

## Atlantic Mackerel Data Update for 2021 Specifications

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The following information seeks to provide a data update of Atlantic mackerel for 2020. The management track assessment originally scheduled for June 2020 was postponed until June 2021 due to the impact of the COVID-19 pandemic on availability of both fishery and egg survey data. With this postponement, the U.S. assessment schedule for Atlantic mackerel will also coincide with that of Canada's Department of Fisheries and Oceans (DFO) for the northern contingent.

### *Catch*

Mackerel total catch averaged 112,000 metric tons (mt) from 1960 through the end of foreign catches in 1991 (Table 1, Figure 1). From 1992 through 2001, U.S. and Canadian catches averaged only 36,104 mt before increasing to a peak of 114,646 mt in 2006. Total catch then declined and since 2011 has averaged 17,050 mt. Preliminary estimated 2019 total catch was 16,255 mt. U.S. commercial discards represented an average of 4.4% of U.S. commercial catch over the time series, and 1.3% of commercial catch since 2000. Incorporating the updated MRIP estimates, U.S. recreational catch represented an average of 36.0% of total U.S. catch in the 1980's, decreased to 11.4% during the 1990's and 2000's, and has averaged 38.8% since 2010. The spatial distribution of U.S. commercial landings for 2019 are presented in Figure 2 and Appendix A for 2012-2018.

U.S. fishery total catch-at-age was updated through 2019 (Figure 3). In this terminal year, 43% of the catch represented the 2017 year class, 29% represented the 2015 year class and 21% represented the 2018 year class. The movement of the 2015 year class through the fishery was also apparent, with this year class accounting for 29% of the catch in 2019, 56% of the catch in 2018, 82% of the catch in 2017 and 48% of the catch in 2016. Catch-at-age from the individual components of the U.S. fishery (commercial landings, commercial discards and recreational catch) are detailed in Appendix B. Canadian catch-at-age data were available through 2018 and showed similar trends with the 2015 year class representing 55% of the catch in 2017 and 77% of the catch in 2018 (Figure 4). Canadian fishery catch-at-age estimates were not yet available for 2019. Consequently, combined Canadian and U.S. catch-at-age estimates were updated through 2018 with the 2015 year class representing 63% of the catch, the 2014 year class representing 18% of the catch, and the 2017 year class representing 12% of the catch in this terminal year (Figure 5). Similar to trends from the individual countries, the movement of the 2015 year class through the combined fisheries was apparent with this year class accounting for 73% off the combined catch in 2017 and 41% in 2016.

### *NEFSC spring survey indices*

Aggregate relative abundance (arithmetic stratified mean number-per-tow) and biomass (arithmetic stratified mean kg-per-tow) indices were derived using data from the NEFSC spring

bottom trawl survey conducted during 1968-2019. Indices were not available for the 2020 spring survey because only the first leg was completed as a result of the pandemic. In 2009, the survey changed primary research vessels from the *Albatross IV* to the *Henry B. Bigelow*. Due to large changes in the survey design with the change to the *Bigelow*, relative abundance indices in the benchmark assessment were derived as two separate time series, 1968-2008 and 2009 onward. This decision eliminated the need for conversion coefficients and also permitted the use of different strata sets for each time series. Further details can be found in TOR3 of the benchmark assessment (NEFSC 2018). Updates to the *Bigelow* time series are presented in this data update.

Estimated 2019 indices of relative abundance and biomass were 32.91 mackerel-per-tow (CV = 40.2%) and 3.73 kg-per-tow (CV = 35.2%), respectively (Table 2). Additionally, both 2019 estimates were equal to the time series medians (Figure 6). Mackerel lengths from the spring survey ranged from 10 cm to 39 cm during 2009-2019. Length compositions varied over time, with some years exhibiting unimodal distributions (2011, 2017) and other years exhibiting bimodal or trimodal distributions (Figure 7). Average annual length ranged between 20.7 cm - 26.1 cm and varied without trend over the time series (Figure 8). Age-specific indices indicated that since 2009, no individuals older than age-7 have been captured (Table 3, Figure 9). In 2019, the 2017 cohort represented 53% of the catch, the 2018 cohort represented 36%, and the 2015 cohort represented approximately 10%. In 2018, the 2015 and 2017 cohorts each represented approximately 48% of the catch (96% in total) and in 2017, the 2015 cohort represented 89% of the catch.

Recent otolith microchemistry work (Secor et al., Appendix A2 of NEFSC 2018) indicated that age-1 and age-2 individuals caught in the spring survey reflect local recruits, but age-3 onward represent a mix of individuals from both the northern and southern spawning contingents. Consequently, during the benchmark assessment relative abundance indices from the spring survey were also derived using just ages-3<sup>+</sup>; these aggregate indices for ages 3<sup>+</sup> were used in all modeling efforts because they were deemed most representative of the unit stock (NEFSC 2018, Figures A54-A55). For the *Bigelow* years of 2009-2019, relative abundance and biomass for ages-3<sup>+</sup> generally varied without trend (Figure 10). Estimated 2019 indices of relative abundance and biomass for ages 3<sup>+</sup> were 3.58 mackerel-per-tow and 0.84 kg-per-tow, which were both above the time-series medians of 2.34 mackerel-per-tow and 0.57 kg-per-tow, respectively. By number, 90% of the index value represented the 2015 year class.

#### *Range-wide index of spawning stock biomass*

The U.S. component of the spawning stock biomass index (representing the southern spawning contingent) was not available for 2017 onward and estimates for the northern contingent from Canada's DFO were only available through 2018 (Table 4, Figure 11). A preliminary estimate for the southern contingent is available for 2017, but because a quality assurance check on egg identification has not yet been completed, this preliminary value is likely an underestimate and is not presented here. Additionally, an estimate of annual egg production is available for the southern contingent for 2019, but this estimate could not be converted to SSB because the needed fecundity estimates from Canada's DFO are not yet available. Since 2000, the southern contingent has only represented 6.4% of the stock-wide spawning stock biomass on average. Therefore, updated trends in the spawning stock biomass index of the northern contingent through 2018 are likely representative of the entire stock. Since reaching a time-series low in 2012, the spawning stock biomass of the northern contingent increased slightly to approximately 97,600 mt in 2017, but then decreased to 41,200 mt in 2018 (Table 4).

### *2019 Canadian assessment*

Canada's DFO completed an assessment of the northern contingent in March 2019 (Smith et al. 2020). A censored statistical catch-at-age model indicated that estimated spawning stock biomass has been below the limit reference point (LRP), defined as 40% of  $SSB_{F40\%}$ , since 2011, with 2018 SSB estimated to be 77% of the LRP (Figure 12). Due to the influence of the 2015 year class, this terminal year SSB estimate represented a greater proportion of the LRP than that from the prior assessment (DFO 2017), whose terminal year SSB represented only 59% of the LRP. Fishing mortality (for ages 5-10) in 2018 was estimated to be 1.13 and the 2017 recruitment estimate represented a time-series minimum.

### *References*

DFO. 2017. Assessment of the Atlantic Mackerel Stock for the Northwest Atlantic (Subareas 3 and 4) in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/034.

NEFSC (Northeast Fisheries Science Center). 2018. 64th Northeast Regional Stock Assessment Workshop (64th SAW) Assessment Report.

Smith, A.D., Van Beveren, E., Girard, L., Boudreau, M., Brosset, P., Castonguay, M., and Plourde, S. 2020. Atlantic mackerel (*Scomber scombrus* L.) in NAFO Subareas 3 and 4 in 2018. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/013. iv + 37 p.

Table 1: Atlantic mackerel U.S. commercial landings, commercial discards and recreational catch, Canadian landings, and foreign catch (mt) for 1960-2019. U.S. recreational catch estimates were unavailable prior to 1981 and U.S. commercial discard estimates were unavailable prior to 1989. U.S. recreational catch represents the newly calibrated MRIP estimates.

Year	US commercial landings	US recreational catch***	US commercial discards <sup>^</sup>	US total catch	Canadian catch**	Foreign landings**	Total catch
1960	1,396			1,396	5,957	0	7,353
1961	1,361			1,361	5,459	11	6,831
1962	938			938	6,865	175	7,978
1963	1,320			1,320	6,473	1,299	9,092
1964	1,644			1,644	10,960	801	13,405
1965	1,998			1,998	11,590	2,945	16,533
1966	2,724			2,724	12,821	7,951	23,496
1967	3,891			3,891	11,243	19,047	34,181
1968	3,929			3,929	26,097	65,747	95,773
1969	4,364			4,364	21,247	114,189	139,800
1970	4,049			4,049	19,613	210,864	234,526
1971	2,406			2,406	24,280	355,892	382,578
1972	2,006			2,006	26,183	391,464	419,653
1973	1,336			1,336	34,513	396,759	432,608
1974	1,042			1,042	42,300	321,837	365,179
1975	1,974			1,974	24,773	271,719	298,466
1976	2,712			2,712	25,425	223,275	251,412
1977	1,377			1,377	22,511	56,067	79,955
1978	1,605			1,605	25,432	841	27,878
1979	1,990			1,990	30,245	440	32,675
1980	2,683			2,683	22,136	566	25,385
1981	2,941	2,628		5,569	19,296	5,361	30,226
1982	3,330	1,877		5,207	16,378	6,647	28,232
1983	3,805	2,793		6,598	19,792	5,955	32,345
1984	5,954	2,726		8,680	17,331	15,045	41,057
1985	6,632	4,088		10,720	29,862	32,409	72,991
1986	9,637	7,662		17,299	28,469	26,507	72,275
1987	12,310	7,555		19,865	27,492	36,564	83,921
1988	12,309	5,421		17,730	24,051	42,858	84,639
1989	14,556	2,829	160.43	17,546	20,854	36,823	75,223
1990	31,261	3,254	827.38	35,343	21,790	30,678	87,811

*Continued*

Table 1, continued.

