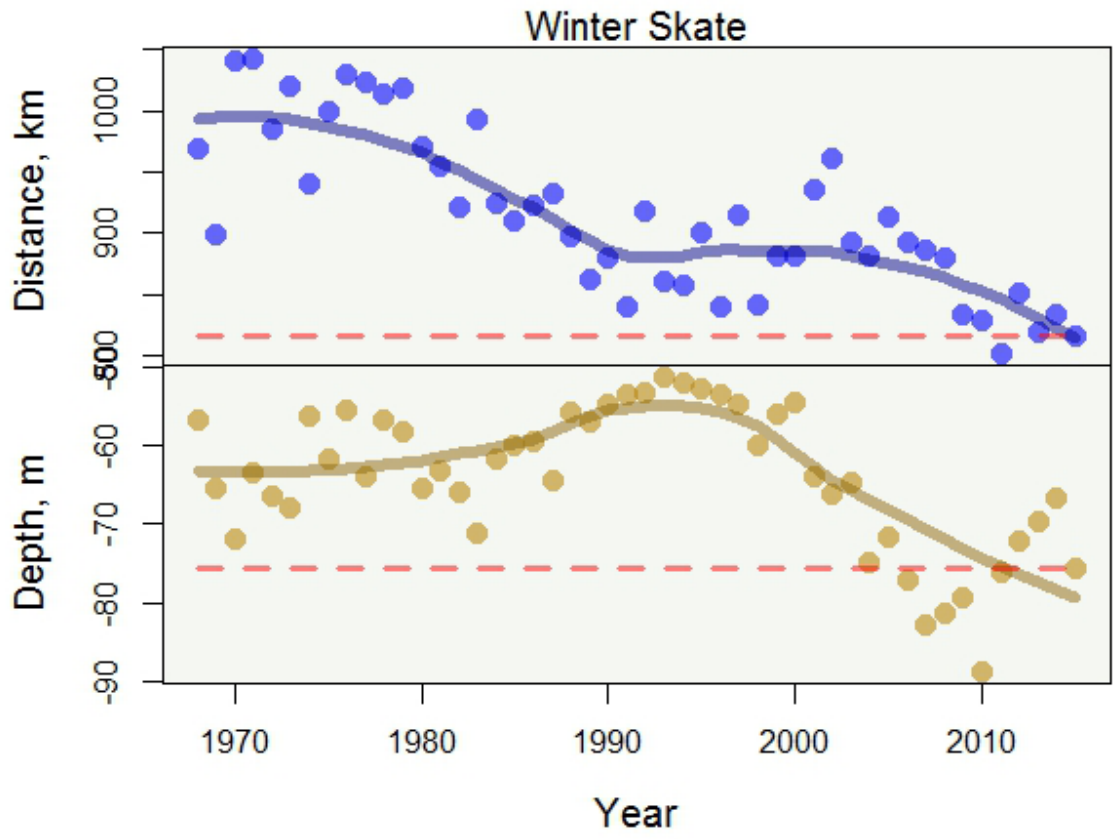
- **Windowpane Flounder**



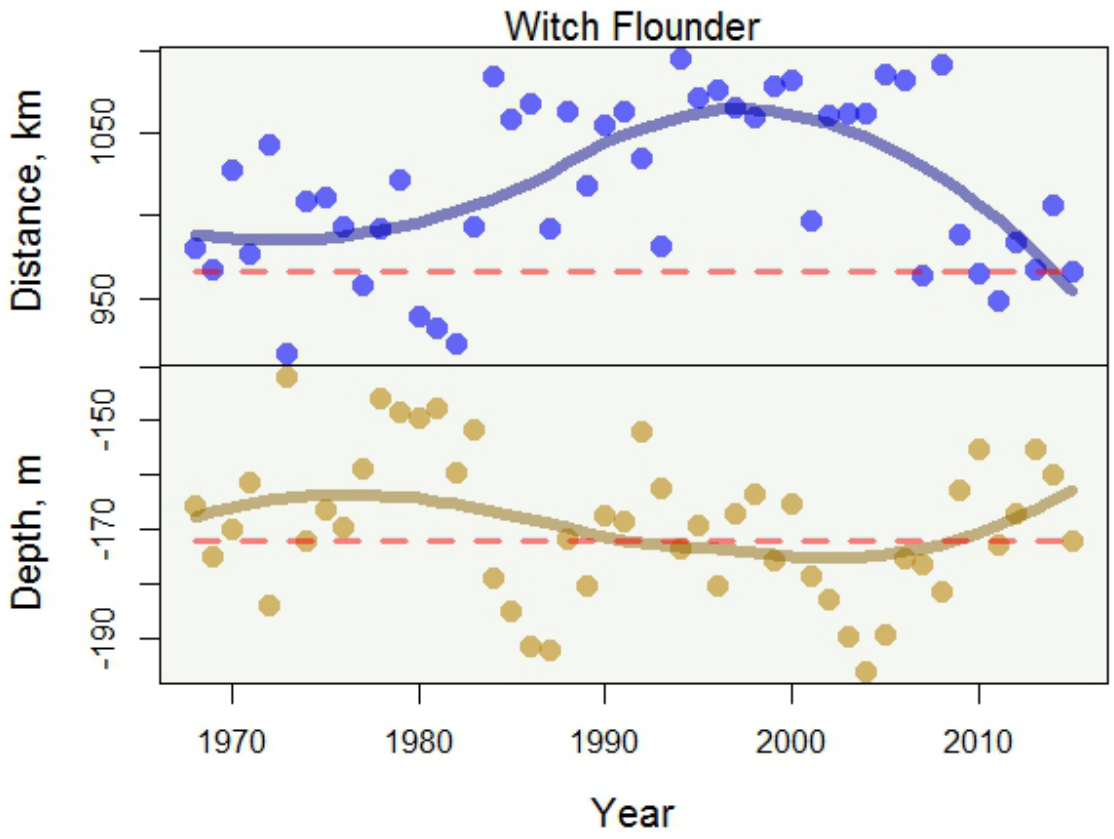
- **Winter Flounder**



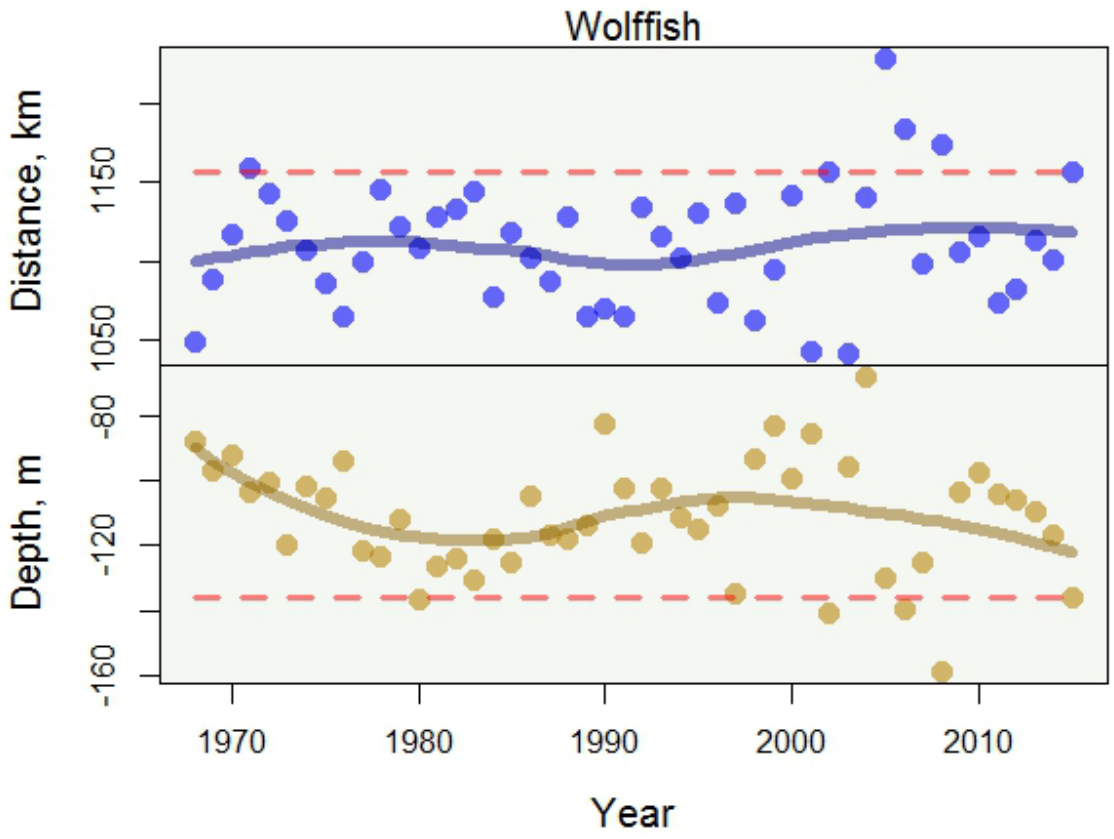
- **Winter Skate**



