

Fall 2016 Update: Annual Condition of the Northeast Shelf Ecosystem

Produced by the Ecosystem Dynamics and Assessment Branch

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166 Water Street

Woods Hole MA 02543-1026

Phone: (508) 495-2000

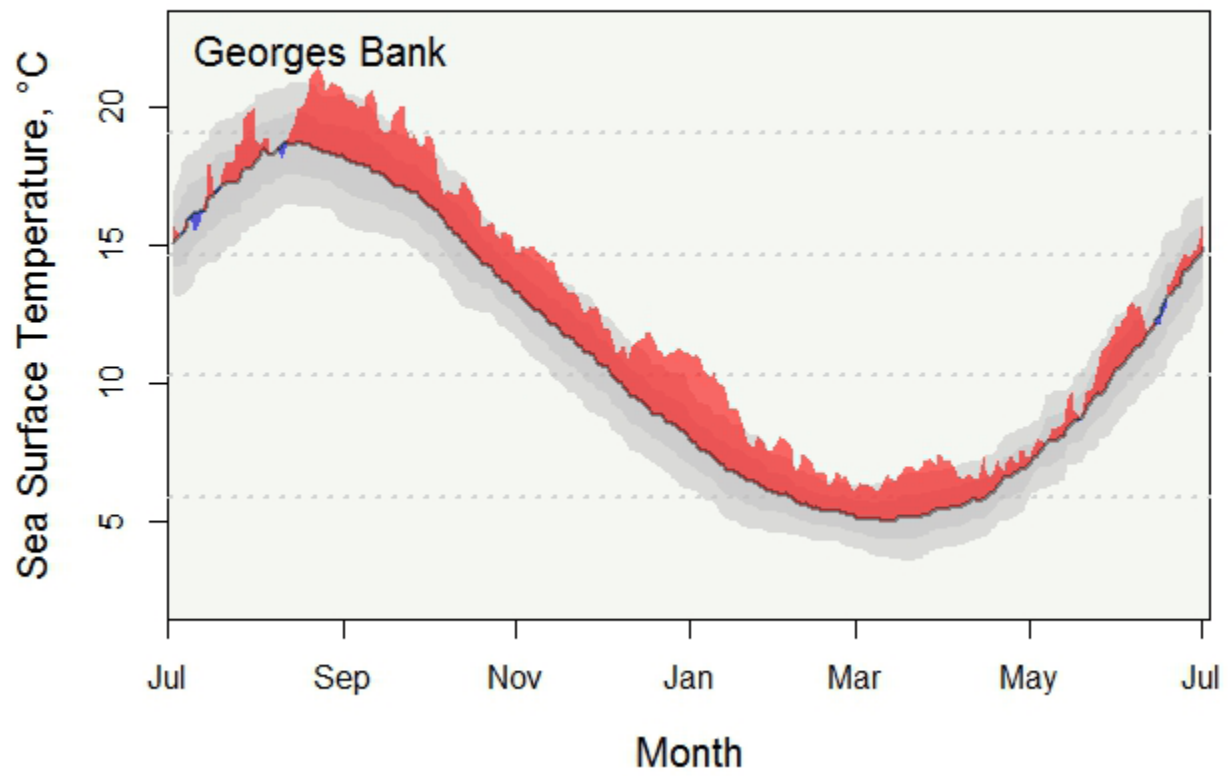
Current Conditions of the Northeast Shelf Ecosystem -- Fall 2016 Update

Summary

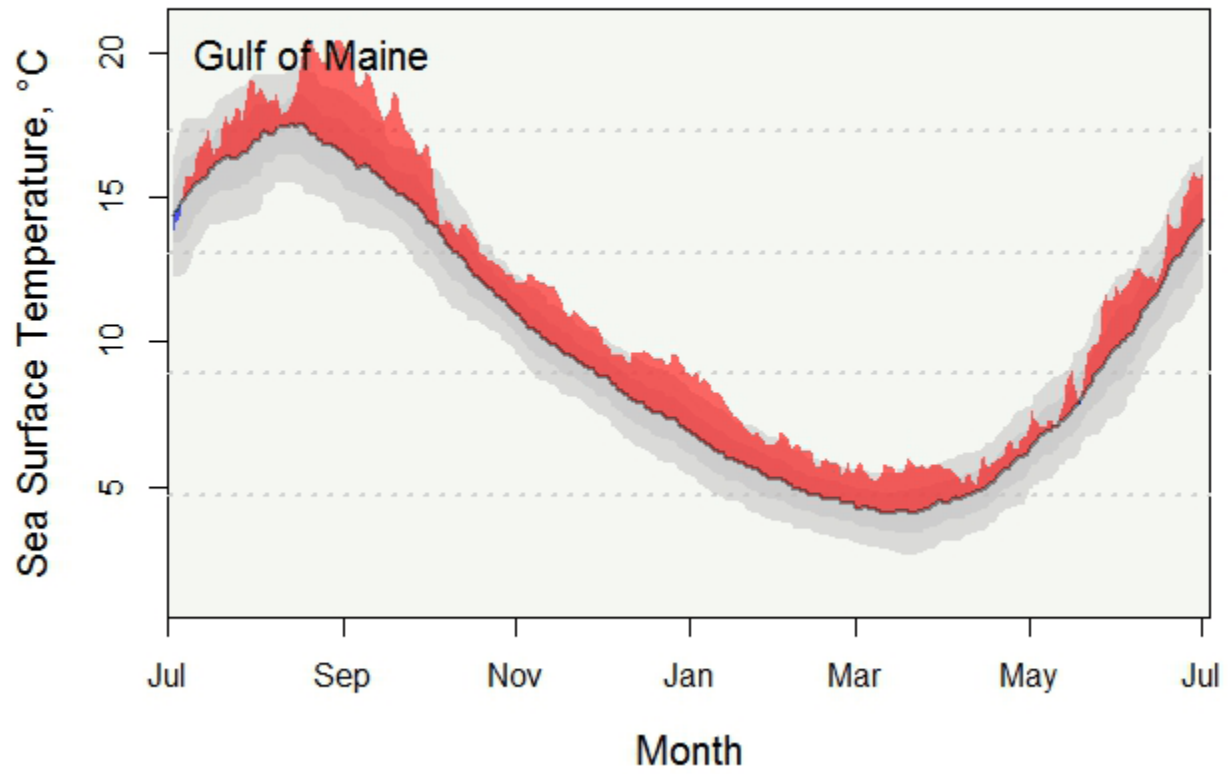
- Sea surface temperature (SST) in the Northeast Shelf Large Marine Ecosystem during the first half of 2016 continued to be moderate compared to the record high temperatures that occurred in 2012; however, temperatures remain above the long-term mean based on both contemporary satellite remote sensing data and shipboard measurements.
- Spring survey hydrocast data indicate that surface and bottom temperatures were above normal across the northeast US shelf at both the surface and the bottom. These warm conditions were likely related to warm air temperature experience during the winter of 2016.
- The spring bloom was intense (high chlorophyll concentration) but of short duration from the Middle Atlantic Bight to the Georges Bank and Scotian Shelf. The Gulf of Maine spring bloom was below average size and duration.
- Spring thermal transition dates for 2016 continue to be among the earliest dates recorded over the past three decades, the exception being the estimate for the Middle Atlantic Bight, which was closer to the average of the time series.
- The distribution of fish and invertebrate species sampled by the NEFSC bottom trawl survey has changed. Utilizing data through the spring 2016 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

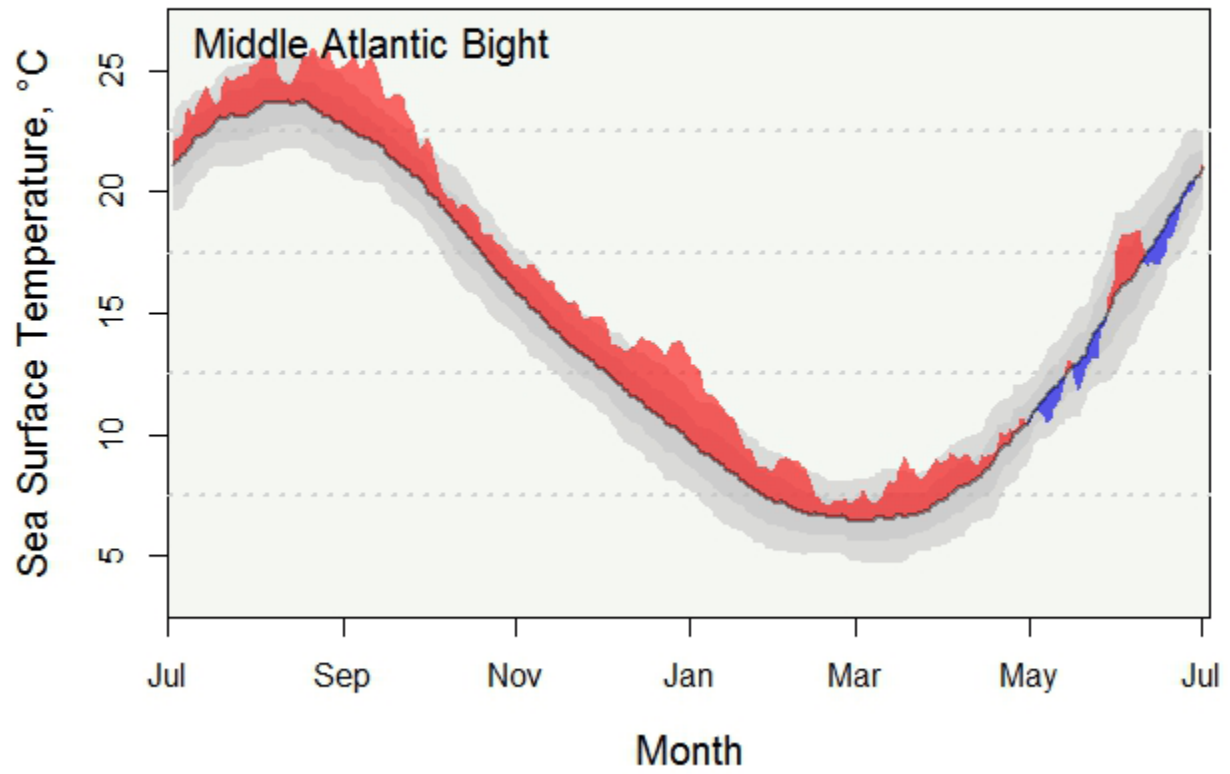
The Northeast Shelf Large Marine Ecosystem experienced average sea surface temperatures during the spring of 2016 following the trend of above average temperatures seen during fall into winter seasons. In the graphs spanning the last half of 2015 and first half of 2016, the long-term mean sea surface 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 figures](#)). SSTs below the long term mean are shown in blue; above the mean are shown in red. The warmest seasonal conditions during the first half of 2016 were found in the northern segments of the Northeast Shelf and at or below average in the Middle Atlantic Bight



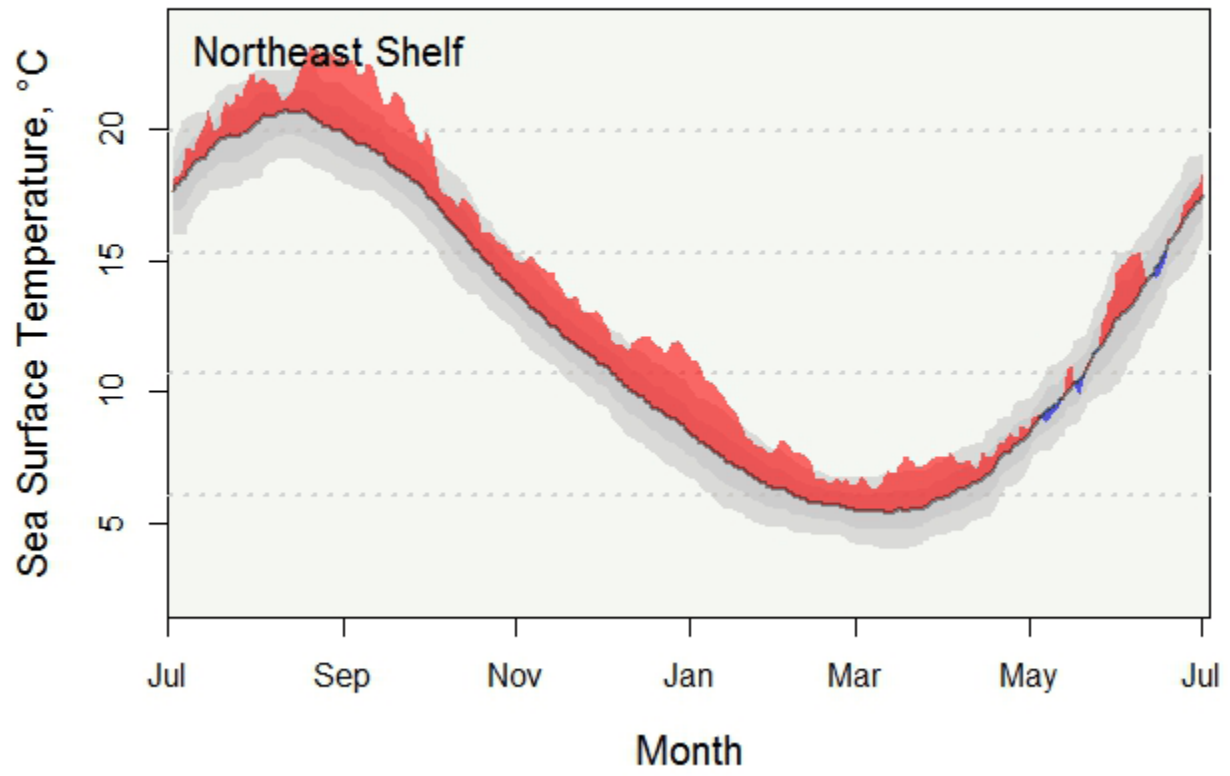
Georges Bank



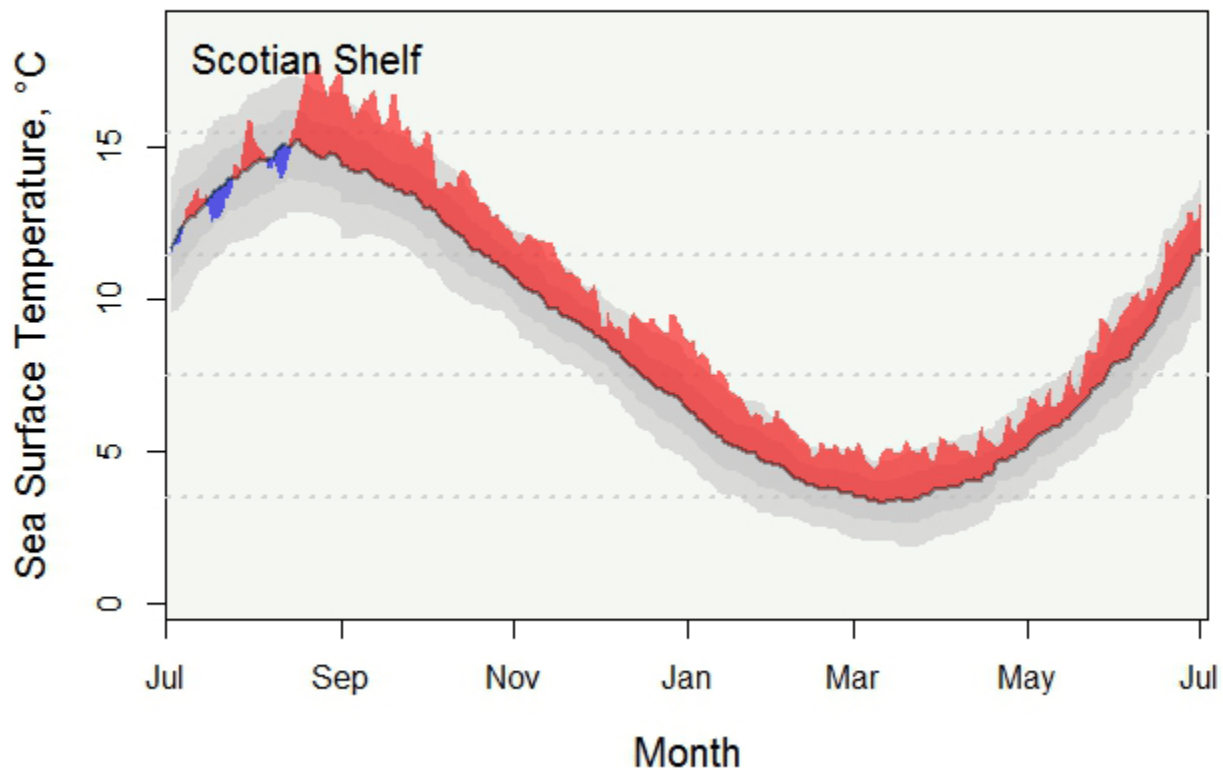
Gulf of Maine



Middle Atlantic Bight



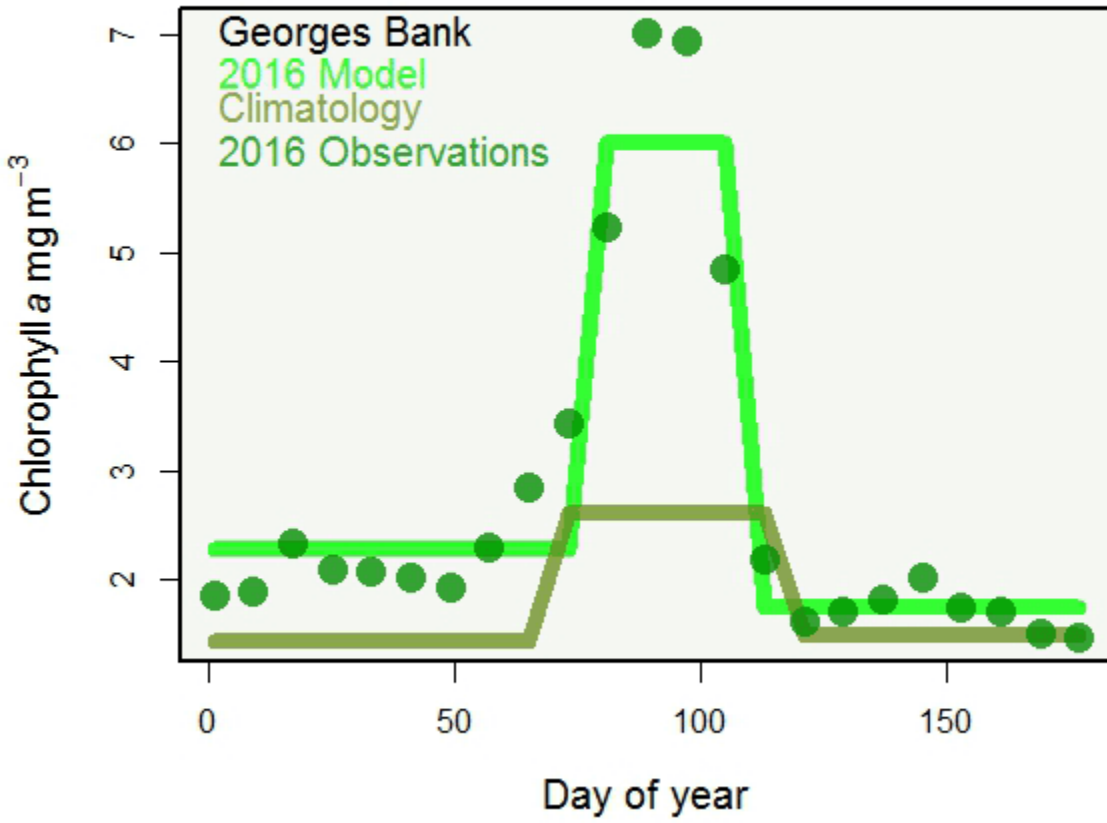
Northeast Shelf



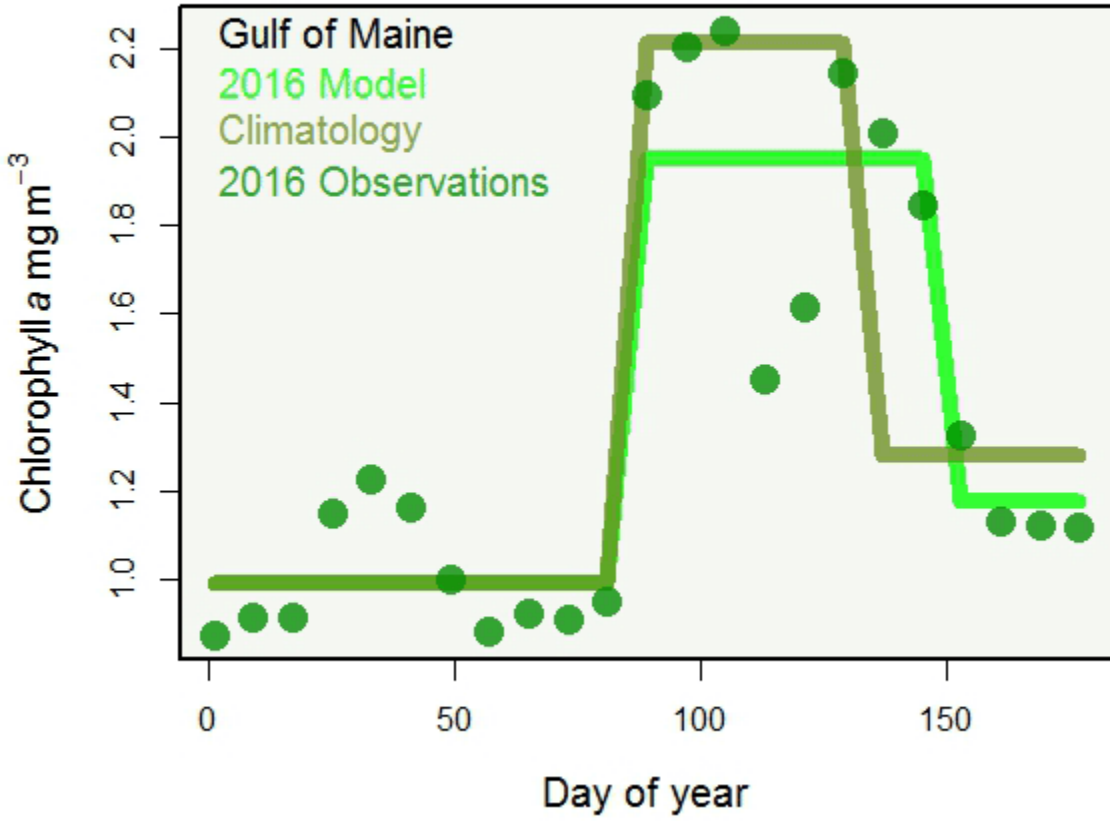
Scotian Shelf

Spring Bloom Development on the Northeast Shelf

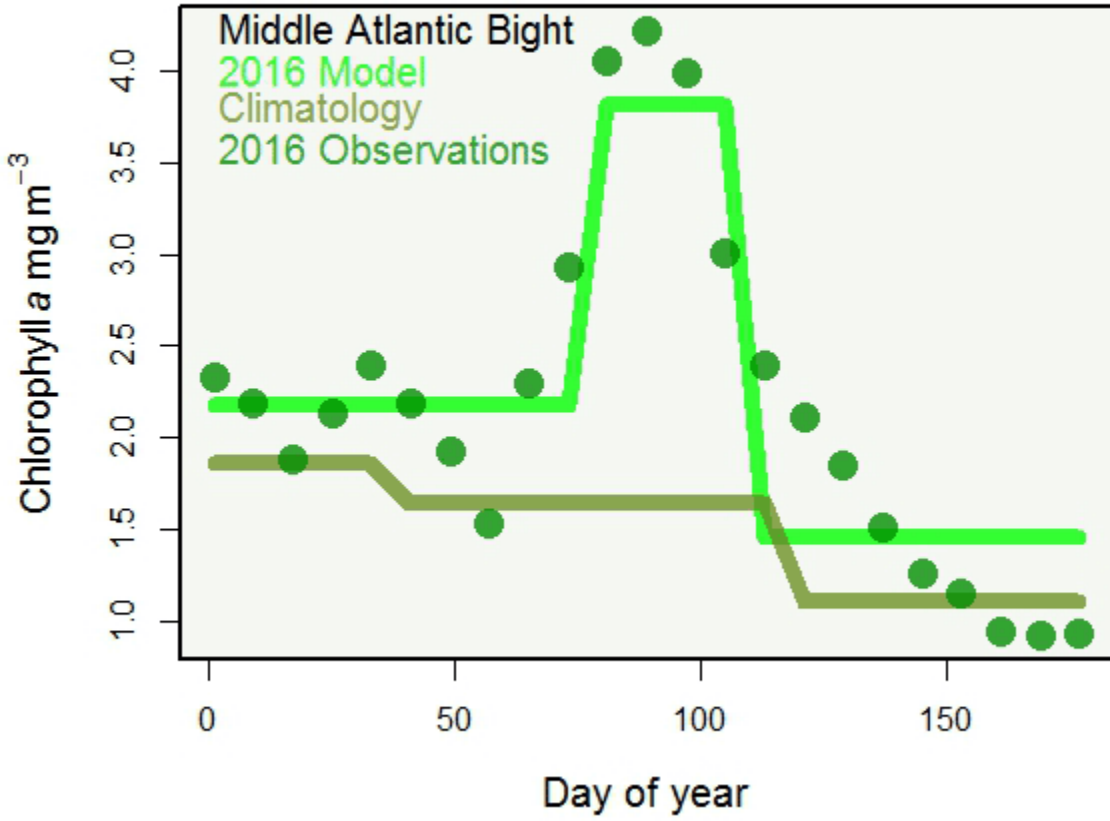
Most ecoregions of the Northeast Shelf Large Marine Ecosystem have a well-developed spring phytoplankton bloom. The impact of the spring bloom will depend on multiple factors related to the time and duration of the bloom and how productive the constituent phytoplankton species are over time. The timing and duration of 2016 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 other ecoregions](#), dark green line is long-term mean bloom pattern, light green line 2016 bloom pattern, points are for 2016 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 slightly below average in 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.



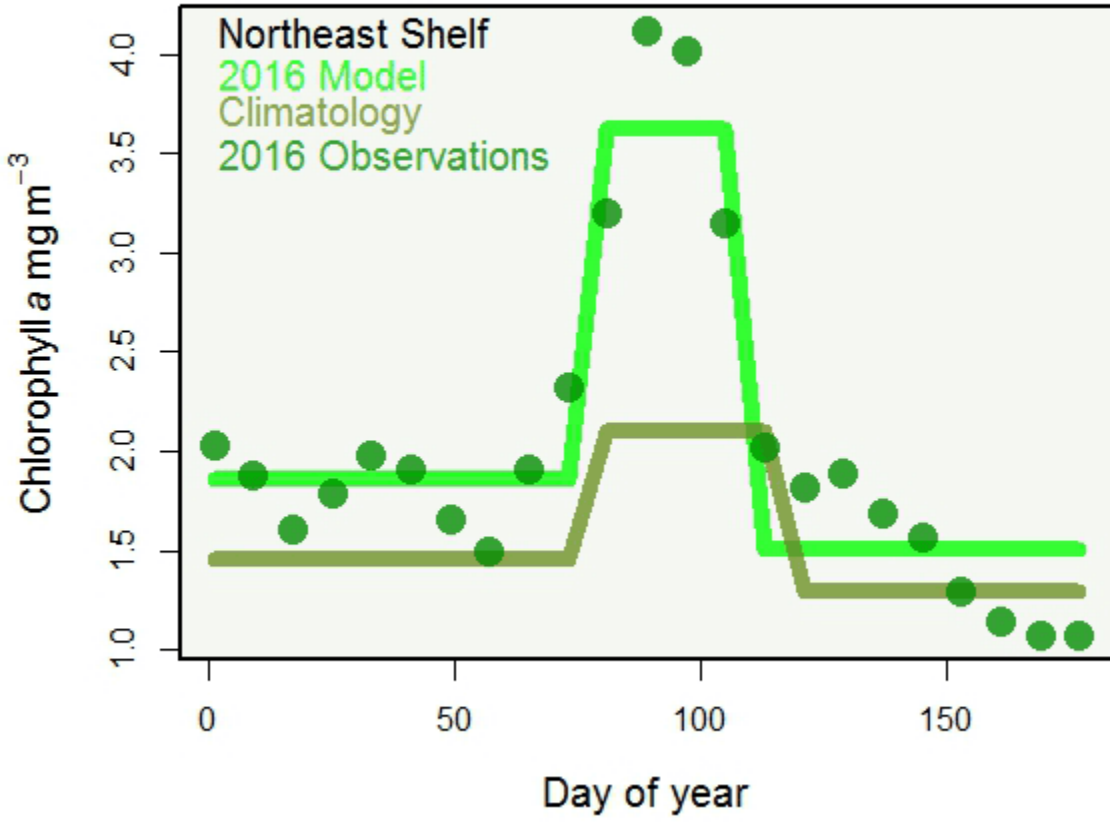
Georges Bank



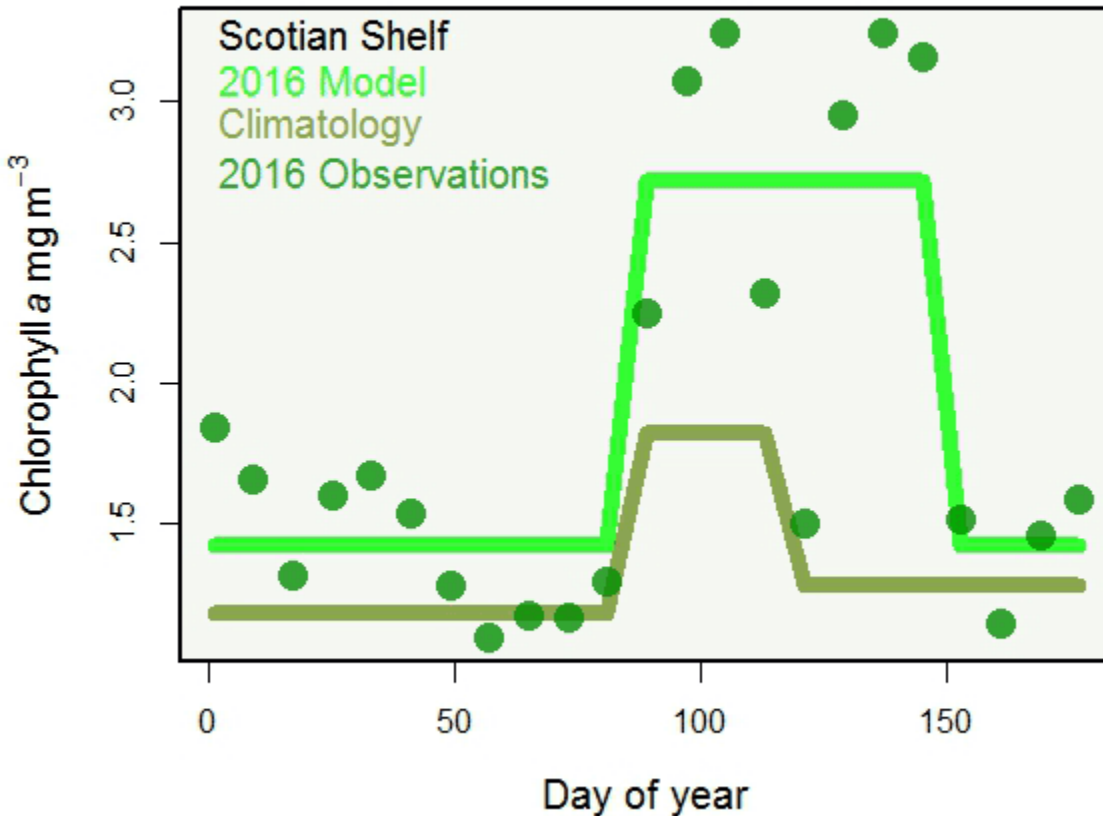
Gulf of Maine



Middle Atlantic Bight



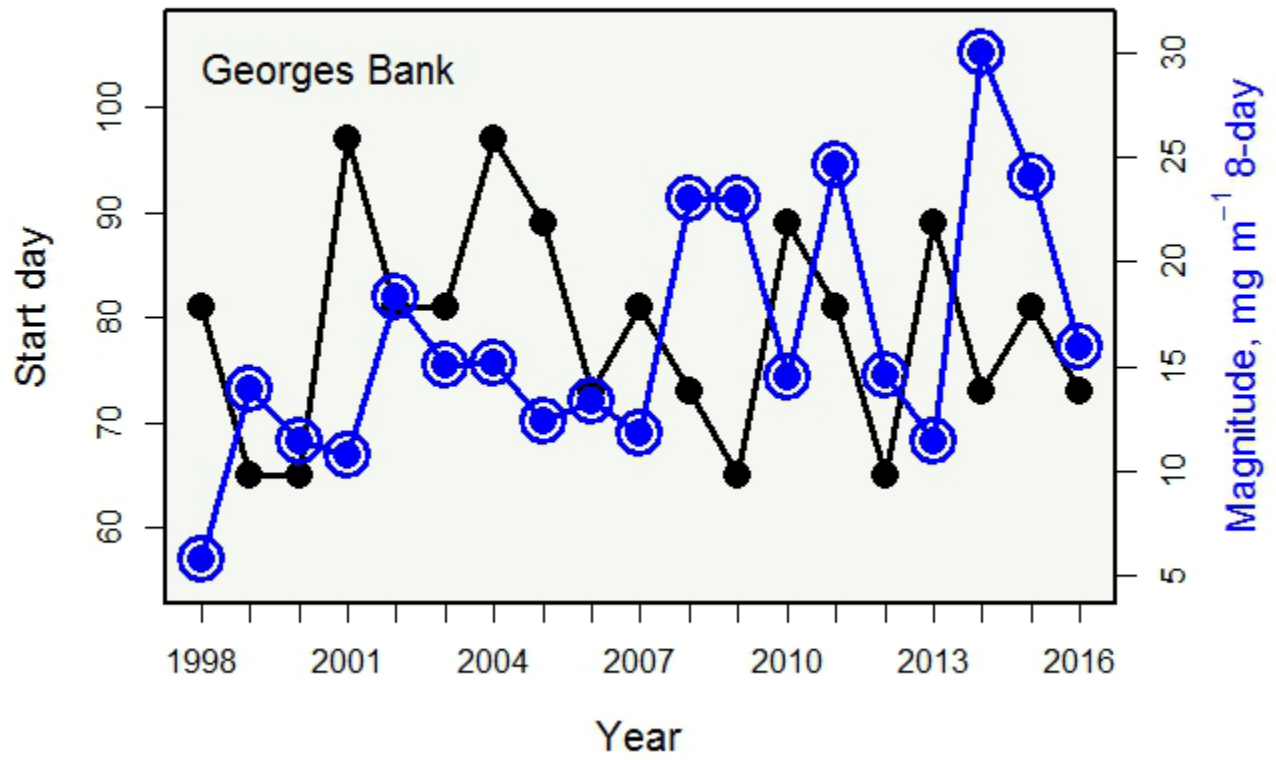
Northeast Shelf



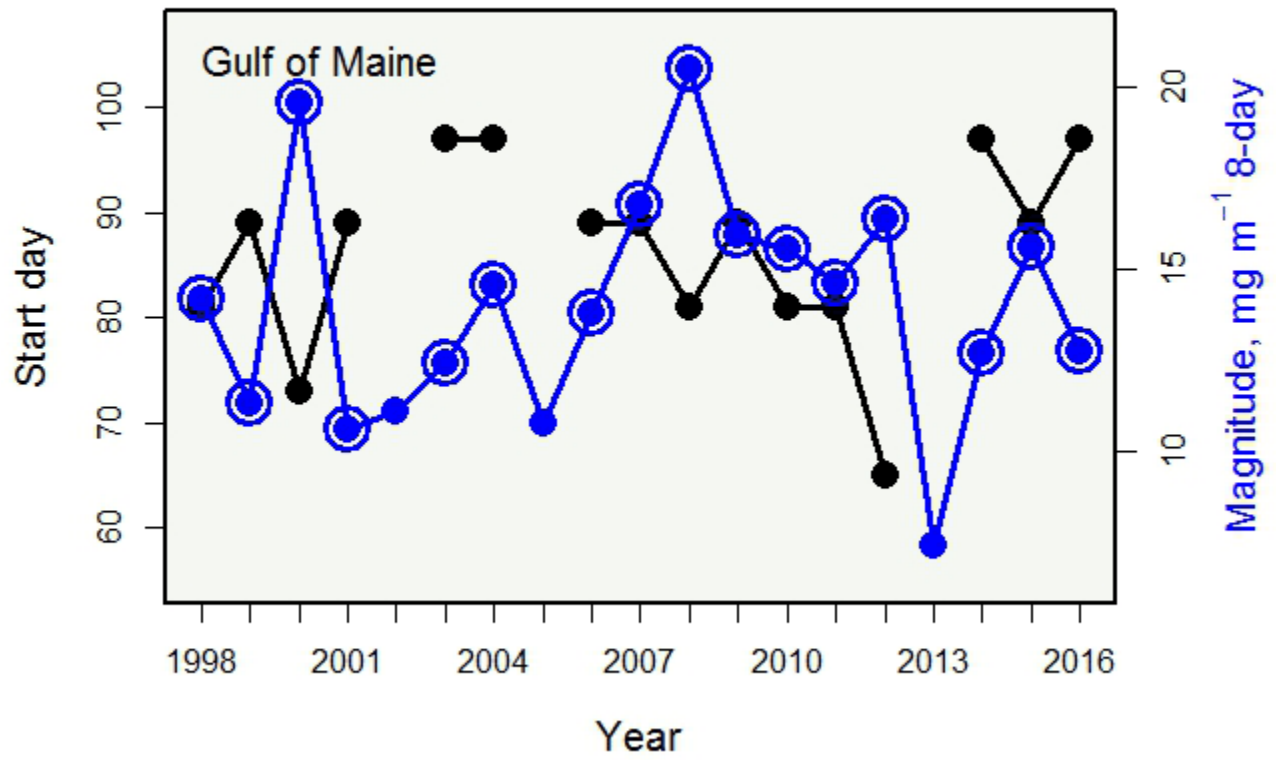
Scotian Shelf

Spring Bloom Start Day and Magnitude

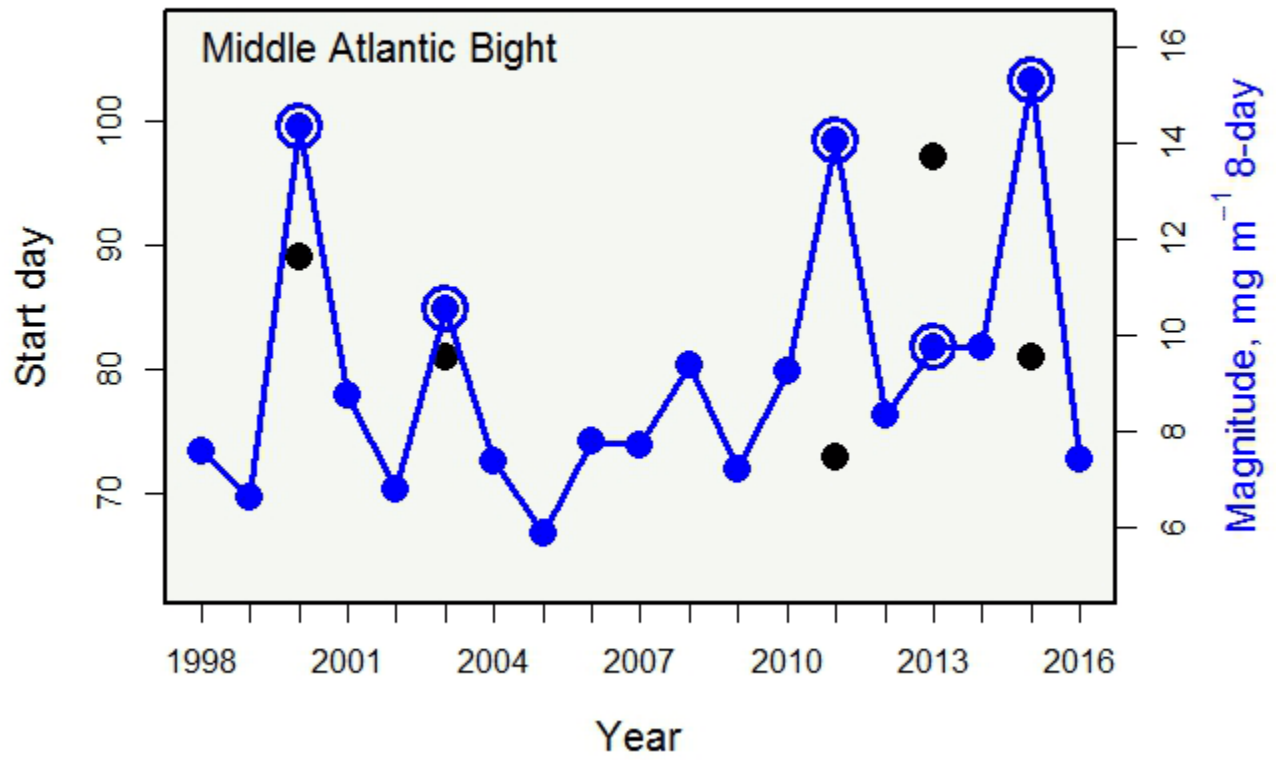
The spring bloom typically starts earlier in the more southern segments of the Northeast Shelf Large Marine Ecosystem (LME). In 2016, the Northeast Shelf composite bloom start date was in mid-March, which was close to the time series average. However, bloom magnitude was nearly 16 mg m^{-1} 8-day, which was the second lowest value in the time series. Spring bloom magnitude is one measure of bloom dimension and is calculated as the sum of chlorophyll concentrations during the bloom period. The Scotian Shelf, Georges Bank, and Middle Atlantic Bight ecoregions had low magnitude blooms due to their short duration, despite the high chlorophyll concentrations associated with these blooms. The Gulf of Maine bloom magnitude was close to the average for the time series. 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.



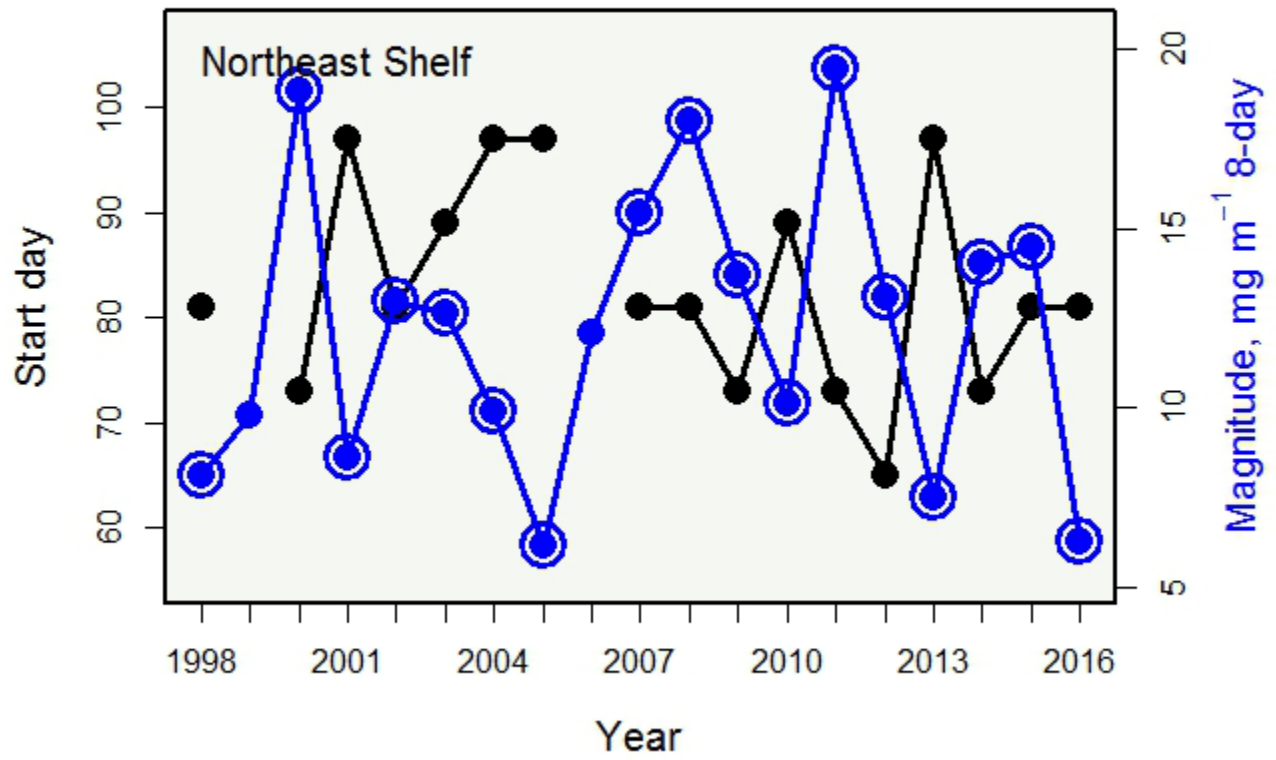
Georges Bank



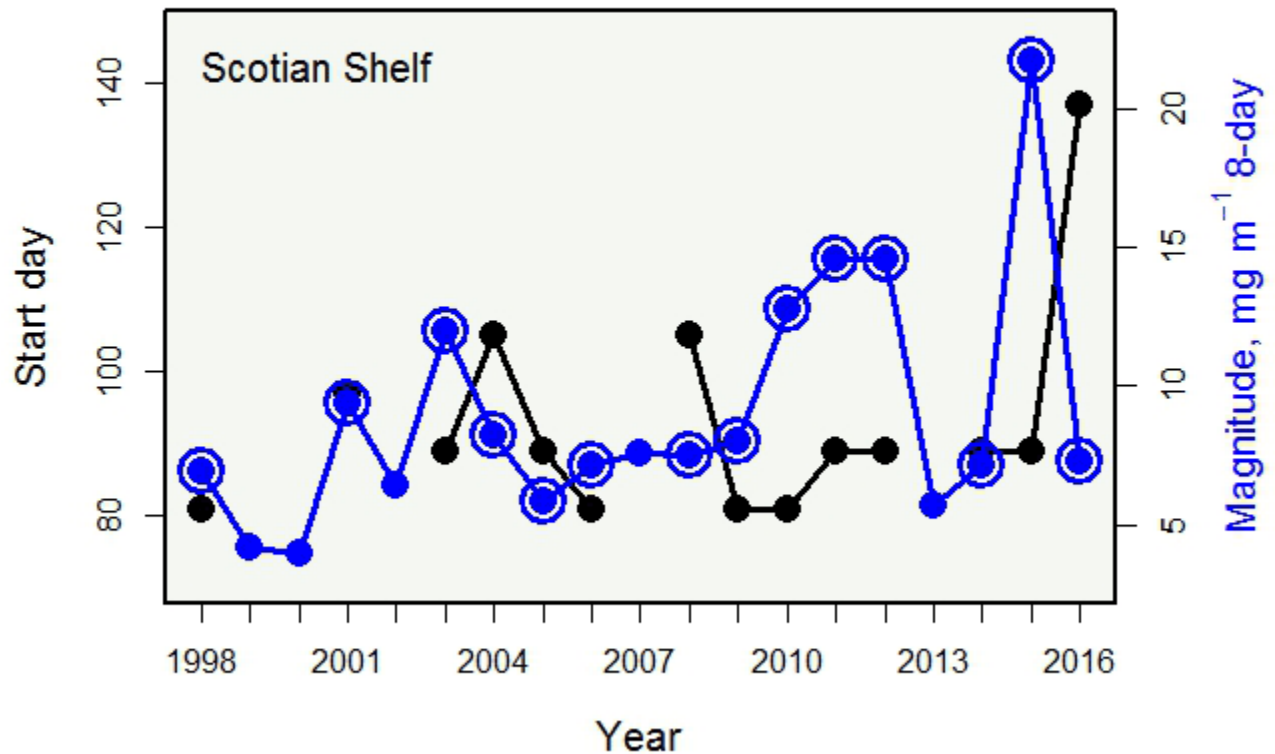
Gulf of Maine



Mid Atlantic Bight



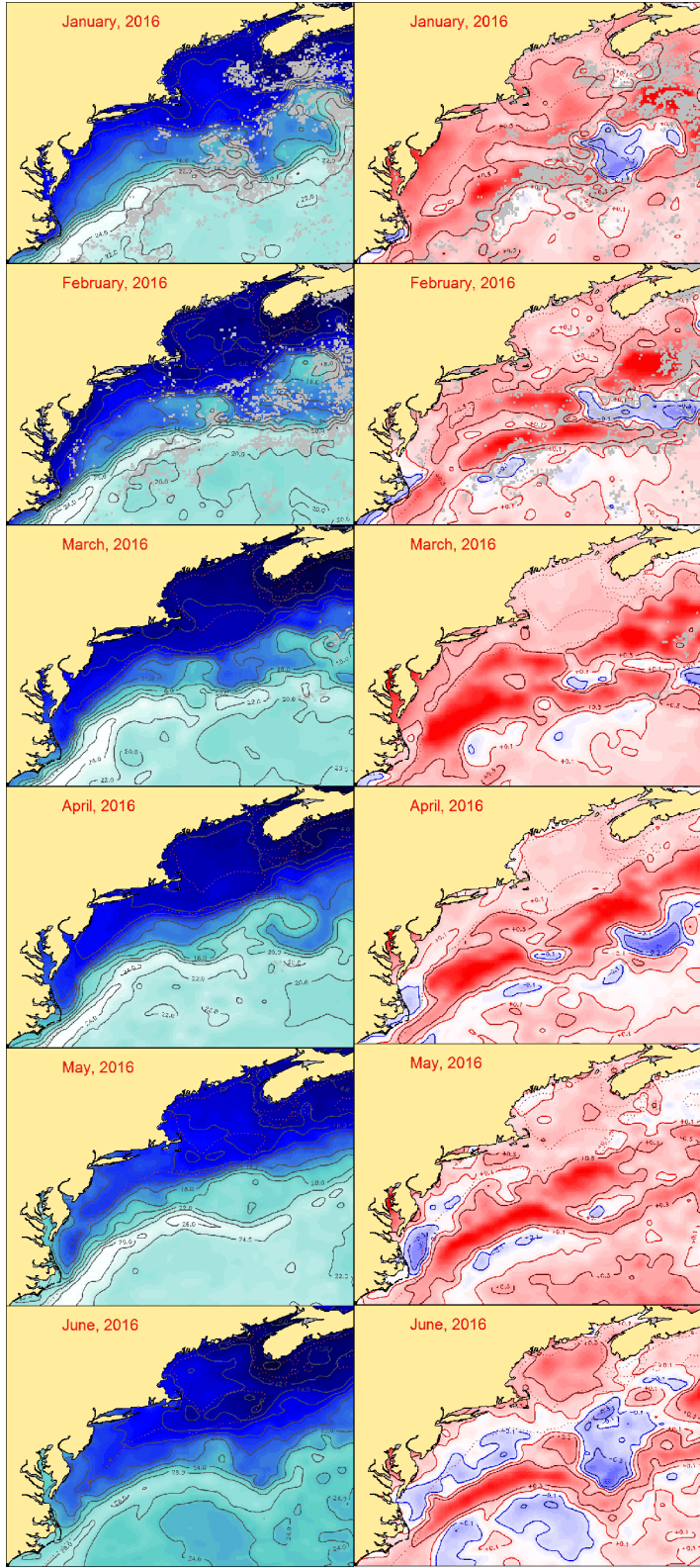
Northeast Shelf



Scotian Shelf

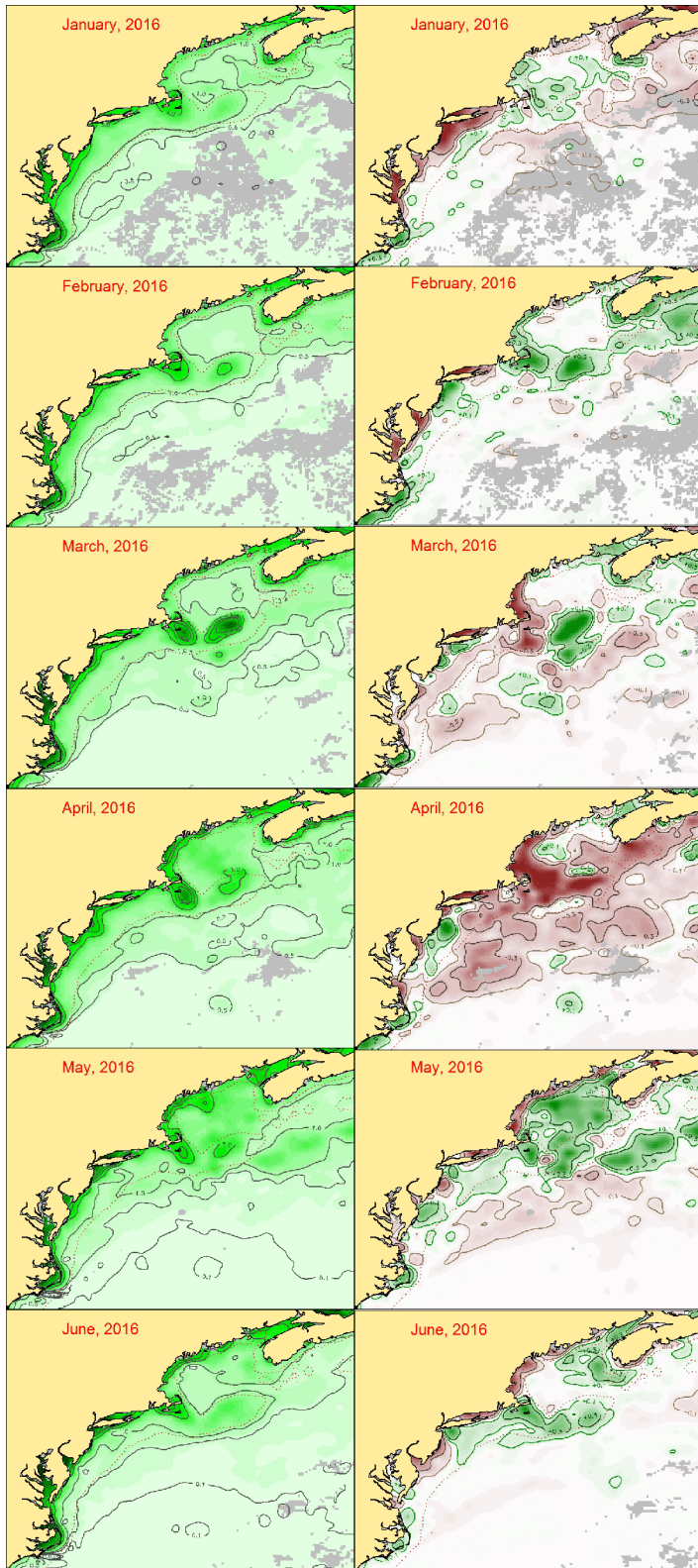
Spring Sea Surface Temperature Distribution

The progression of spring sea surface temperatures (SST) for the months of January through June is shown in the interactive figure below. SSTs appear as progressive shades of cyan to blue in the top row(s) of 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(s) of icons. This type of anomaly tends to highlight high SSTs (the red shades) and low SSTs (the blue shades) in an area. The Northeast Shelf was generally near or slightly above average SST during January. Cooler water conditions can be seen in the Middle Atlantic Bight in April, May, and June, when most of the other portions of the Shelf were at or above average.

