SCIENTIFIC COMMITTEE
THIRD REGULAR SESSION

13-24 August 2007
Honolulu, United States of America

EFFECTIVE FACTORS OF TORI-POLES IN REDUCING INCIDENTAL CATCH OF SEABIRDS IN THE JAPANESE LONGLINE FISHERY

WCPFC-SC3-EB SWG/WP-13

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Effective factors of tori-poles in reducing incidental catch of seabirds in the Japanese longline fishery

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Abstract

Effective factors of tori-poles in reducing incidental catch of albatross were examined with the data from Japanese observer program in southern bluefin tuna fishery. A total of 727 observations were used in the analysis. The data in night settings were not used because observed numbers of albatross and other seabirds were not recorded correctly during night-setting. The tori-pole specifications were categorized as follows: i) bird line material (Type I: multifilament twine, Type II: nylon code, and Type III: nylon monofilament), ii) streamer material (Type A: nylon code and urethane cube, Type B: polypropylene (PP) band, and Type C: combination of Type A and B), iii) bird line length (approx. 50 m, 100 m, 150 m, and 200 m), iv) pole height above sea surface (5 - 10 m, and 10 - 15 m). A Catch model (generalized linear model) was constructed: catch number of albatross was treated as responsible variables with a negative binomial error structure distribution; the potential factors affecting albatross catch were incorporated as explanatory variables. The model was evaluated by model selection based on Akaike's Information Criterion (AIC). In the model, bird line length was selected as explanatory variable, but such factors as bird line material, streamer material, and pole height were not. The model selected the number of albatross observed during line setting, and indicated that the catch increased with the observed number, as might be expected. Results in the model analysis suggest that: 1) the effectiveness of tori-pole in reducing incidental catch of albatross increased with longer bird line; 2) the effectiveness did not differ between Type I, II, and III in bird line material, and between Type A, B, and C in streamer material; 3) the effectiveness did not differ between 5 - 10 m and 10 - 15 m in pole height above the sea surface.

Introduction

Tori-pole (bird streamer) is one of the effective and practical mitigation measures for reducing incidental catch of seabirds in longline fisheries. But various factors may affect the seabirds avoidance effectiveness of tori-poles. In southern bluefin tuna *Thunnus maccoyii* fishery, the relation of incidental catch of seabirds with weather and sea conditions, area, or season were examined (e.g., Klaer and Polacheck 1998; Brothers et al., 1999; Baird and Bradford 2000). Shiode et al. (2001) examined the use conditions of tori-poles in southern bluefin tuna fishery and suggested several conditions for optimizing their effectiveness in reducing incidental catch of albatross: 1) the tori line was needed to be towed above the splashdown point of cast baits; 2) the height of tori-poles should be over 5 m from deck level.

The CCSBT (Commission for the Conservation of Southern Bluefin Tuna) mandated the use of tori-pole during line setting in longline vessels targeting southern bluefin tuna in 1997, and developed a guideline for standard tori-pole configuration. After that, tori-poles with various specifications, fishers have modified independently, have been used in southern bluefin tuna fishery. However few examinations in the relation of tori-pole specifications with seabirds avoidance effect have been conducted.

In this paper, we analyzed the data obtained from the Japanese observer program in southern bluefin tuna fishery, and examined effective factors of tori-poles, which are currently used in the commercial fishery (in large-sized longline vessels), in reducing incidental catch of albatross through model analysis. We did not compare tori-poles experimentally within the range of extreme configurations, but did ones within the range of practical configurations.

Materials and Methods

We used the data obtained form the Japanese observer program in southern bluefin tuna fishery, 2002 - 2005. We only used the data for daytime-setting operations because we used numbers of observed albatross and other seabirds as an important factor in the model analysis mentioned below, and the numbers are correctly recorded only for daytime-settings. A total of 727 observations in 47 vessels were used in the analysis.

Tori-pole specifications (bird line material, streamer material, bird line length, and pole height above sea surface) were categorized as follows.

i) Bird line material

Type I: Multifilament twine (e.g., polyester, or polyvinyl alcohol)
Type II: Nylon code
Type III: Nylon monofilament (including nylon multi-mono filament)

ii) Streamer material

Type A:	Nylon code, urethane cube, or nylon code and urethane tube
Type B:	Polypropylene (PP) band
Type C:	Combination of Type A and Type B

iii) Bird line length

Approx. 50 m, 100 m, 150 m, and 200 m

iv) Pole height above sea surface

5 - 10 m, and 10 - 15 m

We excluded those records that do not fit to the above categories. The proportions of each category in all data are shown in Appendix 1.

