Standardized CPUE for Management Procedure

管理方式のための標準化 CPUE

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Abstract

This paper summarize standardized CPUE of longline fishery for southern bluefin tuna which used for Management Procedure for discussion in the 15th Extended Scientific Committee in 2010. It describes data preparation, the base model and other models for CPUE standardization using GLM.

要旨

本文書は、2010 年の第 15 回拡大委員会での議論のため、管理方式に用いられるミナミマグロ延縄漁業の標準化 CPUE についてまとめたものである。データ準備、ベースケースならびに他のモデルによる GLM を用いた CPUE 標準化について記述する。

Data preparation

The dataset used was added NZ charter vessel data of catch and effort in shot-by-shot resolution provided from New Zealand into the dataset previously used. Proportion of age 4 plus calculated from CCSBT database was applied. In addition, Japanese 2009 data mainly comprised with RTMP data were added. From this dataset, a set of core vessels were nominated with condition of Area 4-9, Month 4-9, x (top rank of SBT catch in a year) = 52 and y (number of years in the top ranks) = 3 (Table 1). It chose 118 vessels as the core vessels and subset data in total of 130,830 records were made.

Some correction was made as in previous, including deleted records operated south of 50 degree S, combined Area 5 and Area 6 into Area 56, and deleted 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 in Base Case

CPUE were standardized with GLM using SAS (version 9.2). Small constant of 0.2 was added into CPUE age 4+ before log transform.

Base model:

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

The value in the most recent year (2009), which was mainly from RTMP, was corrected with the constant of 0.925, the average in three years (1.023 in 2004, 0.883 in 2005 and 0.868 in 2006 of ratio Logbook based CPUE / RTMP based CPUE).

With the estimated parameters obtained from CPUE standardization by GLM, the CS and 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 series between 1986 and 2009 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."

One of the CPUE series made (W0.8) is shown in Fig. 1.

CPUE standardization in other cases

(1) CPUE for OM/MP robustness tests

There are two CPUE series developed to be used for robustness tests of Operating Model and Management Procedure, so called Run-03 and Run-06.

Run-03 : Add % of hauls with presence of by-catch for each 5*5 cell into (Base - BET_CPUE - YFT_CPUE) as categorical variables. From the frequency distribution of the % hauls, four categories were determined as follows; category 1: 0%>= and <25%, category 2: 25%> and <= 50%, category 3: >50 and <= 75%, and category 4: >75% and <= 100%.

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

Run-06 : Use the 5x5 month records of pure SBT (not including BET or YFT catch). The GLM model used was that includes main effects only.

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

One of the CPUE series made (W0.8) using these models are shown in Fig. 2.

(2) Historical CPUE series

Three historical CPUE series were developed for years from 1969 through 1986.

Nishida and Tsuji 1998:

$$\log(CPUE+const) = Intercept + Year + Quarter + Month + Area + Lat5 + (Quarter*Area) + (Year*Quarter) + (Year*Area) + Error,$$

where *const* is 10% of the mean nominal CPUE.

“Base model” used for historical series:

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

Because it originated from “Base case” for glm model post-1986, it is called “base”. However, the model is different that not including terms of *BET_CPUE, YFT_CPUE*, not available in pre-1986 data.

“Reduced Base model” used for historical series:

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

Because it originated from "Reduced Base case" for glm model post-1986, it is called "Reduced Base". This is also not included terms of *BET_CPUE, YFT_CPUE*, not available in pre-1986 data.
CPUE series using the three historical series are shown in Fig. 1.

(3) Nested models of the Base Case
Nested models of the Base case were investigated in the 3rd OMMP Technical meeting held in Seattle in 2010 and "Reduced Base model", delete year*area and year*latitude interactions from the Base case, was kept for monitoring future change. The nested models were investigated again using the data extended up to 2009.
Among seven models, AIC was the lowest in the Base case while BIC was the lowest in the Reduced Base model (Table 2). Because the numbers of parameters were quite large for interaction terms, BIC value was reduced largely if any interaction term was deleted.
The CPUE series are similar to each other but differ in years from 1993 to 1995 for Reduced Base model and "Base – Yellowfin tuna CPUE", lower than others in W0.8 (Fig. 3). There are substantial differences among series in 2008 and 2009 in "no area weighting" (lower in Reduced Base model and "Base – Year*Area") (see appendix figure), but such differences become much smaller in any area weighting.

