

## Butterfish 2017 Stock Assessment Update

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### State of Stock

This stock assessment update was completed by adding catch and indices for 2013–2016 to data for 1989–2012 used in the previous assessment (NEFSC, 2014; Adams et al., 2015). Estimated fishing mortality and spawning biomass in 2016 are 0.05 ( $CV(F_{2016}) = 0.27$ ) and 64,376 mt (141.9 million lb) ( $CV(SSB_{2016}) = 0.25$ ), respectively (Figures 1–2). The current fishing mortality rate ( $F_{2016} = 0.05$ ) is 94% below the overfishing reference point  $F_{MSY}$  proxy = 0.81 accepted by SARC 58. The current SSB (64,376 mt) is 41% above the accepted biomass reference point  $SSB_{MSY}$  proxy = 45,616 mt (100.6 million lb) ( $CV = 0.25$ ).  $SSB_{threshold}$  is one half the  $SSB_{MSY}$  proxy, or 22,808 mt (50.3 million lb). Overfishing is not occurring and the stock is not overfished (Figures 1–2).

### Projections

Projections of total catch and SSB were done with a standard forward projection methodology sampling recruitment from the entire time series (NFT, 2013). It was assumed that the catch of butterfish in 2017 would equal the Domestic Annual Harvest quota (20,652 mt) and that the stock would be fished at the fishing mortality threshold  $F_{MSY}$  proxy = 0.81 in 2018–2020. The projected estimates are in the following table.

OFL Catch and Spawning Stock Biomass (SSB) in metric tons

Year	Catch	SSB
2017	20,652	33,720
2018	28,628	37,031
2019	35,383	44,207
2020	36,973	45,939

### Catch

Commercial landings in 2016 were 1,182 mt (2.6 million lb). Discards and total catch estimates for 2016 will be available in May 2017. Values in the Catch and Status Table below for 2016 are the mean of the three most recent years for the respective estimate.

## Catch and Status Table: Butterfish

(weights are in 000s mt; age-0 recruitment in billions; fishing mortality for ages 2+)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Min <sup>1</sup>	Mean <sup>1</sup>	Max <sup>1</sup>
US landings	0.7	0.5	0.4	0.6	0.7	0.7	1.1	3.1	2.1	1.2	0.4	2.5	11.7
US discards	0.2	1.0	1.1	4.0	1.6	1.0	0.4	1.1	0.9	0.8	0.2	5.7	11.5
Foreign catch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	31.7
Total catch	0.9	1.5	1.5	4.6	2.3	1.7	1.5	4.3	3.0	2.9	0.9	11.2	39.9

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Min <sup>2</sup>	Mean <sup>2</sup>	Max <sup>2</sup>
Spawning biomass	79.5	61.0	53.8	72.0	63.1	67.6	49.8	66.1	69.1	64.4	49.8	77.8	110.5
Recruit numbers	5.8	7.5	10.8	5.9	8.4	4.3	7.9	7.3	6.6	1.9	1.9	8.7	16.3
Fishing mortality	0.01	0.02	0.03	0.07	0.04	0.03	0.03	0.07	0.05	0.05	0.01	0.06	0.14

<sup>1</sup>1965-2016 for landings; 1965-2015 for discards and total catch

<sup>2</sup>1989-2016

## Stock Distribution and Identification

The Mid-Atlantic Fishery Management Council (MAFMC) Fishery Management Plan for butterfish defines the management unit as all butterfish under US jurisdiction north of Cape Hatteras, North Carolina (MAFMC, 1979).

## Data and Assessment

Butterfish were last assessed in 2014 during SAW 58 (NEFSC, 2014; Adams et al., 2015).

*Commercial data.* Landings and discard estimates, and commercial mean weights at age were used in this assessment update. Specifically, total catch for 2013–2015 was added to the data for 1989–2012 used in the previous assessment (NEFSC, 2014; Adams et al., 2015), while the total catch for 2016 was assumed to be the mean of the respective values for 2013–2015. Discard and total catch estimates for 2016 will be available in May 2017.

*Survey data.* Swept area abundances, and abundance indices (number/tow) by age from the Northeast Fisheries Science Center (NEFSC) fall bottom trawl surveys (inshore and offshore) and the Northeast Area Monitoring and Assessment Program (NEAMAP) fall bottom trawl survey were used in this assessment update. NEFSC data for 2013–2016 were added to the data for 1989–2012 used in the previous assessment (NEFSC, 2014; Adams et al., 2015). NEAMAP data for 2007–2016 included revised values for 2007–2012 used in the previous assessment (pers. comm., Chris Bonzek, Virginia Institute of Marine Science, Gloucester Point VA 23062)

*Thermal habitat availability index.* The time series of thermal habitat availability indices used in SAW 58 was revised with an updated and improved Regional Ocean Modeling System numerical ocean model to develop bottom water temperatures (Manderson et al., 2017). The revised values for 1989–2012, along with new estimates for 2013–2015, changed the mean thermal habitat availability from  $A = 0.68$  used in SAW 58 to  $A = 0.62$  for this assessment update (Figure 3).

