Northeast Fisheries Science Center Reference Document 22-04

Update on the Spatial Distribution of Butterfish, 1982-2019

March 2022

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Update on the Spatial Distribution of Butterfish, 1982-2019

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ABSTRACT

This document updates a prior analysis of the spatial distribution of butterfish (*Peprilus triacanthus*) in the Northwest Atlantic Ocean with 6 additional years of Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey data. The primary findings are that there was a significant increase in area occupancy for all ages of butterfish over the spring time series, as well as a significant increase in area occupancy for age 0 butterfish in the fall, due in part to a range expansion into the Gulf of Maine. It is recommended that inclusion of the NEFSC spring bottom trawl survey data in the assessment model should be considered in the upcoming research track, as well as Gulf of Maine and outer Georges Bank strata.

INTRODUCTION

The spatial distribution of butterfish (*Peprilus triacanthus*) in the Northwest Atlantic Ocean from 1982-2013 has been previously characterized (Adams 2017) using several spatial indicators based on Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey data. This analysis found no significant northward movement of butterfish in spring or fall over the course of either time series. However, there was a significant increase in the area occupied by ages 1-3 in the spring that was correlated with surface temperature. It was also concluded that the spatial distribution of age 0 recruits is driven by environmental conditions.

A research track assessment for butterfish is scheduled for fall 2021. In preparation for this, I update the prior spatial distribution analysis with 6 additional years of data (2014-2019) in this document. Given the cancellation of the 2020 NEFSC spring and fall bottom trawl surveys due to the COVID-19 pandemic, this document will provide the most up-to-date information on the spatial distribution of butterfish for the upcoming research track.

METHODS

Survey Data

Methods and equations for the present analysis are identical to those used previously (Adams 2017) and are only briefly summarized here. As noted above, the analysis was based on NEFSC spring and fall bottom trawl survey data. Strata used were a combination of those referred to as offshore in the most recent benchmark assessment (Adams et al. 2015), as well as Gulf of Maine and outer Georges Bank strata (Figure 1).

Age-length keys from each cruise were used to transform the length frequencies observed at each trawl station into age frequencies. Butterfish abundance at each station was disaggregated into age 0 to 4+ for the fall and age 1 to 4+ for the spring. Data for 2009-2019 were converted to FRV *Albatross IV* units using the length-based calibration in Miller (2013).

Spatial Analysis

Distances between points (trawl stations) were computed in a Euclidean reference system. This was done by setting the minimum longitude and latitude of the strata for each stock as (0, 0) and converting all coordinates to kilometers. The cosine of the midpoint latitude (39° 49′ N) was used to convert longitude. This process is also known as geographical referencing (Rivoirard et al. 2000).

Four spatial indices were calculated: the center of gravity (CG), which is the bivariate mean location of the population (hereafter referred to as the X- and Y- components of the CG); the inertia, which is the variance of the CG; abundance weighted depth; and the positive area (PA), which is the area (km^2) occupied by fish abundances greater than 0. The PA is analogous to the proportion of positive tows, albeit weighted with the areas of influence.

Changes in the spatial distribution of butterfish over time were evaluated with a linear regression (i.e., a generalized linear model with Gaussian distribution and identity link function) that modeled the relationship between each spatial indicator and year. This was done for each age class within a season. Models that exhibited serial correlation were corrected with a first order autoregressive fit. Spring 2014 and fall 2017 were omitted from this analysis due to limited or no sampling of Southern New England and Mid-Atlantic strata in those surveys.

RESULTS

Spatial indicators showed interannual variation in the spring for all age classes (Figure 2). There was a significant increase in area occupancy for all ages of butterfish over the course of the time series. However, there was no change in the CG, inertia, or depth for any age class in the spring.

Spatial indicators also showed interannual variation in the fall for all age classes (Figure 3). There was a significant eastward movement of the XCG for age 0 butterfish, but no change in the YCG. This was primarily due to 2016 and 2019, which had the 2 easternmost XCGs in the time series. There was no change in inertia for any age class over the course of the time series. Age 1 butterfish exhibited a significant decrease in depth. Finally, age 0 butterfish have shown a significant increase in area occupancy over the course of the fall time series. A *post hoc* summarization (Table 1, Figure 4) reveals that this is due in part to an increase of age 0 butterfish in the Gulf of Maine over the past decade.

