Northwest Atlantic Fisheries Organization

Serial No. N6690 **NAFO SCR Doc. 17-035REV**

SCIENTIFIC COUNCIL MEETING – JUNE 2017

Statistical Catch-at-Age Operating Models for the Greenland Halibut Resource

Rebecca A. Rademeyer and Doug S. Butterworth

June 2017

Summary

This document provides details of the SCAA assessment model fits and associated diagnostics that correspond to the SCAA-based OMs used for Greenland halibut CMP testing in NAFO SCR Doc. 17-026.

Introduction

This document provides results for the baseline Statistical-Catch-at-Age (SCAA) assessment of the Greenland halibut resource. This assessment constitutes an update of the assessment presented in Rademeyer and Butterworth (2017a), to take account of discussion at the April Scientific Council (SC) meeting held in Vigo (NAFO 2017a). This baseline corresponds to the baseline Operating Model (OM0) used for CMP testing in Rademeyer and Butterworth (2017b).

Results are also presented for all the other SCAA OMs identified during the Vigo SC meeting, and also used in this CMP testing process.

Data and Methodology

The catch and survey based data (including catch-at-age information), together with some biological data, that are used in these assessments are listed in Tables in Appendix A.

Baseline OM

The SCAA methodology is described in Appendix A of Rademeyer and Butterworth (2017b). The changes made to the "StartA" baseline in Rademeyer and Butterworth (2017a) to provide this updated baseline assessment are:

- h=0.8;
- σ_R=0.4;
- M=0.12;
- Start in 1960 with specifications for the initial numbers-at-age vector;
- The "sqrt(p)" approach for the commercial and survey catch-at-age negative log-likelihood;
- Maximum data plus group of 10+ (model plus group remains 14+);
- Weight-at-age for 10+ applies to all older fish;
- Survey timing T^i modified;
- Flat selectivity for the plus group for the EU surveys;
- W_{CAA}=0.2;
- Commercial selectivity periods: 1960-1989, 1990-1995, 1996-2003 and 2004+

Sensitivities

The trials selected during the Vigo SC meeting affecting the past (and hence requiring assessment re-runs) are:

1) Alternative to past input survey data set:
   a. O3
2) Alternative steepness parameter (baseline: h=0.8):
   a. h=0.7
   b. h=0.9
3) Alternative natural mortality (baseline: M=0.12):
   a. M=0.2
   b. M increasing linearly from 0.12 at age 10 to 0.5 at age 14+
4) Alternative maturity-at-age (baseline: 100% mature at 10+):
   a. 100% mature at 14+
5) Alternative CAA -lnL weighting (baseline: Wcaa=0.2):
   a. Wcaa=0.1
   b. Wcaa=0.5
6) Alternative σ_R value (baseline: σ_R =0.4):
   a. σ_R =0.6
7) Alternative σ_C value (baseline: σ_C =0.1):
   a. σ_C =0.2
8) Starting (1960) biomass:
   a. Force to XSA/SAM-style level (total biomass of 200 000t in 1975)
9) Sensitivity for methods for estimating 1960 starting numbers-at-age vector
   a. This was to be decided, but was not pursued given insensitivity of results to other aspects of the starting situation
10) Current (2016) numbers: (only affects the future, so that results are not reported below as in almost all respects they would be identical to those for OM0)
   a. 1.2 baseline estimates
   b. 0.8 baseline estimates
11) Commercial selectivities:
   a. 6 instead of 4 selectivity blocks
   b. Descending (right side) limb: normal changed to negative exponential:

$$S_a = \begin{cases} \exp\left(-\frac{(a-a_{max})^2}{2\sigma_{left}^2}\right) & \text{for } a \leq a_{max} \\ \exp\left(-\frac{(a-a_{max})}{\sigma_{right}}\right) & \text{for } a > a_{max} \end{cases}$$

c. Force less doming: in equation A.24 of Rademeyer and Butterworth (2017b): σ_{right} is fixed at twice the value estimated for OM0

12) EU survey selectivity shape:
  a. Exponential decrease from plus group (instead of flat)
  b. Force less doming: flat from 9+: 0.2 is added to the value estimated for OM0.

Results

Results are given in Table 1 for all these OMs. Figure 1 compares the catch, fishing mortality, biomass and recruitment trajectories for OM0 and StartA (the updated and earlier baselines respectively), as well as the stock-recruitment curves and estimated selectivities. Figure 2 plots the fits to the survey biomass indices, and to the survey and commercial catch-at-age data, for OM0 and StartA.

Results comparing each of the OMs to the updated baseline OM0 are given in Appendix B.

Discussion

This is primarily a "for the record" document, so that there is a record of the details of the assessment results with associated diagnostics that correspond to the OMs used in CMP testing in Butterworth and Rademeyer (2017b). These results could also be pertinent if there is consideration to be given to selecting a current "best assessment" of the resource.

In broad terms, most of the alternatives to the updated baseline assessment (which corresponds to OM0) show fairly similar historical biomass trajectories. The exceptions are those with differing natural mortality (OM3a and 3b) for which unsurprisingly the biomass scale differs in absolute terms. The historical trend also differs appreciably from that for OM0 for OM8a (by construction, as that difference is forced in that fit), and for OM11c and OM12b for which selectivities are forced to be less domed.

References

NAFO. 2017. Report of the Scientific Council Meeting on Greenland halibut Management Strategy Evaluation, 3-7 April 2017, Vigo, Spain. NAFO document XX.

Rademeyer R.A. and Butterworth D.S. 2017a. Initial applications of Statistical Catch-at-Age Assessment Methodology to the Greenland Halibut Resource. NAFO document: SCR Doc 17/02.

Rademeyer R.A. and Butterworth D.S. 2017b. Results for Initial Candidate Management Procedure Testing for Greenland Halibut. NAFO document: SCR Doc 17/26.

Table 1a: Results from fits of the SCAA OMs. Hessian-based CVs are shown in parentheses.

	OM0		OM1a		OM2a		OM2b		OM3a		OM3b		OM4a		OM5a		OM5b	
-lnL:Overall	-342.18		-475.93		-341.25		-342.73		-341.71		-340.07		-342.59		-205.80		-767.05	
	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA
Can. Fall 2J3K	-4.38	-59.40	-3.50	-58.56	-4.26	-59.42	-4.24	-59.19	-4.01	-59.41	-4.35	-58.64	-4.41	-59.76	-9.87	-26.35	-4.41	-149.94
EU 3M 0-700m	1.69	-34.13	0.74	-33.82	1.40	-33.91	2.12	-34.37	1.59	-33.73	1.62	-33.60	1.84	-34.26	-2.27	-15.61	2.66	-87.52
EU 3M 0-1400m	-2.15	-35.66	-1.27	-36.08	-2.08	-35.62	-2.28	-35.67	-1.79	-35.73	-1.30	-35.50	-2.13	-35.72	-1.18	-17.38	-2.07	-89.57
Can. Spring 3LNO	13.76	-46.81	12.62	-47.13	13.59	-46.59	13.95	-47.06	13.65	-46.80	13.61	-46.97	13.76	-46.48	13.38	-22.85	14.09	-118.44
Commercial		-104.14		-102.84		-103.44		-105.34		-104.60		-103.78		-104.40		-50.20		-267.19
-lnL:RecRes	5.45		5.64		5.68		5.44		5.66		5.39		5.32		3.65		9.13	
-lnL:CatchPen	-76.41		-75.27		-76.60		-76.10		-76.54		-76.55		-76.35		-77.13		-73.83	
h	**0.80**		**0.80**		**0.70**		**0.90**		**0.80**		**0.80**		**0.80**		**0.80**		**0.80**	
M	**0.12**		**0.12**		**0.12**		**0.12**		**0.20**		**0.12-0.5**		**0.12**		**0.12**		**0.12**	
ϑ	0.00	(999.98)	0.00	(999.83)	0.00	(999.97)	0.00	(999.98)	0.00	(999.97)	0.00	(999.85)	0.00	(999.95)	0.00	(999.95)	0.00	(1000.00)
K^{sp}	880	(0.09)	857	(0.08)	991	(0.09)	771	(0.08)	490	(0.08)	441	(0.09)	523	(0.09)	947	(0.13)	860	(0.08)
B^{sp}_{1960}	901	(0.38)	860	(0.38)	998	(0.37)	808	(0.39)	498	(0.39)	445	(0.40)	529	(0.38)	955	(0.40)	938	(0.38)
B^{sp}_{1975}	577	(0.36)	544	(0.36)	672	(0.34)	486	(0.38)	273	(0.35)	218	(0.35)	404	(0.43)	624	(0.39)	609	(0.34)
B^{sp}_{2015}	134	(0.41)	124	(0.34)	175	(0.36)	87	(0.58)	80	(0.38)	92	(0.40)	64	(0.46)	202	(0.56)	99	(0.26)
B^{sp}_{2015}/K^{sp}	0.15	(0.38)	0.14	(0.33)	0.18	(0.33)	0.11	(0.56)	0.16	(0.37)	0.21	(0.38)	0.12	(0.42)	0.21	(0.47)	0.12	(0.26)
$B^{sp}_{2015}/B^{sp}_{1975}$	0.23	(0.50)	0.23	(0.45)	0.26	(0.45)	0.18	(0.66)	0.29	(0.48)	0.42	(0.48)	0.16	(0.57)	0.32	(0.55)	0.16	(0.41)
$B^{5\text{-}9}_{1975}$	173	(0.19)	167	(0.19)	199	(0.19)	148	(0.19)	199	(0.18)	195	(0.20)	165	(0.19)	192	(0.23)	167	(0.17)
$B^{5\text{-}9}_{2015}$	109	(0.18)	96	(0.15)	118	(0.18)	98	(0.20)	121	(0.17)	119	(0.20)	106	(0.18)	138	(0.26)	98	(0.12)
$B^{5\text{-}9}_{2015}/B^{5\text{-}9}_{1975}$	0.63	(0.23)	0.57	(0.21)	0.59	(0.23)	0.66	(0.24)	0.61	(0.23)	0.61	(0.25)	0.64	(0.22)	0.72	(0.25)	0.59	(0.19)
	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA
Can. Fall 2J3K	0.19	0.06	0.20	0.06	0.19	0.06	0.19	0.06	0.20	0.06	0.19	0.06	0.19	0.06	0.15	0.08	0.19	0.06
EU 3M 0-700m	0.29	0.05	0.26	0.06	0.28	0.06	0.31	0.05	0.29	0.06	0.29	0.06	0.30	0.05	0.19	0.07	0.33	0.05
EU 3M 0-1400m	0.20	0.055	0.22	0.05	0.20	0.05	0.20	0.05	0.21	0.05	0.22	0.06	0.20	0.05	0.22	0.06	0.20	0.05
Can. Spring 3LNO	0.52	0.09	0.49	0.09	0.51	0.09	0.53	0.09	0.52	0.09	0.52	0.09	0.52	0.09	0.51	0.09	0.53	0.09
Commercial		0.07		0.07		0.07		0.07		0.07		0.07		0.07		0.07		0.06
MSY	26.86	(0.09)	26.86	(0.09)	25.18	(0.09)	28.26	(0.08)	27.87	(0.08)	29.12	(0.09)	25.76	(0.08)	28.67	(0.10)	26.39	(0.08)
F_{MSY}	0.39		0.38		0.32		0.49		0.40		0.40		0.38		0.39		0.39	
$F^{5\text{-}9}_{MSY}$	0.22		0.22		0.18		0.28		0.23		0.23		0.22		0.22		0.22	
B^{sp}_{MSY}	182.54	(0.21)	178.48	(0.24)	242.21	(0.20)	123.83	(0.25)	98.14	(0.21)	91.99	(0.19)	107.53	(0.24)	196.20	(0.38)	178.24	(0.14)
B^{sp}_{MSY}/K^{sp}	0.21	(0.18)	0.21	(0.21)	0.24	(0.16)	0.16	(0.22)	0.20	(0.18)	0.21	(0.16)	0.21	(0.21)	0.21	(0.31)	0.21	(0.11)
$B^{sp}_{2015}/B^{sp}_{MSY}$	0.73	(0.39)	0.70	(0.33)	0.72	(0.34)	0.70	(0.53)	0.81	(0.38)	1.00	(0.40)	0.60	(0.40)	1.03	(0.43)	0.56	(0.26)
$B^{5\text{-}9}_{MSY}$	123.25	(0.11)	122.04	(0.12)	135.28	(0.12)	110.66	(0.10)	139.23	(0.11)	133.05	(0.12)	119.14	(0.12)	131.63	(0.18)	121.13	(0.09)
$B^{5\text{-}9}_{2015}/B^{5\text{-}9}_{MSY}$	0.89	(0.18)	0.78	(0.16)	0.87	(0.19)	0.88	(0.20)	0.87	(0.18)	0.90	(0.21)	0.89	(0.18)	1.05	(0.20)	0.81	(0.14)

Table 1b: Results from fits of the SCAA OMs. Hessian-based CVs are shown in parentheses.

	OM0		OM6a		OM7a		OM8a*		OM11a		OM11b		OM11c		OM12a		OM12b	
-lnL:Overall	-342.18		-318.50		-306.54		-330.34		-345.06		-342.18		-330.02		-341.71		-329.22	
	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA	-lnL: index	-lnL: CAA
Can. Fall 2J3K	-4.38	-59.40	-4.49	-59.76	-6.48	-59.78	-4.27	-58.81	-5.94	-59.32	-4.38	-59.40	-3.97	-58.94	-4.36	-59.40	-2.92	-59.48
EU 3M 0-700m	1.69	-34.13	2.04	-34.74	0.85	-34.92	1.61	-33.87	0.96	-34.10	1.69	-34.13	1.53	-34.19	1.57	-33.75	2.07	-31.78
EU 3M 0-1400m	-2.15	-35.66	-2.43	-35.78	-1.95	-35.92	-1.89	-35.91	-1.48	-35.47	-2.15	-35.66	-2.09	-35.91	-1.68	-35.82	-2.34	-27.95
Can. Spring 3LNO	13.76	-46.81	13.88	-47.01	13.18	-47.21	13.47	-47.05	13.54	-46.84	13.76	-46.81	13.39	-46.93	13.78	-46.73	13.41	-46.57
Commercial		-104.14		-104.88		-105.86		-100.85		-106.07		-104.14		-94.70		-104.18		-105.44
-lnL:RecRes	5.45		30.90		6.23		8.79		5.97		5.45		6.68		5.25		7.80	
-lnL:CatchPen	-76.41		-76.25		-34.69		-76.01		-76.31		-76.41		-76.54		-76.39		-76.17	
h	**0.80**		**0.80**		**0.80**		**0.80**		**0.80**		**0.80**		**0.80**		**0.80**		**0.80**	
M	**0.12**		**0.12**		**0.12**		**0.12**		**0.12**		**0.12**		**0.12**		**0.12**		**0.12**	
ϑ	0.00	(999.98)	0.00	(999.97)	0.00	(999.98)	0.08		0.00	(1000.00)	0.00	(999.97)	0.14	(0.54)	0.00	(999.95)	0.05	(1.88)
K^{sp}	880	(0.09)	969	(0.12)	881	(0.09)	1101		871	(0.08)	880	(0.09)	938	(0.17)	880	(0.09)	881	(0.10)
B^{sp}_{1960}	901	(0.38)	1023	(0.56)	910	(0.38)	100		921	(0.38)	901	(0.38)	69	(0.90)	893	(0.38)	359	(1.33)
B^{sp}_{1975}	577	(0.36)	658	(0.51)	585	(0.36)	63		587	(0.36)	577	(0.36)	130	(0.53)	572	(0.36)	360	(0.57)
B^{sp}_{2015}	134	(0.41)	117	(0.43)	114	(0.37)	111		119	(0.34)	134	(0.41)	93	(0.33)	137	(0.43)	62	(0.30)
B^{sp}_{2015}/K^{sp}	0.15	(0.38)	0.12	(0.42)	0.13	(0.35)	0.10		0.14	(0.32)	0.15	(0.38)	0.10	(0.38)	0.16	(0.40)	0.07	(0.31)
$B^{sp}_{2015}/B^{sp}_{1975}$	0.23	(0.50)	0.18	(0.63)	0.19	(0.49)	1.75		0.20	(0.48)	0.23	(0.50)	0.72	(0.58)	0.24	(0.52)	0.17	(0.65)
$B^{5\text{-}9}_{1975}$	173	(0.19)	170	(0.26)	174	(0.19)	115		170	(0.19)	173	(0.19)	124	(0.14)	173	(0.19)	155	(0.17)
$B^{5\text{-}9}_{2015}$	109	(0.18)	105	(0.18)	103	(0.16)	104		99	(0.16)	109	(0.18)	95	(0.14)	110	(0.19)	87	(0.13)
$B^{5\text{-}9}_{2015}/B^{5\text{-}9}_{1975}$	0.63	(0.23)	0.62	(0.29)	0.59	(0.23)	0.90		0.58	(0.23)	0.63	(0.23)	0.77	(0.20)	0.64	(0.23)	0.56	(0.22)
	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA	σ index	σ CAA
Can. Fall 2J3K	0.19	0.06	0.19	0.06	0.17	0.06	0.19	0.06	0.18	0.06	0.19	0.06	0.20	0.06	0.19	0.06	0.21	0.06
EU 3M 0-700m	0.29	0.05	0.30	0.05	0.27	0.05	0.29	0.06	0.27	0.05	0.29	0.05	0.29	0.05	0.29	0.06	0.30	0.06
EU 3M 0-1400m	0.20	0.055	0.20	0.05	0.21	0.05	0.21	0.05	0.21	0.06	0.20	0.05	0.20	0.05	0.21	0.05	0.20	0.07
Can. Spring 3LNO	0.52	0.09	0.52	0.09	0.50	0.09	0.51	0.09	0.51	0.09	0.52	0.09	0.51	0.09	0.52	0.09	0.51	0.09
Commercial		0.07		0.07		0.06		0.07		0.06		0.07		0.08		0.07		0.07
MSY	26.86	(0.09)	29.84	(0.12)	26.95	(0.09)	34.04		25.58	(0.09)	26.86	(0.09)	30.43	(0.17)	26.87	(0.09)	28.67	(0.11)
F_{MSY}	0.39		0.39		0.39		0.38		0.40		0.39		0.33		0.39		0.36	
$F^{5\text{-}9}_{MSY}$	0.22		0.22		0.22		0.22		0.25		0.22		0.20		0.22		0.21	
B^{sp}_{MSY}	182.54	(0.21)	201.27	(0.23)	182.59	(0.20)	229.05		180.05	(0.21)	182.54	(0.21)	198.26	(0.18)	182.63	(0.22)	184.50	(0.25)
B^{sp}_{MSY}/K^{sp}	0.21	(0.18)	0.21	(0.18)	0.21	(0.17)	0.21		0.21	(0.19)	0.21	(0.18)	0.21	(0.05)	0.21	(0.18)	0.21	(0.22)
$B^{sp}_{2015}/B^{sp}_{MSY}$	0.73	(0.39)	0.58	(0.42)	0.62	(0.37)	0.48		0.66	(0.36)	0.73	(0.39)	0.47	(0.39)	0.75	(0.40)	0.34	(0.32)
$B^{5\text{-}9}_{MSY}$	123.25	(0.11)	136.72	(0.14)	123.69	(0.11)	155.67		118.63	(0.12)	123.25	(0.11)	136.49	(0.17)	123.26	(0.12)	129.59	(0.13)
$B^{5\text{-}9}_{2015}/B^{5\text{-}9}_{MSY}$	0.89	(0.18)	0.77	(0.20)	0.83	(0.18)	0.67		0.83	(0.18)	0.89	(0.18)	0.70	(0.23)	0.90	(0.19)	0.67	(0.17)

* Not converged

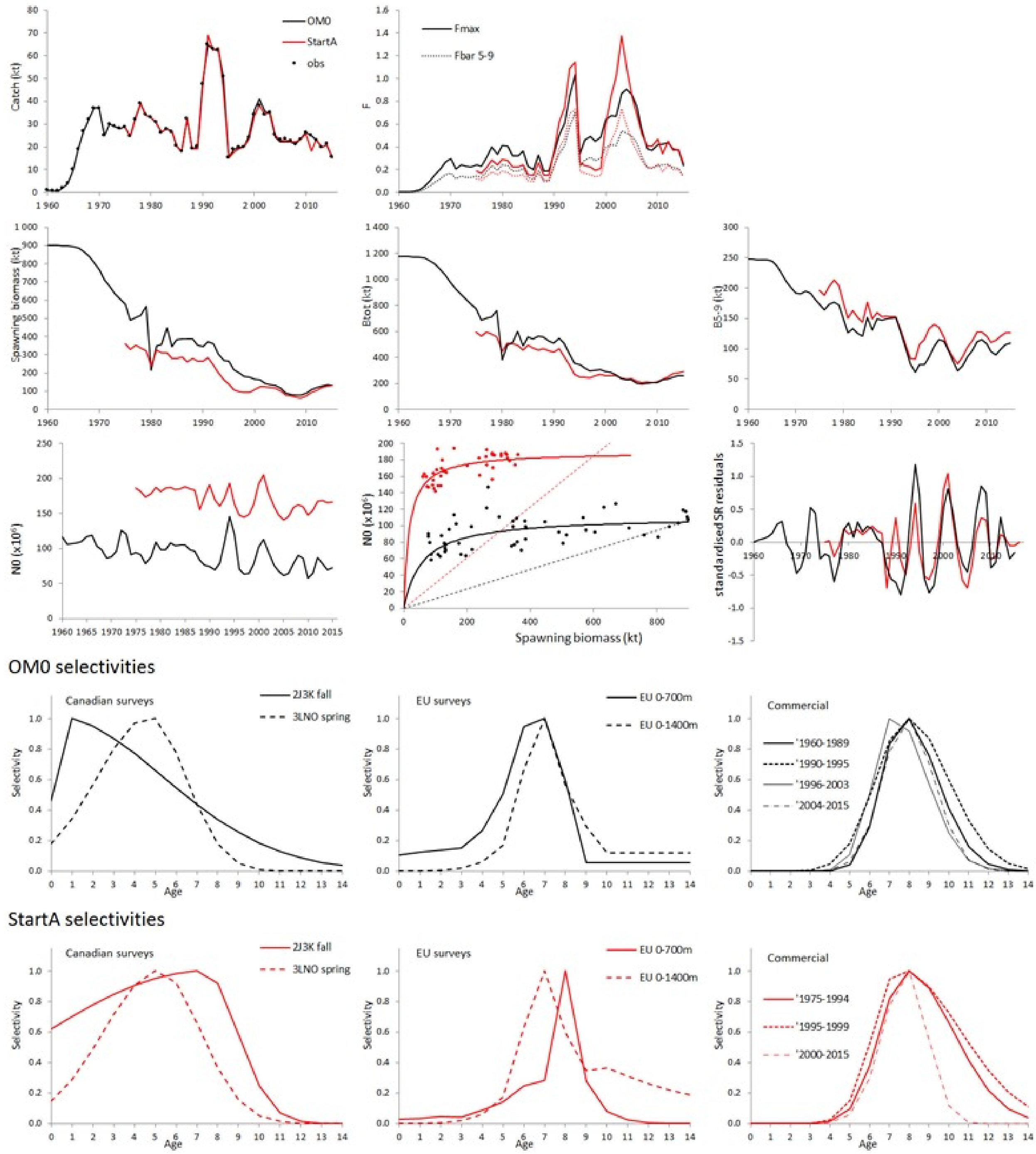

Fig. 1. Results for SCAA baseline OM0 (in black) and "StartA" of Rademeyer and Butterworth (2017a) (in red).

