Review of seabird bycatch from 1996-2013 in Japanese scientific observer data
日本科学オブザーバーデータを用いた 1996 年から 2013 年の海鳥の混獲のレビュー

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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 effectiveness of the regulation needs to be tested (Conservation Measurement and Monitoring, CMM). In this document, the points which should be considered to examine the effectiveness of the regulation were discussed using long-term Japanese scientific observer data. In particular, how the variability of bycatch rate occurred was examined by investigating the seasonal and temporal variation.

目的

近年、ICCAT, IOTC, WCPFC 海域に新たな回避措置の制度が導入され(ICCAT; Rec11-09, 2013 年 7 月から実施，IOTC; Res 12/06, 2014 年 7 月から実施，WCPFC; Conservation Measure 2012-07, 2014 年 7 月から実施)、この制度の効果を検証することが求められている (Conservation Measurement and Monitoring 以後 CMM)。本ドキュメントでは、長期的に記録された日本の科学オブザーバーデータを用いて、制度の効果の検証の際に配慮すべき点について、検討する。具体的には、混獲率の変動がどのような要因で起きているかを、季節変異、海区変異を示すことで考察する。

Material and Method

1. Analysis of bycatch

Number of total seabirds and observed hooks in the Japanese observer data from 1996 to 2013 were used for the examination of factors affecting the bycatch rate. Sets of which the number of observed hooks was less than 100 were excluded from the analysis.

2. Very preliminary analysis on the effectiveness of new mitigation measures

As the detail implementation of mitigation measure have been recorded only from recent year, limited number of observer data of sets using new mitigation measure were available in this study. The bycatch rate of total seabird were tentatively compared with ones without new mitigation measures. For this purpose recent observer data which contains information on mitigation measures were used. As these comparisons are indirect (data with and without new mitigation measures only available in different, season or area strata) and the number of data is insufficient to conduct stochastic approach on this data set, the results of comparisons in this study can only offer some insights on the effects of new mitigation measure.

For this analysis, the data were divided into two groups according to the occurrence level of seabirds around the longline boat during gear setting; one is the data from trips with higher occurrence level of seabirds, and the other is the data from trips with lower occurrence level. At the each data set of two different occurrence level of seabirds, the average seabird bycatch rate were compared between trips with the night setting and with the daytime setting, and trips with the weighting branch line and with un-weighting branch line. Because Japanese longliners always uses Tori-line during their gear setting, it was ignored in this analysis.

材料と方法

1. 混獲解析

日本のオブザーバーデータにおける、1996 年から 2013 年までの観察鉤数とすべての混獲された海鳥の数を用いて、混獲率に影響している要因を検討した。観察鉤数が 1 セット 100 鉤以下のものは、解析から除外した。

2. 混獲回避措置の効果の暫定的検討

混獲回避措置の履行の詳細は近年から記録されたため、この解析には、限られている新たな回避措置の履行の有無が記録されたオブザーバーデータを利用した。すべての海鳥の混獲率について、回避措置を履行しているものとしていないものを、暫定的に比較した。この目的のために、混獲回避措置の履行の有無が分かる近年のオブザーバーデータを利用した。この比較は、間接的で(混獲回避措置の使用 - 不使用の比較を、異なる季節・エリアで比較)、このデータセットにおいて統計的なアプローチを用いるには不十分な数のデータのため、本研究において比較した結果は、新たな混獲回避措置の効果における見解を示すのみにとどまった。

この解析において、投縄時に船の周囲に集まる海鳥の観察数によって、データを二つのグループに分け、一つを海鳥の数が比較多いグループ、もう一つを海鳥の数が比較的少ないグループとした。海鳥の数が異なる二つのデータセットにおいて、夜間投縄をおこなった航海と昼間の投縄をおこなった航海間、もしくは、加重枝縄を使用した航海と使用していない航海間で、海鳥の平均混獲率を比較した。日本のはえ縄漁船は、投縄時に常にトリラインを使用しているので、この解析においては、トリラインの効果については検討しなかった。

Result and discussion

The effect on bycatch rate

Tweedie model assuming the Poisson distribution were constructed to explain bycatch rate. In the model, the bycatch number was defined as response variable, and the year, season and area were defined as explanatory variables. The season and the area affected bycatch rate (Table 1). The effect of season and area in detail is shown below.

