Atlantic Mackerel Update for 2015 Specifications

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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 February 2014. The MAFMC requested that the NEFSC update the document provided for last year's specifications, "Atlantic Mackerel Update for 2014 Specifications."

NEFSC spring survey indices and length compositions

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 1968-2013. Indices were not yet available for the ongoing 2014 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 conversion factors for relative abundance (1.188) and biomass (0.868) (Miller et al. 2010). Estimated 2013 indices of relative abundance and biomass were 20.79 mackerel-per-tow (standard error = 4.89) and 3.82 kg-per-tow (standard error = 1.26), respectively (Table 1). Estimated 2013 relative abundance and biomass indices were both lower than the time series medians of 23.77 mackerel-per-tow and 4.32 kg-per-tow (Figure 1).

Mackerel lengths from the spring survey ranged from 7 cm to 48 cm during 1968-2013. Length compositions varied over time, with some years exhibiting unimodal distributions and other years exhibiting bimodal or trimodal distributions (Table 2, Figure 2). Annual stratified mean proportions-at-length were averaged over nine-year intervals, with the exception of the most recent time period which included 10 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 3). During the most recent time interval (2004-2013), mackerel size composition range was the smallest of the time series, with 95% of individuals between 18 cm and 31cm fork length. Average length structure was trimodal during the first 27 years of the time series, but then became bimodal (modes = 20 cm and 27 cm) from 1995 onward (Figure 3). In 2011, the length composition was unimodal (mode = 20 cm), with less than 4% of individuals greater than 24 cm (Figure 2). Updated age-composition data were not available.

Canadian mackerel assessment

In 2012, the 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 4). This decline was attributed to low recruitment and high fishing mortality rates (Figure 5). The assessment document 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. However, model diagnostics were not presented in the published science advisory report (DFO 2012) and the corresponding research document has not yet been published in English (Grégoire et al. 2014). A portion of the research document was translated into English by a member of the population dynamics branch at the NEFSC. 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. The research document described the mackerel stock as "overfished but overfishing is not occurring" 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. Additionally, NOAA recently recommended a project for approval for the Saltonstall-Kennedy Grant Program that aims 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.

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.

Table 1: Atlantic mackerel stratified mean number-per-tow and weight (kg)-per-tow derived from the NEFSC spring bottom trawl survey for 1968-2013.

	Number-per-tow		Weight-per-tow	
Year	**Mean**	**Standard error**	**Mean**	**Standard error**
1968	70.87	26.38	5.60	2.61
1969	0.48	0.25	0.06	0.03
1970	9.41	2.96	2.21	0.68
1971	12.62	5.28	3.18	1.46
1972	8.49	3.39	1.54	0.76
1973	68.09	62.03	21.90	20.56
1974	7.27	2.68	2.13	1.05
1975	6.79	4.75	0.43	0.21
1976	5.85	2.68	0.82	0.37
1977	0.93	0.36	0.26	0.08
1978	3.15	0.72	1.12	0.24
1979	0.56	0.19	0.29	0.10
1980	1.82	0.63	0.66	0.21
1981	19.07	9.18	8.02	4.45
1982	5.19	3.51	0.85	0.43
1983	0.90	0.30	0.14	0.06
1984	16.23	8.02	2.61	1.21
1985	8.24	2.54	2.23	0.75
1986	4.18	2.58	1.26	0.82
1987	35.23	13.79	7.49	2.35
1988	16.79	6.11	4.13	1.12
1989	12.27	4.41	1.10	0.41
1990	10.75	4.69	1.55	0.68
1991	23.26	10.60	5.60	2.80
1992	24.28	8.38	4.71	2.02
1993	26.09	10.92	5.58	1.63
1994	38.64	10.80	5.99	1.66
1995	24.39	7.56	5.10	1.66
1996	40.89	17.81	11.10	7.58
1997	22.05	8.55	2.49	0.78
1998	25.11	9.31	3.38	1.41
1999	50.62	16.27	7.11	1.79
2000	70.36	18.68	6.93	1.86
2001	116.45	44.30	15.72	6.03
2002	35.20	12.44	7.65	2.79
2003	60.49	16.47	11.08	3.85
2004	110.68	32.85	8.09	2.46
2005	32.32	15.29	4.27	1.85
2006	69.51	24.07	10.16	3.04
2007	30.14	12.52	5.60	2.41
2008	72.31	35.71	11.62	6.86
2009	105.07	30.21	14.70	6.97
2010	32.66	9.43	6.49	2.80
2011	94.62	22.75	9.47	3.15
2012	43.77	14.66	4.36	1.78
2013	20.79	4.89	3.82	1.26

Table 2: Stratified mean number-at-length derived from the NEFSC spring bottom trawl survey for 1968-2013.

