Agreement on the Conservation of Albatrosses and Petrels

Third Meeting of the Seabird Bycatch Working Group

Mar del Plata, Argentina, 8 – 9 April 2010

Static water sink rate trials to improve understanding of sink rates estimated at sea

Graham Robertson
Australia

Static water sink rate trials to improve understanding of sink rates estimated at sea

Graham Robertson and John van den Hoff

Australian Antarctic Division, Channel Highway, Kingston Tasmania 7050 Australian Antarctic Division

Introduction

Sink rate trials conducted in still water under controlled conditions are a useful adjunct to sink rates collected in at-sea experiments. Static water trials eliminate the variances associated with data collected at sea and can be useful in informing the decision making process regarding the design of at-sea experiments and the interpretation of findings. In this report we describe the results of trials designed to examine the effect on the sink rates of baited hooks of 1) bait thaw status; and 2) bait species, bait size (length and mass) and hooking position in baits. We also completed trials on the effect of attaching star oddi DC Centi time-depth recorders (TDRs) on sink rates, and the effect of Wildlife Computers Mk9 TDRs on sink rates. The results of the last two trials are presented in the appendices of Robertson et al., (in press) and Robertson, et al., (submitted), respectively. This report presents information on items 1 and 2, which are addressed separately below.

The trials were conducted in a 3 m high, 2 m diameter, tank of stationary seawater at the Australian Antarctic Division in August 2009.

1) DOES BAIT THAW STATUS AFFECT SINK RATES?

Rationale

Previous work by Brothers et al., (1995) revealed that baits used in the Japanese tuna fishery in Australian waters floated if frozen and sank if thawed. Since the publication of these findings the importance of thawing bait in pelagic and demersal longline fisheries has been widely promoted. However, it is unlikely that fishermen abide by requests to fully thaw bait. Fishermen generally prefer handling baits that are partially (not fully) thawed. Partially thawed baits are less slippery to handle (especially in the case of squid), easier to hook and retention on hooks during deployment is considered to be improved compared to fully thawed baits. Bait is usually frozen by suppliers in 10-15 kg blocks. Baits are impossible to separate from the block when frozen (note that is it not possible to insert a hook into fully frozen bait without the aid of an electric drill). Blocks of bait are usually left on deck for periods of time before deployment to thaw out, and thawing is often aided by spraying with the sea hose. In practice, baits are deployed in a range of degrees of thawing, ranging from fully thawed (those on the outside of the block) to mostly frozen (inside of the block). The work by Brothers et al., (1995) examined frozen versus thawed baits but not various degrees of thaw. Examination of the effect of adding lead sinkers to baits was included in their research but the fully frozen versus fully thawed approach excluded determination of the amount of added weight required to override differences in thaw status.

In this trial we assess the effect of three levels of bait thaw and determine the amount of weight (leaded swivel routinely used in tuna fisheries) required to eliminate difference in sink rates due to thaw status.

Methods

The three stages of bait thaw assessed were fully frozen, fully thawed and "fisherman's thawed". Fully frozen baits were rock hard (-20 degrees C). Fully thawed baits were soft and pliable to handle. Fisherman's thawed baits were defined as being hard but easily separated from other baits in the block and a hook could be inserted by hand without undue force. Two species of baits were assessed - blue mackerel (*Scomber australasicus*) and squid (*Nototodarus gouldi*). Hooks were #14/0 circle hooks (15 g) which were inserted in the tail of squid and in the eye of mackerel. We compared baits with hook only (no added weight), hook and 60 g swivel and hook and 100 g swivel. Weights were attached 0.2 m from hooks and suspended beneath baits which were held horizontal the water surface before release. By this configuration each drop was 2.80 m (e.g., the 3 m depth of the tank minus the 0.2 m distance between hook and swivel). Sink rates estimated were the final, not initial, rates (see Robertson, et al., submitted). Each test comprised 15 drops and timing baits to the bottom of the tank with a digital stop watch. Fifteen individual baits were used for all drops with each one being dropped 15 times. Using 15 individual baits for each species prevented the thaw status of baits being affected by previous drops (important for the fully frozen and fisherman's thaw states). In the case of fully frozen baits with hook attached but no swivel, only five individual mackerel baits were dropped to provide a measure of the length of time baits in this condition without added weight floated.

