Determining the efficacy of warp strike mitigation devices: trial design for the 2006 southern squid fishery

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Final Version

17 January 2006

Summary

Trials are proposed to investigate the relative efficacy of warp strike mitigation devices (twin Tori lines, the Carey warp scarer and bird bafflers) in the southern squid fishery (SQU 1T, SQU 6T) in 2006. The trials will utilise existing observer coverage to collect data from normal commercial fishing trips where different warp strike mitigation treatments will be used on different tows according to a randomised experimental design.

The rate of heavy contacts between seabirds and a trawl warp will be the primary indicator of device efficacy, but data on the durability of the devices, seabird contacts with the device itself, and seabirds captured will also be collected.

The trials have been designed collaboratively by a group comprising scientists from SeaFIC, MFish, DoC and WWF-NZ.

Introduction

Incidental mortality of seabirds as a result of collisions with net-sonde monitoring cables was identified in the early 1990s (Bartle, 1991). The use of net monitor cables by New Zealand trawlers was subsequently prohibited, and net monitors that communicate with the vessel acoustically have been widely adopted in NZ and other southern hemisphere fisheries.

Recent research has highlighted other sources of incidental mortality in trawl fisheries, including collisions with trawl warps (Wienecke and Robertson, 2000; Sullivan et al, 2003). A number of devices have been developed to prevent seabirds from congregating at the stern of vessels, where they are at risk from warp strikes. However, there are relatively few scientific studies on the efficacy of these devices.

In June-July 2004 the Hoki Fishery Management Company undertook observer and video-based monitoring of warp strike aboard the New Zealand factory trawler FV *Rehua* (Robertson & Blezard, 2004). The use of a Baffler mitigation device[1] (Anonymous, 2002) and the discharge of offal were experimentally manipulated. The use of the Baffler appeared to reduce the overall rate of warp strikes in both the offal discharge and no-discharge treatments, although the inability to control discharge via the "sump pump" complicated interpretation of the no-discharge treatment.

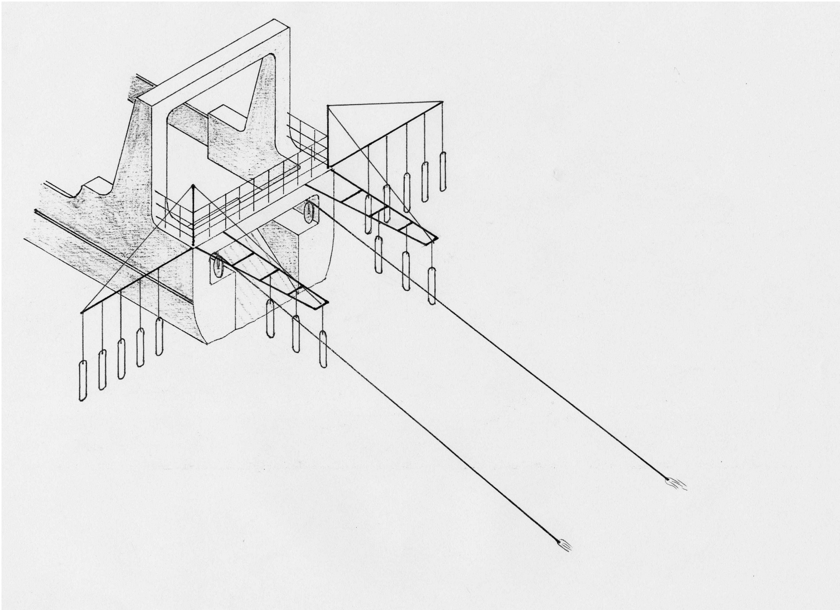
Sullivan et al. (in press) carried out trials of three devices designed to reduce seabird collisions with warp cables during trawling (Falkland Islands Warp Scarer, Brady Baffler and Tori lines). This is the only study where the efficacy of different mitigation devices has been experimentally compared. In that study, paired Tori lines were the most effective mitigation device, achieving significantly greater reductions in contact rates than the Brady Baffler, and slightly greater reductions than the Falkland Islands Warp Scarer.

In the 2005 squid season in New Zealand, observers on board factory trawlers operating in the SQU6T and SQU1T fisheries carried out warp-strike observations as part of their routine observer duties. In that case the use of mitigation devices, and conditions of offal discharge, were observed rather than experimentally manipulated. This was primarily intended as a trial of the warp strike recording protocol, and the initial data set did not allow observer and vessel effects to be accounted for in the model. The Bafflers in use varied from vessel to vessel; nevertheless, these data provide good evidence that use of Bafflers was associated with lower warp contact rates, with Bafflers reducing warp strikes by a factor of approximately two (Abraham, 2005).

[1] "Bafflers" is used here generically to refer to both the Brady Bird Baffler (NZ patent pending, 508603) and similar devices.

Figure 1. Warp strike mitigation devices tested in the Falkland Islands. (a) Brady Bird Bafflers, (b) Falkland Islands Warp Scarer, (c) twin Tori lines. Diagrams from Sullivan et al. (in press).