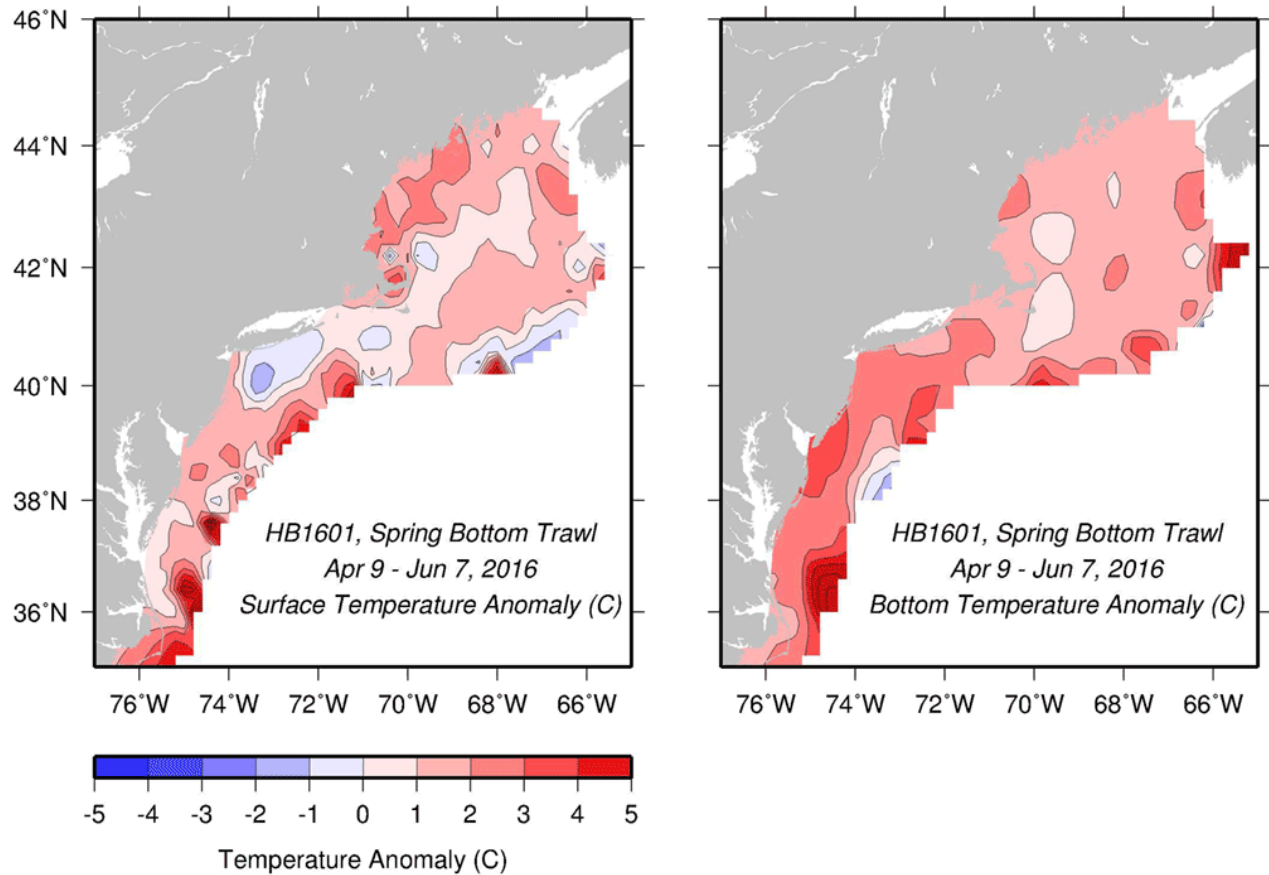


Spring Chlorophyll Distribution

The progression of spring chlorophyll concentrations for the months of January through June are shown in the interactive figure on this page. Chlorophyll concentrations appear as progressive shades of green in the top row(s) of 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(s) of icons. The short duration spring blooms along the Northeast Shelf can be seen developing first on Georges Bank in March and along the New Jersey coast in April. Since these blooms lasted less than one month and occurred during a period spanning March into April, they do not appear to register prominently in the monthly chlorophyll images.



Spring Temperature from Survey



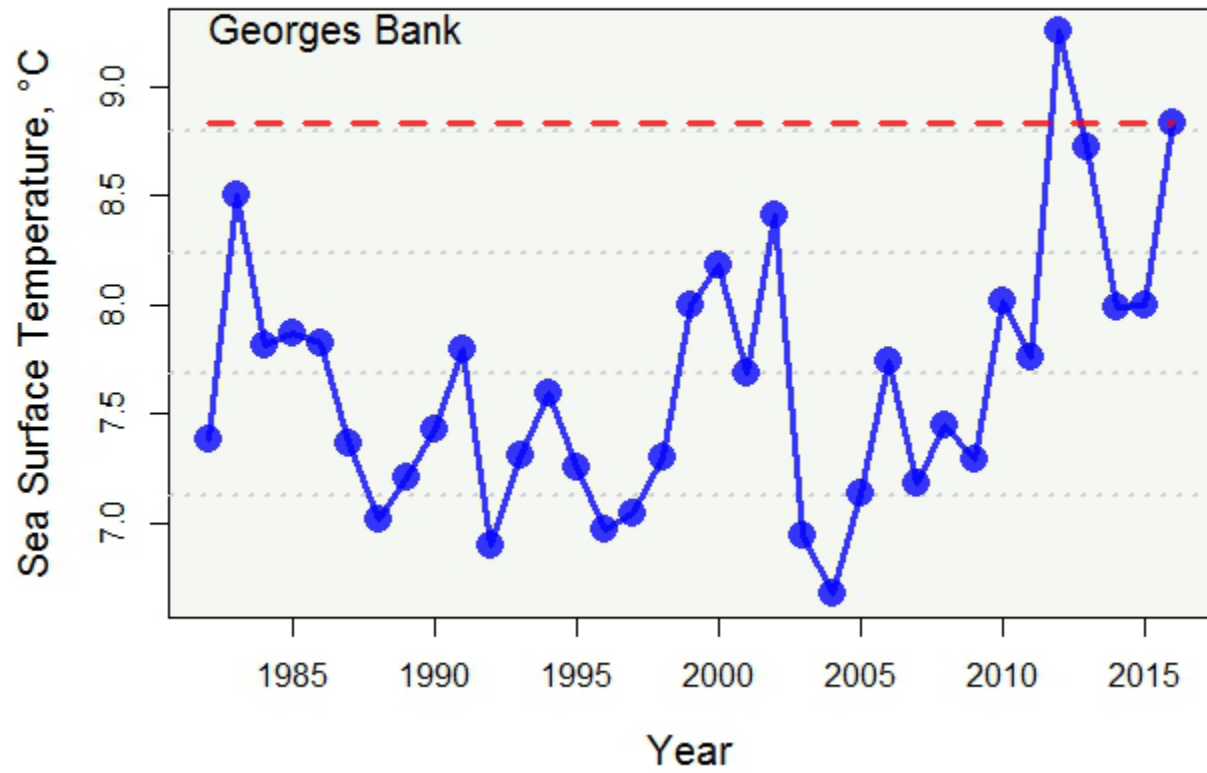
Spring 2016 temperature anomalies

During Spring 2016, ocean temperatures averaged warmer than normal across the Northeast US Shelf at both the surface and bottom (relative to 1977-1987). Warming was enhanced near the bottom, with **anomalies** exceeding 1°C throughout the Gulf of Maine and 2°C over much of the Middle Atlantic Bight. Warming at the bottom is consistent with the prevalence of anomalously warm air temperatures observed over the Northeastern US during winter this year. In addition, isolated warm anomalies along the outer shelf probably reflect the influence of shoreward intruding slope waters at these locations. Air temperatures over the region were cooler than normal beginning in April. This may explain the modulation of warming at the sea surface relative to the bottom, as sea surface temperatures respond more directly to atmospheric influences.

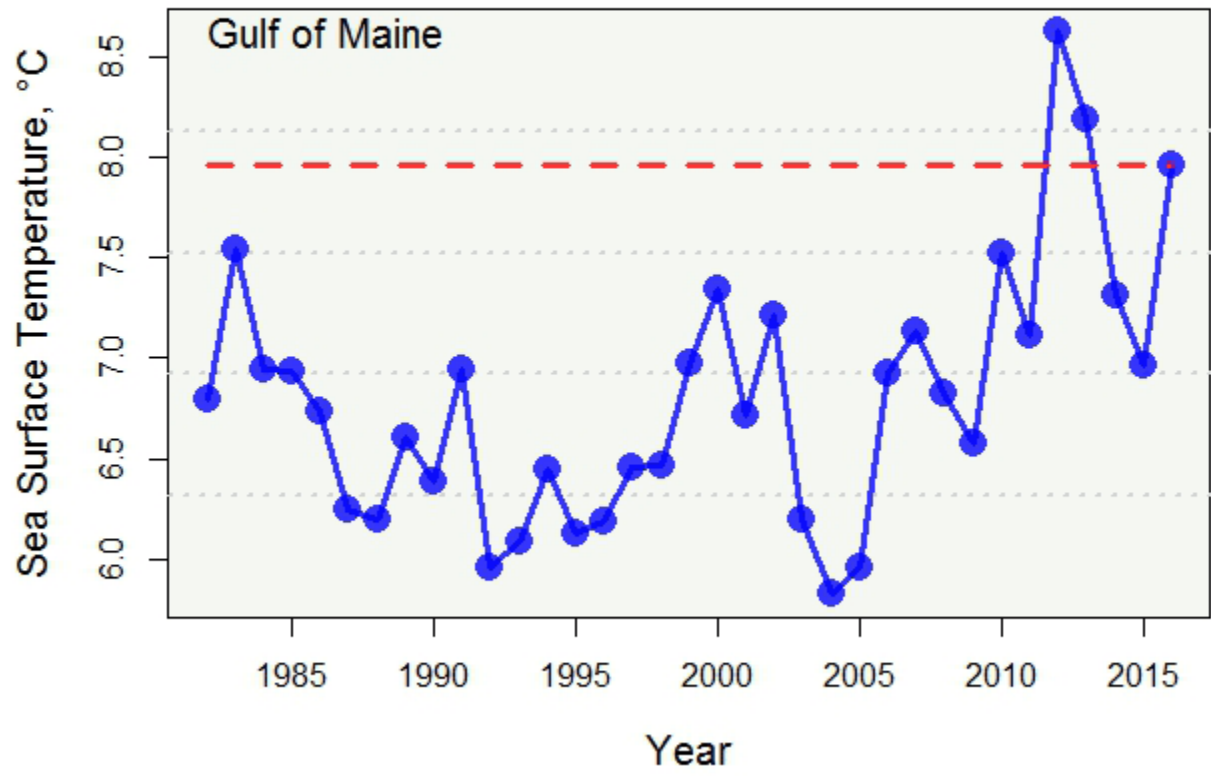
Satellite SST for the First Half of the Year

The Optimum Interpolation Sea Surface Temperature (OISST) data are based on satellite measurements and provide high spatial and temporal resolution depictions of temperature trends. The SST conditions for the first half of 2016 were generally **above average levels in all ecoregions**. The temperatures in the Scotian Shelf and on Georges Bank were the second highest

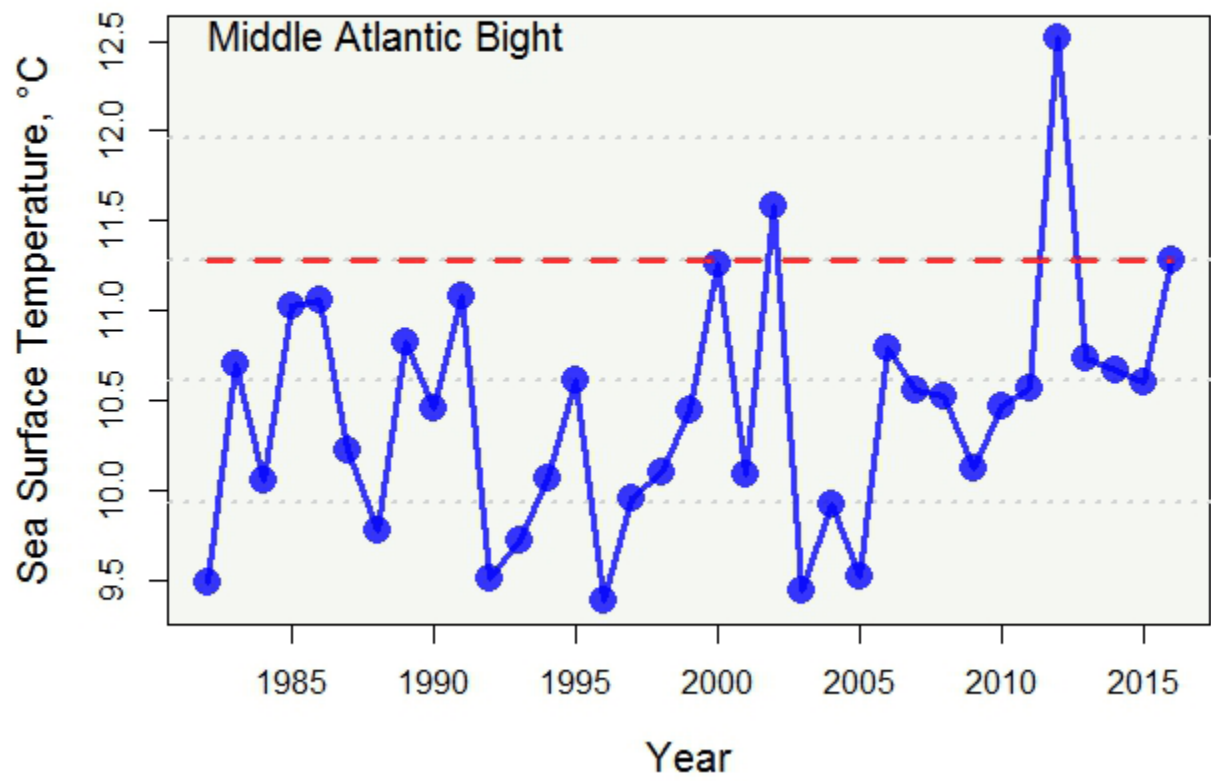
in these time series, whereas temperatures in other segments of the ecosystem were among the highest.



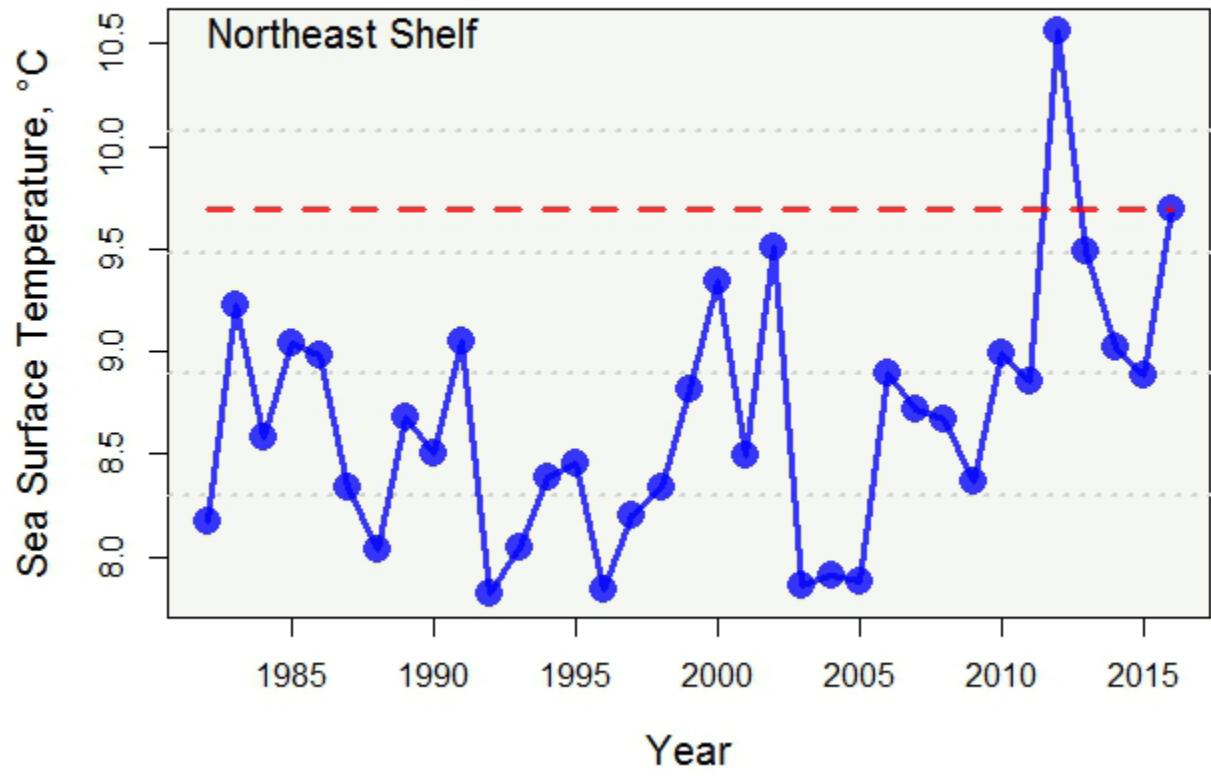
Georges Bank



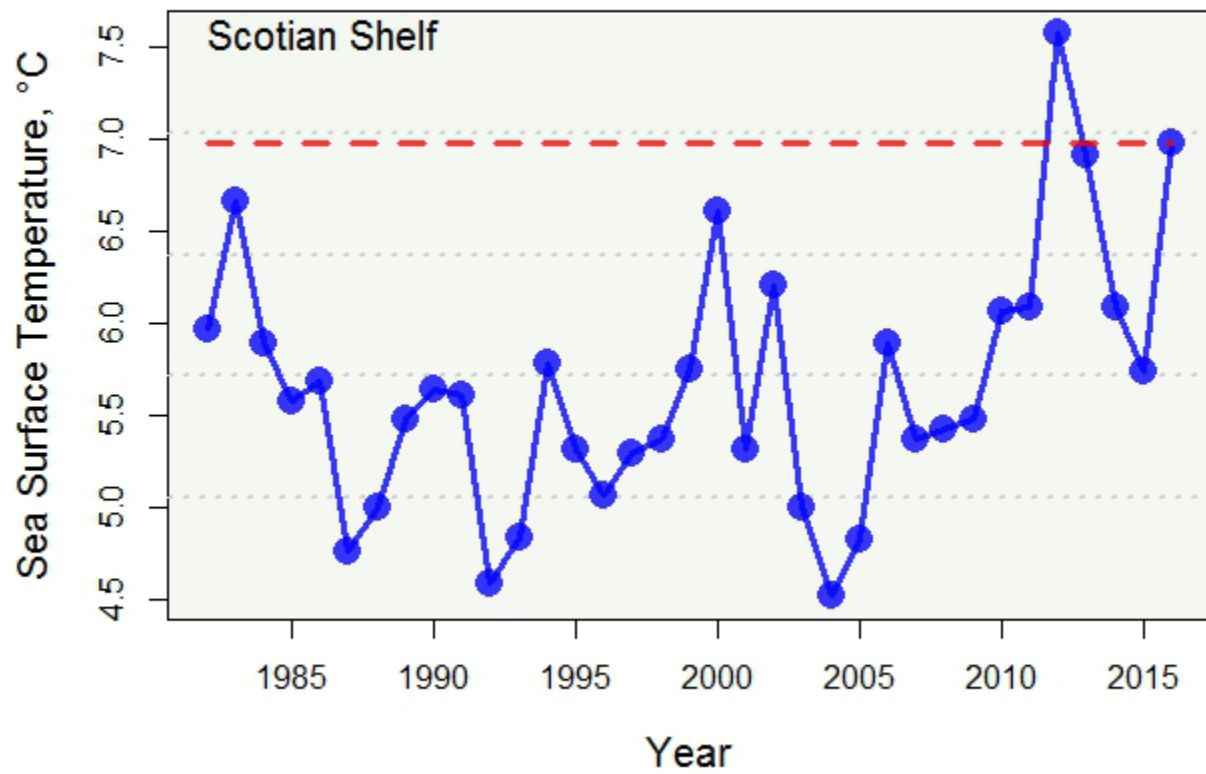
Gulf of Maine



Mid Atlantic Bight

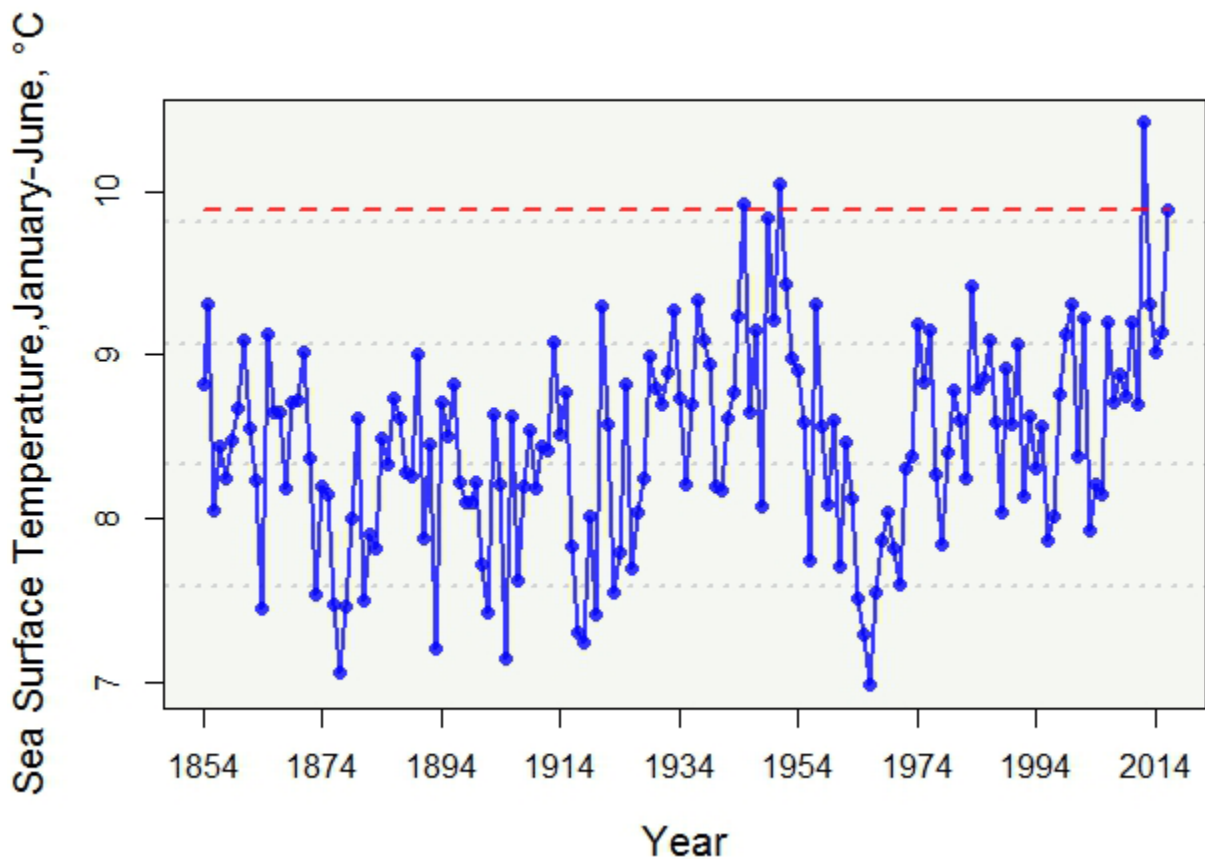


Northeast Shelf



Scotian Shelf

Extended Reconstruction SST for First Half Year



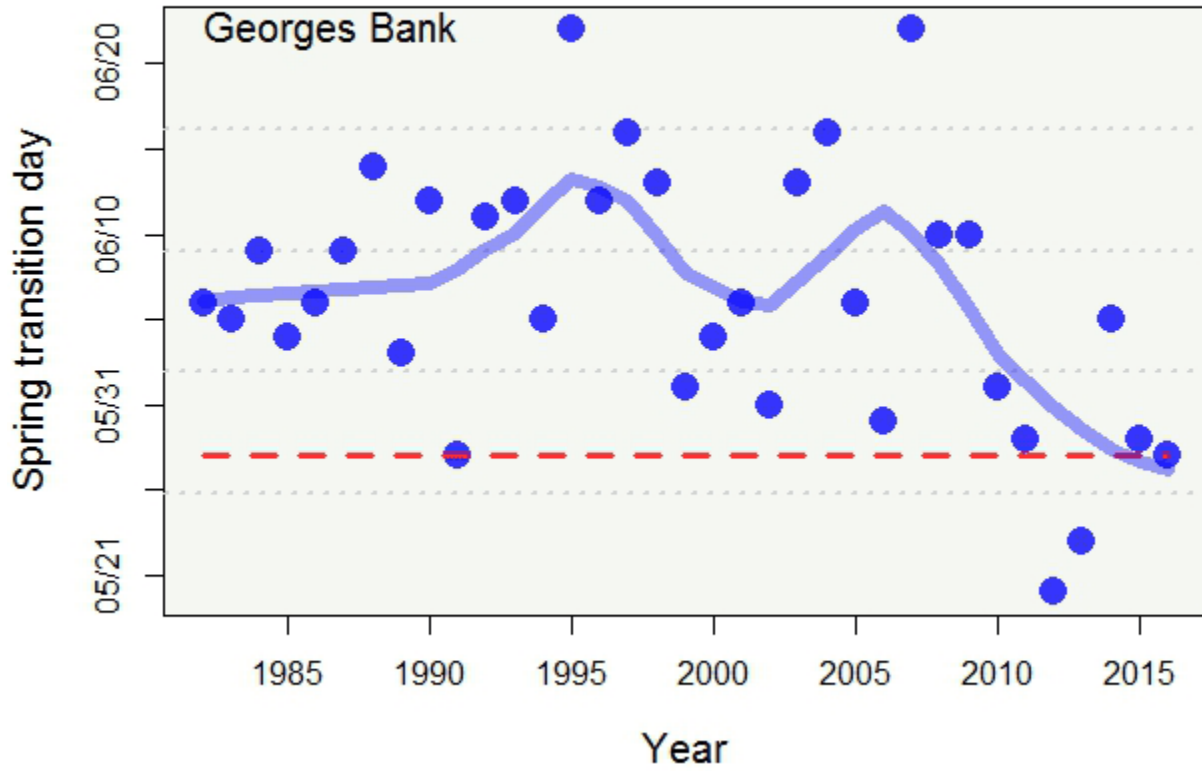
ERSST

The Extended Reconstruction Sea Surface Temperatures (ERSST) **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 2016 were above average and generally match the sea surface temperatures seen during the warm period of the late 1940s and early 1950s.

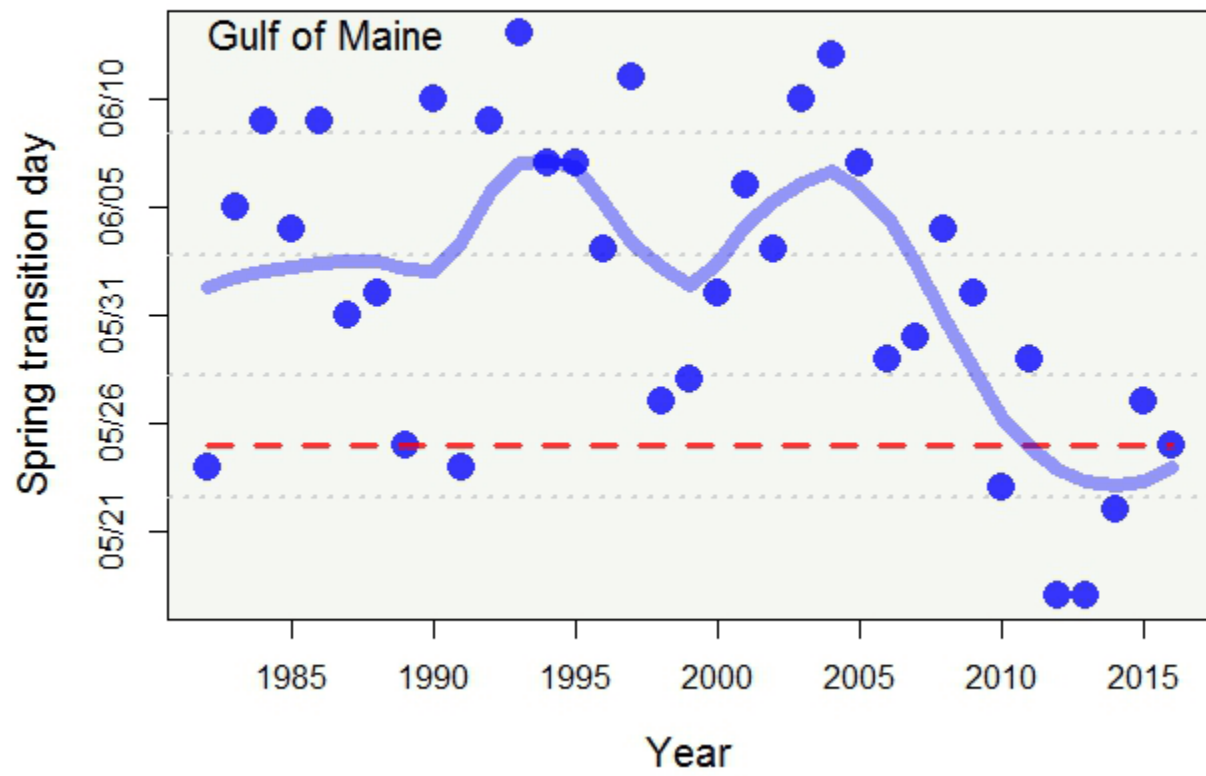
Spring Thermal Transition Date

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 was relatively constant since 1982 to approximately 2006 for the Northeast Shelf as a whole and its constituent ecoregions ([see figures](#)). Since 2006, spring

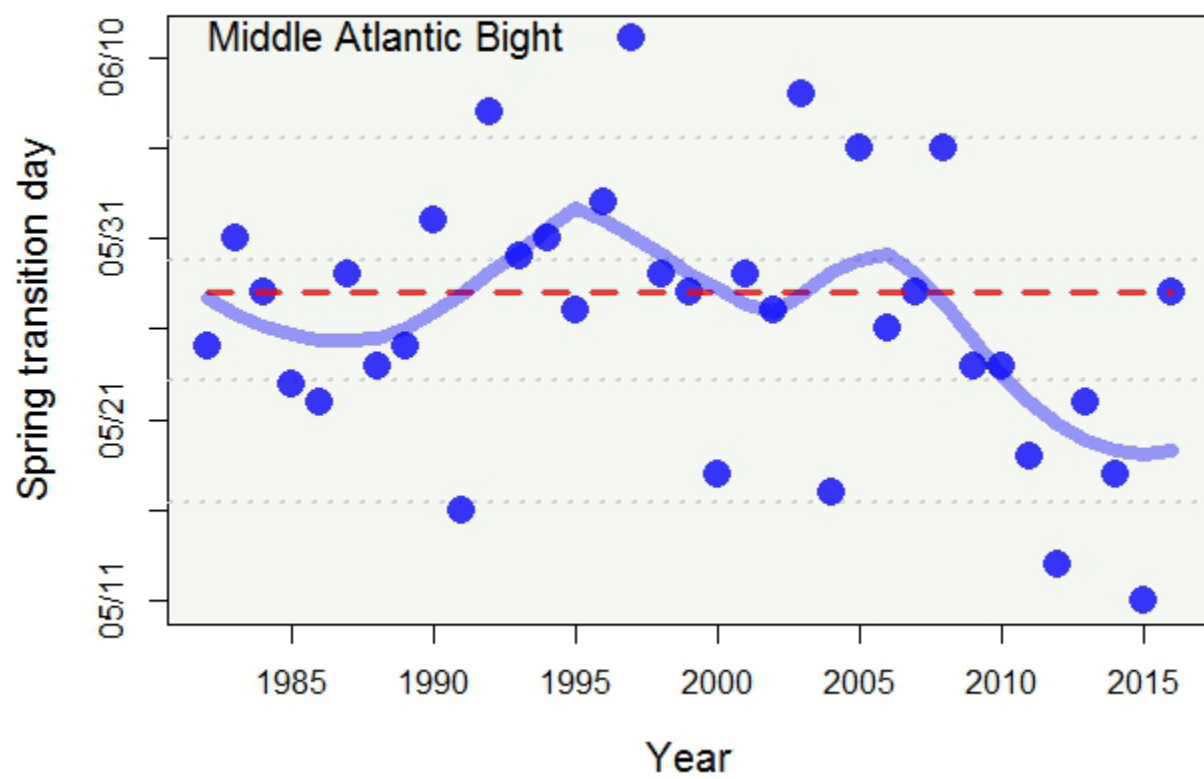
transition date has advanced on the order of two weeks. The 2016 spring transition dates continue the trend of early spring transition seen in recent years.



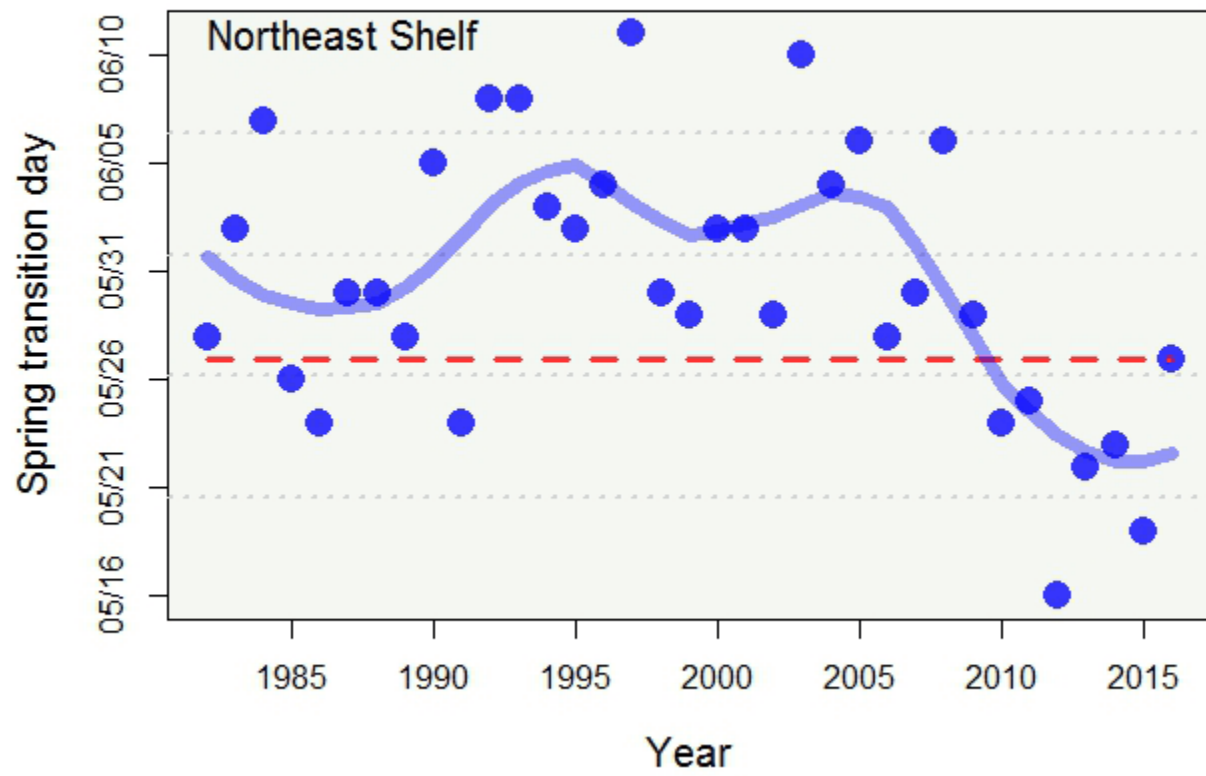
Georges Bank



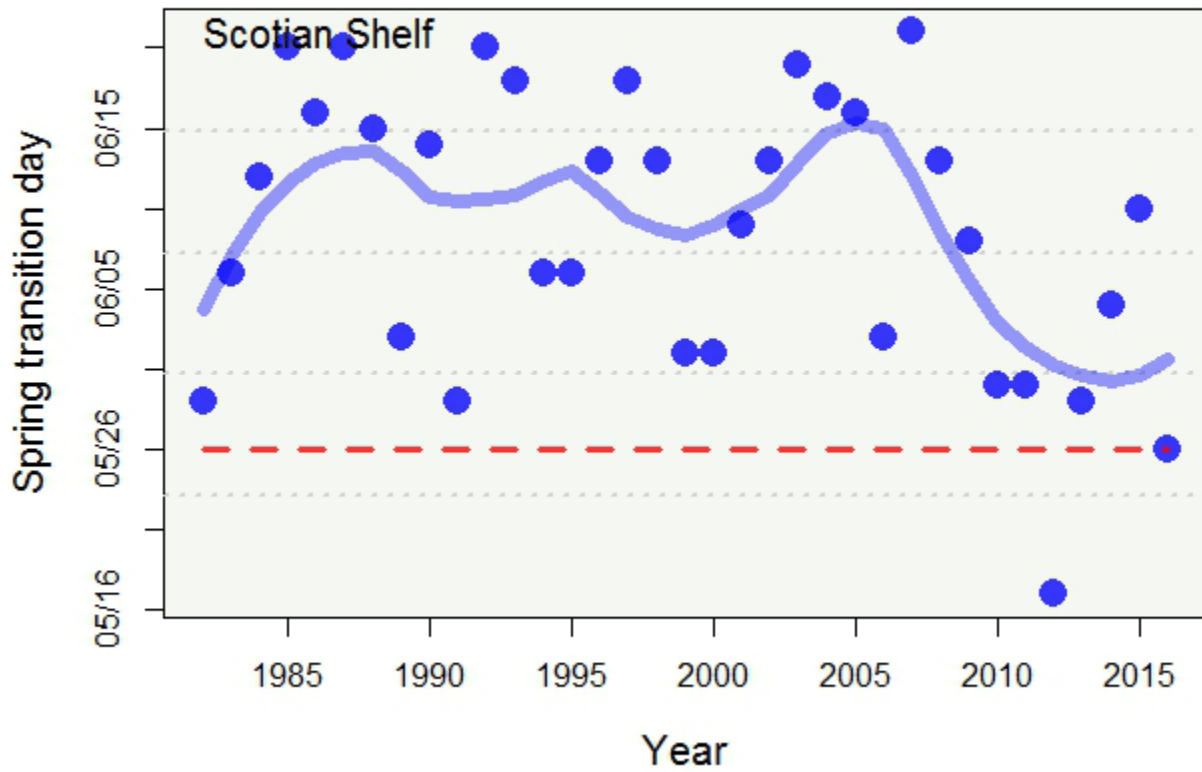
Gulf of Maine



Mid Atlantic Bight

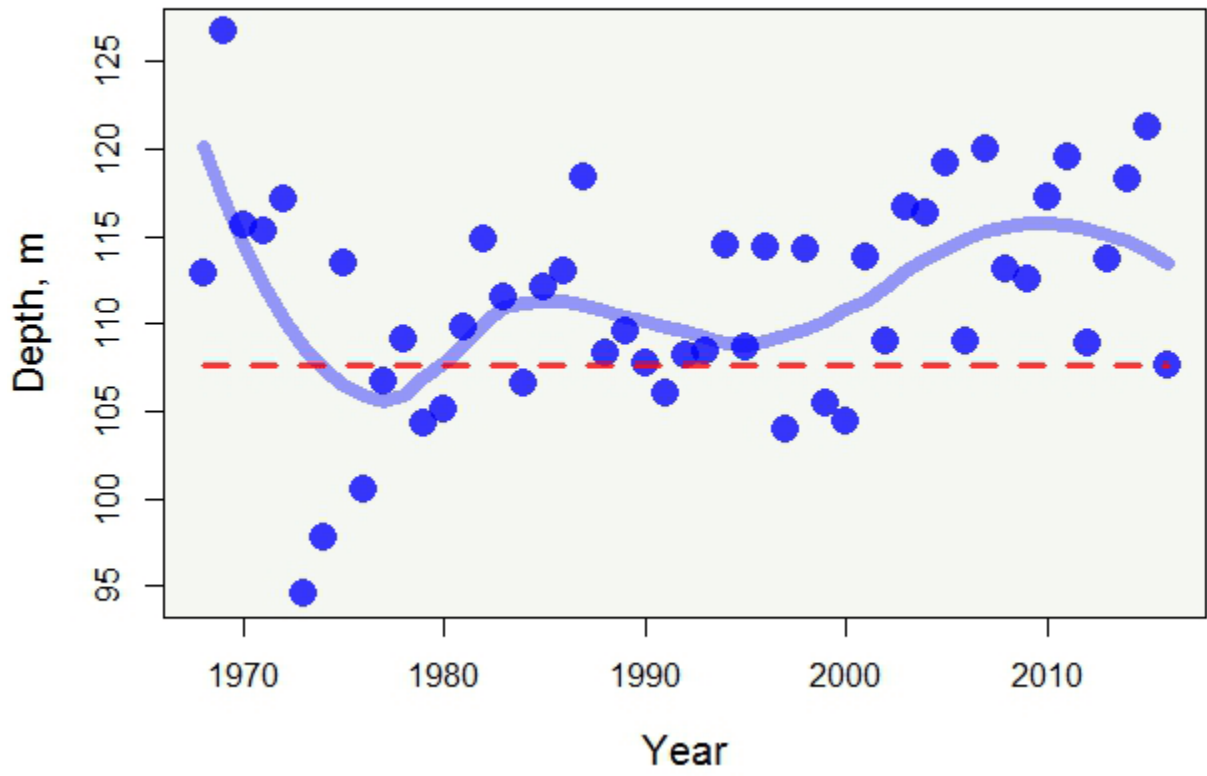


Northeast Shelf

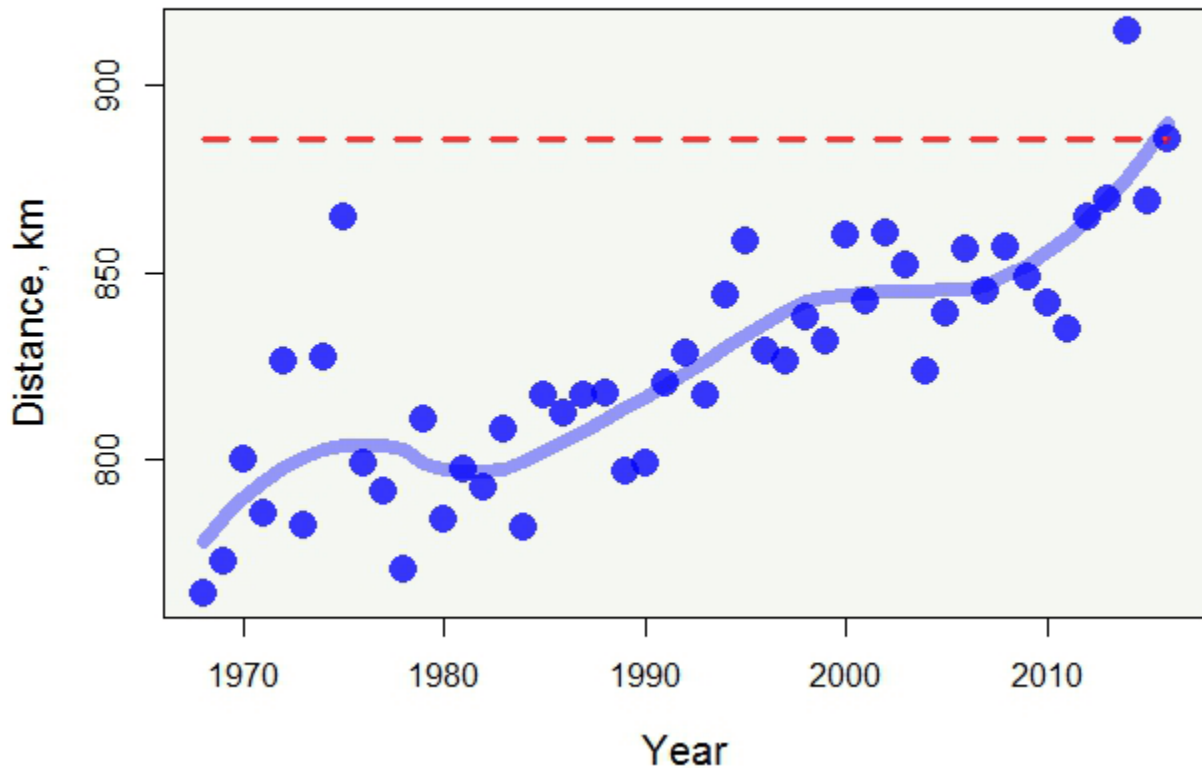


Scotian Shelf

Trends in Spring Species Distribution



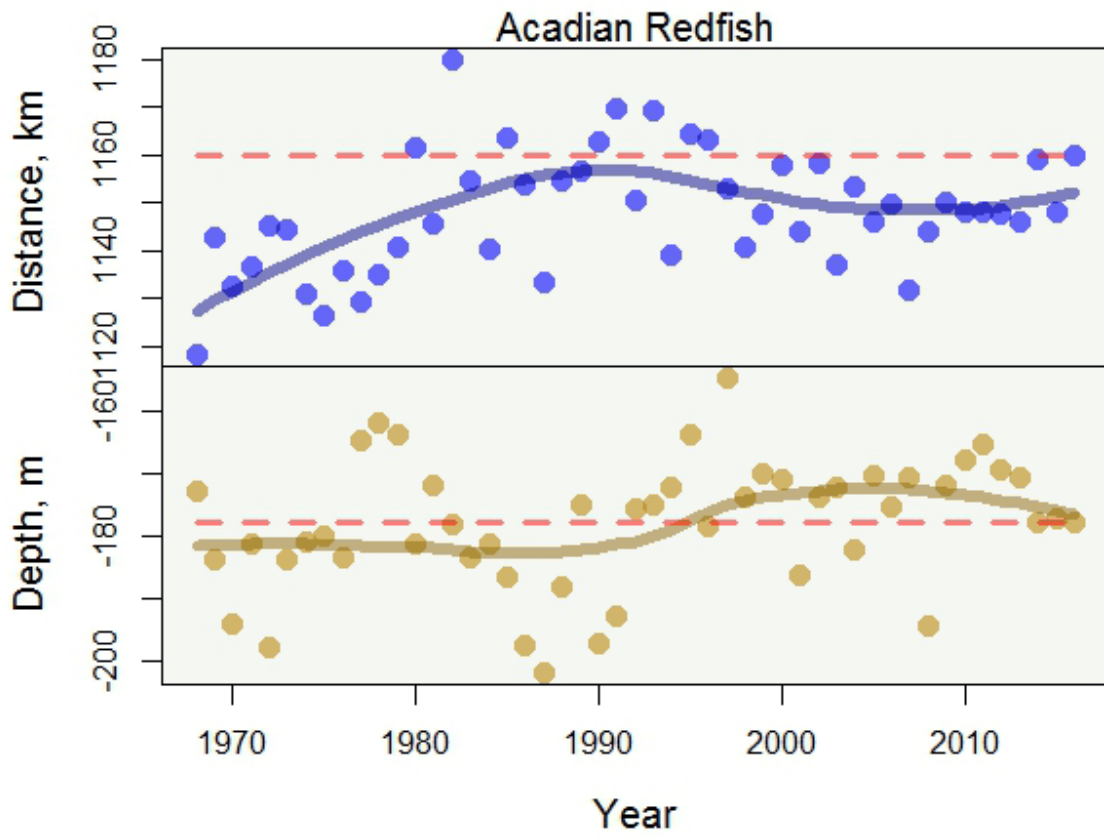
Along-shelf depth trend



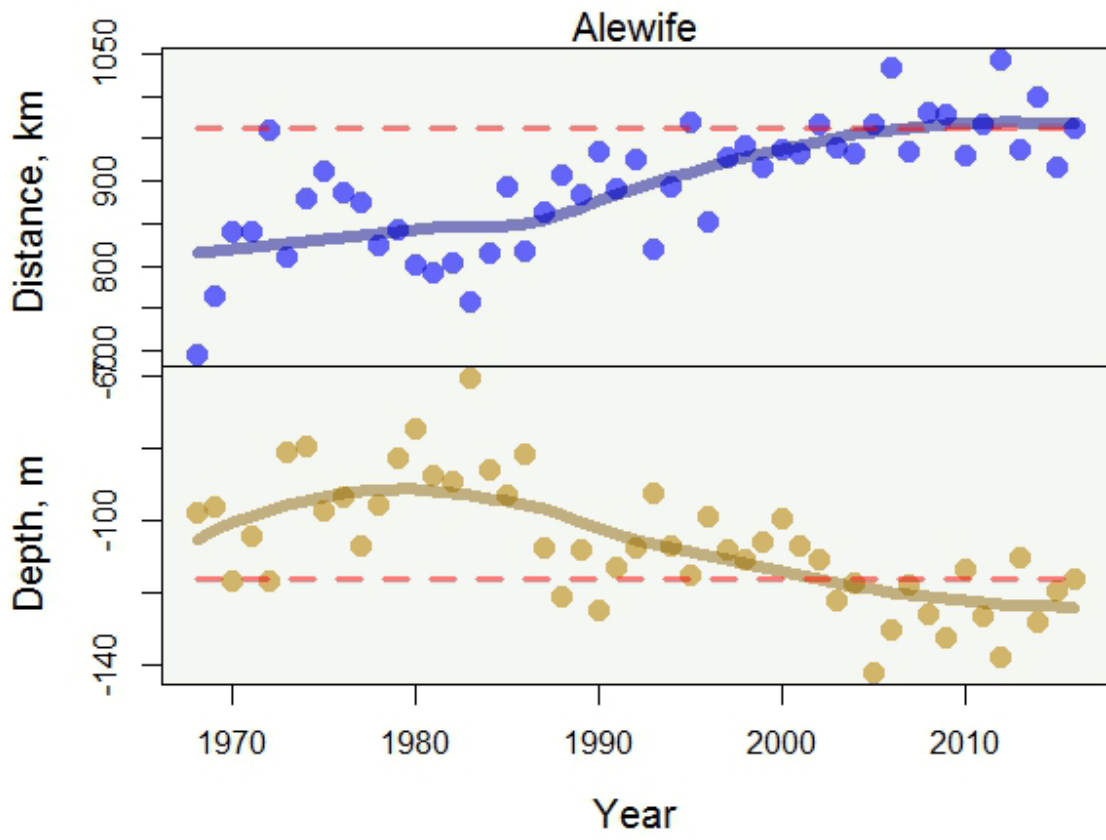
Along-shelf distance trend

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 the southwest to the 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. 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 790 km at the beginning of the time series. They now have a distance of over 880 km. There has been little change in the depth distribution of these species during the spring survey.

