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Discard management as a seabird by-catch mitigation tool: The effect of batch-discarding on seabird interactions in the Falkland Islands trawl fishery

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SUMMARY

Seabird by-catch in trawl fisheries is driven by the foraging opportunities provided through fish waste discard. Limiting these foraging opportunities by managing the discard such as through strategic discharging has been shown to reduce the risk of seabird mortality. As part of the 'Falkland Islands National Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries, 2014' (FI-NPOA-S-T-2014), the Falkland Islands Fisheries Department is conducting experimental studies in support of discard management research and development. Here we evaluate the effectiveness of batch discarding on seabird interactions in the trawl fishery aboard a finfish bottom-trawler. Using a 3m^3 discard storage tank, waste was retained on board for ca. 30-60 minutes, or discharged continuously as a control treatment. One of each treatment was applied each day using a randomised block design. In addition, abundance data were also collected opportunistically during periods of zero discarding. Over a total of 48 days across three different seasons, we determined the level of seabird interactions to the various discharge frequencies by using the abundance of black-browed albatrosses *Thalassarche melanophris* and giant petrels *Macronectes spp.* The results from preliminary analyses show that the waste discard management system has a significant impact on reducing seabird abundances. Important lessons were learned about discard storage tank designs and effectiveness, and these are discussed in addition to other recommendations relating to the temporary storage of fish waste as a discard management option.

Discard management as a seabird bycatch mitigation tool: the effect of batch-discarding on seabird interactions in the Falkland Islands trawl fishery

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1. INTRODUCTION

1.1. Background

The major cause of seabird mortality in the Falkland Islands trawl fishery is the result of cable strikes during periods of fish waste discharges (Sullivan & Reid, 2003; Kuepfer, 2016). This fish waste is highly attractive to seabirds and is the primary reason for seabird interactions with fishing vessels (e.g. Sullivan et al., 2006; Bull, 2009; Abraham et al., 2009; Pierre et al., 2010; Løkkeborg, 2011; Pierre et al., 2012a,b). Before the introduction of the tori-lines in 2003, seabird mortality estimates in the Falkland Island finfish trawl fishery was estimated at 1,529 (Sullivan & Reid, 2003). The most recent estimates from 2014-2015 suggest a mortality estimate of 1003 (Kuepfer, 2016), of which 88% were the result of heavy warp strikes, and a further 9% the result of tori-line entanglements.

Species suffering the greatest levels of mortalities are the black-browed albatross *Thalassarche melanophris* and, to a much lesser extent, giant petrels (*Macronectes spp.*). By-catch of black-browed albatross is of particular concern as the Falkland Islands hold over 70% of the world's breeding population (Huin & Reid, 2007; Wolfaardt, 2012). The population is currently increasing at a rate of c. 4% per annum, which has led to the recent down-grading of the IUCN conservation status from *Endangered* to *Near Threatened* (Birdlife International, 2014). Continued efforts to improve bycatch mitigation measures will buffer the local population against possible future changes, and will improve the conservation status of other populations and species (Wolfaardt, 2012).

Whilst mitigation devices such as bird-scaring lines have shown to reduce contact rates with the fishing gear, numerous issues relating to the practical, effective and safe use of tori-lines have been identified (e.g. Snell et al., 2011; Løkkeborg, 2011; ACAP, 2013). Reducing the attractiveness of trawlers to seabirds should reduce the need to rely on such mitigation devices (e.g. Pierre et al., 2010).

A number of studies over the past years have consistently shown that managing fish waste through discard retention, strategic batch discarding, discard processing, or a combination of these can successfully prevent cable strikes and seabird mortalities (e.g. Abraham et al., 2009; Pierre et al., 2010; Pierre et al., 2012a,b). The Falkland Islands Fisheries Department (FIFD) acknowledges the potential of waste discard management and has embraced this avenue in the current Falkland Islands National Plan of Action for Reducing Incidental Catch of Seabirds in Trawl Fisheries (FI-NPOA-S-T 2014, Quintin & Pompert, 2014). In line with this Action Plan, the FIFD has undertaken experimental studies to support the movement towards discard management.

