The update of input data of stock assessment of Pacific Bluefin Tuna, *Thunnus orientalis* for Stock Synthesis III

Masayuki Abe[1] , Kazuhiro Oshima[1], Mikihiko Kai[1], Momoko Ichinokawa[1], Izumi Yamazaki[1], Chien-Chung Hsu[2], Joon-Taek Yoo[3], John Childers[4], Michel Dreyfus[5], Alexandre Aires-da-Silva[6] and Yukio Takeuchi[1]

[1]National Research Institute of Far Seas Fisheries Research Agency 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan

[2]Institute of Oceanography National Taiwan University 1, Section 4, Roosevelt Road, Taipei 106 Taiwan

[3]National Fisheries Research & Development Institute Fisheries Resources Research Division 152-1 Haean-ro, Gijang-up, Gijang-gun Busan, 619-705 Korea

[4]NMFS/SWFSC,8604 La Jolla Shores Drive, La Jolla, California, 92037 USA

[5]Instituto Nacional de la Pesca CRIP-Ensenada,B.C. Mexico[6]Inter-American Tropical Tuna Commission, 8604 La Jolla shores Drive, La Jolla, CA 92037-1505, USA

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Summary

This paper summarizes the updated input data used for Stock Synthesis 3 (SS3) of a stock assessment model on Pacific bluefin tuna (PBF), as well as conducts sensitivity analyses on the updated fishery data to assess which data sets have effects on the updated stock assessment results and on the different version of SS3 used in July 2009 and in July 2010.

New set of the fishery data include fishing year for the period of July 1st, 1952 to June 30th, 2008. With regard to the CPUE time series, only three time series of CPUEs; Japanese coastal longline, Japanese troll and Taiwanese longline fisheries were updated to be used for SS3 model. Remaining time series of Purse seine CPUE in EPO was not updated.

In the sensitivity analysis, different versions of SS3 hardly influenced the major benchmarks such as SSB and recruitment. The updated input-data had large influence on SSB. The intermediate data sets which incorporated only two years catch or two years catch and length frequency data highly influenced SSB. CPUE of the Japanese coastal longline fishery, the length data of the tuna purse seine fishery and the Taiwanese longline fishery also influenced SSB.

1. Introduction

At the ISC PBF Working Group (ISC PBF-WG) meeting held in April 2007, the Working Group agreed to use the Stock Synthesis model (SS) (Methot 2007) as stock assessment model on Pacific bluefin tuna (PBF) (Anonymous 2006). The last full stock assessment of this species was conducted at the ISC PBF-WG meeting held in May – June 2008 (Anonymous 2008), although there remained a difficulty on low-plausible initial biomass estimate with a huge absolute value. The ISC PBF-WG meeting was held in July 2009 in order to examine effects of up-grading of stock synthesis model from SS2 to SS3 (Kai *et al.* 2009) and perform SS3 with revised age-specific natural mortality (M) vector, which was developed to overcome the low plausible initial biomass estimated with the previous M vector (Aires-da-Silva *et al.* 2009). Based on the result of the stock assessment, the Western and Central Pacific Fisheries Commission (WCPFC) adopted the conservation and management measures for PBF (CCM-2009-07). It states that ”The Northern Committee shall annually review reports CCMs submit pursuant to paragraph 4 above as well as the ISC advice on fishing mortality and status of the stock and consider, if necessary, further measures with particular attention to the recent trend of increasing fishing mortality rate on ages 0–3 fish”. At the 2010 ISC PBF-WG meeting, stock assessment is conducted by using the input data such as quarterly catch, CPUE and length frequency data updated until the 2nd quarter 2008 and fishing mortality rate trend will be evaluated.

In updating input data, only catch and length frequency data for two years, 2006 and 2007

fishing years were added, no changes being made on the base up to 2005. The CPUE series before 2006 fishing year have been replaced by new series up to and including 2007. Because of the nature of CPUE standardization by GLM, inclusion of two additional year's catch and effort data would change standardized CPUE of previous years.

The latest version of SS3 (*ver.*3.10b) released on March 2010 is applied for the present stock assessment, while, in the previous ISC PBF-WG meeting in 2009, an older version of SS3 (*ver.3.03a*) was used. The SS3 model structure was modified through version up (Methot 2009; 2010). It is required to examine whether output of SS3 will be changed by modification of model structure of SS3.

In section 2, updated input data for the stock assessment in July 2010 are compiled and summarized. In section 3, sensitivity analysis was conducted in order to evaluate effects of the modification of model structure in SS3 and the input data update.

2. Input data update

2.1. Quarterly catch

Fishery definition in the Stock Synthesis model was determined at the previous ISC PBF-WG meeting. There is a variety of fisheries for PBF operated by more than eight countries and each of them is classified to each fleet in SS3. Definitions of the fleets are listed in **Table 1** (Anon. 2008; Oshima *et al.* 2008). Annual catch and quarterly catch are listed in **Tables 2 and 3**.

2.2. CPUE

2.2.1. Japanese coastal longline and troll fisheries

Updated CPUEs of Japanese longline and troll fisheries are detailed in **Appendix**.

2.2.3. Taiwanese longline fishery

Updated CPUEs of Taiwanese longline fishery are listed in **Table 4**. Taiwanese longline CPUE increased from 0.11 in 2006 to 0.14 in 2007 and declined to 0.12 in 2008.

2.3. Length frequency data

Length frequency data from 2004 to 2008 are shown in **Fig. 1**. The mode in the fork length frequencies of Japanese longline (Fleet1; JLL) shifted to larger side slightly every year. In the length distributions of catches by tuna purse seine (Fleet3; TPS), the mode of the fork length larger than 170 cm was disappeared in 2007 and 2008.

3. Sensitivity runs

3.1. Specifications of the analysis

A series of sensitivity runs and their specifications are listed in **Table 5**. Run 1, where the previous version of SS3 and the previous input data of catch, CPUE and size were used, corresponds to SS3 run conducted in Kaohsiung 2009 (Anon. 2009). In contrast, in Run 2, the latest version of SS3 released in March 2010 was applied with the same input data as Run 1. The latest version of SS3 was applied in all other runs except the Run 1. Run 3, where all kinds of input data were updated up to an including the 2nd quarter of 2008 (the 4th quarter in fishing year of 2007), is the base case of the 2010 stock assessment (Ichinokawa *et al.* 2010). Only the catch data were updated in Run 4. The CPUE or size data coupled with catch data were updated in Run 5 and Run 6, respectively. Sensitivities of CPUE or size data of individual fleet were evaluated in Runs 7 – 19.

3.2. Results

SSB and recruitment estimated in Run 2 were almost identical with those in Run 1 except for recruitment from 1966 to 1968 (**Fig. 2** and **Table 6**). Consequently, change of SS3 version does not influence major benchmarks such as SSB and recruitment.

On the contrary, SSB had high sensitivity to the input data update, in particular, update with only the catch data (Run 4) and both with the catch and size data (Run 6), whereas recruitments except for the last 3 years were robust for data update (**Fig. 3**, upper panel). Especially, differences in the absolute values of SSB among runs became larger after mid 1990s. In Run 3, SSBs after the mid 1990s were by about 10,000 tons smaller than SSBs estimated in Run 1. As a result, the base case of the 2010 stock assessment (Run 3) showed decrease in absolute values of SSB from those in the previous stock assessment (Run 1) and details on these results were analyzed in Ichinokawa *et al.* (2010). The SSBs estimated in Run 5 where the catch and CPUE were updated were almost consistent with those in Run 1. Consequently, it is concluded that the update of size data contributed to the decrease in estimated absolute levels of SSBs in Run 3, because difference between Runs 3 and 5 was inclusion of the size data in recent two years or not.

The SSBs in the base case shows sensitivity to CPUE from the Japanese longline fishery, because SSB increased in Run 8 which used non-updated CPUE of this fishery (**Fig. 3**, middle panel). On the other hand, the update of CPUE from the troll or Taiwanese longline fishery did not influence the results of the base case, because SSBs did not change in Runs 7 and 9 where CPUE from the troll and Taiwanese longline fisheries were not updated. Recruitment was robust for CPUE update of each fishery.

Absolute level of SSB increased, if the size data of the tuna purse seine (Fleet 3; TPS) or

the Taiwanese longline (Fleet 7; TWLL) were not updated (Runs 16 and 18) (**Fig. 3**, lower panel). Hence, SSB is sensitive to the size data update of those fisheries. Recruitment was robust for the size data update of individual fisheries.

4. References

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Table 1 Summary of fishery category in the SS3 model.

Fleet No.	Country	Fishery	Name	Short name
Fleet 1	Japan	Longline(Distant and offshore) Longline(Coastal)	Japanese longline	JLL
Fleet 2	Japan Korea	Small pelagic fish purse seine Purse seine Trawl	Small pelagic fish purse seine	SPPS
Fleet 3	Japan Taiwan	Tuna purse seine Purse seine	Tuna purse seine	TPS
Fleet 4	Japan	Troll	Troll	TR
Fleet 5	Japan Taiwan	Pole and line Drift net Distant drift net Others	Pole-and-line	PL
Fleet 6	Japan	Set net Unclassified	Set net	SN
Fleet 7	Taiwan Other	Longline NZ Other	Taiwanese longline	TWLL
Fleet 8	United States Mexico EPO Other	Purse seine Others Purse seine Others	EPO commercial fleet	EPOCOM
Fleet 9	United States	Sport	EPO sport	EPOSP
Fleet 10	Japan	Angling Trawl Other longline	Other fleet	OTH

Table 2 Bluefin tuna's annual catch in the SS3 input-data.

