Update of Standardized CPUE of Striped Marlin in Northwestern Central Pacific Ocean by the Japanese Offshore and Distant Water Longline Fleets

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Abstract

Updated estimates of standardized CPUE for the Japanese offshore and distant water longline fleets during 1975 to 2013 are provided. For the standardization model, year, sub-area, quarter and hooks per basket are used as the independent factors to predict the response of log-transformed CPUE. The normal distribution is used as the model error distribution. Three areas, which were estimated using the GLM-tree algorithm, and three time blocks were used in the standardization model. The model settings and assumptions were the same as in the previous standardization analyses in 2011. There were different CPUE trends in each area. The CPUE trend in area 3, which includes Hawaii, showed a small decrease and this suggested that some local depletion may have occurred.

Introduction

In this paper, we update estimates of standardized CPUE of striped marlin in Northwestern Central Pacific Ocean (WCNPO) for the Japanese offshore and distant water longline fleets during 1975 to 2013.

Data set

Catch and effort data used in this analysis was provided from the Japanese longline fishery statistics compiled at the National Research Institute of Far Seas Fisheries for 1975-2013. The fishery area was the region west of 140º W and north of the equator. The fishery data consisted of information on catch number and number of hooks which were aggregated by month and 5x5 degree blocks area. This included gear configuration, i.e. the number of branch lines between floats (hooks par baskets: hpb). Data with hpb smaller than 3 or greater than 22 were removed from this analysis.

Procedure

The same analysis procedure was adopted from the previous standardization (Kanaiwa et al. 2011). A brief summary of the procedure is provided below.

1) We used GLM-Tree analysis which was the same GLM model used by Kanaiwa et al. (2011), between 1975 and 2013, i.e.,

$$\log(\text{CPUE} + \text{Constant}) \sim \text{year} * \text{area} + \text{year} * \text{hpb} + \text{quarter} * \text{area} + \text{normal error}$$

In the document of Kanaiwa et al. (2011), hpb was initially fit with a spline function but in the actual CPUE standardization, it was treated as a normal linear factor. So in this update, we used hpb as a linear continuous factor.

2) 10 separate areas (9 splits) were adopted as subareas, and the first 3 areas from the GLM-Tree analysis were adopted as areas where separate CPUE standardizations were calculated (Fig. 1).

3) 3 time blocks were adopted. The first time block was between 1975 and 1986, the second time block was between 1987 and 1999, and the third time block was between 2000 and 2013, noting that the distribution changed in the 2000s (Kanaiwa and Yokawa 2009).

4) Standardized CPUE was calculated for each area and time block combination The equation is same with Kanaiwa et al. 2011, i.e.,

log(CPUE + Constant) ~ year * subarea + year * hpb + quarter * subarea + normal error.

The predicted CPUE was calculated for each year, quarter and subarea by using median of HPB in each year. Area-weighted averages in each year was used as the point estimate of annual standardized CPUE.

Bootstrap method was used to calculate standard deviation of standardized CPUE with 1000 bootstrap replicates being resampling from each category, i.e. year, quarter and subarea. Because the area stratification changed slightly from the GLM-Tree analyses, both nominal and standardized CPUE between 1975 and 2009 differed from the previous standardization study.

Results & Discussion

We provide standardized CPUE between 1952 and 1974 from Kanaiwa et al. (2011) in Table 1 as reference information. CPUE from All nominal and standardize CPUE and standard deviation are shown in Tables 2 - 4 and all statistics are shown in Tables 5 - 7 between 1975 and 2013. In some time blocks and some areas, hpb has higher p value than 0.05, however based on an AIC analysis there was no reason to remove hpb from the model.

The annual trend of indices in area 1 exhibited large fluctuations because of the decreasing number of fishing operations in this area. The annual trend of CPUE in area 2 showed small increases after 2009. This is similar trend with

coastal longline (Ohshimo and Yokawa 2015). The annual trend of CPUE in area 3 showed a small decrease. This might suggest that some local depression of CPUE has occurred in area 3, which includes Hawaii. It would be useful to compare the CPUE trends in area 3 with the CPUE trend from the Hawaiian longline fishery.

