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Recruitment abundance indices of young Pacific bluefin tuna revealed by Japanese Troll Fisheries[1]

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[1] Time series of standardized CPUE proposed in the text were estimated through mistaken model selection. Errors were detailed in Appendix 2 of this document.
Revised CPUE time series were used for the stock assessment.

Summary

In order to determine the yearly trends of abundance indices of young Pacific bluefin tuna (PBF), CPUE derived from Japanese troll fishery operated in the East China Sea (off Nagasaki prefecture) were standardized for the period of 1980-2012. The standardized CPUE were standardized based on the same procedures and assumptions as previous studies (Ichinokawa et al. 2012, Oshima et al. 2013). The standardized CPUE shows similar trend with the previous CPUE until 2011, and then greatly decreased in 2012. The CPUE in 2012 is the historically second lowest.

Introduction

Japanese troll fisheries have been operating for mostly age-0 PBF in the western and southern coastal areas of Japan. Ichinokawa et al. (2012) provided three time series of standardized CPUE of troll fisheries operated off Nagasaki, Kochi and Wakayama. In the 2012 stock assessment of PBF, the ISC-PBFWG decided to select the CPUE time series off Nagasaki as a representative CPUE for the troll fishery.

In this document, we updated CPUE off Nagasaki up to 2012 following the procedure of previous studies (Ichinokawa et al. 2012, Oshima et al. 2013).

Materials and Methods

Data source of catch and effort was identical with that used in Ichinokawa et al. (2012) (Table 1). Briefly, the catch-and-effort data were obtained at the 5 main fishing ports (Kamitsushima, Kamiagata, Are, Ojika, Tomie) in Nagasaki during 1980-2012. Generalized liner model (GLM) with lognormal error distribution was applied, because there were no zero-catch data. Response variable is log (CPUE) and explanatory variables are fy (fishing year), ports (fishing ports), fm (fishing month) and all possible second-order interactions. The GLM was carried out through GLM procedure of SAS 9.3. The best model was determined based on BIC. The standardized CPUE was calculated from least squire (marginal) mean of ‘fy’ effect. The explanatory variables used for the standardization were as follows:

1) Fishing year (fy); 1980-2012. Fishing year is starting from July and ending to June.
2) Fishing month (fm); aligned with fishing year
3) Port; five ports. These ports are located in Goto and Tsushima Islands.

Results and Discussions

The final model included the effect of ‘fy’ and ‘fm*port’ (Table 2). Residuals distributed approximately with mean of zero, although those distributions showed slightly left-skewed shapes (Fig. 1). Standardized CPUE, CV and 95% confidence limits are listed in Table 3. Range of CV was between 0.02 and 0.04, rarely different from that in Oshima et al. (2013). Figure 2 shows time-series of nominal CPUE and standardized CPUE estimated in this study and standardized CPUE provided by the

previous study (Oshima et al. 2013). The standardized CPUE and nominal CPUE from 2011 to 2012 were both decreased at this time. In 2012, the standardized CPUE was the historically second lowest for the past 1993, and the nominal CPUE value was the third lowest subsequent to the year 1992 and 1993 (Table 3). The annual trend of CPUE in this study did not changed from that by previous studies (Ichinokawa et al. 2012, Oshima et al. 2013). Downward trend of the standardized CPUE has continued the recent five years during 2008-2012 (Table 3). In addition, the standardized CPUE and nominal CPUE in Kochi were also suggested decreasing trends from 2011 to 2012 at the same periods (See Table A-4 and Fig. A-1 of Appendix).

References

Ichinokawa, M., Oshima, K. and Takeuchi, Y. (2012) Abundance indices of young Pacific bluefin tuna, derived from catch-and-effort data of troll fisheries in various regions of Japan. ISC/12-1/PBFWG/11.

Oshima, K., Fujioka, K, Ichinokawa, M. and Takeuchi, Y. (2013) Updated Japanese troll CPUE targeting age 0 PBF through 2011. ISC/13/PBFWG/Appendix C.

Table 1 Total catch (mt), effort (boat-day) and CPUE (kg/boat-day) by year and by fishing port, recorded in catch-and-effort data used for standardization of CPUE in Nagasaki Prefecture.

