CCAMLR Science, Vol. 2 (1995): 123-129

THE INFLUENCE OF BAIT QUALITY ON THE SINK RATE OF BAIT USED IN THE JAPANESE LONGLINE TUNA FISHING INDUSTRY: AN EXPERIMENTAL APPROACH

N. Brothers and A. Foster
Parks and Wildlife Service
134 Macquarie Street, Hobart 7000
Tasmania, Australia

G. Robertson
Australian Antarctic Division
Channel Highway, Kingston 7050
Tasmania, Australia

Abstract

Experiments were conducted to determine the effects of bait size (large versus small) and bait condition (frozen versus thawed) on the sink rate of five species of bait used in the Japanese longline tuna fishery in Tasmanian waters. The effect of adding lead sinkers to baited hooks was also examined. While all factors (bait species, size, condition) were statistically significant, the most powerful effect was due to bait condition: thawed bait sank whereas frozen bait floated. Fish with inflated swim bladders floated, however, even when thawed. The addition of a 20 g lead sinker to a conventional 20 g tuna hook reduced the sink time of bait bearing a hook alone by 50% to 2 sec. m^{-1}. The results highlight the importance of careful bait selection (to avoid fish species with swim bladders which cause the bait to float), the proper thawing of bait and the addition of small amounts of weight to baited hooks before deployment from longline tuna vessels.

Résumé

Une étude expérimentale a été réalisée pour déterminer les effets de la taille (grande ou petite) et la condition (congelée ou décongelée) de l'appât sur le taux d'immersion de cinq espèces d'appât utilisées dans la pêcherie japonaise thonière à la palangre dans les eaux tasmaniennes. Le fait de plomber les hameçons appâtés a également été examiné. Alors que tous ces facteurs (espèce, taille et condition de l'appât) étaient significatifs sur le plan statistique, l'effet le plus marqué résultait de la condition de l'appât: l'appât décongelé coulait alors que l'appât congelé flottait. Par contre, les poissons, même décongelés, dont les vessies natatoires étaient gonflées flottaient. En fixant un poids de 20 g à un hameçon à thon conventionnel de 20 g, on réduisait le temps d'immersion de l'appât de 50%, soit 2".m^{-1}. Ces conclusions mettent en évidence l'importance du soin avec lequel l'appât doit être choisi (pour éviter les espèces de poissons que la vessie natatoire empêcherait de couler) et décongelé et celle de l'addition de petits poids aux hameçons appâtés avant le déploiement des palangres à thon.

Резюме

Проводены эксперименты с целью определения влияния размера наживки (крупная или мелкая) и состояния наживки (замороженная или размороженная) на темп погружения пяти видов наживки, применяемых при японском ярусном промысле тунца в водах Тасмании. Также было изучено влияние прикрепления свинцовых грузил к наживленным крючкам. Все факторы (вид, размер, состояние наживки) имели значение со статистической точки зрения, однако наиболее сильное воздействие было вызвано состоянием наживки: размороженная наживка погружалась, тогда как замороженная всплывала. Однако рыба со вздутым плавательным пузырем не тонула даже в размороженном состоянии. Прикрепление 20-граммового свинцового грузила к стандартному 20-граммовому тунцовому крючку сокращало время погружения крючка с наживкой на 50% до 2 сек. $м^{-1}$. Результаты этого исследования указывают на важность тщательного выбора типа наживки (избегать использование видов рыб, имеющих плавательный пузырь, не позволяющий наживке затонуть), правильного размораживания наживки и прикрепления к наживленным крючкам небольших грузил перед установкой с ярусных судов, ведущих промысел тунца.