References

Kanaiwa, M., A. Kimoro and K. Yokawa 2011 Standardized CPUE of Striped Marlin in North Western Central Pacific Ocean by using GLM. ISC/11/BILLFISH WG-2/06. 17pp.

Kanaiwa, M. and K. Yokawa 2009 The analysis of stock structure for striped marlin in North Pacific Ocean. ISC/09/BILLWG-3/02 14pp.

Ohshimo, S. and K. Yokawa. 2015 Update of standardized CPUE of striped marlin in the Northwestern Pacific Ocean, based on coastal small longline fishery from 1994 to 2013. ISC/15/BILLFISHWG-1/04 22pp

Figure. 1 Area separation by GLM-Tree

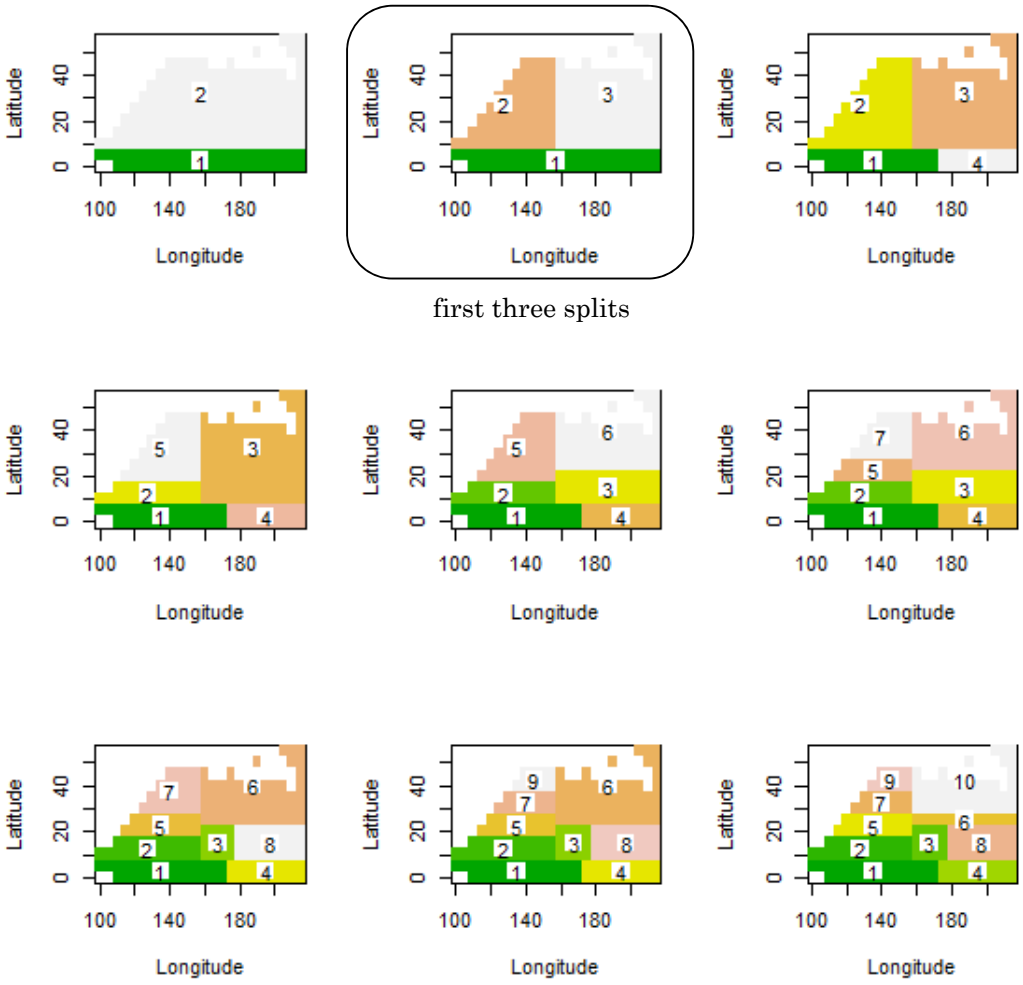


Table 1 nominal, standardize CPUE and standard deviation between 1952 and 1974

Year	nCPUE	sCPUE	stdev.
1952	0.02513	0.03016	0.00464
1953	0.01310	0.01410	0.00256
1954	0.03000	0.02420	0.00486
1955	0.02997	0.03688	0.00458
1956	0.02892	0.03337	0.00403
1957	0.03238	0.02596	0.00324
1958	0.05161	0.04371	0.00678
1959	0.07391	0.06115	0.00661
1960	0.04257	0.03397	0.00364
1961	0.03915	0.03051	0.00331
1962	0.07267	0.04419	0.00487
1963	0.07679	0.03389	0.00381
1964	0.12248	0.06195	0.00575
1965	0.15409	0.06259	0.00503
1966	0.05135	0.04748	0.00401
1967	0.04418	0.04111	0.00366
1968	0.04031	0.03318	0.00296
1969	0.05950	0.04494	0.00425
1970	0.04087	0.05302	0.00497
1971	0.04284	0.04640	0.00470
1972	0.06331	0.03269	0.00357
1973	0.07515	0.03035	0.00274
1974	0.04591	0.02305	0.00227