Fishing year	Catch (mt)						Effort (boat-day)						CPUE (kg/boat-day)					
	Kami-tsushima	Kami-agata	Are	Ojika	Tomie	Total	Kami-tsushima	Kami-agata	Are	Ojika	Tomie	Total	Kami-tsushima	Kami-agata	Are	Ojika	Tomie	Total
1980	11.2	18.2	7.2	11.4	210.4	258.3	142	339	670	723	5330	7204	78.7	53.7	10.7	15.7	39.5	35.9
1981		118.1		125.7	423.0	666.8		1633		2952	9740	14325		72.3		42.6	43.4	46.5
1982	8.9	45.9	14.3	17.9	62.5	149.5	274	1503	694	725	1301	4497	32.4	30.5	20.7	24.7	48.1	33.3
1983	153.4	350.9	51.3	102.4	242.9	900.9	2012	3958	1756	2278	6264	16268	76.2	88.7	29.2	45.0	38.8	55.4
1984	63.5	355.0	72.8	132.6	482.2	1106.2	1130	6715	1591	3381	12383	25200	56.2	52.9	45.8	39.2	38.9	43.9
1985	85.0	130.8	78.3	91.4	182.7	568.1	1035	2470	1753	1787	6932	13977	82.1	53.0	44.6	51.1	26.4	40.6
1986	24.0	130.5	67.0	77.3	378.5	677.2	338	2420	1729	2367	11457	18311	70.9	53.9	38.7	32.6	33.0	37.0
1987	23.2	132.3	14.3	15.1	115.1	300.0	447	2502	500	658	4406	8513	51.8	52.9	28.6	23.0	26.1	35.2
1988	37.3	150.3	6.0	51.1	281.2	525.9	555	2465	283	1079	9115	13497	67.3	61.0	21.1	47.3	30.8	39.0
1989	36.1	81.2	17.4	24.8	119.5	279.0	696	1583	776	868	5744	9667	51.8	51.3	22.4	28.6	20.8	28.9
1990	145.4	173.2	46.3		240.9	605.8	1537	1739	903		6733	10912	94.6	99.6	51.3		35.8	55.5
1991	95.5	111.7	44.0	127.1	79.0	457.3	1008	1603	865	2195	1546	7217	94.7	69.7	50.9	57.9	51.1	63.4
1992	23.1	12.9	1.9	15.1	66.4	119.4	630	446	234	953	2416	4679	36.7	29.0	8.0	15.9	27.5	25.5
1993		60.1	17.8	4.9	42.4	125.2		2040	986	487	1810	5323		29.4	18.0	10.1	23.4	23.5
1994		874.2	105.3	426.3	464.1	1869.9		5719	1343	3668	5363	16093		152.9	78.4	116.2	86.5	116.2
1995		243.4		41.0	104.6	389.0		2055		1116	2981	6152		118.4		36.7	35.1	63.2
1996		507.1	104.5	127.6	340.5	1079.8		4793	1543	2065	6134	14535		105.8	67.7	61.8	55.5	74.3
1997	59.1	138.8	23.4	39.5	90.4	351.2	690	2605	761	767	2334	7157	85.6	53.3	30.7	51.6	38.7	49.1
1998	196.0	268.8	45.4	21.5	234.3	766.0	2348	3908	1236	399	4525	12416	83.5	68.8	36.7	53.9	51.8	61.7
1999		355.9	101.8	74.7	202.0	734.4		2691	1167	833	4294	8985		132.3	87.3	89.6	47.1	81.7
2000	207.2	318.3	113.4	48.2	48.4	735.5	1353	2216	1213	668	2571	8021	153.1	143.6	93.5	72.2	18.8	91.7
2001	163.8	159.3	76.4	48.0	87.5	535.1	1682	1729	1111	776	1582	6880	97.4	92.2	68.8	61.8	55.3	77.8
2002	44.4	69.1	34.5	24.6	105.5	278.2	951	1495	902	806	2725	6879	46.7	46.2	38.3	30.5	38.7	40.4
2003	68.5	8.1	30.0	13.0	18.0	137.6	842	239	631	357	853	2922	81.3	33.8	47.6	36.4	21.2	47.1
2004	188.2	324.1	83.4	40.0	117.5	753.3	1478	3101	923	692	2304	8498	127.3	104.5	90.4	57.7	51.0	88.6
2005	125.9	68.2	15.2	23.6	22.5	255.4	1014	721	365	354	550	3004	124.1	94.6	41.8	66.5	40.9	85.0
2006	30.7	20.0	9.5	0.4		60.7	437	490	231	28		1186	70.4	40.8	41.3	16.0		51.2
2007	91.8	163.8	22.6	29.8	5.3	313.3	753	1920	376	393	64	3506	121.9	85.3	60.1	75.9	82.6	89.4
2008	142.0	53.8		60.9	179.7	436.3	854	760		792	2668	5074	166.3	70.8		76.9	67.3	86.0
2009	75.6		35.7	5.3	97.3	213.9	693		743	175	1339	2950	109.1		48.0	30.1	72.7	72.5
2010	76.7	171.9	14.7	6.5	115.3	385.1	806	2350	439	135	2119	5849	95.1	73.2	33.4	48.4	54.4	65.8
2011	96.9	216.6	13.2	1.7	28.7	357.0	665	2286	195	55	979	4180	145.7	94.7	67.4	31.2	29.4	85.4
2012	0.3	62.2	18.9	3.2	8.4	93.0	12	1526	761	94	236	2629	27.4	40.8	24.8	33.6	35.6	35.4

Table 2 Type III analysis of the explanatory variables in the final model for CPUE standardization.

