

Atlantic Mackerel Update for 2017 Specifications

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Population Dynamics Branch

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The following information addresses the request by Dr. Chris Moore, Executive Director of the Mid-Atlantic Fisheries Management Council (MAFMC), in his letter to Dr. Bill Karp on 20 January 2016. The MAFMC requested that the NEFSC provide a data update for Atlantic mackerel for this year's specifications.

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, catches averaged only 33,100 mt before increasing to a peak of 111,900 mt in 2006. Total catch then declined and since 2011 has averaged 12,400 mt. U.S. discards, the only discard estimates available, represented an average of 2.7% of U.S. landings over the time series, and 1.4% of landings since 2000. Since the implementation of annual catch limits in 2011, total catch has been less than 40% of the annual ABC's, with the exception of 2015 where catch was approximately 51% of the ABC (Table 2). Updated age and length catch composition data were not available.

The spatial distribution of total commercial landings from dealer reports for 2005-2009 and 2010-2014, as well as vessel trip report (VTR) estimates from 2015 are depicted in the appendix.

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 1968-2015. Indices were not yet available for the ongoing 2016 spring survey. In 2009, the survey changed primary research vessels from the *Albatross IV* to the *Henry B. Bigelow*. Indices for 2009 onward were converted from *Bigelow* units to *Albatross IV* equivalents using single conversion factors for relative abundance (1.188) and biomass (0.868) (Miller et al. 2010). In 2014, stations south of Maryland (offshore strata 61-68) were not sampled due to delays in the survey (Figure 2). Accordingly, 1968-2013 indices were previously re-estimated using an abbreviated set of offshore strata and compared to estimates based on the full offshore strata set historically used to estimate mackerel spring survey indices (NEFSC 2015). This comparison indicated that the use of an abbreviated set of strata did not impact temporal trends in relative abundance or biomass; therefore, the abbreviated set of offshore strata was used to derive relative abundance and biomass indices from 1968-2015 so that the 2015 estimate could be directly compared to that of 2014. Estimated 2015 indices of relative abundance and biomass were 97.64 mackerel-per-tow (CV = 46.5%) and 10.56 kg-per-

tow (CV = 60.5%), respectively (Table 3). Estimated 2015 relative abundance and biomass indices were both higher than the time series medians of 22.13 mackerel-per-tow and 4.13 kg-per-tow (Figure 3).

Mackerel lengths from the spring survey ranged from 11 cm to 48 cm during 1968-2015. Length compositions varied over time, with some years exhibiting unimodal distributions and other years exhibiting bimodal or trimodal distributions (Table 4, Figure 4). Annual stratified mean proportions-at-length were averaged over ten-year intervals, with the exception of the earliest two time periods which included nine years, to further examine changes in length composition over time. Mackerel length structure expanded between the first (1968-1976) and second (1977-1985) time intervals, but contracted thereafter (Figure 5). During the most recent time interval (2006-2015), mackerel size composition range was the smallest of the time series, with 96% of individuals between 18 cm and 31cm fork length. Average length structure was trimodal during the first 29 years of the time series, but then became bimodal (modes = 20 cm and 27 cm) from 1995 onward (Figure 5). Average annual length over the time series was also analyzed (Figure 6). Average length exhibited substantial interannual variability, but generally increased over beginning of the time series, reaching a peak in 1981, and then declined over the latter part of the time series.

While not requested in the MAFMC's letter, age-specific indices of mackerel from the NEFSC spring bottom trawl survey were updated. Age-specific indices as geometric stratified mean number-per-tow-at-age were updated from the 2010 TRAC through 2013 using the full offshore strata set (Table 5, Figure 7). Indices from years 2009 through 2013 were converted from *Bigelow* units to *Albatross IV* equivalents. Age-specific indices suggested a truncation in age structure since approximately 2001. Geometric mean indices could not be updated for the entire time series using the abbreviated strata set, so stratified arithmetic mean indices-at-age were developed for the *Bigelow* years (2009-2015) using the abbreviated strata set (Table 6, Figure 8). Since all years were from the *R/V Bigelow*, relative abundance estimates were not converted to *Albatross IV* equivalents. Indices-at-age were predominantly comprised of one through three year-old fish.

Canadian mackerel assessment

In 2012, the Canadian Department of Fisheries and Oceans (DFO) assessed the Canadian contingent of Atlantic mackerel in NAFO Subareas 3 and 4 (DFO 2012). A sequential population analysis was conducted using time series of Canadian landings-at-age (1968-2011) and spawning stock biomass indices from the southern Gulf of St. Lawrence egg survey (1996-2011). Catches from bait and recreational fisheries were not recorded, and commercial discards did not appear to be available for the analysis. Canadian landings increased in the early 2000's, reaching a historic high in 2005. Landings were variable but generally decreased beginning in 2006, reaching a low in 2011. Spawning stock indices from egg surveys exhibited a decline between 1993-1998, subsequently increased due to a strong-1999 year class, and then declined to historical lows since 2005. A 2009 egg survey on the Scotian Shelf and southern Newfoundland coast also exhibited low egg densities.

The assessment indicated a decline in estimated mackerel spawning stock biomass since approximately 2006 (Figure 9). This decline was attributed to low recruitment and high fishing mortality rates (Figure 10). The assessment noted a slight retrospective pattern for predicted abundance and fishing mortality but not for spawning stock biomass, and further noted that the diagnostics did not suggest any major adjustment problems (Grégoire et al. 2014).

Total spawning stock biomass in 2011 (SSB_{2011}) was estimated to be 72,175 tons and fishing mortality (F_{2011}) was estimated to be 0.137 (Grégoire et al. 2014). The ratio between F_{2011} and $F_{40\%}$ was 0.7, and the ratio between SSB_{2011} and SSB_{MSY} was 0.515 and 0.543 for the analytical and random methods, respectively. Accordingly, the mackerel stock was described as overfished but without overfishing in 2011. The assessment recommended a reduction in fishing mortality compared to the 2011 estimate and that catches in 2012-2013 should not exceed 9,000 mt.

An Icelandic project is currently underway to investigate Atlantic mackerel stock structure in the North Atlantic and both the U.S. and Canada have contributed samples for this project. A University of Maryland project is also underway to investigate mackerel contingent structure in the northwest Atlantic through the use of otolith stable isotopes. However, at this time no additional information is available regarding Atlantic mackerel stock structure in the northwest Atlantic and in particular whether the U.S. and Canadian contingents should be classified as two distinct mackerel stocks or one unit stock. The NEFSC received funding to identify and stage mackerel eggs from shelf-wide ichthyoplankton surveys to estimate total annual egg production of the southern spawning contingent. These total annual egg production estimates will then be combined with those of the northern contingent (estimated through DFO's egg survey) and evaluated as an index of spawning stock biomass.

References

- DFO. 2012. Assessment of the Atlantic Mackerel Stock for the Northwest Atlantic (Subareas 3 and 4) in 2011. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/031.
- Grégoire, F., L. Girard, and J.-L. Beaulieu. 2014. Analytical assessment of Atlantic mackerel (*Scomber scombrus* L.) in NAFO Subareas 3 and 4 in 2011. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/137: v + 31p.
- Miller T.J., C. Das, P.J. Politis, A.S. Miller, S.M. Lucey, C.M. Legault, R.W. Brown, and P.J. Rago. 2010. Estimation of Albatross IV to Henry B. Bigelow calibration factors. Northeast Fish Sci Cent Ref Doc. 10-05; 233 p.
- NEFSC (Northeast Fisheries Science Center). 2015. Atlantic mackerel update for 2016 specifications. Update report provided to the SSC and available at: [http://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/553aa6fbe4b06d9495148da0/1429907195000/Mackerel Update For 2016 Specs.pdf](http://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/553aa6fbe4b06d9495148da0/1429907195000/Mackerel+Update+For+2016+Specs.pdf).

Table 1: Atlantic mackerel US commercial landings, recreational landings and discards, Canadian landings, and foreign catch (mt) for 1960-2015.

Year	US			Canada	Foreign	Total
	Commercial	Recreational**	Discards*			
1960	1,396	-	-	5,957	-	7,353
1961	1,361	-	-	5,459	11	6,831
1962	938	-	-	6,865	175	7,978
1963	1,320	-	-	6,473	1,299	9,092
1964	1,644	-	-	10,960	801	13,405
1965	1,998	-	-	11,590	2,945	16,533
1966	2,724	-	-	12,821	7,951	23,496
1967	3,891	-	-	11,243	19,047	34,181
1968	3,929	-	-	20,819	65,747	90,495
1969	4,364	-	-	17,364	114,189	135,917
1970	4,049	-	-	19,959	210,864	234,872
1971	2,406	-	-	24,496	355,892	382,794
1972	2,006	-	-	22,360	391,464	415,830
1973	1,336	-	-	38,514	396,759	436,609
1974	1,042	-	-	44,655	321,837	367,534
1975	1,974	-	-	36,258	271,719	309,951
1976	2,712	-	-	33,065	223,275	259,052
1977	1,377	-	-	22,765	56,067	80,209
1978	1,605	-	-	25,899	841	28,345
1979	1,990	-	-	30,612	440	33,042
1980	2,683	-	-	22,296	566	25,545
1981	2,941	3,210	-	19,294	5,361	30,806
1982	3,330	1,191	-	16,380	6,647	27,548
1983	3,805	3,002	-	19,797	5,955	32,559
1984	5,954	2,319	-	17,320	15,045	40,638
1985	6,632	2,713	-	29,855	32,409	71,609
1986	9,637	4,223	-	30,325	26,507	70,692
1987	12,310	4,032	-	27,488	36,564	80,394
1988	12,309	3,265	-	24,060	42,858	82,492
1989	14,556	1,787	160	20,795	36,823	74,121
1990	31,261	1,867	827	19,190	30,678	83,823
1991	26,961	2,566	1,098	24,914	15,714	71,253
1992	11,775	284	1,157	24,307	-	37,523
1993	4,666	600	336	26,158	-	31,759
1994	8,917	1,705	718	20,564	-	31,905
1995	8,468	1,249	30	17,706	-	27,454
1996	15,728	1,340	2,335	20,394	-	39,797
1997	15,403	1,737	56	21,309	-	38,505
1998	14,525	690	53	19,334	-	34,602
1999	12,031	1,335	249	16,561	-	30,176
2000	5,649	1,448	111	13,383	-	20,591

Table 1, continued.