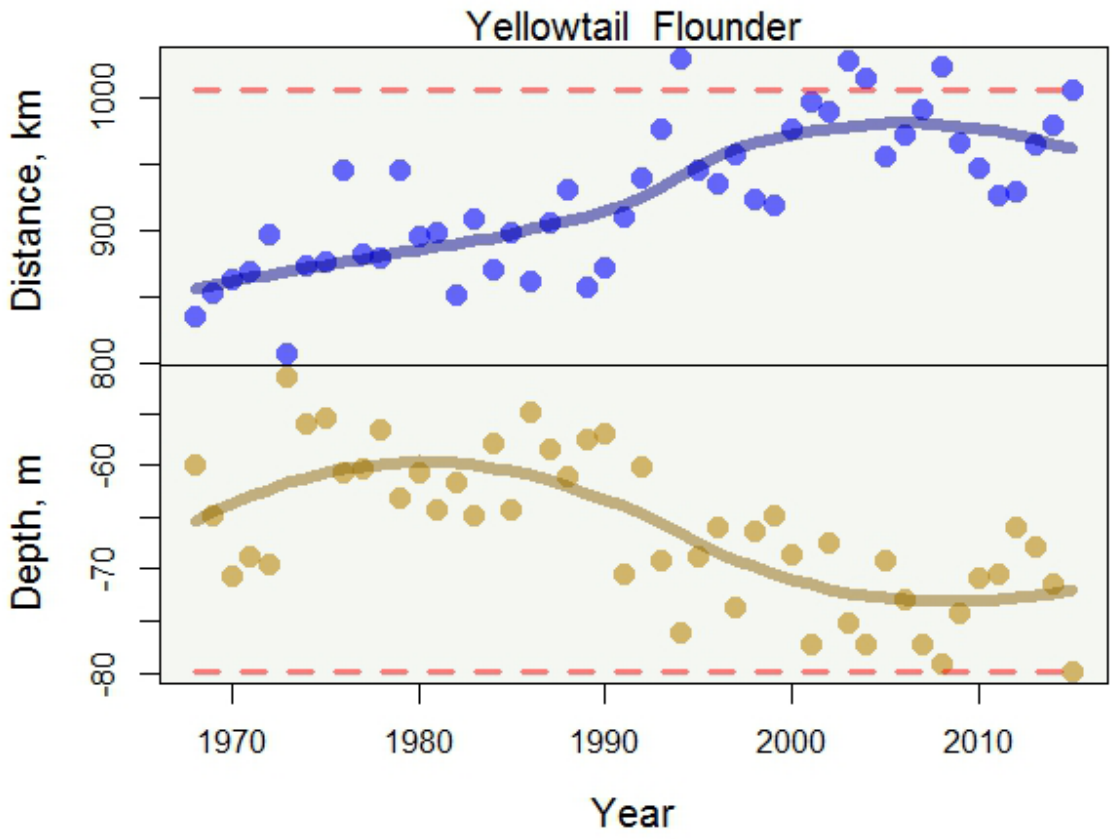
- **Witch Flounder**



- **Wolffish**


Wolffish
Distance, km
1150
1050
Depth, m
-80
-120
-160
1970
1980
1990
2000
2010
Year

- Yellowtail Flounder

