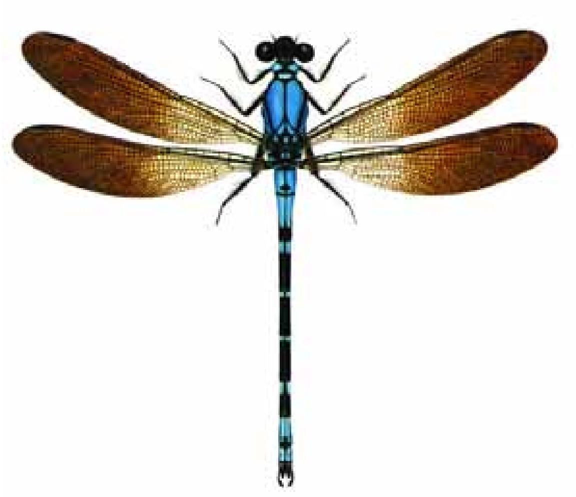
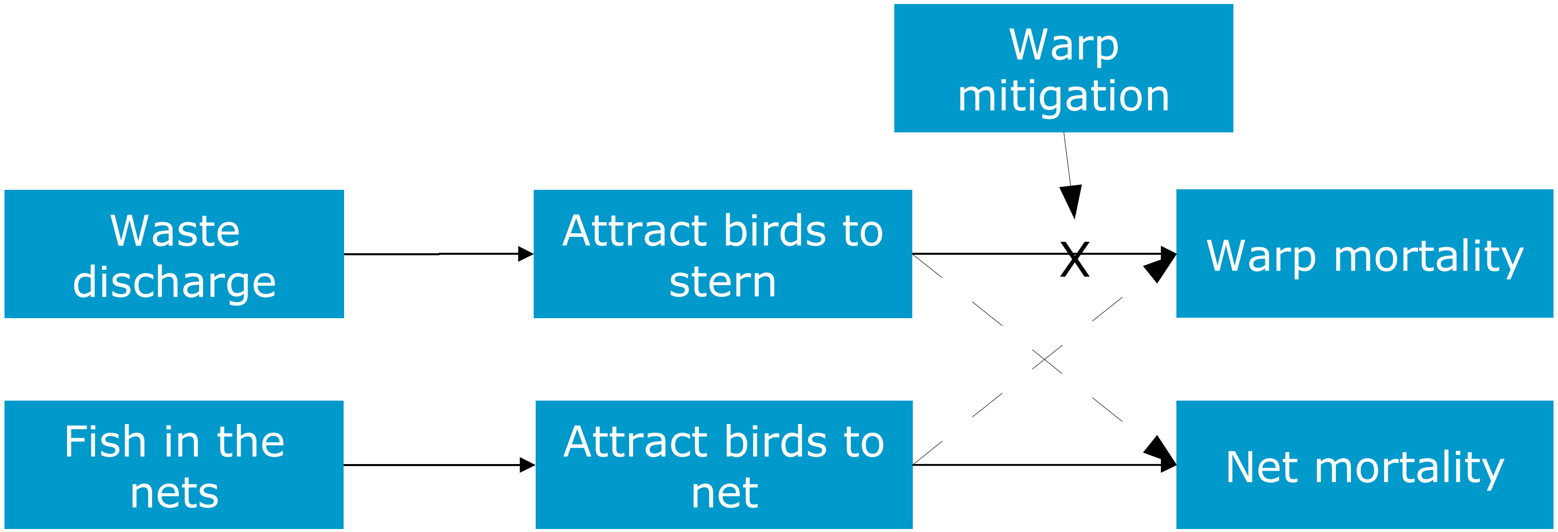
Batching discharge to reduce seabird numbers behind trawl vessels

Edward Abraham

Dragonfly



Strategies for reducing seabird mortality



- Bird are attracted to vessels by fish in the nets and by discharge of processing waste
- Mitigation reduces the risk that birds feeding behind the vessel are struck by the warps
- Reducing waste discharge reduces numbers of birds behind the vessel and so directly reduces the risk of warp mortality
- May also reduce net mortality

Reducing discharge

- Use meal plants to retain more of the waste stream
- Hold waste and discharge when the vessel is not fishing and so there is no risk of birds being struck by warps
- Often offal is discharged in a semi-continuous stream. It is possible that batching offal (storing it for a period and then dumping it in a burst) will reduce the numbers of birds behind the vessel. This would work if
  - » The birds lost interest while there was no waste being discharged, and went away
  - » They didn't respond quickly at the start of the discharge event, so it was all over before they knew about it

Batching experiment

- Experimentally control the interval between discharge events
- Define response of birds behind the vessel to discrete discharge events
- Determine whether there is a change in bird numbers with an increase in the interval between batches
- Experiment commissioned by DOC, and planned and coordinated by the Mitigation Technical Advisory Group (Rebecca Bird, David Middleton, Johanna Pierre, Nathan Walker, Susan Waugh). Liaison with fishing vessel and technical implementation provided by John Cleal. Experiment jointly conducted by vessel crew and the fisheries observer.
- Carried out on a New Zealand squid trawler, fishing on the Stewart Snares shelf and around the Auckland Islands, between 5 February and 14 March 2008

Protocol

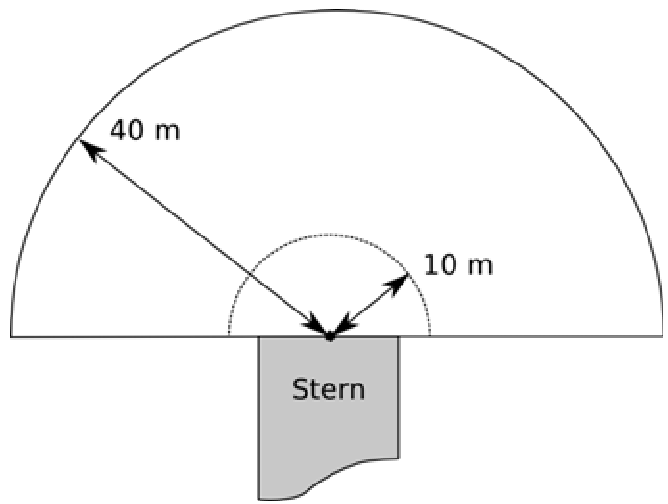
- Four experimental treatments with a 30min, 2 hour, 4 hour and 8 hour interval between batches

- Numbers of seabirds behind the vessel counted at 5 minute intervals, for up to an hour, covering the period of the discharge. Counts made within two semicircular sweeps of 40m and 10m.

- Birds counted in 3 species groups
  - Large birds (albatross and giant petrel)
  - Cape petrel
  - Other birds

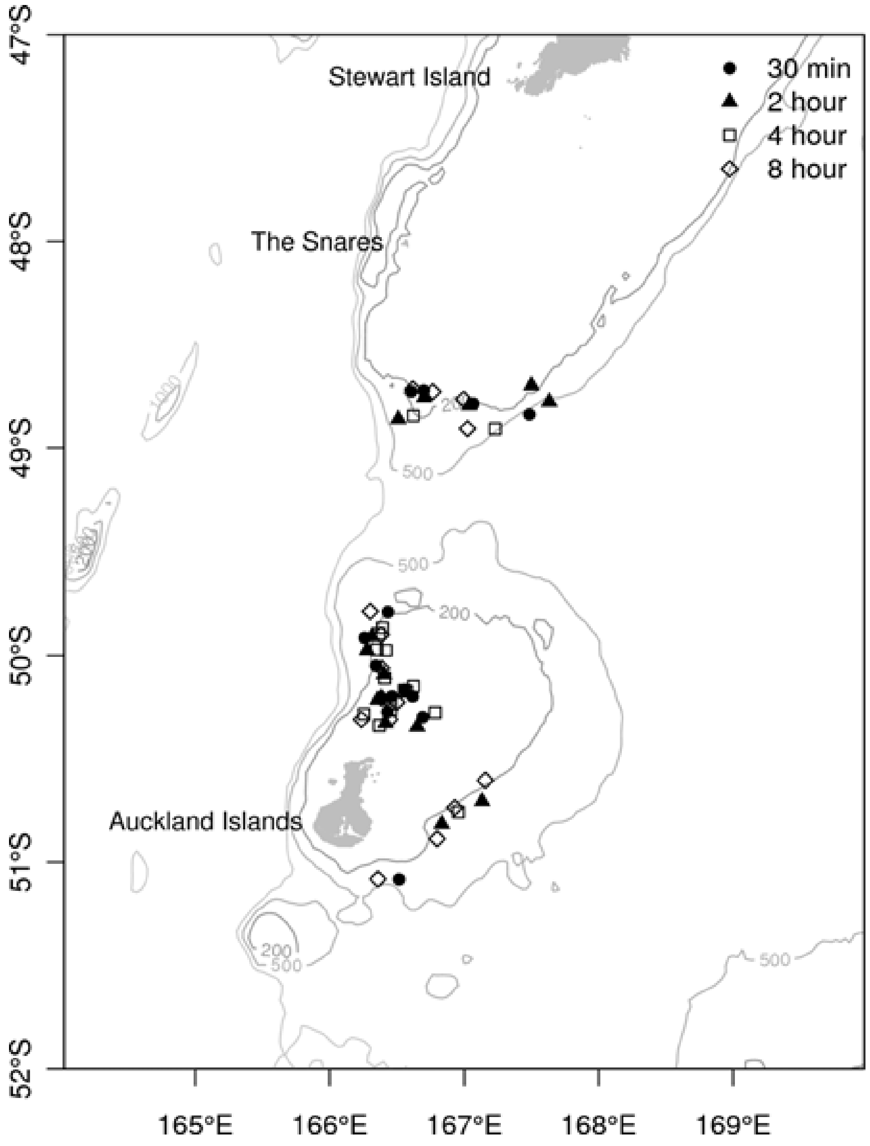
- Each species group counted in 2 behavioural groups
  - In air
  - On the water

- Discharge either
  - No discharge (no processing)
  - Sump water
  - Batch discharge

