Black Sea Bass Recreational Bag Limit Analysis

A New Proposed Methodology

Introduction

Analyzing the effect of reducing a bag limit on the estimated landings of a particular stock has become a fairly routine procedure in fisheries management. One simply analyzes the data on a trip-by-trip basis and reduces the catch of each trip that originally landed more than the proposed bag limit. However, analyzing bag limit increases isn't as straight forward. The problem is estimating by how much to increase the landings as the bag limit increases.

It may be safe to assume that if a trip did not reach the current bag limit, it would not reach a proposed bag limit that is higher than the current one. However, what about the trips that did reach the bag limit? One possible assumption of the bag limit increase analysis is that if a trip reached the current bag limit, it would reach whatever proposed increases were made to that bag limit without any limitations. Another, more refined approach limited the increase in landings to the reported discards per trip. However, there was no way to distinguish whether a fish was discarded because it was under the legal size limit or because the angler reached the bag limit.

The new method proposed here is an attempt to solve this conundrum using the available information from the most recent stock assessment. The abundance at age, recreational selectivity, discard selectivity, and proportion of fish above and below the size limit at age are all used to estimate the proportion of the discards that are due to the size limit versus those that are due to reaching the bag limit.

This analysis examines increasing the recreational bag limit for Black Sea Bass from the current bag limit of 5 fish per angler to proposed bag limits ranging from 6 to 10 fish per angler. Two data sources are used in this analysis: the MRIP intercept data (Marine Recreational Information Program, which includes private recreational trips and charter boat trips) from 2013 and 2014, and the headboat data (obtained from the Southeast Region Headboat Survey) from 2013 and 2014. The data ranges from Cape Hatteras, NC down to the FL Keys and includes all trips that encountered at least one Black Sea Bass (either landed, discarded, or both).

2013 and 2014 were chosen because of the change in minimum size from 12 in to 13 in that went into effect in 2013. Also, 2013 was the first year the new MRIP sampling protocol was used. MRIP began using a new Access Point Angler Intercept Survey (APAIS) in Wave 2 of 2013 that was designed to better sample times of day outside of the peak activity times. Each year was analyzed individually and the average of 2013 and 2014 was also looked at to get a range of estimated landings values under each of the proposed bag limits. All assessment data came from the SEDAR 25 update for Black Sea Bass completed in 2013.

Preliminary Statistics

The data were analyzed on a trip basis and an angler basis (for the headboat data). A trip is defined as a party of anglers that were fishing together, usually on the same vessel. This is slightly different for Shore Mode, where a trip is comprised of a single angler. These parties of anglers are typically intercepted together as a group and their catch is added up to equal the total catch for that trip. Headboats were also examined on a per angler basis because it is unlikely all the anglers on a single headboat would know each other and be fishing together as a group, as is typically the case on private and charter trips.

The percent of trips (for both MRIP and headboat) that reached the bag limit in 2013 and 2014 ranged from 0.7% to 3.3% and the % of anglers (for headboat) that reached the bag limit ranged from 17.4% to 21.7% (Table 1-Table 3). On headboat trips that did not reach the bag limit, the total number of Black Sea Bass landed was divided by 5 to estimate the maximum number of anglers that could have reached the bag limit on each trip.

Table 1-Table 3 and Figure 1 show a very small number of trips are reaching the bag on average in any given year. A look at the percentage of landed Black Sea Bass and discarded Black Sea Bass to the total encountered confirms that most of the Black Sea Bass caught in 2013 and 2014 were discarded (Table 4-Table 7). Table 2 does suggest that trips in federal waters (> 3 miles from shore) are almost 10 times as likely to reach their bag limits as those that occur in state waters (≤ 3 miles from shore). However, that still leaves only 2% of trips on average reaching the bag limit in federal waters.

The landings and discards per angler were calculated on a per trip basis. Then, the frequency of trips that fell within each landings and discards per angler category were plotted to evaluate the percent of trips that fell within each of the categories. Figure 2 -Figure 4 show the distribution of trips by landings and discards per angler. These data combined the MRIP and headboat data.

For all trips that encountered Black Sea Bass, over 88% of them didn't land any Black Sea Bass per angler on average between 2013 and 2014, which means that every black sea bass they encountered was discarded. On trips that landed at least 1 Black Sea Bass, almost 60% of those landed less than 1 Black Sea Bass per angler on average between 2013 and 2014. Data on catch per angler can show landings in units of partial fish since the number of fish on a trip are divided among all the anglers associated with that trip. For example, if 3 anglers on a trip land 2 fish, the catch per angler will be 0.66. Of the trips that landed at least 1 Black Sea Bass, fewer than 7% achieved or exceeded the current bag limit of 5 Black Sea Bass per angler. About 2% of those trips landing at least 1 Blacks Sea Bass reported exceeding the 5 fish per person bag limit. Including all trips that either landed or discarded (or both) Black Sea Bass, less than 1% of trips had a landings rate of 5 or more Black Sea Bass per angler on average.

Approximately 85% of trips that encountered Black Sea Bass had 1 or more discards of Black Sea Bass per angler (Figure 4). Over the 2 years analyzed, approximately 2,420,000 anglers on 1,350,000 trips landed 743,300 Blacks Sea Bass and discarded 9,139,000 of them. Only 0.3% of

these anglers reached the 5 fish bag limit and on average kept 0.3 per angler and discarded 3.75 per angler. So, for every Black Sea Bass kept, about 12 were discarded.

The overall conclusion from these basic statistics is that the recreational black sea bass fishery is being limited by the size limit rather than the bag limit. Very few anglers are reaching the bag limit. In fact, 98% of anglers who even encounter a black sea bass are keeping one or less. This is not because anglers are not encountering black sea bass. These approximately 2,420,000 anglers encountered over 4 million sea bass on average, of which 93% were discarded.

Table 1. Percent of MRIP trips that did and did not reach the bag limit by mode.

Year	% Trips Hit Bag			% Trips Did Not Hit Bag			
	Charter	Private	Total	Charter	Private	Shore	Total
2013	3.8%	1.0%	0.5%	96.2%	99.0%	100.0%	80.1%
2014	2.2%	1.2%	0.9%	97.8%	98.8%	100.0%	70.5%
Avg.	2.4%	1.1%	1.1%	97.6%	98.9%	100.0%	98.9%

Table 2. Percent of MRIP trips that did and did not reach the bag limit by distance from shore.

Year	% Trips Hit Bag		% Trips Didn't Hit Bag	
	≤ 3 mi	> 3 mi	≤ 3 mi	> 3 mi
2013	0.2%	1.7%	99.8%	98.3%
2014	0.1%	2.2%	99.9%	97.8%
Avg.	0.2%	2.0%	99.8%	98.0%

Table 3. Percent of Headboat trips and anglers that did and did not reach the bag limit.

Year	% Trips		% Anglers	
	Did Not Hit Bag	Hit Bag	Did Not Hit Bag	Hit Bag
2013	96.7%	3.3%	89.8%	10.2%
2014	96.8%	3.2%	91.3%	8.7%
Avg.	96.1%	3.9%	90.6%	10.4%

Table 4. Number of Black Sea Bass that were landed and discarded on MRIP trips.

Year	Did Not Hit Bag			Hit Bag			All Trips		
	Landed	Discarded	Total	Landed	Discarded	Total	Landed	Discarded	Total
2013	148,671	2,800,018	2,948,689	97,633	64,542	162,175	246,304	2,864,561	3,110,864
2014	234,198	4,757,448	4,991,646	104,040	209,754	313,794	338,237	4,967,202	5,305,439
Avg.	191,434	3,778,733	3,970,168	100,836	137,148	237,984	292,271	3,915,881	4,208,152

Table 5. Percent of Black Sea Bass that were landed and discarded on MRIP trips.

Year	Did Not Hit Bag		Hit Bag		All Trips	
	% Landed	% Discarded	% Landed	% Discarded	% Landed	% Discarded
2013	5.0%	95.0%	60.2%	39.8%	7.9%	92.1%
2014	4.7%	95.3%	33.2%	66.8%	6.4%	93.6%
Avg.	4.8%	95.2%	44.5%	55.5%	6.7%	93.3%

Table 6. Number of Black Sea Bass that were landed and discarded on Headboat trips.

Year	Did Not Hit Bag			Hit Bag			All Trips		
	Landed	Discarded	Total	Landed	Discarded	Total	Landed	Discarded	Total
2013	75,258	719,624	794,882	11,453	21,593	33,046	86,711	741,217	827,928
2014	67,587	636,935	704,522	10,781	19,674	30,455	78,368	656,609	734,977
Avg.	71,423	678,280	749,702	11,117	20,634	31,751	82,540	698,913	781,453

Table 7. Percent of Black Sea Bass that were landed and discarded on Headboat trips.

Year	Did Not Hit Bag		Hit Bag		All Trips	
	% Landed	% Discarded	% Landed	% Discarded	% Landed	% Discarded
2013	9.5%	90.5%	34.7%	65.3%	10.5%	89.5%
2014	9.6%	90.4%	35.4%	64.6%	10.7%	89.3%
Total	9.5%	90.5%	35.0%	65.0%	10.6%	89.4%