*Model.* The age-structured assessment program (ASAP) version 4 (Miller and Legault, 2015) used in SAW 58 was used in this assessment update. Modifications in version 4 relevant to the previous butterfish assessment and this assessment update are: catchability can be fixed as

the product of availability and efficiency (see special comments); which allows 2) the estimation of natural mortality; and 3) a length-based calibration performed internal to the model

Internal model retrospective analysis for  $F$  and  $SSB$  gave Mohn's rho values of 0.29 (Figure 4) and  $-0.22$  (Figure 5), respectively. Both of these values fell within the respective 90% confidence interval (Figure 2). Thus, no retrospective adjustment was necessary for the terminal year estimate of  $F$  and  $SSB$ .

### **Biological Reference Points (BRPs)**

The existing overfishing reference point from SAW 58 is based on Patterson (1992), i.e.,  $F = 2M/3 = 2 \times 1.22/3 = 0.81$  ( $CV = 0.05$ ). The biomass reference point from SAW 58 is  $SSB_{MSY}$  proxy = 45,616 mt (100.6 million lb) ( $CV = 0.25$ ).  $SSB_{threshold}$  is one half the  $SSB_{MSY}$  proxy, or 22,808 mt (50.3 million lb).

### **Fishing Mortality**

The peak in fishing mortality rate on fully selected ages (ages 2+) was  $F = 0.15$ , which occurred in 1993 (Figure 6). Fishing mortality ranged between 0.04 and 0.14 during 1994–2001, but has been  $\leq 0.07$  since 2002. In 2016 estimated  $F = 0.05$ .

### **Spawning Stock Biomass**

$SSB$  averaged 77,824 mt (171.6 million lb) during 1989–2016 (Figures 1 and 4–5).  $SSB$  peaked in 2000 at 110,500 mt (243.6 million lb), and has been above the  $SSB_{MSY}$  proxy for the entire time period considered in the assessment model (Figures 1–2). In 2016 estimated  $SSB = 64,376$  mt (141.9 million lb).

### **Recruitment**

Recruitment, which can be highly variable from year to year, averaged 8.7 billion butterfish during 1989–2016 (Figures 7–8). The 1997 year class was the largest in the time series at 16.3 billion butterfish, while the 2016 year class was the smallest at 1.9 billion butterfish. A similar pattern was observed in SAW 58 when the terminal year estimate of recruitment was the lowest in the time series. Additional years of data have since raised the 2012 recruitment estimate, suggesting a possible retrospective pattern. However, internal model retrospective analysis for recruitment produced a relatively low Mohn's rho of  $-0.21$  (Figure 9).

### **Special Comments**

The effect of the revised thermal habitat availability index is to scale  $SSB$  up and  $F$  down (Figure 10). Assumed values for the other component of catchability (i.e., efficiency) remained the same as in the previous assessment, e.g. daytime efficiency of the Bigelow = 100%, etc.

The estimated natural mortality changed from  $M = 1.22$  in the previous assessment to  $M = 1.25$  in this assessment update.

