Spring 2017 Update: Annual Condition of the Northeast Shelf Ecosystem

Produced by the Ecosystem Dynamics and Assessment Branch

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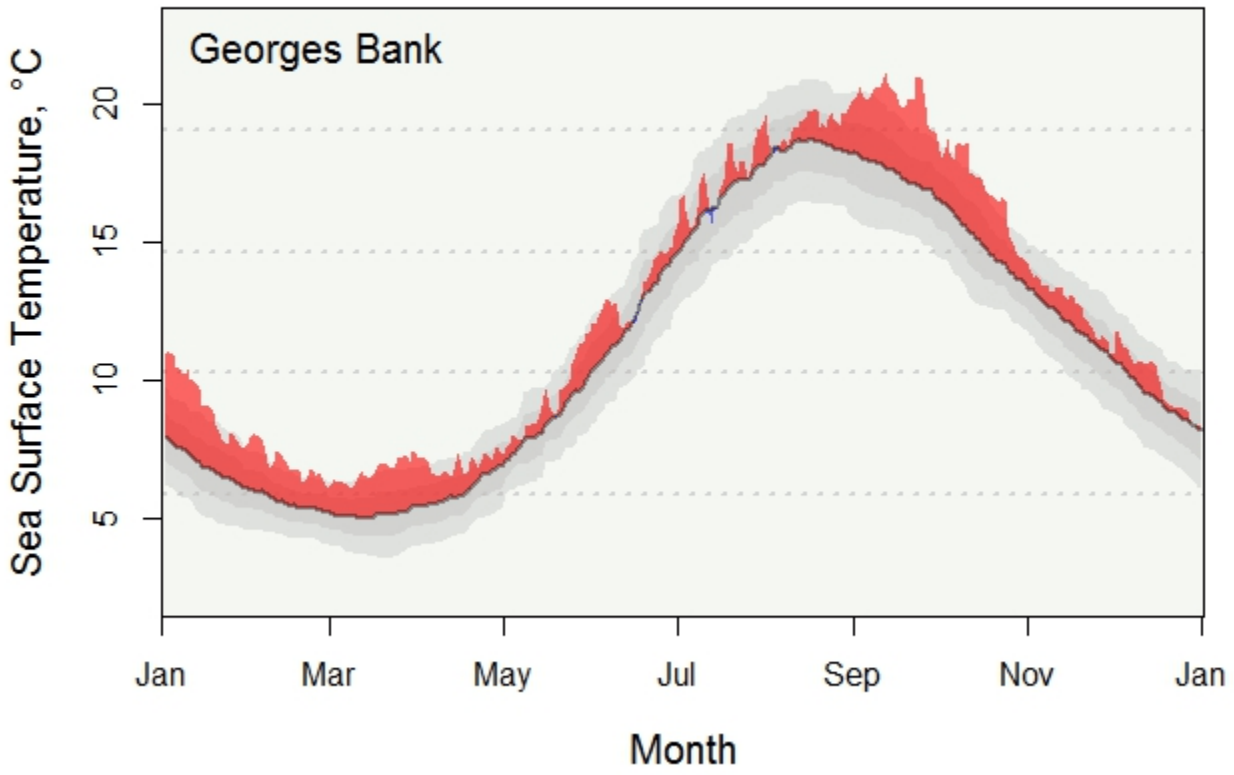
Current Conditions of the Northeast Shelf Ecosystem -- Spring 2017 Update

Summary of Conditions of the Northeast Shelf Ecosystem

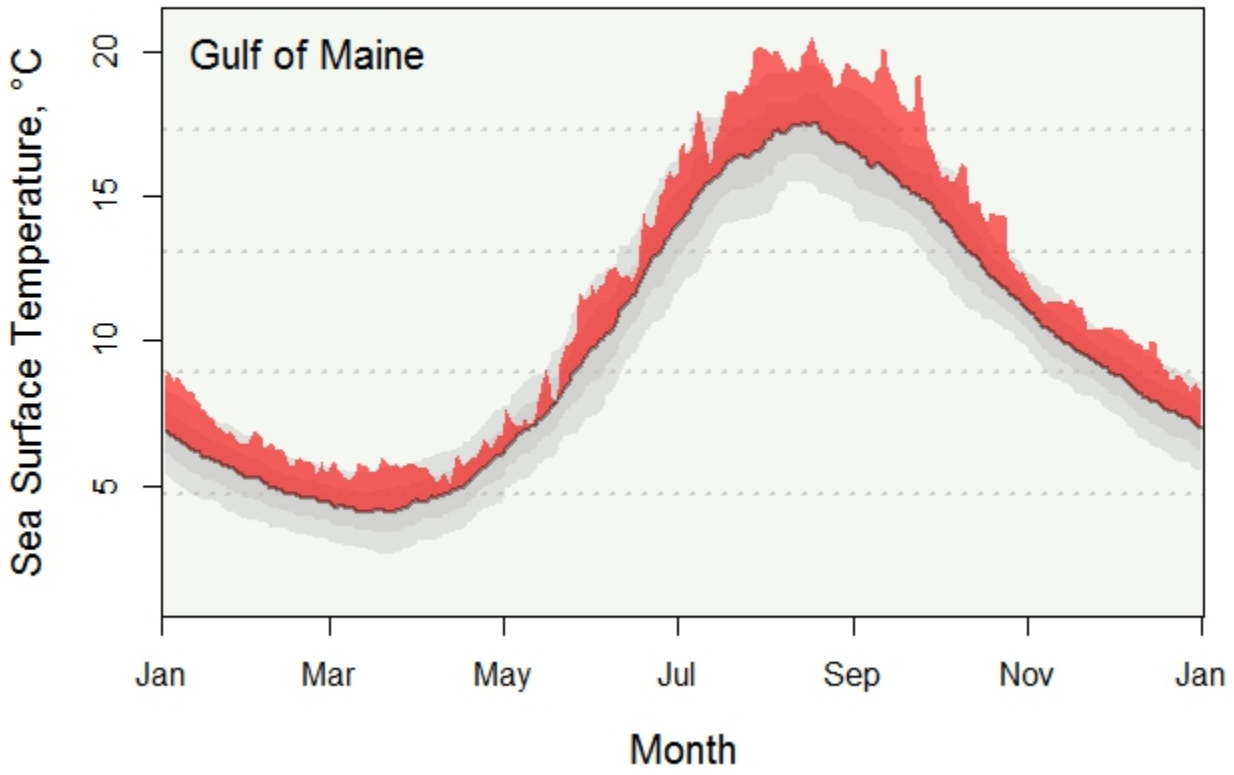
- Sea surface temperatures (SSTs) in the Northeast Shelf Large Marine Ecosystem during 2016 continue to be above average; in some season/area time series, 2016 was the second warmest year on record.
- The fall bloom on the Northeast Shelf was well developed in the Gulf of Maine, and, though chlorophyll concentrations on Georges Bank were elevated, a distinct bloom was not detected.
- Cool water habitats (5-15°C), which form the core thermal habitats of the Northeast Shelf, were at average levels in 2016, whereas warm habitats (16-27°C) were at high levels reflecting the trend of increasing warm habitat in recent years.
- The variability of daily sea surface temperature has increased over recent decades as indicated by the trends in standard deviation of daily temperature.
- The fall distribution of fish and invertebrate species sampled by the NEFSC shows that most species have moved to the Northeast and into deeper water.
- The strength of temperature fronts has increased over much of the Northeast Shelf; the 2016 frontal magnitudes for Northeast Shelf ecoregions moderated compared to recent years.

Fall Sea Surface Temperature - Northeast Shelf Ecosystem

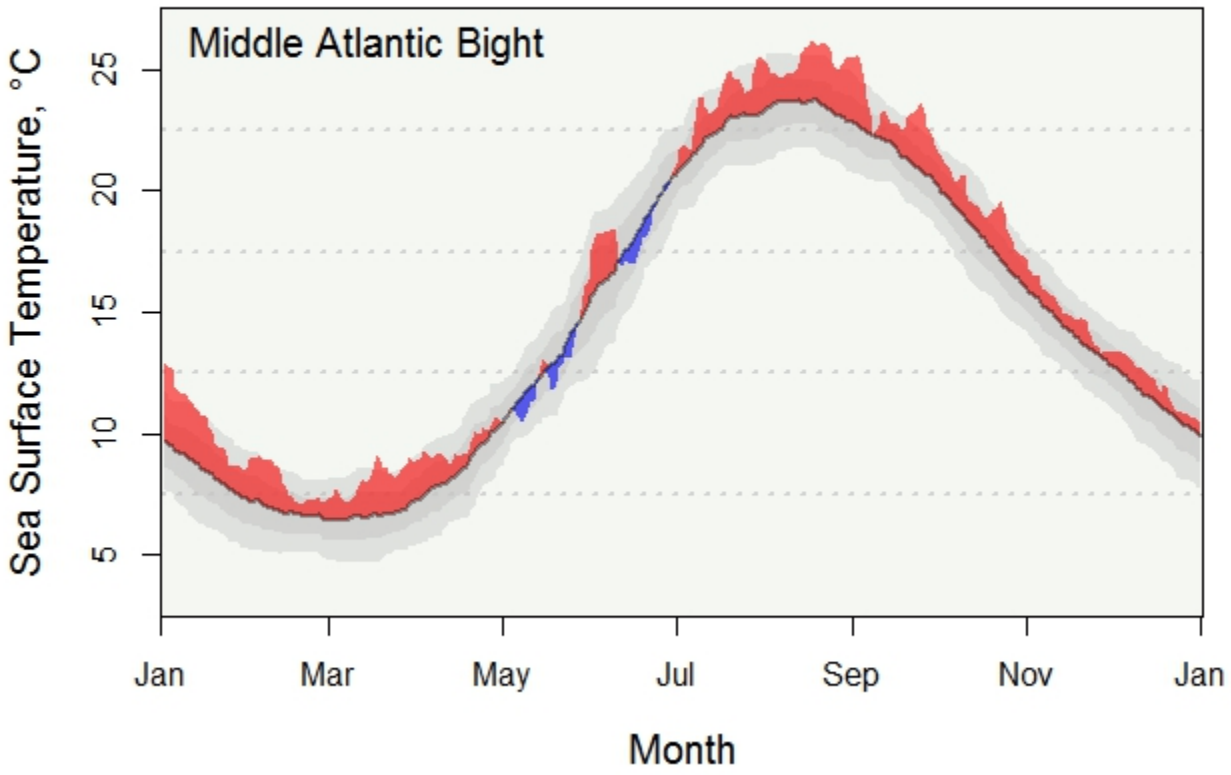
The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures (SSTs) during the fall of 2016 after a relatively warm spring in most ecoregions. In each graph, the long term mean SST is shown as a dark gray line with areas representing plus and minus one and two standard deviations of the mean, or moderately and well above the long term mean, respectively, as progressive shades of gray, respectively. SSTs for 2016 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 and Scotian Shelf and only moderately above average in the Georges Bank and Middle Atlantic Bight subareas. Many days were above the mean by more than two standard deviations in these areas.



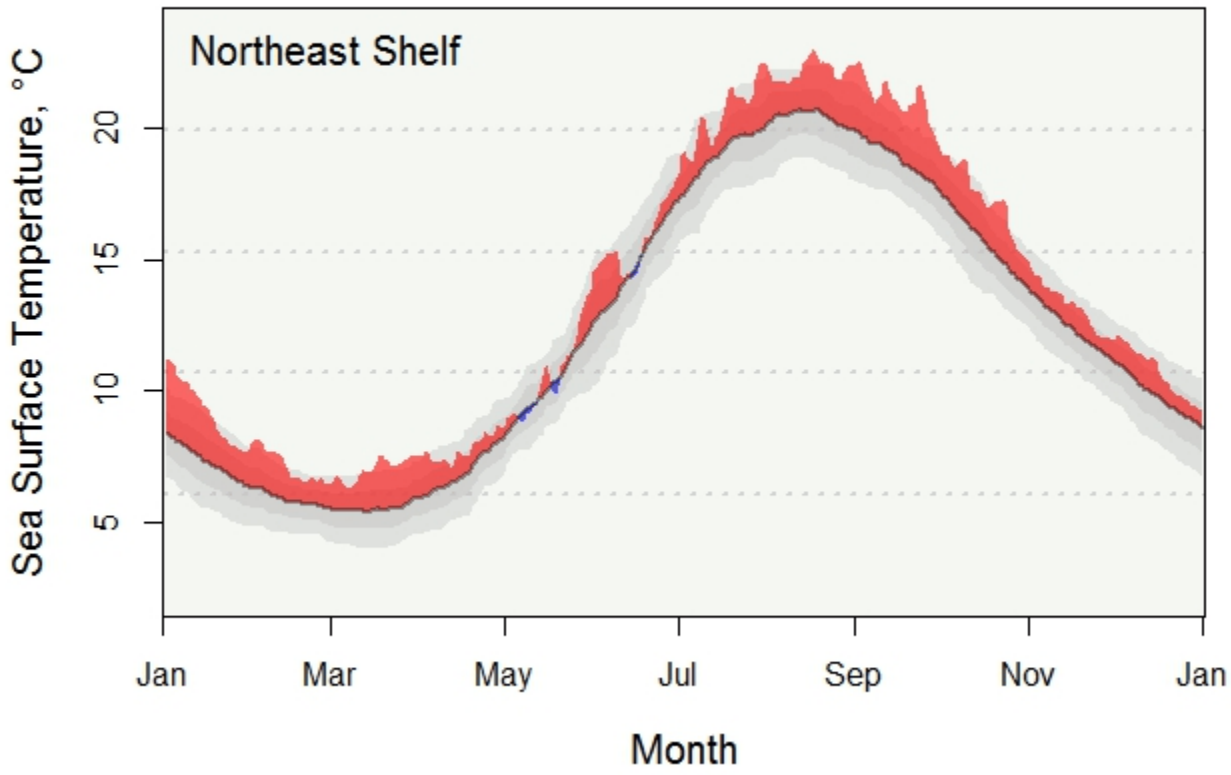
Georges Bank



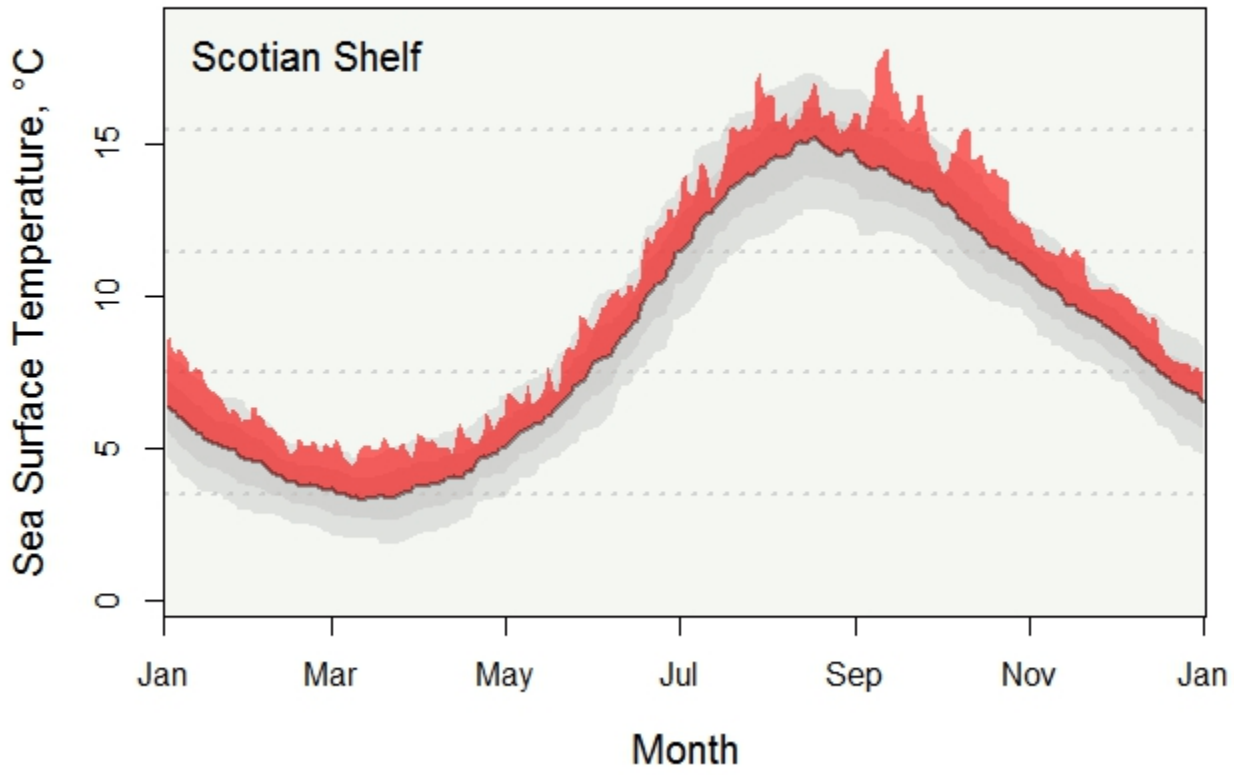
Gulf of Maine



Middle Atlantic Bight



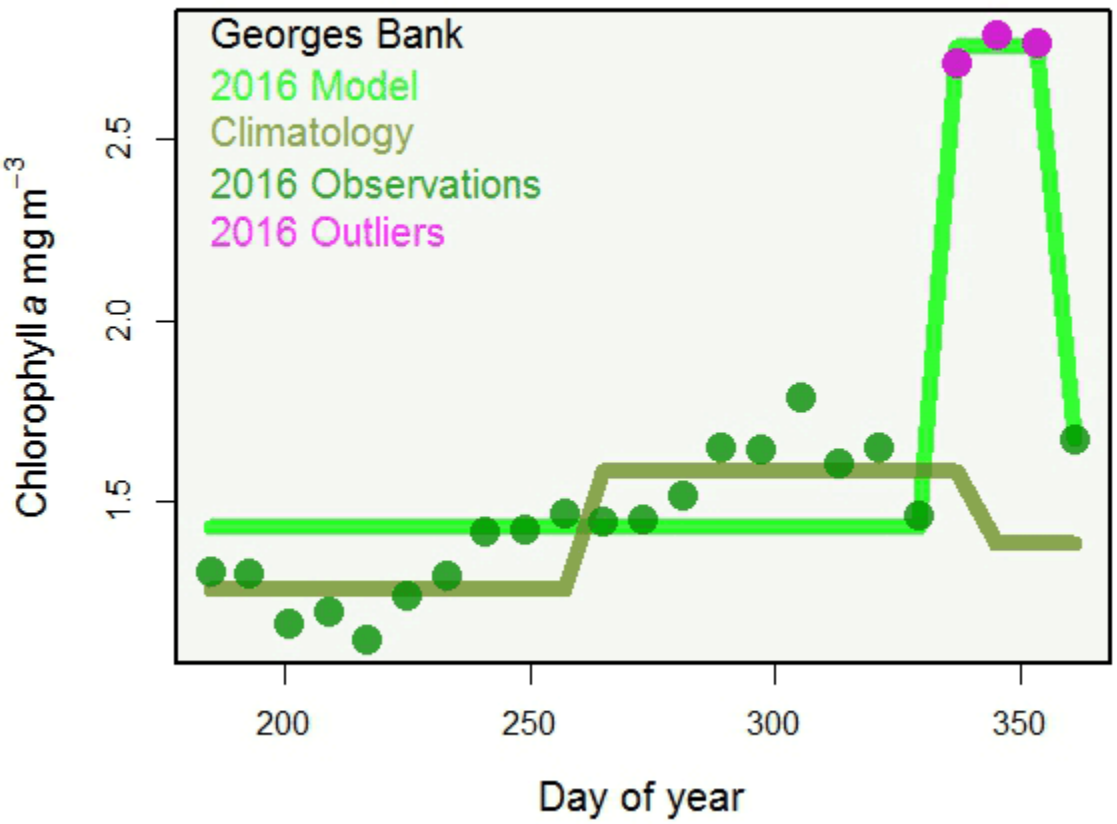
Northeast Shelf



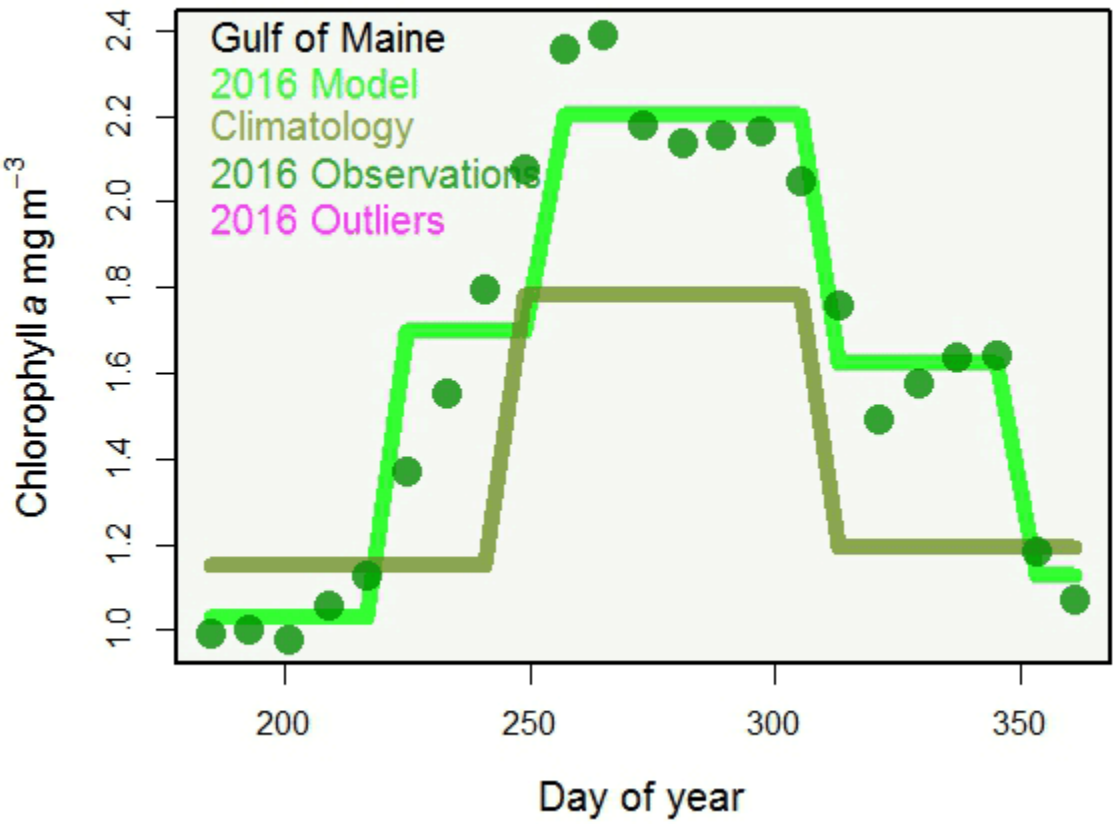
Scotian Shelf

Fall Bloom Development on the Northeast Shelf

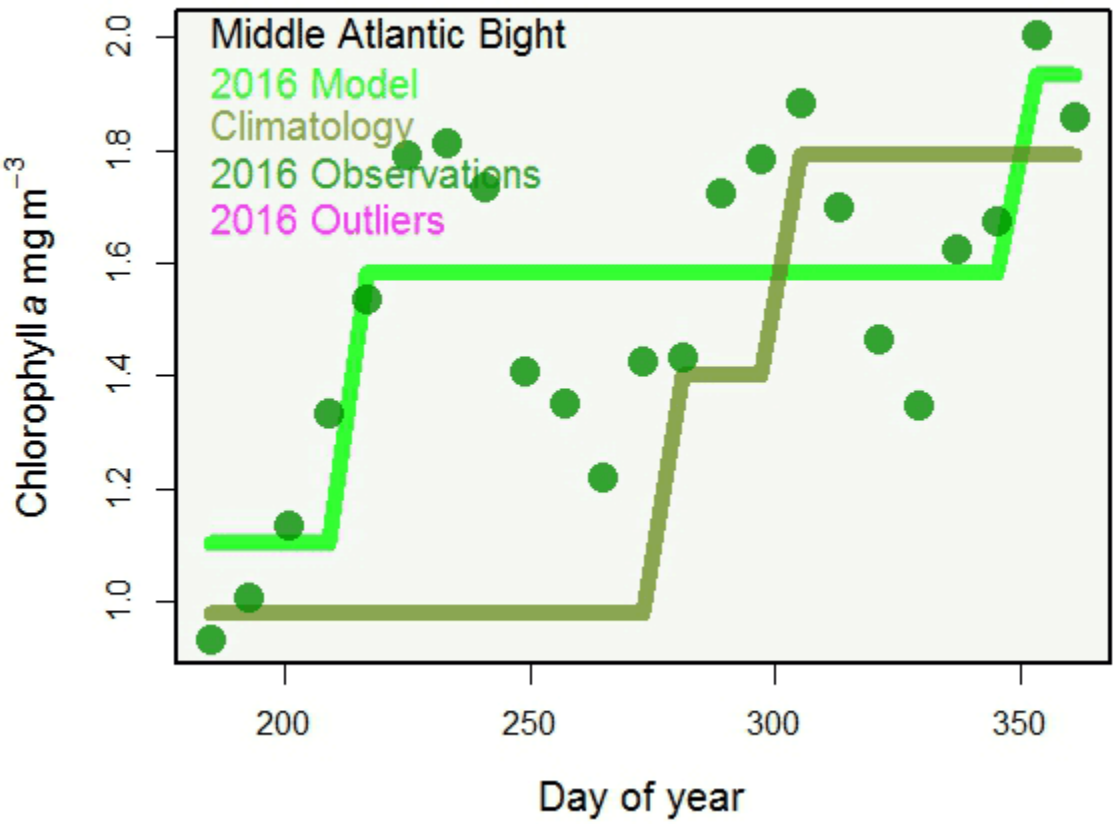
There were well developed fall blooms detected in the Gulf of Maine and Scotian Shelf ecoregions, with both blooms starting early and lasting longer than the long term mean (see figures). Blooms could not be differentiated during the fall bloom time window in Georges Bank or the Middle Atlantic Bight, with apparent high chlorophyll concentrations in the December time frame on Georges Bank likely due to an artifact of poor sensor coverage during that month. The Gulf of Maine had average bloom chlorophyll levels in excess of 2 mg m-3 during the peak of the bloom, exceeding climatological levels on the order of 30%. The fall bloom in the Scotian Shelf ecoregion also exceeded the climatological levels; however, on a more modest level on the order of 20%. The composite depiction of the bloom pattern for the Northeast Shelf does not reflects the fall blooms in the Gulf of Maine and Scotia Shelf, instead simply reflects higher than average chlorophyll concentration.



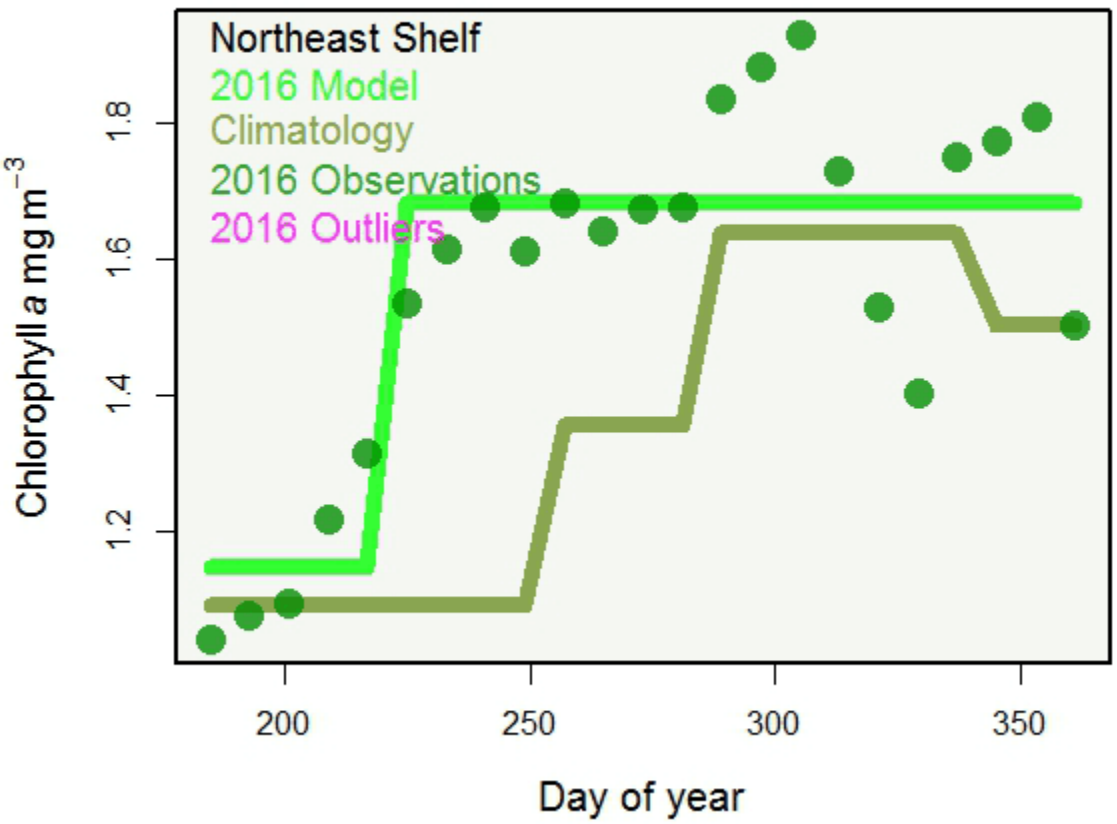
Georges Bank



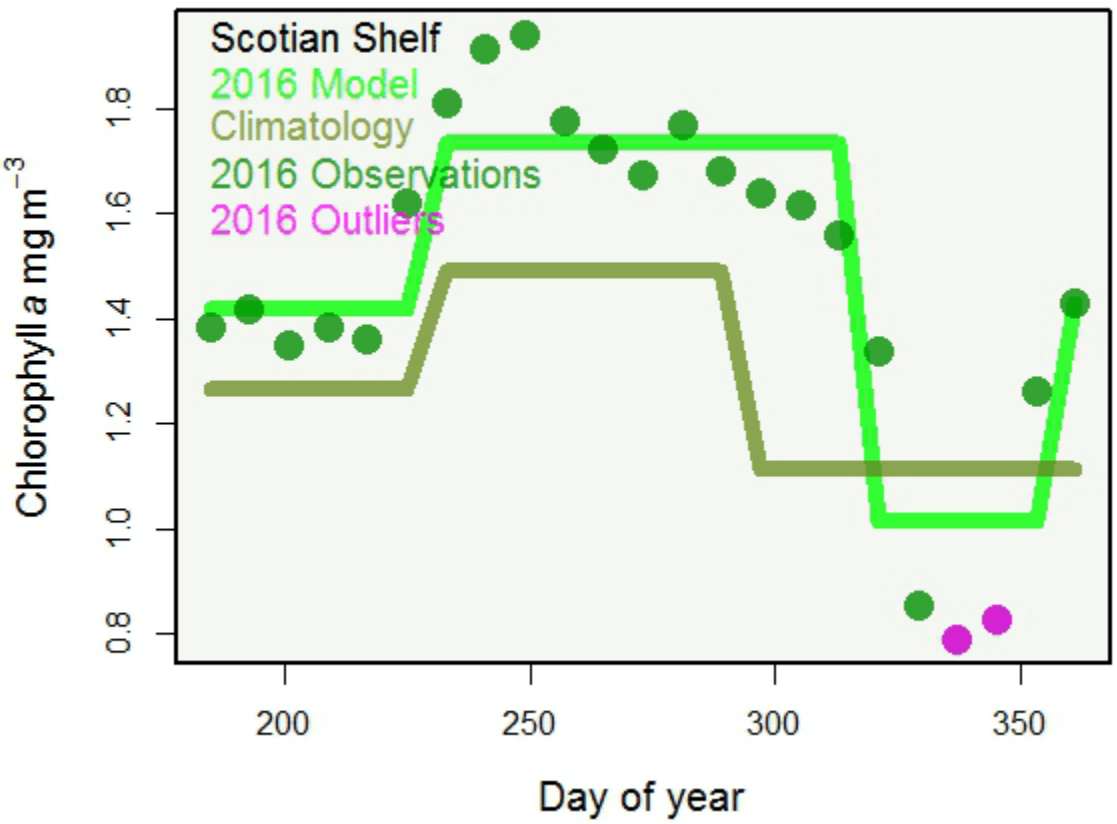
Gulf of Maine



Middle Atlantic Bight



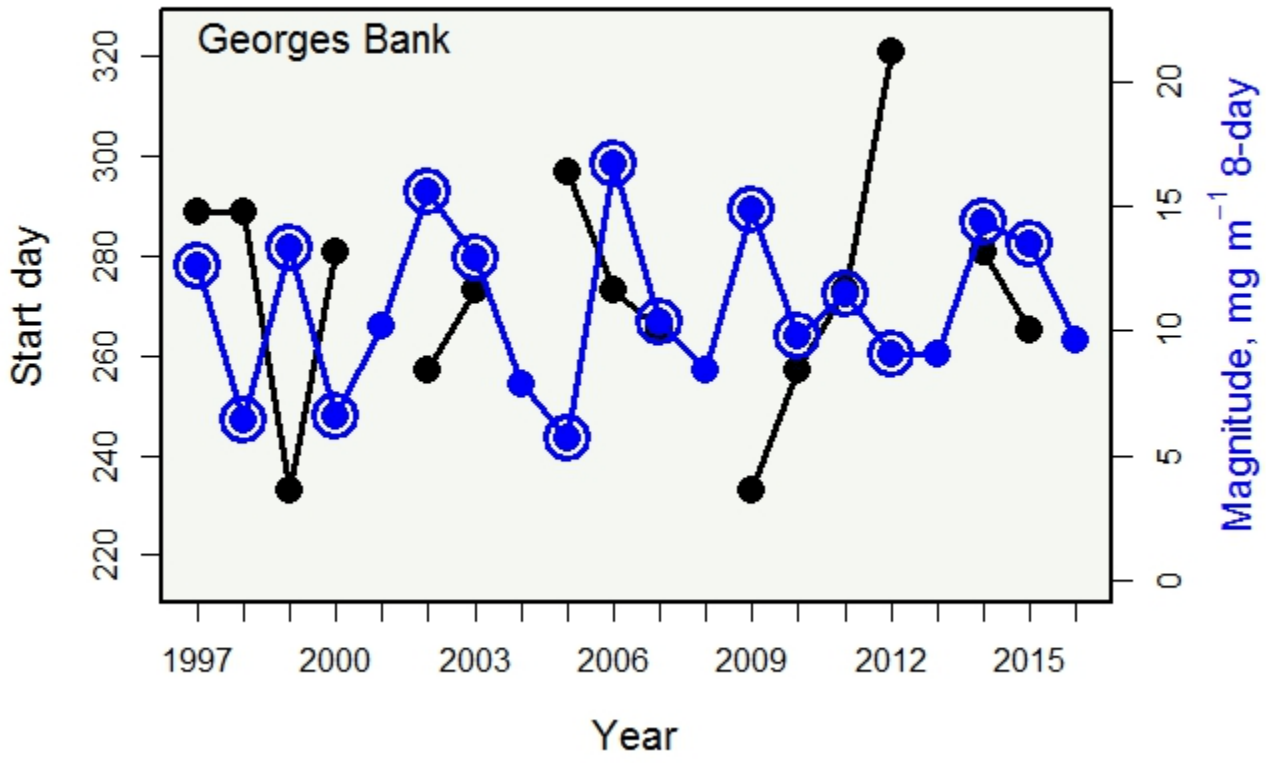
Northeast Shelf



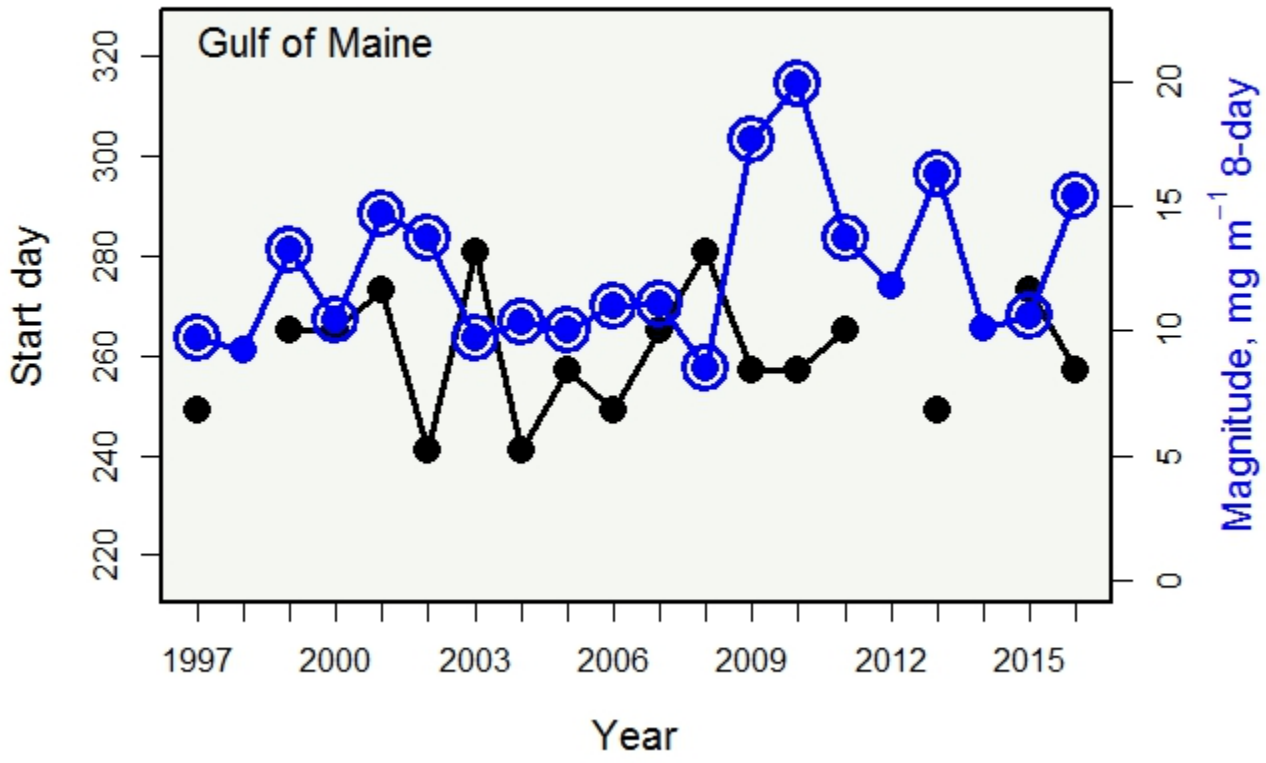
Scotian Shelf

Fall Bloom Start Day and Magnitude

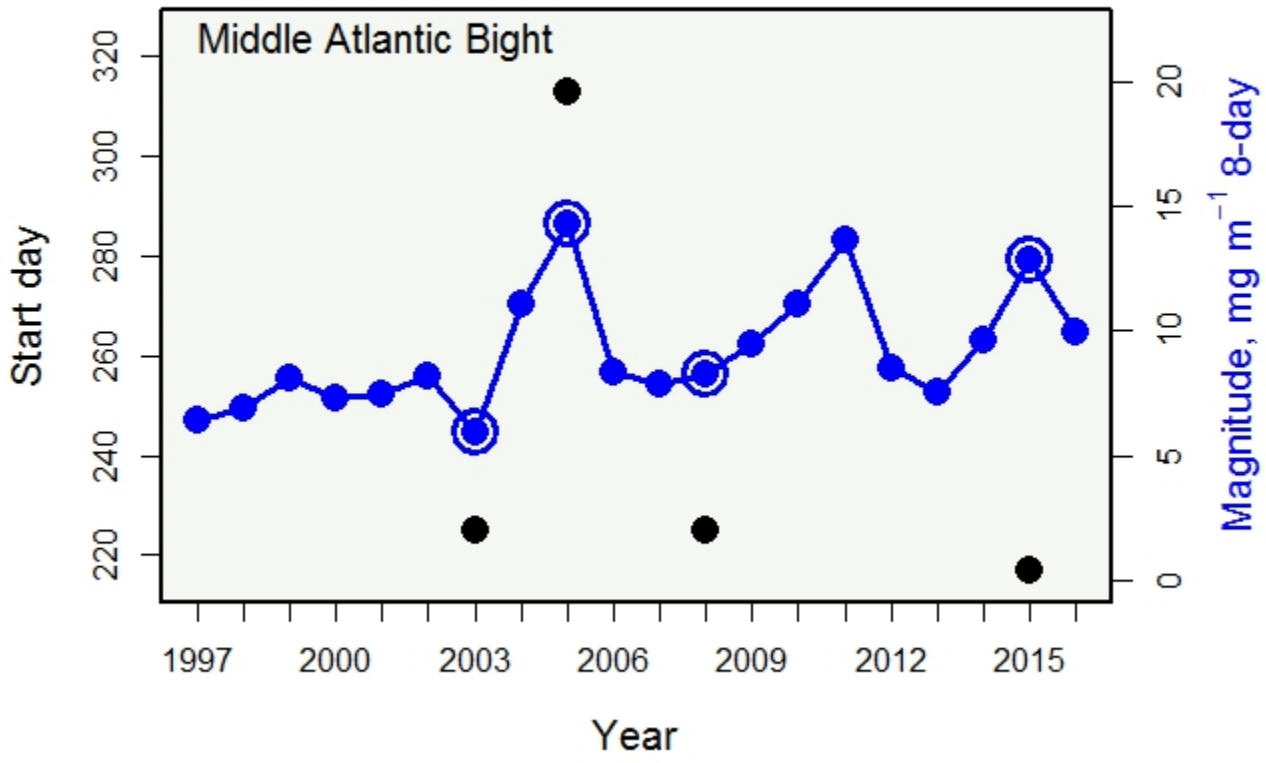
Fall blooms have been most frequently detected in the Georges Bank, Gulf of Maine and Scotian Shelf regions. In 2016, a fall bloom was detected in the Gulf of Maine. The time series figures for these regions show the start day of detected blooms (black circles) and bloom magnitudes for both detected blooms (large blue circles) and climatological bloom magnitudes for years where a bloom was not detected (small blue circles). The Gulf of Maine bloom was of slightly higher than average magnitude and average start day. It would appear that there was also a bloom on the Scotian Shelf though not shown as a detection in the times series; when implemented, the bloom detection algorithm constrained the duration of a detected bloom, hence the 2016 bloom was not considered a detection. This assumption will be revisited in future versions of the algorithm.



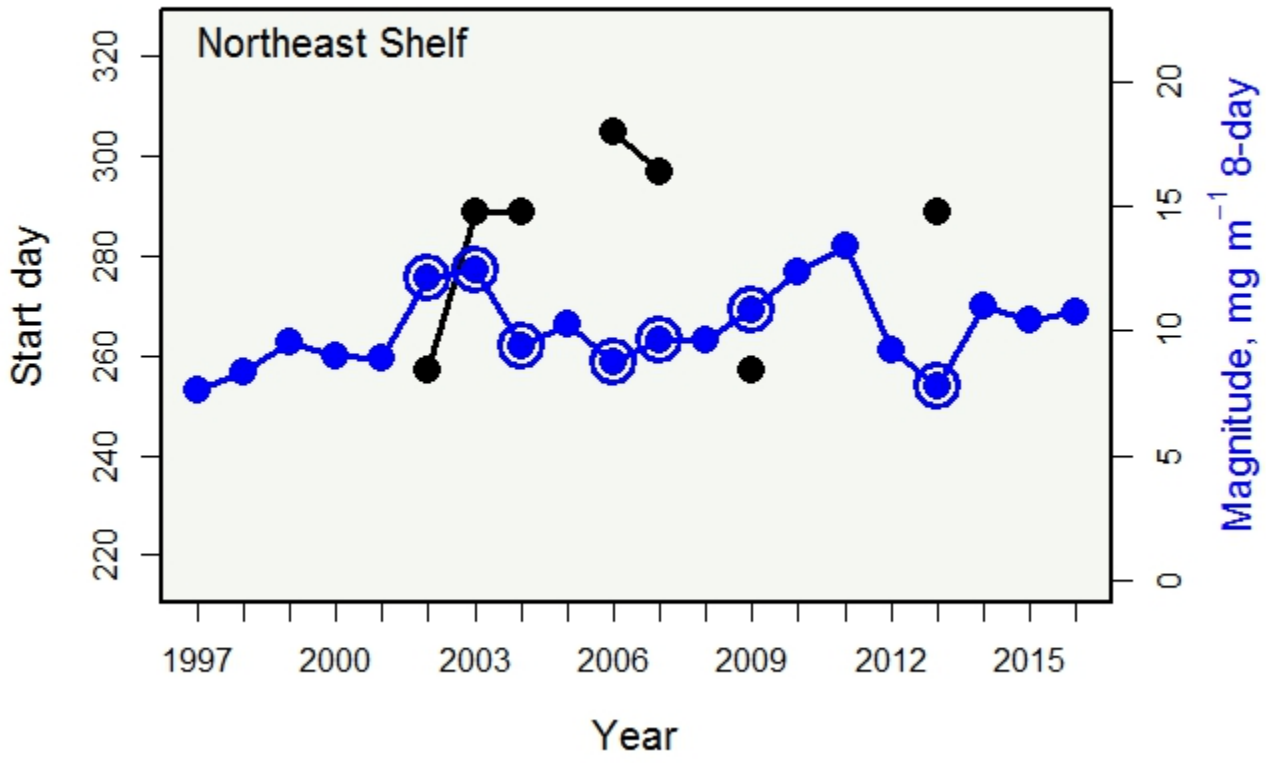
Georges Bank



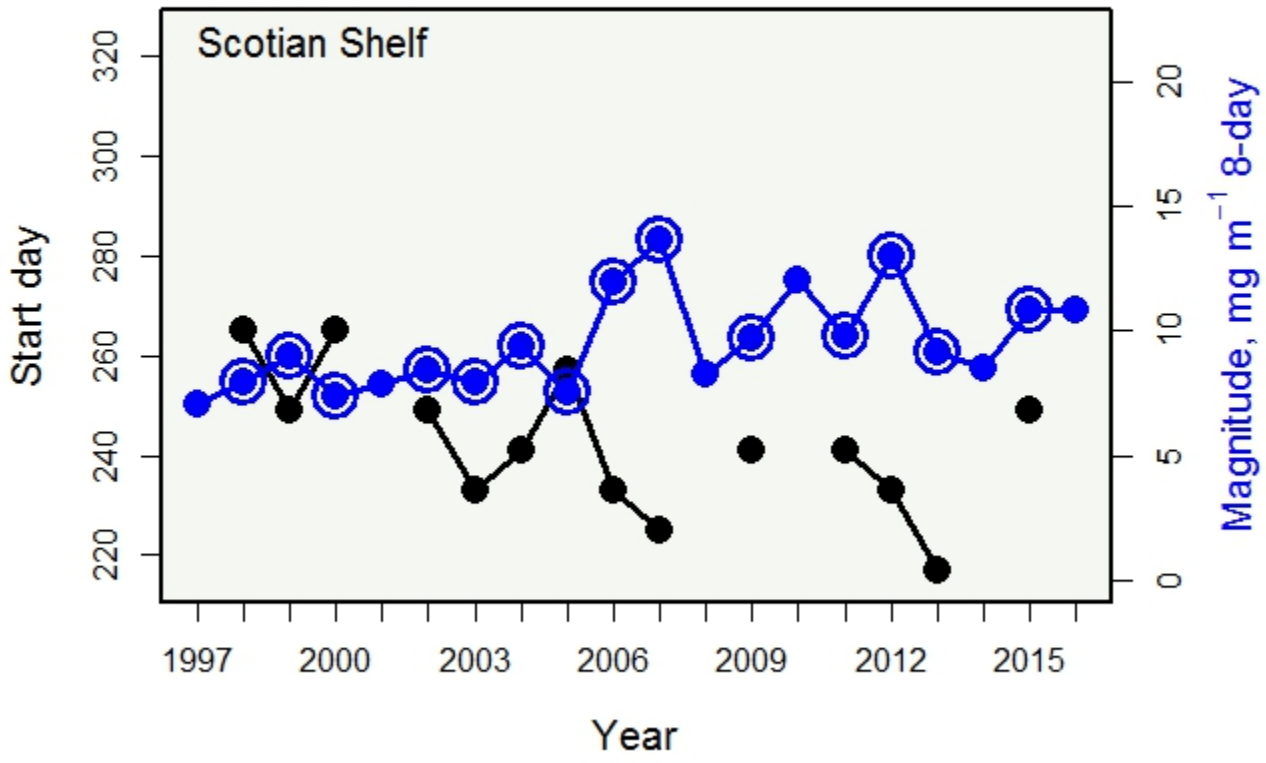
Gulf of Maine



Middle Atlantic Bight



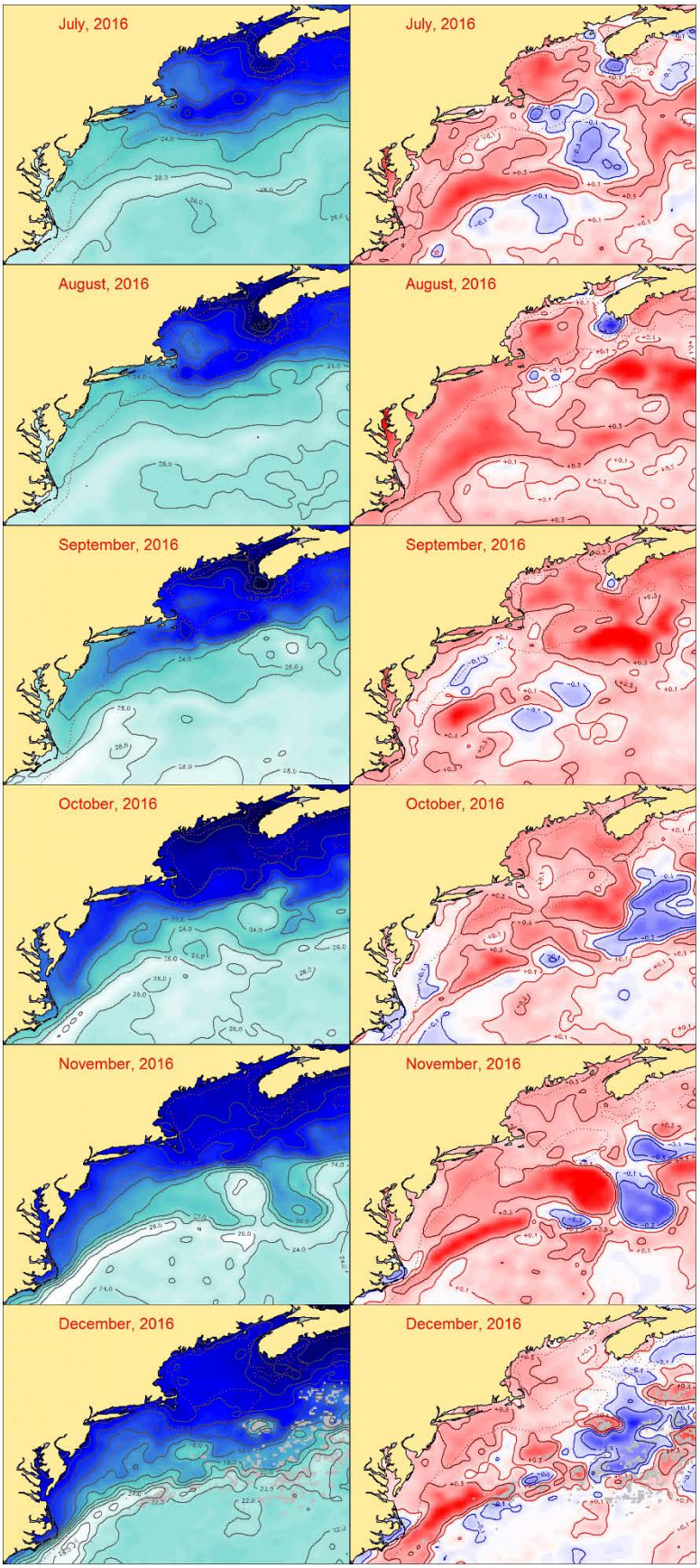
Northeast Shelf



Scotian Shelf

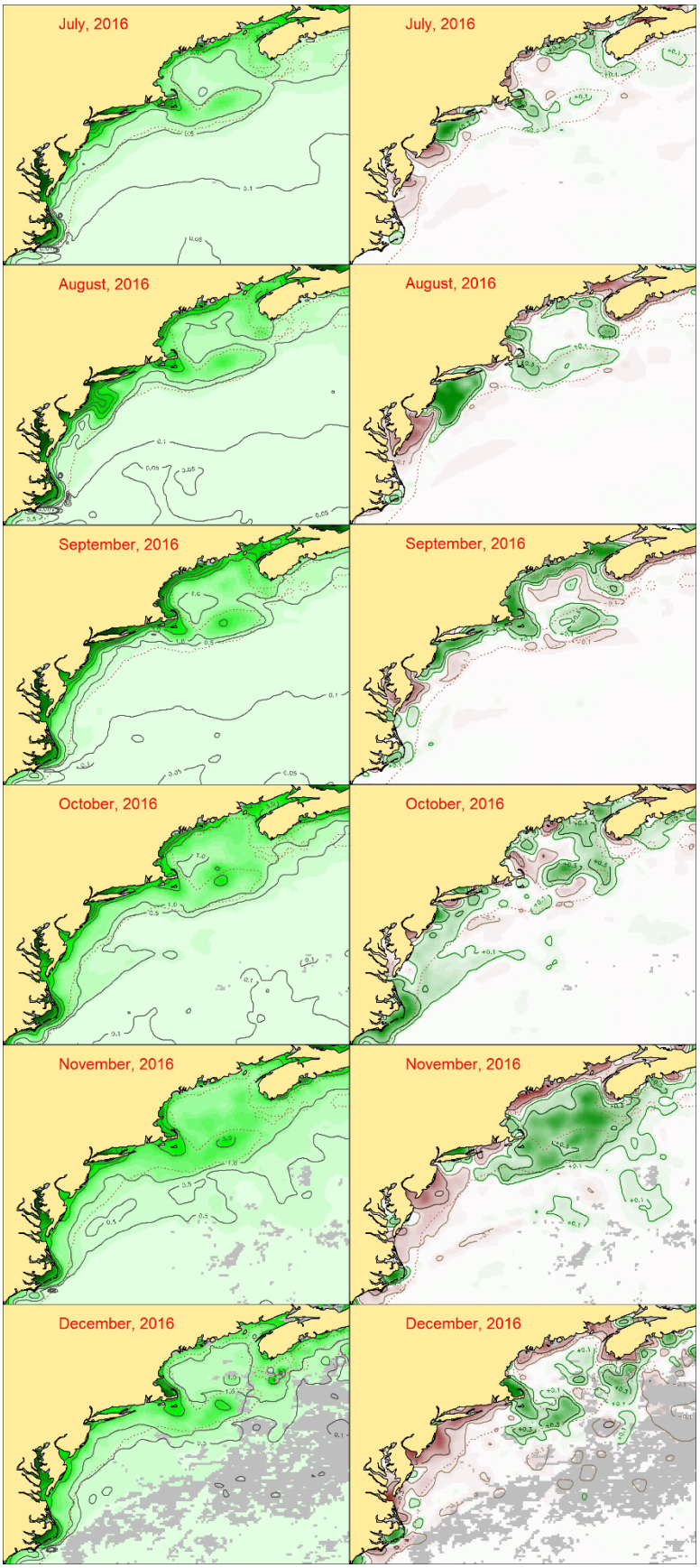
Fall Sea Surface Temperature Distribution

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 row 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 row 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 well above average temperature during the months July through December with the exception of some segments of the Middle Atlantic Bight in September and October. Temperature anomalies off the continental shelf are highly variable due to mesoscale movement of the Gulf Stream.