Length	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0.01	0	0	0	0	0	0	0	0	0	0
12	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
14	0	0.01	0	0	0	0.09	0	0.01	0	0	0
15	0.42	0	0	0	0	0.36	0.06	0.12	0.04	0	0
16	3.72	0	0.01	0	0	0.52	0.30	1.61	0.08	0	0
17	6.67	0.01	0.03	0	0.09	0.32	0.58	2.61	0.06	0	0
18	19.91	0	0.33	0.01	0.64	0.18	0.57	1.13	0.04	0.01	0.02
19	19.13	0	0.54	0.06	1.81	0.07	0.27	0.28	0.08	0.01	0.02
20	8.78	0.01	0.70	0.27	0.79	0.07	0.14	0.18	0.06	0	0.01
21	1.91	0.02	0.13	0.36	0.22	0.13	0.08	0.07	0.04	0	0
22	0.37	0.05	0.18	0.20	0.21	0.13	0.08	0.01	0.0038	0	0.01
23	0.04	0.16	0.03	0.18	0.15	0.08	0.02	0.01	0.05	0.01	0.02
24	0.03	0.15	0.00	0.25	0.03	0.23	0.09	0.09	0.84	0.02	0.02
25	0.04	0.01	0.02	0.59	0.08	0.77	0.22	0.14	1.88	0.05	0.08
26	0.32	0.01	0.26	0.53	0.07	0.76	0.21	0.04	1.59	0.07	0.04
27	1.45	0.01	0.81	0.48	0.17	0.49	0.13	0.03	0.51	0.08	0.08
28	1.94	0.01	1.55	0.70	0.49	2.50	0.09	0.05	0.15	0.04	0.07
29	2.85	0.01	1.18	1.36	0.72	1.08	0.23	0.06	0.08	0.04	0.07
30	1.70	0	0.92	2.30	0.68	3.93	0.55	0.09	0.11	0.11	0.08
31	0.96	0	0.55	1.61	0.87	10.67	0.46	0.06	0.11	0.13	0.10
32	0.21	0.01	0.61	1.67	0.74	17.33	0.26	0.06	0.05	0.09	0.36
33	0.11	0	0.56	1.06	0.32	14.18	0.44	0.03	0.02	0.07	0.62
34	0.22	0	0.27	0.41	0.18	7.59	0.67	0.03	0.03	0.06	0.83
35	0.05	0	0.12	0.33	0.10	3.50	0.86	0.04	0.01	0.05	0.46
36	0.02	0	0.11	0.07	0.02	1.83	0.43	0.02	0	0.04	0.09
37	0	0	0.12	0.05	0.03	0.51	0.27	0.01	0	0.02	0.07
38	0	0	0.17	0.09	0.06	0.45	0.16	0.01	0.01	0.03	0.05
39	0	0	0.13	0.02	0.02	0.09	0.03	0	0	0.01	0.03
40	0	0	0.04	0.02	0	0.02	0.03	0	0	0	0.01
41	0	0	0	0	0	0.20	0.01	0	0	0	0
42	0	0	0	0	0	0.01	0.02	0	0	0	0
43	0	0	0	0	0	0.01	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0.01	0	0	0	0	0	0	0	0

Table 2, continued.

