

日本の公海ミナマグロ漁業における海鳥類の偶発捕獲数の推定, 2013 年

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**Estimation of incidental catch of seabirds in the Japanese  
southern bluefin tuna longline fishery in 2013**

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摘要

2013 年における日本のミナマグロはえ縄漁業による海鳥類の偶発的捕獲数を、科学オブザーバープログラムを通じて収集されたデータに基づいて推定した。海鳥の偶発的捕獲数の推定値は、2,862 羽 (95%信頼区間: 1,257-4,964 羽) であった。全体として、2000 年以降の海鳥の偶発的捕獲数は減少する傾向を示している。日本の近年の海鳥捕獲数は年間 1,000~4,000 羽程度と考えられる。

Abstract

Estimates of annual incidental catch of seabirds in the Japanese southern bluefin tuna longline fishery in 2013 were updated based on the data collected through the scientific observer programs. Annual seabird bycatch were 2,862 (95% CI: 1,257-4,964) in 2013. As a whole, estimates of seabird bycatch have been showing decreasing trends since 2000. Recent estimates of seabird bycatch by the Japanese high-sea SBT longline fishery were approximately 1,000-4,000 birds/year.

## 1. はじめに

日本の公海ミナミマグロ漁業における海鳥類の偶発捕獲については、Takeuchi (1998a), Kiyota et al. (2001), Kiyota and Takeuchi (2004, 2006, 2007), Minami et al. (2009), Minami and Inoue (2012, 2013)によって RTMP 及びオブザーバープログラムのデータに基づき、2012 年までの推定値が報告されている。本報では、Minami and Inoue (2013)に従って 2013 年の日本のミナミマグロ漁業における海鳥の偶発捕獲数を推定値したので報告する。

## 1. Introduction

Takeuchi (1998a), Kiyota et al. (2001), Kiyota and Takeuchi (2004, 2006, 2007), Minami et al. (2009) and Minami and Inoue (2012, 2013) estimated annual incidental catch of seabirds by the Japanese high-sea SBT longline fishery up to 2012 based the data collected through the RTMP (real time monitoring program) and the observer program. This paper updates the estimates of annual catch of seabirds in 2013 according to Minami and Inoue (2013).

## 2. 材料と方法

### 2.1 使用したデータセット

2013 年に乗船オブザーバープログラムによって収集された海鳥の偶発捕獲記録(観察された海鳥混獲数と操業あたりの釣钩数)を分析に使用した。さらに、RTMP において計算された総漁獲努力データ(操業数と釣钩数)を用いて推定を行った。各プログラムにおける各年の操業とオブザーブの規模は Sakai et al. (2015)が報告している。

### 2.2 データの層化

日本のミナミマグロ漁業における海鳥の偶発捕獲は、海区4～10で発生するため、本解析ではこの範囲を対象とした。Takeuchi (1998a)に従い、海域と四半期によって次の RTMP のデータを4層に分けて層化した。

層	四半期	海区
1	2・3	4・5
2	2・3	6・7・8
3	2・3	9・10
4	1・4	4～10 (主に第4四半期・海区8)

### 2.3 偶発捕獲数の推定

船間のばらつきを考慮に入れるため Takeuchi (1998a)を修正した方法を用いて海鳥偶発捕獲数を推定した。基本的に2段階標本抽出法を用いた、すなわち、1)層内の航海の抽出、2)抽出した航海内の操業の抽出である。この方法に従えば、ある層における偶発捕獲の

総数は次のように表される；

$$\hat{C}_s = H_s \text{takêrate}_s$$

$$\text{takêrate}_s = N_s^{-1} \sum_{j=1}^N n_{s_j}^{-1} \sum_{i=1}^{n_j} \frac{c_i}{ho_i}$$

ここで  $C_s, H_s, \text{takêrate}_s, N_s, n_s, n_j, c_i, ho_i$  は捕獲数の推定値、層内の総使用鈎数、捕獲率の期待値、観察航海数、観察操業数、航海  $j$  における観察操業数、操業  $i$  における海鳥捕獲数と観察鈎数を各々表す。年間総捕獲数は各層の合計値で

$$\hat{C} = \sum_s H_s \text{takêrate}_s$$

となる。ここで  $\hat{C}$  と  $S$  は総捕獲数および層の数を表す。

ノンパラメトリック・ブートストラップ法を用いて分散と信頼区間を推定した。上述の方法と同様に2段階ブートストラップ法を用いて、i) 航海の反復サンプリング、ii) 操業の反復サンプリングを行った。ブートストラップ・シミュレーションを2000回行い、各年の偶発捕獲率推定値と95%信頼区間を求めた。