Year	US commercial landings	US recreational catch***	US commercial discards <sup>^</sup>	US total catch	Canadian catch**	Foreign landings**	Total catch
1991	26,961	3,540	1,098	31,599	25,899	15,714	73,212
1992	11,761	921.1	2,072	14,754	26,382	0	41,136
1993	4,662	1231.45	3,902	9,796	26,712	0	36,508
1994	8,917	2,654	5,409	16,980	20,830	0	37,810
1995	8,468	1,697	53.92	10,219	18,309	0	28,528
1996	15,728	2,466	2,053	20,246	21,025	0	41,271
1997	15,403	2,857	228.83	18,489	21,306	0	39,795
1998	14,525	1553.23	97.5	16,176	18,940	0	35,116
1999	12,031	2,832	770.5	15,634	17,695	0	33,329
2000	5,649	3,055	152.86	8,857	17,856	0	26,713
2001	12,340	3,301	718.2	16,359	24,474	0	40,833
2002	26,530	2,679	155.31	29,364	34,847	0	64,211
2003	34,298	1874.18	264.28	36,436	44,912	0	81,348
2004	54,990	1169.31	2,141	58,300	53,730	0	112,030
2005	42,209	1,694	1,083	44,986	55,282	0	100,268
2006	56,640	3,911	134.87	60,687	53,960	0	114,646
2007	25,546	762.64	159.45	26,468	53,394	0	79,862
2008	21,734	2730.99	747.11	25,212	29,671	0	54,883
2009	22,634	1768.59	125.95	24,529	42,232	0	66,761
2010	9,877	4287.7	96.97	14,261	38,736	0	52,997
2011	533.06	4,040	37.84	4,610	11,534	0	16,144
2012	5,333	2670.9	33.24	8,037	6,468	0	14,505
2013	4,372	2406.31	19.82	6,799	9,017	0	15,815
2014	5,905	2,296	51.44	8,252	6,872	0	15,124
2015	5,616	4,275	13.02	9,905	4,280	0	14,185
2016	5,687	4,572	17.69	10,277	8,055	0	18,332
2017	6,975	4,161	82.82	11,219	9,783	0	21,002
2018	8,717	2,394	177.07	11,288	10,798	0	22,085
2019*	5,379	2,119	199.87	7,699	8,557	0	16,255

\* 2019 estimates of Canadian catch, and therefore total catch, are preliminary.

\*\* Canada's Department of Fisheries and Oceans, in their March 2019 assessment of the northern contingent, updated the time series of Canadian and foreign landings; however, these updated time series were not included because discrepancies are still being resolved.

\*\*\* To estimate the weight of live discards, average individual weights of the harvested individuals were applied to the live discard estimates in numbers.

<sup>^</sup> Discard mortality was assumed to be 100%.

Table 2: Atlantic mackerel stratified mean number-per-tow and weight (kg)-per-tow derived from the NEFSC spring bottom trawl survey for the *Bigelow* years of 2009-2019.

Year	Number-per-tow			Weight-per-tow		
	Mean	Standard error	CV	Mean	Standard error	CV
2009	86.76	25.93	29.88	8.63	3.16	36.60
2010	26.00	7.96	30.60	3.83	1.24	32.46
2011	73.55	18.41	25.04	5.52	1.28	23.25
2012	40.48	13.26	32.75	3.40	1.05	30.99
2013	21.79	4.88	22.41	3.01	0.68	22.66
2014	3.46	0.94	27.12	0.60	0.17	28.06
2015	101.84	49.18	48.29	13.79	8.66	62.79
2016	20.32	6.05	29.76	2.73	0.63	23.14
2017	68.53	20.86	30.43	7.45	2.14	28.71
2018	18.74	9.56	51.05	2.49	1.28	51.57
2019	32.91	13.22	40.17	3.73	1.31	35.24

Table 3: Stratified mean number-per-tow-at-age from the NEFSC spring bottom trawl survey for 2009-2019.

	1	2	3	4	5	6	7
2009	63.09	21.33	1.63	0.70	0.00	0.01	0.00
2010	8.06	16.13	1.66	0.06	0.07	0.00	0.01
2011	69.71	2.02	1.62	0.16	0.03	0.00	0.00
2012	31.83	7.35	0.57	0.61	0.12	0.01	0.00
2013	8.06	10.61	3.03	0.03	0.04	0.01	0.00
2014	1.31	1.15	0.93	0.07	0.00	0.00	0.00
2015	63.99	20.99	9.41	6.63	0.74	0.08	0.00
2016	11.39	7.59	1.25	0.06	0.01	0.02	0.00
2017	5.08	60.86	2.38	0.17	0.02	0.01	0.00
2018	8.99	0.32	8.99	0.40	0.03	0.00	0.00
2019	11.82	17.52	0.23	3.23	0.10	0.02	0.00

Table 4: U.S., Canadian and combined (U.S. plus Canadian) spawning stock biomass (SSB) estimates from egg (Canada) and ichthyoplankton (U.S.) surveys from 1977-2018. For 2017-2018, only index values from the Canadian egg survey were available.

Year	Combined SSB Index	U.S. SSB Index	Canadian SSB Index	U.S. SSB Proportion
1977	NA	389975	NA	NA
1978	NA	NA	NA	NA
1979	1131094	310540	820554	0.27
1980	NA	363192	NA	NA
1981	NA	185736	NA	NA
1982	NA	130673	NA	NA
1983	597553	254962	342591	0.43
1984	798037	71854	726183	0.09
1985	1237678	20500	1217178	0.02
1986	1846983	92931	1754052	0.05
1987	952925	80222	872703	0.08
1988	NA	NA	739208	NA
1989	NA	NA	757877	NA
1990	NA	NA	725415	NA
1991	NA	NA	1284928	NA
1992	NA	NA	796459	NA
1993	NA	NA	935545	NA
1994	NA	NA	467261	NA
1995	NA	NA	NA	NA
1996	NA	NA	123464	NA
1997	NA	NA	NA	NA
1998	NA	NA	105801	NA
1999	NA	NA	NA	NA
2000	184827	23254	161573	0.13
2001	NA	10334	NA	NA
2002	449102	60095	389007	0.13
2003	NA	NA	307091	NA
2004	173186	10384	162802	0.06
2005	88986	1027	87959	0.01
2006	NA	1840	NA	NA
2007	78689	2157	76532	0.03
2008	NA	NA	99631	NA
2009	74911	1168	73743	0.02
2010	29257	3297	25960	0.11

*Continued*



Table 4, contd.

Year	Combined SSB Index	U.S. SSB Index	Canadian SSB Index	U.S. SSB Proportion
2011	36538	824	35714	0.02
2012	NA	NA	14568	NA
2013	34108	746	33362	0.02
2014	NA	NA	49796	NA
2015	48131	5559	42572	0.12
2016	59613	3138	56475	0.05
2017	NA	NA	97612	NA
2018	NA	NA	41241	NA

Figure 1: Total annual mackerel catch (mt) by the U.S., Canada and other countries for 1960-2019.

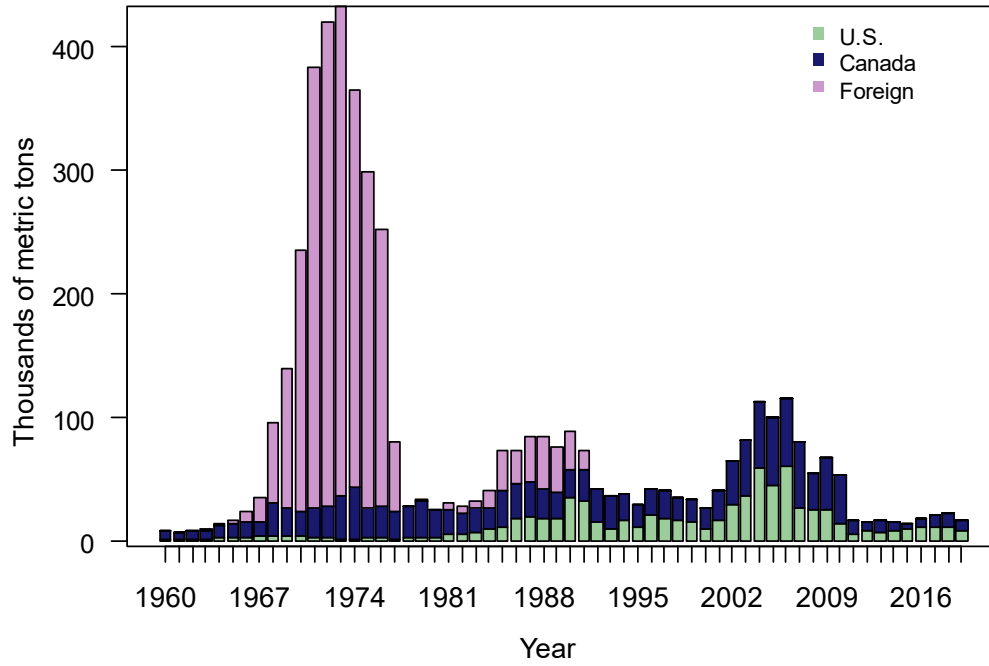


Figure 2: Atlantic mackerel commercial landings (mt) from 2019. Landings for all gears other than paired midwater trawls were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels are reported via VTRs. Total dealer landings reported (mt): 5,347.3. Dealer landings from trips with location data (mt): 4,881.5 (91.3% of total).

