Updated trotline standardised CPUE series for toothfish (*Dissostichus eleginoides*) in the Prince Edward Islands EEZ over the period 2008–2016

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Abstract

An updated GLMM standardisation of trotline toothfish CPUE data is presented which includes new data for the 2016 "fishing"-year. Updated standardisation of the trotline CPUE data shows a marked decrease from the 2015 to the 2016 season, with the 2016 index being the lowest in the series.

Introduction

Brandão and Butterworth (2014a) presented results for the GLMM (General Linear Mixed Model) standardisations of longline and trotline to be used in the assessment of toothfish, and this was updated for trotlines in Brandão and Butterworth (2016). This paper presents results for a further update of the GLMM standardised CPUE for trotlines. The standardisation presented here is based on a "fishing"-year[1] for better comparability with the structure of the assessment, and also assumes that the two *Koryo Maru* vessels are identical in terms of power (rendered reasonable by the fact that the same skipper operated on both vessels).

[1] A "fishing"- year *y* is defined to be from 1 December of year *y*-1 to 30 November of year *y*.

The Data

Trotline CPUE data are now available for the 2008 to 2016 "fishing"-years. The effort for a trotline is defined as:

$$\left(\frac{\text{Length of line}}{\text{Spacing of droppers}}\right) \times \text{Number of clusters per dropper.}$$

A total of 3 307 trotline sets (Table 1) is available for analyses. No further longline sets have been deployed since 2013 and so it is not necessary to update the GLMM standardised CPUE series for longlines presented in Brandão and Butterworth (2015).

Methods

The changes to the General Linear Mixed Model (GLMM) of Brandão and Butterworth (2013) to standardise the trotline CPUE data for toothfish in the Prince Edward Islands EEZ are detailed below.

The GLMM applied to the trotline CPUE data is of the form:

$$\ln(CPUE + \delta) = X\alpha + Z\beta + \varepsilon, \tag{2}$$

where

CPUE is the trotline catch per unit effort for a set,

δ is a small constant (10% of the average of all CPUE data values = 0.121 for trotlines) added to the toothfish CPUE to allow for the occurrence of zero CPUE values,

α is the vector of fixed effects parameters (whose values are unknown) which includes:

$\mu + \kappa_{vessel} + \omega_{year} + \gamma_{month} + \lambda_{area}$, where

μ is the intercept,

vessel is a factor with 2 levels associated with each of the vessels that have operated in the trotline fishery:

El Shaddai

Koryo Maru 11 (which represents the old and the new *Koryo Maru* vessels)

year is a factor with 9 levels associated with the "fishing"-years 2008–2016 for trotlines,

month is a factor with 12 levels (January – December),

area is a factor with 18 levels associated with the new spatially distinct fishing areas shown in Figure 1 of Brandão and Butterworth (2014b),

X is the design matrix for the fixed effects,

β is the vector of random effects parameters whose values are unknown, which includes the following interaction terms:

$\eta_{year \times area} + \theta_{year \times month} + \phi_{month \times area}$,

year×area is the interaction between year and area (this allows for the possibility of different trends in abundance with time in the different areas),

year×month is the interaction between year and month,

month×area is the interaction between month and area,

Z is the design matrix for the random effects, and

ε is an error term assumed to be normally distributed and independent of the random effects.

It is assumed that both the random effects and the error term have zero mean, i.e. E(β) = E(ε) = 0, so that E($\ln\left(CPUE + \delta\right)$) = **X**α. The variance-covariance matrix for the residual errors (ε) is denoted by **R** and the variance-covariance matrix for the random effects (β) by **G**. In the analyses of this paper it is assumed that the residual errors as well as the random effects are homoscedastic and are uncorrelated, so that both **R** and **G** are diagonal matrices given by:

$$\mathbf{R} = \sigma_{\varepsilon}^{2}\mathbf{I}$$
$$\mathbf{G} = \sigma_{\beta}^{2}\mathbf{I}$$

where **I** denotes an identity matrix. Thus, in the mixed model, the variance-covariance matrix (**V**) for the response variable is given by:

$$\mathrm{Cov}(\ln(CPUE + \delta)) = \mathbf{V} = \mathbf{ZGZ}^{\mathrm{T}} + \mathbf{R},$$

where $\mathbf{Z}^{\mathrm{T}}$ denotes the transpose of the matrix **Z**.

The estimation of the variance components (**R** and **G**), the fixed effects (α) and the random effects (β) parameters in GLMM requires two steps. First the variance components are estimated. Once estimates of **R** and **G** have been obtained, estimates for the fixed effects parameters (α) can be obtained as well as predictors for the random effects parameters (β). Variance component estimates are obtained by the method of residual maximum likelihood (REML) which produces unbiased estimates for the variance components as it takes the degrees of freedom used in estimating the fixed effects into account.

