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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数の推定, 2008-2010年

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Estimation of incidental catch of seabirds in the Japanese Southern Bluefin Tuna longline fishery in 2008-2010

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Abstract

Estimates of annual incidental catch of seabirds in Japanese Southern Bluefin Tuna longline fishery for 2008-2010 fishing years were updated based on the data collected through the RTMP (real time monitoring program) and observer programs. Annual seabird catch were 4,392 (95% CI: 2,414-6,394) in 2008, 2,820 (95% CI: 1,176-4,499) in 2009 and 6,147 (95% CI: 579-14,902) in 2010, respectively. The recent level of incidental catch of seabirds in RTMP has been stable around 3,000-6,000 birds/year.

摘要

2008-2010 年の漁期における日本のミナミマグロはえ縄漁業による海鳥類の偶発的捕獲数を、RTMP(Real Time Monitoring Program)と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、2008 年 4,392 羽（95%信頼区間: 2,414-6,394 羽)、2009 年 2,820（95%信頼区間: 1,176-4,499 羽)、2010 年 6,147（95%信頼区間: 579-14,902 羽)であった。海鳥偶発捕獲数の近年のレベルは概ね横ばい状態である。

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)によって2007年までの推定値が報告されている。本報では、Minami et al. (2009)に従って 2008-2010 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) and Minami et al. (2009) estimated annual incidental catch of seabirds up to 2007 fishing year 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 from 2008 to 2010 according to Minami et al. (2009).

２．材料と方法

2.1 使用したデータセット

2008年から2010年にRTMP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（操業数と釣鈎数）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. (2012)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､南緯35度～45度で発生するため、本解析ではこの範囲を対象とした。過去の推定と比較するため、Takeuchi(1998a)に従い、海域と四半期によって次のRTMPのデータを４層に分けて年ごとに層化した。

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

日本の漁船は1997年以降トリポールストリーマーの使用が義務づけられているが、一部の年のオブザーバー船ではトリポールの効果を確認するため、試験的にトリポール使用操業と不使用操業を行う場合がある。しかし、この解析ではオブザーバーのカバー率を確保するため、これらの操業を区別しないで取り扱った。

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；

$$\hat{C}_s = H_s \ tak\hat{e}rate_s$$

$$tak\hat{e}rate_s = N_s^{-1} \sum_{j=1}^{N} n_{s_j}^{-1} \sum_{i=1}^{n_j} \frac{c_i}{ho_i}$$

ここで $C_s, H_s, tak\hat{e}rate_s, N_s, n_s, n_j, c_i, ho_i$ 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

$$\hat{C} = \sum_{s}^{S} H_s tak\hat{e}rate_s$$

となる。ここで $\hat{C}$ と S は総捕獲数および層の数を表す。

海鳥の偶発捕獲記録にはゼロ捕獲の操業が多く、捕獲率の分布は非常に歪度が高く、正規分布を仮定した分散の推定は適切ではないため、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、各年の偶発捕獲数率推定値と 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 2008, 2009 and 2010 fishing years were used for analysis. Data on total efforts (number of sets and hooks) were collected by the RTMP. The extent of fishing operations and observer activities is summarized in Sakai et al. (2012).

2.2 Data stratification

Data of operations within the area between S35° to S45° 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 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), 4th quarter and 1st quarter of the following year

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;

$$\hat{C}_S = H_S \ tak\hat{e}rate_S$$

$$tak\hat{e}rate_s = N_s^{-1} \sum_{j=1}^{N} n_{s_j}^{-1} \sum_{i=1}^{n_j} \frac{c_i}{ho_i}$$

where $\hat{C}_s$, H_s, *takêrates*, N_s, n_s, n_j, c_i, and ho_i are estimated number of seabirds taken, total number of observed hooks 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;

$$\hat{C} = \sum_{s}^{S} H_s tak\hat{e}rate_s$$

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 0.09-15.37％であった。2010 年の第２層のオブザーバーカバー率（0.09%）が低かったため、2010 年における海鳥の総捕獲数の推

定には過去５年間（2005-2009 年）の第２層の平均値を利用した。RTMP における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。海鳥の年間捕獲総数は、2008 年 4,392 羽（95%信頼区間：2,414-6,394 羽)、2009 年 2,820（95%信頼区間：1,176-4,499 羽)、2010 年 6,147（95%信頼区間：579-14,902 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 年および 2010 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)。2008-2010 年の年間総捕獲数の推定値は 2001-2007 年の推定値とほぼ同レベルにあった。全体として、日本の RTMP における近年の海鳥捕獲数は年間 3,000～6,000 羽の水準で安定した状態にあると言えよう。

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 年以降はトリポールが一定の効果を表していると思われる。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中である。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。

