Stock assessment for yellowfin tuna in the Indian Ocean from 1963 to 2009 by Stock Synthesis III (SS3) including tagging data

Hiroshi Shono, Yu-Min Yeh, Hiroaki Okamoto, Ian Taylor, Miguel Herrera and Julien Million

Abstract:

We conducted the stock assessment for bigeye tuna in the Indian Ocean using Stock Synthesis III (SS3) (made by Rechard, Methot: Methot, 2005; Methot, 2010), a kind of length-based integrated model, including the data on tagging experiment and using the similar sub-area and fishery definition this year. The main objectives of our analyses are to compare with the result obtained from the Multifan-CL (Langlay et al.,2010) and/or ASPIC (Nishida, 2010) and estimate (i.e. measure) the influence of the tagging data. Estimated MSY related values (MSY-300,000 MT, Total-Biomass at MSY-1,200,000 MT etc.) obtained from SS3 are rather similar to those by ASPIC.

Introduction:

We tried to assess for yellowfin tuna in the Indian Ocean using Stock Synthesis III (SS3), a kind of length-based integrated and statistical approach. The advantages to utilize such length-based integrated model (e.g. Multifan-Cl, A-SCALA, CASAL etc.) instead of traditional stock assessment model (such as ASPM, ASPIC or Tuned VPA and so on) are as follows:

- To reduce the aging error (i.e. error from the catch-at-size to catch-at-age) because SS3 (and other integrated models) can be dealt with the various length information (i.e. length-composition, length-based selectivity etc.)
- To introduce the prior information (regarding the unknown parameters)
- To check the influence of the tagging release-recapture data on the stock
- To use the flexible conditions/assumptions about selectivity, catch-ability, spawning-recruitment relationship and biological parameters (growth, M, maturity etc.) and so on.

In this paper, we again carried out stock assessment for yellowfin tuna in the Indian Ocean by SS3 model using the similar assumptions to the stock assessment by Multifan-Cl and updated datasets for 1963 up to 2009 for the comparison purpose of stock assessment results in 2007 and 2008 using SS2 and by other methods like production model e.g. ASPM/ASPIC etc.

Material and Methods:

The following datasets and model structures were utilized in our analyses and population dynamics are calculated from 1963 to 2009.

1) Data used

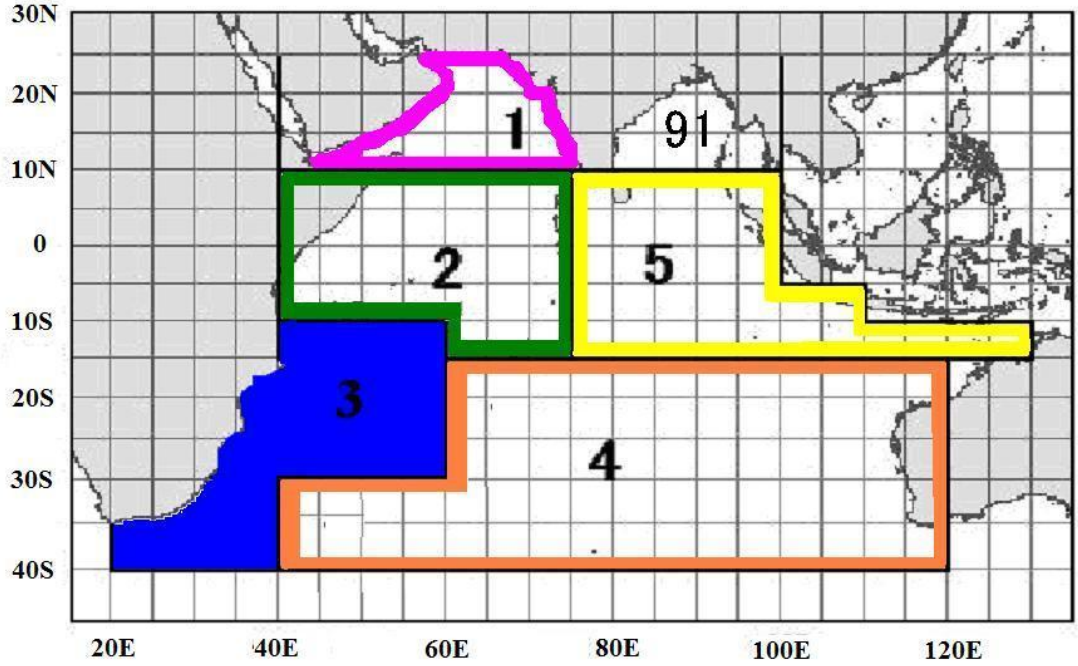
We utilized the quarterly-based data (catch amount, CPUE and length-frequency) in our SS3 calculation.

(1). Fleet definitions and Catch
The following fleet definition similar to Multifan-CL was used for 1963-2009.