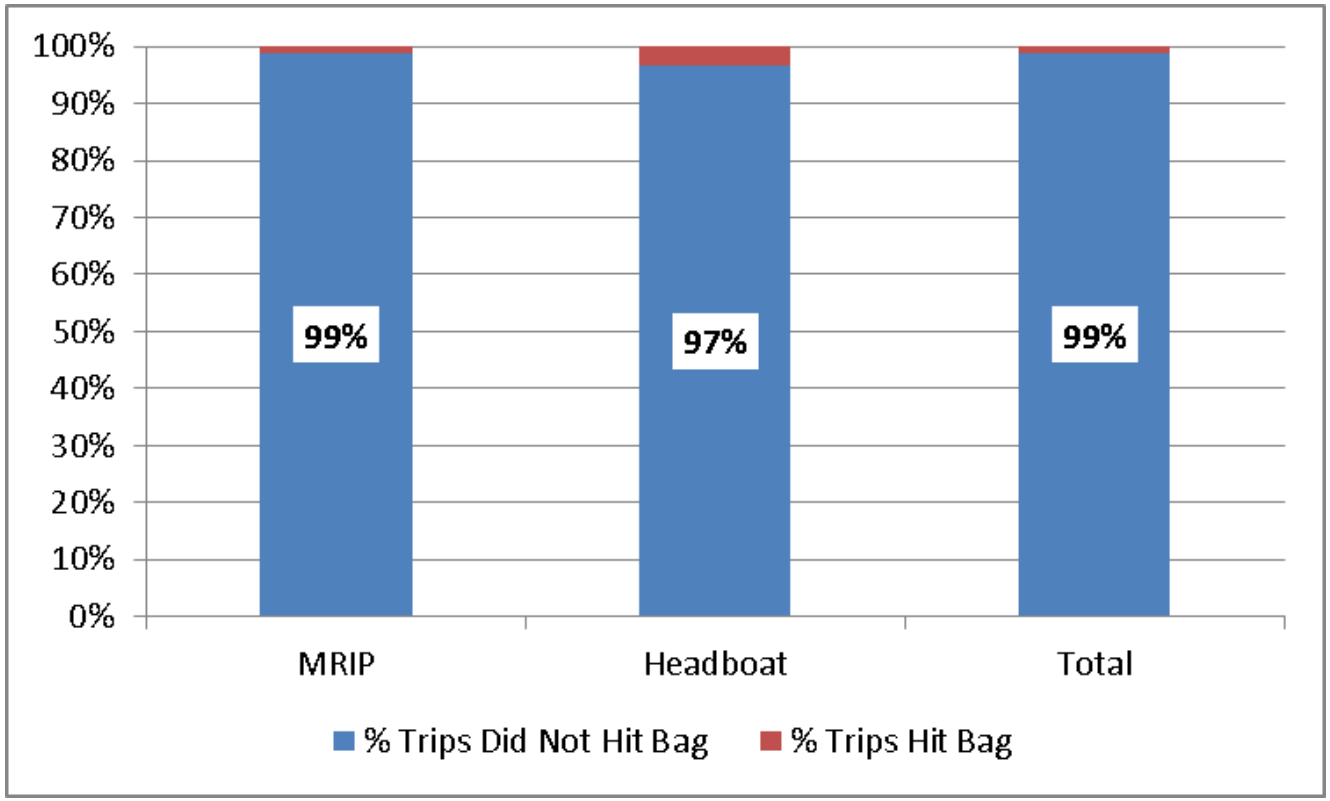

Figure 1. Percent of MRIP (private recreational and charter) and headboat trips that did and did not retain the bag limit averaged across 2013 and 2014.

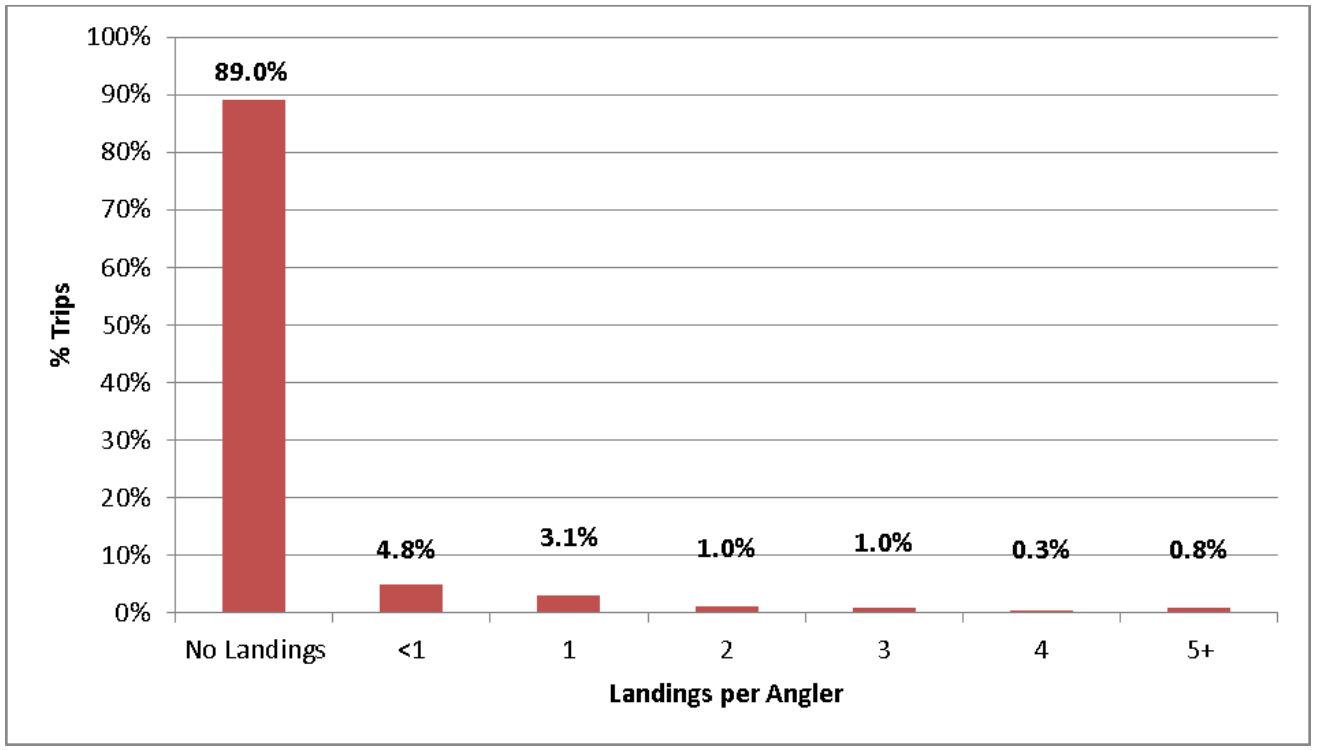

Figure 2. Number of Black Sea Bass landed per angler on recreational trips that encountered Black Sea Bass. Landings per angler categories run from the listed number up to, but not including the next category number (i.e. 1 to 1.99= 1).

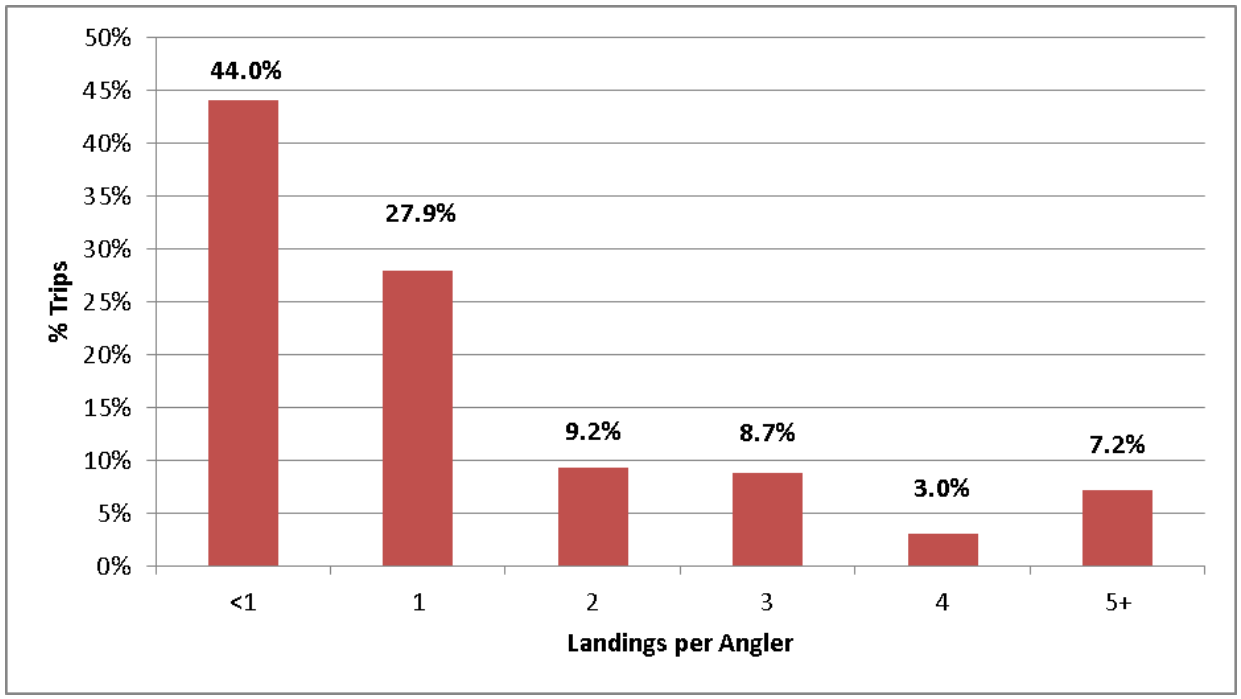

Figure 3. Number of Black Sea Bass landed per angler on recreational trips that kept at least 1 Black Sea Bass. Landings per angler categories run from the listed number up to, but not including the next category number (i.e. 1 to 1.99= 1).

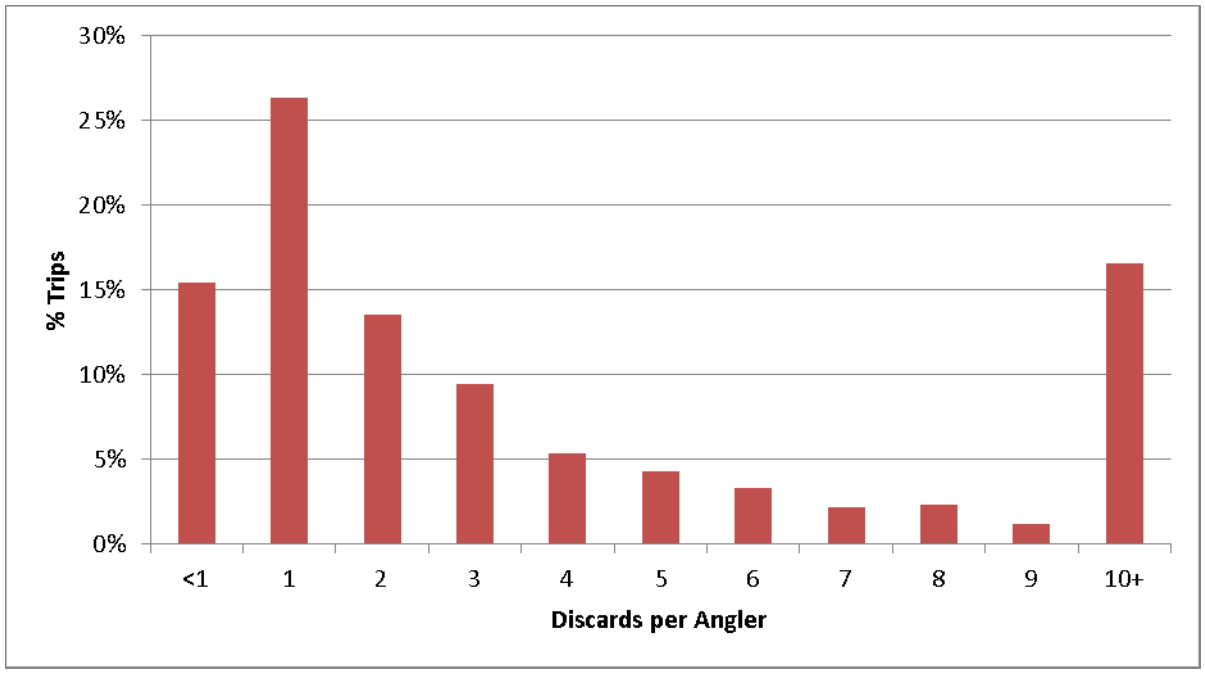

Figure 4. Number of Black Sea Bass discarded per angler on recreational trips that encountered Black Sea Bass. Discards per angler categories run from the listed number up to, but not including the next category number (i.e. 1 to 1.99= 1).