Area and spatial effects

Bycatch rates by area and seabird taxon were shown in figure 1. The bycatch rate in the Tasman Sea (area 4,5,6,7) was lower than off South Africa (area 9,14,15) and western Indian Ocean (area 2, 8). At the same time, the bycatch rate of petrels which provoke secondary attacks was lower in the Tasman Sea than that in other areas. The bycatch rate in the Tasman Sea was low probably because the occurrence of the petrels in the Tasman Sea were fewer than that in other areas.

To examine whether the distribution of bycatch rate in each trip were spatially autocorrelated or spatially random, we used Moran's I. In the second quarter, the bycatch rate in each trip has spatial autocorrelation (Observed Moran's I = 0.108, expected=-0.008, $p<0.001$, Figure 2) while in the third and fourth quarters, the bycatch rate in each trip did not have spatial autocorrelation (Respectively, observed Moran's=-0.0005, expected=0.026, *p*=N.S, observed Moran's I=-0.043, expected=-0.024, *p*=N.S., Figure 2). From this result, it is suggested that bycatch occurred in particular area in the second quarter, while bycatch occurred rather spatially scattered or disordered in 3rd and 4th quarters. Further analysis should be necessary to clarify the spatial and temporal feature of seabird bycatch occurrence.

Seasonal effect

The bycatch rate was not varied by quarters, except that the first quarter was lower than others (Figure 3). This may be due to the mismatch between seabird distribution pattern and operational pattern of Japanese longline boats in this quarter. In addition, only limited number of data was obtained for the first quarter from positions where relatively lower bycatch rate was recorded in other quarters (Fig. 2).

Effect of seabird occurrence level around the vessel

Tweedie model assuming Poisson distribution were constructed with defining the bycatch number of total seabird as response variable, and the number of the albatrosses around the vessel in setting and the number of the other seabirds around the vessel in setting as explanatory variables. Those two factors affected the bycatch rate, and when the number of the albatrosses/the other seabirds around the vessel in setting increased, the bycatch rate became high (respectively, F=9.02, P<0.005, F=31.80, P<0.0001, Coefficiencies =0.297, Coefficiencies =0.227).

Effect of bycatch mitigation measures

The effect of bycatch mitigation measures was shown using observer data in recent years (Figure 4). Though only indirect comparison can be made, it was suggested that both night setting and blanch line weighting seemed to have strong effect for the reduction of bycatch rate when the larger number of seabirds flying around the vessel during gear setting (Figure 4). This corresponds to the research experiment conducted by Melvin et al. (2013). On the other hand, when the number of seabirds flying around the vessel during gear setting is small, because of their smallness of the bycatch rate, the effectiveness of mitigation measure cannot be detected. Further and detailed studies should be conducted to examine effectiveness of mitigation measures under the situation where the level of seabird occurrence around vessels is low.

結果と考察

混獲率の効果

混獲数を従属変数、年、季節、海域を説明変数、観察鉤数をオフセットとしたモデルを作成したところ、季節、海域によって、混獲率は変動することが示された(Table 1)。よって、以後、季節および海域の効果の詳細を示す。

海域・空間的な効果

海域別および分類群別に混獲率を Figure 1 に示した。南アフリカ沖(海区 9・14・15)、東インド洋沖(海区 2・8)と比較して、タスマン海(海区 4・5・6・7)では、混獲率も低かった。同時に、タスマン海は、二次攻撃を引き起こすミズナギドリ類が少ない傾向にあった。タスマン海では、二次攻撃を引き起こすミズナギドリが少ないために、混獲率が低くなる可能性が考えられる。