Year	US			Canada	Foreign	Total
	Commercial	Recreational**	Discards*			
2001	12,340	1,536	670	23,950	-	38,497
2002	26,530	1,294	36	34,309	-	62,169
2003	34,298	770	175	44,736	-	79,979
2004	54,990	530	1,499	53,777	-	110,797
2005	42,209	1,033	553	54,621	-	98,417
2006	56,640	1,491	85	53,649	-	111,866
2007	25,546	596	88	53,016	-	79,246
2008	21,734	755	358	29,671	-	52,518
2009	22,634	599	280	42,231	-	65,744
2010	9,877	845	122	38,753	-	49,597
2011	533	947	7	11,401	-	12,888
2012	5,333	668	22	6,468	-	12,491
2013	4,372	887	62	7,431	-	12,752
2014	5,905	788	68	6,545	-	13,306
***2015	5,616	1,157	56	3,868	-	10,697

* Discards estimates from 2009-2011 were based on the average discard ratio from 2004-2008. Discards from 2012-2014 were estimated using GARFO's methodology for quota monitoring. The 2015 discard estimate was based on the average discard ratio from 2012-2014.

** Recreational catch was unavailable prior to 1982.

*** 2015 values are preliminary.

Table 2: Annual mackerel quotas (mt), total mackerel catch (mt) and the proportion of the annual quota caught.

Year	Quota	Total Catch	Proportion
1994	120,000	31,905	0.27
1995	100,000	27,454	0.28
1996	105,500	39,797	0.38
1997	90,000	38,505	0.43
1998	80,000	34,602	0.43
1999	75,000	30,176	0.40
2000	75,000	20,591	0.28
2001	85,000	38,497	0.45
2002	85,000	62,169	0.73
2003	175,000	79,979	0.46
2004	170,000	110,797	0.65
2005	115,000	98,417	0.86
2006	115,000	111,866	0.97
2007	115,000	79,246	0.69
2008	115,000	52,518	0.46
2009	115,000	65,744	0.57
2010	115,000	49,597	0.43
2011	47,395	12,888	0.27
2012	36,264	12,491	0.34
2013	36,264	12,752	0.35
2014	33,821	13,306	0.39
2015	20,872	10,697	0.51

Table 3: Atlantic mackerel stratified mean number-per-tow and weight (kg)-per-tow derived from the NEFSC spring bottom trawl survey for 1968-2015.

Year	Number-per-tow			Weight-per-tow		
	Mean	Standard error	CV	Mean	Standard error	CV
1968	37.64	24.39	64.79	1.89	1.20	63.46
1969	0.07	0.03	44.55	0.01	0.00	75.83
1970	10.08	3.32	32.96	2.39	0.77	32.06
1971	13.17	5.96	45.25	3.44	1.66	48.37
1972	9.64	3.86	40.05	1.75	0.86	49.38
1973	76.74	70.59	91.98	24.89	23.39	93.99
1974	8.25	3.05	36.93	2.41	1.20	49.64
1975	7.42	5.19	70.04	0.47	0.23	49.61
1976	4.67	2.35	50.34	0.69	0.34	49.79
1977	0.97	0.41	41.90	0.27	0.09	34.96
1978	2.50	0.61	24.28	0.95	0.22	22.93
1979	0.35	0.10	29.19	0.17	0.05	30.62
1980	2.03	0.72	35.34	0.74	0.24	32.90
1981	15.47	9.40	60.77	8.07	5.02	62.25
1982	5.84	3.99	68.30	0.96	0.49	51.26
1983	1.00	0.34	34.49	0.15	0.07	44.09
1984	17.78	9.12	51.31	2.72	1.37	50.59
1985	8.44	2.77	32.85	2.04	0.71	34.93
1986	4.41	2.93	66.50	1.36	0.93	67.87
1987	35.47	15.58	43.91	6.96	2.49	35.82
1988	17.69	6.94	39.24	4.08	1.26	30.85
1989	12.39	4.83	39.01	1.02	0.43	42.40
1990	11.26	5.31	47.15	1.58	0.76	48.43
1991	25.90	12.05	46.53	6.08	3.17	52.18
1992	22.76	9.17	40.29	4.18	2.18	52.10
1993	15.62	4.80	30.71	4.39	1.34	30.45
1994	30.00	11.19	37.31	4.57	1.67	36.65
1995	27.10	8.60	31.72	5.65	1.88	33.31
1996	45.54	20.26	44.49	12.40	8.63	69.58
1997	21.13	9.09	43.03	2.50	0.85	34.07
1998	28.31	10.59	37.41	3.80	1.60	42.14
1999	55.33	18.45	33.34	7.23	1.95	26.97
2000	79.99	21.26	26.58	7.87	2.12	26.91
2001	132.47	50.41	38.06	17.88	6.86	38.38
2002	40.02	14.16	35.39	8.69	3.18	36.54
2003	66.51	18.71	28.14	12.21	4.38	35.89
2004	125.41	37.38	29.81	9.12	2.80	30.68
2005	34.39	17.37	50.51	4.43	2.10	47.35

Table 3, continued.

Year	Number-per-tow			Weight-per-tow		
	Mean	Standard error	CV	Mean	Standard error	CV
2006	73.03	26.88	36.81	11.13	3.45	30.98
2007	34.01	14.25	41.90	6.31	2.75	43.54
2008	82.27	40.64	49.40	13.22	7.81	59.03
2009	118.71	34.29	28.89	16.56	7.91	47.78
2010	32.14	10.04	31.23	6.28	2.96	47.18
2011	90.94	22.20	24.41	8.87	2.98	33.57
2012	49.76	16.68	33.52	4.95	2.02	40.87
2013	21.50	5.32	24.75	3.77	1.30	34.42
2014	4.25	1.16	27.19	0.99	0.40	40.02
2015	97.64	45.41	46.51	10.56	6.38	60.47

* 2009 through 2015 are calibrated to *Albratross IV* units

Table 4: Stratified mean number-at-length derived from the NEFSC spring bottom trawl survey for 1968-2015.

Length	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
11	0.01	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0.01	0	0.01	0	0	0	0
14	0	0.01	0	0	0	0.08	0	0.01	0	0	0	0
15	0.37	0	0	0	0	0.32	0.07	0.13	0.04	0	0	0
16	2.48	0	0	0	0	0.34	0.34	1.76	0.09	0	0	0
17	2.21	0	0.03	0	0.1	0.24	0.66	2.85	0.07	0	0	0
18	11.31	0	0.37	0.01	0.73	0.17	0.65	1.23	0.05	0.01	0	0
19	11.83	0	0.6	0.04	2.06	0.05	0.3	0.31	0.09	0.01	0	0.01
20	7.32	0	0.79	0.22	0.9	0.08	0.16	0.2	0.07	0	0	0.02
21	1.71	0	0.14	0.24	0.24	0.14	0.09	0.08	0.05	0	0	0
22	0.36	0	0.21	0.11	0.24	0.13	0.09	0.01	0	0	0	0.01
23	0.04	0.03	0.03	0.11	0.17	0.06	0.03	0.01	0.06	0.01	0	0
24	0	0.02	0	0.22	0.03	0.22	0.11	0.09	0.66	0.03	0	0.01
25	0.02	0	0.02	0.55	0.09	0.84	0.26	0.16	1.25	0.06	0.01	0
26	0	0	0.26	0.47	0.08	0.85	0.24	0.04	1.1	0.07	0.01	0
27	0	0	0.75	0.51	0.2	0.53	0.15	0.03	0.5	0.09	0.01	0
28	0	0	1.51	0.76	0.55	2.85	0.11	0.05	0.16	0.04	0.01	0
29	0	0.01	1.27	1.5	0.81	1.23	0.26	0.07	0.09	0.04	0.02	0
30	0	0	1.03	2.55	0.78	4.47	0.62	0.09	0.12	0.11	0.05	0
31	0	0	0.62	1.79	0.99	12.14	0.53	0.07	0.13	0.12	0.06	0.01
32	0	0	0.69	1.85	0.84	19.72	0.3	0.07	0.06	0.09	0.27	0
33	0	0	0.64	1.19	0.36	16.14	0.5	0.03	0.02	0.08	0.57	0.01
34	0	0	0.31	0.44	0.2	8.62	0.76	0.03	0.04	0.07	0.81	0.02
35	0	0	0.14	0.34	0.11	3.98	0.96	0.04	0.01	0.05	0.45	0.07
36	0	0	0.13	0.07	0.02	2.08	0.49	0.02	0	0.04	0.09	0.09
37	0	0	0.14	0.05	0.03	0.58	0.3	0.01	0	0.02	0.05	0.05
38	0	0	0.2	0.11	0.07	0.51	0.18	0.01	0.01	0.03	0.04	0.01
39	0	0	0.15	0.02	0.02	0.1	0.04	0	0	0.01	0.03	0.01
40	0	0	0.04	0.02	0	0.02	0.04	0	0	0	0	0.02
41	0	0	0	0	0	0.23	0.01	0	0	0	0	0
42	0	0	0	0	0	0.01	0.03	0	0	0	0	0.01
43	0	0	0	0	0	0.01	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0.01	0	0	0	0	0	0	0	0	0

Table 4, continued.