Table 2 nominal, standardize CPUE and standard deviation between 1975 and 2009 for trial scenario in area 1

Year	nCPUE	sCPUE	std
1975	1.37E-03	1.54E-03	2.67E-04
1976	1.45E-03	1.76E-03	1.65E-04
1977	9.72E-04	9.44E-04	1.10E-04
1978	9.12E-04	8.37E-04	8.82E-05
1979	1.72E-03	1.62E-03	1.47E-04
1980	1.65E-03	1.68E-03	1.57E-04
1981	1.55E-03	1.53E-03	1.54E-04
1982	8.79E-04	9.70E-04	9.61E-05
1983	9.95E-04	1.14E-03	1.22E-04
1984	1.24E-03	1.20E-03	1.06E-04
1985	1.17E-03	1.11E-03	1.07E-04
1986	3.08E-03	3.26E-03	3.13E-04

Year	nCPUE	sCPUE	std
1987	1.47E-03	1.38E-03	2.67E-04
1988	2.08E-03	2.01E-03	4.00E-04
1989	1.92E-03	1.73E-03	3.42E-04
1990	1.09E-03	1.00E-03	2.00E-04
1991	9.21E-04	7.39E-04	1.65E-04
1992	1.50E-03	1.30E-03	2.63E-04
1993	2.00E-03	1.83E-03	3.40E-04
1994	1.85E-03	1.80E-03	3.47E-04
1995	1.12E-03	1.02E-03	2.07E-04
1996	1.53E-03	1.43E-03	2.76E-04
1997	7.96E-04	6.98E-04	1.54E-04
1998	2.05E-03	1.91E-03	3.56E-04
1999	2.46E-03	2.47E-03	4.19E-04

Year	nCPUE	sCPUE	std
2000	2.33E-03	1.04E-03	2.38E-04
2001	1.93E-03	9.02E-04	2.32E-04
2002	2.81E-03	1.17E-03	2.84E-04
2003	1.94E-03	8.63E-04	2.60E-04
2004	2.71E-03	1.19E-03	3.07E-04
2005	2.00E-03	7.96E-04	2.75E-04
2006	2.48E-03	9.79E-04	3.48E-04
2007	1.34E-03	3.44E-04	2.11E-04
2008	1.11E-03	3.19E-04	2.14E-04
2009	1.29E-03	3.25E-04	2.15E-04
2010	3.16E-03	1.28E-03	4.31E-04
2011	5.78E-03	3.17E-03	9.74E-04
2012	2.57E-03	1.19E-03	4.53E-04
2013	2.83E-03	1.24E-03	5.01E-04

