2012 年のミナミマグロのコア船 CPUE の計算についての記述

Description of CPUE calculation from the core vessel data for southern bluefin tuna in 2012

伊藤智幸・境磨・高橋紀夫
Tomoyuki ITOH, Osamu SAKAI and Norio TAKAHASHI
（独）水産総合研究センター 国際水産資源研究所
National Research Institute of Far Seas Fisheries, Fisheries Research Agency

要旨

本文書は、CCSBT の管理方式に用いられるミナミマグロの資源指数であるコア船 CPUE についてまとめたものである。データ準備、GLM を用いた CPUE 標準化、エリア重み付けについて記述する。データは 2011 年までに更新した。2011 年の指数は、ベース GLM モデルによる W0.8 及び W0.5 において、この 10 年間の平均より高く、2010 年値よりは減少した。

Summary

This paper summarizes the core vessel CPUE which is an abundance index of southern bluefin tuna used for the Management Procedure in CCSBT. It describes data preparation, CPUE standardization using GLM and area weighting. The data were updated up to 2011. The index values in 2011, W0.8 and W0.5 by the base GLM model, are higher than the average in the last 10 years, though decreased from 2010.

Introduction

Stock management of southern bluefin tuna *Thunnus maccoyii* in CCSBT come to new era with the agreement and implementation of Management Procedure in 2011. The Management Procedure adapted output TAC by using longline CPUE and aerial survey index, so that those indices should be evaluated with high transparency. However, because shot-by-shot data is critically important intellectual property for fishermen, Japanese government is not able to open it for CCSBT scientists. Therefore, we describe the data preparation and indices made in detail in the present paper and try to ensure transparency and evaluation.

Data preparation

The dataset used was made from shot-by-shot records of Japanese longline from Japan (1986-2011), from Australia (RTMP data; 1989-2005) and from New Zealand (Joint venture; 1990-2011). Data from Japan are based on logbook data, but RTMP data were used for the most recent years if logbook data were not yet available and RTMP data of the vessel were available. Note that logbook data will be available after one or two years later so that data of operations especially for non-SBT targeting will be added later years.

Dataset was limited within CCSBT statistical areas between Area 4 and Area 9 and months between 4 and 9. CPUE was defined as the number of SBT caught whose age was more than equal age 4 per 1000 hooks used. Proportion of age 4+ by 5x5 degree square and month was calculated from the CCSBT catch-at-age database, adding catch-at-age data made by Japan for 2010 and 2011.

Core vessels which caught many SBT were selected with x (top rank of SBT catch in a year) = 56 and y (number of years in the top ranks) = 3. A sub-dataset from vessels with a total records of 154,385 was made (Table 1). The number of vessels chosen ranged from 34 to 98 in each year.

As a reference, the number of area operated in terms of five degrees / month, one degree / month and the number of one degree square in five degrees square are shown in Fig. 1 for all operations and operations with SBT positive.

Following corrections were further carried out before CPUE standardization. Delete records operated south of 50 degree South, combined Area 5 and Area 6 into Area 56, and delete operations with extremely high CPUE (>120). The shot-by-shot data were aggregated into 5x5 degree and month. Aggregated data with little effort (< 10,000 hooks) were deleted.

CPUE standardization

CPUE were standardized with GLM using SAS (version 9.3). Small constant of 0.2, 10% of nominal CPUE, was added into CPUE age 4+ before log transform (Nishida and

Tsuji 1998).

Base series:

$$log(CPUE+0.2) = Intercept + Year + Month + Area + Lat5 + BET\_CPUE + YFT\_CPUE + (Month*Area) + (Year*Lat5) + (Year*Area) + Error,$$

Two additional CPUE series are made for monitoring purpose of the status of the stock and MP implementation.

Monitoring series 1 (Reduced base model):

$$log(CPUE+0.2) = Intercept + Year + Month + Area + Lat5 + (Month*Area) + Error,$$

Monitoring series 2: Same procedure as in Base series, but the data used are shot-by-shot daily level rather than the aggregated 5x5 month level.

