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Net binding trials to mitigate seabird entanglement during bottom trawl shooting

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SUMMARY

Since 2006 several strategies have been implemented to mitigate seabird interactions in the Falkland Islands Patagonian squid bottom trawl fishery (FIPSF). Although incidental mortality was presumed to be low due to average mesh size in the mouth of the net and net wings being around 120-140 mm, over time these have increased to 400-600 mm. Between 2018-2021 observed incidental mortality of black-browed albatross registered a 6.5-fold increase, mostly related to net entanglements in 200-400 mm mesh. Net binding is known to be effective in reducing seabird entanglements in the mackerel icefish pelagic trawl fishery in CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) waters, so a decision was made to trial this technique in the FIPSF. Between the 1st and 3rd October 2021 three-ply sisal strings placed approximately 3 m apart were used to bind trawl meshes in a total of 12 shoots. Binding arrangements comprised three configurations that differed in the bind's location in the trawl and the mesh sizes covered: body of the net/100-200 mm (configuration A), mouth of the net and net wings/200-400 mm (configuration B), and net wings/200-400 mm (configuration C). Although weather conditions were optimal, most of the binds in the trawl wings and mouth of the net broke during shooting, even before entering the sea. These trawl sections are under a lot of tension and force during shooting, so a number of consecutive modifications in bind arrangements were applied, with little success. The contrasting success of this technique in pelagic trawls relies in the fact that net binds are applied to an area that suffers low physical stress during shooting. Our results showed that the application of net binding to the FIPSF is neither efficient nor practical. Therefore, it is necessary to explore other techniques in order to mitigate these specific seabird entanglements.

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1. INTRODUCTION

Since 2006 several mitigation methods had been implemented to reduce seabird interactions, principally with the warp cables in the Falkland Islands Patagonian Squid (*Doryteuthis gahi*) bottom trawl Fishery (FIPSF). The bycatch mitigation toolbox comprises a variety of strategies to monitor and mitigate the incidental mortality of albatross and petrels, including the use of bird scaring lines (BSL), 100% of marine mammal/seabird observer coverage, net and deck cleaning, and discard management.

Although in the FIPSF seabird mortality was historically assumed to be low (Crofts, 2006; Sullivan et al., 2006; Kuepfer et al., 2018), between 2018-2021 observed incidental mortality of the black-browed albatross (*Thalassarche melanophris*, hereafter DIM) rose from 20 (2018) to 130 (2021) individuals, comprising a 550% increase. Because 82% of these mortalities included net entanglements, and the net binding technique used in the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) mackerel icefish pelagic trawl fishery (*Champsocephalus gunnari*, hereafter CHG) has proved effective to reduce seabird entanglements (CCAMLR, 2006), it was decided to assess whether net binding could also be applied to Falkland Islands bottom trawls.

2. METHODS

Trials were carried out between 1st-3rd October 2021 aboard the *F/V New Polar*, a 74.5 length stern trawler equipped with a 15 m fixed BSL (see Parker et al., 2013) and a 5 m^3 discard storage tank.

The bottom trawl used had a total length of approximately 200 m, with mesh panels made of two threads with different composition, diameter, and resistance. Mesh sizes ranged from 100 to 400 mm (Fig.1). Floats were of 300 mm in diameter and of 10 kg of flotation.

Following mandatory pinniped conservation measures, the trawl included a 5 m net extension containing a seal exclusion device (SED) *model ii* (Iriarte et al., 2020) fitted between the body of the net and the cod end (Fig.1), the SED weighing approximately 200 kg.

Stations (i.e. shoot and haul) were monitored from the gantry by two observers to record sisal binds/net surface behaviour, seabird abundance, and seabird interactions. Additional observations were recorded every 10 min whilst trawling.

No discarding took place during fishing gear manoeuvring or trawling; net and deck cleaning took place before every shoot.

Incidentally killed seabirds were frozen for post-mortem.

2.1 Binds

Three-ply sisal strings of around 2 m of length placed approximately 3 m apart were used to bind trawl meshes before shooting the net (Fig.2).

Changes to bind arrangements (i.e. location of the binds along the trawl and number of sisal string loops) were applied to consecutive stations based on bind behaviour observations carried out from the gantry (Fig.3).

