Spring 2018 Update: Annual Condition of the Northeast Shelf Ecosystem

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Current Conditions of the Northeast Shelf Ecosystem -- Spring 2018 Update

Summary of Conditions of the Northeast Shelf Ecosystem

- Sea surface temperatures (SSTs) in the Northeast Shelf Large Marine Ecosystem during 2017 continue to be above average; however, they represent some moderation from the extremely warm conditions recorded in 2016.

- The 2017 spring phytoplankton bloom was poorly developed in most areas of the Northeast Shelf. The fall bloom tended to below average in intensity and duration. This reduced bloom activity was reflected in the 2017 mean annual chlorophyll concentration, which was the lowest in the time series.

- As seen in both surface and bottom water temperature time series, there appears to have been a regime shift in thermal conditions in the Gulf of Maine. The shift represent an increase in temperature on the order of 1.5°C.

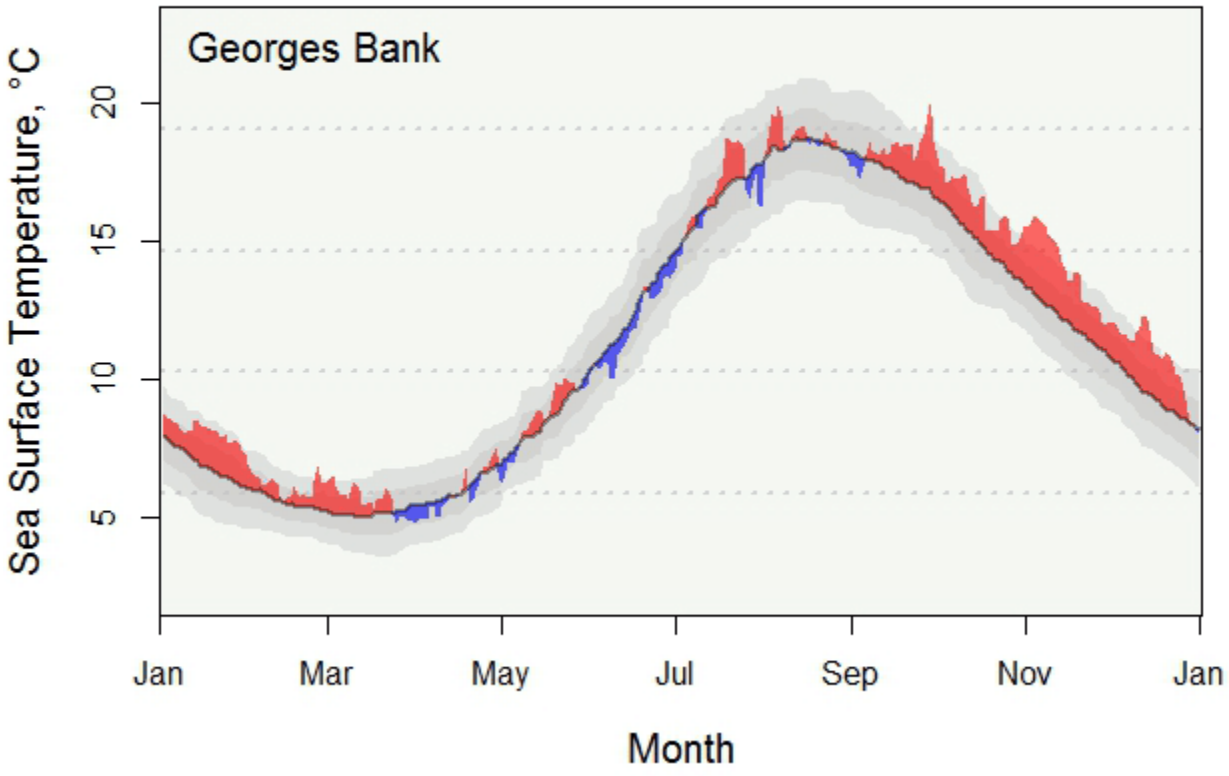
- The variability of daily SST has increased over recent decades as indicated by the trends in standard deviation of daily temperature. There is an emerging pattern of cyclic variation in SST variability in the Middle Atlantic Bight.

- The combined occupancy habitat for the main species occurring on the Northeast Shelf has increased dramatically indicating greater niche overlap among species.

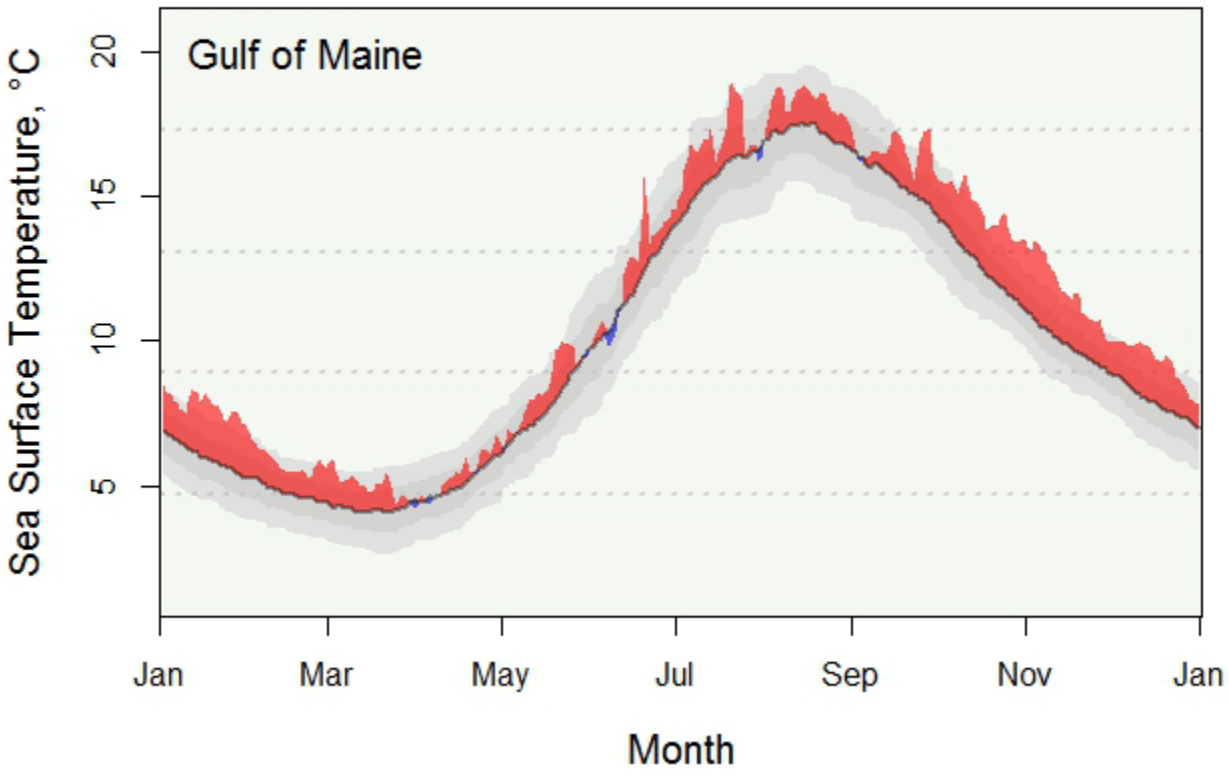
Fall Sea Surface Temperature - Northeast Shelf Ecosystem

The Northeast Shelf Large Marine Ecosystem experienced above average sea surface temperatures (SSTs) during the fall of 2017 after a relatively cool 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

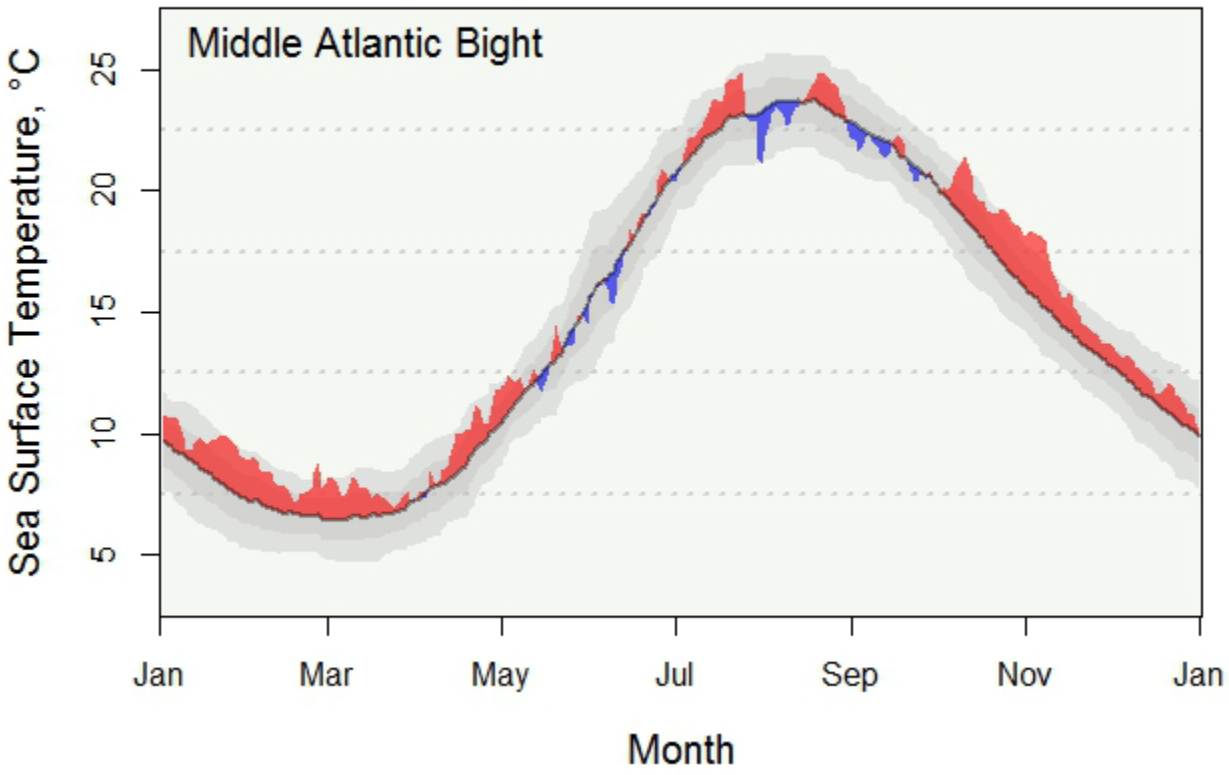
and Middle Atlantic Bight subareas (see figures below). Many days were above the mean by more than two standard deviations in these areas.



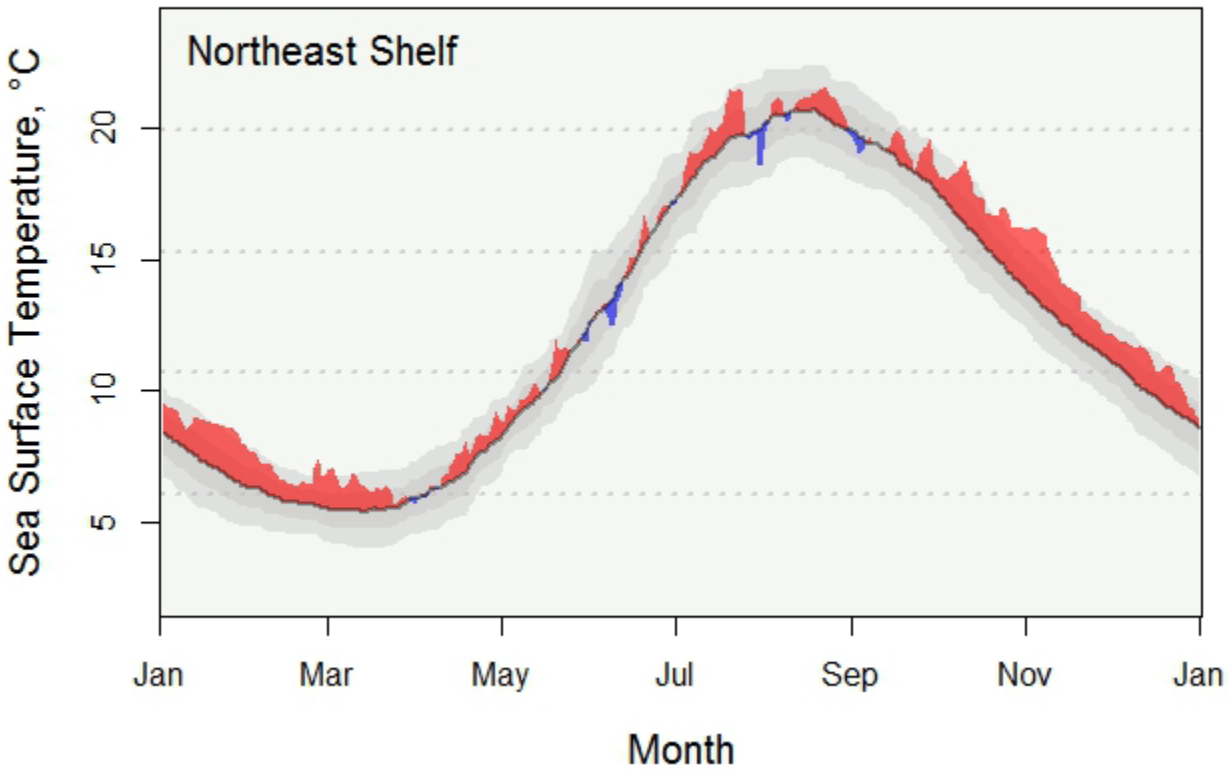
Georges Bank



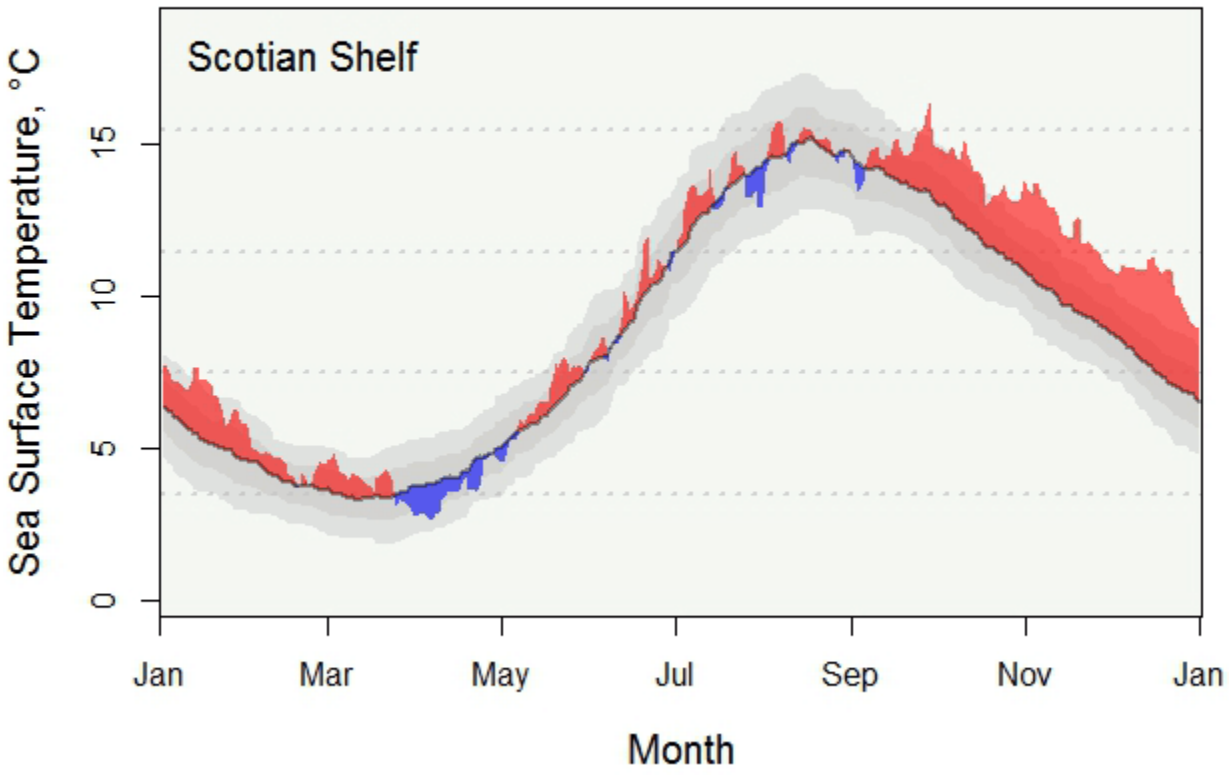
Gulf of Maine



Middle Atlantic Bight

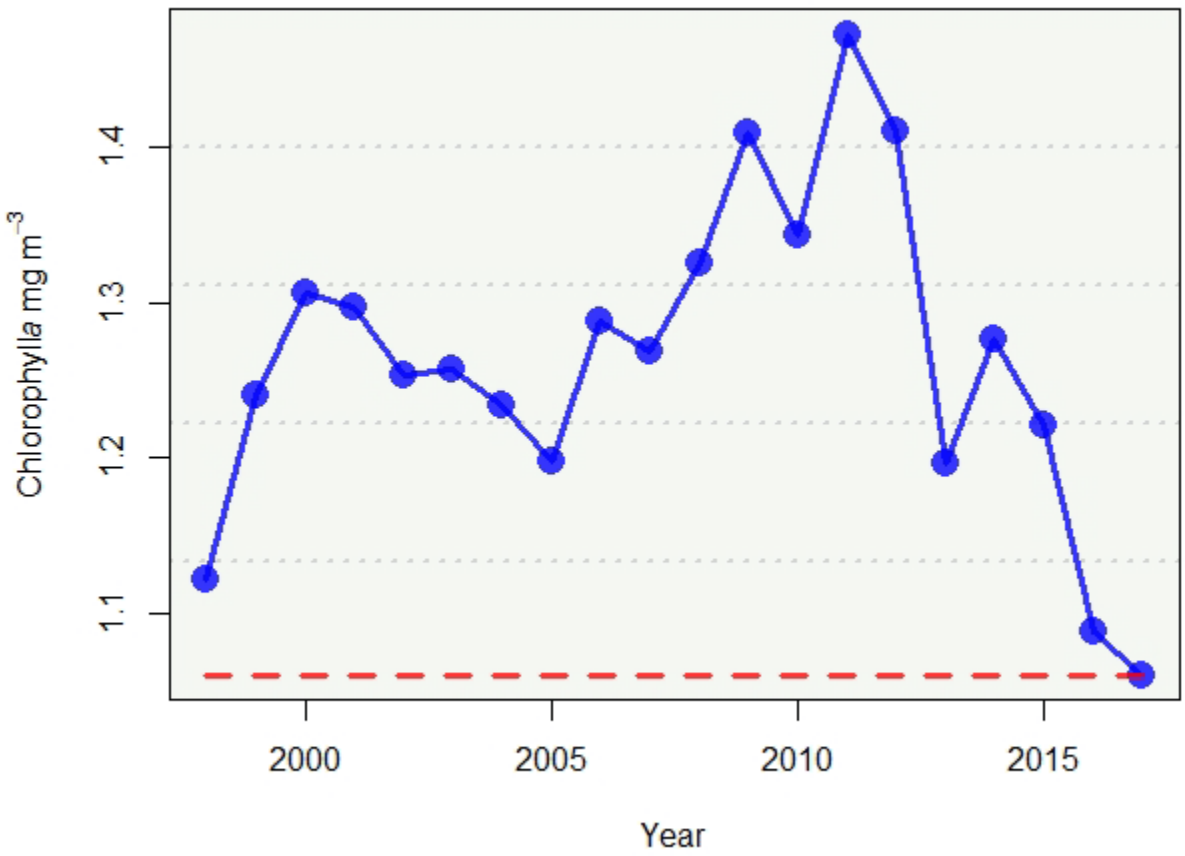


Northeast Shelf



Scotian Shelf

Ecosystem Chlorophyll Concentration Trends



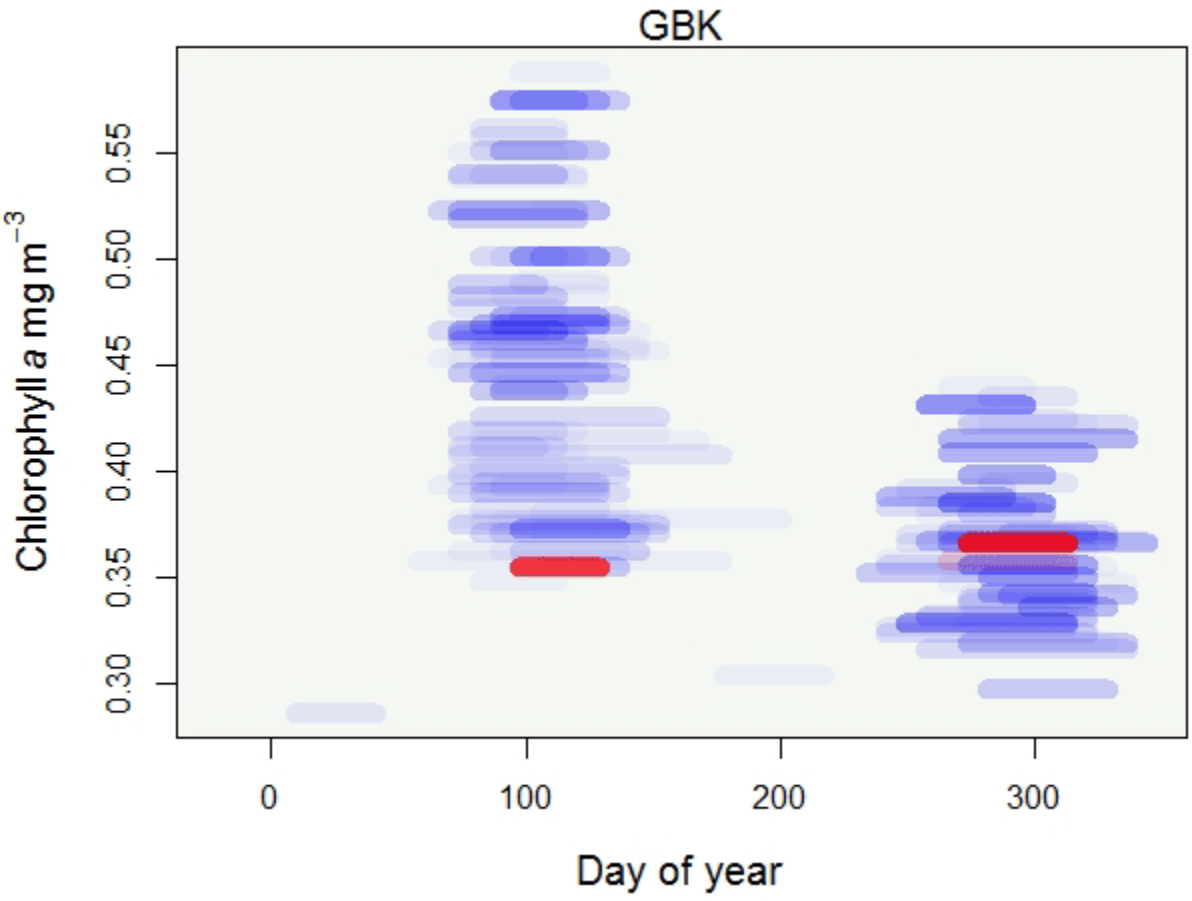
Chlorophyll trends

The base of the food chain is reflected in the standing stock of phytoplankton and the rate of primary production. The two aspects of the plankton community are associated with different pathways of energy flow to consumer populations. Standing stock, which reaches its highest levels during bloom periods, is an indicator of potential flux of plankton to the benthos of the ecosystem. The concentration of chlorophyll is an indicator of phytoplankton standing stock. After a period of increasing chlorophyll concentration in the Northeast Shelf Ecosystem that peaked in 2011, chlorophyll concentration has been declining on an annual basis. The 2017 mean was the lowest in the time series.

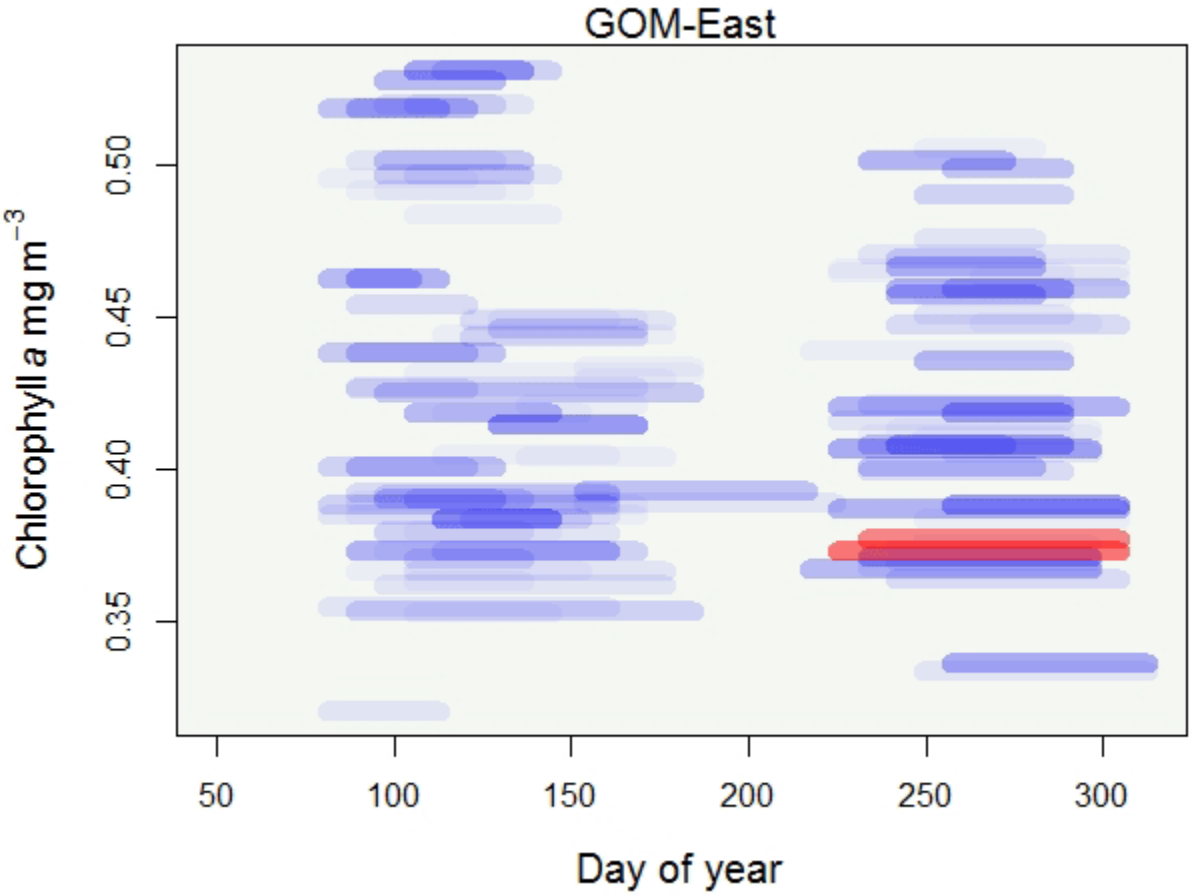
Continuous Detection of Phytoplankton Blooms on the Northeast Shelf

In previous assessments of phytoplankton blooms, seasonal blooms were detected in two fixed periods during the year, spring and fall. In this assessment, the approach has been modified to detect blooms incrementally throughout the year and in five shelf

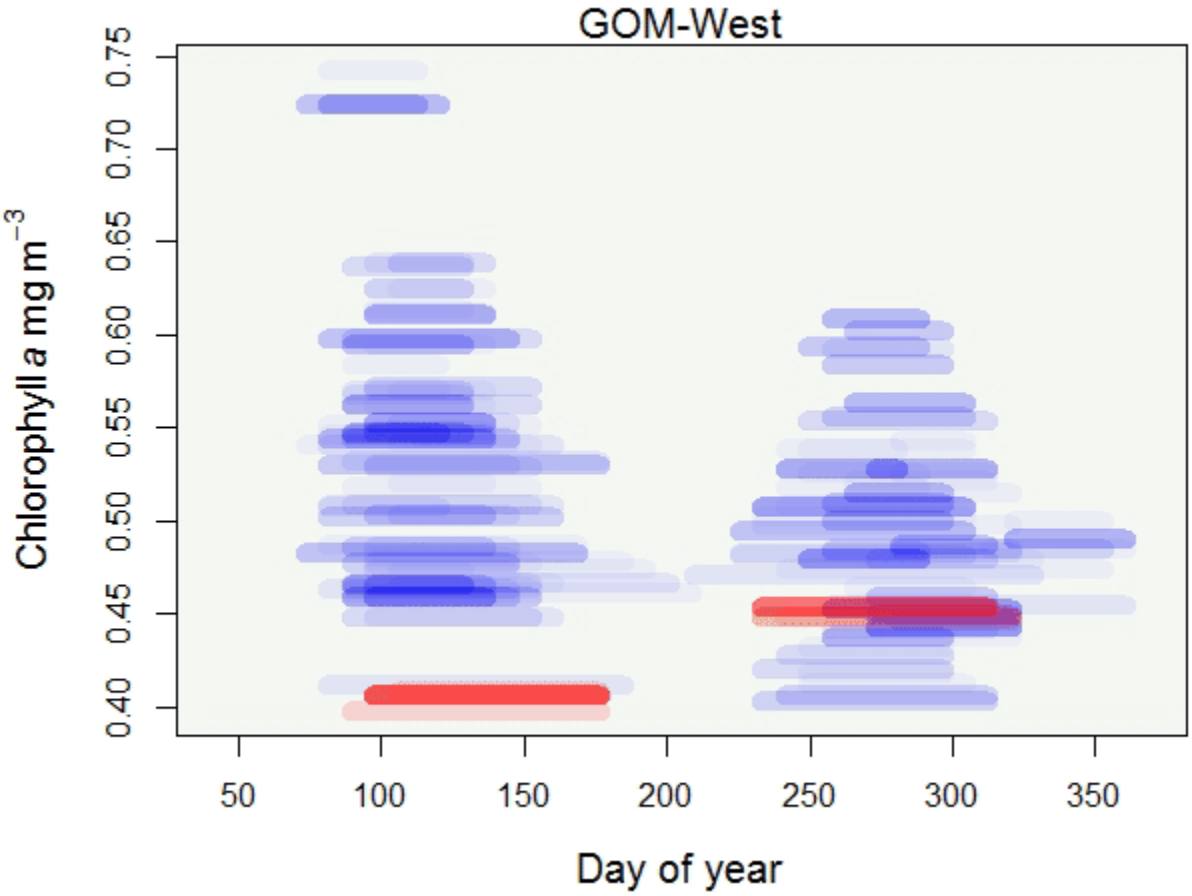
subareas (see Cont. Shelf Res. 102:47). A bloom event is represented by a line, the length of which reflects the length of the bloom and the position on the y-axis the chlorophyll concentration during the bloom period. An event line is plotted in a transparent tone, thus if a bloom is detected by multiple searches, it will appear in a deeper tone, which reflects greater confidence in the detection. In 2017, spring blooms in all areas were among the smaller spring blooms ever detected (see figure; red bloom events are detections in 2017, blue bloom events are for all previous years). There were no spring bloom detections in Gulf of Maine east and the Middle Atlantic Bight south tends to have a rolling pattern of blooms throughout the year. The fall bloom on Georges Bank was of short duration and average intensity. The fall blooms in the Gulf of Maine lasted longer, but were of lower than average intensity.



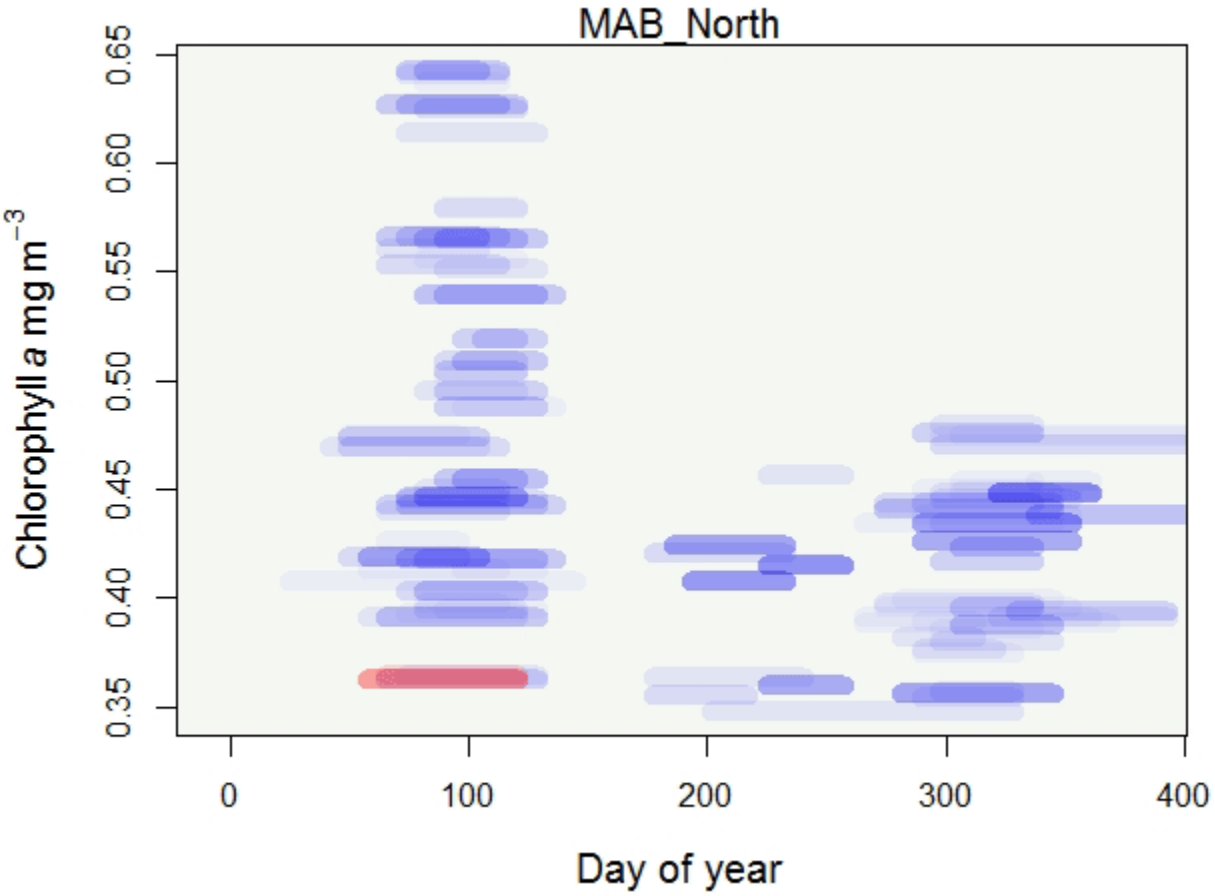
Georges Bank



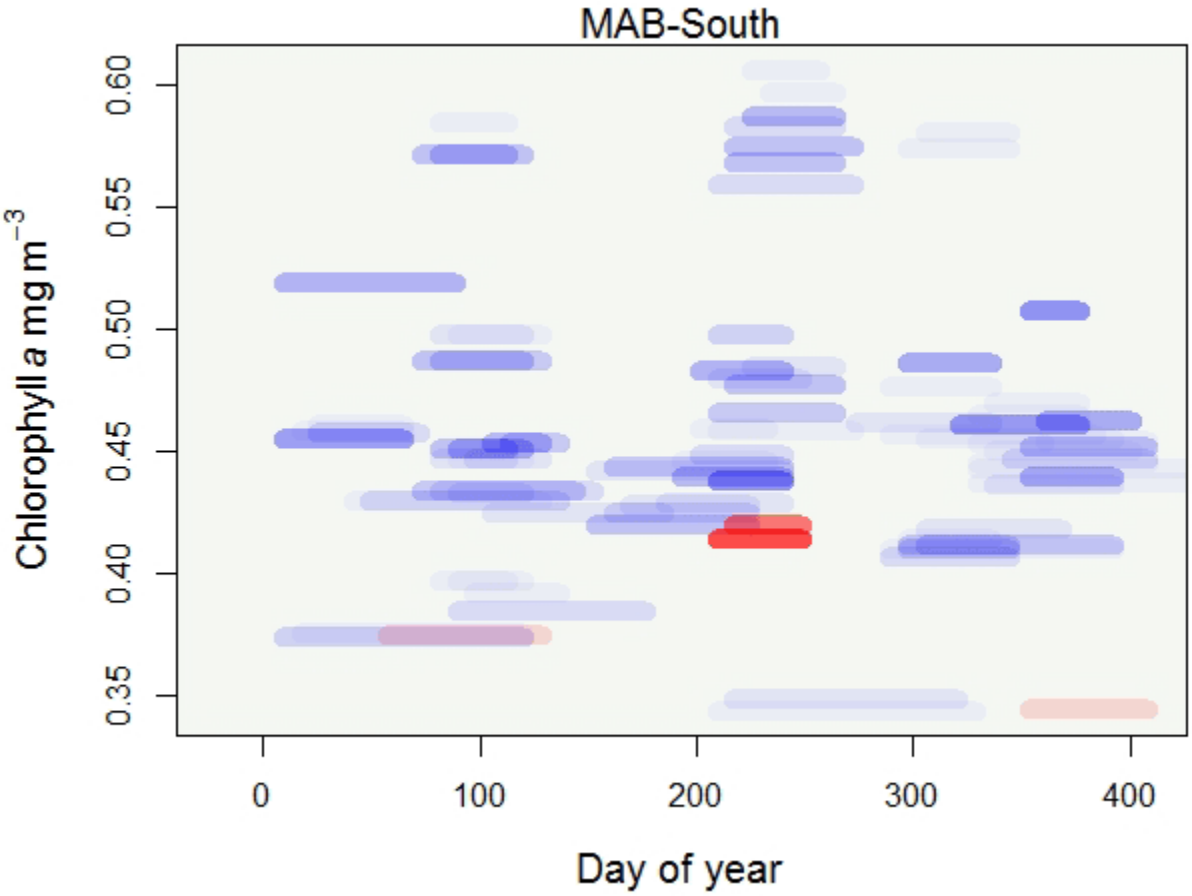
Gulf of Maine East



Gulf of Maine West



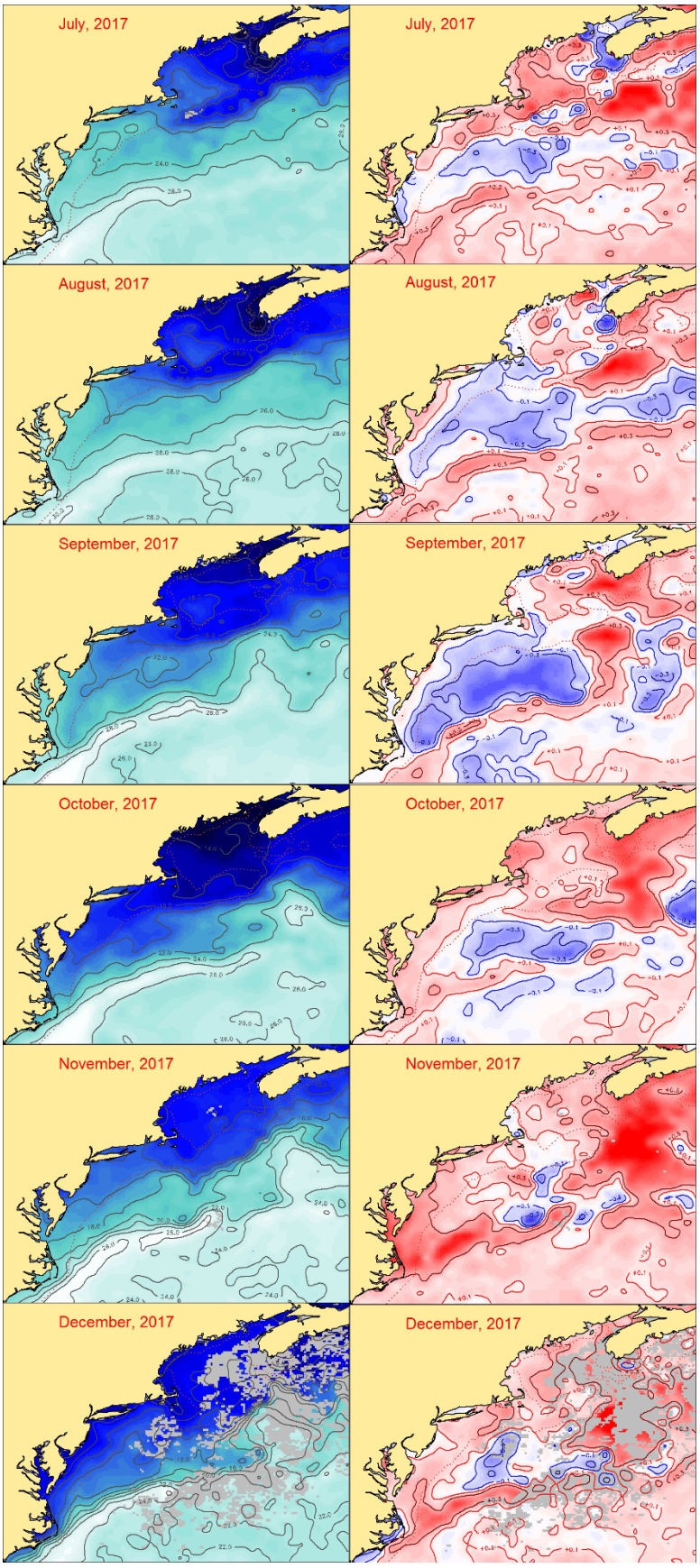
Middle Atlantic Bight North



Middle Atlantic Bight South

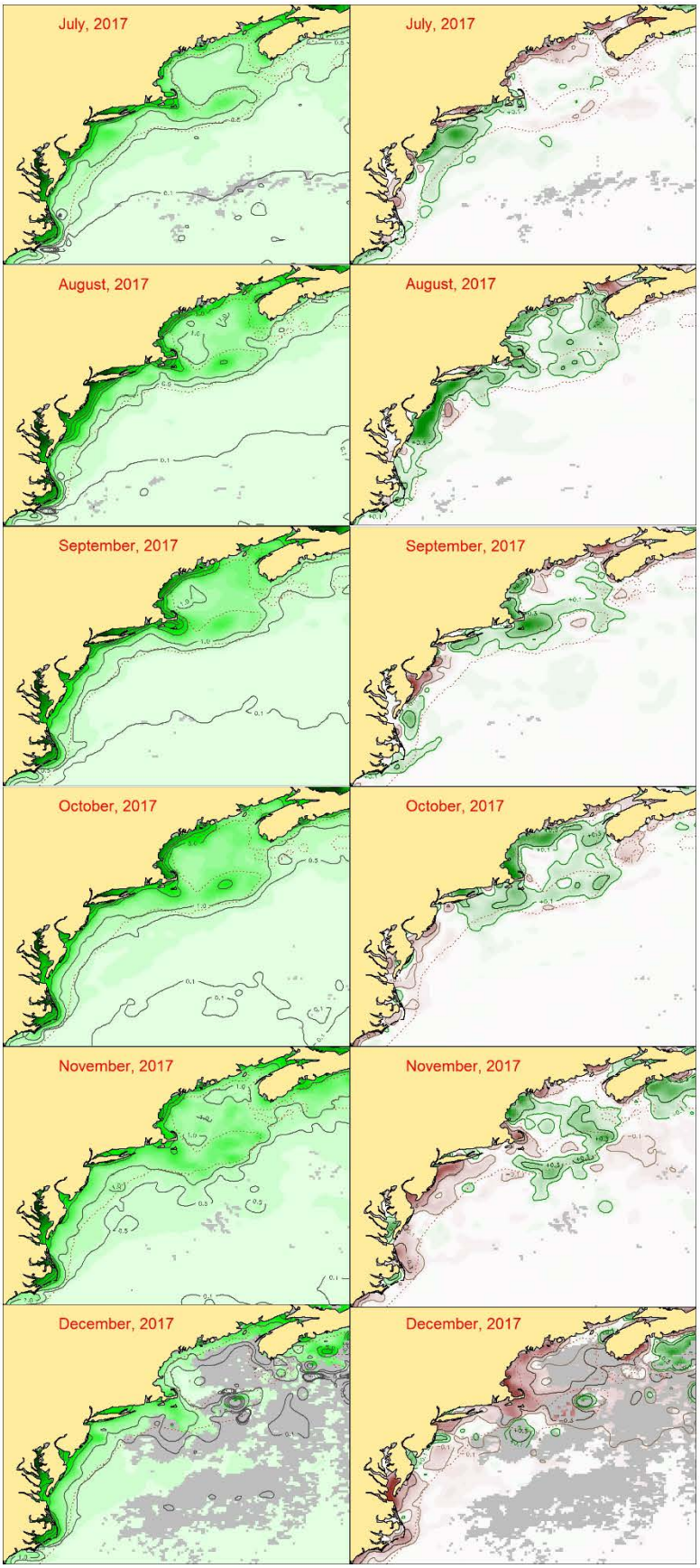
Fall Sea Surface Temperature Distribution

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 set of icons. This type of anomaly tends to highlight high SSTs in an area, the red shades, and low SSTs in an area, the blue shades. The Northeast Shelf was generally well above average temperature during the month of July. There was widespread cooling in the Middle Atlantic Bight in August and September, before the continental shelf generally remained at above average temperature for the balance of the year.


July, 2017
July, 2017
August, 2017
August, 2017
September, 2017
September, 2017
October, 2017
October, 2017
November, 2017
November, 2017
December, 2017
December, 2017

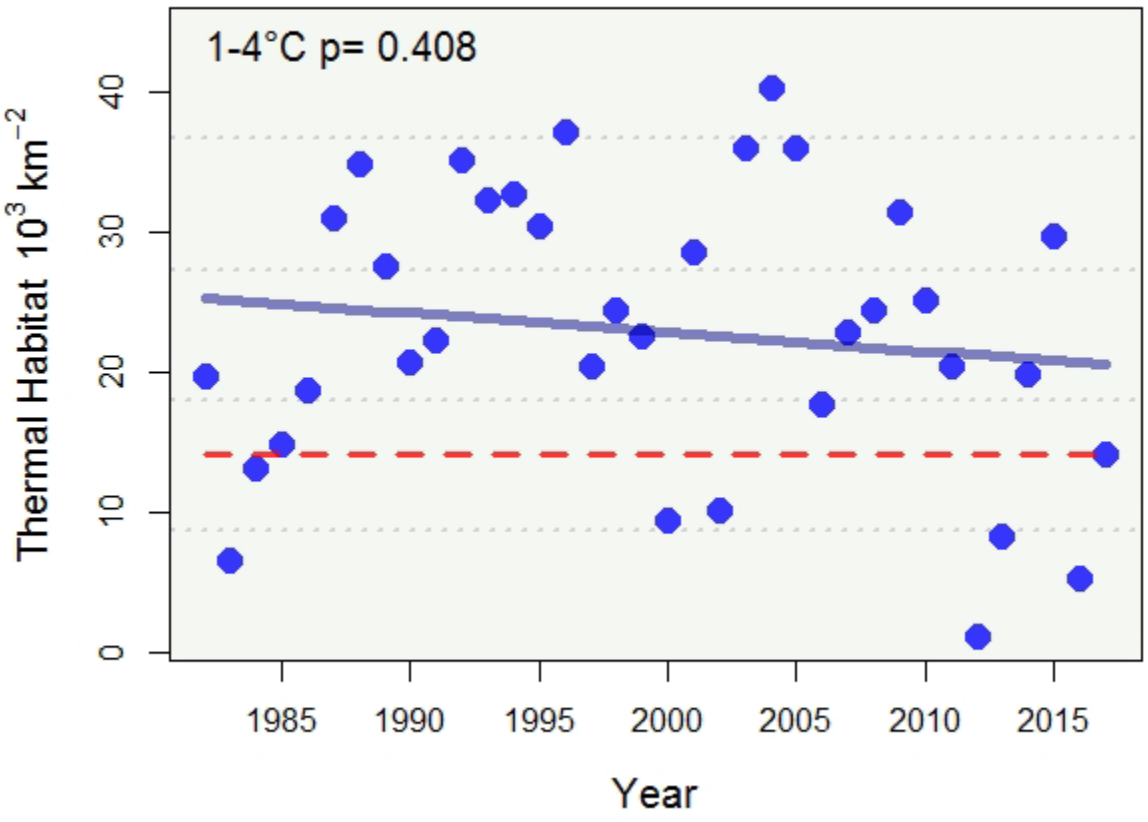
Fall Chlorophyll Distribution

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 set of icons. This type of anomaly tends to highlight strong blooms in an area, the green shades, and weak blooms in an area, the brown shades. A large fall bloom developed off the coast of New Jersey during July into August and appears to have dissipated by September. The Gulf of Maine bloom can be seen off the Maine coast in September and October and was restricted spatially to the inshore area. The Georges Bank area was in bloom condition during October and November.

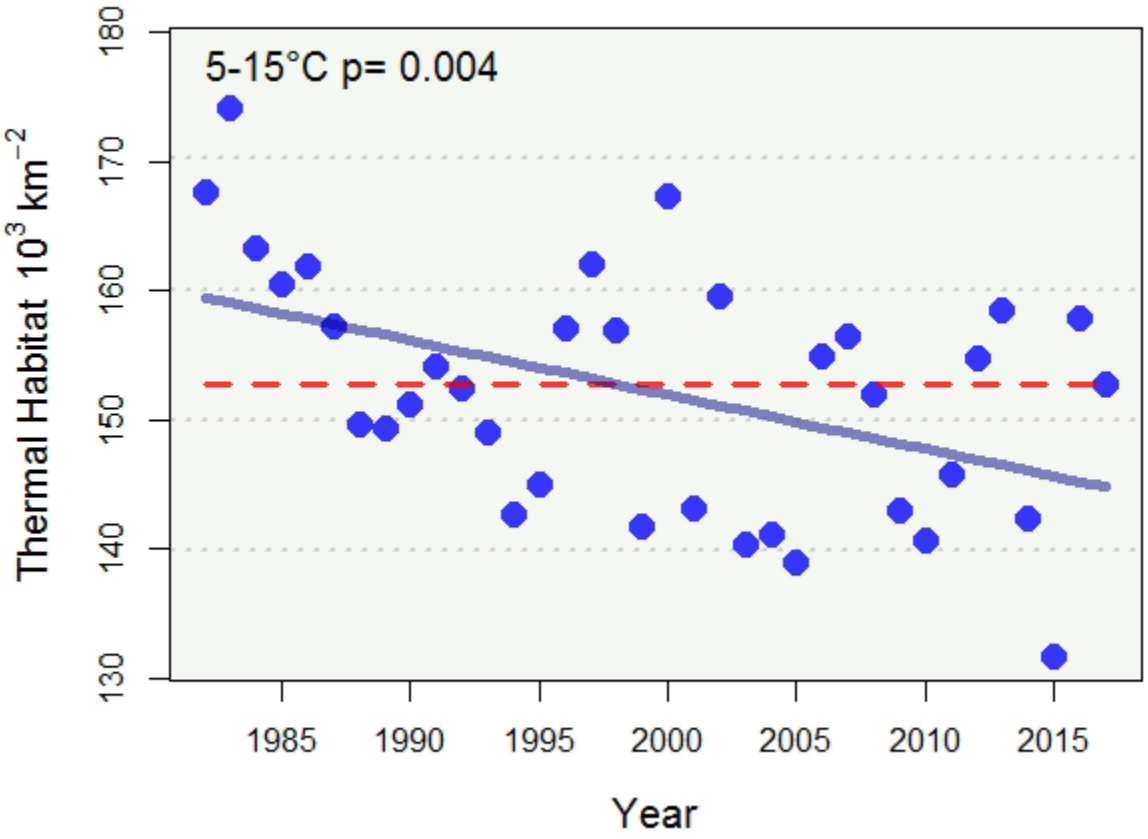

July, 2017
July, 2017
August, 2017
August, 2017
September, 2017
September, 2017
October, 2017
October, 2017
November, 2017
November, 2017
December, 2017
December, 2017

Ecosystem Shift in Thermal Habitat

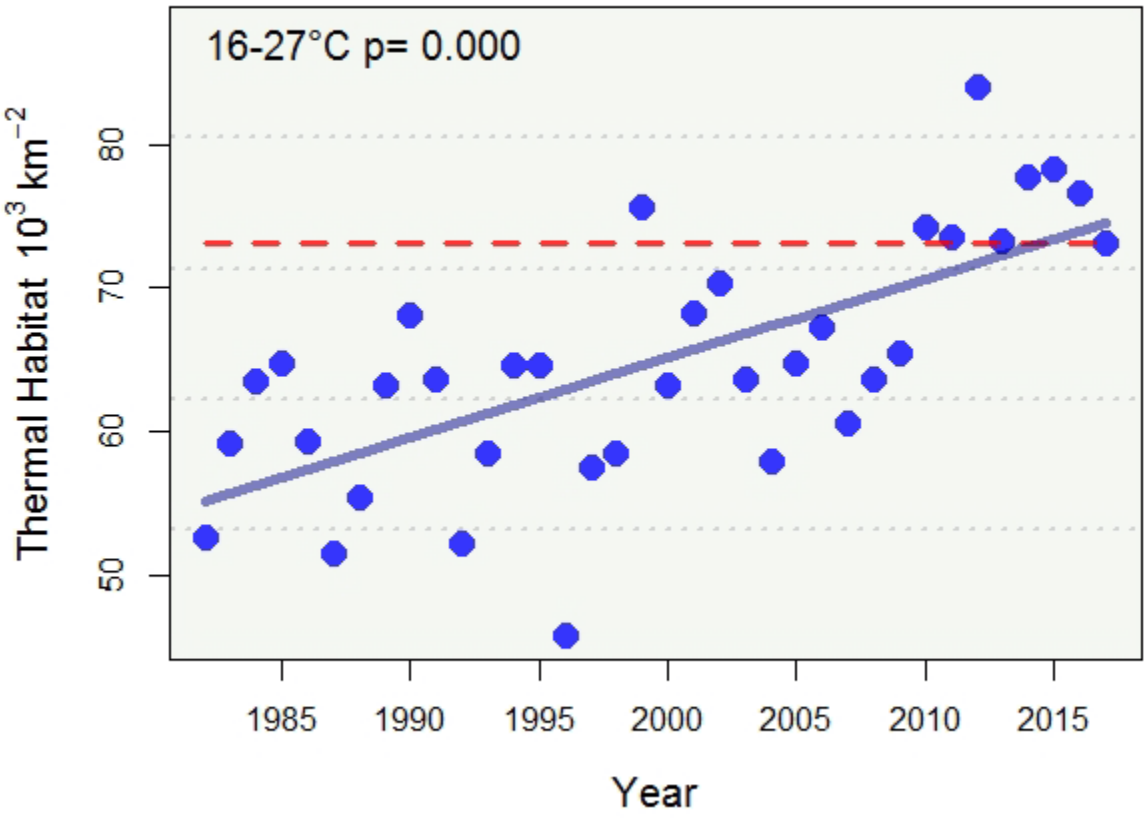
Temperature affects the behavior and physiology of marine organisms; thus, it is a key determinant of habitat within the ecosystem. The area of cold water habitats (1-4°C) shows no time series trend despite extremely low values in recent years. Cold water habitats in 2017 were approximately 14,000 km^2 (2017 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 419 km^2 yr^{-1}, which is matched by a corresponding increase in warm water habitats (16-27°C) at a rate of 552 km^2 yr^{-1}.



Cold water habitats

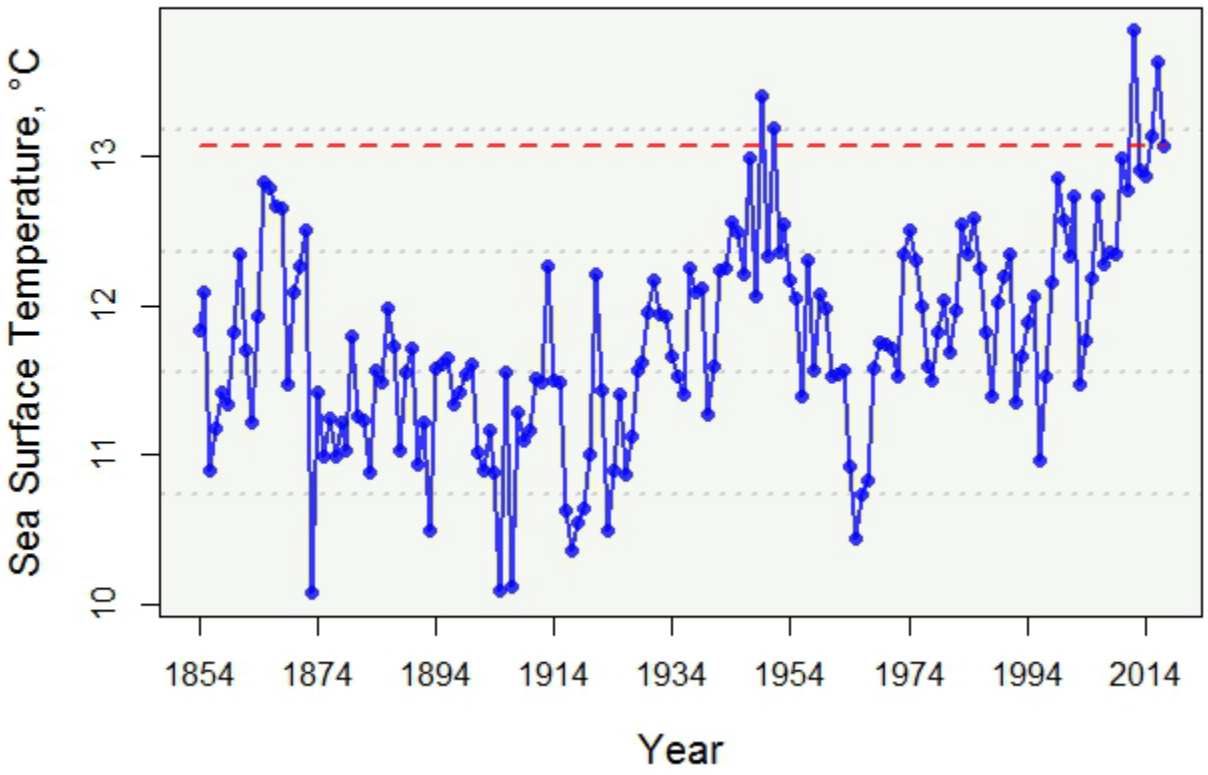


Cool water habitats



Warm water habitats

Long-Term Temperature Trends for the Northeast Shelf Ecosystem

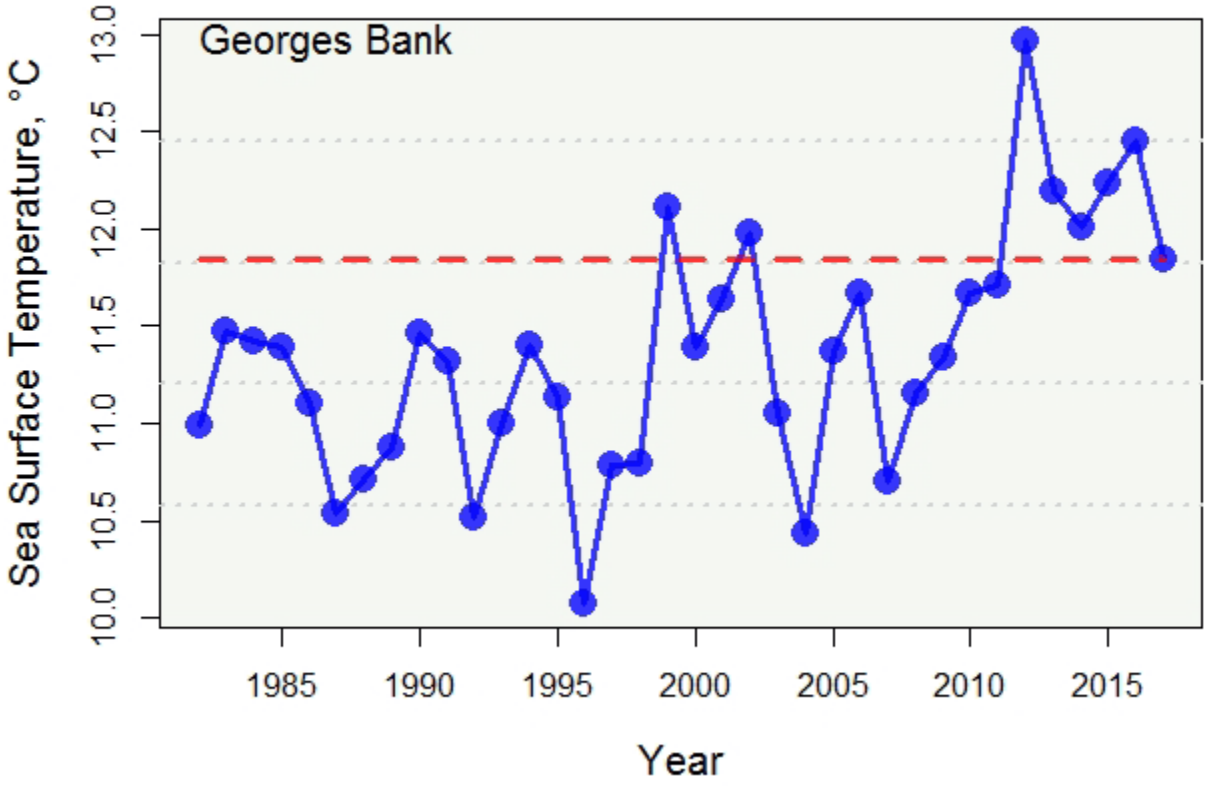


ERSST

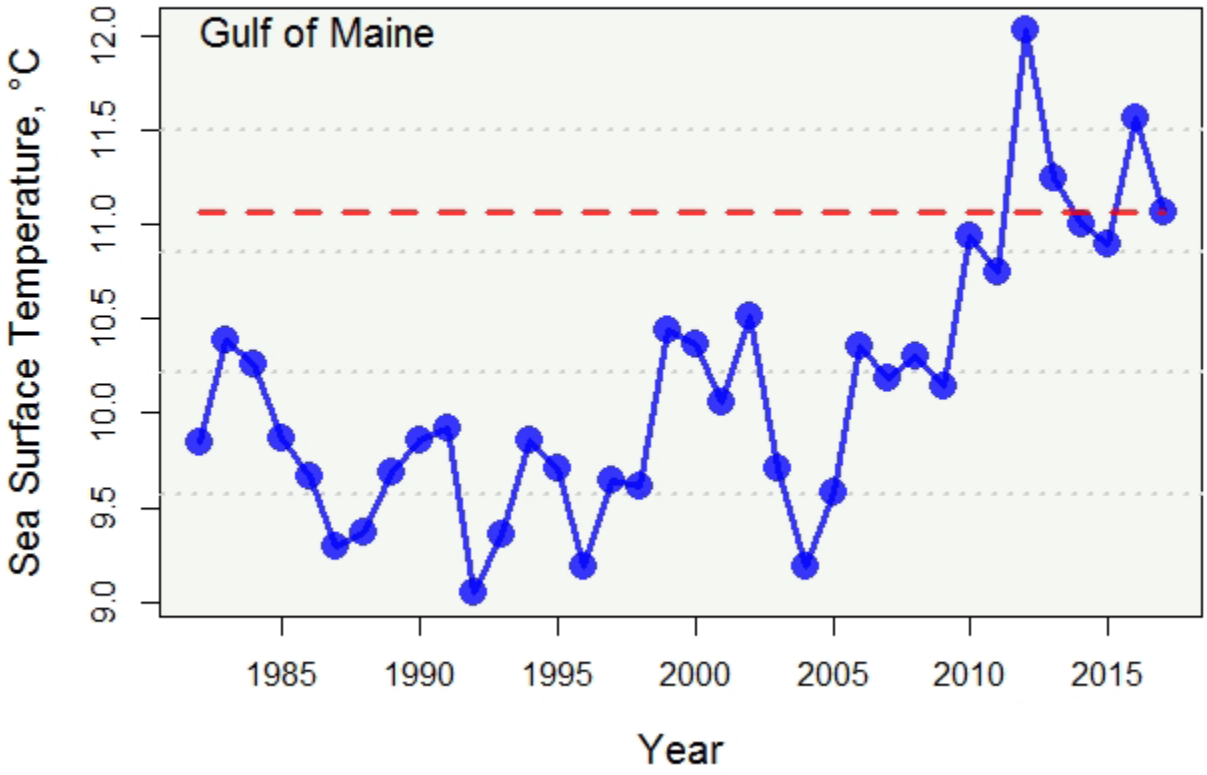
The Extended Reconstructed Sea Surface Temperature (ERSST) dataset provide SST data since the year 1854. The dataset integrates observational temperature data from a variety of sources and uses mean patterns to influence the reconstruction of SST fields. The annual SST index from this dataset for Northeast Shelf Ecosystem was at a record high SST in 2012, the 2017 annual mean level (2017 value marked over the time series with dashed red line) was among the highest values in the time series.

Satellite SST Trends for the Northeast Shelf Ecosystem

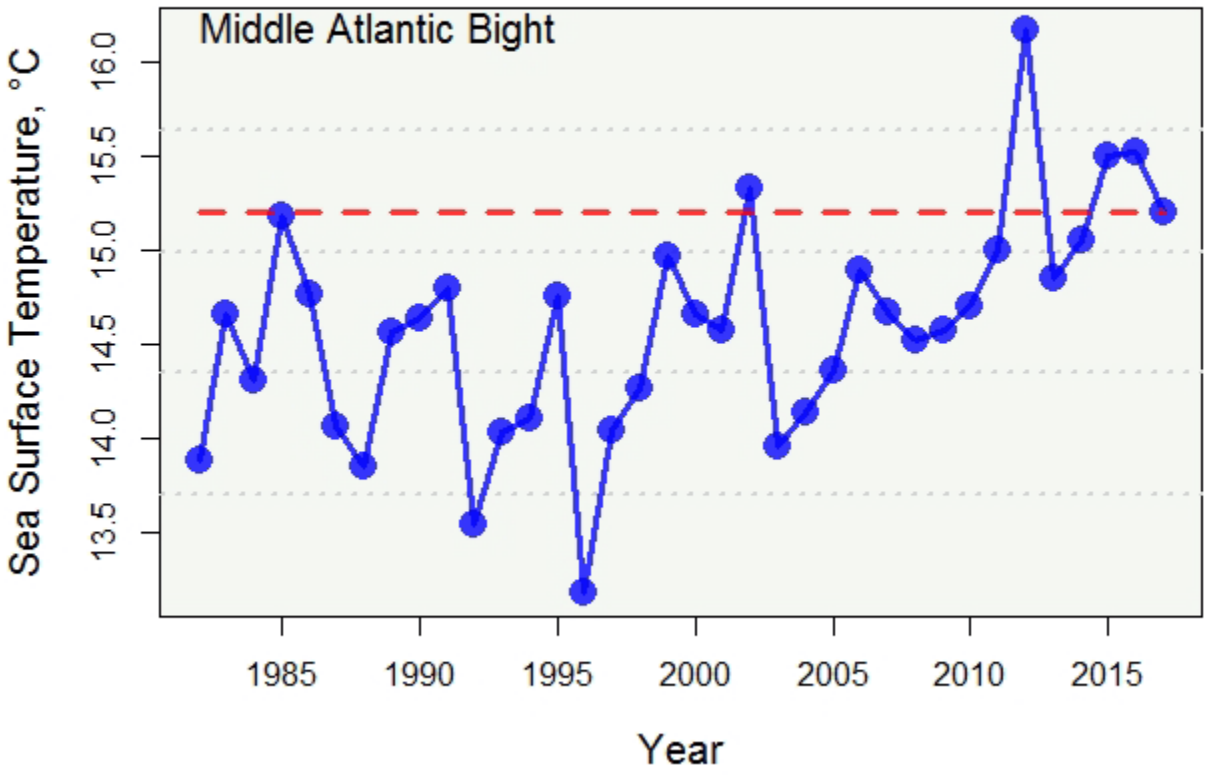
Satellite sensors provide a synoptic depiction of sea surface temperature in the ecosystem beginning in 1982. The SST conditions for 2017 were among highest in the in the data series for many of the NE Shelf ecoregions (see figure, red dashed line marks the 2017 value). The Gulf of Maine appears to have entered a new regime of thermal conditions considering that the last eight years of the time series are also the warmest years by a wide margin.



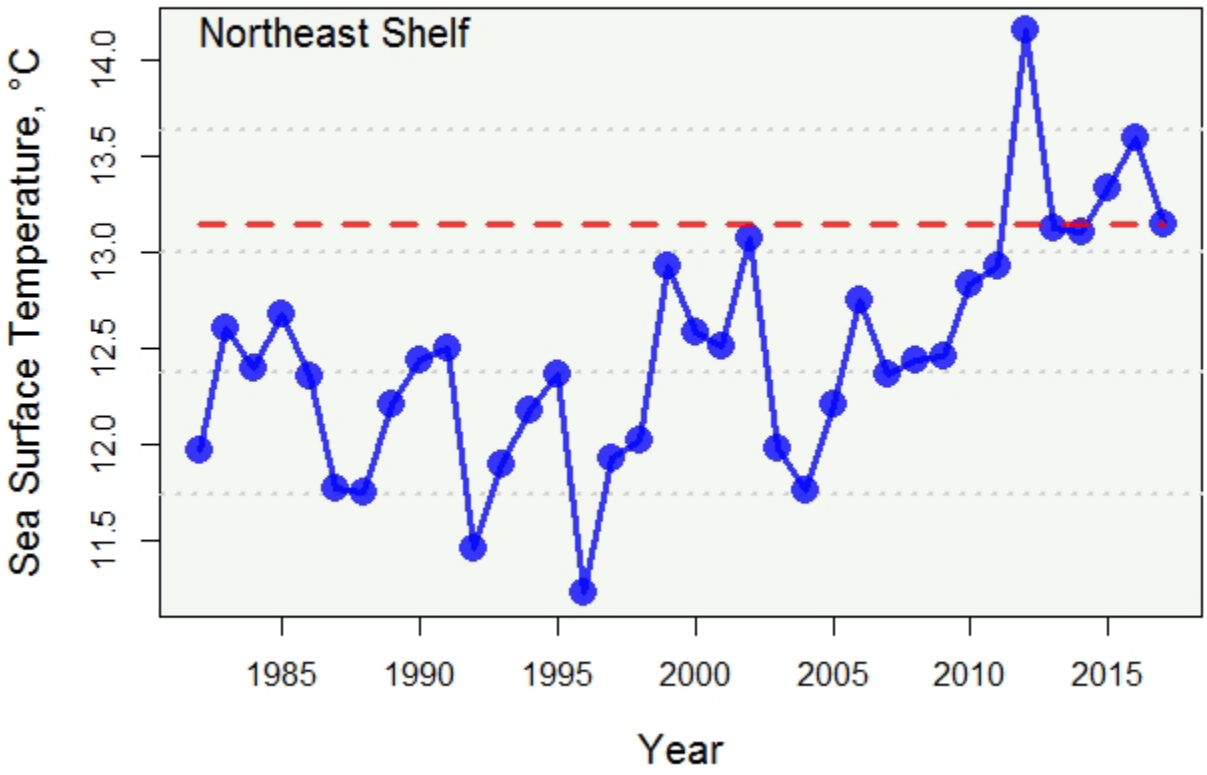
Georges Bank



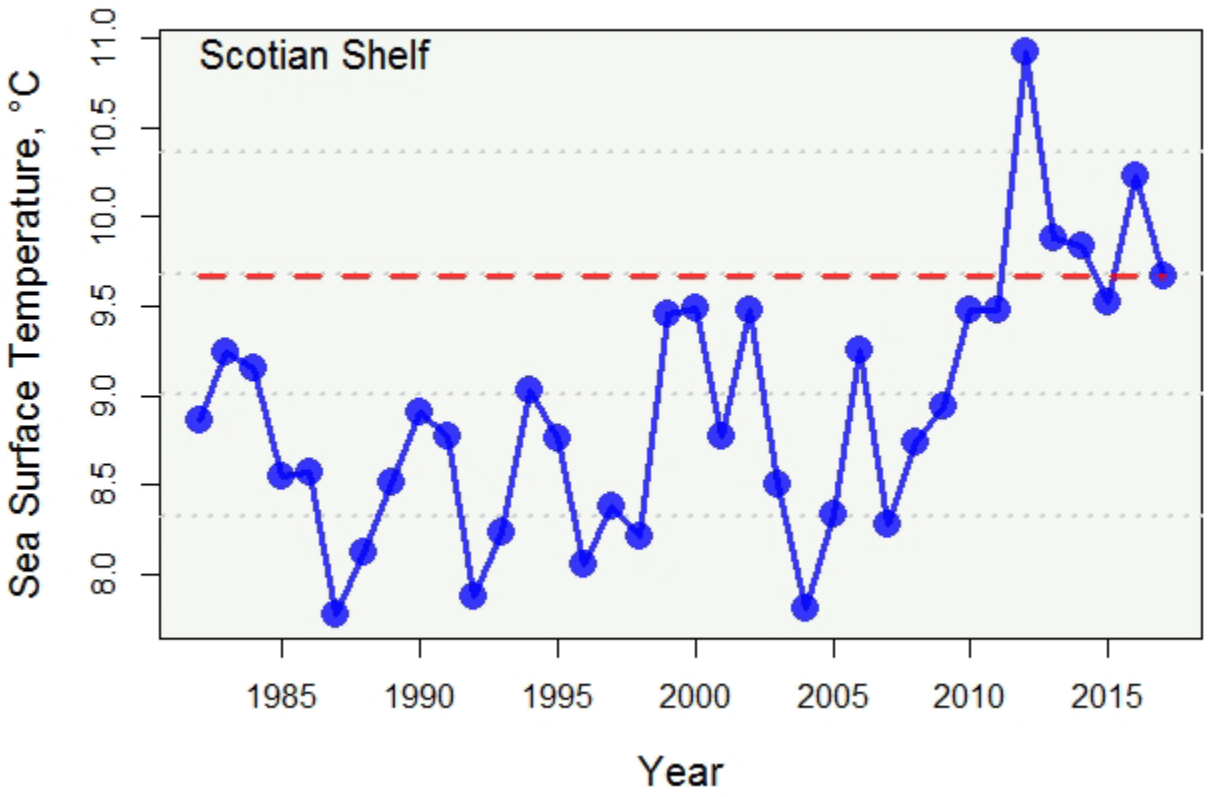
Gulf of Maine



Middle Atlantic Bight



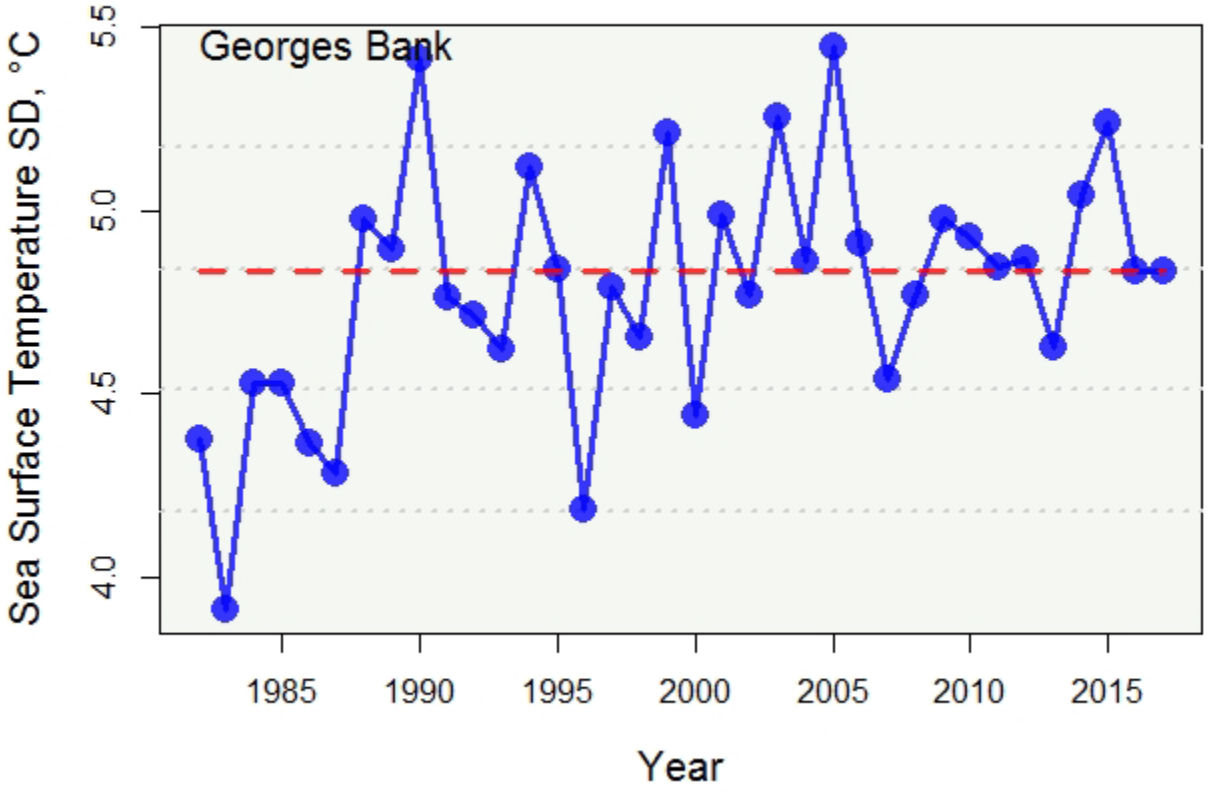
Northeast Shelf



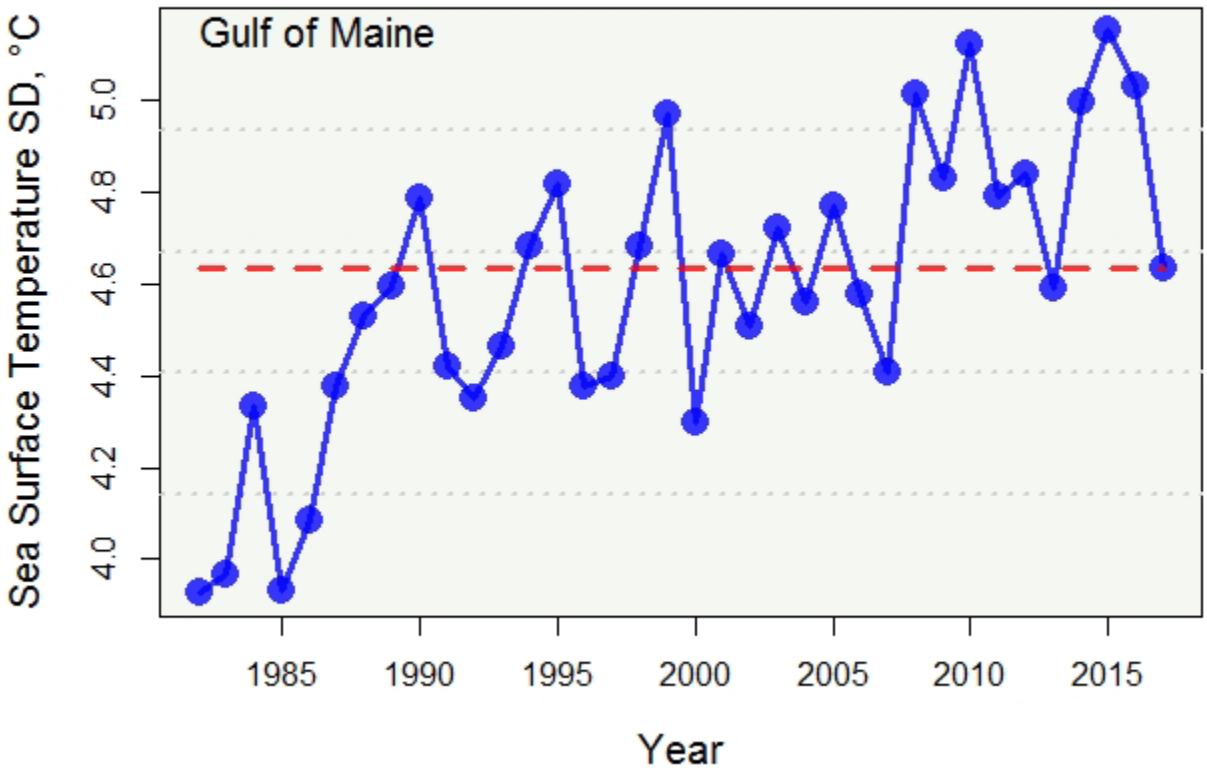
Scotian Shelf

Satellite SST Standard Deviation Trends for the Northeast Shelf Ecosystem

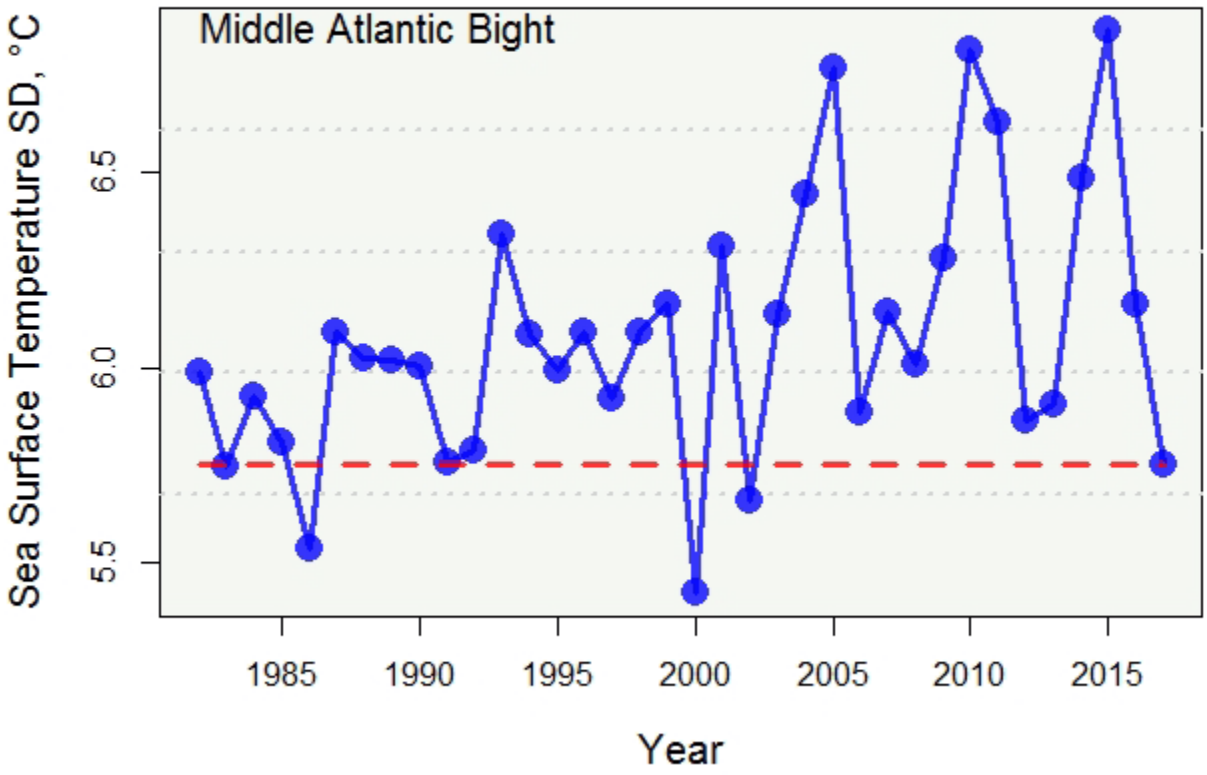
Climate change involves not only the change in level of climate parameters, it also involves change in system variability that can be seen in more dramatic shifts in weather in terrestrial systems and in ocean parameters on the Northeast Shelf. In an examination of daily sea surface temperatures in the NE Shelf ecosystem, system thermal 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 seen a cumulative trend increase of nearly 0.6°C in the standard deviation over the period. Similar trends can be seen in the other shelf subareas. The Middle Atlantic Bight has experienced wide swings in SST variability with an emerging frequency of five years.