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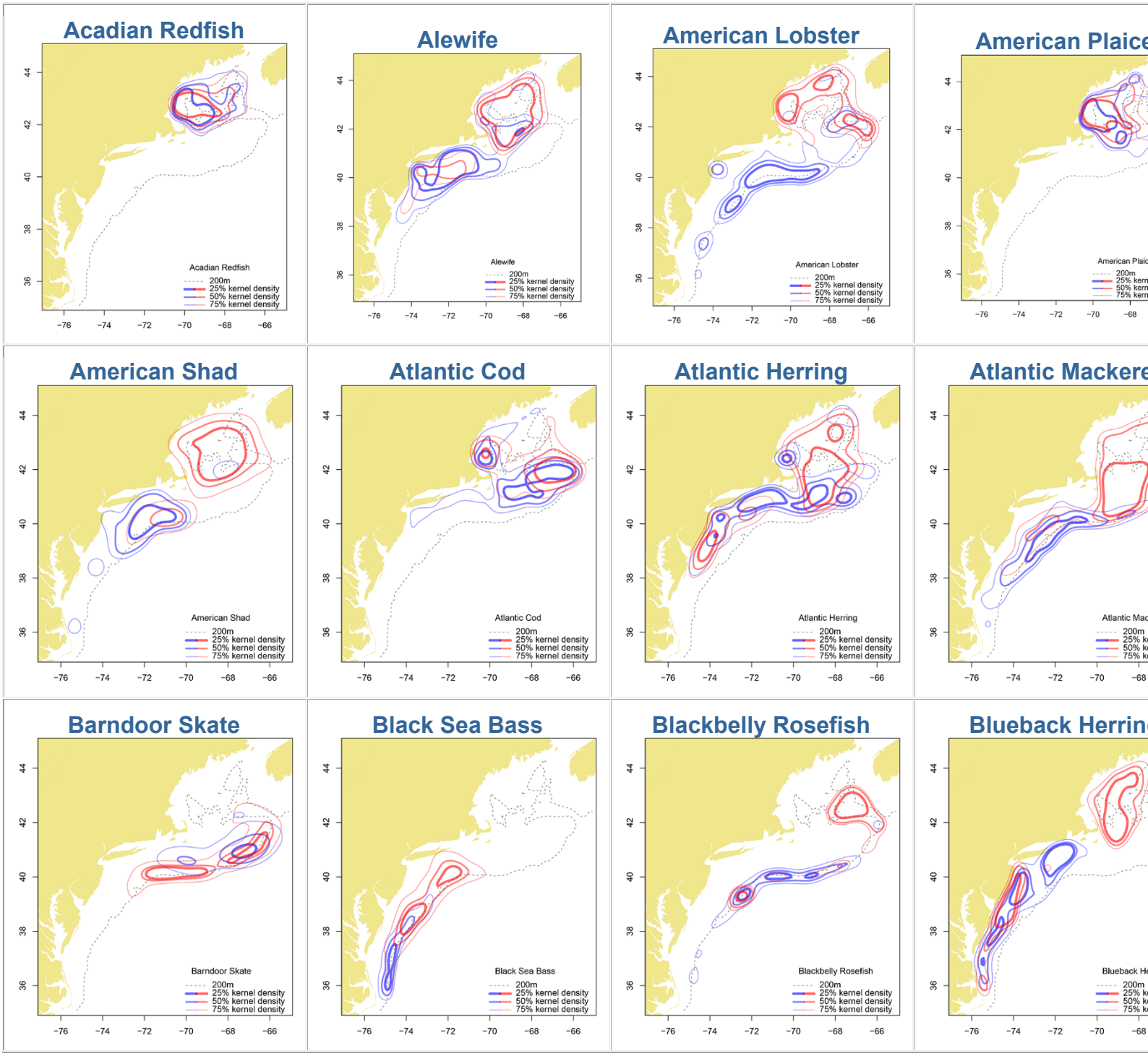
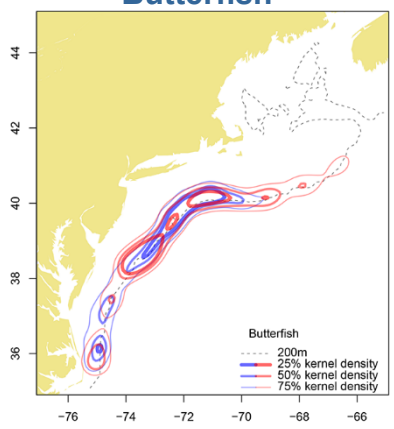
# Kernel Density Plots of Fall Species Distribution