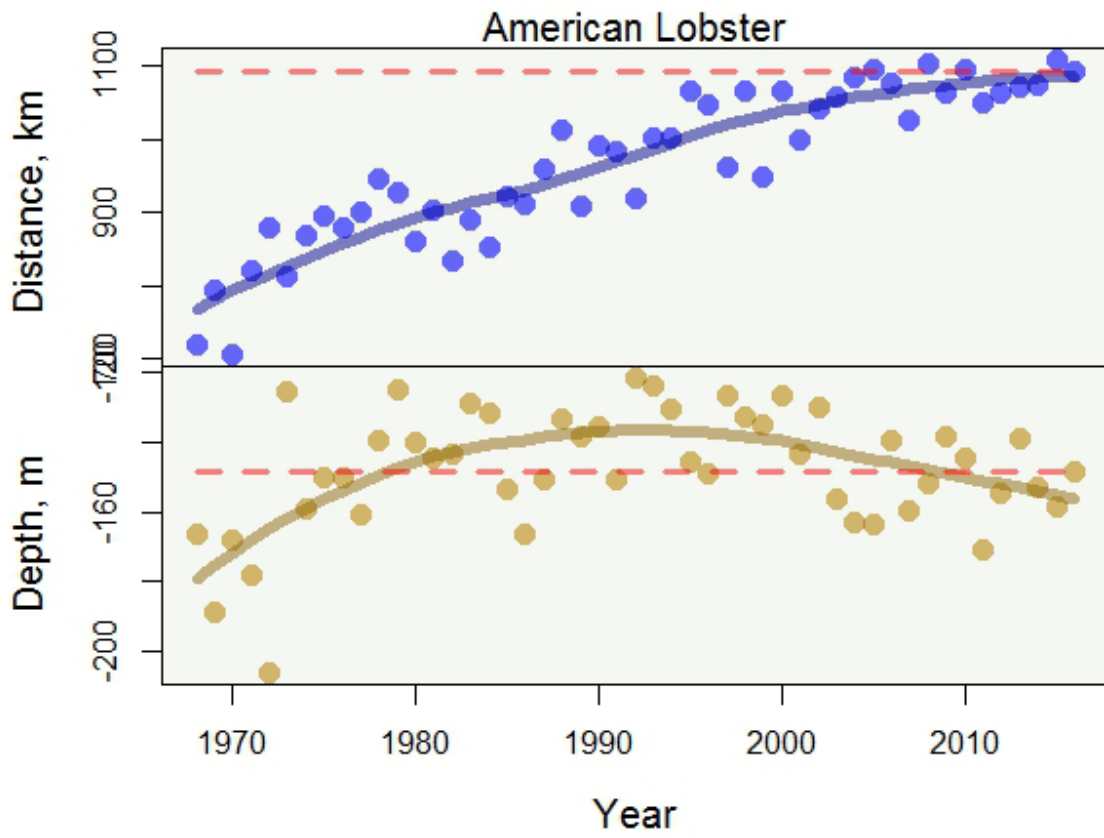
Acadian redfish



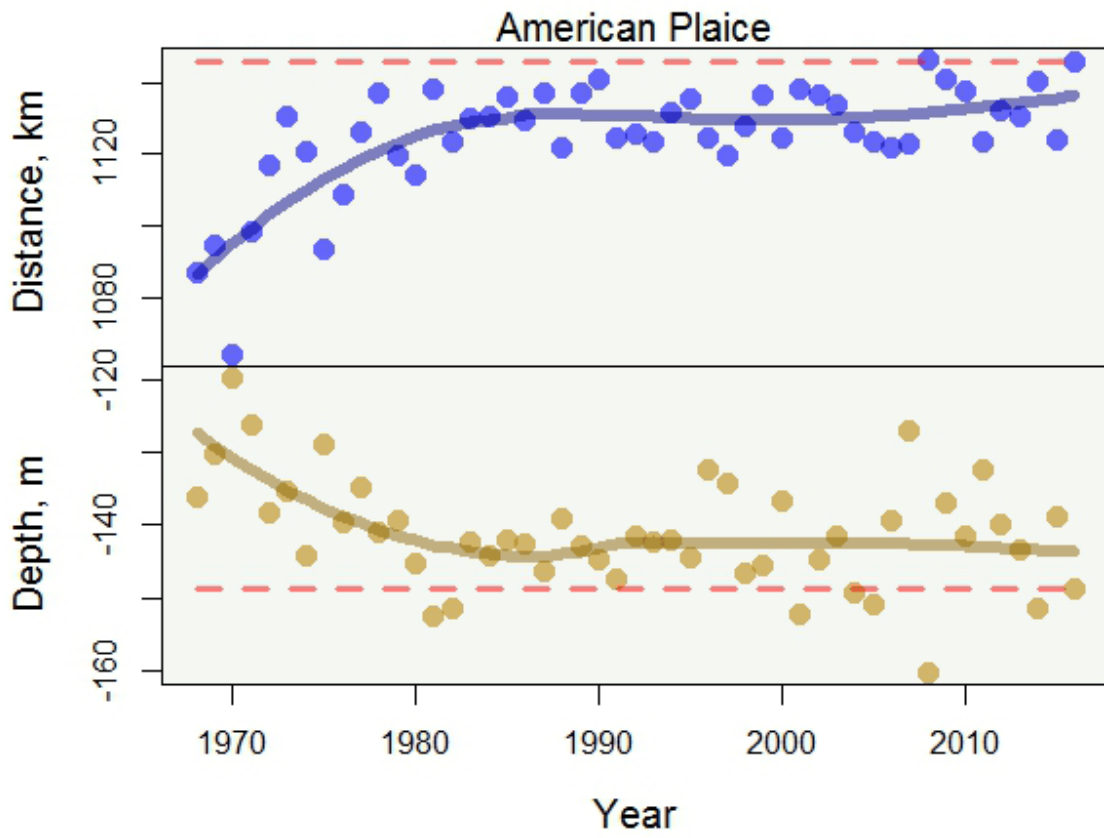
Alewife



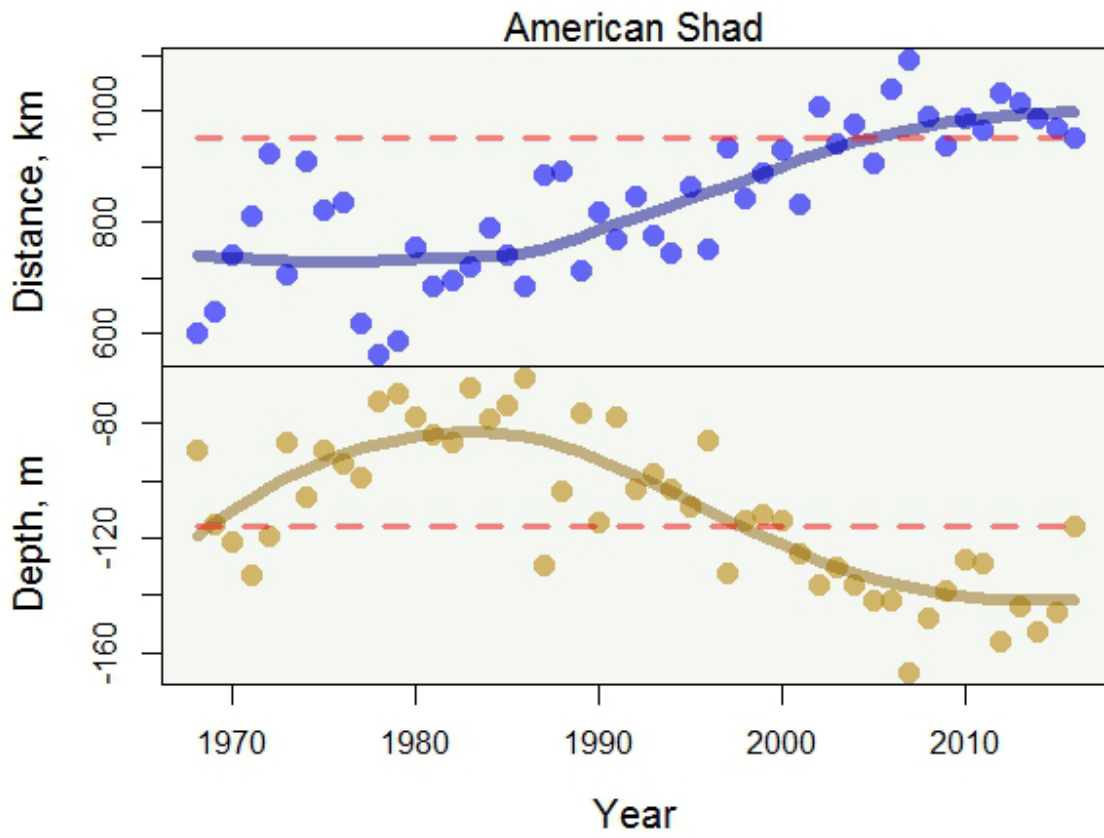
American lobster



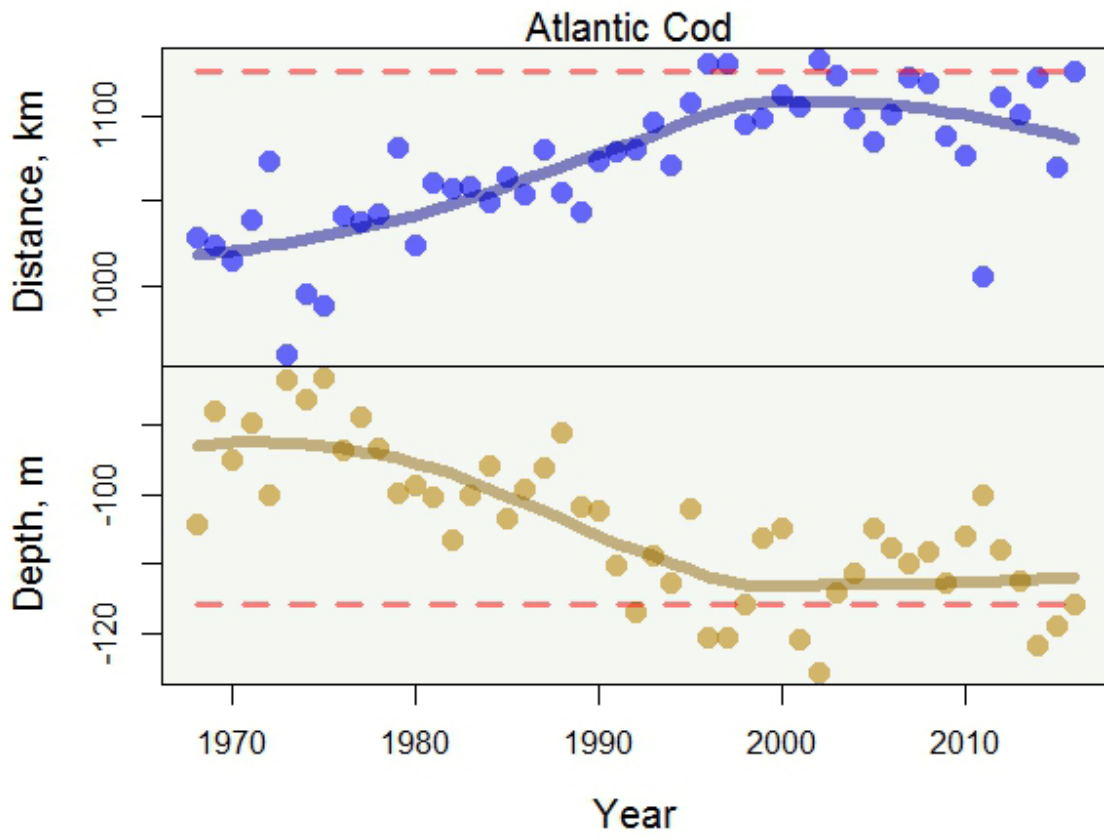
American plaice



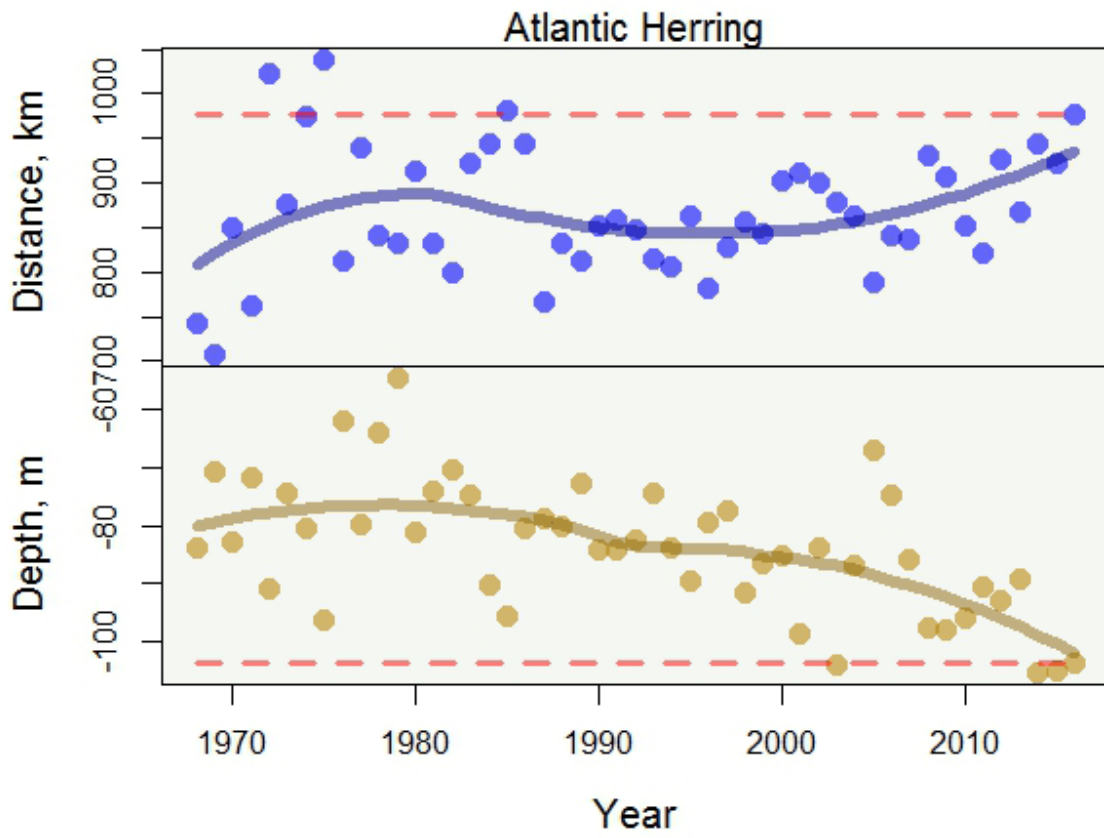
American shad



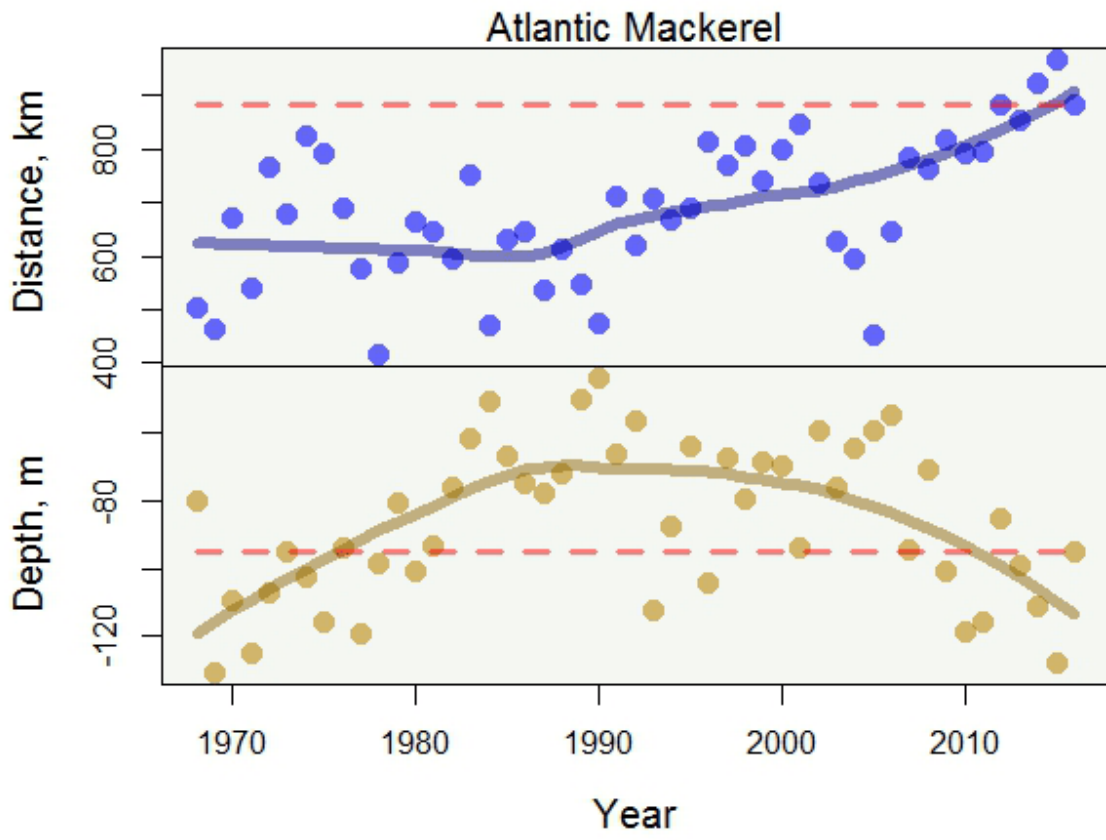
Atlantic cod



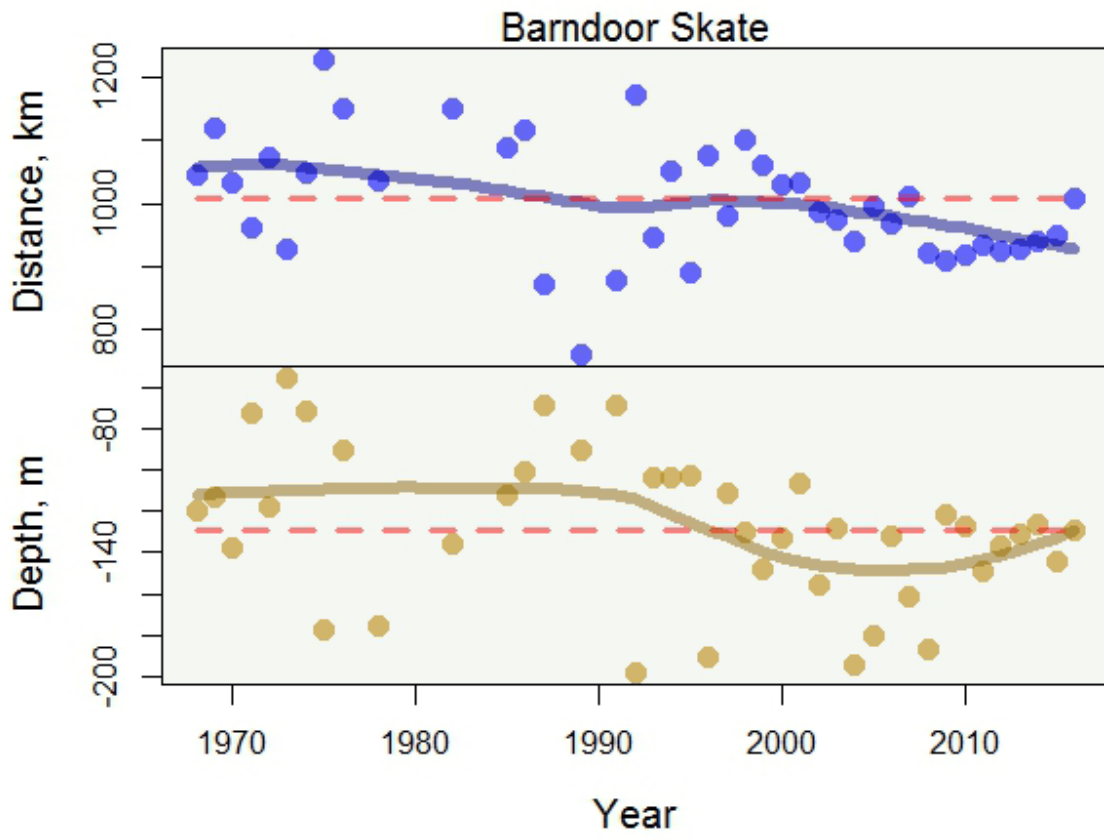
Atlantic herring



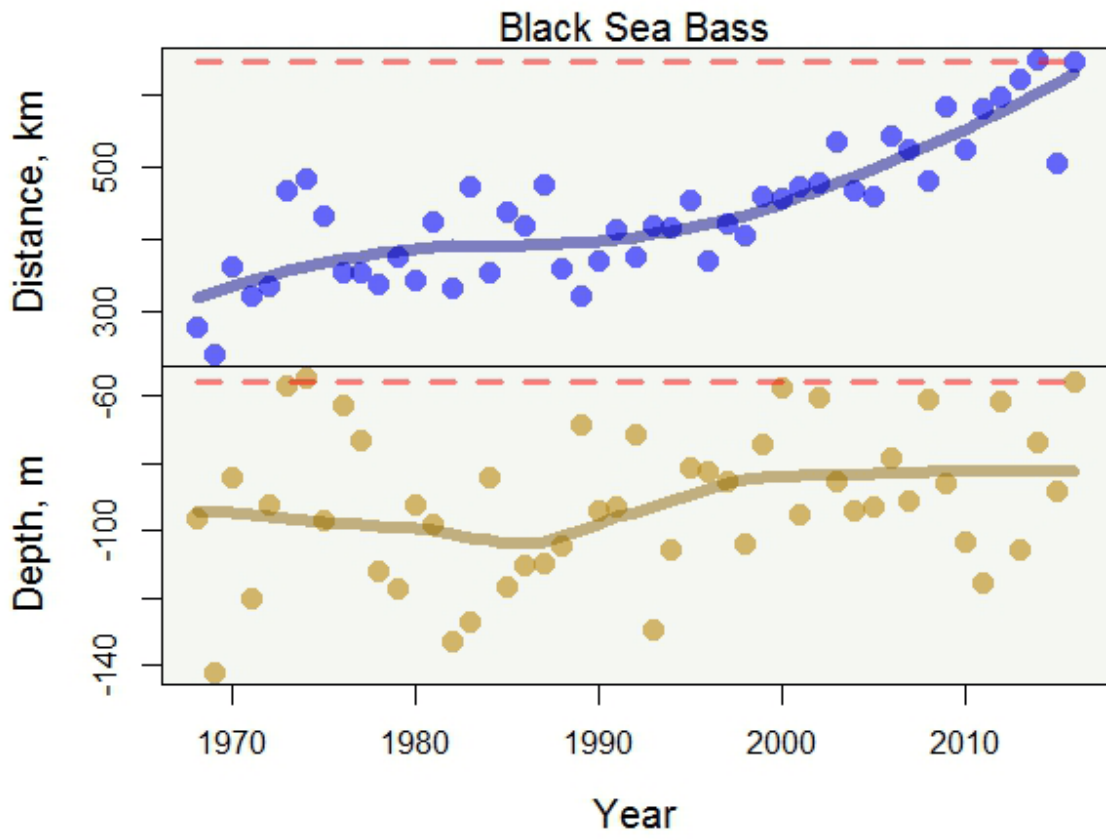
Atlantic mackerel



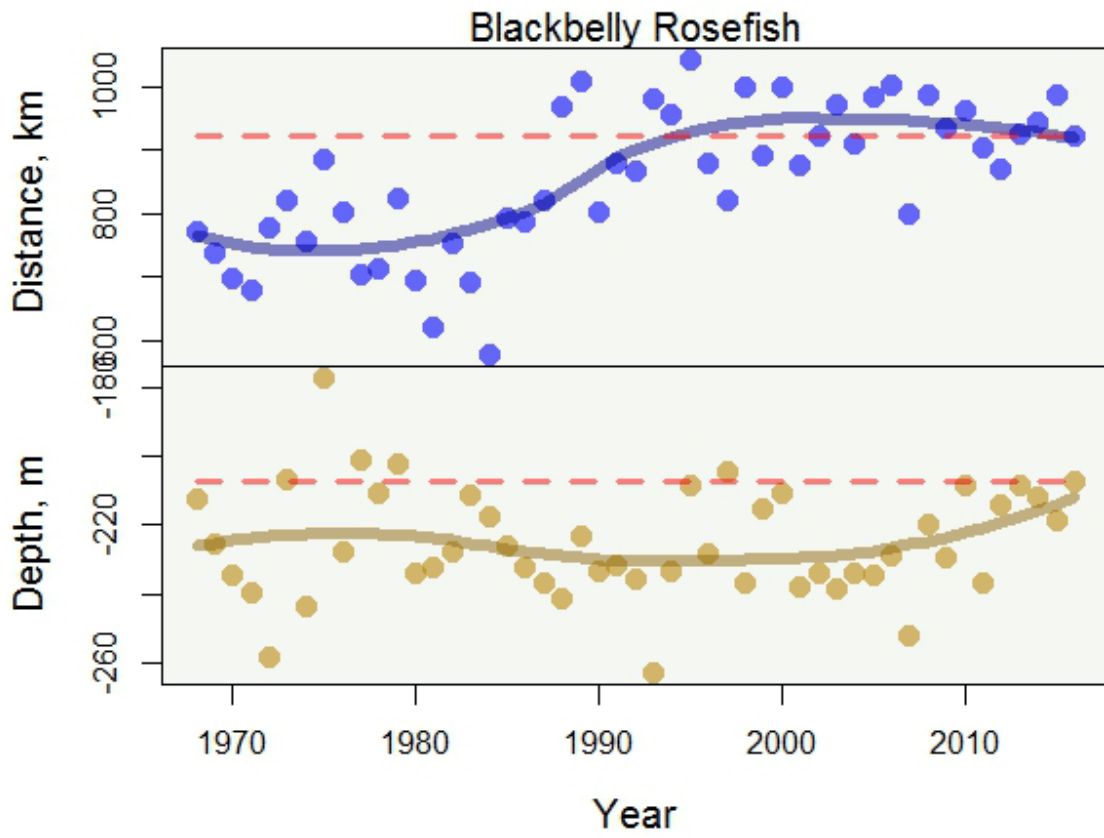
Barndoor skate



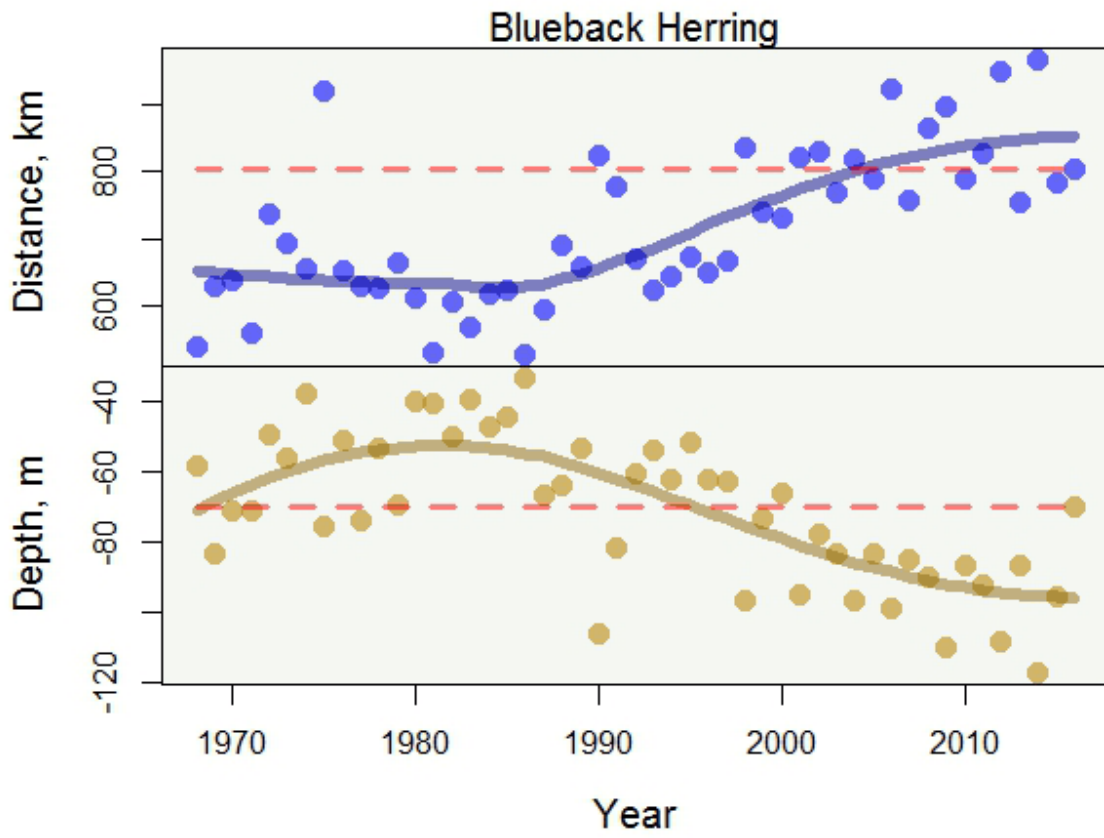
Black sea bass



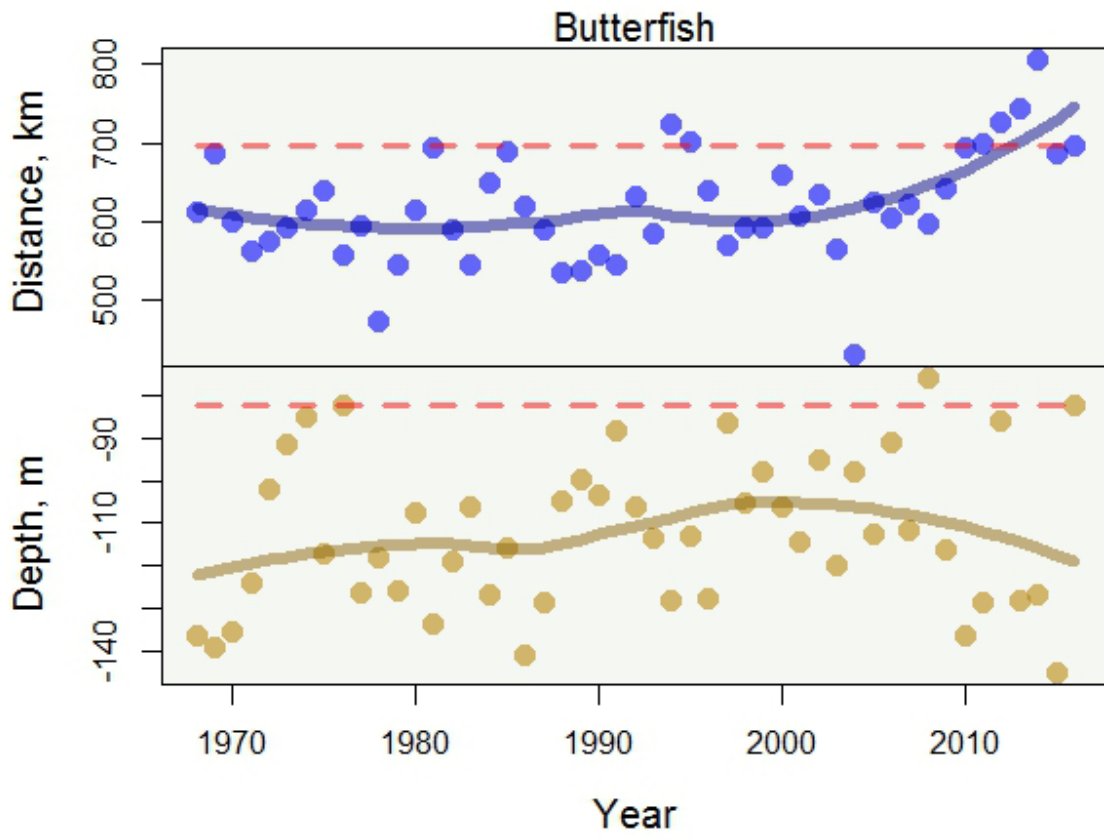
Blackbelly rosefish



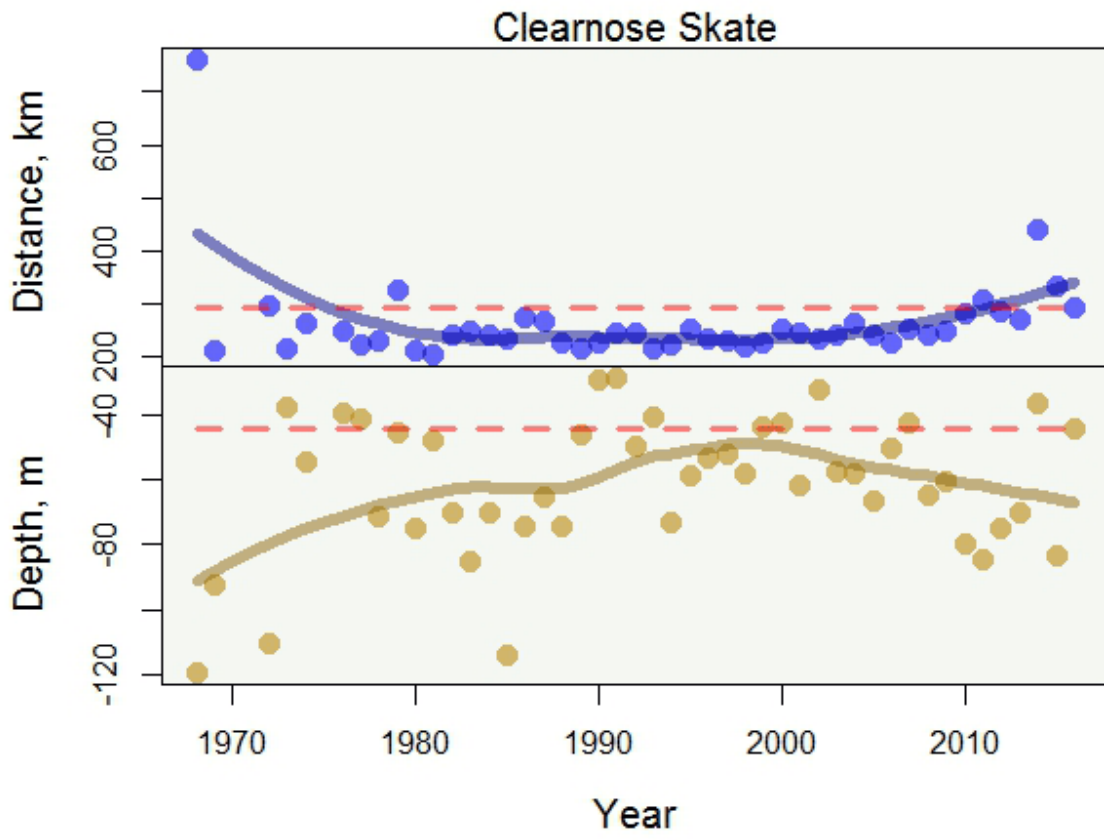
Blueback herring



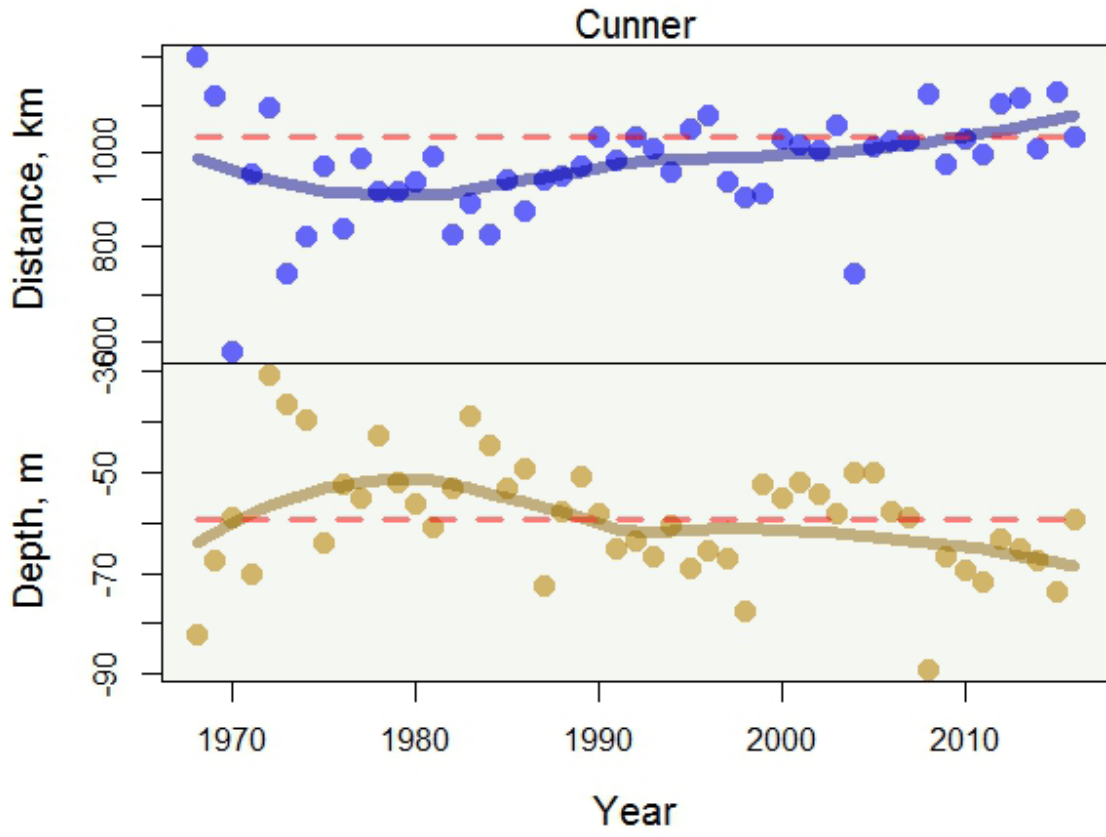
Butterfish



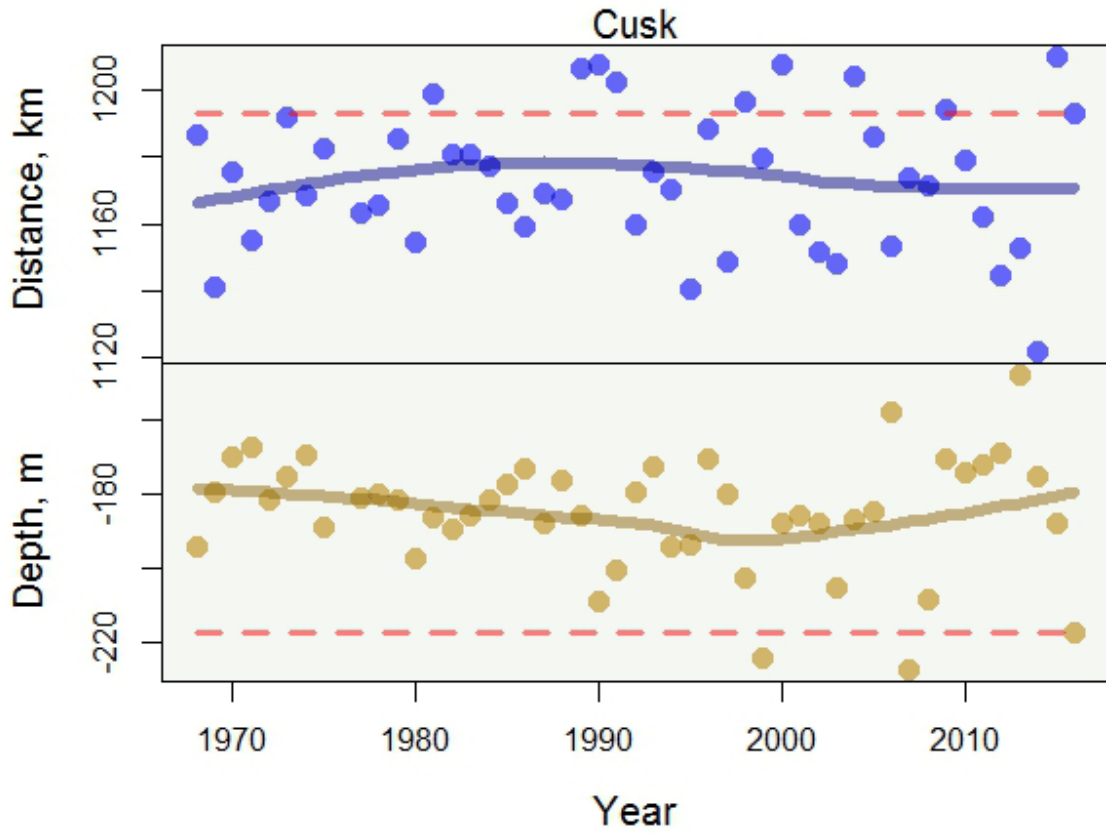
Clearnose skate



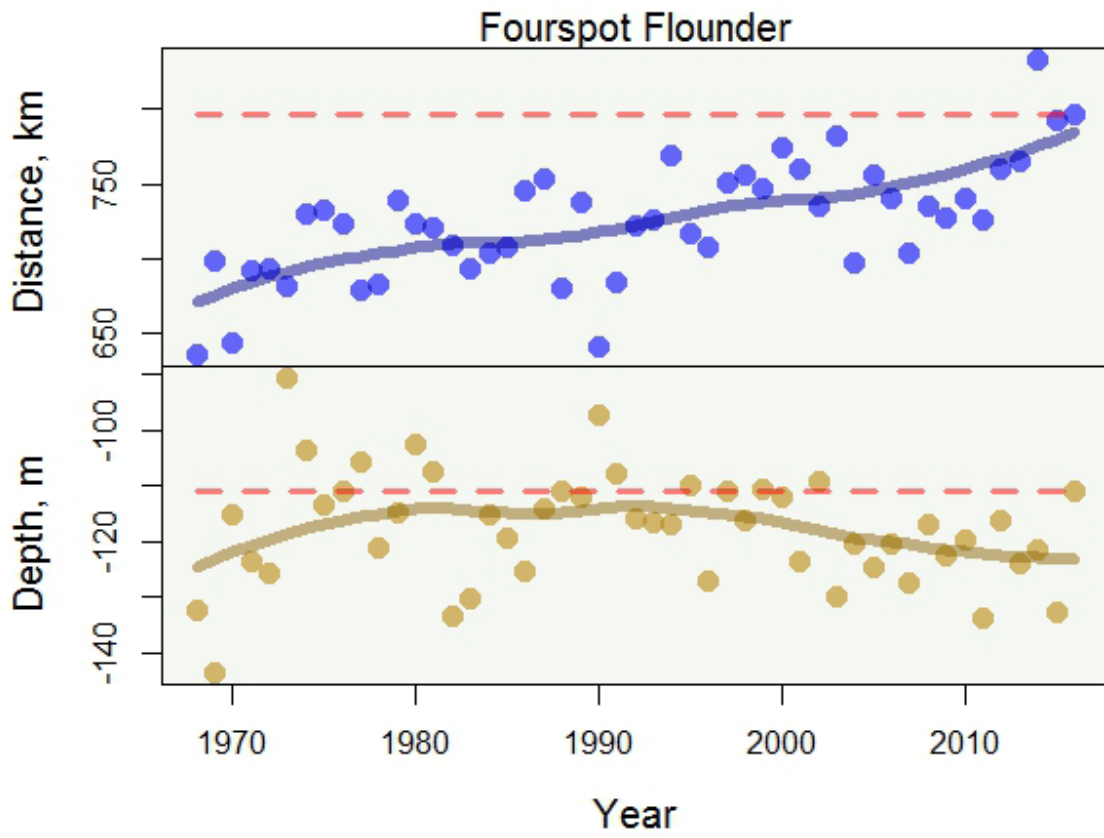
Cunner



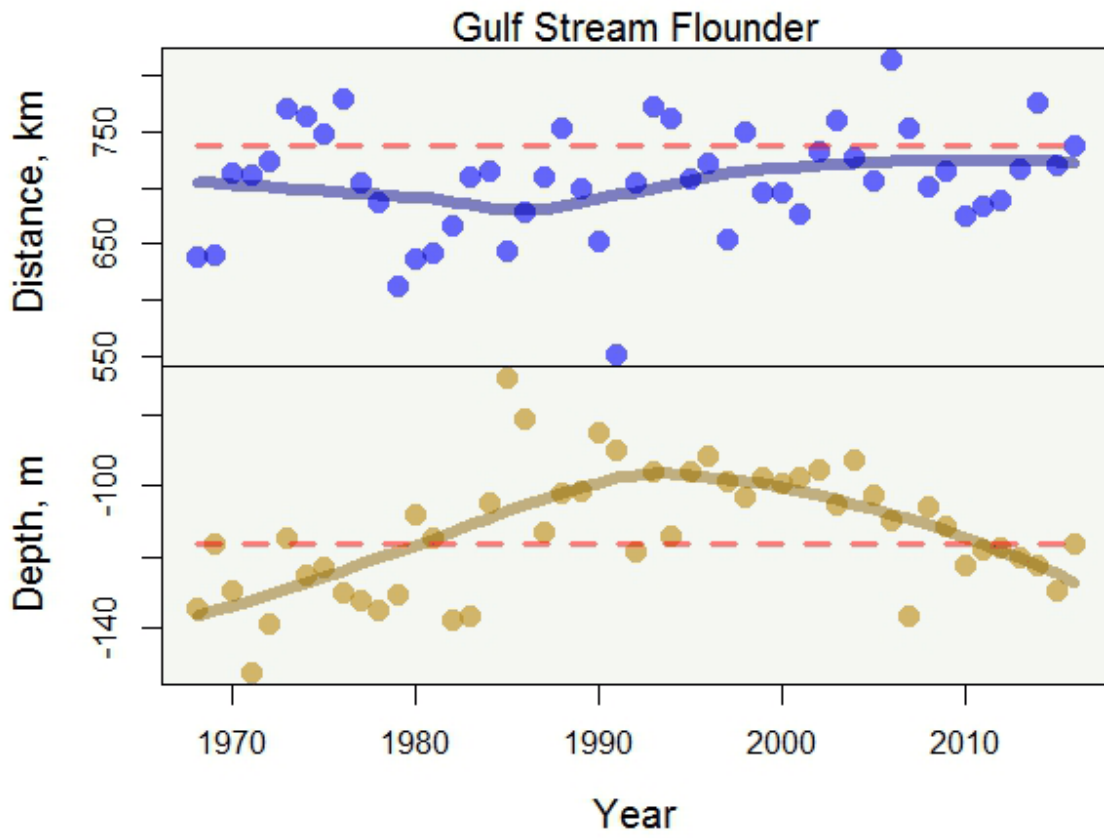
Cusk



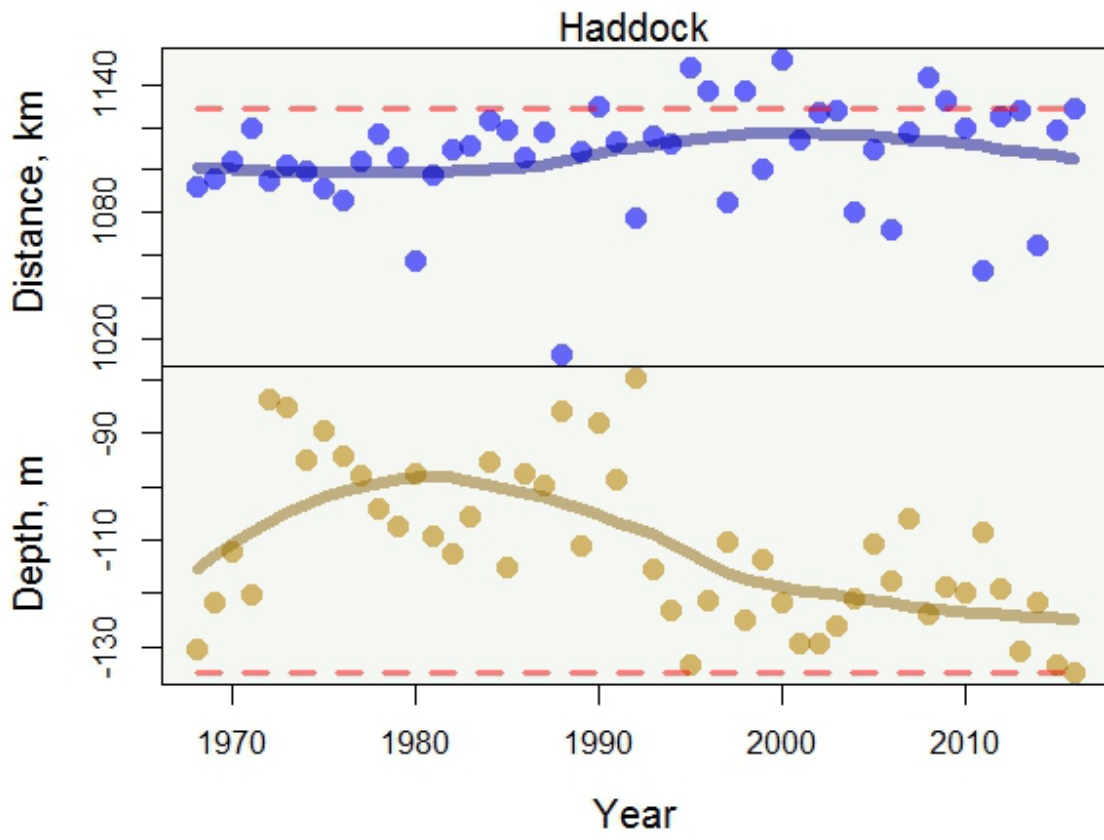
Fourspot flounder



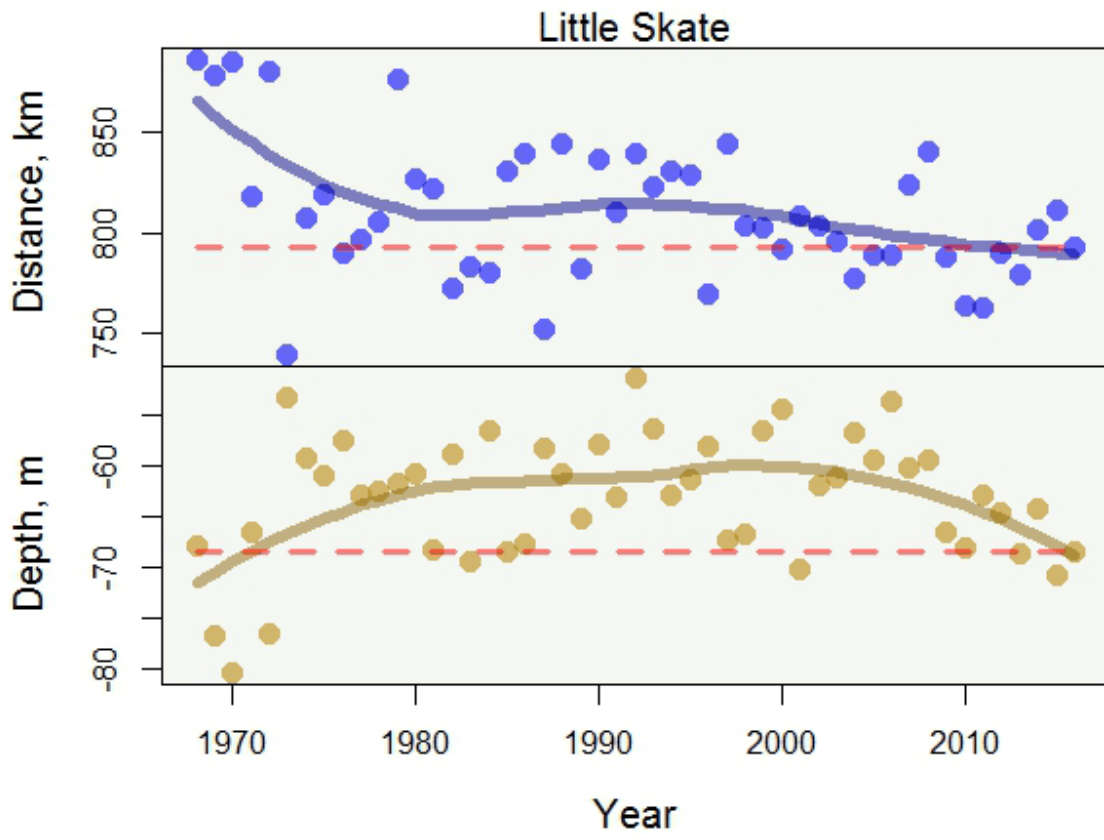
Gulf Stream flounder



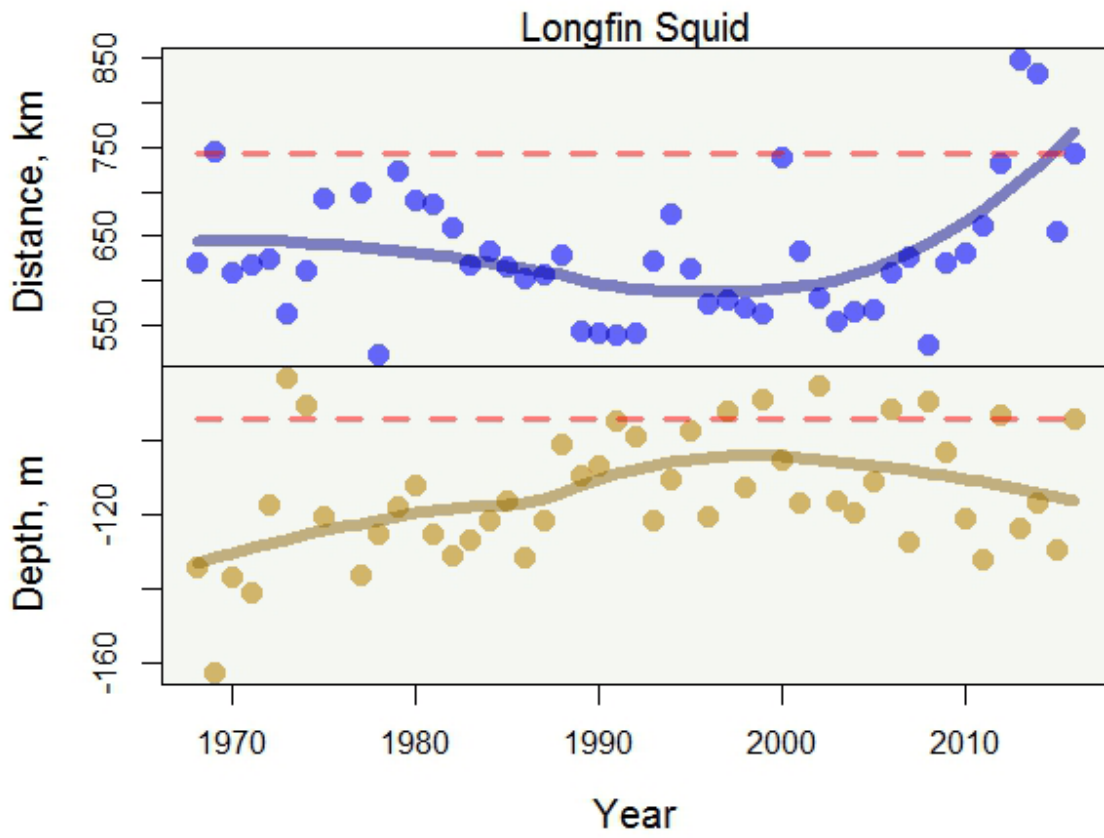
Haddock



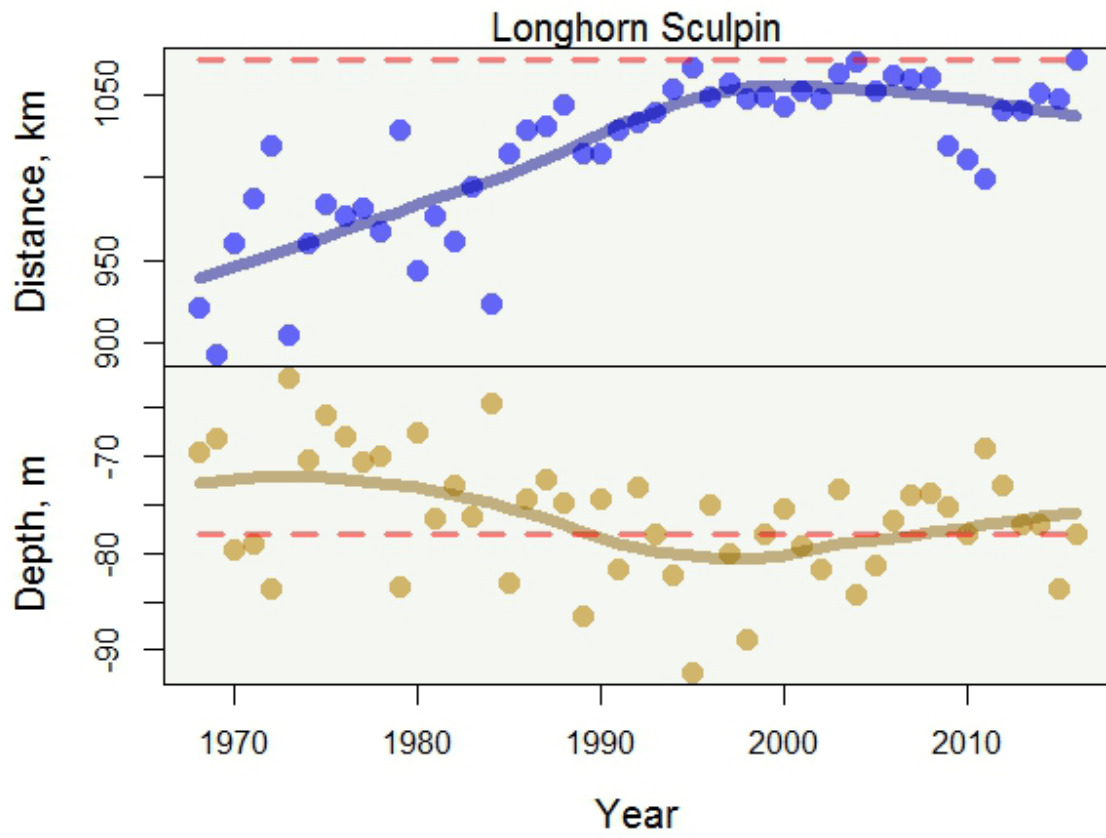
Little skate



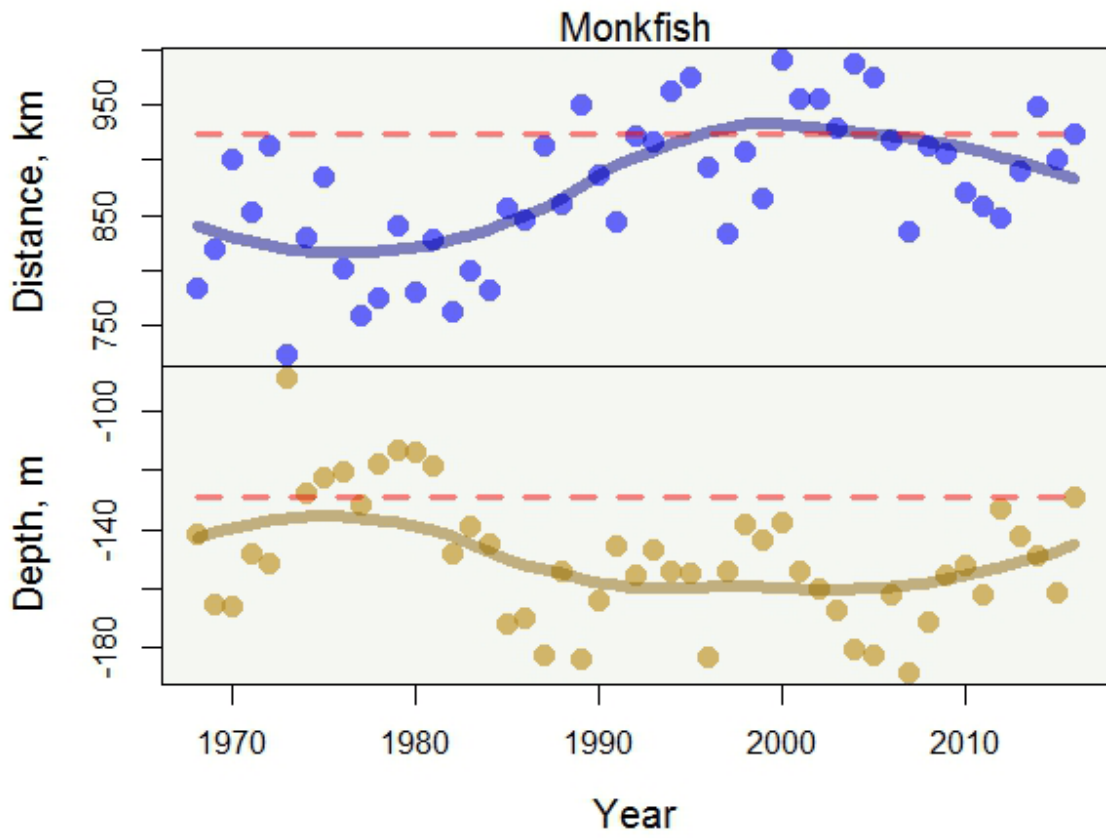
Longfin Squid



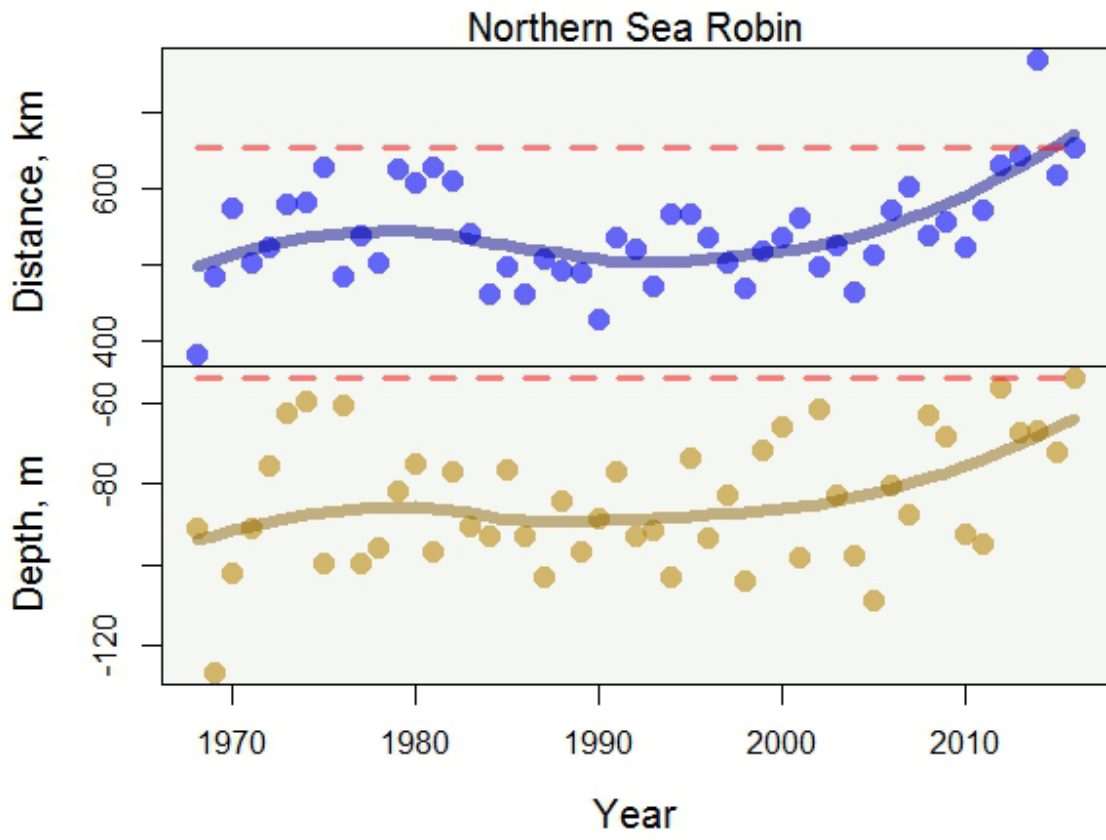
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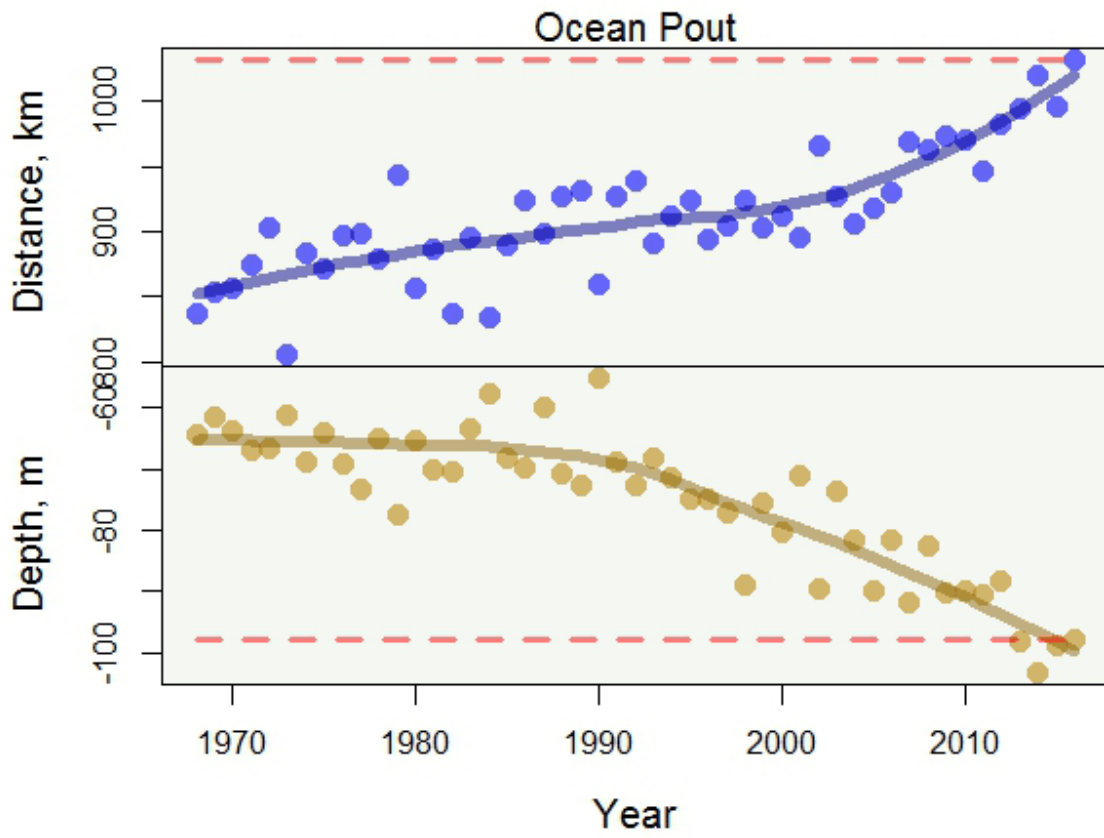
Monkfish