Length	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0.02	0	0
15	0	0	0	0.04	0	0	0	0	0.04	0.01	0	0
16	0	0	0.23	0.09	0	0	0	0	0.04	0.01	0	0.01
17	0	0.23	1.31	0.08	0	0	0	0	0.38	1.53	0.02	0
18	0	0.34	1.41	0.07	0	0.02	0.01	0.04	2.04	4.19	0.17	0.11
19	0	0.07	0.85	0.01	0	0.07	0.03	0.4	2.43	2.09	0.6	1.2
20	0.04	0.08	0.42	0.03	0.02	0.09	0.08	1.61	3.3	0.39	1.29	1.29
21	0.02	0.02	0.15	0.02	0.28	0.08	0.05	3.35	0.69	0.21	1.05	0.4
22	0.01	0.01	0.13	0.04	0.86	0.06	0.02	7.55	0.19	0.11	0.51	0.28
23	0	0	0	0.01	2.21	0.1	0.01	6.14	0.02	0.28	0.06	0.07
24	0	0	0	0.02	2.89	0.08	0.01	1.55	0.02	0.51	0.05	0
25	0.01	0	0.01	0.03	3.08	0.03	0.01	0.13	0	1.58	0.11	0.1
26	0	0	0.01	0.07	3.02	0.05	0.09	0.22	0.19	0.49	1.5	0.53
27	0.04	0	0.02	0.12	2.45	0.16	0.26	0.61	0.34	0.21	2.88	1.73
28	0.05	0	0.03	0.16	1.42	0.56	0.33	0.75	0.34	0.34	1.71	2.54
29	0.14	0.08	0.07	0.11	0.49	1.23	0.32	0.74	0.21	0.16	0.29	1.78
30	0.37	0.18	0.12	0.06	0.32	2.91	0.2	0.38	0.17	0.05	0.43	3.46
31	0.46	0.09	0.1	0	0.14	2.04	0.22	0.48	0.11	0.02	0.18	4.11
32	0.18	0.15	0.02	0	0.25	0.62	0.93	1.75	0.17	0.03	0.2	4.34
33	0.04	0.37	0.01	0	0.11	0.17	1.1	2.73	0.33	0.03	0.07	1.79
34	0.03	0.67	0	0.02	0.11	0.05	0.46	3.64	1.19	0.01	0	1.08
35	0.02	2.1	0.02	0.01	0.05	0.07	0.14	1.88	2.03	0.04	0.02	0.58
36	0.18	2.24	0.02	0	0	0.01	0.03	0.86	1.85	0	0	0.12
37	0.16	2.58	0.16	0	0	0	0.04	0.3	0.78	0.04	0	0.21
38	0.11	2.81	0.25	0	0	0	0	0.08	0.47	0.01	0.04	0.09
39	0.06	1.55	0.2	0.01	0	0.01	0.02	0.05	0.14	0.02	0.03	0.07
40	0.05	1.23	0.17	0	0.02	0	0	0.02	0.1	0.01	0.01	0.02
41	0.03	0.46	0.08	0	0.02	0	0.05	0.12	0.06	0	0	0
42	0.02	0.17	0.02	0	0.01	0	0	0.06	0.05	0	0.01	0
43	0	0.01	0.01	0	0	0	0.01	0.02	0.01	0.01	0	0
44	0	0.02	0.01	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0.01	0	0.01	0	0	0
46	0	0	0	0	0	0	0	0	0.01	0	0	0
47	0	0	0	0	0	0	0	0	0.01	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0

Table 4, continued.

Length	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0.02	0	0	0
16	0.1	0	0	0	0	0	0	0	0	0	0	0.01
17	0.34	0	0	0.01	0	0.04	0.07	0	0.8	0	0	0.75
18	1.9	0	1.26	0.04	0.04	0.68	0.73	0.06	12.18	0.23	0.01	6.58
19	3.21	0.23	6.28	0.95	0.75	3.26	2.18	1.95	21.44	2.37	0.01	7.38
20	2.7	0.44	3.45	3.12	4.41	5.45	8.21	13.09	16.61	6.87	0.15	4.37
21	1.5	0.65	2.52	2.54	5.07	4.37	5.12	14.54	7.64	15.49	1.06	2.82
22	1.04	0.23	2.75	1.09	2.19	0.96	1.05	3.22	3.29	11.59	0.52	0.64
23	0.14	0.16	1.33	0.14	1.35	0.21	0.27	0.37	2.21	1.28	0.51	0.64
24	0.12	0.09	0.62	0.69	0.33	0.02	0.24	1.73	0.9	2.75	0.21	0.42
25	0.25	0.95	0.11	2.1	0.36	0.28	0.25	4.4	0.83	18.3	1.9	0.78
26	0.66	2.55	0.4	2.54	0.88	0.39	1.05	3.54	1.48	31.32	3.43	2.65
27	1.12	1.55	1.35	2.54	2.48	1.64	2.19	1.74	2.43	23.49	2.78	6.24
28	1.99	0.6	1.87	1.89	3.88	1.41	2.23	1.1	3.46	11.88	3.86	5.54
29	0.53	0.57	1.43	1.38	2.18	0.5	1.52	0.93	2.33	3.36	6.89	3.26
30	0.46	0.84	1.96	0.68	1.66	0.23	0.43	1.64	1.27	1.39	10.12	2.49
31	0.49	0.5	0.51	0.45	1.39	0.21	0.58	2.68	0.55	0.48	5.14	4.27
32	1.3	0.46	0.42	0.86	1.19	0.16	0.72	1.77	0.25	0.63	1.97	6.99
33	1.92	0.7	0.58	1.07	1	0.31	0.58	0.92	0.38	0.59	0.99	5.48
34	1.51	1.47	0.84	1.02	2.31	0.28	0.23	0.73	0.58	0.15	0.16	3.86
35	0.38	1.04	1.08	1.19	3.72	0.22	0.31	0.53	0.62	0.05	0.21	0.88
36	0.42	0.53	0.61	1.35	4.47	0.15	0.14	0.32	0.27	0.12	0.01	0.26
37	0.1	0.44	0.24	0.82	3.37	0.17	0.04	0.02	0.22	0.08	0.02	0.09
38	0.16	0.47	0.18	0.28	1.67	0.16	0.1	0.02	0.1	0.01	0.08	0.07
39	0.25	0.53	0.1	0.21	0.43	0.01	0.04	0.05	0.05	0.01	0	0
40	0.09	0.39	0.08	0.02	0.27	0.01	0.06	0	0.06	0.02	0	0.03
41	0.06	0.16	0.02	0.13	0	0	0	0.01	0.02	0	0	0
42	0.03	0.03	0.01	0	0	0	0	0	0	0	0	0
43	0	0.01	0.01	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0.03	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0.13	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0

Table 4, continued.

Length	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0.01	0	0.01	0	0.01	0	0	0.05	0.01	0	0	0
17	1.97	0	0.32	0	0.14	0	0	0.61	1.7	0	0	0.24
18	20.57	0.3	4.31	0	2.08	0.29	0.79	6.85	7.36	0	0.01	2.6
19	28.96	2.36	9.97	0.07	8.01	7.93	3.25	21.22	20.99	0.01	0.05	9.25
20	38.53	7.2	4.22	0.79	10.48	42.09	4.94	29.71	9.52	0.3	0.22	28.68
21	15.27	3.11	1.24	1.06	10.38	26.82	2.19	16.31	1.66	2.02	0.33	33.72
22	3.04	0.16	0.11	2.08	6.64	4.21	0.28	6.26	0.46	4.22	0.18	16.1
23	2.41	0.46	0.38	1.09	0.6	0.79	0.02	3.6	0.85	2.58	0.15	1.93
24	0.46	1.72	1.25	0.23	0	0.85	0.03	3.43	0.85	1.08	0.41	0.5
25	0.25	3.28	5.9	1.3	0.04	5.49	0.64	0.77	2.28	3.46	0.37	0.76
26	1.86	7.28	12.39	6.64	0.69	8.23	2.3	0.55	1.88	3	0.25	0.13
27	2.69	4.29	8.61	7.32	2.81	8.21	7.9	0.29	1.01	2.04	0.53	0.27
28	5.46	1.31	4.8	4.41	6.79	6.72	5.9	0.1	0.32	1.24	0.68	0.55
29	2.05	0.56	7.72	0.74	7.57	2.45	1.97	0.03	0.28	0.72	0.44	1.04
30	1.45	0.39	6.24	1.08	9.29	1.38	1.14	0.25	0.25	0.41	0.31	1.04
31	0.08	0.57	3.26	1.82	10.79	1.45	0.28	0.41	0.08	0.23	0.17	0.46
32	0.01	0.41	1.2	2.28	3.71	0.84	0.34	0.31	0.08	0.14	0.1	0.16
33	0.16	0.26	0.56	1.6	1.44	0.86	0.07	0.13	0.06	0.04	0.02	0.09
34	0.02	0.13	0.24	1.12	0.68	0.05	0.06	0.03	0.07	0.01	0	0.06
35	0.1	0.34	0.05	0.25	0.07	0.02	0.04	0.02	0.05	0	0	0.03
36	0.04	0.14	0.22	0.03	0	0	0	0.02	0.02	0	0	0.02
37	0.01	0.08	0.03	0.04	0.03	0	0	0	0	0	0	0
38	0	0.04	0	0.06	0.03	0	0.01	0	0	0	0	0
39	0	0.01	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0