New Proposed Methodology and Assumptions

MRIP (Private and Charter vessels)

1. Assumption: All discarded fish reported on trips that did not reach the bag limit at the trip level are below the minimum size limit.
2. Assumption: Fish discarded on trips that reached the bag limit could be both above and below the minimum size limit. In other words, discards on these trips could be due to the bag limit or the size limit.
3. Population estimates from the most recent stock assessment were used to estimate the size composition of discarded fish for trips that reached the bag limit. The intent is to determine the proportion of discarded fish above and below the size limit, which can be used to determine how many of the discarded fish can contribute to landings if the bag limit is increased.
4. Assumption: Trips that reach the bag limit discard some fish due to the bag limit. Therefore, some legal-sized Black Sea Bass are discarded.
    - The model estimated discard selectivity from the SEDAR 25 update for fish up to age 3 was used (Table 8-Table 9, Figure 7). This estimated discard selectivity accounts for the recreational gear selectivity and the assumed size composition of fish up to age 3.
        - The SEDAR 25 update assumed no fish age 3 or less has yet reached the minimum size, therefore the model estimated discard selectivity was needed to estimate the proportion of fish age 3 and less that would be selected by the fishery to be discarded.
        - It was assumed to be zero for discards above the minimum size.
    - For ages 4+, the selectivity at age for discards below the minimum size was estimated by using data obtained from the SERFS program to estimate the probability at age that a fish is below the minimum size. It was assumed the distribution of size at age was normal with $N(\mu,\sigma)$. (MARMAP/SEAMAP, Table 8-Table 9, Figure 7).
        - Figure 5 shows the size at age samples for fishery dependent (black) and independent (orange) samples from the SEDAR 25 update. The fishery independent data were selected since the size at age distribution of the fishery dependent samples is truncated by the size limit.
        - MARMAP tends to sample outside of 3 miles on average so differences in discard rates, landings rates, and % trips in State waters vs. Federal waters was examined.
        - If more fish are discarded in State waters, then perhaps using the MARMAP data here would not be appropriate. However, the discard rate per angler is higher in Federal waters than in state waters, as well as the landings rate (Table 12).
        - Although 70% of the trips that encountered Black Sea Bass are occurring in waters <= 3 miles, the total number of discarded Black Sea Bass is similar between State and Federal waters (Table 13).

- The estimated probability at age that a fish was above the minimum size was used to calculate the discard selectivity of fish above the minimum size for age 4+ fish, using the same SERFS data. For ages 3 and younger, the assumed discard selectivity for fish above the min size was zero (Table 8-Table 9, Figure 8).
    - These selectivities also needed to be multiplied by the proportion of trips that met the bag limit due to the assumption of only these trips would be able to discard a fish above the minimum size.
- To calculate the proportion of discards below or above the minimum size, an estimate of abundance at age was needed, and was obtained from SEDAR 25. Abundances at age are available through 2012 from SEDAR 25, so 2012 was chosen to represent 2013-2014.
    - Using the MARMAP/SEAMAP data to calculate the proportion of fish at age larger than 13 in, ~1.3% of the estimated 2012 population was greater than 13 in.
    - Using the estimated recreational selectivity, ~1.1% of the population is available to the rec sector for harvest (above the minimum size and able to be selected for retention).
    - This approach suggests that, of the almost 62,000,000 black sea bass estimated in the 2012 population older than age 1, approximately 700,000 were available to harvest by the recreational sector,
    - The average landings from 2013 and 2014 were ~370,000 Black Sea Bass, which is ~50% of the harvestable fish.
    - Also, discards are over 12 times larger than landings, on average between 2013 and 2014. Applying the SEDAR 25 discard mortality rate of 7% results in dead discards nearly equal to total landings (Table 10-Table 11)
- A time period with a representative proportion at age is needed to estimate the proportion of fish discarded due to the size limit vs. the bag limit.
- Multiplying the discard selectivities, for fish below and above the minimum size that were calculated above, by abundance at age gives the total number of discards above and below the minimum size.
    - Summing these discard estimates gives an estimate of total discards (Table 8-Table 9, Figure 6).
- The sum of discards less than the minimum size limit was divided by the total discards. The sum of discards greater than the minimum size limit was also divided by the total discards. This gives an estimate of the appropriate proportion of discards above and below the minimum size limit (Figure 9-Figure 10).

5. As increasing bag limit alternatives were evaluated, the catch increased by the number of discarded Black Sea Bass reported on trips that reached the bag limit multiplied by the proportion of discards from those trips that are greater than the minimum size.
6. All the formulas used to perform the calculations are described in the Appendix.

Headboat

1. Trips that reached the trip bag limit were treated the same as MRIP trips.
2. For trips that did not reach the trip bag limit, an additional step was needed to calculate the discard selectivity.
    - When calculating the proportion of fish above the minimum size, the added step of multiplying by the probability of being one of the anglers that reached the bag limit on that trip was done.
    - This was calculated simply by taking the proportion of anglers that reached the bag limit, on trips that did not reach the trip bag limit, to the total number of angler on trips that did not reach the trip bag limit.
    - The maximum number of anglers that reached the bag limit on trips that did not reach the trip bag limit was estimated by dividing the number of fish landed by the bag limit for each trip.
        - For the current 5 fish bag limit, if 100 fish were landed and there are 50 anglers on board, a maximum of 20 anglers reached the bag limit.
3. The analysis continued as described above for the MRIP data.
4. All the formulas used to perform the calculations are described in the Appendix.

Table 8. MRIP calculated discard selectivities and 2012 estimated abundance from the SEDAR 25 update. Size limit refers to those fish discarded due to them being under the minimum size limit. Bag limit refers to those fish discarded due to reaching the bag and being above the minimum size.

Age	Discard Selectivity		2012 Abundance (numbers)
	Size Limit	Bag Limit	
0	0.001	0	33,042,170
1	0.093	0	13,459,560
2	0.63	0	8,842,770
3	1	0	4,277,590
4	0.812	0.002	1,542,900
5	0.608	0.004	516,580
6	0.345	0.007	145,210
7	0.317	0.007	33,720
8	0.276	0.008	8,310
9	0.160	0.009	3,840
10	0.034	0.010	1,490
11	0.003	0.011	900

Table 9. Headboat discard selectivities for trips that did and did not reach the trip bag limit. Size limit refers to those fish discarded due to them being under the minimum size limit. Bag limit refers to those fish discarded due to reaching the bag and being above the minimum size. 2013 and 2014 Bag Lim Sel refer to the selectivity of fish discarded due to reaching the bag and being above the minimum size, but corrected for the proportion of anglers in that year on trips that did not reach the trip bag limit that reached their personal bag limit.

Age	Trips Hit Bag		Trips Did Not Hit Bag				2012 Abundance (num)
	Size Limit Sel	Bag Limit Sel	Size Limit Sel	Bag Limit Sel	2013 Bag Lim Sel	2014 Bag Lim Sel	
0	0.001	0	0.001	0	0	0	33,042,170
1	0.093	0	0.093	0	0	0	13,459,560
2	0.63	0	0.63	0	0	0	8,842,770
3	1	0	1	0	0	0	4,277,590
4	0.812	0.006	0.812	0.188	0.037	0.029	1,542,900
5	0.608	0.013	0.608	0.392	0.077	0.061	516,580
6	0.345	0.021	0.345	0.655	0.128	0.102	145,210
7	0.317	0.022	0.317	0.683	0.134	0.106	33,720
8	0.276	0.023	0.276	0.724	0.141	0.112	8,310
9	0.160	0.027	0.160	0.840	0.164	0.130	3,840
10	0.034	0.031	0.034	0.966	0.189	0.150	1,490
11	0.003	0.032	0.003	0.997	0.195	0.155	900

Table 10. Landings and total discards of Black Sea Bass from all recreational trips in 2013 and 2014.

Year	Catch All Trips			% Catch All Trips	
	Landed	Discarded	Total	Landed	Discarded
2013	325,013	3,552,391	3,877,404	8.38%	91.62%
2014	415,910	5,579,806	5,995,716	6.94%	93.06%
Avg.	370,461	4,566,098	4,936,560	7.50%	92.50%

Table 11. Landings and dead discards of Black Sea Bass from all recreational trips in 2013 and 2014.

Year	Killed All Trips			% Killed All Trips	
	Landed	Dead Disc	Total	Landed	Dead Disc
2013	326,303	249,005	575,308	56.72%	43.28%
2014	417,001	390,732	807,734	51.63%	48.37%
Avg.	371,652	319,869	691,521	53.74%	46.26%

Table 12. Landings and discard rate per angler for trips occurring in waters less than or equal to 3 miles from shore and those occurring in waters greater than 3 miles from shore. LPA is landings per angler and DPA is discards per angler.

