An assessment of seabird by-catch in Falkland Islands trawl fisheries

July 2016 to June 2017

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SUMMARY

This report estimates the minimum number of incidental seabird mortalities in the trawl fisheries in Falkland Island waters from **1 July 2016 to 30 June 2017**. Estimates are based on an extrapolation approach.

Over **3%** seabird interactions observer coverage was achieved in the finfish, skate, and for the first time, in the Falkland calamari fleet. Over the course of the reporting period, a total of 55 mortalities of high-risk[1] species were recorded in the commercial fishery inside the Falkland Islands fishing zones. An additional four mortalities of high-risk species were recorded during the *loligo* pre-recruitment survey. The mortalities comprised 54 black-browed albatrosses (*Thalassarche melanophris*, IUCN Red-list status *Least Concern*), three giant petrels (*Macronectes giganteus*, IUCN Red-list status *Least Concern*) and two grey-headed albatrosses (*Thalassarche chrysostoma,* IUCN Red-list status *Endangered*). The vast majority of mortalities were related to warp interactions (79.7%), with the remaining contacts being related to net (11.9%), bird-scaring lines (BSL) (6.8%) and vessel collisions (1.7%). Additional mortalities of high-risk species were recorded in international waters to the north of the Falkland Islands EEZ (five black-browed albatrosses as a result of warp cable interactions).

Based on the mortalities recorded in Falkland Islands waters, the estimated annual mortality of high-risk species in the Falkland Islands trawl fleet amounted to **1430** individuals using a conservative and straight extrapolation approach. This value represents the second highest annual seabird mortality estimate for the Falkland Islands trawl fleet as a whole since the introduction of the BSL. If the data is stratified by season and area, the estimate lies at **1188**. This stratified estimate may be more accurate, but relies on adequate observer coverage in all 30 strata used. Furthermore, this year an estimated 173 contacts of unknown fates occurred, which extrapolates to a total of **4,431** of potential additional mortalities**.**

The relatively high level of mortality experienced this year may in parts be related to poor foraging conditions experienced over the past two years, which may affect how birds interact with fishing vessels. Despite the recent downlisting of black-browed albatross to IUCN *Least Concern*, the past two years saw a decreased number of breeding albatrosses in the Falkland Islands at annual monitoring sites. This highlights the importance of continued assessments and effective mitigation of anthropogenic threats, in order to help buffer against future deterioration of environmental conditions, and potentially the population.

The Falkland Islands fishery plays a leading role in seabird by-catch mitigation globally, and, in line with the Falkland Islands National Plan of Action-Trawlers, is committed to further reducing incidental catches in the fleet. Progress is being made in the development and implementation of discard management. Clear regulations and strategic education are important to ensure that the benefits of improved mitigation are maximised.

[1] High-risk species are defined as long-winged species that are at risk of injury or mortality resulting from heavy contacts with fishing gear, and species that are listed under ACAP (Agreement on the Conservation of Albatrosses and Petrels) http://www.acap.aq/en/acap-species/307-acap-species-list/file. In the Falkland Islands waters, these are predominantly black-browed albatross and giant petrel species, as well as grey-headed albatross, royal albatross species, wandering albatross and white-chinned petrel.

Contents

Glossary of acronyms

ACAP	Agreement on the Conservation of Albatrosses and Petrels
APP	Albatross and Petrel Programme
BSL	Bird Scaring Lines
CV	Coefficient of Variation
FAA	Fixed Aerial Array
FC	Falklands Conservation
FICZ	Falklands Interim Conservation and Management Zone
FOCZ	Falklands Outer Conservation Zone
FI	Falkland Islands
FIFD	Department of Natural resources - Fisheries
GLM	Generalised Linear Model
NPOA-T	National Plan of Action for Reducing Incidental Catches of Seabirds in Trawl Fisheries
SAST	Seabirds At Sea Team

1. Introduction

1.1. Background

Worldwide, the incidental by-catch of non-target species such as seabirds is a significant problem for fisheries management (Anderson et al. 2011; Løkkeborg 2011). For albatrosses, incidental by-catch in fisheries continues to be the biggest threat to many populations (ACAP 2018). Due to their life history traits of longevity, with delayed maturity and low fecundity, albatross and petrel species are particularly vulnerable (Brooke 2004; Cuthbert et al. 2004).

The Falkland Islands are an important feeding and breeding area for seabirds. The archipelago supports over 70% of the world's breeding population of black-browed albatross *Thalassarche melanophris* and 43% of the world's breeding population of Southern giant petrel *Macronectes giganteus* (Birdlife International 2016; Crofts & Stanworth 2017; Stanworth & Crofts 2017). The Falkland Islands marine ecosystems support large scale finfish, squid and skate fisheries, and foraging seabirds are known to interact with vessels in these fleets.

Following the introduction of mitigation measures in the Falkland longline fishery in 1994, attention turned to the trawler fleet. Discarding unwanted wholefish and offal from trawlers provides feeding opportunities for seabirds, attracting them to the vessels where they can fatally interact with the fishing gear. High levels of incidental seabird mortality as a result of this interaction were first recorded in the commercial finfish trawl fishing fleet in the early 2000s (Sullivan & Reid 2003). The main two seabird species affected by the Falkland Islands trawl fishery are black-browed albatross and, to a lesser extent, giant petrels (see previous mortality reports; Sullivan et al. 2006).

As a signatory to the Agreement for the Conservation of Albatross and Petrels (ACAP) since 2004, the Falkland Islands Government is part of a multilateral agreement which aims to conserve albatrosses and petrels by coordinating international activity to mitigate known

threats to albatross and petrel populations. In consequence, the Falkland Islands Fisheries Department (FIFD) adopted a National Plan of Action-Trawling (NPOA-T) in 2004, and introduced the mandatory use of Bird Scaring Lines (BSL) into the licence conditions (Sullivan 2004). The NPOA-T was updated in 2009 (Sancho 2009a) and again in 2014 (Quintin & Pompert 2014) with a clear four year strategy to strive towards the elimination (or negligible occurrences) of incidental seabird mortality in the trawl fishery.

1.2. Previous mortality assessments

The first incidental seabird mortality assessment in demersal trawlers fishing within the Falkland Islands' Conservation Zones (FICZ) was carried out in the finfish trawl fishery in 2002 and 2003, estimating a minimum of 1,529 seabirds killed, predominantly black-browed albatrosses (Sullivan et al. 2006). Following the introduction of BSL, an initial 90% reduction in incidental mortality was recorded in 2004-2005 in the finfish fishery (Reid & Edwards 2005) (Table 1). Further work from a collaborative project between FIFD and FC, investigating seabird by-catch over a two year period between 2007 and 2009 in all Falklands trawl fisheries, showed an increase in mortalities since 2005 (Sancho 2009b), to 0.14-0.15 bird mortality per vessel day. Whilst this was double the value reported by Reid and Edwards (2005) the two reports are unfortunately not directly comparable, since Sancho (2009b) included mortalities caused by paravane cables and net entanglements, whereas Sullivan et al. (2006) and Reid and Edwards (2005) only used warp strikes. Since 2008, seabird mortality estimates have been produced solely by the FIFD, using the same criteria as in Sancho (2009b); therefore, not directly comparable to Sullivan et al. (2006). Mortality estimates since Sancho (2009b) have varied substantially between years, ranging from 103 mortalities to 1,447 mortalities in the finfish fishery (Table 1), and from 0 to 523 in the Falkland calamari fishery (Table 2). All estimates are likely to represent minimum values as they do not consider undetected (cryptic) mortalities (e.g. Watkins et al. 2008; Parker et al. 2013). The level of undetected mortality was investigated in a preliminary study by Parker et al. (2013) and was estimated to be at a minimum of 23-38%.

