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Preliminary analyses; evaluation of the effects of the newly employed seabird bycatch regulation for longline fisheries in IOTC conventional area with using current observer data

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Abstract

The new seabird mitigation regulation was enforced in July 2014 in the area south of 25S in IOTC convention area. It demand for fisheries to adopt two of three mitigation measures of tori-line, night setting and blanch line weighting which have high effectiveness for mitigation of seabird bycatch (Melvin et al. 2014, Sato et al. 2014). In this document, Japanese seabird by catch data in the south Indian Ocean (south of 25S) collected by on-board observers in the period before and after the introduction of the new regulation were reviewed, to explore the possibility to evaluate the effectiveness of the new mitigation measures. It seems that the distribution of the observer data collected form almost main fishing areas of Japanese longliners in the period analyzed. The observer data indicated that many Japanese tuna longline vessel (71-94%) had already adopted the combination use of weighting blanch line and Tori line or night setting and Tori line before the introduction of regulation (2012 - 2013). This would be mostly due to the fact that bait loss by seabirds is one of serious concern of Japanese fishers but also suggest their positive attitude toward seabird conservation. The amount of data seemed insufficient as data after the introduction of the new regulation was only one year, analytical method supposed to be rather preliminary. However, the good efficiency of the regulation with using fisheries data, further collection of data appeared to be necessary for the stochastic evaluation of the effect of new mitigation measure, such as considering the effect of the interaction of each mitigation, target species. Also, the detail situation when the mitigation measures were used would be needed to investigate in the future.

Introduction

Recently, new seabird mitigation regulation was introduced in ICCAT, IOTC and WCPFC conventional area (ICCAT; Rec11-09 started from July 2013, IOTC; Res 12/06 started from July 2014, WCPFC; Conservation Measure 2012-07 started from July 2014), and the commission of these tuna RFMOs tasked their scientific committee to evaluate its effectiveness of the regulation needs to be tested. It demand for fisheries to adopt two of three mitigation measures of tori-line, night setting and blanch line weighting which have high effectiveness for mitigation of seabird bycatch (Melvin et al. 2014, Sato et al. 2014). In this document, Japanese seabird by catch data in the south Indian Ocean (south of 25S) collected by on-board observers in the period before and after the introduction of the new regulation were reviewed, to explore the possibility to evaluate the effectiveness of the new mitigation measures. It seems that the distribution of the observer data collected form almost main fishing areas of Japanese longliners in the period analyzed.

Material and Method

1. Bycatch data correction

As indicated in Inoue and Minami (2015), the number of seabird crowded around astern of longline boats at the gear setting were supposed to have positive relationship with the seabird bycatch number, and thus we selected the data possessing this information, which is corresponding to those in the period between 2012 and 2014, for this study. Observer data of this information were used in this study. Japanese observer data from 2012 to 2014 were used for the analysis.

In regard to (or in relation to) the seabird mitigation measure, Japanese scientific observer program had recorded the use of tori line, the use of bait casting machine, the use of magnet, and the condition of bait thawing (use of bait casting machine) from 1996 to 2010, and after that, another 9 measures were added to list checked by observers as those area also recognized to be effective. Those are; the number of tori line, the use of weighted blanch line, the use of blue dyed bait, adoption of the underwater setting, management of discards (proper management of offal discharge) the adoption of side setting with weighted blanch line and bird curation, the adoption of night setting with light management, bait casting robot setting. The number of seabirds gathered around the vessel in gear setting was counted by the visual observation by the trained observers using the simple method created by National Research Institute of Far Seas Fisheries (NRIFSF). During the observation each observer collect data for the number of albatrosses and other seabirds, time of the observation conducted, the area (distance from stern) covered by the visual observation, day or night, the degree of moon light during night at time of the observation.

Though observers took photo of each by caught seabird in the designated way by NRIFSF (2015) for the identification of species and its developmental stages (Inoue et al. 2012), species and developmental stage were combined for the in this study.

