Agreement on the Conservation of Albatrosses and Petrels

Fourth Meeting of the Seabird Bycatch Working Group

Guayaquil, Ecuador, 22 – 24 August 2011

Concluding six years of research on seabird bycatch reduction through modified discharge management regimes: Is batch discharge better than ad-hoc discharge from trawl vessels?

Johanna Pierre, Edward Abraham & Yvan Richard
New Zealand

PROJECT REPORT TO THE ADVISORY COMMITTEE

Progress report: ACAP Project Application 2010-04

Concluding six years of research on seabird bycatch reduction through modified discharge management regimes:

Is batch discharge better than ad-hoc discharge from trawl vessels?

Project initiated by: *New Zealand*

Project Manager: *Dr Johanna Pierre*

Summary of project activities (max 300 words)

Holding fish waste onboard trawl vessels is widely agreed to be the ideal form of waste management for reducing seabird bycatch (Bull 2007, 2009; Lokkeborg 2008). However, under current operational conditions, many deepwater trawl vessels worldwide do not have the capacity to hold fish waste for the duration of a trawl tow. Consequently, waste is discharged overboard, increasing the risk of albatrosses, petrels and other seabirds striking trawl warps, and getting caught in trawl nets during shooting and hauling (Abraham and Thompson 2009; Bull 2007, 2009).

New Zealand research on reducing seabird bycatch by modifying the management of fisheries waste (offal and discards) began in earnest in 2004. In the subsequent six years, numerous trials have been conducted on deepwater trawl vessels examining the effects of a variety of waste discharge regimes on seabird attendance at trawl vessels, and seabird bycatch (e.g. Abraham et al. 2009; Pierre et al. 2010).

This project analyses data from the last in that series of experiments. In early 2010, an experimental trial conducted on a New Zealand trawl vessel sought to compare the effects of discharging fish waste ad hoc, versus discharging fish waste in batches at different timed intervals, on seabird attendance at the experimental vessel. With attention previously focused on the form of discharge, and optimal time intervals between discharge events, this comparison reflected the last significant question unresolved in the research programme to date: is batch discharge actually an improvement on ad hoc discharge (i.e. traditional 'no-effort' offal management)?

Experimental data were collected and underwent exploratory analysis (funded by the Department of Conservation, and summarised online at: http://www.doc.govt.nz/upload/documents/conservation/marine-and-coastal/marine-conservation-services/2011-04-11-offal%20batching-doc-csp.pdf).
Exploratory analyses delivered interesting preliminary conclusions, however they did not consider the effects of covariates, for example. We sought funding from ACAP to allow a comprehensive modelling analysis of the data to be undertaken to support the development of robust conclusions and, consequently, quality management decision-making.

Project outcomes (detailed by objective) (max 300 words)

Data collection methods followed those reported in Abraham et al. (2009); a randomised block design was employed, with three experimental treatments operating from midnight to midnight on randomly selected days. Modelling methods used broadly followed those reported previously. In brief, we created models of the effects of discharge treatments on the abundances of certain seabird species groups, on the water and in the air, astern the experimental vessel. Covariates were examined using an automated step procedure, and negative binomial generalised linear models. After such an initial exploration, we built generalised linear models using Bayesian methods. For more detail about modelling approaches we expect to use, please see Abraham et al. (2009), Pierre et al. (2010), and Pierre et al. (*in prep. – journal article emerging from this work*).

Final modelling analyses are now nearing completion. In brief, results to date suggest that:

- Ad hoc discharge maintains seabirds at higher abundances astern the vessel compared to when waste is held for periods of ≥30 minutes in duration.
- During a discharge event, seabird abundances astern the vessel increase rapidly. After discharge, bird abundances on the sea surface drop much faster than abundances of birds in the air astern vessels.
- Reductions in abundances in response to increasing holding intervals appear to be greater than any response to increasing batch size on discharge.

Results will be presented in more detail at the SBWG meeting prior to AC6, and in final reporting on this project (Appendix 1).

Were the funds spent in accordance with the original budget? (max 100 words)

Funds have allocated as per the estimated budget. When work is completed, funds will be requested.

Were there any unforeseen difficulties with the project? (max 300 words)

No.

Have you identified any questions or issues that need to be addressed further? (max 300 words)

While there are many more issues to be investigated around trawl discharge management, the programme of research started in 2004 has reached a tidy conclusion with the results emerging from this project.

Remaining work

Final modelling analyses and a scientific paper describing the work are near completion. Results of this work will be promulgated via scientific and industry venues, e.g. journal publication and industry newsletters/magazines. Conclusions will also be incorporated into industry educational packs for broader dissemination amongst fisheries practitioners.

We thank ACAP for supporting this work, which would not have been possible otherwise.
We look forward to providing the full final report at the conclusion of the project.

Literature cited

Abraham, E.R., Thompson, F.N., 2009. Warp strike in New Zealand trawl fisheries, 2004–05 to 2006–07. New Zealand Aquatic Environment and Biodiversity Report no. 33. Ministry of Fisheries, Wellington.