(a)



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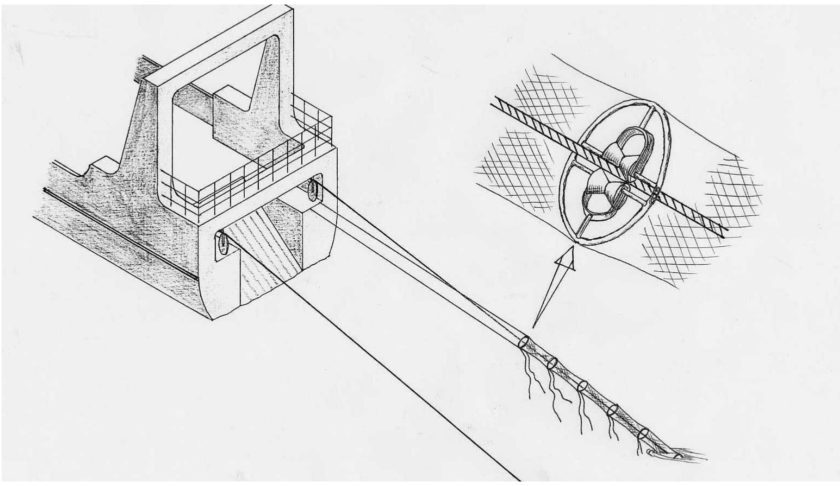

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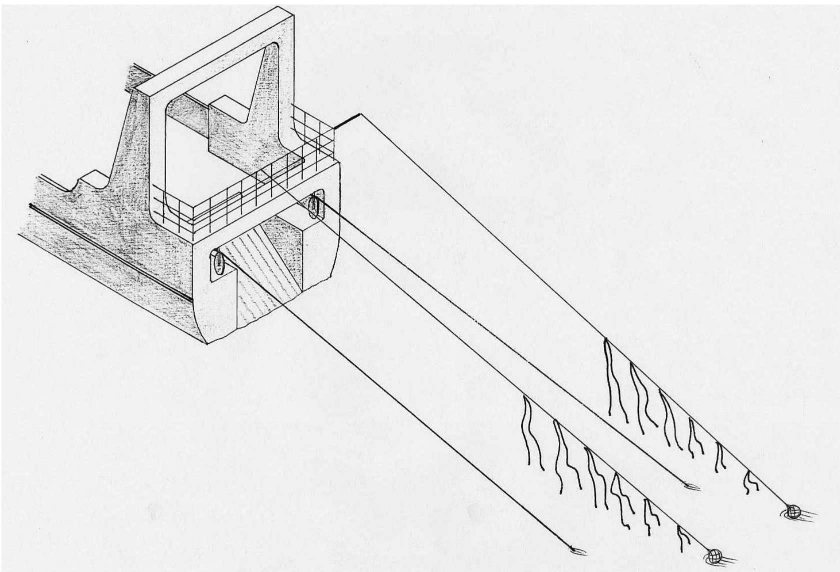

By standardising the conditions of experimental trawls as much as possible, and randomising the treatments, the Falklands and *Rehua* studies provide confidence that the differences in strike rates observed are the result of the different mitigation devices employed. However, the restricted conditions of the studies (single vessel/fishery/etc.) provide no information on the extent to which the results can be generalised to other vessels and fisheries. As a result Sullivan el al. (in press) concluded that while "*our findings are likely to have application to a range of trawl fisheries around the world*", "*further testing would be required to identify any local variations in the cause and nature of trawler related seabird mortality*".

The analysis reported by Abraham (2005) used data from 19 different vessels operating in broadly the same fishery. However, in these data the use of warp strike mitigation devices was not randomised over tows. In general vessels either used Brady Bafflers, or no mitigation device, and this was consistent throughout the observed trip. In addition, data from individual observers was generally from a single vessel. Thus, the effect of the mitigation device was partly confounded with vessel and observer effects.

The recent mandating of the use of twin Tori lines by trawlers of lengths 28 m and above operating in FMAs 3 to 7 was primarily on the strength of the Falklands study. No studies of their effectiveness in New Zealand waters have been undertaken to date. Likewise there is no information on the between vessel variation in their efficacy.

A recognised limitation of twin Tori lines is the fact that they are not attached to the trawl warps and so may provide limited protection in cross-winds, when the lines are deflected from the warps. Warp scarers, where the mitigation device is attached to the warp, have the potential to outperform Tori lines in these conditions. Anecdotal reports indicate that a recently developer warp scarer, dubbed "Carefree's Cunning Contraption" has proved effective (Carey, 2005)[2].

The NZ fishing industry and Government agencies have recognised the importance of carrying out studies which demonstrate the efficacy of warp-strike mitigation devices in New Zealand fisheries, and across a range of vessels. This has resulted in a collaborative approach to the development of the trials proposed here. These trials aim to determine the relative efficacy of twin Tori lines and the Carey warp scarer in the southern squid fishery (SQU1T/6T) in 2006.