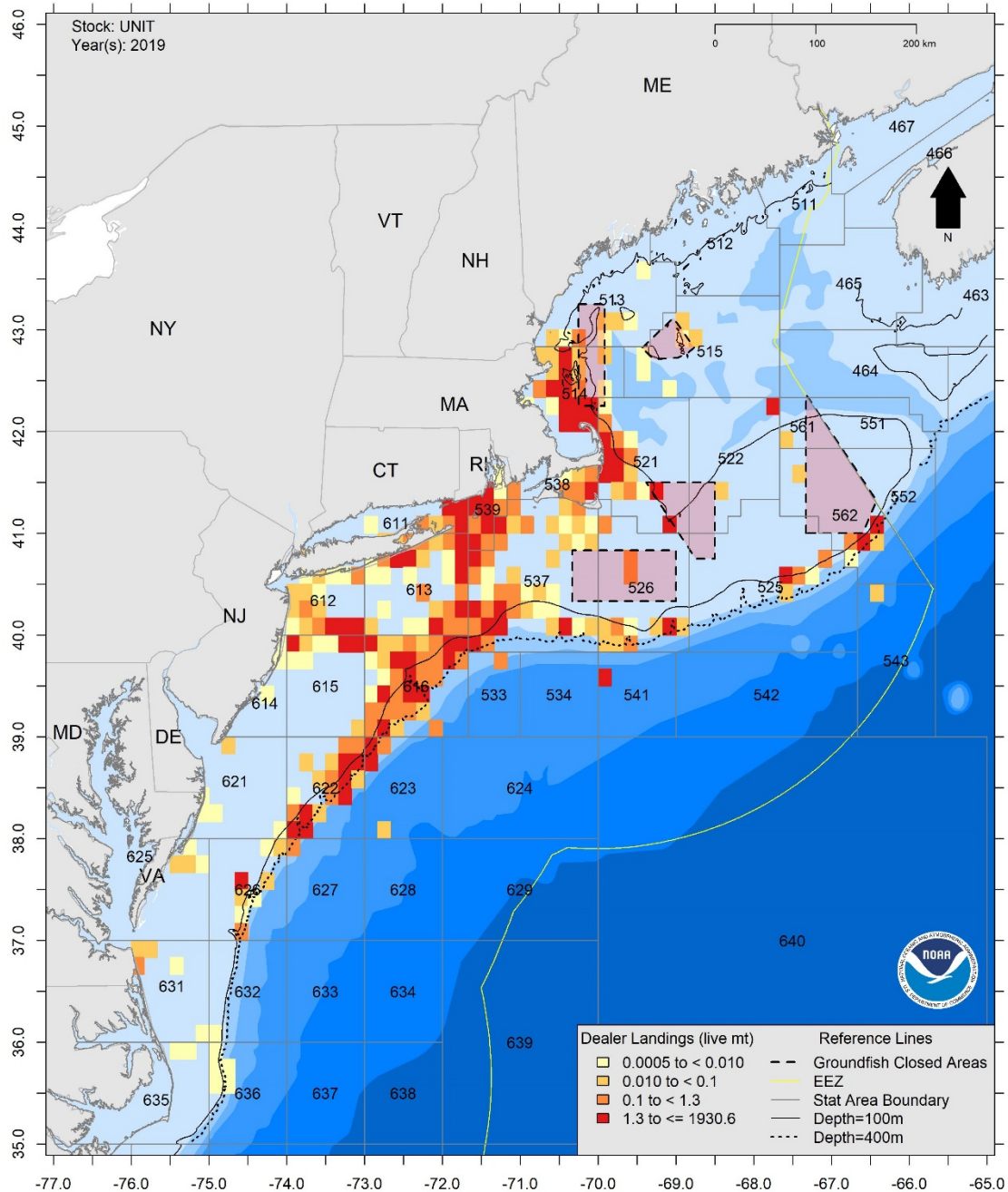


Figure 3: Total U.S. catch-at-age (millions of fish) of Atlantic mackerel during 1992-2019.

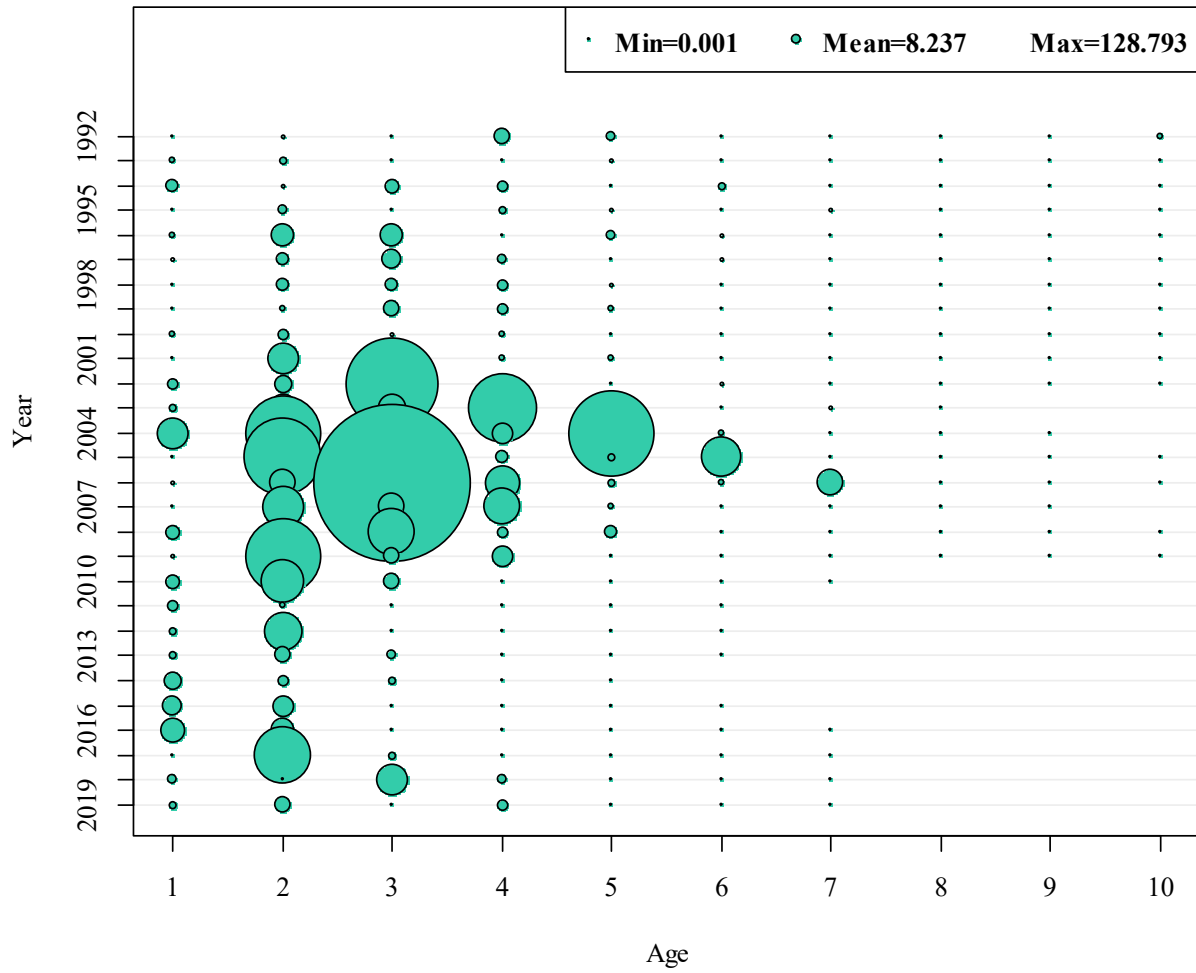


Figure 4: Total catch-at-age (millions of fish) of Atlantic mackerel in the Canadian commercial fishery during 1992-2018. Catch-at-age estimates from the Canadian commercial fishery were not available for 2019.