We analyzed if these factors affected albatross catches in a model. We assumed a Catch model (generalized linear model) of which response variable was catch number of albatross with a negative binomial error structure distribution (Venables and Ripley, 1999).

A basic model function with expected albatross catch $E\ (C)$ is shown as follows:

$$\begin{aligned} E\ (C) = (Hook) * \exp\ \{&(Intercept) + (Bird\ Line\ Material) + (Streamer\ Material) \\ &+ (Bird\ Line\ Length) + (Pole\ Height) + (Bird\ Line\ Number) \\ &+ (Bird\ Line\ Alignment\ Over\ Bait) + (No.\ of\ Observed\ Albatross) \\ &+ (No.\ of\ Observed\ Other\ Seabirds) + (Year) + (Season) + (Area) \\ &+ (Wind) + (Wave) + (Weather)\} \end{aligned}$$

$$C \sim \text{Negative Binomial } (\mu, \theta),$$

where *Hook* is the observed hook number in an operation, treated as offset variable; *Intercept* is the intercept; *Bird Line Material*, *Streamer Material*, *Bird Line Length* and *Pole Height* are the above defined factors; *Bird Line Number* is the bird line number, *Bird Line Alignment Over Bait* is if the bird line was located over the thrown baited hooks on the sea surface (Yes or No); *No. of Observed Albatross* is the number of observed albatross during line setting; *No. of Observed Other Seabirds* is the number of observed other seabirds during line setting; *Year* is the year, *Season* is the season; *Area* is the area; *Wind* is the wind speed; *Wave* is the wave height; and *Weather* is the weather condition. The details in categorizations of each explanatory variable are shown in Table 1.

We performed the model selection by Akaike's Information Criterion (AIC; Akaike 1973) to select potential factors affecting albatross catch. We used R version 2.4.1 for the analysis (R Development Core Team, 2004).

Results and Discussion

The final model selected by AIC is shown as follows:

$$E\,(C) = (Hook) * \exp\,\{(Intercept) + (Bird\ Line\ Length) + (No.\ of\ Observed\ Albatross) + (Year) + (Area)\}.$$

The AIC value (AIC = 771.63) in the model was improved, compared to that (AIC = 796.08) in the basic model. The likelihood-ratio statistics and the coefficient estimate of each explanatory variable in the GLM are shown in Table 2 and 3, respectively and the frequency distribution of catch estimated in the GLM plotted against the observed frequency is shown in Fig. 1.

Bird line length

The coefficient estimates in explanatory variable of *Bird Line Length* indicated that the albatross catch decreased with longer bird line (Table 3). Even though the bird line lengths used in the present analysis were approximate length and therefore treated as categorical variables, the result suggests that bird line has to have sufficient length to optimize the effectiveness of tori-line in reducing incidental catch of seabirds.

In another regard, the upper limit of bird line length, longline vessels can tow, depends on vessel size, vessel speed, or sea condition. It is recommended to tow as long bird line as possible within vessel capacity, with consideration of the safety of fishing operation and the practical feasibility.

Bird line material and streamer material

Explanatory variables of *Bird Line Material* and *Streamer Material* were not selected by AIC in the model. This suggest that the effectiveness of tori-line in reducing incidental catch of albatross do not differ significantly among the types of bird line and streamers currently used in Japanese SBT longline vessels.

Pole height, bird line number, and bird line alignment over bait

Explanatory valuable of *Pole height* was not selected by AIC in the model. This suggests that the effectiveness of tori-pole did not differ largely between 5 – 10 m and 10 – 15 m in pole height above the sea surface. Explanatory valuables of *Bird Line Number* and *Bird Line Alignment Over Bait* were not selected, possibly due to the small proportions data with twin tori-pole or with bird line not being located over the thrown baited hooks (see Appendix 1).

Though the past studies described that pole height or alignment point of baited hook were important factors in seabird avoidance effect of tori-pole (e.g., Shiode et al., 2001), the present analysis does not show the significant difference in tori-pole effectiveness between pole heights, bird line numbers, or bird line alignment over cast bait within the range of tori-pole variation currently used in the commercial fishery.

Other factors

The model selected *No. of Observed Albatross* as explanatory variable, and showed that the albatross catch increased with the observed number, as is naturally expected (Table 3).