Year	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
1952	1204.8	0.0	4935.9	521.4	1217.2	1205.2	0.0	1974.7	1.9	171.5
1953	3046.9	0.0	5569.6	1471.5	3058.1	2357.4	0.0	4433.0	48.0	131.2
1954	3114.7	0.0	5365.5	1656.2	3092.1	5579.2	0.0	9537.0	11.1	218.5
1955	2968.9	0.0	14016.1	1506.5	2856.3	4291.1	0.0	6172.9	93.0	100.9
1956	2909.5	0.0	20979.3	1762.9	4083.9	4338.2	0.0	5727.0	388.0	192.3
1957	1732.0	0.0	18147.4	2391.6	1808.9	3027.8	0.0	9214.9	73.1	194.3
1958	843.1	0.0	8586.1	1496.9	2344.2	1212.4	0.0	13934.0	10.0	183.2
1959	3701.2	0.0	9995.7	736.2	586.7	1587.7	0.0	3765.1	13.5	153.4
1960	6104.5	0.0	10540.8	1884.8	667.1	2032.3	0.0	4550.0	1.0	302.2
1961	6789.7	0.0	9123.9	3193.1	680.7	2710.2	0.0	8139.1	23.3	580.0
1962	6182.5	0.0	10657.3	1682.8	752.3	2545.3	0.0	11294.0	25.1	287.6
1963	6526.2	0.0	9786.2	2541.7	1273.7	2797.1	0.0	12289.1	6.9	276.3
1964	3253.5	0.0	8973.1	2783.6	1045.7	2984.3	0.0	9221.0	6.5	365.7
1965	2763.5	0.0	11495.6	1962.8	883.2	2862.6	54.0	6902.0	1.0	312.6
1966	1544.2	0.0	10082.3	1613.6	654.9	1266.3	0.0	15899.0	20.7	81.3
1967	922.8	0.0	6461.5	3273.3	1249.3	2607.7	53.0	5897.0	32.4	258.5
1968	507.8	0.0	9267.5	1568.4	989.6	3063.0	33.0	5985.0	12.2	205.6
1969	899.3	0.0	3236.0	2218.7	753.7	2188.6	23.0	6927.0	14.7	160.3
1970	618.8	0.0	2906.5	1198.1	785.9	1778.7	0.0	3999.1	19.3	161.1
1971	747.9	0.0	3721.2	1492.2	972.9	1624.6	1.0	8384.0	8.0	212.4
1972	538.7	0.0	4212.1	842.4	982.3	1140.9	14.0	13381.0	15.6	123.8
1973	901.0	0.0	2266.4	2107.8	835.0	2391.8	33.0	10765.9	54.3	285.8
1974	1069.1	0.0	4106.4	1656.4	1541.7	6070.4	47.0	5674.0	58.2	368.3
1975	1101.8	0.0	4491.6	1030.7	2082.3	2433.0	61.0	9597.0	34.2	131.9
1976	403.2	0.0	2148.4	829.5	2169.4	2996.3	17.0	10658.9	21.4	151.9
1977	360.8	0.0	5109.9	2165.8	3141.9	2257.1	131.0	5472.0	18.8	168.1
1978	656.3	0.0	10427.2	4517.0	3186.4	2546.3	66.0	5403.0	5.0	246.4
1979	762.7	0.0	13881.1	2655.2	2790.9	4558.6	58.0	6113.9	11.0	888.2
1980	852.3	0.0	11327.0	1530.8	2875.5	2520.9	114.0	2933.9	7.0	473.9
1981	617.5	0.0	25421.9	1776.9	2883.7	2129.3	179.0	1089.0	9.0	523.0
1982	737.6	31.0	19233.9	863.5	3356.0	1666.8	207.0	3152.0	11.0	132.4
1983	222.6	13.0	14783.3	2027.6	1165.7	971.6	175.0	838.0	33.0	309.5
1984	164.5	4.0	4438.5	1873.9	1127.6	2234.1	477.0	860.0	49.0	336.2
1985	113.4	1.0	4234.4	1849.9	2555.9	2562.3	210.0	4020.0	89.0	447.0
1986	115.6	344.0	7428.4	1467.4	1415.0	2913.9	70.0	5095.0	12.0	402.6
1987	243.6	89.0	8673.8	880.5	1837.0	2198.0	365.0	1002.0	34.0	186.8
1988	186.9	54.3	3779.7	1123.5	1340.0	842.6	108.0	1426.1	6.0	127.2
1989	241.4	183.6	6336.4	902.6	981.0	747.9	205.0	1123.0	112.0	109.5
1990	335.1	286.7	2983.2	1250.2	1107.0	716.1	189.0	1530.1	65.0	198.5
1991	238.0	5737.3	4335.7	2068.6	641.0	1485.2	343.5	427.9	92.0	414.4
1992	529.2	3195.0	4328.4	915.3	1062.1	1208.4	464.3	1956.9	110.0	193.3
1993	822.2	1484.5	5156.5	545.9	290.7	848.1	476.6	623.0	298.0	206.5
1994	1226.4	836.0	7344.6	4110.5	288.5	1158.4	560.9	1011.1	89.0	271.8
1995	687.7	14396.1	5333.9	4778.3	381.8	1859.2	336.8	672.9	258.0	476.3
1996	909.7	2206.1	5540.3	3640.2	161.4	1149.1	960.2	8285.1	40.0	503.3
1997	1312.5	8068.8	6136.8	2740.0	143.0	803.5	1828.3	2726.9	156.0	702.0
1998	1266.4	2863.7	2714.8	2864.6	175.5	874.4	1930.4	1962.0	413.0	608.7
1999	1174.9	4809.7	11618.9	3386.9	93.8	1264.9	3110.2	2870.0	441.0	481.6
2000	959.7	10268.7	8192.6	5121.5	154.6	1124.8	2800.9	3903.0	342.0	637.8
2001	796.3	5459.5	3138.7	3328.9	284.1	1365.8	1888.8	1077.0	356.0	682.5
2002	854.7	5870.4	4171.0	2427.6	314.5	1110.0	1588.6	1795.0	654.0	409.1
2003	1204.1	7539.5	944.8	1838.8	108.0	839.1	1922.5	3343.0	394.0	403.1
2004	1806.7	3213.2	4791.9	2182.4	228.0	895.9	1791.3	8924.0	49.0	420.5
2005	1890.4	7983.0	3871.3	3406.4	683.8	2182.3	1394.9	4763.0	79.0	412.9
2006	1097.2	3750.2	3889.1	1544.0	421.3	1554.3	1148.0	9806.0	105.8	331.0
2007	2317.1	3895.5	3058.3	2384.6	379.3	1555.3	1205.6	4191.0	14.7	1012.9
2008*	860.3	3066.0	1909.1	1416.9	40.1	1275.5	847.3	1783.6	6.4	0.0

*Catch in the 2nd qupater 2008 included.

Table 3 Bluefin tuna's quarterly catch on the SS3 input-data.

Year	Quarter	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
1952	3	1073	0	4936	23	713	859	0	1951	2	0
	4	132	0	0	498	505	346	0	24	0	172
1953	1	145	0	0	282	796	109	0	0	0	0
	2	1898	0	1990	39	907	1379	0	0	0	0
	3	764	0	3580	51	650	639	0	3843	37	0
	4	241	0	0	1098	706	231	0	590	11	131
1954	1	263	0	0	318	609	203	0	0	0	0
	2	1578	0	1917	44	815	2763	0	2289	1	0
	3	1096	0	3448	58	744	1976	0	6845	10	0
	4	178	0	0	1236	923	637	0	403	1	219
1955	1	177	0	0	289	569	187	0	483	0	0
	2	1310	0	5008	40	761	2527	0	3131	17	0
	3	1172	0	9008	53	665	1165	0	2467	76	0
	4	311	0	0	1125	862	413	0	93	0	101
1956	1	124	0	0	338	813	190	0	0	0	0
	2	1104	0	7496	47	1087	2761	0	0	0	0
	3	1521	0	13483	62	953	1080	0	4753	365	0
	4	161	0	0	1316	1232	308	0	974	23	192
1957	1	163	0	0	459	359	186	0	0	0	0
	2	905	0	6036	64	481	1438	0	141	0	0
	3	566	0	12111	84	425	783	0	8779	72	0
	4	98	0	0	1785	545	622	0	296	1	194
1958	1	135	0	0	287	468	114	0	0	0	0
	2	384	0	3937	40	626	605	0	2635	0	0
	3	113	0	4650	52	541	283	0	11188	8	0
	4	211	0	0	1117	709	211	0	112	2	183
1959	1	371	0	0	141	117	131	0	0	0	0
	2	1573	0	4431	20	157	853	0	1278	0	0
	3	841	0	5565	26	135	359	0	2487	13	0
	4	916	0	0	550	178	245	0	0	0	153
1960	1	642	0	0	362	120	173	0	103	0	0
	2	4029	0	3475	50	161	833	0	1493	0	0
	3	706	0	7066	66	204	560	0	2914	1	0
	4	729	0	0	1407	182	467	0	40	0	302
1961	1	781	0	0	613	133	292	0	0	0	0
	2	3940	0	3356	85	177	1240	0	1164	0	0
	3	1472	0	5768	112	170	637	0	6759	22	0
	4	597	0	0	2383	201	542	0	217	1	580
1962	1	800	0	0	323	149	236	0	110	0	0
	2	4331	0	3981	45	200	1144	0	2403	0	0
	3	593	0	6677	59	176	631	0	8753	22	0
	4	459	0	0	1256	227	533	0	29	3	288
1963	1	541	0	0	488	251	220	0	73	0	0
	2	5130	0	3485	68	336	872	0	2432	0	0
	3	600	0	6301	89	305	940	0	9731	4	0
	4	255	0	0	1897	381	765	0	54	3	276
1964	1	313	0	0	534	208	375	0	17	0	0
	2	2321	0	3175	74	278	1211	0	1769	0	0
	3	360	0	5798	97	246	718	0	7423	6	0
	4	260	0	0	2078	315	681	0	13	1	366
1965	1	322	0	0	377	229	282	0	26	0	0
	2	1945	0	4024	52	242	1053	54	546	0	0
	3	160	0	7471	69	213	873	0	5410	1	0
	4	336	0	0	1465	200	654	0	920	0	313

Table 3 Continued.