(4) 5x5 Month vs Shot-by-shot
Standardized CPUE were compared between data in 5x5 month resolution and data in shot-by-shot. Although such comparison was made in 2009 (working paper for CPUE group meeting 2009-b10.1), the data series has extended to 2009 for the present analysis.
Both series show similar trend (Fig. 4).

(5) Effect of vessel ID
Standardized CPUE were compared between the Base model and adding vessel effect into the Base model. Although such comparison was made in 2009 (working paper for CPUE group meeting 2009-b10.1), the data series has extended to 2009 for the present analysis. As found in previous, no substantial difference was observed in the series of the two models (Fig. 5).

Other figures are also presented in the appendix (ESC24_CPUE_appendix.ppt).

Reference

Nishida, T., and S. Tsuji. 1998. Estimation of abundance indices of southern bluef in tuna (*Thunnusmaccoyii*) based on the coarse scale Japanese longline fi sheries data (1969-97). Paper submitted to the Commission for the Conse rvation of Southern Bluefin Tuna, Scientific Meeting. CCSBT/SC/9807/13. 27 pp.

Table 1. Number of records in the dataset used.

Vessels	All AU	All Japan	All NZ	All Total	Core Total
1986		27,043		27,043	3,612
1987		26,821		26,821	4,203
1988		24,418		24,418	4,895
1989	1,156	23,985		25,141	6,074
1990	504	19,865	475	20,844	5,710
1991	1,204	18,244	460	19,908	6,103
1992	1,717	17,168	499	19,384	6,036
1993	2,001	14,632	486	17,119	5,925
1994	1,436	12,267	268	13,971	5,031
1995	800	12,678	373	13,851	5,127
1996		14,854		14,854	5,950
1997		16,322	379	16,701	7,038
1998		16,310	310	16,620	7,143
1999		14,414	306	14,720	6,724
2000		11,745	265	12,010	6,247
2001		14,075	198	14,273	6,763
2002		10,693	228	10,921	5,159
2003		11,563	294	11,857	5,389
2004		13,101	349	13,450	6,714
2005		13,848	198	14,046	6,690
2006		9,124	183	9,307	4,938
2007		5,540	387	5,927	3,546
2008		6,841	167	7,008	3,786
2009		3,228	239	3,467	2,027
Total	8,818	358,779	6,064	373,661	130,830

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

Table 2. AIC and BIC of nested models of Base Case

Model	Subtract from Base	N_parameter reduced	AIC	BIC	Remark
Base	–		5,157	6,425	
	Year*Area	120	5,272	6,008	
	Year*Lat5	96	5,246	6,115	
	Month*Area	30	5,337	6,490	
	YFT_CPUE	1	5,265	6,528	
	BET_CPUE	1	5,329	6,592	
	Year*Area, Year*Lat5	216	5,334	5,670	Reduced Base model

Shadow denotes the lowest.