Table 3 nominal, standardize CPUE and standard deviation between 1975 and 2009 for trial scenario in area 2

Year	nCPUE	sCPUE	std
1975	7.13E-03	6.30E-03	1.03E-03
1976	6.75E-03	6.00E-03	9.44E-04
1977	2.95E-03	2.64E-03	4.54E-04
1978	6.25E-03	2.49E-03	4.50E-04
1979	1.29E-02	6.31E-03	1.16E-03
1980	1.26E-02	1.28E-02	2.03E-03
1981	6.02E-03	4.48E-03	7.51E-04
1982	4.72E-03	4.38E-03	7.77E-04
1983	6.53E-03	3.30E-03	6.04E-04
1984	6.96E-03	3.91E-03	6.95E-04
1985	1.69E-02	1.35E-02	2.72E-03
1986	3.01E-02	1.54E-02	2.40E-03

Year	nCPUE	sCPUE	std
1987	9.95E-03	6.36E-03	1.18E-03
1988	1.60E-02	6.04E-03	1.21E-03
1989	1.41E-02	6.73E-03	1.48E-03
1990	1.20E-02	5.63E-03	1.45E-03
1991	1.79E-02	7.42E-03	1.52E-03
1992	3.44E-02	8.35E-03	2.01E-03
1993	2.69E-02	1.81E-02	3.35E-03
1994	2.10E-02	9.98E-03	1.86E-03
1995	2.00E-02	1.30E-02	2.43E-03
1996	1.34E-02	1.07E-02	2.21E-03
1997	4.55E-02	1.40E-02	3.31E-03
1998	4.09E-02	2.47E-02	4.82E-03
1999	2.80E-02	1.40E-02	3.45E-03

Year	nCPUE	sCPUE	std
2000	8.05E-03	1.30E-02	2.51E-03
2001	8.37E-03	9.45E-03	2.07E-03
2002	8.92E-03	7.43E-03	1.73E-03
2003	5.06E-03	4.03E-03	8.39E-04
2004	4.25E-03	4.56E-03	1.09E-03
2005	1.94E-03	2.38E-03	6.23E-04
2006	1.26E-03	1.44E-03	4.08E-04
2007	3.01E-03	3.40E-03	8.10E-04
2008	3.37E-03	2.67E-03	6.26E-04
2009	3.78E-03	2.84E-03	6.39E-04
2010	3.91E-03	3.73E-03	9.57E-04
2011	2.58E-03	3.06E-03	7.77E-04
2012	3.73E-03	5.43E-03	1.18E-03
2013	9.28E-03	5.97E-03	1.24E-03

Table 4 nominal, standardize CPUE and standard deviation between 1975 and 2009 for trial scenario in area 3

Year	nCPUE	sCPUE	std
1975	8.09E-02	1.40E-01	1.71E-02
1976	1.11E-01	9.11E-02	1.06E-02
1977	6.56E-02	5.38E-02	7.93E-03
1978	1.34E-01	9.04E-02	9.31E-03
1979	2.24E-01	1.37E-01	1.36E-02
1980	1.93E-01	1.23E-01	1.42E-02
1981	1.56E-01	1.17E-01	1.13E-02
1982	7.99E-02	8.72E-02	9.71E-03
1983	9.79E-02	6.51E-02	7.73E-03
1984	1.89E-01	1.46E-01	1.48E-02
1985	1.64E-01	1.30E-01	1.47E-02
1986	1.32E-01	1.34E-01	1.36E-02

Year	nCPUE	sCPUE	std
1987	1.95E-01	1.64E-01	1.43E-02
1988	2.80E-01	2.30E-01	1.72E-02
1989	2.13E-01	1.85E-01	1.39E-02
1990	1.02E-01	9.03E-02	9.48E-03
1991	1.11E-01	8.65E-02	9.91E-03
1992	1.74E-01	1.38E-01	1.39E-02
1993	1.96E-01	1.57E-01	1.62E-02
1994	1.32E-01	1.18E-01	1.06E-02
1995	1.98E-01	1.41E-01	1.23E-02
1996	1.31E-01	8.82E-02	9.15E-03
1997	1.13E-01	7.38E-02	8.21E-03
1998	1.20E-01	9.87E-02	9.55E-03
1999	1.22E-01	8.92E-02	8.76E-03