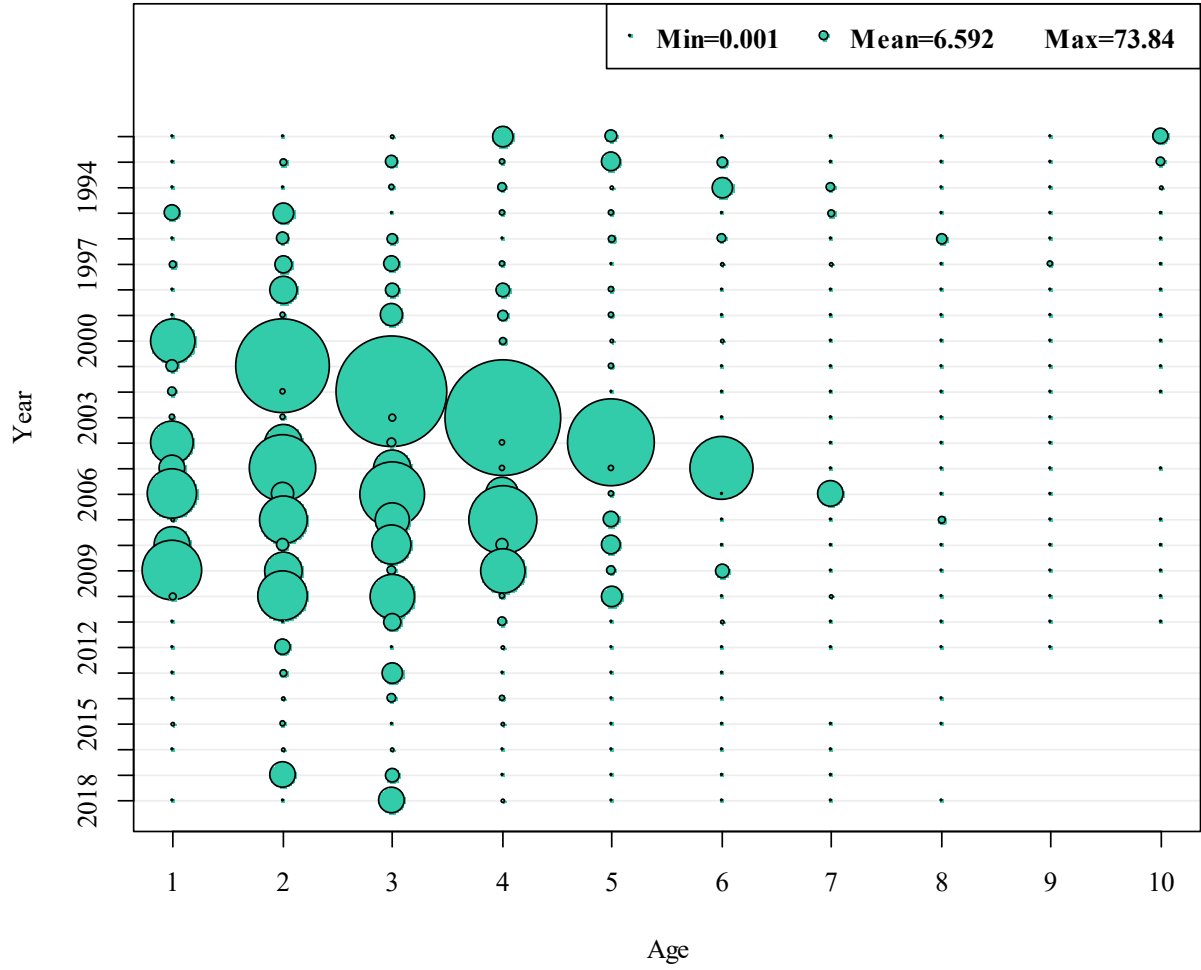


Figure 5: Total U.S. and Canadian catch-at-age (millions of fish) of Atlantic mackerel during 1992-2018. Canadian, and therefore total catch-at-age, estimates were not available for 2019.

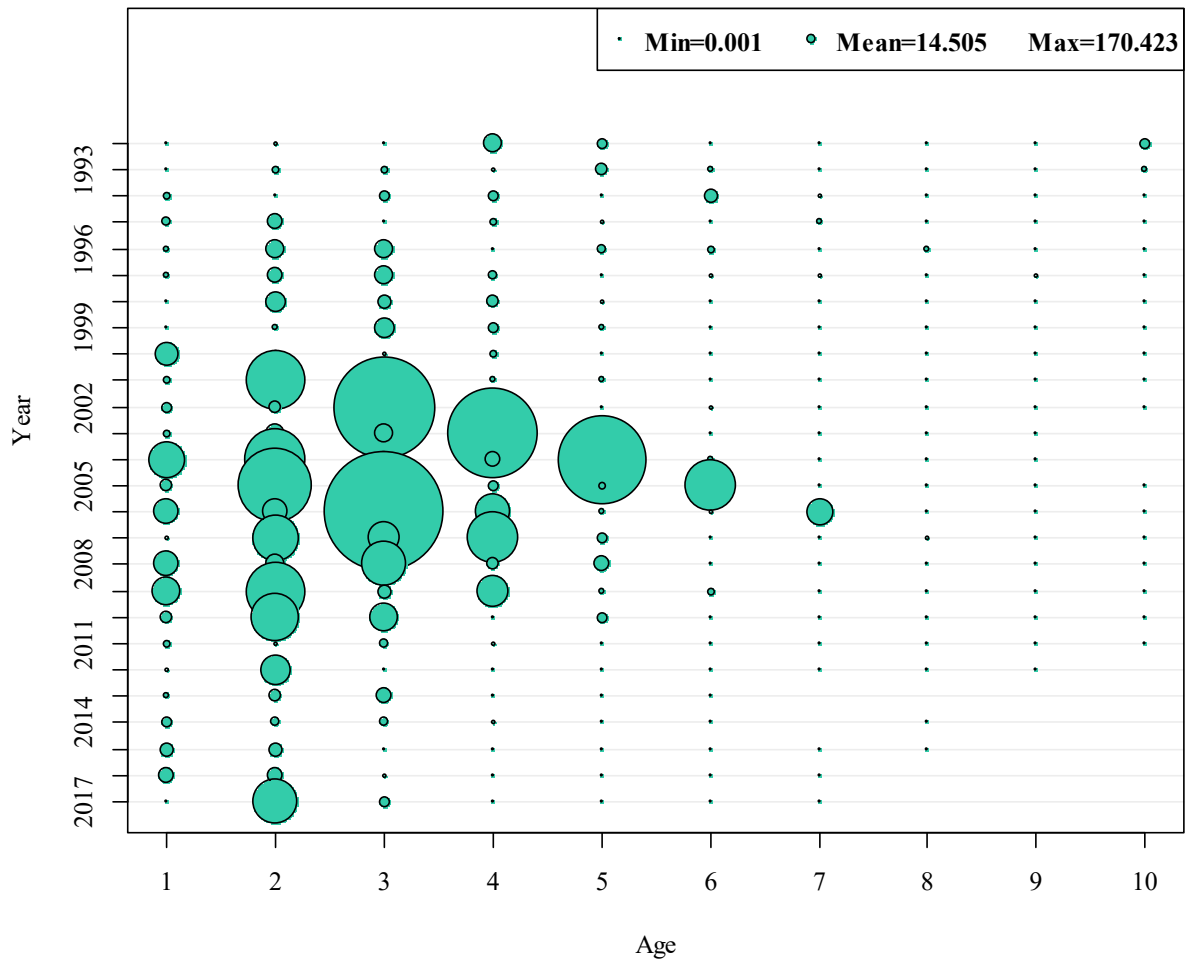


Figure 6: Atlantic mackerel relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices derived from the NEFSC spring bottom trawl survey for the *Bigelow* years of 2009-2019. The median number- and weight-per-tow values represent the median indices over 2009-2019.

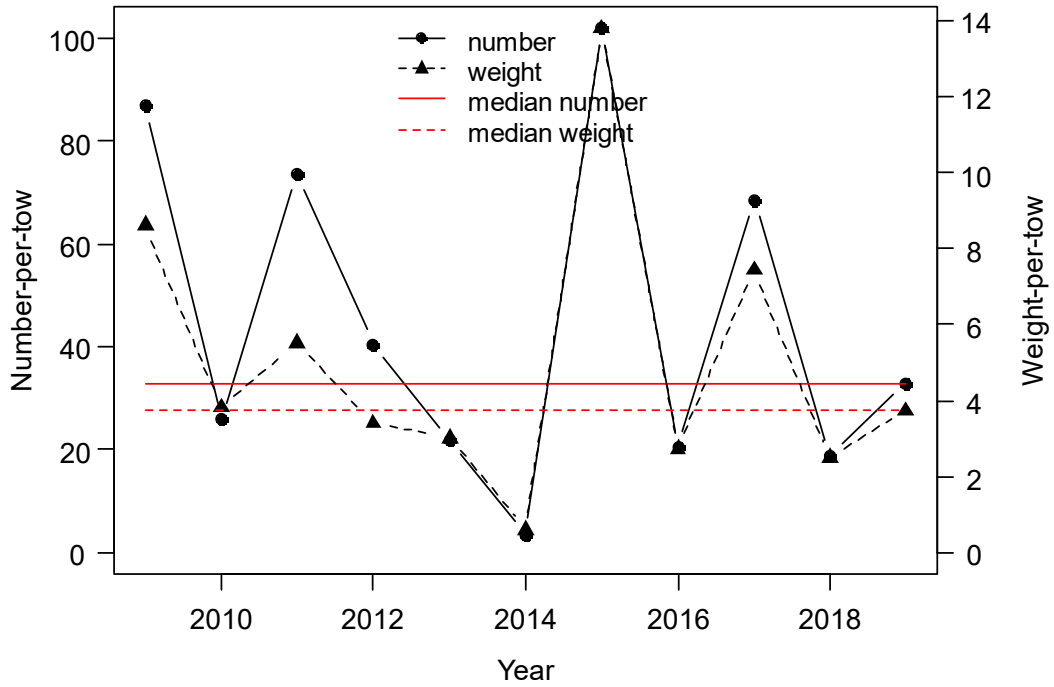


Figure 7: Annual mackerel length compositions from the NEFSC spring bottom trawl survey for the *Bigelow* years of 2009-2019.