Populations of black-browed albatross and southern giant petrel breeding in the Falkland Islands are currently showing a stable population trend (Crofts & Stanworth 2017), and based on counts from 2010 to 2015, the black-browed albatross has recently been downgraded to IUCN *Least Concern*. However, in the Falkland Islands, between 2015 to 2017, annual monitoring sites have experienced a decrease in breeding numbers of black-browed albatrosses, possibly linked to food shortages (Crofts pers. comm., 2018; Crofts & Stanworth 2017). This highlights the importance of continuously assessing the risk to the species, and mitigating anthropogenic impacts (Wolfaardt 2012; Granadeiro et al. 2011; 2013).

1.3. Purpose and scope of this report

The current report aims to update the status of incidental seabird mortality in the Falkland Islands trawl fisheries for the period from 1 July 2016 to 30 June 2017, and to provide recommendations to establish work priorities in line with NPOA-T objectives.

Table 1 Summary of previous and current seabird mortality estimates from the Falkland Island finfish trawl fishery (minimum values only). Values are based on straight extrapolation (i.e. not stratified by season / area). Colour of shaded cells indicate comparable data. See text and relevant references for further information.

Year [a]	Obs. days	% fishing days obs.	Agency	Recorded mortality	Estimated annual mortality
2002-2003	157	?	SAST	73	1529
2004-2005	88	?	APP	16	169
2007-2008	86	?.	APP & FIFD	10	510
2008-2009	99	?	FIFD	25	590
2009-2010	91	2.6	FIFD	8	311
2010-2011	103	3	FIFD	43	1447
2011-2012	139	4.3	FIFD	29	679
2012-2013	102	3.2	FIFD	32	999
2013-2014	60	1.9	FIFD	2	103
2014-2015	98	3.3	FIFD	33	1009
2015-2016	107	3.6	FIFD	11	308
2016-2017[1]	69	4.0	FIFD	46	1155

[1] Based on data from all vessels (incl. with BSL, Fixed Aerial Arrays, discard management tanks) (See Appendix 1, Table A)

Table 2 Summary of previous and current seabird mortality estimates from the Falkland calamari trawl fishery (minimum values only). Incomplete data is available for the years of 2003-2004 and 2006-2007. Values are based on straight extrapolation (i.e. not stratified by season / area). Shaded cells indicate comparable data; see text and relevant references for further information.

Year[a]	Obs. days	% fishing days obs.	Agency	Recorded mortality	Estimated annual mortality
2002-2003	8	?	SAST	0	0
2005-2006	48	2.6	APP	12	358
2007-2008	86	4.1	APP & FIFD	0	0
2008-2009	99	3.0	FIFD	1	17
2009-2010	41	2.4	FIFD	0	0
2010-2011	46	3.9	FIFD	0	0
2011-2012	39	2.1	FIFD	0	0
2012-2013	42	2.2	FIFD	0	0
2013-2014	33	1.6	FIFD	2	125*
2014-2015	45	2.2	FIFD	2	91*
2015-2016	42	2.5	FIFD	13	523*
2016-2017[1]	64	3.2	FIFD	8	252*

*dedicated seabird observers on board the calamari vessels
[1] Based on data from all vessels (incl. with BSL, Fixed Aerial Arrays, discard management tanks) (See Appendix 1, Table A)

2. Methods

2.1. Trawling observations

FIFD observers conducted seabird monitoring on demersal trawlers, recording species abundance, seabird interactions and relevant environmental and operational variables according to the FIFD Seabird Monitoring Protocol (v. 2016; see also details in previous mortality estimates reports, e.g. Kuepfer 2016a). Note that for the Falkland calamari fishery, data collected by Fisheries Observers in the first season (August/September 2016) is based exclusively on observations during hauling. As of February 2017, the standard FIFD Seabird Monitoring Protocol applied to finfish vessels was also applied to the Falkland calamari vessels (i.e. observations included interactions monitoring during trawling), with the exception that only half days could be dedicated to this task (fisheries observers were still required to sample one station in the factory on seabird days).

As a result of resource prioritisation, the Seabird Observer's primary task at sea has been to assess the effectiveness of new mitigation measures. This typically involved the application of the standard monitoring protocol with the addition of supplementary data being collected.

2.2. Data analysis

FIFD data from 01 July 2016 to 30 June 2017 were analysed using the methodology applied in previous estimation reports. The methodology was developed by Falklands Conservation's Seabirds At Sea Team (later to become the Albatross and Petrel Programme), which followed the methods of Wienecke and Robertson (2000).

Observed mortalities were extrapolated from observation effort (number of days where at least one haul was observed) to the total trawl effort (number of fishing days). In order to avoid possible inflation of numbers, only data from high-risk species[2] collected inside the Falkland Islands Conservation Zones (FCZ = FICZ and FOCZ) were included in the analysis. In addition, the analysis took into account the seasonal presence of grey-headed albatross by extrapolating grey-headed albatross mortalities separately to only the seasons in which they were present in Falkland Islands waters.

Data were analysed separately for each fishery. In line with previous reports, data were also stratified spatially and temporally (Figure 1, Table 3), as recommended by Sullivan and Reid (2003). The temporal and spatial components aim to capture variation in both fishing effort and the various stages of the breeding cycle of black-browed albatross; however, due to ship movement and limited observer coverage, it is unrealistic to adequately balance fishing effort and observer effort for each stratum, and results should therefore be treated with caution.

[2] High-risk species (HR) are defined as long-winged species that are at risk of injury or mortality resulting from heavy contacts with fishing gear, and species that are ACAP (Agreement on the Conservation of Albatrosses and Petrels) listed: http://www.acap.aq/en/acap-species/307-acap-species-list/file. In the Falkland Islands waters, these are predominantly black-browed albatross and giant petrel species, as well as grey-headed albatross, royal albatross species, wandering albatross and white-chinned petrel.

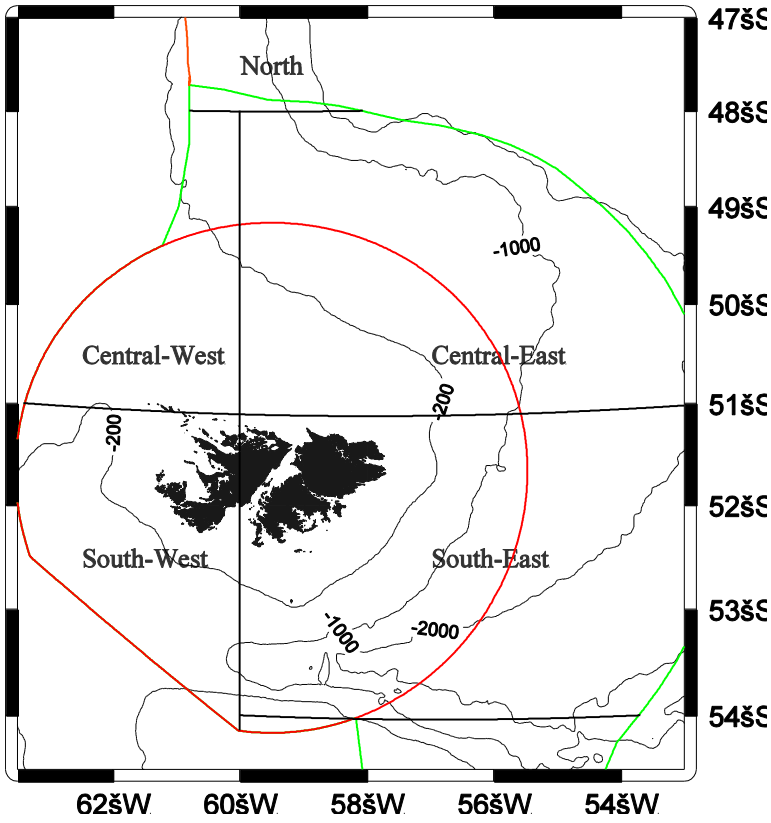

Figure 1 The five areas used for spatial stratification. The inner red line represents the Falkland Islands Interim Conservation and Management Zone (FICZ) and the outer green line the Falkland Islands Outer Conservation Zone (FOCZ).

