A. BUTTERFISH ASSESSMENT SUMMARY FOR 2014

State of Stock

Estimated fishing mortality and spawning biomass in 2012 are 0.02 (CV(F_{2012}) = 0.33) and 79,451 mt (175.2 million lb) (CV(SSB_{2012}) = 0.25), respectively. Butterfish are relatively short-lived and have a high natural mortality rate (M = 1.22) which results in the spawning stock biomass (SSB) being strongly dependent on recruitment. The current fishing mortality rate (F_{2012} = 0.02) is well below the overfishing reference point accepted by SARC 58 (2/3 M = 0.81 [CV = 0.05]; Patterson, 1992). The current SSB (79,451 mt) is well above the accepted biomass reference point 45,616 mt (100.6 million lb) (CV = 0.25). Therefore, based on the point estimates, the stock is considered rebuilt. $SSB_{threshold}$ 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.

Projections

Projections of SSB and fishing mortality were made using a standard forward projection methodology sampling recruitment from the entire time series. If preliminary butterfish catch (landings plus discards) for 2013 (2,489 mt; 5.5 million lb) is used, the median projection of SSB in 2013 is 51,746 mt (114.1 million lb), with 5% and 95% confidence limits of 32,489 mt (71.6 million lb) and 81,073 mt (178.7 million lb), respectively.

If the 2014 butterfish ABC (9,100 mt; 20.1 million lb) is assumed for 2014 catch, the median projection of SSB in 2014 is 53,580 mt (118.1 million lb), with 5% and 95% confidence limits of 38,365 mt (84.6 million lb) and 73,885 mt (162.9 million lb), respectively. The probability of overfishing in 2014 associated with this catch is <1%.

Catch

Total catches of butterfish increased from 15,167 mt (33.4 million lb) in 1965 to a peak of 39,896 mt (88.0 million lb) in 1973, and were dominated by catches from the offshore foreign fleets (Figure A1). Total catches then declined to 11,863 mt (26.2 million lb) in 1977, following the implementation of the Fishery Conservation and Management Act of 1976. Foreign landings were completely phased out by 1987. A domestic fishery was developed to supply the Japanese market, leading to a peak catch of 22,401 mt (49.4 million lb) in 1984, but then declined to 2,831 mt (6.2 million lb) in 1990. During 1991-2001, catches ranged between 3,928 mt (8.7 million lb) and 12,185 mt (26.9 million lb). Catches were relatively lower during 2002-2012 due to the lack of a directed fishery and management restrictions, ranging between 918 mt (2.0 million lb) and 4,593 mt (10.1 million lb). Discards comprised a majority of the total butterfish catch, averaging 58% during 1989-2001 and 67% during 2002-2012. Total catch estimates were highly variable and imprecise, with CVs ranging from 0.07 – 1.43 due to the uncertain discard estimates.

Table A1. Catch and status table: butterfish. Weights are in 000s mt; age-0 recruitment in billions, fishing mortality for ages 2+.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min[1]	Mean[1]	Max[1]
US landings	0.5	0.5	0.4	0.6	0.7	0.5	0.4	0.6	0.7	0.7	0.4	2.6	11.7
US discards	2.1	1.3	0.6	0.9	0.2	1.0	1.1	4.0	1.6	1.0	0.2	6.0	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	2.6	1.8	1.1	1.4	0.9	1.5	1.5	4.6	2.3	1.7	0.9	11.7	39.9

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Min[2]	Mean[2]	Max[2]
Spawning biomass	80.4	85.3	56.1	67.5	79.6	62.6	57.0	77.9	71.2	79.5	56.1	79.4	106.6
Recruit numbers	9.1	5.1	7.6	7.4	5.7	7.6	11.1	6.5	9.5	2.4	2.4	8.5	14.8
Fishing mortality	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.07	0.03	0.02	0.01	0.07	0.15

[1]1965-2012 [2]1989-2012

Stock Distribution and Identification

Butterfish (*Peprilus triacanthus*) are distributed from Florida to Nova Scotia, occasionally straying as far north as Newfoundland, but are primarily found from Cape Hatteras to the Gulf of Maine, where the population is considered to be a unit stock (Collette and Klein-MacPhee, 2002). Butterfish are a fast growing species, overwintering offshore, and then moving inshore and northwards in the summer. Butterfish mature during their second summer (age 1), spawn primarily during June-July, and begin schooling around 60 mm. The diet consists primarily of urochordates (Larvacea, Ascidacea, Thaliacea) and thecosome mollusks (*Clione*). They are preyed upon by a number of commercially important fishes such as haddock, silver hake, swordfish, bluefish, weakfish, summer flounder, goosefish, and hammerhead shark. Although it is generally thought that butterfish comprise a large part of the diet of longfin squid, recent stable isotope and fatty acid work suggests this is not the case (Jensen, pers. comm.).