Year	nCPUE	sCPUE	std
2000	3.63E-02	3.20E-02	4.10E-03
2001	6.74E-02	4.95E-02	5.78E-03
2002	3.03E-02	2.41E-02	3.39E-03
2003	4.98E-02	3.74E-02	4.31E-03
2004	3.44E-02	3.33E-02	4.24E-03
2005	2.50E-02	2.03E-02	2.80E-03
2006	3.43E-02	1.72E-02	2.61E-03
2007	9.49E-03	6.03E-03	1.27E-03
2008	1.95E-02	1.34E-02	2.41E-03
2009	1.00E-02	7.63E-03	1.56E-03
2010	6.04E-03	2.19E-03	7.01E-04
2011	2.17E-02	1.51E-02	3.23E-03
2012	1.62E-02	1.45E-02	2.76E-03
2013	3.15E-02	9.44E-03	1.95E-03

Table 5a statistics of trial scenario in area 1 between 1975 and 1986

Factors	LR Chisq	Df	P	Deviance	% of Deviance	Dev. / Df	Resid. Df	Resid. Dev.
NULL							17515	177992
year	217.2	11	0.0000	2008.6	5.6	182.6	17504	175983
area	3495.4	1	0.0000	28561.4	79.3	28561.4	17503	147422
hpb	35.8	1	0.0000	492.5	1.4	492.5	17502	146929
quarter	465.8	3	0.0000	3609.1	10.0	1203.0	17499	143320
year:area	72	11	0.0000	548.7	1.5	49.9	17488	142771
year:hpb	73.9	11	0.0000	600.2	1.7	54.6	17477	142171
area:quarter	25.5	3	0.0000	206.9	0.6	69.0	17474	141964

Table 5b statistics of trial scenario in area 1 between 1987 and 1999

Factors	LR Chisq	Df	P	Deviance	% of Deviance	Dev. / Df	Resid. Df	Resid. Dev.
NULL							16773	173467
year	246.6	12	0.0000	3488	7.9	290.7	16761	169979
area	3720.3	1	0.0000	32821	74.4	32821.0	16760	137157
hpb	62.4	1	0.0000	581	1.3	581.0	16759	136576
quarter	648.7	3	0.0000	4934	11.2	1644.7	16756	131642
year:area	172.2	12	0.0000	1403	3.2	116.9	16744	130239
year:hpb	33.8	12	0.0007	277	0.6	23.1	16732	129962
area:quarter	82.2	3	0.0000	635	1.4	211.7	16729	129327

Table 5c statistics of trial scenario in area 1 between 2000 and 2009

Factors	LR Chisq	Df	P	Deviance	% of Deviance	Dev. / Df	Resid. Df	Resid. Dev.
NULL							10816	110127
year	161.57	13	0.0000	1622.5	7.6	124.8	10803	108505
area	1467.4	1	0.0000	15017.8	70.5	15017.8	10802	93487
hpb	0.51	1	0.4760	20.5	0.1	20.5	10801	93466
quarter	243.1	3	0.0000	2032.2	9.5	677.4	10798	91434
year:area	140.92	13	0.0000	1262.1	5.9	97.1	10785	90172
year:hpb	47.23	13	0.0000	390.7	1.8	30.1	10772	89782
area:quarter	115.89	3	0.0000	955.9	4.5	318.6	10769	88826