Fig. 2. Fits to the survey data for the SCAA baseline OM0 (in black) and "StartA" of Rademeyer and Butterworth (2017a) (in red).

APPENDIX A – Data

Table A1: Landings (tons) for Greenland Halibut in Sub-area 2 and Div. 3KLMNO.

Year	Landings (t)	Year	Landings (t)
1960	900	1988	19215
1961	700	1989	20034
1962	600	1990	47454
1963	2000	1991	65008
1964	4000	1992	63193
1965	10000	1993	62455
1966	19000	1994	51029
1967	27000	1995	15272
1968	32000	1996	18840
1969	37000	1997	19858
1970	37000	1998	19946
1971	25000	1999	24226
1972	30000	2000	34177
1973	29000	2001	38232
1974	28000	2002	34062
1975	28814	2003	35151
1976	24611	2004	25486
1977	32048	2005	23255
1978	39070	2006	23531
1979	34104	2007	22747
1980	32867	2008	21180
1981	30754	2009	23156
1982	26278	2010	26174
1983	27861	2011	24960
1984	26711	2012	22978
1985	20347	2013	19976
1986	17976	2014	21433
1987	32442	2015	15471

Table A2. Catch at age matrix (000s) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1975	0	0	0	0	334	2819	5750	4956	3961	1688	702	135	279	288
1976	0	0	0	0	17	610	3231	5413	3769	2205	829	260	101	53
1977	0	0	0	0	534	5012	10798	7346	2933	1013	220	130	116	84
1978	0	0	0	0	2982	8415	8970	7576	2865	1438	723	367	222	258
1979	0	0	0	0	2386	8727	12824	6136	1169	481	287	149	143	284
1980	0	0	0	0	209	2086	9150	9679	5398	3828	1013	128	53	27
1981	0	0	0	0	863	4517	9806	11451	4307	890	256	142	43	69
1982	0	0	0	0	269	2299	6319	5763	3542	1684	596	256	163	191
1983	0	0	0	0	701	3557	9800	7514	2295	692	209	76	106	175
1984	0	0	0	0	902	2324	5844	7682	4087	1259	407	143	106	183
1985	0	0	0	0	1983	5309	5913	3500	1380	512	159	99	87	86
1986	0	0	0	0	280	2240	6411	5091	1469	471	244	140	70	117
1987	0	0	0	0	137	1902	11004	8935	2835	853	384	281	225	349
1988	0	0	0	0	296	3186	8136	4380	1288	465	201	105	107	129
1989	0	0	0	0	181	1988	7480	4273	1482	767	438	267	145	71
1990	0	0	0	95	1102	6758	12632	7557	4072	2692	1204	885	434	318
1991	0	0	0	220	2862	7756	13152	10796	7145	3721	1865	1216	558	422
1992	0	0	0	1064	4180	10922	20639	12205	4332	1762	1012	738	395	335
1993	0	0	0	1010	9570	15928	17716	11918	4642	1836	1055	964	401	182
1994	0	0	0	5395	16500	15815	11142	6739	3081	1103	811	422	320	215
1995	0	0	0	323	1352	2342	3201	2130	1183	540	345	273	251	201
1996	0	0	0	190	1659	5197	6387	1914	956	504	436	233	143	89
1997	0	0	0	335	1903	4169	7544	3215	1139	606	420	246	137	89
1998	0	0	0	552	3575	5407	5787	3653	1435	541	377	161	92	51
1999	0	0	0	297	2149	5625	8611	3793	1659	623	343	306	145	151
2000	0	0	0	271	2029	12583	21175	3299	973	528	368	203	129	104
2001	0	0	0	448	2239	12163	22122	5154	1010	495	439	203	156	75
2002	0	0	37	479	1662	7239	17581	6607	1244	659	360	224	126	81
2003	0	0	203	1279	4491	10723	16764	6385	1614	516	290	144	76	85
2004	0	0	17	897	4062	8236	10542	4126	1307	529	289	184	87	75
2005	0	0	40	534	1652	5999	10313	3996	1410	444	244	114	64	46
2006	0	0	10	216	1869	6450	12144	4902	1089	372	136	47	32	40
2007	0	0	0	88	570	3732	11912	5414	1230	472	163	80	41	29
2008	0	0	0	29	448	3312	10697	5558	1453	393	115	46	26	15
2009	0	0	0	61	476	3121	8801	7276	1949	508	206	67	31	34
2010	0	0	0	146	825	5077	11202	6171	2134	520	214	64	22	21
2011	0	0	430	690	1385	4101	7257	3953	1255	455	155	66	21	18
2012	0	0	1216	706	1982	3422	7618	5529	1992	657	287	134	36	29
2013	0	0	127	481	1966	4850	5894	5370	1263	401	93	35	15	17
2014	0	0	119	263	1106	3818	5784	7441	1314	302	85	34	11	15
2015	0	0	59	89	429	1237	4037	5546	1571	223	58	22	9	19

Table A3. Catch weights-at-age (kg) matrix for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO. Pre-1975 weights-at-age are taken as the 1975-1979 average.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1975	0	0	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.850	2.850	2.850	2.850	2.850
1976	0	0	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.510	2.510	2.510	2.510	2.510
1977	0	0	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.700	2.700	2.700	2.700	2.700
1978	0	0	0.126	0.244	0.609	0.760	0.955	1.190	1.580	2.910	2.910	2.910	2.910	2.910
1979	0	0	0.126	0.244	0.609	0.760	0.955	1.190	1.580	3.440	3.440	3.440	3.440	3.440
1980	0	0	0.126	0.244	0.514	0.659	0.869	1.050	1.150	1.400	1.400	1.400	1.400	1.400
1981	0	0	0.126	0.244	0.392	0.598	0.789	0.985	1.240	2.400	2.400	2.400	2.400	2.400
1982	0	0	0.126	0.244	0.525	0.684	0.891	1.130	1.400	2.580	2.580	2.580	2.580	2.580
1983	0	0	0.126	0.244	0.412	0.629	0.861	1.180	1.650	3.370	3.370	3.370	3.370	3.370
1984	0	0	0.126	0.244	0.377	0.583	0.826	1.100	1.460	2.750	2.750	2.750	2.750	2.750
1985	0	0	0.126	0.244	0.568	0.749	0.941	1.240	1.690	3.190	3.190	3.190	3.190	3.190
1986	0	0	0.126	0.244	0.350	0.584	0.811	1.100	1.580	3.310	3.310	3.310	3.310	3.310
1987	0	0	0.126	0.244	0.364	0.589	0.836	1.160	1.590	3.440	3.440	3.440	3.440	3.440
1988	0	0	0.126	0.244	0.363	0.569	0.805	1.163	1.661	3.490	3.490	3.490	3.490	3.490
1989	0	0	0.126	0.244	0.400	0.561	0.767	1.082	1.657	3.100	3.100	3.100	3.100	3.100
1990	0	0	0.090	0.181	0.338	0.546	0.766	1.119	1.608	3.010	3.010	3.010	3.010	3.010
1991	0	0	0.126	0.244	0.383	0.592	0.831	1.228	1.811	3.380	3.380	3.380	3.380	3.380
1992	0	0	0.175	0.289	0.430	0.577	0.793	1.234	1.816	3.460	3.460	3.460	3.460	3.460
1993	0	0	0.134	0.232	0.368	0.547	0.809	1.207	1.728	3.230	3.230	3.230	3.230	3.230
1994	0	0	0.080	0.196	0.330	0.514	0.788	1.179	1.701	3.290	3.290	3.290	3.290	3.290
1995	0	0	0.080	0.288	0.363	0.531	0.808	1.202	1.759	3.750	3.750	3.750	3.750	3.750
1996	0	0	0.161	0.242	0.360	0.541	0.832	1.272	1.801	3.410	3.410	3.410	3.410	3.410
1997	0	0	0.120	0.206	0.336	0.489	0.771	1.159	1.727	3.300	3.300	3.300	3.300	3.300
1998	0	0	0.119	0.228	0.373	0.543	0.810	1.203	1.754	3.170	3.170	3.170	3.170	3.170
1999	0	0	0.176	0.253	0.358	0.533	0.825	1.253	1.675	3.190	3.190	3.190	3.190	3.190
2000	0	0	0.000	0.254	0.346	0.524	0.787	1.192	1.774	3.130	3.130	3.130	3.130	3.130
2001	0	0	0.000	0.249	0.376	0.570	0.830	1.168	1.794	3.180	3.180	3.180	3.180	3.180
2002	0	0	0.217	0.251	0.369	0.557	0.841	1.193	1.760	3.000	3.000	3.000	3.000	3.000
2003	0	0	0.188	0.247	0.389	0.564	0.822	1.199	1.651	2.870	2.870	2.870	2.870	2.870
2004	0	0	0.180	0.249	0.376	0.535	0.808	1.196	1.629	2.910	2.910	2.910	2.910	2.910
2005	0	0	0.252	0.301	0.396	0.564	0.849	1.247	1.691	2.780	2.780	2.780	2.780	2.780
2006	0	0	0.129	0.267	0.405	0.605	0.815	1.092	1.495	2.360	2.360	2.360	2.360	2.360
2007	0	0	0.000	0.276	0.389	0.581	0.833	1.137	1.500	2.410	2.410	2.410	2.410	2.410
2008	0	0	0.000	0.278	0.404	0.617	0.891	1.195	1.605	2.440	2.440	2.440	2.440	2.440
2009	0	0	0.000	0.279	0.390	0.599	0.862	1.158	1.611	2.430	2.430	2.430	2.430	2.430
2010	0	0	0.000	0.250	0.350	0.570	0.840	1.210	1.650	2.450	2.450	2.450	2.450	2.450
2011	0	0	0.125	0.215	0.314	0.541	0.870	1.270	1.755	2.650	2.650	2.650	2.650	2.650
2012	0	0	0.170	0.240	0.300	0.570	0.890	1.280	1.750	2.730	2.730	2.730	2.730	2.730
2013	0	0	0.140	0.270	0.420	0.630	0.870	1.230	1.820	2.850	2.850	2.850	2.850	2.850
2014	0	0	0.150	0.240	0.400	0.613	0.890	1.280	1.900	2.960	2.960	2.960	2.960	2.960
2015	0	0	0.160	0.240	0.410	0.630	0.890	1.220	1.760	2.930	2.930	2.930	2.930	2.930

Table A4: Proportion mature-at-age for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

1	2	3	4	5	6	7	8	9	10	11	12	13	14+
0	0	0	0	0	0	0	0	0	1	1	1	1	1

Table A5: Survey catch-at-age data (numbers) and biomass indices (mean weight (kg) per tow) for Greenland Halibut in Sub-Area 2 and Divisions 3KLMNO.

Canadian Fall 3J3K

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
1996	4.92	98.68	47.82	32.01	9.54	6.28	2.47	0.84	0.19	0.18	0.04	0.02	0.01	0.02	0.01	21.60
1997	2.18	28.05	58.62	43.61	21.13	10.37	5.01	2.00	0.64	0.20	0.06	0.03	0.02	0.01	0.00	24.80
1998	1.52	23.35	25.07	31.19	21.87	10.86	4.45	2.07	0.57	0.13	0.06	0.03	0.02	0.01	0.00	23.80
1999	6.46	15.99	34.42	24.07	28.28	20.04	10.53	3.81	0.70	0.14	0.07	0.02	0.01	0.03	0.00	32.50
2000	3.08	38.60	22.09	16.48	13.29	13.90	7.27	2.17	0.50	0.06	0.03	0.02	0.00	0.00	0.01	23.90
2001	8.49	43.90	22.72	17.00	14.07	9.77	7.59	3.40	0.69	0.11	0.02	0.01	0.00	0.01	0.00	22.70
2002	8.30	40.67	24.08	12.50	9.68	6.03	1.97	0.72	0.19	0.04	0.01	0.00	0.00	0.00	0.00	14.10
2003	9.94	45.70	26.67	11.69	9.49	6.39	2.27	0.89	0.27	0.04	0.02	0.01	0.01	0.00	0.00	15.30
2004	4.15	32.49	32.93	13.89	12.31	9.21	2.68	1.20	0.36	0.08	0.03	0.01	0.00	0.01	0.00	17.50
2005	5.07	16.06	16.15	8.56	13.84	10.98	6.85	3.96	0.66	0.12	0.03	0.03	0.01	0.01	0.01	20.30
2006	3.75	32.34	17.98	8.50	17.60	13.03	9.11	4.18	1.15	0.18	0.03	0.02	0.01	0.00	0.00	25.70
2007	2.21	32.61	14.51	12.81	18.77	9.57	10.35	6.17	2.14	0.34	0.08	0.04	0.02	0.01	0.01	29.10
2009	5.49	50.62	19.15	11.40	8.42	9.89	5.40	3.59	1.39	0.25	0.08	0.02	0.01	0.01	0.01	19.90
2010	19.54	50.94	39.25	14.81	9.45	6.74	3.77	2.20	1.02	0.18	0.07	0.04	0.02	0.01	0.01	19.50
2011	4.81	44.14	42.06	20.97	18.79	10.32	5.50	3.15	1.26	0.33	0.13	0.06	0.02	0.00	0.01	26.70
2012	5.16	12.28	9.61	11.27	11.86	10.96	9.03	4.31	1.69	0.29	0.11	0.05	0.02	0.01	0.02	23.50
2013	0.10	24.32	12.92	6.74	7.40	10.91	9.09	7.76	3.96	0.50	0.15	0.04	0.02	0.02	0.01	29.60
2014	3.10	22.08	30.41	11.39	4.54	7.96	7.38	8.92	6.62	0.97	0.20	0.04	0.02	0.01	0.04	33.30
2015	0.50	17.17	13.98	15.14	7.77	6.82	4.18	3.91	3.92	0.65	0.14	0.06	0.01	0.01	0.02	22.30

Canadian Spring 3LNO

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
1996	0.00	1.62	4.24	4.60	2.18	0.83	0.28	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
1997	0.00	1.16	3.92	5.16	3.23	1.46	0.51	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.50
1998	0.00	0.23	0.84	3.89	6.22	4.96	1.24	0.33	0.07	0.01	0.00	0.00	0.00	0.00	0.00	4.60
1999	0.00	0.29	0.55	1.15	1.98	3.39	1.09	0.24	0.05	0.01	0.00	0.00	0.00	0.00	0.00	2.80
2000	0.02	0.79	1.07	1.07	1.51	1.95	2.04	0.56	0.03	0.01	0.00	0.00	0.00	0.00	0.00	3.00
2001	0.00	0.57	0.71	0.74	0.68	0.80	0.72	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.50
2002	0.00	0.64	0.57	0.60	0.58	0.61	0.21	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.70
2003	0.00	0.93	2.14	1.66	1.57	1.06	0.21	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.50
2004	0.00	0.66	0.57	1.18	1.18	1.16	0.26	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.10
2005	0.00	0.35	0.31	1.09	0.95	1.37	0.82	0.21	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.70
2007	0.00	1.60	0.52	0.80	0.40	1.41	1.49	1.12	0.18	0.02	0.00	0.00	0.00	0.00	0.00	3.00
2008	0.00	0.44	0.77	0.96	0.71	1.25	0.75	0.64	0.28	0.02	0.01	0.00	0.00	0.00	0.00	2.10
2009	0.00	0.27	0.22	0.19	0.39	0.45	0.26	0.13	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.70
2010	0.00	0.77	0.66	0.52	0.40	0.84	1.08	0.35	0.14	0.02	0.01	0.00	0.00	0.00	0.00	1.70
2011	0.00	1.96	1.40	0.92	0.65	0.62	0.29	0.16	0.10	0.01	0.00	0.00	0.00	0.00	0.00	1.00
2012	0.02	0.32	0.80	2.48	1.40	1.16	0.50	0.18	0.06	0.02	0.00	0.00	0.00	0.00	0.00	1.90
2013	0.00	1.28	0.68	0.05	0.38	0.61	0.23	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.70
2014	0.00	1.62	1.19	0.32	0.20	0.24	0.24	0.14	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.70

Canadian Fall 3LNO

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
1996	0.25	5.27	4.92	3.84	1.41	1.00	0.40	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52
1997	0.24	1.22	3.33	4.46	3.63	1.88	0.48	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	2.76
1998	0.06	0.53	1.76	1.86	2.99	4.10	1.50	0.32	0.08	0.01	0.00	0.00	0.00	0.00	0.00	3.98
1999	0.22	0.04	0.62	0.73	1.04	1.97	1.67	0.39	0.04	0.01	0.01	0.00	0.00	0.00	0.00	2.82
2000	0.12	1.76	1.24	0.39	0.78	1.21	1.35	0.47	0.04	0.01	0.00	0.00	0.00	0.00	0.00	2.39
2001	0.49	1.40	0.62	0.68	1.39	0.75	1.15	0.61	0.05	0.01	0.00	0.00	0.00	0.00	0.00	2.01
2002	0.13	1.28	0.90	1.04	1.01	0.91	0.39	0.17	0.04	0.01	0.00	0.00	0.00	0.00	0.00	1.40
2003	0.17	1.79	1.07	1.55	1.87	0.91	0.28	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.59
2004	0.06	1.18	1.32	1.56	1.69	1.51	0.39	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.99
2005	0.08	0.60	0.89	0.50	1.76	1.58	1.14	0.56	0.06	0.01	0.00	0.00	0.00	0.00	0.00	2.67
2006	0.16	0.85	0.49	0.12	0.68	1.33	1.35	0.59	0.13	0.01	0.00	0.00	0.00	0.00	0.00	2.42
2007	0.10	0.83	0.47	0.27	0.81	0.61	1.24	0.75	0.21	0.02	0.01	0.00	0.00	0.00	0.00	2.38
2008	0.26	0.95	0.28	0.82	1.13	0.90	1.00	0.76	0.44	0.04	0.00	0.00	0.00	0.00	0.00	2.87
2009	0.23	2.15	0.24	0.42	0.47	0.88	0.61	0.30	0.14	0.03	0.01	0.00	0.00	0.00	0.00	1.58
2010	0.44	1.95	0.62	0.86	0.68	0.68	0.67	0.31	0.11	0.02	0.01	0.00	0.00	0.00	0.00	1.66
2011	0.33	1.30	4.13	1.20	2.02	0.93	0.67	0.32	0.06	0.02	0.01	0.00	0.00	0.00	0.00	2.21
2012	0.33	0.62	0.20	0.45	1.19	0.93	0.70	0.27	0.08	0.01	0.00	0.00	0.00	0.00	0.00	1.71
2013	0.08	2.77	1.00	0.37	0.41	1.02	1.06	0.62	0.26	0.01	0.01	0.01	0.01	0.00	0.00	2.59
2015	0.05	0.78	0.60	0.33	0.31	0.25	0.34	0.17	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.87

Table A5: continued

EU 3M 0-700m

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
1995	0.00	12.41	2.54	2.23	1.91	2.66	5.10	3.77	2.12	1.31	0.26	0.07	0.02	0.00	0.01	13.52
1996	0.00	5.84	7.97	2.41	3.04	4.20	5.82	2.49	1.62	0.42	0.09	0.03	0.04	0.00	0.01	14.42
1997	0.00	3.33	3.78	6.00	6.50	7.11	8.46	4.99	2.15	0.66	0.22	0.03	0.02	0.02	0.02	20.01
1998	0.00	2.74	2.13	7.68	11.00	12.33	11.30	7.84	2.62	0.75	0.20	0.03	0.01	0.02	0.00	30.13
1999	0.00	1.06	0.70	3.01	10.47	13.41	12.58	5.55	1.82	0.35	0.10	0.01	0.00	0.00	0.01	26.37
2000	0.00	3.75	0.29	0.60	2.16	7.09	14.10	5.40	2.32	0.45	0.11	0.05	0.00	0.00	0.00	21.08
2001	0.00	8.03	1.43	1.81	0.99	2.79	7.79	6.63	3.21	0.18	0.04	0.01	0.00	0.00	0.00	17.25
2002	0.00	4.08	2.94	2.79	1.67	3.79	5.59	5.73	1.28	0.13	0.06	0.02	0.01	0.00	0.00	15.05
2003	0.00	2.20	1.00	0.61	1.51	2.48	2.94	1.93	0.47	0.13	0.10	0.02	0.00	0.00	0.00	7.73
2004	0.00	2.19	3.29	4.37	1.97	6.96	7.80	2.54	0.64	0.29	0.13	0.08	0.05	0.01	0.00	15.28
2005	0.00	0.54	0.81	3.18	2.50	6.89	7.59	2.92	0.61	0.11	0.12	0.06	0.02	0.00	0.00	14.55
2006	0.00	0.68	0.39	0.65	1.18	5.97	7.46	3.31	0.77	0.22	0.18	0.13	0.06	0.01	0.00	14.56
2007	0.00	0.37	0.08	0.57	0.34	3.44	7.37	5.76	1.51	0.31	0.21	0.08	0.05	0.01	0.00	16.22
2008	0.00	0.20	0.10	0.15	0.19	1.50	5.70	6.16	1.13	0.35	0.26	0.12	0.05	0.02	0.01	14.91
2009	0.00	0.08	0.01	0.04	0.10	0.75	3.61	4.05	0.89	0.19	0.27	0.08	0.06	0.04	0.02	9.67
2010	0.00	0.05	0.01	0.04	0.06	1.11	3.07	2.94	0.89	0.32	0.17	0.06	0.03	0.01	0.00	8.28
2011	0.00	0.00	0.00	0.00	0.08	1.08	3.58	3.46	0.68	0.21	0.11	0.02	0.01	0.01	0.01	8.05
2012	0.00	0.00	0.01	0.05	0.11	1.02	2.27	1.75	0.44	0.14	0.10	0.07	0.02	0.01	0.02	5.34
2013	0.00	0.01	0.00	0.01	0.14	0.80	2.16	0.89	0.20	0.05	0.06	0.02	0.01	0.01	0.01	3.48
2014	0.00	0.03	0.00	0.00	0.12	1.35	2.88	1.95	0.35	0.08	0.08	0.03	0.01	0.02	0.01	6.43
2015	0.00	0.05	0.02	0.00	0.06	0.89	4.28	2.60	0.61	0.15	0.14	0.06	0.02	0.00	0.00	8.18

