INTERIM MANAGEMENT MEASURES FOR ACHIEVING SUSTAINABLE HARVEST OF SPOTTED SEATROUT

ISSUE

Establish interim management measures to enable a higher proportion of spotted seatrout to reproduce while the spotted seatrout stock assessment is being updated and the fishery management plan is being developed.

BACKGROUND

The first stock assessment of NC's spotted seatrout, "Stock Status of Spotted Seatrout in North Carolina, 1991-2006", determined that the stock is overfished and overfishing is occurring (Jensen 2009). A statistical catch-at-age model was used to determine fishing mortality rates and stock abundance levels, and yield per recruit and biomass per recruit analyses were used to identify appropriate fishing mortality and spawning stock biomass benchmark thresholds. The models indicated that the population of spotted seatrout has been overfished for the entire time series and that overfishing occurred in all but one year.

The FRA mandates that fishery stocks be managed to allow for sustainable harvest and prevent overfishing. Sustainable harvest is defined as the amount of harvest, including release and discard mortality, that can be taken on a continuing basis without reducing the stock biomass of the fishery or causing the fishery to become overfished.

Because the status of spotted seatrout has been determined to be overfished and overfishing is occurring, and while the spotted seatrout FMP is in the process of being developed, the MFC could choose to adopt interim management measures to reduce harvest and help to increase spawning stock biomass.

All Atlantic states that have a proclaimed interest in spotted seatrout have established at least a 12 inch minimum total length size limit (Table 1). Most states have a recreational bag limit ranging from 4 to 15 fish, with the exception of no bag limit in Delaware. The commercial fisheries are limited using several different control measures ranging from total commercial closure (SC) to quotas (VA), seasonal closures, and gear limits. The current size limit of spotted seatrout is 12 inches in NC and 14 inches in VA, and the current bag limit is 10 fish in both NC and VA. There are currently no trip limits in NC, while the state of VA adopted a 51,104 pound quota in August 1995 (this value represents an average of the 1993 & 1994 commercial landings plus 25%). To date, this quota has not been met.

Size limit data and analyses are presented herein. Further analyses of bag limits and trip limits are attached in Appendix A.

METHODS

All analyses assumed regulations would impact only fishermen in North Carolina, while all future harvest and dead discards from Virginia were assumed to remain the same. Numbers shown include both North Carolina and Virginia harvest. All calculations were based on input data

averaged from 2004 to 2006. Essentially, the following analyses show the average reduction that would have been observed from 2004 to 2006 if a size limit change was in place during those years.

Size Limit Analysis

Changes to commercial and recreational harvest and dead discards were predicted for changes from the current size limit of 12 inches to proposed limits of 13, 14, and 15 inches. Input data included weighted length frequencies at age for North Carolina commercial landings, recreational harvest, and recreational releases and Virginia commercial and recreational catch at age data (Appendix B). Other estimated inputs which were developed for the stock assessment included natural mortality at age, proportion released, and weight at age of the catch were included. Selectivity at age, population numbers at age, and F_{mult} parameter estimates were output by the assessment (Jensen 2009). Equations used in the calculations were standard equations used in the ASAP model (NOAA Fisheries Toolbox 2008; Appendix C).

Weighted length frequencies at age were examined to determine the new catch at age and release estimates expected under each proposed size limit. A weighted average of undersized harvest from 2004 to 2006 was used to determine the proportion harvested in size bins that would be illegal under the proposed size limits. These data were then used to calculate a new proportion of fish that would be released under each size limit scenario. The new release proportions were used to calculate new F rates for each fishery and their associated discards. These F rates were then used to calculate the new predicted harvest and discards, in both numbers and pounds, associated with each proposed size limit increase. Percent reduction was calculated for each fishery and percent increases were determined for the dead discards expected in each fishery.

This analysis assumes noncompliance with proposed size limits in the future recreational fishery based on past history of undersized fish in the harvest observed in MRFSS survey estimates. The commercial fishery does not typically harvest fish less than the current size limit of 12 inches and currently has no associated discard component; therefore, a 10% noncompliance rate was assumed with future increases in size limits for the commercial fishery.

A release mortality of 10% was assumed for the recreational fishery to mirror the recent stock assessment (Jensen 2009), and an 80% release mortality estimate was assumed for the commercial fishery based on a study of small mesh gill nets in North Carolina (Price and Gearhart 2002).

Size and Age at Maturity

Life history information has been collected for NC spotted seatrout since 1991. When possible macroscopic determinations of the reproductive condition of male (n=2,385) and female (n=5,527) spotted seatrout were made in the laboratory. During 1991-1995, a representative subsample was selected for microscopic (histological) confirmation of macroscopic determinations.

Fecundity

Unfortunately, accurate annual fecundity estimates for use in stock assessments are not available for spotted seatrout in North Carolina. This research is very labor intensive, and results can be highly variable. The need for fecundity estimates for NC spotted seatrout will be

a research recommendation of the FMP since fecundity estimates would help to improve calculations of the spawning potential ratio (SPR), which is crucial to the determination of sustainability of the stock. However, general fecundity trends for spotted seatrout from other states and can be assumed for NC's stock.

RESULTS

Size Limit Analysis

The commercial fishery, which is largely composed of gill nets, tends to catch larger, older fish than the recreational hook-and-line fishery. As a result, the recreational fishery is predicted to experience 2.5 to 4 times more reduction in harvest than the commercial fishery under size limit restrictions (Table 2). In addition, the average recreational fishing mortality rate from 2004 to 2006 is over 3 times greater than the commercial fishery (Jensen 2009). Therefore, the recreational fishery will experience a much larger reduction under size limit increases than the commercial fishery. An increase in the size limit can play an important role in reducing the overall harvest and allowing smaller fish the chance to spawn at least once before being harvested.

Life History Information

Since the stock assessment for spotted seatrout is being updated to include 2007 and 2008 landings data, it might be best to base interim management options on the basic life history information available for spotted seatrout. Myers et al (1998) used a simple model to demonstrate that a spawn-at-least once policy may prevent the collapse of the stock. The spawn-at-least once policy requires that fish be permitted to spawn at least once before they become vulnerable to fishing gear, and the stock will not collapse if fishing mortality targets are breached.

Maturity data is presented herein by length, age, and sex (Figure 1, Tables 3 & 4). There is a large size range in each year class due to the extended spawning season. Therefore maturity and fecundity data are best based on fish size rather than age.

Size and Age at Maturity

Spotted seatrout mature at an early age, with most fish mature by 12 inches (age 1) (Figure 1, Tables 3 & 4). Males mature at a smaller size, younger age, and earlier in the season, with 50% mature by 8 inches, and 100% mature by 12 inches (age 1). Females mature a little later, with 50% mature by around 10 inches, 93% mature by 13 inches (age 1), and 99% mature by 14 inches (age 2), and 100% mature by 15 inches (age 2). Any increase in minimum size at or above 14 inches would essentially allow all of the female spotted seatrout to mature, increasing the reproductive potential of the stock.

Fecundity

The reproductive biology of spotted seatrout throughout their range has been summarized as being incredibly prolific due to the early age of maturity and females releasing eggs in several batches over a protracted spawning season. Annual fecundity in this species is determined by

the number of eggs released during each spawning event (batch fecundity) and the number of spawning events occurring during the course of the spawning season (spawning frequency) to estimate the reproductive output for an entire spawning season (Brown-Peterson et al. 1988; Brown-Peterson and Warren 2001; Nieland et al. 2002). Most estimates of spawning frequency suggest that spotted seatrout spawn, on average, once every 4 to 5 days. Estimates of the number of times an individual spawn varies but in most regions, spotted seatrout appear to have the ability to spawn 40 to 50 times in a single season (Brown-Peterson 2003).

Fecundity research has shown that older (larger) females spawn more frequently than younger fish (Roumillat et al. 2002, Crabtree and Adams 1998, Sundararaj and Suttkus 1962). Most of these studies only include ages 1 to 4 fish due to small sample sizes of older fish. A South Carolina study estimated fecundity for age classes 1 to 3 were approximately 3.2, 9.5, and 17.6 million eggs for each age class, respectively (Roumillat et al. 2002).

Harvest by Length

Recreational Fishery

Length frequency distributions of the recreational hook and line harvest (Type A and B1) and live releases (Type B2) were obtained through MRFSS surveys for North Carolina and Virginia.