Dist Shore	All Trips		Trips Landed BSB		% Trips	
	LPA	DPA	LPA	DPA	All	Landed BSB
<= 3 mi	0.03	1.95	0.96	2.27	69.0%	29.8%
> 3 mi	0.35	2.30	1.47	2.82	31.0%	70.2%

Table 13. Total number of discarded Black Sea Bass from trips that occurred inside and outside of 3 miles from shore.

Year	<= 3 mi	> 3 mi
2013	1,716,353	1,094,821
2014	2,060,023	2,863,174
Avg.	1,888,188	1,978,998

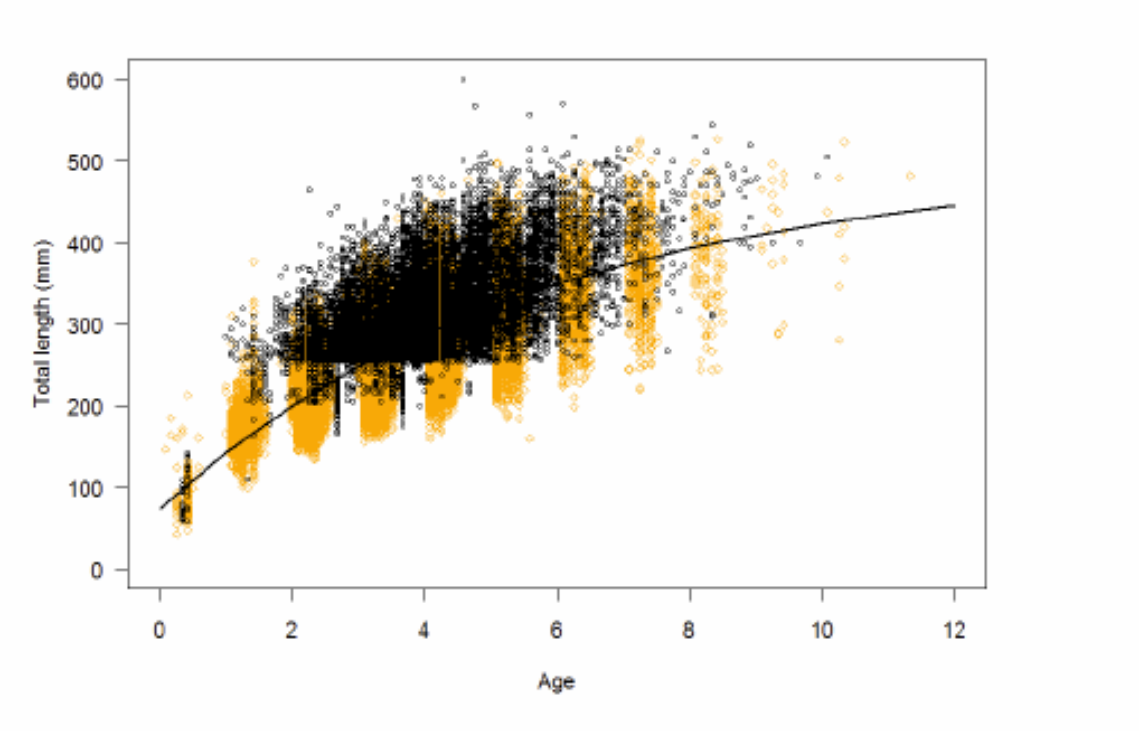

Figure 5. von Bertalanffy growth model for all combined length/age data from the SEDAR 25 update, corrected for minimum size limit bias. Black circles represent fishery dependent age samples, orange circles represent fishery-independent age samples.

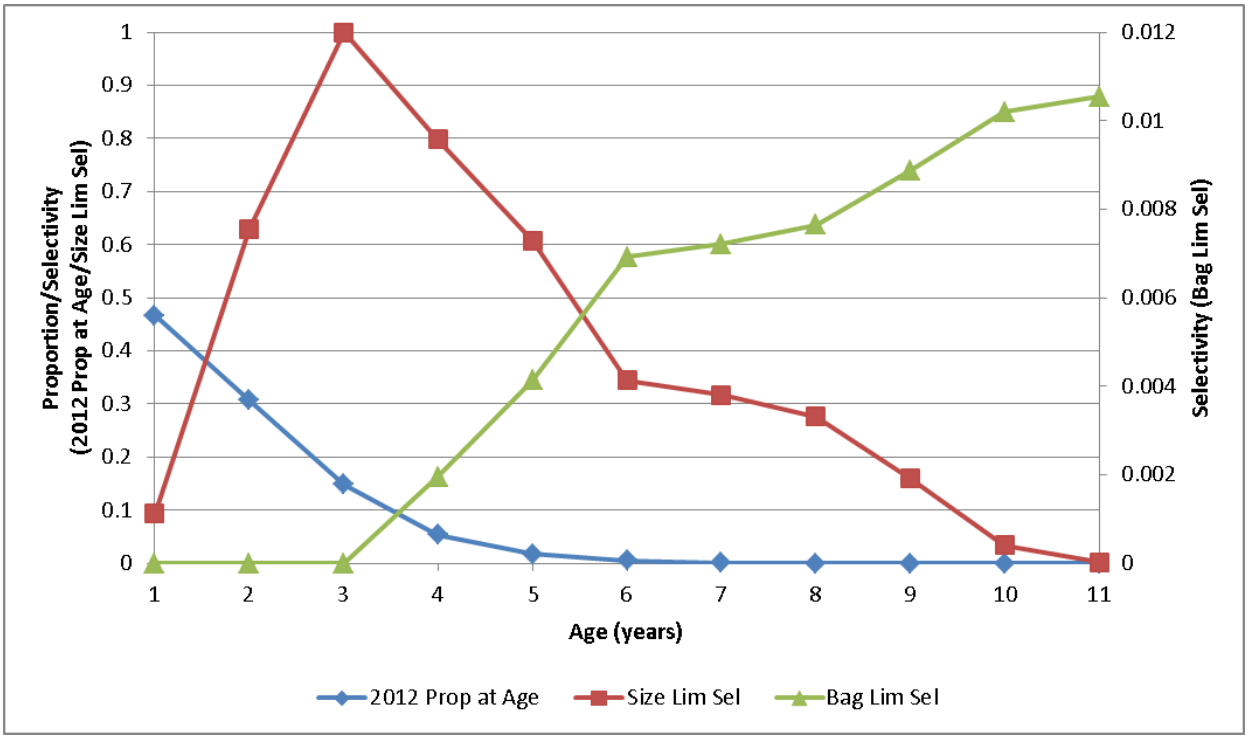

Figure 6. The calculated discard selectivities and the estimated 2012 proportion of fish at age from the SEDAR 25 update used to estimate the proportion of fish discarded due to being under the minimum size limit vs. due to reaching the bag limit and being above the minimum size limit.

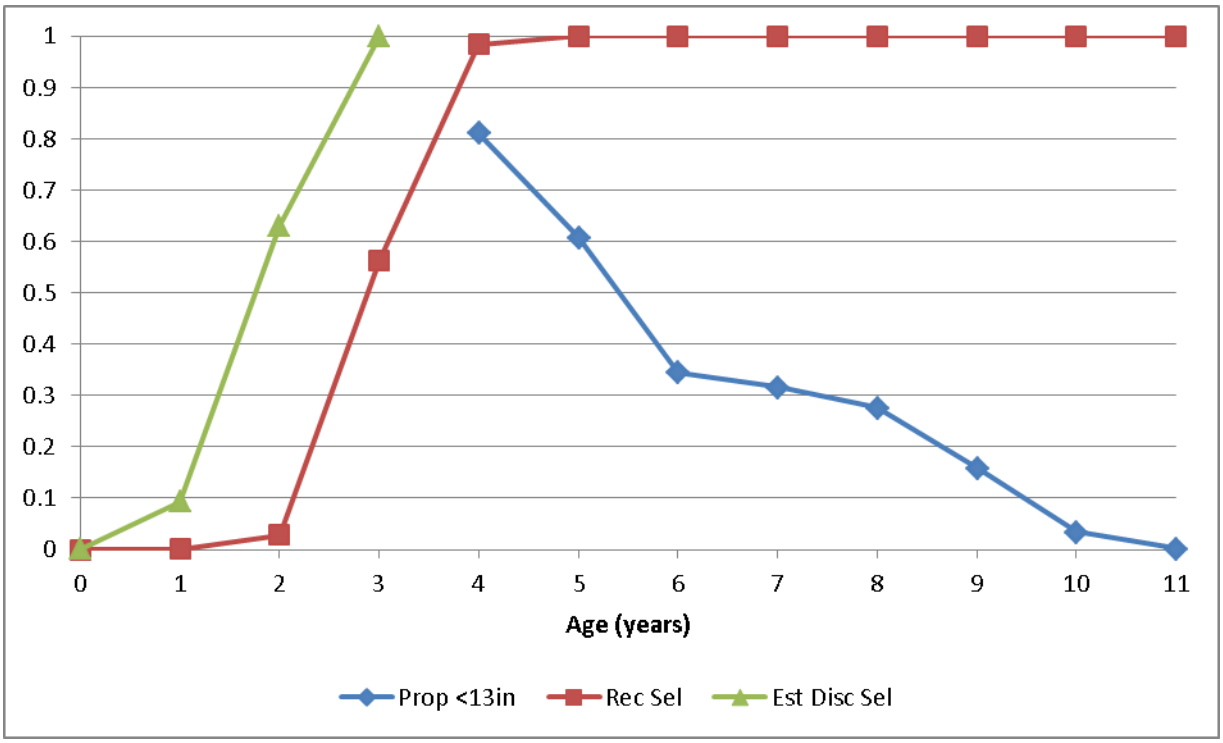

Figure 7. Selectivities and proportion less than 13 in. at age used to calculate the size limit discard selectivity. The selectivities were estimated in the SEDAR 25 update. The proportion of fish < 13in. at age was calculated from MARMAP/SEAMAP data.

