Bluefish 2014 Stock Assessment Update

Data and Model Update Through 2013

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Executive Summary

The updated stock assessment was completed by adding catch and independent indices through 2013 to the previous 1982-2012 assessment. Catch information consisted of commercial landings and length frequencies from Maine to Virginia collected by the Northeast Fisheries Science Center, North Carolina landings and length information collected by NC Division of Marine Fisheries, Florida landings and length information collected by FL Fish and Wildlife Research Institute, and recreational landings and discards from Maine to Florida collected in the NMFS Marine Recreational Information Program (MRIP). The catch data were combined with fisheries independent survey data from the Northeast Fisheries Science Center, DE DNR, NJ DEP, CT DEEP, coast-wide recreational catch per angler, as well as juvenile indices from the SEAMAP program in the South Atlantic, in a forward projecting catch at age model (ASAP). Fishery dependent and independent information was partitioned into ages using a 2013 age-length key developed by Old Dominion University.

The result of the analysis shows that bluefish is not overfished or experiencing overfishing. Fishing mortality in 2013 was 0.118, below the biological reference point (F_{MSY}) of 0.19. Fishing mortality steadily declined from 0.32 in 1987 to 0.11 in 1999 and has remained steady since 2000 with an average F=0.133. Total stock biomass estimates peaked in 1982 at 363 thousand MT, then declined to 80.9 thousand MT by 1996 before increasing steadily to the 128 thousand MT in 2010 and slightly declining again to 123.7 thousand MT in 2013. Recruitment estimated in the ASAP model has remained relatively constant since 2002 at around 20 million age-0 bluefish, with the exception of a relatively large 2006 cohort estimated as 32.5 million fish. However, beginning in 2009 recruitment dropped to 14.3 million and the 2010 and 2011 recruitment estimates were also below average at 16.1 and 12.9 million fish, respectively. Recruitment for 2013 is 13.3 million fish, up from an all-time low in 2012 of 8.9 million fish. Low estimates of recruitment in previous years were likely due to retrospective bias resulting in the model underestimating recruitment near the end of the time series. This bias has minimized and flipped with the 2013 model update. A projection of the abundance through 2016, under five different fishing scenarios between F=0.10 and F=0.19, suggest that biomass will continue to decline due to poor incoming year classes. Changes in the NMFS survey (no

longer sampling inshore strata, timing off in 2013), limited age information, discard size data and model configuration all contribute to the uncertainty in the assessment.

Introduction

The Atlantic coast stock of bluefish (*Pomatomus saltatrix*), distributed from Maine through eastern Florida, is jointly managed by the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fishery Management Council (MAFMC). A total annual quota is established and allocations given to commercial and recreational fisheries. The management plan requires a distribution of 80% to recreational and 20% to commercial, with provisions to shift unused recreational quota to commercial fisheries.

A bluefish stock assessment was presented for peer-review at the Northeast Fisheries Science Center Stock Assessment Review Committee meeting in 2005 (NEFSC SARC 41). The reviewers accepted the assessment for use in management decisions although there were some reservations about the modeling approach. Since the review, the bluefish stock assessment sub-committee (SASC) has produced annual updates while maintaining the basic model settings from the approved assessment. The current assessment is a continuation of the model update with the addition of 2013 catch at age and indices at age information.

Life History

Bluefish, *Pomatomus saltatrix*, is a coastal, pelagic species found in temperate and tropical marine waters throughout the world (Goodbred and Graves 1996; Juanes et al. 1996). Bluefish spawn in offshore waters (Kendall and Walford 1979; Kendall and Naplin 1981). Larvae develop into juveniles in continental shelf waters and eventually move to estuarine and nearshore shelf habitats (Marks and Conover 1993; Hare and Cowen 1994; Able and Fahay 1998; Able et al. 2003). Bluefish are highly migratory along the U.S. Atlantic coast and seasonally move between the U.S. South Atlantic and Middle-Atlantic, traveling as far north as Maine (Shepherd et al., 2006).

Several studies show bluefish to be a moderately long-lived fish with a maximum age of 14 years (Hamer 1959; Lassiter 1962; Richards 1976; Barger 1990; Chiarella and Conover 1990; Terceiro and Ross 1993; Austin et al. 1999; Salerno et al. 2001; Sipe and

Chittenden 2002). Bluefish up to 88 centimeter (cm) fork length (FL) have been aged (Chiarella and Conover 1990; Salerno et al. 2001), although Terceiro and Ross (1993) noted considerable variation in mean bluefish size-at-age. Scale ages have been used to estimate von Bertalanffy growth parameters (Lassiter 1962; Barger 1990; Terceiro and Ross 1993; Salerno et al. 2001). The values for L_∞ from these studies (87-128 cm FL) match closely to the largest individuals in catch data and growth rates do not differ between sexes (Hamer 1959; Salerno et al. 2001).

Bluefish grow nearly one-third of their maximum length in their first year (Richards 1976, Wilk 1977). Variation in growth rates or sizes-at-age among young bluefish is evident from the appearance of intra-annual cohorts. Lassiter (1962) identified a spring-spawned cohort and a summer-spawned cohort from the bimodal appearance of size at Annulus I for fish aged from North Carolina and the seasonal cohorts can differ in age by two to three months. Summer-spawned larvae and juveniles grow faster than spring-spawned larvae and juveniles (McBride and Conover 1991) although size differences at annual age diminish greatly after three to four years (Lassiter 1962).

Spawning occurs offshore in the western North Atlantic Ocean, from approximately Massachusetts to Florida (Norcross et al. 1974; Kendall and Walford 1979; Kendall and Naplin 1981; Collins and Stender 1987). Bluefish are characterized as iteroparous spawners with indeterminate fecundity and spawn continuously during their spring migration (Robillard et al. 2008). In addition to distinctive spring and summer cohorts, Collins and Stender (1987) identified a fall-spawned cohort, demonstrating the potential of an extended bluefish spawning season.

Bluefish in the western North Atlantic are managed as a single stock (NEFSC 1997; Shepherd and Packer 2006). Genetic data support a unit stock hypothesis (Graves et al. 1992; Goodbred and Graves 1996; Davidson 2002). For management purposes, the ASMFC and MAFMC define the management unit as the portion of the stock occurring along the Atlantic Coast from Maine to the east coast of Florida.

Fisheries Dependent Data

Annual catch information was developed for five components of the commercial fishery. Commercial landings from Maine to Virginia, North Carolina commercial

landings, Florida commercial landings, coast-wide recreational landings and coast-wide recreational discards.

Commercial fisheries from Maine to Virginia were sampled as part of the NEFSC data collection program. Lengths were sampled from a variety of gears and market categories. Expansion of length data was completed by market category and quarter of the year, with the results merged into half year periods. In 2013 a total of 5,379 measurements were collected across all market categories from total landings of 1,381 MT (70% of all commercial landings; Table 1). Market category/quarter with inadequate length samples were filled with length information from adjacent quarters within the same market category.

North Carolina commercial landings were expanded using length samples collected by NC Division of Marine Fisheries. A total of 795 measurements were collected from landings of 515 MT (Table 1). Expansion of landings at length were done by quarter, market category and gear type and then combined into half year totals.

Length samples from Florida 2013 commercial landings were also available. A total of 182 lengths were used to expand commercial landings of 65 MT (Table 1). No landings were reported for South Carolina or Georgia. Total coast-wide commercial landings in 2013 were 1,961 MT, a decrease of 275 MT from 2012 (Figure 1).

Length frequencies from commercial fisheries are characterized by a skewed distribution, lacking the multi-modal distribution seen in previous years. In 2013 the distribution had a strong peak at 36 cm and lacked the definitive second peak at around 70 cm seen in previous years (Figure 2).

Recreational landings are sampled for length as part of the MRIP program. The 2013 recreational landings were 6,980 MT, an increase from 4,846 MT in 2012 (Table 2, Figure 3). The MRIP 2012 length samples were used to expand recreational landings per half year. Recreational discards in 2013 were estimated at 15,207 MT and after adjusting for a 15% mortality rate the resulting discard loss was 2,281 MT. A recent publication (Fabrizio et al 2008) shows that mortality may be higher and the 15% should be reevaluated in the next benchmark assessment. Length sampling of bluefish tagged and released in the American Littoral Society tagging program (by definition B2 catches) were included in the length distribution (n=730). Length frequencies from the

recreational catch and discards show a similar trend to the commercial length frequency. While previous years were characterized by a bimodal distribution, the 2013 length frequency is a skewed distribution, with a main peak around 28 cm and a flat/slightly-decreasing distribution out to 90 cm (Figure 4). Total combined (commercial and recreational) length frequencies are presented in Figure 5.

Recreational landings are also used to develop a recreational catch per angler trip index. In 2013 this CPA index showed a small decrease to 0.34 fish per angler trip from 0.37 in 2012 (Table 3). The recreational catch per angler was modeled in a generalized linear model using a negative binomial error structure. The year coefficient partitioned into ages (assuming the same proportion as the recreational catch) was used in the ASAP model as a relative index of abundance.

Age data were provided by Virginia Marine Resources Commission and Old Dominion University ageing lab (n = 466). It should be noted that other age data from multiple states along the Atlantic coast is available for bluefish. For consistency with previous years (adhering to the definition of an update assessment) only ODU data were used. Various sources of new age data will be considered and peer reviewed at the upcoming benchmark assessment (2015).

The length frequencies by age were converted to weight for calculation of annual weights at age (Table 4, Figure 6). Length-weight equations from the spring and fall NEFSC bottom trawl survey were used for calculating weights at age. Due to low sample size in spring surveys, all years beginning with 1992 were used in the equation (n=290, a = -11.377, b = 3.009). Fall equations were estimated from combined 2004-2013 length-weight data (n = 3867, a = -11.604, b = 3.092).

The 2013 catch at age (includes commercial landings, recreational landings and recreational discards) is presented in table 5. As in previous bluefish assessments the ages are summarized in a plus category for ages 6 and above to reduce the effect of aging error.