The southern squid fishery, which operates around the Auckland Islands (SQU6T), Stewart-Snares shelf and the East Coast of the South Island from February to June each year, has had consistently higher mean seabird bycatch rates than most other NZ trawl fisheries (Baird, 2005, Table A2), and therefore provides a suitable opportunity to assess the performance of devices designed to reduce seabird captures that result from warp strikes.

Methods

The general procedure adopted in this study is the addition of an experimental design (simple randomised treatments) to normal commercial fishing trips, and the use of existing observer coverage to collect the required data.

Treatments

An experimental treatment will be applied at random to each tow carried out by participating vessels. Three standard treatments will be used on all[3] participating vessels:

[2] Referred to as the Carey warp scarer in the remainder of this document.

[3] Subject to the standard Carey warp scarer device being deployable on all vessels.

1. Use of Twin Tori lines (as per Gazette notice specification, or subsequently agreed improved specification)
2. Use of Carey warp scarer (to a standard specification)
3. No warp-strike mitigation device (control).

These mitigation devices will be built to a standard specification, and vessels will be equipped with spare devices and repair materials. Where participating vessels are equipped with a bird baffler to a minimum specification use of the baffler will be included as a fourth treatment[4].

Other than the tow by tow variation in the warp strike mitigation device deployed, participating vessels will otherwise operate normally. In particular, they will follow the offal management regime specified in their Vessel Management Plan. Any other mitigation devices on the vessel will not be deployed during these trials.

Participating vessels will be issued with a sequential list of randomly generated mitigation treatments to be applied to each tow. It will be the responsibility of the master to deploy the devices as specified. The sequential list of treatments will be followed for all tows on the trip.

The rate of heavy seabird contacts with the trawl warps will provide the primary measure of mitigation device efficacy. Observers will carry out warp strike observations according to the protocols trialled in the 2005 squid fishery. This entails 15 minute counts of heavy strikes by large/small birds on a single warp. Observers also record environmental and other covariates (e.g. offal discharge) and observation periods are terminated early if these conditions change.

Observers will be required to carry out a number of periods of warp-strike observation each day. In particular they will aim to carry out at least one observation period during each trawl conducted in daylight.

Observers will also be tasked with the collection of additional data relevant to the broader efficacy of warp strike devices, including the durability of the devices. The extent of seabird contacts with the devices themselves will be quantified via a modification of the warp strike protocol.

The current observer warp strike protocol, and notes on proposed alterations for this trial, are included here as Appendix B.

Analysis

Following Sullivan et al. (in press) and Abraham (2005), generalised linear models, utilising the negative binomial distribution, will be fitted to assess the effect of the experimental treatment and other covariates (offal discharge etc). Between vessel differences in the treatment effect will be explored. In the case of bird bafflers it is likely that variations in their design will preclude their inclusion as a single treatment effect across the whole fleet. At a minimum, however, vessel specific baffler effects (i.e. the effect of a particular baffler on a particular vessel, relative to the standard treatments) will be derived.

[4] It is not considered possible to fully standardise the bird bafflers used in these trials, or to include this treatment on vessels where they are not already installed. Nevertheless bafflers, to a variety of designs, are widely deployed in the NZ fleet and, following comments made by members of the NPOA Technical Working Group at its meeting on 7 December 2005, it is clear that further information on their efficacy would be valuable.

Appendix A includes an analysis of the ability to detect an overall treatment effect, and distinguish between mitigation methods with similar performance, as sample size and the strike rate in the control treatment are varied.

Trial period and participating vessels

The trials will be carried out in the southern squid trawl fisheries (SQU 1T and SQU 6T) in the 2005/06 fishing year. The timing and duration of these fisheries varies from year to year due to variation in the abundance of squid. The SQU 1T operates from December to June, although most catch is taken from January to March (Langley, 2001). Agreements restrict the SQU 6T fishery from starting before 1 February, and most of the catch is taken between February and April.

These trials plan to include all observed trips that depart port in the period 20 January to 15 June 2006 intending to fish in the SQU 1T or 6T fisheries. Trips departing prior to 20 January 2006 will also be included if logistically possible.

In May/June 2006 an initial analysis of data from trips completed by mid-April 2006 will be undertaken. This is intended to allow an opportunity to review the need to continue trials in the squid fishery, and to provide a basis for discussion on the continuation of trials in other middle depths and deep water fisheries. An analysis of all data from southern squid fishery will be presented to the NPOA-TWG by the end of September 2006.

In order to achieve the desired level of observer coverage (30%) in the SQU 6T fishery for monitoring bycatch of New Zealand Sea Lions, the Operational Plan for the SQU 6T fishery (Ministry of Fisheries, 2005) requires the Squid Fishery Management Company (now Deepwater Stakeholders Group) to supply a list of all likely SQU 6T vessels to the MFish observer programme. These vessels will be considered to form the pool of potential participating vessels. In the event that an MFish observer is then placed on one of these vessels for a trip that plans to operate in the SQU 1T or 6T fisheries, that vessel will then participate in these trials. It is recognised that a number of factors determine the vessels on which observers are placed: the intent is that all observed vessels will participate in these trials irrespective of the proximate reason for the observer placement.