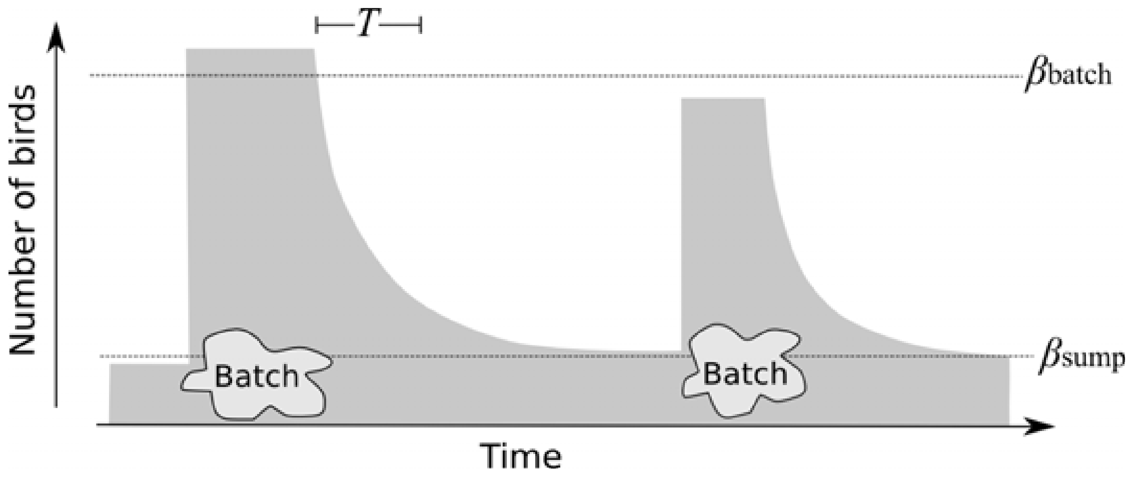


Experiment summary

- Observations made on 39 days, with the experimental treatment being followed on 36 of those
- 144 separate forms completed (with up to 12 sets of counts over up to an hour)
- 1,269 sets of counts (observations)
- A total of 15,093 individual sweep counts
- In general, actual intervals between batches reflected design intervals. Use design intervals when allocating observations to treatments
- Intermediate observations were also made between discharges, particularly during the 4 and 8 hour treatments



Data model



- Mean counts may be different for each treatment and discharge level (non, sump or batch)
- Birds arrive quickly when discharge begins
- There is a transition time-scale (T) representing how quickly birds leave the sweep zone once discharge has ceased
- There is no influence of discharge in one tow on bird umbers in subsequent tows
- There are other covariates that influence the counts (wind speed, vessel number and area)
- Counts may differ from tow to tow for reasons that are not captured by the covariates (tow level random effects)
- Negative binomial distribution may be used to generate the counts from the mean values

Data model (formally)

- Some terminology
  - N Bird abundance
  - mu: mean count
  - beta: effects influencing the abundance
  - T: response time of the birds
  - i: Tow index
  - k: Observation index
  - j: Covariate index
  - d: discharge level
  - e: experimental treatment

$$\log(N_{ik}) = \log(\beta_{de}) + \sum_j \log(\beta_j) x_{ijk} + \epsilon_{id}$$

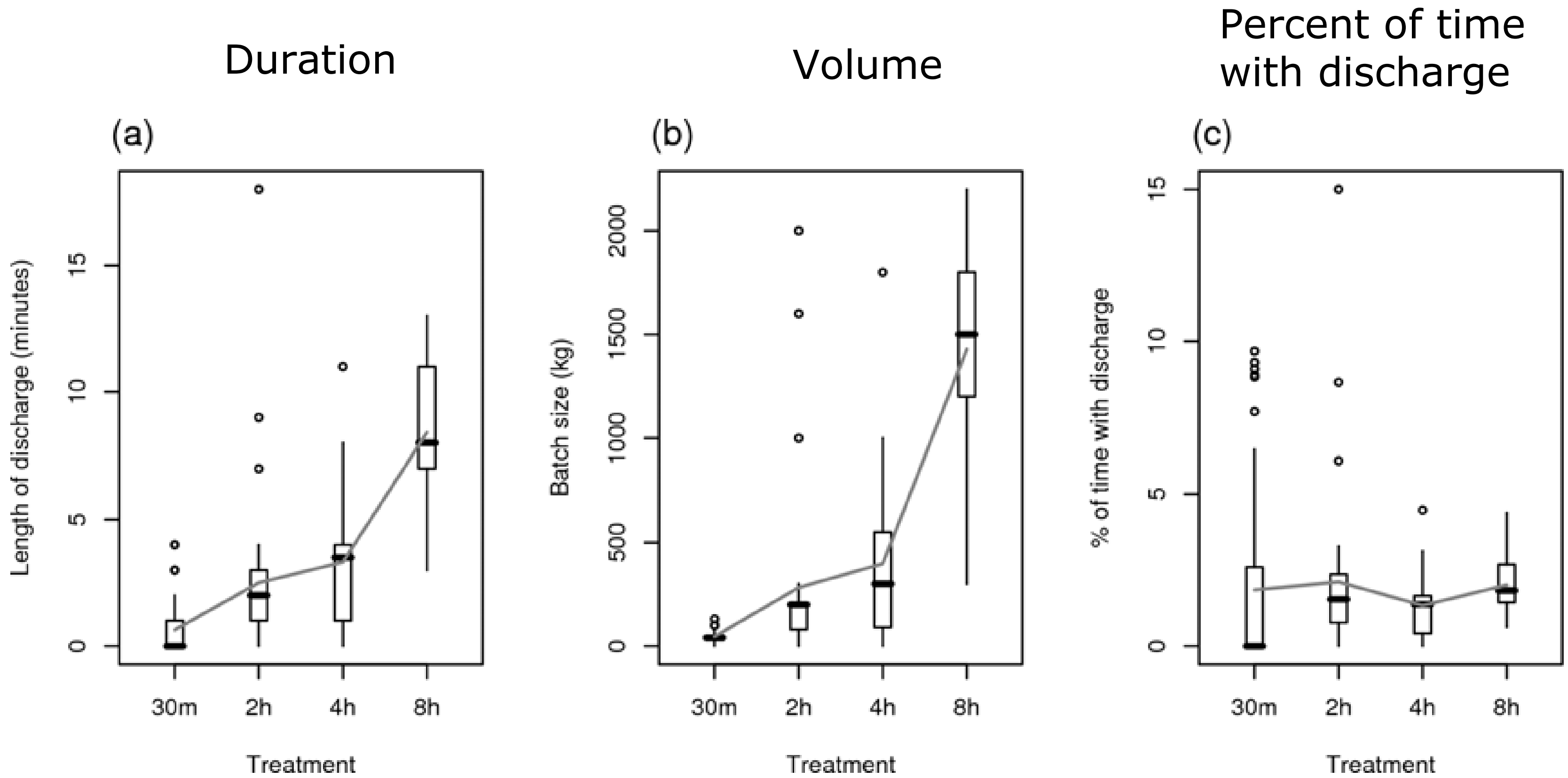
$$\mu_{ik} = \begin{cases} N_{ik}, & k = 1 \text{ or batch discharge} \\ N_{ik} + (\mu_{i,k-1} - N_{ik}) e^{-(t_{ik} - t_{i,k-1})/T}, & k > 1 \text{ and not batch discharge} \end{cases}$$

Data model (formally)

- Fit the model using Bayesian methods (JAGS)
- Uniform prior on the time-scale T (between 0 and 24 hours)
- Scale of the tow level random effect normally distributed, with a half-Cauchy prior on the standard deviation (mean of 2)
- Weakly informative normal priors for the fixed effects (mean of zero and a standard deviation of 10)
- Over-dispersion parameter of the negative binomial taken to be a uniform shrinkage distribution with a mean value given by the mean count over all observations
- Chains burnt in for 10,000 updates and then run for 200,000 updates with every 50^{th} update being retained
- Diagnosis checked using standard diagnostics (Heidelberger and Welch, and Raftery and Lewis)

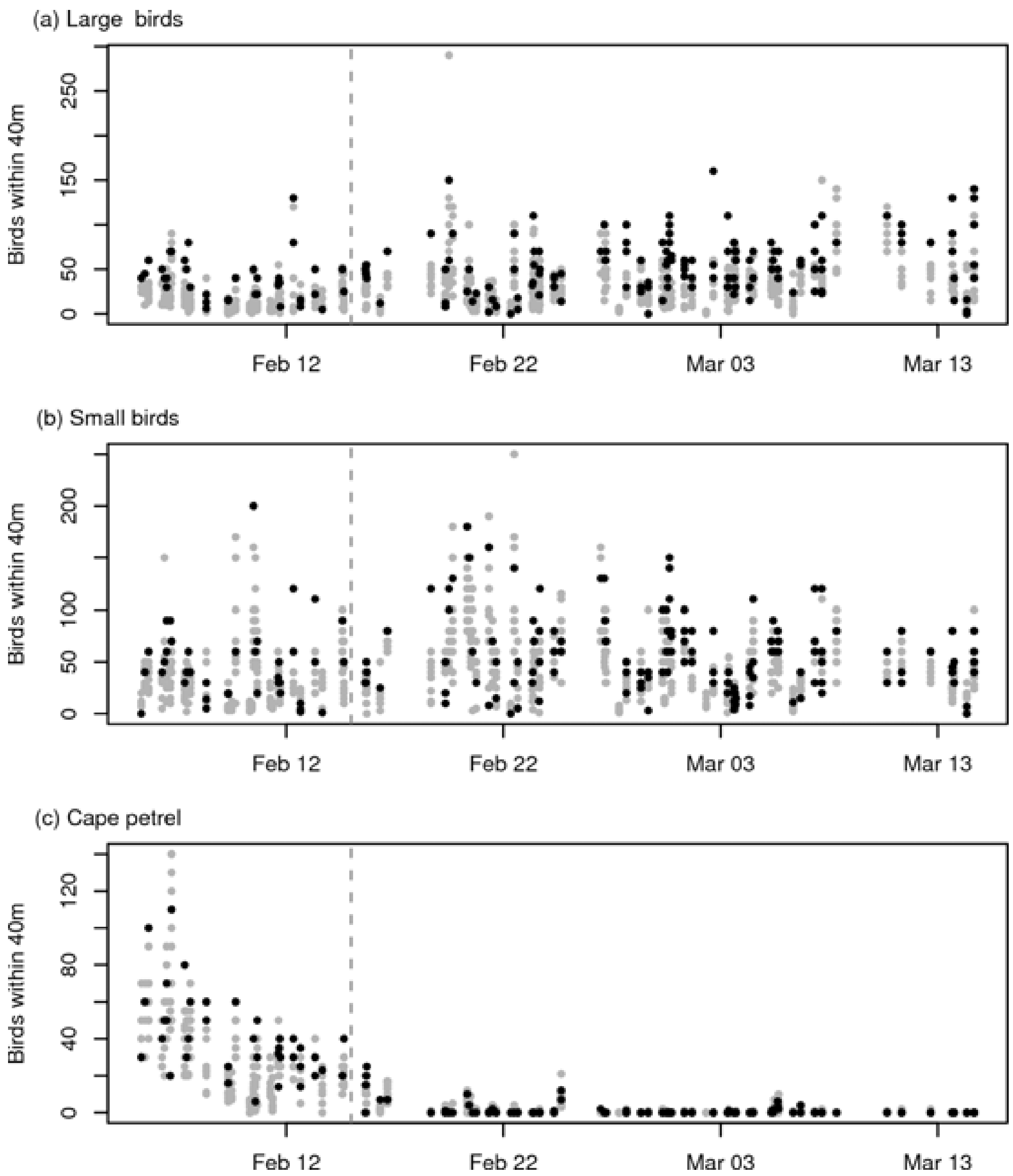
Discharges

- Som-what linear relation between the batch interval and both the duration and volume of the batch discharge
- No strong relationship between the treatment and the percentage of the time that there is batch discharge (a mean of close to 2% for all treatments)

