SCRS/2013/058 Collect. Vol. Sci. Pap. ICCAT, 70(3): 1094-1107 (2014)

A PRELIMINARY STOCK ASSESSMENT FOR NORTHERN ALBACORE USING THE FULLY INTEGRATED STOCK ASSESSMENT MODEL, MULTIFAN-CL

Gorka Merino[1], Paul De Bruyn[2], Gerald P. Scott[2], Laurence T. Kell[2], Haritz Arrizabalaga[3]

SUMMARY

We present a stock assessment with MULTIFAN-CL for the Northern stock of Atlantic albacore with a suite of exploratory data analysis and diagnostics. Furthermore, we propose a factorial course of action to planify scenarios with the aim of analysing the uncertainty associated to the dynamic behaviour of fishing fleets and available data.

RÉSUMÉ

Nous présentons une évaluation des stocks avec MULTIFAN-CL pour le stock de germon de l'Atlantique Nord avec une gamme d'analyses des données et de diagnostics exploratoires. Nous proposons également un plan d'action pour planifier des scenarios dans le but d'analyser l'incertitude associée au comportement dynamique des flottilles de pêche et aux données disponibles.

RESUMEN

Se presenta una evaluación del stock de atún blanco del Atlántico norte realizada con MULTIFAN-CL con una serie de análisis de datos y diagnósticos exploratorios. Asimismo, proponemos un plan factorial para la planificación de escenarios con el fin de estudiar en detalle la incertidumbre derivada del comportamiento dinámico de las flotas y la información disponible.

KEYWORDS

Albacore, Multifan-CL, North Atlantic, Stock assessment, Diagnostics

[1] AZTI-Tecnalia, Herrera Kaia Portualdea, 20110, Pasaia, Spain; gmerino@azti.es; Phone: +34 667 174 456 Fax: +34 94 657 25 55.
[2] ICCAT Secretariat, C/Corazón de María, 8. 28002 Madrid, Spain; Laurie.Kell@iccat.int; Phone: +34 914 165 600 Fax: +34 914 152 12.
[3] AZTI-Tecnalia, Herrera Kaia Portualdea, 20110, Pasaia, Spain; Phone: +34 667 174 456 Fax: +34 94 657 25 55.

1. Introduction

In this document we describe a set of updated MULTIFAN-CL stock assessment files and model structure for North Atlantic albacore and present a range of exploratory data analyses and diagnostics. The last assessment was held in 2009 when several models were ran, including MULTIFAN-CL (Fournier, *et. al.,* 1998). Due to new and updated data now being available a new assessment of the albacore tuna stock has become necessary. We propose a factorial design for specifying scenarios to more fully consider uncertainty about stock and fleet dynamics and data. This paper provides some preliminary results for the updated MULTIFAN-CL model. This paper is not intended as a definitive stock assessment, but as a document to help the work of the stock assessment group.

2. Assessment Methodology

2.1 Model description

MULTIFAN-CL is a computer program that implements a statistical, size-based, age-structured, and spatial-structured model for use in fisheries stock assessment. The program is used routinely for tuna stock assessments by the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC) in the western and central Pacific Ocean (WCPO) and both the Indian Ocean Tuna Commission (IOTC) and ICCAT have used this model for stock assessment. The model is fit to time series of catch and size composition data from either one or many fishing fleets. Size composition data may be in the form of either length or weight-frequency data, or both. The model may also be fit simultaneously to tagging data, if available. Other information is provided to the model in the form of fishing effort data and prior information on estimates of various biological and fisheries parameters and their variability (Hampton *et. al.,* 2002). The data used in the albacore tuna assessment consisted of catch, effort and length- frequency data for the fisheries defined in **Table 1**. The use of tag release-recapture data was intended, however, at this stage, it was excluded to allow comparison with the previous stock assessment and as there was some doubt as to whether the tagging data available prior to the meeting was of sufficient quality to include. The details of the utilised data and their stratification are described below.

2.1.1 Spatial Stratification

Due to the fact that the tagging data was not utilised and hence movement could not be quantified, all the fisheries were grouped into a single region for this assessment.

2.1.2 Temporal Stratification

Catch data from 1930 to 2011 was utilised in this assessment. Size frequency data was available from 1959 to 2011.

2.1.3 Fisheries definitions

MULTIFAN-CL requires the definition of fisheries that consist of relatively homogeneous fishing units. Ideally, the fisheries so defined will have selectivity and catchability characteristics that do not vary greatly over time (although in the case of catchability, some allowance can be made for time-series variation). For most pelagic fisheries assessments, fisheries defined according to gear type and area will usually suffice. In total, 12 separate fisheries where defined following discussion at the albacore group Data Preparatory Meeting.

2.1.4 Catch and Effort data

Catch and effort data were compiled by fishery. Quarterly catch data by fishery were obtained from the ICCAT Secretariat. Updated standardised indices of effort were available for fisheries 1, 2, 5, 6, 7, 8, 9 and 10. For fishery 2, standardised CPUE from the Spanish troll fleet from 1981 to 2011 was spliced to historical French troll CPUE (prior to 1981) using a GLM (following 2007 report of Atlantic albacore assessment). Fleets 3, 4, 11 and 12 CPUEs were not updated from 2009 assessment. Exploratory data analysis indicated that the Japanese and Chinese Taipei LL CPUE series were negatively correlated. This was further discussed during the albacore data preparatory meeting and the invited expert suggested that it would not be appropriate to include both Chinese Taipei and Japanese LL series in the same model as the MFCL model would not be able to resolve these conflicting trends internally. As a result it was suggested that the two series should be used independently to represent two different alternative.

scenarios. In this preliminary first model run, the CPUE series for fisheries 5, 6 and 7 (Jap LL series) were down-weighted. This was a relatively arbitrary selection, and this initial run could just as easily have down-weighted the Chinese Taipei series instead. The only reason the Japanese was down weighted first, was that the Chinese Taipei series appeared to be more closely correlated to the other surface fishery CPUEs included in the model. A future alternate model run would instead down-weight the Chinese Taipei series and put more weight on the Japanese series.

2.1.5 Length Frequency data

Size frequency data held in the Task II data set were organized by MFCL fishery definition and quarter for albacore tuna. A criterion of at least 50 size observations per fishery/quarter was used to filter the data for use. Also, datasets with less than 10 bins measured were not used, following similar criteria as in 2007 and 2009. The size frequency data were compiled into 61, 2 cm length classes (30-32 cm to 150- 52 cm). Size frequency data were few for the initial years of the model due to a lack of sampling during this time. This data was provided by the ICCAT Secretariat. The information content of the length frequency data needs to be evaluated within the assessment framework. The mean length of the sampled catch from the Chinese Taipei longline fishery has been highly variable over time. Large increases in average size in the most recent years coincided with a large increase in the sampling coverage of this eet. The increase in fish size is probably not consistent with the albacore stock dynamics and is likely to represent a shift in the composition of the overall catch sampled and/or a sharp change in the selectivity of the longline fishery or fish retention by the fleet. On that basis, the long term size frequency data may not be not representative of the size composition of the underlying population and so should not be given sufficient weight in the assessment model to influence trends in stock abundance. As a result, the size frequency data for the Chinese Taipei fleets was down-weighted in this model run.

2.2 Structural Assumptions

The following structural assumptions were included in the current albacore tuna stock assessment model runs. For this preliminary run, the specifications were guided by comments made by the external expert on the continuity run conducted in 2009. The mathematical specification of structural assumptions within MULTIFAN-CL is given in Hampton and Fournier (2001).

2.2.1 Observation models for the data

In this model, there are two data components that contribute to the log-likelihood function - the total catch data and the length-frequency data. The observed total catch data are assumed to be unbiased and relatively precise. The probability distributions for the length- frequency proportions are assumed to be approximated by robust normal distributions, with the variance determined by the effective sample size and the observed length-frequency proportion.