Fisheries Independent Data

Survey indices as used in the previous bluefish assessment were updated for 2013. These indices include SEAMAP juvenile (age 0) indices, Northeast Fisheries Science

Center (NEFSC) bottom trawl survey indices for ages 0 to 6+, CT DEEP bottom trawl survey for ages 0-6+, NJ bottom trawl survey indices of ages 0 to 2, and DE bottom trawl survey indices for ages 0 to 2. The CT DEEP bottom trawl survey in 2008 and 2010 were not conducted during the month of September, therefore these indices were treated as missing data. The NEFSC survey in 2009 was modified by the replacement of the FV Albatross IV with the FSV Henry B. Bigelow. The consequence of the replacement was a change in the areas surveyed and the efficiency of the survey due to a change in net size and towing speed (as well as other intangibles associated with a different vessel). Beginning in 2009 only the outer third of the inshore strata set was sampled by the Bigelow. In addition, a conversion coefficient of 1.16 was used to convert Bigelow mean number per tow into equivalent Albatross units (Miller et al., 2010).

Among these survey indices, there were no consistent trends in total abundance. The total NEFSC index (log re-transformed stratified mean number per tow) declined from 38.05 in 2006 to 6.66 in 2010, increased to 7.45 in 2011, and dropped to 5.27 in 2012 (Table 6). The value of the index for 2013 is 0.99, the lowest in the time series. This low value is likely a result of the later timing of the survey in 2013 due to a 2+ week government shutdown. The 2013 Delaware survey index of ages 0 to 2 was 0.17 fish per tow, and below the time series average (0.48 per tow; Table 7). New Jersey trawl survey indices of ages 0 to 2 for 2013 (4.2 fish/tow) was also below the time series average of 6.7 per tow (Table 7). The Connecticut DEP survey index for 2012 was 17.12, lower than the mean of 32.3, and a drop from the 2012 estimate of 25.19 (Table 8).

ASAP Model

The ASAP model was run as an update of previous 1982-2012 input file, updated for 2013 total catch, catch at age, weight at age, and indices at age. The fishery was modeled as a single fleet with selectivity fixed as a bimodal pattern with full recruitment at age 1 (coded age 2). Model weighting factors remained the same as previous assessments with the model weighted towards the fishery total catch more than the survey indices. Input CVs around the NMFS fall survey indices were relaxed in 2013 to provide the model more flexibility and to mitigate the effects of the survey timing. Natural mortality was fixed at 0.2 and maturity at age was held constant with full maturity at age

3. The updated model was run using the same parameter settings while substituting the updated catch and weight at age matrices.

The results of the updated ASAP model showed a decrease in total abundance since 2006, declining from 90.4 million to 59.5 million fish (Table 9, Figure 7). Poor recruitment began in 2009 with a below average estimate of 13.5 million fish compared to the series average of 21.4 million. Low recruitment persisted for 2010 and 2011, and estimated recruitment in 2012 was the lowest in the time series at 8.9 million fish. Recruitment for 2013 increased to an estimate of 13.3 million (Table 9, Figure 8). The estimate of age 6-plus bluefish for 2013 continued to be large at 14.3 million. Total mean biomass in 2013 equaled 123,716 MT, a slight increase from the 2012 estimate of 121,998 MT (Table 10, Figure 9). Corresponding spawning stock biomass (SSB) in 2012 was 114,382 MT, a slight decrease from the 2012 estimate of 117,417 MT (Figure 9, Table 11).

Fishing mortality estimates in ASAP are based on a separability assumption with F at age the product of F_{MULT} and selectivity. Full selectivity is fixed at age 1. The 2013 F_{MULT} value equals 0.118 (Figure 7, Table 11). Fishing mortality steadily declined from 0.32 in 1987 to 0.11 in 1999 and has remained relatively steady since 2000, with a slight declining trend in recent years.

Retrospective bias for the final model was examined for F, total abundance, recruitment (age 0) and total biomass. The analysis shows little evidence of bias in the estimates of SSB, F, and total abundance. A small retrospective bias has been present in the recruitment estimates going back to the early 2000's (Figure 10). This bias has been increasing in recent years, however, for 2013 the direction of the bias flipped and the magnitude decreased. The variation in the final model results for F and SSB was determined using a Monte Carlo Markov chain with 1000 iterations and a thinning factor of 100. The MCMC results of variation around F ranged from 0.098 to 0.145, with the 80% CI between 0.111 and 0.126. Estimates for SSB ranged from 93,500 to 138,700 MT, with an 80% CI between 108,000 MT and 124,200 MT. (Figure 11).

Projections

Bluefish abundance and biomass through 2016 were examined for a range of fishing scenarios with a stochastic projection in AGEPRO software. Weight at age in 2014-2016 was assumed equal to 2013, recruitment was derived from a random draw of 32 empirical estimates of age 0 abundance since 1982 and initial population size was drawn from the output of the MCMC run. Fishing quota for 2014 was set equal to the ACL of 11,082 MT. Five standard projection scenarios were examined: F =0.10, F=status quo (0.118), F_{target} (0.17) which equals 90% of F_{MSY} as defined in FMP, $F_{0.1}$ (0.16) from the yield per recruit, and F_{MSY} (0.19).

Results of the projections show a decrease in mean biomass and SSB for each scenario (Table 12). Abundance increased slightly in all cases except for projections at F_{MSY}. Yield through 2016 would be projected as lower for F scenarios of F_{low} or F_{sq} or less. Under status quo F (0.118), projected 2015 yield would decrease to 9,920 MT, which includes commercial and recreational landings as well as recreational discards losses.

Biological Reference Points

The current biological reference points for bluefish were determined in SARC 41 and are F_{MSY} (0.19) and B_{MSY} (147,052 MT). The basis for the reference points was the Sissenwine-Shepherd method using the Beverton-Holt stock recruitment parameters and SSB per recruit results generated by the SARC 41 ASAP model results. B_{MSY} was calculated using mean weights at age and is therefore comparable to mean biomass in year *t*. The 2013 estimate of mean total biomass is 123,716 MT, which is below B_{MSY} but well above ½ B_{MSY} of 73,526 MT. The 2013 estimate of fishing mortality (0.118) remains well below F_{MSY}.

Model Uncertainty

Model uncertainty can be characterized using the MCMC simulations to produce a distribution of possible outcomes given the model input parameters. However, these results do not capture the uncertainty from variations in the model input parameters. Forward projecting catch at age models are extremely flexible in applying weighting

factors to emphasize either catch data or survey data. It should be noted that the current model is weighted toward the catch. Sensitivity analyses exploring changes in effective sample size and changes to index lambdas and CVs will be explored in the upcoming benchmark (2015).

Conclusion

The conclusion of the updated assessment is that the Atlantic coast bluefish stock continues below B_{MSY} while remaining below F_{MSY} and is not considered overfished or experiencing overfishing. The estimates of the model show little variation, and a retrospective bias that was present in the recruitment estimates has flipped and reduced in magnitude. The overall lack of variation is due in part to the fixed parameters for selectivity. Nevertheless, uncertainty remains in several aspects of the assessment input data. Age data continues to be limited to one age key built from a limited set of samples. The assumption that this age information is applicable to all areas remains untested but will be explored during the benchmark assessment in 2015. Length samples from recreational discards are limited and contribute to the uncertainty as does the lack of commercial discard estimates. Changes in the NEFSC inshore survey series, from both vessel changes and sample area adjustments, significantly alter indices. Strata inshore of 15 fathoms are currently sampled as part of the NEMAP survey, but the time series is not yet adequate to provide a tuning index. For 2013, the delayed timing of the NMFS fall survey likely resulted in an unrepresentative index.

The highly migratory nature of bluefish populations and the recruitment dynamics of the species create a unique modeling situation. Migration creates seasonal fisheries with unique selectivity patterns resulting in a bimodal partial recruitment pattern. This pattern has been identified in previous assessments as a source of uncertainty in the results and has been held constant in the model. The migratory pattern in bluefish also results in several recruitment events. A spring cohort, originating south of Cape Hatteras, NC during spring migrations, and a summer cohort originating in the offshore Mid-Atlantic Bight result in a bimodal age-0 size distribution. It has been hypothesized that the success of the spring cohort controls the abundance of adult bluefish.

It is anticipated that specific modeling and data uncertainties will be explored extensively during the benchmark assessment in 2015.

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Table 1. Commercial landings (mt) by state groupings used in length expansions.

Year	State			**Total**
	ME - VA	NC	SC-FL	
1982	4137	1946	914	**6997**
1983	3421	3061	685	**7166**
1984	3046	1615	720	**5380**
1985	4199	1634	289	**6122**
1986	4559	1562	531	**6651**
1987	3805	2069	705	**6578**
1988	4277	2286	599	**7161**
1989	2793	1493	455	**4740**
1990	3684	2076	489	**6250**
1991	3709	1778	673	**6160**
1992	3423	1288	495	**5205**
1993	3039	1226	543	**4808**
1994	3071	809	424	**4304**
1995	2034	1365	229	**3628**
1996	2654	1496	62	**4212**
1997	2165	1815	129	**4109**
1998	2257	1327	155	**3739**
1999	1921	1252	157	**3330**
2000	2057	1525	64	**3647**
2001	2038	1844	63	**3945**
2002	2025	1054	37	**3116**
2003	1739	1574	45	**3358**
2004	1885	1707	56	**3647**
2005	1844	1122	71	**3037**
2006	1851	1146	45	**3042**
2007	2282	909	76	**3267**
2008	1766	762	57	**2585**
2009	1959	1096	97	**3151**
2010	1601	1463	143	**3206**
2011	1482	862	111	**2455**
2012	1809	347	81	**2236**
2013	1381	515	65	**1961**

Table 2. Commercial landings, recreational landings, recreational discard loss, and total catch for bluefish from Maine to Florida, 1974 to 2013.

