Additional Projections and Analysis of Age Compositions for South Atlantic Blueline Tilefish SEDAR 32 Stock Assessment

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This document responds to requests for additional projections and analysis of 2012 and 2013 age composition information for blueline tilefish following the SEDAR 32 South Atlantic blueline tilefish stock assessment. A previous request for projections was provided in a November 25, 2013 document included here as Appendix A. The methodology for the current request for projections can be found in the Appendix A and in the assessment report (SEDAR 2013).

Projections

I. Pstar Analysis: The first set of projections was run with blueline tilefish catch levels set at the yield that would occur at 75% F_{MSY} under equilibrium conditions (224,100 lbs wet weight) in 2014 followed by fishing at the mortality rate that results in both a 30% and a 50% chance of overfishing (Pstar = 0.3 and 0.5) over the period 2015-2018.

Projections were run for the seven years following the terminal year of the assessment (2012-2018). Catch levels for 2012 were set to those observed (484,867 lbs wet weight; see Appendix A, Table 1). Catch levels for 2013 were calculated similar to those for 2012 and are considered preliminary by the data providers. Total observed 2013 catches were 376,567 lbs wet weight (Table 1). The first year of new management was assumed to be 2014 where the catch level was set to 224,100 lbs wet weight, the 75% F_{MSY} level at equilibrium. Annual levels of projected landings that are consistent with a probability of overfishing (P*) of 0.3 and 0.5 for the remaining years of the projection time period were computed using the sequential PASCL approach of Shertzer et al. (2010). Details of the projection model and methodology can be found in SEDAR (2013) and in Appendix A.

II. Stochastic projections: The second set of projections was run with the 2014 blueline tilefish catch levels set at the yield at 75% F_{MSY} under equilibrium conditions (224,100 lbs wet weight), followed by four additional years (2015-2018) at the same catch level (224,100 lbs wet weight).

The structure of this projection is identical to that described above except that a fixed level of catch (224,100 lbs) is assumed for the projection period. Because catch is fixed in this projection, the model estimates annual F's associated with each year's observed (2012 and 2013) or assumed (2015-2018) catch.

Results

Landings and discard estimates for 2013 by fishery are shown in Table 1. 2013 MRIP and commercial (handline, longline, and other) landings and discards are considered preliminary by the data providers and subject to change. Commercial discards were not available and were estimated using the observed ratio of commercial discards to landings from 2012. Landings and discard estimates for 2012 are shown in Appendix A, Table 1. Results of P* analysis (I above) are shown in Table 2-5 and Fig. 1-2. Results of the stochastic projection (II above) are shown in Table 6 and Fig. 3.

Two additional, constant F projections (75% F_{msy} and F_{msy}) are provided for comparison with those requested. These two projections are identical in structure to the stochastic projection (II above) with the exception that they assume a constant F for 2014-2018 and then estimate an ABC associated with this F, rather than assume a fixed level of catch (i.e., the yield at 75% F_{MSY} at equilibrium). Results of these projections are shown in Table 7-8 and Fig. 4-5.

Comments on Projections:

- The catch level requested for the projections (224,100 lbs) is the yield associated with 75% of F_{MSY} under equilibrium conditions. This catch level results in annual F's (0.804-0.852) greater than the 75% F_{MSY} level (0.226) over the projection period because the stock is not at equilibrium and has experienced several recent years of high landings.

- In general, projections of fish stocks are highly uncertain, particularly in the long-term (> 3-5 years).

- Although these projections included many sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.

- Fisheries were assumed to continue fishing at their estimated current proportions of total fishing effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.

- These projections did not consider any error in implementing regulations (e.g., landings in excess of the ABC). If implementation error were included the projections would be altered.

- The projections assume that the estimated spawner-recruit relationship applies in the future and that past residuals reflect future uncertainty in recruitment. If future recruitment changes, due to environment or harvest effects, then stock trajectories will be altered.

References

SEDAR, 2013. SEDAR 32 Stock Assessment Report for South Atlantic Blueline Tilefish.

Shertzer, K.W., M.H. Prager, and E.H. Williams. 2010. Probabilistic approaches to setting acceptable biological catch and annual catch targets for multiple years: Reconciling methodology with National Standards Guidelines. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:451-458.

Table 1. 2013 landings and discard removals (pounds whole weight) of South Atlantic blueline tilefish.

Fishery	Removals
Com Handline landings	46,969
Com Longline landings	157,195
Com 'Other' landings	22,195
Com Discards	121
MRIP landings & discards	138,995
Headboat landings	11,041
Headboat discards	51
Total:	**376,567**

Table 2. Acceptable biological catch (ABC) of blueline tilefish in units of 1000 lb whole weight based on the annual probability of overfishing P* = 0.3. Landings were set to those observed for 2012 and 2013 and to 224,100 lbs for 2014, with the ABC associated with the specified probability of overfishing calculated for the remaining years (2015-2018). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)
2013	1.25	0.98	NA	153.587	0.03	104.588	NA	NA
2014	0.896	0.94	NA	138.98	0.02	97.900	NA	NA
2015	0.155	0.30	0.3	153.58	0.05	94.151	46.446	0.507
2016	0.156	0.30	0.3	183.03	0.13	96.821	65.853	0.719
2017	0.156	0.30	0.3	207.32	0.26	101.509	84.026	0.917
2018	0.156	0.30	0.3	226.57	0.39	103.411	100.01	1.092

Table 3. Acceptable biological catch (ABC) in units of 1000s of fish based on the annual probability of overfishing P* = 0.3. Landings were set to those observed for 2012 and 2013 and to 224,100 lbs for 2014, with the ABC associated with the specified probability of overfishing calculated for the remaining years (2015-2018). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.25	0.98	NA	153.587	0.03	104.588	NA	NA
2014	0.896	0.94	NA	138.98	0.02	97.900	NA	NA
2015	0.155	0.30	0.3	153.58	0.05	94.151	9.570	0.104
2016	0.156	0.30	0.3	183.03	0.13	96.821	12.869	0.141
2017	0.156	0.30	0.3	207.32	0.26	101.509	15.717	0.172
2018	0.156	0.30	0.3	226.57	0.39	103.411	18.007	0.197

Table 4. Acceptable biological catch (ABC) in units of 1000 lb whole weight based on the annual probability of overfishing P* = 0.5. Landings were set to those observed for 2012 and 2013 and to 224,100 lbs for 2014, with the ABC associated with the specified probability of overfishing calculated for the remaining years (2015-2018). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)
2013	1.25	0.98	NA	152.643	0.03	106.173	NA	NA
2014	0.897	0.94	NA	138.640	0.02	97.991	NA	NA
2015	0.231	0.50	0.5	150.195	0.05	93.120	67.674	0.739
2016	0.231	0.50	0.5	175.259	0.12	95.193	91.171	0.995
2017	0.229	0.50	0.5	193.777	0.21	95.371	111.711	1.220
2018	0.228	0.50	0.5	208.843	0.30	105.174	128.738	1.406

Table 5. Acceptable biological catch (ABC) in units of 1000s fish based on the annual probability of overfishing P* = 0.5. Landings were set to those observed for 2012 and 2013 and to 224,100 lbs for 2014, with the ABC associated with the specified probability of overfishing calculated for the remaining years (2015-2018). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.25	0.98	NA	152.643	0.03	106.173	NA	NA
2014	0.897	0.94	NA	138.640	0.02	97.991	NA	NA
2015	0.231	0.50	0.5	150.195	0.05	93.120	13.983	0.153
2016	0.231	0.50	0.5	175.259	0.12	95.193	17.965	0.196
2017	0.229	0.50	0.5	193.777	0.21	95.371	21.174	0.231
2018	0.228	0.50	0.5	208.843	0.30	105.174	23.607	0.258

Table 6. Scenario 1: Catch set to the yield that would occur at $F=75\%F_{msy}$ (224.1 klb) under equilibrium conditions. Landings were set to those observed for 2012 and 2013 and to 224,100 lbs for 2014-2018. Annual F's associated with an ABC of 224,100 lbs (landings + discards) is calculated (bold). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). ABCs are an assumed fixed single quantity while other values are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings + discards (1000 lb)	ABC landings + discards (1000 fish)
2013	1.202	160.73	0.05	105.674	376.567	77.537
2014	**0.827**	149.96	0.05	98.170	224.100	47.100
2015	**0.813**	149.15	0.06	95.203	224.100	46.905
2016	**0.804**	146.31	0.07	94.005	224.100	46.468
2017	**0.823**	141.87	0.07	91.988	224.100	46.032
2018	**0.852**	136.84	0.08	89.252	224.100	45.538

Table 7. Scenario 2: Constant F projection at $F=75\%F_{msy}$. Landings were set to those observed for 2012 and 2013 and the ABC associated with a constant F was calculated for the projection period (2014-2018, bold). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.362	140.32	0.08	117.750	376.567		79.624	
2014	0.226	143.60	0.11	112.085	**62.859**	**0.686**	**13.398**	**0.146**
2015	0.226	173.62	0.30	112.658	**86.604**	**0.946**	**17.584**	**0.192**
2016	0.226	197.04	0.55	117.088	**110.074**	**1.202**	**21.429**	**0.234**
2017	0.226	214.49	0.74	119.768	**131.522**	**1.436**	**24.725**	**0.270**
2018	0.226	227.90	0.86	121.443	**148.570**	**1.622**	**27.103**	**0.296**

Table 8. Scenario 3: Constant F projection at $F=F_{msy}$. Landings were set to those observed for 2012 and 2013 and the ABC associated with a constant F was calculated for the projection period (2014-2018, bold). F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish).

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.362	140.32	0.08	117.750	376.567		79.624	
2014	0.302	141.90	0.11	112.085	**82.960**	**0.895**	**17.524**	**0.191**
2015	0.302	167.80	0.30	112.363	**108.692**	**1.187**	**22.245**	**0.245**
2016	0.302	186.67	0.55	116.329	**133.751**	**1.460**	**26.387**	**0.288**
2017	0.302	199.51	0.74	118.549	**155.425**	**1.697**	**29.742**	**0.325**
2018	0.302	208.53	0.86	120.019	**171.204**	**1.869**	**31.939**	**0.345**

Figure 1. P* = 0.3 projection results. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (i.e., Landings = Catch). Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