Year	Quarter	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
1966	1	122	0	0	310	145	110	0	9	0	0
	2	862	0	3058	43	189	617	0	4860	0	0
	3	285	0	7025	56	188	337	0	11028	20	0
	4	275	0	0	1204	133	203	0	2	1	81
1967	1	218	0	0	628	285	409	0	16	0	0
	2	387	0	2376	87	373	815	53	3070	0	0
	3	246	0	4085	114	330	655	0	2772	28	0
	4	73	0	0	2443	261	729	0	40	4	259
1968	1	179	0	0	301	221	309	0	50	0	0
	2	140	0	3741	42	307	1189	33	790	0	0
	3	135	0	5527	55	255	842	0	4819	12	0
	4	54	0	0	1171	206	723	0	326	0	206
1969	1	75	0	0	426	160	185	0	11	0	0
	2	661	0	1176	59	197	764	23	1609	1	0
	3	109	0	2061	78	184	699	0	5259	13	0
	4	54	0	0	1656	213	541	0	49	1	160
1970	1	37	0	0	230	178	81	0	14	0	0
	2	524	0	1274	32	204	831	0	1427	3	0
	3	23	0	1633	42	210	517	0	2556	7	0
	4	35	0	0	894	194	351	0	2	9	161
1971	1	181	0	0	286	234	84	0	32	0	0
	2	505	0	2835	40	269	607	1	4051	0	0
	3	19	0	854	52	230	568	0	3359	6	0
	4	43	0	32	1114	240	366	0	942	2	212
1972	1	47	0	0	162	297	128	0	3	0	0
	2	446	0	2049	23	78	402	14	2886	0	0
	3	15	0	1649	29	449	308	0	8884	15	0
	4	31	0	514	629	159	302	0	1608	0	124
1973	1	57	0	0	405	73	266	0	11	0	0
	2	799	0	464	56	160	774	33	2049	18	0
	3	21	0	1286	74	419	737	0	8707	36	0
	4	25	0	517	1573	183	616	0	0	0	286
1974	1	15	0	0	318	450	622	0	0	0	0
	2	977	0	416	44	246	1960	47	1294	0	0
	3	52	0	2833	58	483	1920	0	4225	58	0
	4	24	0	858	1236	363	1569	0	155	0	368
1975	1	29	0	0	198	806	155	0	2	0	0
	2	891	0	3415	28	132	622	61	3066	0	0
	3	121	0	1076	36	1096	984	0	5753	31	0
	4	61	0	1	769	50	673	0	776	3	132
1976	1	37	0	0	159	80	167	0	617	0	0
	2	298	0	1122	22	271	860	17	2286	0	0
	3	54	0	1026	29	1300	1190	0	7259	16	0
	4	15	0	0	619	518	779	0	498	5	152
1977	1	69	0	0	416	169	176	0	2	0	0
	2	244	0	4063	58	1338	717	131	2023	2	0
	3	37	0	1047	76	1258	820	0	3099	16	0
	4	12	0	0	1617	377	544	0	348	1	168
1978	1	58	0	3	867	51	230	0	87	0	0
	2	243	0	10346	121	426	727	66	704	0	0
	3	340	0	78	158	2329	875	0	4591	5	0
	4	16	0	0	3372	380	714	0	21	0	246

Table 3 Continued.

Year	Quarter	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
1979	1	55	0	0	510	454	412	0	11	0	0
	2	580	0	11145	71	211	1201	58	2333	0	0
	3	104	0	2736	93	1720	1633	0	3543	11	0
	4	24	0	0	1982	406	1313	0	227	0	888
1980	1	43	0	0	294	572	228	0	0	0	0
	2	749	0	6168	41	195	710	114	1435	0	0
	3	20	0	5159	54	1641	937	0	1439	7	0
	4	41	0	0	1143	468	647	0	60	0	474
1981	1	185	0	0	283	85	194	0	0	0	0
	2	336	0	6344	0	115	694	179	281	2	0
	3	56	0	19078	68	2382	710	0	807	7	0
	4	41	0	0	1426	302	532	0	1	0	523
1982	1	63	8	0	435	336	122	0	0	0	0
	2	583	12	5410	53	671	667	207	60	2	0
	3	73	6	13685	5	1905	534	0	2686	7	0
	4	20	5	139	370	444	345	0	406	2	132
1983	1	38	3	0	81	31	96	0	99	0	0
	2	161	5	11960	0	107	375	175	8	2	0
	3	8	3	2824	21	897	281	0	611	14	0
	4	15	2	0	1925	131	219	0	121	17	310
1984	1	41	1	0	287	33	265	0	72	0	0
	2	94	2	2453	0	116	668	477	142	4	0
	3	20	1	1985	28	588	690	0	557	35	0
	4	9	1	0	1558	391	611	0	89	10	336
1985	1	24	0	0	538	1011	187	0	62	0	0
	2	74	0	2977	135	464	548	210	1570	0	0
	3	8	0	1257	12	961	1054	0	1262	84	0
	4	8	0	0	1165	120	774	0	1127	5	447
1986	1	19	84	0	224	74	238	0	109	0	0
	2	84	130	6356	0	460	756	70	428	2	0
	3	8	70	1072	5	668	1044	0	3758	10	0
	4	5	60	0	1238	212	876	0	800	0	403
1987	1	20	22	0	354	1089	188	0	93	0	0
	2	195	34	4895	15	132	462	365	31	0	0
	3	20	18	3118	6	519	884	0	814	14	0
	4	9	15	661	505	98	664	0	64	20	187
1988	1	19	8	0	89	146	69	0	0	0	0
	2	123	28	1224	0	357	187	108	210	0	0
	3	35	7	2555	15	796	335	0	981	4	0
	4	10	12	0	1020	42	251	0	236	2	127
1989	1	27	20	0	259	68	50	0	7	0	0
	2	190	29	2393	27	356	177	205	0	0	0
	3	20	102	3944	88	411	298	0	987	90	0
	4	4	32	0	529	146	222	0	130	22	110
1990	1	21	32	0	166	17	105	0	16	0	0
	2	280	55	509	92	213	137	189	1	0	0
	3	24	59	2474	3	830	220	0	1318	62	0
	4	10	140	0	990	47	254	0	195	3	199
1991	1	16	164	0	636	30	296	0	0	0	0
	2	193	126	646	161	79	250	342	87	0	0
	3	14	236	3690	82	429	387	2	336	83	0
	4	14	5211	0	1191	103	552	0	5	9	414

Table 3 Continued.

Year	Quarter	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
1992	1	36	464	0	274	18	174	0	0	0	0
	2	462	2169	1750	0	35	288	464	11	1	0
	3	10	314	2578	0	944	324	0	1623	106	0
	4	20	248	0	642	65	422	0	323	3	193
1993	1	15	592	0	145	12	60	0	0	0	0
	2	708	766	1244	34	38	439	471	41	0	0
	3	62	107	3912	48	204	222	6	479	292	0
	4	37	19	0	320	36	127	0	103	6	207
1994	1	42	37	0	67	0	88	0	2	0	0
	2	1085	581	2886	15	17	558	559	4	4	0
	3	77	24	4448	458	206	215	2	949	85	0
	4	22	194	11	3570	65	297	0	57	0	272
1995	1	11	608	0	2475	9	84	0	0	0	0
	2	616	563	2040	733	136	865	335	0	0	0
	3	35	4223	3294	440	143	451	2	673	258	0
	4	25	9002	0	1130	94	460	0	0	0	476
1996	1	31	1380	0	136	5	41	0	0	0	0
	2	827	178	3152	57	1	401	956	737	24	0
	3	25	471	2388	256	90	286	4	7548	16	0
	4	26	176	0	3191	66	421	0	0	0	503
1997	1	27	853	0	846	1	135	0	1	0	0
	2	1215	1510	1402	550	4	350	1814	61	56	0
	3	27	3215	4735	224	113	142	14	2625	100	0
	4	44	2491	0	1120	25	177	0	40	0	702
1998	1	18	605	0	605	2	115	0	4	0	0
	2	1150	589	183	515	2	259	1910	8	15	0
	3	53	587	2532	131	108	141	20	1927	386	0
	4	46	1082	0	1613	64	360	0	23	12	609
1999	1	33	749	0	798	10	288	0	0	0	0
	2	1076	1083	5688	360	2	485	3089	2095	8	0
	3	25	2280	5922	129	65	187	21	686	422	0
	4	41	698	9	2101	17	305	0	89	11	482
2000	1	39	1266	0	1456	1	148	0	2	3	0
	2	893	3695	3403	770	83	307	2780	908	133	0
	3	15	3238	4789	117	66	304	21	2991	206	0
	4	12	2070	0	2780	6	367	0	3	0	638
2001	1	8	1696	0	934	0	290	0	2	3	0
	2	749	3060	981	464	4	420	1839	343	13	0
	3	13	414	2157	83	167	369	50	728	317	0
	4	26	289	0	1847	113	288	0	4	23	683
2002	1	44	208	0	988	17	47	0	0	0	0
	2	753	2507	596	697	51	251	1523	407	27	0
	3	25	1694	3509	37	224	505	66	1383	600	0
	4	34	1462	66	706	24	307	0	5	27	409
2003	1	42	419	0	520	11	27	0	0	0	0
	2	1046	2421	243	824	34	222	1863	539	16	0
	3	54	1074	588	80	58	477	60	2785	361	0
	4	63	3625	115	416	6	112	0	19	17	403
2004	1	47	94	0	182	5	93	0	0	0	0
	2	1509	1558	680	54	15	397	1714	2674	10	0
	3	60	53	4112	78	114	253	77	6120	39	0
	4	191	1508	0	1868	94	152	0	129	0	421

Table 3 Continued.