Year	Commercial Landings (mt)	Commercial Landings (000 lbs)	Recreational Landings (mt)	Recreational Discard (mt): 0.15 * B2	Recreational Catch (mt)	Total Landings (mt)	Total Catch (mt) (w/o comm. discards)
1974	4538	10005					
1975	4402	9705		**assumes same**			
1976	4546	10022		**mean wt**			
1977	4802	10587		**as landings**			
1978	4986	10992					
1979	5693	12551					
1980	6857	15117					
1981	7465	16457	43222	*2001*	*45223*		52688
1982	6997	15426	37651	*832*	*38483*	44648	45480
1983	7166	15798	40425	*1280*	*41705*	47591	48871
1984	5380	11861	30597	*1260*	*31857*	35977	37237
1985	6122	13497	23821	*599*	*24420*	29943	30542
1986	6651	14663	42133	*1544*	*43677*	48784	50328
1987	6578	14502	34769	*1615*	*36384*	41347	42962
1988	7161	15787	21873	*1146*	*23019*	29034	30180
1989	4740	10450	17808	*989*	*18797*	22548	23537
1990	6250	13778	13860	*929*	*14789*	20110	21039
1991	6160	13580	14967	*1194*	*16161*	21127	22320
1992	5205	11475	11011	*979*	*11990*	16216	17195
1993	4808	10600	9204	*1013*	*10217*	14012	15025
1994	4304	9488	7049	*1128*	*8177*	11353	12481
1995	3628	7998	6489	*1003*	*7492*	10117	11120
1996	4113	9066	5328	*1010*	*6338*	9441	10451
1997	4064	8960	6487	*1287*	*7774*	10551	11838
1998	3739	8242	5595	*999*	*6594*	9334	10333
1999	3330	7341	3744	*1191*	*4935*	7074	8264
2000	3647	8040	4811	*1675*	*6486*	8458	10132
2001	3945	8697	6001	*1857*	*7858*	9946	11803
2002	3116	6869	5158	*1448*	*6606*	8274	9721
2003	3358	7403	5958	*1331*	*7289*	9316	10647
2004	3647	8041	7179	*1761*	*8940*	10826	12587
2005	3187	7026	8225	*1915*	*10140*	11412	13327
2006	2926	6450	7663	*1860*	*9523*	10589	12449
2007	3267	7182	9608	*2653*	*12261*	12874	15527
2008	2585	5655	8573	*2443*	*11016*	11158	13601
2009	3151	6990	6161	*960*	*7121*	9312	10273
2010	3206	7069	8184	*2409*	*10593*	11390	13799
2011	2455	5413	5965	*2856*	*8821*	8420	11276
2012	2236	4930	4846	*2383*	*7229*	7082	9465
2013	1961	4323	6980	*2281*	*9261*	8941	11222

Table 3. Recreational catch per angler trip by age for bluefish from Maine to Florida, 1982 to 2013. Index was predicted from a Generalized Linear Model with a negative binomial transformation.

Year	Age							**Total**
	0	1	2	3	4	5	6+	
1982	0.110	0.100	0.027	0.022	0.010	0.016	0.048	**0.332**
1983	0.040	0.058	0.063	0.025	0.008	0.011	0.042	**0.246**
1984	0.087	0.069	0.056	0.025	0.011	0.008	0.041	**0.297**
1985	0.080	0.097	0.097	0.050	0.018	0.008	0.040	**0.390**
1986	0.055	0.068	0.084	0.035	0.013	0.019	0.054	**0.327**
1987	0.036	0.067	0.065	0.068	0.024	0.015	0.054	**0.329**
1988	0.022	0.027	0.031	0.023	0.028	0.022	0.042	**0.195**
1989	0.059	0.090	0.046	0.017	0.005	0.015	0.040	**0.271**
1990	0.038	0.114	0.033	0.012	0.006	0.005	0.029	**0.236**
1991	0.044	0.056	0.057	0.027	0.005	0.003	0.027	**0.217**
1992	0.016	0.049	0.033	0.054	0.013	0.004	0.024	**0.193**
1993	0.021	0.047	0.023	0.012	0.024	0.016	0.015	**0.158**
1994	0.042	0.063	0.029	0.010	0.006	0.012	0.018	**0.180**
1995	0.026	0.081	0.015	0.004	0.006	0.015	0.013	**0.158**
1996	0.055	0.062	0.017	0.007	0.007	0.008	0.023	**0.179**
1997	0.050	0.101	0.035	0.011	0.004	0.002	0.029	**0.231**
1998	0.031	0.077	0.066	0.029	0.010	0.007	0.018	**0.237**
1999	0.106	0.090	0.065	0.026	0.007	0.008	0.015	**0.318**
2000	0.034	0.180	0.088	0.028	0.003	0.011	0.007	**0.352**
2001	0.060	0.157	0.094	0.035	0.006	0.012	0.008	**0.373**
2002	0.029	0.210	0.064	0.019	0.005	0.006	0.015	**0.348**
2003	0.034	0.092	0.129	0.024	0.007	0.010	0.019	**0.316**
2004	0.018	0.157	0.088	0.051	0.013	0.016	0.024	**0.368**
2005	0.101	0.071	0.106	0.036	0.009	0.014	0.012	**0.349**
2006	0.194	0.151	0.146	0.031	0.012	0.006	0.027	**0.568**
2007	0.022	0.086	0.148	0.042	0.024	0.018	0.038	**0.377**
2008	0.036	0.147	0.137	0.014	0.016	0.006	0.012	**0.367**
2009	0.008	0.133	0.119	0.019	0.014	0.006	0.020	**0.319**
2010	0.012	0.120	0.143	0.022	0.021	0.013	0.029	**0.361**
2011	0.017	0.170	0.097	0.030	0.016	0.026	0.045	**0.401**
2012	0.063	0.130	0.089	0.037	0.023	0.008	0.022	**0.372**
2013	0.041	0.097	0.083	0.060	0.024	0.021	0.017	**0.343**

Table 4. Bluefish mean catch weight at age (kg) from 1982 to 2013

Year	Age						
	0	1	2	3	4	5	6+
1982	0.140	0.490	1.520	2.050	3.200	4.232	4.958
1983	0.100	0.420	0.990	2.150	3.160	4.417	5.577
1984	0.100	0.410	0.930	1.830	2.910	4.483	5.650
1985	0.100	0.400	0.970	1.930	2.820	3.991	5.053
1986	0.120	0.490	1.200	2.320	3.150	4.303	4.848
1987	0.120	0.300	1.180	2.020	2.960	3.927	4.984
1988	0.170	0.400	1.000	2.050	2.840	3.564	4.623
1989	0.130	0.300	1.060	2.120	3.640	4.106	4.720
1990	0.210	0.500	0.880	1.730	3.240	4.177	4.474
1991	0.140	0.330	0.700	1.730	2.810	3.963	4.965
1992	0.160	0.390	1.040	1.890	2.800	3.303	5.107
1993	0.180	0.590	0.950	2.460	2.730	3.237	4.880
1994	0.120	0.400	0.900	1.880	3.040	3.757	4.093
1995	0.170	0.440	0.980	1.730	2.850	4.058	4.696
1996	0.170	0.440	0.980	1.730	2.850	4.058	4.696
1997	0.113	0.483	1.048	2.360	3.301	4.411	6.005
1998	0.173	0.570	0.891	2.314	3.387	4.079	5.906
1999	0.133	0.511	0.890	2.111	3.577	4.168	5.960
2000	0.160	0.430	0.959	2.692	3.508	3.659	5.851
2001	0.134	0.383	0.830	2.339	3.608	3.846	4.926
2002	0.143	0.495	1.119	2.284	2.922	3.872	5.158
2003	0.101	0.556	1.007	2.308	2.774	4.170	5.011
2004	0.069	0.371	1.049	1.949	2.779	3.639	4.488
2005	0.135	0.564	0.980	2.316	3.434	4.310	5.529
2006	0.160	0.525	1.125	2.081	3.379	3.664	5.317
2007	0.066	0.421	1.168	2.408	3.018	3.476	5.006
2008	0.151	0.407	1.263	2.359	3.169	3.747	4.756
2009	0.081	0.450	1.270	2.394	3.444	3.690	4.880
2010	0.098	0.384	0.975	1.580	3.470	4.017	4.979
2011	0.086	0.342	0.833	1.416	2.609	4.377	5.397
2012	0.084	0.366	0.844	1.396	3.148	3.896	5.541
2013	0.084	0.378	1.050	1.654	2.511	3.773	5.793

Table 5. Bluefish catch at age (000s) from Maine to Florida, 1982 to 2013.

Year	Age							Total
	0	1	2	3	4	5	6+	
1982	11164.1	9747.9	2850.8	2439.3	795.3	1213.5	3736.3	**31947.2**
1983	4778.4	7666.7	8686.1	3022.0	970.6	1325.3	4778.4	**31227.5**
1984	7121.3	6807.3	6718.5	2039.9	895.1	744.7	3176.7	**27503.5**
1985	4676.7	6468.8	5773.3	2925.5	1328.5	520.0	2377.1	**24069.9**
1986	5169.3	8070.7	8728.0	2801.7	1056.4	1703.1	4465.0	**31994.2**
1987	3127.1	5419.5	5177.8	5757.4	2009.3	1083.0	3948.2	**26522.3**
1988	1709.8	2083.6	2524.0	1588.6	1984.1	1598.6	2740.4	**14229.1**
1989	3473.6	5672.6	3221.1	992.1	395.9	1168.5	2409.8	**17333.6**
1990	2726.7	7185.8	1840.7	687.2	381.8	431.6	2478.6	**15732.4**
1991	3694.6	5292.6	7391.9	1590.7	310.9	224.7	2136.5	**20641.9**
1992	2131.3	9633.3	1709.8	2352.9	583.4	479.2	967.2	**17857.1**
1993	1194.1	2081.6	1566.9	593.0	1040.8	669.0	1178.9	**8324.3**
1994	1970.8	3144.3	1313.3	368.1	296.7	849.5	1073.1	**9015.8**
1995	1822.8	3371.4	735.7	137.7	214.1	695.7	1057.8	**8035.2**
1996	1701.5	2145.1	631.5	202.2	207.2	545.0	1411.8	**6844.3**
1997	1634.1	4299.3	1496.2	510.5	196.6	93.4	1212.3	**9442.4**
1998	683.5	2754.1	2786.1	861.3	261.0	308.0	458.8	**8112.8**
1999	1638.5	1946.1	2096.7	572.8	174.7	352.5	482.8	**7264.1**
2000	667.4	4396.5	2693.3	717.7	96.9	536.0	155.9	**9263.7**
2001	1414.3	4466.7	3466.2	1151.9	198.3	608.0	243.5	**11548.9**
2002	587.1	5145.6	1661.6	542.6	340.3	236.8	415.9	**8929.9**
2003	819.3	2646.0	3975.0	774.6	377.9	319.8	644.0	**9556.6**
2004	420.9	4445.2	2683.8	1276.9	429.5	507.0	816.4	**10579.8**
2005	2756.1	2139.9	3953.0	1907.3	563.0	629.7	576.5	**12525.4**
2006	1291.6	3212.1	2554.9	1844.1	1392.2	419.2	845.7	**11559.8**
2007	639.0	5181.4	4255.6	1529.3	927.1	300.3	679.1	**13511.7**
2008	839.8	4242.2	3327.5	878.9	762.1	424.3	523.0	**10997.9**
2009	94.5	2858.7	2783.3	682.3	490.3	320.1	633.2	**7862.4**
2010	254.5	2925.0	3924.7	631.5	640.5	377.9	836.2	**9590.2**
2011	342.0	3282.2	2207.8	782.1	296.6	500.6	902.5	**8313.7**
2012	1145.9	2746.2	2357.4	919.5	493.0	188.1	507.1	**8357.2**
2013	858.3	2438.3	2252.2	1436.6	542.9	495.9	388.7	**8412.8**

Table 6. NEFSC bluefish indices by age using fall inshore strata and re-transformed $\log_e$ stratified mean number per tow, 1982 to 2013.

