Mincing offal to reduce the attendance of seabirds at trawlers

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1. INTRODUCTION

Seabirds are attracted to trawlers by the discharge of fish waste. If the discharge occurs while the vessel is trawling, then birds may be killed by being struck by the trawl warps (Wienecke & Robertson 2002, Sullivan et al. 2006a, Watkins et al. 2008, Melvin et al. 2007). In the New Zealand squid fishery, before the use of mitigation devices was made compulsory, approximately half of the birds that were killed by fishing and brought back on board the vessel were killed by being struck by trawl warps (Abraham & Kennedy 2008). The occurrence of warp strike is strongly associated with the discharge of fish offal and other waste (Sullivan et al. 2006b, Abraham & Kennedy 2008, Abraham & Thompson 2009b). Across all the warp strike data collected in New Zealand fisheries between 2004 and 2007, the warp strike rate was found to decrease by over 99% when discharge was eliminated.

Ideally, there would be no discharge while the vessels were fishing. However, many fishing vessels are unable to manage factory wastes to eliminate discharge. The challenge is to find other methods that will reduce the attractiveness or availability of the discharge to the birds, or that keep the discharge away from the danger zone between the stern of the vessel and the trawl warps. There have been two approaches to this problem in New Zealand fisheries. Firstly, in late 2006, mincing of offal was trialled as a method for reducing the numbers of seabirds attending a hoki (*Macruronus novaezelandiae*) trawler (Abraham et al. 2009). The principle behind mincing offal is that the slurried waste should be less available to the birds than the unprocessed offal. This experiment was also repeated in early 2007 on a vessel targeting squid (Abraham 2007). While the first experiment showed that mincing offal reduced the numbers of large albatross (*Diomedea spp.*) immediately behind the vessel, the second experiment was hampered by variability in the material being discarded, and by a low number of forms being completed. While mincing was only partly successful, the first experiment showed that converting waste to fish meal and storing it on board reduced the numbers of small albatrosses (*Thalassarche spp.*) to less than five percent of the number that were behind the vessel when unprocessed discharge was released.

A second approach has been to trial batching waste, storing it in a container and only dumping it at intervals (Abraham 2009). In an experiment in the southern squid trawl fishery in early 2008, the effect of different batch intervals on the abundance of birds immediately behind the vessel was tested. With a four hour or eight hour interval between batches, the number of birds present during the discharge event was reduced when compared to the thirty minute batch interval.

In this report, results are presented from a repeat of the mincing experiments, conducted during two trips, primarily targeting hoki, on the east coast of the South Island of New Zealand in early 2008. As in the first experiments, the numbers of seabirds behind the vessel were counted, and the response of these counts to different treatments of the waste stream was determined. The machinery used for macerating the offal was developed specifically for the vessel used, and the protocol was modified so that more data could be collected. This experiment continues a series of work aimed at reducing the bycatch of seabirds in New Zealand fisheries, including studies of the efficacy of mitigation (Middleton & Abraham 2007, Abraham et al. 2008) and previous trials of different offal management strategies (Abraham 2007, 2008, 2009). These experiments have been designed and coordinated by the Mitigation Technical Advisory Group. This group has representation from the fishing industry, the Ministry of Fisheries, the Department of Conservation, WWF-New Zealand, and Birdlife International. The experiments were conducted during normal fishing operations, with the seabird counts being made by Ministry of Fisheries' observers.

2. METHODS

2.1 Experimental context

The experiments were carried out on two trips. The vessel used was a 40 m long New Zealand flagged trawler, built in 1989, which was equipped to process and freeze catch while at sea. Fishing was on the east coast of the South Island of New Zealand (Figure 1), and normal fishing operations were carried out during both trips. The first trip (referred to as Trip A) ran from March 14 to March 26, 2008, and the second trip (Trip B) ran from April 17 to May 1, 2008. The vessel fished for hoki in the west, south and north locations, with some fishing for silver warehou (*Seriolella punctata*) on the second trip while in the west location. Fishing at the east location was for smooth oreo (*Pseudocyttus maculatus*).

Trawlers over 28 m in length fishing in New Zealand waters are required to use mitigation devices to minimise the risk of seabird bycatch (Department of Internal Affairs 2006). During these trips, the vessel had bird bafflers fixed in place (Carey 2005). Whenever processing was taking place while the vessel was fishing, paired streamer lines were also deployed.

2.2 Experimental treatments

Three different experimental discharge treatments were used:

- Unprocessed. The discharge of all offal and waste in its unprocessed form.
- Hasher. The discharge of offal through a hasher pump that broke the offal into chunks.
- Cutter. Offal put through the hasher into a tank. The slurry then recirculated through a cutter pump, reducing it to a paste.

During the first treatment, factory waste was transferred directly into the offal chute and discharged overboard without further processing. In the second treatment, waste was chopped into rough chunks through a hasher and then discharged through the offal chute. In the third treatment, waste from the

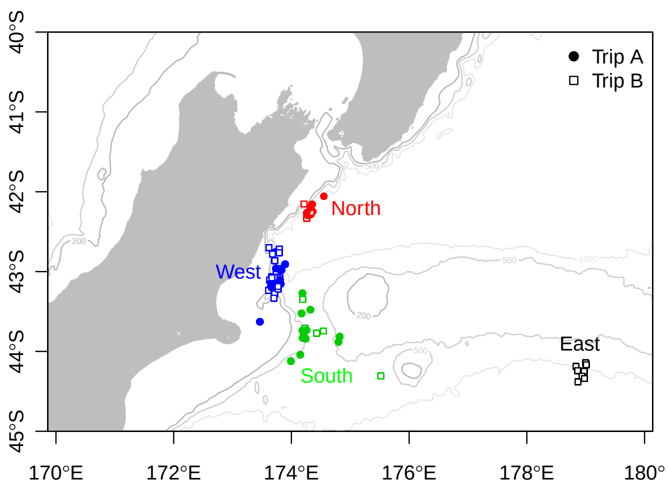

Figure 1: Location of tows with experimental observations, from the two trips. The positions of the tows have been randomly jittered by between ±0.1° to meet Ministry of Fisheries data con dentiality requirements. The tows are grouped into four locations, referred to as North, West, South and East.

(a) Hasher treatment

(b) Cutter pump treatment

Figure 2: Photographs of sh waste after being processed through (a) the hasher, and (b) the hasher and the cutter pump.

hasher pump was dropped into the sump, and a cutter pump fitted into the sump recirculated the water and chopped offal. The rate of water flow into the sump was adjusted to create a close to continuous discharge. The two pump systems were trialled at sea before the first experiment, and during the trials two 1 kg samples of smooth oreo were processed, one through the hasher and one through both the hasher and the cutter pump. A qualitative assessment of the two samples found that approximately 75% of the hashed offal was in chunks. Measurements of the 20 largest pieces from the hasher sample found that they were between 30 mm and 60 mm in size, with an average size of 40 mm. In contrast, most of the material that had been through the cutter pump was in a slurry form, with approx 25% as strips or pieces. Measurements of the 20 largest pieces from the cutter sample found that they were between 10 mm and 40 mm in size. Photographs of the two samples are shown in Figure 2.

Each treatment was run for a full day, from midnight to midnight, with all seabird observations being made during daylight hours. The schedule for the treatments was determined before each trip, using a randomised-block design, so that each treatment was used once within each block of three consecutive days.

2.3 Observations

Birds were counted from the stern of the vessel within a 40 m radius semi-circular sweep extending behind the vessel (Figure 3), following a protocol similar to one used previously (Abraham et al. 2009, Abraham 2009). A separate sub-total was also used to count the number of birds within a smaller 10 m zone, more tightly focussed on the region between the stern and the warps. Separate counts were made of birds in the air and on the water, in each of four species groups (Table 1). Cape petrels were separated from the other petrels into their own group, as there can be large numbers of Cape petrels attending vessels, but they are caught relatively infrequently (Abraham & Thompson 2009a). During a single observation, a separate sweep count was made for each combination of species group and sweep radius, and for birds in the air and on the water. This resulted in a total of up to 16 sweep counts for each observation. The observer was instructed to spend no more than one minute on each individual sweep count. When birds were abundant the counts were necessarily approximate. Because separate counts were made of birds on the water and birds in the air, some individual birds may have landed on or taken

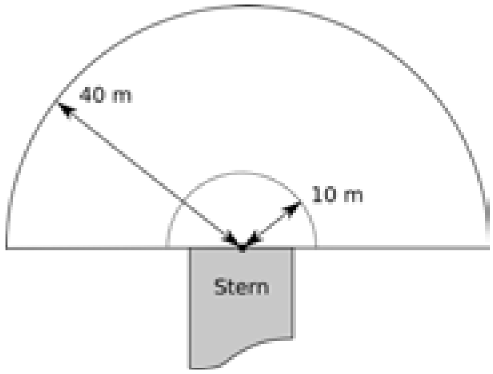

Figure 3: Diagram of the sweep zones aft of the vessel. Birds were counted within 40 m and 10 m radius semi-circles, centered on the middle of the vessel's stern.

Table 1: A summary of the four seabird groups used for sweep counts. Separate counts were made of the number of birds in each group.

Seabird group	Genera
Large albatrosses	*Diomedea*
Small albatrosses and giant petrels	*Thalassarche*, *Phoebetria*, and *Macronectes*
Cape petrels	*Daption*
Other procellarids	principally *Pachyptila*, *Procellaria*, *Pterodroma*, and *Puffinus*

off from the water between sweeps, and been either not counted or counted more than once.

During each observation, the observer recorded the discharge in each of four groups (sump water, minced or macerated material, offal, whole discards). The discharge rate of each type was categorised by whether there was no discharge, or whether there was discharge within the 10 m radius sweep, the 40 m radius sweep and not the 10 m sweep, or both the 10 m and the outer 40 m sweep zones.