EU 3M 0-1400m

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
2004	0.00	1.40	2.19	2.92	1.54	6.80	9.16	4.95	1.46	0.73	0.37	0.26	0.16	0.15	0.17	23.33
2005	0.00	0.36	0.53	2.09	1.73	5.28	6.79	3.42	0.99	0.26	0.41	0.23	0.13	0.06	0.05	16.71
2006	0.00	0.45	0.26	0.44	0.91	5.85	8.56	4.68	1.39	0.42	0.36	0.30	0.15	0.05	0.04	19.17
2007	0.00	0.25	0.05	0.39	0.29	3.84	9.09	8.57	2.88	0.72	0.59	0.30	0.17	0.07	0.07	25.10
2008	0.00	0.13	0.07	0.10	0.16	2.03	9.00	12.53	3.18	1.14	0.87	0.44	0.25	0.13	0.22	32.35
2009	0.00	0.05	0.01	0.03	0.08	1.13	6.80	11.43	3.55	0.93	1.03	0.36	0.28	0.25	0.24	29.44
2010	0.00	0.03	0.01	0.02	0.11	2.00	6.01	7.83	2.50	0.98	0.83	0.31	0.17	0.12	0.19	22.13
2011	0.00	0.00	0.00	0.01	0.09	1.85	6.70	8.49	2.57	1.11	1.22	0.46	0.26	0.22	0.19	26.15
2012	0.00	0.00	0.01	0.04	0.16	2.42	5.78	5.00	1.92	0.75	0.74	0.48	0.19	0.10	0.27	19.20
2013	0.00	0.01	0.00	0.01	0.32	2.11	7.03	4.53	1.64	0.53	0.84	0.34	0.29	0.13	0.22	19.11
2014	0.00	0.02	0.00	0.01	0.16	2.78	8.04	6.87	1.62	0.45	0.64	0.33	0.15	0.19	0.22	23.92
2015	0.00	0.03	0.01	0.01	0.12	2.54	14.85	14.04	4.62	1.67	1.41	0.78	0.29	0.17	0.41	47.52

EU 3M 700-1400m

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
2004	0.00	0.02	0.00	0.06	0.73	5.99	12.36	9.57	3.15	1.59	0.84	0.61	0.36	0.40	0.49	38.72
2005	0.00	0.00	0.00	0.02	0.26	2.22	5.26	4.37	1.70	0.55	0.96	0.57	0.35	0.18	0.16	20.85
2006	0.00	0.00	0.00	0.04	0.40	5.61	10.65	7.29	2.56	0.79	0.71	0.63	0.32	0.11	0.14	28.00
2007	0.00	0.03	0.00	0.05	0.20	4.60	12.39	13.93	5.51	1.51	1.31	0.72	0.40	0.17	0.21	42.10
2008	0.00	0.00	0.00	0.00	0.12	3.05	15.33	24.73	7.09	2.67	2.02	1.05	0.62	0.33	0.64	65.72
2009	0.00	0.00	0.00	0.02	0.05	1.83	12.90	25.56	8.64	2.33	2.48	0.88	0.69	0.64	0.67	67.28
2010	0.00	0.00	0.00	0.02	0.05	1.83	12.90	25.56	8.64	2.33	2.48	0.88	0.69	0.64	0.67	48.64
2011	0.00	0.00	0.00	0.03	0.11	3.33	12.66	18.09	6.15	2.85	3.34	1.29	0.75	0.63	0.53	60.79
2012	0.00	0.00	0.00	0.02	0.27	5.09	12.49	11.23	4.76	1.93	1.96	1.27	0.52	0.27	0.74	45.73
2013	0.00	0.00	0.00	0.02	0.67	4.62	16.38	11.47	4.40	1.44	2.34	0.95	0.81	0.35	0.63	49.00
2014	0.00	0.00	0.00	0.01	0.25	5.51	17.91	16.30	4.06	1.15	1.70	0.91	0.41	0.53	0.60	57.41
2015	0.00	0.00	0.00	0.02	0.24	5.69	35.08	35.94	12.28	4.57	3.86	2.17	0.83	0.50	1.19	122.81

Table A5: continued

EU 3L

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
2006	0.00	8.58	3.95	2.30	3.36	11.41	7.15	2.36	0.41	0.07	0.13	0.06	0.01	0.03	0.02	15.32
2007	0.00	5.56	1.33	2.16	0.82	9.22	8.58	4.16	0.63	0.18	0.15	0.06	0.01	0.01	0.03	16.64
2008	0.00	3.44	0.62	5.73	1.64	6.61	11.00	7.85	1.54	0.43	0.32	0.17	0.04	0.05	0.16	24.40
2009	0.00	7.11	1.48	1.16	2.50	7.54	8.20	5.77	1.63	0.37	0.40	0.09	0.07	0.03	0.11	20.75
2010	0.00	1.29	3.50	2.12	3.32	7.39	8.14	4.54	1.67	0.84	0.53	0.16	0.18	0.17	0.20	23.41
2011	0.00	4.60	1.57	1.80	1.57	3.54	5.26	2.37	1.46	0.69	0.32	0.33	0.13	0.06	0.11	14.61
2012	0.00	3.18	2.58	8.65	2.41	4.13	5.66	2.27	0.66	0.40	0.33	0.18	0.10	0.03	0.06	14.67
2013	0.00	13.05	1.72	1.11	4.00	6.19	6.92	3.30	0.66	0.37	0.31	0.13	0.13	0.09	0.14	17.31
2014	0.00	8.49	9.98	2.56	1.43	7.33	6.92	5.47	1.83	0.84	0.45	0.33	0.22	0.08	0.20	24.09
2015	0.00	1.51	4.71	2.58	2.62	2.99	8.86	3.89	2.62	0.62	0.81	0.25	0.27	0.12	0.23	23.90

EU 3NO

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Mean weight/tow
1997	0.00	9.92	5.52	3.49	3.81	2.24	1.97	1.22	0.60	0.07	0.05	0.05	0.02	0.01	0.03	7.73
1998	0.00	1.71	5.24	9.09	8.47	5.06	2.77	1.10	0.66	0.21	0.08	0.03	0.03	0.02	0.03	11.73
1999	0.15	4.38	4.81	7.21	9.31	6.29	2.92	0.78	0.49	0.23	0.09	0.03	0.05	0.03	0.05	12.00
2000	0.00	2.92	0.49	0.80	1.39	3.84	4.42	2.56	0.71	0.28	0.08	0.06	0.04	0.05	0.12	9.48
2001	0.00	8.87	5.90	1.18	1.07	2.84	3.96	1.56	0.22	0.06	0.05	0.04	0.05	0.05	0.06	8.17
2002	0.00	2.91	0.64	1.02	0.70	1.14	0.92	0.44	0.23	0.02	0.01	0.02	0.02	0.01	0.02	2.64
2003	0.00	3.56	2.40	1.69	1.91	1.58	0.90	0.78	0.26	0.06	0.04	0.01	0.07	0.01	0.02	5.10
2004	0.00	1.22	6.96	2.09	2.06	1.24	0.85	0.51	0.21	0.05	0.03	0.01	0.03	0.02	0.02	3.68
2005	0.00	1.07	0.97	1.81	1.04	1.32	1.44	0.68	0.19	0.08	0.06	0.03	0.03	0.02	0.02	3.39
2006	0.00	2.31	1.12	0.41	1.55	1.38	0.82	0.52	0.23	0.05	0.03	0.02	0.02	0.01	0.01	3.03
2007	0.00	1.81	0.65	0.51	0.32	1.48	1.40	1.02	0.29	0.10	0.09	0.03	0.03	0.00	0.02	3.98
2008	0.00	0.62	0.99	0.90	0.69	0.94	2.70	2.50	0.74	0.40	0.15	0.10	0.03	0.02	0.04	7.66
2009	0.00	0.70	3.22	2.21	2.61	2.73	4.94	5.67	0.85	0.35	0.19	0.14	0.03	0.02	0.12	14.78
2010	0.00	0.37	2.21	0.94	0.73	3.42	5.58	5.16	1.24	0.39	0.26	0.24	0.04	0.02	0.05	14.80
2011	0.00	2.20	1.30	0.48	0.62	0.95	2.01	2.12	0.43	0.23	0.24	0.05	0.06	0.02	0.10	7.09
2012	0.00	0.08	1.80	1.34	0.44	1.09	1.71	2.00	0.54	0.40	0.34	0.11	0.05	0.06	0.12	7.37
2013	0.00	0.27	0.45	0.23	0.81	1.18	1.48	1.22	0.33	0.21	0.24	0.13	0.09	0.03	0.09	5.46
2014	0.00	0.51	1.28	0.26	0.15	0.54	1.65	1.75	0.45	0.21	0.23	0.18	0.11	0.05	0.10	6.24
2015	0.00	0.93	0.62	0.20	0.21	0.47	1.81	3.38	0.94	0.44	0.35	0.19	0.10	0.03	0.12	9.49

Appendix B

Full set of results from fits of the SCAA OMs

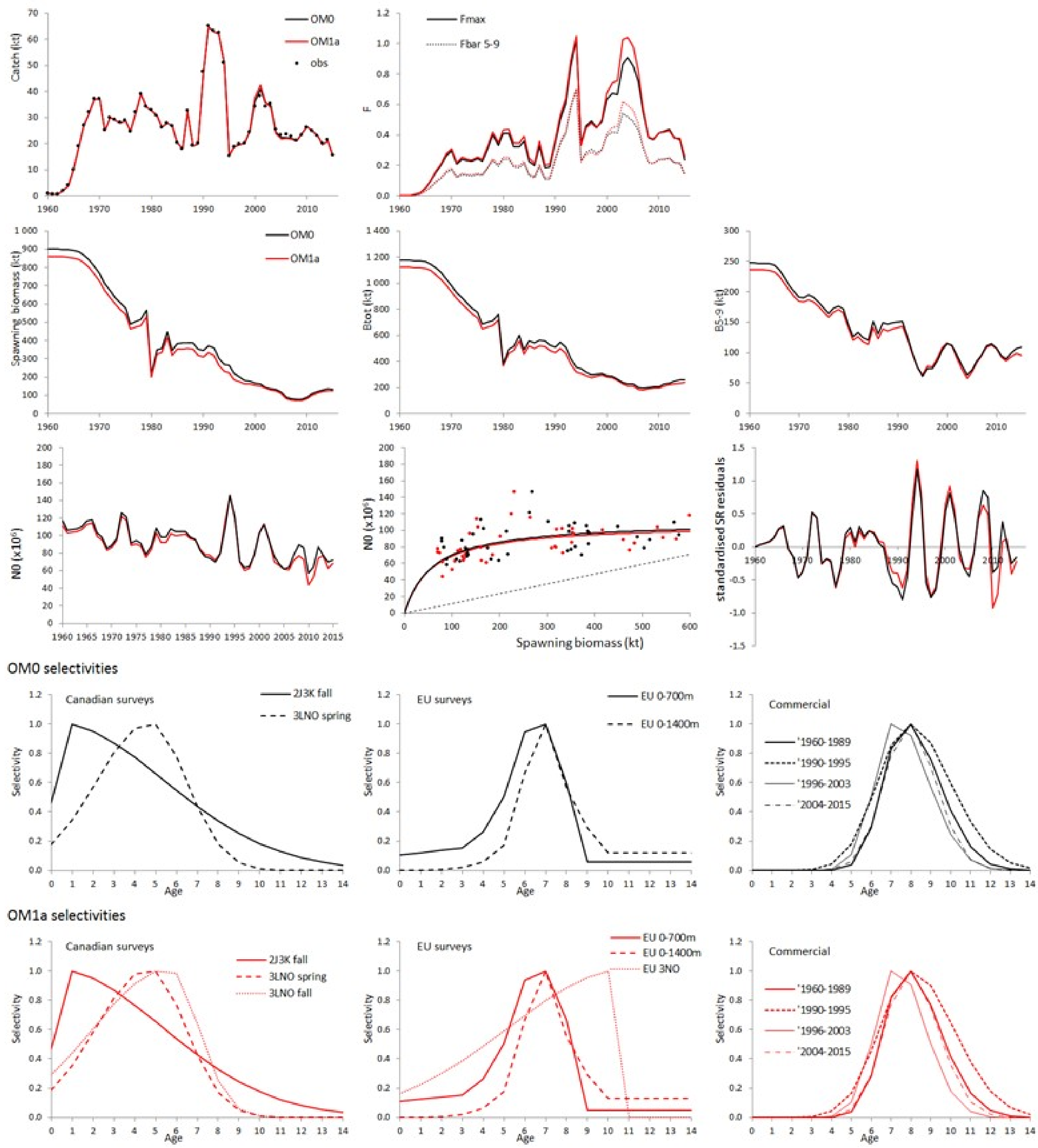

Fig. App.B.1a. Results for SCAA baseline OM0 (in black) and **OM1a** (O3 survey data set, in red).

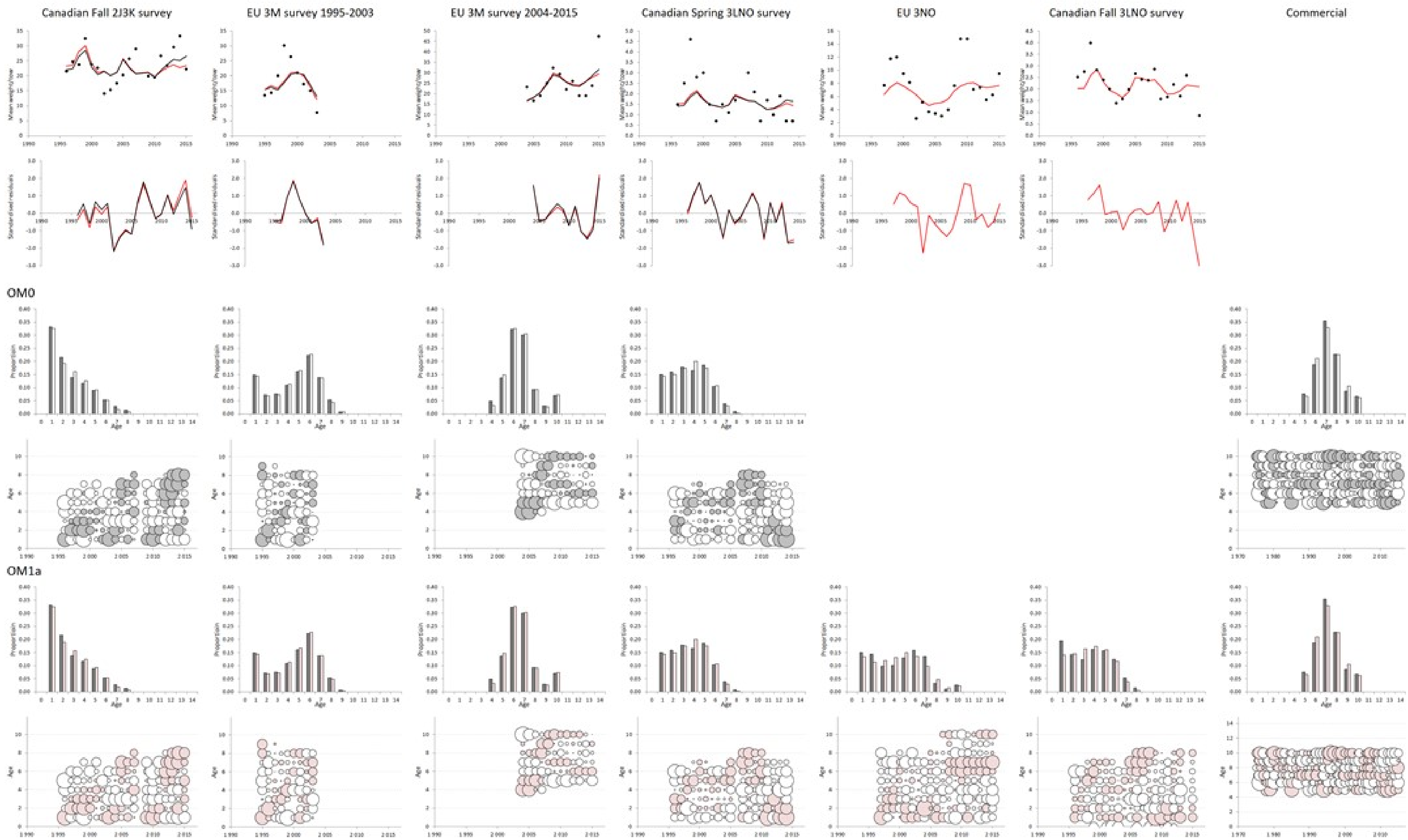

Fig. App.B.1b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM1a** (O3 survey data set, in red).

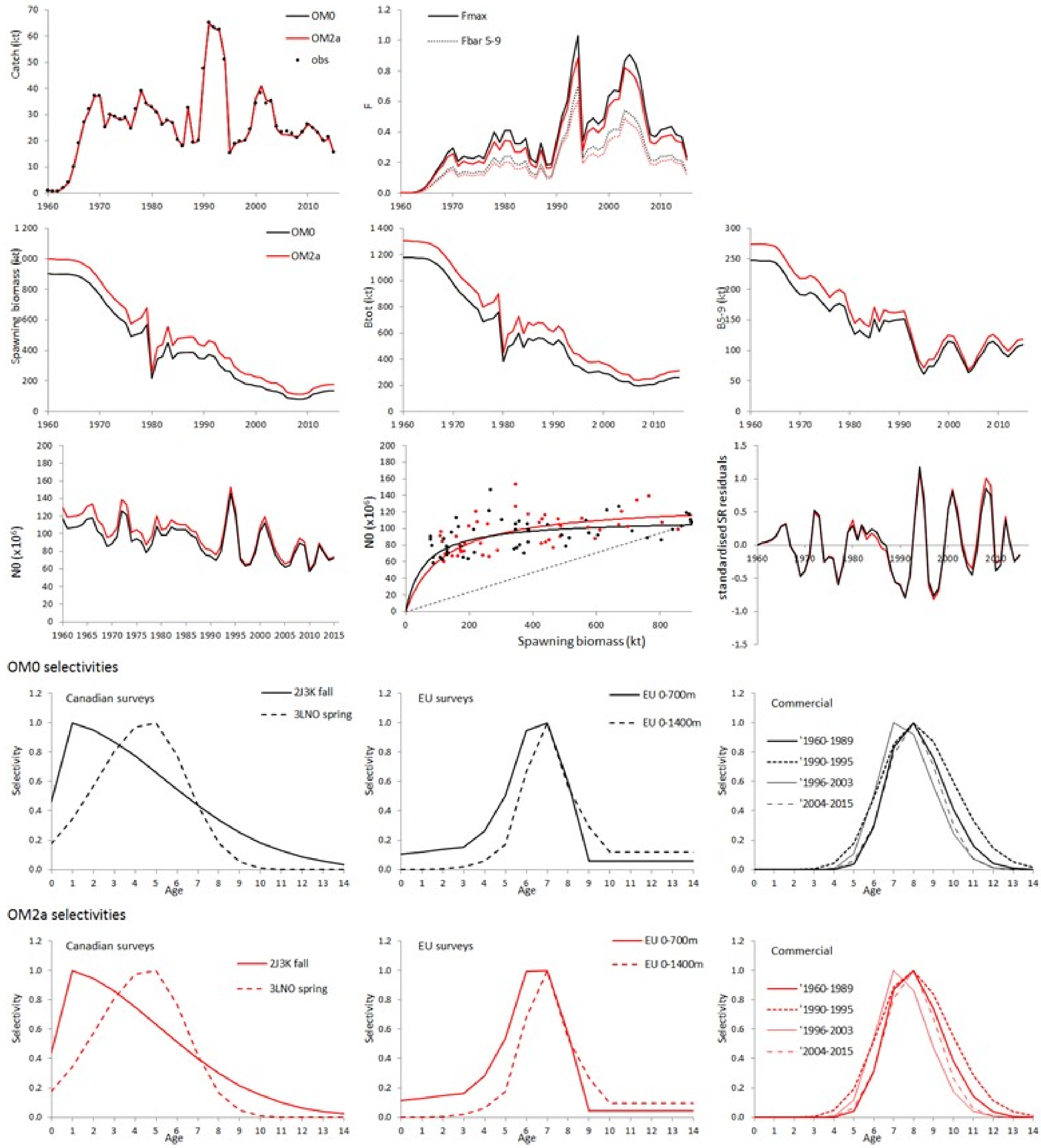

Fig. App.B.2a. Results for SCAA baseline OM0 (in black) and **OM2a** (h=0.7, in red).