Abraham, E.R., Pierre, J.P, Middleton, D.A.J., Cleal, J., Walker, N.A., Waugh, S.M., 2009. Effectiveness of fish waste management strategies in reducing seabird attendance at a trawl vessel. Fisheries Research 95:210–219.

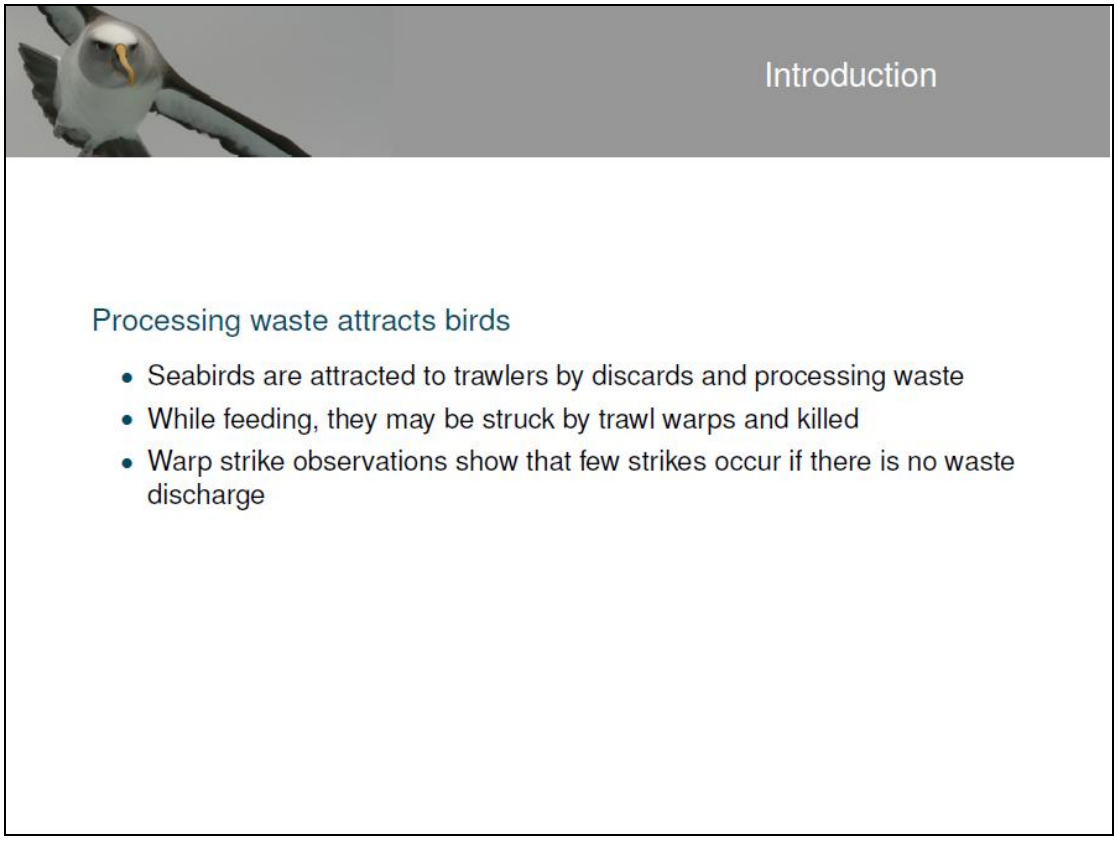
Bull, L.S., 2007. Reducing seabird bycatch in longline, trawl and gillnet fisheries. Fish and Fisheries 8:31-56.

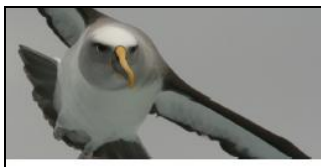
Bull, L.S., 2009. New mitigation measures reducing seabird by-catch in trawl fisheries. Fish and Fisheries 10: 408–427; DOI: 10.1111/j.1467-2979.2009.00327.x

Løkkeborg, S. 2008. Review and assessment of mitigation measures to reduce incidental catch of seabirds in longline, trawl and gillnet fisheries. FAO Fisheries and Aquaculture Circular. No. 1040. Rome, FAO. 24p.

Pierre, J.P., Abraham, E.R, Middleton, D.A.J., Cleal, J., Bird, R., Walker, N.A. and Waugh, S.M. 2010. Reducing interactions between trawl fisheries and seabirds: responses to foraging patches provided by fish waste batches. Biological Conservation 143: 2779-2788.

Appendix 1. Presentation of results to SBWG-4.





