LOL 2022-C MMO Monitoring Program Report

LOL 2022-C

Verónica Iriarte

Fisheries Department
Directorate of Natural Resources
Falkland Islands Government
Stanley, Falkland Islands

23 May 2022

Participating/Contributing Scientific Staff

Verónica Iriarte (Seabird & Marine Mammal Scientific Officer)

Acknowledgements

To all Marine Mammal Observers, captains and crew. MRAG supplied observers and managed overall deployment. Thanks to the Loligo Producers Group for their continuous support to the MMO Monitoring Program.

For citation purposes this publication should be referenced as follows:

Iriarte, V. (2022). LOL 2022-C MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 19 pp.

Previous related reports:

Iriarte, V. (2022). LOL 2021-X MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 19 pp.

Iriarte, V. (2021). LOL 2021-C MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 19pp.

Iriarte, V. (2020). LOL 2020-X MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 22 pp.

Iriarte, V. (2020). LOL 2020-C MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 20 pp.

Iriarte V., Arkhipkin A., Blake D. (2018). License X-2017 Pinniped Bycatch Mitigation Report: Implementation of seal exclusion devices (SEDs) in the Loligo (*Doryteuthis gahi*) fishing fleet during the 2nd season 2017. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 28 pp.

Iriarte V., Pompert J. (2016). Pinniped Bycatch Report: Squid & Finfish Trawlers. Preliminary information on the bycatch of pinnipeds in the Falkland Islands. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 13 pp.

Table of Contents

1. Introduction

The Patagonian longfin squid (*Doryteuthis gahi*) fishery is currently the only bottom-trawl fishery in the Southwest Atlantic with a full observer coverage and Seal Exclusion Device (SED) usage (Iriarte *et al*., 2020). This aligns with the 2030 Agenda and Sustainable Development Goals of the United Nations, and supports the *D. gahi* (hereafter LOL) product potential future certification and its possible expansion to new markets.

The Marine Mammal Observer Program is funded and managed by the Falkland Islands Government (FIG) and it is supported by the Loligo Producers Group (LPG). Marine Mammal Observers (MMO) record pinniped [i.e. South American sea lion (*Otaria flavescens*, hereafter OTB), South American fur seal (*Arctocephalus australis*, hereafter ARA), southern elephant seal (*Mirounga leonina*, hereafter MIL)] abundance, behaviour, net interactions, live deck releases, live SED escapees and incidental mortalities in at least three trawls per day. Following FIFD discard management policy that came into effect on 1 January 2021, observations of the discard management plan aboard and monitoring the occurrence of organic material in the water was added to the primary MMO duties. MMO seabird bycatch mitigation activities include monitoring bird scaring lines (BSL) efficiency, recording seabird interactions with the fishing gear, mortalities, and seabird carcass collection. In addition, since season 2022-C MMOs carry out compliance monitoring and reporting to Fisheries Operations (FishOps).

The LOL 2022-C season started on 23 February 2022, with 15 vessels with an MMO aboard and one -due COVID-19 regulations - for the first three fishing days using a trawl fitted with a SED until observer embarkation. The 16 MMOs were supplied by MRAG (U.K) and were briefed at the Falkland Islands Fisheries Department (FIFD) between 21-23 February. The first part of the briefing focused on the Seabird and Marine Mammal Bycatch Mitigation Program, including an introduction to local otariids (eared seals, OTB and ARA) and seabird species, identification, behaviour, types of interactions with fishing vessels and mortality mitigation methods. The second part of the briefing was concentrated on discard management, monitoring interactions, examining carcasses, data gathering and recording, biometrics of LOL and Patagonian toothfish (*Dissostichus eleginoides*, hereafter TOO). Training on licence conditions, compliance and specific weekly reporting to FishOps was given by FIFD's Operations Manager.

2. Objectives

The objective of this report is to present all the data collected during the 2022-C season regarding marine mammal and seabird interactions with the LOL fleet, to evaluate the mortality mitigation methods in place, and to formulate recommendations. Information includes data and samples collected by the MMOs and collated/processed by the FIFD.

3. Methods

3.1 *Manoeuvre monitoring*

MMOs principal duty is to monitor the shoot and haul of at least three trawls per day to record seal abundance and behaviour, and to observe any seal and seabird bycatch. As shoots and hauls represent the most critical moment for both seabird and marine mammal incidental mortality, and as seabird bycatch is extremely cryptic and very difficult to detect (Parker *et al*., 2013a; Iriarte & Pompert, 2016; Kuepfer, 2016b), MMOs are required to carry out their observations principally from the gantry. Observer monitoring from the bridge, bridge wings and deck do not provide enough view to properly assess seabird and seal interactions with the fishing gear. However, as a secondary option monitoring from the bridge/bridge wings may be used during night hours and unsafe weather conditions.

3.2 *Bird scaring lines monitoring*

The LOL fleet has been directly involved in the development and implementation of both *tori lines* (Sullivan *et al*., 2006; Snell *et al*., 2012) and the *fixed aerial array* (Parker, 2012; Parker *et al*., 2013b). Although *tori line* (TL) requirements are included in the License conditions, specific *recommendations* for the fixed aerial array (FAA) had been produced by FIFD (Kuepfer, 2016a, 2017, 2018) and general FAA conditions were introduced for the season 2021-C. As different FAA models have been fitted on vessels, in order to evaluate their performance and to compare them to TL, MMOs are required to carry out one hour of BSL daily observations from the gantry, preferably while the vessel is processing catch. This also allows monitoring discard management and observing discard storage tank performance. At the beginning of the observations the MMO estimates the overall vulnerable seabird abundance within 200 m astern, followed by 40 m estimations in 10 min periods and counting seabird presence within 2 m of the warp-water interface during each period. Vulnerable seabirds comprise species with large wing-span, which are prone to fishing gear entanglement (i.e. albatrosses and big petrels). Although the most common species interacting with the LOL fishery are the black-browed albatross (*Thalassarche melanophris*, hereafter DIM) and the giant petrel species (*Macronectes giganteus* and *Macronectes halli*, hereafter MAX), other species can also interact with the vessels, like the grey-headed albatross (*Thalassarche chrysostoma*, hereafter DIC), the white-chinned petrel (*Procellaria aequinoctialis*, hereafter PRO), Wilson’s storm petrel (*Oceanites oceanicus*, hereafter OCO), and the grey-backed storm petrel (*Garrodia nereis*, hereafter GAN).

3.3 *Seabird and marine mammal bycatch mitigation measures*

In order to mitigate seabird and seal mortality in the fishery, license conditions mandate the use and maintenance of BSL, prohibit discarding during manoeuvres (i.e. shoot, turn, haul), require cleaning the net thoroughly prior to shooting, and establish parameters for discard management as a long-term seabird bycatch mitigation measure. License conditions also describe three SED models approved by the FIFD and emphasize that "*during the haul crew should make their bests efforts to detect seals trapped in the net and facilitate their escape whilst the SED is still in the water, by working cables/bridles back and forth*".

As overall compliance to good practices is a key factor to megafauna bycatch mitigation efficiency, good practices aboard are also monitored by the MMOs.

3.4 *Mortalities & necropsies*

Observers must report seal mortalities to the FIFD via WhatsApp as soon as they have occurred, providing photographs of the head and genital area, and possible cause of mortality. If female, observers are instructed to preserve the carcass for necropsy ashore, while male carcasses are marked (partially cut/complete removal of the left pectoral fin) and dumped overboard, unless instructed for preservation.

In the case of seabirds, all carcasses recovered should be preserved frozen for posterior necropsy. Collected individuals are then aged following Prince and Rodwell (1994).

3.5 *Data reporting*

Scientific data collected by the observers are daily entered in an excel file which is sent to the FIFD and MRAG twice a week (Mondays and Thursdays); BSL data is entered into a separate file and sent once a week (Fridays). After being checked by FIFD's Data Manager and MRAG, all the data is shared with the respective fishing companies.

4. Results

4.1 *Manoeuvre monitoring*

A total of 2446 trawls were reported, of which 2444 (99.9%) were monitored in at least one manoeuvre (i.e. either a shoot or haul). Of a total of 2444 shoots observed, (87%) were monitored from the gantry, 231 (9%) from the bridge/bridge wings, and 97 from the stern/upper deck (4%) (Fig.1). Regarding the 2445 hauls observed, 2256 (92%) were monitored from the gantry, 165 (7%) from the bridge/bridge wings, and 24 (1%) from the stern deck (Fig.1).

Because during the pre-recruitment survey sampled squid from the southern fishing grounds had a small size, the LPG requested the closure of the fishing area south of 52°30' S for the first seven days of the season. Further closures occurred within the next two weeks of the fishery, totalling 22 days with the fishing activity being carried out exclusively in the north.

Fifty-nine percent of the fishing effort took place north of 52° S and 41% south (Fig.2). However, XVAK was the most visited grid square (268 shoots; 378 hauls), followed by XPAP (302 shoots; 259 hauls), XNAQ (220 shoots; 272 hauls), XNAP (220 shoots; 247 hauls), XVAL (246 shoots; 193 hauls), XLAN (217 shoots; 220 hauls), and XVAJ (245 shoots; 188hauls) (Fig.3).

