Fall 2015 Update: Annual Condition of the Northeast Shelf Ecosystem

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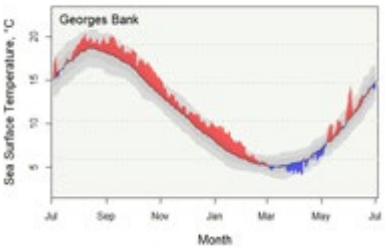
Current Conditions of the Northeast Shelf Ecosystem-- Fall 2015 Update

Summary

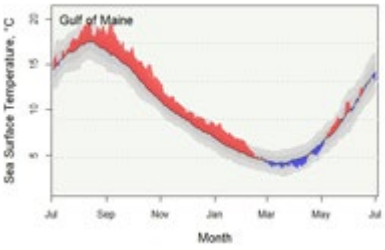
- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem during the first half of 2015 continued to moderate compared to the record high temperatures that occurred in 2012; however, temperatures remain above the long-term mean based on both contemporary satellite remote-sensing data and ship-board measurements.
- Spring survey hydrocast data indicate that surface and bottom temperatures were near normal across the northeast U.S. shelf at both the surface and bottom. However, the spatial pattern of SST distribution were suggestive of oceanic influences, perhaps reflecting a shoreward shift in the position of the shelf-slope front – a persistent feature that separates cooler shelf waters from warmer slope waters offshore.
- The spring bloom was the largest recorded involving continuous bloom conditions from the Middle Atlantic Bight, to the Georges Bank and Scotian Shelf. The Gulf of Maine spring bloom was of average size and duration.
- Spring thermal transition dates for 2015 continue to be among the earliest dates recorded over the past three decades; the spring transition estimate for the Middle Atlantic Bight was the earliest in the time series.
- The distribution of fish and invertebrate species sampled by the NEFSC bottom trawl survey has changed; utilizing data through the spring 2015 survey, kernel density plots and the assessments of species distributions both along- and across-shelf show mixed distribution movements over time.

Spring Sea Surface Temperature - Northeast Shelf Ecosystem

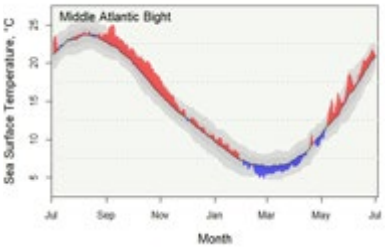
The Northeast Shelf Large Marine Ecosystem experienced below average sea surface temperatures during the spring of 2015 following the trend of above average temperatures seen during fall into winter seasons. In the graphs spanning the last half of 2014 and first half of 2015, the long-term mean sea surface temperature (SST) is shown as a dark gray line with areas representing plus and minus one and two standard deviations of the mean as progressive shades of gray, respectively (see figure). SSTs below the long term mean are shown in blue, above the mean in red. The warmest seasonal conditions during the first half of 2015 were found during May into June, below average conditions were widespread in all ecoregions during March into May.



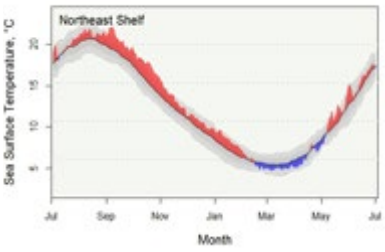
Georges Bank



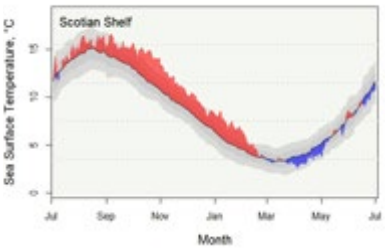
Gulf of Maine



Mid-Atlantic Bight



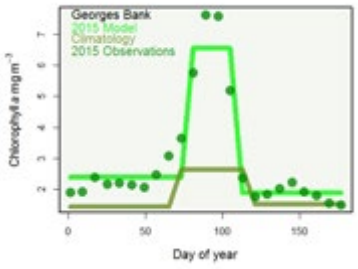
Northeast Shelf



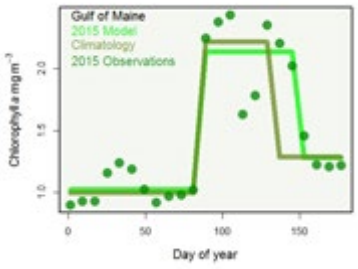
Scotian Shelf

Spring Bloom on the Northeast Shelf

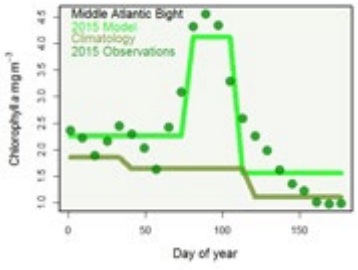
Most ecoregions of the Northeast Shelf Large Marine Ecosystem have a well developed spring phytoplankton bloom. The impact of the spring bloom will depend on multiple factors related to the time and duration of the bloom and how productive the constituent phytoplankton species are over time. The timing and duration of 2015 spring bloom for the Northeast Shelf ecosystem as a whole was similar to historical patterns; however, the bloom was much larger than historical blooms with chlorophyll levels more than twice as high as the average level (see Northeast Shelf figure; for this and figures for ecoregions, dark green line is long-term mean bloom pattern, light green line 2015 bloom pattern, points are for 2015 data). Above average blooms were found in the Scotian Shelf, Georges Bank, and Middle Atlantic Bight areas with chlorophyll concentrations at twice the average levels in all areas. The Gulf of Maine spring bloom was of average size compared to historical data. This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area correction between the two sensors.



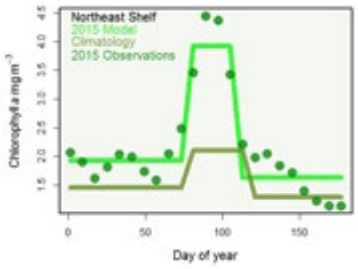
Georges Bank



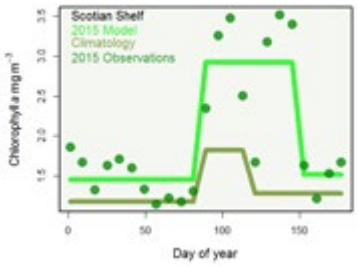
Gulf of Maine



Mid-Atlantic Bight



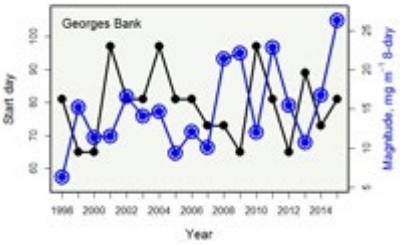
Notheast Shelf



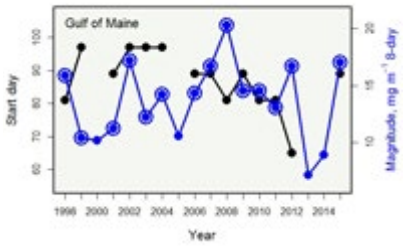
Scotian Shelf

Spring Bloom Start Day and Magnitude

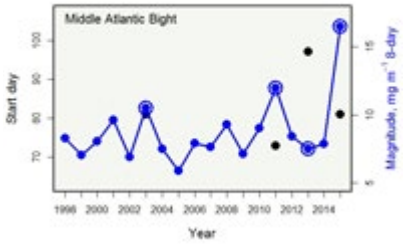
The spring bloom typically starts earlier in the more southern segments of the Northeast Shelf Large Marine Ecosystem (LME). In 2015, the Northeast Shelf composite bloom start date was in mid-March, which was close to the time series average. However, bloom magnitude was nearly 16 mg m-1 8-day which was a record high for the system. Spring bloom magnitude is one measure of bloom dimension and is calculated as the sum of chlorophyll concentrations during the bloom period. Among the ecoregions, the Scotian Shelf, Georges Bank and Middle Atlantic Bight had large blooms that were also at the highest magnitudes level in the respective time series. The Gulf of Maine bloom magnitude was among the larger magnitudes measured. This analysis was based on a blended time series of MODIS and SeaWiFS remote sensing data that utilized a time and area corrections between the two sensors.



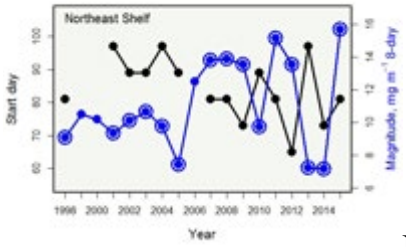
Georges Bank



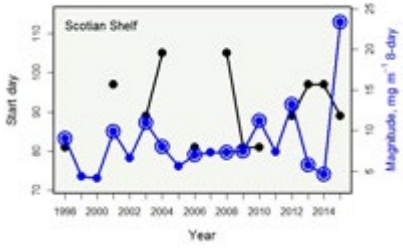
Gulf of Maine



Mid-Atlantic Bight



Notheast Shelf



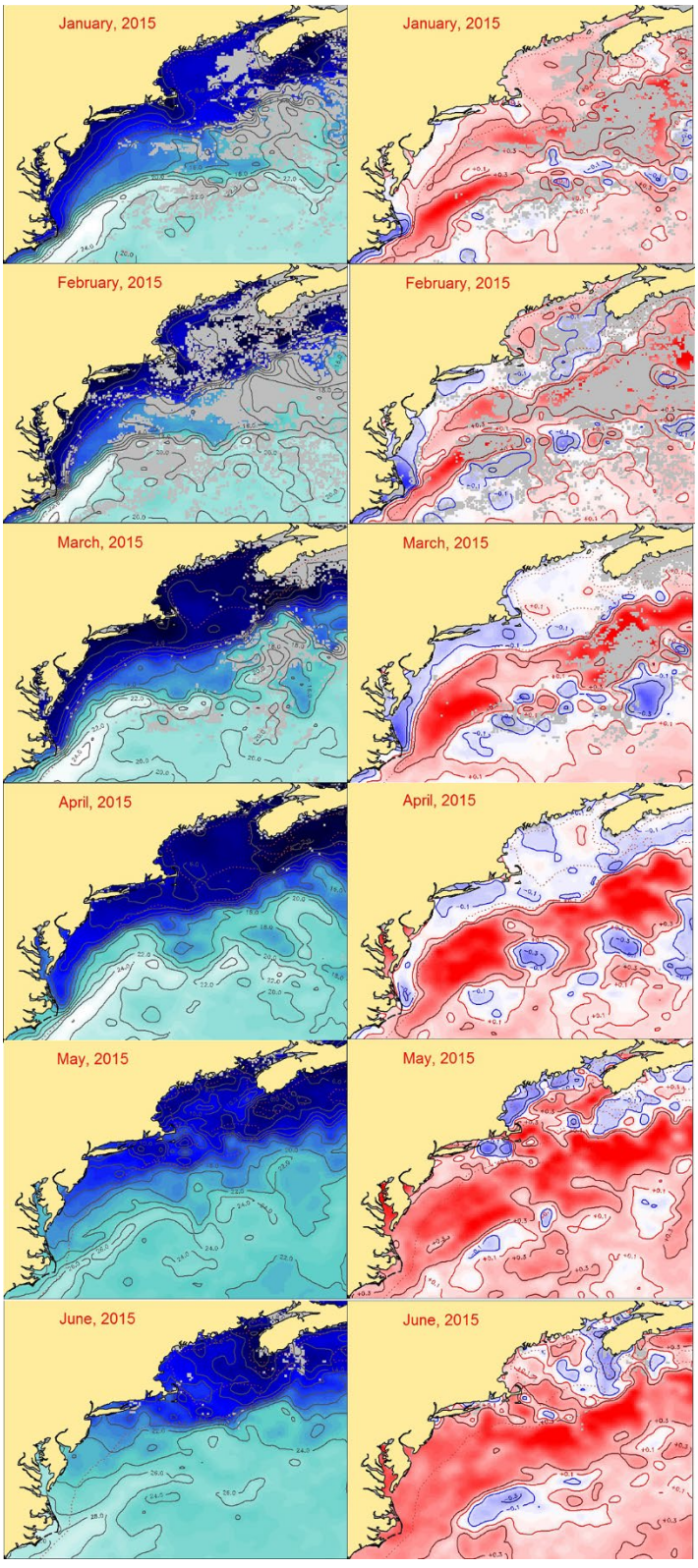
Scotian Shelf

Fall Sea Surface Temperature Distribution

Spring Sea Surface Temperature Distribution

The progression of spring sea surface temperatures for the months of January through June is shown in the interactive figure. SSTs appear as progressive shades of cyan to blue in the left hand icons. Anomalies of SST, those tending to exceed plus or minus one quarter of a standard deviation of the overall SST for the field, are in the right hand set of icons. This type of anomaly

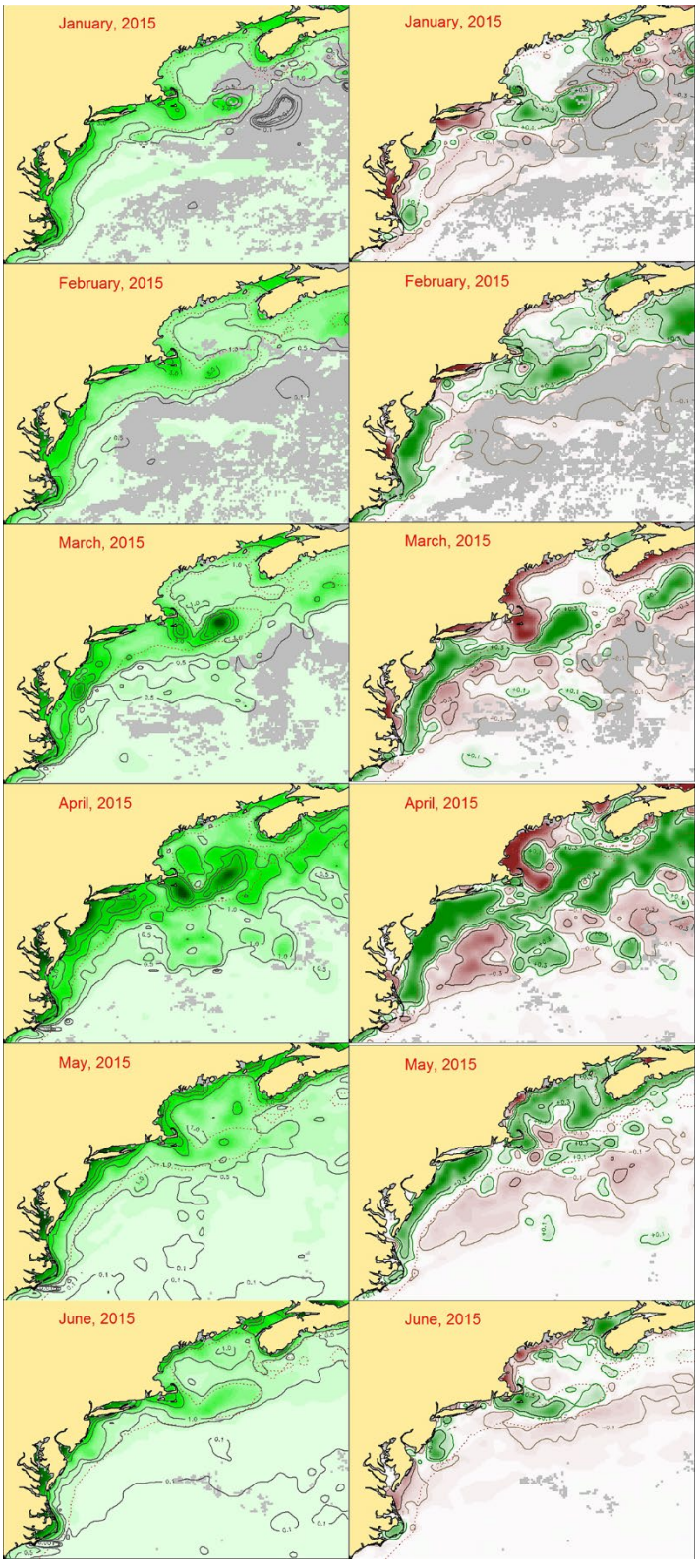
tends to highlight high SSTs in an area, the red shades, and low SSTs in an area, the blue shades. The Northeast Shelf was generally near or slightly above average SST during January. Cooler water conditions can been seen in the Middle Atlantic Bight in February and over most of the Shelf during March and April. The ecosystem warmed to above average conditions from south to north during May into June.


January, 2015
January, 2015
February, 2015
February, 2015
March, 2015
March, 2015
April, 2015
April, 2015
May, 2015
May, 2015
June, 2015
June, 2015

Fall Chlorophyll Distribution

Spring Chlorophyll Distribution

The progression of spring chlorophyll concentrations for the months of January through June are shown in the interactive figure. Chlorophyll concentrations appear as progressive shades of green in the left hand icons. Anomalies of chlorophyll concentration, those tending to exceed plus or minus one quarter of a standard deviation of the overall concentration for the field, are in the right hand set of icons. The record spring bloom along the Northeast Shelf can be seen developing first in the Middle Atlantic Bight in February and March, followed by bloom conditions on Georges Bank in April, forming a continuous area of above average bloom conditions the length of the ecosystem. By May, inshore areas including the Gulf of Maine were in bloom conditions, but not at the same intense levels seen earlier in the spring.


January, 2015
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February, 2015
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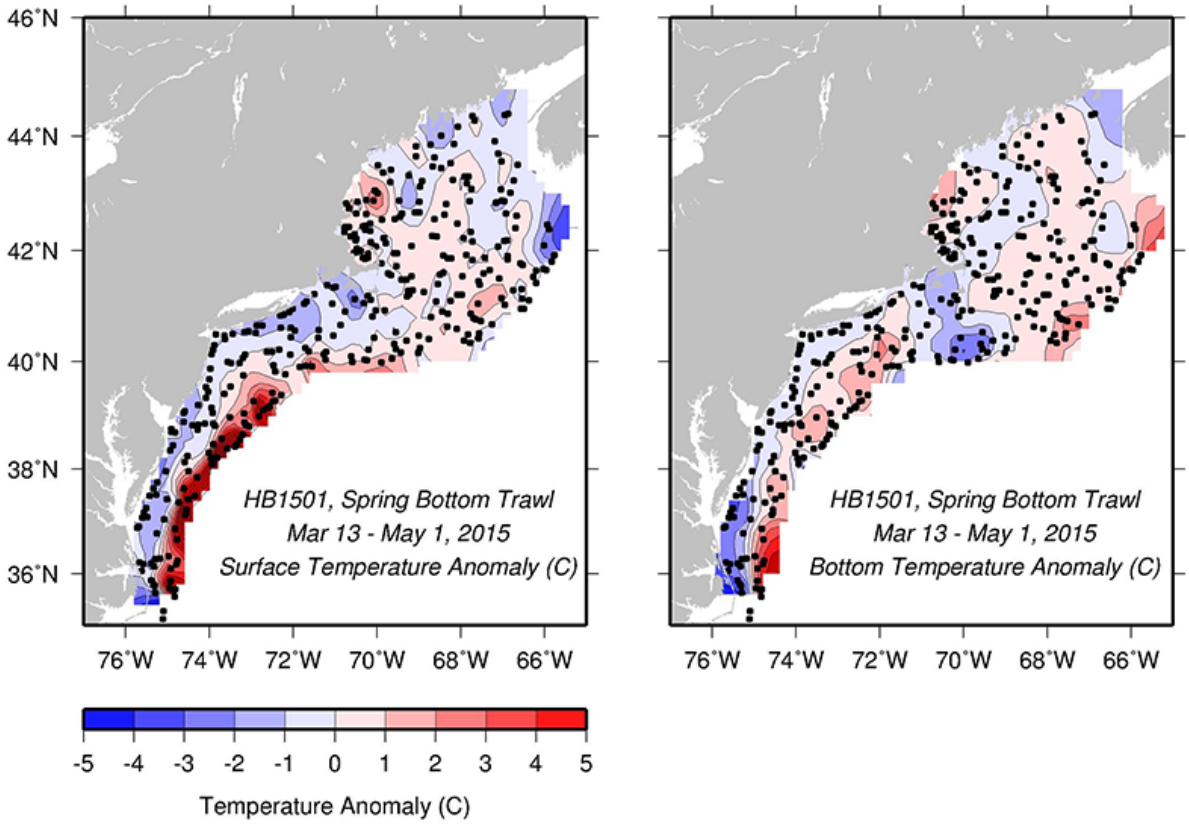
May, 2015
May, 2015
June, 2015
June, 2015

Temperature from Spring Survey



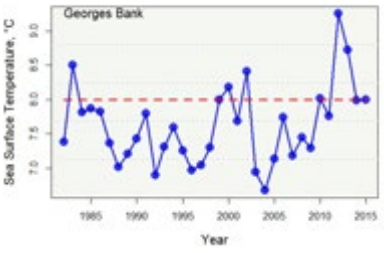
Spring bottom temperature anomalies

During spring, ocean temperatures averaged near normal across the northeast U.S. shelf at both the surface and bottom (relative to 1977-1987). Surface temperatures were cooler than normal near shore in the Middle Atlantic Bight and eastern Gulf of Maine and warmer than normal in the central Gulf of Maine and over Georges Bank. The warmest conditions were observed along the outer shelf in the Middle Atlantic Bight, where anomalies exceeded 5°C at the surface and bottom. These anomalies are suggestive of oceanic influences, perhaps reflecting a shoreward shift in the position of the shelf-slope front – a persistent feature that separates cooler shelf waters from warmer slope waters offshore.

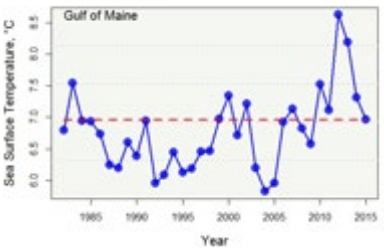
Satellite SST for First Half Year

The OISTT sea surface temperature data is based on satellite measurements and provides high spatial and temporal resolution depictions of temperature trends. The SST conditions for the first half of 2015 were generally at average to above average levels in all ecoregions. The

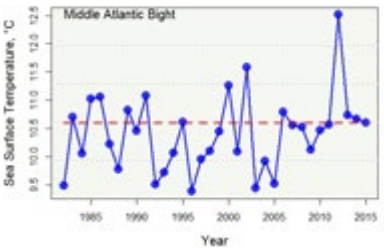
combination of both warm conditions in early winter and late spring were a contrast to the cool conditions in March, April and May, resulting in moderate temperatures.