Results

Unweighted

Five fully frozen blue mackerel baits with a 14/0 circle hook and no swivel attached took 128 s, 127 s, 39 s, 59 s and 168 s to sink to the bottom of the tank. Bait floated on the surface for the majority of these times and only sank when sufficiently thawed.

The difference between unweighted (#14/0 circle hook only) fully thawed and fisherman's thawed blue mackerel was statistically significant (ANOVA: $F_{1, 29} = 6.37$, $P = 0.02$). The same comparison for squid bait was also significant (ANOVA: $F_{1, 29} = 5.98$, $P = 0.02$). The differences between the sink rates are shown in Table 1.

Table 1. Sink rates of blue mackerel and squid baits as a function of thaw status. n = 15 for each cell in the table.

Bait species	Thaw status	Swivel (g)	m/s (± s.d.)
Blue mackerel	Fully thawed	0 g	0.37 ± 0.03
Blue mackerel	Fisherman's thawed	0 g	0.34 ± 0.03
Squid	Fully thawed	0 g	0.22 ± 0.05
Squid	Fisherman's thawed	0 g	0.26 ± 0.04

Weighted

The differences in the sink rates of fully frozen, fisherman's thawed and fully thawed blue mackerel with 60 g swivels attached were not statistically significant (ANOVA: $F_{2, 44} = 2.245$, $P = 0.098$, Table 2). The sink rates of fully frozen, fisherman's thawed and fully thawed squid baits with 60 g swivels attached were also not statistically significant (ANOVA: $F_{2, 44} = 0.10$, $P = 0.91$, Table 2). Since there was no difference between effects with 60 g swivels attached we saw no point in including the 100 g swivels as originally intended.

Table 2. Sink rates of blue mackerel and squid baits as a function of thaw status and swivel weight. n = 15 for each cell in the table.

Bait species	Thaw status	Swivel (g)	m/s (± s.d.)
Blue mackerel	Frozen stiff	60 g	0.71 ± 0.05
Blue mackerel	Fisherman's thawed	60 g	0.72 ± 0.04
Blue mackerel	Fully thawed	60 g	0.74 ± 0.03
Squid	Frozen stiff	60 g	0.54 ± 0.09
Squid	Fisherman's thawed	60 g	0.54 ± 0.05
Squid	Fully thawed	60 g	0.54 ± 0.08

Discussion

Unweighted

The differences in mean sink rate between fully thawed and fisherman's thawed blue mackerel without a leaded swivel attached was 3 cm/s, with fully thawed bait sinking the fastest. The comparable result for squid was 4 cm/s, with fisherman's thawed sinking the fastest. The likely reason why fisherman's thawed squid sank faster was that squid with this thaw status had stiffer bodies and sank with a more linear sink profile to the bottom of the tank (the tail fins on fully thawed squid tended to make baits plane down the water column). That these differences were statistically significant reflects the degree of control and precision achieved in the 15 drops in the tank under tightly controlled conditions. It is unlikely differences in the order of 3-4 cm/s would be detectible at sea because at sea. Sink rates at sea vary greatly due to branch line deployment method, angle of baits when they land in the water, propeller turbulence and sea state. The variances associated with these effects would dominate subtle differences due to bait thaw status. We consider the effect of thaw state for unweighted blue mackerel and squid to be minor.

Weighted

The sink rates among the three levels of thaw state for gear with 60 g swivels attached were identical within each of the two bait species. Hence, bait thaw status made no difference to the sink rates once 60 g swivels were added to the line.

Conclusion

The majority of countries operating 'domestic' pelagic longline fisheries throughout the southern hemisphere use leaded swivels ranging from 60-80 g in branch lines (source: ACAP 2007). The results of the tank trial show that swivels in this weight range will negate differences due to bait thaw status. With respect to unweighted gear, the results of the trial show that differences due to bait thaw status are very small. Provided bait blocks are thawed enough to enable separation of individual baits, and provided hooks can be inserted without undue force (= fisherman's thaw status), the differences should be undetectable at sea, including in the initial stages of sink profiles. Based on these findings and the consideration that fishermen prefer to thaw bait to the point where it is practical to fish with – in terms of handling, feasibility of hook insertion and hook retention during deployment – we conclude that stipulations about the thaw status of bait have no practical bearing on seabird conservation in pelagic longline fisheries.