July, 2016
July, 2016
August, 2016
August, 2016
September, 2016
September, 2016
October, 2016
October, 2016
November, 2016
November, 2016
December, 2016
December, 2016

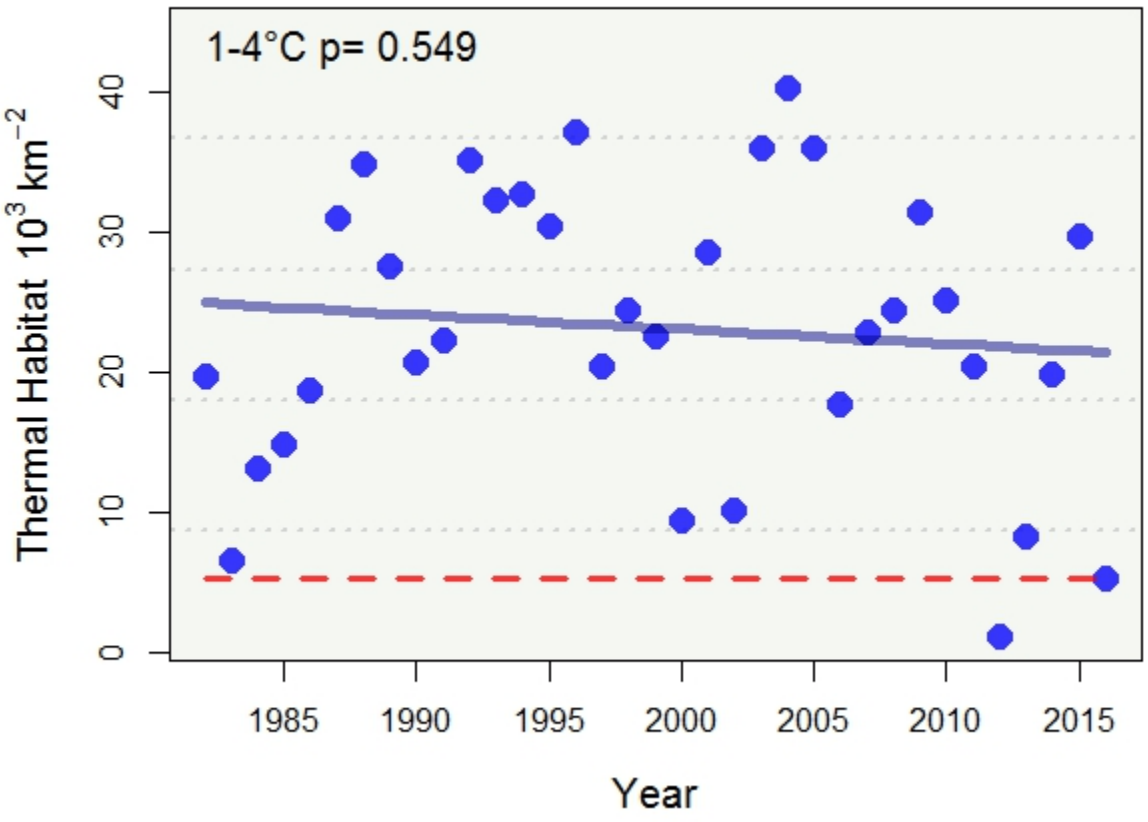
Fall Chlorophyll Distribution

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 row 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 row 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 off the coast of New Jersey during August and appears to have dissipated by September. The Gulf of Maine bloom can be seen off the Maine coast in September and October, with much of the Gulf of Maine and Georges Bank regions in bloom condition through November.

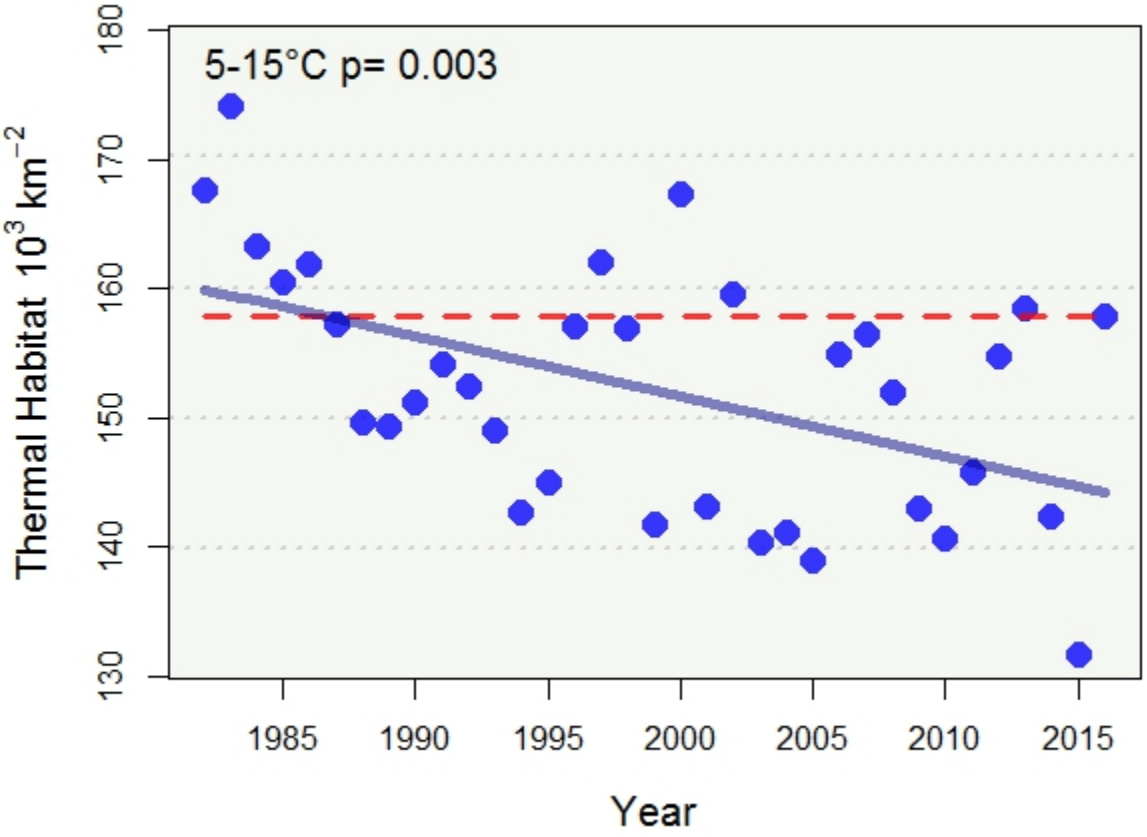

July, 2016
July, 2016
August, 2016
August, 2016
September, 2016
September, 2016
October, 2016
October, 2016
November, 2016
November, 2016
December, 2016
December, 2016

Ecosystem Shift in Thermal Habitat

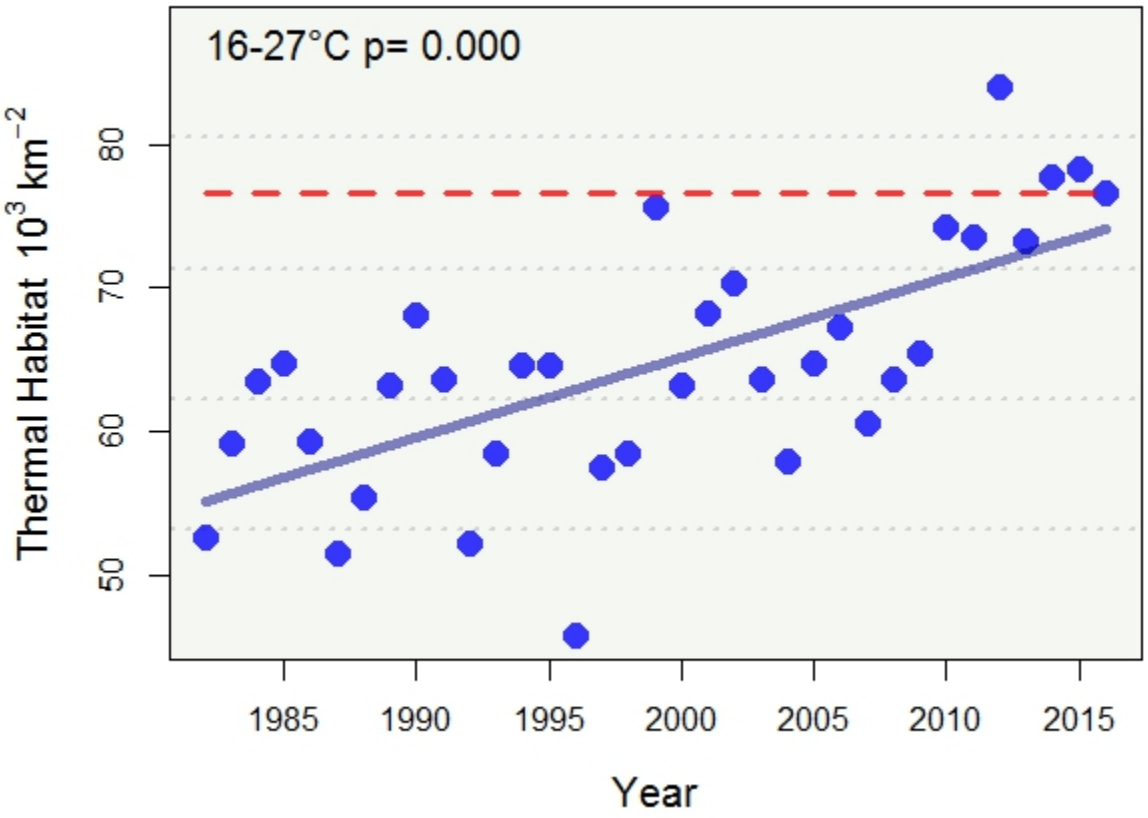
Temperature affects the behavior and physiology of marine organisms, thus it is a key determinant of habitat within the ecosystem. The area of cold water habitats (1-4°C) show no time series trend despite extremely low values in recent years. Cold water habitats in 2016 were approximately 5,000 km2 (2016 value marked over the time series with dashed red line, linear trend shown with blue line, regression model significance shown in upper left). Cool water habitats (5-15°C) show a negative trend over time declining on the order of 531 km2 yr-1, which is matched by a corresponding increase in warm water habitats (16-27°C) at a rate of 545 km2 yr-1.



Cold habitat



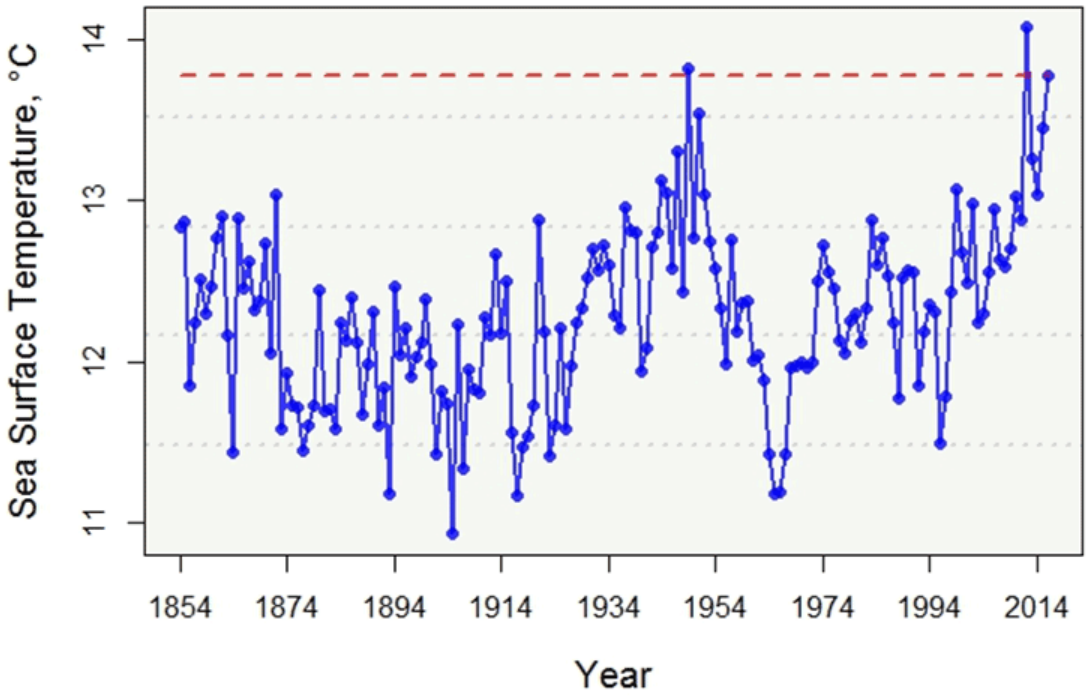
Cool habitat



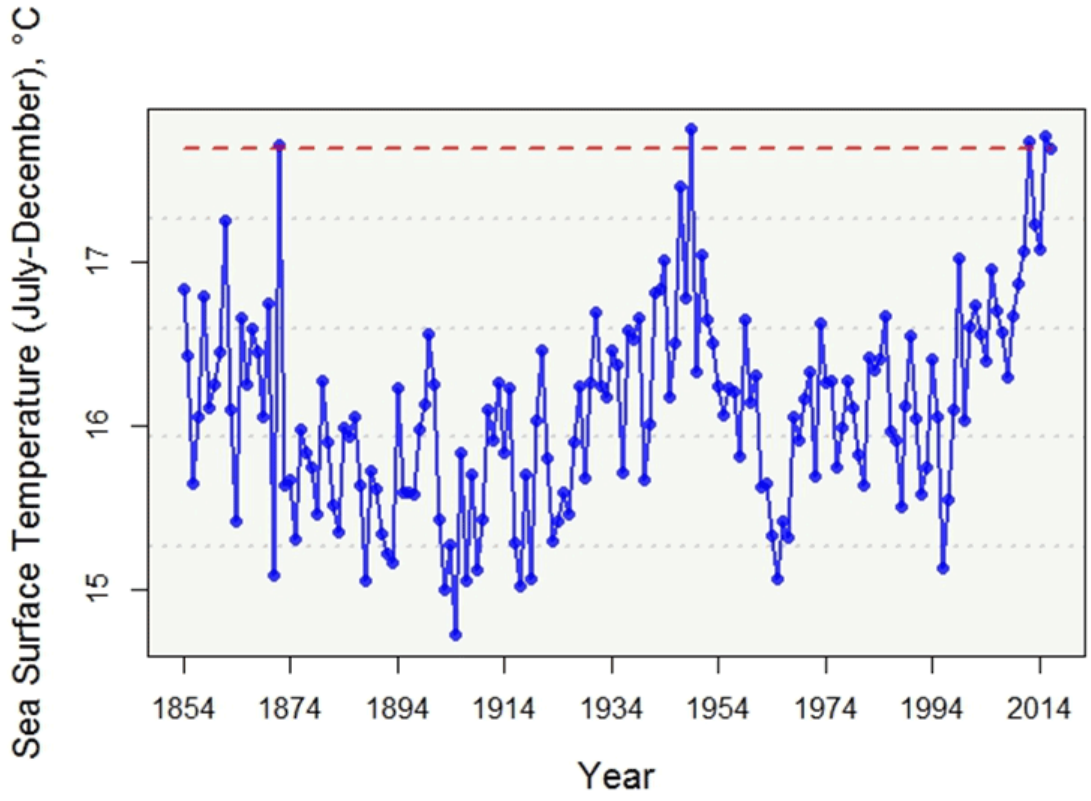
Warm habitat

Long-Term Temperature Trends for the Northeast Shelf Ecosystem

The Northeast Shelf Ecosystem was at a record high SST in 2012, the 2016 annual mean level (2016 value marked over the time series with dashed red line) was among the highest values in the time series. The SST from the second half of the year (July to December) was also among the highest in the time series. The Extended Reconstructed Sea Surface Temperature (ERSST) dataset includes temperature records back to 1854.



Long-term SST

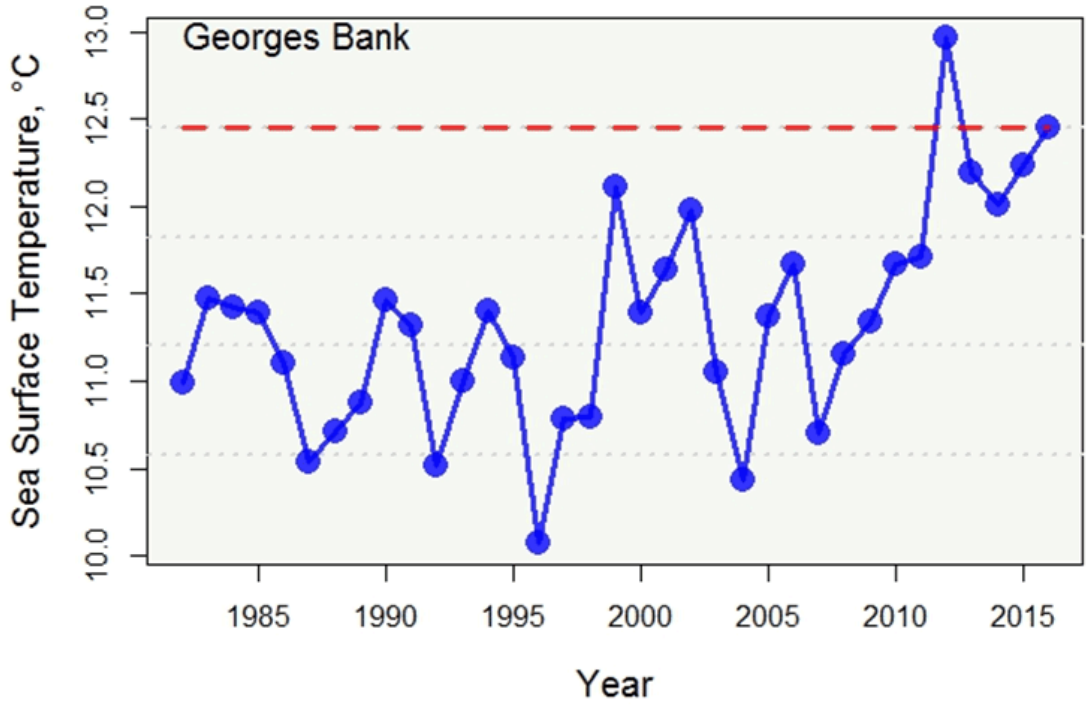


Jul-Dec

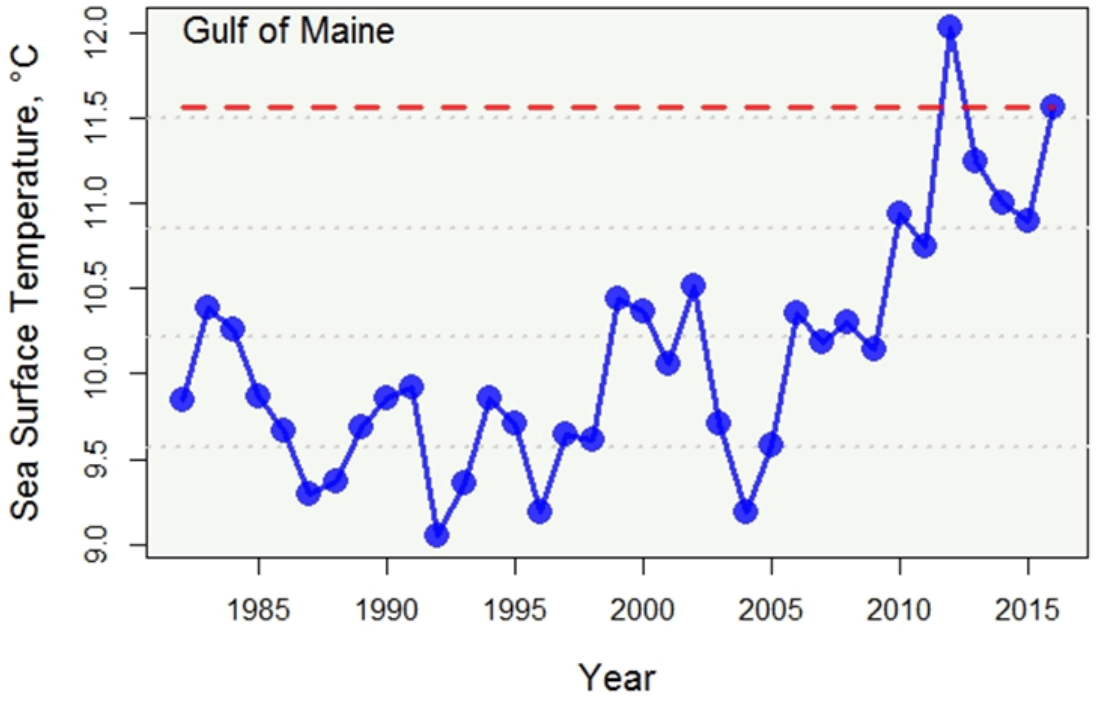
SST

Satellite SST Trends for the Northeast Shelf Ecosystem

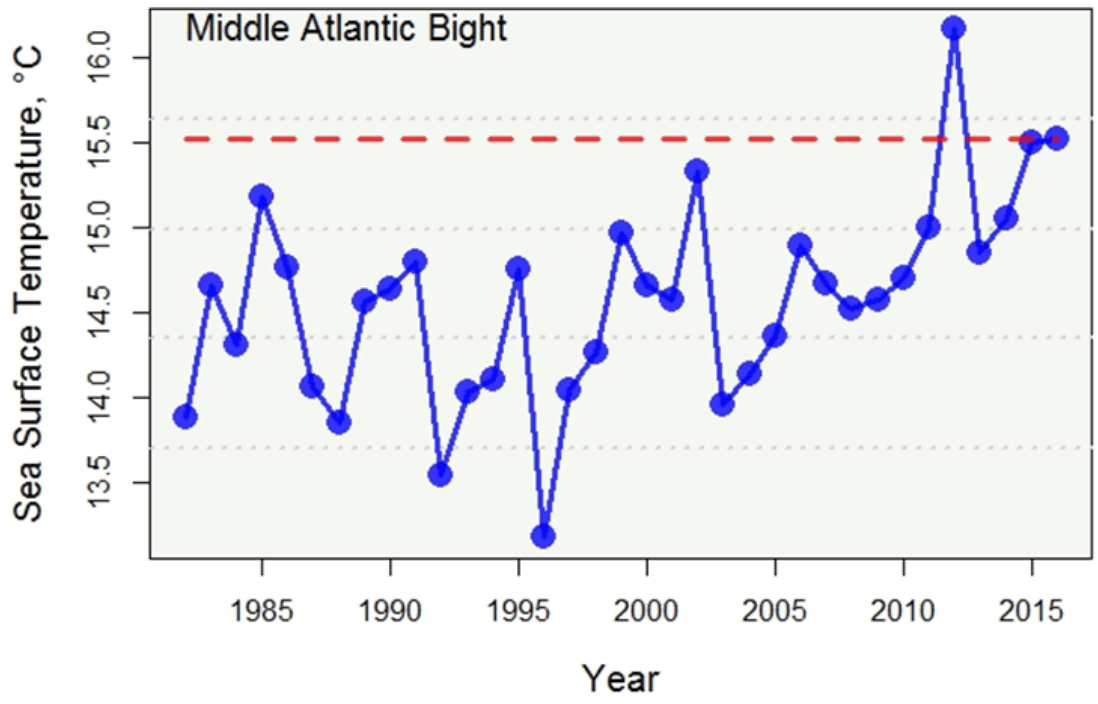
The SST conditions for 2016 were the second highest in the satellite remote sensing data series for many of the NE Shelf ecoregions. The NES SST was in excess of 13.5°C in 2016 (2016 values marked over the time series with dashed red lines), which was less than the record level set in 2012, but well above average for the ecosystem. Temperatures continue to be well above average in the all the subregions of the ecosystem.



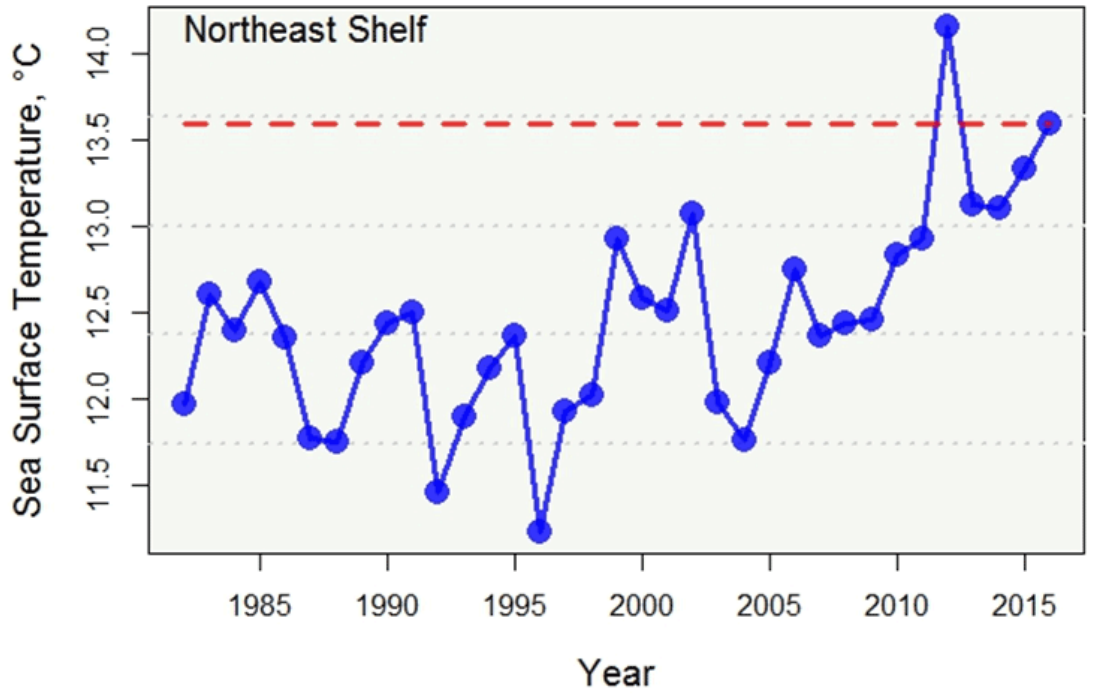
Georges Bank



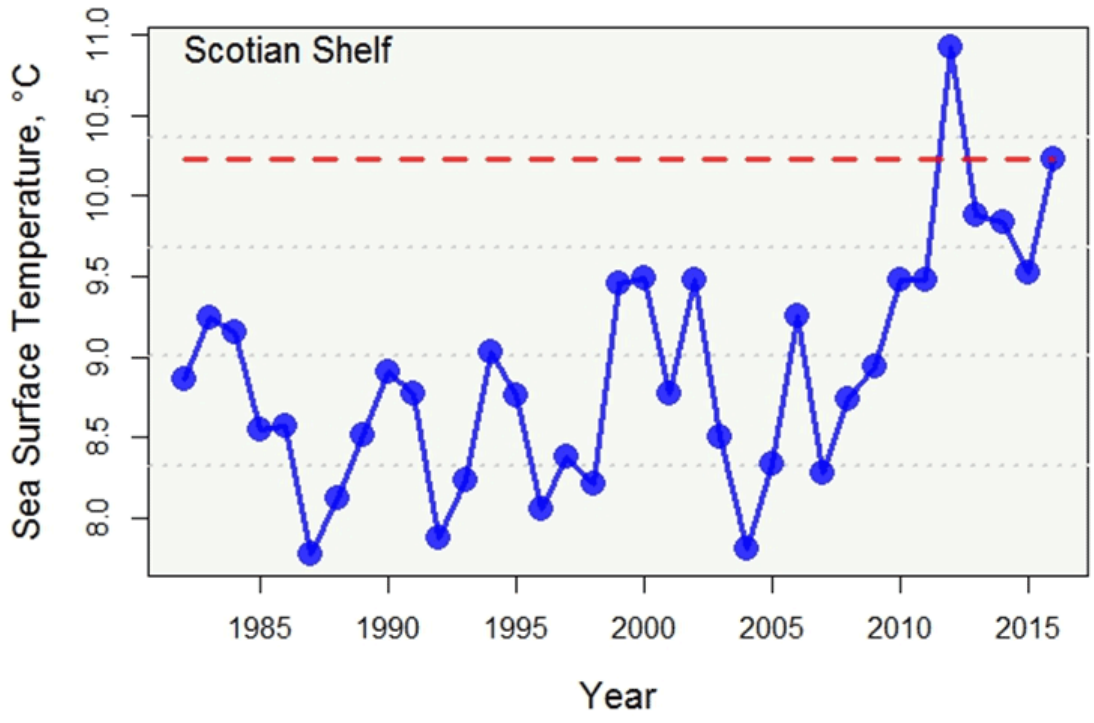
Gulf of Maine



Middle Atlantic Bight



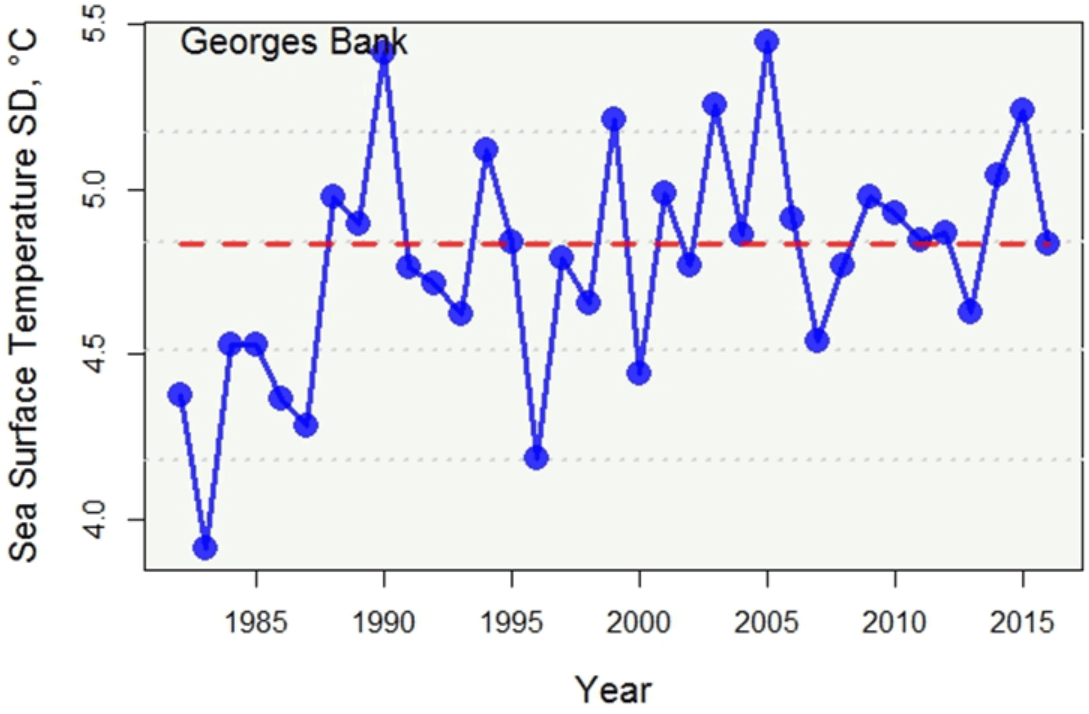
Northeast Shelf



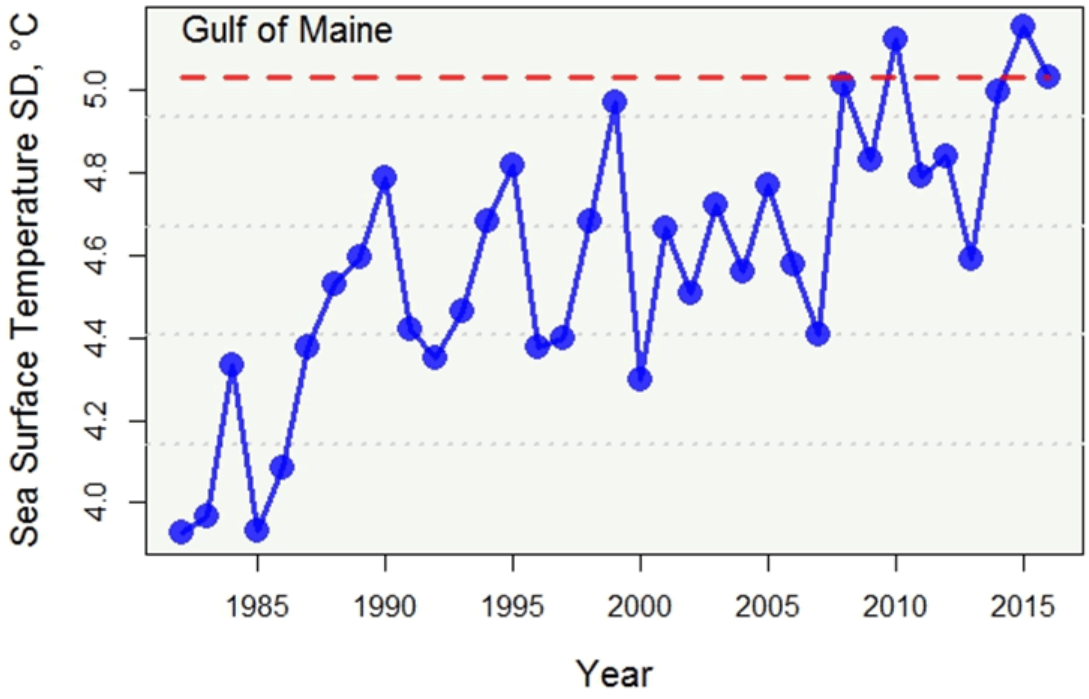
Scotian Shelf

Satellite SST Standard Deviation Trends for the Northeast Shelf Ecosystem

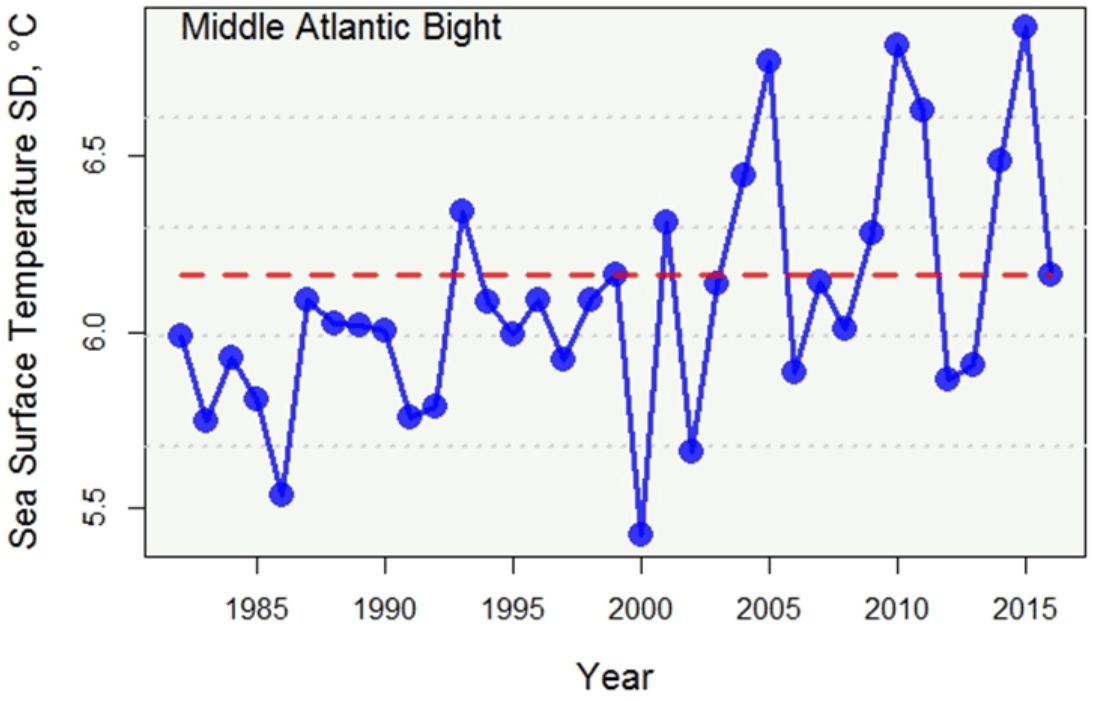
Climate change involves not only the change in level of climate parameters, it also involves change in system variability that can be seen in more dramatic shifts in weather in terrestrial systems and in ocean parameters on the Northeast Shelf. In an examination of daily sea surface temperatures in the NE Shelf ecosystem, system variability has increased as evidenced by the increase in the annual standard deviation of sea surface temperature. For example, for the NE Shelf as a whole, daily temperature standard deviation has gone from approximately 4.9 to 5.6 over the time period, indicating organisms have experienced greater day to day temperature excursions.



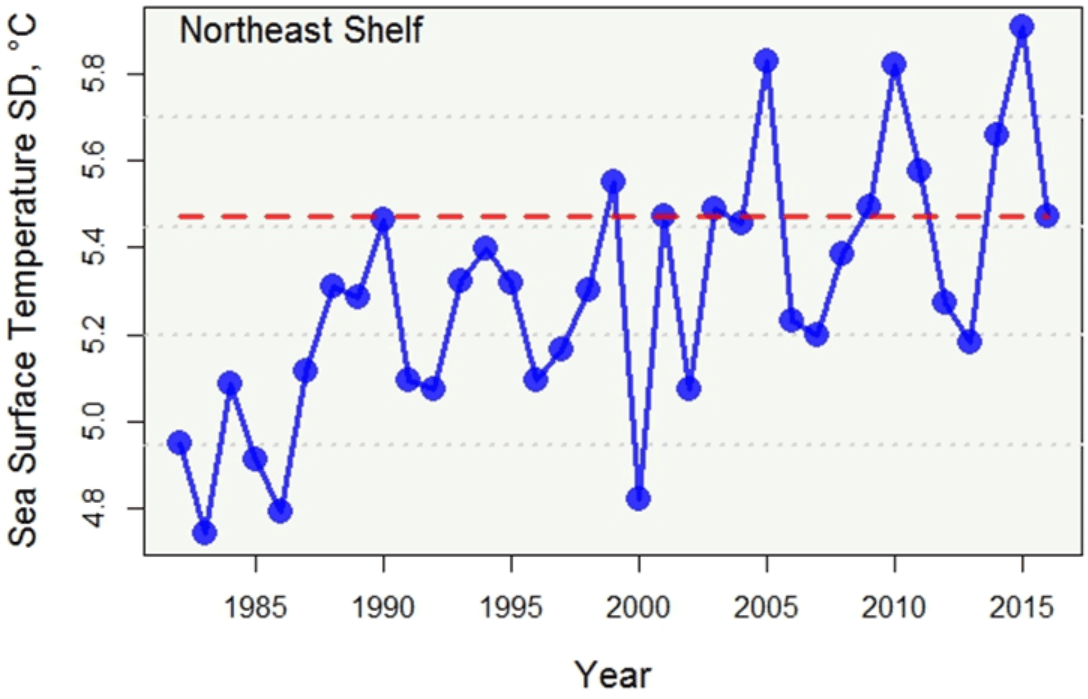
Georges Bank



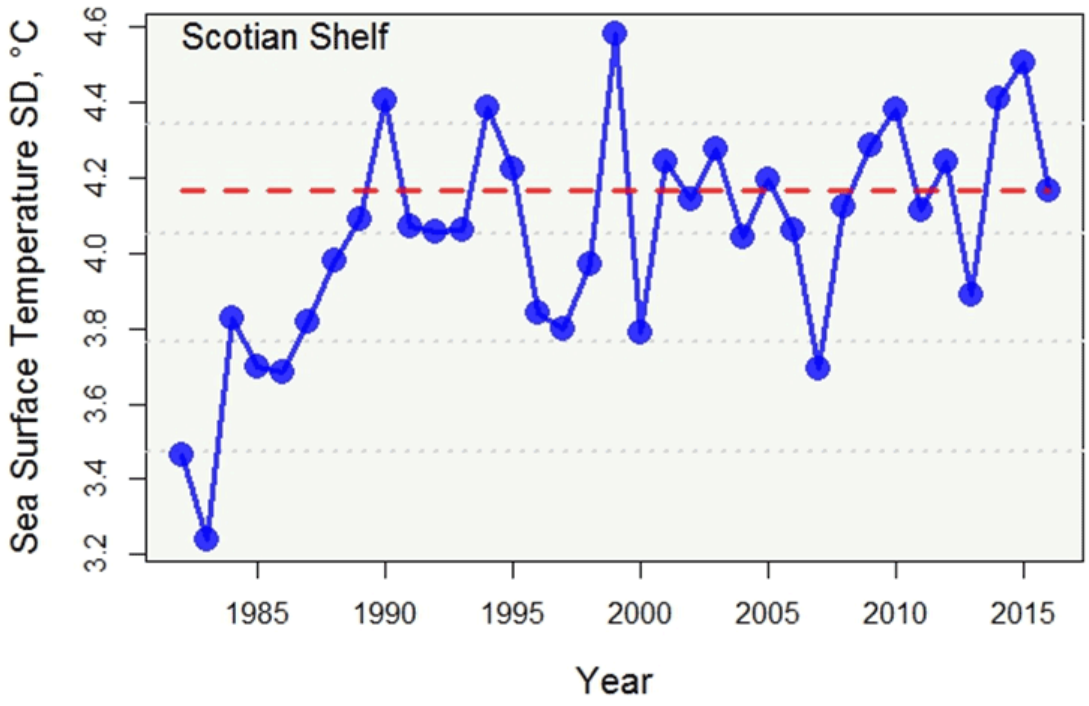
Gulf of Maine



Middle Atlantic Bight



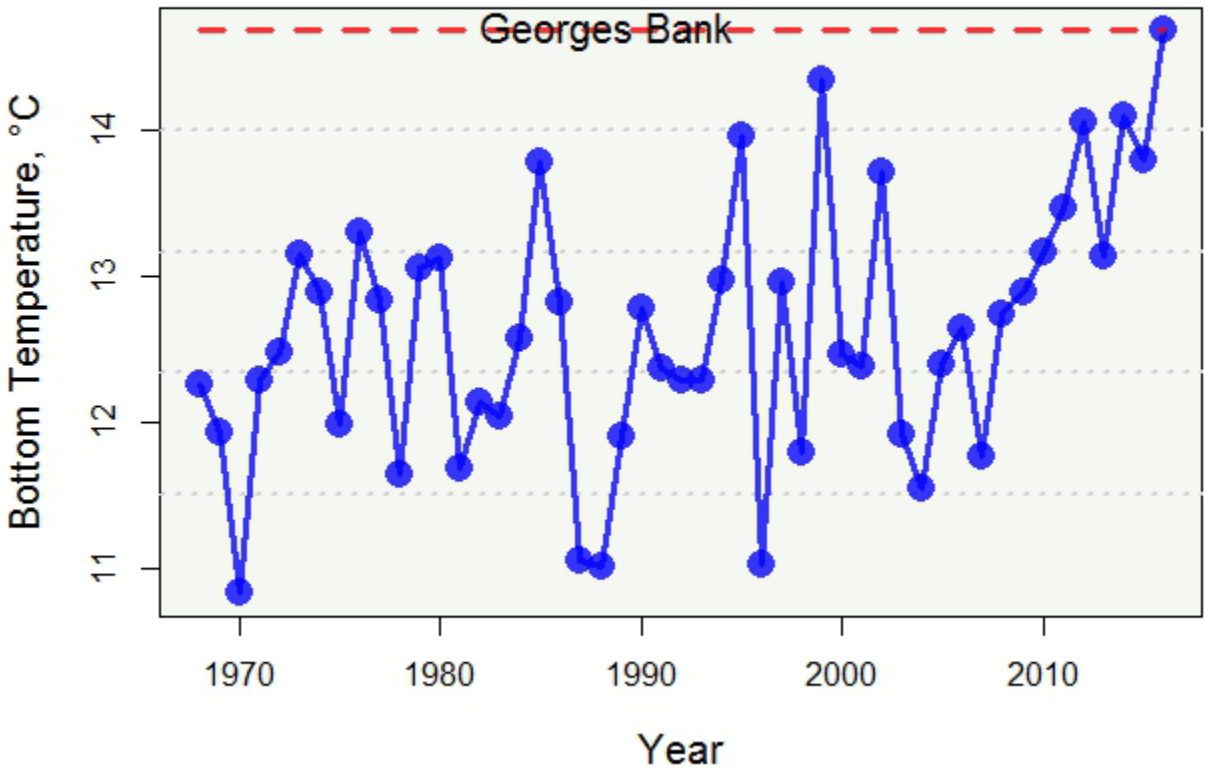
Northeast Shelf



Scotian Shelf

Fall Temperature from the Survey

The thermal conditions at the bottom of the water column are extremely important in defining the habitats for the majority of resource species. Unlike sea surface temperatures that can be measured synoptically with satellite telemetry, bottom temperatures must be measured directly from ship surveys and other means. Thus, we often have incomplete spatial and temporal sample coverage to describe bottom temperature conditions. Recently, scientists at the NEFSC developed an interpolation approach that provides a more accurate depiction of spring and fall bottom temperatures. The time series of October time frame temperatures steadily increased over the past half century and in some ecoregions were the highest in this time series estimation procedure.