船ごとの混獲率に、空間的自己相関があるのか、それともランダムに起きているかを調べるため、Moran's I を用いて調べたところ、第 2 期においては、空間的自己相関があることが示された一方で(Observed Moran's I = 0.108, expected=-0.008, p<0.001, Figure 2)、第 3 期、第 4 期においては、空間的自己相関があるとは言えなかった(それぞれ、Observed Moran's=-0.0005, expected=0.026, p=N.S, Observed Moran's I=-0.043, expected=-0.024, p=N.S., Figure 4)。このことから、第 2 期においては、混獲率は、ある場所で高くなる傾向にある一方で、第 3 期 4 期においては、空間的に散在している、もしくは無秩序に分布していることが示された。海鳥混獲発生の時間的、空間的な特徴を明らかにするために、さらなる解析が必要である。

季節の効果

四半期別に混獲率を算出したところ、第一期を除き、季節間で混獲率に大きな違いは認められなかった (Figure 3)。この時期においては、日本のはえ縄漁船の操業パターンと海鳥の

分布パターンがマッチしていないためかもしれない。加えて、第一期は、限られたデータのみしかなく、それが、他の時期の同じ場所で比較的混獲率の低い位置に分布していた。

船の周囲の海鳥出現レベルの効果
すべての海鳥類の混獲数を応答変数、投縄の時に船の周囲に集まるアホウドリ類の数およびその他の海鳥類の数を説明変数、観察された鉤数をオフセットに入れ、ポアソン分布を仮定した Tweedie モデルを作成したところ、すべての海鳥類の混獲数は、船の周囲に集まるアホウドリ類の数およびその他の海鳥類の数に影響を受けており (それぞれ、F=9.02, P<0.005, F=31.80, P<0.0001)、両者とも、個体数が多いほど、混獲率が高くなる傾向にあった(それぞれ、Coefficiencies =0.297, Coefficiencies =0.227)。

混獲回避措置の効果
2013 年のオブザーバーデータの記録を用いて、混獲回避措置の効果を示した (Figure 4)。間接的な結果ではあるが、投縄の際に船の周囲の海鳥の数が多い時、夜間投縄と加重枝縄両者とも、混獲を減少される効果があることが示された。これは、Melvin et al. (2013)によって行われた実験調査に合致していた。一方で、投縄の際に、船の周囲に海鳥の数が少ない時には、その混獲率の小ささのために、混獲回避措置の効果は検出できなかった。海鳥の密度が低い場合における混獲回避措置の効果の検証のために、さらなる研究が必要である。

The results of the analysis of seasonal and spatial distribution pattern of seabird bycatch rate suggested that bycatch occurred widely in the fishing ground of Japanese longliners in the 3rd and 4th quarters while bycatch occurrences appeared to be concentrated into particular areas such as offshore area of the west of Cape Town and the southern offshore area of South Australia (Fig. 2). The species composition of by-caught seabird seems to differ among Oceans (Fig. 1). Further analysis should be done to clarify this.

The bycatch rate of total seabird from 1996 to 2013 varied between seasons and the first quarter tended to be low compared to other quarters. First quarter is off-fishing season of southern bluefin tuna for Japanese longliners, and observations only occurred in positions where relatively lower bycatch rate was obtained in other quarters (Fig. 2). In addition, bycatch rate of petrels, which were reported to induce bycatches of albatrosses (Melvin et. al., 2013), were very low in the first quarter. And also, since it seems that the breeding season and/or migration are related to the variation of the bycatch rate, those factor might be explain that the bycatch rate in the first quarter was relatively low. Since the breeding season in each species is different (Tickell 2000), the bycatch rate in each species might vary between seasons, but the bycatch rate of all species combined kept at a certain level between seasons.