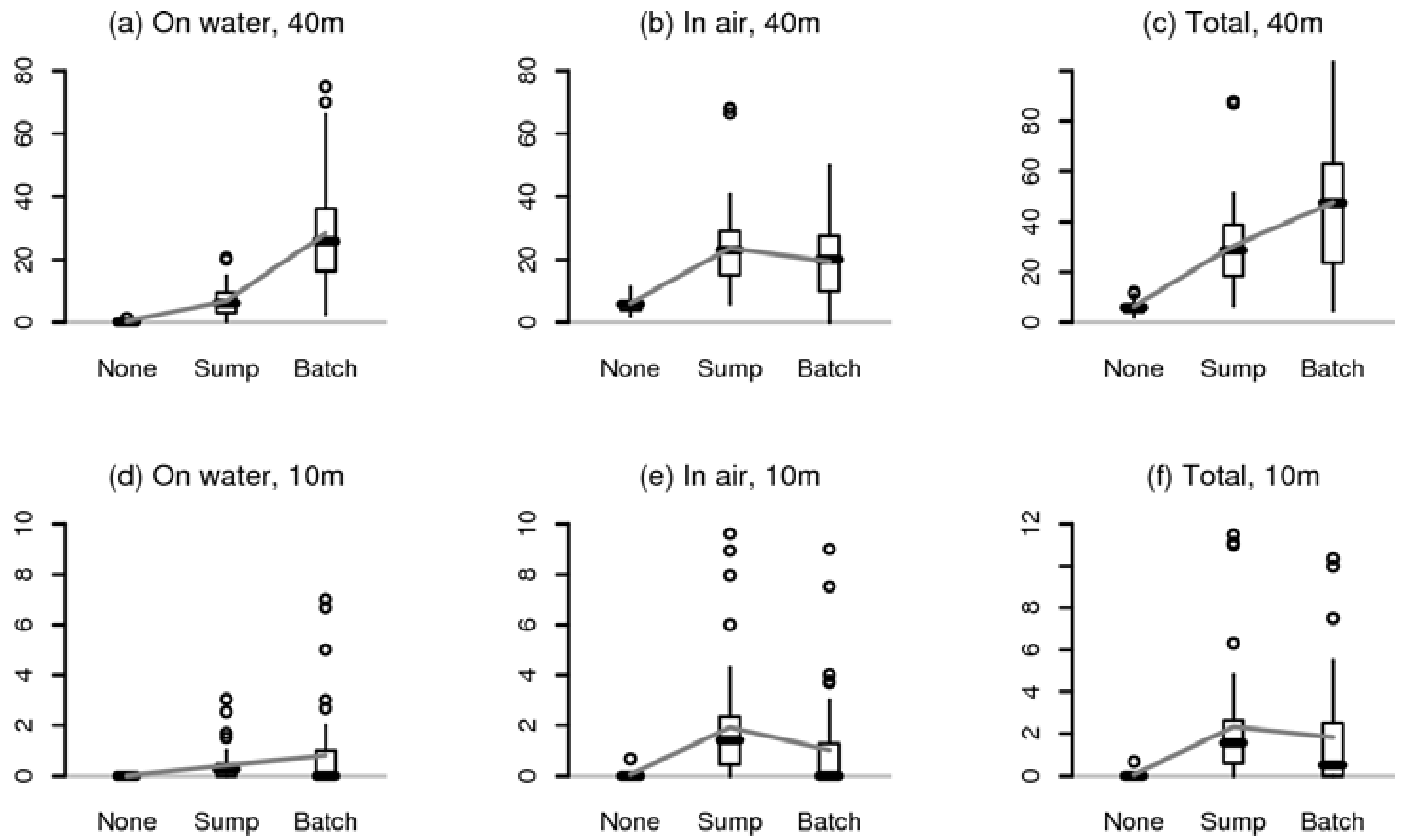


Total bird numbers

- Similar numbers of large and small birds throughout the experiment
- Most abundant birds are white-capped albatross, white-chinned petrel, sooty shearwater, and Cape petrel
- End of the Cape petrel breeding season is in February and they leave the area during the experiment. Data not analysed.

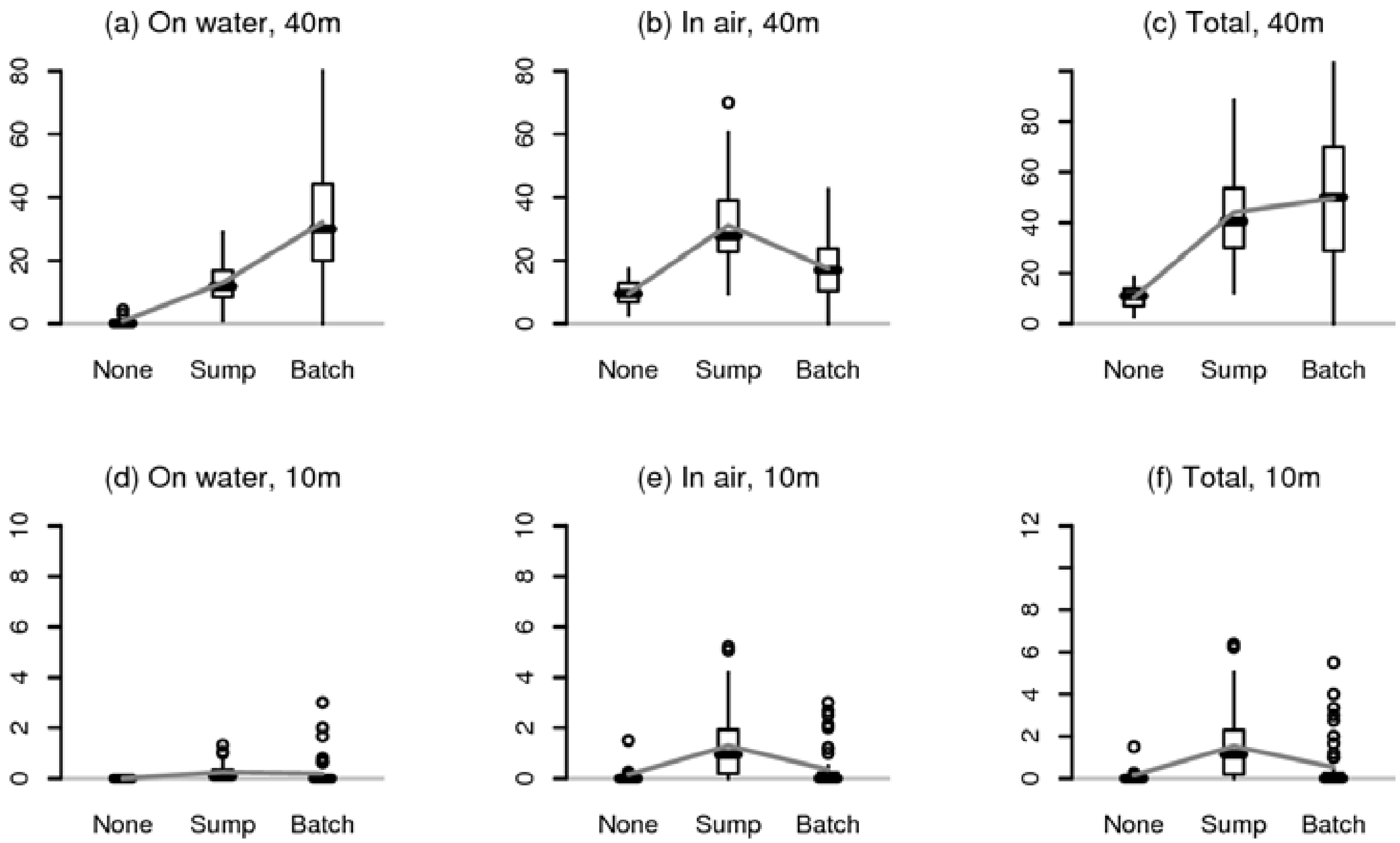


Raw large bird counts, by discharge



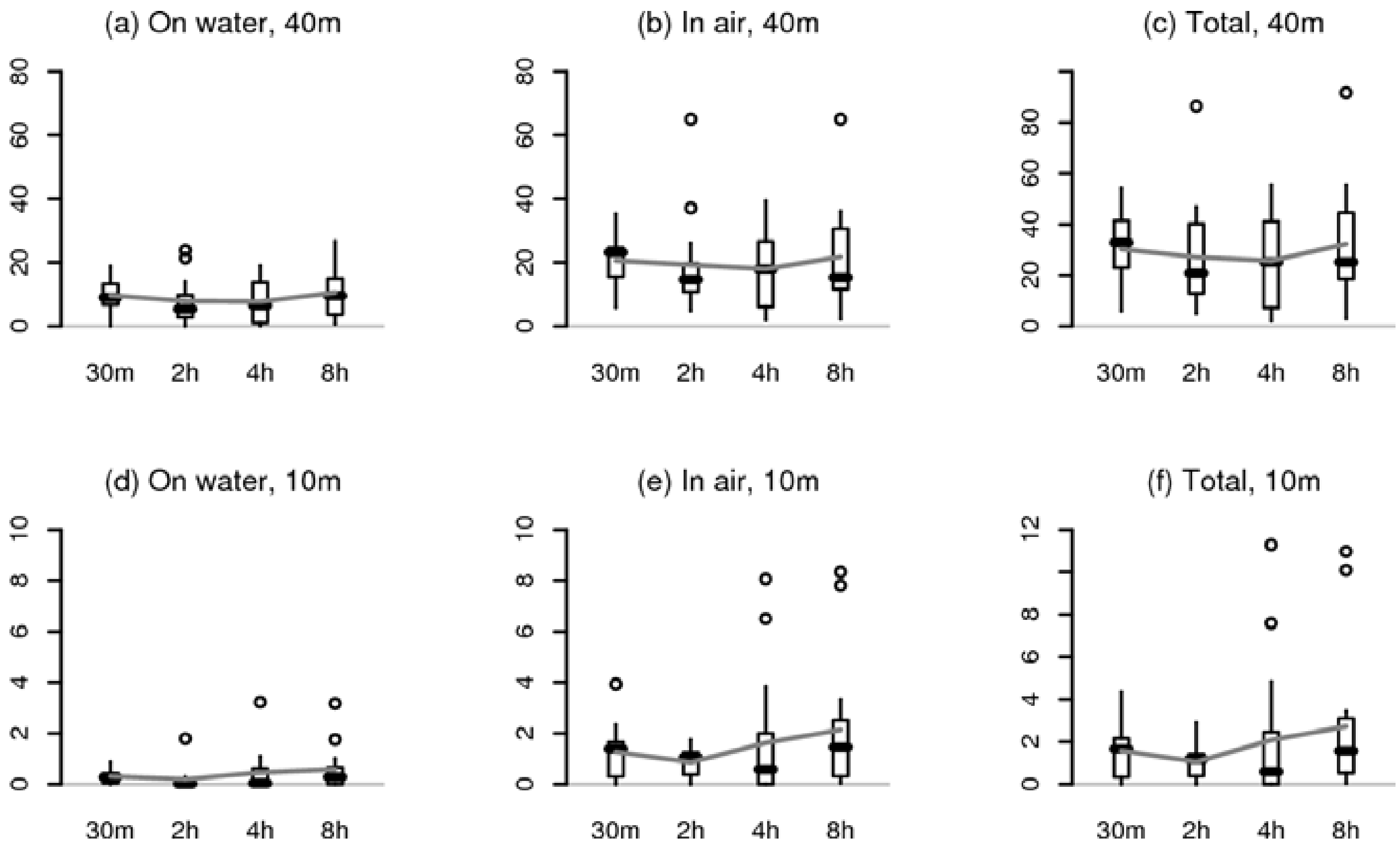
- Increase in numbers with discharge for birds on the water and for total birds (40m)
- Humped response for birds in the air and for total birds (10m)