Standardized CPUE and QQ plots of residual are shown in Fig.2 and Fig. 3.

AIC and BIC were calculated for the base model and the reduced base model which are nested models each other. The base model is appropriate model in terms of AIC, but not in BIC (Table 2).

Area weighted standardized CPUE

With the estimated parameters obtained from CPUE standardization by GLM, the Constant Square (CS) and Variable Square (VS) abundance indices were computed by the following equations:

$$CS_{4+,y}=\sum_m \sum_a \sum_l (AI_{CS})_{(1969\text{-}present)}[\exp(Intercept + Year + Month + Area + Lat5 + BET\_CPUE + YFT\_CPUE + (Month*Area) + (Year*Lat5) + (Year*Area) + \sigma^2/2) - 0.2]$$

$$VS_{4+,y}=\sum_m \sum_a \sum_l (AI_{VS})_{ymal}[\exp(Intercept + Year + Month + Area + Lat5 + BET\_CPUE + YFT\_CPUE + (Month*Area) + (Year*Lat5) + (Year*Area) + \sigma^2/2) - 0.2]$$

where

$CS_{4+,y}$ is the CS abundance index for age 4+ and y-th year,

$VS_{4+,y}$ is the VS abundance index for age 4+ and y-th year,

$(AI_{CS})_{(1969\text{-}present)}$ is the area index of the CS model for the period 1969-present,

$(AI_{VS})_{ymal}$ is the area index of the VS model for y-th year, m-th month, a-th

SBT statistical area, and l-th latitude,

σ is the mean square error in the GLM analyses,

Then, w0.5 and w0.8 (B-ratio and geostat proxies) were calculated using the equation below.

$$I_{y,a} = wCS_{y,a} + (1-w)VS_{y,a}$$

The area weighted CPUE value in the most recent year (2011), which was mainly from RTMP and targeting on SBT, was corrected with the constant of 0.942, the average in three years (0.947 in 2008, 0.880 in 2009 and 1.000 in 2010 of ratio Logbook based CPUE / RTMP based CPUE in the core vessel dataset).

The area weighted CPUE series between 1986 and 2011 were calibrated to the historical time series since 1969 based on the agreed method (SAG9 Report in 2008, attachment 5) derived from GLM model using data from all vessels described in Nishida and Tsuji (1998). At the 3rd OMMP Technical meeting held in Seattle in 2010, it was agreed that the pre-1986 series used in MP implementation will be fixed at the values estimated based on data to 2008 only. Calibration would thus in future always be based upon the 1986-2008 points of this series."

Calculated area weighted standardized CPUE are shown in Table 3 and Fig. 4. The relative index values of W0.8 in 2011 with the base GLM model (0.768) is as 1.22 times high as the average of the previous 10 years (0.630), though decreased from 2010 (0.952). That of W0.5 in 2011 (0.566) is as 1.09 times high as the average of the previous 10 years (0.521) and decreased from 2010 (0.676).

The trends of the indices among GLM models were similar but different in last two years. The index value in 2010 was increased sharply from 2009 in the base model but stable in the reduced-model for both W0.8 and W0.5. Nominal CPUE showed similar trend to the base model.

No substantial difference was observed among the indices of the base model that based on the aggregated data in 5x5 degree square and month to that based on the shot-by-shot data.

Reference

Nishida, T., and S. Tsuji. 1998. Estimation of abundance indices of southern bluefin tuna (*Thunnus maccoyii*) based on the coarse scale Japanese longline fisheries data (1969-97). CCSBT/SC/9807/13.27.

Table 1. Number of records in the dataset used.