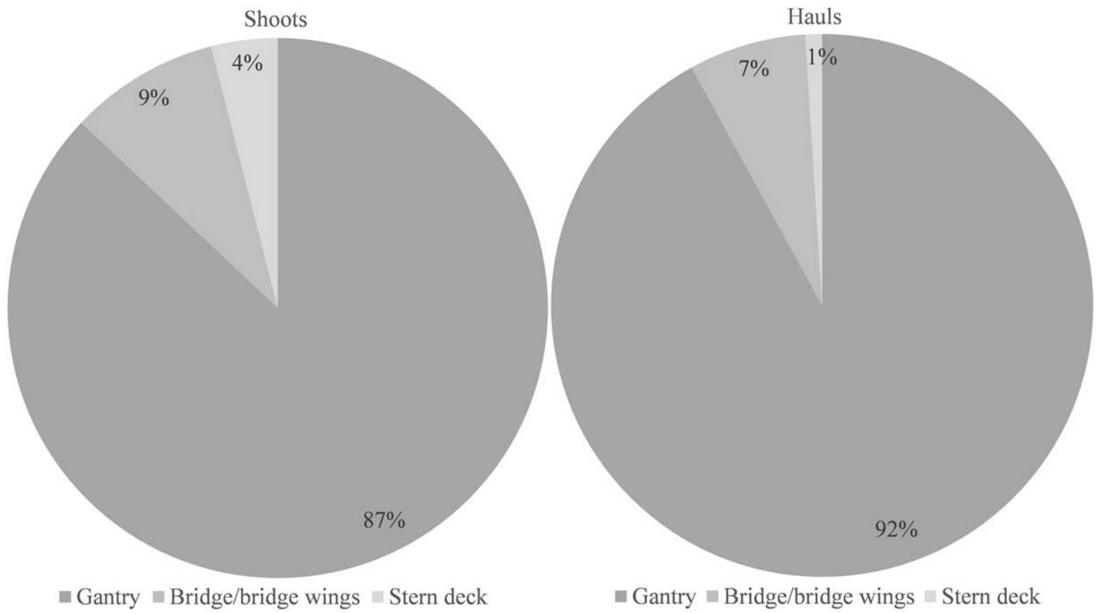

Fig.1. MMO position in manoeuvres.

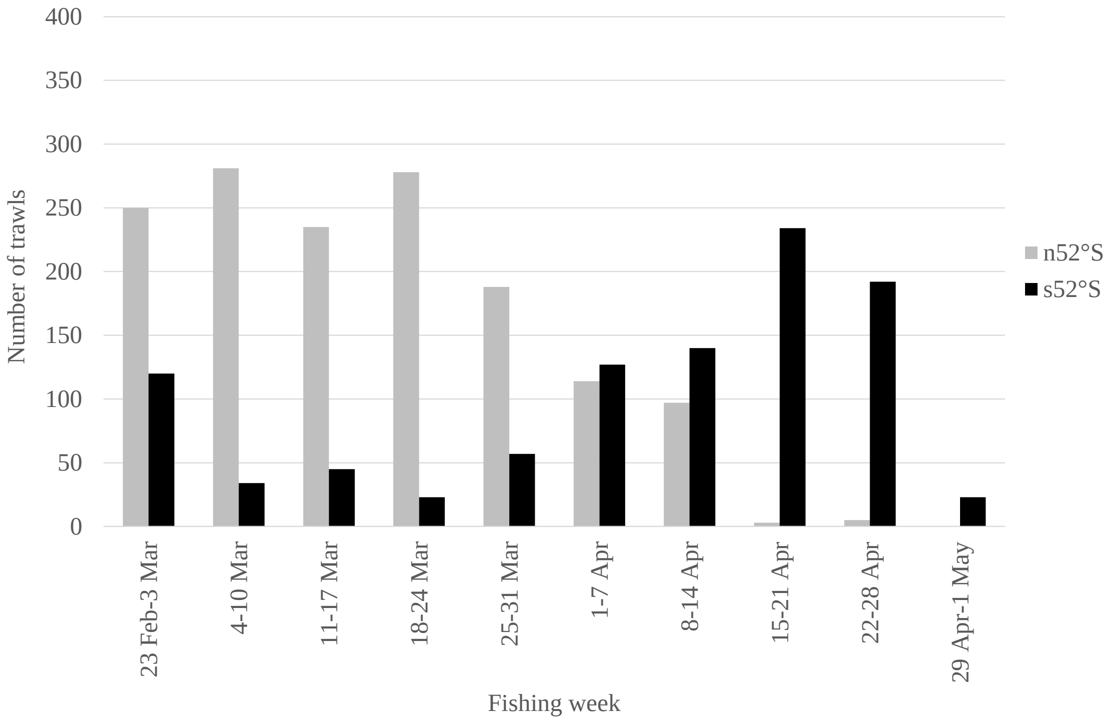

Fig.2. Fishing effort north and south of 52°S.

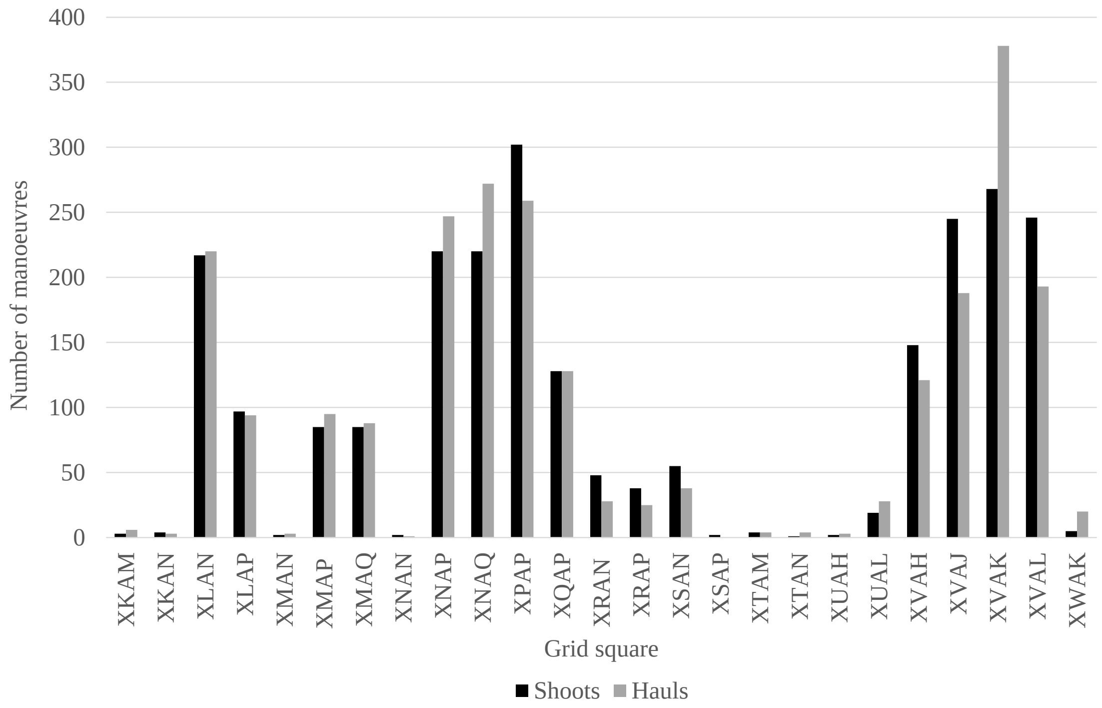

Fig.3. Fishing effort per grid square.

4.2 Pinniped sightings

A total of 3758 seals [3079 ARA, 647 OTB, 32 unknown species (UN)] were seen attending vessels. Eighty-five percent of the interactions occurred south of 52ºS (Table 1), particularly in grid squares XVAK (27%), XVAL (24%), and XVAJ (18%) (Fig.4), with ARA representing 82% of the sightings (Table 1).

Similar to season 2021-C, overall pinniped attendance to vessels increased throughout the season, reaching a peak during week 8 (15-21 Apr) (Fig.5).

Table 1. Pinniped interactions per region.

Region	Species	N° sighted	SED escapees	Deck releases	Mortalities	Total
North 52° S	OTB	513	0	0	1(+1)	514
	ARA	23	0	0	0	23
	UN	18	0	0	0	18
	MIL	0	0	0	1	1
Sub-total north		***554***	***0***	***0***	***3***	***556***
South 52° S	OTB	130	2	0	2	134
	ARA	3043	10	2	1	3056
	UN	13	1	0	0	14
Sub-total south		***3186***	***13***	***2***	***3***	***3204***
TOTAL		**3740**	**13**	**2**	**6**	**3760**

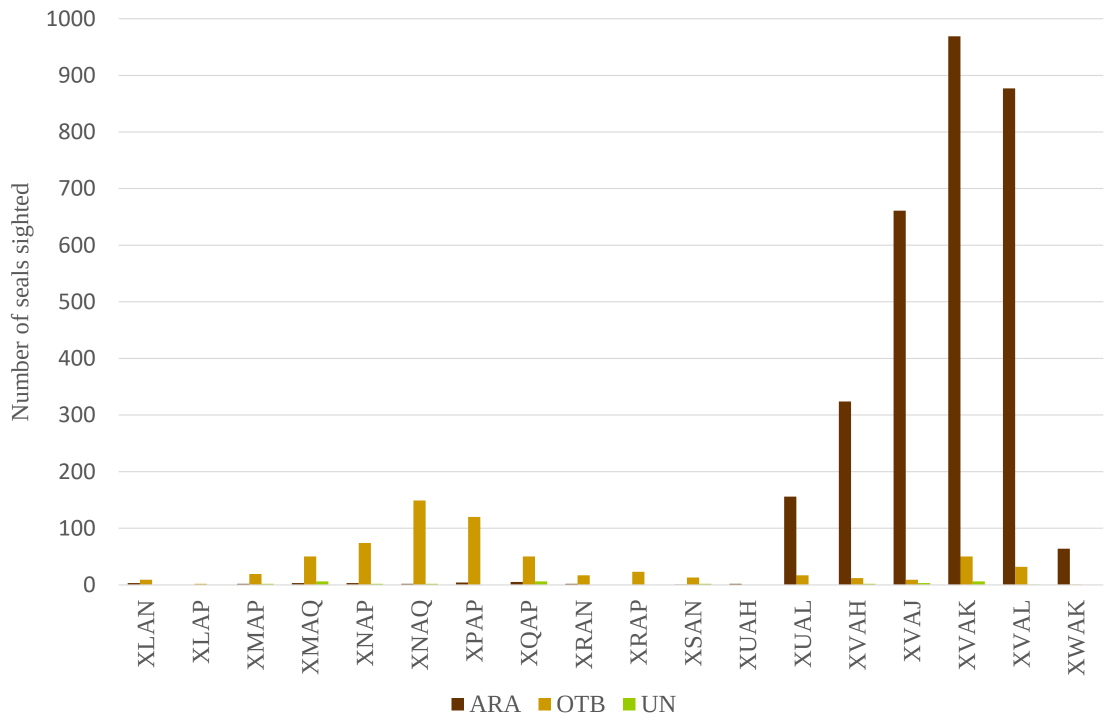

Fig.4. Pinniped sightings per grid square.

