2013 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 2013

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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 2012 年までに更新した。2012 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 年間の平均より高かった。

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 2012. The index values in 2012, W0.8 and W0.5 by the base GLM model, are higher than the average in the last 10 years.

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 (1986-2012), from Australia (RTMP data; 1989-2005) and from New Zealand (Joint venture; 1990-2012). 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 2011 and 2012.

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 162,500 was made (Table 1). The number of vessels chosen ranged from 34 to 99 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 residuals 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 (2012), which was mainly from RTMP and targeting on SBT, was corrected with the constant of 0.934, the average in three years (0.880 in 2009, 1.000 in 2010 and 0.922 in 2011[1] of ratio Logbook based CPUE in W0.8 / RTMP based CPUE in W0.8 in the core vessel dataset).

The area weighted CPUE series between 1986 and 2012 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 2012 with the base GLM model (0.892) is high as 136% of the previous 10 years mean (0.654). That of W0.5 in 2012 (0.643) is high as 122% of the previous 10 years mean (0.527).

The trends of the indices among GLM models (Base vs Reduced Base) were similar but different for recent three years. Cause of this difference was further explored by various models that differ GLM model terms. Among terms different from Base model to Reduced base model (*BET_CPUE, YFT_CPUE, Year*Lat5 and Year*Area*), the combination of *Year*Lat5* and *Year*Area* was responsible for the difference (Fig. 5).

There was a difference in the 2012 value between the core vessel data of 5x5 degree square and month and the data based on shot-by-shot. It was found that Year*Area interaction term in GLM was responsible for the difference. In area 7 in 2012, many operations (15% of total operations) were given but concentrated in the small number of time-area cells (less than 5% of total cells) as same as previous years (Fig. 6). The

[1] X=58 was used for core vessels selection for 2011 data because there was a few data absent year*area combination which prevent calculation of year*area interaction in GLM.

nominal CPUE difference was large in area7 in 2012. Then, with lower CPUE in larger number of data, index value of 2012 became lower in 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	27,005			27,005	3,961	34
1987	26,759			26,759	4,716	40
1988	24,418			24,418	5,283	48
1989	24,315	1,156		25,471	6,649	60
1990	19,899	504	475	20,878	6,581	73
1991	18,316	1,204	460	19,980	7,051	71
1992	17,233	1,717	499	19,449	6,944	84
1993	14,797	2,001	486	17,284	6,614	81
1994	12,610	1,394	268	14,272	5,853	89
1995	12,804	800	373	13,977	6,025	94
1996	14,854			14,854	6,684	94
1997	16,322		379	16,701	7,602	89
1998	16,310		310	16,620	7,971	99
1999	14,414		306	14,720	7,520	93
2000	11,746		265	12,011	6,877	92
2001	14,075		198	14,273	7,600	97
2002	10,721		228	10,949	5,984	87
2003	11,563		294	11,857	6,356	88
2004	13,101		349	13,450	8,173	91
2005	13,848		198	14,046	8,435	92
2006	9,124		183	9,307	6,239	80
2007	5,540		387	5,927	4,309	78
2008	6,850		167	7,017	4,993	84
2009	5,055		231	5,286	4,022	66
2010	4,135		144	4,279	3,306	60
2011	4,790		151	4,941	3,616	58
2012	4,470		163	4,633	3,136	60
Total	375,074	8,776	6,514	390,364	162,500	

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	6,456	7,904
Reduced Base	6,655	7,019