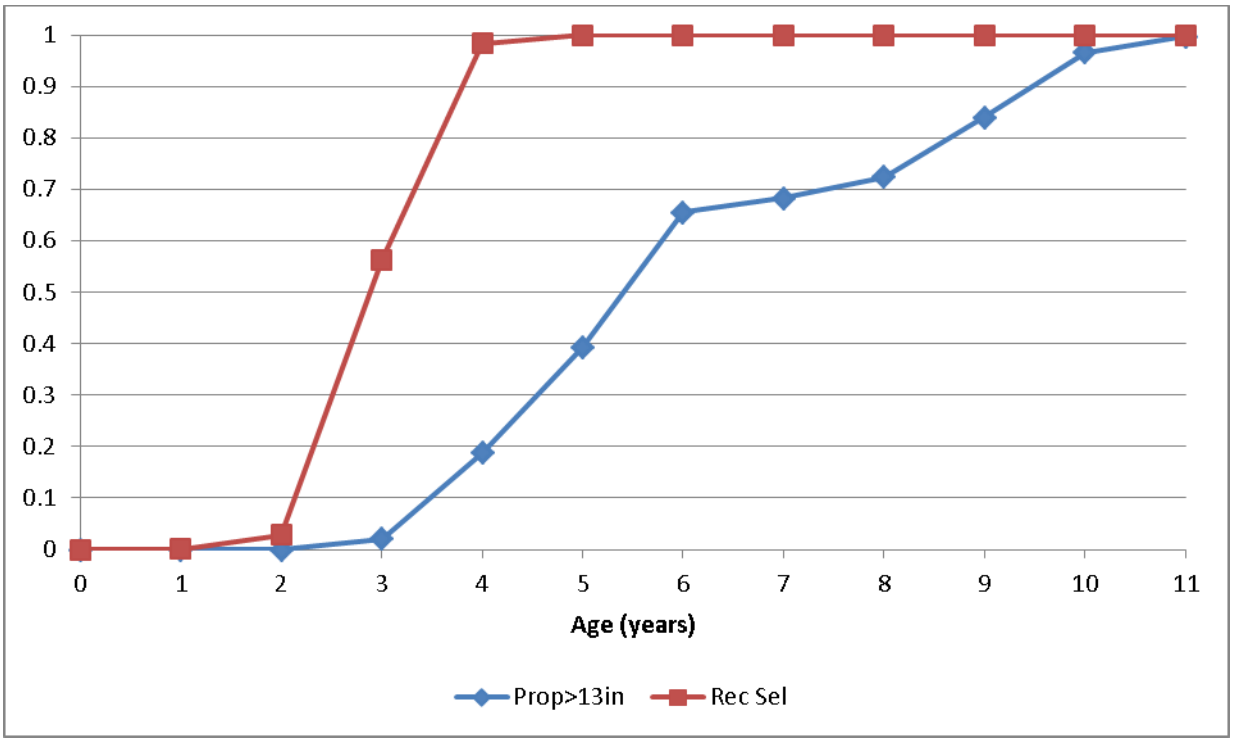

Figure 8. Recreational fishery selectivity and proportion of fish at age above 13 in. used to calculate the bag limit discard selectivity. The recreational selectivity was estimated in the SEDAR 25 update. The proportion of fish > 13in. at age was calculated from MARMAP/SEAMAP data.

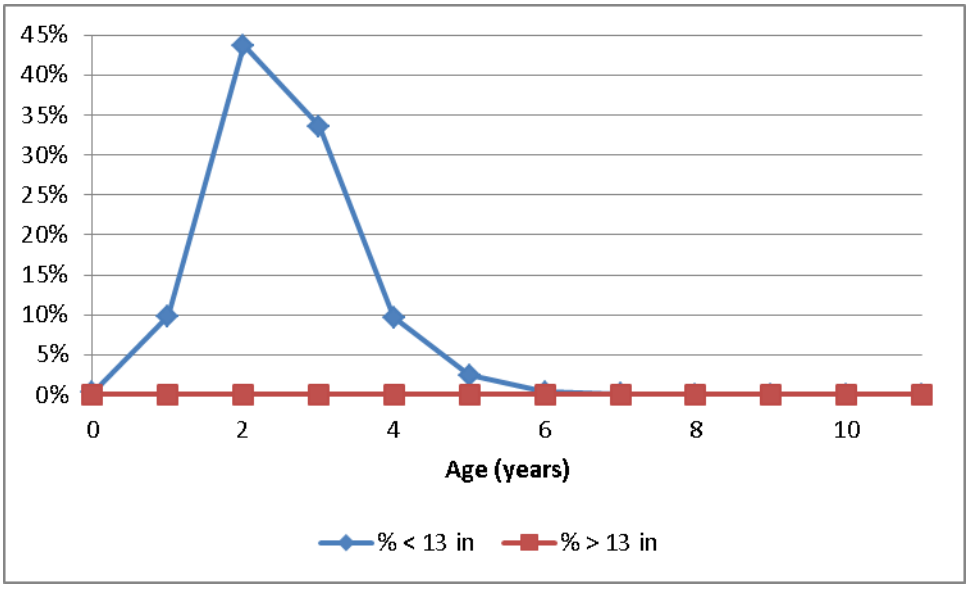

Figure 9. Estimated percent of fish discarded that are above and below 13 in. within each age class.

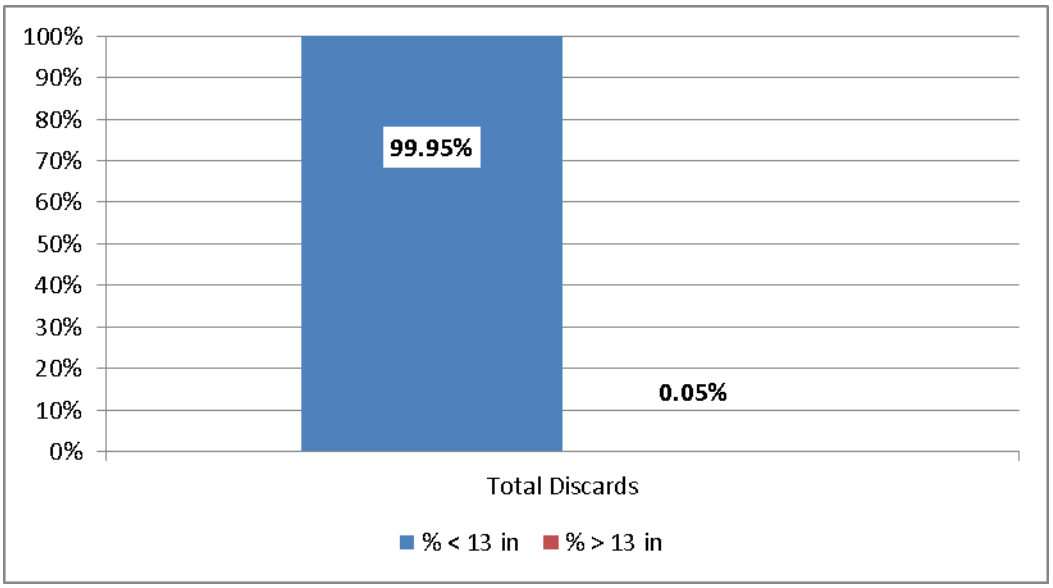

Figure 10. Estimated percent of total discards that are above and below 13 in.

New Proposed Methodology Results

The overall result is that increasing the bag limit has a negligible impact on the recreational landings of Black Sea Bass (Table 14-Table 19, Figure 11). As seen in Figure 10, this is because almost 95% of the discarded Black Sea Bass are estimated to be below the minimum size of 13 in. This new methodology estimates that even under a bag limit of 10 fish, about 50% of the 2016 ACL will be taken, which is only about a 1.5% increase from the current bag limit of 5 (Table 20) assuming fishing behavior does not change.

On average, recreational anglers are discarding 12 times more Black Sea Bass than they are landing. Even on trips that reached the bag limit, anglers are discarding 30% more Black Sea Bass on average than they are landing. Therefore, it doesn't seem reasonable to assume that on trips where anglers caught the bag limit, they would be able to retain all their discarded Black Sea Bass if the bag limit was high enough. This new methodology calculates the percentage of legal sized Black Sea Bass by estimating the proportion of the discarded fish that were discarded due to the size limit versus those that were discarded due to reaching the bag limit. It is due to this estimation of discard proportions that the results of the new methodology show almost no change in landings after a bag limit of 6 (Table 18-Table 19). There are few discards above the minimum size to increase the landings by an appreciable amount.

Table 14. Estimated MRIP landings and percent increase from current conditions in numbers of fish under different bag limit scenarios using the newly developed methodology.

Year	Estimated Landings (num)						% Increase from Current				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	248,493	250,201	250,829	251,700	253,062	253,091	0.7%	0.9%	1.3%	1.8%	1.9%
2014	347,405	357,011	359,070	361,653	355,418	355,548	2.8%	3.4%	4.1%	2.3%	2.3%
Avg.	**297,949**	**303,606**	**304,950**	**306,676**	**304,240**	**304,320**	**1.9%**	**2.3%**	**2.9%**	**2.1%**	**2.1%**

Table 15. Estimated MRIP landings and percent increase from current conditions in lbs. ww under different bag limit scenarios using the newly developed methodology.

Year	Estimated Landings (lbs ww)						% Increase from Current				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	312,412	315,026	315,710	316,715	318,244	318,295	0.8%	1.1%	1.4%	1.9%	1.9%
2014	490,792	504,796	507,734	511,542	502,351	502,652	2.9%	3.5%	4.2%	2.4%	2.4%
Avg.	**401,602**	**409,911**	**411,722**	**414,128**	**410,298**	**410,474**	**2.1%**	**2.5%**	**3.1%**	**2.2%**	**2.2%**

Table 16. Estimated headboat landings and percent increase from current conditions in numbers of fish under different bag limit scenarios using the newly developed methodology.

Year	Est. Landings (number)						% Increase from Current				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	88,001	90,964	91,374	91,630	91,823	91,972	3.4%	3.8%	4.1%	4.3%	4.5%
2014	79,459	82,569	83,003	83,169	83,258	83,319	3.9%	4.5%	4.7%	4.8%	4.9%
Avg.	**83,730**	**86,766**	**87,189**	**87,400**	**87,541**	**87,646**	**3.6%**	**4.1%**	**4.4%**	**4.6%**	**4.7%**

Table 17. Estimated headboat landings and percent increase from current conditions in lbs. ww under different bag limit scenarios using the newly developed methodology.