In addition to the discharge and bird counts, the observer recorded the start time of each observation; the wind strength (on the Beaufort scale); the wind direction (on a 12 point scale corresponding to the numbers on a clock, where 12 is from directly in front of the vessel, 3 is from the starboard side, etc.); the tow stage (shooting, fishing, hauling or not fishing); and the number of vessels visible.

Observations were made on forms developed for the trip ('Seabird observation form, Mincing trials, dated 7 March 2008'). An example of a completed fully form is shown in Figure 4. The observer made up to ten observations on each form, at five minute intervals, with a complete form requiring up to 1 hour. On each form, the observer also recorded the vessel speed (knots); swell height (metres); the experimental treatment (Offal chute, Cutter pump, Hasher pump); and information need to link the form to other data (trip number, tow number, and date). On each form, there was also opportunity for the observer to make general comments related to the observations.

The observers were asked to complete at least four forms per day, on every day of the voyage, weather and safety permitting. They were not expected to conduct observations while it was dark, but were otherwise asked to spread the observations throughout the day. Observations were made during trawling and when the vessel was not fishing, but not when shooting or hauling. If the vessel was shooting or

Seabird observation form
Mincing trials (68)

Date observations started (ddmmyy): 25 03 08

Sample identification

Trip number:

Tow number (if towing): 1156

Treatment
- ☐ Offal chute
- ☐ Cutter pump
- ☑ Hasher pump

Background information (record before first observation):

Vessel speed (knots): 4.3 | Swell height (metres): 1

Observation			1	2	3	4	5	6	7	8	9	10
Time	Hour		12	12	12	12	12	12	12	12	12	12
Time	Minute		00	05	10	15	20	25	30	35	40	45
Wind strength			4	4	4	4	4	4	4	4	4	4
Wind direction			2	2	2	2	2	2	2	2	2	2
Tow stage			F	F	F	F	F	F	F	F	F	F
# vessels visible			0	0	0	0	0	0	0	0	0	0
Discharge	Sump		3	3	3	2	2	3	2	2	2	2
Discharge	Mince/Cutter		2	3	2	2	0	3	0	3	2	3
Discharge	Offal		0	0	0	0	0	0	0	3	0	0
Discharge	Discards		0	3	0	0	0	0	0	0	0	0
Large albatross	40m	Air	1	2	1	2	1	2	2	1	1	0
Large albatross	40m	Water	3	4	2	1	2	3	1	4	2	0
Large albatross	10m	Air	0	0	0	0	0	0	0	0	0	0
Large albatross	10m	Water	0	0	0	0	0	0	0	0	0	0
Small albs + GPs	40m	Air	50	60	40	50	40	45	30	70	35	30
Small albs + GPs	40m	Water	70	100	20	65	35	60	25	120	30	40
Small albs + GPs	10m	Air	2	4	0	1	0	0	0	8	0	1
Small albs + GPs	10m	Water	8	30	4	3	0	0	0	20	0	0
Cape pigeons	40m	Air	0	0	0	0	0	0	0	0	0	0
Cape pigeons	40m	Water	0	0	0	0	0	0	0	0	0	0
Cape pigeons	10m	Air	0	0	0	0	0	0	0	0	0	0
Cape pigeons	10m	Water	0	0	0	0	0	0	0	0	0	0
Other procellarids	40m	Air	30	30	40	30	30	40	30	30	40	30
Other procellarids	40m	Water	40	60	60	70	30	70	35	60	20	60
Other procellarids	10m	Air	4	10	0	6	0	5	0	3	2	9
Other procellarids	10m	Water	10	15	2	15	0	15	0	8	2	4

Comments
EAT and JAV discarded whole during obs 8.
Large LIN heads discarded during obs. 8.
In both cases dramatic increase in bird nos occurred in the sample areas.

Figure 4: An example of a completed form from the rst trip. The original form was A4 size, and is shown reduced by 50%.

hauling then a form would not be started until the shooting or hauling was completed. However, if the vessel started shooting or hauling while a form was being completed, then the observer continued making observations until the form was complete, recording the tow stage of each observation.

During the first trip, the observer made an informal record of the different species of birds that were seen and, during the second trip, the observer made a formal count of the birds within 50 m of the vessel stern during the first daylight trawl of each day. These daily counts were made to species level, where possible.

2.4 Data grooming

On Trip A there were 45 forms with completed 10 observations, 1 form with only 1 observation, and 1 form with 6 observations. On this trip, the experiment was conducted on 13 days. On Trip B there were 40 fully completed forms, and 6 forms with between 6 and 9 completed observations. The experiment was conducted on 15 days. In total, 901 observations were made, each with 16 separate sweep counts. The observers recorded that the designated treatment was followed on all days, with the exception of a single day during Trip A when the hasher pump broke down and unprocessed offal was discharged for part of the day.

All data from the forms were double entered, with the exception of the comments, which were only entered once. On both trips the forms were completed legibly, and data entry errors were small. There were 14 discrepancies found out of a total of over 24 000 values entered, an error rate of 0.06 percent. These discrepancies were reconciled by comparison with the original forms. Some minor corrections were also made to correct trip numbers, a missing tow number, missing treatments, and to clarify comments.

After the grooming, there were still some missing data. There were two forms with a missing vessel speed, 50 observations with missing wind direction (as there was no wind), and two sets of observations where the header information had been completed but the bird counts were left empty.

Not all observations were used in the modelling. The number of observations that were removed before analysis are shown in Table 2. During the second trip, the observer made observations from the bridge when the weather was bad. These observations were identified from the comments field. Preliminary exploration showed that counts made from the bridge were lower than other counts. To avoid confounding the dataset, data from forms completed from the bridge were removed. The protocol allowed for observations to made when the vessel was not fishing. When not fishing the streamer lines were withdrawn, and the vessel travelled at speeds outside of the usual fishing speed (between 3 and 4.5 knots). For these reasons, the counts made when the vessel was not fishing were not comparable. As there was no also risk to seabirds from warp strike when the warps were not in the water, these observations were removed from analysis. After removing these observations only 574 of the original 901 observations remained.

In addition, there were 53 observations where there was discharge that was either not consistent with the experimental treatment, or where the discharge of both cut material and raw offal was recorded at the same time. On one day (1 May 2008), the observer recorded the experimental treatment as ‘unprocessed discharge’, but recorded cutter pump discharge and no offal discharge during all observations. There were no data that could be used to resolve this discrepancy. Observations where the discharge did not match the treatment were removed to ensure a clean dataset.

Table 2: A summary of the rules used to groom the dataset, with the associated number of observations removed by sequentially applying the rules in the order given. The number of observations that remained in the dataset after applying each rule is also given.

Description	Obs. removed	Obs. remaining
Initial observations	-	901
Observations from bridge	110	791
Vessel not fishing	217	574
Cut or hashed material during offal treatment	7	567
Offal during pump treatment	39	528
Mixed discharge	7	521

Table 3: A summary of the derived discharge categories used for analysis and modelling.

Category	Discharge
None	No discharge of any type
Sump	Sump water in either sweep zone, but no discharge of any other type
Pump	Minced or cutter material in any zone, but no offal or discards, or
	Minced or cutter material in the 40 m zone, and offal or discards only in the 10 m zone
Offal	Offal in any zone, no minced or cut material

2.5 Discharge

For each of four discharge types (sump, mince/cutter, offal, and discards), a presence score was given according to whether there was no discharge, discharge within the 10 m sweep, discharge within the 40 m sweep but not the 10 m region, or discharge within both the 10 m and the 40 m regions. From these categorisations a simplified set of discharge groups was derived (Table 3) that classified the discharge as either none, sump, pump, or offal. The 'pump' category was further defined as either 'hasher' or 'cutter' depending on the experimental treatment that was being used on that day. In past work it was found that seabird abundance within the sweep zone changed rapidly in response to the discharge (Abraham 2009). It was expected that the abundance of birds would be primarily be determined by the recorded discharge, rather than the nominal treatment. In the analysis, the discharge category was used as the main experimental variable.

2.6 Statistical modelling

The estimation of the effect of discharge on bird counts was carried out using Generalised Linear Models (GLMs). For each species group, location (in the air or on the water), and sweep radius, the mean count was estimated as a linear function of a number of covariates including the treatment. Typically, count data are overdispersed. We allowed for overdispersion in the data by representing the count data as samples from a negative binomial distribution (e.g., Hilbe 2007). The negative binomial was parametrised by a mean, μ, and an overdispersion, θ. The variance is then given by $\mu + \mu^2/\theta$. As the overdispersion increases to infinity the variance goes to the mean, and the negative binomial distribution converges to a Poisson. As θ gets small relative to the mean, the negative binomial distribution becomes increasingly peaked at zero and develops a long right hand tail.

The negative binomial may be generated by a Poisson mixture distribution, with a gamma distributed mean. The count y_i made during observation i may be modelled as

$$y_i \sim \text{Poisson}(\mu_i \delta_i), \quad (1)$$

$$\delta_i \sim \text{Gamma}(\theta, \theta), \quad (2)$$

where the Gamma distribution has shape θ and a mean of one. In this sense, the negative binomial is a natural choice for modelling bird counts, as the overdispersion may be taken to represent the effect of unknown processes on the variation of the mean count.

The logarithm of the mean count during a single observation, μ_i, was assumed to be a linear function of N covariates, x_{ij}, with

$$\mu_i = \lambda \nu_{k_i} \exp(\sum_{j=1}^{N} \beta_j x_{ij}), \quad (3)$$

where β_j are the coefficients of the covariates, x_{ij}, λ is the average count, and ν_{k_i} are tow-level random

Table 4: A description of the covariates used in the modelling, giving the values and a description of each covariate.