Investigating the observer effect

Current practice is that observed trips in the southern squid fishery carry a single observer. Statistical separation of the “observer effect” from the “vessel effect” is, therefore, difficult unless observers make multiple trips in the fishery, and some vessels are observed on more than one trip by different observers. Of 29 observer trips in the 2005 squid fishery only four vessels were observed on multiple trips, and only three observers made multiple trips. To address this problem, in these trials a subset of vessels will carry two observers. Where two observers are present on a vessel they will carry out observations on the same tows, but not at the same time. All observers will receive the same briefing on the observation protocol.

It is intended that at least four trips during the 2006 southern squid fishery will carry two observers to carry out warp strike observations.

Decision rule

Recent trials of seabird-bycatch mitigation techniques in New Zealand fisheries have been subject to limits on the number of seabirds that can be taken during the course of the experiment (e.g. Lydon & Starr, 2004). Such precautions must balance the need to allow statistically robust investigations of mitigation efficacy, with the avoidance of unnecessary mortalities of protected species. The operation of the trials detailed here will require dispensation (via a Special Permit under section 97 of the Fisheries Act) from the regulated use of paired Tori lines on all tows in FMAs 3 to 7 by vessels of length 28 m and above. The purpose of a decision rule is to manage the increased risk of seabird mortality that results from the use of different treatments.

It is proposed that MFish observers will maintain a running total of dead seabirds recovered from the warps, mitigation device, or unknown sources (i.e. not net captures) and will inform the master of the vessel immediately the cumulative total on the trip exceeds 20. The master should then cease the use of experimental treatments and revert to the use of the regulated mitigation measure on all trawls until the either the end of the trip or until notified by the Special Permit holder that particular treatments should resume. Observers will continue warp strike observations.

The Special Permit holder may instruct vessels to resume trials following consultation with the Technical Advisory Group who will examine the nature of the captures reported.

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Appendix A. Analyses in support of the design of warp strike studies.

Introduction

Two existing datasets provide an opportunity to explore the likely power of the proposed experimental design in establishing the efficacy of the various mitigation devices. These are:

- The Falklands warp strike data (Sullivan et al., in press), and
- Warp strike data from the 2005 squid fishery (Abraham, 2005).

The Falklands data provides the opportunity to investigate the sample sizes required to detect a change in warp strike rate under different mitigation measures on a single vessel, whilst the 2005 squid data provides insight into the magnitude of between vessel variability in strike rate.

Detecting a mitigation effect: the Falklands data

The warp strike data reported by Sullivan et al. (in press) relates to the experimental testing of three mitigation devices aboard a single vessel (a 68 m factory trawler with a GRT of 1 354 t) operating in the mixed finfish bottom trawl fishery north of the Falkland Islands in August – November 2003.

Four treatments were randomly assigned to individual trawls; these were use of one of three mitigation devices (Brady Bafflers, twin Tori lines, or the Falklands warp scarer), or a control treatment of no mitigation device. Warp strike observations were carried out by experienced seabird observers and restricted to periods when offal was being discharged. Observation periods lasted for variable lengths of time and multiple observation periods within a single trawl were combined. Tow by tow rates of heavy warp contacts (by all birds, although the vast majority were black-browed albatross) for the four treatments are illustrated in Figure 2.

Sullivan et al. (in press) assessed the significance of differences between the various treatments by fitting generalised linear models with a negative binomial error distribution, and selecting models using Akaike's Information Criterion (AIC). The observation time was included as an offset term.

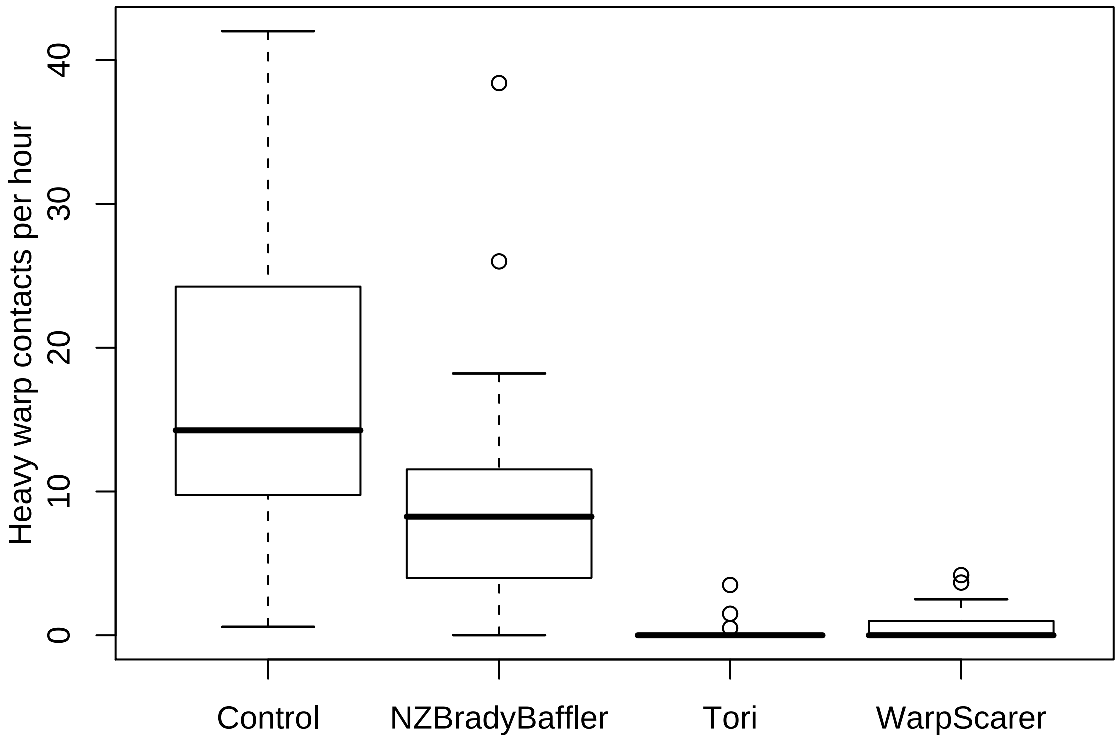
The analyses reported here exclude data from trawls where the Brady Baffler was deployed, leaving observations from 56 tows (Table 1). Figure 2 illustrates that both the Tori lines and Warp Scarer substantially reduce the rate of contacts over that of the control treatment.