# Fishery 1	Gillnet (GI)	[region 1]
# Fishery 2	Handline (HD)	[region 1]
# Fishery 3	Longline (LL)	[region 1]
# Fishery 4	Other (OT)	[region 1]
# Fishery 5	Baitboat (BB)	[region 2]
# Fishery 6	Purse-seine - free schools (FS)	[region 2]
# Fishery 7	Longline (LL)	[region 2]
# Fishery 8	Purse-seine - log schools (LS)	[region 2]
# Fishery 9	Troll (TR)	[region 2]
# Fishery 10	Longline (LL)	[region 3]
# Fishery 11	Longline (LL)	[region 4]
# Fishery 12	Gillnet (GI)	[region 5]
# Fishery 13	Longline (LL)	[region 5]
# Fishery 14	Other (OT)	[region 5]
# Fishery 15	Troll (TR)	[region 5]
# Fishery 16	Purse-seine - free schools (FS)	[region 3]
# Fishery 17	Purse-seine - log schools (LS)	[region 3]
# Fishery 18	Old-FisheTroll (TR)	[region 3]
# Fishery 19	Purse-seine - free schools (FS)	[region 5]
# Fishery 20	Purse-seine - log schools (LS)	[region 5]

Quarterly catch entered the model as biomass (i.e. in weight: MT).

(2). Area stratification (i.e. Region 1-5: see below)



(3). Survey definition (i.e. CPUE indices for tuning as the inputs in the SS3)
Fishery 21 Taiwanese Longline (LL) standardized CPUE [region 1]
Fishery 22 Japanese Longline (LL) standardized CPUE [region 2]
Fishery 23 Japanese Longline (LL) standardized CPUE [region 3]
Fishery 24 Japanese Longline (LL) standardized CPUE [region 4]
Fishery 25 Japanese Longline (LL) standardized CPUE [region 5]

Standardized quarterly CPUE from 1963 to 2009 caught by Japanese longline fishery (Okamoto and Shono, 2010) in region 2 to 5 and standardized CPUE for 1979-2009 caught by Taiwanese longline fishery (Yeh, Y. M. and Chang S. T. 2010) were incorporated into the SS3 model as tuning indices. Standard deviation of natural logarithm of CPUE in region 2 to 5 are integrated into the SS3 and these in region 1 were uniformly assumed to 0.2.

(4). Gender

Male and female were divided. i.e. number of sex was assumed to 2.

(5). Length-frequency

The proportion of quarterly catch-at-size in each length-bin (2cm) (from 10cm to 198cm, 95bin: processed by Miguel Herrera) for each 20 fishery was utilized and age-frequency is not used.

(6). Tagging information

The tagging data for releases-and recaptures of yellowfin tuna in the Indian Ocean on MS-Access database (made by Julien Million) are included.

2) Model structures

The following conditions/assumptions in each component were used for our SS3 computation.

(1). Selectivity patterns

Selectivity was modeled as length-based not age-based. We adopted dome-shaped double-normal selectivity (#24) with six parameters in all fisheries and estimated unknown parameters in each fishery, individually. Initial values were set up based on the actual size-frequency in each fishery.

(2). Stock-Recruitment relationship

Recruitment was modeled assuming a Beverton and Holt curve and (h, R0) was defined as the parameters instead of (a, b) in the B-H function. In our analysis, we fixed h (steepness value) =0.8, sigma-R=0.6 and estimated R0 (equilibrium recruitment in an un-fished state corresponding to S0). Regarding the steepness, we used the fixed value at 0.8 as the default because we did not obtain the reasonable value if estimated. We changed the value of steepness (from 0.7 to 0.9) as the sensitivities and the differences of these quarterly trends (e.g. Total Biomass, SSB and Recruitment and so on) were not so large. Recruitment deviations were estimated from 1963 to 2009.

3) Biological parameters

We basically fixed the following biological parameters based on the agreement in the IOTC-WPTT-2008 and also IOTC-WPTT-2009 for yellowfin assessment. Biological information is based on ASPM and/or ASPIC analysis in 2008 by T. Nishida *et.al,* and MULTIFAN-CL in 2009 by A. Langley *et.al,*.

(1). Growth curve

We used the von-Bertalanffy growth and fixed parameters (Linf=166, K=0.38 and t0= -0.336) provisionally, and we will change to Richard's curve.

(2). Weight-Length relationship

The weight at length relationship was taken from the past analyses,

$W=1.585*10^{-5} L^{3.045}$ (1)

(3). Natural mortality (M)

The following quarter-specific M vector was utilized as: 0.2 0.11237 0.09046 0.11449 0.12509 0.10177 0.09117 0.09117 0.09117 0.09117 0.09117.

(4). Maturity

We used age-specific maturity vector instead of logistic curve as: 0 0 1 1 1 1 1 1 1 1 1; i.e. 0 age is less than 2) and 1 (age is equal to or larger than 2.

Results and discussion:

Tables are shown in this section and figures are attached in the Appendix. Estimated MSY related values obtained from SS3 are similar to those by ASPIC and the current status seems to be neither overfished nor overfishing.