2.2.2 Recruitment

In the model, the number of recruitment events was limited to one per year. Recruitment was assumed to follow a weak Beverton and Holt stock-recruitment relationship (SRR). The SRR was incorporated mainly so that a yield analysis could be undertaken for stock assessment purposes. A relatively weak penalty for deviation from the SRR was applied so that it would not have a large effect on the recruitment and other model estimates. Fisheries data are usually uninformative about SRR parameters. It was thus necessary to constrain the parameterisation in order to maintain stable model behaviour. A beta- distributed prior on the steepness (S) of the SRR was included, with S defined as the ratio of the equilibrium recruitment produced by 20spawning biomass to that produced by the equilibrium unexploited spawning biomass (Francis 1992; Maunder and Watters 2001). The prior was specified by mode = 0.75 and SD = 0.15 (a = 35, b = 21).

2.2.3 Age and Growth

Length at age is assumed to be normally distributed for each age class; the mean lengths at age followed a von Bertalanfiy growth curve; the standard deviations of length for each age class are assumed to be a linear function of the mean length at age. The number of significant age-classes in the exploited population is assumed to be 15, the last age- class being a plus group. Description of growth for both North and South albacore stocks follows a von Bertalanfiy model fit to age information using otoliths and tagging data (Santiago, 2004).

2.2.4 Selectivity

Selectivity is fishery-specific and was assumed to be time-invariant. Most longline fisheries were assumed to have non-decreasing selectivity with age. The coefficients for the last ten age-classes, for which the mean lengths are very similar, are constrained to be equal for all fisheries. Due to the combination of multiple fleets in fisheries 11 and 12, the size frequency data were not considered to be representative of the underlying population dynamics and thus these fleets were assigned selectivities of other similar, less aggregated fisheries. Fishery 11 was assigned the same selectivity as fishery 10 and fishery 12 was assigned the selectivity of fishery 4.

2.2.5 Catchability and Effort variability

A time series of catchability was estimated for fisheries 4, 5, 6 and 7 , and random walk steps were taken every two years for these fisheries. This decision aimed to avoid misleading the program with the same reasons as we did in the catch and effort series selection. The seasonal component of catchability was also estimated. Effort deviations, constrained by prior distributions of zero mean, were used to model the random variation in the effort fishing mortality relationship.

2.2.6 Initial Population

The population age structure in the initial time period is determined as a function of the average total mortality during the first 10 quarters. This assumption avoids having to treat the initial age structure as independent parameters in the model.

2.2.7 Natural Mortality

Natural mortality assumed to be constant for all age-class (M= 0.3).

2.2.8 Maturity

The vector of maturity was the same as the one used in VPA-2 box model: 50% mature at age-class 5 and 100 age-class 6 onwards until designated plus group.

3. Uncertainty

3.1 Scenarios

Choice of scenarios are based on a factorial design. A full factorial experiment is one whose design consists of two or more factors, each with discrete possible values or levels, and where experimental units take on all possible combinations of these levels across all factors. Such a design is better able to represents the complexity of the real world and allows an evaluation of whether the effect of one factor depends on the level of another factor. The potentially large number of combinations in a full factorial design may mean that it is not possible to run them all in the time available in a stock assessment working group. Therefore a fractional factorial design in which some of the possible combinations are omitted may be preferred.

However, when conducting a Management Strategy Evaluation (MSE, SCRS/2013/35) a large number of scenarios need to be considered to evaluate the main sources of uncertainties. I.e. the Operating Models (OM) will need to be conditioned on a wider range of data and knowledge that routinely considered within a stock assessment.

In other words while only a few scenarios are routinely be considered within an ICCAT stock assessment, many more scenarios will need to be run as part of an MSE. This presents a potential problem if the Scenarios from an MSE result in different conclusions from those ran in a stock assessment. We first specify a base case and then factors with levels that represent the main uncertainties. In the stock assessment WG the main effects can be evaluated by varying 1 factor at a time. Hopefully this will allow the stock assessment to bracket the main uncertainty and act as a simple screening experiment, to determine the factors have the greatest influence on the perception of stock dynamics. Based on the identification of the most important factors, a multi-level designed experiment can then be developed for the MSE that includes interactions between factors. Choice and/or weighting of scenarios depends on plausibility.

Suggested alternative runs deviating from the base case described above are:

1. Chinese Taipei LL CPUE weighted out, Japan LL fixed catchability; fixed catchability for major surface fleets
2. Chinese Taipei LL SF data no longer downweighted
3. Biological parameters (M, growth, maturity) based on Santiago (2004)
4. Biological parameters (M, growth, maturity) based on Life History (Kell *et al*. 2012)
5. Set all LL selectivities to be logistic
6. Higher penalty on recruitment deviations
4. Diagnostics

A range of stock assessment models are used by the SCRS, i.e. from biomass dynamic models using catch and effort data with only a few parameters to statistical catch-at-size models with over a 1000 parameters. Despite these differences they are being used for the same purpose i.e. to use fisheries data to estimate population parameters. Therefore it is essential that as part of the stock assessment process that the input data can be evaluated and fits compared ensuring some consistency when decisions are being made about model choices. A set of common diagnostics were presented in SCRS/2013/36 that can be used for different stock assessment models. In this paper we apply these diagnostics to the North Atlantic albacore MULTIFAN-CL assessment.

The paper is not intended to be used as a check list but an example of what to look at, how to do it, potential problems, consequences and how to overcome, but even better to avoid them, i.e. the intention is to not provide strict guidelines but to look at some methods that can be used for a range of stock assessment models that use indices of abundance such as Catch per Unit Effort (CPUE) and size data for fitting.

All analysis is performed using R using the getmfclstufi, R4MULTIFAN-CL and diags packages. The diagnostic methods fall into three categories: Exploratory analysis, Indices and Size samples.

4.1 Exploratory analysis

To help identify changes in the input data various plots are presented. The CPUE series in each trimester, for data used in the 2009 and 2013 assessments, are compared in **Figures 1, 2, 3 and 4**. The size measurements used in the 2009 and 2013 assessment are compared by decade for each fishing incident in **Figures 5** and the mean size for **Figure 6**. To explore correlations and conflicting signals in the CPUE series the correlation matrix of the CPUE series is plotted in **Figure 7**. From the correlation plot we see the conflicting trend between Japanese and Chinese Taipei longline fleets that caused the decisions explained in subsections 2.14 and 2.25.

5. Results

The basic outputs from the MULTIFAN-CL base case model are presented although it is acknowledged that these results are preliminary and are presented here for discussion during the albacore assessment working group session. Although the growth curve parameters in the MULTIFAN-CL model were fixed, the mean lengths of the first 2 age classes were estimated independently in order to accommodate deviations from the VBGF. The final growth curve is presented in **Figure 11.**

Figure 8 shows the estimated biomass trajectory for the Northern albacore stock over the assessment period. Estimated current biomass appears to be approximately 50% of the virgin biomass. **Figure 9** provides the estimated recruitments over the assessment period. The recruitments appear to be highly variable although average recruitment appears to be declining in the last decades.

Time series of F by age class are presented in **Figure 10**. Although F appears to increase sharply in the 1950s, this corresponds to the first period in which size frequency data is available and so more information is available to separate the catches into age classes.

The yield analysis conducted here incorporated the stock-recruitment relationship **Figure 11** into the equilibrium biomass and yield estimates. The steepness was estimated to be 0.9, which is quite different to the prior mode of 0.75. This would imply that there is thus no strong relationship between the spawning stock and recruitment.