Table 3. Area weighted standardized CPUE

Year	Base w08	Base w05	Reduced Base w08	Reduced Base w05	Base with SxS w08	Base with SxS 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	0.6508	0.6824	0.6713	0.7052	0.6670	0.6948
1987	0.6542	0.6786	0.6913	0.7106	0.6583	0.6791
1988	0.5524	0.5637	0.5222	0.5243	0.5956	0.5981
1989	0.5414	0.5611	0.5286	0.5502	0.5537	0.5661
1990	0.5587	0.5462	0.5966	0.5791	0.4969	0.4865
1991	0.4685	0.4701	0.5160	0.5116	0.4645	0.4708
1992	0.5784	0.5615	0.6255	0.6003	0.5593	0.5454
1993	0.7182	0.6564	0.6908	0.6264	0.6968	0.6550
1994	0.7354	0.6107	0.5764	0.4846	0.7677	0.6366
1995	0.7474	0.6571	0.7071	0.6294	0.8689	0.7400
1996	0.5663	0.5202	0.5473	0.5091	0.5888	0.5472
1997	0.5250	0.4747	0.5558	0.5054	0.5104	0.4679
1998	0.5102	0.5044	0.5331	0.5129	0.4897	0.4804
1999	0.4571	0.4530	0.4750	0.4569	0.4529	0.4501
2000	0.5359	0.4779	0.5272	0.4715	0.5272	0.4772
2001	0.5959	0.5530	0.5989	0.5537	0.5958	0.5524
2002	0.9038	0.7447	0.8086	0.6731	0.8434	0.6996
2003	0.6834	0.5726	0.7168	0.5950	0.6650	0.5621
2004	0.5985	0.5499	0.6571	0.5873	0.5493	0.5079
2005	0.5029	0.4723	0.5495	0.4993	0.5094	0.4789
2006	0.3774	0.3307	0.3743	0.3382	0.4053	0.3488
2007	0.2919	0.2462	0.3544	0.2888	0.3207	0.2707
2008	0.5985	0.4552	0.5286	0.4298	0.5658	0.4270
2009	0.7226	0.5548	0.6569	0.5133	0.6972	0.5201
2010	1.0015	0.7132	0.6341	0.4703	0.9582	0.6679
2011	0.8555	0.6287	0.6872	0.5150	0.8300	0.5895
2012	0.8922	0.6430	0.5769	0.4225	0.7027	0.5153

