Analysis of 2008 RTTP-IO tagging data for Skipjack

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1 Introduction

This document details the analysis of tagging and catch data from the Indian Ocean Skipjack fishery, employing an age-structured model detailed in IOTC-08-WPTT-15, IOTC-08-WPTT-16 and IOTC-10-WPTT-26. The model is used to estimate abundance and exploitation rates for 2008. No recruitment is included: each cohort is simply tracked through the annual quarters, according to the population, tag and recapture models.

2 Methods

The model implemented in this work matches closely that described in IOTC-10-WPTT-26, the specifics of which are not repeated here. Refering back to that work, a number of differences are noted:

1. Since the tagging program ended in 2007, tag 'releases' at the start of 2008 are obtained from estimates of the surviving tags at the end of the previous year

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2. All of these tags are assumed to fully mixed and available to be caught by the purse-seine and other fleets ($\kappa(g, \tau, a) = 1$; Equation 3, IOTC-2010-WPTT-26)

Tag recapture and reference catch data were aggregated according to Option 3 in IOTC-2010-WPTT-26. Specifically, we include at-sea European Union Purse Seine recaptures and all recaptures from stevedores in the Seychelles, Mauritius, Kenya and Madagascar, reefers and cannery workers. The at-sea reporting rate is assumed to be 1, with an overall reporting rate estimated from all tag seeding data applied to the remaining recaptures.

2.1 Estimation of 2008 tag releases

The number of tags in the first quarter of 2008 was derived from the number of tags estimated to have survived until the end of 2007. In previous analyses of the tag data for 2007 (IOTC-2010-WPTT-26), the number of tags in the population at the beginning of the 4th Quarter in 2007 was estimated. From these estimates the number of tags at the beginning of the first quarter in 2008 was derived by projecting forward for a single quarter, taking into account harvest, natural mortality, tag shedding and recapture. Thus the number of 'releases' in the first quarter of 2008 is given by

$$T_{2008,1,a+1} = T_{2007,4,a} \exp(-M_a) \pi^R(\tau) \left(1 - \sum_g h_{2007,g,4,a}\right) - R_{2007,4,a} \quad (1)$$

where M_a is the natural mortality at age a, $\pi^R(\tau)$ is the probability of retaining a tag for the given time-at-liberty $\tau = 0.25$, $h_{y,g,q,a}$ is the harvest rate by year y, gear type g, quarter q and age a, and $R_{y,q,a}$ is the observed number of tag returns (adjusted by the reporting ratea). For each release event in 2007 (Quarters 1 to 3), Equation 1 gave us estimated tag 'releases' for the year 2008. These allow an independent evalution of population size and harvest rates for 2008, and were thus data we kept dissagregated. Since ages 2 to 5 were considered in IOTC-2010-WPTT-26, Equation 1 gave us releases for ages 3 to 6 (Table 1). The number of recaptures for age 6 was small and thus harvest rates and numbers at age were not estimated for this age cohort.

2.2 Summary statistics

Outputs for the model consist of estimated numbers at age and the harvest rate per quarter and gear type for each age cohort. The harvest rate across gear types is given by:

$$h_{y,q,a} = 1 - \prod_{g} (1 - h_{y,g,q,a}) \tag{2}$$

From these harvest rates for each quarter we calculate the annual harvest rate as a weighted average of the harvest rates by quarter. The weighting accounts for the number of individuals that will have survived to a given quarter. The annual harvest rate is therefore given by:

$$\begin{aligned} \bar{h}_{y,a} = h_{y,1,a} + e^{-M_a}(1 - h_{y,1,a})h_{y,2,a} + e^{-2M_a}(1 - h_{y,1,a})(1 - h_{y,2,a})h_{y,3,a} \\ + e^{-3M_a}(1 - h_{y,1,a})(1 - h_{y,2,a})(1 - h_{y,3,a})h_{y,4,a} \end{aligned} \tag{3}$$

3 Results and Discussions

Results for 2008 are given in Tables 3 to 5, and illustrated in Figures 1 and 2. Data fits are given in Figure 3. For reference, we also provide estimates of the numbers at age from 2006 and 2007, obtained from IOTC-2010-WPTT-26.