For the reduced (no Brady Baffler) Falklands dataset, a model where the number of heavy contacts observed is a fitted only to the observation time yields an AIC of 321.17. Including a treatment term in the model (i.e. a categorical variable with a level for each of the three treatments) reduces the AIC to 277.73, indicating a clear treatment effect. Fitting a model where the Tori lines and Warp Scarer treatments are recoded as the same factor level yields an AIC of 280.63. Thus the AIC model selection favours the model where the Tori lines and Warp Scarer are considered separate treatments.

Table 1. Number of tows observed under the different experimental treatments in the Falklands dataset.

Treatment	*Observed tows*
Control	20
Tori	19
Warp Scarer	17

Figure 2. Boxplots of heavy warp strike contact rates for trawls in the Falklands mitigation device trials.



Here, a re-sampling approach is adopted to assess the sample size required to distinguish a treatment effect as the contact rate in the control treatment is varied. In the Falklands dataset there is a considerable difference in contact rate between the control and the mitigation treatments. On other vessels or in other fisheries this difference may be more or less pronounced. In the 2006 squid fishery it is anticipated that the widespread adoption of industry standard offal management plans will significantly reduce the amount of offal discharged while towing. This has the potential to reduce contact rates by 80 – 90% in the control treatment (e.g. Abraham, 2005, Figure 10).

The general procedure adopted here is to resample (with replacement, i.e. bootstrap re-sampling) from the observed tows under each treatment. Two models are then fitted: model 0 has an offset term for observation time only, whilst model 1 adds a treatment term. If the difference in AIC between these two models (AIC0 – AIC1) is positive then this indicates that the model with the treatment effect would be selected in preference over the null model. Re-sampling and model fitting was repeated 500 times for each case considered.

Lowered background strike rate

The effect of a lower background strike rate on the ability to detect a treatment effect (i.e. a differential contact rate with the mitigation devices) was tested by multiplying the number of heavy contacts in the each tow under the control treatment by factors of 0.5, 0.2, 0.1 and 0.05 prior to resampling. As the contact rate in the control treatment is reduced, so the AIC difference in models with and without a treatment effect reduces (Figure 3). However, even when the number of contacts in the control tows is reduced to just 5% of the observed levels, a treatment effect is still identified in the majority of bootstrap samples.

Varying sample size

The effect of different sample sizes (number of observed tows under each treatment) was investigated with the number of heavy contacts in the control treatment at 100% (Figure 4) and 20% (Figure 5) of the observed numbers. Reducing the number of tows sampled per treatment to 10 or 5, from the approximately 20 in the original dataset, reduces the ability to detect a treatment effect, whilst increasing the sample size increases the AIC differential between the models. However, even when the control contacts are scaled to 20% of the observed numbers the model with a treatment effect is selected in the majority of replicates even when sample sizes are small.

However, smaller samples sizes reduce the ability to distinguish between the two mitigation treatments (Figure 6).

Between vessel variation: the 2005 squid fishery data

A subset of the warp strike data from the 2005 southern squid fishery (Abraham, 2005) was supplied by MFish data management. These data comprise 389 (378 after data grooming) warp strike observation periods from seven observed trips (in contrast to 1094 observations from 18 observers on 19 vessels, as reported by Abraham, 2005). Within each of these trips there was no variation in mitigation method. On three trips bird Bafflers were used on every observed trawl, whilst on four trips no mitigation method was used. However these data (Figure 7) do give an indication of the level of between vessel variation in warp strike rate, albeit confounded with between observer variability.

Conclusions

Re-sampling the data from the Falklands study of mitigation device performance demonstrated that a treatment effect was still detectable in the 56 observed tows, even when the warp strikes observed in the control treatment were reduced to 10% of their actual level. This provides some confidence that, with devices of similar effectiveness, a treatment effect should still be detectable even in the case where the “background” level of warp strike contacts is reduced as a result of offal management.