Raw small bird counts, by discharge



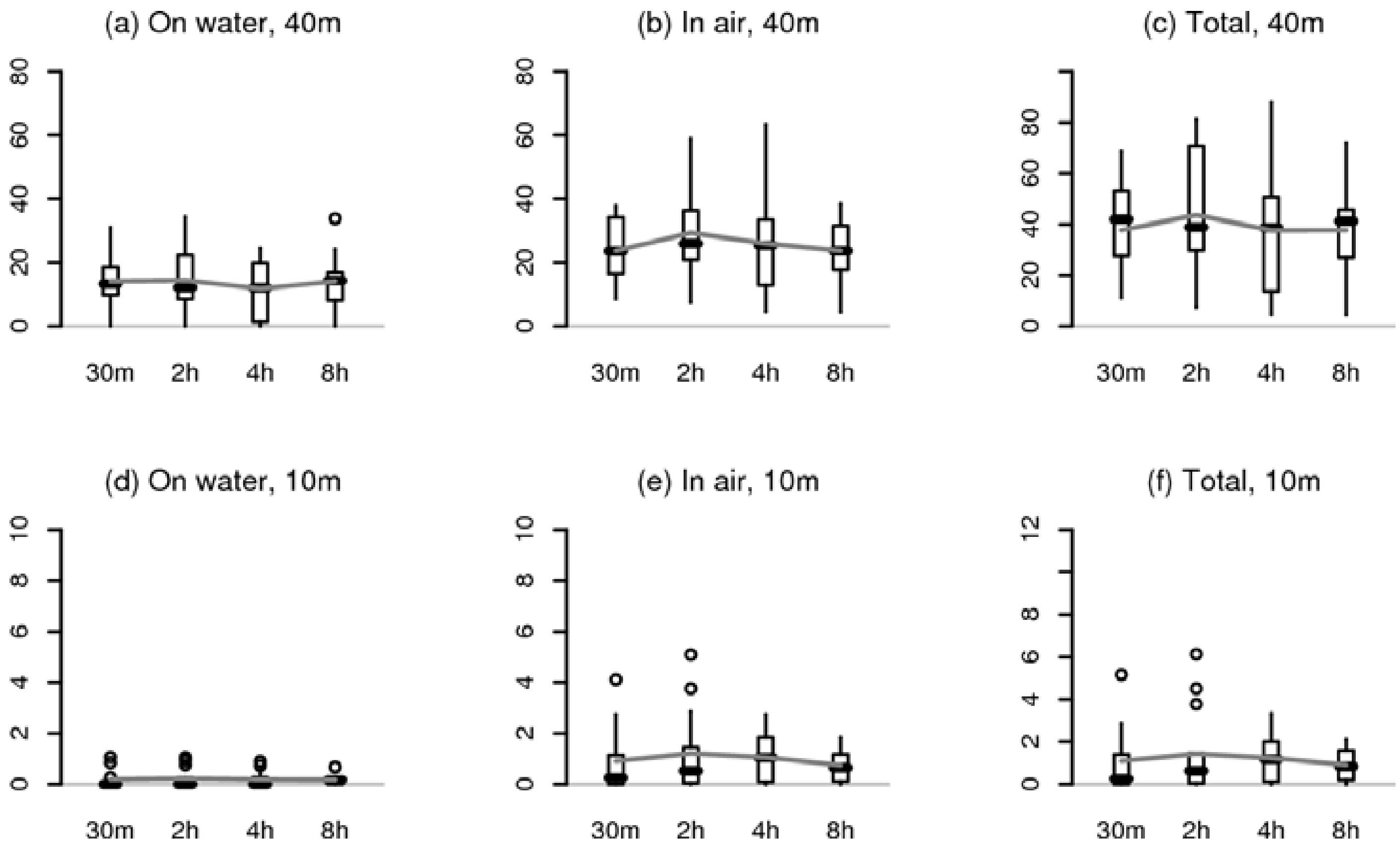
- Increase in numbers with discharge for birds on the water and for total birds (40m)
- Humped response for birds in the air and for total birds (10m)

Raw large bird counts, by treatment



- No clear trend in abundance with increase in batch interval

Raw small bird counts, by treatment

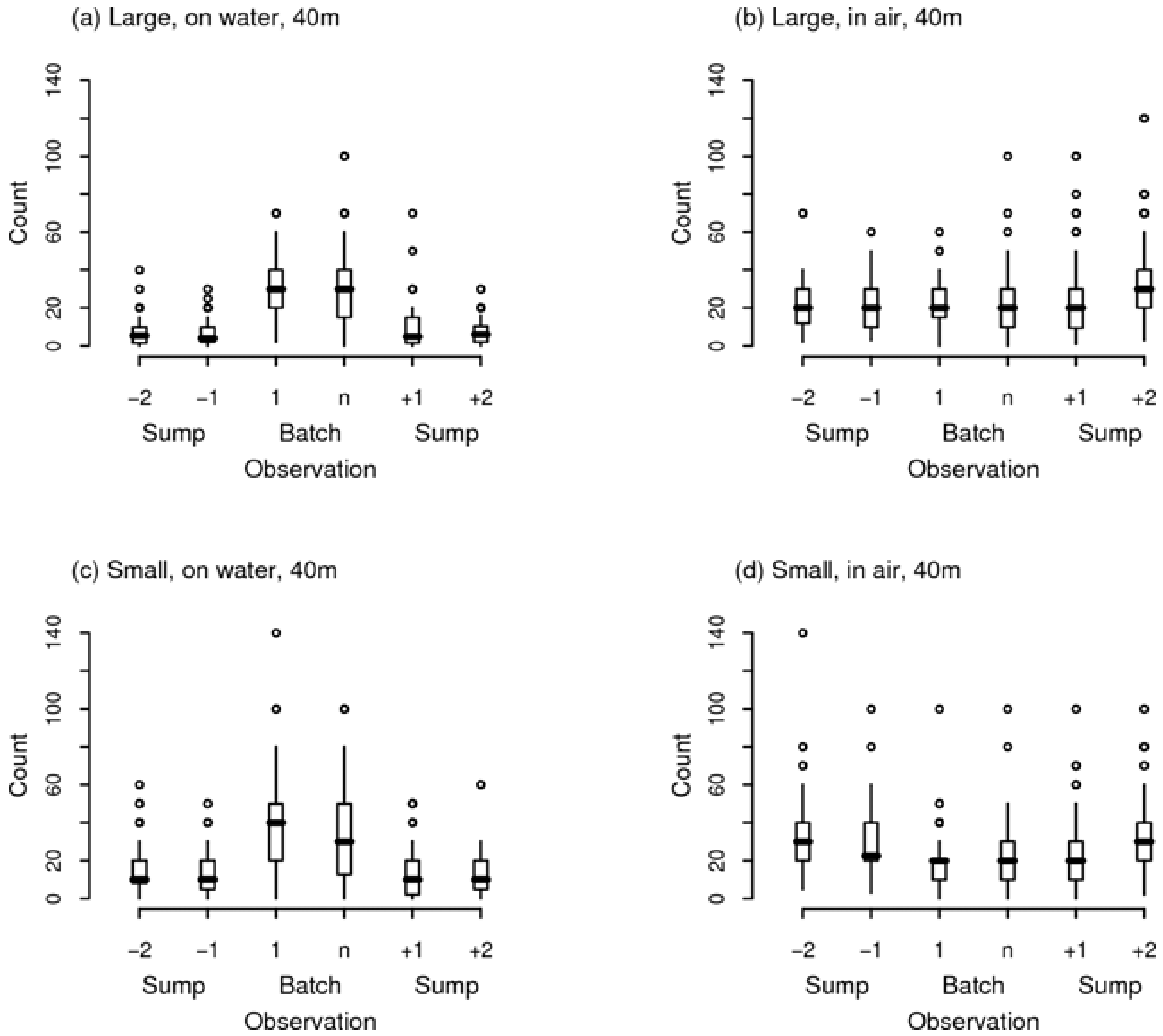


- No clear trend in abundance with increase in batch interval

Response to discharge events

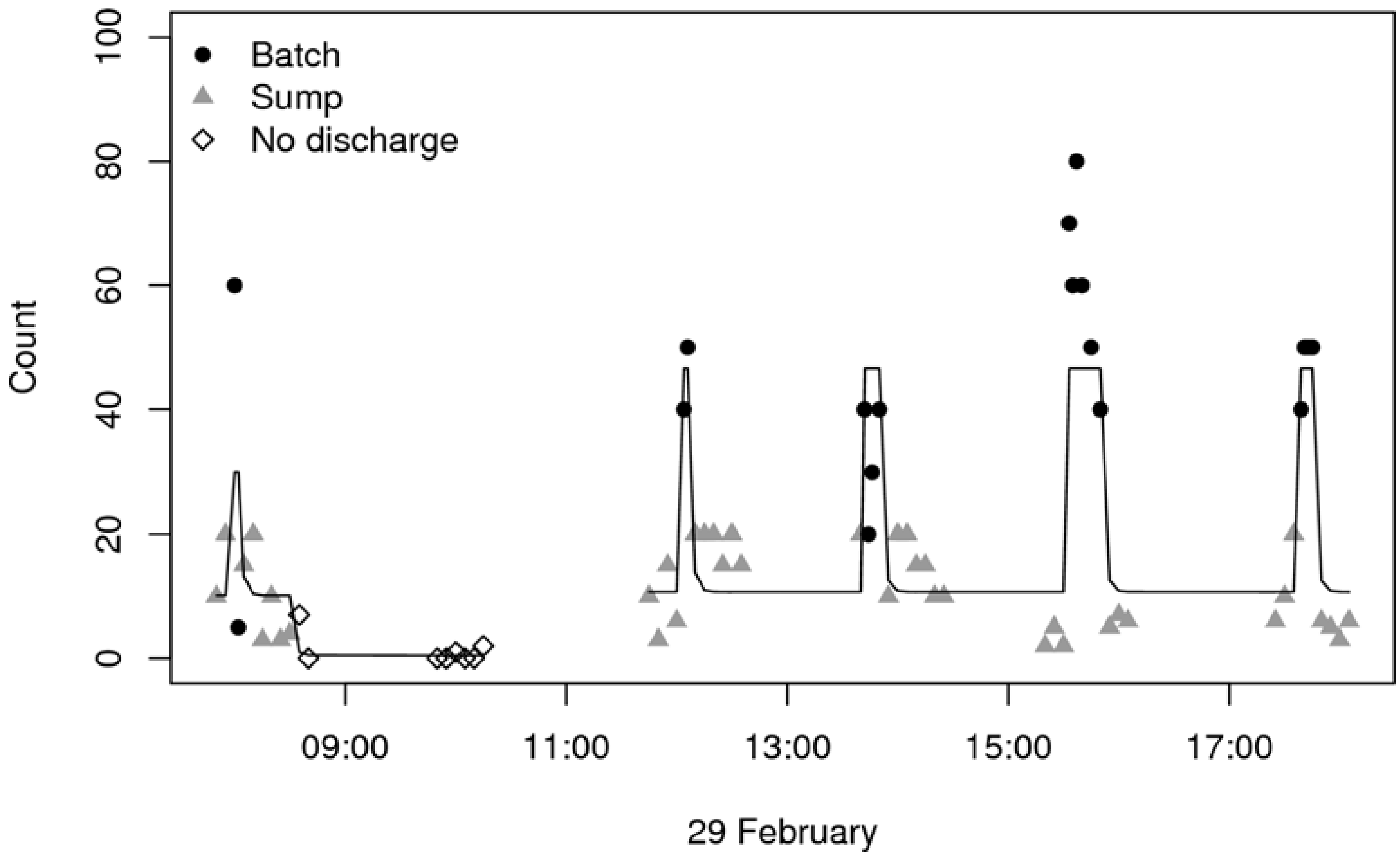
- Raw data shows an immediate response to discharge for birds on the water