Data and Assessment

Butterfish were last assessed in 2009 during SAW 49 (NEFSC, 2010).

Commercial data. US landings and discard estimates, and commercial mean weights at age were used in the current assessment. Catch data prior to 1989 were not used due to uncertainty in discards, which account for a large proportion of total catch. The observer time series for calculating discards begins in 1989 as well.

Survey data. The current assessment relies on swept area abundances, and abundance indices (number/tow) by age from 1989-2012 Northeast Fisheries Science Center (NEFSC) fall surveys (inshore and offshore). Additionally, swept area abundances from the Northeast Area Monitoring and Assessment Program (NEAMAP) fall (2007-2012) survey were used. The NEFSC fall offshore bottom trawl survey (Figure A2) is considered the most reliable biomass index because most of the population is thought to be well distributed within the survey domain and coefficients of variation (CVs) were low (0.13 – 0.47).

Model. A modification of an age-structured catch at age model (ASAP) (Legault and Restrepo, 1999) was used in the current assessment. The modified model estimates natural mortality and survey vessel length-based calibration as model parameters. Other changes, relative to the last assessment, include: updated data through 2012; reassignment of survey strata into offshore and inshore series; use of NEAMAP survey data; and improvements to how catchability is determined in the ASAP model (see Special Comments).

Biological Reference Points

A proxy for F_{MSY} is based on Patterson (1992). The accepted overfishing reference point is F = 2M/3 = 2 ×1.22/3 = 0.81; CV = 0.05. The current fishing mortality (F_{2012} = 0.02, CV = 0.33) is well below the accepted overfishing reference point (Figure A3). The accepted biomass reference point SSB_{MSY} proxy (median SSB based on a 50 year projection at F_{MSY}) is 45,616 mt (100.6 million lb); CV = 0.25. SSB_{2012} is estimated to be 79,451 mt (175.2 million lb), which is well above the accepted SSB_{MSY} proxy (Figure A4). The accepted MSY proxy is 36,199 mt (79.8 million lb); CV = 0.20. $SSB_{threshold}$ 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.

Fishing Mortality

The peak in fishing mortality rate on fully selected ages (ages 2+) was F = 0.15, which occurred in 1993 (Figure A3). Fishing mortality ranged between 0.04 and 0.14 during 1994-2001, but has been ≤ 0.07 since 2002 (Table A1).

Spawning Stock Biomass

Spawning stock biomass averaged 79,410 mt (175.1 million lb) during 1989-2012 (Table A1; Figures A4, A5 and A6). Spawning biomass is strongly dependent on recruitment because butterfish are relatively short-lived, mature early (A_{50} = 1 year), and have a high natural mortality rate (estimated at M = 1.22). Spawning stock biomass peaked in 2000 at 106,590 mt (235.0 million lb). Spawning stock biomass has been above the SSB_{MSY} proxy for the entire time period considered in the assessment model (Figure A4).

Recruitment

Recruitment, which can be highly variable from year to year, averaged 8.5 billion fish during 1989-2012 (Table A1; Figures A5 and A6). The 1997 year class was the largest, at 14.8 billion fish, and the 2012 year class was the smallest, at 2.4 billion fish, in the time series. The 2012 year class was estimated with more uncertainty than other year classes.

Special Comments

Relative to the previous assessment, a new modeling approach was used in this assessment. The previous assessment was based on the KLAMZ model, however it was not possible to establish BRPs in SARC 49 (NEFSC 2010) due to assessment uncertainties. The population was thought to be declining over time but fishing mortality was not considered to be the cause in the previous assessment. The current research on estimation of catchability provided an improved basis for understanding the stock history and allowed estimation of BRP.