2. Analysis of the effect of the newly employed seabird bycatch regulation

The generalized linear mixed models (GLMMs) were used for the analysis of seabird bycatch data. Because the bycatch rate is generally low and many zero catch data, which is partially due to the use of mitigation measures, delta lognormal model were used for the analysis. For the analysis, explanatory variables of area (two categories: western area = 20-80E and 25S-45S, eastern area = 80-150E and 25S-45S), season (first quarter =January to March, second quarter=April to June, third quarter=July to September, fourth quarter=October to December), the number of seabird gathered around astern of longline boats at the gear setting, were introduced in to the model in addition to the ones of use of the weighted blanch line, the use of the night setting and number of the Tori line (single or double) to adjust/eliminate the spatio temporal effects on seabird by catch ratio as well as that of seabirds numbers at the time of gear setting. The number of seabird gathered around astern of longline boats at the gear setting were arbitrarily categorized into 7 ranks; I counted number of albatrosses gathered around astern categorized into 0, 1-5, 5-10, 10-15, 15-20, 20-30 and over 30. Other seabirds around the vessel in setting were also categorically counted with divided into 0, 1-5, 5-10, 10-20, 20-50, 50-100, over 100. Those two categories were standardized by dividing by the number of categories and summed then the index of the abundance of seabirds around the vessel was obtained. Due to the hard work of on-board observers, information of the number of seabird crowded around astern at the time of gear setting were only collected part of observed sets when observers can afford to observe gear setting. Thus, the sample size were limited because of those intermittent observation. To consider vessel effect to bycatch rate (Inoue et al. 2015), the Ship ID was set in a random effect. Models were selected by Akaike's Information Criteria (AIC) with second-order correction for small sample size (AICc) as selection criterion of most appropriate model. Delta AIC values exceeding 2 are considered indicative of substantial differences in support for the compared models (McCarthy 2007).

Sets reported to use tori line and line weighting believed to adopt night setting during time before sunrise as most of Japanese longliners starting gear setting before dawn and end after dawn. Thought detailed about this are not available now, those data are decided to use under the assumption that the only regulation which recorded its use would affect to bycatch rate in the set.

In the model analysis, no interaction term was introduced due to the shortage of data. Though there are records of other mitigation measures in Japanese observer data as described in above, those other mitigation measures were not employed for the GLMMs as sets used these measures were small and limited to particular cruises. Number of observed hooks were set into the offset in GLMMs so that the analysis consequently evaluate the bycatch rate rather than bycatch number. Unit is each set.

All analysis for this paper was carried out with the R Project for Statistical Computation version 3.0.2 (R Core Team 2013) using a few additional libraries (Barton 2013, Bates et al. 2014).

Result

Outline of used data in Japanese observer program

Figure 1 showed the fishing effort in IOTC convention area south of 25^{o} S from 2012 to 2014 in each season. **Figure 2** showed the observed hook number in observer data in same area as **Figure 1** in each season. The fishing effort were larger from first to third quarter than fourth quarter, while the observed hooks in observer data were larger in the second and third quarters than other quarters. It seems that the distribution of the observer data covered main of the fishing area. **Table 1** shows the observer coverage in IOTC convention area south of 25^{o}S in each year. The level were remained 3-4 % in each year.

Table 2 showed sample size in each number of tori line, in use or non-use of weighted blanch line and in use or non-use of night setting in each year. Before regulation introduction in 2014 Jul., some of the Japanese tuna longline vessel voluntary employed the weighted blanch line and Tori line, or the night setting and Tori line or all those three mitigation measure (**Table 2**). Weighted blanch line used more than night setting in 2012 and 2013. The major combination were "weighted blanch line and single tori line" and "night setting and single tori line" which is same as ICCAT convention area (Inoue et al. 2015).

Figure 3 showed the bycatch rate (the total number of seabird per 1000 hooks in 5x5 degree). The 5x5 block which is the higher bycatch rate were appeared off cape area. Overall, the bycatch rate tend to be lower than ICCAT area (Inoue et al. 2015).

The effect of the mitigation measures

Blanch line weighting, Night setting and number of Tori line were chosen for the best model of the proportion positive/total observation (binary model). Thought the number of seabirds around the vessel in setting affected to the bycatch rate of seabirds in ICCAT area (**Inoue et al. 2015**), it did not chosen at the best model in IOTC area (**Table 34**). Area and season were not chosen, either (**Table 3**). The weighted blanch line affected to the bycatch rate of seabirds, which is decreased with using the weighted blanch line (**Table 3, Table 4** and **Figure 4**). The night setting affected to the bycatch rate of seabirds, which is decreased with using night setting (**Table 3, Table 4** and **Figure 4**). Number of Tori line affected to the bycatch rate of seabirds but it is tended to increase with using double tori line (**Table 3, Table 4** and **Figure 4**). The model of positive bycatch rates (log-normal model) was not affected to any factors in the best model (**Table 3**).