Covariate	Value	Description
Discharge	None, Sump, Hashed, Cut, Offal	Discharge, the primary experimental covariate
Location	North, East, South, West	Position of the observation, divided into four groups (Figure 1)
Swell	log(swell height + 1)	Swell height, the logarithm is taken to make the distribution less skewed
Wind	log(wind speed + 1)	Wind speed, the logarithm is taken to make the distribution less skewed
Vessels	log(vessels + 1)	The number of visible vessels, the logarithm is taken to make the distribution less skewed
Trip	A, B	The trip number, included as a two-level factor

effects. The covariates were all normalised before the model fitting, by subtracting the mean value and dividing by the standard deviation. After fitting, the regression coefficients, β_j, were converted back into standard units for presentation purposes.

The tow-level random effects, v_{k_i}, allow for the fact that bird numbers may change between tows for reasons that are not captured by the other covariates. A tow level effect was chosen, as this reflects the disruption to the seabirds attending the vessel that results from hauling and re-setting the net. The tow-level random effects were drawn from a gamma distribution with unit mean and shape θ_v,

$$v_{k_i} \sim \text{Gamma}(\theta_v, \theta_v), \tag{4}$$

where k_i indicates the tow associated with observation i.

During the model fitting, estimates were made for the parameters β_j, λ, θ, and θ_v. Prior distributions were required for these parameters. Diffuse normal priors were used for the logarithm of the overall mean, $\log(\lambda)$, and the regression coefficients, β_j. Uniform-shrinkage priors were used for the overdispersion parameters θ and θ_v (Gelman 2006):

$$\begin{aligned}
\log(\lambda) &\sim \text{Normal}(\mu = \log(\bar{y_i}), \sigma = 100), && (5)\\
\beta_j &\sim \text{Normal}(\mu = 0, \sigma = 100), && (6)\\
\theta &\sim \text{Uniform-shrinkage}(\mu = \bar{y_i}), && (7)\\
\theta_v &\sim \text{Uniform-shrinkage}(\mu = \bar{y_k}), && (8)
\end{aligned}$$

where $\bar{y_i}$ is the mean count per observation and $\bar{y_k}$ is the mean count per tow.

The models were run for 10 000 updates during burn-in, and then run for a further 50 000 updates, with every 20$^{\text{th}}$ sample being retained for analysis.

2.7 Covariates

The model structure allowed for mean counts to depend on covariates. For each model, a step analysis was used to select the covariates from those given in Table 4 that had explanatory power (Venables & Ripley 2002), with discharge always being included. The covariates were transformed before being included. Although the range of wind speeds, swell heights or visible vessels was not large enough to necessitate the use of the logarithmic transform, the transformations were made for consistency with the analysis of the batching experiment (Abraham 2009). Maximum likelihood methods were used to fit a negative binomial GLM to the count data. At each stage of the step analysis, the model was fitted repeatedly, with each of the potential covariates included (or removed) in turn. The covariate was selected that produced the greatest reduction in the AIC (Aikake Information Criterion, Akaike 1974). Steps continued until the deviance was not reduced by more than 2%. Placing a requirement on the deviance reduction prevented the inclusion of covariates that had little explanatory power. The selection was carried out separately for each model, and the appropriate covariates included in the full Bayesian fit.

3. RESULTS

3.1 Seabird species

A summary of the daily seabird counts is given in Table 5. On Trip B, the daily counts were completed, and the table presents the median and range of these data for each recorded species. Some changes to the observer's coding have been made. The observer recorded the presence of XSY (Shy albatross, *Thalassarche steadi*). This was changed to white-capped albatross, as the use of the XSY code reflects practice prior to the taxonomic separation of these two species. The observer also used the code XSS (Seabird - small), and it was assumed that these were unidentified petrels. On Trip A, the observer did not make the formal species counts, but made a note in their diary indicating a range for the numbers of each bird species that were present.

The species with the highest recorded counts were Cape petrel, but these were only present in large numbers during Trip B. White-capped albatross were the most abundant albatross species, with Salvin's albatross also present. During Trip A, the observer recorded the presence of Buller's and Campbell albatrosses. Giant petrels and great albatrosses were present in low numbers (median values of less than 10). Neither of these taxa were identified to species level. In addition, there were large numbers of unidentified petrels. No further information on the identification of these species was given.

3.2 Data

A summary of the total bird counts during offal discharge, when the numbers of birds behind the vessel was expected to be highest, is given in Table 6. These totals are from the sum of the counts of birds on the

Table 5: A summary of daily seabird species counts of the birds behind the vessel, giving the species composition of the seabird assemblage. Identi cations are reported as they were made by the observer.

Seabird	Taxon	Trip B		Trip A
		Median	Range	Range
Cape petrel	*Daption capense*	50	23 – 295	1 – 10
White-capped albatross	*Thalassarche cauta*	30	4 – 80	1 – 100
Salvin's albatross	*Thalassarche salvini*	10	5 – 20	1 – 10
Giant petrels	*Macronectes*	5	1 – 15	1 – 20
Great albatrosses	Diomedeidae	3	1 – 23	1 – 10
Buller's albatross	*Thalassarche bulleri*			1 – 20
Campbell albatross	*Thalassarche impavida*			1 – 20
Unidentified petrels		40	5 – 80	1 – 200

Table 6: Summary of the seabird counts by trip and location, during offal discharge. The median and range of the total counts (on the water and in the air) with the 40 m sweep zone are given.

	Trip A						Trip B			
	West		South		North		West		East	
	Med.	Range	Med.	Range	Med.	Range	Med.	Range	Med.	Range
Large albatross	4	(0 - 10)	2	(0 - 7)	8	(3 - 17)	15	(6 - 30)	6	(1 - 8)
Small albatross	30	(16 - 52)	48	(22 - 65)	80	(50 - 100)	90	(50 - 160)	28	(20 - 35)
Cape petrel	0	(0 - 17)	0	(0 - 1)	0	(0 - 0)	115	(50 - 290)	40	(20 - 60)
Other petrel	120	(55 - 240)	110	(60 - 210)	29	(15 - 85)	55	(35 - 140)	75	(50 - 100)

Table 7: The mean number of seabirds in the air and on the water, and within the 10 m and 40 m sweep zones, during offal discharge.

	40 m			10 m		
	Air	Water	Total	Air	Water	Total
Large albatross	2.5	4.1	6.6	0.4	0.5	0.9
Small albatross	21.4	34.2	55.5	5.7	5.8	11.5
Cape petrel	13.4	26.1	39.5	6.9	10.9	17.8
Other petrel	37.0	56.5	93.4	9.5	8.7	18.1

water and in the air, within the 40 m sweep. During the first trip, the assemblage of birds was dominated by other petrels, at the west and south locations, and by small albatross at the northern location. Cape petrel were largely absent during the first trip. During the second trip, Cape petrel were the main species at the west location, but other petrel where the main species at the east location. Even though the two trips visited similar areas, the assemblage of seabirds changed between the trips. With the exception of the west location during the second trip, the numbers of large albatross were low (always less than 20 birds, and sometimes none).

A summary of the individual bird counts during offal discharge is given in Table 7. This table gives the average count, during offal discharge, for birds in the air and on the water, and for birds within the 10 m and 40 m sweep zones. Within the 40 m sweep, the mean number of birds on the water was greater than the mean numbers of birds in the air, for each of the four species groups. Within the 10 m sweep zone the numbers of birds in the air was closer to the number of birds on the water.

The ratio of the total number of birds within the 10 m sweep, compared to the number within the 40 m sweep, ranged from 14% for large albatross to 45% for Cape petrel. This ratio was similar for small albatross and other petrel, at 19% and 21% respectively. There were more Cape petrel within the 10 m sweep zone, relative to the 40 m sweep, than would be expected if either the birds where distributed evenly throughout the 40 m sweep, when the ratio would have been 6%, or if they were spread in a linear way behind the vessel, when the ratio would have been expected to be 25%. This was consistent with a concentration of Cape petrel close behind the vessel. The other bird groups were distributed in a way that was intermediate between an even and a linear distribution, without evidence of concentration within the 10 m sweep.

The distributions of the covariates that were used for the modelling are given in Figure 5. There were a similar number of good observations made on each trip (Figure 5a). Most observations were made in the west and south locations (Figure 5b), with the least number of observations being made in the north. The

