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Research update about the effective design of tori-line for Japanese small-scale fleet in the North Pacific

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Summary

In order to examine the design of the tori-line suitable for Japanese small-scale longline fleet in the North Pacific Ocean, operational experiments were carried out in the North Pacific Ocean by chartered small commercial vessel from the winter to the spring of 2018 to 2019. In order to verify the effect of bycatch reduction by increasing the aerial extent, we compared the attacking behavior to baited hooks and bycatch rate between a control (conventional design) group and a tori-line using light materials. The use of lightweight materials enabled the line to expand the aerial extent more widely than control even with smaller drag power. However, there was no statistically significant effect on the performance of bycatch reduction by using the lightweight line, although there was a tendency to reduce both the behavioral and bycatch risks. From the results, it is possible that the expansion of the aerial extent using the lightweight material is effective for bycatch reduction from this experiment, but the conclusion could not be made due to the insufficient data. During the experiment, it was found that the practical tori-line design would be limited due to the lack of strength of tori-pole for specifications of Japanese small-scale vessels. When considering designs for small-scale fleet, it is also necessary to consider the structural characteristics of the poles.

Introduction

Incidental mortalities (bycatch) of seabirds caused from fishing operation is one of major risks for seabird population and its reduction is strongly demanded internationally. For tuna longline fisheries, many seabird bycatch mitigation techniques are recently developed, and the appropriate seabird bycatch mitigation measures (SBMMs) are discussed in all tuna RFMOs.

In the case of WCPFC, mandatory use of SBMM for small-scale longline fleet north of the 23 degrees north has been implemented according to CMM2015-03. It seems that Japanese coastal small-scale fleet mainly chooses tori-line as SBMM (Ochi et al. 2014). However, it is difficult for the small-scale fleet to deploy long and heavy tori-line designs such as large-scale longline fleet uses. Therefore, it is strongly needed to consider effective and practical design for the coastal small-scale longline fleet.

Japanese scientists tried to develop appropriate design of tori-line for small-scale fleet and continues on-board researches. Katsumata et al. (2015, 2016) showed that tori-lines for the small-scale fleet effectively reduce seabird attacks and bycatch even without streamers. And, Katsumata et al. (2018) focused on relationships physical characteristics of tori-line and aerial extent with considering the cases in New Zealand (Pierre et al. 2016, Goad & Debski 2017) They found that too high pole is not suitable because of extra drag power to create enough aerial extent and lightweight line material is able to efficiently create wider aerial extent than heavier material with same line length.

Based on the results up to last year, we conducted an experiment focusing on the relationship between the aerial extent of tori-line and bycatch reduction. It is reported that longer aerial extent can protect seabird attacks to baited hooks until the hooks sink to enough depth not to access by seabirds (Sato et al. 2013, Melvin et al. 2014). For the purpose of creating extra drag power, we produced a lightweight tori-line. Then, operational experiment carried out to evaluate its effectiveness of bycatch mitigation compared with conventional design.

Research Method

The research longline operation had been carried out around the western North Pacific (33-36N, 132-133E) in March 2018, and February and March in 2019. The chartered Japanese commercial small-scale vessel "Hanei-maru No. 188" (Total length 19.9 m; 19GRT) carried out deep set (16 hooks per basket) longline operations 13 times mainly targeting bigeye and albacore. Tuna hook (2.8 sun) and fish bait (Japanese Sardine) were used for the operation. Longline had been set morning after dawn with 8 knot vessel speed over a four-hour period and 1488-1512 hooks were set in each operation. Line hauling had been started at the noon in the same day. We stress that the observed BPUE and attack intensity would not reflect the actual commercial operations because we choose the fishing ground only based on seabird density even if the catch rate is low.

Deployed tori-line designs were described in Table 1. The design of tori-line in the control group is same as Katsumata et al. (2016) which had been confirmed its effectiveness to reduce seabird interaction. A fiberglass pole was attached to the stern of the vessel to extend to the port side, and a starting point of each tori-line was fixed at about 5 meters from the water surface. In actual experiments, four types of tori-line designs were tested in each year, but this time, we focused on only two types of designs whose specifications were same in both years due to the number of samples used for analysis. A experiment block was assigned to divide the line setting sequence into four equal blocks corresponding to the total number of hooks, and order of tori-line deployment was changed for each operation.