- Response of birds in the air is less clear



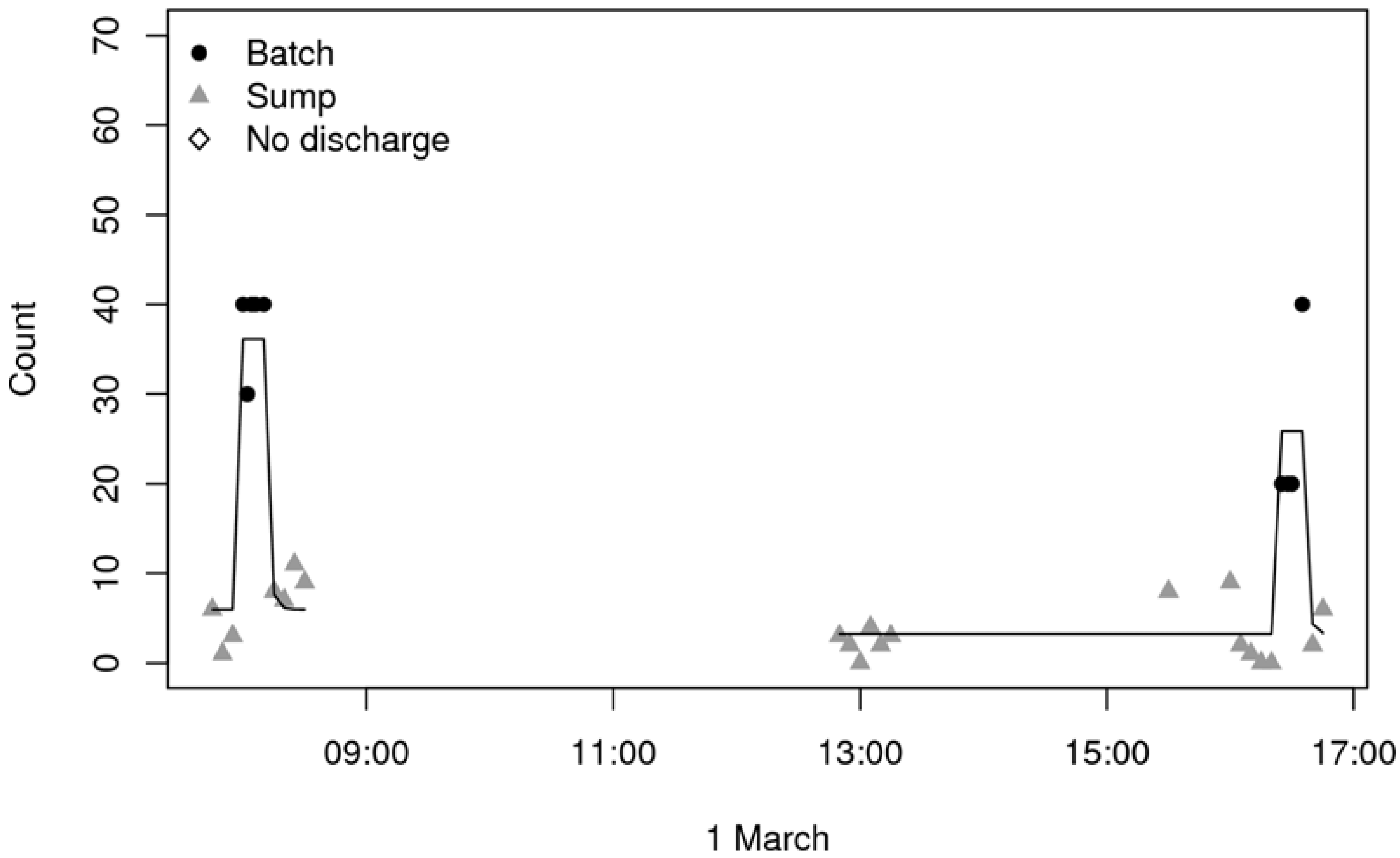
Model fits

- Large birds on the water, 29 Feb (2 hour batch interval)



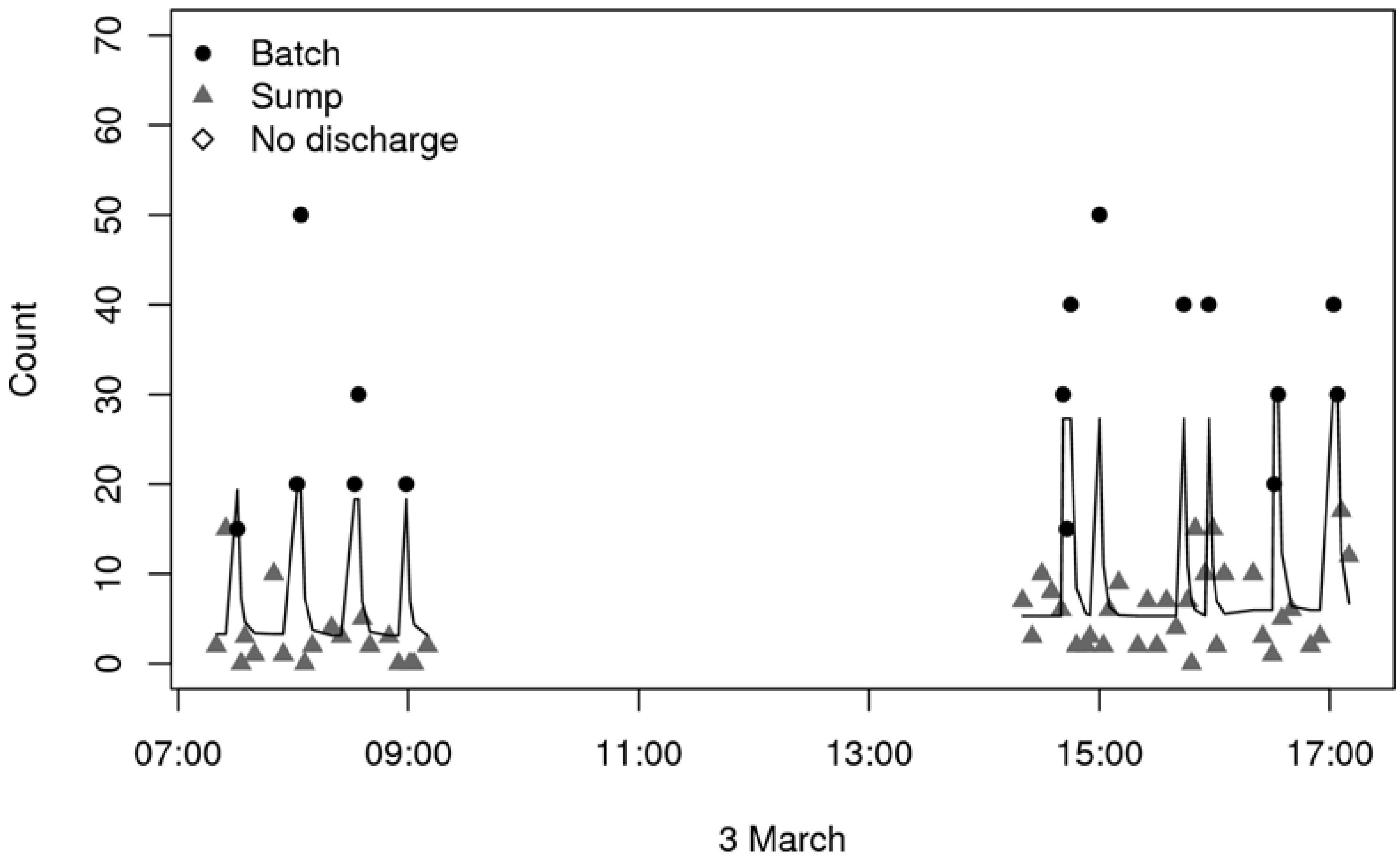
Model fits

- Large birds on the water, 1 March (8 hour batch interval)