3. Results and discussion

Total fishing efforts (sets and hooks) and observed efforts of the RTMP for 2008-2010 are summarized by stratum in Table 1. The observer coverage of the stratum ranged from 0.09 to 15.37 % of the hooks. Average catch calculated from annual average CPUE over 5 years between 2005 and 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. Estimates of seabird catch from 1996 to 2010 are shown in Table 2. In general, seabird catch were lower in stratum 1 (Area 4-5, Quarter 2-3), but higher in stratum 3 (Area 9-10, Quarter 2-3). Annual seabird catch were 4,392 (95% CI: 2,414-6,394) in 2008, 2,820 (95% CI: 1,176-4,499) in 2009 and 6,147 (95% CI: 579-14,902) in 2010, respectively. Trends in the estimated annual catch of seabirds are shown in Figs. 1. The point estimates of seabird catch were higher in 2000 and 2010; however, this was probably due to sampling error (Kiyota et al. 2001). The estimates for 2008, 2009 and 2010 were almost equal to the estimates for 2001-2007. As a whole, recent incidental catch of seabirds by Japanese high-sea SBT longline fishery have been stable around the level of 3,000-6,000 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, and 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. In 2011, new conservation and management measures were also adopted at ICCAT and IATTC.

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Table 1. Number of sets and hooks and observer coverage by data stratum in the RTMP in 2008-2010.

Year	Stratum	Quarter	Area	Sets operated	Sets observed	Hooks operated	Hooks observed	observer coverage
2008	1	2,3	4,5	443	46	1,501,694	108,750	7.24%
	2	2,3	6,7,8	1,979	106	6,320,535	255,875	4.05%
	3	2,3	9,10	3,005	60	9,120,253	138,769	1.52%
	4	4,1	all	908	38	3,019,584	94,592	3.13%
2009	1	2,3	4,5	362	52	1,197,320	135,762	11.34%
	2	2,3	6,7,8	1,909	57	6,232,339	150,228	2.41%
	3	2,3	9,10	1,479	96	4,320,200	192,894	4.46%
	4	4,1	all	860	72	2,912,279	185,736	6.38%
2010	1	2,3	4,5	296	9	977,154	24,423	2.50%
	2	2,3	6,7,8	803	1	2,626,136	2,405	0.09%
	3	2,3	9,10	1,569	202	4,799,835	399,881	8.33%
	4	4,1	all	369	64	1,242,768	191,058	15.37%

Table 2. Estimates of annual incidental catch of seabirds in the RTMP from 1996 to 2010.

Year	Estimated catch of seabirds (by data stratum) stratum 1	stratum 2	stratum 3	stratum 4	Total catch	CV	Lower 95%CI	Upper 95%CI
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*[*1]	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	231	*507*[*2]	5,386	23	6,147	0.733	579	14,903

*1: Average catch calculated from annual average CPUE over 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 over 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.

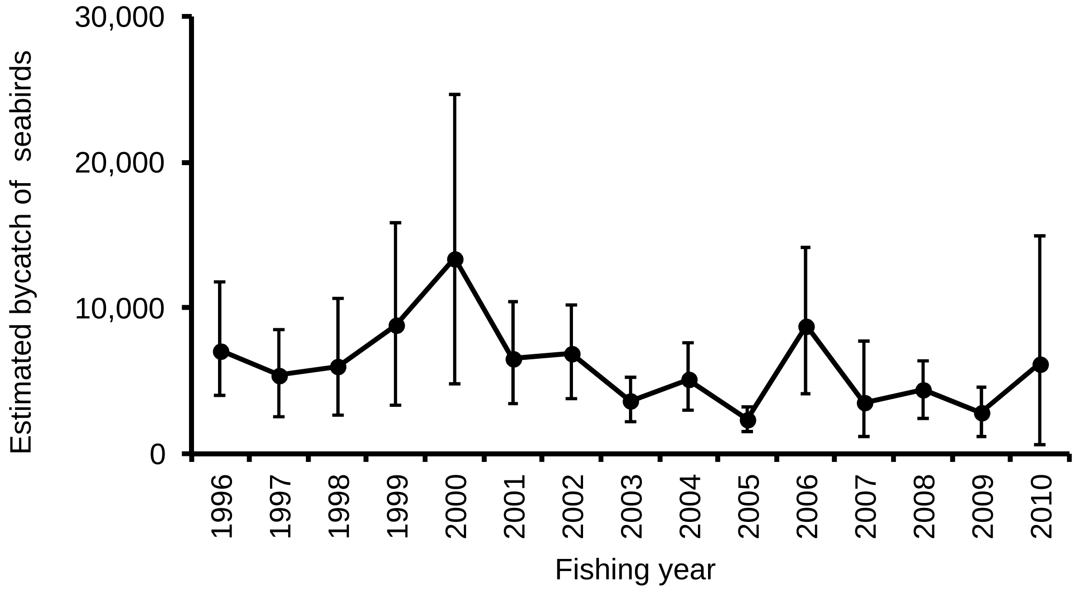

Fig. 1. Annual trends in estimated incidental catch of seabirds in the Japanese RTMP for 1996-2010 fishing years. Vertical bars indicate 95% confidence intervals.