At starting of the experiment, heavier and longer design planned to be deployed in order to create wider aerial extent based on the result of previous experiment (Katsumata et al. 2017), but we should give up this plan because the strength of the pole was insufficient against the drag power and failure of the pole was seriously concerned. Twenty-five minutes observation of seabird attacking behavior was carried out during line setting. In the first 5 minutes, seabirds flying around the observer's posterior radius of 250 m were counted for each species, and the maximum number of each species was recorded. After counting seabirds, seabird attacking behavior toward thrown baited hooks was recorded for each seabird species in the same way as in the previous studies (Katsumata et al. 2016). The frequency of primary attacks (first approaches to a baited hook; Sato et al. 2012) had been recorded according to the distance from the astern. The observation had been done twice for an experimental block and cloud coverage, wind direction, wind velocity, swelling height, rainfall and aerial extent of deployed tori-line are recorded during the observations. During line hauling, number of by-caught seabirds were recorded for each experiment block.

All statistical analyses were carried out with R3.6.1. The effect of tori-line design on seabird attacks was examined by generalized liner model with Poisson error. Frequency of observed seabird attack was set as a dependent variable and link function including explanatory variable and offset was described as below:

$$\log(Attack) = [Toriline] + [Species] + [Attack\ area] + [Wind\ speed] + \sin[Wind\ direction] + \cos[Wind\ direction] + [\text{Swelling height}] + [Rain\ (Y/N)] + \text{offset}(\log(Species\ abundance))$$

Based on observed aerial extent of tori-lines, attack area is arranged from observed attacking area to three categories: tori-line covered, submerging (end point of aerial extent), and outside area. Goodness-of-fit was checked with AIC and the best model was selected from all possible combination of explanatory variable with keeping the factor of tori-line.

The effect on bycatch number was also examined by generalized liner model with Poisson error. Number of bycatches was set as dependent variable, deployed tori-line design and by-caught species were set as explanatory variable. There was no model selection because of small number of explanatory variables.

Results

Observed seabird species and mean number during the observation was described in Table1. Black-footed and Laysan albatross, and streaked shearwater was considered for latter analysis because bycatch event could be observed only for those species. Aerial extent of tori-line was statistically wider in the lightweight tori-line (mean: 61.3m±6.9SD) than control (mean; 37.9m±8.4SD, Fig. 1) (t-test; P<0.001).

In the result of GLM analysis, lightweight tend to reduce seabird attacks but the effect is not significant (Table 2). The best model showed effects of the other variables that Laysan albatross mostly attacked to baited hook, higher swelling and cloud coverage reduces seabird attacks, wind from port and astern side reduces the attacks and higher intensity of attacking behavior was observed submerging area than the others.

Total 17 seabirds captures were observed and Laysan albatross was the most (14birds) followed by black-footed albatross (2 birds) and streaked shearwater (1 bird). Statistical approach cannot detect significant difference between control and lightweight tori-line, but overall bycatch rate of lightweight tori-line was quite smaller than that of control tori-line (Fig. 3).

Discussion

The results are still preliminary, and there is not enough information to recommend an effective design of tori-line for small-scale vessels in the North Pacific at this time. It is necessary to continue the verification by increasing the trial in order to obtain the conclusion on the appropriate design. However, the use of lightweight materials has enabled smaller power to create a larger aerial extent as shown in the last year report (Katsumata et al. 2018), which helps to keep the seabird attacks toward baited hooks away from the vessel astern. It means that seabird attacks only occur the areas where baited hooks sink deeper. Therefore, it would lead to reduce possibility to access baited hooks in the North Pacific where no deep diving seabird exist around longline vessel (Sato et al. 2012) even if there is no difference in the total frequency of attacks. The observation of significantly many attacking behavior in the submerged area of the tori-line supports the suggestion above. They imply that the tori-line blocks the area near the astern where the bait has not sunk, so they are flooding into the most accessible area.

As noted in the Results section, there was no statistically significant reduction in by catches due to the use of lightweight tori-line. However, the overall trend is that the number of bycatches has decreased. The result showed a possibility that the number of bycatches may decrease as the reduction of successful bait taking event due to an increase in the aerial extent.

Thus, while no conclusions can be drawn regarding effective tori-line design for small-scale longline vessels in the North Pacific, it is possible that the use of lightweight materials to gain aerial extent may be an effective design option.