Year	Age							Total
	0	1	2	3	4	5	6+	
1982	18.768	10.788	0.064	0.053	0.011		0.023	**29.71**
1983	8.189	16.695	0.845	0.034	0.004	0.017	0.068	**25.85**
1984	81.356	40.869	1.257	0.201	0.120	0.052	0.147	**124.00**
1985	17.473	9.703	0.925	0.428	0.096	0.036	0.088	**28.75**
1986	21.055	0.923	0.042	0.060	0.024	0.028	0.033	**22.17**
1987	7.589	1.768	0.167	0.238	0.098	0.049	0.158	**10.07**
1988	9.493	0.067	0.009	0.010	0.028	0.006	0.023	**9.64**
1989	237.573	1.254	0.113	0.130		0.014	0.119	**239.20**
1990	6.186	3.637	0.006	0.016	0.016		0.084	**9.95**
1991	7.878	0.154	0.050	0.026	0.001		0.001	**8.11**
1992	6.625	0.637	0.016	0.022	0.002	0.002	0.008	**7.31**
1993	1.109	0.123	0.044	0.003	0.034	0.023		**1.34**
1994	6.580	0.760	0.010	0.019	0.030	0.021	0.006	**7.43**
1995	9.222	4.122	0.115	0.015	0.015	0.025	0.062	**13.58**
1996	9.643	1.638	0.211	0.144	0.027	0.021	0.019	**11.70**
1997	4.179	0.482	0.217	0.107	0.002	0.007	0.013	**5.01**
1998	4.793	0.387	0.074	0.045	0.017			**5.32**
1999	15.266	1.528	0.061	0.051	0.018	0.002	0.008	**16.93**
2000	2.485	1.517	0.157	0.017	0.015	0.006		**4.20**
2001	8.819	0.754	0.148	0.020	0.002	0.001	0.003	**9.75**
2002	7.815	1.210	0.042	0.037				**9.10**
2003	48.332	3.085	0.277	0.019	0.006	0.022	0.043	**51.78**
2004	7.048	5.307	0.372	0.079	0.008	0.012	0.031	**12.86**
2005	24.086	0.705	0.107	0.098	0.031	0.030	0.012	**25.07**
2006	36.300	1.017	0.714	0.016				**38.05**
2007	8.837	7.064	0.583	0.082	0.012	0.004	0.009	**16.59**
2008	7.444	4.543	0.797	0.012	0.010	0.009	0.026	**12.84**
2009*	1.050	5.385	0.503	0.013	0.011	0.000	0.037	**7.00**
2010*	2.559	3.352	0.527	0.029	0.069	0.028	0.093	**6.66**
2011*	2.641	4.357	0.299	0.036	0.045	0.030	0.039	**7.45**
2012*	1.746	2.763	0.587	0.123	0.043	0.004	0.008	**5.27**
2013*†	0.786	0.195	0.001	0.003	0.003	0.006		**0.99**

*indices adjusted with conversion factor = 1.16 (Miller et al., 2010)

† Timing of survey off. 2-3 weeks late because of government shutdown.

Table 7. Bluefish survey indices by age from the Delaware (stratified geometric mean number per tow) and New Jersey (stratified mean number per tow) trawl surveys.

	Delaware				New Jersey			
Year	Age			**Total**	Age			**Total**
	0	1	2		0	1	2	
1982	0.025							
1983	0.024							
1984	0.039							
1985	0.022							
1986	0.081							
1987	0.073							
1988	0.114				26.066	0.411	0.002	**26.48**
1989	0.267				7.041	0.544	0.026	**7.61**
1990	0.082	0.683	0.015	**0.780**	5.947	0.299	0.005	**6.25**
1991	0.132	0.209	0.004	**0.345**	3.652	0.009	0.020	**3.68**
1992	0.071	0.211	0.003	**0.285**	3.747	0.582	0.040	**4.37**
1993	0.063	0.220	0.013	**0.296**	2.483	0.085	0.109	**2.68**
1994	0.103	0.295	0.004	**0.401**	11.179	0.231	0.017	**11.43**
1995	0.093	0.376	0.031	**0.500**	5.055	0.238	0.050	**5.34**
1996	0.081	0.426	0.017	**0.524**	2.483	0.096	0.015	**2.59**
1997	0.147	0.317	0.023	**0.486**	3.930	0.075	0.034	**4.04**
1998	0.080	0.581	0.107	**0.768**	1.719	0.243	0.154	**2.12**
1999	0.097	0.439	0.034	**0.570**	1.710	0.350	0.035	**2.10**
2000	0.113	0.365	0.047	**0.525**	1.410	0.395	0.102	**1.91**
2001	0.290	0.555	0.107	**0.952**	0.400	0.068	0.090	**0.56**
2002	0.159	1.210	0.047	**1.416**	7.924	3.469	0.077	**11.47**
2003	0.038	0.224	0.012	**0.274**	6.793	0.196	0.077	**7.06**
2004	0.074	0.836	0.030	**0.940**	2.019	0.684	0.318	**3.02**
2005	0.060	0.127	0.009	**0.195**	6.141	0.235	0.168	**6.54**
2006	0.039	0.070	0.020	**0.129**	6.573	0.126	0.061	**6.76**
2007	0.093	0.321	0.021	**0.436**	6.136	6.718	0.342	**13.20**
2008	0.087	0.172	0.016	**0.275**	9.041	0.843	0.028	**9.91**
2009	0.031	0.282	0.029	**0.342**	3.013	0.187	0.010	**3.21**
2010	0.031	0.383	0.066	**0.481**	1.934	0.136	0.020	**2.09**
2011	0.054	0.214	0.022	**0.290**	7.364	6.989	0.017	**14.37**
2012	0.024	0.162	0.016	**0.202**	7.959	2.535	0.081	**10.57**
2013	0.041	0.125	0.000	**0.166**	3.846	0.350	0.000	**4.20**

Table 8. Bluefish survey indices by age (stratifed geometric mean number per tow) from the Conneticut DEP trawl survey.

Year	Age							Total
	0	1	2	3	4	5	6+	
1984	52.101	0.800	0.760	0.298	0.054	0.014	0.041	**54.068**
1985	36.368	1.573	1.075	0.498	0.244	0.044	0.131	**39.933**
1986	8.727	0.547	0.352	0.083	0.053	0.028	0.018	**9.808**
1987	14.357	2.229	0.951	0.279	0.213	0.131	0.070	**18.230**
1988	13.122	0.851	0.567	0.358	0.234	0.173	0.106	**15.411**
1989	47.873	1.900	0.732	0.205	0.347	0.282	0.072	**51.411**
1990	28.027	3.499	0.742	0.106	0.141	0.200	0.024	**32.739**
1991	36.482	5.233	2.078	0.194	0.135	0.164	0.075	**44.361**
1992	24.585	3.359	1.750	0.172	0.152	0.283	0.005	**30.306**
1993	25.810	1.241	2.161	0.877	0.385	0.107		**30.581**
1994	30.018	1.410	0.752	0.512	0.386	0.251	0.010	**33.339**
1995	26.588	6.967	1.313	0.303	0.168	0.202	0.034	**35.575**
1996	42.334	0.491	1.031	0.360	0.060	0.036	0.159	**44.471**
1997	40.413	0.586	0.536	0.140	0.051	0.022	0.058	**41.806**
1998	34.831	1.453	0.512	0.130	0.058	0.011	0.025	**37.020**
1999	44.950	5.617	0.287	0.188	0.046	0.049	0.079	**51.216**
2000	22.593	3.652	1.408	0.178	0.021	0.016	0.029	**27.897**
2001	34.050	2.294	2.180	0.283	0.026	0.021	0.042	**38.896**
2002	12.419	4.926	0.578	0.135	0.045	0.048	0.063	**18.214**
2003	27.307	0.357	0.655	0.104	0.024	0.034	0.044	**28.525**
2004	20.134	3.944	3.315	1.336	0.071	0.160	0.171	**29.131**
2005	29.687	0.047	0.243	0.099	0.037	0.021	0.007	**30.141**
2006	14.353	0.719	0.558	0.030				**15.660**
2007	25.680	16.460	0.940	0.260	0.040	0.010	0.040	**43.430**
2008	no september sampling							
2009	30.217	1.702	0.733	0.107	0.067	0.006	0.029	**32.860**
2010	mechanical failure							
2011	12.237	0.306	0.190	0.081	0.014	0.034	0.069	**12.930**
2012	22.346	2.563	0.165	0.066	0.024	0.008	0.017	**25.190**
2013	16.432	0.144	0.406	0.106	0.026	0.007		**17.120**

Table 9. Abundance at age (000s) for bluefish from the ASAP model updated through 2013.

Year	Age							Total
	0	1	2	3	4	5	6+	
1982	44069	42328	13007	6950	6716	11662	51532	**176263**
1983	34084	34109	29347	9105	5257	5194	44750	**161847**
1984	44537	26138	23009	20020	6798	4028	34411	**158940**
1985	24594	34323	17892	15915	15052	5234	26834	**139843**
1986	20885	18932	23416	12336	11947	11576	22372	**121465**
1987	14439	15354	11272	14201	8679	8769	21288	**94002**
1988	20409	10558	8997	6735	9916	6336	18531	**81482**
1989	45480	15091	6395	5546	4777	7321	15727	**100337**
1990	18834	34184	9594	4125	4025	3586	15246	**89594**
1991	23242	14221	22030	6269	3014	3036	12516	**84328**
1992	11440	17213	8654	13638	4457	2229	9836	**67467**
1993	12566	8606	10971	5596	9911	3348	7939	**58938**
1994	18356	9474	5521	7139	4080	7464	7516	**59551**
1995	16609	13945	6216	3669	5260	3096	10267	**59062**
1996	15923	12802	9551	4302	2760	4051	9380	**58769**
1997	14520	12316	8857	6673	3251	2133	9535	**57284**
1998	19716	11249	8562	6216	5054	2516	8282	**61595**
1999	23050	15331	7906	6071	4733	3927	7751	**68769**
2000	15409	18135	11156	5793	4700	3721	8660	**67574**
2001	26177	12055	12977	8046	4448	3674	9044	**76421**
2002	20422	20223	8312	9037	6070	3434	8999	**76496**
2003	22731	16006	14552	6026	6958	4755	9118	**80145**
2004	16002	17785	11459	10499	4628	5441	10150	**75963**
2005	22477	12374	12300	8003	7932	3576	11084	**77746**
2006	32573	17496	8725	8748	6102	6170	10555	**90369**
2007	18618	25428	12442	6255	6697	4760	12179	**86380**
2008	20768	14378	17513	8656	4717	5168	11970	**83169**
2009	13516	16179	10160	12482	6607	3672	12387	**75002**
2010	16461	10658	11853	7492	9693	5207	11945	**73310**
2011	14904	12771	7441	8353	5686	7514	12273	**68943**
2012	8939	11699	9230	5417	6444	4461	14607	**60797**
2013	13284	7074	8665	6876	4228	5098	14319	**59543**

Table 10. Biomass at age (mt) for bluefish as estimated from the ASAP model updated through 2013.