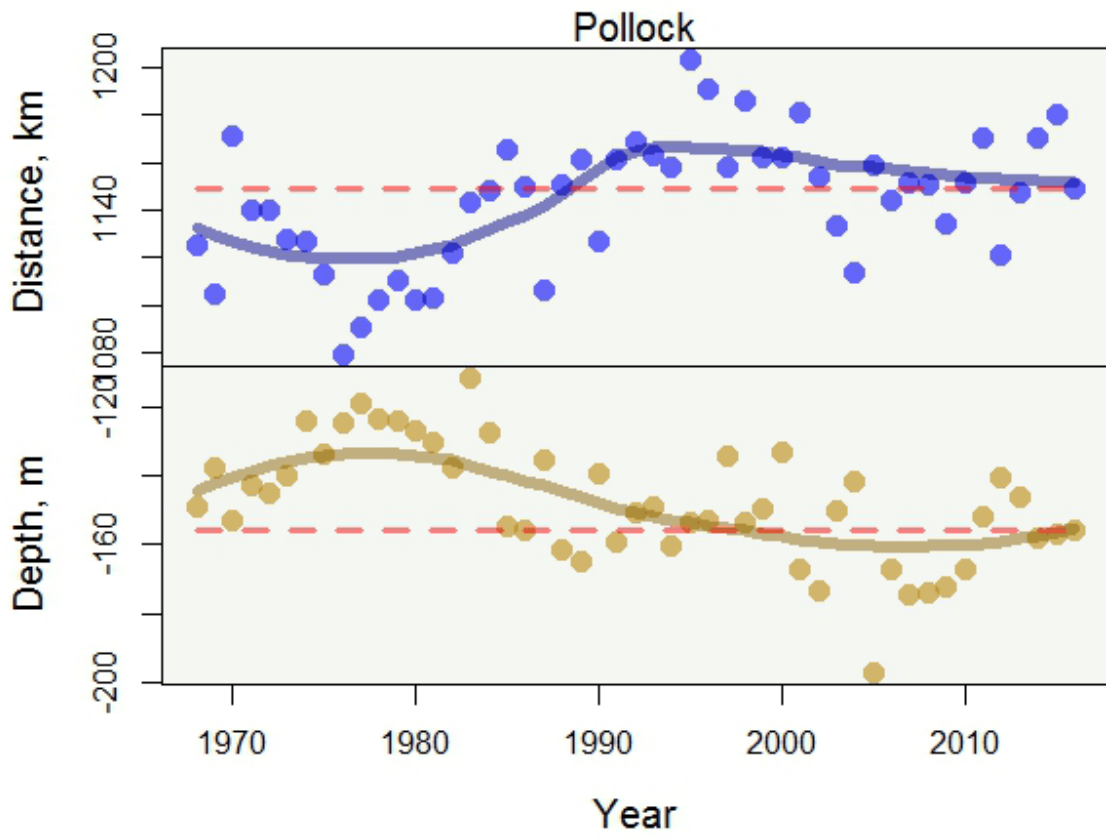
Northern sea robin



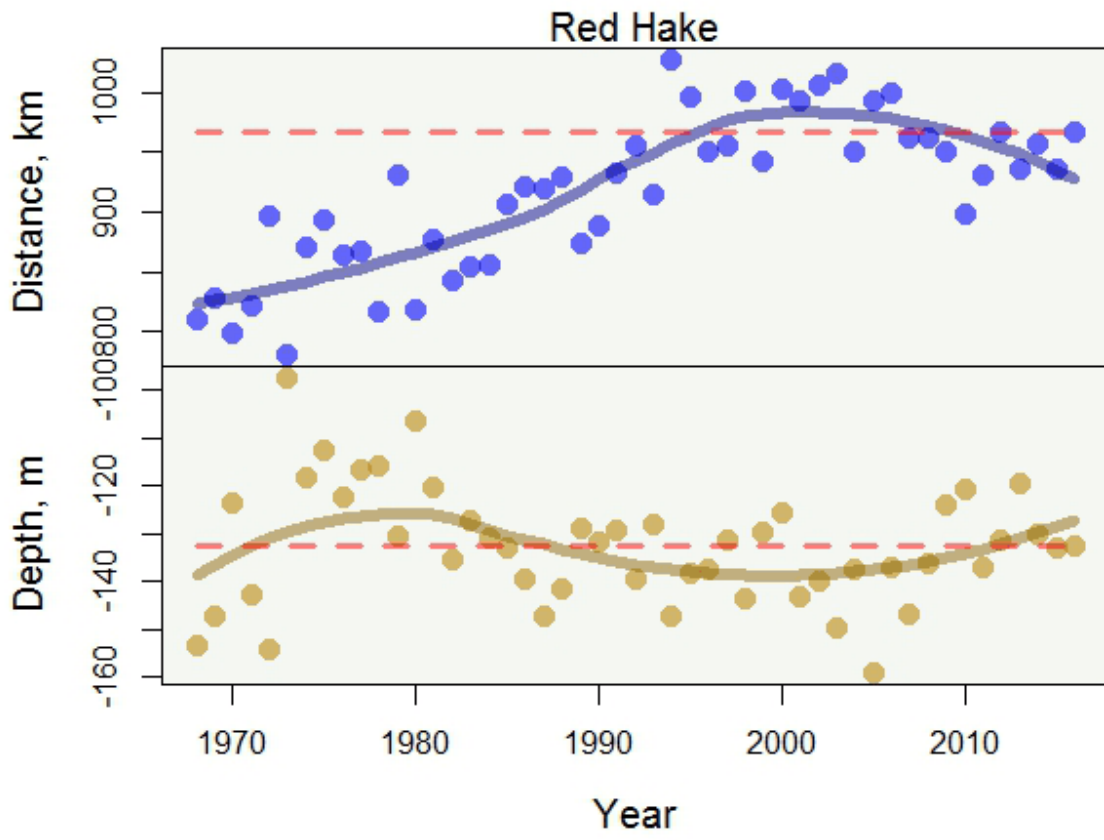
Ocean pout



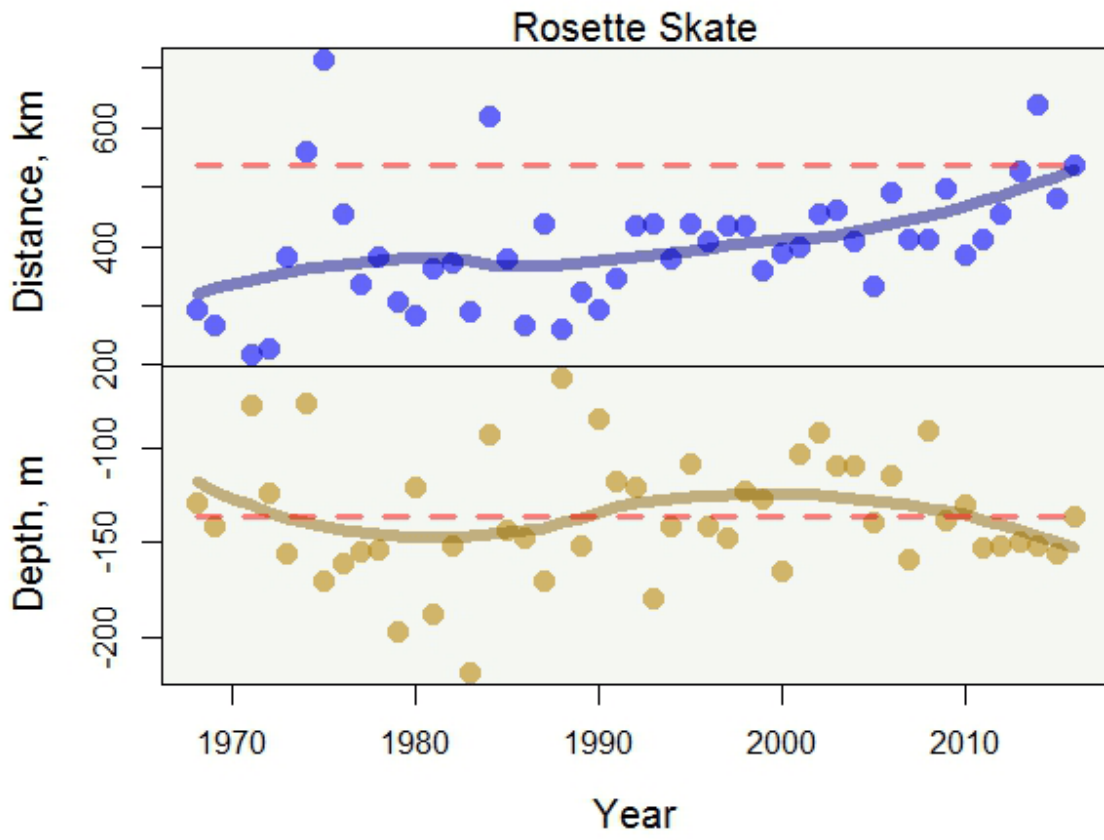
Pollock



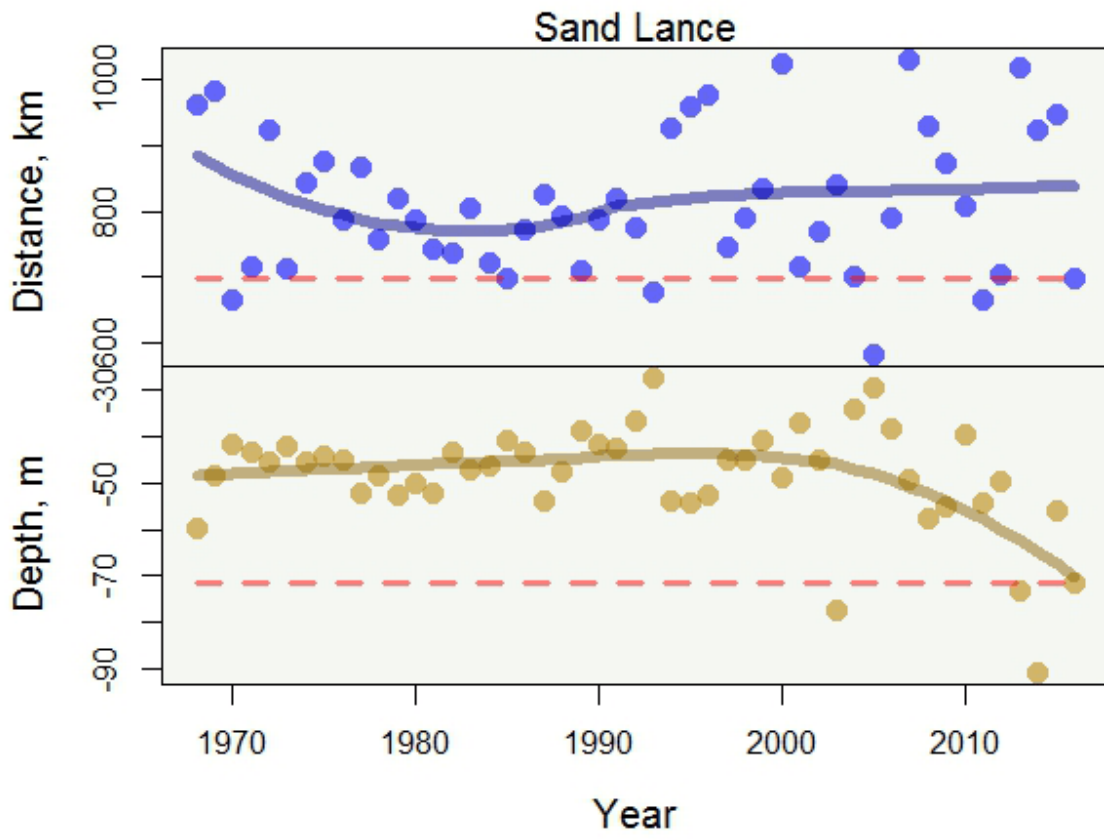
Red Hake



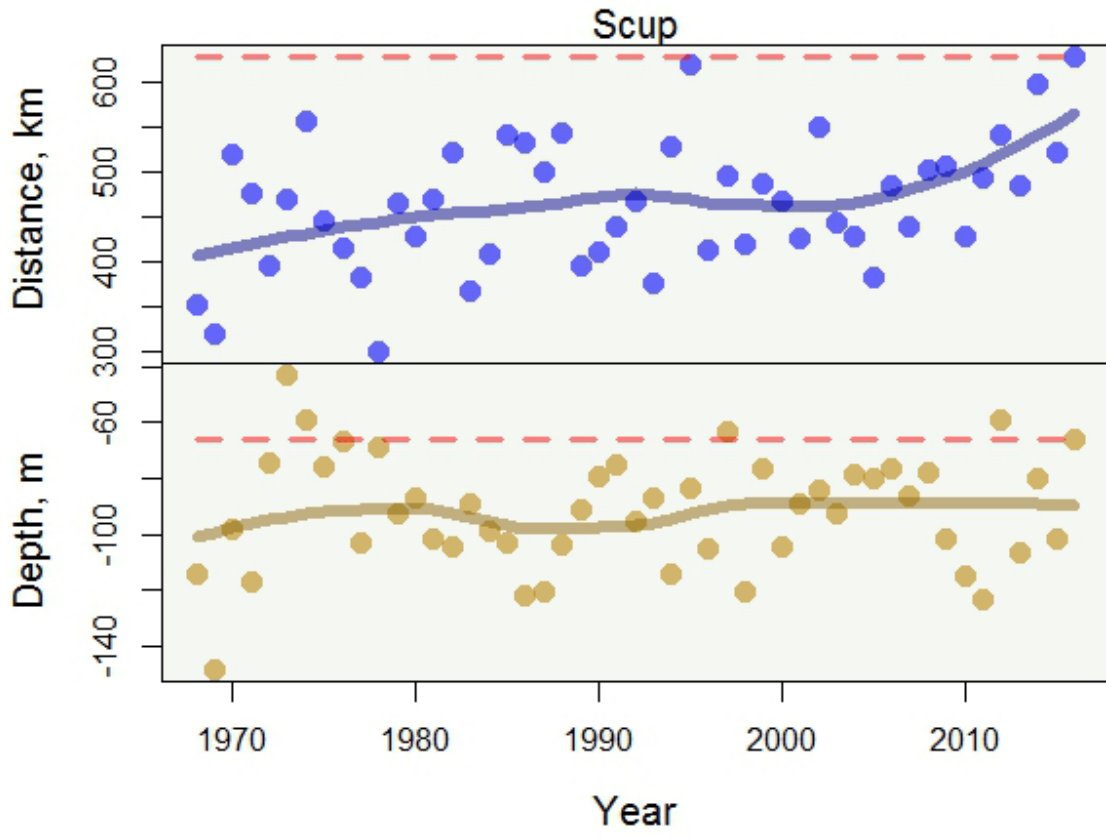
Rosette skate



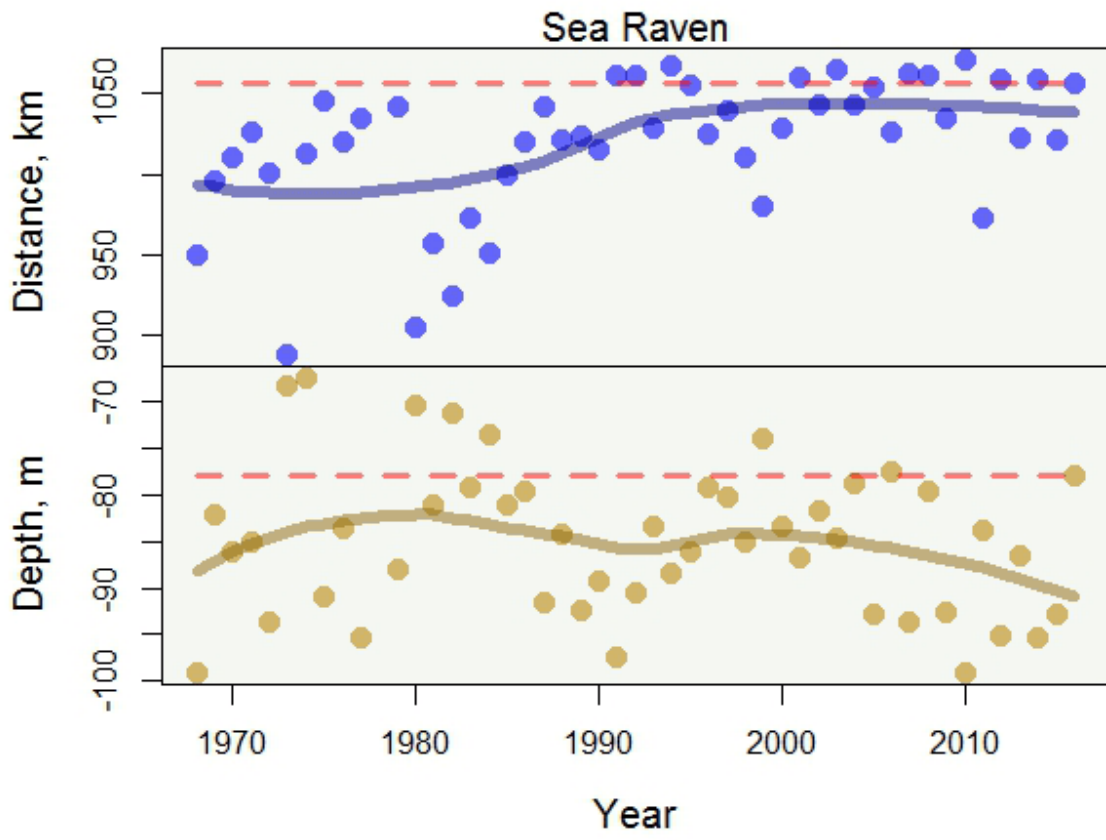
Sand lance



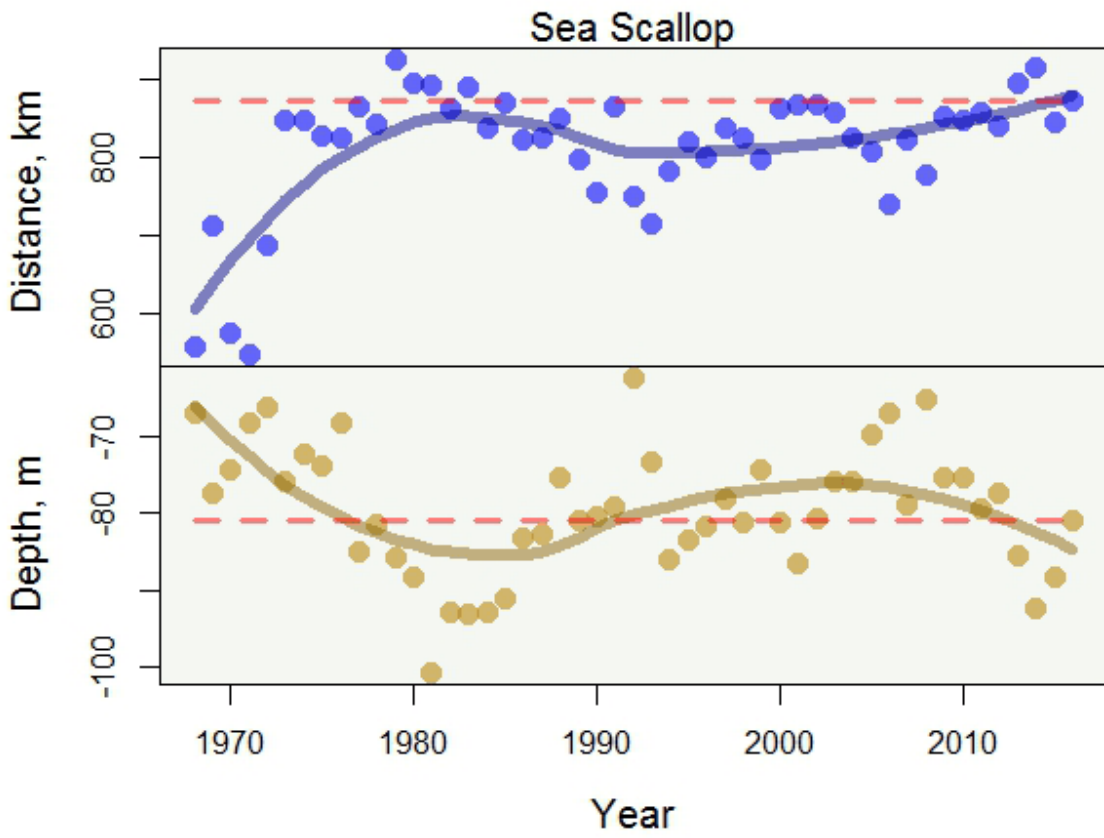
Scup



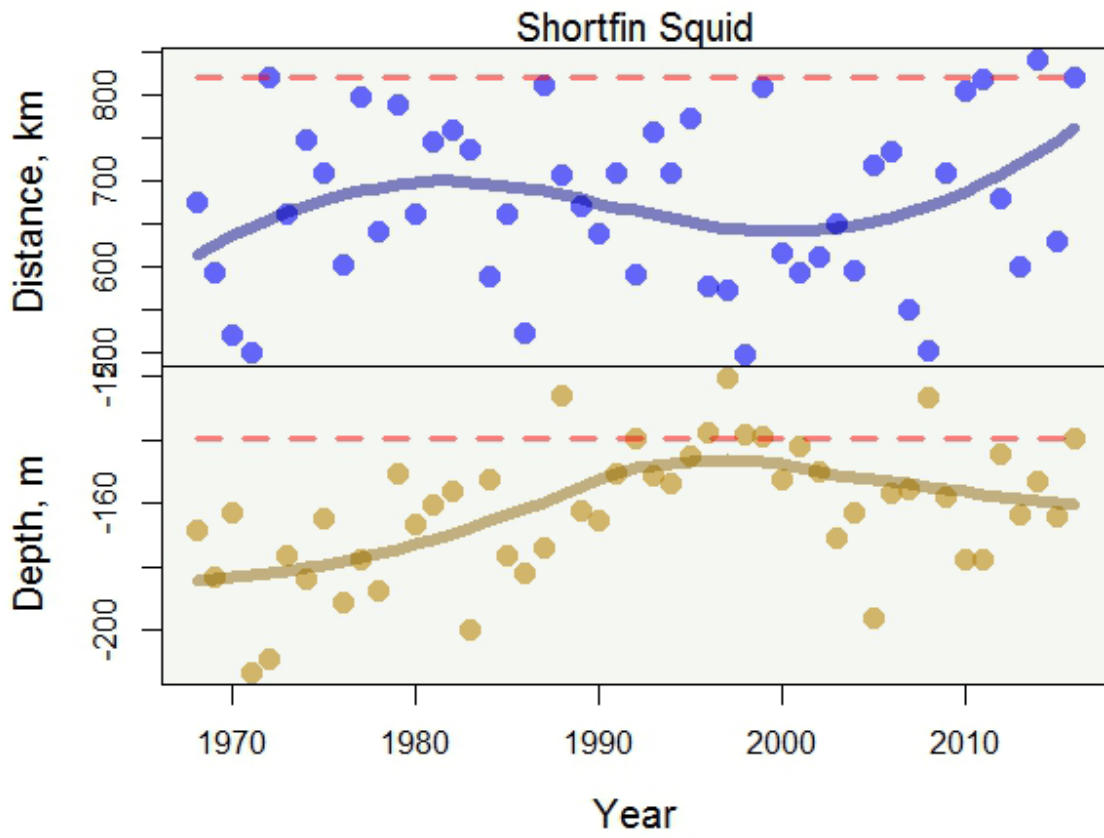
Sea raven



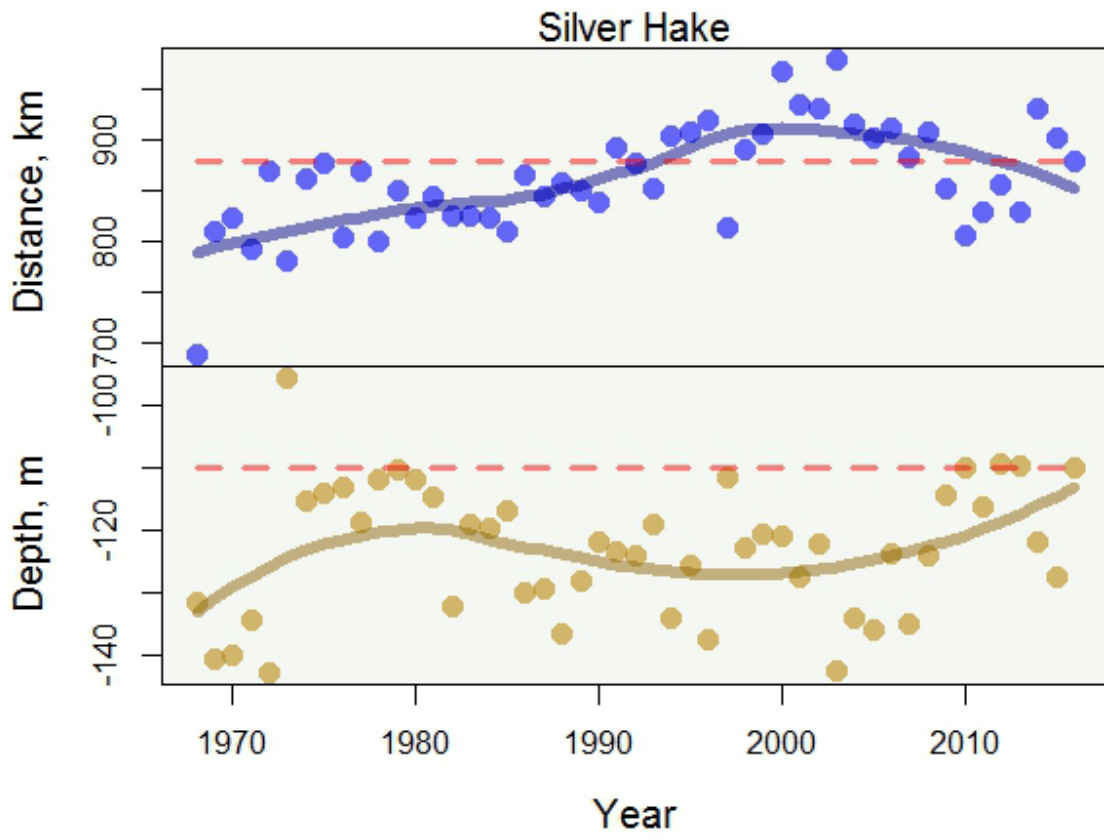
Sea Scallop



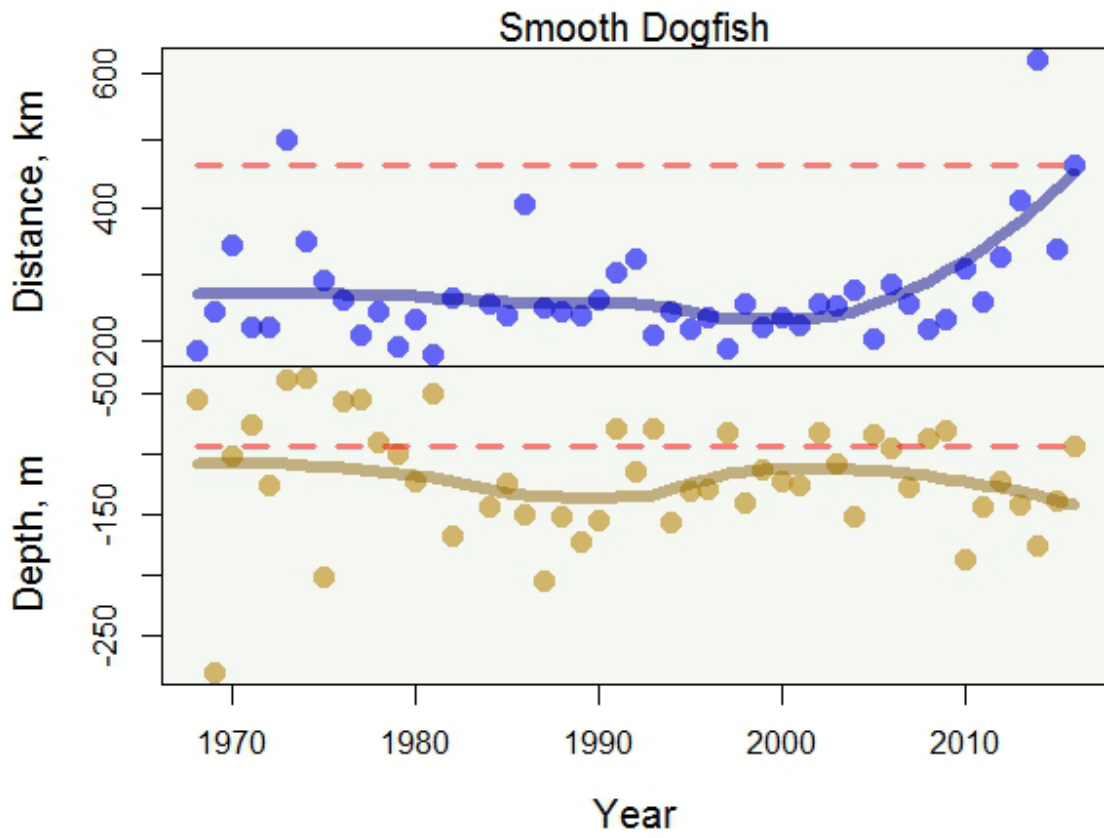
Shortfin squid



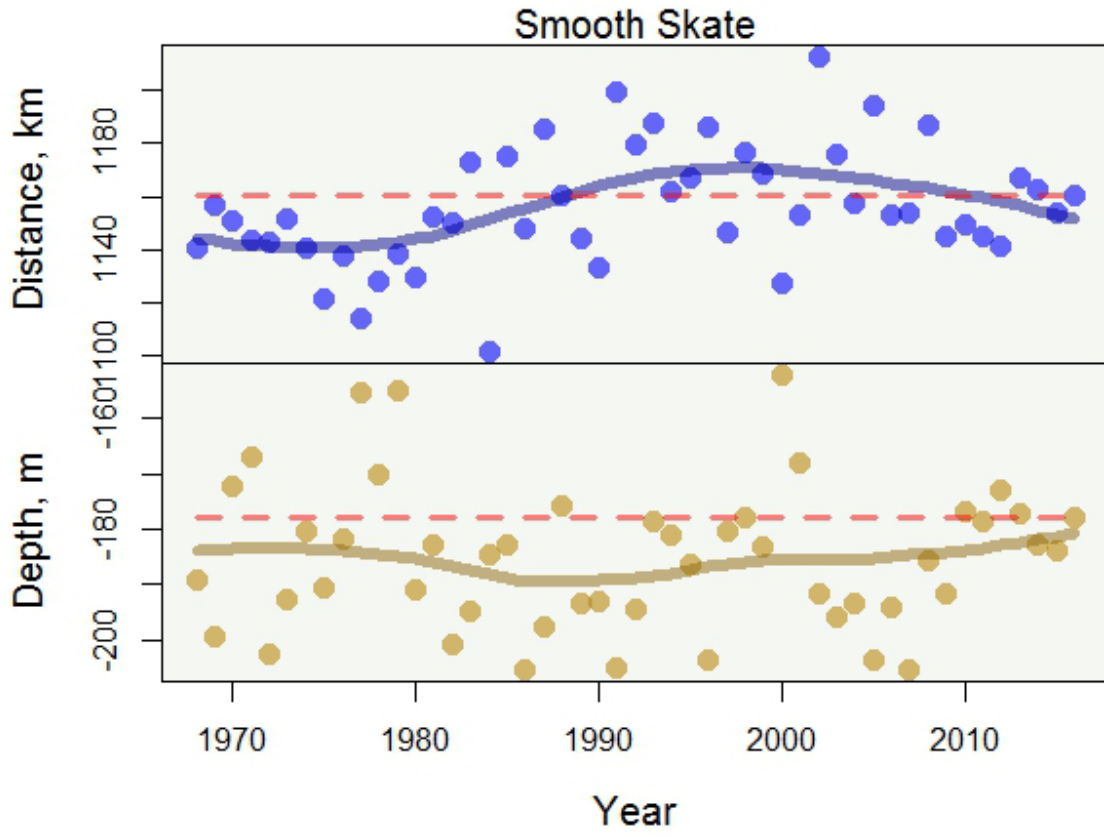
Silver Hake



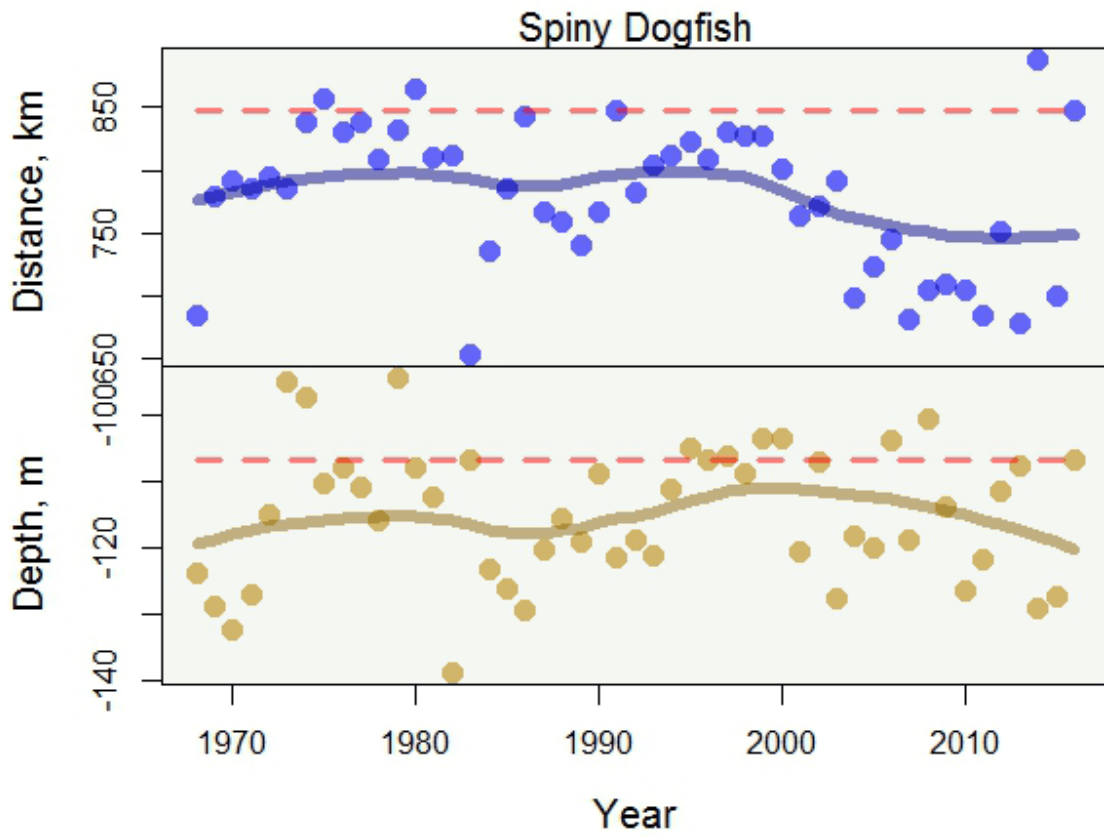
Smooth dogfish



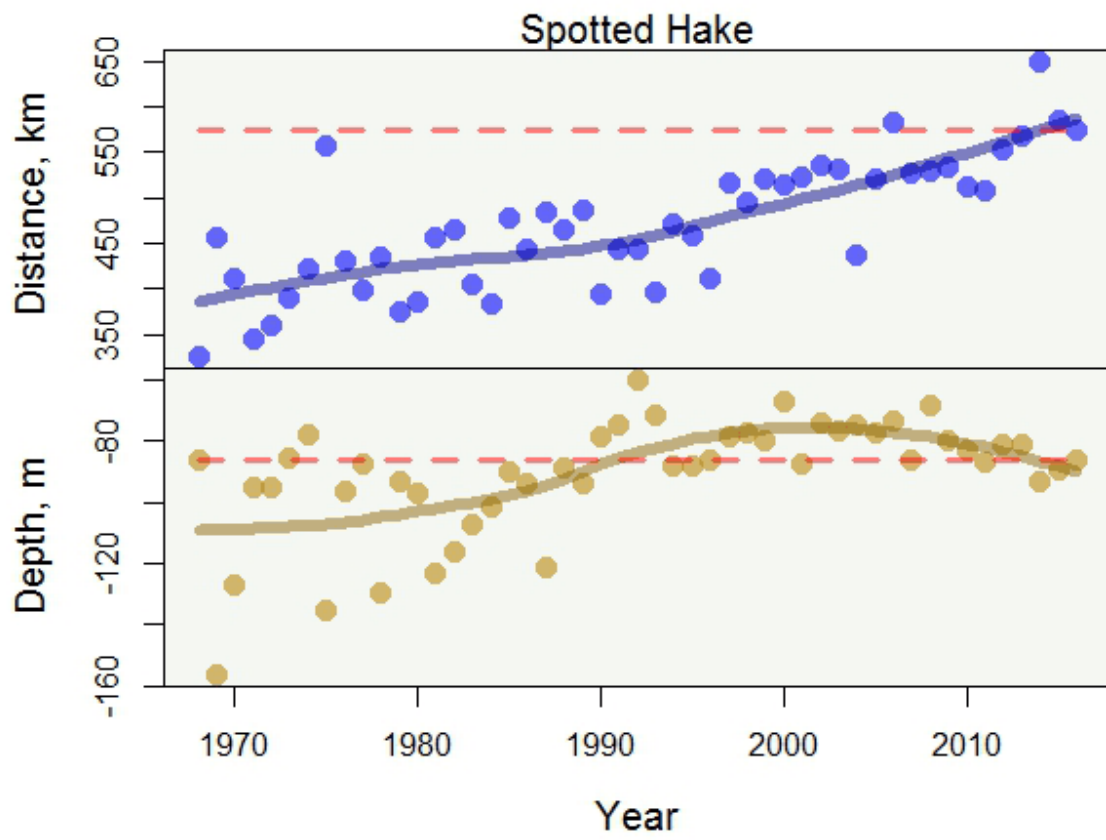
Smooth skate



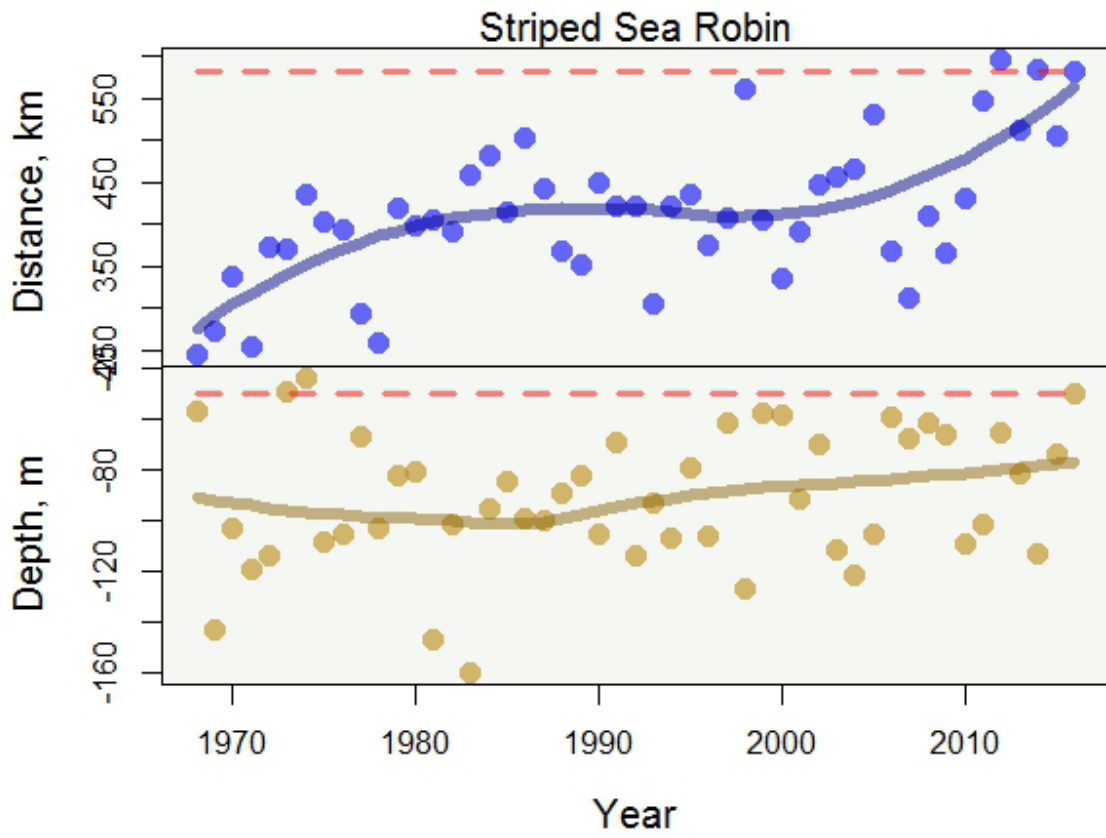
Spiny dogfish



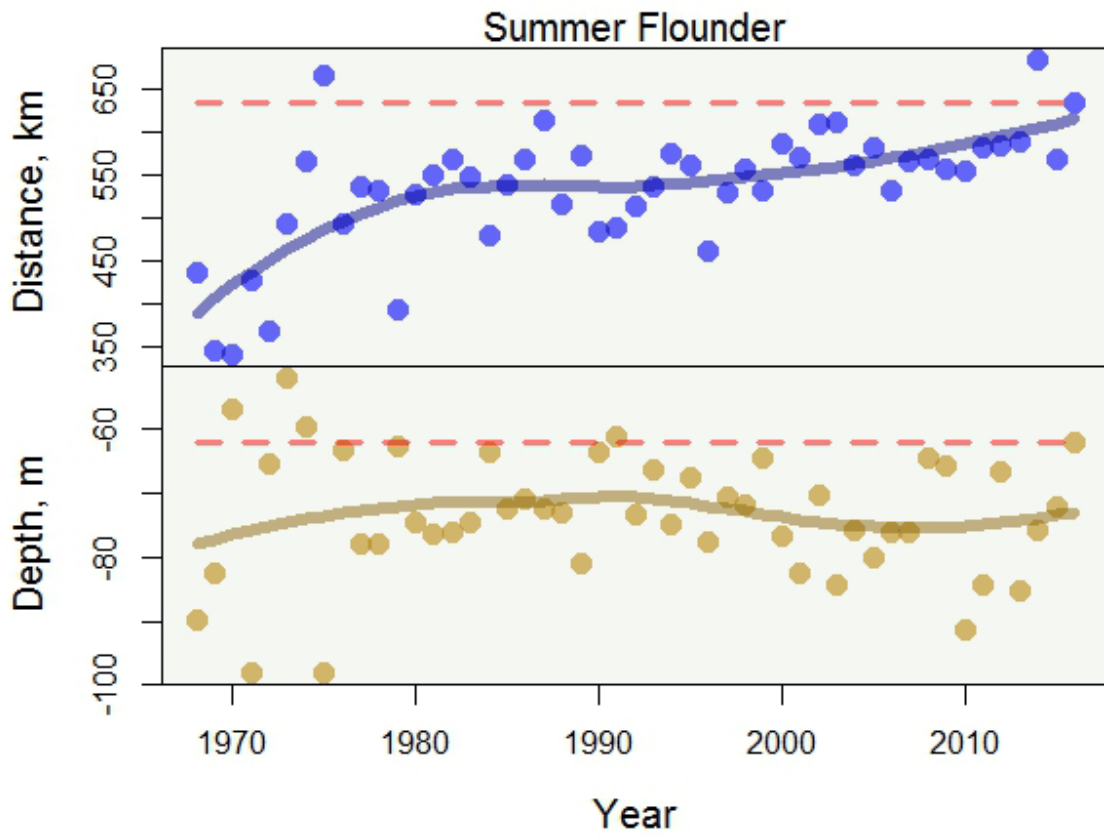
Spotted hake



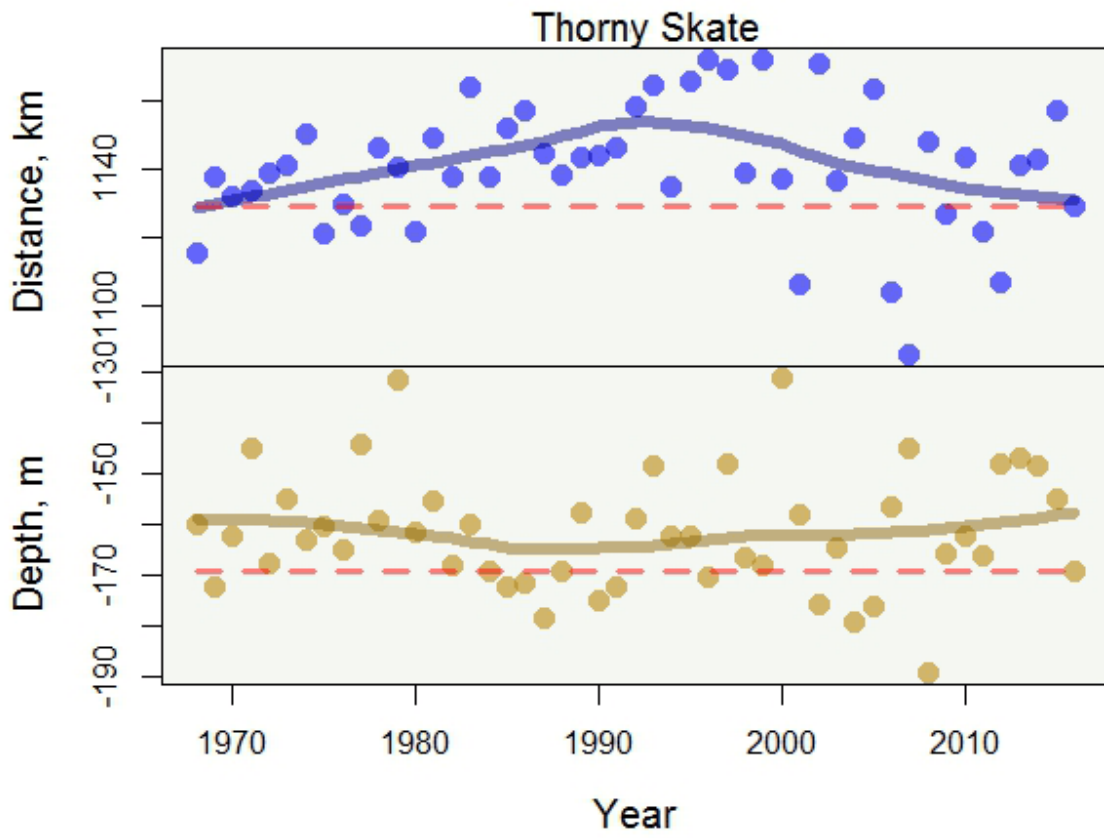
Striped sea robin



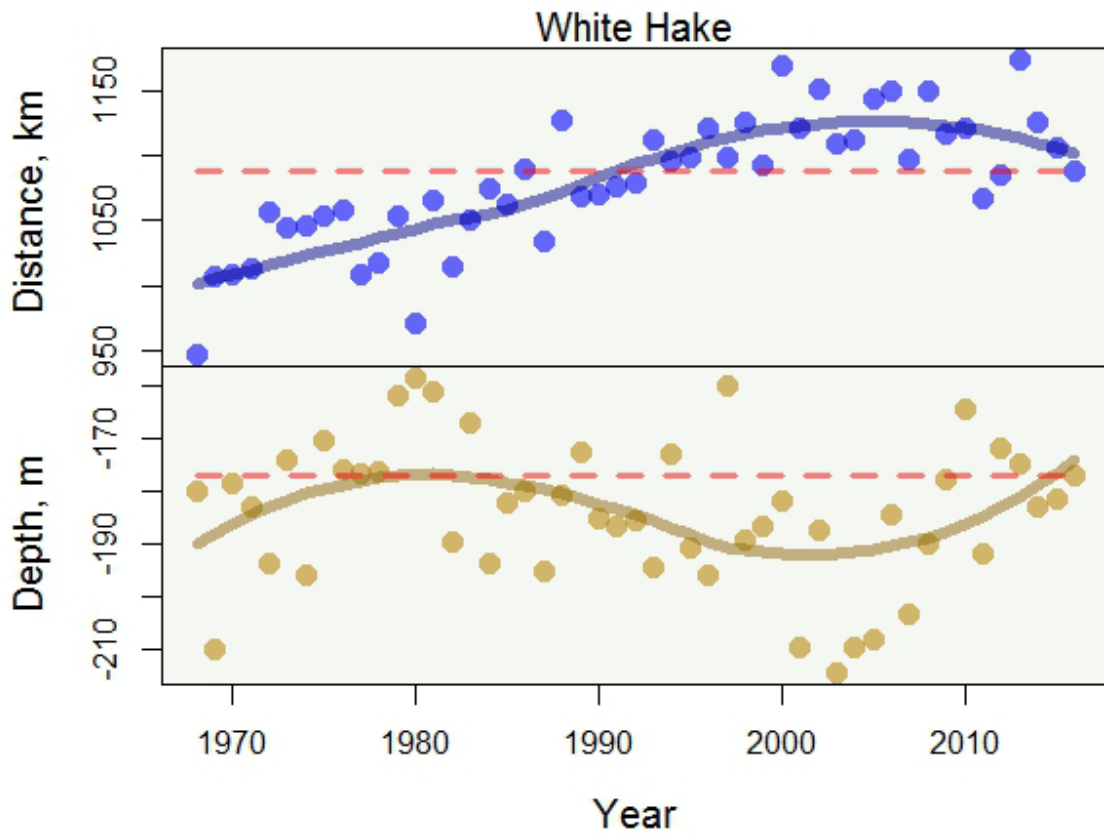
Summer flounder



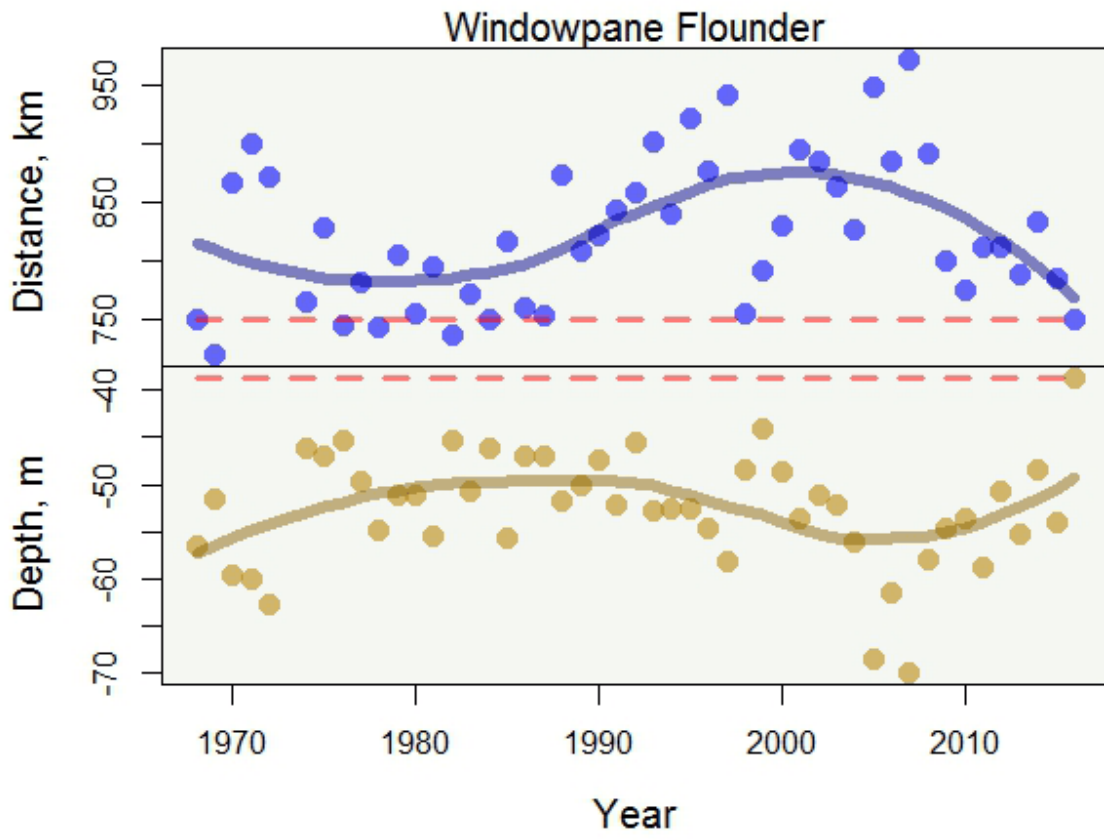
Thorny skate



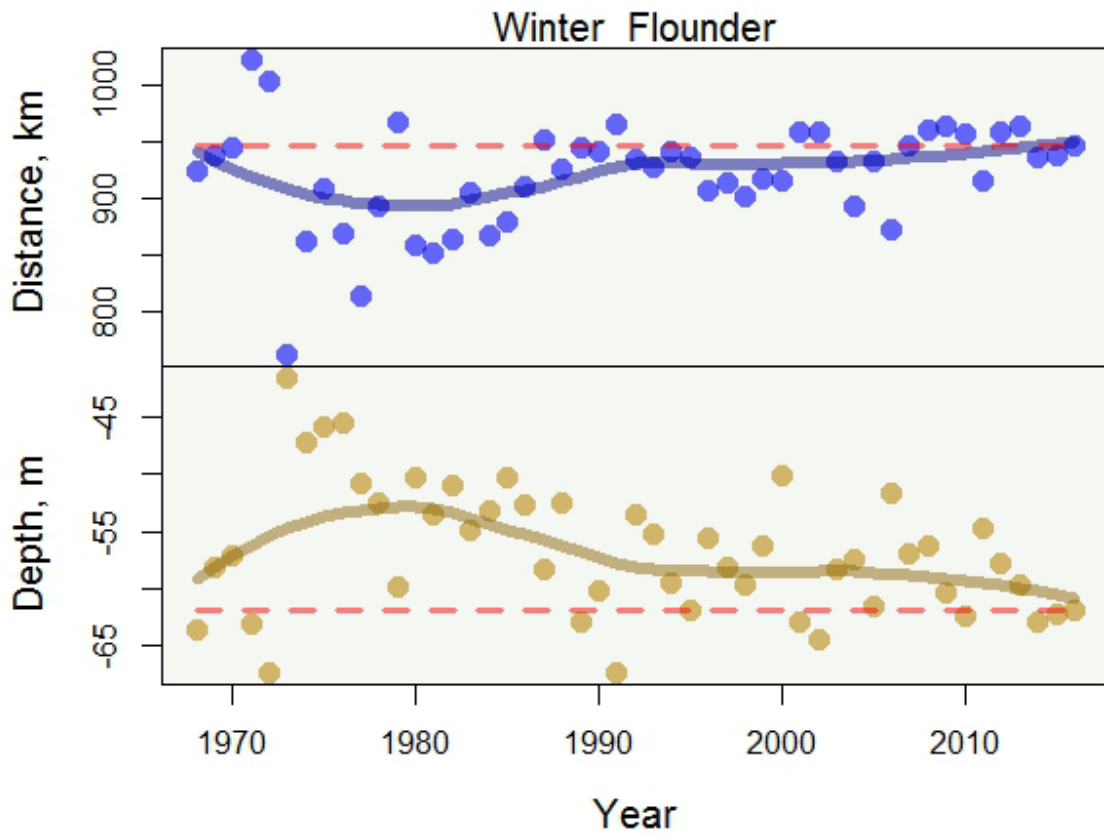
White hake



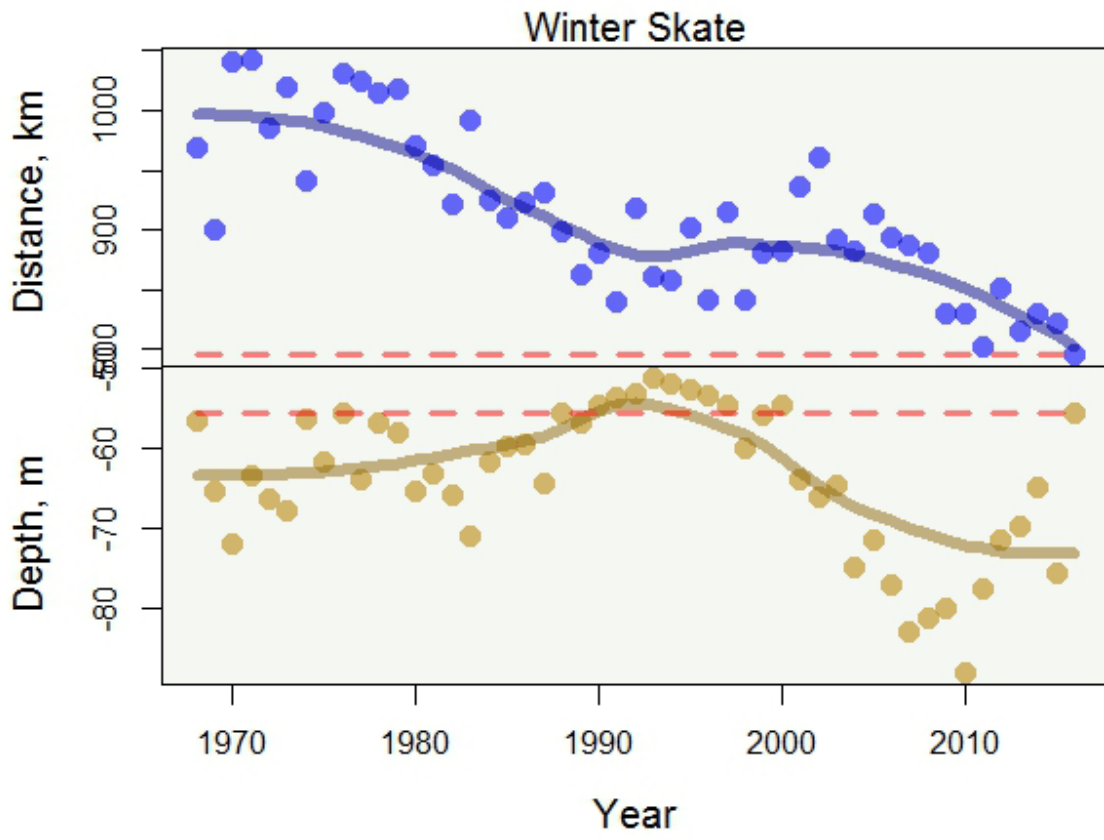
Windowpane flounder



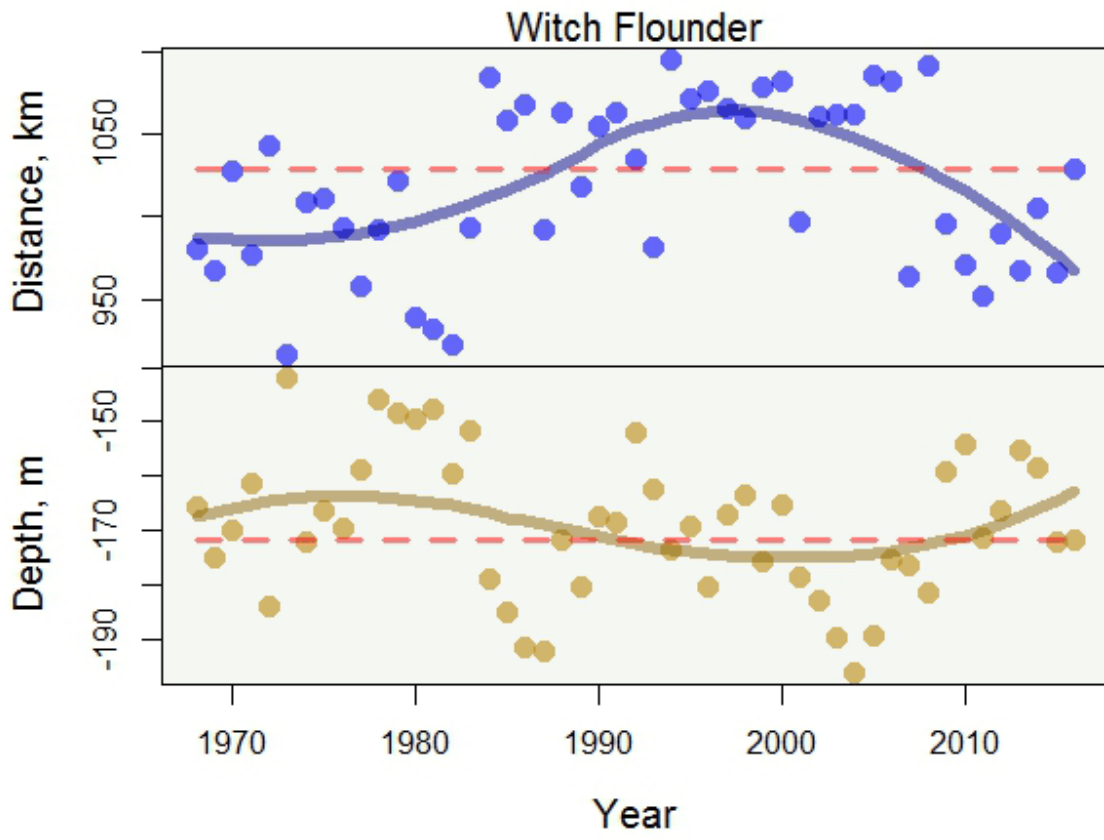
Winter flounder



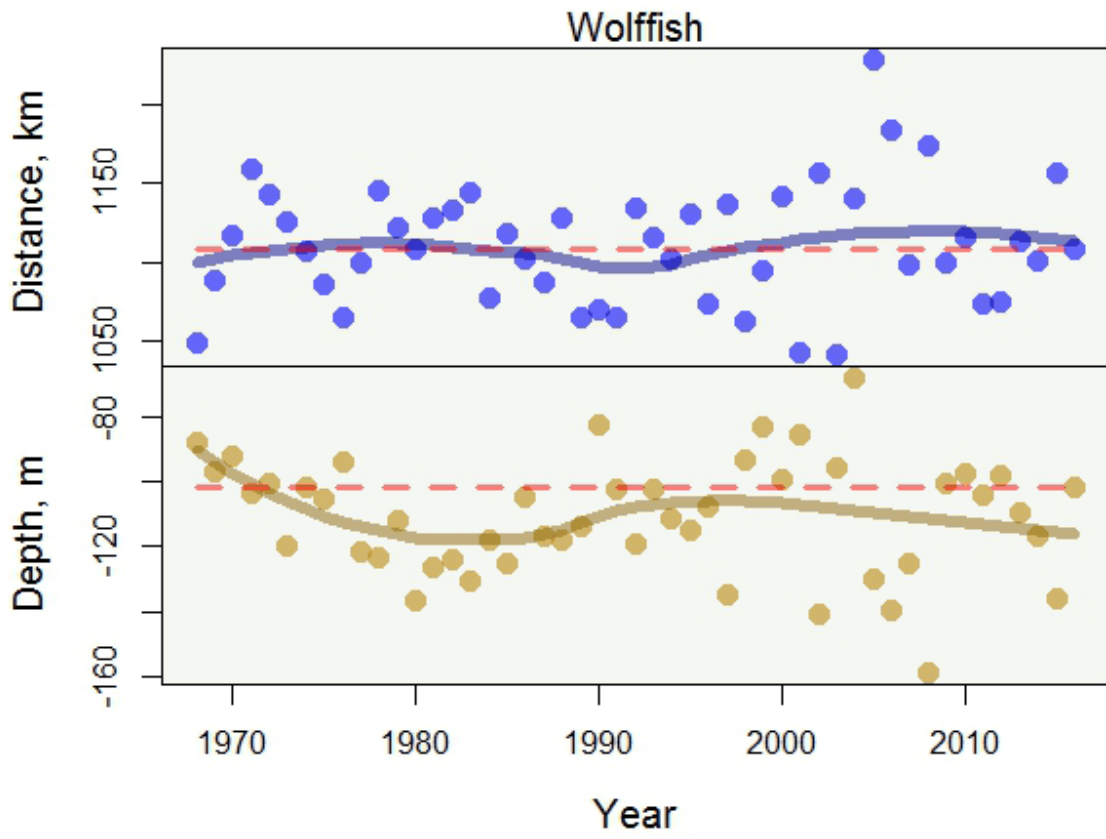
Winter skate



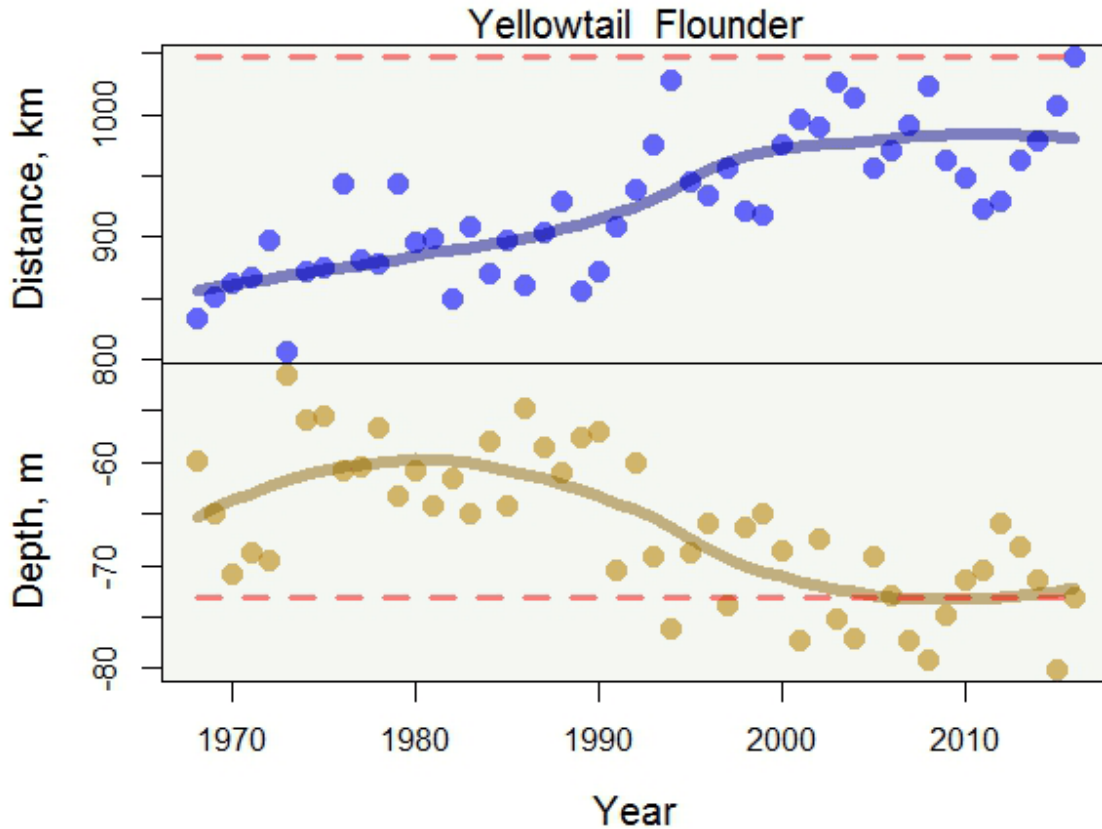
Witch flounder



Wolfish



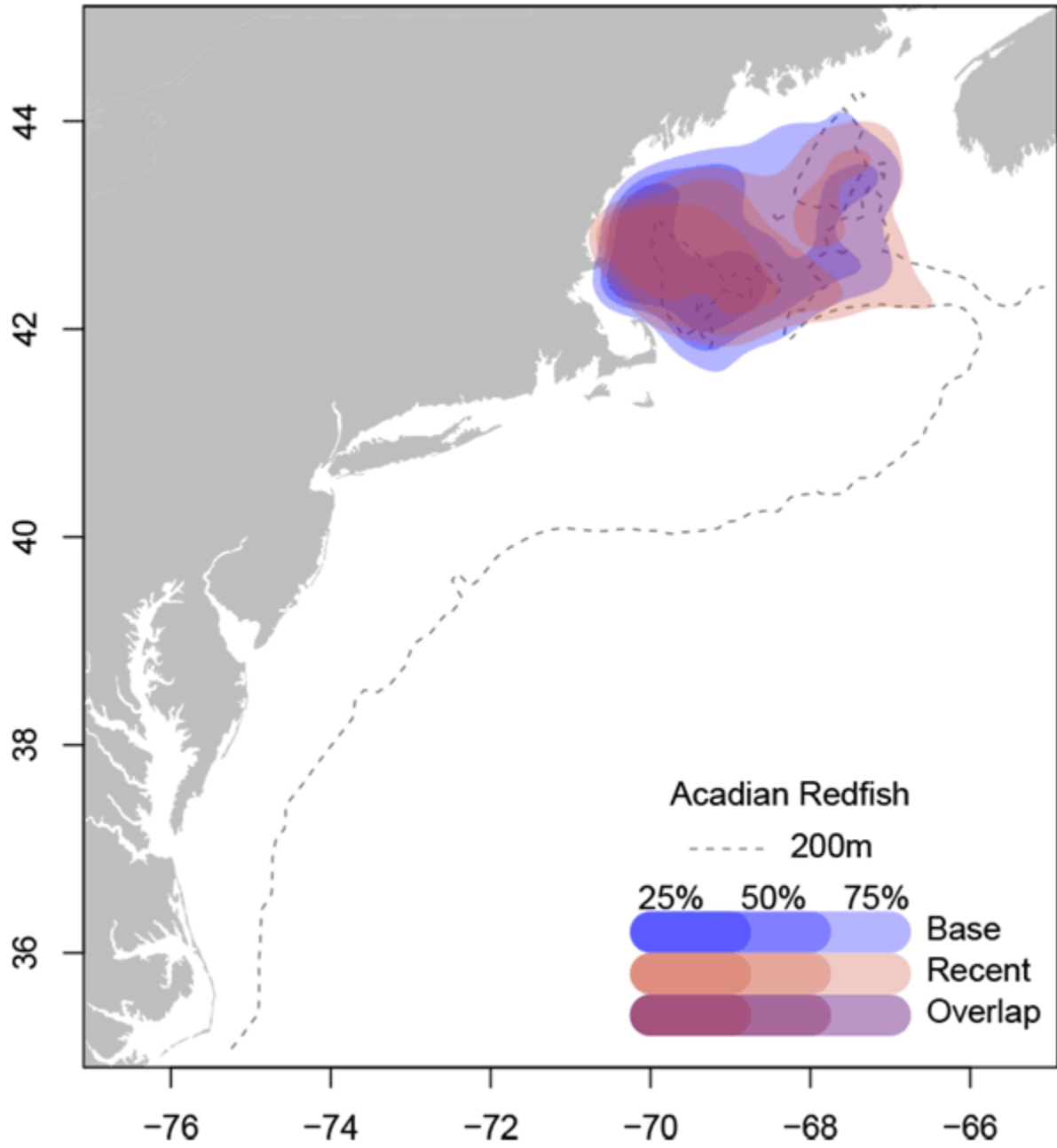
Yellowtail flounder



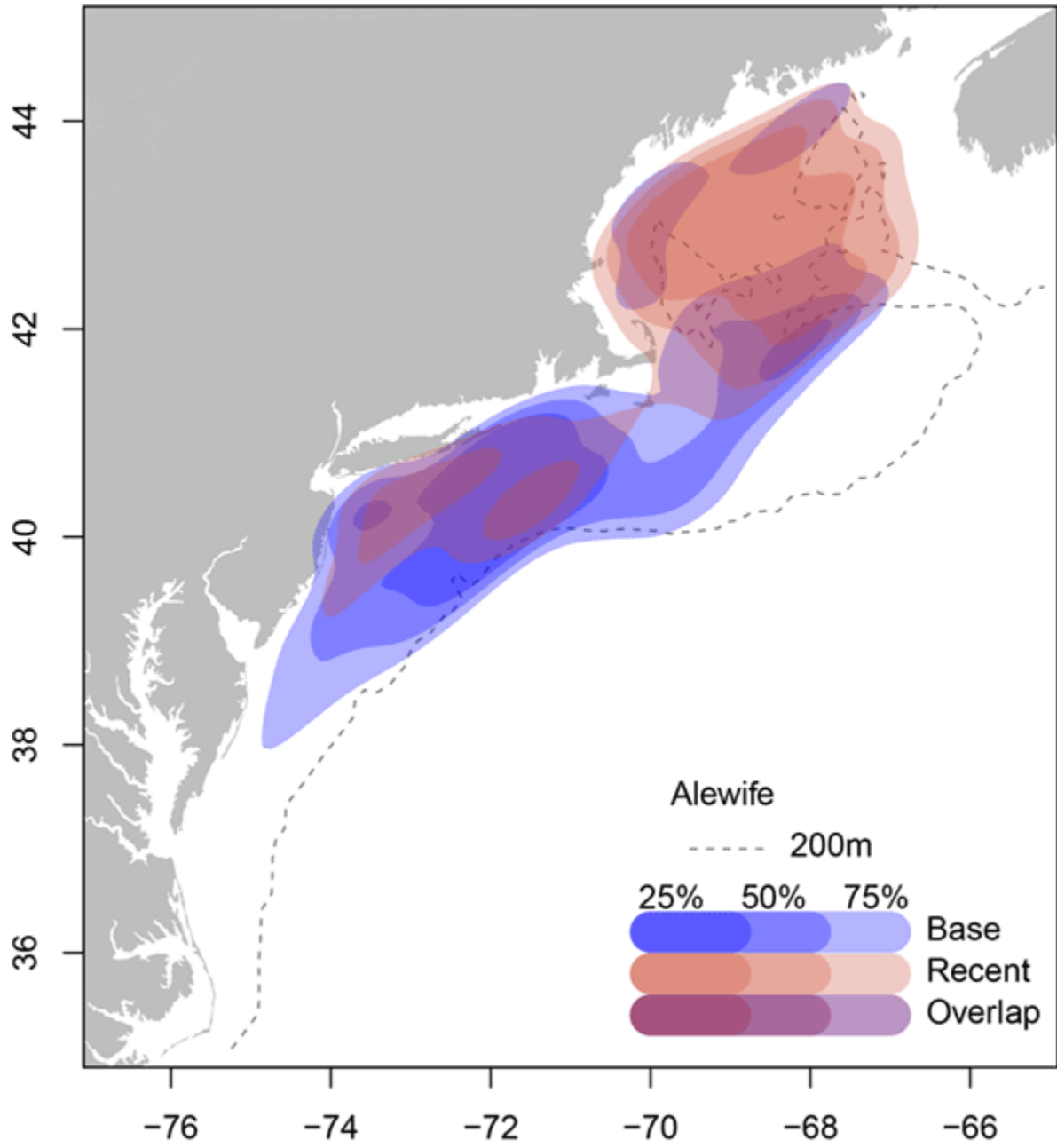
Kernel Density Plots of Spring Species Distribution

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 (2014-2016) for the spring survey (shown as red kernel densities). The table below shows the species analyzed.