DISCUSSION

The objective of this study was to update a prior analysis of butterfish spatial distribution (Adams 2017) with 6 more years of data in preparation for the upcoming research track assessment. Some trends continued, new ones emerged, and others were no longer significant.

There has been a significant increase in area occupancy for all age classes in the spring. In the earlier analysis, these trends were only observed for age 1-3 butterfish; they have continued and now include age 4+. This adds further support for my previous suggestion that the spring index should be considered for inclusion in the assessment model (Adams 2017). It should be noted that butterfish distribution over the shelf is still not on the scale as in the fall (which can be seen by comparing the PA plots in Figures 2 and 3), but the trajectory appears to be that this difference will shrink as shelf warming continues.

Several significant trends were observed in the fall. The significant eastward trend in the XCG was due primarily to 2 new years of data. Previously, there was a significant increase in the inertia for ages 1-2, indicating that these age classes were becoming more dispersed around their respective CGs (Adams 2017); however, the additional years of data show that this is no longer the case. There was also a significant decrease in depth for ages 1-2, which now only applies to age 1 butterfish. Finally, there is now an increase in area occupancy for age 0 butterfish, which is due in part to a range expansion into the Gulf of Maine.

In conclusion, this update of butterfish spatial distribution provides additional evidence that inclusion of the NEFSC spring bottom trawl survey data in the assessment model should be considered in the upcoming research track, as well as Gulf of Maine and outer Georges Bank strata.

TABLES

Table 1. Northeast Fisheries Science Center fall bottom trawl survey number of positive tows for age 0 butterfish in Gulf of Maine strata (24, 26-30, and 36-40), 1982-2019.

Year	Positive
2016	59
2015	43
2014	35
2009	34
2012	31
2019	30
2010	27
2013	27
2000	26
2011	24
2018	19
1998	18
1994	16
1995	15
2002	14
1990	13
1997	13
1999	12
2006	8
1985	7
1982	6
1984	6
1986	6
1993	6
2004	6
2007	6
1996	5
2001	5
2008	5
1983	4
1989	4
1987	3
1991	3
1992	3
2003	3
1988	2
2005	2