Table 5: Geometric stratified mean number-per-tow-at-age of Atlantic mackerel from the NEFSC spring bottom trawl survey for 1968-2013.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1968	12.940	0.415	0.189	0.052	0.016	0	0	0	0	0
1969	0.030	0.142	0.017	0.006	0.000	0.001	0.001	0.001	0	0
1970	0.280	0.185	1.391	0.612	0.181	0.062	0.055	0.088	0.083	0.047
1971	0.328	0.941	0.438	1.125	0.393	0.062	0.014	0.007	0.006	0.008
1972	0.872	0.308	0.593	0.226	0.325	0.058	0.011	0.001	0.002	0
1973	0.351	0.340	0.176	0.234	0.126	0.285	0.182	0.152	0.046	0.102
1974	0.348	0.180	0.236	0.048	0.099	0.060	0.208	0.091	0.059	0.023
1975	0.654	0.230	0.041	0.023	0.006	0.007	0.004	0.004	0.003	0
1976	0.096	0.387	0.071	0.014	0.002	0.001	0.003	0	0.002	0.001
1977	0.010	0.047	0.085	0.045	0.015	0.005	0.003	0.007	0.004	0.014
1978	0.050	0.110	0.103	0.194	0.096	0.028	0.011	0.003	0.015	0.018
1979	0.011	0.004	0.007	0.013	0.050	0.014	0.010	0.006	0.006	0.048
1980	0.023	0.188	0.007	0.005	0.023	0.049	0.011	0.011	0.007	0.028
1981	0.336	0.137	0.429	0.048	0.046	0.161	0.404	0.230	0.139	0.402
1982	0.432	0.195	0.022	0.098	0.018	0.010	0.025	0.097	0.044	0.084
1983	0.236	0.287	0.022	0.002	0.004	0.001	0	0.001	0.002	0.002
1984	0.260	1.801	0.606	0.042	0.005	0.043	0.004	0.003	0.016	0.084
1985	0.338	0.085	1.851	0.235	0.028	0.011	0.047	0.003	0.010	0.186
1986	0.130	0.450	0.078	0.591	0.118	0.008	0.001	0.020	0	0.047
1987	1.484	1.795	0.874	0.372	2.945	0.497	0.143	0.016	0.138	0.256
1988	0.634	0.458	0.367	0.336	0.375	1.769	0.443	0.051	0.048	0.223
1989	1.583	1.641	0.071	0.284	0.009	0.011	0.067	0.009	0.005	0.018
1990	1.300	1.385	0.501	0.016	0.013	0.006	0	0.076	0.009	0.016
1991	1.670	0.889	1.484	0.537	0.240	0.114	0.058	0	0.269	0.003
1992	2.979	2.642	0.556	1.159	0.725	0.116	0.130	0.020	0.049	0.345
1993	1.207	2.660	1.009	0.381	1.054	0.720	0.149	0.133	0.333	0.610

Table 5, continued.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1994	4.139	1.744	2.114	0.870	0.281	0.602	0.207	0.051	0.010	0.225
1995	3.170	3.487	0.589	1.182	0.712	0.285	0.719	0.226	0.065	0.131
1996	4.006	3.226	1.326	0.148	0.618	0.420	0.193	0.280	0.154	0.132
1997	3.000	1.162	0.449	0.225	0.025	0.124	0.115	0.045	0.070	0.007
1998	5.647	3.119	0.679	0.286	0.121	0.017	0.087	0.063	0.018	0.024
1999	4.993	4.135	2.921	0.922	0.406	0.178	0.050	0.082	0.044	0.014
2000	14.769	2.456	1.116	0.727	0.251	0.119	0.050	0	0.024	0.019
2001	12.461	26.596	1.758	0.362	0.212	0.038	0.011	0.009	0.004	0.001
2002	1.266	2.977	5.742	0.444	0.123	0.049	0.019	0.001	0	0
2003	9.116	8.391	2.915	3.300	0.403	0.121	0.056	0	0	0
2004	21.919	3.006	0.317	0.117	0.152	0.012	0.002	0	0	0
2005	1.775	3.729	0.932	0.170	0.135	0.367	0.026	0.005	0	0
2006	4.439	9.574	6.272	0.655	0.137	0.052	0.127	0.012	0	0
2007	1.996	6.956	1.210	1.224	0.156	0.014	0.022	0.032	0.006	0
2008	3.262	1.665	1.621	0.245	0.229	0	0	0	0.031	0
2009	15.171	4.929	0.630	0.368	0.002	0.004	0	0	0	0
2010	2.687	4.977	0.728	0.028	0.053	0	0.010	0	0	0
2011	30.017	0.883	0.703	0.080	0.046	0.003	0	0	0	0
2012	4.862	2.244	0.140	0.150	0.026	0.007	0	0	0	0
2013	2.978	5.510	1.399	0.029	0.007	0	0	0	0	0

Table 6: Arithmetic stratified mean number-per-tow-at-age of Atlantic mackerel from the NEFSC spring bottom trawl survey for 2009-2015.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
2009	100.050	36.824	2.891	1.231	0.003	0.006	0	0	0	0
2010	13.612	21.767	2.666	0.046	0.079	0	0.014	0	0	0
2011	104.475	2.127	1.211	0.136	0.078	0	0	0	0	0
2012	50.643	7.789	0.333	0.296	0.036	0.01	0	0	0	0
2013	11.120	11.980	2.398	0.038	0	0	0	0	0	0
2014	1.902	1.729	1.354	0.063	0	0	0	0	0	0
2015	111.188	3.913	0.646	0.217	0.015	0	0	0	0	0

Figure 1: Total annual mackerel catch by the U.S., Canada and other countries for 1960-2015.

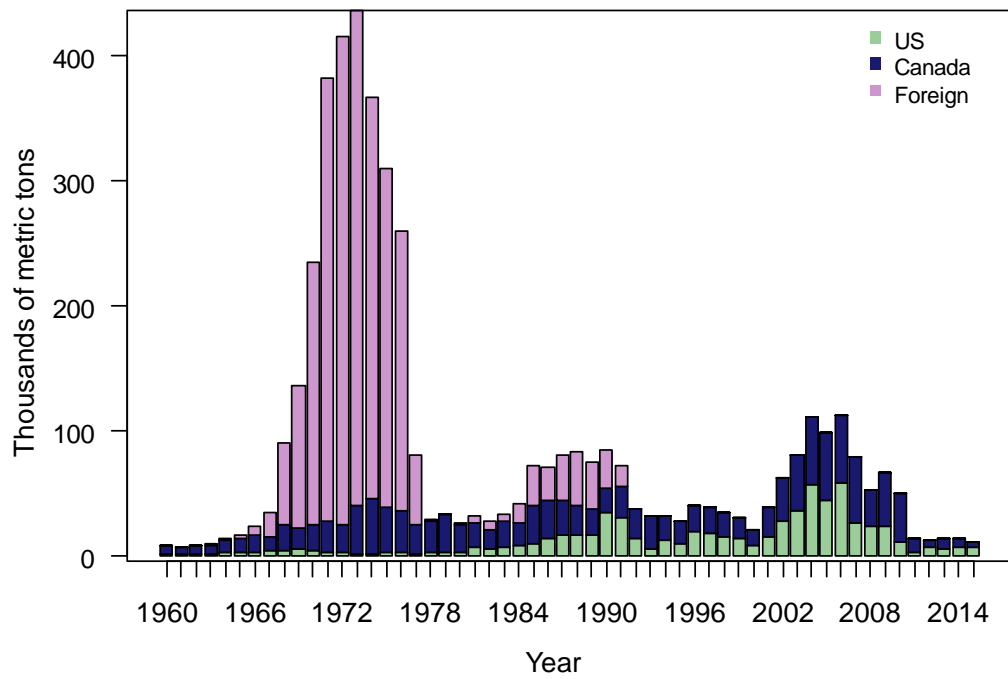


Figure 2: Offshore depth strata from the NEFSC bottom trawl research surveys. Some of these strata may not be sampled presently.

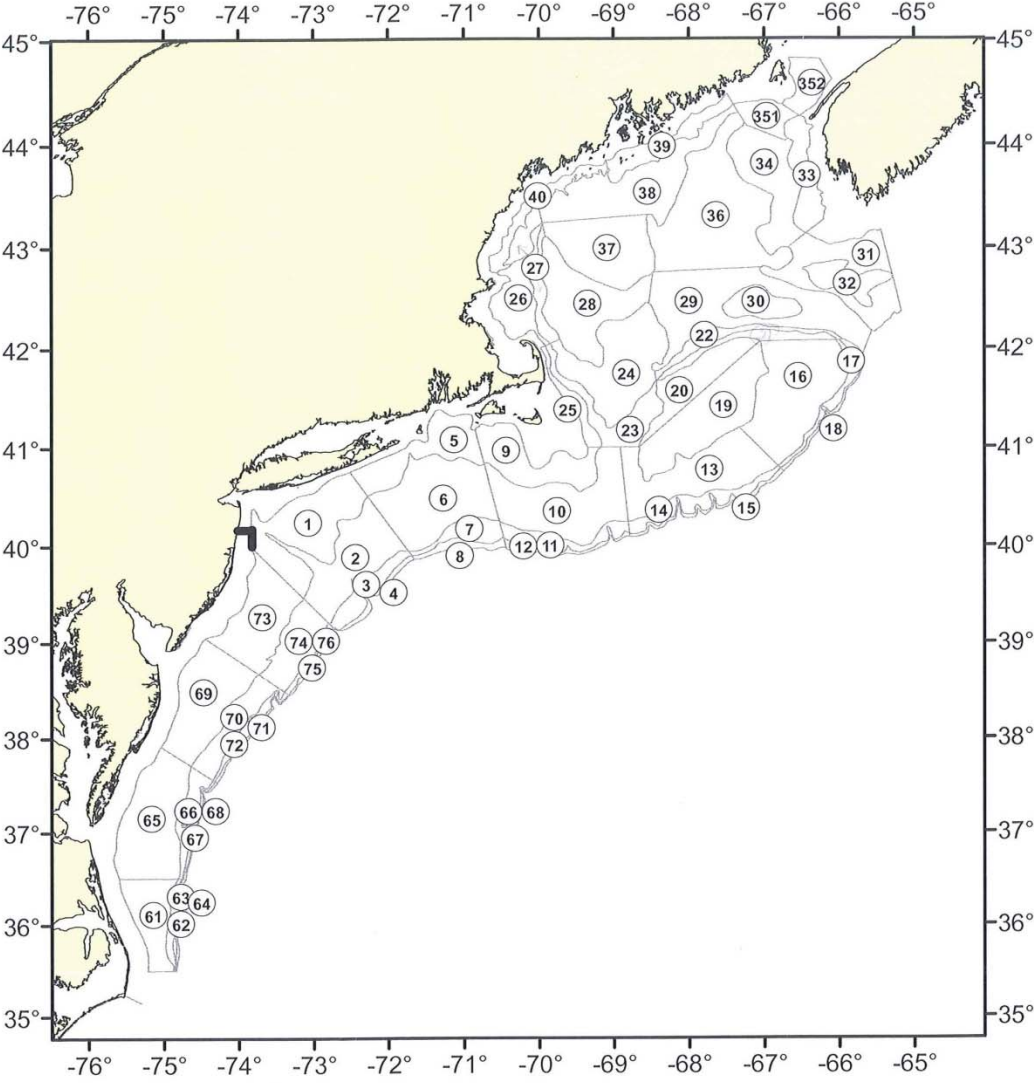


Figure 3: Atlantic mackerel relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices derived from the NEFSC spring bottom trawl survey for 1968-2015. The median number- and weight-per-tow values represent the median indices over 1968-2015.