Year	Quarter	Fleet 1; JLL	Fleet 2; SPPS	Fleet 3; TPS	Fleet 4;TR	Fleet 5; PL	Fleet 6; SN	Fleet 7; TWLL	Fleet 8; EPOCOM	Fleet 9; EPOSP	Fleet 10; OTH
2005	1	44	936	0	1173	164	173	0	0	0	0
	2	1706	1444	1562	906	319	1334	1368	1950	16	0
	3	53	3223	2309	293	171	544	27	2754	63	0
	4	88	2380	0	1034	30	132	0	59	0	413
2006	1	25	311	0	513	68	196	0	247	0	0
	2	977	2028	1413	85	22	808	1148	5469	20	0
	3	50	144	2464	251	315	358	0	3999	83	0
	4	46	1267	13	695	17	192	0	91	3	331
2007	1	116	601	0	228	32	252	0	0	0	0
	2	2003	915	1309	70	5	411	1206	1386	5	0
	3	118	466	1737	101	238	593	0	2724	9	0
	4	81	1914	13	1985	105	300	0	81	1	1013
2008	1	111	704	0	1120	12	393	0	0	0	0
	2	750	2362	1909	297	28	882	847	1784	6	0

Table 4 Updated Taiwanese Longline CPUE.

Calender Year	Absolute CPUE	Lower CPUE	Upper CPUE
1999	0.41	0.36	0.46
2000	0.34	0.30	0.38
2001	0.20	0.18	0.22
2002	0.12	0.11	0.14
2003	0.17	0.15	0.20
2004	0.17	0.16	0.19
2005	0.09	0.08	0.10
2006	0.11	0.10	0.12
2007	0.14	0.12	0.16
2008	0.12	0.11	0.14

Table 5 Specification of each sensitivity run.

Name	SS3 version	Catch data	CPUE	Size data
Run 1				
Run 2	*			
Run 3	*	*	*	*
Run 4	*	*		
Run 5	*	*	*	
Run 6	*	*		*

Name	SS3 version	Catch data	CPUE			Size data									
			TR	JLL	TWLL	TR	PL	SPS	SN	EPOCOM	EPOSP	TPS	JLL	TWLL	OTH
Run 7	*	*		*	*	*	*	*	*	*	*	*	*	*	*
Run 8	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Run 9	*	*	*	*		*	*	*	*	*	*	*	*	*	*
Run 10	*	*	*	*	*		*	*	*	*	*	*	*	*	*
Run 11	*	*	*	*	*	*		*	*	*	*	*	*	*	*
Run 12	*	*	*	*	*		*		*	*	*	*	*	*	*
Run 13	*	*	*	*	*	*	*	*		*	*	*	*	*	*
Run 14	*	*	*	*	*	*	*	*	*		*	*	*	*	*
Run 15	*	*	*	*	*	*		*	*	*		*	*	*	
Run 16	*	*	*	*	*	*	*	*	*	*			*	*	*
Run 17	*	*	*	*	*	*		*	*	*	*	*			
Run 18	*	*	*	*	*	*	*	*	*	*	*	*	*		*
Run 19	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

Table 6 Likelihood values obtained for different version of SS3.

	Fleet	Run 1	Run 2
CPUE	11	-45.912	-45.493
	14	-136.408	-138.028
	15	-104.736	-104.705
	20	-7.391	-7.307
	23	7.955	8.460
	24	82.420	84.596
Sum		-204.071	-202.477
Length composition	1	901.537	902.285
	2	419.383	418.983
	3	793.092	793.031
	4	796.563	796.607
	5	126.802	126.767
	6	559.174	558.702
	7	173.754	173.646
	8	632.175	631.821
	10	2.273	2.271
Sum		4404.750	4404.110
Catch		0.095	0.084
Equil_catch		0.007	0.007
Recruitment		8.298	8.687
Softbounds		0.009	0.010
TOTAL		4209.090	4210.420

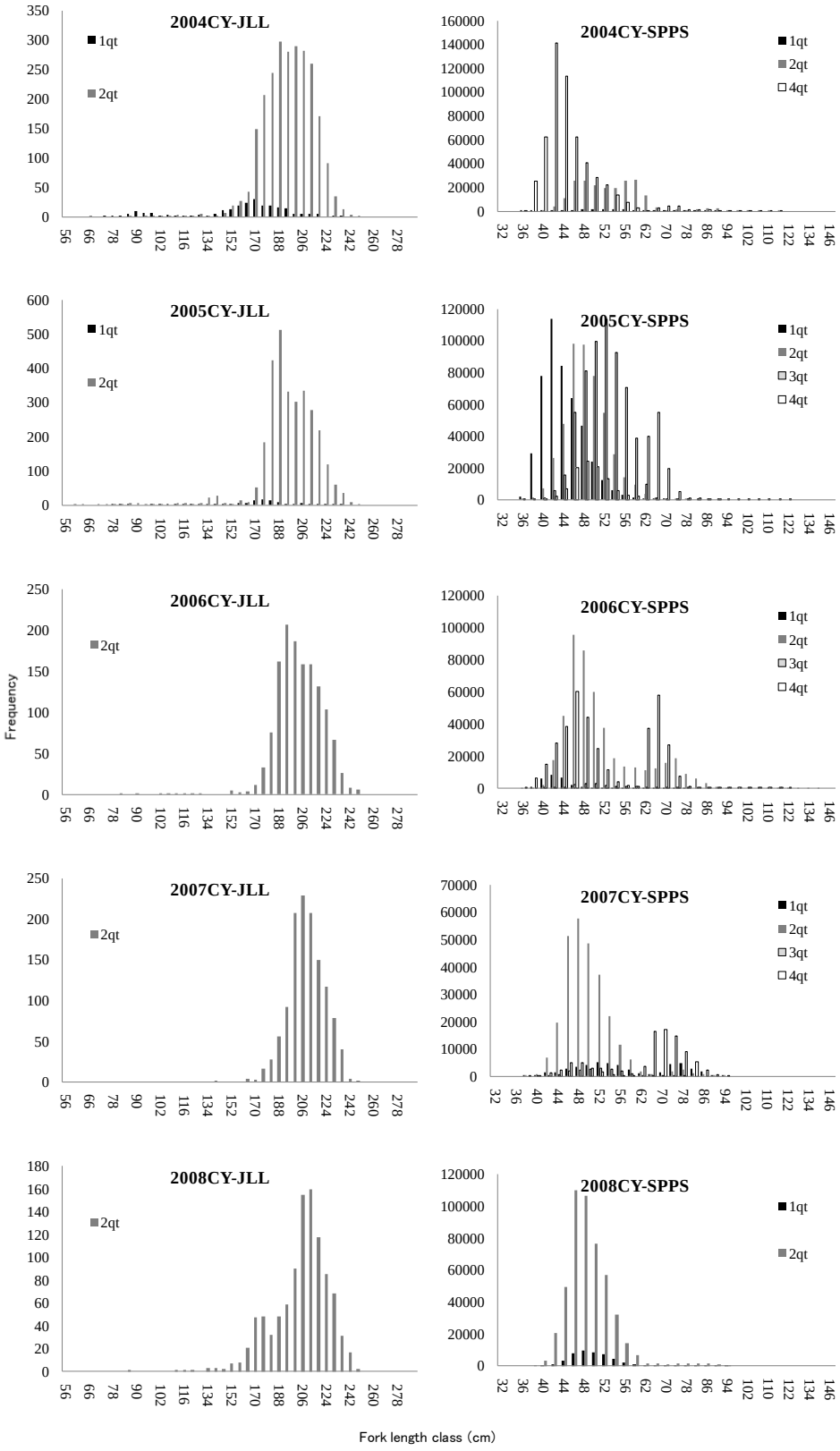

Fig. 1 Length frequency of each fleet.