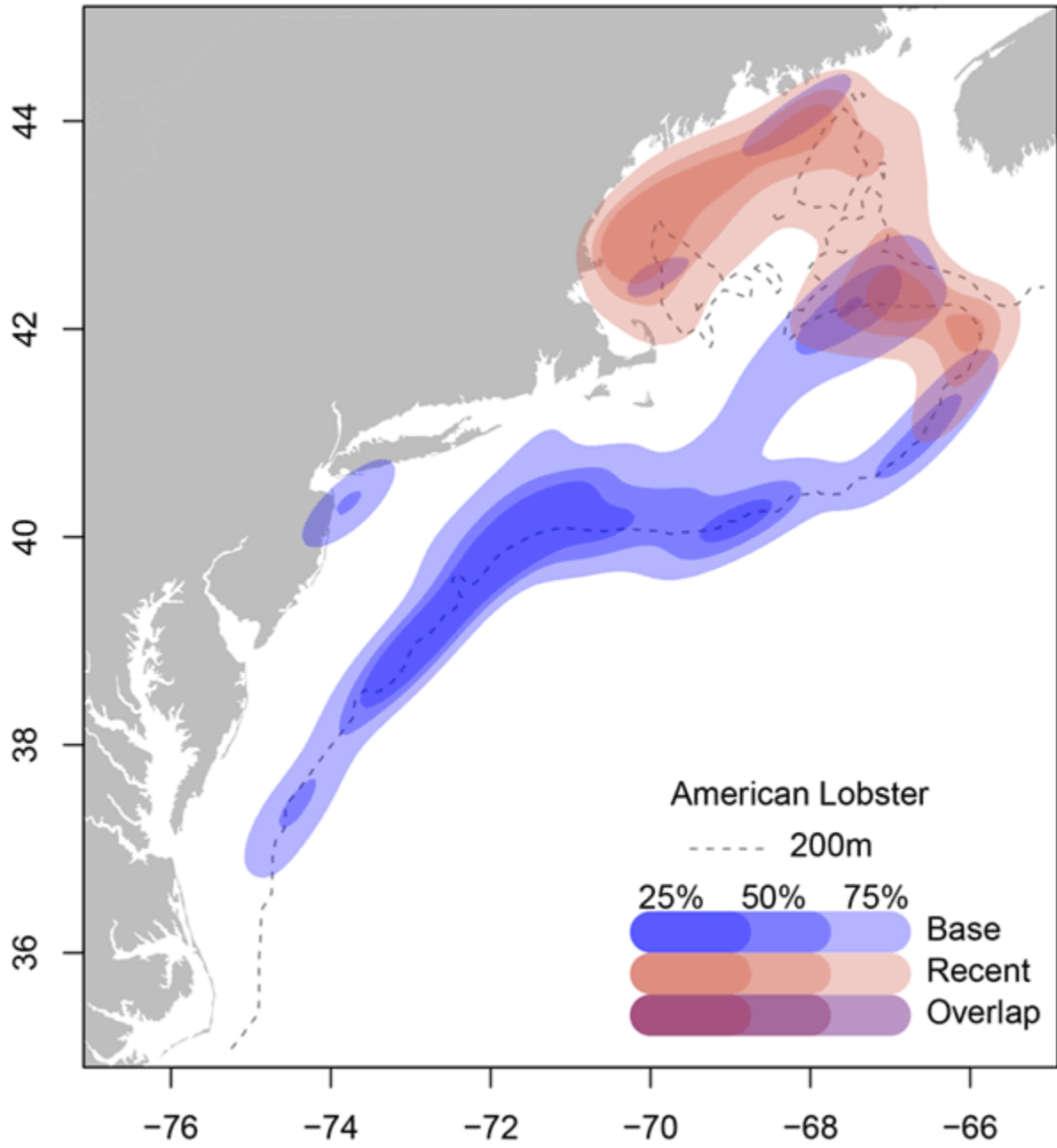
Acadian redfish



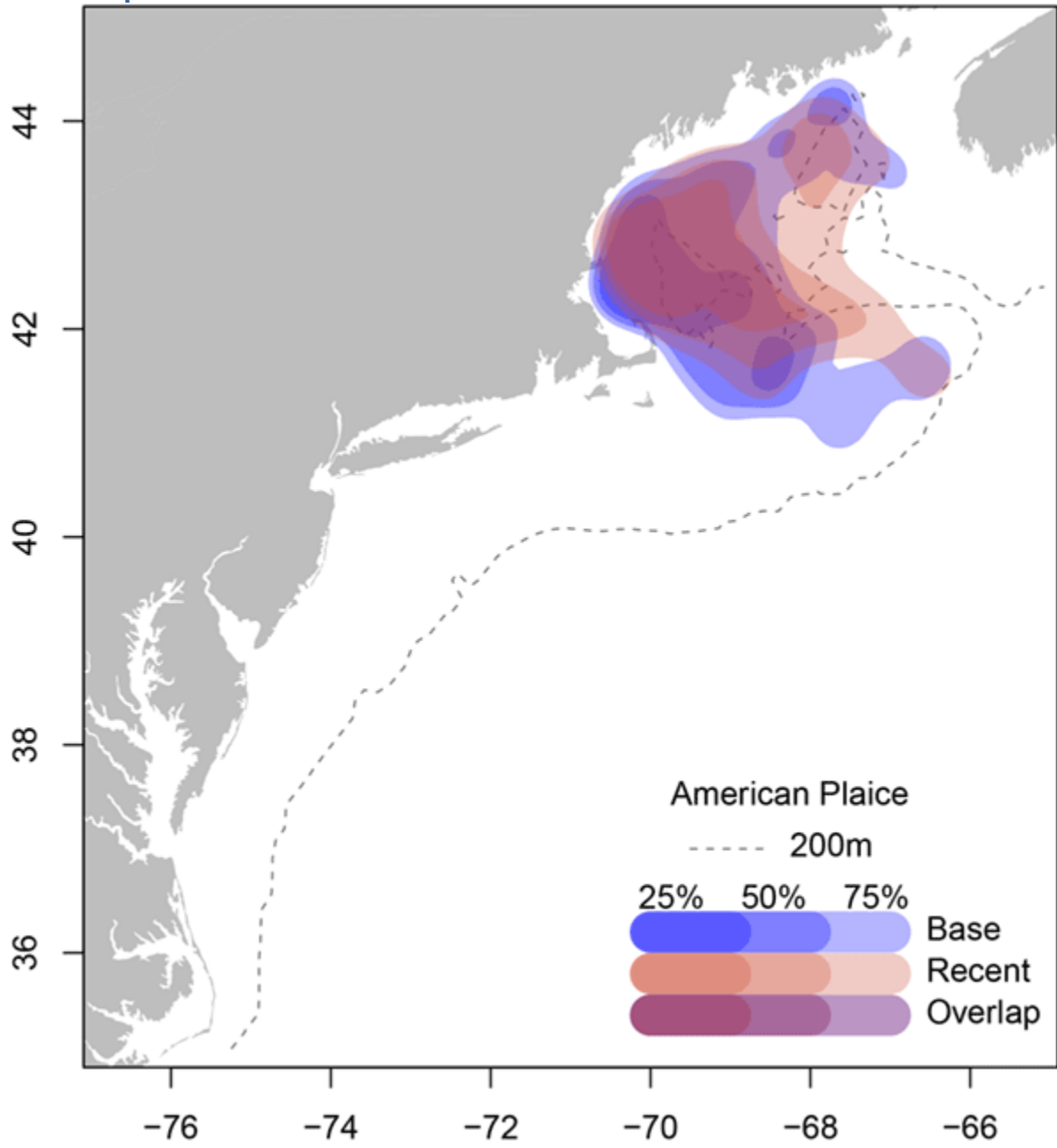
Alewife



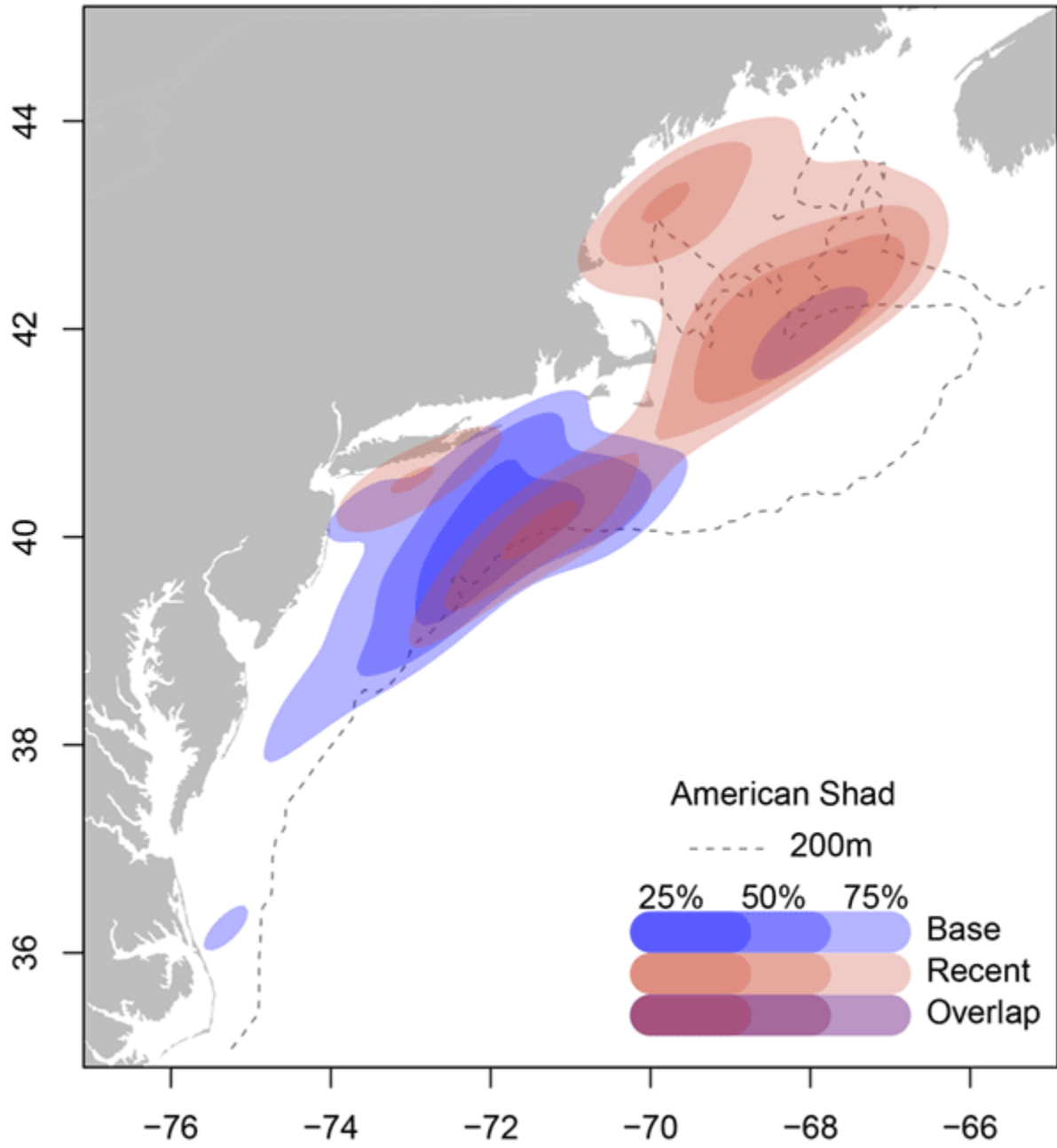
American lobster



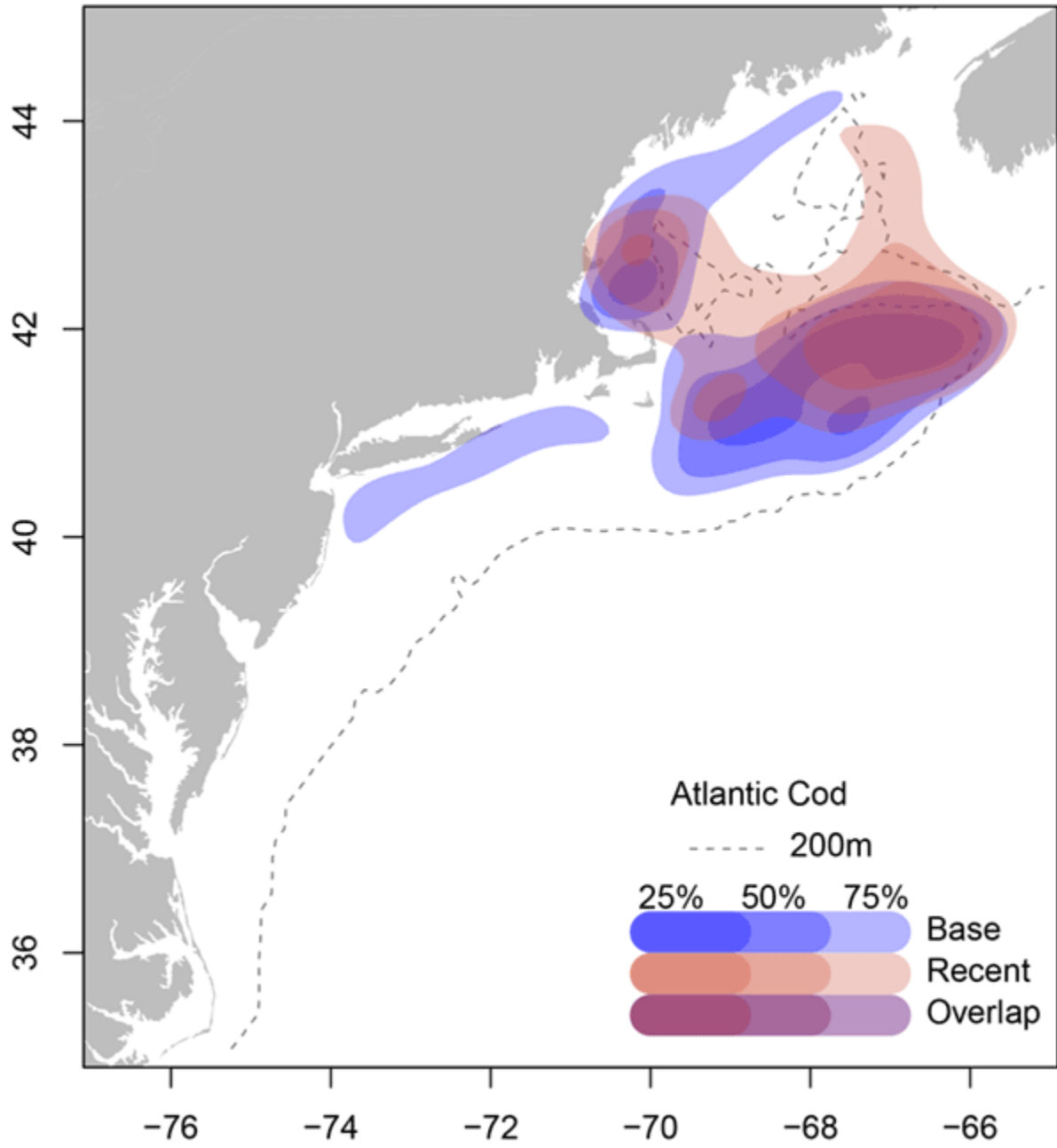
American plaice



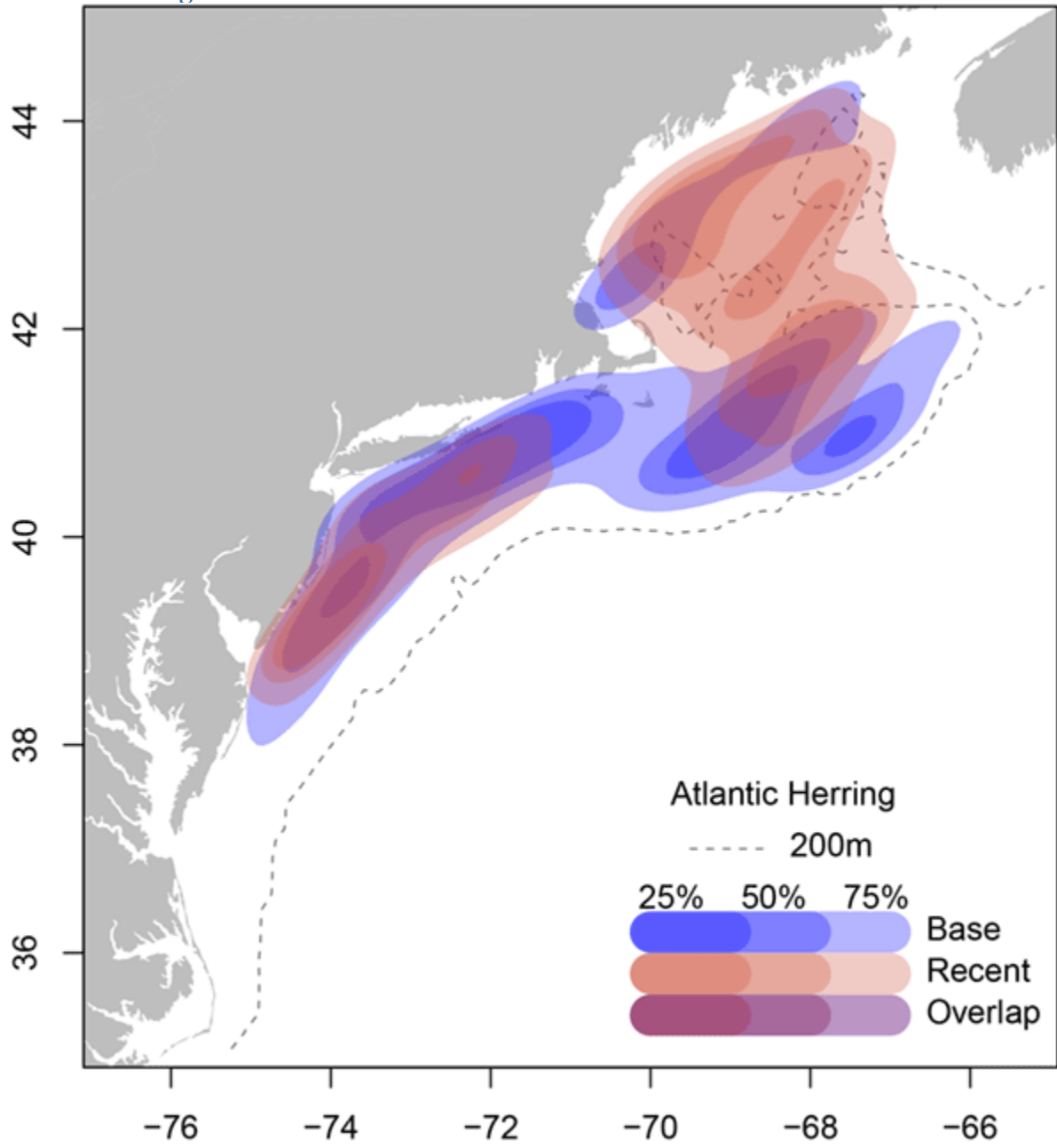
American shad



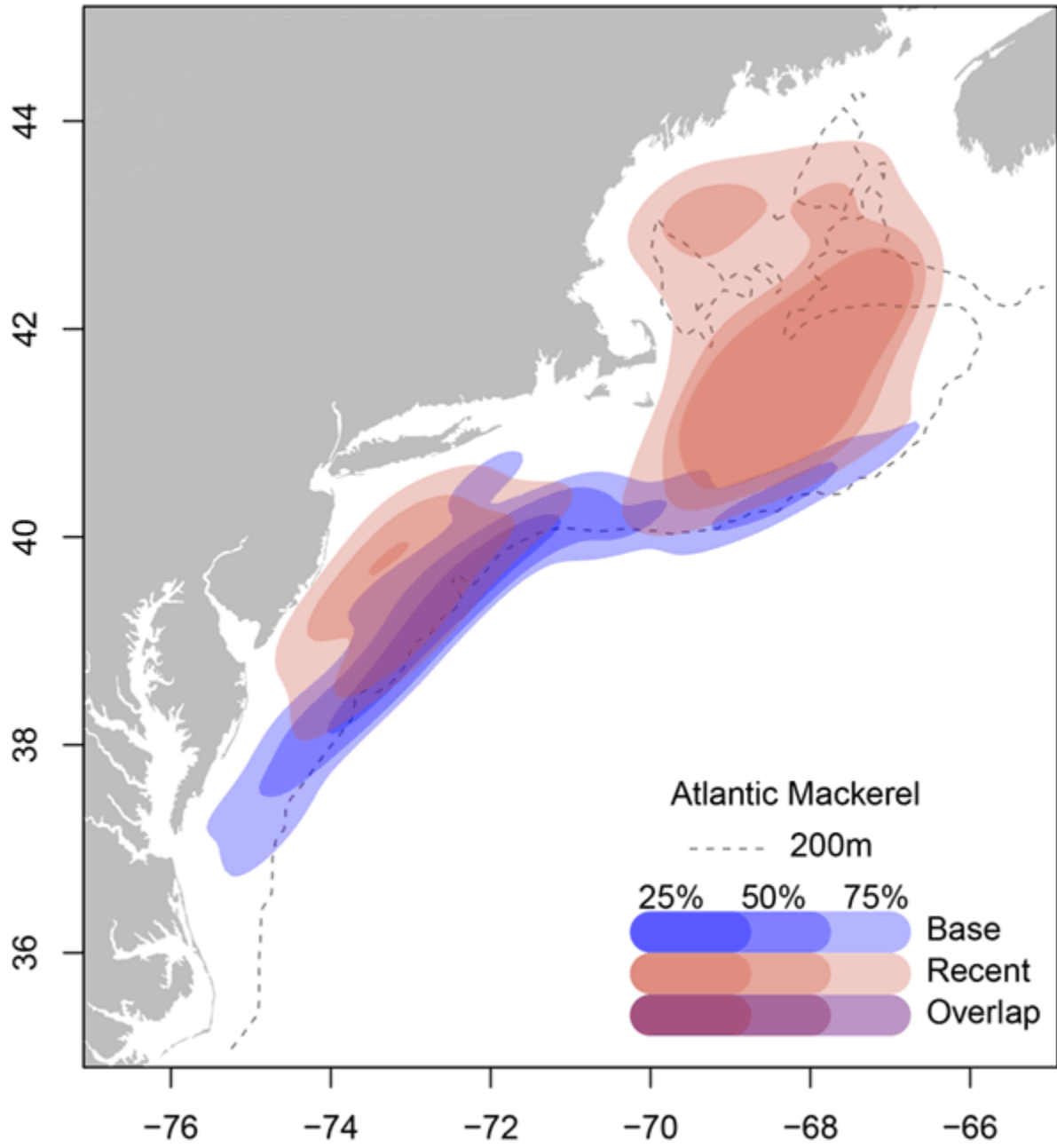
Atlantic cod



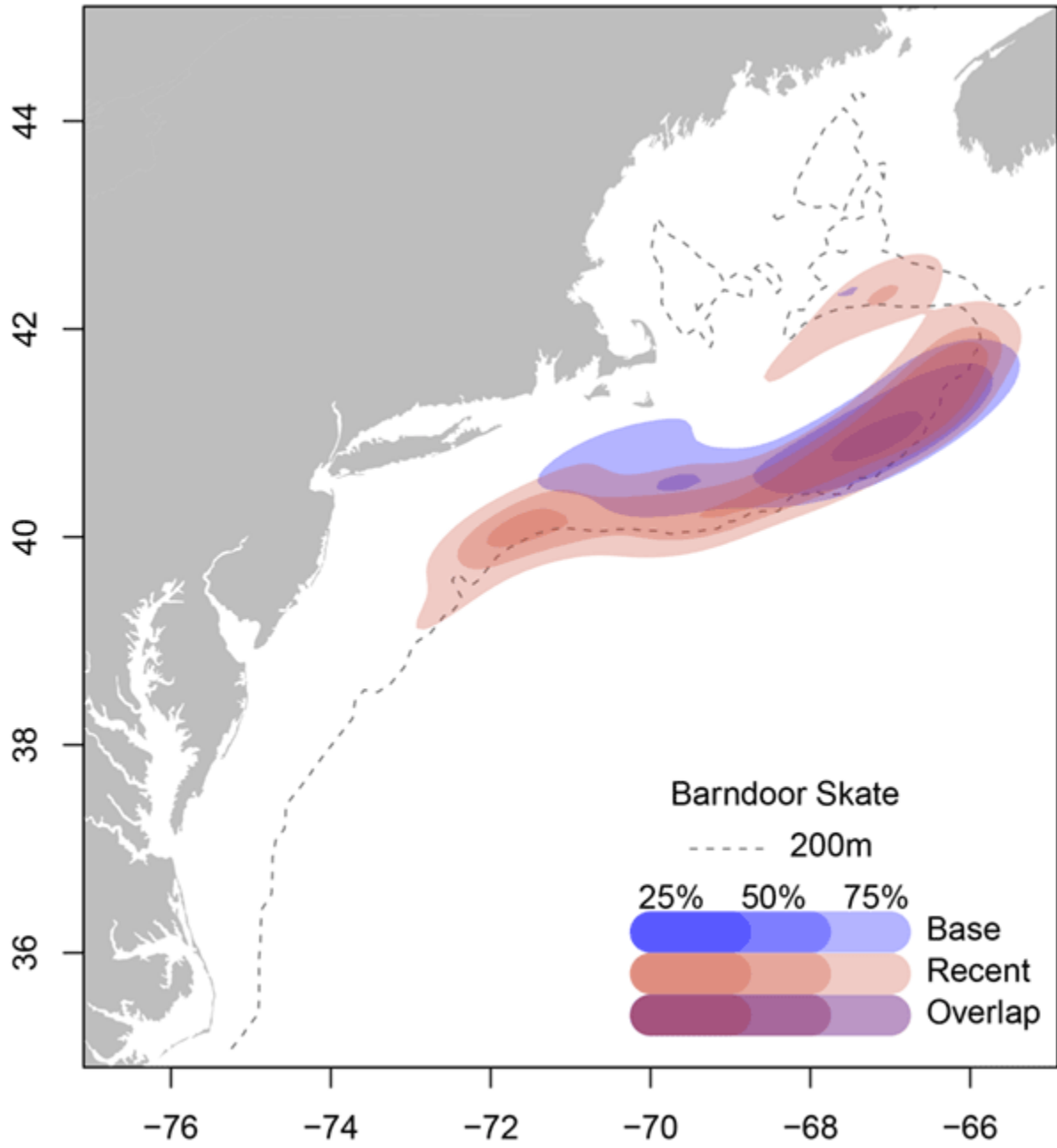
Atlantic herring



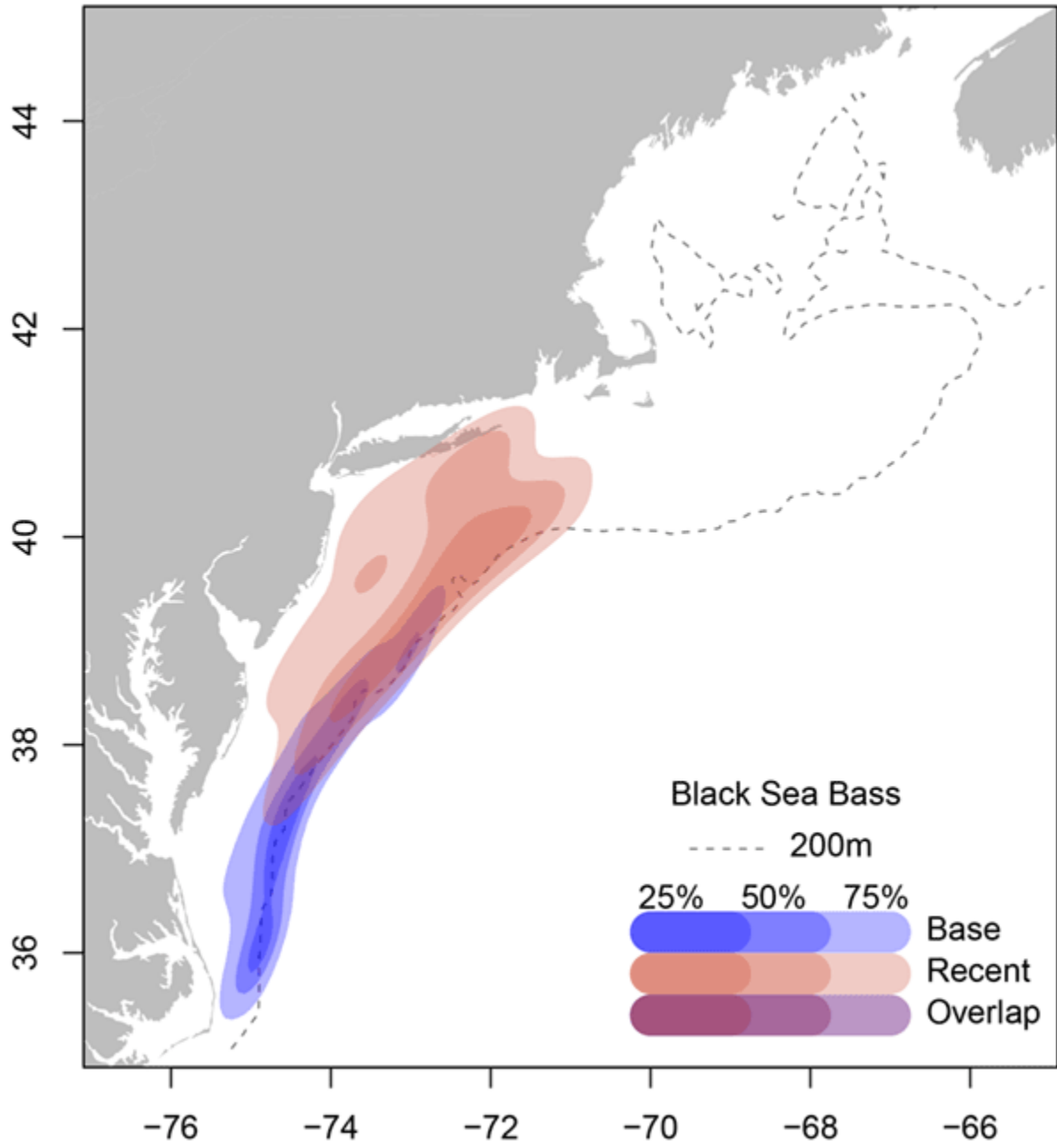
Atlantic mackerel



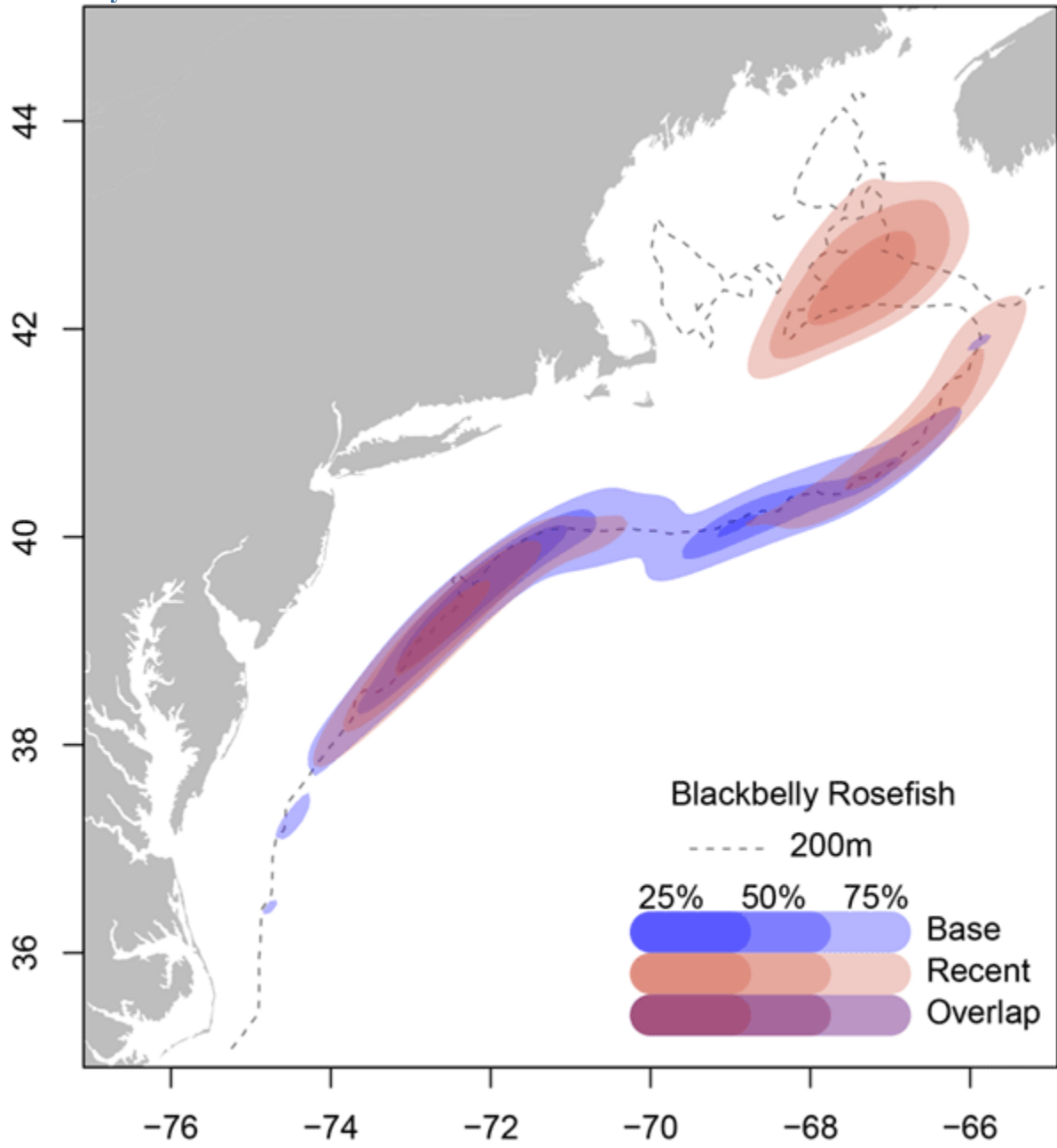
Barndoor skate



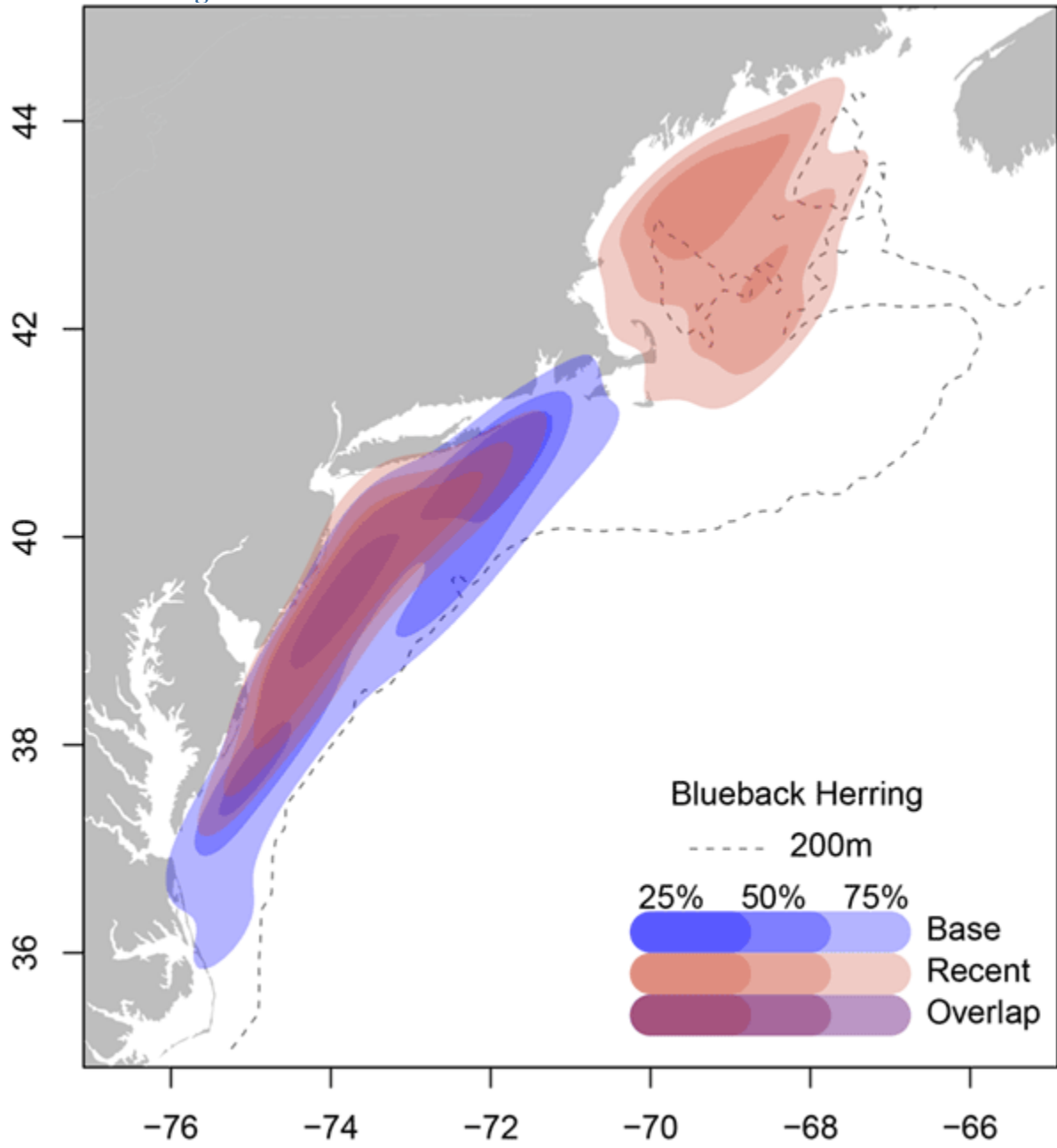
Black sea bass



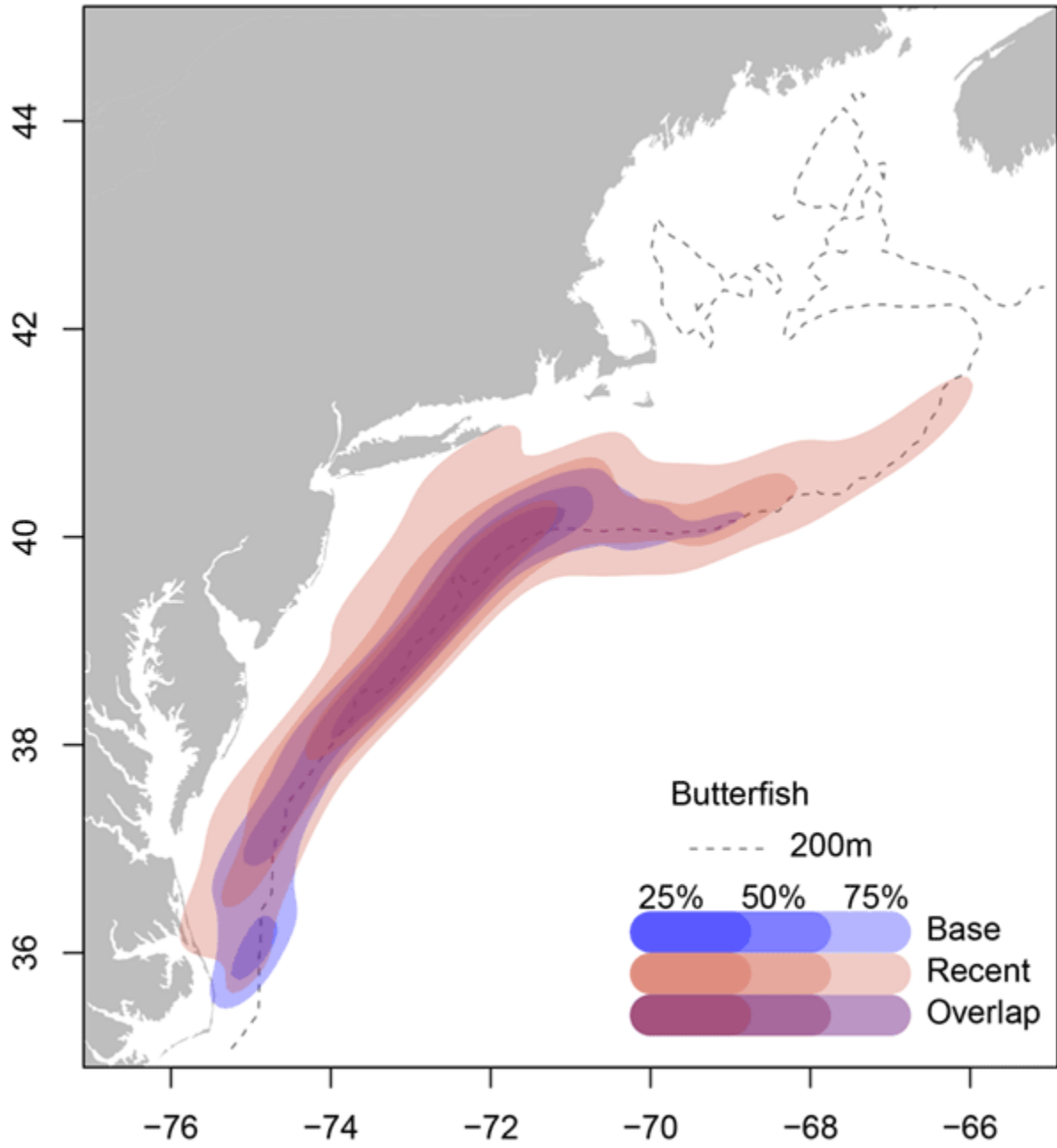
Blackbelly rosefish



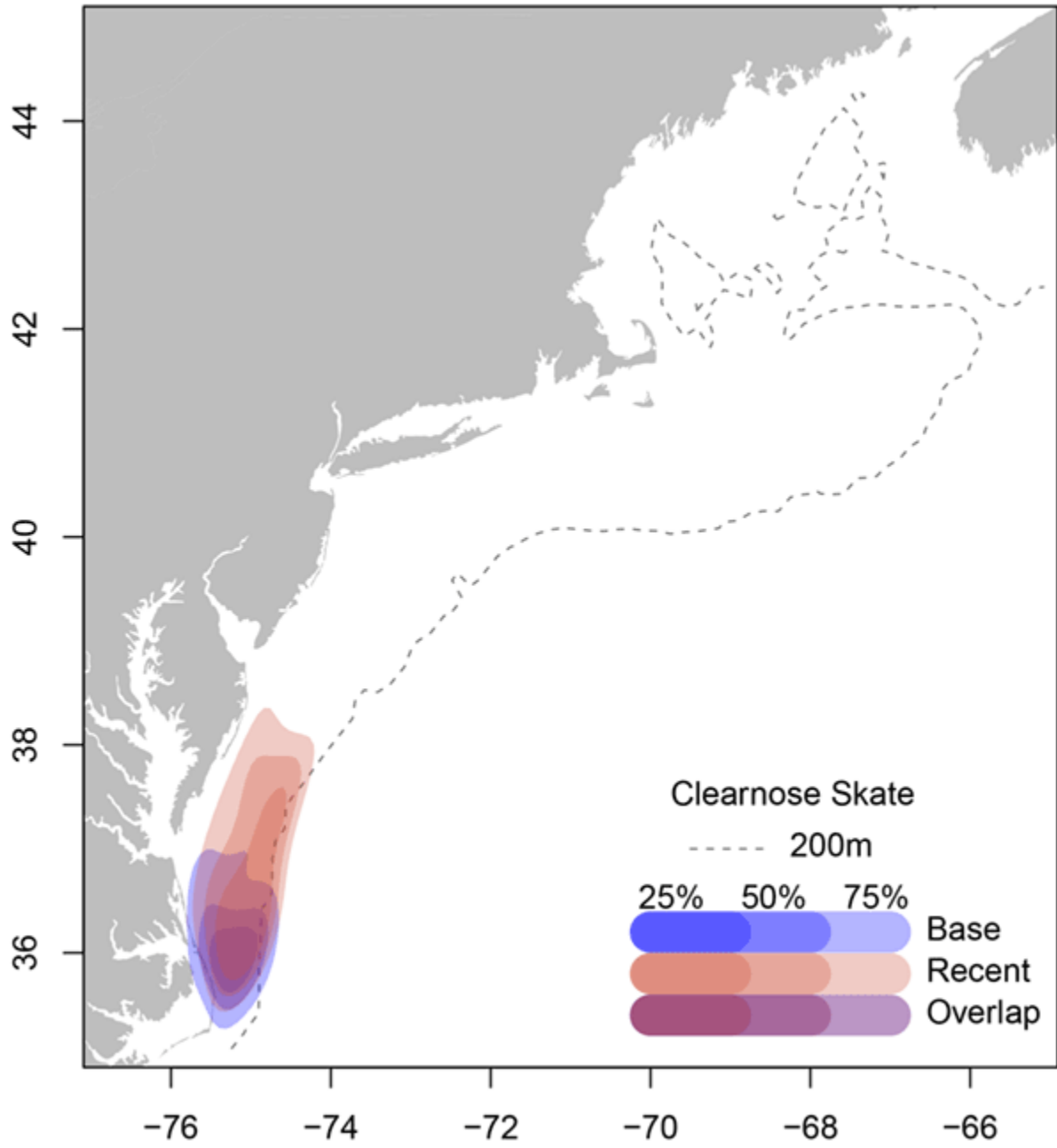
Blueback herring



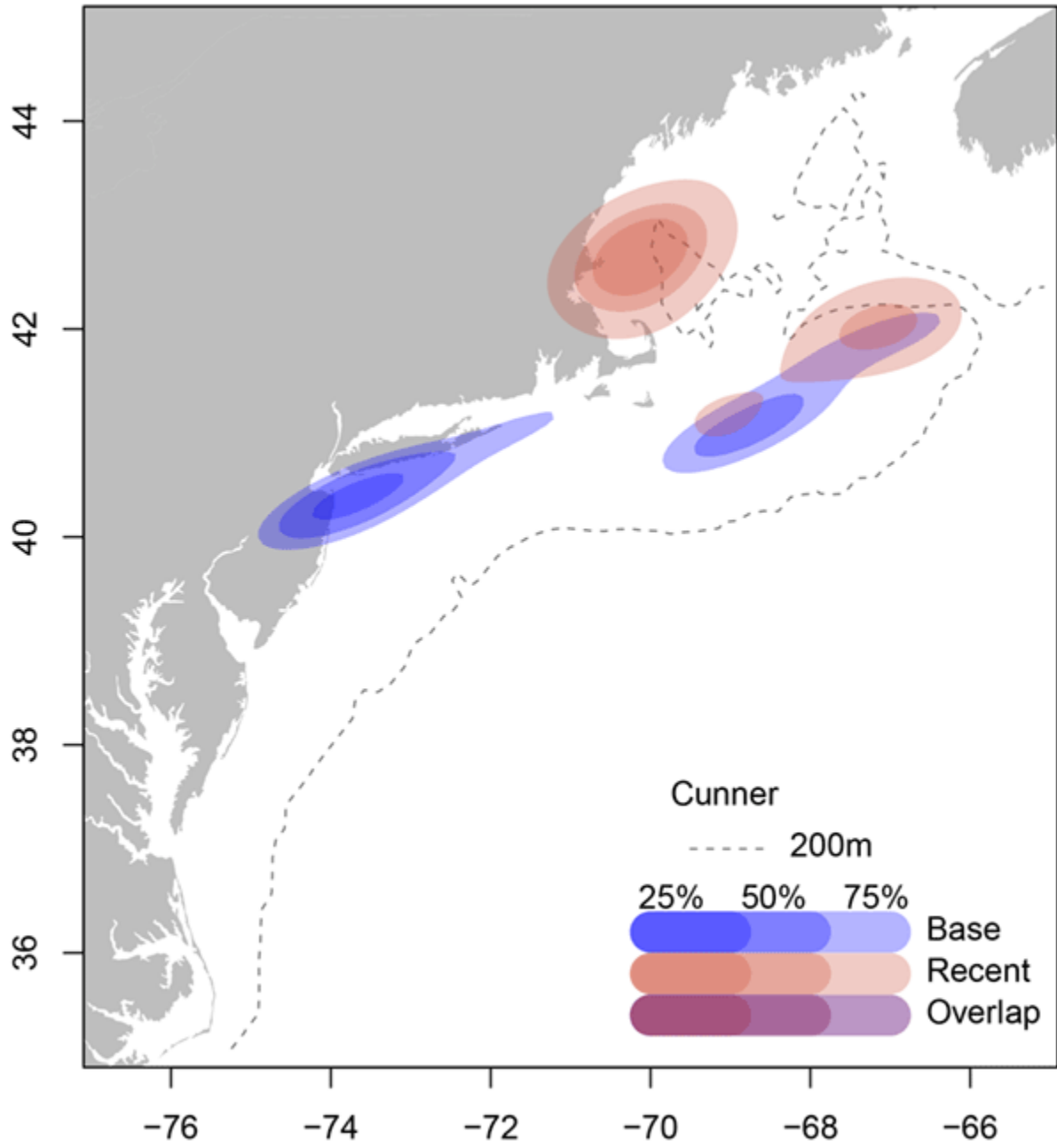
Butterfish



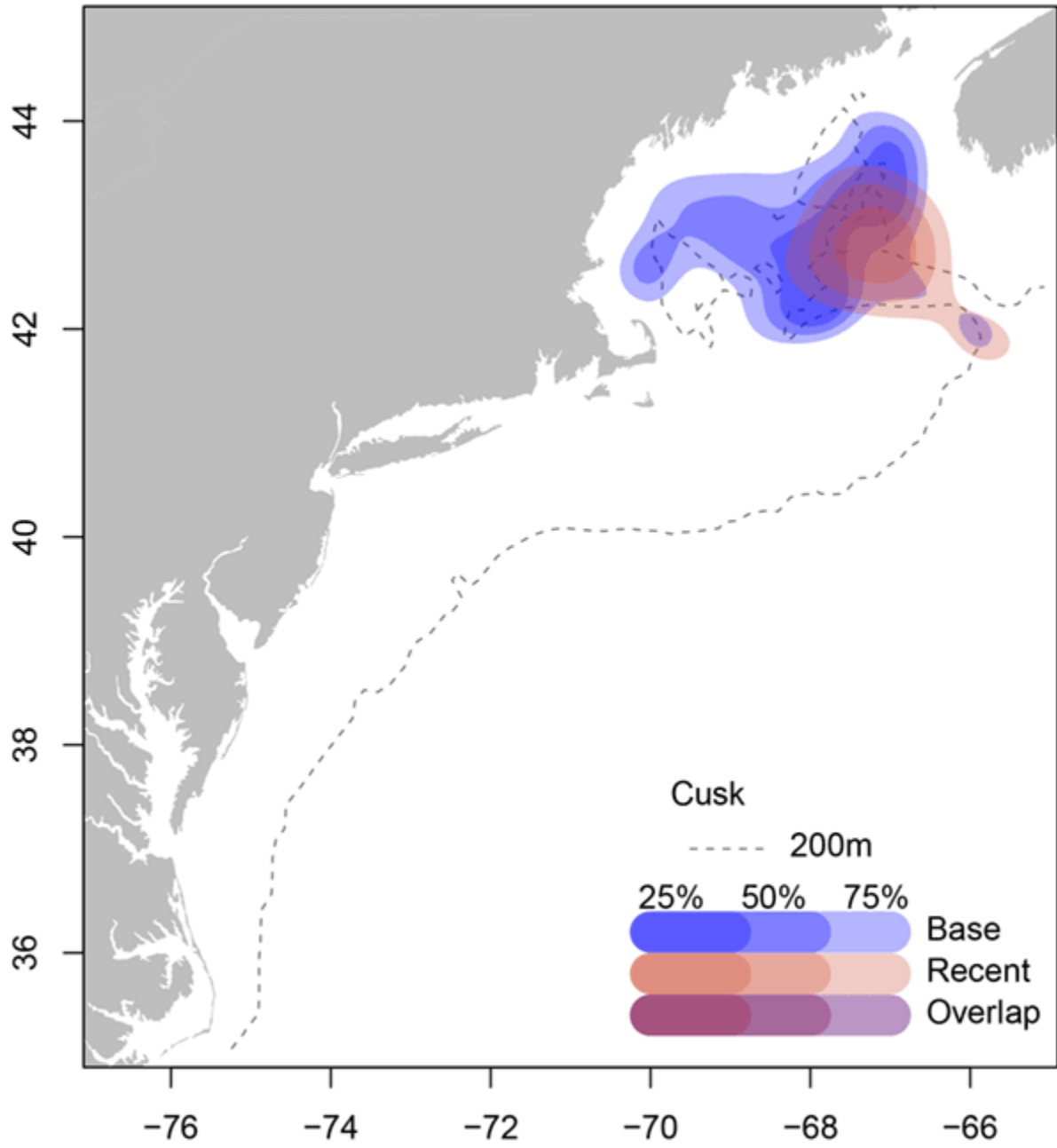
Clearnose skate



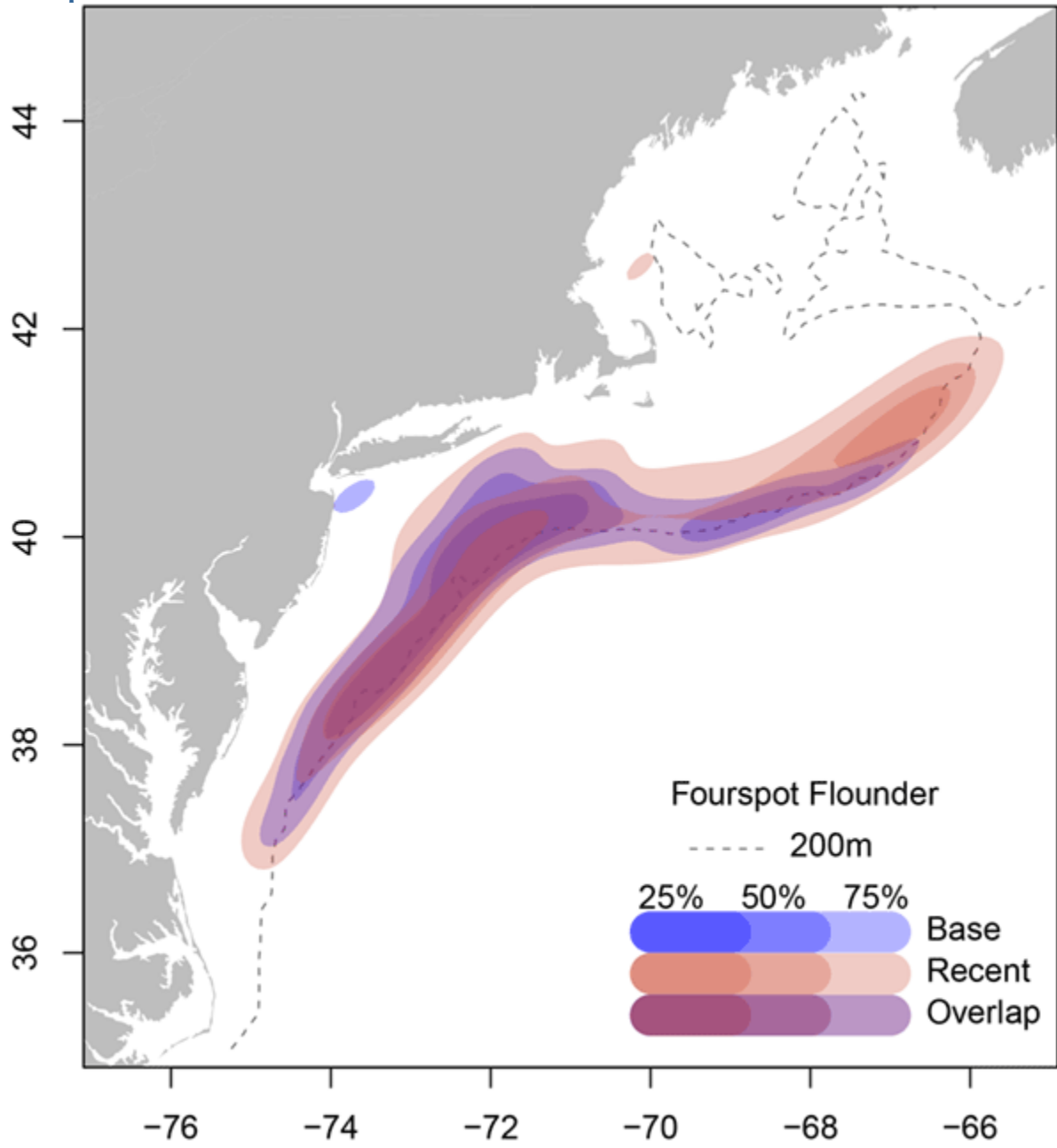
Cunner



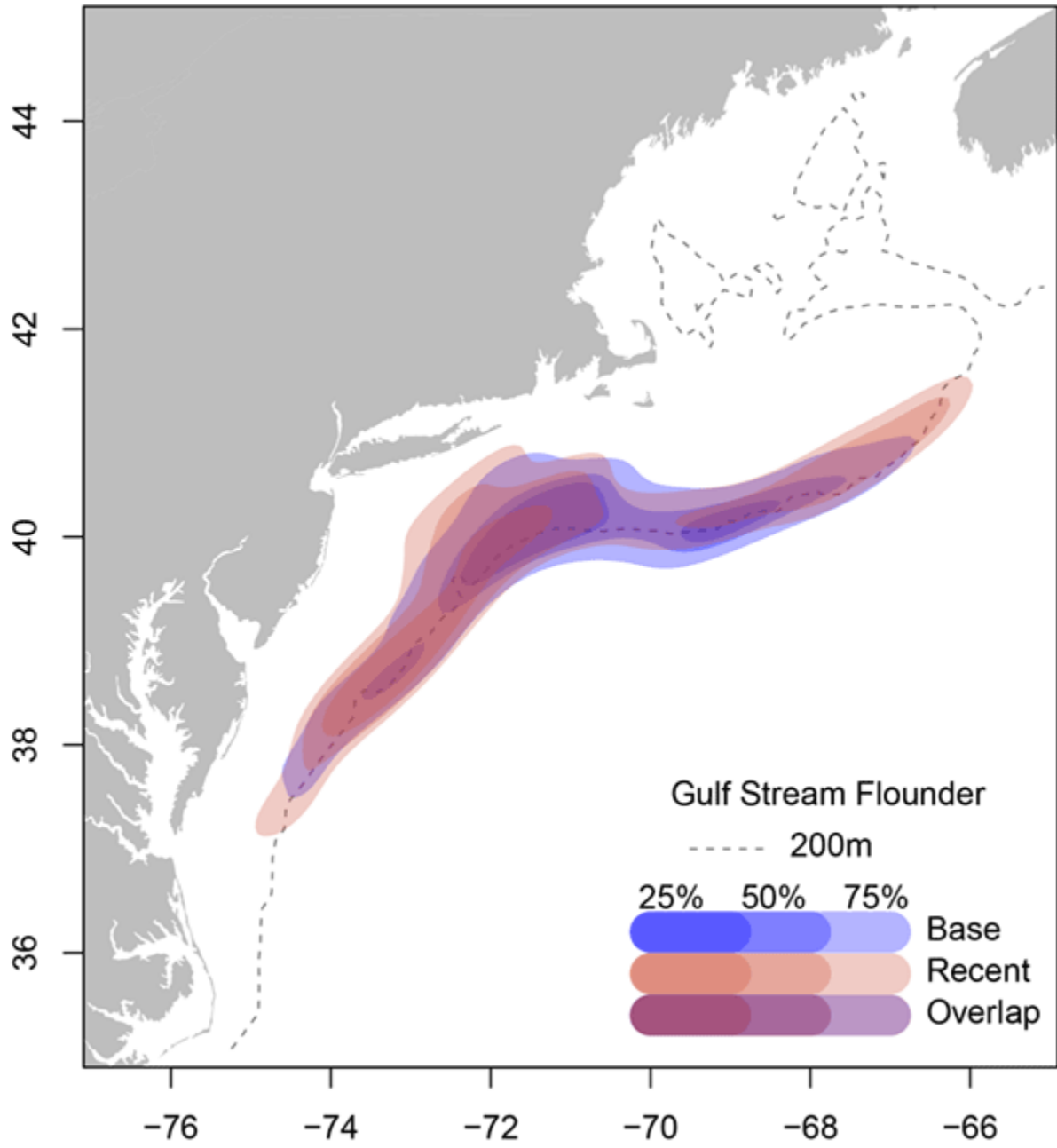