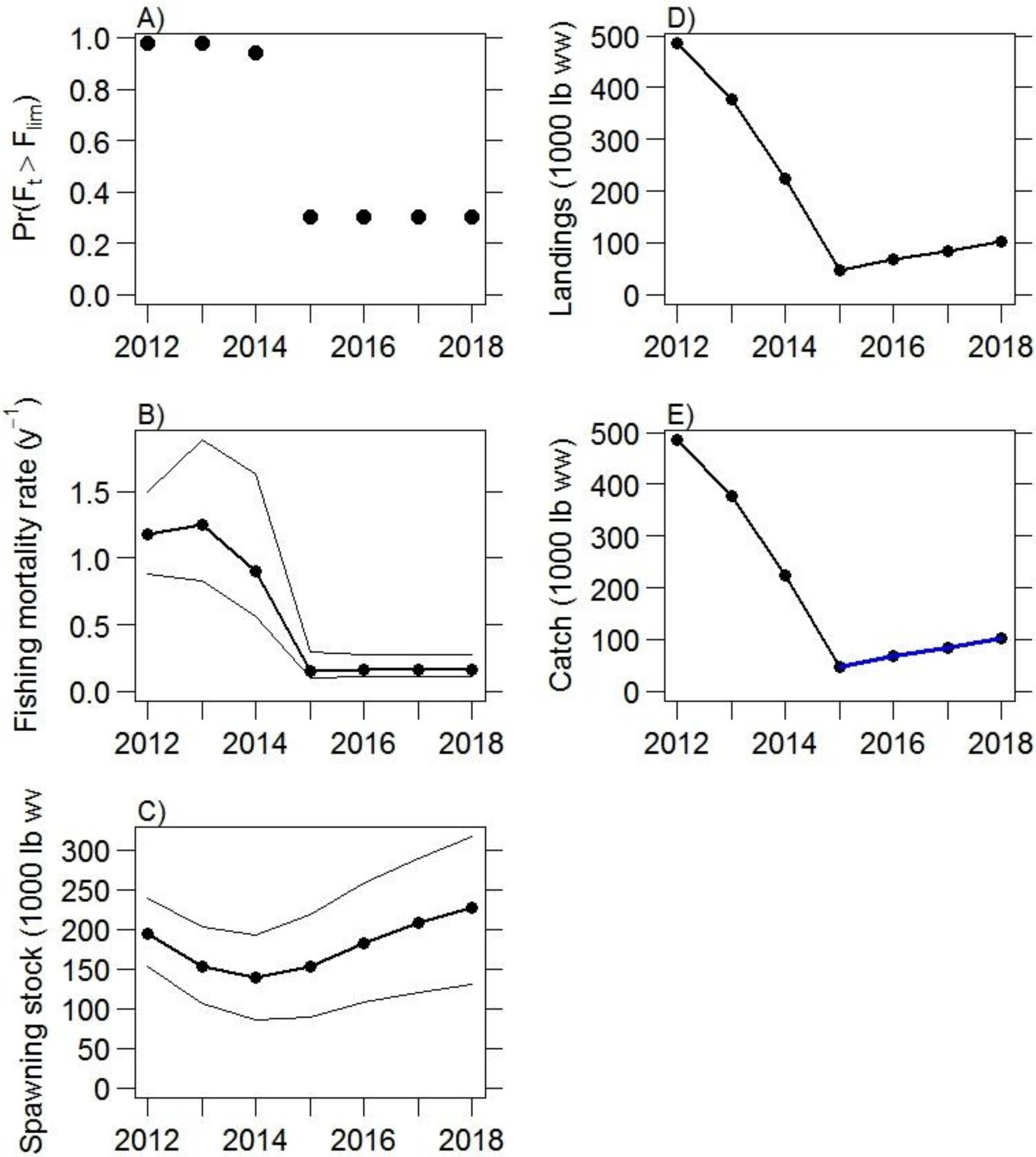


Figure 2. P* = 0.5 projection results. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (i.e., landings = catch). Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

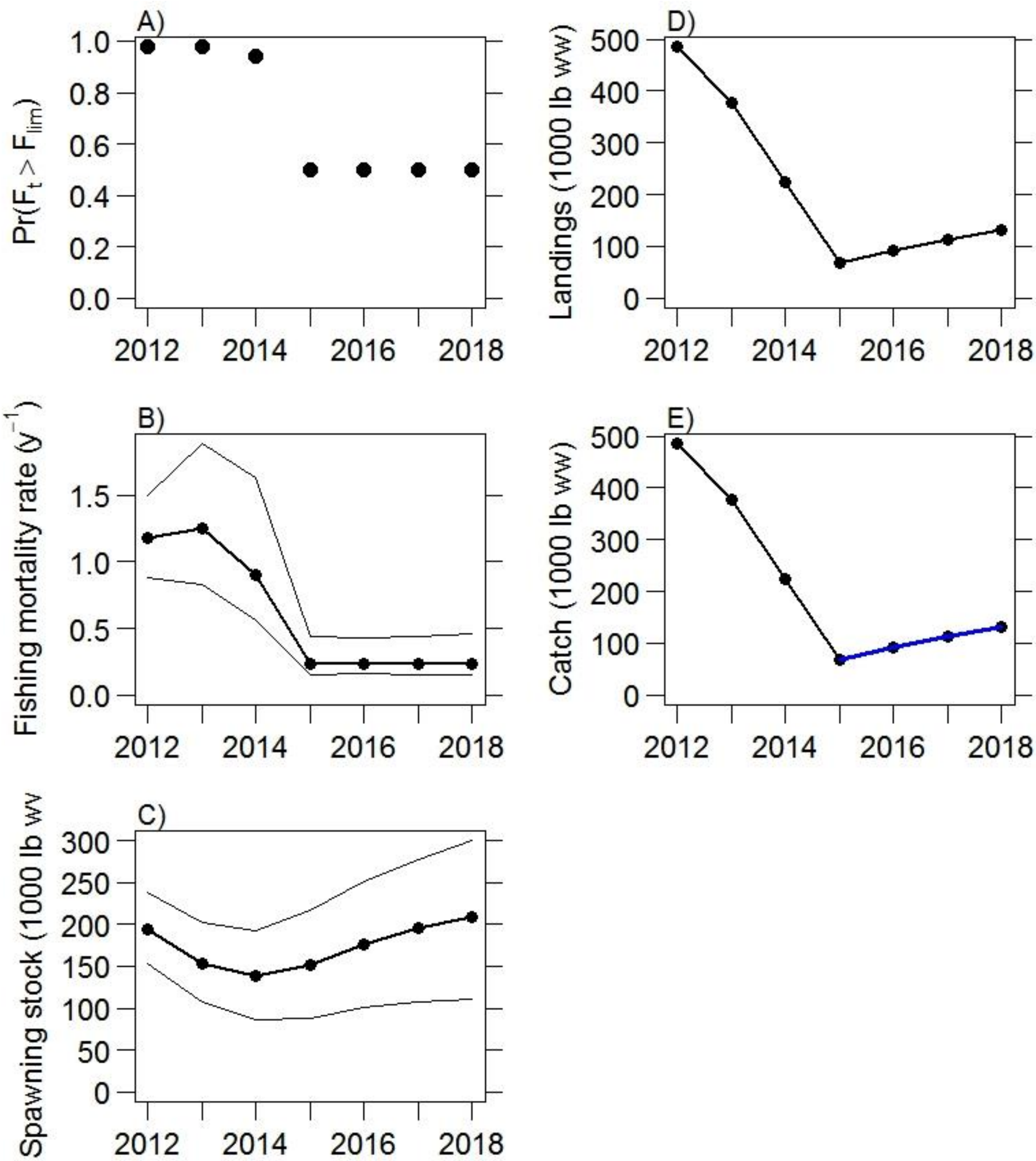


Figure 3. Scenario 1: Landings set to the yield that would result at $F=75\%F_{msy}$ under equilibrium conditions (224.1 klb). For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

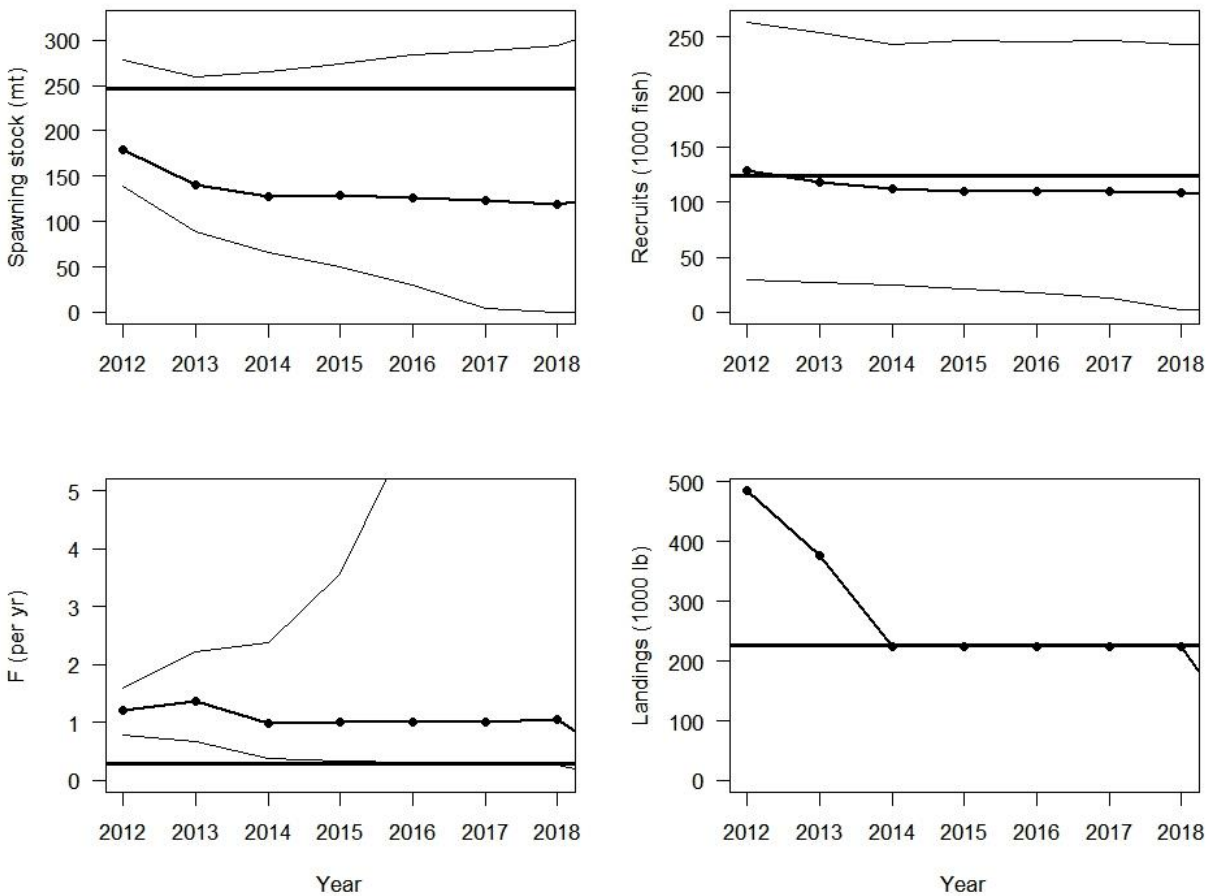


Figure 4. Scenario 2: Constant F projection at $F=75\%F_{msy}$. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables. Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5^{th} and 95^{th} percentiles of the 10,000 projection runs.