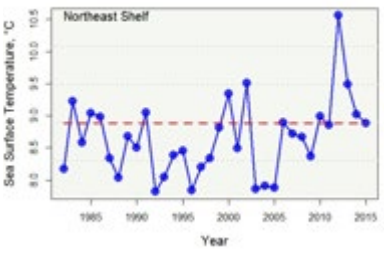
Georges Bank



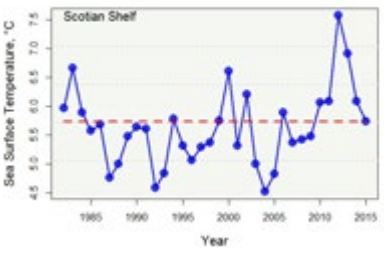
Gulf of Maine



Middle Atlantic Bight

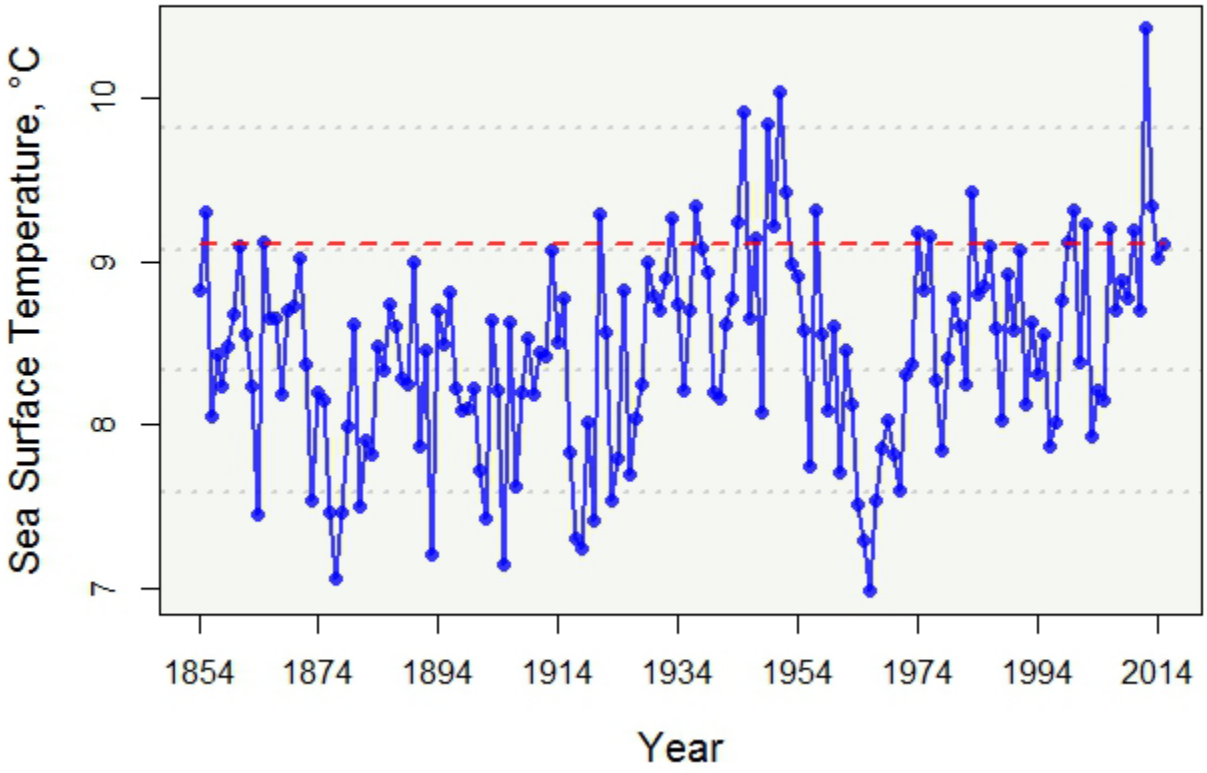


Northeast Shelf



Scotian Shelf

Extended SST for First Half Year



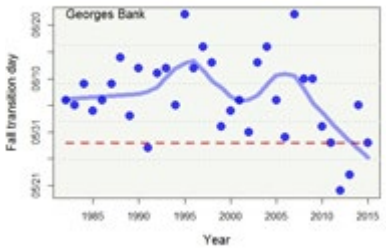
ERSST temperature time series

The ERSST temperature time series provides a low resolution depiction of sea surface temperature on the Northeast Shelf since the 1850s and is based on historical shipboard measures and augmented with other data in recent years. The SST conditions for the first half of 2015 were above average but still generally below the sea surface temperatures seen during the warm period of the late 1940s and early 1950s.

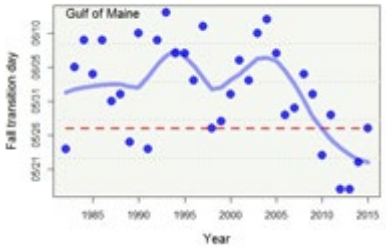
Spring Thermal Transition Date

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

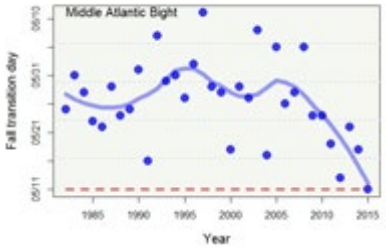
spring bloom. One measure to characterize the change in the timing of thermal forcing is the date of arrival of a spring transition temperature, which will vary by region and is meant to mark the average temperature between winter and summer. The date of arrival of the spring thermal transition temperature has been relative constant since 1982 to approximately 2006 for the Northeast Shelf as a whole and its constituent ecoregions (see figure). Since 2006, spring transition date has advanced on the order of two weeks. The 2015 spring transition dates was exceptionally early in the Middle Atlantic Bight, in fact the earliest date in this data series. The spring transitions were progressively later in the Georges Bank, Gulf of Maine and Scotian Shelf areas.



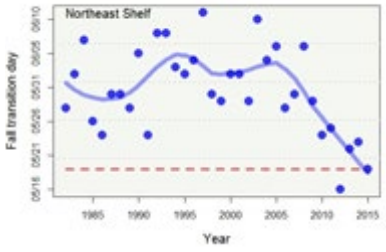
Georges Bank



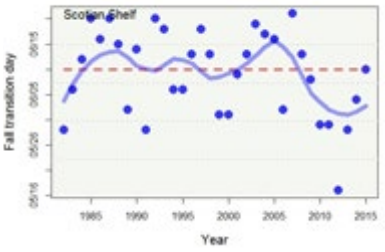
Gulf of Maine



Mid-Atlantic Bight



Northeast Shelf

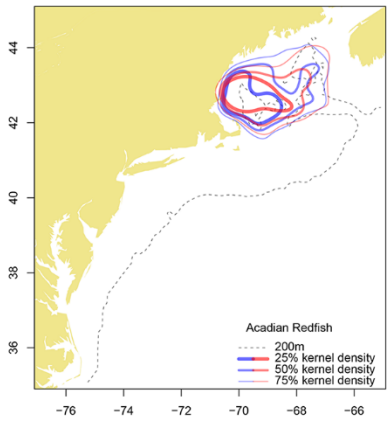


Scotian Shelf

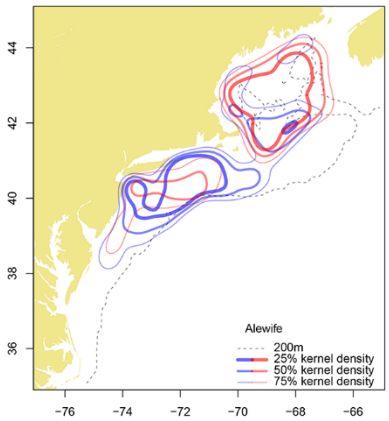
Kernel Density Plots of Spring Species Distribution

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 probability 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 (2013-2015) for the spring survey (shown as red kernel densities). The list below shows the species analyzed.