2.1.1. Bind arrangements

- Configuration A: Following the vessel's previous experience in the CHG fishery, the first trial day started with single binds applied to the body of the trawl (Fig.4). In the beginning, these binds covered a distance of around 40 m from the proximal boundary of the SED net extension towards the mouth of the net, covering 120-160 mm meshes (Fig.5). The bind coverage was then extended up to approximately 60 m to reach part of the 200 mm meshes in the body of the trawl.

- Configuration B: Because in the FIPSF seabird entanglements are recorded mostly in 200-400 mm meshes in the net wings and close to the floats, it was decided to transfer the net binds to apply them on the mouth of the trawl and the net wings (Fig.6). This configuration aimed to unite the net wings in order to close the mouth of the trawl and eliminate the exposure of the most dangerous meshes to attending seabirds. Consecutive modifications included an increase in the number of binds, an increase in bind tightness, and manoeuvring efforts to maintain warp cables aligned during shooting.
- Configuration C: This configuration aimed to eliminate the exposure of the trawl wings only (Fig.7). Double, triple and quadruple net binds (Fig.8) were applied onto the headline along the wings (Fig.9). Consecutive modifications included an increase in the number of binds and an increase in bind tightness.

3. RESULTS

Net binds were applied to the trawl in 12 stations, where the average trawl duration was 72 min (Table 1). Although weather conditions were optimal, most of the binds broke during shooting, even before entering to the sea (Table 1). Binds did not affect the usual fishing gear exposure time on the surface, which was an average time of 4min:20sec. Consecutive modifications in bind arrangements were applied, but with little improved success (Table 1).

Table 1. Net binding stations.

Date	St	BA Shoot	N in S Shoot	Td	BA Haul	N in S Haul	Br	Bt	Bc	Problems	Comments
01/10/21	1	201-500	04:23	60	501+	03:50	4	S	A- 40m	W&ME	NBbsl; NWcTr; BsTNSh&Ha
01/10/21	2	51-200	03:19	60	501+	05:06	3	S	A- 60m	W&ME	NBbsl; NWcTr; BsTNSh&Ha
01/10/21	3	501+	03:54	135	201-500	03:46	3	S	B	BBrSh	NBbsl; NWcTr; BsTNSh&Ha
01/10/21	4	501+	03:58	60	501+	03:50	4	S	B	BBrSh	NBbsl; NWcTr; BsTNSh&Ha
01/10/21	5	501+	04:08	60	501+	04:00	3	D	B	BBrSh	NBbsl; NWcTr; BsTNSh&Ha
02/10/21	6	501+	03:31	60	501+	04:16	4	D	B	BBrSh	NBbsl; NWcTr; BsTNSh&Ha; DIMm1
02/10/21	7	501+	04:49	60	501+	03:51	4	S&D	C; D=port; S=star	BBrSh	NBbsl; NWcTr; BsTNSh&Ha; ShExt
02/10/21	8	501+	04:24	105	501+	04:17	4	D	C	BBrSh	NBbsl; NWcTr; BsTNSh&Ha;
02/10/21	9	501+	03:03	60	501+	03:00	4	T&Q	C; T=star; Q=port	BBrAftTr	NBbsl; NWcTr; BsTNSh&Ha;
02/10/21	10	501+	05:24	60	501+	03:26	3	D	C	BBrSh	ShExtNE; NBbsl; BsTNSh&Ha; DIMm2
03/10/21	11	501+	07:00	70	501+	04:56	3	D	C	BBrSh	Sh&HaExtMp; NBbsl; NWcTr; BsTNSh&Ha
03/10/21	12	501+	04:06	C	--------	-------	3	D	C	BBrSh	BsTNSh; HaNm

St=station; **BA**=bird abundance 200 m; **N in S**=net in surface (min:sec); **Td**=trawl duration (min); **Br**=Beaufort; **Bt**=bind type; **Bc**=bind configuration.

C=commercial fishing; **S**=single; **D**=double; **T&Q**=triple and quadruple; **Port**=portside; **Star**=starboard.

W&ME=wings and mouth mesh exposed; **BBrSh**=most of binds broke while shooting; **BBrAftTr**=binds broke after trawling began.

NBbsl=no birds entering the BSL protected area; **NWcTr**=no warp cable contacts during trawling; **BsTNSh&Ha**=birds scavenging on top of the net during shooting and hauling; **DIMm1**=black-browed albatross mortality #1; **ShExt**=shoot manoeuvre extended; **ShExtNE**=shoot manoeuvre extended due net entanglement; **DIMm2**= black-browed albatross mortality #2; **Sh&HaExtMp**=shoot and haul extended due mechanical problems; **HaNm**=haul not monitored.

