Testing the Hookpod-mini in the New Zealand pelagic longline fishery

Final Report

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Abstract

Hookpods are one of the hook shielding devices recognised as a stand-alone best practice mitigation measure for pelagic longline fisheries. Following initial Hookpod trials in 2013, a new model of Hookpod, the Hookpod-mini, was developed to suit the fishing operations of the New Zealand surface longline fishery. We tested the operational and mitigation effectiveness of the Hookpod-mini relative to current fishing practices in the fleet, through depth opening trials, experimental and long-term trials during commercial fishing and collection of sink rate data.

Hookpod-mini opening depth tests and sink rates of weighted snoods indicated that Hookpod-minis provided protection to seabirds from hooks to a depth greater than that achieved through the combined use of tori lines and line weighting. Hookpod-minis had an advantage of being more consistent in achieving protection from hooks to a given depth compared to line weighting (sink rate profiles were highly variable) and tori lines (correct deployment was dependent on conditions such as wind).

Hookpod-minis were used for half the hooks set for total of 20 experimental sets on two vessels. The control gear comprised the vessels' normal setup of either unweighted snoods or snoods with 60 g sliding weights at 1 m from the hook, plus tori lines. Catch comparisons indicated no significant difference in target fish or shark bycatch between Hookpod-minis and the vessels' control gear.

A long-term skipper-collected dataset covered 10 months fishing with Hookpod-minis and the vessel's control gear (unweighted gear with tori line and night setting). Hookpod-mini loss and failure rates were well below the target 1 % per set and seabird bycatch rates were considerably lower on the Hookpod-mini snoods.

Our findings suggest that Hookpod-minis are an operationally feasible and effective seabird bycatch mitigation measure in the New Zealand surface longline fishery.

Introduction

Seabirds are caught globally in pelagic longline fisheries, which is recognised as one of the most important and pervasive sources of mortality, contributing to an increased risk of their extinction (Brothers 1991, Anderson et al. 2011; Yokata et al. 2011, Gilman et al. 2007, Peterson et al. 2009).

Recognised best practice mitigation measures for pelagic longliners such as a combination of line weighting, night setting and streamer lines (ACAP 2016) have been successful in reducing capture rates and reducing the availability of hooks (e.g. Brothers 1991, Lokkebourg 2011). However, uptake is variable and captures continue to occur in New Zealand (Pierre 2016).

The Hookpod has been in development since 2007 and aims to provide a 'one stop' solution to seabird bycatch in pelagic longline fisheries. The Hookpod encloses the barb of the hook until it reaches 10 m depth and a pressure activated mechanism then releases the hook (Figure 1).

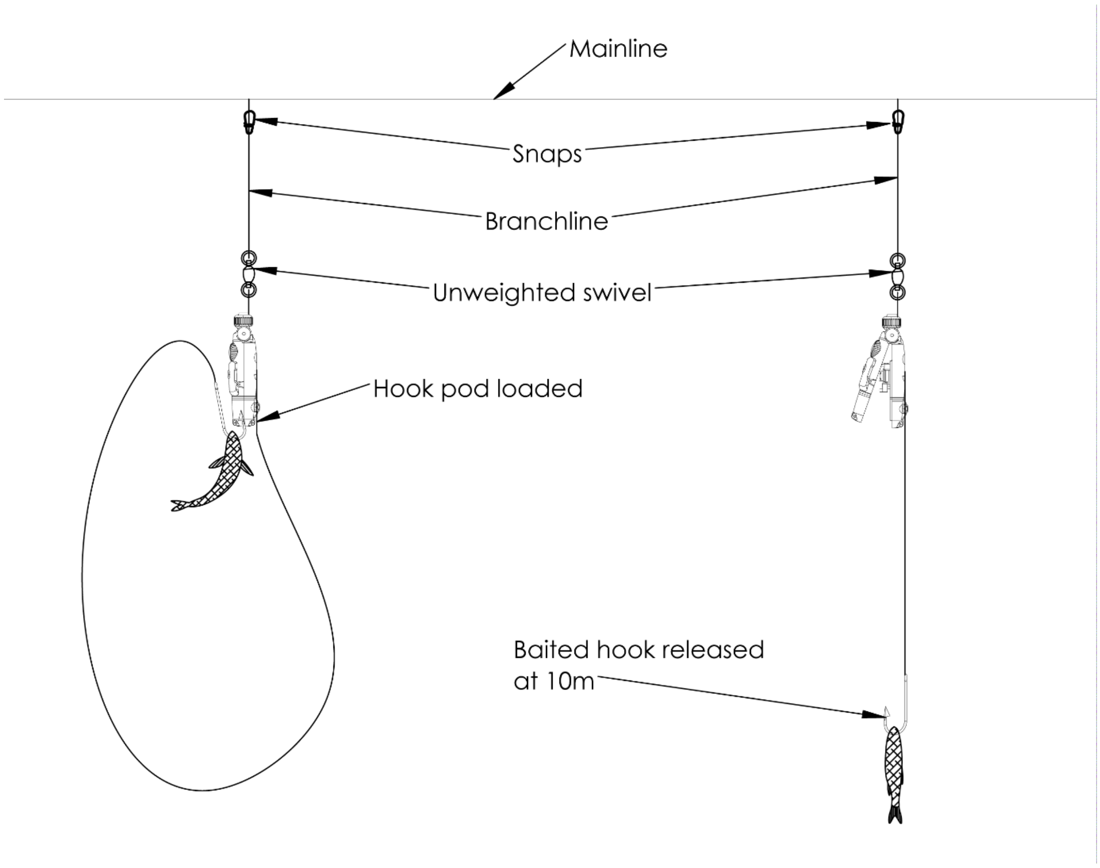

Figure 1: The Hookpod in situ prior to, and after, the pressure release mechanism opens the pod. Unweighted swivel is optional.

Between 2010-2015, operational trials of the original version of the Hookpod, which includes an LED (autonomous light source) have been completed in Australia, Brazil, South Africa and Uruguay. The results of these trials were tabled for discussion at the Ninth Meeting of the Agreement on the Conservation of Albatrosses and Petrels (ACAP). Based on these findings ACAP recommended that the Hook Pod be considered a standalone best practice mitigation measure for pelagic longline fisheries. These findings are currently under review with Animal Conservation (Sullivan *et al.* submitted).

Preliminary trials of the Hookpod were conducted in New Zealand in August 2013. Following positive and constructive feedback from these trials (Pierre *et al.* 2015) more extensive trials were undertaken in April 2016. These latter trials were undertaken with a new version of the Hookpod, the Hookpod-mini, which does not contain an LED light. This version is around 30% smaller and 25% lighter than the original Hookpod and maintains flexibility for skippers to change whether they add light to snoods on a set by set basis.