In this study, we evaluate the effectiveness of temporary discard storage and batch discharges on seabird interactions in the Falkland Islands demersal finfish trawl fishery. The effects of batch discarding are compared with both continuous and zero discarding. Treatment effects are measured using seabird abundance of high risk species, following the method of Abraham et al. (2009). Although seabird by-catch is the result of direct interactions by birds with the fishing gear, the rate of these interactions has been shown to relate to seabird abundance around the vessel (Abraham et al., 2009). Recommendations relating to batch discarding are provided in relation to results discussed.

2. METHOD

2.1. Vessel and storage tank design

The study was conducted aboard a Spanish-flagged stern trawler targeting demersal finfish in Falkland Island waters. The vessel's factory had been retro-fitted with a $3m^3$ discard storage tank. Maximum possible storage time depends on the processing rate and fish species, but can be as much as one hour. Unwanted whole fish and solid pieces of processing waste (heads and tails) were transported via a conveyor belt to this tank for temporary storage. The storage tank emptied directly out to sea above sea level at portside through manual operation of the hydraulic tank door. With the tank floor built at an incline, a full tank emptied within a matter of ca. 5-10 seconds, and the waste passed the warp-water interface over a period of ca. 10-30 seconds.

The tank installation design did not allow guts to be collected in the storage tank. Instead, these were passed to two $1m^3$ gut scuppers via suction tubes, and were discharged at an intermittent rate (every 1-2 minutes) at both starboard and portside. A further discharge sluice was present at both starboard and portside through which only sump water was discharged.

2.2. Experimental set-up and data collection

The study was carried out by the FIFD seabird observer during three separate trips from 05 April – 22 April 2015, 14 May – 02 June 2015 and 29 October – 10 November 2015. Two experimental treatments were implemented: 'batch discarding' and 'continuous discarding' (Table 1). The treatments were applied on alternative days based on a randomised block design. For batch discarding treatments the tank was emptied either when full, when factory work stopped, or when advised by the observer. In addition to these experimental treatments, data were opportunistically collected during periods of zero waste discharge ('Zero discarding') as a third comparative treatment (Table 1). These data were collected either after discarding had stopped from experimental treatment trawls, or during trawls which had no discard throughout.

Table 1 Discharge treatments compared in the analysis.

Treatment	Definition
Continuous	All waste (processed waste, whole fish and sump water) is discharged continuously as of when it became available, at a continuous, intermittent or infrequent rate.
Batch	Unwanted whole fish, heads and tails were temporarily stored in the discard storage tank for ca. 30-60 minutes before being batch discharged. Between the batch discharges, guts and sump water continued to be discharged at an intermittent or infrequent rate.
Zero	No discard of any kind was discharged.

The effects of the three discard treatments on seabird interactions were measured using seabird abundance of commonly present high risk species groups (here the black-browed albatross and giant petrels). Seabird abundance was assessed separately for each species group in four defined areas at the stern of the vessel (summarised in Table 2) by conducting a series of count sweeps (where the observer swept their view once through the observation area, after Abraham et al., 2009). A single sweep was conducted at the start of every 10 minute sample period for the 40m area counts, and every two minutes for the feeding and the danger area counts (see Table 2). During batch discard treatments, whenever a batch discharge event occurred, a new sample period of 1 minute duration was started, and a new sweep count conducted for all areas. Due to the very quick influx and outflow of birds during batch discard events, batch discharges were filmed using a wide angle camera lens, and sweep counts were made from the videos.

Table 2 Areas at the back of the stern used for sweep counts.