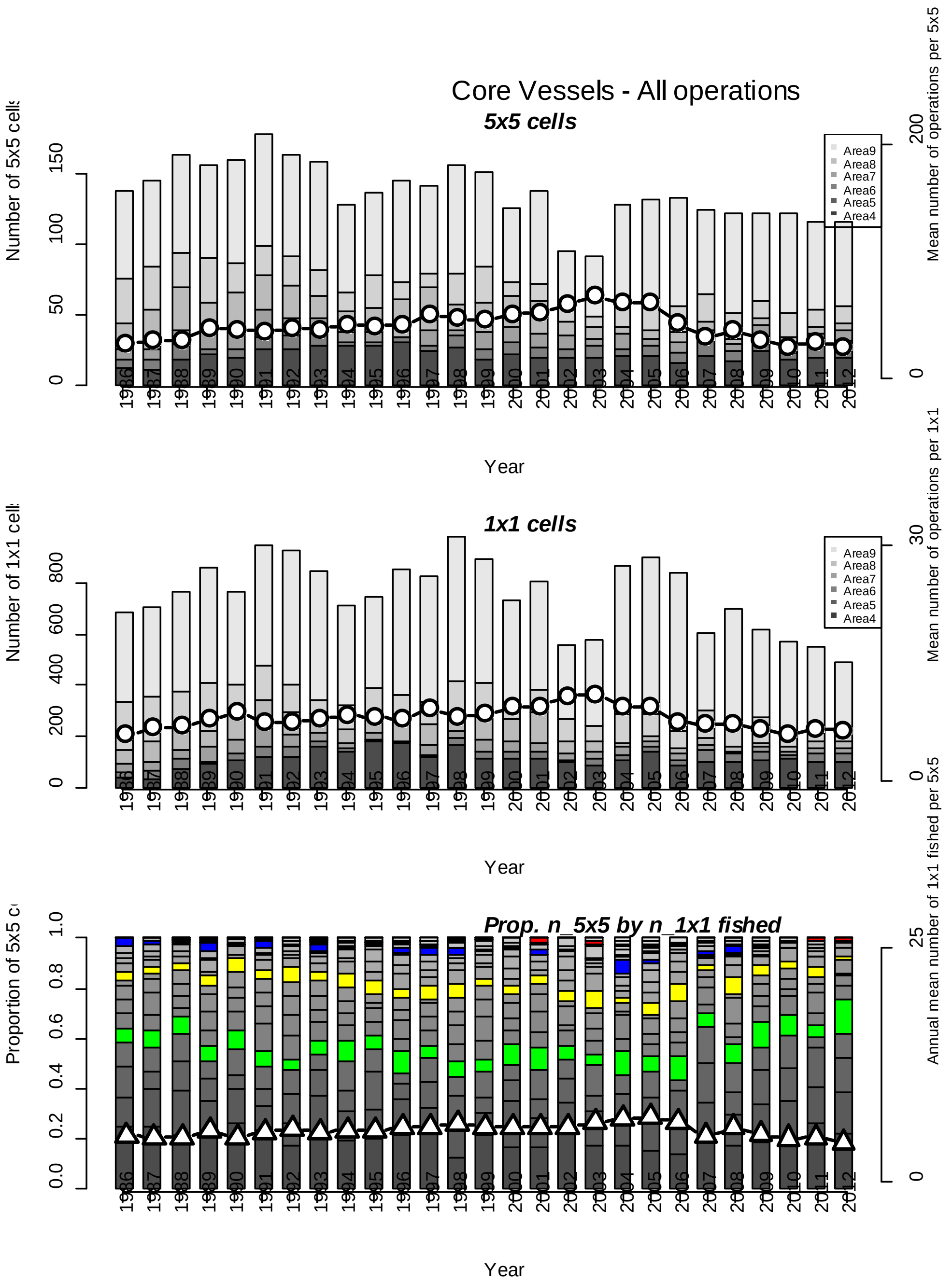


Figure 1a. Number of cells in the core vessel for <u>all operations</u>.

(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.