Resumen

Se realizaron pruebas experimentales para determinar los efectos del tamaño (grande o chico) y condición (congelado o descongelado) del cebo en la velocidad de hundimiento en cinco especies utilizadas como cebo en la pesquería de palangre japonesa dirigida al atún en las aguas de Tasmania. También se examinó el efecto causado por la adición de plomos a los anzuelos cebados. Si bien todos los factores (especie de cebo, tamaño y condición) tuvieron significación estadística, el efecto más importante fue causado por la condición del cebo: el cebo descongelado se hunde, mientras que el congelado flota. Sin embargo, aquellos pescados cuya vejiga natatoria estaba inflada flotaron aún en estado descongelado. La adición de un plomo de 20 gramos a un anzuelo convencional de 20 gramos utilizado en la pesca del atún, redujo el tiempo de hundimiento en un 50% a 2 seg. m^{-1} con respecto a los anzuelos cebados sin plomos. Estos resultados reflejan la importancia de una correcta selección del cebo (para evitar las especies con vejigas natatorias que producen la flotación del cebo), de una cuidadosa descongelación del mismo y de la utilización de plomos pequeños en los anzuelos cebados antes de lanzarlos al mar desde los barcos atuneros.

Keywords: albatross mortality, bait quality, longline fishing, tuna, CCAMLR

INTRODUCTION

Longline fishing for tuna (*Thunnus* spp.) has been shown to cause significant mortality of albatrosses and other seabird species (e.g., Brothers, 1991; Murray *et al.*, 1993) and is considered to be the most likely cause of the abnormally high rates of mortality and the decline of breeding populations recorded for several southern albatross species (Weimerskirch and Jouventin, 1987; Croxall *et al.*, 1990; Gales, 1993). Reducing the impact of incidental mortality on seabirds requires changes to be made to fishing practices and techniques less harmful to seabirds to be adopted.

In the Japanese longline tuna fishery the rate at which baited hooks sink once deployed is an important factor contributing to seabird mortality and the associated economic cost to fishermen of bait loss induced by birds (Brothers, 1991). Seabirds rely on visual location of baits during line setting operations and opportunities for this are greatest when bait sink rates are slow. The likelihood of successful bait strikes and subsequent hooking of seabirds should decrease with increased bait sink rates, particularly if the baits can be made to sink to a depth greater than that achievable by diving birds within the area astern of a ship that is protected by a bird scaring streamer line.

The sink rates of bait may vary according to the type of bait used and the treatment of the bait prior to deployment. With this in mind, the purpose of this study was to determine the sink rates of bait of different species, size and condition (thawed or frozen), and to examine the contribution to sink rates of adding weight to baited hooks. Although the Japanese tuna fishery does not operate within CCAMLR waters, many of the albatrosses caught by longliners breed on islands within CCAMLR waters and are killed when they interact with the Japanese fishery and the fisheries of other nations operating further north (Croxall and Prince, 1990). If attempts to conserve albatrosses breeding within CCAMLR waters are to be successful, conservation measures must consider the fate of albatrosses which undertake oceanic flights outside the limits of the waters controlled by CCAMLR.

METHODS

An experiment was conducted to measure the effects of bait species, bait condition and bait size on the sink rates of bait used commonly in the Japanese longline tuna fishing industry in Tasmanian waters. The bait species tested and their Japanese names were mackerel scad (*Decapterus macarellus*) or 'aji' from two different suppliers (referred to as aji-1 and aji-2); chub mackerel (*Scomber japonicus*) or 'saba'; Japanese pilchard (*Sardinops melanostichus*) or 'iwashi'; and squid (*Todarodes pacificus*) or 'ika'. All bait was supplied by Japanese fishing masters and details of the locations and time of capture of the two samples of aji were not available. Bait condition means whether baits were thawed or frozen when deployed. Baits of two contrasting sizes were considered: small baits were ≈ 150 g and large baits were ≈ 250 g.

The effects of all combinations of factors (bait species, size and condition) were examined in the experiment. Baits were grouped into two size classes and chosen at random from these classes. For each treatment (e.g., small, frozen, saba) the descent time of 10 baits was measured to a depth of 3 m in a tank of stationary salt water. Individual baits were sunk five times frozen and five times thawed. Records of baits that floated were included in the analysis by assigning them a sink time of 100 seconds, which is an approximation of the amount of time after deployment from a longliner that a bait would be well beyond the protection zone of the line trailed behind longliners to scare birds from baits.