Strategies for managing waste

Mealing, mincing

- Previous studies have shown that when a meal plant is used, and so all processing waste is retained, then fewer birds are attracted to the stern
- Mincing offal reduced the number of large albatrosses (*Diomedea*) behind trawlers

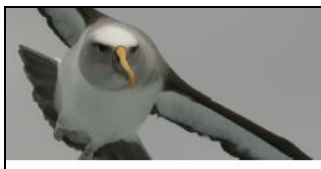
Batching

- Another approach is to hold the offal and discharge it at intervals
- A previous study found that as the batch interval increased from 30-min to 8-hour, there was some decrease (between 12% and 44%) in the number of birds that were close to the vessel

Offal batching

The 2010 experiment

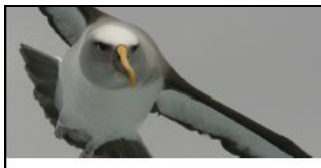
- An offal batching experiment was carried out on a trawler fishing for hoki (*Macruronus novaezelandiae*) and *Beryx* species
- Three experimental treatments were used (continuous discharge, 30-min discharge interval, 2-hour discharge interval)
- The number of birds behind the vessel was counted during each of the three treatments
- Counts were made when vessel processing catch while fishing



Collaborative research

The Mitigation TAG

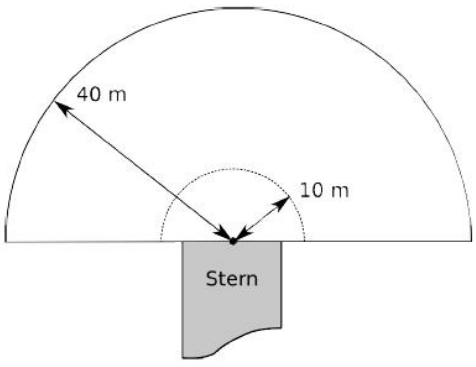
- Experiment coordinated by a Mitigation Technical Advisory Group
- A collaboration between New Zealand Department of Conservation, Ministry of Fisheries, World Wildlife Fund, and the Seafood Industry Council
- Experiment carried out by a fisheries observer with support from vessel crew
- Vessel operations coordinated by John Cleal (Vessel Management Services Ltd)
- Project and preliminary analysis funded by the Department of Conservation
- Further analysis funded by ACAP



Protocol

An observation

- Counts made of
  - Large birds (Albatrosses and giant petrels)
  - Cape petrel (*Daption* spp.)
  - Small birds (other birds)
- Counts made with 10 m and 40 m sweeps
- Counts made of birds in air and on water
- Observations at 5-minute intervals around a discharge event



Seabird observation form
(Controlled batch vs 'continuous')

Date observations started (ddmmyy): 18/02/10

Sample identification — Trip number: [redacted] Tow number: 38 — Batching 2010 Number 38 www.dragonfly.co.nz — Experimental regime: 30 min batch / 2 hr batch / Continuous discharge

Background information (record before first observation)

Vessel speed (knots)	4.1	End time of previous discharge (i.e. end of previous batch or stream of 'continuous' discharge)	1103
Swell height (metres)	2m	Previous batch volume (kg)	300

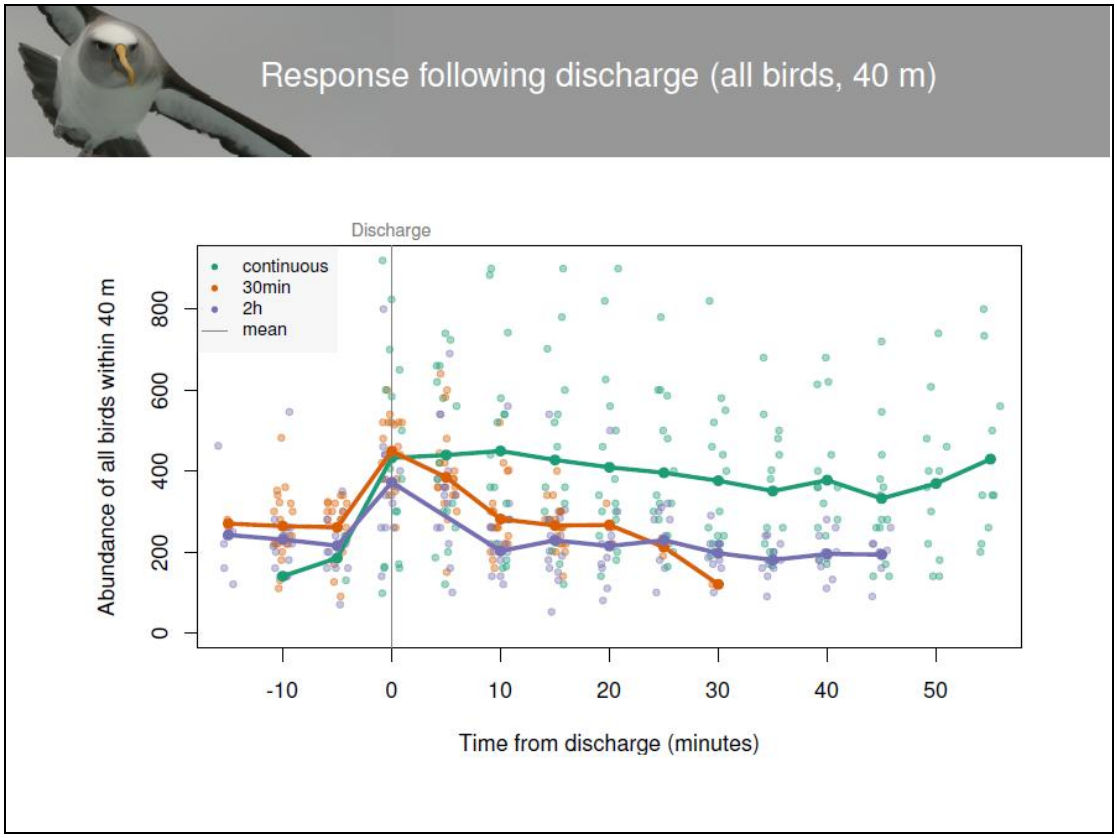
Observation			1	2	3	4	6	6	7	8	9	10	11	12
Time	Hour		11	11	11	11	11	11	11	11	12	12	12	12
	Minute		20	25	30	35	40	45	50	55	00	05	10	15
Wind strength (Beaufort)			5	5	5	5	5	5	5	5	5	5	5	5
Tow stage (S, F, H)			F	F	F	F	F	F	F	F	F	F	F	F
# vessels visible			0	0	0	0	0	0	0	0	0	0	0	0
Discharge	Sump		3	3	3	3	3	3	3	3	3	3	3	3
	Minced		0	0	0	0	0	0	0	0	0	0	0	0
	Offal		0	0	3	0	0	0	0	0	3	0	0	0
	Whole discards		0	0	1	0	0	0	0	0	0	0	0	0
Large birds	40m	Air	50	60	100	80	50	50	40	60	70	80	30	40
		Water	10	20	60	40	20	10	20	30	80	40	20	10
	10m	Air	5	0	10	5	3	2	0	1	20	20	2	5
		Water	0	0	20	2	0	1	0	0	10	0	4	0
Sm. birds	40m	Air	60	40	50	30	20	40	30	20	40	20	50	60
		Water	40	40	50	30	20	20	30	30	80	40	20	30
	10m	Air	10	0	10	5	3	4	2	0	5	0	2	0
		Water	2	0	5	0	0	0	0	0	5	0	0	0
Cape pigeon	40m	Air	1	0	0	0	0	0	0	0	0	0	0	0
		Water	0	0	0	0	0	0	0	0	0	0	0	0
	10m	Air	0	0	0	0	0	0	0	0	0	0	0	0
		Water	0	0	0	0	0	0	0	0	0	0	0	0