Table 3 Description of spatial strata and seasonal periods.

Seasonal periods	Description	Spatial Strata	Description
Winter	May – 20 Aug	North	<48°S
Prospecting	21 Aug – Sept	Central West	≥48°S<51°S, ≥60°W
Laying	October	Central East	≥48°S<51°S, <60°W
Egg	Nov – Dec	South West	≥51°S<54°S, ≥60°W
Young chick	Jan – Feb	South East	≥51°S<54°S, <60°W
Old chick	Mar – Apr		

3. Results

3.1. Effort: fishing and observed

3.1.1. Finfish fishery (Licence A/G/W)

The demersal trawl finfish effort in the FCZ from 1 July 2016 to 30 June 2017 was 1,732 days (Table 4), which is substantially lower compared with the previous year's effort (2,995 days). Observations of seabird interactions with finfish trawl fishing gears were conducted on 69 days, representing 4.0% seabird-specific observer coverage of the finfish fishing effort over the one year period.

Additional 17 days of seabird interaction observations aboard a finfish vessel were conducted in international waters (located north of 47.75° S). However, it is not possible to calculate the proportion of fishing observed in international waters because total trawl effort in this area is unknown.

Table 4 Fishing and observation effort in the Finfish trawl fishery, 01/07/2016 – 30/06/2017.

Year	Trawling days	Observed days	Observed Effort (%)
2016-2017	1,732	69	4.0

Seabird observations within the FCZ were conducted for 147 separate stations (trawls) by seven different observers on 14 out of 28 finfish trawl vessels (Appendix 2 Table C). The number of stations (trawls) observed per vessel varied greatly, averaging 10.5 stations, and range between 1 and 37 stations, depending on the length and number of observer trips.

Stratified effort

Stratified fishing and observation effort in the FCZ is summarised in Table 8. Corresponding with finfish targeting areas, the Central West strata had the highest proportion of finfish trawling and received almost 60% of the overall observation coverage for this fleet. In contrast, the North and the South East held the lowest proportion of finfish trawling effort (1.8% each), and respectively received 0.0 and 1.4% of the overall observation effort.

In terms of seasons, the Winter season held the highest proportion of fishing effort (33.1%), of which 2.6% was observed (representing 21.7% of the total observation effort). The highest observer coverage was during the Old Chick season (42% of overall observer effort) when 21.2% of fishing effort occurred. Fishing effort was lowest during the Egg and Young Chick season (8.7 and 2.9 %, respectively).

3.1.2. Falkland calamari fishery (Licence C/X)

The Falkland calamari trawl effort was 2,001 fishing days, 311 days more than the previous year when the spring season was shortened. Bird observations were conducted by four separate observers on 64 days (3.2% of total fishing effort, Table 5). On 11.3% of observer days, only hauling activities were conducted (see methods section). Overall, 133 separate stations were observed aboard 10 out of 20 vessels (Appendix 2 Table D).

Table 5 Fishing and observation effort in the Falkland calamari trawl fishery, 01/07/2016 – 30/06/2017.

Year	Trawling days	Observed days	Observed Effort (%)
2016-2017	2,001	64	3.2

Stratified effort

Table 9 summarises the distribution of Falkland calamari fishing and observed effort under stratification. Corresponding with calamari-targeting areas, fishing effort was concentrated in the South East (87.0% of total fishing days), which received 82.8% of the overall observation effort in this fleet. No fishing took place in the North and Central West.

Fishing effort was concentrated in the Old Chick season (47.0%), followed by the Prospecting and Winter season (31.3% and 19.3% respectively). Observation effort mirrored fishing effort and was focused on the Old Chick and Prospecting strata (43.8% and 46.9%, respectively, of total observation effort).

3.1.3. Skate fishery (Licence F)

Fishing effort under F Licence was 116 days of which six (5.2%) were observed (Table 6). Observations were conducted on 12 stations by one observer on one of five vessels that fished under this licence (Appendix 2, Table D).

Table 6 Fishing and observation effort in the Skate trawl fishery, 01/07/2016 – 30/06/2017.

Year	Trawling days	Observed days	Observed Effort (%)
2016-2017	116	6	5.2

Stratified effort

Table 10 summarises the distribution of Skate fishing and observed effort under stratification. The majority of fishing effort took place in the Central East (54.3%) and Central West (41.4%). These areas received 16.7% and 83.3% of observer effort, respectively. The majority of F licence fishing took place in the Laying season (39.7%), which is when all the observation effort occurred.

3.1.4. Experimental fishing (Licence E)

As usual, two fortnight *loligo* pre-recruitment surveys (30 days in total) took place in the period of 1 July 2016 to 30 June 2017. Although no seabird interactions monitoring took place (Table 7), seabird by-catch was recorded by scientists on board (see Section 5.2.).

Table 7 Fishing and observation effort for the *loligo* pre-recruitment survey, 01/07/2016 – 30/06/2017).

Year	Trawling days	Observed days	Observed Effort (%)
2016-2017	30	0	0.0

Stratified effort

The majority of trawling for the *loligo* pre-recruitment surveys took place in the South East (86.7%). The remaining fishing effort occurred in the Central East. This survey always takes place prior to the start of the Falkland calamari season, and corresponds with the Winter and the Young Chick strata.

Table 8 Finfish trawling and observation effort under stratification in the FCZ, 01/07/2016 – 30/06/2017.

2016-2017	North		Central West		Central East		South West		South East		GRAND TOTAL		EFFORT (%)		STRATIFIED
	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	**Trawl**	**Obs.**	**EFFORT (%)**
Winter	8	0	371	13	59	0	119	2	17	0	574	15	**33.1**	**21.7**	**2.6**
Prospecting	8	0	161	0	17	0	88	4	4	0	278	4	**16.1**	**5.8**	**1.4**
Laying	10	0	116	4	14	2	171	7	0	0	311	13	**18.0**	**18.8**	**4.2**
Egg	2	0	21	0	3	0	124	3	0	0	150	3	**8.7**	**4.3**	**2.0**
Young Chick	0	0	6	3	4	0	36	2	5	0	51	5	**2.9**	**7.2**	**9.8**
Old Chick	4	0	216	21	42	5	101	2	5	1	368	29	**21.2**	**42.0**	**7.9**
GRAND TOTAL	32	0	891	41	139	7	639	20	31	1	**1732**	**69**			
EFFORT (%)	**1.8**	**0.0**	**51.4**	**59.4**	**8.0**	**10.1**	**36.9**	**29.0**	**1.8**	**1.4**					
STRAT. EFFORT (%)		**0.0**		**4.6**		**5.0**		**3.1**		**3.2**					

Table 9 Falkland calamari trawling and observation effort under stratification in the FCZ, 01/07/2016 – 30/06/2017.