## 2. Materials and methods

### 2.1 Data sets used

Data on incidental catch of seabirds (number of seabirds caught and hooks observed per set) collected by onboard scientific observers in 2013 was used for analysis. Data on total efforts (number of sets and hooks) were collected by the RTMP. The scale of fishing operations and observer activities is summarized in Sakai et al. (2015).

### 2.2 Data stratification

Data of operations within statistical area between 4 to 10 were used in this analysis because little catch of seabirds were recorded outside the area by the Japanese SBT longline fishery. Data from the RTMP were stratified by area and quarter of the year according to Takeuchi (1998a);

Stratum 1: statistical areas 4+5 (off Tasman), 2nd and 3rd quarter

Stratum 2: statistical areas 6+7+8 (South Indian), 2nd and 3rd quarter

Stratum 3: statistical areas 9+10 (off Cape), 2nd and 3rd quarter

Stratum 4: statistical areas 4-10 (mainly area8), 1st and 4th quarter

### 2.3 Estimation of incidental catch

We modified the method to estimate seabird catch used by Takeuchi (1998a) to take account the variability of catch rates among ships. Essentially, sampling process of observed sets follows two-stage sampling, i.e., i) selection of cruise within a stratum, and ii) selection of observed set within the selected cruise. According to this two-stage sampling, number of incidental catch in each stratum is estimated as follows;

$$\hat{C}_s = H_s \text{takêrate}_s$$

$$\text{takêrate}_s = N_s^{-1} \sum_{j=1}^N n_{s_j}^{-1} \sum_{i=1}^{n_j} \frac{c_i}{ho_i}$$

where  $\hat{C}_s$ ,  $H_s$ ,  $\text{takêrates}$ ,  $N_s$ ,  $n_s$ ,  $n_j$ ,  $c_i$ , and  $ho_i$  are estimated number of seabirds taken, number of hooks of all operations and expected catch rate in a stratum, number of cruises and sets in a stratum, number of observed sets in cruise  $j$ , and observed catch of seabirds and number of observed hooks in set  $i$ , respectively. Annual total of seabird catch is simply a sum of the expected catch by stratum;

$$\hat{C} = \sum_s^S H_s \text{takêrate}_s$$

where  $\hat{C}$  and  $S$  are estimated annual total of seabird catch and number of strata.

Non-parametric bootstrap method was used to estimate variance and confidence intervals of the estimates. In order to mimic the above sampling process, we conducted bootstrap simulation in two stage resampling by replacements in each stage; i) resample cruise with replacement, ii) resample set within cruise with replacement. The bootstrap simulation was repeated 2000 times to construct 95% confidence intervals.

### 3. 結果と考察

RTMP の層別の努力量（操業数・釣鈎数）と観察した操業数・釣鈎数を Table 1 に示した。層別のオブザーバーカバー率は釣鈎数に対し 5.10-24.73%であった。海鳥の総捕獲数の推定値を Table 2 に示した。一般に第1層（2・3 四半期、4・5 海区）では捕獲数は少なく、第3層（2・3 四半期、9・10 海区）の捕獲数が高くなっている。2013 年における海鳥の年間捕獲総数は、2,862 羽（95%信頼区間：1,257-4,964 羽）と推定された。1996 年以降の海鳥偶発捕獲率の推移を Fig. 1 に示した。2000 年、2006 年および 2010 年の年間総捕獲数の推定値が高くなっているが、サンプリング上の誤差によるものであろう（Kiyota et al. 2001）。全体として、2000 年以降の海鳥の偶発的捕獲数は減少する傾向を示している。日本の RTMP における近年の海鳥捕獲数は年間 1,000~4,000 羽程度と考えられる。