The yield curve which estimates a maximum yield of around 27,000 t at an effort multiplier of 1.25 is presented in **Figure 12.** The corresponding reference points B/B(MSY), SSB/SSB(MSY) and F/F(MSY) are shown in **Figures 13, 14 and 15** respectively. These would indicate that the current population biomass is very close to the biomass at MSY, the spawning stock biomass is slightly below the SSB at MSY and current F is slightly below the F that would give MSY.

6. Discussion

- We presented a preliminary assessment of the Northern albacore stock using the model Multifan-CL. Running such a complex model requires the adoption of decisions and we explain the criteria to adopt them with an example. Decisions need to be adopted based on expertise knowledge and a set of input data and model output diagnostics.
- In the preliminary assessment, we avoided conflicting CPUE trends by down weighting some series to avoid misleading the assessment process. We do not intend to provide a definitive assessment but to provide guidelines about the diagnostics that can facilitate the incoming North Atlantic albacore assessment.
- We also identify a potential factorial design for development of scenarios to best represent the real state of North Atlantic albacore and evaluate potential dependencies among factors.

Bibliography

Fournier, D. A., Hampton, J., and Sibert, J. R. (1998). MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to south pacific albacore, *Thunnus alalunga*. Canadian Journal of Fisheries and Aquatic Sciences, 55(9):2105-2116.

Hampton, J., Kleiber, P., Langley, A., and Hiramatsu, K. 2002. Stock assessment of bigeye tuna in the western and central Pacific Ocean. In Sec. Pacif. Comm., Oceanic Fish. Prog., 15th meeting, Stand. Comm. Tuna Billfish, BET-1.

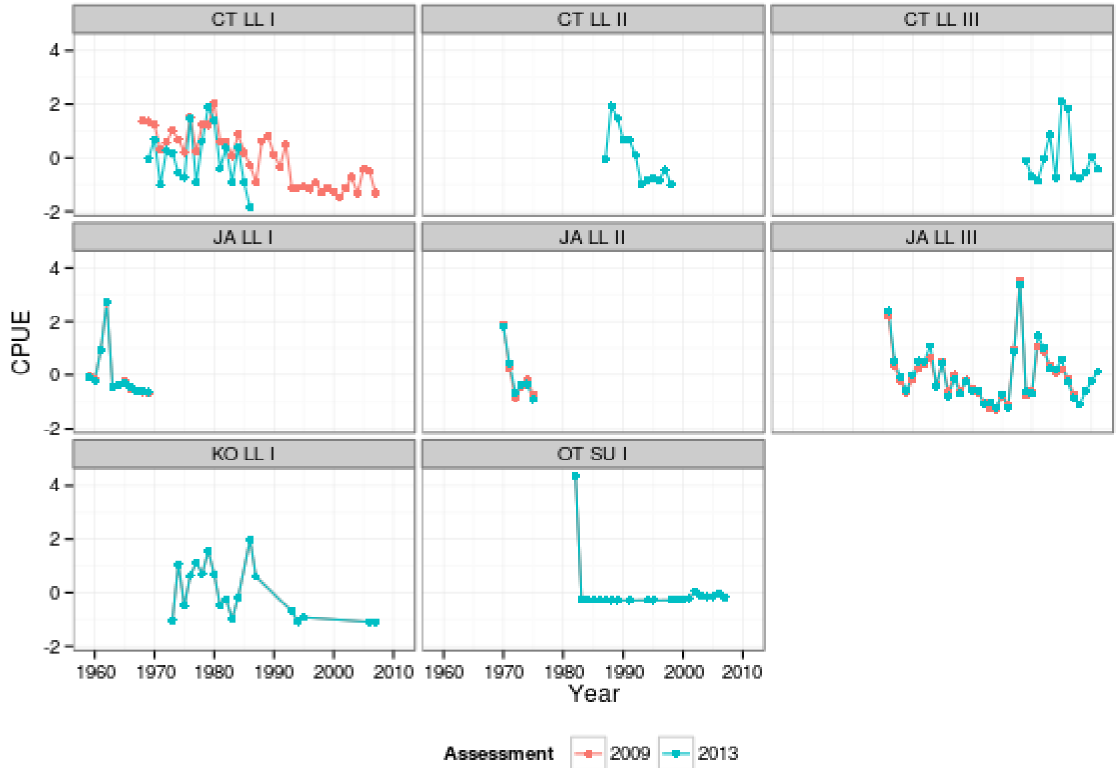

Figure 1. A Comparison of 1st trimester CPUE series for data used in the 2009 and 2013 assessments; CT, JA, KO, OT correspond to China-Taipei, Japan, Korea and Others; LL, SU to longline and surface fisheries.

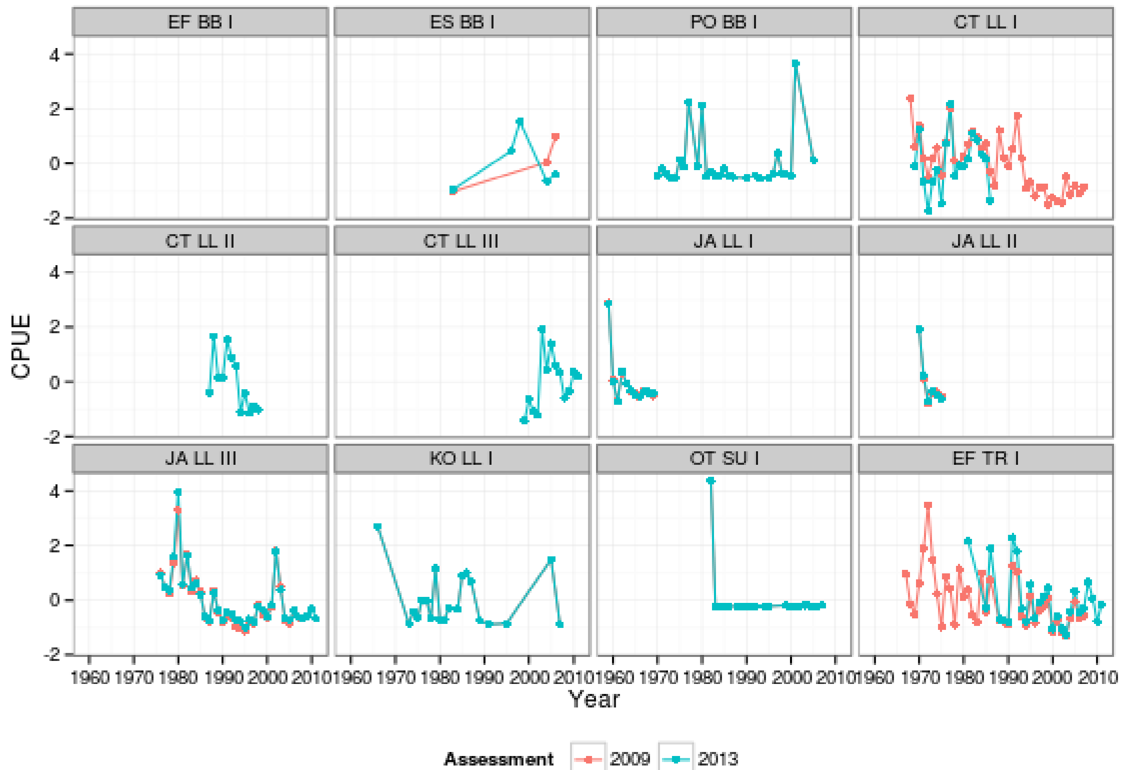

Figure 2.: A comparison of second trimester CPUE series for data used in the 2009 and 2013 assessments; CT, JA, KO, OT correspond to China-Taipei, Japan, Korea and Others; LL, SU to longline and surface fisheries.