Cusk



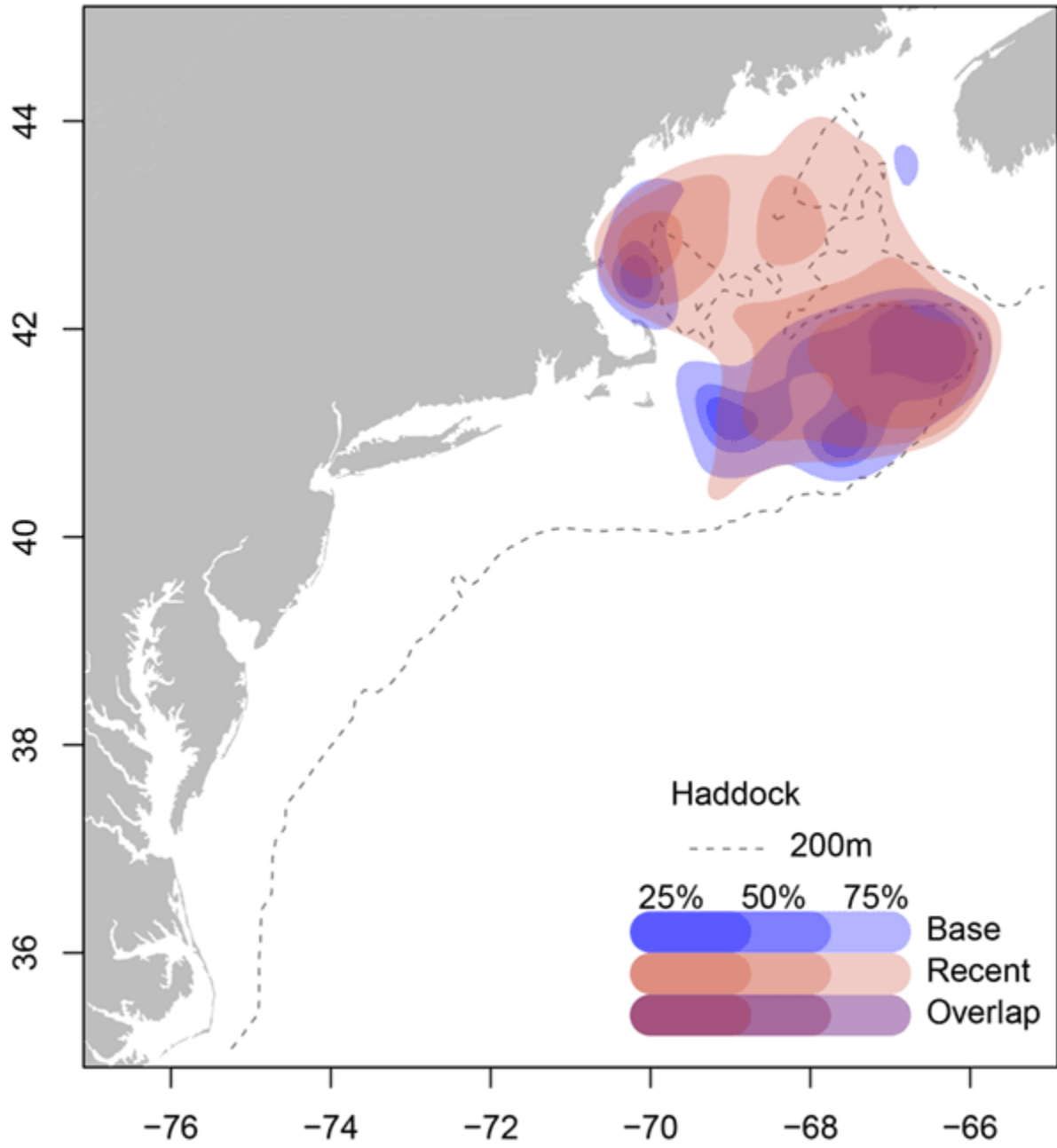
Fourspot flounder



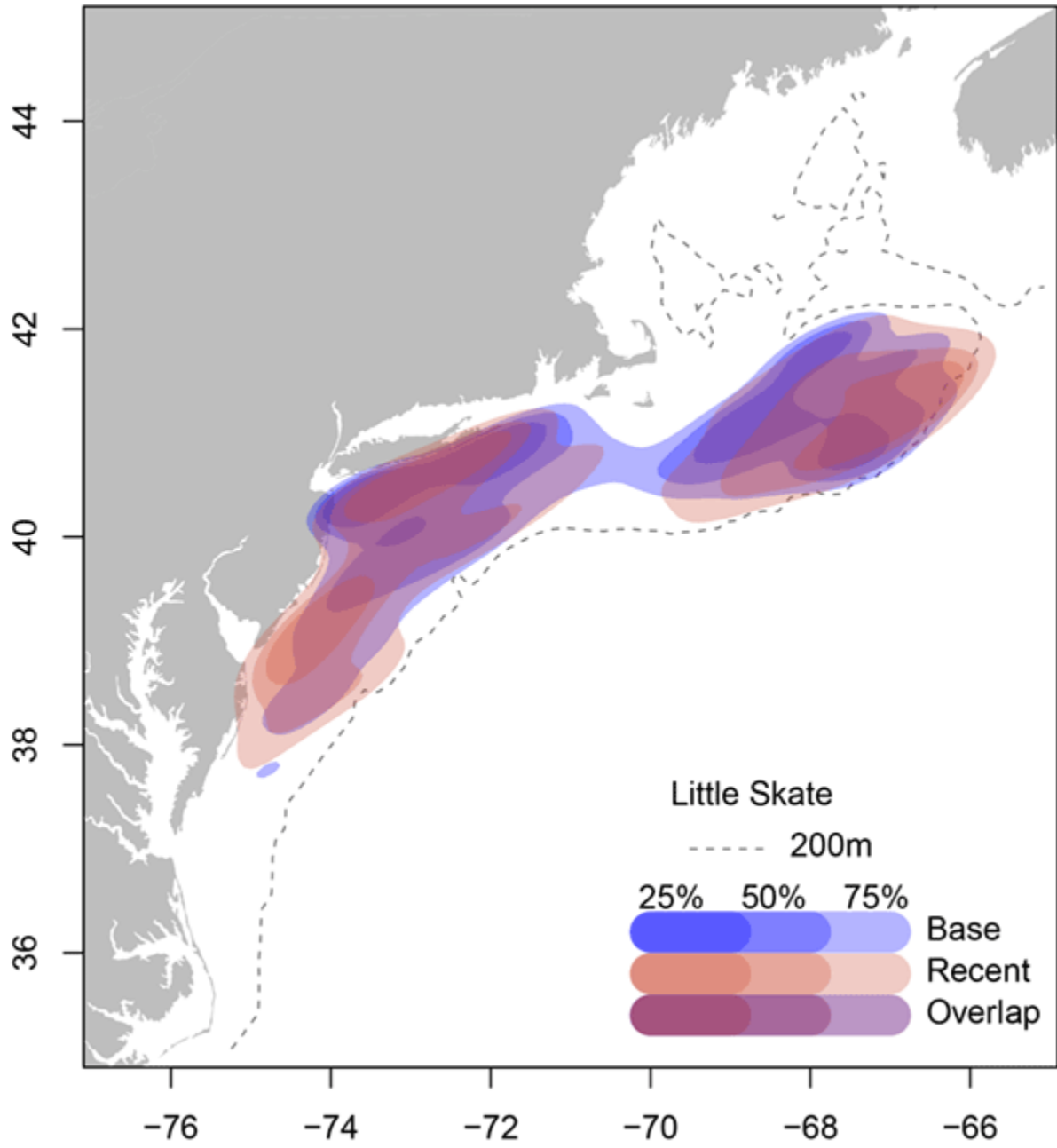
Gulf Stream flounder



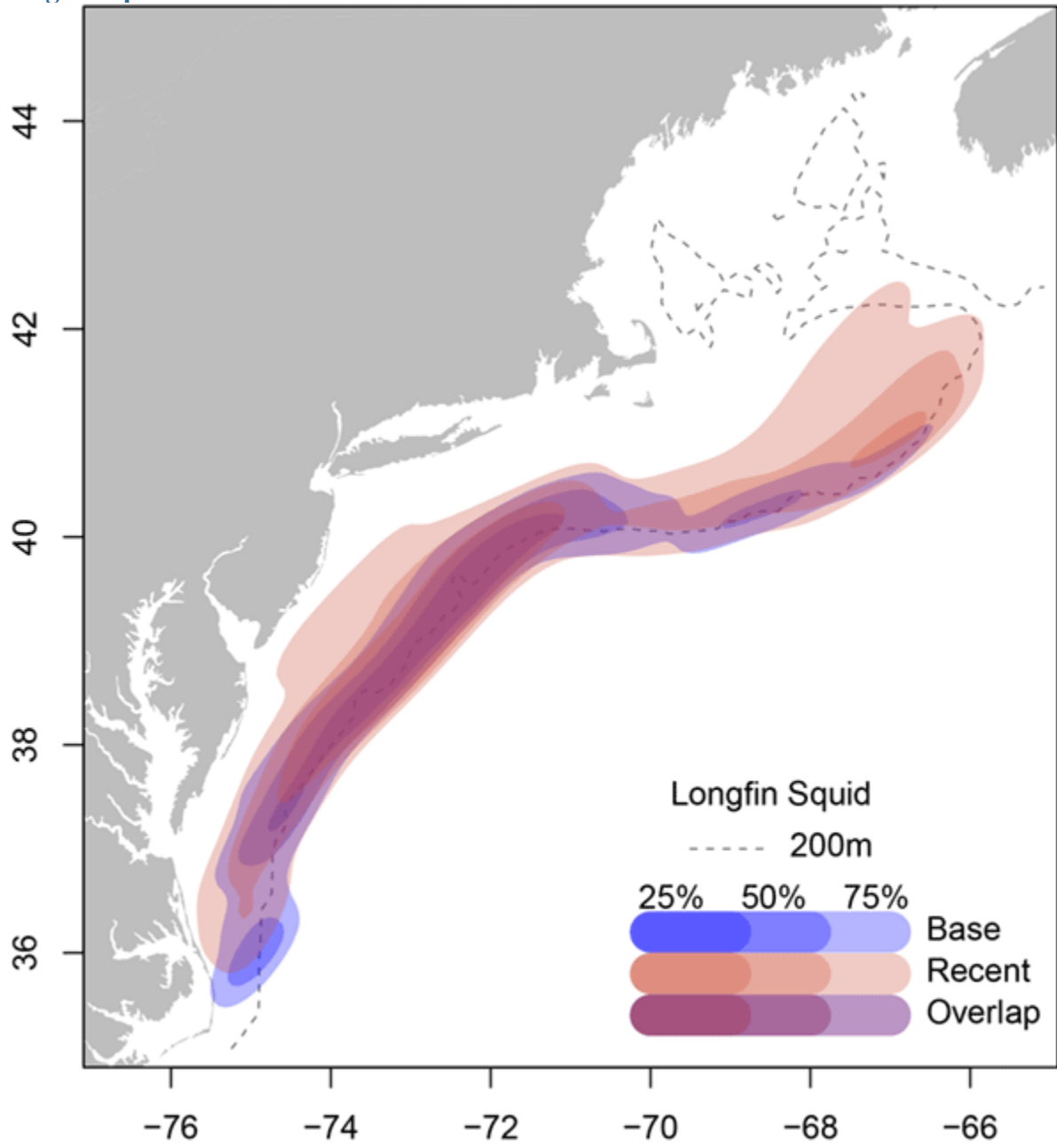
Haddock



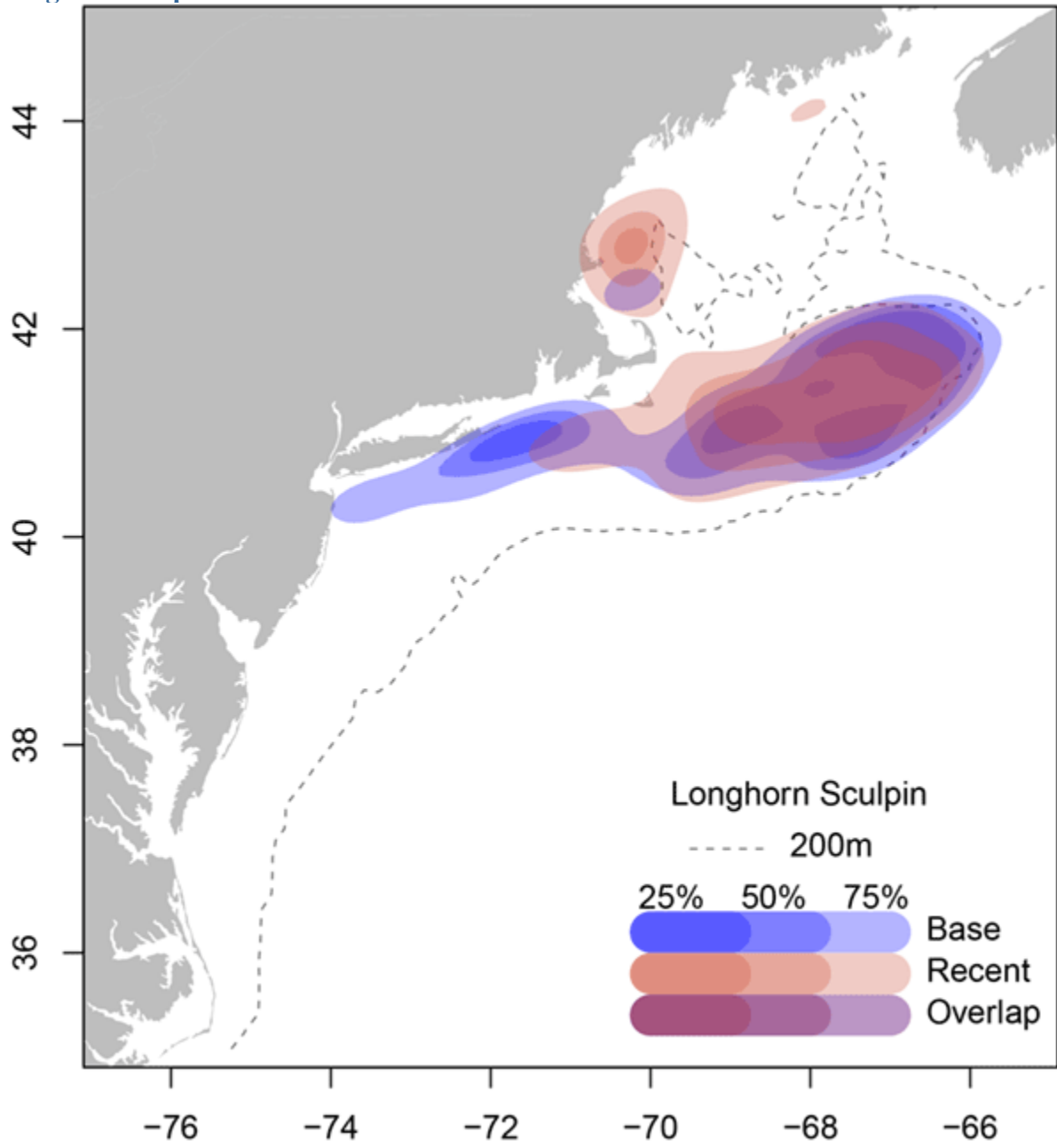
Little skate



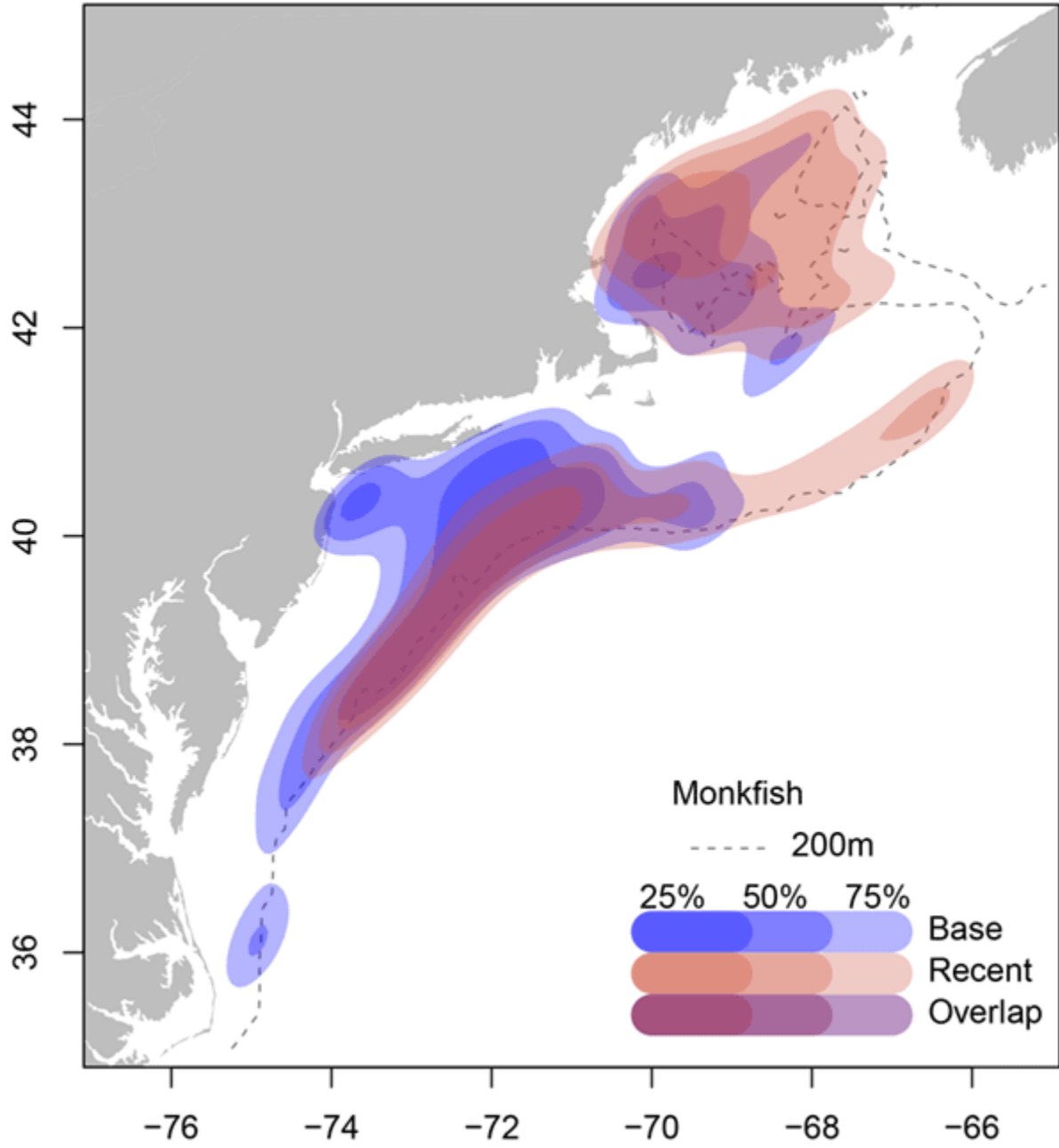
Longfin Squid



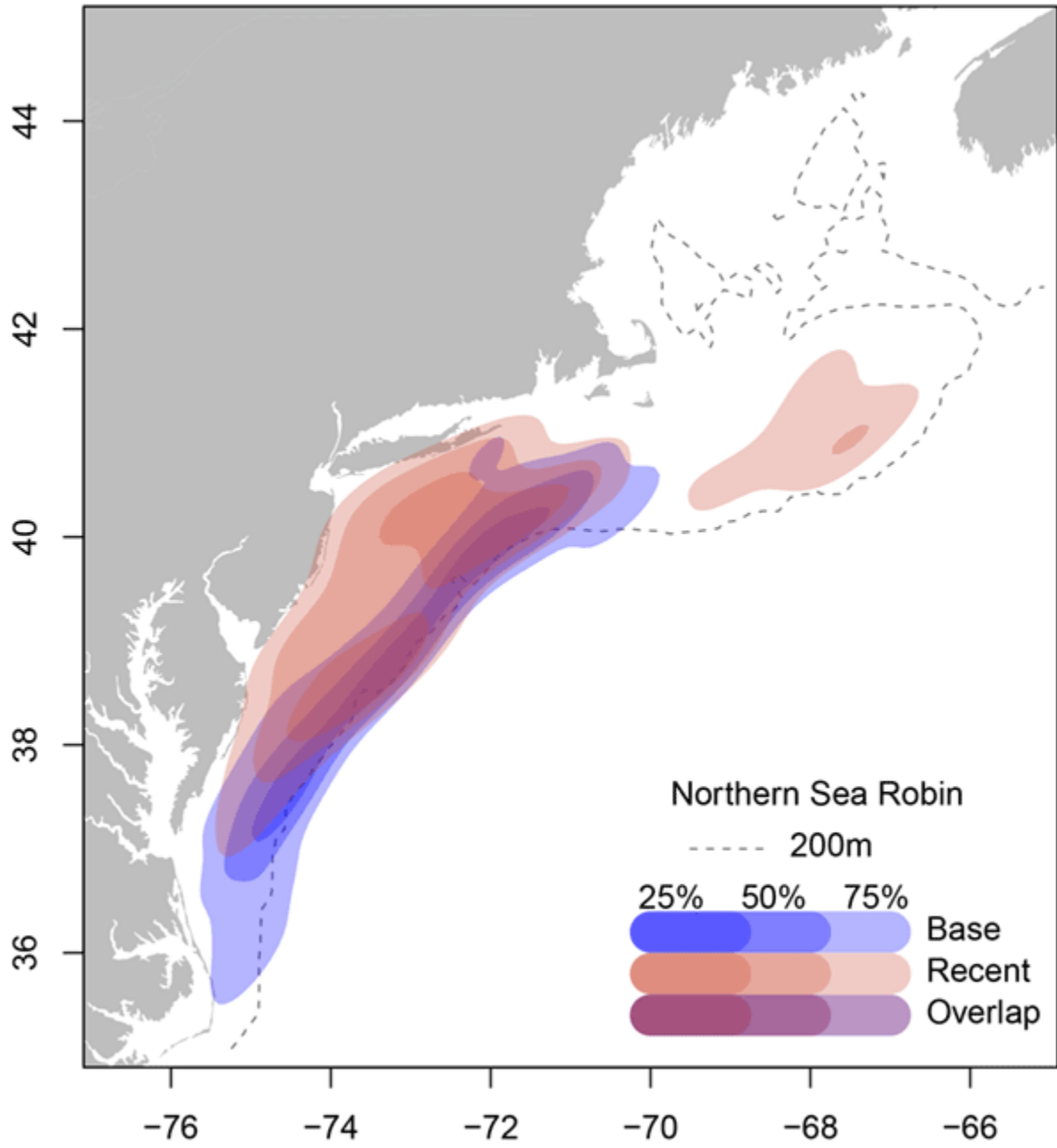
Longhorn sculpin



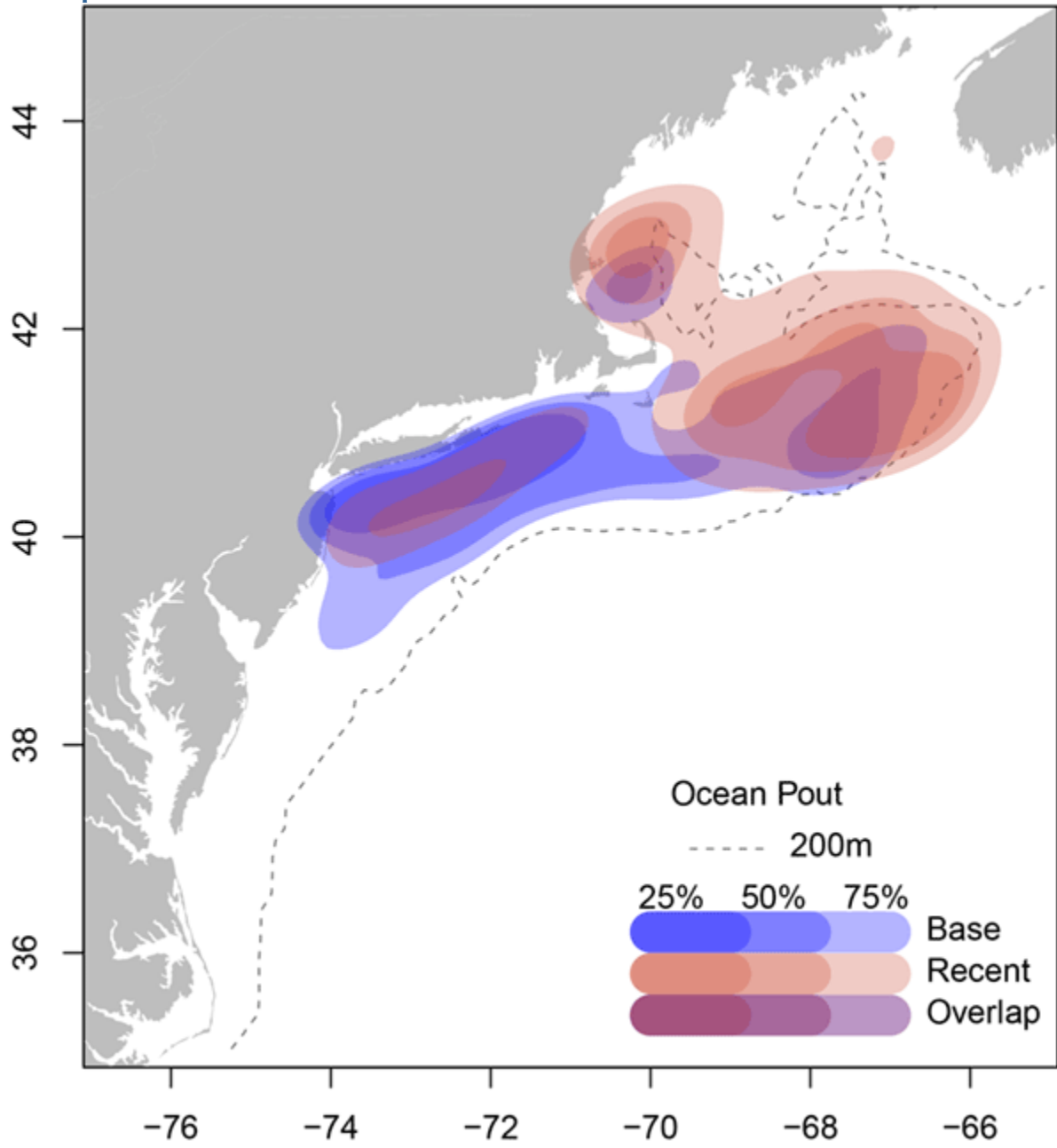
Monkfish



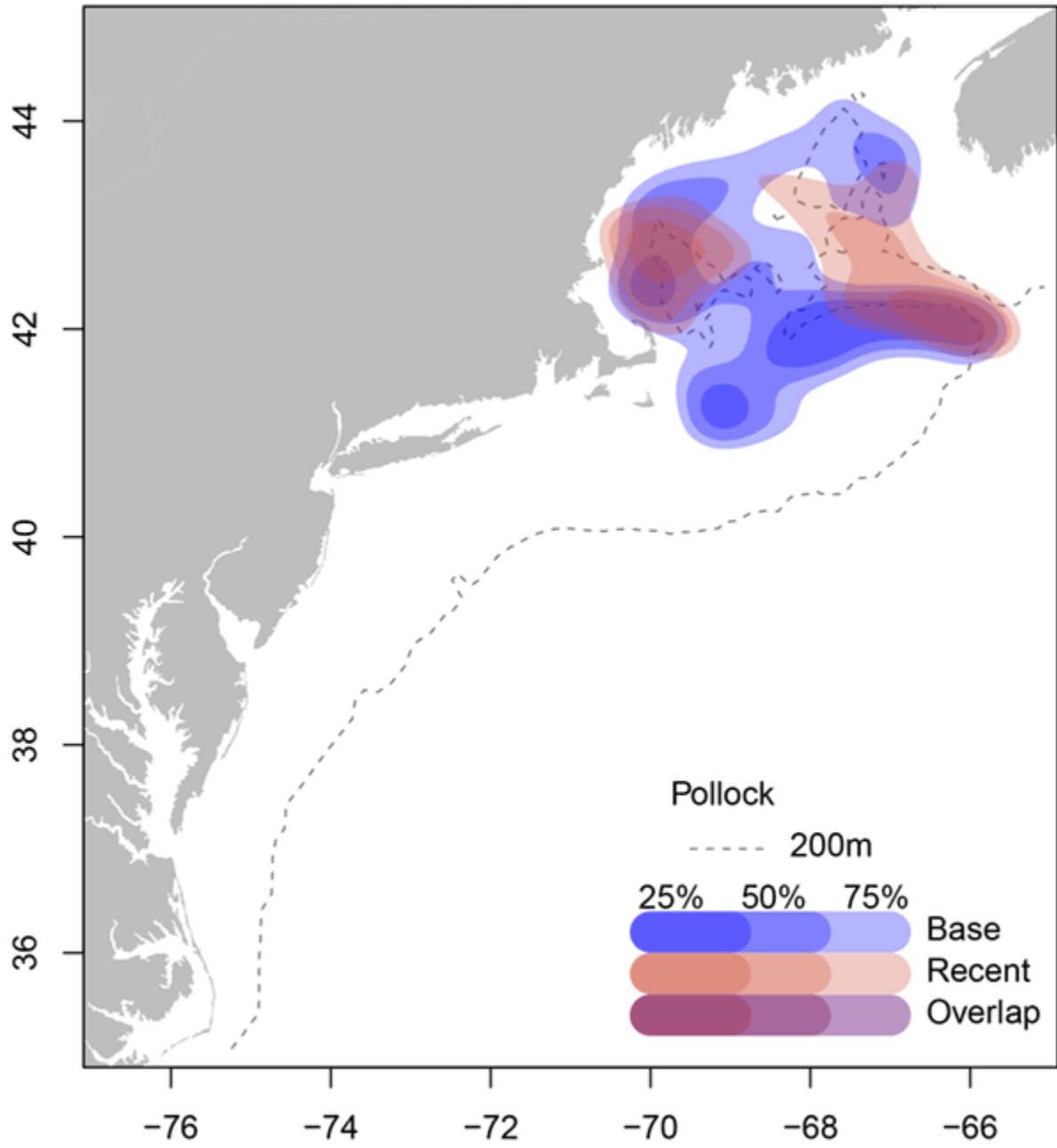
Northern sea robin



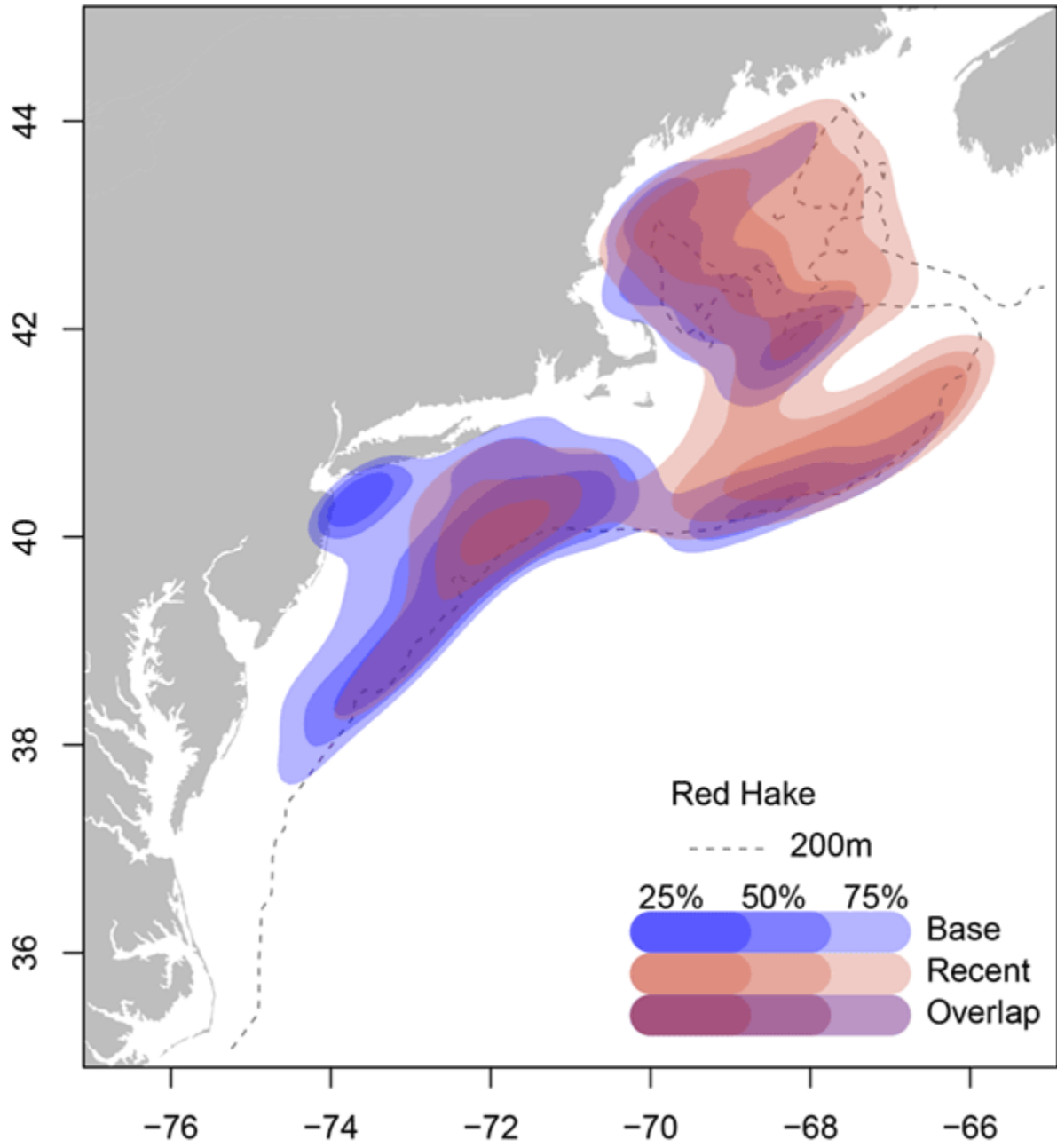
Ocean pout



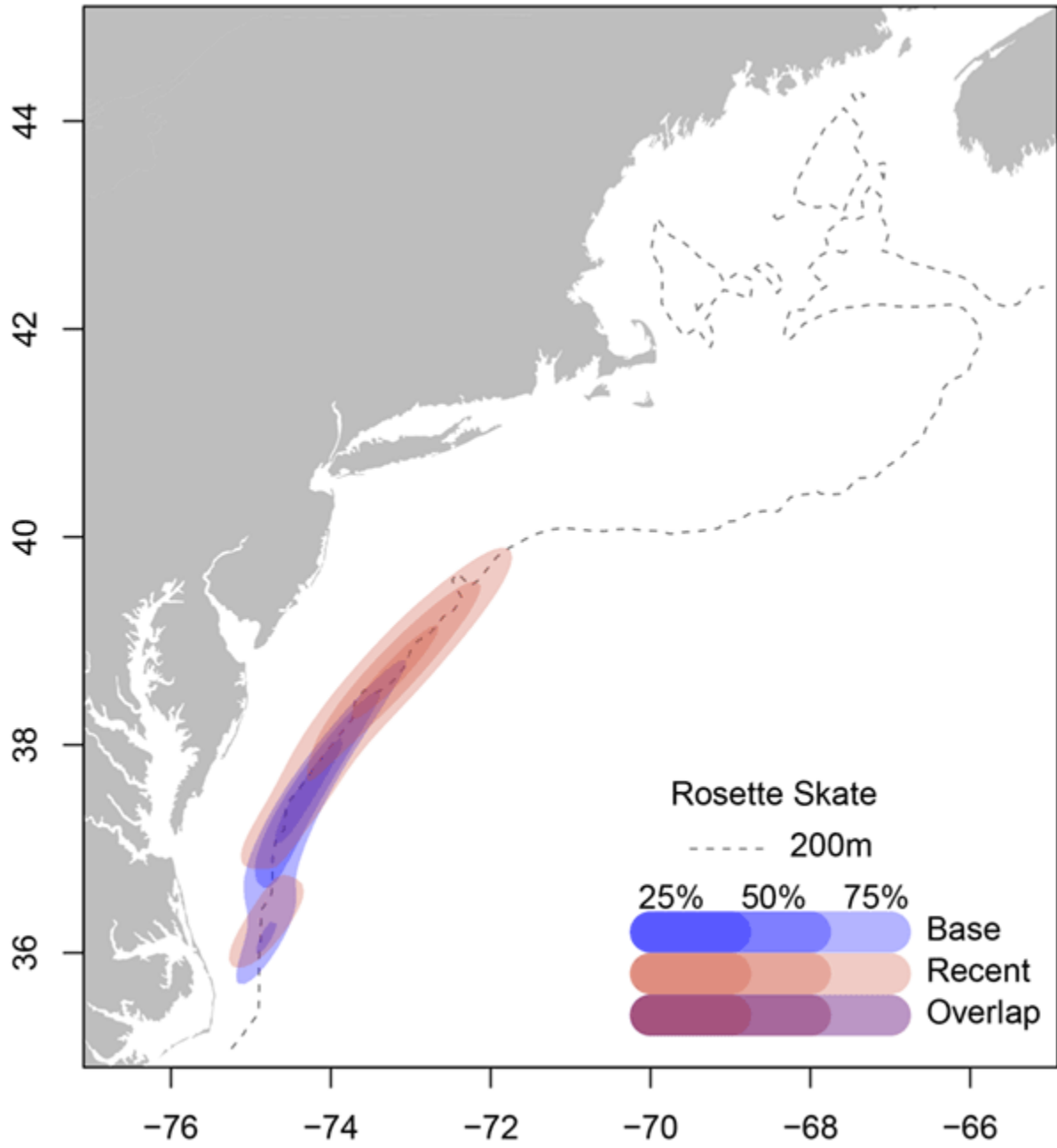
Pollock



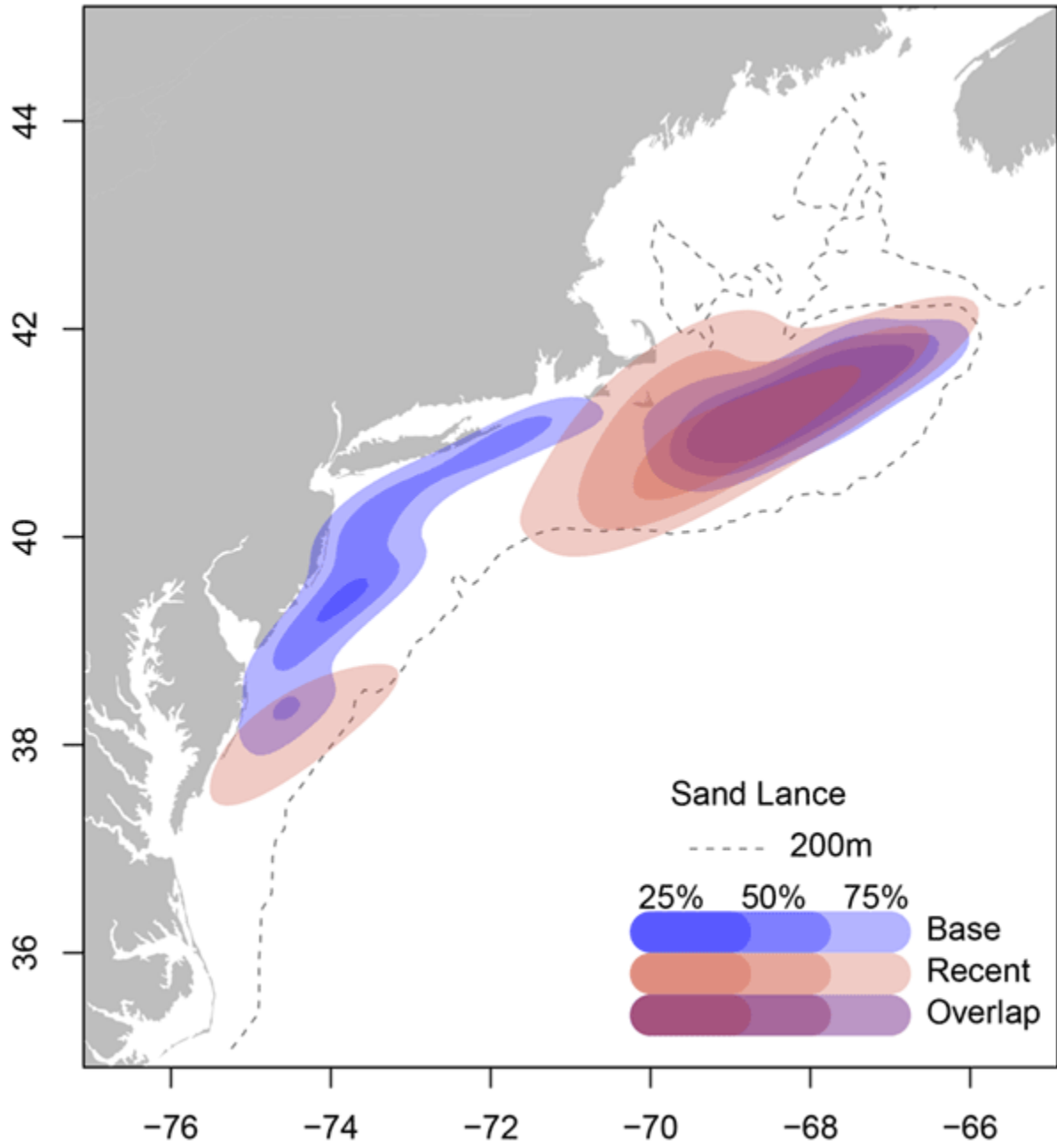
Red Hake



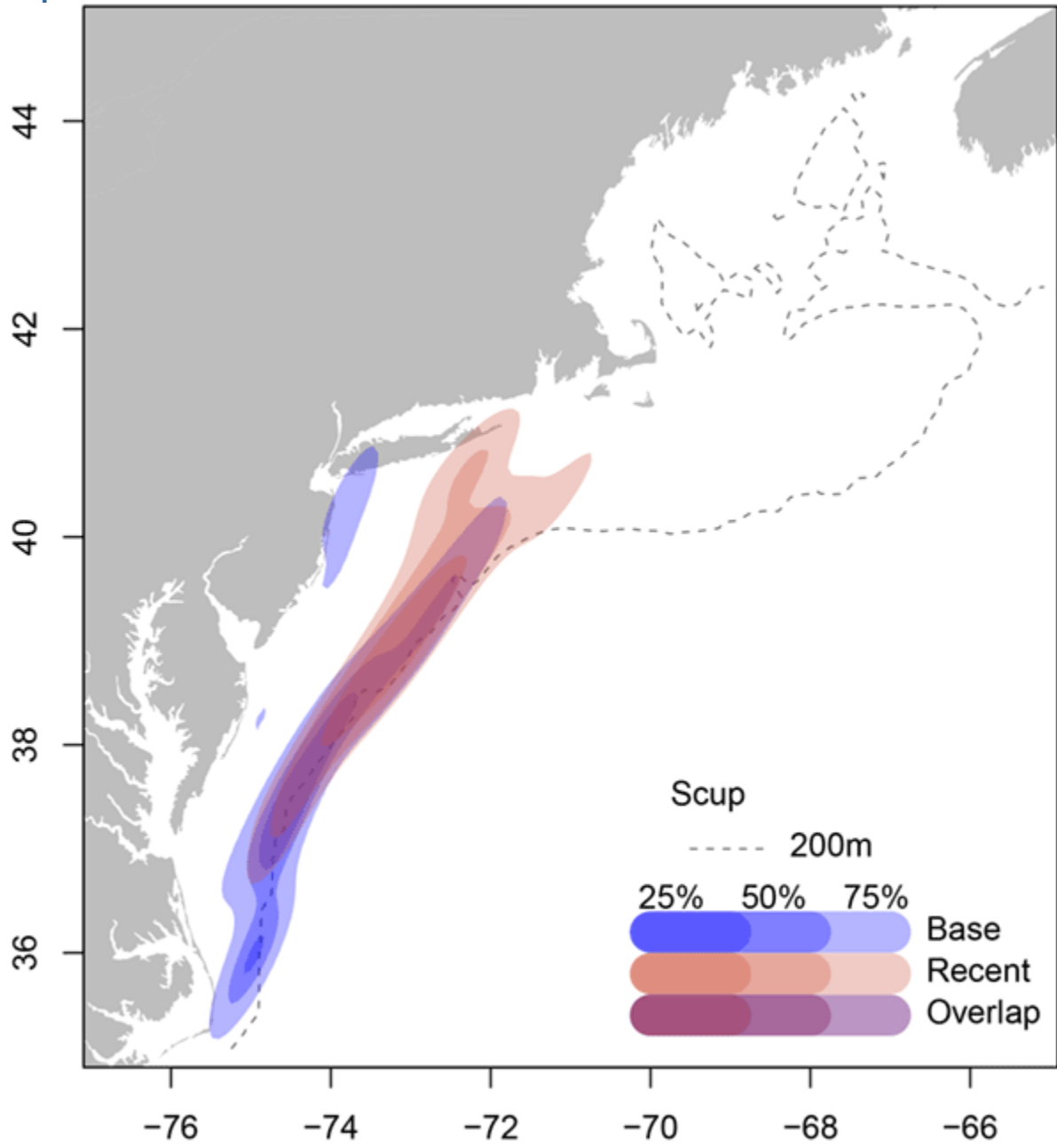
Rosette skate



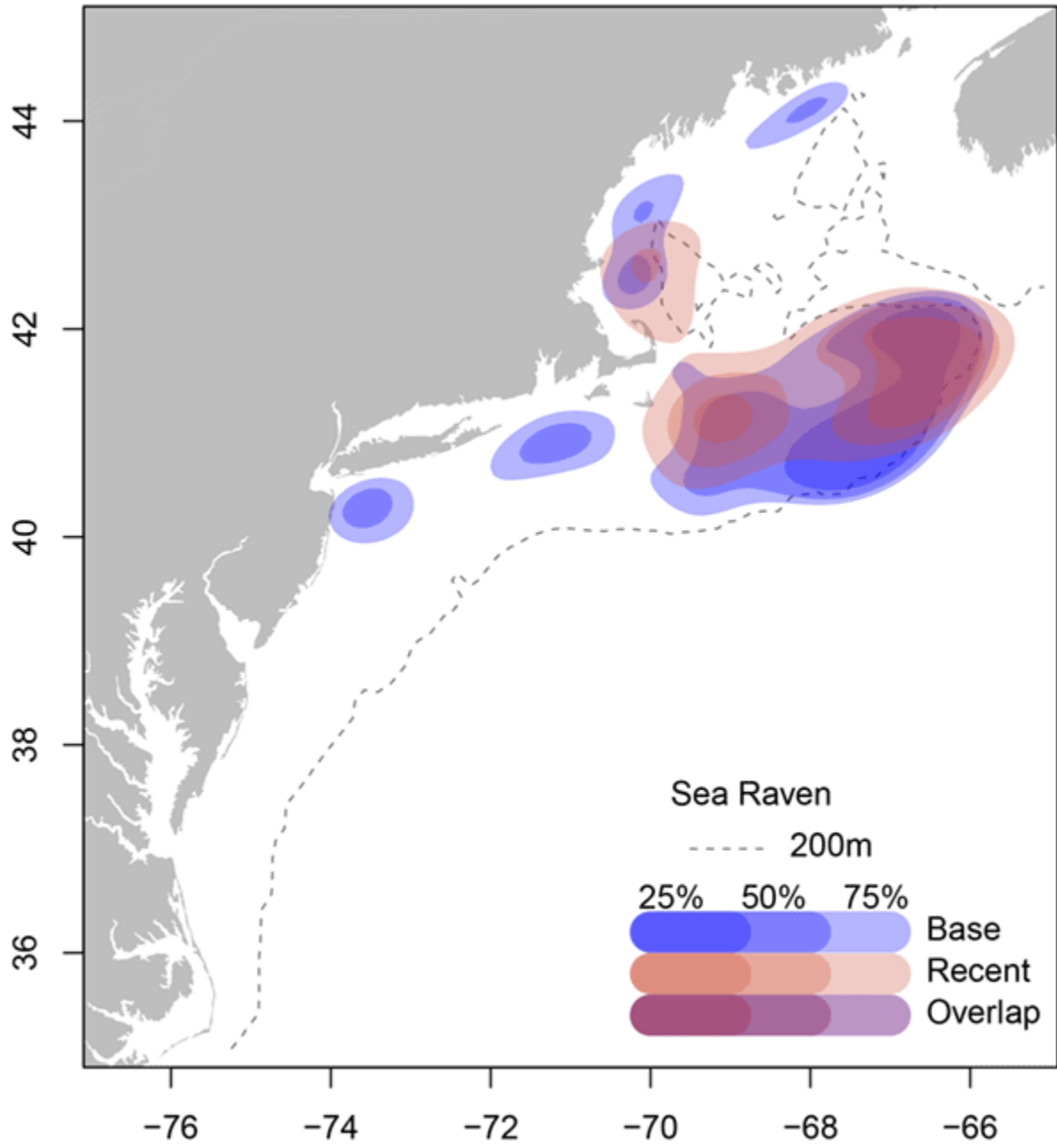
Sand lance



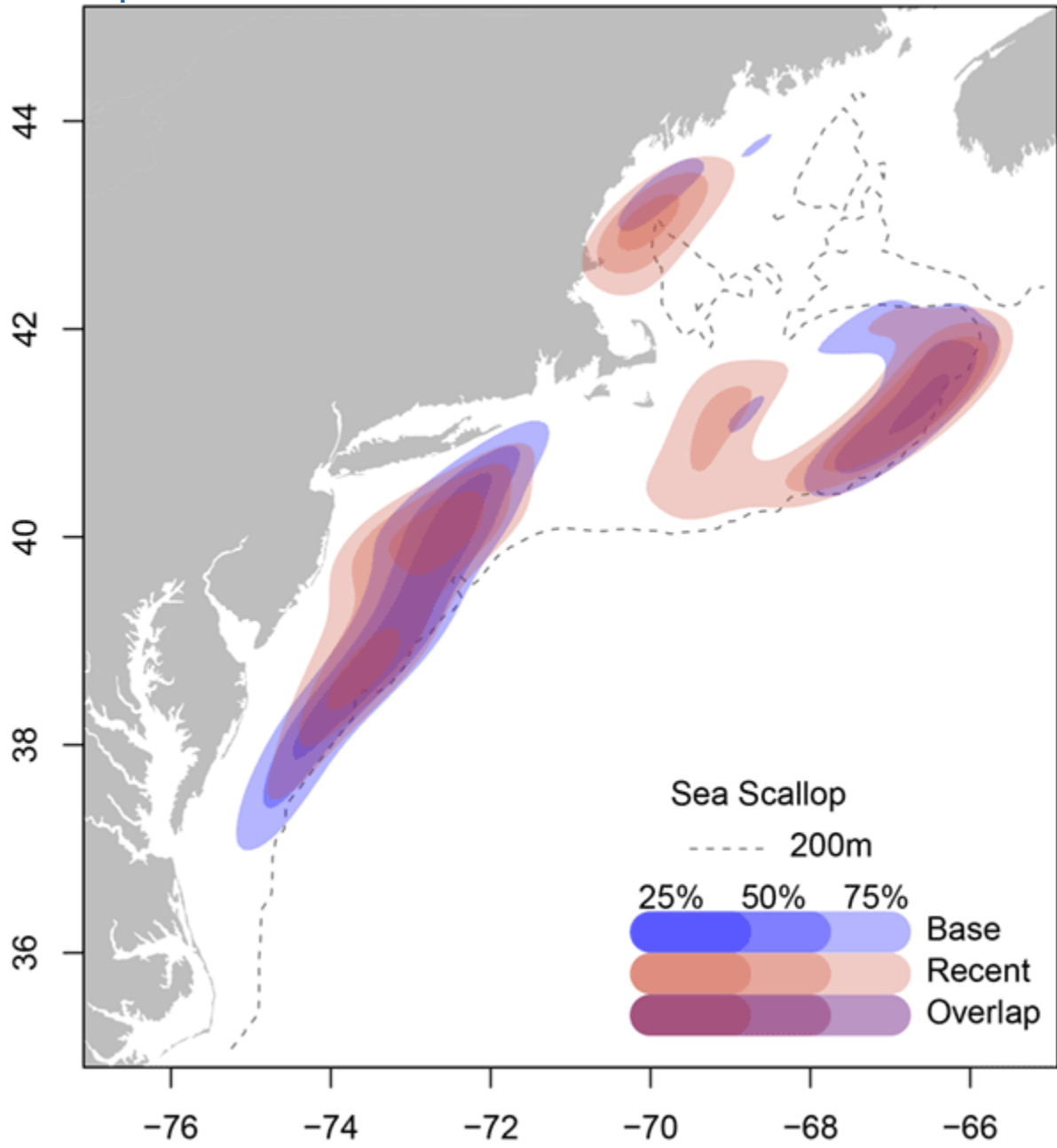
Scup



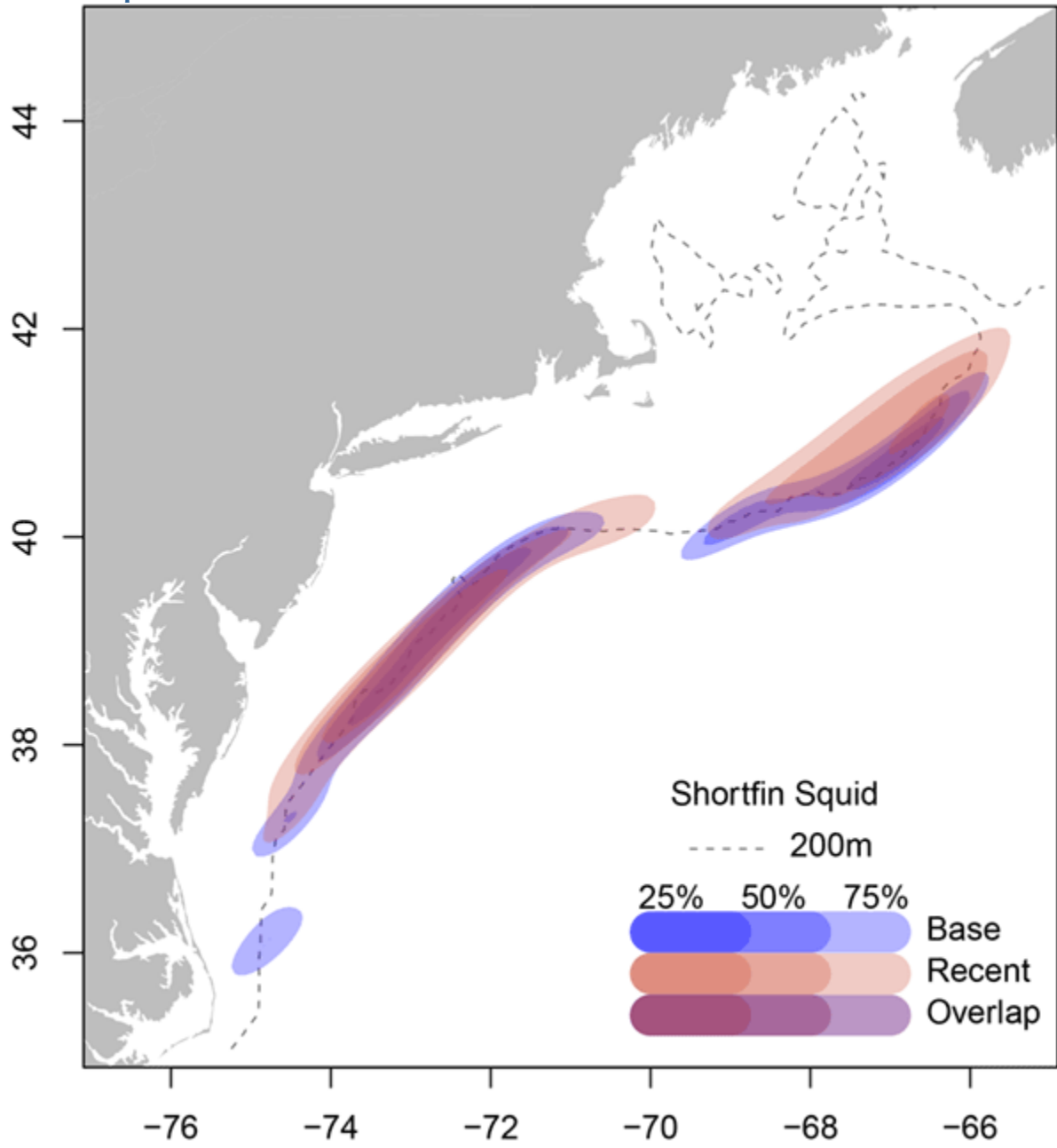
Sea raven



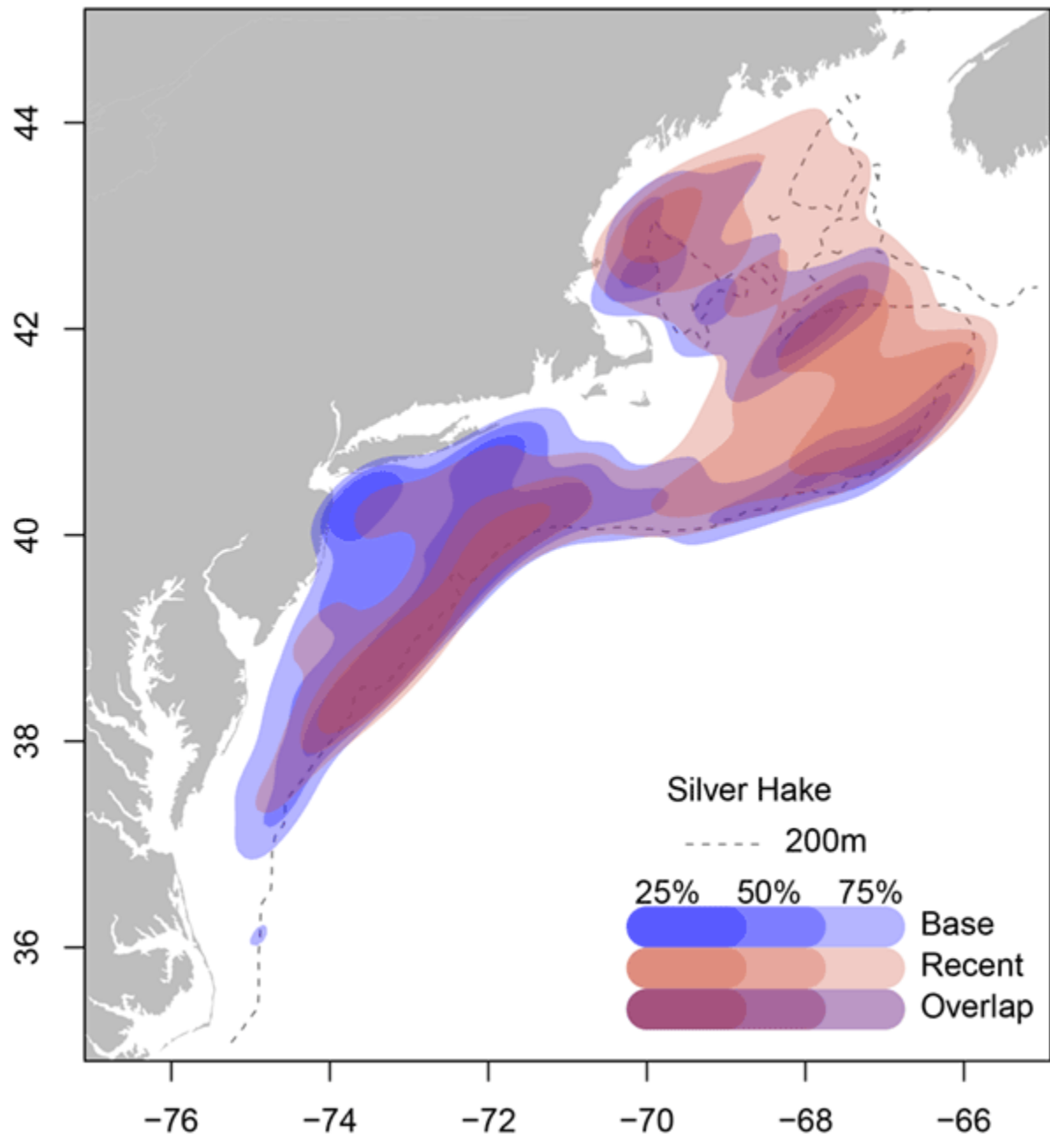
Sea Scallop