Table 1 Estimated MSY related values

MSY	286,239-333,504 (about 300,000 MT)
Total Biomass (TB) at MSY	1,180,280 (about 1,200,000 MT)

Table 2 Estimated recruitment level in each quarter and region (sub-areas)

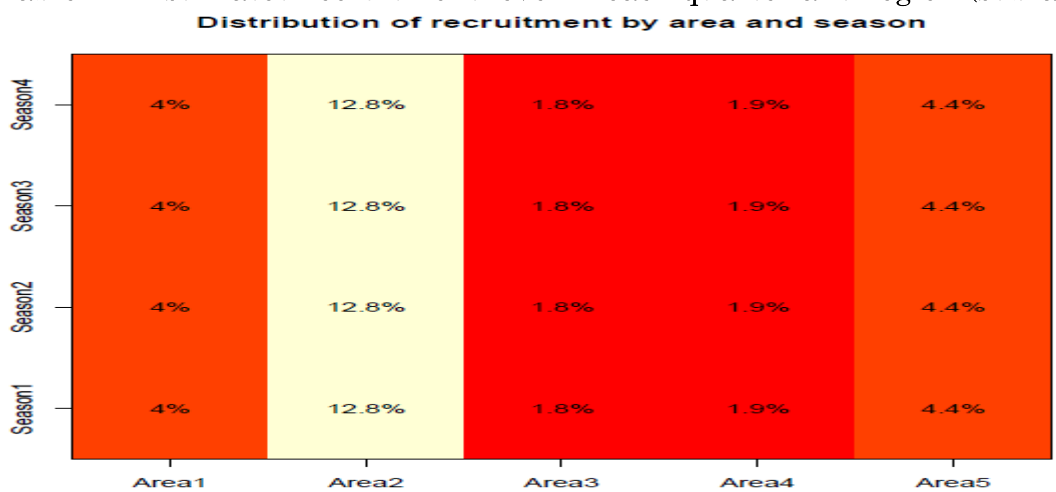
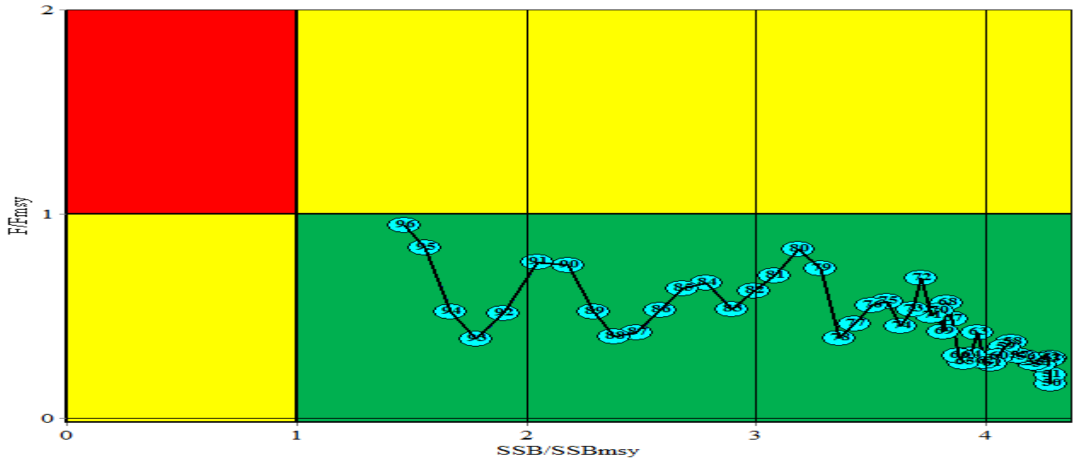


Figure 0 KOBE-plot



Acknowledgement: We sincerely acknowledge Richard D. Method, developer of the Stock Synthesis 3, Tom Nishida and Momoko Ichinokawa, for giving us useful comments and help, Adam Langlay for processing input data for SS3.

References:

Langley, A. Herrera M. and Million, J. (2010) Stock assessment of yellowfin tuna in the Indian Ocean using Multifan-CL. IOTC-2010-WPTT12-23, 72p.

Method, R. D. (2005) Technical description of the stock synthesis II assessment program: Version 1.17 (March, 2005), 54p.

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Nishida, T. (2010) Stock assessment of YFT in the Indian Ocean by ASPIC. IOTC-2010-WPTT-34.

Okamoto, and Shono, H. (2010) Japanese longline CPUE for yellowfin tuna in the Indian Ocean up to 2009 standardized by generalized linear model. IOTC-2010-WPTT-30, 27p.

Yeh, Y. M. and Chang, S.T. (2010) CPUE standardization for Yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized linear model. IOTC-2010-WPTT-40, 14p.

Appendix: (i.e. Figures)