The habitats used by species of the Northeast Shelf ecosystem have changed over recent decades. Species have moved in response to a complex set of factors resulting in changes in distribution in respect to latitude and depth, among a number of habitat indicators. Kernel density plots provide a way of characterizing where a species is distributed by defining an area with an associated probability that a species will be found there. We compared the kernel densities for three probability levels between two time periods. The three probably levels were 25, 50, and 75% kernel densities; the 25% kernel defines the core area of the distribution whereas the 75% defines the broader use of the ecosystem. The two time periods were a base distribution period based on species distribution during the 1970s (shown as blue kernel densities) and a contemporary distribution period based on the last three years (2012-2014) for the fall

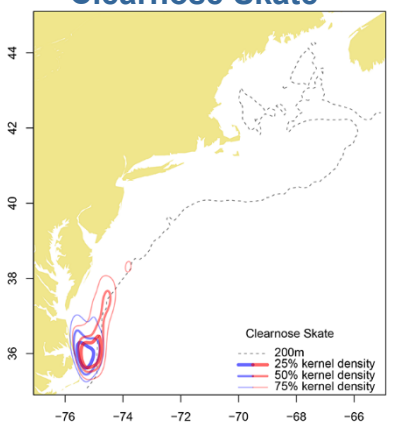
survey (shown as red kernel densities). The table below shows the species analyzed; click on a species name to see kernel density plots.