Efffects	df	Type Ⅲ SS	Mean squire	F value	Pr > F
fy	32	1212.2	37.9	40.5	<.0001
fm*port	31	1095.1	35.3	37.8	<.0001

Table 3 Total catch (mt), effort (boat-day) and CPUE (kg/boat-day) by year and by fishing port, recorded in catch-and-effort data used for standardization of CPUE in Nagasaki Prefecture. All CPUEs are scaled by each average.

Fishing year	Nominal CPUE	Record Number	Standardized CPUE				Oshima et al. (2013)	
			Estimation	CV	Lower 5%	Upper 5%	Estimation	CV
1980	0.58	255	0.66	0.03	0.55	0.79	0.65	0.02
1981	0.88	265	1.14	0.03	0.95	1.37	1.14	0.02
1982	0.56	183	0.58	0.04	0.48	0.71	0.58	0.03
1983	0.88	328	0.89	0.03	0.75	1.06	0.88	0.02
1984	0.74	396	0.89	0.03	0.75	1.05	0.88	0.02
1985	0.82	375	0.83	0.03	0.70	0.99	0.83	0.02
1986	0.70	492	0.95	0.03	0.81	1.12	0.94	0.01
1987	0.58	310	0.68	0.03	0.57	0.81	0.67	0.02
1988	0.70	356	0.77	0.03	0.65	0.92	0.77	0.02
1989	0.51	351	0.62	0.03	0.52	0.74	0.62	0.02
1990	1.16	333	1.23	0.03	1.03	1.46	1.22	0.02
1991	1.09	271	1.32	0.03	1.10	1.58	1.31	0.02
1992	0.48	308	0.57	0.03	0.48	0.68	0.57	0.02
1993	0.40	330	0.47	0.04	0.40	0.56	0.47	0.02
1994	1.76	439	1.97	0.02	1.67	2.33	1.96	0.01
1995	0.94	243	1.07	0.03	0.89	1.29	1.07	0.02
1996	1.18	448	1.60	0.02	1.36	1.89	1.59	0.01
1997	0.93	251	0.90	0.03	0.75	1.08	0.89	0.02
1998	0.96	350	0.82	0.03	0.69	0.97	0.81	0.02
1999	1.46	286	1.49	0.03	1.25	1.78	1.49	0.02
2000	1.55	273	1.15	0.03	0.96	1.38	1.14	0.02
2001	1.28	265	1.16	0.03	0.97	1.39	1.15	0.02
2002	0.72	275	0.73	0.03	0.61	0.88	0.73	0.02
2003	0.79	184	0.65	0.04	0.53	0.79	0.64	0.03
2004	1.48	369	1.29	0.02	1.09	1.53	1.28	0.01
2005	1.66	230	1.36	0.03	1.13	1.64	1.34	0.02
2006	1.04	106	0.71	0.04	0.56	0.90	0.70	0.03
2007	1.57	244	1.38	0.03	1.15	1.66	1.36	0.02
2008	1.65	285	1.44	0.03	1.20	1.72	1.43	0.02
2009	0.99	206	1.11	0.03	0.92	1.35	0.91	0.02
2010	1.08	324	1.09	0.03	0.92	1.30	1.08	0.02
2011	1.37	266	0.94	0.03	0.79	1.12	0.93	0.02
2012	0.49	231	0.52	0.03	0.43	0.62		

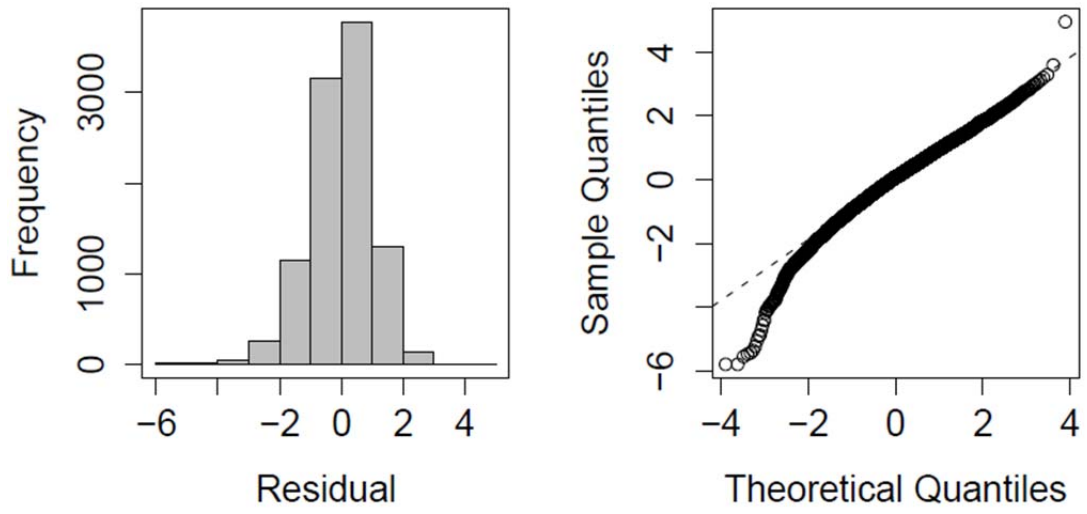

Fig. 1 Standardized residuals (left panel) and Q-Q plot of them (right panel).