4.2.1 Pinniped attendance to vessels and behaviour

Of the 3758 seals sighted, 2415 (1901 ARA, 496 OTB, 18 UN) were observed during hauling, comprising 64% of the individuals recorded. The remaining individuals (1343) were seen during shooting (12%), trawling (14%), turning (7%) and steaming (3%). In 92% of the hauling attendance, seal behaviour was strictly related to foraging (cover photo), with both ARA and OTB directly targeting lost catch around the fishing gear (62%) and eating from the net (30%) (Fig.6). In the remaining vessel manoeuvres, the most common pinniped behaviour was to follow the vessel (52%), swim astern (19%), forage around the net (8%), and forage in the discard chute area (9%) (Fig.7). The presence of seals directly eating from the discard chute (2%) was related to correct tank discharges during steaming and trawling (Fig.7).

4.3 *Pinniped bycatch and SED implementation*

Although most of the fishing effort occurred north of 52°S (Fig.2), bycatch concentrated south of 52°S (90%), particularly around Beauchêne Island, in grid squares XVAK (35%), XVAL (20%), XVAJ (20%), and XUAL (10%) (Fig.8). A total of 20 seals were bycaught, of which 13 were seen escaping through the SED during hauling (10 ARA, 2 OTB, 1 UN), two ARA were safely released from deck, and 6 [1 ARA, 2 male OTB, 1 OTB lactating female (pup ashore), 1 MIL) comprised incidental mortalities (Fig.8; Table 2). SED implementation north of 52°S took place on 26/02 at 13:18 (fishing day 4) after the mortality of the female OTB and the MIL. SED implementation south of 52°S occurred on 03/03 (fishing day 9) at 21:12, following the opening of the southern fishing grounds on 02/03 and triggered by the two male OTB mortalities.

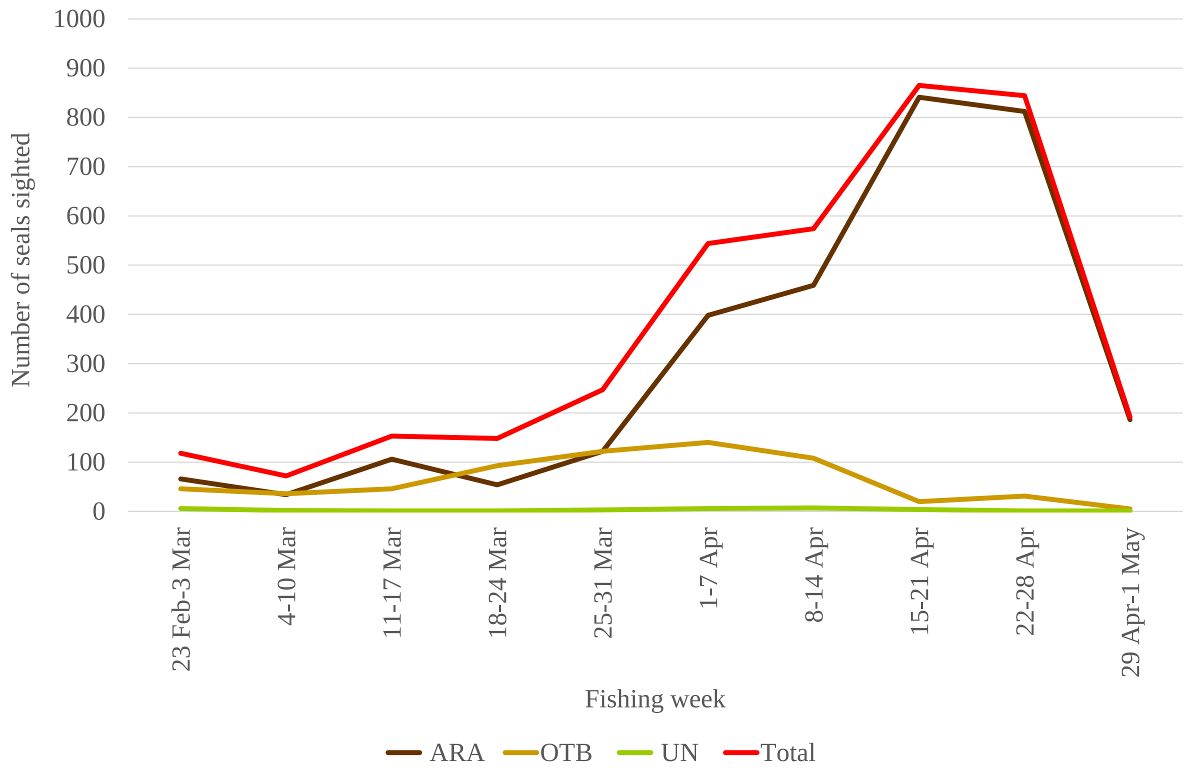

Fig.5. Cumulative pinniped sightings per fishing week.

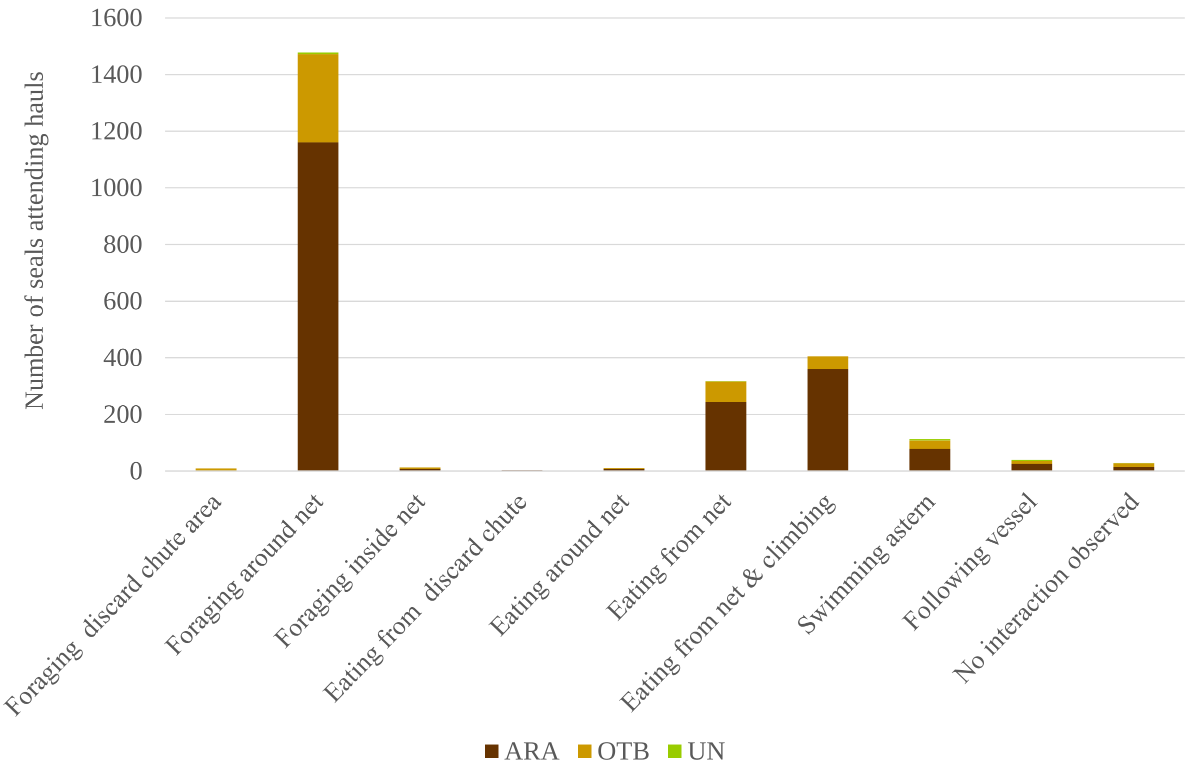

Fig.6. Pinniped behaviour exhibited during hauling.

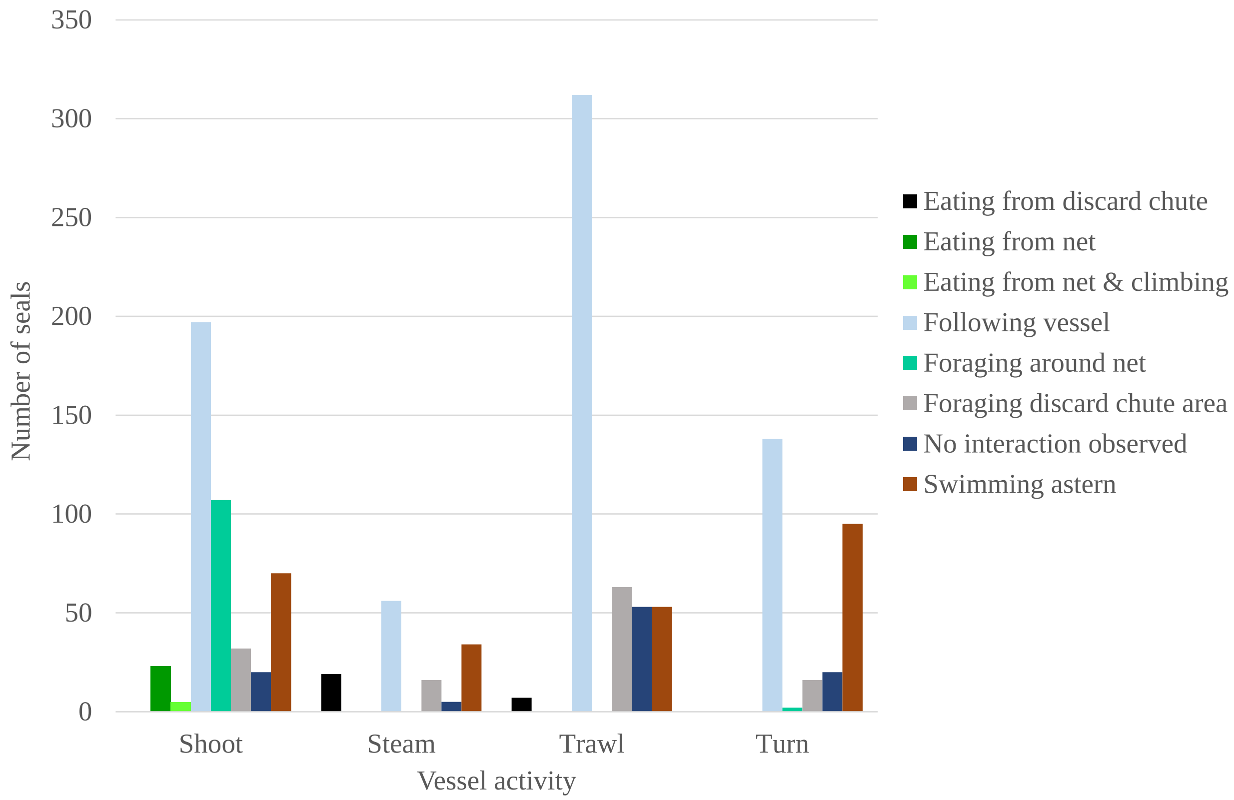

Fig.7. Pinniped behaviour exhibited during vessel manoeuvres.