Explanatory valuables for season and environmental factors, such as wave height or wind speed were not selected. Klaer and Polacheck (1998) described that season significantly influenced seabirds catch rates, but wind speed, wave height or weather did not. In contrast, Brothers et al. (1999) indicated that season, wind speed, and wave height strongly affected seabirds catch likelihood. The model in the present study included the number of albatross during line setting as explanatory valuable, which should largely reflect the variation in catch related to area and season.

Analysis of the interactions between explanatory factors might reveal the secondary effects of other factors, but we couldn’t treat interactions in the model due to limited data size.

Experimental approaches are ideal to newly modify configurations of tori-pole. However, the present analysis would provide valuable information to consider the enhancement of seabirds avoidance effectiveness in tori-poles within practical specifications which are applicable to longline vessels.

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Table 1. Explanatory variables in the generalized linear model (GLM) with a negative binomial error structure distribution.

Explanatory variables	Category
Bird Line Material	Type I, II, III [1]
Streamer Material	Type A, B, C [2]
Bird Line Length	Approx. 50m, 100m, 150m, 200 m
Pole Height	5-10m, 10-15m
Bird Line Number	1, 2 [3]
Bird Line Alignment Over Bait [4]	Yes, No
No. of Observed Albatross	0, 1-5, 6-10, 11-15, 16-20, 21-30, 30<
No. of Observed Other Seabirds	0, 1-5, 6-10, 11-20, 21-50, 51-100
Year	2002, 2003, 2004, 2005
Season	Oct. - Mar., Apr. - Sep. [5]
Area	Cape, Tasman, South Indian
Wind	*as continuous*
Wave	*as continuous*
Weather	Fine, Cloudy, Fogy, Rainy
Hook	Hook number [6]

[1] Type I: multifilament ropes (e.g., polyester, polyvinyl alcohol), Type II: nylon code, Type III: nylon-monofilament (including multi-monofilament).

[2] Type A: nylon code, urethane cube, or nylon code and urethane cube, Type B: polypropylene (PP) band, Type C: combination of Type A and B in a streamer line.

[3] Two bird lines; One was towed from the portside and the other one was secondary from the center of stern.

[4] Was the bird line located over the thrown baited hooks on the sea surface?
(Most of the answers were “Yes”. See “Appendix 1”.)

[5] October to March was assumed as breeding season.

[6] Hook number was treated as offset variable in the GLM.

Table 2. Likelihood ratio statistics in the GLM with a negative binomial error structure distribution.

Factor	LR Chisq	d.f.	*P*
Bird Line Length	9.8604	3	0.0198
No. of Observed Albatross	24.0355	6	0.0005
Year	6.9317	3	0.0741
Area	5.2700	2	0.0717

Table 3. The coefficient estimates and standard errors in the GLM with a negative binomial error structure distribution, selected by AIC.

Factor	Coefficient	S.E.	*Z* value	*P*
Intercept	-10.1328	1.1126	-9.107	$<2\times10^{-16}$
Bird Line Length (Approx. 100m)	-0.3619	0.3573	-1.013	0.3111
Bird Line Length (Approx. 150m)	-0.9397	0.4036	-2.328	0.0199
Bird Line Length (Approx. 200m)	-1.4108	0.599	-2.355	0.0185
No. of Observed Albatross (1-5)	1.2387	1.0481	1.182	0.2373
No. of Observed Albatross (6-10)	2.0159	1.0298	1.958	0.0503
No. of Observed Albatross (11-15)	1.8294	1.0516	1.74	0.0819
No. of Observed Albatross (16-20)	2.6443	1.0713	2.468	0.0136
No. of Observed Albatross (21-30)	2.847	1.0921	2.607	0.0091
No. of Observed Albatross (30<)	2.2818	1.1323	2.015	0.0439
Year (2003)	-0.4739	0.3604	-1.315	0.1886
Year (2004)	-0.5466	0.3052	-1.791	0.0733
Year (2005)	-1.0931	0.4277	-2.555	0.0106
Area (Tasman)	-0.4453	0.2791	-1.595	0.1107
Area (South Indian)	-0.5768	0.2978	-1.937	0.0528

Bird Line Length (Approx. 50m), *No. of Observed Albatross* (0), *Year* (2002), and *Area* (Cape) were the reference categories.