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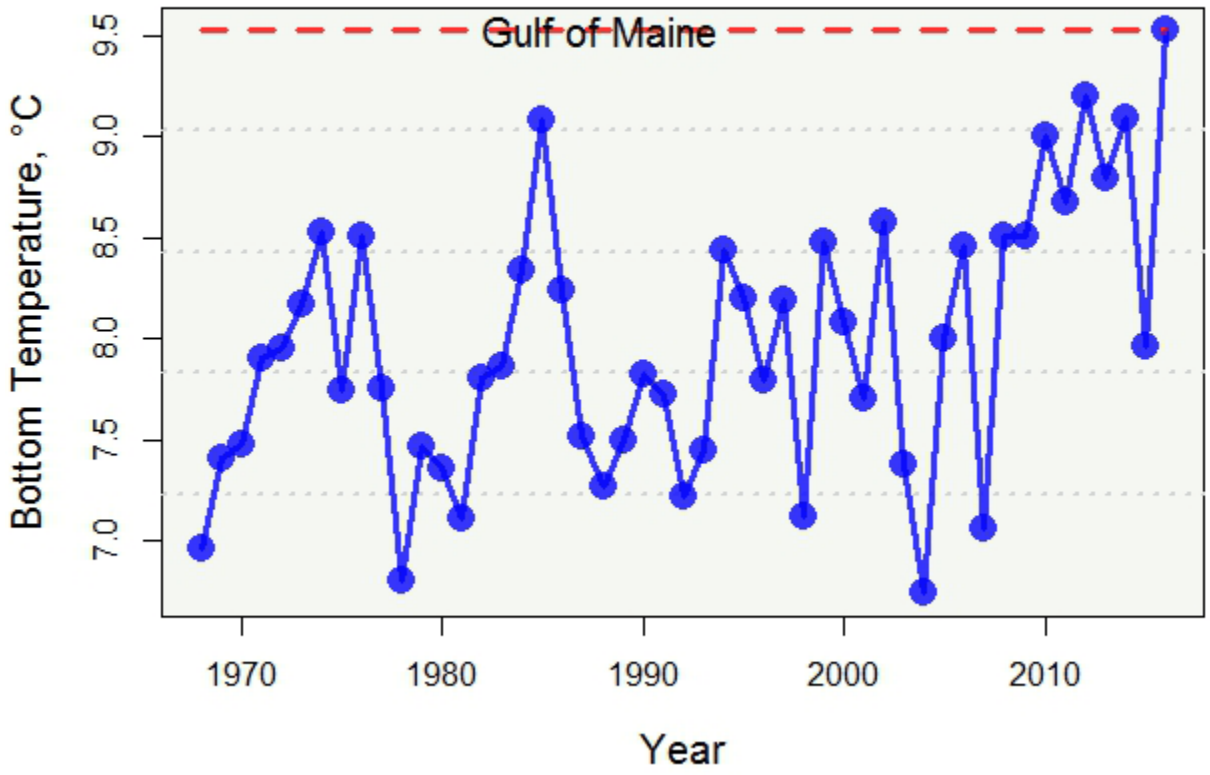
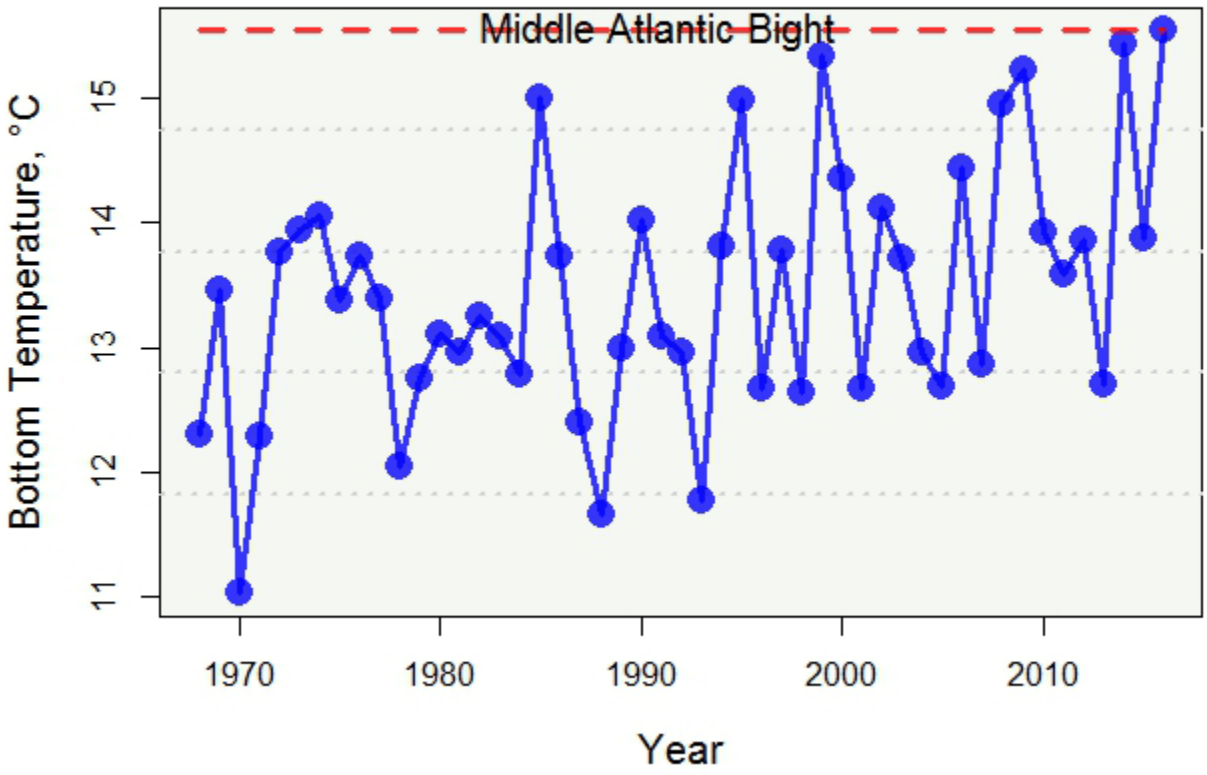


Gulf of Maine



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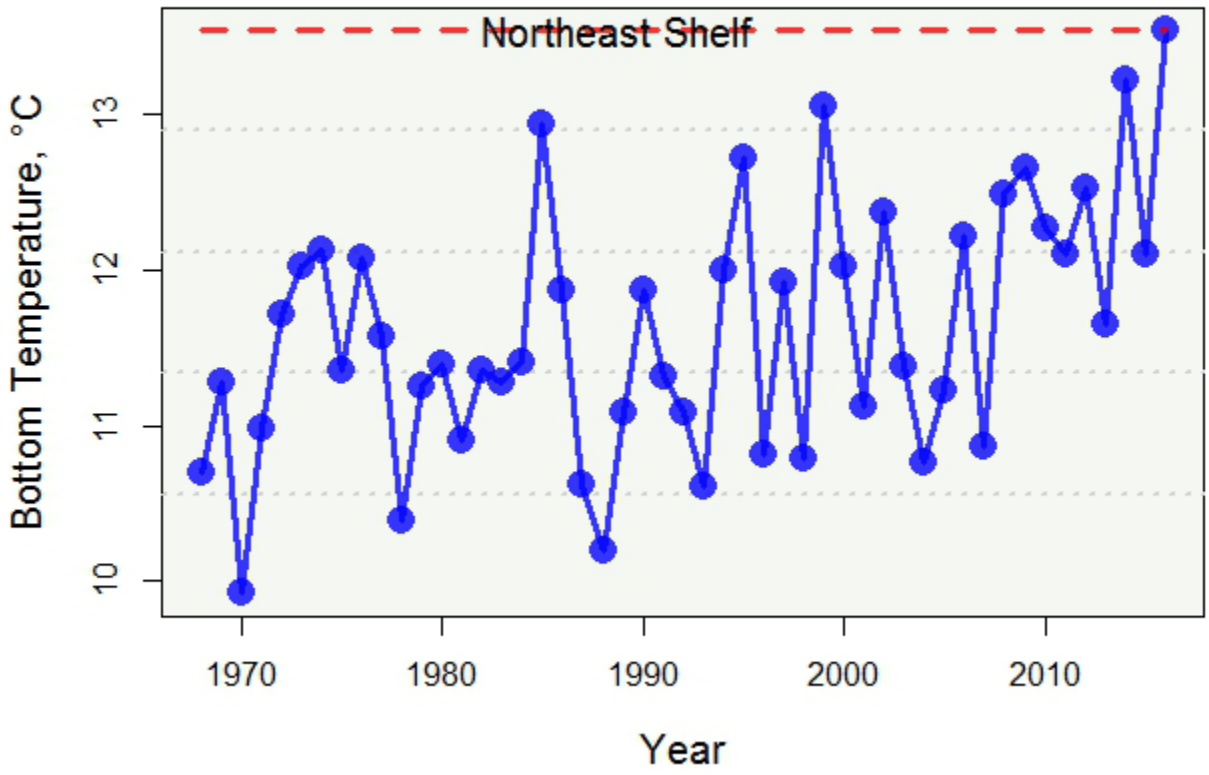
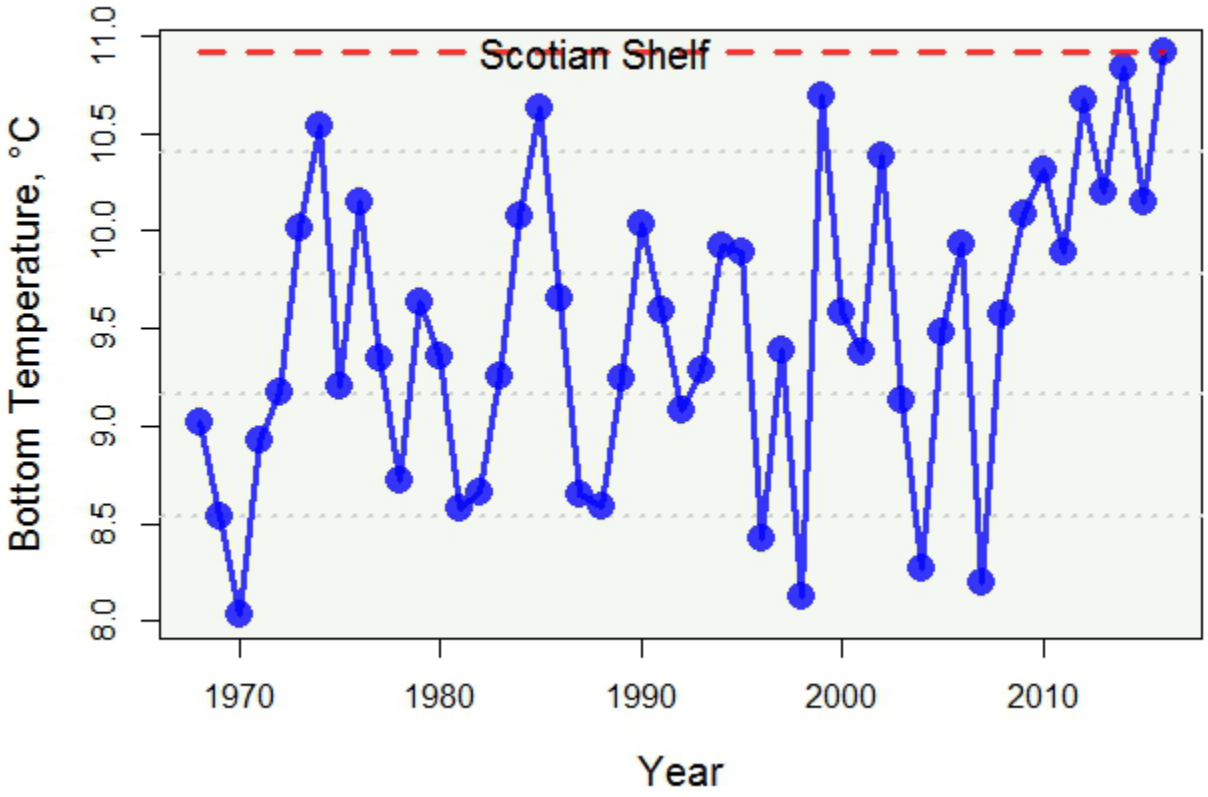


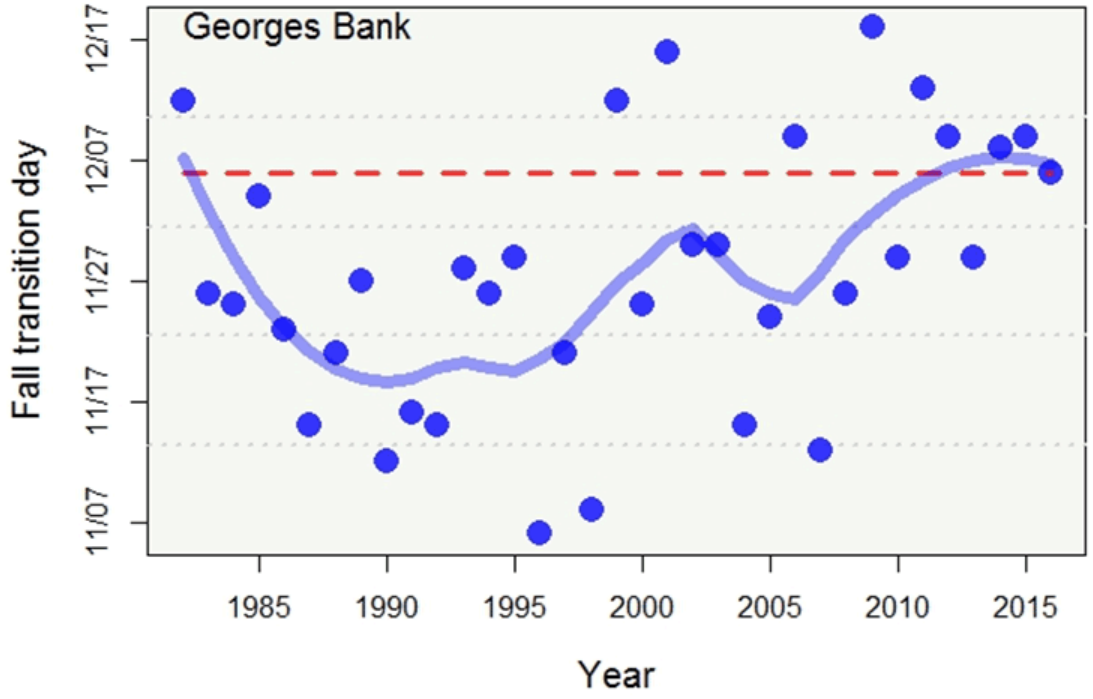
Northeast Shelf



Scotian Shelf

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 (see figures, blue line is time series smoother, red dashed line marks 2016 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 the latest in the time series occurring in early December.



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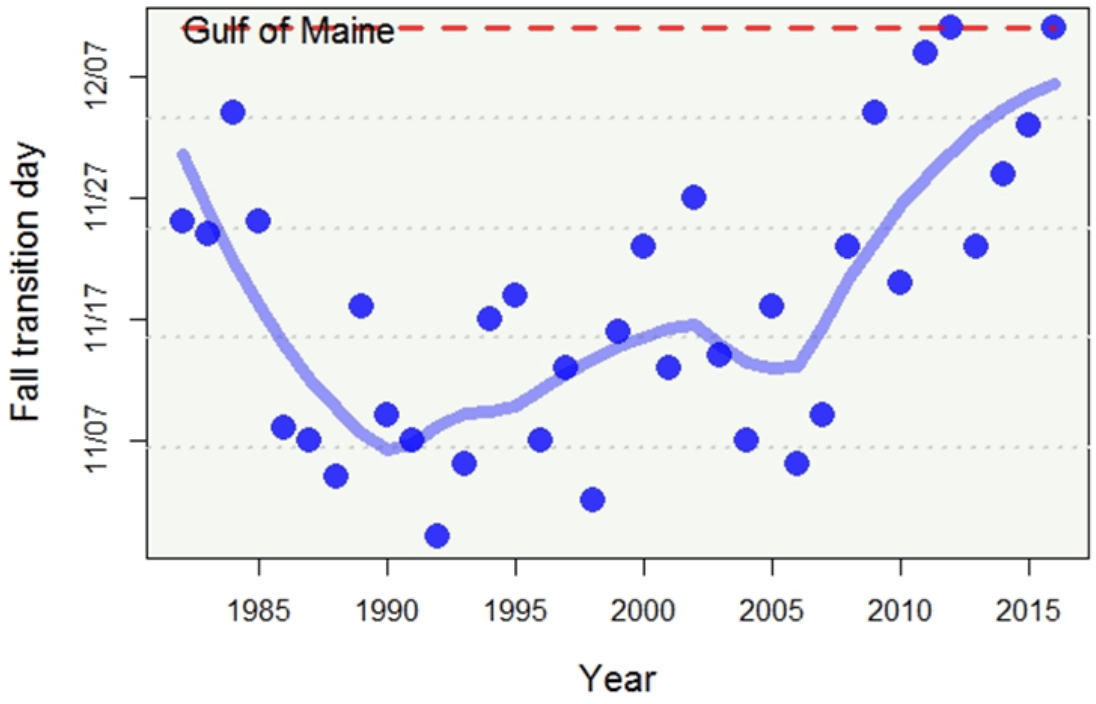
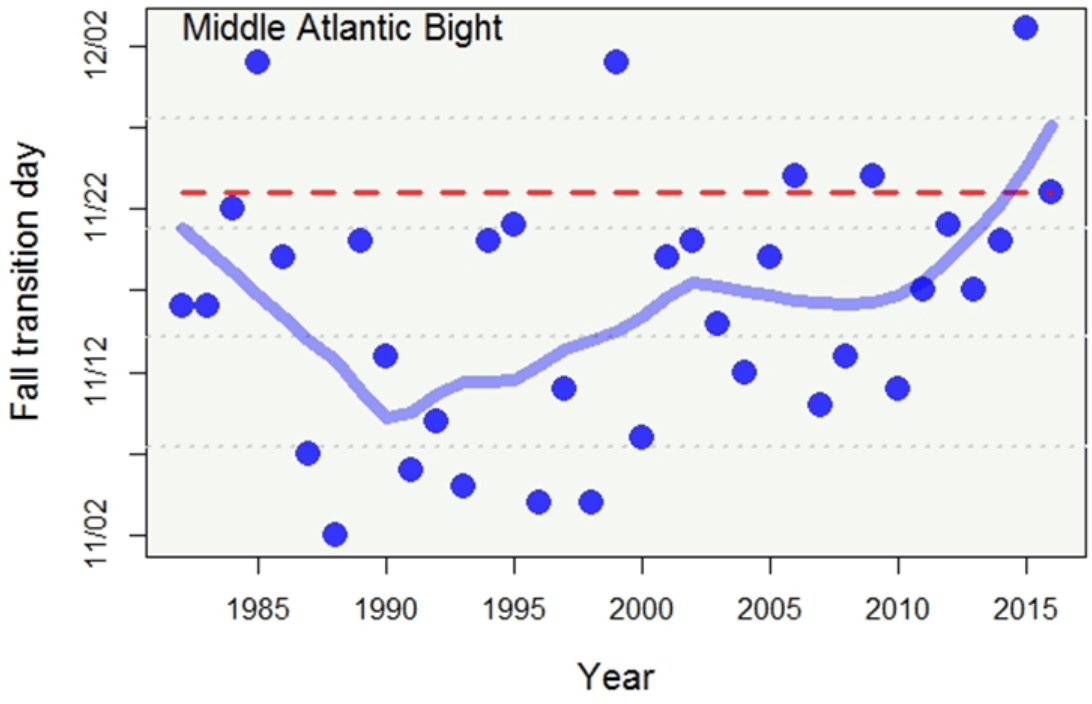
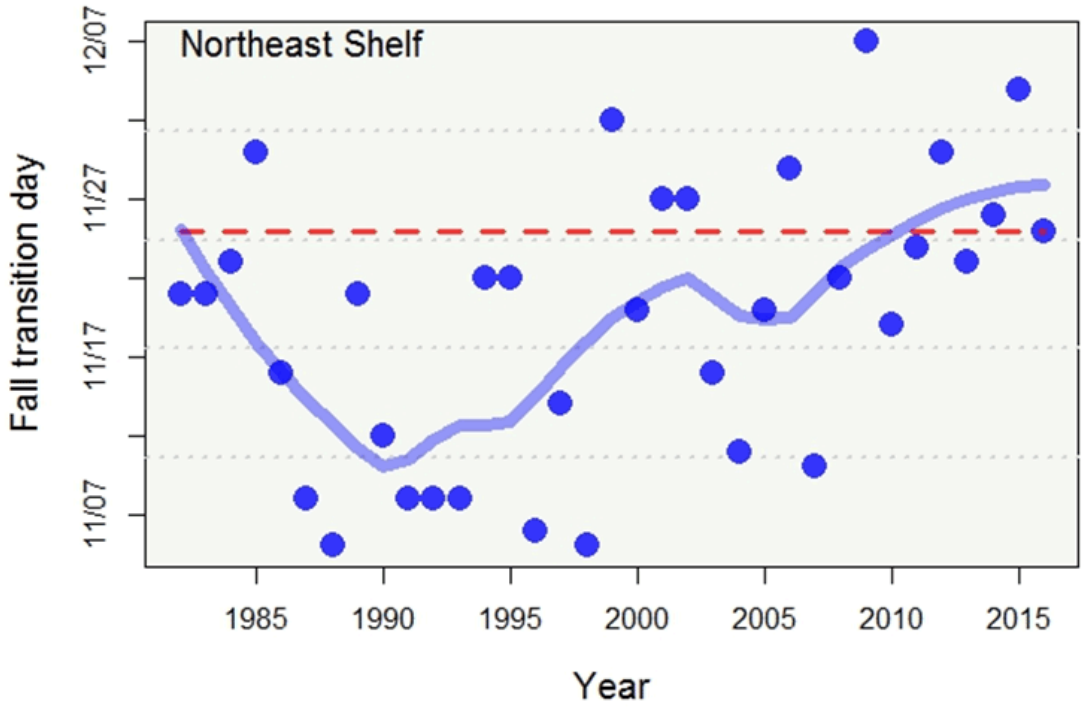


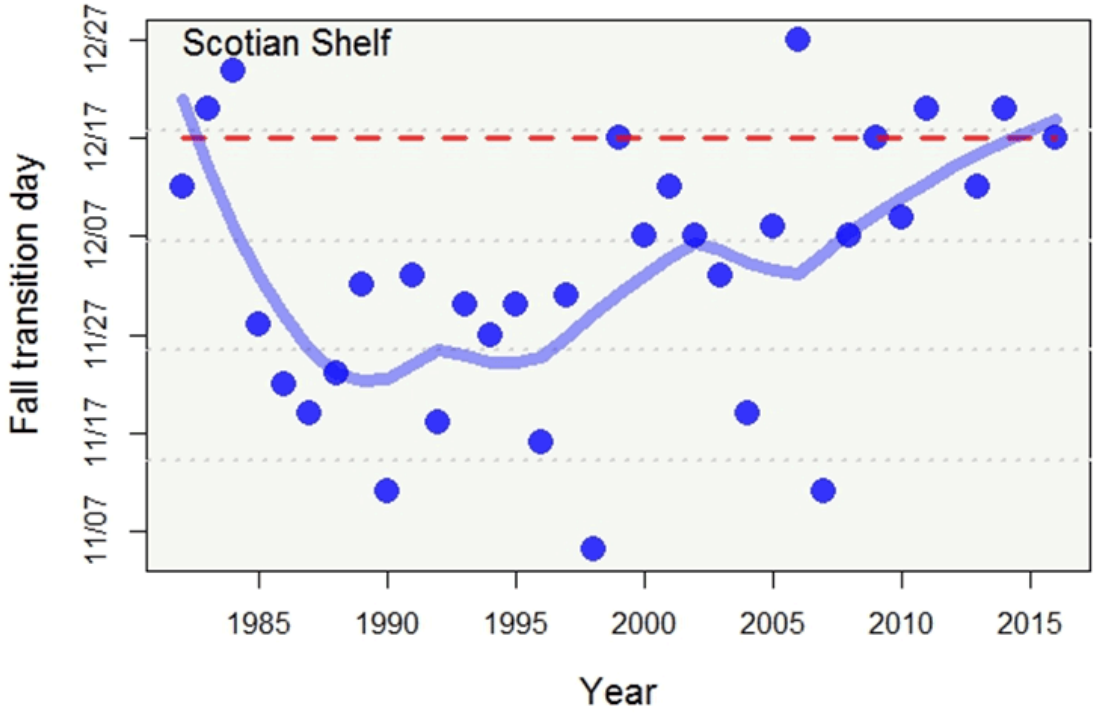
Gulf of Maine



Middle Atlantic Bight



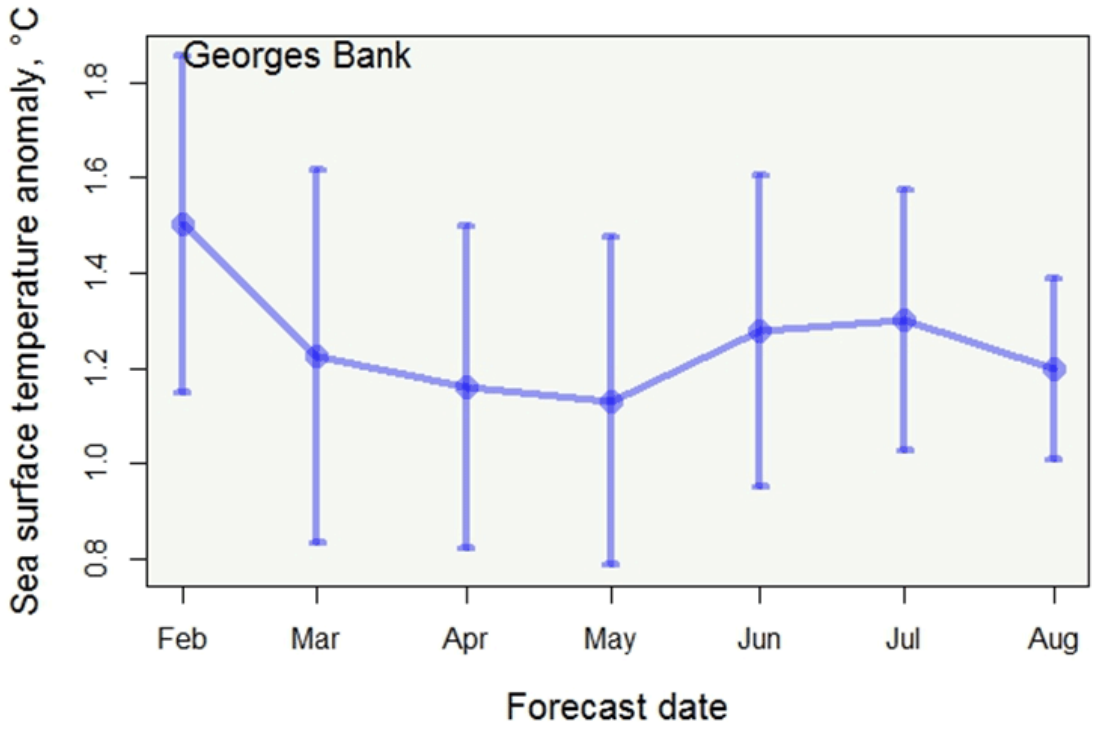
Northeast Shelf



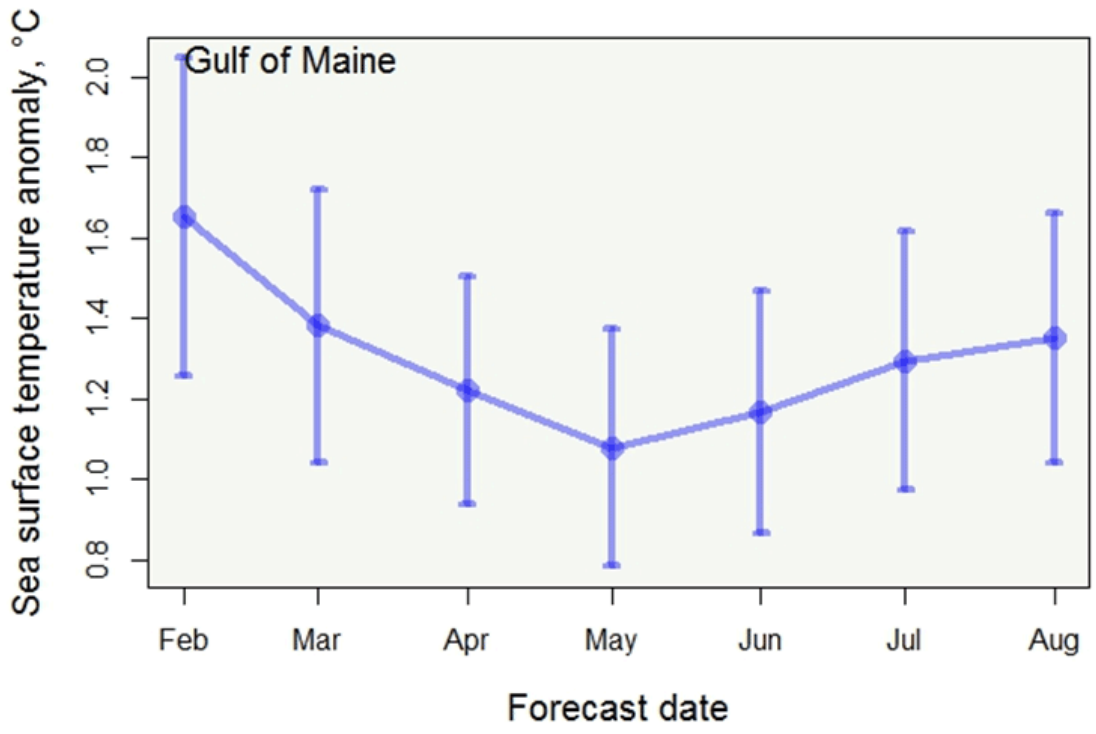
Scotian Shelf

Ecosystem Forecast-Experimental Data Product

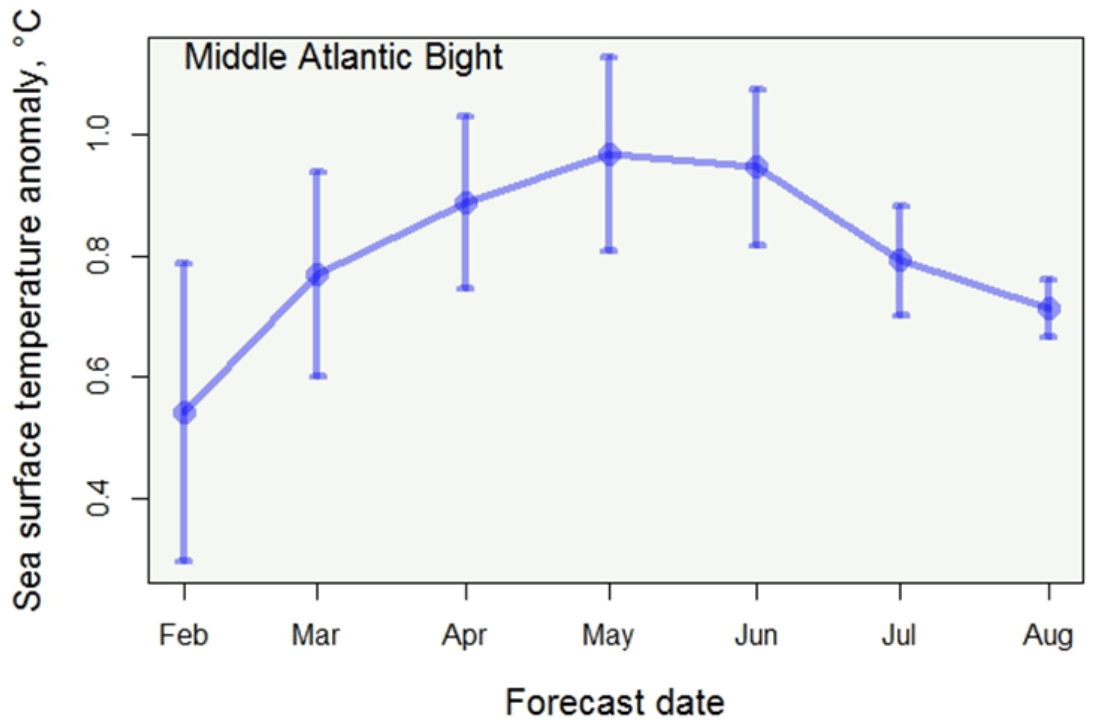
As weather and earth system models have improved, monthly forecasts over seasonal scales ranging up to seven months in advance have improved in quality. For each of the ecoregions of the Northeast Shelf, forecasts from an ensemble of seven forecast models are provided starting with the forecast estimates for February 2017 and ending in August 2017. 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 mean of approximately 0.9°C above average. In the Northern subareas there was less model agreement as suggested by wider error bands on the ensemble forecast; however, the forecasts suggest SST will be approximately 1.2°C above average in these areas.



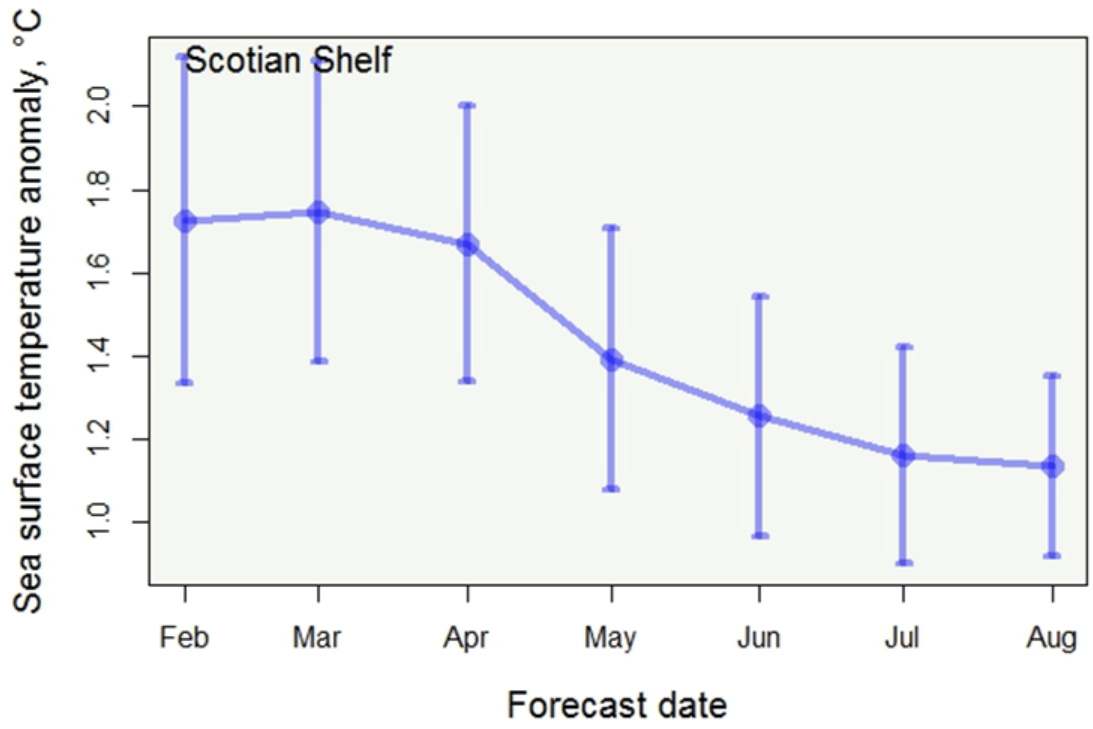
Georges Bank



Gulf of Maine

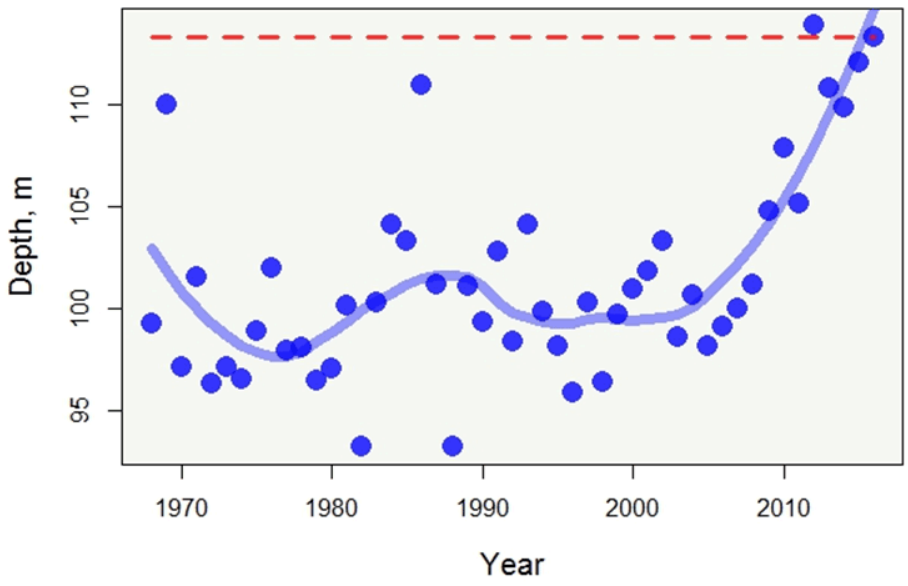


Middle Atlantic Bight

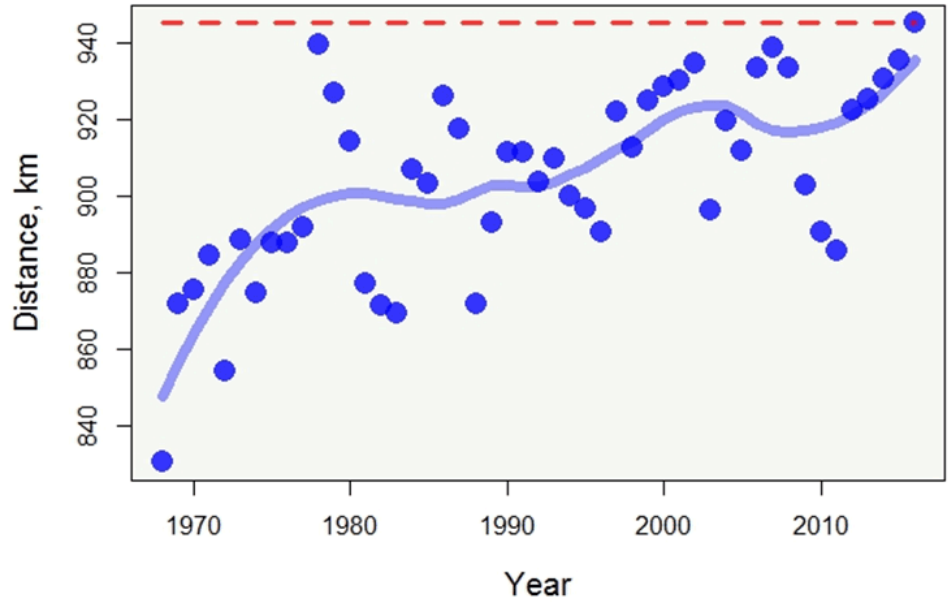


Scotian Shelf

Trends in Fall Species Distribution



Along-shelf depth trend

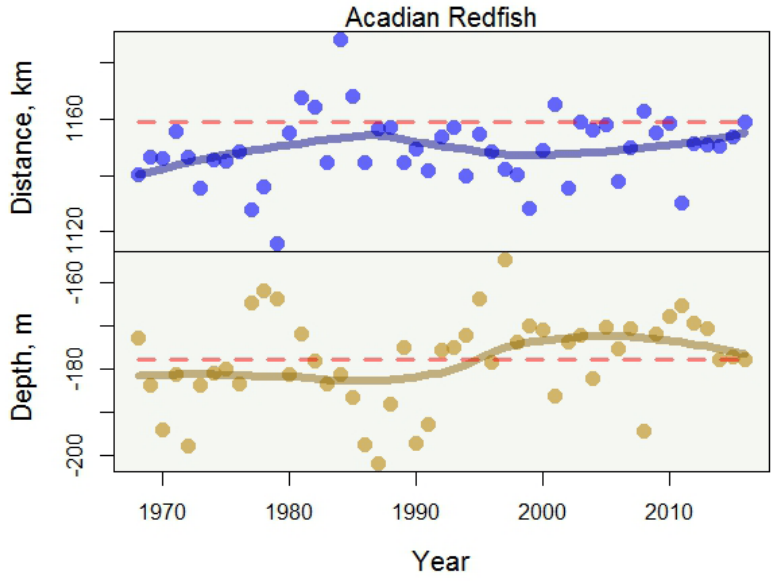


Trends in Fall Species Distribution

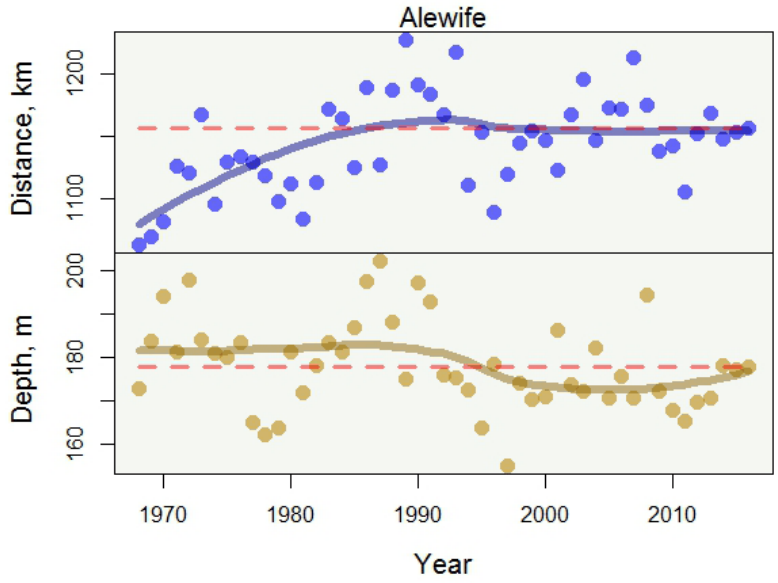
The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades. Individual species have shifted distribution for a number of reasons, and these shifts can

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. The mean along shelf distance and depth of occurrence for all species by year are shown in the two graphs, with the 2016 values marked with a dashed red line. As a group, these species had an along shelf distance of approximately 870 km, they now have a distance of over 930 km. For most of the time series, the species averaged a depth of 100 m, they now average approximately 113 m.