In preparation for the experiment, it was also planned to test a tori-line with a wider coverage area (e.g. more drag power or longer lines), but we realized that it could not be used due to the lack of strength of the tori-poles, and that it would be difficult for Japanese small-scale longline vessels to mount a steel or fiberglass large and heavy pole like large-scale longline vessel. For large-scale fleet, and small-scale fleet operating in the southern hemisphere, it is a best practice to install streamers on the line (ACAP 2018). However, in the case of small-scale fleet in the North Pacific, the adding many streamers increases the weight of the tori-line itself, leading to two problems: one is the inability to secure sufficient aerial extent, and the other is the increased likelihood of not being able to tow the line due to the strength of the poles mentioned above. Previous studies have shown that even a tori-line without streamers can sufficiently reduce the bycatch rate of seabirds in the small-scale fleet, so it seems to be better not to consider installing streamers in the designs at this time. Therefore, the design of the tori-line should be carefully considered in consideration of the weight of the line itself, drag power, and strength of the tori-pole.

Since the report did not reach a conclusion on the effective design in this report, it is planned to continue the verification of the tori-line by the on-board experiment and also to carry out the research on the strength of the tori-pole for deployment of tori-line.

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Table 1 Specifications of tori-lines used for the experiment

Tori-line design	Main line Material	Total length (m)	Diameter (cm)	Dry weight (g/m)	Drag power* (kg)
Control	Polyethylen rope	100	6	24.5	11.5
Lightweight	Dyneema rope	175	3	7.0	9.5

*Data from Katsumata et al. 2018

Table 2 Observed seabird species and numbers during observation survey for attacking behavior.

Species	Mean observed birds (/obs. set)
Laysan Albatross	11.27
Streaked Shearwater	10.77
Black-footed Albatross	1.47
Northern Fulmar	0.38
Larus spp.	0.17
Pomarine Jaeger	0.01
Pterodroma spp.	0.01

Table 3 Lists of estimated coefficients to explain attacking behavior with GLM analysis

Coefficients	**Estimate**	**Std. Error**	**z**	**p-value**
Intercept	-3.42	1.20	-2.86	0.004
Tori-line (Control as 1)				
Lightweight	-0.47	0.24	-1.96	0.051
Attack area (Covered area as 1)				
Submerging area	1.01	0.32	3.14	0.002
Outside area	0.47	0.31	1.51	0.130
Species (Black-footed as 1)				
Laysan Albatross	2.43	1.02	2.39	0.017
Streaked shearwater	1.50	1.03	1.47	0.143
Wind direction				
Sine component	-1.68	0.39	-4.31	<0.001
Cosine component	-0.93	0.16	-5.71	<0.001
Swelling height	-0.81	0.34	-2.41	0.016
Cloud coverage	-0.02	0.01	-3.59	<0.001