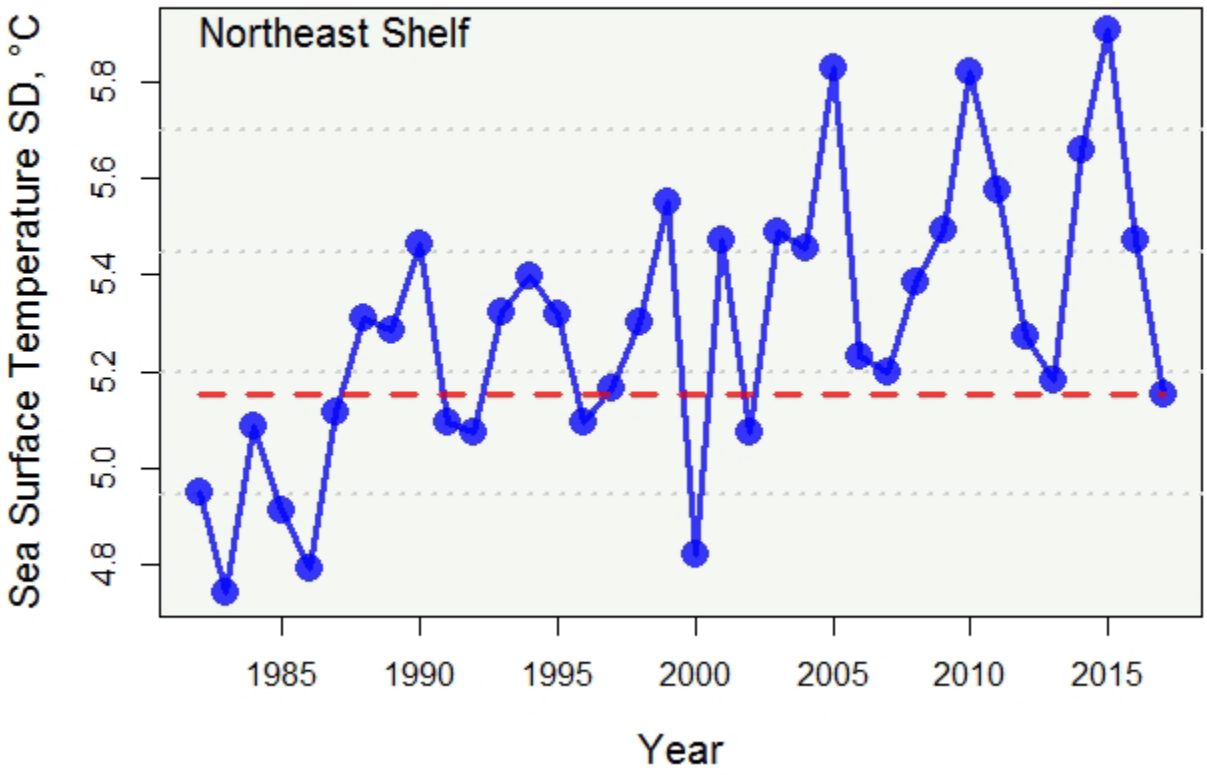
Georges Bank



Gulf of Maine



Middle Atlantic Bight



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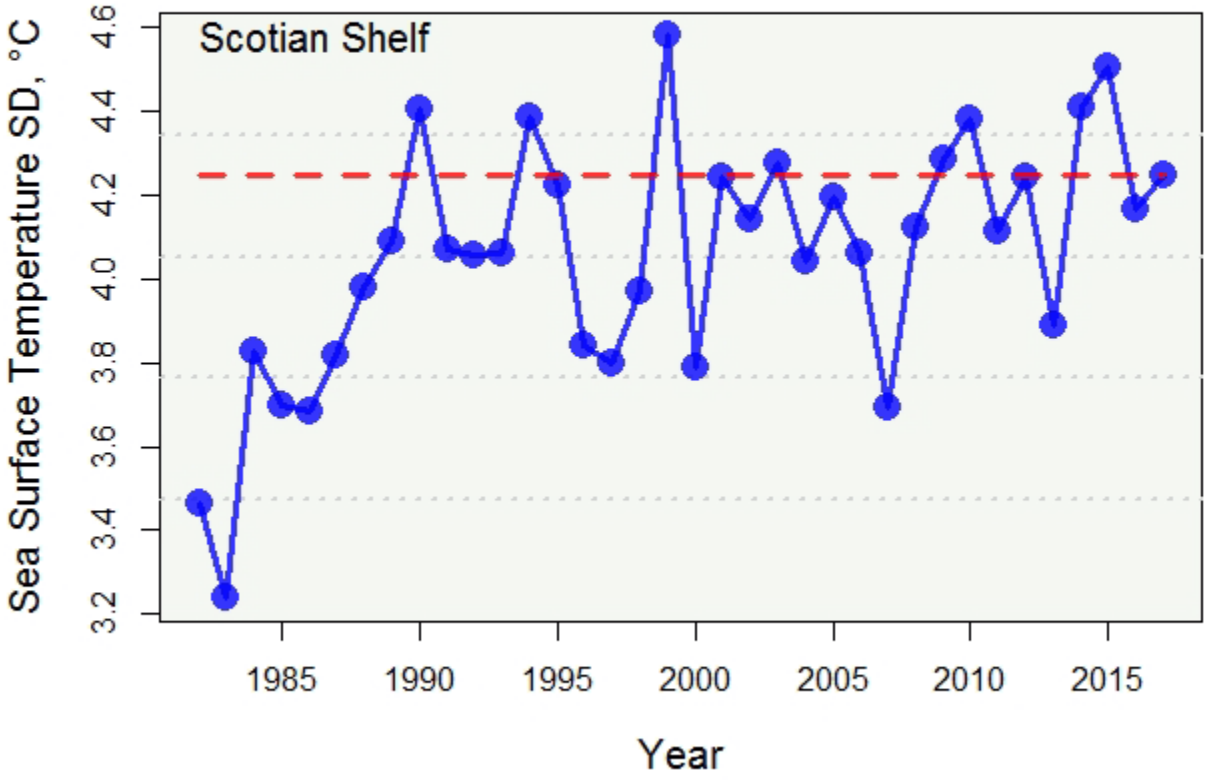
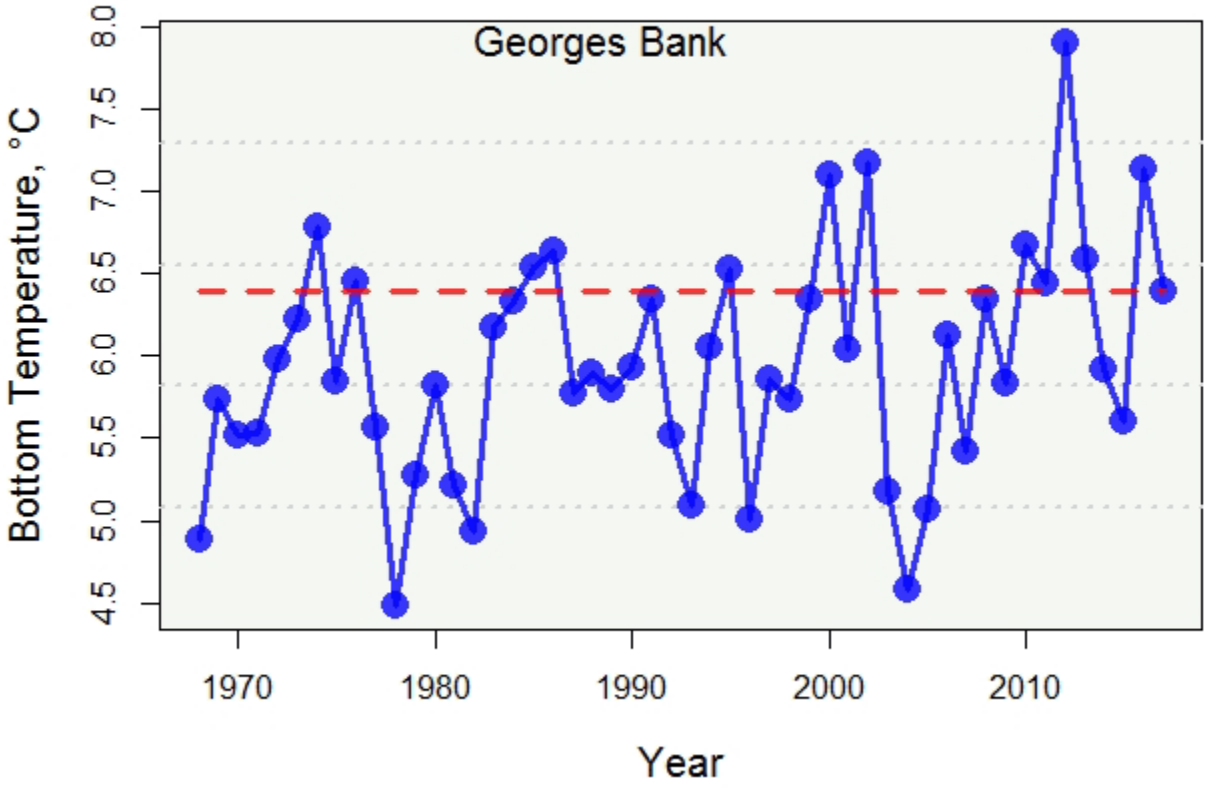


Scotian Shelf

Spring 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 April time frame temperatures suggest there has been some degree of warming in the northern ecoregions; the only ecoregion without a significant time series trend was the Middle Atlantic Bight (see figure; red dashed line marks 2017 data point).



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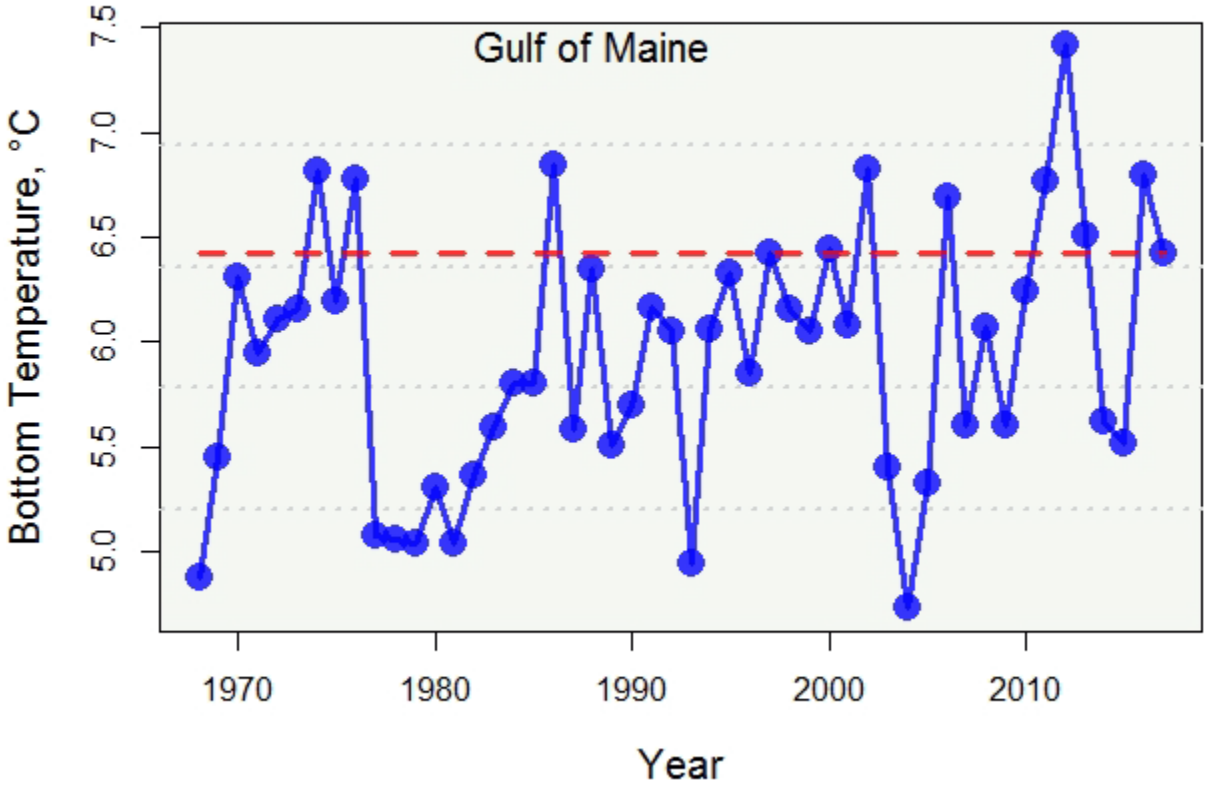

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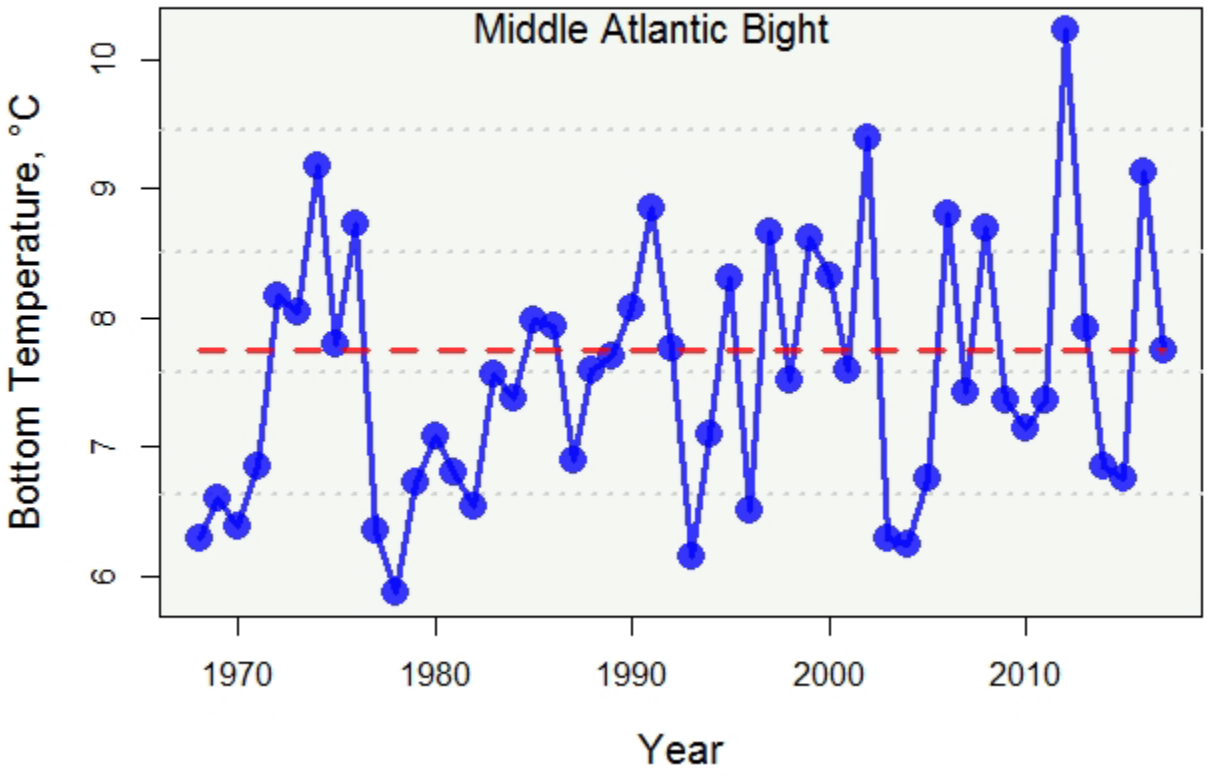
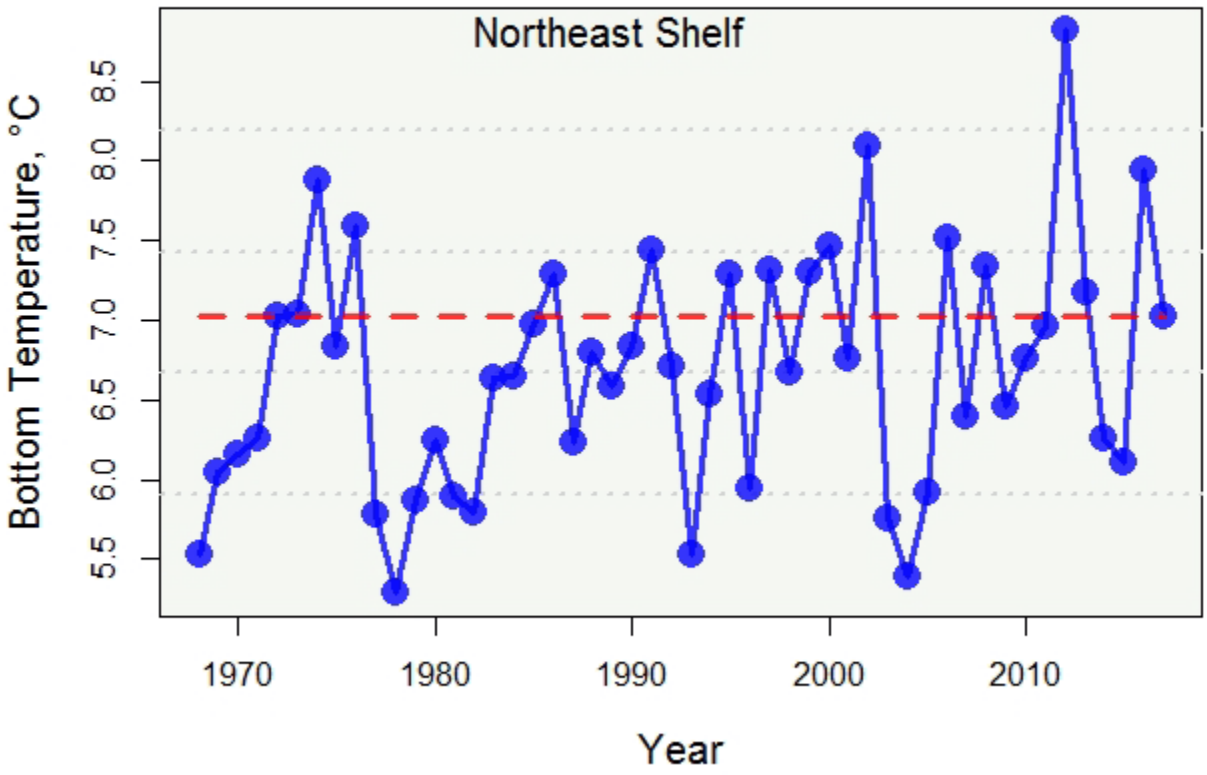


Middle Atlantic Bight



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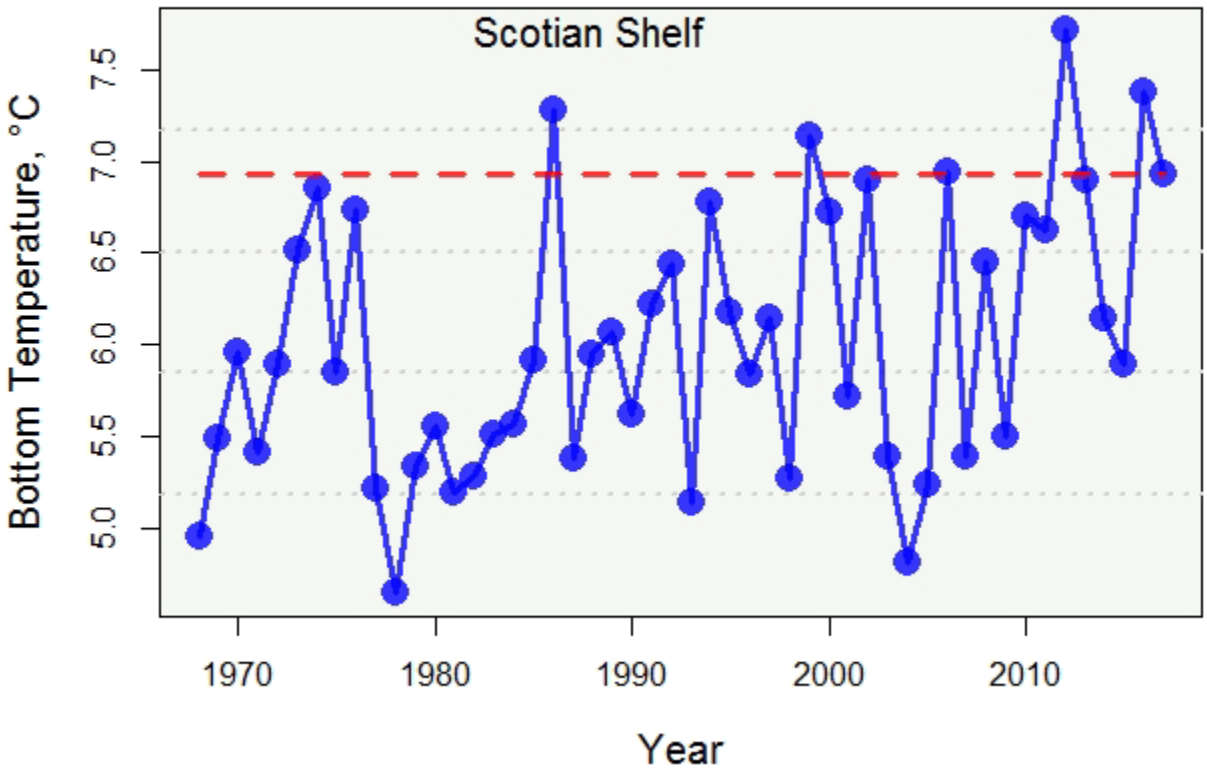
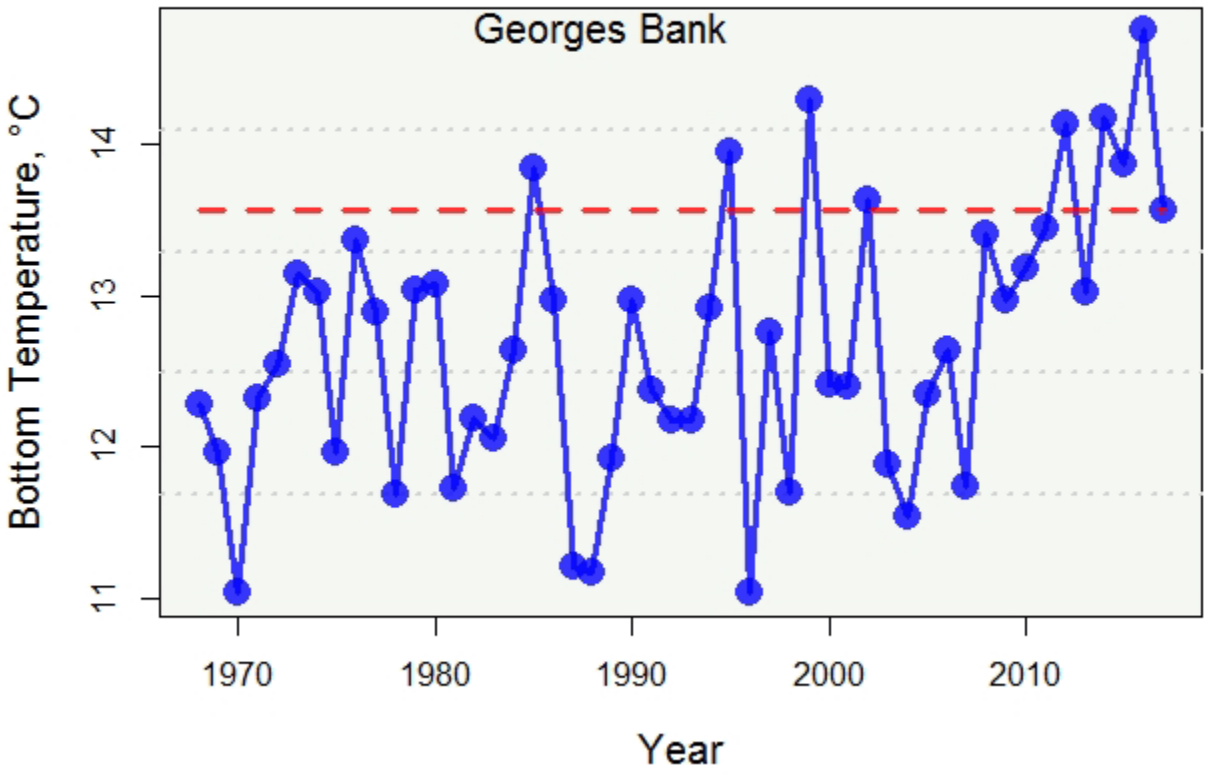


Scotian Shelf

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 suggest there has been significant warming thought the ecosystem; all the ecoregion had significant time series trends (see figure; red dashed line marks 2017 data point).



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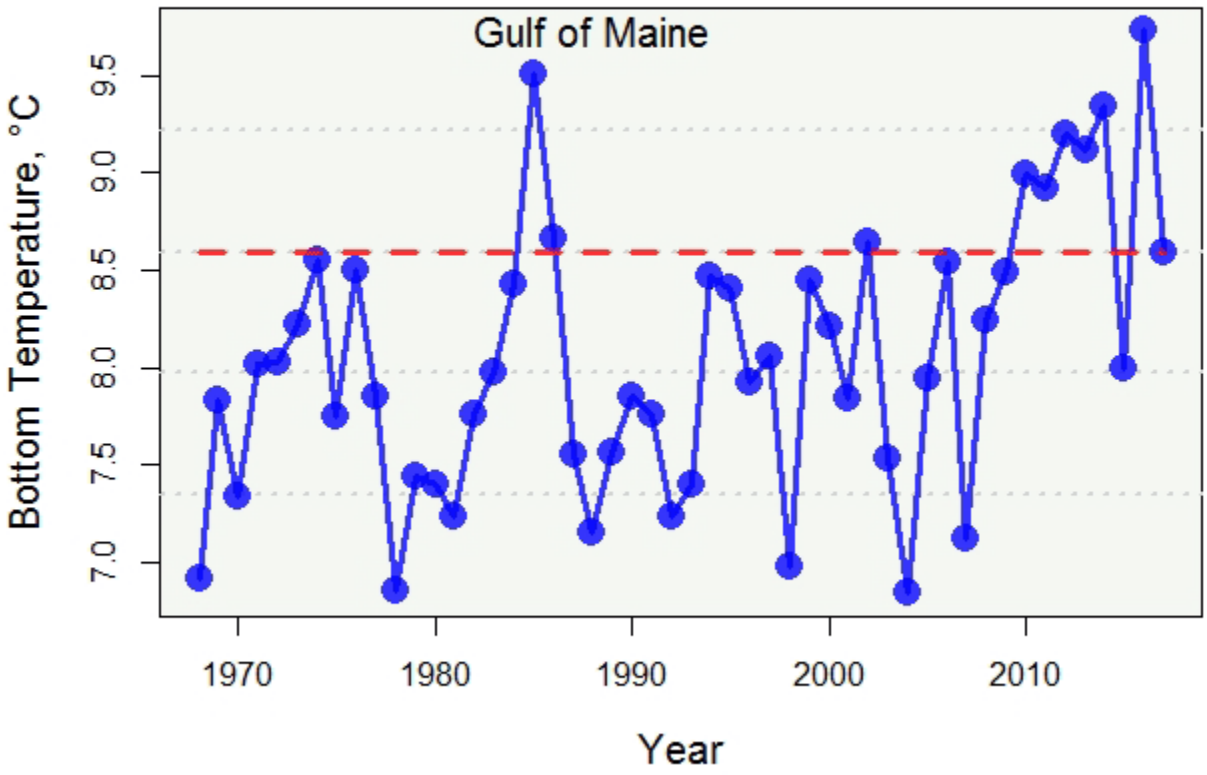

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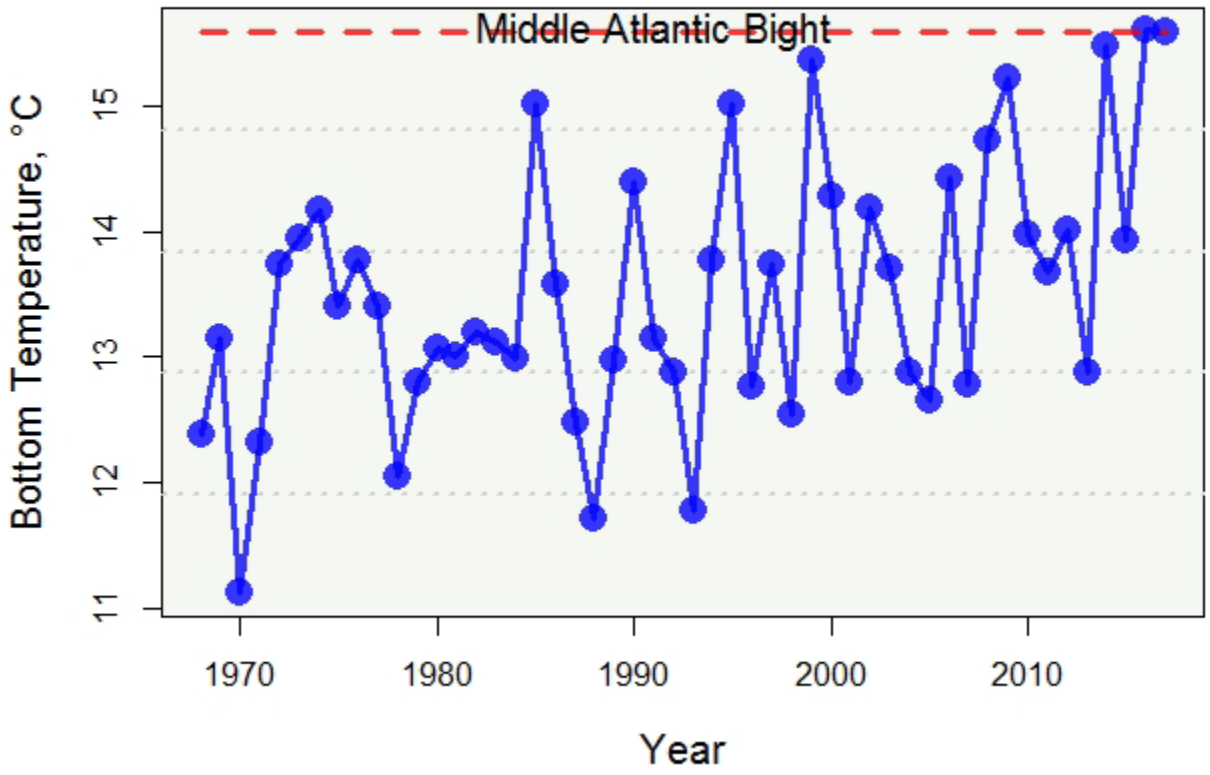

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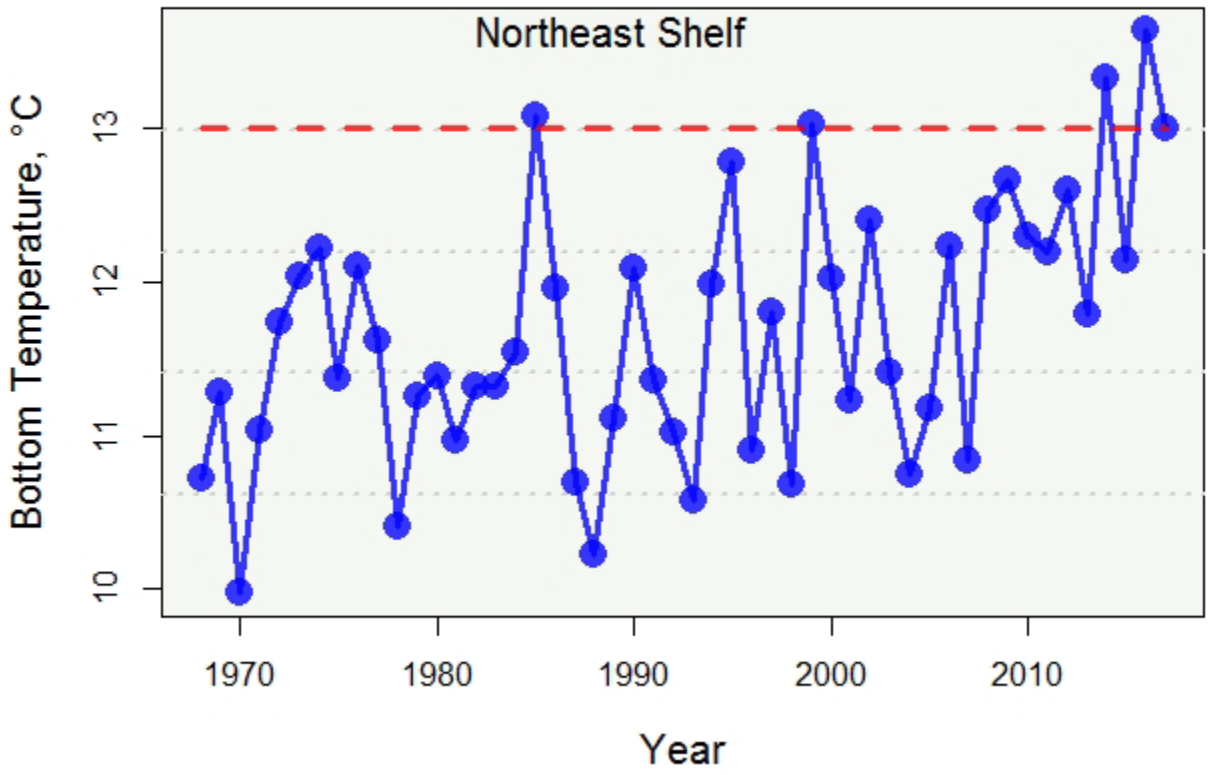

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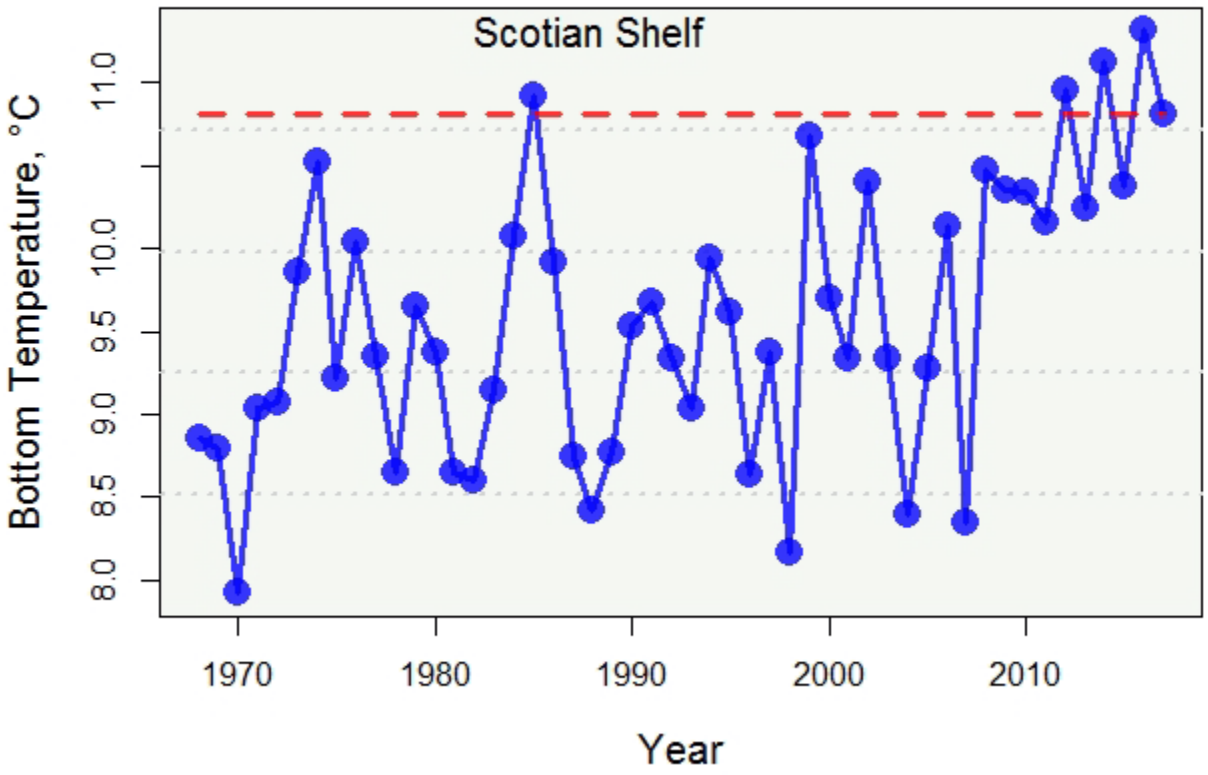
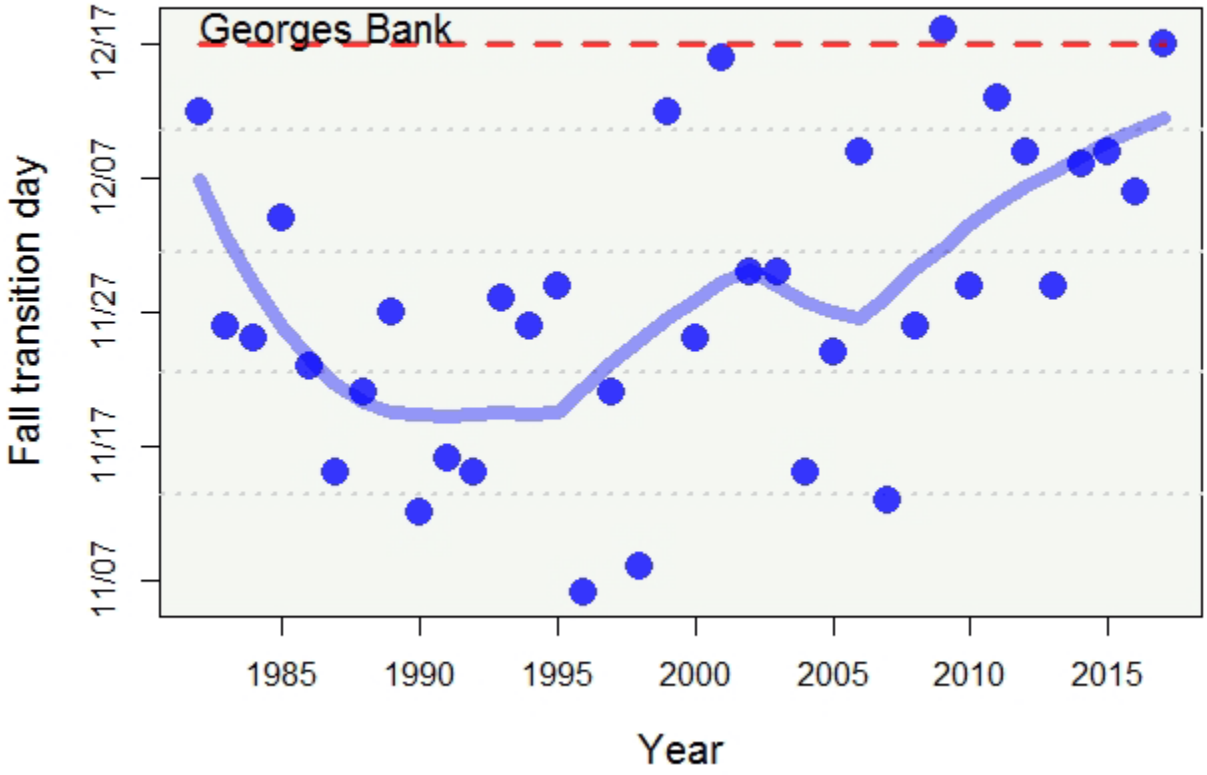


Scotian Shelf

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 2017 data). The transition has shifted by nearly a month in the northern part of the ecosystem as seen in the data for the Gulf of Maine and Georges Bank where the transition date was in November during the 1980s and is now occurring in December. The 2017 Scotian Shelf occurred so late that it was off scale for the detection algorithm. The shift at the southern end of the ecosystem was not as large with the transitions in the Middle Atlantic Bight largely confined to the month of November.



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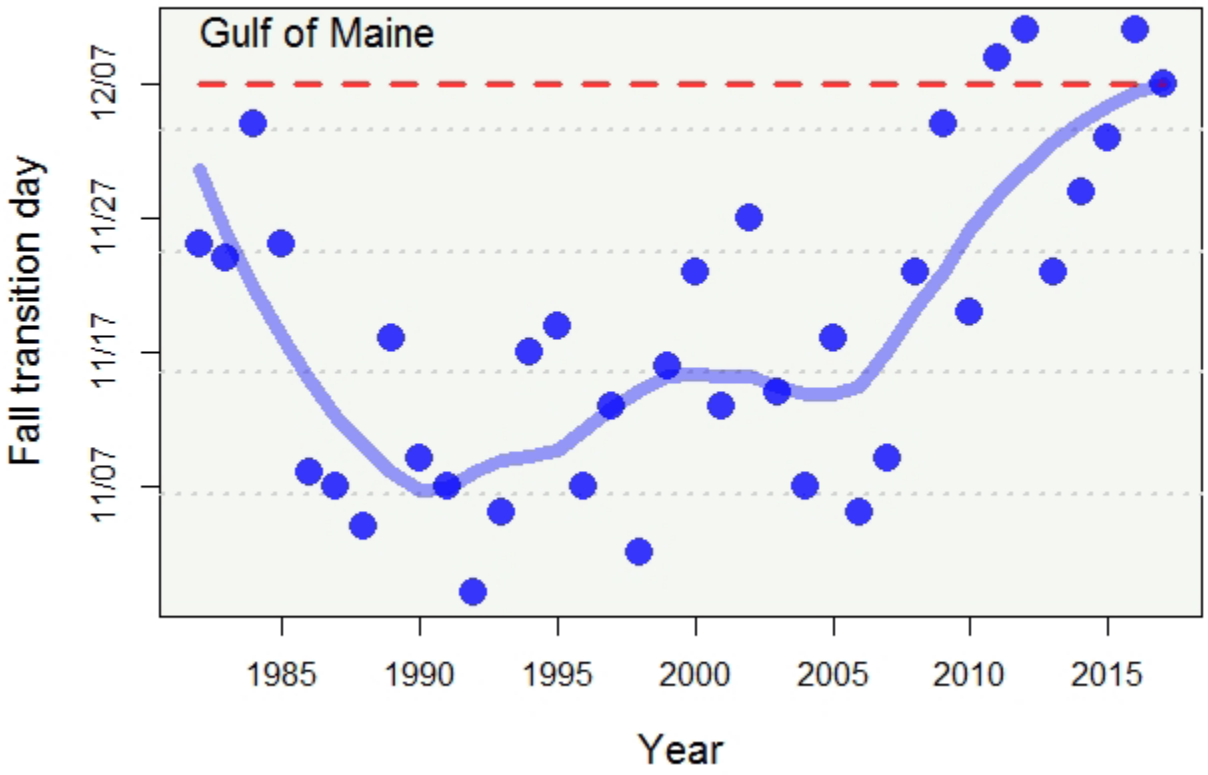
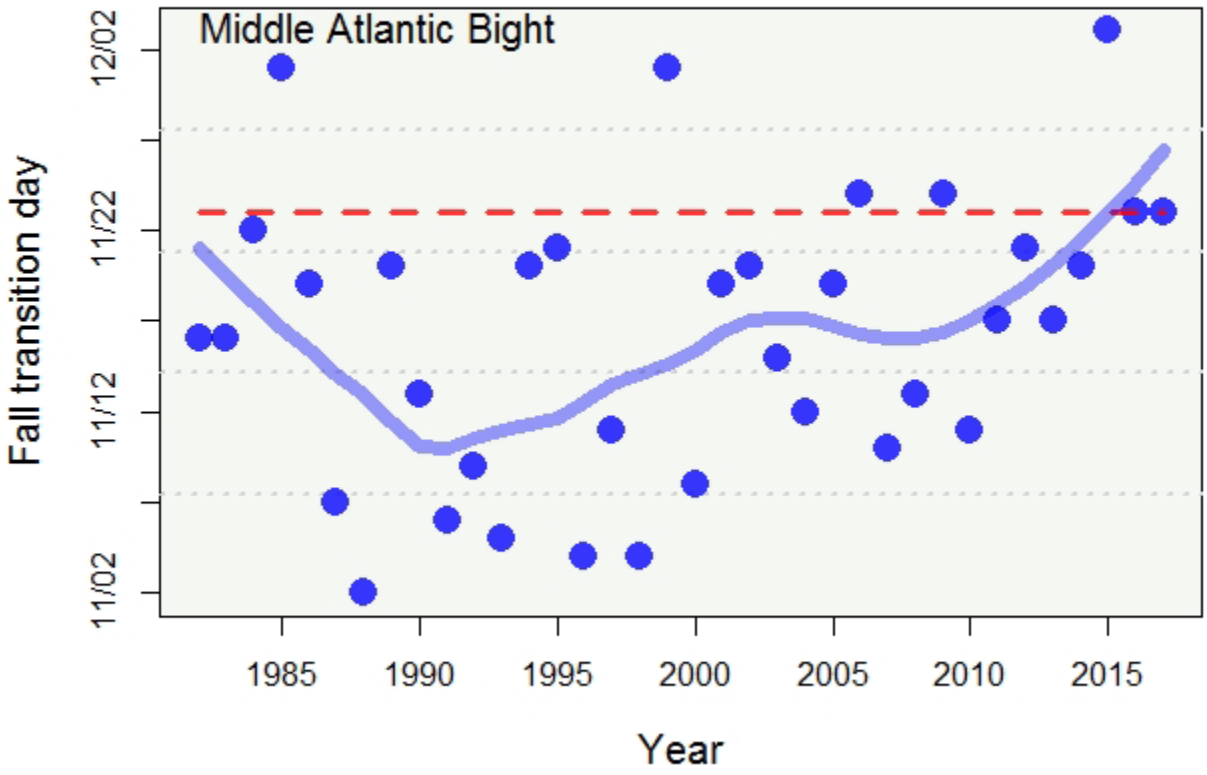


Gulf of Maine



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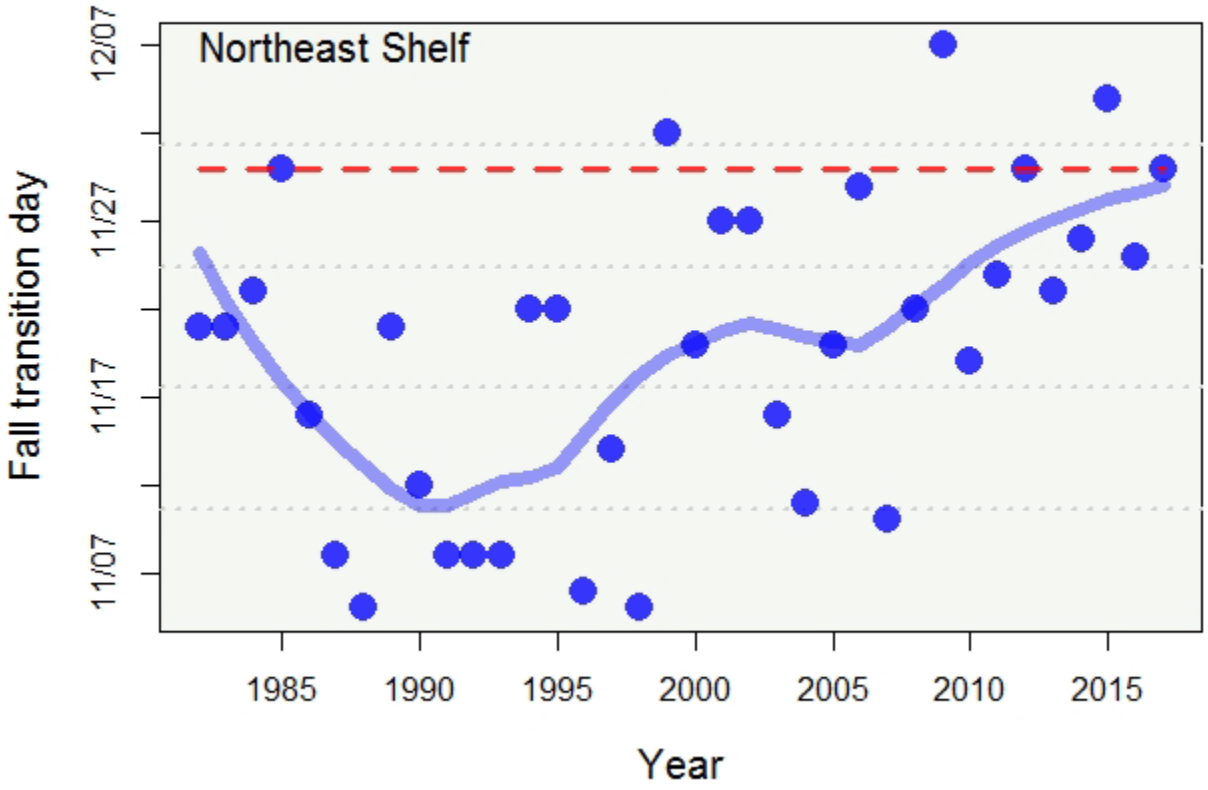

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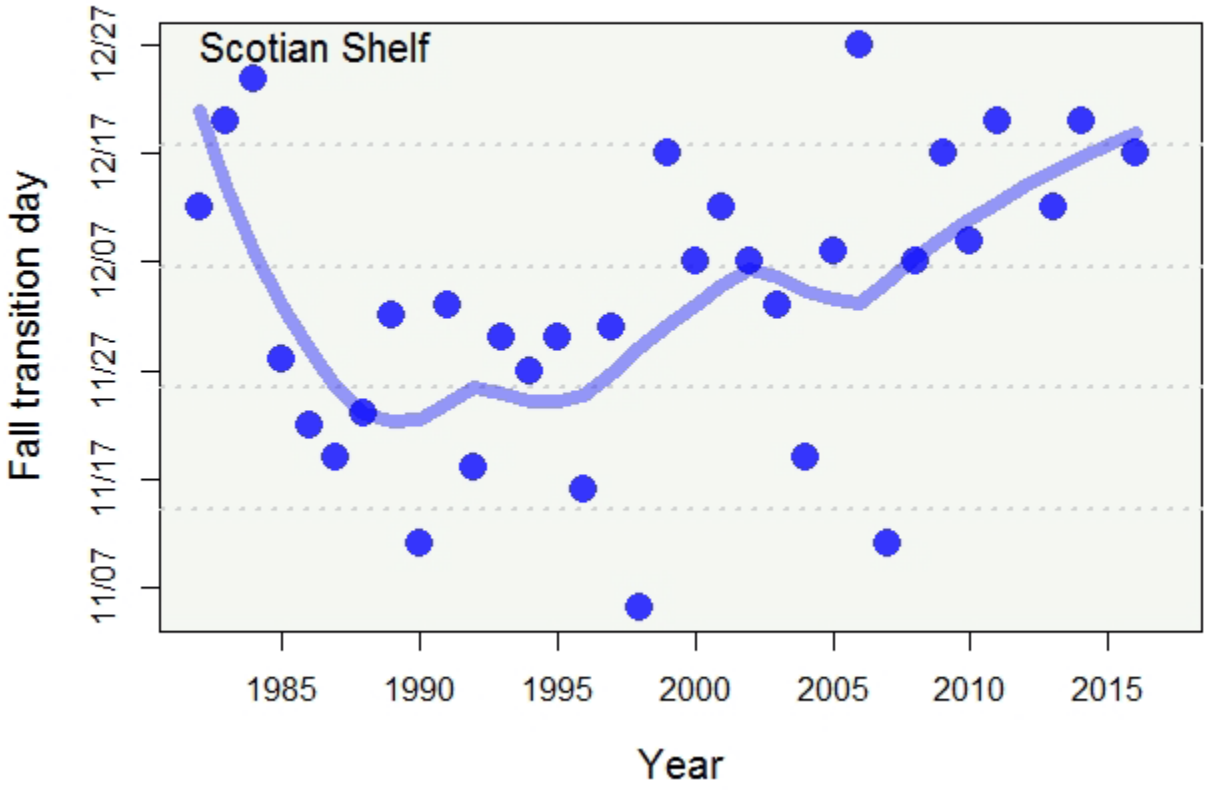
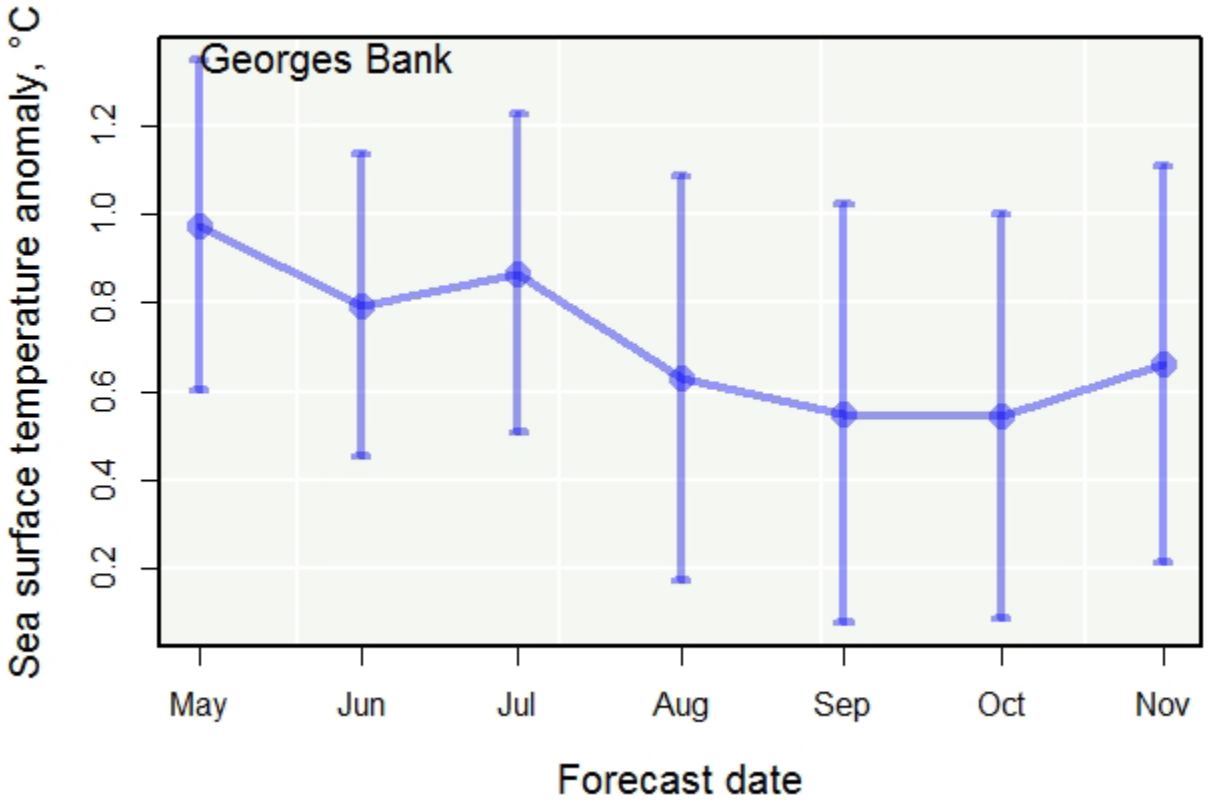


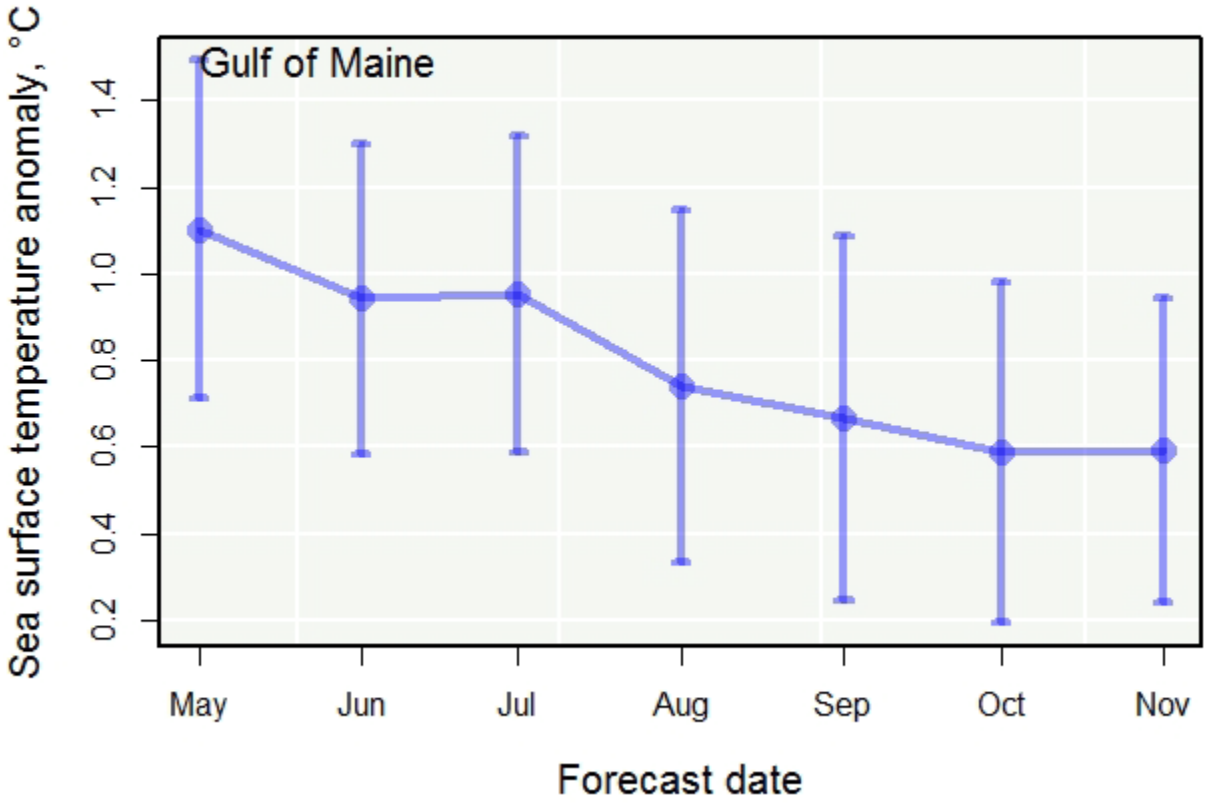
Scotian Shelf

Ecosystem Forecast - Experimental Data Product

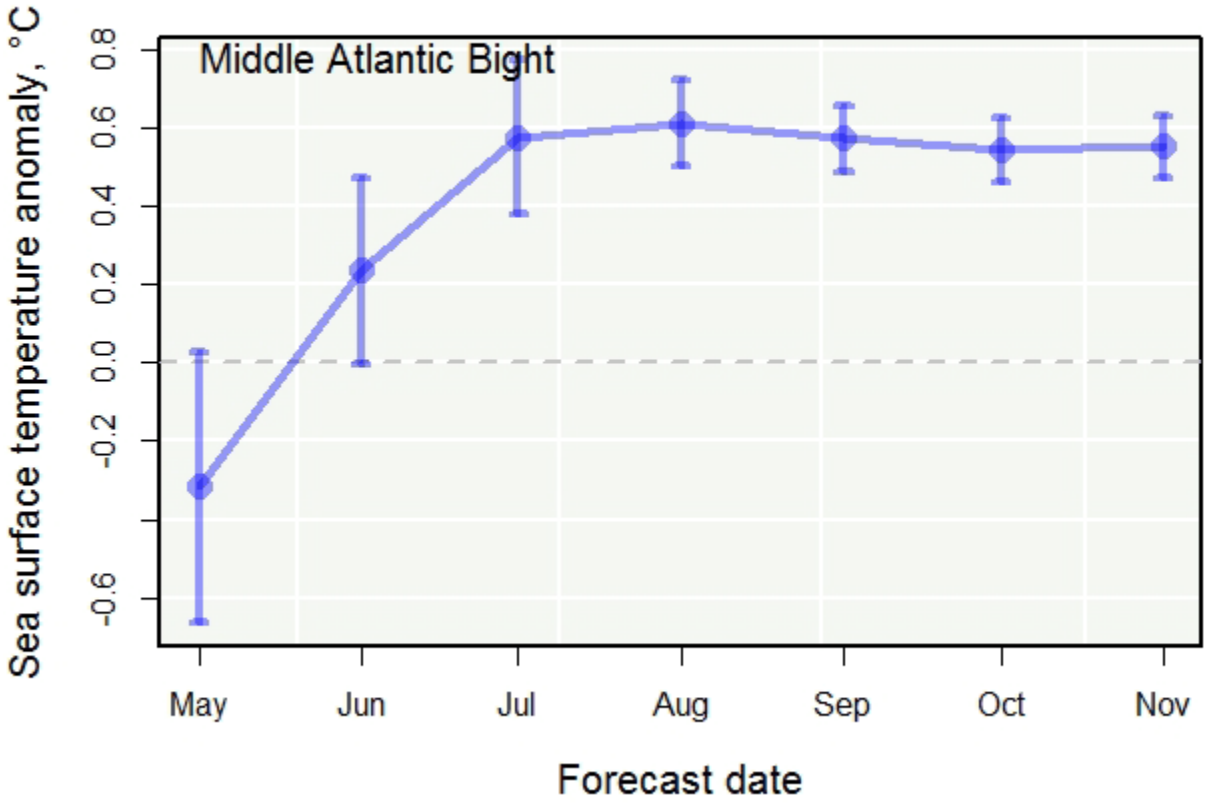
As weather and earth system models have improved, monthly forecasts over seasonal scales ranging up to seven months in advance have improved in quality. For each of the ecoregions of the Northeast Shelf, forecasts from an ensemble of seven forecast models are provided starting with the forecast estimates for May 2018 and ending in November 2018. There was model agreement in the forecasts for the Middle Atlantic Bight suggesting that sea surface temperature will rebound in the coming months to an ensemble means of approximately 0.6°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 1.0°C above average in these areas.



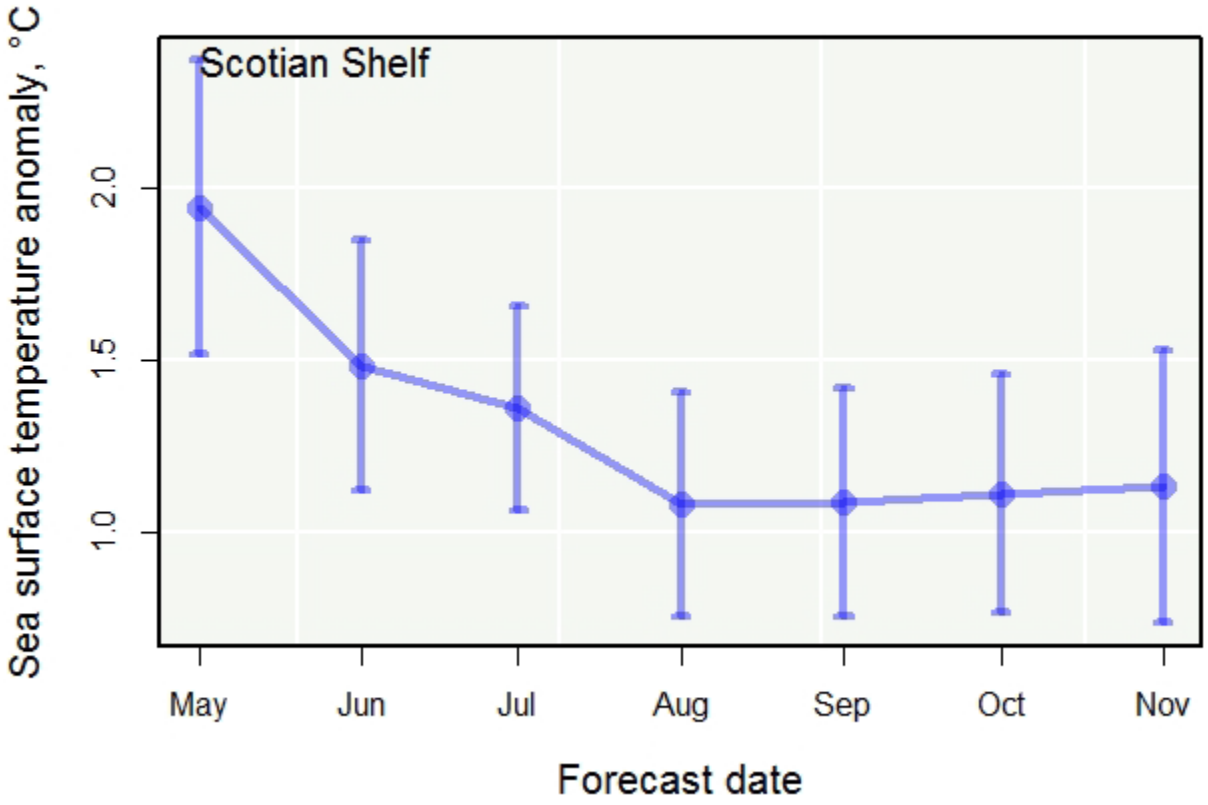
Georges Bank



Gulf of Maine

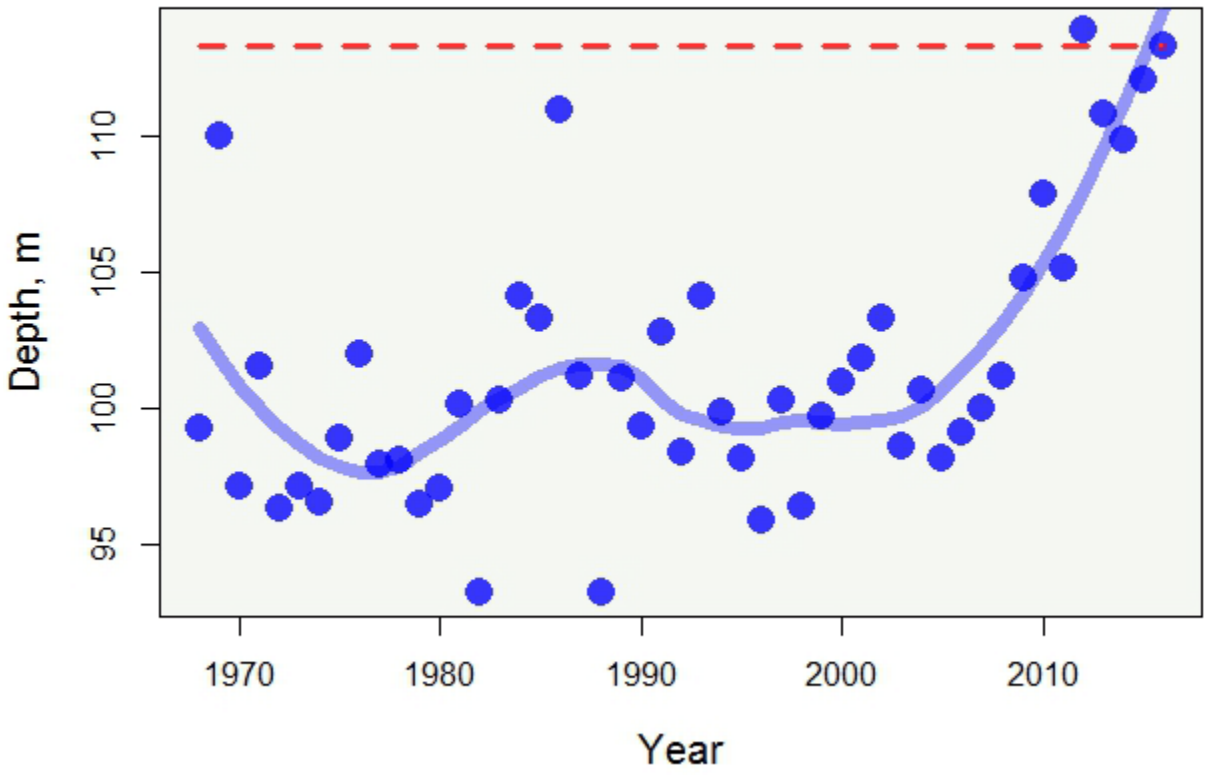


Middle Atlantic Bight

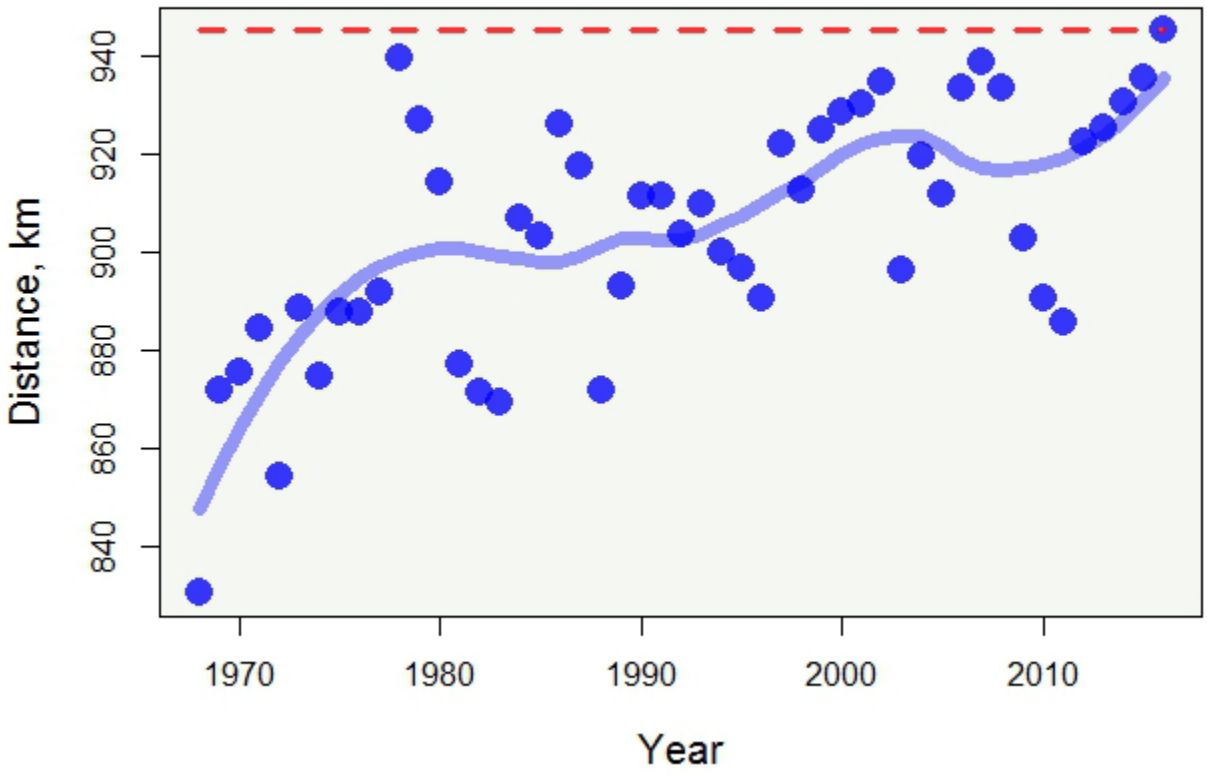


Scotian Shelf

Trends in Fall Species Distribution



Along-shelf depth trend



Trends in Fall Species Distribution

Note: Since the 2017 fall bottom trawl survey was incomplete, these distribution statistics could not be updated, so the 2016 analysis is represented.
The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades. Individual species have shifted distribution due to a number of reasons and these shifts can be characterized in a number of different ways.

Two metrics that have been used to characterize distribution on the NE Shelf include:

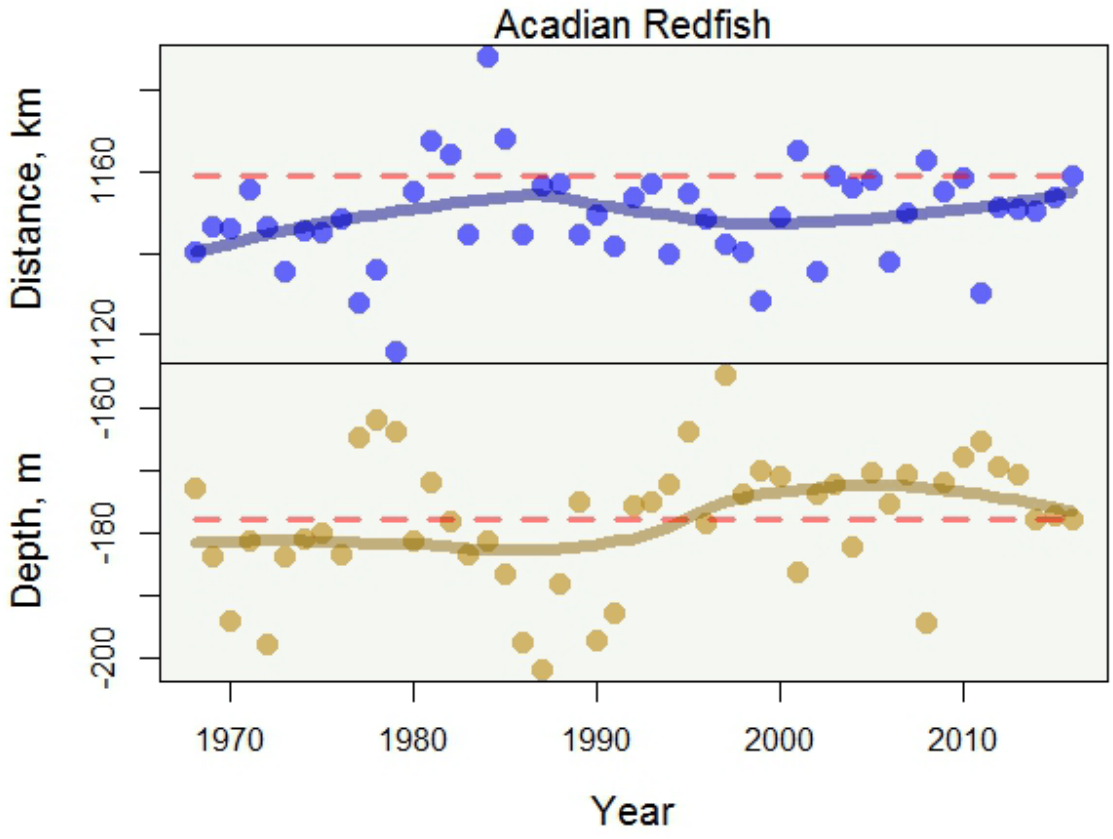
1. the position in the ecosystem along an axis oriented from the southwest to the northeast referred to as the along shelf distance; and,

2. the depth of occurrence. Along shelf distances range from 0 to 1360, which relates to positions along the axis from the origin in southwest to northeast in kilometer units.

Depth ranges from 0 to -260, which relates to depth of occurrence in meters.

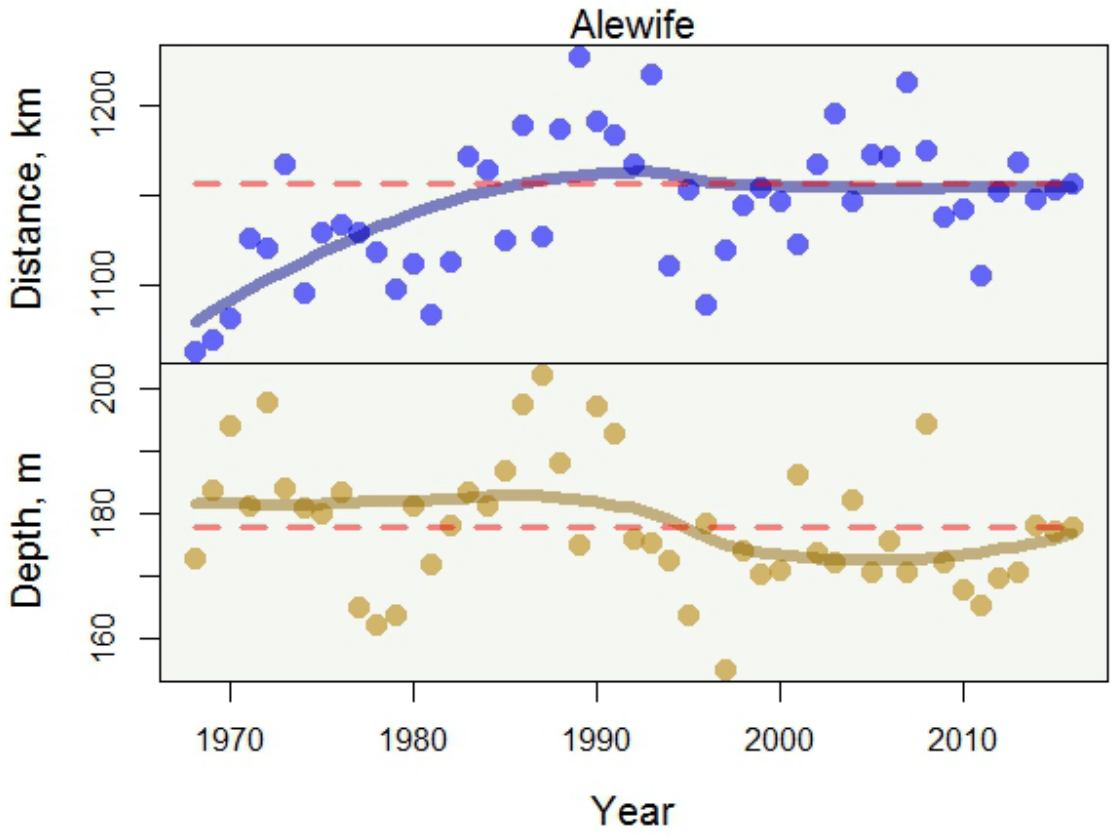
The mean along shelf distance and depth of occurrence for all species by year are shown in the two graphs, with the 2016 values marked with a dashed red line. As a group, these species had an along shelf distance of approximately 870 km, they now have a distance of over 930 km. For most of the time series,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

Acadian redfish



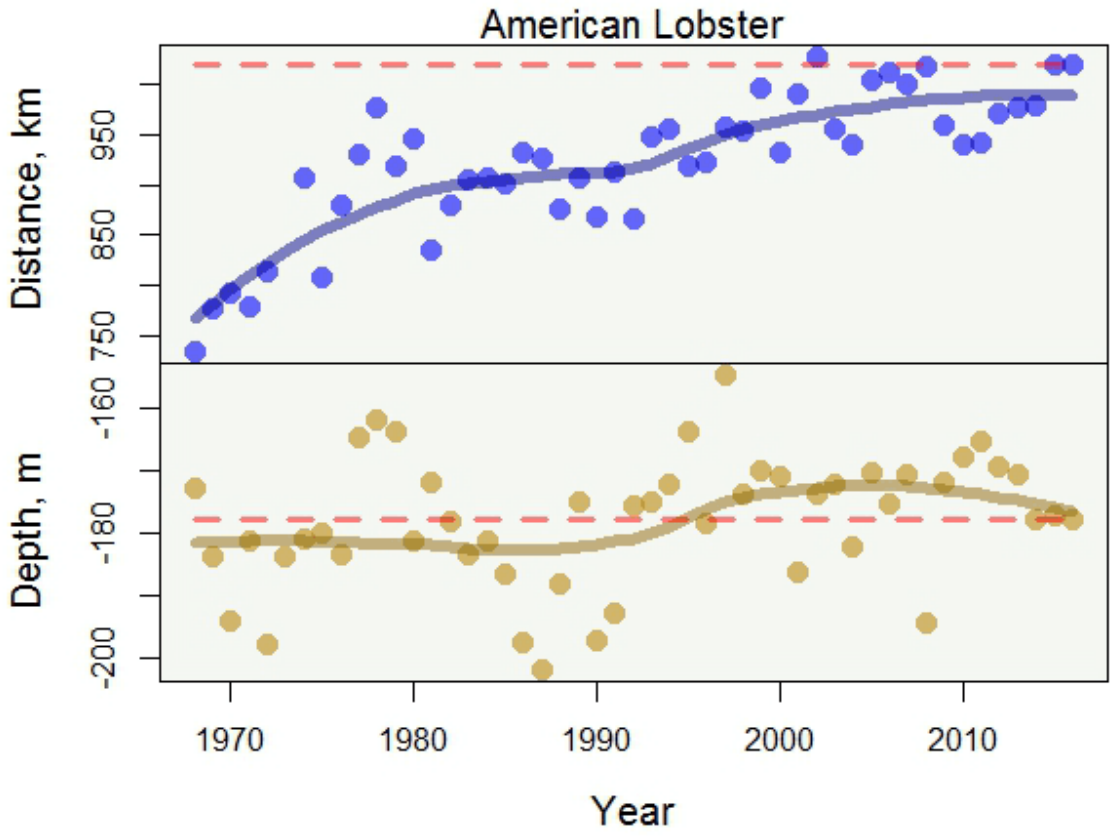
Acadian redfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Alewife



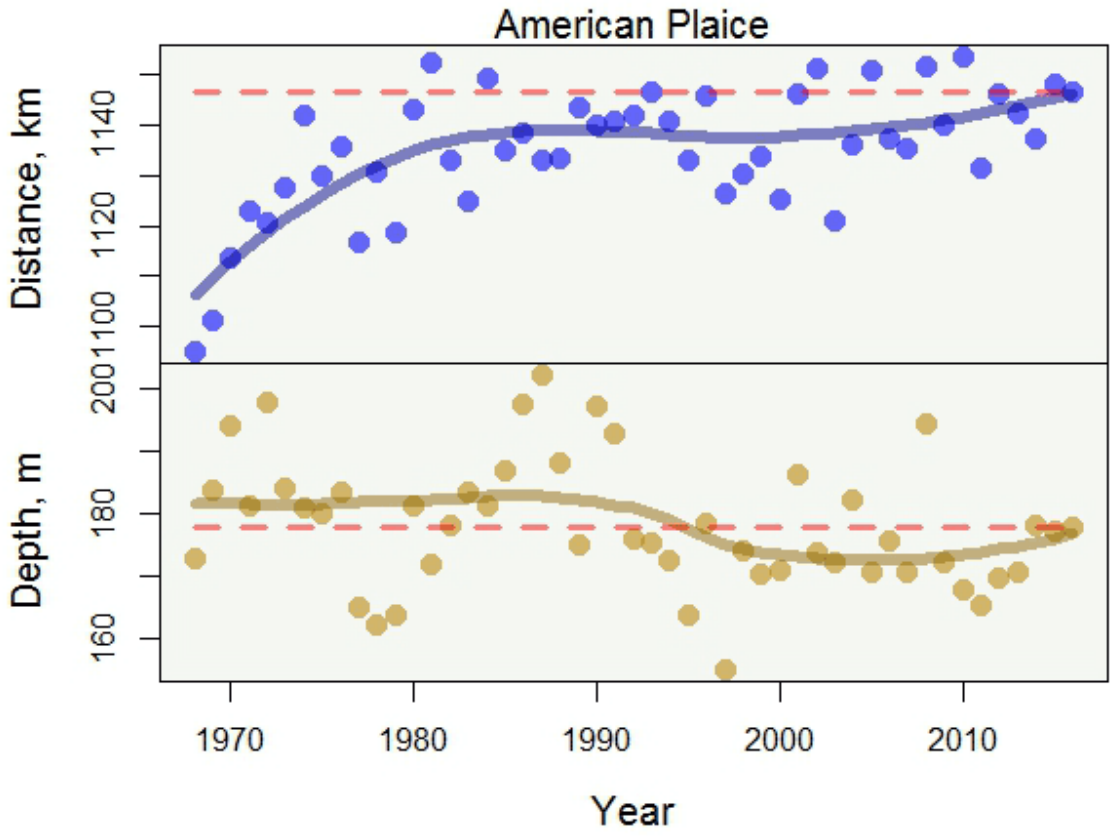
Alewife distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

American lobster



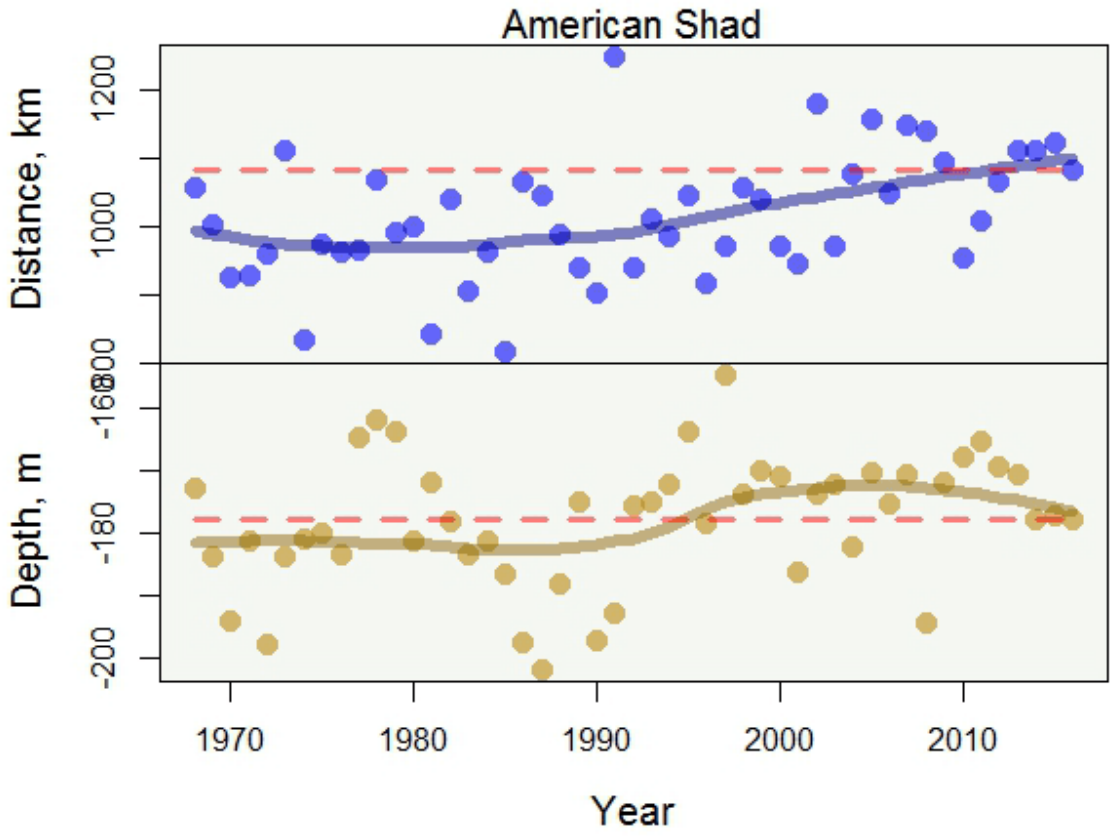
American lobster distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

American plaice



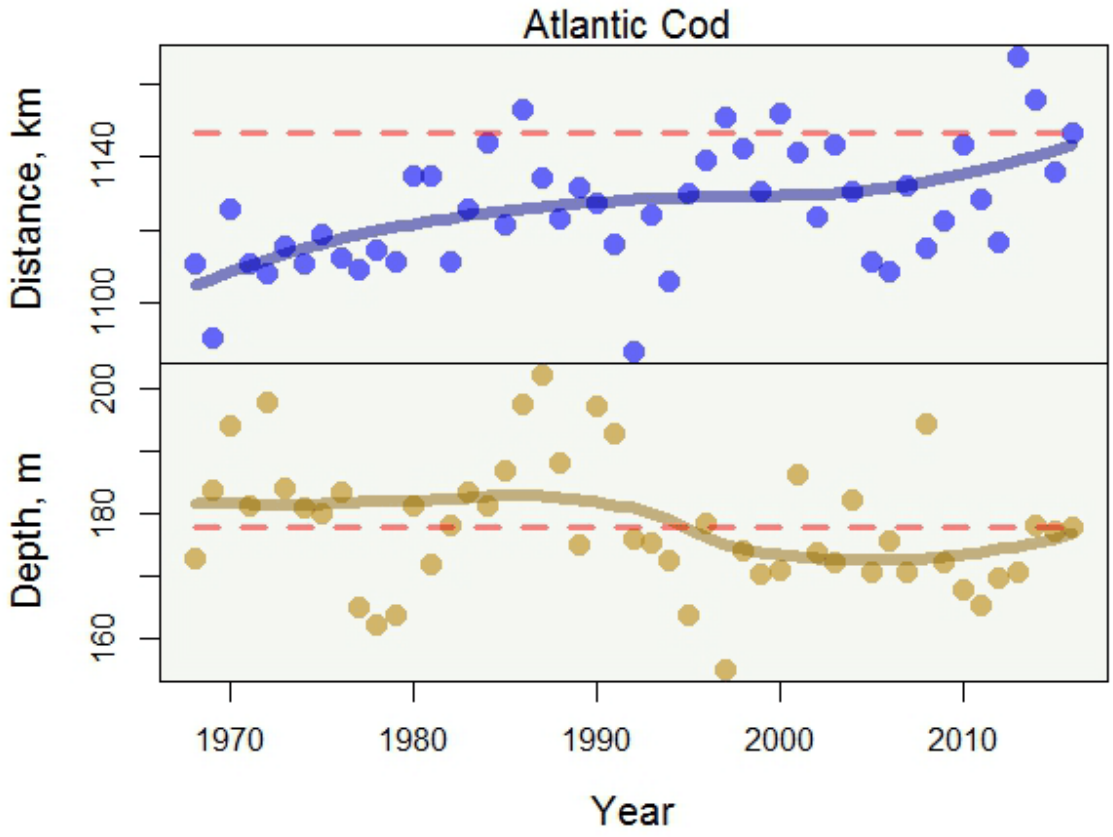
American plaice distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