The bycatch rate in trips with weighted branch line or with the night setting tended to be much lower than ones not using these mitigation measures when relatively high number of seabirds flying around the vessel during gear setting. Though this comes from in direct comparison, it was indicated that these mitigation measures had good power to reduce the seabird bycatch at the actual longline fishing operations when used with Tori-line. We could find that the mitigation measure was effective even with using the observer data which was obtained from various area, various fishing gear and various vessel. On the other hand, these two mitigation measures do not seem to have clear effect on the reduction of seabird bycatch when the number of seabirds flying around the vessel during gear setting is small. Since the probability of bycatch occurrence itself would be very low when seabirds around the vessel are very few, the effectiveness of mitigation measure cannot be detected. There is little information of bycatch mechanism under the few number of seabirds around the vessel during gear setting. When the number of seabirds around the vessel in setting is few, the mechanism of bycatch might be different from the one when the number of seabirds around the vessel is many, which has been explained by Melvin et al, (2013). Further study would be needed to discuss the effect of the mitigation measure in the situation where few number of seabirds occur around the vessel.

海鳥混獲率の季節的、空間的な分布のパターンの解析の結果より、第三期および第四期において日本のはえ縄漁船の操業場所において広く起きていることが示され、一方で、混獲の発生は、ケープタウンの西や南オーストラリアの南沖など、特定の地域に集中してあらわれていた。混獲される海鳥の種組成は、海域毎で異なる。これを明らかにするためにさらなる解析が必要となる。

1996 年から 2013 年の海鳥類の混獲率は季節毎で変動し、第 1 期は低い傾向が認められた。第一期は、日本のはえ縄漁船においては、ミナミマグロの操業の休みの時期であり、他の時期において比較的混獲率の低い場所においてのみの観察となった(Fig. 2)。加えて、アホウドリ類の混獲を誘発する(Melvin et al. 2013)と報告されているミズナギドリの混獲率が非常に低かった。繁殖期や移動などは、混獲率の変動要因と考えられ、これらの要因によって、第一期の混獲率は低かったのかも知れない。繁殖期は種によって異なるため(Tickell 2000)、種ごとの混獲率は季節で変動するかもしれないが、すべての海鳥類を総合し、四半期という大きなスケールで見ると、混獲率はどの季節でもある一定の水準を示すと考えられた。

加重枝縄または夜間投縄をおこなっている船の方が、混獲率が非常に低い傾向を示した。これは間接的な比較の結果ではあるが、加重枝縄および夜間投縄は、投縄時に船の周囲の海鳥が多い時に、トリラインとの併用で、混獲回避に強い効果があることが示された。オブザーバーデータのような様々な海域、漁具、航海で行われているデータを利用しても、回避措置は効果があることが示唆された。一方で、これら二つの混獲回避措置は、船の周囲の海鳥の数が小さい時には、混獲率の減少の効果が明らかでなかった。船の周囲の海鳥が少ない時は、混獲が発生する確率そのものもが非常に低いため、効果が検証できなかった。投縄時に

漁船の周囲に集まる海鳥が少ない時の混獲の発生メカニズムに関しては情報が少ない。海鳥が少ない時の混獲の発生メカニズムは、Melvin et al. (2013)に示されたような多い時のものと異なるかもしれない。漁船の周囲の海鳥が少ない時の効果を議論するには、さらなるデータが必要と考えられる。