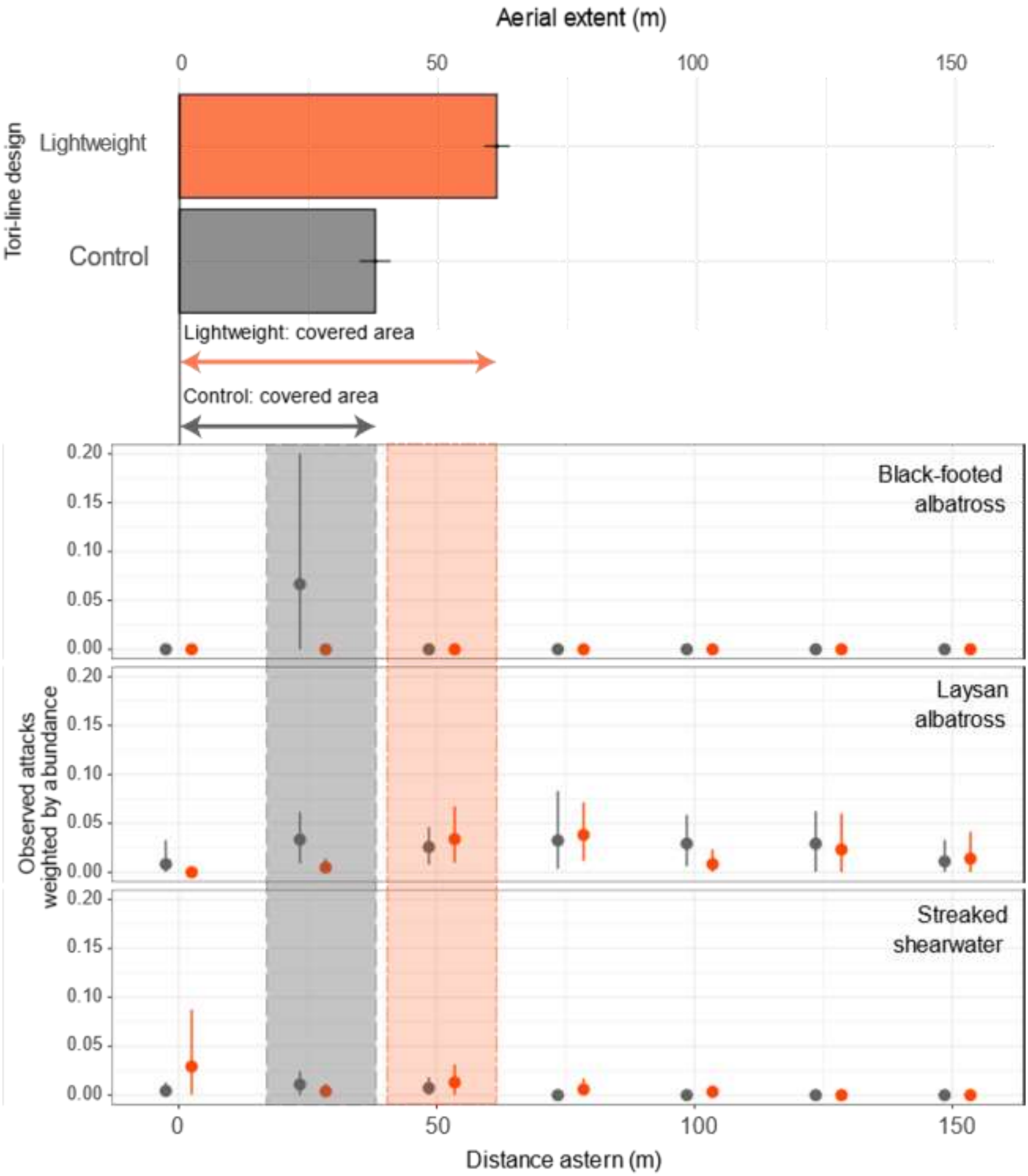

Figure 1　The average value of the aerial extent of the tori-line observed during the observation (upper: bin and error bar (confidence interval)) and the horizontal distribution of attacking behavior with each tori-line (lower: dot with error bar (confidence interval)). The control group was shown in gray and the lightweight group in orange. The shaded area in the figure below shows the area where each line begins to sink into the sea.

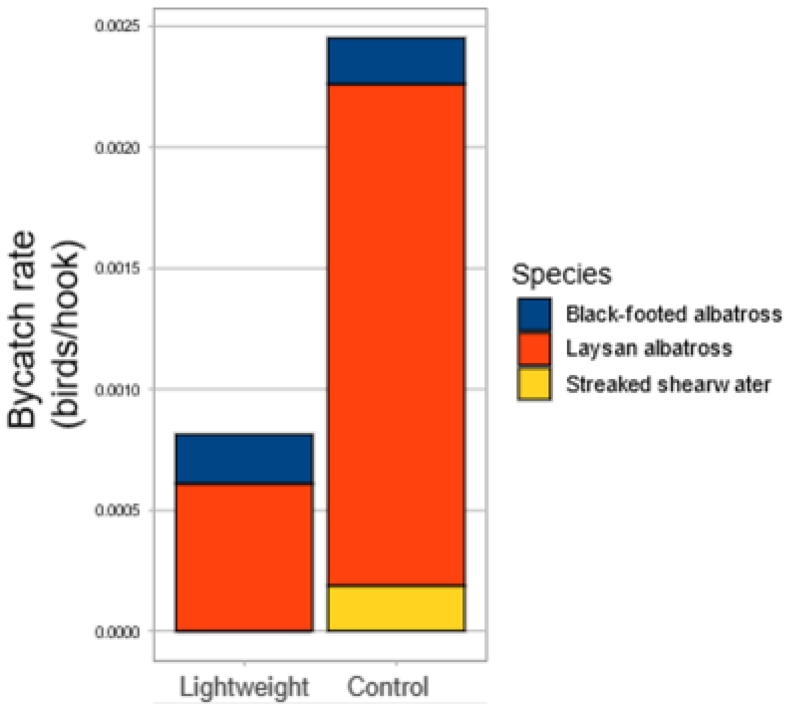

Figure 2 Species specific bycatch rate (birds/hook) by each tori-line