## References

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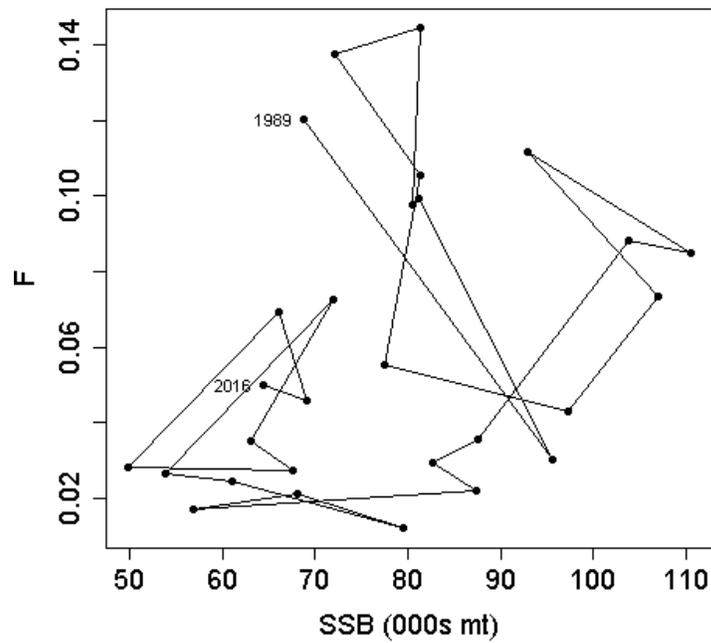
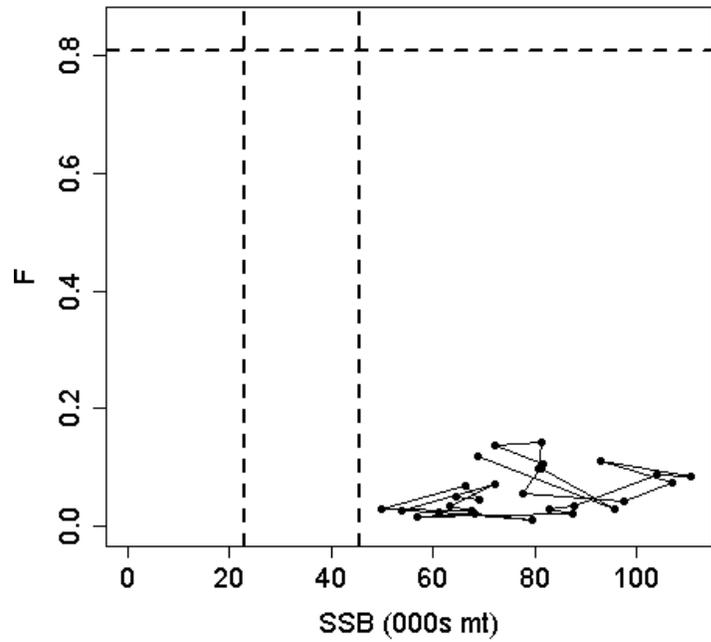


Figure 1. Butterfish stock status, 1989–2016, relative to the SAW 58 biological reference points  $SSB_{threshold} = 22,808$  mt,  $SSB_{MSY}$  proxy = 45,616 mt, and  $F_{MSY}$  proxy = 0.81. The tight grouping of points is expanded in the lower panel for clarity.