Length	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0.02
15	0	0	0	0	0.03	0	0	0	0	0.03	0.01
16	0	0	0.13	0.20	0.08	0	0	0	0	0.03	0.01
17	0	0	2.12	1.15	0.07	0.01	0	0	0	0.34	1.35
18	0	0	1.74	1.24	0.06	0	0.02	0.01	0.03	1.79	3.69
19	0.01	0	0.53	0.74	0.01	0	0.06	0.02	0.36	2.13	1.83
20	0.01	0.05	0.21	0.37	0.03	0.02	0.08	0.07	1.51	2.90	0.34
21	0	0.02	0.02	0.13	0.02	0.25	0.07	0.06	3.14	0.61	0.18
22	0	0.01	0.01	0.12	0.04	0.75	0.05	0.01	6.86	0.16	0.10
23	0	0	0	0	0.01	1.95	0.10	0.01	5.52	0.02	0.34
24	0.01	0	0	0.01	0.02	2.54	0.07	0.01	1.44	0.02	0.73
25	0	0.01	0	0.01	0.03	2.71	0.03	0.03	0.30	0	1.91
26	0	0	0	0.01	0.06	2.68	0.05	0.12	0.33	0.17	0.71
27	0	0.03	0	0.02	0.11	2.17	0.16	0.28	0.75	0.31	0.23
28	0	0.05	0	0.05	0.15	1.29	0.52	0.33	0.85	0.31	0.34
29	0	0.13	0.07	0.06	0.10	0.46	1.13	0.31	0.75	0.30	0.20
30	0	0.34	0.16	0.12	0.05	0.32	2.59	0.21	0.38	0.26	0.04
31	0.01	0.40	0.08	0.09	0.01	0.21	1.82	0.20	0.48	0.16	0.04
32	0	0.16	0.17	0.03	0	0.30	0.58	0.85	1.81	0.18	0.03
33	0	0.04	0.36	0.01	0	0.16	0.18	0.98	2.69	0.33	0.03
34	0.04	0.03	0.66	0	0.02	0.14	0.11	0.40	3.78	1.18	0.01
35	0.07	0.02	2.02	0.02	0.01	0.06	0.09	0.13	1.92	1.92	0.04
36	0.14	0.17	2.11	0.02	0	0.02	0.05	0.03	1.08	1.85	0
37	0.11	0.14	2.53	0.14	0	0.01	0.03	0.03	0.42	0.81	0.04
38	0.04	0.10	2.62	0.22	0	0.03	0.03	0	0.12	0.46	0.01
39	0.04	0.05	1.55	0.18	0.01	0.02	0.04	0.02	0.07	0.19	0.02
40	0.03	0.04	1.20	0.15	0	0.07	0.13	0	0.04	0.10	0.01
41	0.02	0.02	0.49	0.07	0	0.02	0.09	0.04	0.15	0.09	0
42	0	0.02	0.24	0.02	0	0.03	0.14	0.01	0.18	0.08	0.02
43	0	0	0.02	0.01	0	0	0.01	0.01	0.18	0.04	0.01
44	0	0	0.02	0.01	0	0	0	0	0.04	0	0
45	0	0	0	0	0	0	0	0.01	0	0.02	0
46	0	0	0	0	0	0	0	0	0	0.01	0
47	0	0	0	0	0	0	0	0	0.02	0.01	0
48	0	0	0	0	0	0	0	0	0	0.01	0

Table 2, continued.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
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	0.02	0
16	0	0.01	0.09	0	0	0	0	0	0	0	0	0
17	0.02	0	0.30	0	0	0.01	0	0.03	0.06	0	0.70	0
18	0.15	0.10	1.67	0	1.15	0.03	0.04	0.72	0.64	0.05	10.71	0.21
19	0.53	1.05	2.83	0.21	7.26	0.84	0.66	3.43	1.92	1.71	18.84	2.09
20	1.22	1.13	2.38	1.40	4.34	2.75	3.90	5.95	7.24	11.50	14.59	6.04
21	1.03	0.35	1.33	2.51	2.88	2.24	4.48	4.85	4.51	12.77	6.71	13.61
22	0.51	0.24	0.95	4.41	3.19	0.97	1.95	0.98	0.93	2.84	2.89	10.18
23	0.07	0.06	0.16	0.41	1.38	0.13	1.20	0.25	0.24	0.32	1.94	1.12
24	0.04	0	0.22	0.62	0.67	0.62	0.29	0.02	0.21	1.52	0.79	2.42
25	0.14	0.08	0.62	1.68	0.23	1.95	0.37	0.31	0.23	3.87	0.73	16.09
26	1.40	0.46	1.31	3.02	0.83	2.31	0.79	0.36	0.96	3.11	1.31	27.52
27	2.69	1.52	1.72	2.06	2.35	2.35	2.30	1.59	2.01	1.53	2.13	20.64
28	1.61	2.24	2.18	1.22	3.12	1.68	3.57	1.31	1.97	0.98	3.06	10.45
29	0.28	1.56	0.54	0.52	2.79	1.26	2.00	0.46	1.34	0.88	2.06	2.97
30	0.43	3.06	0.52	0.89	3.44	0.60	1.55	0.23	0.41	1.62	1.11	1.22
31	0.19	3.65	0.53	0.61	0.95	0.40	1.30	0.18	0.51	2.56	0.49	0.43
32	0.21	3.84	1.35	0.46	0.52	0.79	1.13	0.18	0.64	1.95	0.22	0.55
33	0.07	1.62	2.27	0.81	0.53	0.96	0.91	0.28	0.51	1.09	0.35	0.52
34	0.01	0.97	1.72	1.71	0.82	0.94	2.06	0.26	0.20	0.92	0.52	0.13
35	0.03	0.56	0.45	1.02	1.00	1.07	3.30	0.20	0.27	0.65	0.54	0.06
36	0	0.15	0.46	0.56	0.57	1.21	3.93	0.14	0.12	0.36	0.24	0.10
37	0	0.21	0.14	0.43	0.24	0.73	2.96	0.15	0.03	0.17	0.19	0.07
38	0.05	0.20	0.14	0.45	0.19	0.25	1.47	0.14	0.09	0.12	0.09	0.01
39	0.03	0.14	0.25	0.52	0.10	0.19	0.38	0.01	0.03	0.11	0.04	0.01
40	0.01	0.05	0.08	0.36	0.07	0.01	0.24	0.01	0.06	0	0.05	0.01
41	0.01	0	0.05	0.16	0.02	0.12	0	0	0	0	0.01	0
42	0.02	0	0.03	0.02	0.01	0	0.01	0	0	0	0	0
43	0	0	0	0.01	0.01	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0.03	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0.12	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 2, continued.