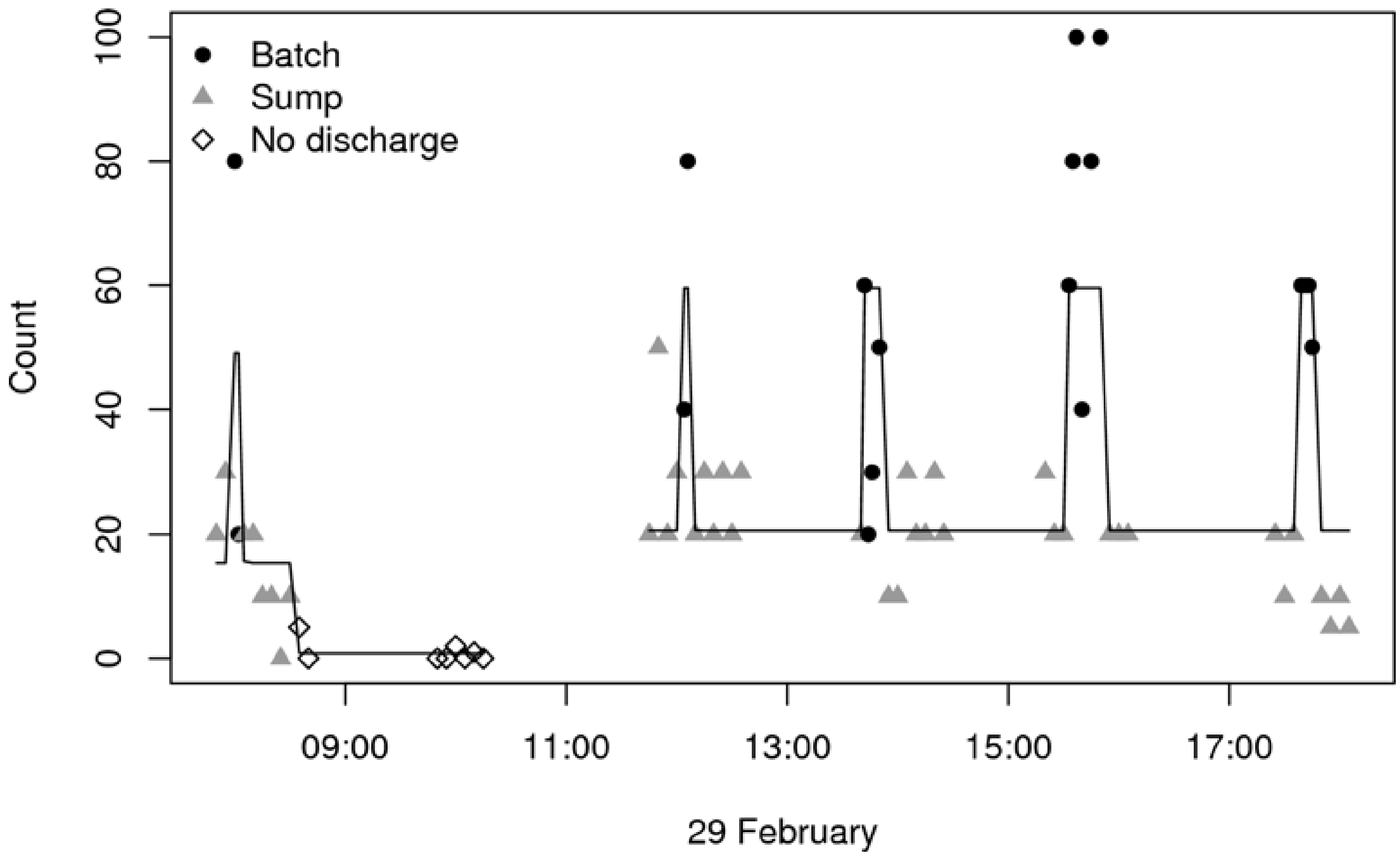
Model fits

- Large birds on the water, 3 March (30 minute batch interval)



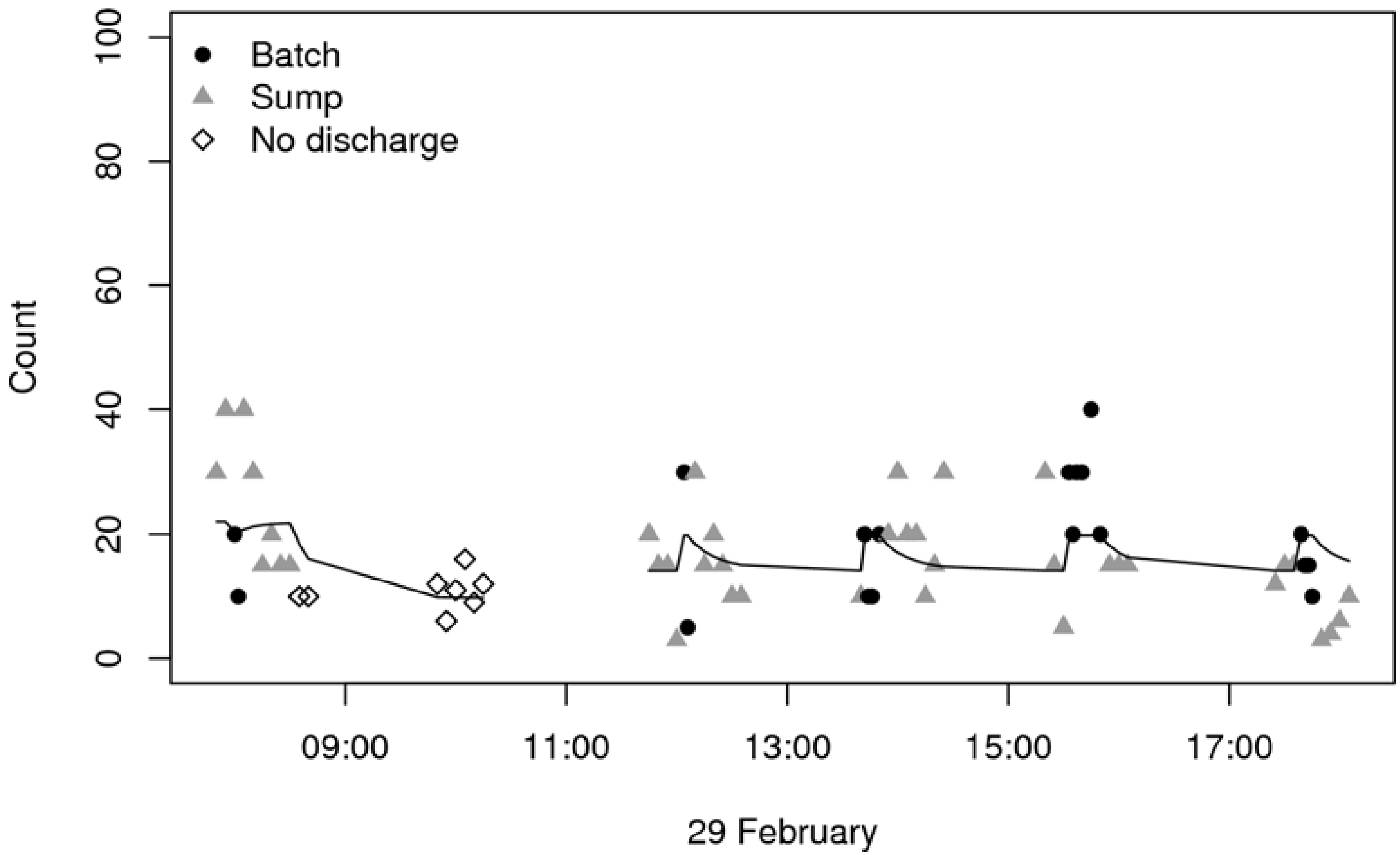
Model fits

- Small birds on the water, 29 Feb (2 hour batch interval)



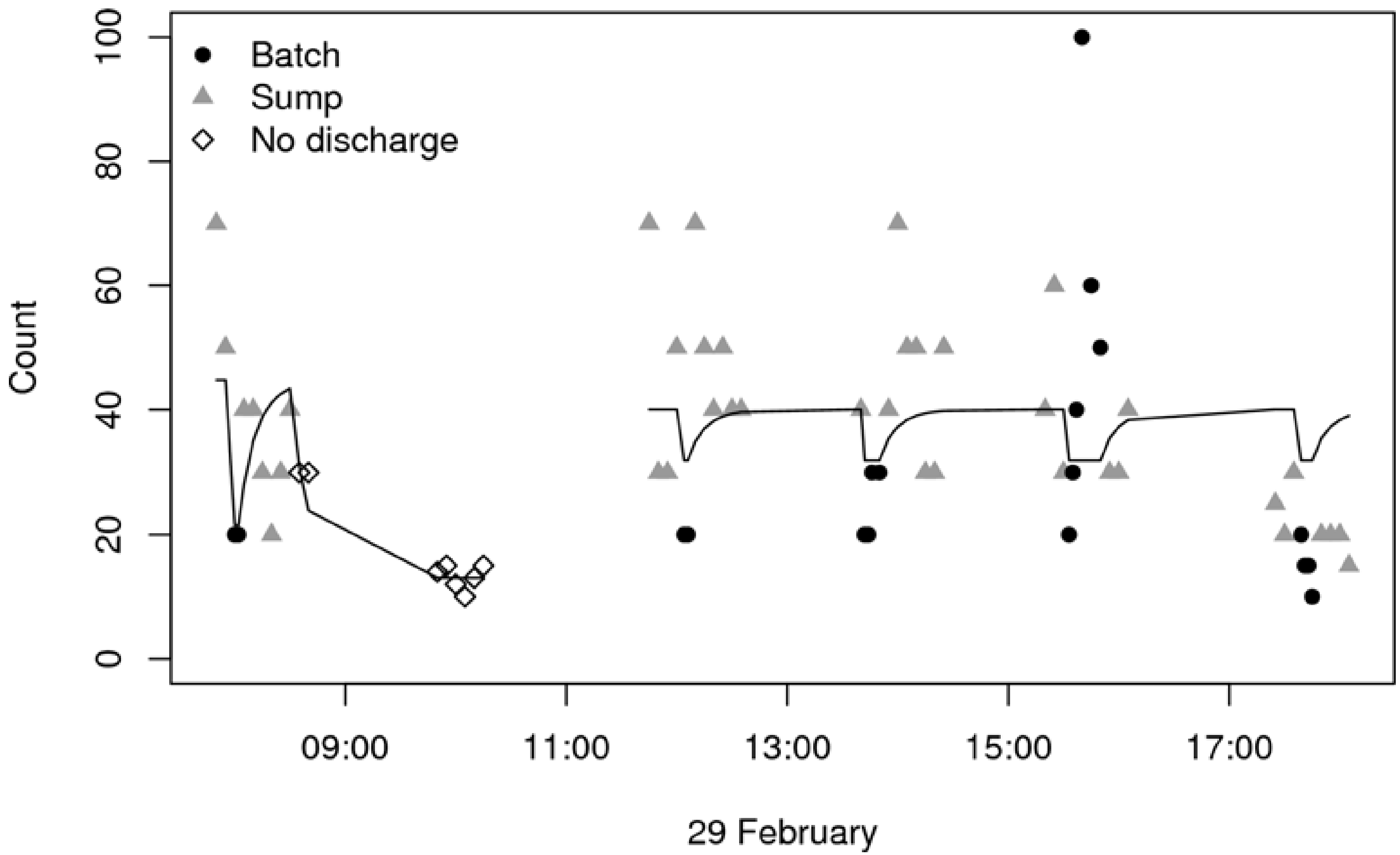
Model fits

- Large birds in the air, 29 Feb (2 hour batch interval)