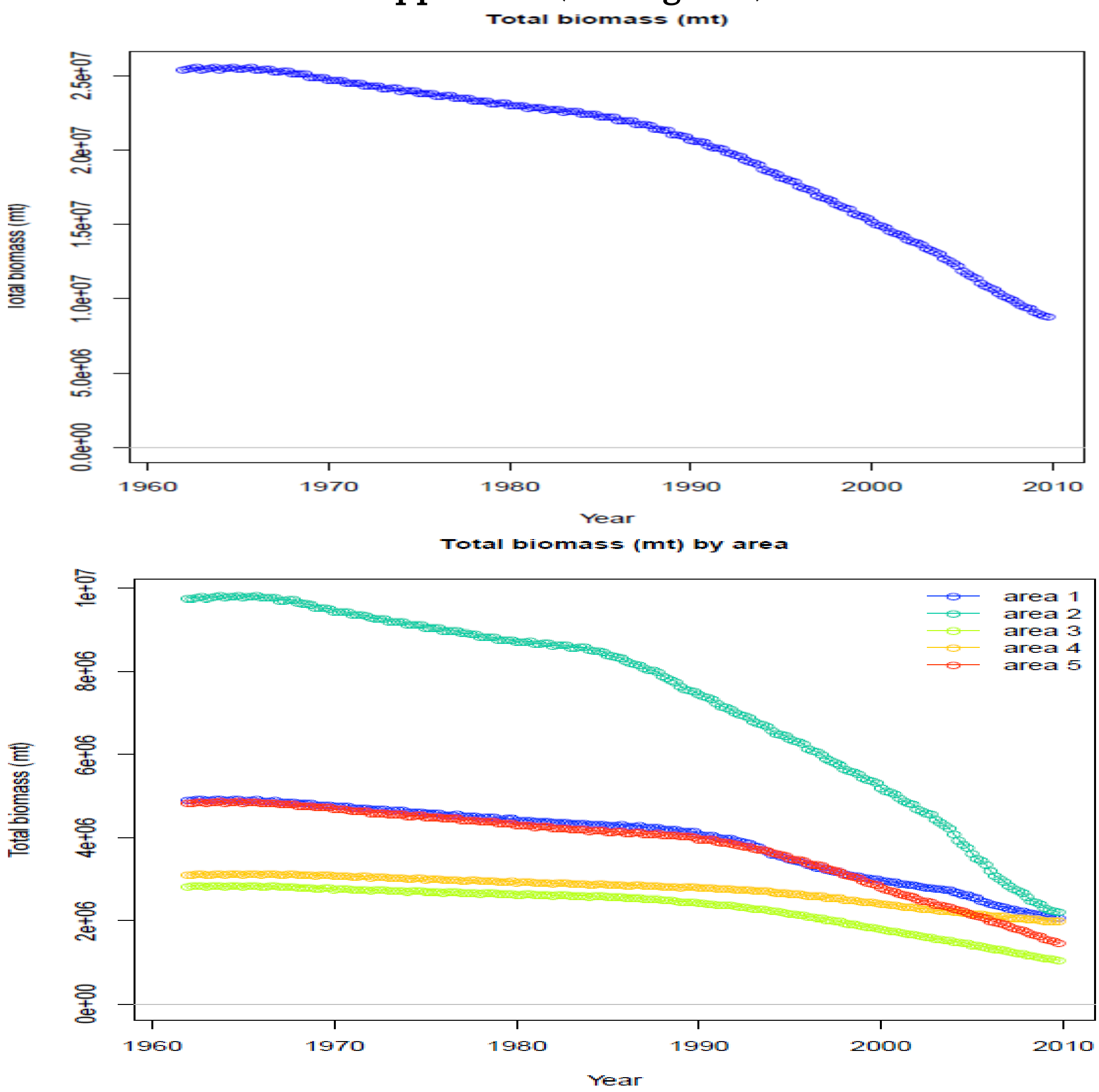
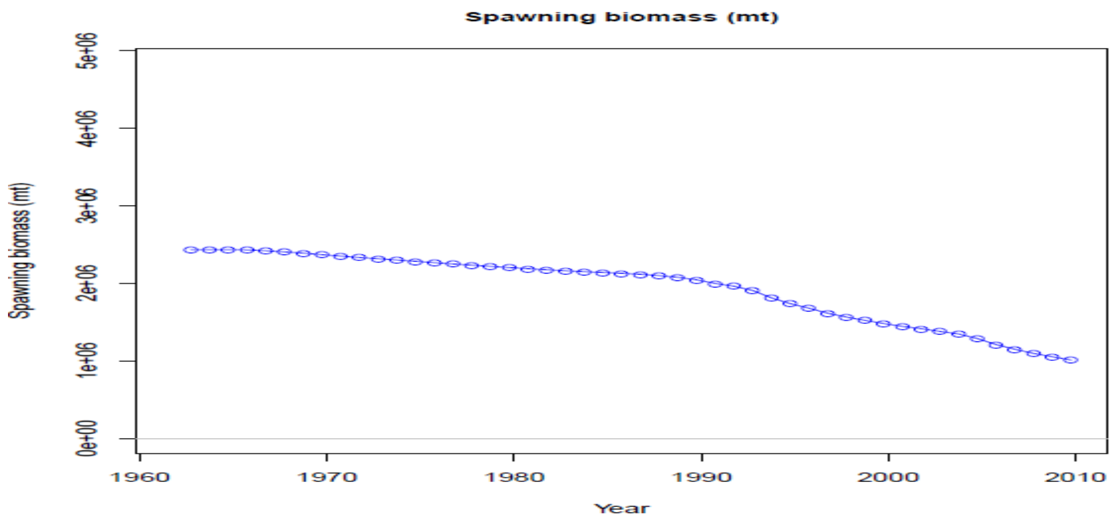


Figure 1 Absolute trends of TB (total biomass)