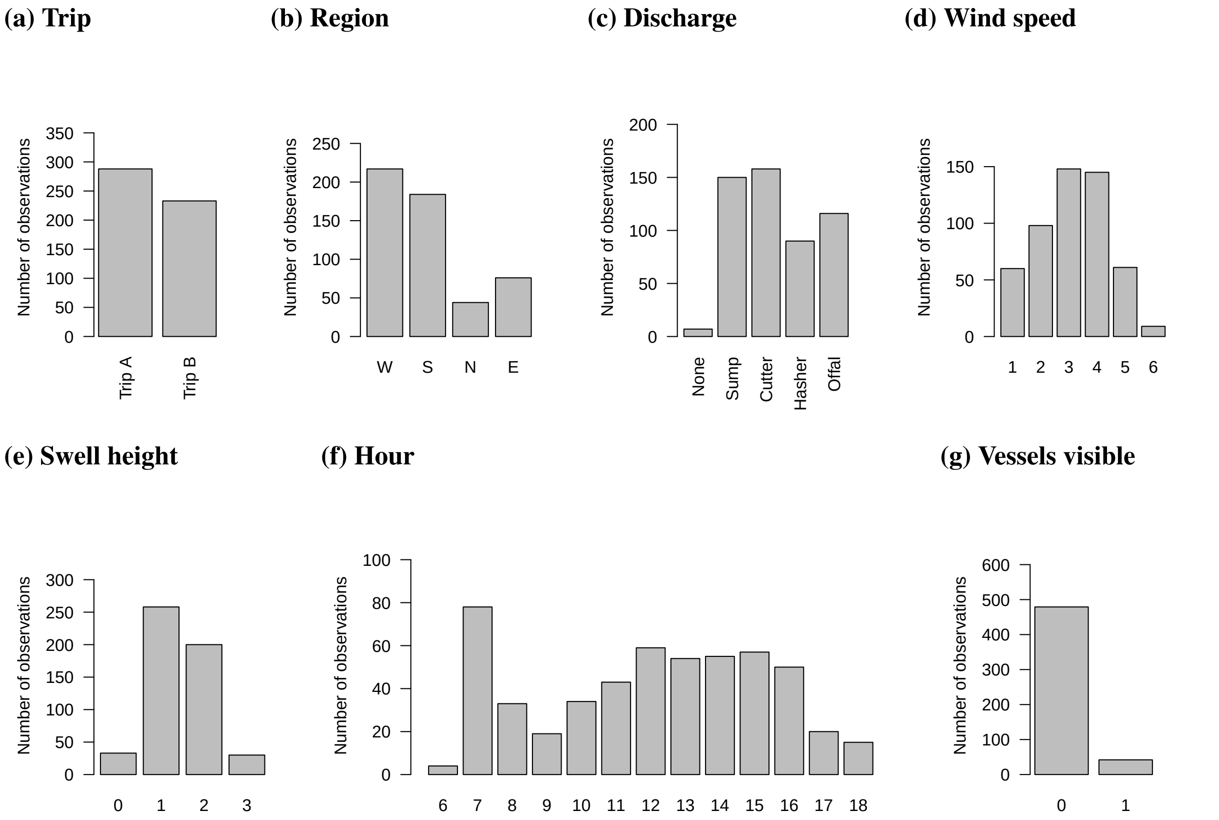

Figure 5: Distribution of the potential covariates, from observations that were used for the modelling, giving (a) the trip number, (b) the location (W - west, S - south, N - north, E - east), (c) the discharge, (d) wind speed in Beaufort scale, (e) swell height in meters, (f) hour of the observation, (g) the number of vessels visible.

most frequent discharge types were either sump or cutter (Figure 5c). There were only 7 observations made when there was no discharge. The wind speed was most frequently between 3 and 4 on the Beaufort scale (Figure 5d). The swell height was most frequently between 1 m and 2 m (Figure 5e), with no good observations being made when the swell height was greater than 3 m. Observations were made between 6 a.m. and 6 p.m. (Figure 5f), with most observations being made between 12 noon and 4 p.m., and with a pronounced peak in the number of observations at 7 in the morning. Typically, there were no other vessels visible, with at most one other vessel being seen (Figure 5g).

A summary of the bird counts, grouped by the discharge type, is given in Figure 6. These figures give the ratio of the mean numbers of birds in each category (species group, sweep zone, and in the air or on the water), relative to the mean number in the same category during offal discharge, across all observations. The error bars give the 95% confidence intervals, calculated as percentiles of the results from an ordinary bootstrap. In calculating the bootstrap, the individual observations have been treated as independent, without accounting for the structured nature of the experimental design. In most cases, the ratios for birds in the air and on the water were similar, and there was no consistent evidence from the raw data for an effect of cutter or hasher discharge on bird counts. For some bird groups, the cutter or hasher pump treatments were associated with higher numbers than the offal treatment. In other cases, they were associated with lower numbers. There were, however, consistently fewer birds behind the vessel during sump discharge. There were also significantly fewer birds within the sweep zones when there was no discharge, despite the very low number of observations.

While it can be instructive to look at the patterns in the raw data directly, their interpretation relies on

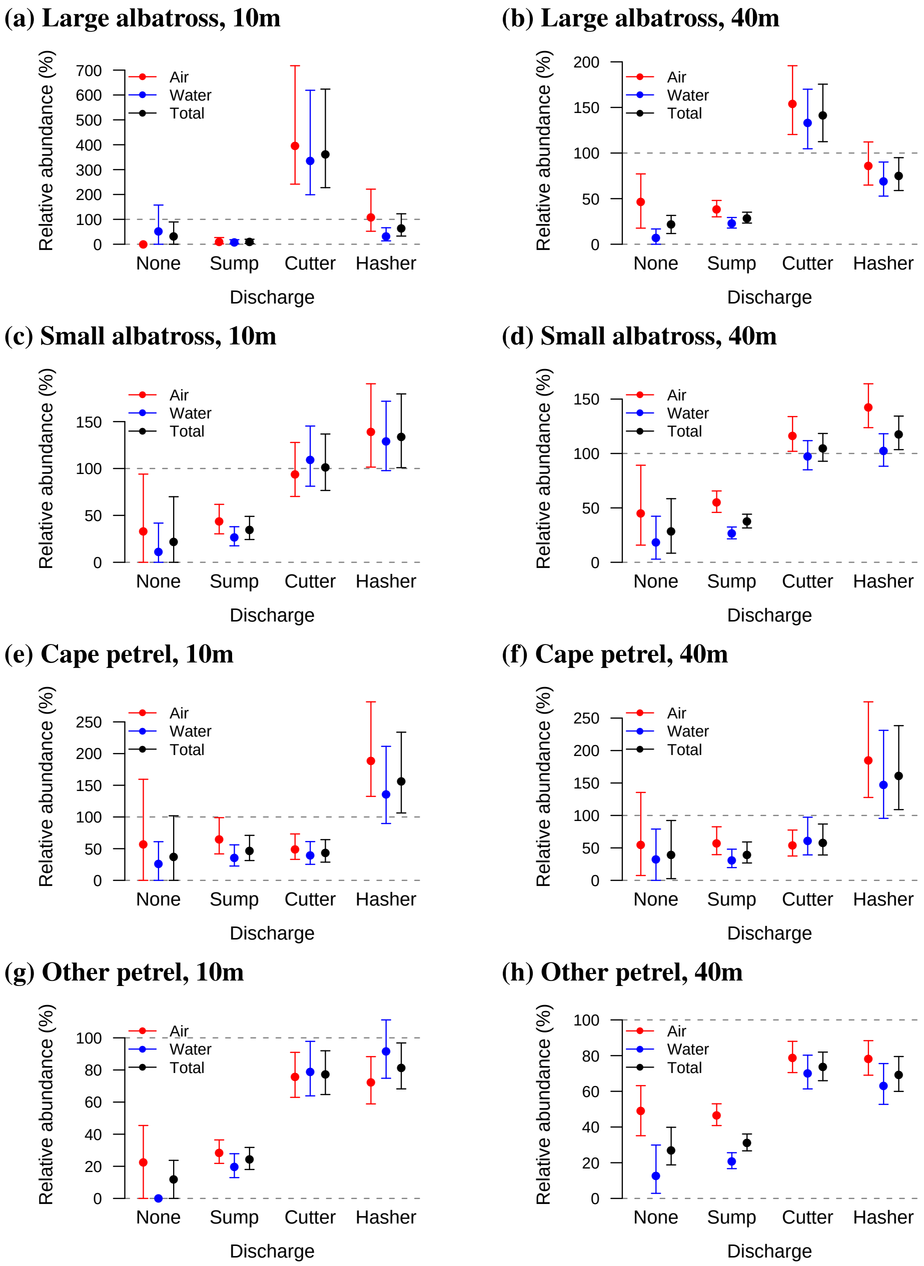

Figure 6: A summary of the raw data, giving the mean number of seabirds during different discharge conditions, relative to the mean abundance during offal discharge. The error bars are the 95% con dence intervals of the ratio calculated from a simple bootstrap.

the experiment being balanced with respect to any other factors that are associated with variations in the bird numbers. Despite the randomised-block experimental design, there was variation in the distribution of observations by discharge type between the different locations (Figure 7). While there were more observations made during offal and sump discharge in the west location than in the other locations, there were more observations during cutter pump discharge in the east location than in any of the other locations. There were no observations made during hasher pump discharge in either the east or north location. Because of the variation in the relative numbers of birds between the locations for the same discharge condition (Table 6), this lack of balance in the experimental treatments between locations makes interpretation of the raw data more difficult.

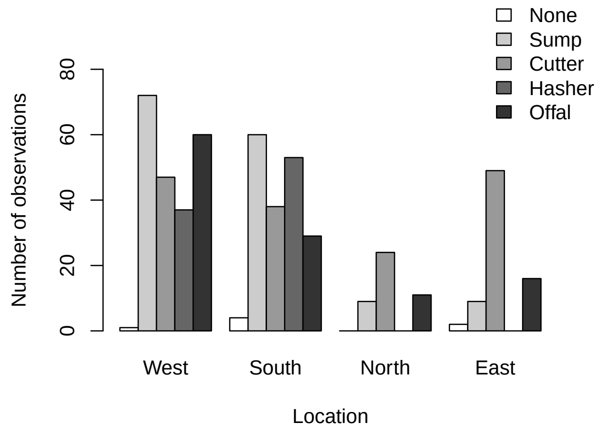

Figure 7: Number of observations with different discharge conditions, by location.

3.3 Covariate selection

A summary of the step analysis is given in Table 8. The table gives the percentage deviance explained by the addition of each term to the model. The discharge type was always included in the models. The order in which terms were added to the model by the step analysis is not shown, however, aside from discharge, it was generally in decreasing order of the deviance explained. In nearly all of the models, trip and location were included. In many of the models, they explained more deviance than the discharge, and in most of the models the trip covariate explained more deviance than the location covariate. The other covariates were not consistently included in the models, and in all but one case, they each explained less deviance than the discharge covariate. The covariates shown were all included in the Bayesian models, however we focus on the discharge effects and do not present results for the other covariates.

3.4 Statistical modelling

The Bayesian models were successfully fitted in all cases, with the exception of large albatross in the air and on the water, within the 10 m sweep zone. These two large albatross models were unstable, and did not complete the model fitting. This fitting problem appeared to be associated with the low absolute counts in these categories. Convergence of the fitted models was checked by using a stationarity test (Heidelberger & Welch 1983), checking the chains for each of the discharge related parameters. In all cases, with the exception of the total large albatross within the 10 m zone, convergence was achieved for all 8 of these chains. For the total 10 m large albatross model, there were convergence problems in both chains for the no discharge factor, and in one chain for the cutter pump factor, so these results must be treated with some caution.