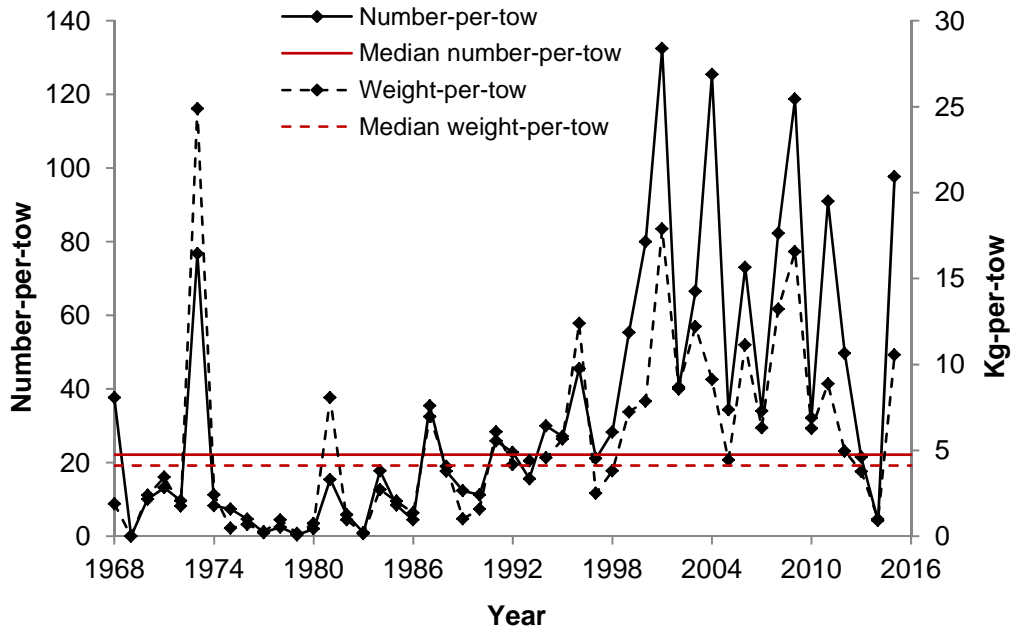


Figure 4: Annual mackerel length compositions from the NEFSC spring bottom trawl survey, 1968-2015.