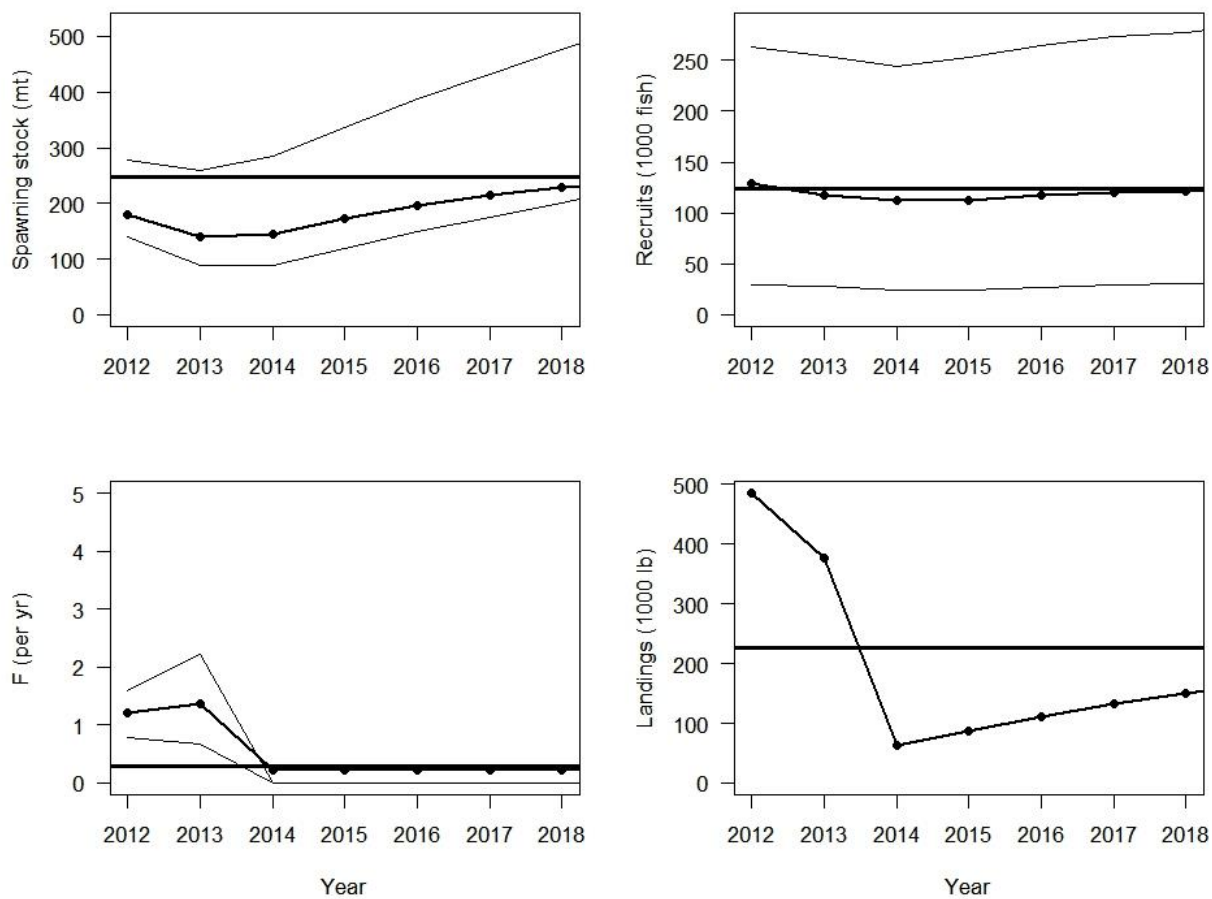
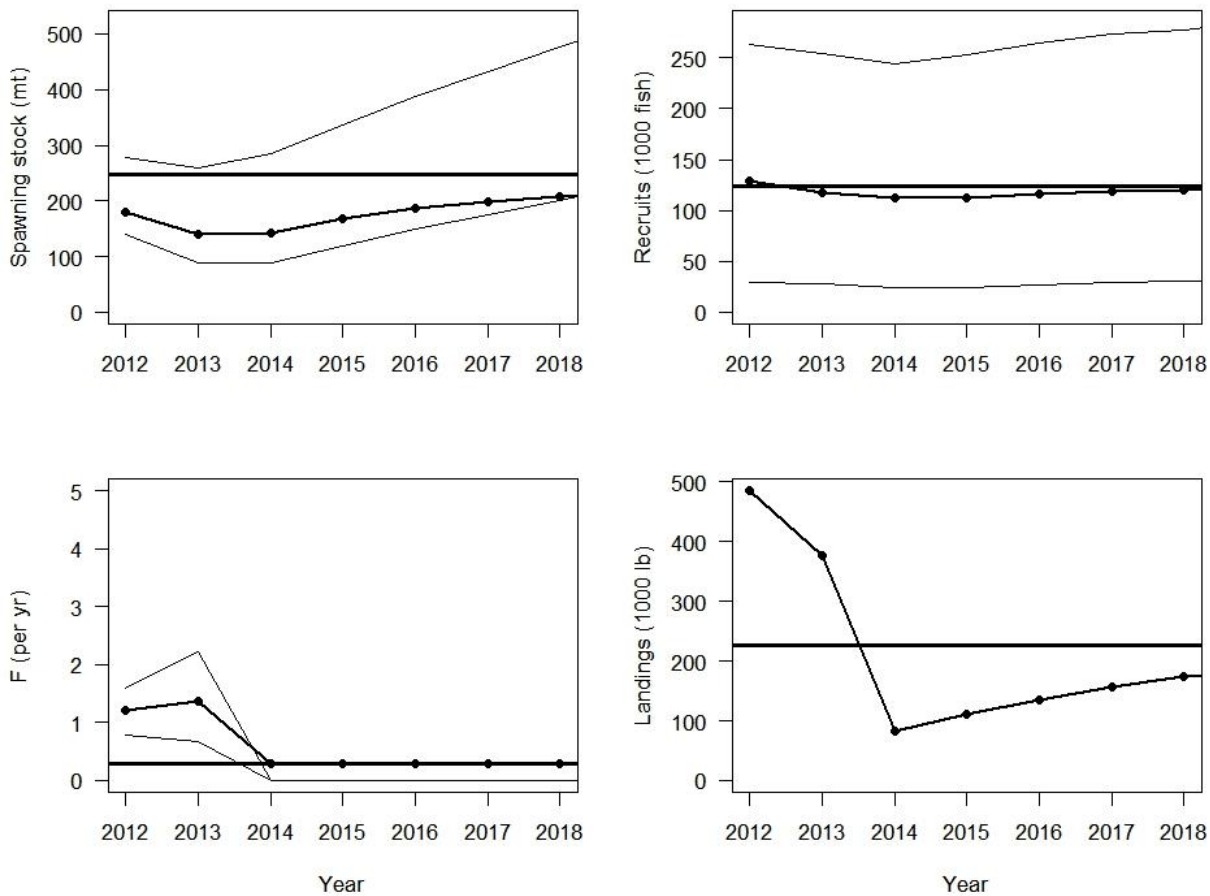


Figure 5. Scenario 3: Constant F projection at F=F_{msy}. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables. Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.



Analysis of Blueline Tilefish 2012 and 2013 Age Compositions

Age compositions were developed for 2012 and 2013 for the commercial longline fishery, the commercial handline fishery, and the general recreational fishery, and compared with age compositions available from the assessment (2007-2011) to investigate the potential for recent high recruitment (i.e., strong year classes).

Age compositions for 2007-2013 are shown in Figure 6-8. The relative abundance of age classes in the handline fishery in 2012 and 2013 is similar to that for the other years and near the middle of the available range (Fig. 6).

The relative abundance of age classes in the longline fishery in 2012 is also similar to that in the other years and near the middle of the available range (Fig. 7). The longline fishery harvested slightly younger fish in 2013 compared to the other years. The most common ages harvested in 2013 were age 4 and 5 which is slightly younger than the peak in the other years (typically age 5 and 6). There was also a higher relative abundance of three year olds in 2013.

Sample sizes from the general recreational fishery were small (58-70 fish per year) and age compositions should be interpreted with caution. In 2011, there was a peak in recreational catches at age-2 (Fig. 8). The relative abundance of age classes in the general recreational fishery in 2012 is similar to the pooled recreational age compositions (2003-2011) used in the assessment. Similar to the longline fishery, slightly younger fish were harvested by the recreational sector in 2013.

There is no indication of relatively high abundance of age-0 or age-1 or the progression of a strong year class in the commercial or recreational age compositions (Fig. 9-12). The relative proportion of young fish (≤ age 1 or ≤ age 3) in the handline fishery was constant or declined slightly from 2007 to 2013 (Fig. 12). Because the longline fishery typically harvests older fish, there are no age-0 and very few age-1 fish in the age compositions from this fishery. The relative proportion of fish ≤ age-2 increased slightly in 2011 and the proportion of fish ≤ age-4 has increased in recent years, but overall there is no trend in the abundance of young fish that would suggest recent enhanced recruitment (Fig. 12). While the recreational fishery typically takes younger fish (≤ age-4) than the commercial sector, there were no age-0 fish in the recreational age compositions. The relative abundance of age-1 and age-2 fish declined from 2011 to 2013 (Fig. 12). Age compositions from the recreational sector are based on low sample sizes (n = 58-70 fish per year) and should be interpreted with caution.

Comments on Age Compositions:

- The terminal year of the blueline stock assessment was 2011. In the assessment, average recruitment (defined as the abundance of age-1 fish from the stock-recruitment relationship) was assumed for 2009 to 2011 and for the projections (2012 to 2018). Higher than average recruitment during these years has been put forth as an explanation for the continued observed high landings (2012 and 2013), particularly in the recreational sector. Alternative explanations for continued high landings include increases in fishing effort and/or increases in catchability.

- The available age compositions do not show indications of a strong year class. particularly in 2009 or 2010, that would support high recreational catches in 2012 and 2013 or continued high commercial catches in the later years of the assessment (2009-2011) or more recently (2012-2013). While the relative proportions of young fish are low, there is no evidence of a “pulse” of age-0 or age-1 fish in the age compositions from the commercial handline, commercial longline, or recreational fisheries. The range of ages and the relative proportions of young fish represented in the age compositions has remained relatively constant or in some cases declined over time. Comparing the relative proportions of the 2009 and 2010 year classes across years does not provide indications of a strong year class passing through the fishery. There is an increase in the proportion of young fish in 2013 in both the longline and the recreational age compositions (but not the handline age composition) that could indicate increased recruitment, increased mortality of older fish, shifts in selectivity, and/or sampling issues. Overall, there is little support to date for the hypothesis that a recent large year class is supporting recent high landings in the fishery.

- Annual age compositions should be interpreted with caution because they reflect the combined effects of multiple processes that can vary in time, in particular, annual recruitment and age-specific mortality and selectivity. Inspecting empirical age compositions for evidence of recruitment variability in the absence of auxillary information assumes that age-specific mortality and selectivity are constant. Annual variation in these processes is likely, hence limiting the utility of a small number of annual age compositions for providing signals of year class strength.

- Age compositions were available from fishery-dependent data sources, only for a small number of years (3 yrs for the recreational fishery, 5-7 years for the commercial fishery), and sample sizes were often low (particularly for the recreational sector). If age compositions are from regions not previously heavily exploited then they may not reflect the exploitation history of the stock. This limits the utility of these data for inferring information about the dynamics of the fishery or the actual stock of blueline tilefish.

- There is limited information to date with which to evaluate the alternative hypotheses (i.e., increased fishing effort and increased catchability) for recent high landings of blueline tilefish. Anecdotal evidence suggests effort directed toward blueline tilefish has increased due to regulations on other higher-valued species (e.g., snowy grouper, sharks) and an apparent shift to deeper water in some sectors (e.g., charterboat) of the recreational fishery. Catchability to the fishery may also have increased if previously unexploited fish have been ‘discovered’ by the fishery so that an increased proportion of the stock is available to harvest. Catchability could also increase due to increased harvest efficiency in targeting and capturing blueline tilefish, as might have occurred in recent years concurrent with the increased interest in this species. The recent high landings of blueline will only reflect high abundance (i.e., large standing stock and/or increased recruitment) if catchability and fishing effort for this species have remain constant.

- Figure 6. Commercial handline age compositions (2007-2013). 2012 and 2013 are in bold.

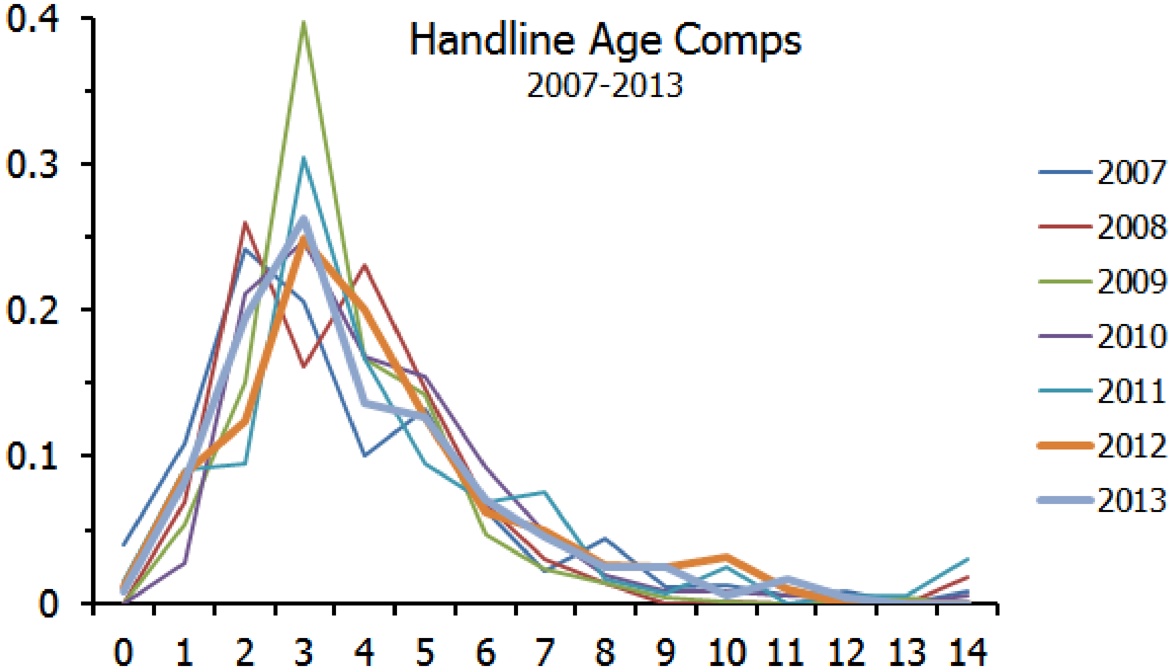


Figure 7. Commercial longline age compositions (2009-2013). 2012 and 2013 are in bold.