2016-2017	North		Central West		Central East		South West		South East		GRAND TOTAL		EFFORT (%)		STRATIFIED
	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	**Trawl**	**Obs.**	**EFFORT (%)**
Winter	0	0	0	0	86	1	2	0	299	3	387	4	**19.3**	**6.3**	**1.0**
Prospecting	0	0	0	0	63	5	2	0	561	25	626	30	**31.3**	**46.9**	**4.8**
Laying	0	0	0	0	9	0	1	0	7	0	17	0	**0.8**	**0.0**	**0.0**
Egg	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
Young Chick	0	0	0	0	0	0	2	0	29	2	31	2	**1.5**	**3.1**	**6.5**
Old Chick	0	0	0	0	58	5	21	0	861	23	940	28	**47.0**	**43.8**	**3.0**
GRAND TOTAL	0	0	0	0	216	11	28	0	1757	53	**2001**	**64**			
EFFORT (%)	**0.0**	**0.0**	**0.0**	**0.0**	**10.8**	**17.2**	**1.4**	**0.0**	**87.8**	**82.8**					
STRAT. EFFORT (%)		**0.0**		**0.0**		**0.0**		**0.0**		**3.0**					

Table 10 Skate & ray trawling and observation effort under stratification in the FCZ, 01/07/2016 – 30/06/2017.

2016-2017	North		Central West		Central East		South West		South East		GRAND TOTAL		EFFORT (%)		STRATIFIED
	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	EFFORT (%)
Winter	2	0	0	0	31	0	0	0	1	0	34	0	**29.3**	**0.0**	**0.0**
Prospecting	1	0	0	0	23	0	0	0	1	0	25	0	**21.6**	**0.0**	**0.0**
Laying	0	0	43	5	3	1	0	0	0	0	46	6	**39.7**	**100.0**	**13.0**
Egg	0	0	5	0	6	0	0	0	0	0	11	0	**9.5**	**0.0**	**0.0**
Young Chick	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
Old Chick	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
GRAND TOTAL	3	0	48	5	63	1	0	0	2	0	**116**	**6**			
EFFORT (%)	**2.6**	**0.0**	**41.4**	**83.3**	**54.3**	**16.7**	**0.0**	**0.0**	**1.7**	**0.0**					
STRAT. EFFORT (%)		**0.0**		**10.4**		**1.6**		**0.0**		**0.0**					

Table 11 Experimental trawling (*loligo* pre-recruitment survey only) and observation effort under stratification in the FCZ, 01/07/2016 – 30/06/2017.

2016-2017	North		Central West		Central East		South West		South East		GRAND TOTAL		EFFORT (%)		STRATIFIED
Experimental	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	Trawl	Obs.	EFFORT (%)
Winter	0	0	0	0	3	0	0	0	12	0	15	0	**50.0**	**0.0**	**0.0**
Prospecting	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
Laying	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
Egg	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
Young Chick	0	0	0	0	1	0	0	0	14	0	15	0	**50.0**	**0.0**	**0.0**
Old Chick	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**	**0.0**	**0.0**
GRAND TOTAL	0	0	0	0	4	0	0	0	26	0	**30**	**0**			
EFFORT (%)	**0.0**	**0.0**	**0.0**	**0.0**	**13.3**	**0.0**	**0.0**	**0.0**	**86.7**	**0.0**					
STRAT. EFFORT (%)		**0.0**		**0.0**		**0.0**		**0.0**		**0.0**					

3.2. Recorded mortality

3.2.1. Finfish fishery (Licence A/G/W)

Forty-six mortalities of high-risk seabird species were recorded during 69 days of seabird-vessel interaction monitoring in the finfish fishery this year (black-browed albatross: n = 43 (all with adult plumage); giant petrel spp.: n = 3 (age unknown)). The mortalities occurred on four out of the 10 vessels observed on 10 separate days. One vessel accounted for 27 mortalities, which were observed by two different observers on two separate trips.

Extrapolating observed mortalities of high-risk species to the year's fishing effort of 1,732 days, incidental mortality in the finfish fishery totalled 1154.7 high-risk birds (CV = 2.24), of which 1079.4 black-browed albatrosses and 75.3 giant petrels.

Note that, in addition to the high-risk species mortalities stated above, a mortality of a Cape petrel was recorded in the finfish-fleet; however, this species is not considered a high-risk species and is therefore not included in the annual mortality estimates. Similarly, five mortalities of black-browed albatross were recorded in 17 days of observations in international waters; however, as it is not possible to quantify fishing effort in the high seas, these mortalities are not extrapolated to an annual estimate.

Mortality by cause

Warp-related mortalities accounted for 87.0% of the mortalities observed; the remainder being equal numbers of net and BSL related deaths (Table 12). The Cape petrel mortality was also associated with the warp cable, as were the international mortalities observed. Recorded warp-related mortalities all resulted from birds drowning after being pushed underwater by the warp cable. Two of the net mortalities were reported to have almost certainly occurred during the shoot, whilst the point of death for the third net mortality was unclear. All of the BSL related mortalities occurred as a result of a bird becoming entangled at the float end of the line and drowning before the line could be hauled.

Table 12 Summary of seabird mortality information of high-risk species for the Falkland Islands finfish trawl fishery, 01/07/2016 – 30/06/2017.

Cause of mortality	Number recorded	Annual estimate
Warp	40	1004.1
Net	3	75.3
BSL	3	75.3
TOTAL	**46**	**1154.7**

Stratified mortality

Under spatial and seasonal stratification, an estimated 907 mortalities of high-risk seabird species occurred in the finfish fishery (Table 15). This value differs from the value obtained without stratification due to the differences in observation efforts within the various strata.

As in the previous year, mortalities occurred primarily in the Central West and South West strata, which correspond with the areas where most of the fishing and observations had taken place. Mortalities were observed primarily in the Old Chick and the Laying season, but were recorded in all seasons, except during Young Chick.

3.2.2. Falkland calamari fishery (Licence C/X)

Eight mortalities of high-risk species were recorded during the 64 days of observations in the Falkland calamari fishery (black-browed albatross n = 7; grey-headed albatross n = 1; all with adult plumage). In addition, a mortality of an Atlantic petrel, and a mortality of a Gentoo penguin were recorded during observation periods. However, these latter two species are not considered high-risk species (in the sense of seabird by-catch), and are therefore not included in the annual mortality estimates. The mortalities were recorded by two observers aboard two separate vessels.

Extrapolating observed mortalities of high-risk species to the year's fishing effort of 2,001 days, and considering the seasonal presence of grey-headed albatrosses, incidental mortality in the Falkland calamari fishery totalled 252 high-risk birds (CV = 3.90), of which 219 black-browed albatrosses and 33 grey-headed albatrosses.

Cause of mortality

The majority of mortalities were the result of interactions with the warp cables (87.5%), were birds drowned after being pushed underwater by the warp-cable (Table 13). One mortality occurred as a result of a bird becoming entangled in the BSL net float.

Table 13 Summary of seabird mortality information of high-risk species for the Falkland calamari trawl fishery, 01/07/2016 – 30/06/2017.

Cause of mortality	Number recorded	Annual estimate
Warp	7	220.8
BSL	1	31.3
TOTAL	**8**	**252.1**

Stratified mortality

Under spatial and seasonal stratification, an estimated 277 mortalities of high-risk species occurred in the Falkland calamari fishery. Mortalities were only recorded in the South East (where the majority of fishing effort took place) and were predominantly restricted to the Old Chick season (87.5%; Table 16).

3.2.3. Skate fishery (Licence F)

A single mortality of an adult black-browed albatross was recorded. Extrapolated to the 116 days of fishing, the mortality estimated in the ray fishery is calculated at 19 black-browed albatrosses for the year (CV = 2.45).

Cause of mortality

The cause of mortality is believed to have been a collision with the vessel which resulted in a broken neck (Table 14).