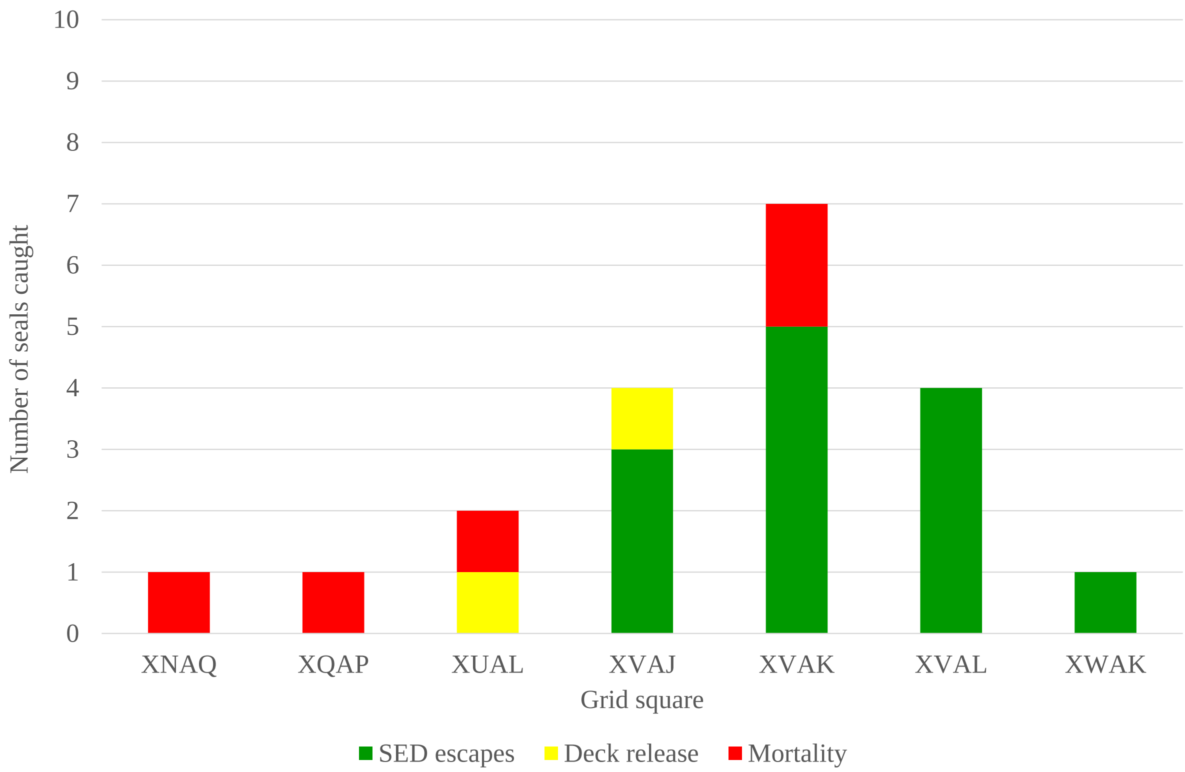

Fig.8. Pinniped bycatch per grid square.

4.3.1 *Incidental mortalities*

Eighty percent of the pinniped mortalities comprised drownings associated to the absence of a SED fitted in the net [OTB: 2 adult males, 1 lactating female (pup ashore); MIL: 1 male yearling], whilst after SED implementation in the whole fishing area one adult male ARA mortality occurred, presumably during a turn (Table 2). Drowning of seals in trawls fitted with a SED is usually correlated to the loss of tension of the net during manoeuvres, which results in the blockage of the escape path towards the SED. This can be exacerbated in manoeuvres carried out in rough weather conditions south of 52°S (Iriarte, 2022).

Table 2. Pinniped incidental mortalities

Date	SED	Grid	Beauf.	Trawl (min)	#Turns	Spp.	#Mort.	Cause mort.	Comments
24/02/22	N	XQAP	3	455	0	OTB	1 (+1)	D/CbyN	FC; PKH; LF
26/02/22	N	XPAP/XNAQ	2	265	0	MIL	1	D/CbyN	FC; PKTr; JM
02/03/22	N	XVAK	2	140	1	OTB	1	D	FC; RM; PKS/PKT; AM
03/03/22	N	XVAJ	4	450	1	OTB	1	D	FC; RM; PKS; AM
07/04/22	Y	XUAL	6	480	1	ARA	1	D	FC; RM; PKT (12 ARA seen); AM

D=drowned; D/CbyN=drowned/confirmed by necropsy; FC=fresh carcass; PKH=presumably killed in haul; LF= lactating female; PKTr= presumably killed during trawling; JM= juvenile male; RM=*rigor mortis*; PKS=presumably killed in shoot; PKT=presumably killed on a turn; AM=adult male.

4.3.2 *SED escapees and live deck releases*

During hauling 11 ARA, one OTB and one UN were seen escaping from the fishing gear through the SED hatch (cover photo). The number of individuals that escaped when the SED was below the surface during both shooting and hauling remains unknown.

Regarding deck releases, 2 ARA were brought aboard inside the SED net extension and were safely released from deck after cutting the net.

4.3.3 *Necropsies*

Following the mortality of the female OTB and the juvenile MIL, observers were asked to preserve their carcasses for post-mortem examination (Table 2). Necropsies were carried out by a team of four DoNR professionals, which included one Scientific Fisheries Observer (R. Nicholls), one Fishery Scientist (Z. Shcherbich), a Veterinary Officer (P. van der Riet), and the Seabird and Marine Mammal Scientific Officer (V. Iriarte). Upon examination of the Respiratory System of the individuals, it was confirmed that the cause of mortality was drowning (Table 2).

4.4 *Seabird bycatch*

A total of 207 seabird interactions were recorded throughout the season, of which 67 (32%) comprised entanglements in bird scaring lines, 66 (32%) warp cable heavy hits/entanglements recorded during trawling, 32 (15%) net entanglements, 23 (11%) landings on deck, 11 (5%) collisions with either FAA booms (6 individuals) or the vessel itself (5), and 8 (4%) SED entanglements (Fig.9). The outcome of these interactions was 25 (12%) mortalities, 148 (71%) live escapes and 34 (16%) live releases (Fig. 10).

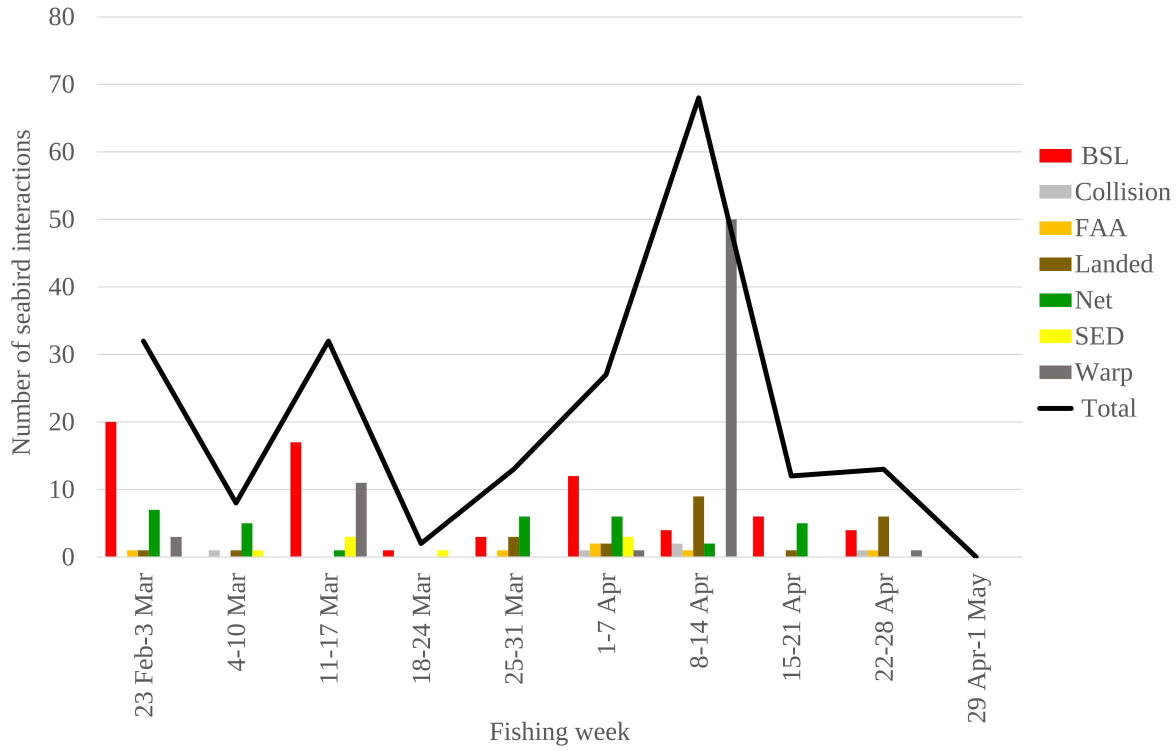

Fig.9. Number and type of seabird interactions recorded per fishing week.