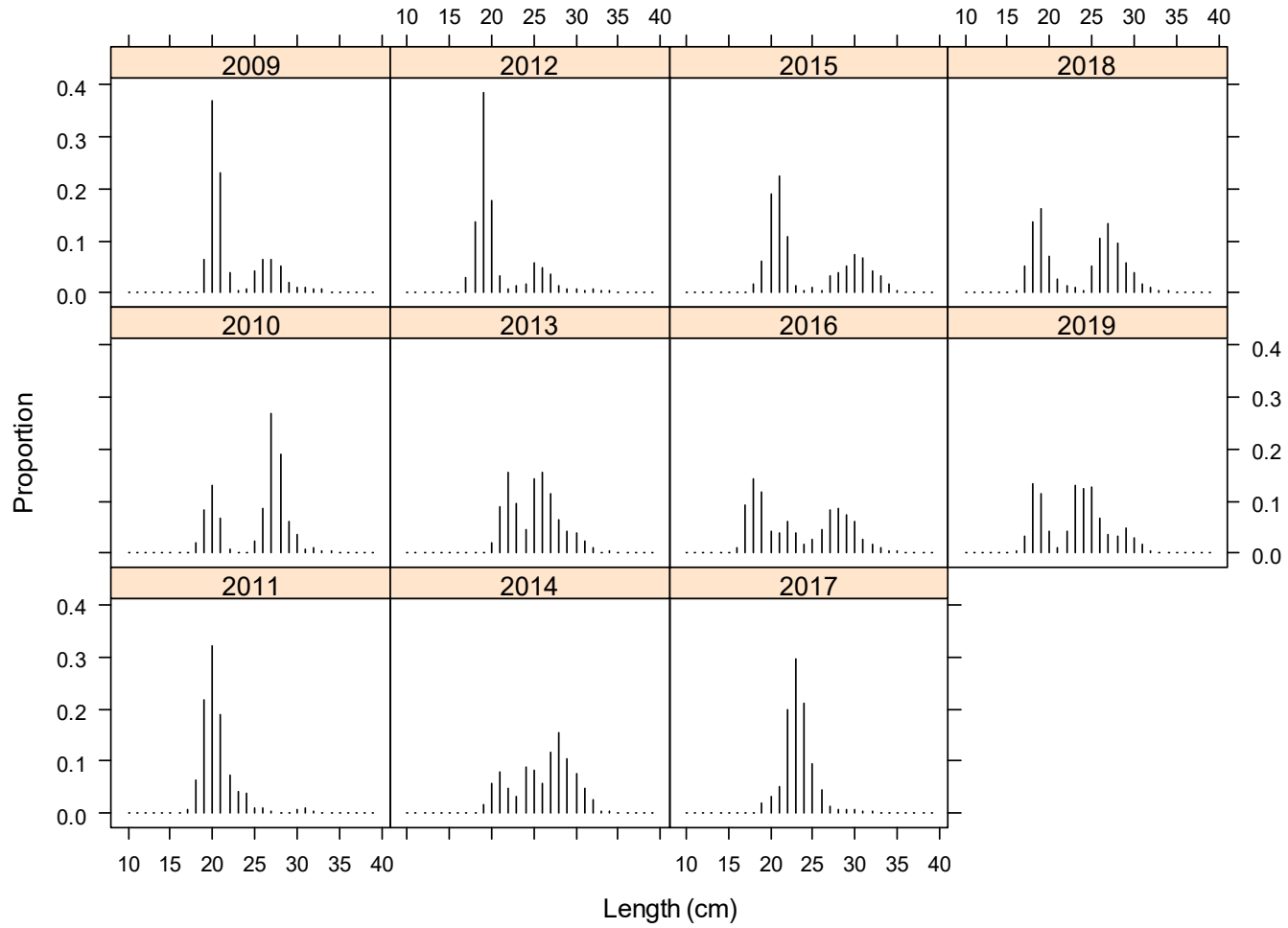




Figure 8: Stratified mean length (cm) of mackerel from the NEFSC spring bottom trawl survey, 2009-2019.

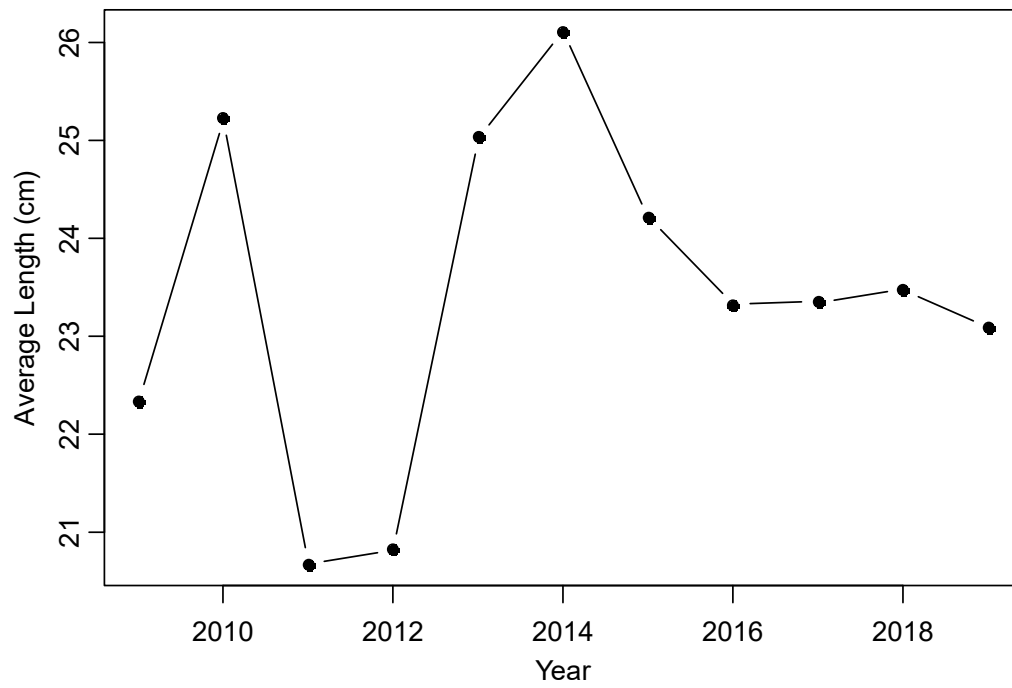


Figure 9: Atlantic mackerel catch proportions-at-age in the NEFSC spring survey for the *Bigelow* years of 2009-2019.

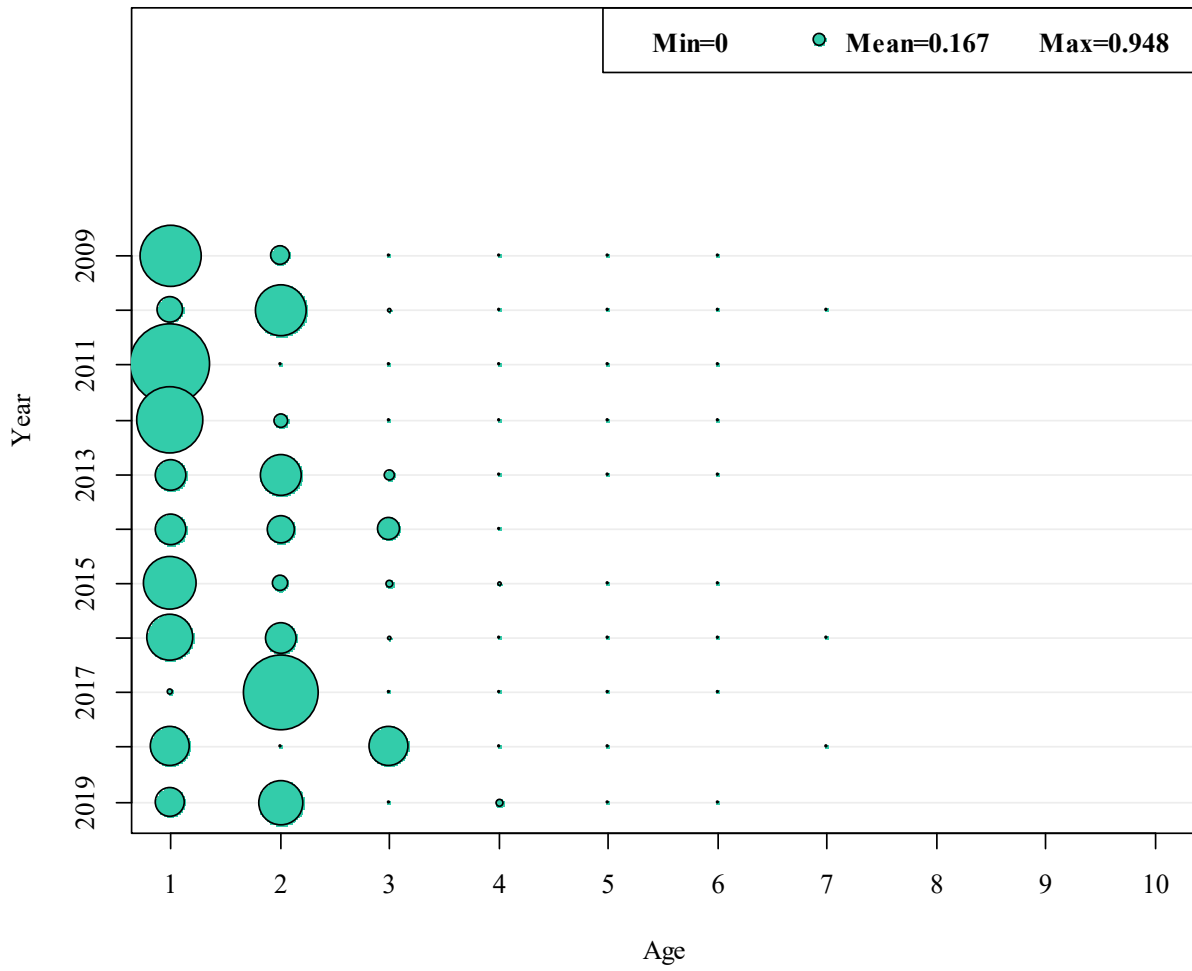


Figure 10: Atlantic mackerel relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices for ages-3+ derived from the NEFSC spring bottom trawl survey for the *Bigelow* years of 2009-2019. The median number- and weight-per-tow values represent the median indices over 2009-2019.