The large reduction in warp strike rate ensured that the overall treatment effect remained detectable even with considerably reduced sample sizes. However, reduced sample sizes greatly reduced the ability to distinguish the Tori lines and Warp Scarer treatments.

The data from the New Zealand southern squid fishery in 2005 provide no information on the between vessel variation in relative efficacy of mitigation methods, but indicate that mean warp strike rates do vary considerably between vessels.

Figure 3. Density plots of 500 bootstrap samples of the AIC difference between models with (AIC1) and without (AIC0) a treatment effect, with different scalers applied to the number of heavy contacts in the control treatment. Observations under each treatment as Table 1.

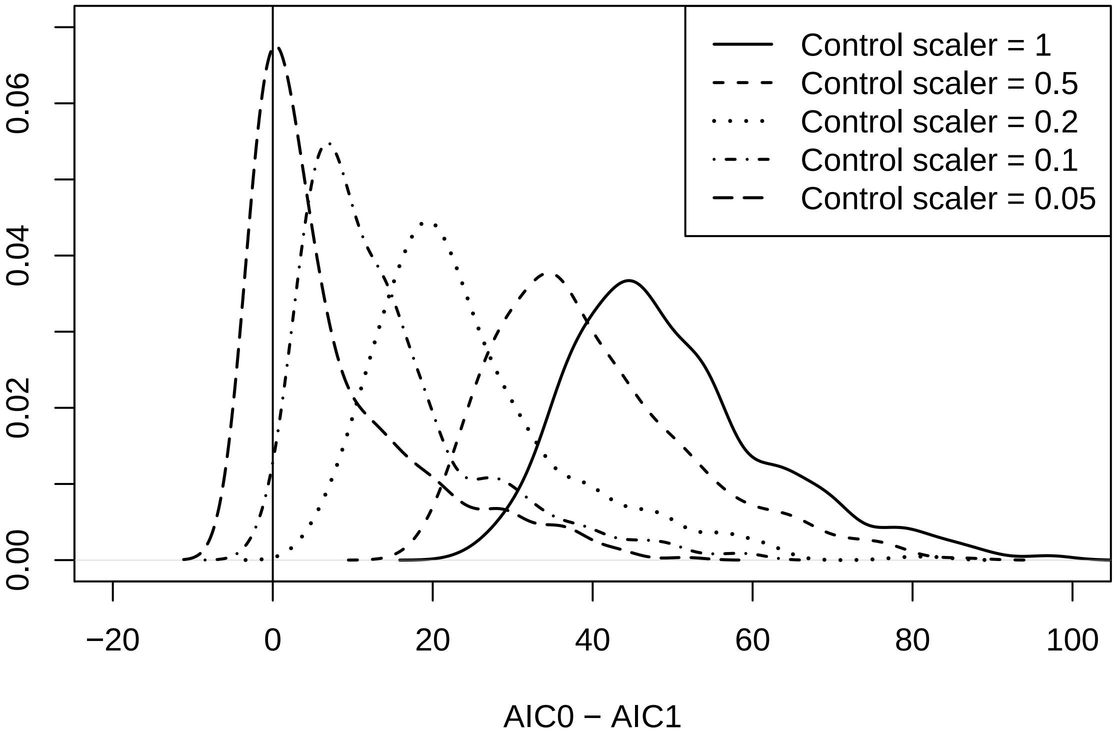


Figure 4. Density plots of 500 bootstrap samples of the AIC difference between models with (AIC1) and without (AIC0) a treatment effect, with different numbers of observations per treatment. No scaling applied to control treatment heavy contacts.