American shad



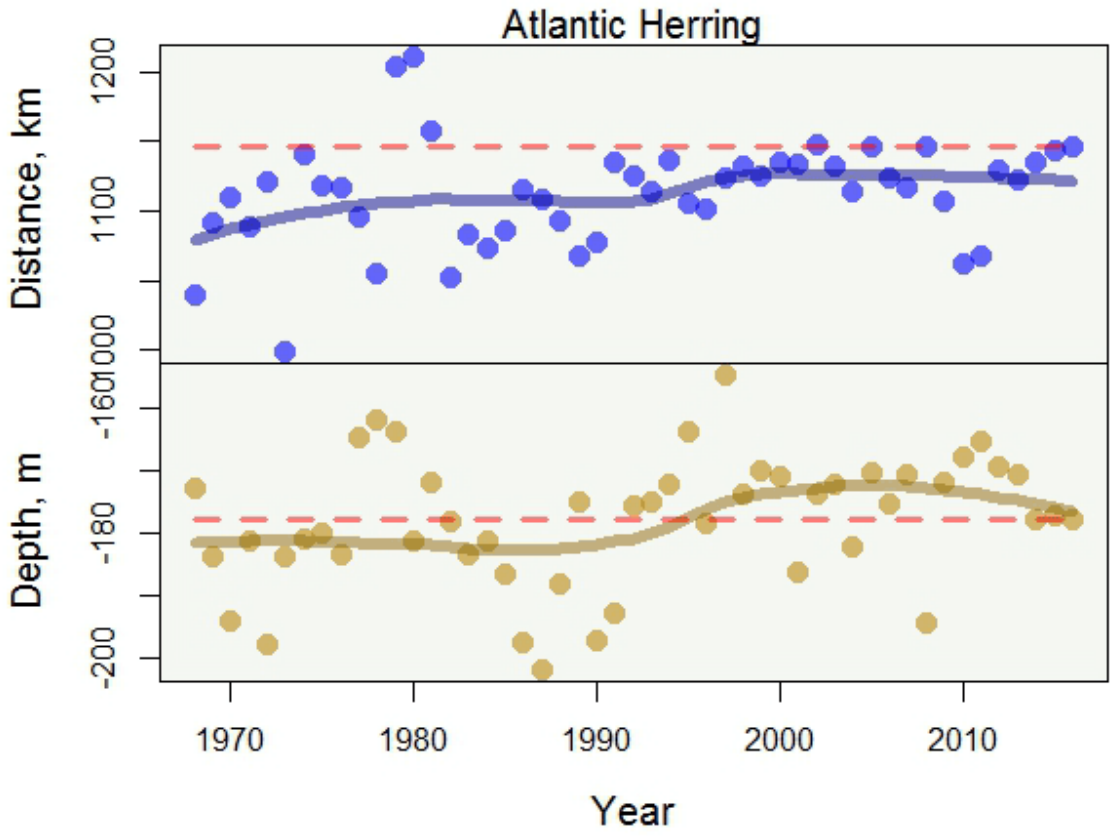
American shad distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Atlantic cod



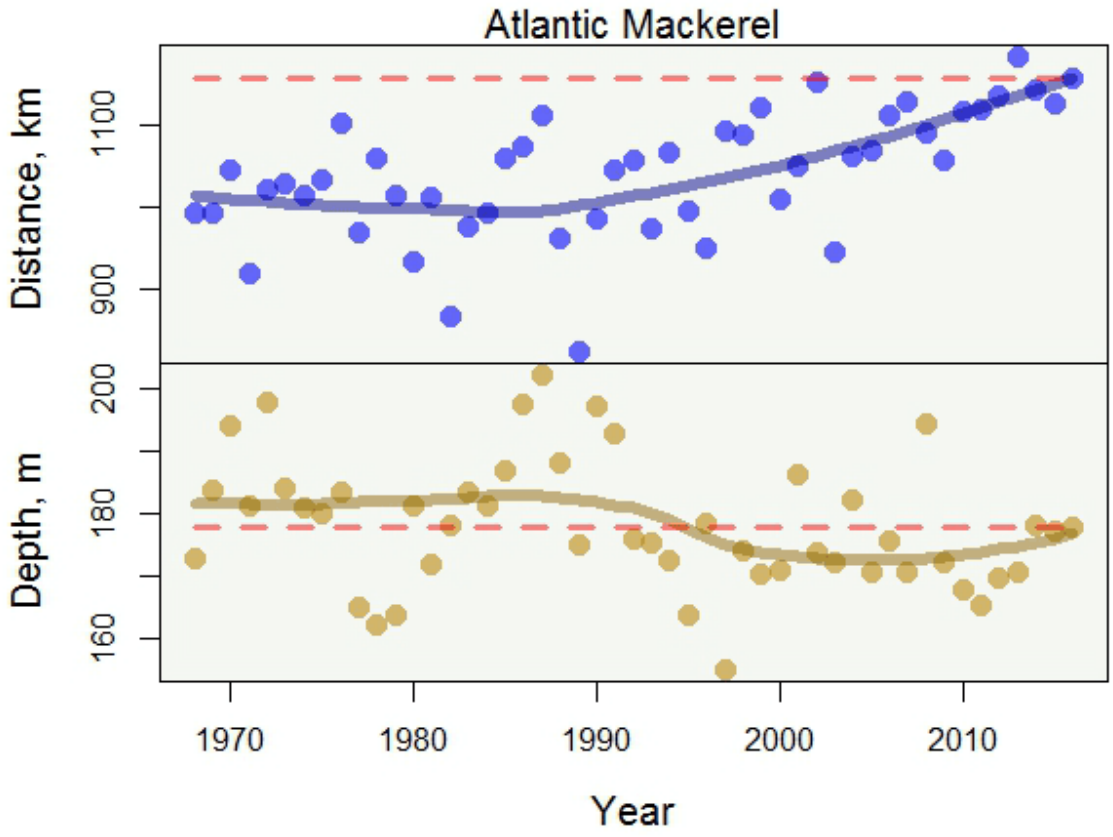
Atlantic cod distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Atlantic herring



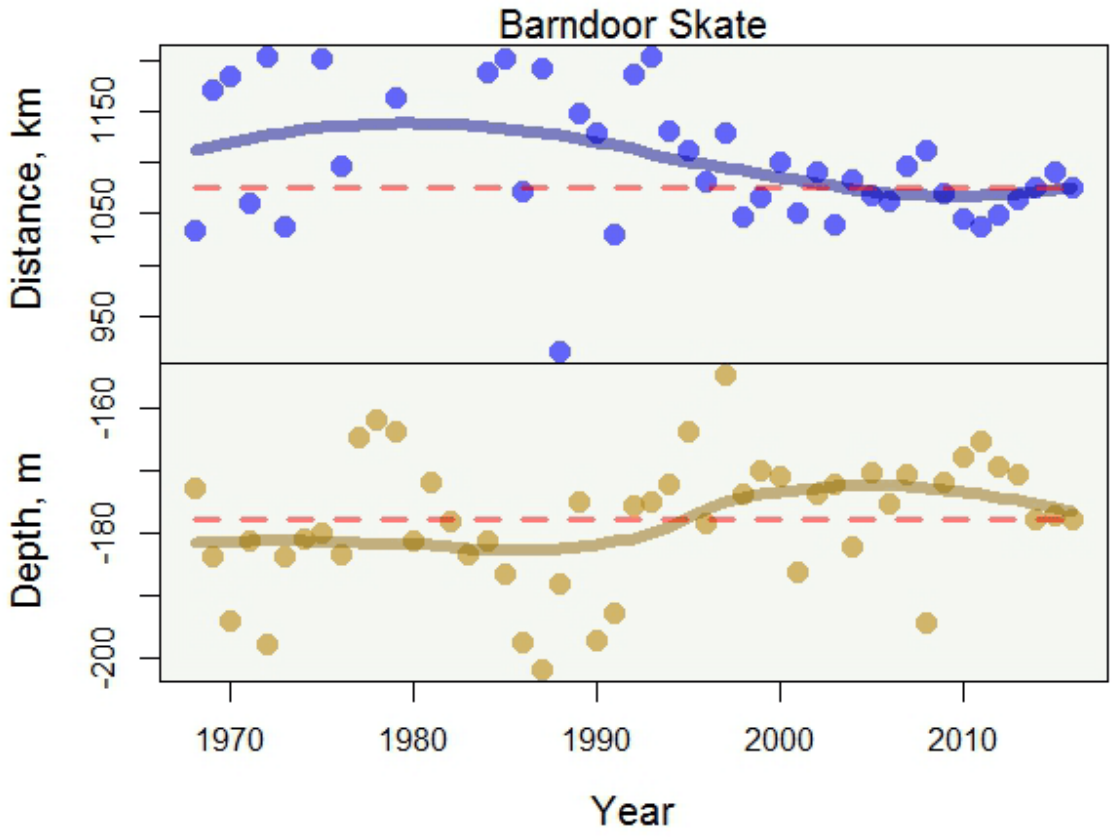
Atlantic herring distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Atlantic mackerel



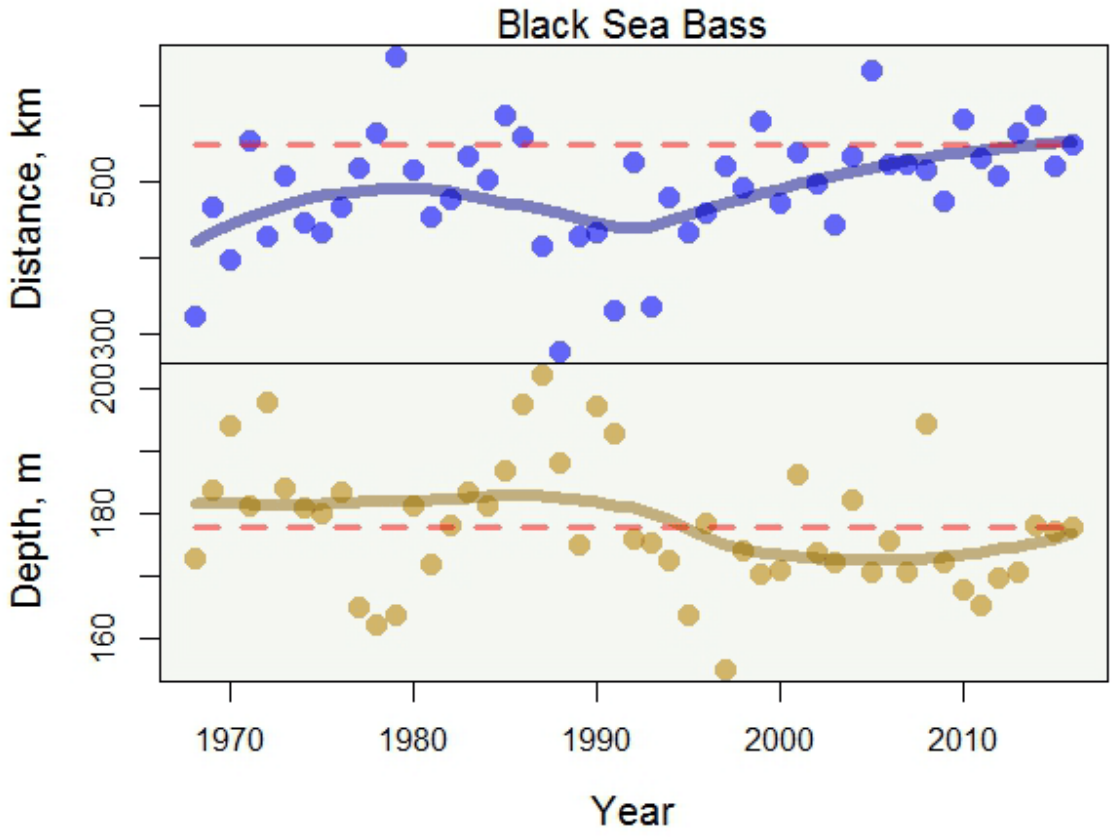
Atlantic mackerel distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Barndoor skate



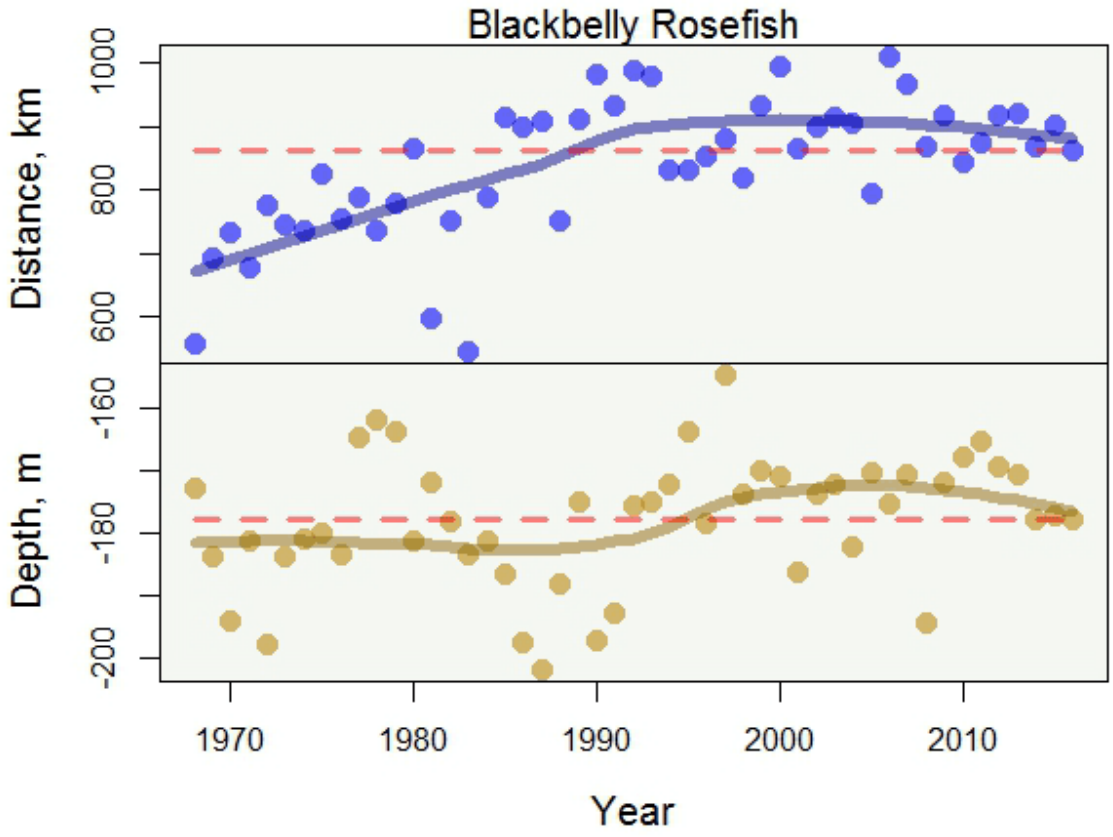
Barndoor skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Black sea bass



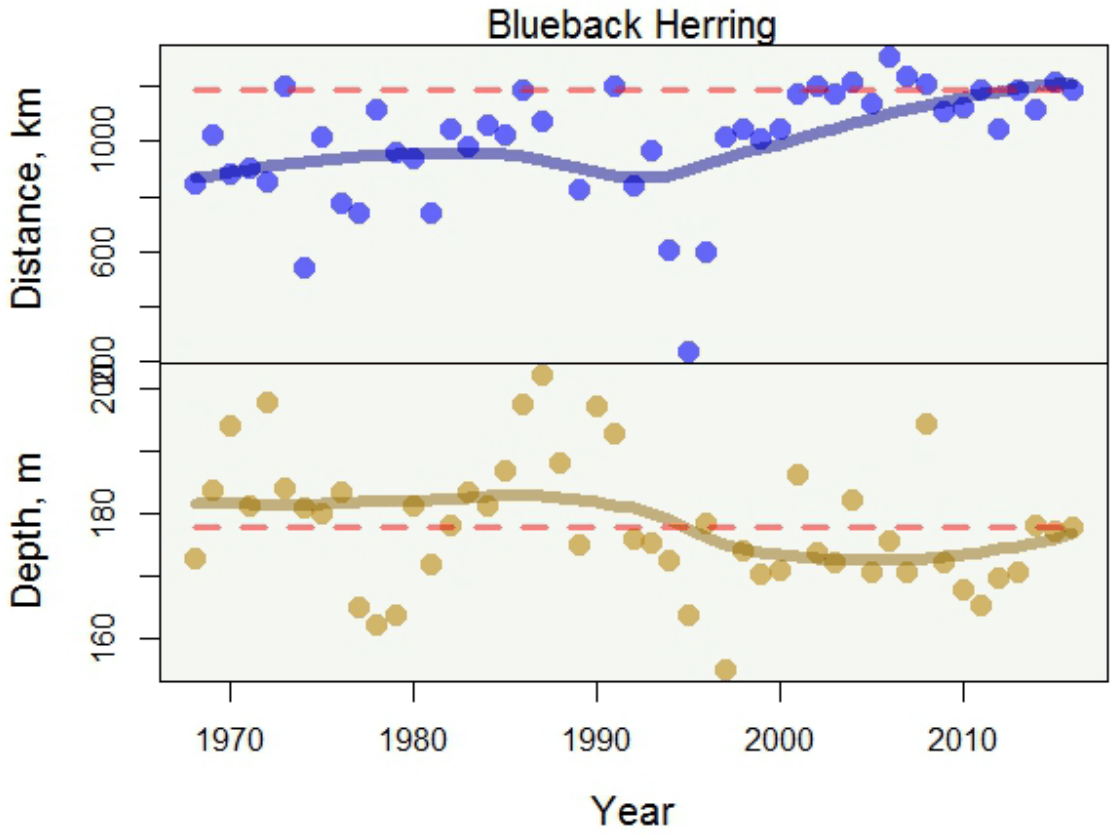
Black sea bass distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Blackbelly rosefish



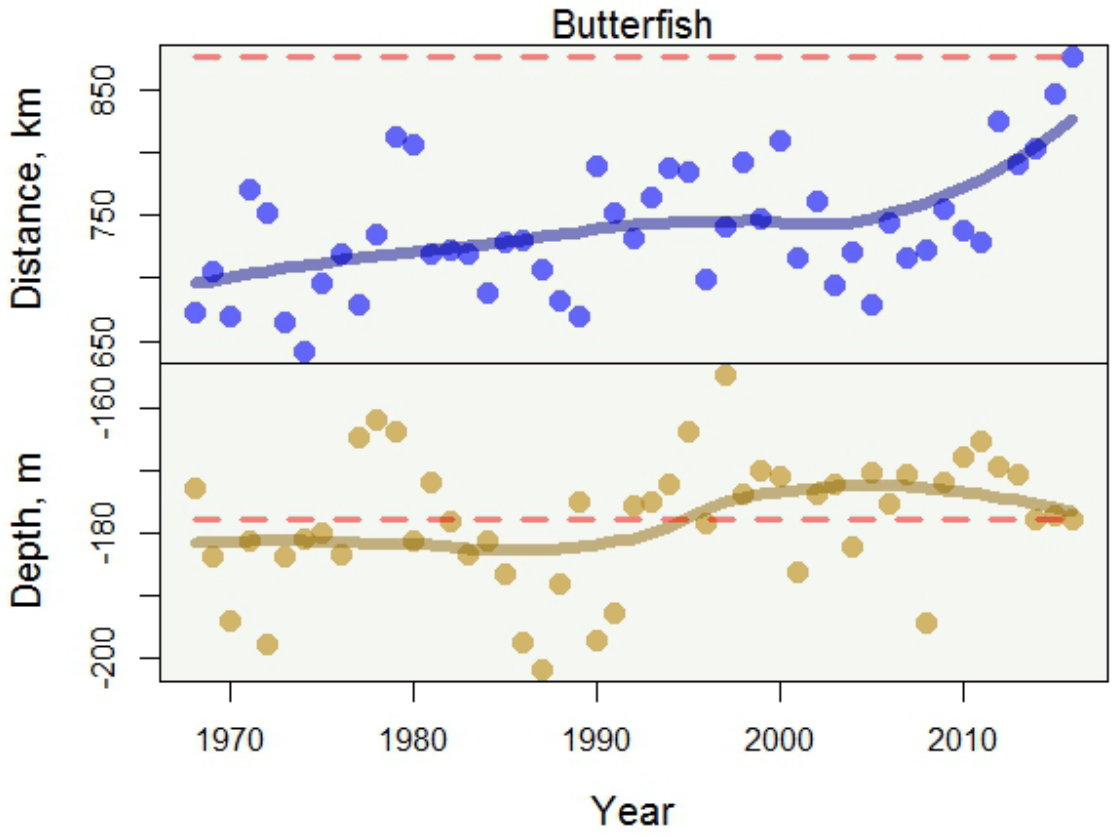
Blackbelly rosefish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Blueback herring



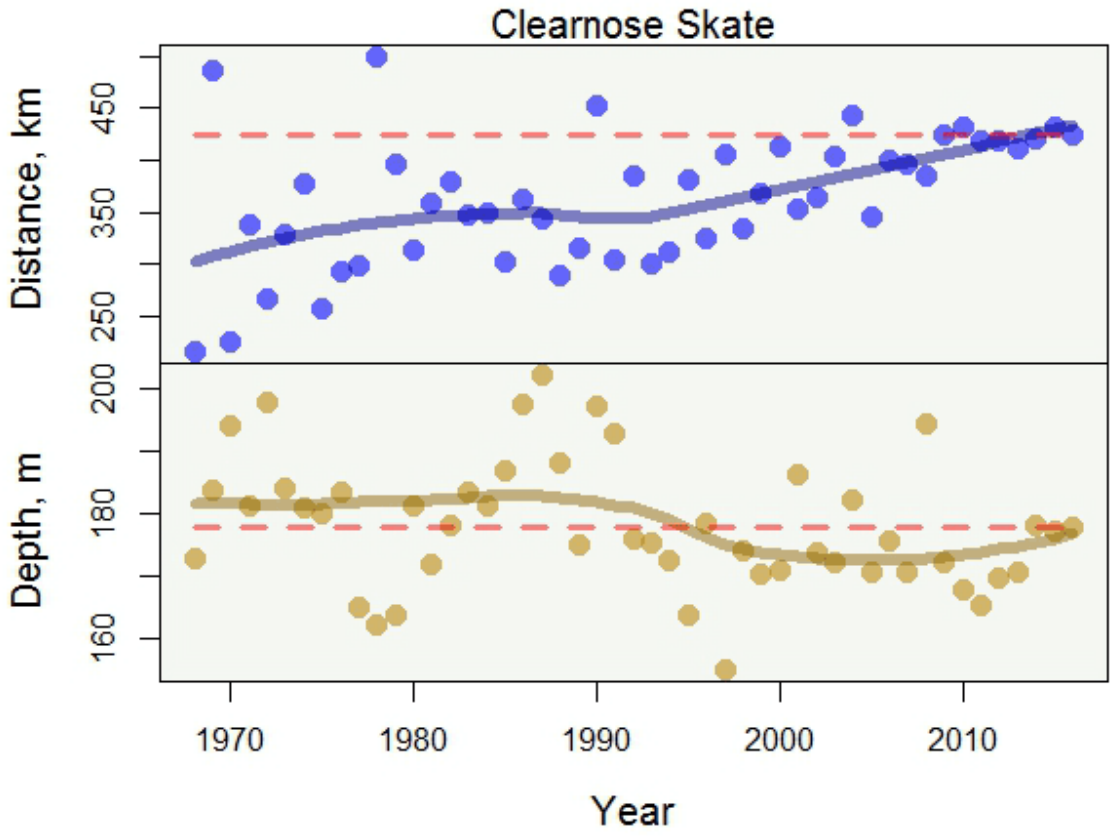
Blueback herring distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Butterfish



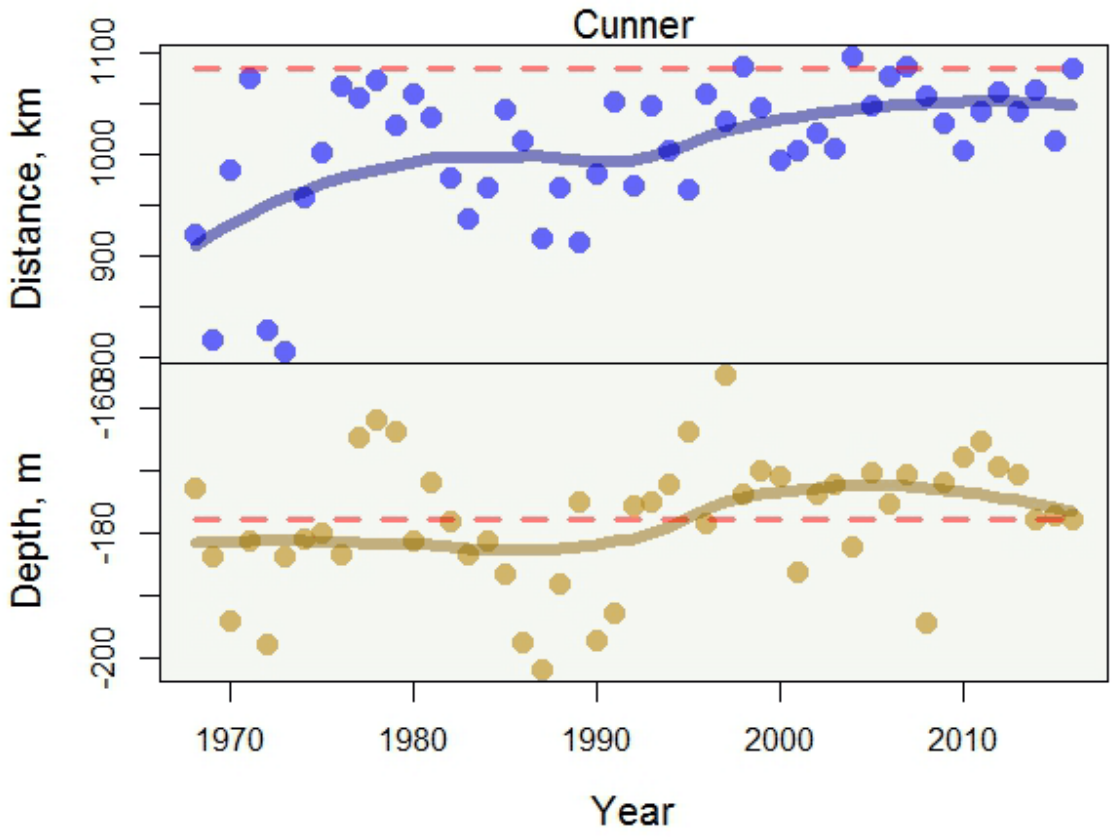
Butterfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Clearnose skate



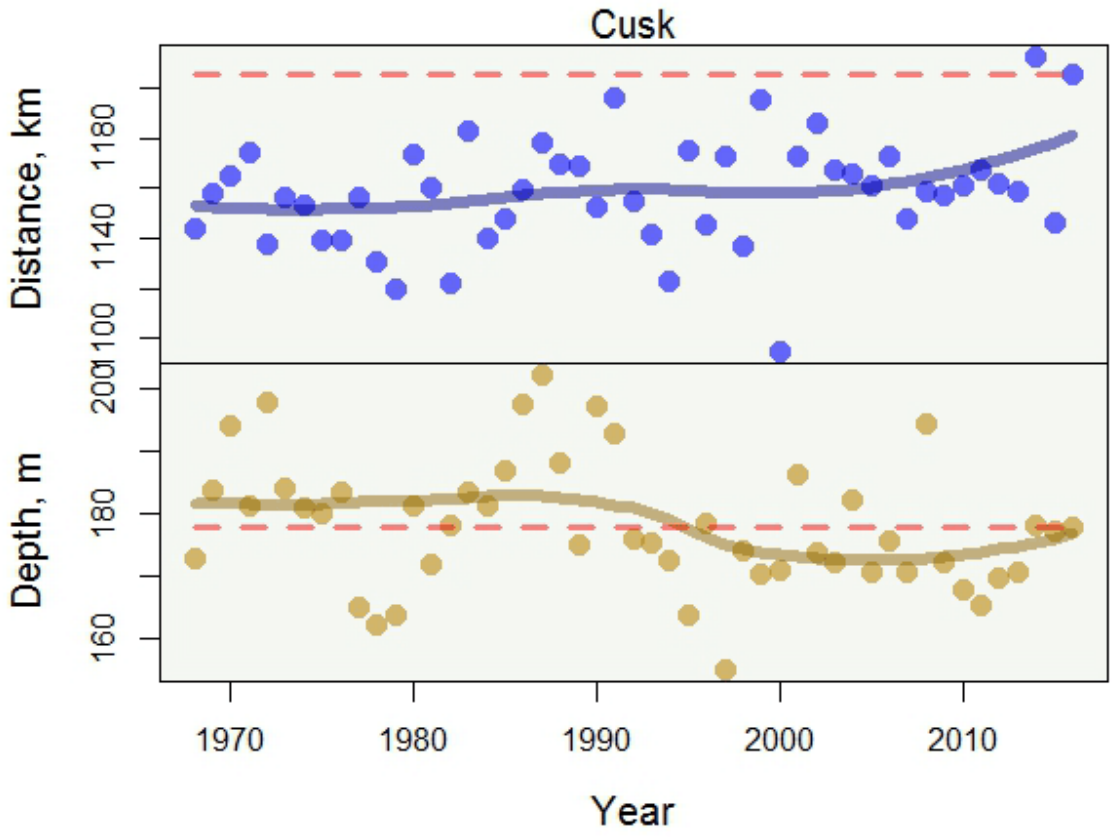
Clearnose skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Cunner



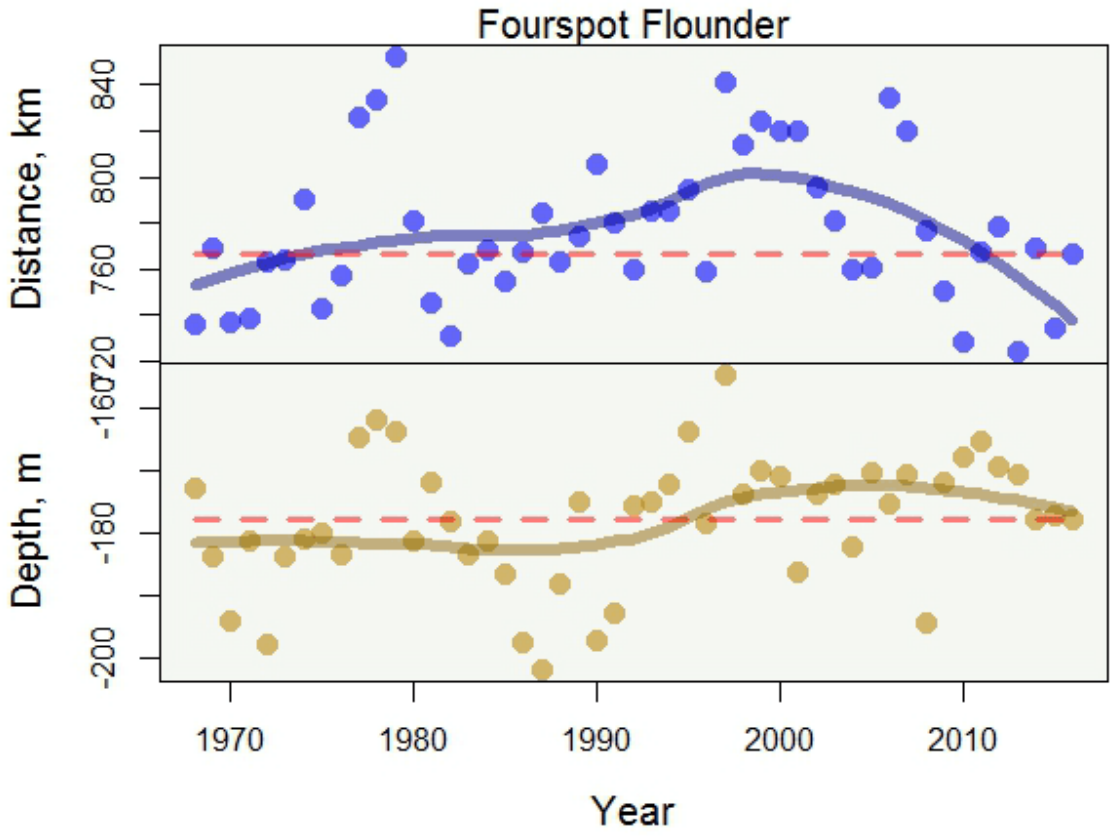
Cunner distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Cusk



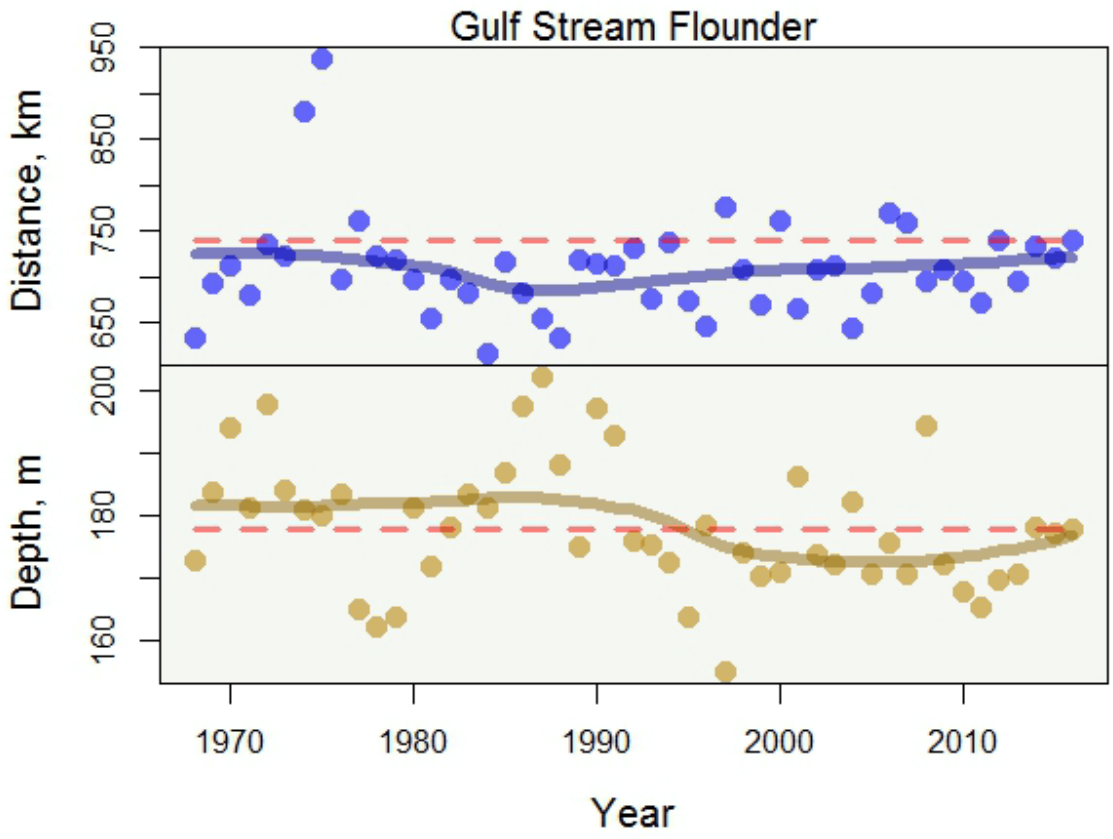
Cusk distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Fourspot flounder



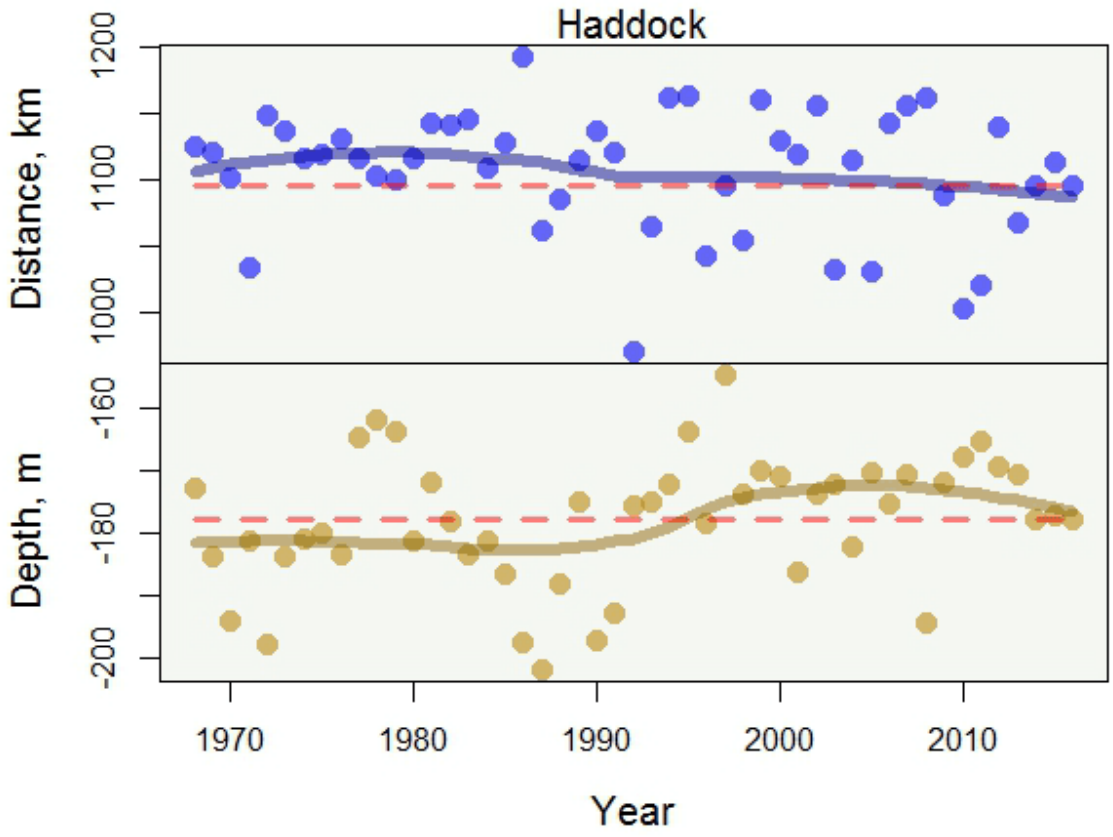
Fourspot flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Gulf Stream flounder



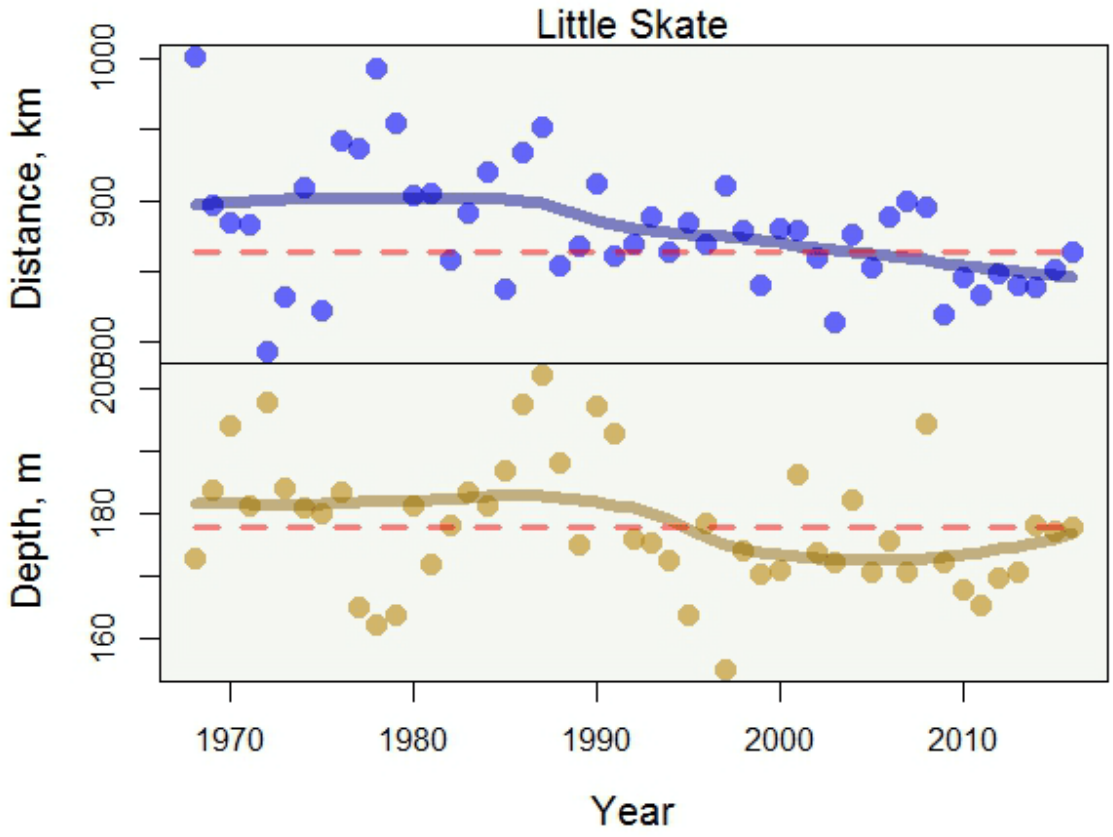
Gulf Stream flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Haddock



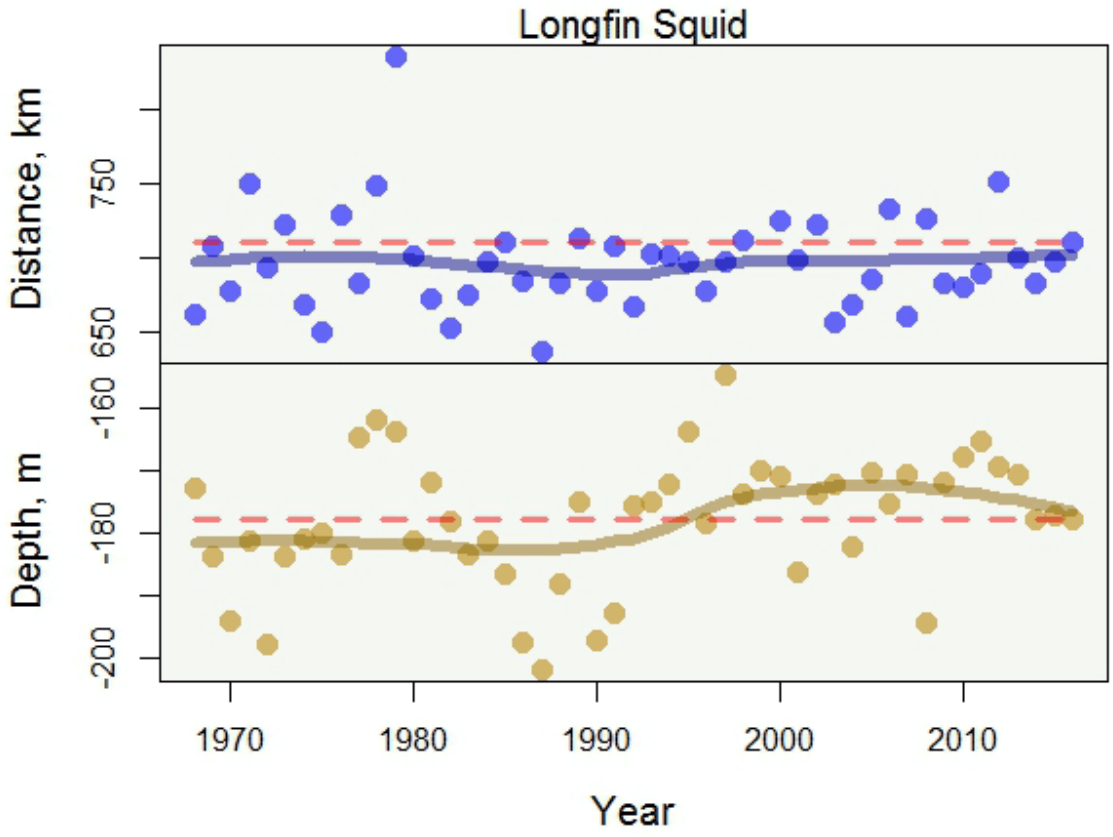
Haddock distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Little Skate



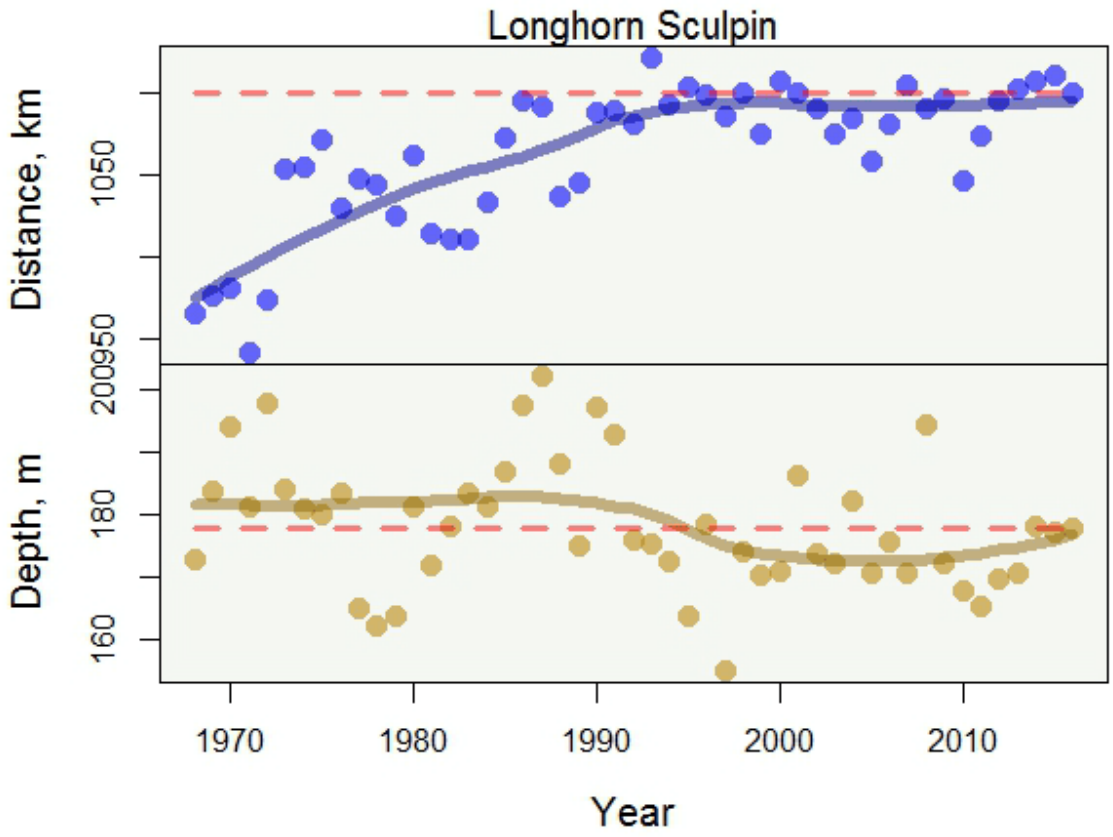
Little skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Longfin squid



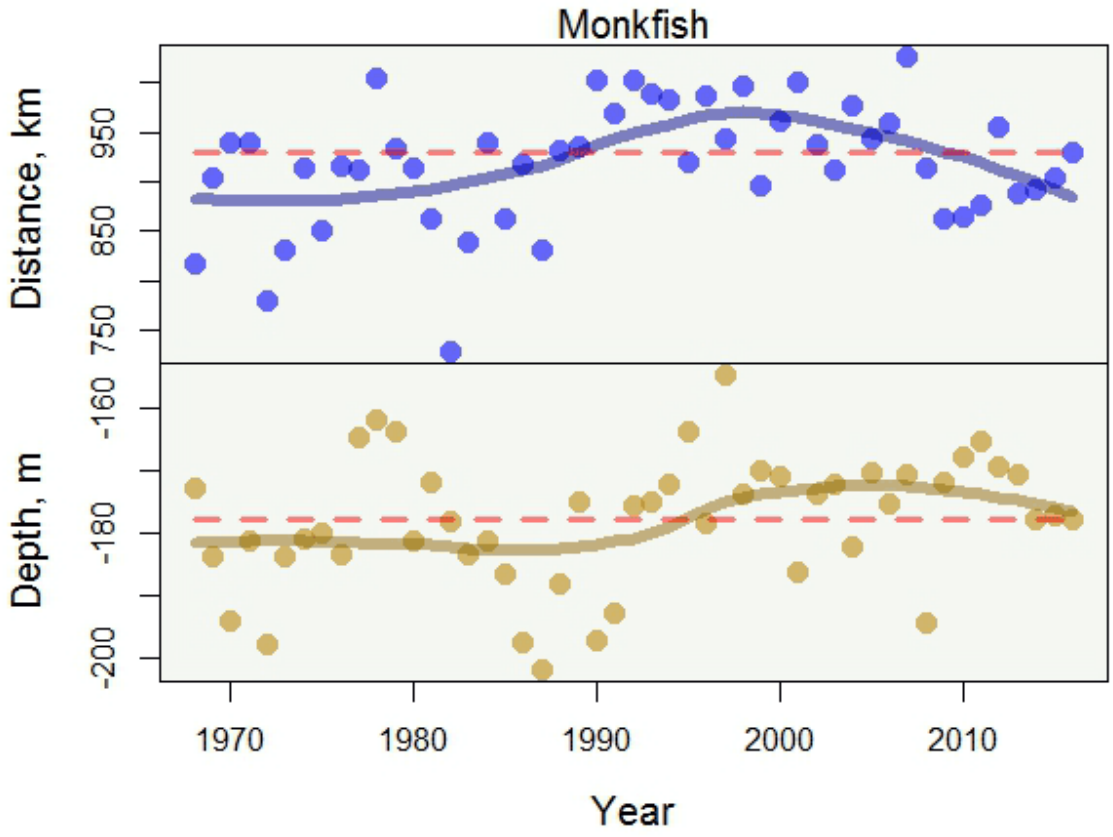
Longfin squid distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Longhorn sculpin



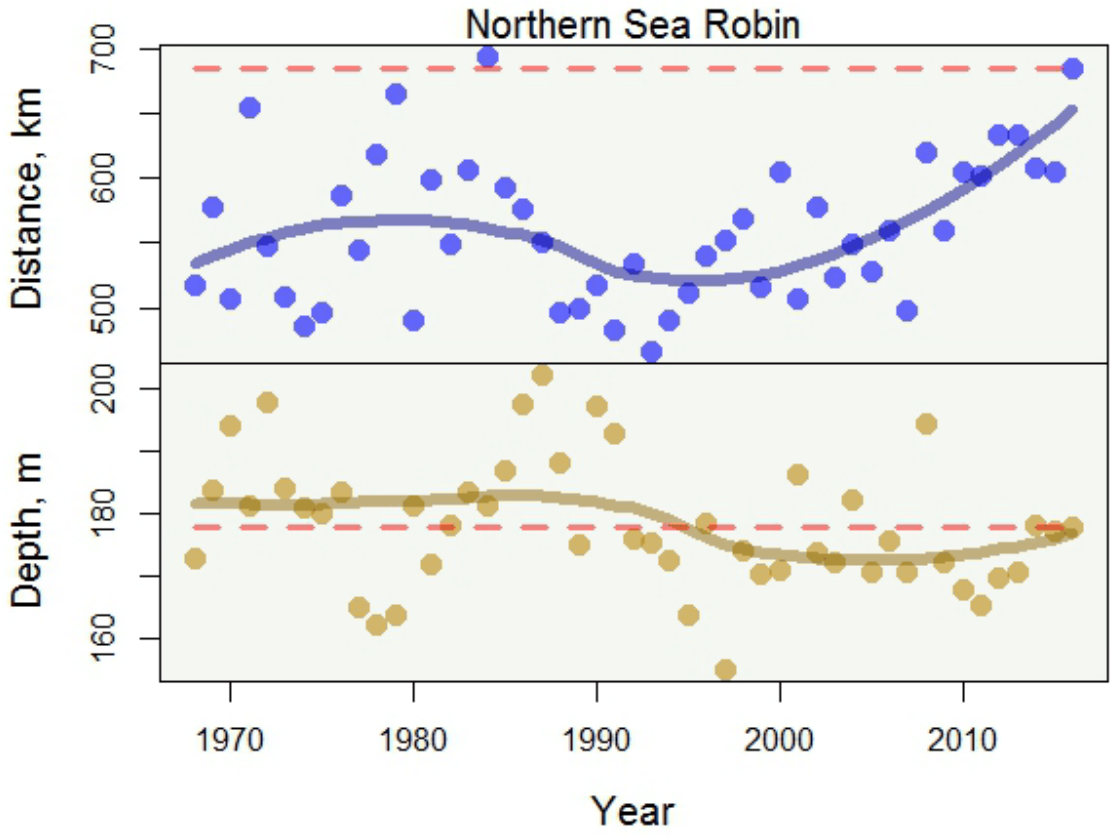
Longhorn sculpin distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Monkfish



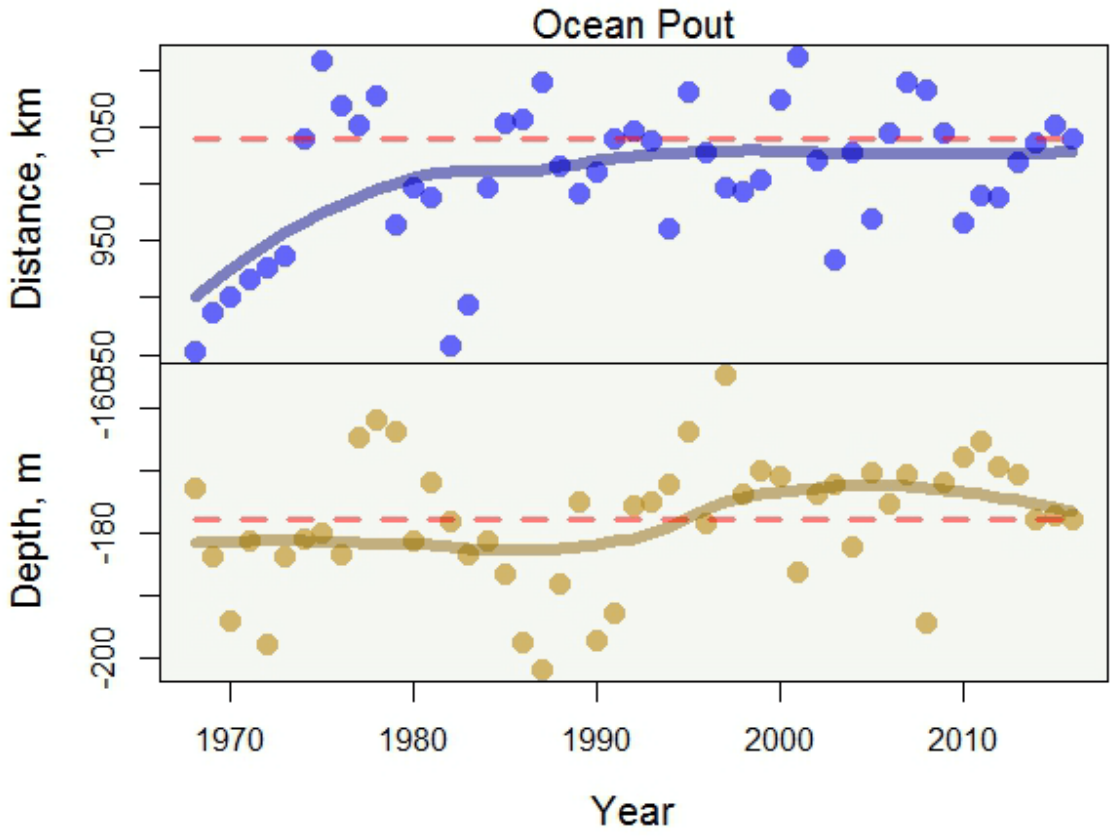
Monkfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Northern sea robin



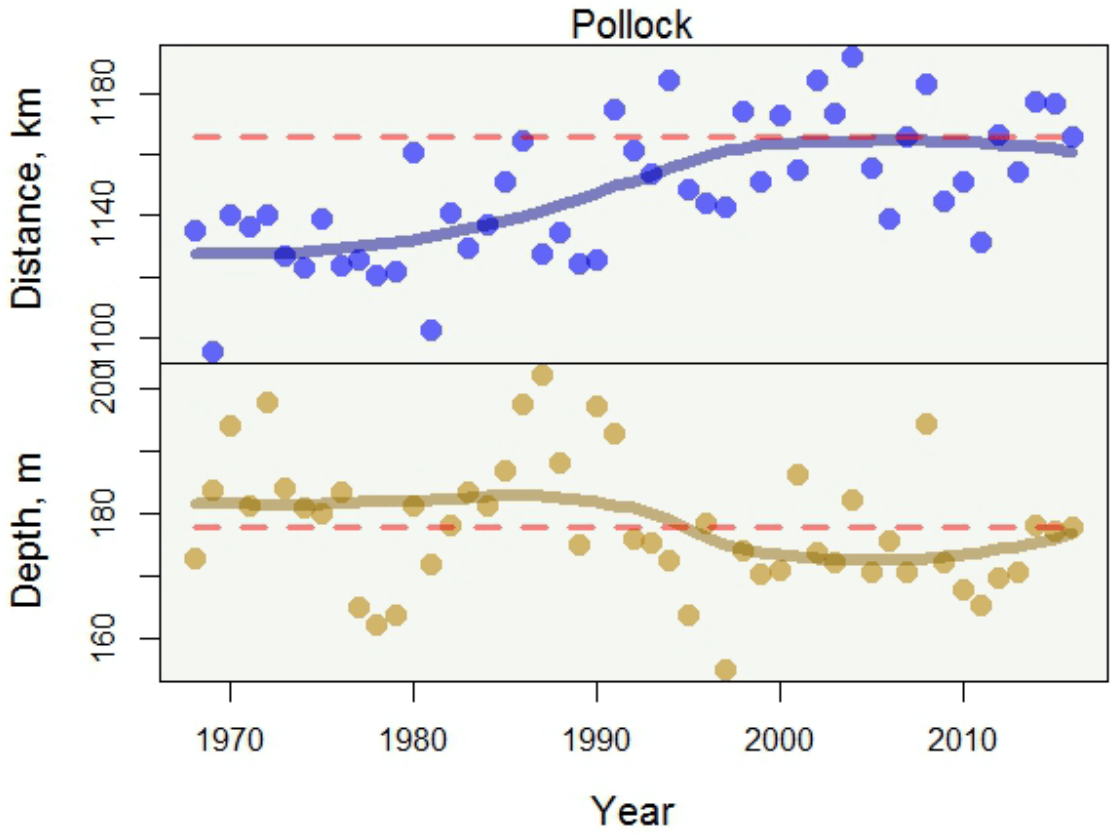
Northern sea robin distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Ocean pout



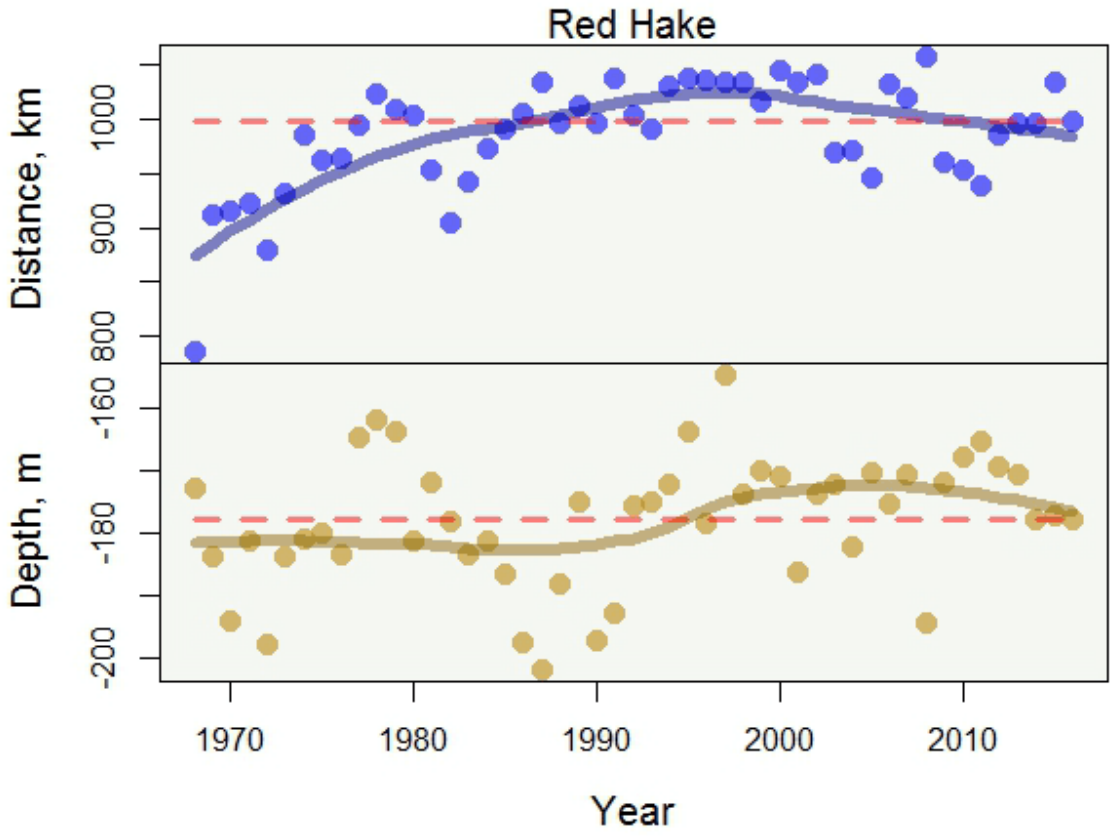
Ocean pout distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Pollock



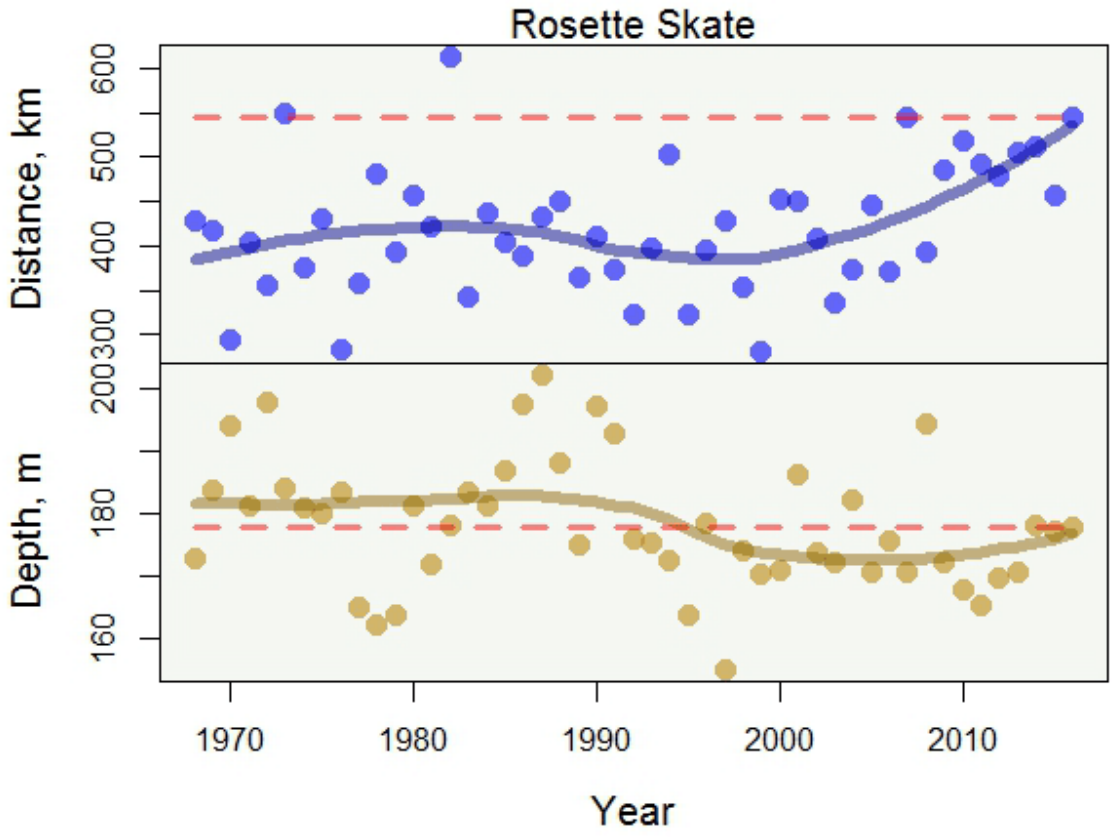
Pollock distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Red hake



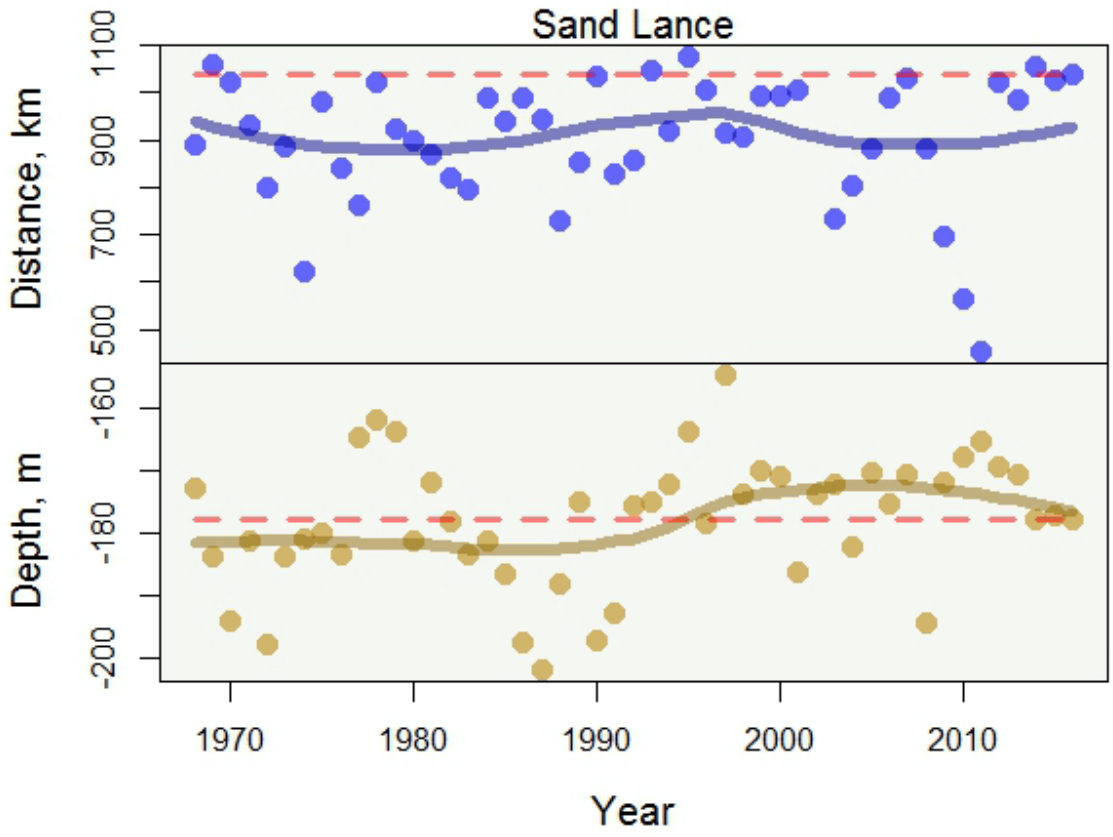
Red hake distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Rosette skate



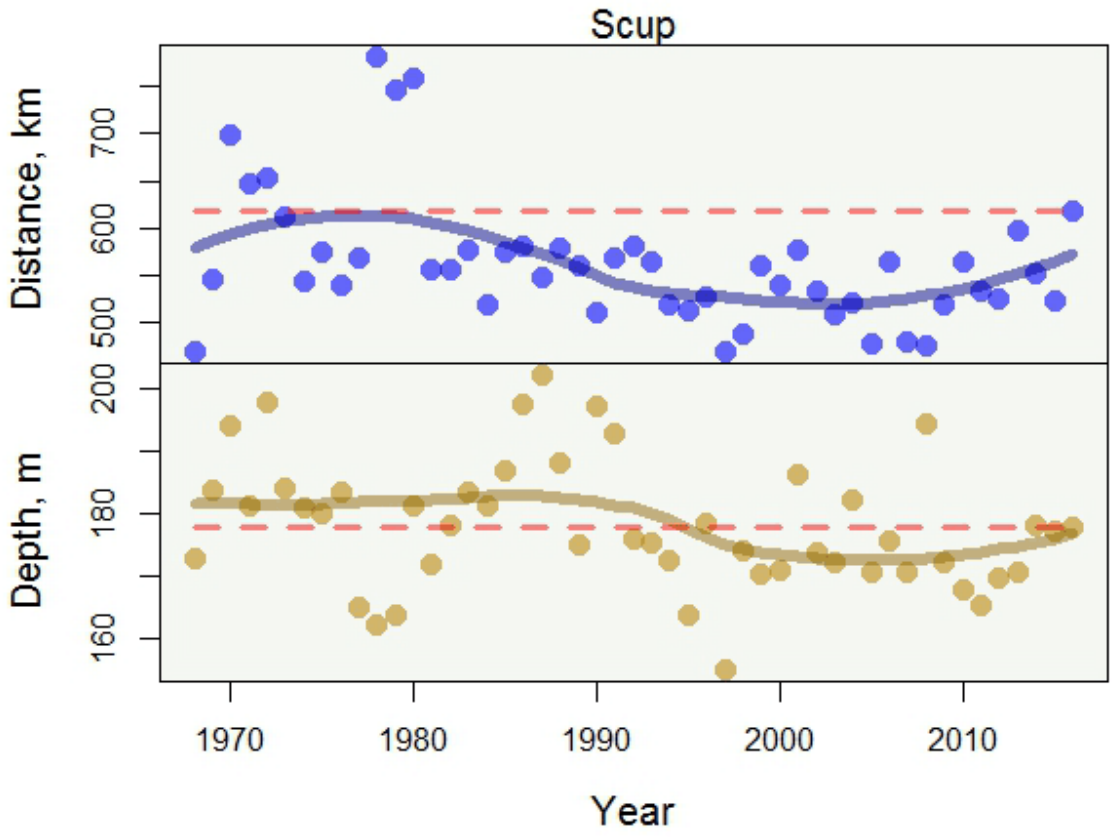
Rosette skae distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Sand lance



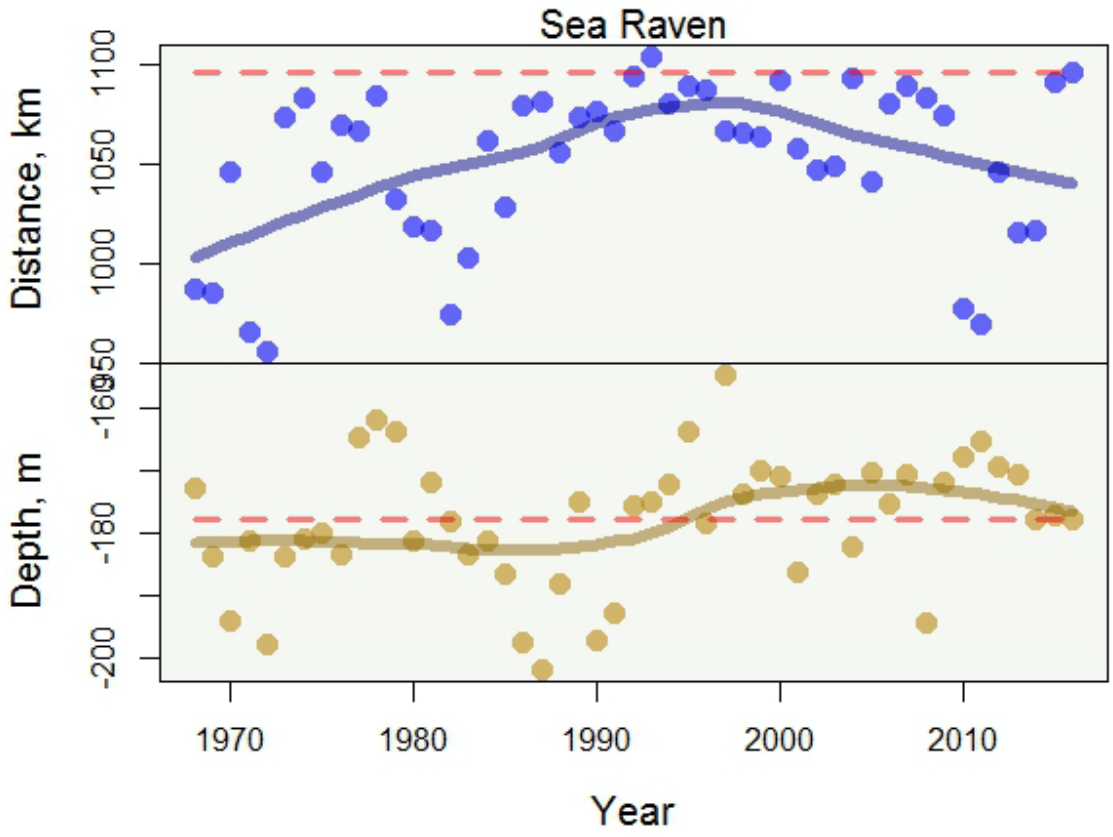
Sand lance distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Scup



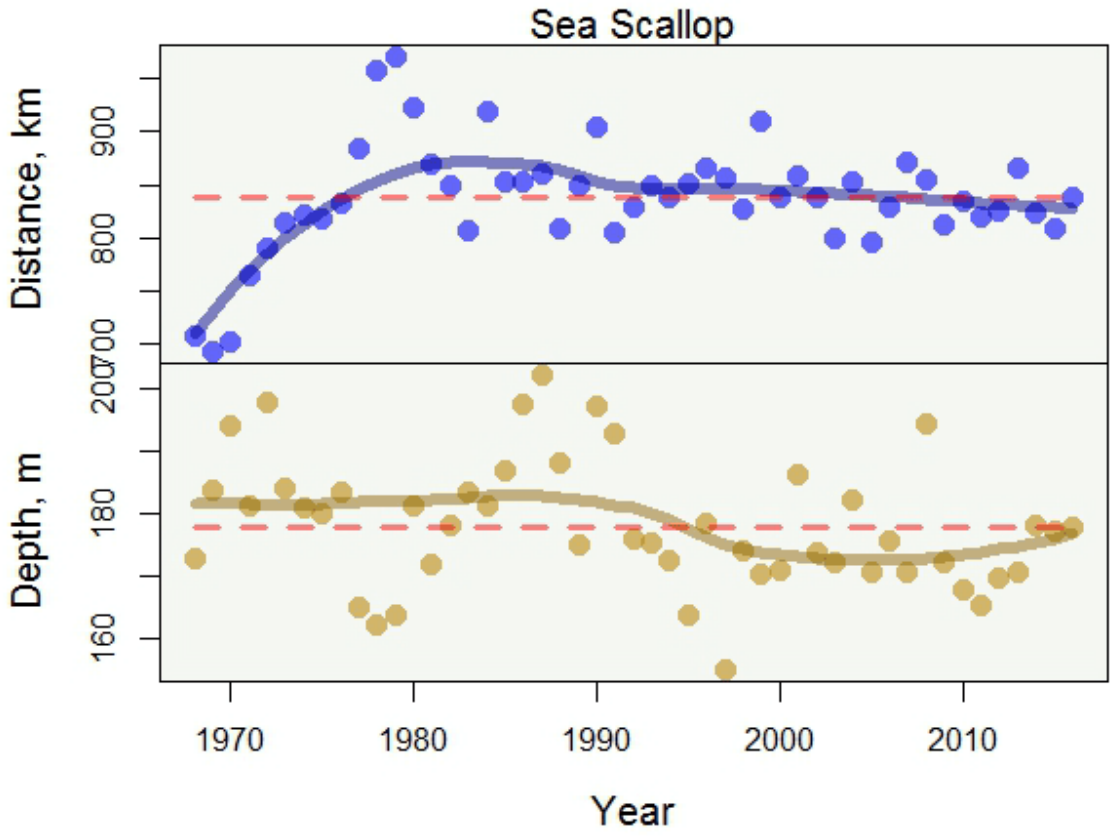
Scup distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Sea raven



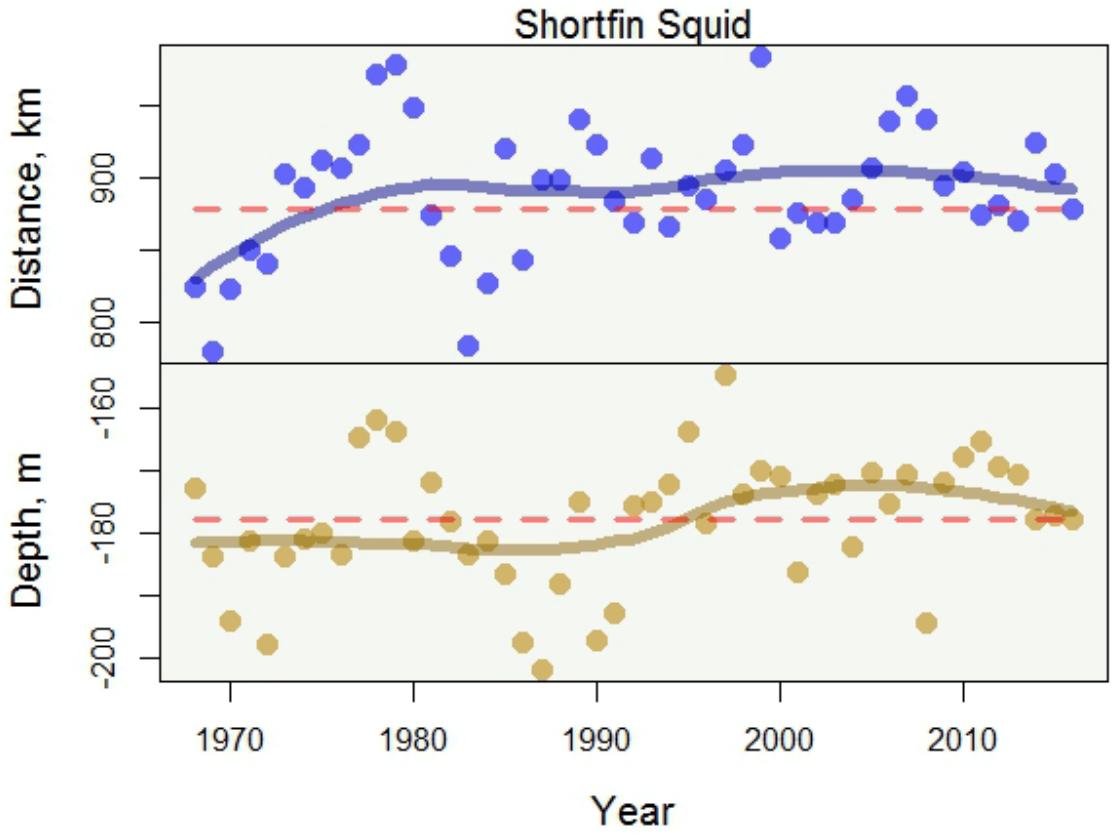
Sea raven distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Sea scallop



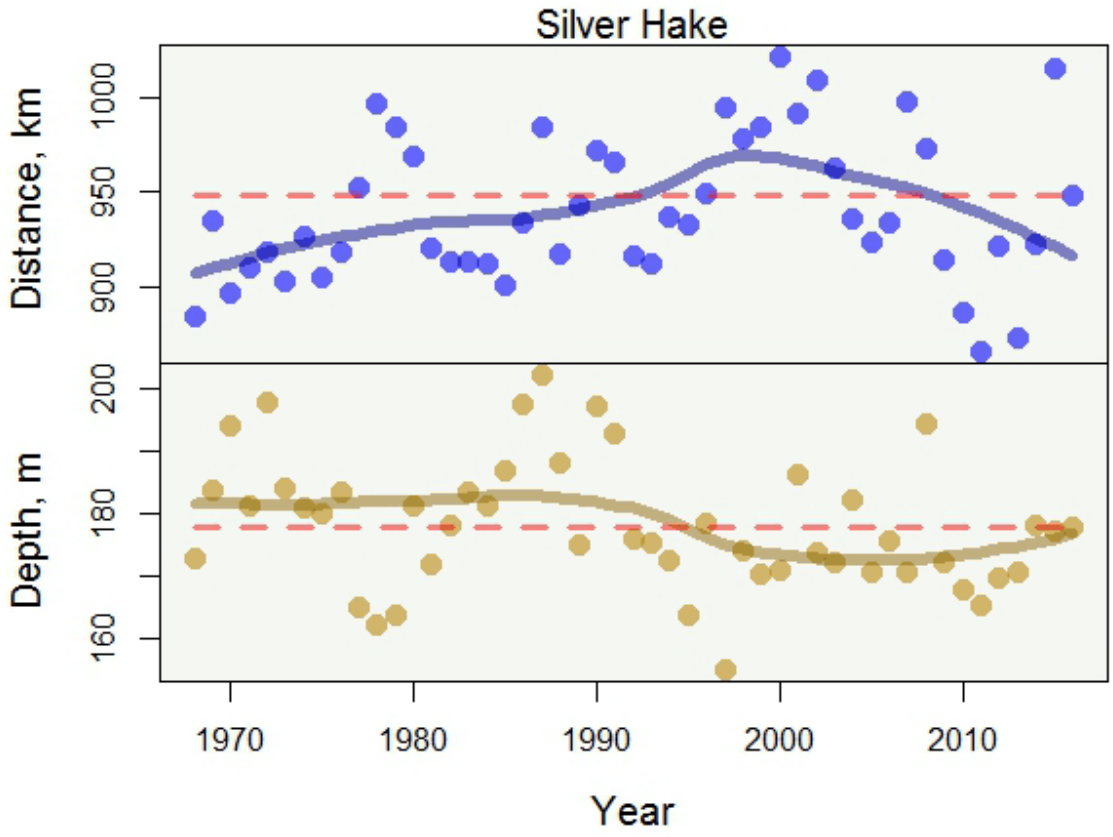
Sea scallop distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Shortfin squid



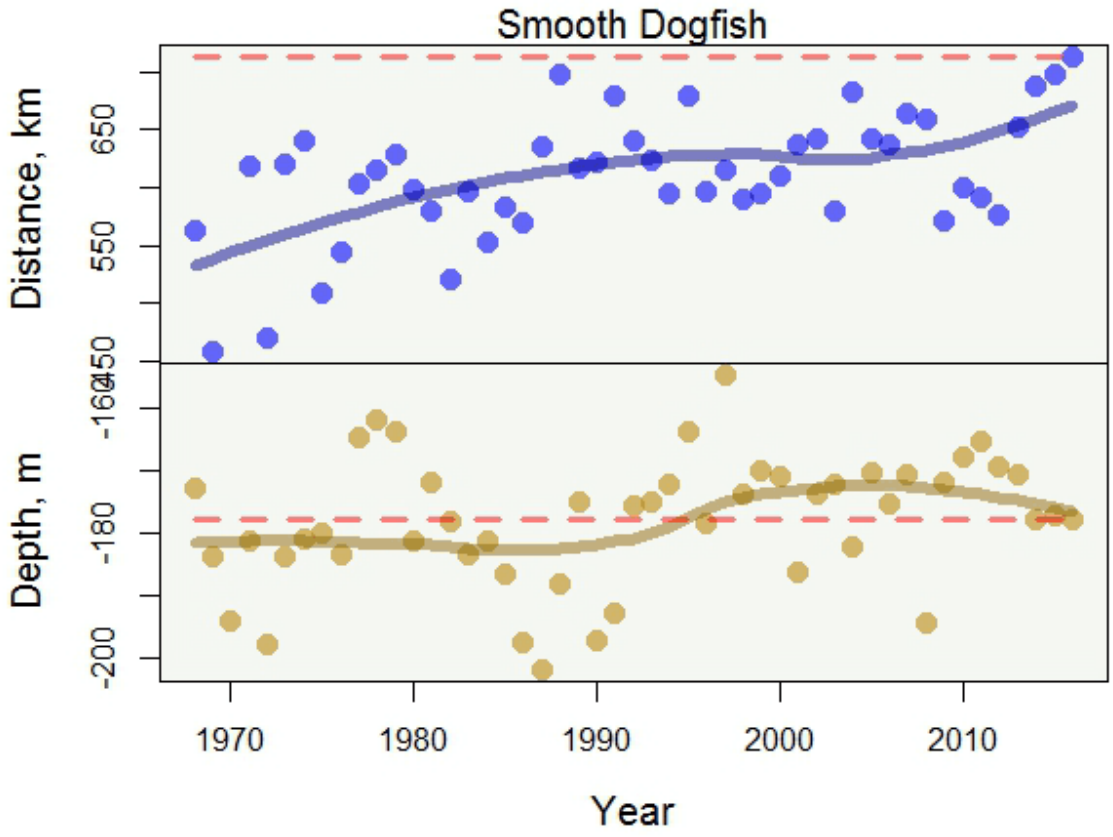
Shortfin squid distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Silver hake



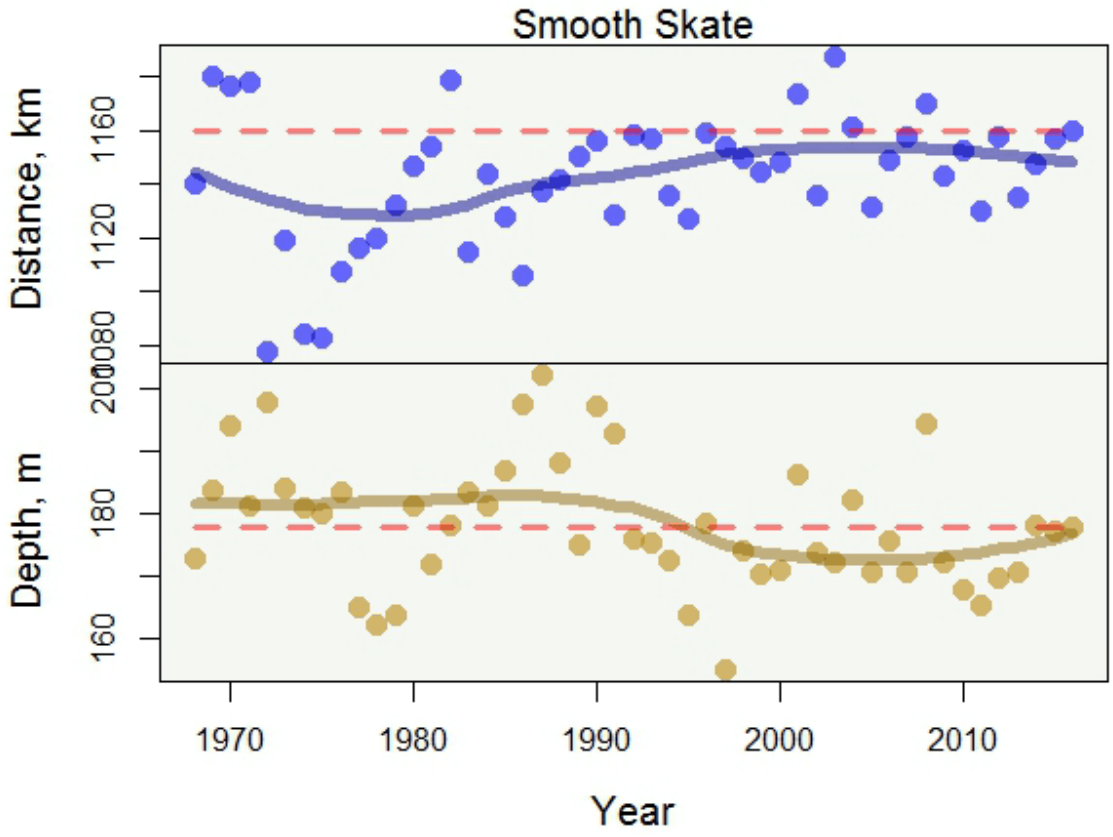
Silver hake distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Smooth dogfish