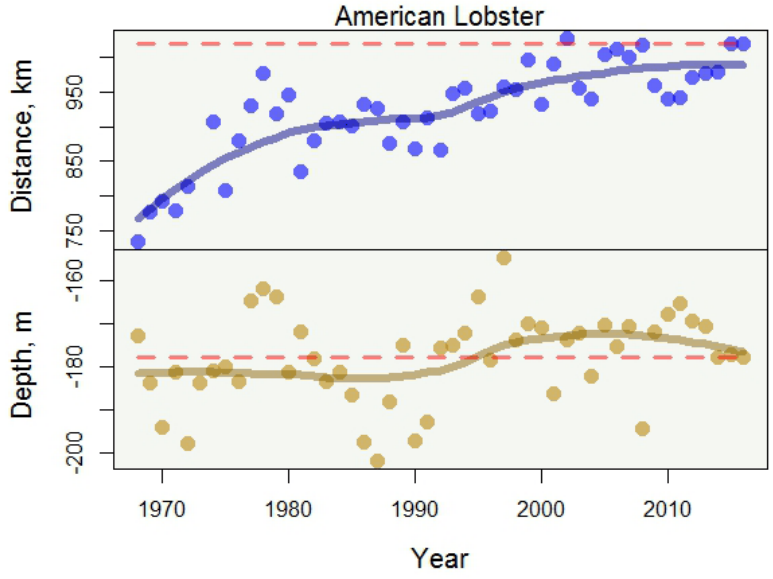
Acadian redfish



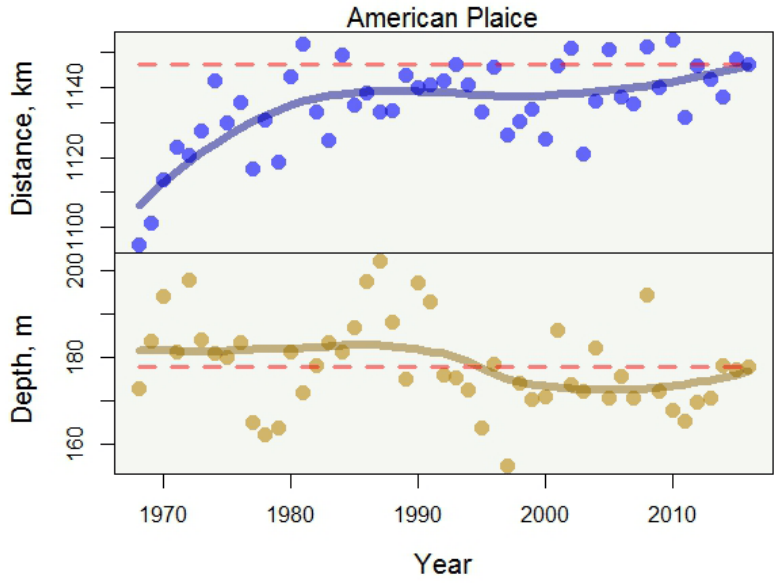
Alewife



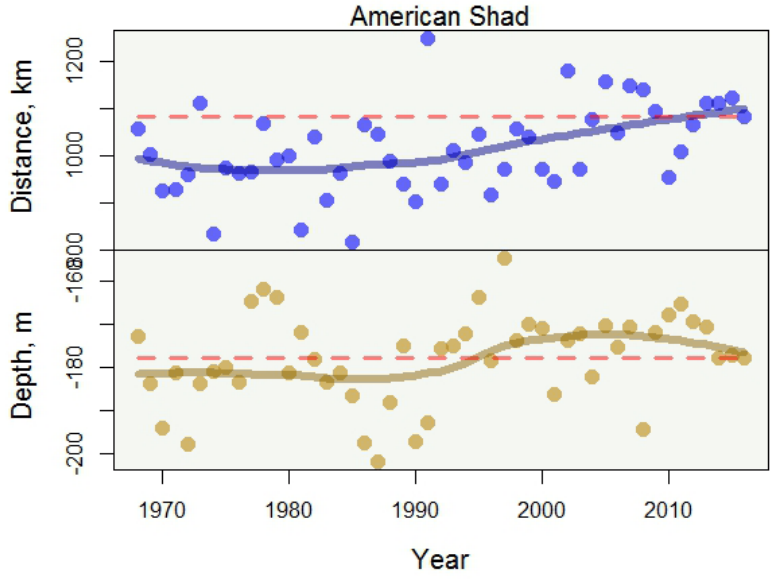
American lobster



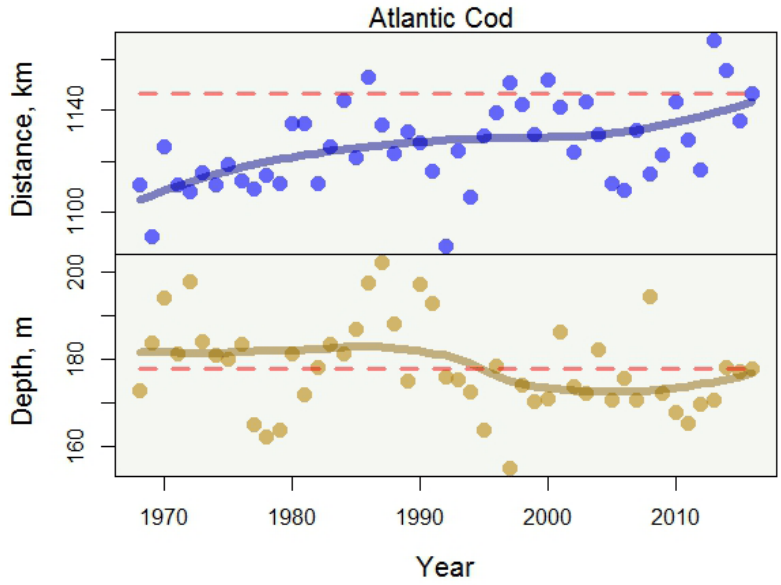
American plaice



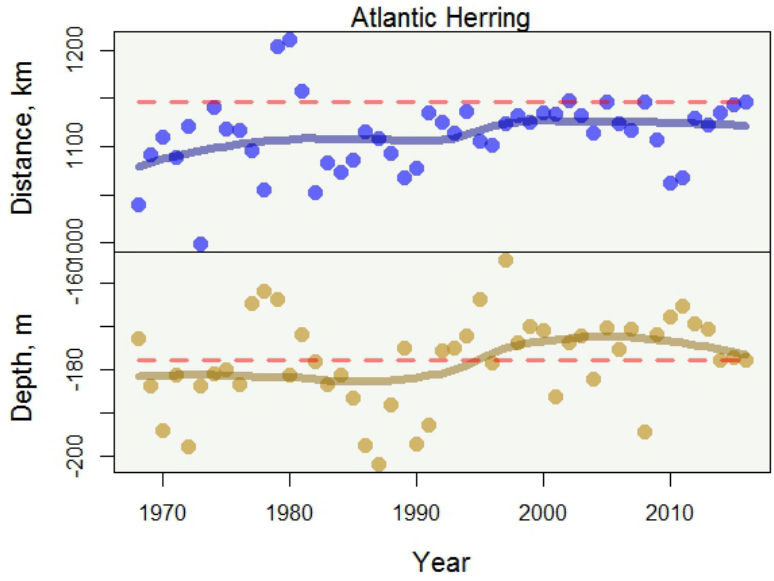
American shad



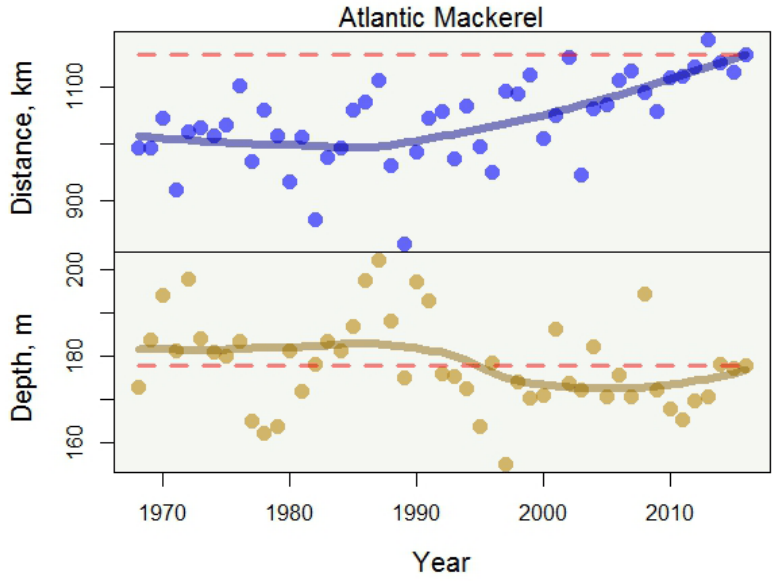
Atlantic cod



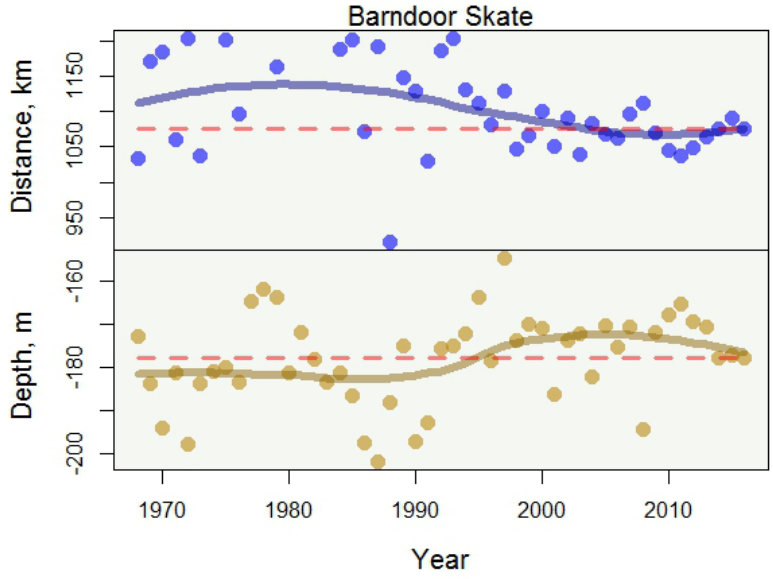
Atlantic herring



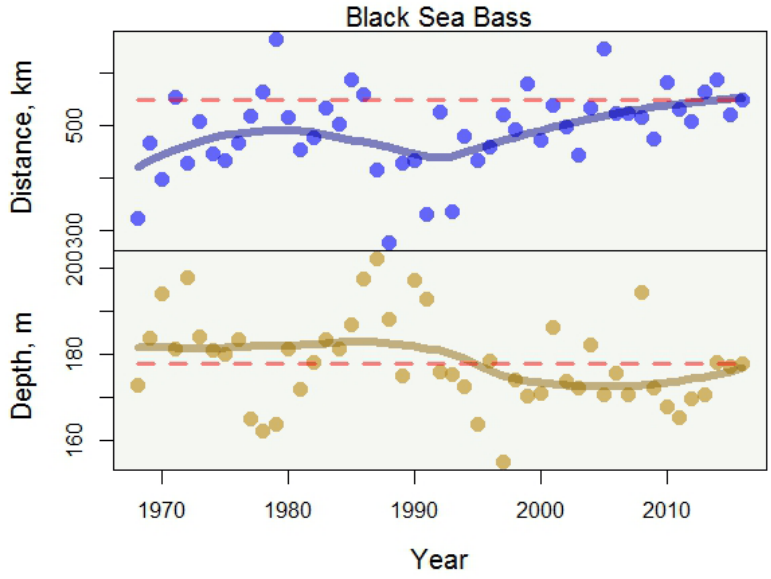
Atlantic mackerel



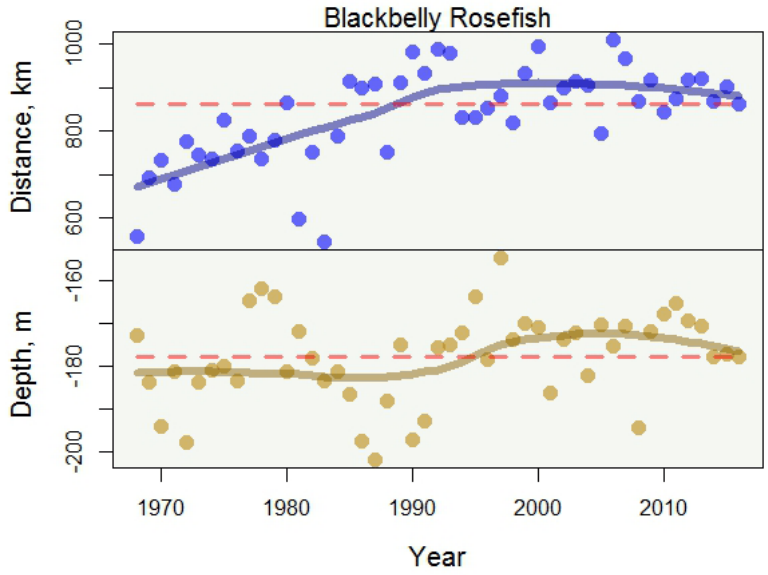
Barndoor skate



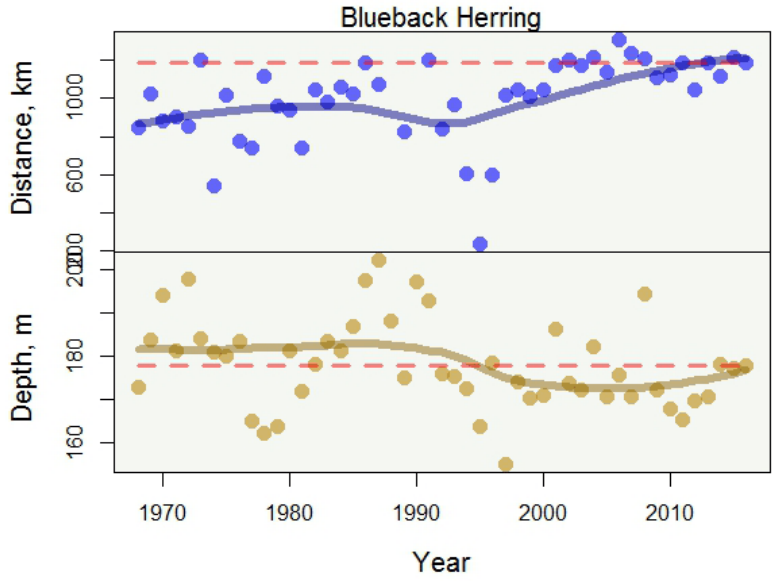
Black sea bass



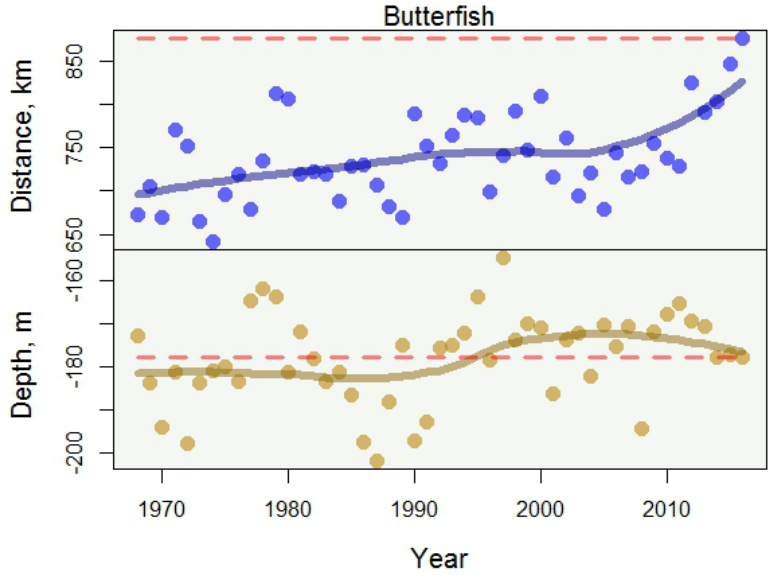
Blackbelly rosefish



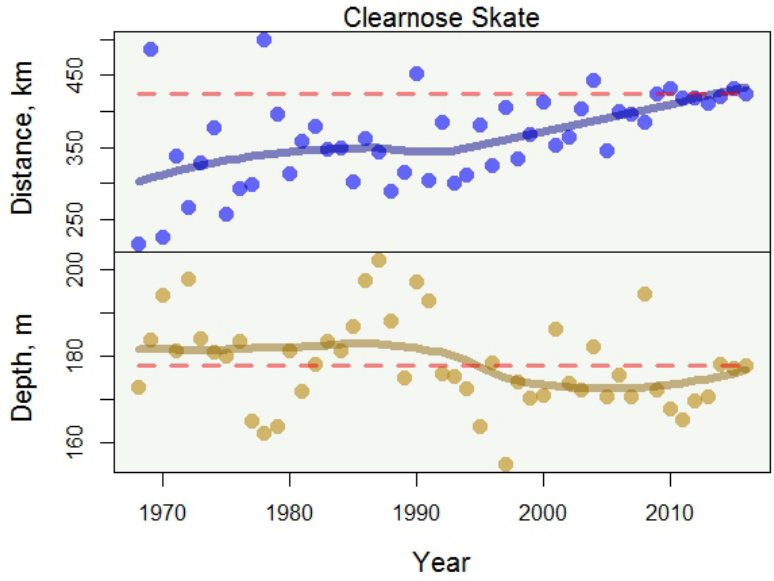
Blueback herring



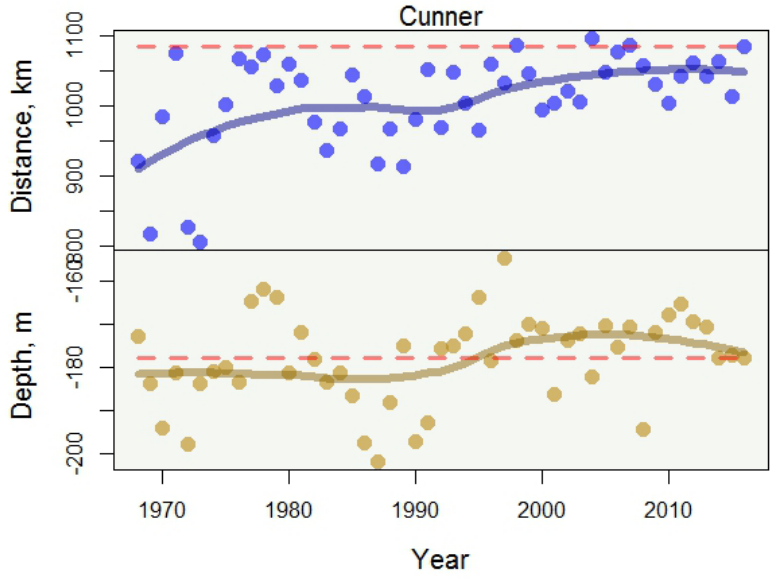
Butterfish



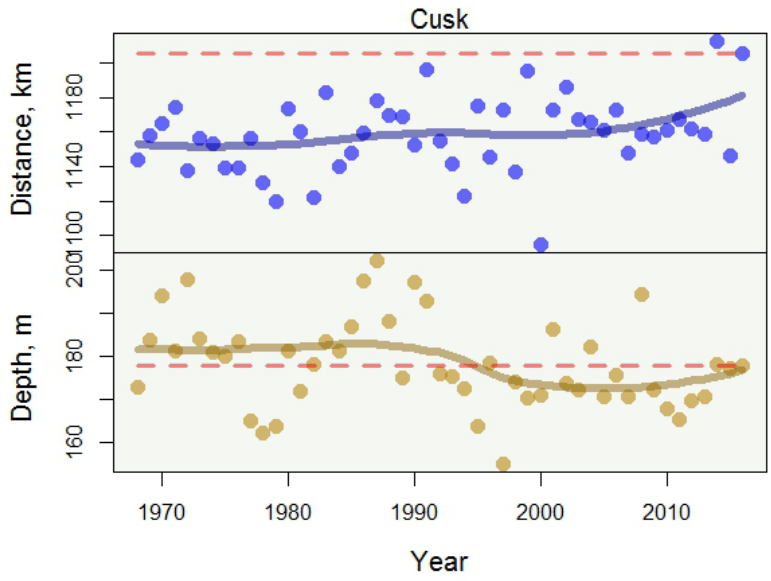
Clearnose skate



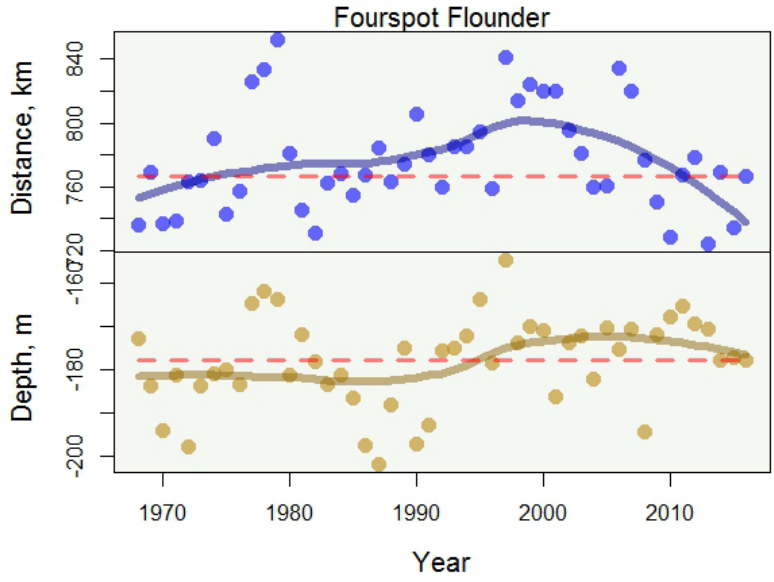
Cunner



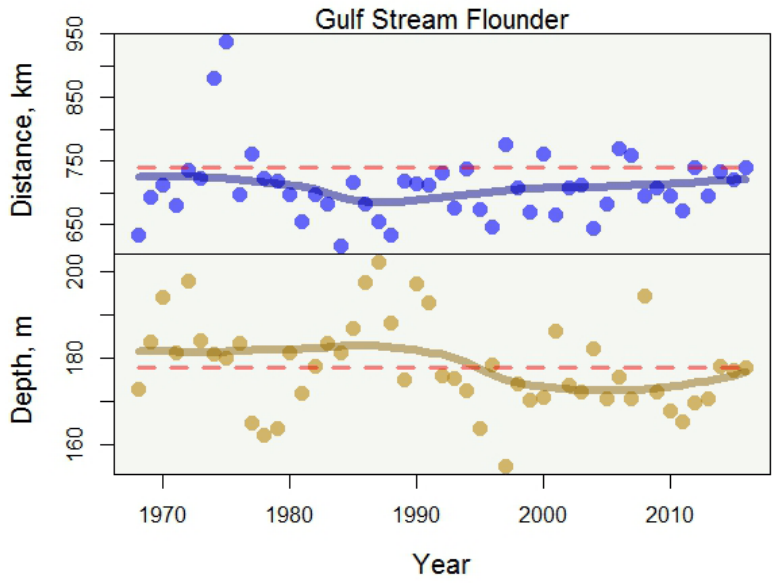
Cusk



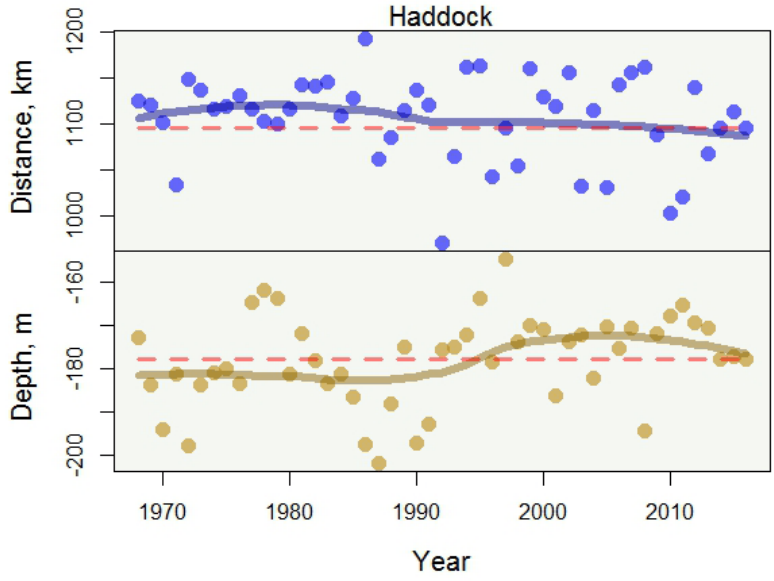
Fourspot flounder



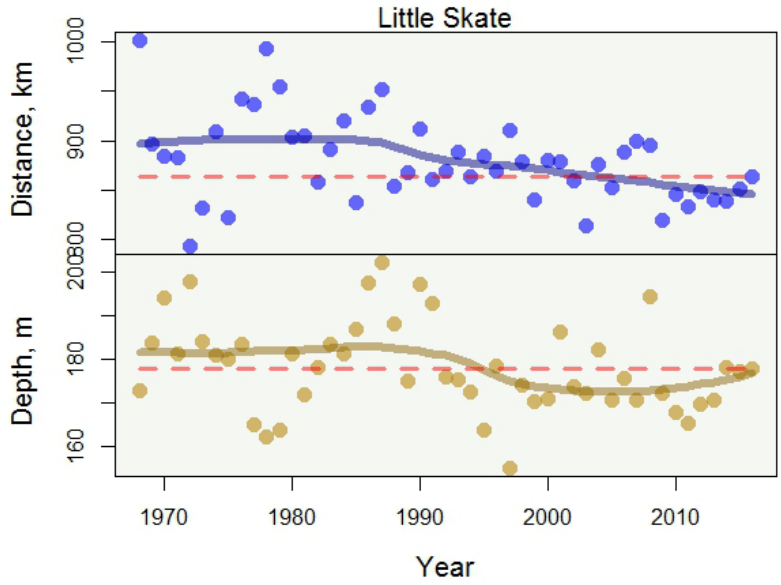
Gulf Stream flounder



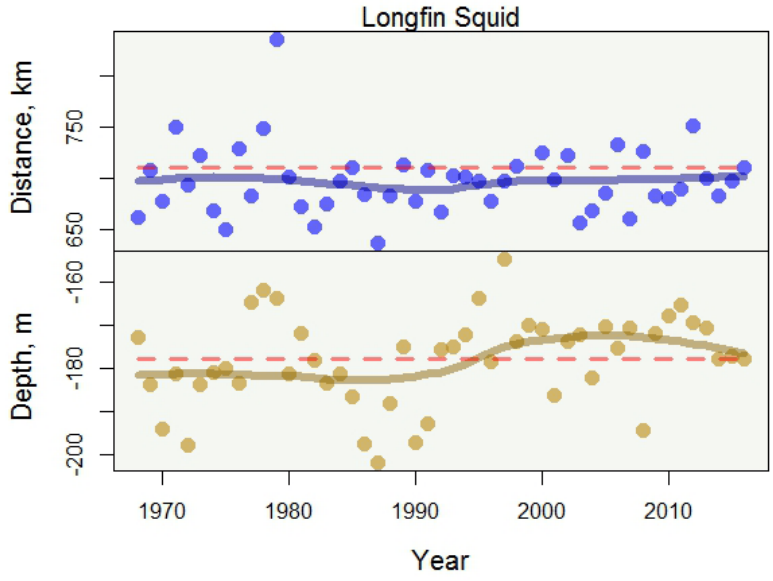
Haddock



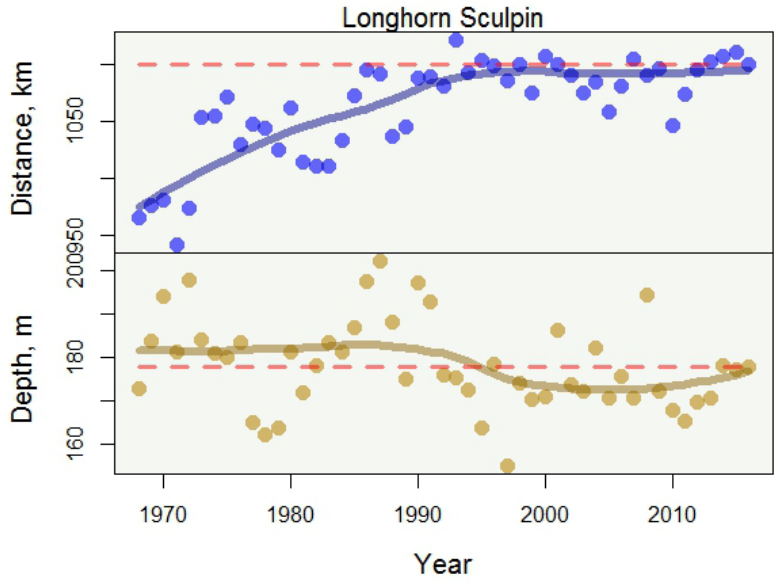
Little skate



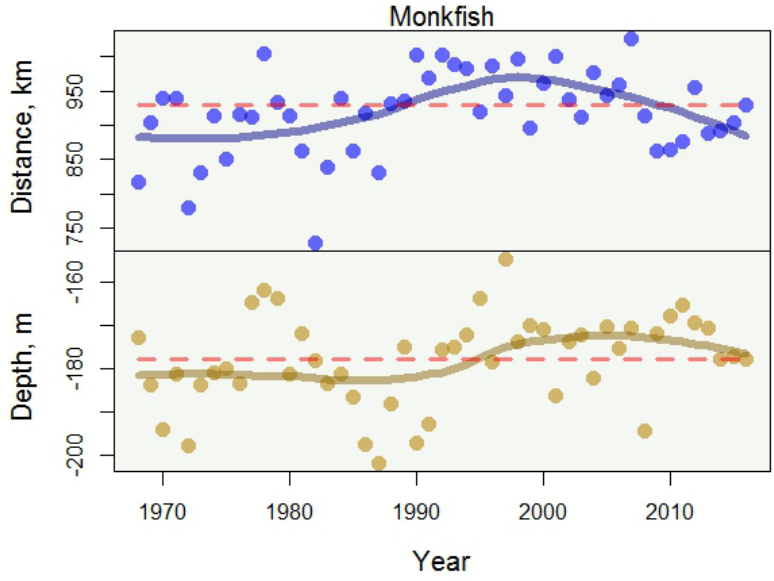
Longfin squid



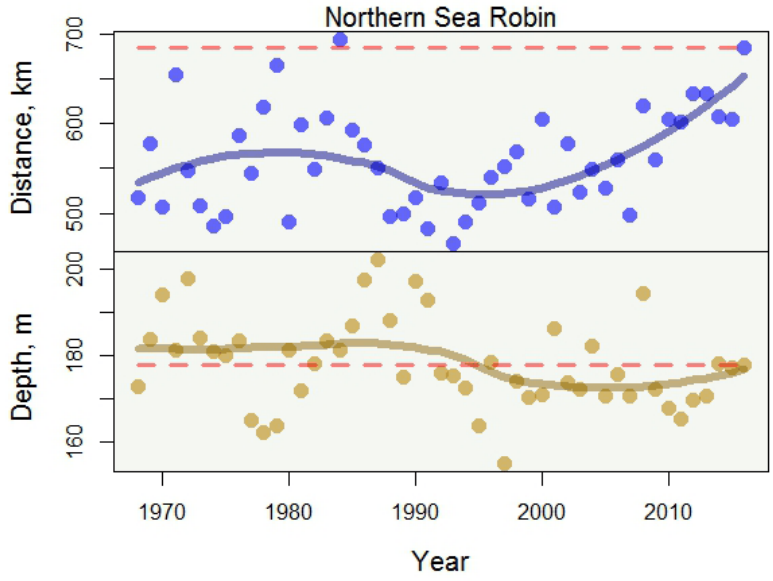
Longhorn sculpin



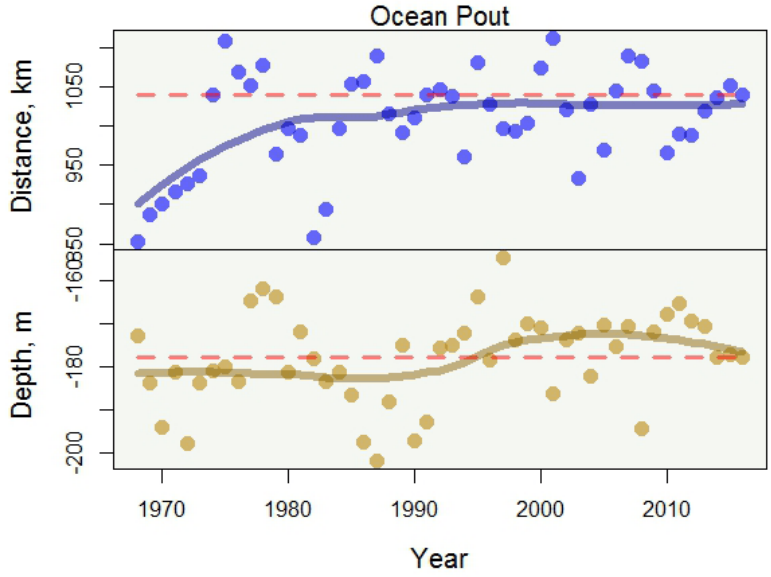
Monkfish



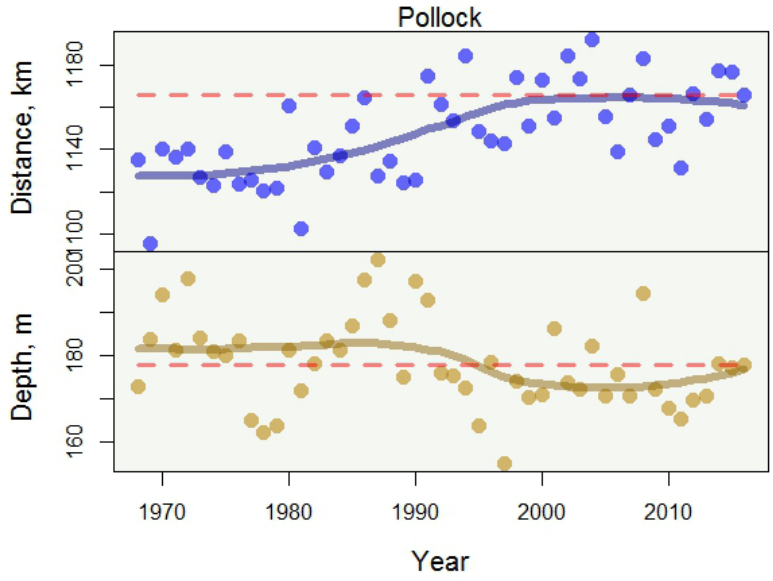
Northern sea robin



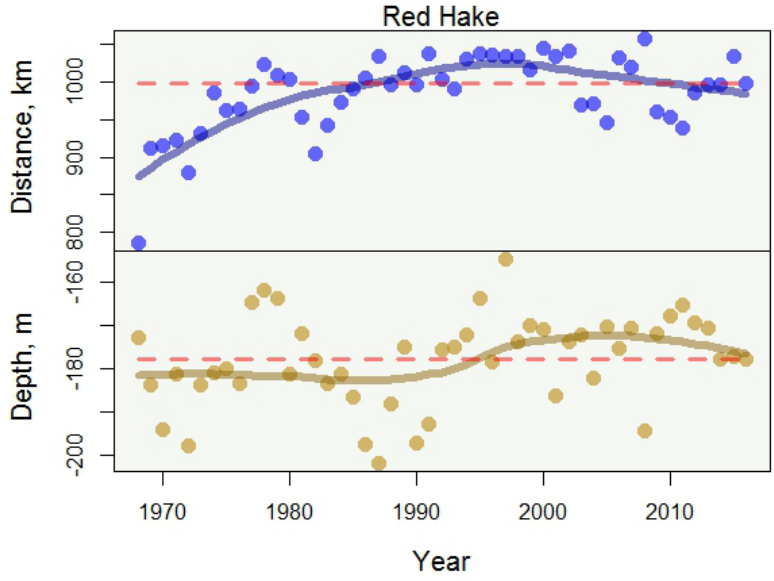
Ocean Pout



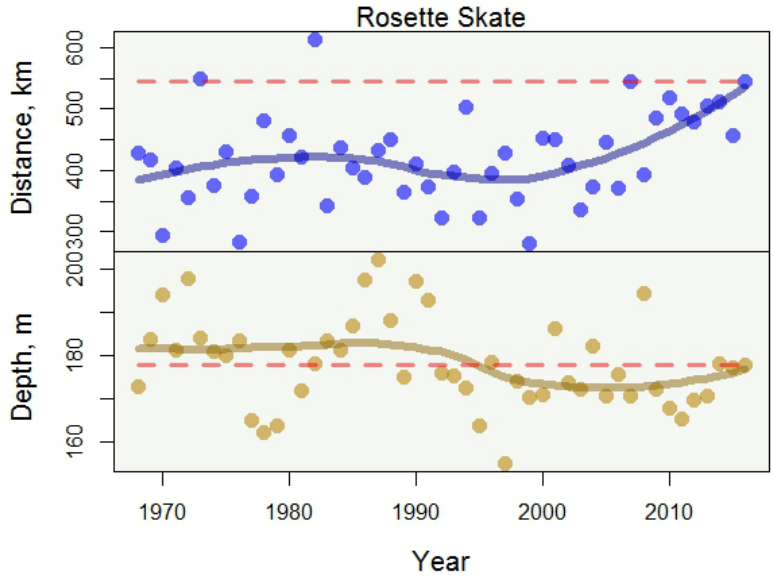
Pollock



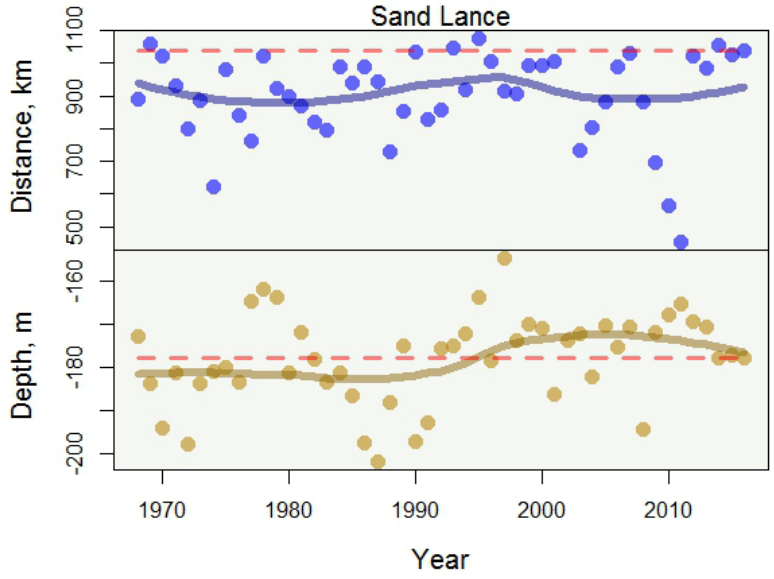
Red hake



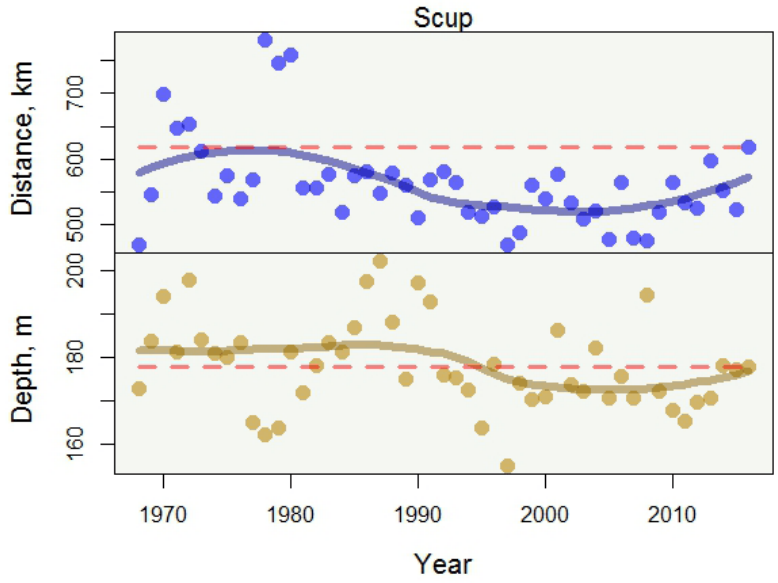
Rosette skate



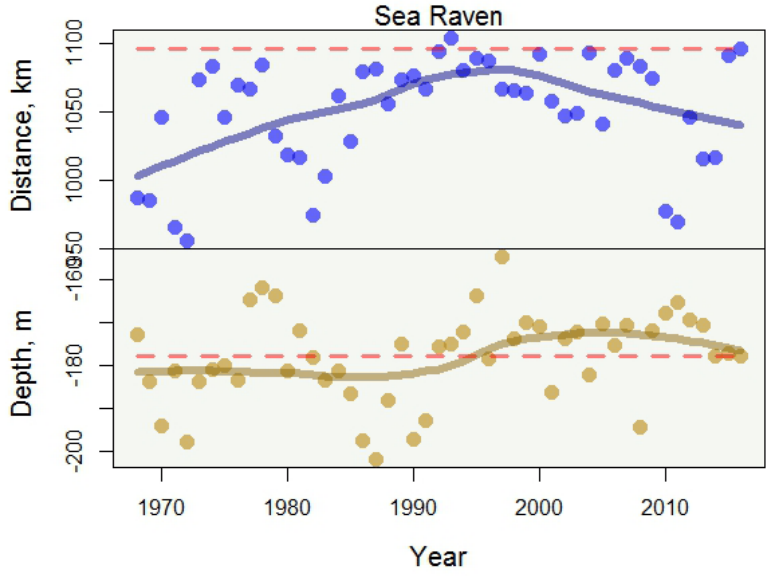
Sand lance



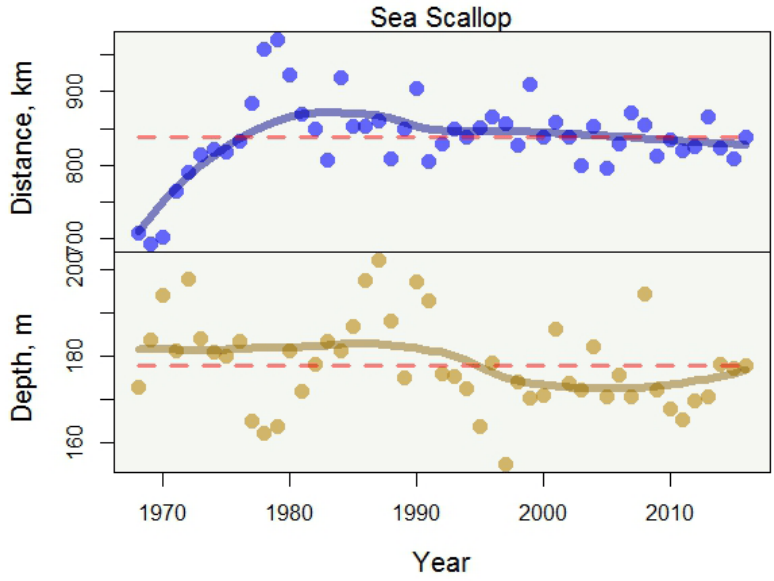
Scup



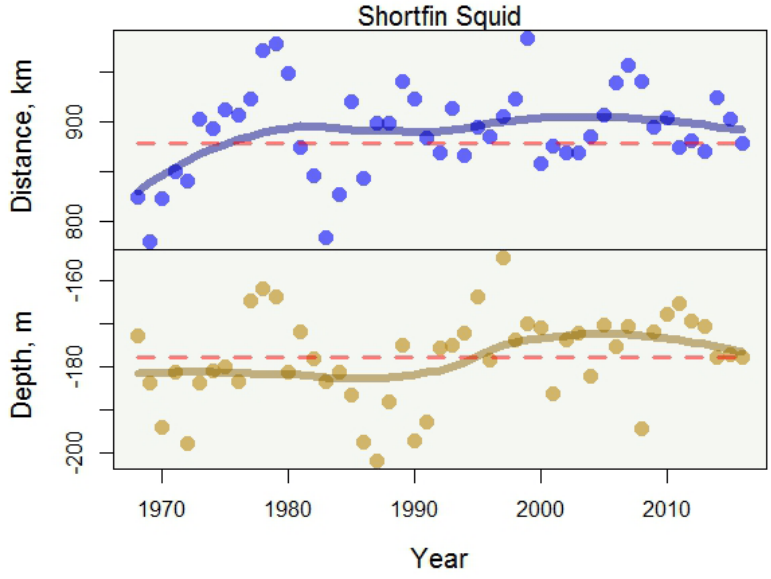