The bycatch rate were decreased after introduction of regulation (**Table 5, Figure 5**). Because the Bycatch rate was zero after the introduction of the regulation, we did not use the statistical analysis. The bycatch rate before the regulation were relatively low comparing with ICCAT area.

Discussion

1. The outline of the implementation of the seabird mitigation measure

Total of 685 set in Indian Oceans were obtained during the period between 2012 and 2014 (**Table 1**).

According to the Japanese scientific observer data, there are quite a few ships which had used blanch line weighting and/or night setting with tori line before the regulation started (**Table 1**). 72% and 94% (207 and 170 sets) of the all observed sets in 2012 and 2013 respectively had adopted two of three mitigation measures (night setting, weighted blanch line and Tori line) in the period before the introduction of the new seabird regulation. One of the major reasons why many sets adopted line weighting, which expected to give burden for fishers, is that many Japanese skippers seriously concerned for bait loss and at the same time, they recognized line weighting is effective for this.

The coverage at south of 25S were lower than 5% which was set as the minimum coverage rate by the IOTC commission. However the part of observer data in 2013 and 2014 were not used in this analysis because data has not been checked completely their error check is not finished yet, so the result is tentative and would increase. In CCSBT, it is requested that observer coverage of southern bluefin tuna should be at least 10% so the observer are arranged mainly to board southern bluefin tuna fisheries so the data obtained by sets targeting southern bluefin tuna occupied large part of the total. And the observer coverage at south of 35S achieved over 10% (Sakai et al. 2014), where the albatross bycatch rate is relatively high (Inoue et al. 2011).

2. Effectiveness of the mitigation measure which introduced to the regulation: model result

The results of model analysis indicates that the bycatch rate decreased when the weighted blanch line or night setting were used. The use of night sets and weighted blanch line significant effects on the reduction of seabird bycatch rate when they used with tori line (**Table 1** and **3**). This indicate that the newly mandate mitigation measure has effect to reduce the seabird bycatch rate in the IOTC commercial longline fishery. This is preliminary result, so the analysis needs to be continued. Also, it is needed to quantify the effectiveness in future.

In our GLMM analysis, the interaction could not be considered due to shortage of data coverage, further collection of data as well as the cleaning up of existing data such as data of sets eliminated from this study should enable us to conduct detailed analysis. The new regulation mandated fishermen to use at least two mitigation measures among three, and combination use of mitigation measures may have combination effect, but the model used in this study could not evaluate this possibility. Because the GLM model used in the analysis assumes independent effect for each explanatory variables, further investigation for the mechanism of effects of mitigation measures should be conducted with increased and improved data.

The effect of interaction between number of tori line (single-double) and weighted blanch line or the effect of interaction between number of tori line (single-double) and night setting could not be tested. Consequently, the result of our GLM analysis showed the effect of weighted blanch line/ night setting with ignoring the effect of number of tori line. Though the effect might change among number of tori line, at least the weighted blanch line and night setting is effective with tori line.

The target species in south of 30ºS would probably be southern bluefin tuna. In the analysis of tuna CPUE, the clustering group which obtained from the cluster analysis among catch species were often employed to one of explanatory variables as block factor (McKechnie et al. 2014, Coelho et al. 2015). In terms of target species, considering the mechanism of the seabird bycatch, vulnerability of seabird would be affected at following situation; the weight might change for the adjustment of sink rate among each target species; the weight might change for the adjustment of sink depth among each target species. Because of the data limitation, we did not put the effect of the target species. However, the effect of the target species would be considered in future model after the data accumulated. Log-normal model did not affected any factors. This would be because the bycatch rate were too low to fit the log-normal model. The model distribution would also need to be considered in the future model.

3. Why the bycatch number became higher in use of double tori line than in use of single one?

Number of tori line reported affecting on the seabird abundance around the vessel at gear setting (Inoue et al. 2015). When seabird abundance is increased, the vessel increased the tori line. Inoue et al. (2015) suggests that fishing masters determine to use the double tori line when the seabird abundance around the vessel become high, for preventing from losing baits and catching seabirds and that the seabird number around the vessel has strong positive effect to bycatch rate so the bycatch rate seem to become higher in use of double tori line.