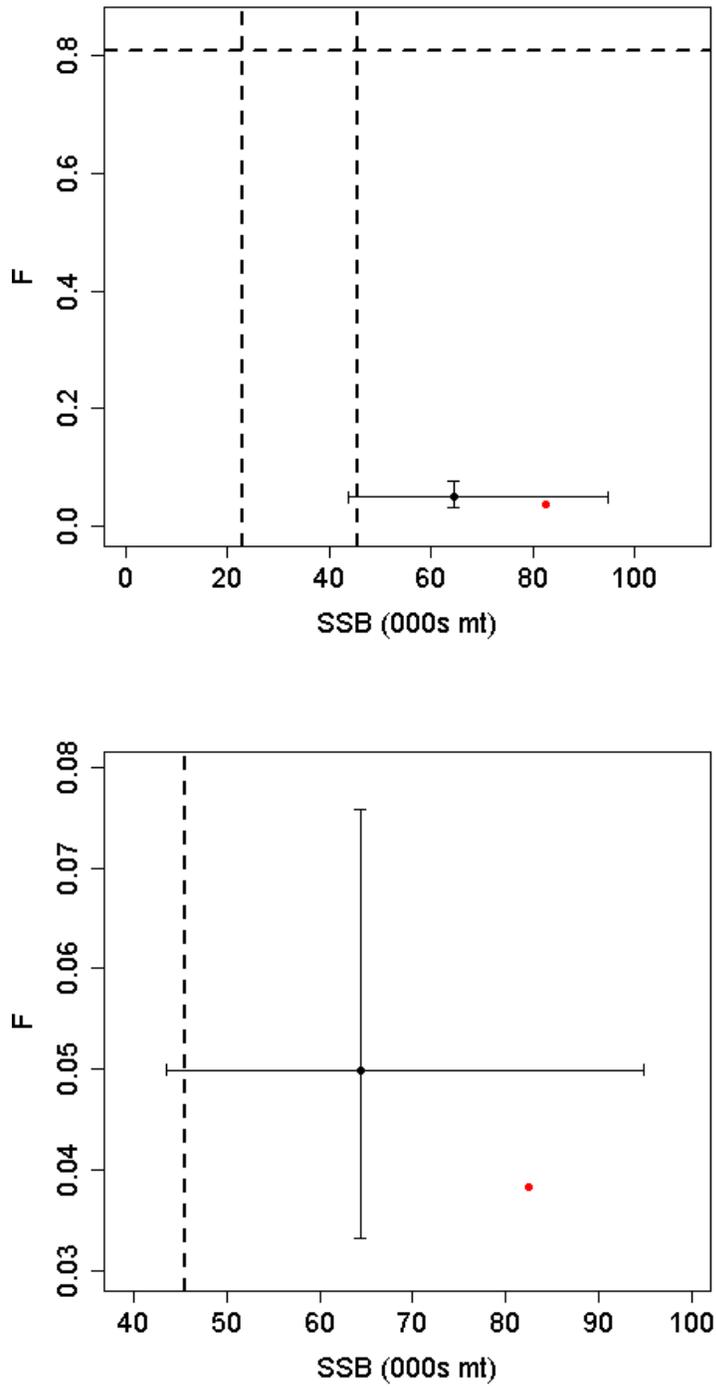


Figure 2. Butterfish stock status in 2016 relative to the SAW 58 biological reference points  $SSB_{\text{threshold}} = 22,808$  mt,  $SSB_{\text{MSY proxy}} = 45,616$  mt, and  $F_{\text{MSY proxy}} = 0.81$ . The black circle is the model estimate and the error bars are 90% confidence intervals; the red circle is the model estimate adjusted for internal model retrospective error. The plot is expanded in the lower panel to clarify that the retrospective adjustment is within the 90% confidence bounds.

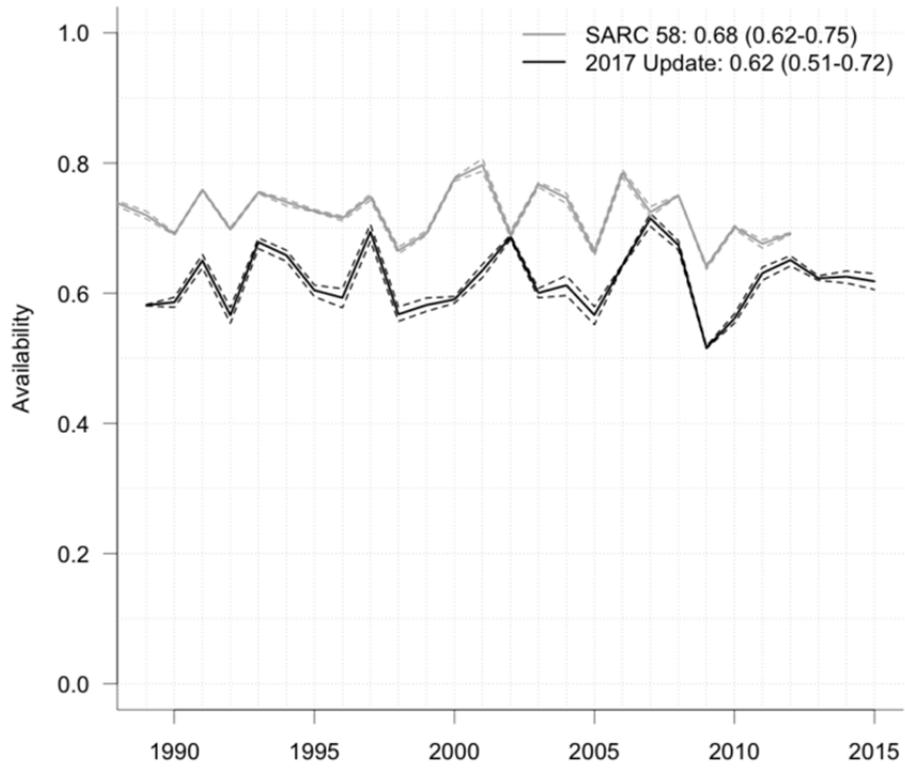


Figure 3. Availability of butterfish to the Northeast Fisheries Science Center (NEFSC) offshore survey, 1989–2015. Solid lines indicates availability  $A$ , while dashed lines show the respective 95% confidence intervals.