Objectives

The aim of this project was to test the operational and mitigation effectiveness of the Hookpod-mini relative to current fishing practices in the New Zealand pelagic longline fishery. This was addressed through the follow specific elements:

- Test the opening depth of Hookpod-minis.
- Compare catch rates between snoods fitted with Hookpod-minis and gear configurations currently in use in New Zealand.
- Test the sink rate of the Hookpod-mini relative to other snood configurations in use in New Zealand.
- Test the durability of Hookpod-minis under longer-term under fishing conditions.
- Gather feedback from skippers.
- Test the efficacy of Hookpod-minis as a standalone mitigation measure

Methods

Hookpod-mini opening depth trial

Opening depth tests were conducted on two occasions, whilst anchored in calm water, and with no noticeable tide. Pods were labelled, opened, immersed in seawater, shaken dry, and then closed. During the first test, pods were deployed in batches to 10 m depth and recovered. Any open pods were shaken dry and closed and then all pods were redeployed to 15 m depth and recovered. The number of pods that opened was recorded after each recovery.

Following inconclusive results from the first test, a second test was undertaken using the same protocol with three repeat drops to each of three depths: 7 m, 10 m, and 15 m. The additional depth of 7 m was chosen based on sink rate data indicating this to be the depth to which weighted hooks would sink under the protection of a tori line in favourable conditions.

At sea trials

Trials were conducted on two vessels with two separate batches of Hookpod-minis.

Gear setup / Treatments

On vessel A, Hookpod-minis were trialled against unweighted gear and both treatments included tori line use. Hookpod-minis were fitted to new snoods to provide the vessel with half an extra set of gear. Half of the Hookpod-minis had an internal shock cord added to the design to strengthen the pod in the open position and these were mixed throughout the Hookpod-mini snoods.

Snoods were 2 mm diameter monofilament nylon, 13 m long and fitted with a 16/0 circle hook. Approximately half of the vessel's normal gear had unweighted swivels at the clip and approximately half had 60 g weighted swivels at the clip. When damaged close to the hook the snood monofilament was shortened and the hook was re-crimped onto the shortened snood. Minimum snood length following repair was 9 m. Snoods with a hook bitten off were treated in a similar manner. Over the trip some J hooks were used, on both gear types, up to 5% of the total hooks set.

All hooks were baited with whole squid, and cast sideways to land outside the propeller wash. A 3 mm monofilament backbone was used and was set directly from a hydraulic reel without a brake applied and without a line shooter. Basket arrangement was 10 hooks between floats with 300 mm and 150 mm hard floats used in a pattern of 2 large floats then one small float. Setting speed was 5.5 – 6 knots and snood spacing was 13 s.

The two treatments: Hookpod-mini snoods and the control snoods (vessel's standards unweighted gear) were set in four alternate blocks, with the first treatment assigned randomly.

On vessel B, fishing was conducted under a Special Permit (654) issued by the Ministry for Primary Industries (MPI). This permitted the use of Hookpod-minis without a tori line compared to weighted gear deployed with a tori line. Due to the added complication of deploying or recovering a tori line part way through a set the two treatments were set in two blocks, with the first treatment assigned randomly.

Gear setup was similar to vessel A, and differences are described here. Most clips were unweighted, with approximately 5% of each treatment having 60 g swivels on the clip. The vessel's normal gear was weighted with 60 g GloLeads, approximately 1 m from the hook. At the start of the trial, approximately 60% of the GloLeads were luminescent and as gear was replaced the proportion of glowing weights was reduced to 30%. When damaged, snood monofilament was completely replaced such that all snoods were 13 m long. A 3.2 mm monofilament backbone was used and 300 mm diameter hard floats or 400 mm cube-shaped plastic drums were attached every 12 hooks. Hook spacing was at 12 seconds with a setting speed of 7.3 knots, reduced to 7 knots towards the end of the set.

Data collection

Set location, gear setup, and environmental conditions were recorded for all sets. For each treatment block the following data was recorded: Number of snoods set, number of tangles which interrupted the setting process, and the number of snoods in each tangle. Bird abundance and behaviour was recorded periodically through the set and haul. During hauling everything caught on the line was recorded to species level and a weight was estimated by eye. The fate of all snoods was recorded using the following descriptions:

- Pod still closed
- Pod open but hook still in pod
- Pod lost
- Snood tangled with floats

- Snood tangled with mainline
- Snood tangles with another snood
- Snood tangled with itself
- Snood damaged and removed for repair
- Knot in snood
- Twist in snood around hook
- Hook lost
- Hook ripped out
- Fish cut off.
- Snood OK
- Twist in snood around hook

In some cases several descriptions would be noted against a single snood. For example a snood may have tangled with another snood, have no hook on, and so be removed for repair.

All fly-backs were described in detail.

Time Depth Recorder (TDR) data collection

Separate snoods were made for TDR deployments to collect sink rate data of Hookpod-minis and the 'control' gear on all three vessels. Snoods were 13 m long, 2 mm diameter monofilament snoods, with unweighted clips. 16/0 tuna circle hooks were all baited with whole thawed squid. Starr Oddi DST centi TDRs were attached to the snood 50 cm from the hook. TDR snoods were all deployed mid-basket and mid-section between the ends of the longline. The time snoods were clipped onto the longline was recorded on a digital watch and was used to identify start time (zero seconds) on TDR records. Baited hooks were then cast sideways, outside the propeller wash. TDR data was calibrated to read 0 m prior to deployment and temperatures used to calculate depth immediately after immersion were estimated from first stable temperature records above the thermocline.

A further trip was undertaken (vessel C) to collect sink rate data comparing Hookpod-minis with 38 g weighted swivels at 0.5 m from the hook and 60 g lumo leads at 1 m from the hook. On vessel C, snoods with TDRs attached were deployed in the middle section of the longline, mid basket, amongst the vessel's normal gear (38 g at 0.5m from the hook).

Assessing fish catch rates

The experimental design was relatively simple: only 2 vessels that each had 12 and 8 sets. Consequently, complex models such as generalised linear mixed models that could account for between-set correlation within each vessel were not used. Instead, to ensure a robust analysis we conducted a paired t-test for each set of observations based on Hookpod-mini versus 'control', noting that the control for each vessel differed). Analysis was conducted in the statistical software program R (v.3.4.0, www.cran.r-project.org).