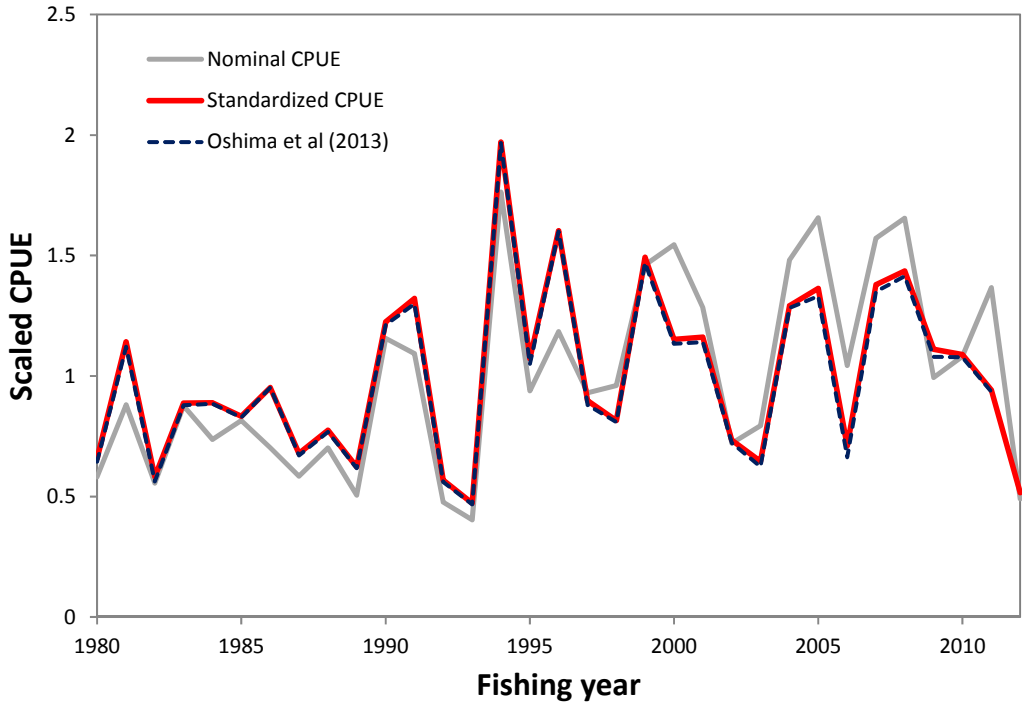

Fig. 2 Comparison of time series of CPUE. Gray and red lines indicates nominal and standardized CPUE from 1980 to 2012 fishing year. Broken line shows standardized CPUE estimated by Oshima et al. (2013).

Appendix

Update of CPUE from troll fishery operated off Kochi

In order to confirm decreasing of recruitment in recent years, CPUE time series of troll fishery off Kochi was updated up to 2012. Standardization of CPUE was conducted through the identical procedure applied in Ichinokawa et al. (2012). The time series of estimated CPUE depicted multi-peaked annual variation during the period of 1980-2012 (Fig. A-1). It also showed a remarkable decrease in 2012 as shown in the time series of CPUE off Nagasaki. The ISC-PBFWG decided to exclude the time series of CPUE off Kochi from recruitment abundance indices for the stock assessment model in the previous stock assessment. As a problem relevant to this time series, the stock assessment model had a poor fit to it due to its multi-peaked variation.

Table A-1 Total catch (mt), effort (boat-day) and CPUE (kg/boat-day) by year and by fishing port, recorded in catch-and-effort data used for standardization of CPUE in Kochi Prefecture.