The effect of discharge on the bird counts, from the Bayesian modelling, is summarised in Figure 8, with the data being presented in Table 9. There were some clear patterns in the median values of the discharge effects:

- In all cases, there were fewer birds on the water during any of the non-offal discharges, relative to the number that were present when there was offal discharge, and in most of these cases, this decrease in the counts was significant (the only exception was small albatross during the cutter pump treatment).

Table 8: Summary of the model selection, from an analysis of variance, giving the percentage of the remaining deviance explained by the addition of each term to the model. Terms that explained less than 2% of the remaining deviance are not included.

Model			Covariates							
Birds	Sweep	Location	Discharge	Trip	Region	Swell	Wind	Vessels	Sin(h)	Cos(h)
Small alb.	10	Air	9.3	70.7	16.9		5.8			4.4
		Water	16.2	47.9	7.8					4.1
		Total	11.4	60.1	9.8					3.1
	40	Air	25.7		8.0	3.7	17.2			
		Water	36.9	8.0	6.6		2.6			
		Total	38.5	7.2	9.4		12.4		2.5	
Large alb.	10	Air	28.9	53.1		6.6		4.1	2.7	12.8
		Water	33.8	46.4	5.2					8.1
		Total	33.5	53.9	7.2	2.6				8.8
	40	Air	19.4	32.0	7.5	13.6				
		Water	27.1	26.5	4.9					2.5
		Total	29.2	35.8	7.6		4.4		2.0	
Cape petrel	10	Air	10.6	82.9	43.9	3.1				
		Water	9.7	82.0						
		Total	9.7	84.9	43.3		3.0			
	40	Air	9.5	74.7	32.5				6.5	
		Water	8.1	67.7	24.8				6.4	
		Total	7.0	68.9	27.3				10.0	
Other petrel	10	Air	14.2	33.4	5.3	2.1				
		Water	20.3	24.6	7.6					2.3
		Total	16.7	31.5	5.1					
	40	Air	19.8	27.0	5.3	5.8			2.1	
		Water	32.7	7.2	12.9				3.4	
		Total	33.7	19.2	12.3	5.2			3.0	

- In most cases there was also a reduction in the total number number of birds during non-offal discharge (the only exception was the 40 m counts of small albatross during the cutter pump treatment).
- In all cases (bird groups, sweep zones, and discharges) where the models were successfully fitted, there was a greater reduction in the number of birds on the water than in the air, for discharges other than offal discharge.
- The reduction in both the total number of birds and the number of birds on the water, was greater during observations when there was only sump pump water being discharged, than during cutter and hasher discharges (with the exception of Cape petrel). The cutter and hasher discharges reduced the total number of birds within the 40 m zone to between 41% and 99% of the number that were present during offal discharge, with the smallest reduction being for the small albatross group. In comparison, the discharge of sump water reduced the total number of birds within the 40 m zone to between 32% and 68%, depending on the species.
- The experiment allows the efficacy of the hasher and cutter pump discharges to be directly compared. For birds on the water, the reduction during hasher discharge was greater than the reduction from cutter discharge, with the exception of Cape petrel. While the result is consistent across the range of bird categories, there was typically overlap between the confidence intervals, and the difference between the cutter and hasher discharge effects was often not significant.
- Across the range of discharges (none, sump, cutter, and hasher), there was a greater reduction for the 10 m counts than the 40 m counts (Table 9). This held in all models, with the single exception

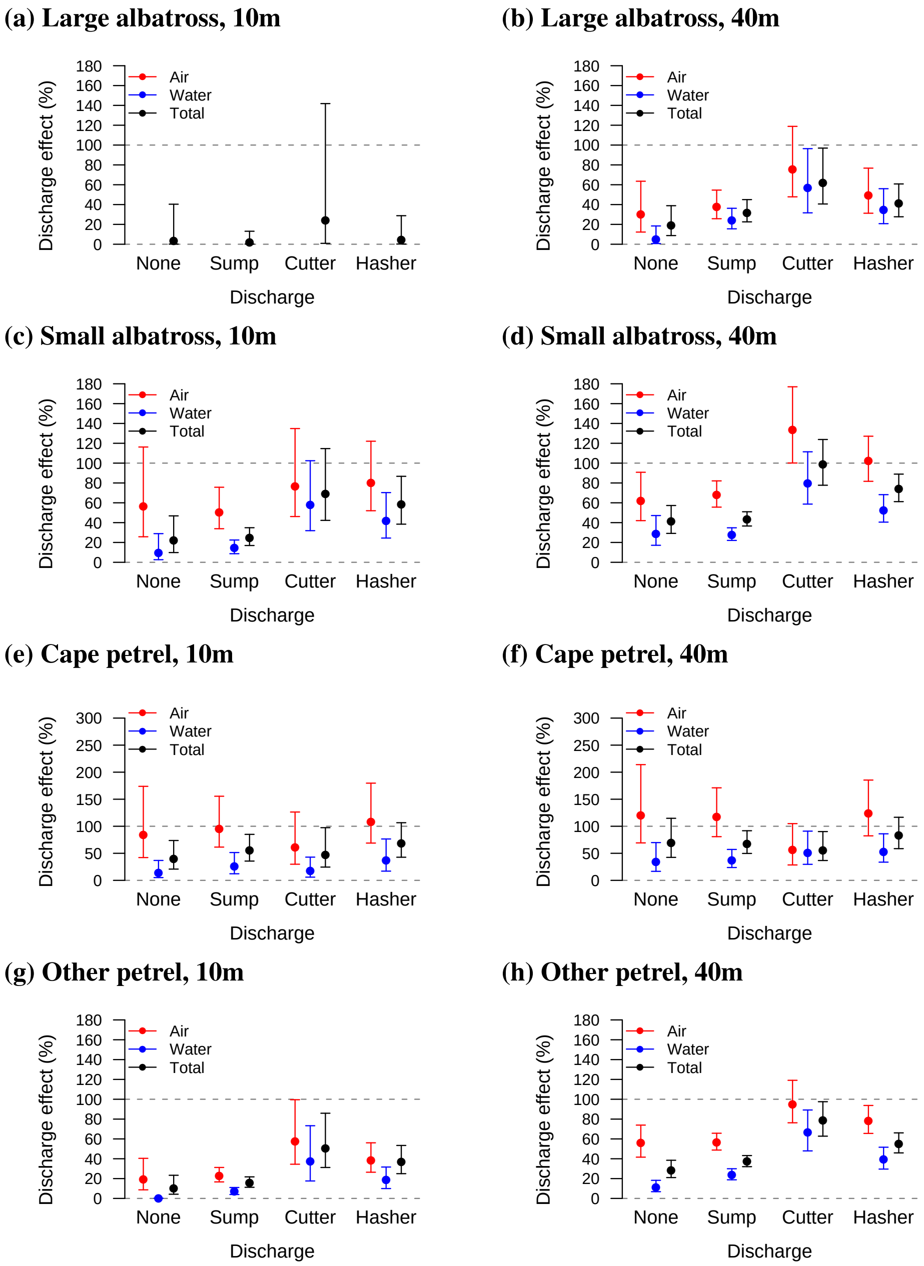

Figure 8: A summary of the model results, giving the estimated effect of different discharges on bird abundance, relative to offal discharge. The gures gives the median and 95% con dence intervals of the posterior distribution of the model estimated coef cients of the discharge covariates. The data are given in Table 9.

of Cape petrel in the air, during cutter pump discharge. The 10 m zone includes the warps, and so was the area behind the vessel where there was the greatest risk of warp strike.

These results confirm that both the total number of birds and the number of birds on the water, are reduced by hashing or hashing and cutting factory waste. The effect of cutter and hasher discharge on numbers of birds in the air was less clear.

Table 9: A summary of the model results, giving the effect of discharge on bird abundance, relative to offal discharge. The table summarises the posterior distributions of the discharge parameters from the Bayesian model, giving the median and the 95% con dence intervals.