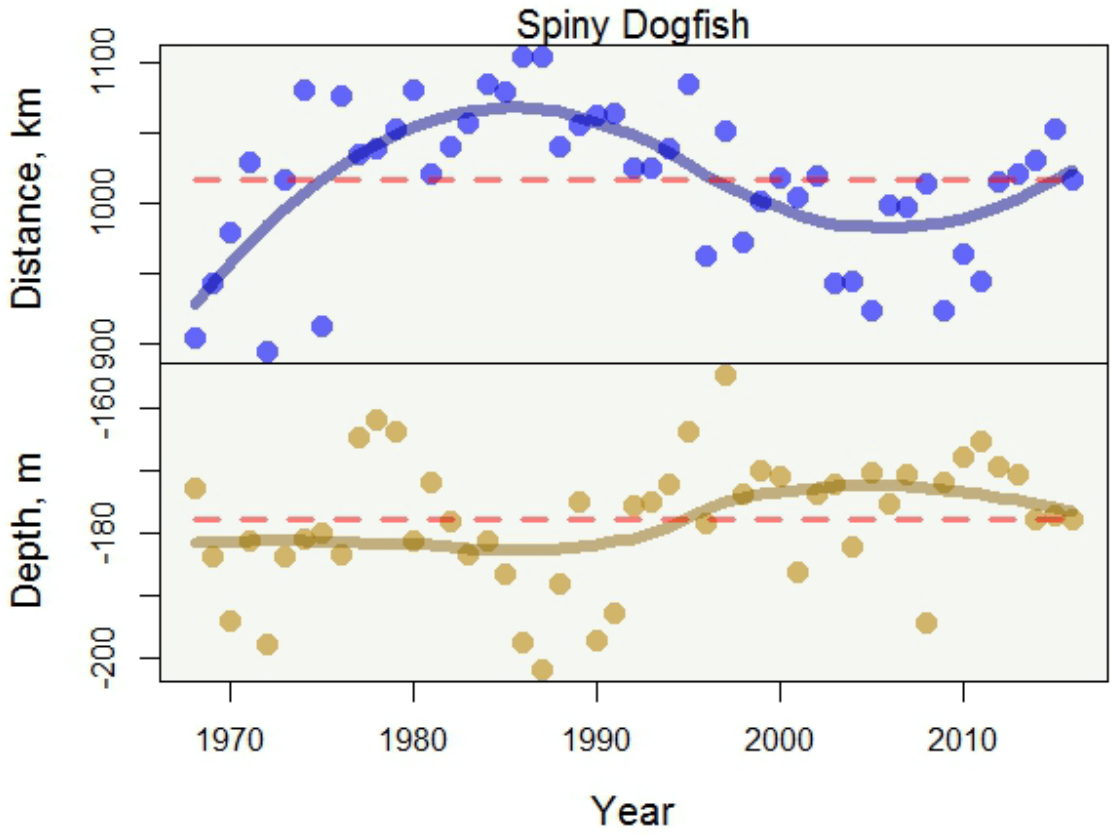
Smooth dogfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Smooth skate



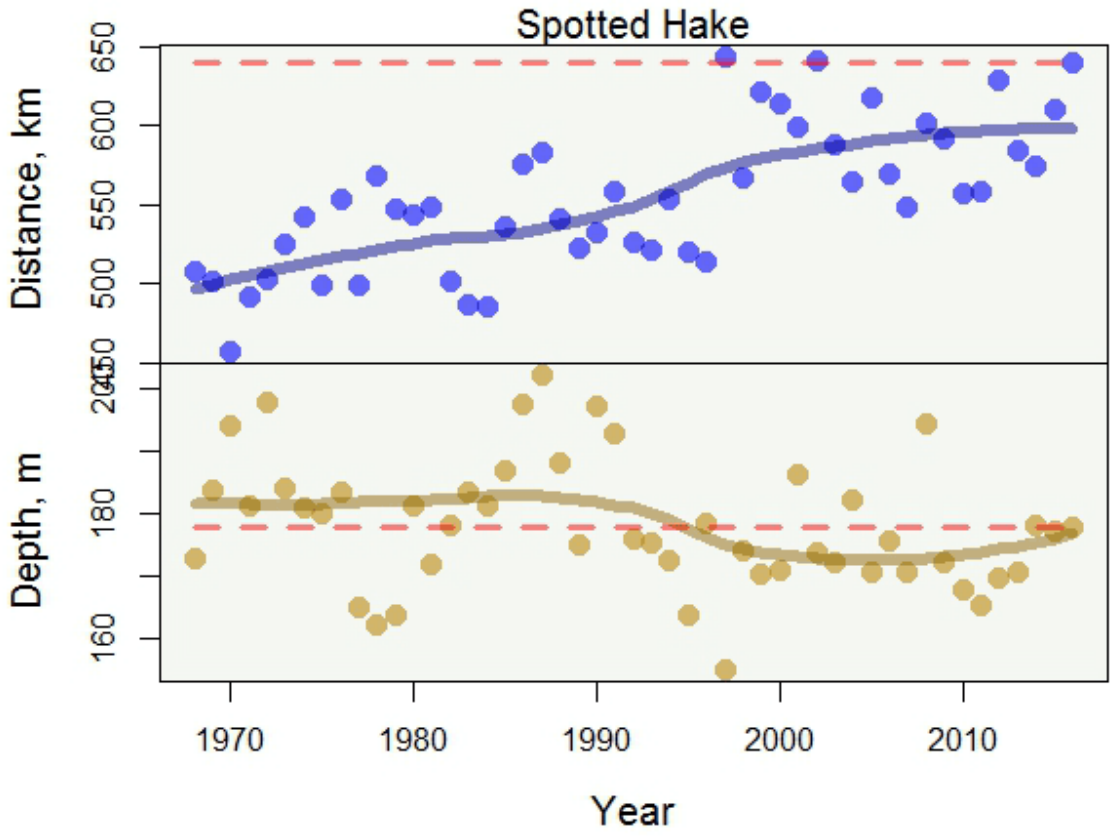
Smooth skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Spiny dogfish



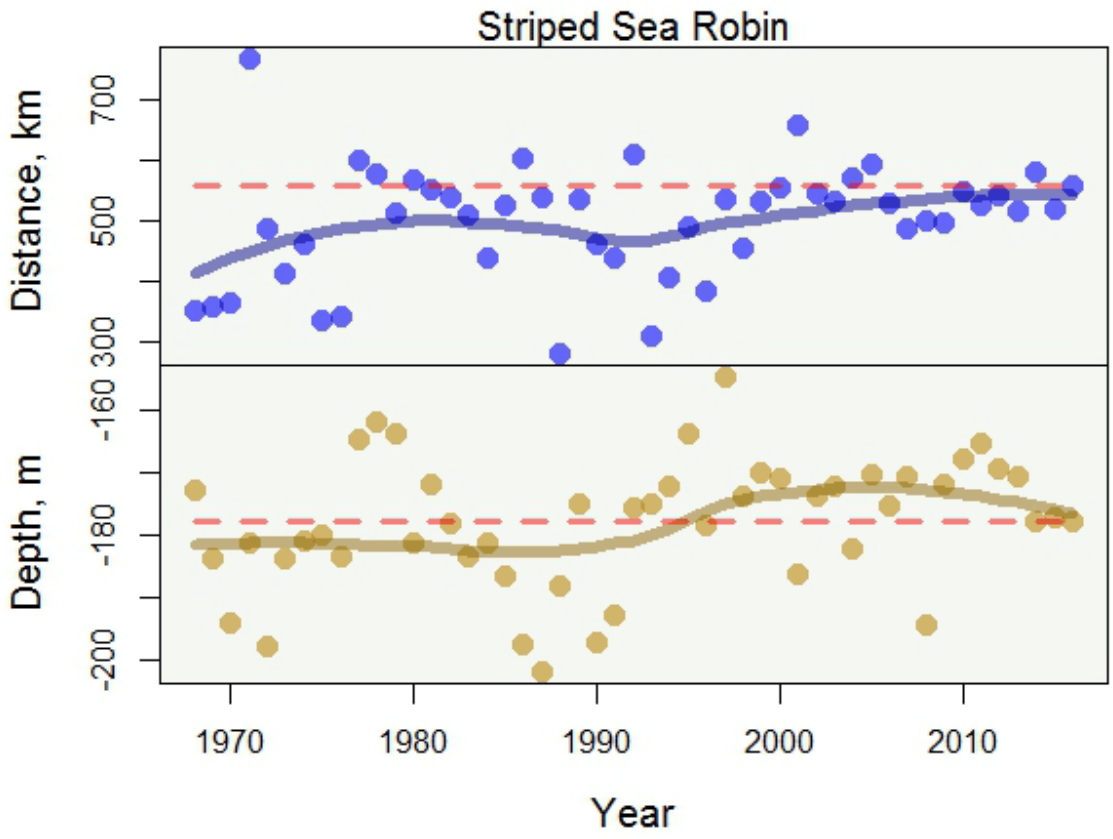
Spiny dogfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Spotted hake



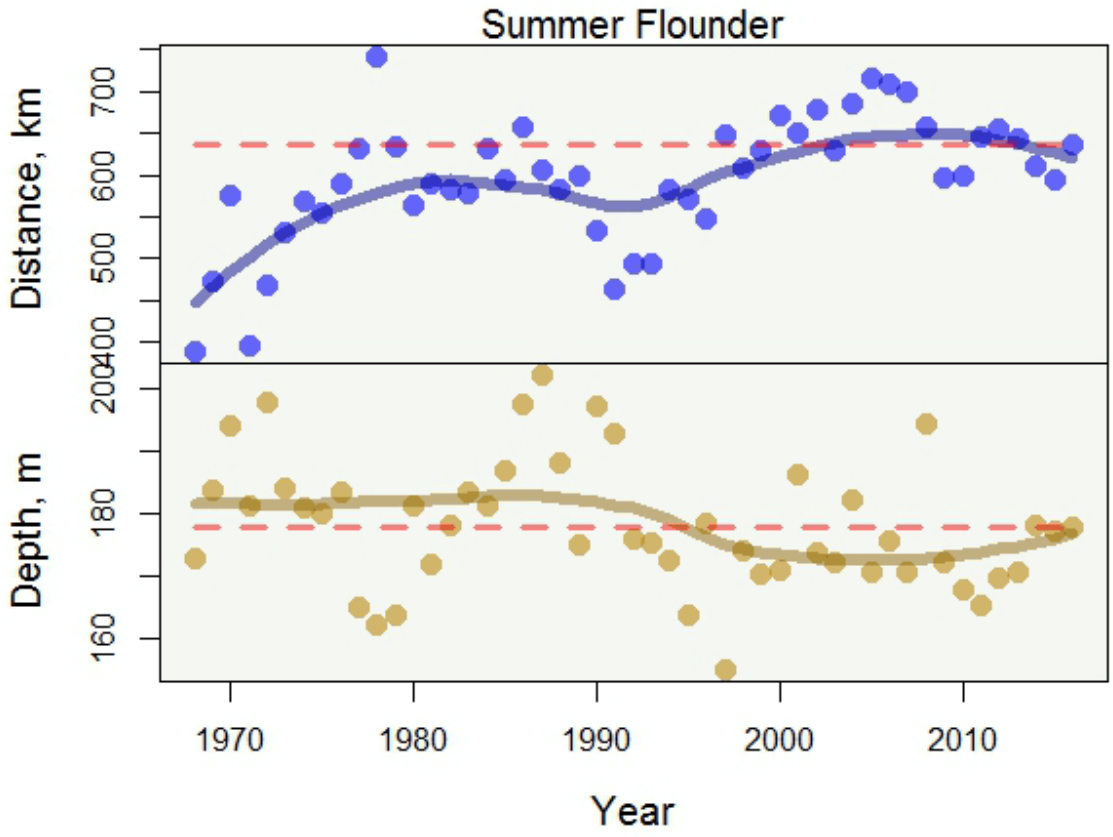
Spotted hake distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Striped sea robin



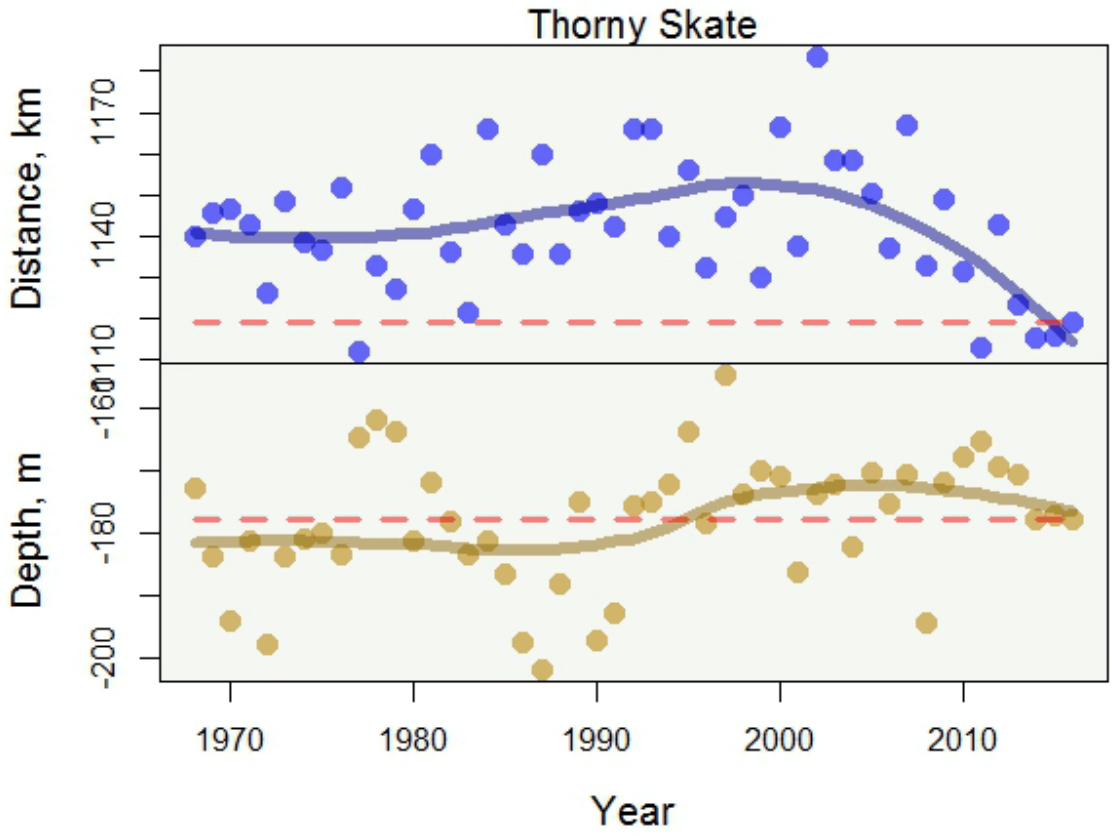
Striped sea robin distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Summer flounder



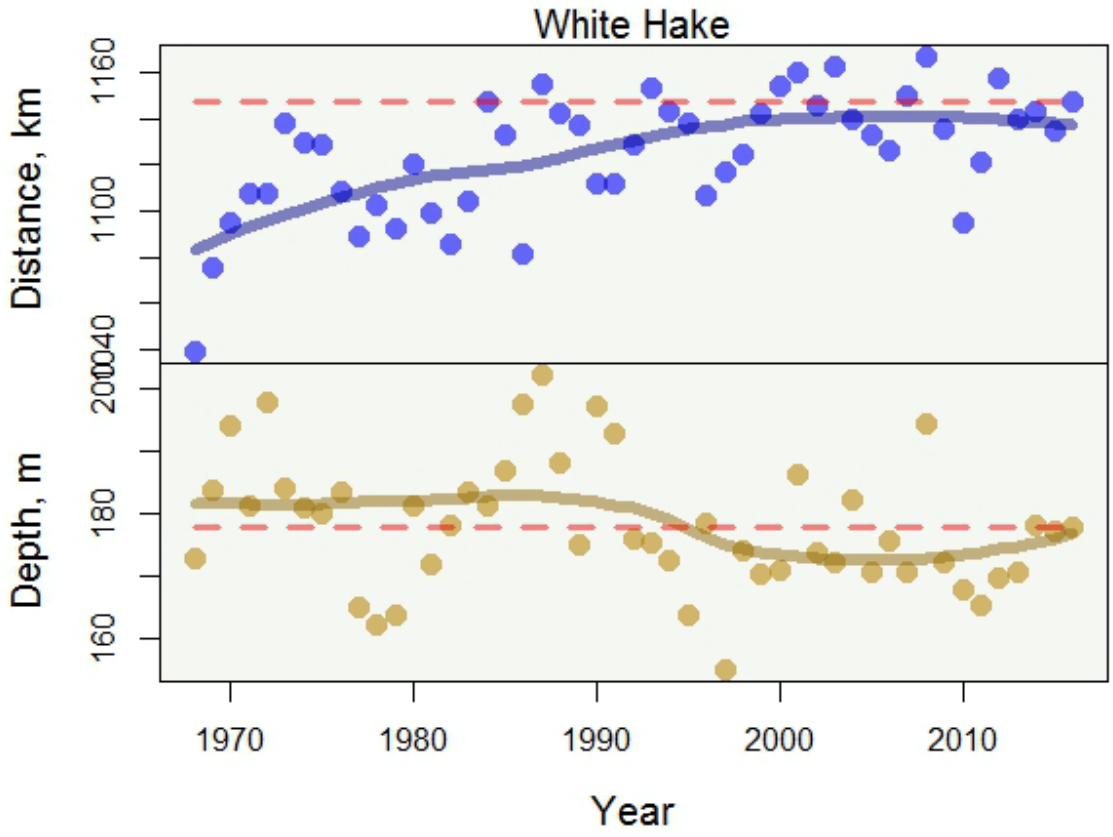
Summer flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Thorny skate



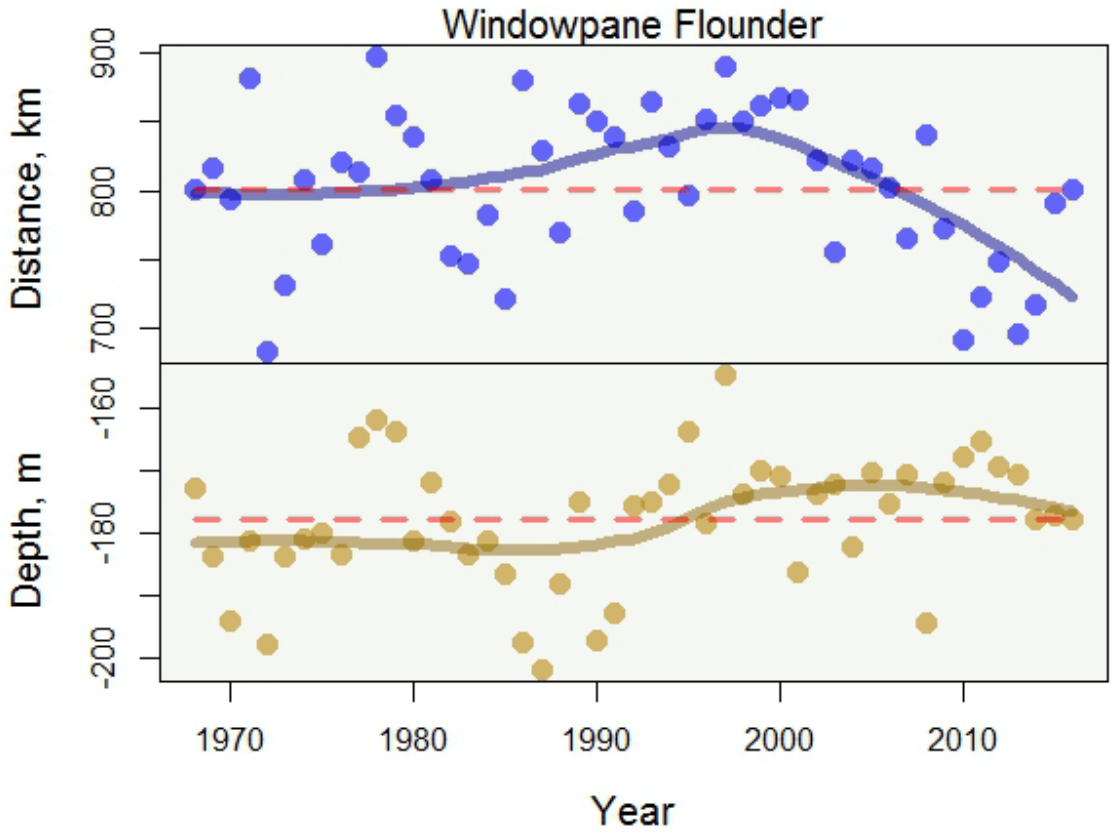
Thorny skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

White hake



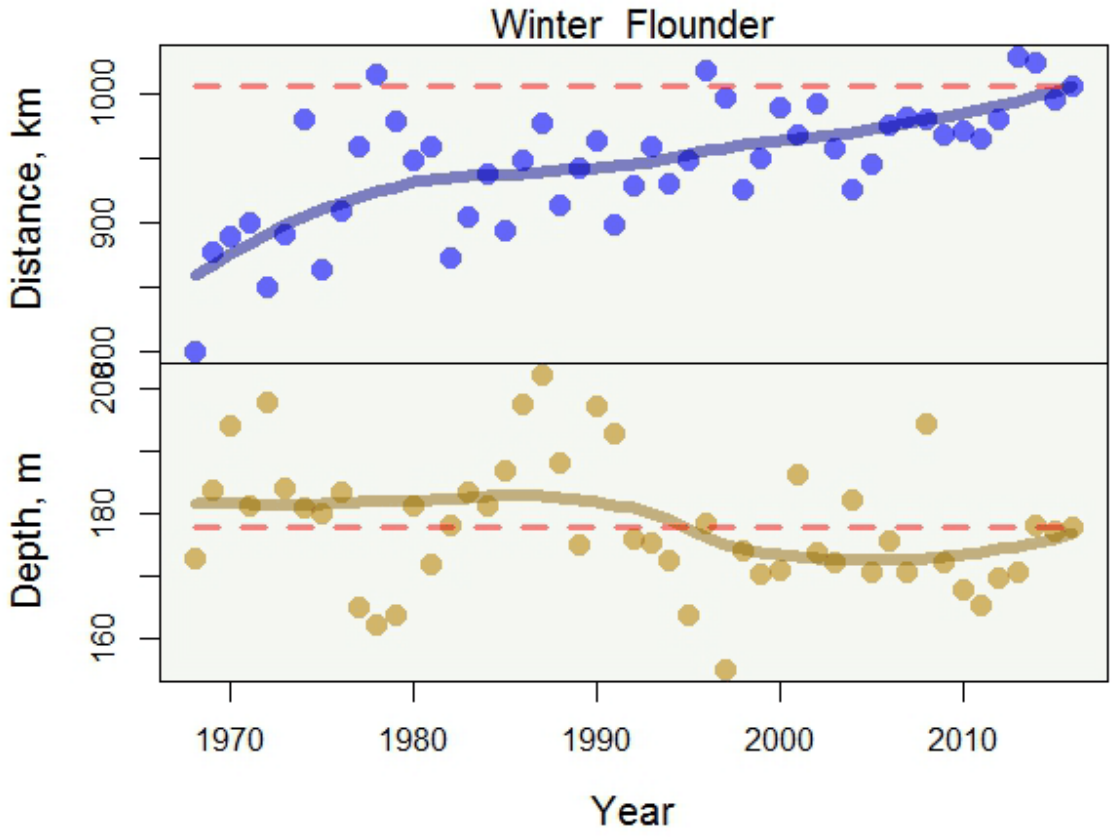
White hake distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Windowpane flounder



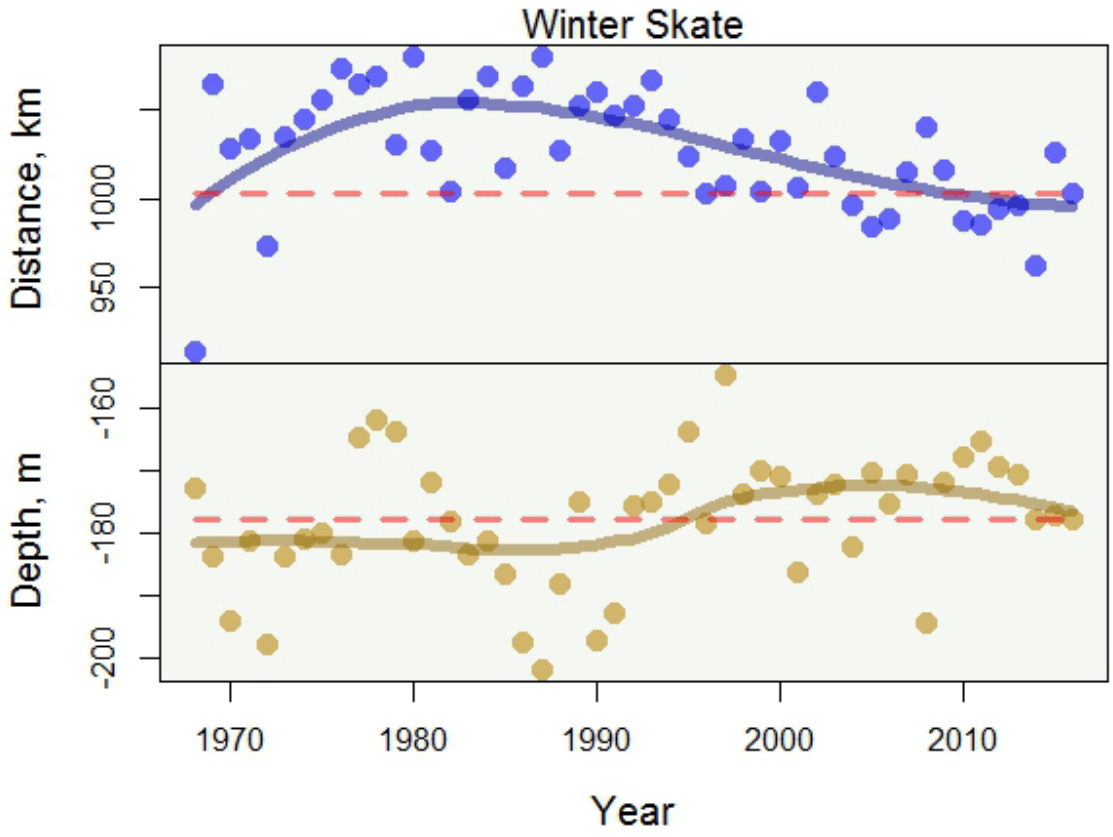
Windowpane flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Winter flounder



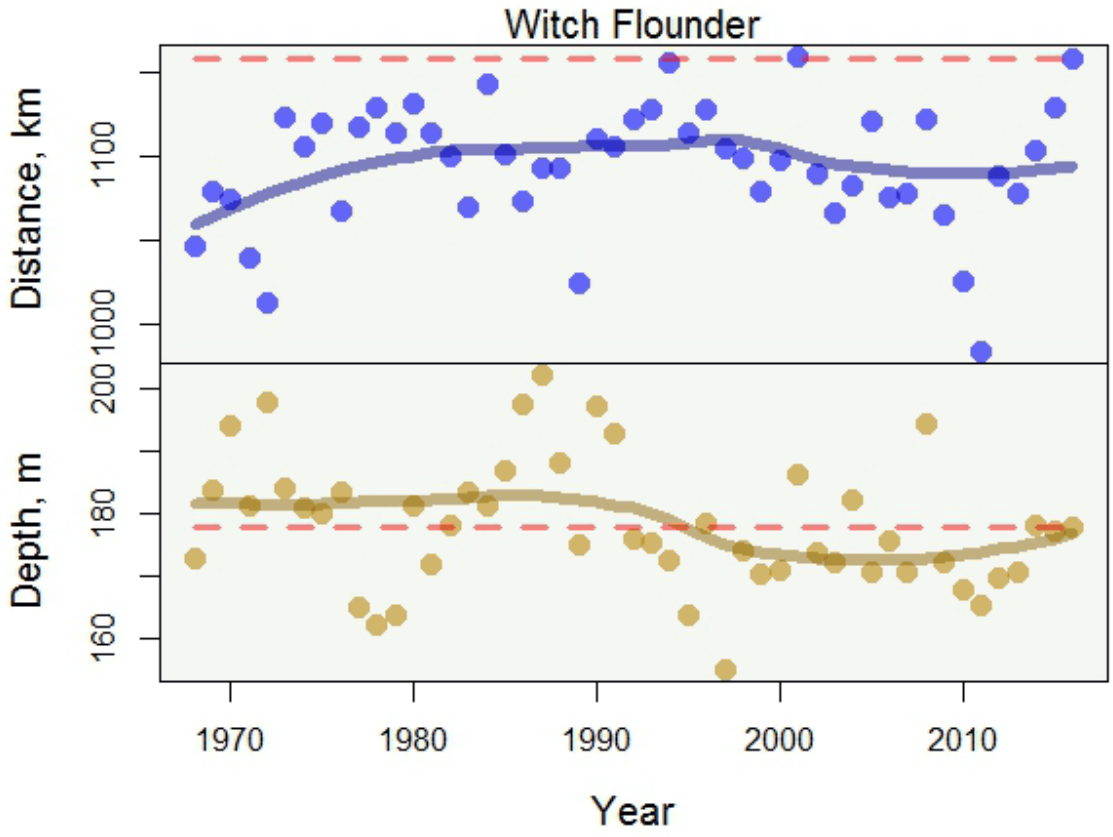
Winter flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Winter skate



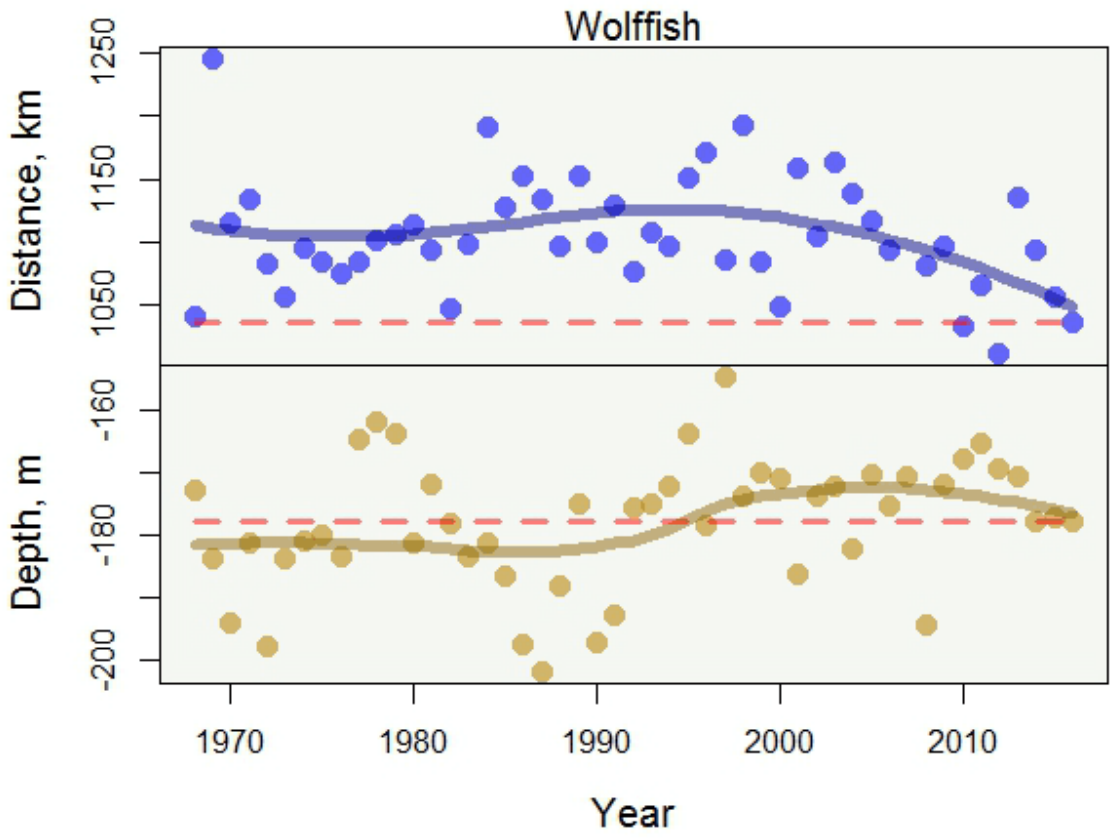
Winter skate distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Witch flounder



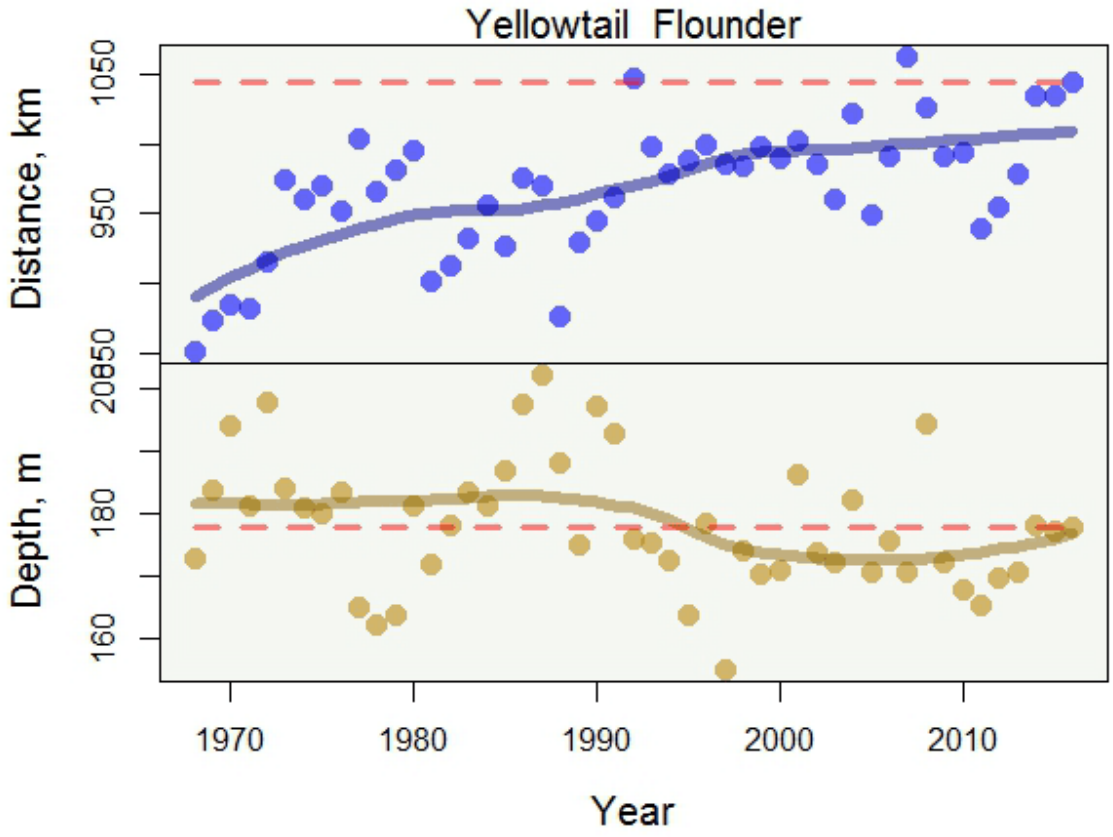
Witch flounder distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Wolffish



Wolffish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

Yellowtail flounder



Butterfish distribution trend: mean along-shelf distance and depth of occurrence. Dashed red line = 2016 values.

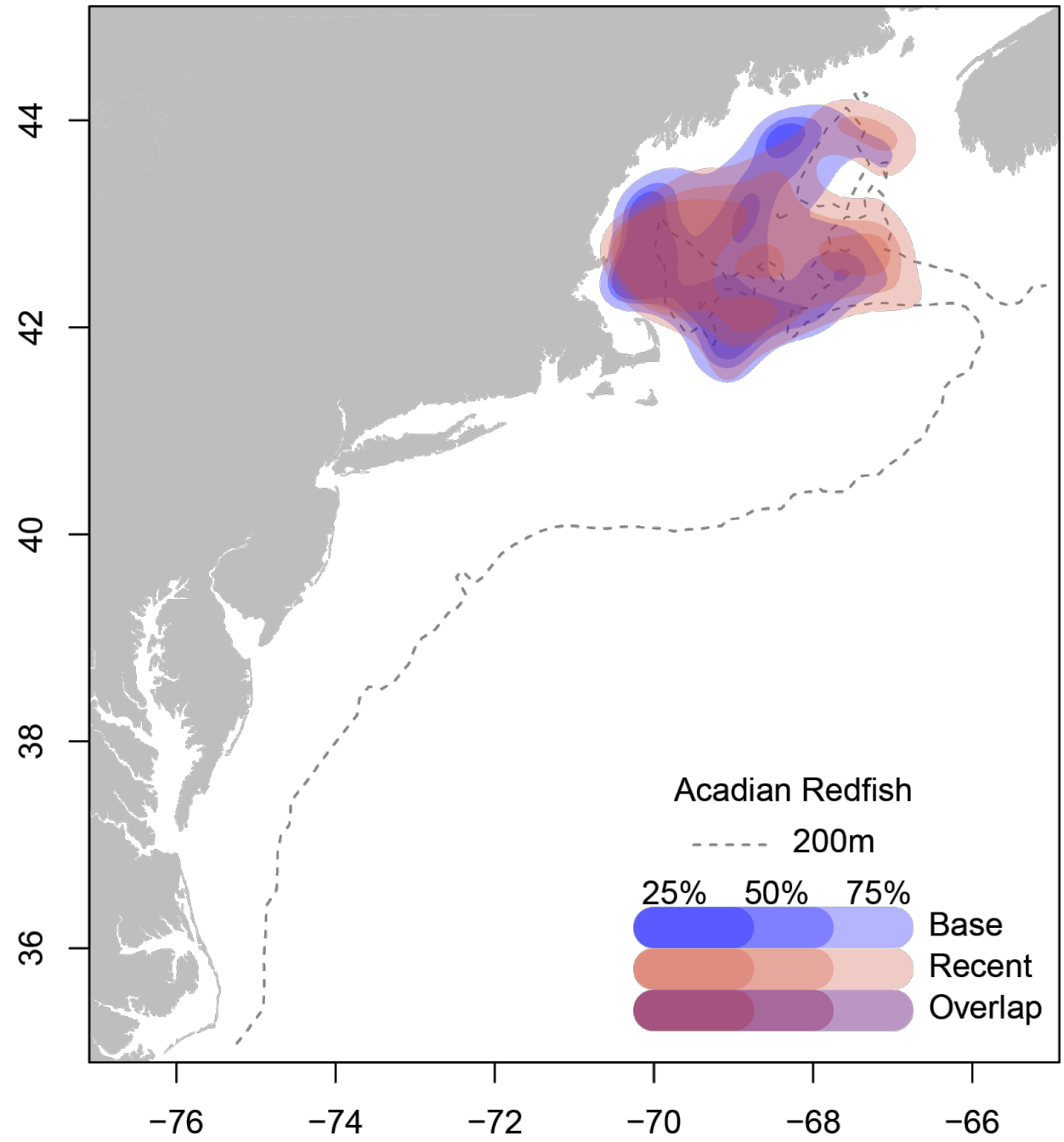
Kernel Density Plots of Fall Species Distribution

Note: Since the 2017 fall bottom trawl survey was incomplete, these distribution statistics could not be updated, so the 2016 analysis is represented.

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

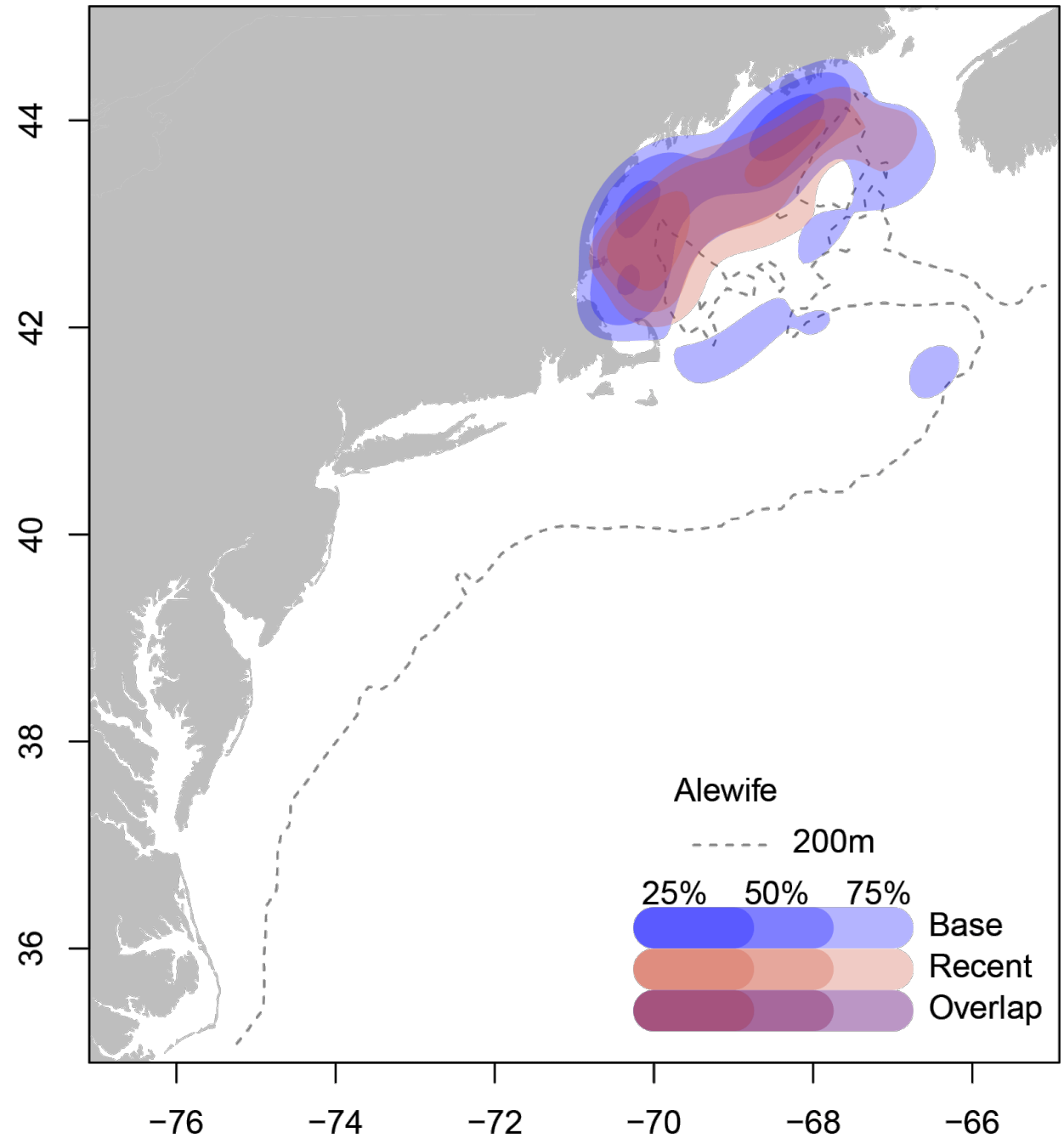
contemporary distribution period based on the last three years (2014-2016) for the fall survey (shown as red kernel densities).

Acadian redfish



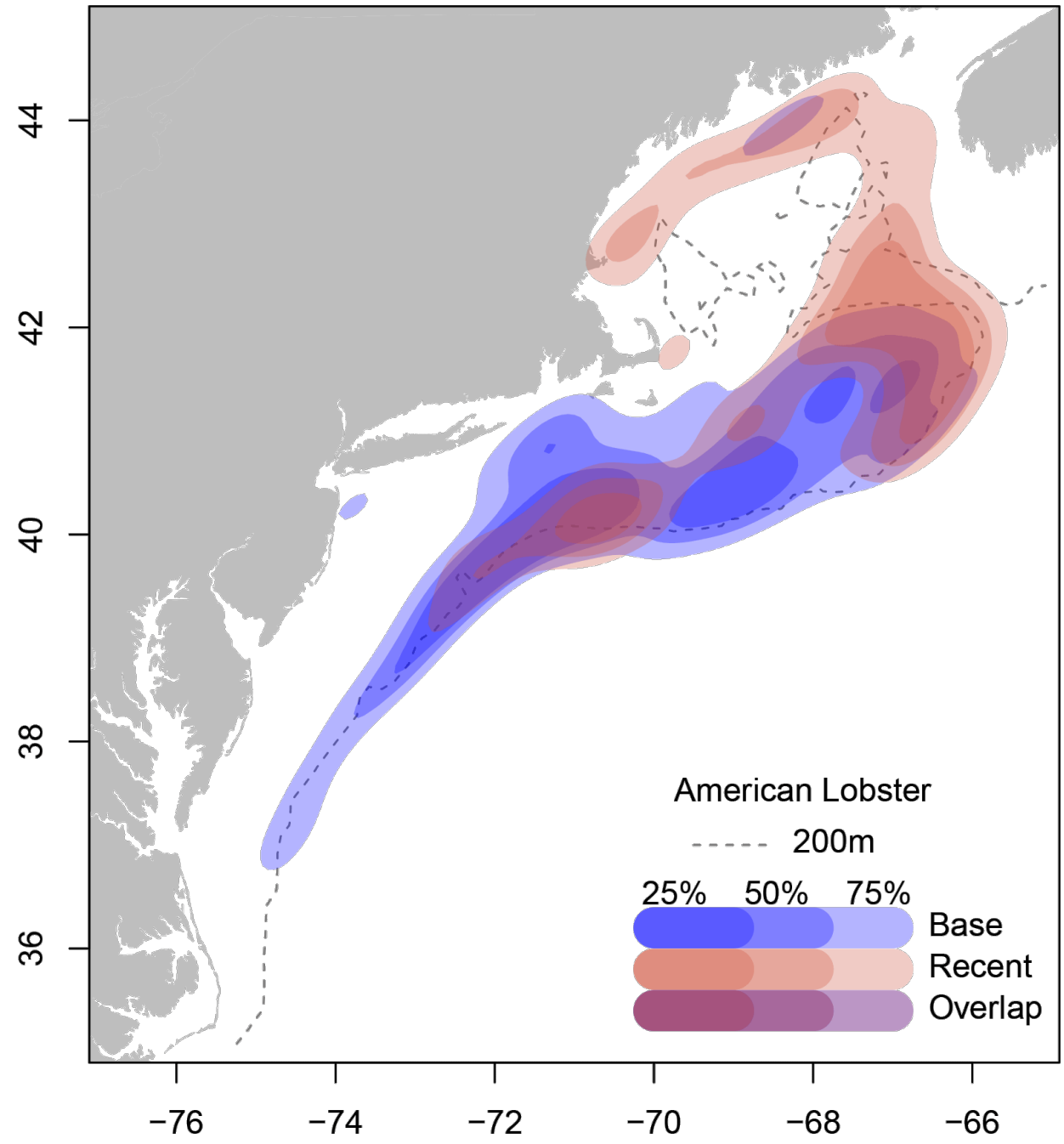
Kernel density plot of Acadian redfish. Blue = 1970s distributions; red = 2014-2016.

Alewife



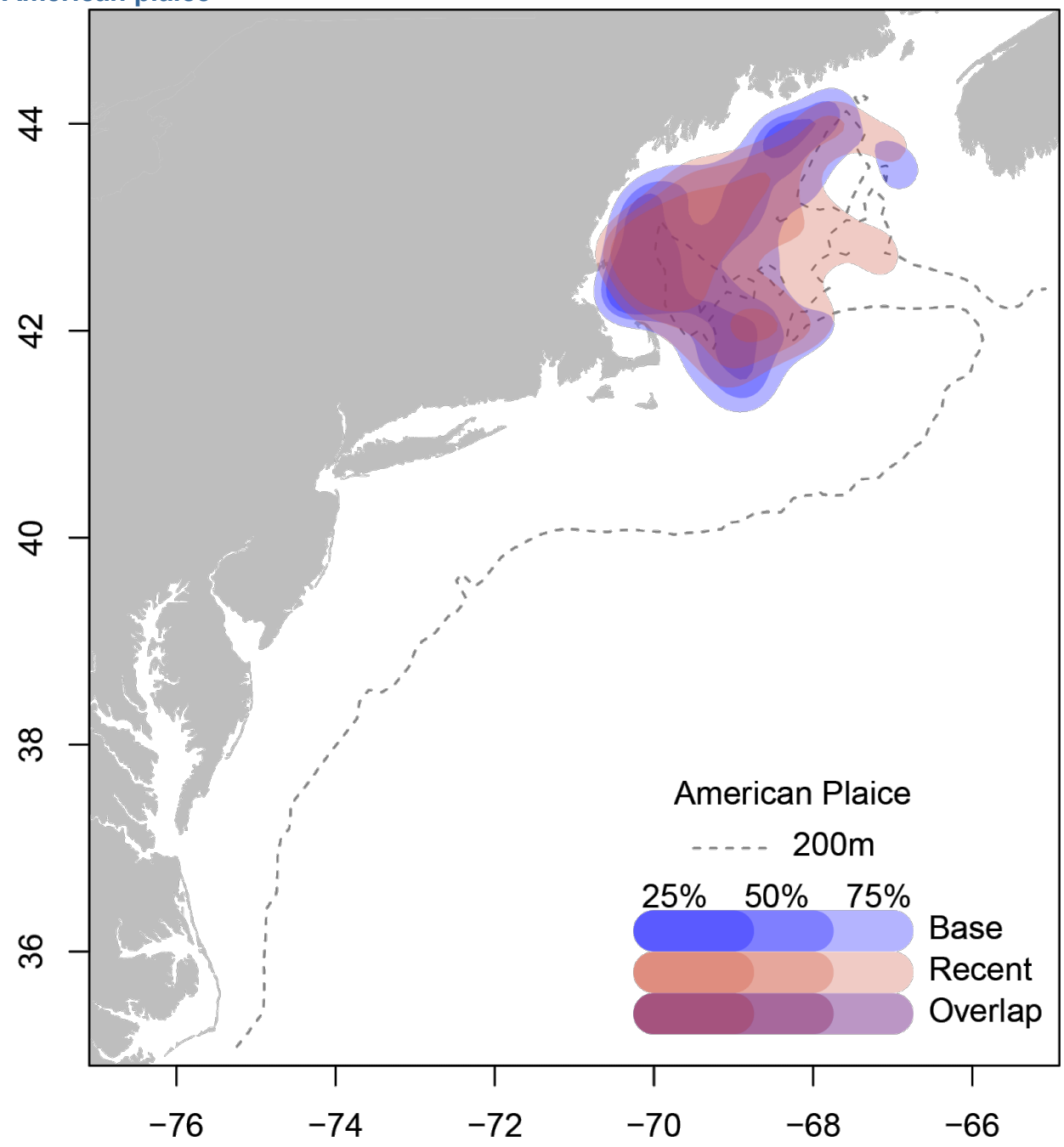
Kernel density plot of Alewife. Blue = 1970s distributions; red = 2014-2016.

American lobster



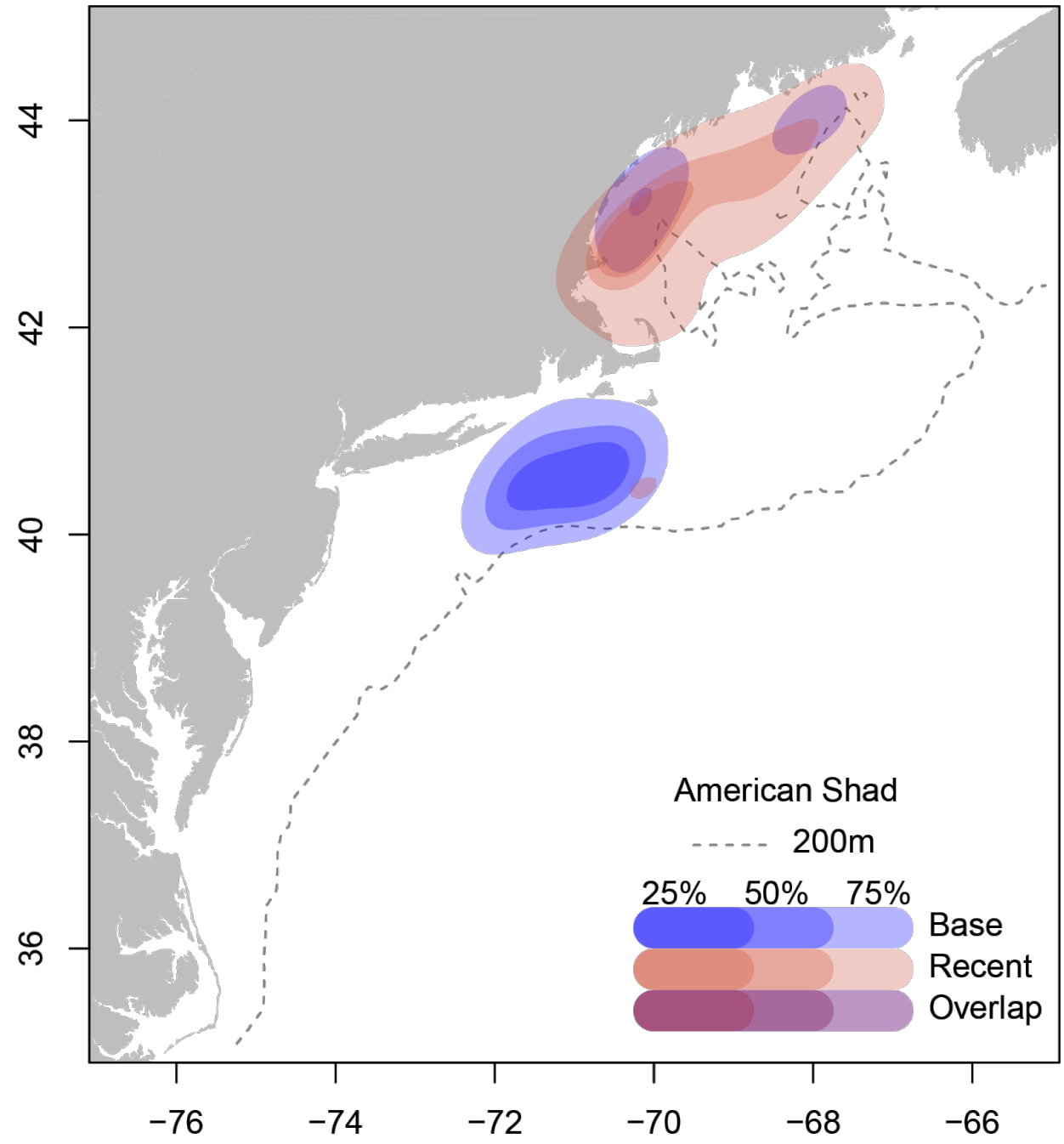
Kernel density plot of American lobster. Blue = 1970s distributions; red = 2014-2016.

American plaice



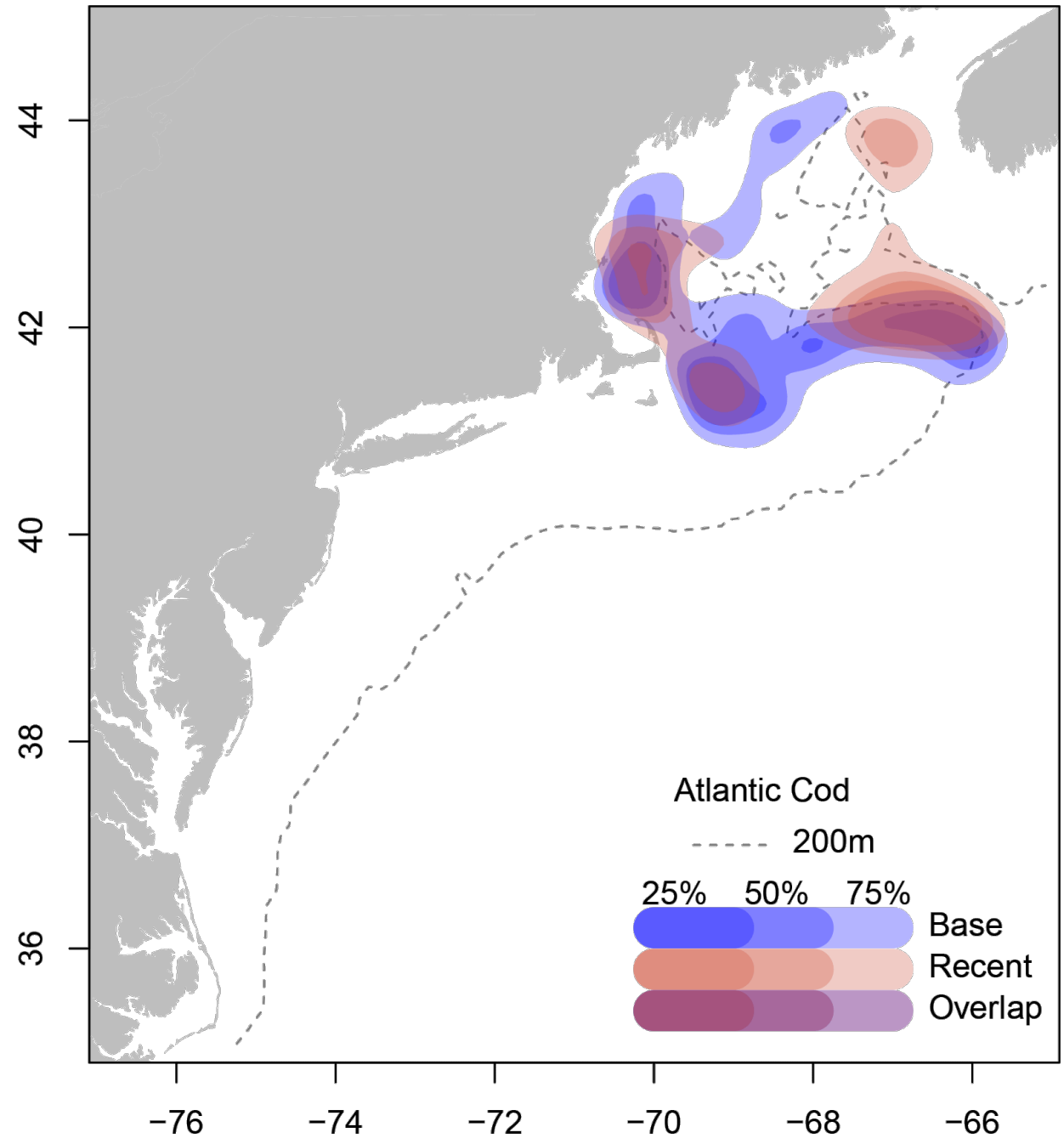
Kernel density plot of American plaice. Blue = 1970s distributions; red = 2014-2016.

American shad



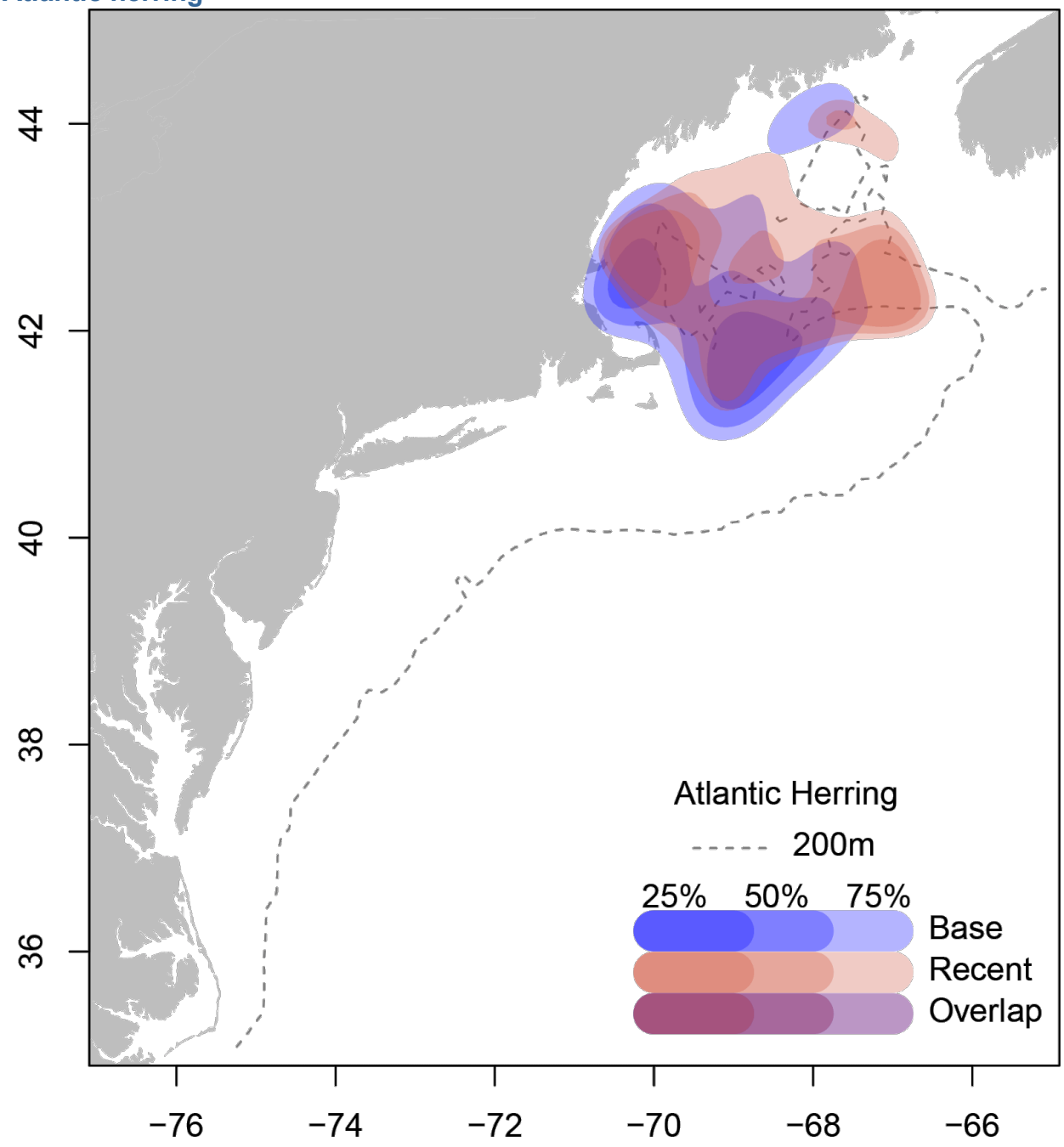
Kernel density plot of American shad. Blue = 1970s distributions; red = 2014-2016.

Atlantic cod



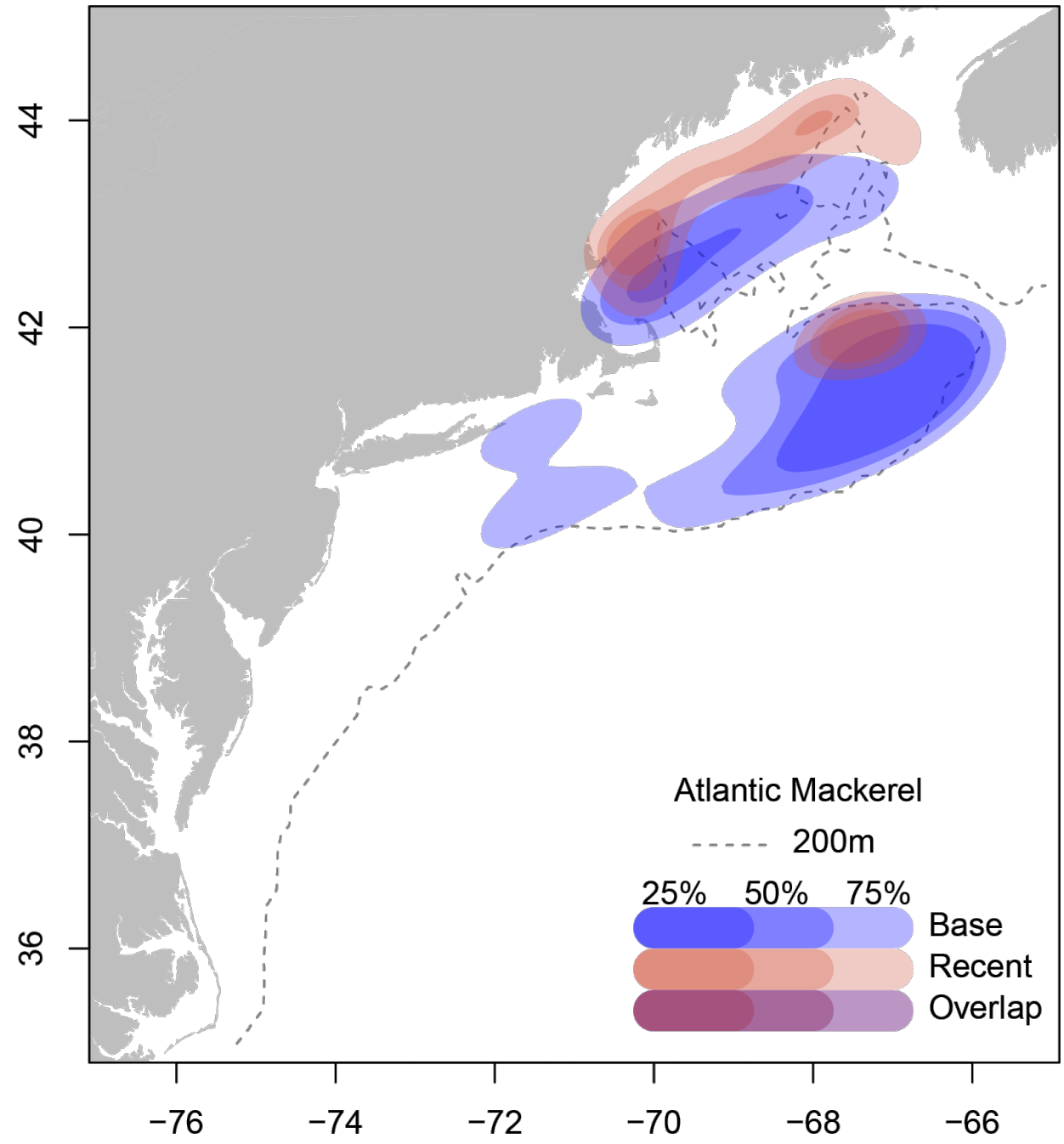
Kernel density plot of Atlantic cod. Blue = 1970s distributions; red = 2014-2016.

Atlantic herring



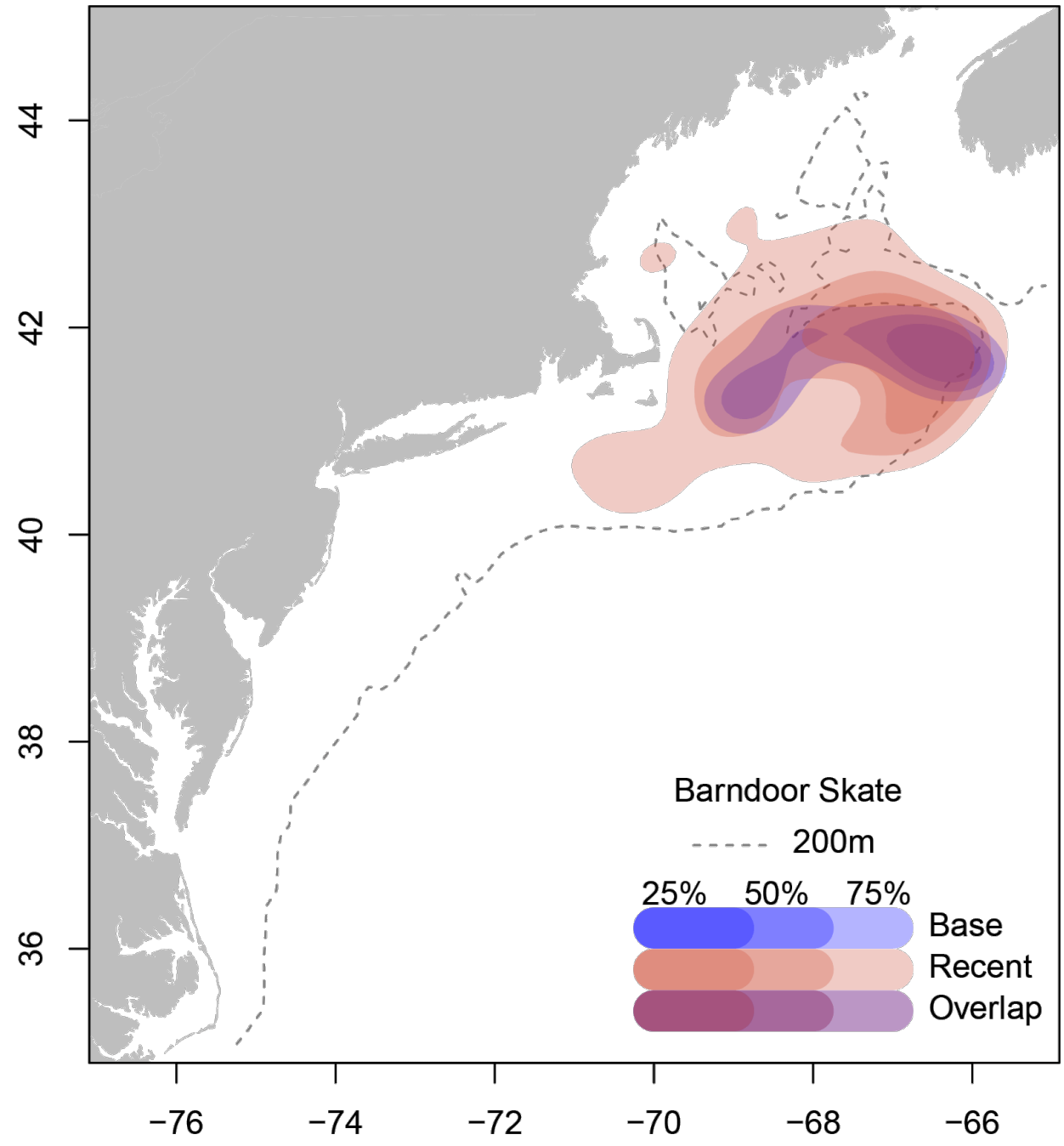
Kernel density plot of Atlantic herring. Blue = 1970s distributions; red = 2014-2016.

Atlantic mackerel



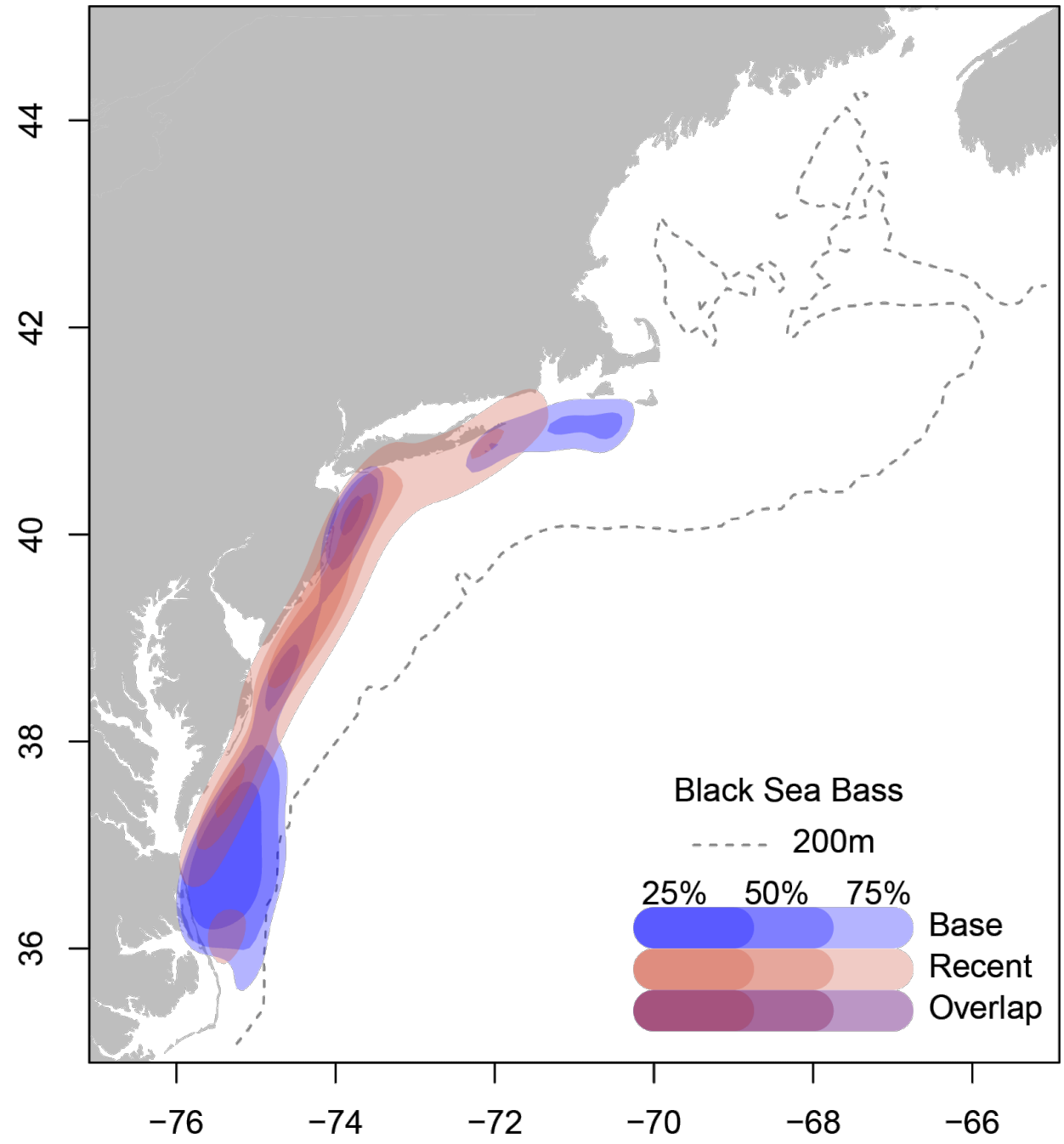
Kernel density plot of Atlantic mackerel. Blue = 1970s distributions; red = 2014-2016.

Barndoor skate



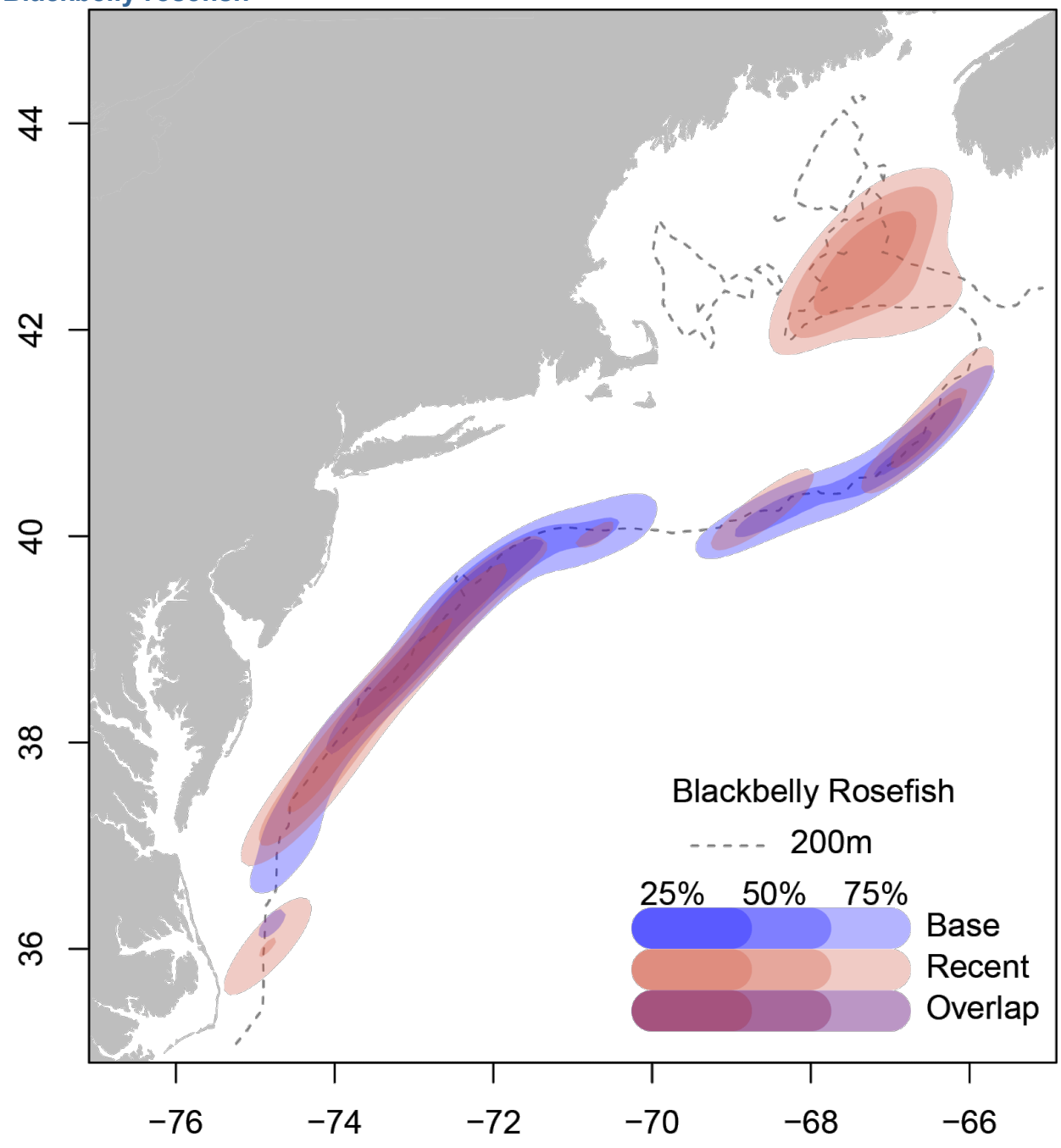
Kernel density plot of Barndoor skate. Blue = 1970s distributions; red = 2014-2016.

Black sea bass



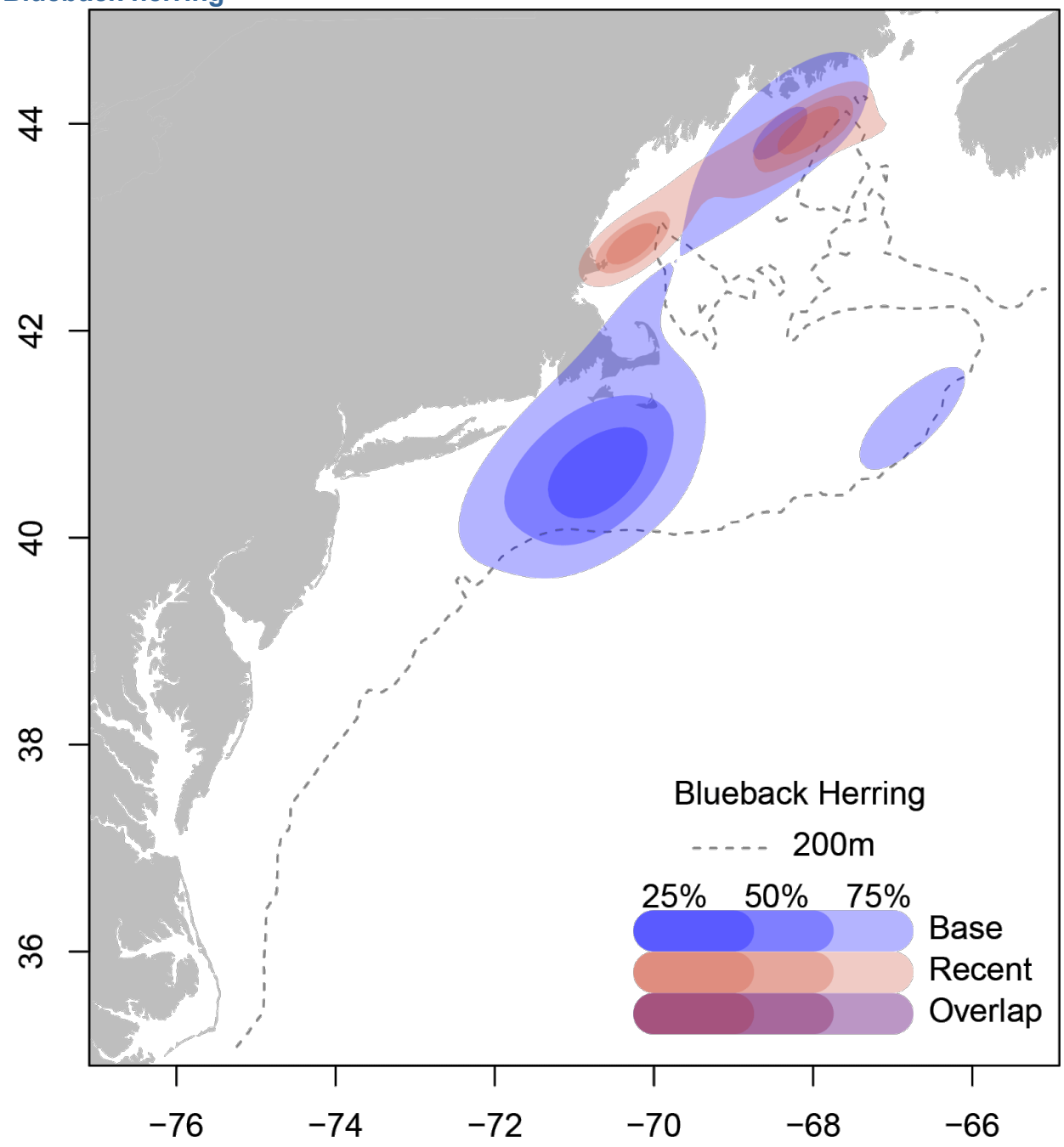
Kernel density plot of Black sea bass. Blue = 1970s distributions; red = 2014-2016.

Blackbelly rosefish



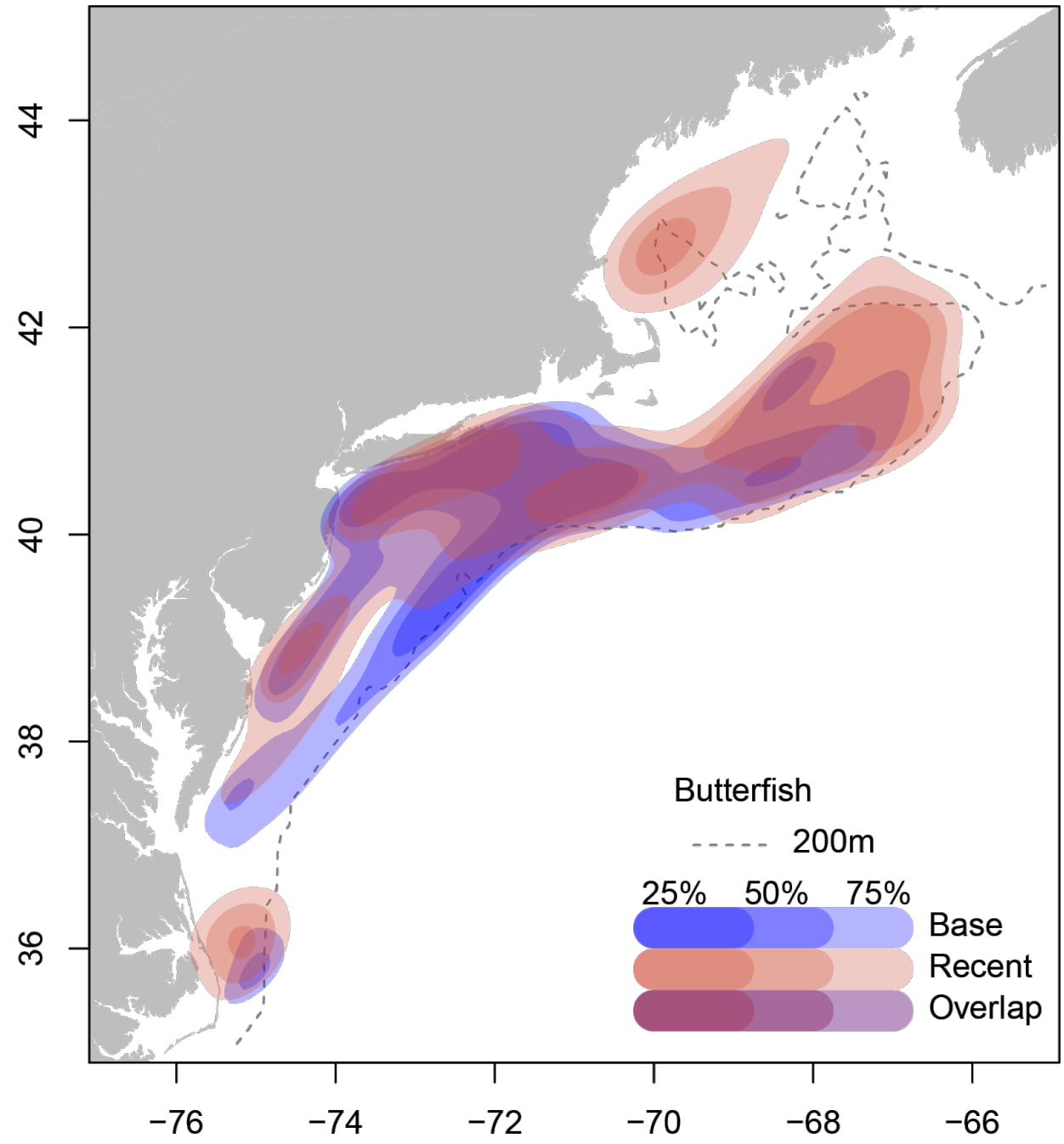
Kernel density plot of Blackbelly rosefish. Blue = 1970s distributions; red = 2014-2016.

Blueback herring



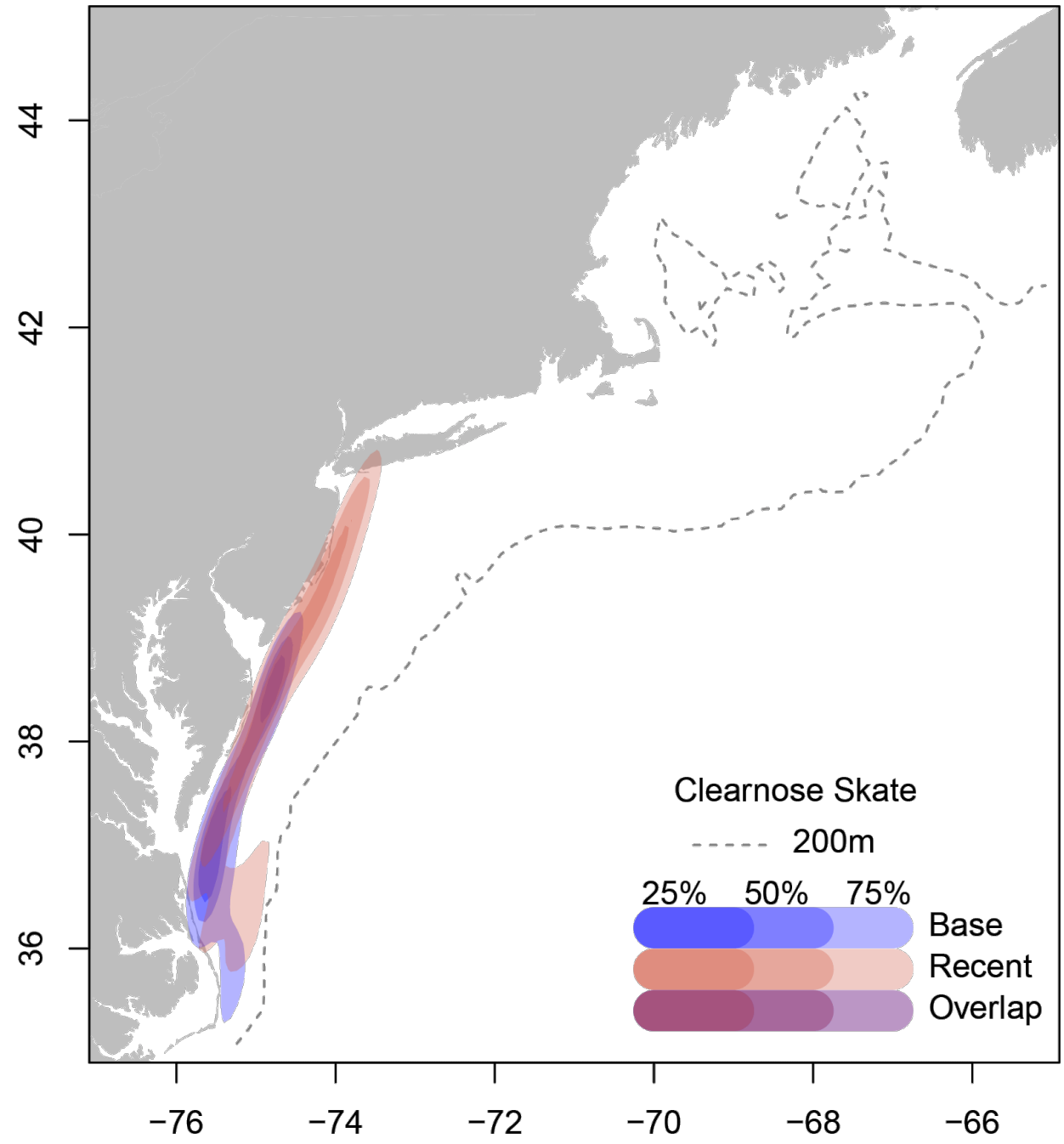
Kernel density plot of Blueback herring. Blue = 1970s distributions; red = 2014-2016.