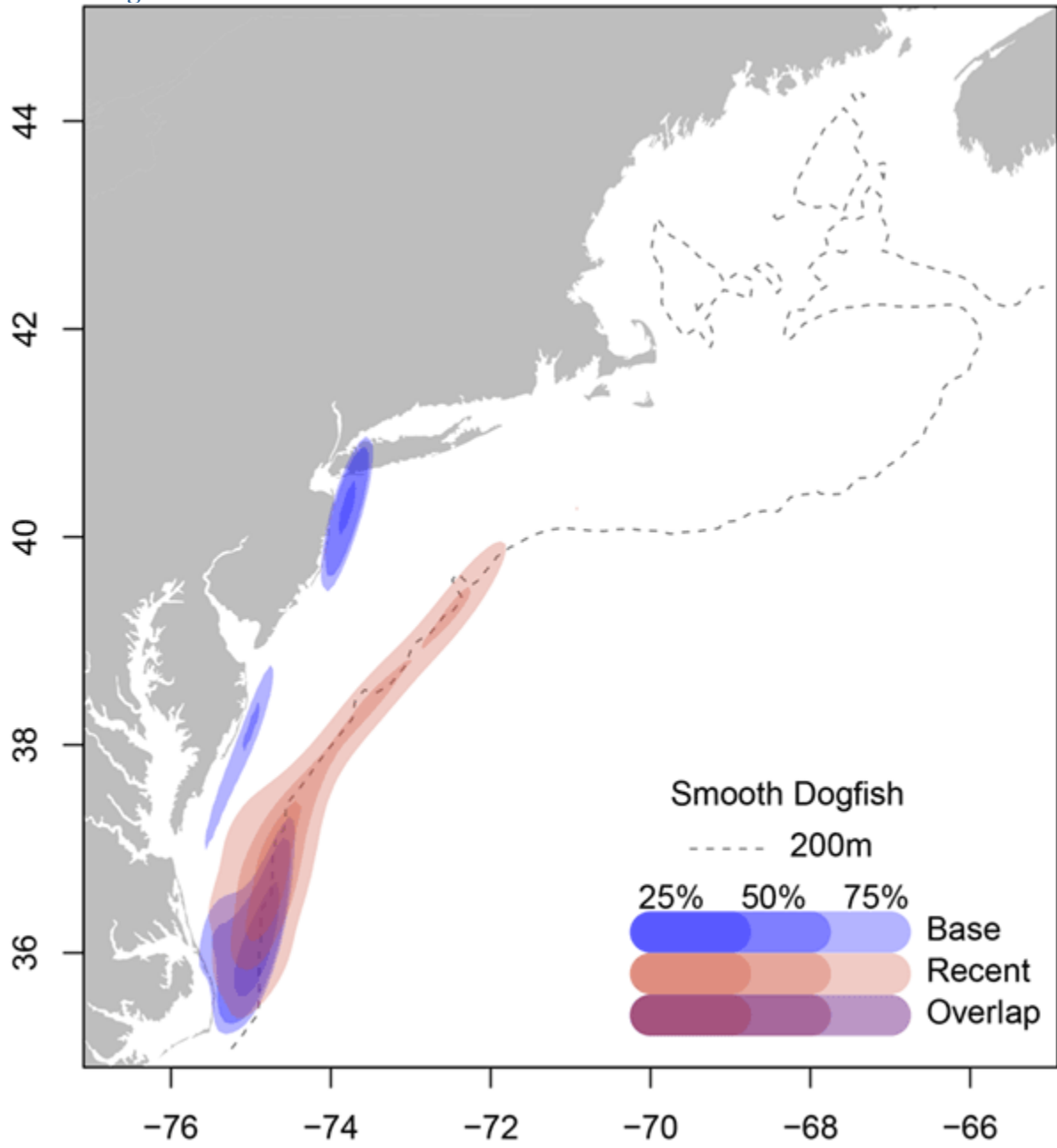
Shortfin squid



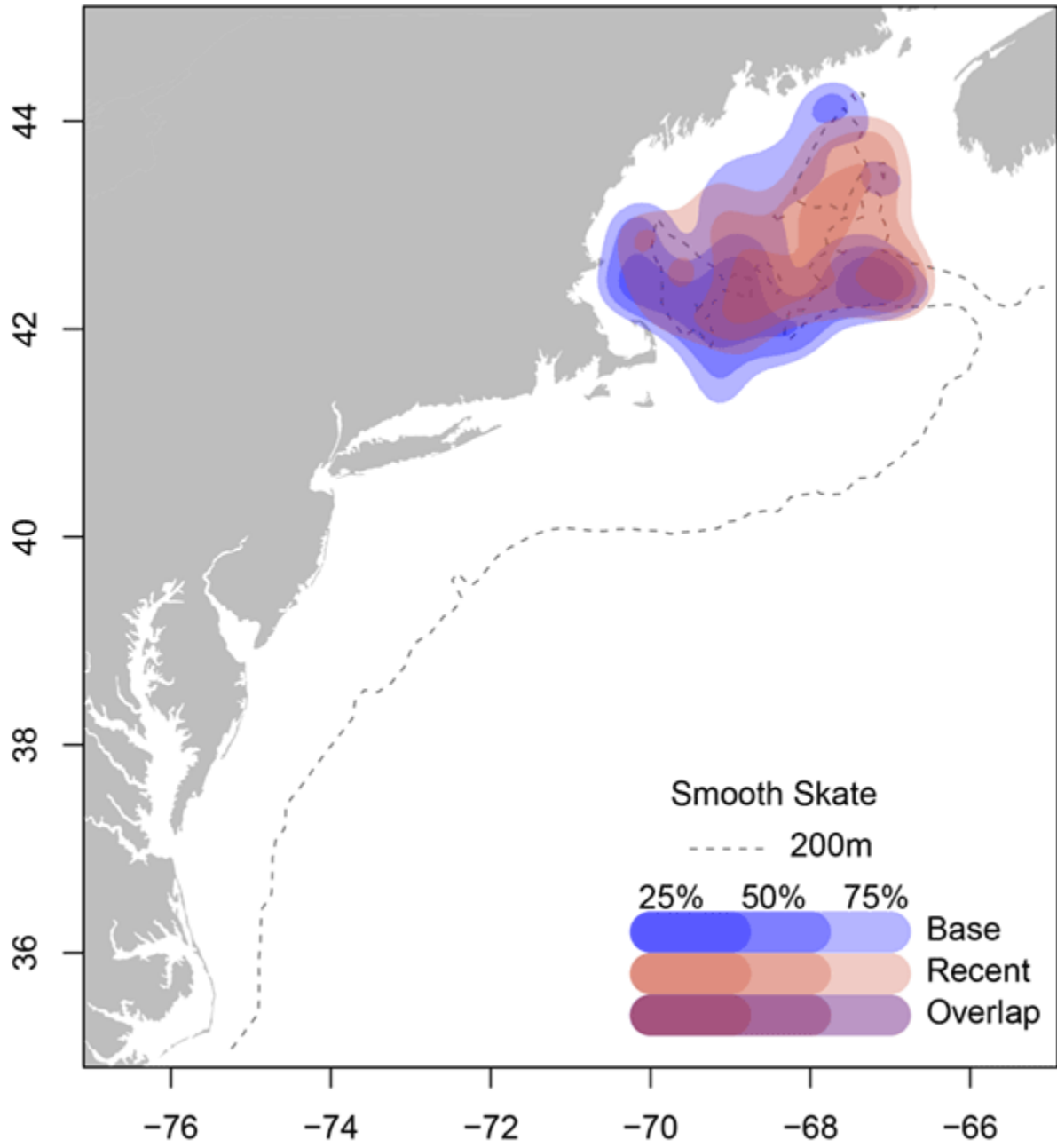
Silver Hake



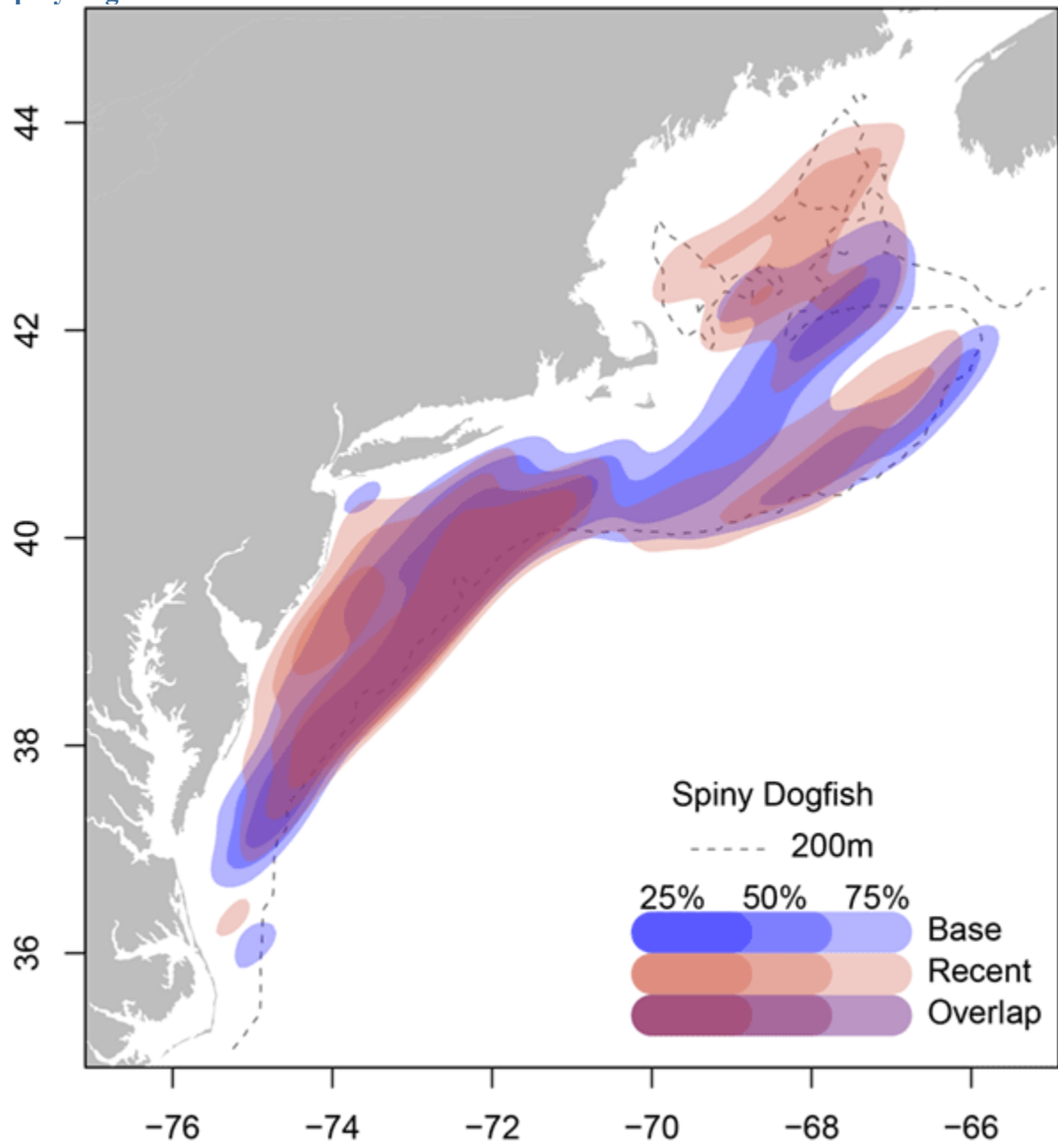
Smooth dogfish



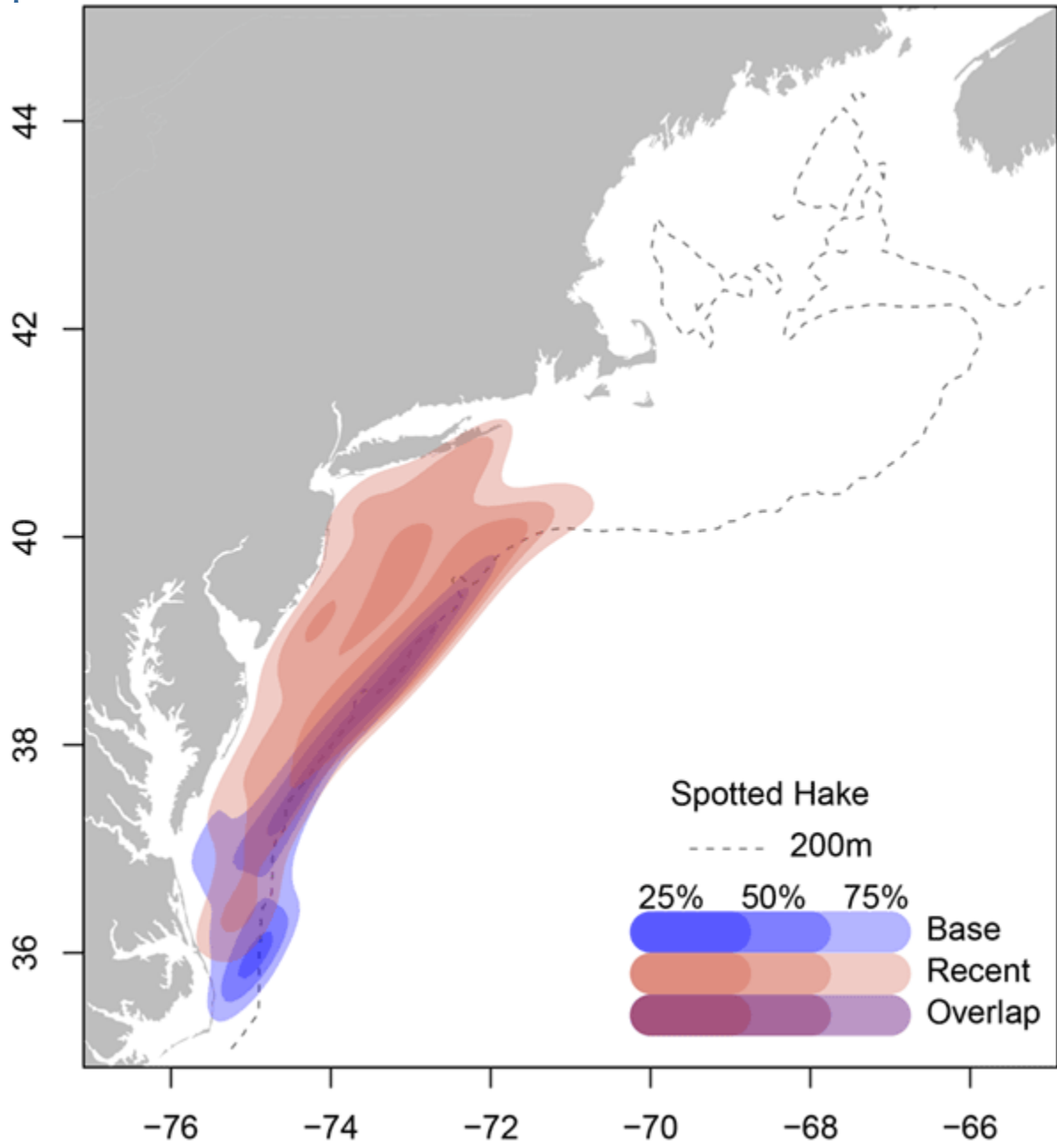
Smooth skate



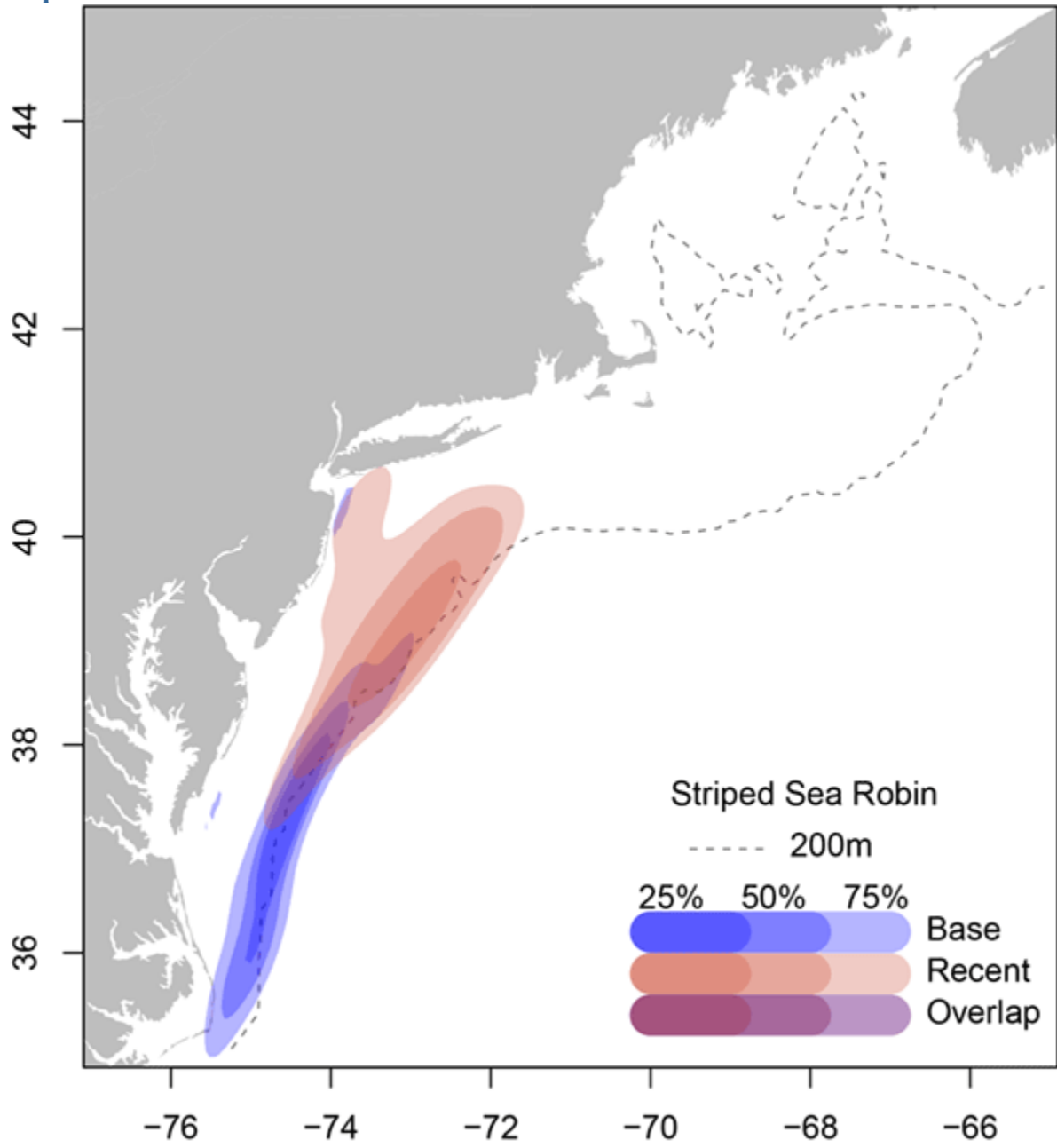
Spiny dogfish



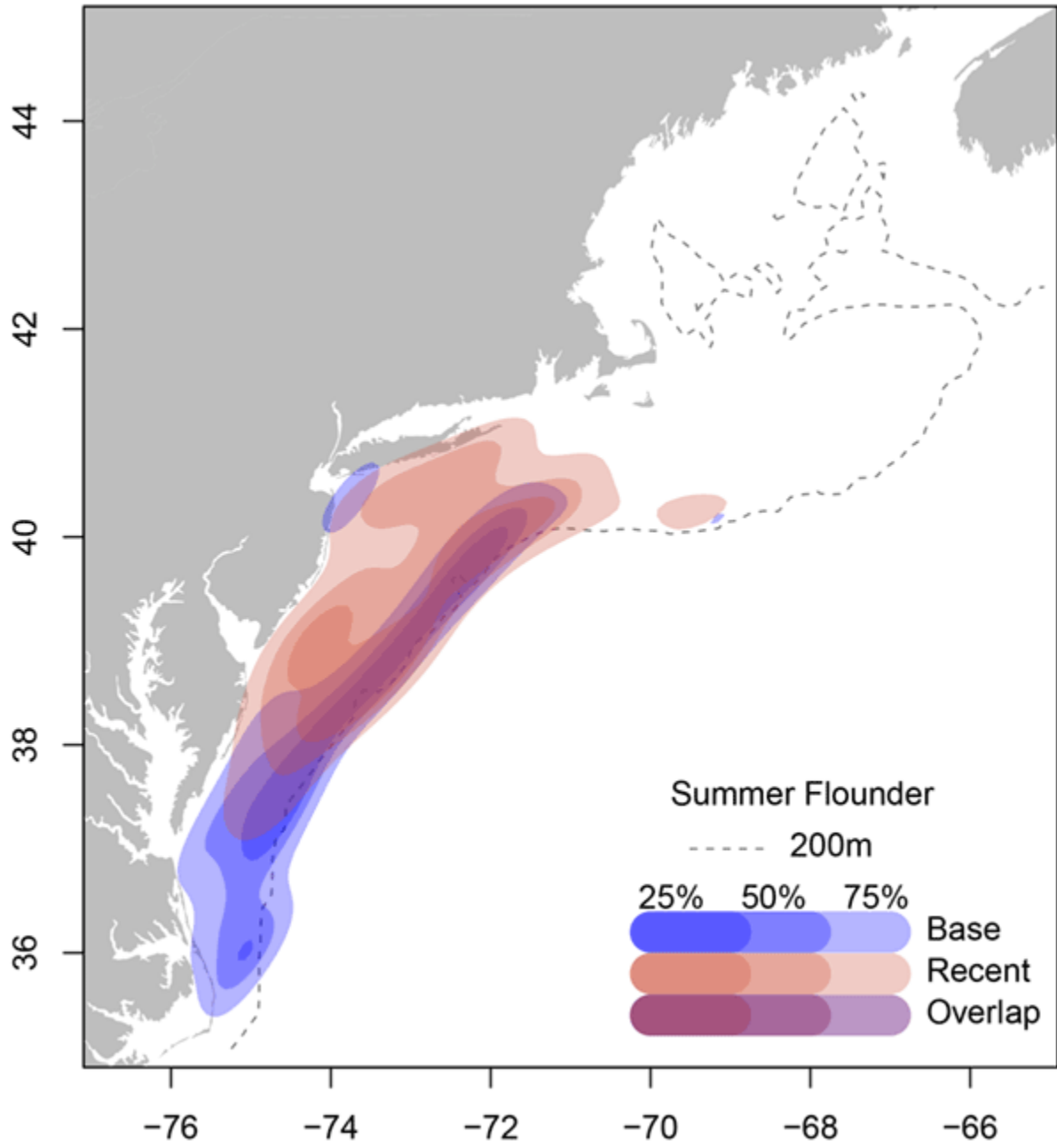
Spotted hake



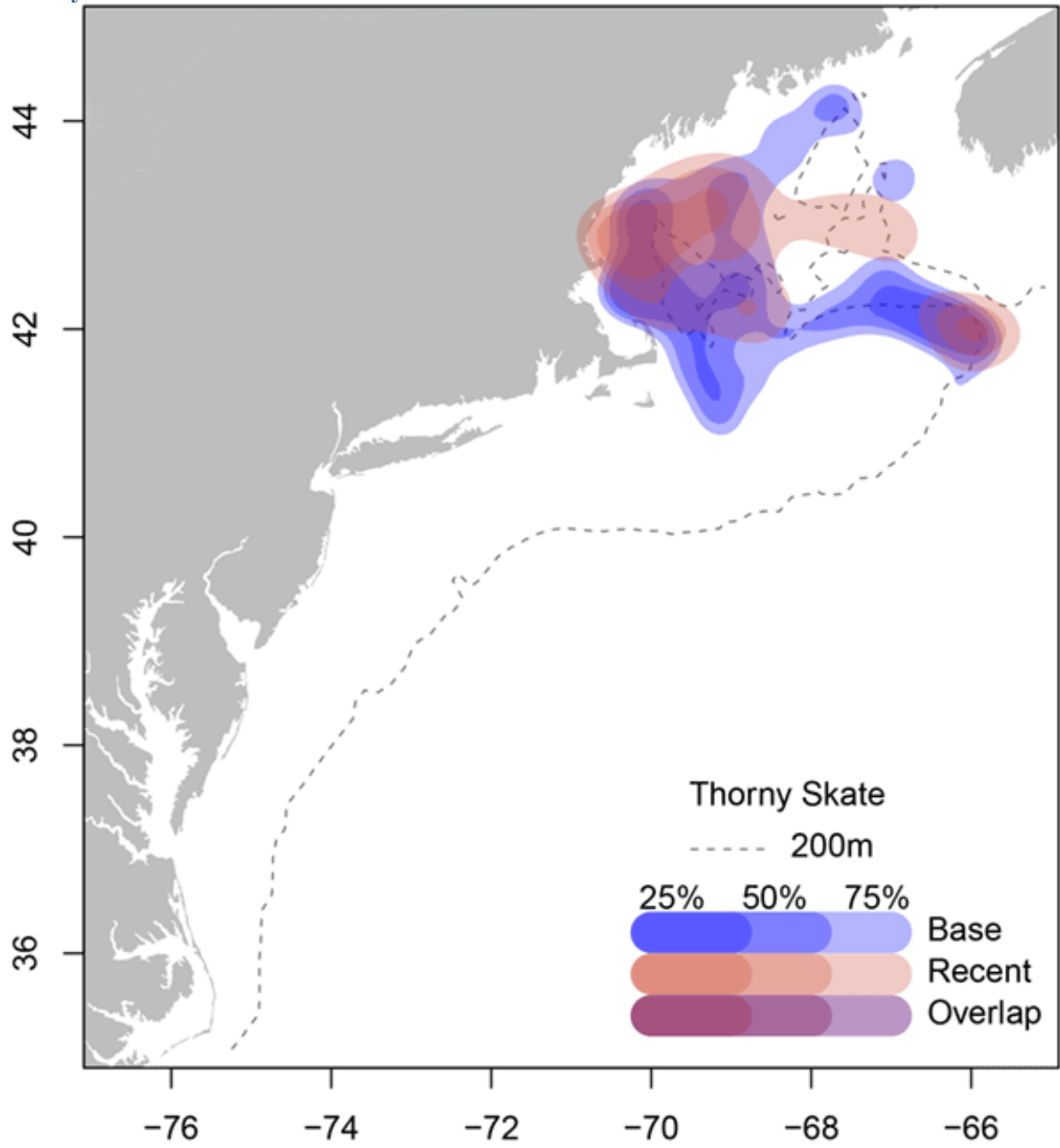
Striped sea robin



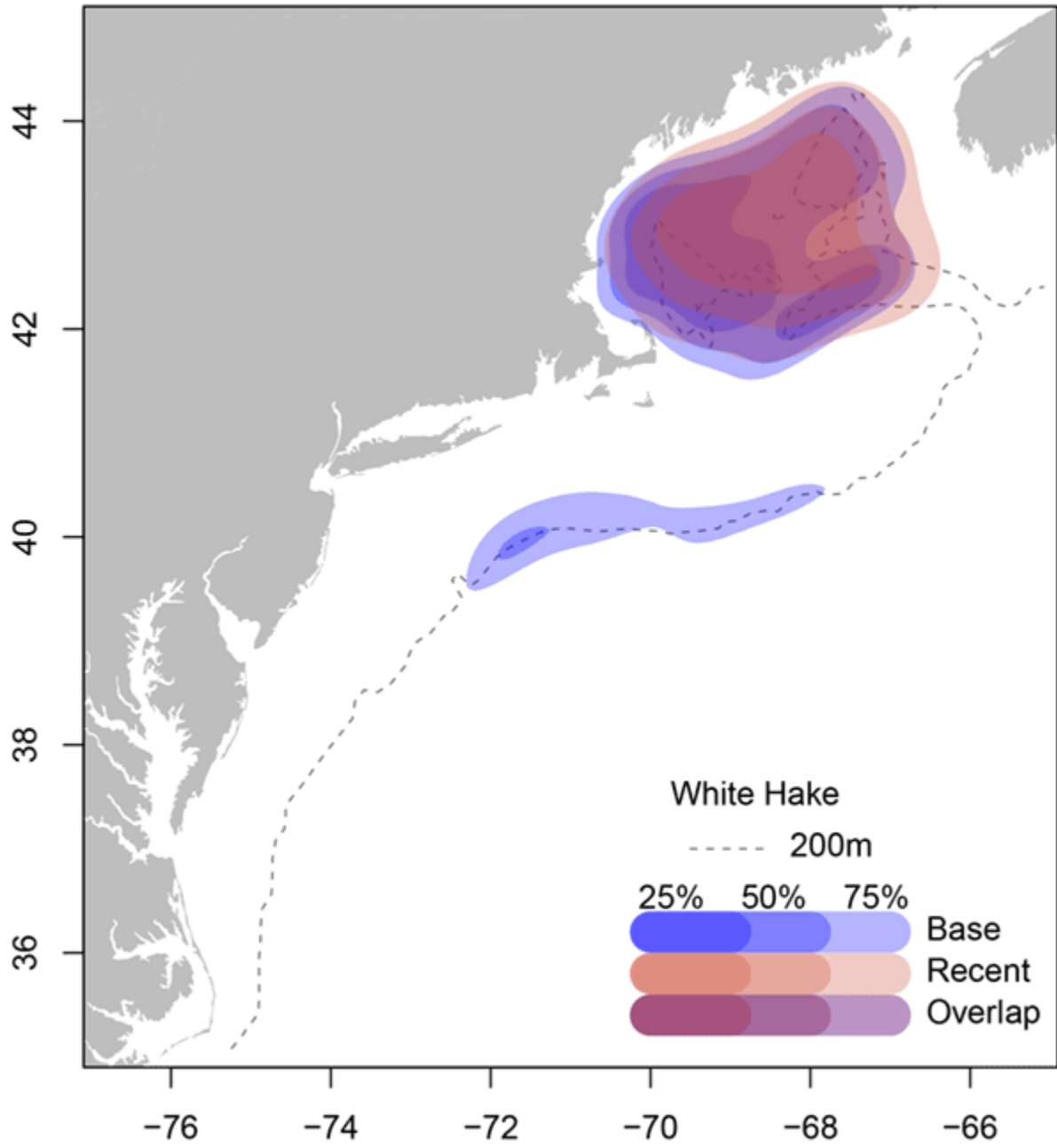
Summer flounder



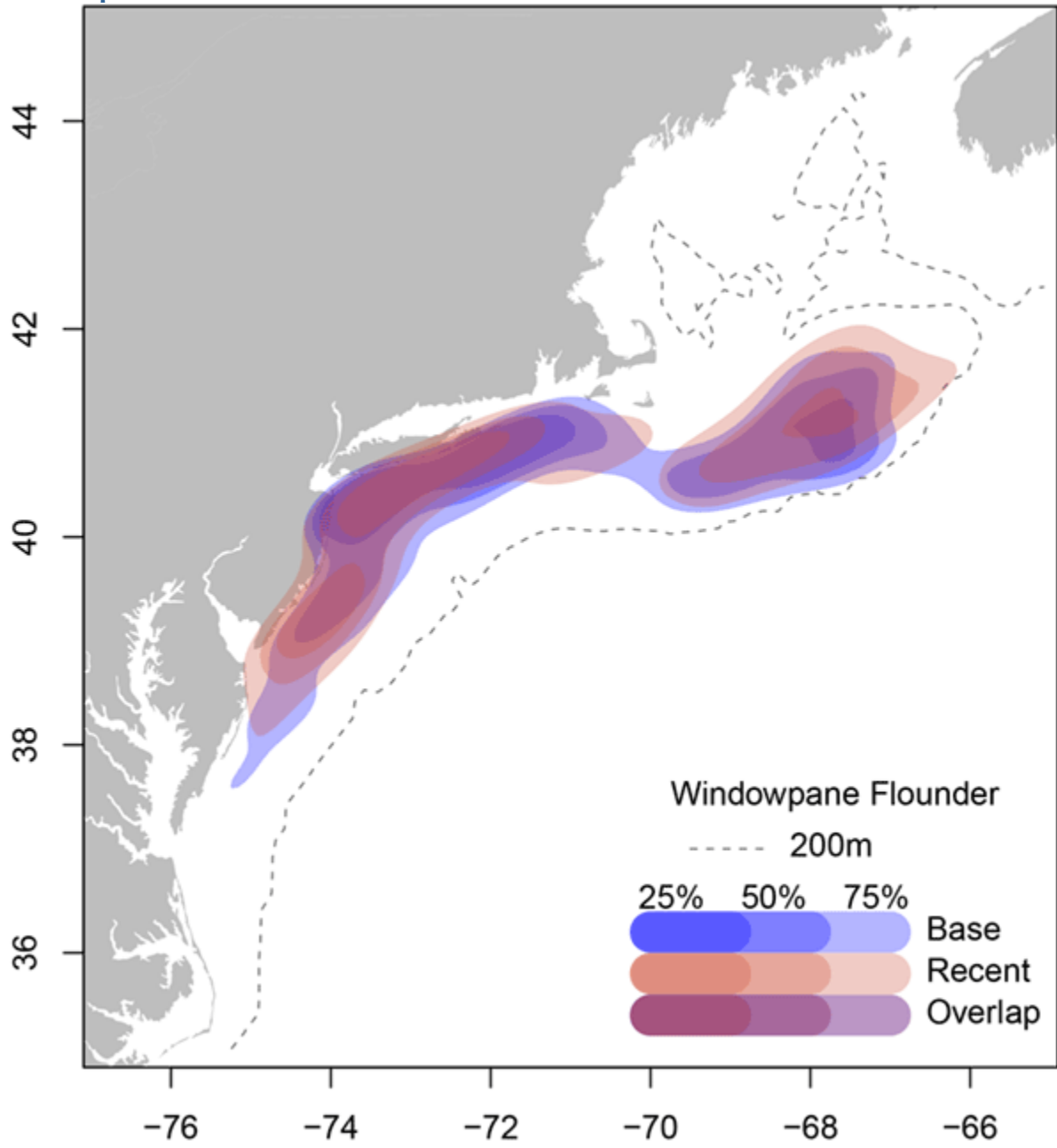
Thorny skate



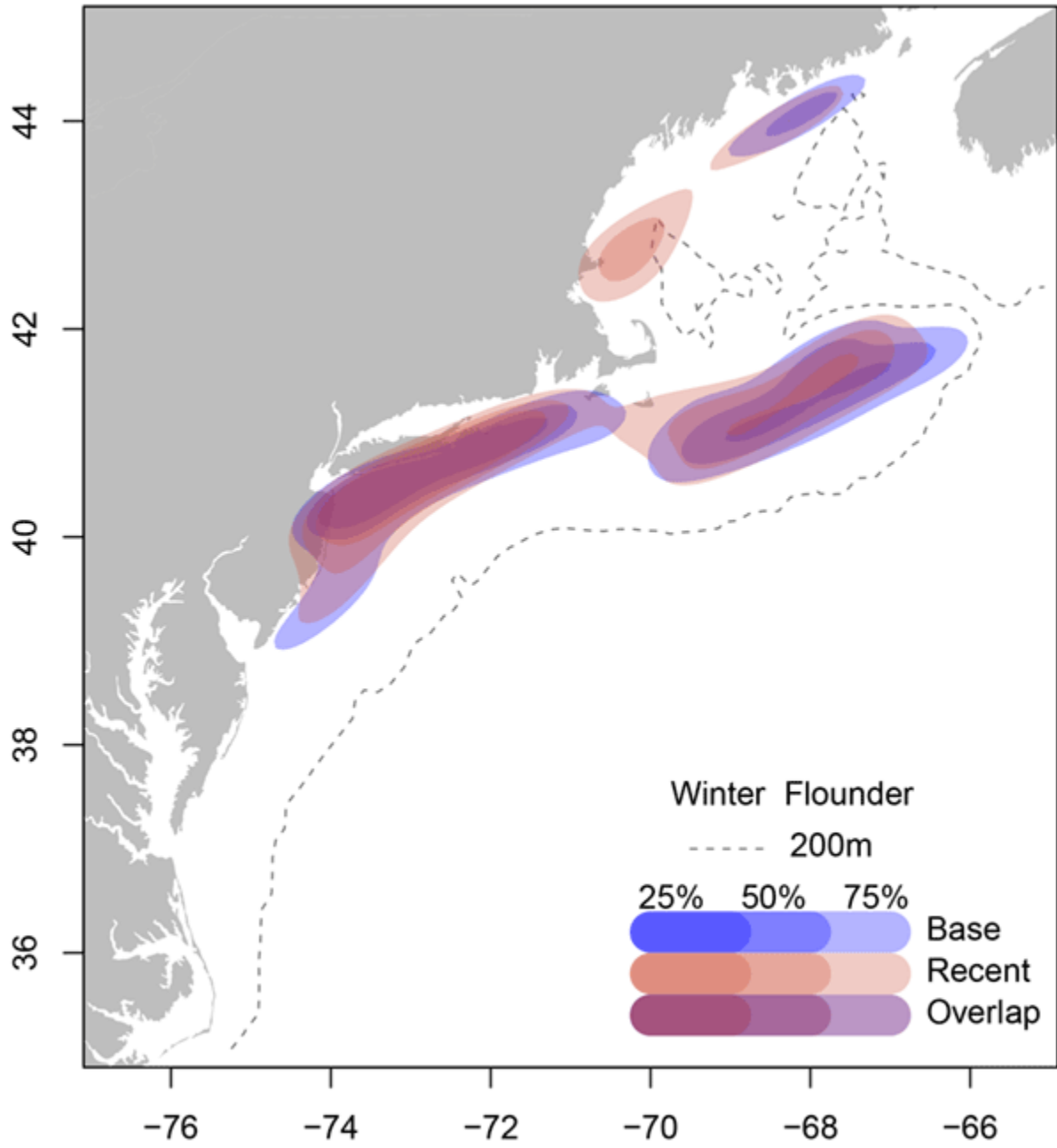
White hake



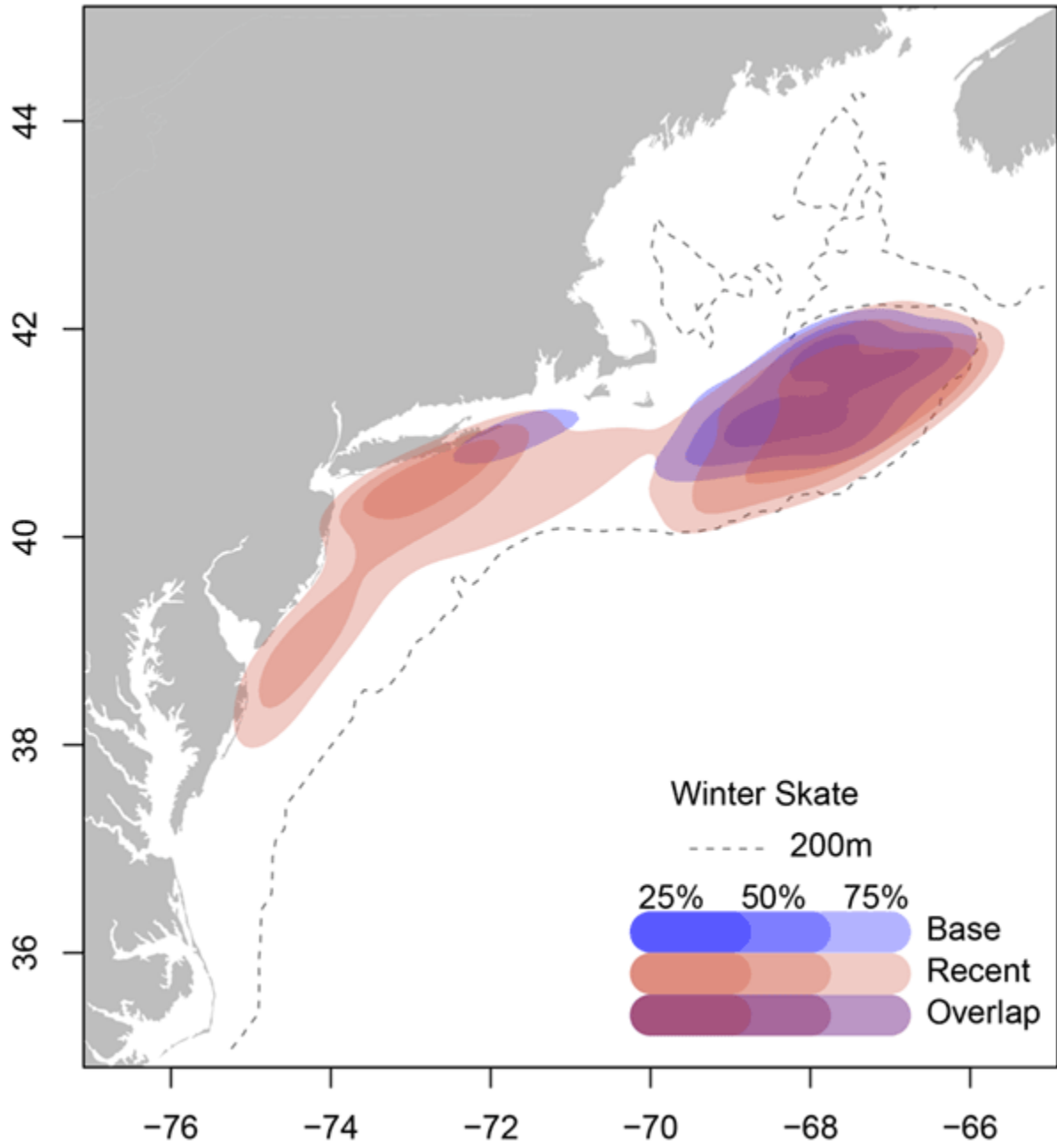
Windowpane flounder



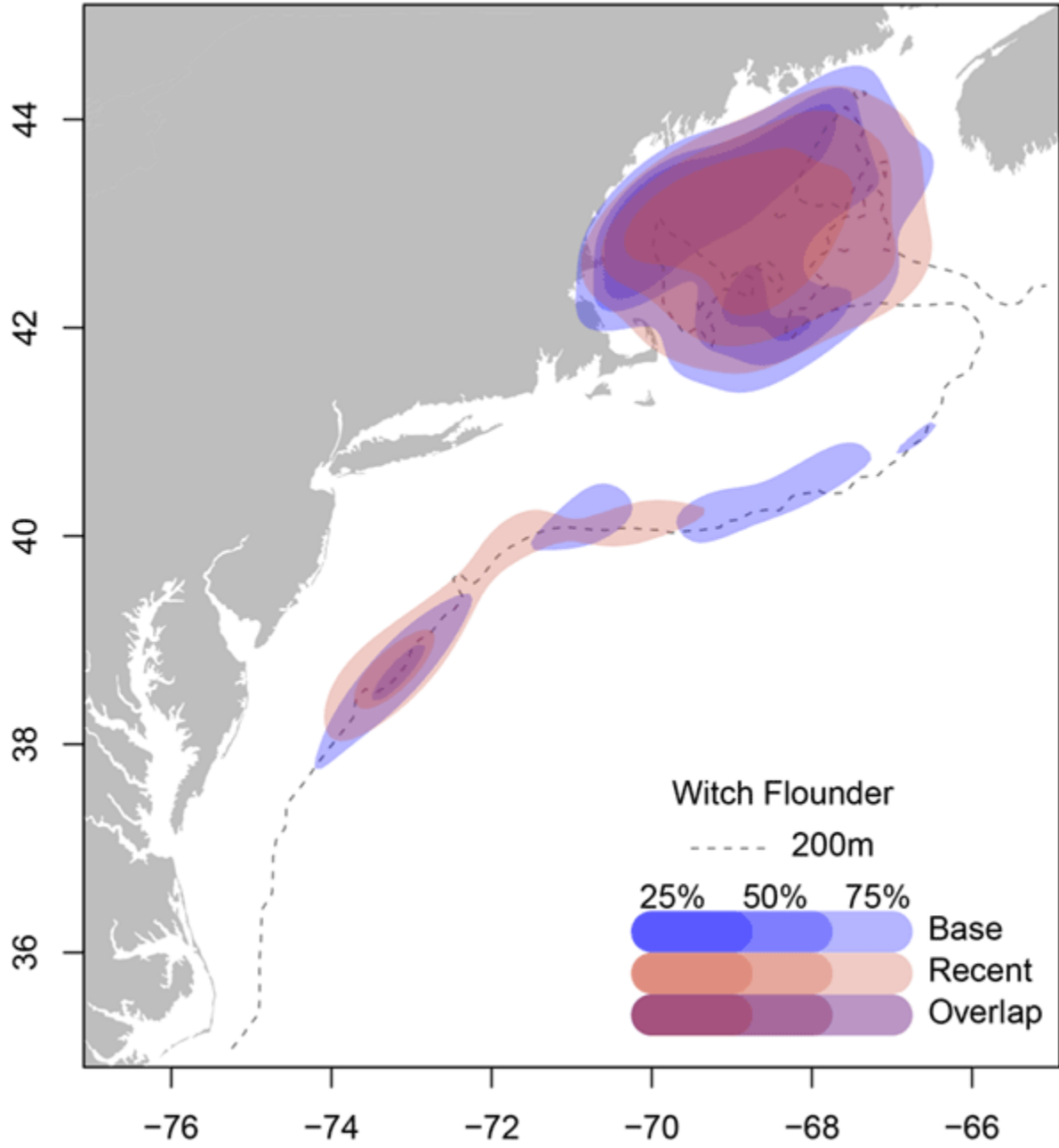
Winter flounder



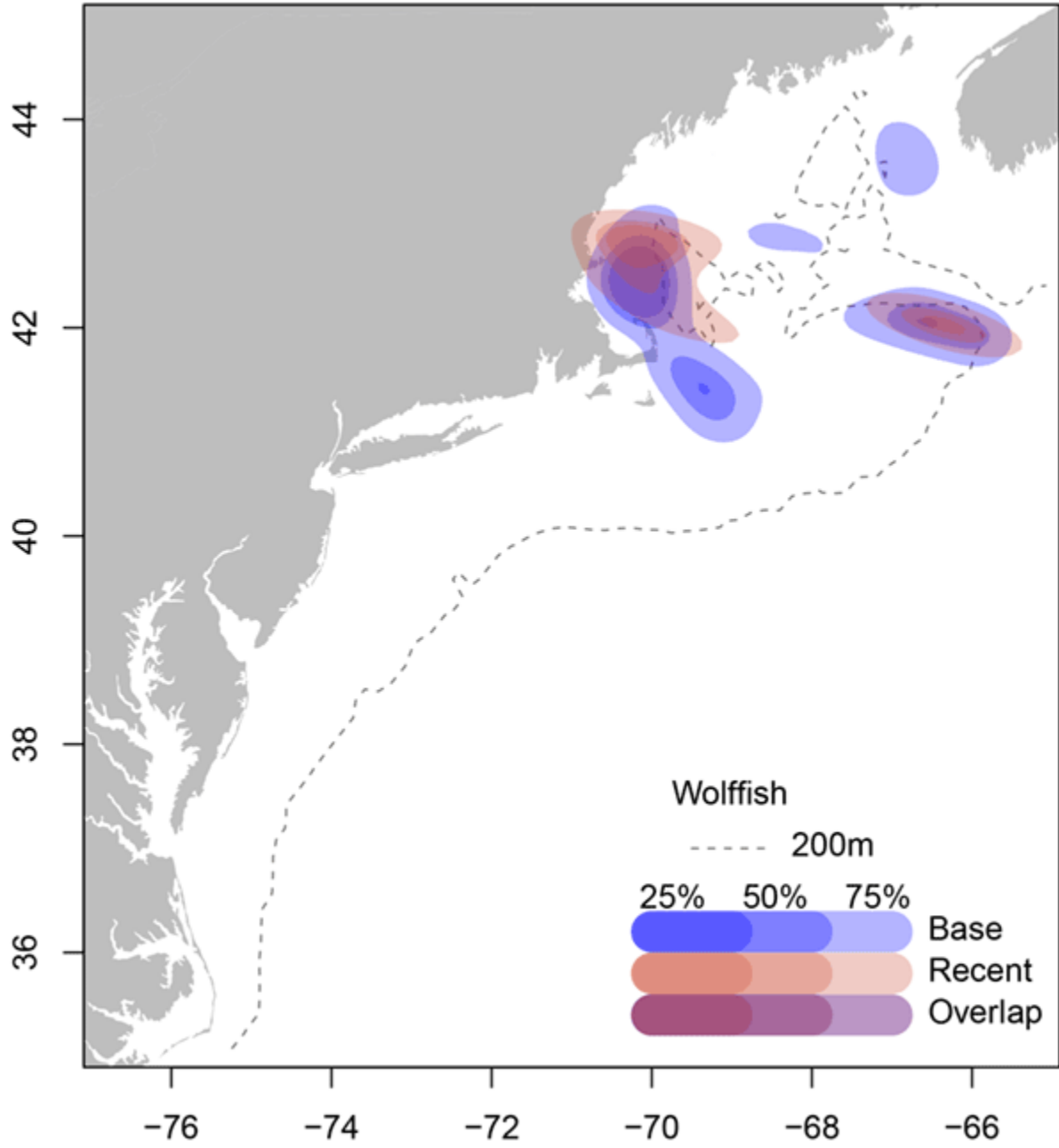
Winter skate



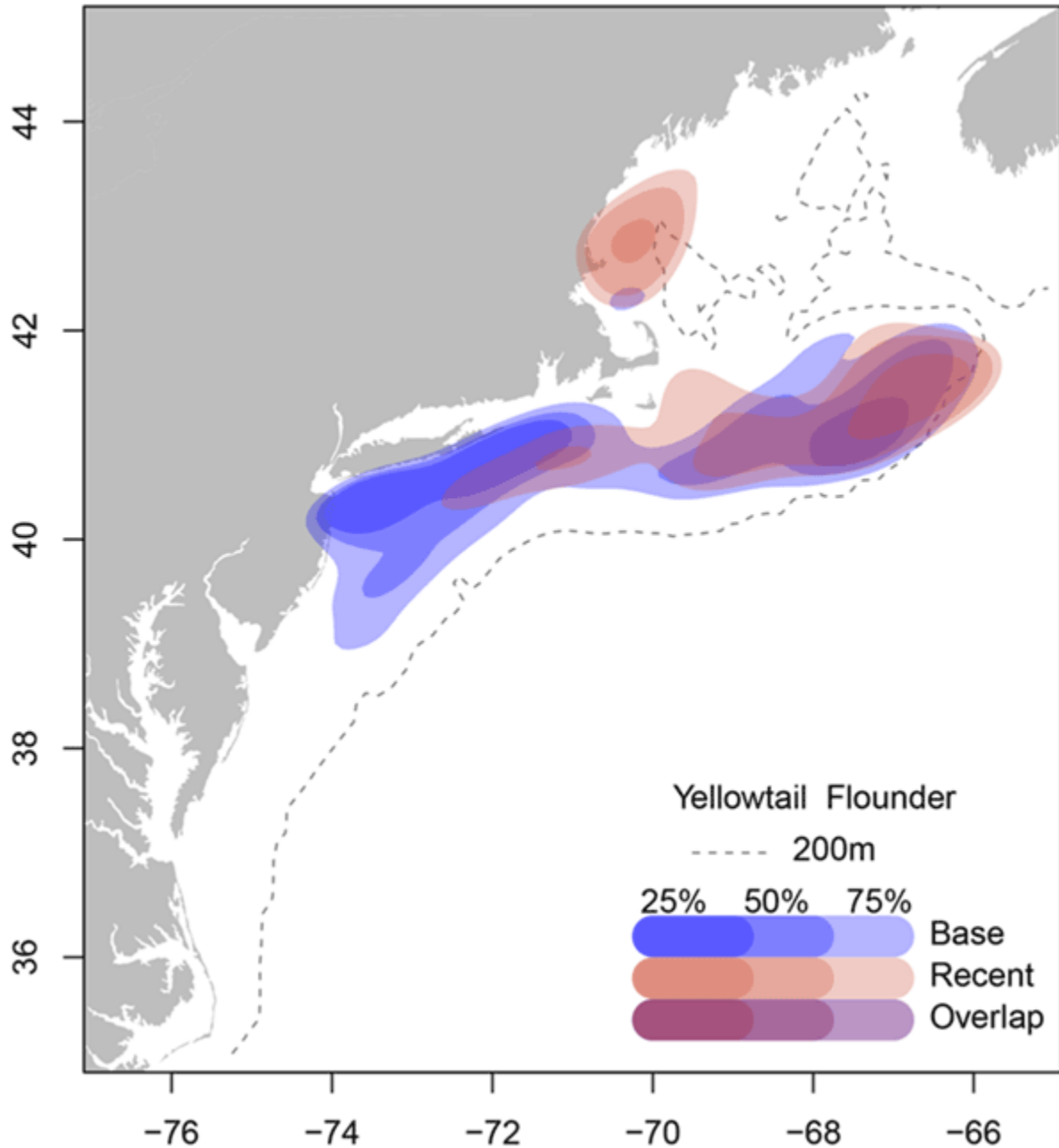
Witch flounder



Wolffish



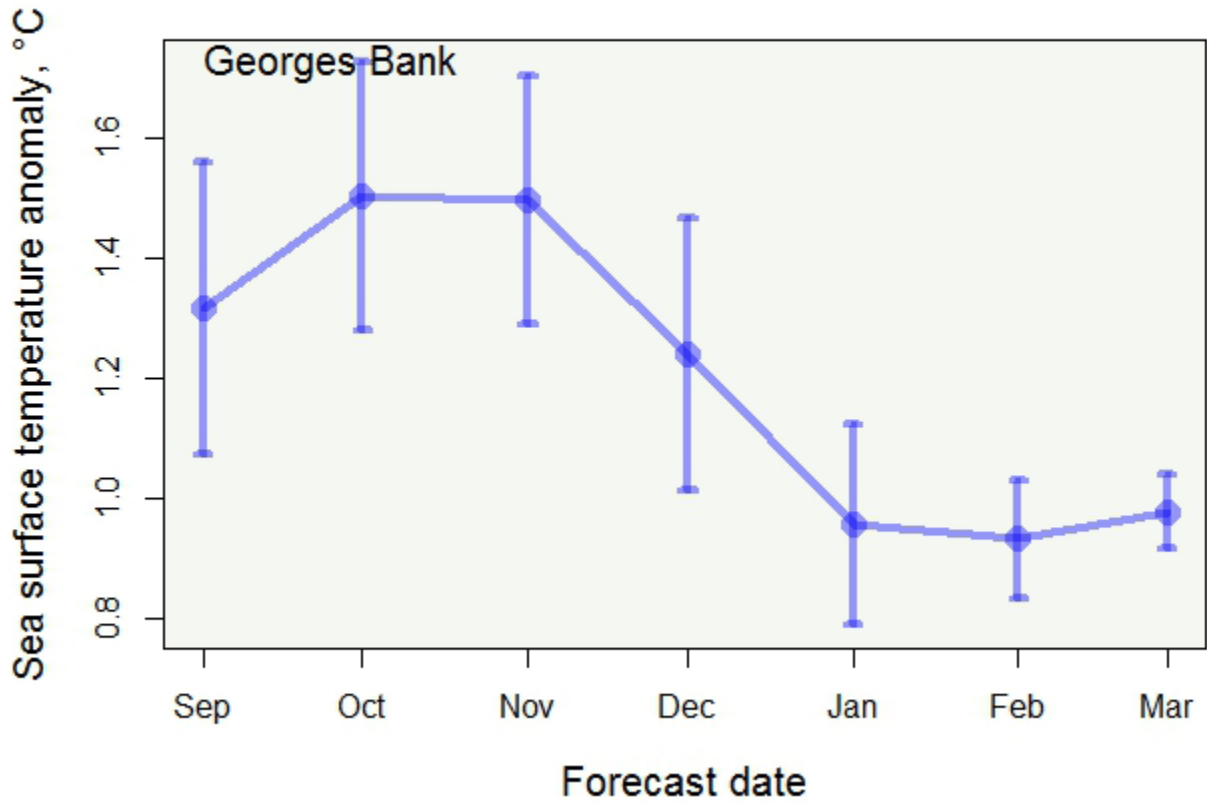
Yellowtail flounder



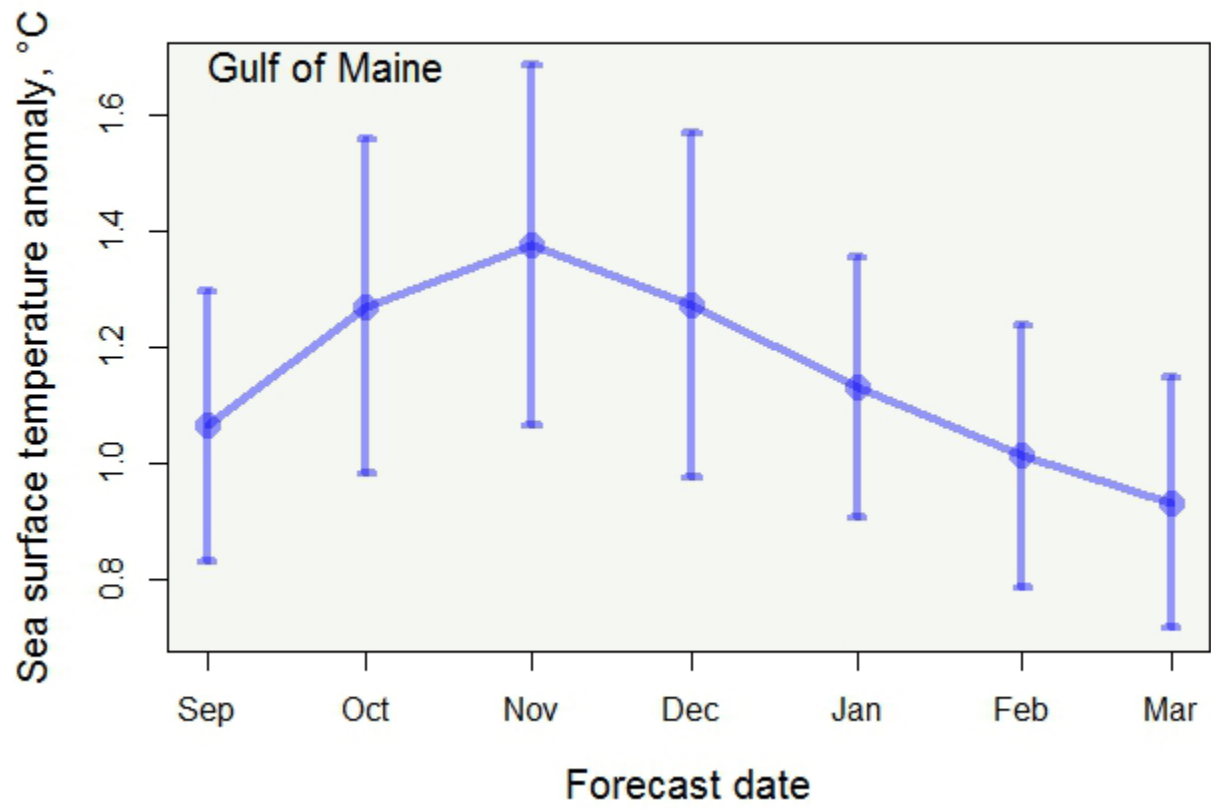