The criteria to switch single to double tori line, which may change by fishing master, are not clear at now but better to be investigated it for the detailed evaluation of the effect of mitigation measures. According to Mervin et al. (2014), double tori-line was effective with combination use of night setting and weighted blanch line though the effect of single tori-line were not examined. Sato et al. (2012) reported that paired tori line performed better than single tori line in reducing bait attacked and seabird mortality though the combination effect with other mitigation measure were not examined. The effect of number of tori line (single or double) with combination use of night setting and line weighting would better be examined in the future.

Reference

Bates D, Maechler M, Bolker B and Walker S (2014)._lme4: Linear mixed-effects models using Eigen and S4_. R package version 1.1-7, <URL: http://CRAN.R-project.org/package=lme4>.Barton K (2013) MuMIn: Multi-model inference. http://cran.r-project.org/web/packages/MuMIn/index.html

Coelho R, Lino PG, Rosa D, Santos MN (2015) Update of blue shark catches and standardized CPUE for the Portuguese pelagic longline fleet in the Indian Ocean: exploring the effects of targeting. IOTC-2015-WPEB11-26.

McKechnie S, Harley S, Chang SK, Liu HI, Yuan TL (2014) Analysis of longline catch per unit effort data for bigeye and yellowfin tunas. WCPFC-SC10-2014/SA-IP-03.

Inoue Y and Minami H (2015) Review of seabird bycatch from 1996-2013 in Japanese scientific observer data CCSBT-ERS/1503

Inoue Y, Yokawa K, Minami H (2011) Preliminary view of bycatch hotspot: distribution of seabirds from tracking data, interaction map between seabird distribution and longline effort and bycatch distribution in the ICCAT conventional area of the southern hemisphere ICCAT-SCRS/2011/198

Inoue Y, Yokawa K, Minami H (2012) Improvement of data quality of seabird bycatch in Japanese Scientific observer program ICCAT-SCRS/2012/083

Inoue Y, Yokawa K, Minami H (2015) Preliminary analyses; evaluation of the effects of the newly employed seabird bycatch regulation for longline fisheries in ICCAT conventional area with using current observer data ICCAT-SCRS/2015/130.

McCarthy MA (2007) Bayesian Methods for Ecology. Cambridge University Press, New York. pp 312.

Melvin, EF, Guy TJ and Read LB (2014) Best practice seabird bycatch mitigation for pelagic longline fisheries targeting tuna and related species. Fish. Res. (2013), http://dx.doi.org/10.1016/j.fishres. 2013.07.012NRIFSF (2015) Pelagic longline observer research manual.

R Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Sakai O, Itoh T, Minami H and Abe O (2014) Report of Japanese scientific observer activities for southern bluefin tuna fishery in 2012 and 2013. CCSBT-ERS/1503/BGD 01.

Sato N, Ochi D, Minami H, Yokawa K (2012) Evaluation of the effectiveness of light stereamer Tori-lines and characteristics of bait attacks by seabirds in the Western North Pacific. PloS ONE 7: e37546.

Sato N, Minami H, Katsumata N, Ochi D and Yokawa K (2013) Comparison of the effectiveness of paired and single tori lines for preventing bait attacks by seabirds and their bycatch in pelagic longline fisheries. (2013) Fisheries Research 140 14-19.

Shono H (2008) Confidence interval estimation of CPUE year trend in delta-type two-step model. Fis Sci 74: 712 – 717.

Table 1 Observed rate in ICCAT convention area

	Effort	Overved hooks	Cover rate
2012	17245808	671417	3.89%
2013	14068946	414190	2.94%
2014	16811177	587735	3.50%

Table 2 Sample size (sets) in each mitigation measure in each year in IOTC area.

Weighted Blanch Line	Night Setting	Tori line	2012	2013	2014
use	use	Single	50		
use	use	Double		36	
use	Unknown	Single	13		
use	non-use	Single	99	102	66
use	non-use	Unknown	1		
use	non-use	Double		1	
non-use	use	Single	38	4	141
non-use	use	Unknown			1
non-use	use	Double	7	27	
non-use	Unknown	Single			1
non-use	non-use	Single	58	1	2
non-use	non-use	Double	10	10	
Unknown	use	Single			2
Unknown	Unknown	Single	9		1
Unknown	Unknown	Unknown	1		
Unknown	non-use	Single	1		
Total			287	181	214

Table 3 The summary for the model selection. The models of which delta AIC were less than 2 were selected.