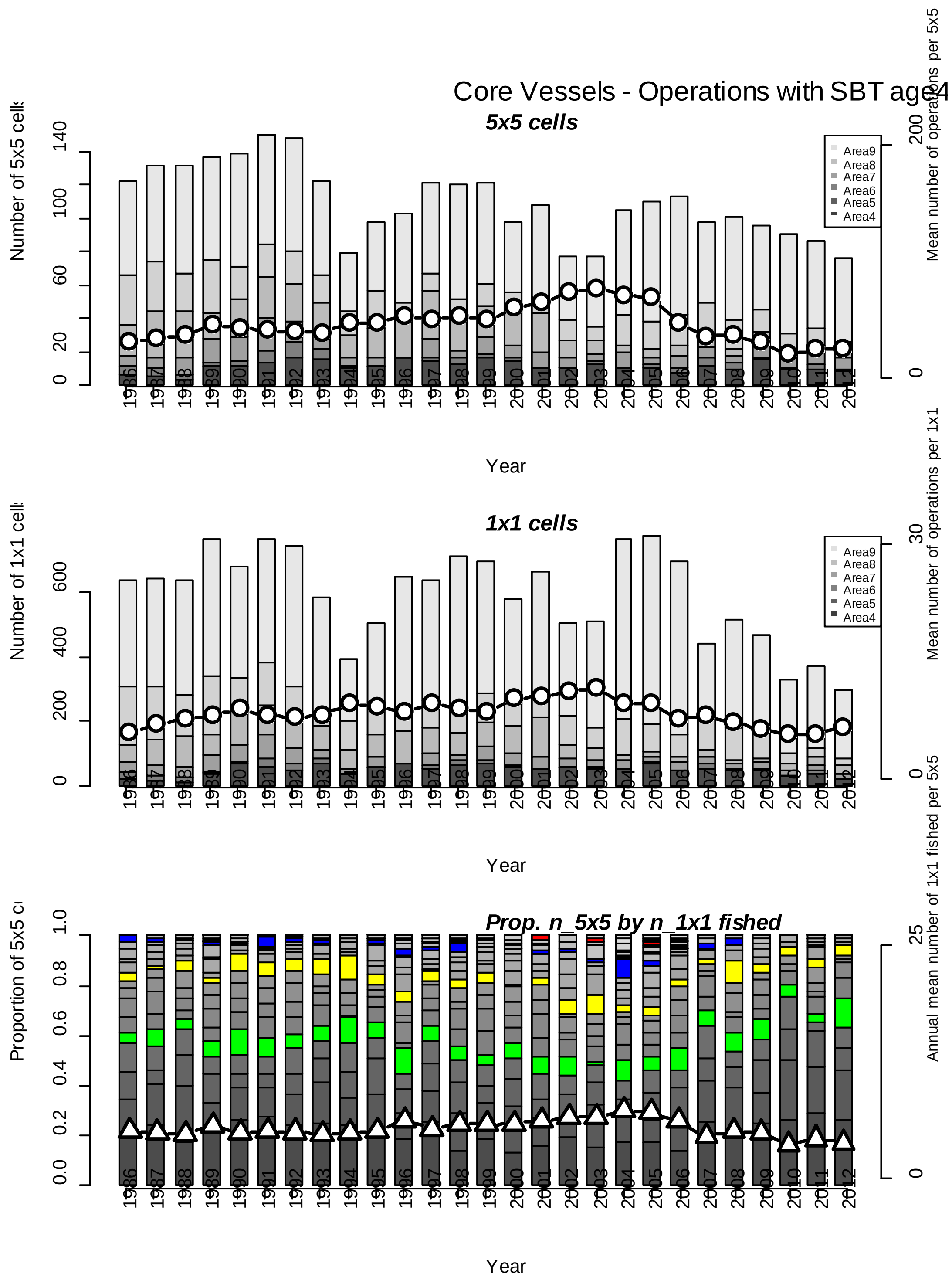
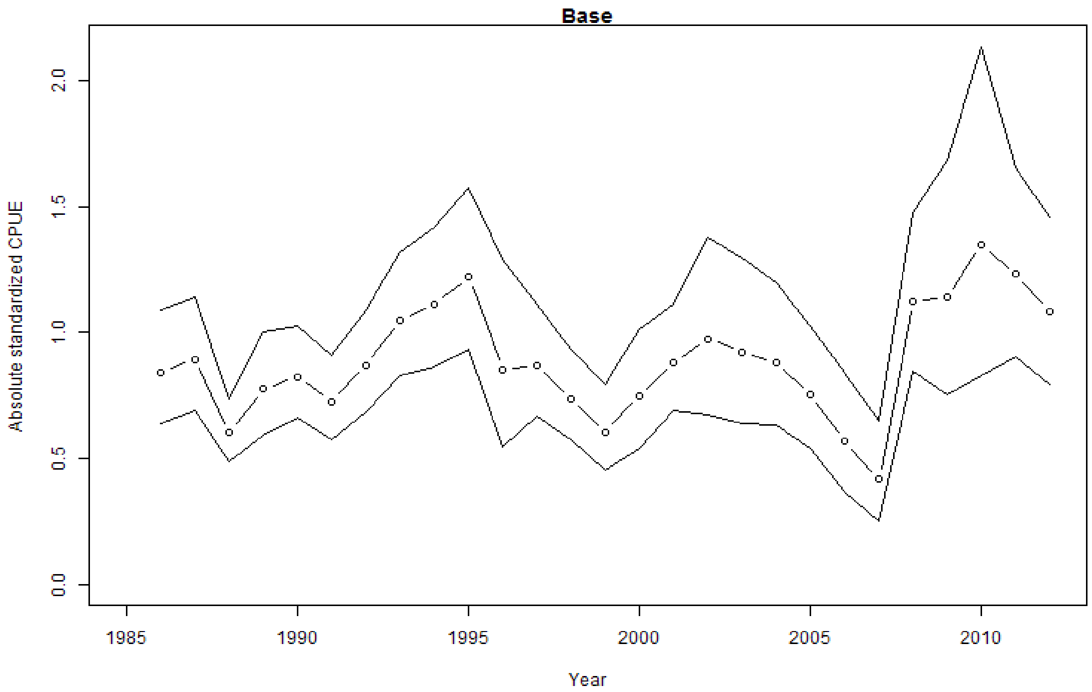


Figure 1b. Number of cells in the core vessel for <u>SBT 4+ catch positive</u>. See explanation in Fig. 1a.