Comments: Small birds are not recorded by the Large Birds during discharge. Vessel hauled immediately after shooting.

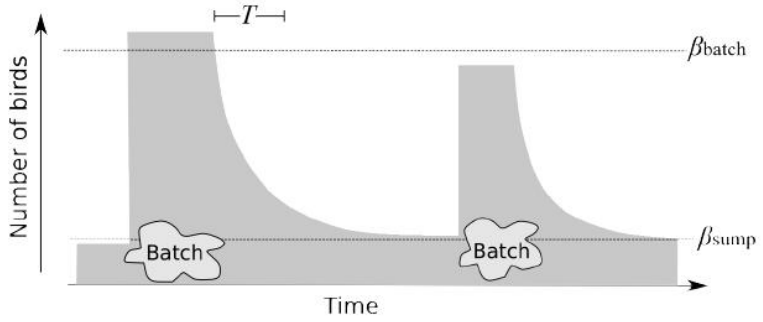
Diagram of tori lines and sampling area during sampling: 40 m, x = ship, Stern midpoint, Tori lines

Batch characteristics (batching treatments only)

Batch start time	1130
Batch finish time	1132
Batch volume (kg)	300
Main type (S, F, C)	F



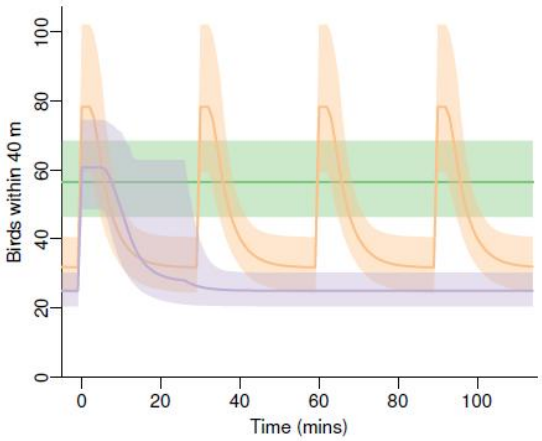
Statistical modelling



- Number of birds modelled as a no-discharge number (β_{sump}), followed by a jump at time of discharge (to β_{batch}), with an exponential decay (at rate $1/T$)
- Observations drawn from a Poisson distribution
- Tow-level random effects

Modelled response

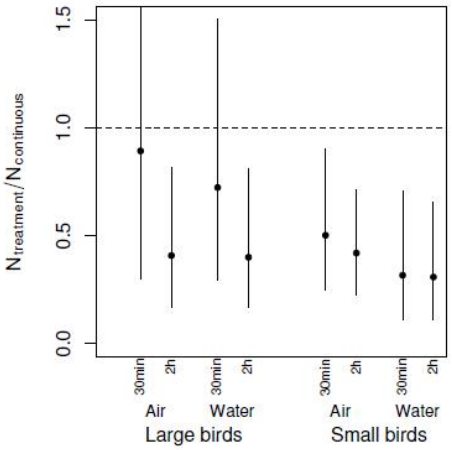
Large birds within 40 m of the stern, on the water