FIGURES

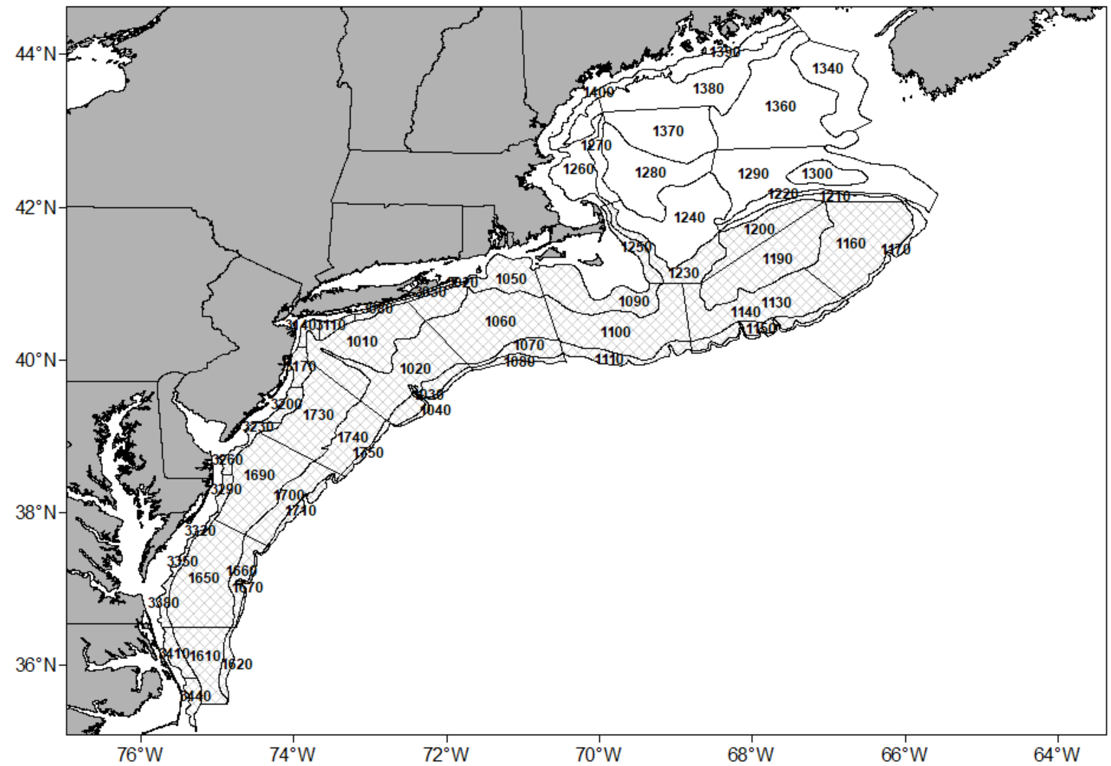

Figure 1. Northeast Fisheries Science Center bottom trawl survey strata used in this study include the butterfish stock assessment offshore strata (cross hatch), as well as Gulf of Maine and outer Georges Bank strata (white).