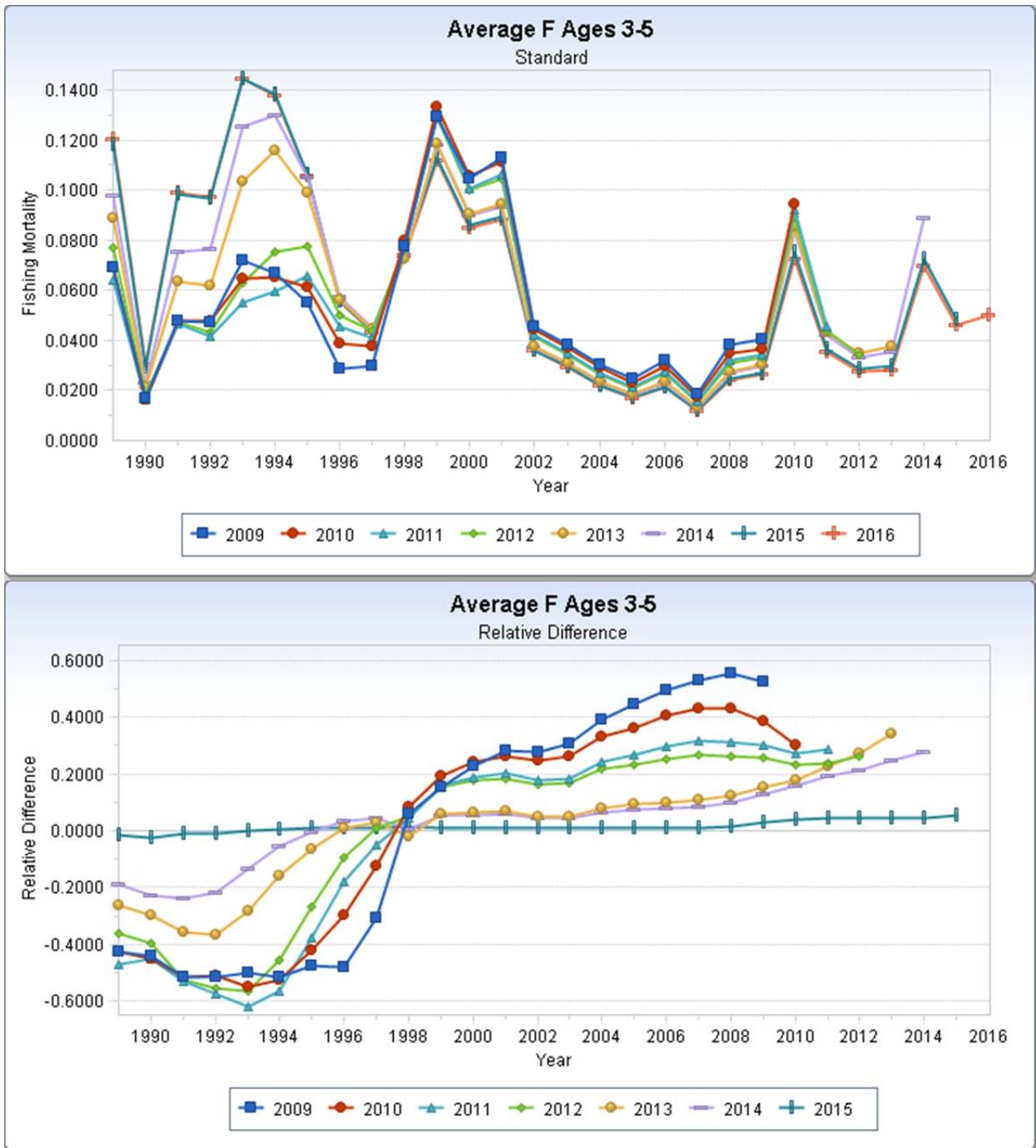


Figure 4. Results of internal model retrospective analysis for fully recruited F (model ages 3–5; true ages 2–4+). Mohn’s rho = 0.29