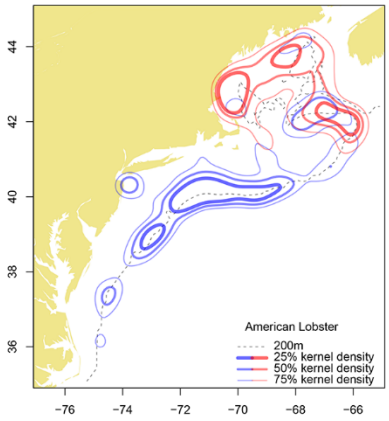
Acadian Redfish



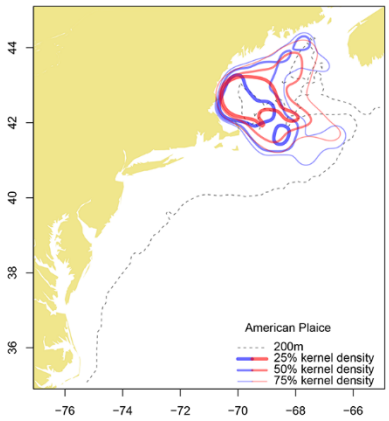
Alewife



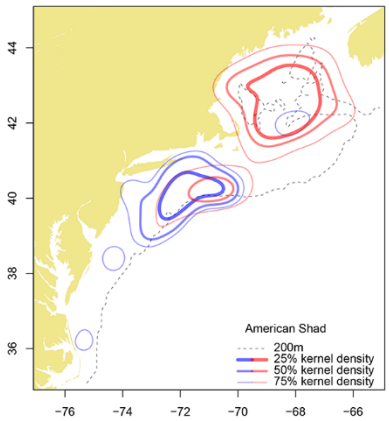
American Lobster



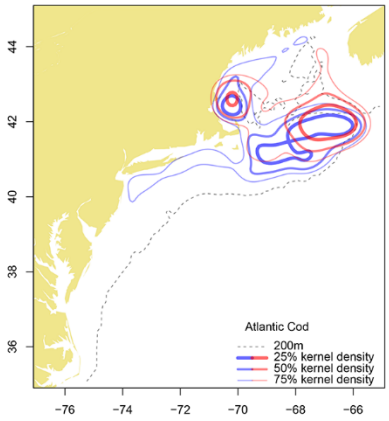
American Plaice



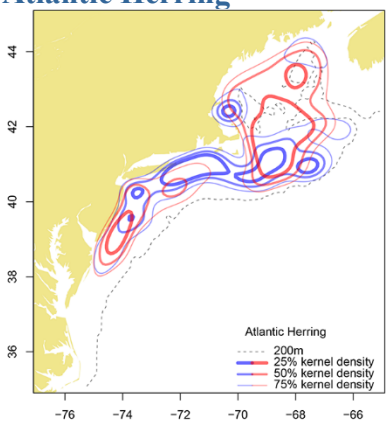
American Shad



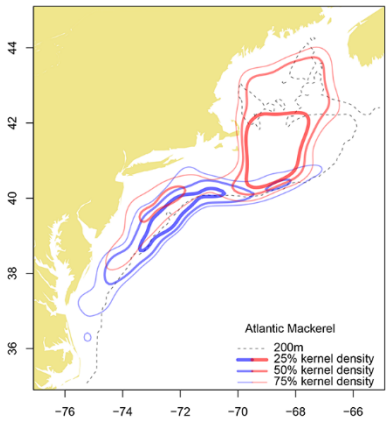
Atlantic Cod



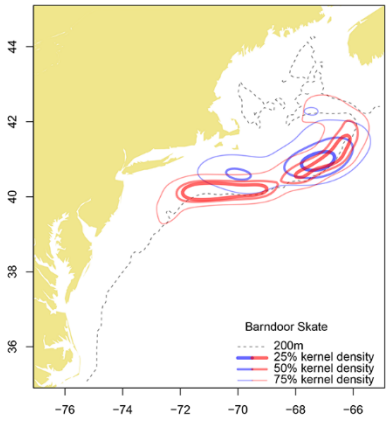
Atlantic Herring



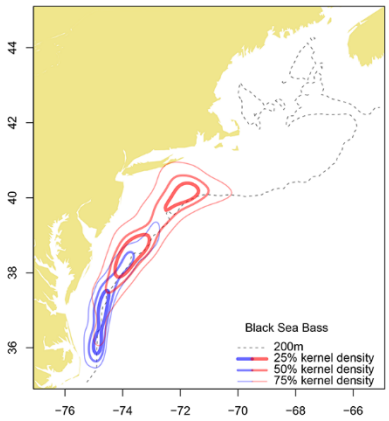
Atlantic Mackerel



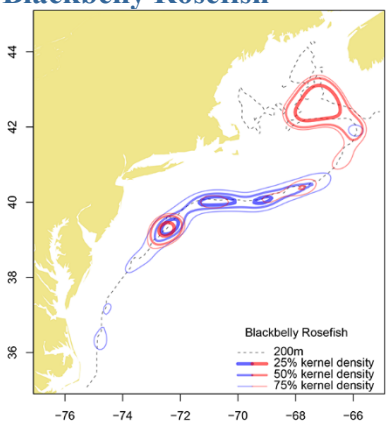
Barndoor Skate



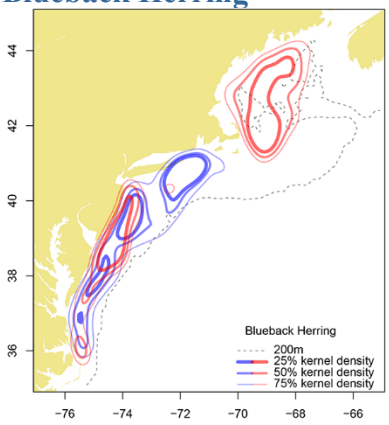
Black Sea Bass



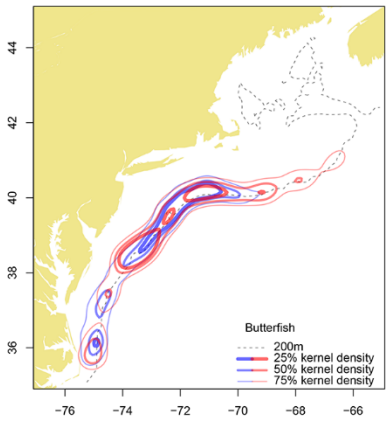
Blackbelly Rosefish



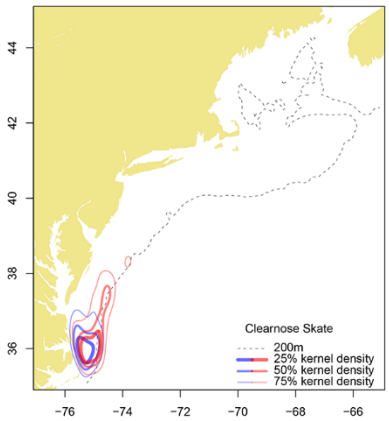
Blueback Herring



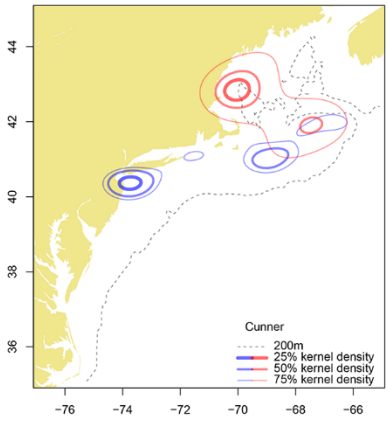
Butterfish



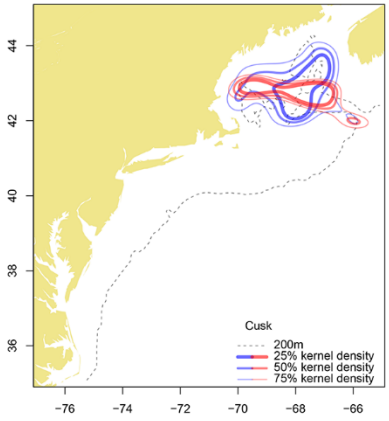
Clearnose Skate



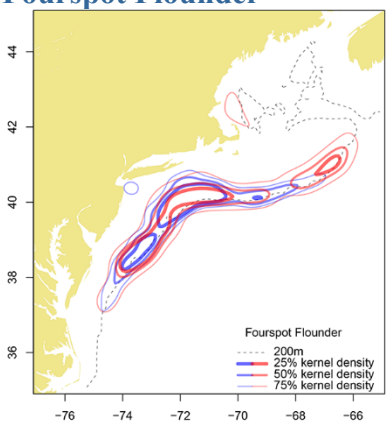
Cunner



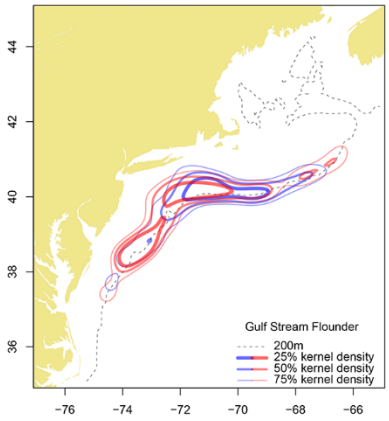
Cusk



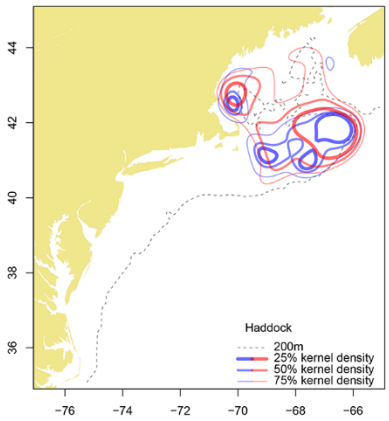
Fourspot Flounder



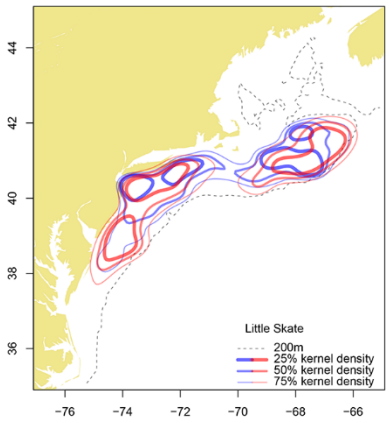
Gulf Stream Flounder



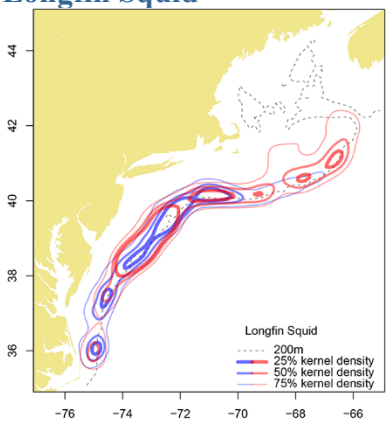
Haddock



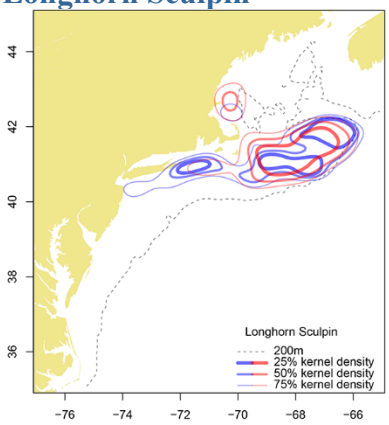
Little Skate



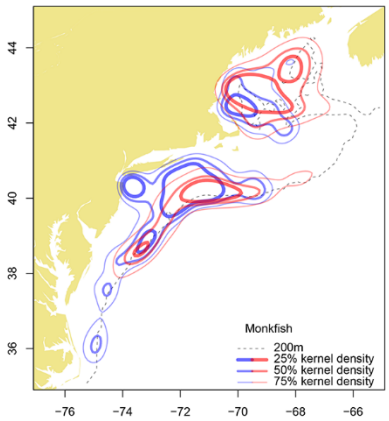
Longfin Squid



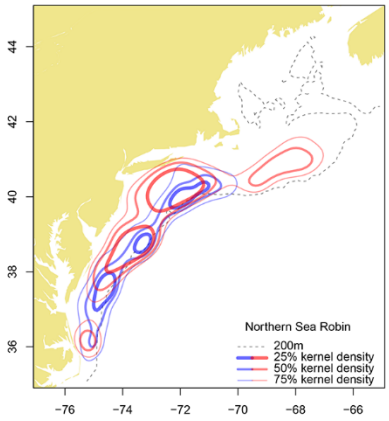
Longhorn Sculpin



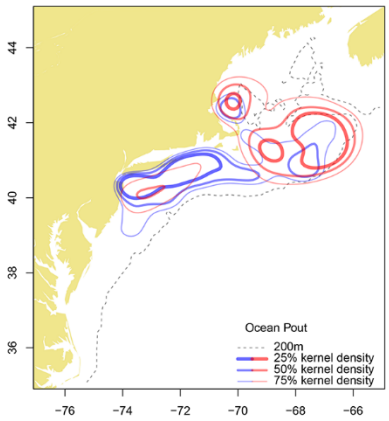
Monkfish



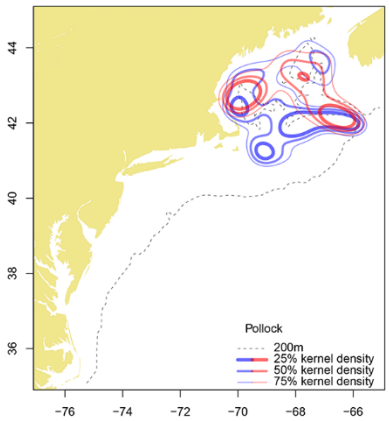
Northern Sea Robin



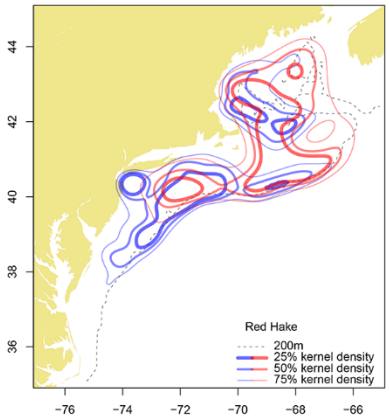
Ocean Pout



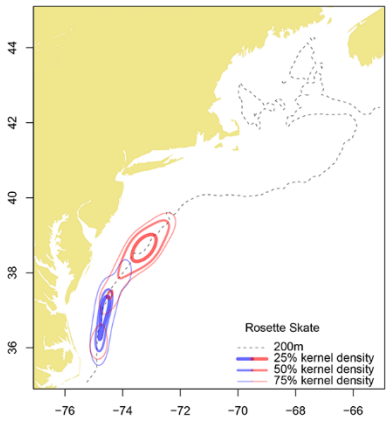
Pollock



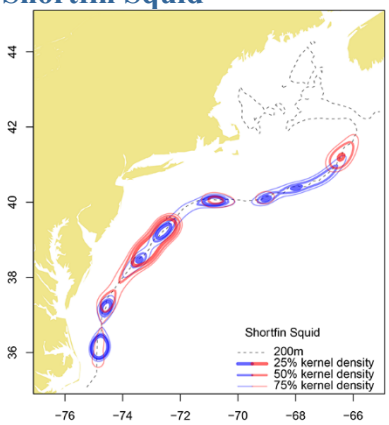
Red Hake



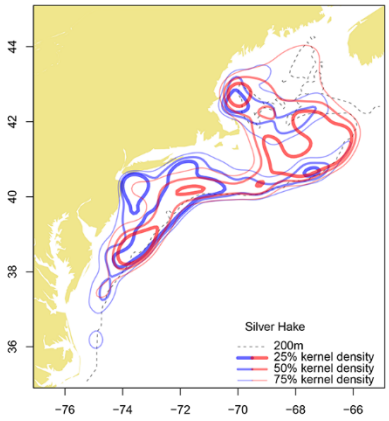
Rosette Skate



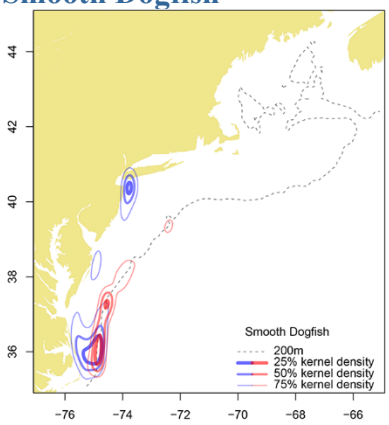
Shortfin Squid



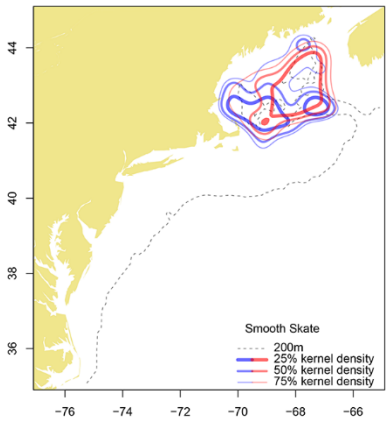
Silver Hake



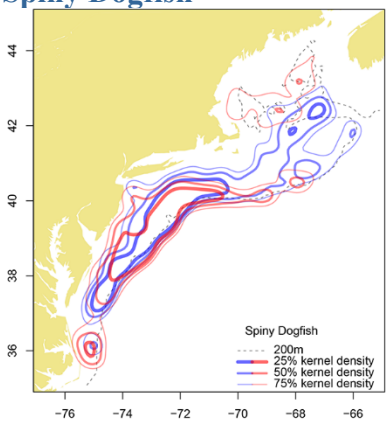
Smooth Dogfish



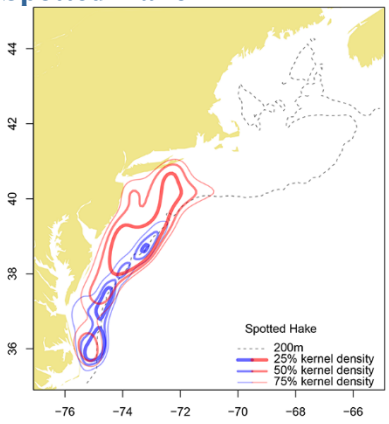
Smooth Skate



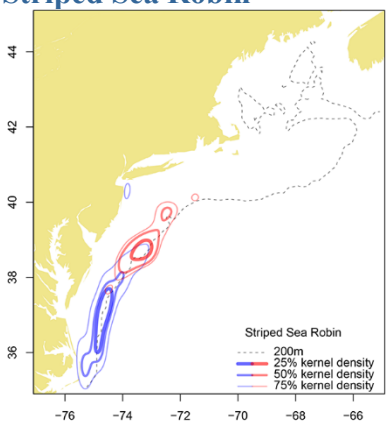
Spiny Dogfish



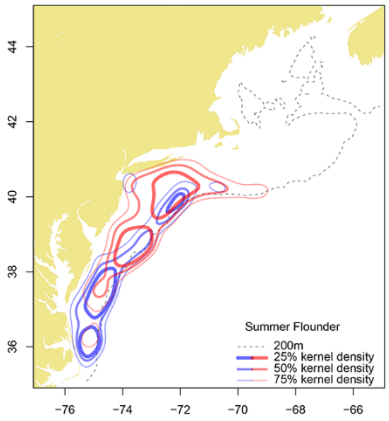
Spotted Hake



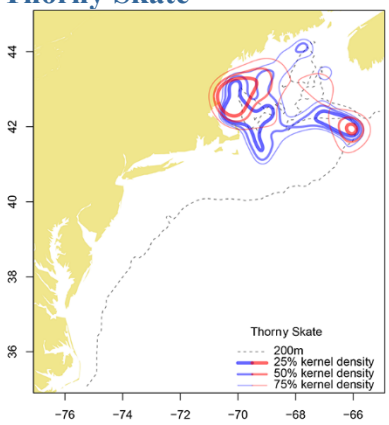
Striped Sea Robin



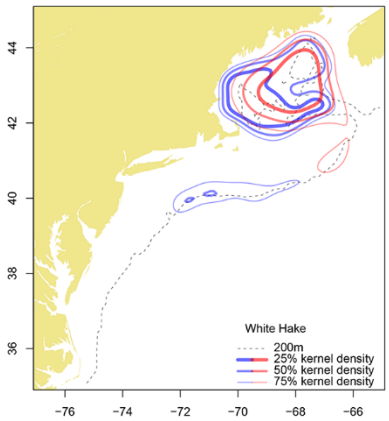
Summer Flounder



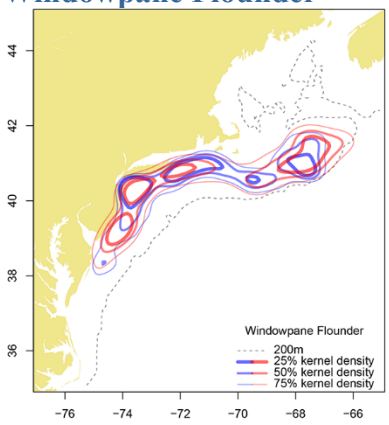
Thorny Skate



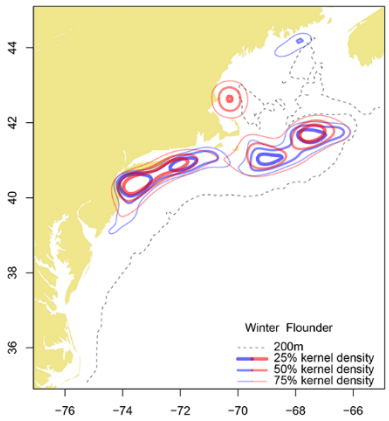
White Hake



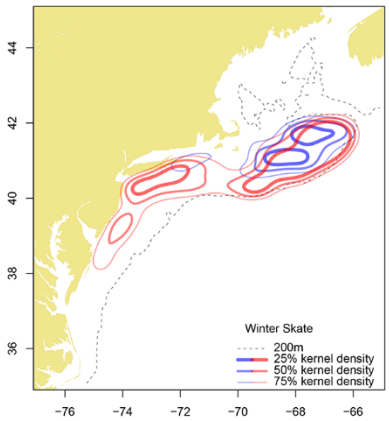
Windowpane Flounder



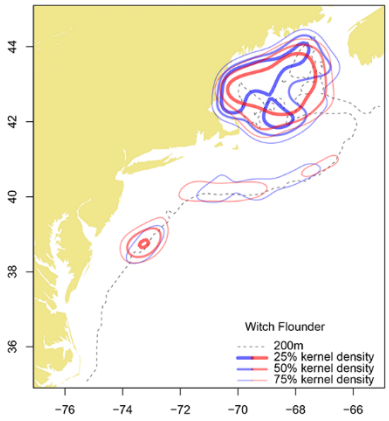
Winter Flounder



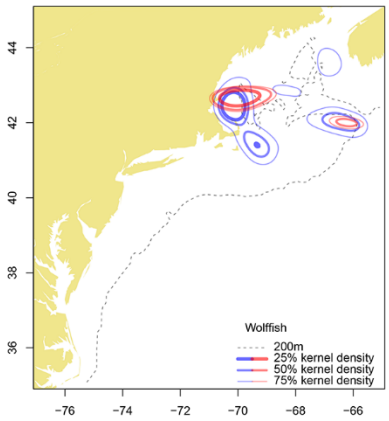
Winter Skate



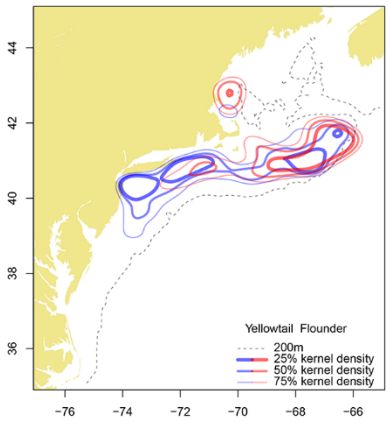
Witch Flounder



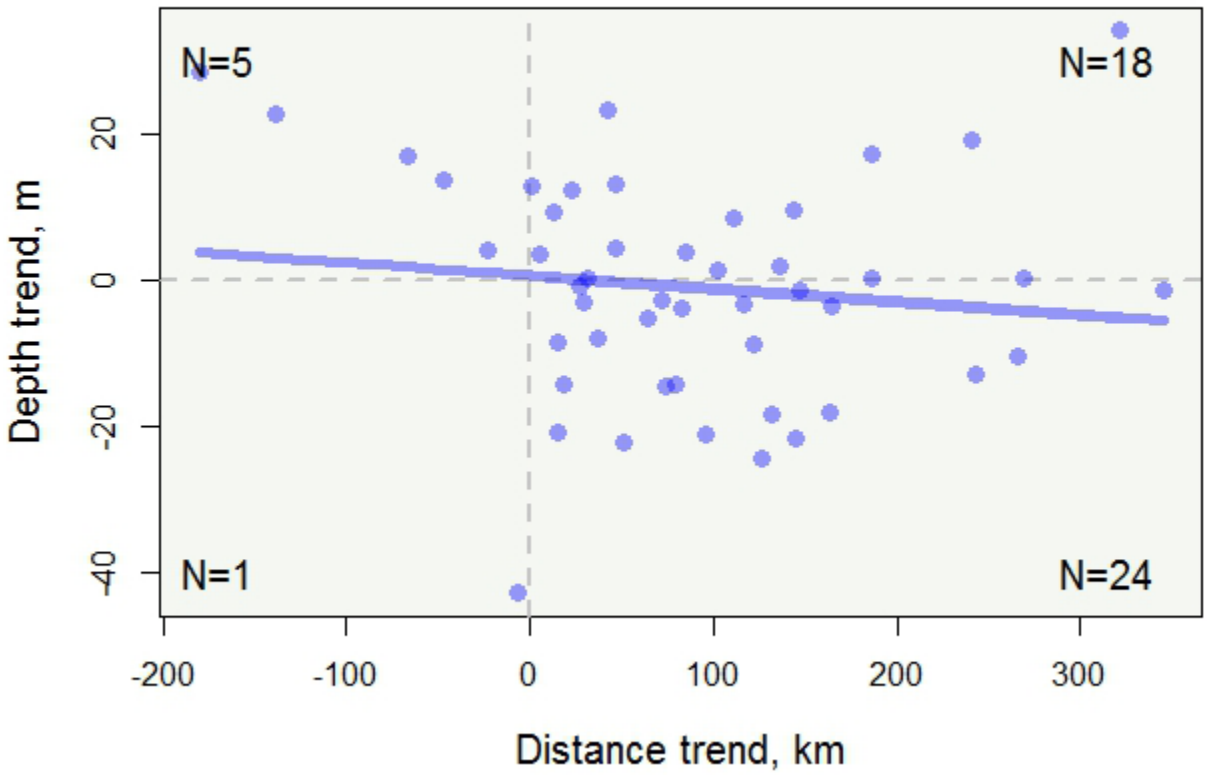
Wolffish



Yellowtail Flounder



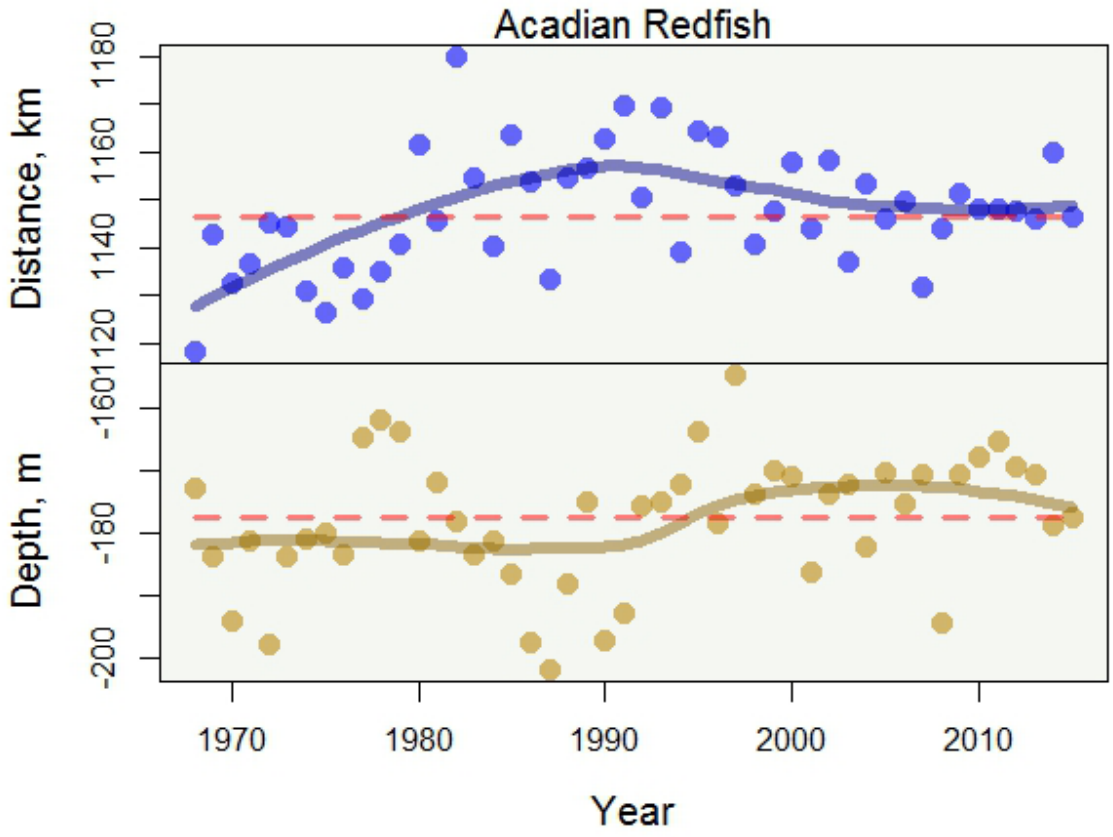
Trends in Spring Species Distribution



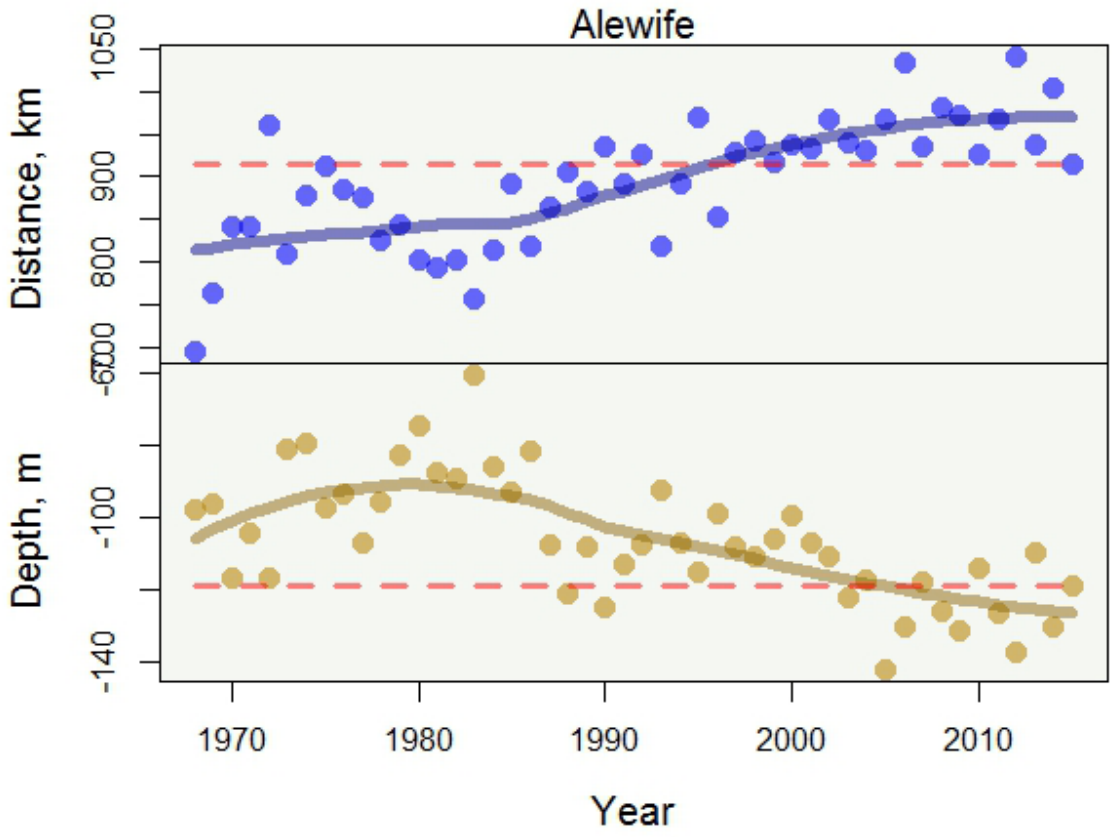
Along shelf trend

The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades. Individual species have 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. 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 1968-2015 (see figure). Most species have moved to the Northeast and into deeper water (N=24) followed by species moving the Northeast and into shallower water (N=18). Six species distributions have along shelf trends to the Southwest, most of which going into shallower water.