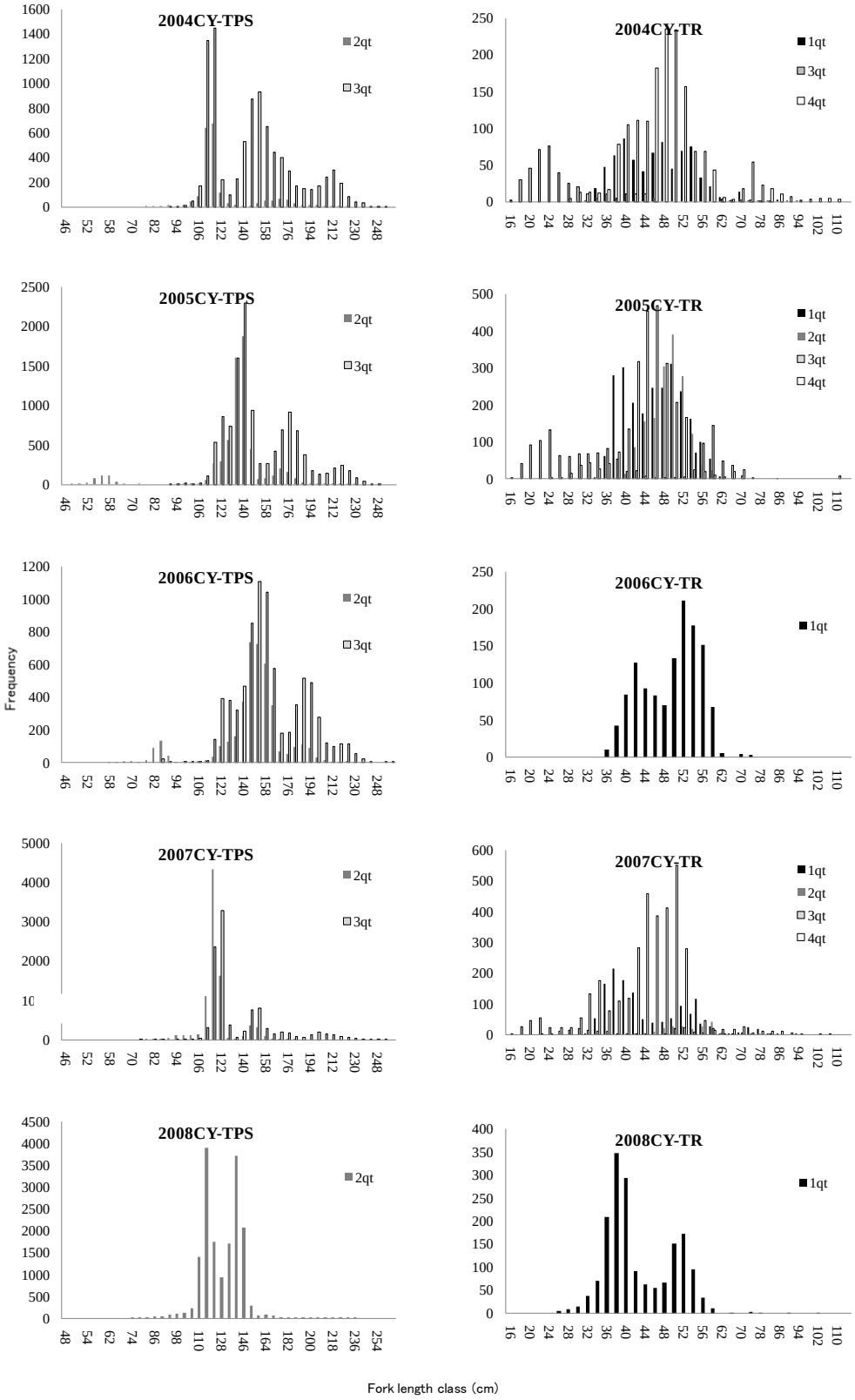

Fig. 1 Continued.

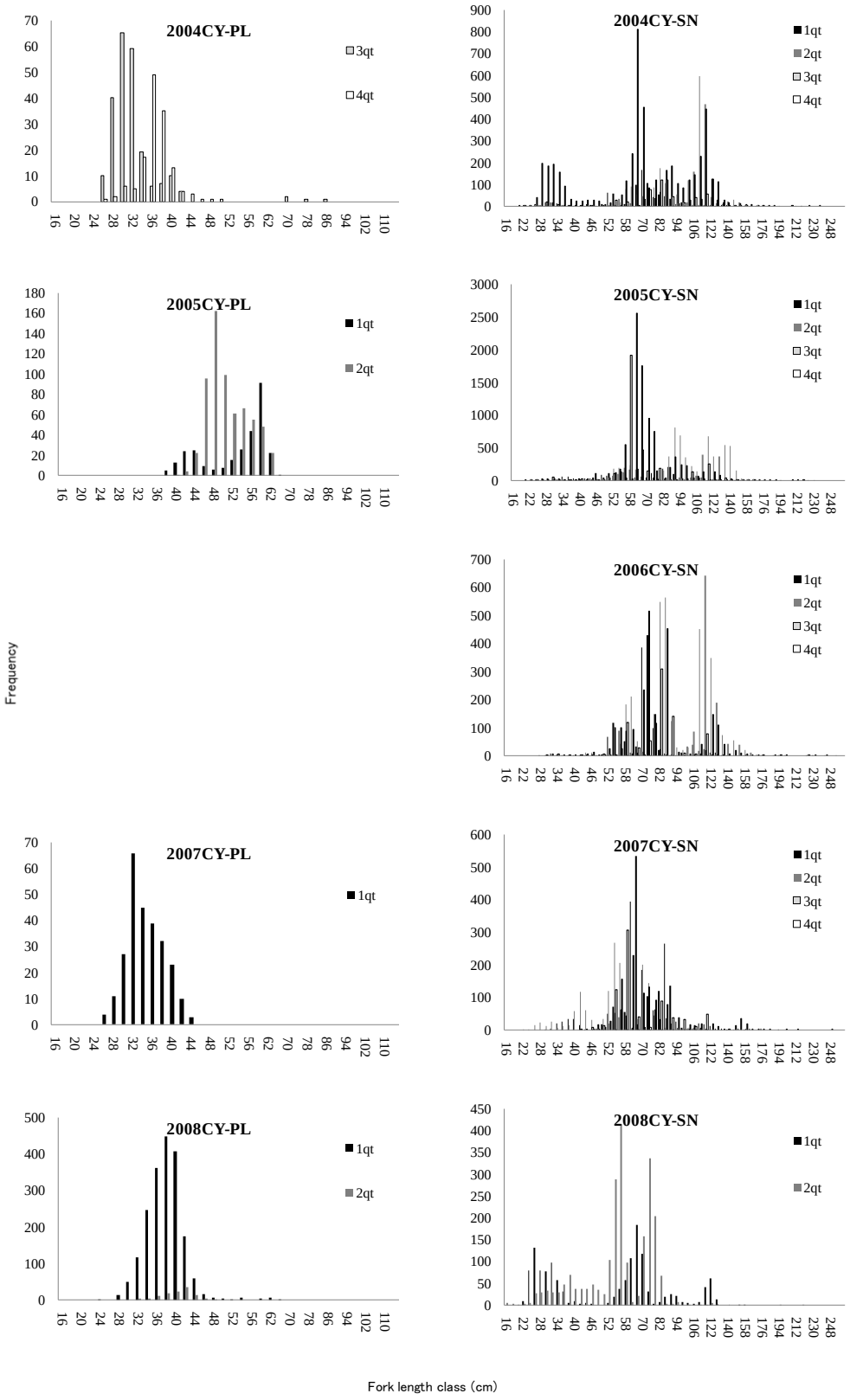

Fig. 1 Continued.

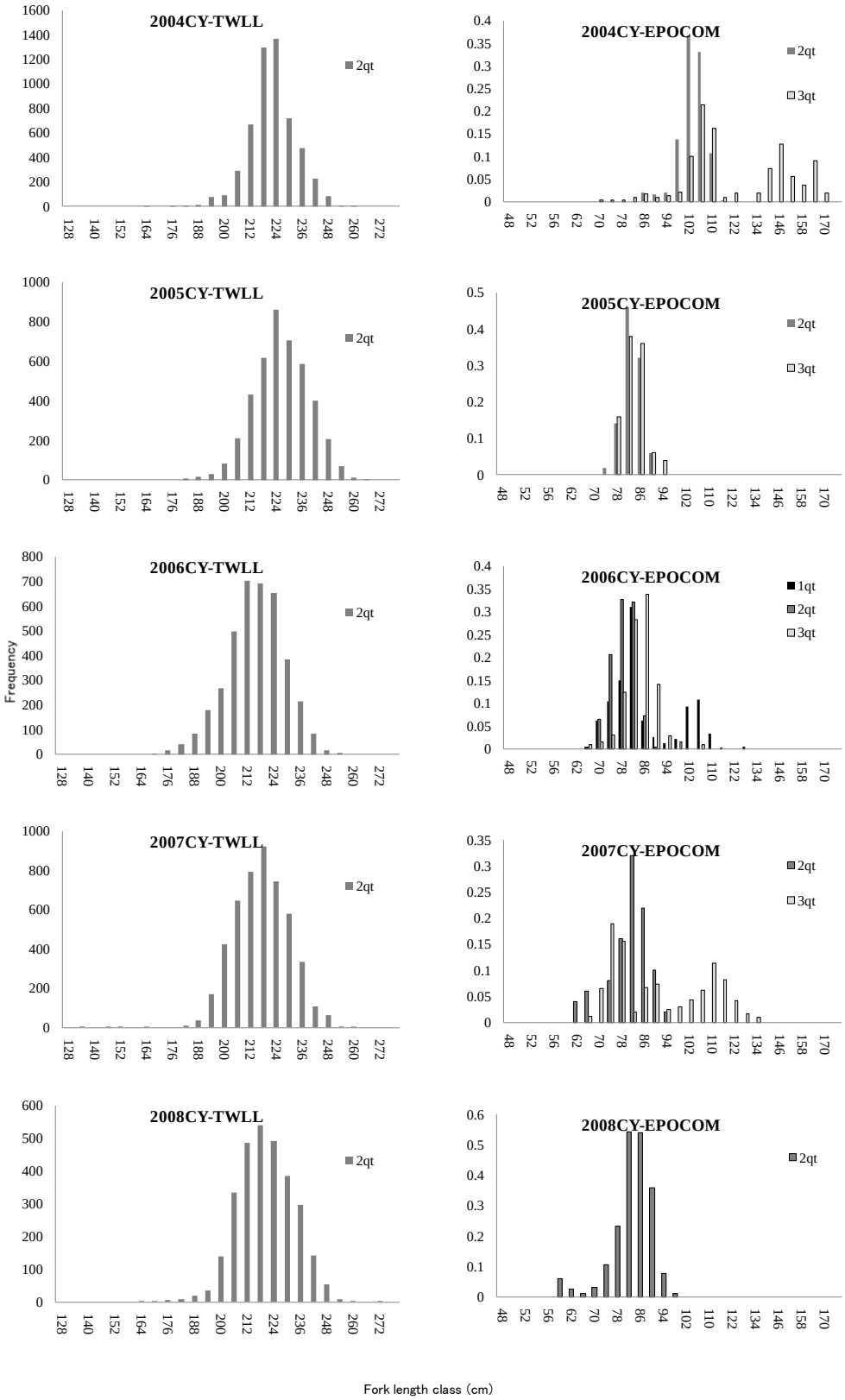

Fig. 1 Continued.