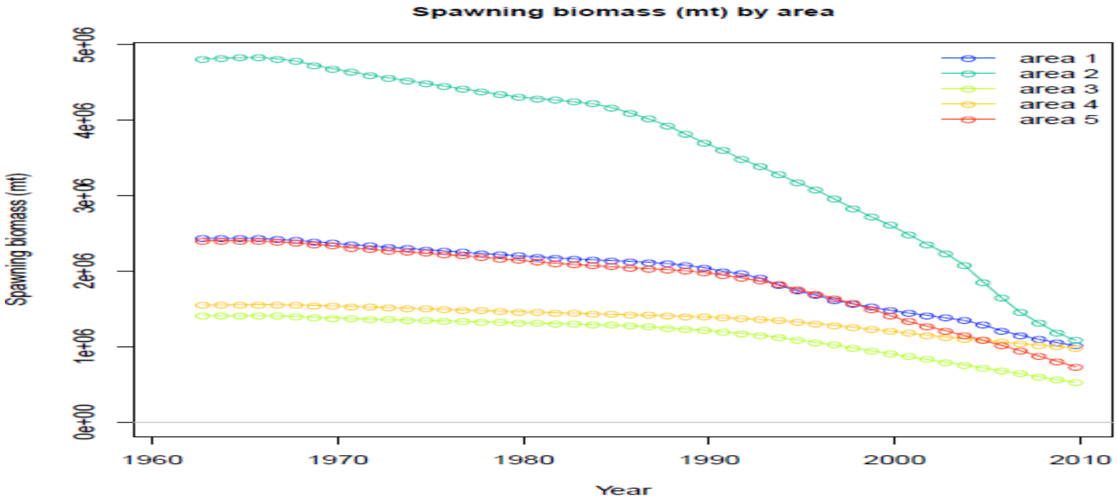


Figure 2　Absolute trends of SSB (spawning stock biomass)

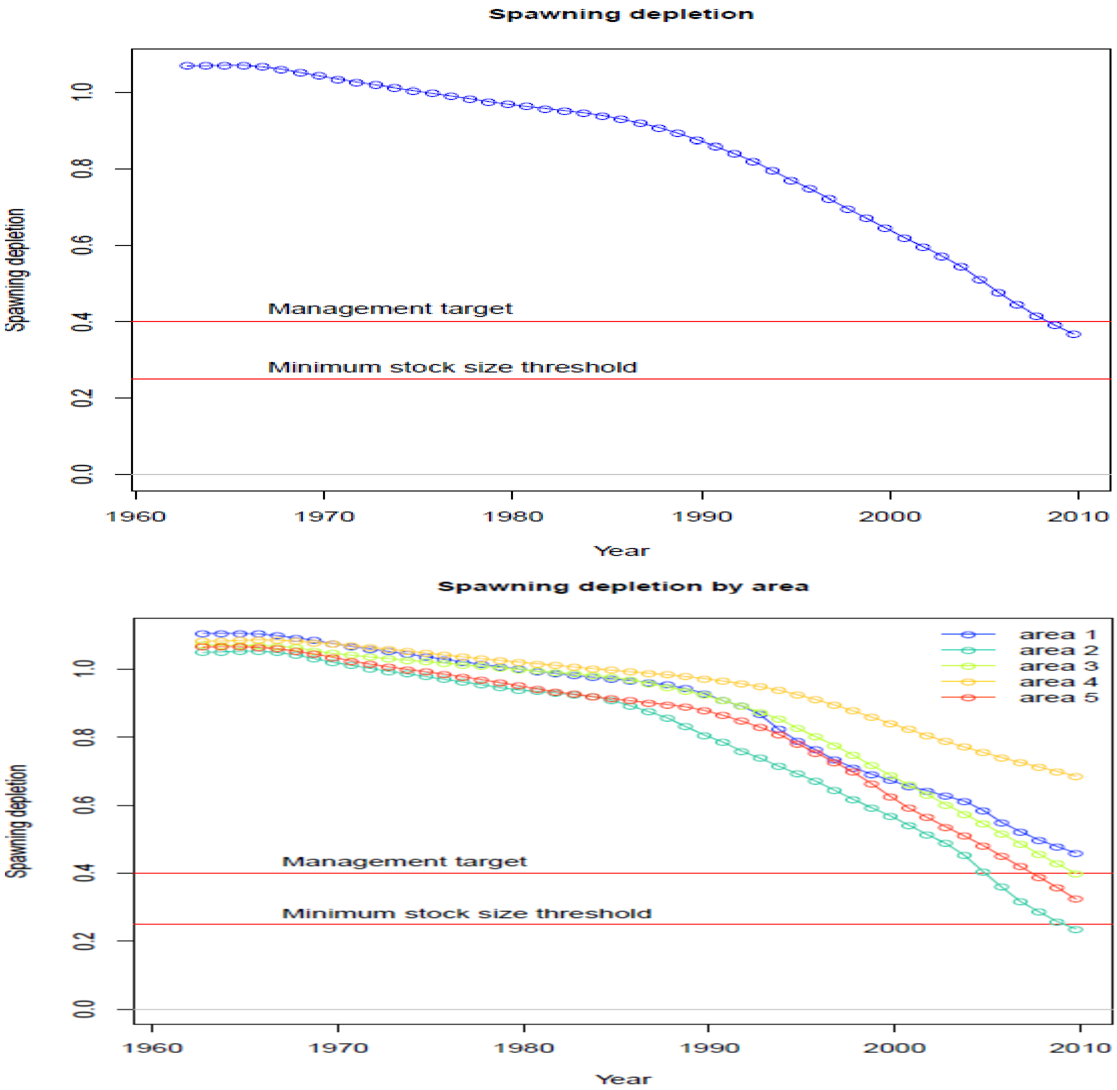


Figure 3　Relative trends of SSB (spawning stock biomass)