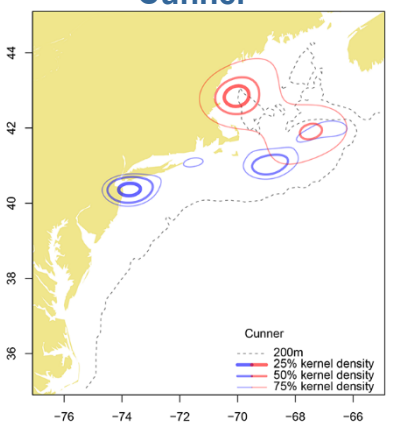
## Butterfish



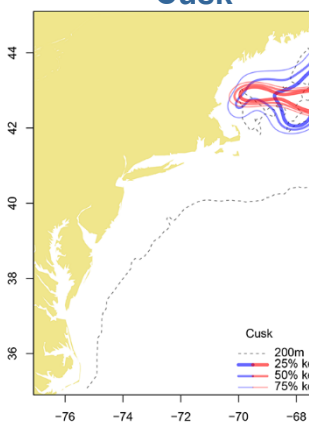

## Clearnose Skate



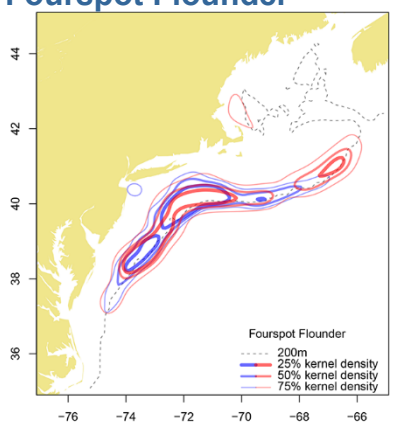

## Cunner



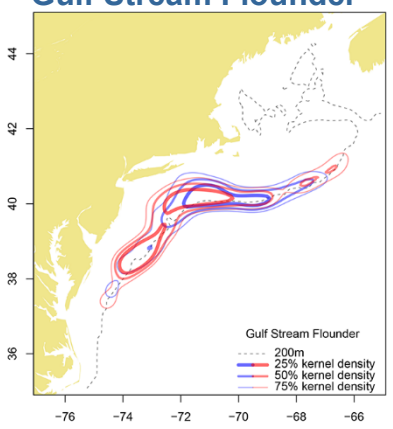

## Cusk



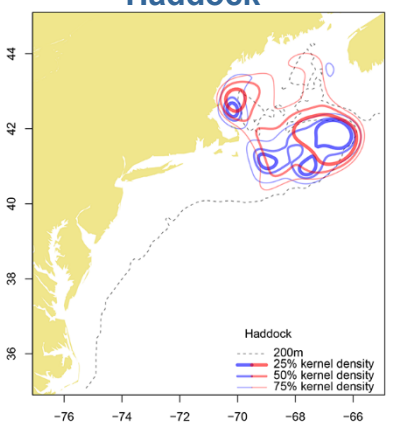

## Fourspot Flounder



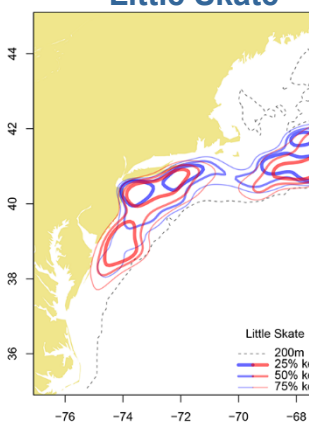

## Gulf Stream Flounder



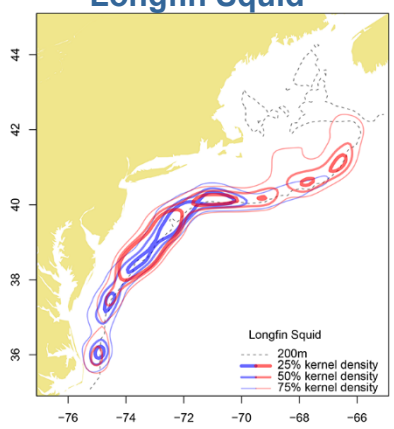

## Haddock



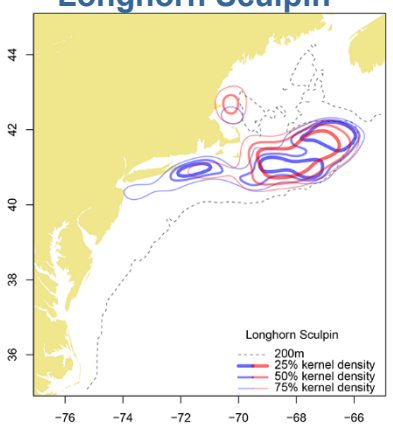

## Little Skate



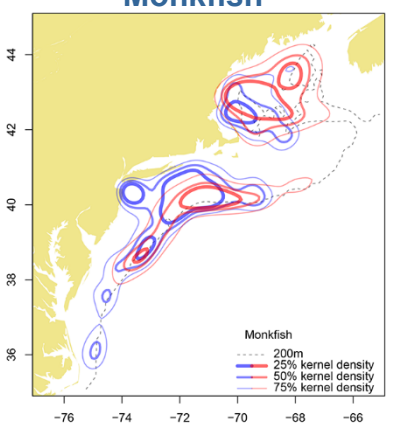

## Longfin Squid



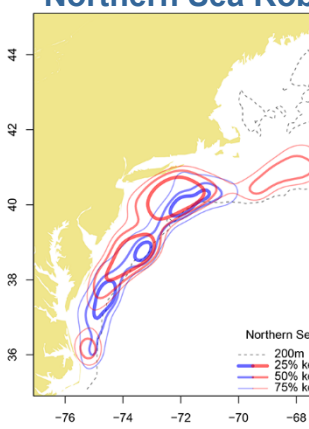

## Longhorn Sculpin



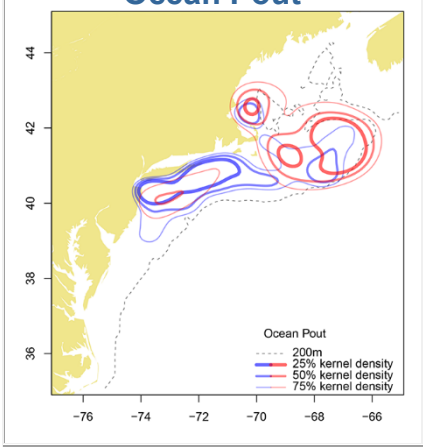