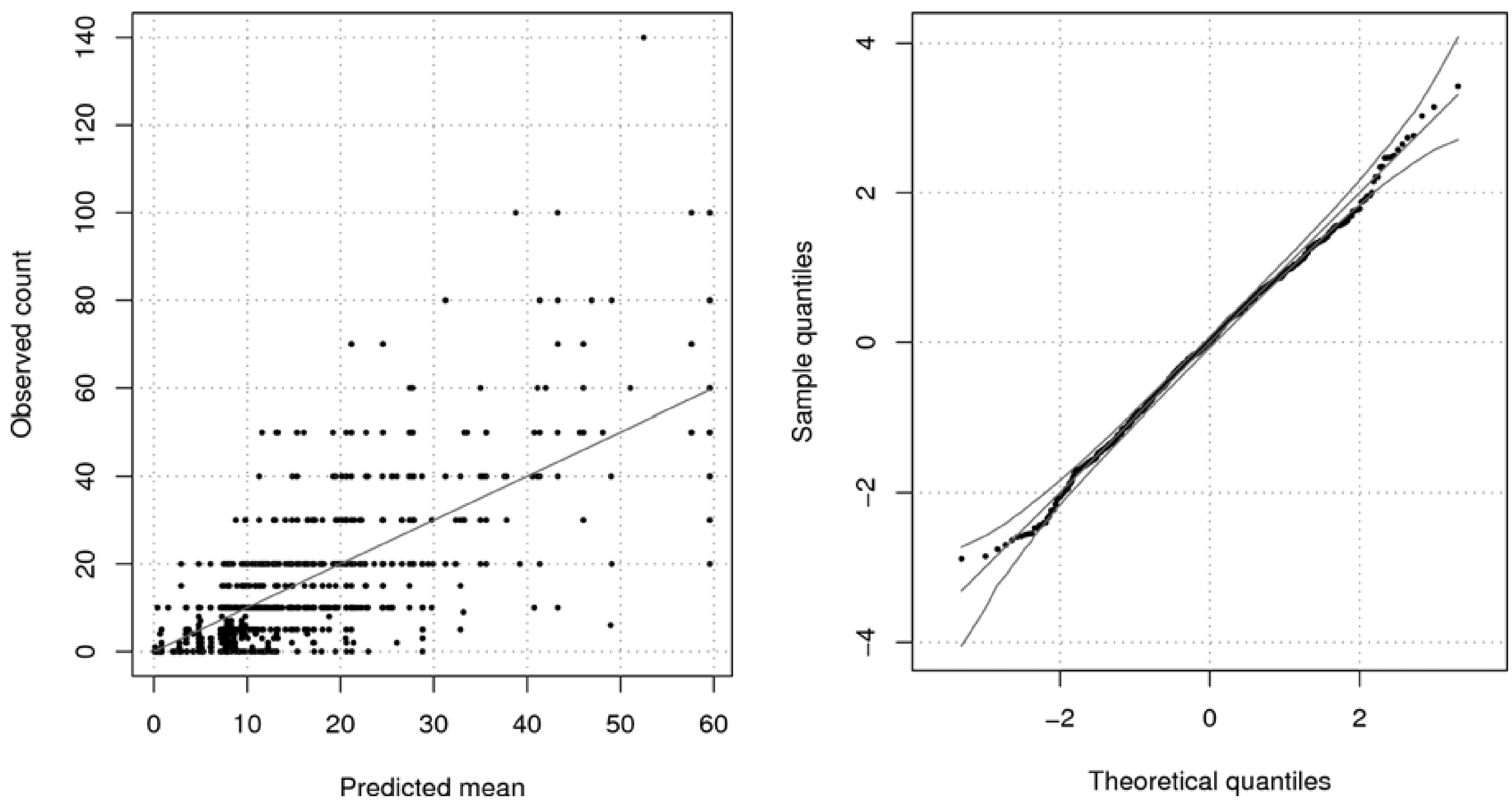
Model fits

- Small birds in the air, 29 Feb (2 hour batch interval)



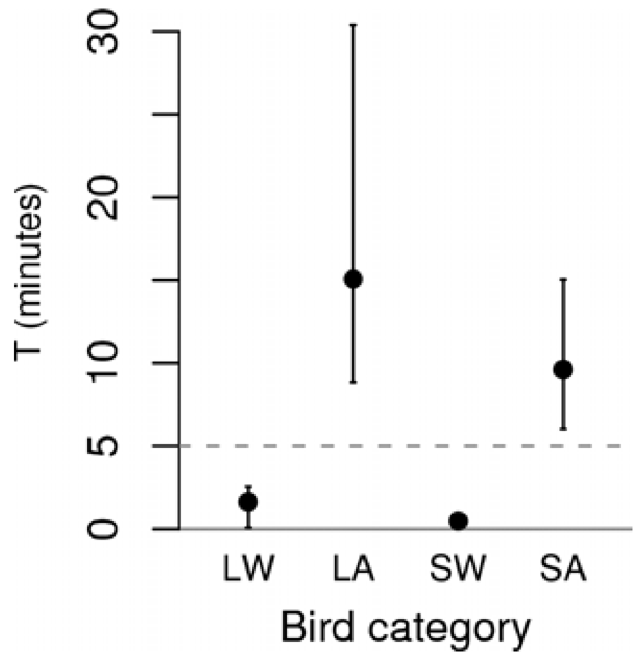
Model fits

- Comparison between model mean and actual bird counts, and quantile residuals, for large birds on the water



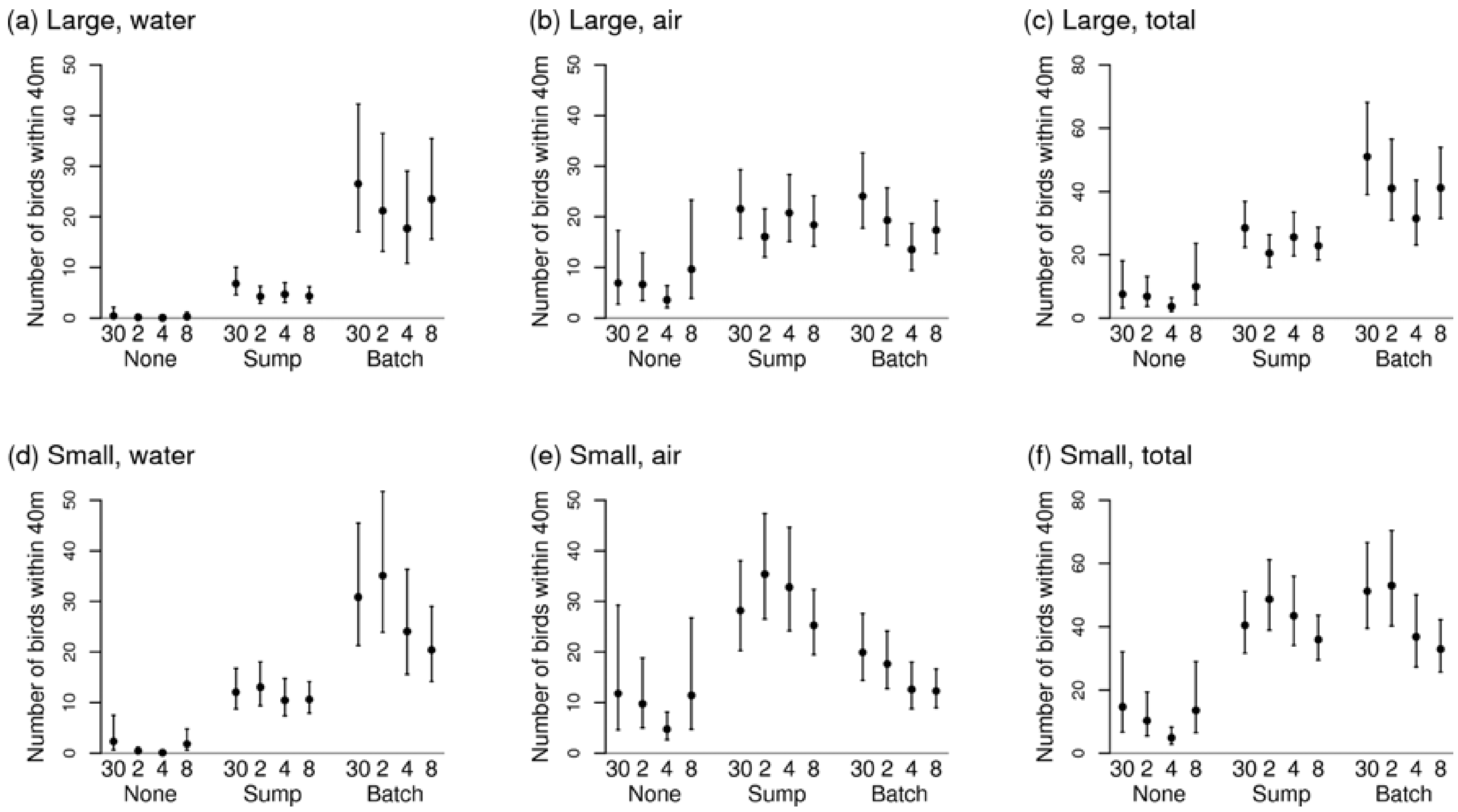
Time scale

- For birds on the water, the time scale of the response to the finish of the discharge is shorter than the typical 5 minute interval between observations
- For birds on the air, the increase in numbers once discharge finishes takes 10 to 30 minutes



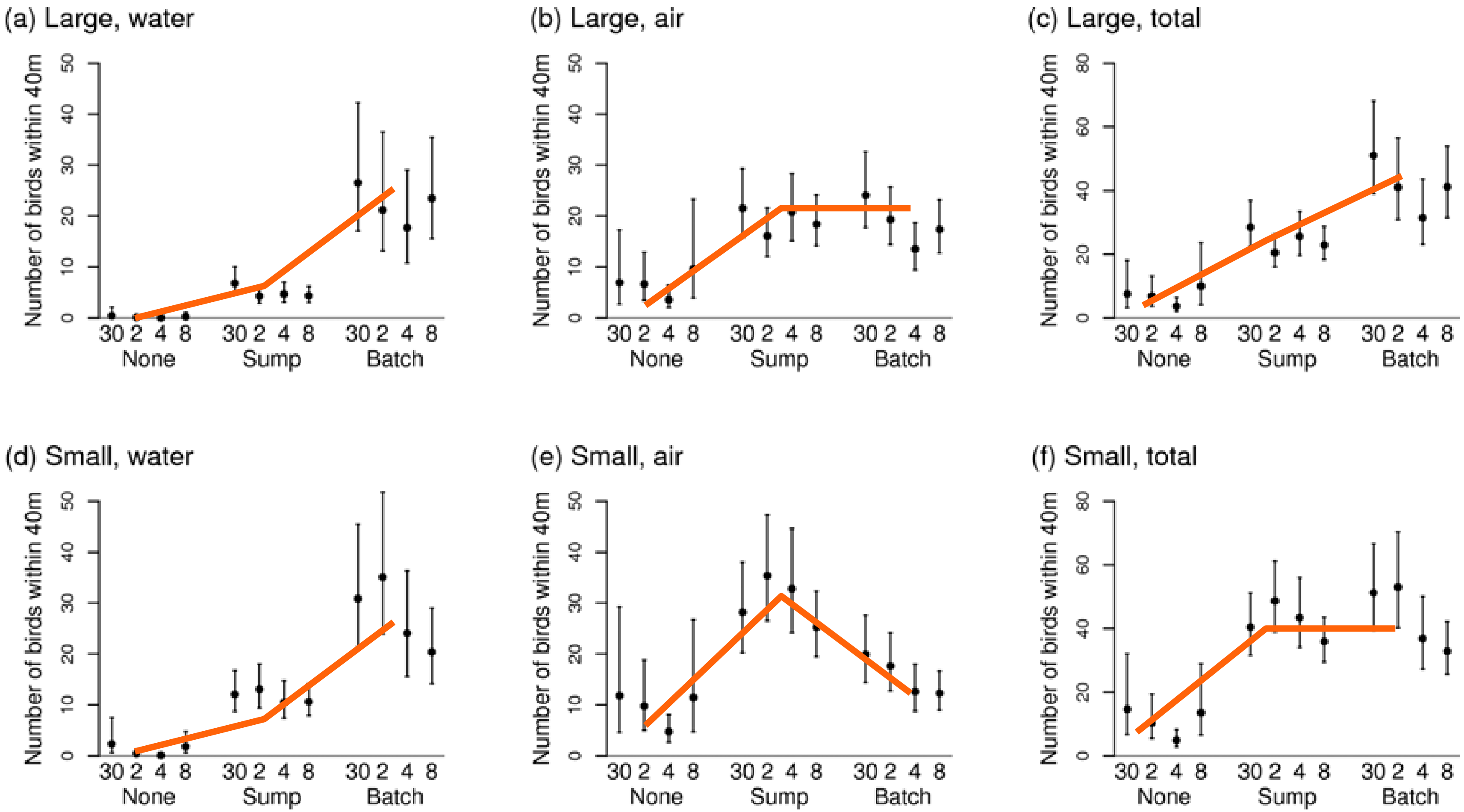
Model summary

- Model estimated asymptotic counts for each combination of discharge and experimental treatment, showing median and 95% credible intervals