Butterfish



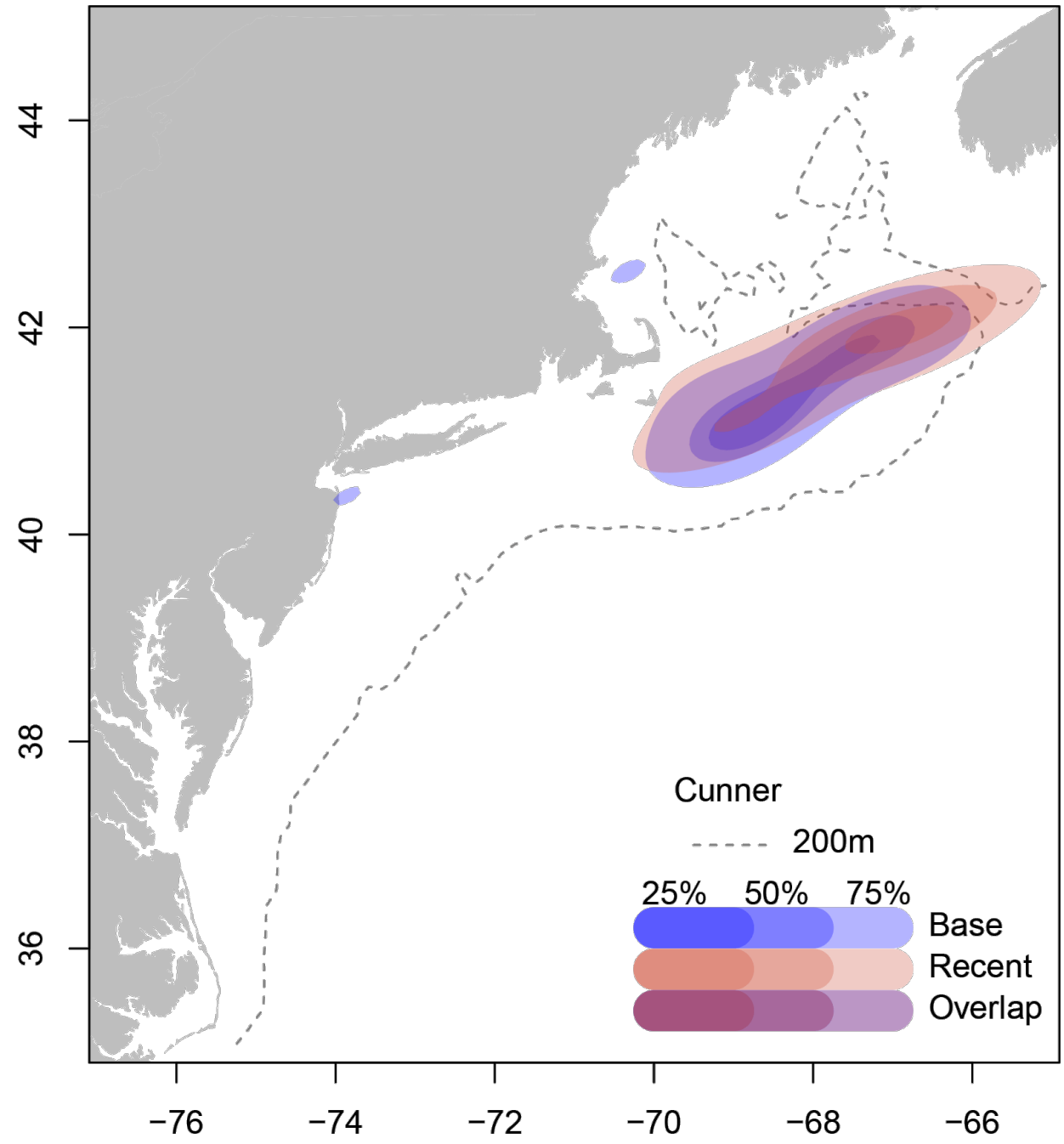
Kernel density plot of Butterfish. Blue = 1970s distributions; red = 2014-2016.

Clearnose skate



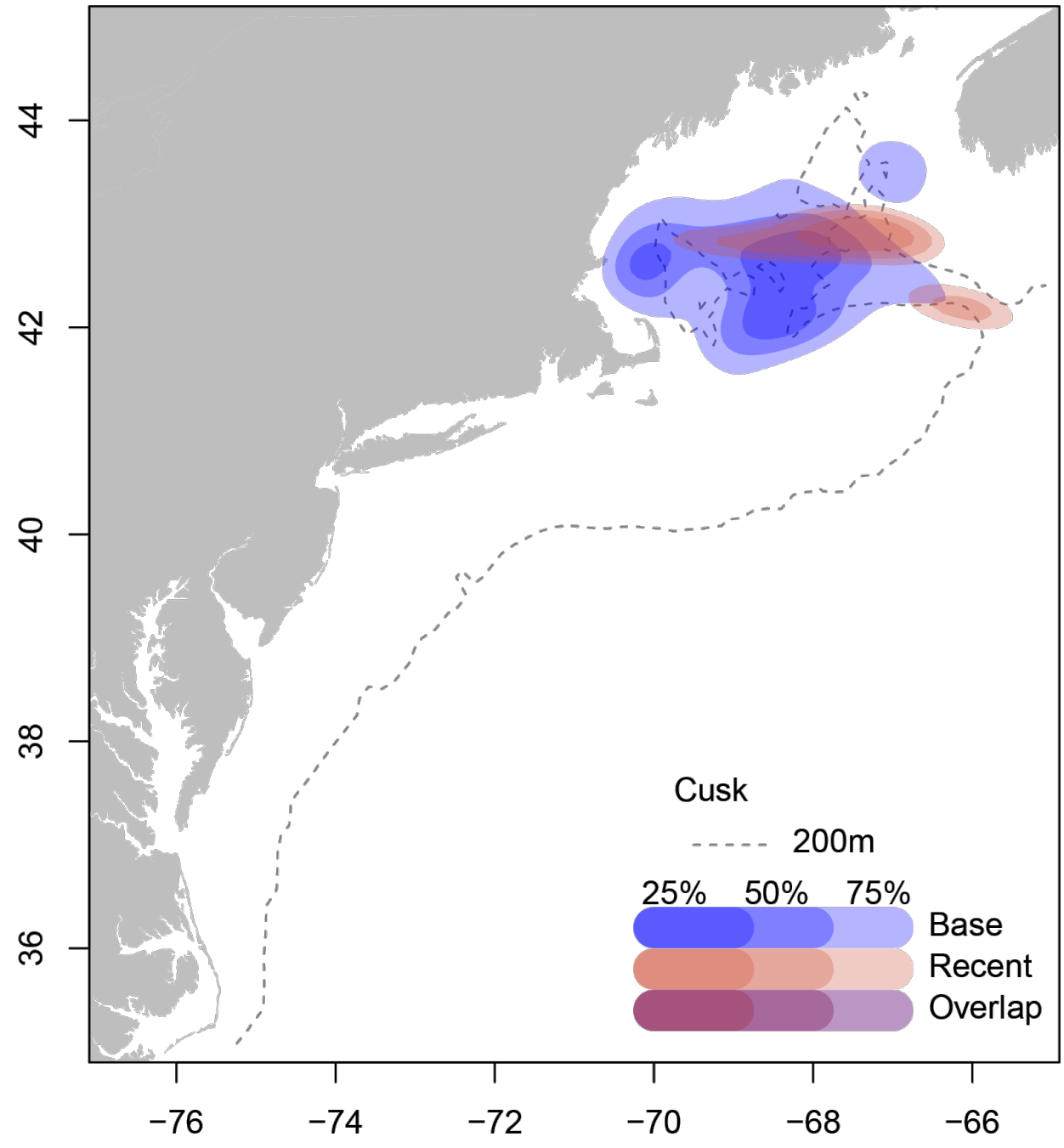
Kernel density plot of Clearnose skate. Blue = 1970s distributions; red = 2014-2016.

Cunner



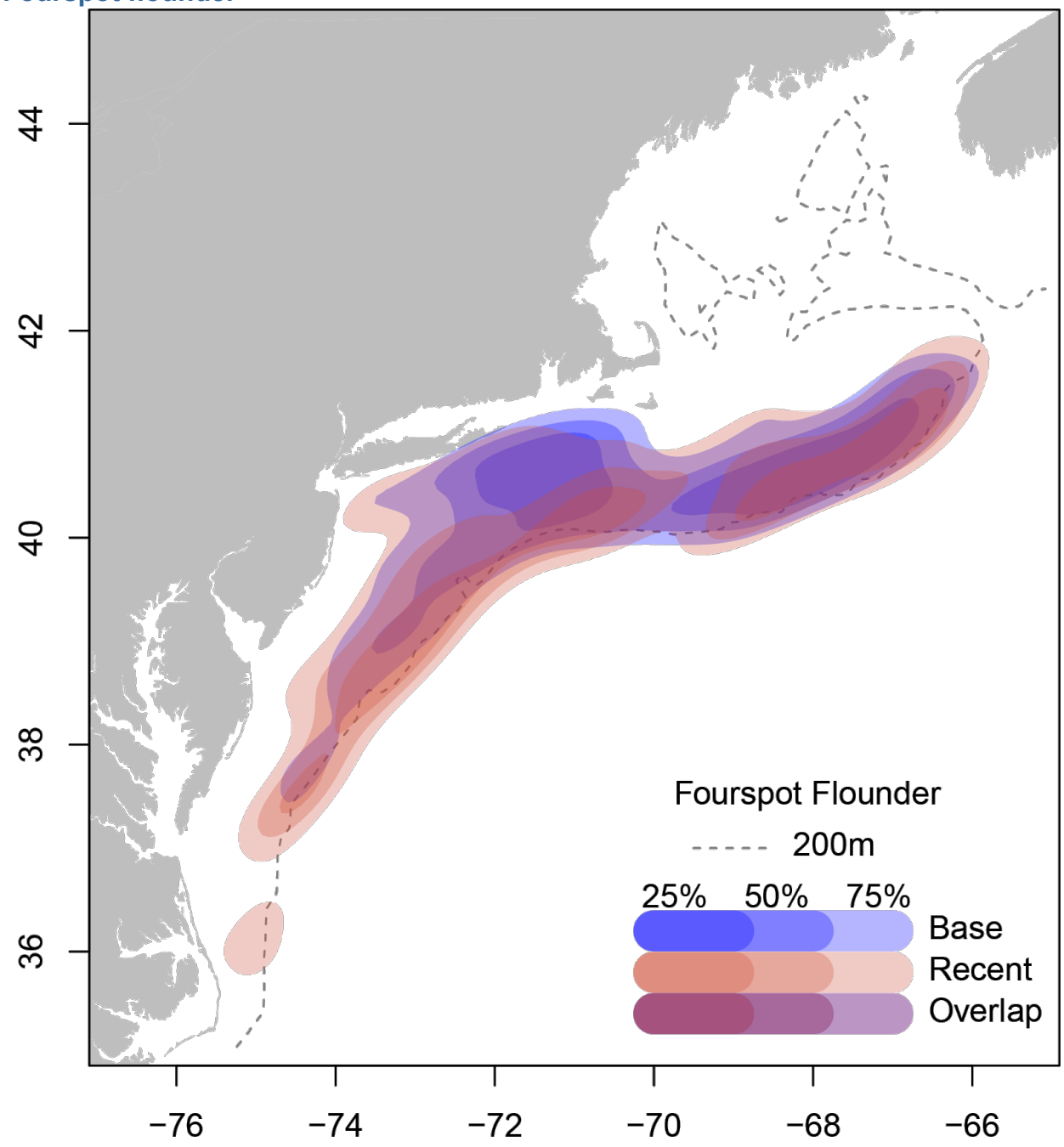
Kernel density plot of Cunner. Blue = 1970s distributions; red = 2014-2016.

Cusk



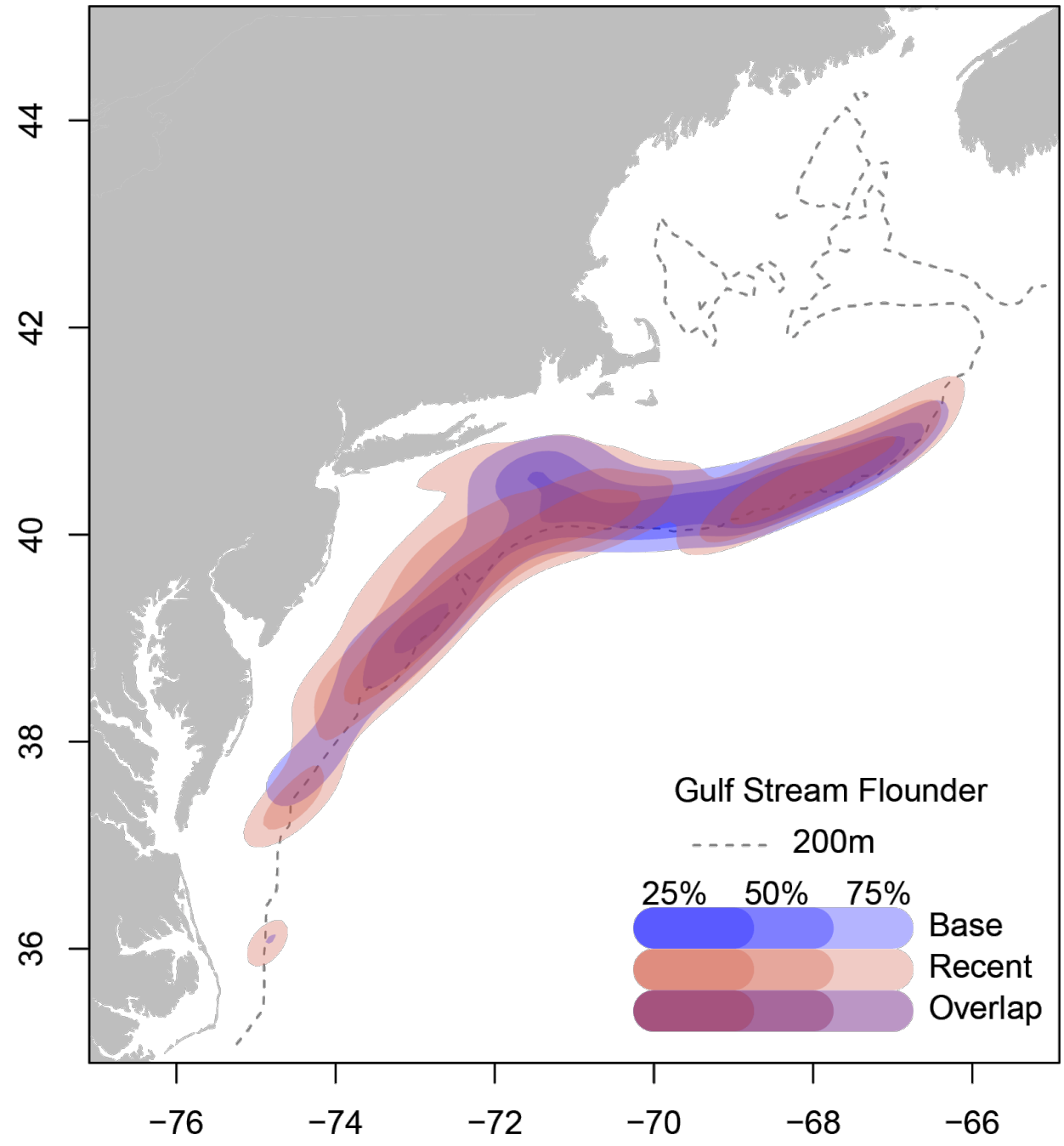
Kernel density plot of Cusk. Blue = 1970s distributions; red = 2014-2016.

Fourspot flounder



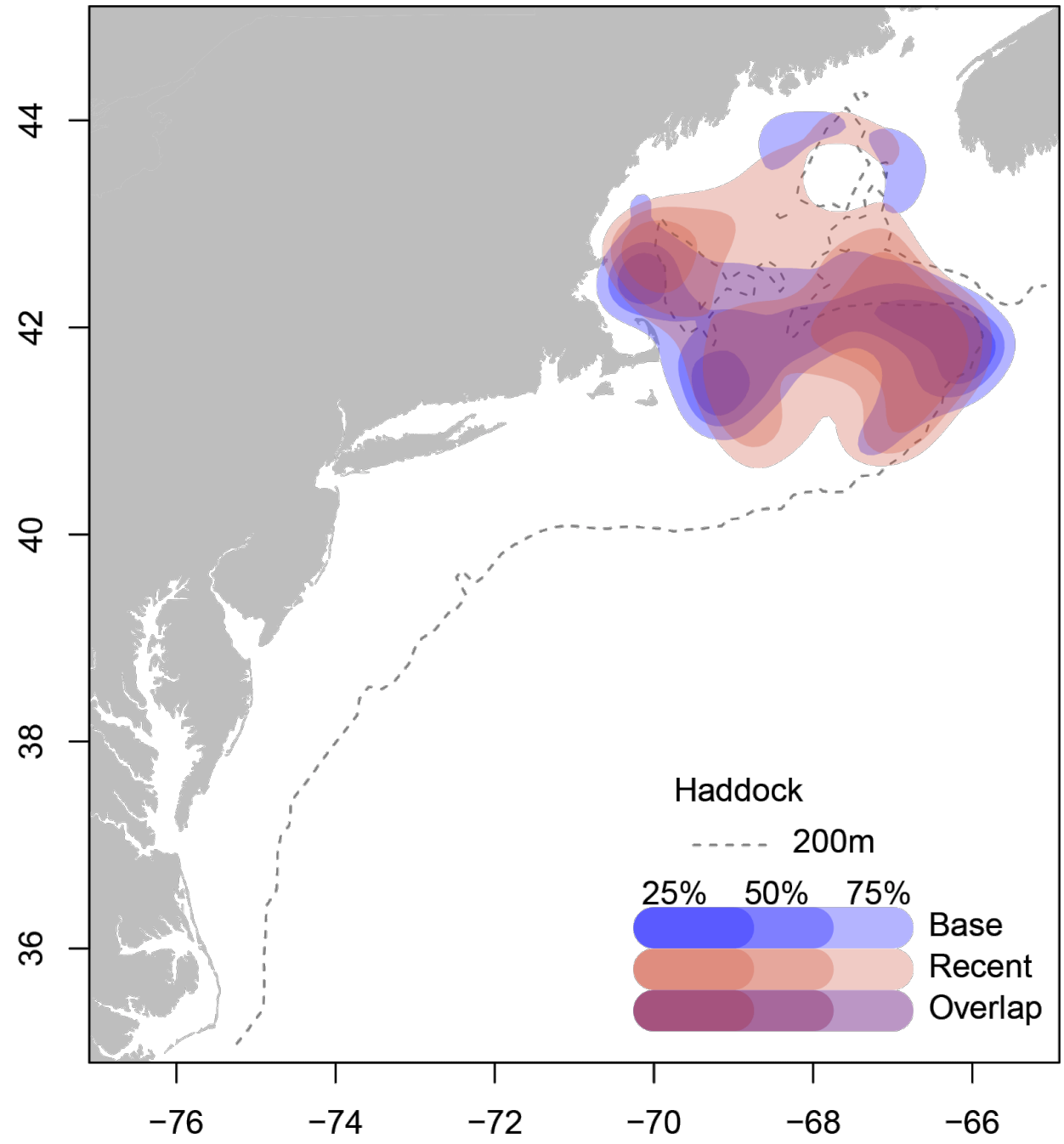
Kernel density plot of Fourspot flounder. Blue = 1970s distributions; red = 2014-2016.

Gulf Stream flounder



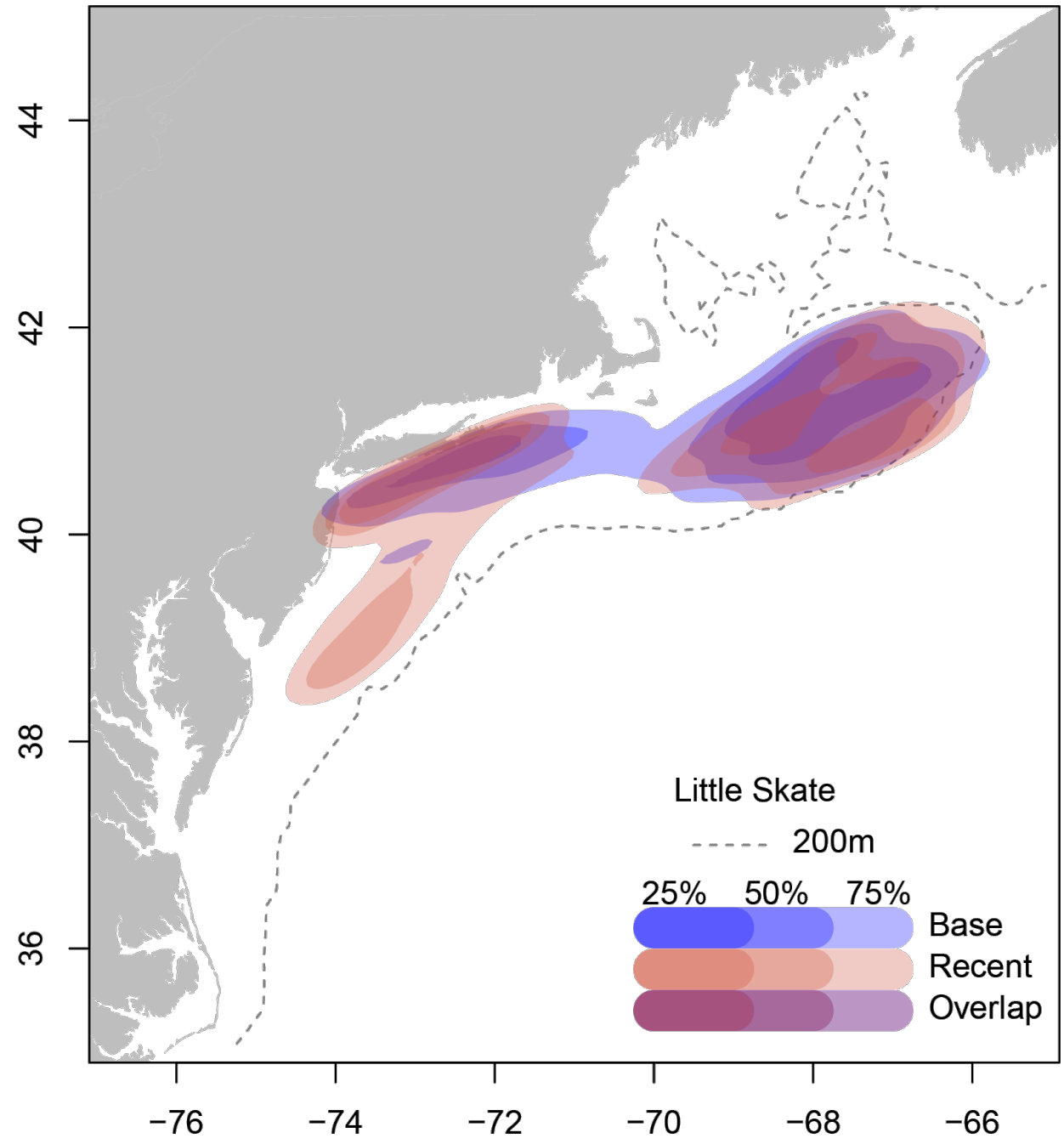
Kernel density plot of Gulf Stream flounder. Blue = 1970s distributions; red = 2014-2016.

Haddock



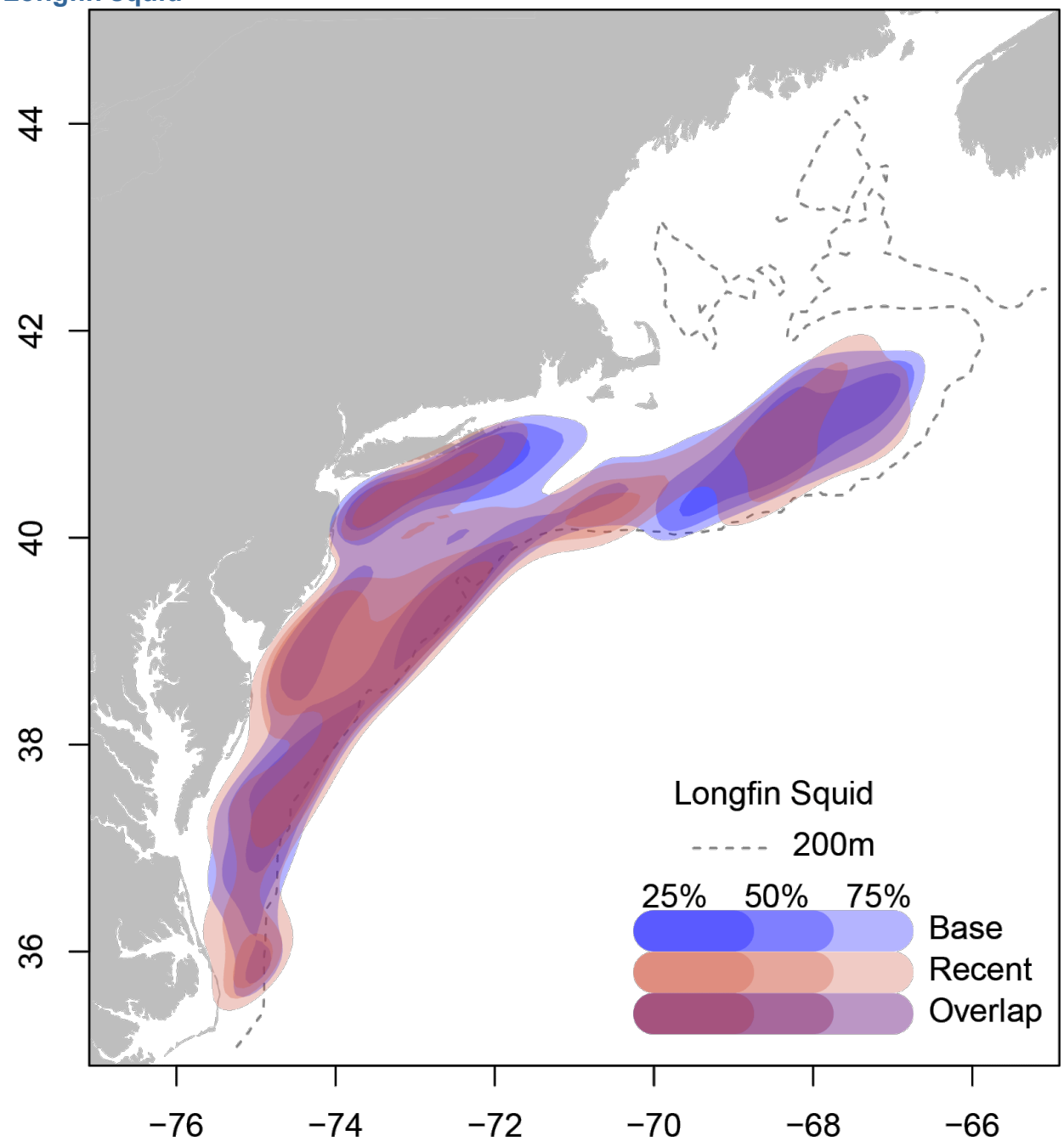
Kernel density plot of Haddock. Blue = 1970s distributions; red = 2014-2016.

Little Skate



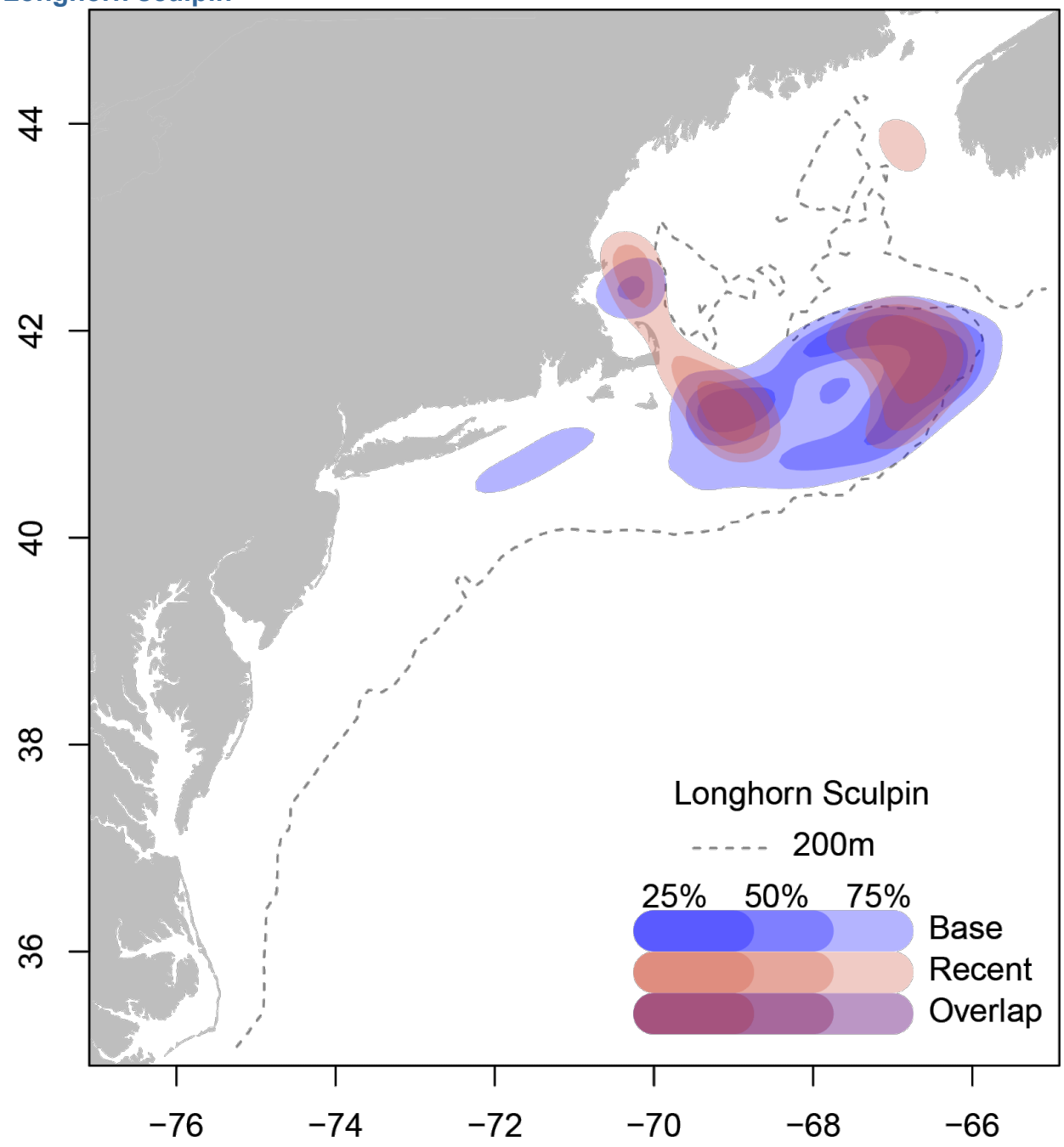
Kernel density plot of Little skate. Blue = 1970s distributions; red = 2014-2016.

Longfin squid



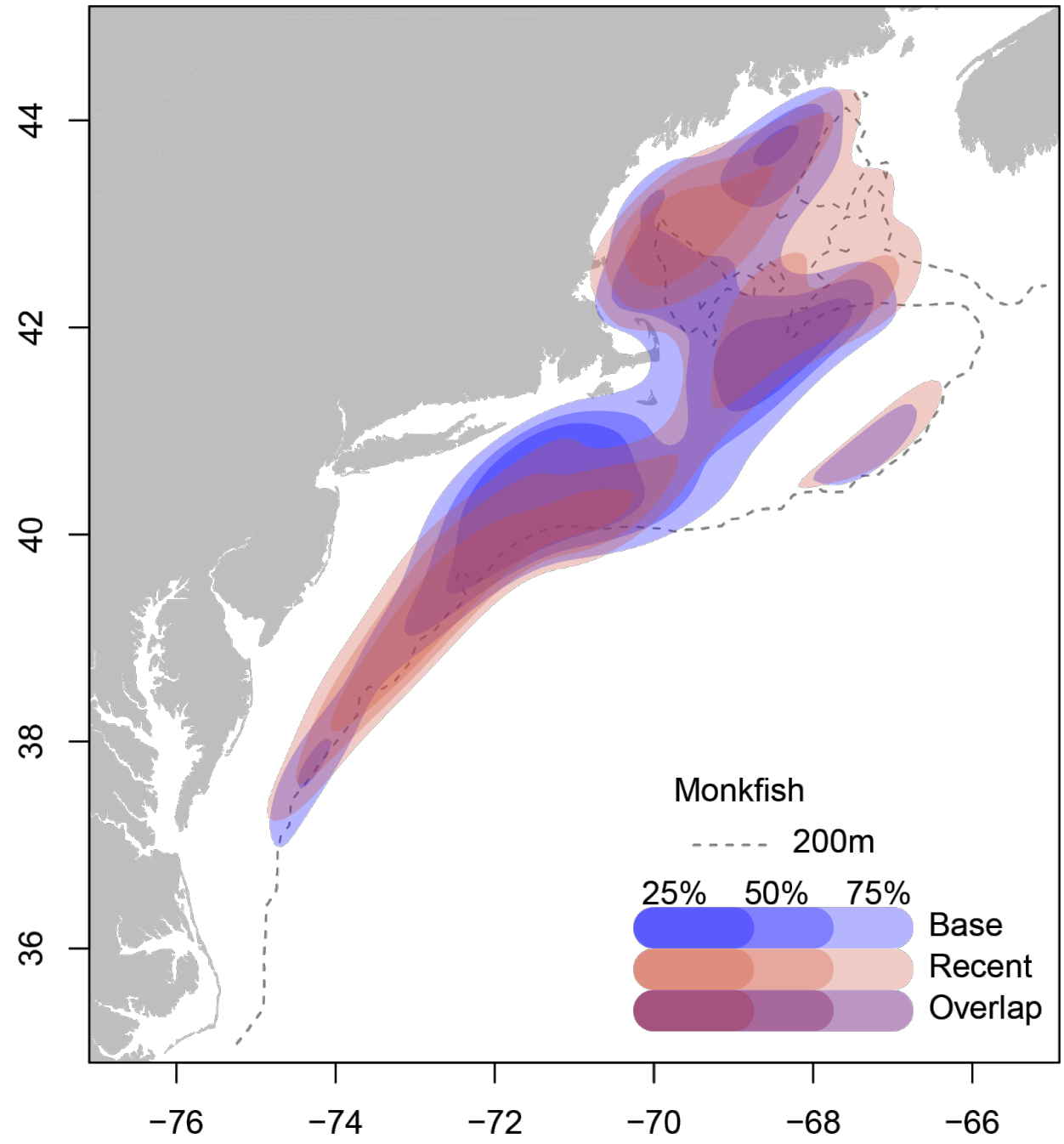
Kernel density plot of Longfin squid. Blue = 1970s distributions; red = 2014-2016.

Longhorn sculpin



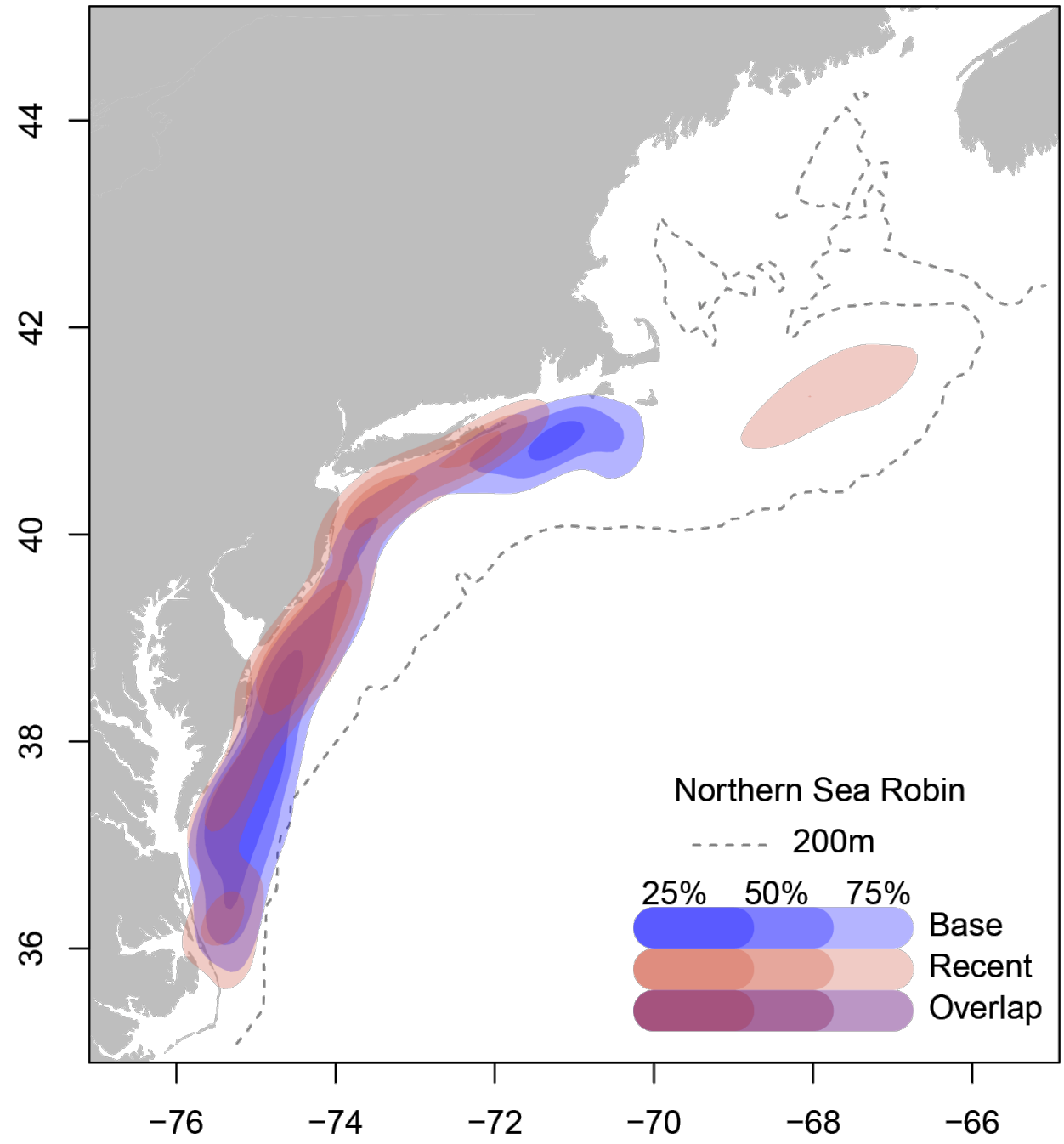
Kernel density plot of Longhorn sculpin. Blue = 1970s distributions; red = 2014-2016.

Monkfish



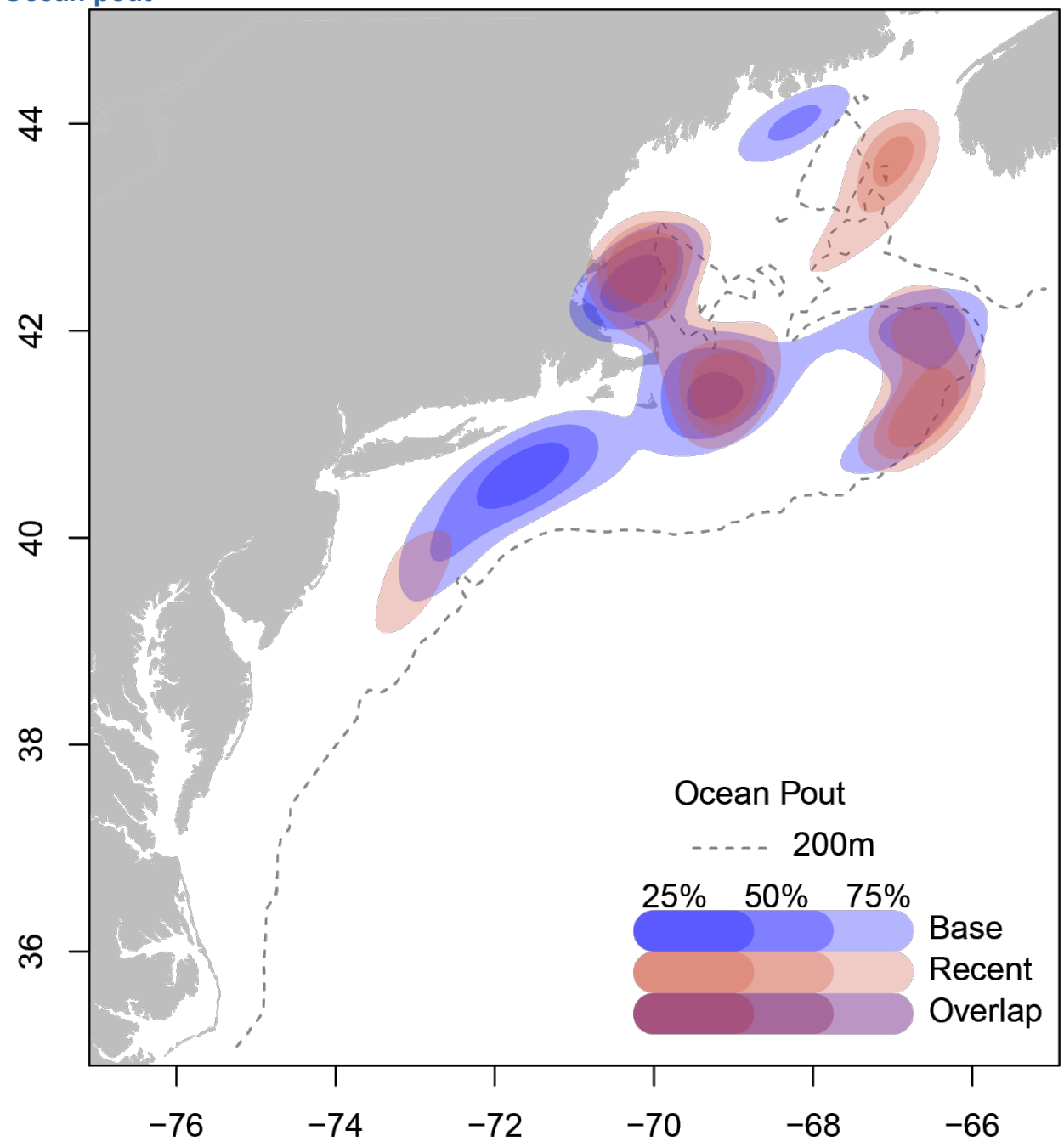
Kernel density plot of Monkfish. Blue = 1970s distributions; red = 2014-2016.

Northern sea robin



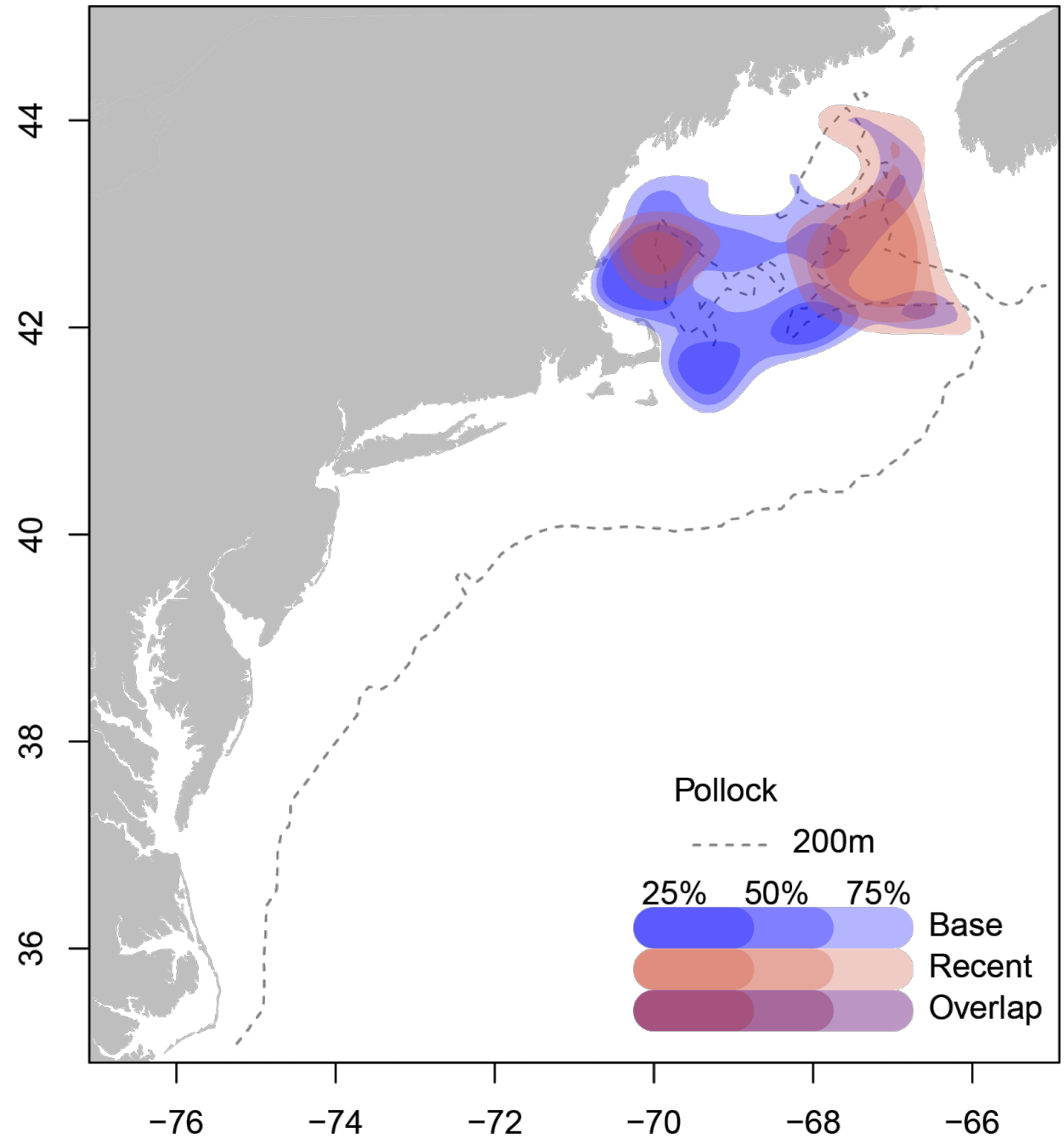
Kernel density plot of Northern sea robin. Blue = 1970s distributions; red = 2014-2016.

Ocean pout



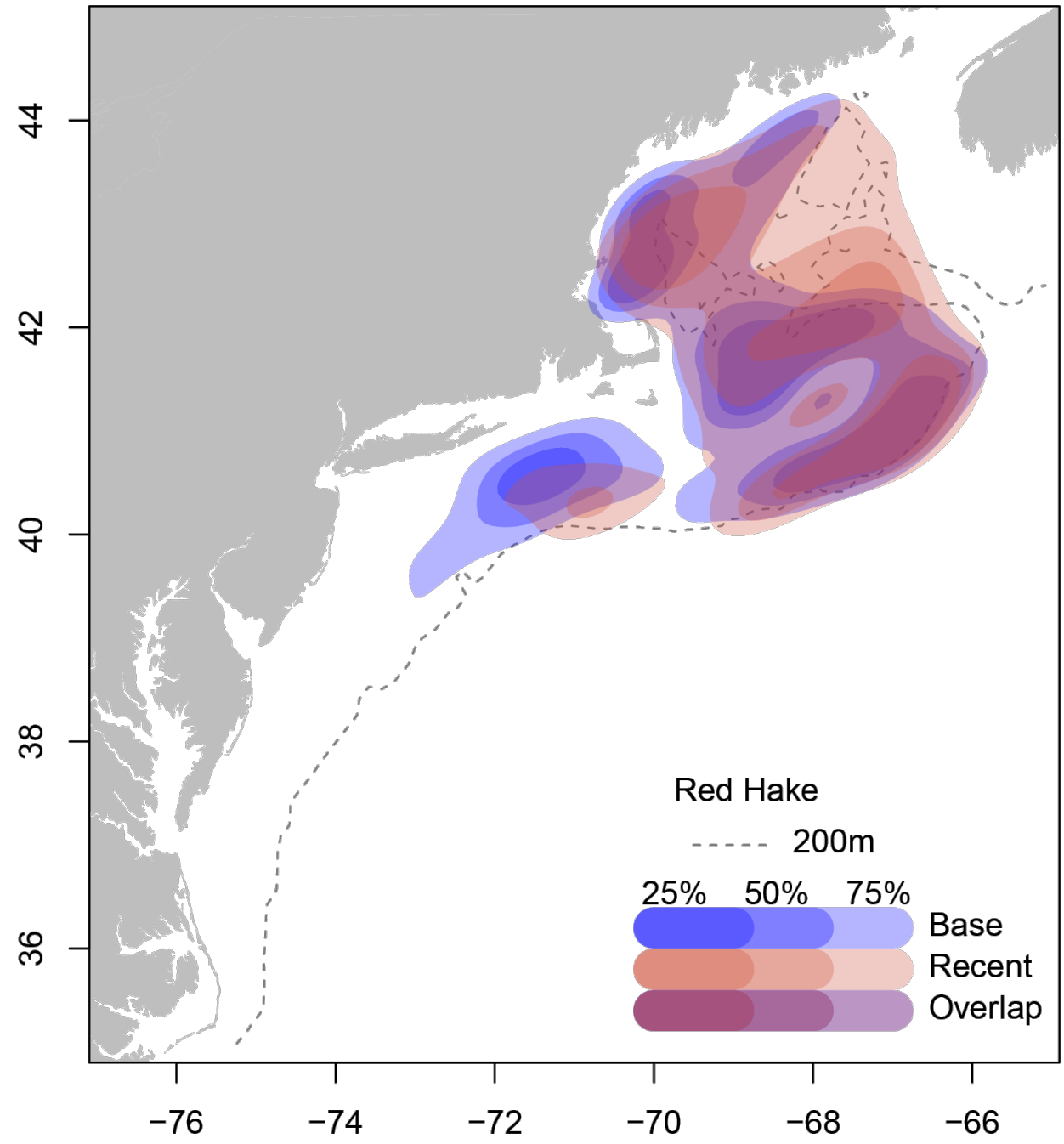
Kernel density plot of Ocean pout. Blue = 1970s distributions; red = 2014-2016.

Pollock



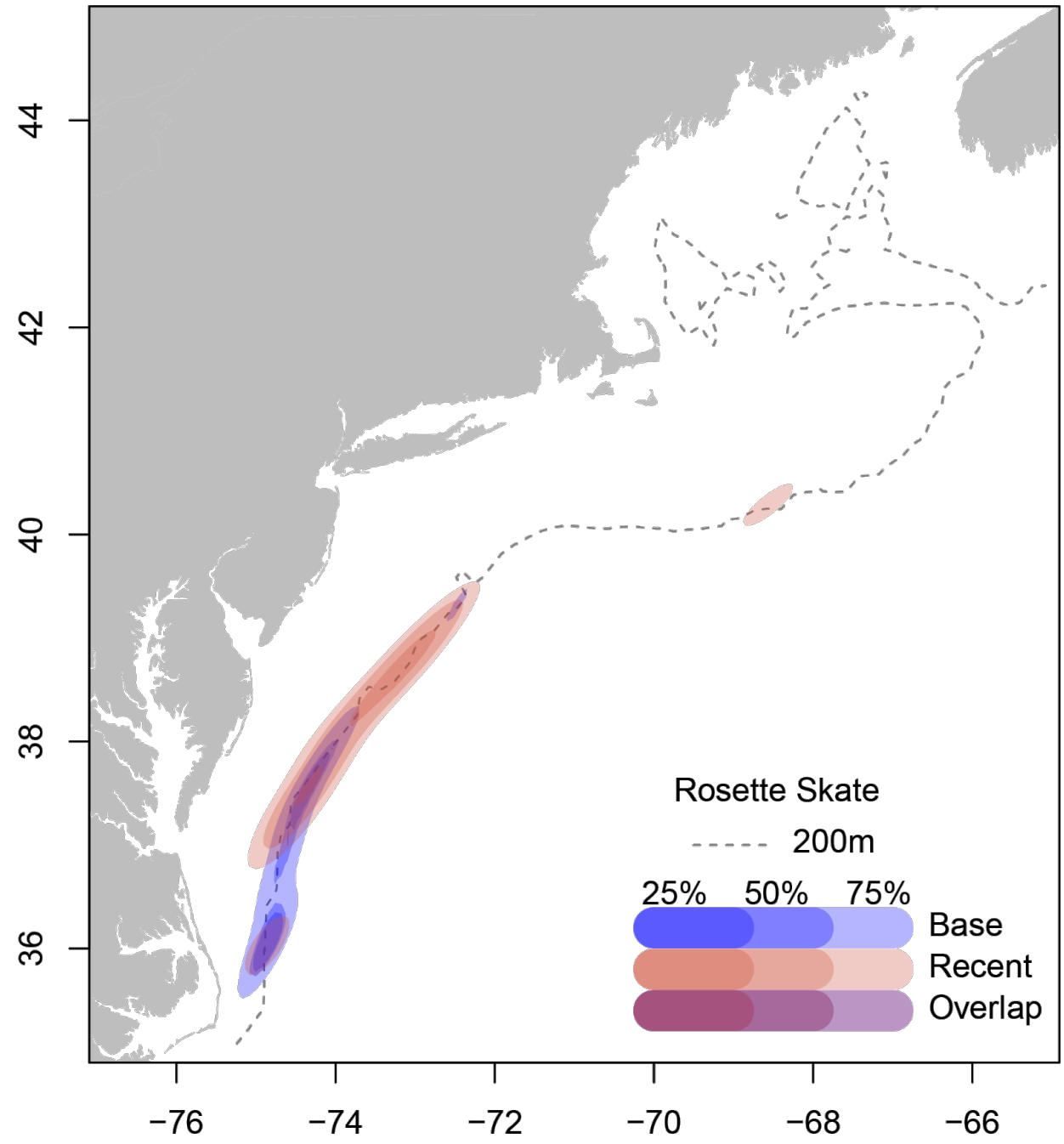
Kernel density plot of Pollock. Blue = 1970s distributions; red = 2014-2016.

Red hake



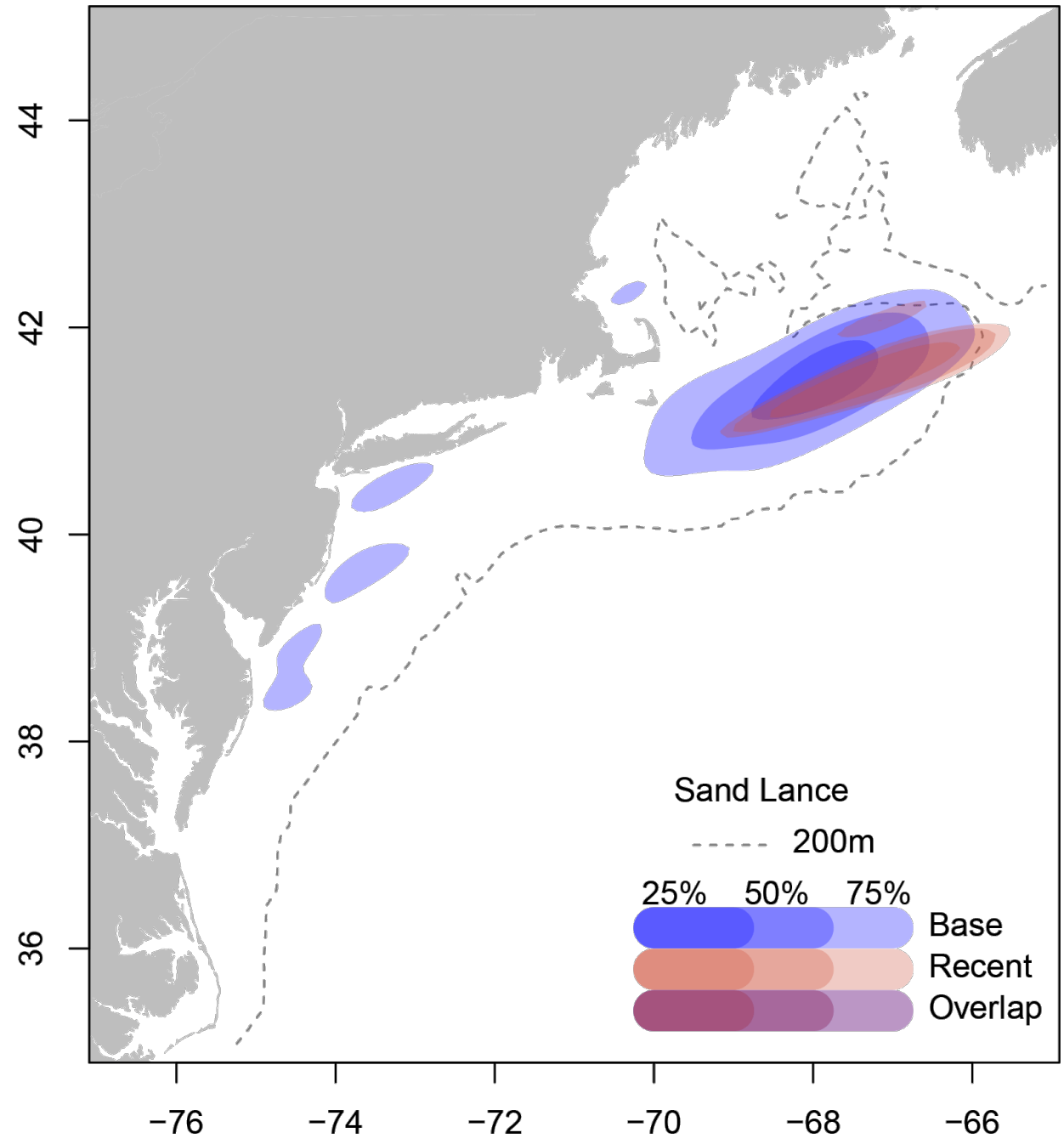
Kernel density plot of Red hake. Blue = 1970s distributions; red = 2014-2016.

Rosette skate



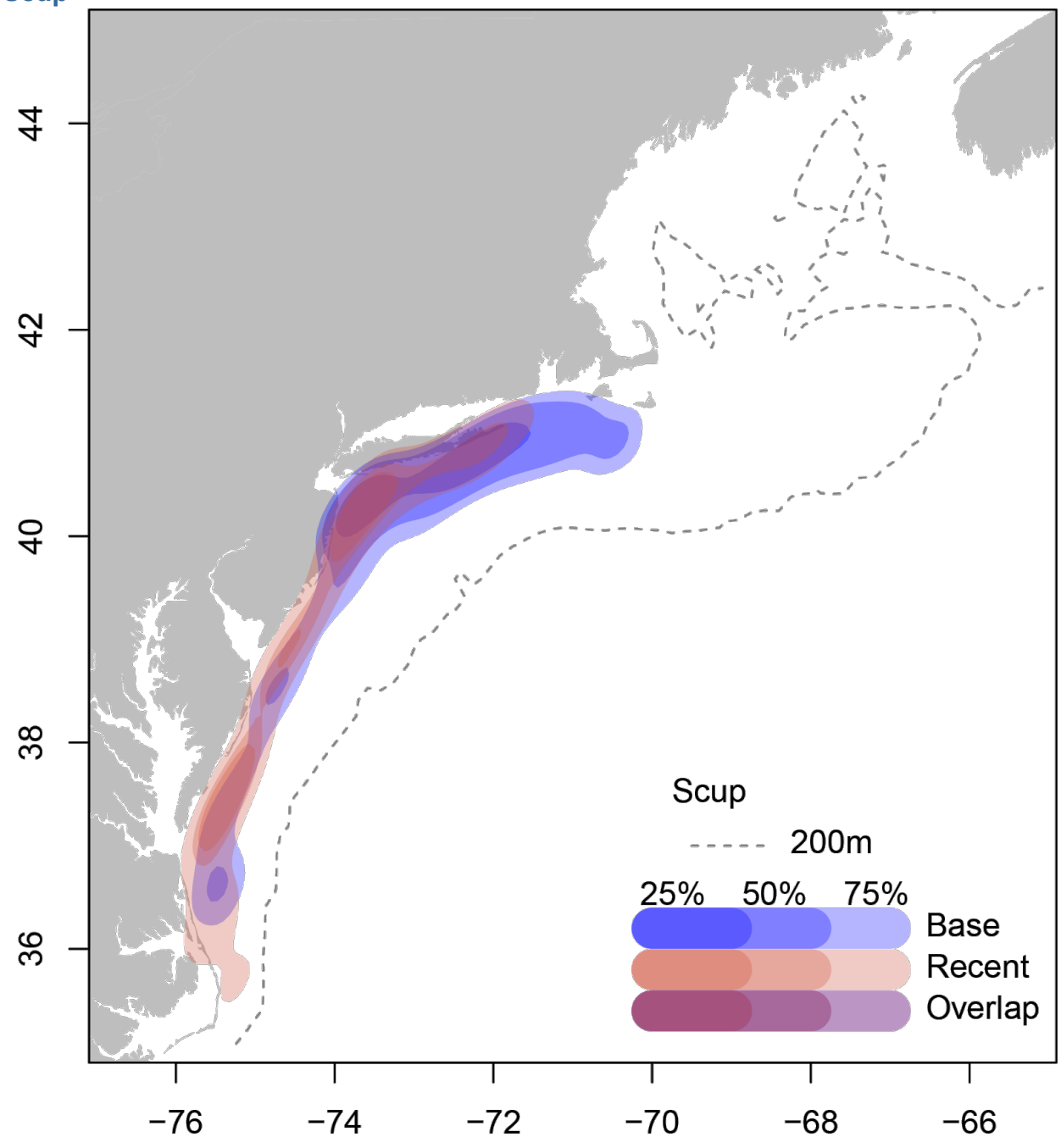
Kernel density plot of Rosette skate. Blue = 1970s distributions; red = 2014-2016.

Sand lance



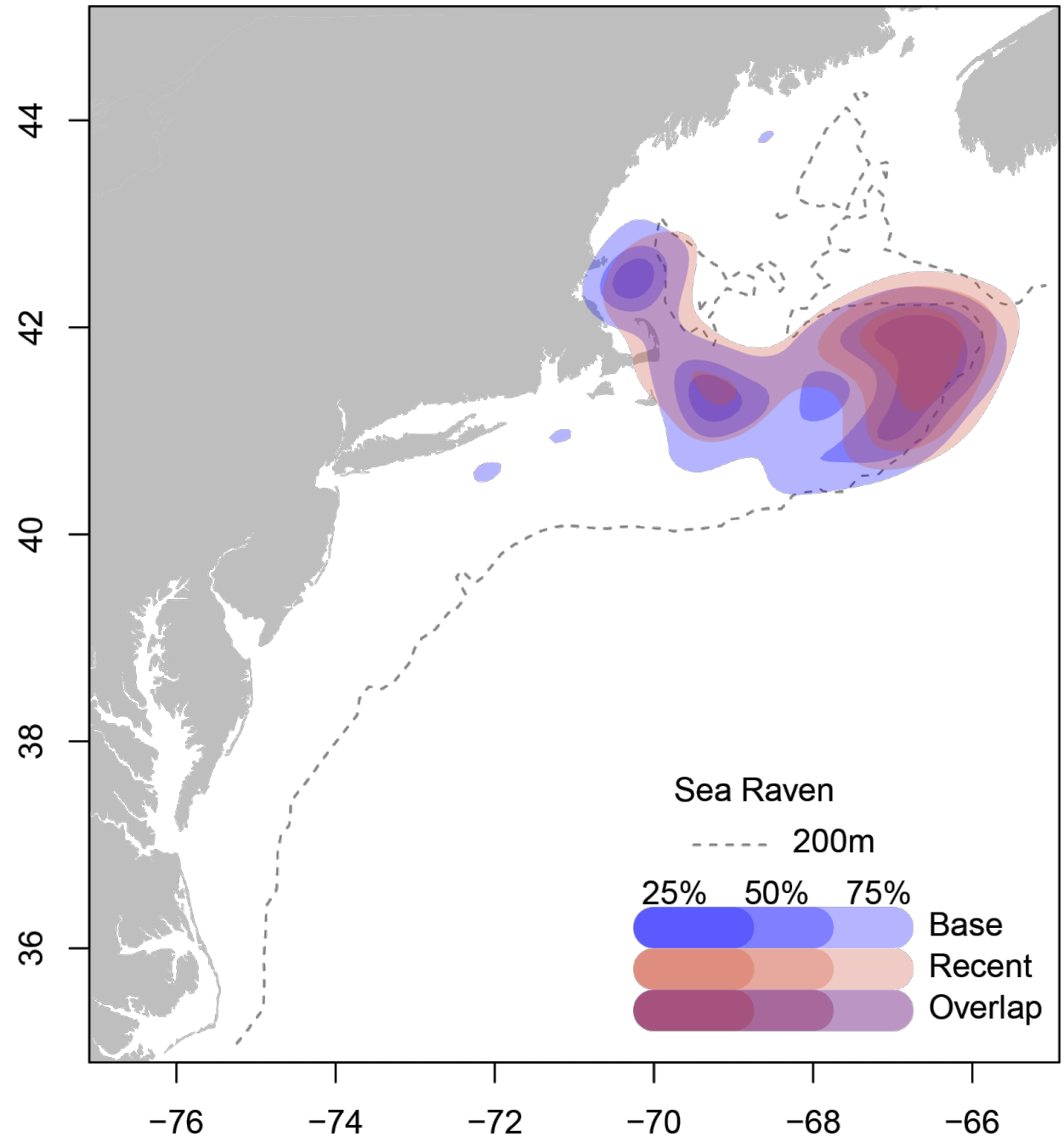
Kernel density plot of Sand lance. Blue = 1970s distributions; red = 2014-2016.

Scup



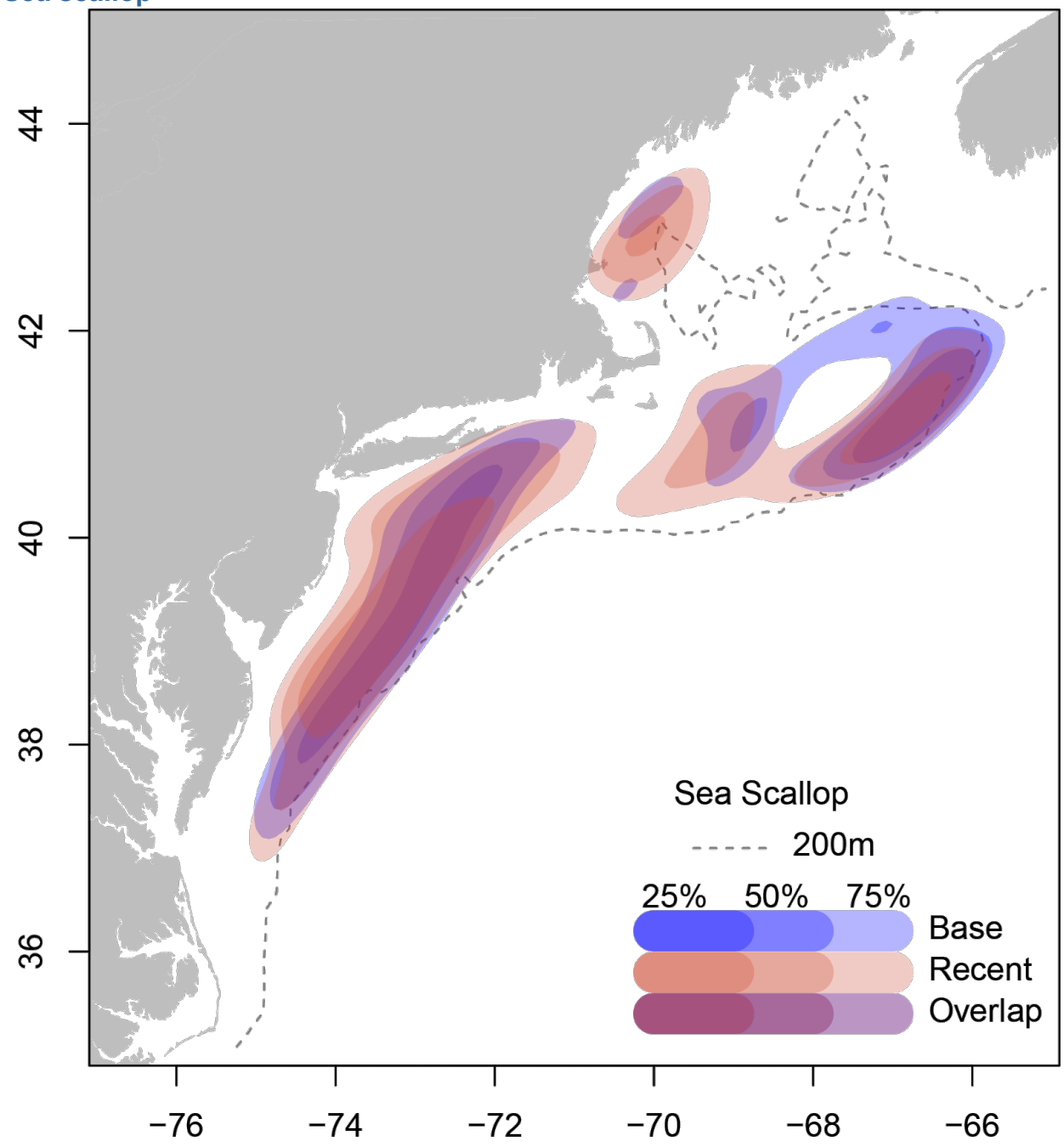
Kernel density plot of Scup. Blue = 1970s distributions; red = 2014-2016.

Sea raven



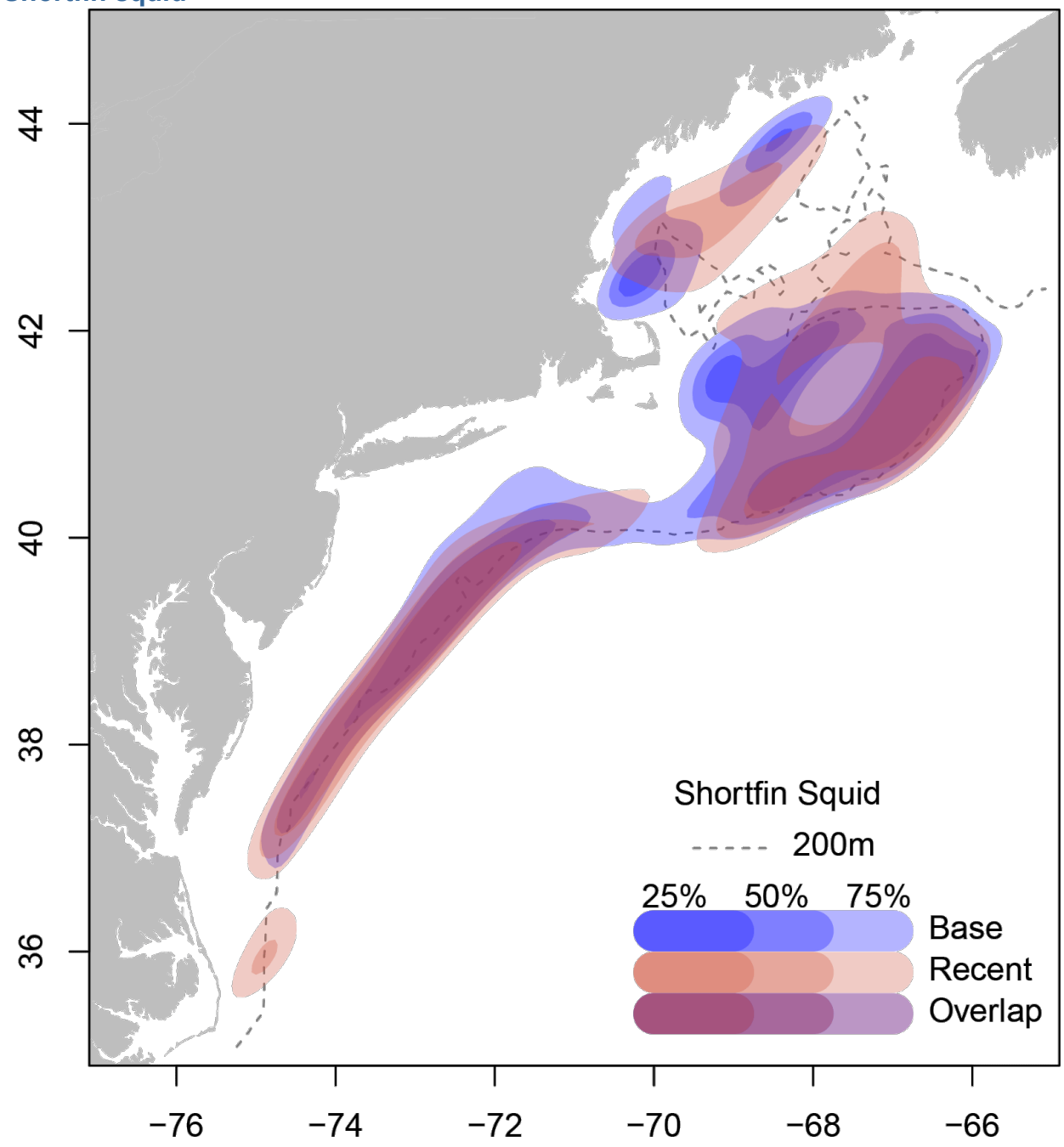
Kernel density plot of Sea raven. Blue = 1970s distributions; red = 2014-2016.

Sea scallop



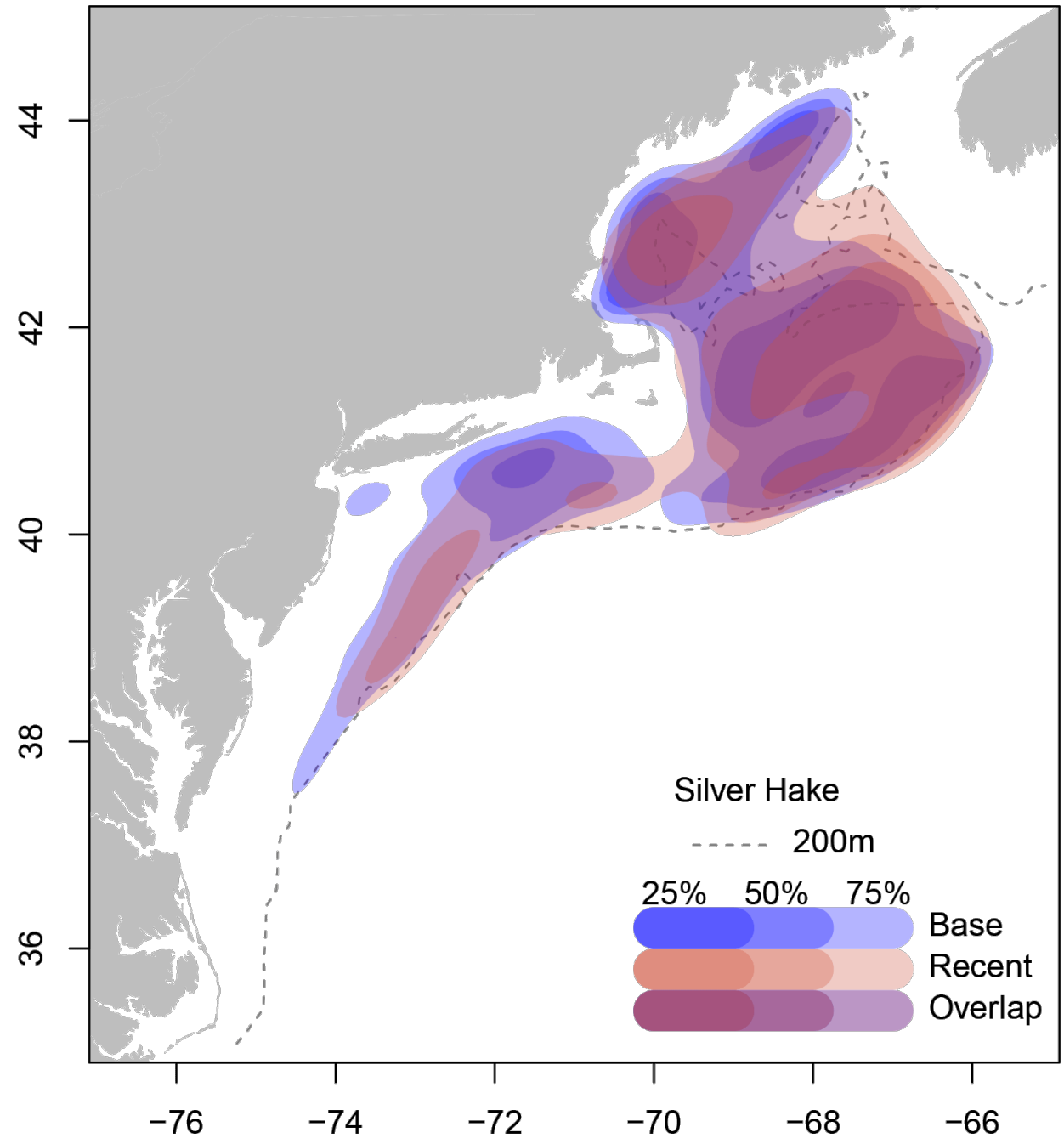
Kernel density plot of sea scallop. Blue = 1970s distributions; red = 2014-2016.

Shortfin squid



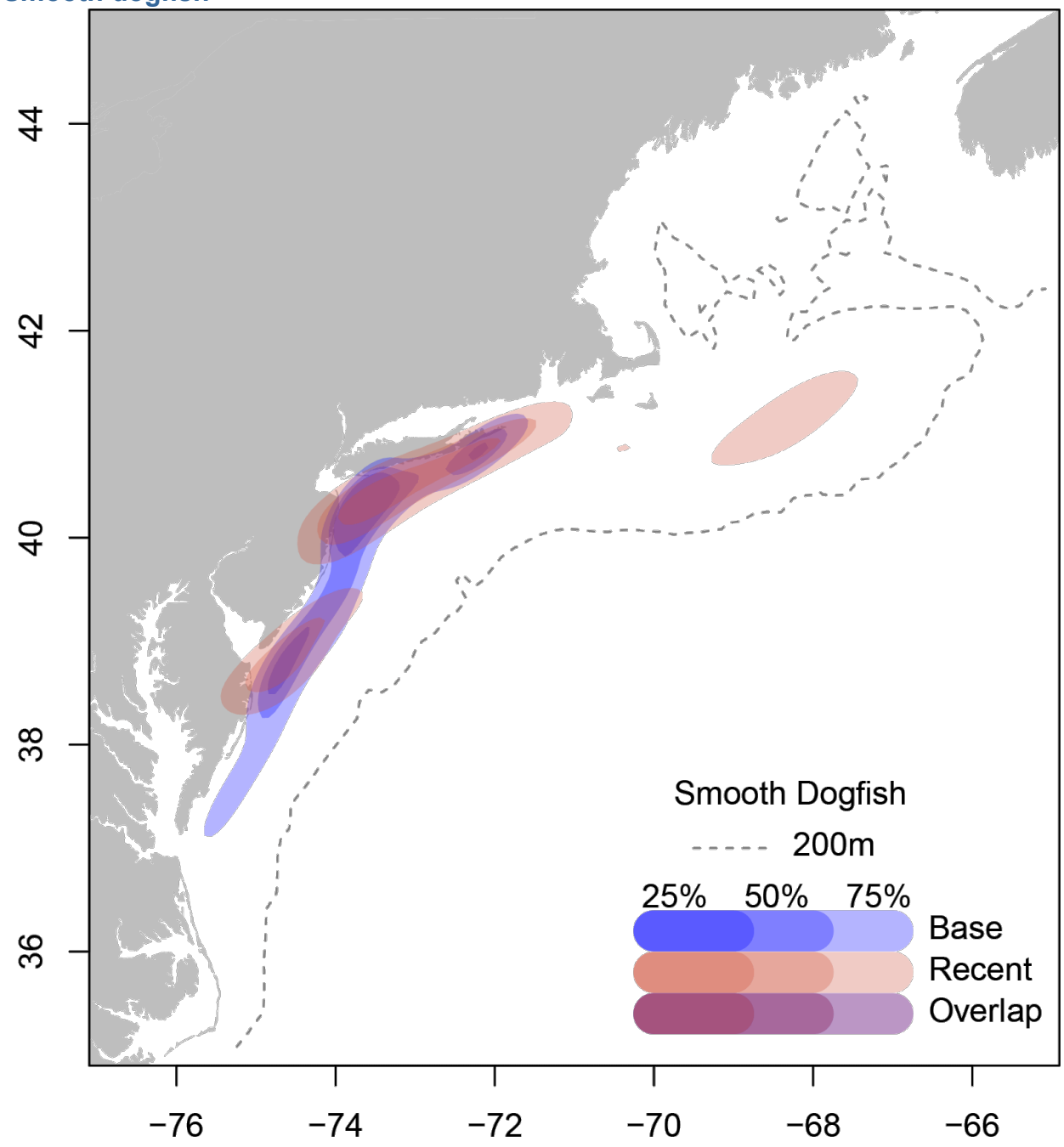
Kernel density plot of Shortfin sqid. Blue = 1970s distributions; red = 2014-2016.

Silver hake



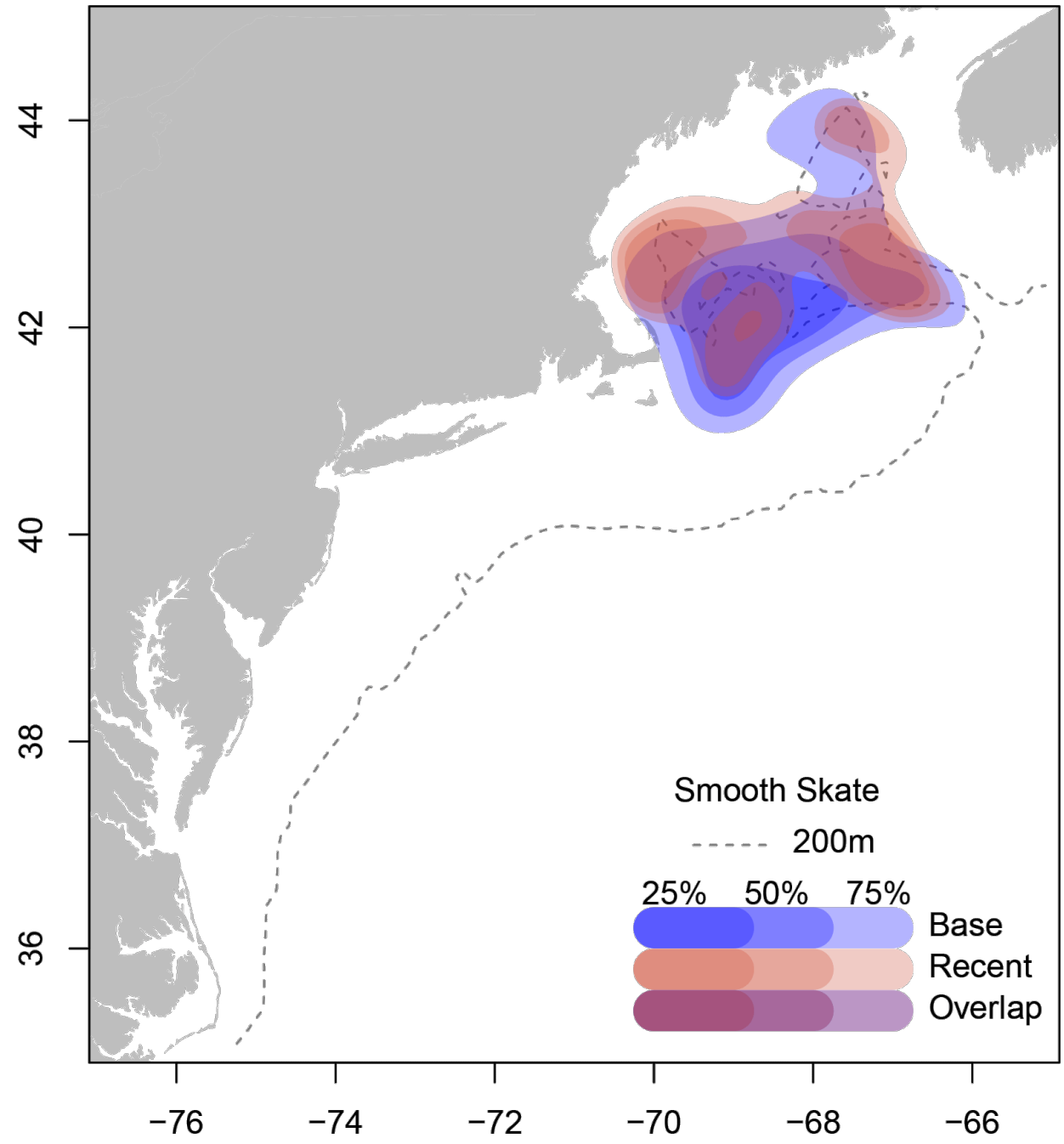
Kernel density plot of Silver hake. Blue = 1970s distributions; red = 2014-2016.