Year	All vessels Japan	All vessels Australia	All vessels New Zealand	All vessels Total	Core vessel Total	Core vessel Vessel number
1986	27,045			27,045	3,958	34
1987	26,825			26,825	4,704	40
1988	24,426			24,426	5,267	48
1989	24,315	1,156		25,471	6,604	60
1990	19,899	504	475	20,878	6,394	71
1991	18,316	1,204	460	19,980	7,064	71
1992	17,233	1,717	499	19,449	6,848	83
1993	14,818	2,001	486	17,305	6,551	80
1994	12,610	1,394	268	14,272	5,960	89
1995	12,804	800	373	13,977	6,072	93
1996	14,854			14,854	6,737	92
1997	16,322		379	16,701	7,555	88
1998	16,310		310	16,620	7,854	98
1999	14,414		306	14,720	7,302	90
2000	11,746		265	12,011	6,742	90
2001	14,075		198	14,273	7,375	93
2002	10,721		228	10,949	5,818	85
2003	11,563		294	11,857	6,060	85
2004	13,016		349	13,365	7,673	86
2005	13,749		198	13,947	7,802	86
2006	9,025		183	9,208	5,703	73
2007	5,478		387	5,865	4,176	75
2008	6,807		167	6,974	4,668	77
2009	5,015		231	5,246	3,619	59
2010	4,135		144	4,279	2,836	53
2011	4,697		151	4,848	3,043	50
Total	364,471	8,776	6,200	379,447	154,385	

Data are from Area 4-9 and month 4-9.

Table 2. AIC and BIC of Base case model and reduced base case

Model	AIC	BIC
Base	6,016	7,408
Reduced Base	6,207	6,562

Table 3. Area weighted standardized CPUE

	Base	Base	Reduced Base	Reduced Base	Base with SxS	Base with SxS
Year	w08	w05	w08	w05	w08	w05
1969	2.2841	2.4934	2.2841	2.4934	2.2841	2.4934
1970	2.2268	2.4169	2.2268	2.4169	2.2268	2.4169
1971	2.0654	2.2054	2.0654	2.2054	2.0654	2.2054
1972	2.1669	2.2273	2.1669	2.2273	2.1669	2.2273
1973	1.8263	1.9271	1.8263	1.9271	1.8263	1.9271
1974	1.8989	1.9710	1.8989	1.9710	1.8989	1.9710
1975	1.4556	1.4974	1.4556	1.4974	1.4556	1.4974
1976	1.8715	1.9279	1.8715	1.9279	1.8715	1.9279
1977	1.6556	1.6850	1.6556	1.6850	1.6556	1.6850
1978	1.4300	1.3820	1.4300	1.3820	1.4300	1.3820
1979	1.1472	1.2558	1.1472	1.2558	1.1472	1.2558
1980	1.3862	1.3852	1.3862	1.3852	1.3862	1.3852
1981	1.3103	1.2917	1.3103	1.2917	1.3103	1.2917
1982	1.0285	1.0220	1.0285	1.0220	1.0285	1.0220
1983	1.0103	1.0228	1.0103	1.0228	1.0103	1.0228
1984	1.0261	1.0603	1.0261	1.0603	1.0261	1.0603
1985	0.8578	0.8861	0.8578	0.8861	0.8578	0.8861
1986	0.6471	0.6840	0.6701	0.7092	0.6545	0.6881
1987	0.6386	0.6667	0.6780	0.7010	0.6415	0.6658
1988	0.5422	0.5561	0.5112	0.5150	0.5773	0.5834
1989	0.5245	0.5460	0.4971	0.5194	0.5469	0.5646
1990	0.5337	0.5264	0.5821	0.5672	0.4849	0.4799
1991	0.4609	0.4653	0.5187	0.5149	0.4562	0.4665
1992	0.5607	0.5476	0.6127	0.5879	0.5480	0.5394
1993	0.7055	0.6458	0.6749	0.6117	0.6868	0.6470
1994	0.7287	0.6058	0.5656	0.4762	0.7592	0.6329
1995	0.7010	0.6176	0.6618	0.5901	0.8011	0.6866
1996	0.5099	0.4712	0.5138	0.4770	0.5317	0.4959
1997	0.5422	0.4906	0.5744	0.5206	0.5209	0.4751
1998	0.5548	0.5379	0.5728	0.5499	0.5521	0.5265
1999	0.5479	0.5260	0.5760	0.5509	0.5353	0.5136
2000	0.5460	0.4829	0.5261	0.4693	0.5456	0.4879
2001	0.6322	0.5783	0.6174	0.5675	0.6176	0.5674
2002	0.9107	0.7511	0.8291	0.6889	0.8580	0.7118
2003	0.6931	0.5804	0.7190	0.5955	0.6810	0.5747
2004	0.6135	0.5624	0.6687	0.5949	0.5639	0.5186
2005	0.5091	0.4780	0.5354	0.4859	0.5094	0.4765
2006	0.3792	0.3330	0.3772	0.3402	0.4060	0.3498
2007	0.2868	0.2436	0.3486	0.2850	0.3148	0.2673
2008	0.5840	0.4459	0.5216	0.4245	0.5594	0.4235
2009	0.7376	0.5644	0.6480	0.5072	0.7077	0.5276
2010	0.9519	0.6755	0.5892	0.4368	0.9149	0.6332
2011	0.7683	0.5656	0.6055	0.4537	0.7236	0.5137