In North Carolina, where the size limit is 12 inches TL, the majority of the length frequency distribution of the recreational harvest (Type A and B1) ranged between 12 and 19 inches TL and averaged approximately 15 inches TL (Figure 4). Most of North Carolina's releases (Type B2) were small fish, with most of the released fish below the 12 inch TL minimum size.

In Virginia, the length frequency distribution of the recreational harvest (Type A and B1) was slightly larger since Virginia has a larger size limit of 14 inches TL (Figure 5). The majority of the Virginia recreational harvest ranged between 12 and 19 inches TL. Virginia's releases were also primarily small fish, with most of the released fish just below the 14 inches TL minimum size.

Commercial Fishery

NCDMF commercial fish house sampling data were used to characterize the length composition of each major commercial fishery (Figure 2). Spotted seatrout less than 12 inches, the current minimum size limit in North Carolina, are likely to pass through mesh sizes in the estuarine gill nets that dominate the commercial fishery (74% of the 2006-2008 commercial catch was by estuarine gill nets). The majority of spotted seatrout caught in the beach seine, estuarine gill net, pound net, and trawl fisheries ranged from 14 to 20 inches TL and averaged around 17 to 18 inches TL. Spotted seatrout harvested with ocean gill nets and haul seines was slightly smaller, but these fisheries contributed 2 to 14% of the total commercial harvest in recent years (2006-2008).

Virginia commercial fish house sampling data, provided by the Virginia Marine Resources Commission staff, were used to characterize the length composition of major commercial fisheries in Virginia (Figure 3). Virginia's commercial harvest of spotted seatrout was only a fraction of the North Carolina commercial harvest. Most of Virginia's landings were by a haul seine fishery that operates in both the Chesapeake Bay and nearshore ocean waters. Larger

spotted seatrout were harvested in Virginia's haul seine and ocean gill net fisheries, with the majority of the catch from 15 to 23 inches TL and averaged 18 to 19 inches TL. Virginia's commercial harvest by hook and line had the smallest fish, with most of the harvest from 10 to 19 inches TL and averaged 14 and 15 inches TL.

DISCUSSION

There is evidence that the population levels of spotted seatrout have increased since the terminal year in the last stock assessment (2006). The stock assessment showed that spotted seatrout population dynamics are largely driven by cold stun events (Jensen 2009). There have not been any cold stuns observed since 2003 and, as a result, this may have allowed the population to expand.

When interpreting the percent reductions presented in this paper, it should be noted that recruitment is highly variable and, when combined with the vulnerability to environmental influences such as cold stuns, the resulting catch is also highly variable. Thus, the harvest reductions predicted here only hold true if environmental parameters, recruitment, and fishing pressure in the future are similar to that seen in 2004 to 2006. Future catches next year are assumed to be similar to the recent past.

Spotted seatrout population dynamics are naturally variable. Reliance on only a few age classes leads to variability in population size and a higher potential for over-exploitation in the long-term. Expansion in the age structure is required to provide the best chance for a sustainable fishery.

Increasing the minimum size limit would protect young fish from being harvested before they had the opportunity to spawn. This would especially help to increase the size of the spawning stock biomass since age-1 fish make up the largest percentage of the spawning stock. Although older fish may produce more eggs per spawning season, egg production by the predominant age groups may overshadow contributions by older bigger fish. The historical view was that age-1 fish contributed very little to the overall yearly reproductive effort (Moody, 1950; Tabb, 1961; Sundararaj and Suttkus, 1962), but recent research suggest that age 0 and 1 females do make an important contribution to the total spawning biomass (Brown-Peterson 2003, Roumillat 2003, Lowerre-Barbieri et al., 1999, Crabtree and Adams 1998, Wenner et al 1990). The importance of age- 1 spotted seatrout spawning is considerable due to the high percentage of age-1 fish in the overall age distribution of spotted seatrout populations throughout the southeastern US and in NC.

An increase in minimum size will likely increase the number of discarded spotted seatrout in the commercial and recreational fisheries. For the commercial fishery, an increase from 12 inches to 14 inches would result in a slight increase in discards (11,516 fish; Table 2). An increase in the minimum gill net mesh size used might become necessary to minimize discards of undersized spotted seatrout, particularly in the ocean gill net fishery. Because of the cost involved in gear replacement, increases in minimum mesh size requirements might be better received as addressed through the fishery management plan rather than interim management measures. The practice of releasing spotted seatrout in the recreational fishery has increased considerably in recent years. An increase in the minimum size would likely further increase the number of released undersized fish. Fishing tackle and fishing techniques could be modified to decrease the amount of discard mortality of released fish.

Given the potential changes to the stock, we cannot say with much certainty how much of a reduction is required until the stock assessment is updated; however, fishing rates likely remain high. It makes biological sense to raise the size limit to allow fish to spawn at least once before being caught.

IV. CURRENT AUTHORITY

G.S. 113-134. RULES
G.S. 113-182. REGULATIONS OF FISHING AND FISHERIES
G.S. 143B-289.52. MARINE FISHERIES COMMISSION—POWERS AND DUTIES
15A NCAC 3M .0504 TROUT

V. MANAGEMENT OPTIONS

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo
   + No additional burden on fishermen, dealers, or managers
   - Does not address historical trend of overfishing
   - Does not address dependence of fishery on year-class strength
   - Maintenance of fishing mortality at or below $F_{Threshold}$, as required by the Fisheries Reform Act, will likely not be achieved

2) Size limit increase
   + Allows opportunity for fish to spawn at least once before they are harvested
   + Gets closer to goal of ending overfishing
   - Given potential change in stock dynamics, it is uncertain what level of harvest reduction is needed to rebuild the stock
   - Additional burden on fishermen, dealers, and managers

VI. MANAGEMENT RECOMMENDATIONS

DMF Position:

- Implement a 14 inch size limit.
- Get results of updated stock assessment through 2008.
- Additional changes should be made through the FMP process (bag limits, slot limits, trip limits, gear restrictions, seasonal closures, etc).

RESEARCH NEEDS

- The stock assessment needs to be updated through 2008 to determine the harvest reduction required to end overfishing and achieve an appropriate F rate to rebuild the stock.

- Size specific fecundity estimates for North Carolina spotted seatrout would help to improve calculations of spawning potential ratio (SPR) crucial to the determination of sustainability of the stock.

VII. LITERATURE CITED

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Table 1. Rules regarding spotted seatrout management in other states along the Atlantic coast.

State	Recreational	Commercial	Other
New Jersey	13" TL; 8 fish	13" TL; 12" TL taken by otter trawl 9/1-12/31	Weakfish regulations apply to spotted seatrout
Delaware	12" TL	12" TL	Gill net restrictions
Maryland	14" TL; 10 fish	12" TL; seasonal closure	Minimum mesh size restrictions for trawl and gill nets
Virginia	14" TL; 10 fish	14" TL; H&L 10 fish	Commercial quota/ Pound net haul seine allow 5% <14" by weight
North Carolina	12" TL; 10 fish	12" TL; H&L 10 fish	BRD requirement for trawl; gill net attendance regulations
South Carolina	14" TL; 10 fish	No commercial harvest or sale	Gamefish status
Georgia	13" TL; 15 fish	13" TL; 15 fish	BRD requirements for trawl; gear mesh regulations
Florida	15-20" TL slot, 1 fish>20"; 5 fish Northern Region; 4 fish Southern Region; Seasonal Closures	15-24" TL; 6/1-8/31 season; 75 fish per day or vessel (lesser); H&L or cast net only	-

Table 2. Predicted numbers of spotted seatrout and percent change in harvest and dead discards with size limit changes. Values are based on average ASAP model predictions from 2004 to 2006. Assumes some harvest of undersized fish based on past history in recreational fishery and 10% retention of undersized fish in commercial fishery with new regulations.