Smooth dogfish



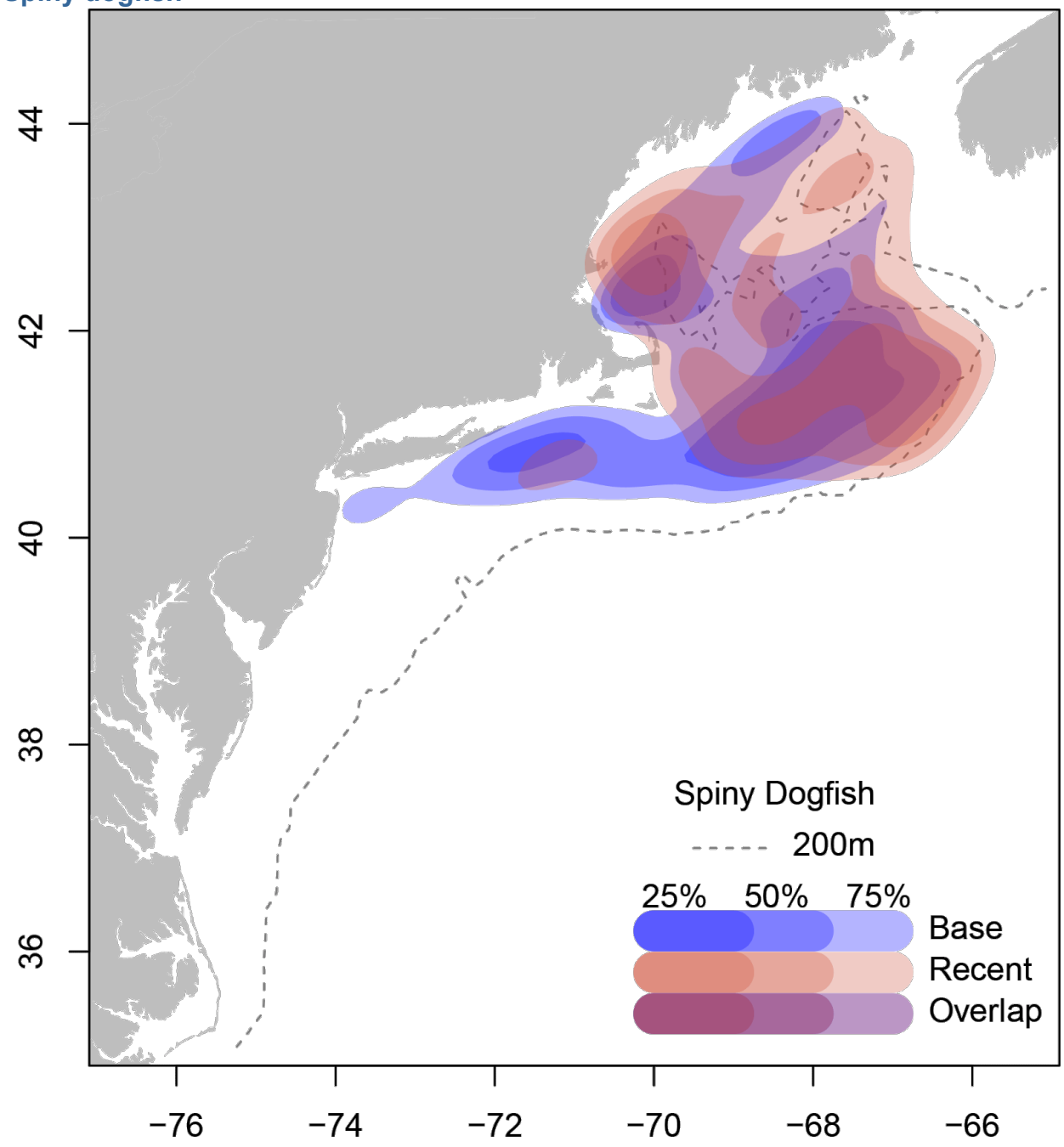
Kernel density plot of Smooth dogfish. Blue = 1970s distributions; red = 2014-2016.

Smooth skate



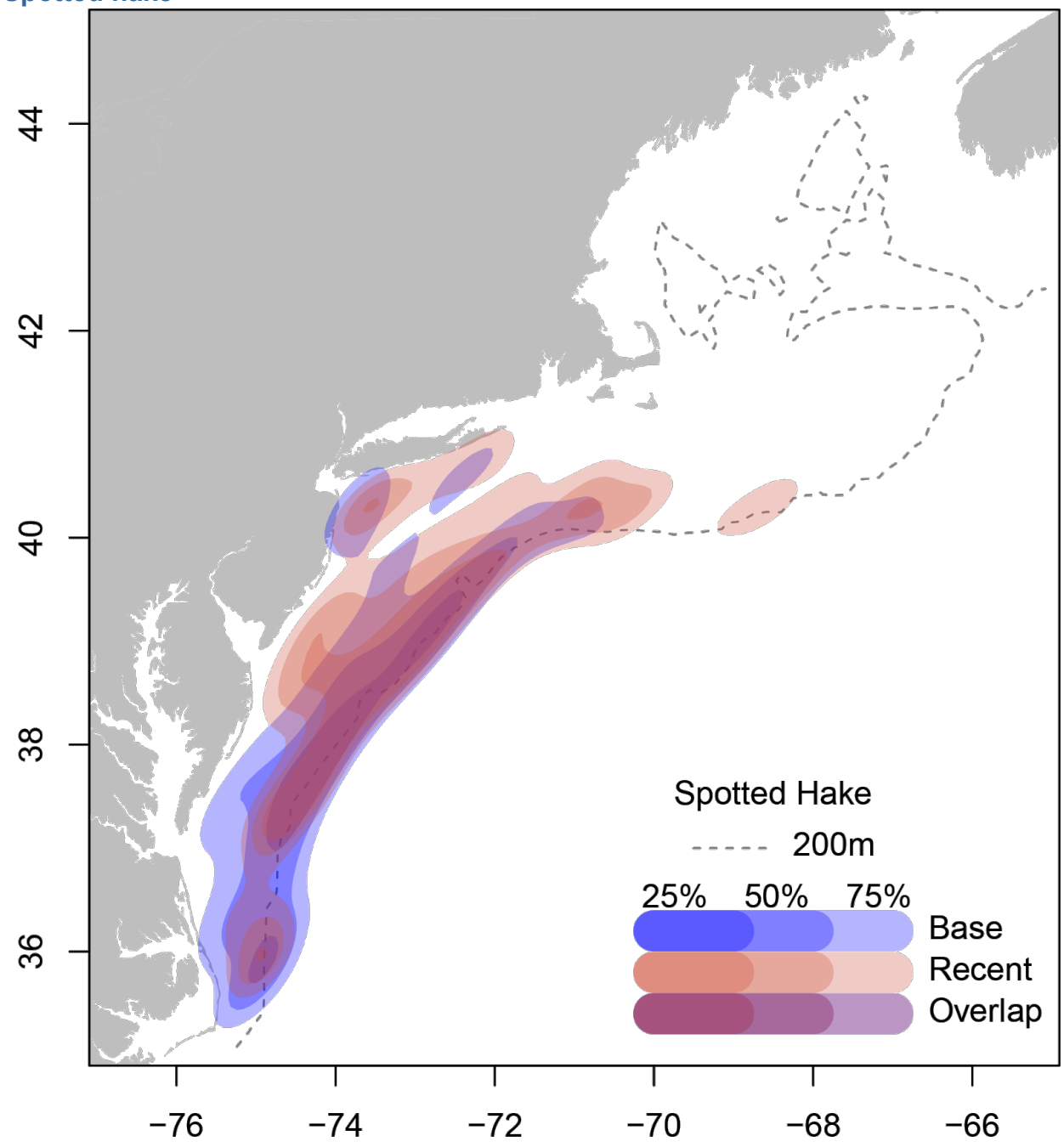
Kernel density plot of Smooth skate. Blue = 1970s distributions; red = 2014-2016.

Spiny dogfish



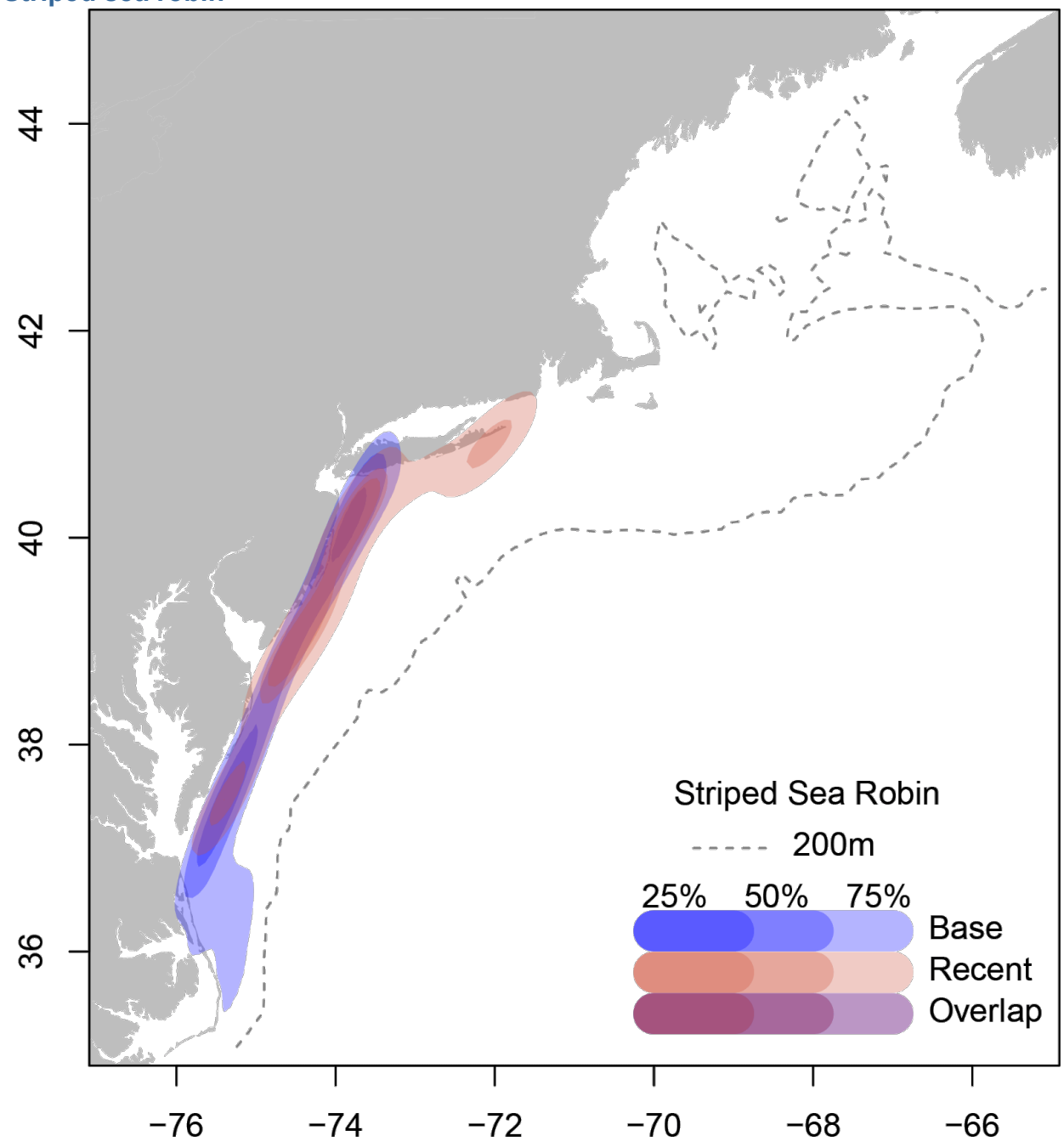
Kernel density plot of Spiny dogfish. Blue = 1970s distributions; red = 2014-2016.

Spotted hake



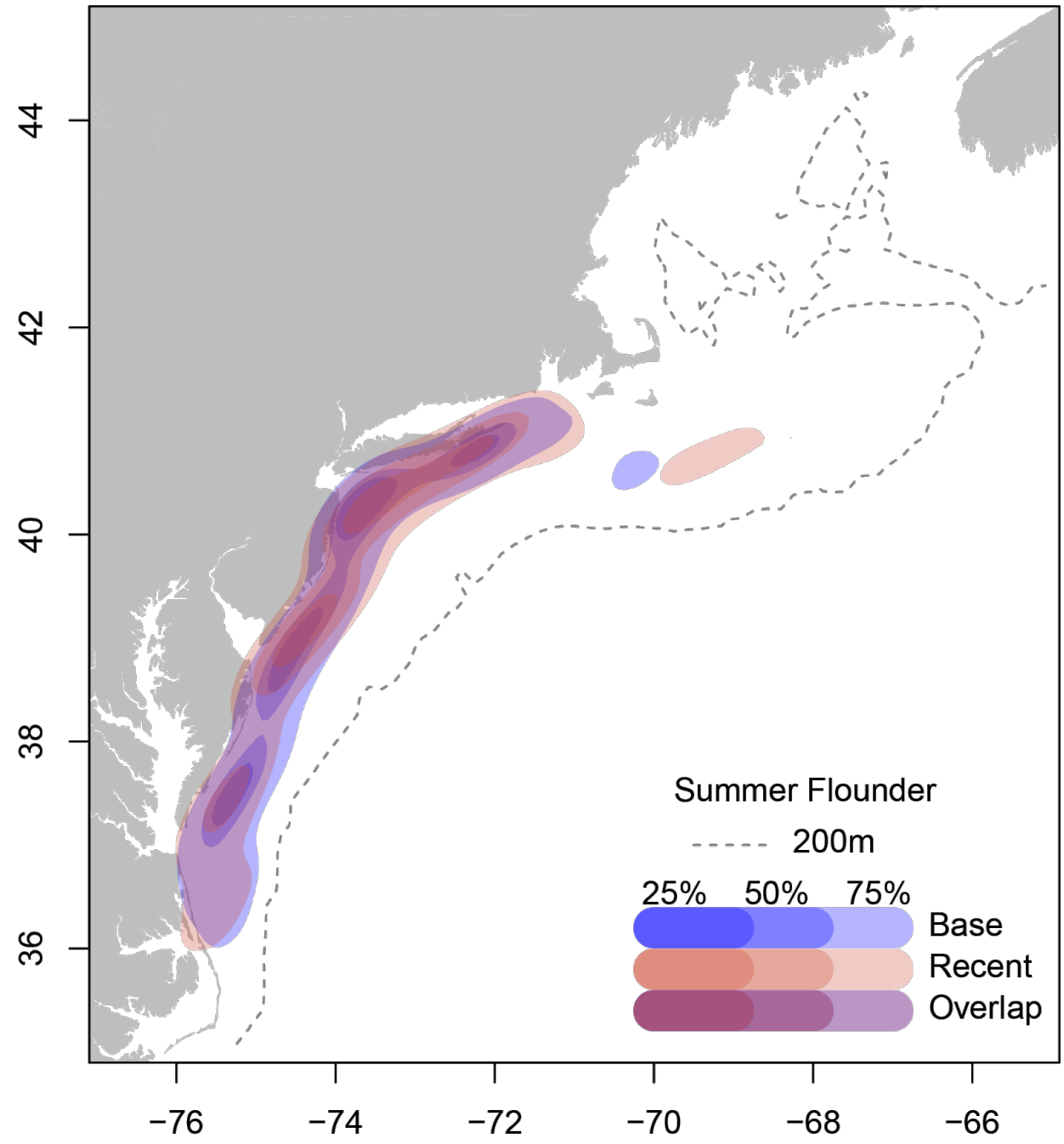
Kernel density plot of Spotted hake. Blue = 1970s distributions; red = 2014-2016.

Striped sea robin



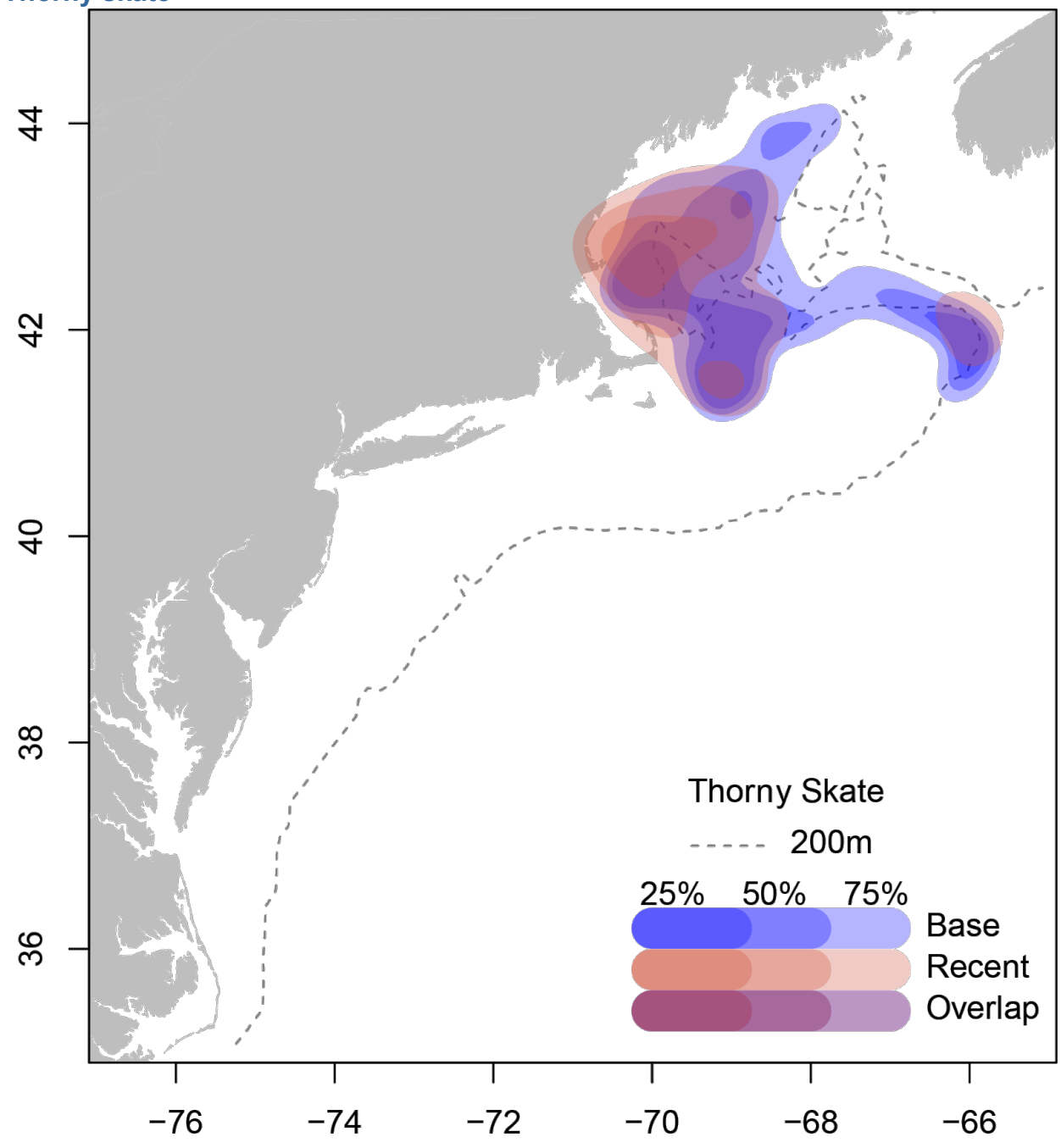
Kernel density plot of Striped sea robin. Blue = 1970s distributions; red = 2014-2016.

Summer flounder



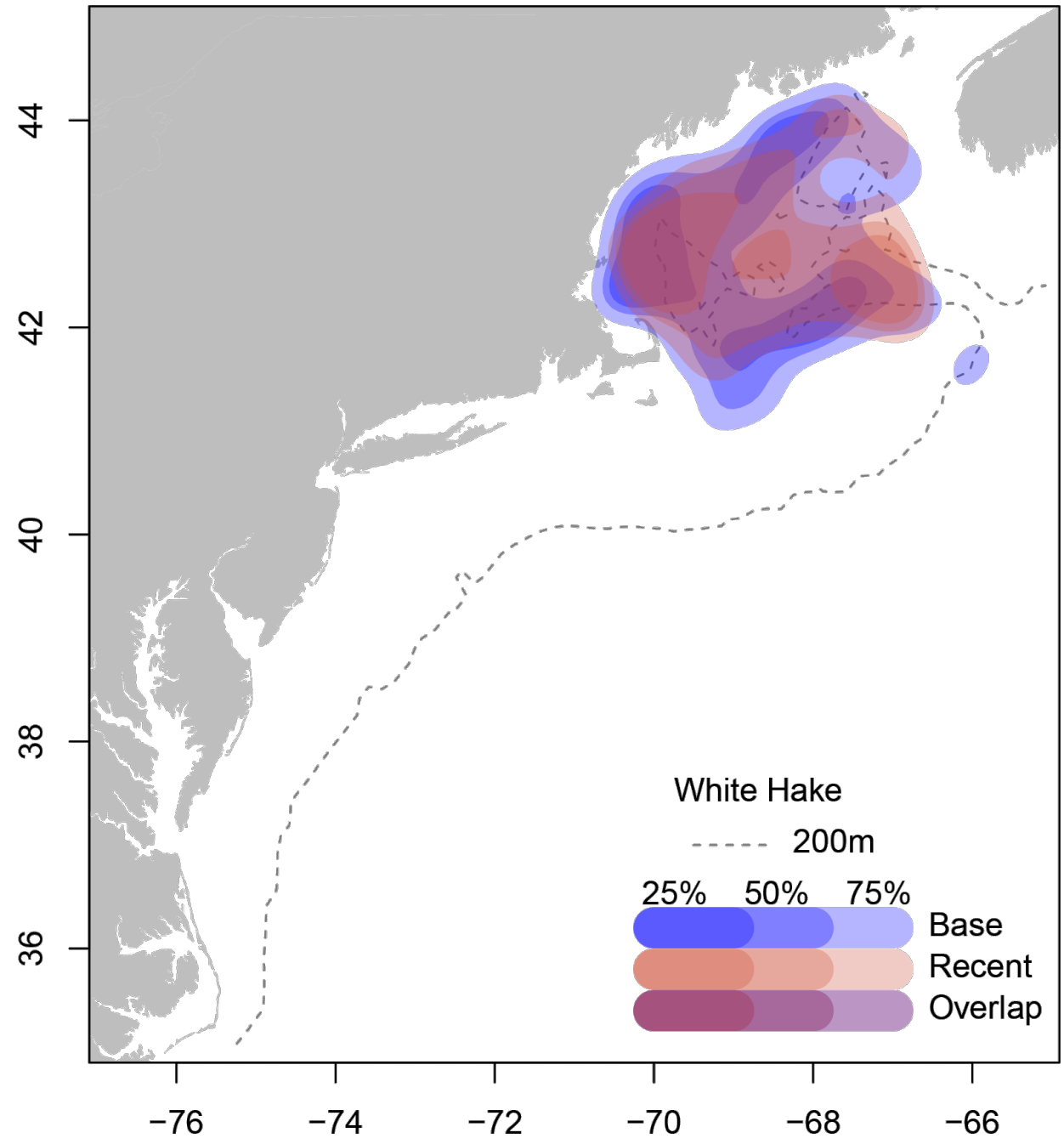
Kernel density plot of Summer flounder. Blue = 1970s distributions; red = 2014-2016.

Thorny skate



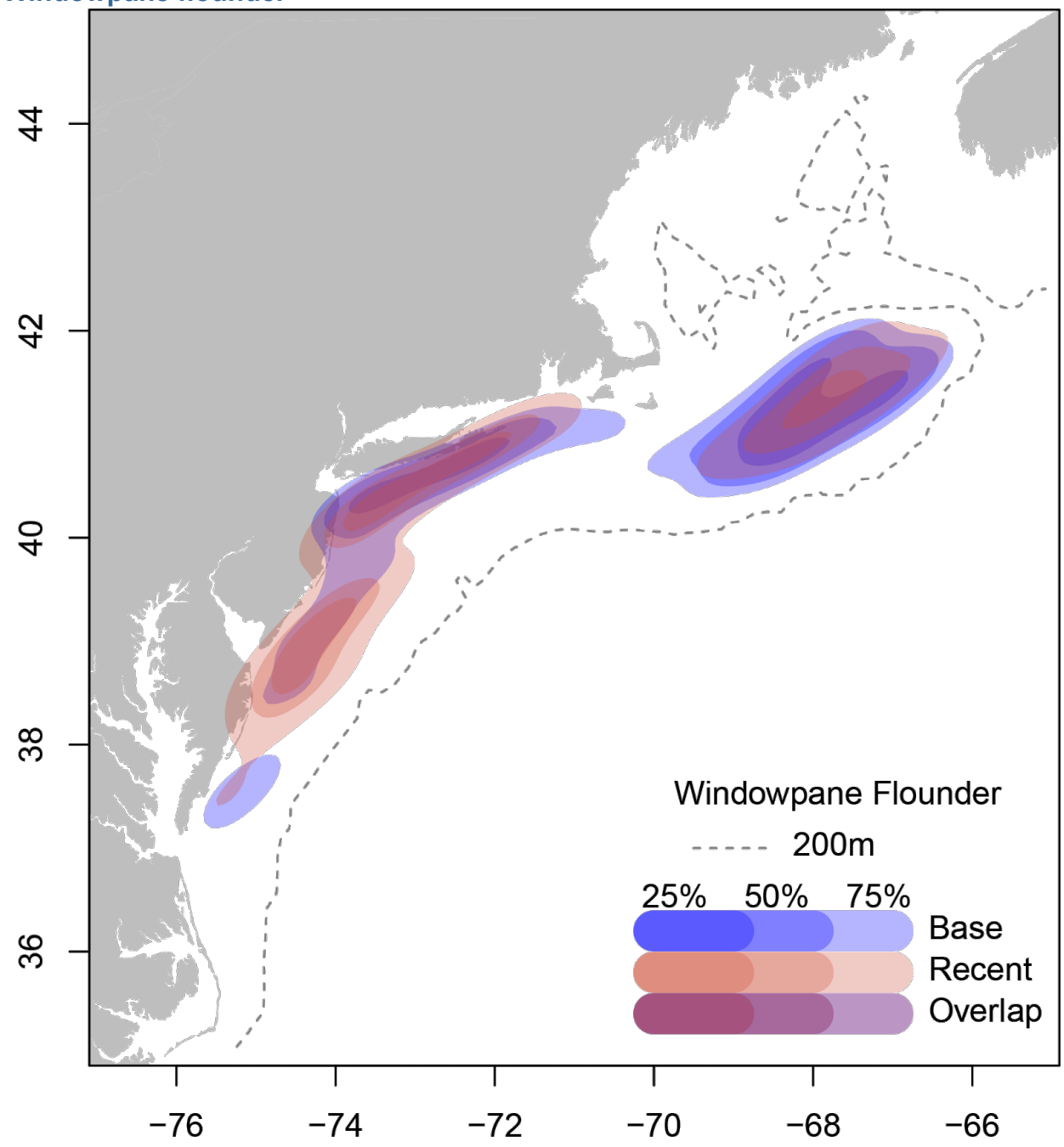
Kernel density plot of Thorny skate. Blue = 1970s distributions; red = 2014-2016.

White hake



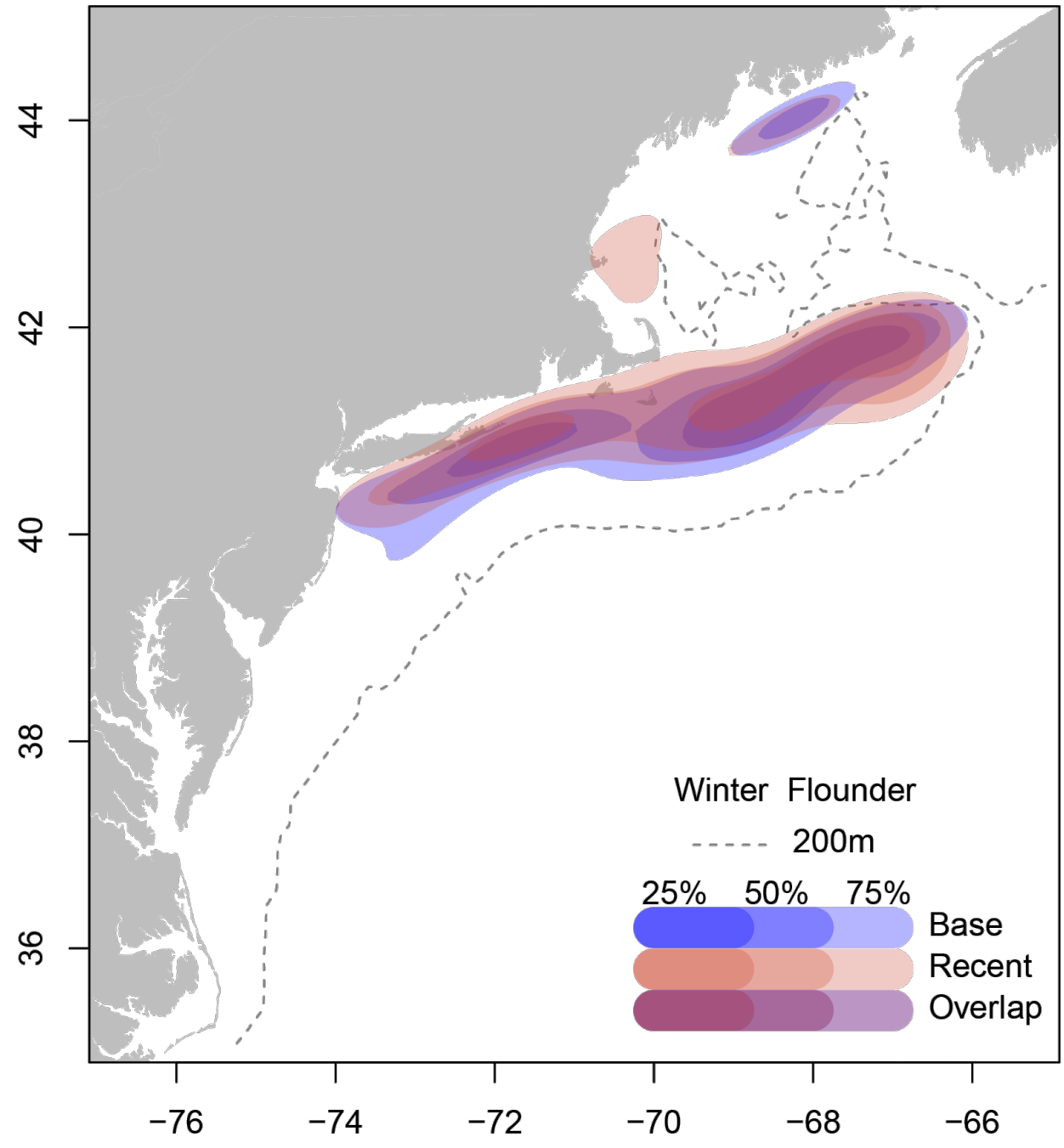
Kernel density plot of White hake. Blue = 1970s distributions; red = 2014-2016.

Windowpane flounder



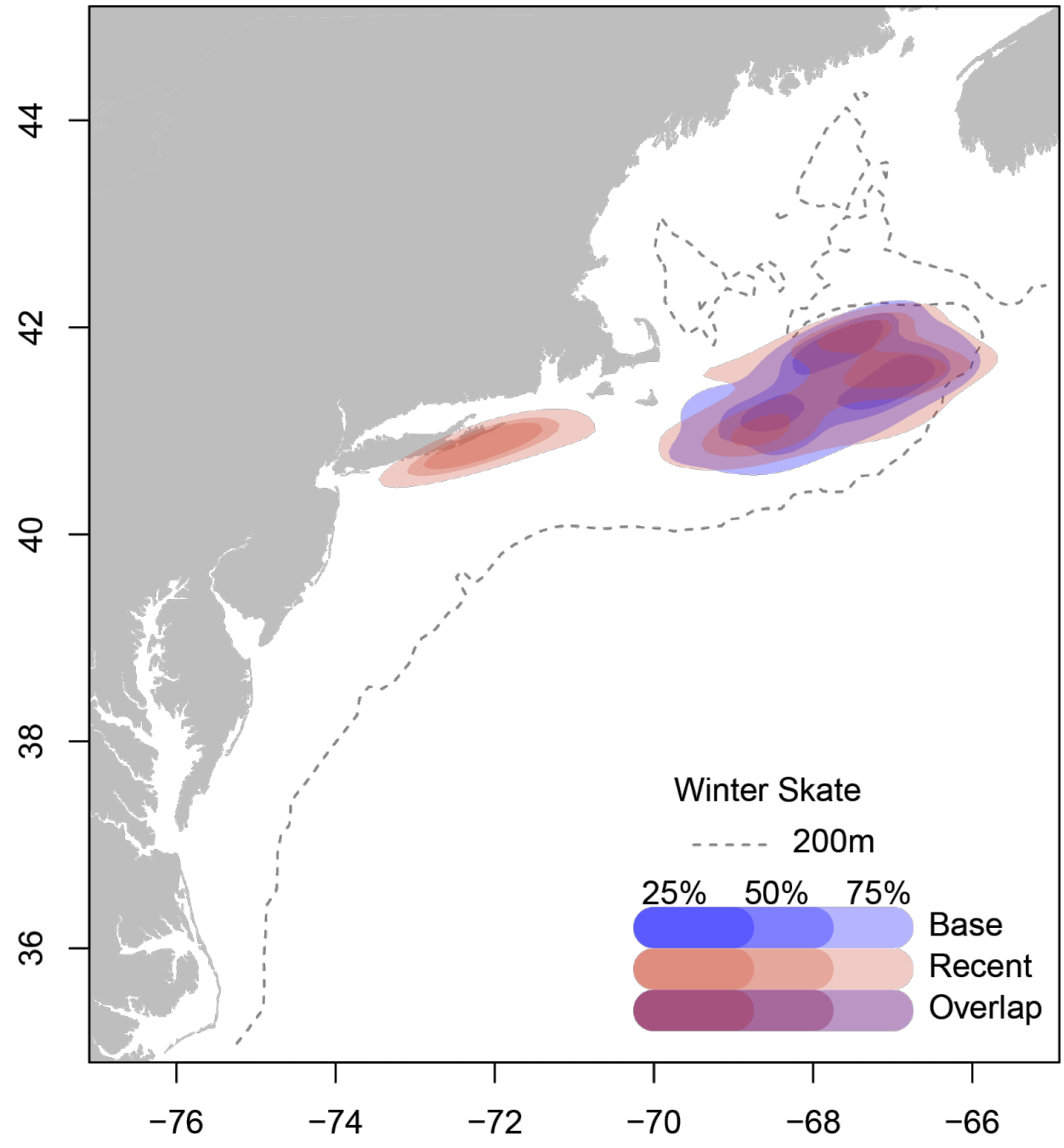
Kernel density plot of Windowpane flounder. Blue = 1970s distributions; red = 2014-2016.

Winter flounder



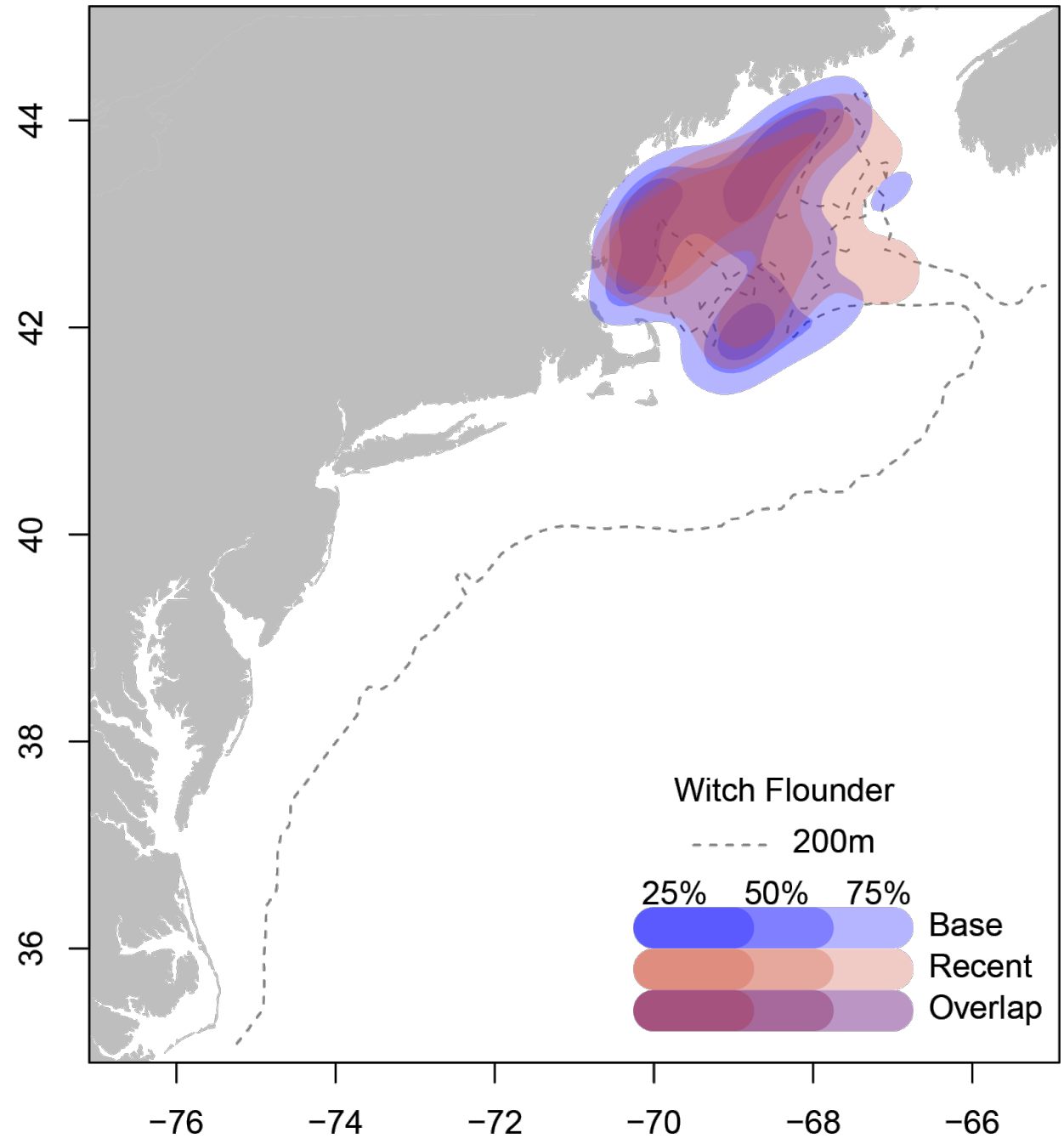
Kernel density plot of Winter flounder. Blue = 1970s distributions; red = 2014-2016.

Winter skate



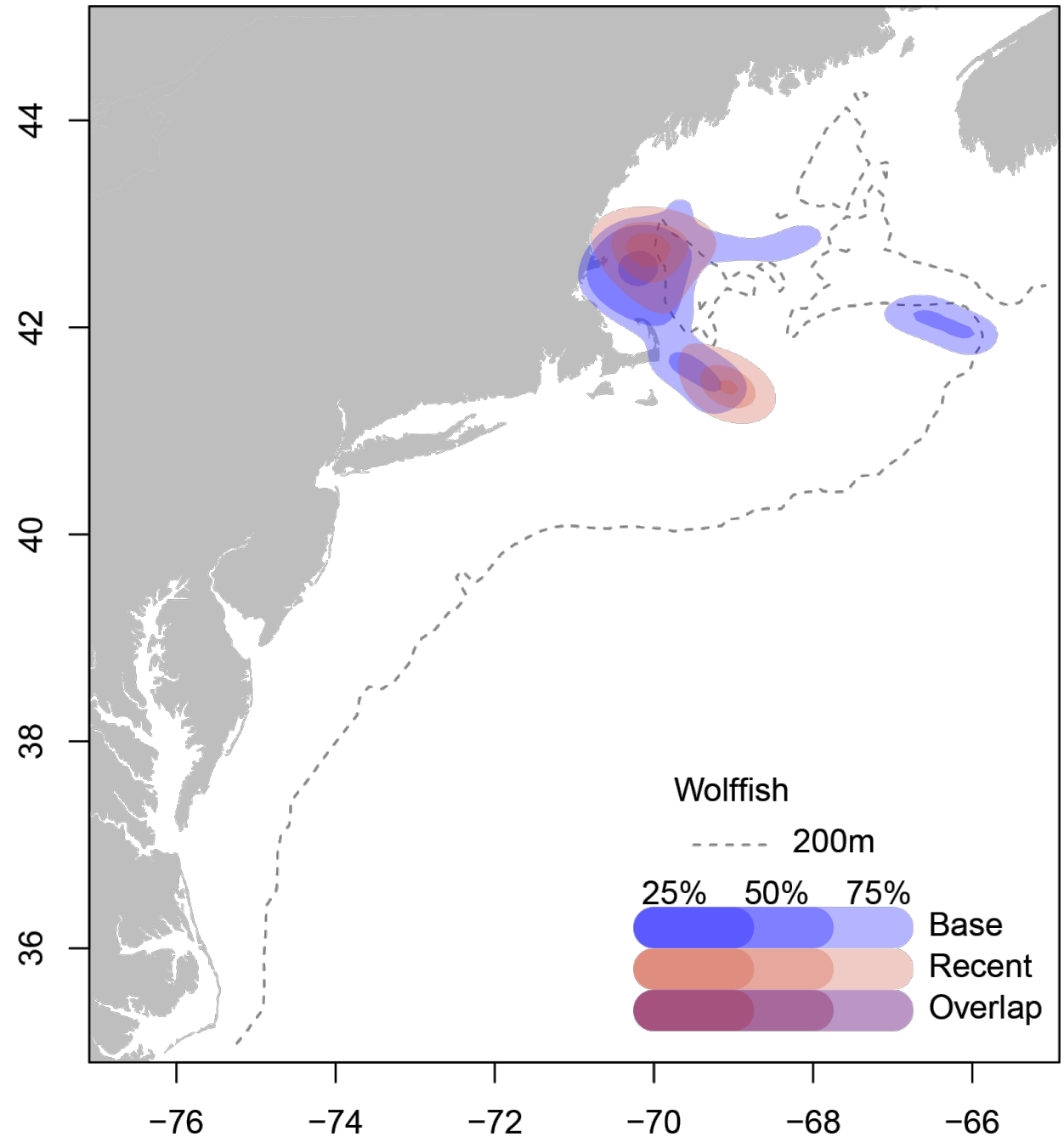
Kernel density plot of Winter skate. Blue = 1970s distributions; red = 2014-2016.

Witch flounder



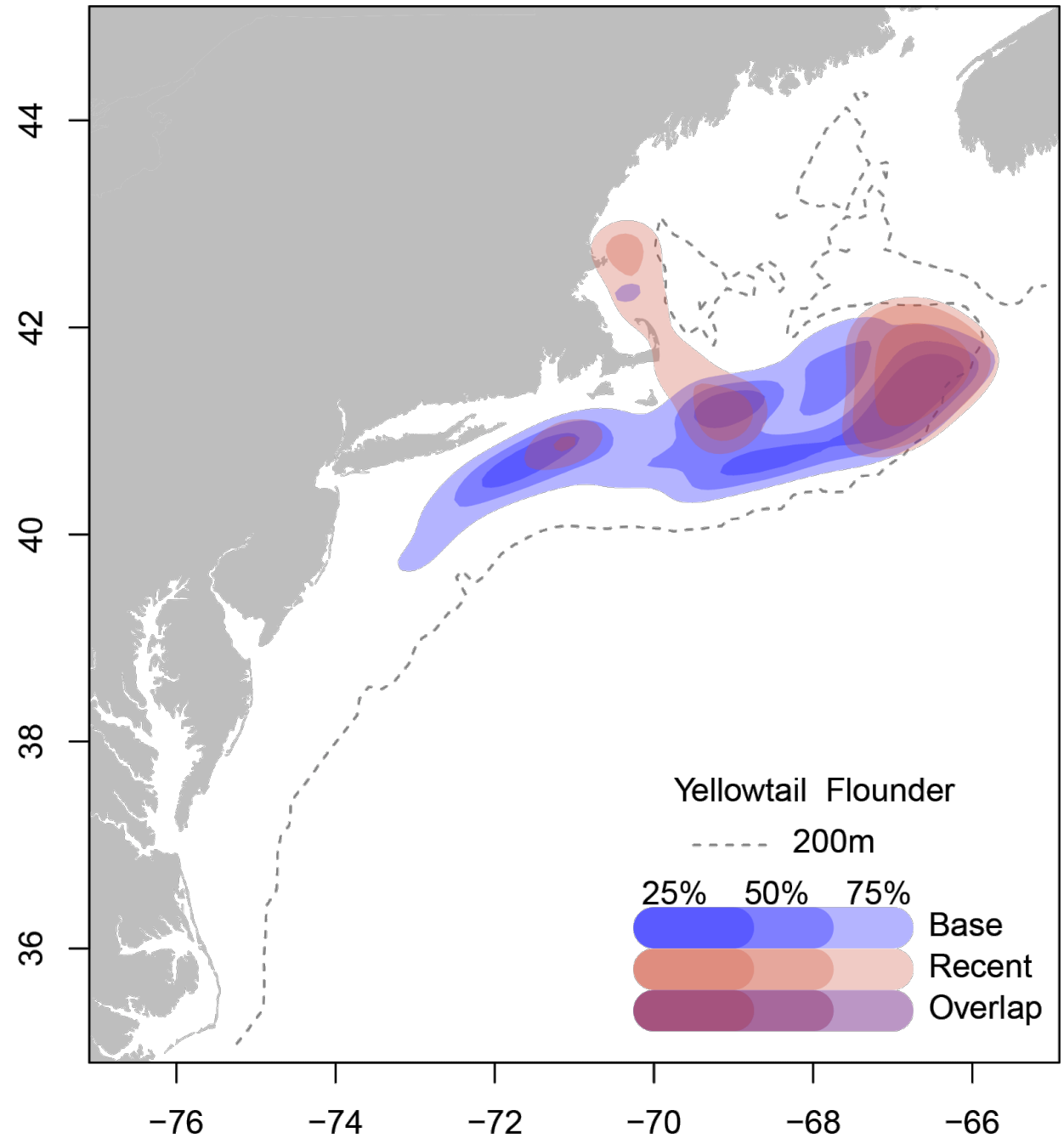
Kernel density plot of Witch flounder. Blue = 1970s distributions; red = 2014-2016.

Wolffish



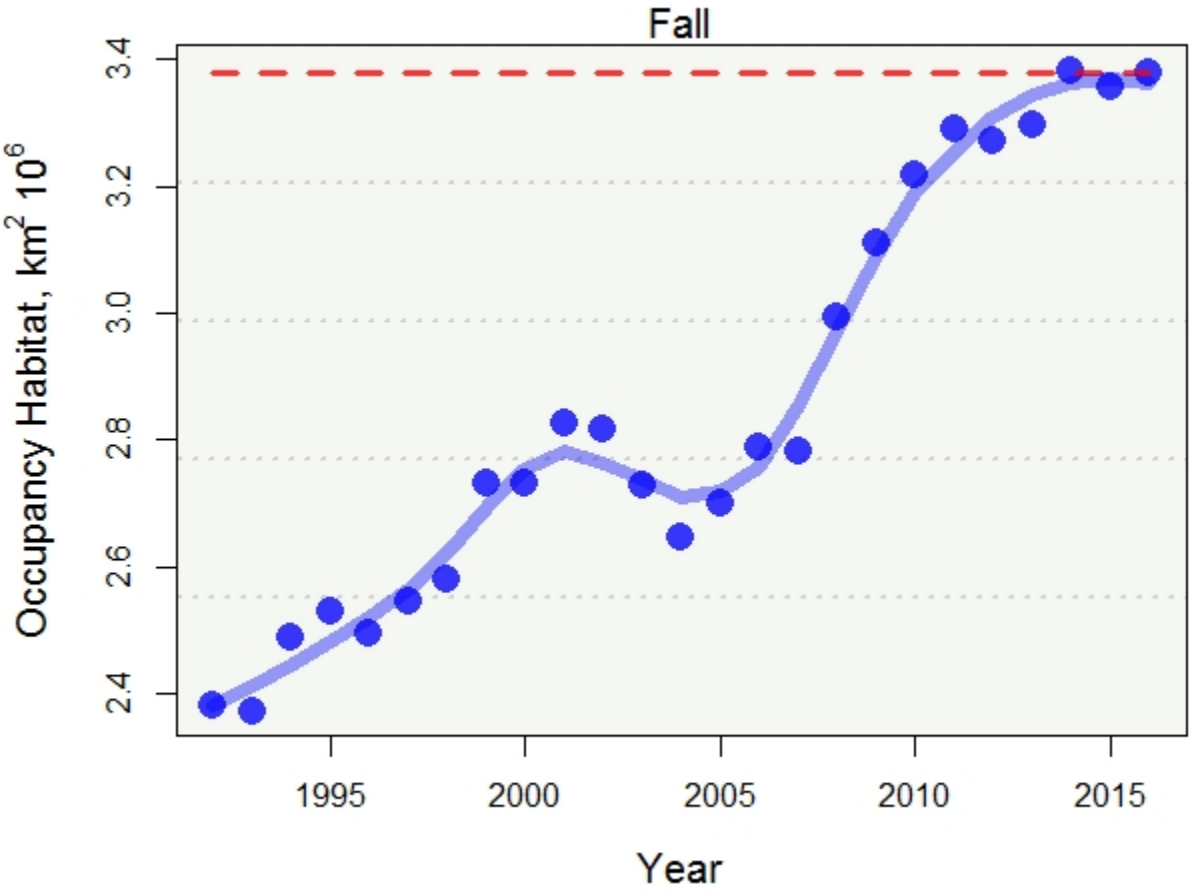
Kernel density plot of Wolffish. Blue = 1970s distributions; red = 2014-2016.

Yellowtail flounder

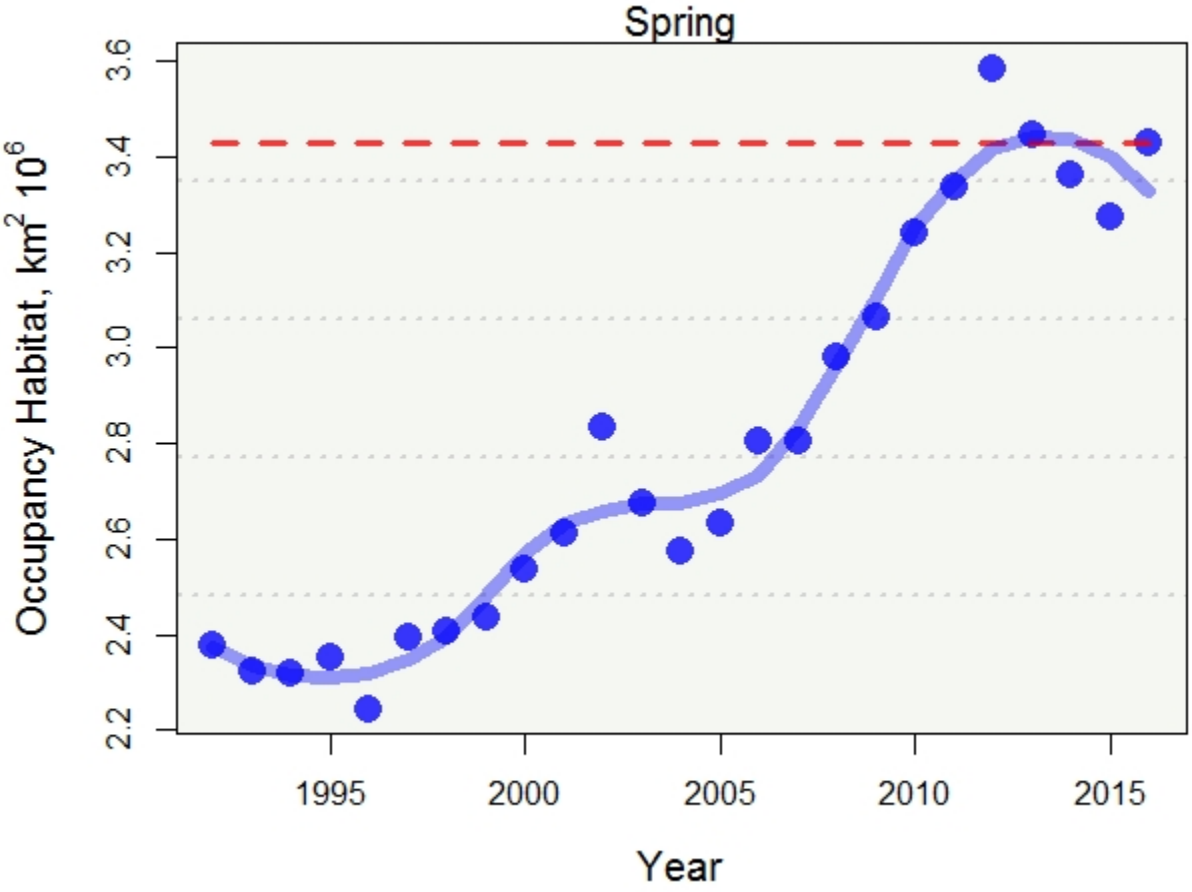


Kernel density plot of Yellowtail flounder. Blue = 1970s distributions; red = 2014-2016.

Change in Fish and Macroinvertebrate Occupancy Habitat



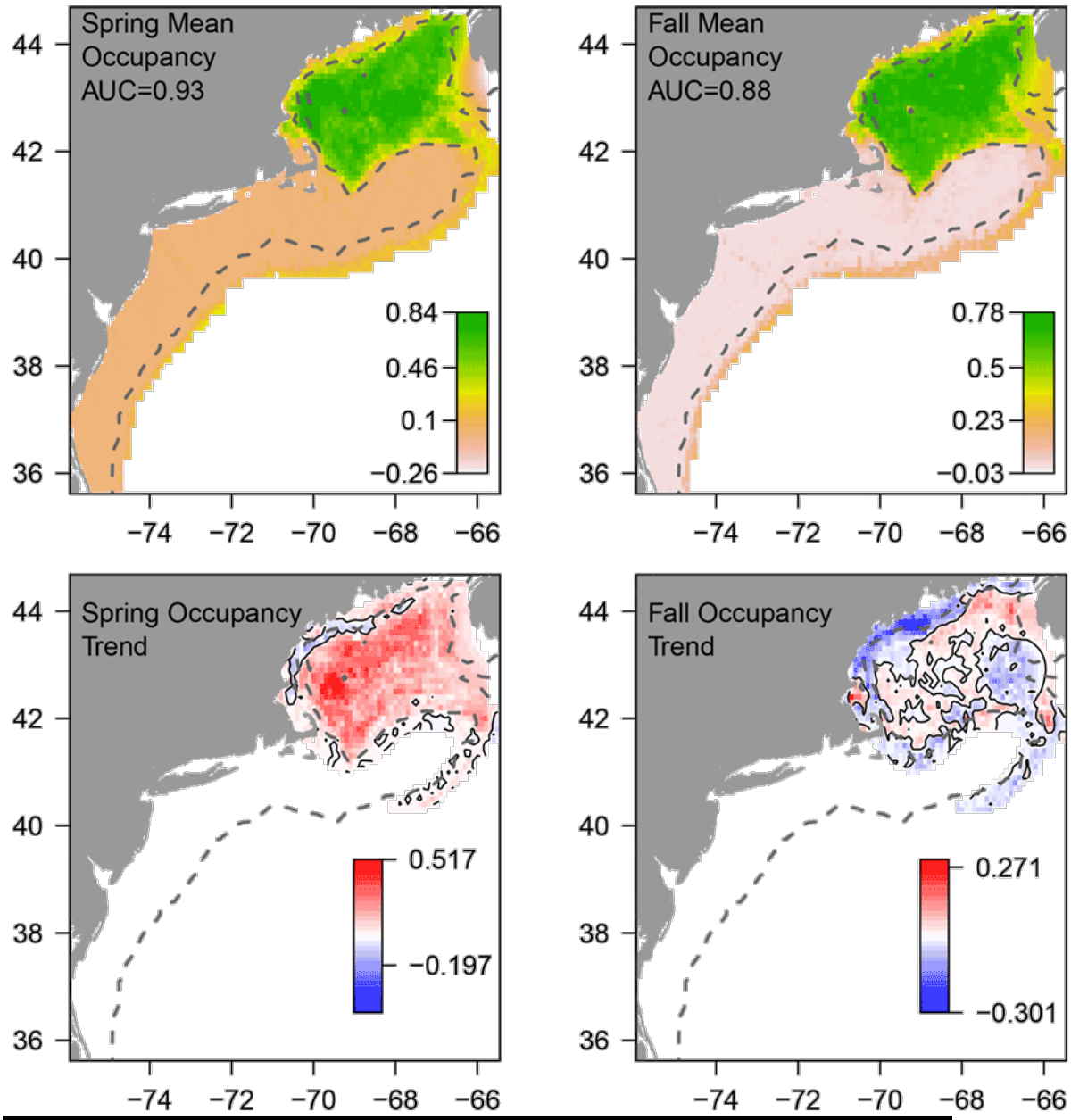
Fall occupancy habitat



Spring occupancy habitat

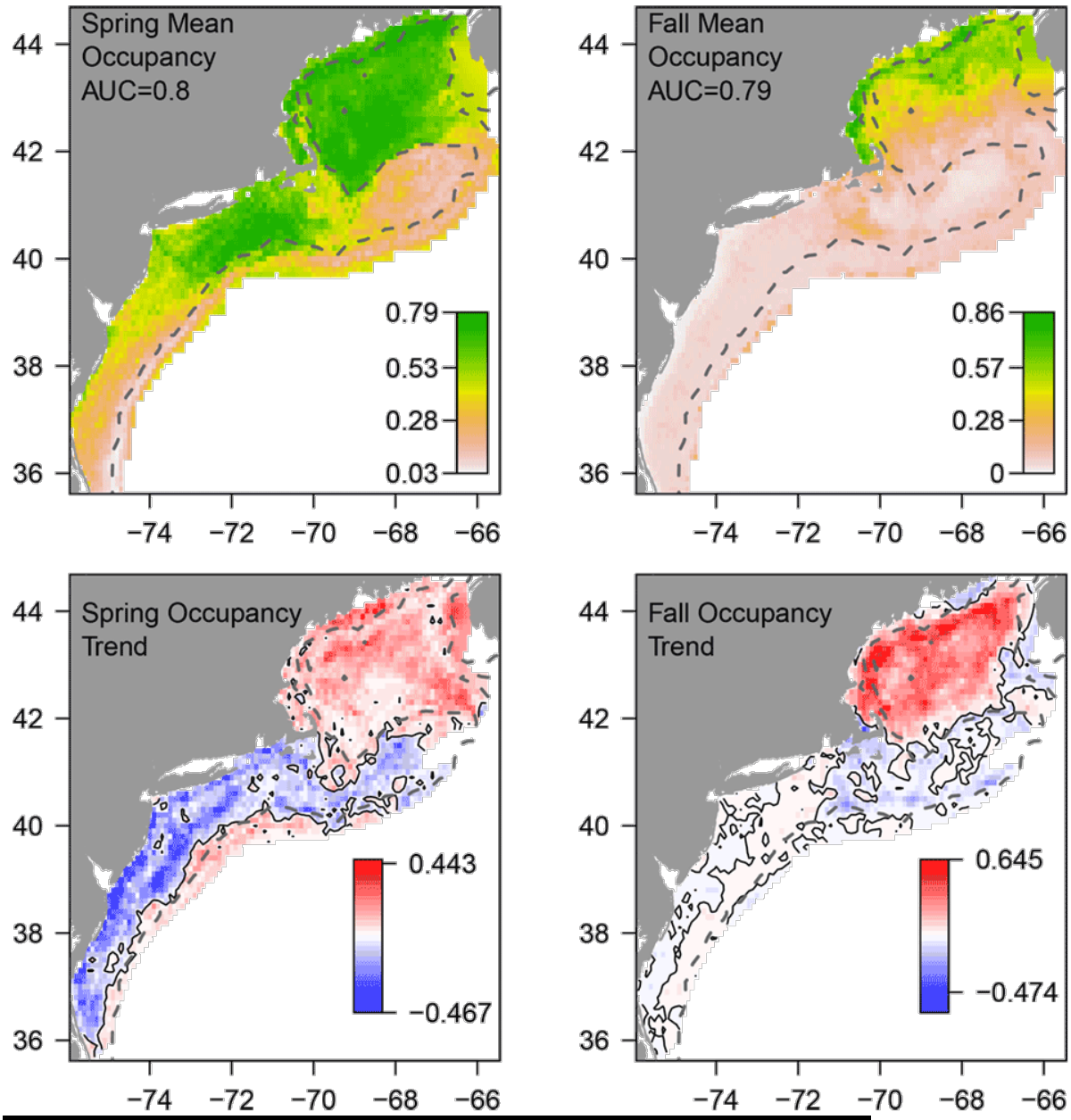
Occupancy habitat models have been developed for the main fish and macroinvertebrate species captured in the NEFSC bottom trawl survey. Using a benchmark of an occupancy probability of 0.5, the amount of occupancy habitat for all species were summed for the spring and fall survey periods (see figure; dashed line marks final year of the model estimates, 2016). Total spring occupancy habitat area has increased steadily to approximately 3.4 million km^2; likewise, in fall, total occupancy has also increased to a similar level, though it may have declined slightly in recent years. This increase in total occupancy habitat indicates most species increased their distributional footprint and are experiencing greater habitat overlap with other species. Information on occupancy habitat for individual species can be found in the table below; click on a species name to see mean spring and fall occupancy habitat and their associated trends. Only species with at least one seasonal model fit with a minimum fit statistic of AUC = 0.65 were included (AUC 0.65-0.75 acceptable fit; 0.75-0.85 good fit; >0.85 excellent fit).

Acadian redfish



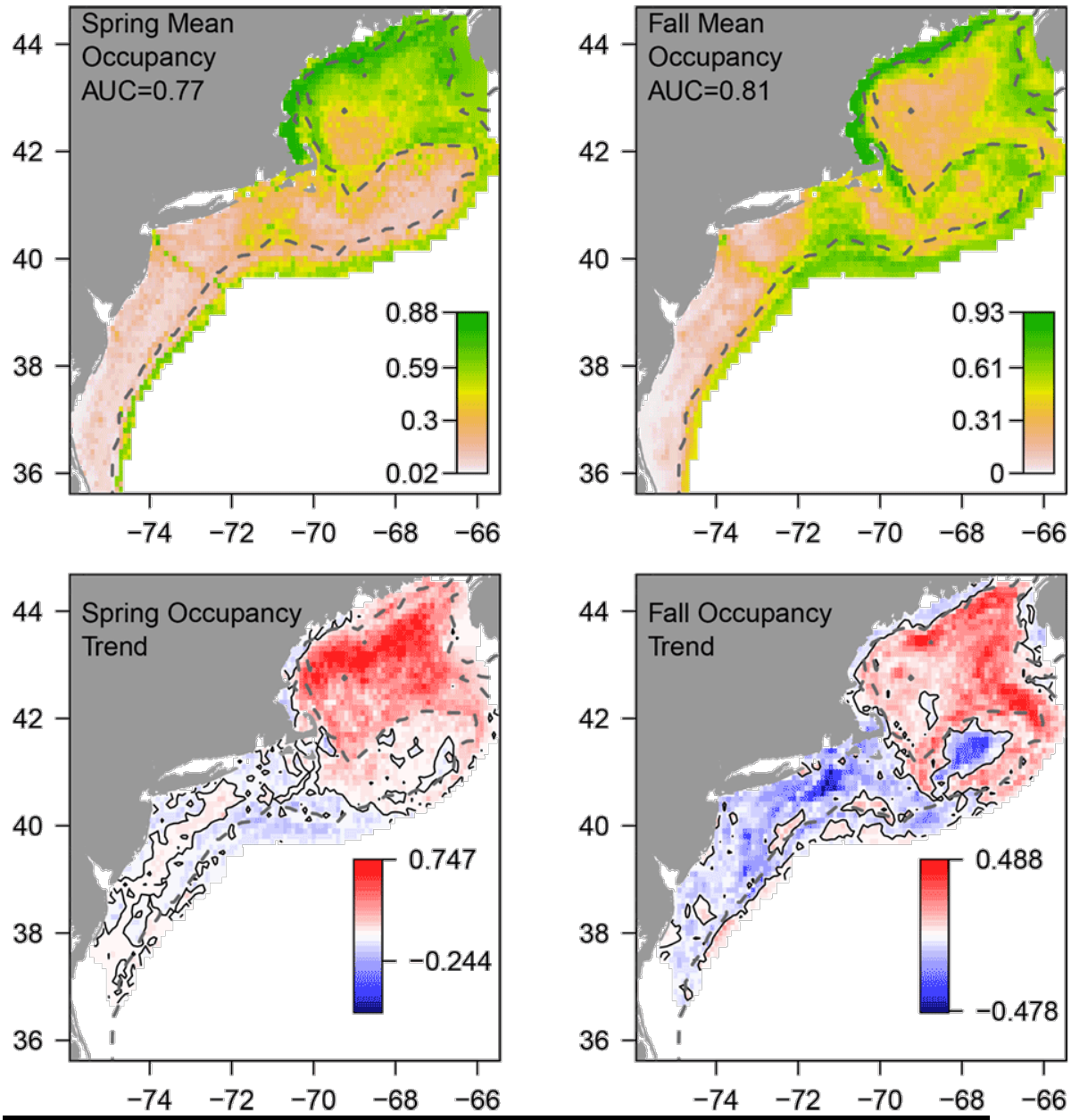
Mean spring and fall occupancy habitat and their associated trends for Acadian redish

Alewife



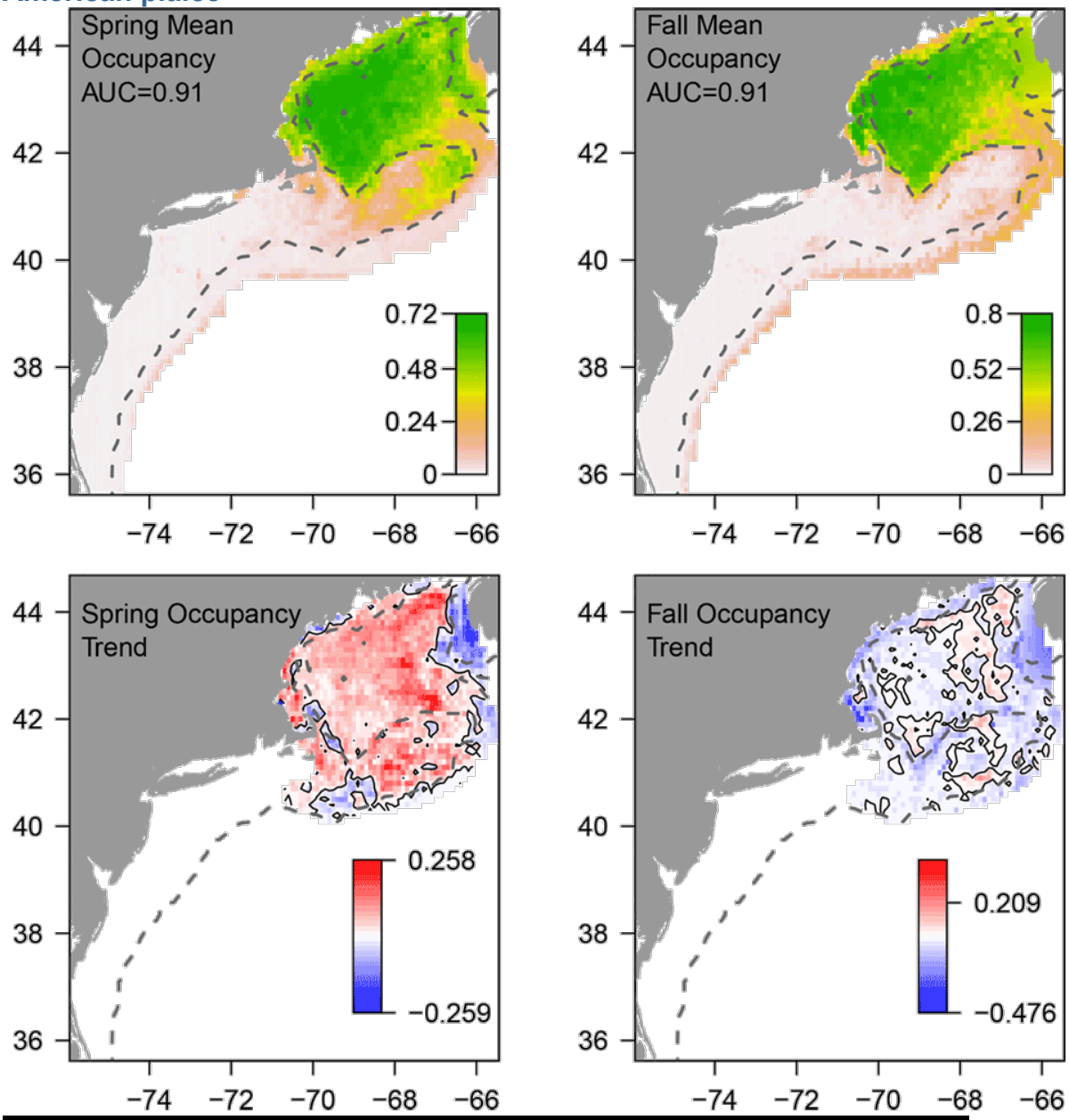
Mean spring and fall occupancy habitat and their associated trends for alewife.

American lobster



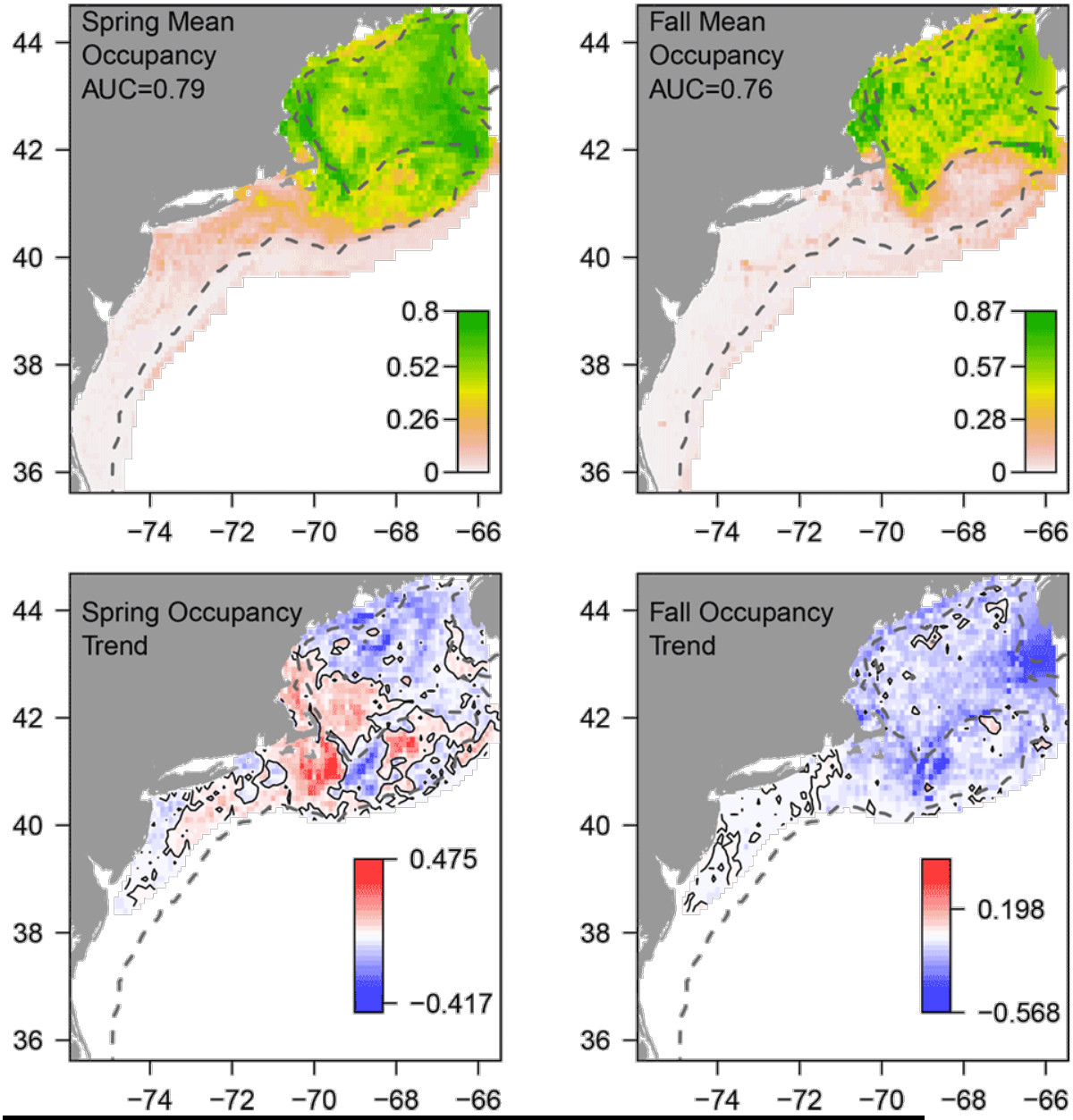
Mean spring and fall occupancy habitat and their associated trends for American Lobster.

American plaice



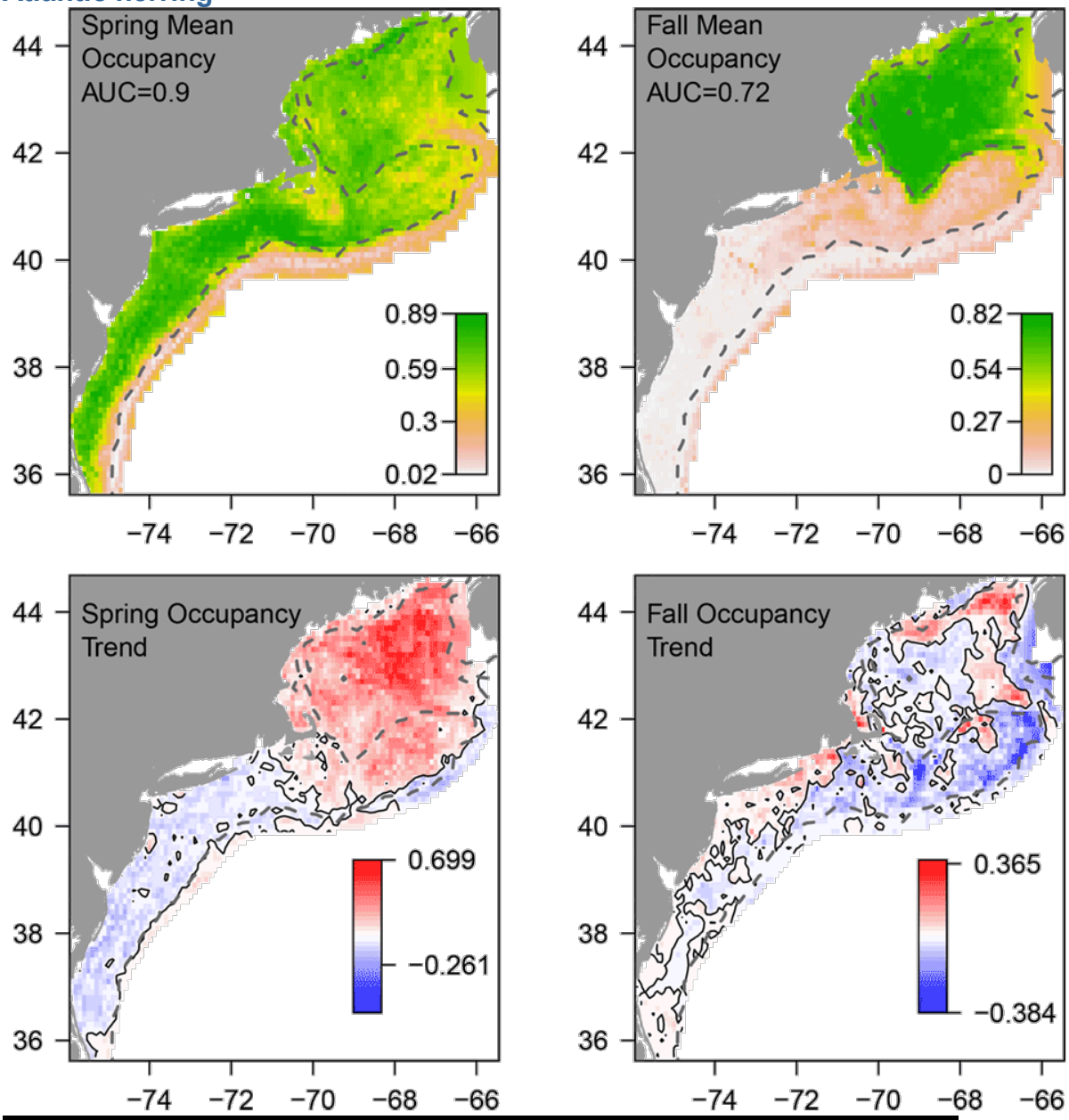
Mean spring and fall occupancy habitat and their associated trends for American plaice.

Atlantic cod



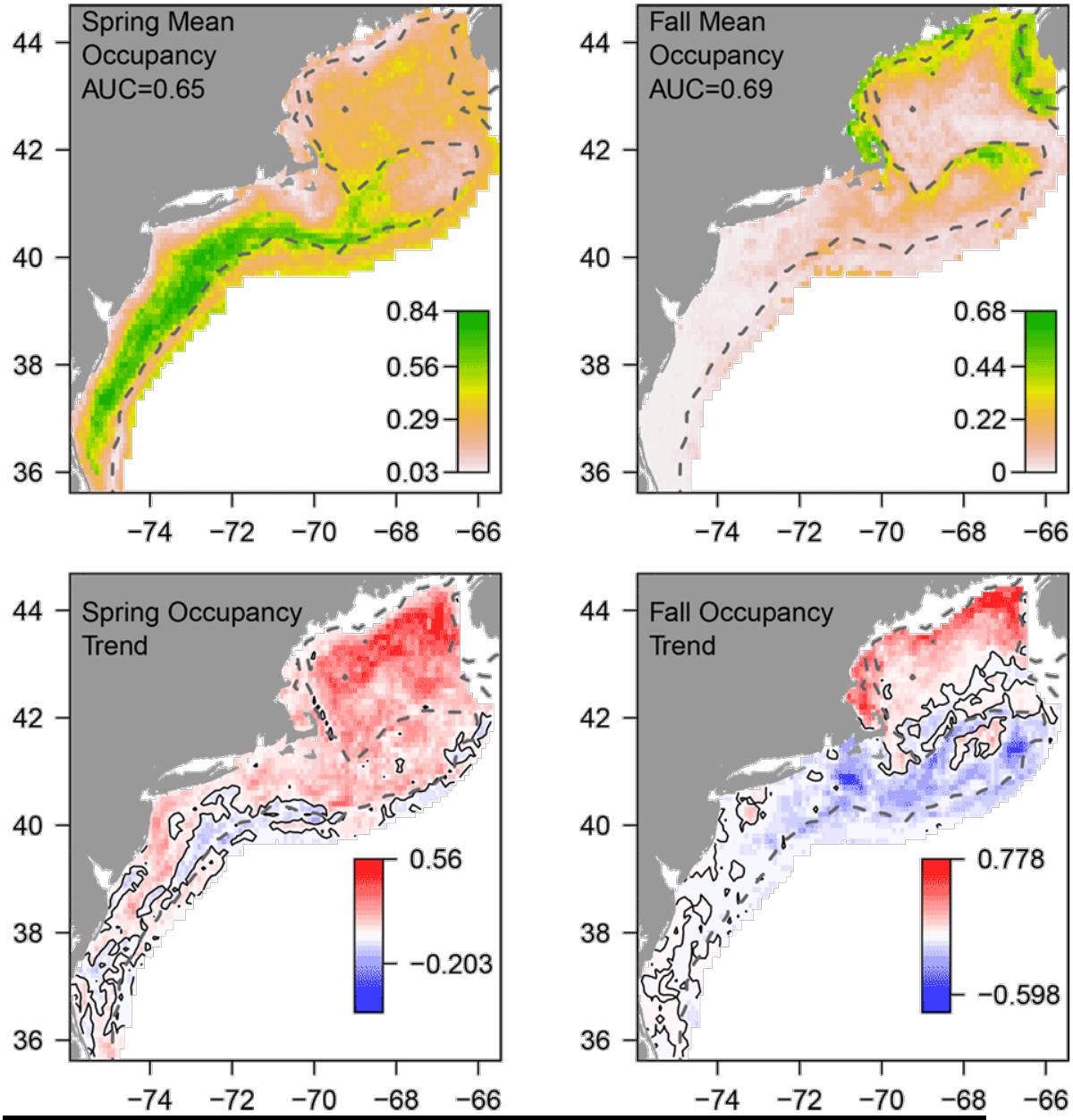
Mean spring and fall occupancy habitat and their associated trends for Atlantic cod.

Atlantic herring



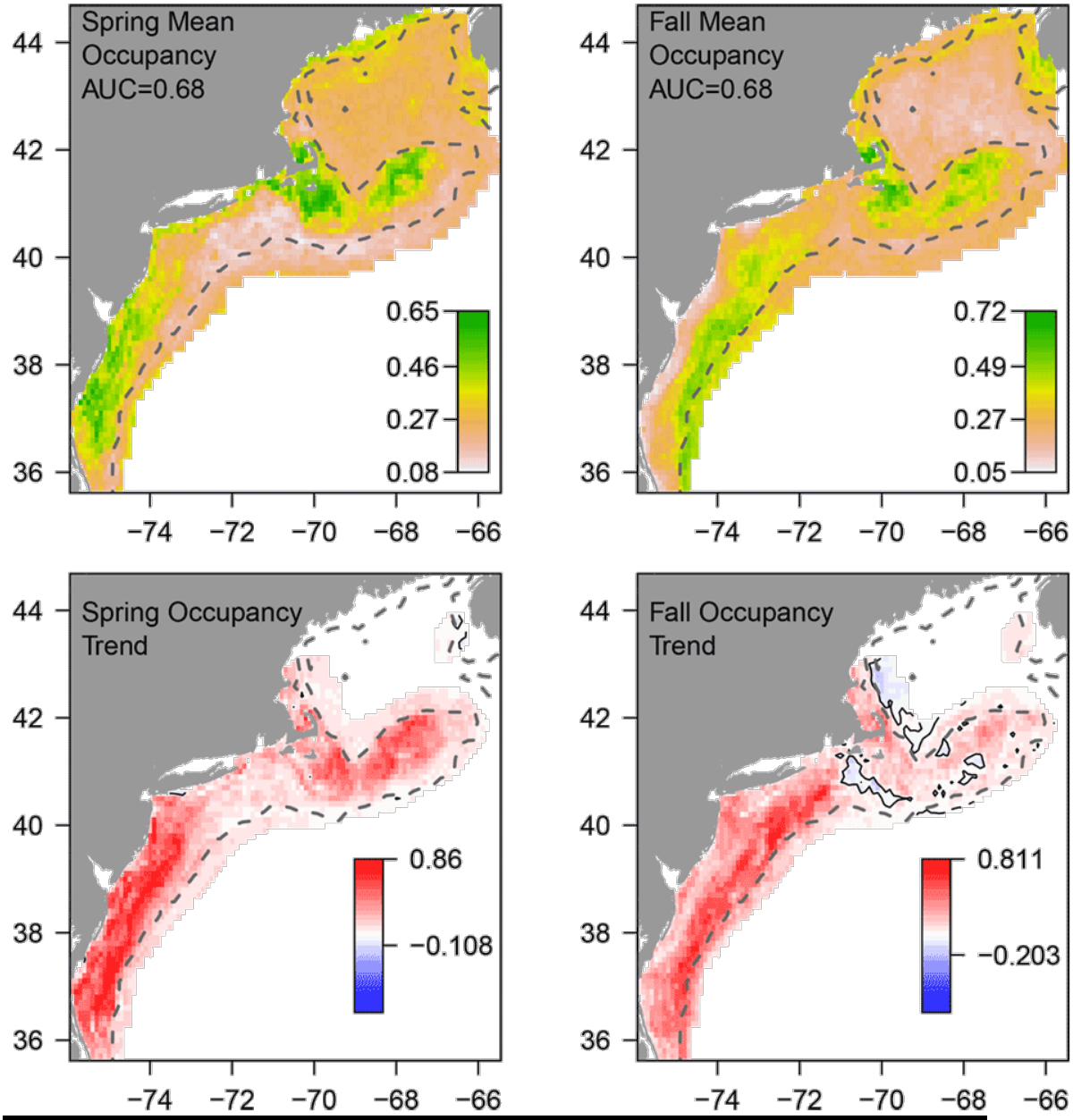
Mean spring and fall occupancy habitat and their associated trends for Atlantic herring.

Atlantic mackerel



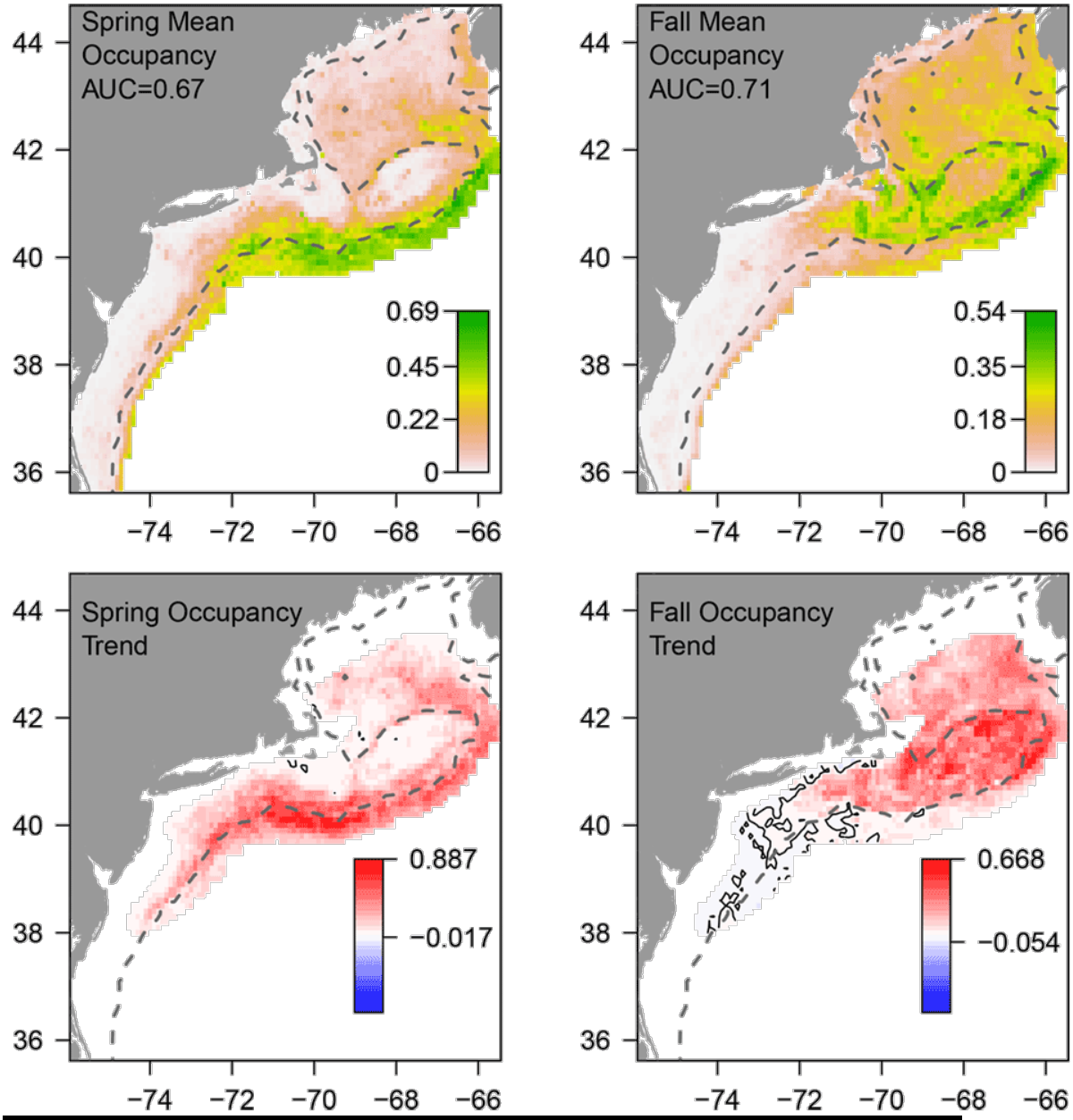
Mean spring and fall occupancy habitat and their associated trends for Atlantic mackerel.