Length	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
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	0.01	0.01	0	0.01	0	0.01	0	0	0.04	0.01	0
17	0	0.66	1.73	0	0.28	0	0.12	0	0	0.54	1.49	0
18	0.01	5.80	18.08	0.26	3.89	0	1.83	0.26	0.69	6.03	6.47	0
19	0.01	6.49	25.46	2.11	9.29	0.06	7.04	6.98	2.86	20.84	18.44	0.01
20	0.13	3.94	33.89	6.40	6.54	0.69	9.21	37.08	4.38	30.72	8.36	0.26
21	0.93	2.58	13.44	2.75	2.58	0.93	9.12	23.64	2.23	17.97	1.45	1.78
22	0.46	0.59	2.72	0.14	0.30	1.82	5.84	3.72	0.30	7.08	0.40	3.72
23	0.45	0.56	2.13	0.44	0.34	0.96	0.52	0.70	0.01	3.94	0.75	2.27
24	0.18	0.38	0.41	1.58	1.12	0.20	0.00	0.7535	0.04	3.73	0.74	1.00
25	1.67	0.76	0.24	3.14	5.23	1.15	0.04	4.86	0.78	0.83	2.00	3.21
26	3.01	2.54	1.70	7.05	10.94	5.85	0.61	7.37	2.82	0.79	1.67	2.98
27	2.44	6.15	2.53	4.08	7.58	6.46	2.47	7.42	8.80	0.41	0.89	2.04
28	3.39	5.24	4.87	1.31	4.22	3.92	5.97	6.03	5.99	0.15	0.30	1.34
29	6.07	3.00	1.82	0.55	6.82	0.65	6.65	2.19	1.95	0.11	0.25	0.85
30	8.91	2.33	1.30	0.42	5.49	0.98	8.16	1.21	1.11	0.38	0.23	0.70
31	4.52	3.83	0.07	0.65	2.88	1.65	9.49	1.28	0.25	0.52	0.07	0.39
32	1.74	6.17	0.01	0.39	1.05	2.06	3.27	0.74	0.30	0.35	0.07	0.21
33	0.87	4.82	0.14	0.26	0.49	1.43	1.27	0.77	0.06	0.11	0.05	0.03
34	0.14	3.43	0.02	0.16	0.21	0.99	0.59	0.04	0.06	0.04	0.06	0.01
35	0.19	0.79	0.09	0.30	0.04	0.22	0.06	0.02	0.04	0.02	0.05	0
36	0.01	0.25	0.03	0.17	0.19	0.02	0	0	0	0.01	0.02	0
37	0.02	0.08	0.01	0.09	0.02	0.03	0.02	0	0	0	0	0
38	0.07	0.06	0	0.04	0	0.05	0.02	0	0.01	0	0	0
39	0	0	0	0.02	0	0	0	0	0	0	0	0
40	0	0.02	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

Figure 1: 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 1968-2013. The median number- and weight-per-tow values represent the median indices over 1968-2013.