日本のミナミマグロ漁業では 1990 年代後半より自主的にトリポールを導入し、1997 年以降はトリポールの使用が義務化された。1 本のトリポールは海鳥の偶発捕獲を平均 70% 削減する効果があり、1996 年以降の安定的な海鳥の混獲水準は、トリポールが一定の効果を表しているものと思われる。一方トリポールの効果には船によってばらつきがあることが知られており (Takeuchi 1998b, Shiode et al. 2001)、トリポール使用法の改善により海鳥の偶発捕獲の一層の削減も可能である。また、トリポール以外に加重枝縄などの回避技術も開発されてきている。日本は 2001 年に延縄漁業における海鳥類の偶発捕獲の削減のための国内行動計画を策定した。国内行動計画に従って、日本では海鳥回避技術の開発や漁業者のための教育啓発プログラムが実施されている。WCPFC では 2006 年に、IOTC では 2008 年に海鳥の保存管理措置が採択され、それに合わせて国内法を策定し、日本のほえ縄漁業で実施された。近年、ICCAT, IOTC および WCPFC にて新しい保存管理措置が採択され、それぞれ 2013 年 7 月 (ICCAT) 及び 2014 年 7 月 (IOTC, WCPFC) に発効した。日本においてもこれに合わせて国内制度を改正し、実施しているが、今回の分析の対象となった操業は、多くが以前の規制の下での操業であることに留意されたい。

### 3. Results and discussion

Total fishing efforts (sets and hooks) and observed efforts of the RTMP for 2013 are summarized by stratum in Table 1. The observer coverage of the stratum ranged from 5.10 to 24.73 % of the hooks. Estimates of seabird bycatch from 1996 to 2013 are shown in Table 2. In general, seabird bycatch were lower in stratum 1 (Area 4-5, Quarter 2-3), but higher in stratum 3 (Area 9-10, Quarter 2-3). Annual seabird bycatch in 2013 was 2,862 (95% CI: 1,257-4,964). Trends in the estimated annual catch of seabirds are shown in Figs. 1. The point estimates of seabird catch were higher in 2000, 2006 and 2010; however, this was probably due to sampling error (Kiyota et al. 2001). As a whole, estimates of seabird catch have been showing decreasing trends since 2000. Recent estimates of seabird catch by the Japanese high-sea SBT longline fishery were approximately 1,000-4,000 birds/year.

Tori-line streamers began to be used voluntarily in the Japanese high sea SBT longliners in the early 1990s, and the use became mandatory in 1997. The stable level of incidental catch of seabirds in the Japanese RTMP since 1996 is likely to represent the effect of tori line. Single tori line is known to reduce the seabird catch down to 30% in average. On the other hand, the effectiveness of tori line varies among fishing vessels (Takeuchi 1998b, Shiode et al. 2001). Improvement of the usage of tori line could further reduce the incidental catch of seabirds. Other effective mitigation measures such as weighted branchline have been developed. Japan established the National Plan of Action for reducing incidental catch of seabirds in longline fisheries (NPOA-seabirds) in 2001. Development of mitigation technique and education and outreach programs for fishermen have been conducted in Japan as described in the Japan's NPOA-seabirds.

Seabird conservation and management measures adopted at WCPFC in 2006 and at IOTC in 2008 were translated into domestic regulations and implemented in Japanese longline fishery. Recently, new conservation and management measures were also adopted at ICCAT, IOTC and WCPFC, and entered into force in July 2013 (ICCAT), and July 2014 (IOTC and WCPFC) respectively. Japan has amended its domestic regulations in compliance with those new measures and implemented. However, it should be noted that the sets analyzed in this document were conducted mostly under the previous regulations.

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Table 1. Number of sets and hooks and observer coverage by data stratum in the RTMP in 2013.

Year	Stratum	Quarter	Area	Sets		Hooks		observer coverage
				operated	observed	operated	observed	
2013	1	2,3	4,5	191	72	618,787	153,007	24.73%
2013	2	2,3	6,7,8	1,831	193	6,081,910	468,663	7.71%
2013	3	2,3	9,10	1,121	199	3,246,623	469,888	14.47%
2013	4	4,1	4-10	172	10	557,591	28,455	5.10%

Table 2. Estimates of annual incidental catch of seabirds in the RTMP from 1996 to 2013.