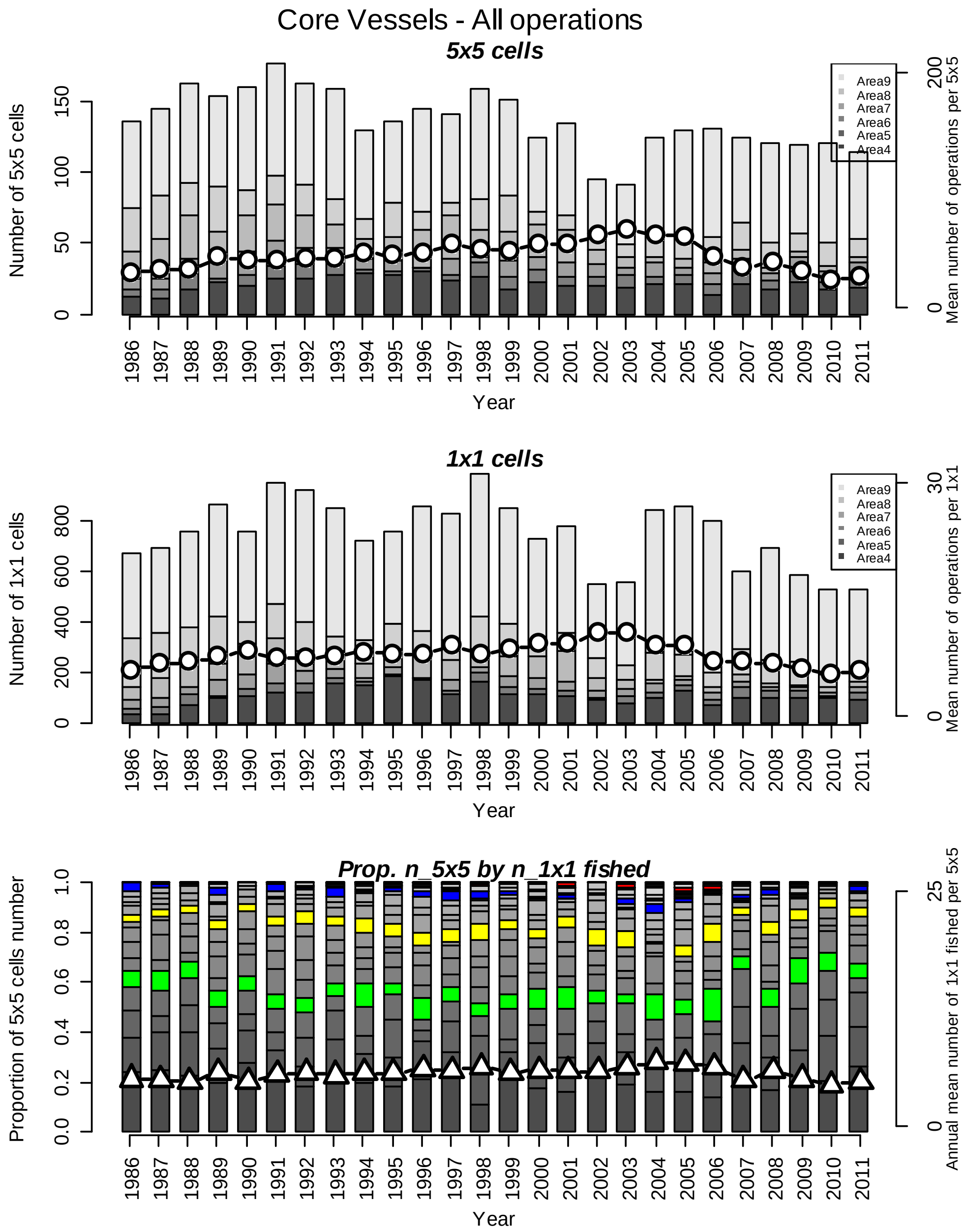


Figure 1a. Number of cells in the core vessel for <u>all operations</u>.

(Top panel) Bar represents the number of 5x5 degrees square and month (cell) where fishing operated by CCSBT statistical area and refer to left side y-axis. Line with circle plot represents the mean annual number of operations per cell and refer to right side y-axis. (Middle panel) Bar represents the number of 1x1 degree square and month (cell) where fishing operated by CCSBT statistical area and refer to left side y-axis. Line with circle plot represents the mean annual number of operations per cell and refer to right side y-axis. (Bottom panel) Composition of frequency for the number of 1x1 degree square and month cells operated in a 5x5 degree squares and month cell. Refer to left side y-axis. The grey band is one of 25 cells and that at top is 25 of 25 cells, and every five is colored. Line with triangle represents the mean number of 1x1 month cells operated in a 5x5 month cell and refer to right side y-axis.