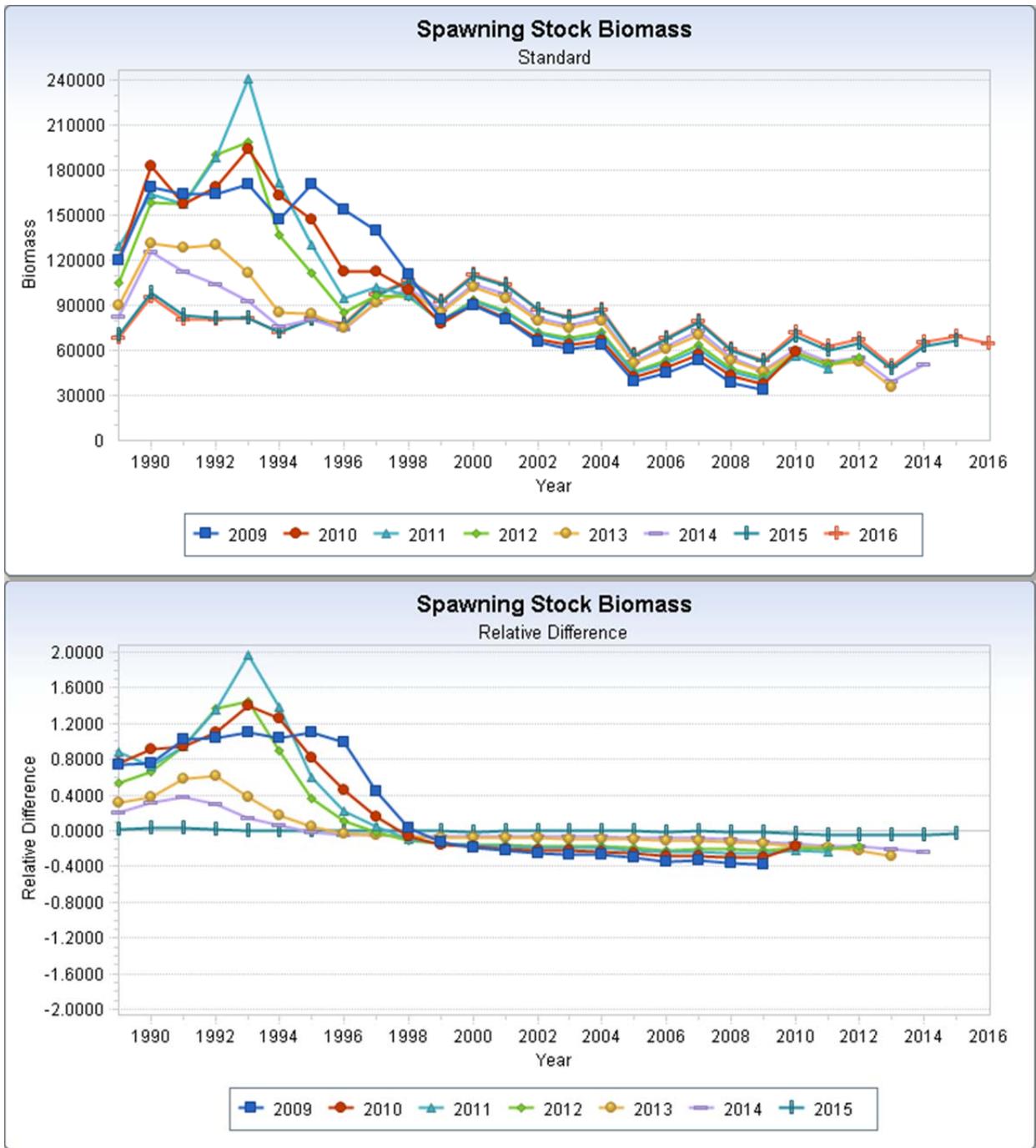


Figure 5. Results of internal model retrospective analysis for spawning stock biomass. Mohn's rho = -0.22

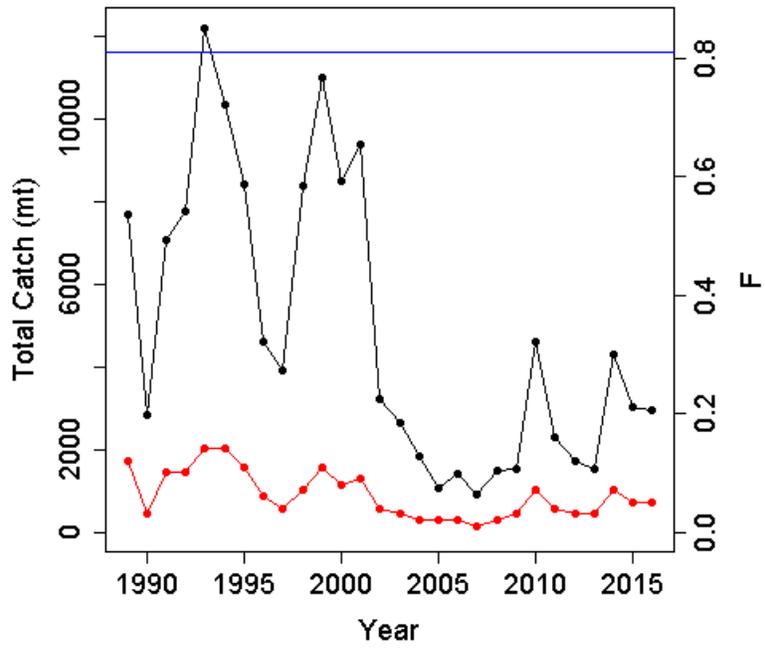


Figure 6. Butterfish total catch (black) and fully recruited fishing mortality (red). The blue line is the SAW 58  $F_{MSY}$  proxy.

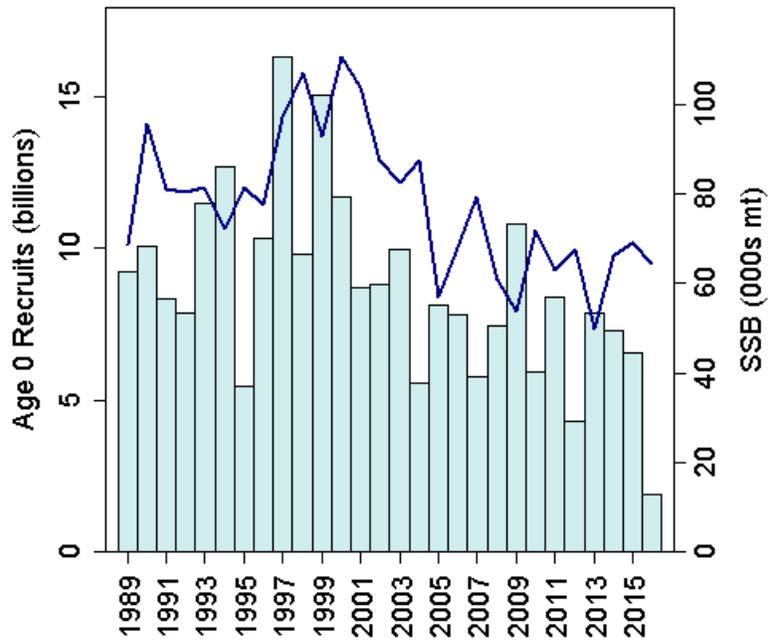


Figure 7. Butterfish recruitment (vertical bars), and the spawning stock biomass (blue line) that produced the corresponding recruitment. Year refers to spawning year.