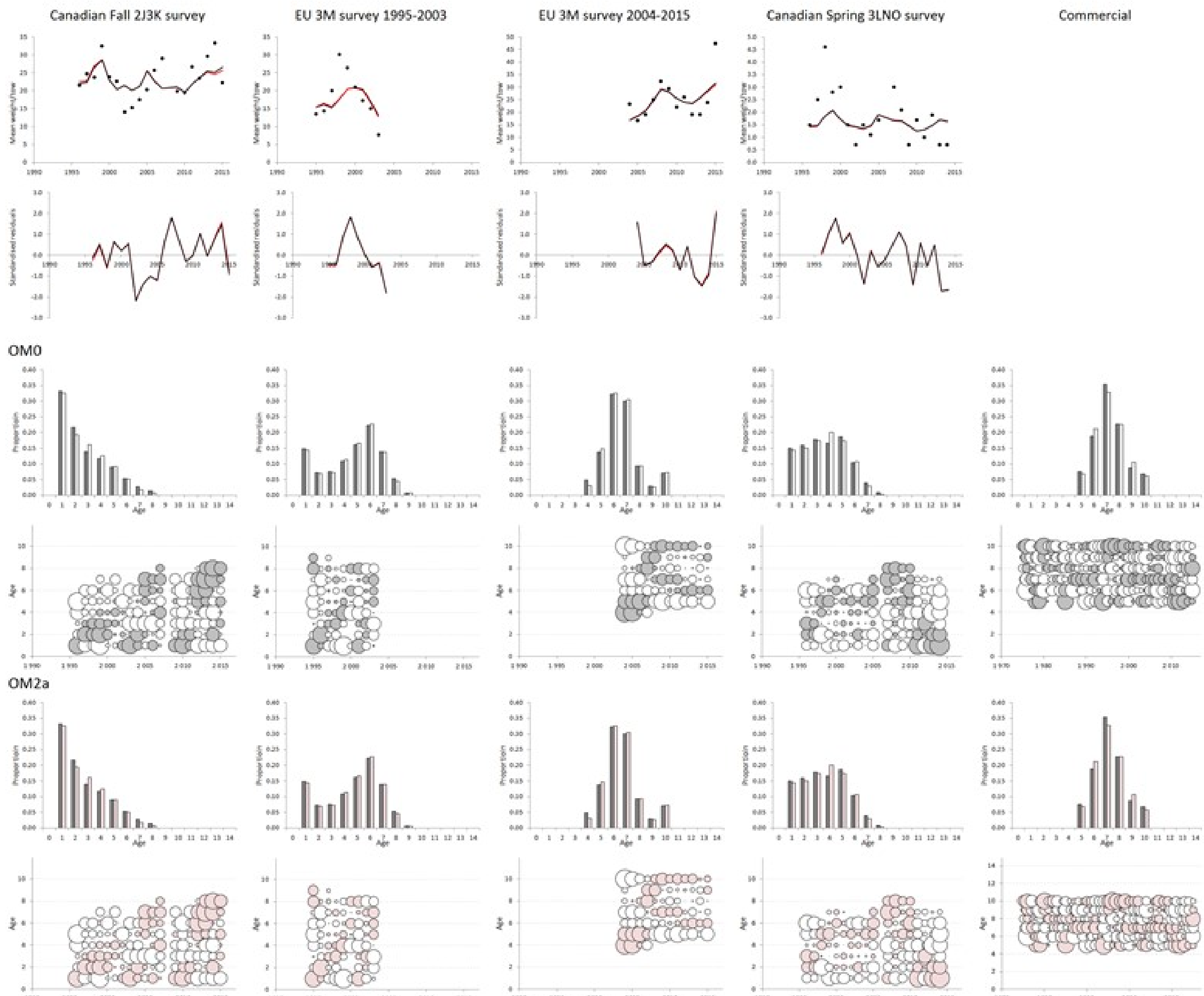

Fig. App.B.2b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM2a** (h=0.7, in red).

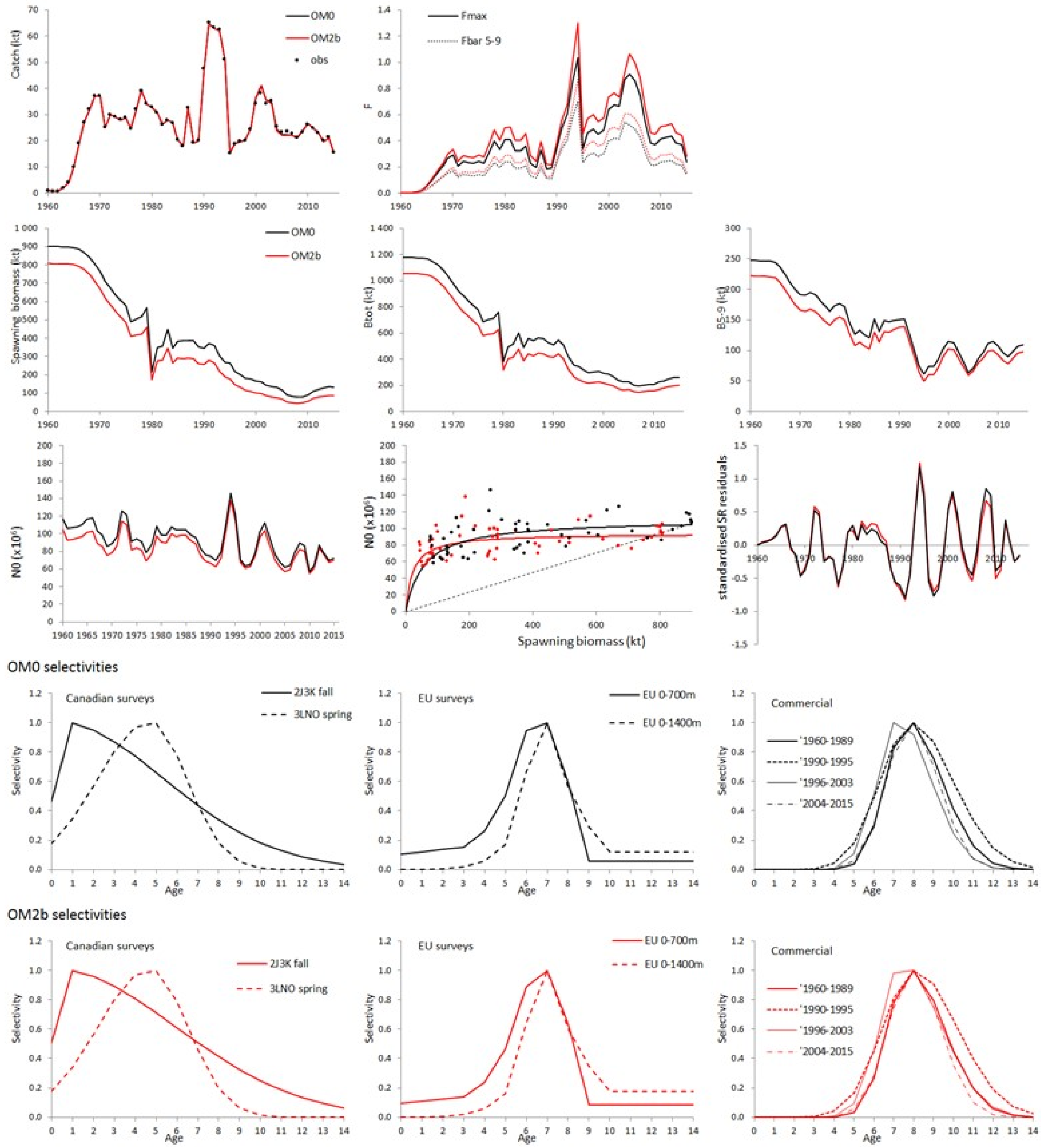

Fig. App.B.3a. Results for SCAA baseline OM0 (in black) and **OM2b** (h=0.9, in red).

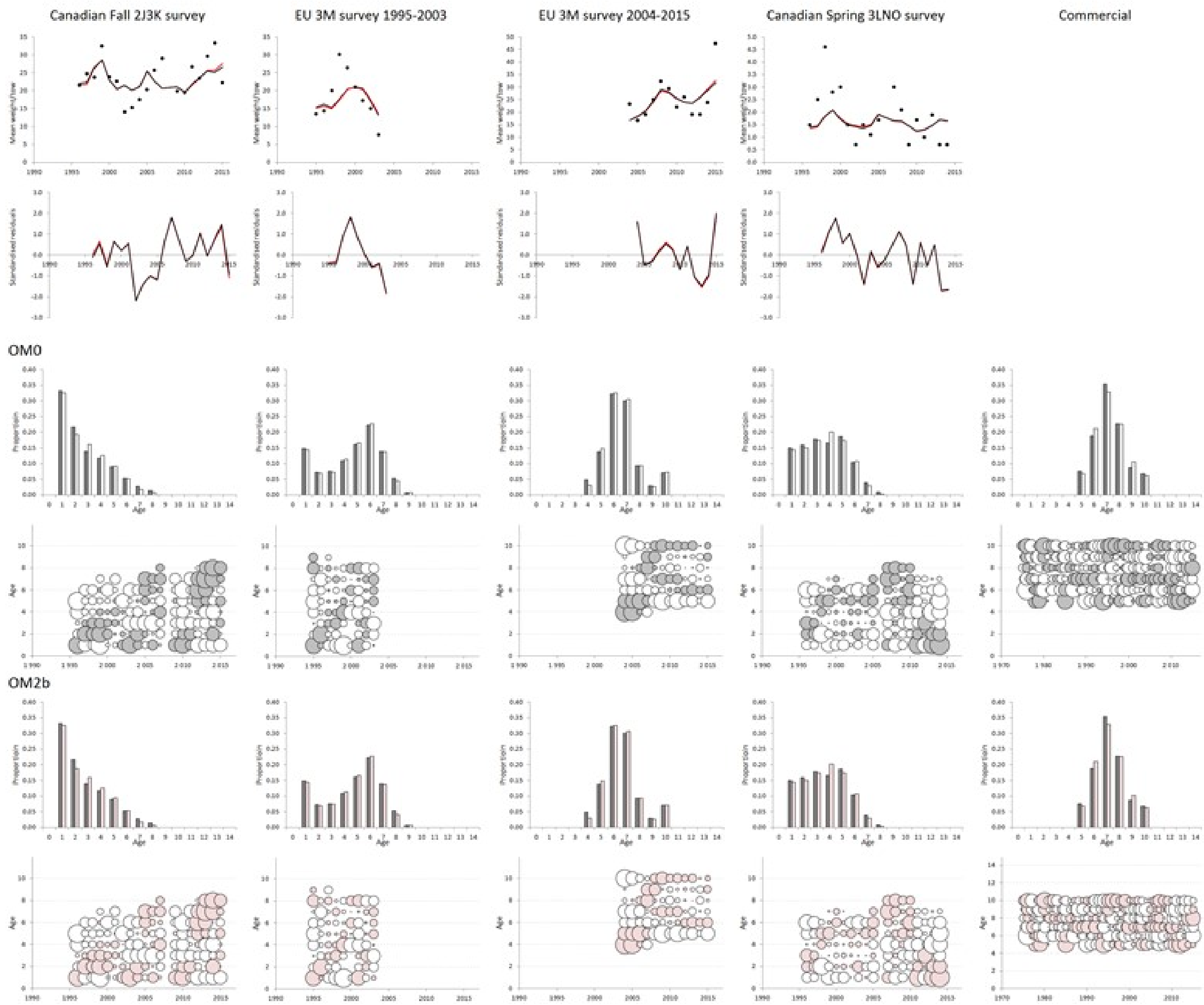

Fig. App.B.3b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM2b** (*h*=0.9, in red).

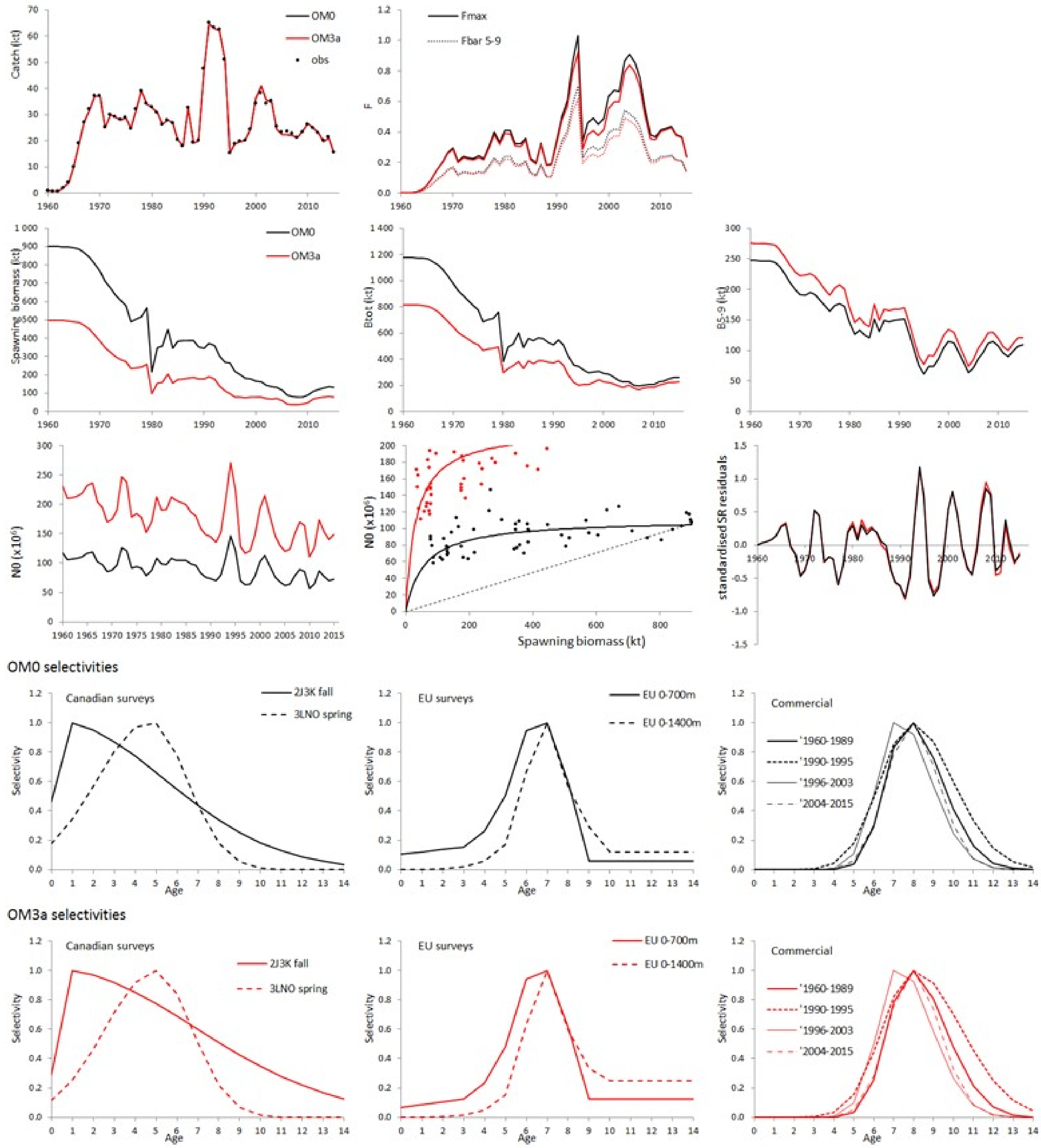

Fig. App.B.4a. Results for SCAA baseline OM0 (in black) and **OM3a** (M=0.2, in red).

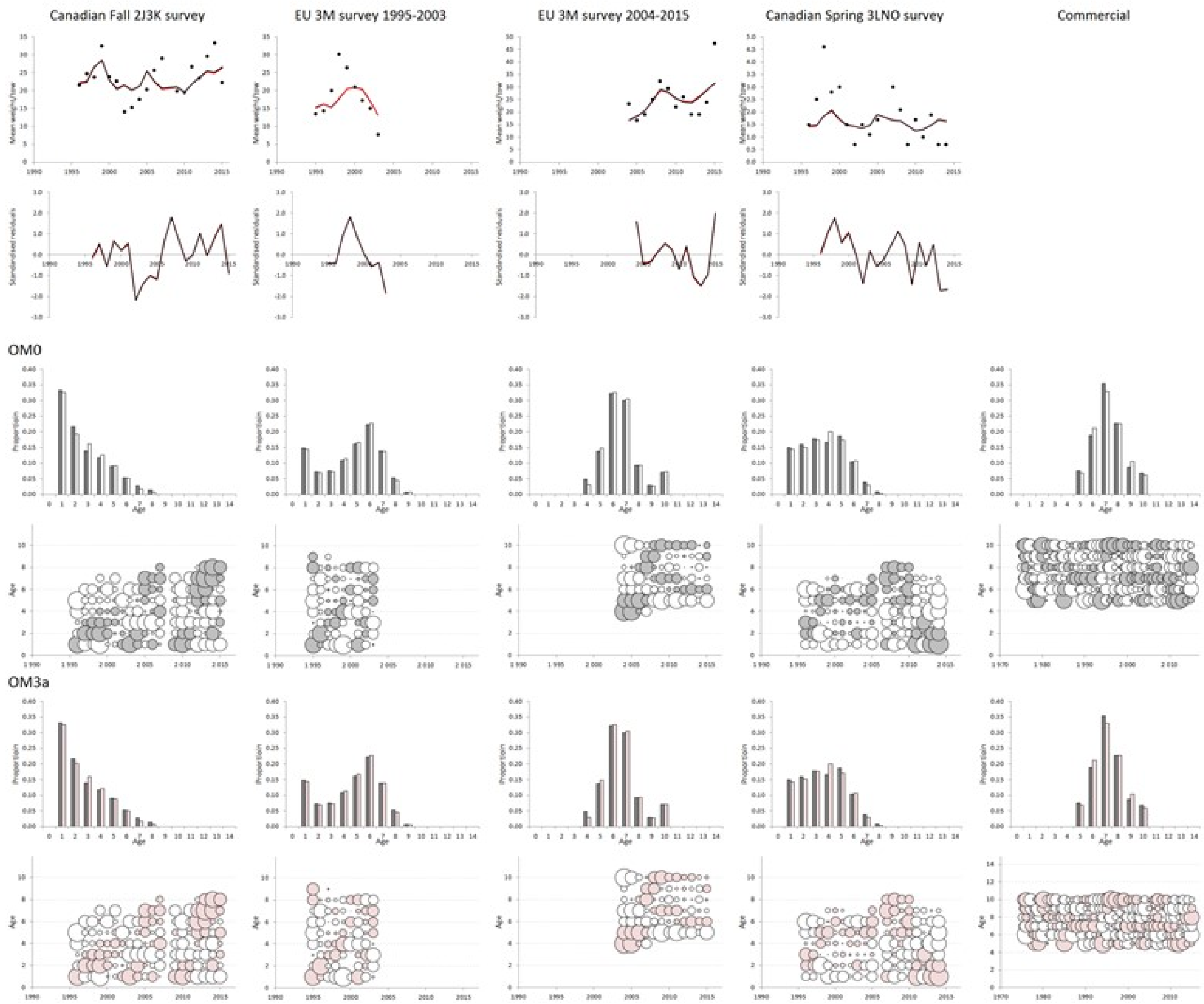

Fig. App.B.4b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM3a** (M=0.2, in red).

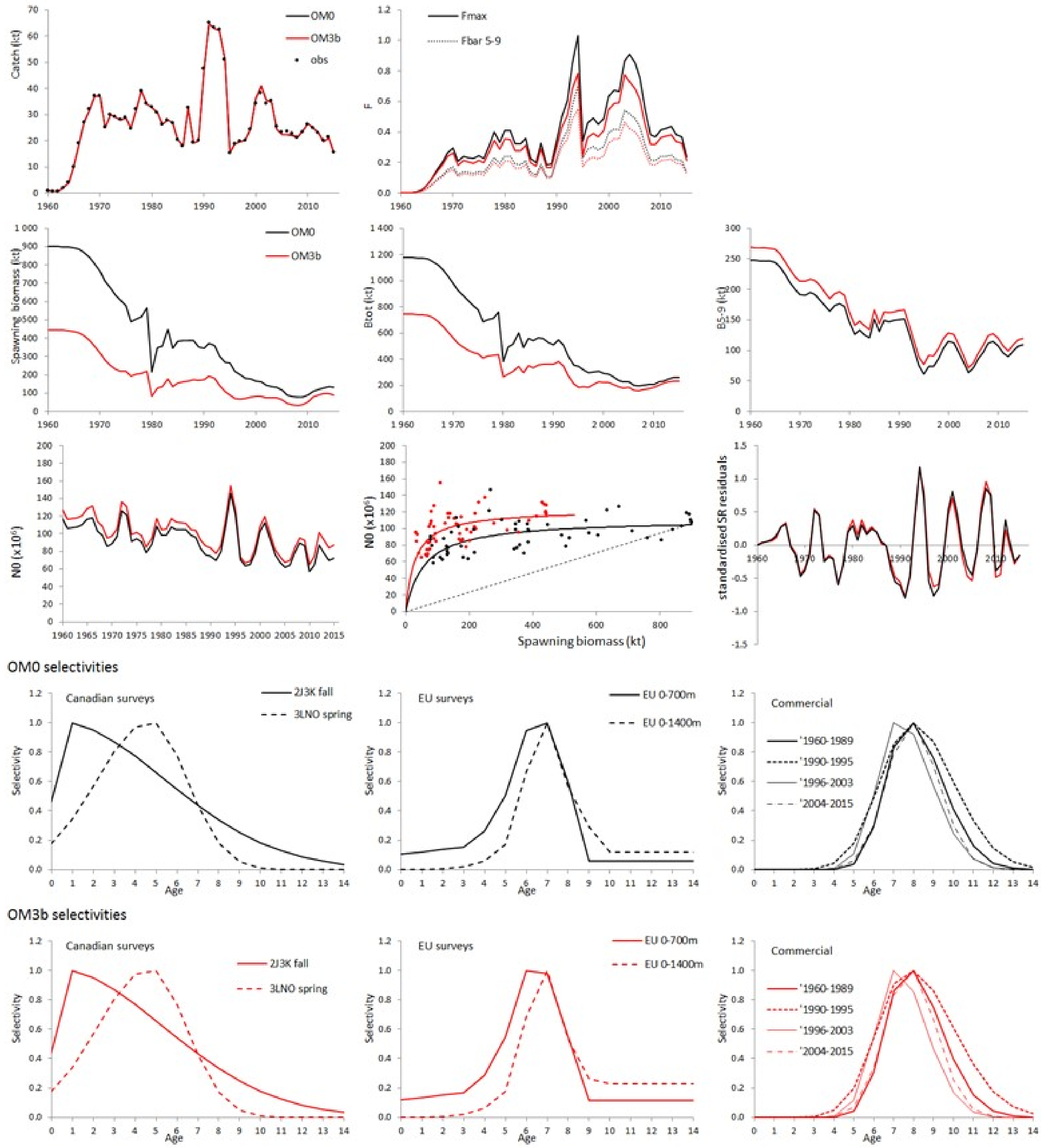

Fig. App.B.5a. Results for SCAA baseline OM0 (in black) and **OM3b** (*M* increasing, in red).