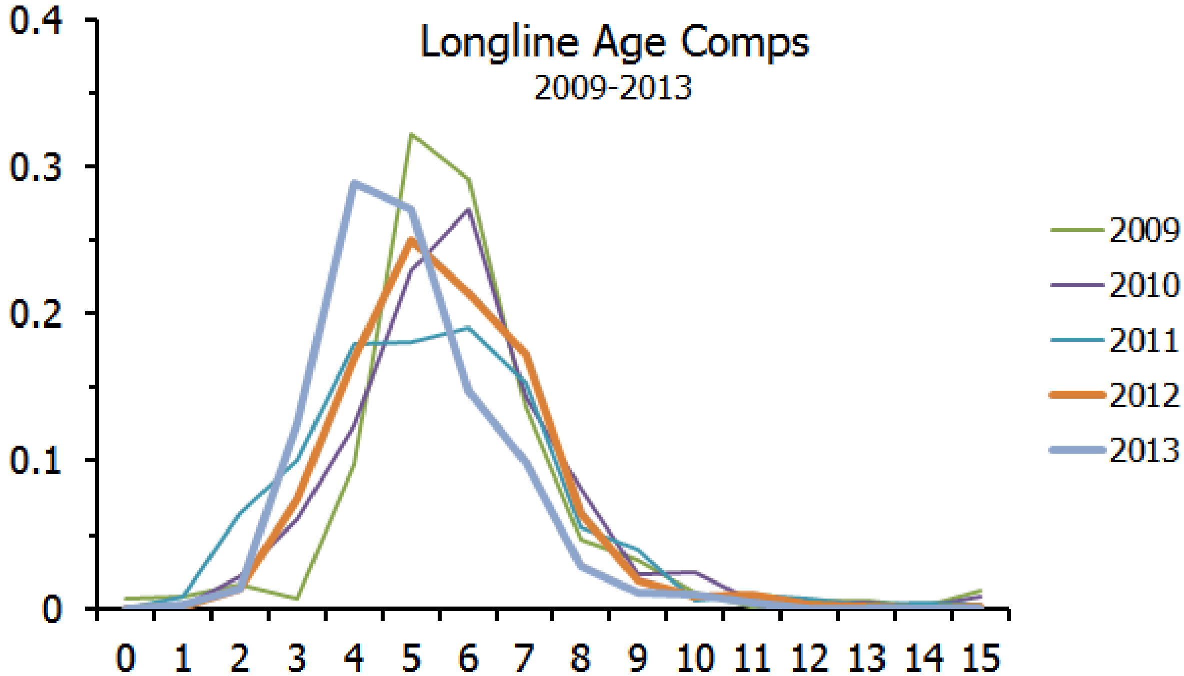


Figure 8. General recreational age compositions (2011-2013). 2012 and 2013 are in bold.

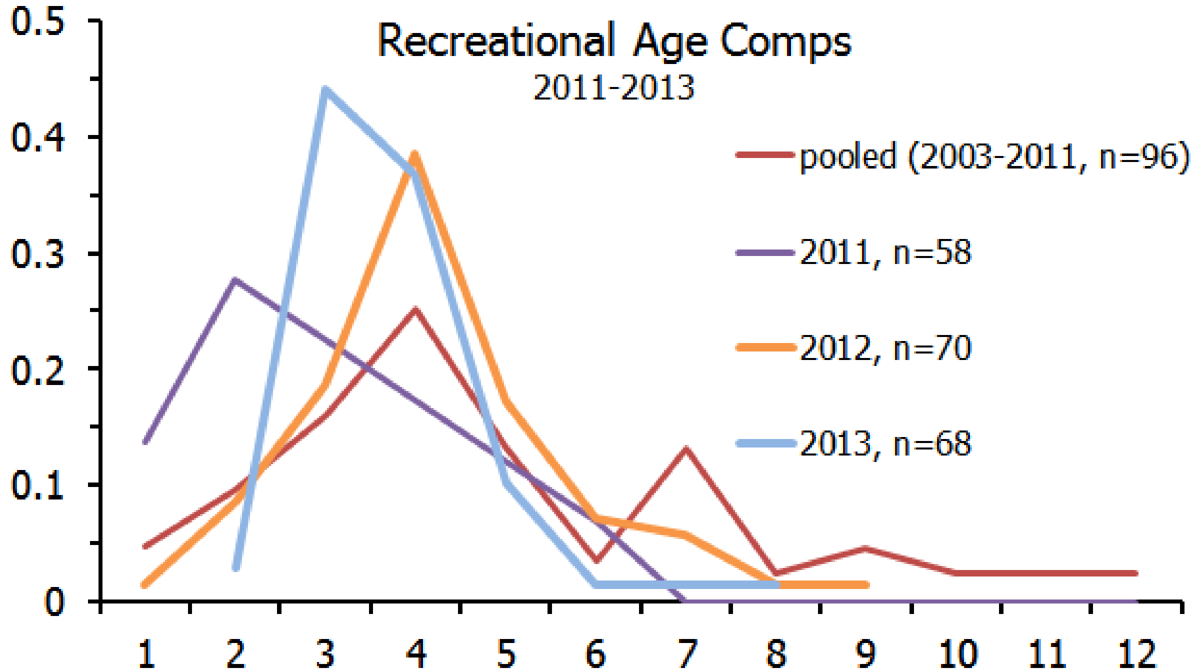


Figure 9. Annual age compositions from the commercial handline fishery.

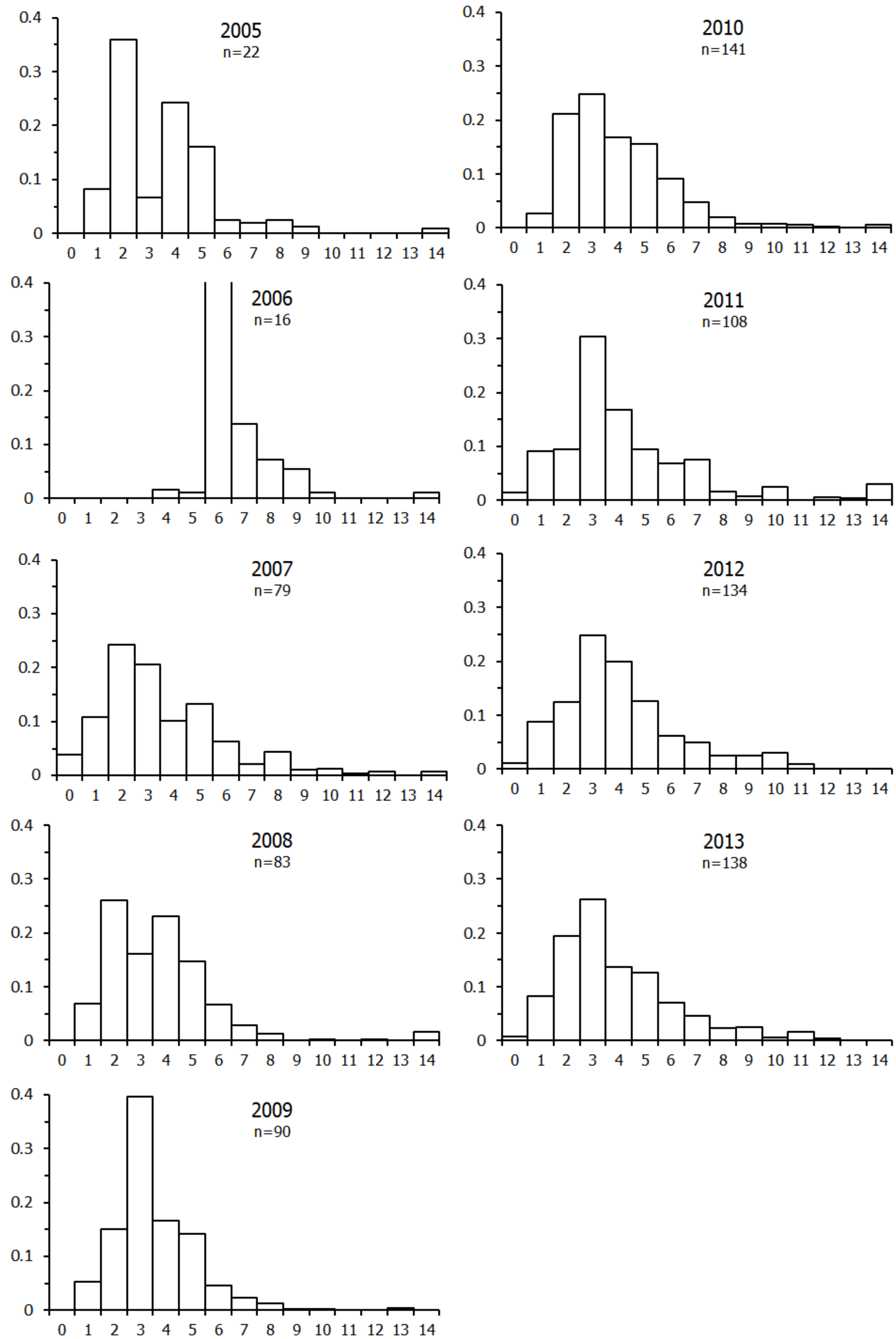


Figure 10. Annual age compositions from the commercial longline fishery.

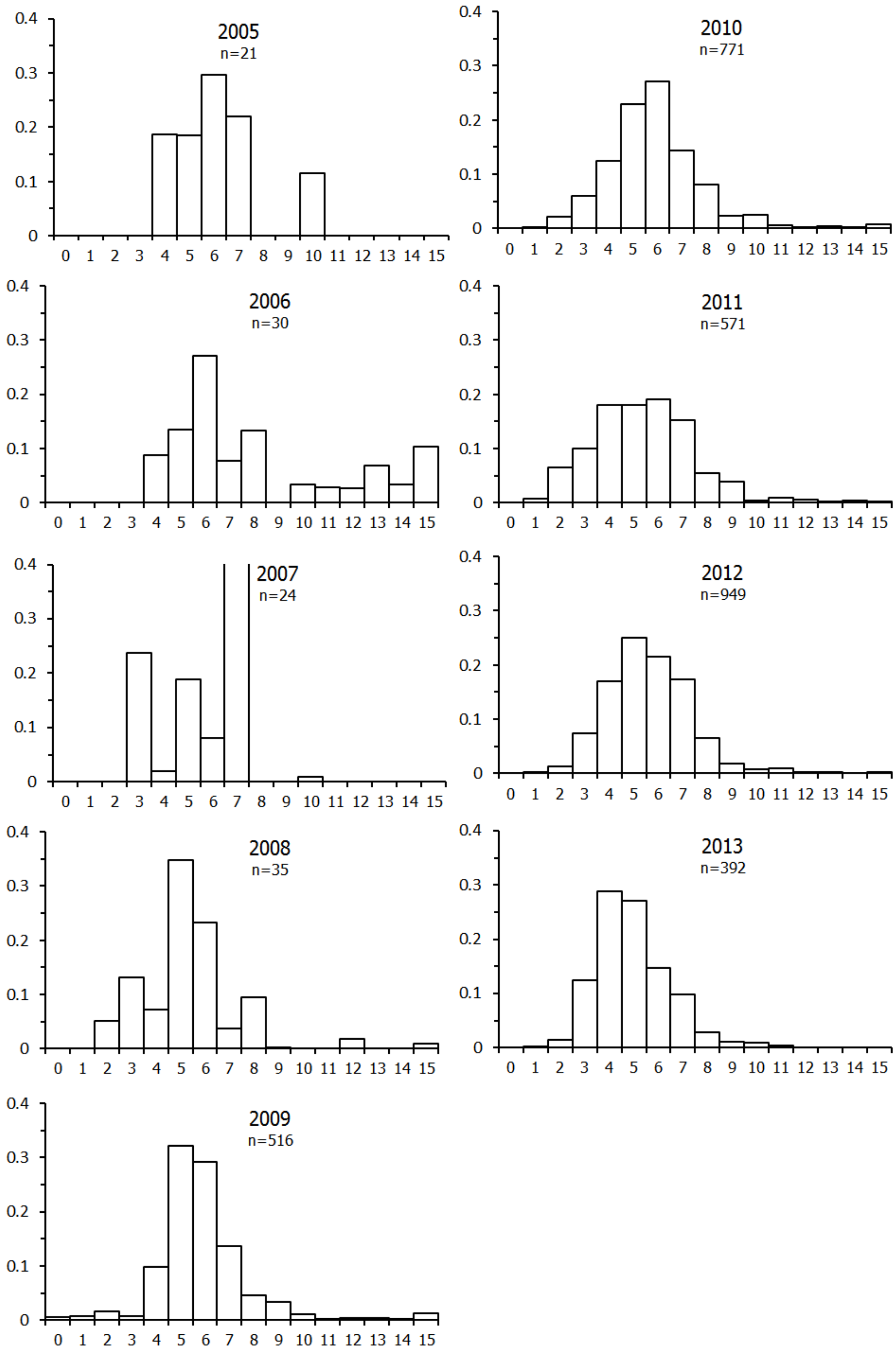


Figure 11. Annual age compositions from the general recreational fishery.