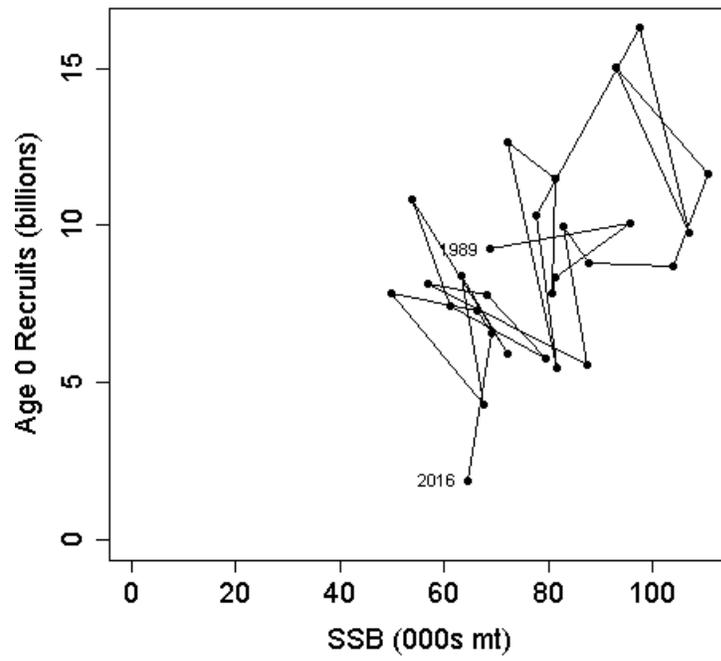


Figure 8. Butterfish stock-recruitment scatter plot.