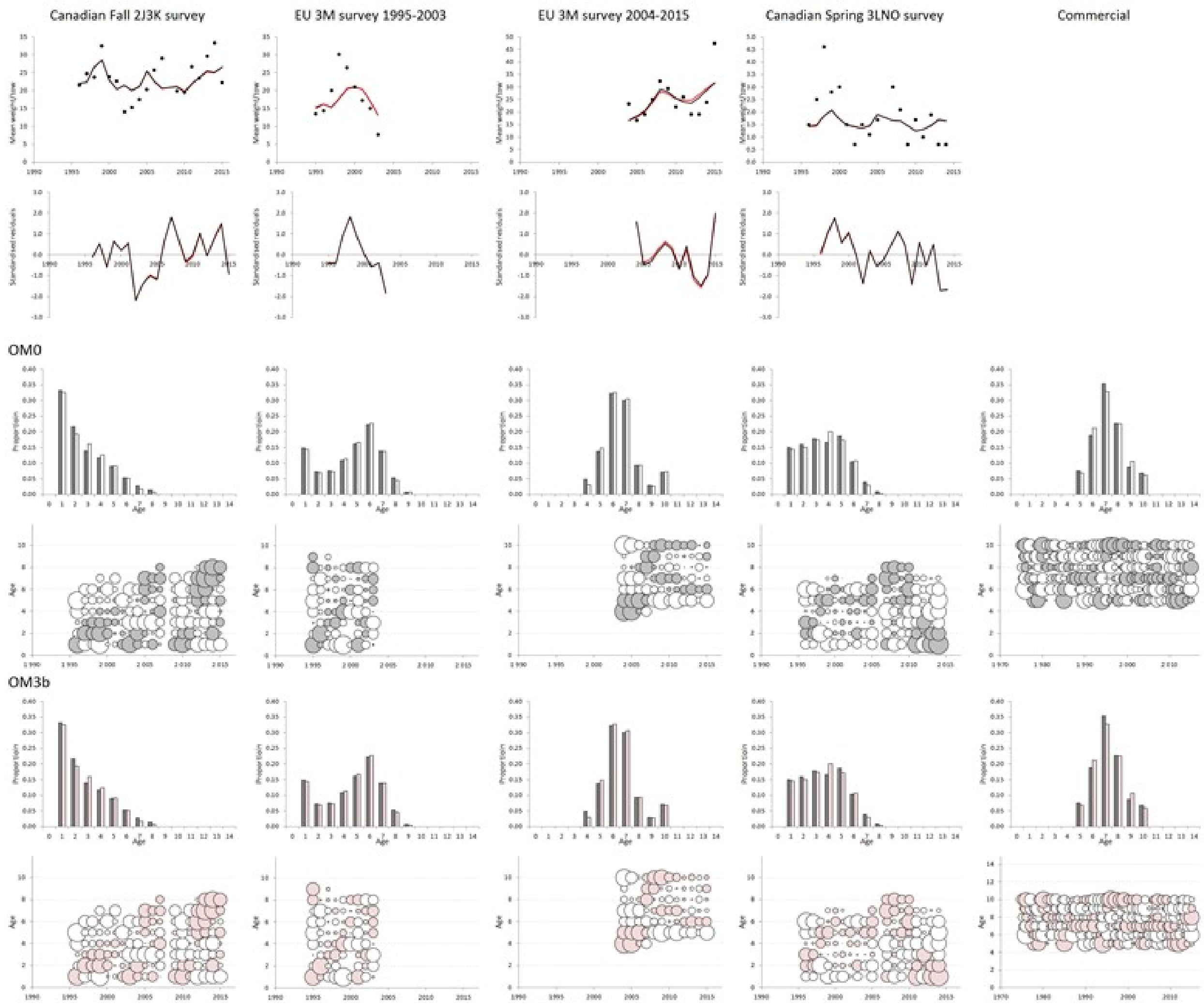

Fig. App.B.5b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM3b** (M increasing, in red).

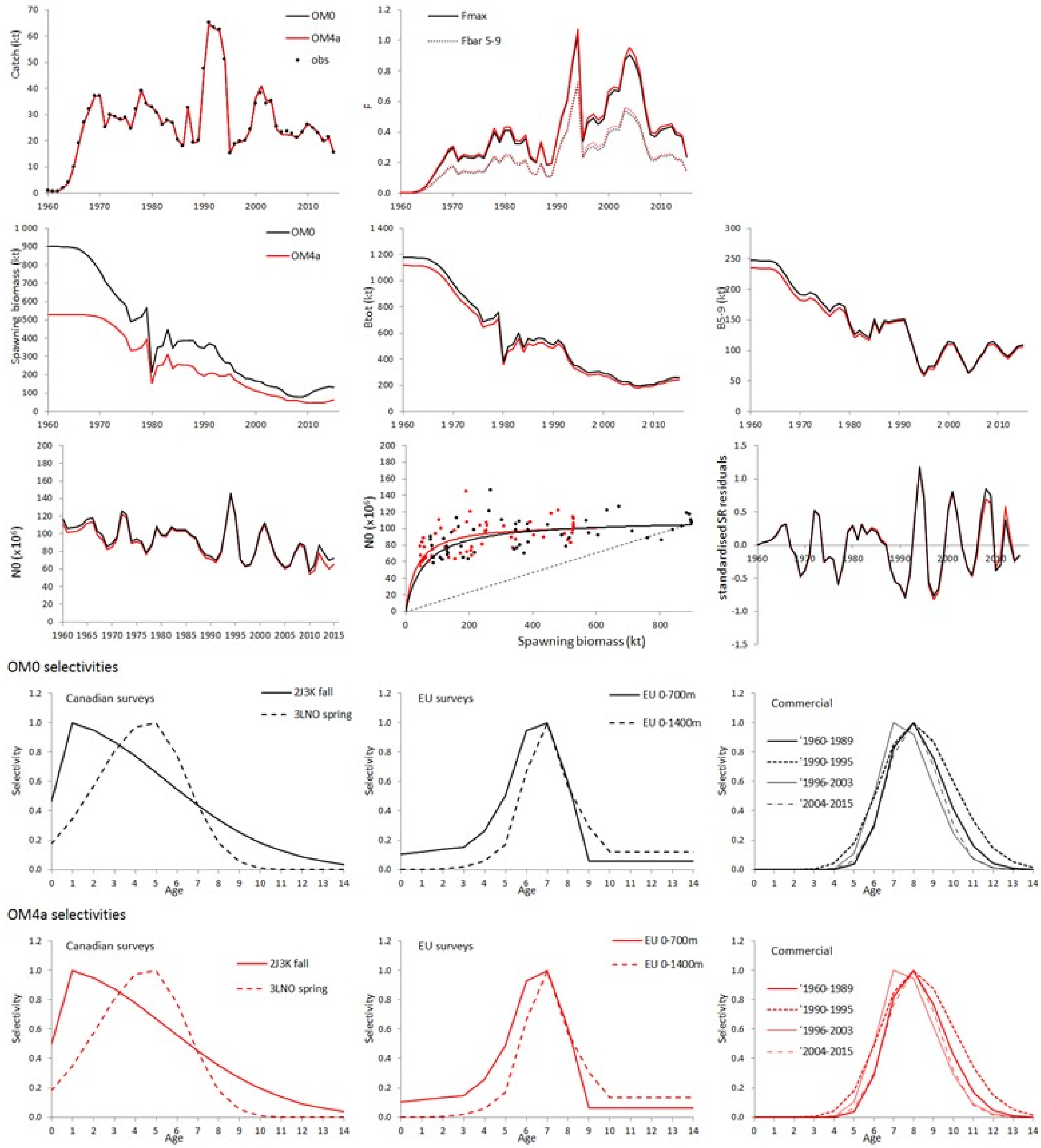

Fig. App.B.6a. Results for SCAA baseline OM0 (in black) and **OM4a** (100% mature at 14+, in red).

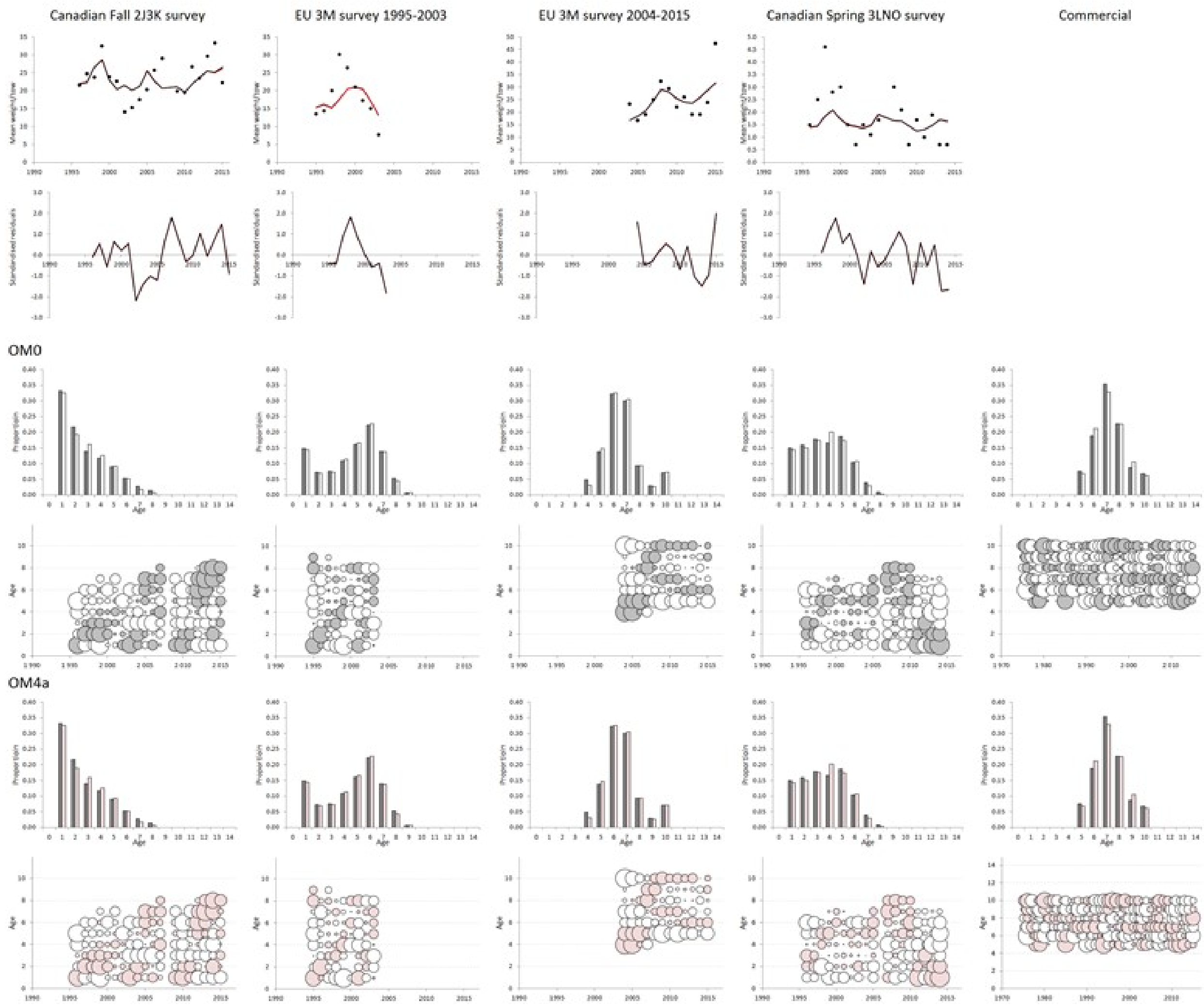

Fig. App.B.6b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM4a** (100% mature at 14+, in red).

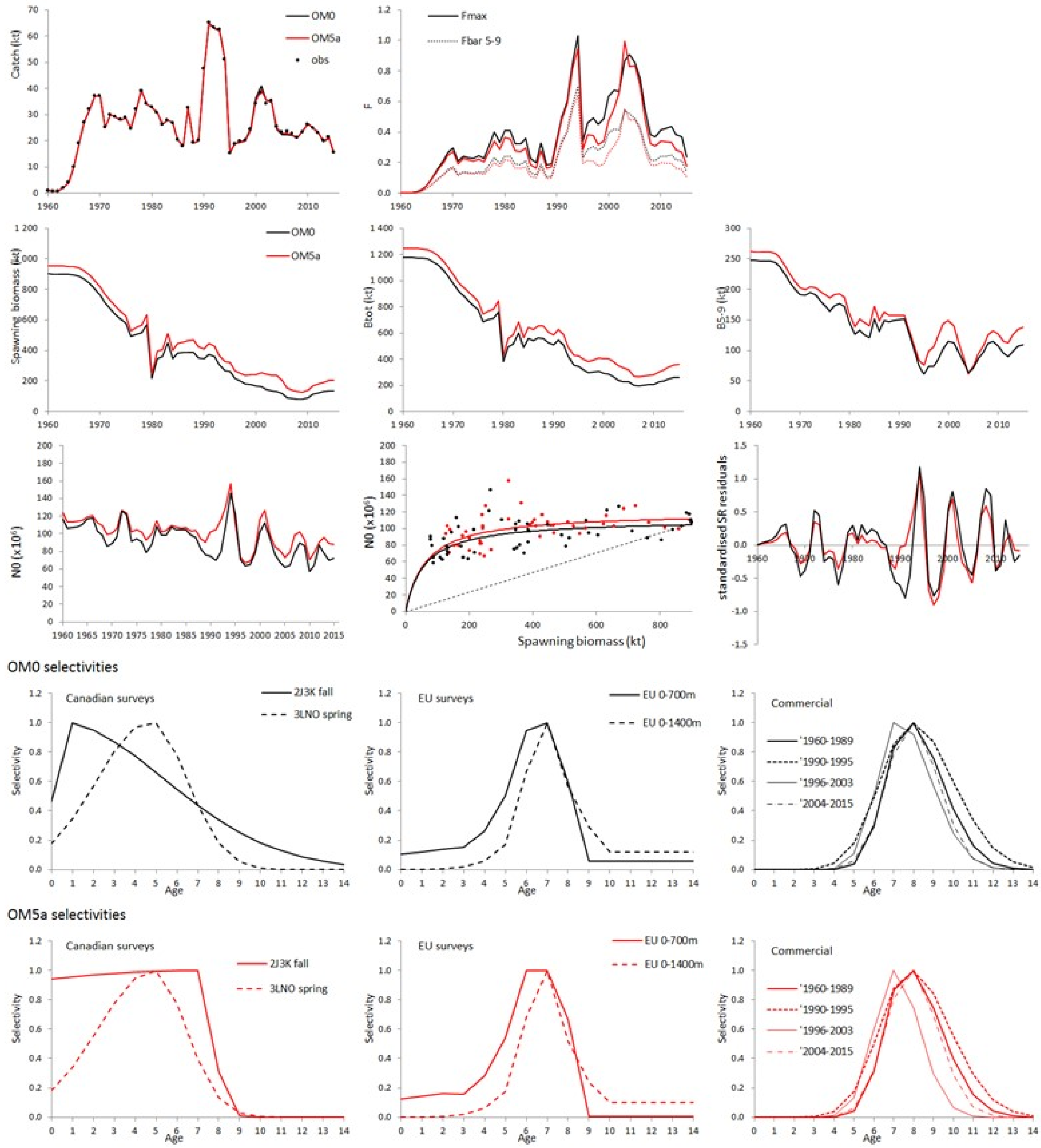

Fig. App.B.7a. Results for SCAA baseline OM0 (in black) and **OM5a** (Wcaa=0.1, in red).

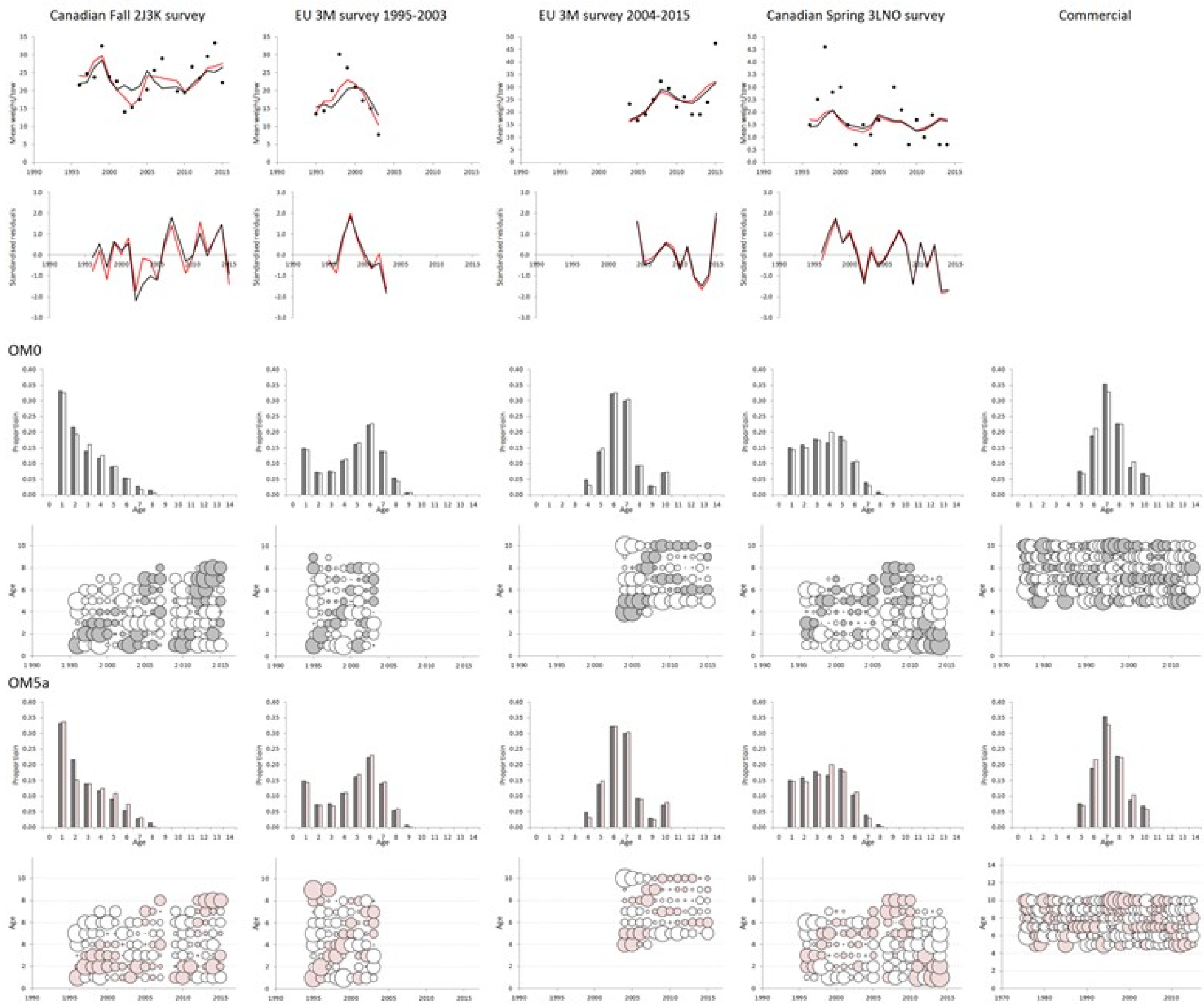

Fig. App.B.7b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM5a** (Wcaa=0.1, in red).

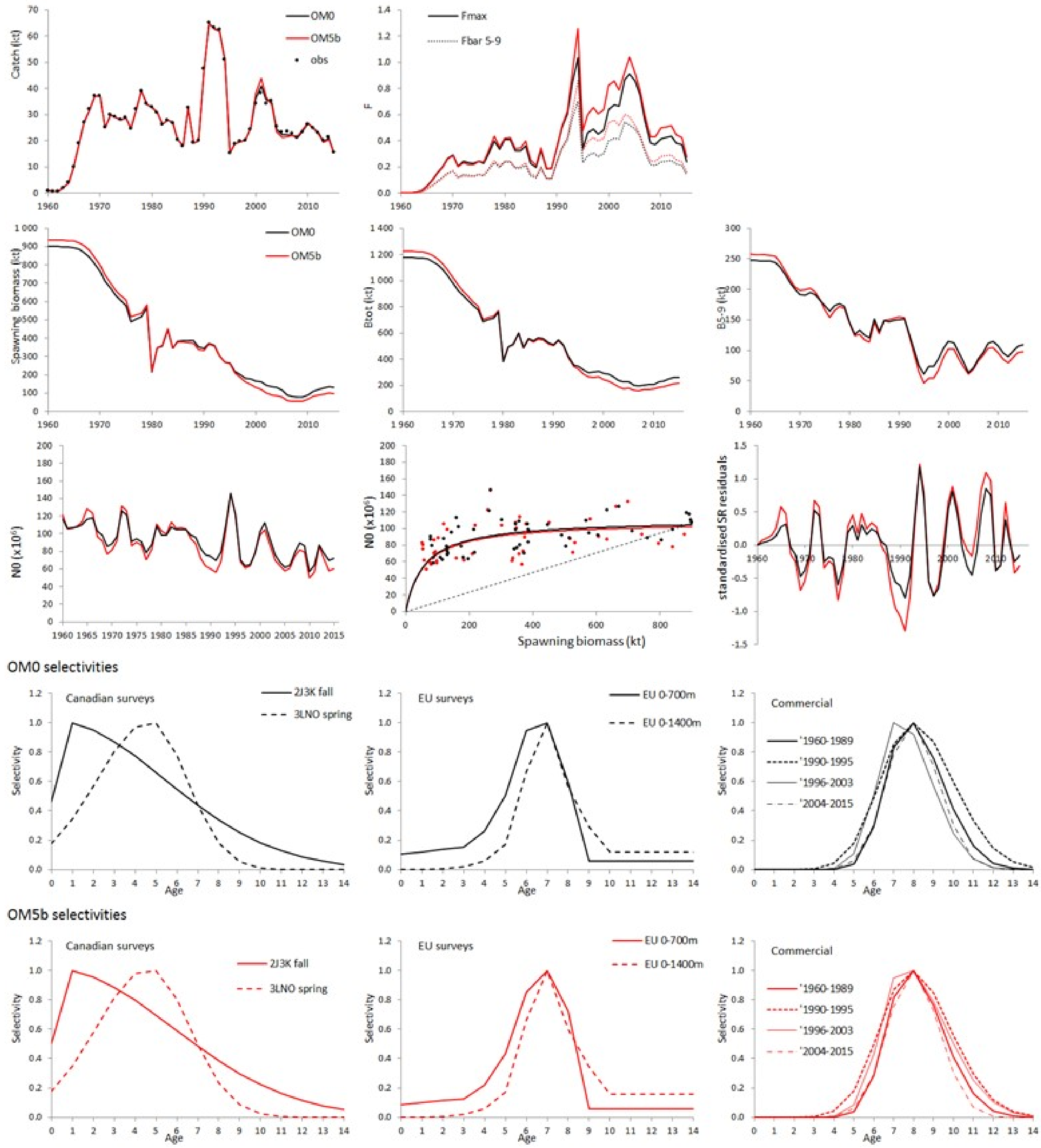

Fig. App.B.8a. Results for SCAA baseline OM0 (in black) and **OM5b** (Wcaa=0.5, in red).