Table 6a statistics of trial scenario in area 2 between 1975 and 1986

Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							13353	196971
year	439.23	11	0.0000	5761	9.6	523.7	13342	191210
area	2986.63	3	0.0000	35603	59.5	11867.7	13339	155607
hpb	0.38	1	0.5367	111	0.2	111.0	13338	155497
quarter	338.51	3	0.0000	3488	5.8	1162.7	13335	152009
year:area	159.27	33	0.0000	1980	3.3	60.0	13302	150028
year:hpb	43.46	11	0.0000	464	0.8	42.2	13291	149564
area:quarte	1208.29	9	0.0000	12472	20.8	1385.8	13282	137092

Table 6b statistics of trial scenario in area 2 between 1987 and 1999

Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							11363	175991
year	138.23	12	0.0000	3392	5.9	282.7	11351	172599
area	2576.44	3	0.0000	32464	56.7	10821.3	11348	140136
hpb	8.42	1	0.0037	53	0.1	53.0	11347	140082
quarter	103.92	3	0.0000	1094	1.9	364.7	11344	138989
year:area	180.49	36	0.0000	1898	3.3	52.7	11308	137091
year:hpb	21.47	12	0.0439	400	0.7	33.3	11296	136691
area:quarte	1705.37	9	0.0000	17942	31.3	1993.6	11287	118749

Table 6c statistics of trial scenario in area 2 between 2000 and 2009

Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							10488	149993
year	749.61	13	0.0000	3637.3	10.7	279.8	10475	146356
area	976.42	3	0.0000	7383.2	21.8	2461.1	10472	138973
hpb	8.21	1	0.0042	3110.3	9.2	3110.3	10471	135862
quarter	304.33	3	0.0000	2667.4	7.9	889.1	10468	133195
year:area	265.16	39	0.0000	2170.3	6.4	55.6	10429	131025
year:hpb	79.25	13	0.0000	1170.8	3.5	90.1	10416	129854
area:quarte	1410.39	9	0.0000	13774.7	40.6	1530.5	10407	116079

Table 7a statistics of trial scenario in area 3 between 1975 and 1986

Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							16265	167199
year	184.25	11	0.0000	1663.6	6.1	151.2	16254	165535
area	906.29	3	0.0000	9246.1	34.2	3082.0	16251	156289
hpb	20.74	1	0.0000	354.8	1.3	354.8	16250	155934
quarter	435.95	3	0.0000	3959.3	14.6	1319.8	16247	151975
year:area	228.98	33	0.0000	2533.1	9.4	76.8	16214	149442
year:hpb	27.12	11	0.0044	263.2	1.0	23.9	16203	149178
area:quarte	1046.43	9	0.0000	9054.6	33.4	1006.1	16194	140124