Table 1 Coefficient and *P* value of the factor of bycatch rate

	Estimate	Std.Error	t value	P value
(Intercept)	**-8.089**	**0.141**	**-57.510**	**<0.001**
Year_1997	**-0.464**	**0.156**	**-2.967**	**<0.01**
Year_1998	0.160	0.134	1.193	0.233
Year_1999	**0.446**	**0.127**	**3.498**	**<0.001**
Year_2000	0.199	0.151	1.315	0.189
Year_2001	-0.167	0.154	-1.082	0.279
Year_2002	0.057	0.160	0.357	0.721
Year_2003	**-0.728**	**0.179**	**-4.061**	**<0.001**
Year_2004	**-0.473**	**0.165**	**-2.860**	**<0.01**
Year_2005	**-0.533**	**0.152**	**-3.513**	**<0.001**
Year_2006	0.220	0.133	1.651	0.099
Year_2007	-0.226	0.164	-1.375	0.169
Year_2008	**0.557**	**0.167**	**3.330**	**<0.001**
Year_2009	-0.099	0.196	-0.507	0.612
Year_2010	**0.619**	**0.149**	**4.153**	**<0.001**
Year_2011	**0.279**	**0.136**	**2.044**	**<0.05**
Year_2012	**-0.517**	**0.188**	**-2.744**	**<0.01**
Year_2013	**0.567**	**0.141**	**4.023**	**<0.001**
Second_quarter	**-0.363**	**0.096**	**-3.795**	**<0.001**
Third_quarter	**-0.579**	**0.075**	**-7.728**	**<0.001**
Area_2	-0.069	0.077	-0.895	0.371
Area_3	**-0.791**	**0.083**	**-9.508**	**<0.001**

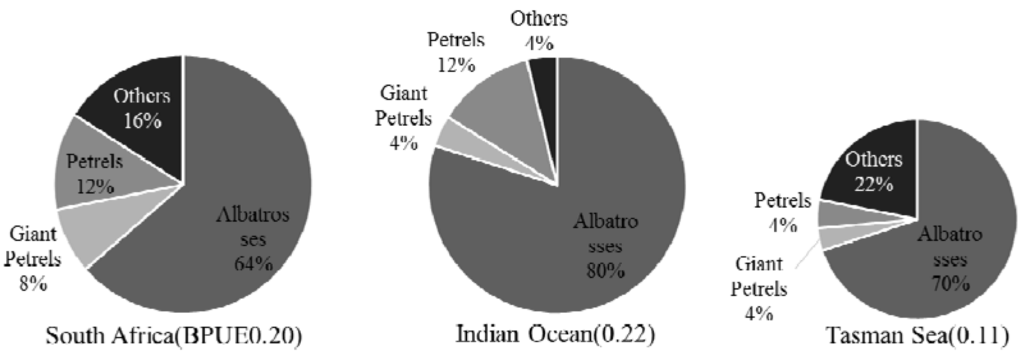

Figure 1 The rate of each seabird taxon in each area.