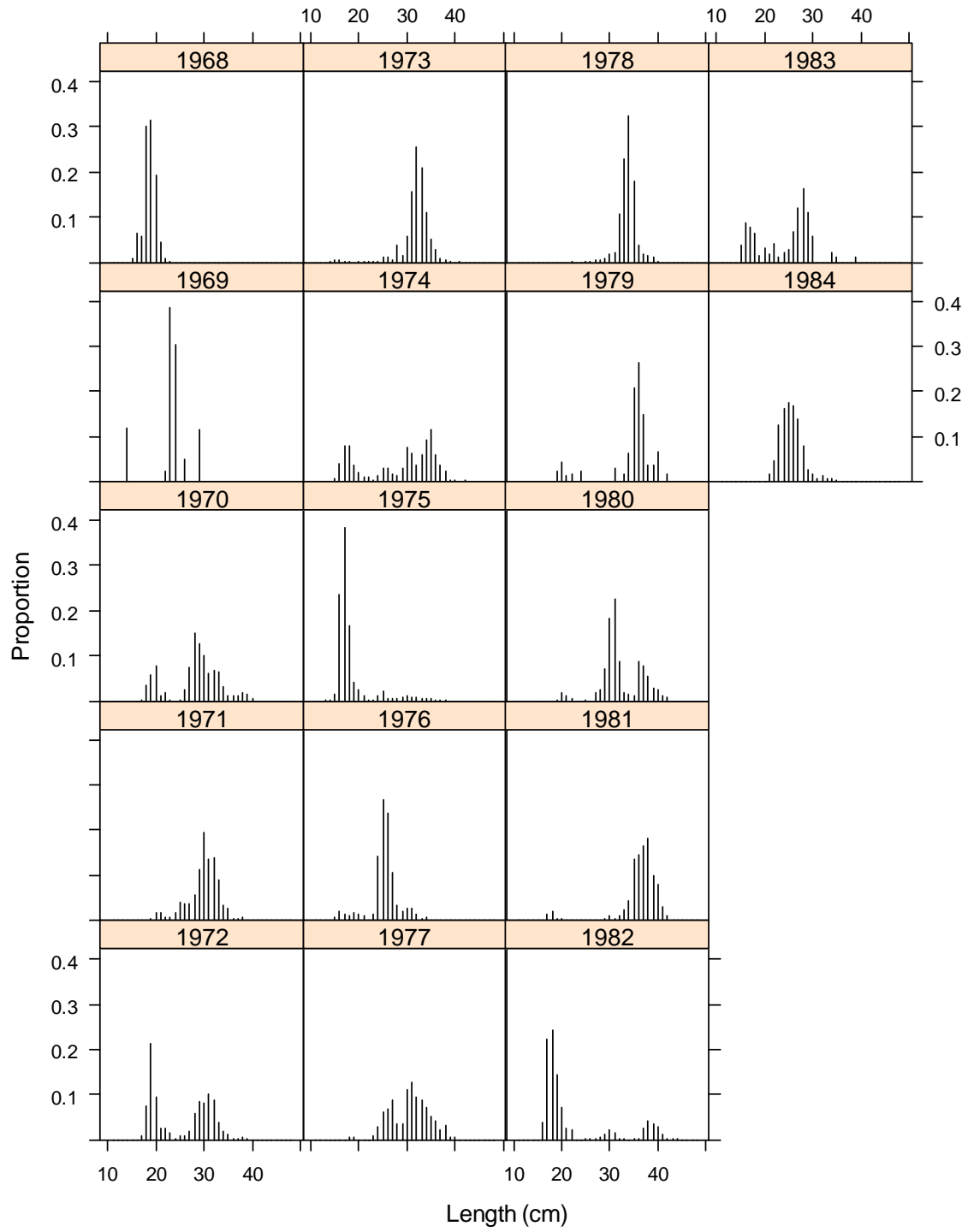


Figure 4, continued

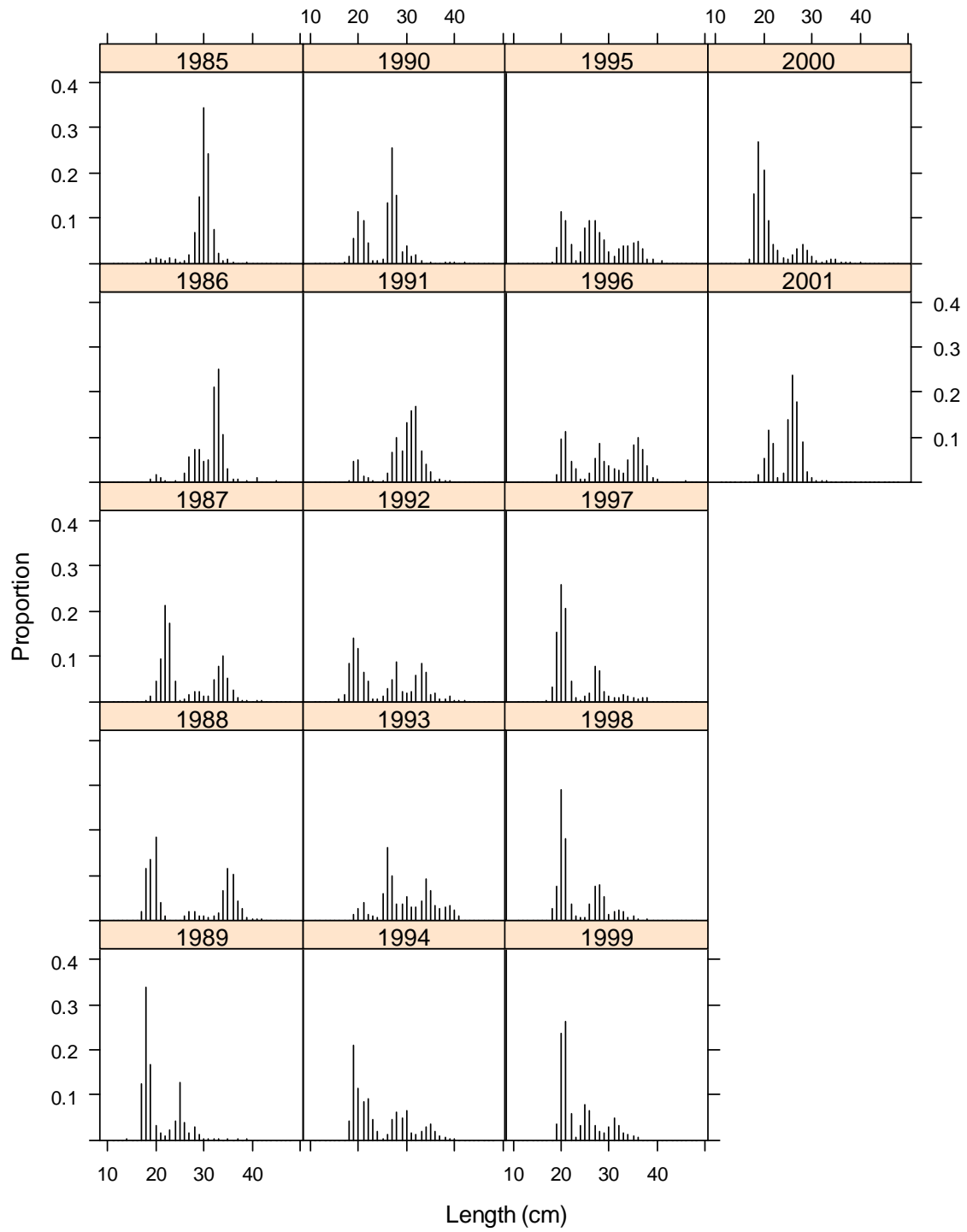


Figure 4, continued

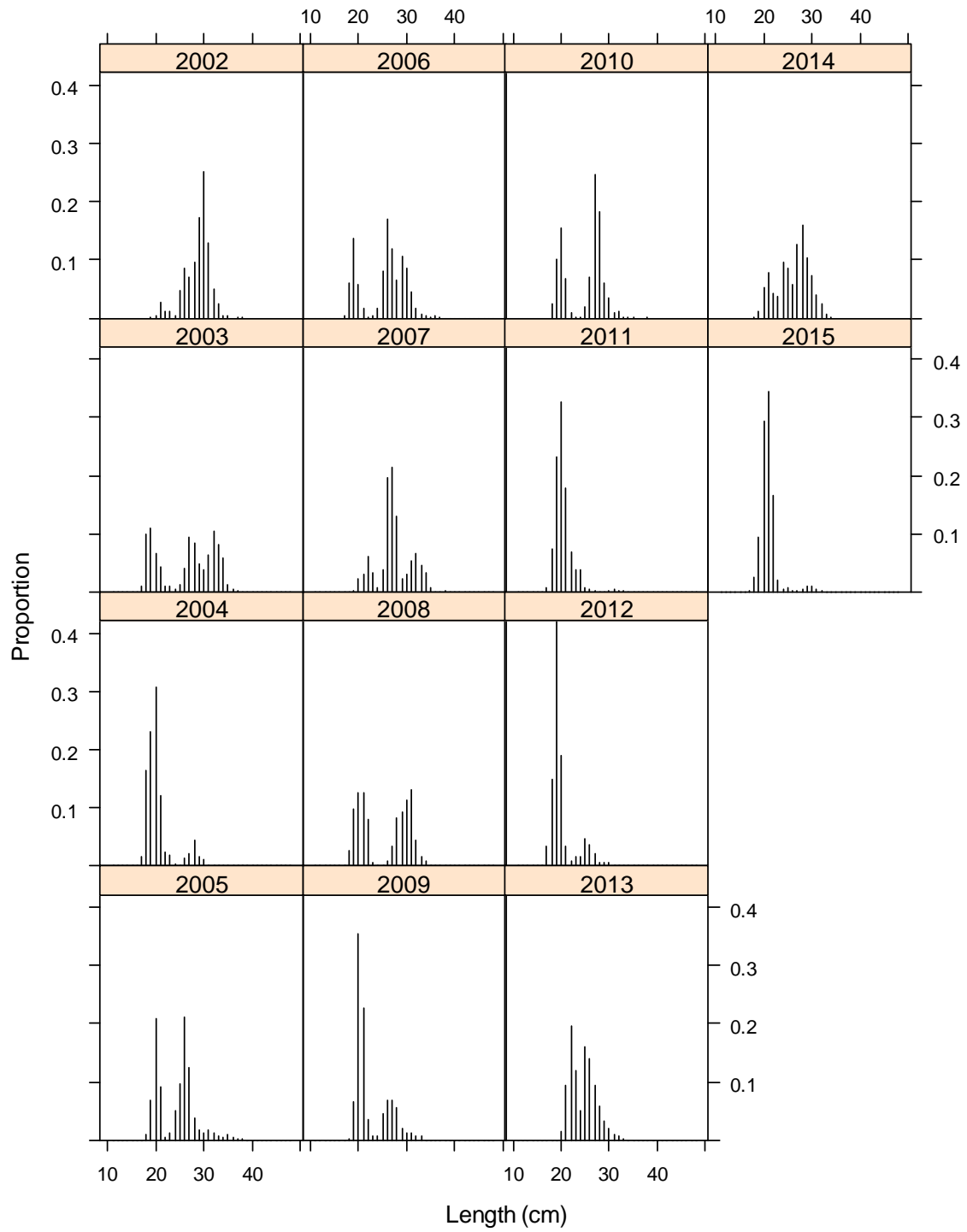


Figure 5: Annual mackerel length compositions (stratified mean numbers-at-length), averaged over nine or ten year time intervals, from the NEFSC spring bottom trawl survey for 1968-2015.

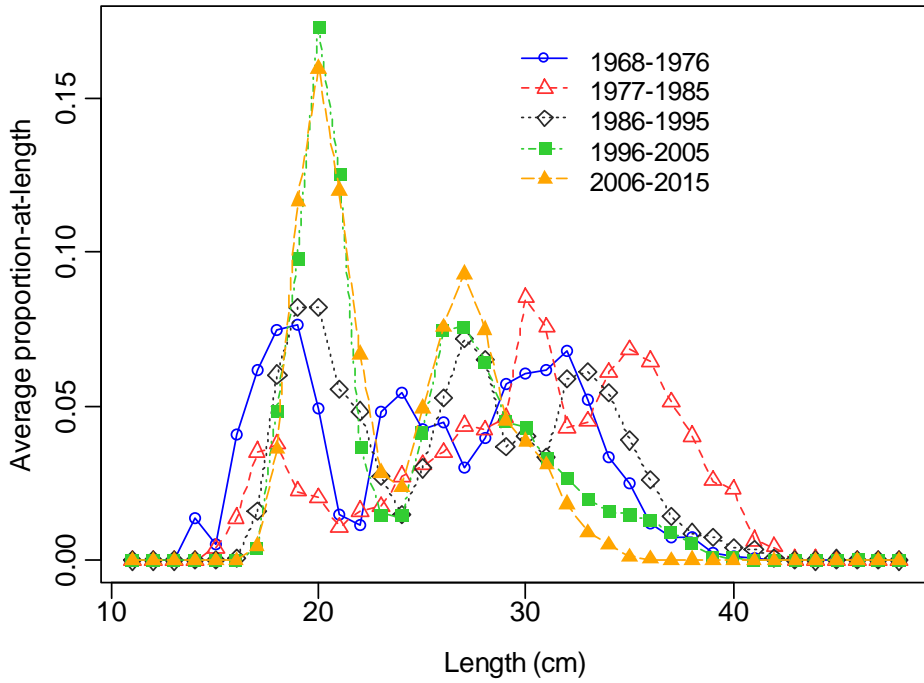


Figure 6: Stratified mean length of mackerel from the NEFSC spring bottom trawl survey, 1968-2015.

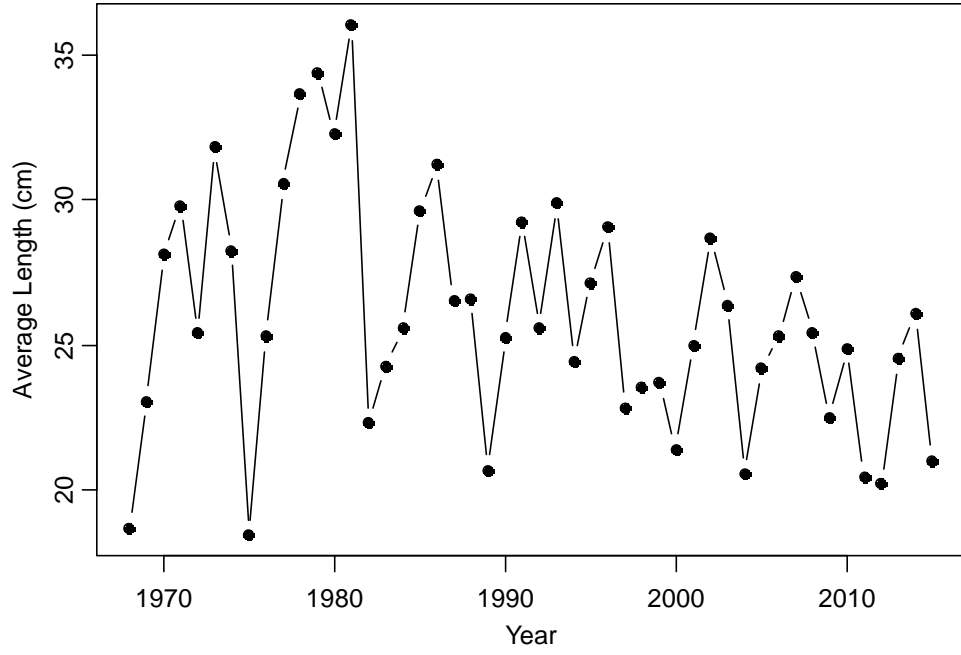


Figure 7: Proportions-at-age of Atlantic mackerel in the NEFSC spring survey from 1968-2013, calculated from geometric mean age-specific indices.