Numbers

Predicted Numbers of Fish

Size Limit	Com Harvest	Com Dead Discards	Rec Harvest	Rec Dead Discards	Total Harvest	Total Dead Discards	Total Harvest + Dead Discards
12	125,914	0	439,654	83,260	565,568	83,260	648,828
13	122,873	4,343	397,759	89,854	520,632	94,198	614,830
14	118,006	11,516	330,742	100,446	448,748	111,962	560,710
15	110,315	19,519	301,153	105,444	411,468	124,963	536,432

Percent Change

Size Limit	Com Harvest	Com Dead Discards	Rec Harvest	Rec Dead Discards	Total Harvest	Total Dead Discards	Total Harvest + Dead Discards
12	0.0	.	0.0	0.0	0.0	0.0	**0.0**
13	-2.4	.	-9.5	7.9	-8.0	13.1	**-5.2**
14	-6.3	.	-24.8	20.6	-20.7	34.5	**-13.6**
15	-12.4	.	-31.5	26.6	-27.3	50.1	**-17.3**

Pounds

Predicted Pounds of Fish

Size Limit	Com Harvest	Com Dead Discards	Rec Harvest	Rec Dead Discards	Total Harvest	Total Dead Discards	Total Harvest + Dead Discards
12	217,920	0	701,621	66,685	919,541	66,685	986,226
13	214,821	2,858	648,805	71,255	863,626	74,113	937,739
14	208,645	8,511	560,407	79,351	769,052	87,862	856,915
15	197,810	15,249	516,771	83,729	714,580	98,978	813,558

Percent Change

Size Limit	Com Harvest	Com Dead Discards	Rec Harvest	Rec Dead Discards	Total Harvest	Total Dead Discards	Total Harvest + Dead Discards
12	0.0	.	0.0	0.0	0.0	0.0	**0.0**
13	-1.4	.	-7.5	6.9	-6.1	11.1	**-4.9**
14	-4.3	.	-20.1	19.0	-16.4	31.8	**-13.1**
15	-9.2	.	-26.4	25.6	-22.3	48.4	**-17.5**

Table 3. Size at maturity for NC spotted seatrout (1991-2006).

% Maturity by Length		
TL (in)	MALE	FEMALE
0	0	0
1	0	0
2	0	0
3	0	0
4	0	1
5	1	2
6	5	4
7	21	9
8	56	20
9	85	37
10	97	59
11	99	77
12	100	89
13	100	95
14	100	98
15	100	99
16	100	100

Table 4. Age at maturity for NC spotted seatrout (1991-2006).

% Mature by Age			
AGE	Male	Female	Combined
0	1	1	1
0.5	12	4	7
0.75	94	62	77
1	100	93	96
2	100	100	100

Table 5. Average age at length for NC spotted seatrout (1991-2006).

	Average Length (TL, in) at Age		
AGE	Male	Female	Combined
1	10	13	11
2	16	19	18
3	20	23	22
4	22	26	25
5	24	28	26
6	25	29	26
7	25	29	27
8	26	30	27
9	26	30	27

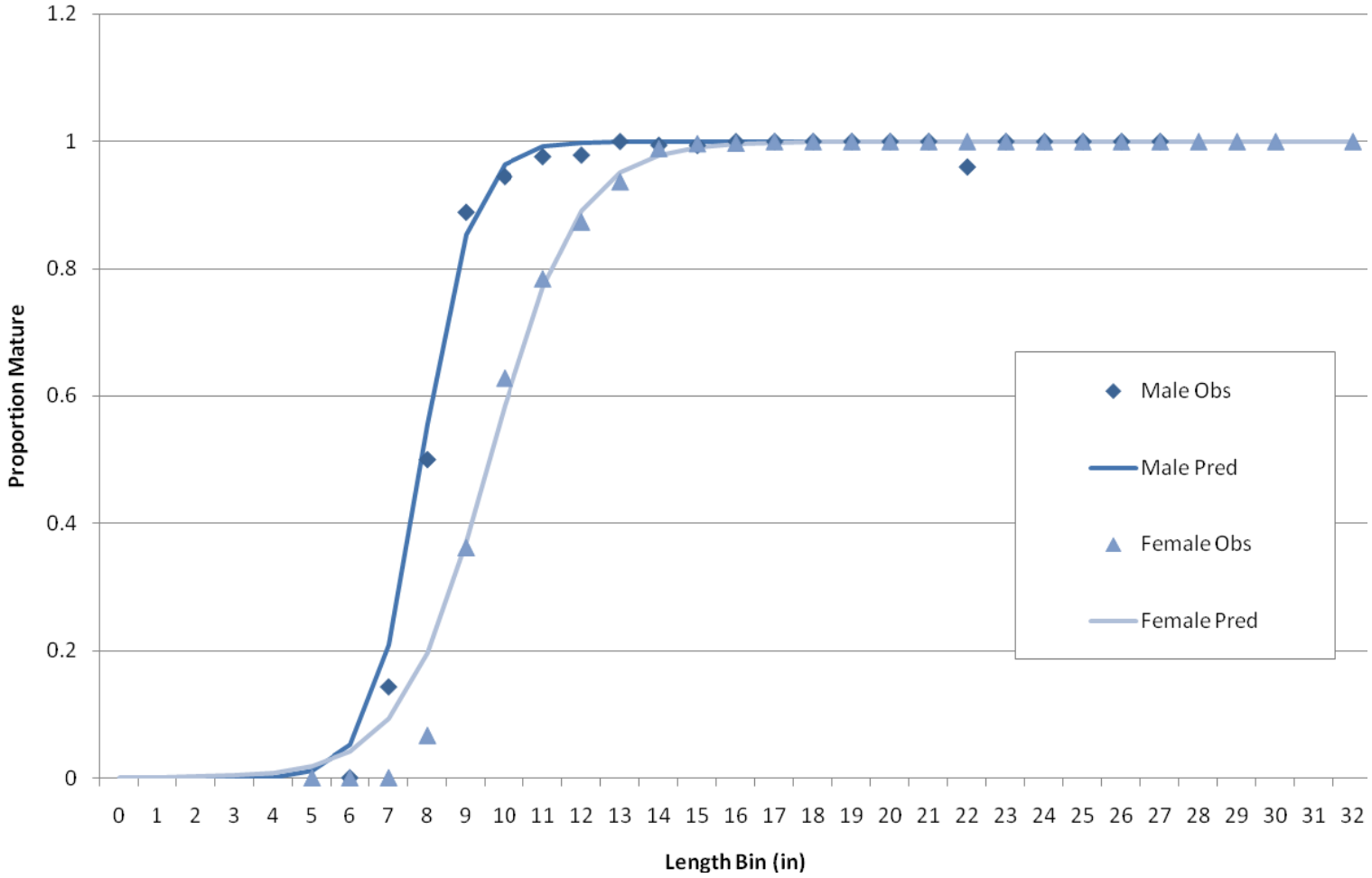

Figure 1. Proportion of spotted seatrout mature by length, 1991-2006.