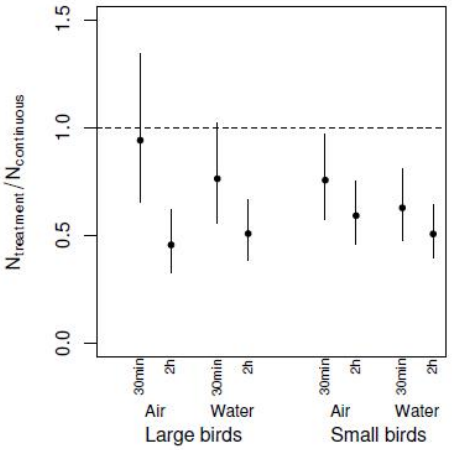
Summary of results

Average abundance relative to continuous discharge

10 m sweep



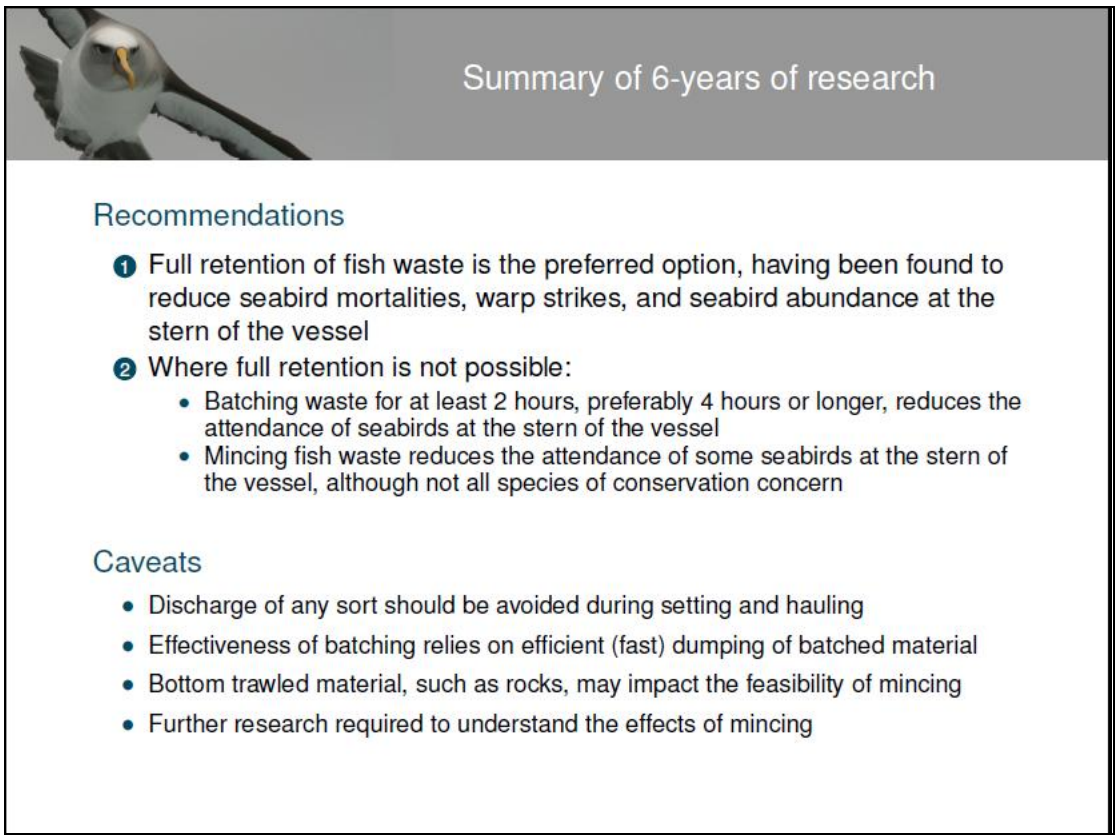
40 m sweep



Summary

Results

- A 2-hour batch interval significantly reduced the average abundance of all categories
- Reduction of average abundance was to around 50% of the continuous discharge value
- A 30-minute reduction reduced the mean abundance, but for large birds the reduction was not significant


Summary of 6-years of research
Recommendations
1 Full retention of fish waste is the preferred option, having been found to reduce seabird mortalities, warp strikes, and seabird abundance at the stern of the vessel
2 Where full retention is not possible:
• Batching waste for at least 2 hours, preferably 4 hours or longer, reduces the attendance of seabirds at the stern of the vessel
• Mincing fish waste reduces the attendance of some seabirds at the stern of the vessel, although not all species of conservation concern
Caveats
• Discharge of any sort should be avoided during setting and hauling
• Effectiveness of batching relies on efficient (fast) dumping of batched material
• Bottom trawled material, such as rocks, may impact the feasibility of mincing
• Further research required to understand the effects of mincing

Appendix 2. Summary of key New Zealand offal management trials and observations.