Individual fish species caught were grouped into family cohorts, as data were too sparse for single-species analyses. Family cohorts were: "TargetTuna", containing bigeye tuna (Vessel A) and southern bluefin tuna (Vessel B); "AllTuna", containing southern bluefin tuna, yellowfin tuna, northern bluefin tuna, albacore, and bigeye tuna; "BlueShark", containing blue shark, and "AllSharks" containing blue shark, as well as porbeagle shark and mako shark.

To identify trends and patterns in the data, boxplots summarising the median, interquartile range, and tails of the distribution of catch rates between treatments for each vessel were visually inspected prior to our analysis (see figures below).

Long term data collection by skipper on vessel A

Following the initial trial on Vessel A the skipper continued to use Hookpod-minis on some snoods, and was briefed to collect the following data for each set:

- Number of Hookpod-minis set
- Number of control snoods set
- Number of Hookpod-minis not open
- Number of Hookpod-minis lost
- Number of Hookpod-minis damaged
- Number of Hookpod-minis open but hook not released
- Number of dead birds returned on Hookpod-minis snoods
- Number of dead birds returned on control snoods

Results

Opening depth testing

During test one all pods opened following deployment to 15 m depth, and 20 out of 100 were open following deployment to 10 m. These results prompted a further test to better estimate the shallowest opening depth of pods, and the repeatability of measurements. During test two all pods remained closed after deployment to 7 m. Following deployment to 10 m results were mixed. A total of 18 pods opened during at least one of the three repeat deployments. Of these 18, six opened during two of the deployments to 10 m and one opened during all three deployments. Over both tests 199 out of 200 pods opened following deployment 15 m, and the pod that did not open stayed closed for all three repeat drops to 15 m (Table 1).

Table 1: Results from opening depth tests. Test 1 comprised single deployments to 10 and 15 m. Test two comprised 3 repeat deployments at each depth (7, 10 and 15 m). Numbers indicate number of pod open out of a total of 100 tested.

Test	7 m			10 m			15 m		
	open once	open twice	open 3 times	open once	open twice	open 3 times	open once	open twice	open 3 times
1	-	-	-	20	-	-	100	-	-
2	0	0	0	18	6	1	99	99	99

Sea trials

Vessel A trip summary

In September 2016, four sets were conducted targeting bigeye tuna in two locations off the north-east of North. The trip was immediately after the full moon and fishing was slow but typical for the time of year and in line with other vessels' catches.

Four fly backs were recorded. Two head height fly backs were recorded from hook pods missing the crew, and one hook from the unweighted control gear, which hit a crew on the forehead. One weak fly back of a hook pod hit the side of the vessel.

Maximum numbers of birds present around the vessel during hauling included fifty grey-faced petrels, four great albatrosses, two Buller's albatrosses, two black-browed albatrosses, three flesh-footed shearwaters and three black petrels. Birds were not seen directly interacting with the gear, and spent most time astern feeding on discarded offal and baits. No birds were observed whilst setting, although visibility was poor for most sets. No birds were caught during the trip.

Hooks were set by two crew from a single bin, one baiting the hook (and loading the hook pod), clearing the snood, and casting the bait. The second crew then clipped the snood onto the mainline. Hook pods were attached to snoods initially at 1.8 m from the hook and then moved to 1.2 m from the hook during the third haul. Pods were stored fleeted into the bin of hooks. Out of 2882 snoods set 15 tangles were recorded whilst setting hook pods and three whilst shooting unweighted gear. Tangles included one or two snoods, or three snoods on one occasion.

Vessel B trip summary

In July 2017, 12 sets were conducted over three trips targeting southern bluefin tuna, off the west coast of South Island. Fishing was over the full moon period and catch rates of tuna were very good, and in line with other vessels fishing nearby.

Four fly-backs were recorded. Single overhead fly backs into the boat were recorded from the hook pod and weighted gear. Two other weak fly backs were recorded from hook pods, both falling into the water before reaching the side of the vessel.

Maximum numbers of birds present around the vessel during hauling included two great albatross, 45 white-capped albatross, 15 Buller's albatross, 10 black-browed albatross, five Salvin's albatross, 20 Westland petrels, 20 prions, 20 cape petrels, and five storm petrels. Birds were not seen directly interacting with the gear, and spent most time astern feeding on discarded offal and baits.

During setting, despite the large moon, cloud cover often restricted visibility. However, albatrosses and cape petrels were observed behind the vessel during four sets. Two of these sets resulted in a dead white-capped albatross returned on snoods at the subsequent haul. One bird was returned on a hook pod snood, hooked in the bill, and was waterlogged with feathers and some flesh missing. The other bird was on a weighted snood, hooked in the wing, and waterlogged but otherwise undamaged.

Hooks were set by two crew, each working independently from separate bins, and setting alternate hooks. The hook and clip were detached from the bin, the snoods cleared then hooks were baited, pods loaded, baits cast, and clips attached to the mainline. For the first four sets pods were fixed to the snood 0.5 m from the hook and stored hanging in the bin. This method of storing pods contributed to 13 tangles comprising mostly one or two snoods but up to 15 snoods. This compared to no tangles over the same period with the weighted gear. From Haul 4 onwards pods were slid to the hook during the haul and stored at the clip, in a similar manner to the sliding weights, and then slid approximately 0.5 m up the snood during the setting operation. This resulted in less tangles and at similar rate to the weighted gear (6 vs 4).

A tori line was used when deploying weighted gear for 8 of the 12 sets. Following a snag with the gear on set 7 the skipper was reluctant to deploy a streamer line in windy conditions when further snags seemed likely.

Newly made snoods were harder to set and tangled more often. All Hookpod-mini gear was made new for the first trip, and new Hookpod-mini snoods were made more regularly during trips than weighted snoods.

Fish catch comparison

Despite slightly smaller sample sizes Hookpod-minis caught similar numbers of target species, and markedly less blue sharks (Table 2). As is typical, pelagic longlining catches were often concentrated in relatively short sections of line.

Table 2: Summary catch numbers and Hookpod-mini performance measures from at sea trials. GloLeads were 60 g and set approximately 1.0 m from the hook. Scientific names for species are as follows: albacore (*Thunnus alalunga*), bigeye (*Thunnus obseus*), southern bluefin (*Thunnus maccoyii*), northern bluefin (*Thunnus orientalis*), yellowfin (*Thunnus albacares*), swordfish (*Xiphias gladius*), blue shark (*Prionace glauca*), porbeagle shark (*Lamna nasus*), mako shark (*Isurus oxyrinchus*), fur seal (*Arctocephalus forsteri*), white-capped albatross (*Thalassarche steadi*).