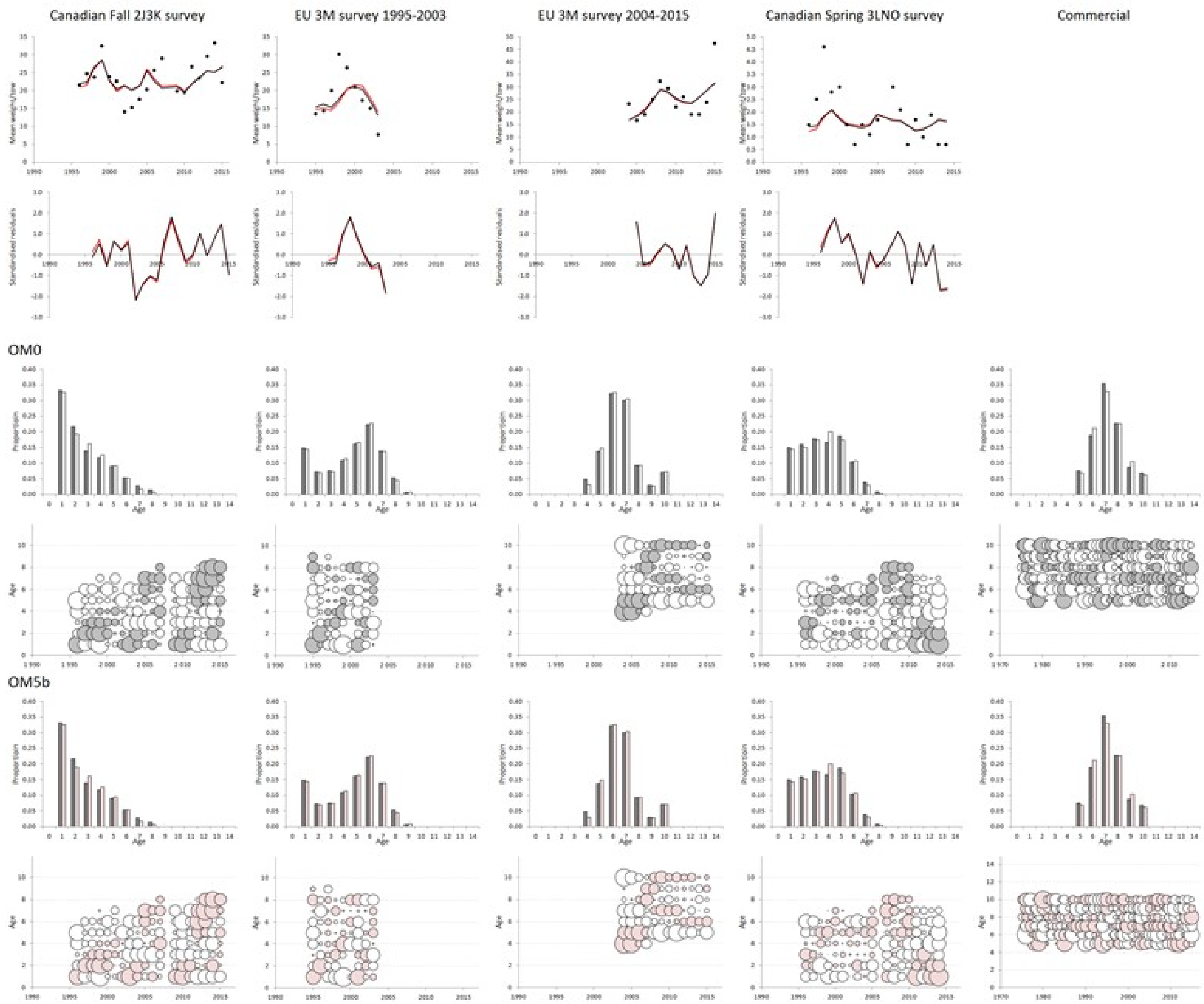

Fig. App.B.8b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM5b** (Wcaa=0.5, in red).

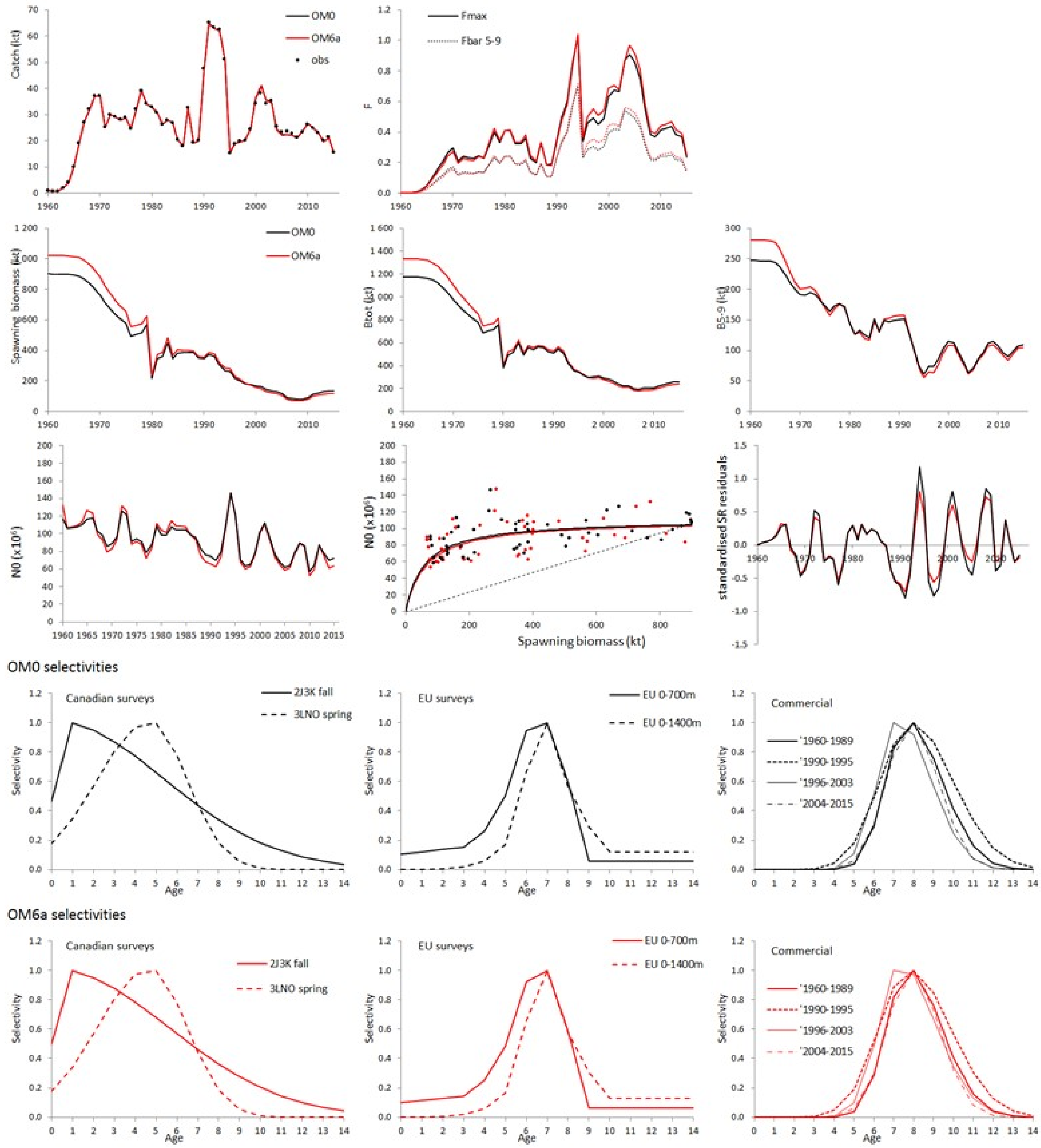

Fig. App.B.9a. Results for SCAA baseline OM0 (in black) and **OM6a** (σ_R=0.6, in red).

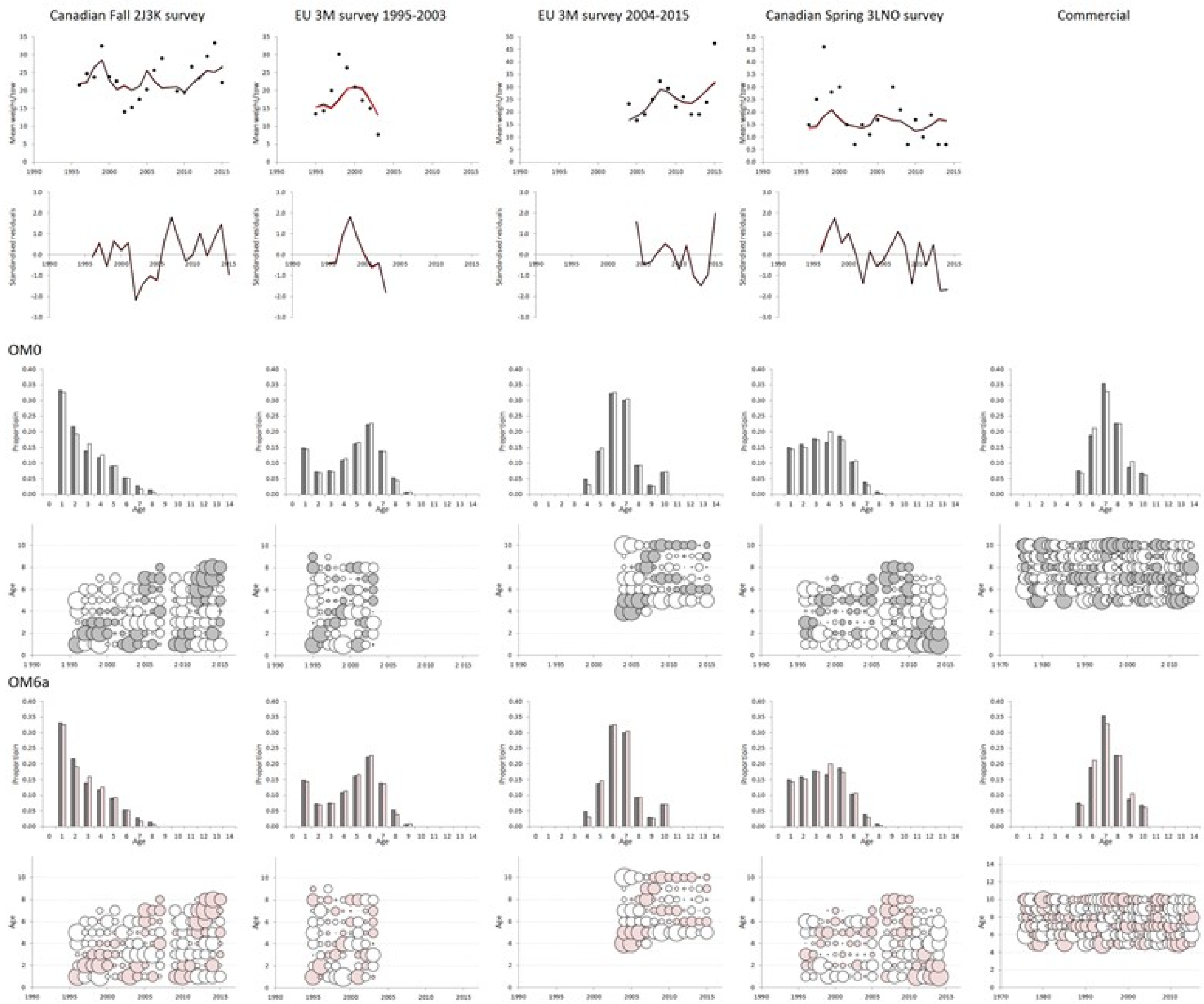

Fig. App.B.9b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM6a** (σ_R=0.6, in red).

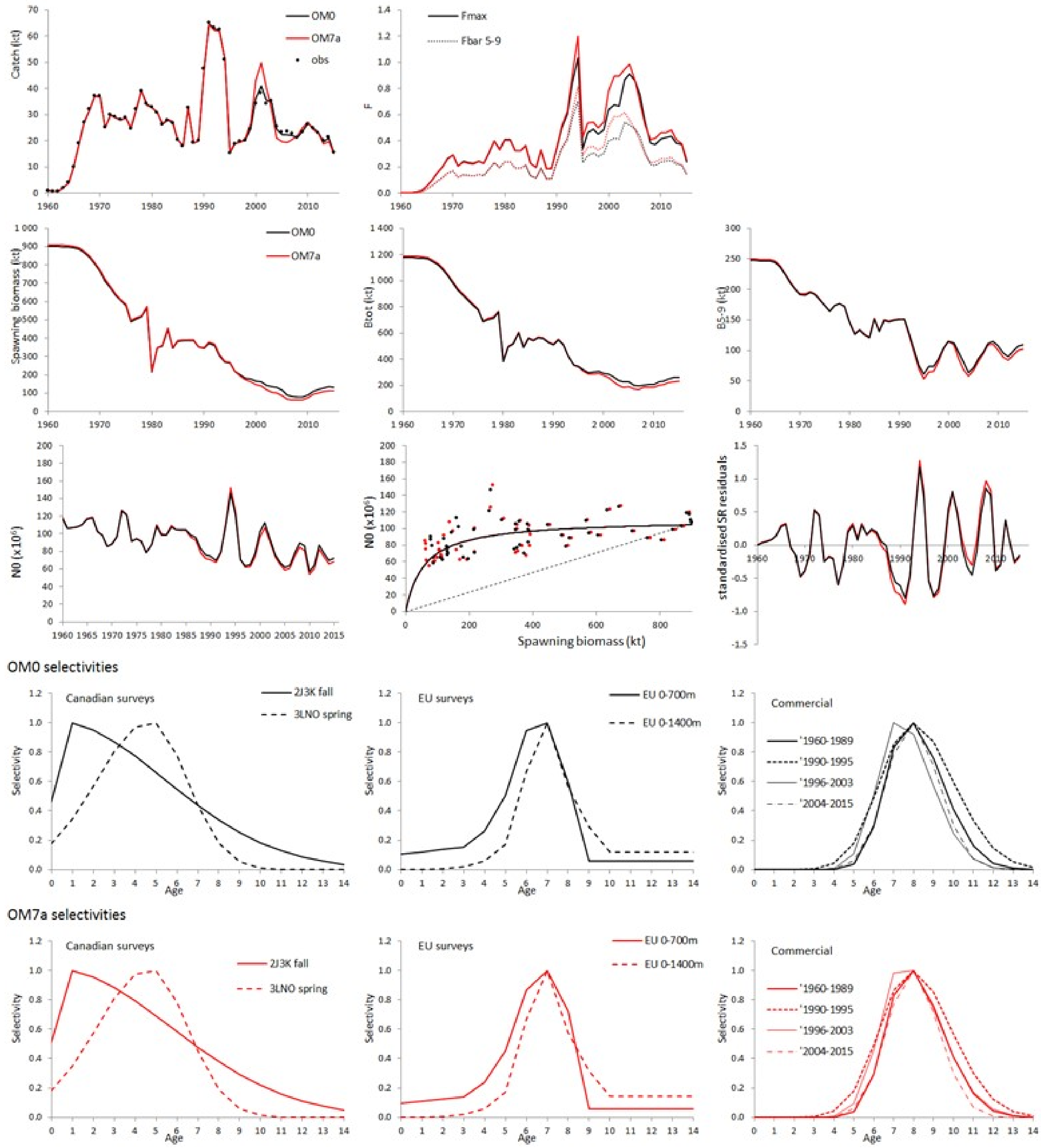

Fig. App.B.10a. Results for SCAA baseline OM0 (in black) and **OM7a** (σ_C=0.2, in red).

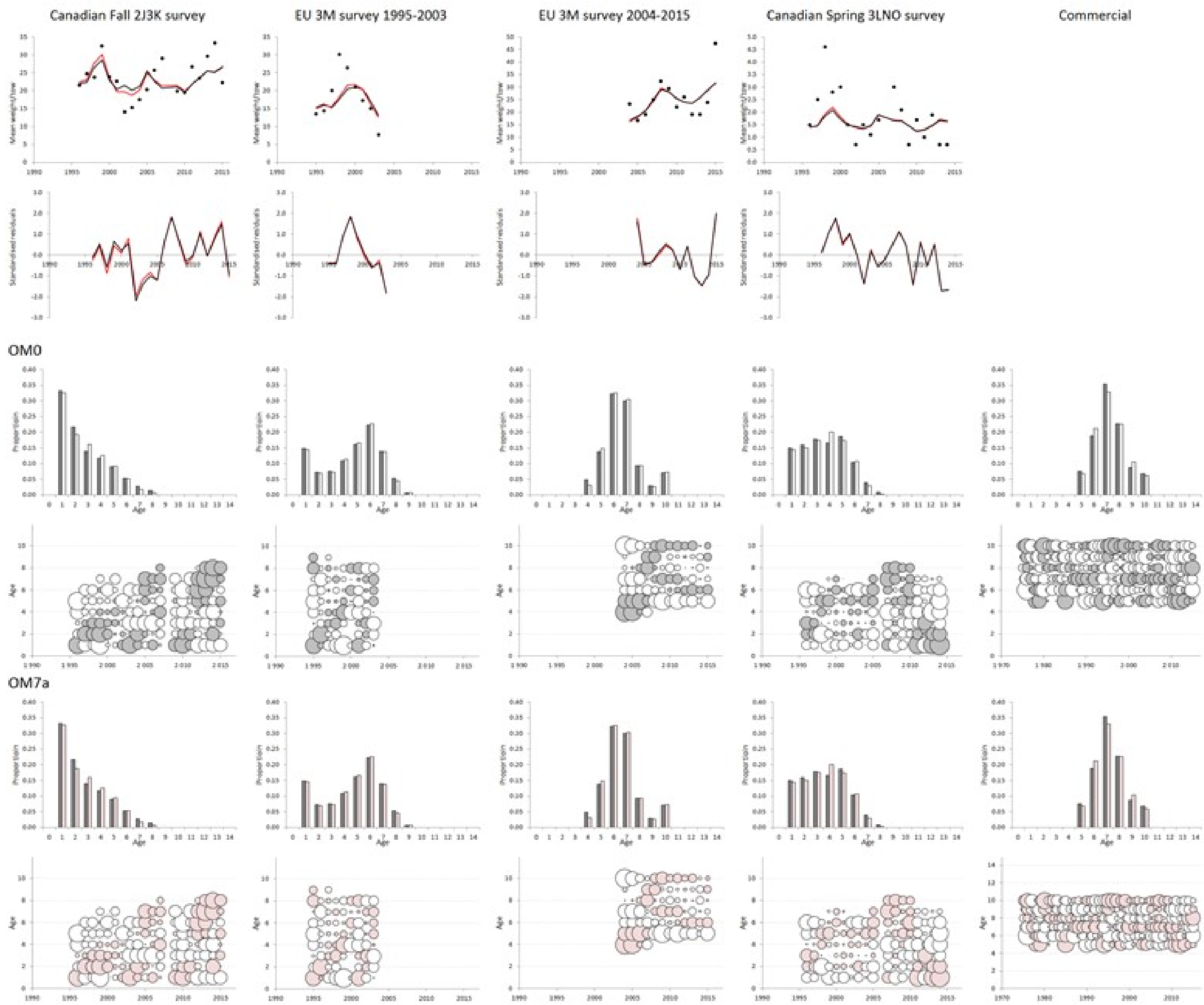

Fig. App.B.10b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM7a** (σ_C=0.2, in red).

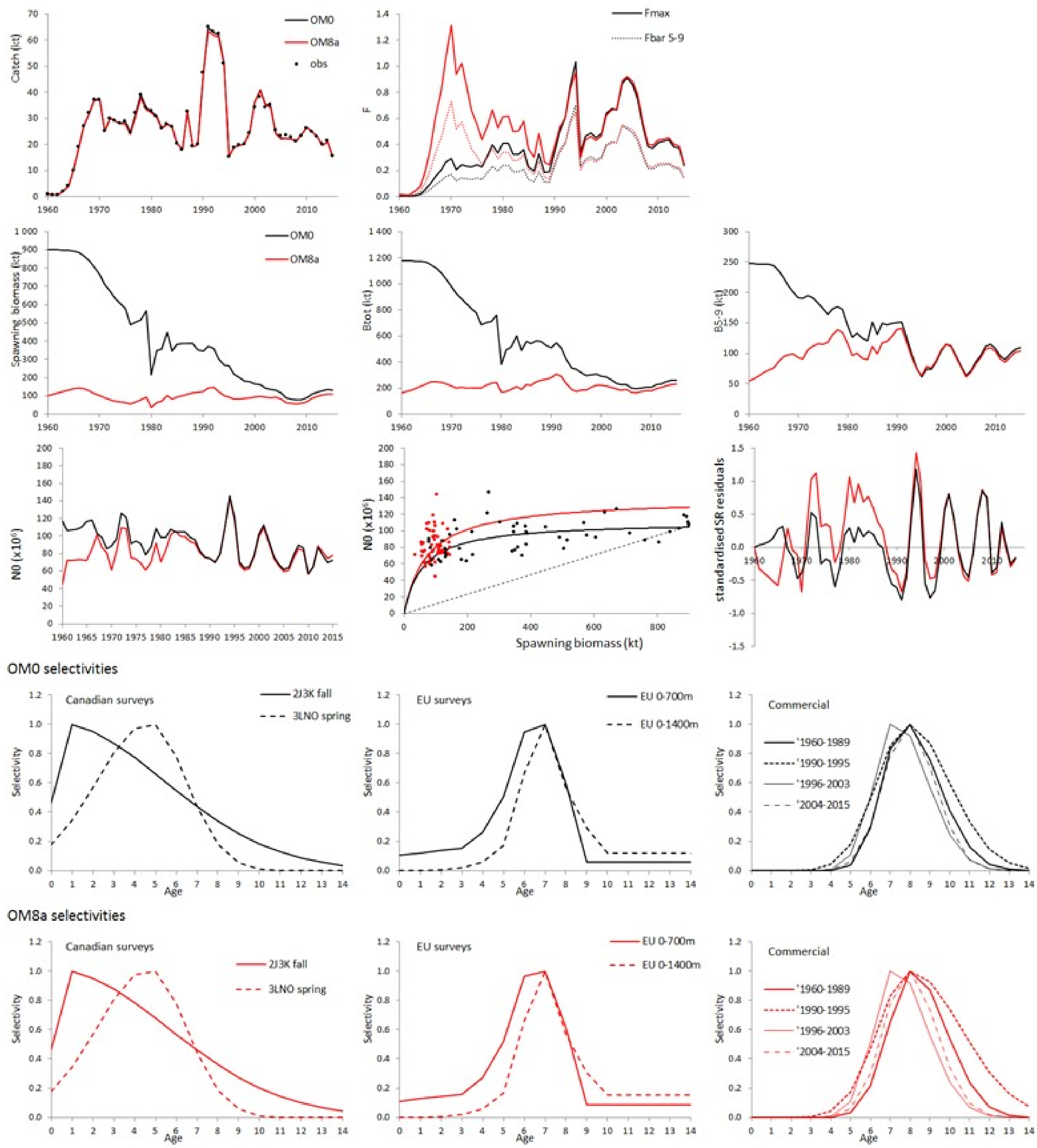

Fig. App.B.11a. Results for SCAA baseline OM0 (in black) and **OM8a** (force XSA/SAM level, in red).