Year	Est. Landings (lbs)						% Increase from Current				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	116,864	120,812	121,380	121,743	122,017	122,229	3.4%	3.9%	4.2%	4.4%	4.6%
2014	104,678	108,741	109,316	109,536	109,655	109,736	3.9%	4.4%	4.6%	4.8%	4.8%
Avg.	**110,771**	**114,777**	**115,348**	**115,639**	**115,836**	**115,983**	**3.6%**	**4.1%**	**4.4%**	**4.6%**	**4.7%**

Table 18. Estimated landings and percent increase from current conditions for combined MRIP and headboat data in numbers of fish under different bag limit scenarios using the newly developed methodology.

Year	Est. Landings (number) from Different Bag Limits						% Increase from Current				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	336,495	341,165	342,203	343,330	344,885	345,063	1.4%	1.7%	2.0%	2.5%	2.5%
2014	426,864	439,580	442,073	444,822	438,676	438,868	3.0%	3.6%	4.2%	2.8%	2.8%
Avg.	**381,680**	**390,372**	**392,138**	**394,076**	**391,781**	**391,966**	**2.3%**	**2.7%**	**3.2%**	**2.6%**	**2.7%**

Table 19. Estimated landings and percent increase from current conditions for combined MRIP and headboat data in lbs. ww under different bag limit scenarios using the newly developed methodology.

Year	Est. Landings (lbs) from Different Bag Limits						% Increase from Currrent				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	429,276	435,838	437,090	438,458	440,261	440,524	1.5%	1.8%	2.1%	2.6%	2.6%
2014	595,470	613,537	617,050	621,078	612,005	612,388	3.0%	3.6%	4.3%	2.8%	2.8%
Avg.	**512,373**	**524,688**	**527,070**	**529,768**	**526,133**	**526,456**	**2.4%**	**2.9%**	**3.4%**	**2.7%**	**2.7%**

Table 20. Percent of 2016 ACL estimated to be landed under different bag limit scenarios.

Year	2016 Rec ACL (lbs)	% of 2016 ACL (lbs)					
		Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	1,001,177	42.9%	43.5%	43.7%	43.8%	44.0%	44.0%
2014		59.5%	61.3%	61.6%	62.0%	61.1%	61.2%
Avg.		**51.2%**	**52.4%**	**52.6%**	**52.9%**	**52.6%**	**52.6%**

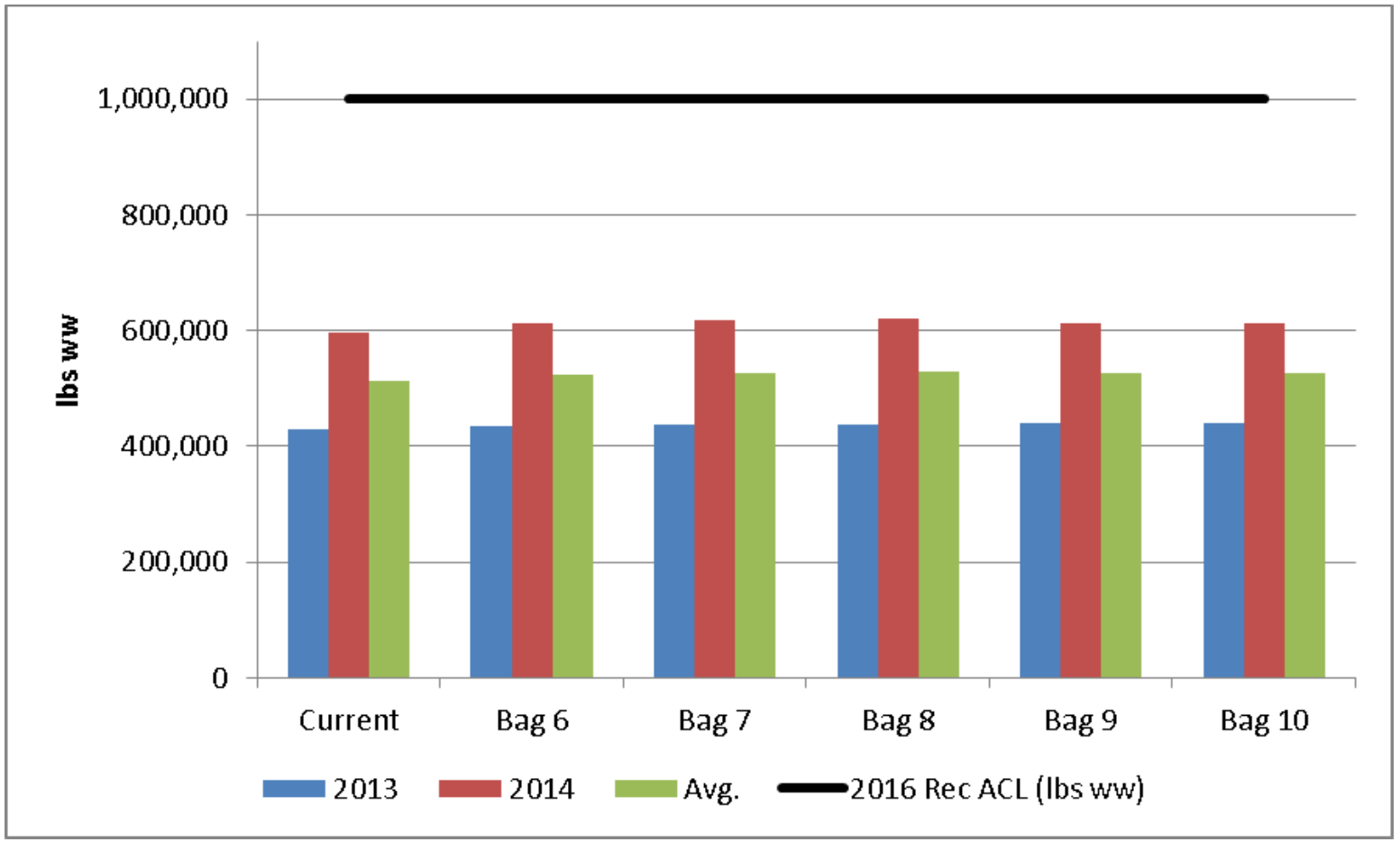

Figure 11. Total estimated recreational landings (lbs. ww) for 2013 (blue), 2014 (red), and the average (green) for different bag limit scenarios against the 2016 Black Sea Bass recreational ACL.

Current Methodology and Assumptions:

This is the methodology that has been used in previous amendments and analyses to determine the effects of proposed increases in the bag limit. It is presented here as a comparison to the new proposed methodology.

MRIP (Private and Charter vessels)

1. Assumption: All discarded Black Sea Bass on trips that reached the bag limit were discarded due to the bag limit, not the size limit.
2. Assumption: All discarded Black Sea Bass on trips that did not reach the bag limit were discarded due to the size limit.
3. Private and charter trips (MRIP data) were analyzed at the trip (rather than angler) level.
    - Assumption: Anglers likely all know each other on a trip and are fishing together, adding their bag limits.
        i. Under a 5 fish bag limit, 3 anglers on a trip would have a 15 fish bag limit for that trip.
        ii. No "partial fish" catch rates
4. Bag limit increases are evaluated by increasing landings per trip to achieve the bag limit, up to the total number of black sea discarded on the trip.
    - Consider 3 anglers on a private boat landing 15 fish and reporting 5 discards under a 5 fish per person bag limit.
        i. Evaluating a 6 fish bag limit for this same trip will result in 18 fish landed with the remaining 2 fish discarded.
        ii. Evaluating a 7 fish bag limit (21 fish trip bag limit) for this trip results in landings of 20 fish, since that is the total assigned to it in the observed data, with no fish discarded.
        iii. These evaluations assume that total effort for that trip does not change. In other words, the anglers do not fish just a little longer to get that last fish under the 7 (or higher) bag limit alternatives, nor do they fish longer and increase their discarded fish.
        iv. As noted above, these analyses also assume that all of the observed discarded fish are of legal size and can be retained if the bag limit changes.
    - Consider 3 anglers on a private boat landing 12 fish and reporting 8 discards under a 5 fish per person bag limit.
        i. Under this scenario, the landings for this trip will not change under any of the bag limit alternatives due to assumption 2.
        ii. It is assumed that all discards on this trip are under the size limit, otherwise 3 of them would have been retained to meet the 5 fish per person (15 fish trip) bag limit.

Headboat:

Two methodologies were used when analyzing the Southeast Region Headboat Survey data. The first followed the MRIP methodology. The second methodology and assumptions are detailed below.

1. Headboat (SRHS data) bag limits were analyzed at the angler level. Note, this is different than the Private data which are analyzed at the trip level.
    - Assumption: Anglers likely do not know each other and are fishing individually or in small groups.
    - The size of these small angler groups can vary and are unknown.
    - The maximum number of anglers that reached the bag on trips that did not reach the trip bag limit was estimated by dividing the number of fish landed by the bag limit for each trip.
    - Trips where all anglers reached the bag limit were treated as the MRIP data were treated.
    - For the current 5 fish bag limit, if 100 fish were landed and there are 50 anglers on board, a maximum of 20 anglers reached the bag limit (40%).
2. For discards, the proportion of anglers that reached the bag was multiplied by the discards to get the discards of the anglers who reached the bag limit.
    - If 200 fish were discarded on the previous trip and 40% of the anglers reached the bag, then 80 fish were available to be caught, as each bag limit alternative was analyzed, to those anglers that reached the bag limit.

Current Methodology Model Results

All the analyses by trip show only a small increase in the overall landed catch of Black Sea Bass (Table 21 -Table 24, Table 27, Table 28, Figure 12). The headboat analysis by angler shows a much higher increase (Table 25-Table 26), but the difference is relatively small in comparison to the total landings (Table 29-Table 30, Figure 13). Also, this is a maximum estimate of the number of anglers that reached the bag limit in 2013 and 2014 and so should be viewed as the maximum increase in landings that might be expected from the headboat sector.

Although the two methodologies have similar results, the current method does estimate the total landings to be higher, on average, than the new proposed methodology does. At a bag limit of 10, the current method estimates the landings to be anywhere from 31,000 fish to 63,000 fish more than the new method on average, depending on whether the headboat data is analyzed on a trip basis or angler basis.

This is almost entirely due to the assumption that all discarded fish on trips that reached the bag limit can be retained under higher bag limits. One issue with these analyses is that they do not have any way of partitioning out the discards into those that are above the size limit and those that are below the size limit. The new proposed methodology attempts to get at that exact problem.