In addition to the factors mentioned above, the sink rate of bait is influenced by the degree of inflation of the swim bladders of fish, and was not known at the time of the experiments. To remove the confounding effect of swim bladder status from the data, on completion of the trials all fish were dissected and swim bladders examined for air content; fish that contained air in their swim bladders were not included in the statistical analysis. Saba (both sizes) was the only species of fish found to contain substantial amounts of air in the swim bladders (Figure 1).

A second experiment was conducted to determine the effect of added weight (sinkers) on the sink rates of bait. Lead sinkers weighing 10 g, 20 g, 30 g, 40 g and 50 g were attached separately to the leading edge of the dorsal fin of five frozen saba and five frozen iwashi baits. In order that the bait remain horizontal in the water when sinking, weights were attached to the fish in the same position as the hook is attached to fish on a Japanese vessel.

Finally, the contribution to sink rate of a 2 mm diameter monofilament branch line and a 20 g hook, as used by the Japanese to catch tuna, was measured. Since the position in which a hook is placed in a bait, the angle at which the shank of the hook protrudes from the fish, and the degree of kinking of the monofilament branch line have a strong and unpredictable effect on the rate at which bait sinks, care was taken to ensure consistency in hook placement and branch line configuration when deploying the baits. The hook was inserted into specimens of frozen iwashi just behind the gills. The effect of a 20 g hook and a 20 g sinker on the same specimens of fish was also measured.

RESULTS

Table 1 shows the results of an analysis of variance testing for differences in sink rate between bait species, bait size (large and small) and bait condition (frozen and thawed) and the interactions between these factors. The variable tested was the time taken for bait to sink to the bottom of a 3-m column of seawater. The parameters species and buoyancy have fixed effects, while bait size has a random effect. All factors in combination were statistically significant. The sink rates of samples of small and large iwashi, saba, aji-2 and squid were similar. Sink rates varied from 14.6 sec. m^{-1} (large, thawed squid) to 5.8 sec. m^{-1} (small, thawed aji-1). The most powerful effect was due to the condition of the samples when deployed: all thawed baits sank and all frozen baits floated. This distinction did not apply consistently to all samples of aji-1. Of the 10 baits tested in each treatment, all

Table 1: Summary of an analysis of variance testing for the effect of bait quality on the sink rate of bait species used in the Japanese longline tuna fishing industry in Tasmanian waters.

Source	SS	df	MS	F	P
Bait species (BS)	29088.2	4	7272.0	8.05	<0.001
Size (S)	1244.0	1	1244.0	16.3	<0.001
Condition (C)	187700.6	1	187700.6	494.4	<0.0001
BS x S	3615.2	4	903.8	11.84	<0.001
S x C	379.6	1	379.6	4.9	NS
BS x C	19740.2	4	4935.0	7.9	<0.001
BS x S x C	2473.9	4	618.5	8.1	<0.001
Residual	13740.6	180	76.33		
Total	257982.3	199			