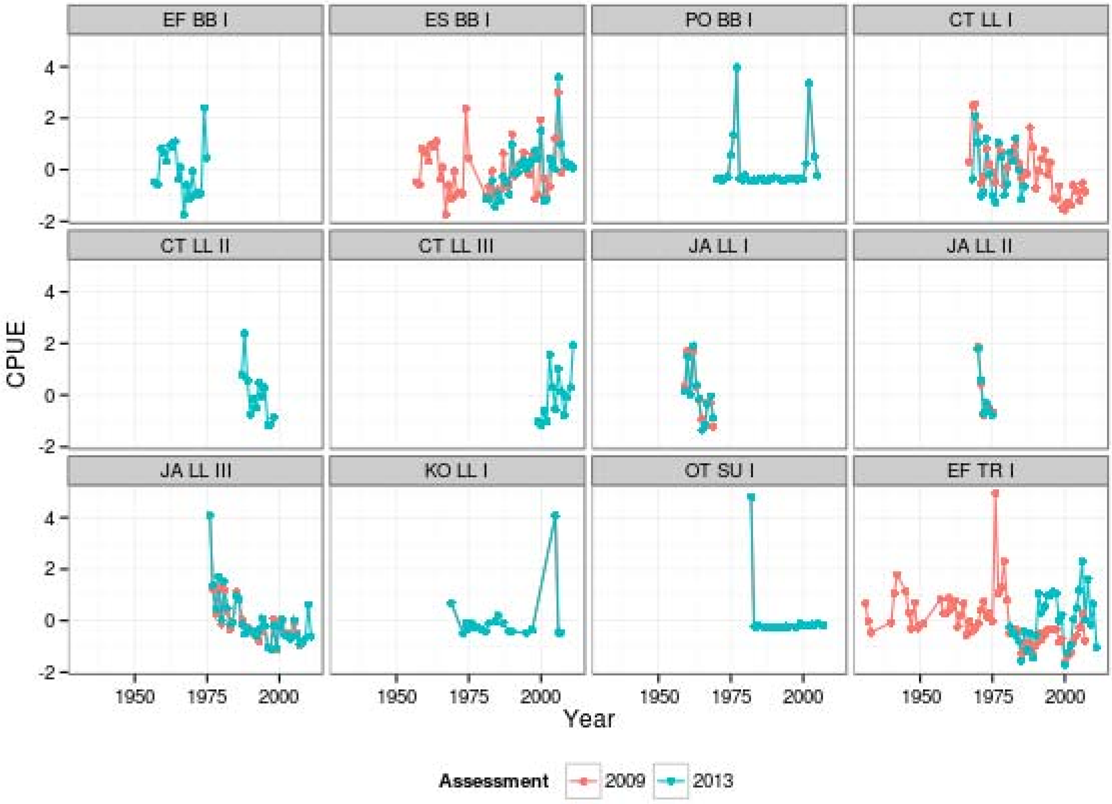

Figure 3. A Comparison of third trimester CPUE series for data used in the 2009 and 2013 assessments; CT,JA,KO,OT correspond to China-Taipei, Japan, Korea and Others; LL,SU to longline and surface fisheries.

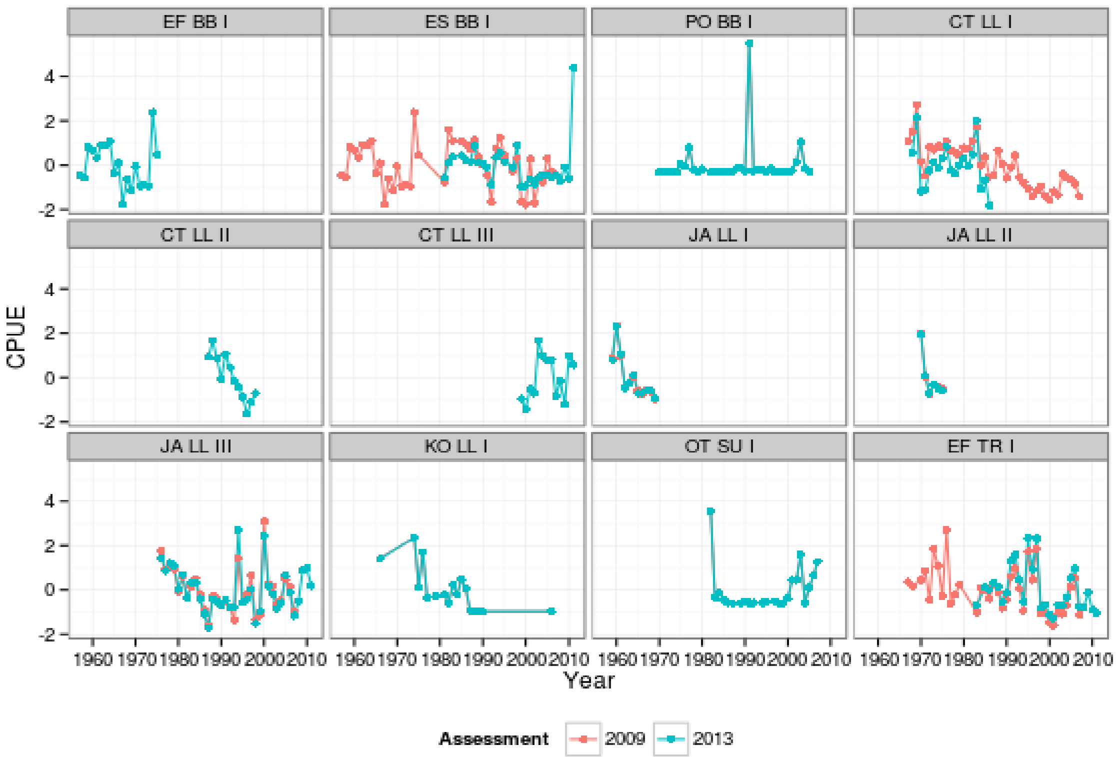

Figure 4. A Comparison of fourth trimester CPUE series for data used in the 2009 and 2013 assessments; CT, JA, KO, OT correspond to China-Taipei, Japan, Korea and Others; LL, SU to longline and surface fisheries.

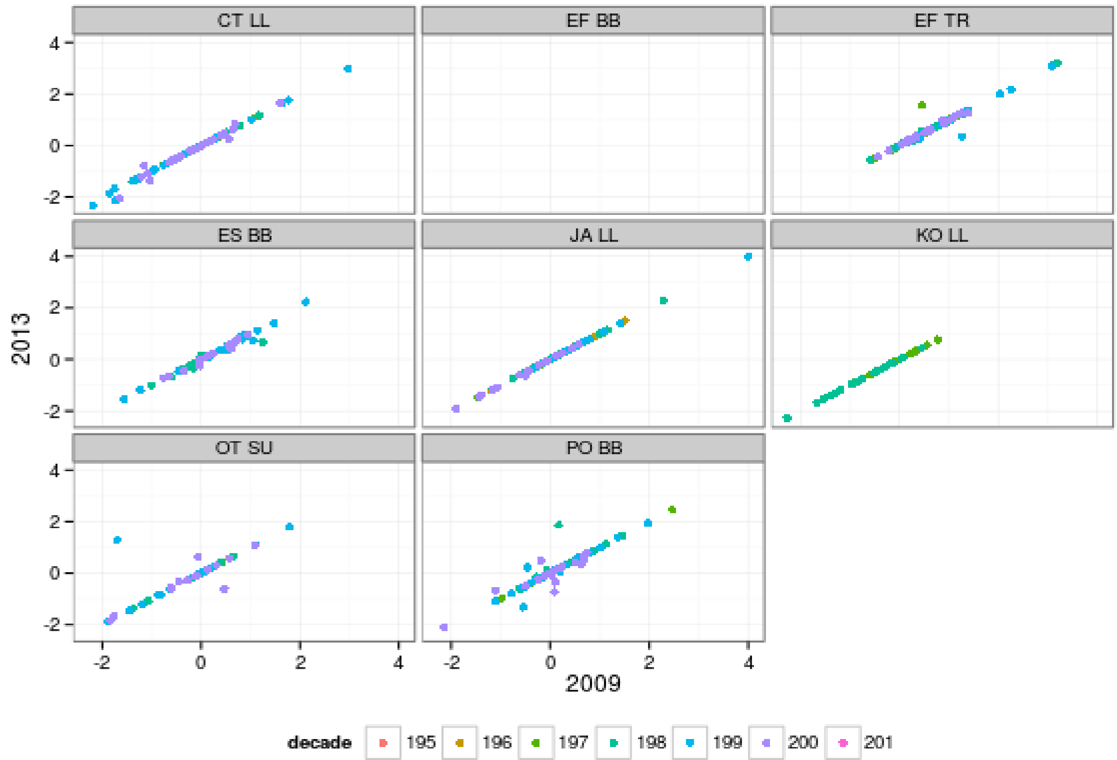

Figure 5. A comparison by decade of the skweness of the size data for each fishing incident.