Table 7b statistics of trial scenario in area 3 between 1987 and 1999

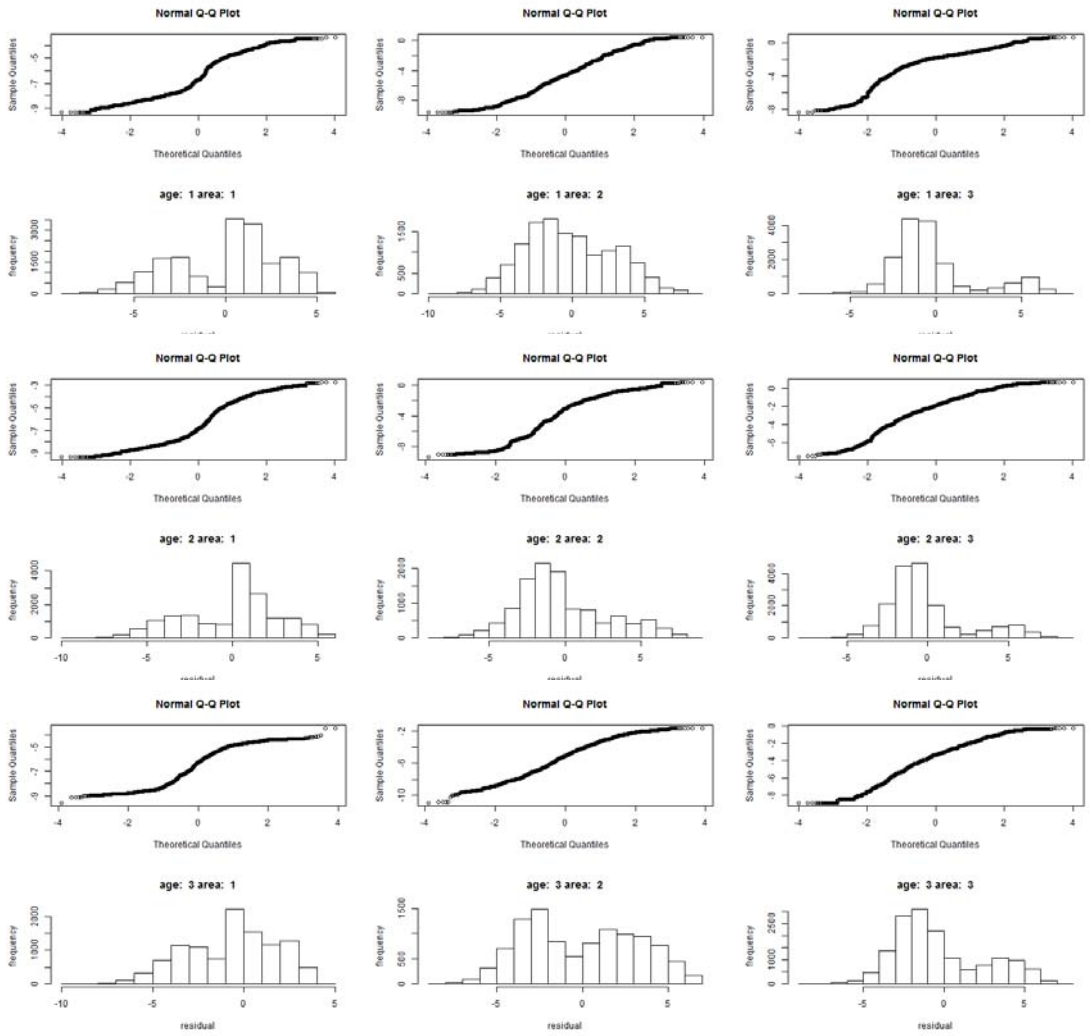
Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							17707	181263
year	205.71	12	0.0000	2018.8	5.8	168.2	17695	179244
area	1413.94	3	0.0000	12846.5	36.9	4282.2	17692	166398
hpb	37.37	1	0.0000	282	0.8	282.0	17691	166116
quarter	161.27	3	0.0000	1398.1	4.0	466.0	17688	164718
year:area	301.93	36	0.0000	2936.6	8.4	81.6	17652	161781
year:hpb	36.81	12	0.0002	352.9	1.0	29.4	17640	161428
area:quarte	1809.44	9	0.0000	15025.1	43.1	1669.5	17631	146403

Table 7c statistics of trial scenario in area 3 between 2000 and 2009

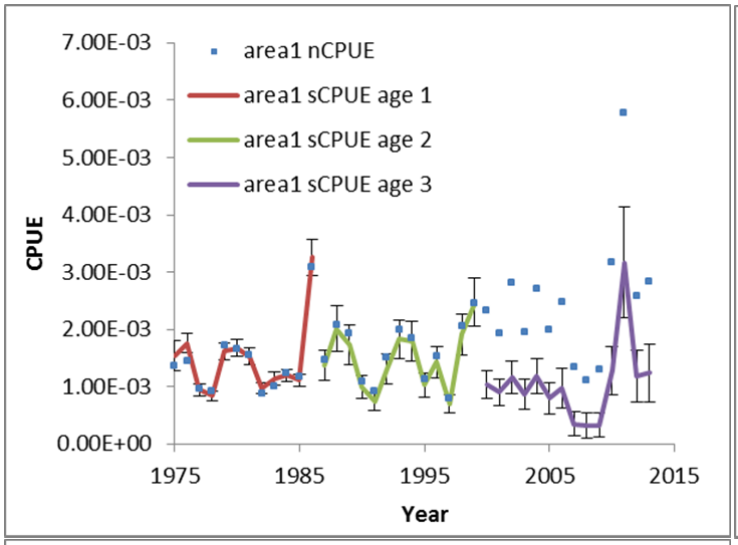
Factors	LR Chisq	Df	P	Deviance	% of Deviar	Dev. / Df	Resid. Df	Resid. Dev.
NULL							15382	201768
year	749.61	13	0.0000	7492.4	17.4	576.3	15369	194276
area	976.42	3	0.0000	12369.3	28.8	4123.1	15366	181906
hpb	8.21	1	0.0042	693.9	1.6	693.9	15365	181213
quarter	304.33	3	0.0000	3358	7.8	1119.3	15362	177854
year:area	265.16	39	0.0000	3525.5	8.2	90.4	15323	174329
year:hpb	79.25	13	0.0000	923.7	2.1	71.1	15310	173405
area:quarte	1410.39	9	0.0000	14634.9	34.0	1626.1	15301	158770