		Model	None		Sump		Cutter		Hasher	
Birds	Sweep	Location	Med.	95% c.i.	Med.	95% c.i.	Med.	95% c.i.	Med.	95% c.i.
Small alb.	10	Air	0.56	(0.26 - 1.16)	0.5	(0.34 - 0.76)	0.77	(0.46 - 1.35)	0.8	(0.52 - 1.22)
		Water	0.1	(0.03 - 0.29)	0.14	(0.09 - 0.22)	0.58	(0.32 - 1.02)	0.42	(0.24 - 0.7)
		Total	0.22	(0.1 - 0.47)	0.25	(0.17 - 0.35)	0.69	(0.42 - 1.15)	0.58	(0.38 - 0.87)
	40	Air	0.62	(0.42 - 0.91)	0.68	(0.56 - 0.82)	1.34	(1 - 1.77)	1.02	(0.82 - 1.27)
		Water	0.29	(0.17 - 0.47)	0.28	(0.22 - 0.35)	0.79	(0.59 - 1.11)	0.52	(0.41 - 0.68)
		Total	0.41	(0.29 - 0.57)	0.43	(0.37 - 0.51)	0.99	(0.78 - 1.24)	0.74	(0.61 - 0.89)
Large alb.	10	Total	0.03	(0 - 0.4)	0.02	(0 - 0.13)	0.24	(0.01 - 1.42)	0.04	(0 - 0.29)
	40	Air	0.3	(0.12 - 0.64)	0.38	(0.26 - 0.55)	0.75	(0.48 - 1.19)	0.49	(0.31 - 0.77)
		Water	0.05	(0.01 - 0.18)	0.24	(0.16 - 0.36)	0.57	(0.32 - 0.96)	0.35	(0.21 - 0.56)
		Total	0.19	(0.09 - 0.39)	0.32	(0.23 - 0.45)	0.62	(0.41 - 0.97)	0.41	(0.28 - 0.61)
Cape petrel	10	Air	0.84	(0.42 - 1.74)	0.95	(0.62 - 1.55)	0.61	(0.3 - 1.26)	1.08	(0.69 - 1.8)
		Water	0.14	(0.05 - 0.37)	0.26	(0.12 - 0.51)	0.17	(0.06 - 0.43)	0.37	(0.17 - 0.77)
		Total	0.39	(0.21 - 0.74)	0.55	(0.36 - 0.85)	0.47	(0.25 - 0.97)	0.68	(0.43 - 1.07)
	40	Air	1.2	(0.69 - 2.14)	1.17	(0.81 - 1.71)	0.57	(0.29 - 1.05)	1.24	(0.82 - 1.85)
		Water	0.34	(0.17 - 0.7)	0.37	(0.24 - 0.57)	0.5	(0.3 - 0.91)	0.53	(0.34 - 0.86)
		Total	0.69	(0.42 - 1.15)	0.68	(0.5 - 0.92)	0.56	(0.37 - 0.9)	0.83	(0.59 - 1.17)
Other petrel	10	Air	0.19	(0.09 - 0.4)	0.23	(0.17 - 0.31)	0.57	(0.34 - 1)	0.39	(0.26 - 0.56)
		Water	0	(0 - 0)	0.07	(0.04 - 0.11)	0.38	(0.18 - 0.73)	0.19	(0.1 - 0.32)
		Total	0.1	(0.04 - 0.23)	0.16	(0.11 - 0.22)	0.5	(0.31 - 0.86)	0.37	(0.25 - 0.53)
	40	Air	0.56	(0.42 - 0.74)	0.57	(0.49 - 0.66)	0.95	(0.76 - 1.19)	0.78	(0.66 - 0.94)
		Water	0.11	(0.07 - 0.18)	0.24	(0.19 - 0.3)	0.66	(0.48 - 0.89)	0.39	(0.3 - 0.52)
		Total	0.28	(0.21 - 0.38)	0.37	(0.32 - 0.43)	0.79	(0.63 - 0.98)	0.55	(0.46 - 0.66)

4. Seabird captures

There were 3 bird captures recorded on Trip A, 1 white-capped albatross and 1 unidentified petrel that were tangled in a tori line and released unharmed, and 1 white-capped albatross that was caught by the wing in the bird baffler and dragged through the water, but that escaped alive. There were 8 birds killed during Trip B, 5 white-chinned petrels and 2 sooty shearwaters caught in the trawl net on a single tow, and 1 white-capped albatross the was killed by hitting the bird baffler while the vessel was fishing. There were no recorded warp captures on either trip.

4.1 Observer comments

The observer on Trip B did not make any detailed comments on the effect of the treatments, however the observer on Trip A made notes on their perception of the effect of changing the treatment in their trip diary. These are reproduced verbatim below:

> Based on observations made over the course of the trip it was seen that there were in fact variations in the activity of the birds around the vessel depending on the way in which processing offal was being discarded.
>
> OFFAL CHUTE:
> This method of discharge appeared to attract the most birds to the vessel as discarded heads and whole fish floated at the surface. It also attracted larger birds, i.e. mollymawks, closer

to the stern of the vessel as they fought over the large pieces of floating debris.

CUTTER PUMP:
This seemed to change the distribution of birds in proximity to the boat rather than decrease the number of birds. Smaller birds such as petrels, shearwaters and cape pigeons followed the constant discharge slick right up to the stern of the vessel whereas the larger mollymawks did not seem interested and hung back around the periphery of the outer sample area.

HASHER PUMP:
The batching discharge produced by this pump created a situation where a large number of birds (both small and large) would descend on the slick as it passed the stern of the vessel and continue to feed from it as it floated away from the vessel. This created a boom or bust distribution with large numbers of birds present for short periods of time when each offal batch was discarded.

NOTES:
Large albatrosses rarely came in close proximity to the boat no matter what treatment was implemented. Large ling heads and sharks that cannot be put through the hasher still have to be discarded and negate the effect of cutting the offal, as vast numbers of birds approach the vessel as these float at the surface. The combination of tori lines and bird bafflers seems very effective in keeping birds away from the warps when offal is passing through the 10 m zone (in any state).

5. DISCUSSION

5.1 The protocol

The two trips both returned complete sets of data with well completed forms. Many of the observations were dropped from the analysis as they were collected while the vessel was not fishing. If this experiment is repeated in the future, it should be modified so that observations are only made while the net is being towed. This is when there is risk of warp strike. When the vessel is not fishing tori lines are not deployed, and the vessel speed is often outside its normal fishing range. Abundance counts are not then comparable.

A second problem with the data collection, was that one observer was unable to stand on the stern for many of the samples, and made their observations from the bridge. Because these observations require a clear view of both sweep zones, they should only be collected if this can be achieved. If the conditions are such that there is no safe position at the stern of the vessel for making the observations, then observations should not be made.

During the previous experiment, on a squid trawler in early 2007 (Abraham et al. 2009), the 10 m counts were largely unusable as the numbers were low and they were dominated by variability. At that time, only a single observation was made on each form. The changes to the protocol, with up to 10 observations being made on each form, and often multiple forms being completed per day, greatly increased the power of the experiment to detect changes in the numbers of birds. In the dataset used for modelling there were a total of 521 observations, compared with 160 in Abraham et al. (2009). As a consequence, significant reductions in the number of birds within the 10 m zone were able to be detected.

The previous mincing protocol obtained separate counts of flying birds, birds sitting on the water and the number actively feeding. In the experiment reported here, the protocol was simplified, and the birds were only divided into two groups: birds in the air and birds on the water. The motivation for this change was firstly to reduce the number of counts that were required, and secondly, because there is not a well described relationship between the activity of the birds (flying, sitting on the water, or feeding) and the

(a) Hasher **(b) Cutter**

Figure 9: Observer sketches of the different discharges from (a) the hasher pump (Trip B, tow 19) and (b) the cutter pump (Trip B, tow 67). The hasher pump discharged in pulses, whereas the cutter pump produced a continuous discharge.

risk of warp-strike. In the previous experiment, the greatest reduction from mincing offal was in the numbers of feeding birds (Abraham et al. 2009). Neglecting to separate feeding birds and birds sitting on the water may have reduced the power of the protocol to detect a response.

6. Offal treatment

In general, the cutter and hasher pumps worked well, and the vessel was able to follow the experimental design for all but 1 of the 29 experimental days. The hasher pump was unable to process some of the large fish and shark bycatch, however, and this led to discards being dumped during the treatments. There were many comments in on the forms on how these intermittent discards attracted the birds (see Appendix). On one occasion the observer noted that discarded galley scraps were attracting birds into the sweep zone. If an offal processing system was installed for operational use, it should be able to process as much of the waste stream as possible.

As the cutter pump discharge was processed more than the hasher discharge (the cutter discharge was put through both the hasher pump and the cutter pump), it may have been expected that there would have been a greater effect for cutter discharge, than hasher discharge. In fact, the model results suggest that the hasher pump treatment caused a greater reduction in the number of birds behind the vessel. The observer comments are revealing, however. The initial assumption of the experiment was that reducing the particle size would make the waste less available to the larger birds. Although the hasher pump produced waste of a larger size than when it was used together with the cutter pump, one of the observers noted that it tended to produce waste in batches. For example on Trip A, tow 20, the observer noted 'Hasher pump discharges every 3 min leaving a 10-15 m offal slick every 300 m'. The birds would be attracted to a patch of waste and then float with it away from the vessel. In contrast, the cutter discharge was produced semi-continuously. On Trip B, tow 19, with cutter pump discharge the observer made the comment 'Cape pigeons most attracted by smaller consistent trail'. During hasher discharge, on Trip B, tow 67, the observer made the comment 'with hasher pump discharging once every few minutes the birds are attracted to the areas of coloured water, hence behind the boat instead of a constant trail of birds following the vessel there are clusters of birds attracted to the coloured water'. The observer's sketches associated with these two different comments are shown in Figure 9. The decrease in abundance during hasher discharge, relative to cutter discharge, may be be a response to the intermittent nature of the hasher discharge, rather than differences in the size of the macerated pieces.

The current protocol does not resolve either the variation in the discharges (at timescales of less than 5 minutes) or fine scale structure in the distribution of birds within the sweep zones. Importantly, variation in the discharge frequency will influence the reproducibility of the experiment. While different treatments may produce waste with a similar typical size, they may incorporate different volumes of seawater, and produce a waste stream that has different temporal characteristics. For offal processing to be compared between vessels, this aspect should be measured and preferably controlled. During the experiments, video footage was made from a backward facing camera and from a camera that looked down the side of the vessel past the discharge chute. Analysis of this video would allow a better characterisation of the discharge stream, and the birds' responses to it.

6.1 Experimental results

The experimental results (summarised in Figure 8 and Table 9) present a clear pattern. Across a range of species, the discharge of cutter pump or hasher pump material reduced the number of birds (both the total number and the number of birds on the water) behind the vessel. This reduction was greater for the counts of birds within the 10 m zone, and was achieved with both the cutter and hasher discharges. For many of the species, the reduction was significant at the 95% confidence level. The model for large albatross had convergence issues for the 10 m counts, for the other species the reduction of total numbers in the 10 m sweep, during either cutter or hasher discharge relative to offal discharge, had a median value of 31% to 63%. For large albatross the reduction in total numbers within the 40 m zone was 38% and 59% for cutter and hasher discharges, respectively.