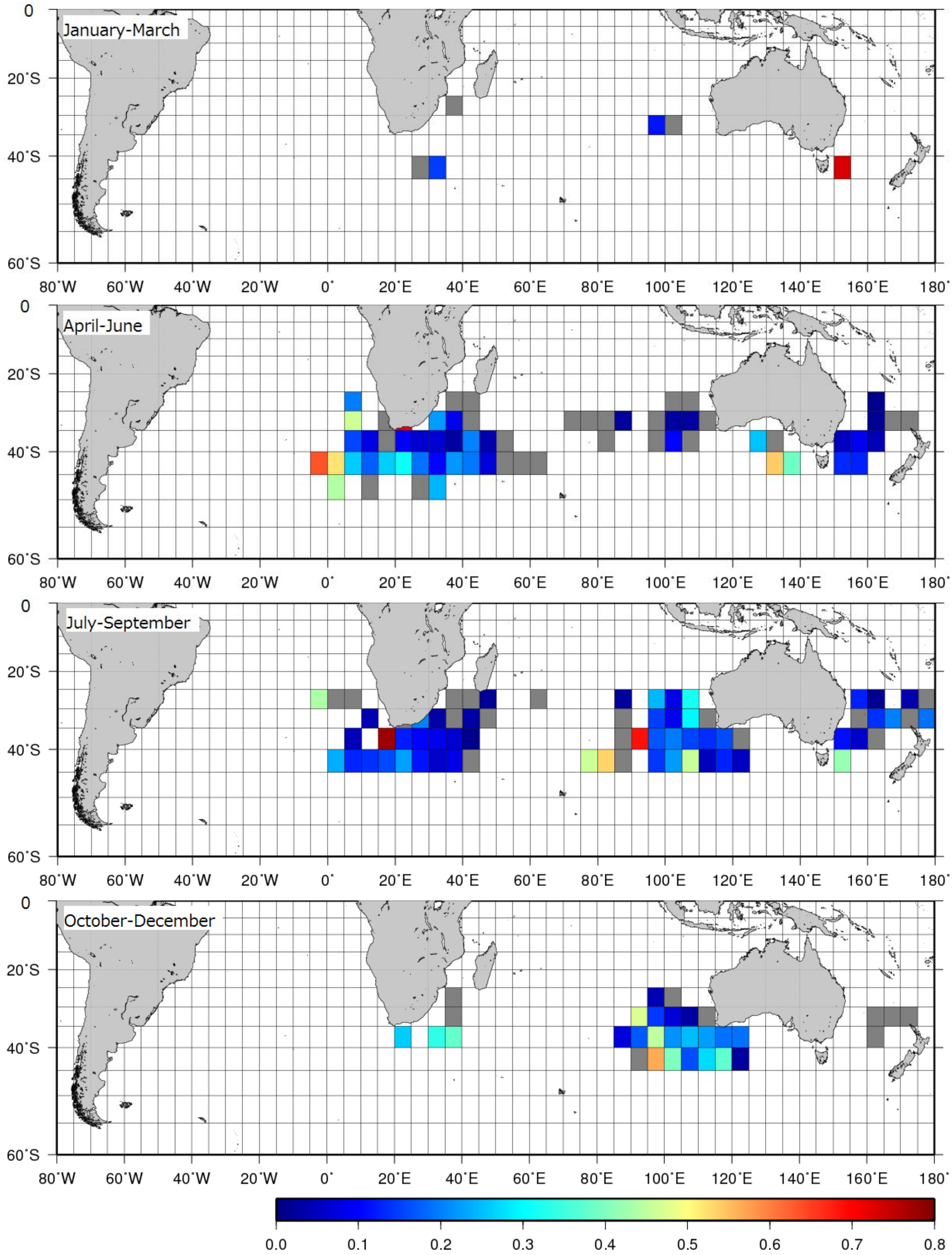

Figure 2 Bycatch distribution of total seabird from 1996 to 2013 in southern Pacific. Data obtained from the observer database.