Sea raven



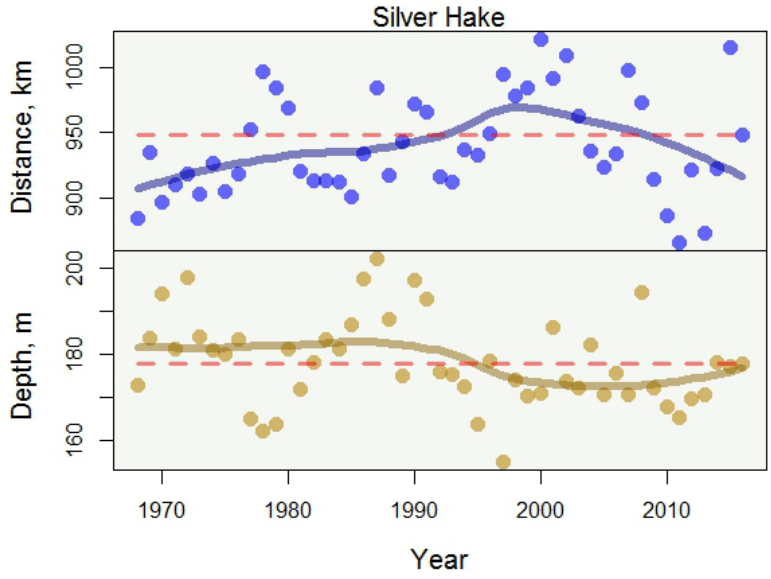
Sea scallop



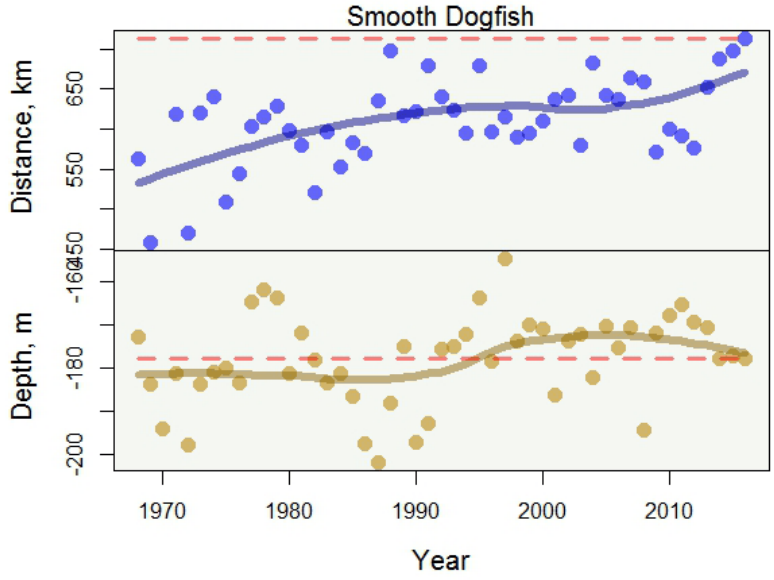
Shortfin squid



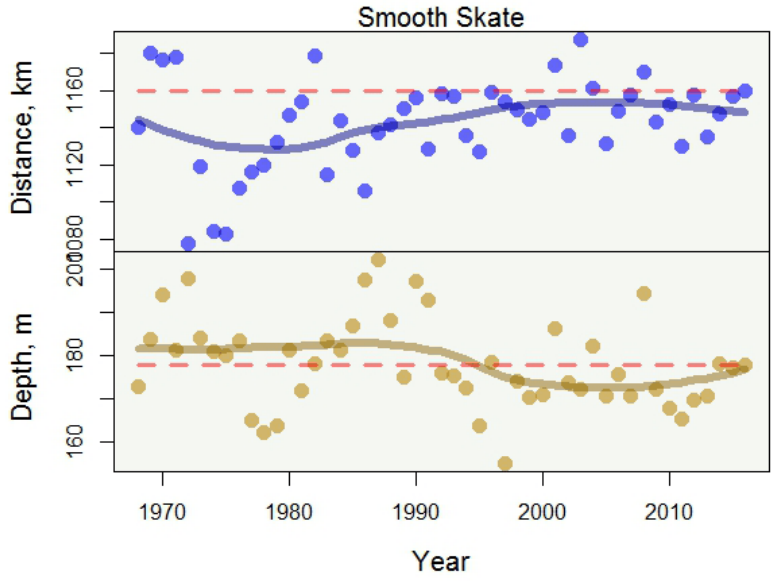
Silver hake



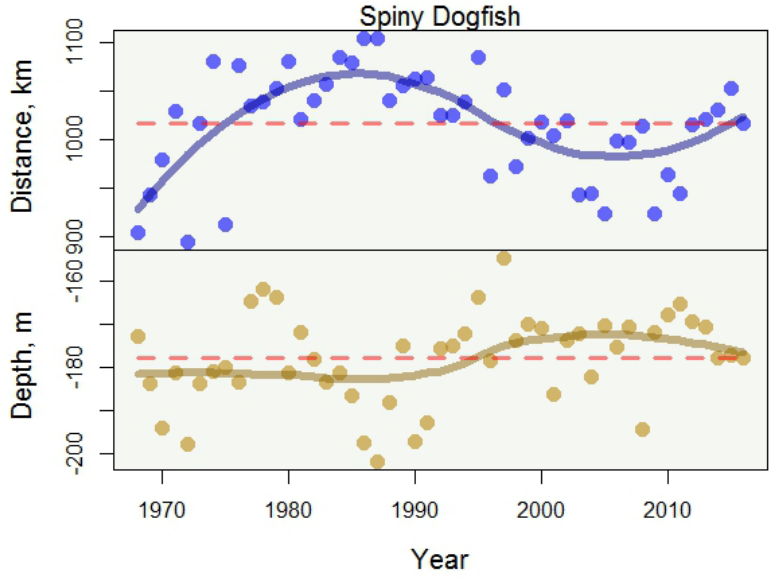
Smooth dogfish



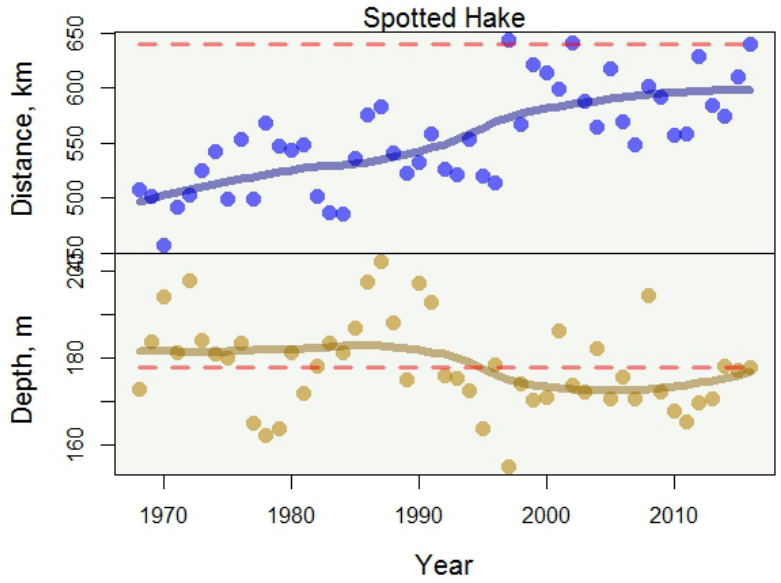
Smooth skate



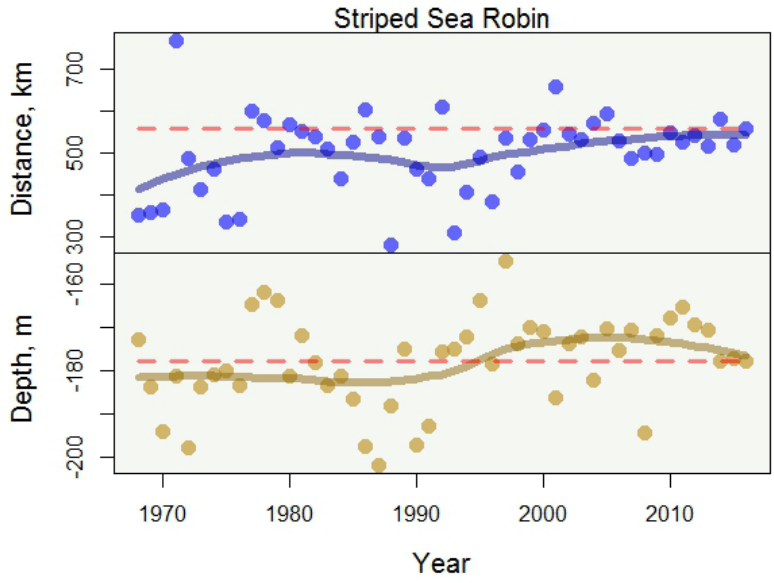
Spiny dogfish



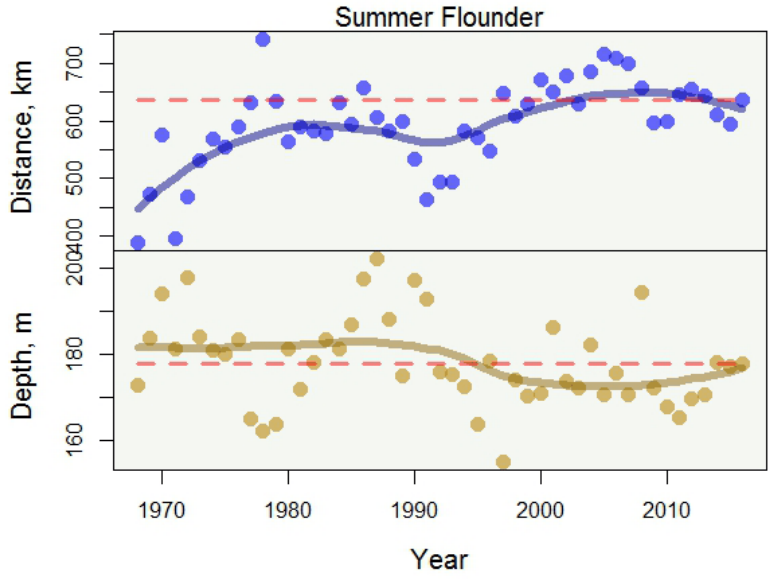
Spotted hake



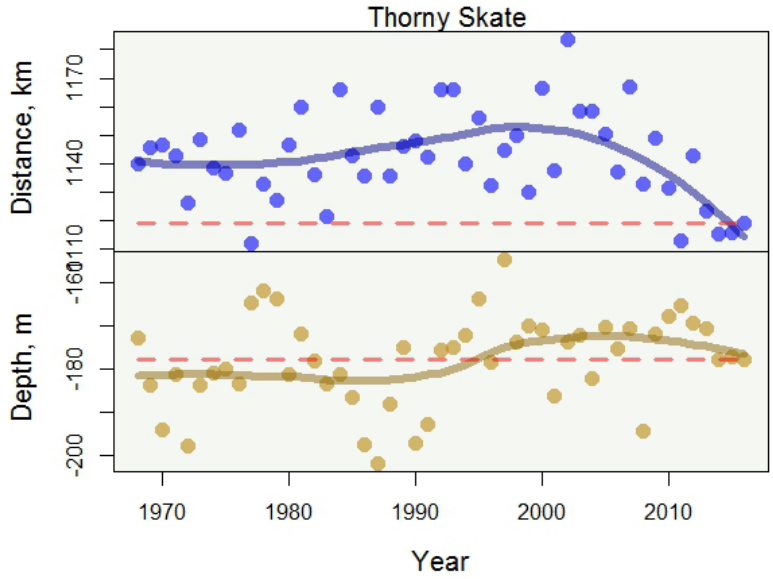
Striped sea robin



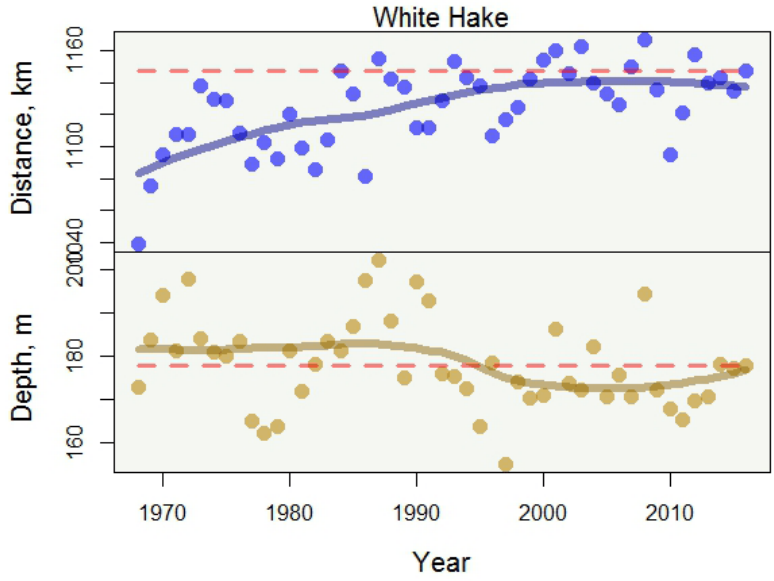
Summer flounder



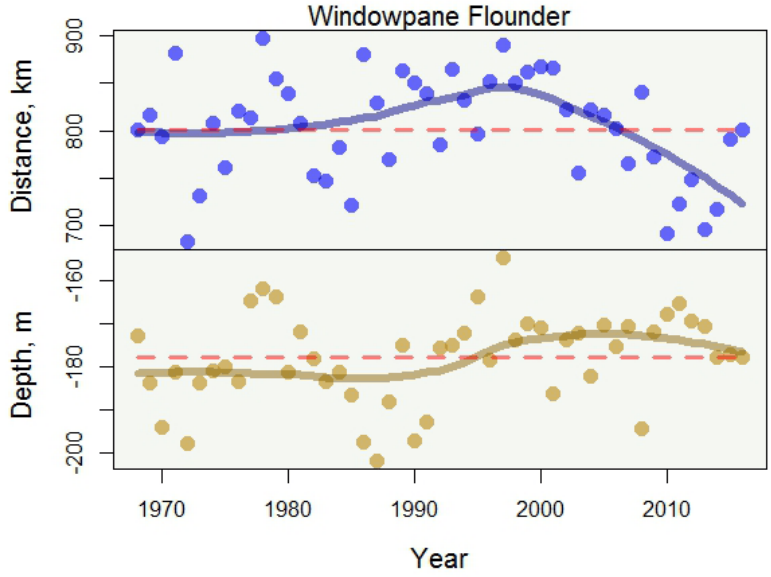
Thorny skate



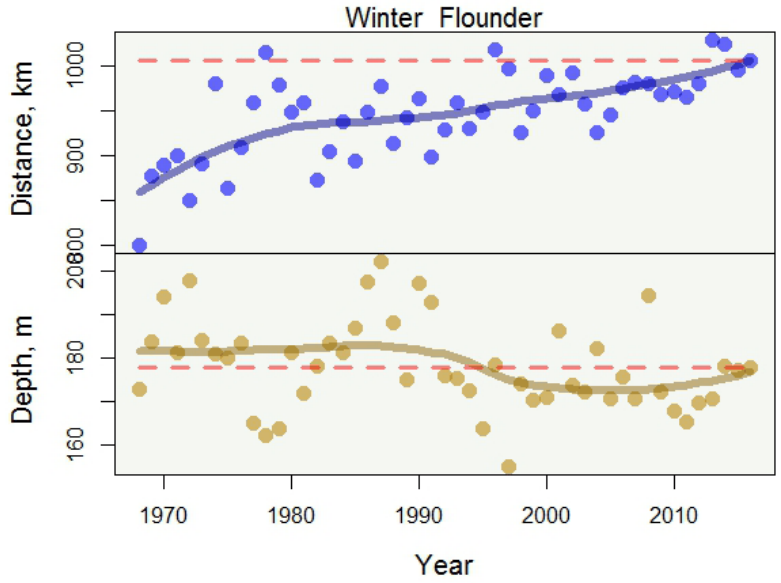
White hake



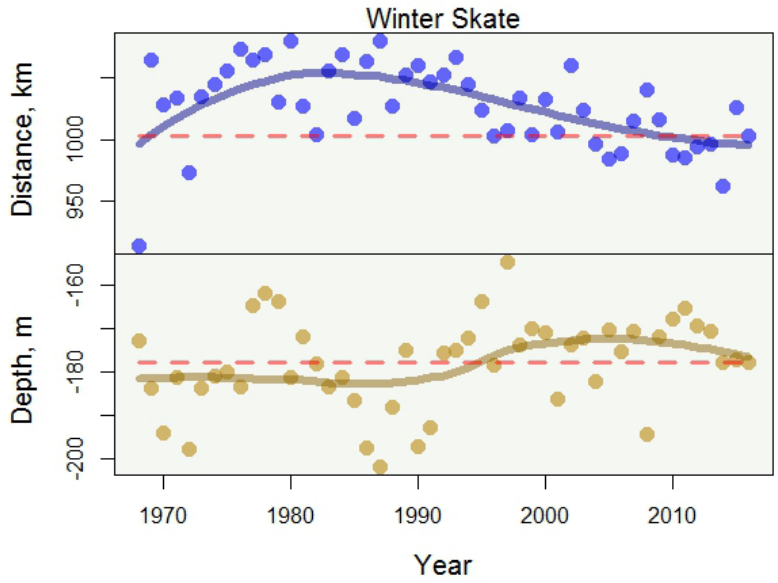
Windowpane flounder



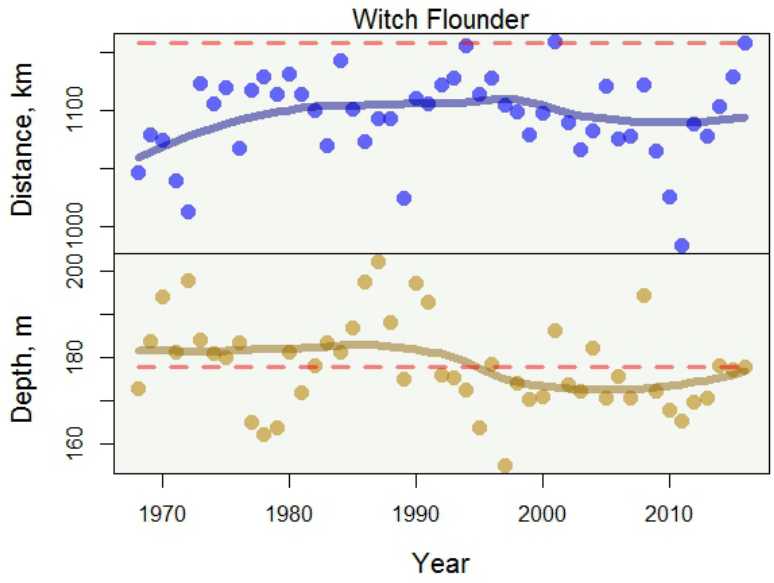
Winter flounder



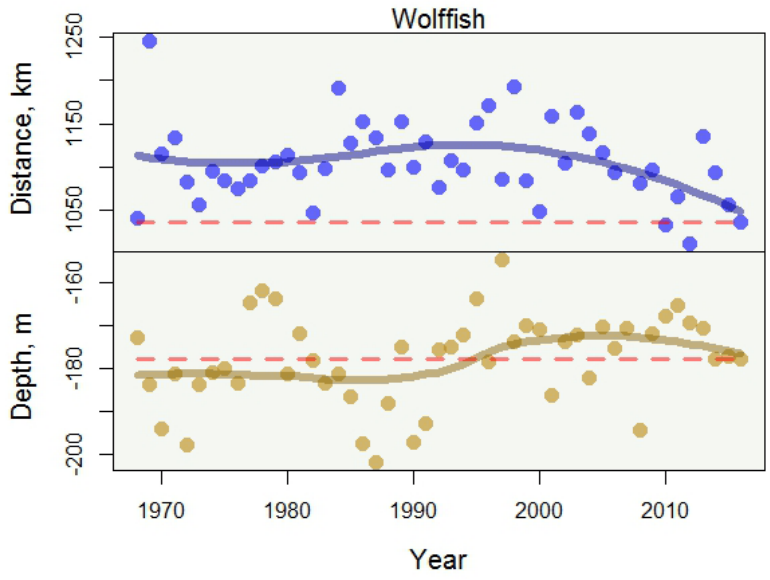
Winter skate



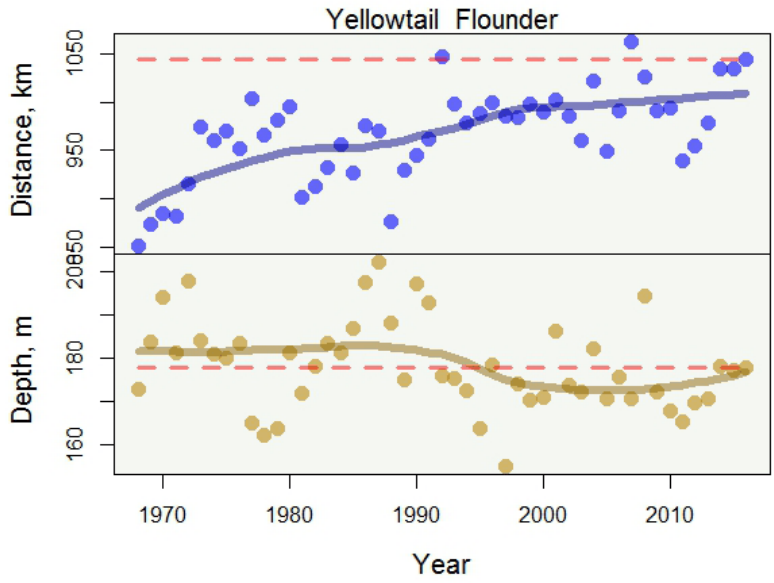
Witch flounder



Wolffish



Yellowtail flounder

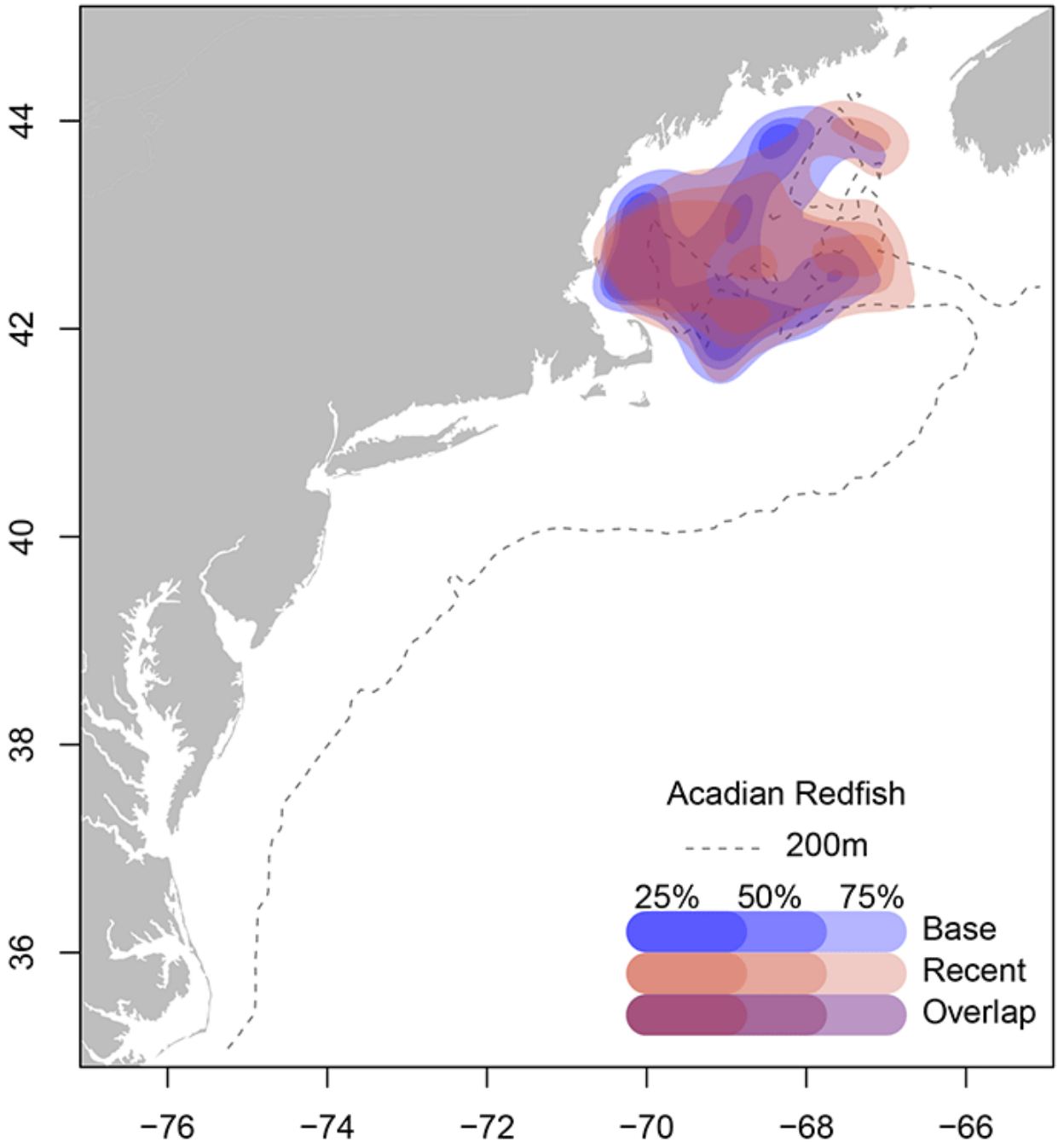


Kernel Density Plots of Fall Species Distribution

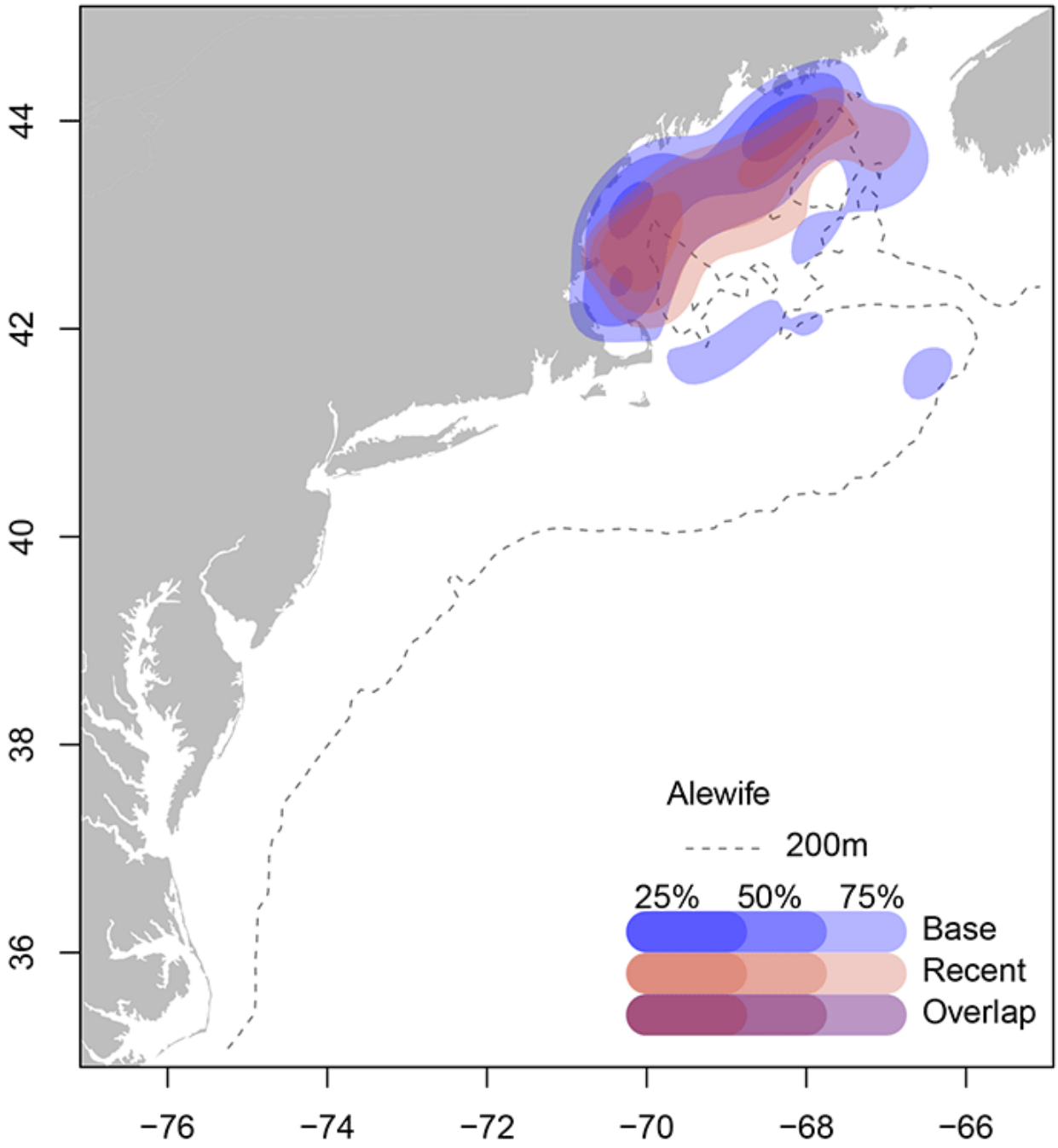
The habitats used by species of the Northeast Shelf ecosystem have changed over recent decades. Species have moved in response to a complex set of factors resulting in changes in distribution in respect to latitude and depth, among a number of habitat indicators. Kernel density plots provide a way of 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 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 (2014-2016) for the fall survey (shown as red kernel densities).

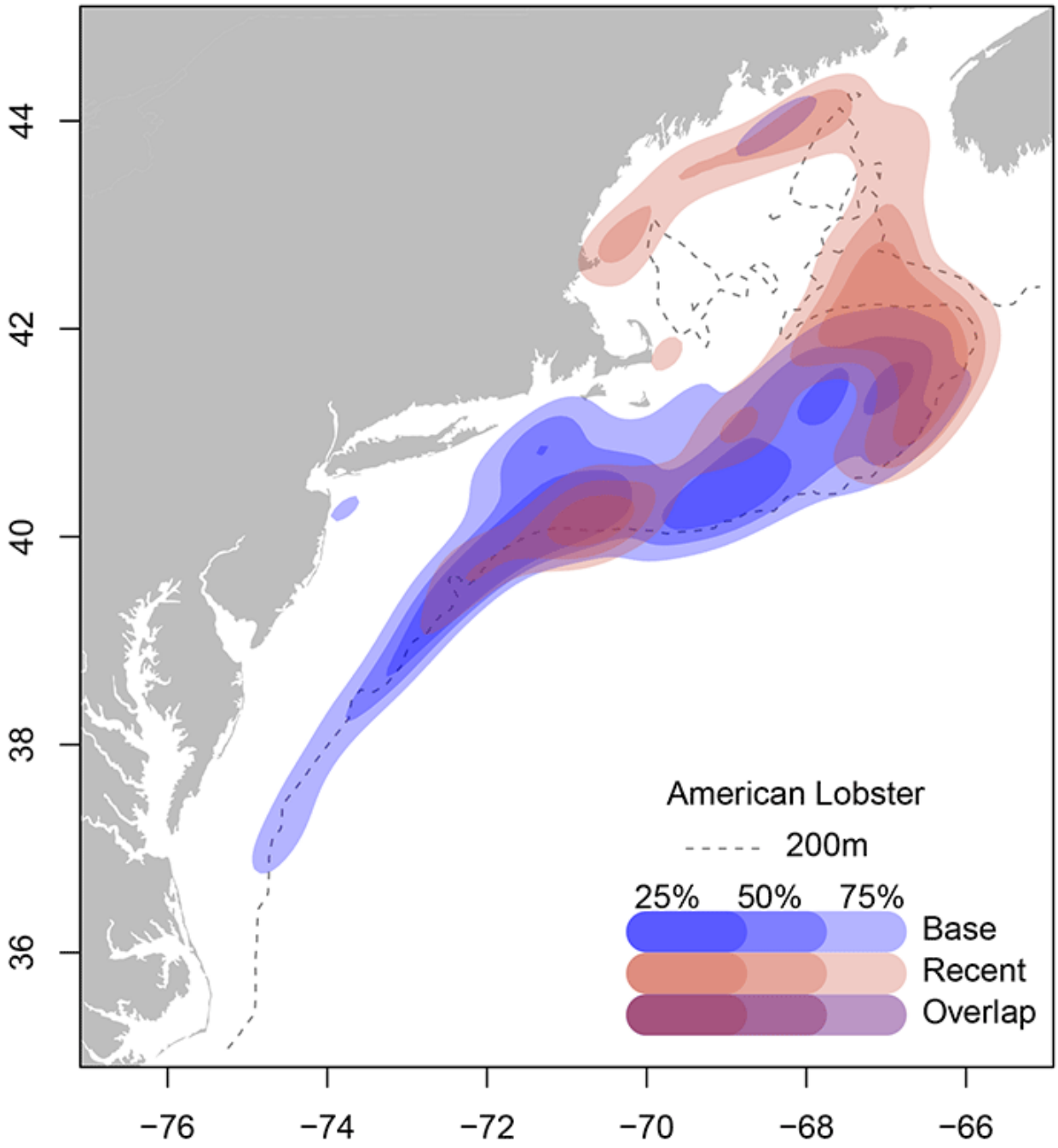
Acadian redfish



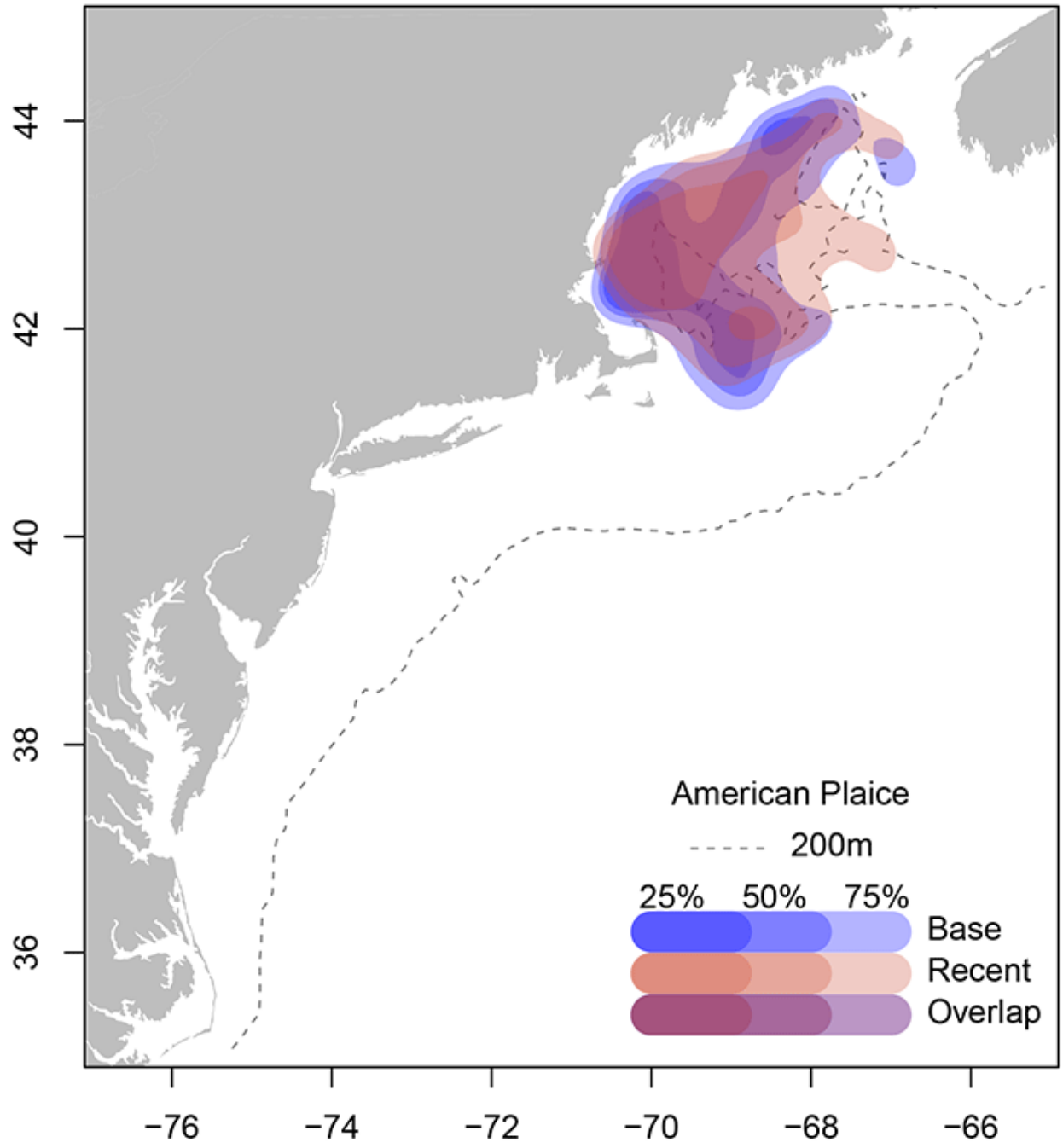
Alewife


44
42
40
38
36
−76
−74
−72
−70
−68
−66
Alewife
200m
25%
50%
75%
Base
Recent
Overlap