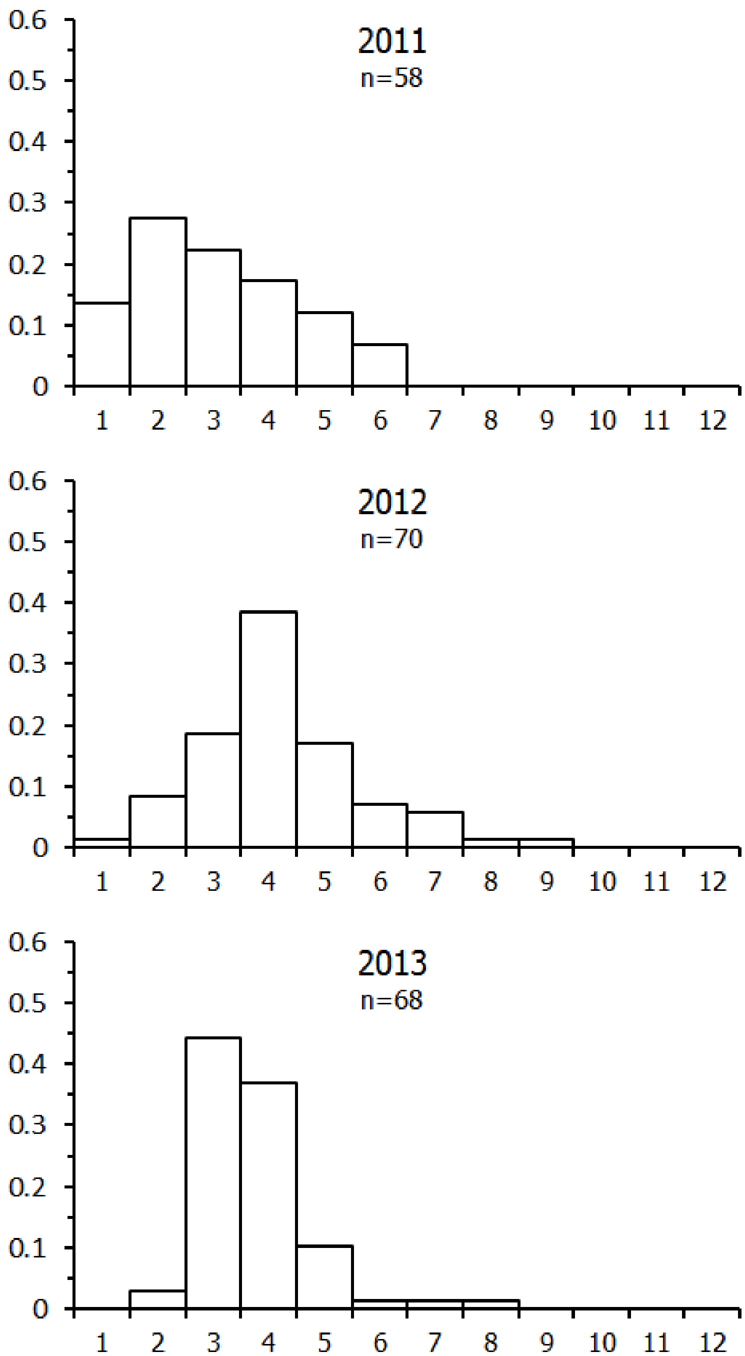
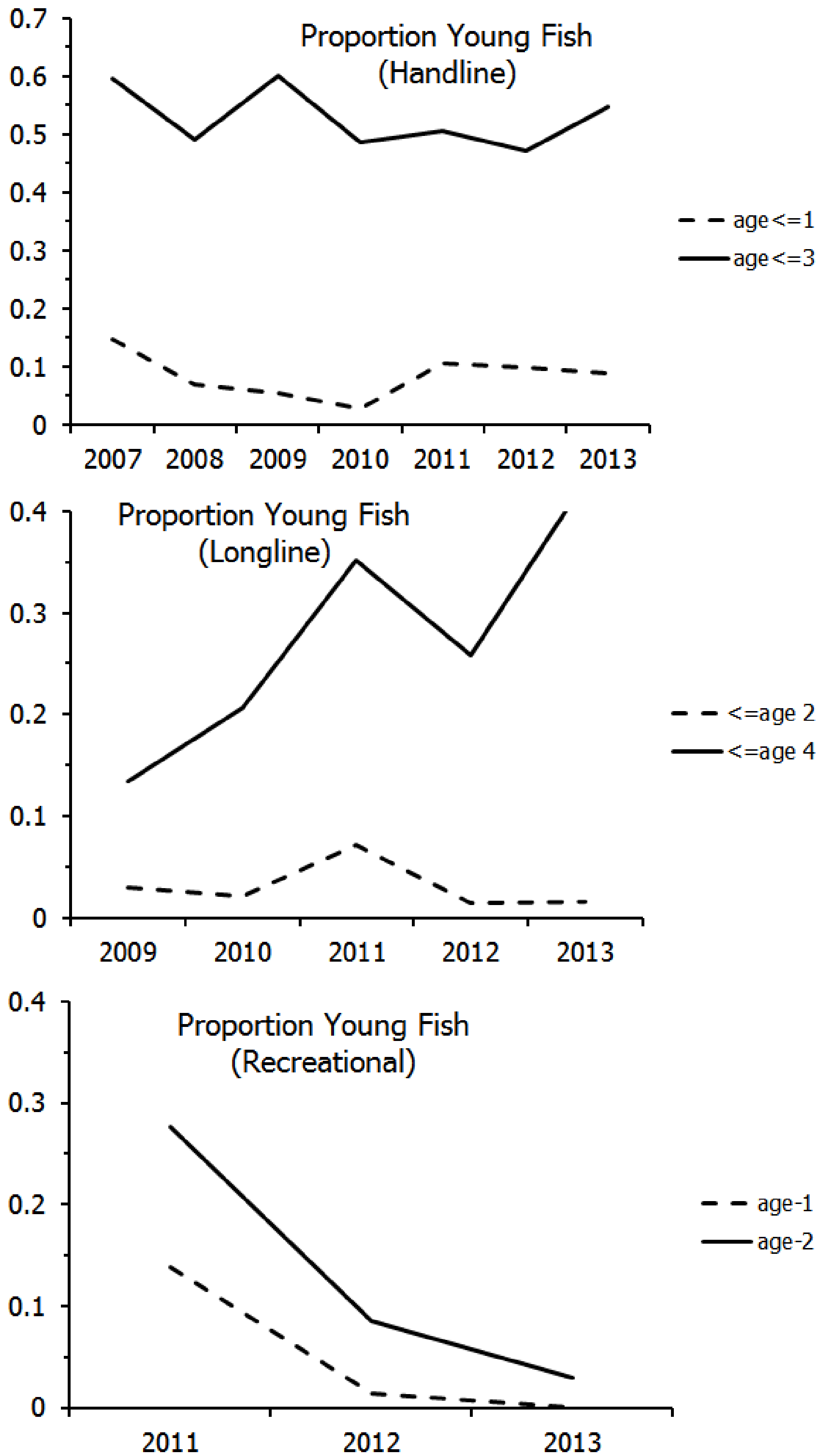


Figure 12. Proportion of younger ages in the commercial handline, longline, and general recreational fishery.



Appendix A. November 25, 2013 response to request.

Projections and Associated Analyses for South Atlantic Blueline Tilefish SEDAR 32 Stock Assessment

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Southeast Fisheries Science Center,
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November 25, 2013

Introduction

This document responds to requests for revised stochastic projections, P* projections, and related information from the SEDAR 32 South Atlantic blueline tilefish stock assessment following the October 2013 meeting of the SSC.

Stochastic Projections

Four constant F projection scenarios were provided in the SEDAR 32 blueline tilefish assessment report:
1. F=0

2. $F=F_{rebuild}$ (F at which 50% of projection replicates achieve stock recovery in 10 yrs (i.e., $SSB_{2023} \geq SSB_{msy}$)

3. $F=F_{msy}$

4. $F=F_{current}$ (geometric mean F from 2009-2011)

In the original report, each scenario was run as a 5-year projection (2012-2016) with 2012 as an interim year, and management first applied in 2013. These projections only included data through 2011 and F in 2012 was taken as the geometric mean F from 2009-2011. Details of the projection methodology and results can be found in the SEDAR 32 blueline tilefish assessment report (SEDAR 2013).

At the SEDAR 32 review workshop (RW) it was noted that blueline landings in 2011 were unusually low compared to 2009 and 2010. This was attributed to a deep water closure that was only in effect for 2011. As a result, the convention of using the geometric mean of the fishing mortality over the terminal three years of the assessment (2009-2011) for projections was questioned. A request was made at the RW to update the projections using actual 2012 landings data. The 2012 landings were similar in magnitude to those in 2009 and 2010 (and higher than 2011), supporting the conclusion that the low 2011 landings were a result of the temporary management regulation.

All projections were re-done including 2012 landings data. 2012-2014 were considered interim years and management was first applied in 2015 as described in the blueline tilefish management overview. The terminal year of the projections was 2023. The original four projection scenarios described above were re-run including these changes. An additional request was made for a rebuilding projection at 72.5% probability of successful rebuilding at $F_{rebuild}$. Hence, a fifth projection was run in an identical manner to those described above:

5. $F=F_{rebuild}$ (F at which 72.5% of projection replicates achieve stock recovery in 10 yrs (i.e., $SSB_{2023} \geq SSB_{msy}$)

Total blueline removals in 2012 were constructed from commercial (handline, longline, other gear) and recreational (headboat, MRIP) landings and discard estimates (Table 1). Landings were provided in pounds whole weight. Discards were converted from numbers to pounds whole weight assuming a mean weight of 5.06 pounds. A 1-yr projection was run with the 2012 landings data to generate a value for fishing mortality (F) in 2012 given the 2012 landings. The geometric mean fishing mortality over

2009, 2010, and 2012 (excluding 2011) was then used as current F for the interim years in the constant F projection scenarios described below.

In the SEDAR 32 blueline assessment, discards were not modeled separate from landings. This was due to the small amount of dead discards relative to landings and the lack of size or age information of discards needed to estimate discard selectivity. This decision was approved by the assessment panel during the assessment workshop and subsequent webinars. Because there were not separate discard and landings data streams in the assessment model, separate fishing mortality rates (Fs) were not estimated for landings and discards and, hence, all projected ABCs reflect combined landings and discards.