Category	Definition
40m semi-circle from the stern (water)	Birds on water counted at the start of every 10 minute sample period.
40m semi-circle from the stern (air)	Birds in air counted at the start of every 10 minute sample period.
Feeding area	Area between tori-lines (ca. 30m x 10m). Feeding birds counted every 2 minutes, with numbers averaged for every 10 minute sample period.
Danger area	Area where birds on water are most likely to come into contact with warp cables. Birds present counted every 2 minutes, with numbers averaged for every 10 minute sample period.

In addition to the abundance data, data collection involved a suite of environmental and operational variables at the start of every 10 minute sample period. These included discard level (the volume of discard discharged), discard rate (the frequency with which it was discharged), discard type, discard size, wind speed and direction, sea state, weather conditions and the number of vessels in the vicinity.

2.3. Data analysis

For each species group in each count area, a separate ANOVA was carried out to compare the mean seabird abundances during the three discard treatments. Other environmental and operational variables have not been considered in this preliminary analysis. A post–hoc Tukey HSD test was used for cross–comparisons between each treatment. All analyses were performed in the R statistical package (R core team, 2015).

3. RESULTS

3.1. Data overview

Table 3 summarises the amount of data that was collected for each discard treatment during the three trips. During trawls where batch discarding was applied, discard was held for an average of 37.17 minutes (between 12 and 71 minutes). Eighty percent of storage periods fell between 30 and 60 minutes (89% between 25 and 65 minutes).

Table 3 Summary of data collection conducted during the three individual trips.

Discard treatment	Observations conducted		
	n(days)	n(trawls)	n(hours)
Continuous	14.5*	22	44.87
Batch	27	38	83.95
Zero	6.5* (+ 19[1])	7 (+ 20[1])	9.83 (+ 12.73[1])
Total	**48**	**67**	**151.38**

[1] data collected during periods of zero discarding on trawls where batch or continuous discarding treatments had been applied.
* the observer observed the first trawl with no discard on the very first day of the study, but implemented the continuous discarding treatment on all subsequent trawls on this day.

3.2. Discard treatment effects on black-browed albatrosses

Discard treatment had a significant effect on mean black-browed albatross abundance (Table 4). The number of birds was significantly reduced in all counting areas when discard was released in batches compared to when discard was continuous (Table 4, Figure 1 and 2). Zero discard further significantly reduced the number of black-browed albatrosses in all count areas, and eliminated all presence within the danger area (Table 4, Figure 1 and 2).

3.3. Discard treatment effects on giant petrels

Discard treatment also showed an effect on the abundance of giant-petrels (Table 4). Within the 40m count area, batch discarding significantly reduced the number of birds present on the water and in the air, in comparison to continuous discarding (Table 4, Figure 3 and 4). Batch discarding had an insignificant effect on the number of giant petrels feeding within the tori-line area and present in the danger area, but still reduced the numbers in each case (Table 4, Figure 3 and 4). As for albatrosses, zero discard significantly reduced the number of giant petrels in all count areas, and eliminated all presence in the danger area (Table 4, Figure 3 and 4).

Table 4 The mean abundance of black-browed albatrosses and giant petrels present in each count area during the various discard treatments. The asterisks highlight the level of significance from the control treatment (continuous discarding): *** = significant at p < 0.0001.

Discard treatment	Black-browed albatrosses				Giant petrels			
	40m (water)	40m (air)	feeding	danger area	40m (water)	40m (air)	feeding	danger area
Continuous	97.25	55.32	23.87	7.66	28.13	7.46	3.42	2.04
Batch	66.41***	39.24***	12.29***	3.35***	22.38***	4.71***	2.55	1.50
Zero	4.72***	3.13***	0.00***	0.00***	3.72***	1.99***	0.00***	0.00***