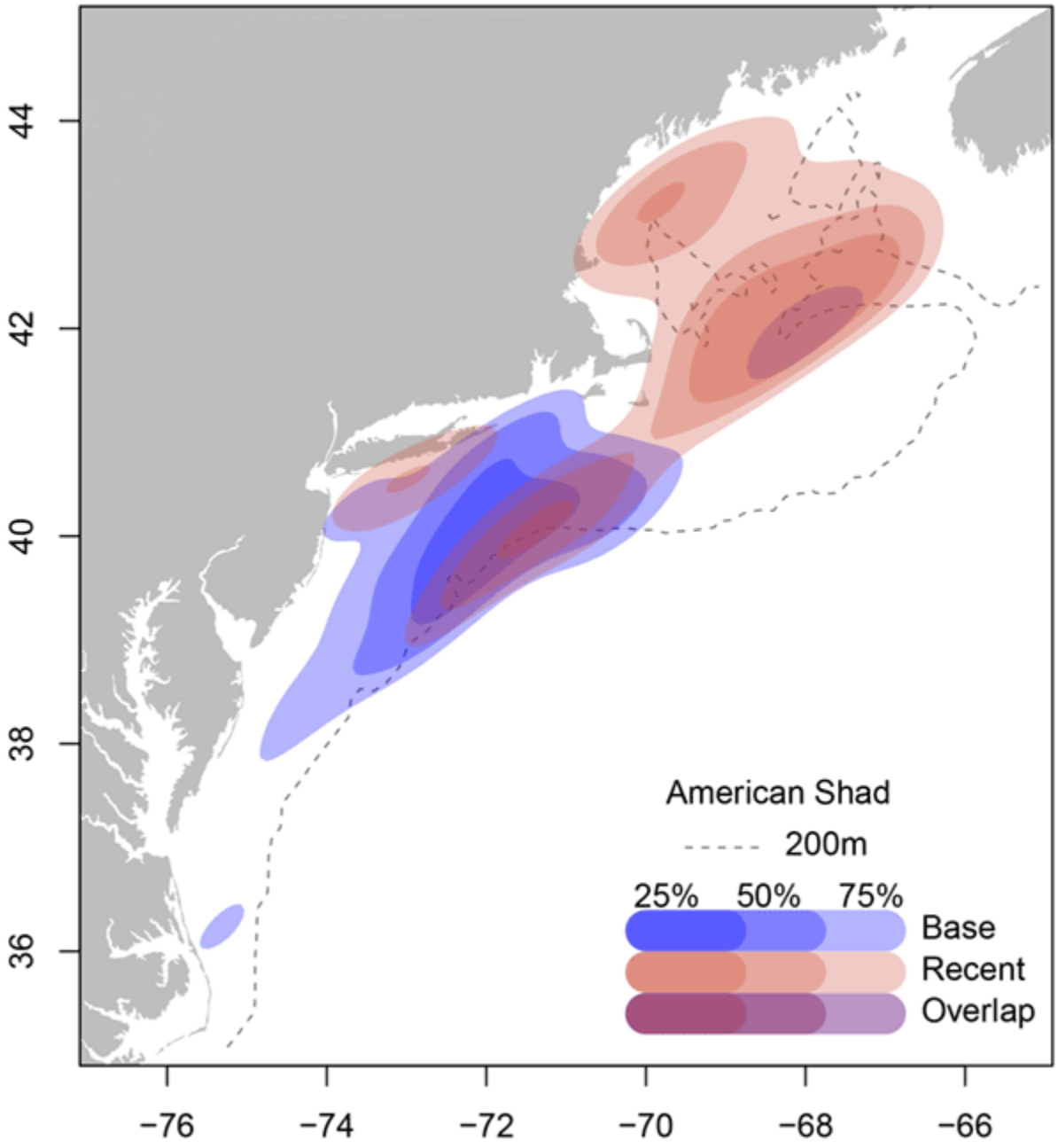
American lobster



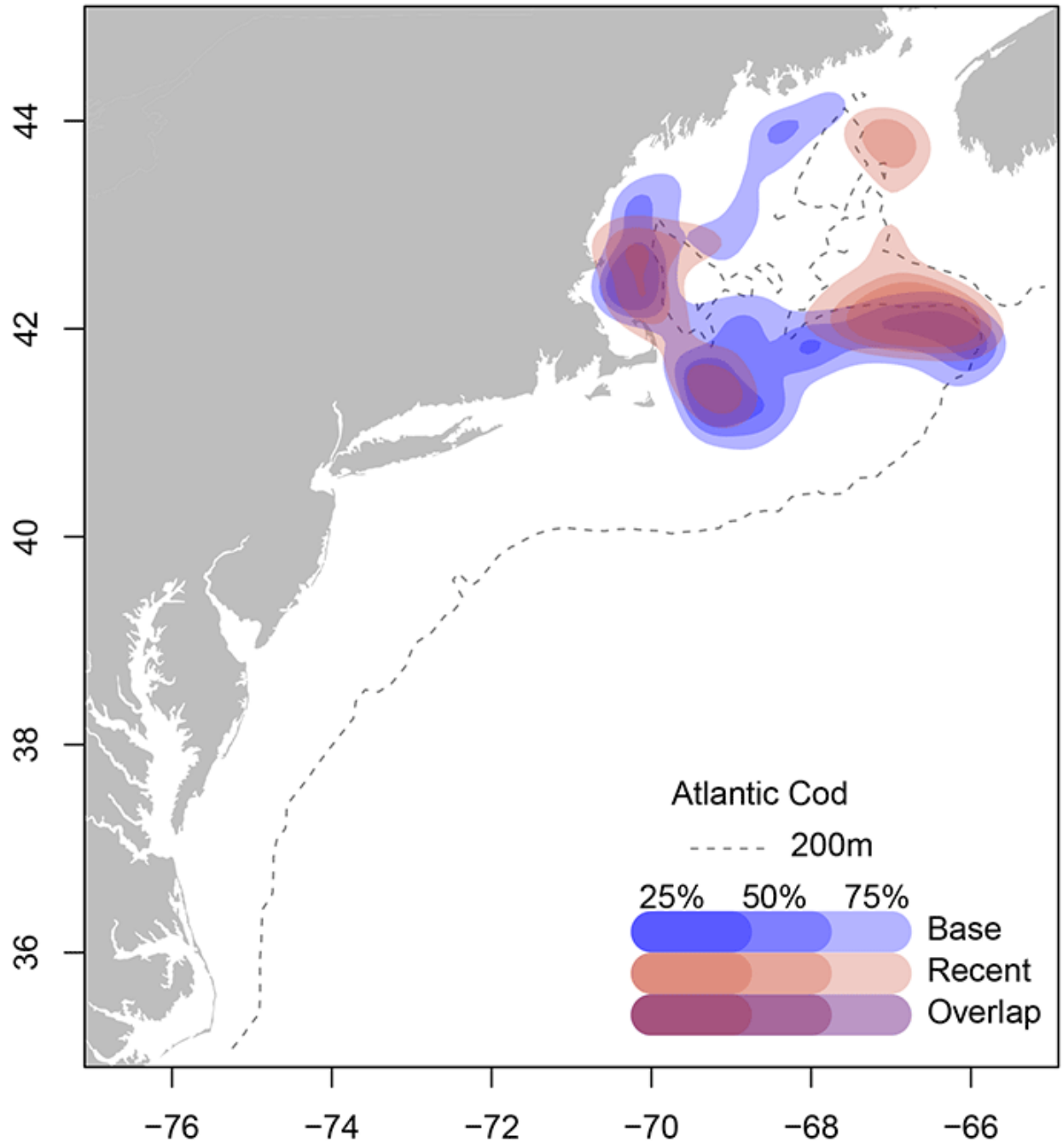
American plaice



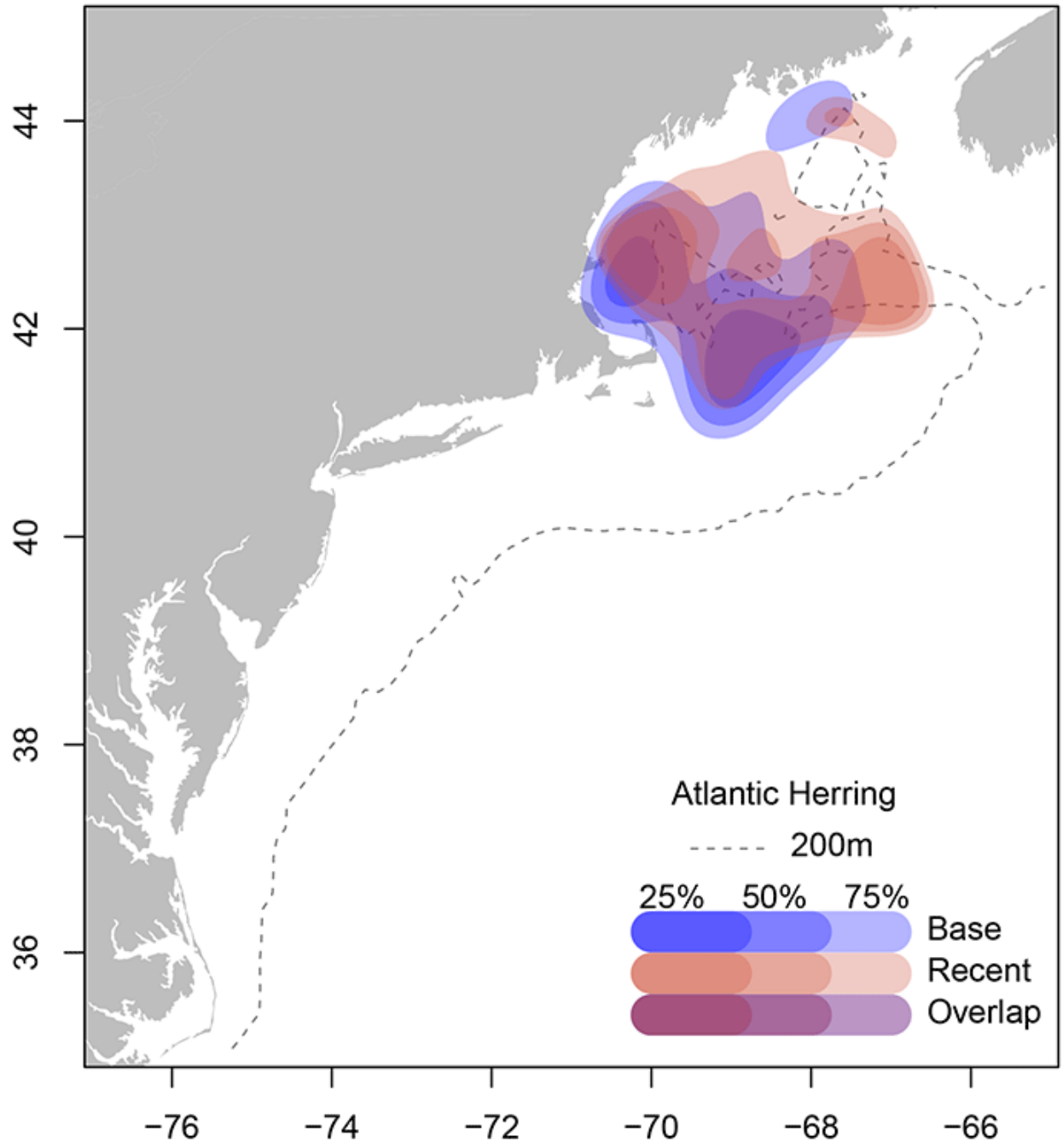
American shad



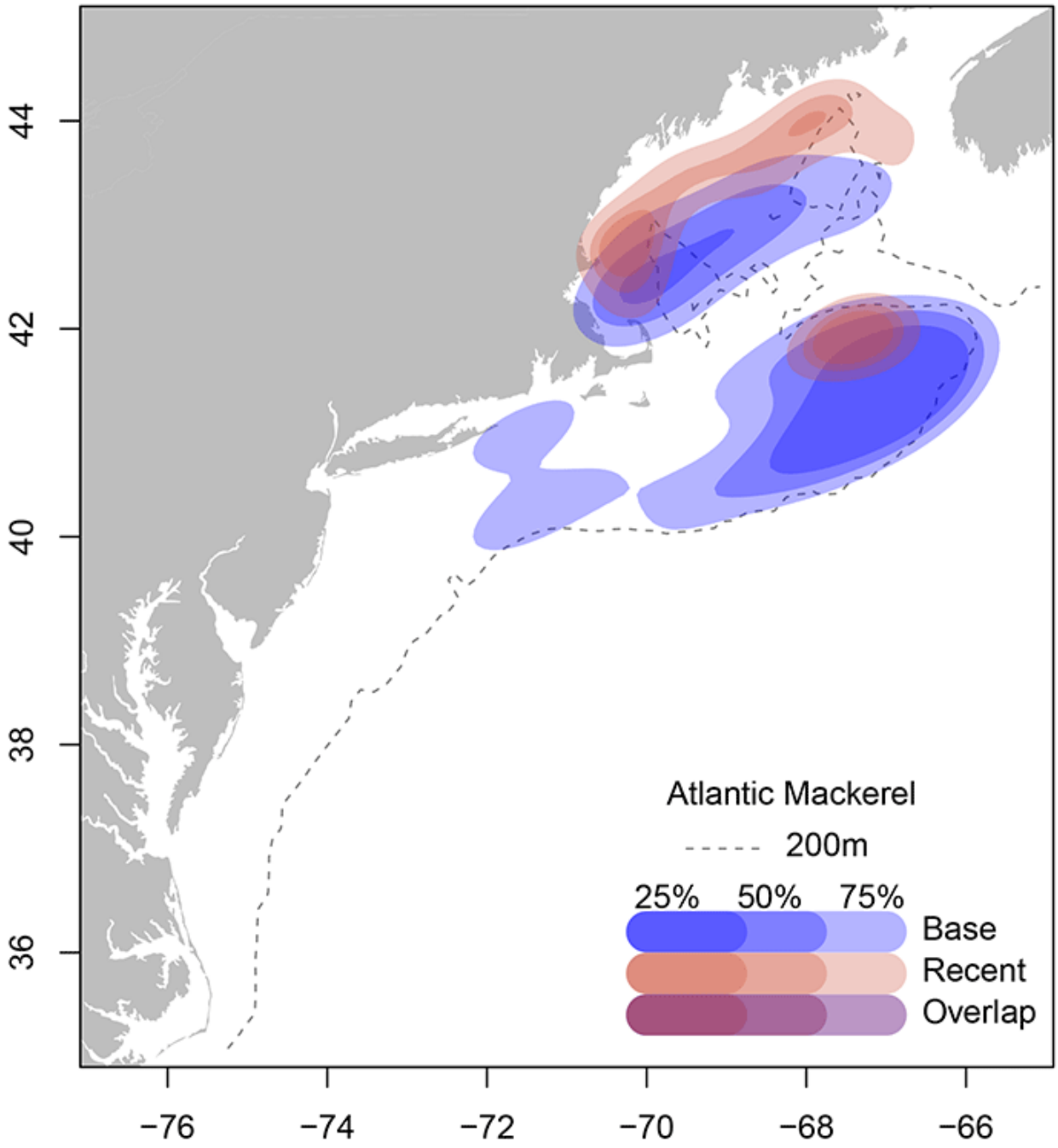
Atlantic cod



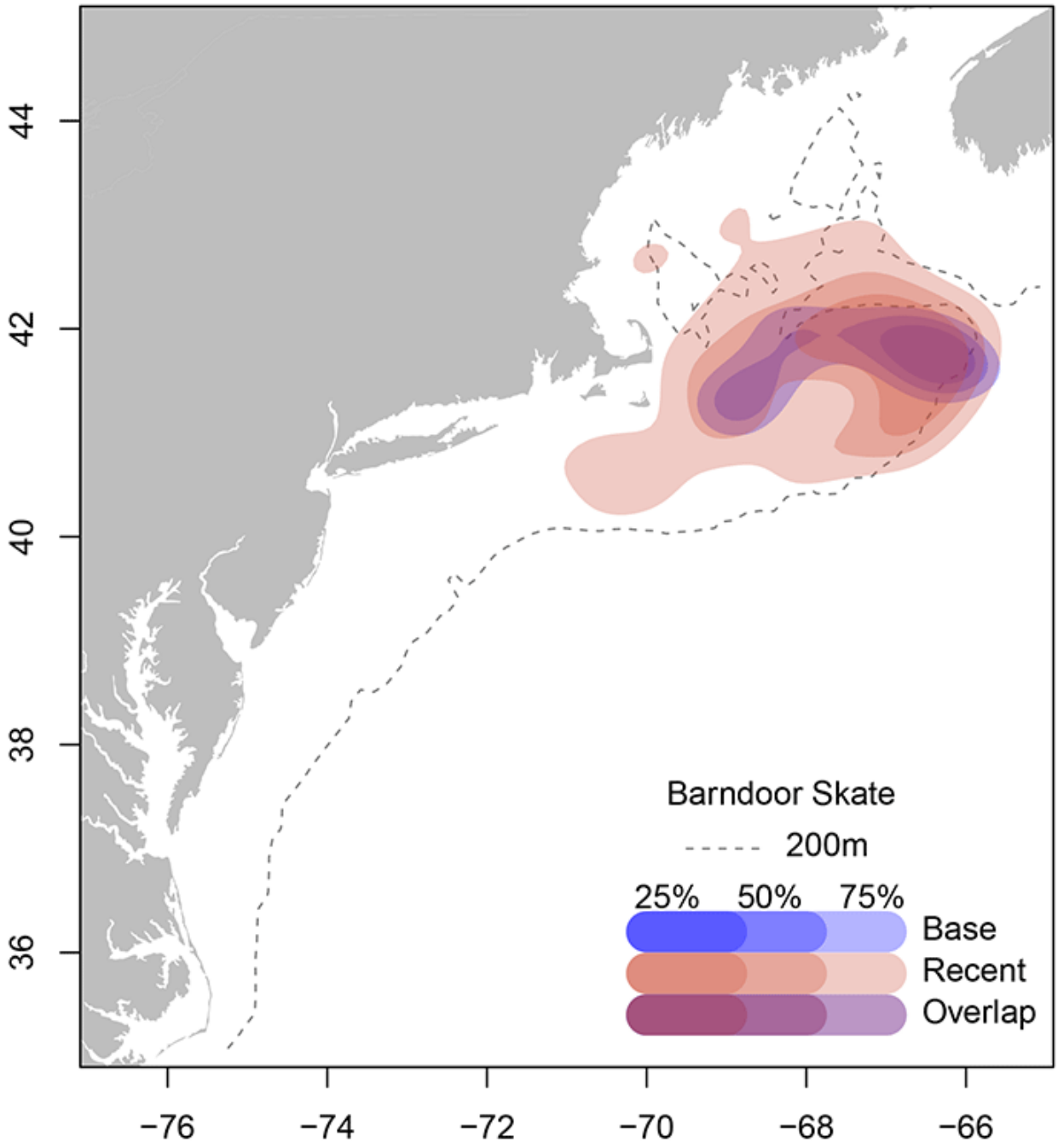
Atlantic herring



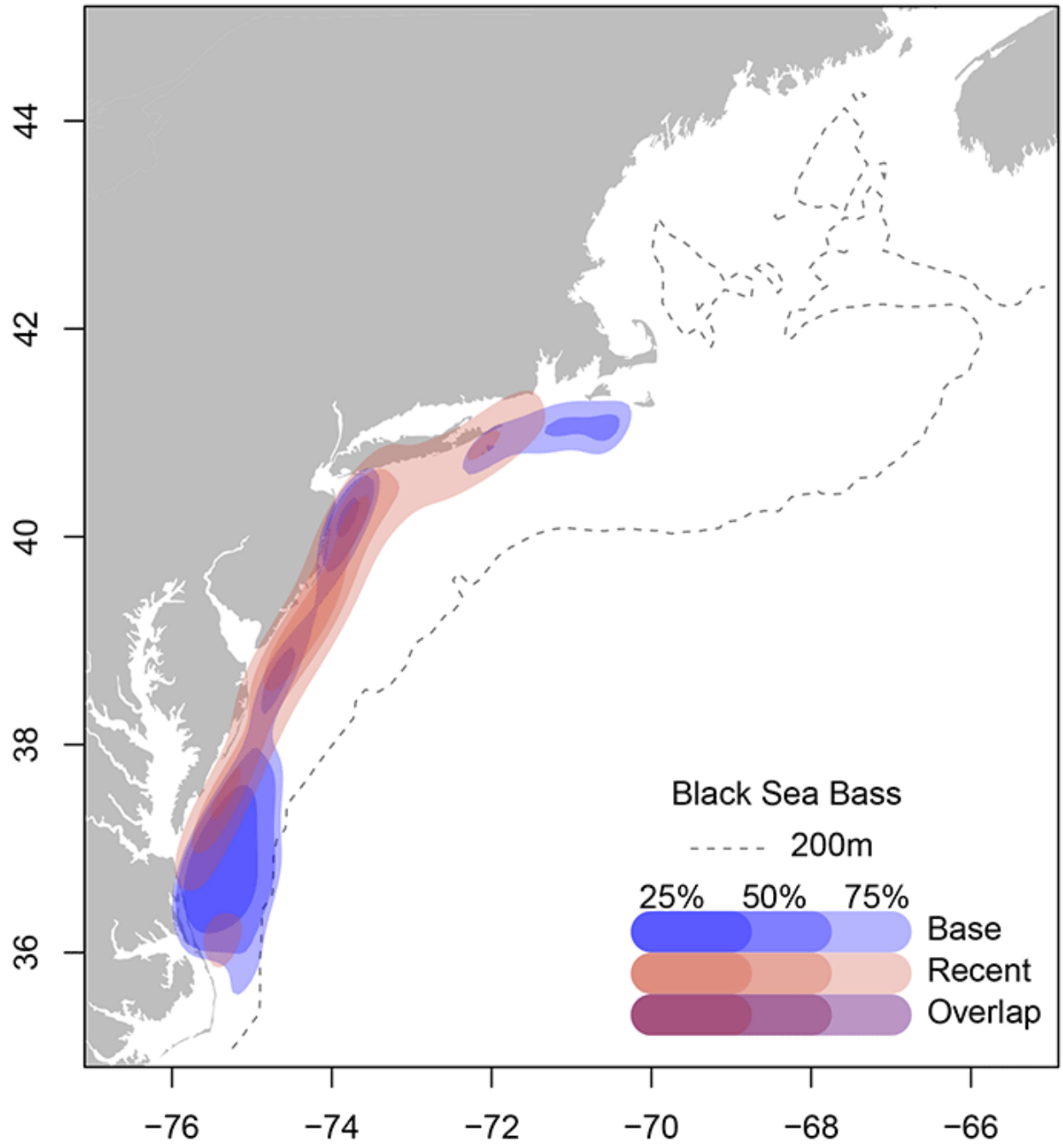
Atlantic mackerel



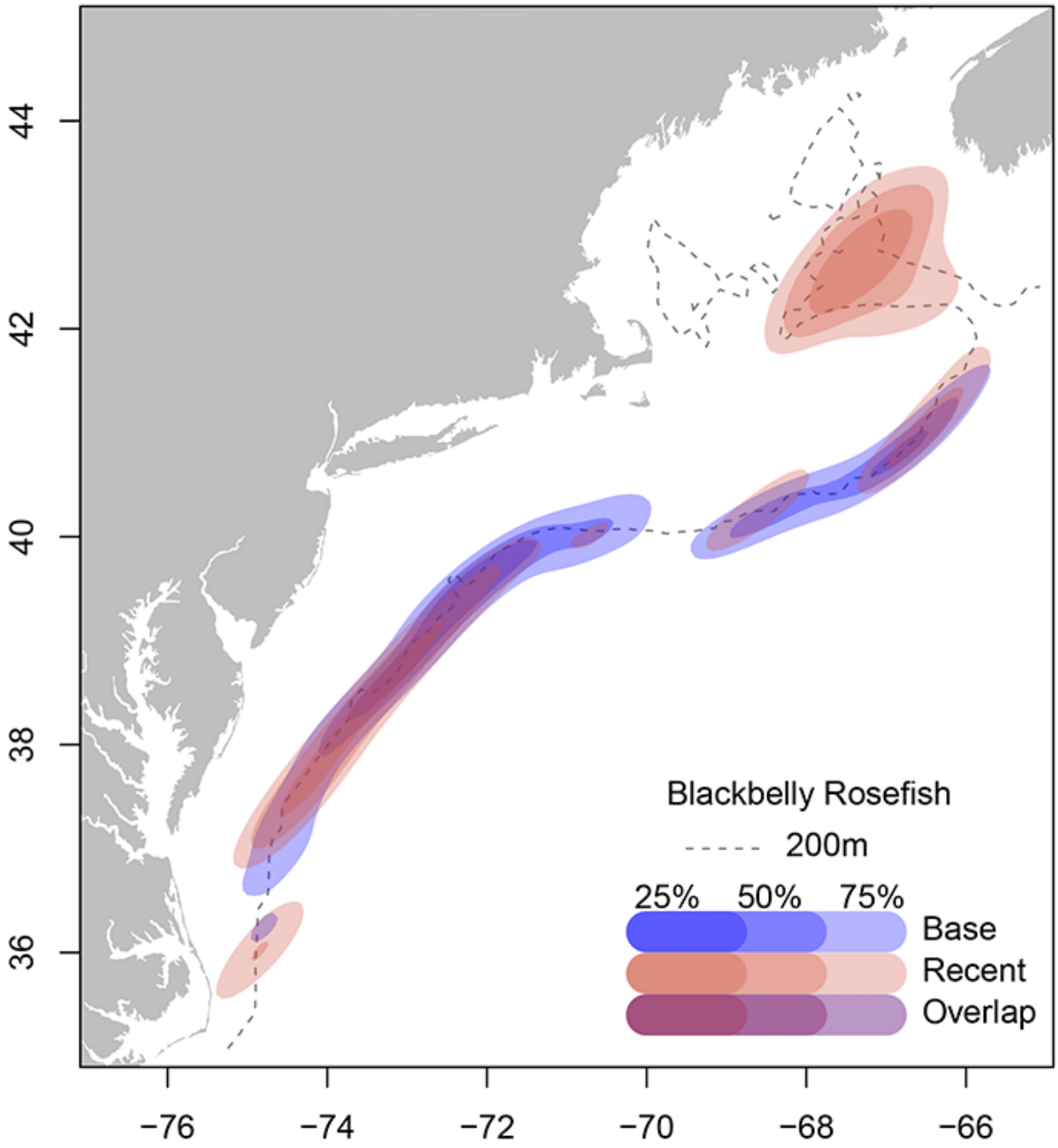
Barndoor skate



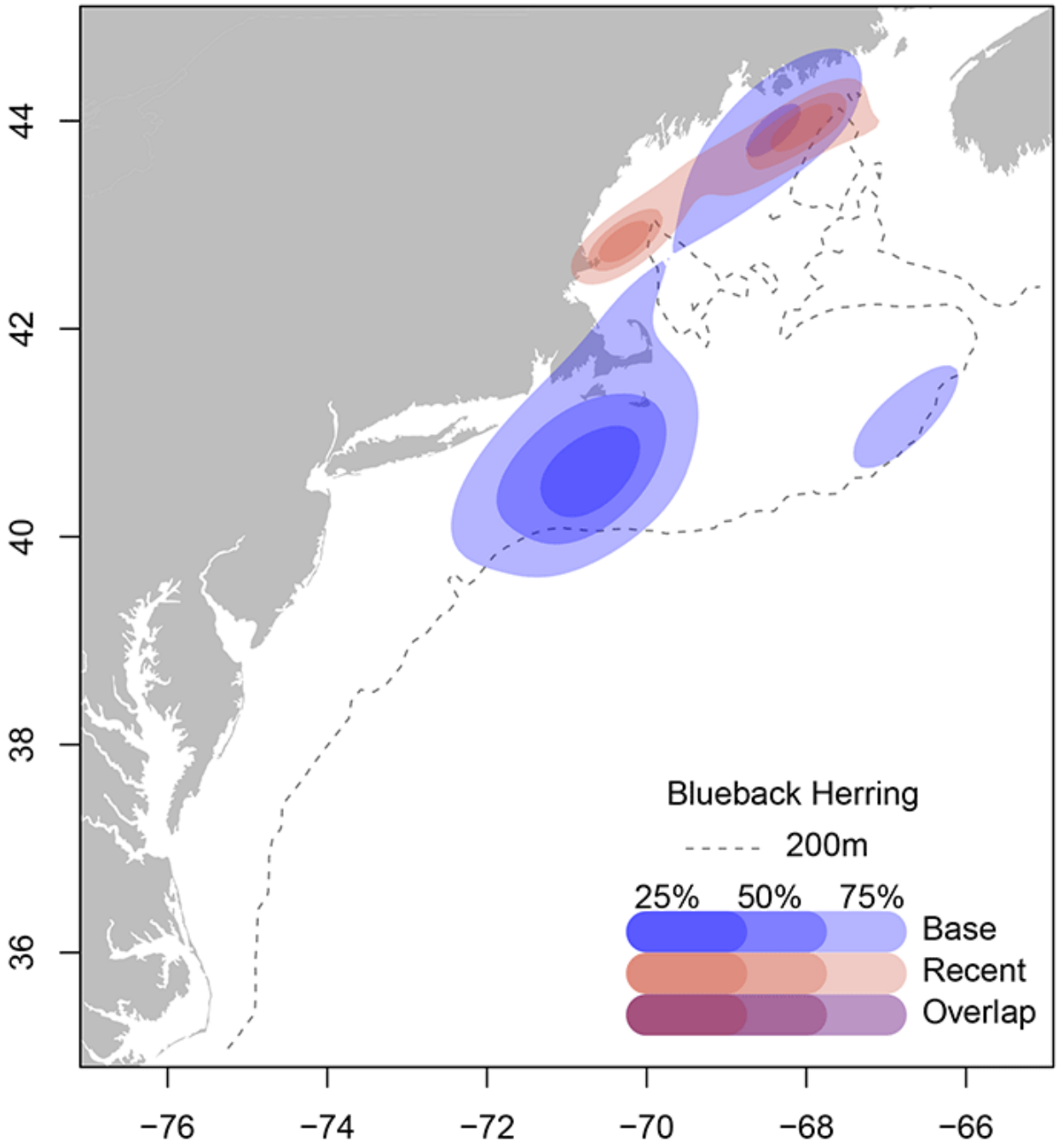
Black sea bass



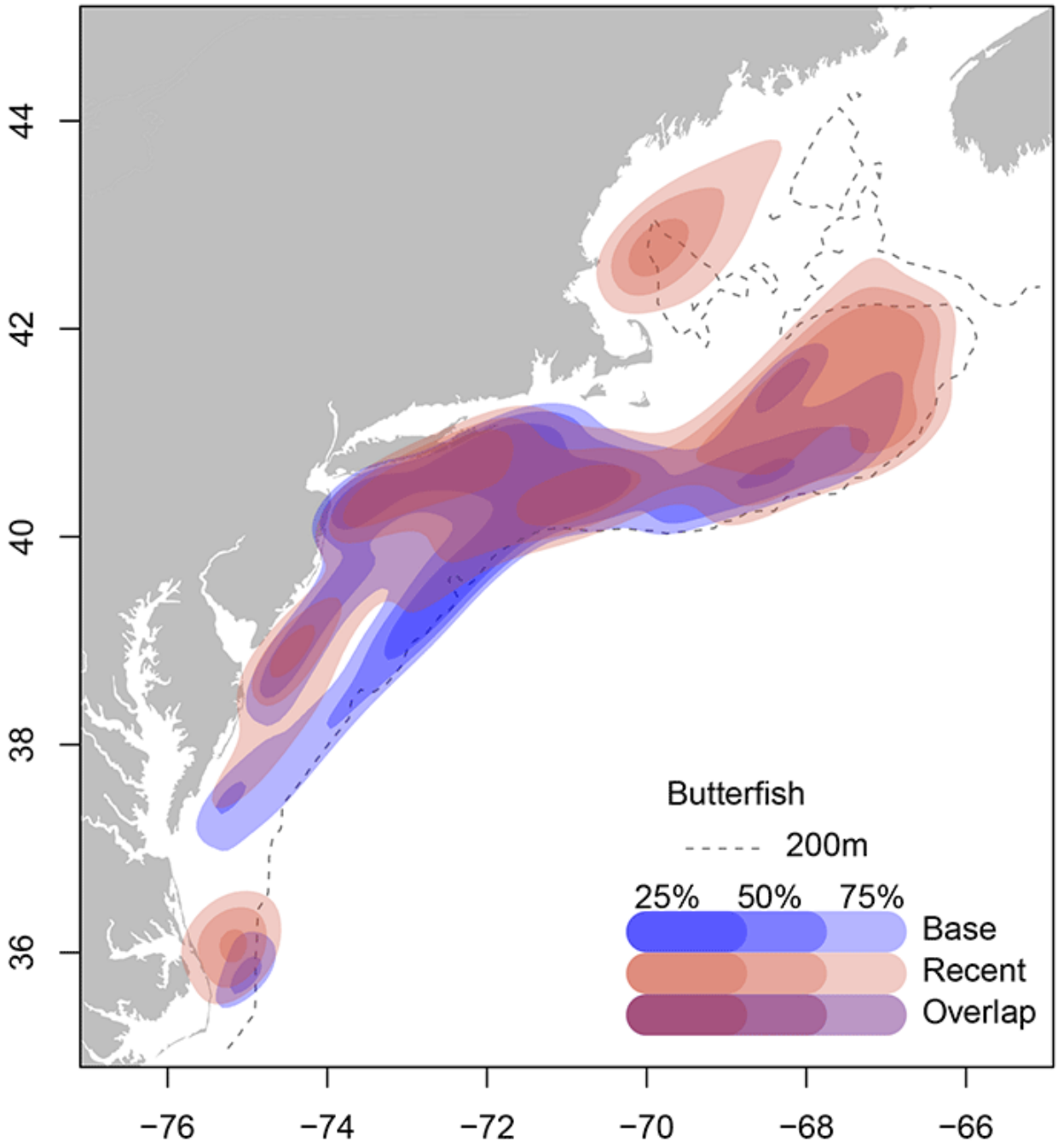
Blackbelly rosefish



Blueback herring



Butterfish


44
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−76
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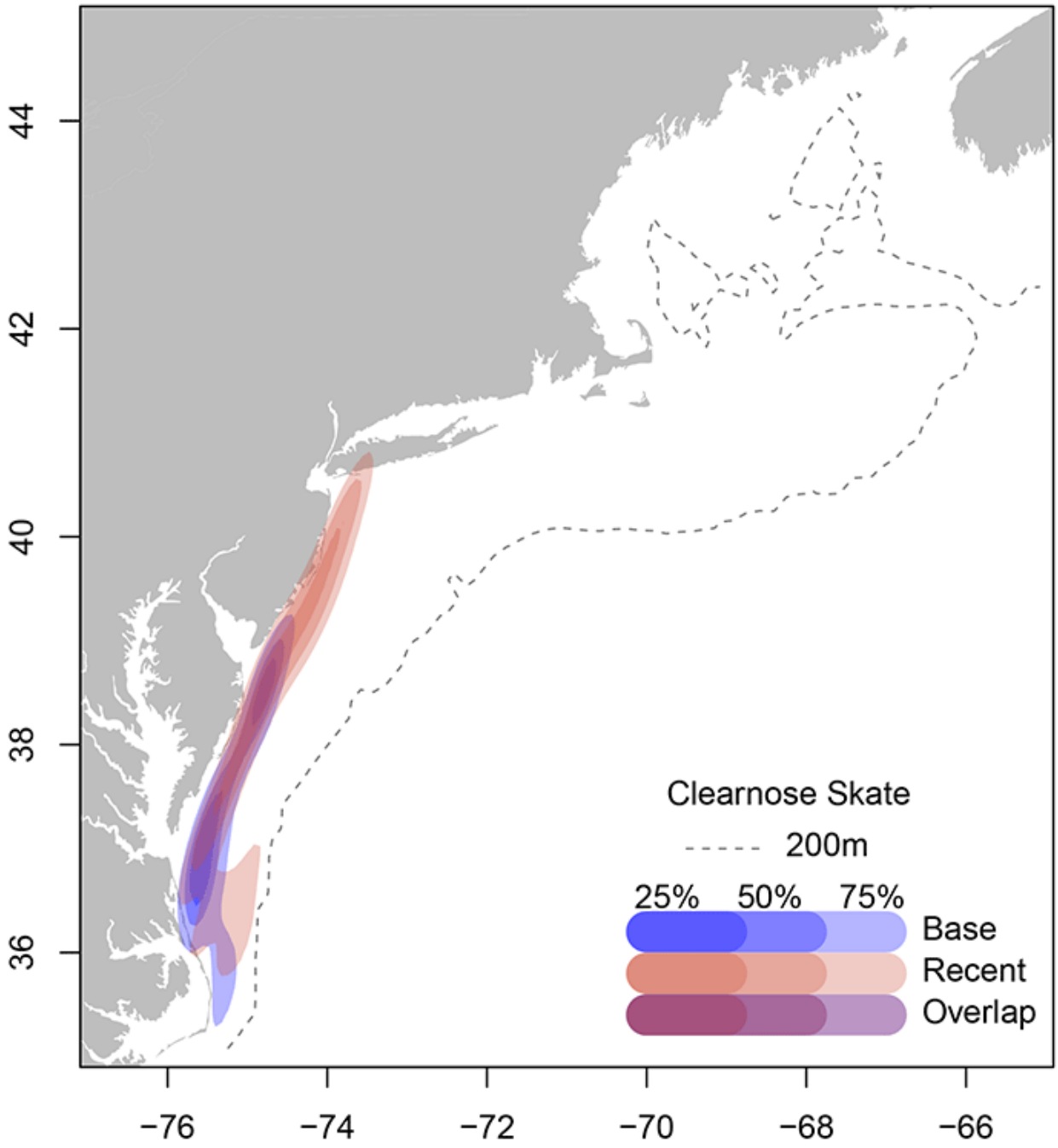
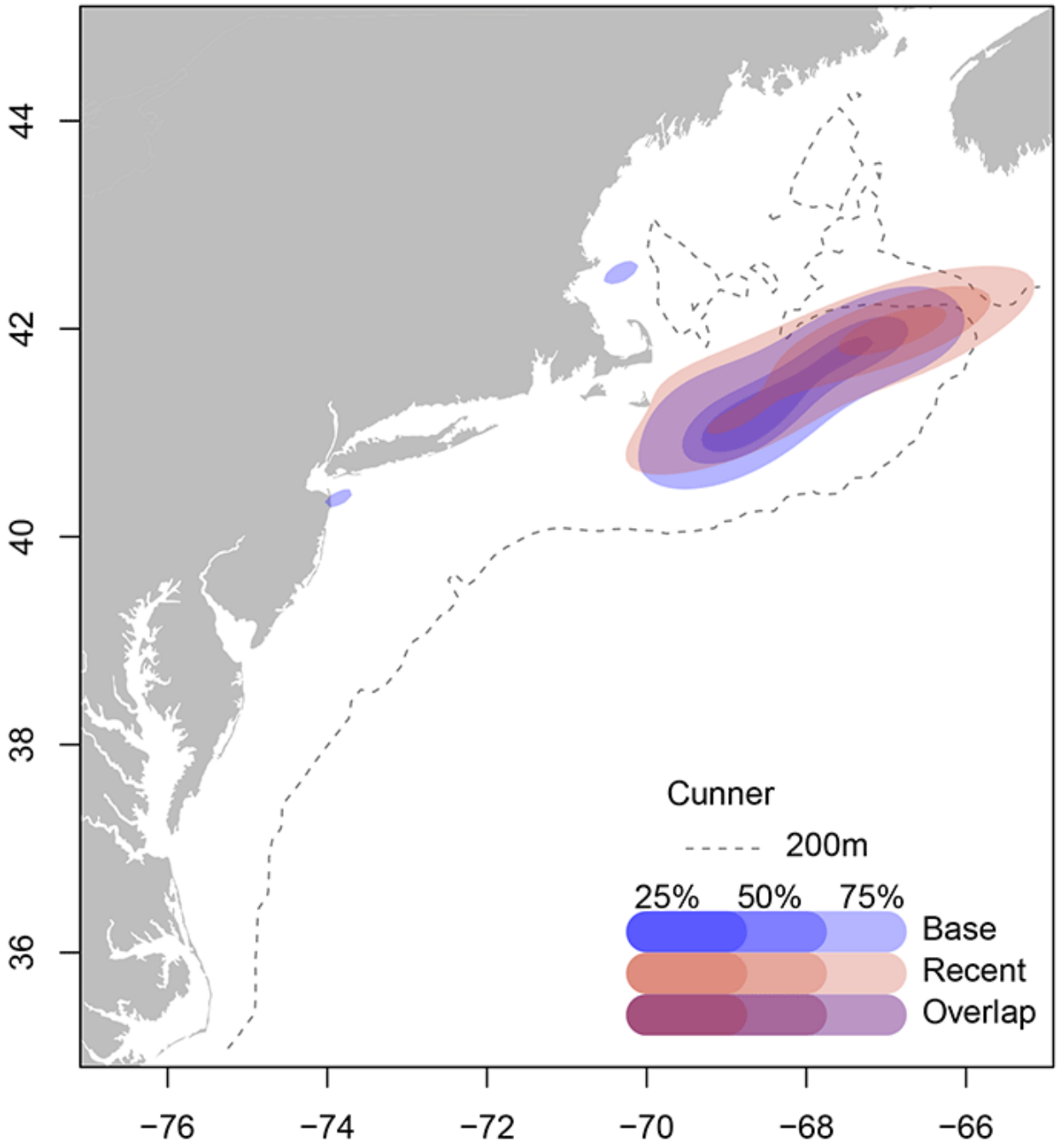
−70
−68
−66
Butterfish
200m
25%
50%
75%
Base
Recent
Overlap

Clearnose skate



Cunner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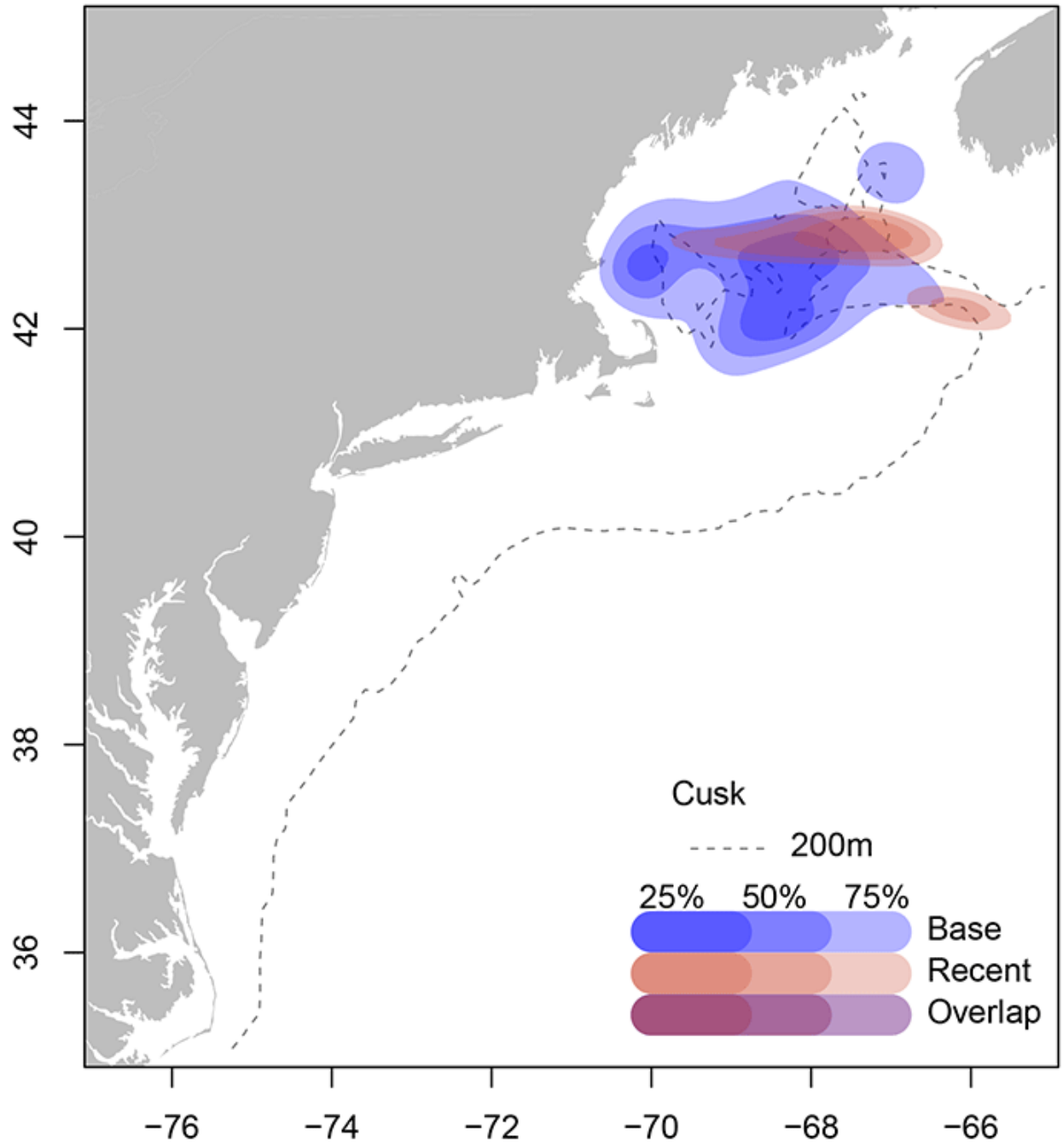
Cunner
200m
25%
50%
75%
Base
Recent
Overlap

Cusk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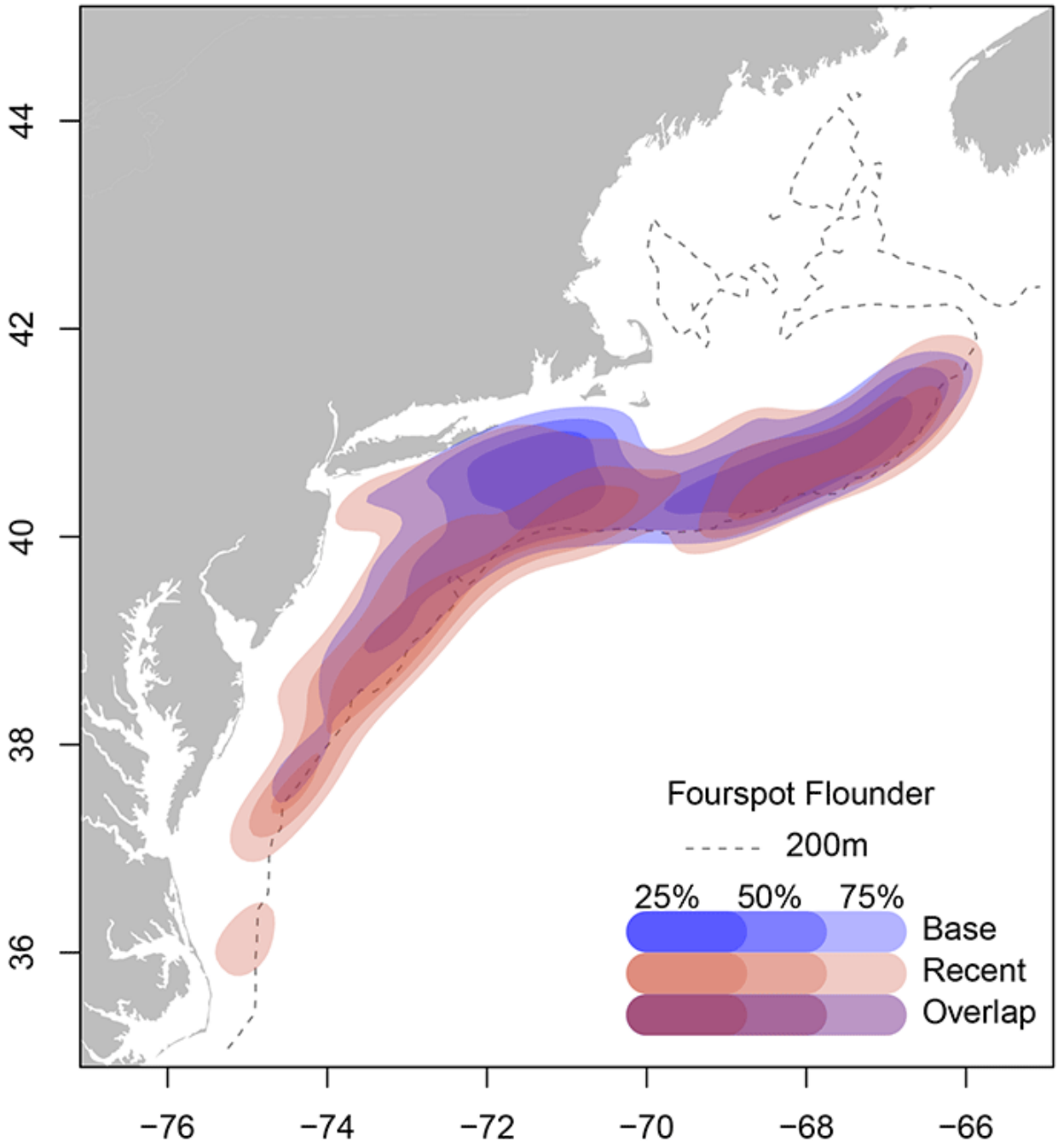
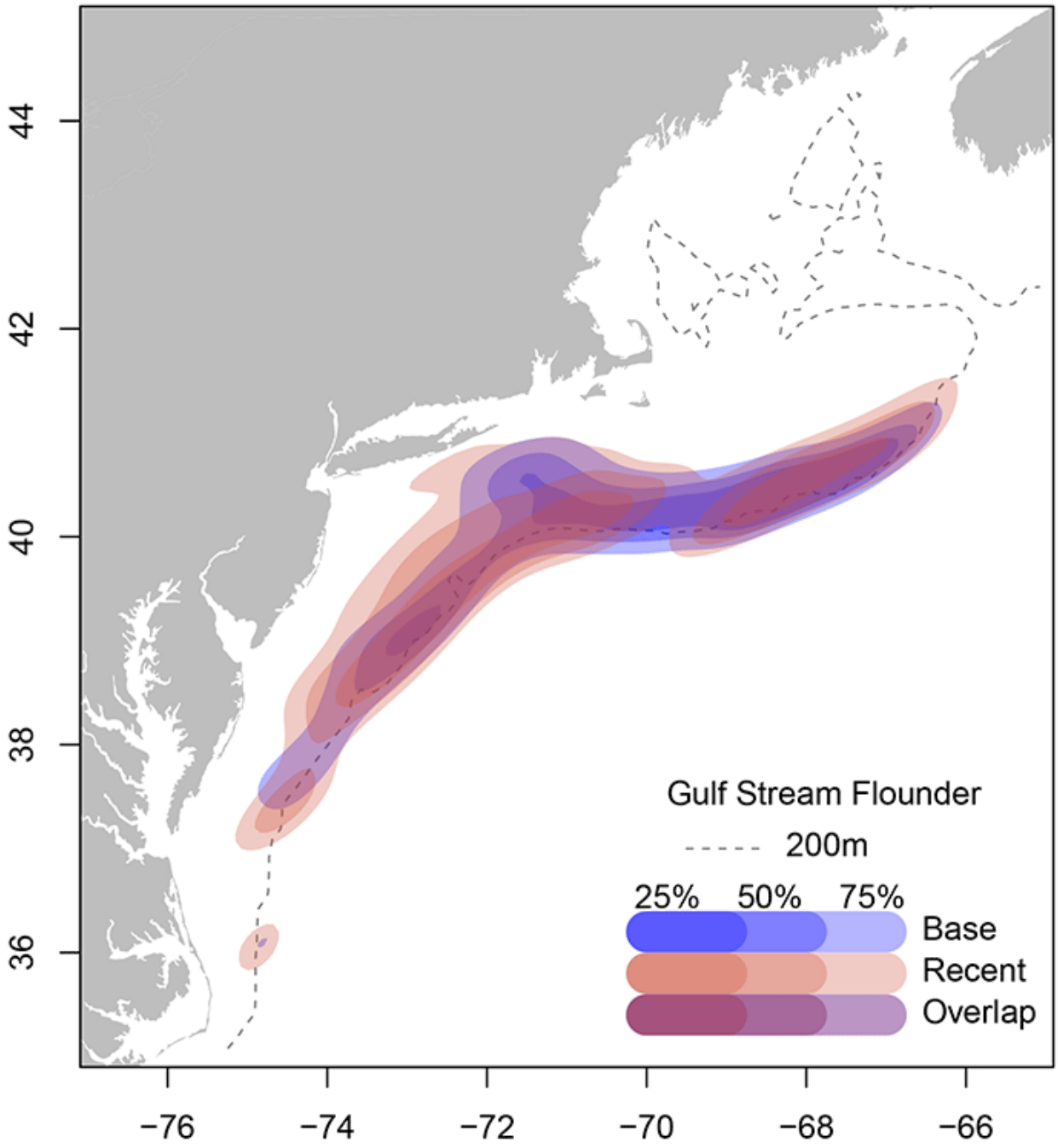
−68
−66
Cusk
200m
25%
50%
75%
Base
Recent
Overlap

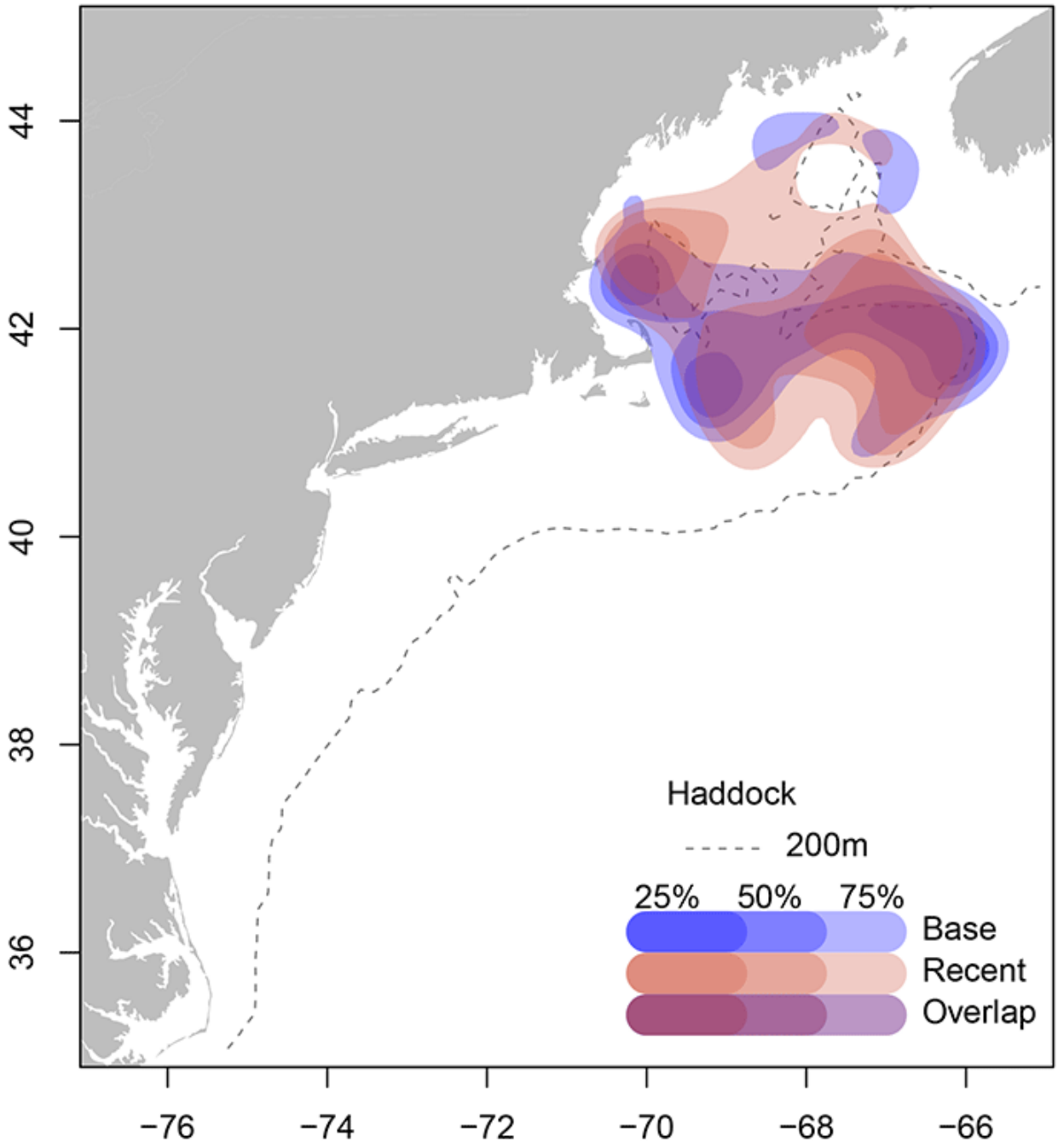
Fourspot flounder



Gulf Stream flounder



Haddock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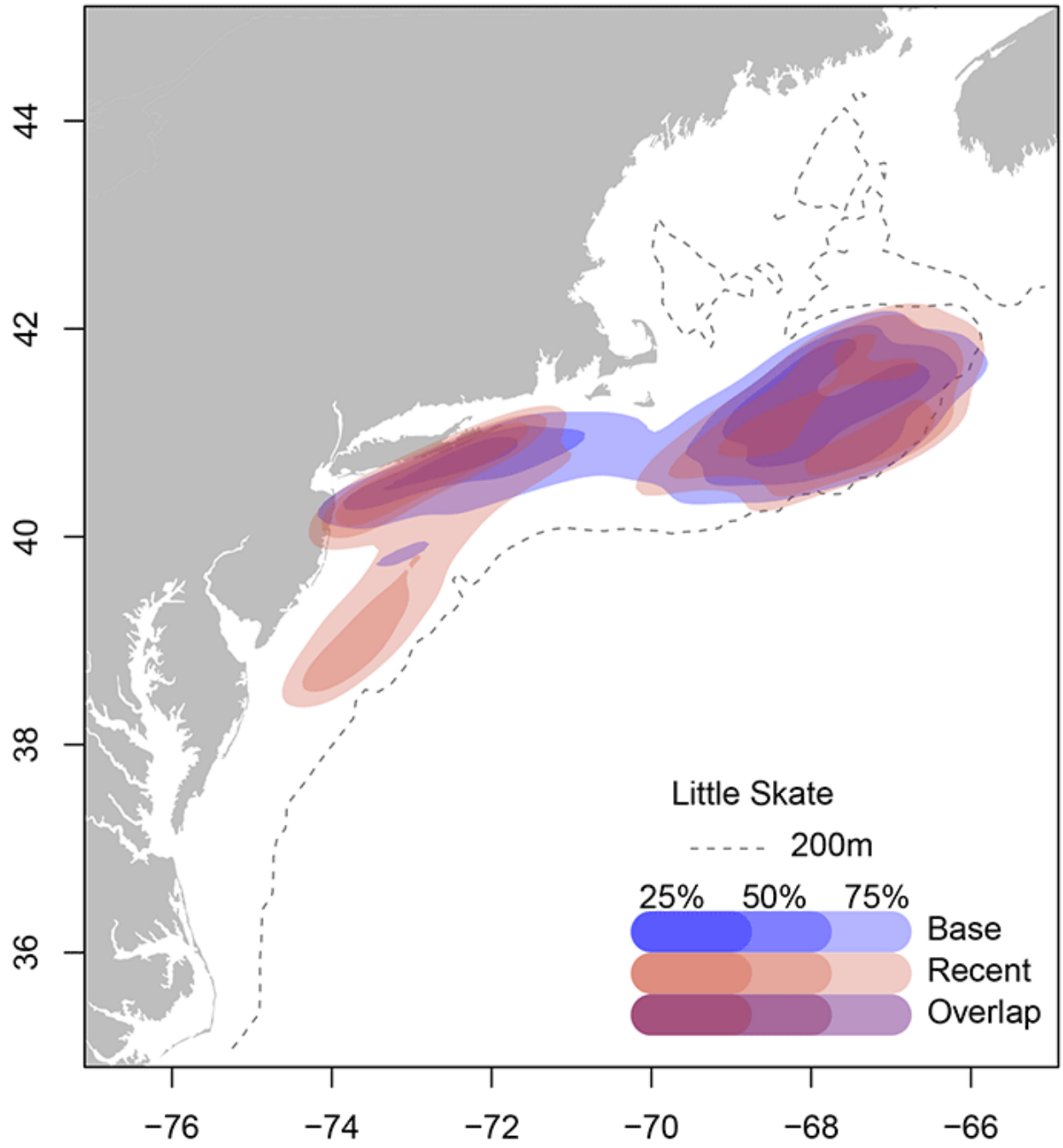
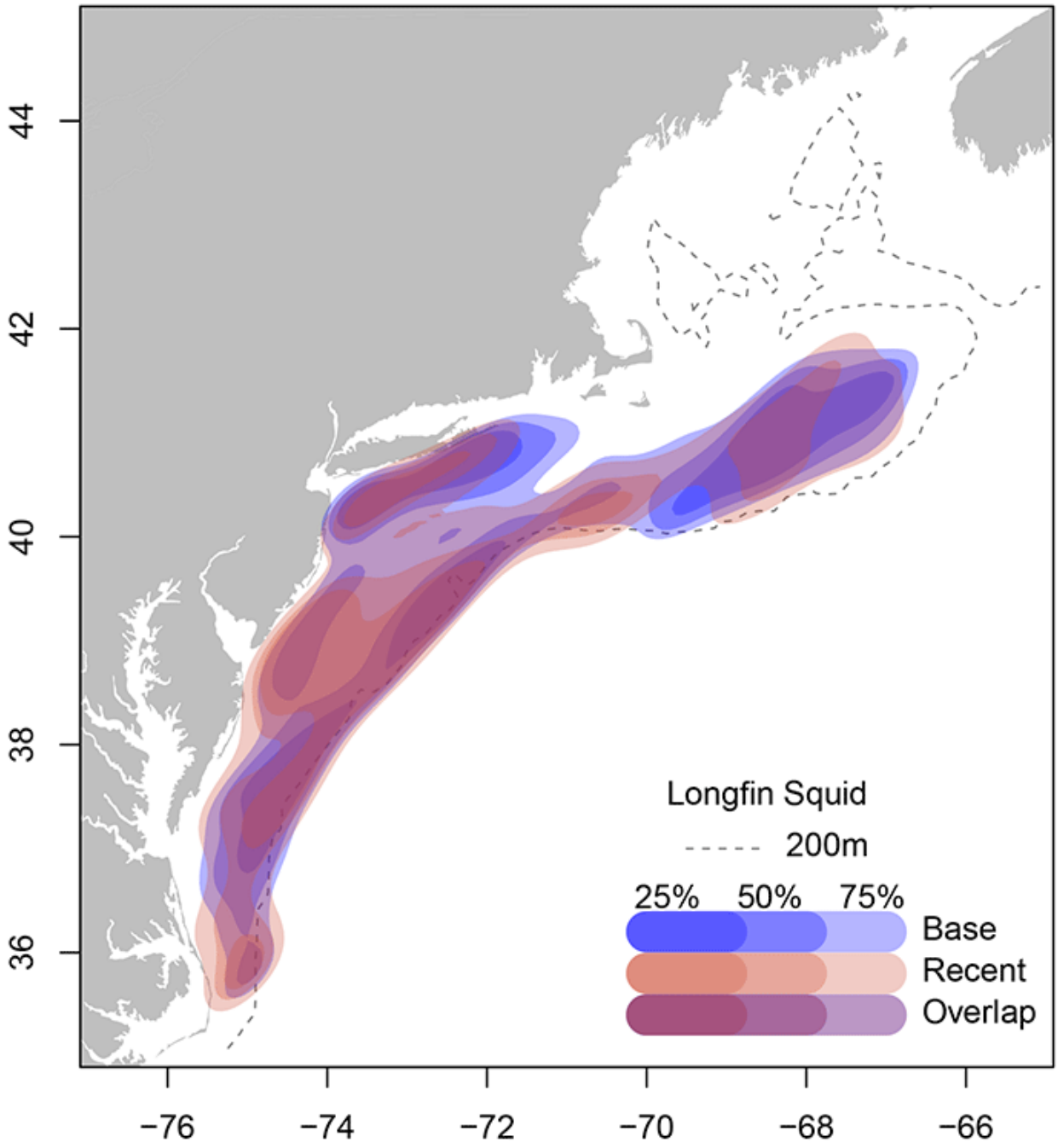
Haddock
200m
25%
50%
75%
Base
Recent
Overlap

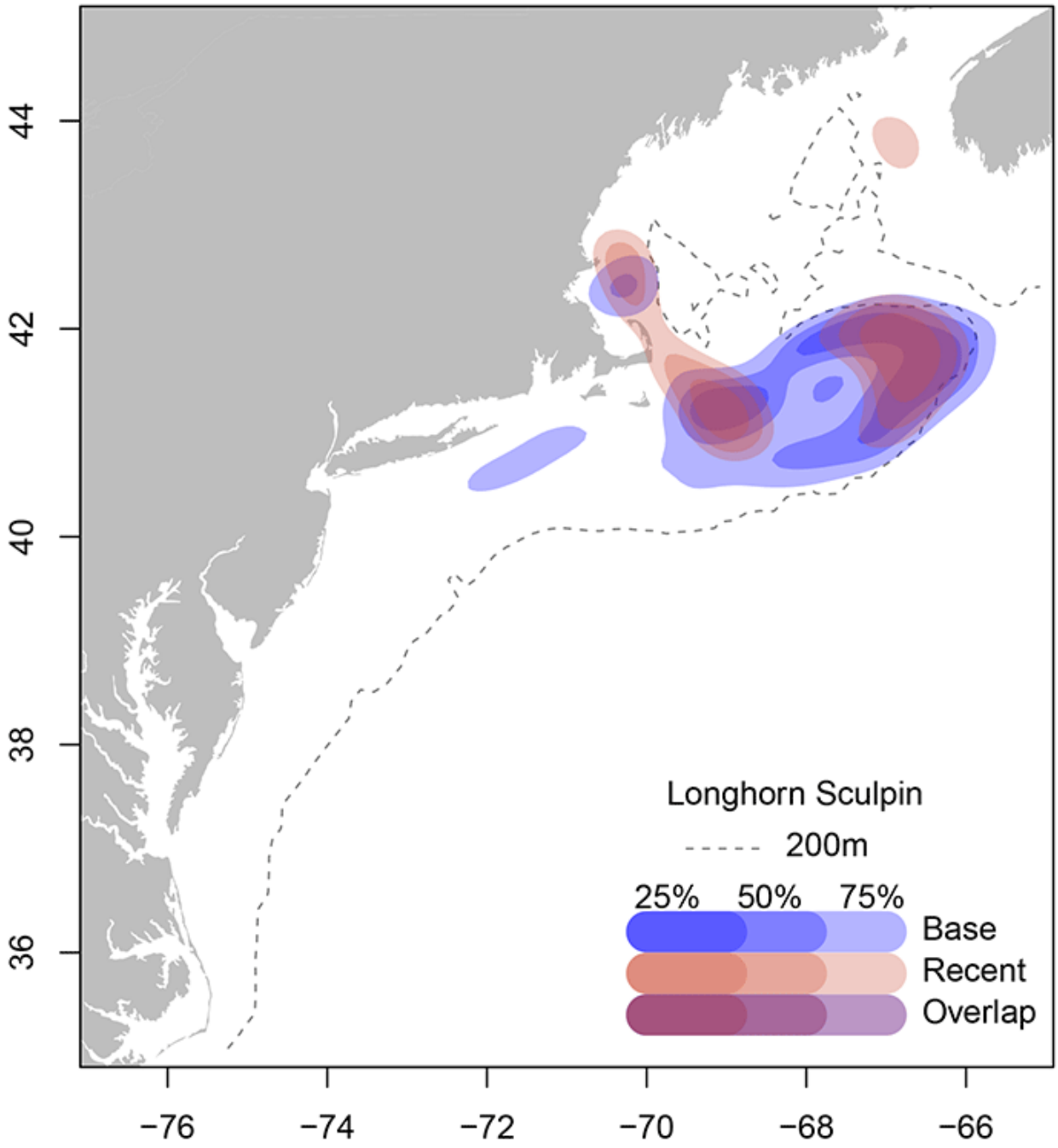
Little skate



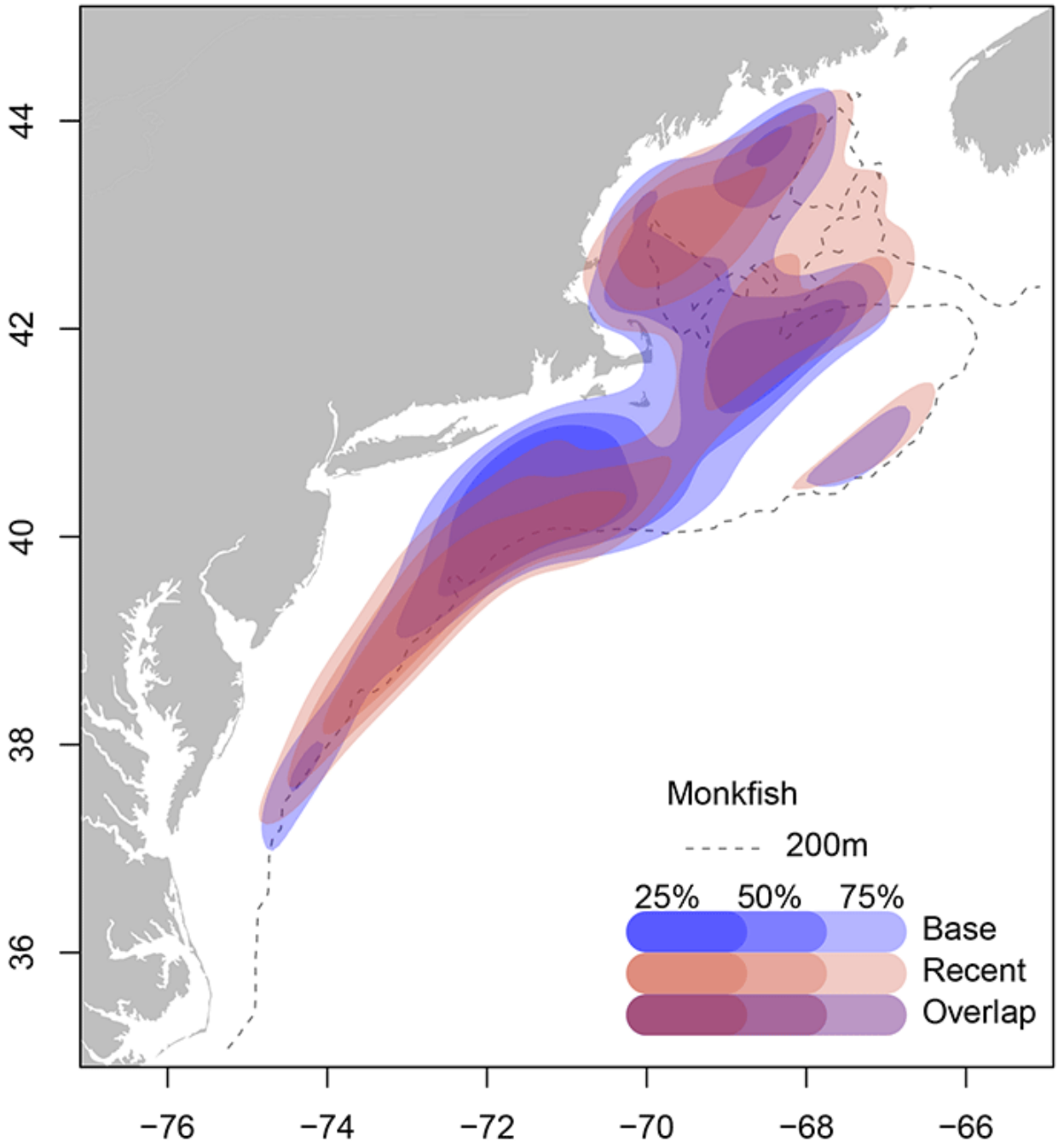
Longfin squid



Longhorn sculpin



Monkfish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Monkfish
200m
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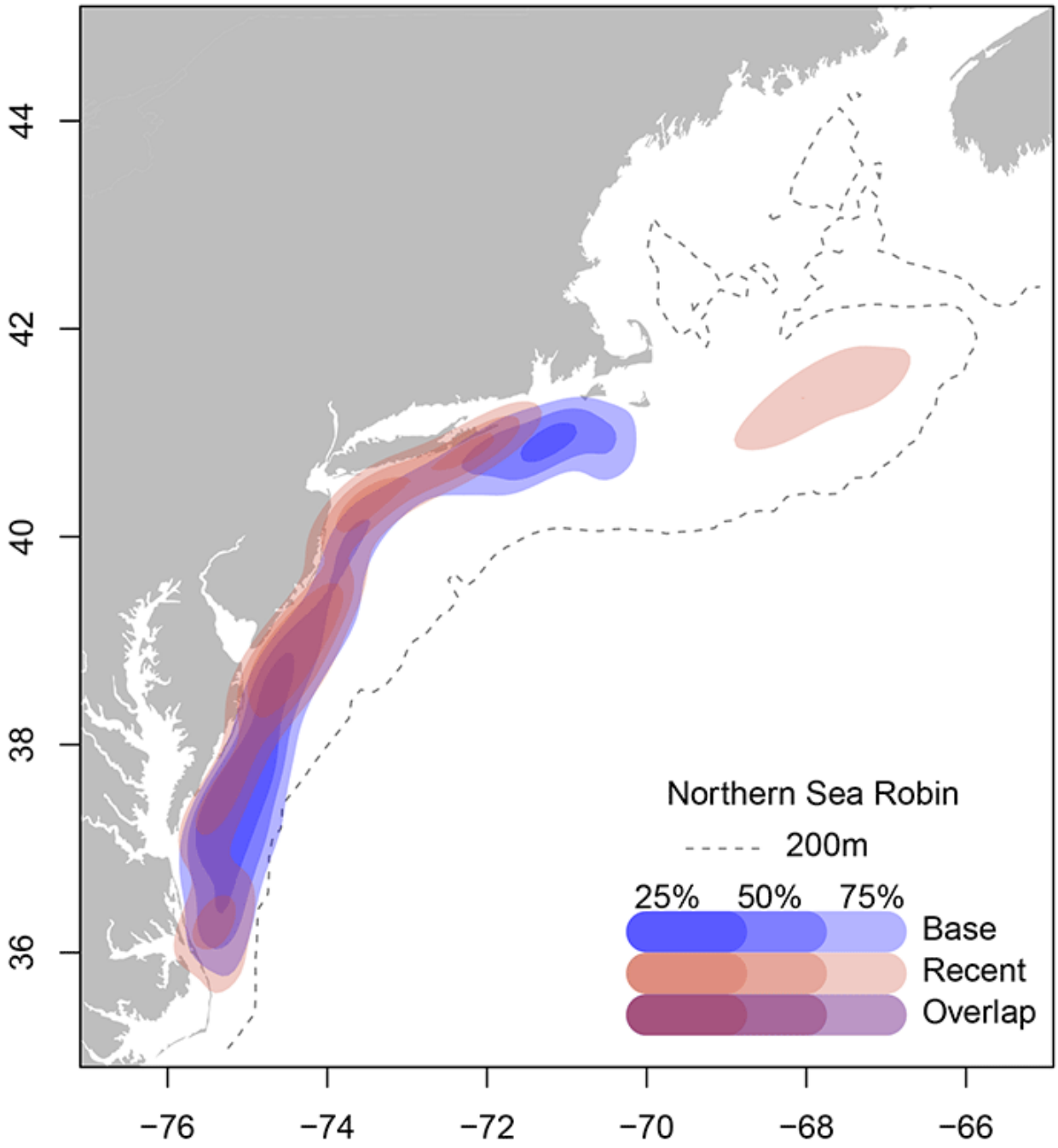
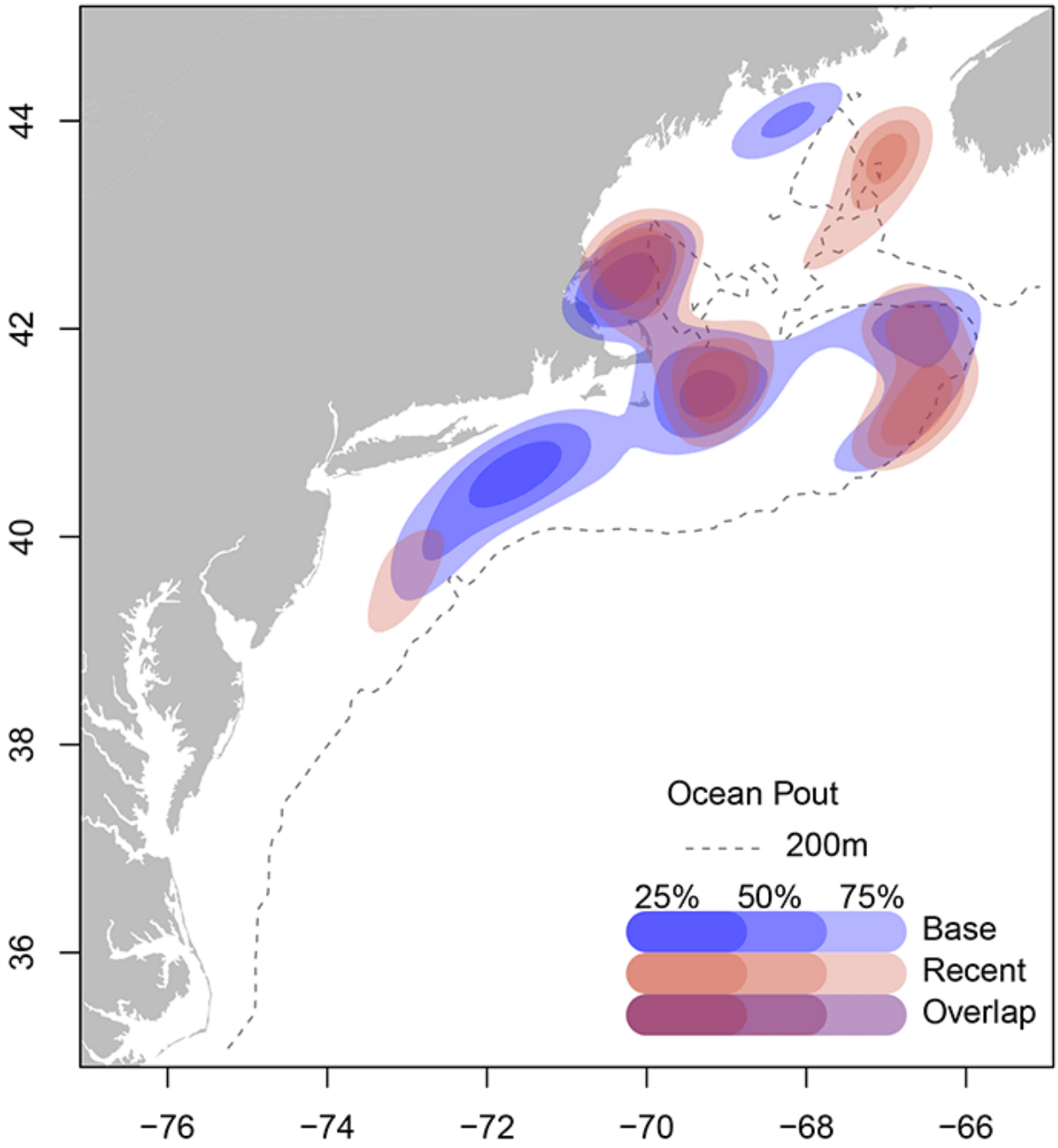
Base
Recent
Overlap