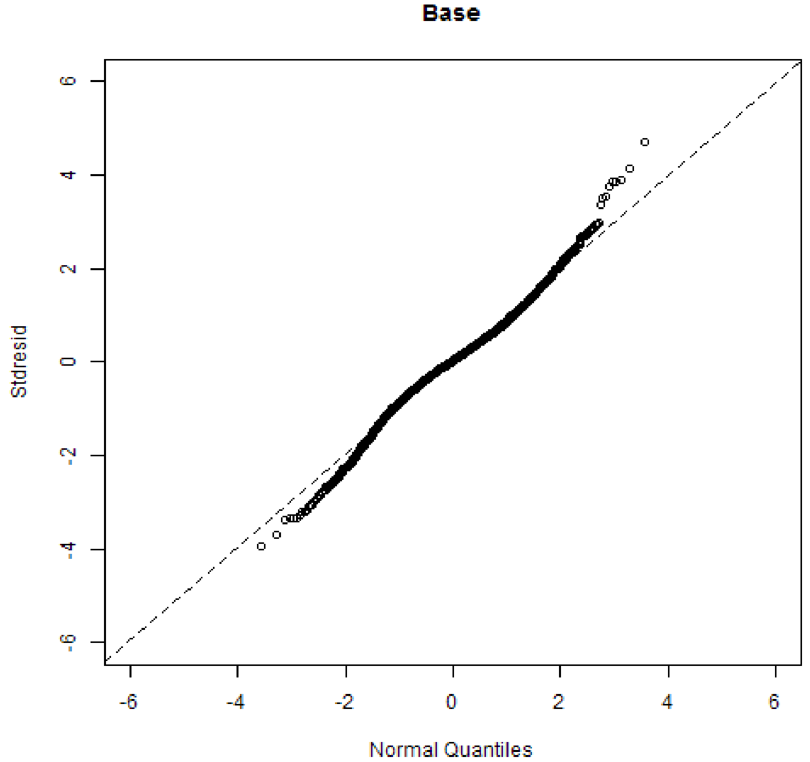


Fig 2. Standardized CPUE (mean with 95% confidence interval) of the core vessel data (upper panel) and