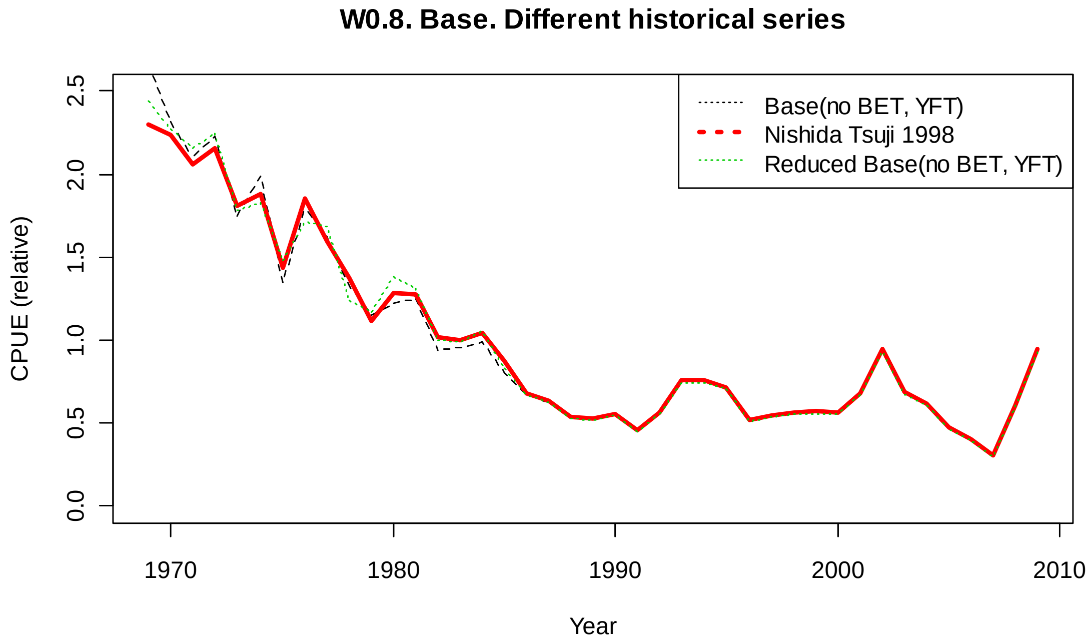

Fig 1. CPUE index of W0.8, using Base case GLM model and calibrated to three historical CPUE series.

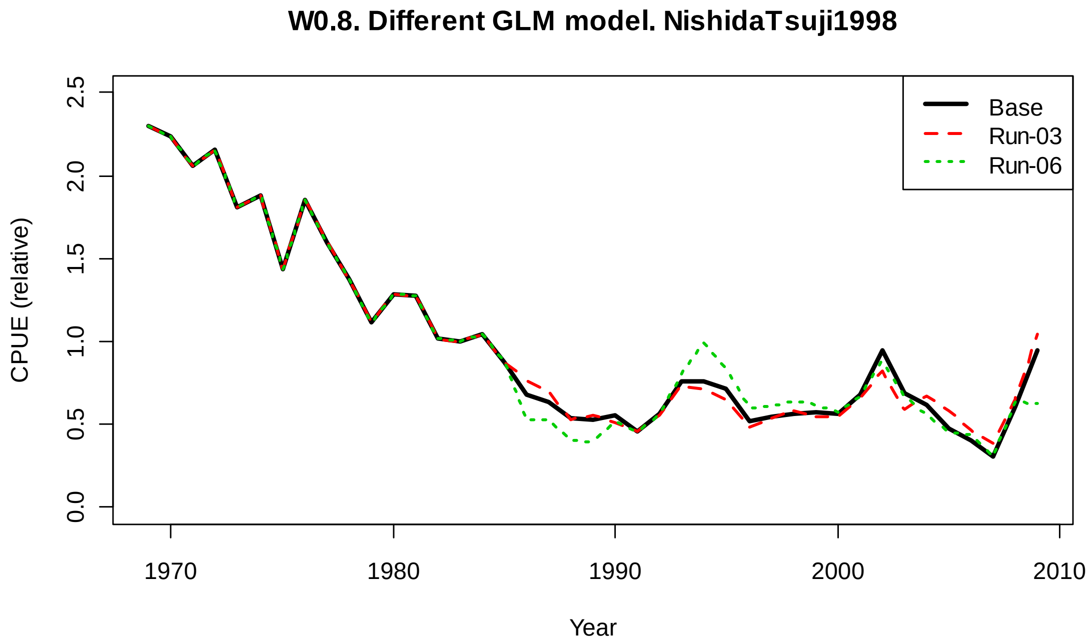

Fig 2. CPUE index of W0.8, using different GLM models for OM/MP robustness tests (Run-03, Run-06). Historical series are from Nishida and Tsuji 1998 model.