	Model factors for proportion postive/total observations (Delta AIC<2)											
	Intercept	Area	Season	Number of Seabirds around Vessel	Blanch line weighting	Night setting	Tori line	df	logLik	AICc	Delta AIC	weight
1	-3.355				+	+	+	5	-94.034	198.3	0	0.310
2	-2.963			-0.3601	+	+	+	6	-93.91	200.1	1.83	0.124
3	-3.344	+			+	+	+	6	-93.929	200.1	1.87	0.122
	Model factors for positive bycatch rates (Delta AIC<2)											
	Intercept	Area	Season	Number of Seabirds around Vessel	Blanch line weighting	Night setting	Tori line	df	logLik	AICc	Delta AIC	weight
1	-0.6946							3	-9.159	25.1	0	0.734

Table 4 The summary of the GLMM that examined the effect of mitigation measure to the bycatch rate. The formula is; Number of total seabird catch = season + seabird abundance around the vessel in the gear setting + use of weighted blanch line + use of night setting.

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-3.355	0.512	-6.553	5.65E-11	***
Blanch line weighting	1.139	0.439	2.594	0.009491	**
Night setting	1.600	0.428	3.741	0.000183	***
Tori line	0.953	0.323	2.955	0.003131	**

	Estimate	Std. Error	t value
(Intercept)	-0.69458	0.05082	-13.67

Table 5 The summary of the bycatch information before and after regulation

	BPUE	Total number of bycatch	Hook number	N
Before regulation	0.054	77	1427111	596
After regulation	0	0	246231	89