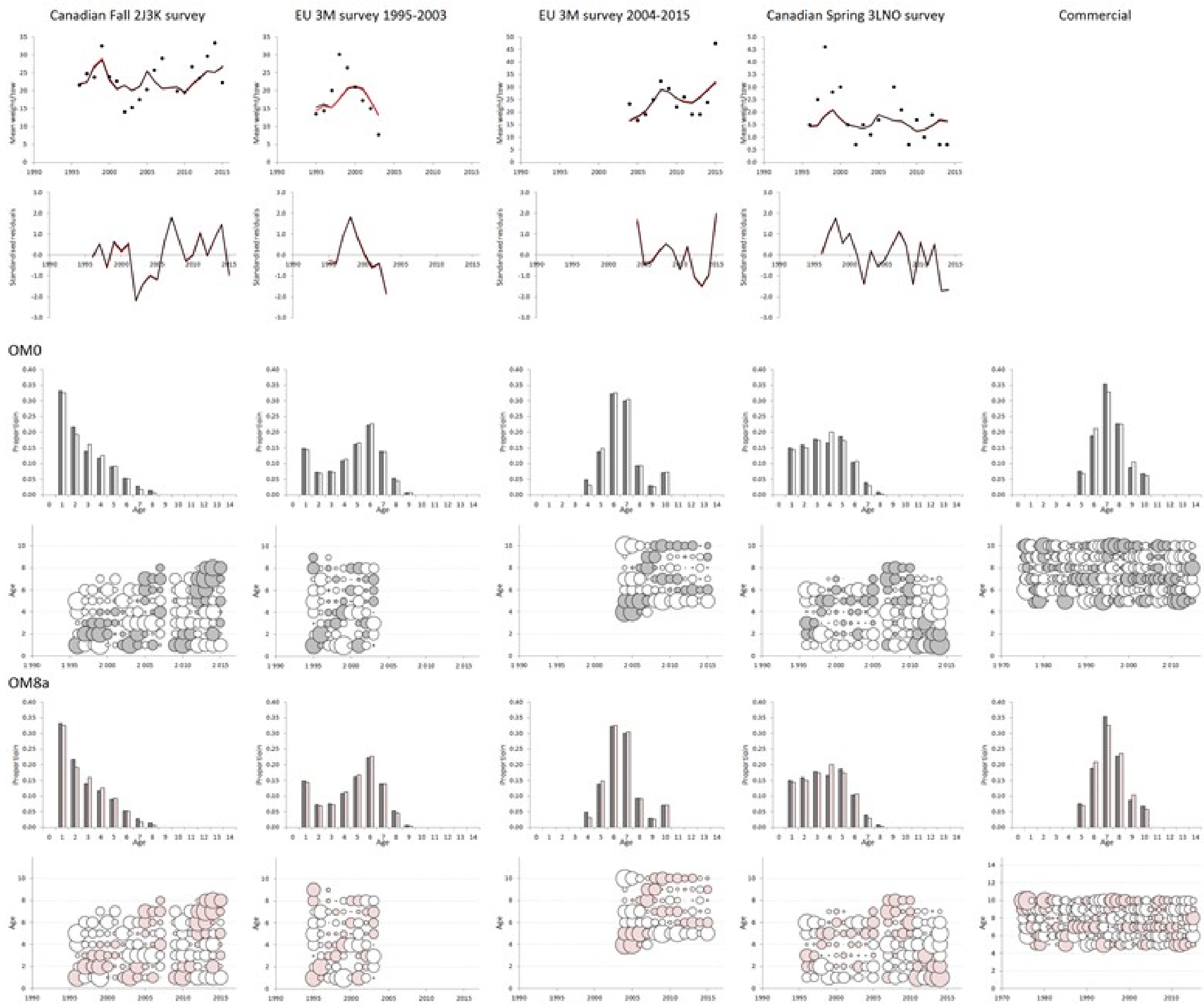

Fig. App.B.11b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM8a** (force XSA/SAM level, in red).

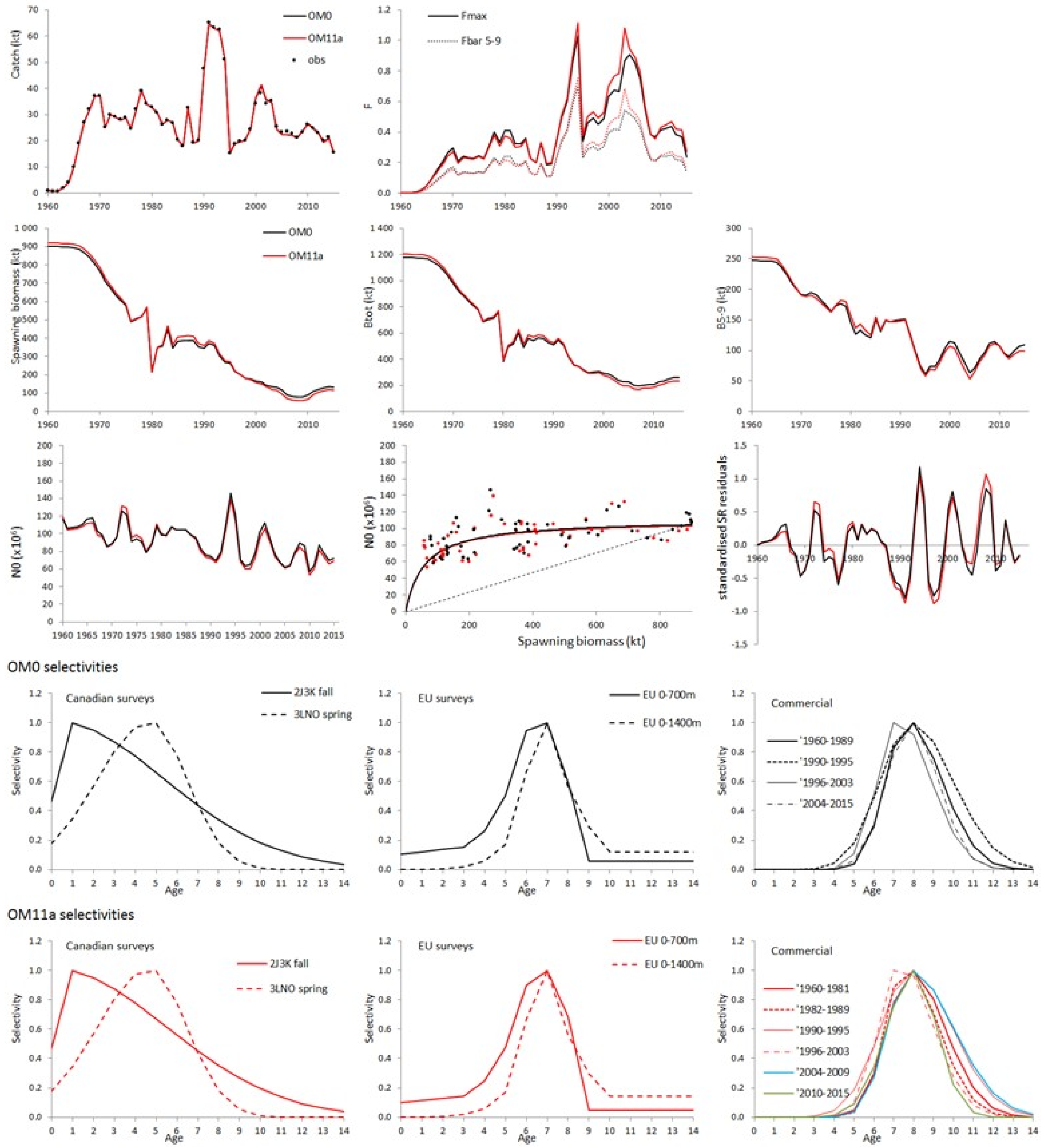

Fig. App.B.12a. Results for SCAA baseline OM0 (in black) and **OM11a** (6 instead of 4 selectivity blocks, in red).

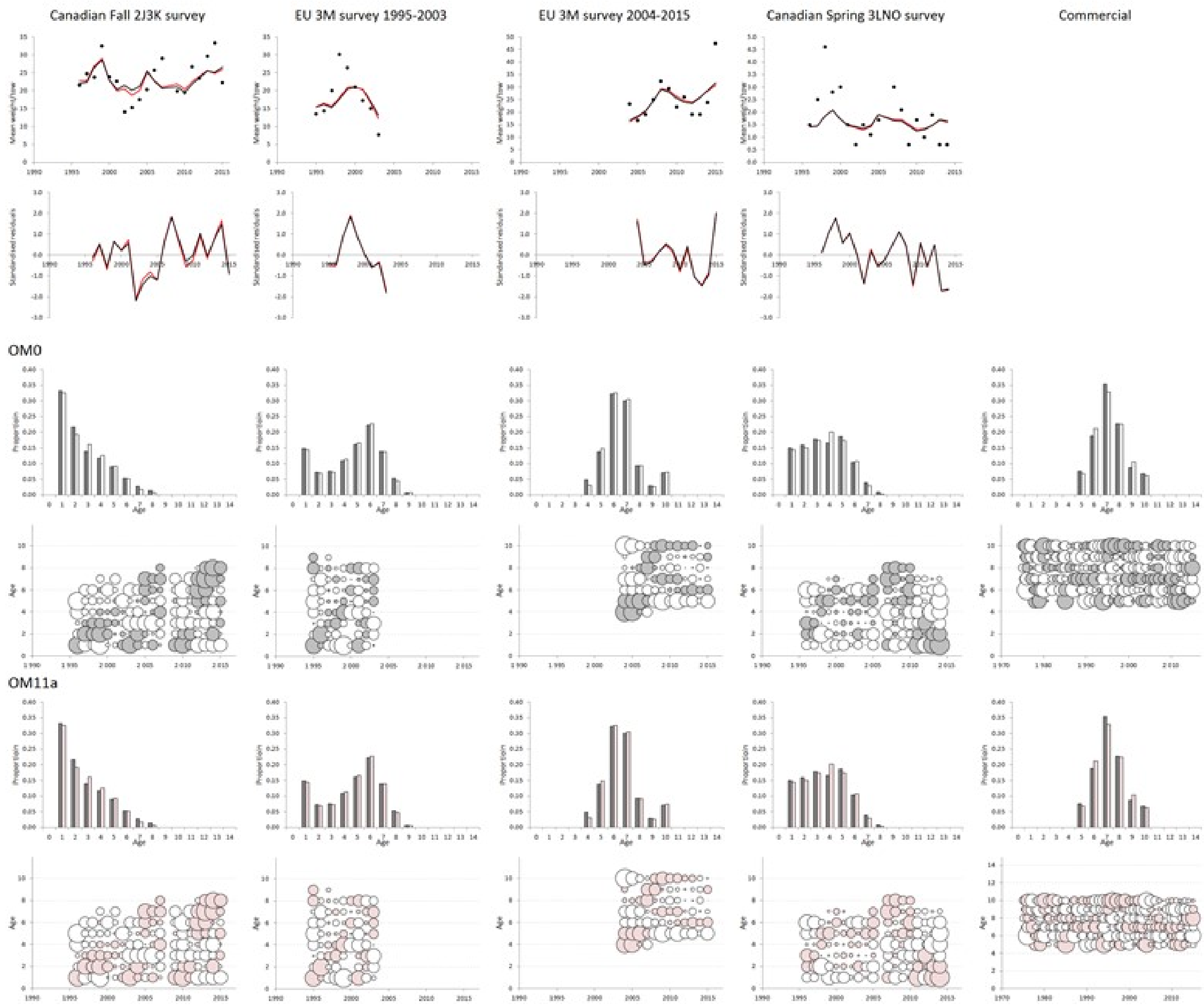

Fig. App.B.12b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM11a** (6 instead of 4 selectivity blocks, in red).

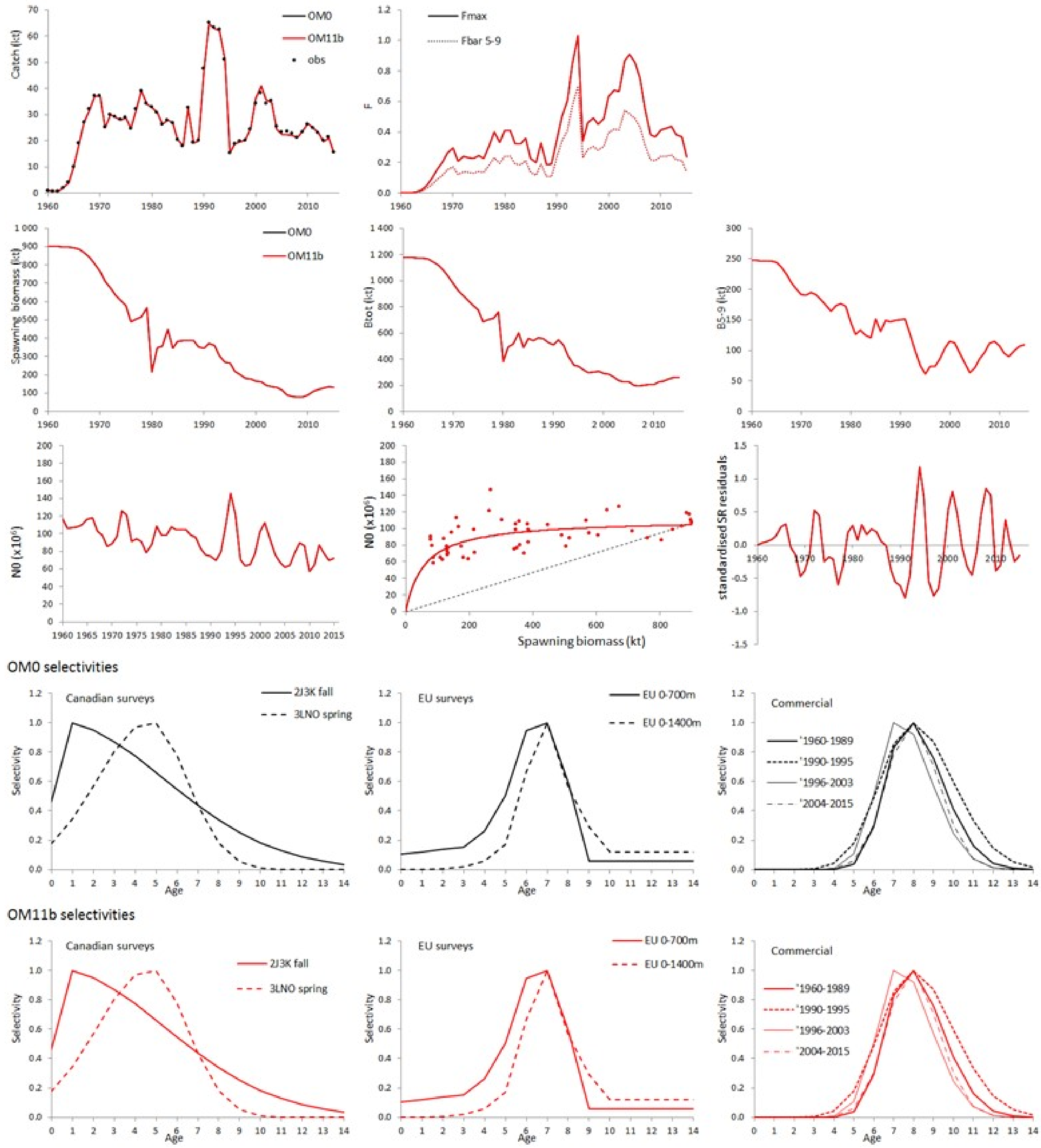

Fig. App.B.13a. Results for SCAA baseline OM0 (in black) and **OM11b** (descending limb negative exponential, in red).

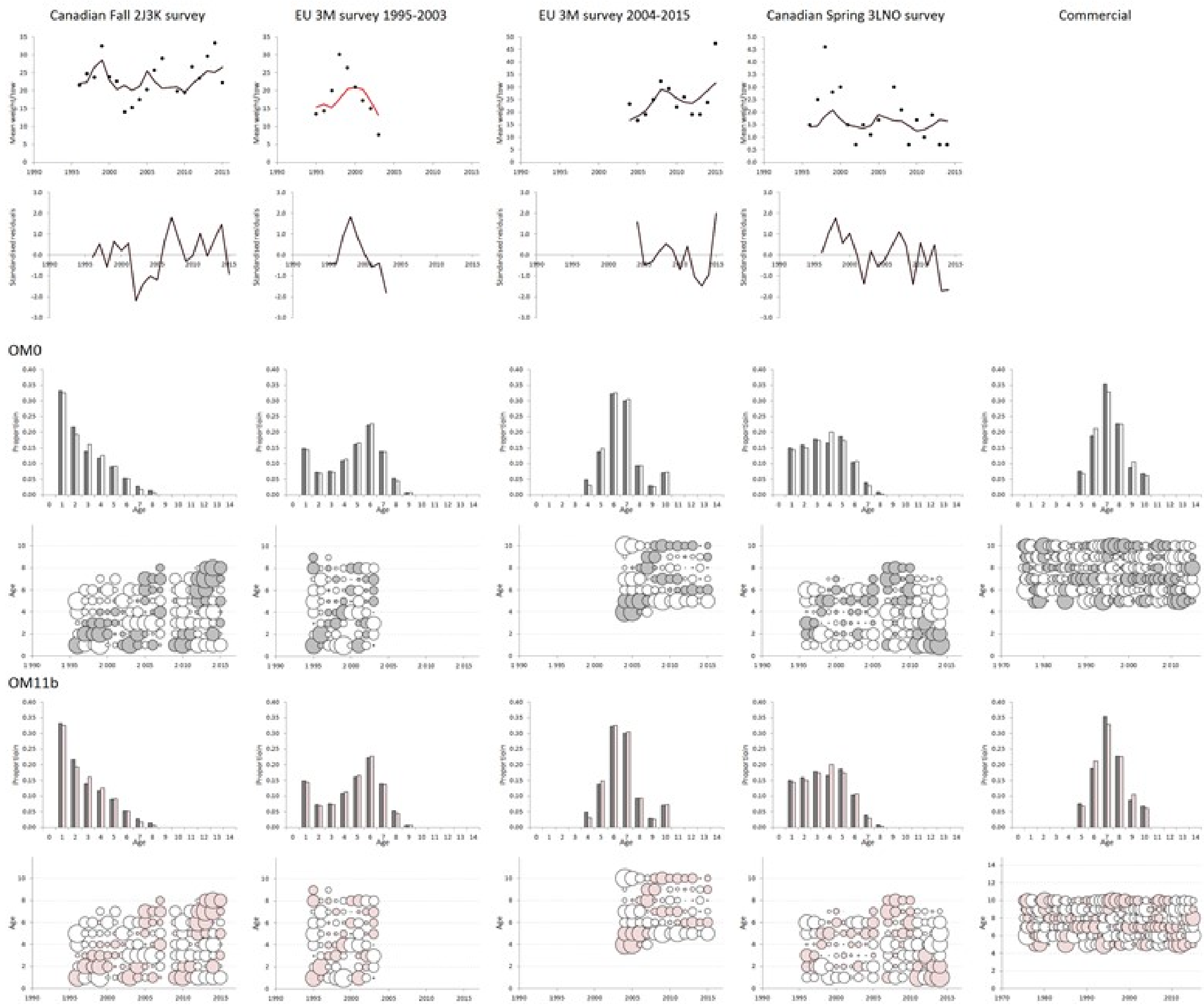

Fig. App.B.13b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM11b** (descending limb negative exponential, in red).