Year	Estimated catch of seabirds (by data stratum)				Total catch	CV	Lower 95% CI	Upper 95% CI
	stratum 1	stratum 2	stratum 3	stratum 4				
1996	353	888	3,336	2,467	7,044	0.299	3,998	11,814
1997	147	1,568	1,205	2,449	5,368	0.284	2,578	8,455
1998	0	1,104	2,374	2,513	5,990	0.354	2,583	10,670
1999	651	4,060	3,481	632	8,825	0.365	3,358	15,831
2000	412	1,180	3,875	7,897	13,364	0.411	4,733	24,613
2001	88	808	3,847	1,772	6,516	0.271	3,376	10,378
2002	272	1,147	4,655	795	6,869	0.243	3,811	10,213
2003	392	548	2,394	296	3,630	0.215	2,207	5,239
2004	127	1,205	2,956	815	5,104	0.237	2,945	7,595
2005	89	0	1,740	510	2,339	0.182	1,548	3,160
2006	1,097	741	4,760	2,148	8,746	0.297	4,082	14,182
2007	140 <sup>*1</sup>	1,960	860	553	3,513	0.455	1,163	7,682
2008	404	1,879	1,154	955	4,392	0.231	2,414	6,394
2009	45	906	1,472	397	2,820	0.317	1,176	4,499
2010	287	507 <sup>*2</sup>	3,194	66	4,054	0.587	754	8,445
2011	233	1,033	611	878	2,755	0.224	1,528	4,001
2012	40	115	788	125	1,067	0.353	484	1,888
2013	25	650	1,973	214	2,862	0.339	1,257	4,964

\*1: Average catch calculated from annual average CPUE in the past 5 years (2002-2006) as substitute for value in the stratum 1 in 2007 was used for the estimates of seabird catch in 2007 because the observer coverage was zero in the 1st stratum in 2007.

\*2: Average catch calculated from annual average CPUE in the past 5 years (2005-2009) as substitute for value in the stratum 2 in 2010 was used for the estimates of seabird catch in 2010 because the observer coverage was low in the 2nd stratum in 2010.

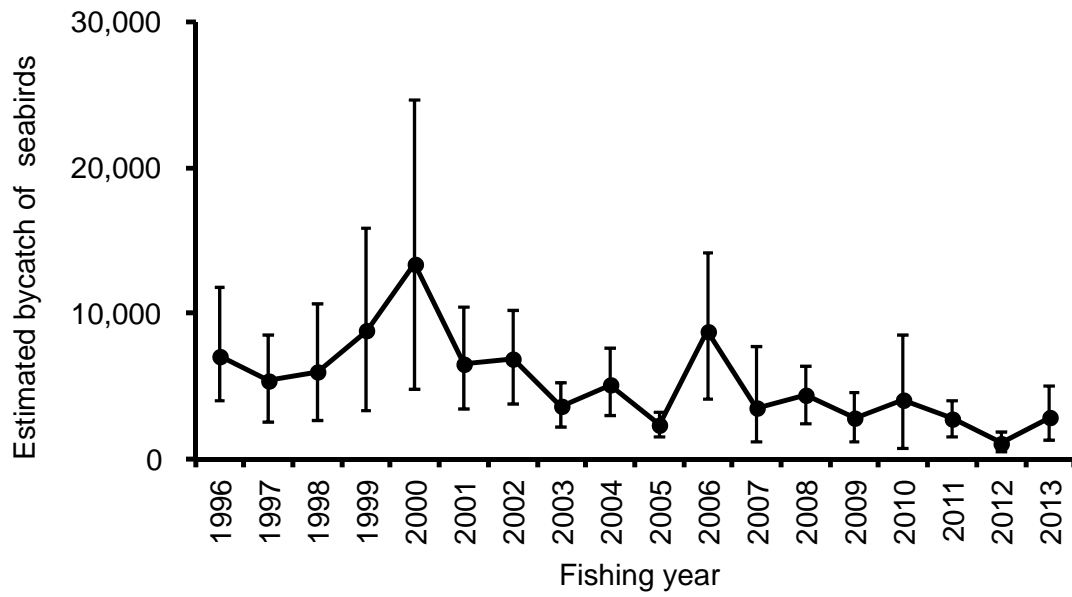


Fig. 1. Annual trends in estimated incidental catch of seabirds in the Japanese RTMP for 1996-2013. Vertical bars indicate 95% confidence intervals.