		Vessel A		Vessel B	
		Minipods	**Unweighted**	**Minipods**	**Gloleads**
Number of snoods set		2882	3274	4982	5462
Number of fish:	albacore	14	16	2	7
	bigeye	19	15	0	0
	southern bluefin	10	7	214	192
	northern bluefin	2	0	0	0
	yellowfin	1	0	0	0
	swordfish	3	3	1	3
	blue shark	64	73	102	142
	porbeagle shark	3	3	21	23
	mako shark	5	6	1	4
	unidentified	1	4	1	3
Bycatch numbers:	fur seal	0	0	2	4
	white-capped albatross	0	0	1	1
Lost pods		10	-	20	-
Broken pods		3	-	3	-
Pods not open at haul		8	-	20	-
Hook stuck in pod		2	-	6	-

The high variability in the catch data, which is evident in Table 2 is further reflected in the boxplots of Target Tuna, All Tuna, Blue shark and All Shark. The dotted lines in the boxplots represent the relationship between paired observations in each set. These boxplots exemplify the high degree of variation in catch rates between vessels, sets and treatments (Figures 2-5).

Target tuna

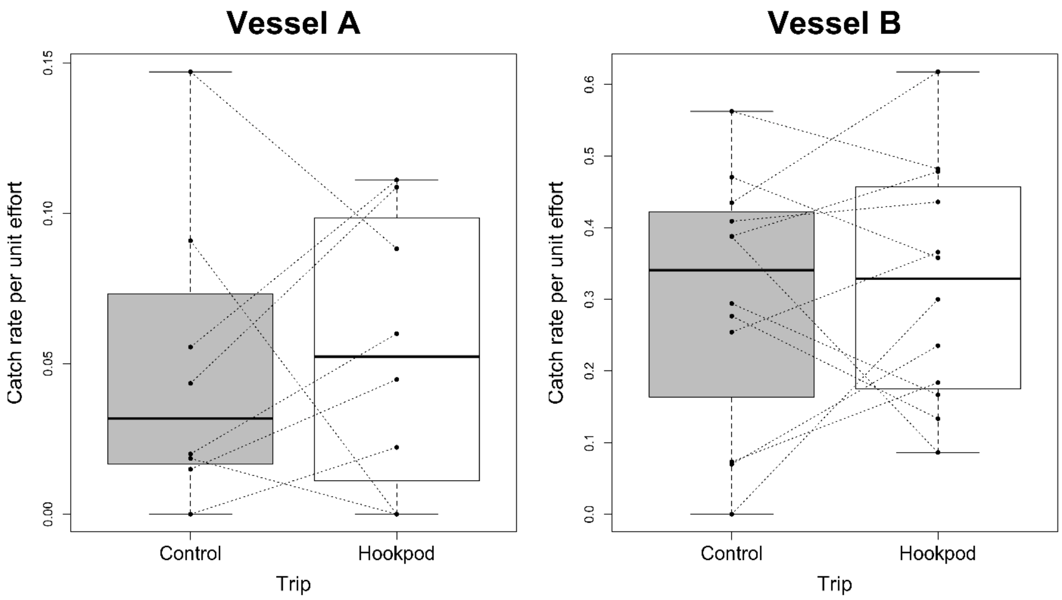

Figure 2: Box plots showing catch rates of 'TargetTuna' on Hookpod-mini snoods and control gear.

There is no obvious visual difference in the target tuna catch rate between the Hookpod-minis and the 'control' snoods on either vessel (Figure 2). From the paired t-tests, both p-values would suggest there is no significant difference between catch-rates (Vessel B: p-value = 0.79, test statistic = -0.27 with 22 d.f.; Vessel A: p-value = 0.31, test statistic = -1.05 with 14 d.f.).

All tuna

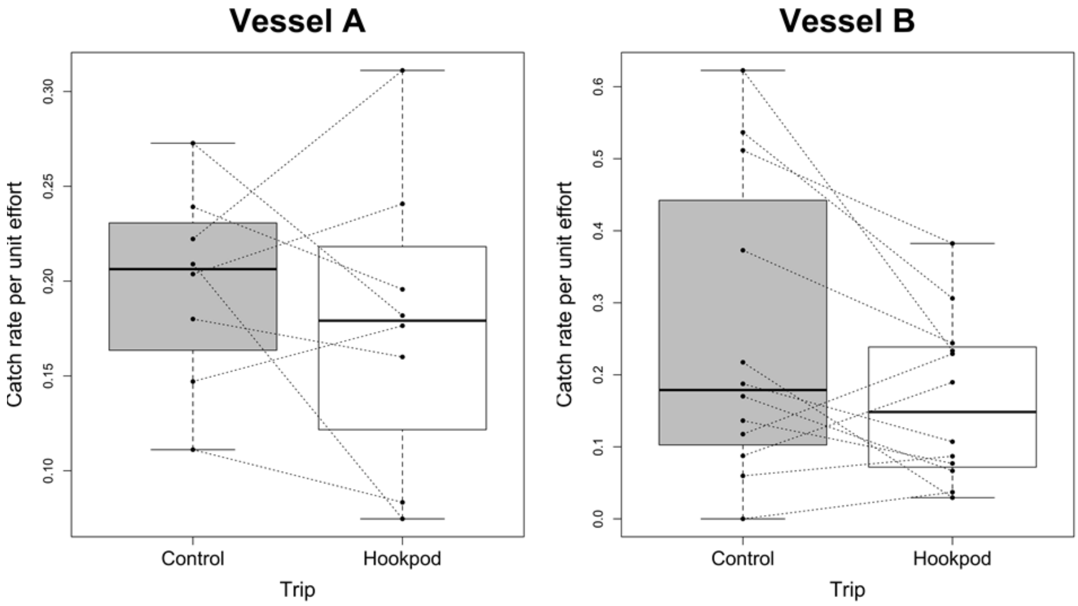

Figure 3: Box plots showing catch rates of 'AllTuna' on Hookpod-mini snoods and control gear.

There is no obvious visual difference in the catch rate of all tuna between the Hookpod-minis and the control snoods on either vessel (Figure 3). From the paired t-tests, both p-values would suggest there is no significant difference between catch-rates (Vessel B: p-value = 0.88, test statistic = -0.16 with 22 d.f.; Vessel A: p-value = 0.68, test statistic = -0.42 with 14 d.f.).