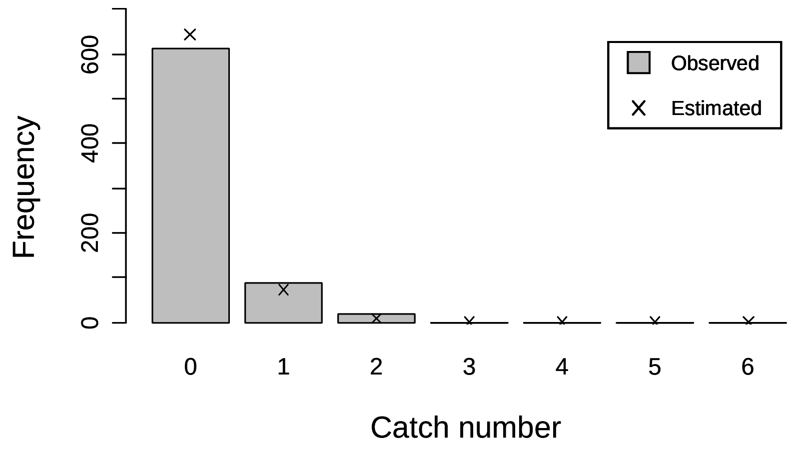
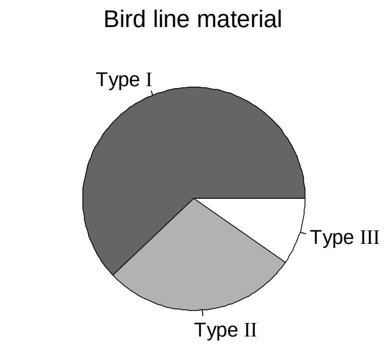
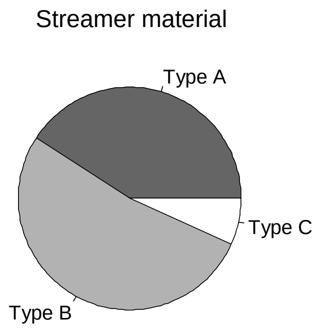
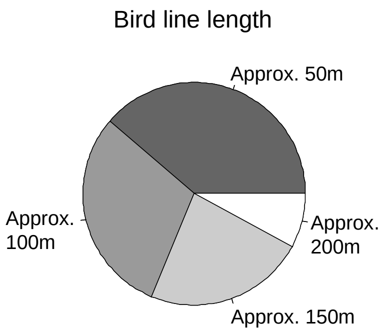


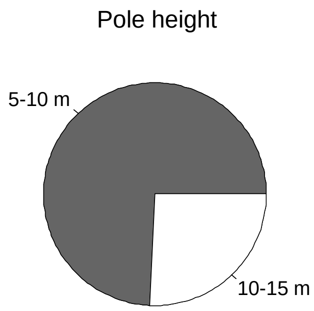
Fig. 1. Frequency distribution of albatross catch observed and one estimated in the GLM with a negative binomial error structure distribution.

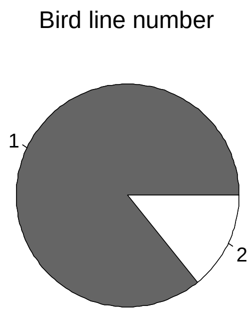
Appendix 1. Proportions of each category (pie charts), frequency distributions (*Wind* and *Wave*), and boxplot (*Hook*) in the explanatory variables used in the present analysis (727 observations).

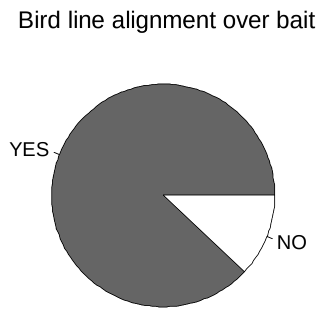


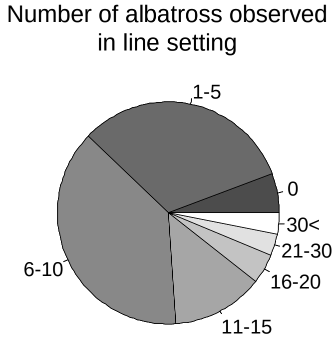


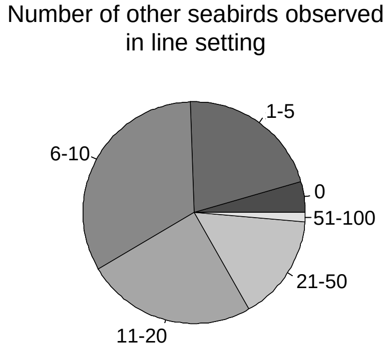












Appendix 1. (continued)