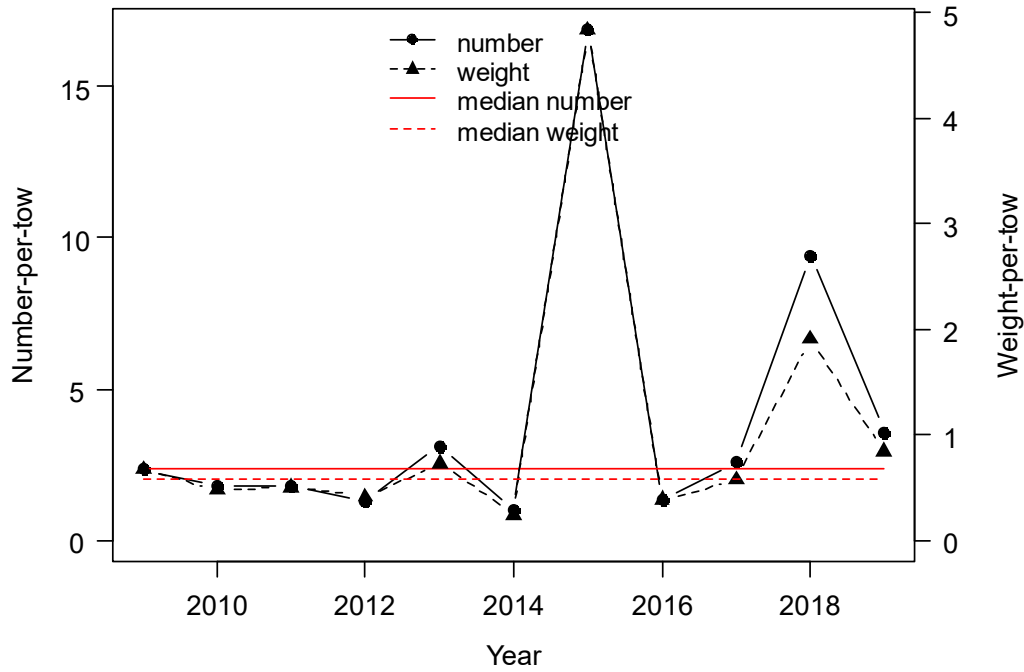


Figure 11: Atlantic mackerel spawning stock biomass index (millions metric tons) calculated using the total egg production method, based on egg densities observed in the southern Gulf of St. Lawrence (northern contingent) and the Northeast U.S. Continental Shelf (southern contingent). The combined SSB index represents the sum of northern and southern contingents and was only calculated in years where indices from both contingents were available. For 2017-2018, only index values from the northern contingent were available.

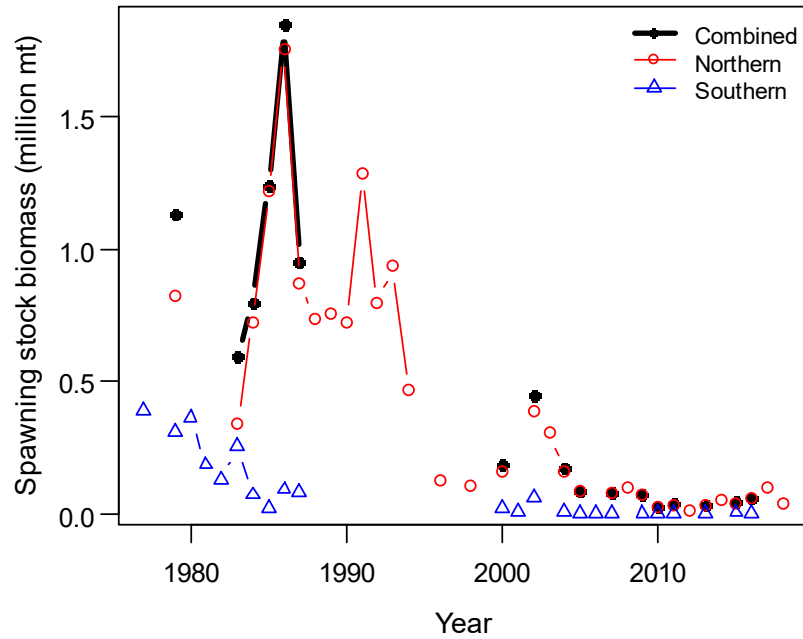
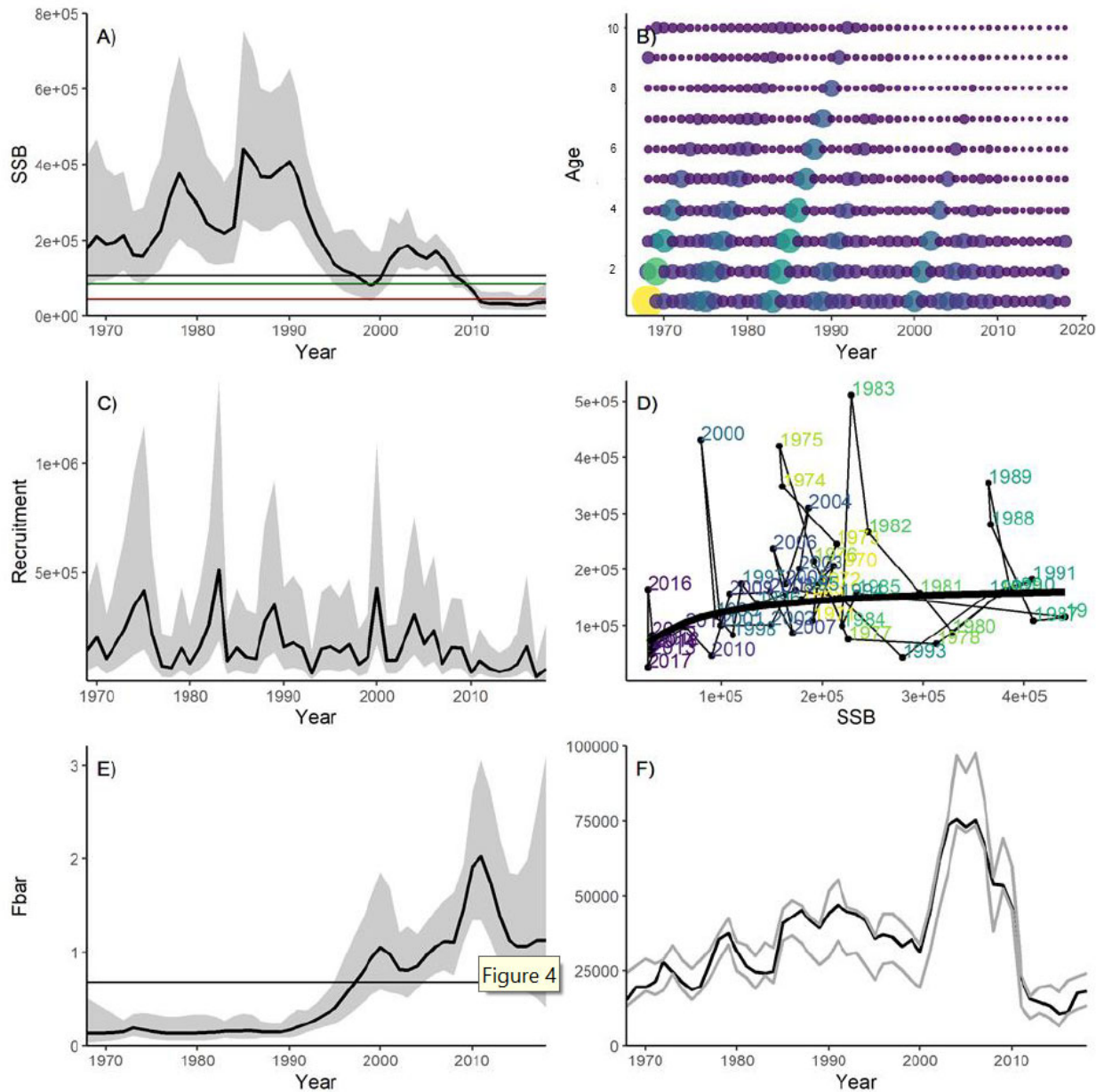


Figure 12: Censored statistical catch-at-age model estimates from the 2019 Canadian assessment of the northern contingent: (A) SSB (t) with horizontal lines indicating  $SSB_{F40\%}$  (black), the upper stock reference corresponding to 80% of  $SSB_{F40\%}$  (green), and the limit reference point corresponding to 40% of  $SSB_{F40\%}$  (red), (B) abundance at age, (C) recruitment (numbers), (D) stock-recruitment, (E) fishing mortality (averaged over the fully selected age classes 5-10), (F) estimated catch (black) between the pre-determined bounds (grey). Obtained from Smith et al. (2020).



**Appendix A:**

**Spatial distribution of U.S. Atlantic mackerel commercial landings for 2012-2018**

Figure A1: Atlantic mackerel commercial landings (mt) for 2012-2016. Landings for all gears other than paired midwater trawls were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels are reported via VTRs. Total dealer landings reported (mt): 26,892.7. Dealer landings from trips with location data (mt): 25,187.8 (93.7% of total).