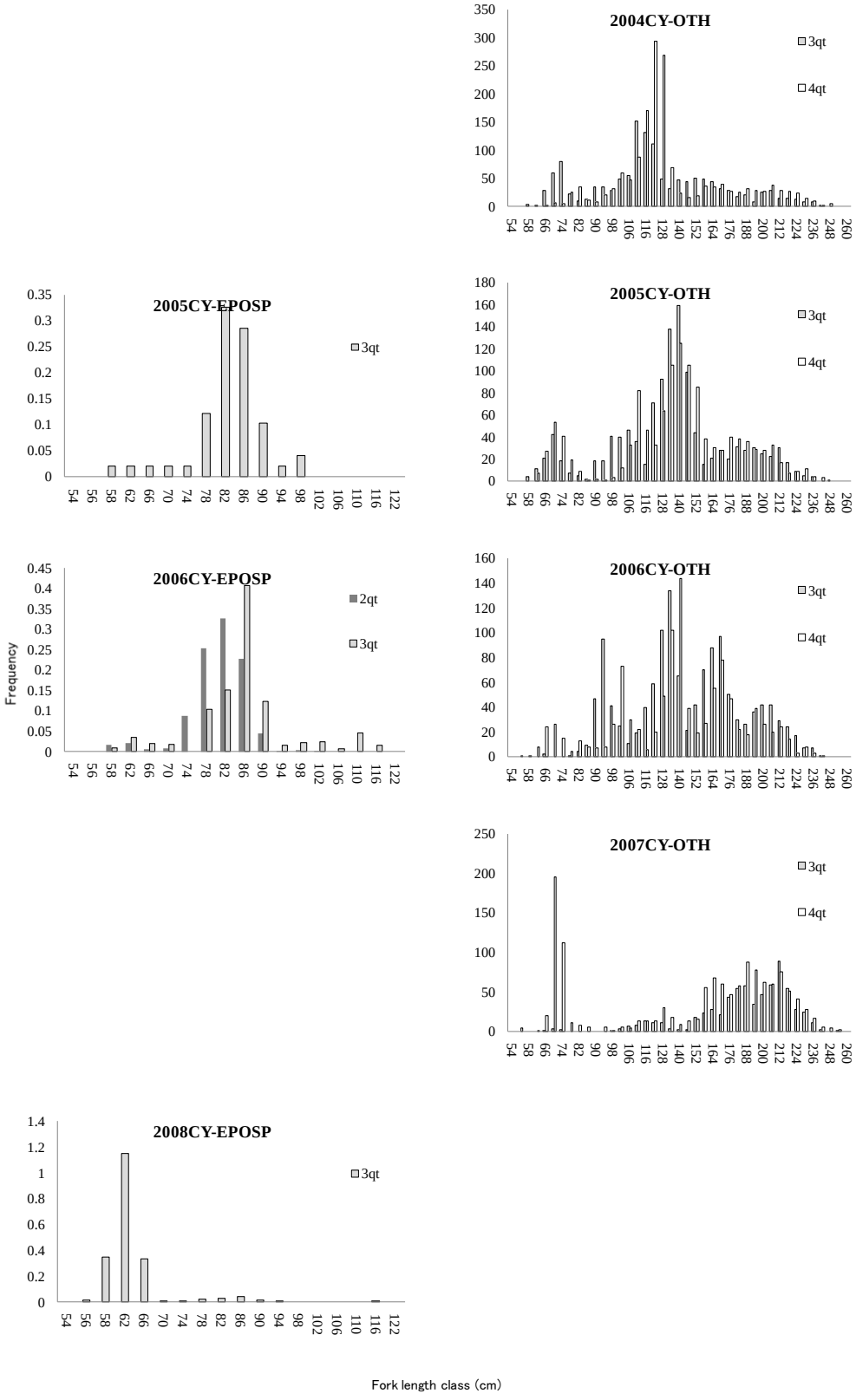

Fig. 1 Continued.

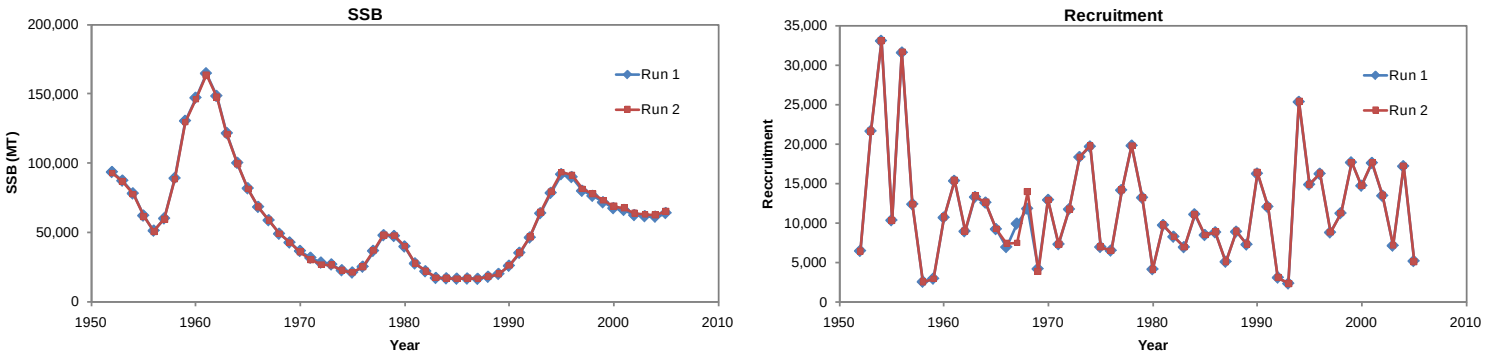

Fig. 2 Trajectories of SSB (upper panel) and recruitment (lower panel) estimated in Runs 1 and 2.

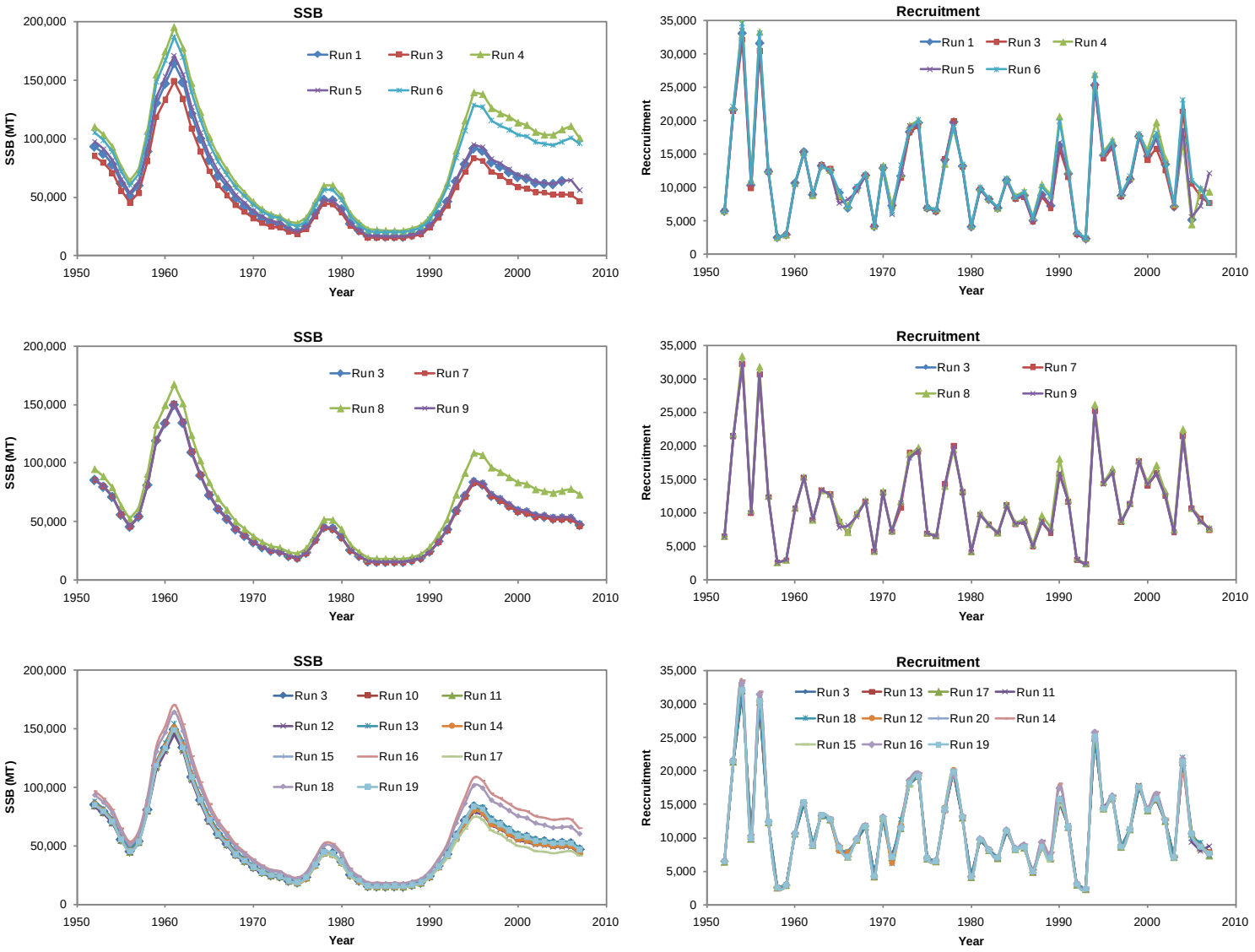

Fig. 3 Trajectories of SSB and recruitment estimated in Runs 1 and 3-19. Upper, middle and lower panels show comparison of outputs between Runs 1 and 3-6, Runs 3 and 7-9 and Runs 3 and 13-19, respectively.

Appendix

CPUE standardization of Japanese coastal longline and troll fisheries

Methods

Methods to standardize CPUEs including covariates considered have not been changed from the method used in the previous estimates. Following the methods used in the previous analysis, delta-type two-step method is used for standardizing CPUE in coastal longline fisheries (Ichinokawa 2007), and simple lognormal generalized linear model (GLM) is used in coastal troll fisheries (Yamada and Oshima 2007). Interaction effects used in the standardizing model are also same as those used in the previous analysis, without conducting model selection.