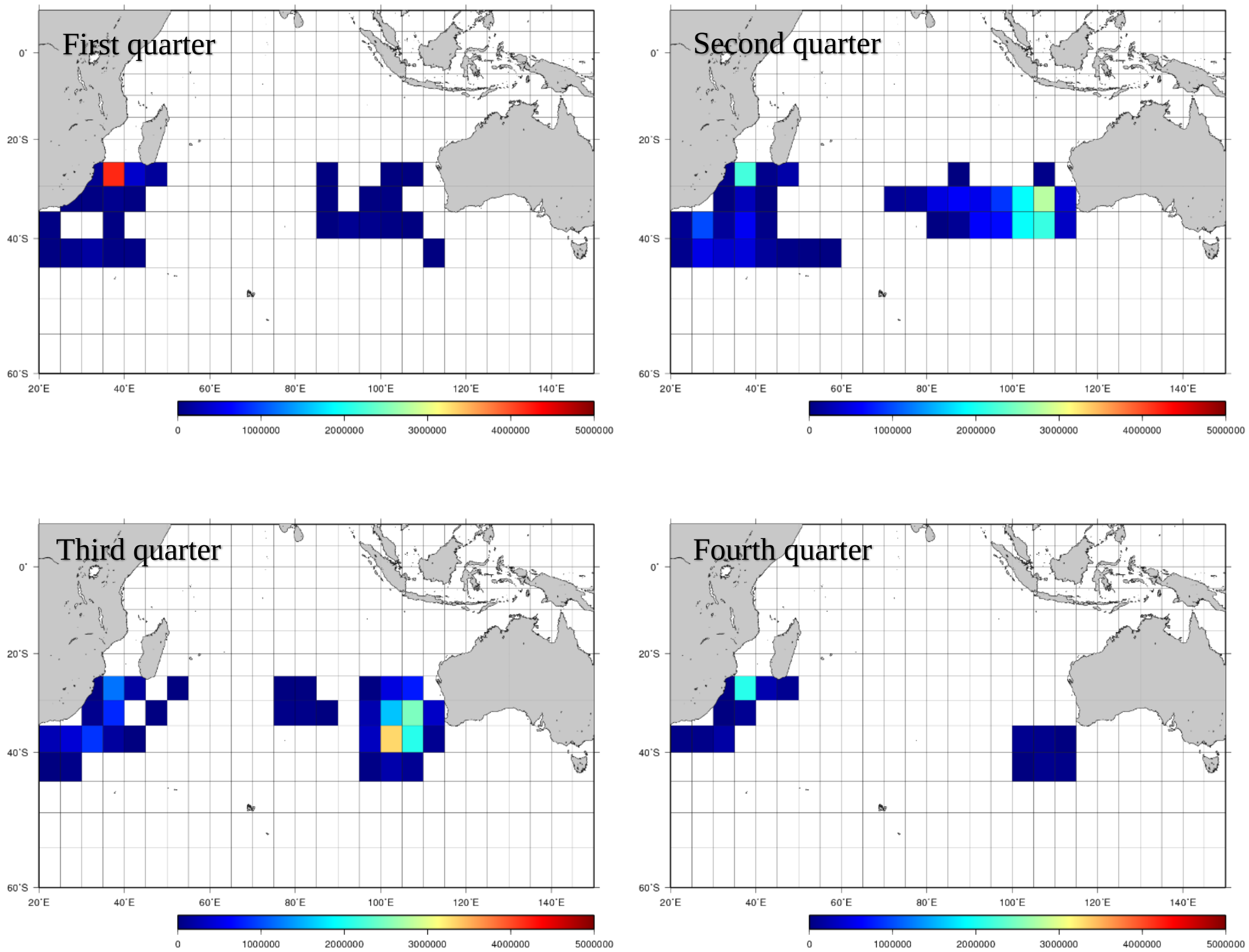

Figure 1 Japanese longline fishing effort (number of hooks)