There were three augmentations to the basic ASAP model for the base model: 1) catchability was reparameterized as the product of availability and efficiency with the former specified using the availability estimates based on bottom water temperature; 2) length-based calibration of bottom trawl survey data in 2009-2012 was performed internal to the model; and 3) estimation of natural mortality. For the NEFSC fall offshore survey, an average measure of availability based on a bottom temperature was used and the efficiency was based on relative efficiency of the FRV *Albatross IV* to the FSV *Henry B. Bigelow* and an assumption that the *Bigelow* was 100% efficient for daytime tows. Ability to estimate parameters within the new model framework was confirmed through simulation.

Validity of ASAP model estimates of biomass and fishing mortality was supported by the application of a simple envelope analysis method that established a feasible range for biomass. Model based estimates of stock biomass and fishing mortality rates were consistent with simple empirical interpretations of the data. The method was based on a feasible range of assumed fishing mortality rates applied to the observed catch series, and a feasible range of catchabilities applied to the NEFSC fall trawl survey catch weights per tow. Additional details are provided in Appendix 3 of the butterfish Assessment Report.

As in the previous assessment, estimates of consumption by the top six finfish predators (bluefish, *Pomatomus saltatrix*; spiny dogfish, *Squalus acanthias*; silver hake, *Merluccius bilinearis*; summer flounder, *Paralichthys dentatus*; goosefish, *Lophius americanus*; and smooth dogfish, *Mustelus canis*) of butterfish within the NEFSC food habits database appear to be very low and similar in magnitude to historic fishing mortality but well below the estimated natural mortality rate. Evidence was presented that longfin squid (*Doryteuthis pealeii*) are not a major predator on butterfish (Jensen, pers. comm.). Food habits of other potential predators, such as sharks, tuna, swordfish, marine mammals and seabirds are not adequately sampled to determine total butterfish consumption.

Continued development of the habitat model could be beneficial in other assessments or in future butterfish assessments.

References

Collette BB, Klein-MacPhee G. 2002. Bigelow and Schroeder's fishes of the Gulf of Maine, 3rd edn. Smithsonian Institution Press, Washington, DC.

Legault CM, Restrepo VR. 1999. A flexible forward age-structured assessment program. Col Vol Sci Pap ICCAT 49:246-253.

NEFSC. 2010. 49th Northeast Regional Stock Assessment Workshop (49th SAW) Assessment Report. NEFSC Ref Doc 10-03. 383 p.

Patterson K.1992. Fisheries for small pelagic species: an empirical approach to management targets. Rev Fish Biol Fisher 2:321-338.