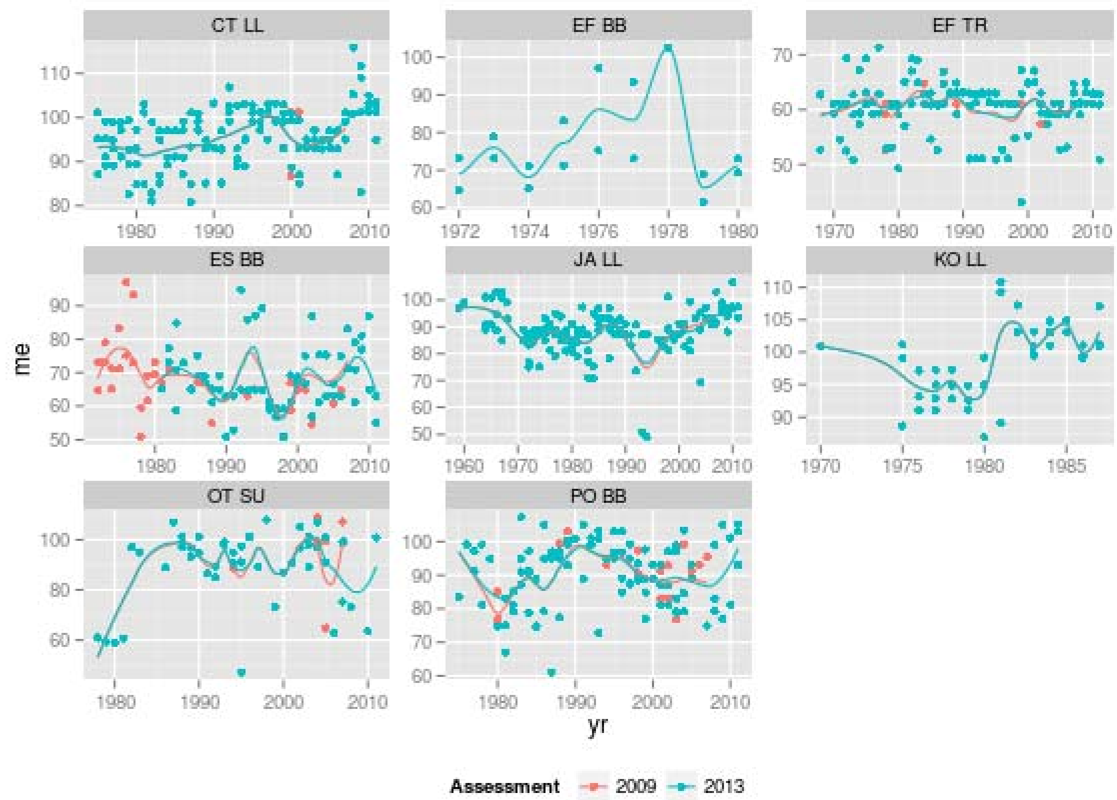

Figure 6. Median size by fishery.

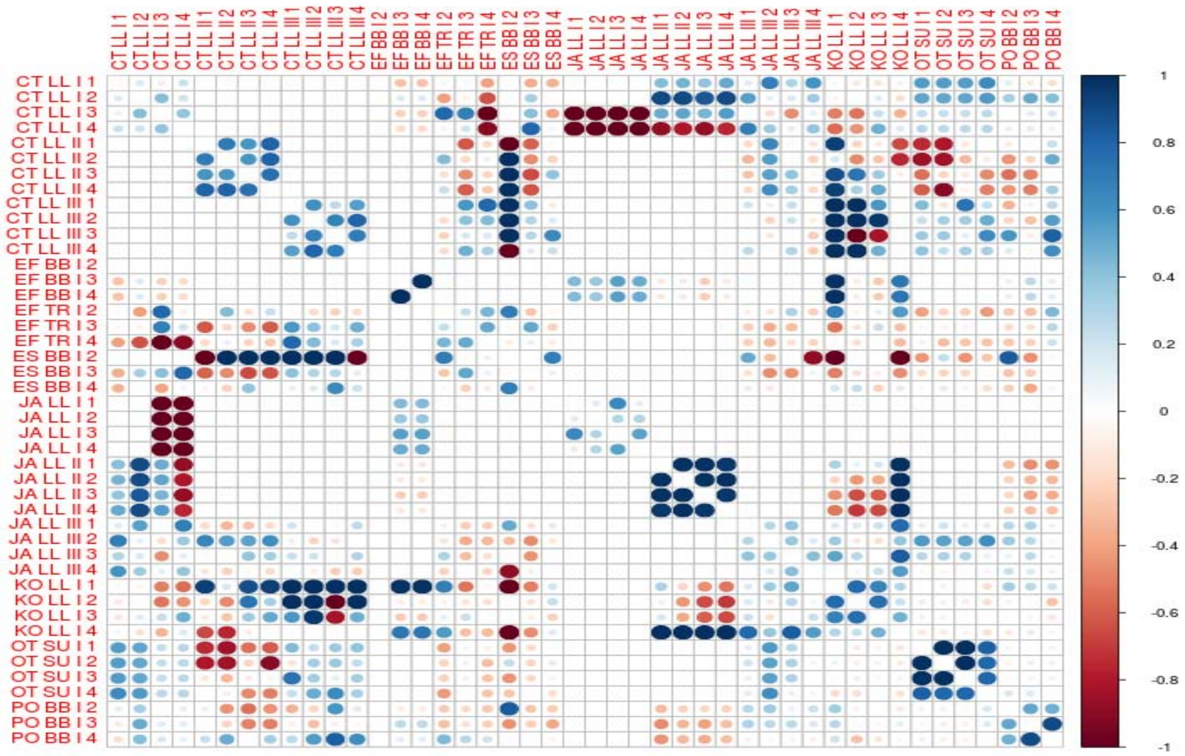

Figure 7. Correlation matrix for CPUE series.