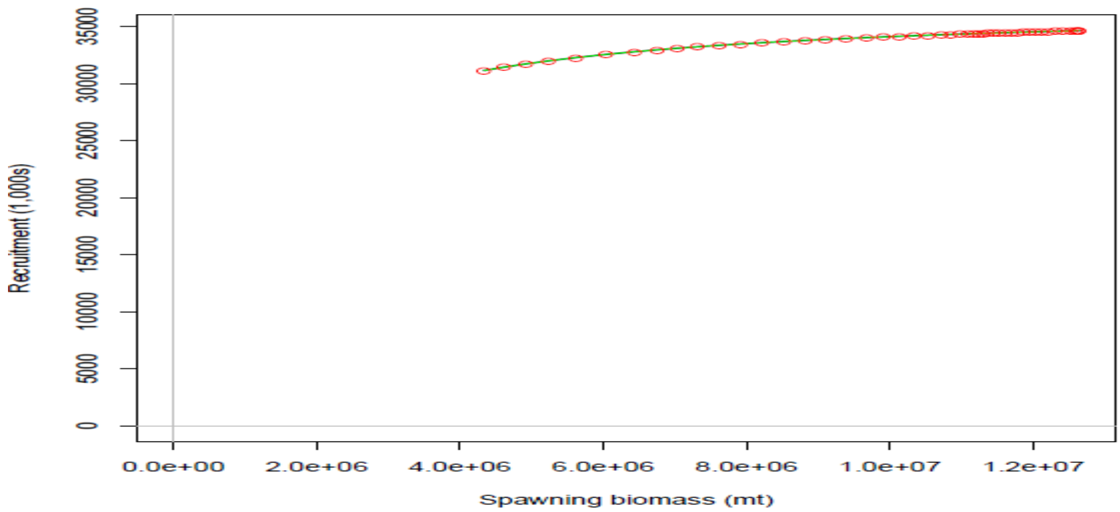
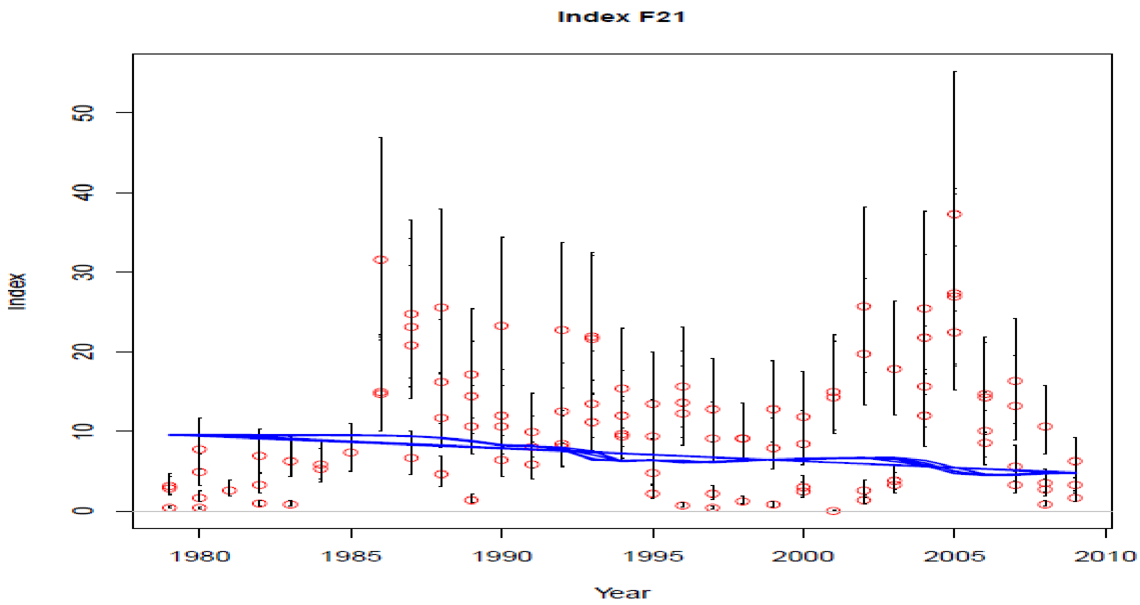
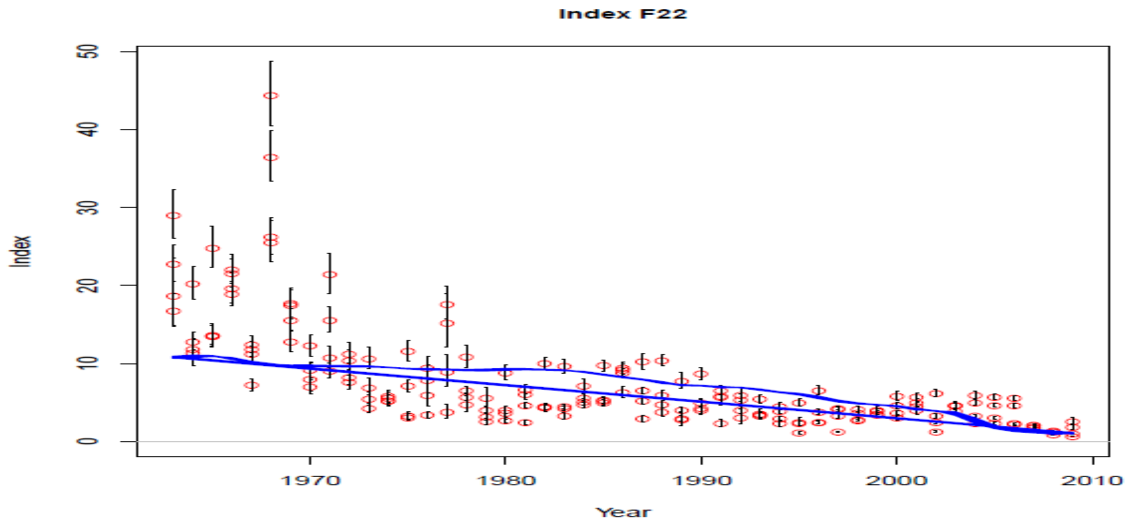