Northern sea robin



Ocean Pout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Ocean Pout
200m
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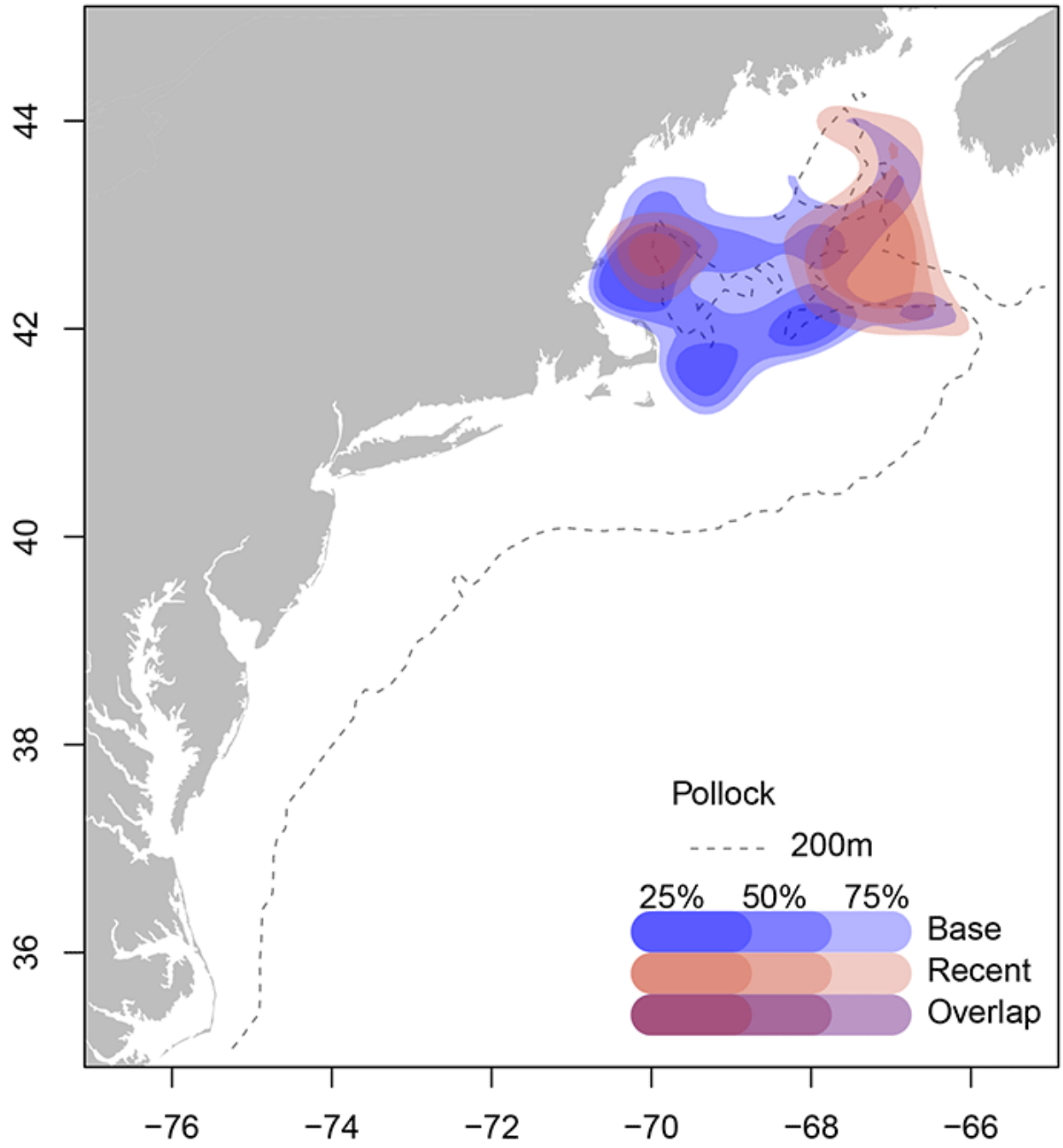
50%
75%
Base
Recent
Overlap

Pollock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Pollock
200m
25%
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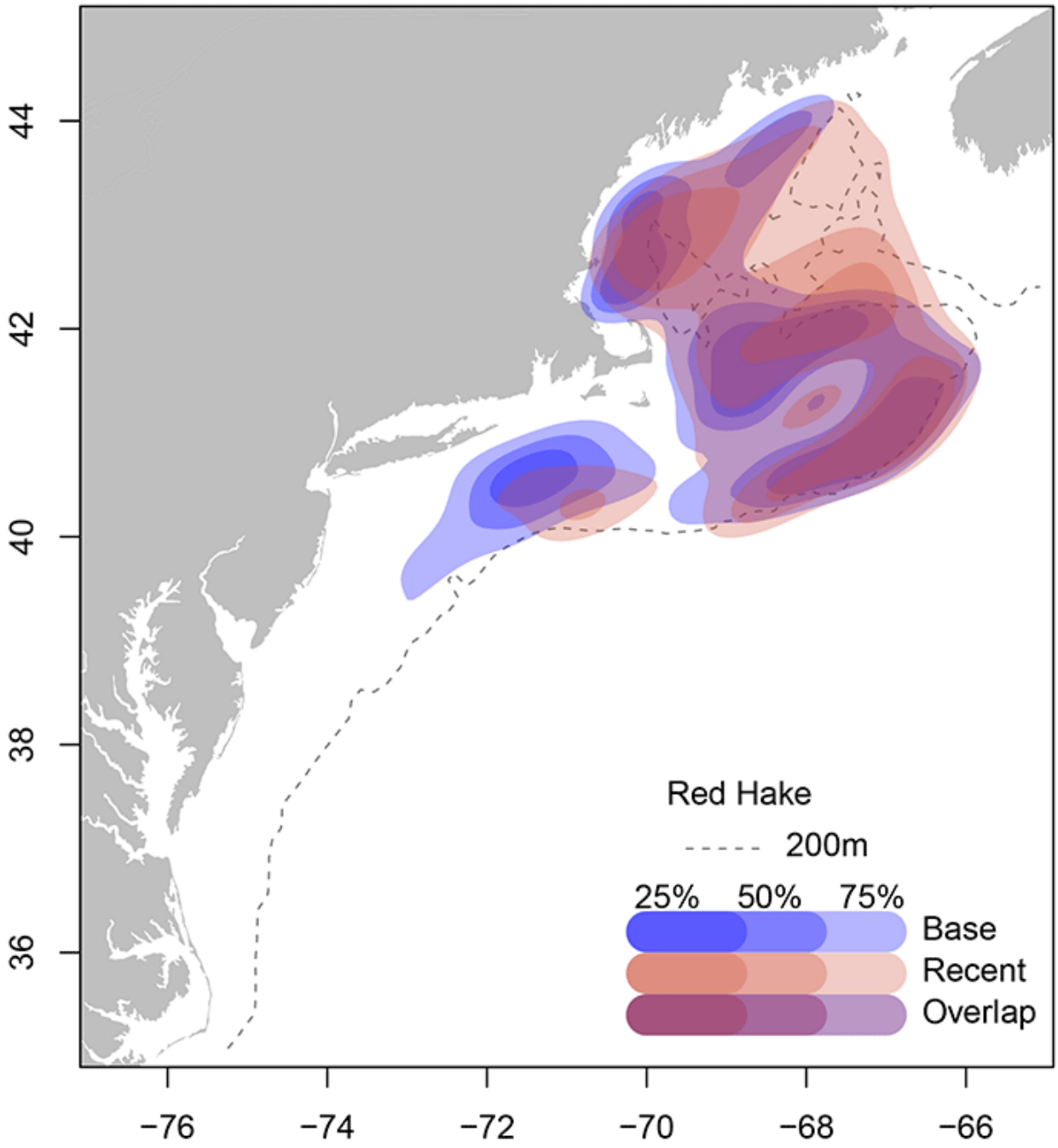
75%
Base
Recent
Overlap

Red hake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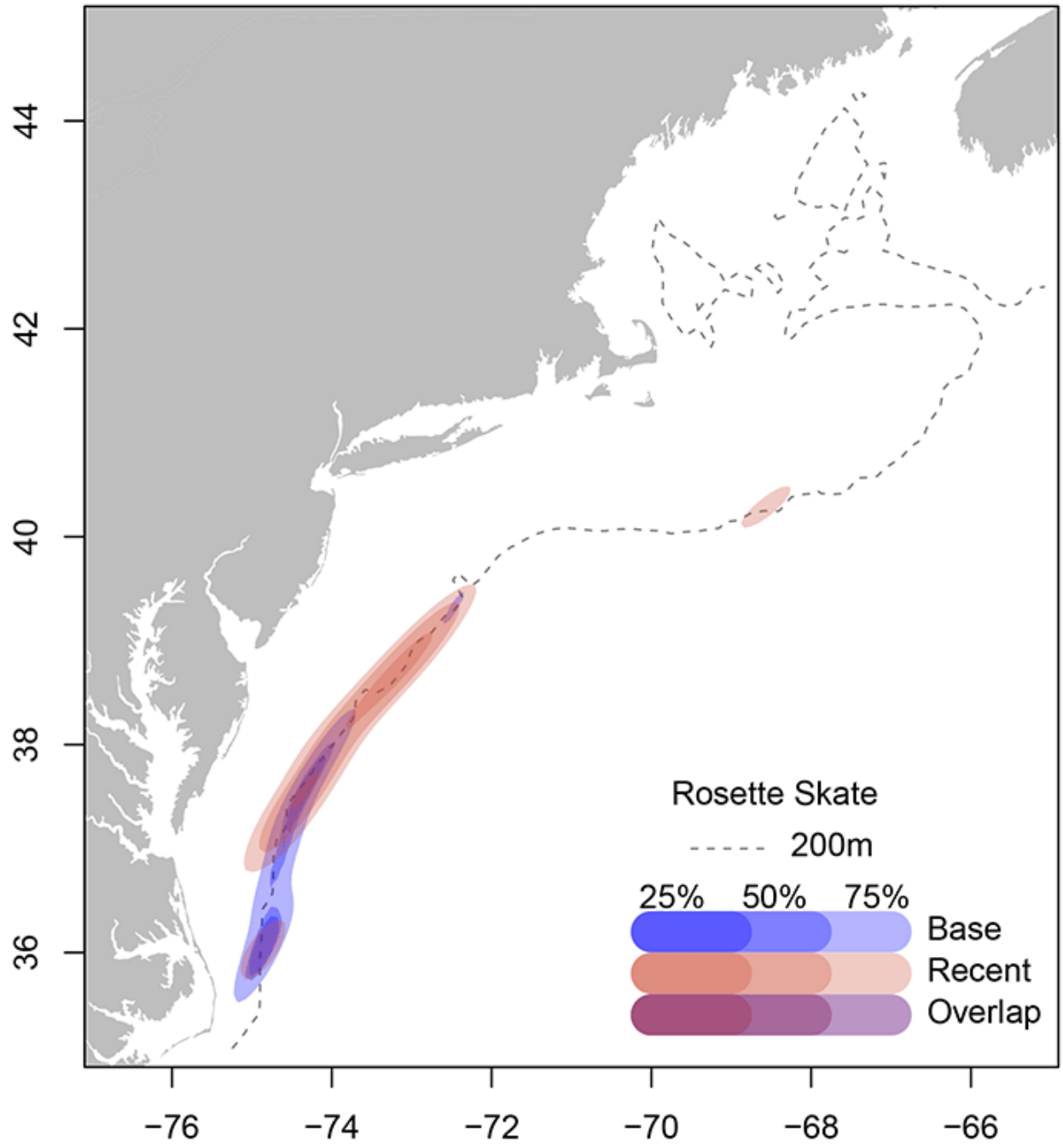
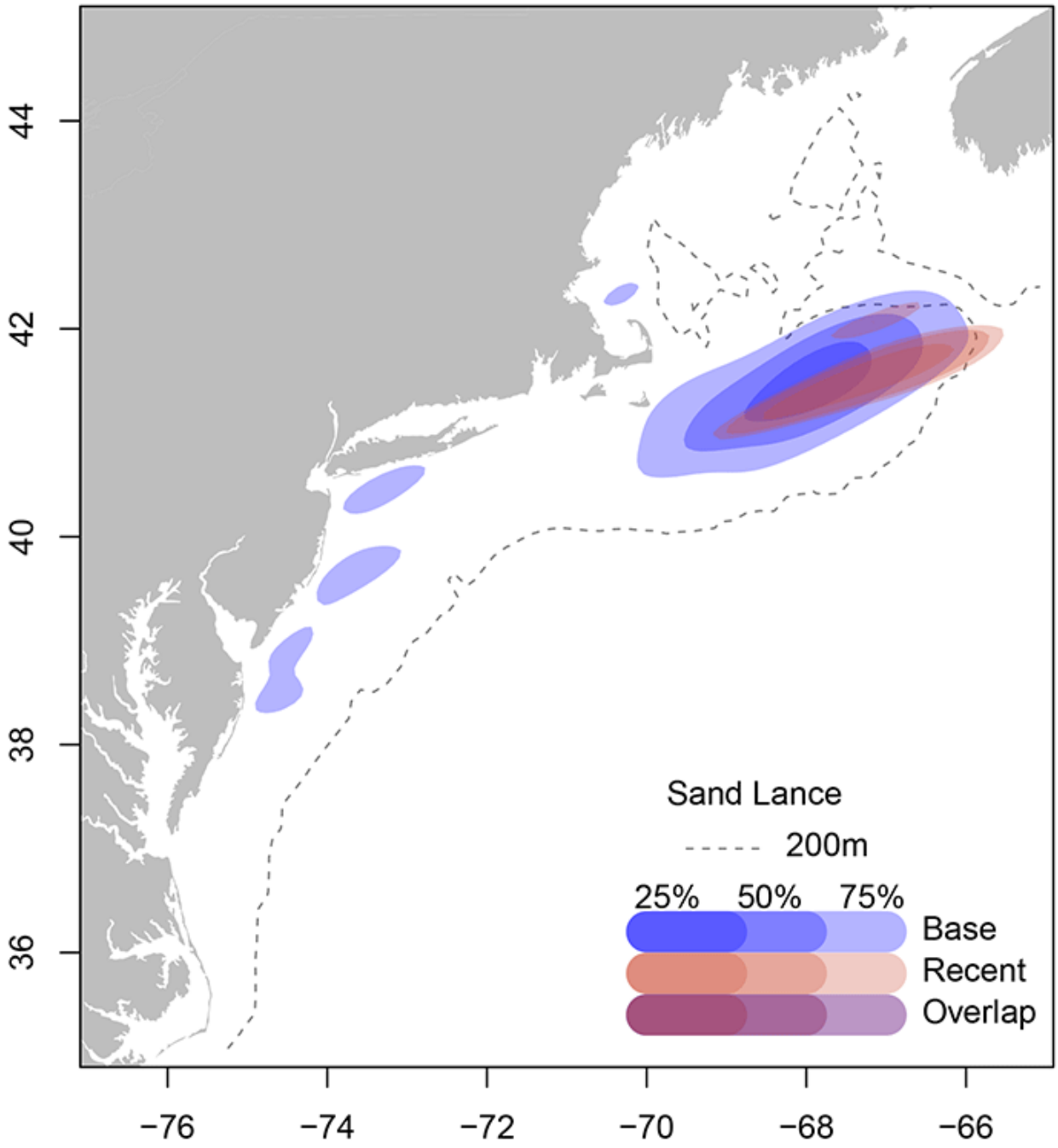
Red Hake
200m
25%
50%
75%
Base
Recent
Overlap

Rosette skate



Sand lance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Sand Lance
200m
25%
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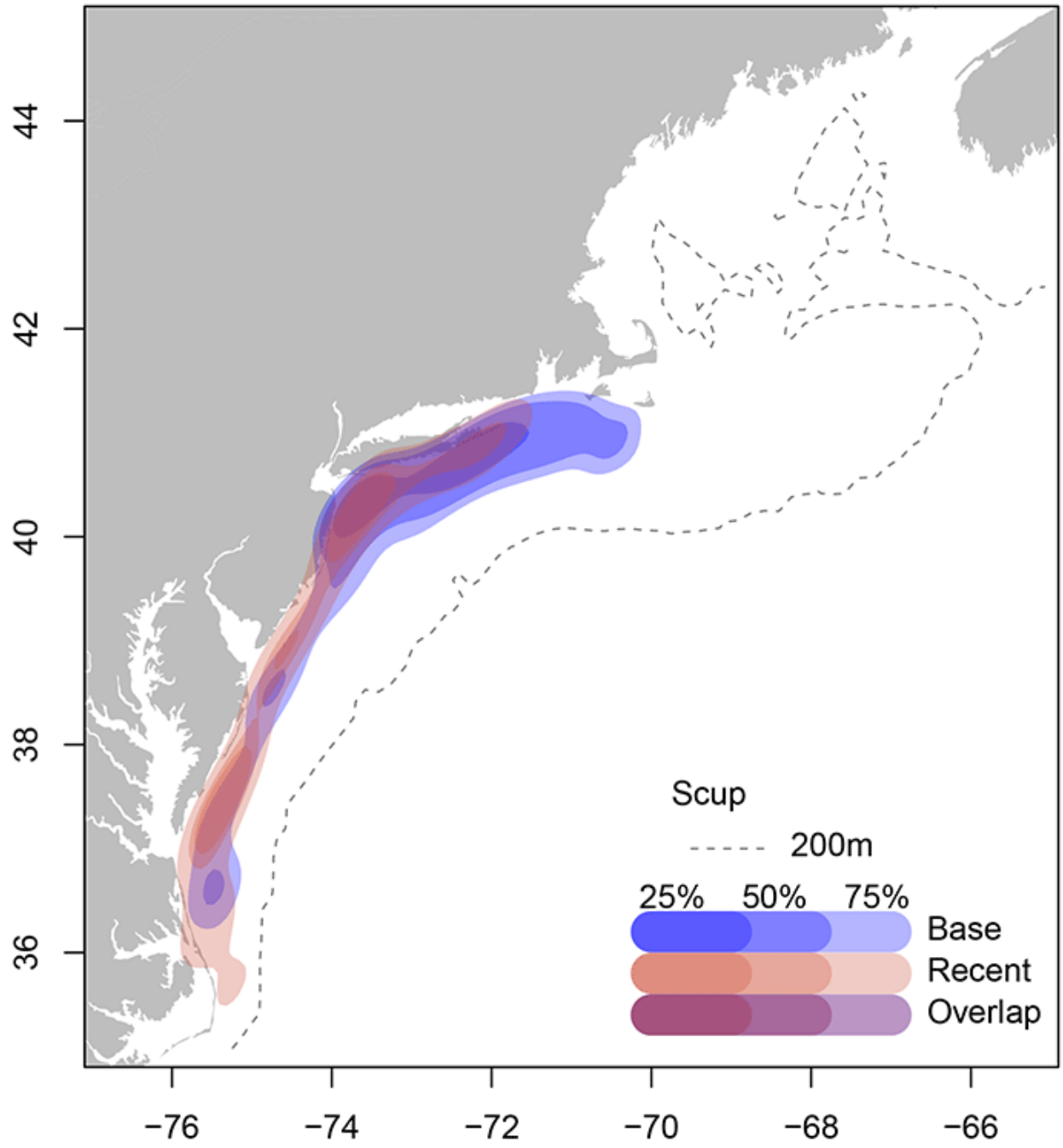
75%
Base
Recent
Overlap

Scup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Scup
200m
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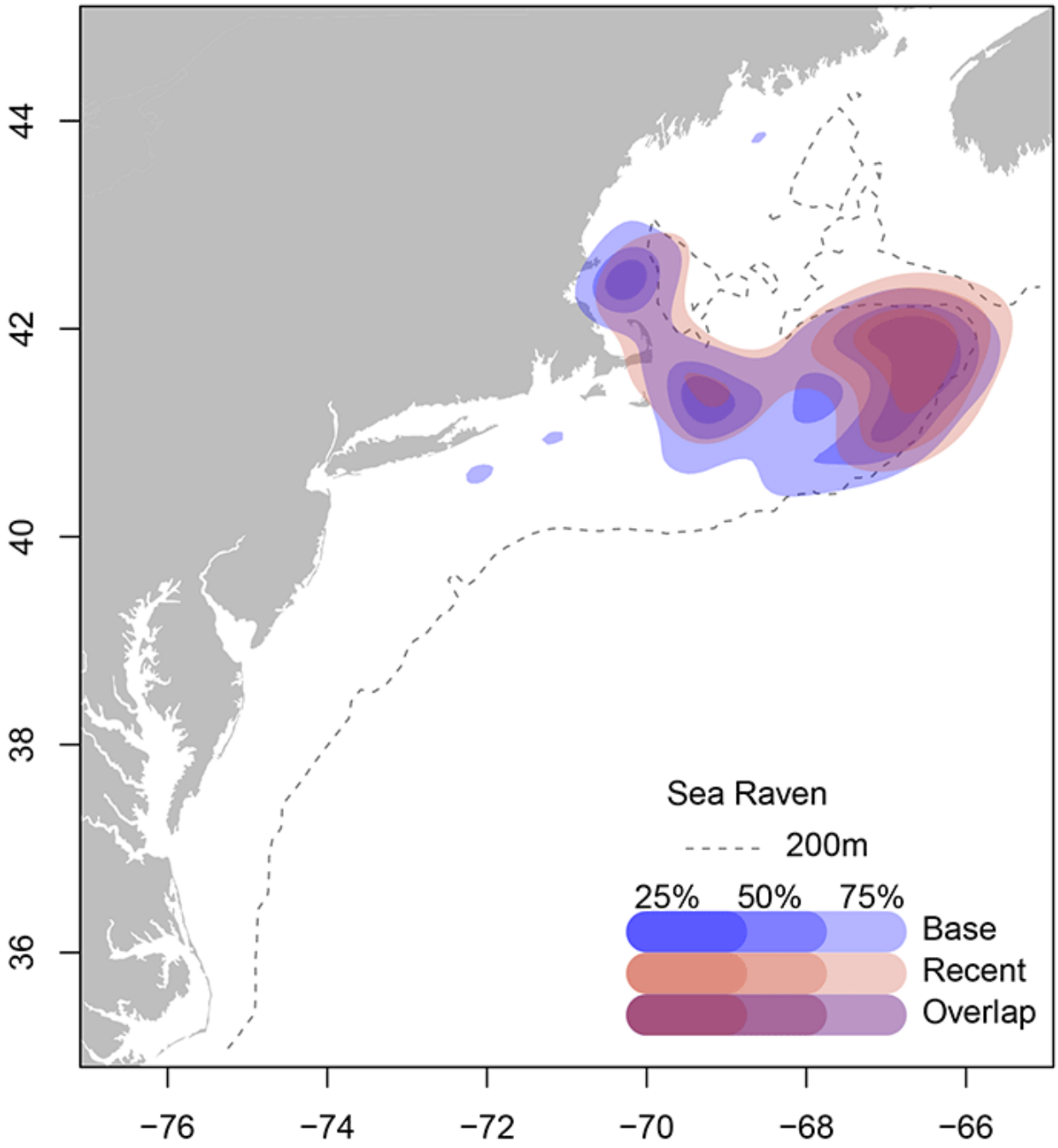
Base
Recent
Overlap

Sea raven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Sea Raven
200m
25%
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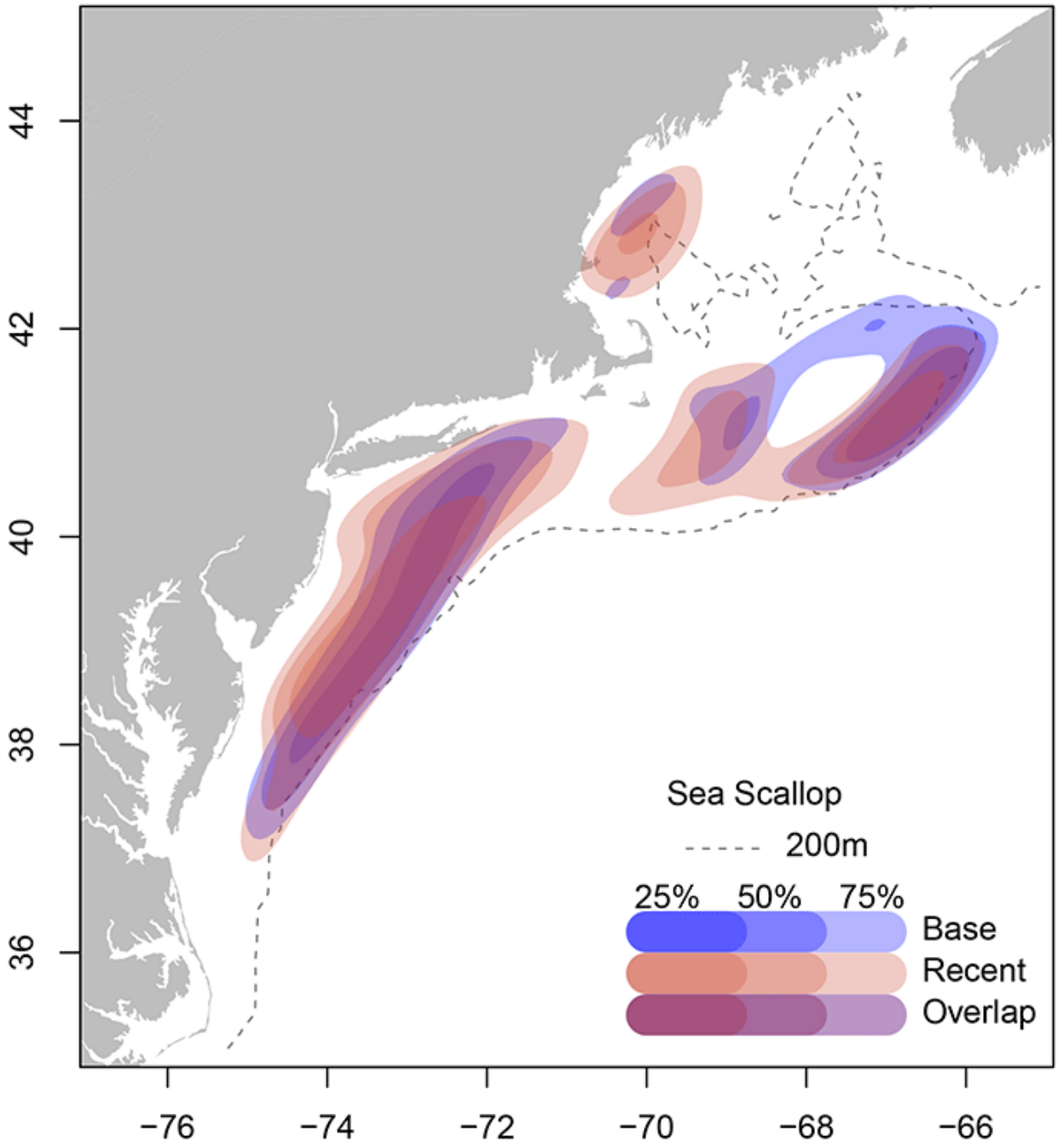
Base
Recent
Overlap

Sea scallop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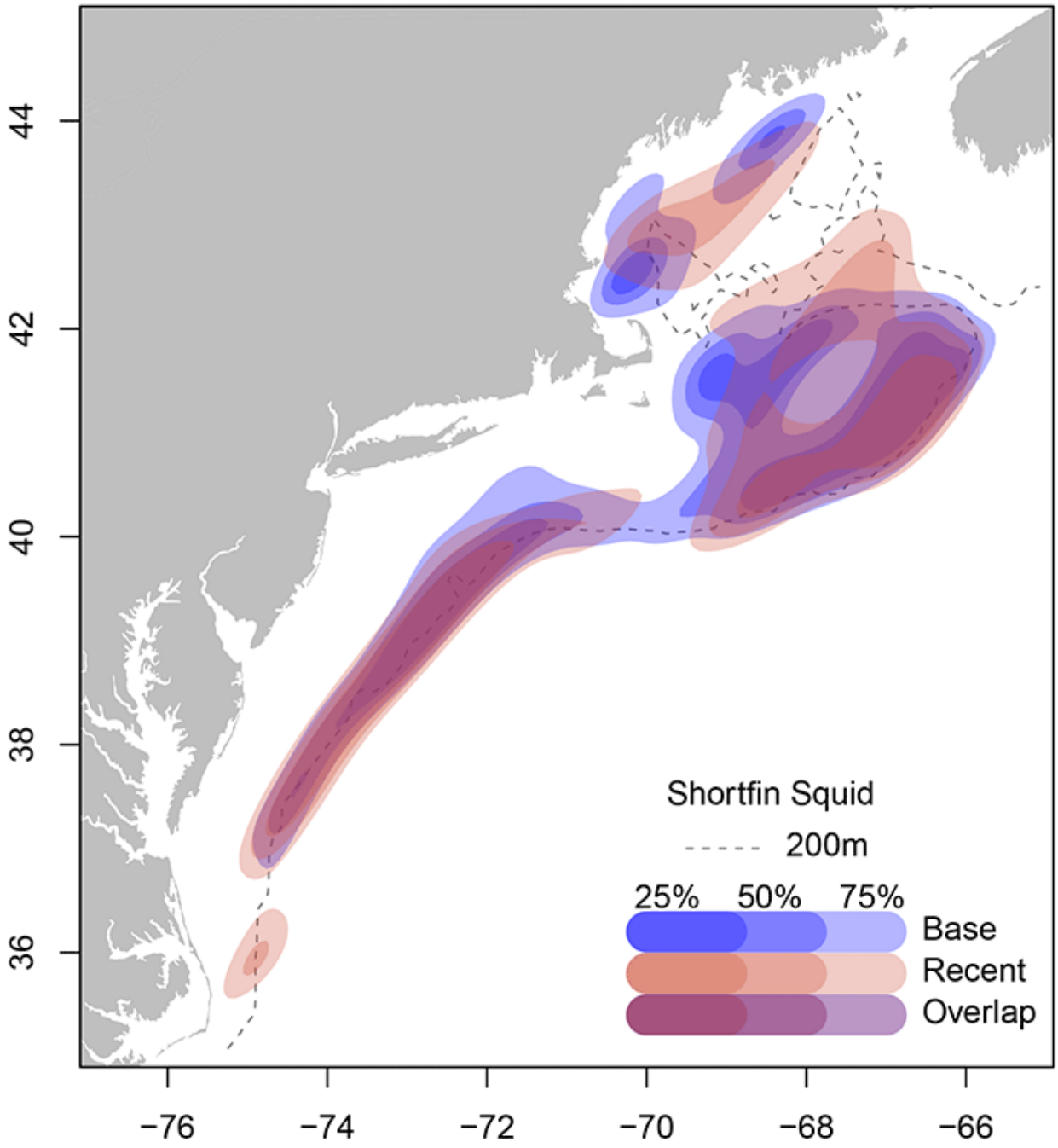
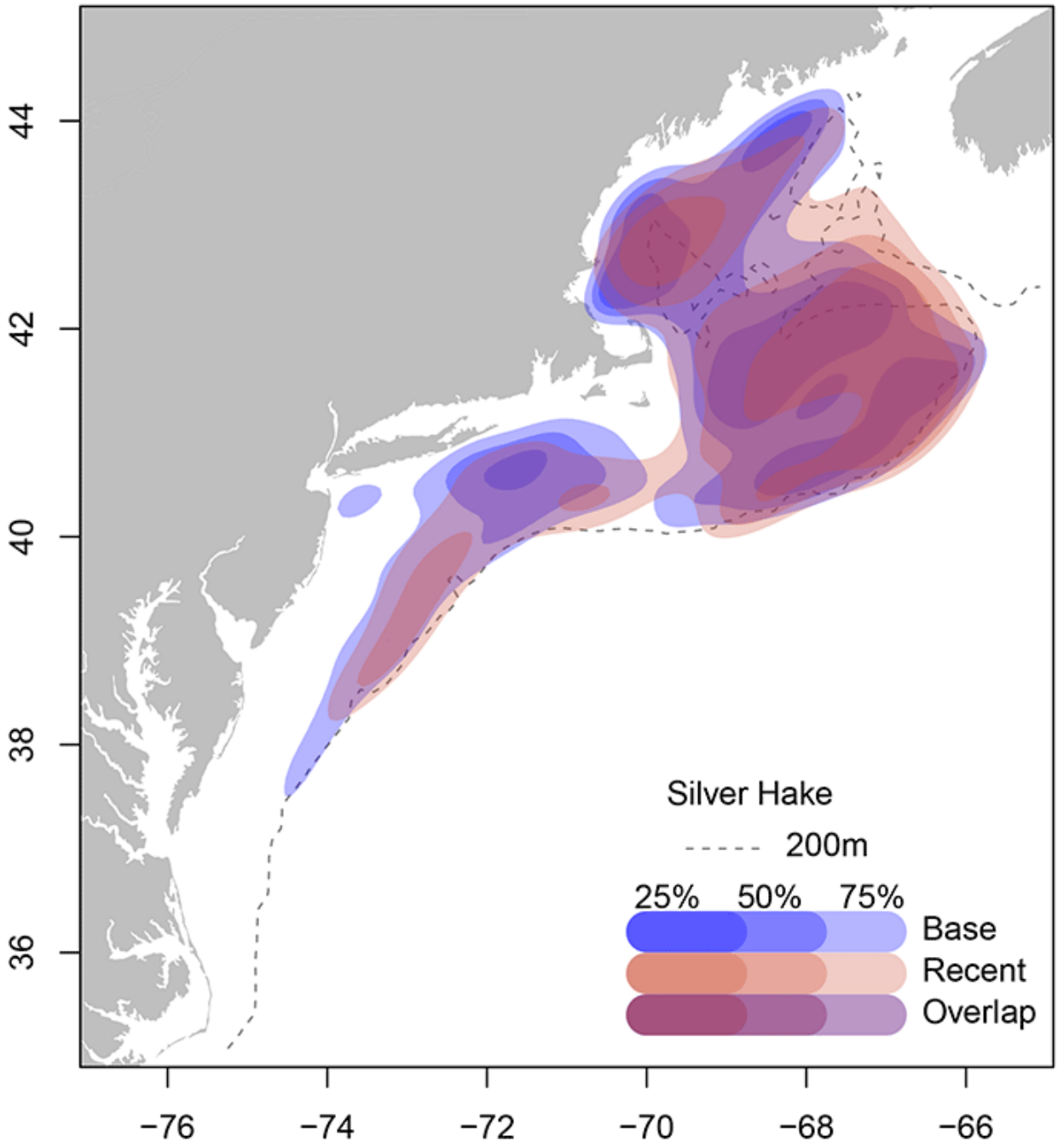
Sea Scallop
200m
25%
50%
75%
Base
Recent
Overlap

Shortfin squid



Silver hake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Silver Hake
200m
25%
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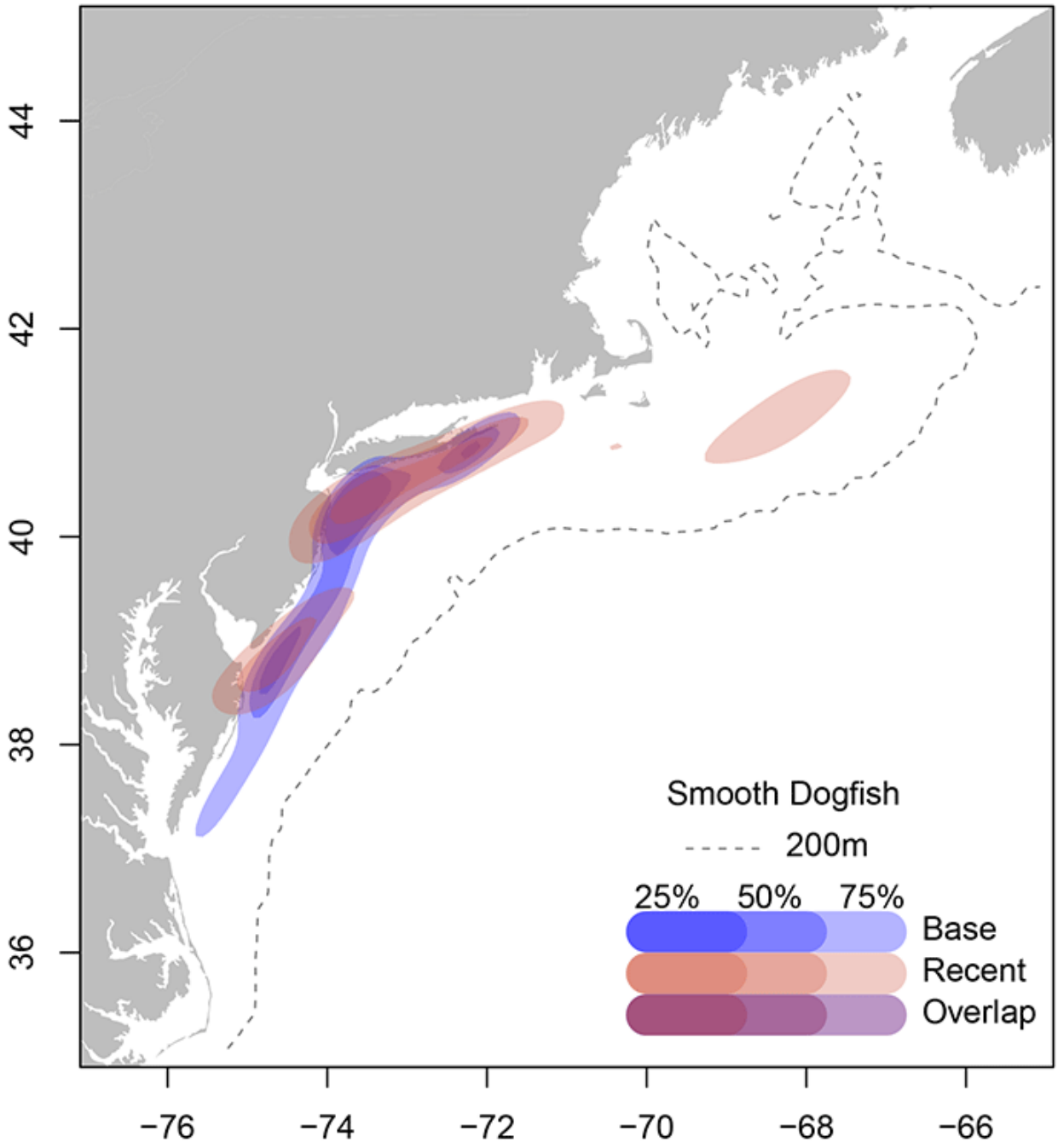
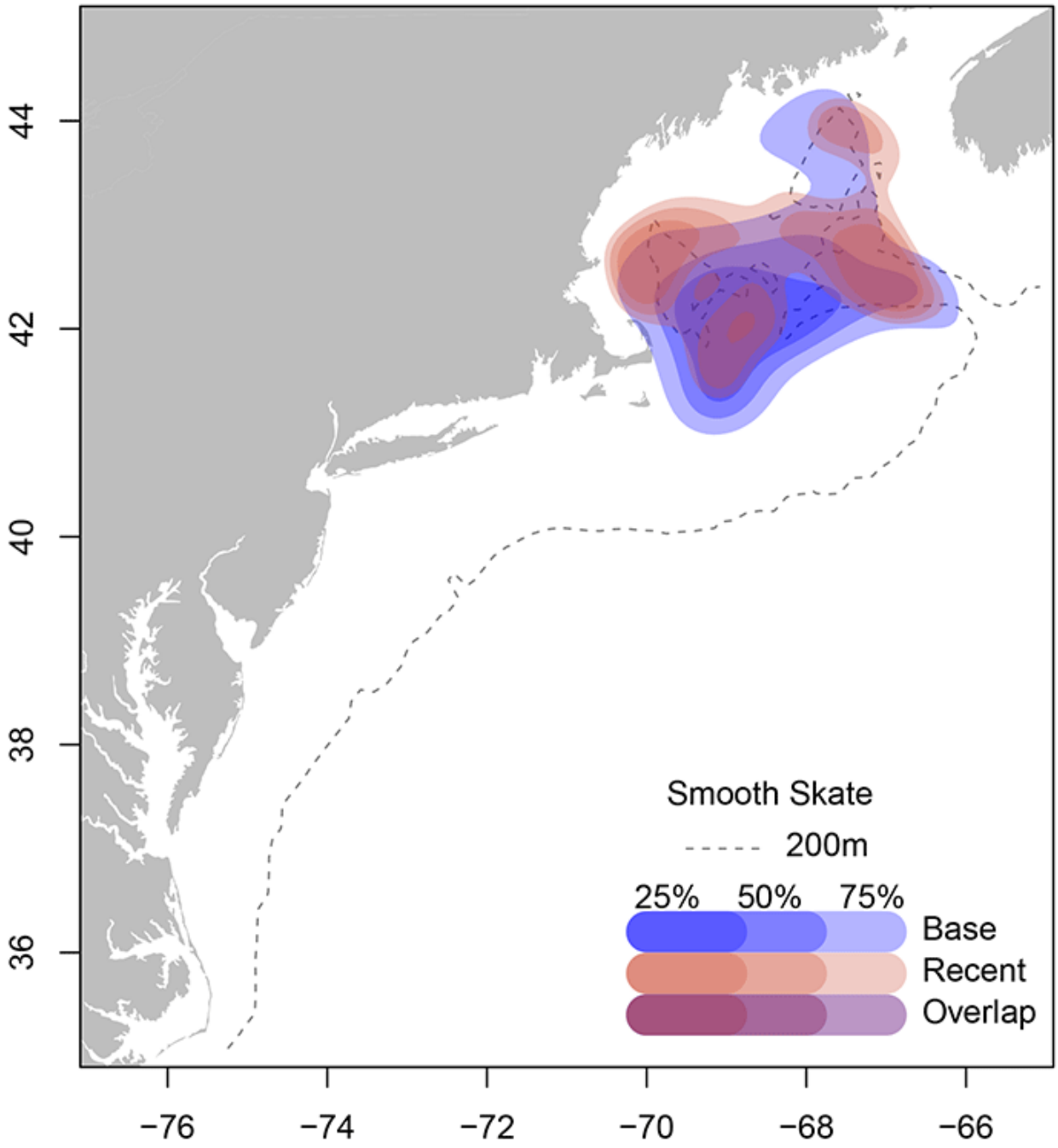
Base
Recent
Overlap