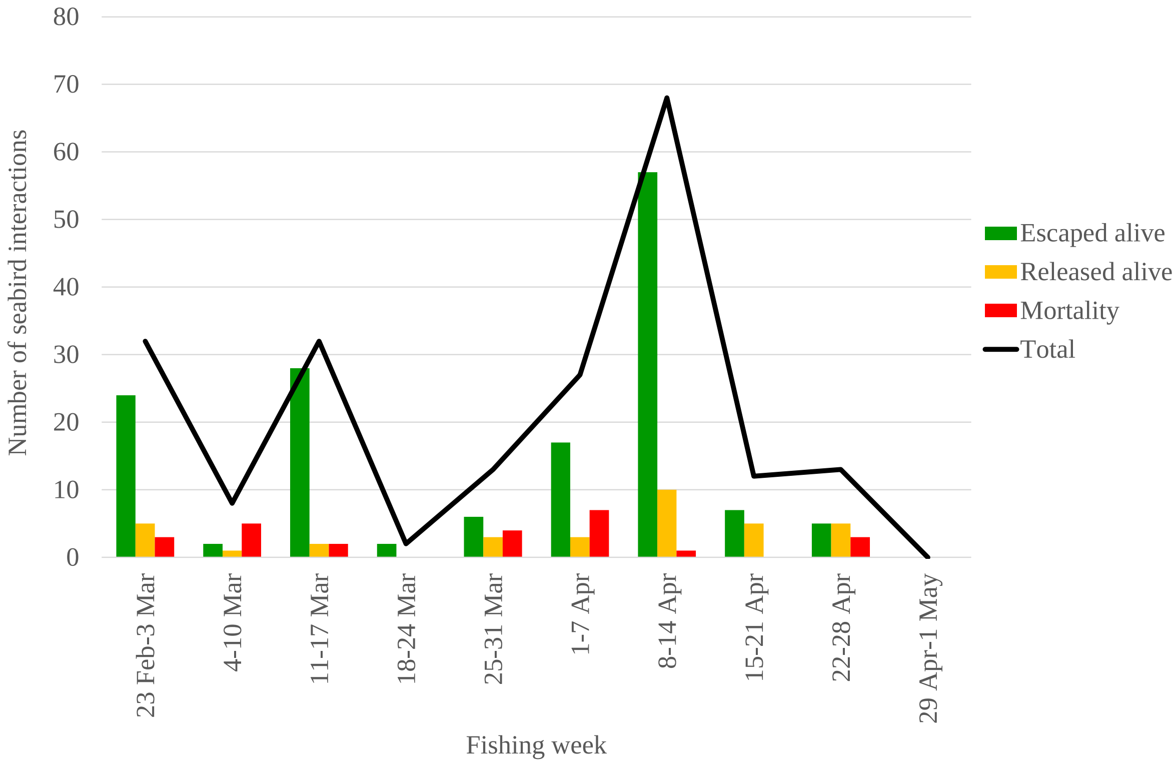

Fig.10. Outcome of the seabird interactions recorded per fishing week.

Of the 32 net entanglements observed, 28 comprised ACAP species (22 DIM, 5 PRO, 1 MAX). Fifty-seven percent of the entanglements occurred in 400 mm mesh size located in either the mouth of the net (25%) or net wings (32%). These were followed by entanglements in 200 mm mesh (18%) located either in the mouth (11%) or body (7%) of the net (Fig.11).

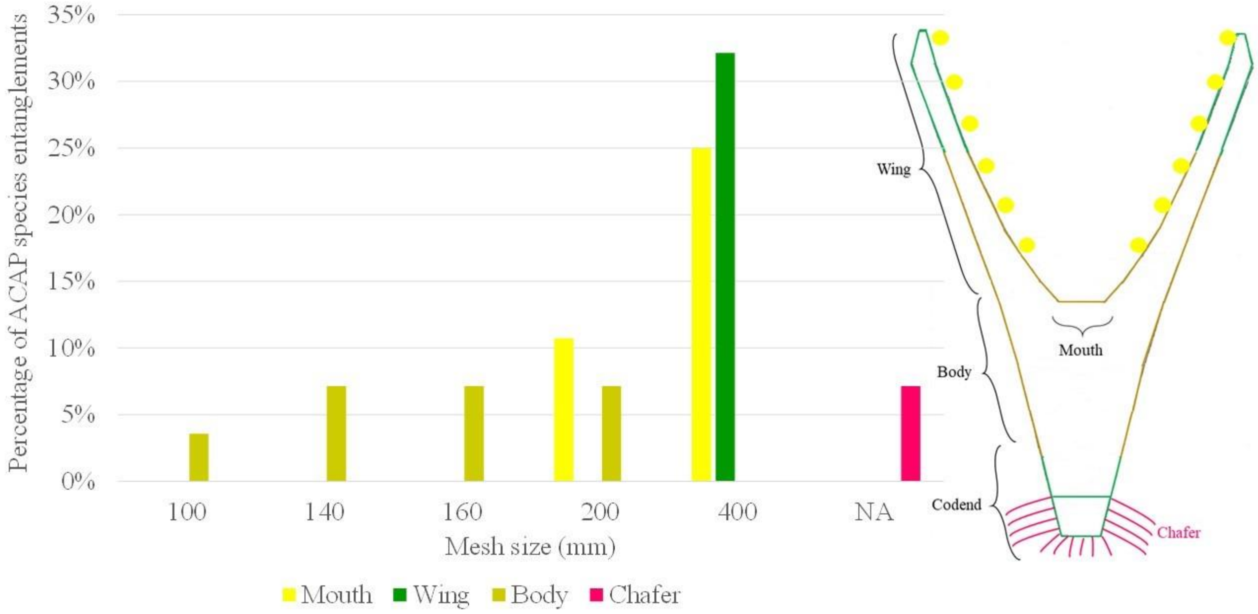

Fig.11. Percentage and location of ACAP species net entanglements. Net plan diagram sectors not to scale.

Eighty-three percent of the interactions were recorded south of 52ºS, particularly in grid squares XVAK (29%), XVAL (39%), XVAJ (8%) (Fig.12).

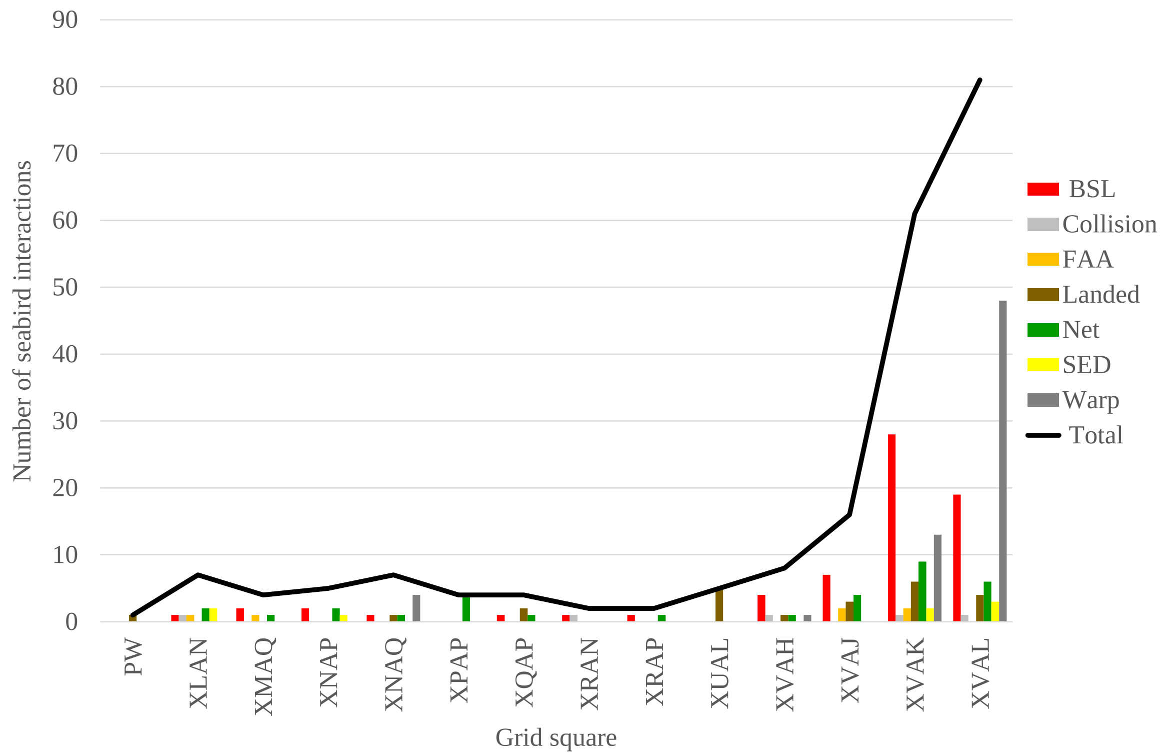

Fig.12. Number and type of seabird interactions recorded per grid square. PW= Port William.

4.4.1 *Live interactions*

Live interactions of ACAP species included 162 individuals (153 DIM, 3 DIC, 4 PRO, 2 MAX) and were mostly recorded during hauling (48%), trawling (44%), and shooting (7%) (Fig.13).