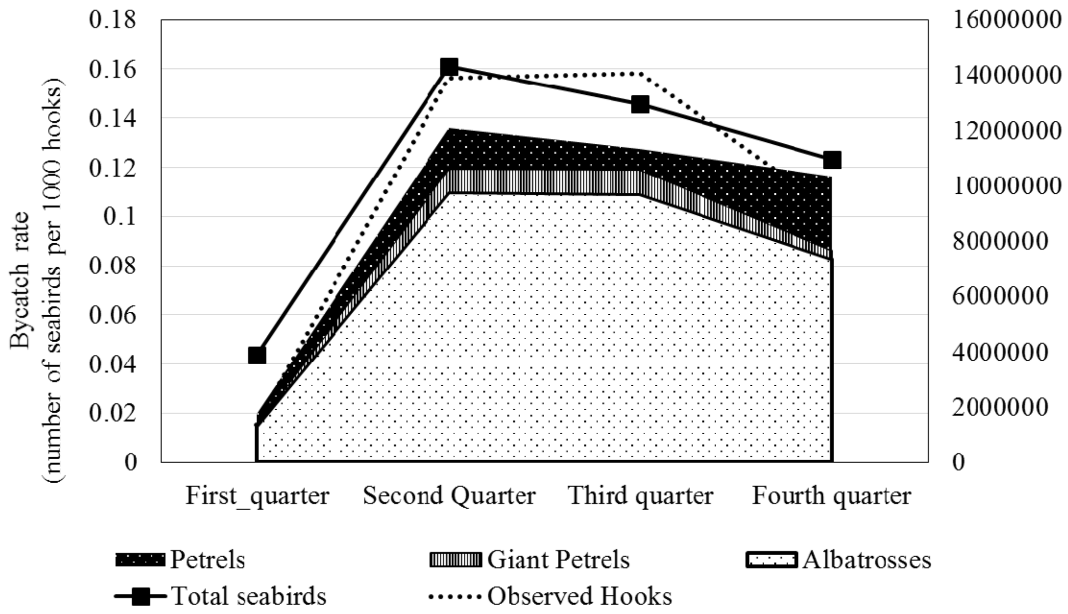

Figure 3 Bycatch rate in each season in each seabird taxon. Black-dot on white pattern shows the nominal bycatch rate of albatross group in each year, stripe pattern shows the nominal bycatch rate of giant petrel group and the white-dot on black pattern shows the nominal bycatch rate of the petrel group.

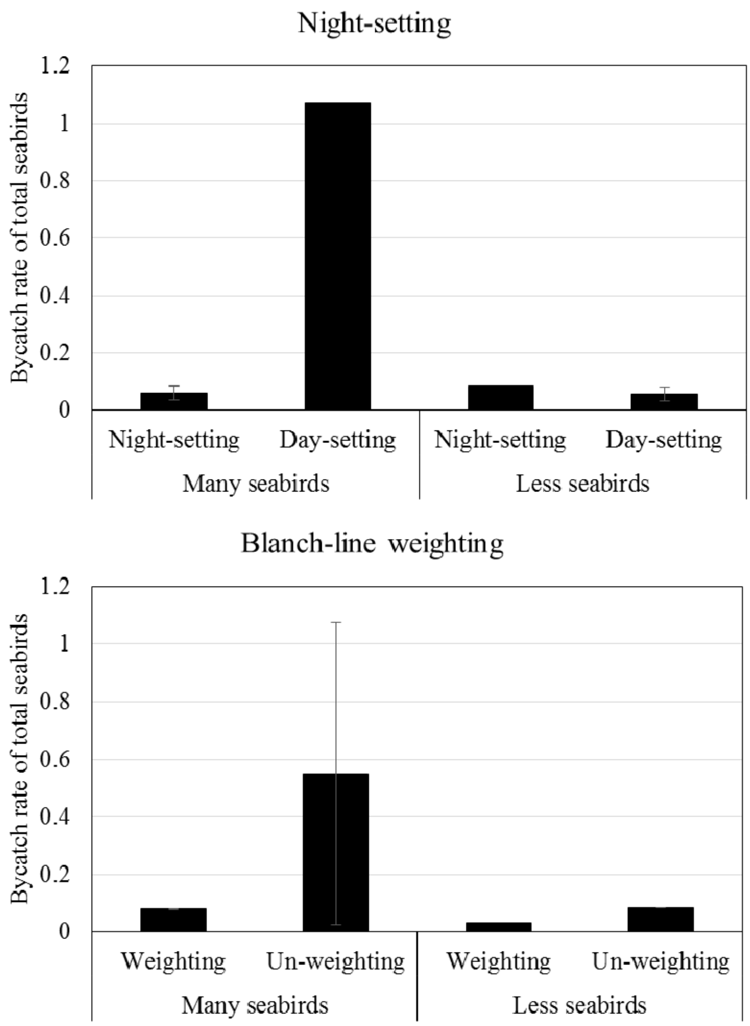

Figure 4 Bycatch rates and its SEs of trips of the higher occurrence level of seabirds around the longline boat during gear setting (left column) and of the lower occurrence level of seabirds (right column), of trips with/without night setting (upper row), and of trips with/without blanch-line weighting (lower row) . This analysis were obtained from observer data only in recent years. Bars without SE indicates number of data is one.

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