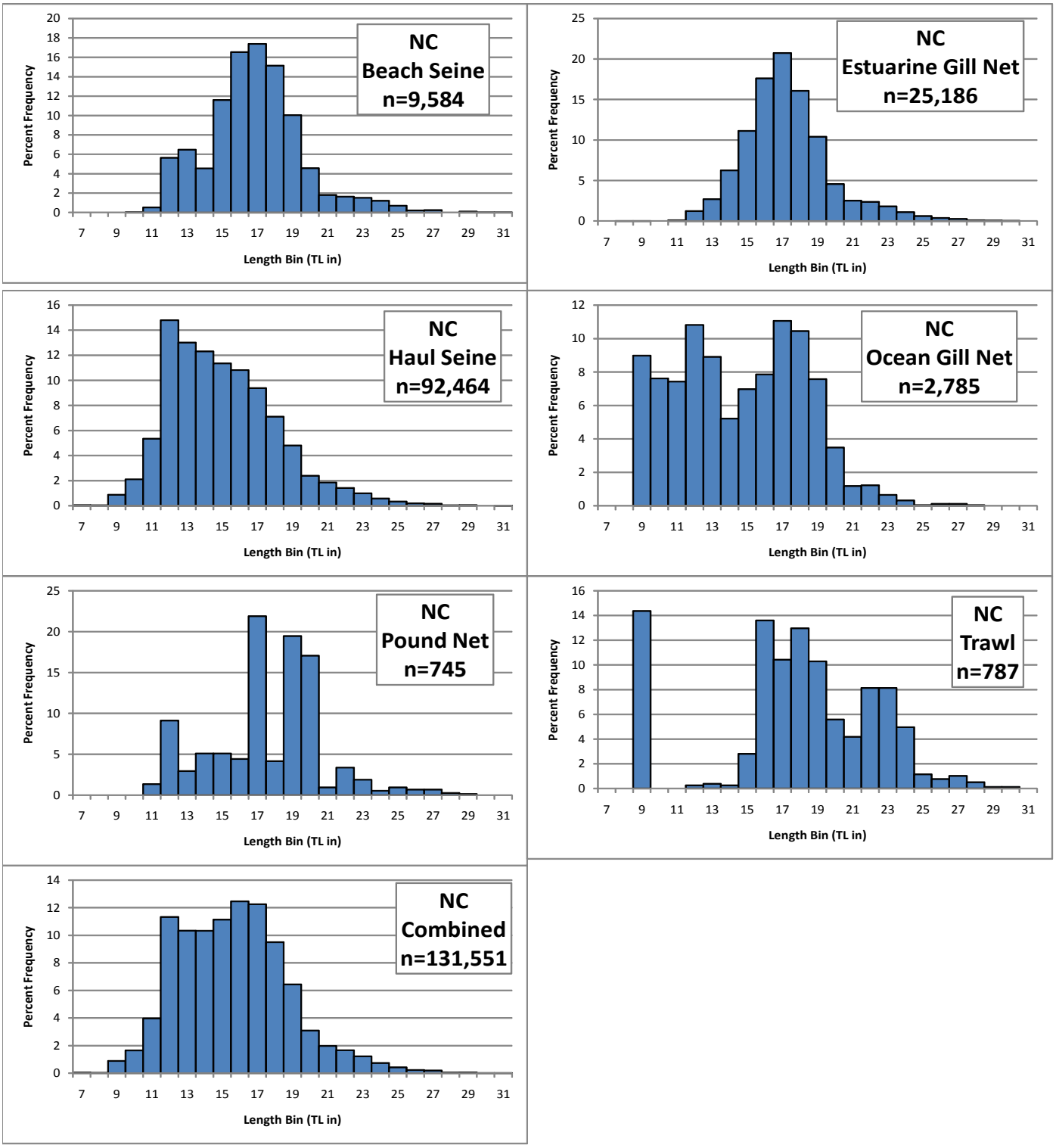

Figure 2. Length frequency distribution of fish sampled from North Carolina's commercial harvest (1991-2008).

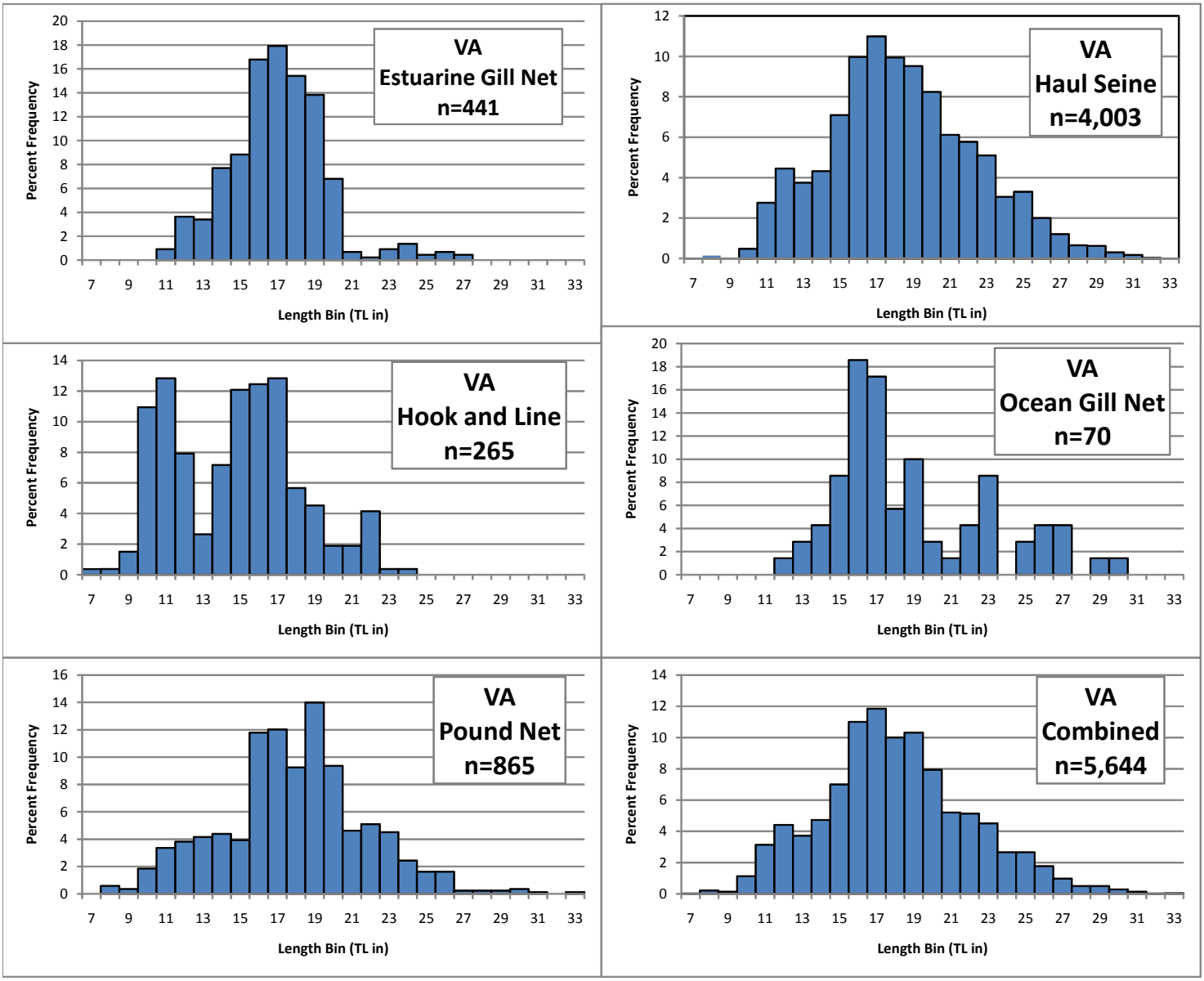

Figure 3. Length frequency distribution of fish sampled from Virginia's commercial harvest distribution (1998-2008).

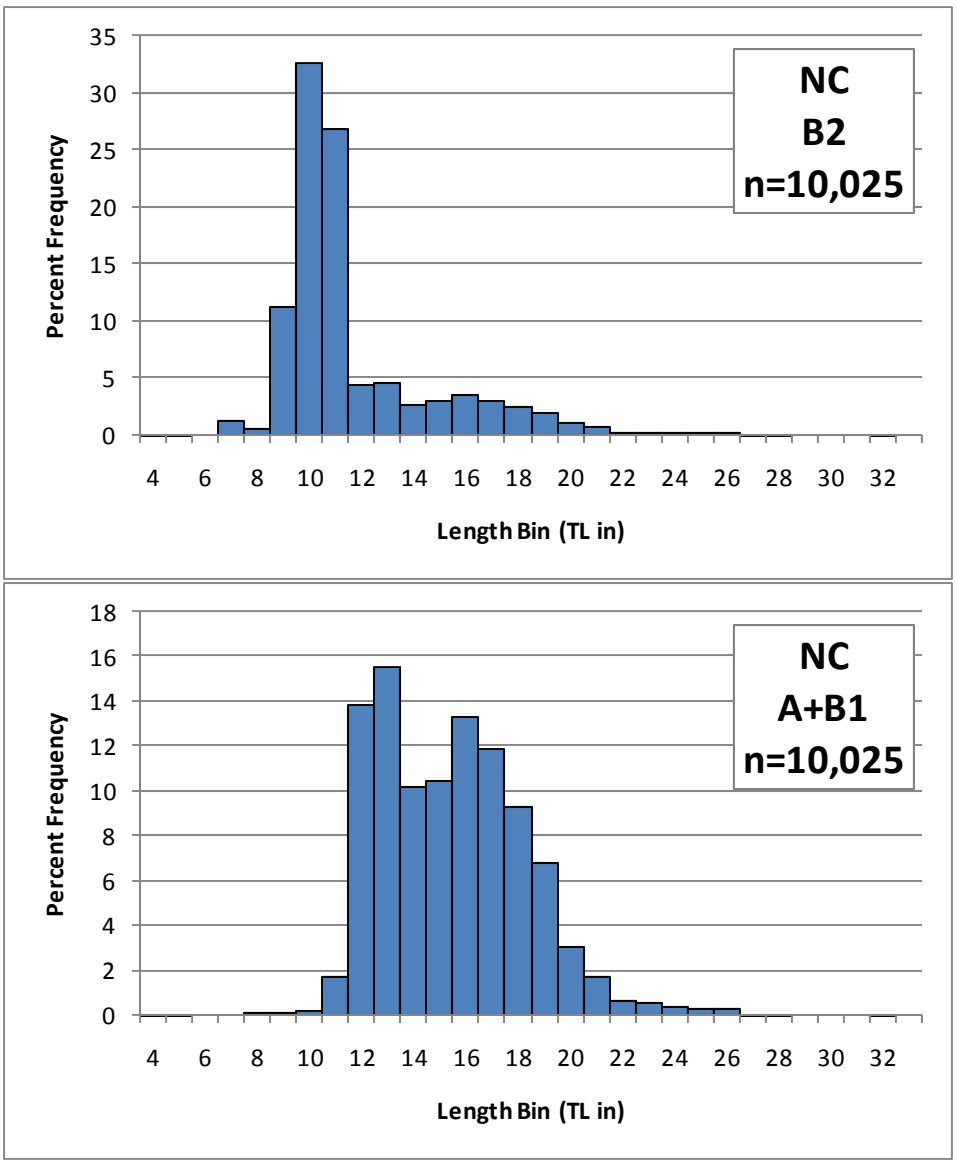

Figure 4. Length-frequency distributions of North Carolina's recreational harvest (A+B1) and releases (B2), 1991-2008 combined.