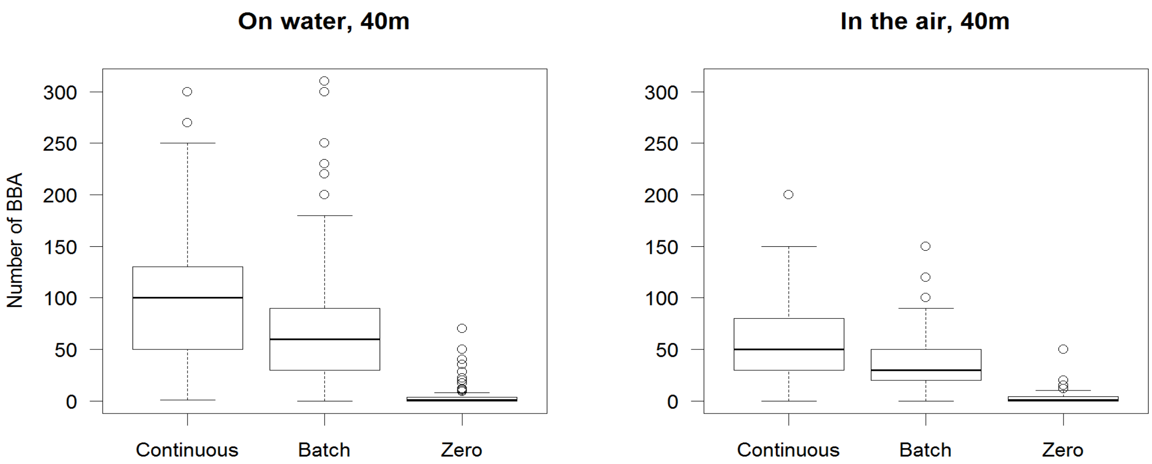

Figure 1 Boxplots showing the relative abundance of black-browed albatrosses (BBA) on the water and in the air within 40m from the stern during the three discarding treatments.

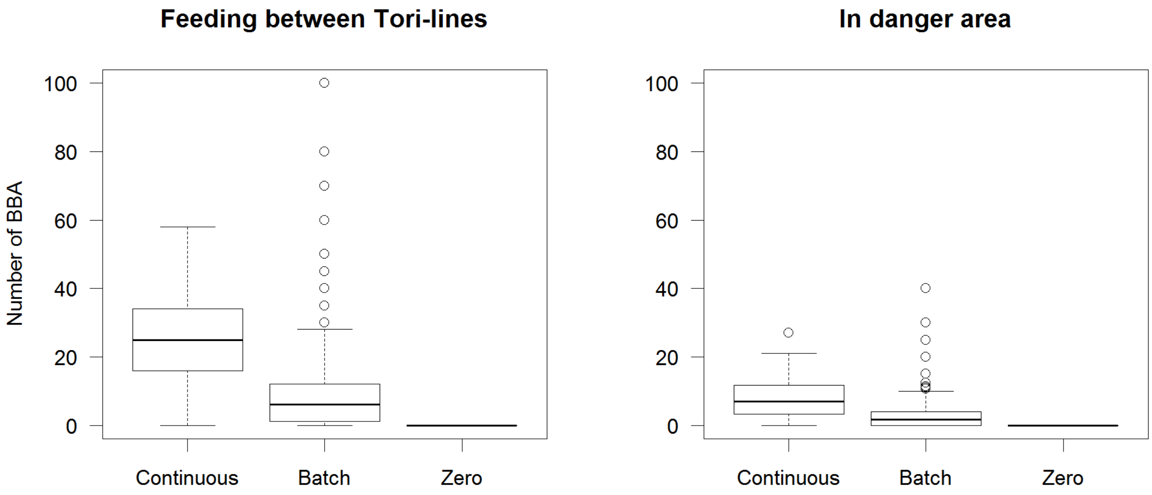

Figure 2 Boxplots showing the relative abundance of black-browed albatrosses (BBA) feeding between the tori-lines and present within the danger area during the three discarding treatments.

