Further analysis of tagging data of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands region

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SUMMARY

Analyses of the tag-recapture data available for the PEI toothfish resource are undertaken to evaluate a vessel effect and an area effect on tag recovery rates as well as to determine a possible difference in tagging "success" between the two vessels operating in the PEI region. Parameter estimates have poor precision because of the scarcity of data, especially when disaggregated by vessel and area. The only statistically significant difference is an area effect on tag recovery rates, with the *Centre* areas having the highest recovery rates and the *West* areas the lowest.

INTRODUCTION

At a Task Group Meeting held on 7 March concerning the Prince Edward Islands (PEI) toothfish (*Dissostichus eleginoides*), several tasks were identified in order to advance the development of a Management Procedure for this resource. These were to:

a) evaluate PEI toothfish data for possible between-vessel differences in tag recovery rates,
b) investigate possible area effects in tag recovery rates, and
c) evaluate possible differences in tagging "success" between the two vessels.

DATA UPDATES

Tagging data of toothfish in the PEI region from 2005 to 2016 are used in this paper. The vessels under consideration here are the *Koryo Maru* and the *El Shaddai*. For the analyses presented in this paper the toothfish fishing areas in the PEI region (Figure 1 of Brandão and Butterworth (2014)) have been aggregated into 3 areas; those that roughly fall on the west side (West), those in the centre (Centre) and those on the east side (East), thus West includes areas 10, 20, 21, 30, 40, 50 and 51; the Centre includes areas 100, 1001, 102, 103, 105, 106 and the East includes areas 60, 70, 90, 91, 92, 93, 94.

METHODOLOGY

Assuming no movement of tags between areas, then the number of tags at large in year *y*+1 and area *a* that were originally released by vessel *v* $\left(N_{y+1,a}^{v}\right)$ is given by:

$$N_{y+1,a}^{v} = \left[N_{y,a}^{v} - R_{y,a}^{v}\right]e^{-\left(M+E^{v}\right)} + T_{y+1,a}^{v}\text{, where}$$

$T_{y,a}^{v}$ is the number of new tags released in year *y* and in area *a* by vessel *v*,

M is the natural mortality rate, which is set to 0.2,

E^{v} is the tagging mortality rate for vessel *v* and gives a measure of the differential tagging effectiveness of vessel *v*, and

$R_{y,a}^{v}$ is the number of tags recaptured by all vessels in year *y* and area *a* originally tagged by vessel *v*, given by:

$$R_{y,a}^{v} = R_{y,a}^{v,u_1} + R_{y,a}^{v,u_2}\text{,}$$

where $R_{y,a}^{v,u}$ is the number of tags recaptured by vessel *u* in year *y* and area *a* originally tagged by vessel *v*.

The expected number of tags recaptured by vessel *u* in year *y* and area *a* originally tagged by vessel *v*, $\hat{R}_{y,a}^{v,u}$ is given by:

$$\hat{R}_{y,a}^{v,u} = k_a^{v} C_{y,a}^{u} N_{y,a}^{v}\text{,}$$

where

$C_{y,a}^{u}$ is the number of toothfish caught by vessel *u* in year *y* and area *a*, and

k_a^{v} is a scalar given by $k_a^{v} = k_{West}^{Koryo\,Maru} e^{\left(\alpha_v + \beta_a\right)}$, where α_v is the between-vessel effect in tag recovery rates and β_a is the area effect in tag recovery rates .

The estimable parameters are E^{v}, α_v, β_a and $k_{West}^{Koryo\,Maru}$, where the parameters for *Koryo Maru* and for the *West* area of E^{v}, α_v and β_a are set as the reference levels and hence equal to zero.

The likelihood function

The likelihood is calculated assuming a Poisson distribution. The negative of the log likelihood (ignoring constants) which is minimised in the fitting procedure is thus given by:

$$-\ln L = \sum_{y=2004}^{2016} \sum_{v=1}^{2} \sum_{a=1}^{3} \left\{\hat{R}_{y,a}^{v} - R_{y,a}^{v} \log\left(\hat{R}_{y,a}^{v}\right)\right\}.$$

Results and Discussion

Table 1 shows the parameter estimates for the tagging model together with 95% confidence intervals provided by the Hessian. Results for when all parameters are estimated simultaneously clearly show that with the exception of the β parameters, these values are not significantly different from 0. Results are also shown for when only the β parameters (which are significantly different from zero) are estimated.

Parameter estimates have poor precision because of the scarcity of data, especially when disaggregated by vessel and area. The only statistically significant difference is an area effect on tag recovery rates, with the *Centre* areas having the highest recovery rates and the *West* areas the lowest.

Reference

Brandão, A. and Butterworth, D.S. 2014. Standardisation of the CPUE series for toothfish (Dissostichus eleginoides) in the Prince Edward Islands EEZ using finer scale fishing areas. DAFF Branch Fisheries document: FISHERIES/2014/JUN/SWG-DEM/17.

Table 1. Parameter estimates together with 95% confidence intervals for the PEI toothfish tagging data model, when all parameters are estimated and when only the area effect parameters (β) are estimated.

Parameter	Estimate all parameters	Estimate only β parameters
$E^{El\ Shaddai}$	-0.246 (-0.725; 0.232)	—
$\alpha_{El\ Shaddai}$	-0.837 (-1.778; 0.104)	—
β_{Centre}	1.991 (0.581; 3.400)	2.210 (0.809; 3.612)
β_{East}	0.615 (0.091; 1.138)	0.748 (0.271; 1.224)
$k_{West}^{Koryo\ Maru}$	1.58X10^{-6} (1.17x10^{-6}; 1.99x10^{-6})	1.27X10^{-6} (1.00x10^{-6}; 1.54x10^{-6})
-ln *L*	-36.43	-33.33