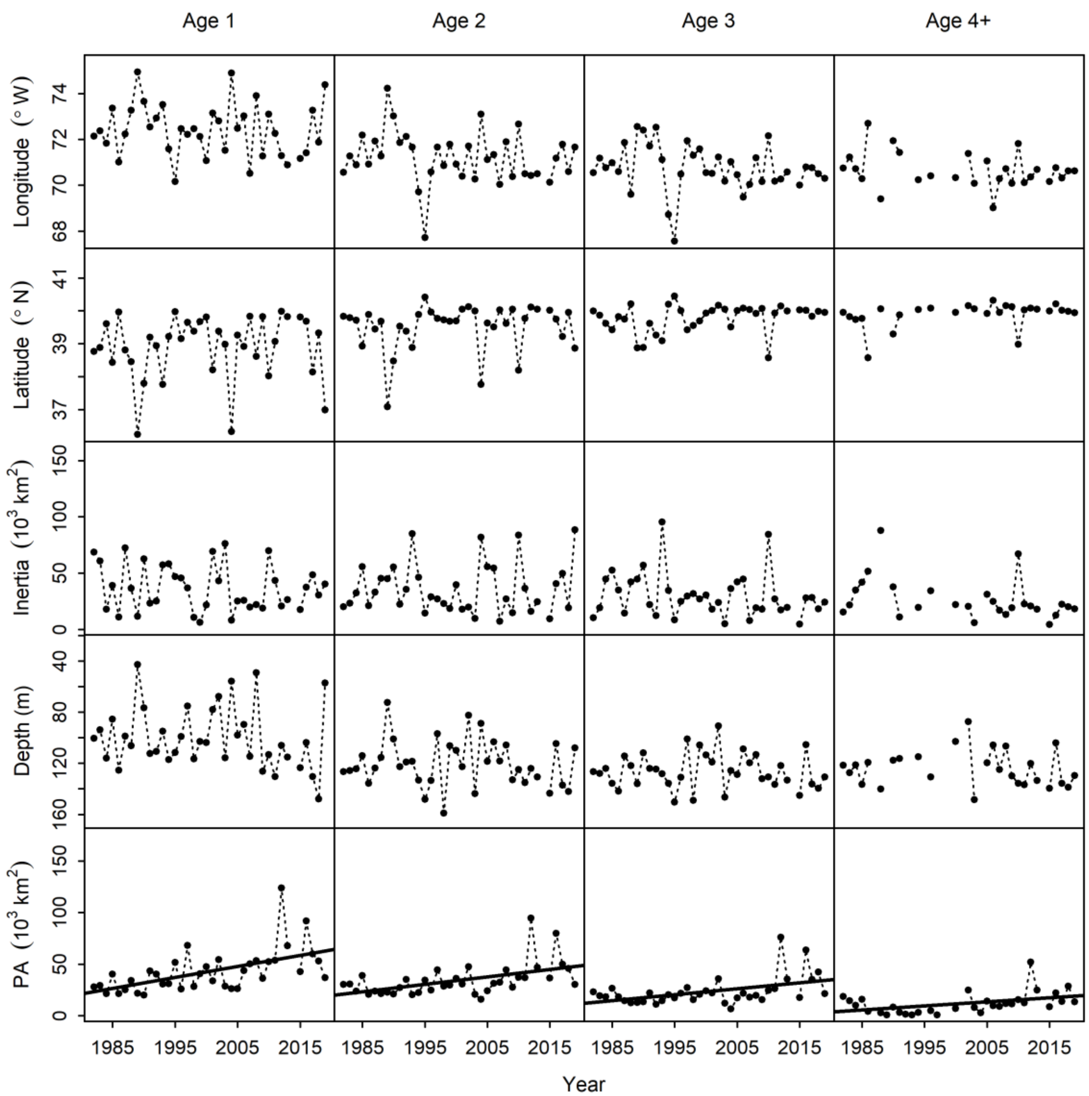

Figure 2. Spring time series of spatial indicators for butterfish ages 1 to 4+. Solid lines indicate a significant linear fit at the level of α = 0.05. Note that linear models were tested on XCG and YCG, not the back-transformed longitude and latitude, which are shown here to aid interpretation.