its QQ plot of residual (lower panel) for Base case.

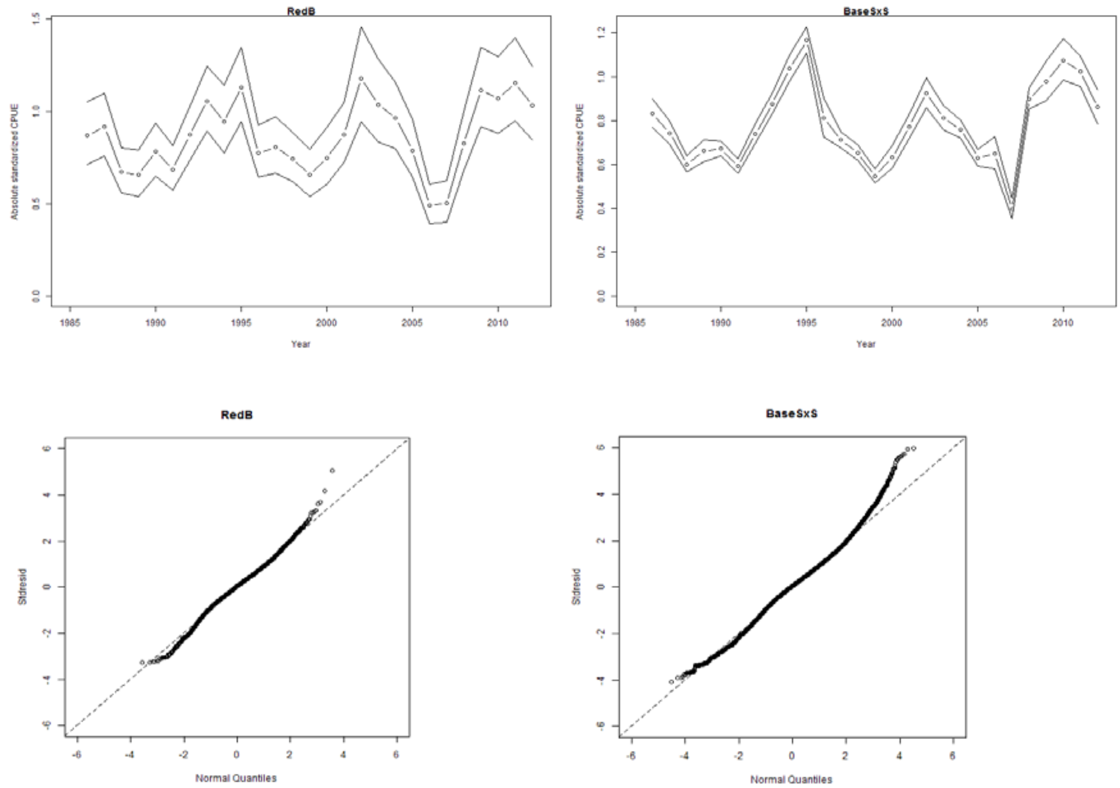
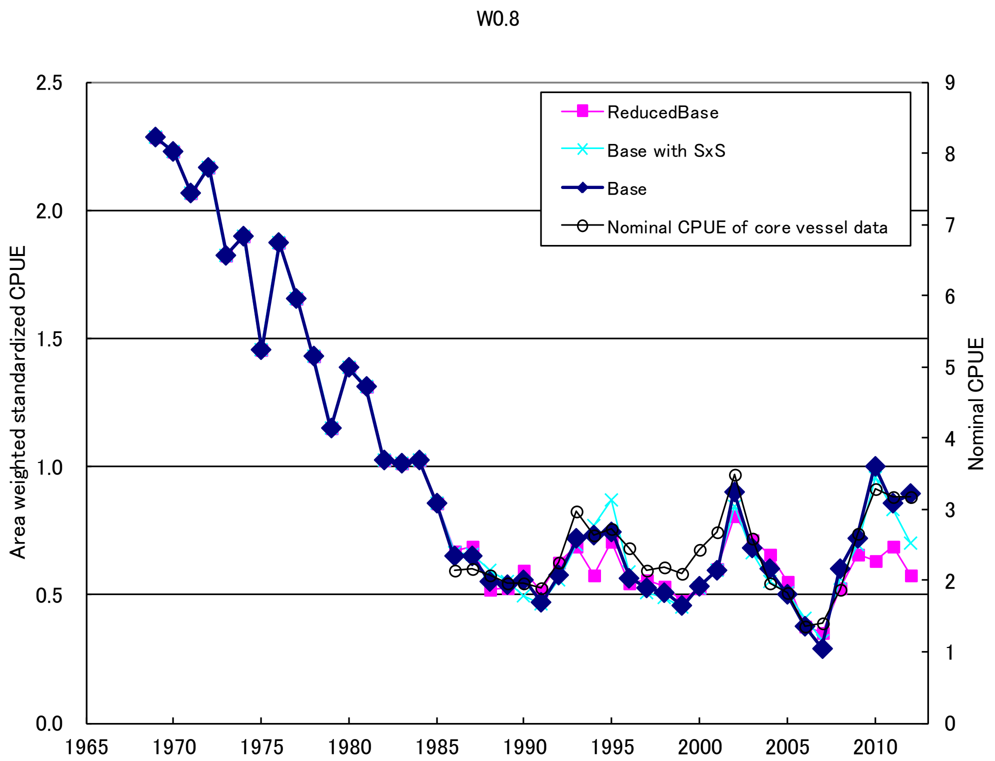