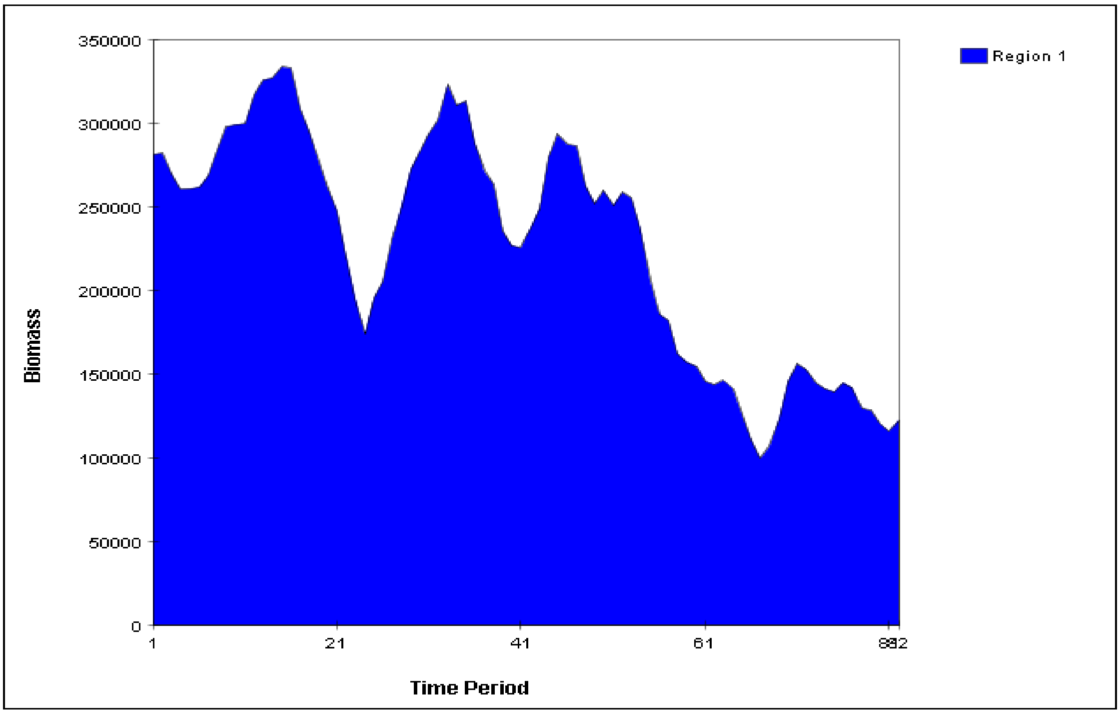

Figure 8. Model estimated biomass over time.

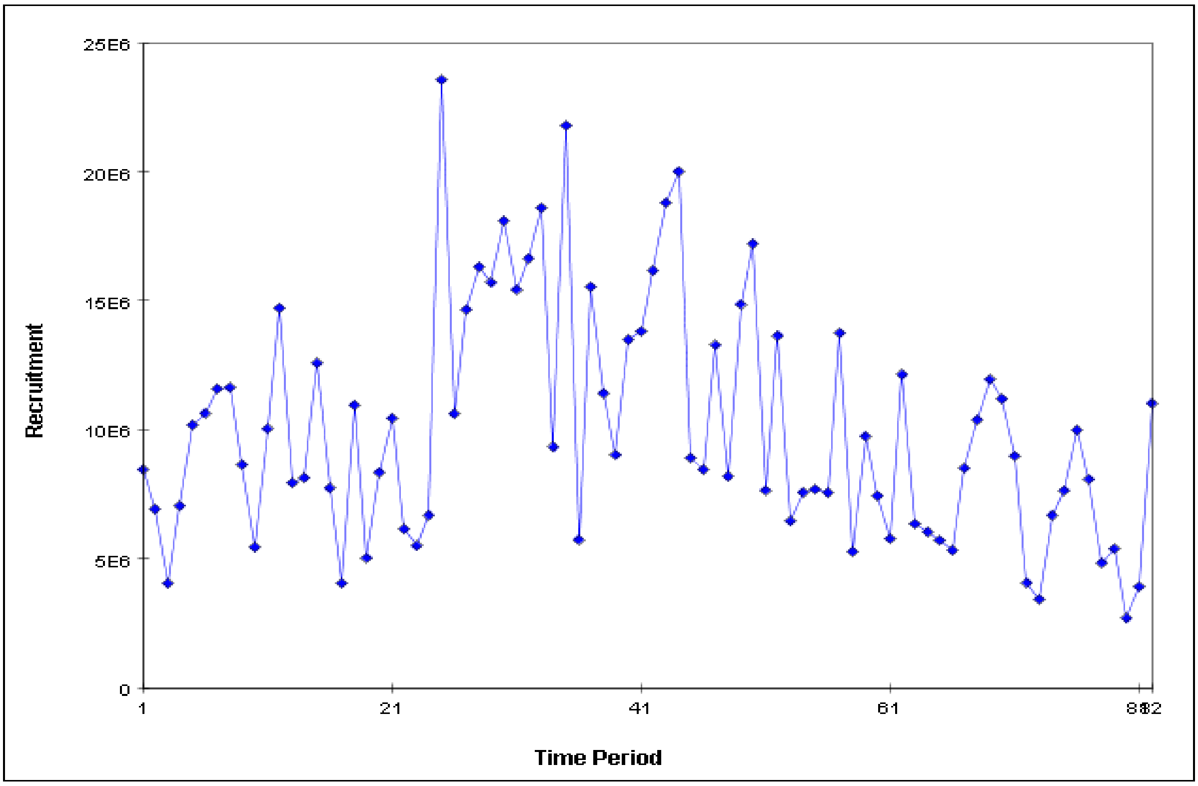

Figure 9. Model estimated recruitment over time.

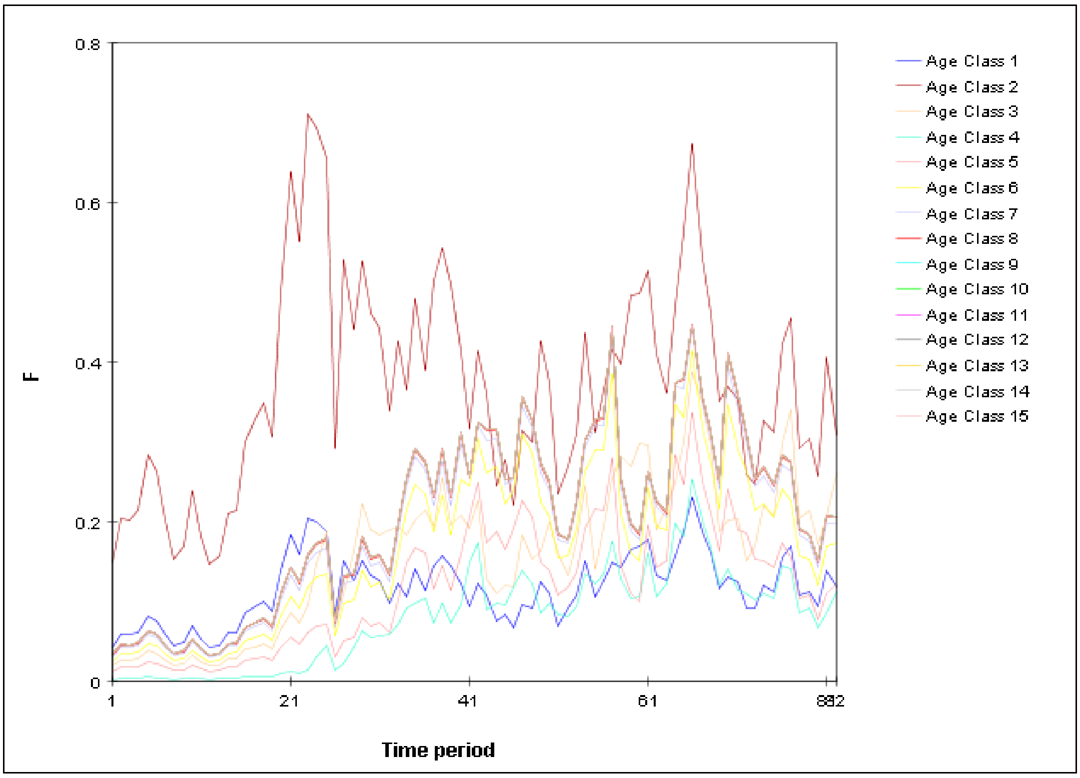

Figure 10. Model estimated F per age group.