Table 14 Summary of seabird mortality information of high-risk species for the Falkland Islands Skate trawl fishery, 01/07/2016 – 30/06/2017.

Cause of mortality	Number recorded	Annual estimate
Vessel collision	1	19.3
TOTAL	**1**	**19.3**

Stratified mortality

The mortality was recorded in the Central West during the Egg Laying stratum. Under spatial and seasonal stratification, the estimated mortality under F licence equates to 9 mortalities this year (Table 17).

3.2.3. Experimental fishing (loligo pre-recruitment surveys)

Three black-browed albatross and one grey-headed albatross were found caught during the two *loligo* pre-recruitment surveys this year. Given these mortalities were recorded outside dedicated seabird observation days, they are not included in the extrapolation, but rather, they were added to the extrapolated total for the Falkland Islands fisheries.

Cause of mortality

Three of the birds were found in the net. At least two of the birds were predicted to have been caught in the net during shooting. One mortality occurred in the warp cables.

Table 15 Observed and extrapolated seabird mortality for the Falkland finfish fleet under stratification, 01/07/2016 – 30/06/2017. Strata where no fishing and/ or observations took place were removed.

	Black-browed albatross								Giant Petrel spp.									
2016-2017	**CW**		**CE**		**SW**		**SE**		**CW**		**CE**		**SW**		**SE**		**GRAND TOTAL**	
	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	**Obs.**	**Extr.**
Winter	1	29	0	0	1	60	0	0	0	0	**0**	0	0	0	0	0	**2**	**88**
Prospecting	0	0	0	0	3	66	0	0	0	0	**0**	0	0	0	0	0	**3**	**66**
Laying	2	58	7	49	9	220	0	0	0	0	**0**	0	0	0	0	0	**18**	**327**
Egg	0	0	0	0	1	41	0	0	0	0	**0**	0	0	0	0	0	**1**	**41**
Young Chick	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	**0**	**0**
Old Chick	17	175	0	0	2	101	0	0	0	0	**1**	8	2	101	0	0	**22**	**385**
GRAND TOTAL	**20**	**261**	**7**	**49**	**16**	**488**	**0**	**0**	**0**	**0**	**1**	**8**	**2**	**101**	**0**	**0**	**46**	**907**

Table 16 Observed and extrapolated seabird mortality for the Falkland calamari fleet under stratification, 01/07/2016 – 30/06/2017. Strata where no fishing and/or observations took place were removed.

	Black-browed albatross				Grey-headed albatross					
2016-2017	**CE**		**SE**		**CE**		**SE**		**GRAND TOTAL**	
	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	**Obs.**	**Extr.**
Winter	0	0	0	0	0	0	0	0	**0**	**0**
Prospecting	0	0	0	0	0	0	0	0	**0**	**0**
Laying	0	0	0	0	0	0	0	0	**0**	**0**
Egg	0	0	0	0	0	0	0	0	**0**	**0**
Young Chick	0	0	1	15	0	0	0	0	**1**	**15**
Old Chick	0	0	6	225	0	0	1	37	**7**	**262**
GRAND TOTAL	**0**	**0**	**7**	**239**	**0**	**0**	**1**	**37**	**8**	**277**

Table 17 Observed and extrapolated seabird mortality for the Falkland ray & skate fleet under stratification, 01/07/2016 – 30/06/2017. Strata where no fishing and/or observations took place were removed.

	Black-browed albatross					
2016-2017	**CW**		**CE**		**GRAND TOTAL**	
	Obs.	Extr.	Obs.	Extr.	**Obs.**	**Extrap.**
Laying	1	9	0	0	**1**	**9**
GRAND TOTAL	**1**	**9**	**0**	**0**	**1**	**9**

3.3. Unknown fates

When conducting seabird-vessel interaction observations, it is not always possible to be confident of the final outcome of an interaction between the bird and fishing gear. If this is the case, the outcome is recorded as an 'unknown fate'. In addition to mortalities, it is important to keep in mind some of these 'unknown fates', may have resulted in mortalities.

A total of 173 'unknown fates' were recorded across the trawl fleet for high-risk species. The vast majority (87.3%) of these events followed a heavy warp contact by birds on the water, although unknown fates were also recorded following suspected heavy contacts with the warp by diving birds, or after heavy BSL entanglements. Extrapolated to the fishing effort for the year, and stratified by fishing licence, a total of 4,431 unknown fates were estimated during the year (Table 18). This excludes fatal contacts which had gone undetected altogether (see discussion on undetected (cryptic) mortalities in Section 4.2).

Table 18 Cause of unknown fates: observed and extrapolated numbers recorded in the Falkland Islands trawl fisheries, 01/07/2016 – 30/06/2017.

Cause of unknown fates	**Fishing licence**						**Total**	
	A / G / W		**C / X**		**F**			
	Obs.	Extr.	Obs.	Extr.	Obs.	Extr.	**Obs.**	**Extr.**
Warp	149.0	3740.1	17.0	531.5	5.0	96.7	**171**	**4368**
BSL	0.0	0.0	2.0	62.5	0.0	0.0	**2**	**63**
Net	0.0	0.0	0.0	0.0	0.0	0.0	**0**	**0**
Other	0.0	0.0	0.0	0.0	0.0	0.0	**0**	**0**
GRAND TOTAL	149.0	3740.1	19.0	594.0	5.0	96.7	**173.0**	**4430.8**

3.4. Heavy Contacts

Mortality defined as a seabird carcass witnessed by the observer is a statistically rare event, particularly given the relatively low observer coverage. This makes the robust assessment of the effectiveness of a mitigation tool, such as the BSL, difficult. A more useful approach is to use the proxy of heavy contacts by seabirds with fishing gear. Heavy contacts have the

potential to cause death or injury, and therefore provide a useful indication for the level of by-catch risk. As such, heavy contacts are considered more in detail here.

3.4.1. Number of heavy contacts

For high-risk species, heavy contacts amounted to 5,177 during the year, accounting for 23.6% of the contacts recorded across the fleet (Table 19). Black-browed albatrosses incurred the highest proportion of heavy contacts (61.5%), followed by giant petrel spp. (37.0%). Heavy contacts occurred with the BSL (55.8%), the warp cable (34.2%) and the net (9.9%) (Table 20). A total of 74% of heavy BSL contacts were recorded on a single vessel during the Old Chick strata. Approximately 57% of heavy contacts with the warp cables were recorded on two vessels during the Laying and Old Chick strata. Of the 2,891 heavy contacts recorded with the BSL, 2% (n = 58) resulted in (possible) damage. Of the 1,771 heavy contacts recorded with the warp cable, 10% (n = 177) resulted in (possible) damage.

Table 19 Number of contacts in the Falkland Islands trawl fisheries, 01/07/2016 – 30/06/2017.

Licence	n(heavy contacts)	n(light contacts)	TOTAL
A/G/W	4662	14466	**19128**
C/X	461	2123	**2584**
F	54	163	**217**
GRAND TOTAL	**5177**	**16752**	**21929**

Table 20 Cause of heavy contacts in the Falkland Islands trawl fisheries, 01/07/2016 – 30/06/2017.

Contact Point	Licence			TOTAL (n)	TOTAL (%)
	A/G/W	C/X	F		
Warp	1642	80	49	**1771**	**34.2**
Net	406	117	0	**515**	**9.9**
BSL	2614	264[1]	5	**2891**	**55.8**
Other	0	0	0	**0**	**0.0**
TOTAL	**4662**	**461**	**54**	**5177**	**100**

[1] Some vessels observed had a Fixed Aerial Array, which typically incurs negligible contacts with the device itself.