Results and Discussion

Table 1 and Figure 1 show the relative abundance indices for toothfish provided by the standardised commercial trotline CPUE series for the Prince Edward Islands EEZ that considers the old and new *Koryo Maru* to be the same and for which the year factor is based on a “fishing”-year. The month factors for this GLMM are also shown, all with 95% confidence intervals. There has been a marked decrease in CPUE from the 2015 to the 2016 fishing season, with the 2016 index being the lowest in the series.

References

Brandão, A. and Butterworth, D.S. 2013. Obtaining a standardised CPUE series for toothfish (*Dissostichus eleginoides*) in the Prince Edward Islands EEZ calibrated to incorporate both longline and trotline data over the period 1997-2013. DAFF Branch Fisheries document: FISHERIES/2013/OCT/SWG-DEM/57.

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Table 1. The number of data entries (*n*) per year available for the GLMM analysis and the relative abundance indices for toothfish provided by the standardised commercial trotline CPUE series for the Prince Edward Islands EEZ.

"Fishing"-year	*n*	GLMM *CPUE*
2008	60	0.697
2009	57	0.861
2010	175	1.252
2011	333	1.000
2012	260	1.112
2013	374	0.935
2014	628	0.773
2015	772	0.820
2016	648	0.546

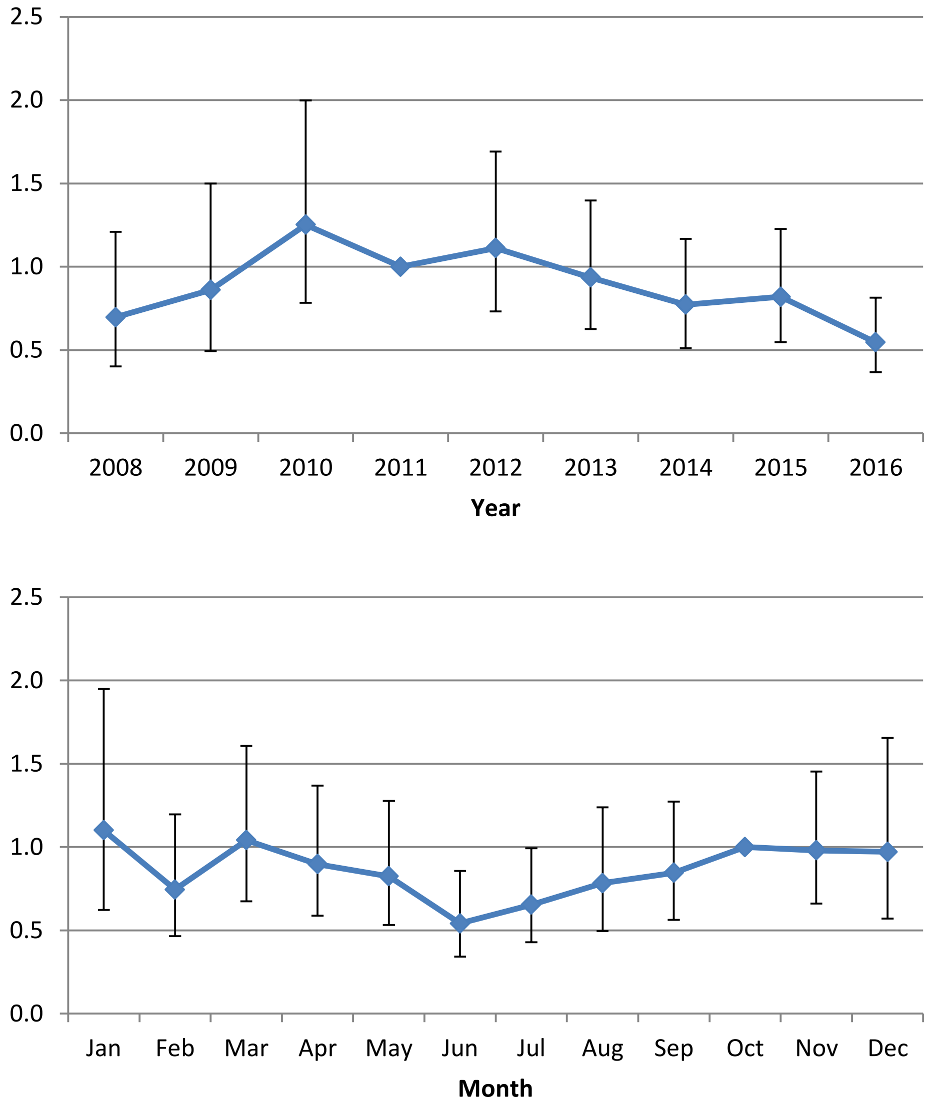

Figure 1. GLMM-standardised CPUE trends (top) and month effects (bottom) together with 95% confidence intervals for the **trotline** toothfish fisheries for the Prince Edward Islands EEZ when the old and new *Koryo Maru* are considered to be the same and the year factor relates to a "fishing"-year. Note that CIs are given relative to 2011 for CPUE and October (set at 1) for the month effect.