Fig 3. Standardized CPUE (mean with 95% confidence interval) of the core vessel data (upper panel) and its QQ plot of residual (lower panel) for monitoring series. Left panels for reduced base case and right panels for shot-by-shot data with base case GLM model.



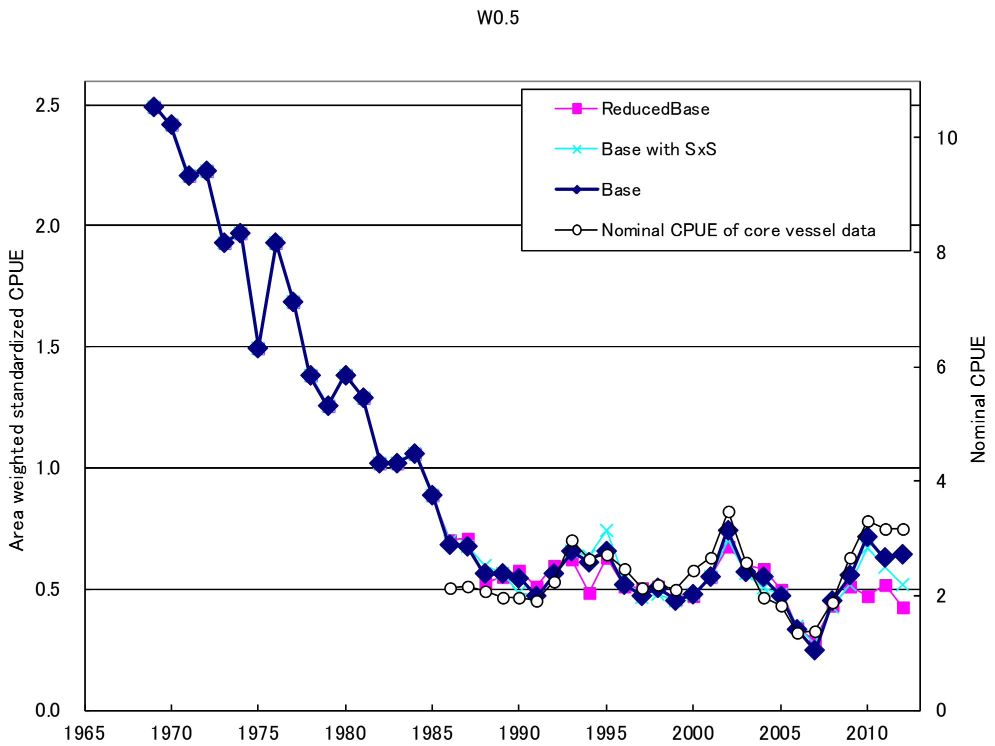


Fig 4. Area weighed standardized CPUEs. Nominal CPUE of the core vessels is also shown.

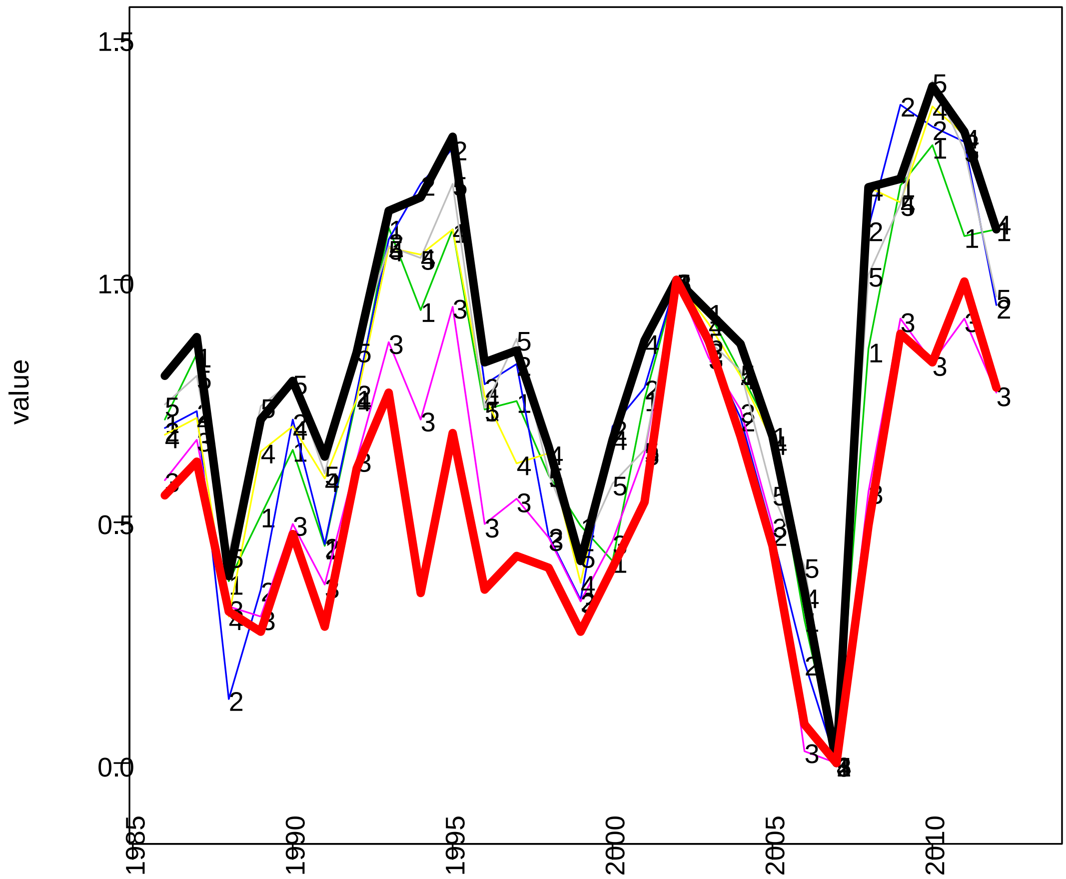


Fig 5. Standardized CPUE series of seven models with different GLM models. Black and red thick lines are Base and Reduced base models, respectively. Values are standardized as difference between 2002 and 2007 is 1.0. Other GLM models are as follows.