Year	Age							Total
	0	1	2	3	4	5	6+	
1982	3561	14590	16623	11476	18293	42915	255494	**362951**
1983	1684	8271	20440	16461	13381	19527	249570	**329333**
1984	2227	5293	14381	26947	17004	15159	194424	**275434**
1985	1112	6865	11283	21321	34194	17838	135590	**228202**
1986	1585	4192	16223	18506	29456	40326	108461	**218749**
1987	949	2913	8571	22110	22744	30840	106098	**194224**
1988	2612	2313	4928	10474	23751	20579	85667	**150324**
1989	3015	3408	4164	8074	13049	25000	74230	**130941**
1990	3155	8717	4929	5587	10549	13982	68211	**115131**
1991	1950	3743	13033	7735	6645	10878	62144	**106129**
1992	953	4023	5070	15687	9809	6790	50234	**92564**
1993	1517	2644	6678	8951	22514	10081	38744	**91128**
1994	1151	2542	4023	9540	11157	23903	30765	**83082**
1995	1756	3205	3892	4579	12176	10874	48212	**84693**
1996	1607	3501	6272	5602	6128	13776	44049	**80935**
1997	730	3528	6015	10148	7769	7561	57259	**93010**
1998	1985	2855	5617	9681	14289	9234	48911	**92571**
1999	1706	4558	5631	8327	13616	14755	46195	**94788**
2000	1593	4336	7809	8967	12789	13463	50671	**99629**
2001	1825	2984	7753	12050	13863	13495	44553	**96522**
2002	1481	5207	5442	12443	15869	12834	46417	**99692**
2003	1198	4514	10273	9684	17514	16597	45690	**105470**
2004	386	3443	8751	14708	11721	17286	45553	**101849**
2005	1540	2441	7417	12474	20522	12377	61283	**118052**
2006	3212	4658	6950	12492	17071	21885	56123	**122390**
2007	495	6599	9743	10296	16784	16314	60967	**121198**
2008	1817	2357	12770	14367	13030	17377	56929	**118648**
2009	503	4218	7305	21705	18832	12556	60447	**125565**
2010	864	1880	7852	10613	27937	19368	59476	**127989**
2011	602	2338	4209	9815	11545	29284	66235	**124028**
2012	356	2075	4959	5842	13606	14221	80938	**121998**
2013	526	1261	5371	8124	7917	17570	82948	**123716**

Table 11. Annual SSB (MT), recruitment (000s), total abundance (000s), and F from the ASAP model updated through 2013.

Year	SSB	Recruitment	Total Abundance	F
1982	314095	44069	176263	0.161
1983	288344	34084	161847	0.187
1984	251449	44537	158940	0.173
1985	216116	24594	139843	0.176
1986	207229	20885	121465	0.307
1987	171621	14439	94002	0.320
1988	133802	20409	81482	0.288
1989	120439	45480	100337	0.241
1990	98483	18834	89594	0.229
1991	89876	23242	84328	0.282
1992	90617	11440	67467	0.238
1993	87018	12566	58938	0.232
1994	78365	18356	59551	0.211
1995	78308	16609	59062	0.170
1996	74793	15923	58769	0.161
1997	90404	14520	57284	0.156
1998	87666	19716	61595	0.146
1999	89952	23050	68769	0.113
2000	95106	15409	67574	0.130
2001	90547	26177	76421	0.166
2002	96099	20422	76496	0.125
2003	99486	22731	80145	0.130
2004	95937	16002	75963	0.164
2005	117524	22477	77746	0.145
2006	112286	32573	90369	0.137
2007	109798	18618	86380	0.169
2008	113381	20768	83169	0.144
2009	122346	13516	75002	0.109
2010	117913	16461	73310	0.156
2011	115466	14904	68943	0.123
2012	117417	8939	60797	0.099
2013	114382	13284	59543	0.118

Table 12. Projection results for bluefish through 2016 under various fishing scenarios.

		Quota (000s mt)	F	Jan 1 Abundance (000s)	Mean Biomass (000s mt)	SSB (000s mt)	Yield (000s mt)
F status quo	**2014**	11.08		64930.90	110.38	104.77	11.08
	2015		0.118	68624.50	105.94	98.48	9.92
	2016		0.118	70609.40	104.38	95.82	10.02
F low	**2014**	11.08		64930.90	110.38	104.77	11.08
	2015		0.10	68624.50	106.66	99.18	8.47
	2016		0.10	71251.80	106.54	97.87	8.68
F0.1	**2014**	11.08		64930.90	110.38	104.77	11.08
	2015		0.16	68624.50	104.28	96.86	13.23
	2016		0.16	69147.00	99.54	91.20	12.93
Ftarget	**2014**	11.08		64930.90	110.38	104.77	11.08
	2015		0.17	68624.50	103.89	96.48	14.00
	2016		0.17	68806.00	98.42	90.14	13.57
Fmsy	**2014**	11.08		64930.90	110.38	104.77	11.08
	2015		0.19	68624.50	103.12	95.72	15.52
	2016		0.19	68132.50	96.23	88.05	14.82

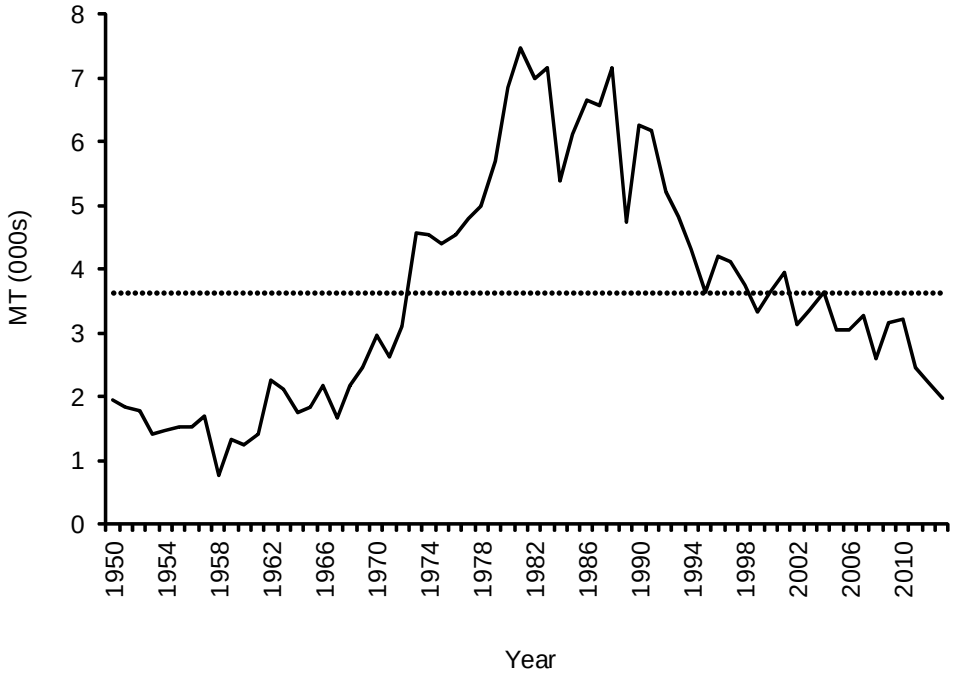


Figure 1. Times series of bluefish commercial landings (mt) along the Atlantic coast from 1950 to 2013.