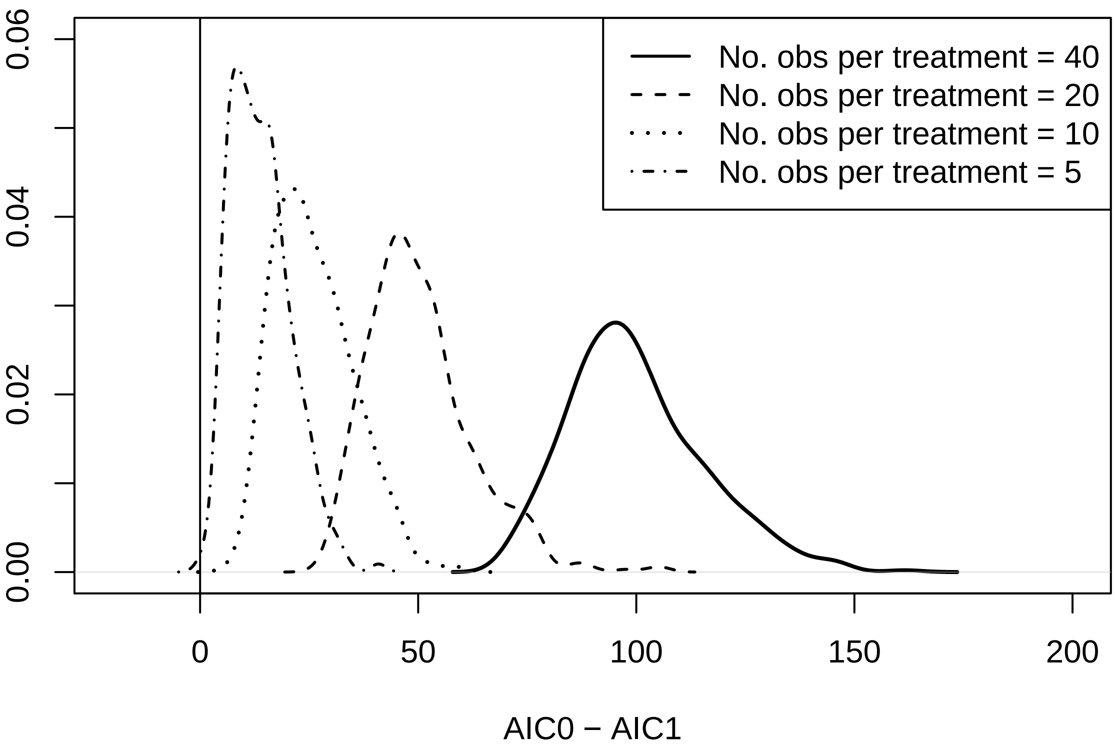


Figure 5. Density plots of 500 bootstrap samples of the AIC difference between models with (AIC1) and without (AIC0) a treatment effect, with different numbers of observations per treatment. Control treatment heavy contacts scaled by a factor of 0.2.

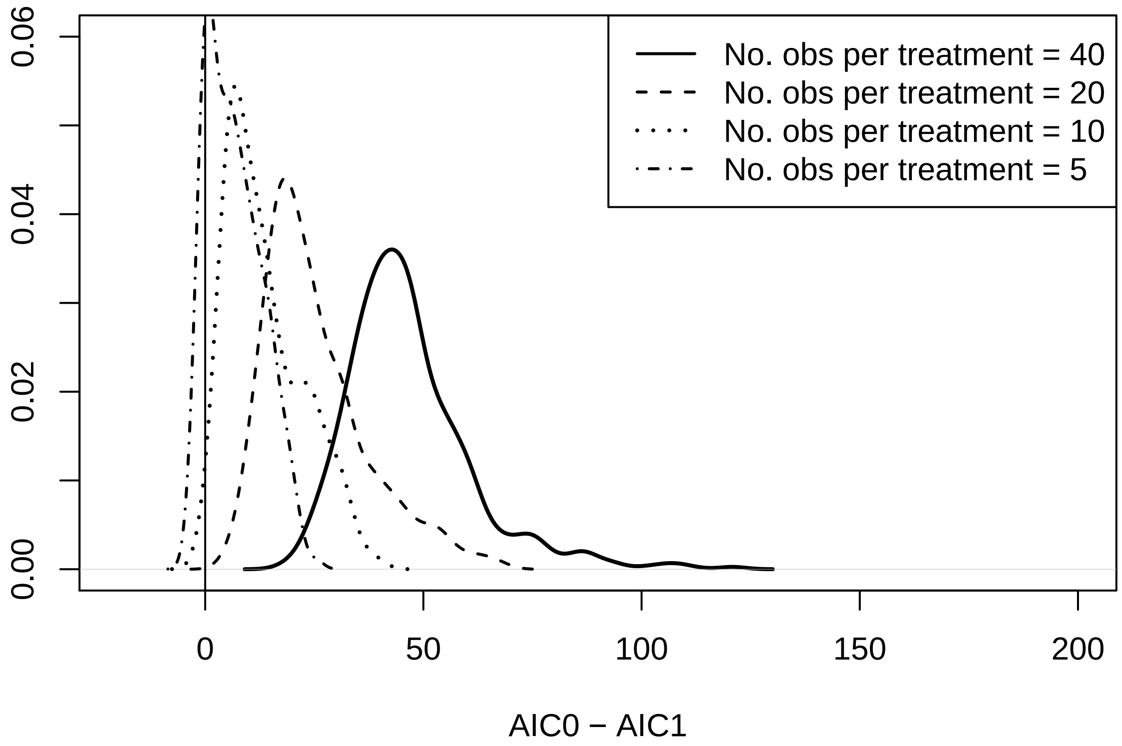


Figure 6. Density plots of 500 bootstrap samples of the AIC difference between models where the warp scarer and tori line treatments are coded separately (AIC1) and merged (AIC2), with different numbers of observations per treatment. No scaling applied to control treatment heavy contacts