Blue shark

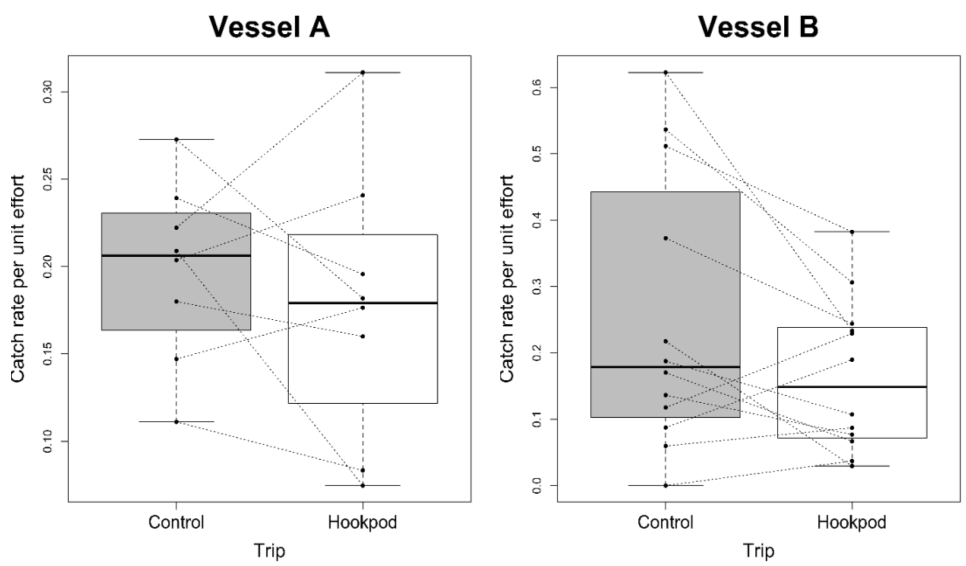

Figure 4: Box plots showing catch rates of 'BlueShark' on Hookpod-mini snoods and control gear.

There is no obvious difference in the catch rate of blue sharks on Hookpod-minis compared to control snoods on both vessel (Figure 4). From the paired t-tests, both p-values would suggest there is no significant difference between catch rates (Vessel B: p-value = 0.22, test statistic = 1.26 with 22 d.f.; Vessel A: p-value = 0.55, test statistic = 0.61 with 14 d.f.).

All sharks

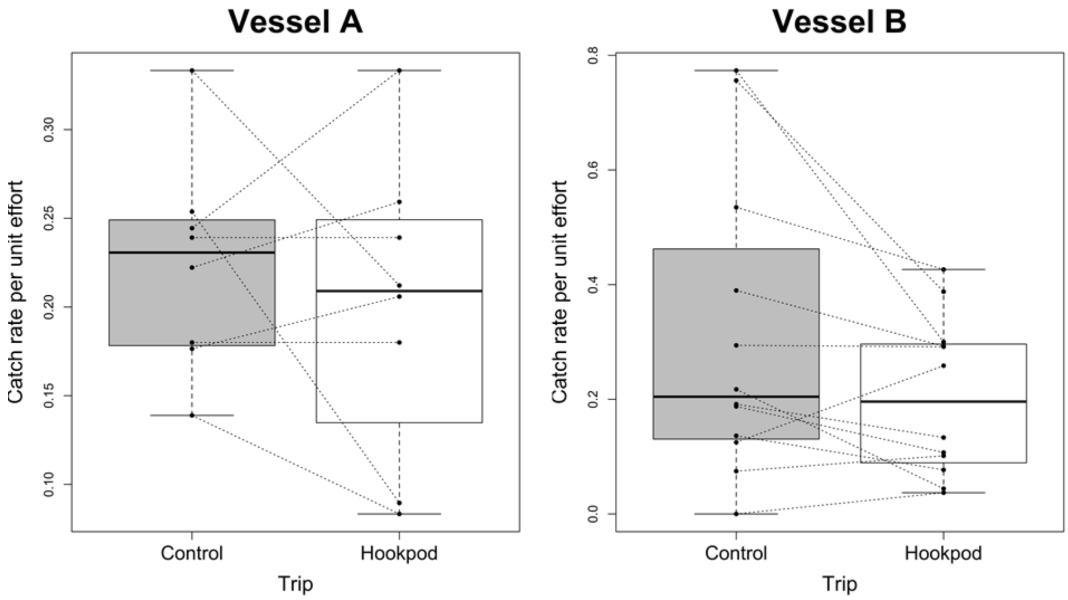

Figure 5: Box plots showing catch rates of 'AllShark' on Hookpod-mini snoods and control gear.

There is no obvious visual difference in the catch rate of all sharks between the Hookpod-minis and the control snoods on either vessel (Figure 5). From the paired t-tests, both p-values would suggest there is no significant difference between catch-rates (Vessel B: p-value = 0.24, test statistic = 1.21 with 22 d.f.; Vessel A: p-value = 0.53, test statistic = 0.64 with 14 d.f.).

Long term skipper data collection and feedback

Hookpod-minis were set in a single separate block every set for 10 months fishing, from September 2016 to July 2017. During this period the vessel fished off the east coast of the North Island for 96 sets, and off the west coast of the South Island in May, for 14 sets. Numbers of pods set diminished gradually over time due to breakages and losses. Sixty gram lumo leads were added into approximately 30 % of 'control' snoods at the end of May 2017.

In total 16 seabirds were killed during this period; 13 on control snoods and 3 on Hookpod mini snoods (Table 3). Six birds were entangled in the snoods, 2 on the Hookpod-mini snoods and 4 on control snoods. All other birds were hooked in the bill or wing. Nine of the 16 dead birds were caught during 14 sets off the west coast. A single live bird was caught and released, off the west coast of the South Island.

Table 3: Summary of skipper-collected long term data on Hookpod-mini performance. *40 g lumo leads were added into approximately 30% of the control gear for the last 26 sets. ** Hookpod-minis that did not open were marked after the first instance and then removed from the gear if they failed to open a second time.

	Totals	Per 1000 deployments
Number of sets	110	
Number of Hookpod-mini snoods set	38152	
Number of control snoods set*	52404	
Number of Hookpod-minis not open**	147	3.9
Number of Hookpod-minis lost	201	5.3
Number of Hookpod-minis damaged	40	0.86
Number of Hookpod-minis open but hook not released	14	0.08
Dead birds returned on Hookpod-mini snoods	3	0.079
Dead birds returned on control snoods	13	0.248

Over the sample period, 0.4% of pod deployments resulted in the pod either failing to open and/or release the baited hook. In terms of replacement lost and damaged pods the rate was 0.62% of pod deployments (Table 3). Losses due to pods not opening is not completely represented in the data as pods were given a 'second chance' by marking them on the first occasion and only taking them out of the gear if they failed to open a second time. However, this seems a reasonable approach going forwards and so the figures here can be considered representative of long-term 'real world' performance. The numbers of pods recorded by the skipper as lost, damaged and not open over the long–term were very similar to those recorded by DG during shorter-term sea trials (Tables 2 and 3).