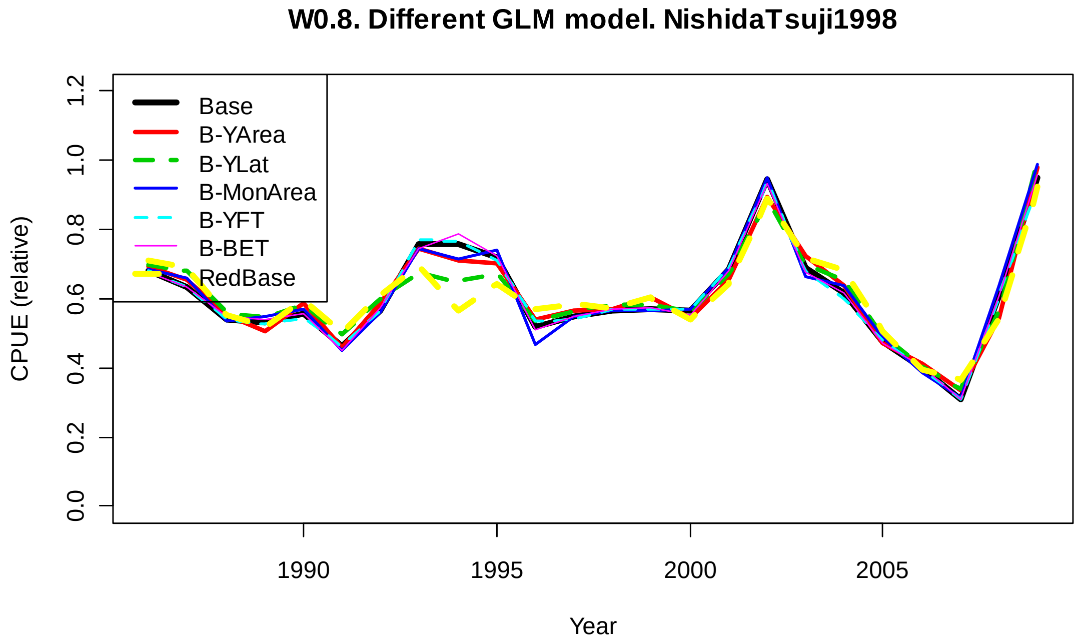

Fig 3. CPUE index of W0.8, using different GLM nested models of the Base case including Reduced base model. Historical series are from Nishida and Tsuji 1998 model.

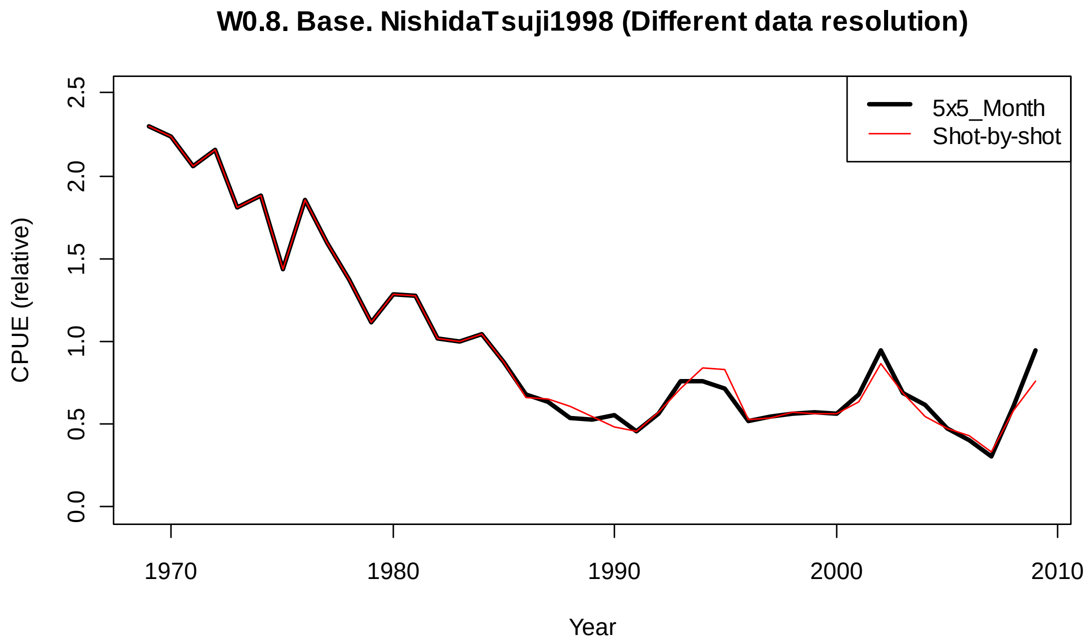

Fig 4. CPUE index of W0.8, using different data (5x5 month data vs shot-by-shot data) with the Base case. Historical series are from Nishida and Tsuji 1998 model.