- Configuration A, stations 1-2: Because the single binds were applied on the body of the trawl, the stress exerted on them during the shoot manoeuvre was not maximised and most of the binds remained in place. However, this bind configuration covered only the 100-160 mm net meshes, leaving the high-risk seabird entanglement zone (mouth and net wings) of 200-400 mm meshes completely exposed (Table 1, Fig.4).

- Configuration B, stations 3-6: During trawl shooting, starboard and portside bridles and sweeps are usually deployed in a dissimilar way, therefore the stress of the manoeuvre exerted on the trawl opening and wings made the binds break on deck. Consecutive changes in bind arrangements included an increase in the number of binds, number of loops, and bind tightness. In addition, efforts were made to shoot bridles and sweeps in a parallel way, however these were not successful (Table 1).

- Configuration C, stations 7-12: Single and double binds applied onto the headline along the trawl wings also suffered stress during the shooting manoeuvre and broke (Table 1). Triple and quadruple binds were then applied. However, although some of these did not break on deck, an unknown number remained in place even after the fishing gear arrived to the bottom and started to be towed, thereby preventing the net to open on time for fishing (Table 1).

3.2 Seabird interactions

Trials were performed during DIM's egg laying season, when concentrations of birds around the vessel during shoot and haul manoeuvres were in the low-middle thousands (3000-7000 individuals). As a result of the seabird bycatch mitigations in place (i.e. discard management and BSL) and the good weather conditions, the warp-water cable interface remained inside the BSL protected area at all times and no interactions of birds with the warp cables were observed during trawling. However, two DIM mortalities were recorded.

3.2.1. DIM mortality #1

Carcass recovered in the haul of station 6. Due the carcass position and condition, it is presumed that during the shoot the diving bird tried to pass through the starboard net wing to enter into the mouth of the net, becoming stuck in the 200 mm mesh (Fig.10). Post-mortem inspection showed enlarged testicles and soil inside the tip of the bill, which indicate the animal was likely a breeding bird that had been undertaking courtship and nesting activities prior to this foraging trip.

3.2.2. DIM mortality #2

The animal entered the net through the SED's top hatch during the haul of station 10 (Fig.11). The bird was seen alive at around 12 m away from the SED. On deck, the bird was crushed due to the tension exerted by the pulling winch as the net was maneuverer up the deck. Post-mortem inspection showed the DIM had a brood patch and testicles with sperm, also indicating it was likely a breeding bird.

4. DISCUSSION

Although net binding is known to be effective in reducing seabird interactions with pelagic trawlers in the CHG fishery (Sullivan et al., 2004; CCAMLR, 2006), our trials identified a number of differences and challenges regarding the application of net binding to mitigate seabird incidental mortality in the FIPSF.

Pelagic trawls are larger (≥250 m) and made of panels in which mesh sizes range from 16 m in the net wings to 90 mm in the cod end (Fig.12). Because in CCAMLR's CHG fishery most of seabird net mortalities are dominated by the white-chinned petrel (*Procellaria aequinoctialis*, hereafter PRO), the danger zone for this seabird is in mesh sizes between 150 and 200 mm which are located in the main body of the net, proximal to the cod end (Fig.12). This seabird entanglement zone extends for around 40 m along the body of the net, where the net binds suffer low physical stress during the shooting manoeuvre.

Bottom trawls currently used in the FIPSF have a length of around 220 m, and are made of panels which mesh sizes range from 600-200 mm in the net wings to 100 mm in the proximal area to the cod end. Most of the seabird entanglements are DIM, a much larger species than PRO, where the danger zone is in the mesh sizes between 200 and 400 mm which are located mostly in the mouth of the trawl and the net wings (Fig.12). This seabird entanglement zone extends throughout the net opening, an extension larger than 150 m, which includes the net wings and mouth, these being unstable areas that suffer a lot of tension and force during shooting.

Although, historically seabird mortalities caused by net entanglements in the Falkland Islands were thought to be minor due to the fact that average mesh sizes near the mouth of the net were around 120-140 mm (Sullivan & Reid, 2004), in the FIPSF mesh sizes around the mouth of the net and net wings have increased under current fishing practices and are now in the range of 400-600 mm (Falkland Islands Fisheries Department, *unpublished data*). Mesh sizes between 200-800 mm have previously been related to DIM entanglements in CCAMLR waters (Hooper et al., 2003).