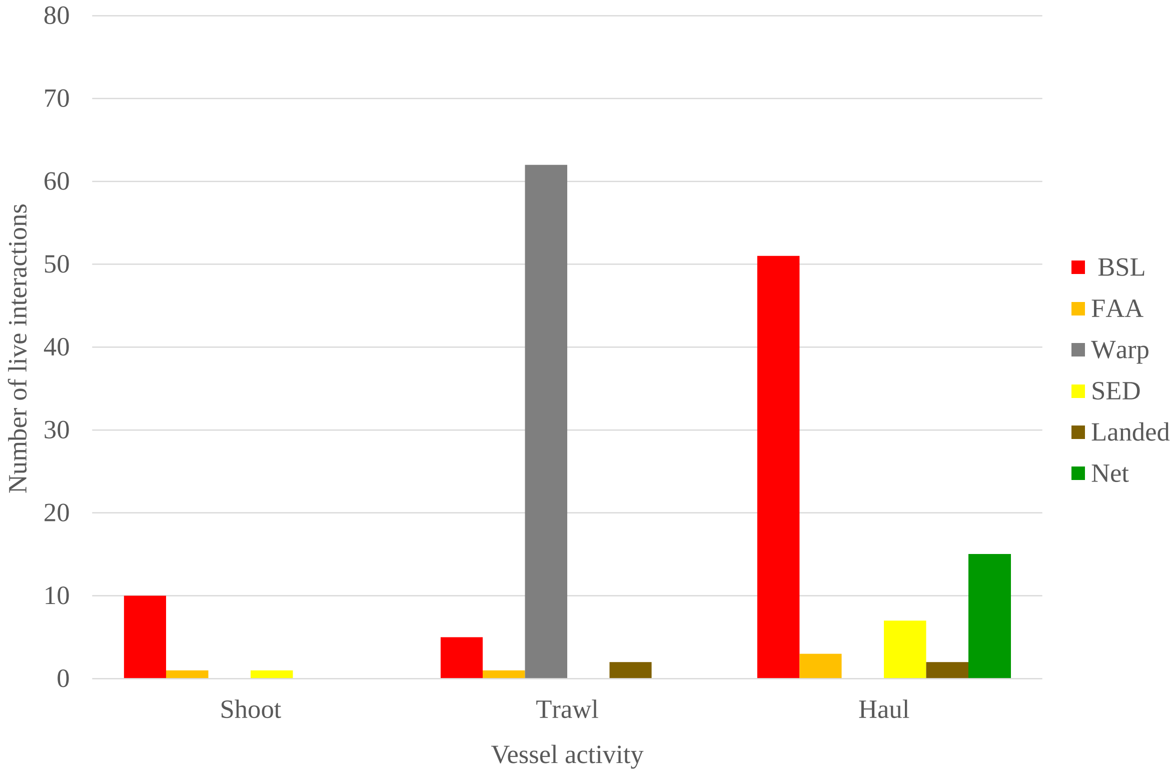

Fig.13. Number and type of live interactions of ACAP species.

Of the 78 interactions observed during hauling, 51 (65%) comprised BSL entanglements (50 DIM, 1 DIC) of individuals which escaped by themselves alive, however post-survival of 9 DIM could have been affected by severe entanglements in highly greasy streamers observed in one of the vessels (Fig.14). It is important to stress that inadequate maintenance and repairing of the streamers increase the probability of seabird entanglements and their survival (Fig.14).

The rest of the ACAP species live interactions observed during hauling comprised 15 (19%) net entanglements, 7 (9%) SED entering, 3 (4%) FAA collisions, and 2 (3%) deck landings. Of these, 15 individuals (10 net, 2 SED, 2 deck, 1 BSL) were rescued by crew and safely released by the MMO, whilst the remaining individuals managed to escape by themselves.

Seventy interactions were recorded during trawling (i.e. during BSL monitoring), which included 62 (89%) warp cable heavy strikes, 5 (7%) BSL entanglements, 2 (3%) landings on deck and 1 (1%) FAA collision (Fig.13).

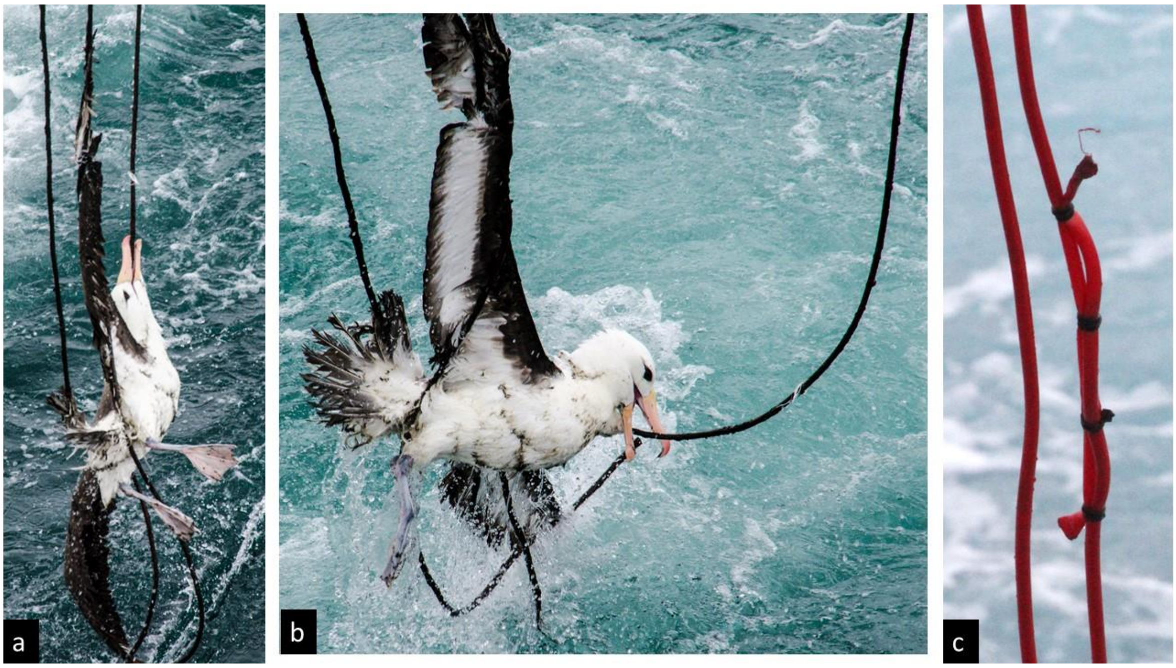

Fig.14. BSL inadequate maintenance and repairing. (a, b) DIM entangled in streamers fully covered in warp grease. Note feather damage and possible wing injure. (c) Streamer with an improper patch; irregularities increase the risk of seabird entanglement.

The unconventional high number of warp heavy strikes observed corresponds to DIM being hit by exposed warp cables on three vessels releasing high quantities of organic material. Of these, 48 took place on a single vessel, whenever a mesh filter on the factory floor lifted up and whole squid was released via the factory pumps (Fig.15). Due the high concentration of foraging albatrosses, it is unknown if any incidental mortality occurred on this occasion. It is important to mention that on this vessel FAA booms are not long enough and warp cables remain constantly exposed distally.

Although on these three vessels the problems were resolved as soon as the observer communicated the issue to the captain, FAA modification and the installation of grinding pumps with fixed filters are needed on the vessel with the highest -and chronic- interactions. In addition, on a second vessel twelve warp hits occurred when whole fish and squid were released through the factory pumps -presumably due problems with factory pump filters; two warp hits were recorded on a third vessel due a discard tank leak.

Live interactions recorded during shooting comprised 10 BSL entanglements (80%), 1 FAA collision, and 1 SED entering (Fig.13).

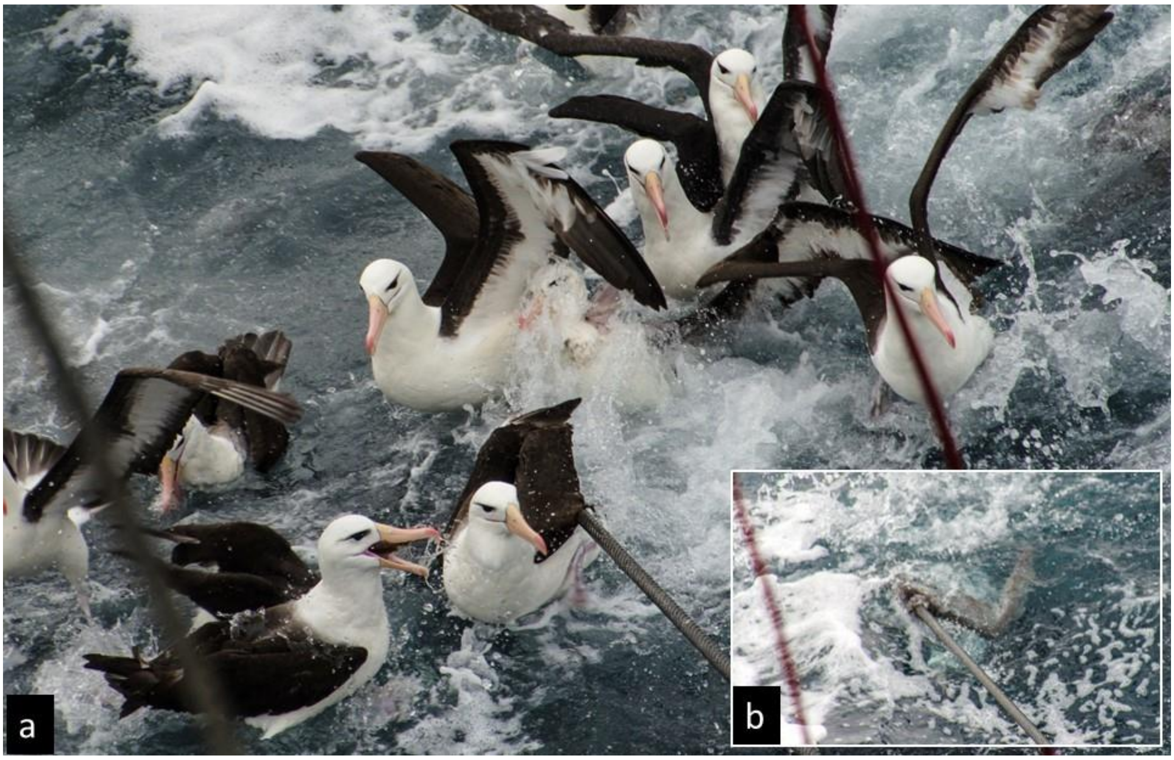

Fig.15. Foraging DIM around an exposed warp cable. (a) The two birds on the bottom left have LOL inside their beaks, one albatross is under the warp, whilst the individual within the splashing water has chest feathers covered in warp grease. (b) Individual being dragged down by the warp cable.

4.4.2 *Incidental mortalities*

A total of 25 seabird mortalities were recorded, of which 20 comprised ACAP vulnerable species (16 DIM, 2 MAX, 2 PRO); the remaining included 4 OCO and 1 GAN (Table 3). Fifty-six percent of ACAP species mortality occurred south of 52°S, in grid squares XVAK (20%), XVAL (16%), XVAJ (12%) and XVAH (8%) (Fig.16). In the north, mortalities were recorded in grid squares XLAN (12%), XNAQ (12%), XPAP (8%), XRAN (8%) and XMAQ (4%) (Table 3, Fig.16).

Table 3. Seabird incidental mortalities.