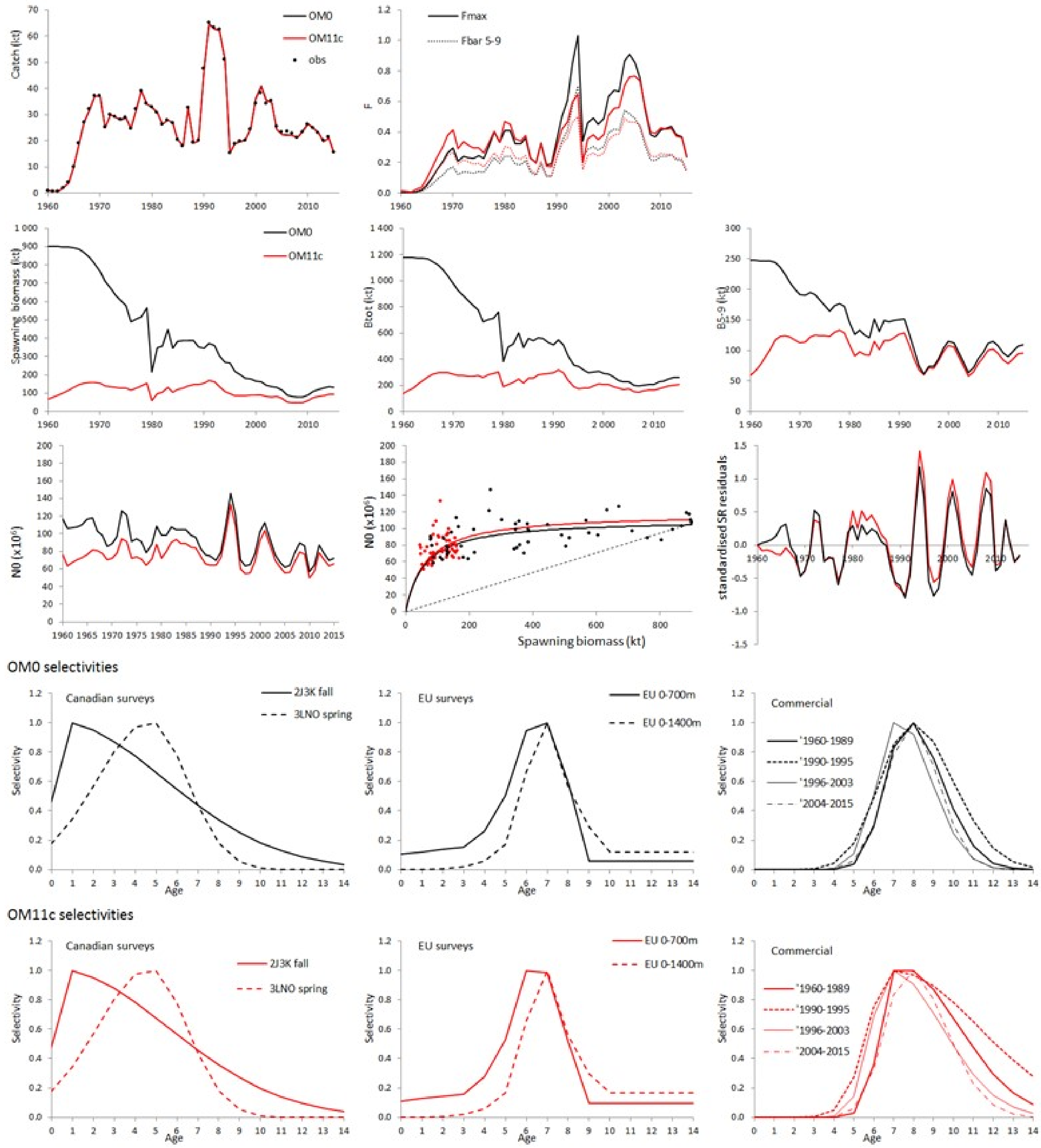

Fig. App.B.14a. Results for SCAA baseline OM0 (in black) and **OM11c** (force less doming, in red).

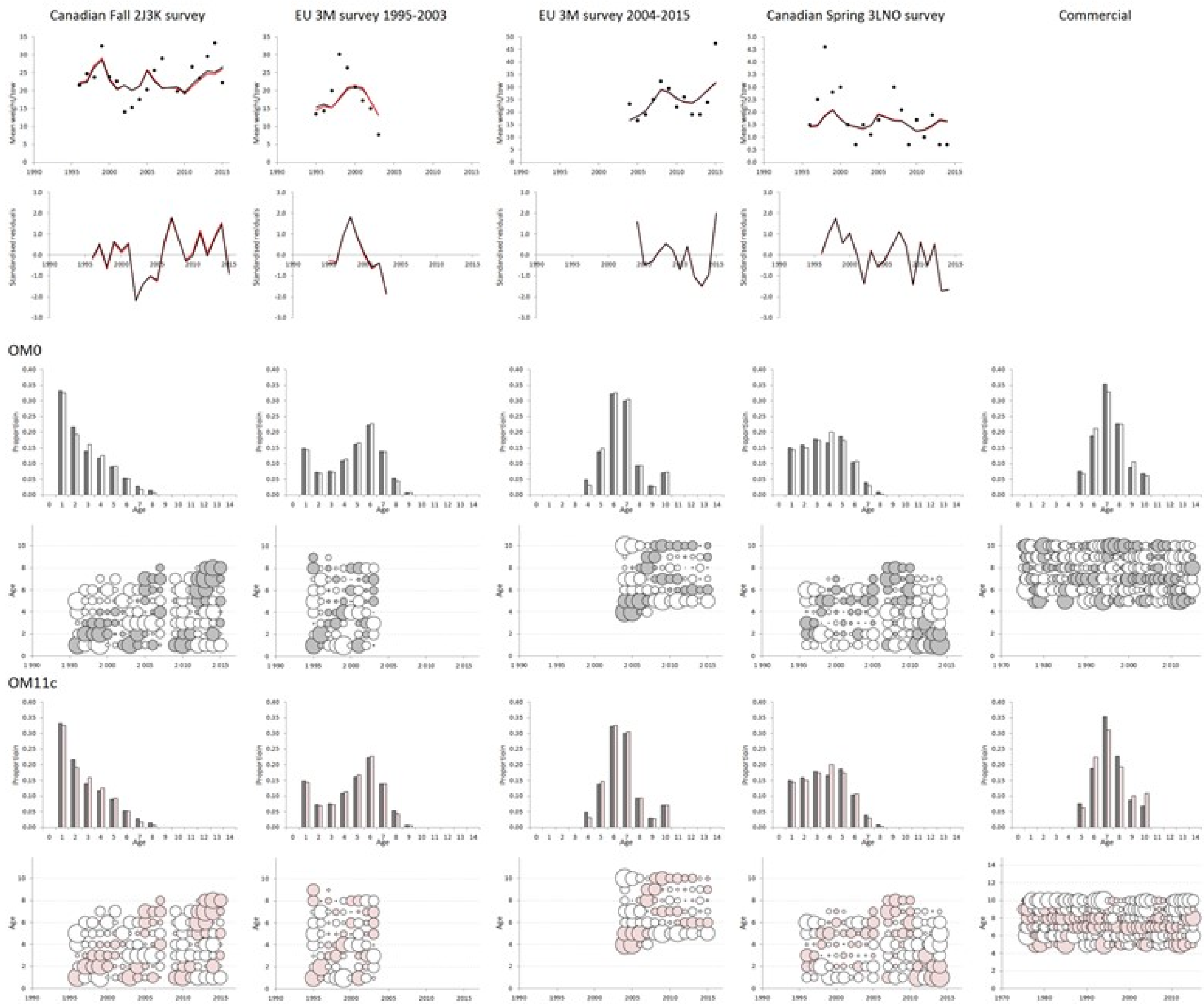

Fig. App.B.14b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM11c** (force less doming, in red).

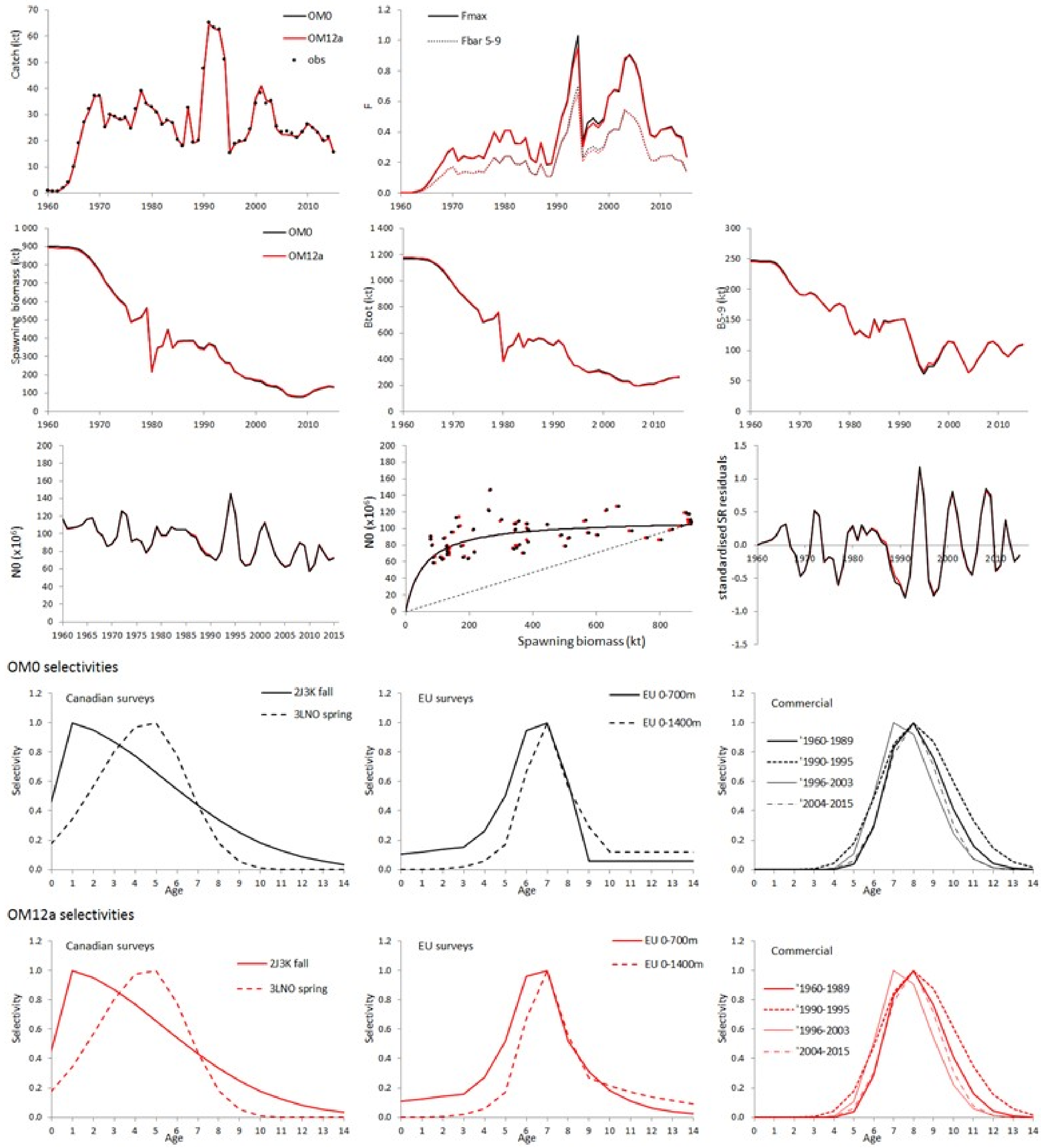

Fig. App.B.15a. Results for SCAA baseline OM0 (in black) and **OM12a** (EU survey selectivity: exponential decrease from plus group, in red).

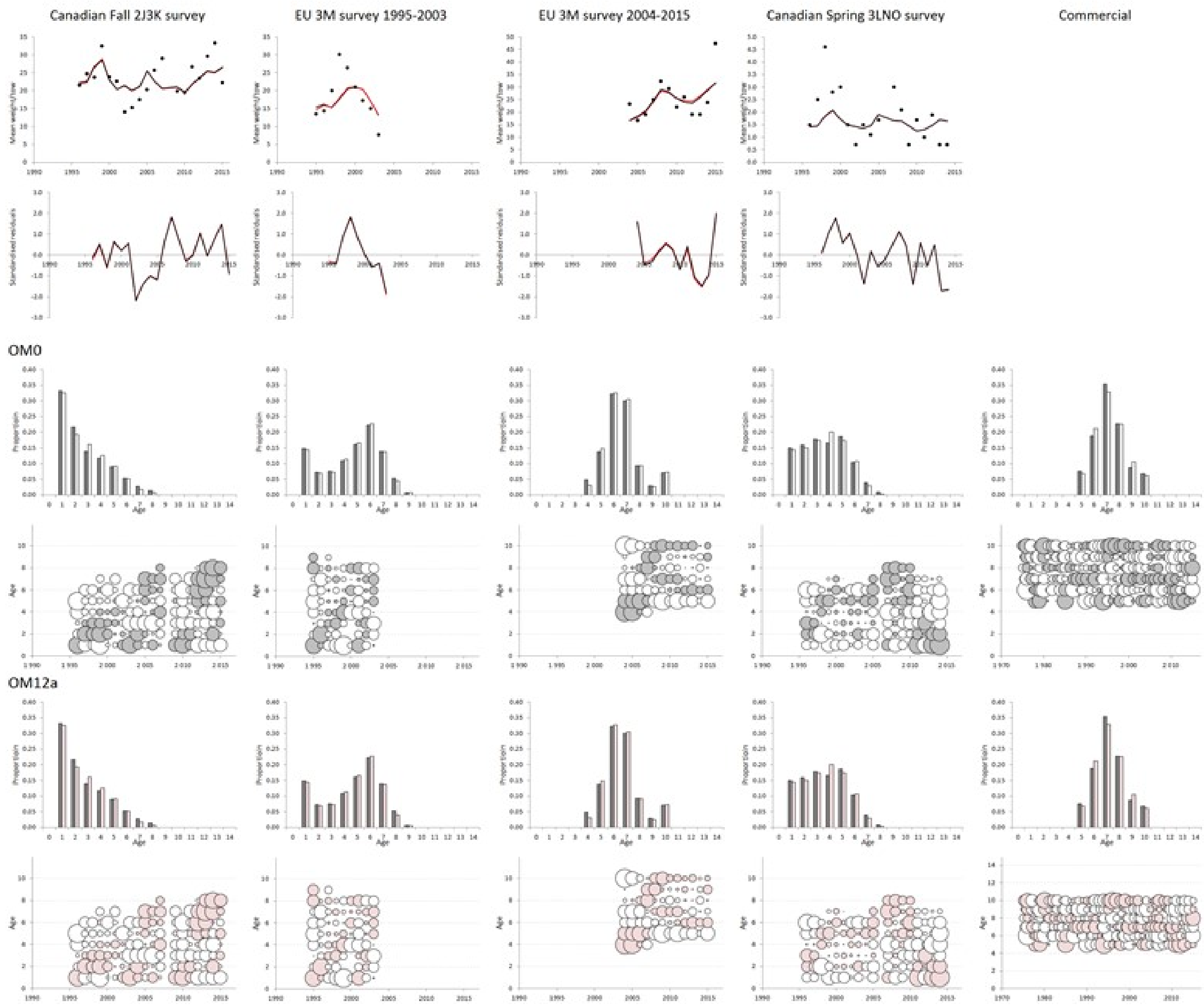

Fig. App.B.15b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM12a** (EU survey selectivity: exponential decrease from plus group, in red).

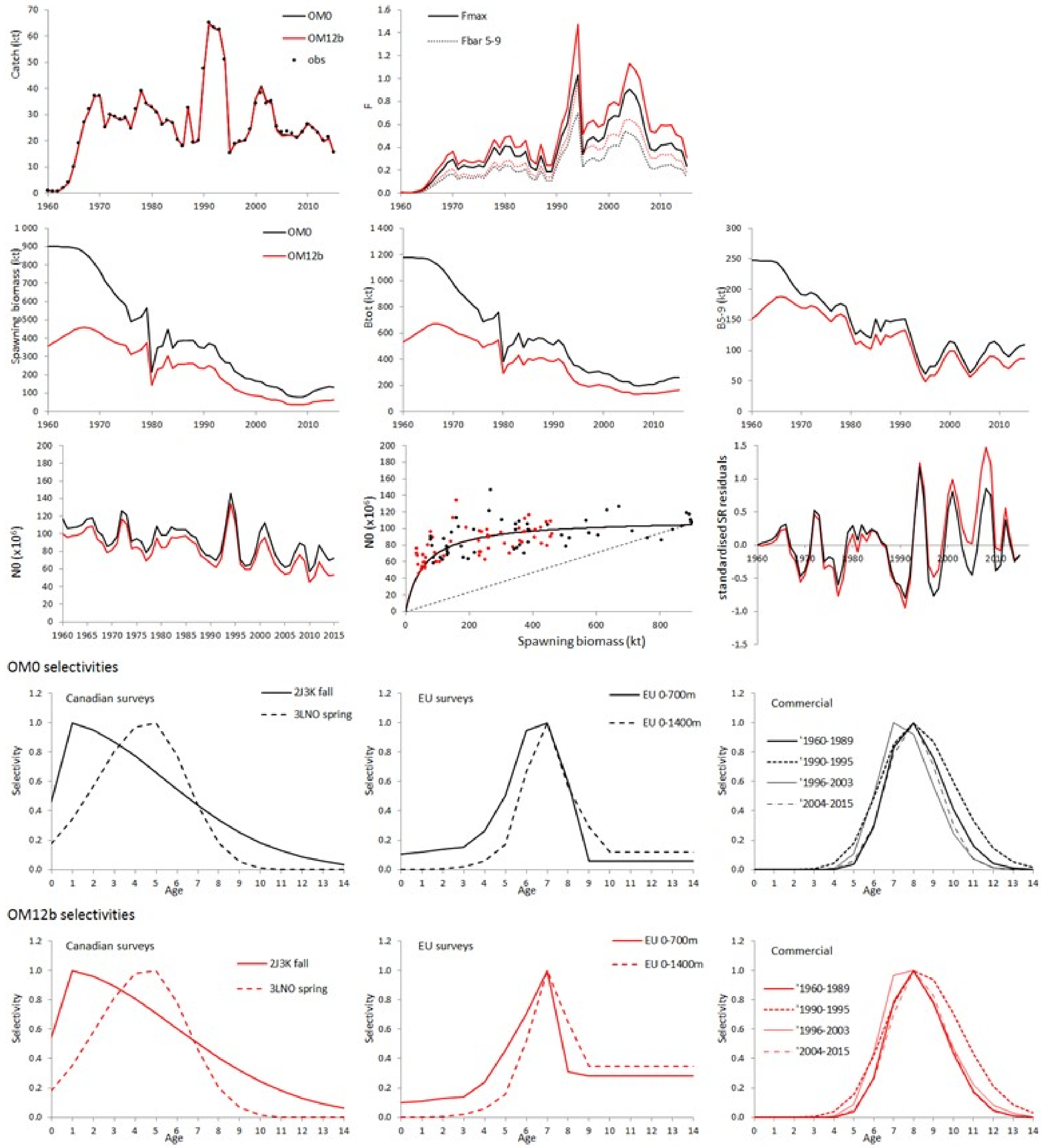

Fig. App.B.16a. Results for SCAA baseline OM0 (in black) and **OM12b** (EU survey selectivity: force less doming, in red).

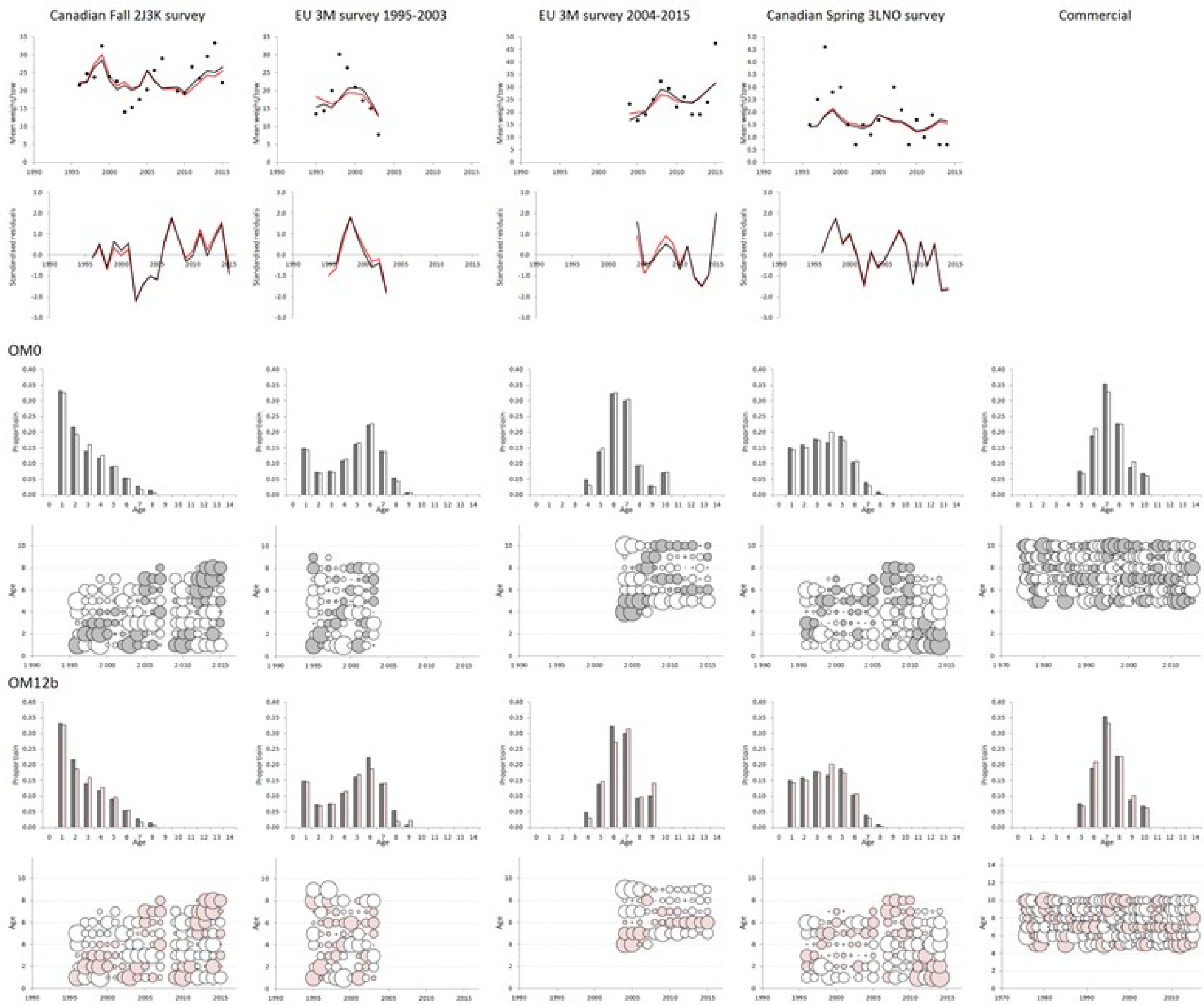

Fig. App.B.16b. Fits to the survey data for the SCAA baseline OM0 (in black) and **OM12b** (EU survey selectivity: force less doming, in red).