Time-depth recorder (TDR) data

TDR records were collected across six sets, three vessels and six weighting configurations (Table 4).

Table 4: TDR data collected and gear configurations tested on each vessel.

Vessel	speed	treatment	number of TDR records	number of sets
A	5.5 - 6.5	mini pod at 1.8 m	27	6
A	5.5 - 6.5	unweighted	31	6
B	7.3	mini pod at 0.5 m	23	6
B	7.3	60 g at 1 m	23	6
C	6.5	mini pod at 1.2 m	22	6
C	6.5	38 g at 0.5 m	22	6
C	6.5	60 g at 1 m	21	6

On all vessels, for all treatments, initial sink rates to 6–8 m were faster than those below these depths. Hookpod-minis sank faster than unweighted gear (Figure 6) and slower than weighted gear (Figure 7). On vessel C the 38 g weights at 1 m from the hook sank with a similar profile and with similar variation to 60 g weights placed at 1 m from the hook (Figure 8).

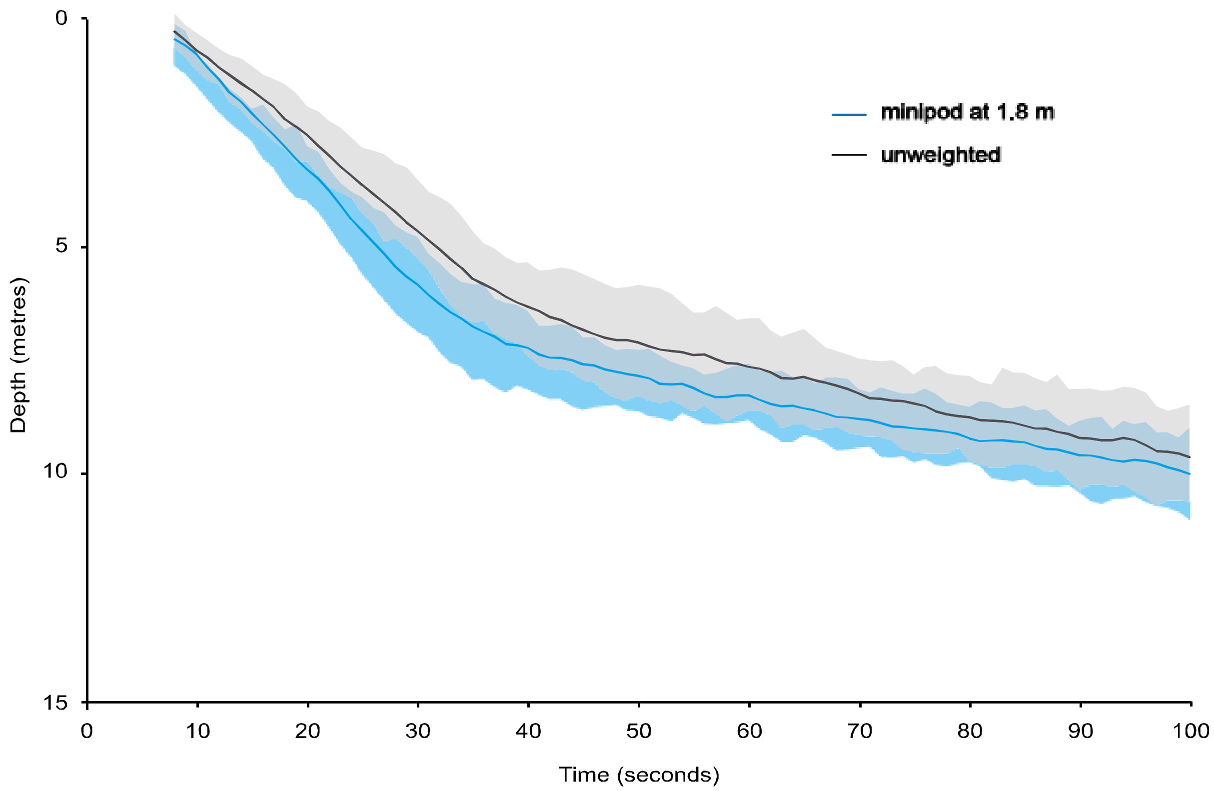

Figure 6: Sink rate results from vessel A. TDRs were placed 50 cm from the hook on unweighted snoods (n=31), and snoods with minipods placed at 1.8 m from the hook (n=27). Solid lines show mean depths and shaded areas represent the interquartile range.