Trial/Measure	Ouputs	Summary	Best practice recommendations
2004-2007 warp strike observations	Abraham, E.R.; Thompson, F.N. 2009: Warp strike in New Zealand trawl fisheries, 2004-05 to 2006-07. *New Zealand Aquatic Environment and Biodiversity Report No. 33*. 21 p. http://fs.fish.govt.nz/Page.aspx?pk=113&dk=21999	The average large bird (all albatrosses and giant petrels) warp strike rate is 0.02 strikes per hour when there is no discharge, compared with 3.22 strikes per hour when discharge is continuous. The large bird warp capture rate when no discharge was recorded during the warp observations was 0.2 birds per 100 tows, compared with an average capture rate of over 7 birds per 100 tows when offal or discards were discharged.	Fish waste retention greatly reduces warp strikes and observable captures for albatrosses and giant petrels at least.
2006 mincing and mealing trials	Abraham, E.R., Pierre, J.P, Middleton, D.A.J., Cleal, J., Walker, N.A., Waugh, S.M., 2009. Effectiveness of fish waste management strategies in reducing seabird attendance at a trawl vessel. *Fisheries Research* 95:210–219.	Mincing reduced the numbers of large albatrosses (*Diomedea* spp.) feeding astern of the vessel, but had no significant effect on other groups of seabirds. Reducing discharge to sump water resulted in a significant reduction in numbers of all groups of seabirds. In particular, the abundance of the small albatross group (principally *Thalassarche* spp.), and some smaller procellarids (e.g. sooty shearwater, *Puffinus griseus*, and white-chinned petrel, *Procellaria aequinoctialis*), was reduced to less than five percent of the number that were within the sweep area when unprocessed discharge was released.	Fish waste retention is a more effective management strategy than mincing for reducing seabird bycatch. Mincing significantly reduces the abundance of large albatrosses at the vessel stern.
2007 mincing trials	Abraham, E.R. 2007: *Summary of data collected during the southern squid fishery mincing trial*. Research report prepared by Dragonfly for the Department of Conservation, Wellington, New Zealand. 39 p. http://www.doc.govt.nz/upload/documents/conservation/marine-and-coastal/fishing/southern-squidfishery-mincing-trial-data.pdf	A number of operational problems limited the full analysis of results, although preliminary analysis suggests that there was a treatment effect, with fewer large and small albatross attending the vessel when the discharge was minced. The batched treatment also reduced the total numbers of large and small albatross within the 40m sweep zone. There were sometimes rocks in the trawl and these could not be put through the mincer. Small numbers of rocks could be removed by hand by the crew, but large numbers meant the minced treatment had to be changed to unprocessed.	Presence of rocks amongst fish waste is an operational limitation to the use of mincing.

2008 mincing trials	Abraham, E.R. 2010: *Mincing offal to reduce the attendance of seabirds at trawlers*. Report prepared by Dragonfly for Department of Conservation, Wellington, New Zealand. 28 p. http://www.doc.govt.nz/publications/conservation/marine-and-coastal/marine-conservation-services/other-publications/mincing-offal-to-reduce-the-attendance-of-seabirds-at-trawlers/	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 a 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. Modeled results found that for non- *Diomedea* seabird 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 *Diomedea* species the reduction in total numbers within the 40 m zone was 38% and 59% for cutter and hasher discharges, respectively.	Mincing, by either cutter pump or hasher pump, significantly reduces seabird numbers at the stern of the vessel. Full retention or mealing has been shown to reduce numbers to a greater extent.
2008 batching trials	Pierre, J.P., Abraham, E.R, Middleton, D.A.J., Cleal, J., Bird, R., Walker, N.A. and Waugh, S.M. 2010. Reducing interactions between trawl fisheries and seabirds: responses to foraging patches provided by fish waste batches. *Biological Conservation* 143: 2779-2788.	Seabirds moved from the air to the water, as the amount of food available increased from no discharge, through sump discharge to batch discharge. When discharge occurred, seabird abundance increased faster than could be resolved with the 5 min sampling period. However, abundance decreased more slowly over a 10–15 min period after the discharge event. The number of large seabirds attending the vessel during discharge events decreased significantly when waste was held for 4 h. For small birds, significant decrease occurred after 8 h. Such holding periods emphasise the tenacity of foraging seabirds, although we have not evaluated any long-term habituation to a particular discharge regime.	Holding waste for less than 4 h may reduce bycatch risk, e.g., prior to and during net shooting and hauling. Holding waste for 4 h or more significantly reduces the attendance of large seabirds. Holding waste for 8 h or more significantly reduces the attendance of large and small seabirds. Least risk to seabirds occurs when there is no discharge.
2010 batching trials	This paper	This paper	Best practice is to not discharge processing waste while fishing If that is not possible, then discharging the offal in batches will reduce the number of birds behind the vessel A 2-hour batch interval resulted in a reduction in seabird numbers of around 50% Efficacy relies on efficient dumping of batched material