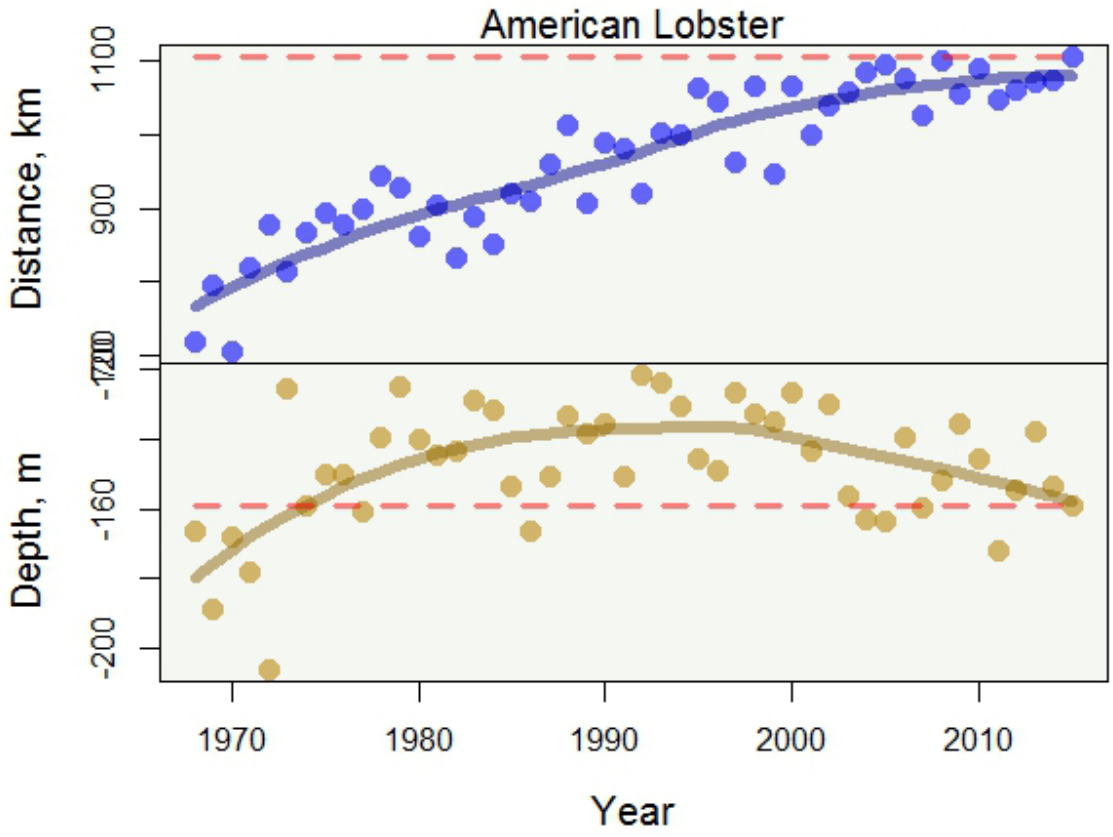
Acadian Redfish



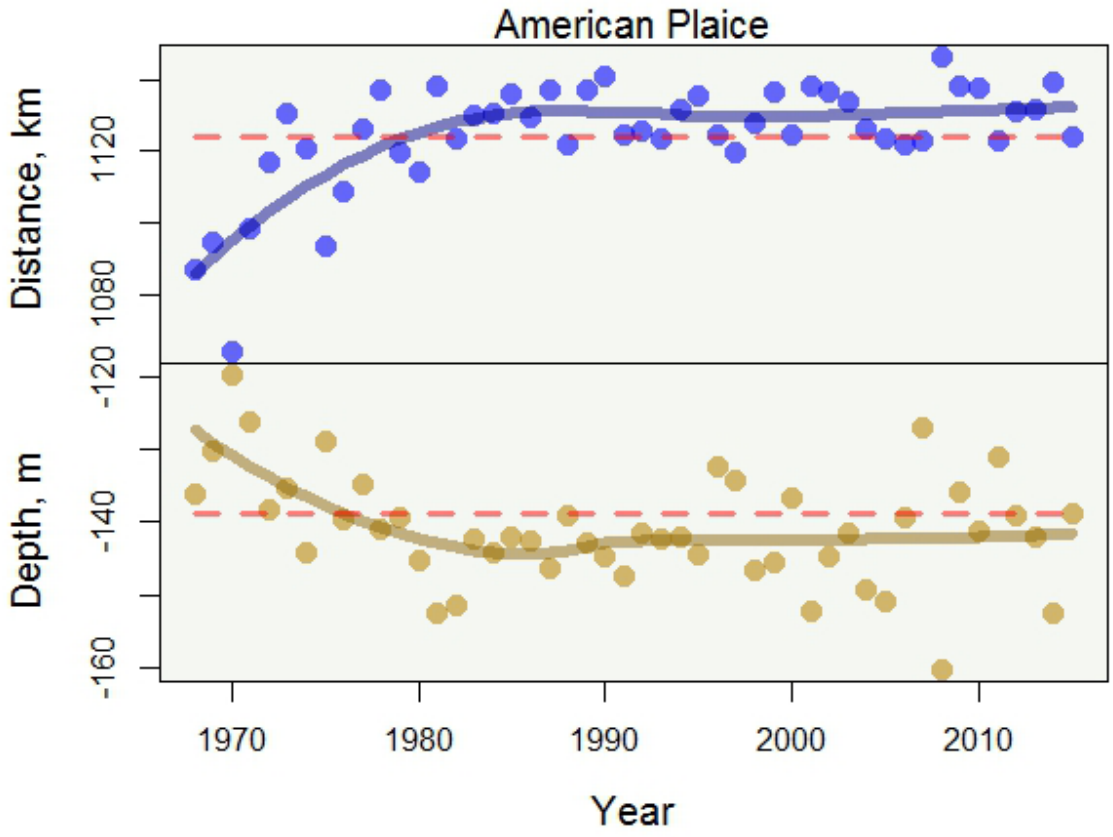
Alewife


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

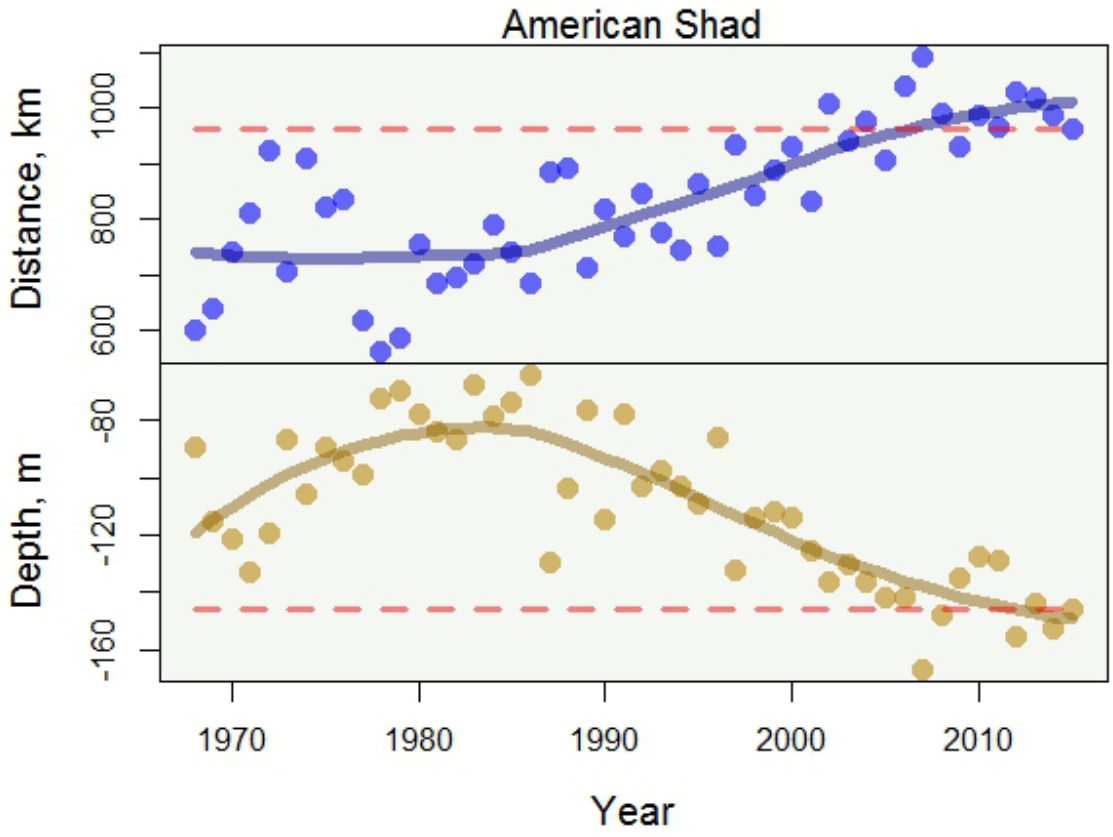
American Lobster



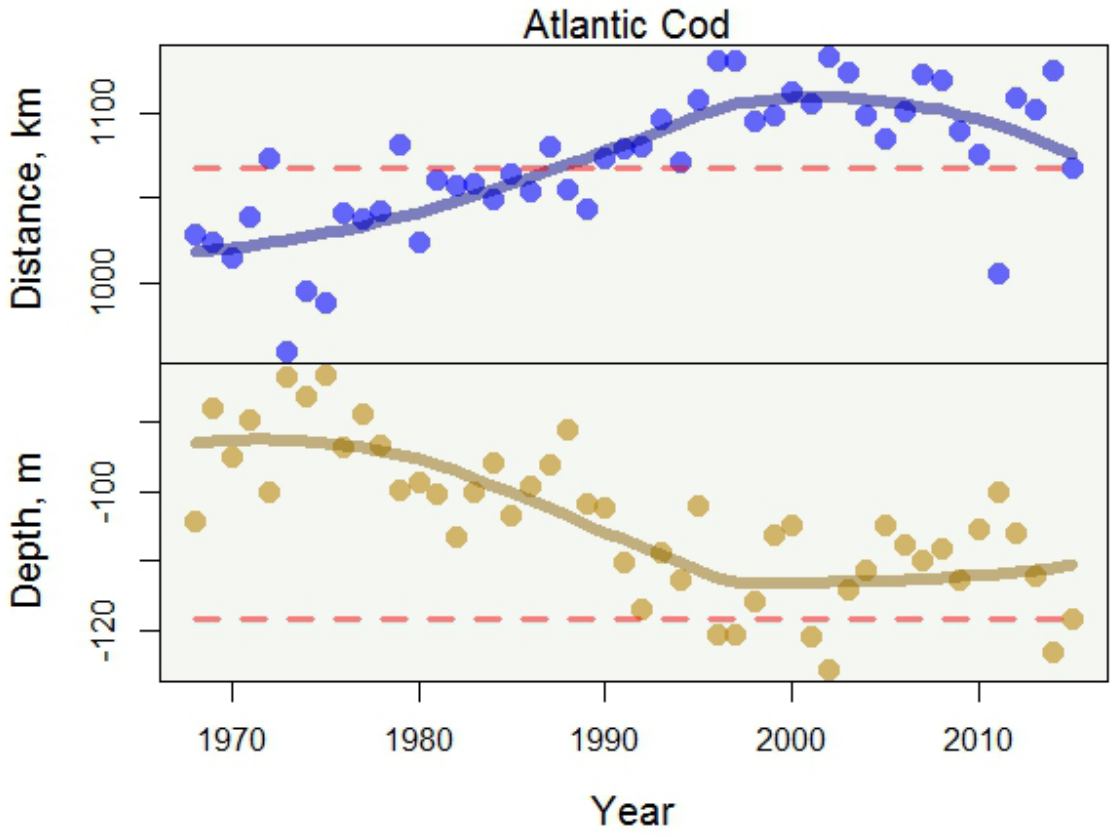
American Plaice



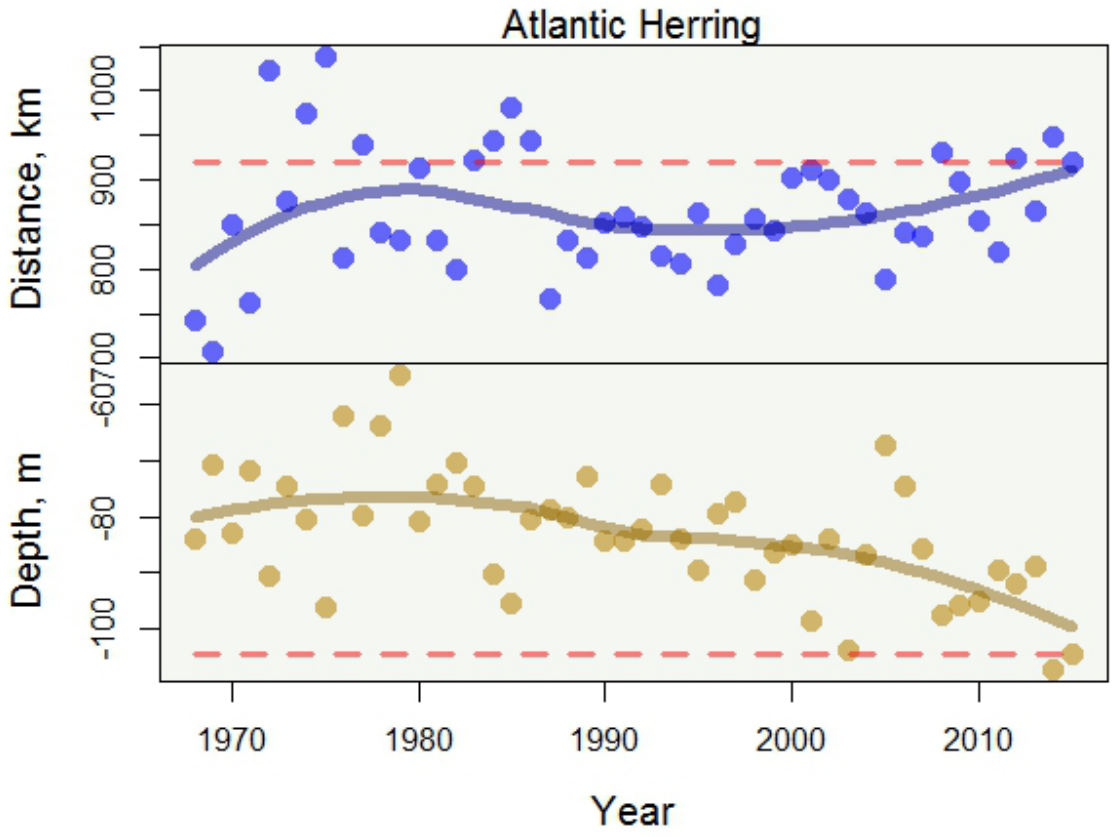
American Shad



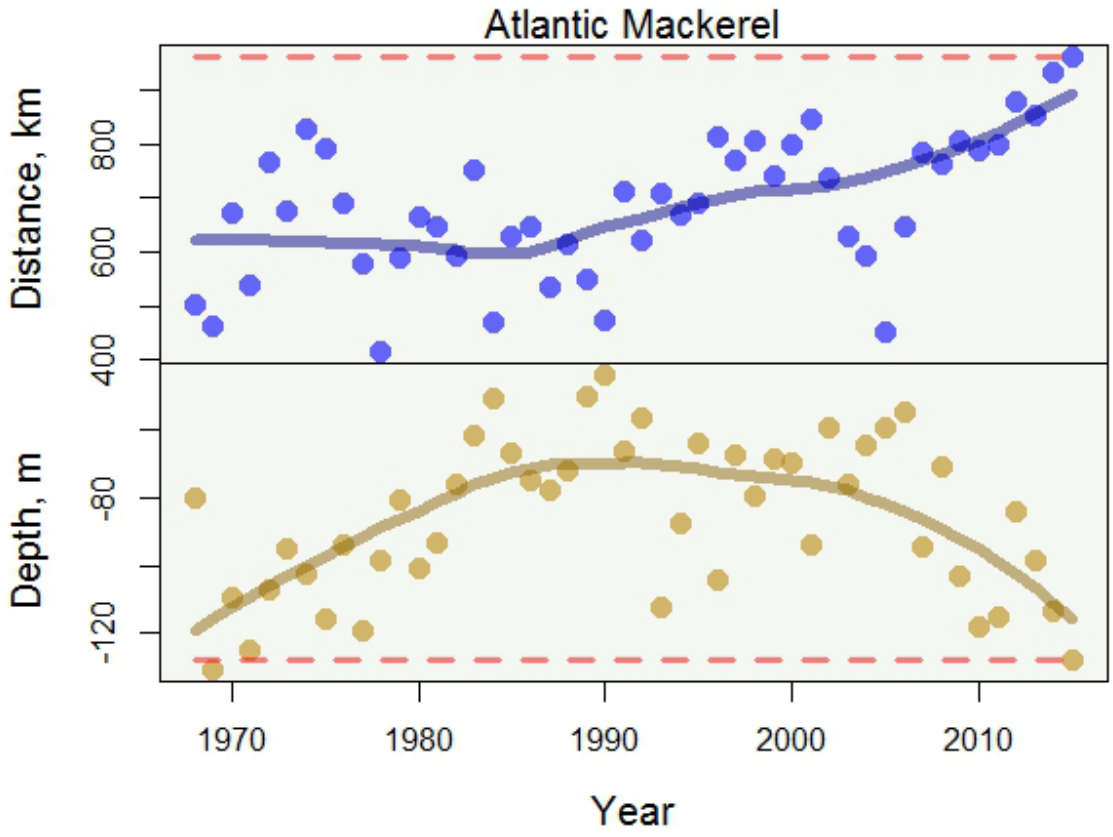
Atlantic Cod



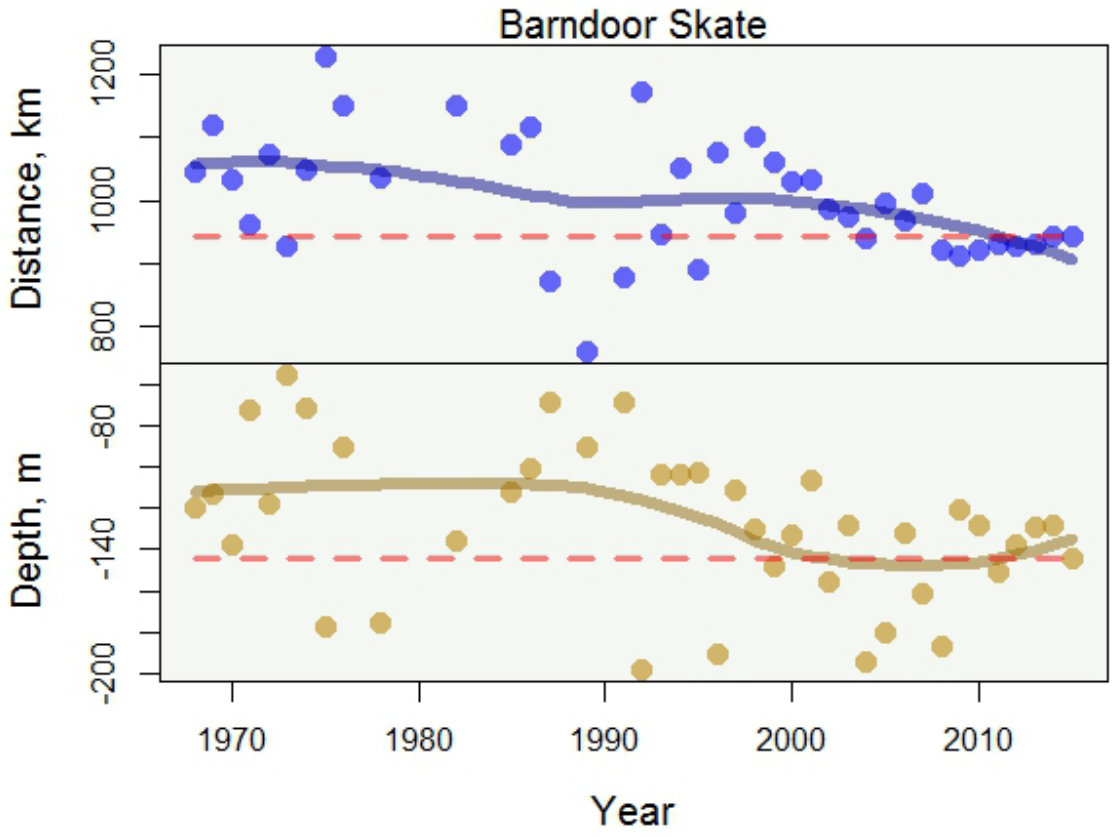
Atlantic Herring



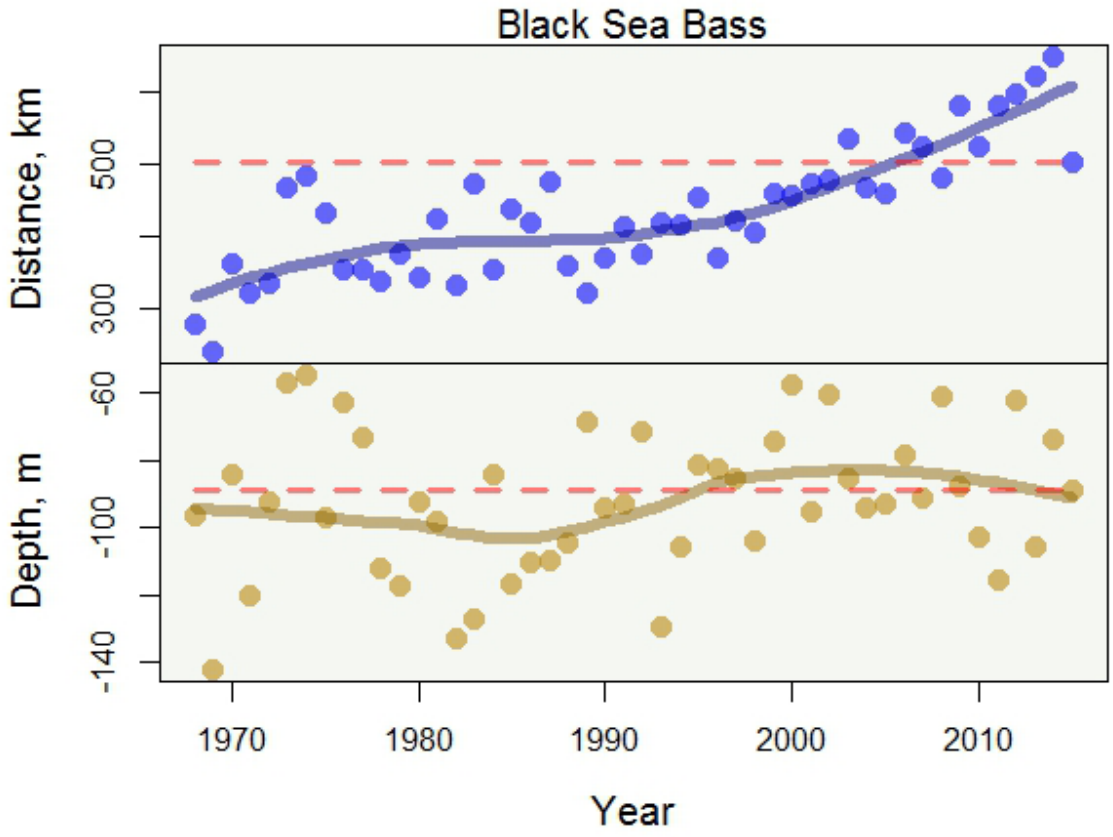
Atlantic Mackerel