To separate the combined ABCs into those for landings and discards a posthoc analysis was conducted using the ratio of dead discards to landings available in the data. Recreational landings and discards were available from 1981 – 2011. Commercial discards were available from 1993 – 2011. Discard mortality was assumed to be 100% as recommended by the SEDAR 32 DW. Dead discards represented on average 0.0108% of total removals (landings + dead discards). Projected ABCs were partitioned between landings and discards using this ratio.

Results of the 5 projection scenarios are shown in Table 2-6 and Fig. 1-5.

P Analysis*

Acceptable biological catch (ABC) was computed using the sequential PASCL approach of Shertzer et al. (2010), a refinement of the probability-based approach described in Shertzer et al. (2008). This approach solves for annual levels of projected landings that are consistent with a preset acceptable probability of overfishing (P*) in any year of the projection time period. The method considers uncertainty in F_{MSY} as characterized by the MCB analysis described in the SEDAR 32 South Atlantic blueline tilefish stock assessment report (SEDAR 2013). No implementation uncertainty is included so that annual catch targets are considered to be centered on the ABC. Two 5-yr projections were run with P* = 0.5 and P* = 0.3. These values were recommended by the SSC following review of the assessment.

Projections were run for the six years following the terminal year of the assessment (2012-2017). The structure of the projection model is described in SEDAR (2013). The first year of new management is assumed to be 2015. Point estimates of initial abundance at age in the projection (start of 2012), other than at age 1, were taken to be the 2011 estimates from the assessment, discounted by 2011 natural and fishing mortalities. The initial abundance at age 1 was computed using the estimated spawner-recruit model and a 2011 estimate of SSB. In the assessment, the terminal two years of recruitment did not deviate from the spawner-recruit curve, which influenced the abundances of ages 1-2 (N_{1-2}) in 2011. In the projections, lognormal stochasticity was applied to these abundances based on recruitment variation (σ_R). Thus, the initial abundance in year one (2012) of the projections included this variability in N_{2-3}, as well as in the SSB_{2011} used to compute initial recruits, N_1. Because the assessment ended in 2011, the projections required an initialization period (2012). As for the stochastic projections described above, the fully selected fishing mortality rate during the initialization period was taken to be the geometric mean of fully selected F for 2009, 2010, and 2012. Any changes in fishing effort were assumed to begin in 2015.

To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single MCB assessment model fit. Thus, projections carried forward uncertainties in natural mortality and steepness, as well as in estimated quantities such as spawner-recruit parameters, selectivity curves, and in initial (2012) abundance at age. Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated Beverton-Holt model of each MCB fit was used to compute mean annual recruitment values. Variability was added to the mean values by choosing multiplicative deviations at random from the recruitment deviations estimated for that chosen MCB run.

The procedure generated 10,000 replicate projections of MCB model fits drawn at random (with replacement) from the MCB runs. In cases where the same MCB run was drawn, projections would still differ as a result of stochasticity in projected recruitment streams. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

Annual ABC (landings plus discard mortalities in 1000 lb whole weight and 1000s fish) was computed for the years 2013-2017. In general, ABC increased with a higher acceptable probability of overfishing (P*) while spawning stock biomass decreased. Because implementation uncertainty was considered zero, these ABC values should be considered possible catch limits. Implementation uncertainty could be included in which case these values would be adjusted downward in setting annual catch targets (ACTs).

The projection method applied here assumed the catch taken from the stock was the annual ABC. If the projection had applied a catch level lower than the ABC, say at ACT < ABC, then the corresponding reduction in applied F would have resulted in higher stock sizes, and higher ABCs in subsequent years.

Results of P* analysis (in weight and numbers) are shown in Table 7-10 and Fig. 6-7.

Comments on Projections:

- Both stochastic projections and P* analysis show a predicted spike in fishing mortality in 2014. The assumed F during the interim years (2012-2014) prior to management in 2015 is about three times F_{msy}. This high F drives down the predicted spawning biomass. In addition, the large recruitments in the early to mid-2000's predicted by the assessment model have pass through the fishery by 2013. The combination of low spawning biomass and a more typical (rather than elevated) recruitment pattern likely account for this spike in fishing mortality.

- In general, projections of fish stocks are highly uncertain, particularly in the long-term (> 3-5 years).

- Although these projections included many sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.

- Fisheries were assumed to continue fishing at their estimated current proportions of total fishing effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- These projections did not consider any error in implementing regulations (e.g., landings in excess of the ABC). If implementation error were included the projections would be altered.
- The projections assume that the estimated spawner-recruit relationship applies in the future and that past residuals reflect future uncertainty in recruitment. If future recruitment changes, due to environment or harvest effects, then stock trajectories will be altered.

References

SEDAR, 2013. SEDAR 32 Stock Assessment Report for South Atlantic Blueline Tilefish.

Shertzer, K.W., M.H. Prager, and E.H. Williams. 008. A probability-based approach to setting annual catch levels. Fishery Bulletin 106:225-232.

Shertzer, K.W., M.H. Prager, and E.H. Williams. 2010. Probabilistic approaches to setting acceptable biological catch and annual catch targets for multiple years: Reconciling methodology with National Standards Guidelines. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:451-458.

Table 1. 2012 landings and discard removals (pounds whole weight) of South Atlantic blueline tilefish.

Fishery	Removals
Com Handline landings	32,726
Com Longline landings	309,320
Com 'Other' landings	25,197
Com Discards	197
MRIP landings	91,421
MRIP discards	7,458
Headboat landings	18,462
Headboat discards	86
Total:	**484,867**

Table 2. Scenario 1: F=0. Acceptable biological catch (ABC) in units of 1000 lb whole weight and 1000s fish. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2012	1.216	178.97	0.14	128.615	484.815	0.0524	97.811	0.0106
2013	2.084	125.48	0.05	117.750	484.815	0.0524	104.953	0.0113
2014	5.363	71.44	0.03	109.205	484.815	0.0524	125.174	0.0135
2015	0	76.24	0.03	92.260	0	0	0	0
2016	0	113.78	0.08	94.403	0	0	0	0
2017	0	152.41	0.19	106.545	0	0	0	0
2018	0	188.59	0.33	114.100	0	0	0	0
2019	0	224.85	0.47	118.864	0	0	0	0
2020	0	262.44	0.60	122.333	0	0	0	0
2021	0	300.26	0.69	125.052	0	0	0	0
2022	0	337.50	0.77	127.182	0	0	0	0
2023	0	373.66	0.82	128.862	0	0	0	0

Table 3. Scenario 2: F=Frebuild with 50% probability. Acceptable biological catch (ABC) in units of 1000 lb whole weight and 1000s fish. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2012	1.216	178.97	0.14	128.615	484.815	0.0524	97.811	0.0106
2013	2.084	125.48	0.05	117.750	484.815	0.0524	104.953	0.0113
2014	5.363	71.44	0.03	109.205	484.815	0.0524	125.173	0.0135
2015	0.185	75.02	0.03	92.260	15.996	0.0017	4.254	0.0005
2016	0.185	107.95	0.06	93.874	31.101	0.0034	7.279	0.0008
2017	0.185	138.32	0.10	105.063	50.792	0.0055	10.889	0.0012
2018	0.185	162.42	0.16	111.724	71.950	0.0078	14.492	0.0016
2019	0.185	183.09	0.23	115.589	91.444	0.0099	17.552	0.0019
2020	0.185	202.47	0.30	118.240	107.108	0.0116	19.790	0.0021
2021	0.185	220.47	0.37	120.315	120.384	0.0130	21.627	0.0023
2022	0.185	236.82	0.44	121.965	133.132	0.0144	23.422	0.0025
2023	0.185	251.29	0.50	123.279	145.395	0.0157	25.145	0.0027

Table 4. Scenario 3: $F=F_{msy}$. Acceptable biological catch (ABC) in units of 1000 lb whole weight and 1000s fish. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2012	1.216	178.97	0.14	128.615	484.815	0.0524	97.811	0.0106
2013	2.084	125.48	0.05	117.750	484.815	0.0524	104.953	0.0113
2014	5.363	71.44	0.03	109.205	484.815	0.0524	125.174	0.0135
2015	0.302	74.27	0.03	92.260	25.592	0.0028	6.827	0.0007
2016	0.302	104.57	0.05	93.544	47.836	0.0052	11.295	0.0012
2017	0.302	130.70	0.07	104.147	74.855	0.0081	16.271	0.0018
2018	0.302	149.31	0.09	110.274	101.639	0.0110	20.871	0.0023
2019	0.302	163.77	0.12	113.608	123.962	0.0134	24.408	0.0026
2020	0.302	176.81	0.15	115.778	139.585	0.0151	26.658	0.0029
2021	0.302	188.76	0.18	117.487	151.690	0.0164	28.398	0.0031
2022	0.302	199.43	0.22	118.883	163.315	0.0176	30.168	0.0033
2023	0.302	208.54	0.25	120.011	174.399	0.0188	31.869	0.0034

Table 5. Scenario 4: $F=F_{current}$ (geometric mean F 2009, 2010, 2012). Acceptable biological catch (ABC) in units of 1000 lb whole weight and 1000s fish. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2012	1.216	178.97	0.14	128.615	484.815	0.0524	97.811	0.0106
2013	2.084	125.48	0.05	117.750	484.815	0.0524	104.953	0.0113
2014	5.363	71.44	0.03	109.205	484.815	0.0524	125.174	0.0135
2015	1.064	69.67	0.02	92.260	80.772	0.0087	21.984	0.0024
2016	1.064	86.65	0.01	91.424	121.080	0.0131	30.152	0.0033
2017	1.064	96.10	0.01	98.488	153.015	0.0165	36.111	0.0039
2018	1.064	98.25	0.00	101.660	172.250	0.0186	39.498	0.0043
2019	1.064	98.26	0.00	102.318	179.166	0.0194	40.566	0.0044
2020	1.064	99.48	0.00	102.321	177.927	0.0192	40.291	0.0044
2021	1.064	101.66	0.00	102.687	178.585	0.0193	40.575	0.0044
2022	1.064	103.57	0.00	103.328	182.755	0.0197	41.492	0.0045
2023	1.064	104.71	0.00	103.870	186.665	0.0202	42.262	0.0046

Table 6. Scenario 5: $F=F_{rebuild}$ with 72.5% probability. Acceptable biological catch (ABC) in units of 1000 lb whole weight and 1000s fish. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)	ABC landings (1000 fish)	ABC discards (1000 fish)
2012	1.216	178.97	0.14	128.615	484.815	0.0524	97.811	0.0106
2013	2.084	125.48	0.05	117.750	484.815	0.0524	104.953	0.0113
2014	5.363	71.44	0.03	109.205	484.815	0.0524	125.174	0.0135
2015	0.075	75.74	0.03	92.260	6.601	0.0007	1.750	0.0002
2016	0.075	111.35	0.07	94.188	13.343	0.0014	3.097	0.0003
2017	0.075	146.37	0.15	105.940	22.754	0.0025	4.813	0.0005
2018	0.075	177.07	0.25	113.126	33.690	0.0036	6.661	0.0007
2019	0.075	205.94	0.37	117.519	44.767	0.0048	8.383	0.0009
2020	0.075	234.54	0.49	120.651	54.818	0.0059	9.808	0.0011
2021	0.075	262.17	0.58	123.105	64.177	0.0069	11.068	0.0012
2022	0.075	288.31	0.66	125.035	73.528	0.0079	12.312	0.0013
2023	0.075	312.60	0.73	126.562	82.872	0.0090	13.529	0.0015

Table 7. Acceptable biological catch (ABC) in units of 1000 lb whole weight based on the annual probability of overfishing P* = 0.5. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)
2013	1.54	0.99	NA	150.285	0.03	106.423	NA	NA
2014	3.17	1.00	NA	101.240	0.02	96.623	NA	NA
2015	0.238	0.50	0.5	102.593	0.02	83.011	32.854	0.00355
2016	0.234	0.50	0.5	132.846	0.05	83.213	54.548	0.00589
2017	0.231	0.50	0.5	158.401	0.10	90.402	77.379	0.00836

Table 8. Acceptable biological catch (ABC) in units of 1000s of fish based on the annual probability of overfishing P* = 0.5. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.54	0.99	NA	150.285	0.03	106.423	NA	NA
2014	3.17	1.00	NA	101.240	0.02	96.623	NA	NA
2015	0.238	0.50	0.5	102.593	0.02	83.011	7.782	0.00084
2016	0.234	0.50	0.5	132.846	0.05	83.213	11.787	0.00127
2017	0.231	0.50	0.5	158.401	0.10	90.402	15.664	0.00169

Table 9. Acceptable biological catch (ABC) in units of 1000 lb whole weight based on the annual probability of overfishing P* = 0.3. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 lb)	ABC discards (1000 lb)
2013	1.54	0.99	NA	150.285	0.03	106.423	NA	NA
2014	3.17	1.00	NA	101.240	0.02	96.623	NA	NA
2015	0.151	0.30	0.3	103.566	0.02	83.011	21.192	0.00229
2016	0.152	0.30	0.3	136.680	0.05	83.562	37.483	0.00405
2017	0.152	0.30	0.3	166.063	0.12	91.495	55.608	0.00601

Table 10. Acceptable biological catch (ABC) in units of 1000s fish based on the annual probability of overfishing P* = 0.3. F = fishing mortality rate (per yr), SSB = mid-year spawning stock biomass (mature female biomass in metric tons whole weight), Pr(SSB > SSB_{MSY}) = proportion of replicates where SSB was above the point estimate of SSB_{MSY} = 246.6 mt, R = recruits (1000 age-1 fish). Annual ABCs are a single quantity while other values presented are medians.