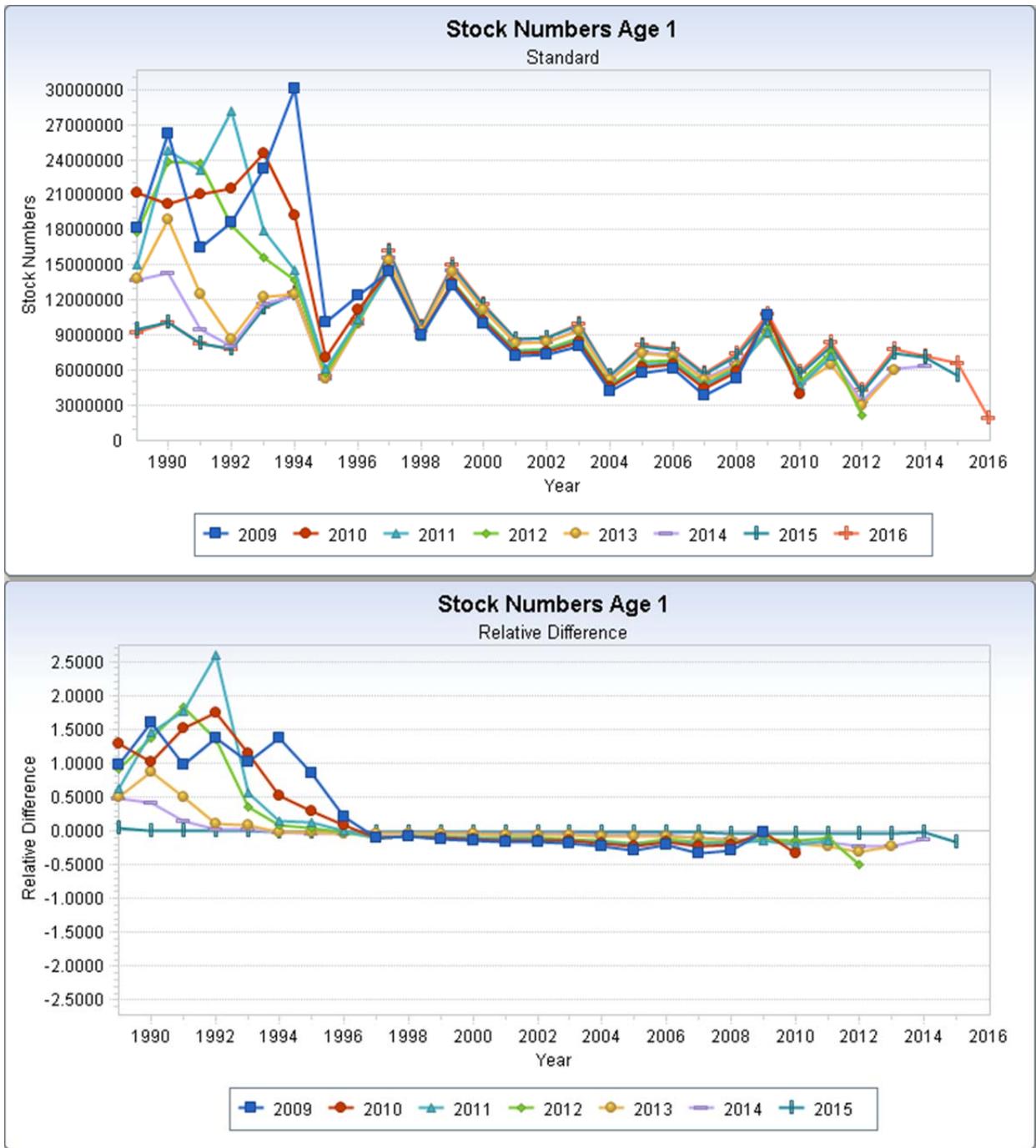


Figure 9. Results of internal model retrospective analysis for recruitment (model age 1; true age 0). Mohn's rho = -0.21

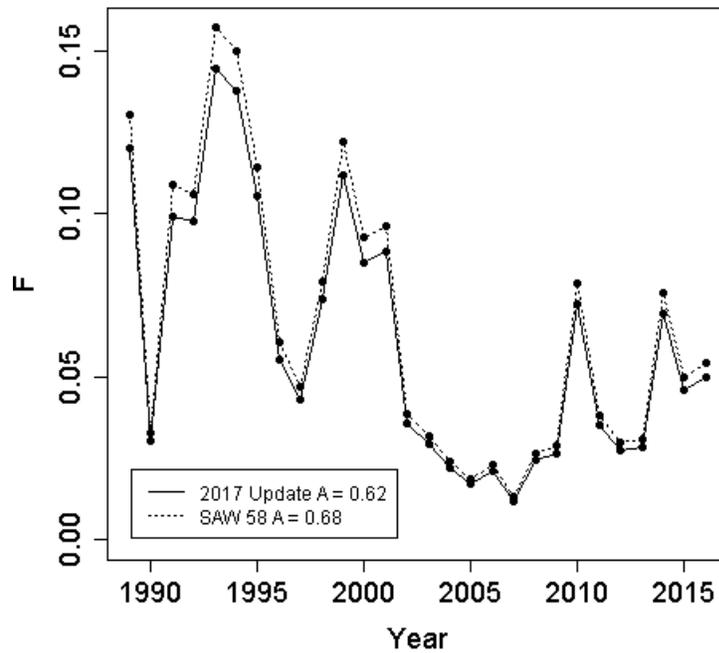
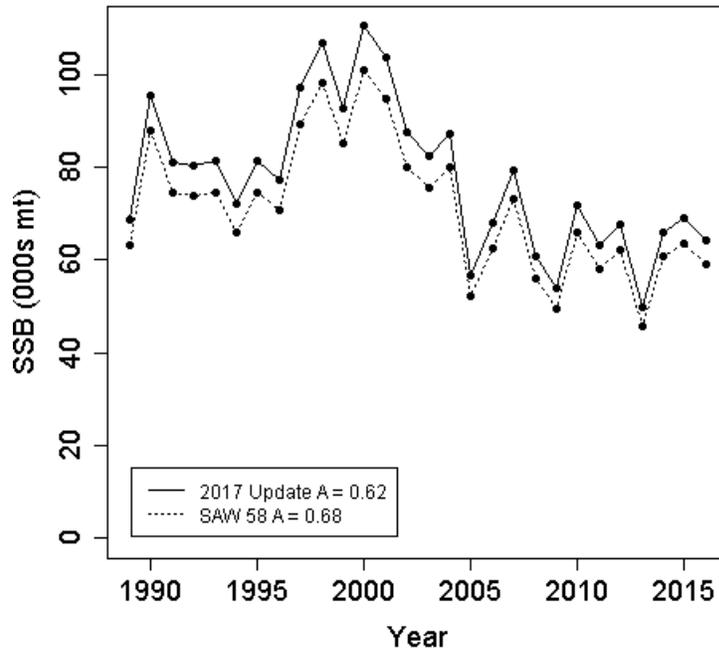


Figure 10. Effect of revised thermal habitat availability index on model estimates of spawning stock biomass (upper) and fishing mortality (lower).