Date	M	Grid	Spp.	#Indiv.	Int.	Ns	Ms	S	Date	M	Grid	Spp	#Indiv.	Int	Ns	Ms	S
23/02/22	H	XRAN	MAX	1	BSL	NA	NA	N	28/03/22	Sh	XVAK	DIM	1	Net	Bo	140	Y
26/02/22	H	XNAQ	DIM	1	Warp	NA	NA	Y	30/03/22	Sh	XVAJ	DIM	1	Net	Ch	NA	Y
26/02/22	H	XPAP	DIM	1	Net	Ch	NA	N	01/04/22	Sh	XVAL	DIM	2	Net	Wi	400	Y
04/03/22	Sh	XVAL	DIM	1	Net	Mo	400	Y	01/04/22	Sh	XVAK	DIM	1	Net	Bo	140	N
06/03/22	H	XMAQ	OCO	1	Net	UN	UN	N	03/04/22	Sh	XVAJ	OCO	1	Net	UN	UN	N
07/03/22	T	XLAN	OCO	1	Col	NA	NA	N	04/04/22	H	XVAK	DIM	1	Net	Bo	160	Y
08/03/22	Sh	XLAN	PRO	1	Net	Wi	400	Y	04/04/22	T	XRAN	MAX	1	Col	NA	NA	Y
08/03/22	Sh	XLAN	DIM	1	Net	Wi	400	Y	06/04/22	T	XNAQ	DIM	1	Warp	NA	NA	N
12/03/22	H	XNAP	DIM	1	Net	Mo	400	Y	10/04/22	Sh	XVAK	GAN	1	Col	NA	NA	N
15/03/22	T	XVAK	DIM	1	Warp	NA	NA	Y	23/04/22	H	XVAJ	DIM	1	FAA	NA	NA	N
25/03/22	Sh	XVAL	DIM	1	Net	Mo	400	Y	24/04/22	T	XVAH	DIM	1	Warp	NA	NA	N
25/03/22	Sh	XPAP	PRO	1	Net	Bo	100	Y	28/04/22	T	XVAH	OCO	1	Col	NA	NA	Y

M=manoeuvre; Int=interaction; Ns=net sector; Ms=mesh size (mm); S=sampled.
H=haul; Sh=shoot; T=trawl; NA=not applicable; UN=unknown; Ch=chafer; Mo=mouth; Wi=wing; Bo=body; Col=collision.

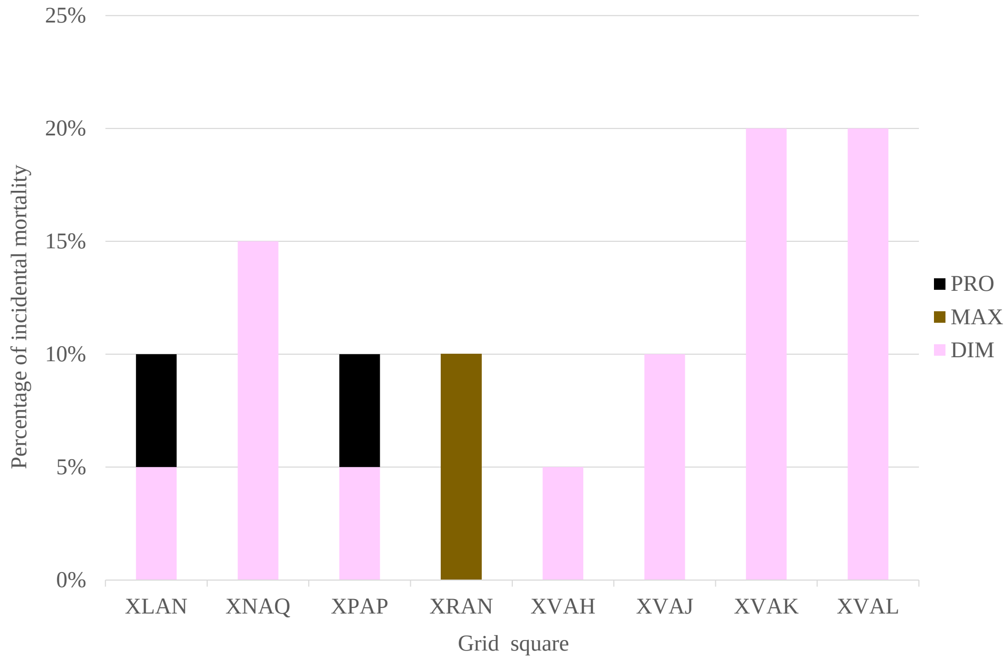

Fig.16. Percentage of ACAP species incidental mortality per grid square.

The cause of mortality were net entanglements (65%), warp cable strikes/entanglements (20%), collision with FAA booms (5%), entanglements in FAA streamers (5%) and vessel collisions (5%) (Table 3, Fig.17).

Net mortality of ACAP species included 13 individuals (11 DIM, 2 PRO) and mostly took place during shooting (77%). Fifty-four percent of the mortalities occurred in 400 mm mesh in the mouth and net wings (Fig.18). The remaining mortalities were recorded either in the body of the net [mesh sizes: 160 mm (8%), 140 mm (15%), 100 mm (8%)] or codend's chafer (15%), the latter with the seabirds presumably entangling in attached jigging lures (Fig.18).

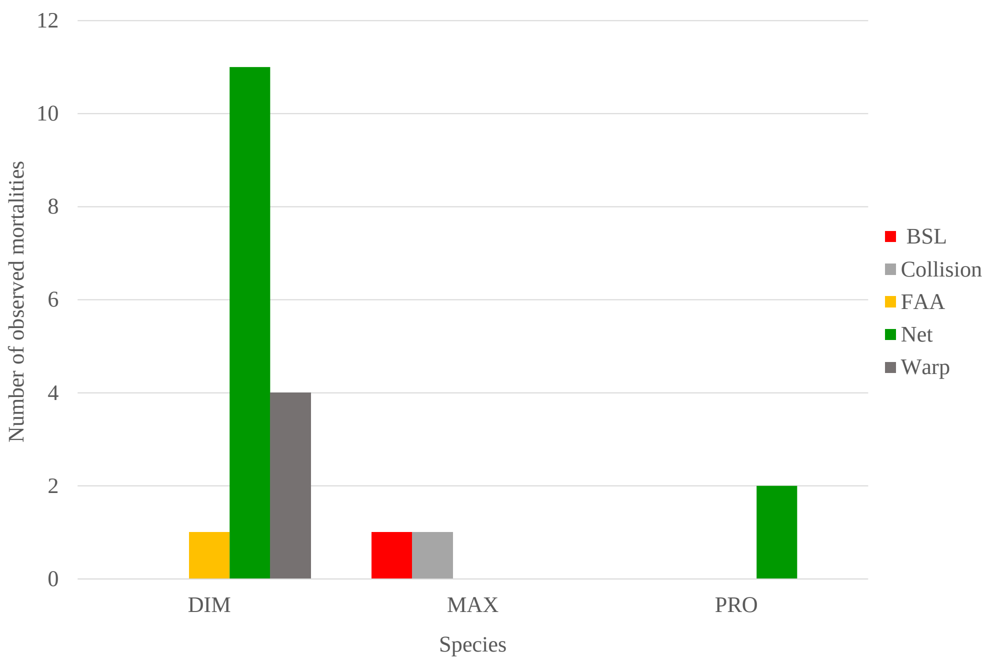

Fig.17. ACAP species cause of mortality.

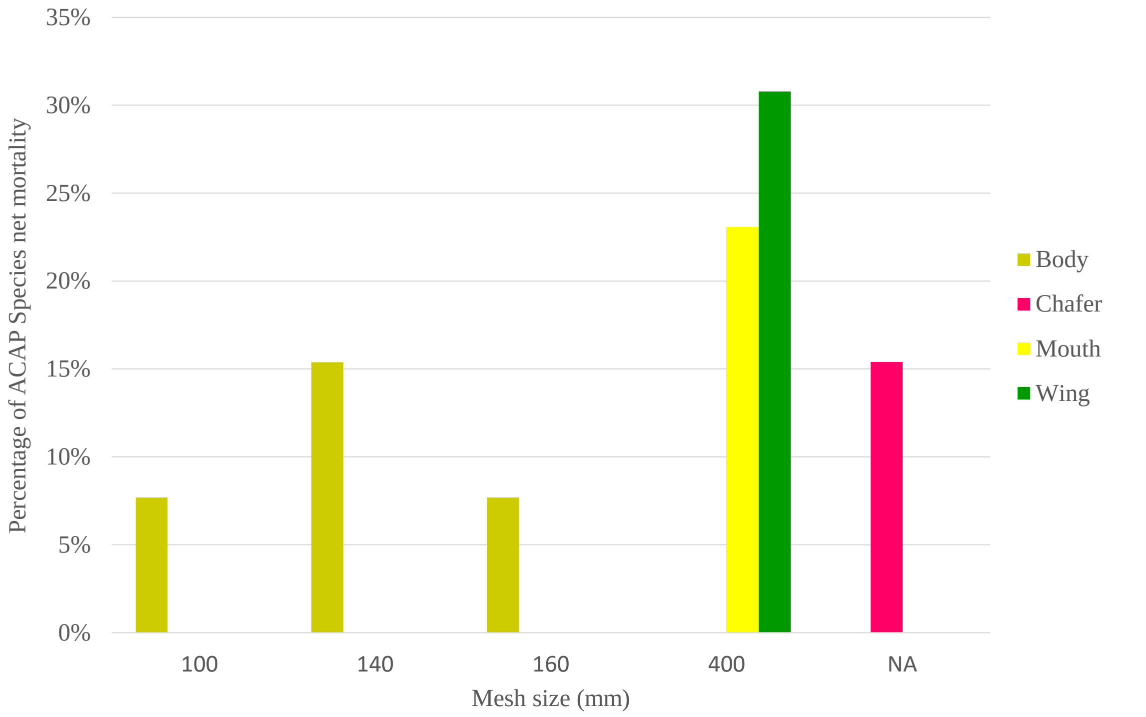

Fig.18. Percentage and location of ACAP species net mortality.

Of the overall ACAP species mortality, 50% was recorded within fishing weeks 5 and 6 (25 Mar-7 Apr) (Fig.19), which coincides with the transfer of the fishing effort to south of 52°S (Fig.2). ACAP species mortality was observed during shooting (50%), hauling (25%), and trawling (25%) (Table 3).