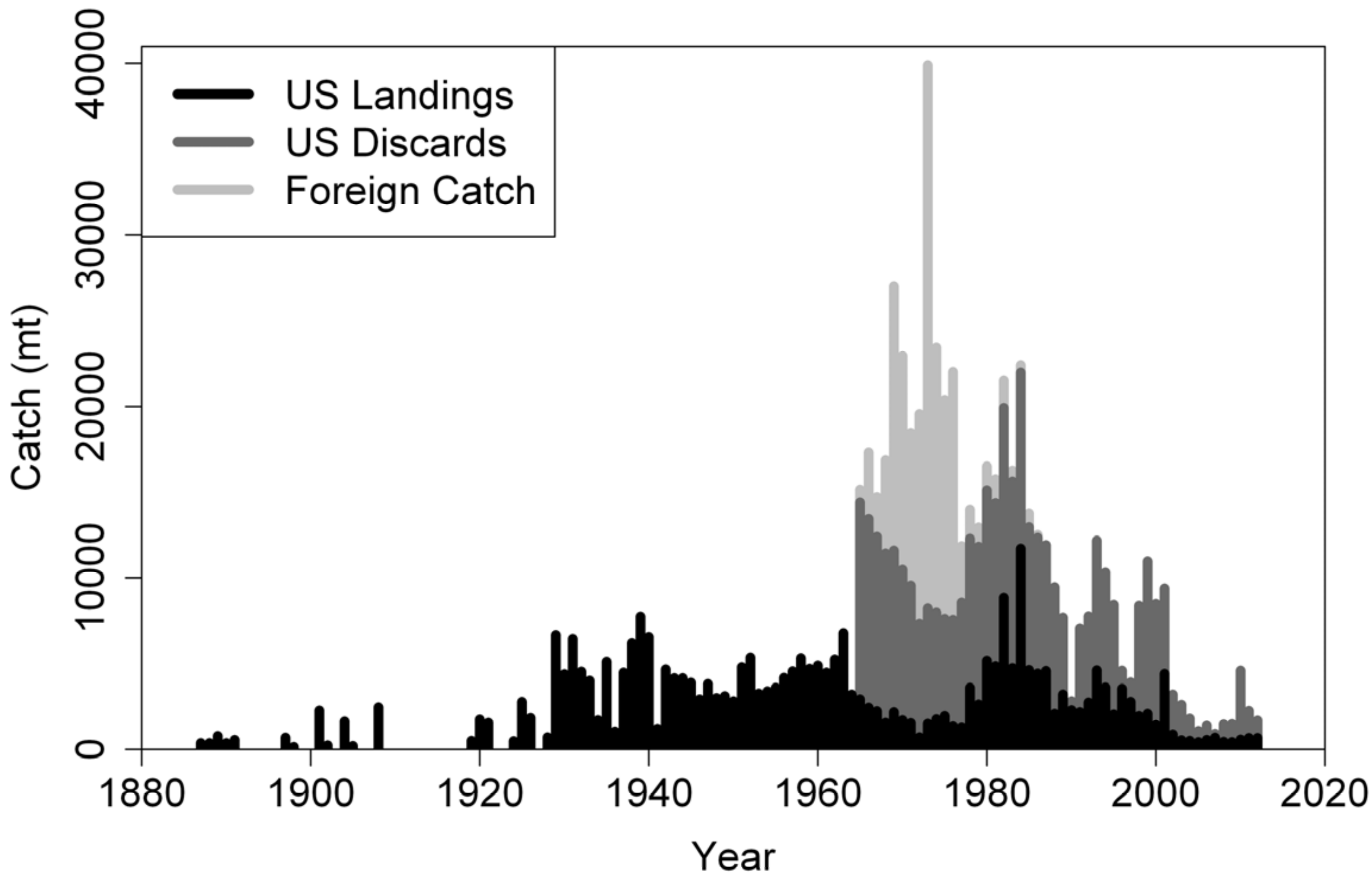

Figure A1. Butterfish total catch, 1887-2012. Annual catch data are missing for some years prior to 1930. Discards estimates are unavailable prior to 1965. Total catch from 1965-1988 includes discards estimated by applying an average of discard rates for trawl gear from 1989-1999 to annual landings of all species between 1965-1988 by trawl gear.