Abstracts

Abraham & Thompson 2009

Since the 2004–05 fishing year, Ministry of Fisheries observers have been carrying out warp strike observations, recording the numbers of birds that are struck by trawl warps during 15 minute observation periods. In 2004–05, the observations were aimed at exploring the relation between offal discharge and warp strikes. In 2005–06, monitoring of mitigation devices was introduced and the observations include those made as part of an experiment exploring the efficacy of warp-strike mitigation devices. In 2006– 07, regulations requiring the use of warp mitigation devices were introduced, and the observations are from ongoing monitoring. In this report, a summary is presented of all the strike data collected from 2004–05 to 2006–07. The analysis provides an overview of the strike data and an indication of the main trends. During this period a total of 12 097 strike observations were made. Most observations (58.8%) were made in the squid trawl fishery, with some also being carried out in hoki (16.9%) and other trawl fisheries.

The average warp strike rate has decreased since 2004–05, when warp strike observations were first made in New Zealand fisheries. For small birds (all birds other than albatrosses and giant petrels), the average warp strike rate has decreased from 3.03 to 0.55 strikes per hour. For large birds (albatrosses and giant petrels), the average warp strike rate has decreased from 2.35 to 0.39 strikes per hour. The decrease is associated with an increase in the use of mitigation devices, which were made mandatory in January 2006 for all trawlers over 28 m in length fishing in New Zealand waters. In 2004–05 mitigation was not compulsory and was used during 48% of the observations. In 2006–07, mitigation was used during 92% of observations. The most frequently used mitigation devices in 2006–07 were tori lines, which were used during 56% of observations. Statistical modelling confirms that the strike rate of both large and small birds is reduced when tori lines are used as a mitigation device. Other devices such as warp scarers and bird bafflers are not found to significantly reduce the warp strike rate.

The warp strike dataset provides strong evidence that the increased use of tori lines has led to a reduction in the number of albatross mortalities. From 2004–05 to 2006–07, there was a decrease in large bird warp capture rate from 6.7 to 0.4 birds per 100 tows. Capture rates of small birds on the warps are too low to infer a trend in the rate. Statistical modelling of large bird warp captures shows that they decrease when tori lines are used, and increase when there is continuous discharge. While the warp capture rate of large birds has decreased, there has been no consistent change in the net captures. The analysis also shows the importance of offal management, with few warp strikes or captures being recorded in the absence of offal discharge. Across all the data the average large bird warp strike rate is 0.02 strikes per hour when there is no discharge, compared with 3.22 strikes per hour when discharge is continuous. The large bird warp capture rate when no discharge was recorded during the warp observations was 0.2 birds per 100 tows, compared with an average capture rate of over 7 birds per 100 tows when offal or discards were discharged.

For every large bird captured on the warps, there are 208 (95% c.i.: 150 to 290) warp strikes, and for every small bird captured on the warps there are 7610 (95% c.i. 3800 to 36 000) warp strikes. It is likely that birds are killed by warp strike but not brought on board, and so not counted as captures. Currently, estimates of seabird mortality in New Zealand fisheries are based solely on landed captures and the true mortality from trawl fishing is likely to be underestimated. An estimate of the ratio of warp strikes to warp mortality is needed to allow total mortality to be assessed.

Abraham et al 2009

The risk of seabird bycatch in trawl fisheries is increased by high numbers of seabirds attending vessels to feed on fish waste discharged. We conducted an experimental test of whether mincing fish waste prior to its discharge from a factory trawler reduced the number of seabirds attending the vessel. The trial was conducted on a mid-water trawler targeting hoki (Macruronus novaezelandiae) in New Zealand waters, and the experiment compared three treatments (1) discharging 'unprocessed' waste (fish offal and whole discards), (2) mincing all waste to a small particle size before discharge, or, (3) converting all waste to fishmeal and reducing discharge to sump water. The response to the experimental treatments was determined using seabird abundance within a 40 m-radius semi-circular area centred on the vessel stern. Mincing reduced the numbers of large albatrosses (Diomedea spp.) feeding astern of the vessel, but had no significant effect on other groups of seabirds. In contrast, reducing discharge to sump water resulted in a significant reduction in numbers of all groups of seabirds. In particular, the abundance of the small albatross group (principally Thalassarche spp.), and some smaller procellarids (e.g. sooty shearwater, Puffinus griseus, and white-chinned petrel, Procellaria aequinoctialis),was reduced to less than five percent of the number thatwere within the sweep area when unprocessed dischargewas released. While mincing significantly reduced the abundance of large albatrosses at the vessel stern, relatively small numbers of these birds attend trawl vessels in New Zealand waters and associated bycatch rates are low. In contrast, reducing the quantity of fish waste discharge by mealing resulted in reduced abundances of a wide range of seabirds at the vessel. Therefore, compared to mincing, we recommend fish waste retention as a more effective management strategy for reducing seabird bycatch.