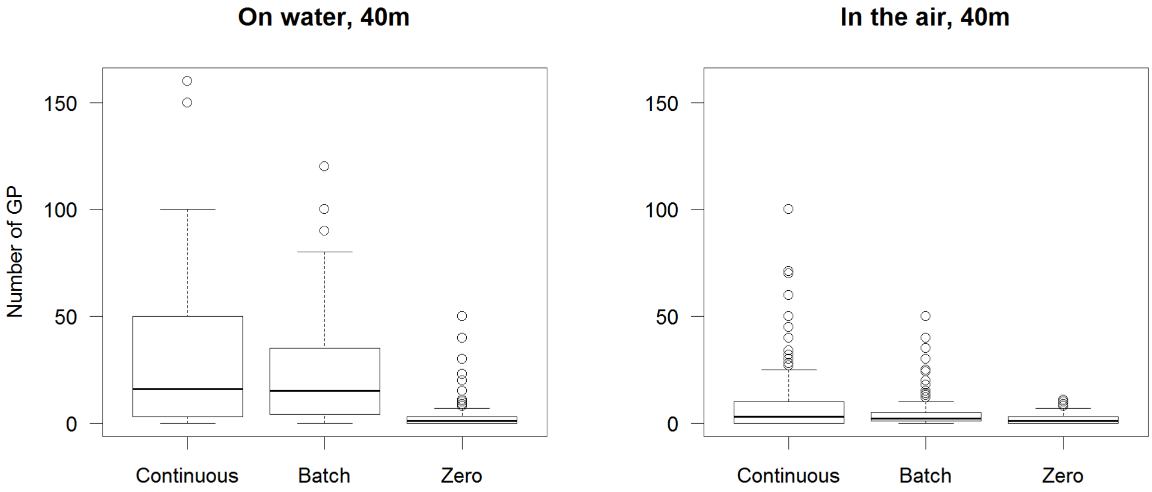

Figure 3 Boxplots showing the relative abundance of giant petrels (GP) on the water and in the air within 40m from the stern during the three discarding treatments.

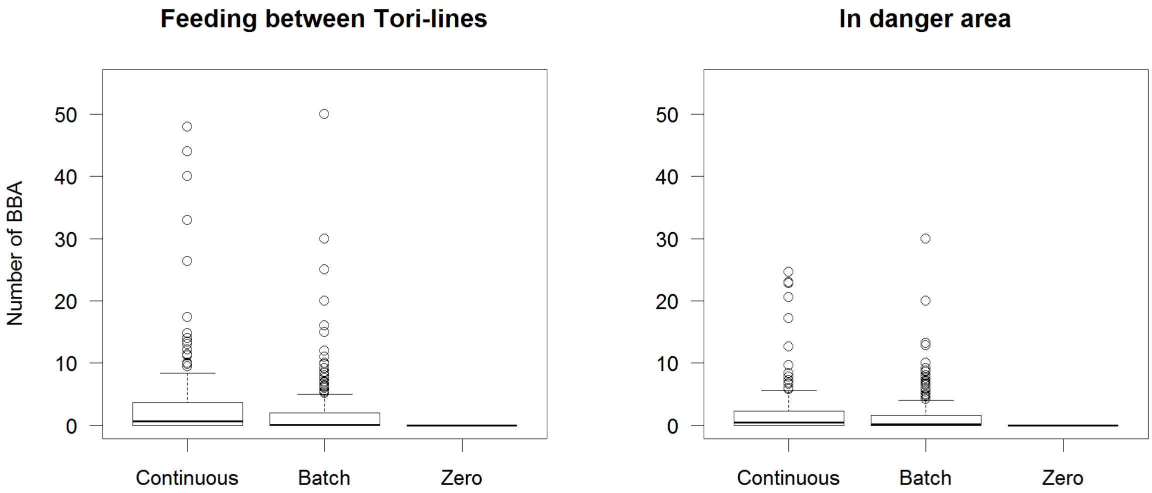

Figure 4 Boxplots showing the relative abundance of giant petrels (GP) feeding between the tori-lines and present within the danger area during the three discarding treatments.