Fishing year	Catch (mt)							Effort (boat-day)							CPUE (kg/boat-day)						
	Tosa-shimizu	Saga	Usa	Karyogo	Muroto	Kannoura	Total	Tosa-shimizu	Saga	Usa	Karyogo	Muroto	Kannoura	Total	Tosa-shimizu	Saga	Usa	Karyogo	Muroto	Kannoura	Total
1980			1.6				1.6			390				390			3.4				4.1
1981			27.2				27.2			3028				3028			4.9				9.0
1982			8.4				8.4			2369				2369			1.9				3.5
1983			1.1				1.1			1596				1596			0.5				0.7
1984			18.9				18.9			2357				2357			6.9				8.0
1985			1.1				1.1			1604				1604			1.8				0.7
1986			1.6				1.6			1319				1319			2.3				1.2
1987	0.2		1.1				1.3	3112		1350				4462	0.0		0.6				0.3
1988	21.0		4.9				25.9	4587		1952				6539	4.0		4.8				4.0
1989	0.7		18.7	0.1			19.5	5965		2779	880			9624	0.1		6.0	0.2			2.0
1990	53.0		1.9	6.0			60.9	6475		2191	4145			12811	5.5		2.4	1.3			4.8
1991	2.1		13.5	7.2			22.7	3809		2863	1910			8582	1.1		3.3	7.2			2.6
1992	3.6	0.0	0.3	5.9	0.0		9.7	5099	232	737	1440	1096		8604	1.8	0.1	0.3	4.2			1.1
1993	10.1	8.2	0.9	1.4	0.1	1.2	21.9	4209	702	522	1242	1487	1239	9401	2.0	11.7	1.1	2.5	0.0	1.6	2.3
1994	26.0	119.7	76.8	19.0	1.7	68.9	312.1	5742	4792	5484	1524	847	4496	22885	5.9	21.2	12.1	10.5	1.9	12.1	12.9
1995	10.4	16.9	3.0	3.4	0.7	10.1	44.5	1953	1892	803	513	1704	2640	9505	7.7	11.5	3.9	9.8	2.8	4.4	4.7
1996	7.1	92.1	17.4	1.6	0.3	19.7	138.1	5414	4869	2444	1122	1807	3361	19017	3.2	13.7	6.0	6.9	0.2	10.0	7.3
1997	14.3	9.7	1.7	0.1	0.0	1.5	27.4	5454	2293	1418	1106	882	1364	12517	6.4	8.2	1.2	0.3	0.0	0.8	2.2
1998	1.0	17.5	13.4	13.9	1.1	7.1	53.9	3179	2812	1639	981	859	1784	11254	0.8	5.3	6.5	11.4	2.3	3.1	4.8
1999	6.7	12.5	1.5	0.1	0.0	5.5	26.3	4837	3039	1471	918	1281	2498	14044	1.0	3.8	1.2	0.1	0.0	2.1	1.9
2000	0.8	7.2	1.4	0.2	0.2	16.2	25.8	2757	3341	1497	1216	1118	3606	13535	0.2	2.7	1.9	0.1	0.1	3.0	1.9
2001	53.0	106.5	52.1	14.3	0.6	10.4	236.8	3558	5210	3585	1335	1432	3642	18762	15.3	17.8	9.7	18.4	0.9	3.5	12.6
2002	18.5	24.5	2.9	0.0	0.0	7.6	53.6	3297	2951	1785	74	752	2449	11308	6.9	13.3	3.5	0.0	0.2	3.7	4.7
2003	15.5	16.9	3.5	0.0	0.1	10.1	46.2	3776	3434	2066	369	708	3093	13446	3.5	4.3	3.0	0.1	0.4	2.4	3.4
2004	6.3	18.8	17.6	10.3	0.0	27.7	80.8	6250	1960	2472	699	491	2970	14842	1.1	8.0	11.1	10.5	0.3	9.2	5.4
2005	81.5	27.8	4.1	3.8	1.3	38.4	156.9	5561	2178	2175	854	691	4036	15495	9.7	7.8	1.8	8.6	2.5	7.9	10.1
2006	31.4	8.2	15.3	0.7	0.1	14.8	70.6	4643	876	2918	326	443	2859	12065	8.2	7.0	8.8	3.5	0.5	5.6	5.9
2007	44.3	57.2	52.3	40.1	0.5	21.5	215.9	8105	3365	4587	1898	344	3645	21944	4.6	13.1	17.5	13.2	5.6	6.8	9.2
2008	14.2	15.9	39.2	2.9	0.1	1.8	74.1	3672	2162	3746	325	305	2426	12636	3.9	6.4	5.6	5.4	0.4	2.8	5.9
2009	1.0	1.8	0.0	0.0	0.0	3.6	6.5	3985	2777	1320	619	335	2219	11255	0.3	0.7	0.0	0.0	0.0	2.6	0.6
2010	26.7	36.5	27.8	21.5	0.6	0.8	113.876	2541	1640	549	686	140	246	5802	8.9	13.7	34.3	17.2	7.4	1.6	19.6
2011	2.4	18.6	13.2	11.6	0.3	0.0	46.065	2474	2194	1162	610	458	515	7413	1.3	7.6	18.6	15.7	4.4	0.0	6.2
2012	7.0	6.4	0.7	0.0	0.0	6.6	20.653	2504	1047	550	221	104	406	4832	2.1	4.2	1.3	0.2	0.0	12.2	4.3

Table A-2 Results of model selection. Underlined models have minimum value in each model. ZINB: zero-inflated negative binomial, NB: simple negative binomial.

	BIC	
	ZINB	NB
fy+season+area	21450.7	21653.7
fy+area*season	21464.1	21691.8
fy*area+season	21826.0	22096.9
fy*area+season*area	21846.8	22114.3
fy*season+area	21908.9	22181.4
fy*season+area*season	21909.6	22181.3
fy*area+season*area+fy*season	22303.9	22623.8
fy*area+fy*season	22320.6	22645.8

Table A-3 Type III analysis table of the explanatory variables in the base case model for standardization of CPUE in Kochi. The table shows the hypothesis tests for each of the variables in the model individually.

Negative binomial model

Effects	Df	Chisq	Pr>Chisq
fy	32	306.36	<.0001
area	5	105.03	<.0001
season	4	377.4	<.0001

Zero-inflation model

Effects	Df	Chisq	Pr>Chisq
season	4	85.87	<.0001

Table A-4 Standardized CPUE in Kochi prefecture, comparing with Ichinokawa et al. (2012) and nominal CPUE. All CPUEs are scaled by each average.