The increase in mesh sizes in the net wings and mouth of the net in the trawls used in the FIPSF are a result of a number of factors including the modernisation of the fleet, so new or upgraded vessels have more powerful engines, and larger nets made of specialised materials have replaced the traditional smaller nets. The latter provide more abrasion resistance, allow an increased flux of water, and diminish drag, characteristics that have made the fishery much more efficient.

This project clearly demonstrates that the application of net binding in the FIPSF is neither efficient nor practical, therefore it is necessary to explore the possibility of developing other measures to mitigate seabird incidental mortalities caused by net entanglements.

5. ACKNOWLEDGMENTS

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6. FIGURES

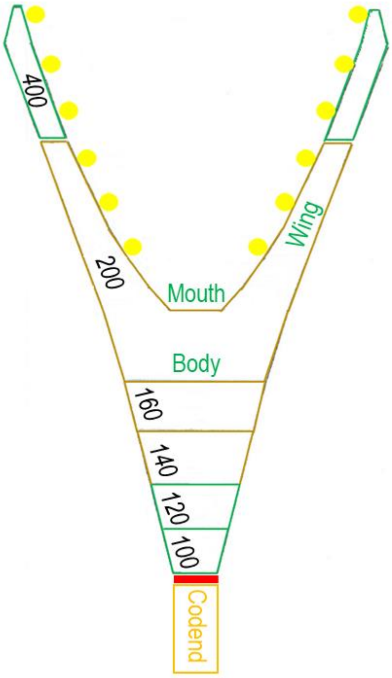

Fig.1. Diagram with trawl's top sectors and mesh size in mm; SED net extension indicated in red. Figure not to scale.

Fig.2. Single net bind applied to the trawl.

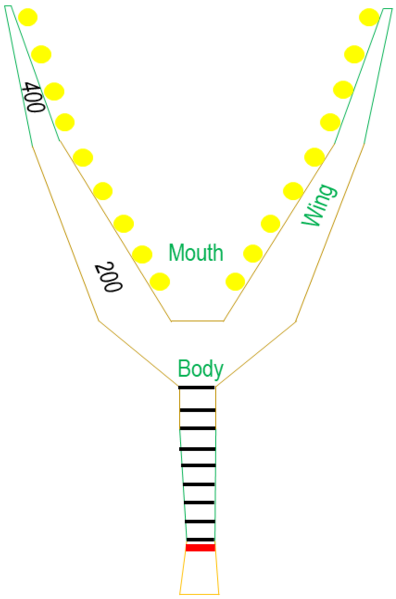

Fig.4. Configuration A. Black stripes indicate location of binds applied. Figure not to scale.

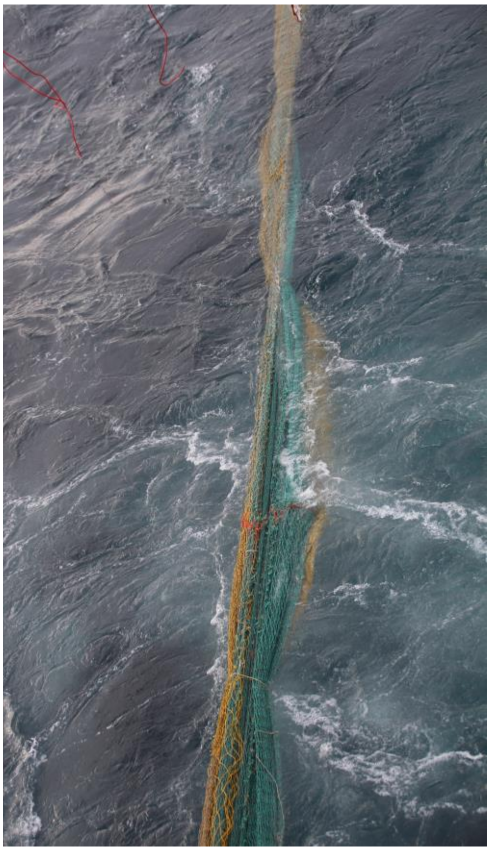

Fig.3. Sisal bind seen from the gantry in the shoot.

Fig.5. Configuration A; trawl on deck.