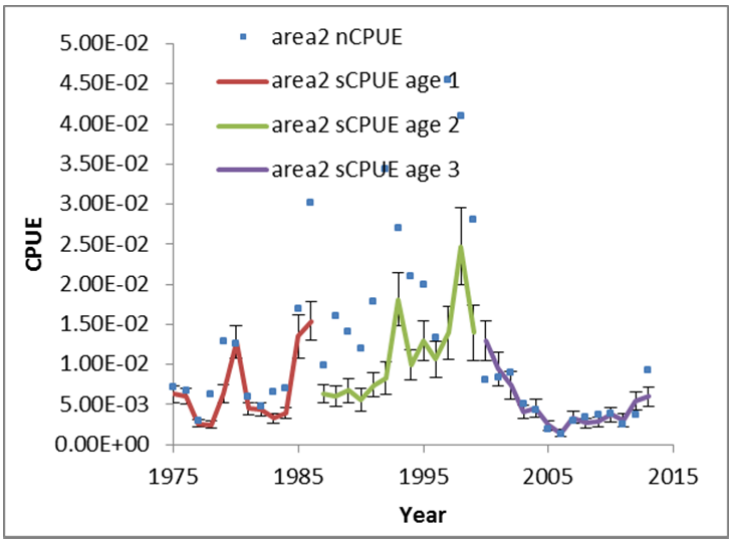
Appendix

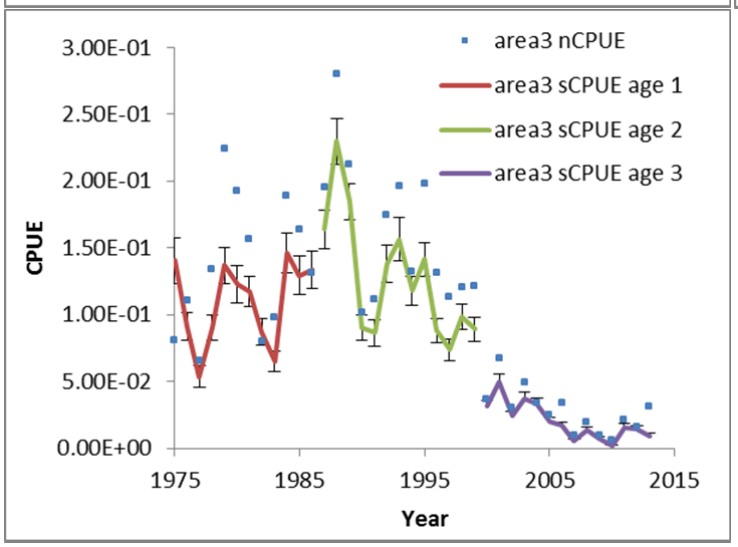
AFig. 1 qqplot and histogram of deviance residuals for each age and area



A Fig. 2 Estimated standardized CPUE with standard deviation.







A Fig. 3 Scaled CPUE of nominal, this standardization and former standardization.