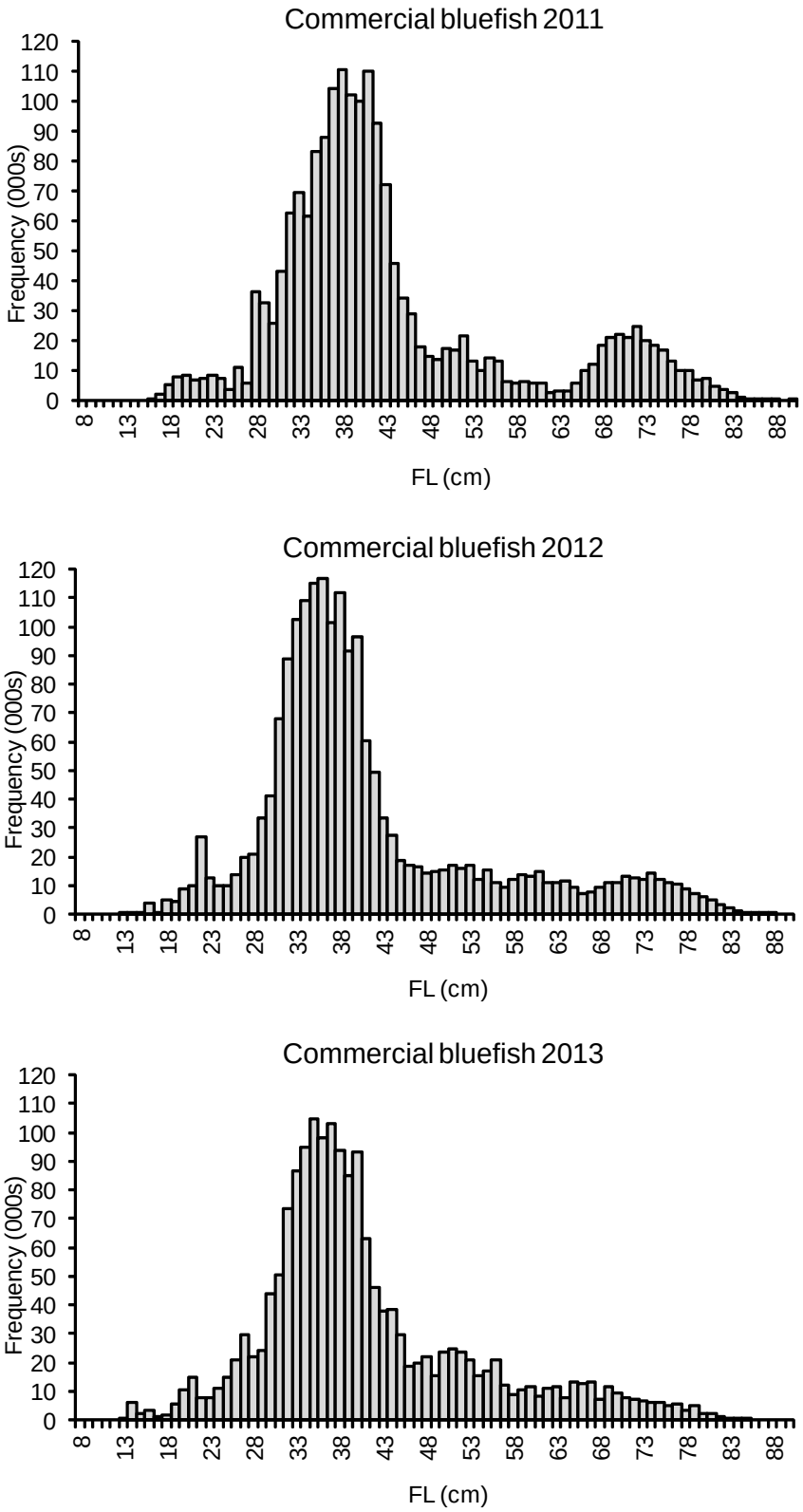


Figure 2. Length frequency distribution of commercial bluefish landings from Maine to Florida, 2011 to 2013.

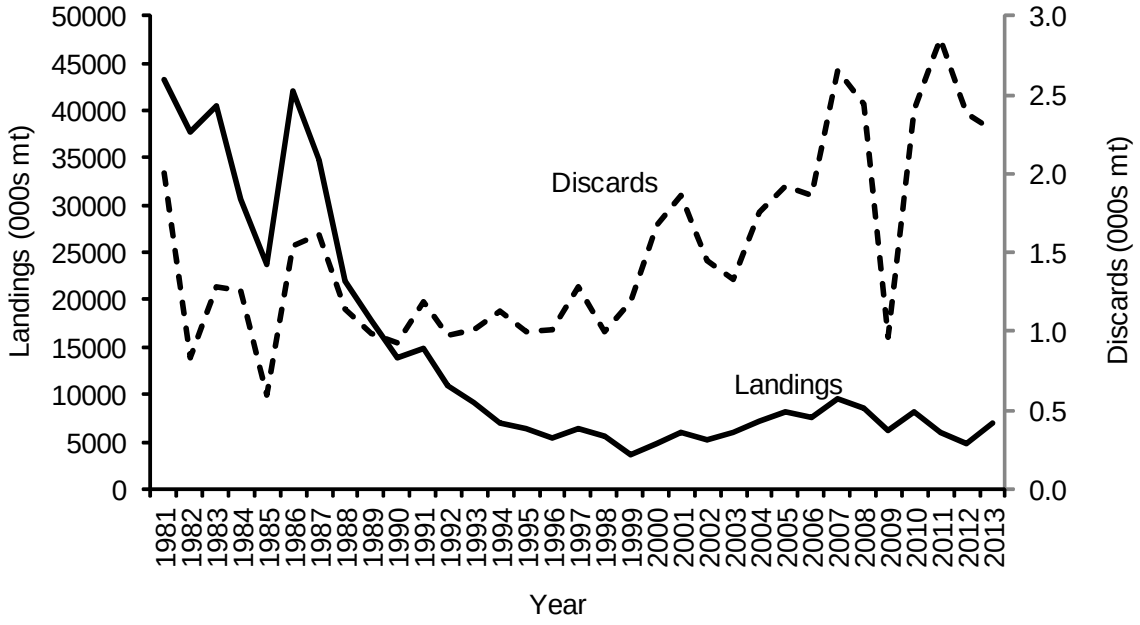


Figure 3. Recreational landings (mt) and recreational discard losses (MRIP B2 estimates*0.15) from Maine to Florida, 1981 to 2013.

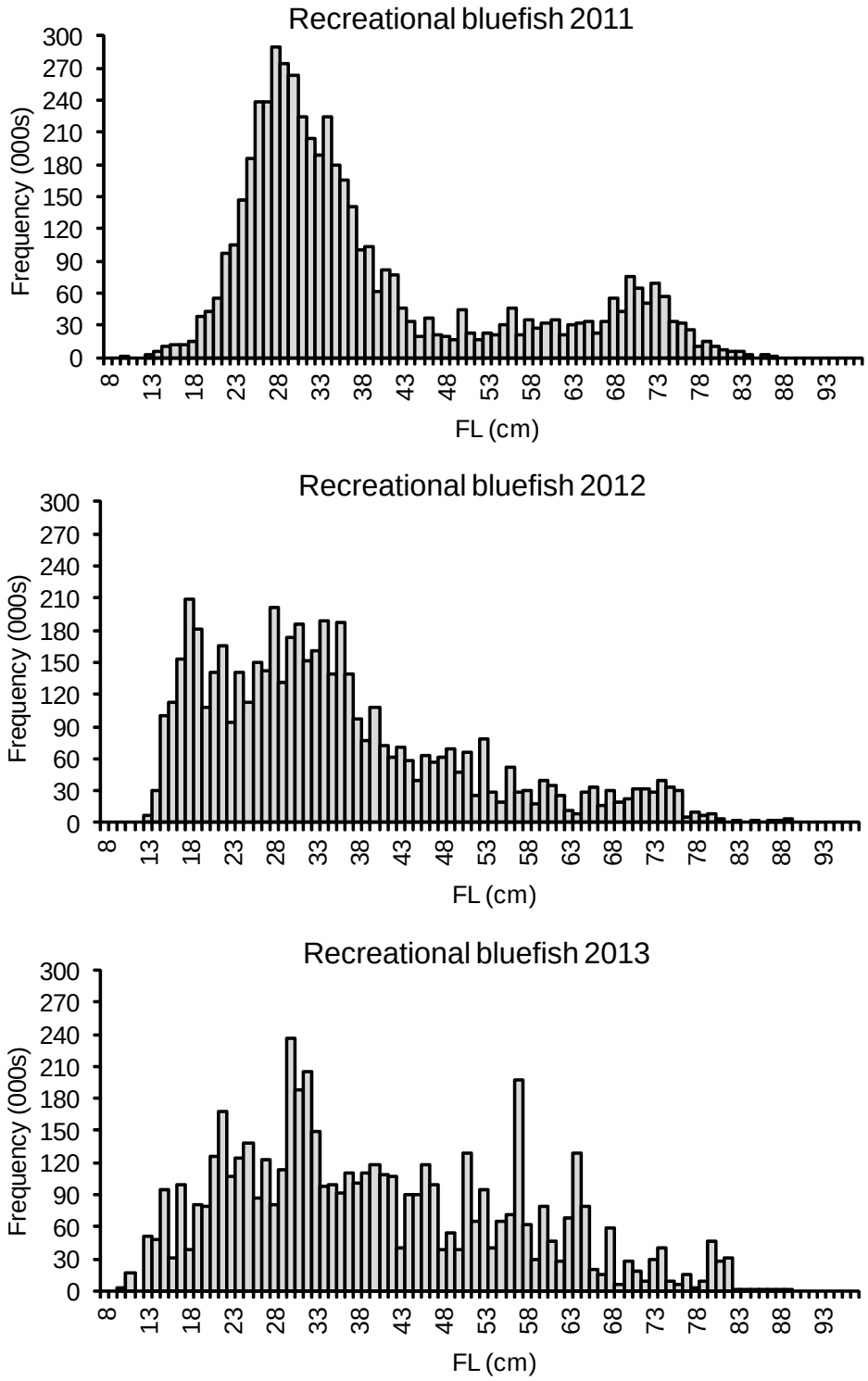


Figure 4. Length frequency distribution of recreational bluefish landings from Maine to Florida, 2011 to 2013.