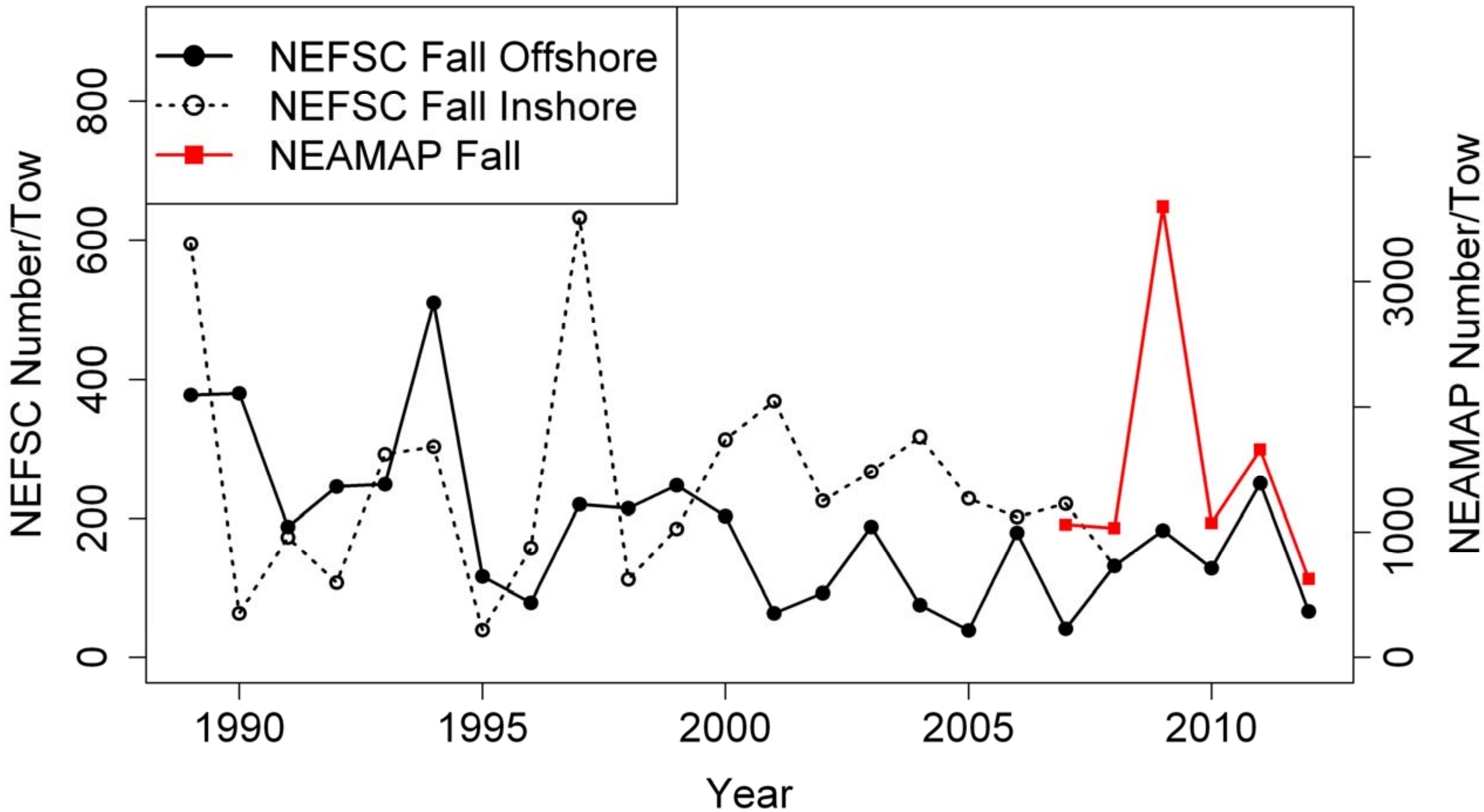

Figure A2. NEFSC and NEAMAP surveys stratified mean number of butterfish per tow. Note the NEFSC fall inshore series ends in 2008.