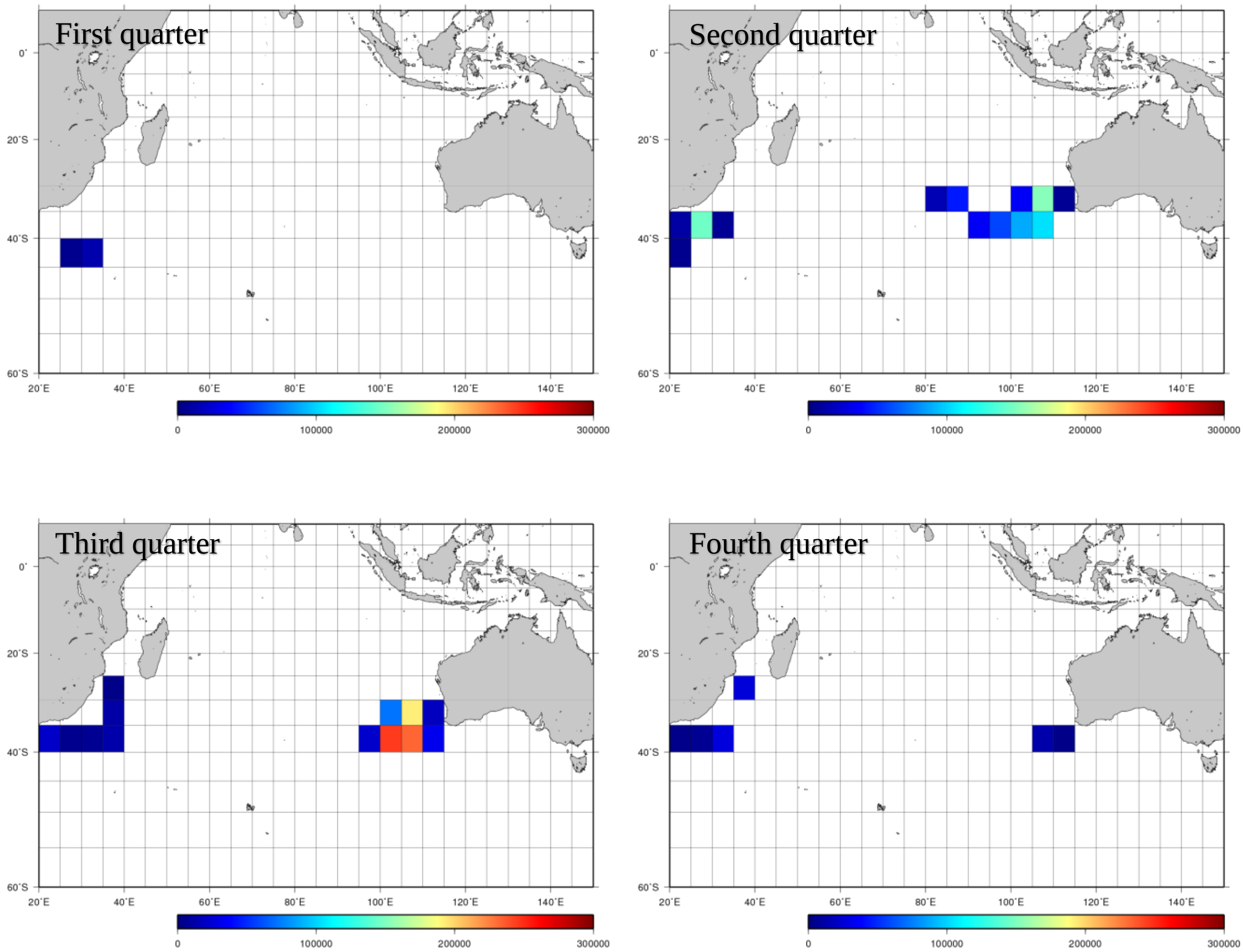

Figure 2 number of observed hooks in the Japanese scientific observer data

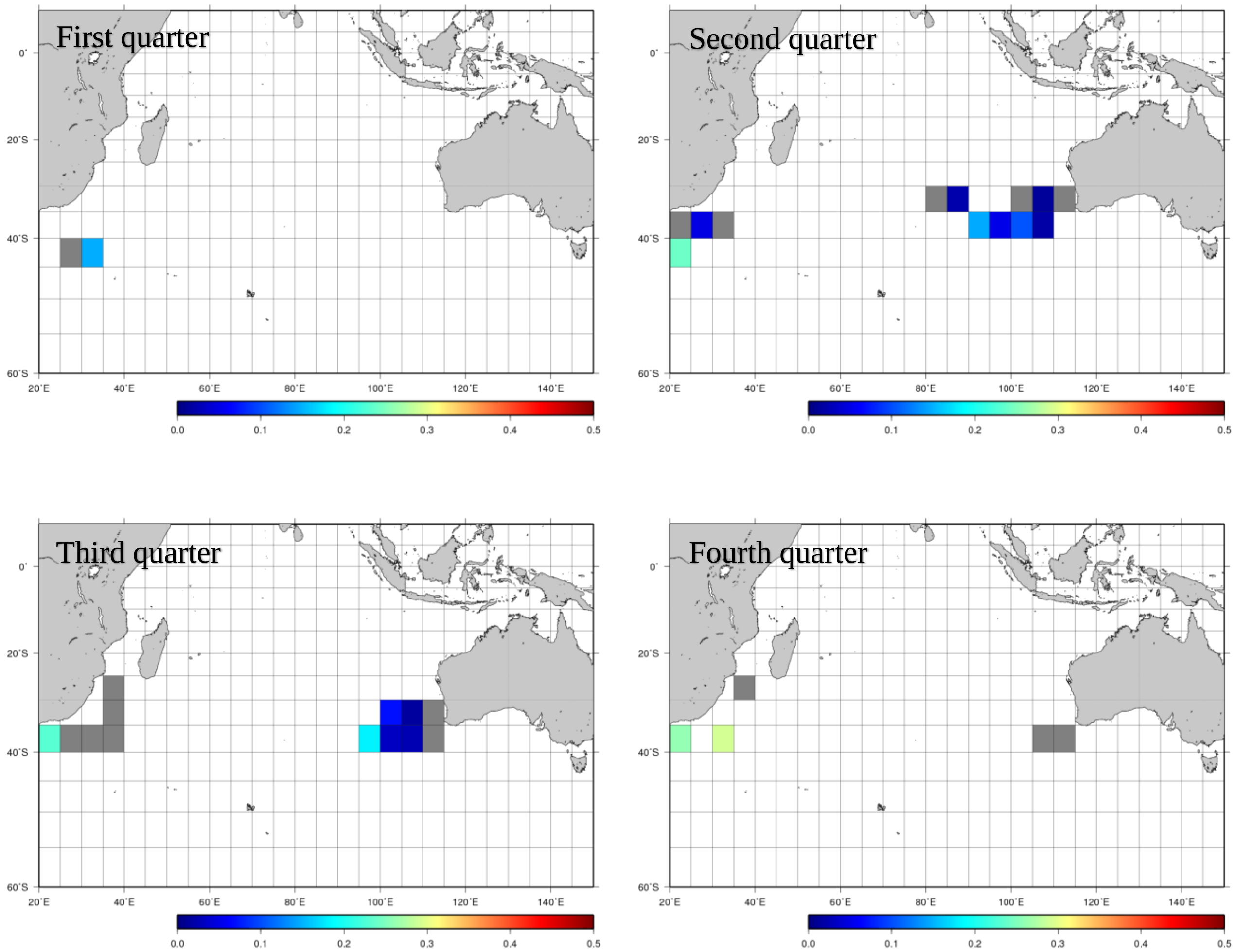

Figure 3 Bycatch rate of total seabirds in the Japanese scientific observer data

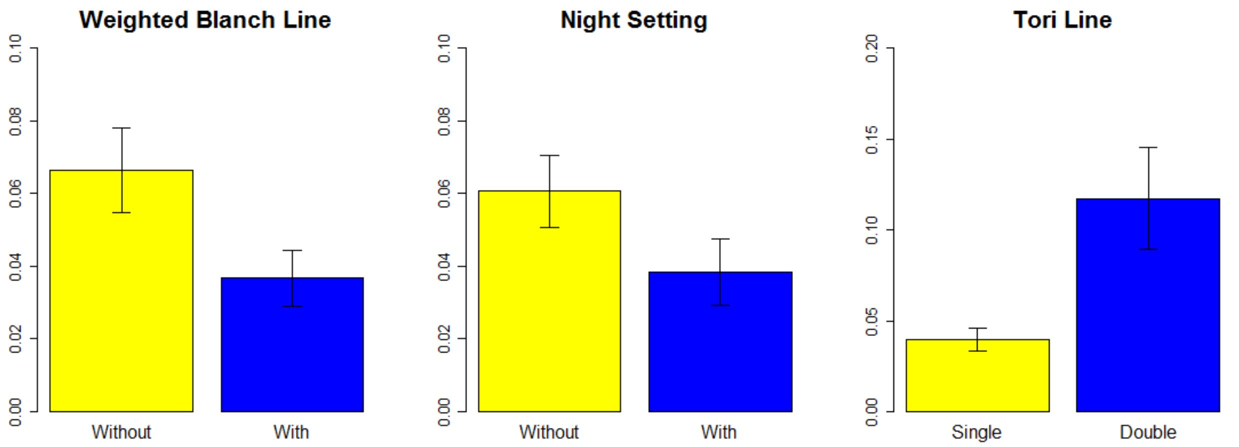