Efforts, PBF catch and nominal CPUE are compared with to the previous series in **Table A1** for coastal longline CPUEs, and nominal CPUE data are shown in **Table A2** for coastal troll fisheries. An apparent technical error was found in the troll data for December 1987 at Kami-agata area, have been corrected. In addition, CPUE data at Izuhara area for the fishing year of 2007 could not obtained, because of mix-up due to the recent renewal of electronic data collecting system in the fishery association at Izuhara area. Nevertheless, the updated CPUEs could be calculated until 2007 even without the data from Izuhara in 2007, since no interaction effect of area and year are assumed in standardization. Although the updated CPUE of Japanese troll fishery used exactly the same statistical model, this series have to improved, because of various difficulties found in fishery data and statistical model through this CPUE standardization. A major updates of fishery data and statistical methods are planned for the use at the next regular stock assessment in 2012.

Results

The updated CPUEs in the Japanese coastal longliners (**Fig. A1**, **Table A3**) indicate relatively low level of CPUE has occurred since 2005. In particular, standardized CPUE for 2008 is approximately 1/3 of the highest CPUE observed in fishing year of 1993, although CPUE for 2007 slightly increases from that for 2006.

The updated CPUEs in troll fisheries are shown in **Table A3** and **Fig. A2**. Absolute standardized CPUEs have changed for 1987, 2000 and 2005 from the previous estimates (**Fig. A3**). While changes of the values in 1987 and 2005 can be explained by revision and updates of the data (**Table A2**), higher estimation of CPUE in 2000 cannot be explained directly by revision of the data. This probably attributes to indirect effect of the changes of parameters estimated in GLM by adding newly updated data, since uncertainty of the standardized CPUE can be considered to be relatively high judging from 90% confidence intervals of the estimated CPUEs (**Fig. A3**).

References

Ichinokawa, M. 2007. An update of standardized CPUE for North Pacific bluefin tuna caught by Japanese coastal longliners. ISC/07/PBF-WG-3/18. p. 12.

Yamada, H., and Oshima, K. 2007. An Updated of Standardized CPUE of age-0 Pacific Bluefin Tuna by Japanese Troll Fisheries. ISC/07/PBF-3/17. p. 11.

Table A1 Total number of data used in the updated CPUEs in Japanese longliners in comparison with those used in the previous estimates in ISC/07/PBF-WG-3/18 (Ichinokawa 2007). Note that, because the coastal longline CPUE is derived from the fishery data from April to June, the calendar year of 1994-2008 is corresponding to the fishing year of 1993-2007.

		Data used in ISC/07/PBF-WG-3/18			Updated data		
Calender Year	Fishign year	Efforts	Catch of PBF	Nominal CPUE	Efforts	Catch of PBF	Nominal CPUE
1994	1993	5049	2768	0.55	5072	2768	0.55
1995	1994	4286	1530	0.36	4358	1561	0.36
1996	1995	4523	2265	0.50	4557	2284	0.50
1997	1996	4813	2251	0.47	4906	2306	0.47
1998	1997	5472	2674	0.49	5634	2719	0.48
1999	1998	8922	3663	0.41	9240	3799	0.41
2000	1999	8104	2199	0.27	8343	2267	0.27
2001	2000	9167	1795	0.20	9553	1847	0.19
2002	2001	8358	2006	0.24	9360	2115	0.23
2003	2002	6685	2336	0.35	7948	2575	0.32
2004	2003	8254	3159	0.38	9326	3413	0.37
2005	2004	7462	3333	0.45	8754	3767	0.43
2006	2005	5882	1499	0.25	8130	1927	0.24
2007	2006	-	-	-	8042	3113	0.39
2008	2007	-	-	-	8552	1501	0.18

Table A2 Raw CPUE data (kg/landing vessel) derived from Japanese troll fisheries conducting in the north of East China Sea, which is used for estimating updated standardized CPUEs. This aggregated data by year, month and 3 defined regions are actual raw input data for GLM. Notation besides each year of 'old' and 'new' represents that the data has revised from the data previously used in ISC/07/PBF-3/17 (old) to updated data (new). In particular, the columns shaded by gray colors are the revised data. The data in the hatched columns (Sept. 2008-Dec. 20008) are not used in this analysis since fishing year of 2007 in this table ends April 2008. The month and year are expressed by calendar year. Blank column suggest no data, and the columns with zero are zero catch.

	Kami-agata Area								Izuhara Area								Goto Area							
Year \ Month	1	2	3	4	9	10	11	12	1	2	3	4	9	10	11	12	1	2	3	4	9	10	11	12
1980						22.2	62.7	2.6						18.1	20.2	65.0							25.9	40.7
1981					146.9	75.3	76.8	61.9						63.6	113.8	76.2	40.3	38.8	28.8			15.7	32.9	45.5
1982					42.9	23.7	42.1						1.1	11.9	15.1	18.4	39.2	43.3	62.9	55.1		28.9	10.2	21.7
1983					25.4	28.5	106.7	70.6					16.5	12.1	81.0	42.4	51.5	41.8				1.2	23.3	42.6
1984						53.8	37.8	56.4					20.7	28.1	28.0	35.8	28.0	42.2	39.7				24.5	31.9
1985						35.6	56.1	48.6					13.8	31.0	49.4	59.7	41.1	28.0	31.3	20.0			53.2	47.2
1986						23.4	17.7	17.0					10.8	3.0	3.1	14.0	30.9	21.3	8.3				15.0	27.5
1987(old)					16.4	65.4	34.1	345.6	22.9				33.8	31.3	25.4	29.9	28.8	21.2	21.6	6.0			22.4	17.2
(new)					16.4	65.4	34.1	40.8	22.9				33.8	31.3	25.4	29.9	28.8	21.2	21.6	6.0			22.4	17.2
1988					23.1	68.5	41.9	36.8					20.3	17.8	26.3	11.0	13.3	10.4	6.3				96.1	30.4
1989					36.5	53.0	46.3	35.1					12.2	15.8	23.9	19.6	19.5	10.0	7.4	23.9			23.7	22.8
1990	51.6					63.7	90.7	57.0							27.0	30.2	18.0	13.6	13.1	31.5				19.5
1991	90.7				4.1	7.9	58.2	35.2	86.8					19.7	19.2	12.1	29.5	25.2	44.7	18.7			39.5	21.9
1992							38.2	18.2							14.4	3.6	35.8					11.7	14.1	10.6
1993					18.7	14.6	36.6	27.0	20.0				20.2	11.2	32.2	20.8	8.0	5.7	11.2	8.4			19.3	7.3
1994	20.0				114.6	113.6	122.8	210.9	9.7				70.7	93.7	53.8	83.5	7.9	4.2	30.8	16.8		40.5	46.4	53.9
1995	228.8	190.8	15.8		34.0	1.9	7.9	18.4	98.9								146.7	133.3	68.0	44.4		68.4	21.5	25.2
1996	16.0				96.6	121.0	84.4	120.0					34.8	66.6	62.1	72.0	39.2	25.5	29.1	51.8	45.2	32.8	33.9	44.4
1997	64.9	33.7		27.9	4.2	6.1	12.0	41.4	36.0	23.9				10.2	12.8	27.6	67.2	76.0	89.3	80.6				45.6
1998	24.5				15.9	50.0	60.1	70.3	15.4			0.0	0.0	12.2	32.5	40.3	37.9	66.9	58.7	29.4	11.3	18.9	7.8	16.7
1999	71.4	47.3			72.9	17.1	185.4	135.8	38.2	19.0					106.5	72.1	64.5	46.9	56.6	51.9			9.5	43.7
2000	102.8	64.3	36.0			183.4	138.6	47.0	73.1	61.6	42.3			154.7	85.5	55.0	77.0	57.4	53.4	61.7				
2001	200.8	47.9	24.7			2.3	86.7	98.1	114.8	28.2	13.4			15.4	32.7	78.2	70.0	21.4	15.6	18.9				46.8
2002	82.0	16.7				14.1	16.4	32.8	99.0	29.6				4.7	6.5	11.5	72.5	30.9	13.3	15.7				14.6
2003	40.1	42.6						15.9	67.9	48.6	44.0	5.6		89.5	142.8	16.1	27.6	43.9	45.8	34.7				3.4
2004	35.0					24.4	48.5	90.7	35.1	16.5	17.5	4.2	11.1	608.3	45.1	96.9	22.2	24.4		35.5			21.7	15.6
2005(old)						75.6	64.1	33.6	112.7	16.2	0.0	7.2	0.0	61.1	65.8	27.8	52.6	75.0	101.3	87.3			0.1	76.8
(new)	152.0					75.6	64.1	33.6	112.7	16.2	0.0	7.2	0.0	61.1	65.8	27.8	52.6	75.0	101.3	87.3			13.9	76.8
2006(old)						57.2	29.4	16.8	32.8	104.3			0.0	66.3	19.7	20.0	66.4							14.4
(new)						57.2	29.4	16.8	32.8	104.3			0.0	66.3	19.7	20.0	22.7	24.7	15.6	81.5	2.5	4.1	1.5	13.0
2007(old)									9.4	5.4	0.0						21.4							
(new)						69.0	68.2	90.5	9.4	5.4	0.0						17.6	10.1	13.9	25.0	5.0	5.0	11.7	60.7
2008(new)	54.7	38.2					79.0	19.2									85.9	52.4	52.9	51.6	6.4	8.3	33.9	19.1

Table A3 The updated CPUEs derived from Japanese coastal longline and troll fisheries to be used for the updated stock assessment. The updated CPUEs and CV of those estimates ('Updated') are compared with that used in the previous stock assessment ('Previous').