These results are comparable with results obtained from batching offal, that resulted in reductions of between 11% and 44% in the median numbers of birds within the sweep zone (comparing four hour and eight hour intervals between batches with a half hour interval). However, the reduction is much less than has been recorded by eliminating discharge. In an earlier experiment, when all waste was converted to fish meal and discharges were reduced to sump water, the abundance of the albatrosses and petrels (excluding giant petrels and Cape petrels) within the 40 m sweep zone was reduced by over 95% (Abraham et al. 2009). Similarly, across all warp strike observations that have been made in New Zealand waters, the average large bird warp strike during discharge was 3.22 birds per hour (Abraham & Thompson 2009b). This reduced to an average rate of 0.02 birds per hour when there was no discharge, a reduction of over 99%. While either cutting or hashing the offal was found to reduce seabird attendance, elimination of waste discharge during fishing should remain the goal.

7. ACKNOWLEDGMENTS

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APPENDIX A: Observer comments

Table A-1: Verbatim observer comments, taken from each observation form. This table gives the comments from the rst trip (Trip A).

Date	Tow no.	Comments
14/03/08	2	NO PROCESSING OF FISH OCCURRED DURING THIS OBSERVATION PERIOD. ONLY CLEAN SUMP WATER WAS BEING DISCHARGED FROM THE FACTORY. SKIPPER STARTED HAULING 10 MINS BEFORE THE COMPLETION OF THE OBSERVATION. DURING THE LAST 2 OBSERVATIONS (9&10) GALLEY SCRAPS WERE BEING DISCARDED WHICH APPEARED TO BE ATTRACTING THE BIRDS CLOSER TO THE VESSEL.
14/03/08		THE VESSEL WAS STEAMING TO KAIKOURA DURING THE OBSERVATION PERIOD. THE SPEED THE VESSEL WAS STEAMING AT (9-10KT) CARRIED TO OFFAL AWAY FROM THE VESSEL AND DISPERSE IT QUICKLY. THERE WAS CONTINUED PROCESSING/DISCHARGE THROUGHOUT THIS OBSERVATION.
15/03/08		BOAT STEAMING QUITE QUICKLY SO OFFAL MOVED AWAY FROM VESSEL VERY FAST. A LARGE STREAM OF BIRDS IN THE WAKE OF THE BOAT WAS OBSERVED BOTH INSIDE AND WELL BEYOND THE 40M TEST RADIUS.
15/03/08	5	BOTH TORI LINES AND BIRD BAFFLERS WERE DEPLOYED DURING THIS OBSERVATION. OBSERVATION WAS ABANDONED AS THE NET CAME FAST AT 0937 AND THE NET HAULED MUCH EARLIER THAN PREDICTED. DURING HAUL VESSEL WAS PULLED BACKWARDS SO DISCHARGED OFFAL MOVED TOWARDS THE BOW OF THE VESSEL. AS SUCH BIRDS CONGREGATED NEAR THE STARBOARD STERN QUARTER OF THE BOAT TO EAT OFFAL IMMEDIATELY AFTER IT LEFT THE DISCARD CHUTE. THE DEPLOYED TORI LINES WERE ALSO REMOVED AS THEY WERE TANGLING IN THE WARPS AS THE NET WAS PULLED LOOSE.
15/03/08	6	VESSEL BEGAN TO HAUL AT 1135. SLOWED TO 1-2KT FOR THIS PERIOD. ONCE HAULED VESSEL SPEED WENT TO APPROX 9KT. OBSERVATIONS 6-8 THE NET WAS ON THE SURFACE. OBSERVATIONS 9-10 NET WAS ON DECK. NOTE: VERY SHORT TOW: (45MIN).
15/03/08	7	NET CAME FAST SO HAD TO BE HAULED EARLY (1440). MISSED OBSERVATION AT 1440 AS 2 BIRDS GOT TANGLED IN TORI LINE AND WERE BEING DRAGGED BEHIND THE VESSEL. LEFT OBS POINT TO PULL IT IN AND FREE THEM. FROM 1440 TO 1500 BOAT WAS PULLED BACKWARDS SO OFFAL DISCHARGE PROCEEDED FORWARD OF THE VESSEL AND BIRDS WERE ATTRACTED AWAY FROM THE OBSERVATION AREAS. 1500 ONWARDS BOAT PROCEEDED AT AROUND 9KT.
16/03/08	12	NO PROCESSING OCCURRED DURING THIS OBSERVATION. AT ONE STAGE SOME OFFAL WAS DISCHARGED FROM THE FACTORY SUMP WHILE THE FACTORY WAS BEING HOSED DOWN AFTER FREEZER BREAKOUT. THIS EITHER SANK OR WAS EATEN BEFORE IT LEFT THE INNER 10M OBS RADIUS.
16/03/08	13	DURING OBSERVATIONS 6&7 WHOLE SHARKS AND LARGE LIN HEADS WERE BEING DISCARDED. BIRDS SEEMED ATTRACTED TO THESE AS THEY FLOATED AT THE SURFACE FOR A LONG TIME AND WERE HIGHLY VISIBLE.
16/03/08	13	NO PROCESSING DURING THIS TOW HOWEVER THE OFFAL SUMP DISCHARGED ONCE AS IT OPERATES ON A FLOAT SWITCH. (OBS 8).
17/03/08	16	NO TORI LINES DEPLOYED DURING THIS OBSERVATION. NO PROCESSING OCCURRED DURING THIS OBSERVATION.

Table A-1: Verbatim observer comments, taken from each observation form. This table gives the comments from the rst trip (Trip A).

Date	Tow no.	Comments
17/03/08	17	BOTH TORI LINES IN OPERATION FOR THIS TOW. LARGE LIN HEADS AND WHOLE DWD WERE BEING DISCARDED AT VARIOUS POINTS DURING THE OBSERVATION. THESE BOTH SEEMED TO ATTRACT THE SMALL ALBATROSSES IN LARGE NUMBERS. THE MINCED UP CUTTER PUMP DISCHARGE DID NOT APPEAR TO ENTICE THE BIGGER BIRDS TO THE WATER. RATHER THEY JUST HOVERED ABOVE WAITING FOR LARGER THINGS TO BE DISCARDED.
17/03/08	18	THE PORT SIDE FACTORY SUMP WAS BEING PUMPED OUT EVERY 5-10 MINS. THIS CONTAINED A LARGE AMOUNT OF LIVERS FROM THE HOKI GUTTING LINE WHICH DROP THROUGH THE FLOOR GRATES AND ATTRACT A LOT OF BIRDS INTO THE OBSERVATION AREA.
17/03/08		BOAT STOPPED WHILE PROCESSING A LARGE BAG BUT THEN STARTED STEAMING AT 1725 (OBS 3/4) STARTED OUT AT 1 KT THEN STEAMED IN A LOOP AND BACK THE OTHER WAY AT 5.8 BECAUSE OFFAL WAS BEING SUCKED INTO THE SEAWATER INTAKES.
18/03/08	20	HASHER PUMP DISCHARGES APPROXIMATELY EVERY 3MIN LEAVING A 10-15M OFFAL SLICK EVERY 300M WHILE STEAMING AT 4KT (FISHING SPEED).
18/03/08		THE HASHER HAS BROKEN DOWN SO OFFAL WAS BEING DISCARDED RAW DURING THIS OBSERVATION.
18/03/08		AS THE BOAT WAS HARDLY MOVING AND THE WIND WAS BLOWING ACROSS THE DECK (PORT - STARBOARD) THE DISCHARGED OFFAL WAS SINKING UNDER THE VESSEL AND DRIFTING AWAY TO PORT OF MIDSHIPS.
19/03/08		CONSTANT DISCHARGE OF RAW OFFAL WITH INTERMITTENT SUMP DISCHARGES CONTAINING MINCED OFFAL THAT HAS BEEN SPILLED IN THE FACTORY. NOTE: VESSEL MADE 2 90 DEGREE TURNS AT OBSERVATIONS 4 & 7. ALSO BOAT SPEED INCREASED AFTER THE 1ST TURN FROM 3.8 TO 6.0 KT. VESSEL SPEED STARTED AT 3.8KT AND THEN ALTERED TO 6.0 KT (SEE DIAGRAM).
19/03/08	23	CONDITIONS PRETTY MUCH CONSTANT THROUGHOUT OBSERVATION.
19/03/08	24	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSTANT THROUGHOUT.
19/03/08		NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT.
19/03/08	25	PROCESSING ENDED AT 1820. NO MORE DISCHARGE OF OFFAL OR DISCARDS AFTER THIS POINT.
20/03/08		VESSEL SHOT GEAR AT 1200 AND NET WAS AT THE SURFACE DURING OBSERVATION 9. EXTREME INCREASE IN BIRDS INSIDE THE SAMPLE AREA. ALSO SLOWED BOAT DOWN TO AROUND 4KT TO SHOOT.
20/03/08	30	NO PROBLEMS WITH THIS OBSERVATION. CONDITIONS WERE CONSISTENT THROUGHOUT.
20/03/08	31	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS WERE CONSISTENT THROUGHOUT.
20/03/08		VESSEL WAS STEAMING AT 10KT SO ANY DISCHARGE ONLY REMAINED IN THE INNER 10M OBSERVATION AREA VERY BRIEFLY. LAST OBSERVATION HAD TO BE ABANDONED AS THE FULL 40M OBSERVATION AREA WAS NO LONGER VISIBLE IN THE DARKNESS.
21/03/08	34	NO PROCESSING DURING THIS OBSERVATION. ALSO THE FACTORY HAD BEEN CLEANED OVERNIGHT SO ONLY DISCHARGE WAS CLEAN SUMP WATER. NOTE: ONLY STARBOARD TORI LINE DEPLOYED DURING THIS TOW.
21/03/08	35	PROCESSING OF TOW 34 STOPPED AT 1040. DISCHARGE DECREASED TO NOTHING OVER THE LAST 5 OBSERVATION PERIODS.

Table A-1: Verbatim observer comments, taken from each observation form. This table gives the comments from the rst trip (Trip A).