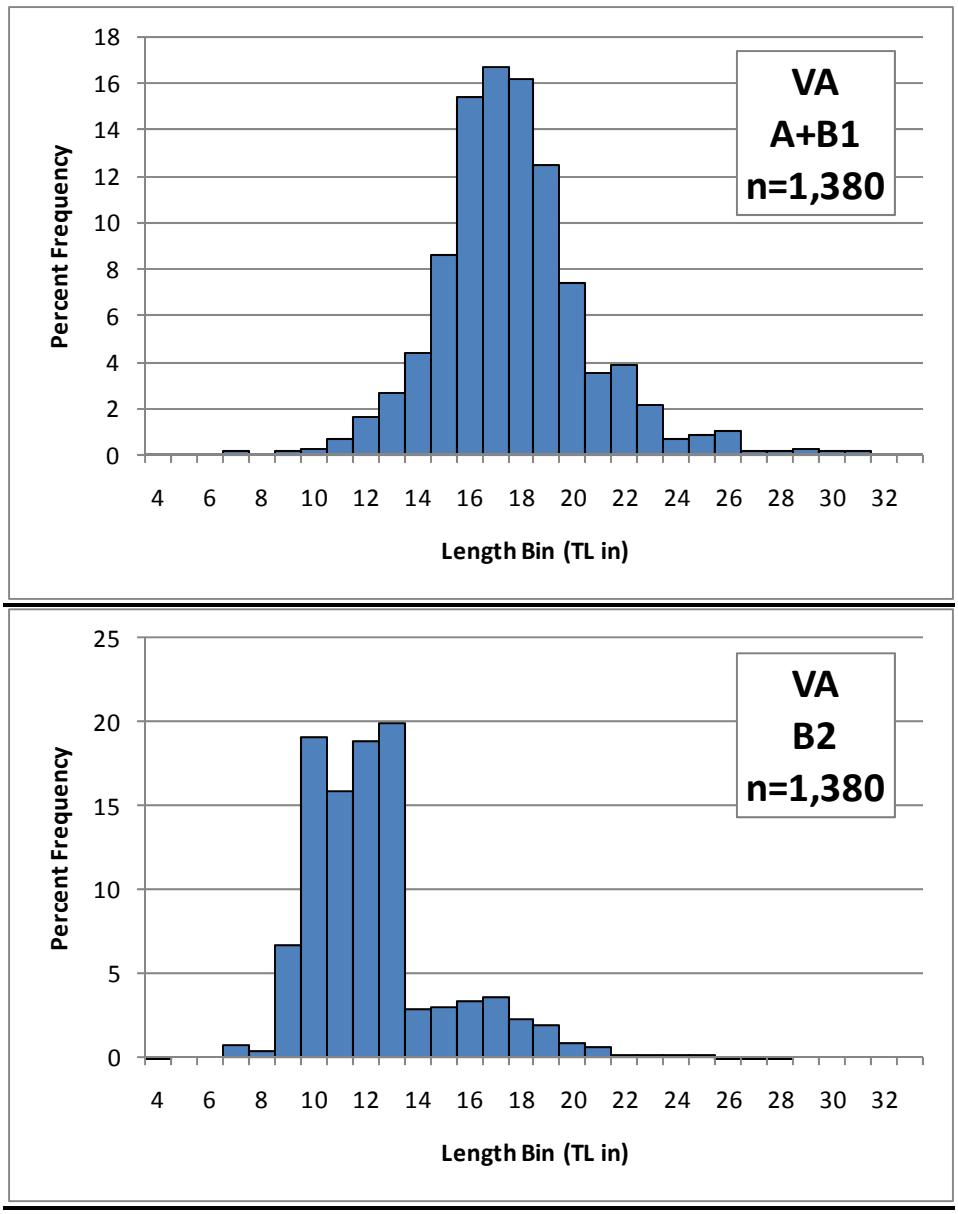

Figure 5. Length-frequency distributions of Virginia's recreational harvest (A+B1) and releases (B2), 1991-2008 combined.

APPENDIX A. CHANGES IN BAG LIMITS AND TRIP LIMITS

INTRODUCTION

There is evidence that the population levels of spotted seatrout have increased since the terminal year in the last stock assessment (2006). This evidence suggests that the spawning stock biomass (SSB) could be closer to the threshold than was seen in the terminal year of the stock assessment (2006). As a result, the stock assessment is being updated with 2007 and 2008 data. Given the potential changes to the stock, we cannot say with much certainty how much of a reduction is required until the stock assessment is updated; however, fishing rates will likely remain high. Possible harvest and reduction estimates are presented for proposed bag limit changes in the recreational fishery (Table A1; Figure A1) and commercial trip limits in the commercial fishery (Table A2; Figure A2).

Examination of the MRFSS and the commercial gill net indices updated through 2008 show that the current catch rates are high relative to the rest of the time series and are near levels seen in the late 1990s (Figure A3). A graph of the catch-at-age matrix updated through 2008 also reveals large numbers of spotted seatrout being caught in the past few years (Figure A4). Large year classes of age-0 recruits were observed 2007 and 2008. In addition, there is also evidence of some age expansion in the population with age-3 fish now being observed in the catch in noticeable amounts for the first time since 2000.

METHODS

All analyses assumed regulations would impact only fishermen in North Carolina, while all future harvest and dead discards from Virginia were assumed to remain the same. Numbers shown include both North Carolina and Virginia harvest. All calculations were based on input data averaged from 2004 to 2006.

Bag Limit Analysis

Reductions in bag limits were empirically-based predictions using the average catch per angler trip estimated from 2004 to 2006 from the MRFSS survey (Table A1; Appendix B). Any trips that landed over the proposed new limit in the past were assumed to land the maximum amount allowed under the proposed new limit. This analysis assumed 100% compliance with proposed regulations. Bag limits affected only the recreational fishery.

Trip Limit Analysis

Reductions in trip limits were empirically-based predictions using the average catch per trip reported on trip tickets from 2004 to 2006 (Table A2; Appendix B). Any trips that landed over the proposed new limit in the past were assumed to land the maximum amount allowed under the proposed new limits. This analysis assumes 100% compliance with proposed regulations. Trip limits affect only the commercial fishery.

RESULTS

Bag Limit Analysis

Bag limits only impact the recreational fishery and, because of the size of the recreational fishery, they can be effective at reducing the overall harvest. Approximately 70% of the trips

that anglers took from 2004 to 2006 landed 3 or fewer spotted seatrout (Figure A1). Of all trips that landed spotted seatrout, 6% attained the 10 fish bag limit, and 1% of the trips exceeded the legal limit. The bag limit must be reduced from 10 to 5 fish to get at least a 10% reduction in total harvest (Table A1).

Trip Limit Analysis

Spotted seatrout are not targeted by the majority of commercial fishermen. The vast majority of trips (65%) landed 10 pounds or less per trip from 2004 to 2006 (Figure A2). Nearly 90% of trips landed 50 pounds or less per trip. Therefore, North Carolina commercial fishermen land so few spotted seatrout per trip and make up a smaller portion of the overall harvest that commercial trip limits alone have limited effectiveness in reducing the overall harvest.