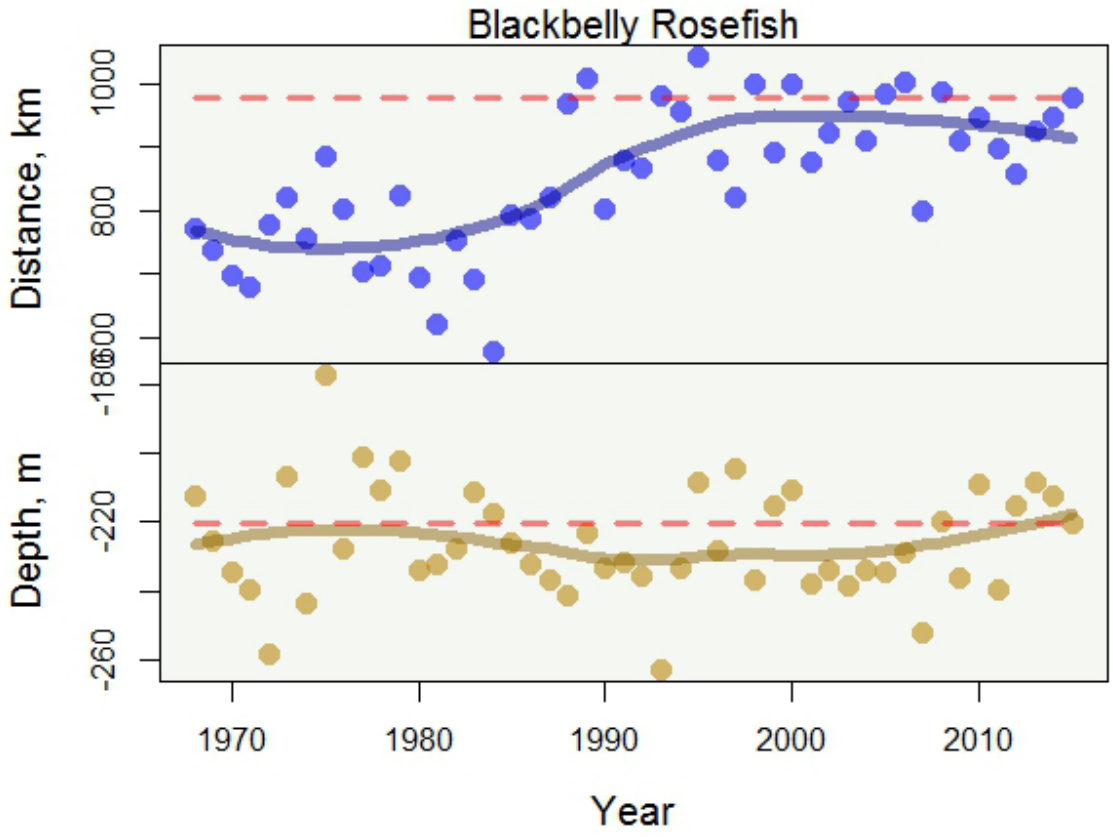
Barndoor Skate



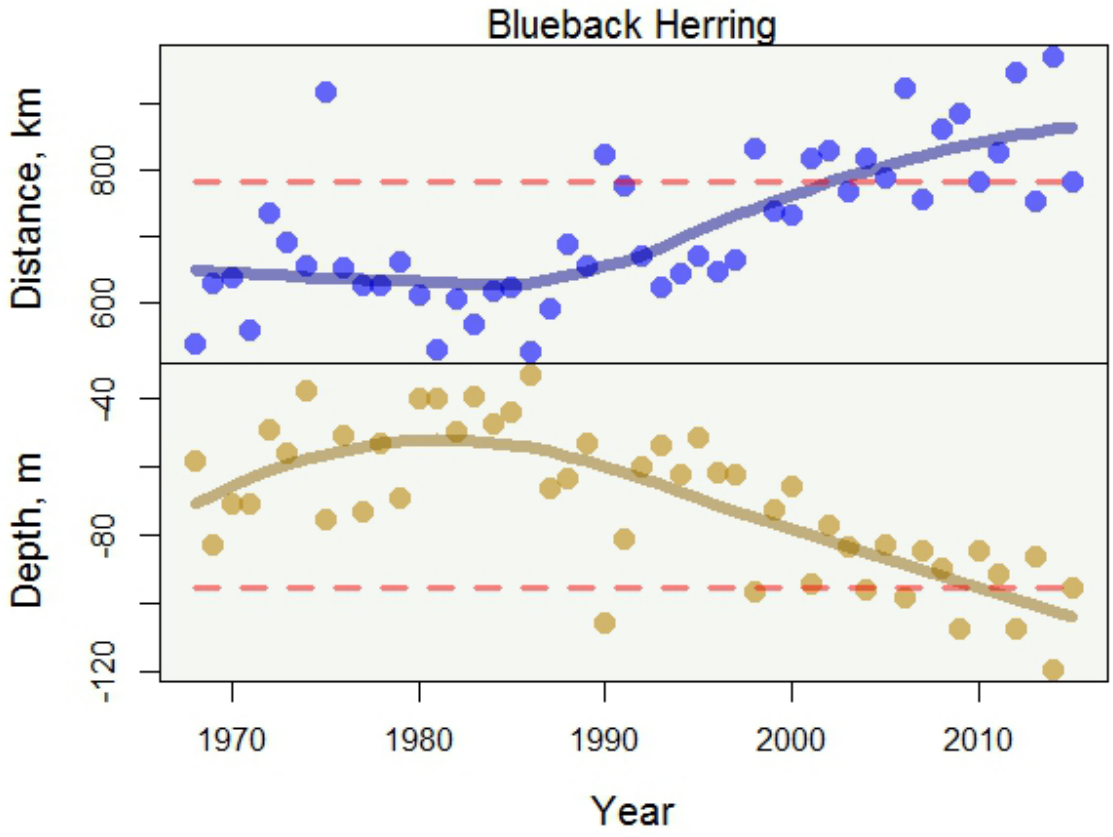
Black Sea Bass



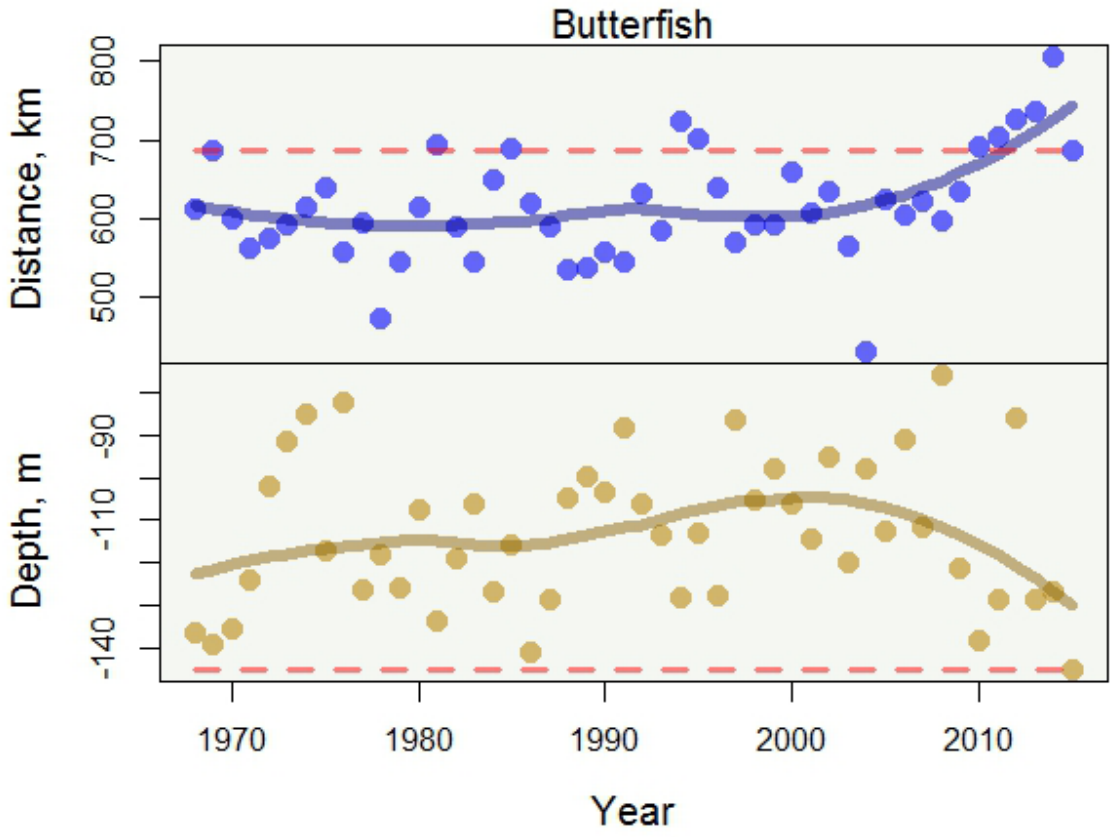
Blackbelly Rosefish



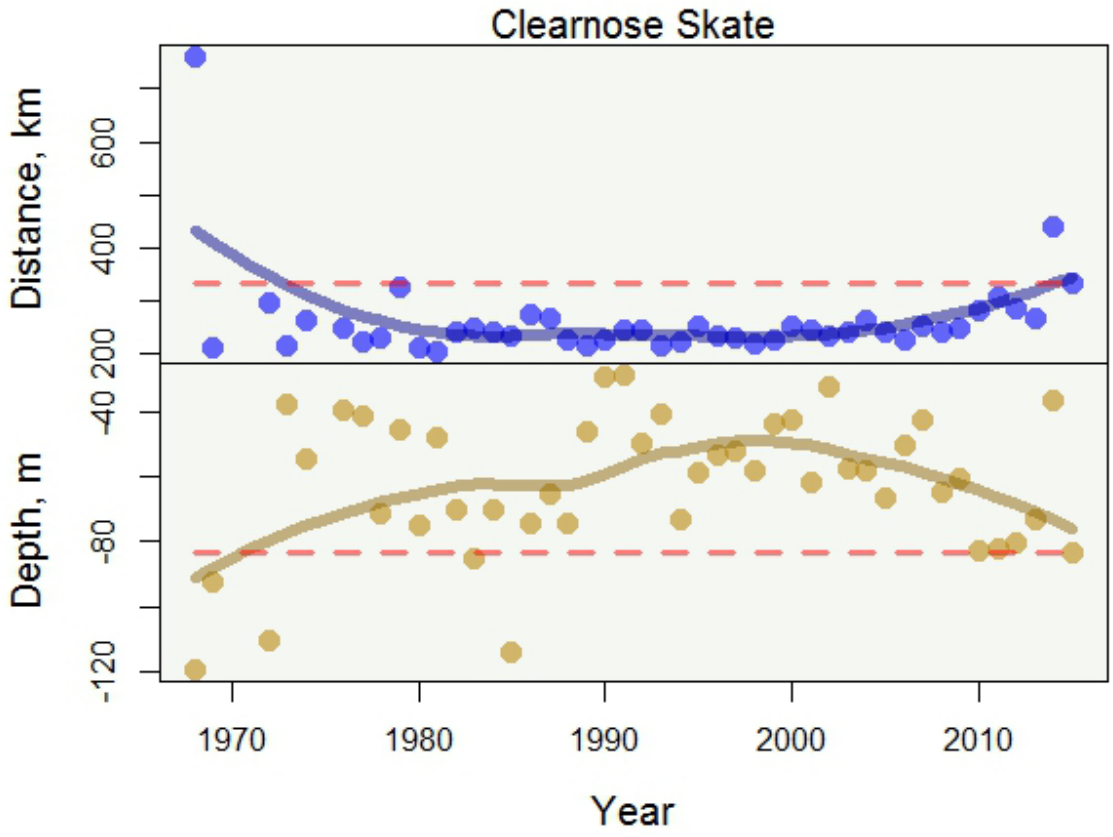
Blueback Herring



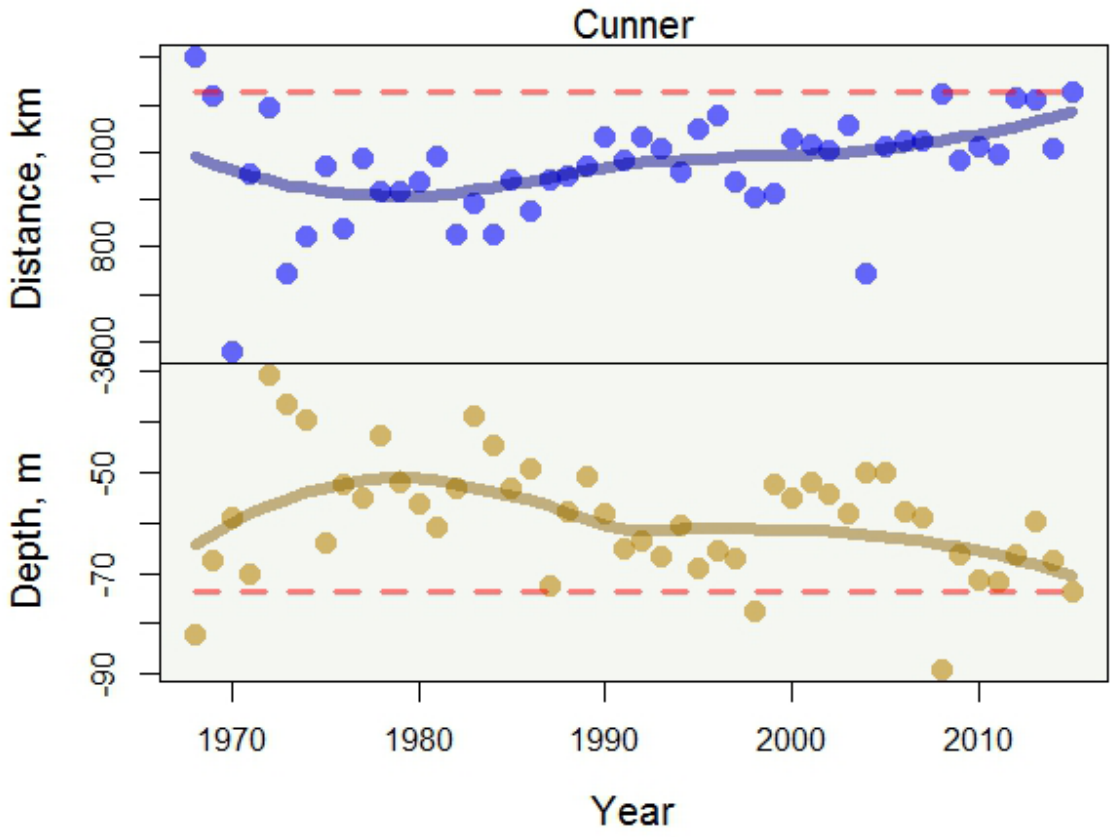
Butterfish


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

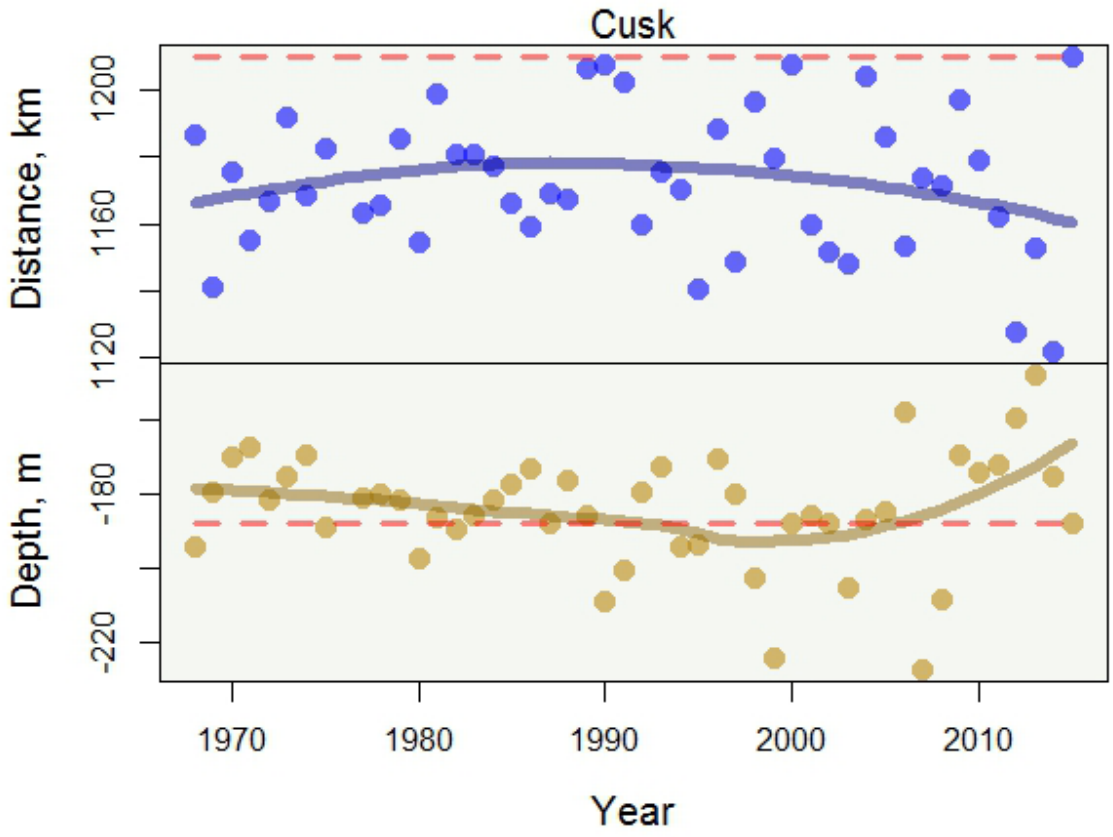
Clearnose Skate



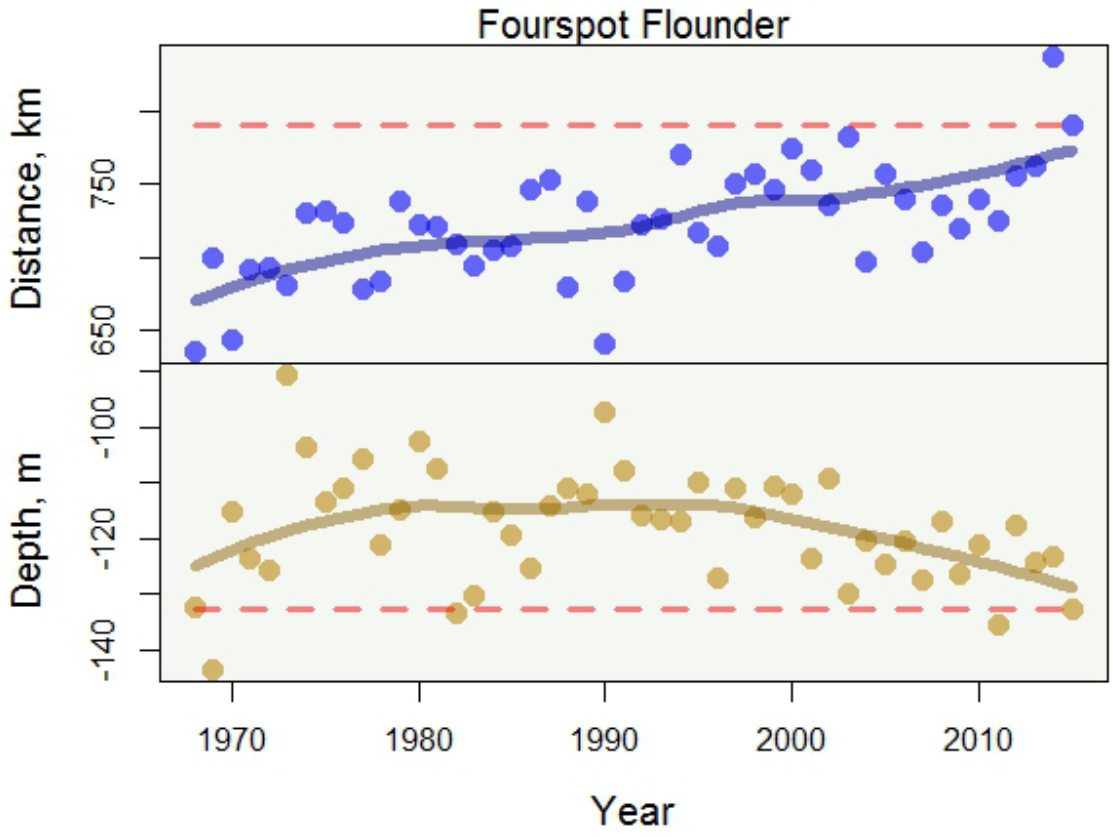
Cunner


Cunner
Distance, km
1000
800
-3600
Depth, m
-50
-70
-90
1970
1980
1990
2000
2010
Year