Date	Tow no.	Comments
21/03/08	36	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT.
21/03/08	36	VESSEL BEGAN HAULING EARLIER THAN ANTICIPATED.
22/03/08	40	NET CAME FAST AT 0845. VESSEL PULLED BACKWARDS UNTIL NET CAME LOOSE. AS SUCH OFFAL FLOATED FORWARD OF THE VESSEL DURING OBSERVATIONS 7 & 8. ONCE LOOSE THE NET WAS RESHOT TO FISHING DEPTH AND CONDITIONS RETURNED TO NORMAL.
22/03/08	42	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT.
23/03/08	45	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT. NO PROCESSING DURING THIS OBSERVATION - VERY FEW BIRDS AROUND VESSEL. NO TORI LINES DEPLOYED FOR THIS TOW.
23/03/08	46	PROCESSING OF HOK CEASED AT 1145 - REMAINDER OF OBSERVATION ONLY HEADS/GUTS OF LARGER BYCATCH SPECIES WERE BEING DISCARDED EG. LIN/HAK/RIB/SOR/WWA.
23/03/08		AS THE BOAT WAS STEAMING QUITE QUICKLY THERE WAS A LOT OF WASH IN THE INNER 10M OBSERVATION ZONE. AS SUCH THE MAJORITY OF BIRDS DIDN'T SEE THE OFFAL DISCHARGED UNTIL IT HAD LEFT THIS AREA.
23/03/08	47	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT.
24/03/08	49	NO PROCESSING DURING THIS OBSERVATION. VESSEL BEGAN HAULING AT 0830 - OBSERVATION WAS COMPLETED BEFORE THE NET REACHED THE SURFACE.
24/03/08		VESSEL WAS STEAMING TO NEW FISHING GROUNDS. CUTTER PUMP DISCHARGE DISSIPATED QUICKLY INTO PROP. WASH. BIRDS DID NOT APPEAR TO NOTICE IT. DURING OBS 9 6-10 LARGE LIN HEADS THAT WERE TOO BIG TO GO TO THE HASHER WERE DISCARDED. BIRD NUMBERS RAPIDLY INCREASED AS THE HEADS FLOATED BEHIND THE VESSEL.
24/03/08	50	THE FACTORY HAD RECENTLY FINISHED PROCESSING SO RESIDUAL HASHER OFFAL WAS BEING DISCHARGED FROM THE SUMP FOR THE 1ST FEW OBSERVATIONS AND THEN WAS JUST WATER. NET CAME FAST AGAIN! SO NET WAS HAULED. VESSEL SLOWED TO 2-3KT WHILE HAULING (ONCE THE NET WAS LOOSE) AND THEN UP TO 8KT ONCE THE NET WAS ONBOARD. OBSERVATIONS 8 & 9 ARE WHILE THE NET WAS AT THE SURFACE. DRASTIC INCREASE IN BIRD ABUNDANCE AROUND THE NET/VESSEL. (ESPECIALLY IN MOLLYMAWKS).
24/03/08	51	BEGAN HAULING AT 1505 BUT ONLY TO SOAK THE BAG WHILE THE POUNDS WERE CLEARED. VESSEL SPEED DROPPED TO AROUND 2KT BUT NET DID NOT COME TO THE SURFACE DURING THE OBSERVATION.
24/03/08	52	NO PROBLEMS WITH THIS OBSERVATION - CONDITIONS CONSISTENT THROUGHOUT.
25/03/08	56	RAT AND JAV DISCARDED WHOLE DURING OBS 3. LARGE LIN HEADS DISCARDED DURING OBS 8. IN BOTH CASES DRAMATIC INCREASE IN BIRD NOS OCCURRED IN THE SAMPLE AREAS.
25/03/08	55	SCAMPI VESSEL STEAMED ACROSS OUR BOW APPROX 500M AWAY AND STEAMED AWAY TO OUR STARBOARD SIDE. WAS NOT PROCESSING AND VERY FEW BIRDS FOLLOWING IT. NO PROCESSING DURING THIS OBSERVATION JUST INTERMITTENT FACTORY SUMP DISCHARGES.
25/03/08	57	NO PROBLEMS WITH THIS OBSERVATION. CONDITIONS CONSISTENT THROUGHOUT.
26/03/08	60	NO PROCESSING DURING THIS TOW - ONLY DISCHARGE WAS CLEAN SUMP WATER.

Table A-1: Verbatim observer comments, taken from each observation form. This table gives the comments from the rst trip (Trip A).

Date	Tow no.	Comments
26/03/08	61	NO PROBLEMS WITH THIS OBSERVATION- CONDITIONS CONSISTENT THROUGHOUT.
26/03/08	62	BOAT WAS SLOWLY TURNING DURING THE LAST 20 MIN OF THE OBSERVATION SO WIND DIRECTION VARIED DURING THAT PERIOD. LARGE LIN HEADS WERE DISCARDED DURING OBSERVATIONS 6&7 AND ALSO OBSERVATION 10. BIRD NUMBERS IN THE SAMPLE AREAS DRAMATICALLY INCREASED AS THE HEADS FLOATED AWAY BEHIND THE VESSEL.

Table A-2: Verbatim observer comments, taken from each observation form. This table gives the comments from the second trip (Trip B).

Date	Tow no.	Comments
14/03/08	1	OBSERVATION WAS ABANDONED AS THE NET CAME FAST SO THE TOW WAS HAULED EARLY. THE OBSERVER HAD TO BE PRESENT TO CHECK OPERATIONS OF PUMPS/CUTTERS FOR THE 1ST TOWS PROCESSING SO WENT DOWN TO THE FACTORY.
17/04/08	3	PROCESSING RUNNING 30 MINS BEFORE OBSERVATION PERIOD. TOW FINISHED SHORTLY AFTER OBSERVATION PERIOD. SOME BIRDS DISTRACTED TO OPPOSITE SIDE OF BOAT WHEN SUMP PUMP DISCHARGE OCCURRED.
18/04/08		PREVIOUS TOW FINISHED PROCESSING 90 MINS BEFORE OBS. VESSEL HAD NOT SHOT AGAIN. OBSERVATION PERIOD FINISHED EARLY BECAUSE OF ATMOSPHERE CHANGE.
18/04/08	6	BAD WEATHER FORCED OBSERVER TO DO OBSERVATIONS FROM BRIDGE, ADEQUATE VIEW ENABLED RELATIVELY ACCURATE NUMBERS. PREVIOUS TOW PROCESSING COMPLETE BEFORE THIS TOW SHOT.
18/04/08	7	OBS DONE SHORTLY AFTER PROCESSING BEGAN.
18/04/08	11	SNOWING.
19/04/08	12	RAIN/HAIL.
19/04/08	13	STRONG WIND, MEDIUM WAVE HIGHT, SUNSHINE. VESSEL JUST BEGINNING PROCESSING OF PREVIOUS TOW.
20/04/08	18	FROM BRIDGE DUE TO WEATHER.
20/04/08	19	CAPE PIGEONS MOST ATTRACTED BY SMALLER CONSISTENT TRAIL. (DIAGRAM) FROM BRIDGE DUE TO WEATHER.
20/04/08	20	PROCESSING OF PREVIOUS TOW JUST FINISHING. FROM BRIDGE DUE TO SWELL HEIGHT.
21/04/08	24	TOWARDS FINISH OF PROCESSING. FROM BRIDGE DUE TO HIGHT WIND/LARGE SWELL.
21/04/08	24	ON BRIDGE DUE TO LARGE SWELL/WIND. VESSEL FINISHED PROCESSING.
21/04/08	25	OBSERVATION FROM THE BRIDGE, VESSEL JUST FINISHING UP THE PROCESSING OF LAST TOW.
22/04/08	30	FROM BRIDGE. THE FACTORY HAD BEEN PROCESSING FOR AN HOUR.
22/04/08	30	FROM BRIDGE.
22/04/08	31	FROM BRIDGE.
22/04/08	32	FROM BRIDGE. PROCESSING OF PREVIOUS TOW HAD BEGUN 30 MINS PRIOR TO OBS PERIOD.
23/04/08	36	PROCESSING FINISHED IN FACTORY.

Table A-2: Verbatim observer comments, taken from each observation form. This table gives the comments from the second trip (Trip B).

Date	Tow no.	Comments
23/04/08	38	OBSERVATION PERIOD AS PROCESSING FINISHED.
25/04/08	42	VESSEL PROCESSING SSO AND BEO.
26/04/08	47	OBSERVATIONS HALTED BECAUSE VESSEL HAULING.
26/04/08	49	FACTORY STOPPED PROCESSING AT 1700HRS AS FREEZERS FULL.
27/04/08	53	VESSEL STUCK FAST 0810, COME FREE 0820.
27/04/08	54	VESSEL HAULING, OBSERVATION ENDED 1220.
28/04/08		VESSEL STREAMING FACTORY JUST FINISHING PROCESSING OF PREVIOUS TOW.
29/04/08		VESSEL PROCESSING PREVIOUS TOW.
29/04/08	64	STOPPED OBSERVATION BECAUSE VESSEL HAULING.
30/04/08	66	FACTORY JUST FINISHING PROCESSING OF PREVIOUS CATCH.
30/04/08	67	WITH HASHER PUMP DISCHARGING ONCE EVERY FEW MINUTES THE BIRDS ARE ATTRACTED TO THE AREAS OF COLOURED WATER HENCE BEHIND THE BOAT INSTEAD OF A CONSTANT TRAIL OF BIRDS FOLLOWING THE VESSEL THERE ARE CLUSTERS OF BIRDS ATTRACTED TO THE COLOURED WATER (DIAGRAM).
01/05/08	71	VISIBLE VESSEL IS CARGO SHIP. VESSEL FINISHED PROCESSING 0830 OBSERVATION STOPPED VESSEL HAULING.