Year	F	Pr(F > Fmsy)	P*	SSB	Pr(SSB > SSBmsy)	R	ABC landings (1000 fish)	ABC discards (1000 fish)
2013	1.54	0.99	NA	150.285	0.03	106.423	NA	NA
2014	3.17	1.00	NA	101.240	0.02	96.623	NA	NA
2015	0.151	0.30	0.3	103.566	0.02	83.011	5.004	0.000540
2016	0.152	0.30	0.3	136.680	0.05	83.562	8.036	0.000868
2017	0.152	0.30	0.3	166.063	0.12	91.495	11.1224	0.00120

Figure 1. Scenario 1: F=0. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Annual ABCs are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

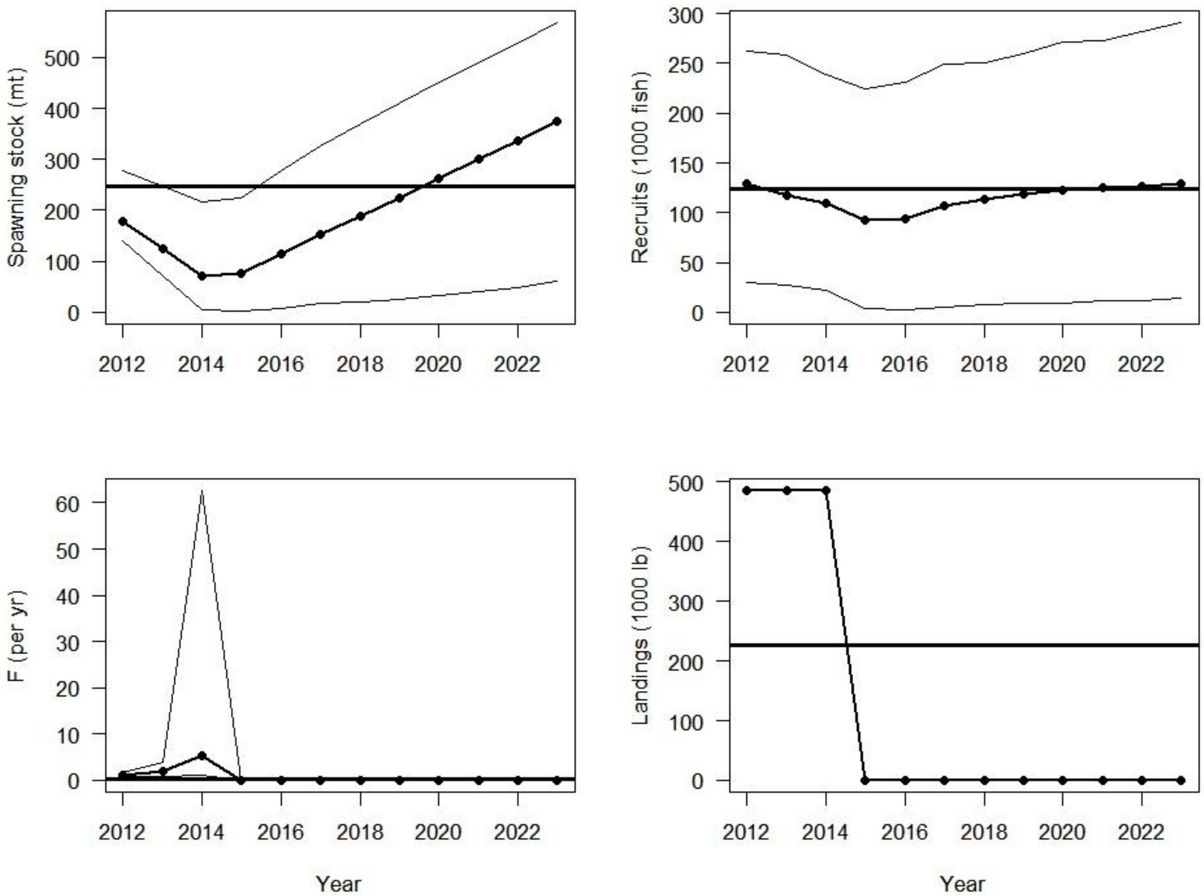

Figure 2. Scenario 1: $F=F_{rebuild}$ with 50% probability. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Annual ABCs are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

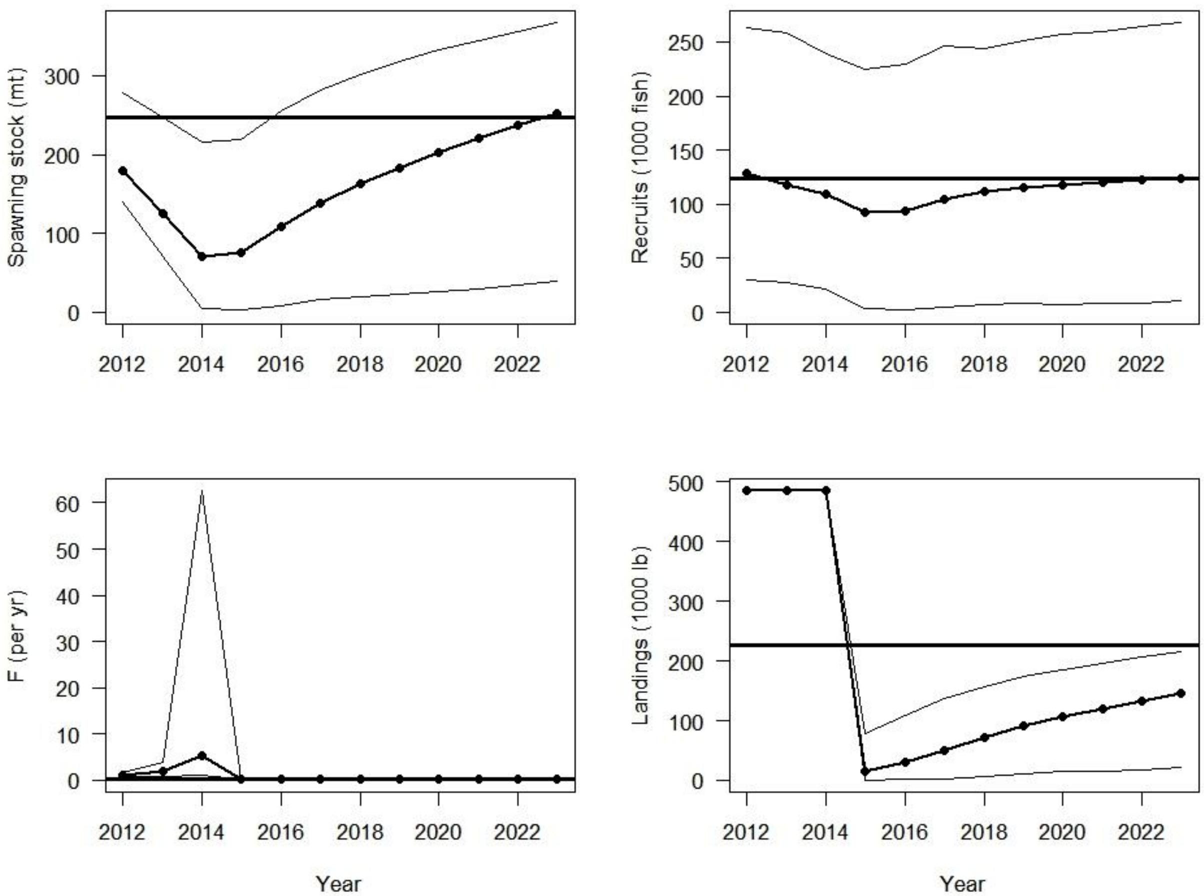

Figure 3. Scenario 1: $F=F_{msy}$. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Annual ABCs are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

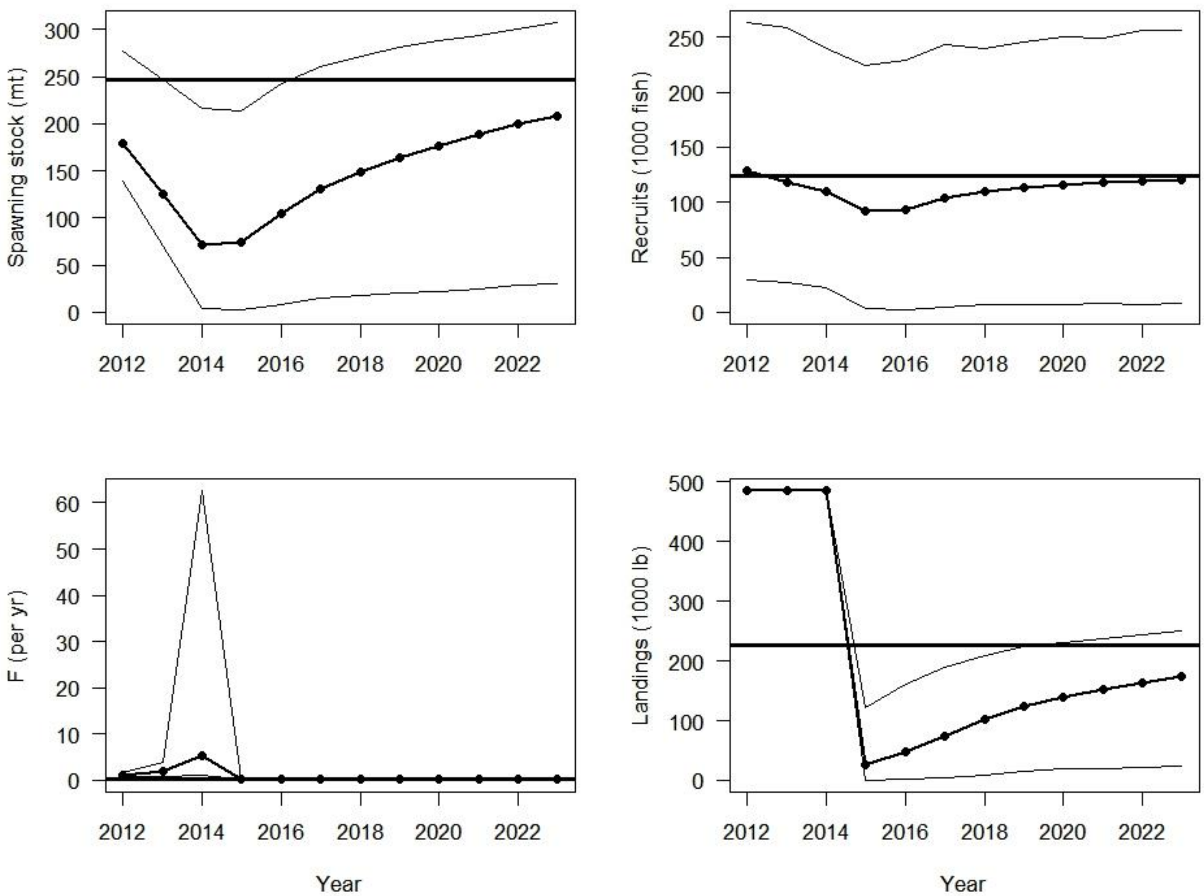

Figure 4. Scenario 1: $F=F_{current}$ (geometric mean F from 2009, 2010, and 2012). For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Annual ABCs are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