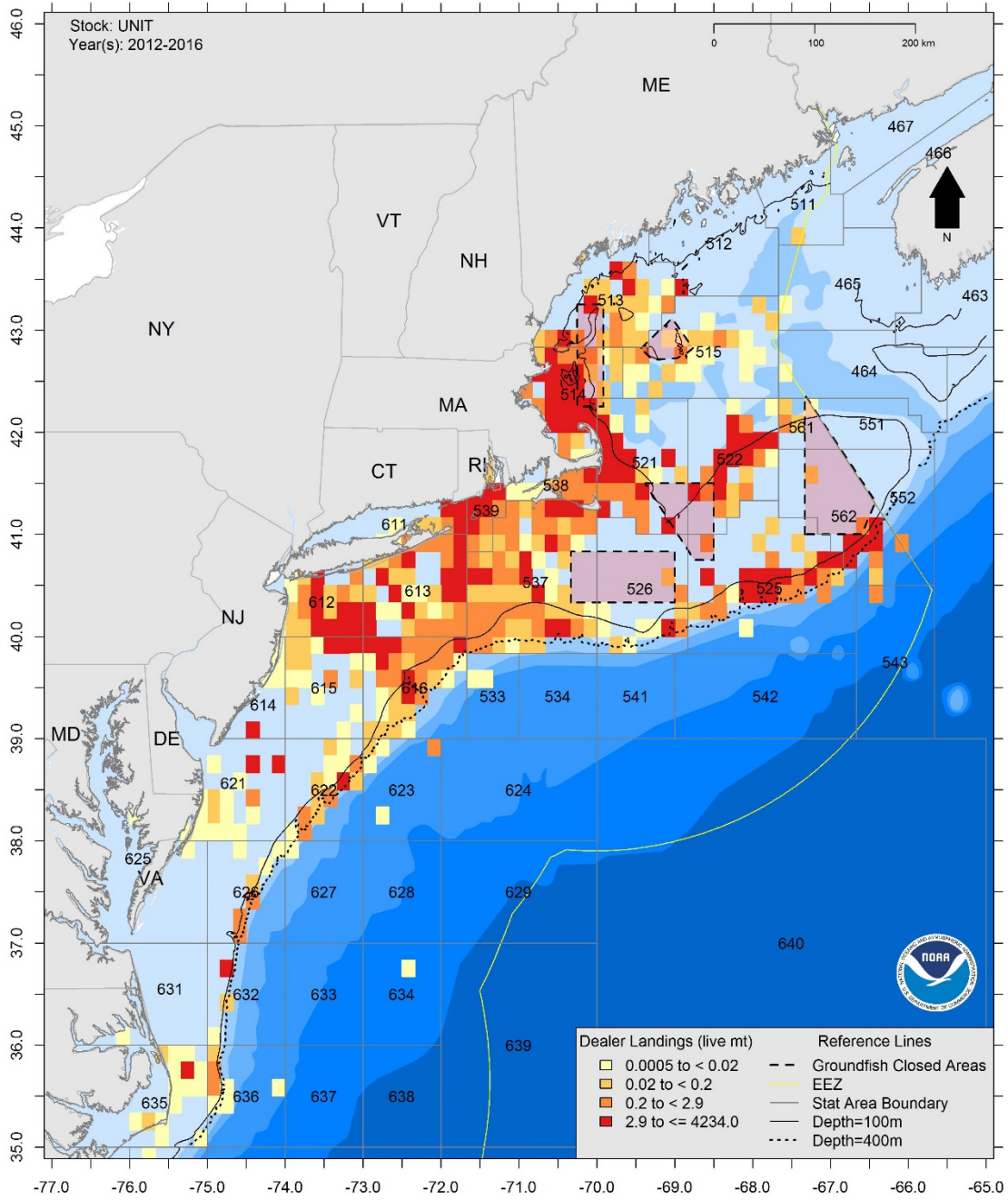


Figure A2: Atlantic mackerel commercial landings (mt) for 2017. Landings for all gears other than paired midwater trawls were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels are reported via VTRs. Total dealer landings reported (mt): 7,598.1. Dealer landings from trips with location data (mt): 6,983.8 (91.9% of total).

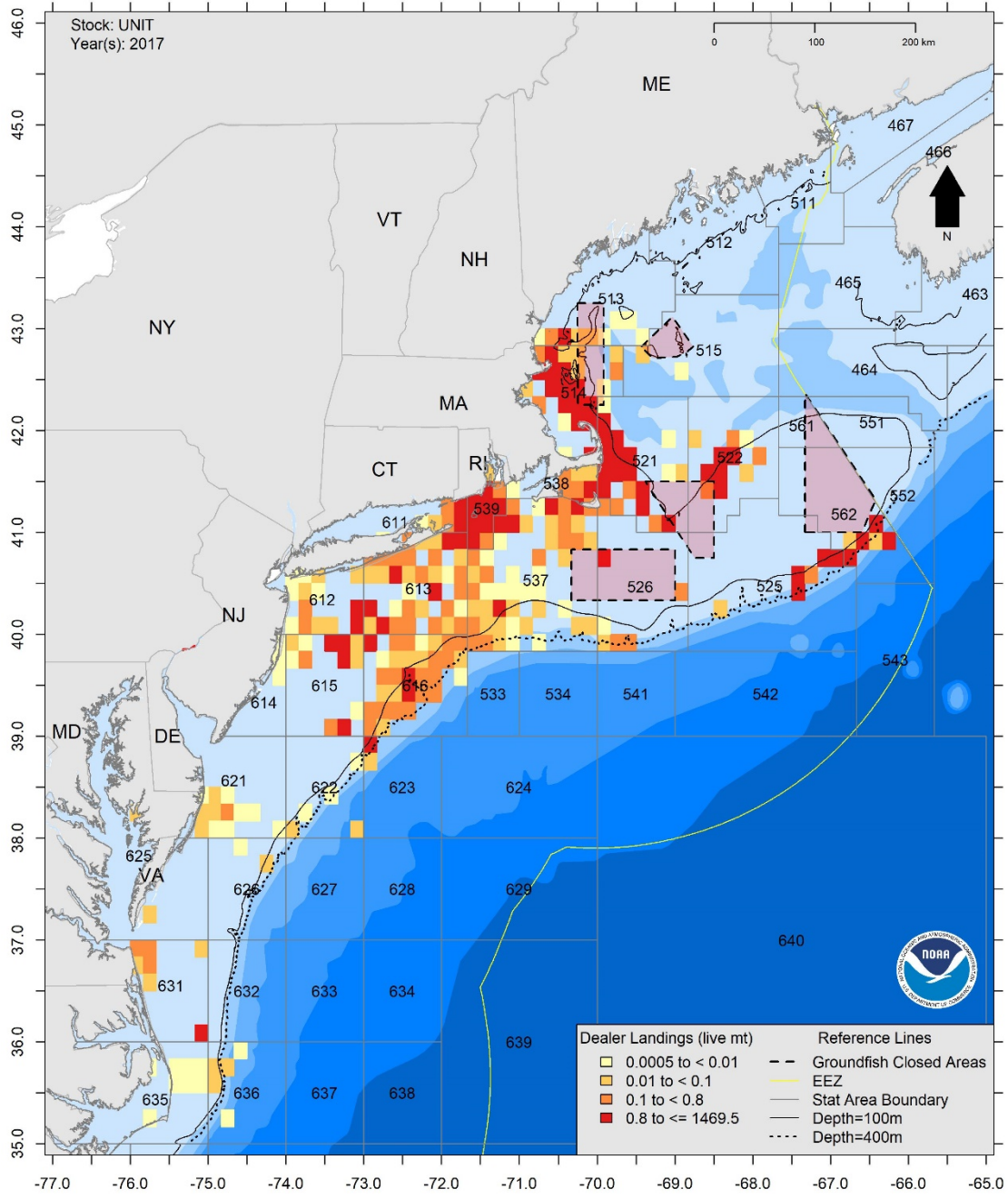
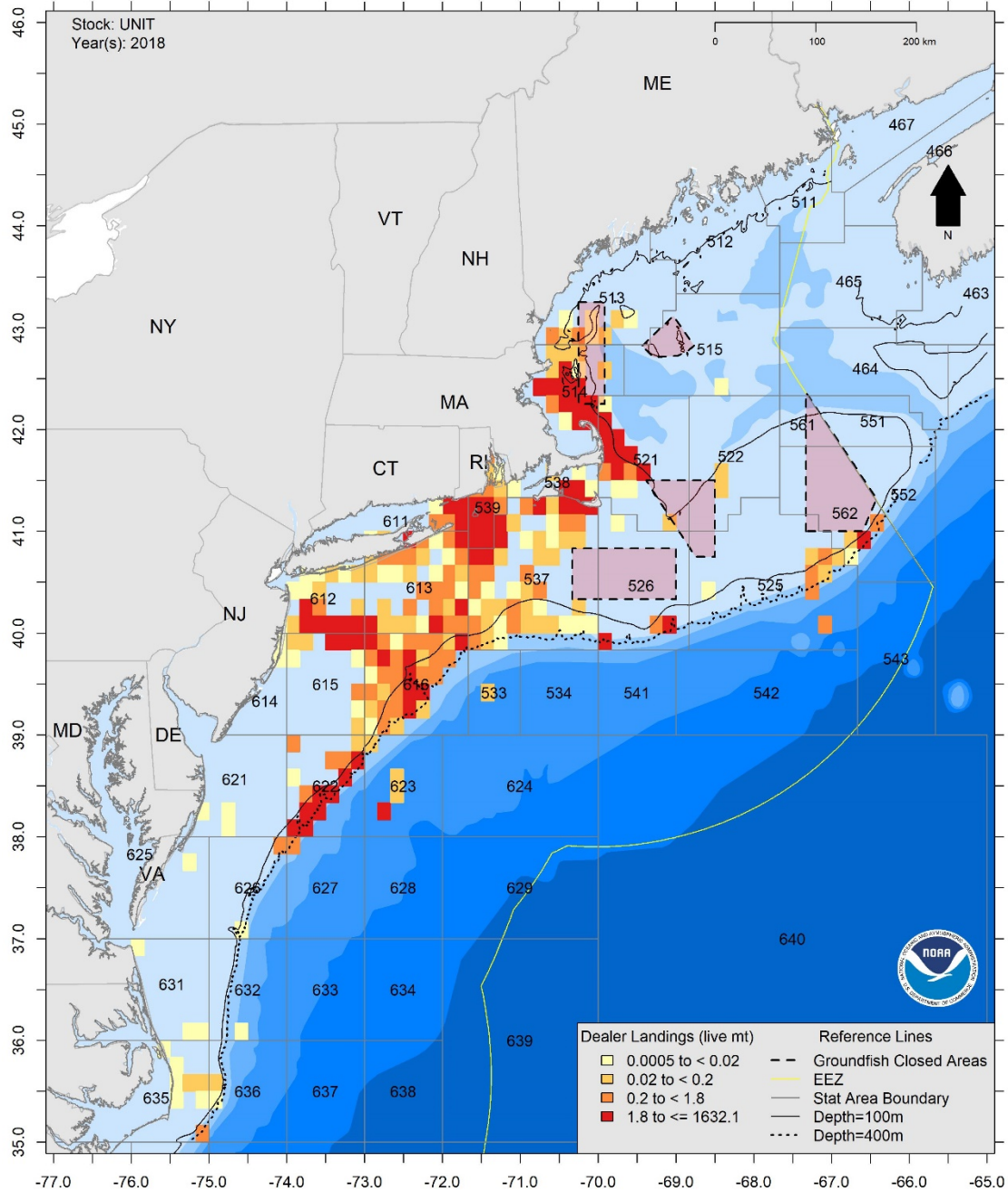