4. DISCUSSION

4.1. Discard management effects on seabird interactions

Consistent with previous findings, our results demonstrate that discharging unwanted whole catch and processed fish from fishing vessels attracts seabirds, and that eliminating all discards can successfully discourage high risk species such as black-browed albatrosses and giant petrels from the area where they are most at risk from being struck by warp cables, thereby reducing the risk of warp strikes to negligible levels.

Similar to Pierre et al. (2010, 2012b), we also show that seabird responses reflect the form in which discard is being released. Whilst continuous discarding resulted in the highest abundance of seabirds astern the vessel, it also brought the highest number of seabirds within the danger area where they are at an immediate risk of warp strikes. Releasing discard in batches of ca. 30-60 minutes significantly reduced the number of black-browed albatrosses, and, to a lesser extent, of giant petrels around the vessel. Batch discarding also significantly reduced the number of black-browed albatrosses feeding between the tori-lines and present in the danger area, inferring a significant reduction in vessel interaction and bycatch risk. Numbers of giant petrels feeding and present within the danger area were also reduced, although not significantly. This compares with reporting from Pierre et al. (2012b), who found that in comparison with continuous discarding, 2 hours of discard retention significantly reduced large seabirds (comprising albatrosses and giant petrels) and small seabirds (smaller petrels) within 10 and 40 m from the vessel, but that 30 minutes of discard retention only significantly reduced small seabirds.

The difference in batch discard effectiveness found between our two species groups may partly be related to behavioural differences, but also to the presence of the tori-lines. Whilst albatrosses generally approach the discard from the air, giant petrels approach the discard from the water and hence tend to land, sit and wait for more discard to become available within the 40 m area, outwith the tori-lines. Throughout the study periods, giant petrels were often observed to feed more abundantly outwith the tori-line area, and hence their presence was reduced to low numbers within the feeding and danger area even during continuous discarding.

4.2. Further work

Our preliminary analysis conducted does not currently account for the time-dependent nature of the abundance data, nor does it consider the effect that other environmental and operational variables may have had on seabird abundance. Whilst our current results nevertheless compare with previous findings, further analyses using mixed effects models for more robust results are envisaged.

When viewing our results, it is also important to remember that the intermittent nature of discarding of guts between batch discharge events will have retained a higher proportion of large seabirds around the vessel than might be expected if discard between batch discharges had been negligible (i.e. sump water only) (see reviews by Bull, 2009 and Løkkeborg, 2011). As such, even greater reductions in abundance and hence by-catch risks can be expected for batch discard treatments if tank design ensured retention of all unwanted catch/processing waste. Whilst work to date shows that longer holding periods reduce interactions (Pierre et al, 2012b), further research is required to determine the minimum holding period required to reduce interactions and mortalities to negligible levels.

4.3. Summary and recommendations

The volume of fish waste on Falkland Islands finfish trawlers is substantial; however, our study shows that storage periods of even 30-60 minutes can significantly reduce abundance of black-browed albatrosses and, to a lesser extent, giant petrels, thereby reducing the risk of warp-related mortalities of these high risk species.

In line with our findings, and in agreement with Pierre et al. (2012b), the following recommendations are drawn for waste retention as a means of discard management.

(1) The retention of all waste whilst warp cables are in the water continues to be the ideal waste management option for reducing seabird interactions with warp cables.
(2) Discharging waste continuously when it becomes available is the least desirable option.
(3) Second to discharging outwith periods of fishing activities, waste should be discarded in batches as infrequently as possible.
(4) Holding waste for 30-60 minutes can significantly reduce the number of high risk species; however, note that previous studies suggest much longer holding periods (Pierre et al., 2010; 2012b).
(5) As the minimum holding period required to reduce interactions to negligible levels has not yet been established, the longest possible holding period is recommended.
(6) Storage tank installations should allow storage of all processing waste and unwanted whole fish as to prevent discharge of anything but sump water during storage periods.
(7) Tank design and installation should be such that all stored waste can be (batch) discharged directly out to sea in a matter of seconds.

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