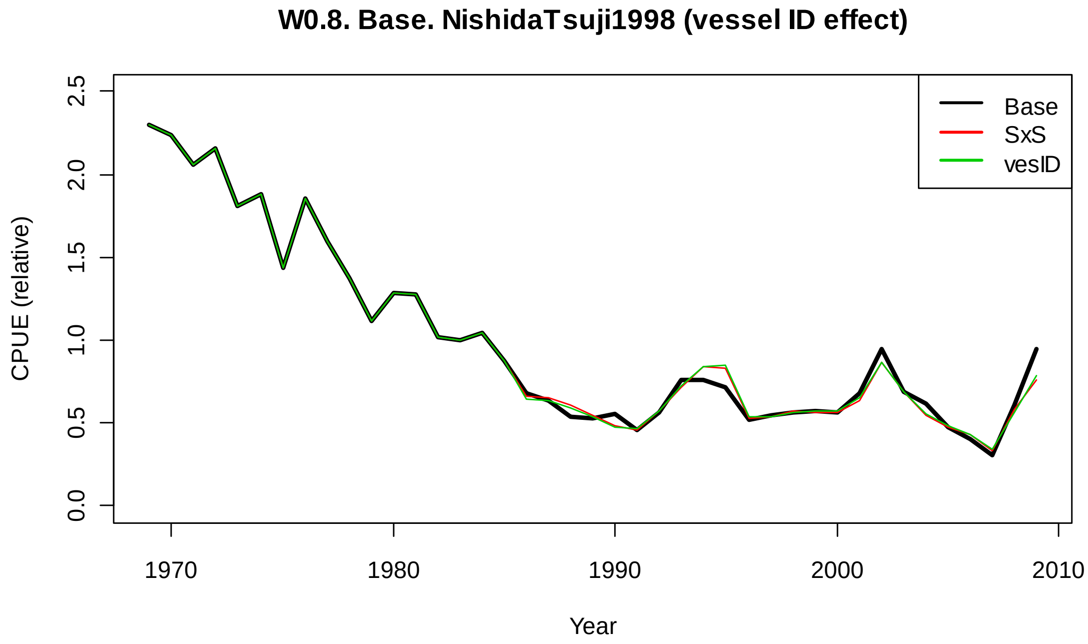

Fig 5. CPUE index of W0.8, using different data (5x5 month data vs shot-by-shot data) with the Base case, adding a model Base+vessel ID using shot-by-shot data. Historical series are from Nishida and Tsuji 1998 model.

CCSBT/ESC/1009/22 Appendix

Output of LL1 CPUE analysis

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Suggested seeing colour version in the Power Point file.

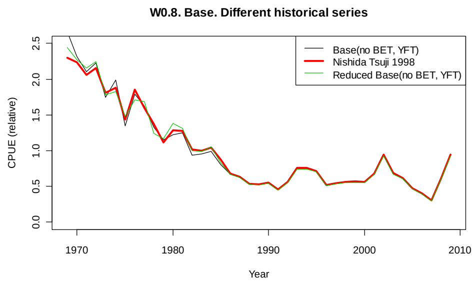

Fig. 1a. CPUE index (different historical series)
Base and Reduced model did not included BET and YFT CPUEs in the GLM models.

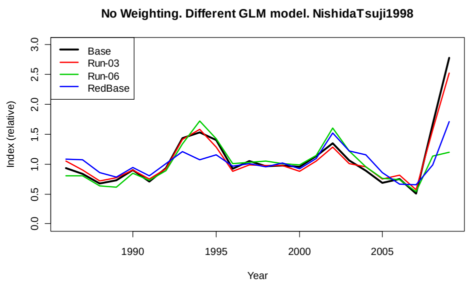

Fig. 1b. CPUE index (Different GLM model; No area weighting)

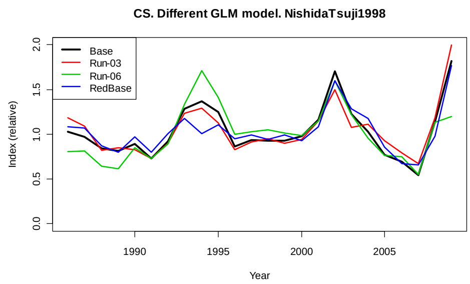

Fig. 1c. CPUE index (Different GLM model; Constant Square)