Figure 4 S-R relationship





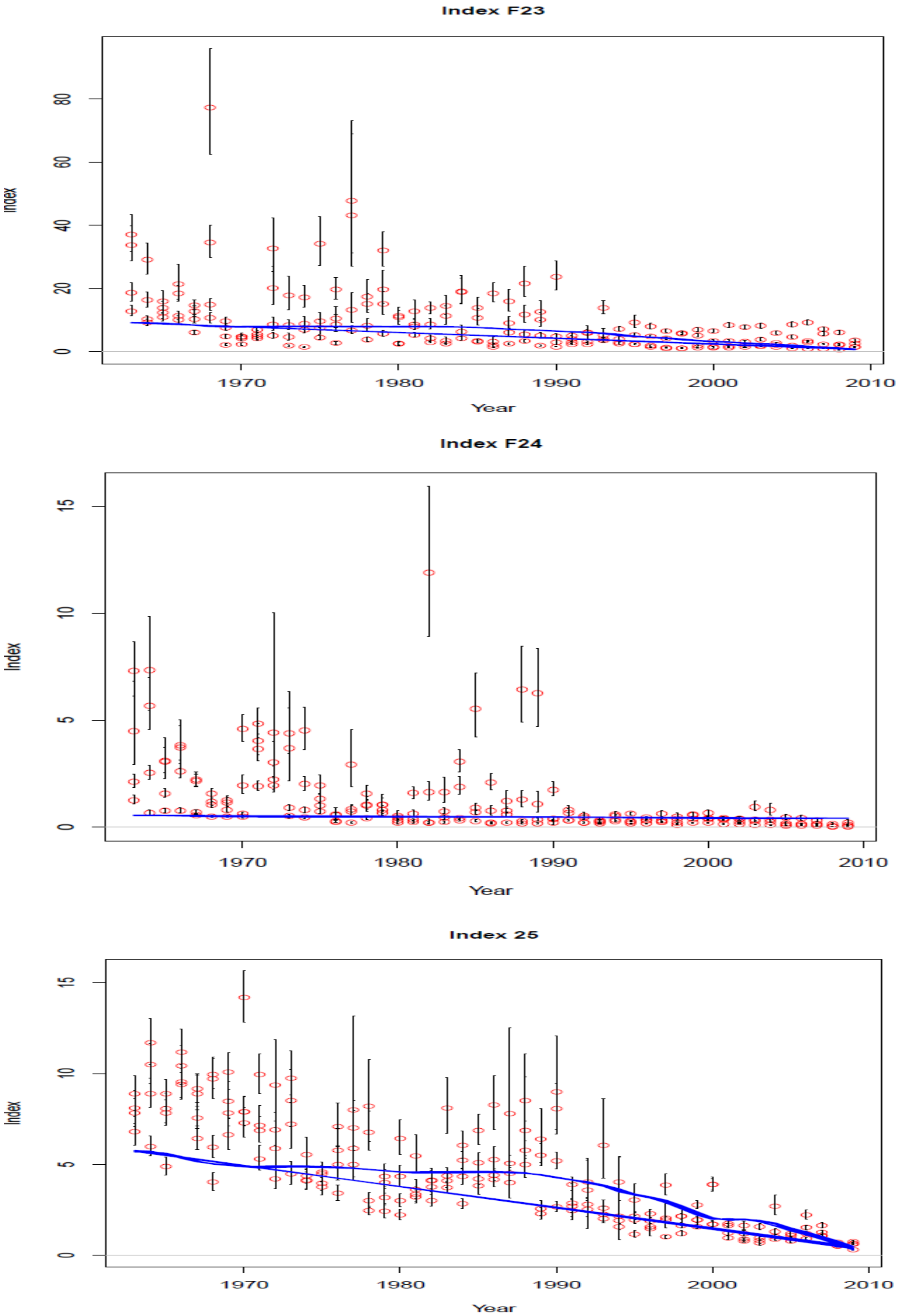


Figure 5　CPUE fitting of observed and estimated values in each region 1-5

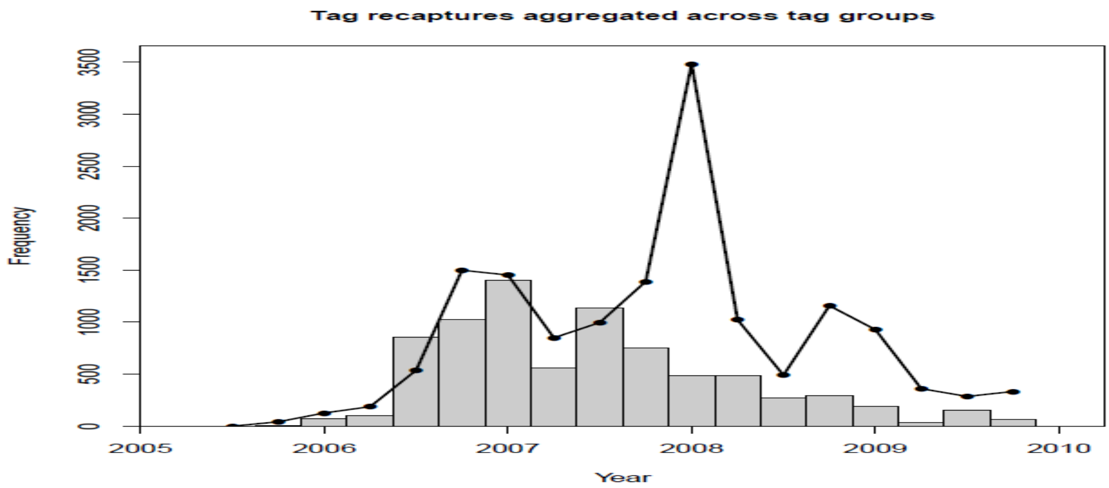