3.4.2. Hourly contact rates

The unit of ‘days of observation’ is quite crude and makes it difficult to reliably compare data between years as the method assigns the same effort to e.g. 1 hour of observation per day as it does to 10 hours of observation per day. As such, observation time has been calculated and hourly contact rates deduced to obtain a unit that is more appropriate for comparative purpose (Table 21). Contact rates per hour were by far the highest in the finfish fishery, and substantially higher than recorded in previous years (Table 22), although the high rate may

have been influenced by the very high contact rates recorded with the BSL and the warp cables on three particular trips (see Section 3.4.1.).

Table 21 Hourly contact rates in the Falkland Islands trawl fisheries, 01/07/2016 – 30/06/2017. HC = heavy contacts, LC = light contacts.

Licence	hrs (obs.)	n(HC)	HC/hr	n(LC)	LC/hr	n (total contacts)	total contacts/hr
A/G/W	257.50	4662	18.10	14466	56.18	**19128**	**74.28**
C/X	162.20	461	2.84	2123	13.09	**2584**	**15.93**
F	16.62	54	3.25	163	9.81	**217**	**13.06**
GRAND TOTAL	436.32	**5177**	24.20	**16752**	79.07	**21929**	**103.27**

Table 22 Contact rates (per hour) observed in the finfish trawl fishery in the FICZ. Each year comprises data from the 01 July to the 30 June.

Year	All contacts	Light (LC)	Heavy (HC)	HC warp	HC BSL
2009-2010	15.8	14.43	1.37	0.92	0.29
2010-2011	8.71	7.44	1.26	0.96	0.17
2011-2012	23.61	21.24	2.37	1.92	0.44
2012-2013	15.6	13.24	2.36	1.77	0.57
2013-2014	32.76	29.64	3.12	1.13	1.98
2014-2015	27.31	22.81	4.51	2.21	2.25
2015-2016	25.00	22.84	2.16	1.59	0.55
2016-2017	74.28	56.18	18.10	6.38	10.18

4. Discussion

4.1. Seabird mortality

The estimated incidental mortalities of high-risk seabirds in the period of 01 July 2016 to 30 June 2017 represent the second highest annual mortality rate since the introduction of the BSL in 2004. Two main cluster mortalities (with 7 and 9 birds, respectively) represented 27% of all mortalities this year, suggesting a potential over-estimation of mortalities if such cluster mortality events were rare. However, over the past years, cluster mortalities have been regularly reported (Parker 2012; Parker 2013; Lopez Gutierrez 2013; Kuepfer 2016a, Kuepfer 2016b; this year), suggesting that capturing more than one bird in a single day can be seen as representative of normal seabird-fishery interactions.

As usual, the black-browed albatross heavily dominated the mortality figures. In addition to their regular presence and high abundance, black-browed albatrosses tend to be particularly vulnerable to fatal interactions as a result of their aggressive feeding behaviour and tendency to extend their long wings when startled, enhancing the risk of a deadly warp strike. The incidental mortality of grey-headed albatross, although less common in the Falkland Islands fishing fleet, presents a conservation issue under the Fisheries (Conservation and Management) Ordinance 2005, given its *Endangered* IUCN Red-list status.

Heavy warp strikes continue to be the primary cause of mortality. Whilst the BSL certainly provide some level of mitigation, it is unfortunate to see that they themselves continue to present another important by-catch risk to high-risk birds. The predominant cause of death in the BSL is from drowning after entanglement at the float end (see Section 4.3. regarding alternative designs being developed to address this issue).

Net mortalities that were recorded on vessels fishing under commercial and experimental licences are believed to have occurred mostly during shooting activities, although some may also have occurred during hauling operations. Whilst it is difficult to mitigate against birds being attracted to the net during hauling, specific licence conditions are in place to reduce the attraction of birds to the net during shooting. These are cleaning and removing from the net any fish clinging to the net (stickers) prior to reshooting, as well as halting discharge of fish waste (discards and offal) until the BSLs are re-deployed. Negligence of these licence conditions can increase the risk of mortalities. Improved educational information and positive reinforcement from the industry should assist the routine cleaning of nets and the routine halting of discarding during manoeuvres.

The majority of mortalities occurred during the Laying season, as well as during the Old Chick season. In the past four years, the Old Chick season has always seen the highest level of mortalities, despite not receiving the highest level of observer coverage. This may be a result of a combined effect of increased fishing effort and increased seabird abundance in the vicinity as a result of the central foraging behaviour of seabirds during the breeding season. It is possible that increased numbers of black-browed albatross leads to increased mortality due to competition, and hence, aggressive feeding behind trawlers (Sullivan et al. 2006).

It is currently unclear whether the high mortality rate this year also bears a relationship with unfavourable foraging conditions experienced over recent years (Crofts & Stanworth 2017). Over the past two years, black-browed albatrosses were found to forage at greater distances from the colonies than in previous years, and chicks were found in significantly poorer body condition (Catry P. pers. comm. January 2018). In October 2016, breeding pair counts of black-browed albatrosses at annual monitoring sites in the Falkland Islands were found to have decreased by 30% (Crofts & Stanworth 2016). Counts in October 2017 showed a slight increase, but still an 18% decrease from October 2015 (S. Crofts pers. comm. 2018; Crofts & Stanworth 2017). If food conditions were still poor into the egg laying and older chick season in 2016/2017, then fisheries discards would become more attractive, and would likely influence how birds behave around vessels (S. Crofts pers. comm. 2018).

4.2. Limitations and uncertainties

It is important to bear in mind the limitations of the data and the analytical method used when considering the annual mortality estimates, and when comparing these estimates with those from previous years.

Definition of observer effort

For reasons of practicality, effort is defined as the number of days observed and fished. This is a relatively crude unit. For example, observation of a single haul is assigned the same effort as 10 hours of contact observations. Equally, a vessel trawling for one hour is assigned the same effort as a vessel trawling for 15 hours.

A more useful unit for mortality estimates calculations would be to use the proportion of observed hours of discarding during fishing activities (after e.g. Maree et al. 2014). It is a well-known fact that seabird mortalities only tend to occur during periods of discarding during fishing activities (Kuepfer 2016b, also see e.g. Sullivan et al. 2006; Løkkeborg 2011). Information on hours of discarding during fishing activities per fishing day is not currently available, but it is hoped that this information can in the future be derived (see Recommendations in Section 4.3).

Low probability of observed mortalities

Mortalities are a rare event, statistically speaking, and the chance of seeing one is reduced by various factors including limited observer effort and, more importantly, undetected mortality. The low numbers of mortalities observed are insufficient for accurate quantification of the overall by-catch within the fishery.

Low observer effort becomes particularly problematic since clustered mortality events, historically considered as extremely rare, have been shown to occur more often than previously believed (Parker 2012; Parker 2013; Lopez Gutierrez 2013; Kuepfer 2016a, Kuepfer 2016b; this year). Whilst higher observer coverage would provide some improvement to estimates, limited resources are currently focused on researching and developing more effective mitigation measures.

Undetected mortality

Enhanced observer coverage alone is unlikely to provide robust mortality estimates. This is because there is a level of undetected (or cryptic) mortality, which is not currently accounted for. In a dedicated research cruise, Parker et al. (2013) found that 23 to 38% of mortalities may remain entirely undetected by the observer aboard the trawler, although the authors warn that their results are of an interim nature due to the limited duration of data collection (7 days in a single season) and the limited environmental variation encountered.