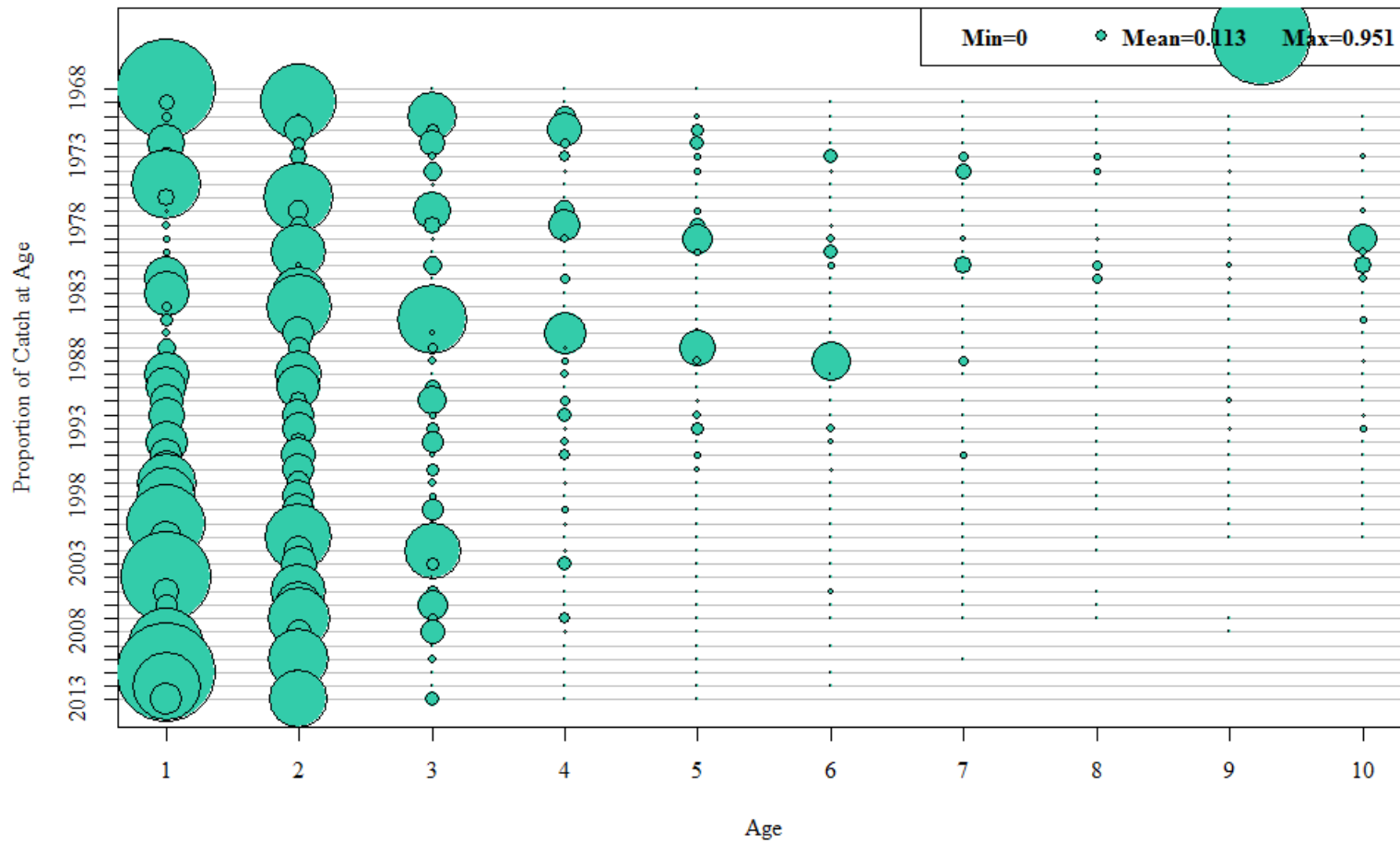


Figure 8: Proportions-at-age of Atlantic mackerel in the NEFSC spring survey from 2009-2015, calculated from arithmetic mean age-specific indices.

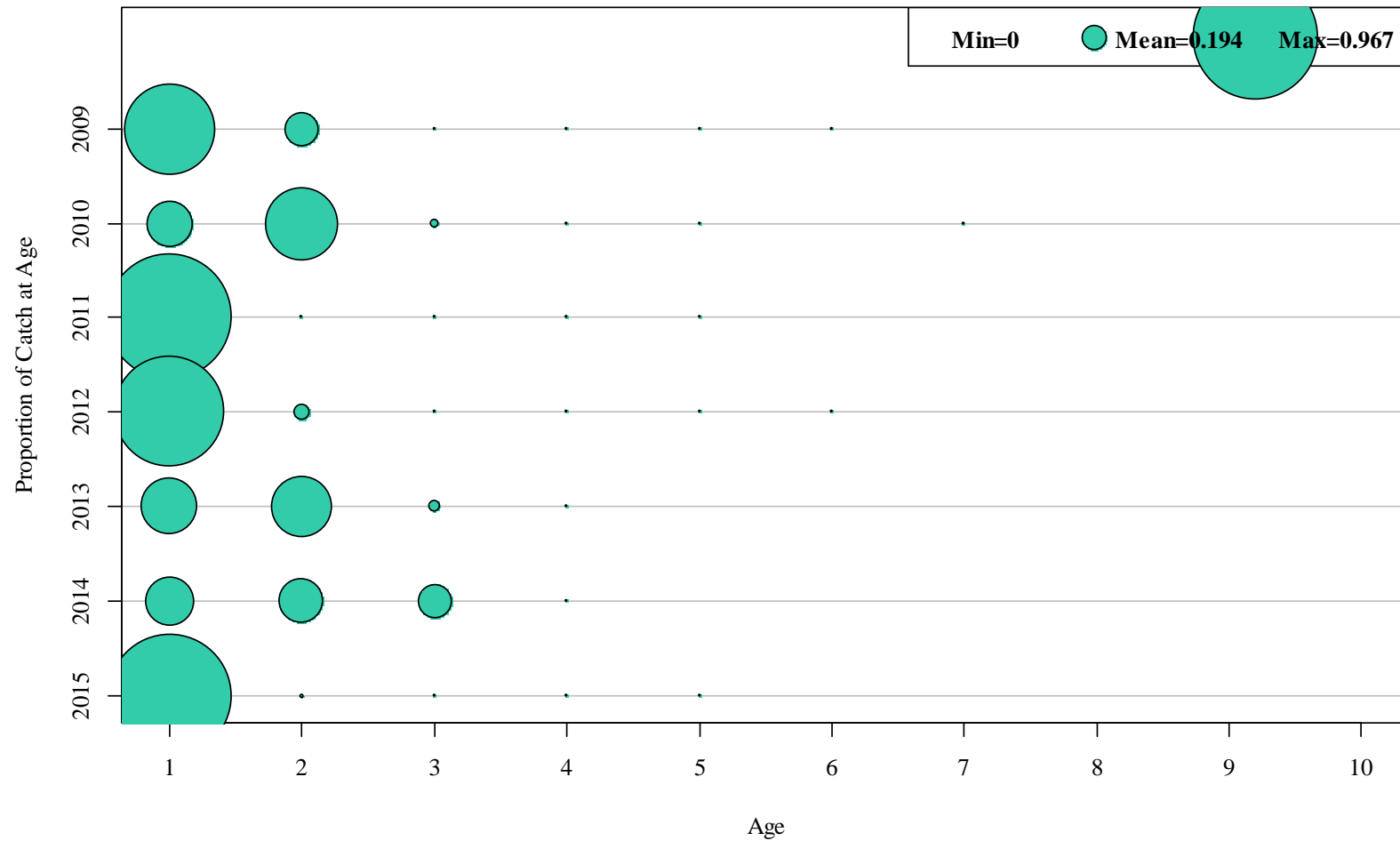


Figure 9: Atlantic mackerel total and spawning stock biomass (tons) in NAFO Subareas 3 and 4 from 1968 to 2011, estimated from a sequential population analysis of the Canadian contingent of mackerel (Reprinted from the 2012 Canadian assessment (DFO 2012, Figure 14)).

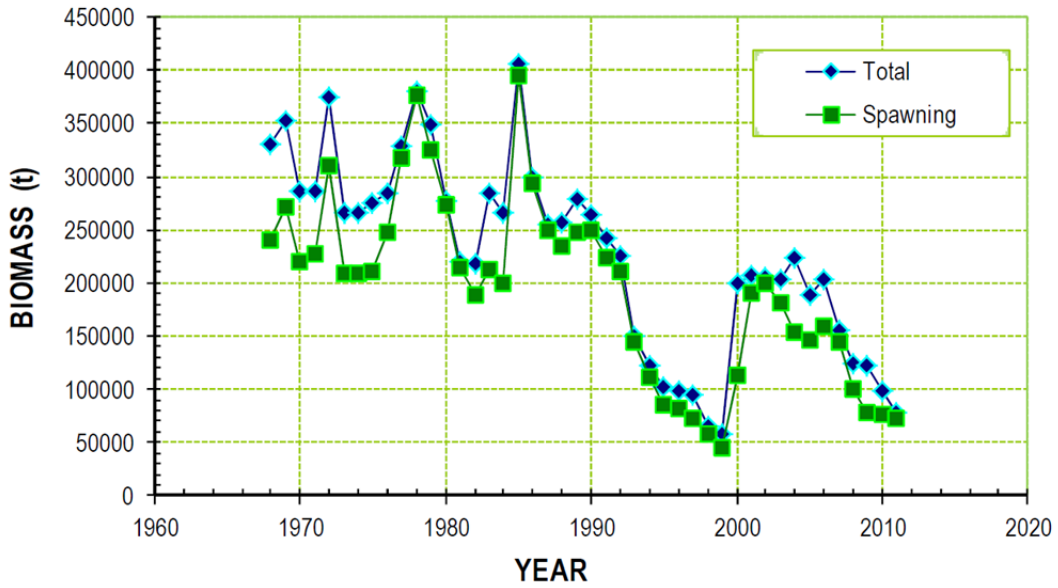
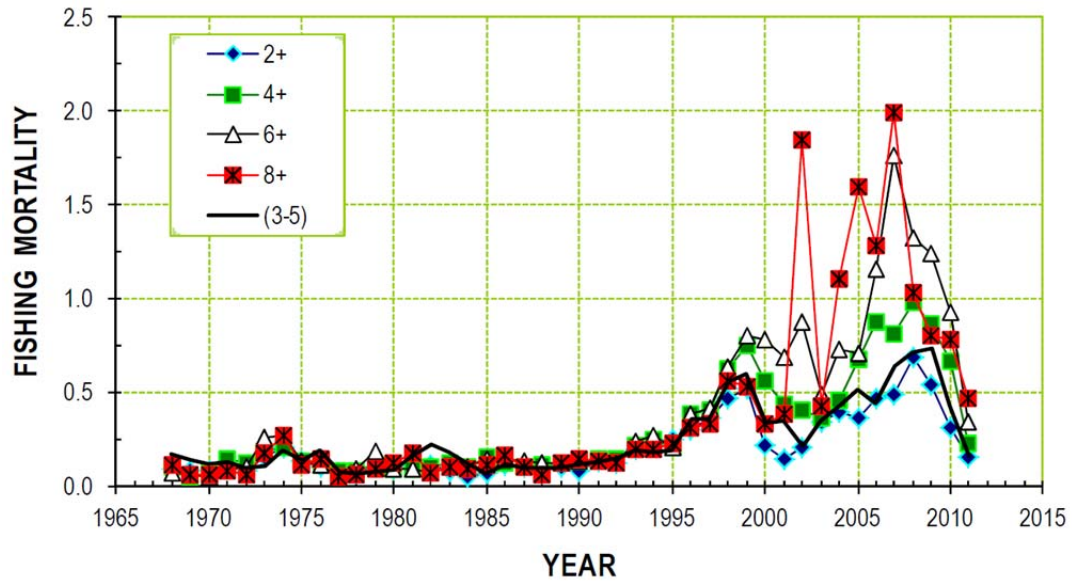


Figure 10: Atlantic mackerel fishing mortality in NAFO Subareas 3 and 4 from 1968 to 2011, estimated from a sequential population analysis of the Canadian contingent of mackerel (Reprinted from the 2012 Canadian assessment (DFO 2012, Figure 13)).