Figure 6　Histgram of tag recaptures and the corresponding estimated curve

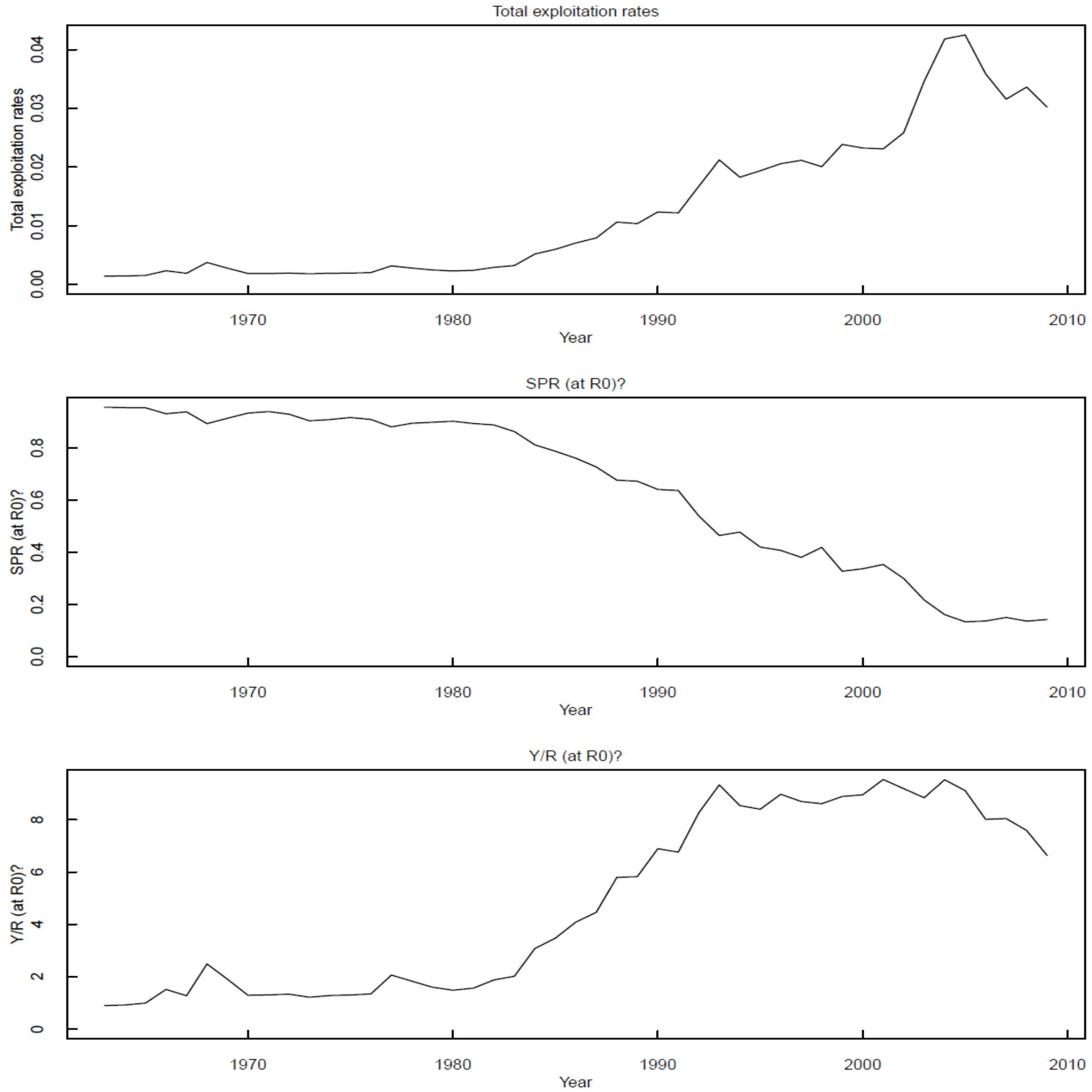


Figure 7　Estimated year trends of total exploitation rate, SPR and YPR