Table 21. MRIP estimated landings in numbers under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Estimated Landings (num)						% Increase				
	Current	Bag = 6	Bag = 7	Bag = 8	Bag = 9	Bag = 10	Bag = 6	Bag = 7	Bag = 8	Bag = 9	Bag = 10
2013	238,302	240,073	242,127	244,564	254,919	264,758	0.7%	1.6%	2.6%	7.0%	11.1%
2014	337,542	347,188	356,870	366,319	374,814	384,638	2.9%	5.7%	8.5%	11.0%	14.0%
Avg.	**287,922**	**293,631**	**299,499**	**305,441**	**314,867**	**324,698**	**2.0%**	**4.0%**	**6.1%**	**9.4%**	**12.8%**

Table 22. MRIP estimated landings in lbs. ww under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Estimated Landings (lbs ww)						% Increase				
	Current	Bag = 6	Bag = 7	Bag = 8	Bag = 9	Bag = 10	Bag = 6	Bag = 7	Bag = 8	Bag = 9	Bag = 10
2013	299,025	301,827	304,806	307,995	321,329	334,245	0.9%	1.9%	3.0%	7.5%	11.8%
2014	474,486	488,297	502,139	515,663	527,241	542,069	2.9%	5.8%	8.7%	11.1%	14.2%
Avg.	**386,755**	**395,062**	**403,473**	**411,829**	**424,285**	**438,157**	**2.1%**	**4.3%**	**6.5%**	**9.7%**	**13.3%**

Table 23. Headboat estimated landings in numbers, analyzed by trip, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (number)						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	88,001	89,194	90,581	91,939	93,243	94,434	1.4%	2.9%	4.5%	6.0%	7.3%
2014	79,459	80,483	81,853	83,231	84,544	85,762	1.3%	3.0%	4.7%	6.4%	7.9%
Avg.	83,730	84,839	86,217	87,585	88,893	90,098	1.3%	3.0%	4.6%	6.2%	7.6%

Table 24. Headboat estimated landings in lbs. ww, analyzed by trip, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (lbs)						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	116,864	118,495	120,376	122,216	123,978	125,597	1.4%	3.0%	4.6%	6.1%	7.5%
2014	104,678	106,047	107,895	109,763	111,541	113,189	1.3%	3.1%	4.9%	6.6%	8.1%
Avg.	110,771	112,271	114,136	115,989	117,759	119,393	1.4%	3.0%	4.7%	6.3%	7.8%

Table 25. Headboat estimated landings in numbers, analyzed by angler, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (number)						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	88,001	99,733	108,659	115,692	121,426	126,081	13.3%	23.5%	31.5%	38.0%	43.3%
2014	79,459	90,184	98,705	105,607	111,282	116,055	13.5%	24.2%	32.9%	40.0%	46.1%
Avg.	83,730	94,958	103,682	110,649	116,354	121,068	13.4%	23.8%	32.1%	39.0%	44.6%

Table 26. Headboat estimated landings in lbs. ww, analyzed by angler, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (lbs)						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	116,864	132,601	144,511	153,938	161,603	167,843	13.5%	23.7%	31.7%	38.3%	43.6%
2014	104,678	118,798	129,960	139,026	146,501	122,866	13.5%	24.2%	32.8%	40.0%	17.4%
Avg.	110,771	125,699	137,235	146,482	154,052	145,354	13.5%	23.9%	32.2%	39.1%	31.2%

Table 27. Combined MRIP and headboat estimated landings in numbers, analyzing headboat by trip, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (number) from Different Bag Limits by Trip						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	326,303	329,268	332,709	336,503	348,162	359,192	0.9%	2.0%	3.1%	6.7%	10.1%
2014	417,001	427,671	438,723	449,550	459,358	470,400	2.6%	5.2%	7.8%	10.2%	12.8%
Avg.	371,652	378,469	385,716	393,026	403,760	414,796	1.8%	3.8%	5.8%	8.6%	11.6%

Table 28. Combined MRIP and headboat estimated landings in lbs. ww, analyzing headboat by trip, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (lbs) from Different Bag Limits by Trip						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	415,888	420,322	425,182	430,211	445,307	459,842	1.1%	2.2%	3.4%	7.1%	10.6%
2014	579,164	594,344	610,035	625,426	638,782	655,258	2.6%	5.3%	8.0%	10.3%	13.1%
Avg.	497,526	507,333	517,608	527,818	542,044	557,550	2.0%	4.0%	6.1%	8.9%	12.1%

Table 29. Combined MRIP and headboat estimated landings in numbers, analyzing headboat by angler, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (number) from Different Bag Limits by Angler						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	326,303	339,806	350,786	360,256	376,345	390,839	4.1%	7.5%	10.4%	15.3%	19.8%
2014	417,001	437,372	455,576	471,926	486,097	500,692	4.9%	9.3%	13.2%	16.6%	20.1%
Avg.	371,652	388,589	403,181	416,091	431,221	445,766	4.6%	8.5%	12.0%	16.0%	19.9%

Table 30. Combined MRIP and headboat estimated landings in lbs. ww, analyzing headboat by angler, under different bag limit scenarios and % increase in landings from current landings under a bag limit of 5.

Year	Est. Landings (lbs) from Different Bag Limits by Angler						% Increase from Bag Limit 5				
	Current	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10	Bag 6	Bag 7	Bag 8	Bag 9	Bag 10
2013	415,888	434,427	449,317	461,933	482,931	502,088	4.5%	8.0%	11.1%	16.1%	20.7%
2014	579,164	607,095	632,099	654,689	673,742	664,934	4.8%	9.1%	13.0%	16.3%	14.8%
Avg.	497,526	520,761	540,708	558,311	578,337	583,511	4.7%	8.7%	12.2%	16.2%	17.3%

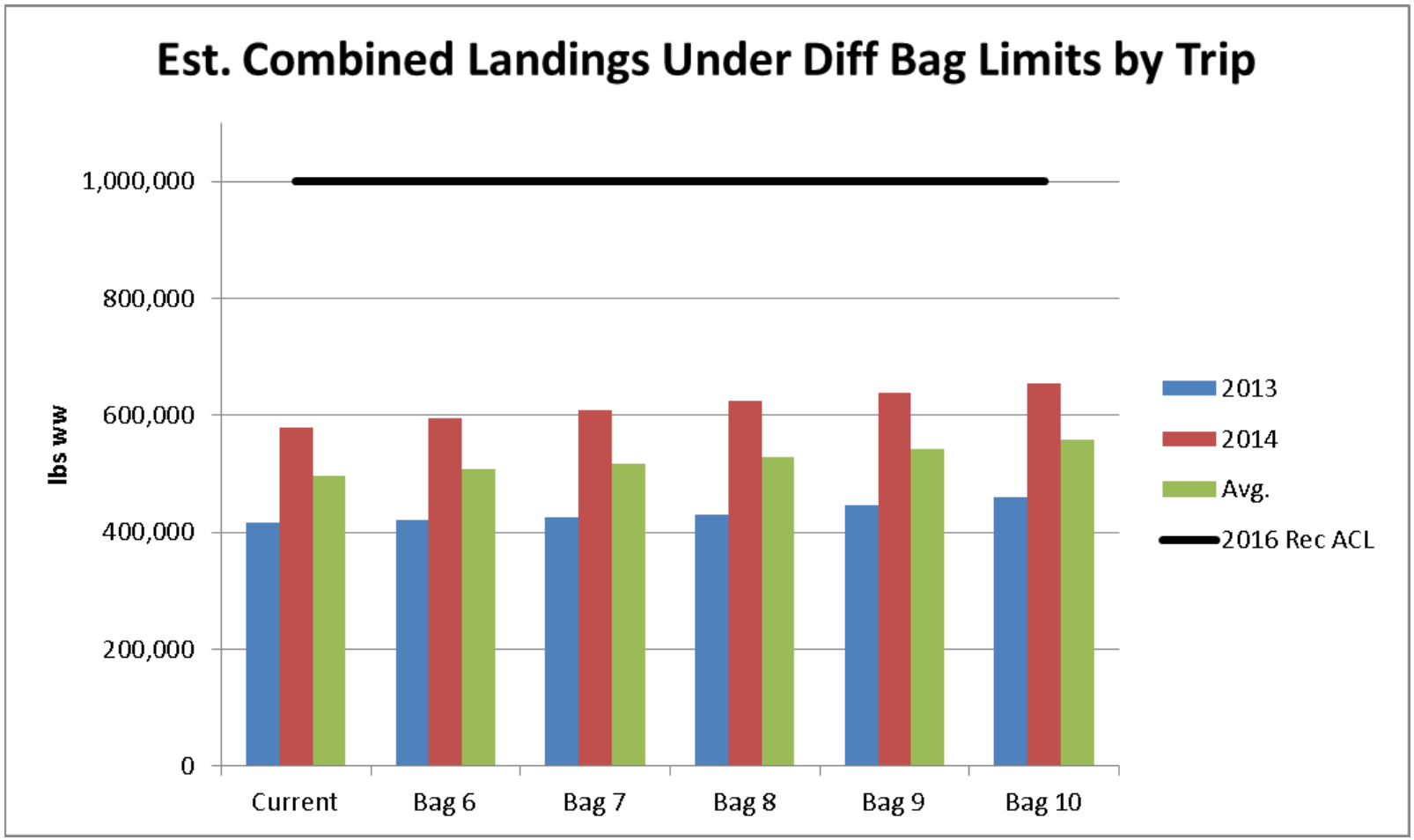

Figure 12. Estimated landings for combined MRIP and headboat data in lbs ww under different bag limit scenarios, analyzing headboat by trip.