Advice to management

The evidence suggests that bait thaw status should not be promoted as a primary method to reduce seabird mortality in longline fisheries (both pelagic and demersal). We recommend SBWG consider revising its advice to fishing management agencies and to fishing industries in accordance with this conclusion. Removal of requirements to fully thaw baits from lists of mitigation options available to fisheries will focus attention on those measures known to yield significant conservation benefits to seabirds.

2) WHAT IS THE EFFECT OF BAIT SPECIES (AND SIZE), HOOKING POSITION AND WEIGHT OF LEADED SWIVELS ON THE SINK RATES OF BAITED HOOKS?

Rationale

Bait species and size, hooking position in the bait and the weight of leaded swivels attached to branch lines are likely to affect the sink rates of baited hooks, but the significance of each is unknown. Differences between effects in static water under controlled conditions may aid in the interpretation of data collected on fishing vessels at sea.

Methods

We assessed the relative significance of bait species, hooking position and swivel weight following the experimental design in Figure 1.

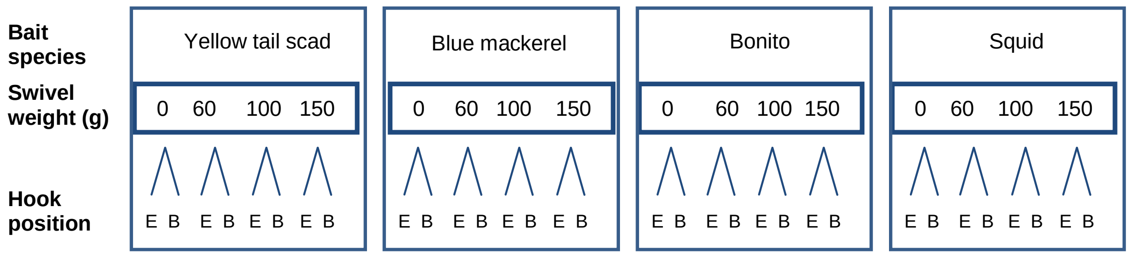

Figure 1. Experimental design examining the effect of bait species (and size), swivel weight and hooking position in baits on the sink rates of baited hooks. E = eye hooked and B = back hooked.

We used four bait species of contrasting sizes: Australian bonito (*Sarda australis*), blue mackerel (*Scomber australasicus*), yellow-tail scad (*Trachurus novaezelandiae*) and Gould's squid (*Nototodarus gouldi*). We used only one individual bait of each species to eliminate the variance associated with individual baits. The lengths and masses of the baits are shown in Table 1. Blue mackerel, yellow-tail scad and squid are commonly used in the Australian pelagic longline fishery. Bonito is not used in the fishery but was included in the experiment to identify trends and to accentuate the differences between large and small baits. Swivels weighing 100 g and 150 g are not used in the fishery but were included to accentuate differences associated with increased weight in branch lines. Bait hooking positions were through the eye and in the middle of the back for fish baits, and 5 cm in from the tip of the tail and in the top of the mantle for squid bait. Fish baits deployed dead are commonly hooked through the eye (or behind the eye) and through the tail (ie., one end of the bait or the other) in pelagic longline fisheries. Squid baits are hooked in either the tail or top of the mantle. Fish baits deployed live in the Australian tuna and swordfish fishery are hooked through the middle of the back.

Species	Length (cm)	Mass (g)
Yellow-tail scad	22.5	136.5
Blue mackerel	29.6	324.0
Bonito	32.0	506.7
Squid	22.8	357.7

Table 1. Lengths and masses of individual baits used in the experiment.

Hooks were # 14/0 circle hooks (15 g) which were connected to 1.8 mm diameter monofilament nylon. Leaded swivels were attached 0.2 m from the baited hooks and this length of line was kept taut for all drops. Thus, drops were 2.8 m and estimates were the final, not the initial, rates or combination of both (see Robertson et al. submitted). Baits were held by hand horizontal to the water surface with the swivel suspended beneath, released and timed to the bottom of the tank with a digital stop watch. The same individual bait was used for all combination of swivel weight and hooking position to eliminate variation associated with different baits within the same species. All bait was fully thawed and each was dropped 15 times for each combination of factors and levels within factors in Figure 1. A total of 480 drops were performed in the experiment.