Sea Surface Temperature Forecast

For each of the ecoregions of the Northeast Shelf, an ensemble mean estimate of forecast sea surface temperature through fall 2016 into winter 2017 is provided ([see figures](#)), with an error bar representing the 95% confidence interval around the mean. The ensemble draws from seven earth systems model forecasts each on a similar model grid assembled by the North American Multi-Model Ensemble project. The forecasts suggest that SST will remain above average in all

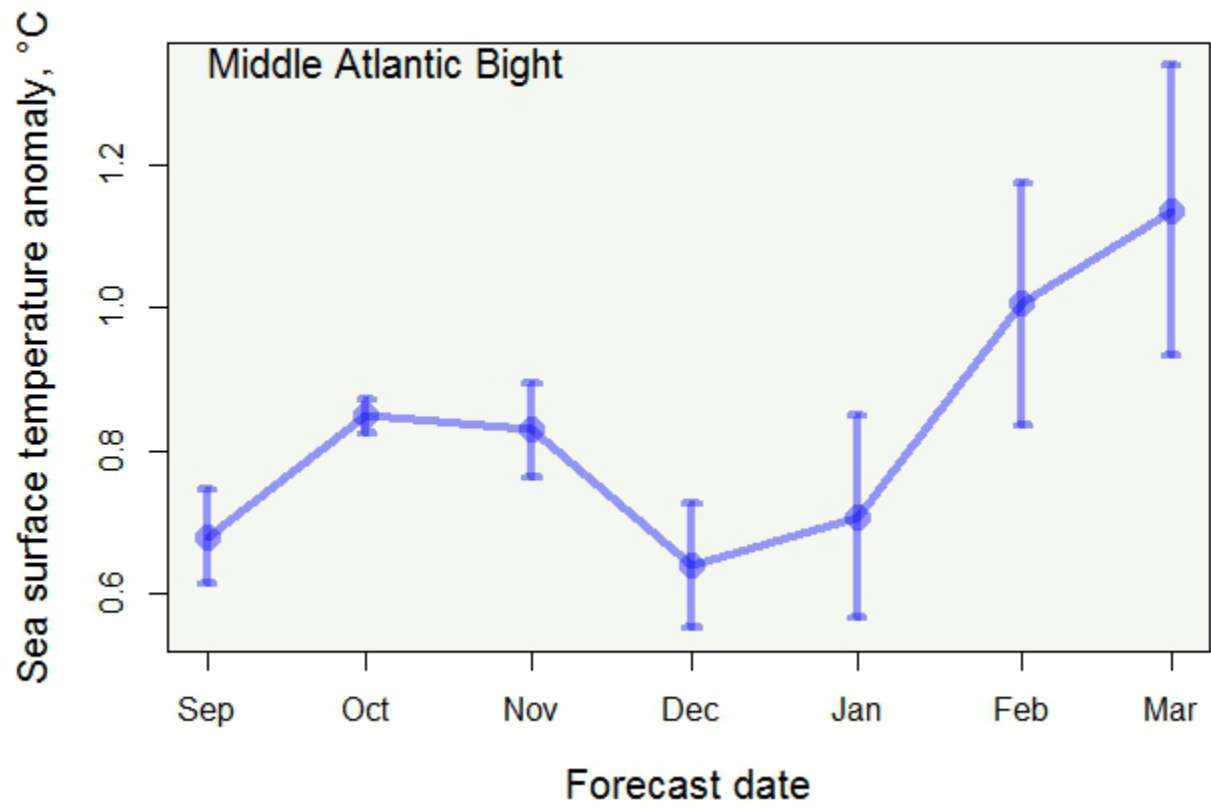
areas through the winter into the spring; however, the SST anomaly levels will decrease by substantial levels in the Gulf of Maine, Scotian Shelf and Georges Bank. The forecasts suggest an increase in early spring condition in the Middle Atlantic Bight.



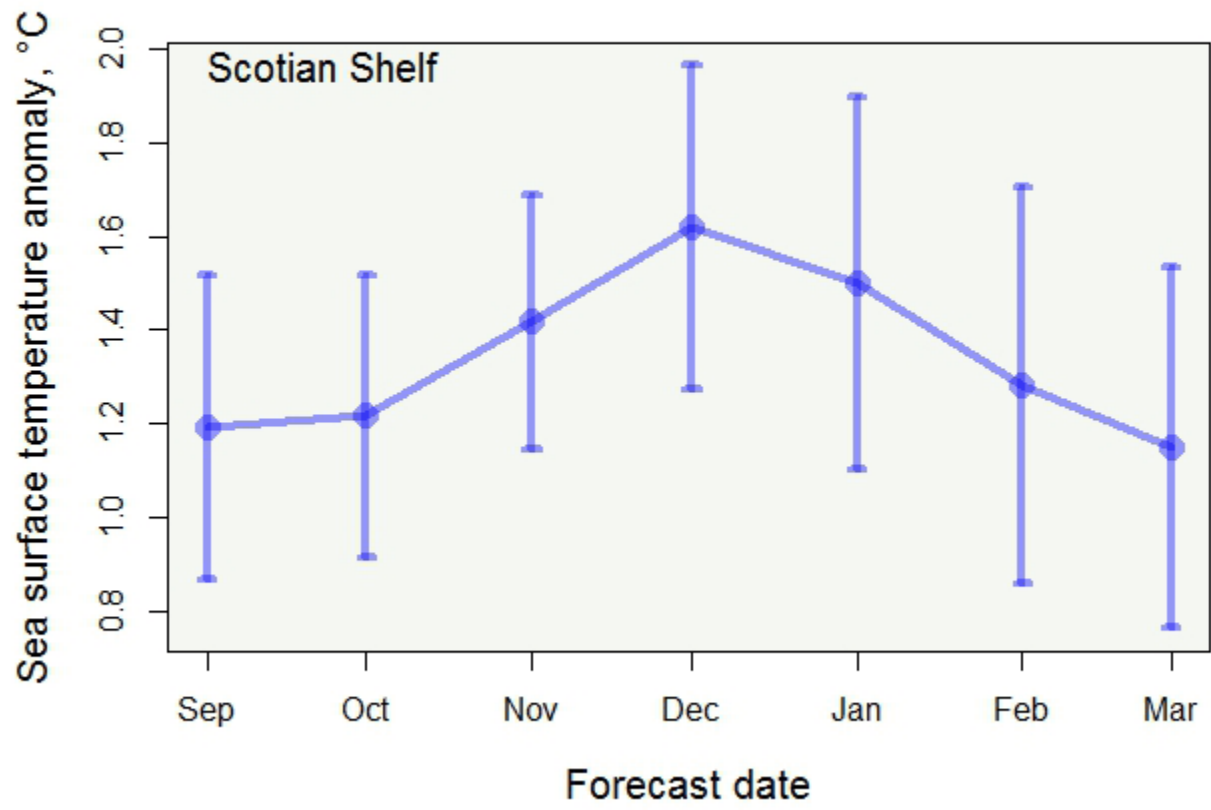
Georges Bank



Gulf of Maine



Mid Atlantic Bight



Scotian Shelf