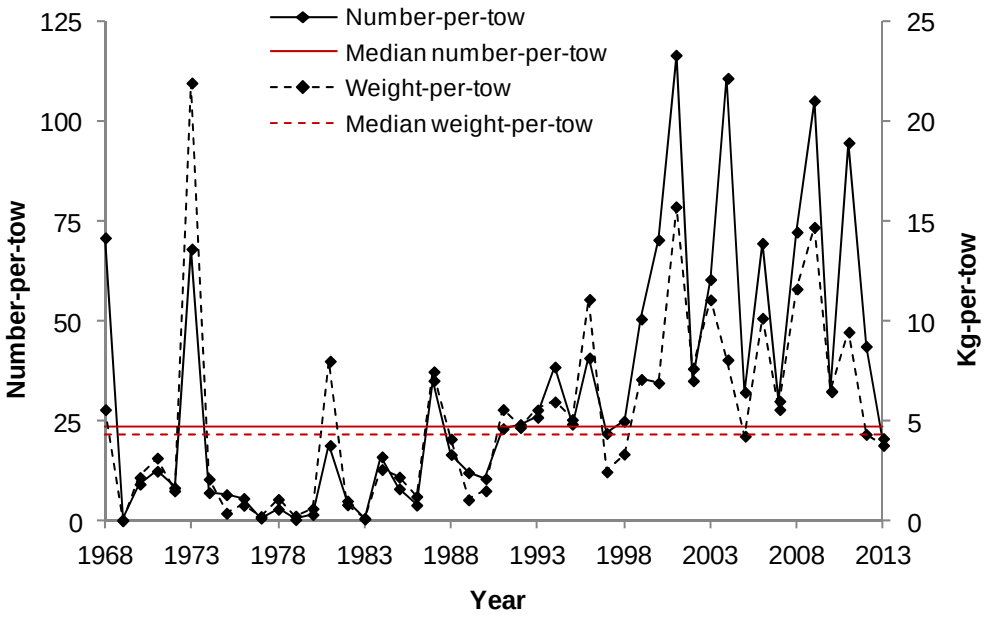

Figure 2: Annual mackerel length compositions from the NEFSC spring bottom trawl survey, 1968-2013.