Results

There was a statistically significant interaction between bait species, swivel weight and hook position (Table 2). This means that the effect of one factor is not consistent in all combinations of the other two factors.

Table 2. Results of an analysis of variance testing for the effect of bait species and size, hooking position and swivel weight on the sink rates of baited hooks. The probability level for test of statistical significant was 0.001.

Source of Variation	DF	SS	MS	F	P
Hook position	1	7.95	7.95	6113.17	<0.001
Bait species	3	3.97	1.32	1017.45	<0.001
Swivel weight	3	22.11	7.37	5665.80	<0.001
Hook position x Bait spp.	3	1.13	0.37	289.09	<0.001
Hook position x Swivel wgt.	3	1.29	0.42	319.81	<0.001
Bait spp. x Swivel wgt.	9	0.29	0.033	25.15	<0.001
Hook position x Bait spp. x Swivel wgt.	9	0.29	0.032	24.94	<0.001
Residual	448	0.58	0.0013		<0.001
Total	479	7.57	0.078		<0.001

All combinations of effects shown in Figure 1 were statistically significant except the combinations shown in Table 3.

Table 3. Comparisons that were statistically indistinguishable at the 0.001 level of probability. BM = Blue mackerel.

Testing for:	Comparison:	P
Bait spp within eye, 0 g	Bonito v BM	0.01
Bait spp within back, 60 g	Bonito v BM	0.005
Bait spp within back, 60 g	Squid v Bonito	0.01
Bait spp within eye, 100 g	Bonito v BM	0.01
Bait spp within back, 100 g	Squid v Bonito	0.01
Bait spp within back, 100 g	Bonito v BM	0.01
Bait spp within eye, 150 g	Bonito v BM	0.01
Bait spp within back, 150 g	Squid v Bonito	0.005
Bait spp within back, 150 g	Bonito v BM	0.01

Within bait species and swivel weight all baits hooked through the eye sank faster than baits hooked in the back (Figure 2). Within bait species within eye hooked, the heavier the swivels the faster they sank. The relationships for 60 g, 100 g and 150 g swivels were linear, the functional relationships being:

Yellow-tail scad: m/s = 0.525 + 0.0049x; r^2 = 0.94
Blue mackerel: m/s = 0.320 + 0.0052x; r^2 = 0.95
Squid: m/s = 0.243 + 0.0038x; r^2 = 0.94,

The relationships indicate that for every 10 g increase in swivel weight the sink rates increased by 0.05 m/s (5 cm/s), 0.05 m/s and 0.038 m/s for yellow-tail scad, blue mackerel and squid, respectively. Note that although the proportional increase for yellow-tail scad is slightly lower than that for blue mackerel, the sink rates of the former exceed the latter through the data range, as can be seen by the value of the intercepts for both species.

Within bait species within hooking position (Figure 3), bonito and blue mackerel baits sank at similar rates even though the bonito was 35% (80 g) heavier than the mackerel. Squid was the slowest sinking bait species and yellow-tail scad was the fastest. The difference between the three species of fish baits was < 0.15 m/s, less than might be expected given the range in bait sizes involved (see Table 2). With squid bait there was little difference between the two hooking positions within swivel weight, although the differences were greater for the fish bait species.