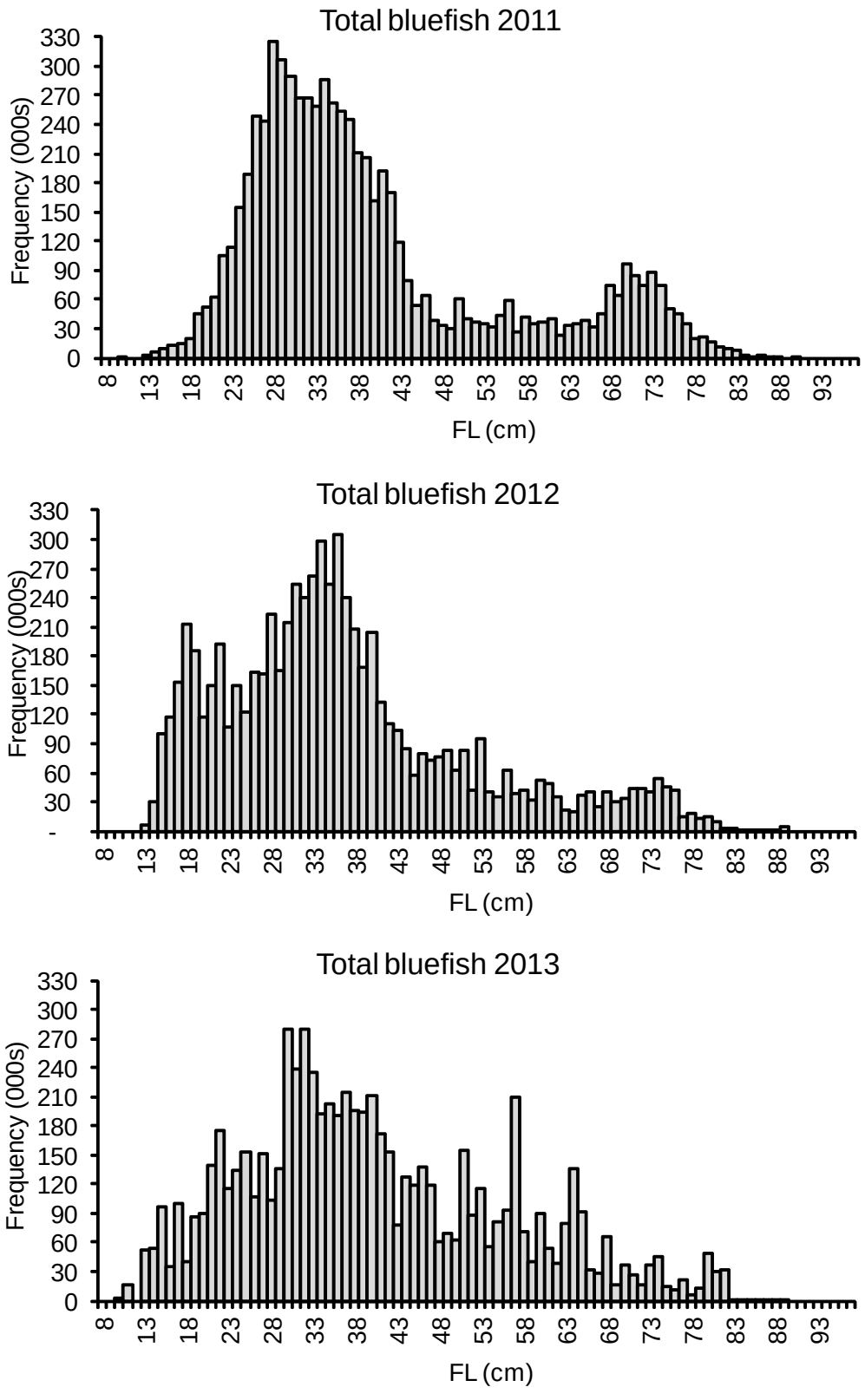


Figure 5. Length frequency distribution of total bluefish landings from Maine to Florida, 2011 to 2013.

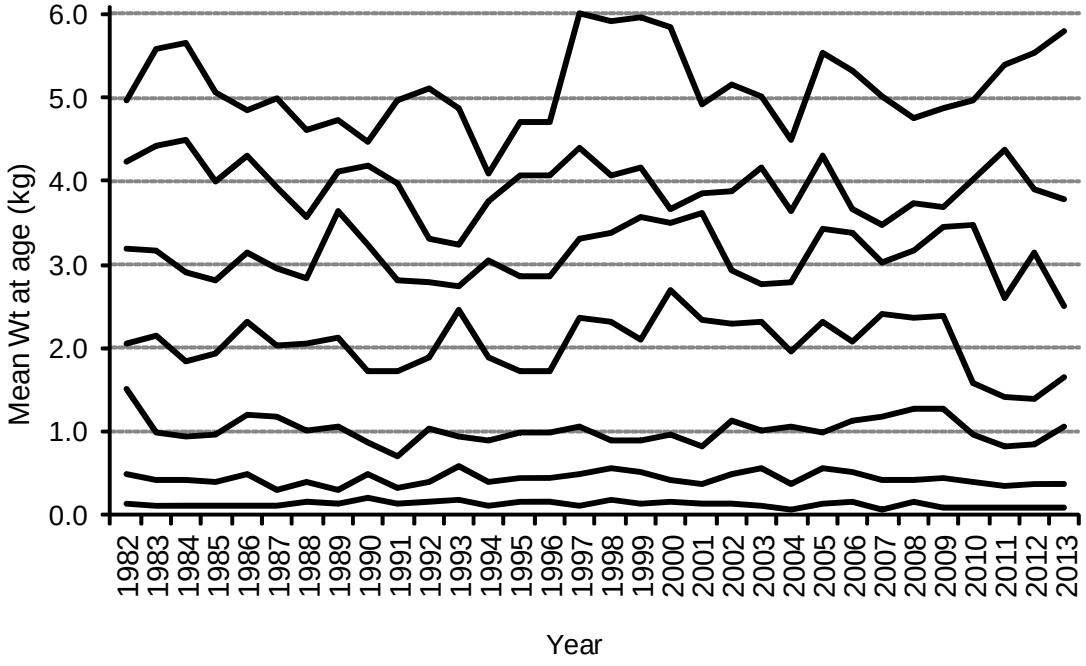


Figure 6. Bluefish mean weights (kg) at ages 0 to 6+ from 1982 to 2013.

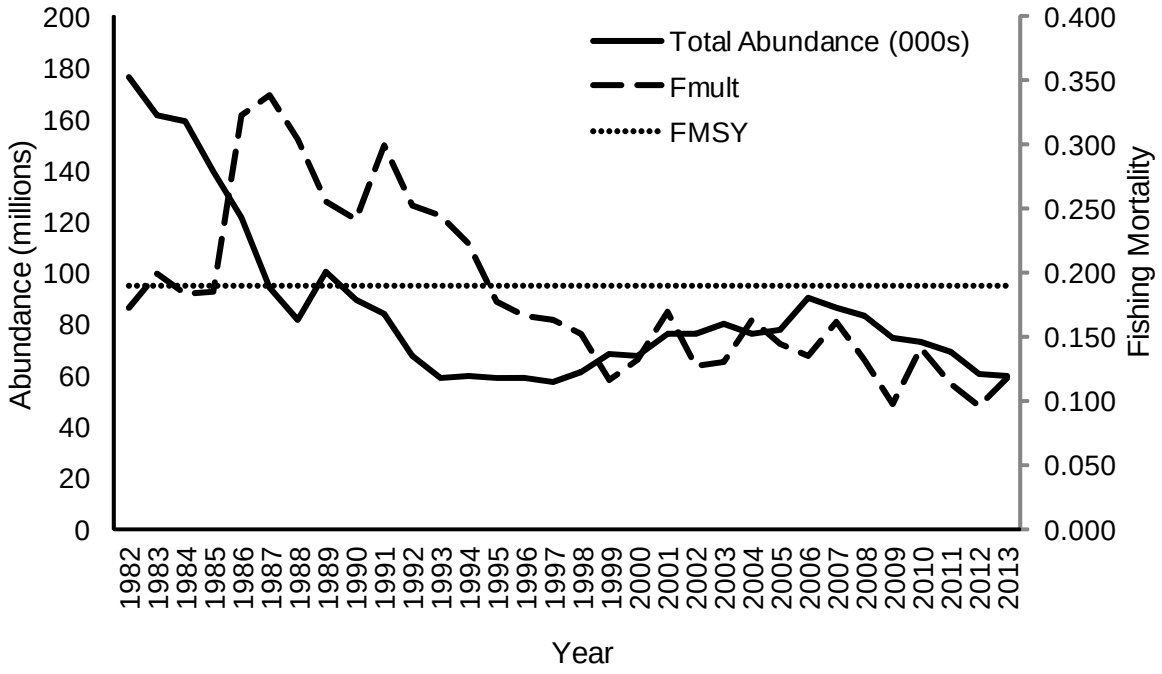


Figure 7. Total bluefish abundance and fishing mortality as estimated in ASAP model updated through 2013. F_{MSY} indicated by dotted horizontal line.

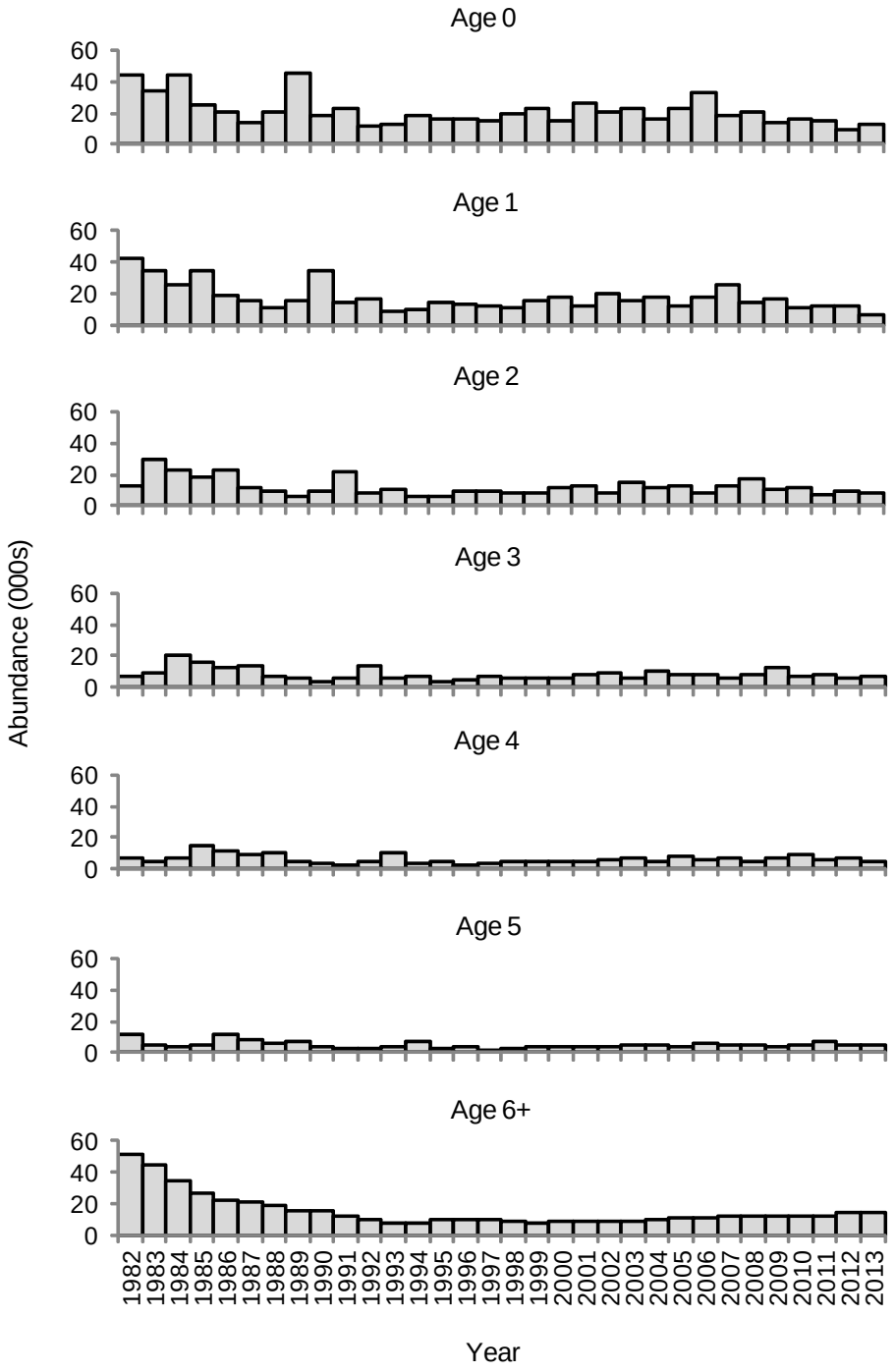


Figure 8. Total bluefish abundance (000s) at age from ASAP model results.