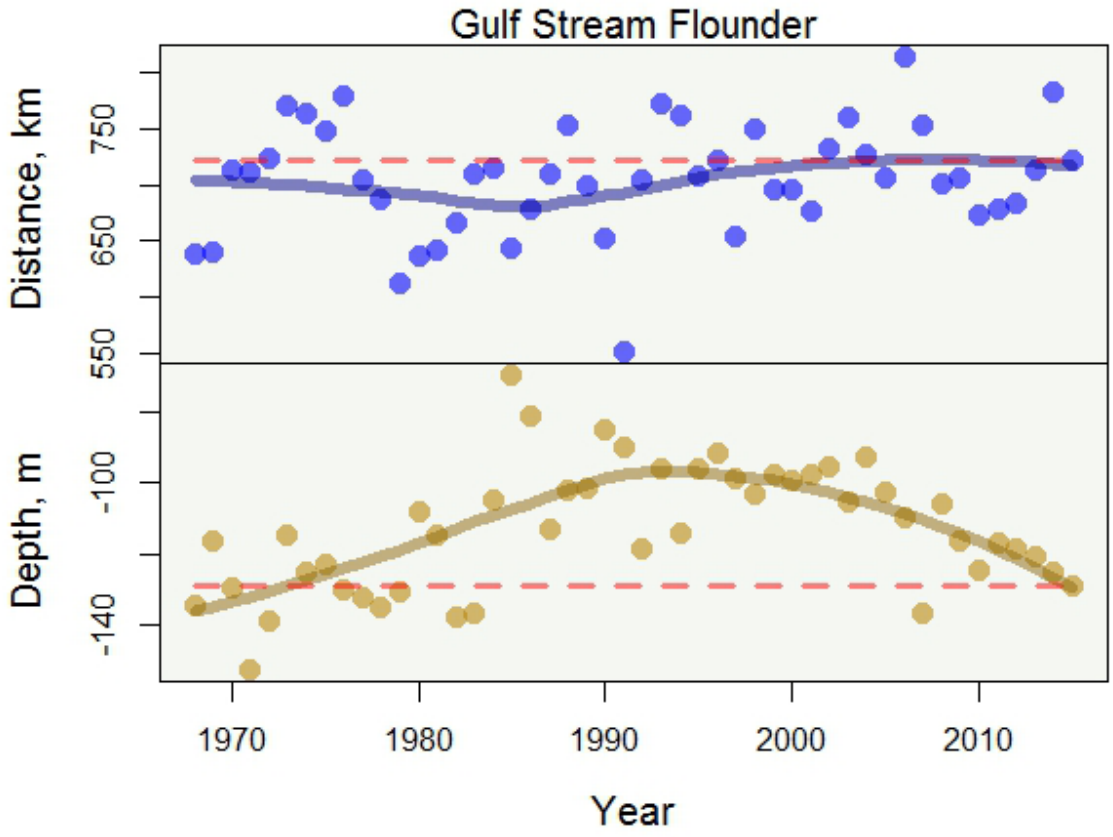
Cusk


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

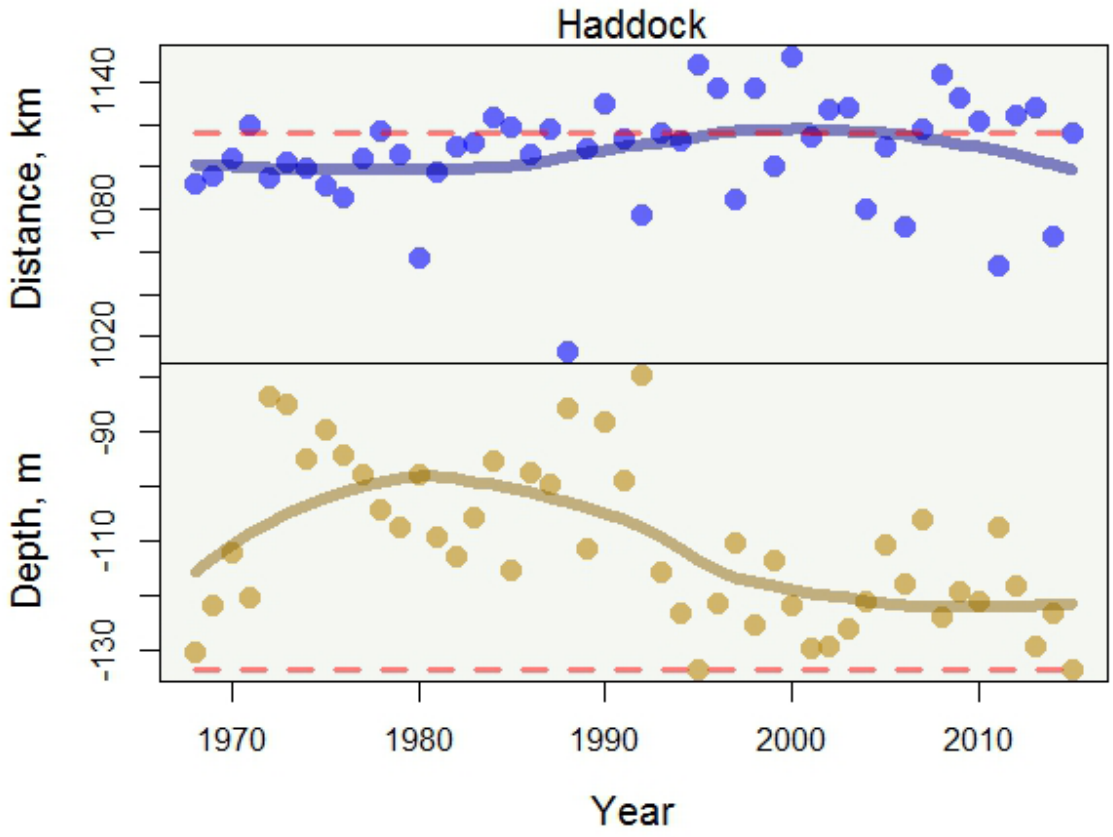
Fourspot Flounder



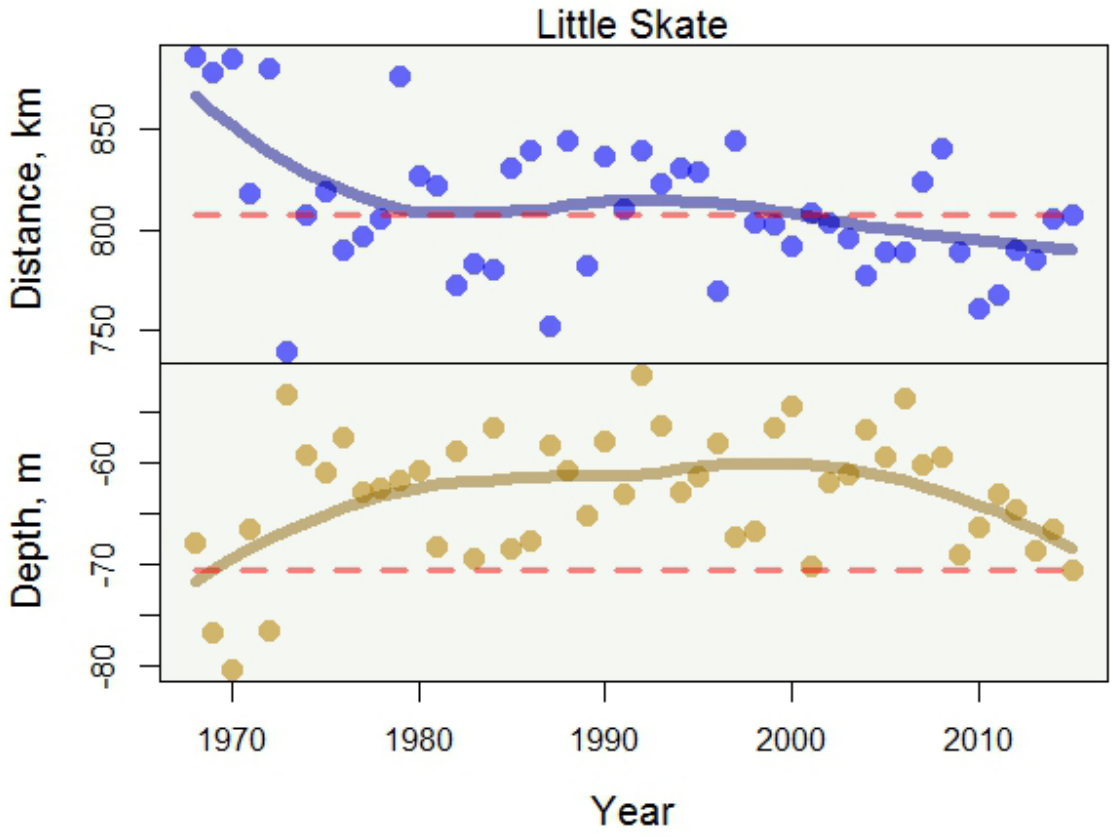
Gulf Stream Flounder



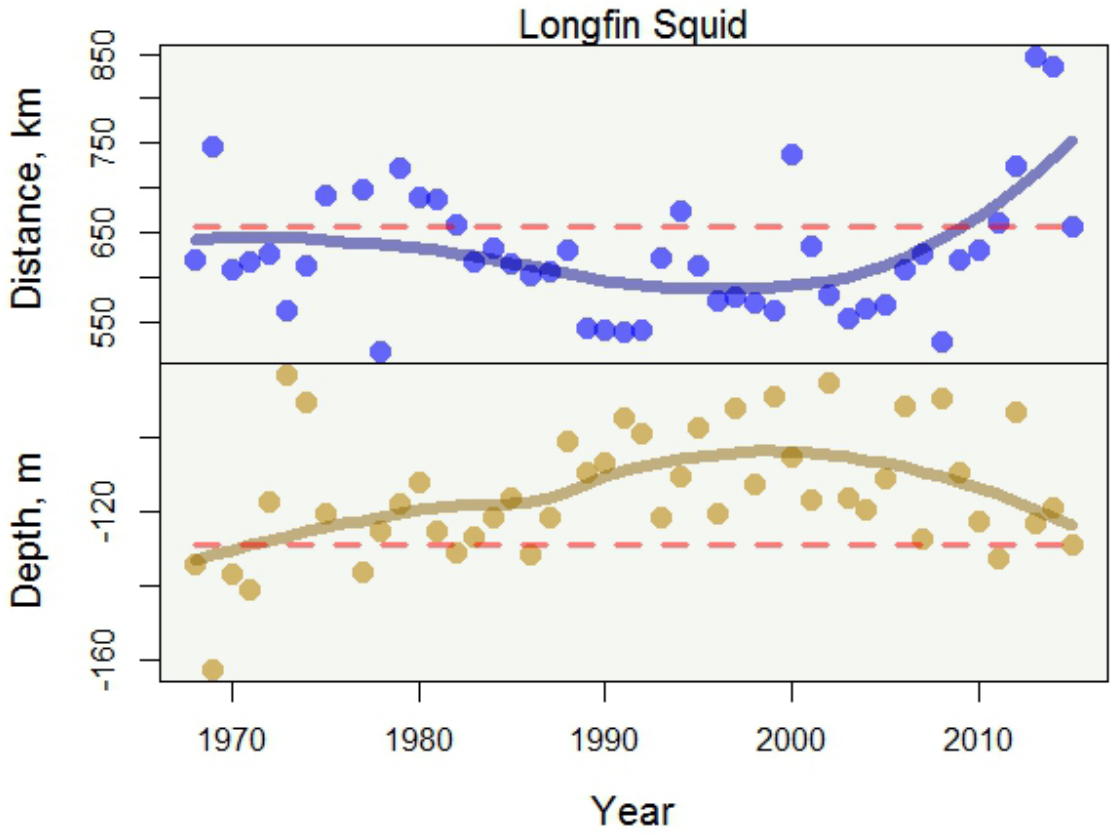
Haddock


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

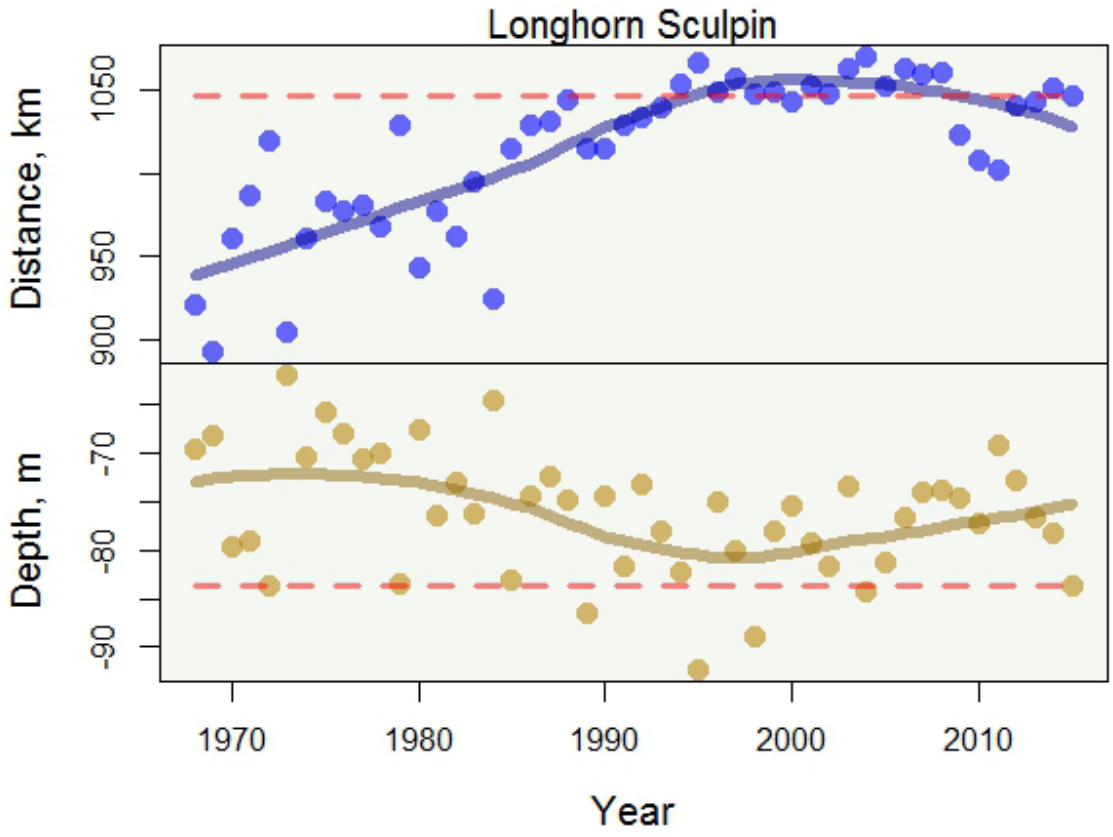
Little Skate



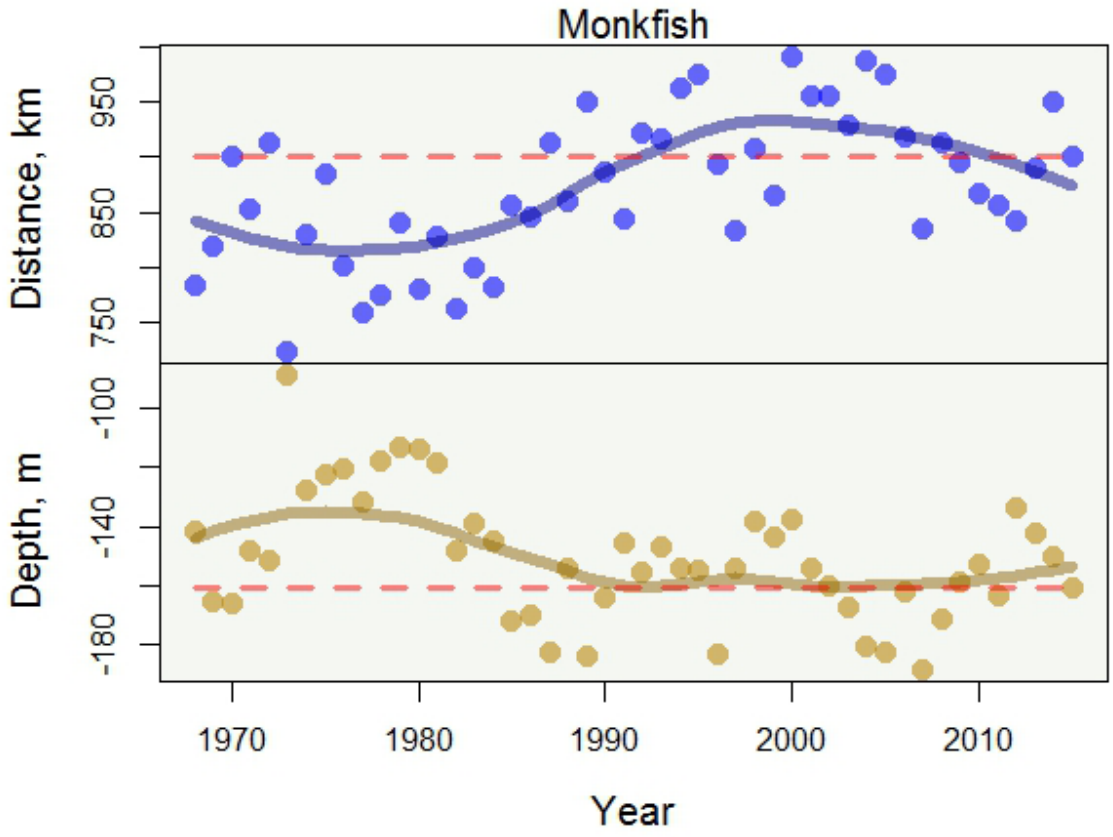
Longfin Squid



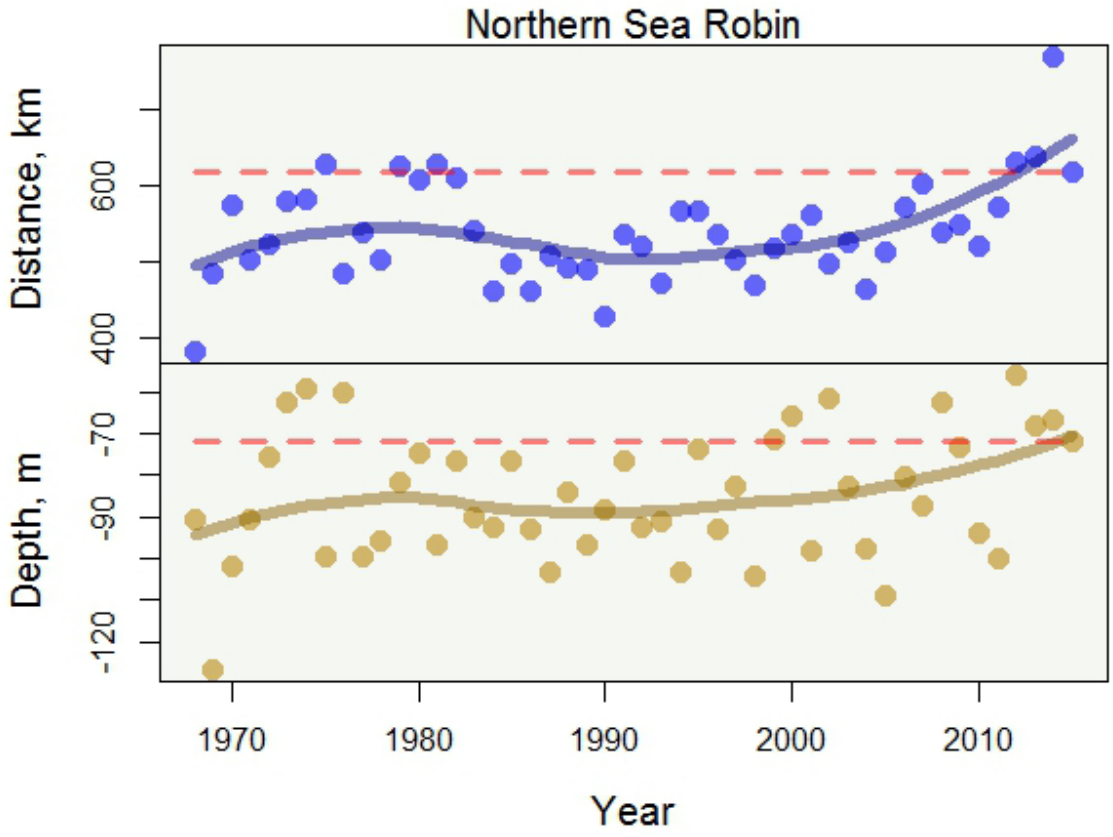
Longhorn Sculpin



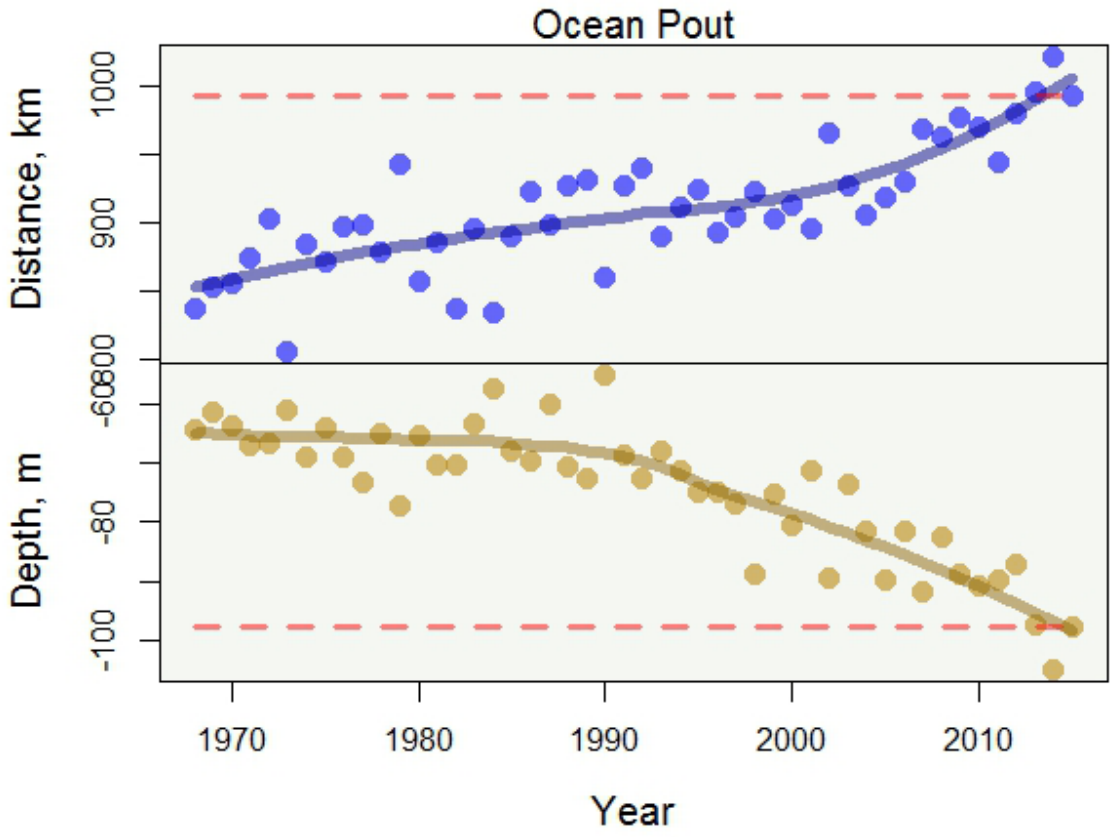
Monkfish


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

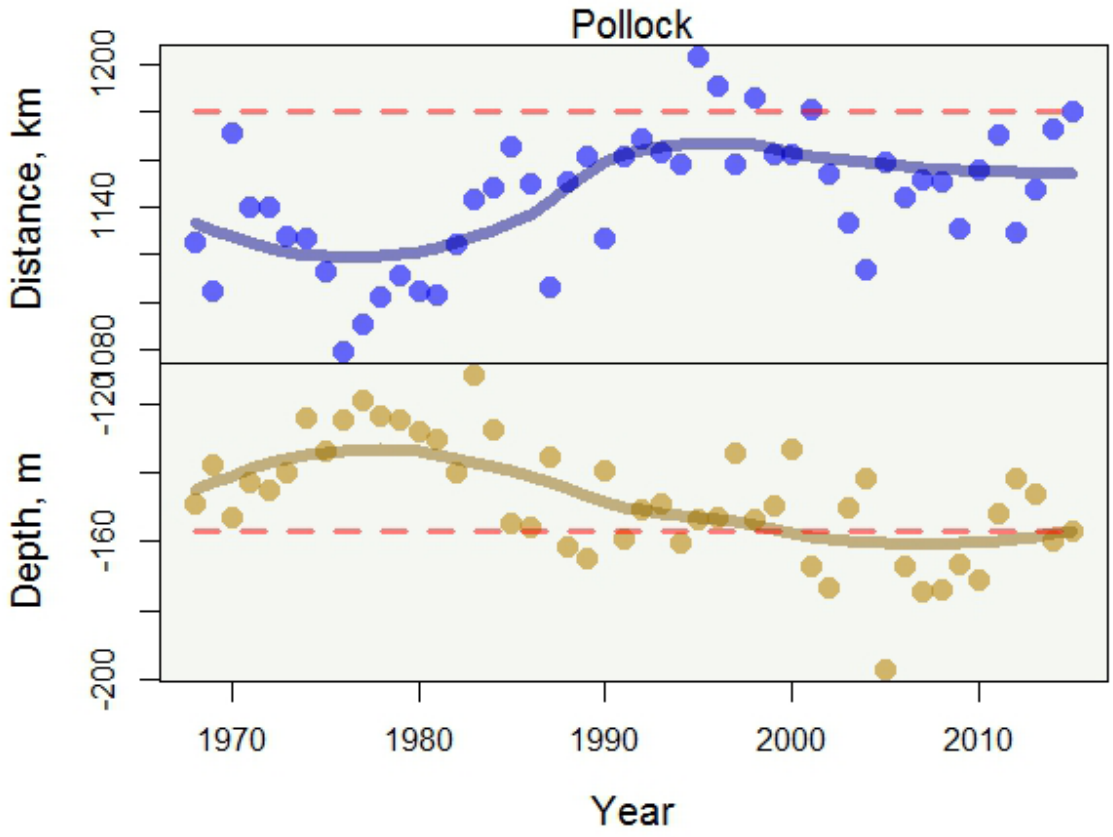
Northern Sea Robin



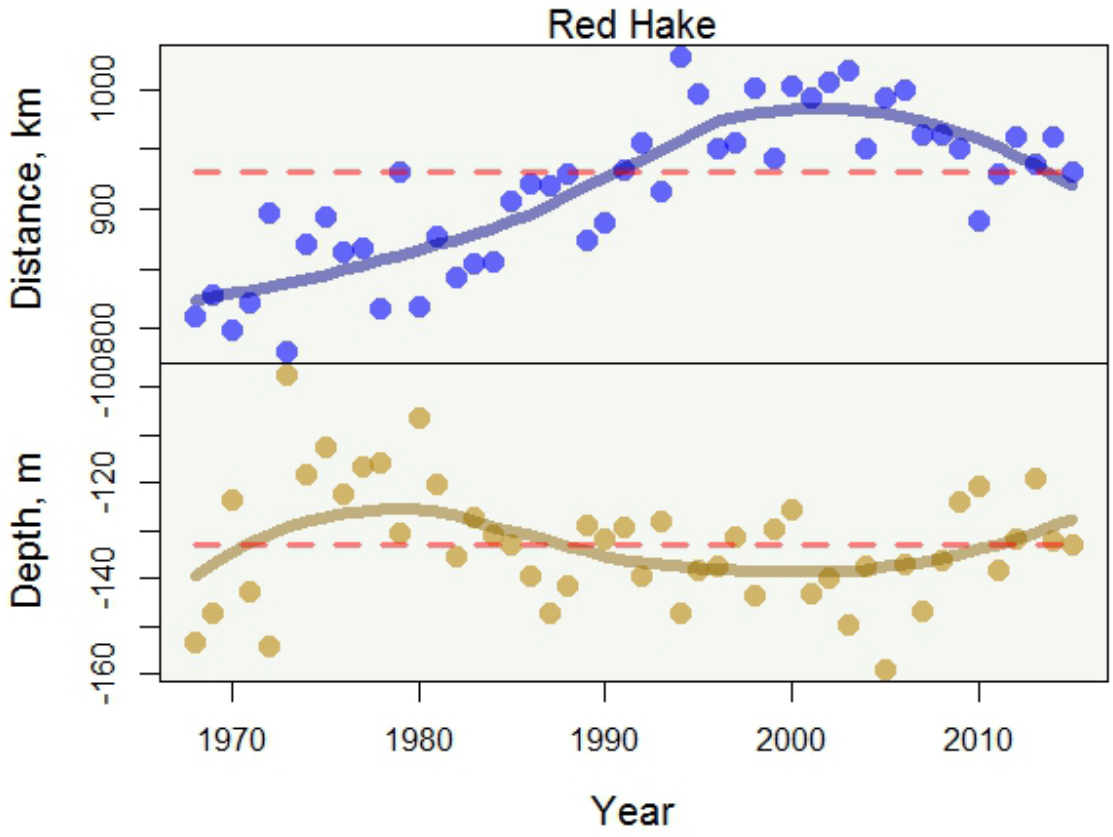
Ocean Pout


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

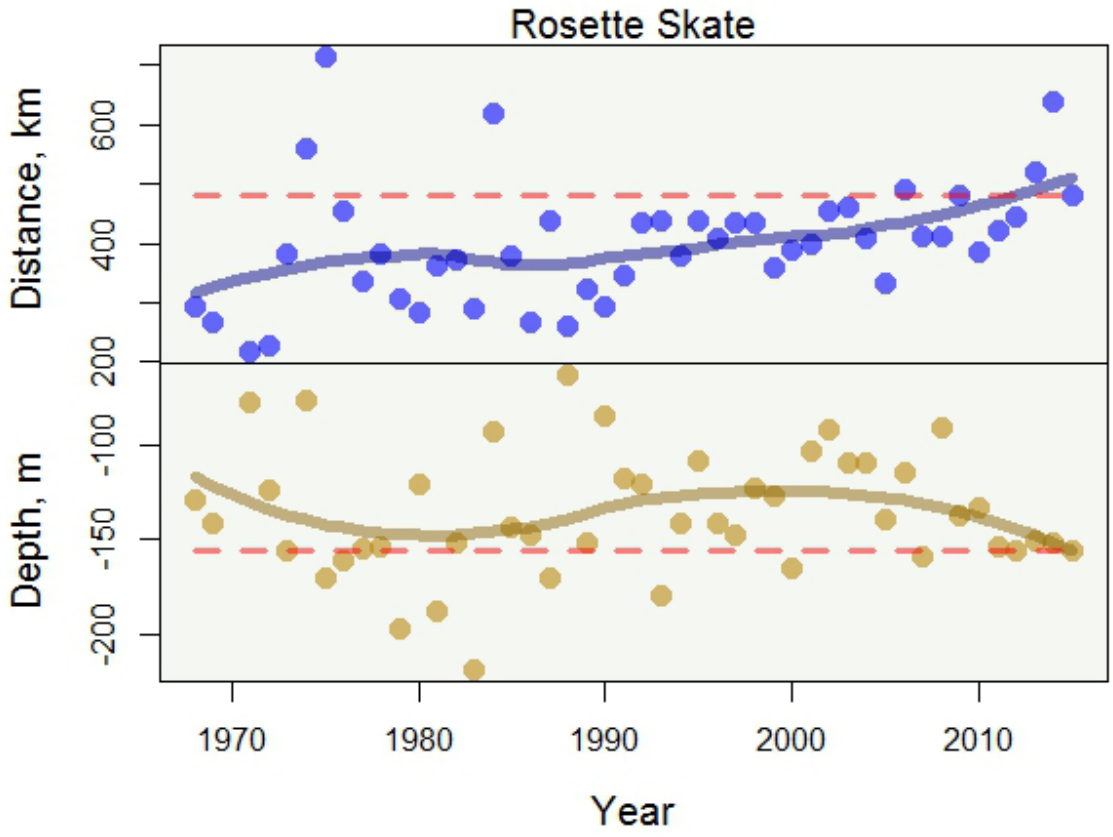
Pollock


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

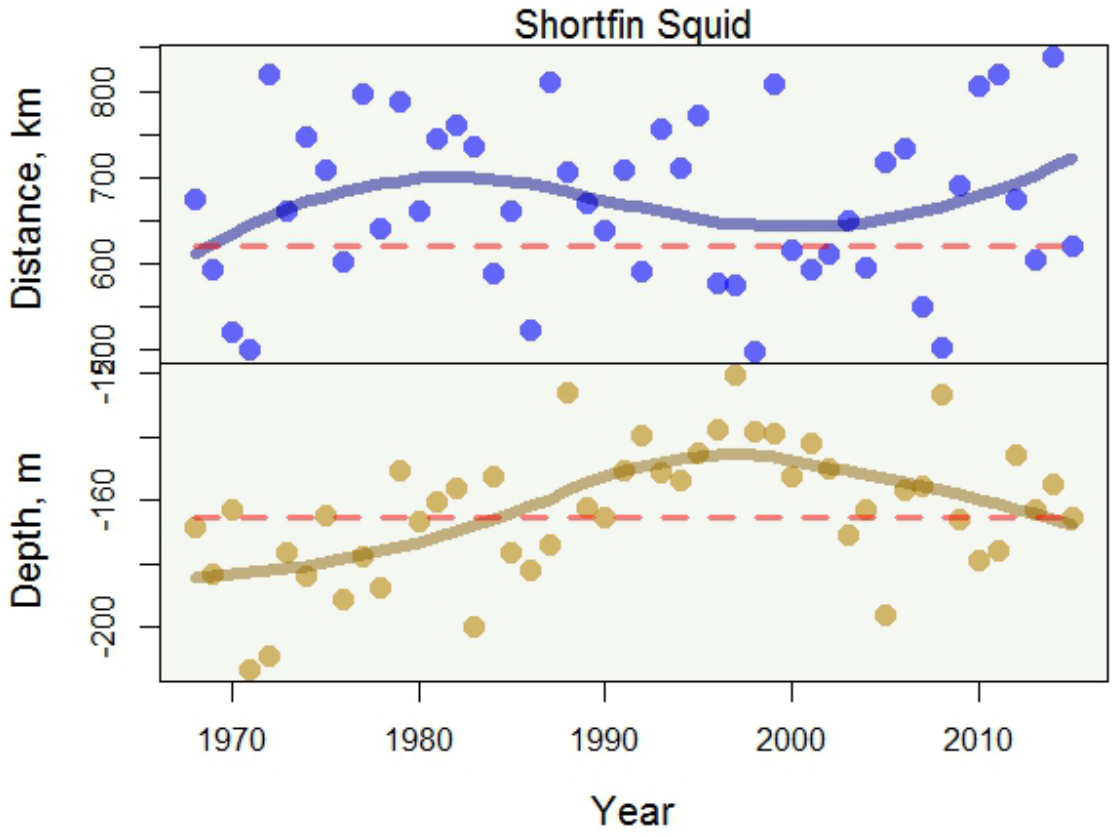
Red Hake


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

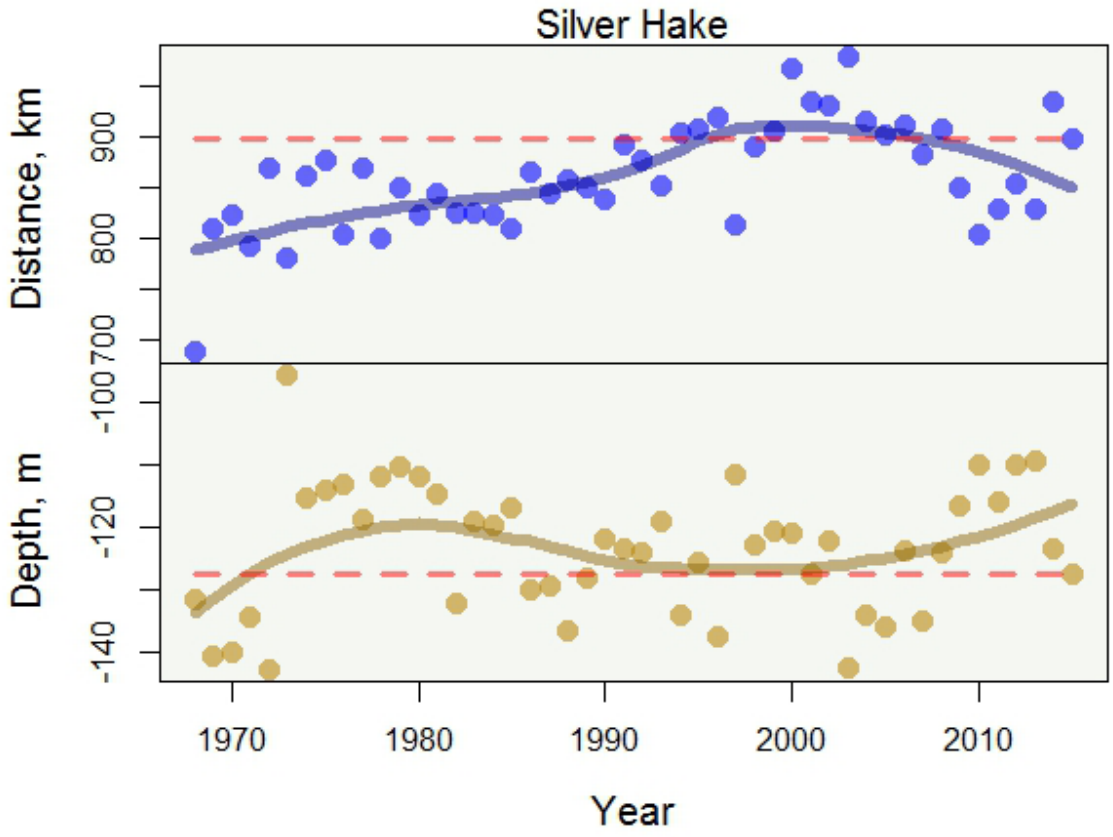