Figure 4 Bar chart of the bycatch rate in each bycatch mitigation measures (weighted blanch line, night setting and tori line) introduced in IOTC convention area south of 25 degree south.

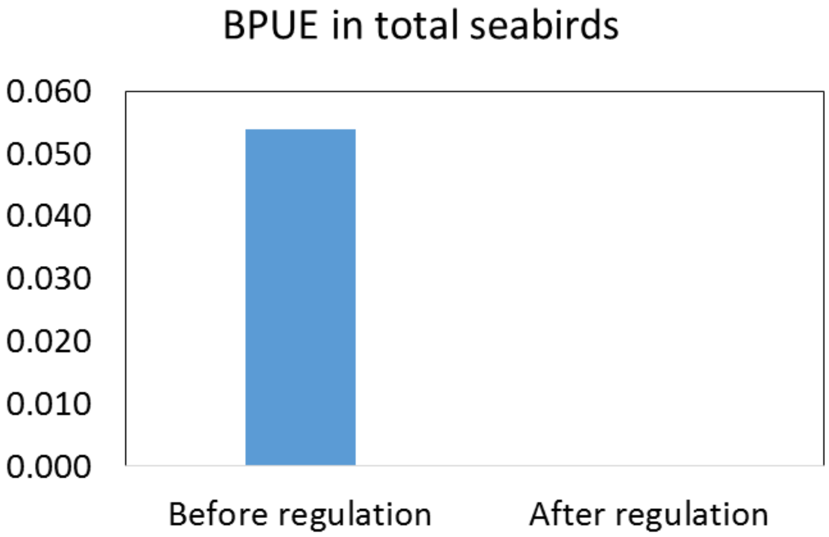

Figure 5 Bar chart of the bycatch rate of before and after regulation in IOTC convention area south of 25 degree south.