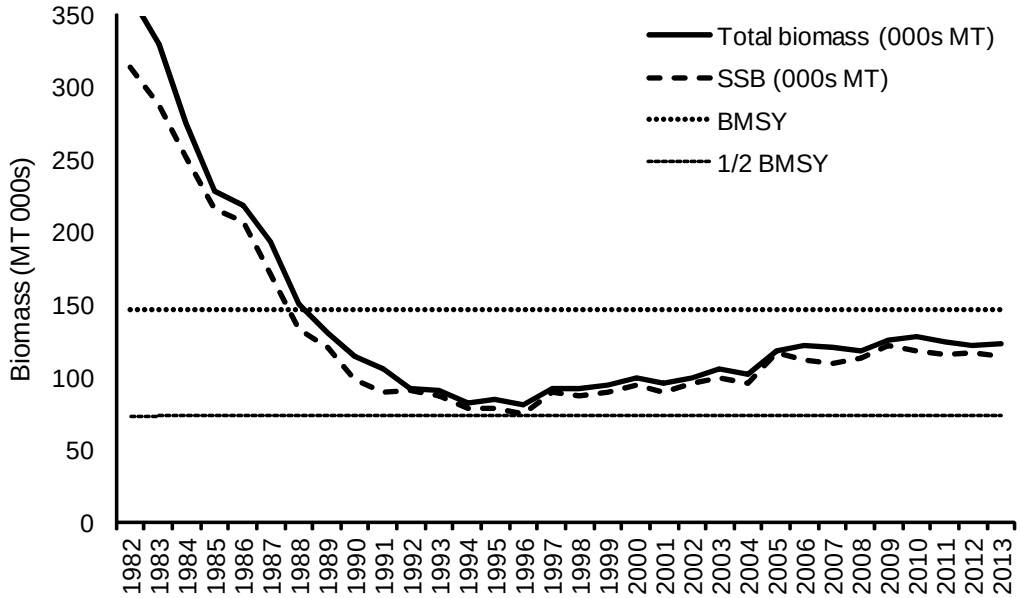


Figure 9. Time series of bluefish total mean biomass (000s mt) and spawning stock biomass (000s mt).

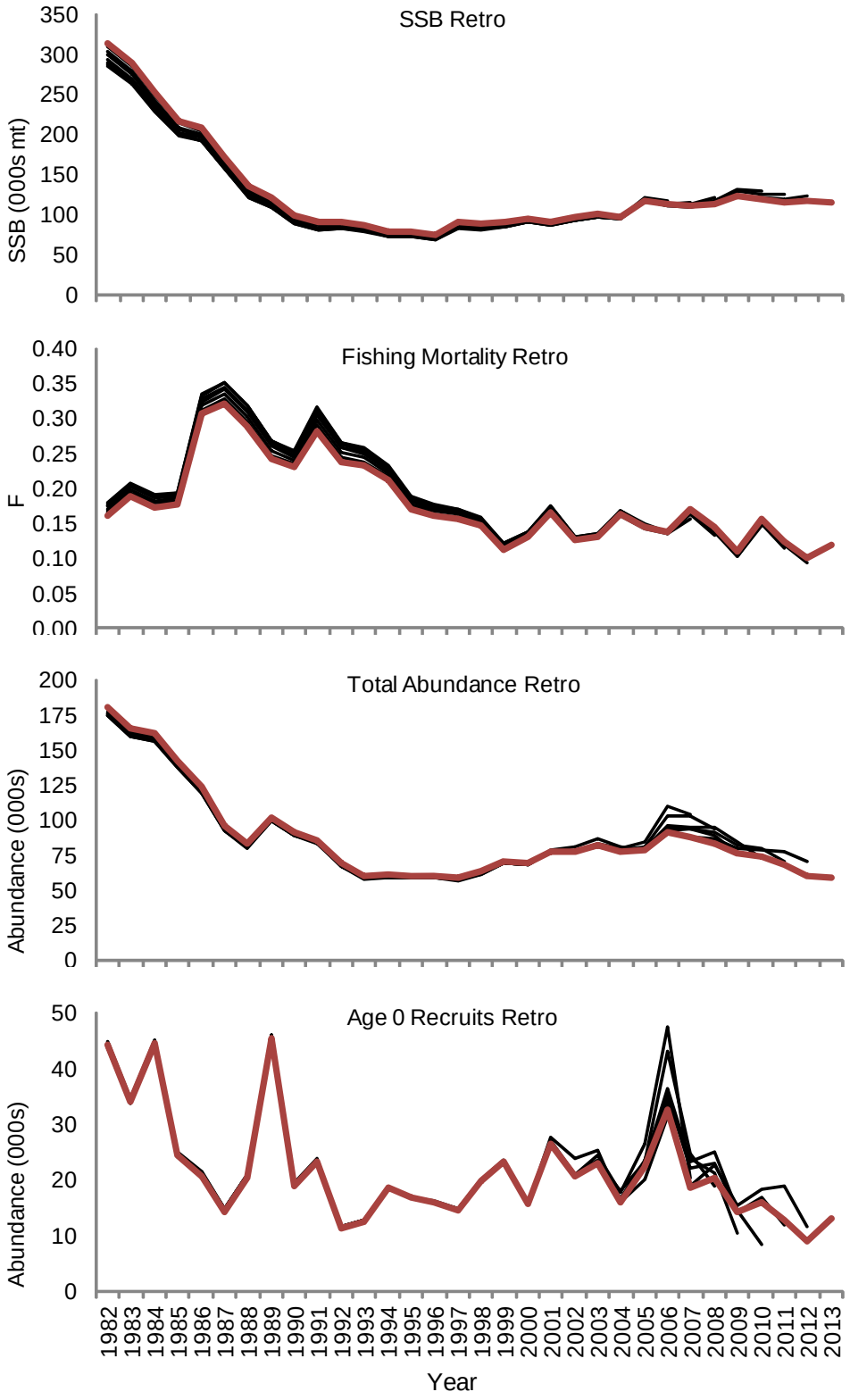
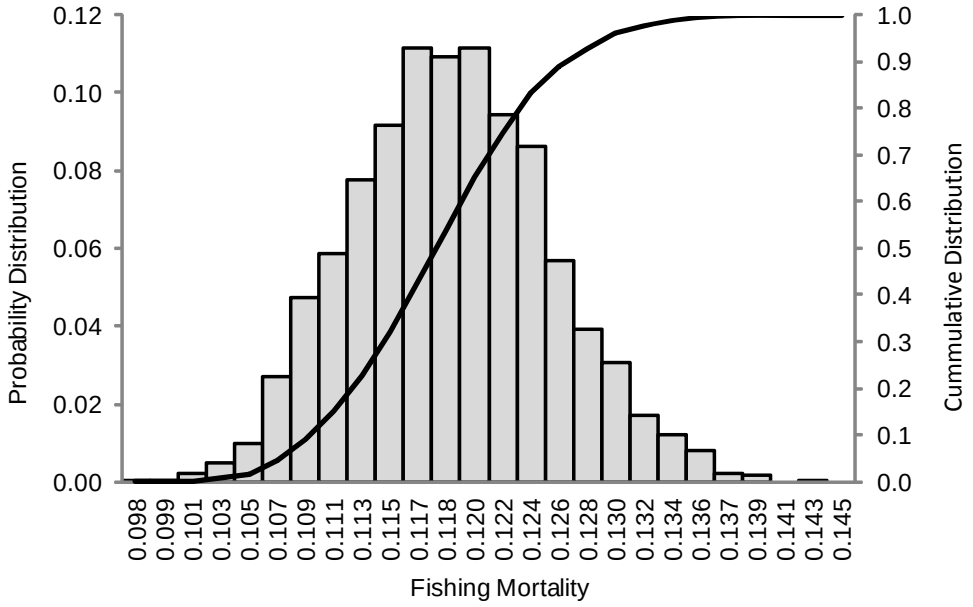


Figure 10. Retrospective bias in bluefish estimates from ASAP model.



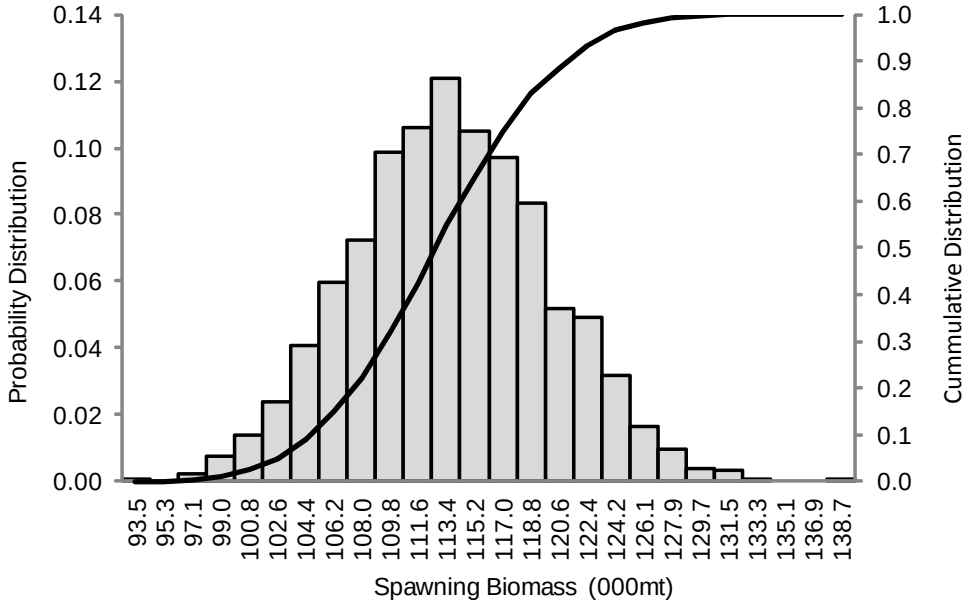


Figure 11. Distribution of bluefish fishing mortality and spawning stock biomass resulting from 1000 MCMC iterations in ASAP model.