Table A1. Predicted harvest and percent reductions under various bag limit changes in the recreational spotted seatrout fishery. Values are based on averages MRFSS survey estimates from 2004 to 2006. Assumes 100% compliance.

Numbers

Bag limit	Rec Harvest	% Reduction in Rec Harvest	Total Harvest (Rec & Com) + Dead Discards	% Reduction in Total Harvest + Dead Discards
1	205,045	-62	414,219	**-44**
2	295,312	-45	504,486	**-32**
3	357,729	-33	566,903	**-24**
4	403,873	-24	613,047	**-18**
5	440,453	-18	649,627	**-13**
6	467,809	-12	676,983	**-9**
7	489,301	-8	698,475	**-6**
8	505,707	-5	714,881	**-4**
9	517,675	-3	726,849	**-2**
10	528,102	-1	737,276	**-1**

Pounds

Bag limit	Rec Harvest	% Reduction in Rec Harvest	Total Harvest (Rec & Com) + Dead Discards	% Reduction in Total Harvest + Dead Discards
1	304,299	-62	588,904	**-45**
2	438,261	-45	722,865	**-33**
3	530,891	-33	815,496	**-24**
4	599,371	-24	883,975	**-18**
5	653,658	-18	938,262	**-13**
6	694,256	-12	978,861	**-9**
7	726,151	-8	1,010,756	**-6**
8	750,499	-5	1,035,103	**-4**
9	768,259	-3	1,052,864	**-2**
10	783,734	-1	1,068,339	**-1**

Table A2. Predicted harvest and percent reductions under various commercial trip limits for spotted seatrout. Values are based on average landings reported on trip tickets from 2004 to 2006. Assumes 100% compliance.

Numbers

Trip Limit	Com Harvest	% Reduction in Com Harvest	Total Harvest (Rec & Com) + Dead Discards	% Reduction in Total Harvest + Dead Discards
10	35,233	-69	558,147	**-12**
25	48,301	-57	571,215	**-10**
50	60,638	-46	583,553	**-8**
100	74,004	-34	596,918	**-6**
150	82,077	-27	604,991	**-5**
200	87,745	-22	610,659	**-4**
250	91,931	-19	614,846	**-3**
300	95,107	-16	618,021	**-3**
350	97,780	-13	620,695	**-2**
400	99,950	-11	622,864	**-2**
450	101,800	-10	624,714	**-2**
500	103,335	-8	626,249	**-1**
None	112,825	0	635,739	**0**

Pounds

Trip Limit	Com Harvest	% Reduction in Com Harvest	Total Harvest (Rec & Com) + Dead Discards	% Reduction in Total Harvest+ Dead Discards
10	63,329	-70	831,635	**-15**
25	88,728	-59	857,034	**-13**
50	112,706	-47	881,012	**-10**
100	138,683	-35	906,989	**-8**
150	154,373	-28	922,679	**-6**
200	165,389	-23	933,695	**-5**
250	173,525	-19	941,831	**-4**
300	179,697	-16	948,003	**-4**
350	184,893	-14	953,199	**-3**
400	189,110	-12	957,416	**-3**
450	192,705	-10	961,011	**-2**
500	195,689	-9	963,995	**-2**
None	214,132	0	982,438	**0**

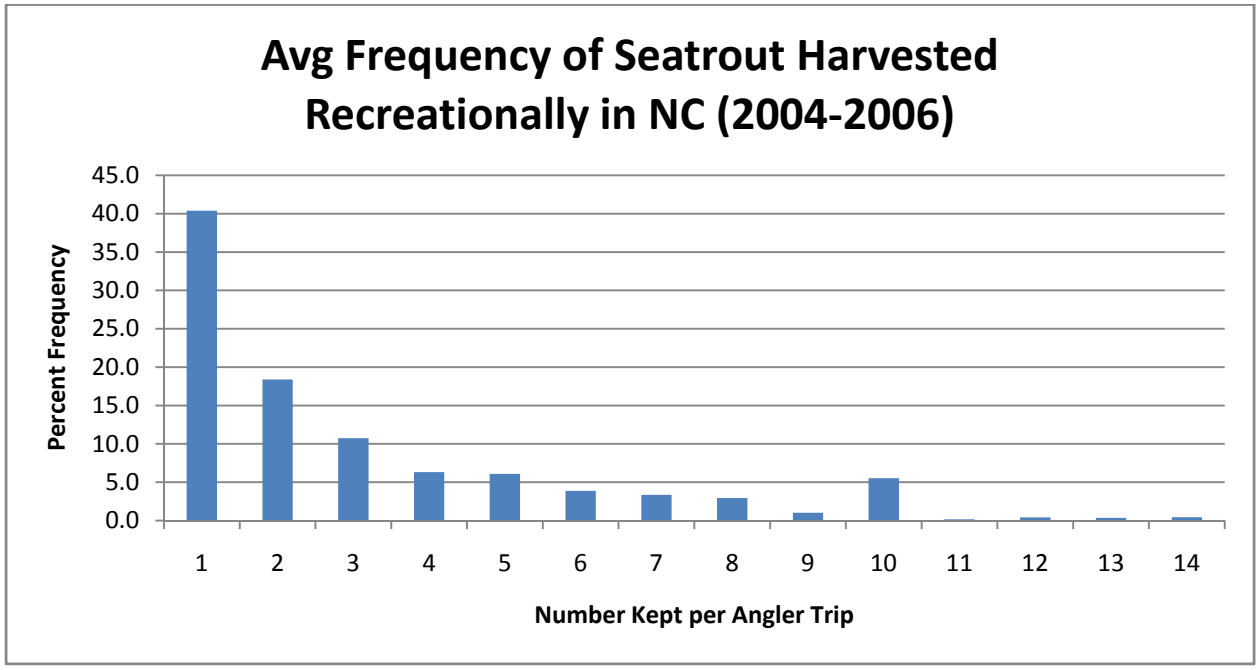

Figure A1. Average Frequency of Spotted Seatrout harvested in the North Carolina recreational fishery from 2004 to 2006.

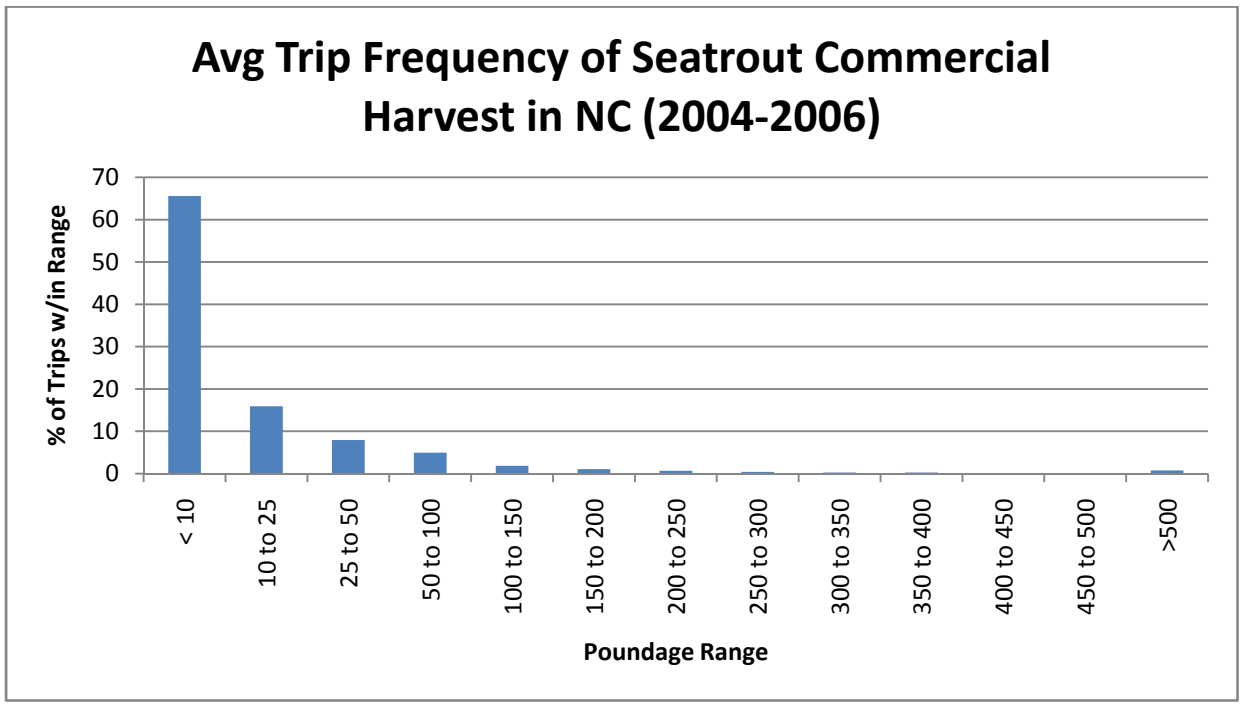

Figure A2. Average frequency of amount of spotted seatrout landed (lb) per trip from 2004 to 2006.