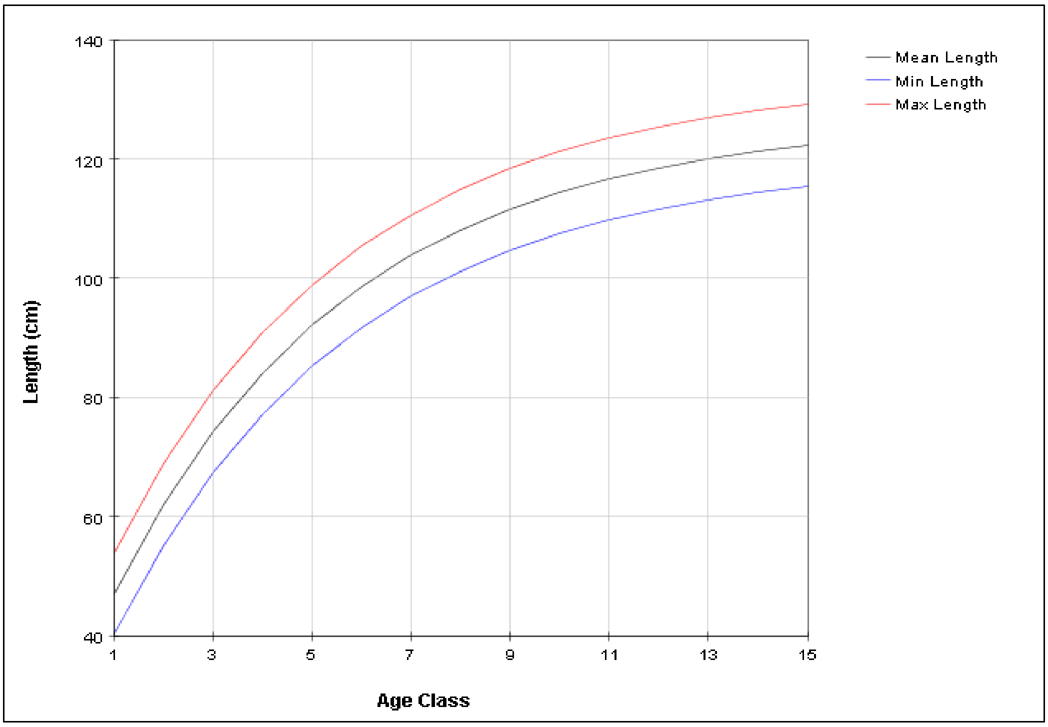

Figure 11. Growth curve used in the MULTIFAN-CL model.

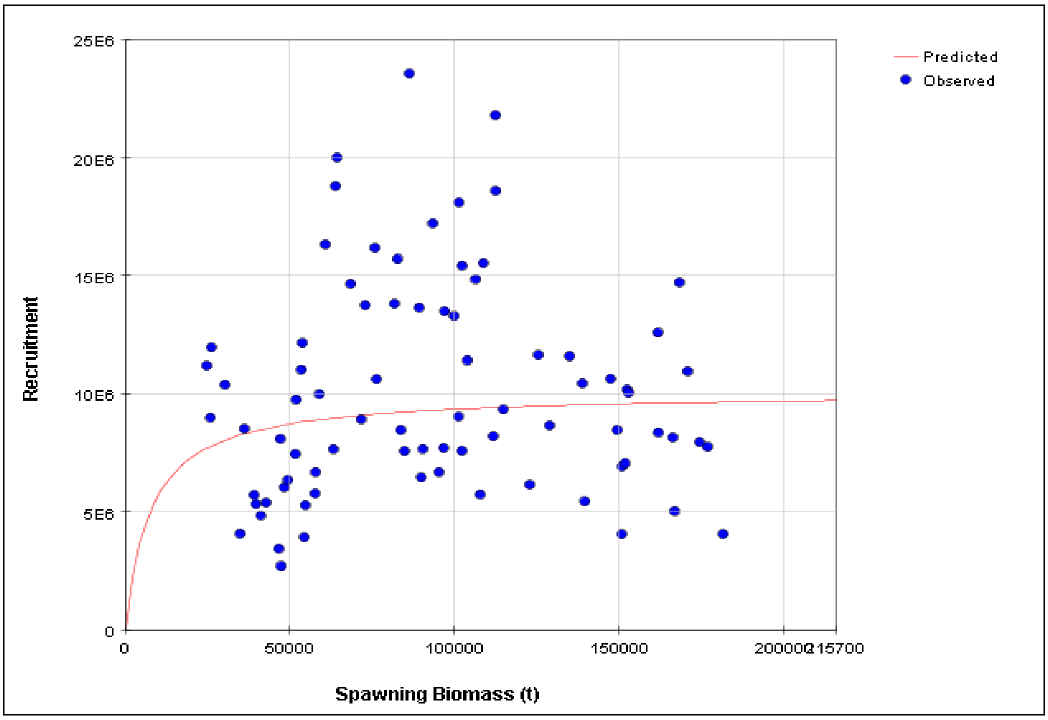

Figure 12. Stock recruitment relationship calculated within the MULTIFAN-CL model.

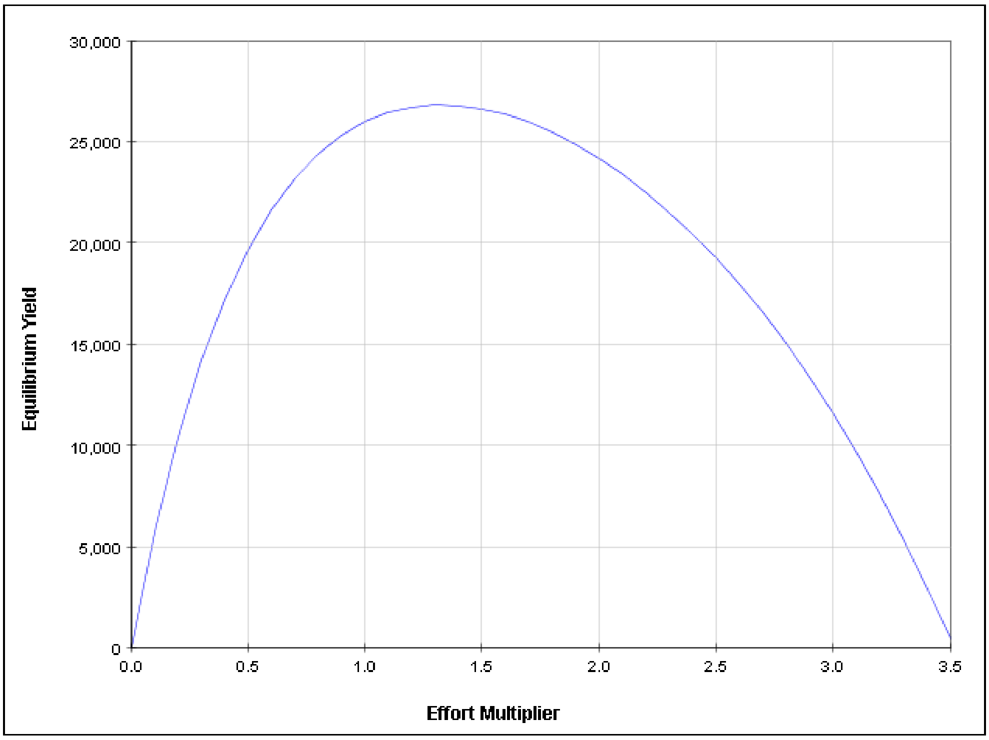

Figure 13. Yield curve calculated within the MULTIFAN-CL model.