Fishing Year	Japanese coastal longline				Japanese troll (East-China Sea)			
	Updated		Previous		Updated		Previous	
	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV
1980	-	-	-	-	28.2	0.38	28.5	0.40
1981	-	-	-	-	59.1	0.33	59.7	0.35
1982	-	-	-	-	20.7	0.36	20.8	0.38
1983	-	-	-	-	29.9	0.33	30.1	0.35
1984	-	-	-	-	34.9	0.35	35.2	0.37
1985	-	-	-	-	36.2	0.36	36.4	0.38
1986	-	-	-	-	15.1	0.33	15.2	0.35
1987	-	-	-	-	24.0	0.35	28.5	0.37
1988	-	-	-	-	25.7	0.33	25.9	0.35
1989	-	-	-	-	25.5	0.32	25.7	0.34
1990	-	-	-	-	43.0	0.36	43.4	0.38
1991	-	-	-	-	20.7	0.40	20.9	0.42
1992	-	-	-	-	12.7	0.36	12.8	0.39
1993	0.353	0.017	0.353	0.017	16.8	0.31	16.9	0.33
1994	0.252	0.017	0.248	0.017	84.9	0.28	85.6	0.30
1995	0.323	0.017	0.317	0.017	19.8	0.36	20.2	0.39
1996	0.310	0.017	0.305	0.018	57.2	0.27	57.6	0.29
1997	0.303	0.017	0.301	0.017	13.2	0.32	13.3	0.34
1998	0.218	0.013	0.222	0.013	21.9	0.28	22.0	0.29
1999	0.164	0.012	0.163	0.013	58.8	0.29	59.3	0.31
2000	0.129	0.010	0.130	0.011	55.4	0.31	40.2	0.33
2001	0.144	0.011	0.153	0.011	35.0	0.32	35.2	0.34
2002	0.224	0.013	0.238	0.014	24.5	0.30	24.6	0.32
2003	0.244	0.012	0.247	0.012	26.8	0.35	26.7	0.37
2004	0.294	0.013	0.295	0.014	34.7	0.29	34.7	0.31
2005	0.151	0.012	0.148	0.014	26.7	0.32	18.5	0.38
2006	0.204	0.013	-	-	6.4	0.29	6.6	0.39
2007	0.121	0.011	-	-	34.2	0.35	-	-

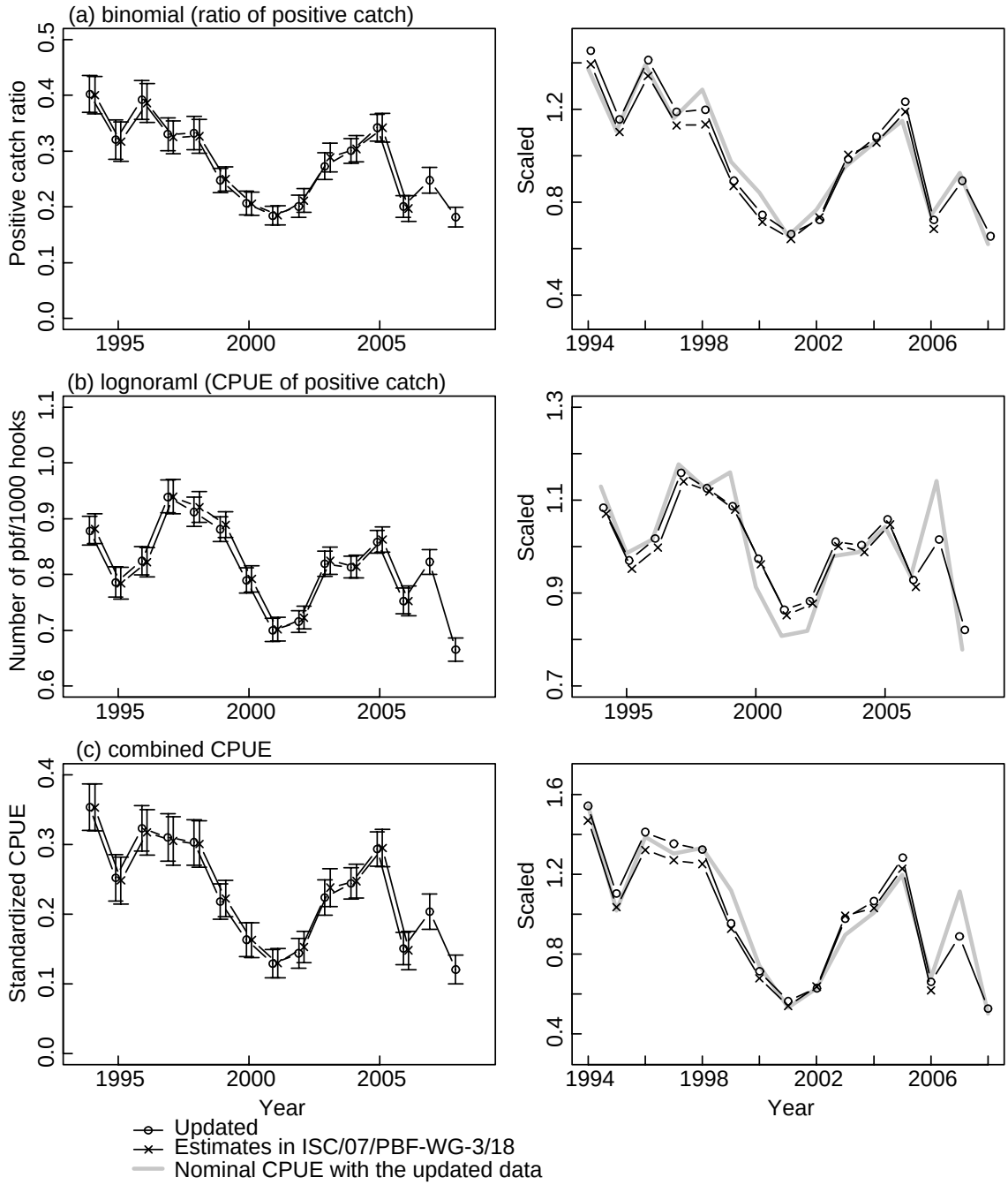

Fig. A1 Standardized zero catch rates (a), positive catch (b) and combined CPUEs (c). The right figures show standardized CPUE, and left panels show the CPUEs normalized with averages. Gray lines with crosses: previous estimates up to 2006, and black lines with circles: new estimates up to 2009, red lines: nominal CPUEs.

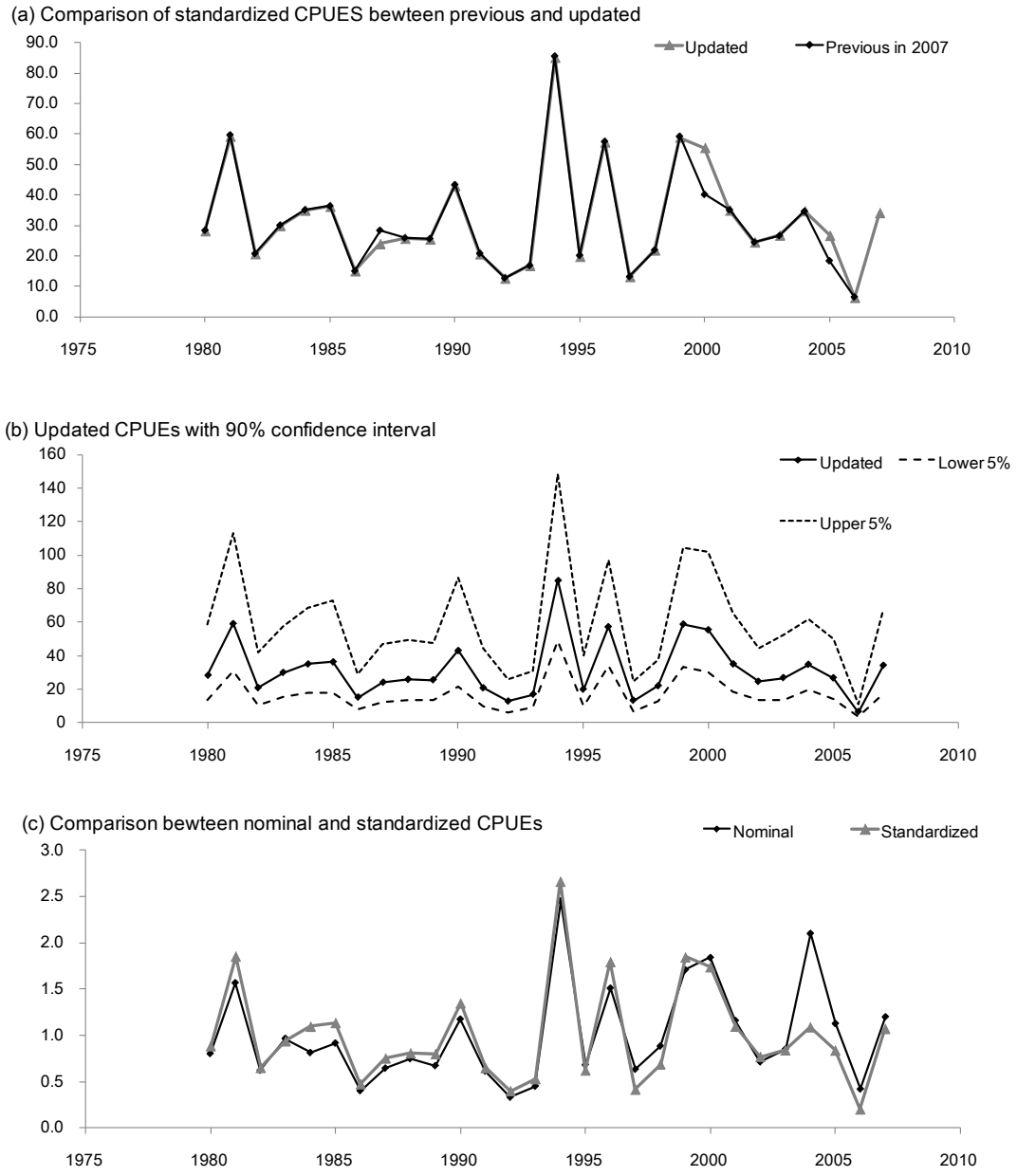

Fig. A2 Standardized CPUEs in comparison with previous estimates by Yamada and Oshima (2007) (a), 90% confidence intervals (b) and nominal CPUEs in coastal troll fisheries (c).