Rosette Skate



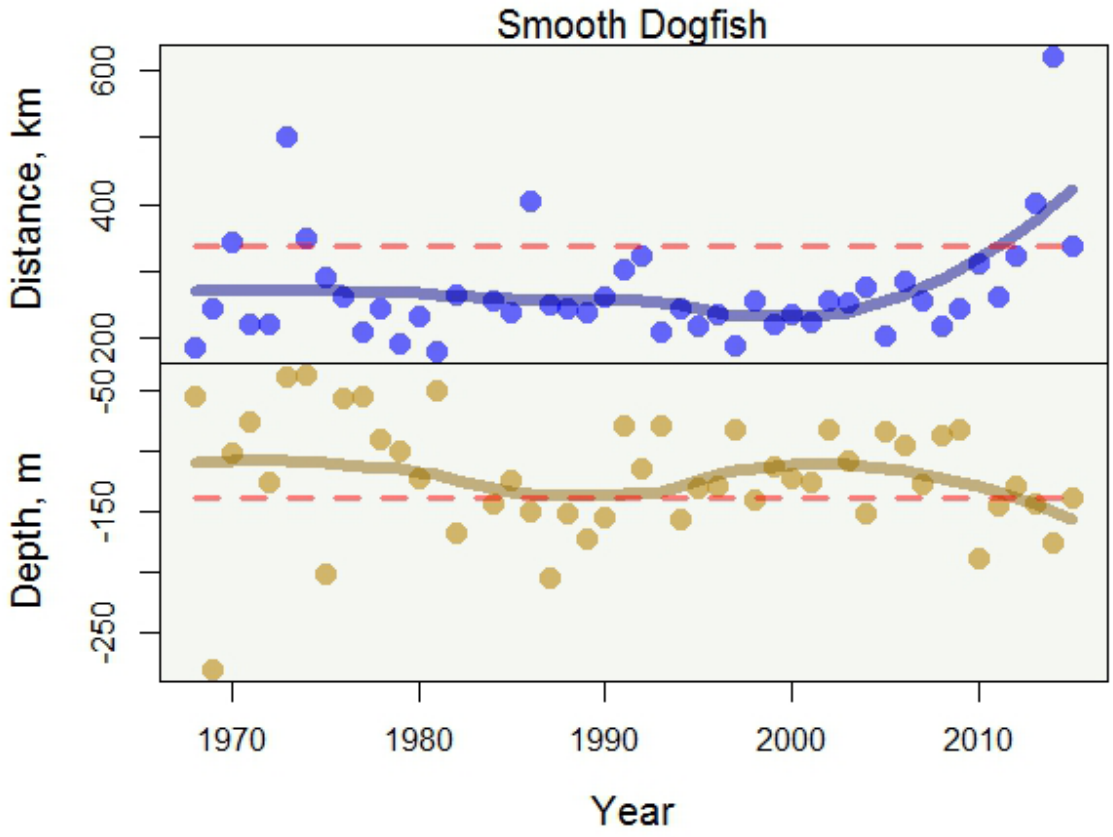
Shortfin Squid



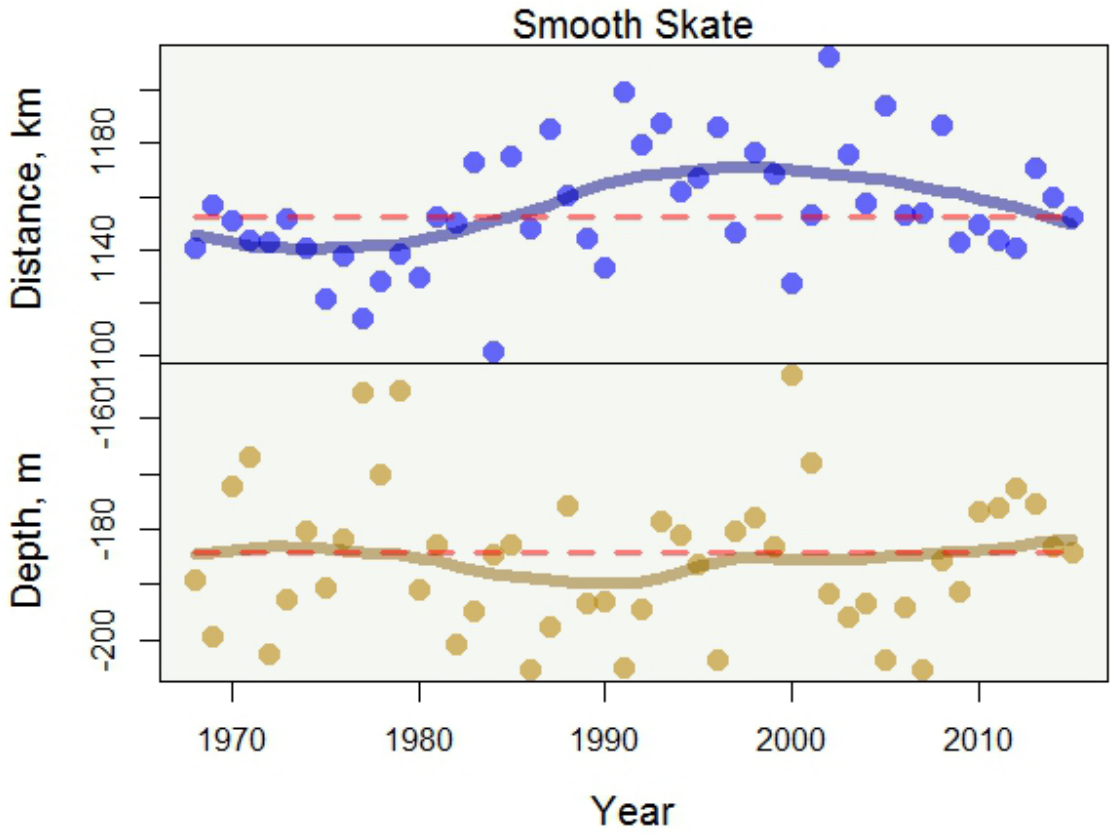
Silver Hake


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

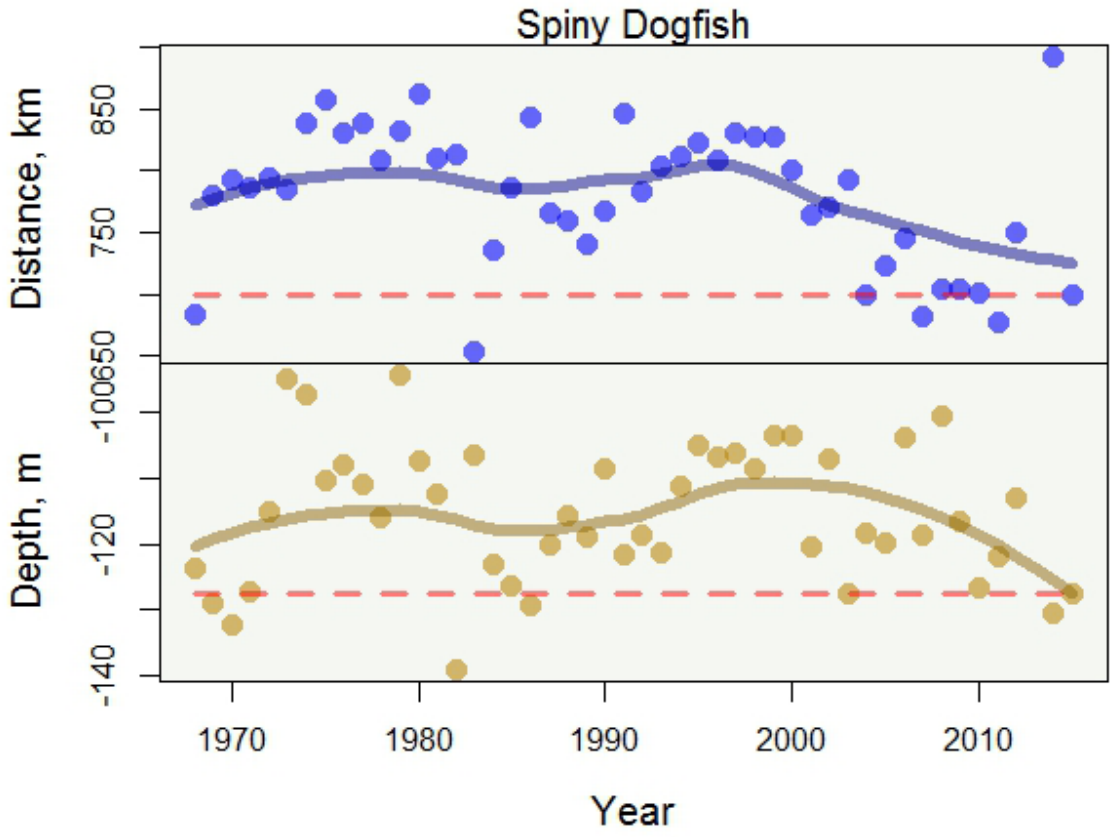
Smooth Dogfish



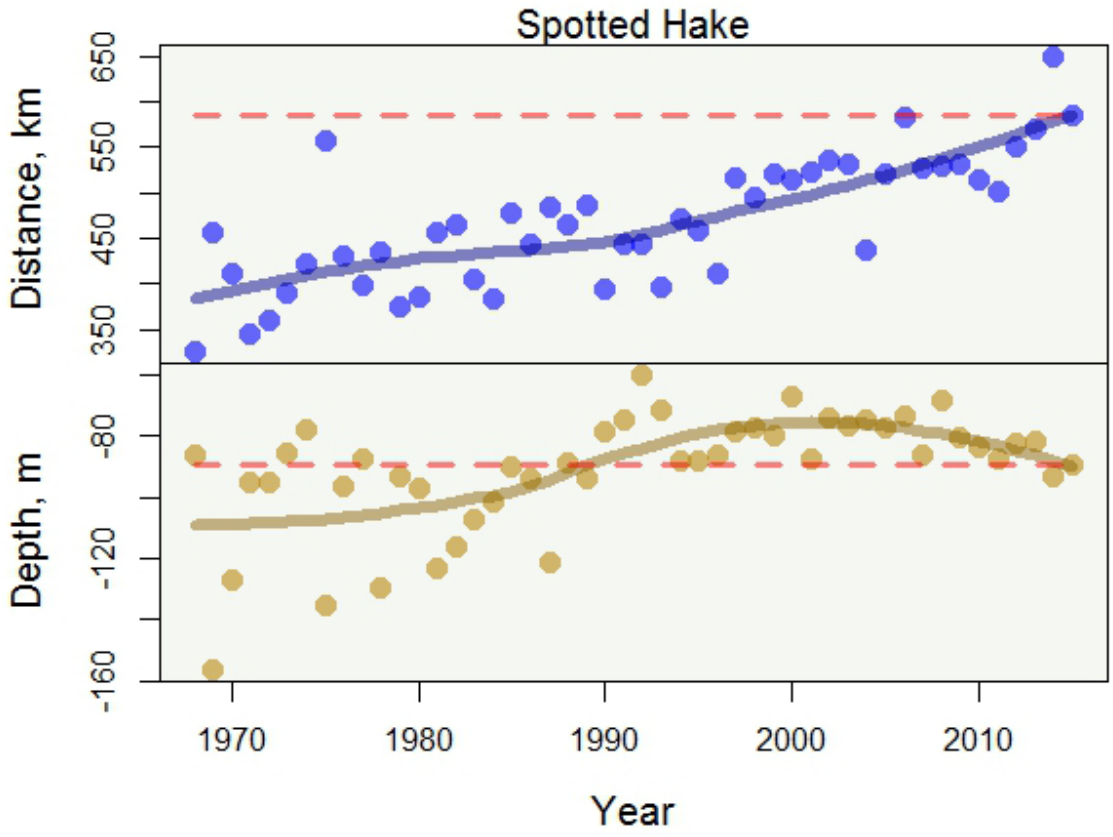
Smooth Skate



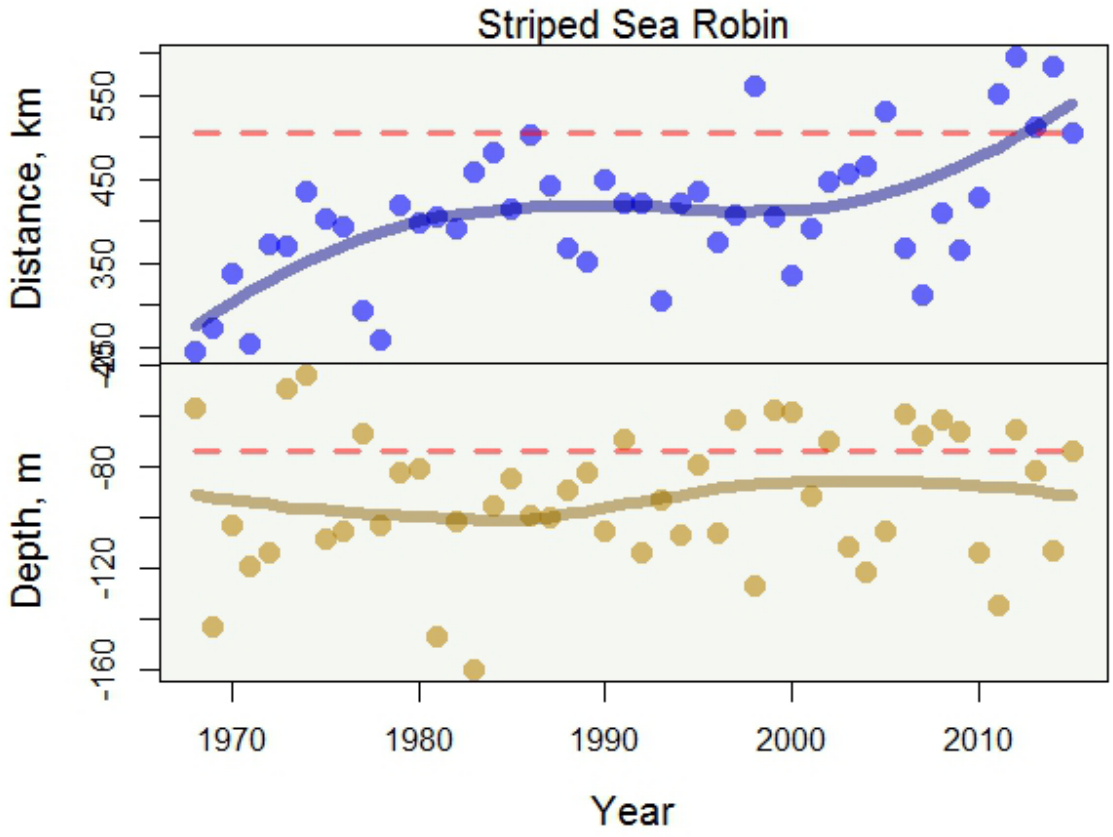
Spiny Dogfish



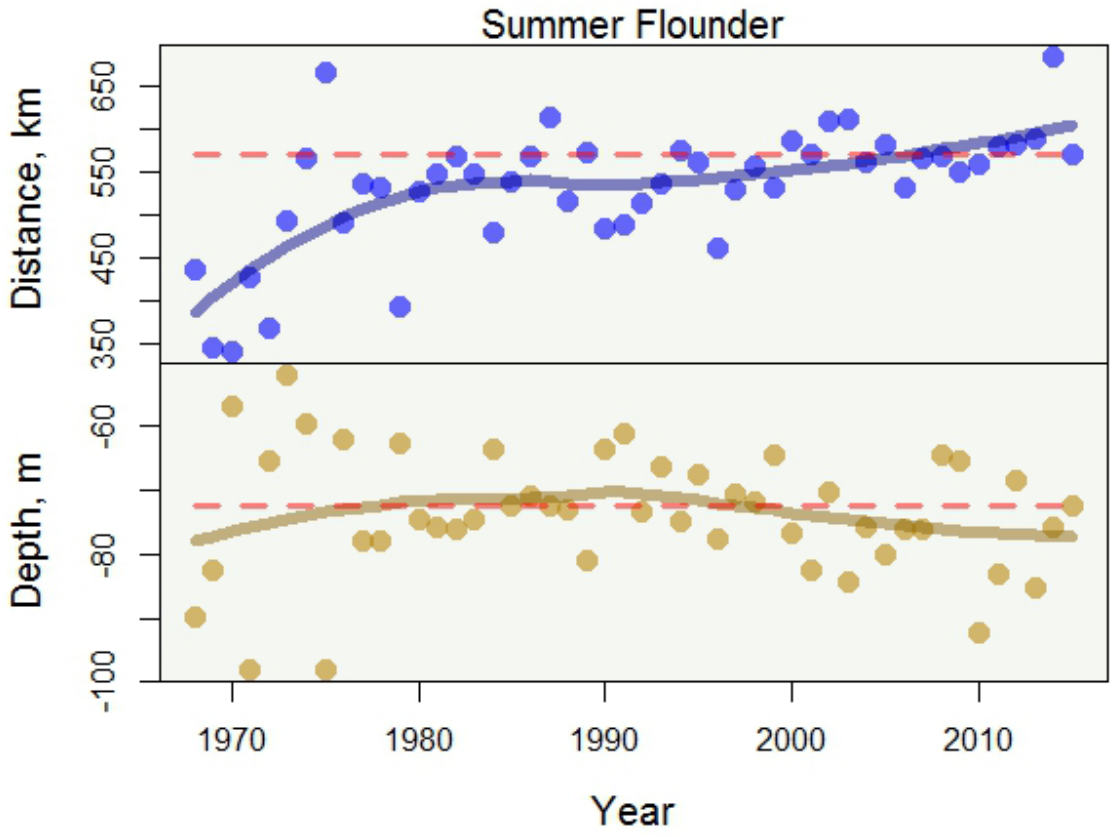
Spotted Hake



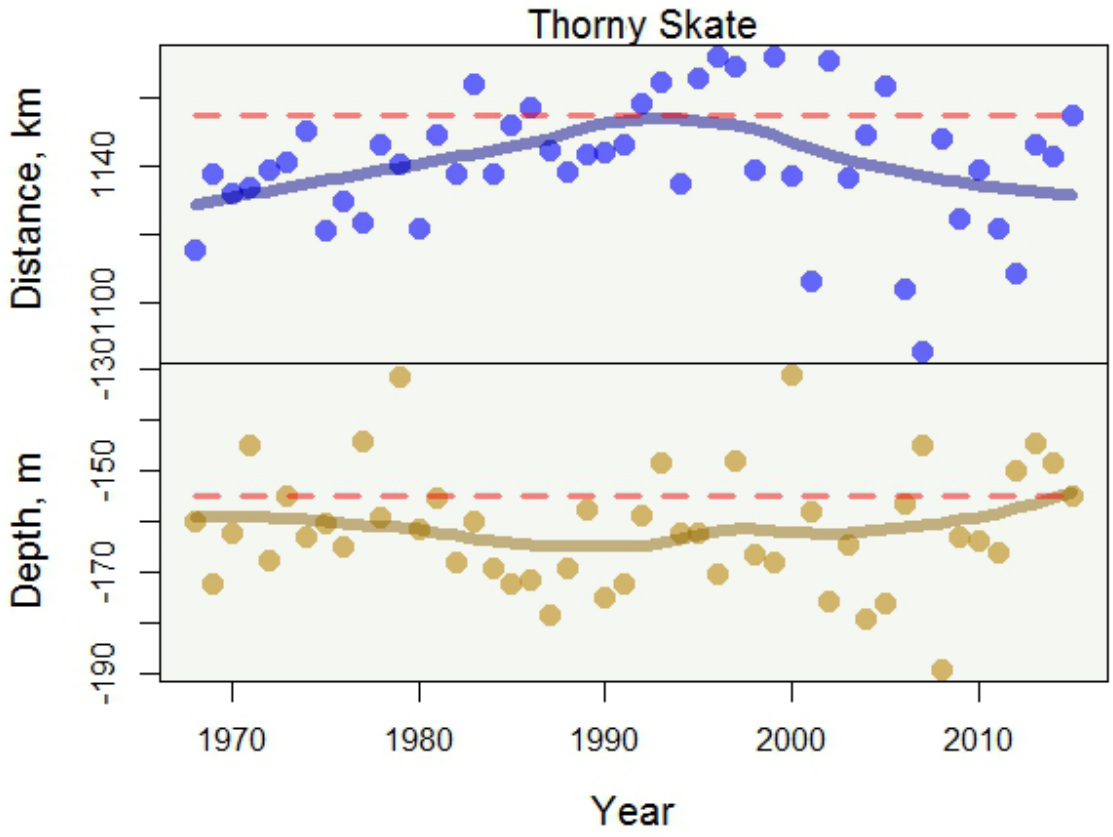
Striped Sea Robin



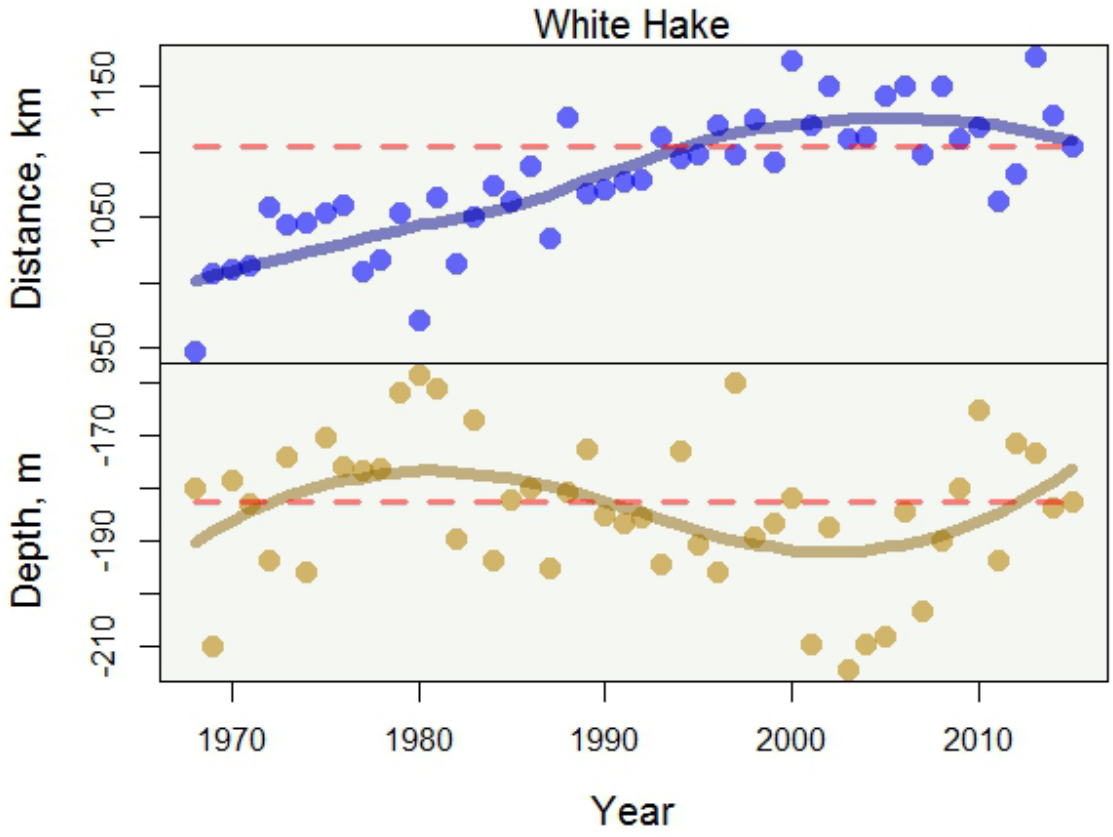
Summer Flounder



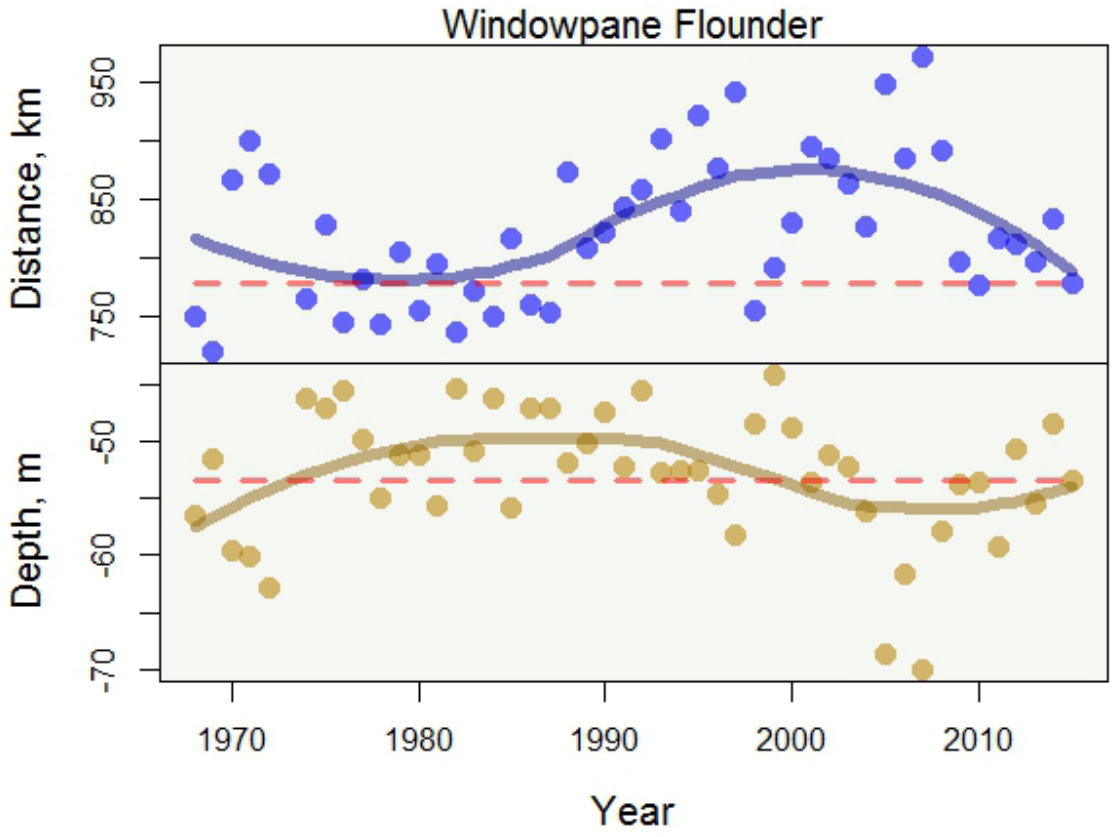
Thorny Skate



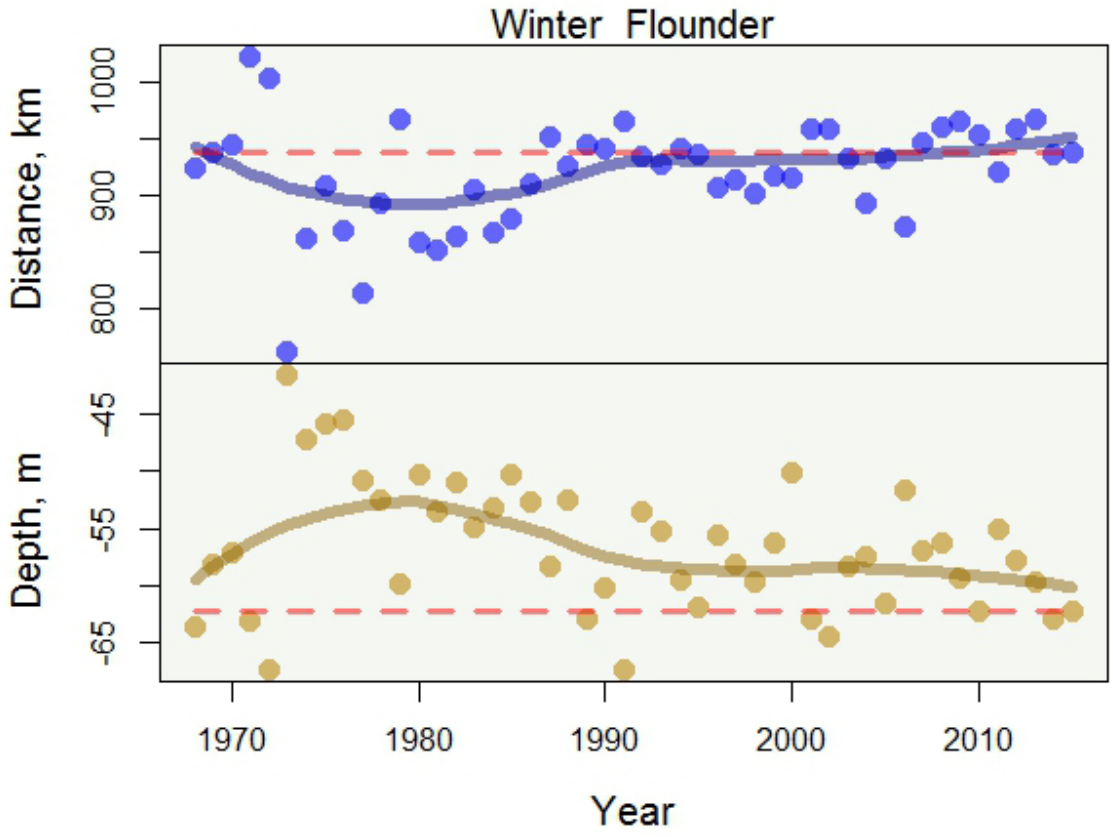
White Hake


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

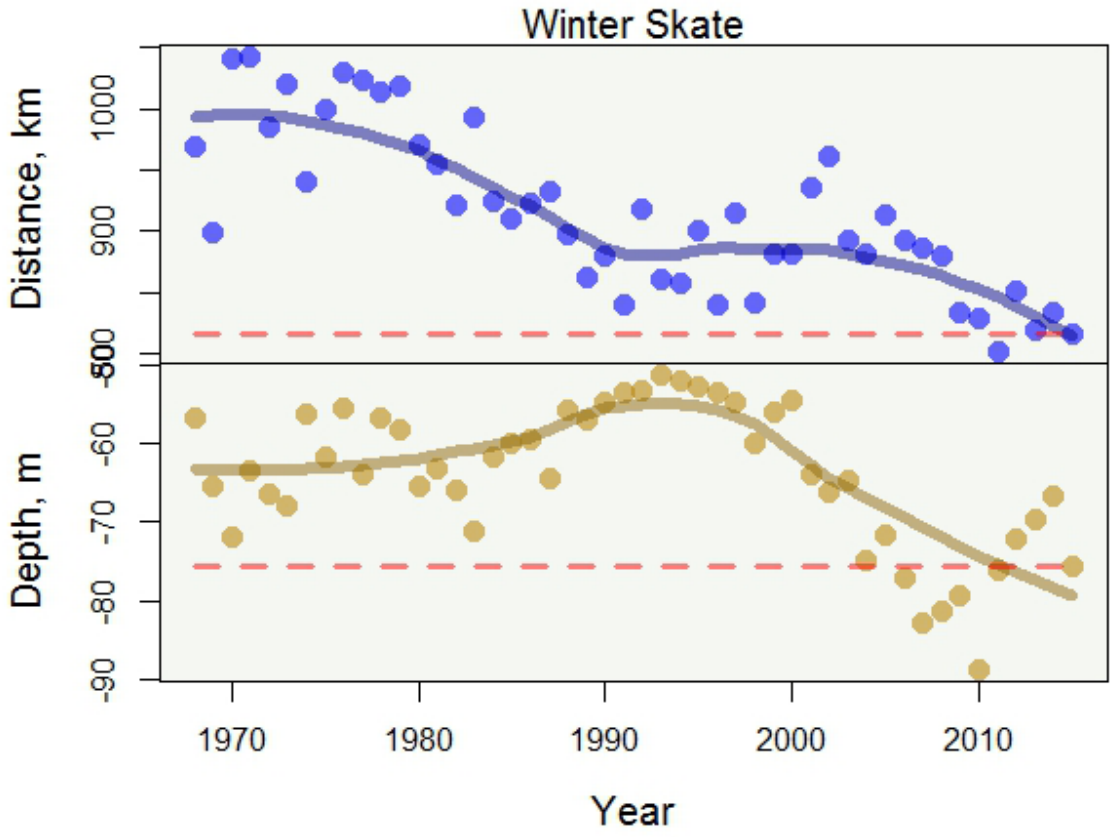
Windowpane Flounder



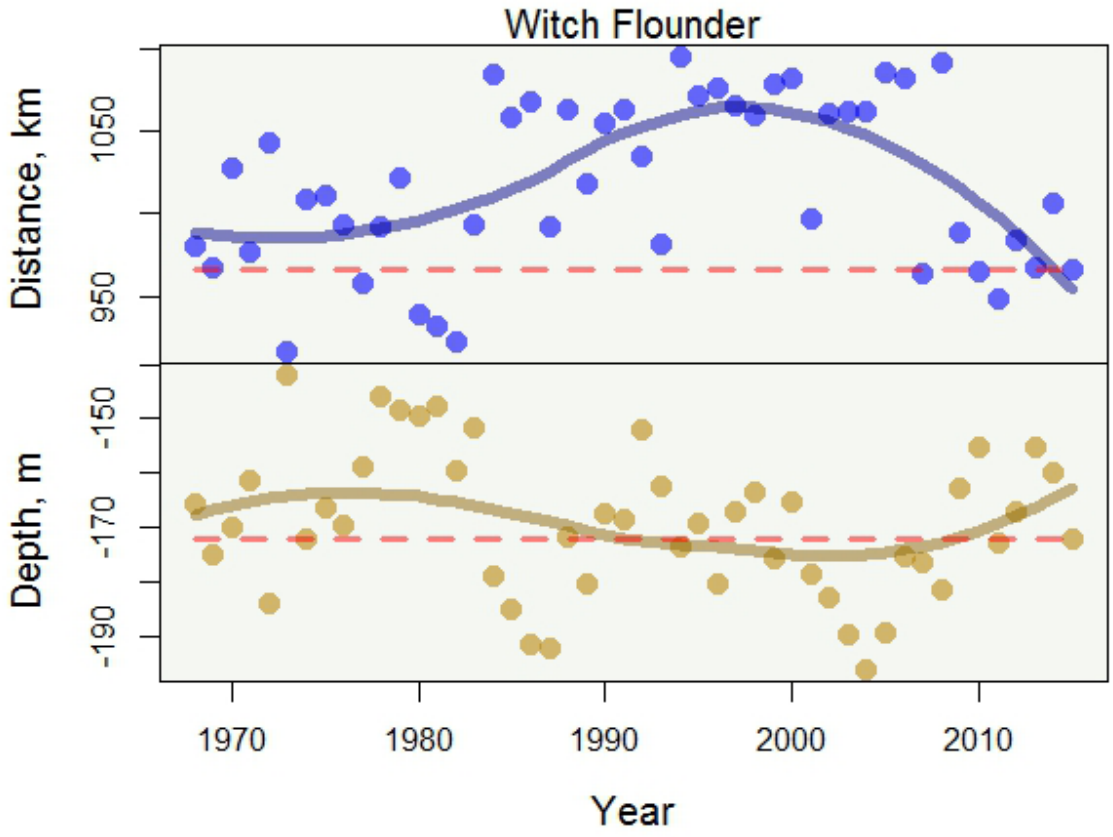
Winter Flounder



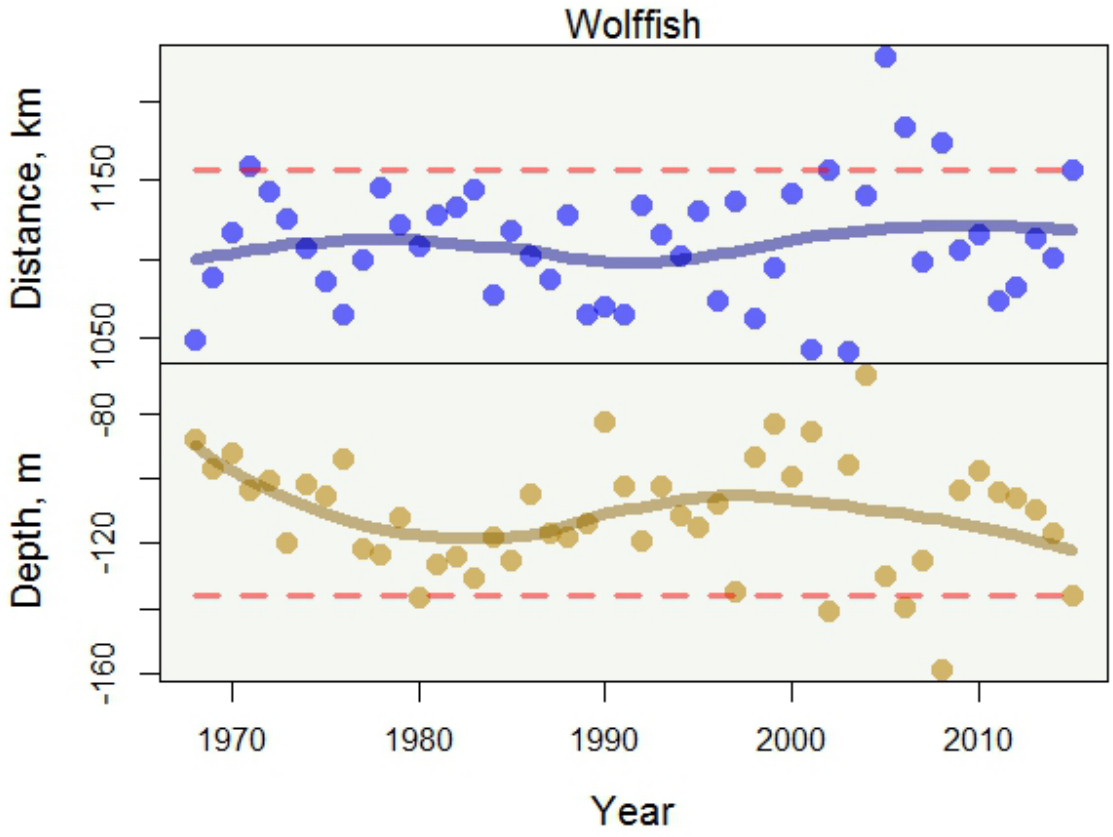
Winter Skate



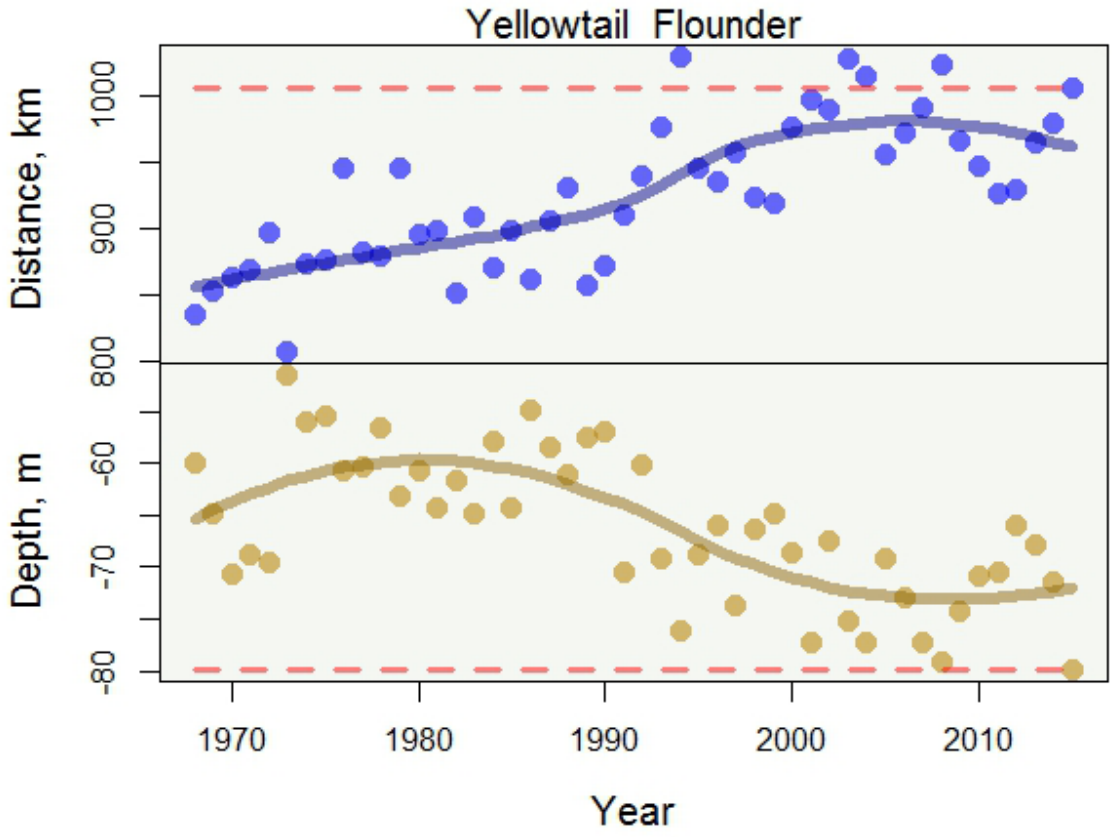
Witch Flounder



Wolffish

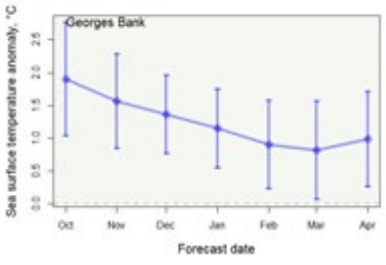

Wolffish
Distance, km
1150
1050
Depth, m
-80
-120
-160