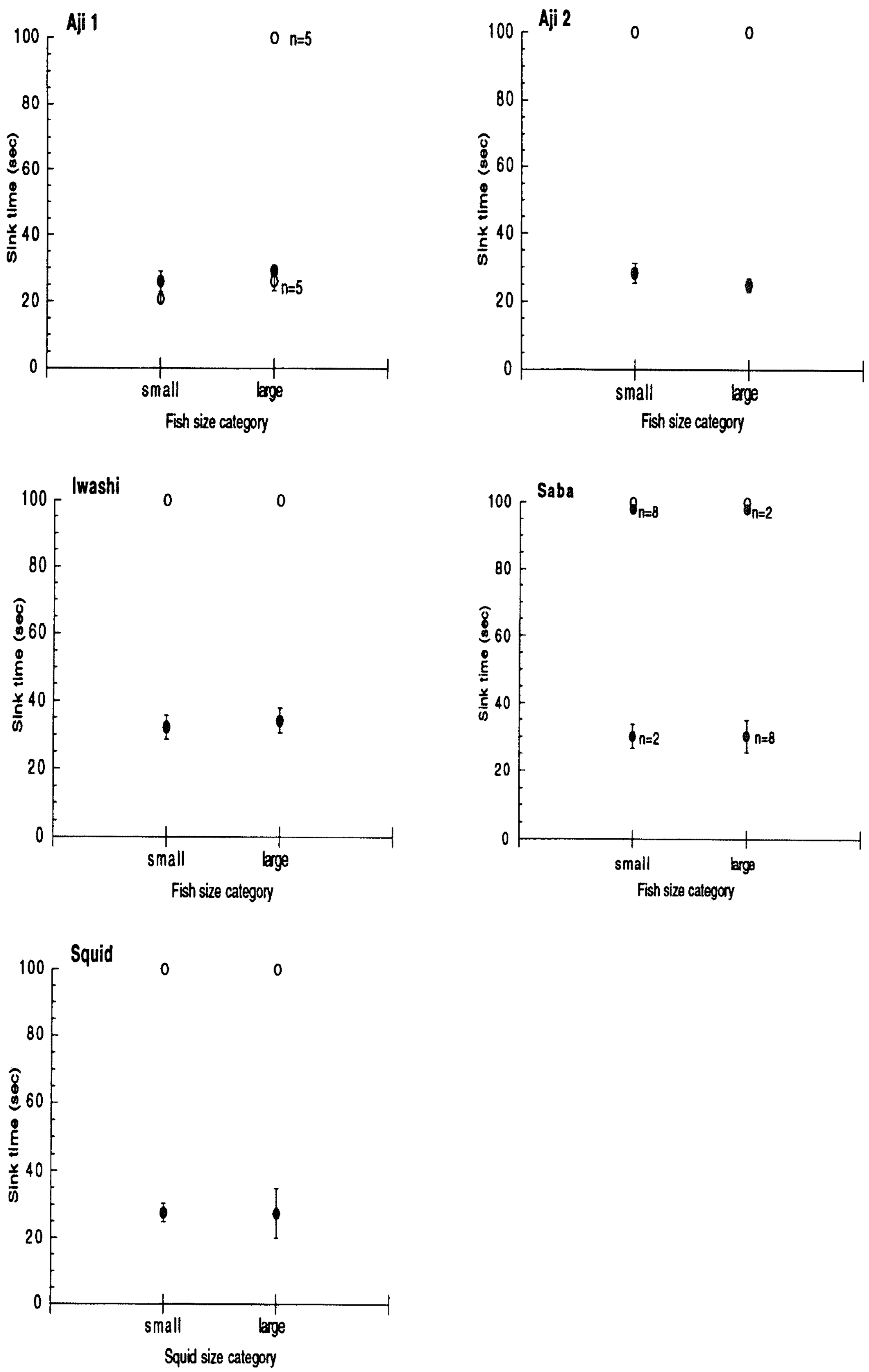
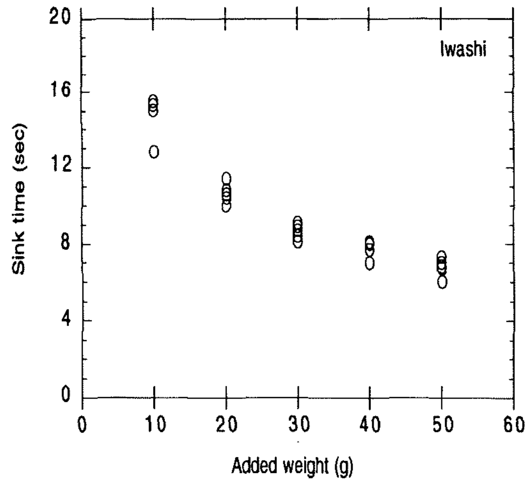


Figure 1: Mean sink time and standard deviation for 10 baits from both large and small size groups for five different types of bait. Open circles refer to frozen bait and closed circles refer to thawed bait.