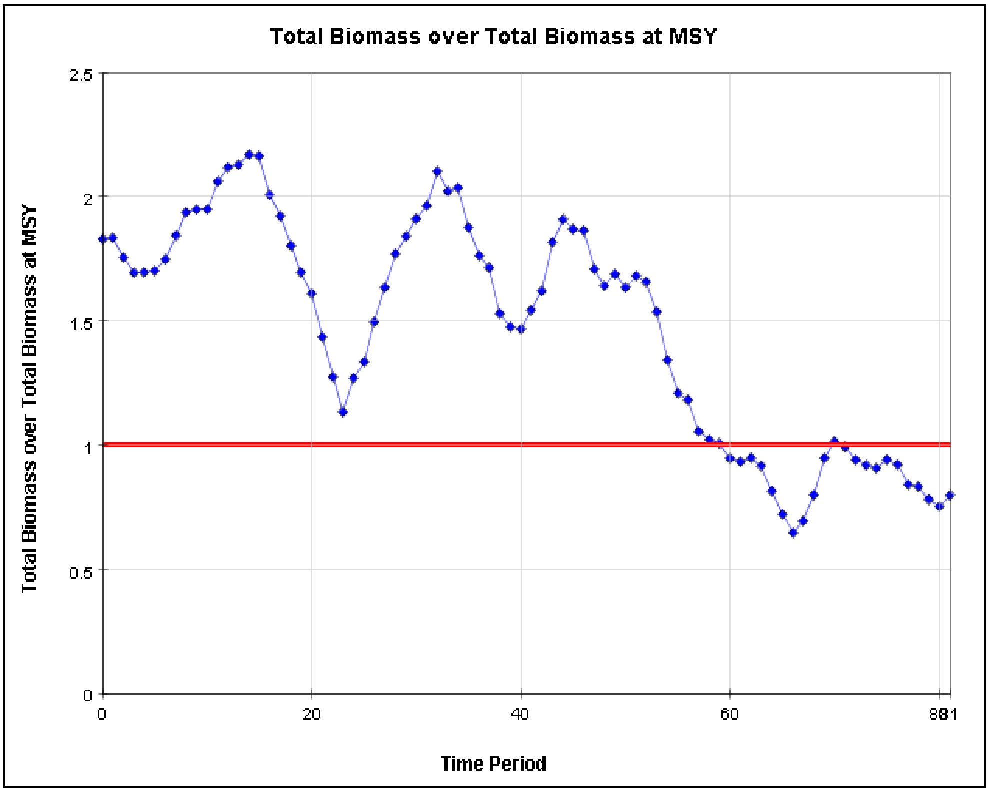

Figure 14. Current biomass relative to biomass at MSY.

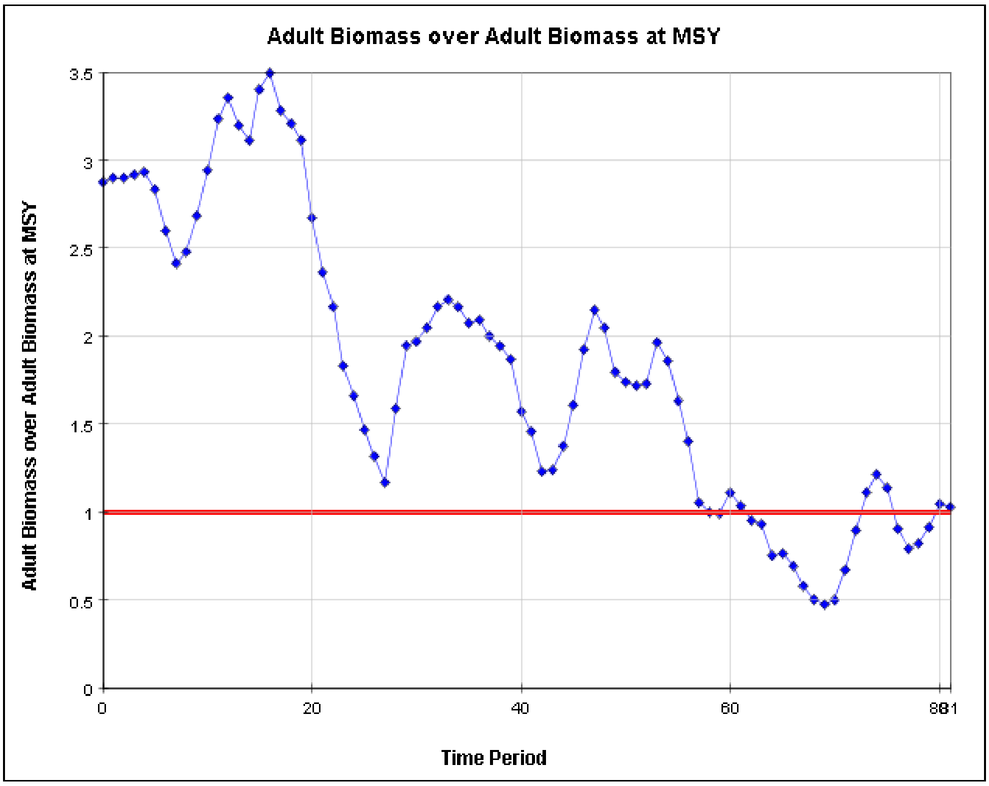

Figure 15. Current spawning stock biomass relative to spawning stock biomass at MSY.

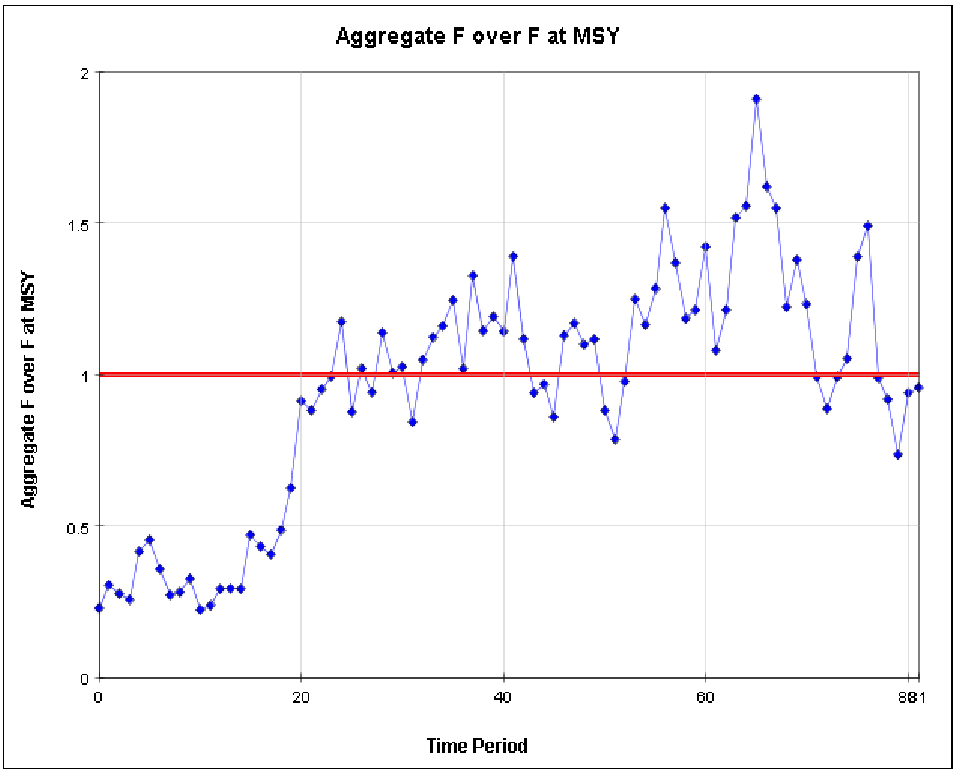

Figure 16. Current F relative to F at MSY.