## Monkfish



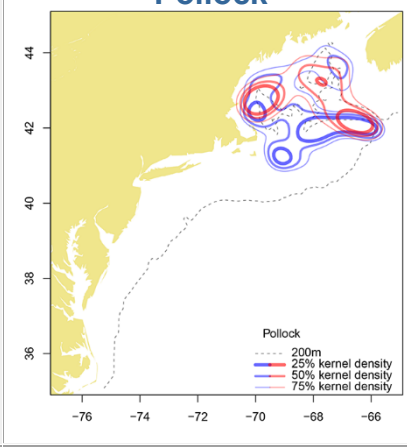

## Northern Sea Rob



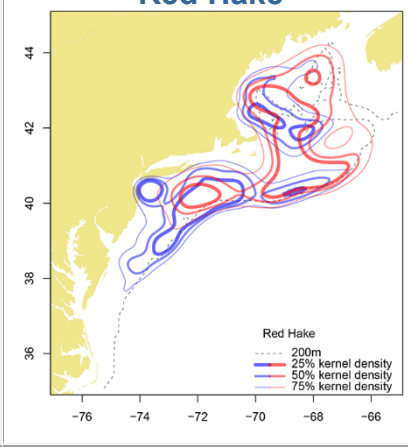
## Ocean Pout



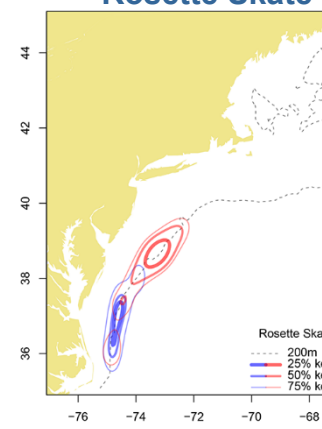

## Pollock



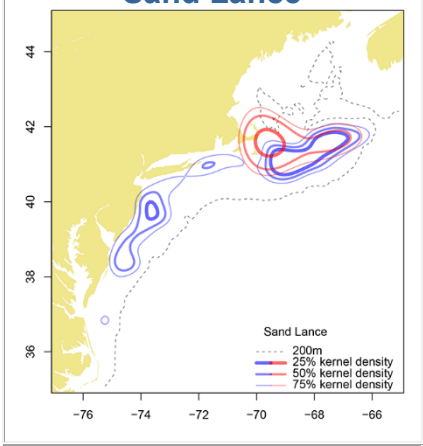

## Red Hake



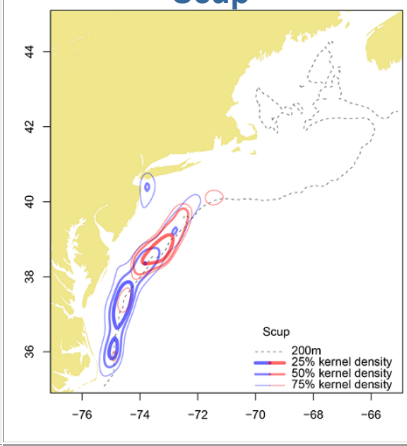

## Rosette Skate



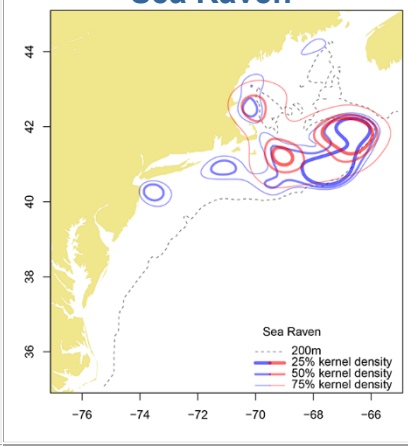

## Sand Lance



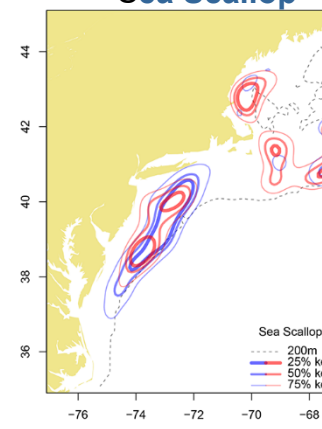

## Scup



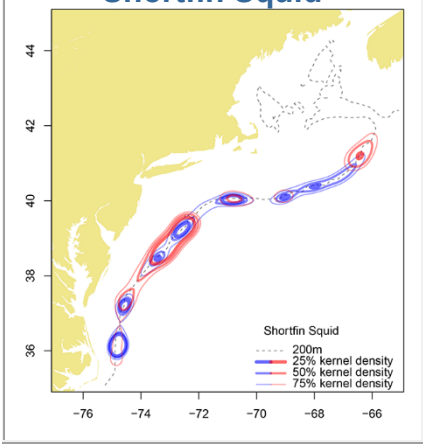

## Sea Raven



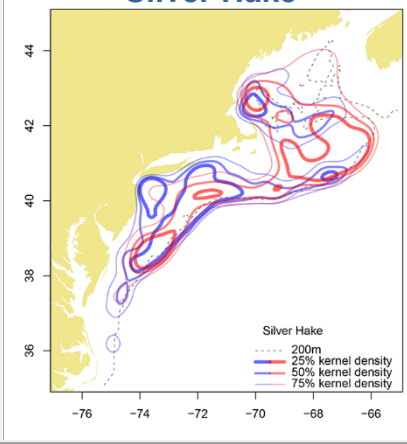

## Sea Scallop



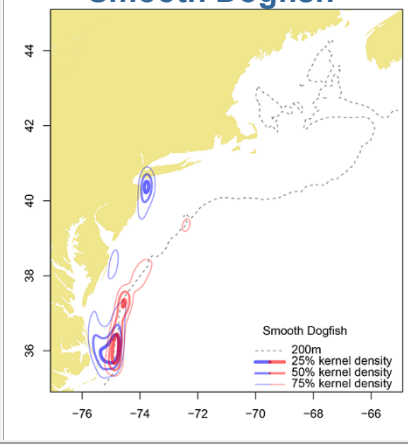

## Shortfin Squid



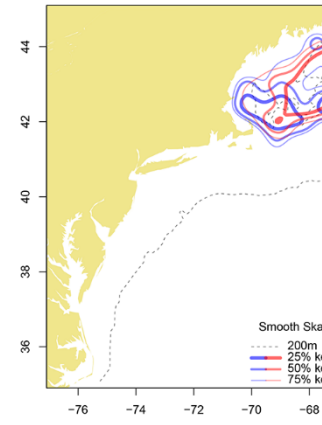