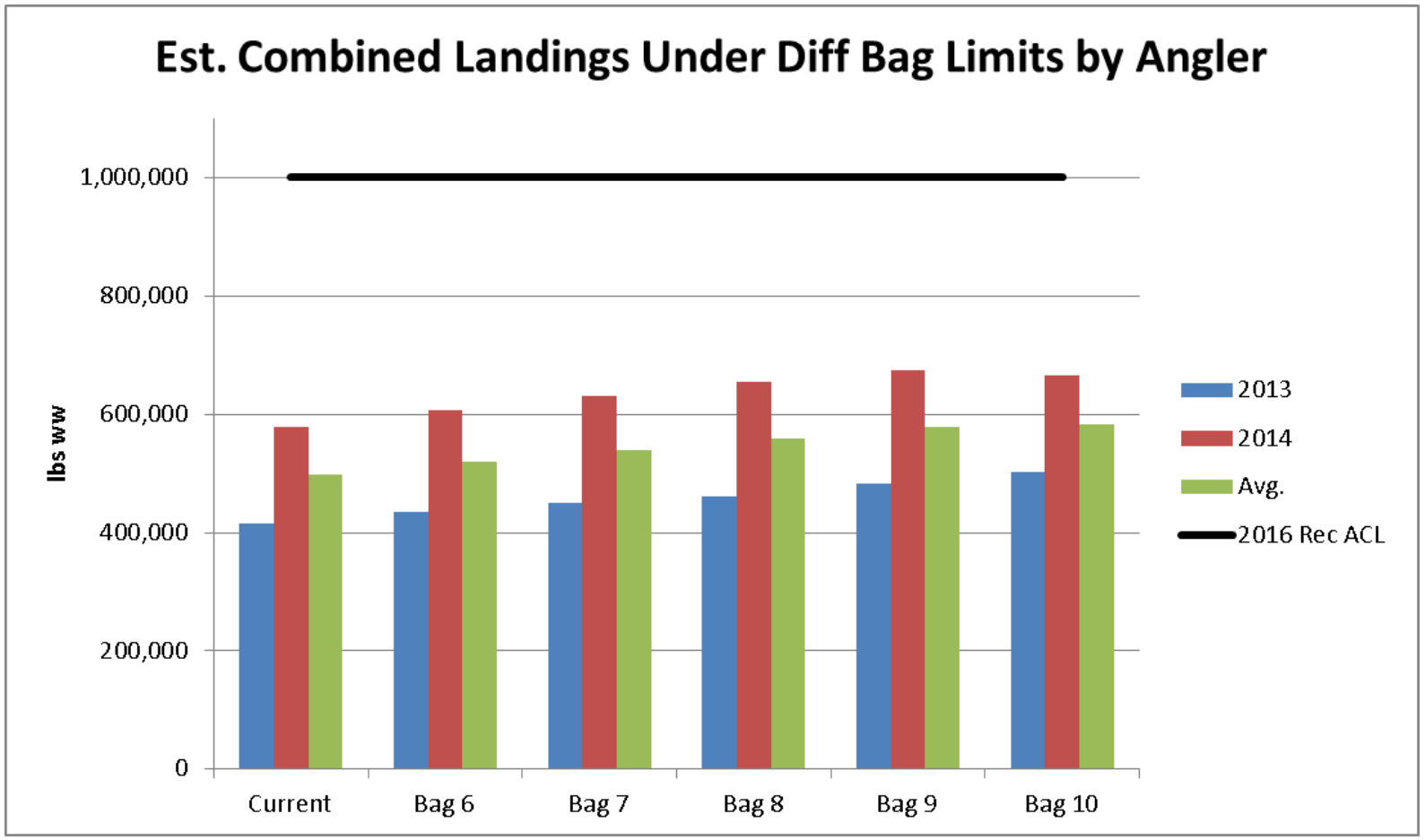

Figure 13. Estimated landings for combined MRIP and headboat data in lbs ww under different bag limit scenarios, analyzing headboat by angler.

Appendix

Formulas and Calculations Used in the New Proposed Methodology

Given:

$S_{a,f}^{D,<min}$ – Discard selectivity for fish less than the minimum size at age a for fishery f.

$S_{a,f}^{D,>min}$ – Discard selectivity for fish greater than the minimum size at age a for fishery f.

$F_{f,y}^{D}$ – Fishing mortality rate for dead discards in year y for fishery f.

$N_{a,y}$ – Total abundance at age a for year y.

M^{D} – Discard mortality.

We can estimate the proportion of total fish discarded that are above the minimum size limit for a given fishery f in a given year y:

$$\frac{\sum_a \left(S_a^{D,>min} F^D N_a\right) / M^D}{\left(\sum_a \left(S_a^{D,<min} F^D N_a\right) / M^D\right) + \left(\sum_a \left(S_a^{D,>min} F^D N_a\right) / M^D\right)}$$

Since this proportion is being calculated for a given fishery in a given year, the discard fishing mortality rate and the discard mortality both become constants and can be removed from the above equation. After removing these constant terms, the above equation reduces to:

$$\frac{\sum_a \left(S_a^{D,>min} N_a\right)}{\sum_a \left(S_a^{D,<min} N_a\right) + \sum_a \left(S_a^{D,>min} N_a\right)}$$

For this analysis, the discard selectivities for fish below the size limit were calculated using the same methodology as was used in both SEDAR 25 and the 2013 update. Below is an excerpt from the SEDAR 25 assessment report.

Selectivities of discards were assumed to be dome-shaped. They were partially estimated, assuming that discards consisted primarily of undersized fish, as implied by observed length compositions of discards. The general approach taken was that age-specific values for ages 0–2 were estimated, age 3 was assumed to have full selection, and selectivity for each age 4+ was set equal to the age-specific

probability of being below the size limit, given the estimated normal distribution of size at age. In this way, the descending limb of discard selectivities would change with modification in the size limit.

However, the discard selectivity for fish under the minimum size could not simply be taken from the 2013 update because the minimum size was increased from 12" to 13" since the terminal year of the assessment. Therefore, data was obtained from the MARMAP program and used to estimate the probability at age that a fish is below the minimum size. It was assumed the distribution of size at age was normal with N(μ,σ). Those probabilities at age were multiplied by the fishery selectivity at age for ages 4^+ to produce new discard selectivities at age. Ages 0-2 were taken directly from the SEDAR 25 update and age 3 was again assumed to be 1.

Discard selectivity for fish greater than the minimum size also needed to be calculated for trips that reached the bag limit of 5 fish per person. To accomplish this, the probability of a fish being greater than 13 inches at age was calculated (as above) and multiplied by the fishery selectivity for all ages, as was done for the discard selectivity of fish less than 13 inches. This discard selectivity was then multiplied by the proportion of trips that reached the bag limit, on average, between 2013 and 2014.

The formulas to calculate these discard selectivities are

$$S_a^{D,<min} \begin{cases} S_a^D \, from \; 2013 \; update, a = 0-3 \\ P(x \leq min)_a, a = 4^+ \end{cases}$$

$$S_a^{D,>min} \begin{cases} 0, a = 0-3 \; (Assessment \; assumption \; of \; all \; fish \; under \; 4 < min \; size) \\ P(x > min)_a * \%Trips^{Hit\ Bag}, for \; a = 4^+ \end{cases}$$

where $P(x>min)_a$ and $P(x\leq min)_a$ are the probabilities that a fish is greater than and less than or equal to the minimum size at a given age a, respectively, and $\%Trips^{Hit\ Bag}$ is the percent of trips in 2013 and 2014 that met the bag limit.

The headboat selectivities have an added step for trips that did not meet the total trip bag limit (# Anglers * Individual Bag Limit). On headboats, it's possible for some of the anglers to meet the bag limit and discard fish above the minimum size. For these trips, the discard selectivity for fish above the minimum size is calculated as it is written above. However, instead of multiplying by the percent of trips that met the bag, instead we multiply by the proportion of anglers, on trips that did not meet the total trip bag limit, who did meet their personal bag limit.

The formula for this discard selectivity is

$$S_{a,HB-NoBag}^{D,>min} \begin{cases} 0, a = 0-3 \; (Assessment \; assumption \; of \; all \; fish \; under \; 4 < min \; size) \\ P(x > min)_a * \%Angs^{Hit\ Bag}, for \; a = 4^+ \end{cases}$$

where $S_{a,HB-NoBag}^{D,>min}$ is the discard selectivity of fish larger than the minimum size on headboat trips that did not meet the bag limit and $\%Angs^{Hit\ Bag}$ is the percent of anglers on those trips that did meet their personal bag limit.

Appendix Table 1. All necessary quantities to calculate the discard selectivities of Black Sea Bass both greater than and less than or equal to 13 inches, including the recreational fishery selectivity and estimated discard selectivity from the 2013 SEDAR 25 update, the probabilities of a fish being above and below the 13-inch minimum size limit at age, and the final selectivities at age. The percent of trips that hit the bag limit in 2013 and 2014 is 1.06%.

Age	Est Discard Selectivity	P(x≤13)	P(x>13)	Discard Selectivity	
				<13 in	>13 in
0	0.001	1	3.103E-10	0.001	0
1	0.093	1	1.69E-11	0.093	0
2	0.63	0.999985072	1.493E-05	0.63	0
3	1	0.978687376	0.0213126	1	0
4	0.818	0.811933435	0.1880666	0.811933435	0.1880666
5	0.64	0.608113	0.391887	0.608113	0.004140401
6	0.549	0.34490246	0.6550975	0.3449025	0.006921298
7	0.508	0.316878211	0.6831218	0.3168782	0.007217383
8	0.488	0.276399305	0.7236007	0.2763993	0.007645054
9	0.479	0.159516271	0.8404837	0.1595163	0.008879958
10	0.473	0.034161243	0.9658388	0.0341612	0.010204371
11	0.47	0.002653271	0.9973467	0.0026533	0.010537262

Appendix Table 2. All the necessary information to calculate the proportion of discarded Black Sea Bass above 13 inches, including the discard selectivities above and below 13 inches, the estimated abundance at age in 2012 (the terminal year) from the 2013 SEDAR 25 update, and the calculated numbers of discards above and below 13 inches at age.

Age	Discard Selectivity		2012 Abundance (num)	Discards ≤13	Discards >13
	≤13 in	>13 in			
0	0.001	0	33,042,170	33,042	0
1	0.093	0	13,459,560	1,251,739	0
2	0.63	0	8,842,770	5,570,945	0
3	1	0	4,277,590	4,277,590	0
4	0.811933435	0.1880666	1,542,900	1,252,732	3,066
5	0.608113	0.004140401	516,580	314,139	2,139
6	0.3449025	0.006921298	145,210	50,083	1,005
7	0.3168782	0.007217383	33,720	10,685	243
8	0.2763993	0.007645054	8,310	2,297	64
9	0.1595163	0.008879958	3,840	613	34
10	0.0341612	0.010204371	1,490	51	15
11	0.0026533	0.010537262	900	2	9
Total				12,763,919	6,575
Proportion				**0.999485**	**0.000515**