Firstly we note that numbers at age estimated for the 1st Quarter in 2008 for ages 3 and 4 are aligned with the estimates for ages 2 and 3 respectively for for the 4th Quarter of 2007. However this is not the case for age 5 in 2008. This suggests that there were too few tag recaptures for that age class compared to what would be expected from the 2007 results. One reason for this may be a change in fishing practices, either spatially or from free-school to FADs, which could change the age profile of the catches.

It can be seen that estimated numbers entering all age classes has progressively decreased from 2006 to 2008, suggesting either a protracted period of low recruitment moving

through the population, or stable recruitment and increased harvest rates. The annual harvest rates for 2008 are illustrated in Figure 2. These are high: 20% for age 3 and approaching 40% for age 4. This is despite low catches for 2008 (relative to previous years).

		Age			
Year	Quarter	3	4	5	6
2007	1	1	27	21	1
	2	93	872	867	350
	3	2420	6095	882	116
	4	0	0	0	0

Table 1: Estimated number of tags released in 2007 that survive until the start of the first quarter in 2008. Note that ages correspond to the ages in 2008.

2007 Quarter	2008 Quarter	Age			
Release	Recapture	3	4	5	6
1	1	0	0	0	0
	2	0	1	0	0
	3	0	0	0	0
	4	0	0	0	0
2	1	3	11	7	2
	2	6	11	3	0
	3	0	6	2	0
	4	2	1	0	1
3	1	97	101	9	0
	2	227	218	11	0
	3	37	75	4	0
	4	27	47	0	0

Table 2: Tag recaptures. Note that ages correspond to the ages in 2008.

Quarter	Age					
	3	*cv*	4	*cv*	5	*cv*
1	86.9	(0.051)	41.4	(0.046)	62.9	(0.169)
2	71.1	(0.054)	32.9	(0.049)	53.7	(0.17)
3	57.3	(0.057)	24.5	(0.057)	45.3	(0.174)
4	44.9	(0.063)	17.7	(0.068)	38.2	(0.177)

Table 3: Numbers-at-age for 2008 (millions)

Year	Quarter	Age							
		2	*cv*	3	*cv*	4	*cv*	5	*cv*
2006	1	666.1	(0.073)	274	(0.023)	151.3	(0.047)	111	(0.143)
	2	535.6	(0.074)	230.4	(0.024)	126.6	(0.048)	94.7	(0.144)
	3	421.2	(0.077)	188.6	(0.025)	103.5	(0.05)	79.7	(0.148)
	4	317.6	(0.084)	154.4	(0.027)	87.8	(0.051)	68.2	(0.148)
2007	1	545.5	(0.095)	129.9	(0.03)	59.4	(0.05)	71.3	(0.234)
	2	437.7	(0.097)	108	(0.031)	48.5	(0.053)	60.8	(0.236)
	3	347.7	(0.1)	85.7	(0.033)	37.1	(0.059)	51.3	(0.241)
	4	275.6	(0.103)	66.3	(0.037)	28.4	(0.067)	43.3	(0.245)

Table 4: Numbers-at-age (millions) for 2006 and 2007 estimated from previous work (IOTC-2010-WPTT-26, Option 3).

Quarter	Age					
	3	*cv*	4	*cv*	5	*cv*
1	0.05	(0.05)	0.08	(0.045)	0.01	(0.165)
2	0.06	(0.053)	0.14	(0.049)	0.02	(0.167)
3	0.09	(0.056)	0.16	(0.056)	0.02	(0.17)
4	0.11	(0.062)	0.2	(0.066)	0.03	(0.174)
All	0.20	(0.05)	0.37	(0.045)	0.06	(0.165)