Undetected mortality may derive from unobserved indirect deaths following an injury sustained from a heavy warp strike or gear entanglement, or as a result of direct mortalities having gone unnoticed. Amongst others, high levels of bird abundance often make it difficult if not impossible to determine the fate of birds (this year an estimated 173 unknown fates were recorded, which extrapolates to 4,430.8 potential additional mortalities). In addition, the absence of warp splices or cable imperfections from many vessels greatly reduces the probability of corpses or feathers being retained until hauling. The vessel from which by far the highest mortality levels were recorded this year had warp imperfections/splices which retained multiple corpses. The splices were located 100 m from the door, i.e. far enough from the surface to rule out direct death caused by the splice itself. Recent screening of underwater video footage by an FIFD observer revealed two albatross mortalities which had gone unnoticed upon hauling.

Investigation into the level of cryptic mortality has been identified as a research priority by ACAP (2017) as results can be used to establish correction rates to enable statistical estimation of the actual seabird by-catch in trawls from recorded heavy contacts. However, research on cryptic mortality is inherently difficult, and as such, the FIFD has, for the time being, downgraded the priority level attached to this work.

Stratified data

Stratifying seabird mortalities into temporal and spatial strata makes biological sense, but it is unrealistic to achieve representative coverage of each stratum given the current level of observed effort available. Efforts are being made to achieve the most representative coverage possible, but the presence of an observer to cover each stratum is not always possible. In consequence, the distribution of observed effort does not always reflect the distribution of fishing effort.

Some studies have found operational factors such as presence/absence of discard to be more important factors in determining risk of by-catch compared to season and proximity of breeding colonies (e.g. Maree et al. 2014). At present, this has not been investigated by the FIFD and should be considered in future years.

An additional consideration that is required for future extrapolations is the increased diversity in mitigation measures being used in the fleet. In line with the NPOA-T, the Falkland Islands Fisheries Department and industry are investing in the research and development of improved mitigation. As a result, there are now various vessels with alternative or additional measures to the standard BSL, specifically Fixed Aerial Arrays and discard management systems. Using the interactions data collected from vessels with alternative and improved measures, and extrapolating these to the remaining fleet which uses the standard BSL, is not ideal. For example, a study conducted aboard the FV *Kestrel* to determine the

effectiveness of a batching system revealed that the bycatch risk was reduced by >80% when the tank was in operation (Kuepfer & Pompert 2017). If for the current reporting period only data from vessels with BSL are considered, the mortality estimates would be a substantial 18% higher. As such, it is recommended that future extrapolations consider mitigation measures as a potential factor by which to stratify mortality data.

4.3. Further work and recommendations

4.3.1. Data quality and protocol

1. It has been agreed that the seabird monitoring protocol for the Falkland calamari fishery will be amended to match that of the finfish fishery, as this will improve data comparability and data quality.

2. Observers should continue to regularly check warp splices during seabird observation days, and comment on the presence and condition of these splices. This is because the presence and condition of splices can influence the likelihood of a corpse being retained until hauling.

3. The Seabird Observer should continue to train Fisheries Observers in seabird interaction observations for the continued collection of reliable and comparable data. Information should be provided for the Fisheries Observers to understand the importance of the data collected.

4.3.2. Robust mortality estimates

4. Analysis of future mortality estimates should trial the approach of a more refined unit effort, which takes into account hours of fishing/observations during discarding activities. An approximation of discarding periods could be calculated using catch reporting data and an approximate vessel-specific figure for processing time per tonne.

5. Appropriate analyses should continue to be carried out by the Seabird Observer to ensure that the mortality data are stratified in the most suitable manner.

4.3.3. Mitigation: Research

6. BSL: Research on an alternative BSL design (Kuepfer 2016c) has been carried out during the year to mitigate entanglements. Analysis of the data should be prioritised to establish whether the small alteration should be implemented fleet-wide.

7. Discard management: With the arrival of vessels with discard management systems, their assessment should be a priority. This is to ensure the systems work as intended as well as to allow issues to be identified and considered to inform future installations.

4.3.4. Mitigation: Regulation

8. Net capture mitigation: Continued educational information and positive reinforcement from the industry is required to ensure full compliance with regulations relating to net cleaning and halting of discarding during manoeuvres.

4.3.5. Educational and information material

9. Appropriate educational material should continue to be prepared and distributed to the vessels, perhaps most effectively in the form of posters, which have in the past proven successful.

10. A public presentation could be provided to the community and the industry in Stanley to provide up-to-date information on the issue of seabird-vessel interaction and important progress made.

5. Conclusion

Incidental mortalities of high-risk species continue to occur in the Falkland Islands trawl fleet, including of species listed as *Endangered* on the IUCN red list. Heavy contacts with warp cables continue to account for the highest percentage of mortalities, although mortalities also occur in the net and the BSL. This annual update of incidental mortalities assists with guiding further management and mitigation work.

Further improvements to the robustness of mortality estimates are envisaged; however, the ultimate objective of the NPOA-T is to reduce mortalities to negligible levels. As such, resources are being focused primarily into the development of improved mitigation, including the implementation of discard management on vessels and amendments to the BSL. In combination with strategic education for crew, and good compliance, previous studies suggest that these advances will significantly reduce mortalities in the Falkland Islands trawl fleet in the future.

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7. References

ACAP (2017) Report of the Seabird Bycatch Working Group. Tenth Meeting of the Advosiry Committee Wellington, New Zealand, 11-15 September 2017. Verion 8. January 2018 Available from: https://www.acap.aq/en/advisory-committee/ac10/ac10-meeting-documents/3125-ac10-doc-13-sbwg-report/file

ACAP (2018) Species Assessments. Version 8 January 2018. Available from https://acap.aq/en/acap-species.

BirdLife International (2016) Species factsheet: *Thalassarche melanophris*.Downloaded from http://www.birdlife.org on 01/07/2017.

Crofts, S. & Stanworth, A. 2016. Falkland Islands Seabird Monitoring Programme - Annual Report 2015/2016 (SMP24). Falklands Conservation, Stanley.

Crofts S. & Stanworth A. (2017).Falkland Islands Seabird Monitoring Programme - Annual Report 2016/2017 (SMP24). Falklands Conservation, Stanley, Falkland Islands.

Anderson O.R.J., Small C.J., Croxall J.P., Dunn. E.K., Sullivan B.J., Yates O., Black A. (2011) Global seabird bycatch in longline fisheries. *Endangered Species Research*, 14, 91-106.

Brooke M. (2004) *Albatrosses and Petrels across the World*. Oxford University Press: Oxford.

Cuthbert R., Sommer E., Ryan P., Cooper J., Hilton G. (2004) Demography and conservation of the Tristan albatross *Diomedea [exulans] dabbenena*. *Biological Conservation*, 117, 471-481.

Granadeiro J.P., Brickle P., Catry P. (2013). Do individual seabirds specialize in fisheries' waste? The case of black-browed albatrosses foraging over the Patagonian Shelf. Animal Conservation 17: 19–26.

Granadeiro J.P., Phillips R.A. Brickle P. Catry P. (2011). Albatrosses following fishing vessels: how badly hooked are they on an easy meal? *PLoS ONE* 6:e17467.

Kuepfer A. (2016a) An Assessment of Seabird Bycatch in Falkland Islands Trawl Fisheries, July 2014 to June 2015. Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Kuepfer A. (2016b) An Assessment of Seabird Bycatch in Falkland Islands Trawl Fisheries, July 2015 to June 2016. Falkland Islands Fisheries Department, 1-39.

Kuepfer (2016c) A Possible Tori-line Design Amendment to Reduce Entanglement Risks. Falkland Islands Fisheries Department, Stanley, Falkland Islands

Kuepfer A. & Pompert J. (2017) Discard management as a seabird bycatch mitigation tool: Results from further batch-discard. Eighth Meeting of the Seabird Bycatch Working. Group. Wellington, New Zealand, 4 – 6 September 2017.

