Estimation of incidental take of seabirds in the Japanese Southern Bluefin Tuna longline fishery in 2003-2004

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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,1998-2004年

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Abstract

Estimates of annual incidental takes of seabirds in Japanese Southern Bluefin Tuna longline fishery for 2003-2004 fishing years were updated based on the data collected through the RTMP observer programs. Annual stratified mean seabird takes were 3,630 in 2003, and 5,104 in 2004, slightly lower than the previous estimates for 2001-2002. Estimated 95% confidence intervals constructed by the two-stage bootstrap method were 2,207-5,239 in 2003 and 3,945-7,595 in 2004. The level of incidental take of seabirds in RTMP has been stable around 4,000-9,000 birds/year since 1996.

摘要

2003-2004 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)オブザーバーによって収集されたデータに基づき推定した．RTMP における年別の層化平均海鳥捕獲数推定値は 2003 年 3,630 羽，2004 年 5,104 羽であり，2001-2002 年の推定値よりも若干低かった．2 段階抽出ブートストラップ法により推定した各年の 95%信頼区間の推定値は，各々2,207-5,239，3,945-7,595 であった．1996 年以降海鳥偶発捕獲は年間 4,000-9,000 羽のレベルで横ばい状態にあったことが確認された．

1. Introduction

Takeuchi (1997a), Kiyota et al. (2001) and Kiyota and Takeuchi (2004) estimated annual incidental takes of seabirds upto 2000 fishing year based the data collected through the RTMP observer program. This paper updates the estimate of Kiyota and Takeuchi (2004) for 2003-2004. We modified the method of Takeuchi (1998a) and recalculated the estimates of annual take of seabirds from 1996 to 2004.

2. Materials and methods

2.1 Data sets used

Data on incidental take of seabirds (number of seabirds caught and hooks observed per set) collected by onboard observers in 2003-2004 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 Kiyota and Minami (2006).

2.2 Data stratification

Data of operations within the area between S35° to S45° were used in this analysis because little catches 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

Number of sets and hooks, and number of observed sets and hooks in each stratum are summarized in Table 1. Observer coverage ranged 1.7-6.1% of the hooks used in the strata.

2.3 Estimation of incidental takes

We modified the method to estimate seabird takes 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 take in each stratum is estimated as follows;

$$\hat{C}_s = H_s \; \hat{takerate}_s$$

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

where $\hat{C}_s$, H_s, $\hat{takerates}$, N_s, n_s, n_j, c_i, and ho_i are estimated number of seabirds taken, total number of observed hooks and expected take 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 take is simply a sum of the expected take by stratum;

$$\hat{C} = \sum_{s}^{S} H_s \hat{takerate}_s$$

where $\hat{C}$ and S are estimated annual total of seabird take 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 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 for each year. We also re-calculated incidental takes of seabirds for 1996-2002 using the revised method*.

*Data for 1995 and previous years was not used for the recalculation because of the incompatibility of the data format. Estimation of seabird take for 1998-2002 reported by Kiyota et al. (2001) and Kiyota and Takeuchi (2004) was actually calculated by the same method described above. Minor difference between the estimates occurred due to data revision thereafter.

3. Results and discussion

Total efforts (sets and hooks) and observed efforts of the RTMP for 2003-2004 are summarized by stratum in Table 1. The observer coverage ranged 1.7-6.1% of the hooks used in a stratum. The observer coverage was low at 1.7% in the 2nd stratum in 2003. Estimates of seabird take and its 95% confidence intervals from 1998 to 2004 are shown in Table 2. In general, seabird catches were low in the stratum 1 (Area 4-5, Quarter 2-3), and high in the stratum 3 (Area 9-10, Quarter 2-3). Annual total of seabird take was estimated at 3,630 in 2003 and 5,104 in 2004. Trends in the estimated annual take of seabirds are shown in Fig. 1. The estimated take increased in 2000, however, this was probably due to sampling error as discussed in Kiyota et al. (2001). The estimates for 2003 and 2004 were lower than the estimates for 1996-2002. As a whole, incidental take of seabirds by Japanese high-sea SBT longline fishery have been stable around the level of 4,000-9,000 birds/year since 1996.