Appendix:

Spatial distribution of Atlantic mackerel landings

Figure A1: Atlantic mackerel commercial landings from 2005-2009. Landings for all gears other than paired midwater trawl were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels were reported via VTRs. Total Dealer Landings reported (mt): 196,881.3. Dealer Landings from trips with location data (mt): 145,997.7 (74.2% of total).

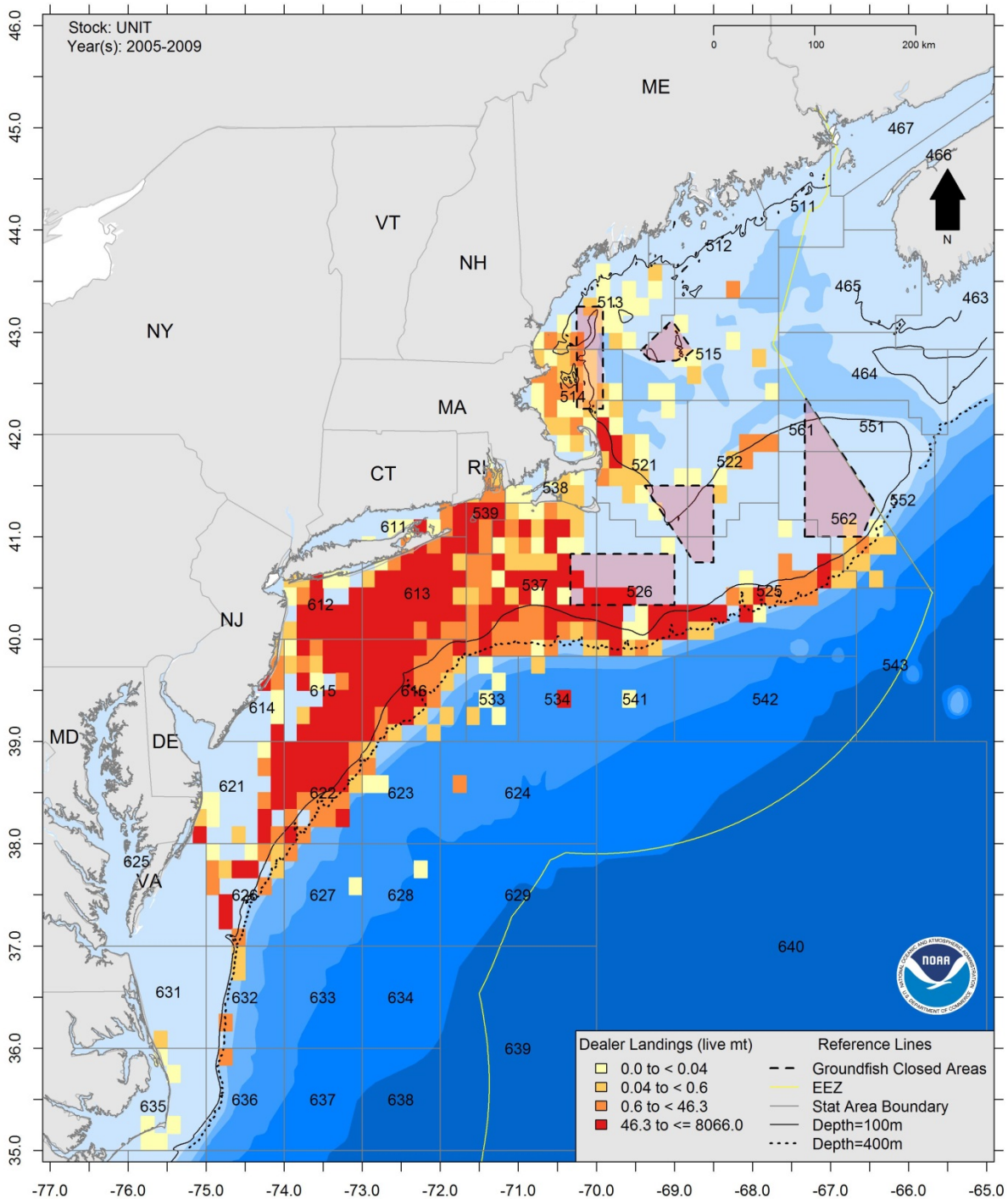


Figure A2: Atlantic mackerel commercial landings from 2010-2014. Landings for all gears other than paired midwater trawl were reported via dealer reports matched to a vessel trip report (VTR). Landings for paired midwater trawl vessels were reported via VTRs. Total Dealer Landings reported (mt): 25,713.0. Dealer Landings from trips with location data (mt): 23,388.9 (91.0% of total).

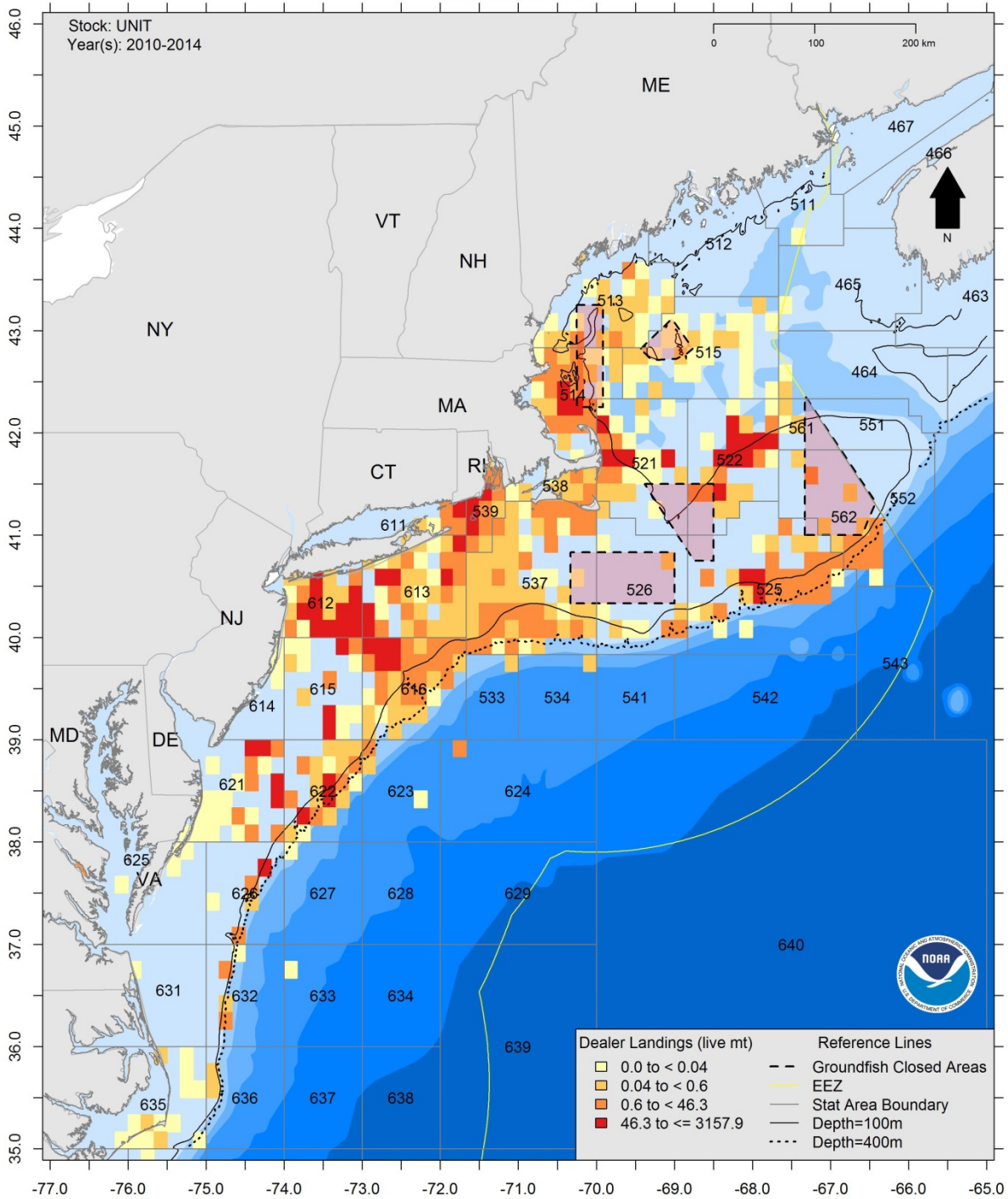


Figure A3: Atlantic mackerel commercial landings from 2015. Landings were reported via vessel trip reports (VTRs). Total VTR Landings reported (mt): 5,783.9. VTR Landings from trips with location data (mt): 5,684.9 (98.3% of total).