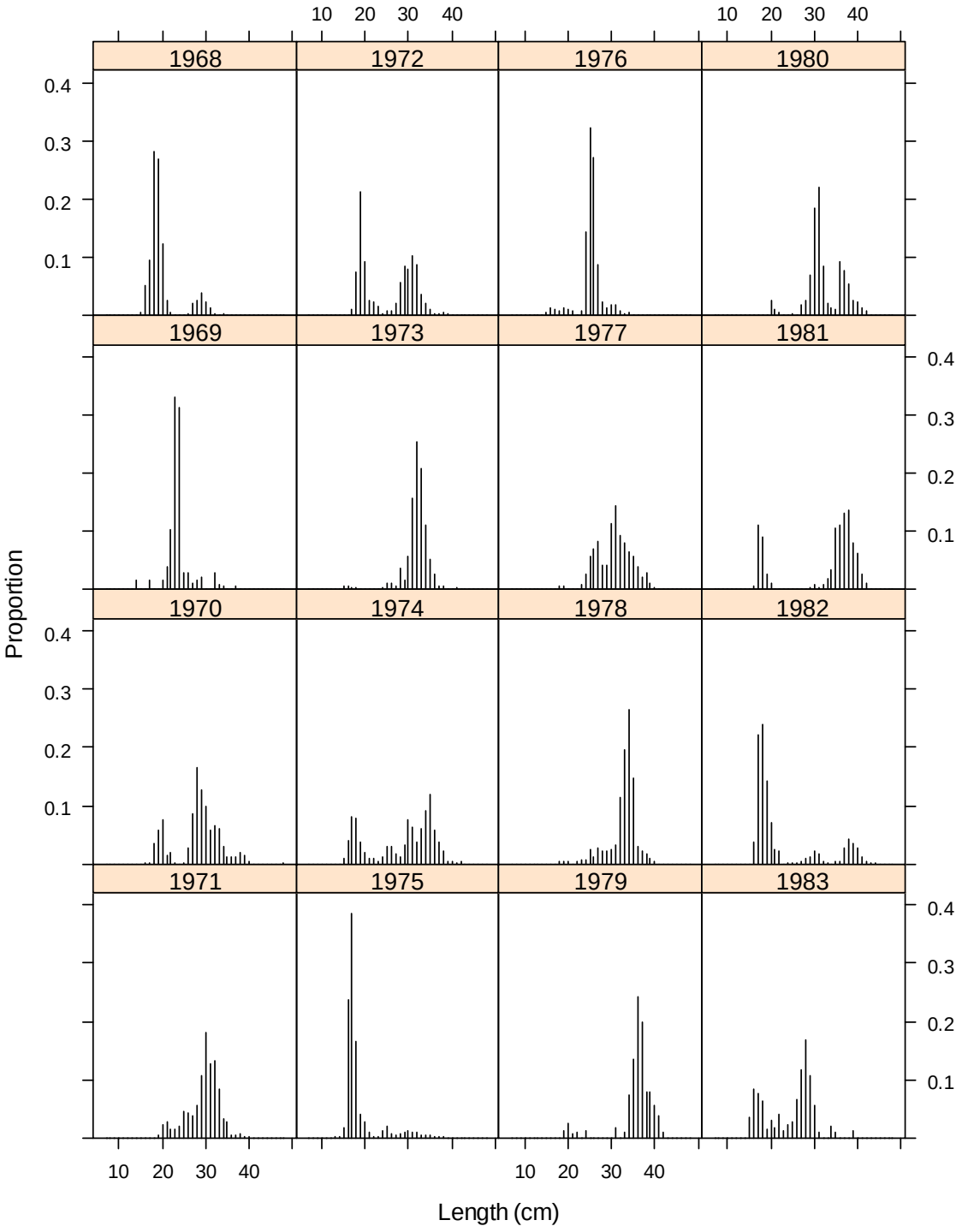

Figure 2, continued

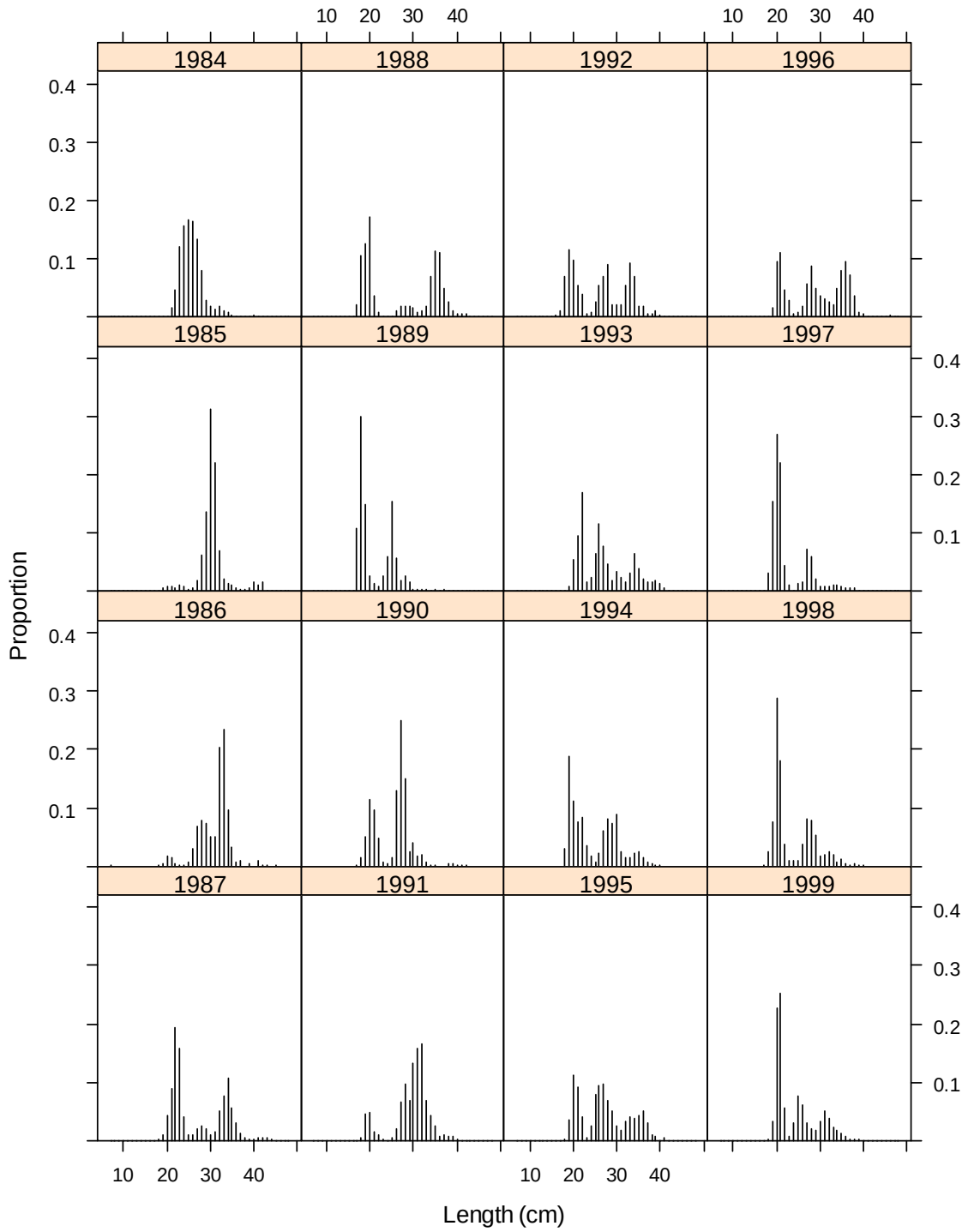

Figure 2, continued

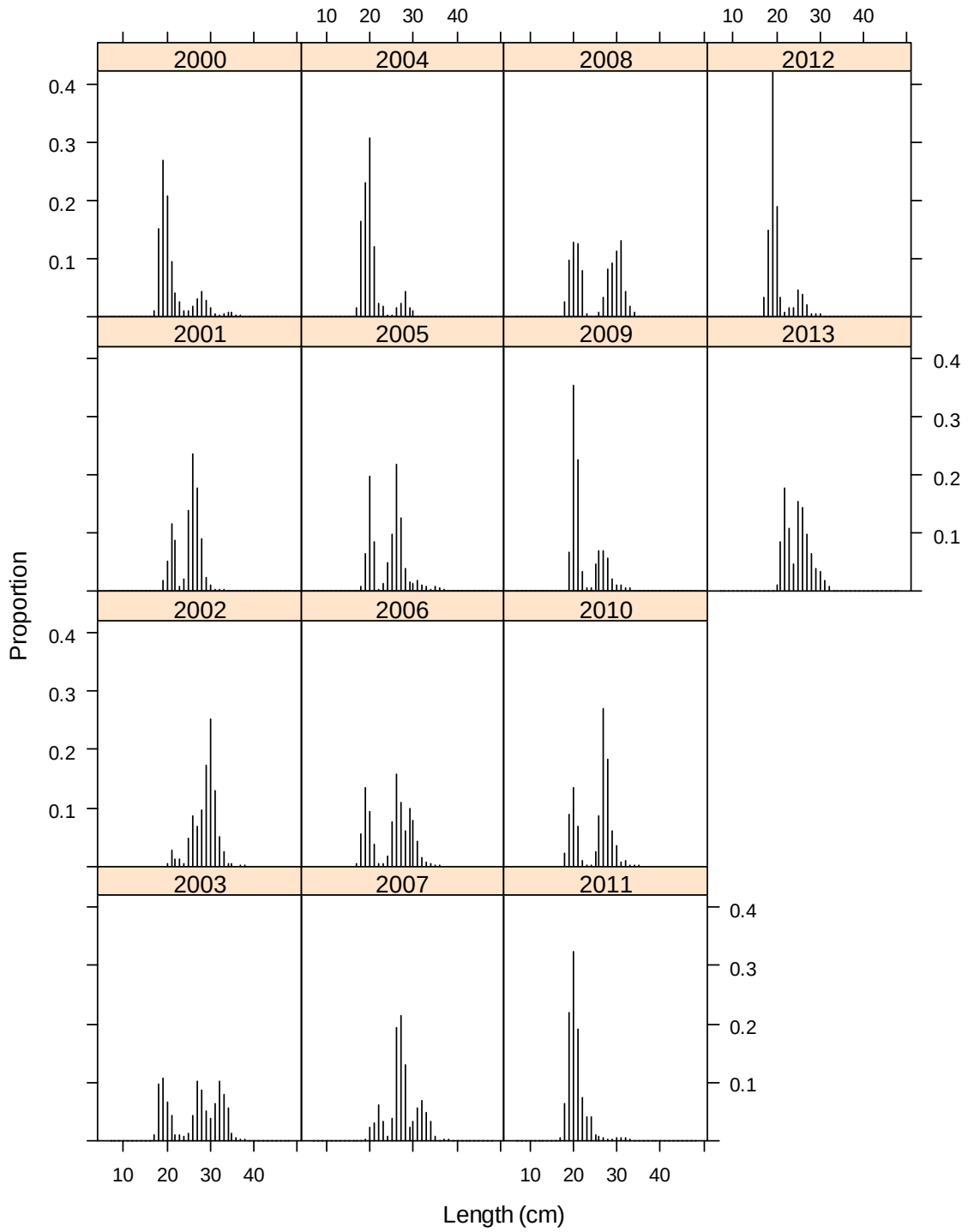

Figure 3: Annual mackerel length compositions (stratified mean numbers-at-length), averaged over nine or ten year time intervals, from the NEFSC spring bottom trawl survey for 1968-2013.