Model summary

- Same pattern of increasing and humped responses as in the raw data

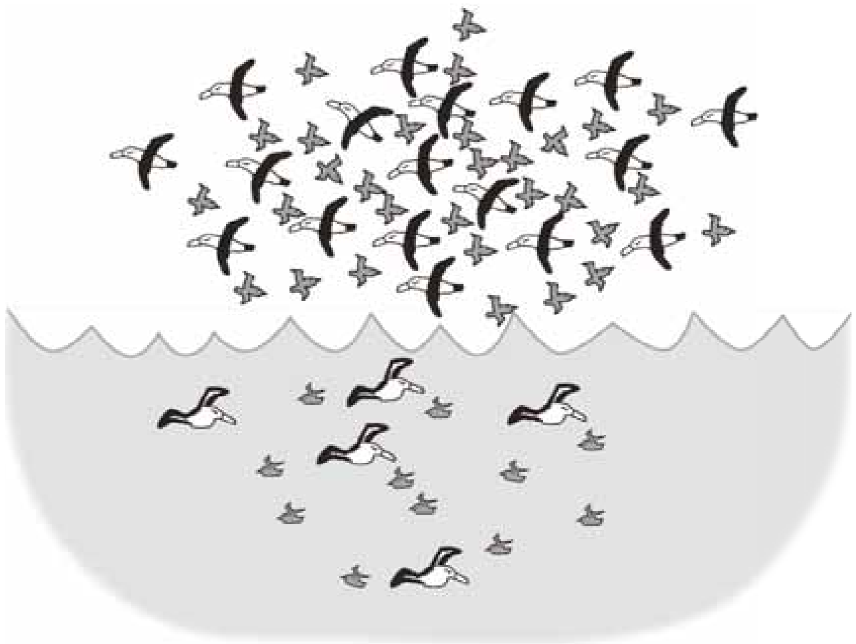


The view from the stern

- No discharge

The view from the stern

- Sump discharge. Many birds in the air, few on the water.

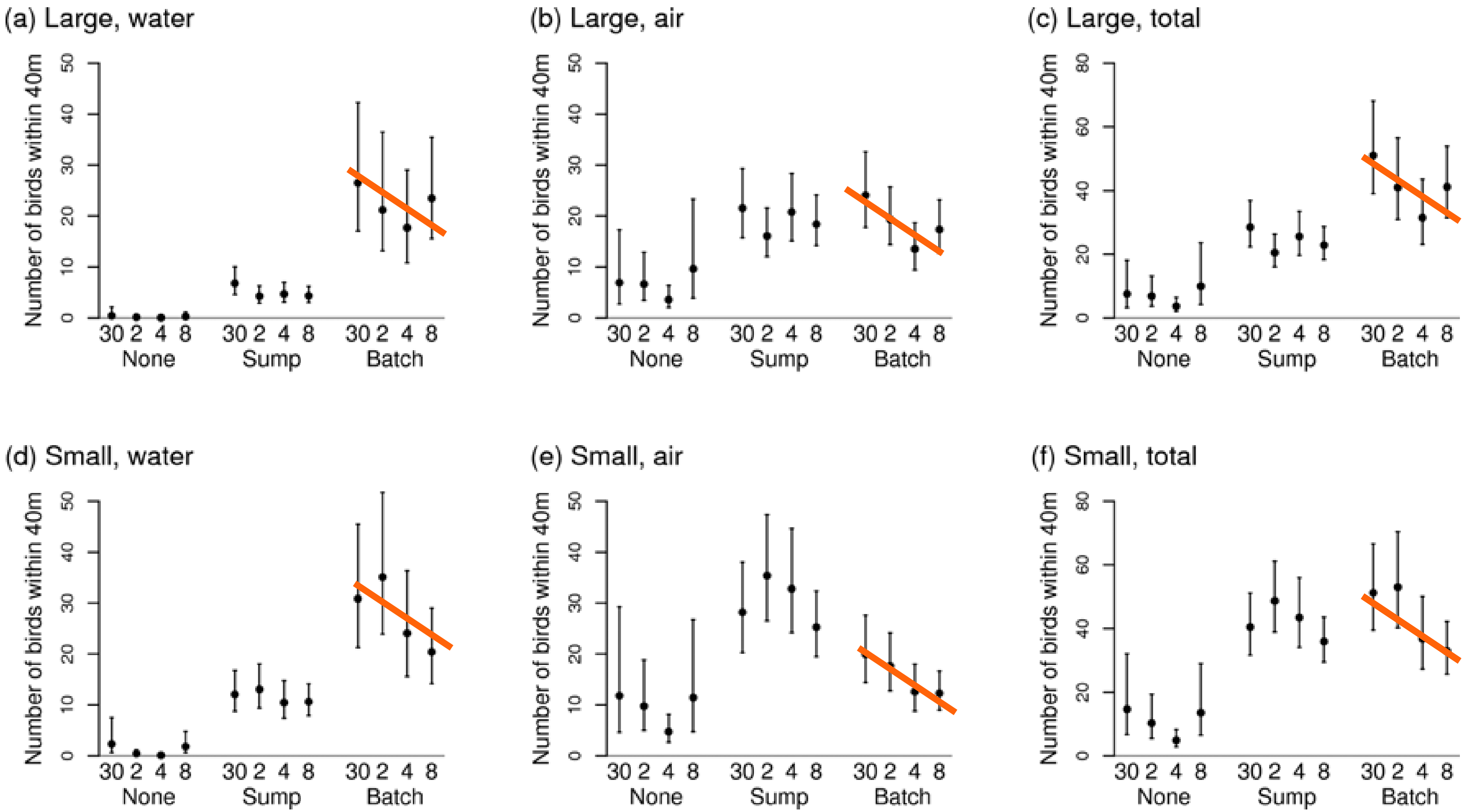


The view from the stern

- Offal discharge. Increase in total numbers of large birds. Small birds move from the air to the water. Marked increase in numbers of large birds on the water.

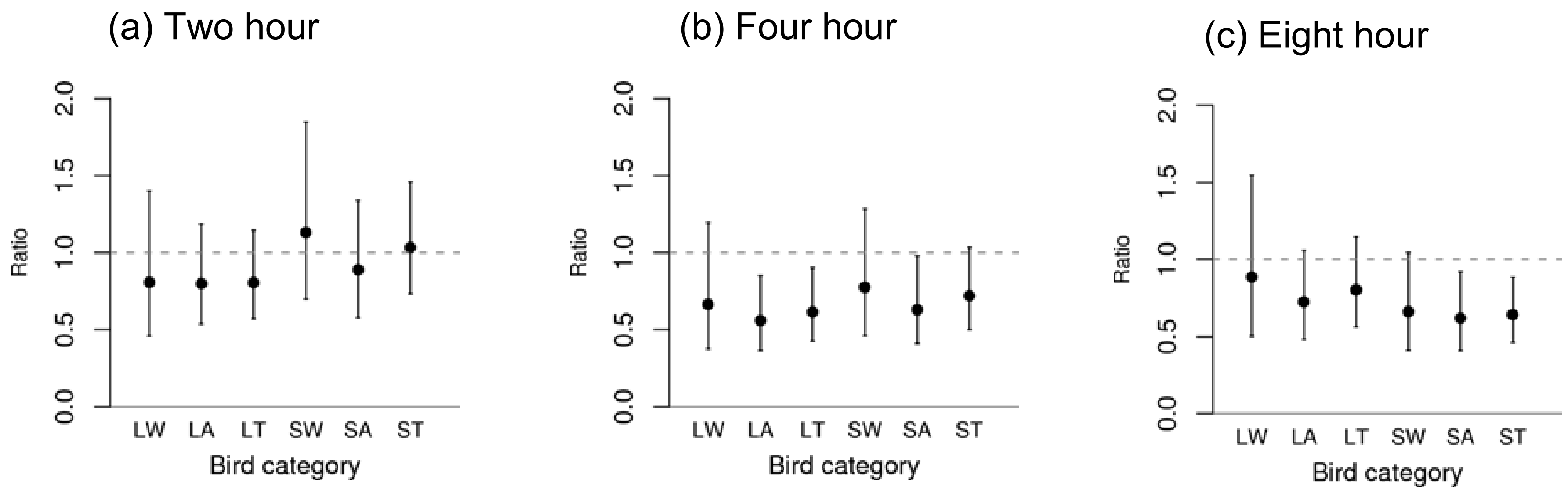
Treatment effect

- Appears to be a decrease in the abundance during batch discharge with an increase in batch interval



Treatment effect

- Look at the ratio of the model estimated counts in each treatment to the corresponding counts during the 30 minute treatment
- Most of these ratios have a median less than one
- All of the medians of these ratios are greater than 0.5
- No significant decreases for two hour treatment
- Large and small air and total are significantly less (or nearly so) for four and eight treatment
- No significant decreases for birds on the water



Ratio of asymptotic counts to corresponding counts during the 30 minute treatment

Summary

- Batching does decrease the numbers of birds present during the batch (by less than a factor of two)
  - Compares with a 99% reduction in warp strike rates when there is no discharge
- The effect is not significant for large birds on the water
  - Large birds are caught on the warps more often than small birds
  - Some evidence that warp strike occur most often on the water
  - If large birds on the water is the category that is most at risk then batching could not be recommended from the results of this experiment
- A two hour batching interval has no (significant) advantage over a 30 minute interval
- Effect of four hour and eight hour batching intervals are similar
  - Over 94% of tows were shorter than 8 hours, so 8 hour batching would allow discharge to be dumped when the vessel was not fishing