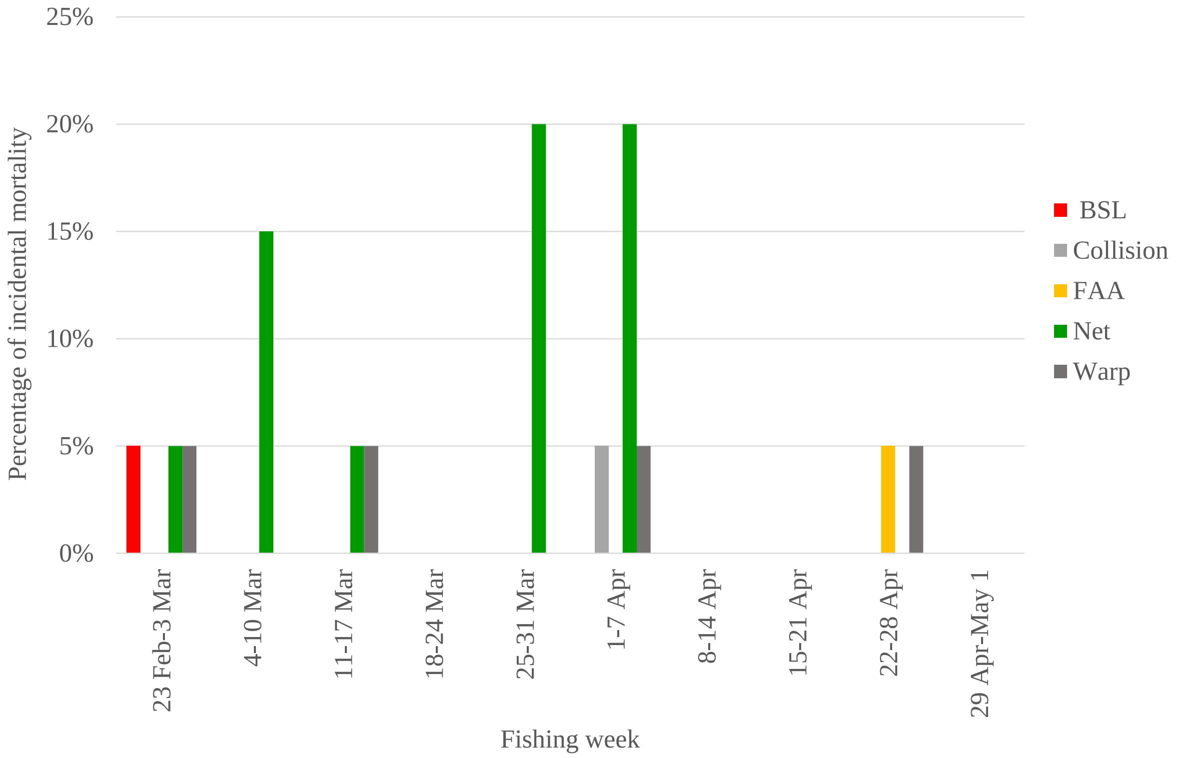

Fig.19. Percentage and type of ACAP species mortality per fishing week.

4.4.3 *Seabird necropsies*

In addition to the 25 incidental mortalities recorded during the fishing season, 2 DIM net mortalities occurred during the pre-recruitment survey (Table 4). Overall, 17 carcasses were collected and preserved (13 DIM, 1 MAX, 2 PRO, 1 OCO), with necropsies performed on 13 individuals (11 DIM, 1 MAX, 1 PRO; Table 4). Of the DIM, all were recruited (i.e. > 5 years-old), being 6 female and 5 males (Table 4).

Table 4. Collected seabird carcasses and post-mortem examination performed.

Date	Grid	M	Spp.	Int.	Sex	Age	BP	RS
11/02/22	XTAM	Shoot	DIM	Net	F	5+	Gr	BA
11/02/22	XTAM	Shoot	DIM	Net	NA	NA	NA	PN
26/02/22	XNAP/XNAQ	Trawl	DIM	Warp	F	5+	Gr	BA
04/03/22	XVAL	Shoot	DIM	Net	M	5+	Gr	BA
08/03/22	XLAN	Shoot	PRO	Net	UN	UN	UN	Lv; PN
08/03/22	XLAN	Shoot	DIM	Net	UN	UN	UN	Lv; PN
12/03/22	XNAQ	Haul	DIM	Net	F	5+	No	UN
15/03/22	XVAK	Trawl	DIM	Warp	M	5+	No	UN
25/03/22	XVAL	Shoot	DIM	Net	F	5+	No	UN
25/03/22	XPAP	Shoot	PRO	Net	M	UN	No	UN
28/03/22	XVAK	Shoot	DIM	Net	5+	M	No	UN
30/03/22	XVAJ	Shoot	DIM	Net	F	5+	No	UN
01/04/22	XVAL	Shoot	DIM	Net	F	5+	No	UN
01/04/22	XVAL	Shoot	DIM	Net	M	5+	Gr	BA
04/04/22	XVAK	Haul	DIM	Net	M	5+	No	UN
04/04/22	XQAP/XRAP	Trawl	MAX	Col	F	UN	No	UN
28/04/22	XVAH	Trawl	OCO	Col	UN	UN	UN	PN

M=manoeuvre; Int=interaction; BP=brood patch; RS=reproductive status.
Col=collision; NA=not applicable; UN=unknown; Gr=growing; BA=breeding adult; PN=pending necropsy; Lv=left on vessel.

5. Conclusions

5.1. Data collected by MMOs evidence high standards in bycatch mitigation measures and good practices among the fleet.

5.2. Subsequent to the trend recorded in the last two years, seal attendance to vessels increased by 33%, whilst SED implementation date reduced in 18 days. In addition, the number of observed SED escapes increased by 116%. Consequently -and following the Recommendation Paper from the Scientific Section dated on 16 November 2020 regarding compulsory SED usage in the second fishing season-, from 2023 onwards it is also recommended SED compulsory use from the beginning of the first season.

5.3. In the first season seal incidental mortalities in trawls fitted with a SED continues to be stable and related to turns. However, the 2100% post-SED mortality increase from 2020-X to 2021-X evidenced the performance of turns in areas of high pinniped abundance seriously limits the possibility of seals to reach the SED. Consequently, the performance of turns and unnecessary manoeuvres (i.e. short trials of new gear) south of 52°S should be limited.

5.4. In comparison to 2021-C, seabird interactions increased by 22%, with DIM live escapes reaching an 85% rise, whilst their mortality reduced by 77%. This steep decrease in DIM mortality is probably a result of the fishery restrictions near Beauchêne Island during the DIM fledging period.

5.5. Modernization of the fleet and the use or more efficient trawl materials has made mesh size in the mouth and net wings to evolve from 120-140 mm to 400-600 mm, allowing more successful catches (FIFD, *unpublished data*). However, since 2017 seabird net mortality has increased over 600% and is mostly related to entanglements in 400 mm meshes located in the mouth and net wings. Taking into account the cryptic characteristic of bycatch, the explosive increase in observed net mortalities, and the reproductive state of the killed albatrosses, it is necessary to discuss the future implementation of new adaptive management measures to reduce the overlap of the fishery with Beauchêne's DIM population, particularly during the chick fledging and egg laying periods, whenever their energetic requirements are higher.

5.5. Accidents in discard management and failure to comply with BSL maintenance of a single vessel can have a huge impact in seabird agonistic interactions. It is recommended all vessels install grinding pumps in the factory floor; fix the mesh filters; carry out proper maintenance of BSL, and use the MMO reports as a reference to improve their good practices for seabird and marine mammal bycatch mitigation.

6. References

Iriarte V., Pompert J. (2016). Pinniped bycatch report: squid and finfish trawlers. Preliminary information on the bycatch of pinnipeds in the Falkland Islands. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 13 pp.

Iriarte, V. (2022). LOL 2021-X MMO Monitoring Report. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 19 pp.

Iriarte V., Arkhipkin A., Blake D. (20200. Implementation of exclusion devices to mitigate seal (*Arctocephalus australis*, *Otaria flavescens*) incidental mortalities during bottom-trawling in the Falkland Islands (Southwest Atlantic). Fish Res, DOI: 10.1016/j.fishres.2020.105537.

Kuepfer A. (2016a). Requirements for the use of a fixed aerial array in the Falkland Islands trawl fishery. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 3 pp.

Kuepfer A. (2016b). *Loligo* pre-recruitment survey, February 2016 –seabird observations. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 7 pp.

Kuepfer A. (2017). Requirements for the use of a fixed aerial array in the Falkland Islands trawl fishery. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 3 pp.

Kuepfer A. (2018). Guidelines for the fixed aerial array in the Falkland Islands trawl fishery. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 9 pp.

Parker G. (2012). A possible new bird scaring method for trawl fisheries. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands. 15 pp.

Parker G., Crofts S., Pompert J., Wolfaardt A. (2013a). In the wake of a factory trawler: research into undetected seabird mortality. Fisheries Department, Directorate of Natural Resources, Falkland Islands Government, Stanley, Falkland Islands, 25 pp.

Parker G., Brickle P., Wolfaardt A., Pompert J. (2013b). Early results from trials of bird scaring lines (BSLs) attached to 14 m booms on a demersal trawler. ACAP research paper, 10 pp. https://acap.aq/documents/working-groups/seabird-bycatch-working-group/seabird-bycatch-wg-meeting-5/2037-sbwg5-doc-08-early-results-from-trials-of-bird-scaring-lines-bsls-attached-to-14-m-booms-on-a-demersal-trawler/file

Prince P.A., Rodwell S.P. (1994). Ageing immature black-browed and grey-headed albatrosses using moult, bill and plumage characteristics. Emu. (94): 246-254.

Snell K.R.S., Brickle P., Wolfaardt A.C. (2012). Refining Tori lines to further reduce seabird mortality associated with demersal trawlers in the South Atlantic. Polar Biol. (35): 677-687.

Sullivan B.J., Brickle P., Reid T.A., Bone D.G., Middleton D.A.J. (2006). Mitigation of seabird mortality on factory trawlers: trials of three devices to reduce warp cable strikes. Polar Biol. (29): 745-753.