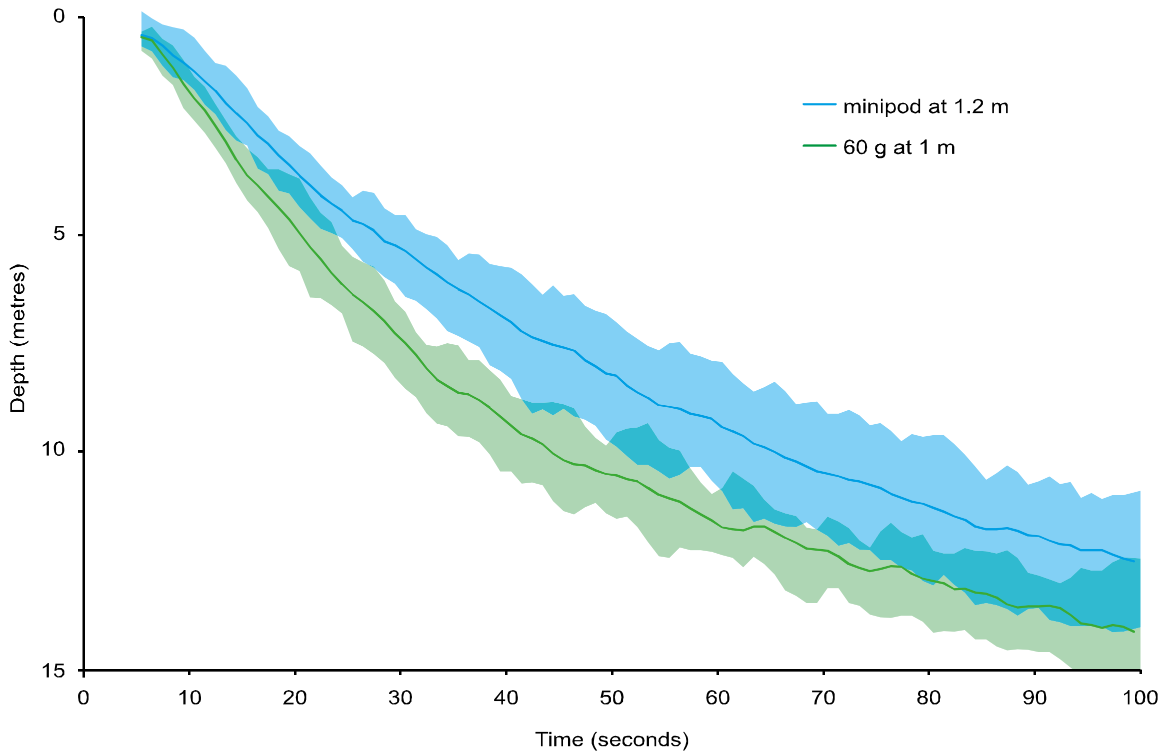

Figure 7: Sink rate results from vessel B. TDRs were placed 50 cm from the hook on snoods with 60 g GloLeads at 1 m (n=23), and snoods with with minipods placed at 0.5 m from the hook (n=23). Solid lines show mean depths and shaded areas represent the interquartile range.

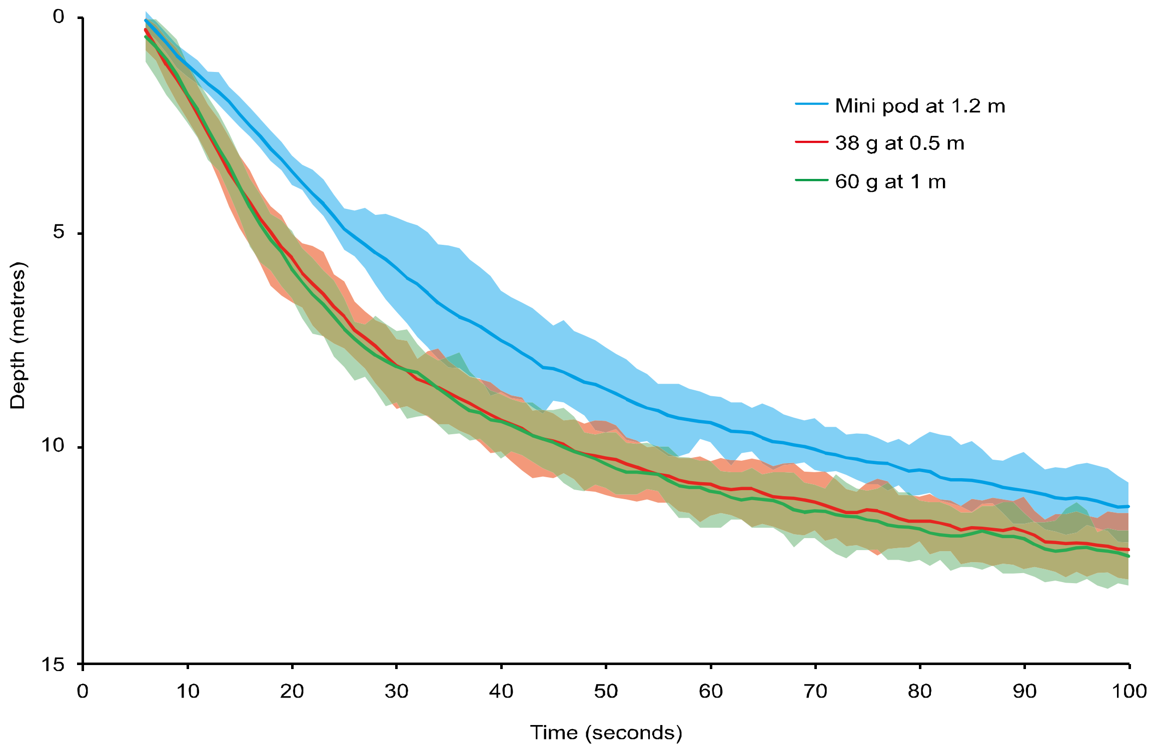

Figure 8: Sink rate results from vessel C. TDRs were placed 0.5 m from the hook on snoods with mini pods at 1.2 m from the hook (n=22), 38 g fixed swivels at 0.5 m (n=22), and 60 g lumo leads at 1 m (n=21). Solid lines show mean depths, and shaded areas correspond to the interquartile range.

In conjunction with setting speed, TDR data can be used to estimate the depth of hooks at given distances behind the vessel, as well as considering time to a given depth (Table 5). Sink times to 2 m and 5 m of depth were similar for equivalent treatments between vessels, however setting speed becomes an important factor when considering the depth at given distance astern of the vessel (Table 5). This depth at 75 m astern the vessel corresponds to the extent of protection achieved by a fully effective tori line (with 75 m of aerial extent).

Table 5: Sink times to 2 m 5 m and 10 m depth, and depths at 75 m and 100 m behind the vessel, of TDRs deployed as per Table 4. Standard error is shown in brackets.

			mean time / depth (+/- SE)				
Vessel	speed (knots)	treatment	time to 2 m (s)	time to 5 m (s)	time to 10 m (s)	depth at 75 m astern (m)	depth at 100 m astern (m)
A	5.5 - 6.5	mini pod	15 (11 - 20)	28 (21 - 34)	126 (60 - 193)	4.4 (3.1 - 5.7)	6.4 (7.9 - 5.0)
A	5.5 - 6.5	unweighted	18 (13 - 22)	36 (24 - 48)	127 (66 - 188)	3.4 (2.2 - 4.6)	5.2 (6.8 - 3.6)
B	7.3	mini pod	15 (11 - 19)	32 (24 - 40)	71 (51 - 91)	3.3 (2.4 - 4.2)	4.6 (3.6 - 5.7)
B	7.3	60 g at 1 m	13 (10 - 16)	22 (17 - 28)	52 (33 - 71)	4.6 (3.2 - 6.1)	6.6 (5.2 - 8.0)
C	6.5	mini pod	15 (12 - 17)	28 (21 - 34)	72 (52 - 93)	4.3 (3.3 - 5.3)	5.8 (4.3 - 7.3)
C	6.5	38 g at 0.5 m	11 (8 - 14)	19 (14 - 24)	52 (26 - 78)	6.4 (5.0 - 7.8)	8.0 (6.3 - 9.7)
C	6.5	60 g at 1 m	11 (9 - 13)	19 (15 - 24)	48 (35 - 62)	6.6 (5.1 - 8.1)	8.1 (6.5 - 9.6)

TDRs have a resolution of 0.24 m and accuracy is somewhat less, even after correction for temperature and calibration to read 0 m at the surface. Pressure changes due to the wake and/or propeller wash contribute to questionable results immediately behind the vessel. The addition of an extra 12 g to the snood, at 50 cm from the hook, may increase sink rate and TDRs are, at least initially, likely to be sinking below the hook. Despite these inaccuracies, and the fact that TDRs may consequently not provide an absolute measure of hook sink rates, the results presented here give an unbiased comparative measure of the different treatments.