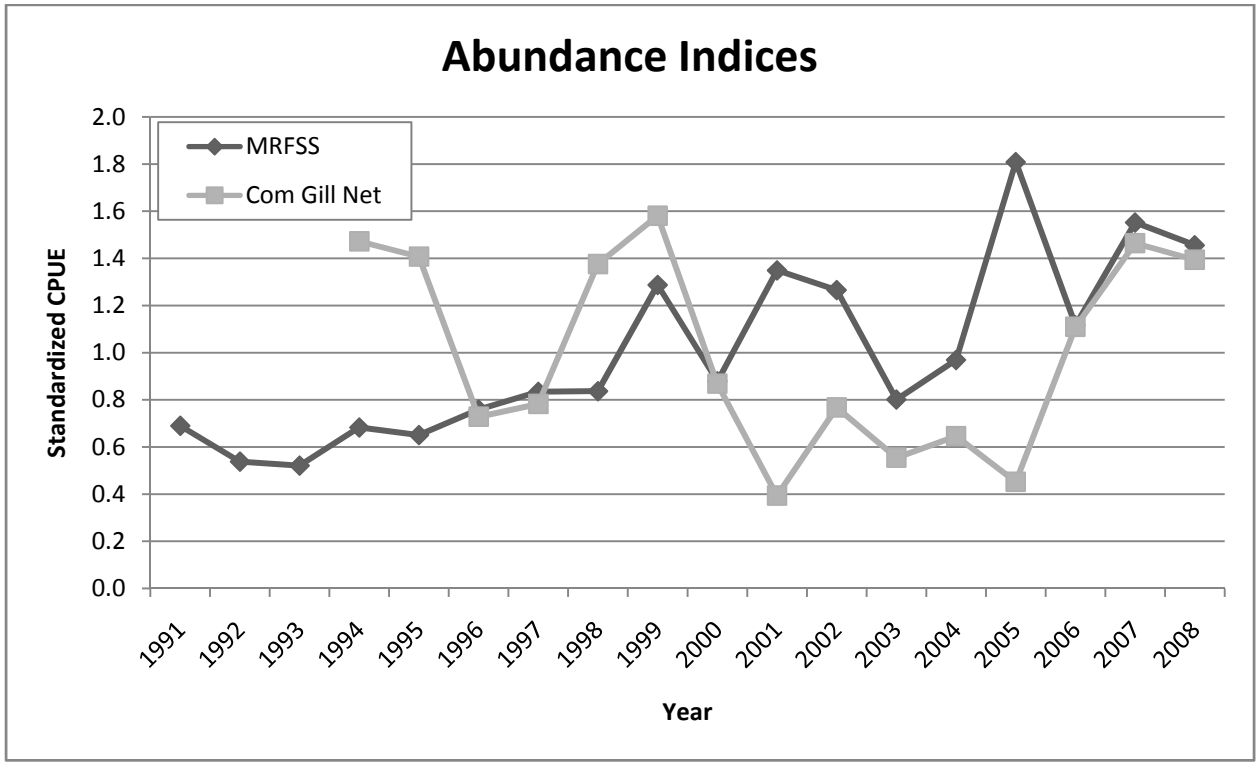

Figure A3. Standardized abundance indices of spotted seatrout from the MRFSS survey and the commercial gill net fishery, 1991-2008

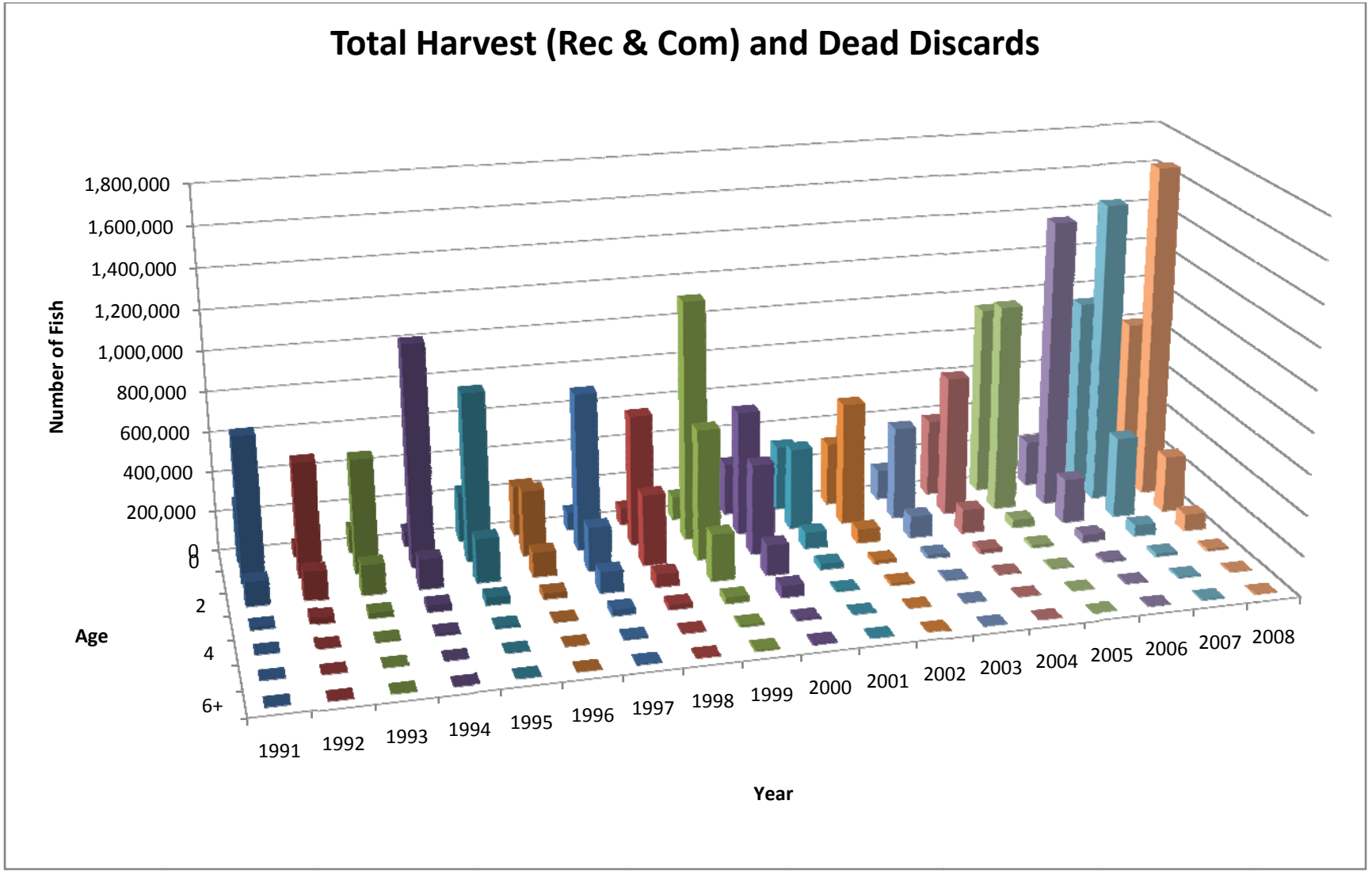

Figure A4. Catch at age matrix for total harvest (recreational and commercial) and recreational dead discards, 1991-2008.