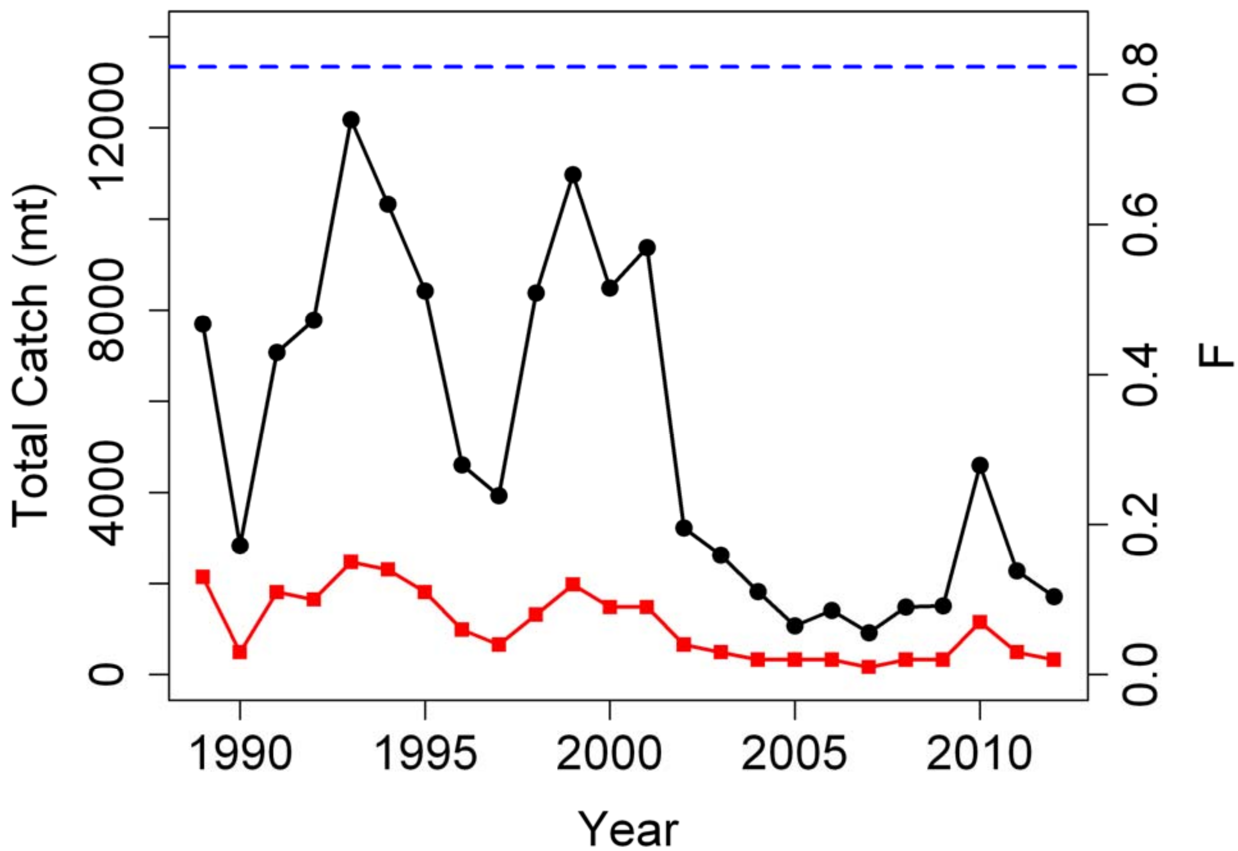

Figure A3. Butterfish total catch in mt (black circles) and fishing mortality, F (red squares). Dashed blue line is the 2014 SAW/SARC F_{MSY} proxy.