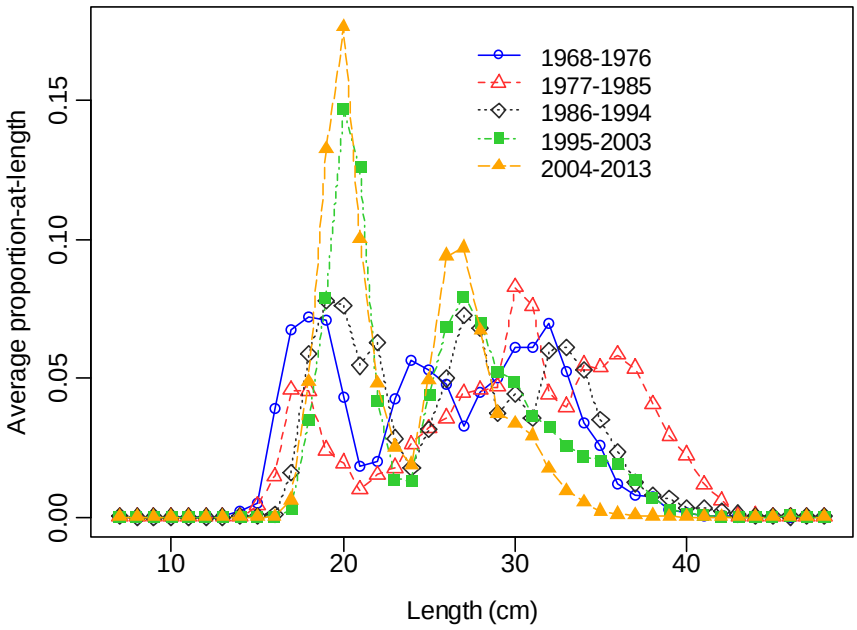

Figure 4: Atlantic mackerel total and spawning stock biomass (tons) in NAFO Subareas 3 and 4 from 1968 to 2011, estimated from a sequential population analysis of the Canadian contingent of mackerel (Reprinted from the 2012 Canadian assessment (DFO 2012, Figure 14).

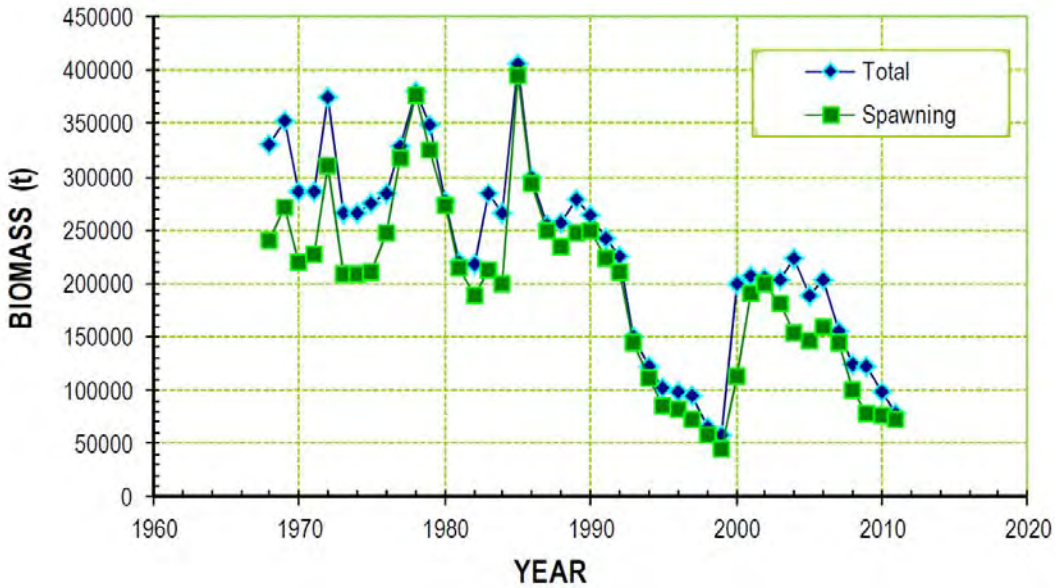

Figure 5: Atlantic mackerel fishing mortality in NAFO Subareas 3 and 4 from 1968 to 2011, estimated from a sequential population analysis of the Canadian contingent of mackerel (Reprinted from the 2012 Canadian assessment (DFO 2012, Figure 13).