Løkkeborg S. (2011) Best practices to mitigate seabird bycatch in longline, trawl and gillnet

fisheries-efficiency and practical applicability. *Marine Ecology Progress Series*, 435, 285-303.

Lopez Gutierrez B. (2013) An assessment of seabird bycatch in Falkland Islands trawl fisheries, July 2012 to June 2013. Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Maree B.A., Wanless R.M., Fairweather T.P., Sulivan B.J., Yates O. (2014) Significant reductions in mortality of threatened seabirds in a South African trawl fishery. Animal Conservation. Print ISSN 1367-9430.

Parker G.C. (2012) An Assessment of Seabird Bycatch in Falkland Islands Trawl Fisheries, July 2010 to June 2011. Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Parker G.C. (2013) An Assessment of Seabird Bycatch in Falkland Islands Trawl Fisheries, July 2011 to June 2012. Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Parker G.C., Crofts, S., Pompert, J., Wolfaardt, A. & Brickle, P. (2013) In the wake of a factory trawler: Research into undetected seabird mortality. Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Quintin M. & Pompert J. (2014). Falkland Islands National Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries, 2014 (FI-NPOA-S-T-2014). Falkland Islands Fisheries Department, Stanley, Falkland Islands.

Reid T. & Edwards M. (2005) Consequences of the introduction of Tori-lines in relation to seabird mortality in the Falkland Islands trawl fishery, 2004/2005. Falklands Conservation, Stanley, Falkland Islands.

Sancho E. (2009a) Falkland Islands National Plan of Action for reducing incidental catch of seabirds in trawl fisheries. Falklands Conservation, Stanley, Falkland Islands.

Sancho E. (2009b) Seabird mortality associated with Trawlers in the Falkland Islands waters during 2007 and 2008. Falklands Conservation, Stanley, Falkland Islands.

Stanworth, A. and Crofts, S. (2017). Population status and trends of Southern Giant Petrels (*Macronectes giganteus*) in the Falkland Islands. Falklands Conservation, Stanley.

Sullivan B. (2004) Falkland Islands Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries. *In:* Falklands Conservation. Falklands Conservation, Stanley, Falkland Islands.

Sullivan B. & Reid T. (2003) Seabird Mortality and Trawlers in Falkland Island Waters 2002/2003. *In:* Falklands Conservation. Falklands Conservation, Stanley, Falkland Islands

Sullivan B.J., Reid T.A., Bugoni, L. (2006) Seabird mortality on factory trawlers in the Falkland Islands and beyond. *Biological Conservation*, 131, 495-594.

Watkins B.P., Petersen S.L., Ryan, P.E. (2008). Interactions between seabirds in deep water hake trawl gear: an assessment of impacts in South African waters. Animal Conservations, 111, 247-254.

Wienecke B. & Robertson G. (2000) Seabird and seal - fisheries interactions in the Australian Patagonian toothfish *Dissostichus eliginoides* trawl fishery. Fisheries Research, 1169, 1-13.

Wolfaardt A.C. (2012) An assessment of the population trends and conservation status of blackbrowed albatrosses in the Falkland Islands. Joint Nature Conservation Committee, Stanley, Falkland Islands.

8. Appendix

Appendix 1: Mortality assessments

Table A Mortality assessment with all observations and high-risk species mortalities included, data from 1 July 2016 to 30 June 2017.

Fishery	Licence	Observed	Fished	%Observed	Mortality	Extrapolated Mortality	Daily rate
Finfish	A	25	628		7		
	G	21	436		19		
	W	23	668		20		
Sub-total		**69**	**1732**	3.98	**46**	**1154.67**	0.67
Calamari	C	30	997		8		
	X	34	1004		0		
	DIM[1]	64	2001		7	218.86	
	DIC[2]	30	997		1	**33.23**	
Sub-total		**64**	**2001**		**8**	**252.09**	
Ray	F	6	116		1		
Sub-total		**6**	**116**	5.17	**1**	**19.33**	0.17
Illex	B	0	44	0.00	NA	NA	NA
Sub-total		0	44	0.00	NA	NA	NA
Experim.	E	0	30	0.00	4	NA	NA
Intl.	O	NA	NA	NA	5	NA	NA
TOTAL (COMMERCIAL inside FCZ)					**55.00**	**1426.09**	
TOTAL (COMMERCIAL & EXPERIMENTAL inside FCZ)					**59.00**	**1430.09**	

[1] Annual presence

[2] Seasonal presence - C Licence only

Table B Mortality assessment with all observations and high-risk species mortalities included, split by mitigation measures, data from 1 July 2016 to 30 June 2017.

Fishery	Mitigation	Observed	Fished	%Observed	Mortality	Mortality Estimates	Daily rate
Finfish	TL	54	1717	2.90	44.5	1414.94	0.82
	FAA	5	5	100.00	0	0.00	0.00
	Tank	10	10	100.00	1.5	1.50	0.15
Sub-total		**69**	**1732**		46	**1416.44**	
Calamari							
DIM[1]	TL	43	1745	10.66731	5.00	202.91	0.03
DIC[2]	TL	18	869	0	1.00	48.28	0.00
	FAA	21	256	8.20	2	24.38	0.10
Sub-total		**64**	**2001**		8.00	**275.57**	
Ray	TL	6	116	5.17	1	19.33	0.17
Sub-total	**RAY**	**6**	**116**	5.17	1	**19.33**	0.17
Illex	TL	0	44	0.00	NA	NA	NA

Sub-total	**ILLEX**	0	44	0.00	NA	NA	NA
Experim.	TL	0	15	6.67	1	NA	NA
	FAA	0	15	13.33	3	NA	NA
Sub-total		0	30		3	**NA**	NA
Intl.	**TL**	NA	NA	NA	5	**NA**	NA
TOTAL (COMMERCIAL inside FCZ)						**1711.33**	
TOTAL (COMMERCIAL & EXPERIMENTAL inside FCZ)						**1715.33**	

[1] Annual presence

[2] Seasonal presence - C Licence only

Appendix 2 Summary of observation effort

Table C 2016-2017 summary of observer effort per vessel and per observer within the FCZ finfish fleet. Vessel callsigns and observer codes were assigned with a number for report purpose only.

Vessel No.	Observed stations	Observer No.	Observer effort
1	2	7	1.36
2	5	4	3.40
3	2	3	1.36
4	10	7	6.80
5	10	4	6.80
6	3	2	2.04
7	5	6	3.40
8	1	4	0.68
9	5	3	3.40
10	32	3,6	21.77
11	17	5,7	11.56
12	37	1,8	25.17
13	4	3	2.72
14	14	1	9.52
Vessels n = 14	**Stations n = 147**	**Observers n = 7**	

Table D 2016-2017 summary of observer effort per vessel and per observer within the FCZ Falkland calamari fleet. Vessel callsigns and observer codes were assigned with a number for report purpose only.

Vessel No.	Observed Stations	Observer No.	Observer effort
7	3*	5	2.26
8	5*	3	3.76
9	3*	3	2.26
10	4*	6	3.01
1	20	8	15.04
2	9	5	6.77
3	25	1	18.80
4	2	3	1.50
5	23	5	17.29
6	39	1	29.32
Vessels n = 6	**Stations n = 133**	**Observers n = 5**	

*Hauling observations only

Table E 2016-2017 summary of observer effort per vessel and per observer within the FCZ Skate fleet. Vessel callsigns and observer codes were assigned with a number for report purpose only.

Vessel No.	Observed Stations	Observer No.	Observer effort
1	12	8	100
Vessels n = 1	**Stations n = 12**	**Observers n = 1**	