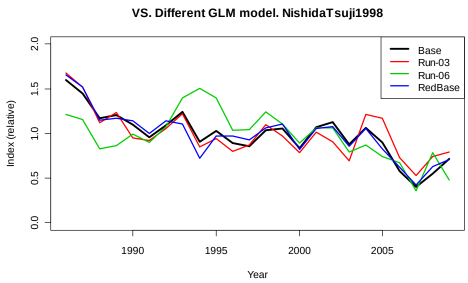

Fig. 1d. CPUE index (Different GLM model; Variable Square)

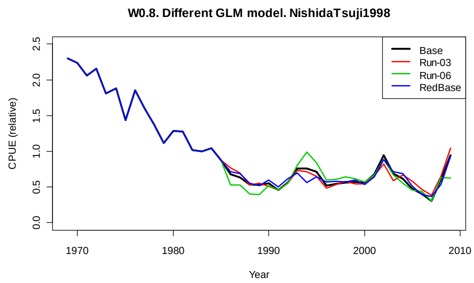

Fig. 1e. CPUE index (Different GLM models; W0.8 area weighting)

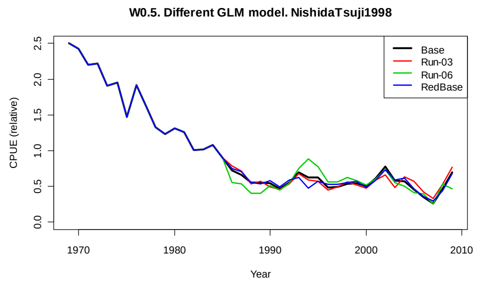

Fig. 1f. CPUE index (Different GLM models; W0.5 area weighting)

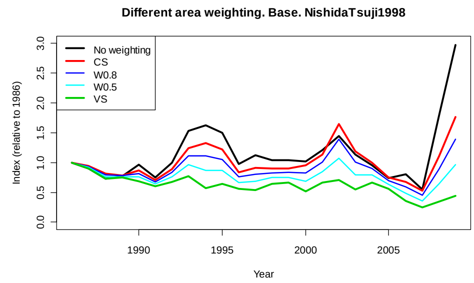

Fig. 1g. CPUE index (Different area weighting; Base)

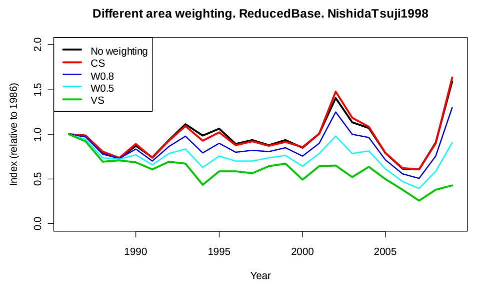

Fig. 1h. CPUE index (Different area weighting; Reduced base)

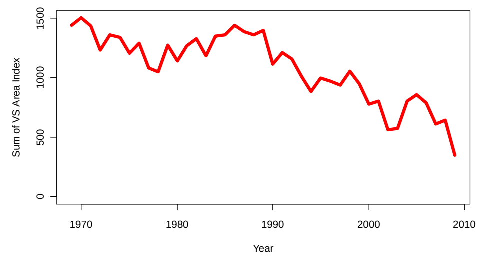

Fig. 2. Sum of area index for variable square by year (Area index is by year, month, Area and Latitude 5 degree.)

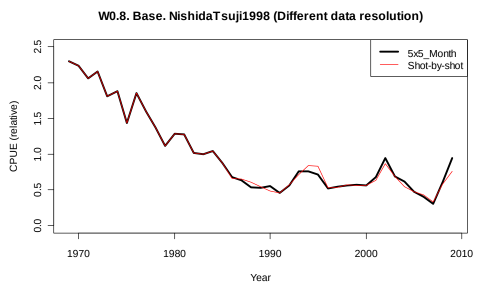

Fig. 3a. CPUE index monitoring (different data resolution) 5x5 month data vs shot-by-shot data