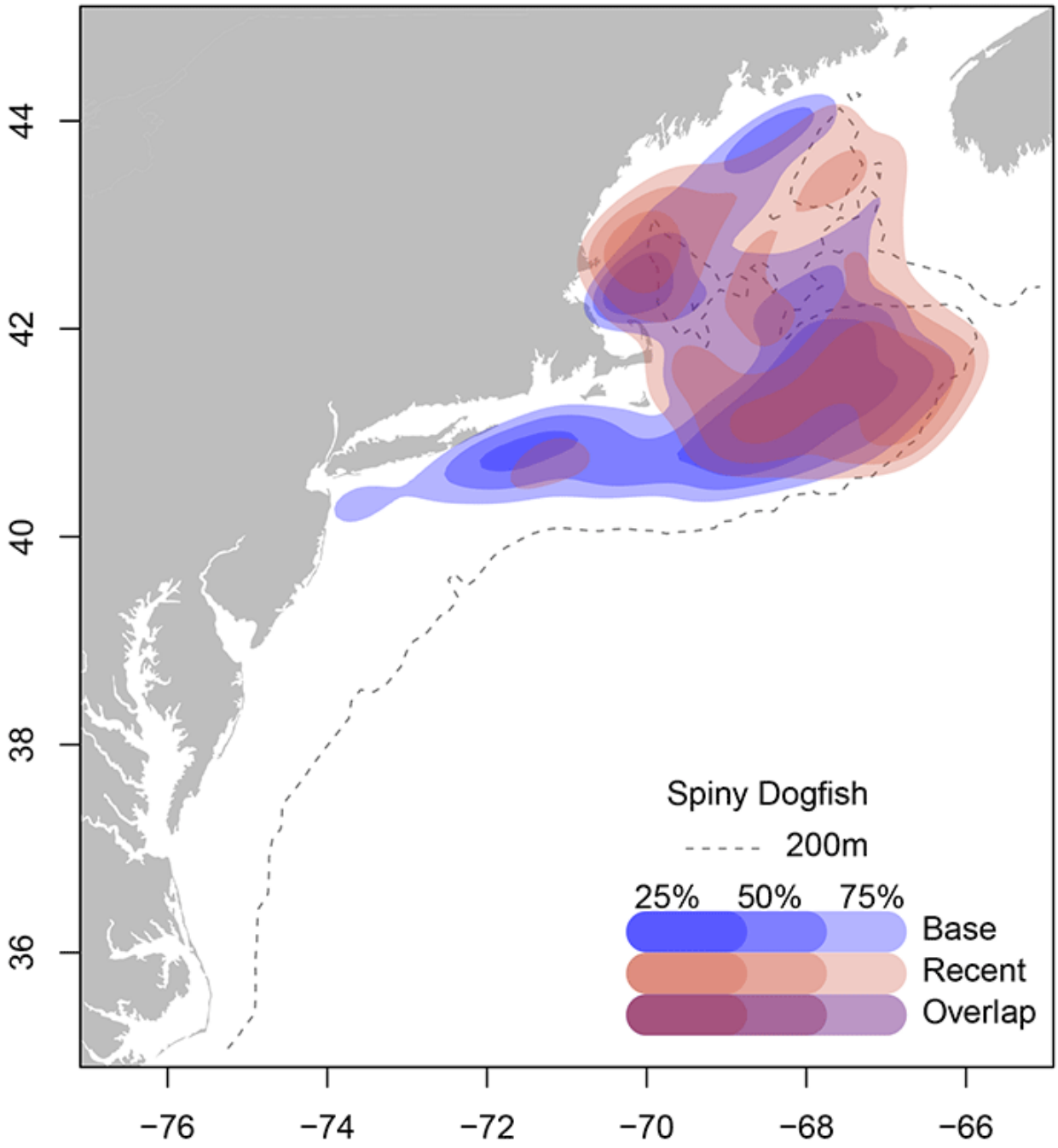
Smooth dogfish



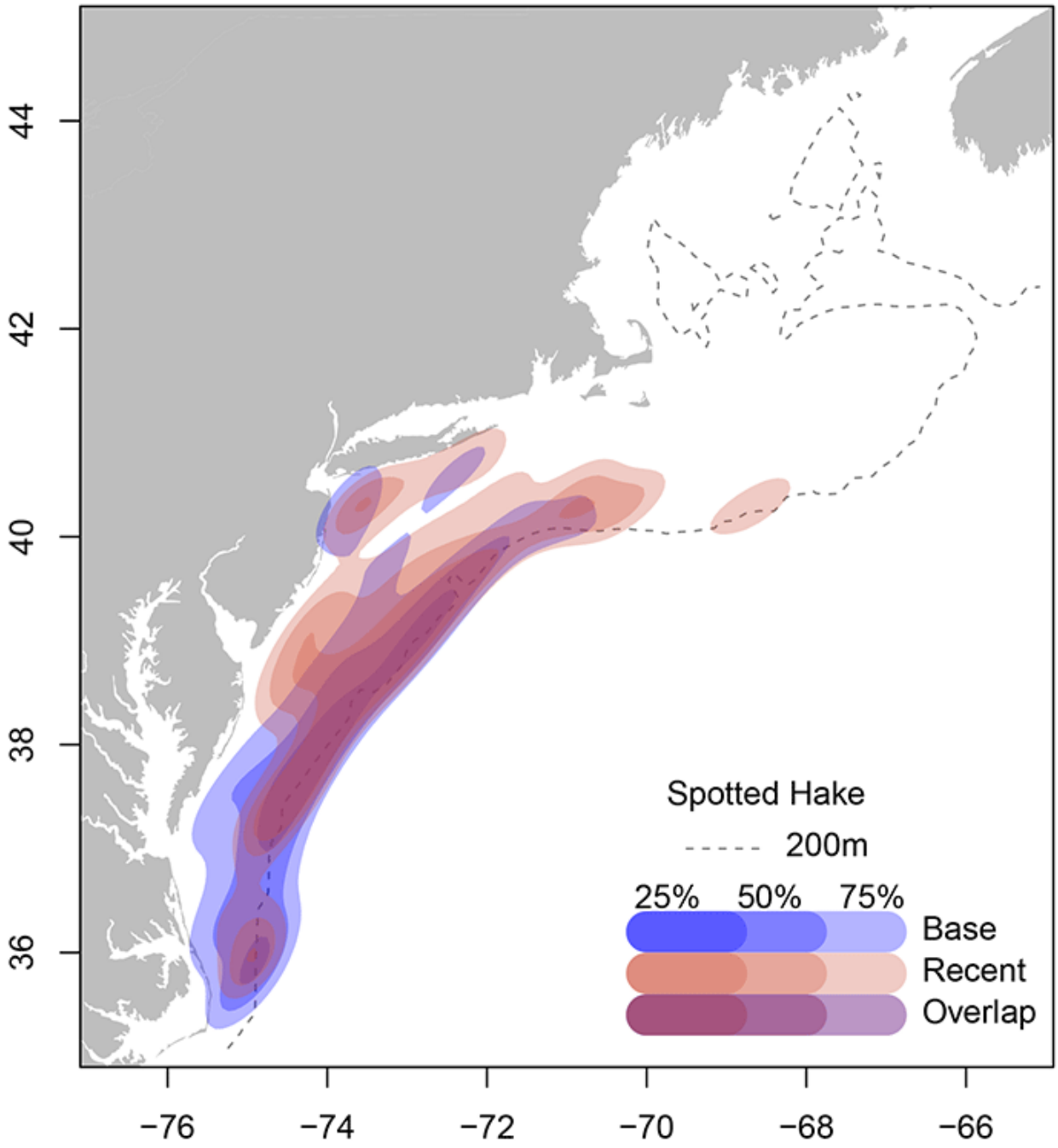
Smooth skate



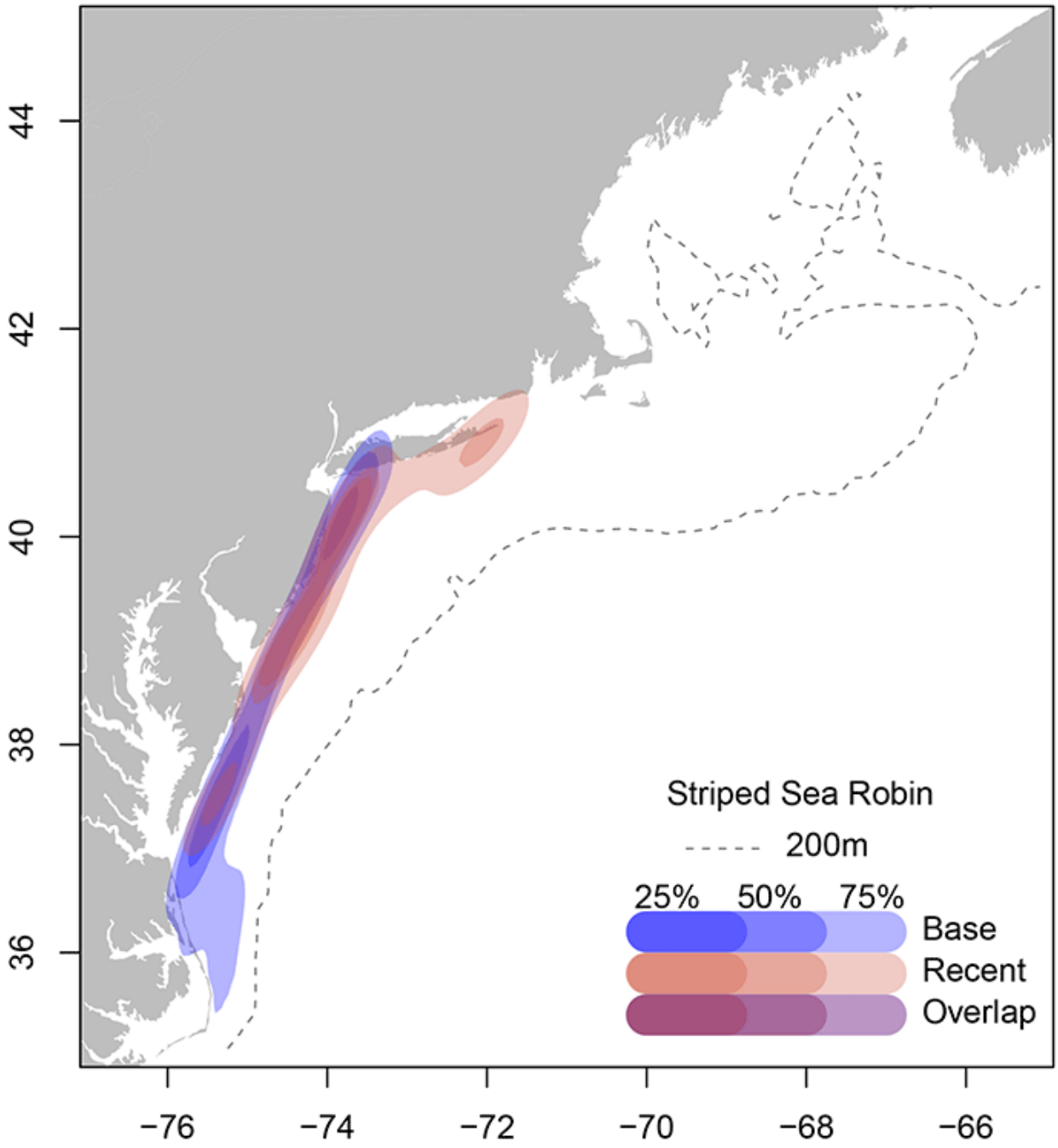
Spiny dogfish



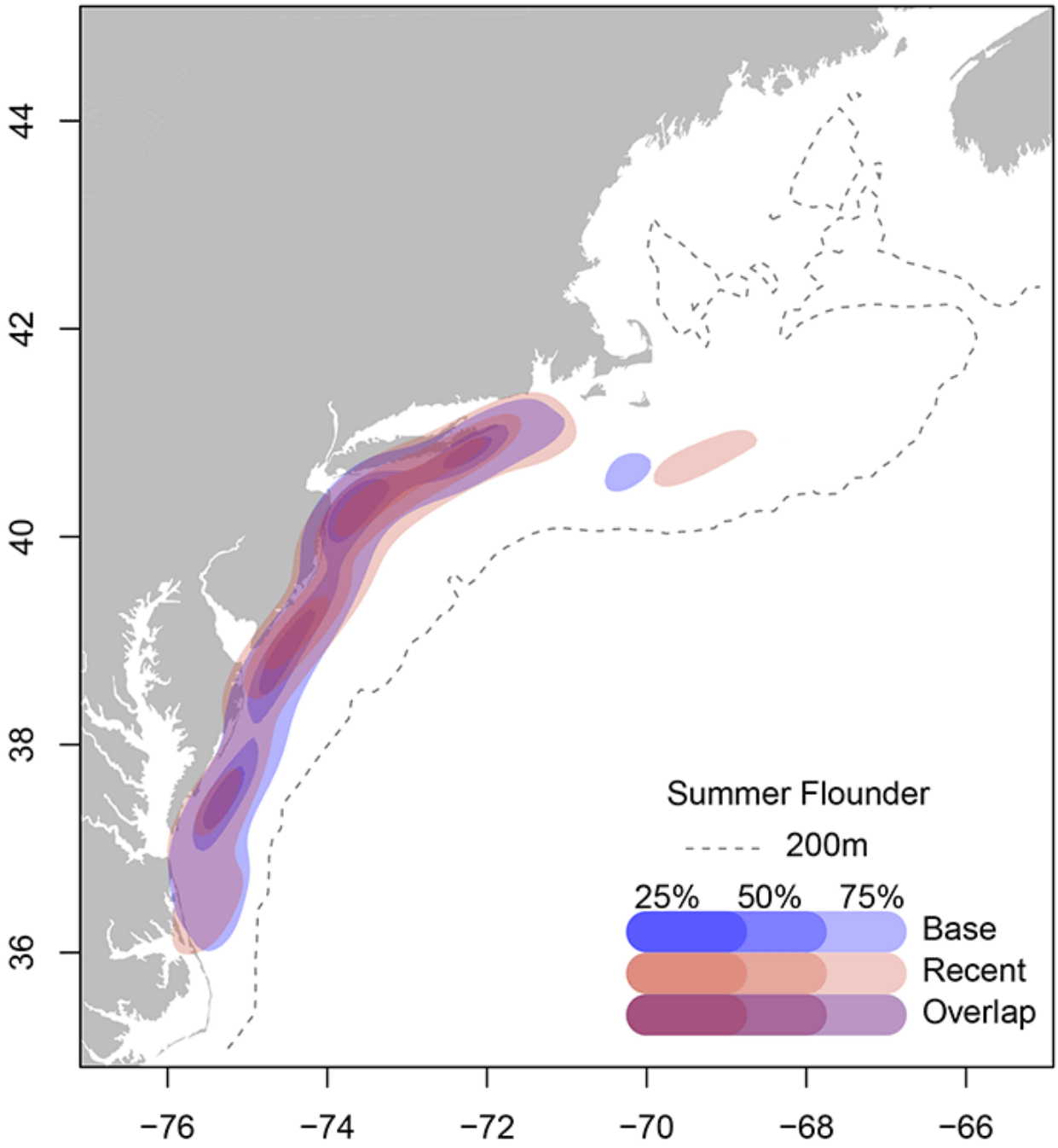
Spotted hake



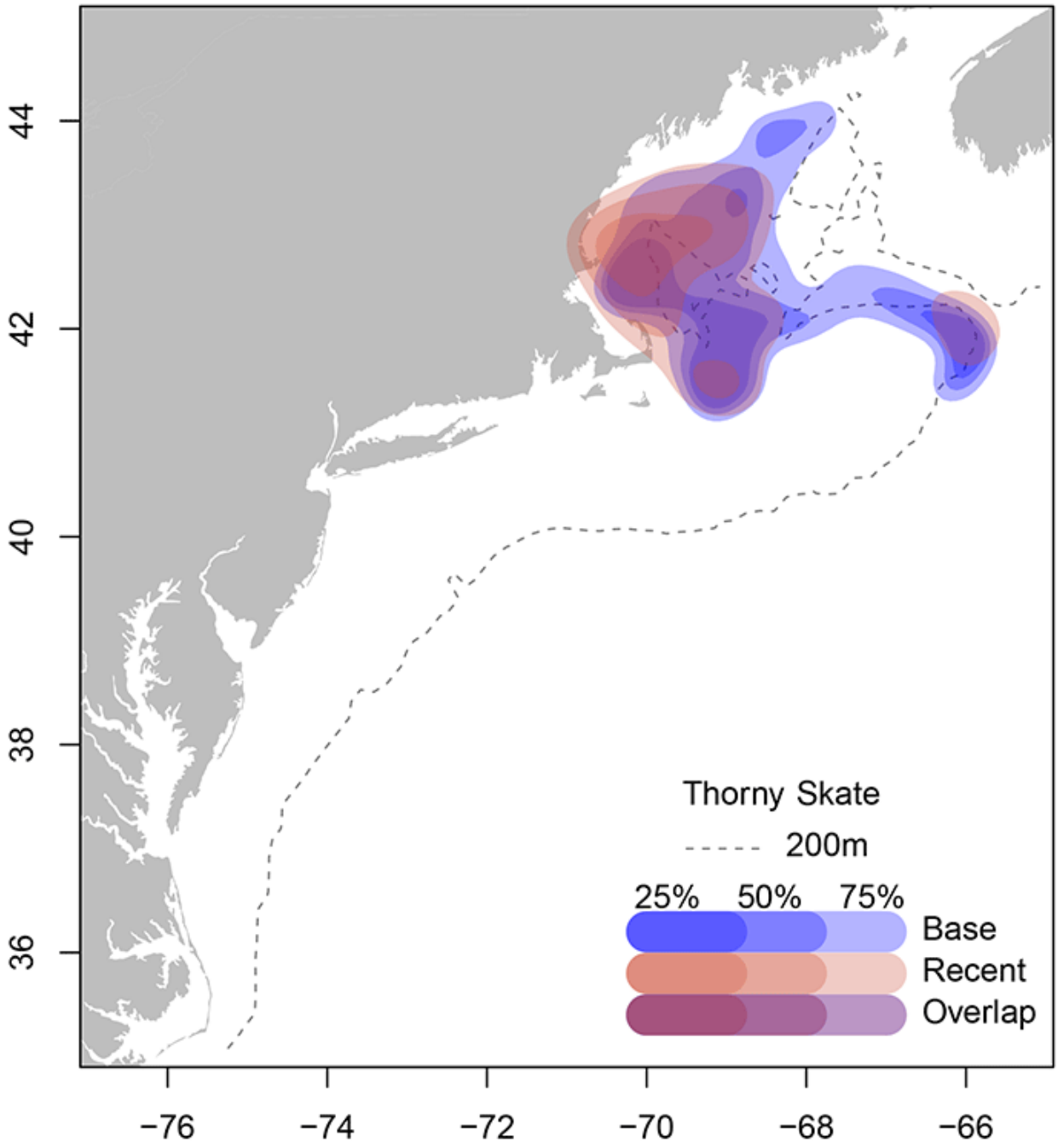
Striped sea robin



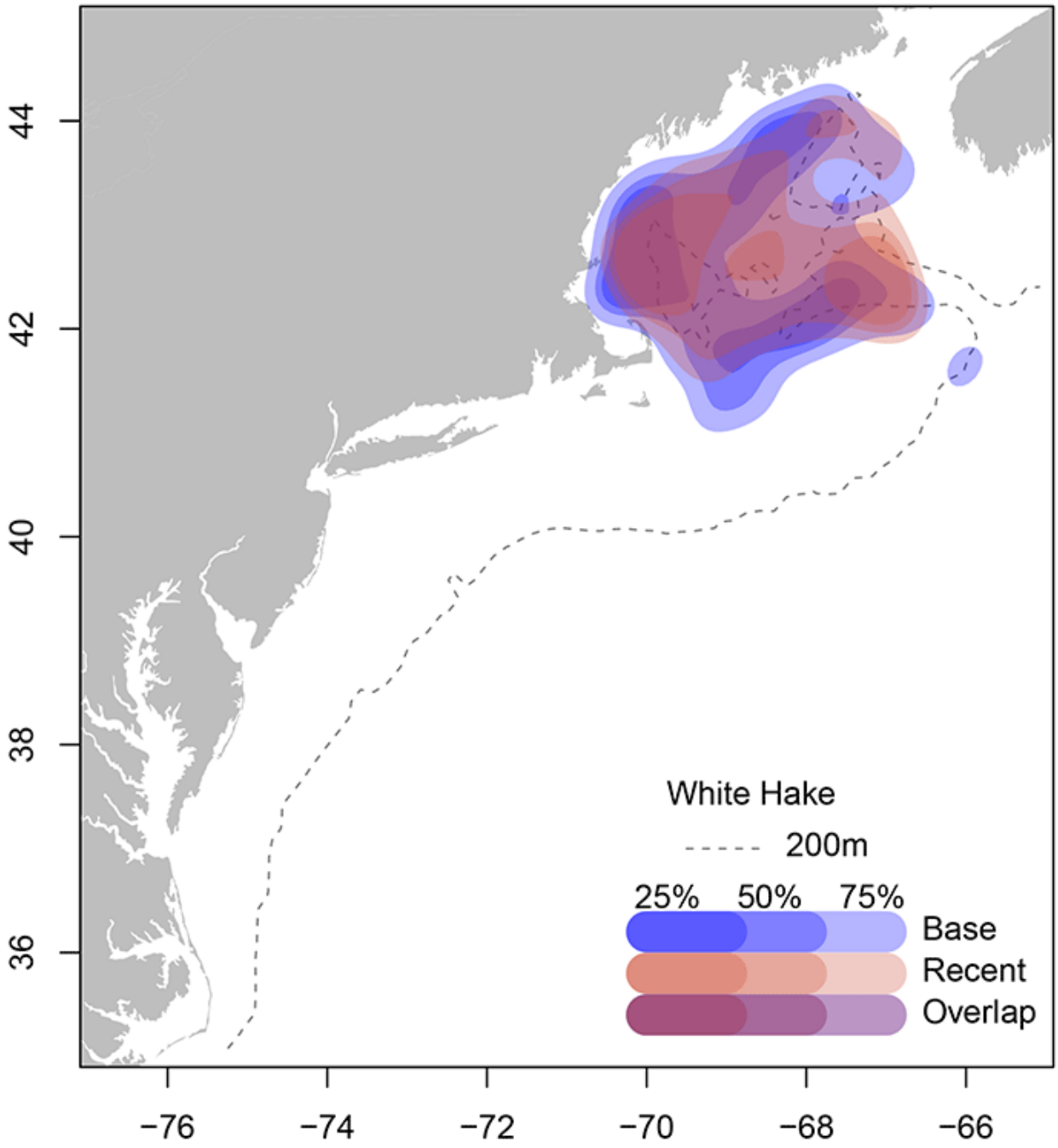
Summer flounder



Thorny skate



White hake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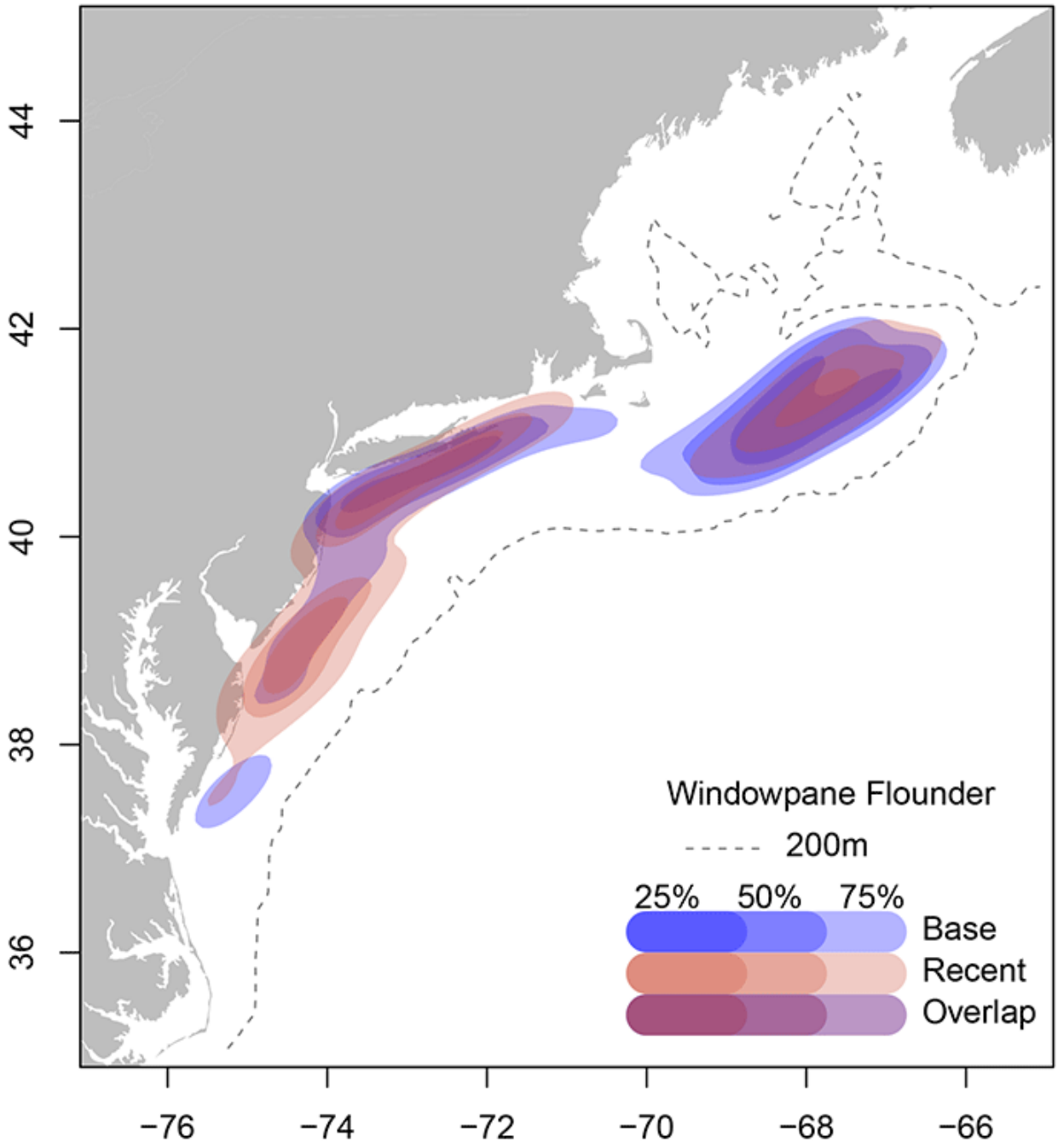
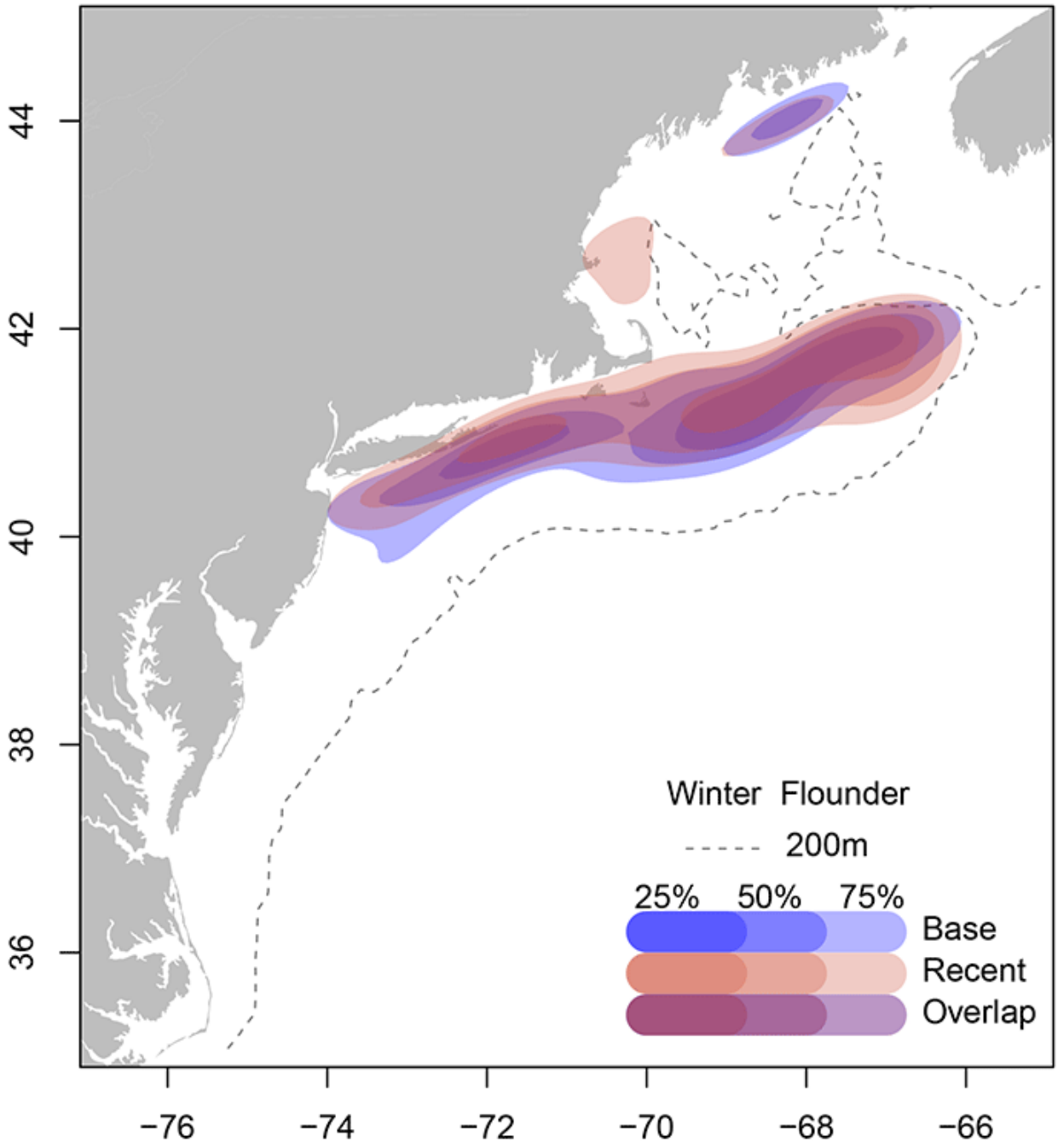
White Hake
200m
25%
50%
75%
Base
Recent
Overlap

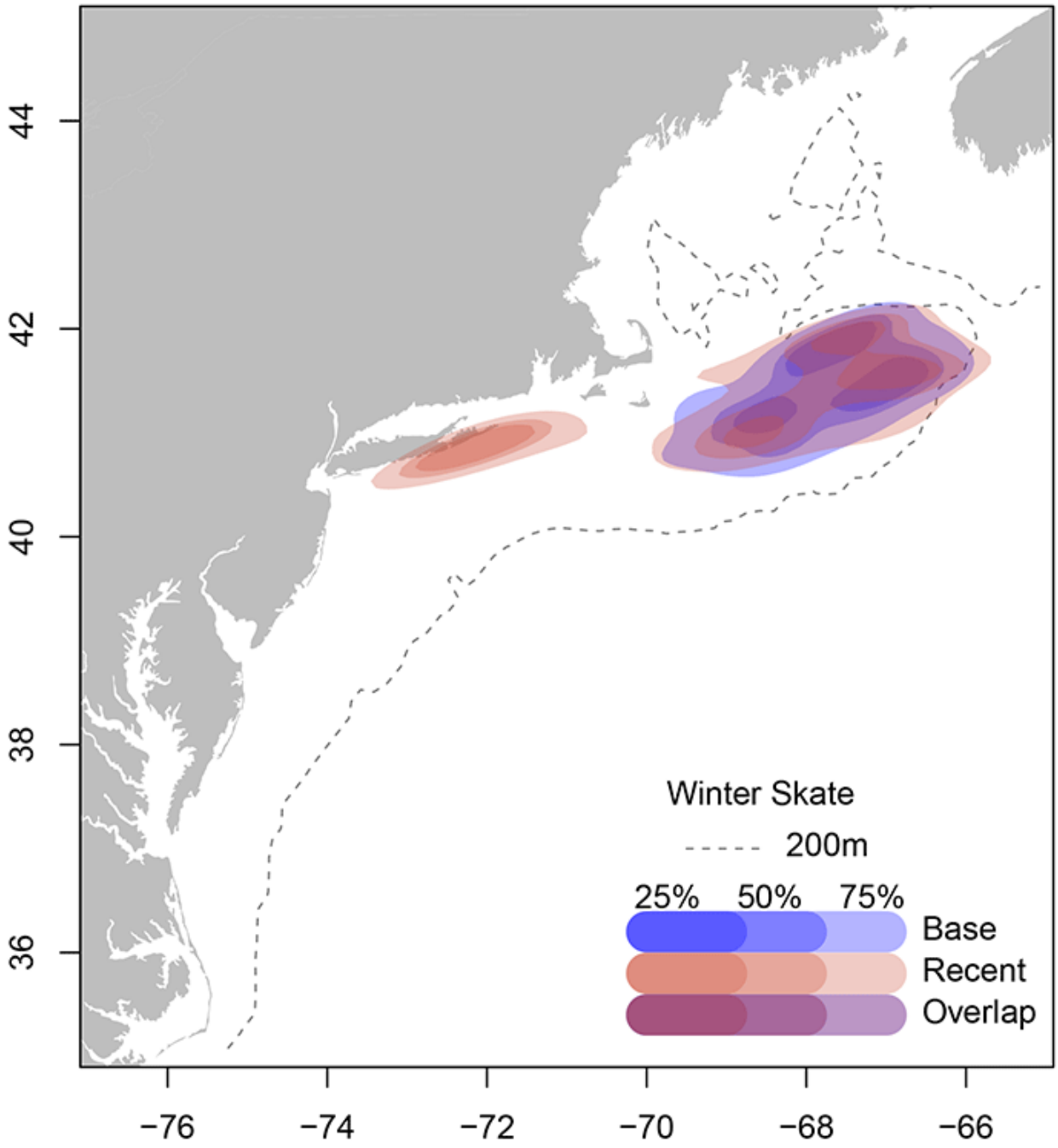
Windowpane flounder



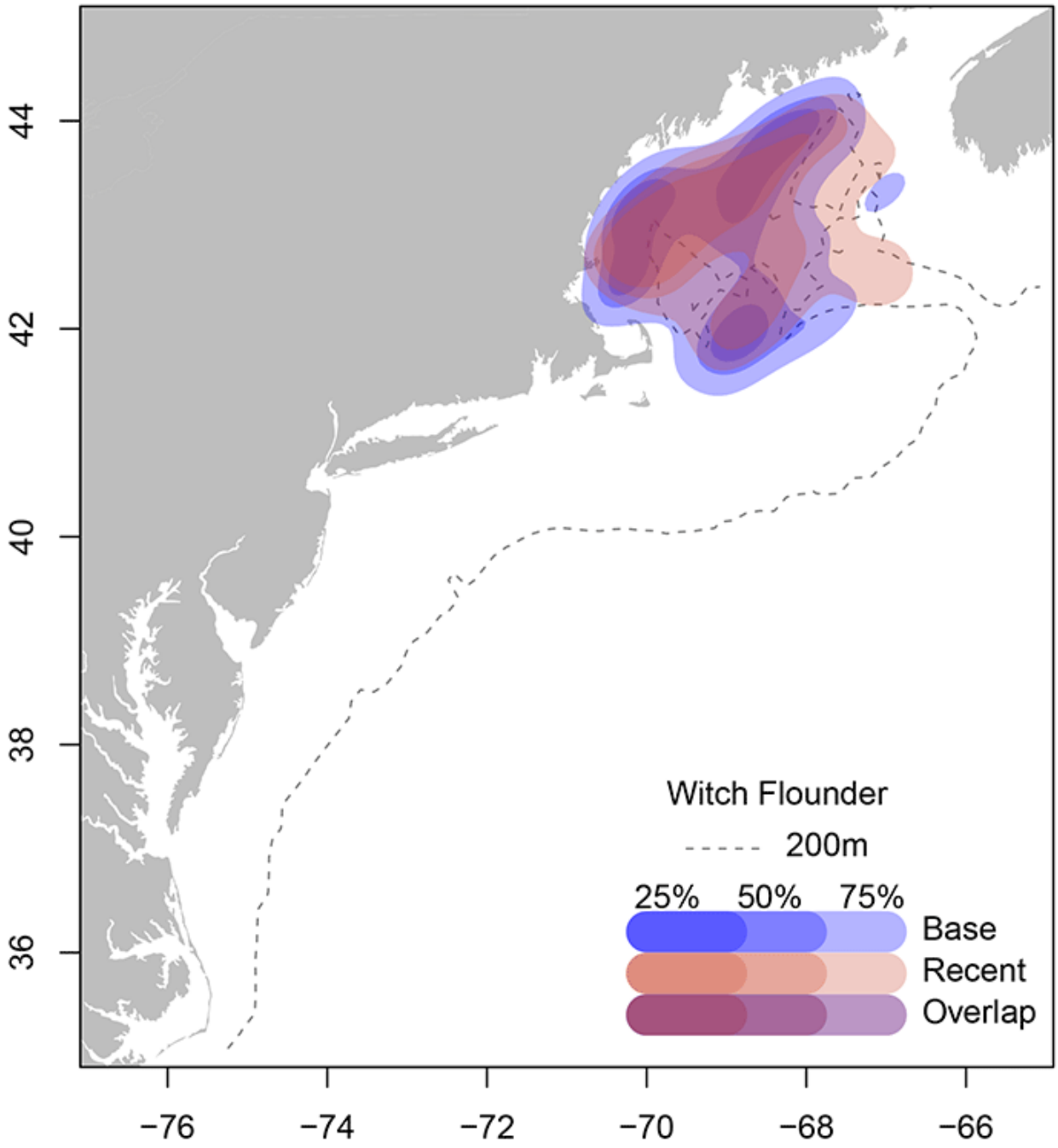
Winter flounder



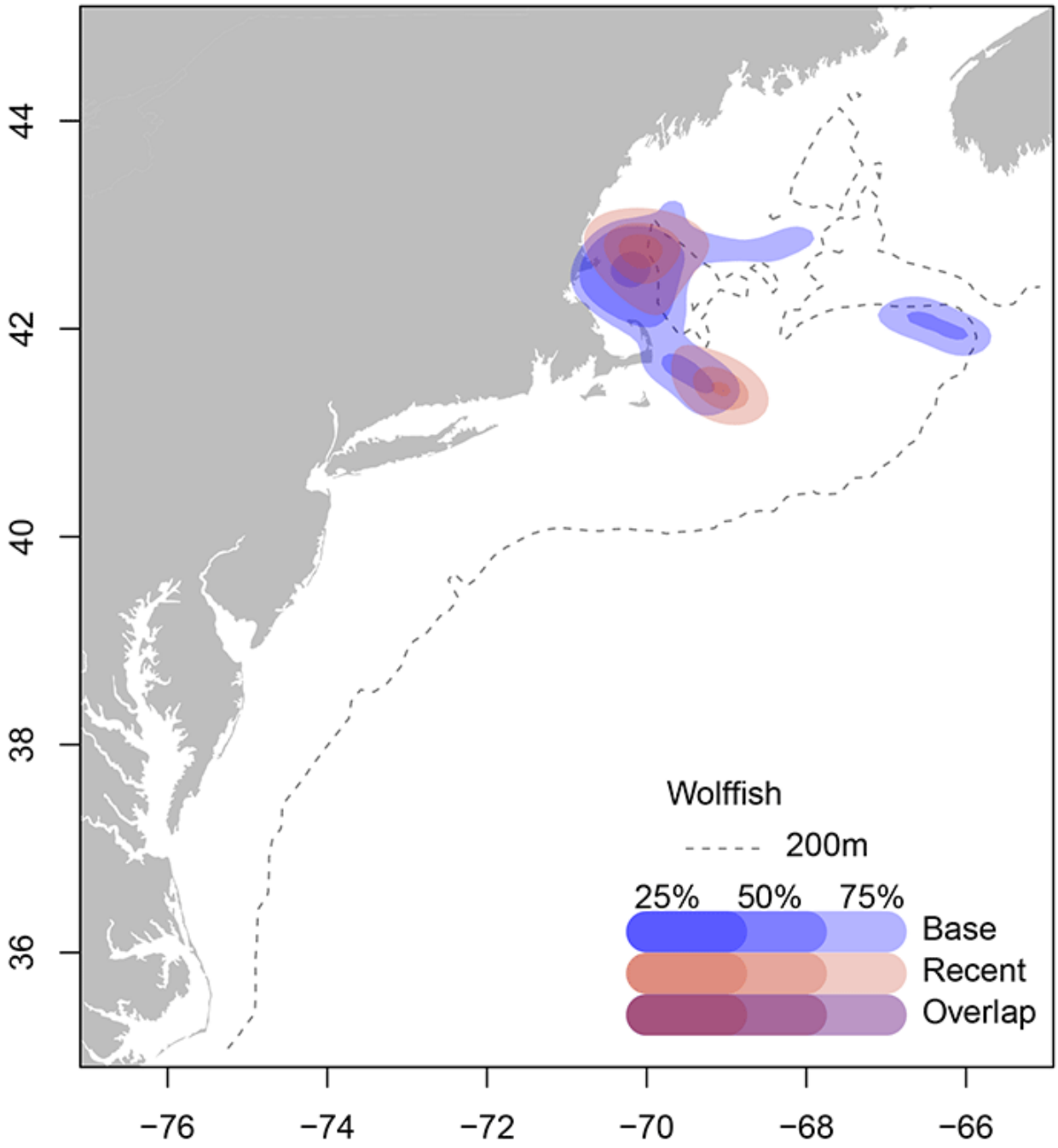
Winter skate



Witch flounder



Wolffish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Wolffish
200m
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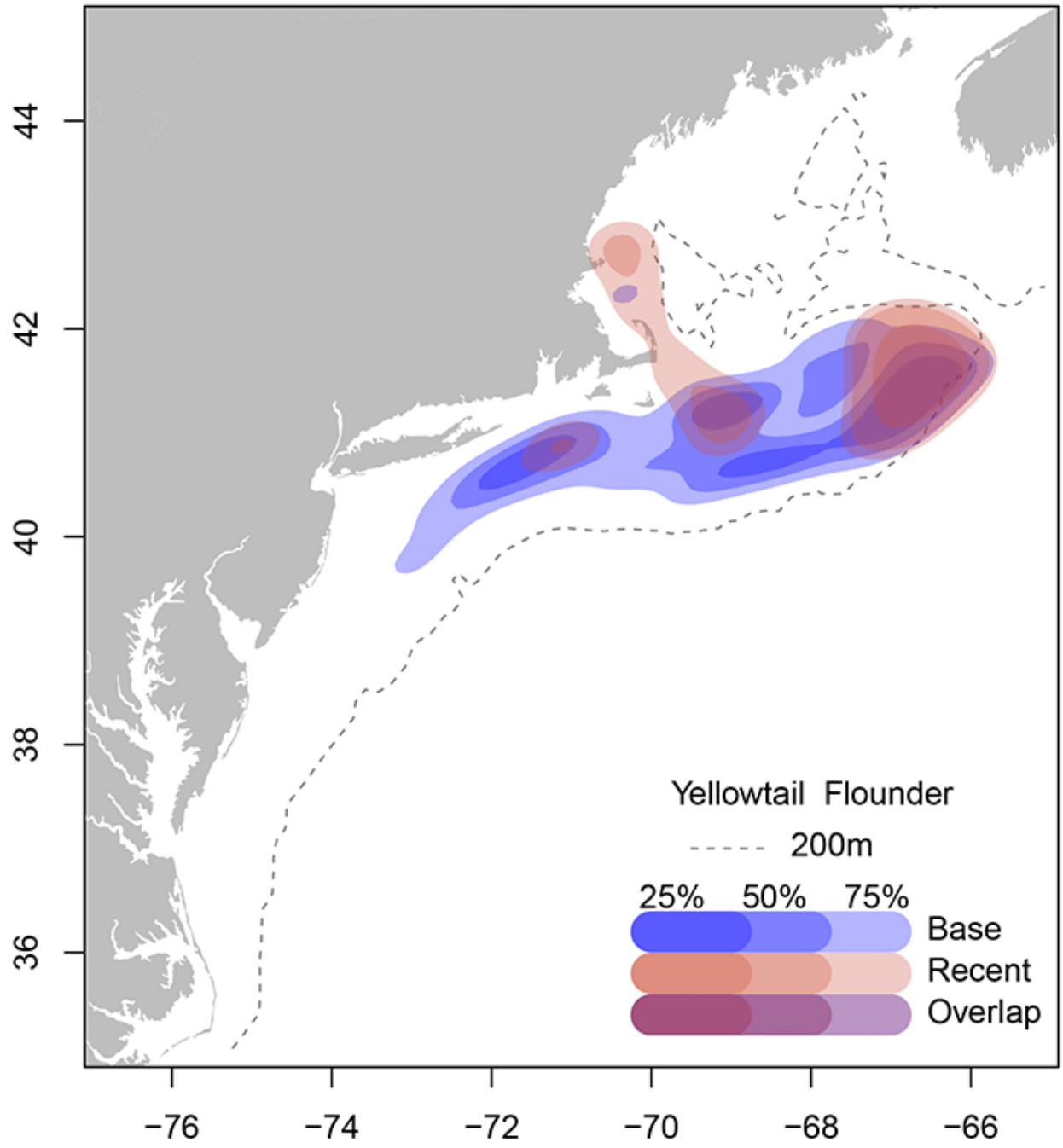
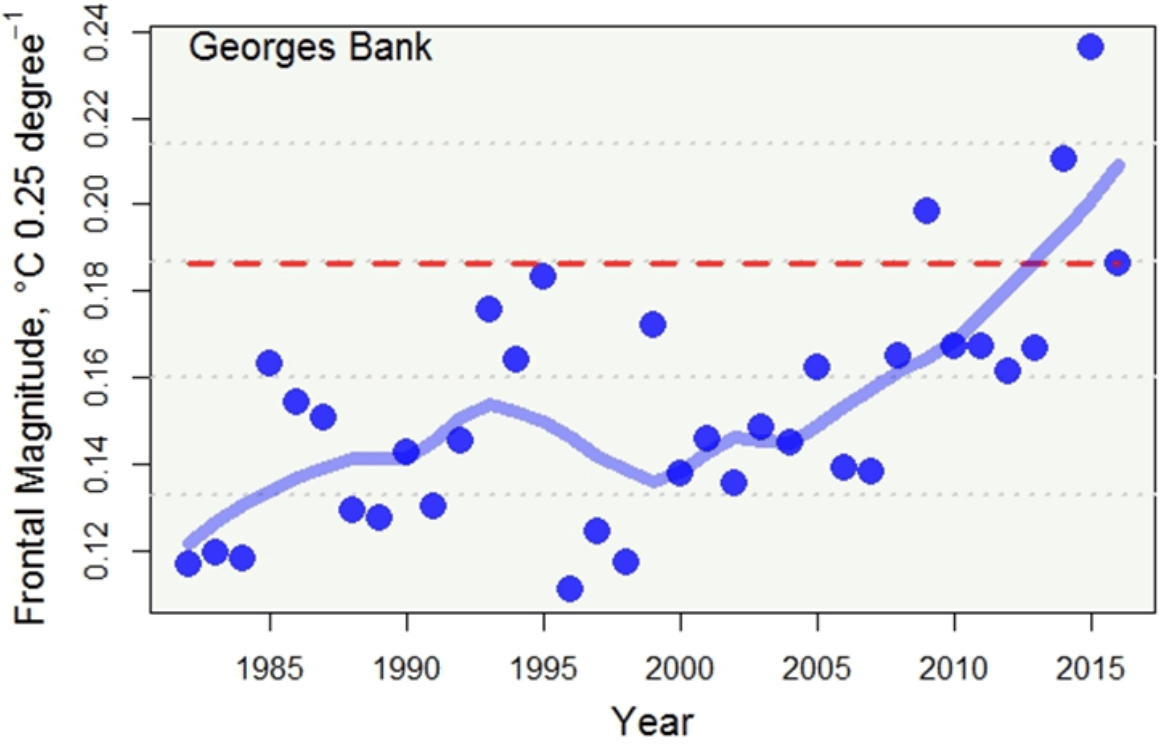
75%
Base
Recent
Overlap

Yellowtail flounder

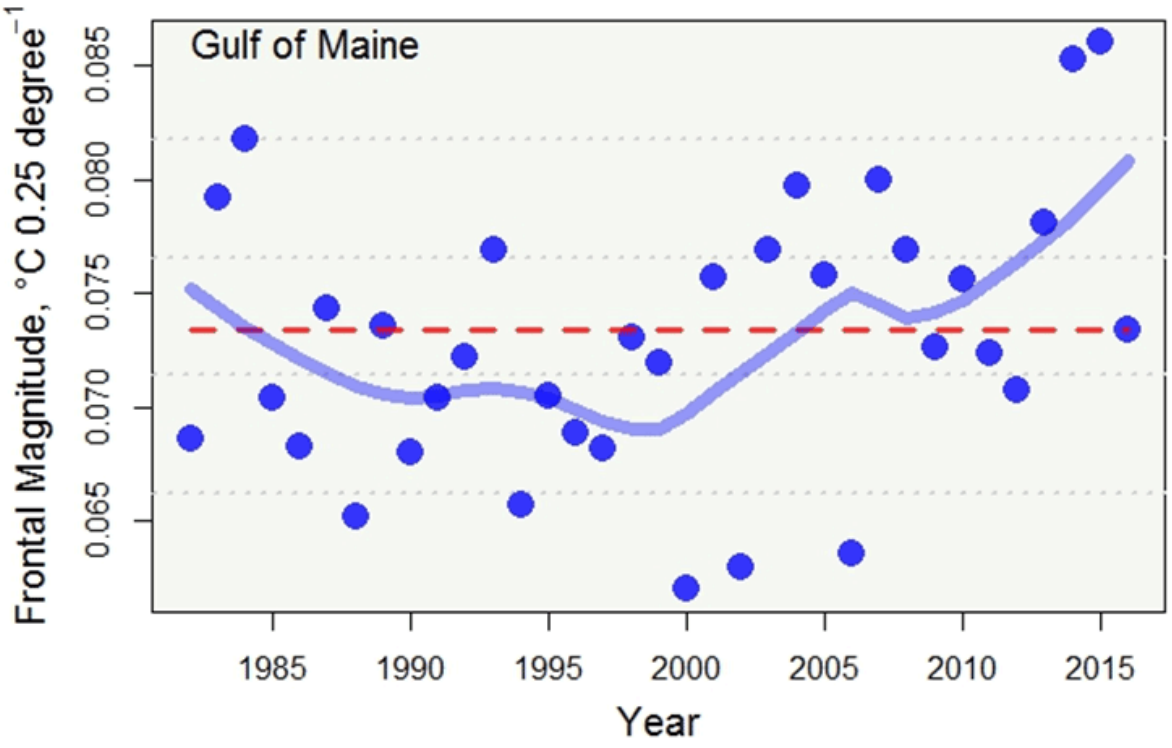


Change in Frontal Strength

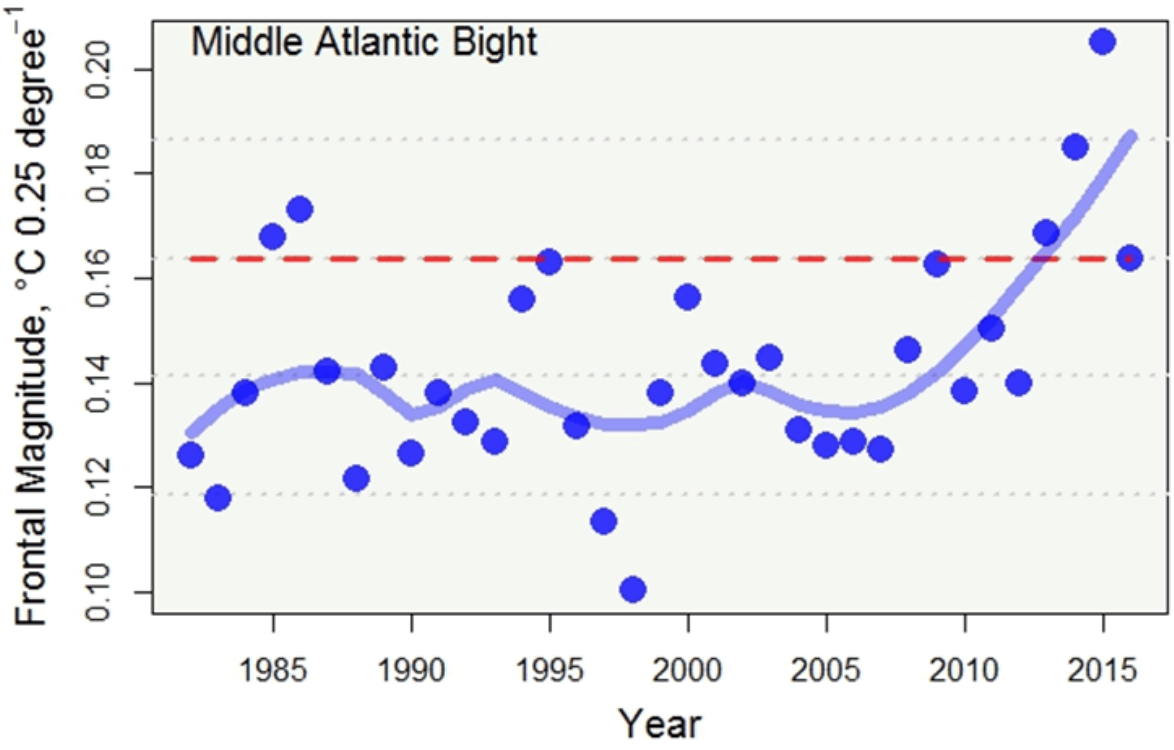
Temperature fronts form at the interface between differing water masses, often marking the boundary of an ocean current within the ecosystem. Fronts are of biological significance because they tend to concentrate organisms at both lower and upper trophic levels. A measure of fronts is the gradient magnitude, which relates the change in SST per unit distance across a frontal feature. Frontal gradient magnitude has increased on Georges Bank and in much of the Middle Atlantic Bight, suggesting that stronger frontal features can be found in these areas over time. Frontal magnitude has decreased in much of the Gulf of Maine, suggesting an opposite trend of less well developed fronts. Time series of frontal magnitude is summarized for the four Northeast Shelf ecoregions. Magnitude has increased dramatically during the most recent decade of the time series in the Middle Atlantic Bight, Georges Bank and Scotian Shelf areas (blue line is time series smoother, dashed red line marks 2016 data). Magnitude in the Gulf of Maine does not have a well develop trend.



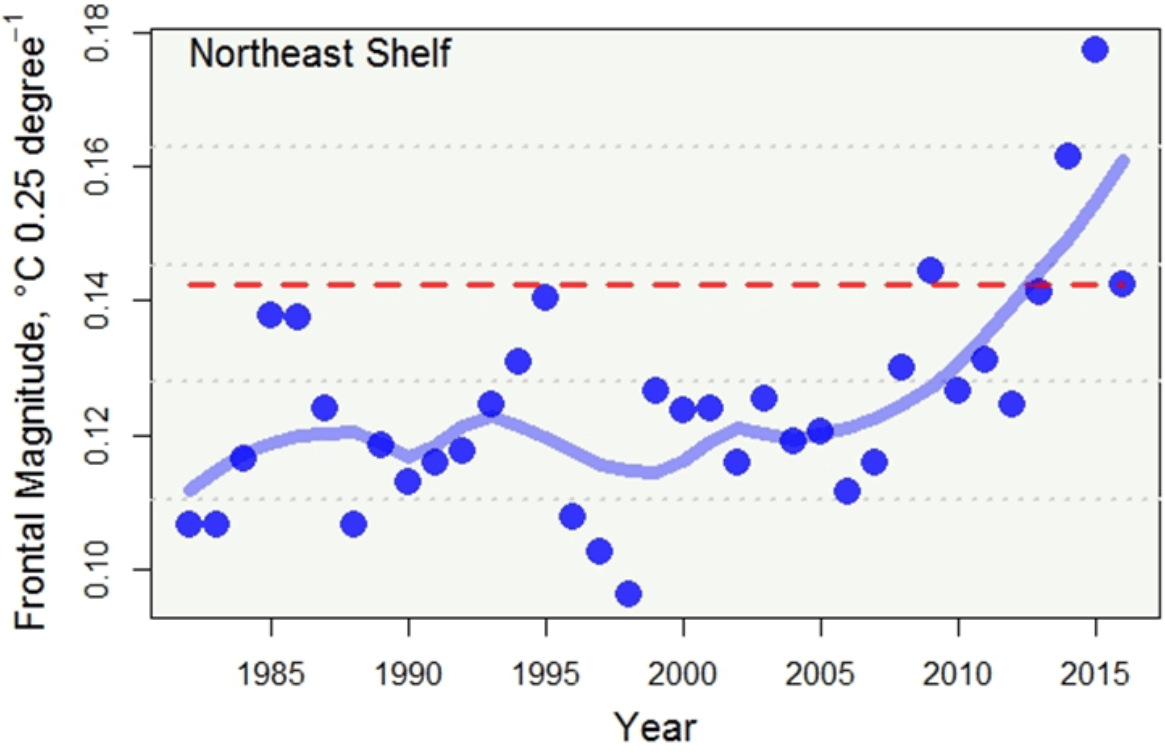
Georges Bank



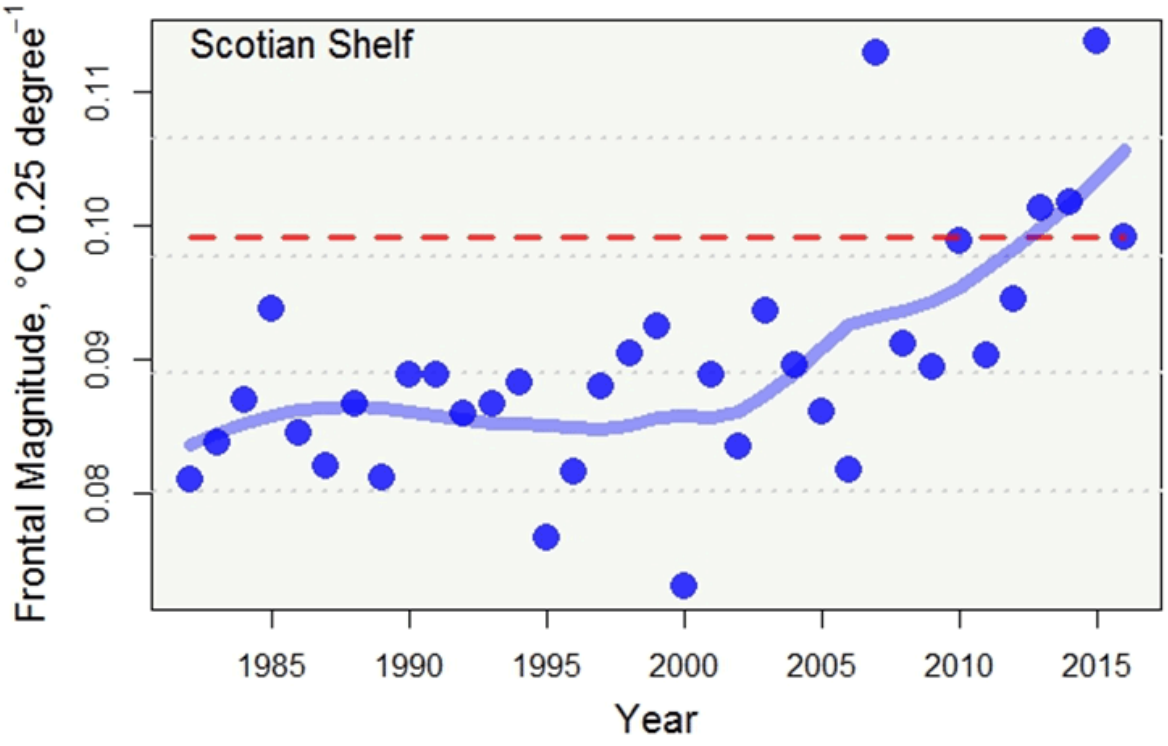
Gulf of Maine



Middle Atlantic Bight



Northeast Shelf



Scotian Shelf