Abraham 2007

This report gives a preliminary analysis of data collected to test whether mincing of waste and discards reduces the number of birds attending fishing trawlers. The trial was carried out on a Korean trawler, fishing in the southern squid fishery during April and March, 2007. The numbers of birds were counted in 40m and 10m semicircular sweep zones extending behind the vessel. Counts were made of five different species categories (large albatross, small albatross, giant petrel, other petrel and shearwater, and cape pigeon). The birds were also classified into three behavioural categories (flying, sitting on the water, and actively feeding).

Three different offal treatments were used (discharge without any processing, mincing all waste with continuous discharge, and mincing all waste with batched discharge). During the trip, the fisheries observer who was implementing the experimental protocol made a total of 85 observations. Of these, 35 were made when the factory was not operating and so when there was no discharge. These observations provide a control, but cannot be used for distinguishing between the different treatments. There were some problems with the minced and batched protocols. Early in the voyage there was a high volume of discards which could not be batched, as there was insufficient room in the factory. The batched protocol was then changed to minced. On one tow, when the vessel was targeting hoki, the bycatch clogged the mincer and an unprocessed treatment was substituted. In addition, there were sometimes rocks in the trawl and these could not be put through the mincer. Small numbers of rocks could be removed by hand by the crew, but large numbers meant the minced treatment had to be changed to unprocessed.

Despite these problems, the preliminary analysis suggests that there was a treatment effect, with fewer large and small albatross attending the vessel when the discharge was minced. The batched treatment also reduced the total numbers of large and small albatross within the

40m sweep zone. The significance of these results will be checked by statistical modelling. The observer also made 100 strike observations, 50 of trawl warp strikes and 50 of strikes on the tori lines. There were no warp strikes observed during the voyage, and so only the tori line strikes are considered. The effect of treatment on the strikes is unclear. There are fewer large bird strikes when the discharge is minced, but more small bird strikes.

Abraham 2010

Many seabird species are attracted to foraging opportunities presented by fish waste discharged from fishing vessels worldwide. We compared the attraction of seabirds to three forms of trawler waste, to identify the discharge regime that most effectively reduced foraging activity and the consequent risk of seabird bycatch on fishing gear. The three, treatments were 'unprocessed' discharge (large chunks of offal and whole fish discards), 'hashed' discharge (smaller chunks passed through a hasher pump), and 'cutter pump' discharge (waste passed through the hasher pump and a cutter pump to further reduce particle size). Each treatment was followed for a day, with the choice of treatment on each day following a pre-determined randomised block design. In response each treatment, counts were made ofthe abundance of large albatrosses (Diomedea sp.), small albatrosses and giant petrels (all other albatrosses, Macronectes giganteus, M. halli), Cape petrels (Daption capense), and all other procellarid species, in the air and on the water, within a 40m-radius semi-circle about the vessel stern. Seabirds on the water were less numerous during hashed and cutter pump treatments, relative to during 'unprocessed' discharge (except small albatross, cutter pump treatment). Also, in some cases, the total number of birds attending the vessel decreased, relative to during unprocessed discharge (but not small and large albatrosses - cutter treatment). Differences in particle size between cutter and hasher treatments may be less important for reducing abundances than temporal discharge patterns, which affected how birds tracked the discharge stream. Amid increasing efforts to reduce the ecosystem effects of fishing, mincing trawler waste could be a partial solution to seabird bycatch. However, seabird attendance, and consequent bycatch risk, remained lowest when no discharging occurred.

Pierre et al 2010

Seabird bycatch in trawl fisheries is driven by the attraction of birds to foraging opportunities, i.e., the discharge of catch processing waste and the contents of trawl nets. The risk of seabird captures increases with seabird abundance and exposure to fishing gear. We investigated (1) how quickly seabirds responded to discharges of trawl catch processing waste and (2) whether decreasing numbers of seabirds attended trawlers during processing waste discharge events as the time interval between these events increased. Waste was retained onboard the vessel for four different holding periods (30 min, 2 h, 4 h, 8 h), one of which was applied each day using a randomised block design. We determined seabird responses to batch discharge events after the prescribed holding periods using the abundance of large (albatrossses and giant petrels Macronectes spp.) and small (all other petrels except cape petrels Daption capense, shearwaters and prions) seabirds in a semi-circle of 40 m radius, centred on the stern of the experimental trawler. Seabird responses reflected the type of discharge released: birds moved from the air to the water, as the amount of food available increased from no discharge, through sump discharge to batch discharge. When discharge occurred, seabird abundance increased faster than could be resolved with the 5 min sampling period. However, abundance decreased more slowly over a 10–15 min period after the discharge event. The number of large seabirds attending the vessel during discharge events decreased significantly when waste was held for 4 h. For

small birds, significant decrease occurred after 8 h. Such holding periods emphasise the tenacity of foraging seabirds, although we have not evaluated any long-term habituation to a particular discharge regime. While holding waste for less than 4 h may not reduce seabird attendance during discharge events, holding for shorter intervals can still reduce bycatch risk, e.g., prior to and during net shooting and hauling.