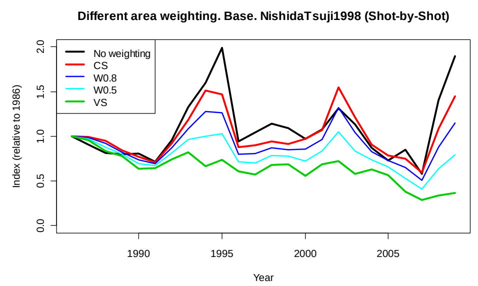

Fig. 3b. CPUE index monitoring (Different area weighting; Base; Using shot-by-shot data)

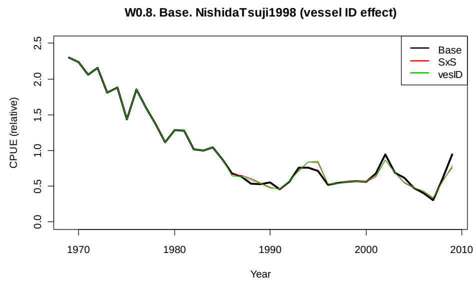

Fig. 4. CPUE index monitoring (adding vessel ID)
Using shot-by-shot data for vessel ID.

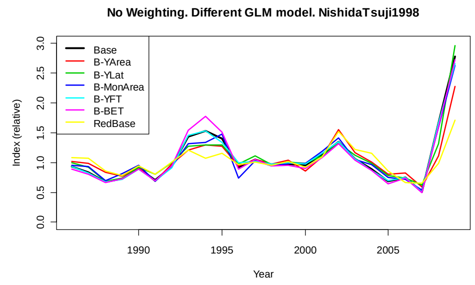

Fig. 5a. CPUE index monitoring (Subtract factor from Base model; No area weighting)

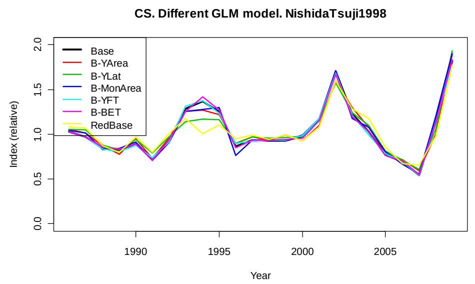

Fig. 5b. CPUE index monitoring (Subtract factor from Base model; Constant Square area weighting)

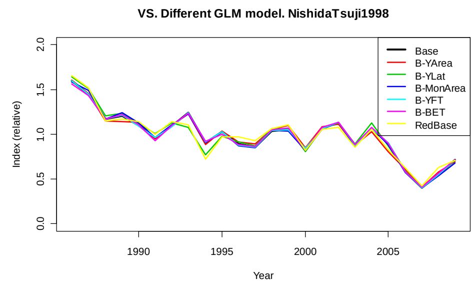

Fig. 5c. CPUE index monitoring (Subtract factor from Base model; Variable Square area weighting)

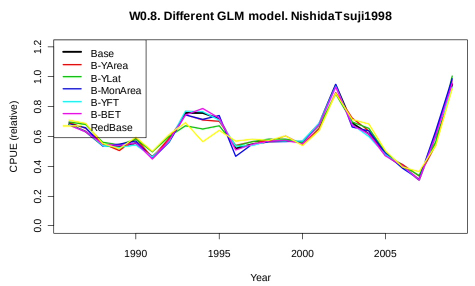

Fig. 5d. CPUE index monitoring (Subtract factor from Base model; W0.8 area weighting)

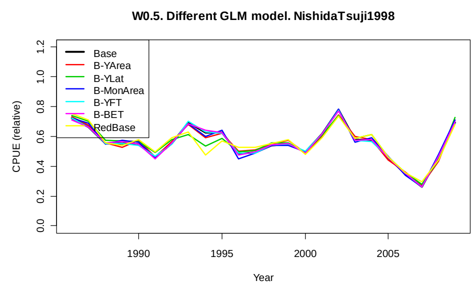

Fig. 5e. CPUE index monitoring (Subtract factor from Base model; W0.5 area weighting)

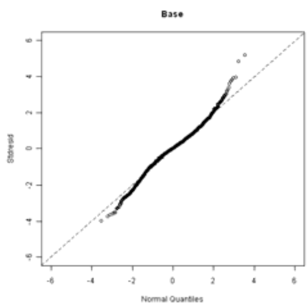

Fig. 6a Q-Q plot of GLM standardization (Base)