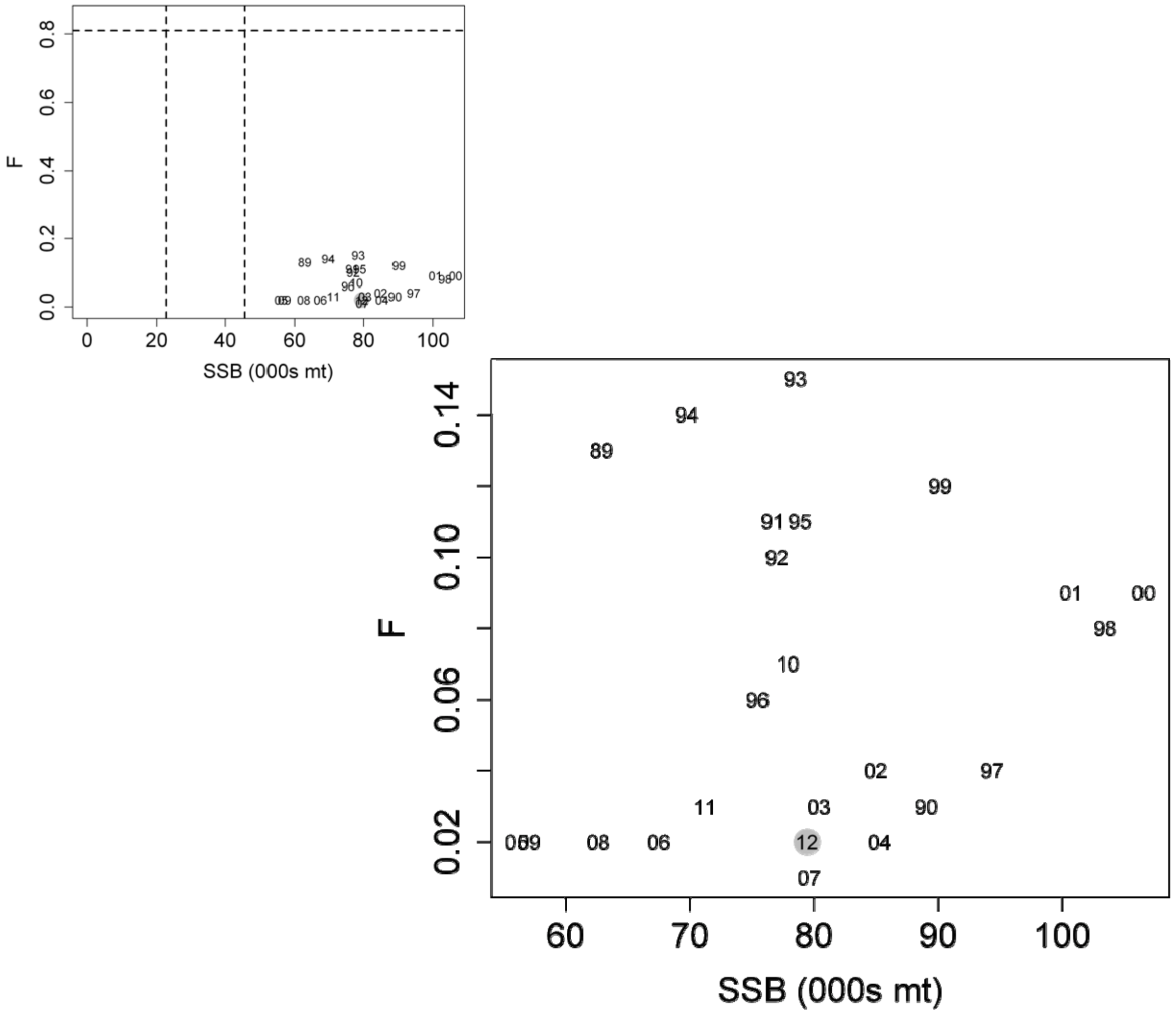

Figure A4. Butterfish spawning stock biomass (SSB) and fishing mortality (F) relative to the 2014 SAW/SARC biological reference points $SSB_{threshold}$ = 22,808 mt, SSB_{MSY} proxy = 45,616 mt, and F_{MSY} proxy = 0.81 (upper left panel). Plot is expanded for clarity in lower right panel.