1="Base – *Year*Lat5*"

2="Base – *Year*Area*"

3="Base – *Year*Lat5 – Year*Area*"

4="Base – *YFT_CPUE*"

5="Base – *BET_CPUE*"

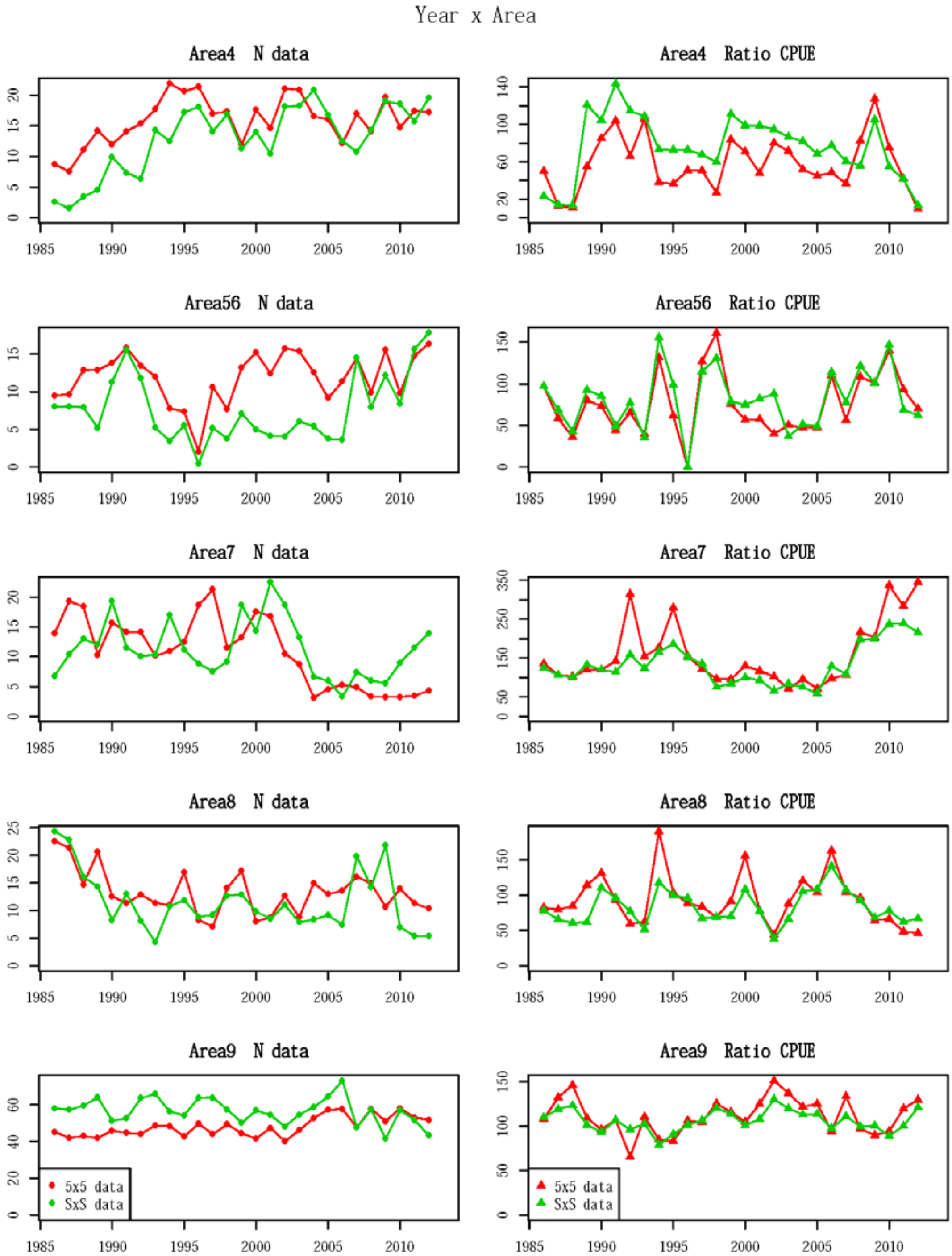


Fig 6. Comparison between 5x5 degree/month data and shot-by-shot data by Area. Left panels show the proportion of the number of record to the whole Area 4-9 (record is each longline operation for shot-by-shot data, and 5x5 degree & month cell for 5x5 month data). Right panels show the proportion of nominal CPUE in the area to the whole Area 4-9.