Atlantic rock crab



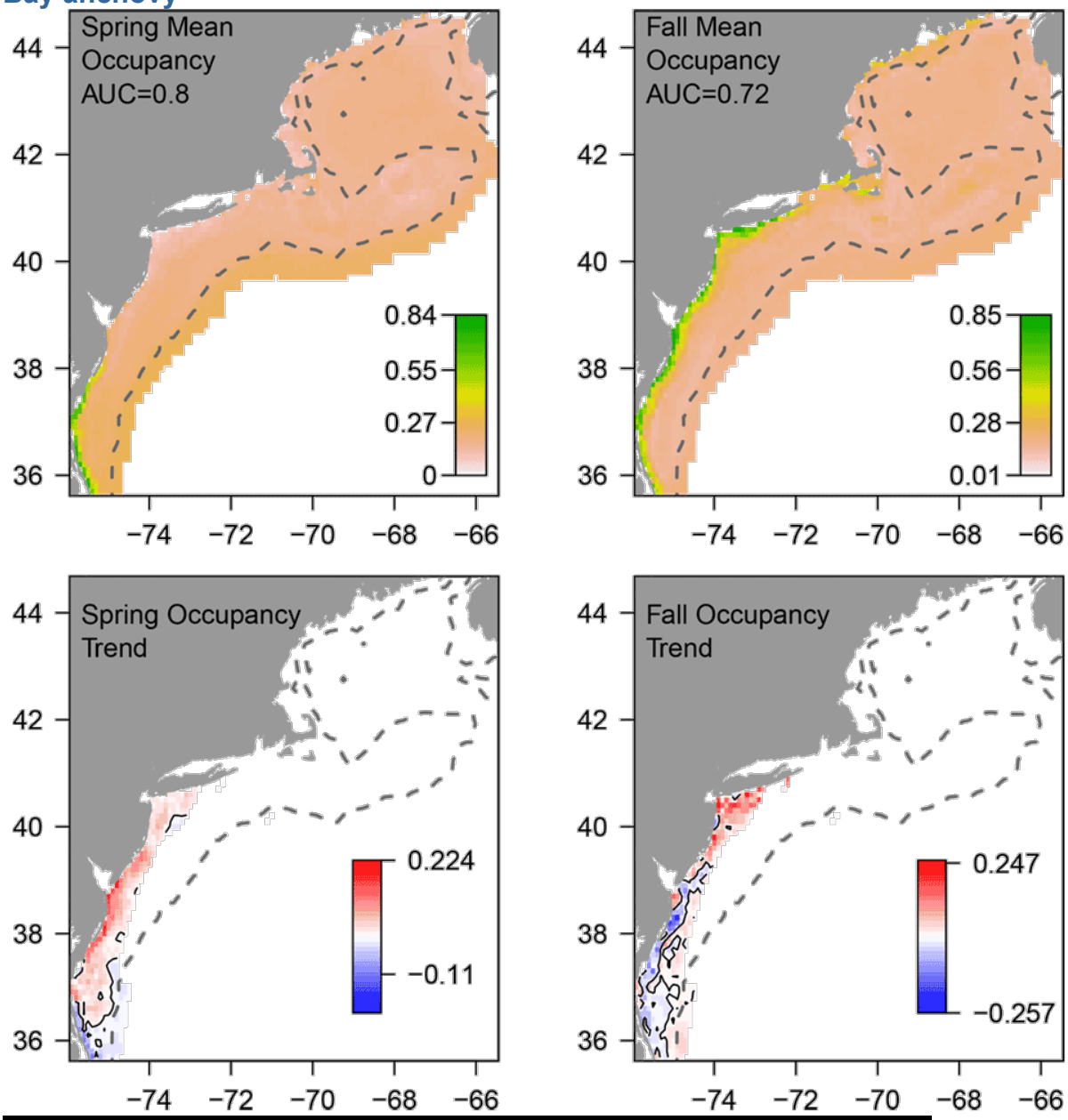
Mean spring and fall occupancy habitat and their associated trends for Atlantic rock crab.

Barndoor skate



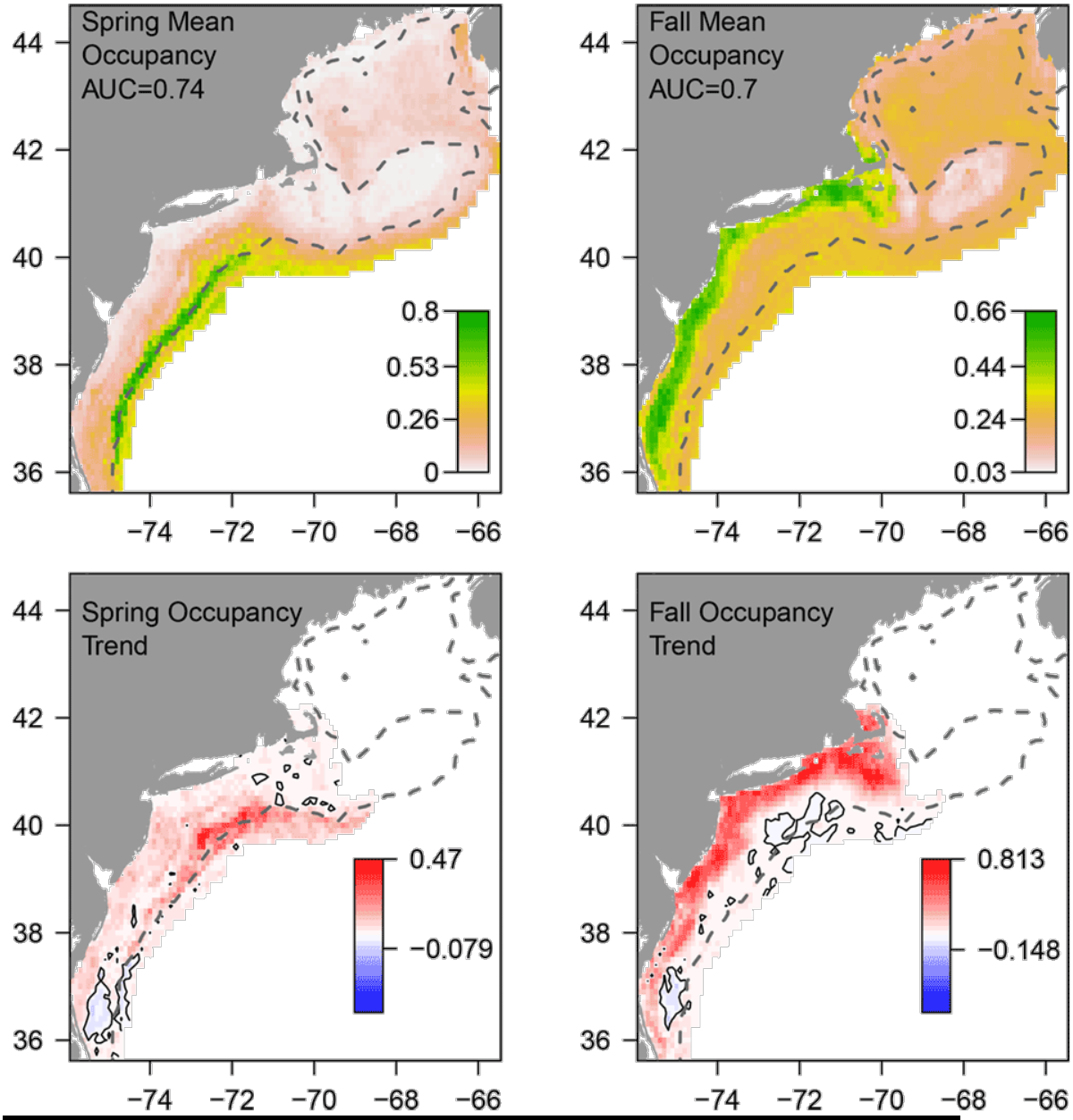
Mean spring and fall occupancy habitat and their associated trends for barndoor skate.

Bay anchovy



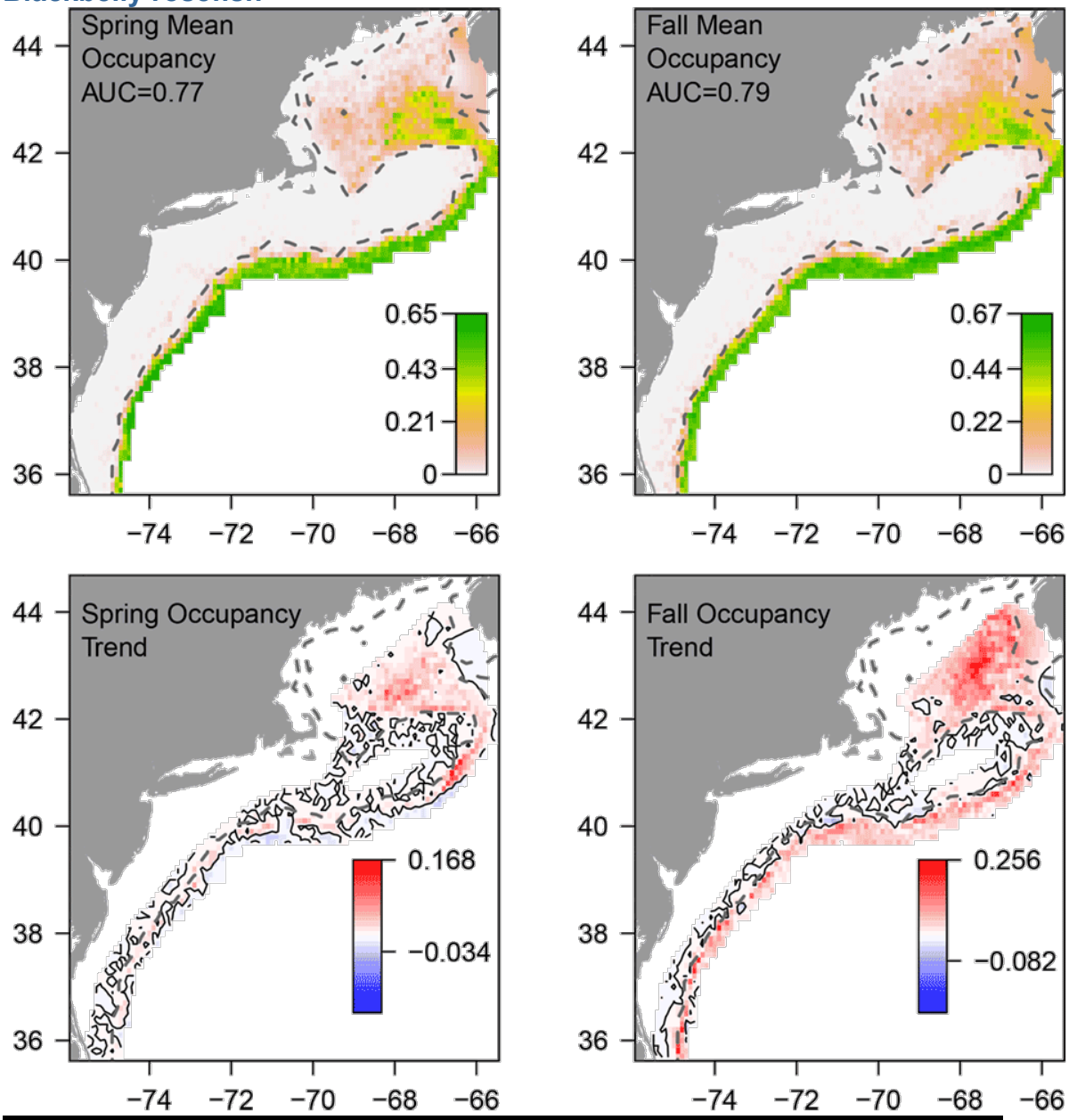
Mean spring and fall occupancy habitat and their associated trends for bay anchovy.

Black sea bass



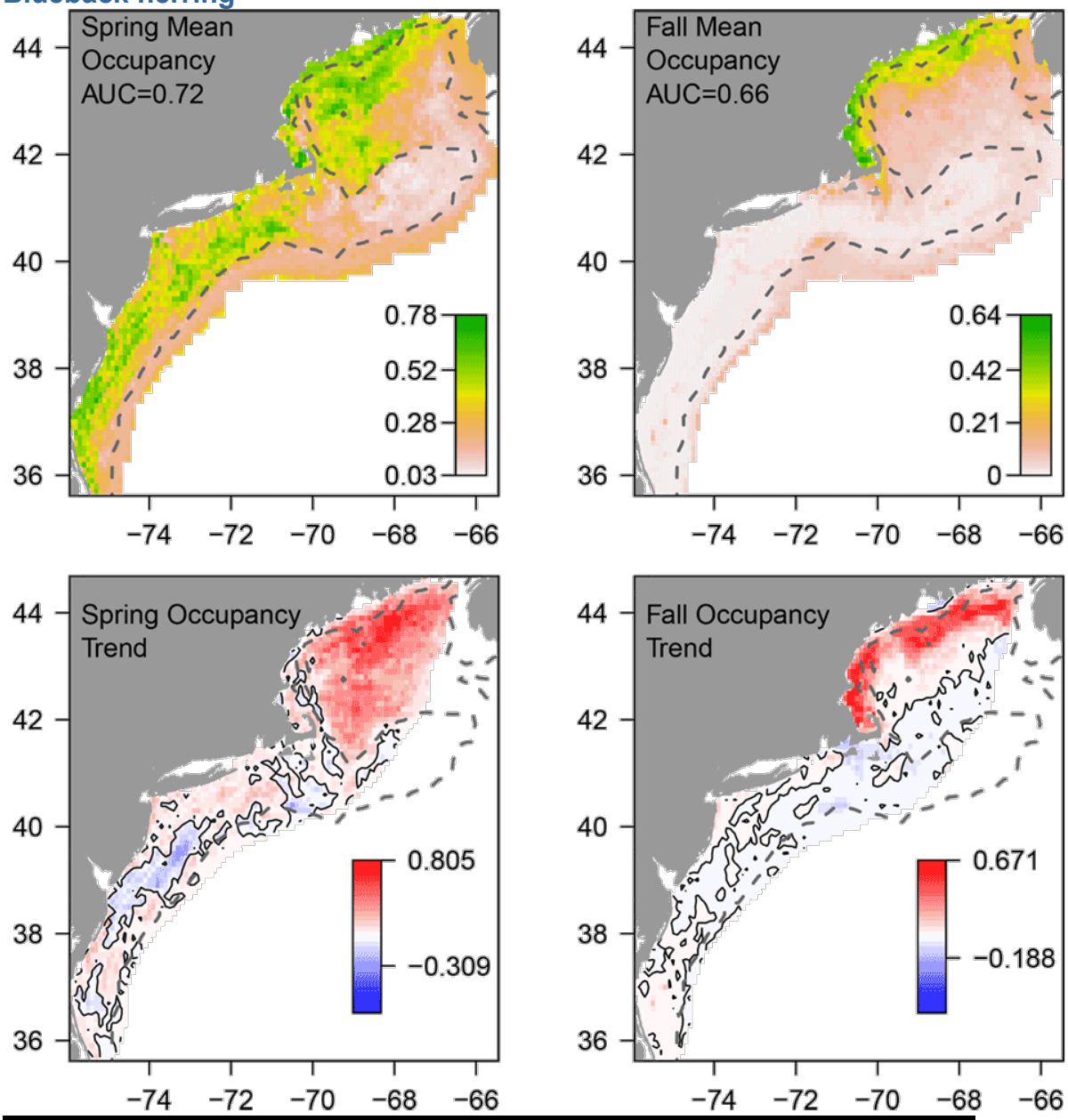
Mean spring and fall occupancy habitat and their associated trends for black sea bass.

Blackbelly rosefish



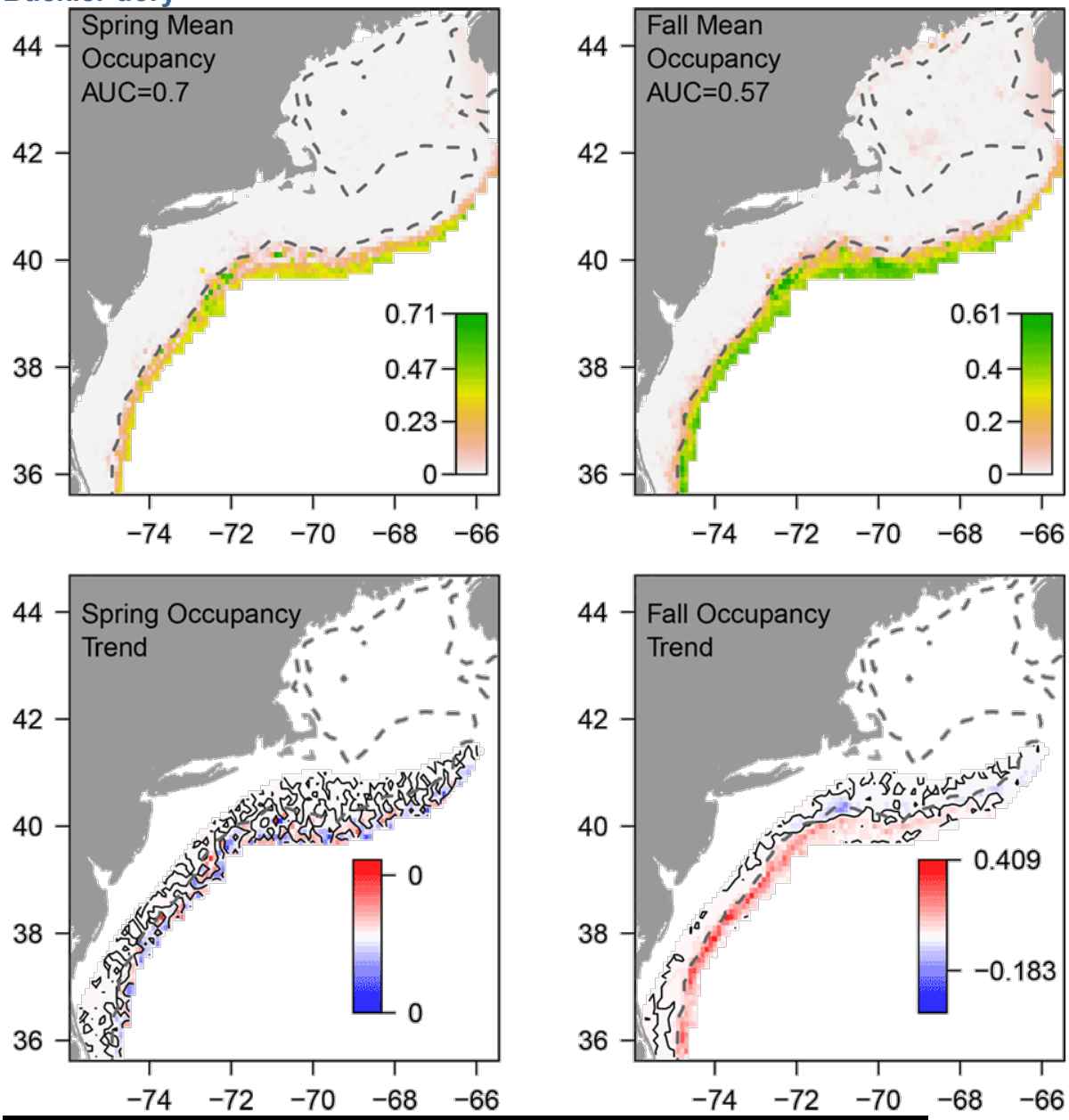
Mean spring and fall occupancy habitat and their associated trends for blackbelly rosefish.

Blueback herring



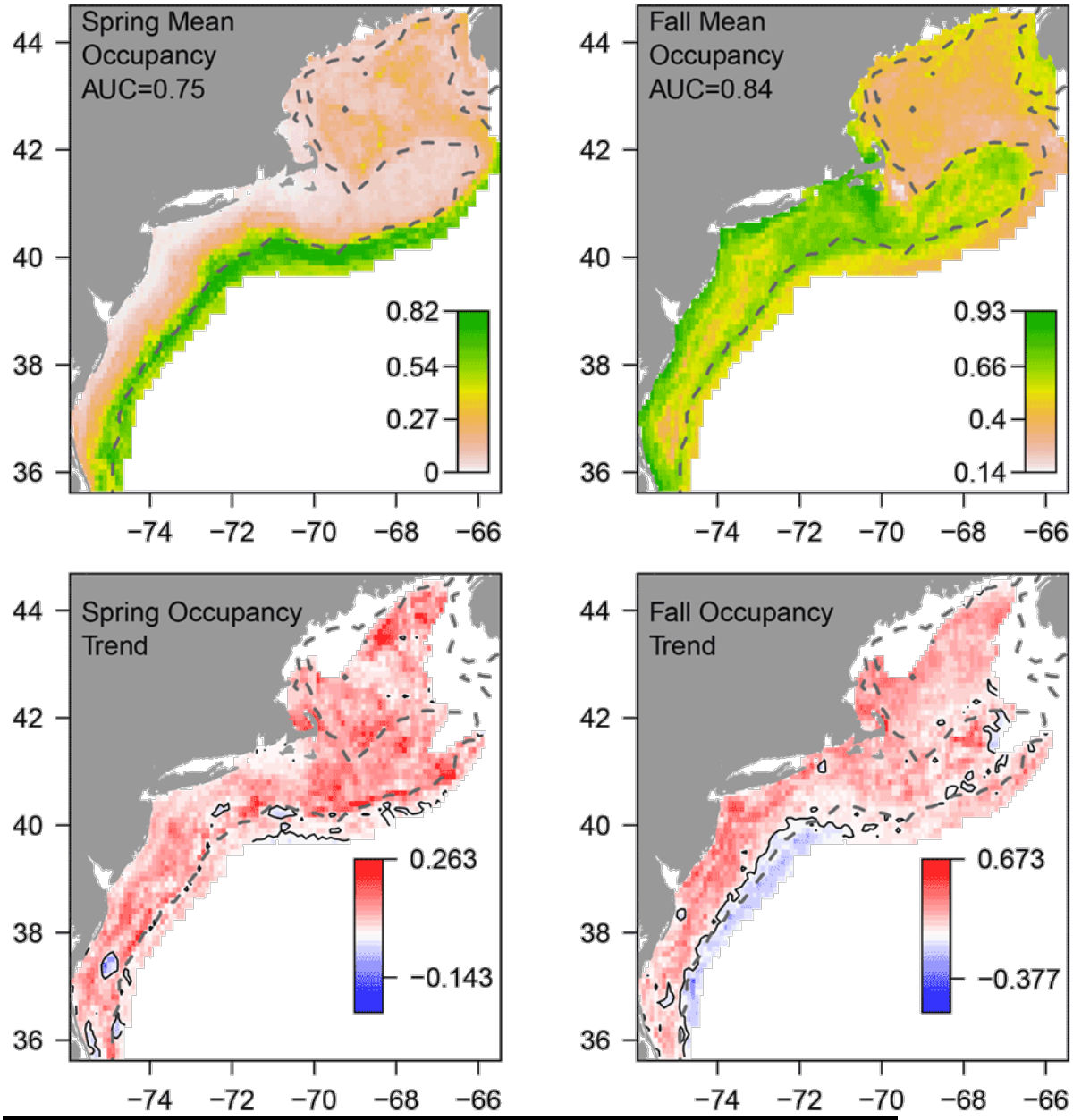
Mean spring and fall occupancy habitat and their associated trends for blueback herring.

Buckler dory



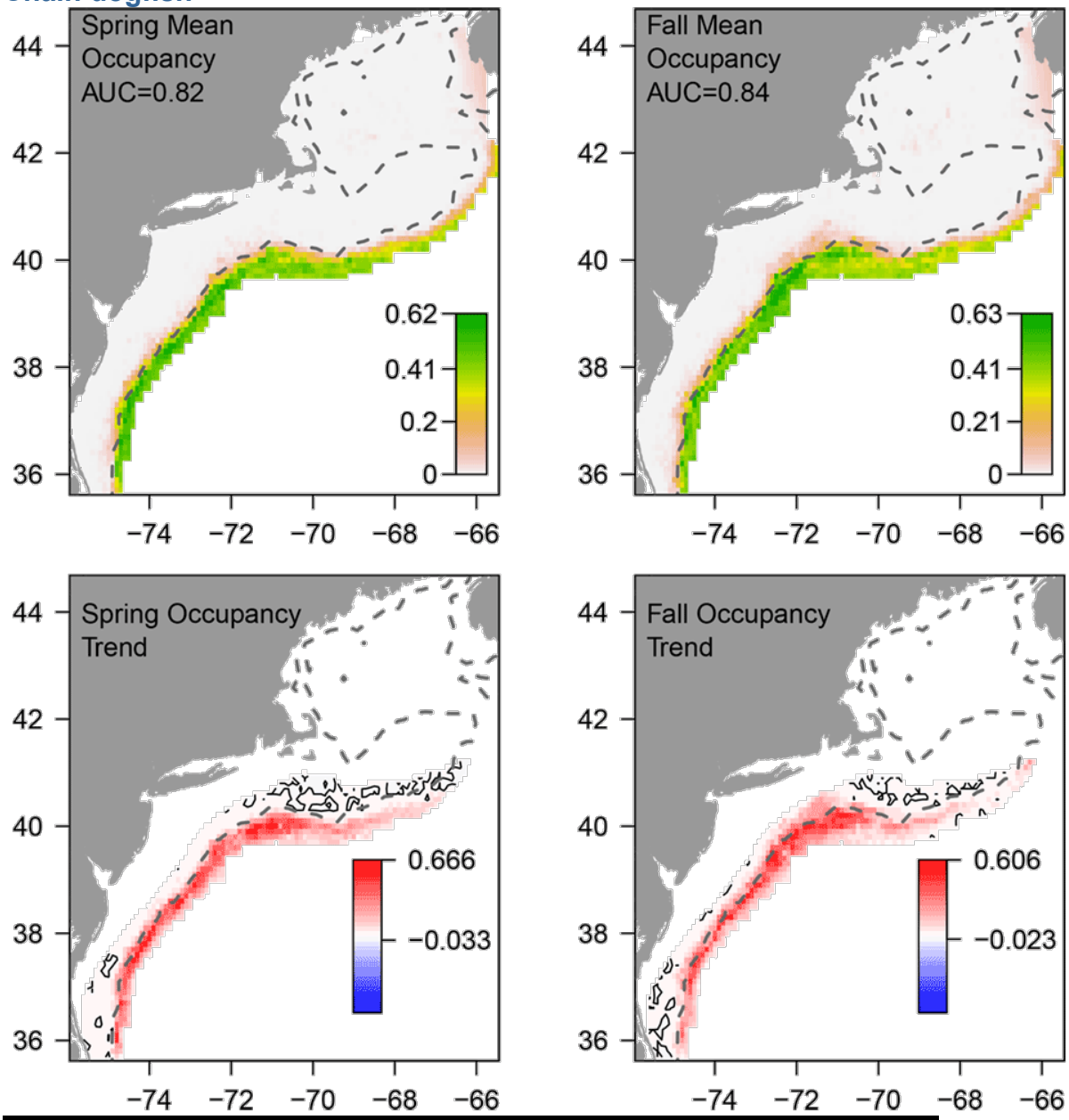
Mean spring and fall occupancy habitat and their associated trends for buckler dory.

Butterfish



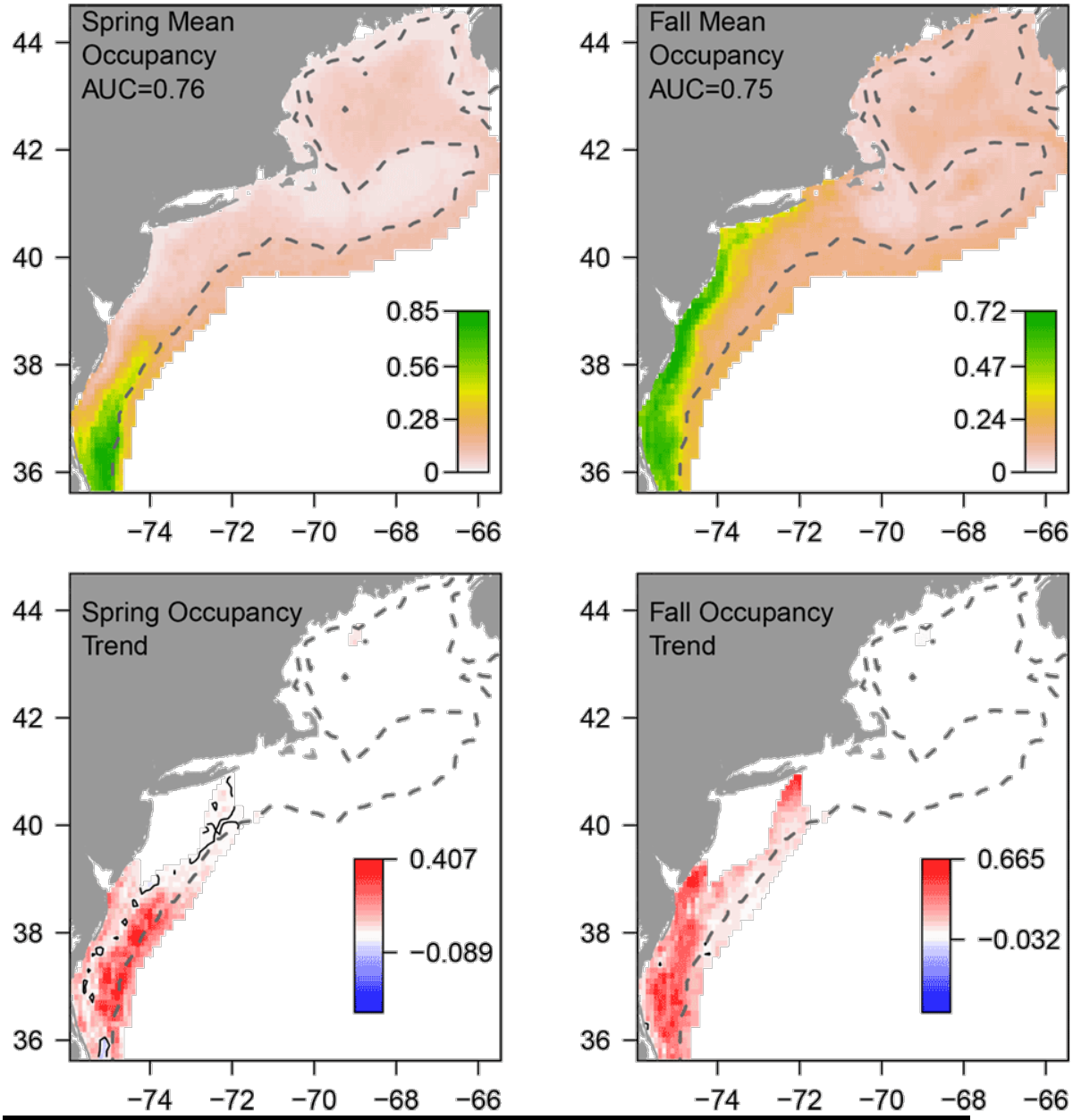
Mean spring and fall occupancy habitat and their associated trends for butterfish.

Chain dogfish



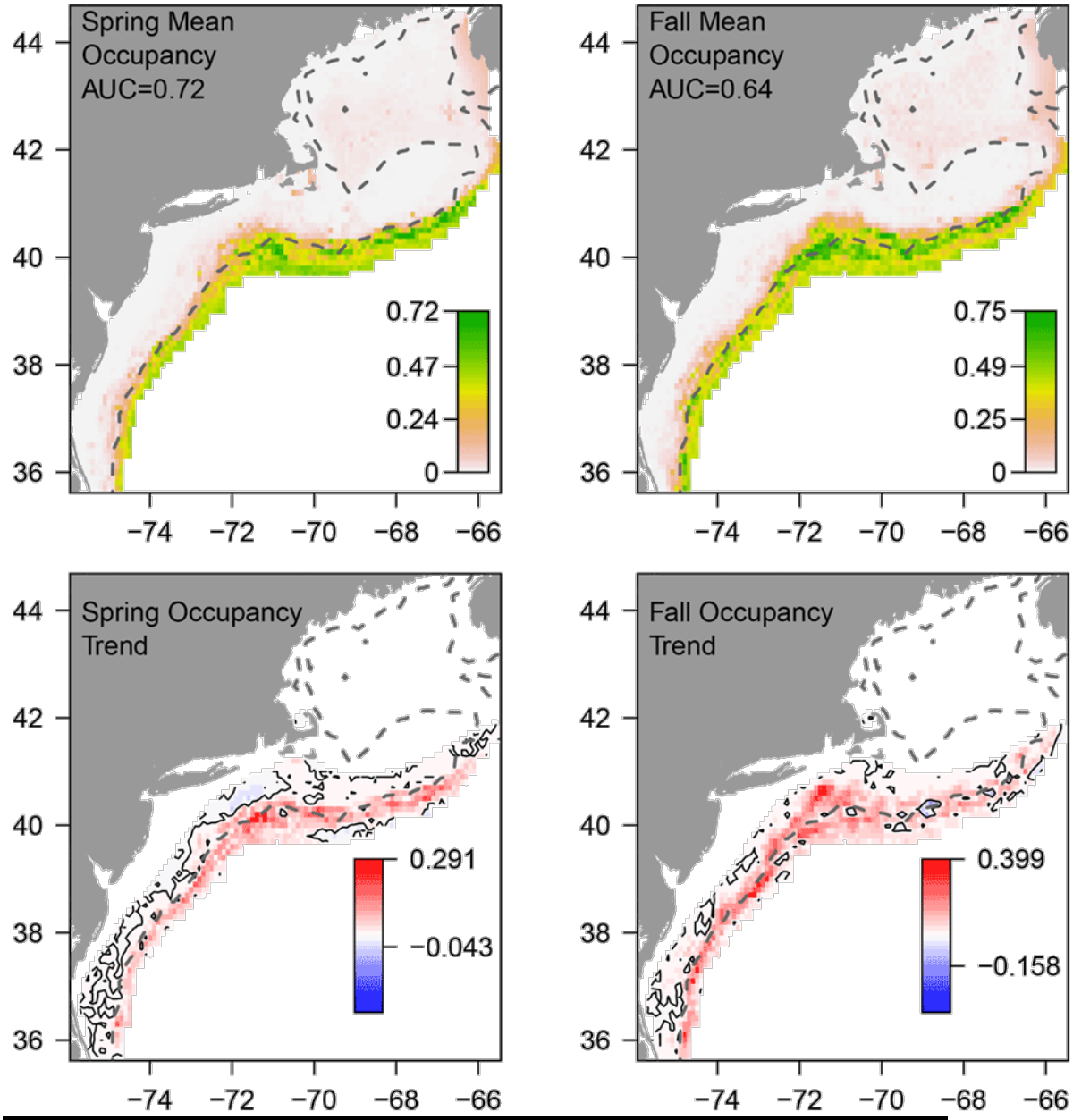
Mean spring and fall occupancy habitat and their associated trends for chain dogfish.

Clearnose skate



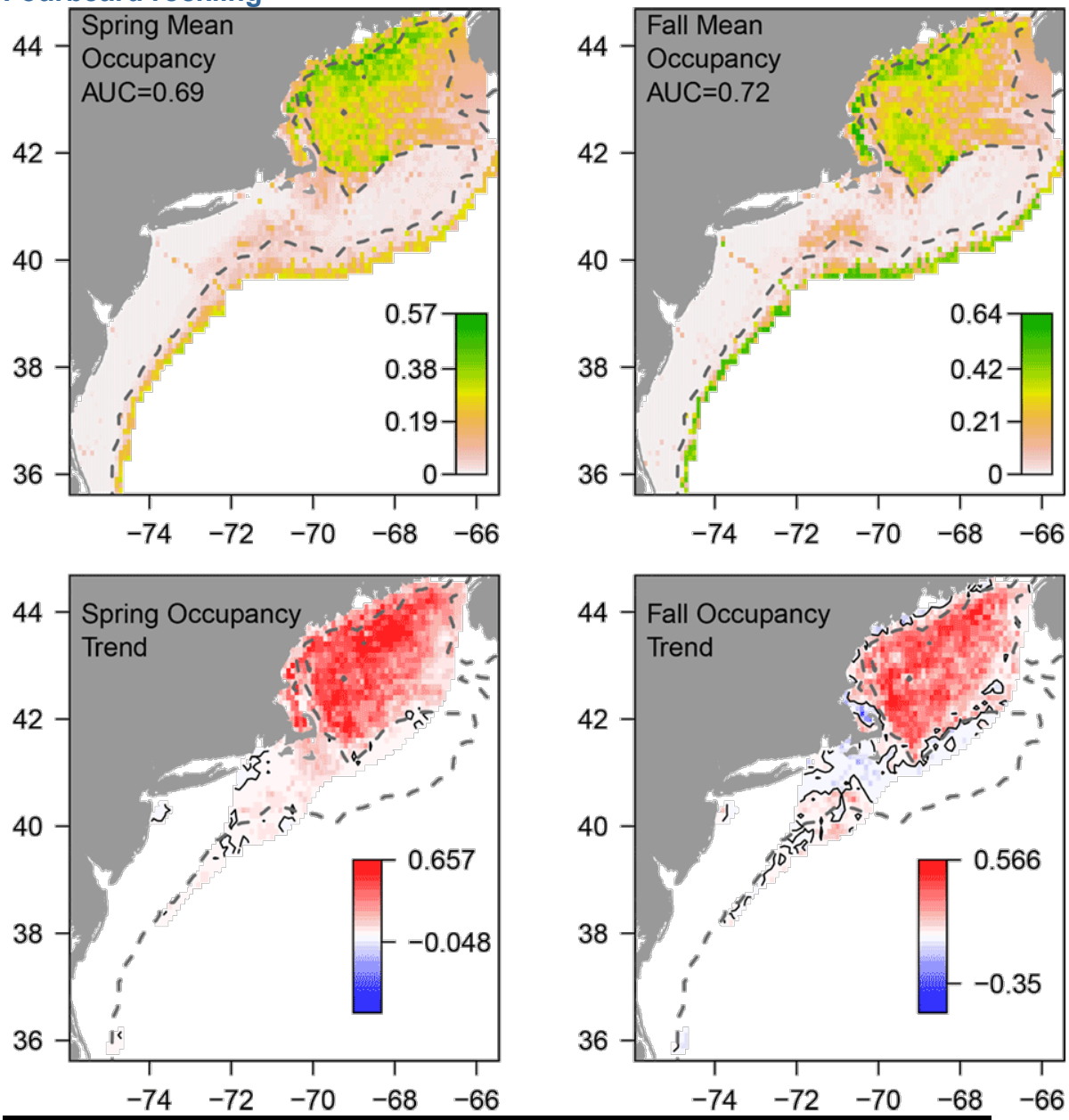
Mean spring and fall occupancy habitat and their associated trends for clearnose skate.

Fawn cusk-eel



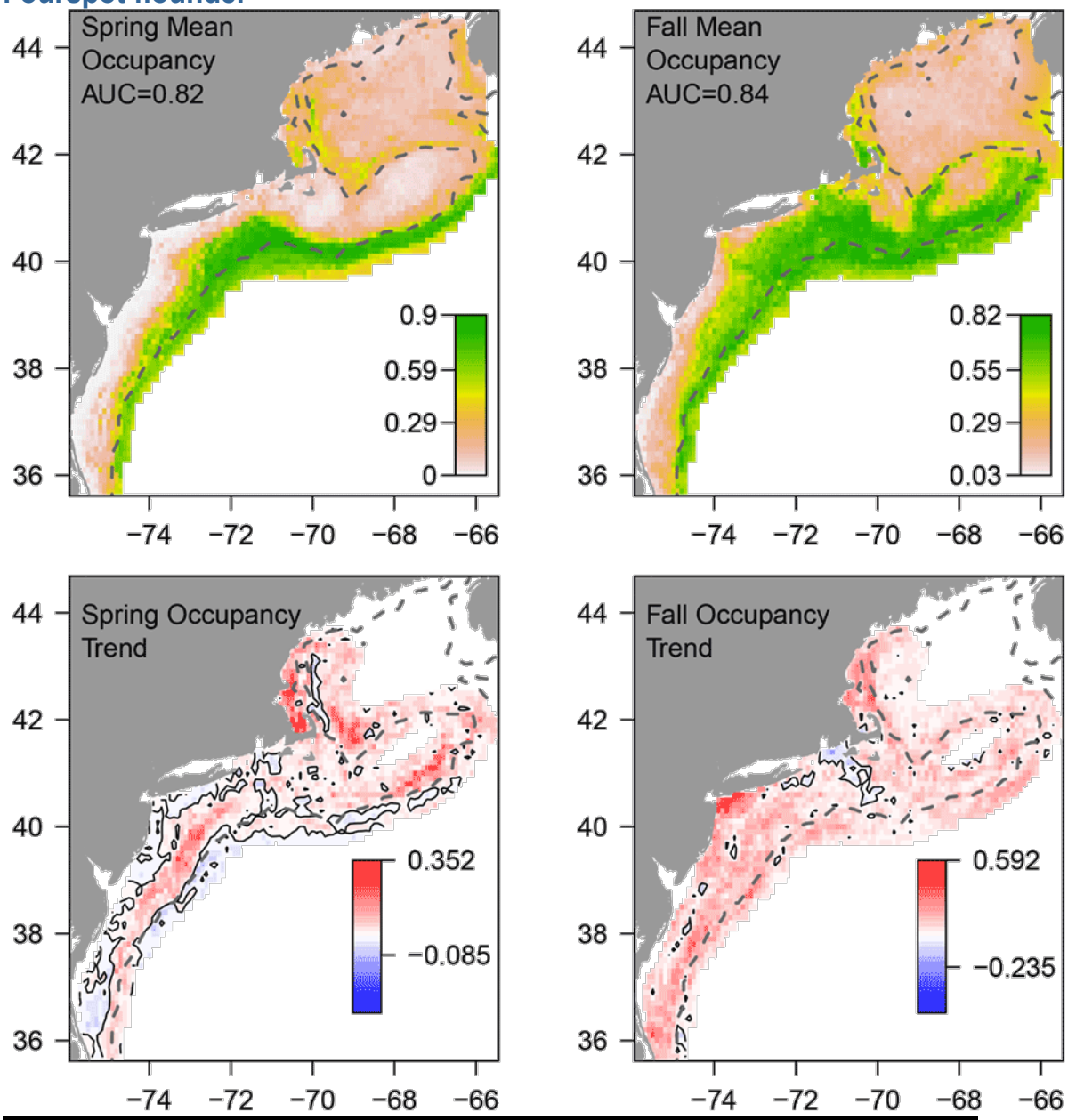
Mean spring and fall occupancy habitat and their associated trends for fawn cusk-eel.

Fourbeard rockling



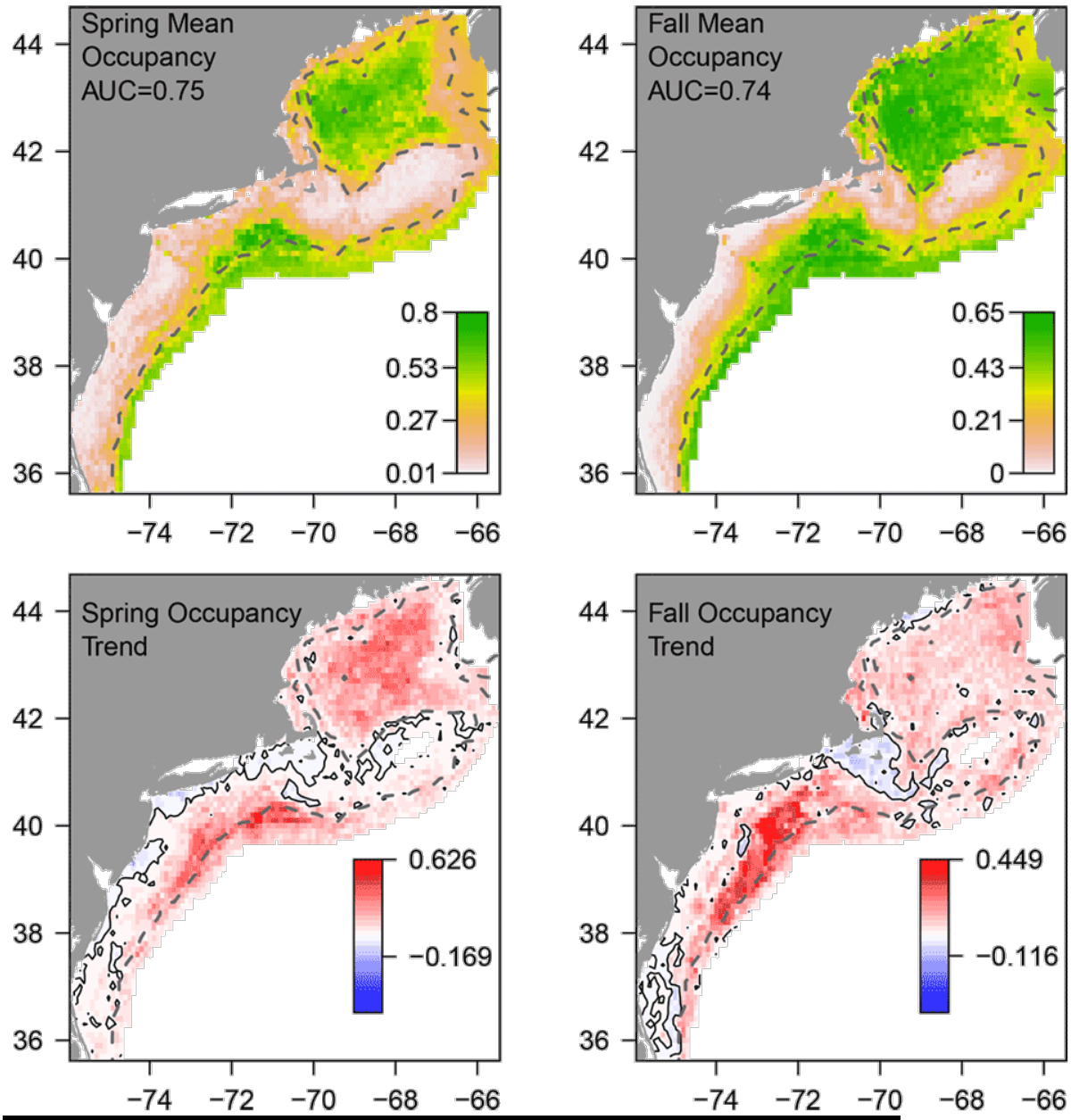
Mean spring and fall occupancy habitat and their associated trends for fourbeard rockling.

Fourspot flounder



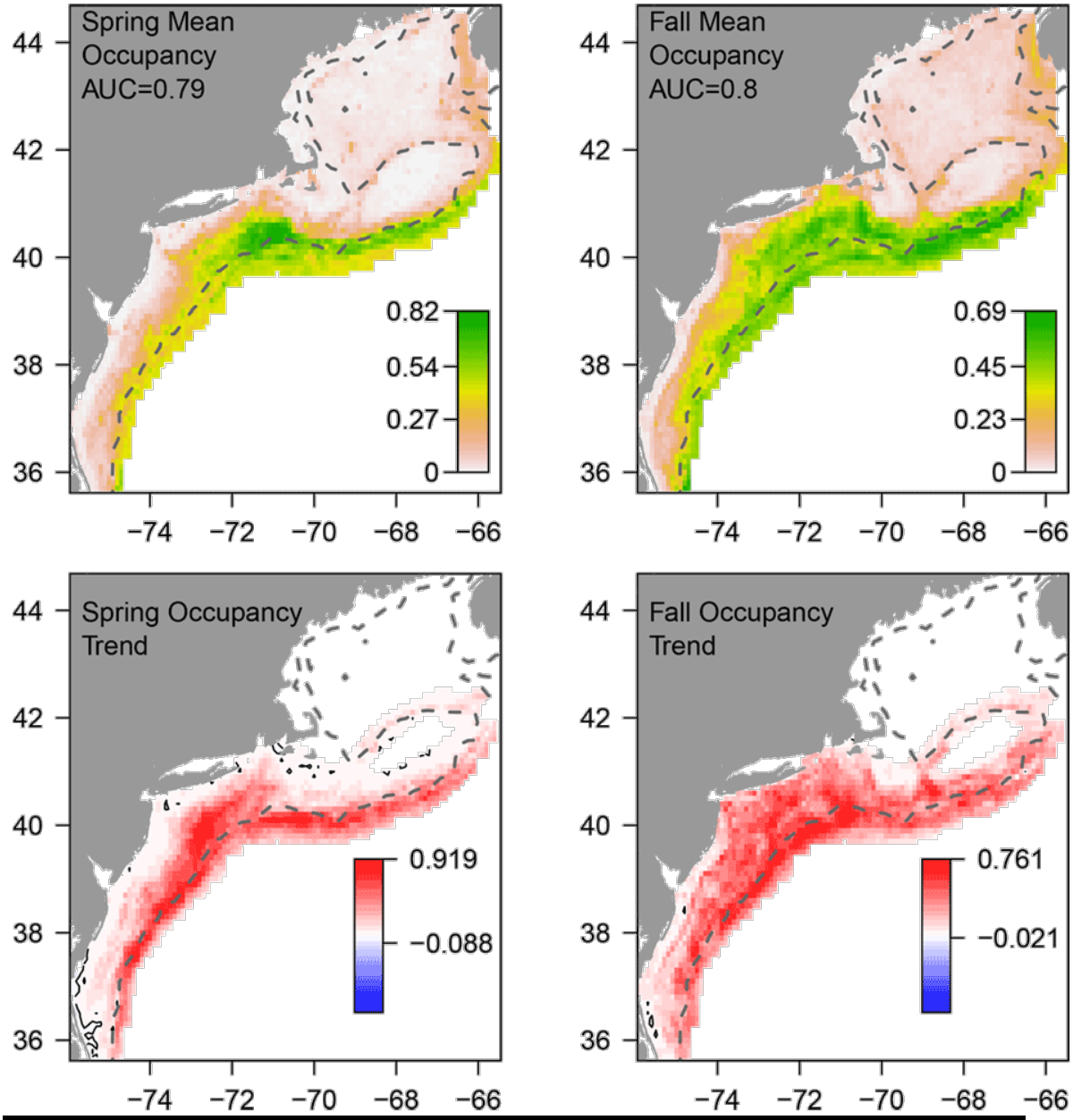
Mean spring and fall occupancy habitat and their associated trends for fourspot flounder.

Goosefish



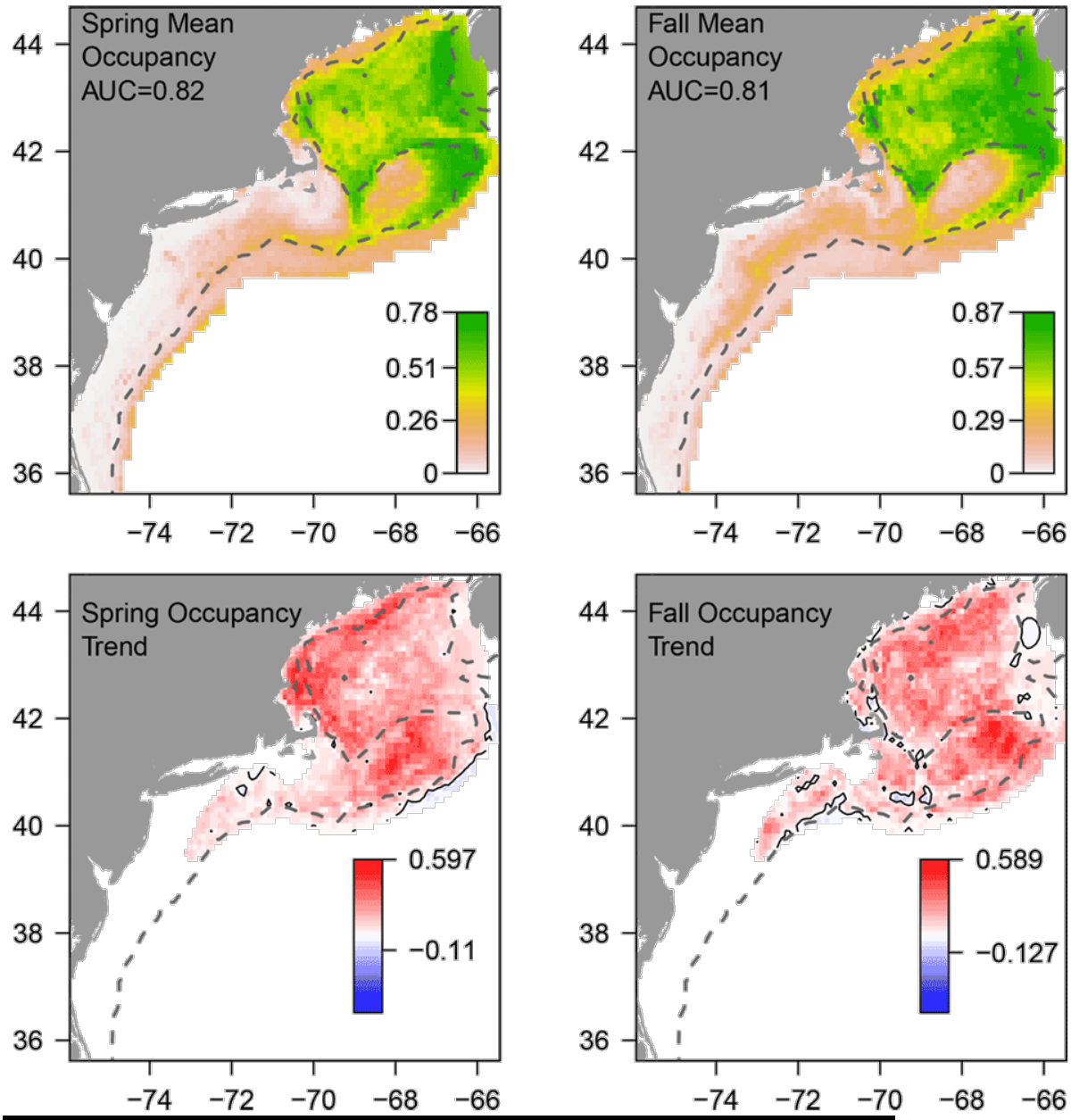
Mean spring and fall occupancy habitat and their associated trends for goosefish.

Gulf Stream flounder



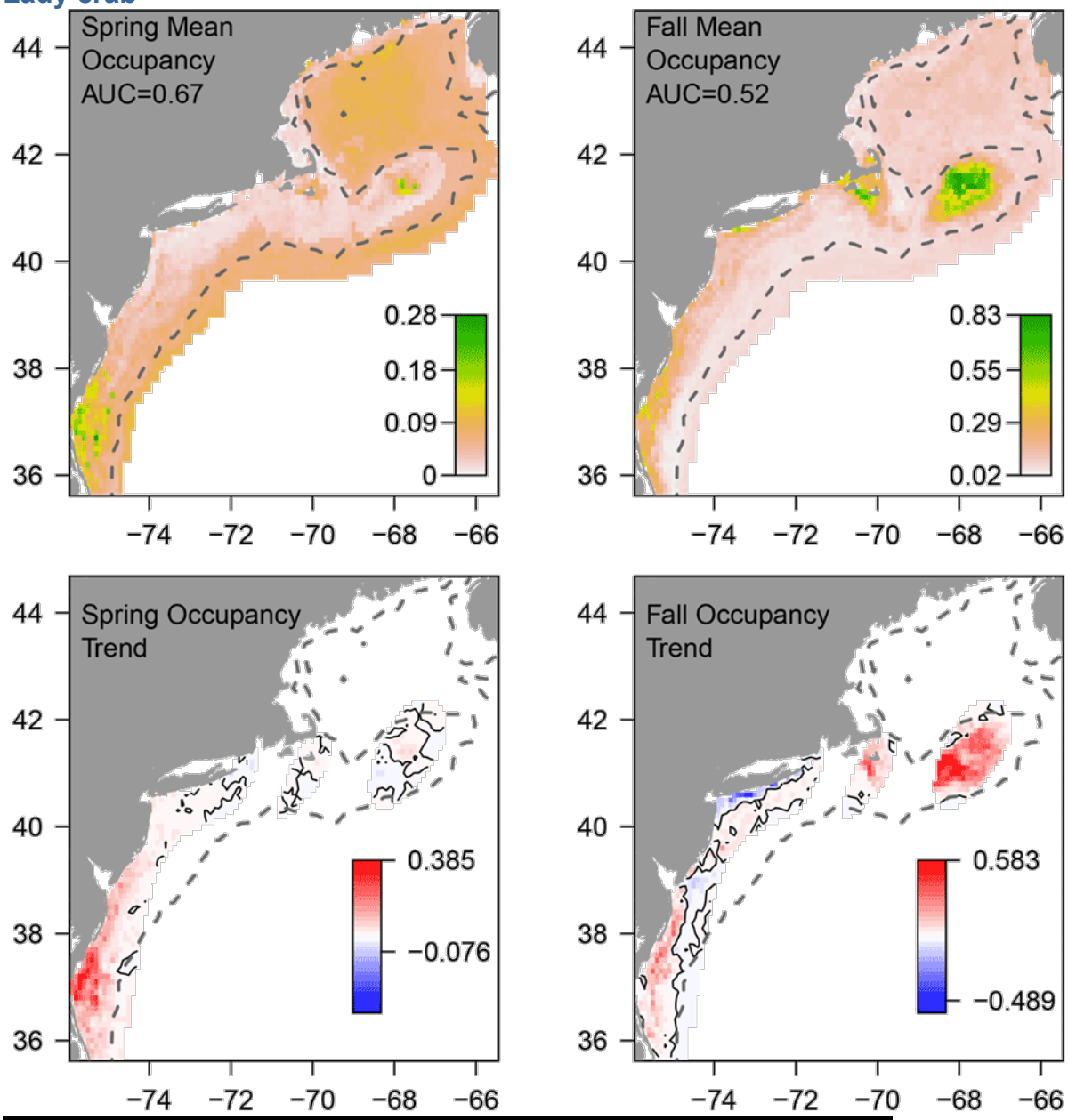
Mean spring and fall occupancy habitat and their associated trends for Gulf Stream flounder.

Haddock



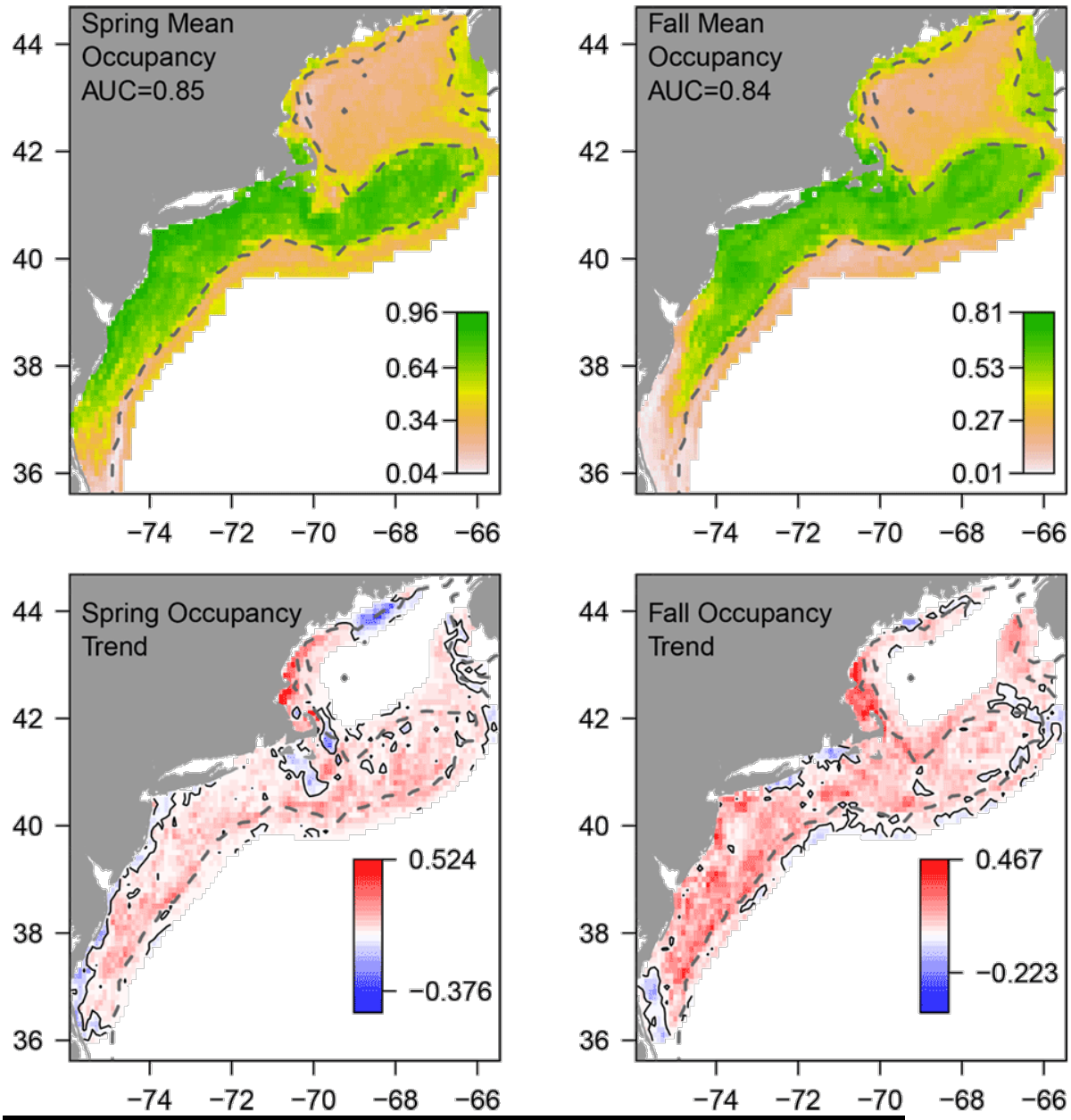
Mean spring and fall occupancy habitat and their associated trends for haddock.

Lady crab



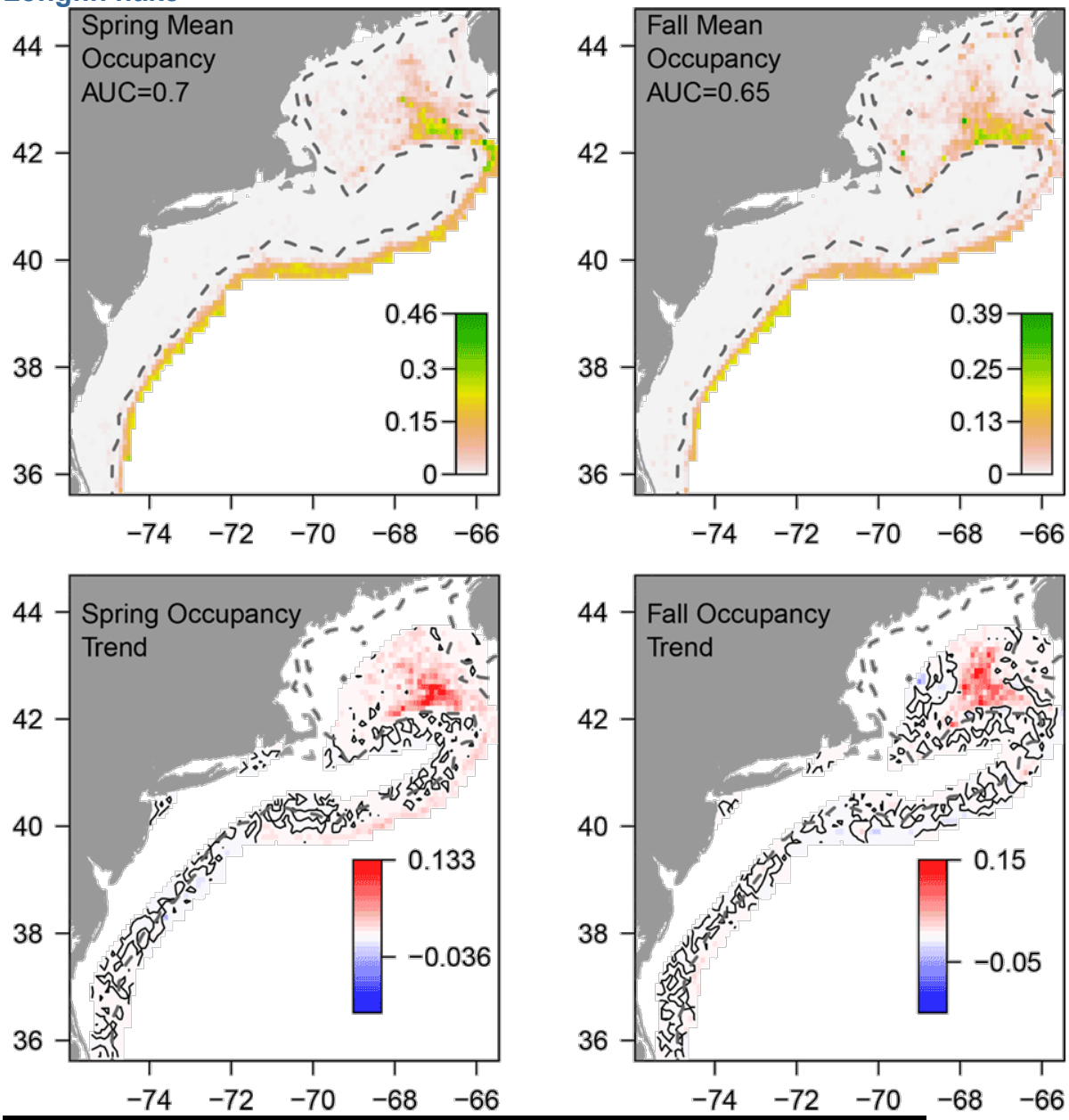
Mean spring and fall occupancy habitat and their associated trends for lady crab.

Little Skate



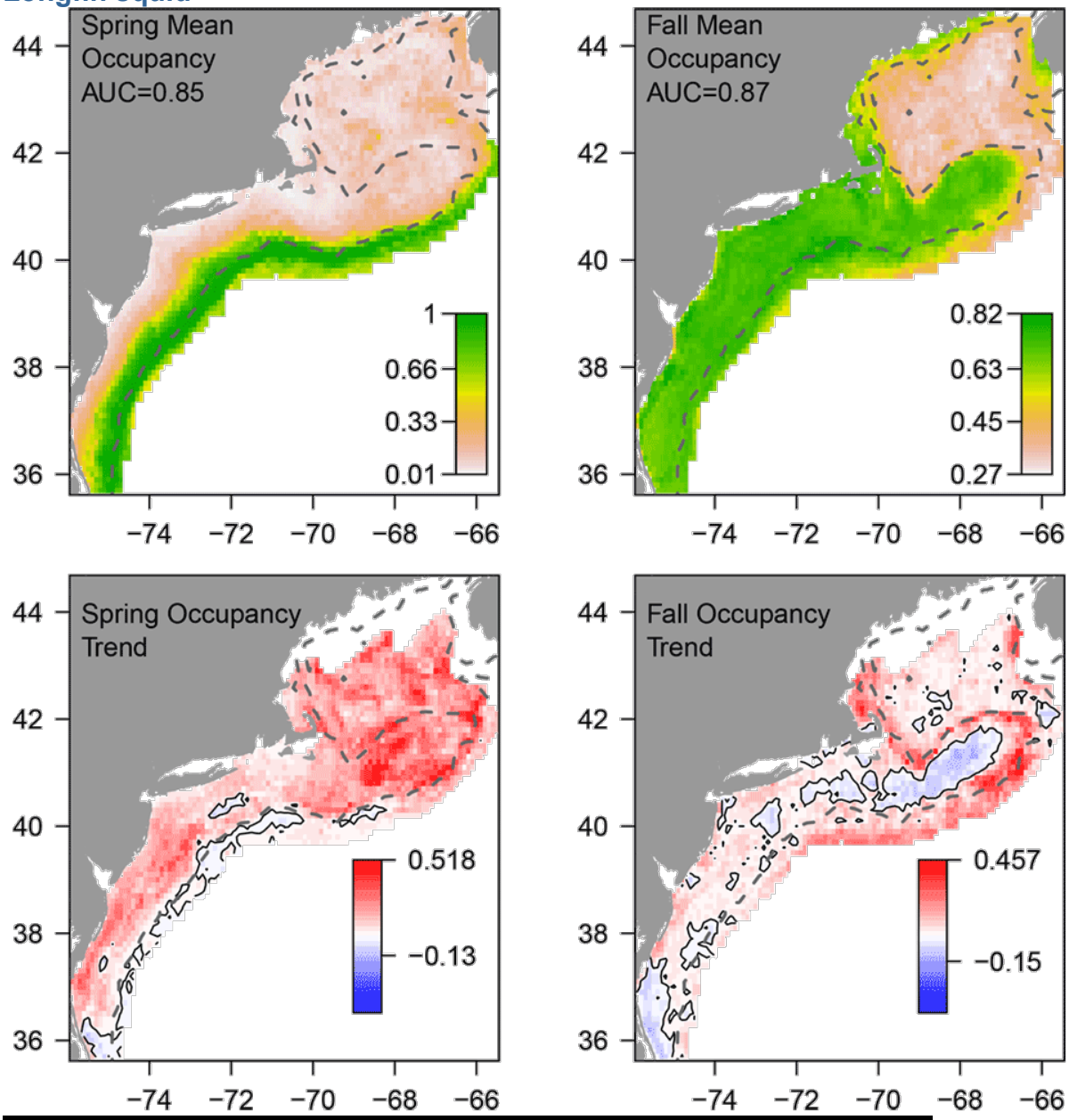
Mean spring and fall occupancy habitat and their associated trends for little skate.

Longfin hake



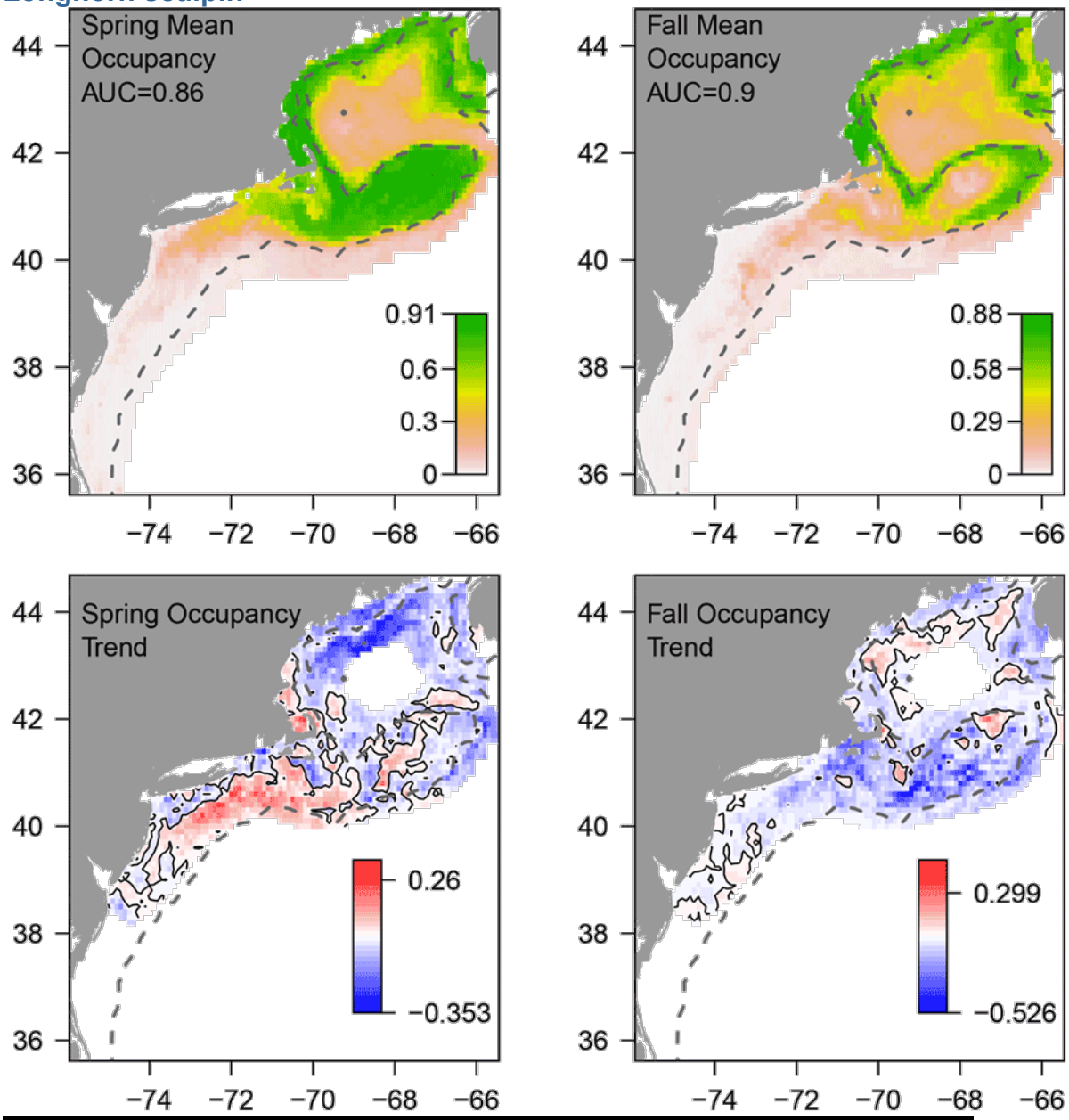
Mean spring and fall occupancy habitat and their associated trends for longfin hake.

Longfin squid



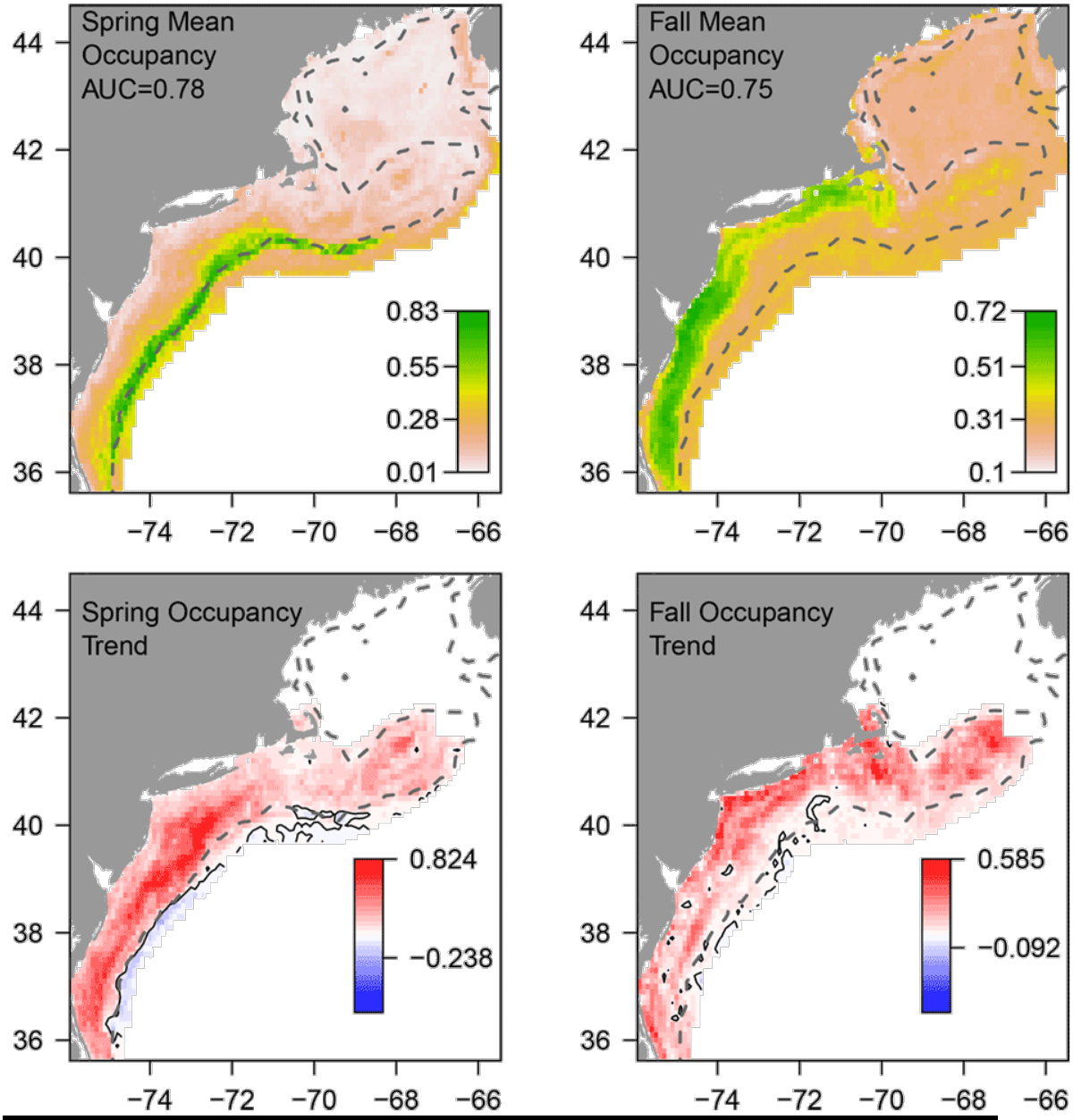
Mean spring and fall occupancy habitat and their associated trends for longfin squid.

Longhorn sculpin



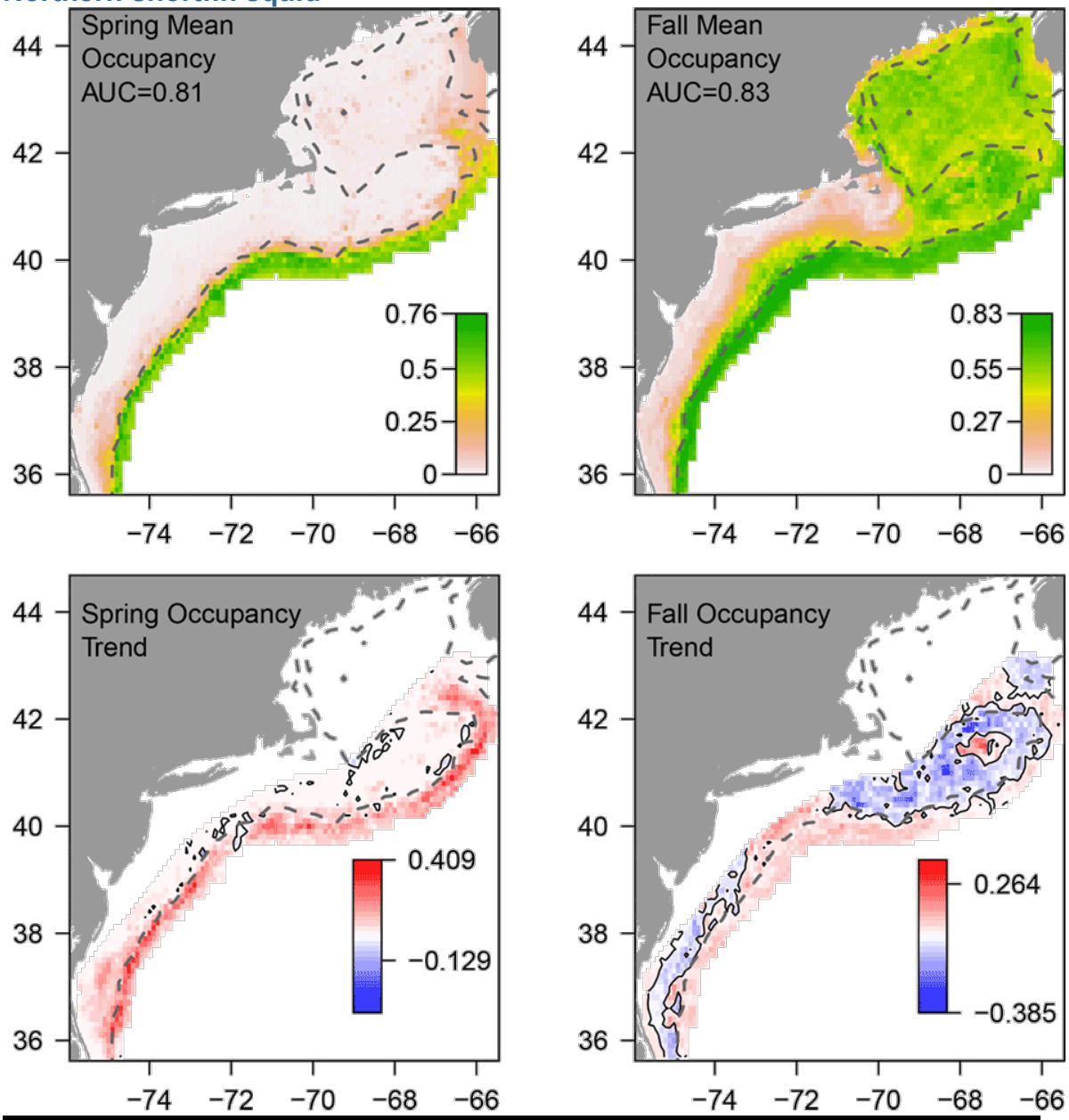
Mean spring and fall occupancy habitat and their associated trends for longhorn sculpin.

Northern sea robin



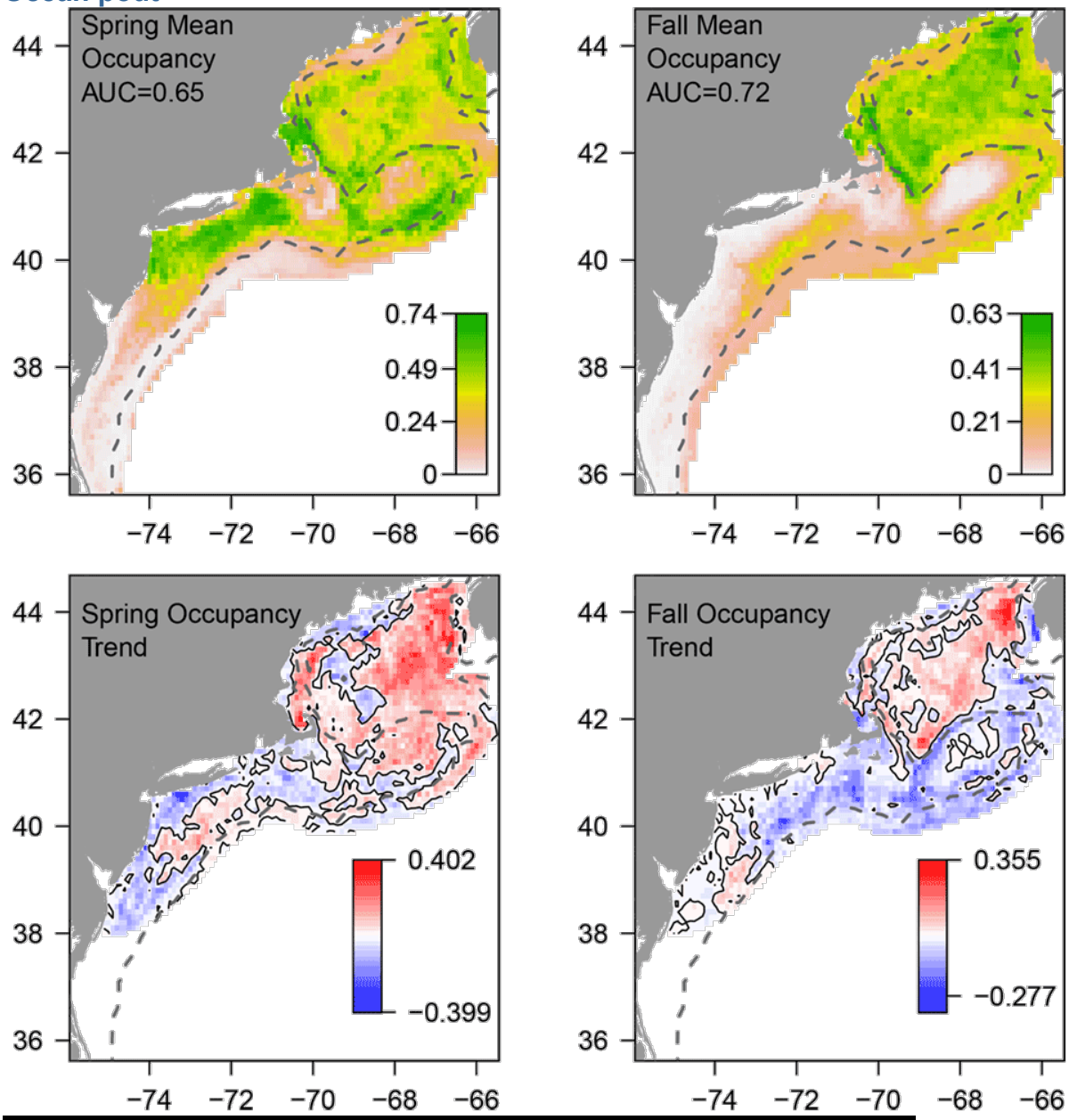
Mean spring and fall occupancy habitat and their associated trends for northern sea robin.