## Silver Hake

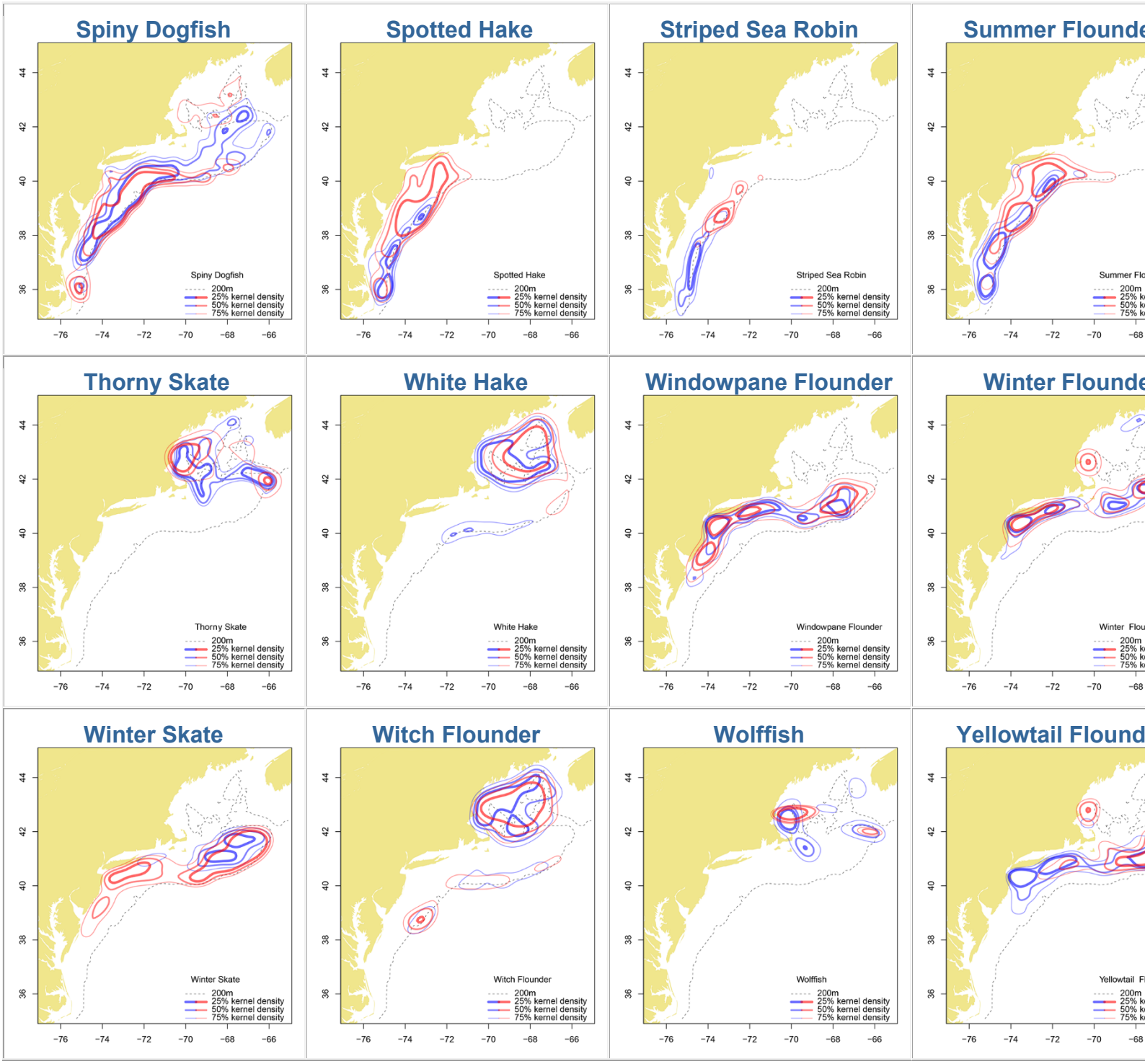



## Smooth Dogfish

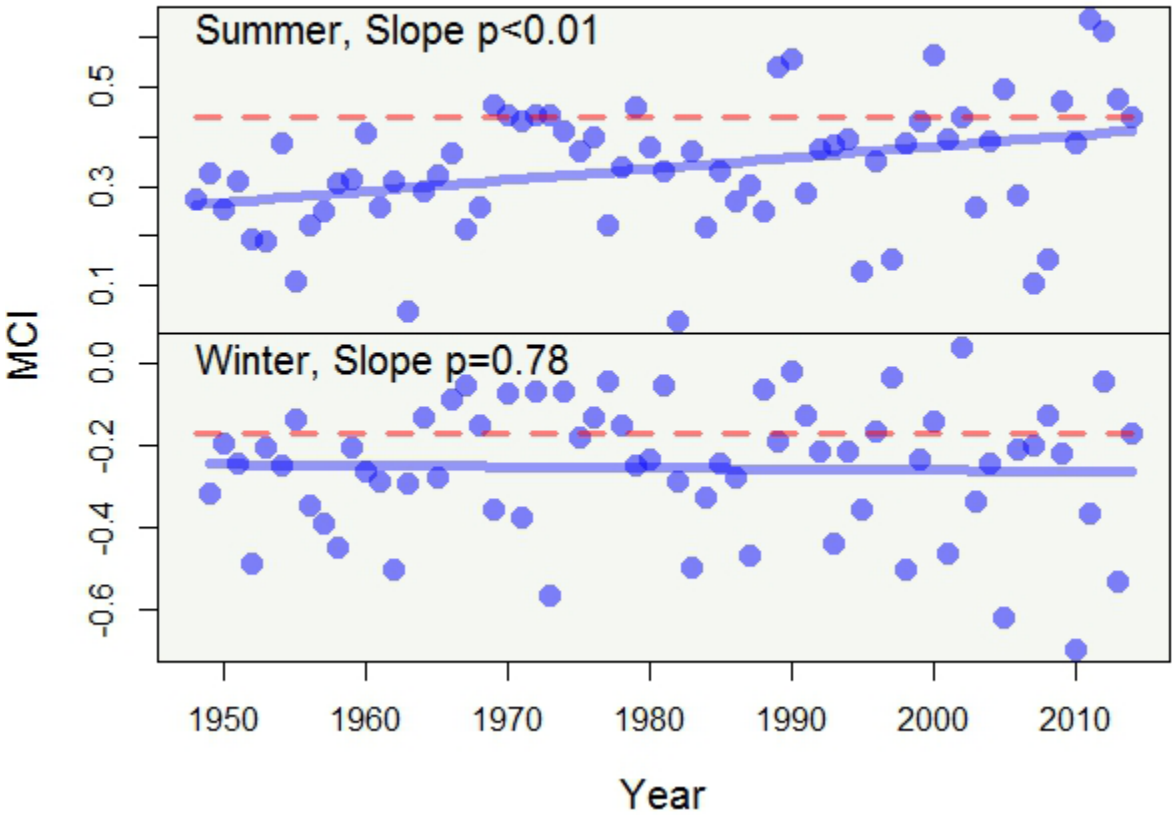



## Smooth Skate






# Wind Direction




The predominant direction of summer winds affecting the Northeast Shelf ecosystem has changed in recent years. Research focusing on changes in the behavior of the jet-stream and its effect on regional weather patterns found that there has been a weakening of poleward or meridional (North/ South) atmospheric flows. These research efforts have made use of a wind index termed the meridional circulation index (MCI), which weighs the relative contribution of directional wind vectors. Predominant wind direction changes seasonally in the Northwest Atlantic, with summer winds directed to the Northeast and winter winds to the Southeast. The Northeast Shelf summer (April-September) MCI index has changed significantly over the period 1948-2014 (see **graph**). A linear model is shown in each graph panel as a blue line, the significance probability (p) of the regression is shown in the upper right, and the dashed red line marks the 2014 observation. Winter (October-March) MCI was without trend. The change in summer MCI is associated with a decrease in summer wind speeds, mainly due to slower west to east movement.