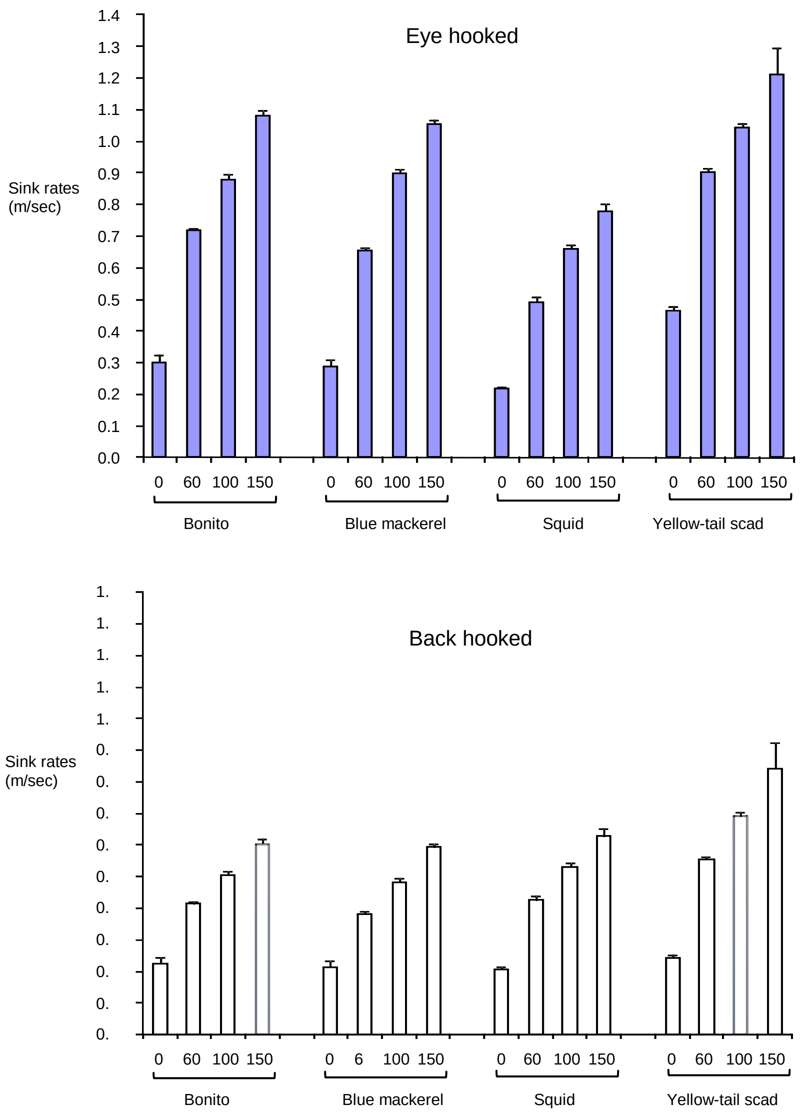

Figure 2. Comparison of effect of swivel weights and hooking position on sink rates within bait species.