Tori-pole 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 take of seabirds in the Japanese RTMP in 1995-2002 is likely to reflect the effect of tori-pole. Tori-pole is known to reduce the seabird take down to 30% in average, but the effectiveness of tori-pole varies among fishing vessels (Takeuchi 1998b, Shiode et al. 2001). Improvement of the usage of tori-pole will result in further reduction of incidental take of seabirds. Other mitigation measures are also developed in Japan (e.g., colored baits and weighted branch lines). Combination of these measures is expected to minimize the seabird take in longline fishery. However, adoption and usage of mitigation measures at sea depend largely on the awareness of fishermen on this problem as well as

efficiency and practicality of these measures. To improve this point, educational programs for fishermen is implemented in Japan as advocated in the National Plan of Action for reducing incidental catch of seabirds in longline fisheries.

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)によって 2002 年までの推定値が報告されている．本報では Takeuchi(1998a)の推定法を修正した方法を用いて，20002-2004 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した．同じ方法を用いて 1996 年以降の傾向を推定した．

２．材料と方法

2.1 使用したデータセット

2003 年から 2004 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 Kiyota and Minami(2006)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７，８）

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，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．データは年別に層化した.

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；

$$\hat{C}_s = H_s \; \hat{takerate}_s$$

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

ここで $C_s, H_s, \hat{takerate}_s, N_s, n_s, n_j, c_i, ho_i$ 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

$$\hat{C} = \sum_{s}^{S} H_s \hat{takerate}_s$$

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，各年の偶発捕獲数推定値の変動係数と 95%信頼区間を求めた．また，同じ方法で 1996-2002 年の偶発捕獲数についても推定をやり直した*.

*1995 年以前のデータはデータ形式が一致しないため，本報の再計算には使用しなかった．Kiyota et al.(2001), Kiyota and Takeuchi (2004)が報告した 1998-2002 年の推定値は実際には本報と同じ計算法を用いているが，その後のデータ改正により若干の違いが生じている．

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 Table１に示した．層別のオブザーバーカバー率は釣鈎数に対し 1.7-6.1%であった．特に，2003 年の第２層のオブザーバーカバー率が 1.7%と低かった．

RTMP における海鳥の総捕獲数の推定値は Table 2 に示した．一般に第１層（２・３四半期，４・５海区）では捕獲は少なく第３層（２・３四半期，９・１０海区）の捕獲数が過半数を占めていた．捕獲総数は 2003 年 3,630 羽，2004 年 5,104 羽と推定された．1996 年以降の海鳥偶発捕獲数の推定値の推移を Fig．1 に示した．2000 年には捕獲数の点推定値が増加しているように見えるが，Kiyota et al．(2001)が議論したように，恐らくこれは低いオブザーバーカバー率に起因する推定精度の低下による見かけ上のものであろう．

2001 年以降のオブザーバープログラムではこうしたカバー率の偏りは比較的解消されている．2003-2004 年の推定値はそれ以前よりも低いレベルにあった．全体として，日本の RTMP における海鳥捕獲数は 1996 年以降年間 4,000～9,000 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．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，1995～2000 年にはトリポールが一定の効果を表しているのであろう．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いる（Takeuchi 1998b, Shiode et al. 2001），日本の漁業者には啓蒙普及活動を通じてトリポールの適切な使用方法を説明し，海鳥偶発捕獲の回避を高めるよう指導している．また，トリポール以外にも着色餌や加重枝縄などの回避手段を開発中であり，これらの手法を組み合わせることにより，今後海鳥偶発捕獲の一層の削減が期待される．最後に，いかに優秀な回避措置を開発しても漁業者が現場で使用しなければ意味がなく，漁業者の意識向上が根本的に不可欠である．日本では 2001 年に策定した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に従って啓蒙普及活動を展開し，この問題に対する漁業者の一層の理解が得られるよう努力している．

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Table 1. Number of sets and hooks and observer coverage by data stratum in the RTMP in 2003-2004.