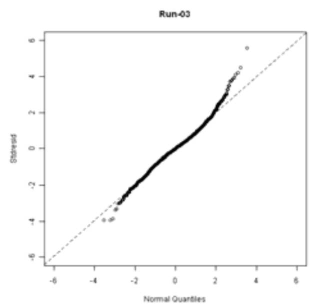

Fig. 6b. Q-Q plot of GLM standardization (Run-03)

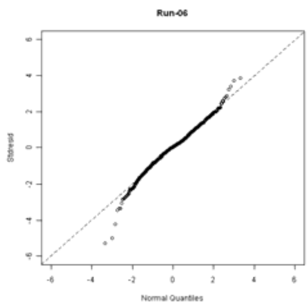

Fig. 6c. Q-Q plot of GLM standardization (Run-06)

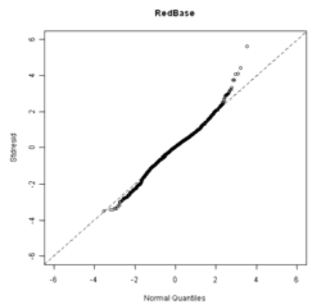

Fig. 6d. Q-Q plot of GLM standardization (Reduced Base)

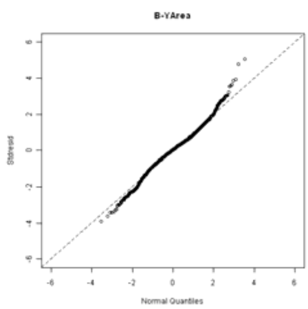

Fig. 6e. Q-Q plot of GLM standardization (Base – Year*Area)

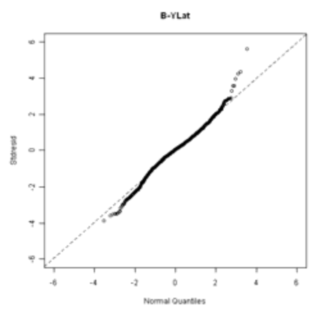

Fig. 6f. Q-Q plot of GLM standardization (Base – Year*Latitude)

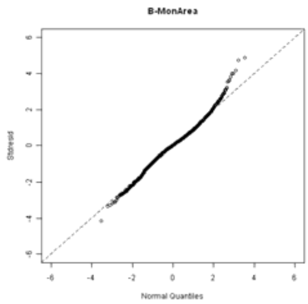

Fig. 6g. Q-Q plot of GLM standardization (Base – Month*Area)

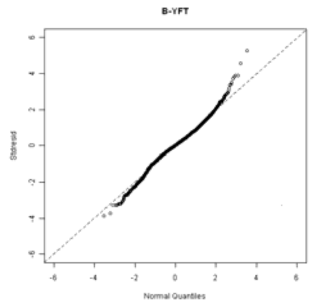

Fig. 6h. Q-Q plot of GLM standardization (Base – Yellowfin tuna CPUE)

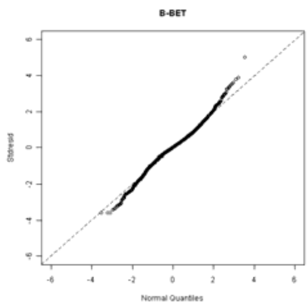

Fig. 6i. Q-Q plot of GLM standardization (Base – Bigeye tuna CPUE)

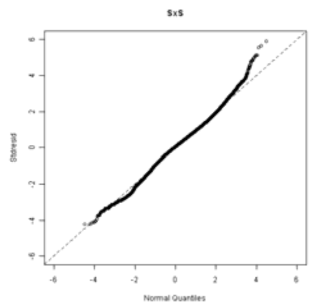

Fig. 6j. b10 Q-Q plot of GLM standardization (Shot-by-shot data)

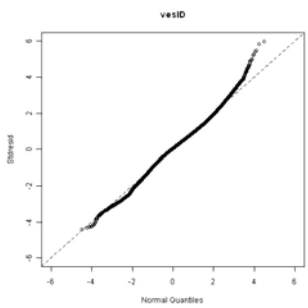

Fig. 6k. Q-Q plot of GLM standardization (Base+vessel ID; Useing shot-by-shot data