Discussion

Opening depth tests

Tests dropping Hookpod-minis to different depths showed that the majority of Hookpod-minis open between 10 and 15 m. The 10 m opening depth is not a knife edge cut off and some Hookpod-minis opened between 7 and 10 m. Further testing could define minimum opening depth of a sample of Hookpod-minis. However, 7 m depth was chosen because this is deeper than the hook protection afforded by current ACAP recommended best practice weighting regimes and tori line performance (75 m aerial extent for vessels <35 m in length) as measured in this study (Table 5).

Sea trials

Comparison of fish catch

Catch rates of all species were similar between Hookpod-mini and control treatments on both vessels. Statistical analysis confirms no significant in difference in catch rates indicating that Hookpod-minis have no detectable effect on catch rates.

Comparison of seabird bycatch

A single bird returned from each treatment during sea trials on Vessel B does not provide sufficient data for drawing robust conclusions as to the relative efficacy of different treatments. To achieve this with bird capture rates alone fishing operations would have to be modified to increase risk to birds, which could result in an unacceptable level of mortality and lack relevance to actual fishing conditions. However, there was no indication that using the Hookpod-mini without a tori line is any less effective than using weighted gear and a tori line.

The fact the skipper elected to not use a tori line for some sets because of high winds indicates that that Hookpod-minis are a more practical and consistent solution in all weather conditions. This in itself is an important consideration when there is currently no method for measuring levels of compliance with tori line regulations or the distance sliding weights are placed away from the hook.

Safety

In terms of comparing the safety of weights and Hookpod-minis no firm conclusions can be drawn from the data beyond the observation that fly backs occurred with both gear types. However, Hookpod-minis are less dense, lighter, and less aerodynamic than 60 g lead weights, suggesting that they may present less of a risk.

Hookpod-minis have recently been part of further line-weighting safety trials undertaken by the Australian Antarctic Division in collaboration with the Australian Maritime College to follow on from McCormack & Rawlinson (2016), the results of which will be discussed at SBWG 9 and will add context to the results of our trials.

Long term skipper-collected data.

Over 10 months fishing, gear set using Hookpod-minis resulted in markedly lower bird capture rates than unweighted gear set under current New Zealand regulations that require the use of a tori line. These results also indicate that Hookpod-minis were operationally practical over the period of a year and can be incorporated into a fishing operation long-term.

This study demonstrated that a reduction in fishing efficiency due to Hookpod-mini failure of well below the target 1% per deployment can be achieved. Loss rates will vary with fishing style, season, and bycatch, and different results could be expected on a different vessel. In this case the skipper reduced hauling speed for all large sharks and made all reasonable efforts to haul sharks aboard and de-hook them or alternatively cut them off on a short snood. This approach maximises the chances of recovering Hookpod-minis and weights, and leaves released sharks with the minimum amount of gear attached.

The capture of a total of four birds on Hookpod-mini snoods across all trials indicates that Hookpod-minis do not eliminate seabird bycatch, but they can result in low levels of bycatch over long-term fishing operations, including the southern bluefin tuna season. Birds may be caught after hooks have been released from Hookpod-minis and/or by becoming tangled in snoods.

The 'tangle rate' of birds on Hookpod-minis was lower than that on the control gear, and whilst this sample size is small this shows no indication that the loop formed in the snood when setting Hookpod-minis increases tangle rate.

Sink rate data

Initially hooks sink relatively quickly, to a depth of around 6–8 m, likely corresponding to hooks sinking freely with a slack snood. Beyond this depth backbone sink rate and snood length are likely to have a greater influence sink rate. However, by this time hooks are beyond the coverage afforded by a tori line with 75 m aerial extent (Table 5). The combination of opening depth and TDR data indicates that Hookpod-minis will routinely provide protection to a greater depth that achieved by using weighted gear and a tori line, even if the tori line fully excludes birds out to 75 m behind the vessel.

Further, the large variability in sink rates (Figure 5) indicates that some hooks sink considerably slower than others. Therefore, although mean sink rates may provide for a good measure of comparative efficacy, absolute risk to birds should consider the slowest sinking hooks of any given treatment. This is particularly important in weather conditions where birds can hold station behind the vessel with little effort and 'wait' for shallower baits (pers. obs. DG). Even if a given branchline is sinking particularly slowly, a Hookpod-mini will continue to provide protection from the hook barb until a depth of approx. 10 m is achieved.

A final consideration when examining sink rate data is that this only compares hook availability at the set, and that at times hooks may be available to birds during the soak and haul.

Conclusions

Our findings suggest that Hookpod-minis are an operationally feasible and effective seabird bycatch mitigation measure. Evidence from Vessel A shows that in the long-term seabird bycatch rates were markedly lower with Hookpod-minis than unweighted snoods when the use of a tori line is required. Data from vessel B indicates that Hookpod-minis are as effective as weighted gear and a tori line.

Opening depth and sink rate data presented here indicate that Hookpod-minis provide protection from baited hooks at the set to a depth greater than that achieved through the combined use of a tori line with 75 m aerial extent and line weighting of either 38 g at 0.5m from the hook or 60 g at 1 m from the hook (corresponding to relevant minimum standards described in ACAP best practice mitigation advice).

Hookpod-minis are a robust solution to achieve protection from hooks to a depth beyond the reach of most seabirds, and once in the gear they are highly likely to be used for all sets. The comparison we have made to availability of hooks using weighted gear and tori lines, assumes that average sink rates are achieved through the use of weights, and that the tori line is completely effective in excluding birds for 75 m behind the vessel. Neither of these assumptions are likely to hold true over the long term, as we have seen large variation in sink rates of snoods (the slowest sinking pose most risk to seabirds) and tori lines were not always deployed due to weather conditions or other factors.

Birds, particularly diving birds, may still become caught by tangling with snoods or on hooks once Hookpod-minis have opened (i.e. during soak). However, there is no indication that this occurs at a higher rate on Hookpod-mini snoods than other treatments tested.

There was no significant difference in catch rate of target species between snoods with Hookpod-minis and control gear in the short-term data. There was a reduction in bycatch rates of blue shark on Hookpod-mini snoods (Table 1) but the result was not significant at the P=0.05 level. Further data collection would be required to explore this possible relationship in more detail. Our findings indicate that Hookpod-minis can be incorporated into both the setting and hauling process with minimal, if any, effect on fishing performance.

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