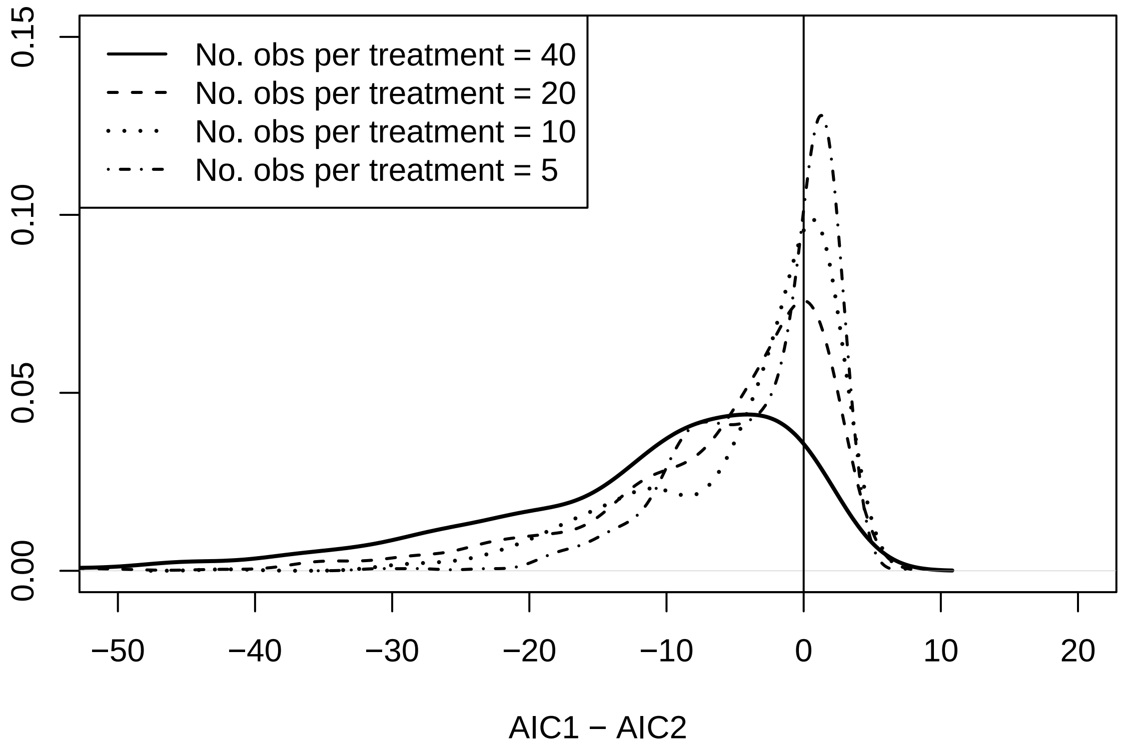
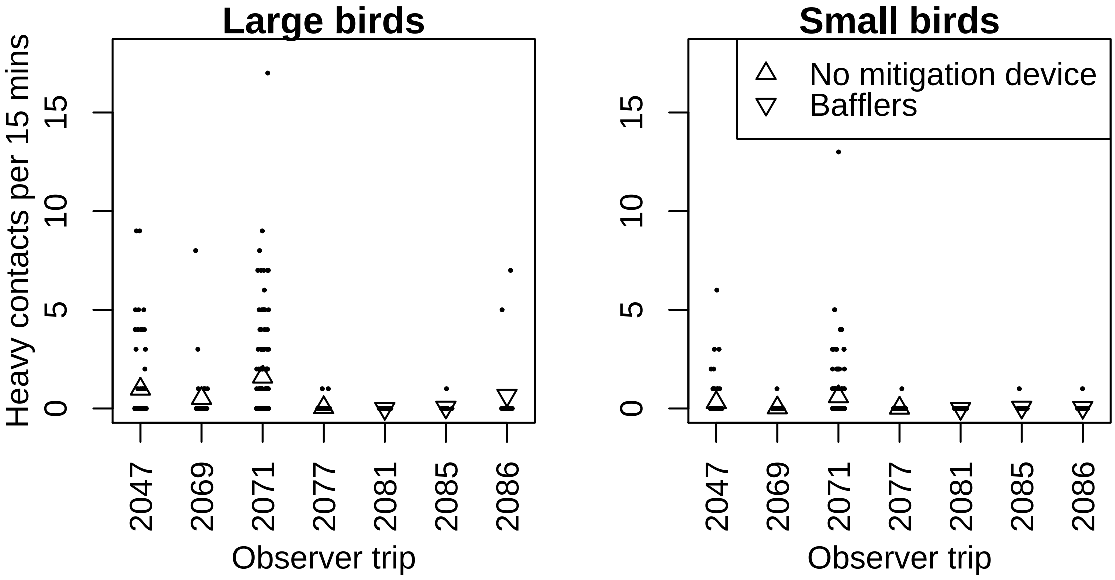


Figure 7. Numbers of heavy warp strikes of large and small birds for trips observed in the 2005 southern squid fishery. Points: raw counts from individual observation periods. Triangles: simple mean of all observation periods conducted on a trip.



Appendix B. Observer warp-strike protocol.

The current observer warp strike instructions and form, as trialled in the southern squid fishery in 2005, are appended. It is proposed to retain the same basic protocol for the trials described here, but to address the following points:

- Collect data to verify that the two mitigation methods tested are deployed according to the standard specifications developed.
- Record heavy warp strikes by small and large birds with the mitigation device, in addition to heavy contacts with the warp. This is likely to be via the use of separate recording periods devoted to recording contacts with the mitigation device.
- Collect data on the durability of the warp strike devices (i.e. loss of components etc.).