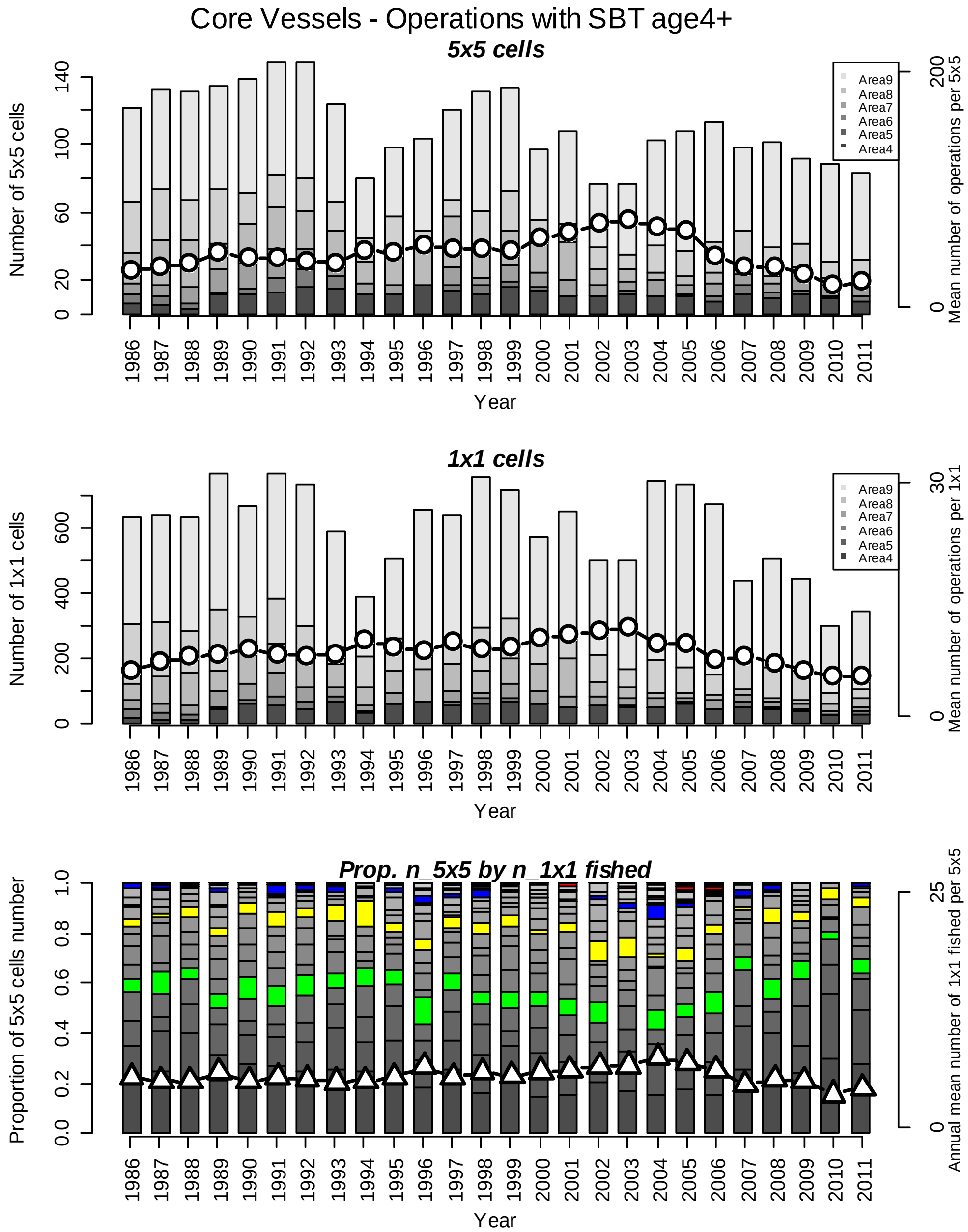


Figure 1b. Number of cells in the core vessel for SBT 4+ catch positive. See explanation in Fig. 1a.

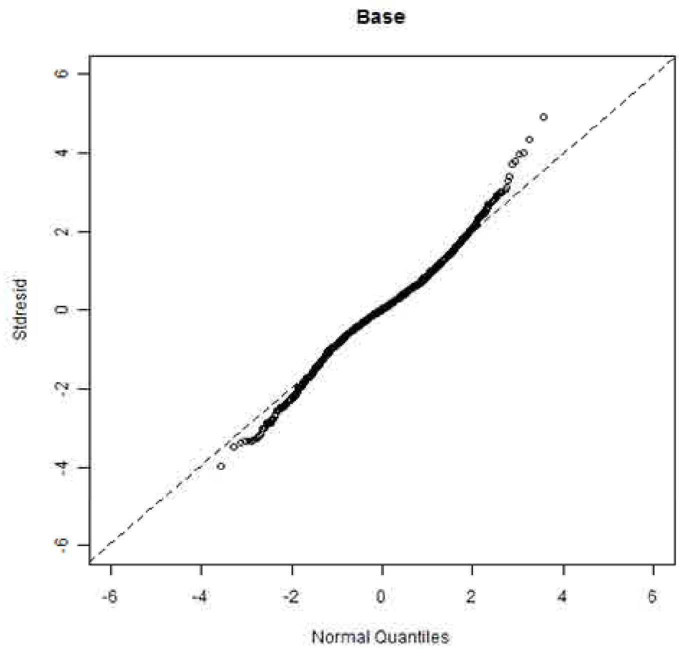


Fig 2. Standardized CPUE (mean with 95% confidence interval) of the core vessel data (upper panel) and its QQ plot of residual (lower panel) for Base case.