Fishing year	Nominal CPUE	Standardized CPUE				Ichinokawa et al. (2012)	
		Estimation	CV	Lower 5%	Upper 5%	Estimation	CV
1980	0.74	3.69	1.04	1.11	10.12	3.72	1.02
1981	1.07	0.81	0.52	0.57	0.94	0.82	0.51
1982	0.41	0.25	0.52	0.18	0.30	0.25	0.51
1983	0.10	0.20	0.58	0.13	0.26	0.21	0.58
1984	1.49	1.13	0.52	0.80	1.32	1.14	0.51
1985	0.39	0.76	0.5	0.56	0.87	0.77	0.49
1986	0.51	0.29	0.49	0.22	0.32	0.28	0.49
1987	0.10	0.16	0.46	0.12	0.17	0.16	0.46
1988	0.96	0.60	0.33	0.58	0.51	0.58	0.33
1989	0.48	0.31	0.32	0.30	0.26	0.32	0.32
1990	0.70	0.65	0.28	0.68	0.51	0.64	0.28
1991	0.85	0.57	0.32	0.56	0.48	0.58	0.31
1992	0.41	0.31	0.31	0.30	0.25	0.3	0.31
1993	0.82	0.51	0.24	0.58	0.38	0.51	0.24
1994	2.29	3.16	0.19	3.86	2.14	3.2	0.19
1995	1.45	1.09	0.21	1.28	0.76	1.04	0.21
1996	1.55	0.91	0.19	1.10	0.62	0.9	0.19
1997	0.76	0.50	0.24	0.56	0.36	0.48	0.23
1998	0.98	1.48	0.23	1.70	1.07	1.54	0.22
1999	0.32	0.33	0.21	0.38	0.23	0.33	0.21
2000	0.32	0.31	0.21	0.37	0.22	0.32	0.21
2001	2.47	2.17	0.2	2.59	1.50	2.11	0.2
2002	1.20	0.86	0.21	1.02	0.61	0.83	0.21
2003	0.56	0.41	0.23	0.47	0.30	0.4	0.23
2004	1.38	3.41	0.23	3.87	2.49	3.47	0.23
2005	1.40	0.92	0.22	1.06	0.66	0.99	0.19
2006	1.29	1.07	0.24	1.20	0.79	0.93	0.21
2007	2.25	1.33	0.23	1.53	0.96	1.47	0.2
2008	0.93	0.71	0.25	0.78	0.53	0.66	0.23
2009	0.14	0.10	0.27	0.11	0.08	0.08	0.25
2010	3.14	1.58	0.26	1.72	1.21	1.97	0.22
2011	1.79	2.05	0.24	2.31	1.50		
2012	0.59	0.39	0.26	0.42	0.30		

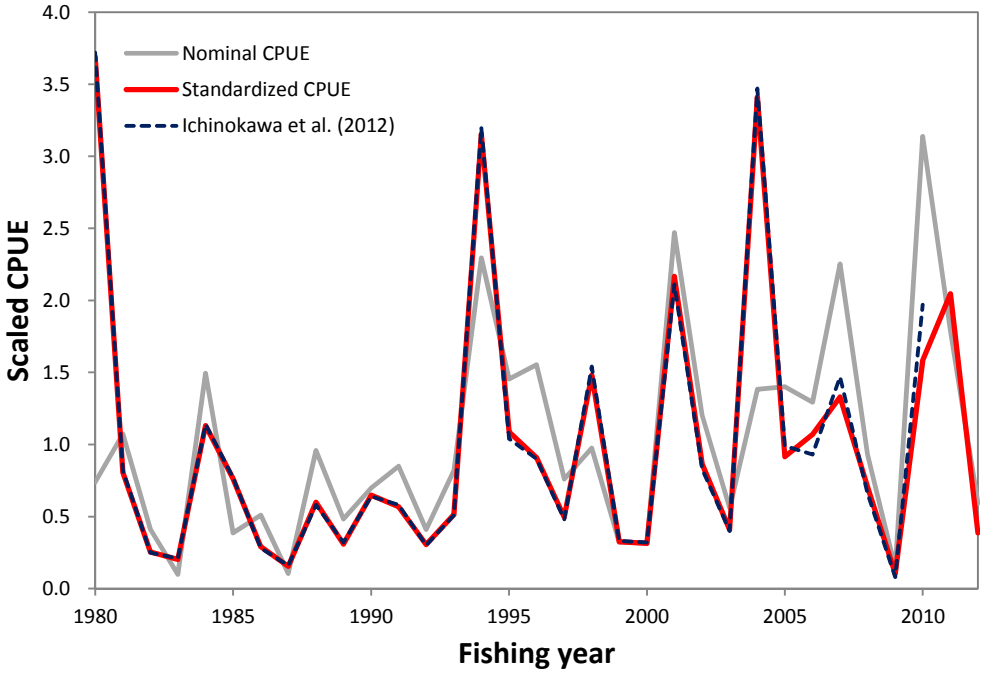

Fig. A-1 Comparison of time series of CPUE in Kochi. Gray and black lines indicates nominal and standardized CPUE from 1980 to 2012 fishing year. Broken line shows standardized CPUE estimated by Ichinokawa et al. (2012).