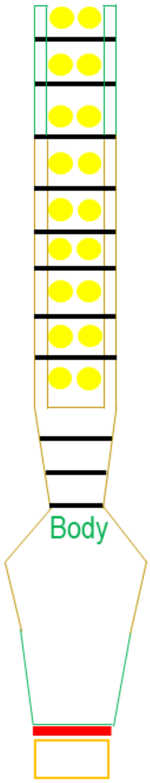

Fig.6. Configuration B. Black stripes indicate location of binds applied. Diagram not to scale.

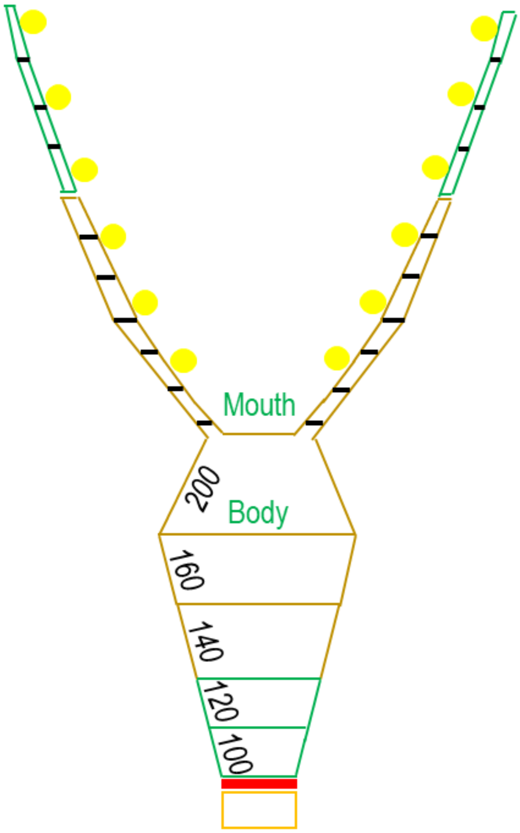

Fig.7. Configuration C. Black stripes indicate location of binds applied. Diagram not to scale.

Fig.8. Configuration C. Triple binds on starboard's headline (top) and quadruple binds on portside's headline (bottom).

Fig.9. Configuration C. Quadruple sisal bind on trawls' portside headline.

Fig.10. DIM mortality #1; carcass (indicated by red circle in image) recorded in the haul of station 6, entangled in the 200 mm mesh starboard net wing. The metal structure on the right comprises the portside boom of the fixed bird scaring lines, made of semi-flexible 10 mm red polyurethane tubing.

Fig.11. DIM mortality #2. The bird entered the net through the SED's top hatch (seen at the centre of the image) during the haul of station 10. The bird was originally seen alive (its position indicated by the yellow dot at the bottom of the image), however died on deck as a result of the hauling manoeuvre. The picture also shows the fixed BSL with two 15 m stern booms and three streamer curtains (two lateral, one distal), and its protected area.

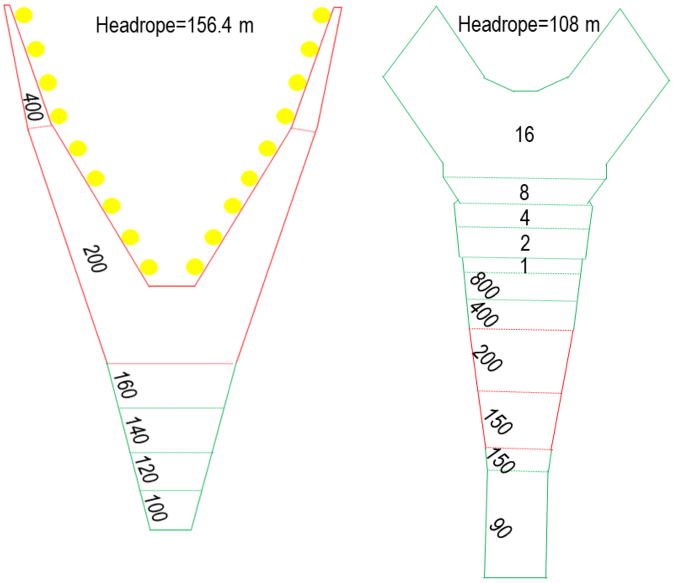

Fig.12. Comparison of a bottom trawl used in the FIPSF (left) and a pelagic trawl used in the CHG fishery (right). The seabird high-risk entanglement zone is indicated in red. Mesh sizes to the left are in mm, while centred mesh sizes in the pelagic net are in m. Diagrams not to scale.

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