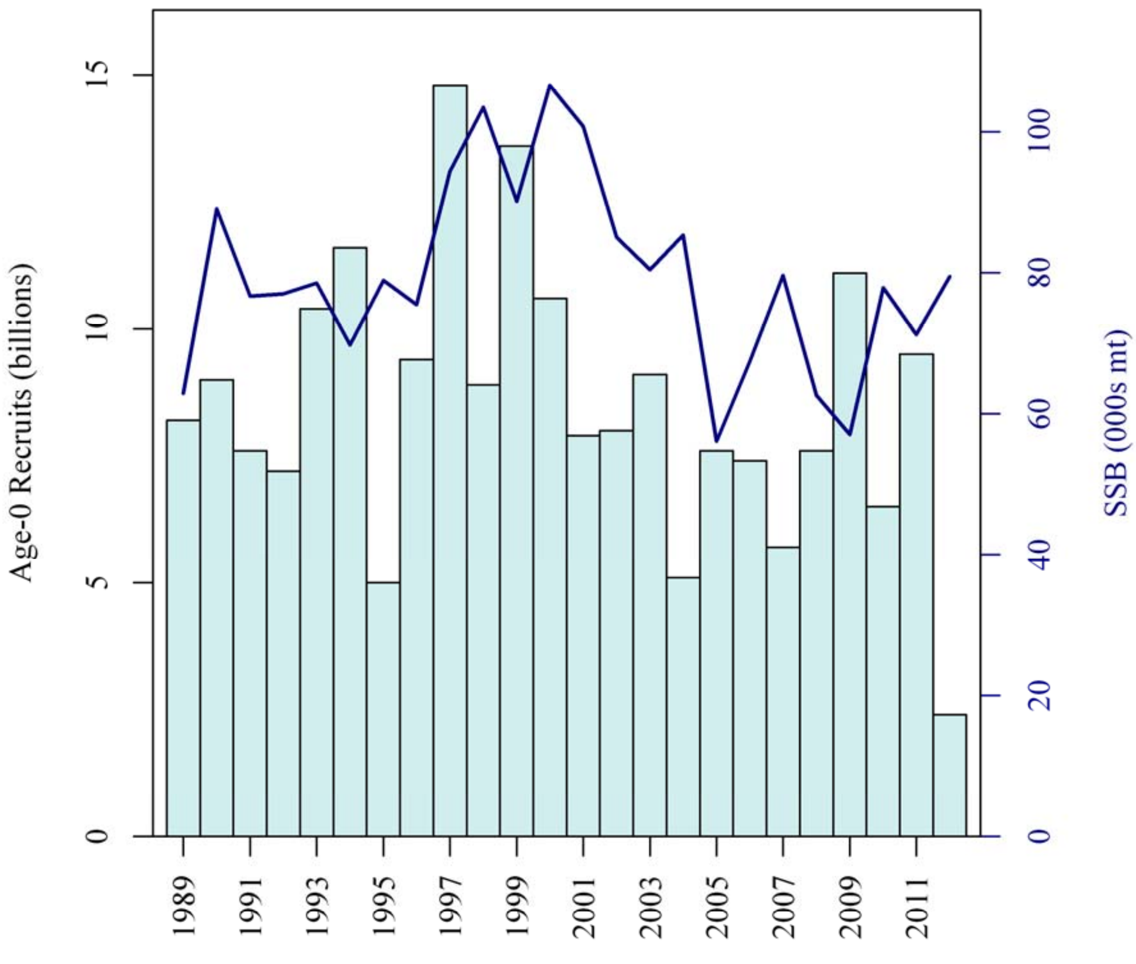

Figure A5. Butterfish recruitment (vertical bars), and the spawning stock biomass (blue line) that produced the corresponding recruitment. Year refers to spawning year.

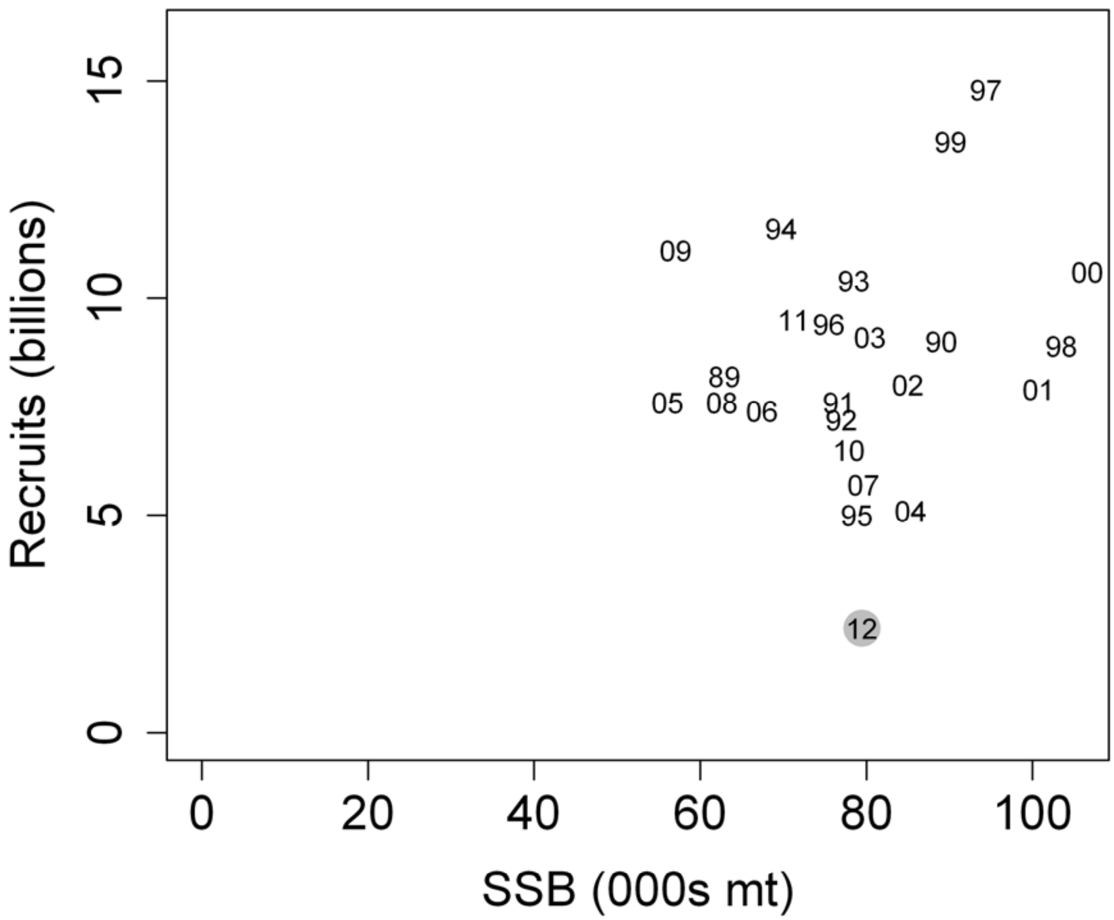

Figure A6. Butterfish stock-recruitment scatter plot, with two digit indicator of the year.