Table 5: Harvest rates-at-age for 2008

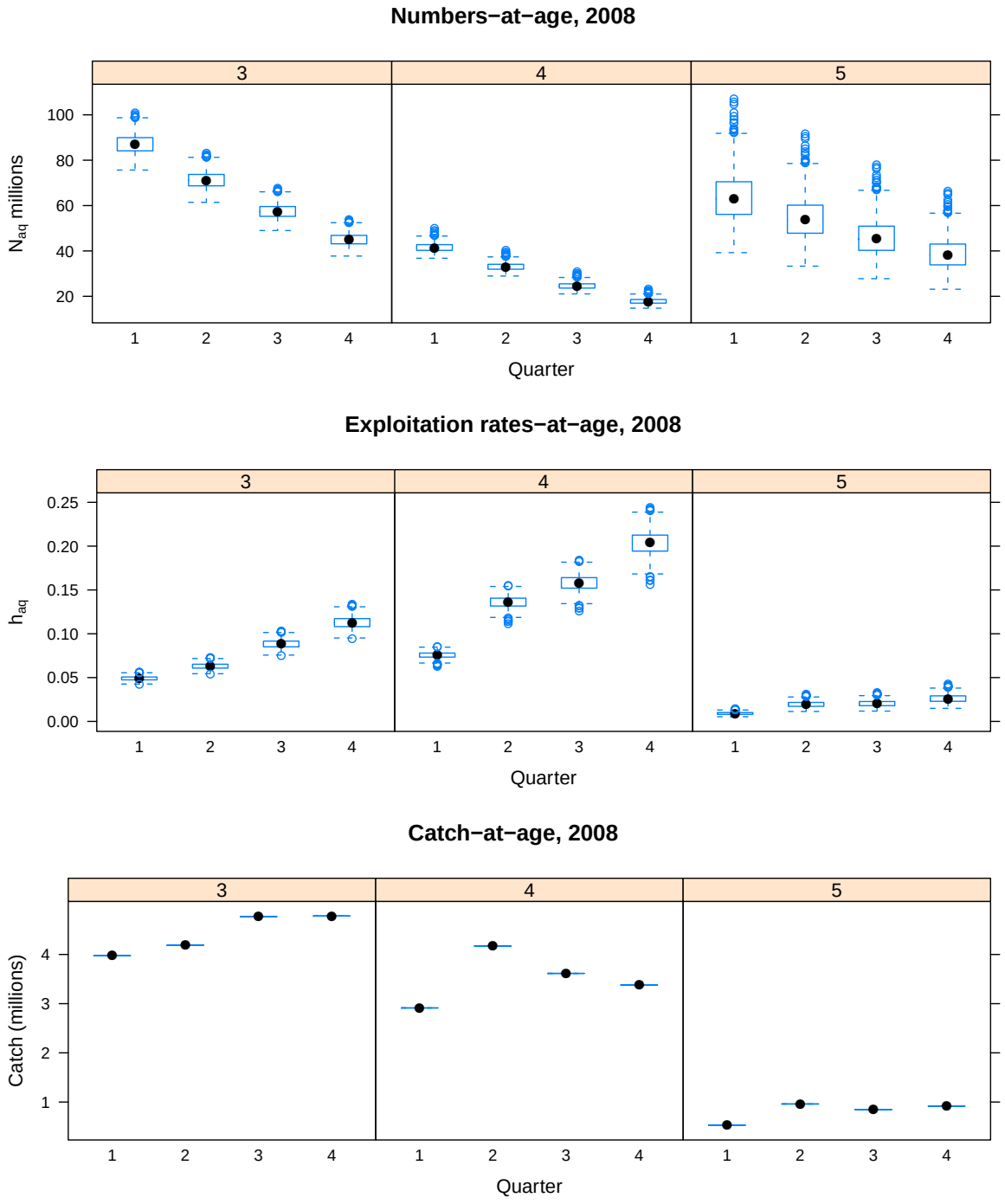

Figure 1: Numbers, exploitation rates-at-age and catches by quarter for 2008

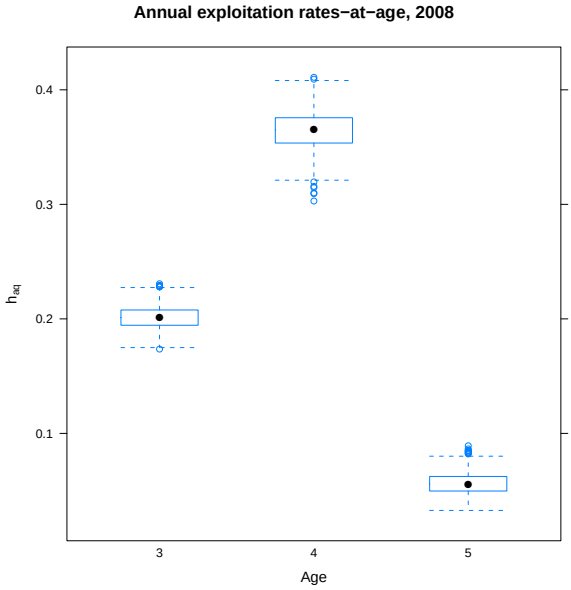

Figure 2: Annual harvest rates