Appendix 2

Description of mistakes and revisions for CPUE time series in the text

This document presented updated CPUE from Japanese troll fishery operated in the East China Sea (off Nagasaki prefecture) up to 2012. However, time series of CPUE were produced through mistaken model selection based on BIC. This Appendix specifies errors in the previous CPUE time series and provides revise one.

The model which consisted of effects of ‘fy’ and ‘fm*port’ was proposed as the best in the text. However, this model resulted in the secondary minimum BIC value and the real best model was a set of main effects of ‘fy’, ‘fm’ and ‘port’ without any interaction terms (Table A2-1 and A2-2). Difference of BIC between the secondary and real best models was 1.4. Residuals distribution was seldom changed from that by the previous best model (Fig. A2-1).

Annual CPUEs were re-standardized with the new best model (Table A2-3). Range of CV was between 0.02 and 0.04, rarely different from that in Oshima et al. (2013). Year trends of CPUE did not change before and after the revision, although differences in relative value of CPUE were slightly apparent in some years (Fig. A2-2). The CPUE time series from the revised best model were applied in the stock assessment model.

Table A2-1 Values of BIC (Bayesian Information Criterion) calculated for all models of possible combinations of main effects and first-order interaction terms.

Model	BIC
fy+fm+port	27766.5
fy*fm+port	27719.5
fy*port+fm	27968.3
fy+fm*port	27767.9
fy*fm+fy*port	28108.5
fy*fm+fm*port	27709.5
fy*port+fm*port	27926.7
fy*fm+fm*port+fy*port	27989.3

Table A2-2 Type III analysis of the explanatory variables in the final model for CPUE standardization.

Efffects	df	Type III SS	Mean squire	F value	Pr > F
fy	32	1198.2	37.4	39.4	<.0001
fm	9	205.7	22.9	24.1	<.0001
port	4	831.2	207.8	218.9	<.0001

Table A2-3 Total catch (mt), effort (boat-day) and CPUE (kg/boat-day) by year and by fishing port, recorded in catch-and-effort data used for standardization of CPUE in Nagasaki Prefecture. All CPUEs are scaled by each average.

Fishing year	Nominal CPUE	Record Number	Standardized CPUE				Oshima et al. (2013)	
			Estimation	CV	Lower 5%	Upper 5%	Estimation	CV
1980	0.58	255	0.65	0.04	0.51	0.82	0.65	0.02
1981	0.88	265	1.14	0.03	0.90	1.44	1.14	0.02
1982	0.56	183	0.60	0.04	0.47	0.77	0.58	0.03
1983	0.88	328	0.89	0.03	0.71	1.12	0.88	0.02
1984	0.74	396	0.91	0.03	0.72	1.14	0.88	0.02
1985	0.82	375	0.85	0.03	0.68	1.07	0.83	0.02
1986	0.70	492	0.96	0.03	0.77	1.20	0.94	0.01
1987	0.58	310	0.70	0.04	0.55	0.88	0.67	0.02
1988	0.70	356	0.80	0.04	0.64	1.00	0.77	0.02
1989	0.51	351	0.64	0.04	0.51	0.80	0.62	0.02
1990	1.16	333	1.25	0.03	1.00	1.58	1.22	0.02
1991	1.09	271	1.28	0.03	1.01	1.62	1.31	0.02
1992	0.48	308	0.56	0.04	0.45	0.71	0.57	0.02
1993	0.40	330	0.48	0.04	0.38	0.60	0.47	0.02
1994	1.76	439	1.98	0.03	1.58	2.47	1.96	0.01
1995	0.94	243	1.06	0.03	0.84	1.35	1.07	0.02
1996	1.18	448	1.58	0.03	1.27	1.97	1.59	0.01
1997	0.93	251	0.92	0.03	0.73	1.17	0.89	0.02
1998	0.96	350	0.81	0.03	0.65	1.02	0.81	0.02
1999	1.46	286	1.49	0.03	1.18	1.88	1.49	0.02
2000	1.55	273	1.14	0.03	0.90	1.44	1.14	0.02
2001	1.28	265	1.14	0.03	0.90	1.44	1.15	0.02
2002	0.72	275	0.74	0.04	0.58	0.93	0.73	0.02
2003	0.79	184	0.64	0.04	0.50	0.82	0.64	0.03
2004	1.48	369	1.27	0.03	1.01	1.59	1.28	0.01
2005	1.66	230	1.39	0.03	1.09	1.76	1.34	0.02
2006	1.04	106	0.71	0.04	0.54	0.94	0.70	0.03
2007	1.57	244	1.37	0.03	1.08	1.74	1.36	0.02
2008	1.65	285	1.40	0.03	1.11	1.76	1.43	0.02
2009	0.99	206	1.13	0.03	0.88	1.44	0.91	0.02
2010	1.08	324	1.09	0.03	0.86	1.37	1.08	0.02
2011	1.37	266	0.94	0.03	0.74	1.19	0.93	0.02
2012	0.49	231	0.51	0.04	0.40	0.64		