V. MANAGEMENT OPTIONS

(+ potential positive impact of action)
(- potential negative impact of action)

1) Status quo
   + No additional burden on fishermen, dealers, or managers
   - Does not address historical trend of overfishing
   - Does not address dependence of fishery on year-class strength
   - Maintenance of fishing mortality at or below $F_{Threshold}$, as required by the Fisheries Reform Act, will likely not be achieved

2) Size limit increase

   + Allows opportunity for fish to spawn at least once before they are harvested
   + Gets closer to goal of ending overfishing
   - Given potential change in stock dynamics, it is uncertain what level of harvest reduction is needed to rebuild the stock
   - Additional burden on fishermen, dealers, and managers

3) Bag limit reduction
   + Gets closer to goal of ending overfishing
   - Given potential change in stock dynamics, it is uncertain what level of harvest reduction is needed to rebuild the stock
   - Would take a large change in the bag limit to get a sizeable reduction in overall reduction
   - Additional burden on fishermen and managers
   - Continues to allow some fish to be harvested before they spawn

4) Trip limit Implementation
   - Given potential change in stock dynamics, it is uncertain what level of harvest reduction is needed to rebuild the stock
   - Limited effectiveness in reducing the overall harvest
   - Additional burden on fishermen, dealers, and managers
   - Continues to allow some fish to be harvested before they spawn

APPENDIX B. INPUT DATA USED IN HARVEST REDUCTION ANALYSES.

Table B1. Average weighted length frequency (in numbers) of North Carolina recreational spotted seatrout harvest, 2004-2006.

Length Bin	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
4	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.
8	1,588	196	.	.	.	.	.
9	752	269	.	.	.	.	.
10	528	360	.	.	.	.	.
11	6,674	3,131	26	.	.	.	.
12	41,856	46,888	754	.	.	.	.
13	26,457	76,005	1,893	.	.	.	.
14	3,327	35,154	2,930	.	6	.	.
15	.	33,725	2,496	16	.	.	.
16	.	37,224	5,893	.	.	.	.
17	.	41,918	5,575	84	.	.	.
18	.	31,008	6,185	.	.	.	.
19	.	22,543	9,873	2,968	590	.	.
20	.	7,801	4,217	1,374	211	322	.
21	.	6,168	4,892	1,484	443	135	58
22	.	583	1,422	2,449	634	101	17
23	.	97	2,244	756	212	200	32
24	.	.	2,831	761	251	180	71
25	.	.	277	433	.	.	54
26	.	.	.	.	345	197	46

Table B2. Average weighted length frequency (in numbers) of North Carolina recreational spotted seatrout releases 2004-2006.

Length Bin	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
4	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
7	11,507	.	.	.	.	.	.
8	5,005	616	.	.	.	.	.
9	75,117	30,652	70	.	.	.	.
10	133,544	149,924	.	.	.	.	.
11	110,846	120,699	910	.	.	.	.
12	21,387	26,009	561	.	.	.	.
13	10,695	39,091	1,579	.	.	.	.
14	1,112	17,979	2,532	.	18	.	.
15	.	15,391	2,593	45	.	.	.
16	.	15,740	3,683	.	.	.	.
17	.	17,390	5,220	116	.	.	.
18	.	13,602	3,499	.	.	.	.
19	.	9,635	5,992	1,739	379	.	.
20	.	3,678	2,916	895	130	240	.
21	.	2,835	2,412	906	256	107	30
22	.	310	654	1,674	371	68	12
23	.	73	913	413	93	96	20
24	.	.	1,139	429	131	104	40
25	.	.	154	241	.	.	30
26	.	.	.	.	257	147	34

Table B3. Average weighted length frequency (in numbers) of North Carolina commercial spotted seatrout harvest 2004-2006.

Length Bin	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
7	.	.	.	.	.	.	.
8	6	1	.	.	.	.	.
9	21	54	1	.	.	.	.
10	39	161	.	.	.	.	.
11	256	607	5	.	.	.	.
12	1,038	2,871	28	.	.	.	.
13	906	7,436	273	.	.	.	.
14	459	8,745	407	.	5	.	.
15	.	10,317	579	11	.	.	.
16	.	13,143	2,198	.	.	.	.
17	.	13,090	3,487	62	.	.	.
18	.	10,201	3,837	542	.	.	.
19	.	5,617	2,699	808	106	.	.
20	.	2,171	1,092	418	49	36	.
21	.	491	785	362	88	38	10
22	.	82	490	288	92	14	2
23	.	22	490	473	113	56	19
24	.	.	355	225	99	40	22
25	.	.	42	174	98	15	20
26	.	.	4	138	124	45	12
27	.	.	.	13	14	5	2
28	.	.	.	2	20	34	25
29	.	.	.	26	79	28	1
30	.	.	.	.	.	4	16
31	.	.	.	.	.	.	.

Table B4. Average catch at age (in numbers) of Virginia recreational spotted seatrout harvest 2004-2006.

Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
320	40,878	9,797	2,113	400	29	59

Table B5. Average catch at age (in numbers) of Virginia recreational spotted seatrout releases 2004-2006.

Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
88,053	128,696	19,462	2,630	420	140	25

Table B6. Average weight (lb) at age of spotted seatrout discards 2004-2006.

Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
0.42	0.78	2.26	3.32	3.52	4.02	4.09

Table B7. Average number of angler trips and number of spotted seatrout harvested in the recreational fishery used in the bag limit analysis, 2004-2006.

Seatrout Bagged	# of Angler Trips	# Seatrout Harvested
0	6,879,603	0
1	61,182	61,182
2	27,850	55,700
3	16,274	48,821
4	9,563	38,253
5	9,224	46,119
6	5,865	35,188
7	5,085	35,598
8	4,439	35,510
9	1,540	13,860
10	8,357	83,572
11	238	2,621
12	644	7,729
13	528	6,859
15	660	9,903

Table B8. Average number of pounds and trips in the North Carolina spotted seatrout fishery used for the trip limit analysis, 2004-2006.

Trip Limit	% of Trips	Avg Trips	Avg Pounds	Cumulative Pounds
10	65.6	4,644	15,917	15,917
25	15.9	1,126	17,039	32,956
50	7.9	562	19,378	52,334
100	5.0	352	23,877	76,211
150	1.9	132	15,790	92,001
200	1.0	73	12,516	104,517
250	0.7	48	10,686	115,203
300	0.4	30	8,122	123,325
350	0.3	18	5,946	129,271
400	0.3	18	6,767	136,038
450	0.2	12	5,245	141,283
500	0.2	11	5,334	146,617
None	0.7	52	44,443	191,060

APPENDIX C. DETERMINING IMPACTS OF SIZE LIMIT CHANGES

Equations used to determine harvest:

$$F_{harvest} = F_{mult} \times selectivity \times (1 - proportion\ released)$$

$$F_{dead\ discard} = F_{mult} \times selectivity \times (proportion\ released) \times (release\ mortality)$$

For recreational fishing, only proportion released will change – not selectivity.

$$Proportion\ Released = \frac{B2}{A + B1 + B2}$$

$$Proportion\ Harvested = \frac{A + B1}{A + B1 + B2}$$

Some undersized fish are still harvested, so a weighted average will be used to get the average proportion of undersized harvest.

Future B2 harvest

For size classes that don't change:

$$B2_{future\ no\ change} = (A + B1 + B2) \times Current\ Proportion\ Released$$

For size classes that do change:

$$B2_{future\ change} = (A + B1 + B2) \times (1 - Avg\ Proportion\ of\ Undersized\ Harvest)$$

$$Total\ B2_{future} = B2_{future\ no\ change} + B2_{future\ change}$$

$$Future\ Proportion\ Released = \frac{Total\ B2_{future}}{A + B1 + B2}$$

Average future proportion released for years of interest (e.g., last 3 years) for further analysis.

To find out what a size limit change equates to in F_{full} (for input into projections) use the following equations (apply to all cells for each age in each year):

$$F_{harvest} = F_{mult} \times selectivity \times (1 - future\ proportion\ released)$$

$$F_{dead\ discard} = F_{mult} \times selectivity \times (future\ proportion\ released) \times (release\ mortality)$$

$$F_{total} = F_{harvest} + F_{dead\ discard}$$

To get projected harvest in <u>numbers</u>, use the Baranov Catch Equation (apply to all cells for each age in each year):

$$C_{numbers} = N \times \left(\frac{F_{harvest}}{M + F_{total}}\left[1 - e^{-(M+F_{total})}\right]\right)$$

To get projected harvest in <u>pounds</u>, multiply the catch in numbers by the mean weight at age (apply to all cells for each age in each year):

$$C_{pounds} = C_{numbers} \times mean\ weight\ at\ age$$

Enter into AGEPRO the new selectivity and F_{full}:

$$new\ selectivity_a = \frac{F_a}{maxtmum\ F_a\ at\ age\ for\ a\ given\ year}$$

a.k.a. F_{full}