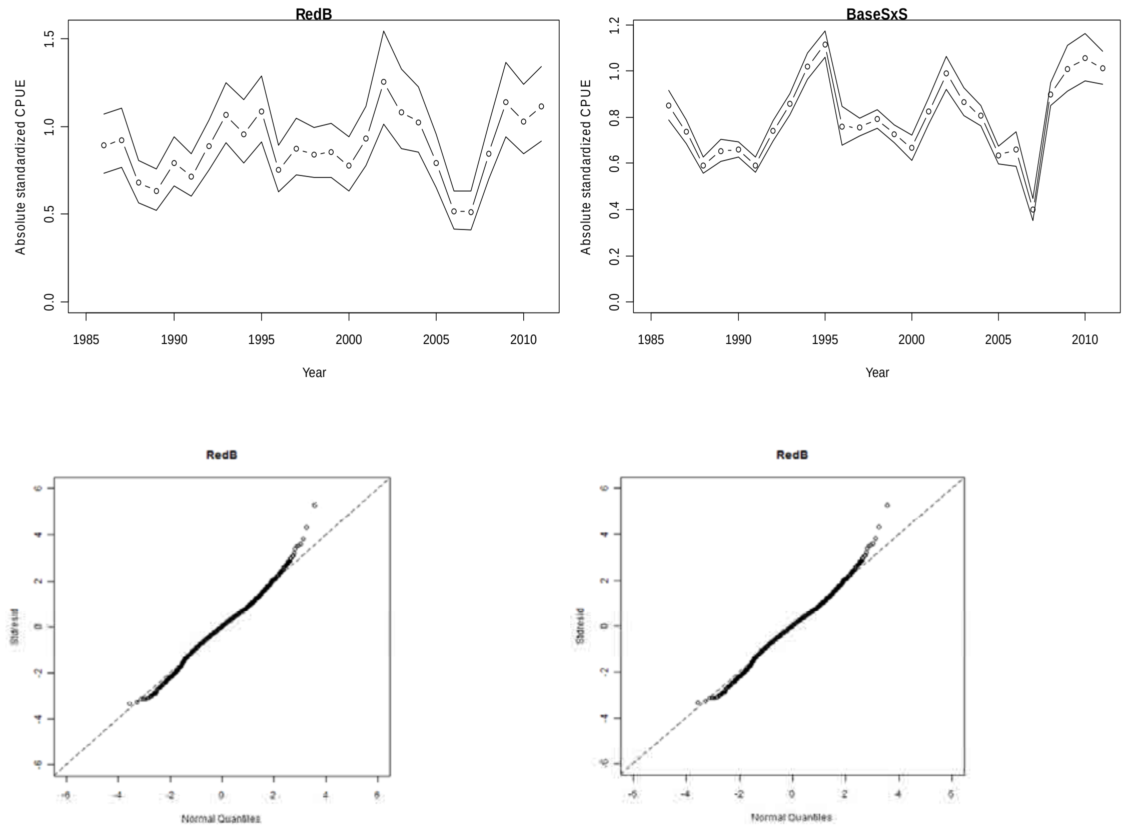
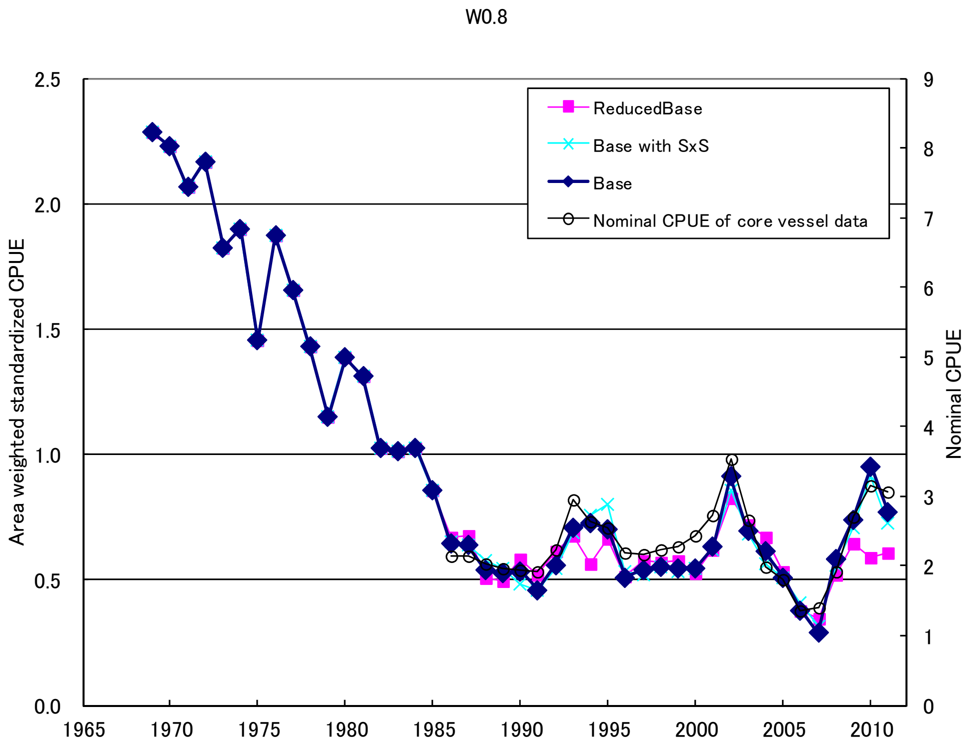