Figure A3: Atlantic mackerel commercial landings (mt) for 2018. Landings for all gears other than paired midwater trawls were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels are reported via VTRs. Total dealer landings reported (mt): 8,447.4. Dealer landings from trips with location data (mt): 7,905.9 (93.6% of total).



**Appendix B:**

**Atlantic mackerel catch-at-age of the individual components of the U.S. fishery**

Figure B1: Atlantic mackerel U.S. commercial landings-at-age (millions of fish) during 1992-2019.

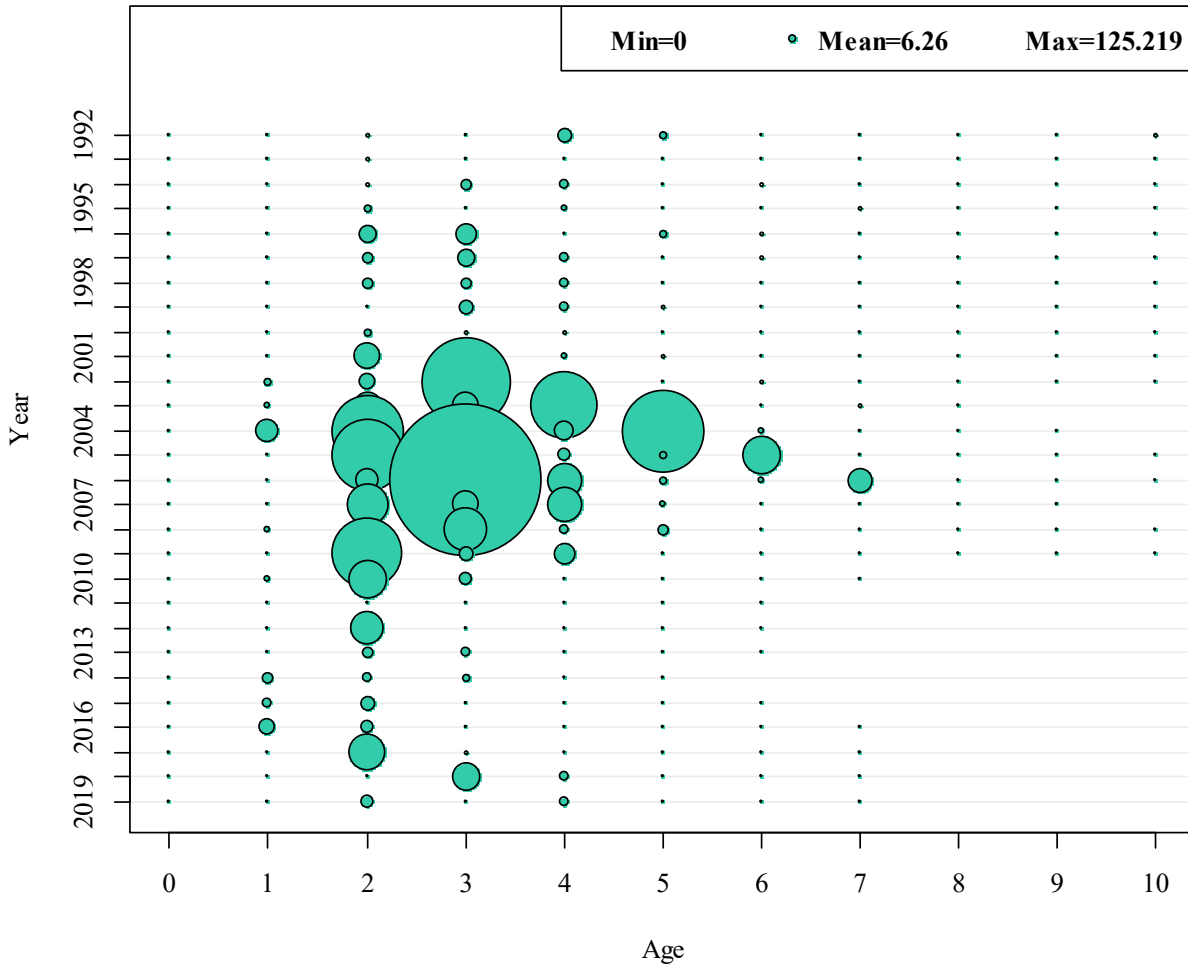


Figure B2: Atlantic mackerel U.S. commercial discards-at-age (millions of fish) during 1992-2019.

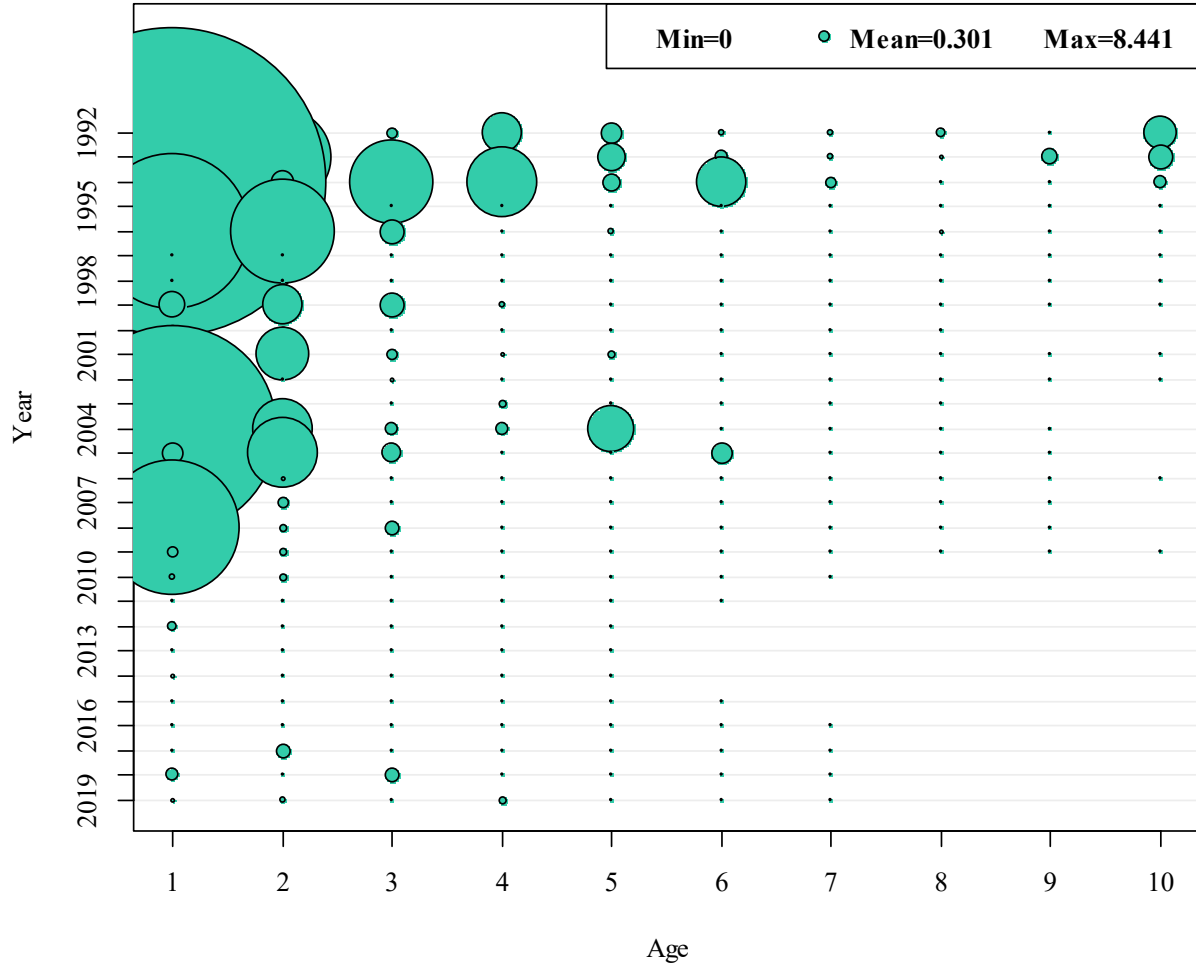


Figure B3: Atlantic mackerel U.S. recreational catch-at-age (millions of fish) during 1992-2019.