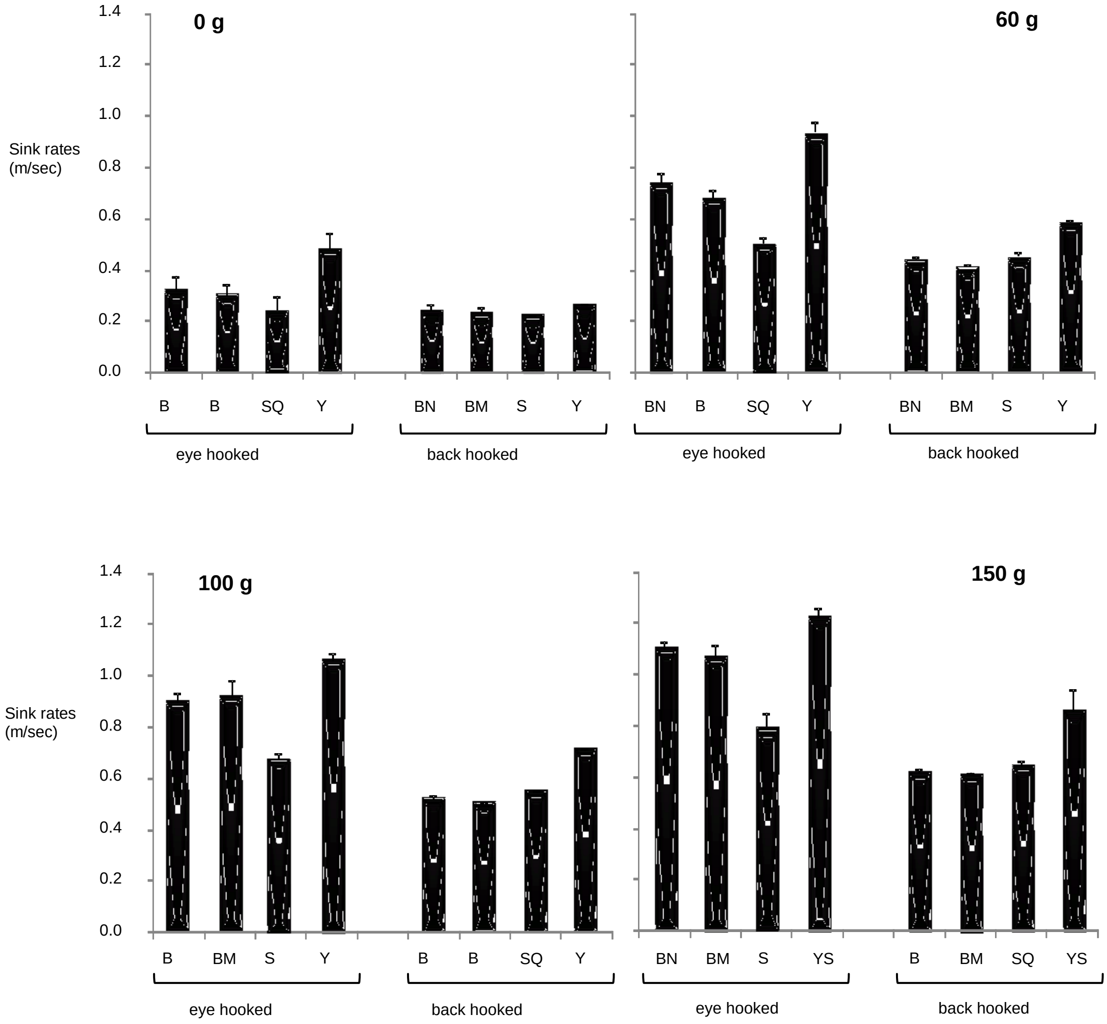

Figure 3. Comparison of bait species within swivel weight for eye hooked and back hooked baits. BN = bonito; BM = blue mackerel; SQ = squid and YS = yellow-tail scad.

Discussion

Nearly all combinations were statistically significant at the 0.001 level of probability and those that were not were significant at the 0.01 level. This reflects the disparity (lack of closeness) in bait sizes and swivel weights chosen in the experiment and the precision associated with test conducted in static water under controlled conditions. However, statistical significance in the tank trial does not necessarily suggest differences would be detectible at sea on fishing vessels. Research on the F/V *Assassin* (Robertson, et al., submitted) showed that 11 sets of the longline set under vessel charter conditions did not yield a detectible difference (at the p = 0.05 level) in sink rates of yellow-tail scad, blue mackerel and squid of similar sizes to those in the tank trial. The difference between 60 g and 100 g swivels was also undetectable. If 11 replicates are insufficient to detect differences it can be argued that the differences are minor and less important than other factors. Thus, comparisons in the tank trial that emphasise strong contrasts are the ones most likely to be relevant to at-sea comparisons of various line weighting regimes and seabird interactions. The 0.4 m/s difference in sink rates between yellow-tail scad and squid (0.5 m/s versus 0.9 m/s) is a case in point.

Conclusion

With the point immediately above in mind the salient findings from the tank trial are:

- Bait hooked through the eye (or tail) sink faster than baits hooked through the back,
- Baits with 60 g swivels sink faster than baits with no added weight,
- Baits with 150 g swivels sink faster than baits with 60 g swivels,
- The increases in sink rates associated with 100 g swivels compared to 60 g swivels, and 150 g swivels compared to 100 g swivels, are modest,
- Small fish baits (e.g., yellow-tail scads; pilchards/sardines) sink faster than large squid baits

Advice to management

The combination of static water trials and at-sea experimentation can inform the decision making process regarding the design of at-sea sink rate trials and experiments involving line weighting regimes and seabird interactions. For comparisons to have practical relevance they should be based on metrics that emphasize strong contrasts between factors being assessed. Incremental changes to gear that are subtle are unlikely to yield detectible differences at sea, both in terms of understanding the sink rate characteristics of gear and in understanding the relationship between the sink rates of baited hooks and seabird mortality.

Acknowledgements

We are grateful to Ian Hay for providing funds for this research

References

Brothers, N., Foster, A., and Robertson, G. (1995). The influence of bait quality on the sink rate of bait used in the Japanese longline tuna fishing industry: an experimental approach. CCAMLR Science, 2: 123-129.

Robertson, G., Candy, S. G., Wienecke, B. (in press). Effect of line shooter and mainline tension on the sink rates of pelagic longlines and implications for seabird interactions. Aquatic Conservation: Marine and Freshwater Ecosystems.

Robertson, G., Candy, S. G., Wienecke, B., and Lawton, K, (submitted). Experimental determinations of factors affecting the sink rates of baited hooks to minimise seabird mortality in pelagic longline fisheries.