1970
1980
1990
2000
2010
Year

Yellowtail Flounder

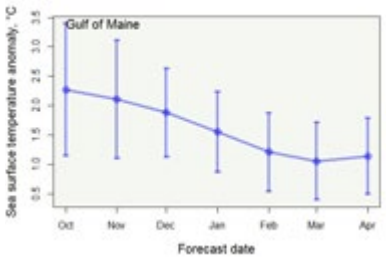


Sea Surface Temperature Forecast

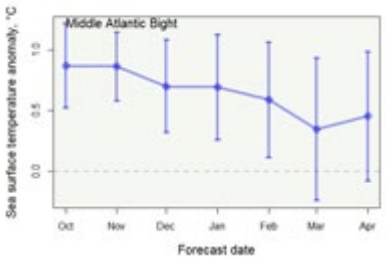
For each of the ecoregions of the Northeast Shelf, an ensemble mean estimate of forecast sea surface temperature through the spring 2016 is provided with error bar representing the 95% confidence interval around the mean. The ensemble draws from seven earth systems models recast on similar models grid by the North American Multi-Model Ensemble project. The forecasts suggest that SST will remain above average in all areas through the winter into the spring; however, the SST anomaly levels will decrease by substantial levels in all areas. The forecasts suggest the SST will only be a degree above average in Georges Bank and Gulf of Maine, a decrease in anomaly level of 1°C in both areas. The decline in anomaly will be on the order of a 0.5°C in the Middle Atlantic Bight and Scotian Shelf ecoregions.



Georges Bank



Gulf of Maine



Middle Atlantic Bight

Scotian Shelf