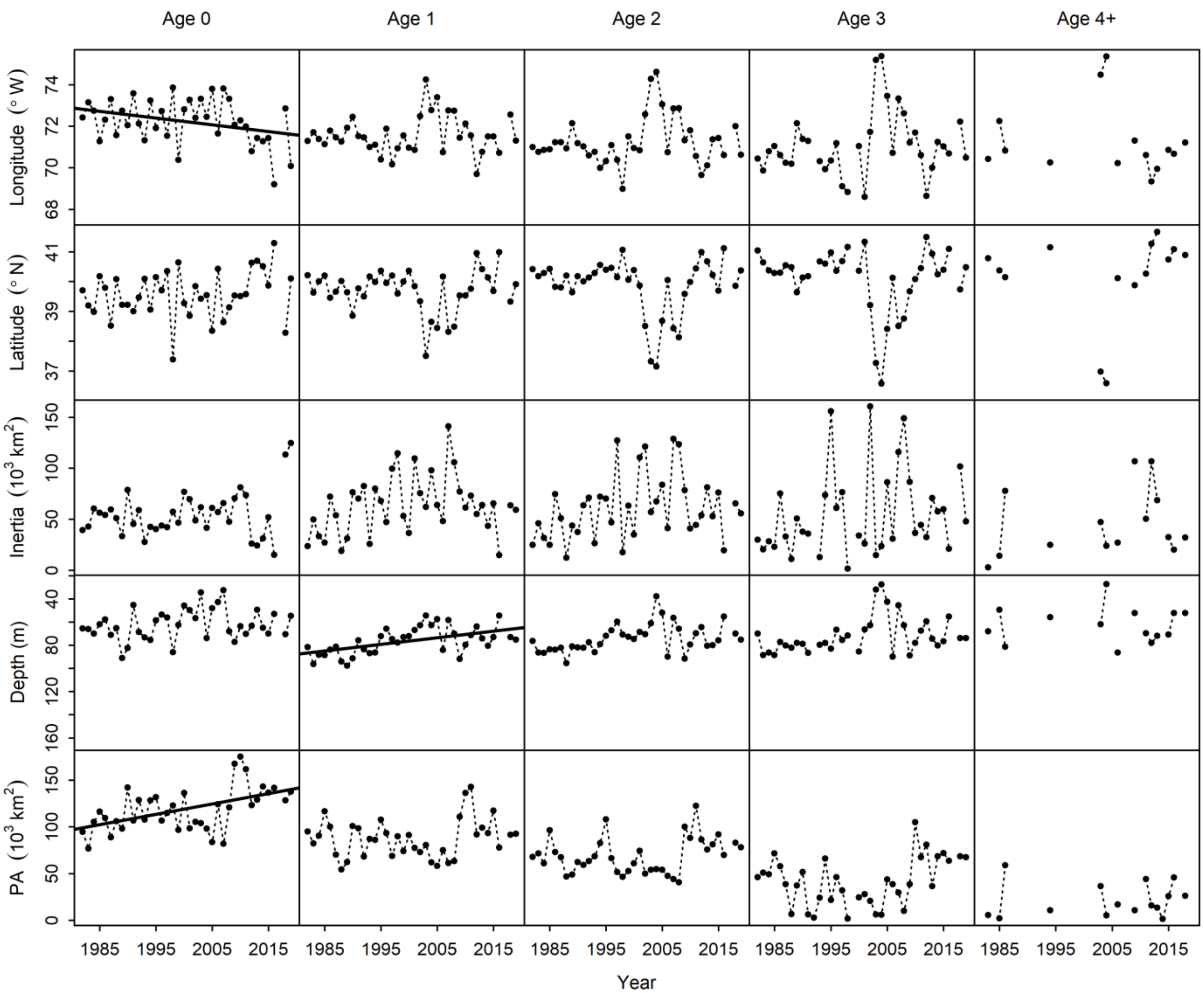

Figure 3. Fall time series of spatial indicators for butterfish ages 0 to 4+. Solid lines indicate a significant linear fit at the level of *α* = 0.05. Note that linear models were tested on XCG and YCG, not the back-transformed longitude and latitude, which are shown here to aid interpretation.

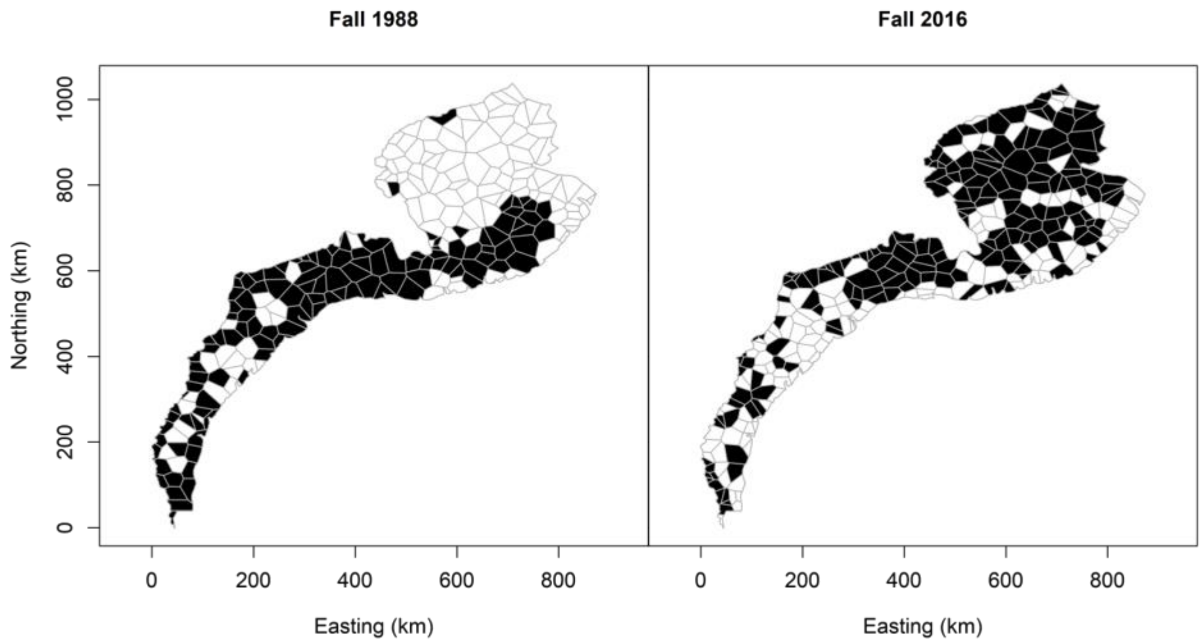

Figure 4. Positive area maps for age 0 butterfish in fall 1988 and fall 2016, when the number of positive tows in Gulf of Maine strata (24, 26-30, and 36-40) were 2 and 59, respectively. Black polygons indicate positive tows.

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