Fig 3. Standardized CPUE (mean with 95% confidence interval) of the core vessel data (upper panel) and its QQ plot of residual (lower panel) for monitoring series. Left panels for reduced base case and right panels for shot-by-shot data with base case GLM model.



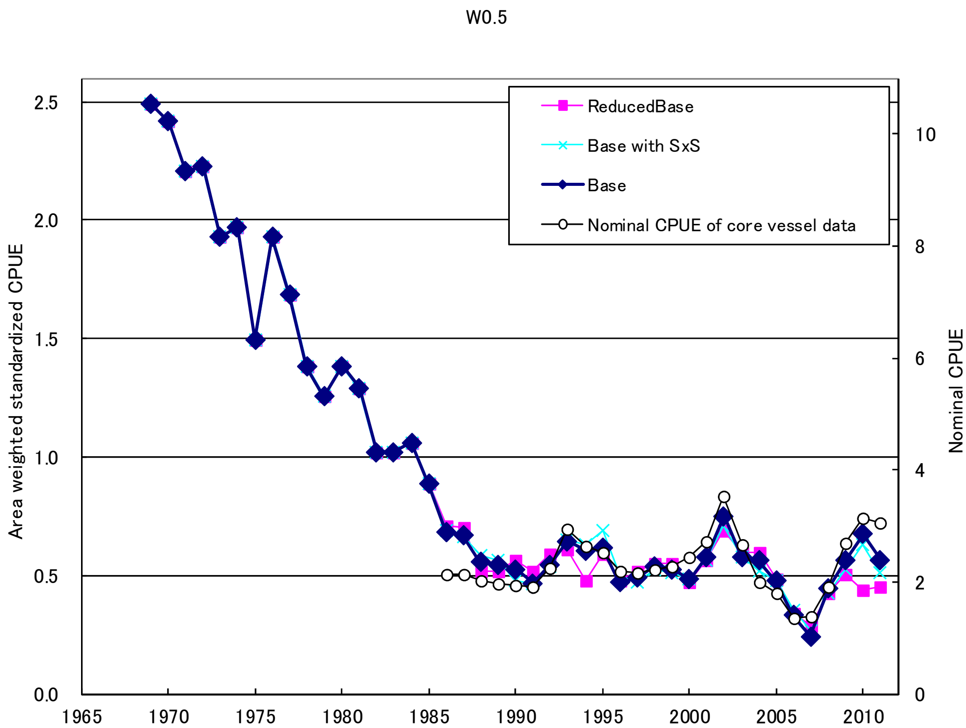


Fig 4. Area weighed standardized CPUEs. Nominal CPUE of the core vessels is also shown.