Northern shortfin squid



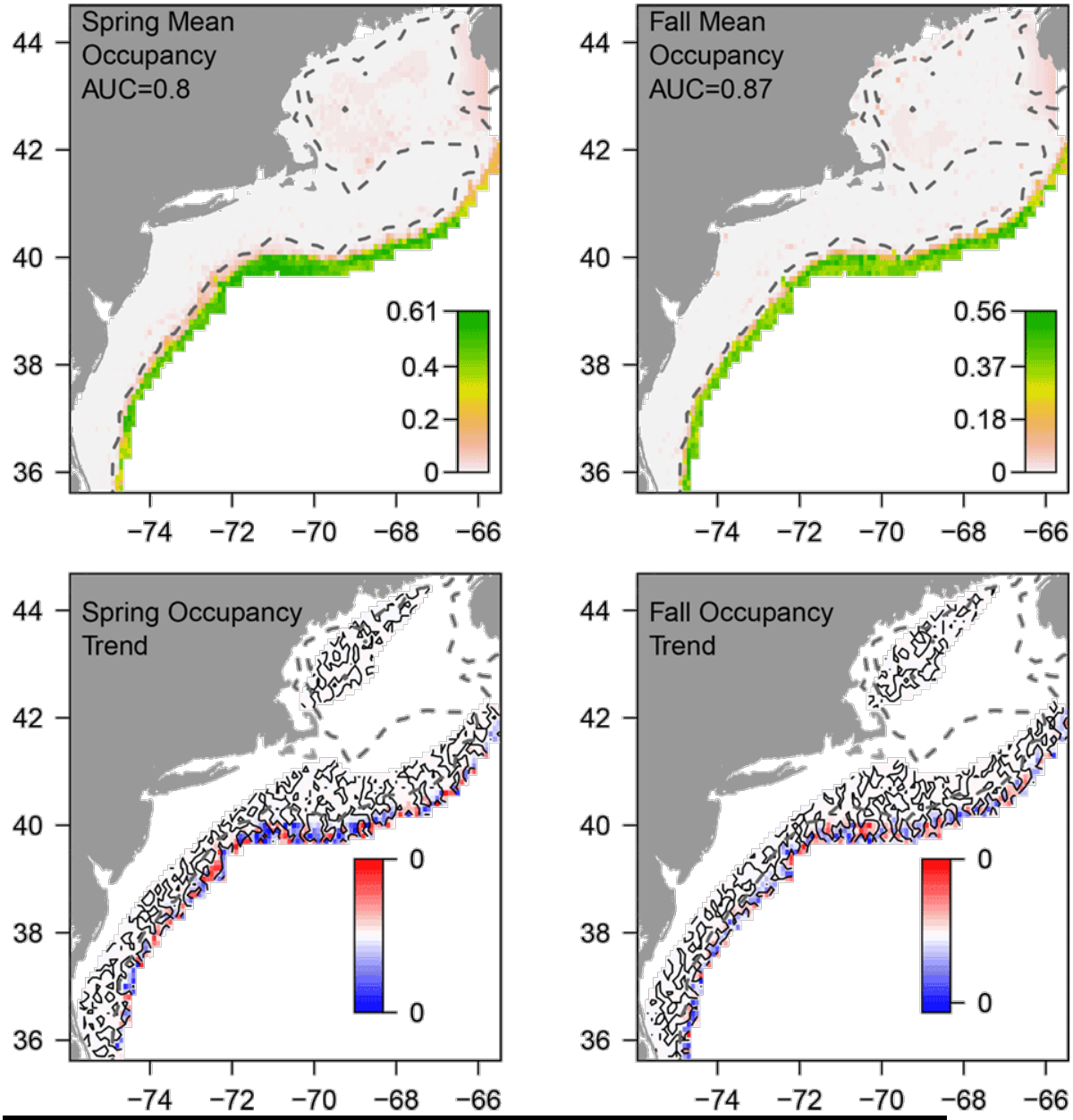
Mean spring and fall occupancy habitat and their associated trends for northern shortfin squid.

Ocean pout



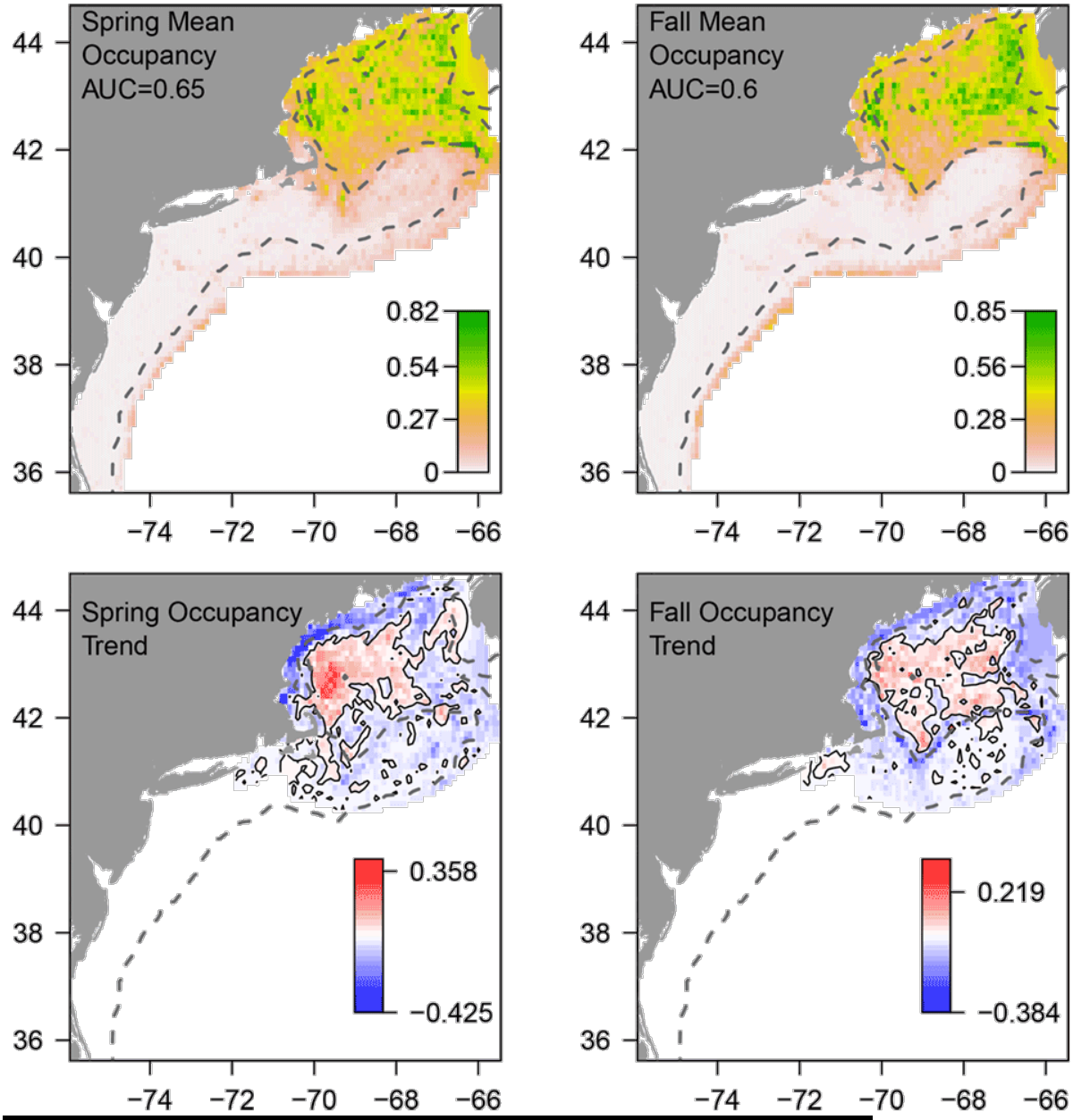
Mean spring and fall occupancy habitat and their associated trends for ocean pout.

Offshore hake



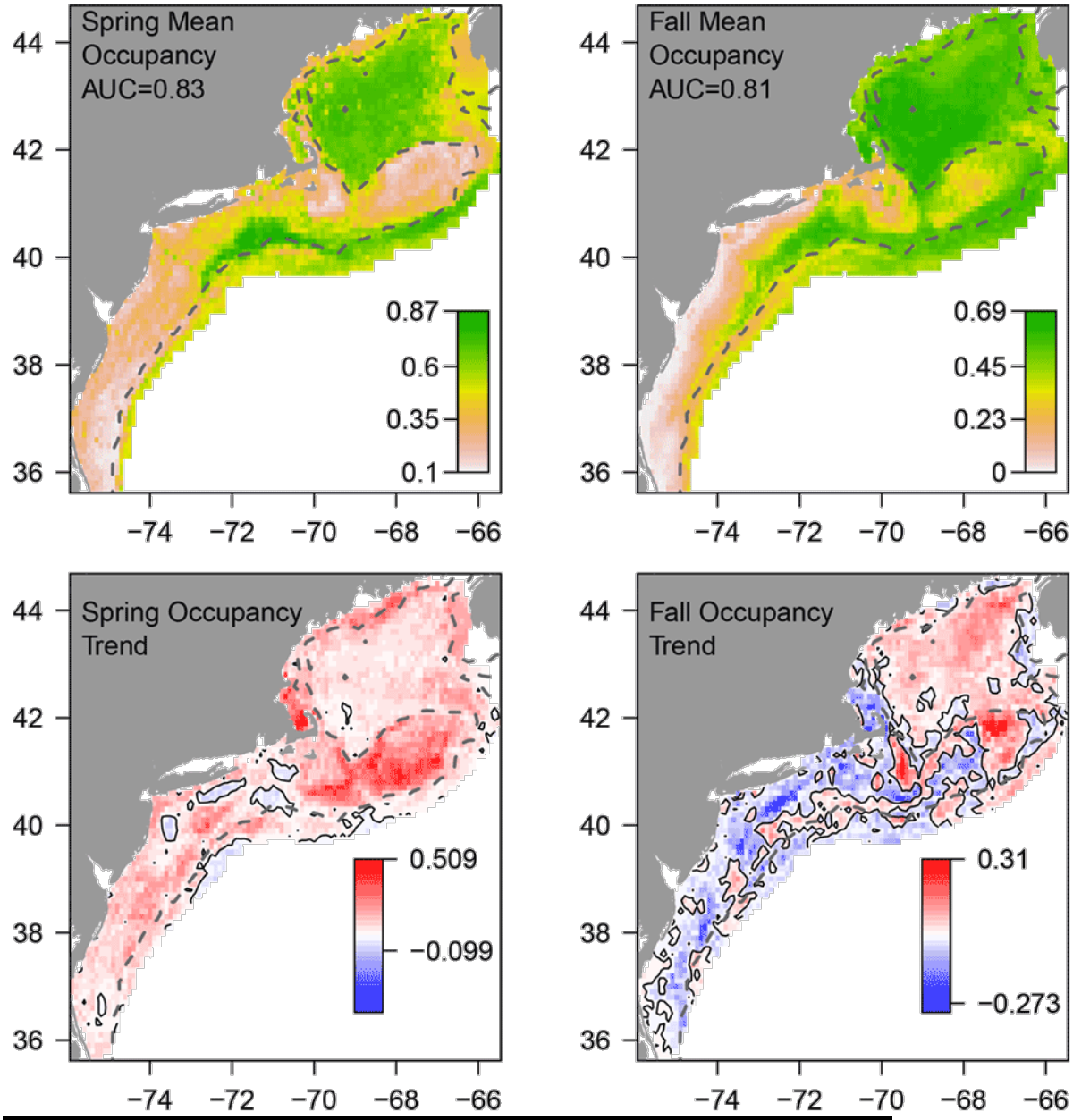
Mean spring and fall occupancy habitat and their associated trends for offshore hake.

Pollock



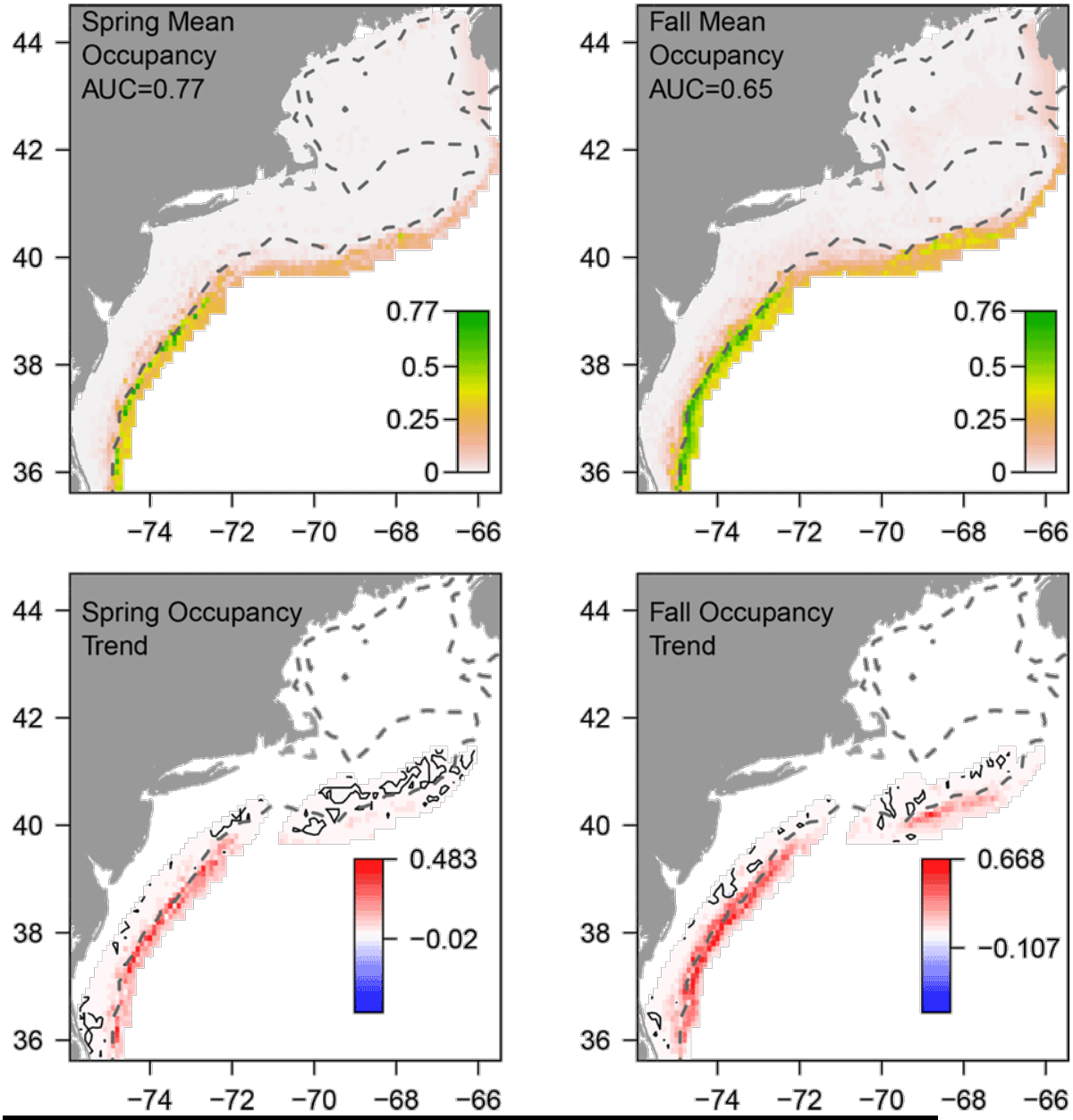
Mean spring and fall occupancy habitat and their associated trends for pollock.

Red hake



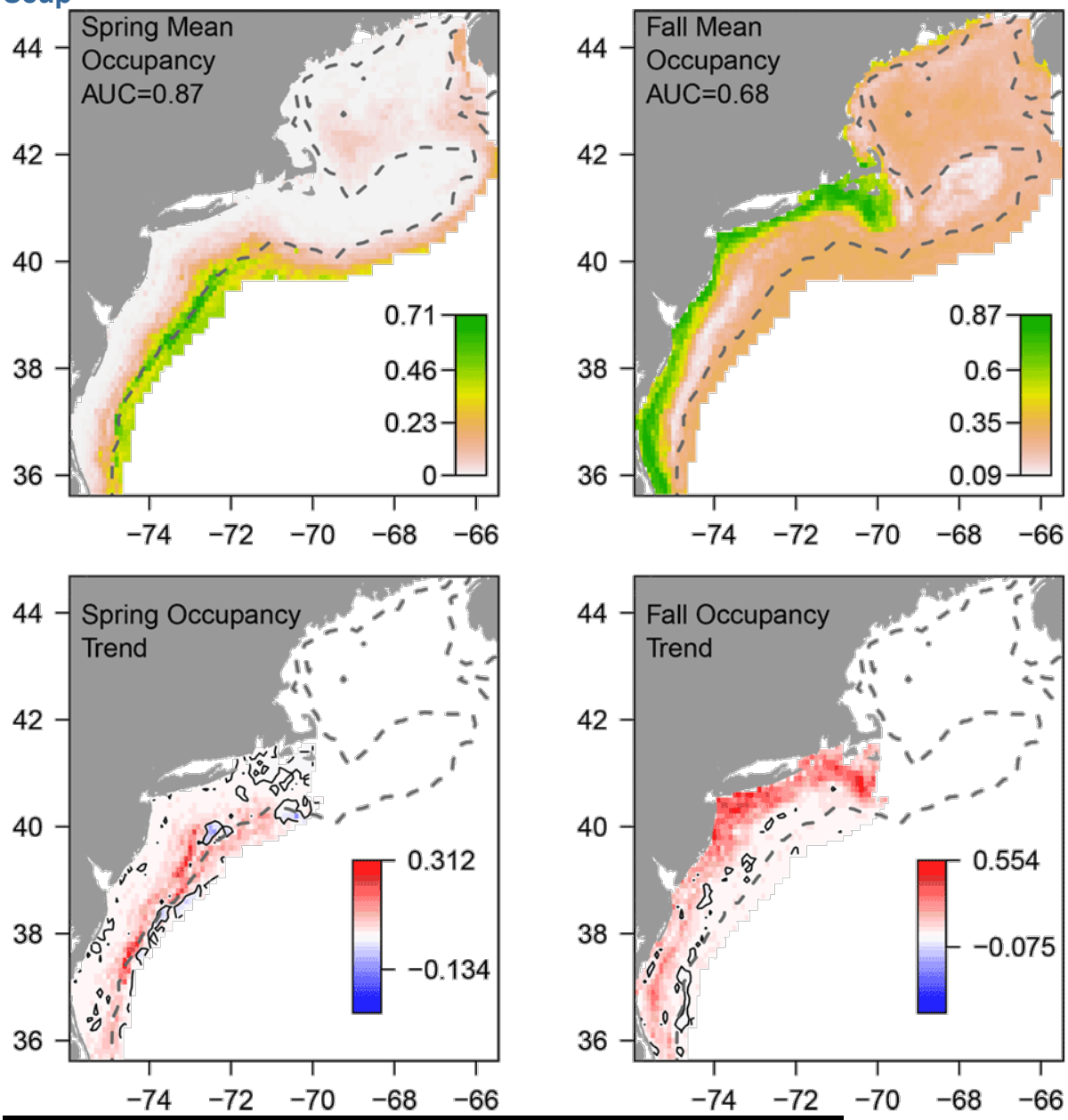
Mean spring and fall occupancy habitat and their associated trends for red hake.

Rosette skate



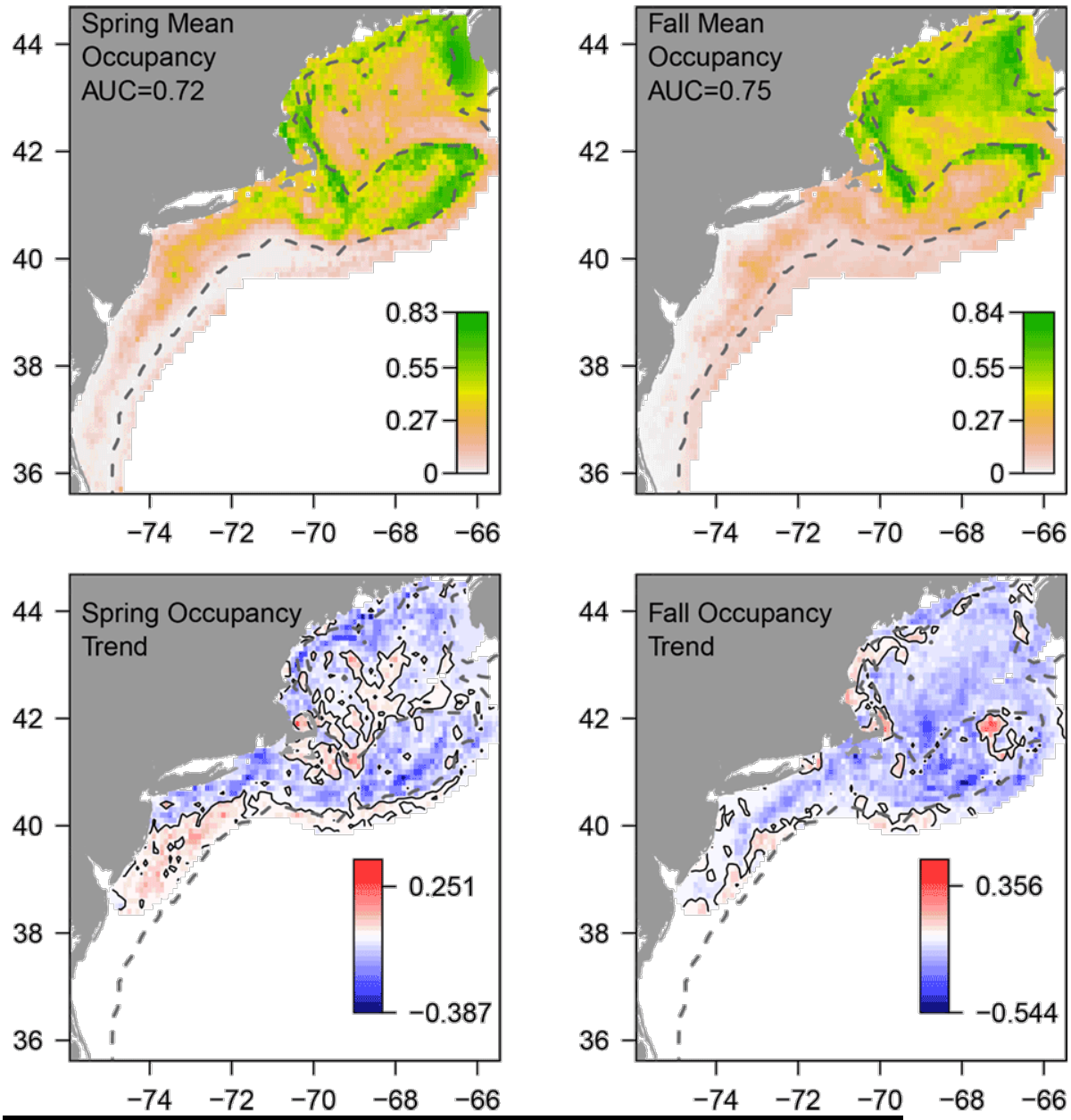
Mean spring and fall occupancy habitat and their associated trends for rosette skate.

Scup



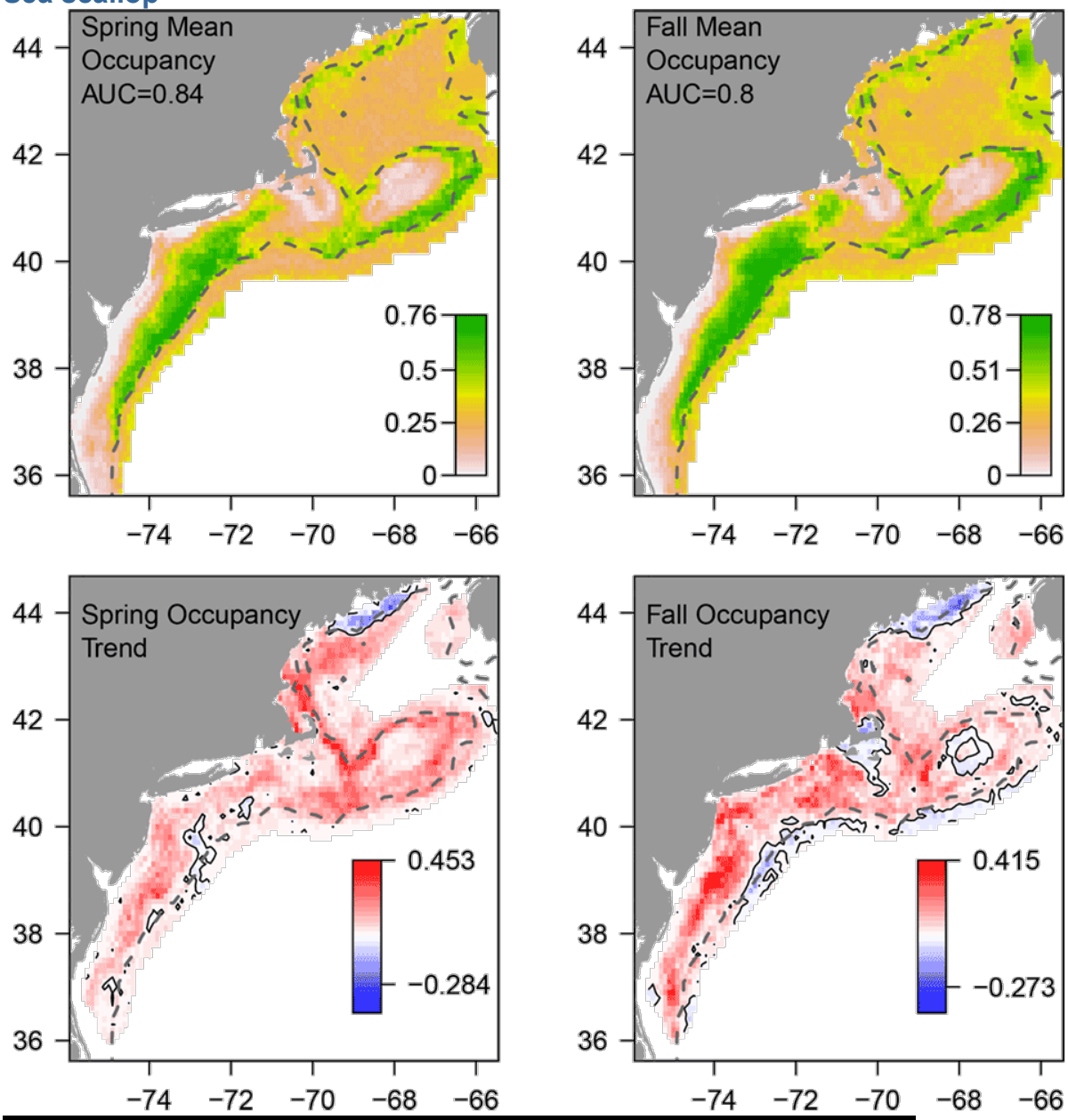
Mean spring and fall occupancy habitat and their associated trends for scup.

Sea raven



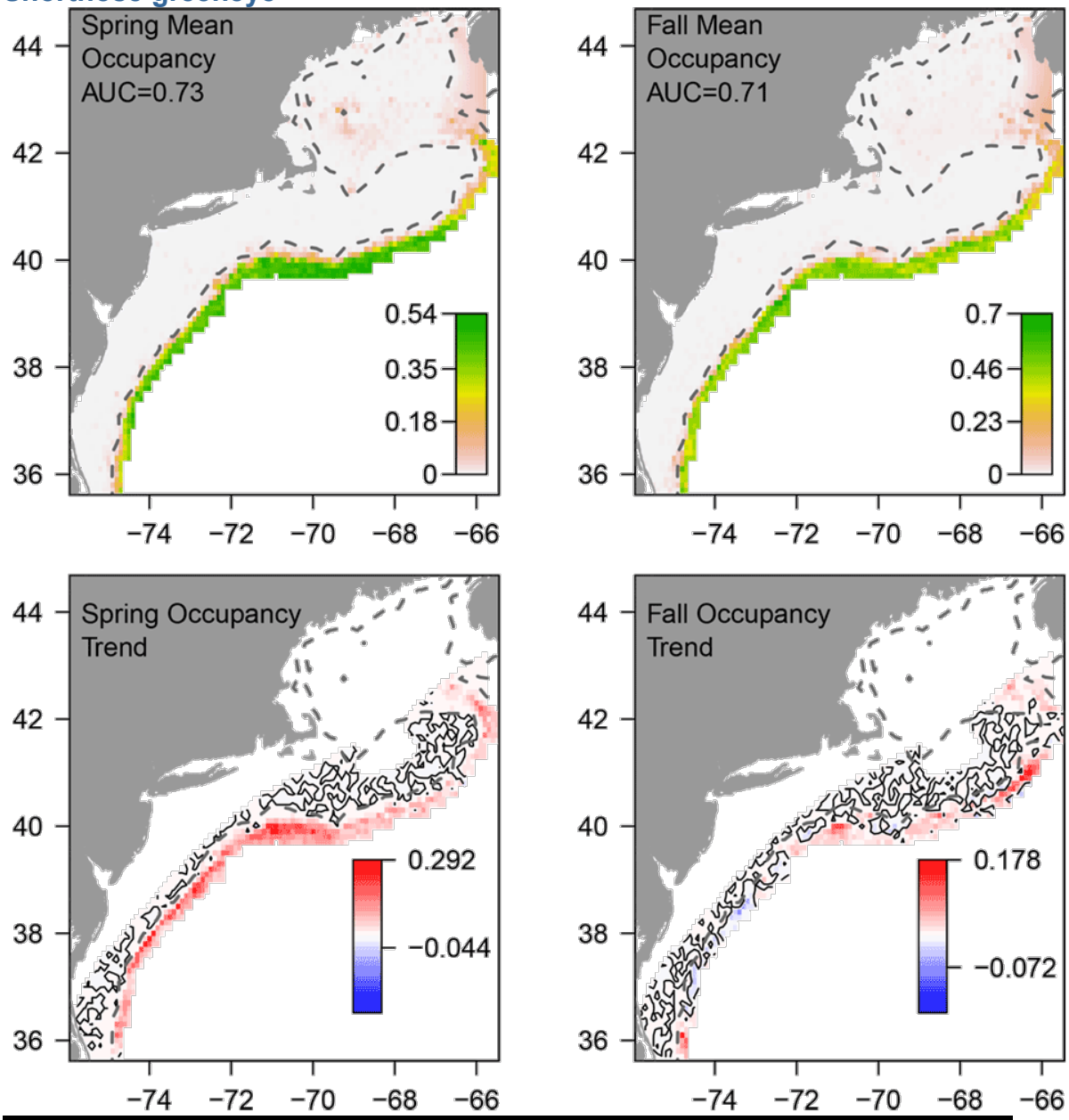
Mean spring and fall occupancy habitat and their associated trends for sea raven.

Sea scallop



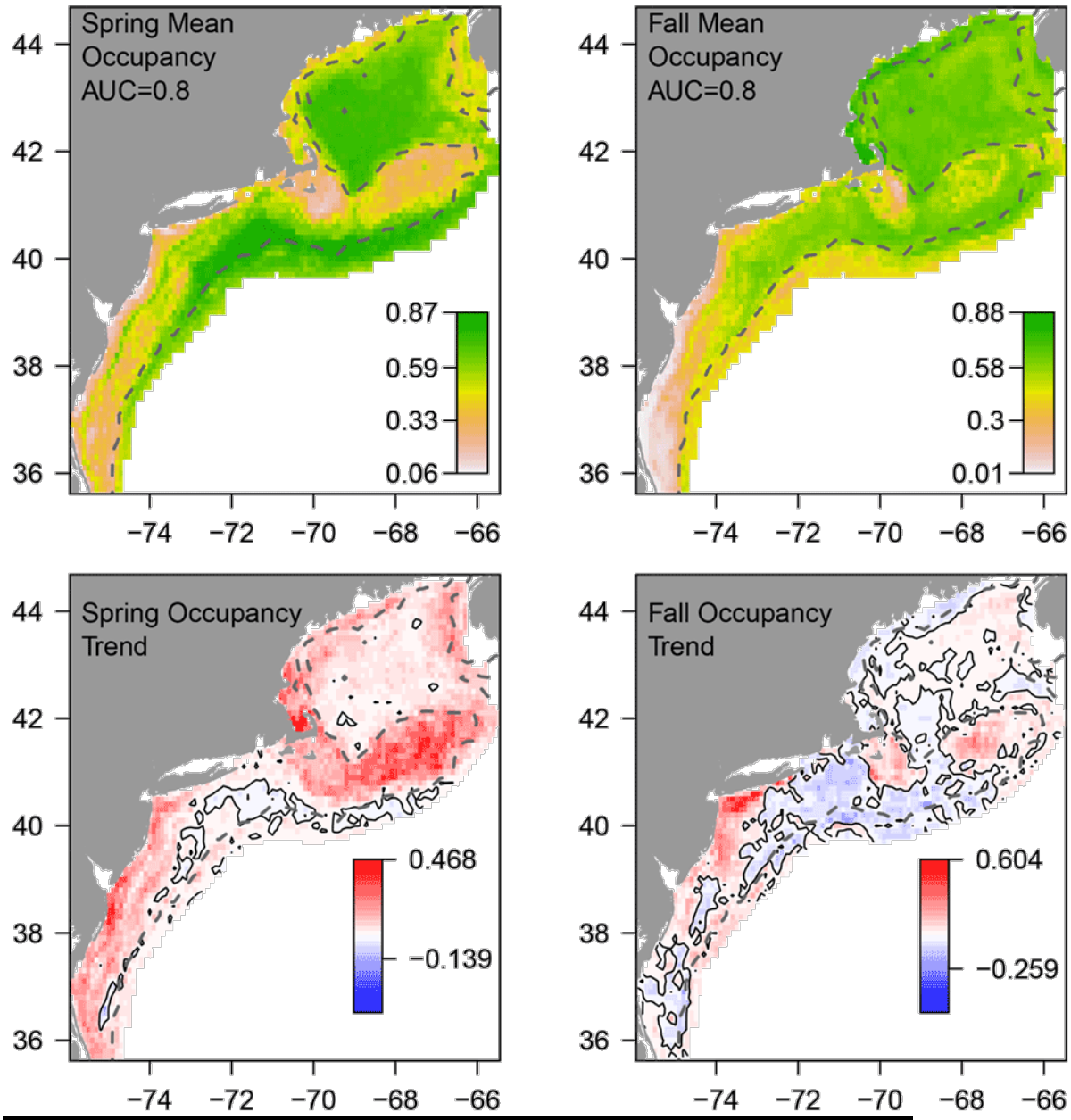
Mean spring and fall occupancy habitat and their associated trends for sea scallop.

Shortnose greeneye



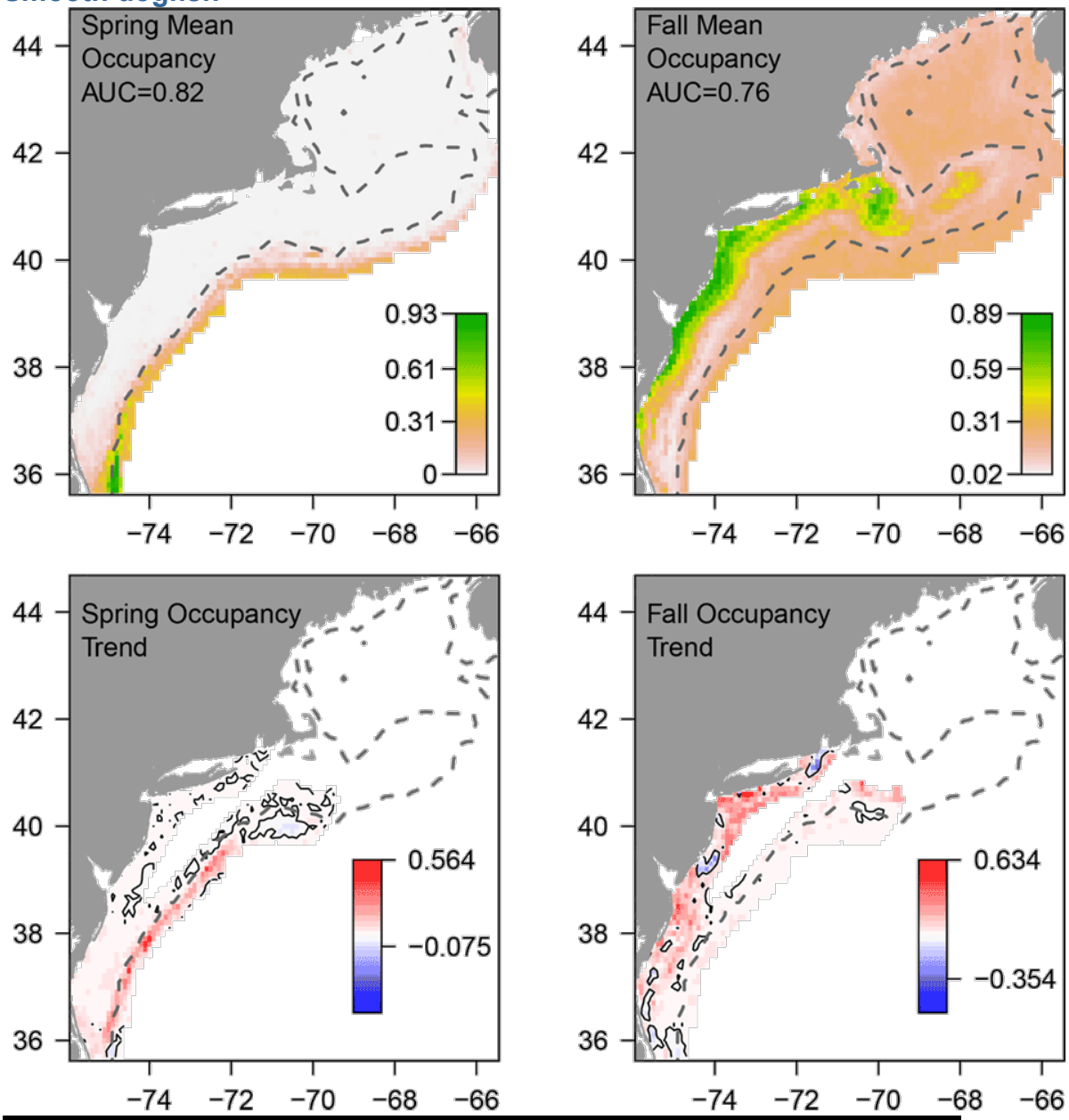
Mean spring and fall occupancy habitat and their associated trends for shortnose greeneye.

Silver hake



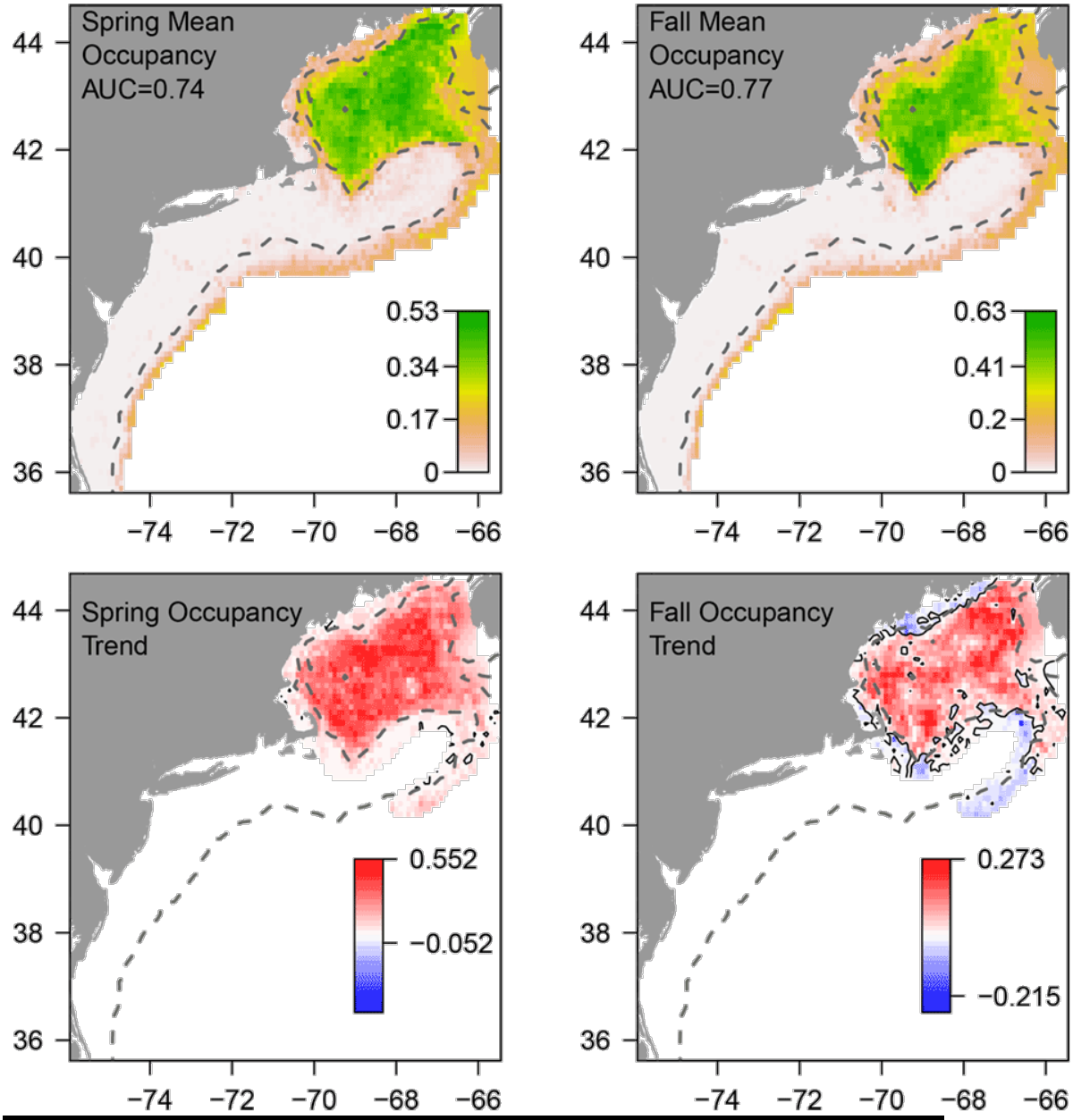
Mean spring and fall occupancy habitat and their associated trends for silver hake.

Smooth dogfish



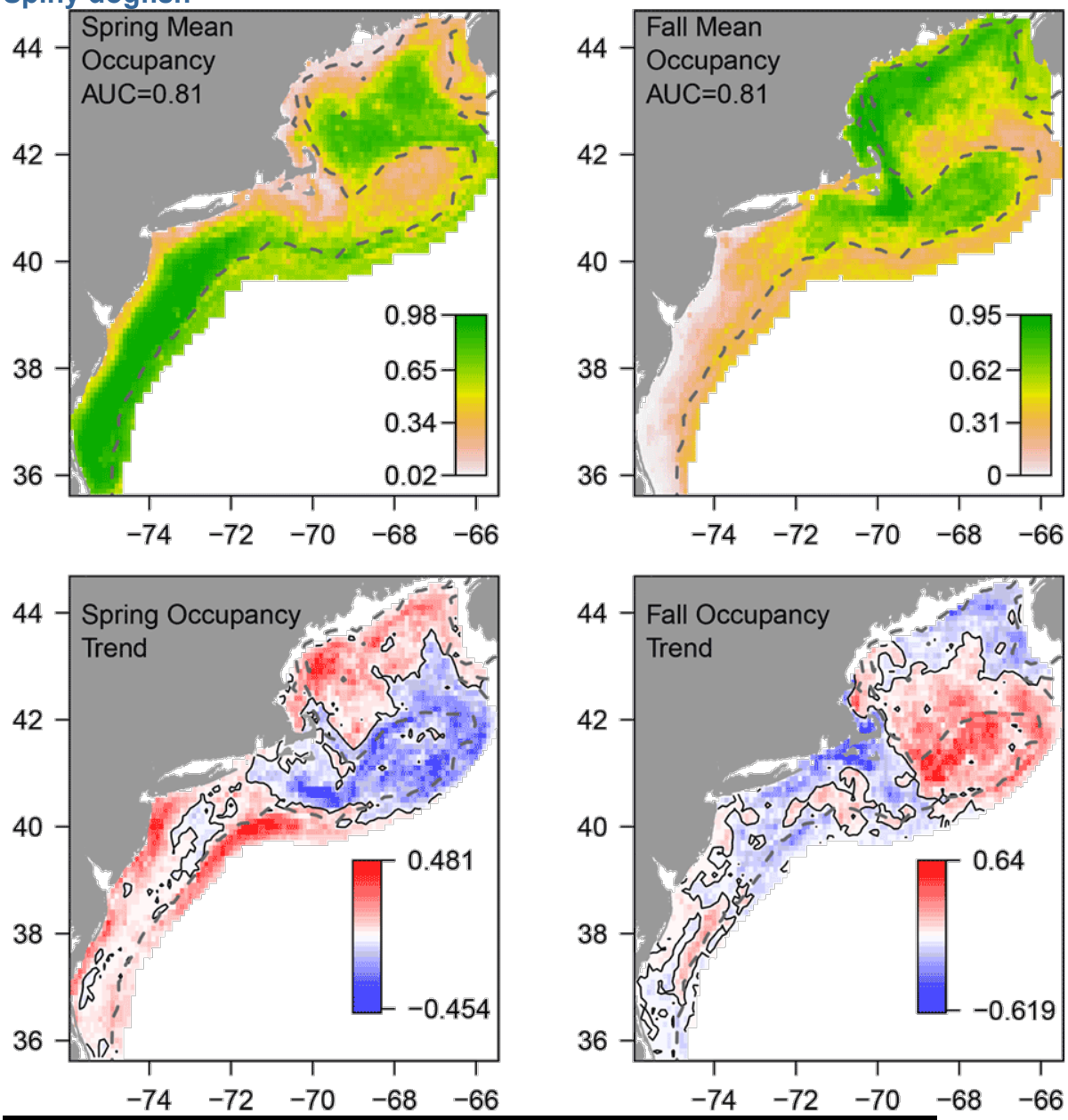
Mean spring and fall occupancy habitat and their associated trends for smooth dogfish.

Smooth skate



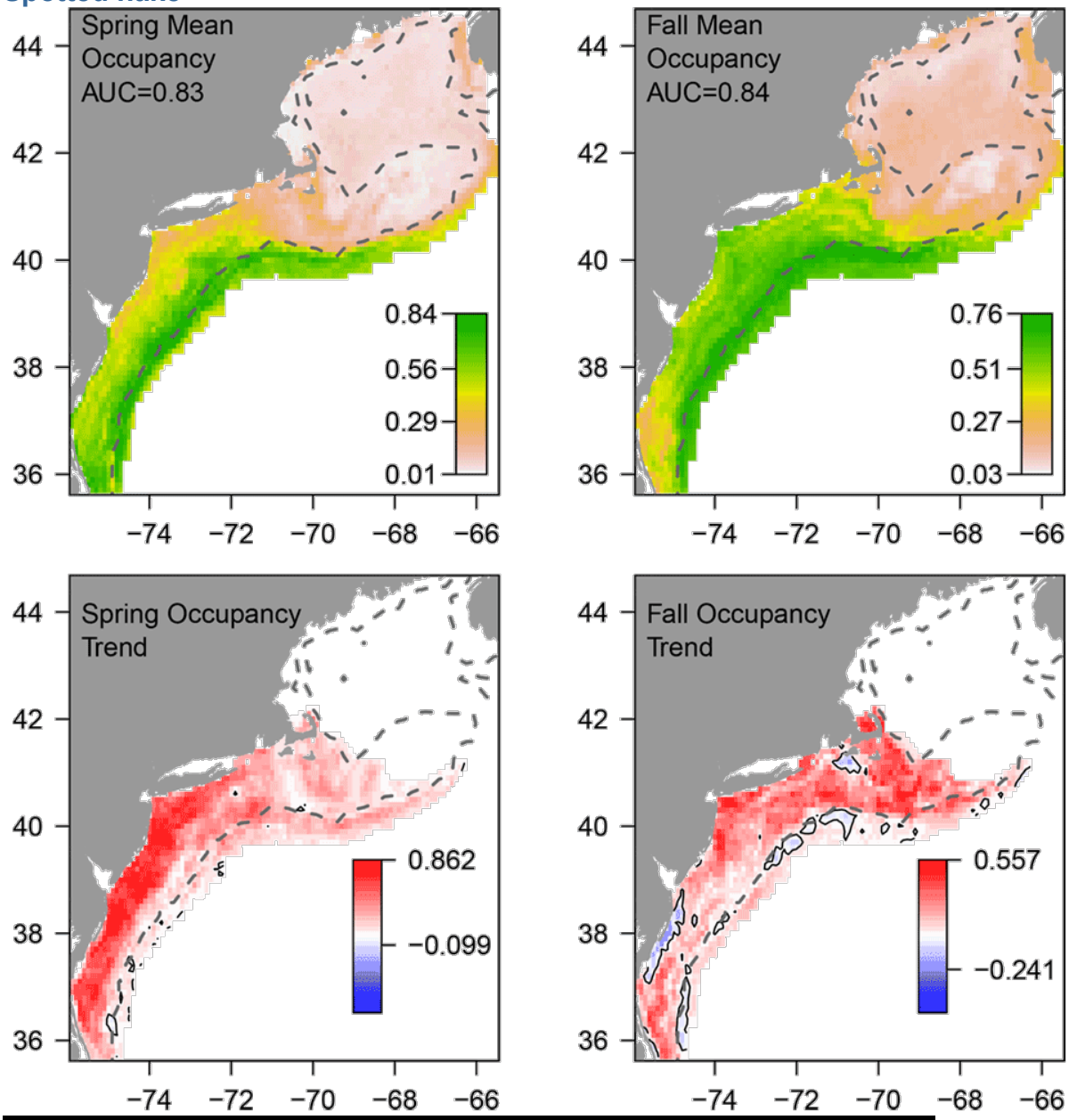
Mean spring and fall occupancy habitat and their associated trends for smooth skate.

Spiny dogfish



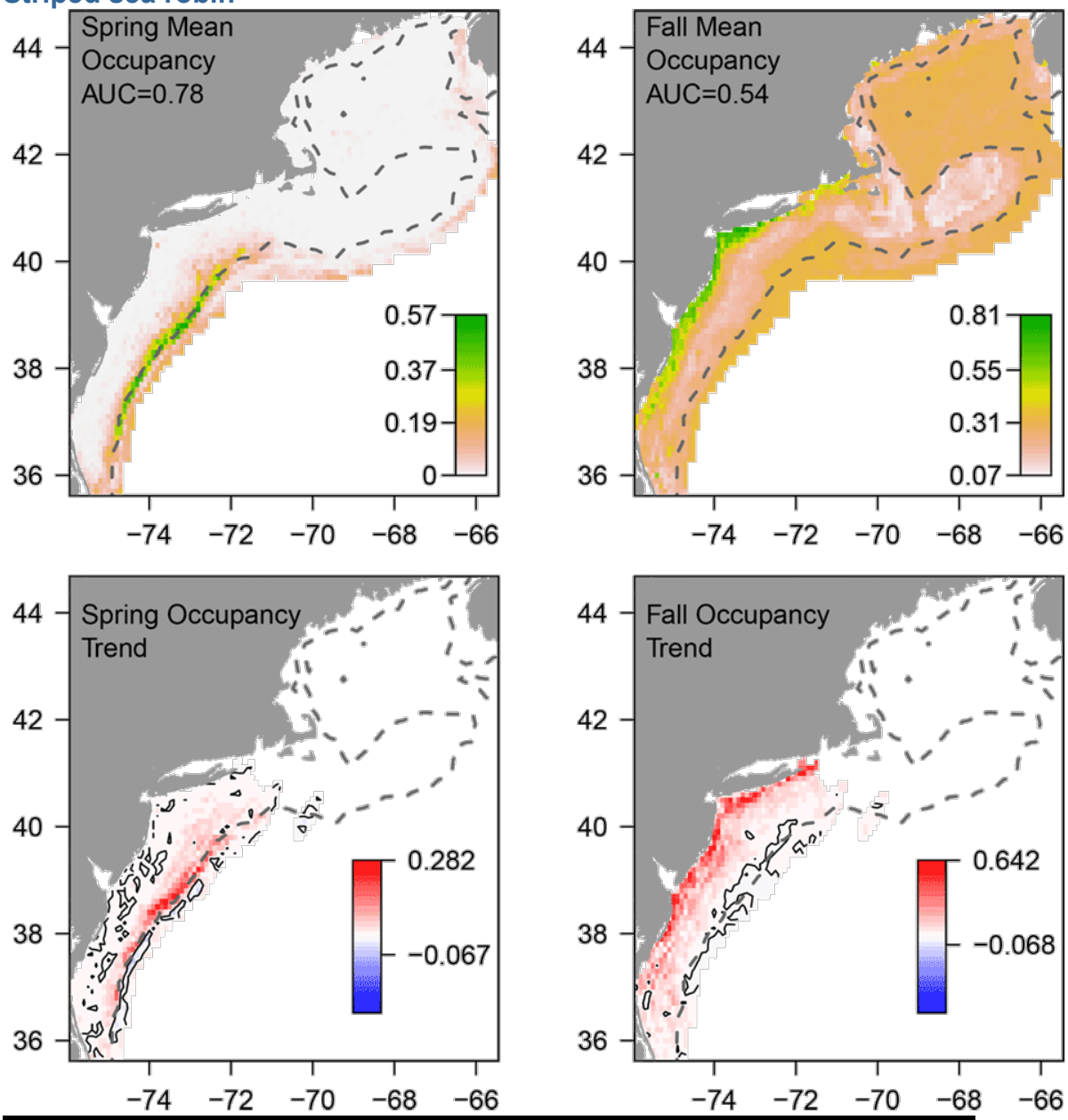
Mean spring and fall occupancy habitat and their associated trends for spiny dogfish.

Spotted hake



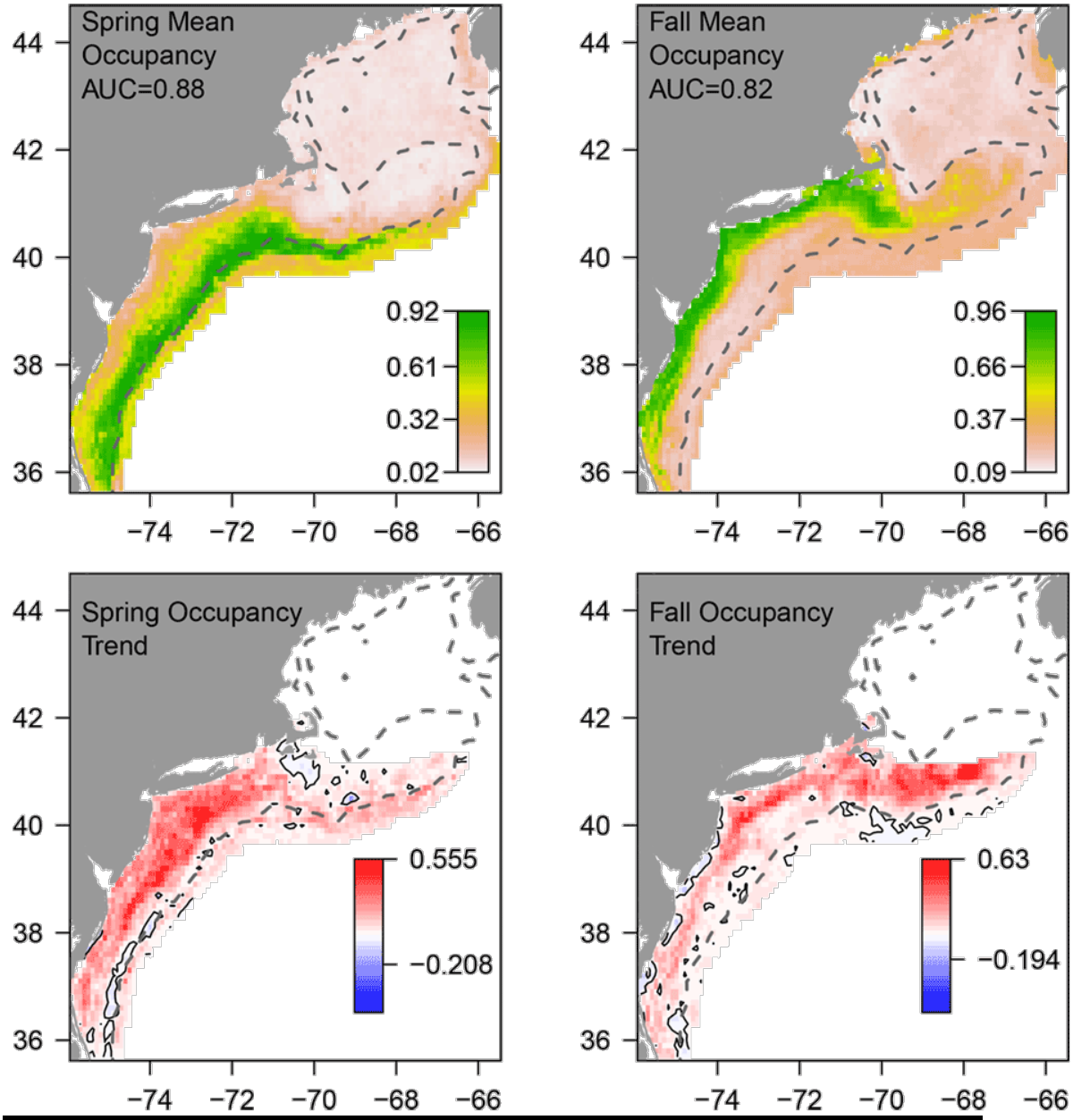
Mean spring and fall occupancy habitat and their associated trends for spotted hake.

Striped sea robin



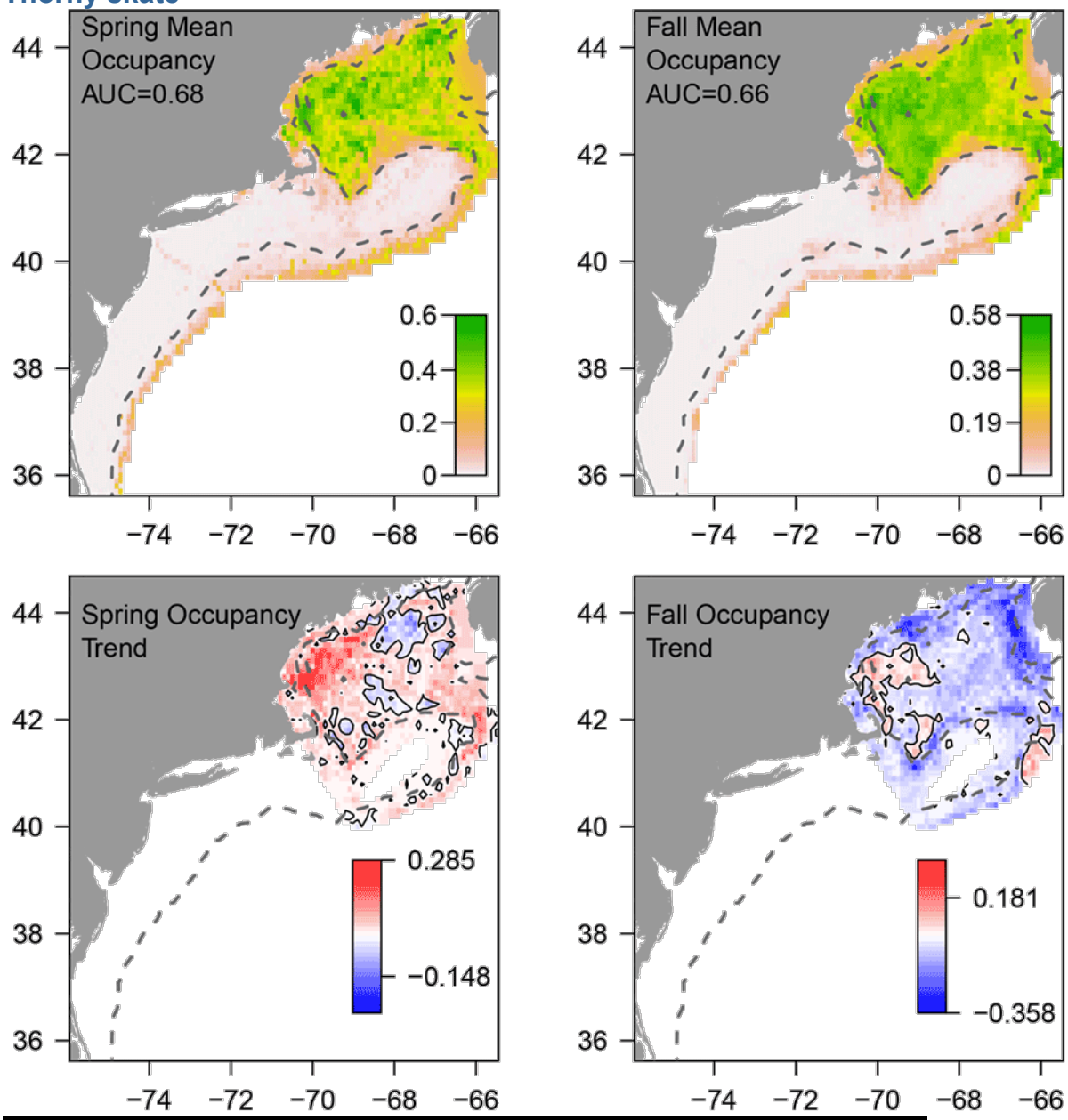
Mean spring and fall occupancy habitat and their associated trends for striped sea robin.

Summer flounder



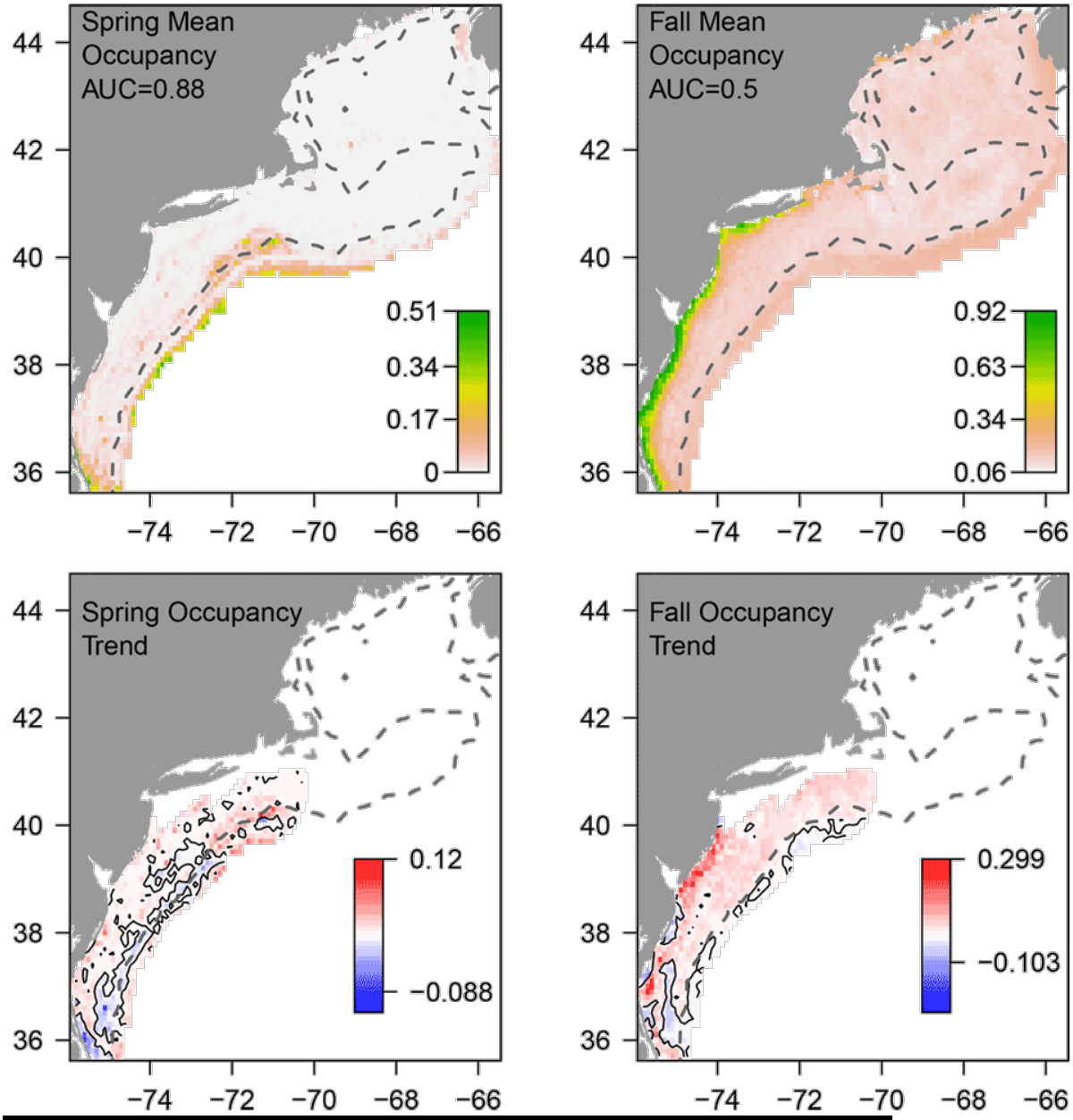
Mean spring and fall occupancy habitat and their associated trends for summer flounder.

Thorny skate



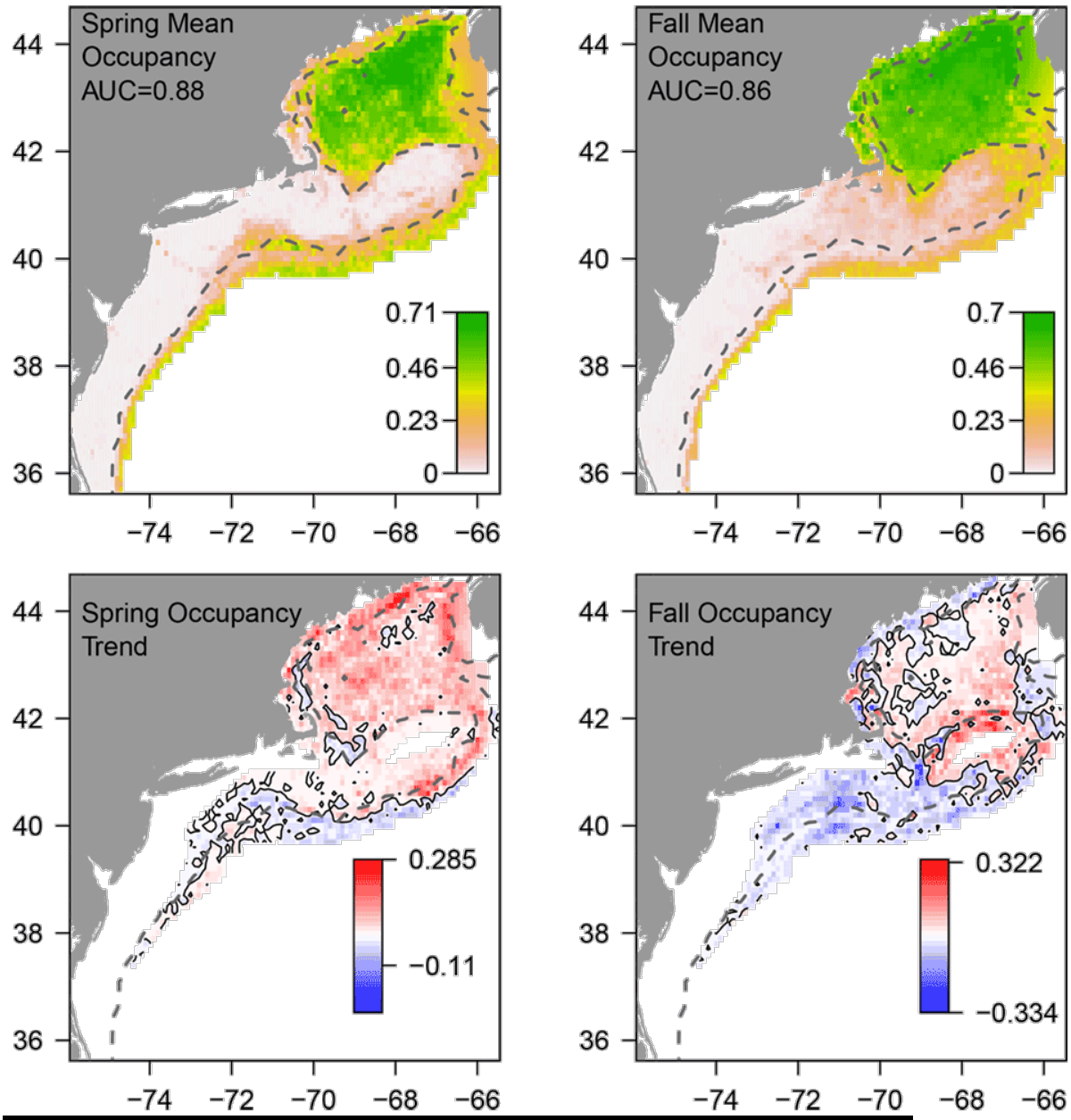
Mean spring and fall occupancy habitat and their associated trends for thorny skate.

Weakfish



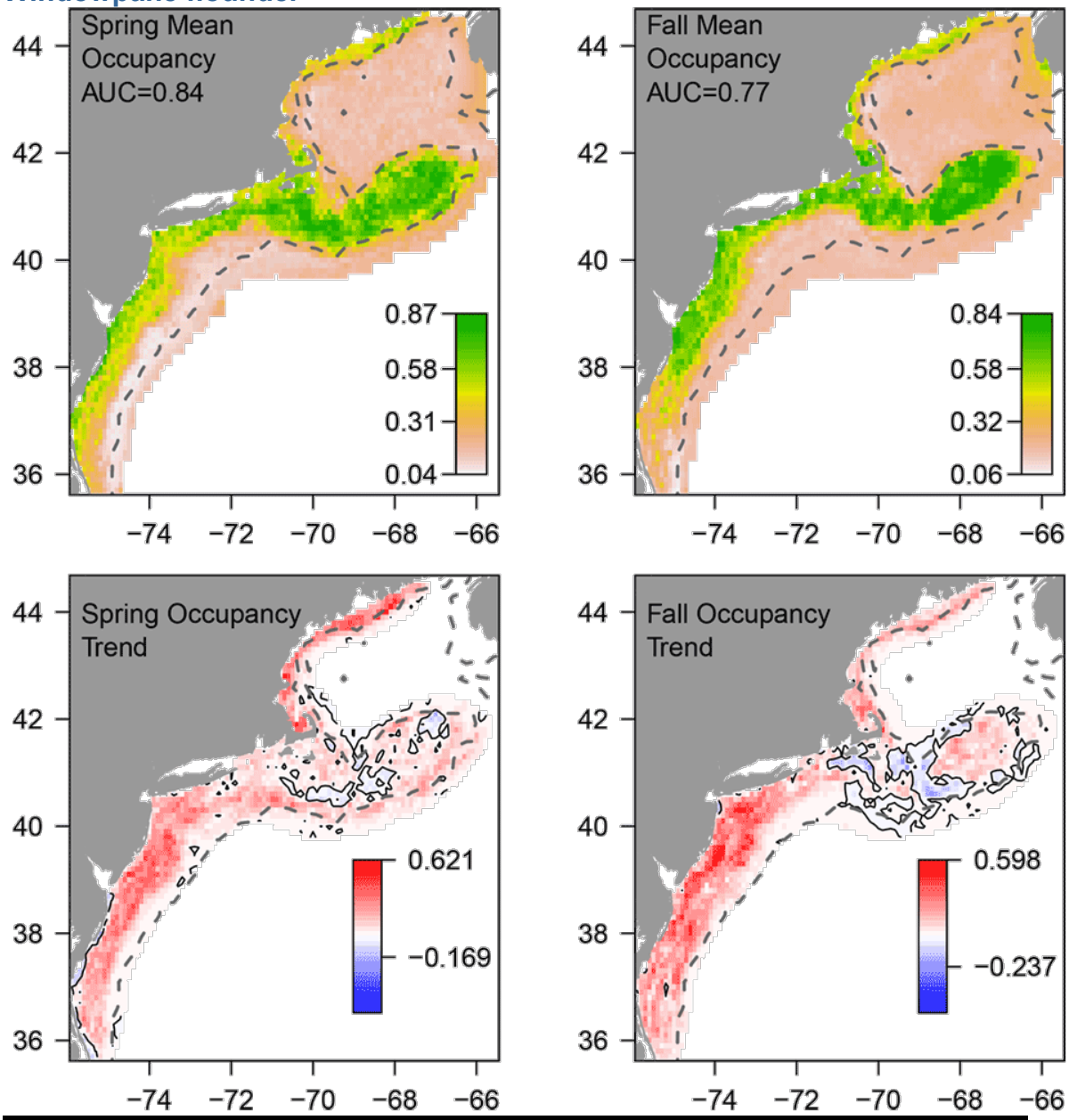
Mean spring and fall occupancy habitat and their associated trends for weakfish.

White hake



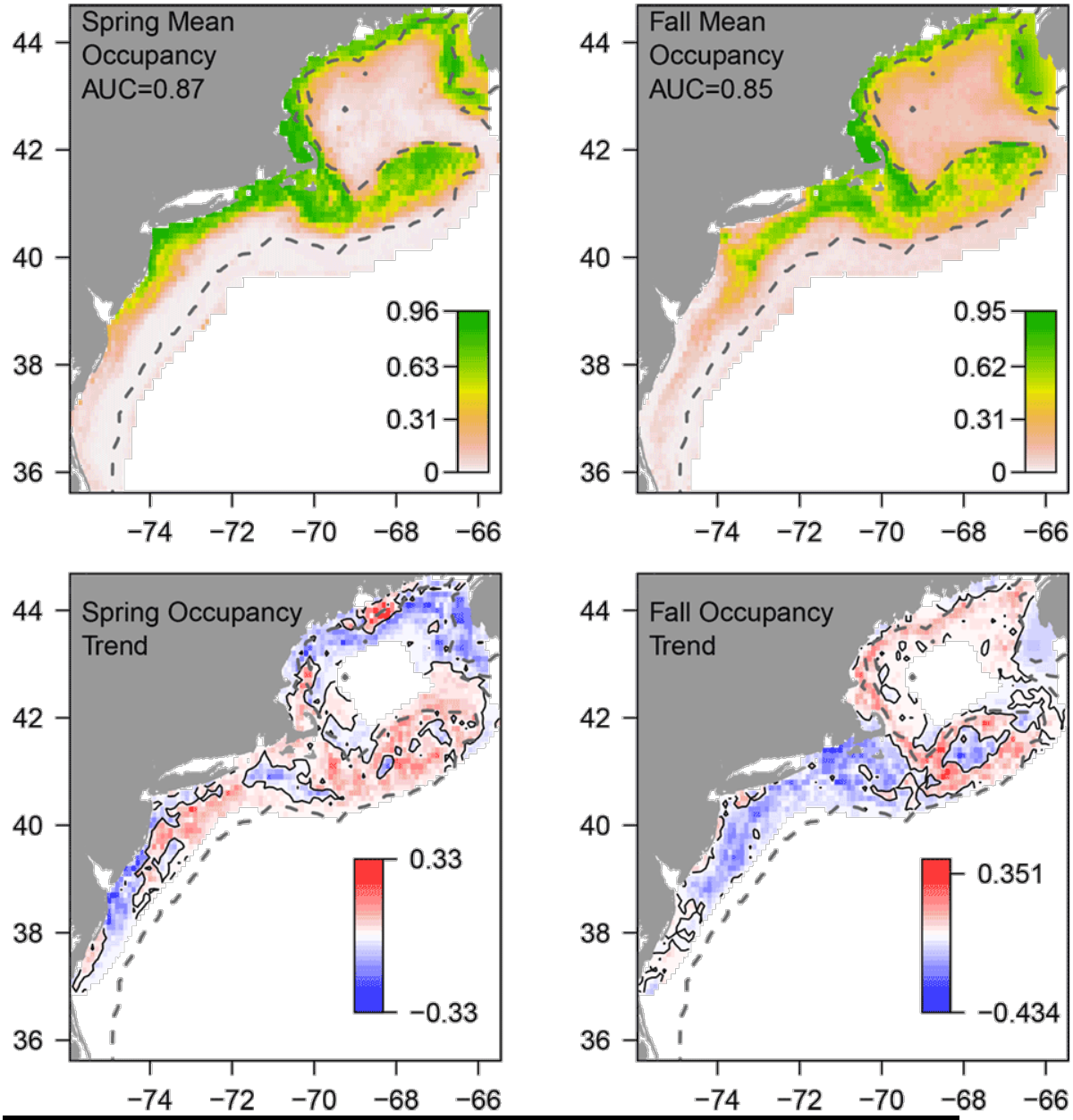
Mean spring and fall occupancy habitat and their associated trends for white hake.

Windowpane flounder



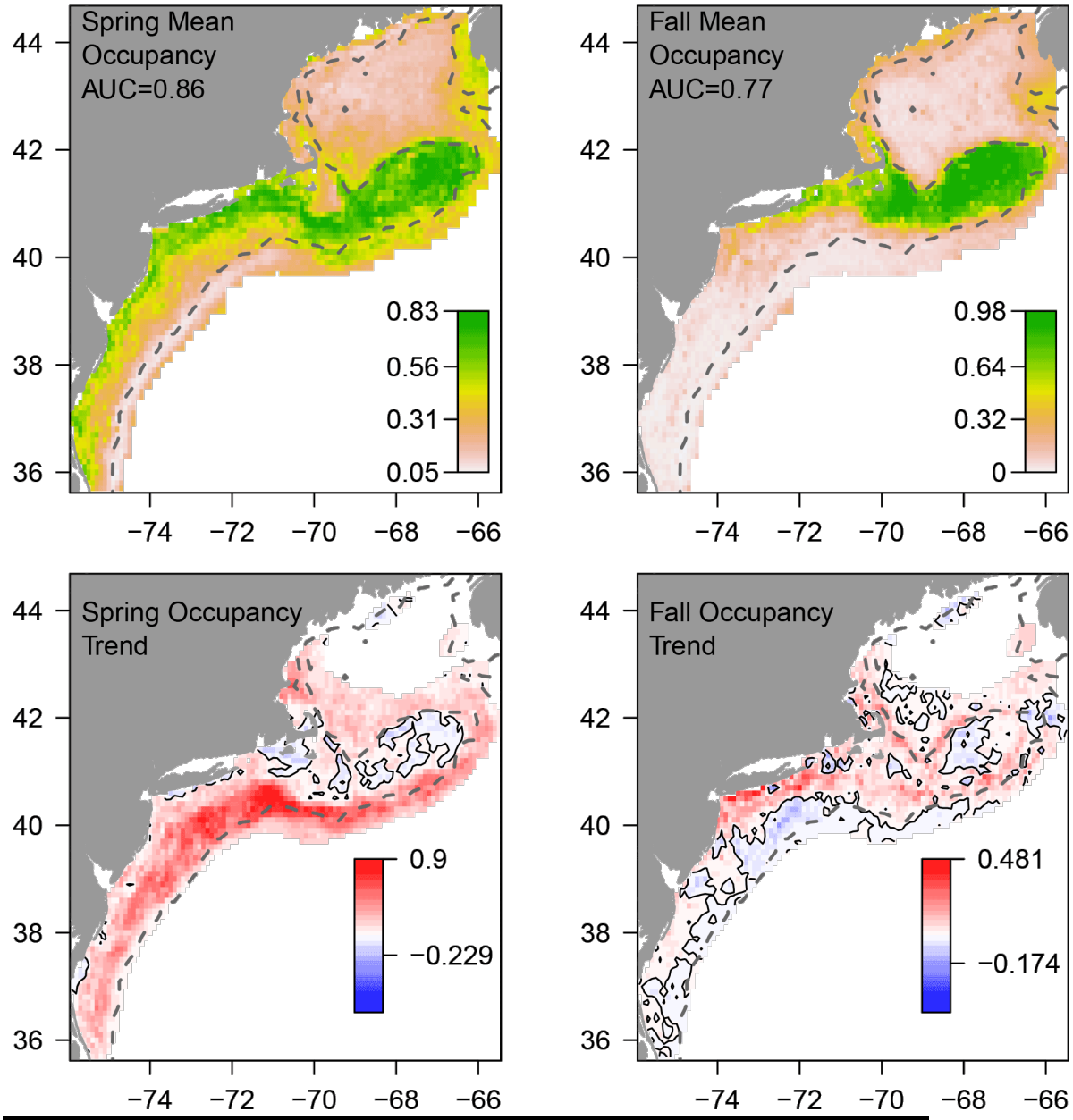
Mean spring and fall occupancy habitat and their associated trends for windowpane flounder.

Winter flounder



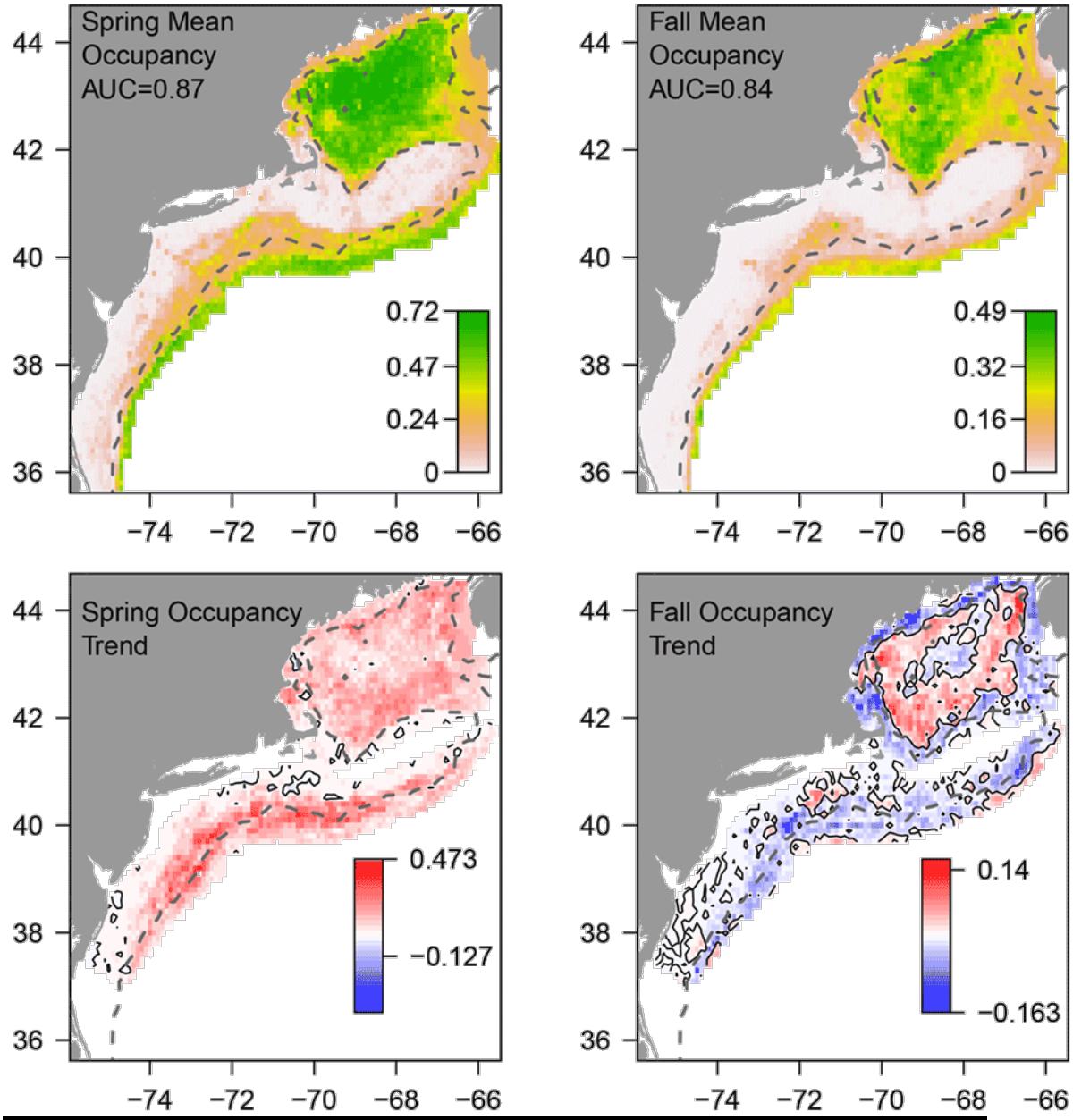
Mean spring and fall occupancy habitat and their associated trends for winter flounder.

Winter skate



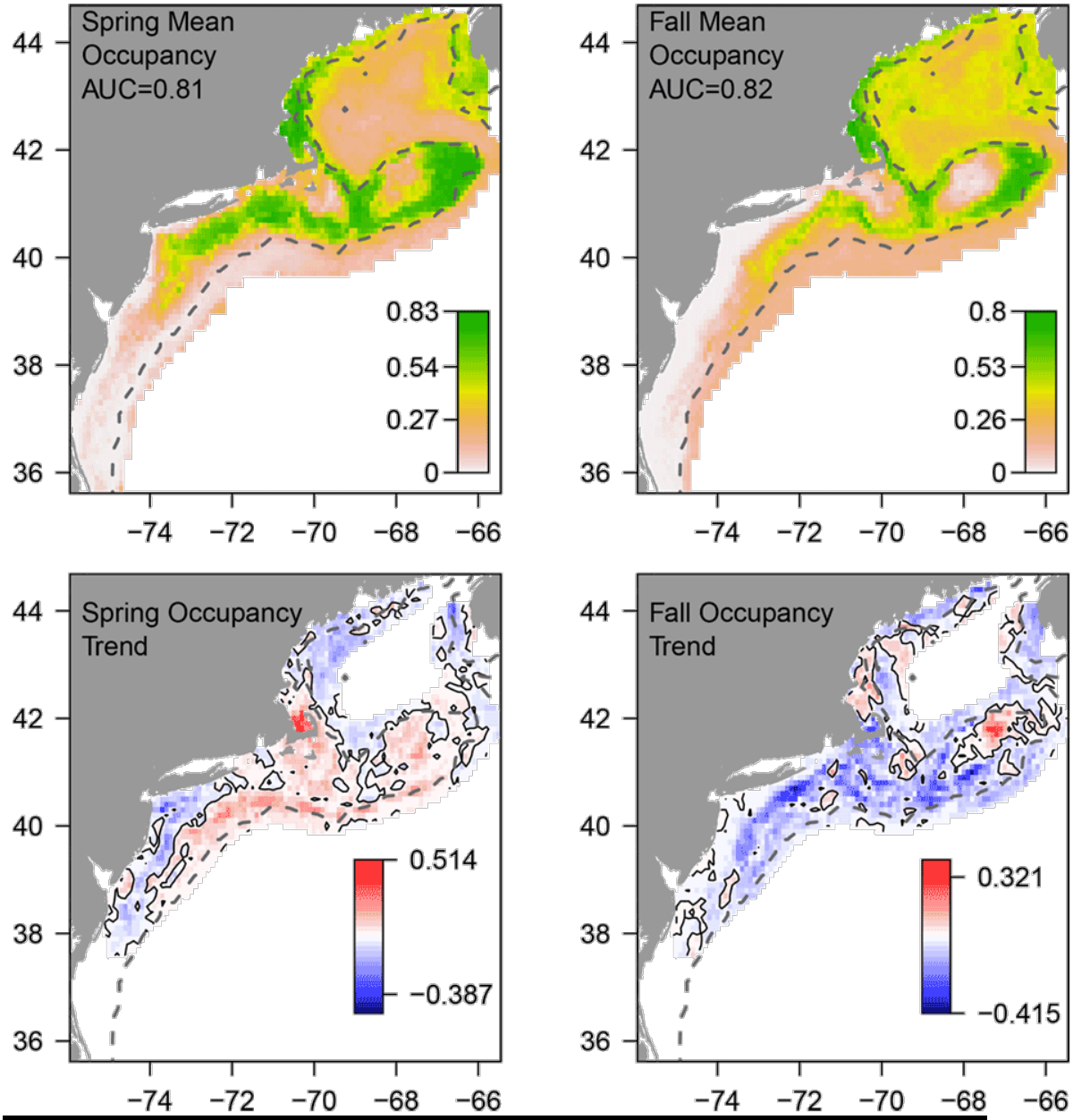
Mean spring and fall occupancy habitat and their associated trends for winter skate.

Witch flounder



Mean spring and fall occupancy habitat and their associated trends for yellowtail flounder

Yellowtail flounder



Mean spring and fall occupancy habitat and their associated trends for yellowtail flounder