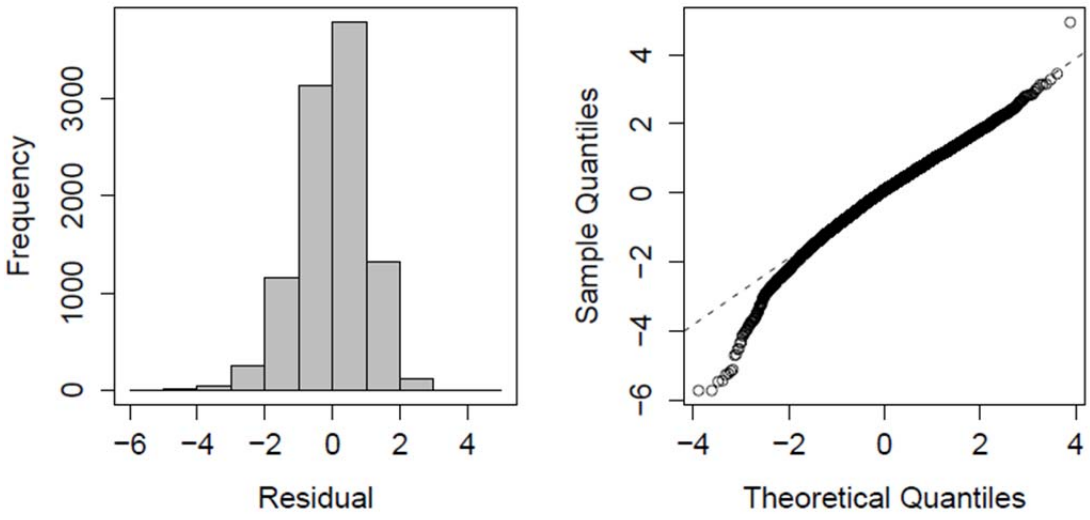

Fig. A2-1. Standardized residuals (left panel) and Q-Q plot of them (right panel).

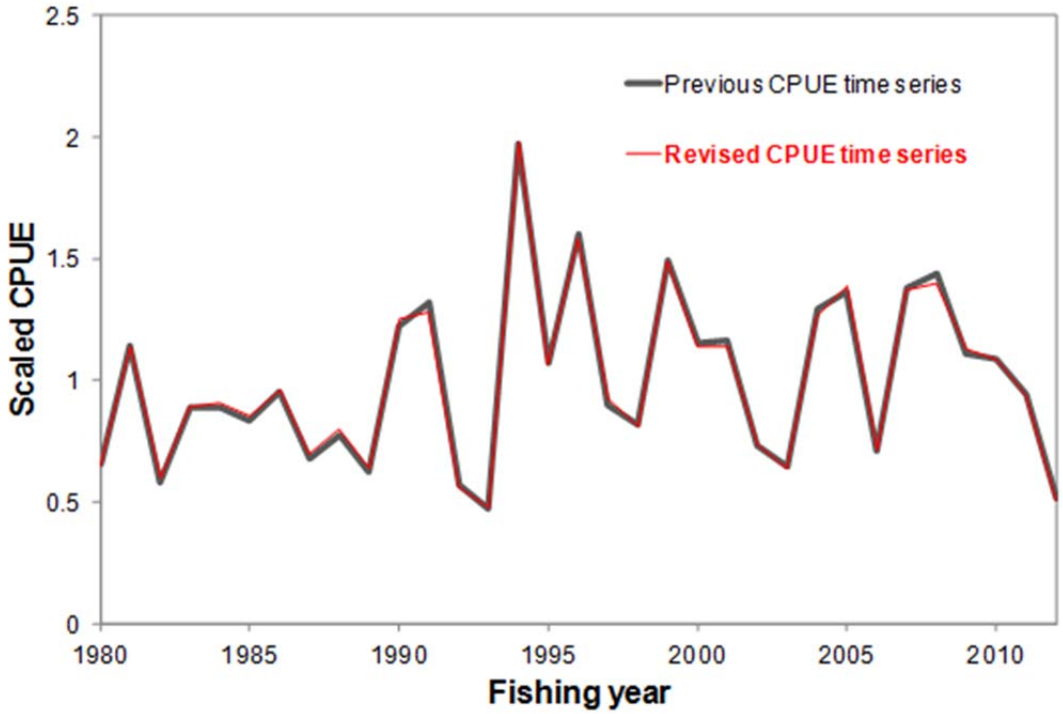

Fig. A2-2. Comparison of year trends of CPUE. Black and red lines indicate time series of the previous and revised standardized CPUE, respectively.