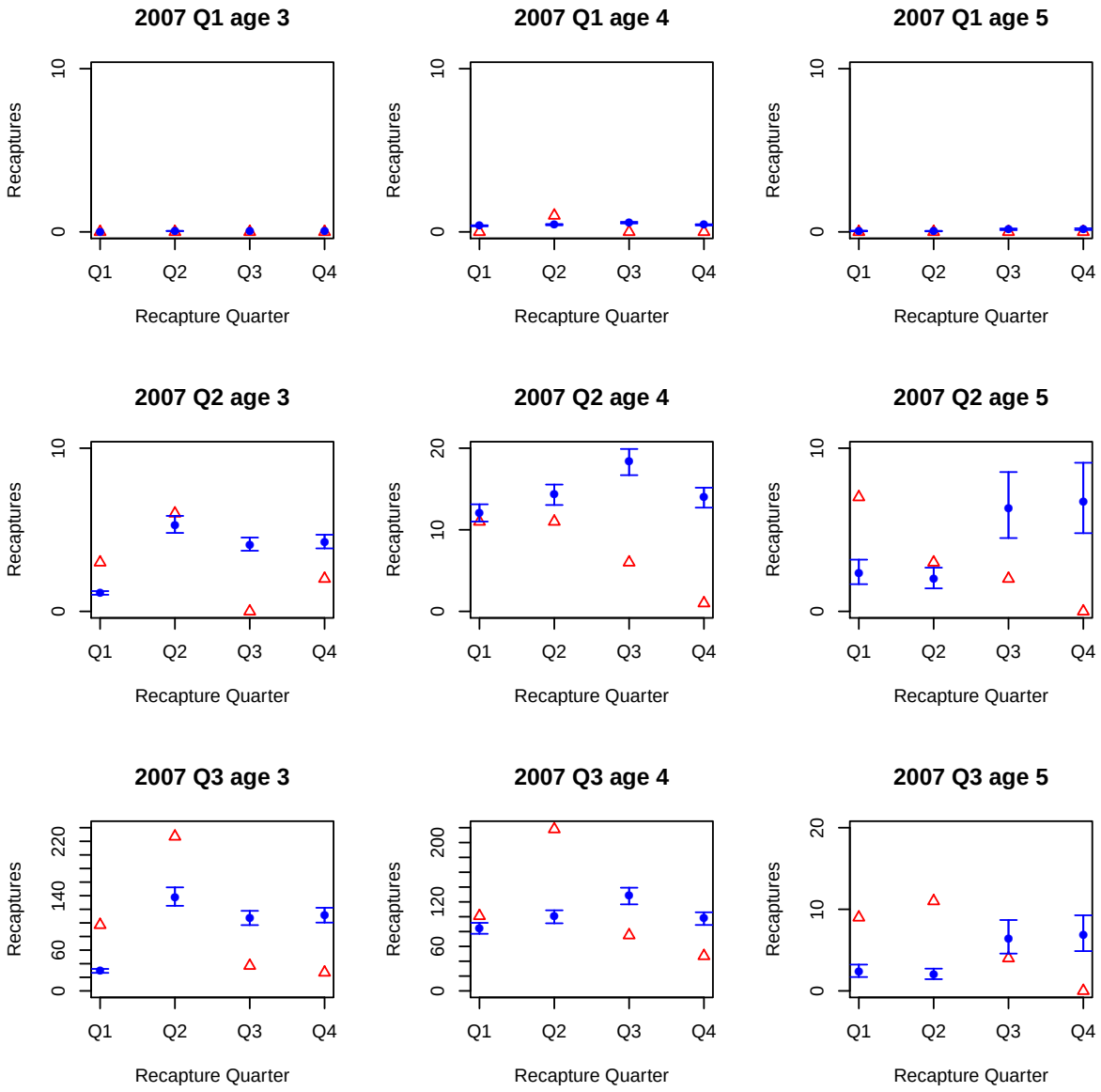

Figure 3: Fits to the tag recapture events by release event and age for 2008. Red triangles denote the observed recaptures and the blue circles and bars represent the median and 95% credible interval for the model-predicted recaptures