				Sets		Hooks		
Year	Stratum	Quarter	Area	operated	observed	operated	observed	observer coverage
2003	1	2,3	4,5	2,265	15	6,488,140	390,818	6.0%
	2	2,3	6,7,8	2,943	61	8,597,260	146,445	1.7%
	3	2,3	9,10	5,779	280	17,502,305	686,720	3.9%
	4	4,1	all	2,195	136	6,280,315	383,390	6.1%
2004	1	2,3	4,5	2,505	88	6,966,655	239,920	3.4%
	2	2,3	6,7,8	2,079	58	5,817,823	148,420	2.6%
	3	2,3	9,10	8,055	407	23,302,709	992,956	4.3%
	4	4,1	all	2,130	124	6,076,730	304,560	5.0%

Table 2. Revised estimates of annual incidental take of seabirds in the RTMP from 1996 to 2004.

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

*Estimates of seabird take for 1998-2002 reported by Kiyota et al. (2000) and Kiyota and Takeuchi (2004) were calculated according to the same method described in this document.

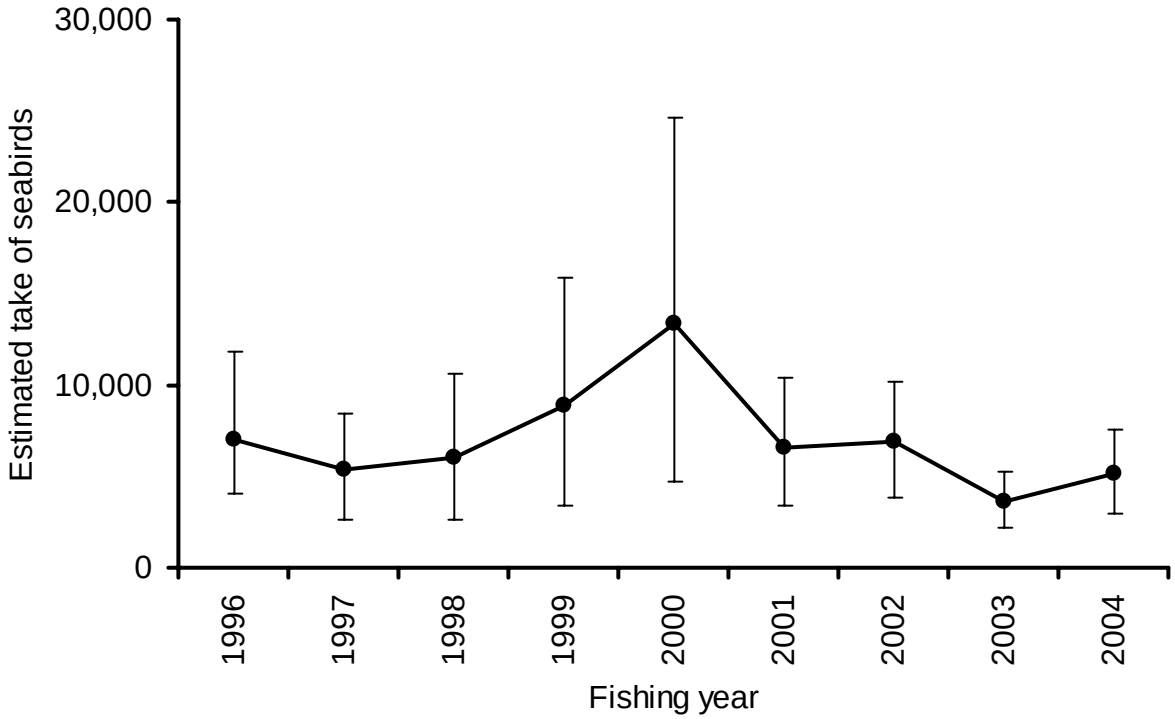

Fig. 1. Annual changes in estimated incidental take of seabirds in the Japanese RTMP for 1996-2004 fishing years. Vertical bars indicate 95% confidence intervals.