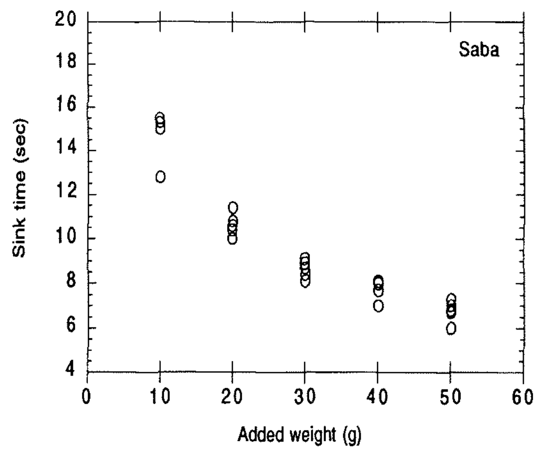


Figure 2: Mean sink time for five frozen baits of two different types when lead weights were attached to the dorsal fin. Individual baits were sunk three times for each weight and the means plotted without standard deviation for the sake of simplicity.

specimens of thawed aji-1 (both sizes) sank at similar rates. However, in contrast to the findings for the other bait species and aji-2, all specimens of small, frozen aji-1 sank and five of the large, frozen baits sank while the remainder of the group floated (Figure 1).

Figure 2 shows the effect on bait sink time of the addition of a range of weights to large thawed saba (250 g; fish with empty swim bladders) and small thawed iwashi (125 g). In both cases, the addition of 50 g of weight reduced sink time by about 50%.

With the Japanese tuna hook (20 g) and monofilament attached to frozen iwashi (unweighted samples of iwashi floated), a sink rate of 3.9 sec. m^{-1} was achieved. The addition of a 20 g lead sinker to the hook halved this time to 2 sec. m^{-1}.

DISCUSSION

Except for some frozen specimens of aji-1, all frozen bait floated and all thawed bait sank. Since ice is less dense than water, presumably the water frozen inside the fish and the thin layer of ice around the gills of the fish prevented them from sinking. With saba, 80% of small baits and 20% of large baits floated when thawed (Figure 1). As mentioned above, these fish had inflated swim bladders and when their swim bladders were deflated they sank at rates similar to the remaining samples of saba. With aji-1, 50% of the large frozen baits and all of the small frozen baits sank at rates similar to thawed baits. This apparent anomaly is difficult to explain. Aji-1 was the same species of fish as aji-2, but both batches of fish were provided by different suppliers and may have been caught at different locations and/or at different times of the year. Some individuals of aji-1 may have contained less lipid than the other fish or they may have lacked ice around the gills. Whatever the case, the fact that frozen samples of aji-2 exhibited the same buoyancy as the other types of frozen bait cautions against the adoption of this species of fish as a preferred bait species. Further testing of aji using larger sample sizes is necessary to understand properly the sink rate characteristics of this species of fish. In spite of the inconsistency with aji, the findings highlight the importance of completely thawing bait and spiking fish with inflated swim bladders (e.g., saba) (to ensure that these are deflated) before deployment from longline vessels if bait-taking by seabirds is to be minimised.

The sink rate of thawed, unweighted bait varied from 5.8 sec. m^{-1} (small aji-1) to 14.6 sec. m^{-1} (large squid). Assuming the sink characteristics of these baits resemble those of bait deployed from a longliner, it is possible to speculate on the protection afforded by the bird scaring streamer line during line setting. At a setting speed of 10.5 knots, baits will be left astern at the rate of 5.4 m sec^{-1} (i.e., 10.5 knots x 1.852 km $\div$ 3 600 sec. h^{-1}). This means that the fastest sinking baits would still only be at a depth of 1 m when 31 m astern, 2 m at 62 m, and 3 m at 93 m. At the latter distance from the ship the bait can be protected by a properly constructed and deployed streamer line, and should be too deep to allow direct attack by albatrosses. In contrast, the slowest sinking baits would not reach a depth of 3 m until over 400 m astern, which is about 300 m or one minute beyond the protection zone of the streamer line.

The finding above highlights the importance of adding weight to the baited hook to increase the sinking rates of bait. All frozen bait which floated could be made to sink at a rate of approximately 5 sec. m^{-1} by the addition of a 10 g weight, and this rate could be increased by 30 to 40% with the addition of another 10 g (Figure 2). Subsequent addition of weight in 10 g increments increased sink rates by smaller amounts. This demonstrates the importance of even a small amount of weight placed on the hook in reducing seabirds' access to bait.