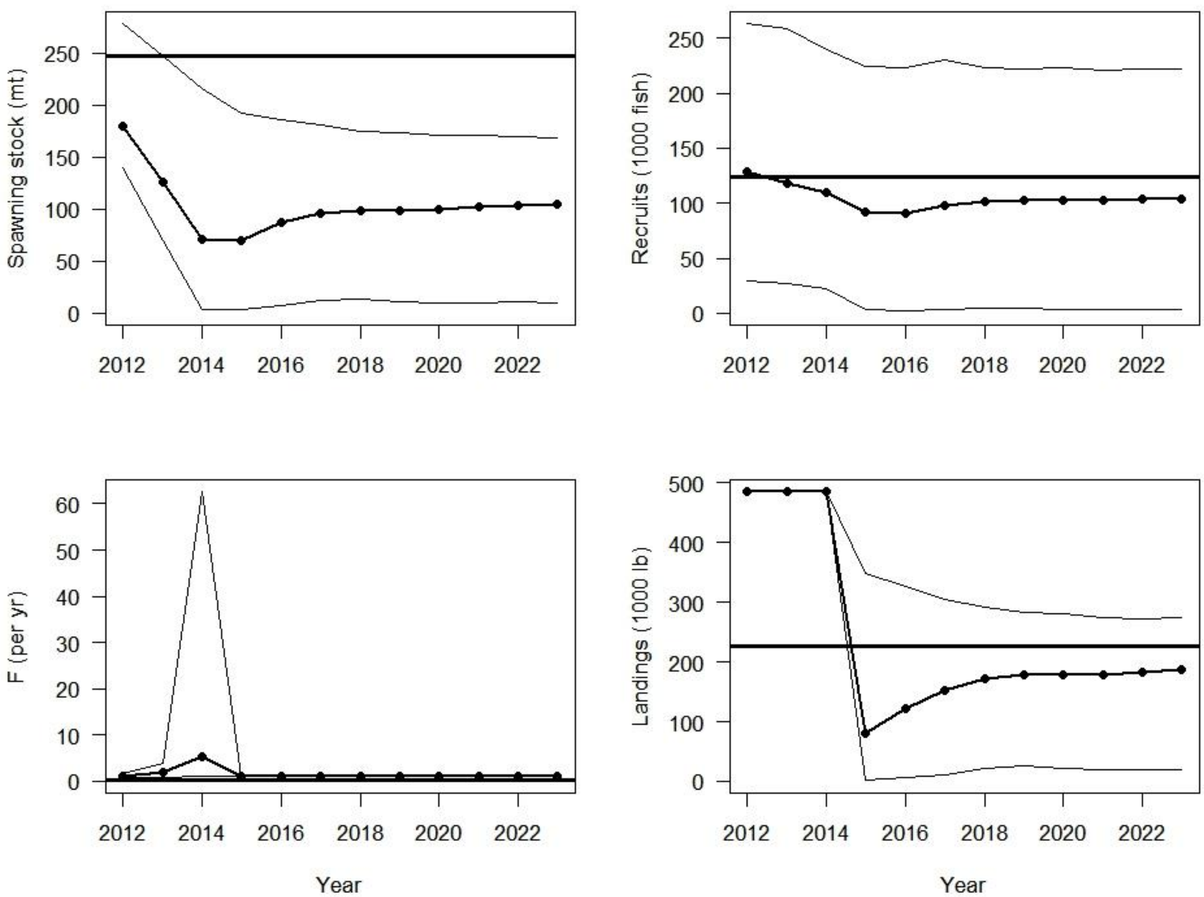

Figure 5. Scenario 1: F=$F_{rebuild}$ with 72.5% probability. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (landings and dead discards are separated in the associated Tables). Annual ABCs are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

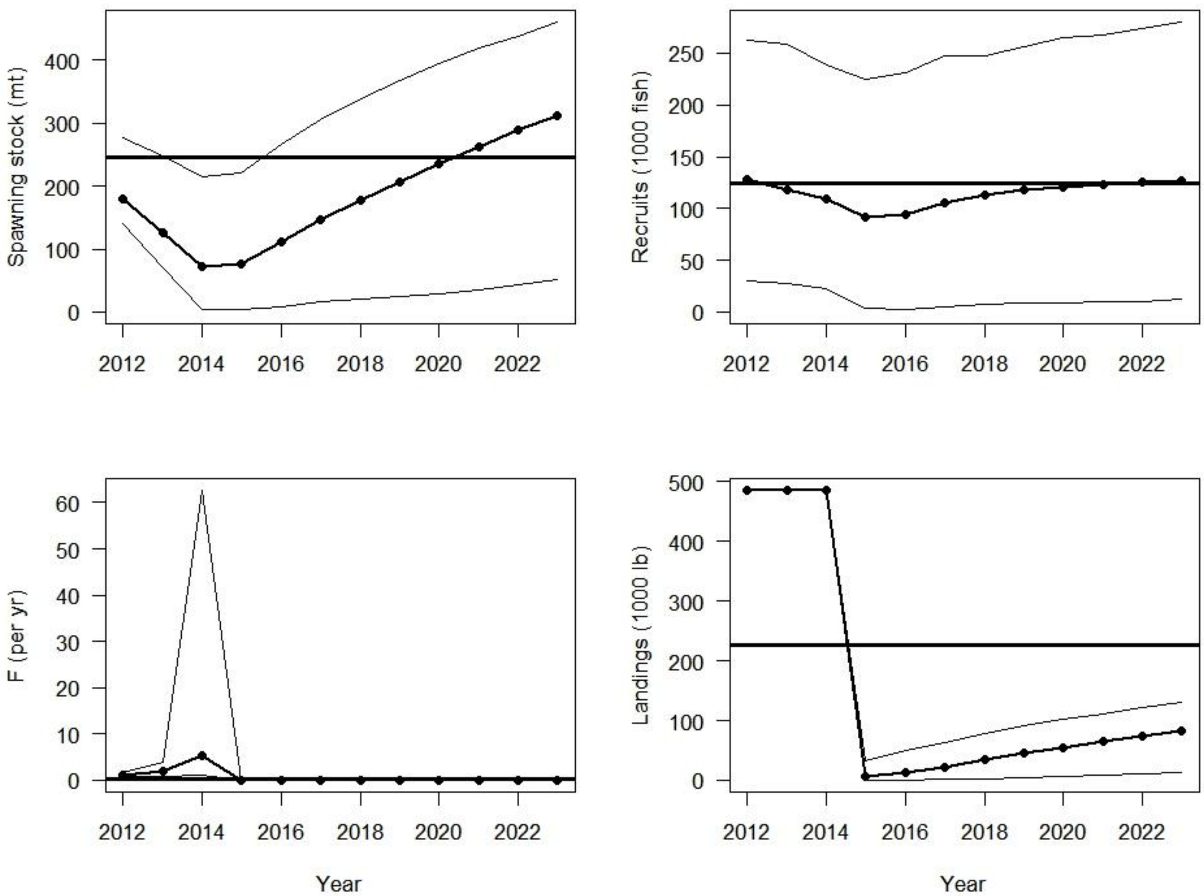

Figure 6. P* = 0.5 projection results. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (i.e., Landings = Catch). Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.

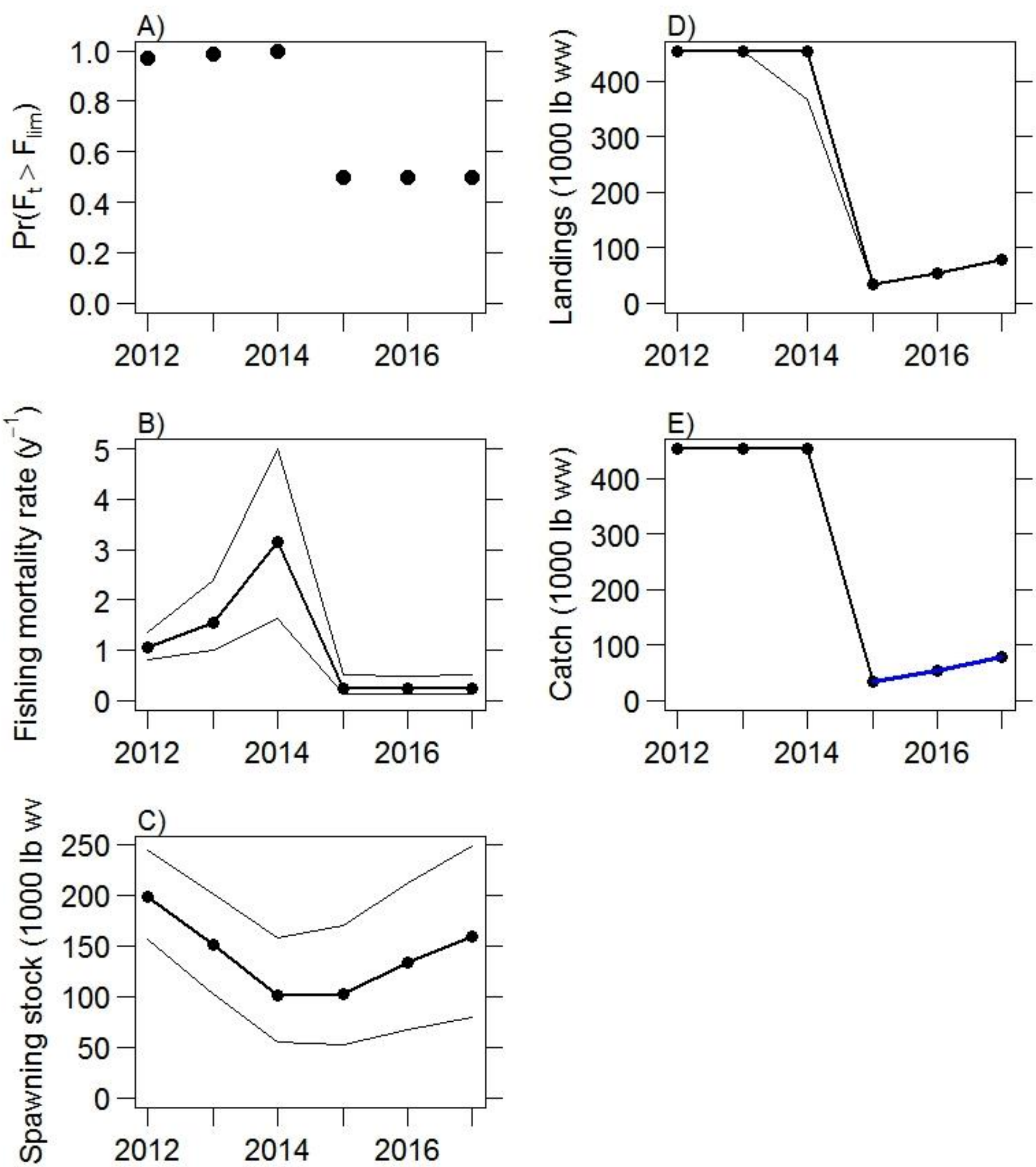

Figure 7. P* = 0.3 projection results. For this assessment, discards were combined with landings so the ABC reflects both landings and dead discards (i.e., landings = catch). Annual ABCs (panel E) are a single quantity while other values presented are medians. Error bars represent the 5th and 95th percentiles of the 10,000 projection runs.