For the tests with the Japanese tuna hook and monofilament branch line, frozen iwashi with deflated swim bladders sank at 3.9 sec. m^{-1} and would therefore be at a depth of 3 m when 63 m astern, but would still be within diving depth range for some seabirds (e.g., small species of petrel) once the 100 m limit of protection afforded by streamer lines was exceeded. With the addition of a 20 g weight to the hook, this sink rate could be almost doubled to 2 sec. m^{-1}. At this sink rate, even frozen baits would be beyond the diving depth range of most seabird species within about 20 seconds of deployment.

When applying the findings of this study to other longline fisheries (e.g., the *Dissostichus eleginoides* fishery in CCAMLR waters; the Australian domestic tuna fishery), it is necessary to consider differences in bait types and hook weights used. Automated baiting systems and some manual systems use only parts of squid or fish, leaving no swim bladder problems but creating others regarding bait size and weight. Sink rates may be slower with small, whole baits or portions of whole bait on hooks lighter than the comparatively large Japanese hooks if no additional weight is used. This problem is compounded by the fact that all seabird species can swallow small pieces of bait on hooks. It is difficult for some species of bird to swallow whole baits so they tend to peck at them, which eventually dislodges them from the hook. This promotes frenzied fights between birds and it is often fights which lead to birds becoming hooked. Thus, if bird strikes are to be minimised, it is important to use whole, large baits because these will conceal the hook for a longer time during fights for bait and are less likely to be swallowed by small species of seabird.

CONCLUSIONS

For the bait species tested the results indicate:

(i) Thawed bait with deflated swim bladders sank while most frozen baits floated. Baits that are totally thawed when deployed by Japanese vessels longlining for tuna are therefore less likely to be taken by seabirds.

(ii) Inflated swim bladders caused some specimens to float when thawed. Fish belonging to species suspected of maintaining air in their swim bladders when caught should be spiked to expel air before they are to be used as bait.

(iii) The sink rate of baited hooks was greatly improved by adding lead sinkers to hooks (e.g., a 20 g sinker to a conventional 20 g tuna hook).

ACKNOWLEDGEMENTS

The baits used in this experiment were generously provided by the longline vessel owner Mr Saito and his fishing master Mr Oyama (*Fukuyo Maru No. 68*). Fishing master Mr Miura (*Kinei Maru No. 85*) also provided baits. Mr Yuji Kawai of Japan Tuna Fisheries Cooperative Associations kindly facilitated supply of the baits.

REFERENCES

Brothers, N.P. 1991. Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Biological Conservation*, 55: 255-268.

Croxall, J.P. and P.A. Prince. 1990. Recoveries of wandering albatrosses *Diomedea exulans* ringed at South Georgia 1958-1986. *Ringing and Migration*, 11: 43-51.

Croxall, J.P., P. Rothery, S.P.C. Pickering and P.A. Prince. 1990. Reproductive performance, recruitment and survival of wandering albatrosses *Diomedea exulans*, at Bird Island, South Georgia. *Journal of Animal Ecology*, 59: 775-796.

Gales, R.P. 1993. *Co-operative Mechanisms for the Conservation of Albatrosses*. Report of the Australian Nature Conservation Agency. Tasmanian Government Printer, Hobart, Australia: 132 pp.

Murray, T.E., J.A. Bartle, S.R. Kalish and P.R. Taylor. 1993. Incidental capture of seabirds by Japanese southern bluefin tuna longline vessels in New Zealand waters, 1988-1992. *Bird Conservation International*, 3: 181-210.

Weimerskirch, H. and P. Jouventin. 1987. Population dynamics of the wandering albatross, *Diomedea exulans*, of the Crozet Islands: causes and consequences of the population decline. *Oikos*, 49: 315-322.

Liste des tableaux

Liste des figures

Список таблиц

Список рисунков

Lista de las tablas

Lista de las figuras