Passive acoustic monitoring during real-world naval exercises as a tool to learn about behavioral responses

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SMM BRS Workshop 12th December 2015

Acknowledgements

- This review talk reports primary research from many BRS teams (see citations during talk)
- BRREW project – Catriona Harris and external reviewers (Janik, Slabberkoorn, Wartzok) ***Opinions and mistakes are mine*!**
- Funding – US Navy
  - ONR: Cheap DECAF, LATTE, MOCHA, BRREW
  - LMR: BRREW
  - NAVFAC LANT

Observational studies

- Differ from experimental:
  Researchers do not control sound sources
- We do often know likely timing and trajectory of sound sources
- Can optimize data collection accordingly

Observational vs Experimental?

- Pros of observational studies
  - Easier logistics → lower cost, more samples, longer times
  - Get real-world conditions without interfering with normal operations
- Cons of observational studies
  - Not a formal experimental design –potential for confounding variables
  - (Although many experimental studies compromised in practice:
    - tiny sample size
    - experiment didn't go as planned)

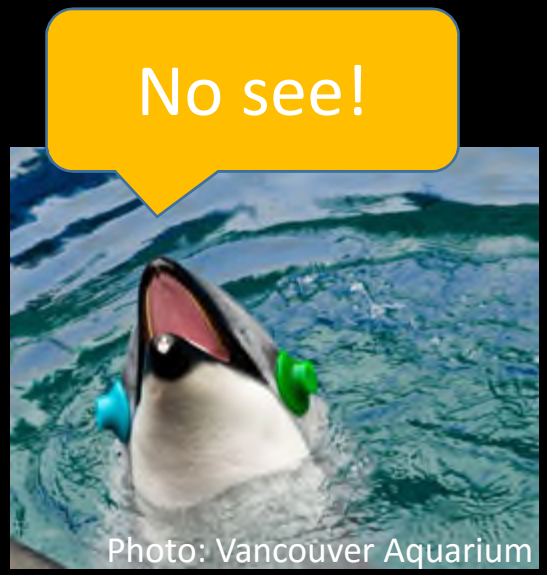
Types of observational study

1. Tags + Passive acoustic monitoring (PAM) (+ visual)
2. Medium to long-term tags
3. Visual + PAM
4. PAM-based localization and tracking
5. PAM detection only
6. Population-level studies

Here, I focus on the role of PAM…

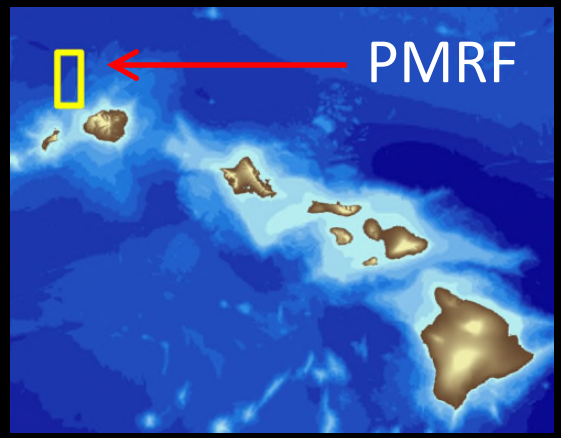
… some example studies given – full reference list is in the BRREW report

Tags + PAM (+ visuals)



- It's like a CEE without the C!
- Lack of control of source means timescales > hours will be better; visuals difficult
- → need longer-lasting fine scale tags

- Sat-tag study: e.g., Baird et al. (2014)
  - PAM used to find Delphinids for tagging and to estimate sonar transmission times and levels

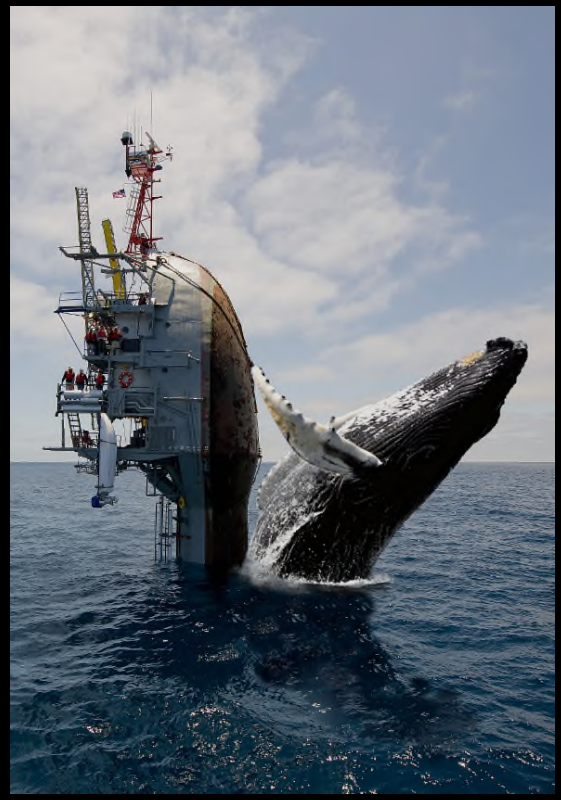


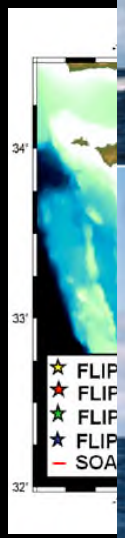
Medium to long-term tags

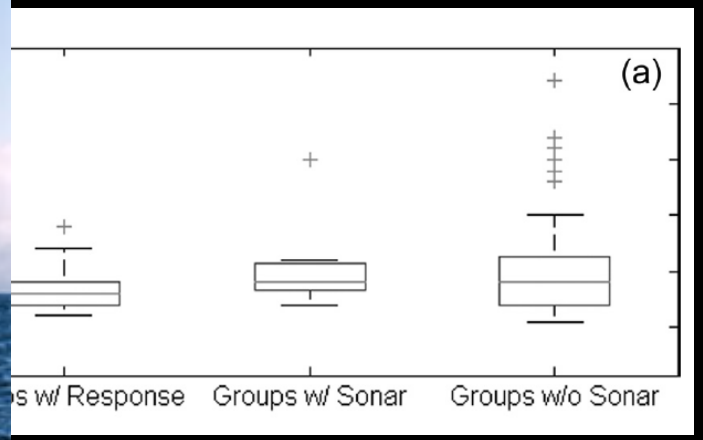
- See next talk!

Visual + PAM

- Visual observations possible in special locations – clifftops, lighthouses, and …
- FLIP (Henderson et al. 2014)

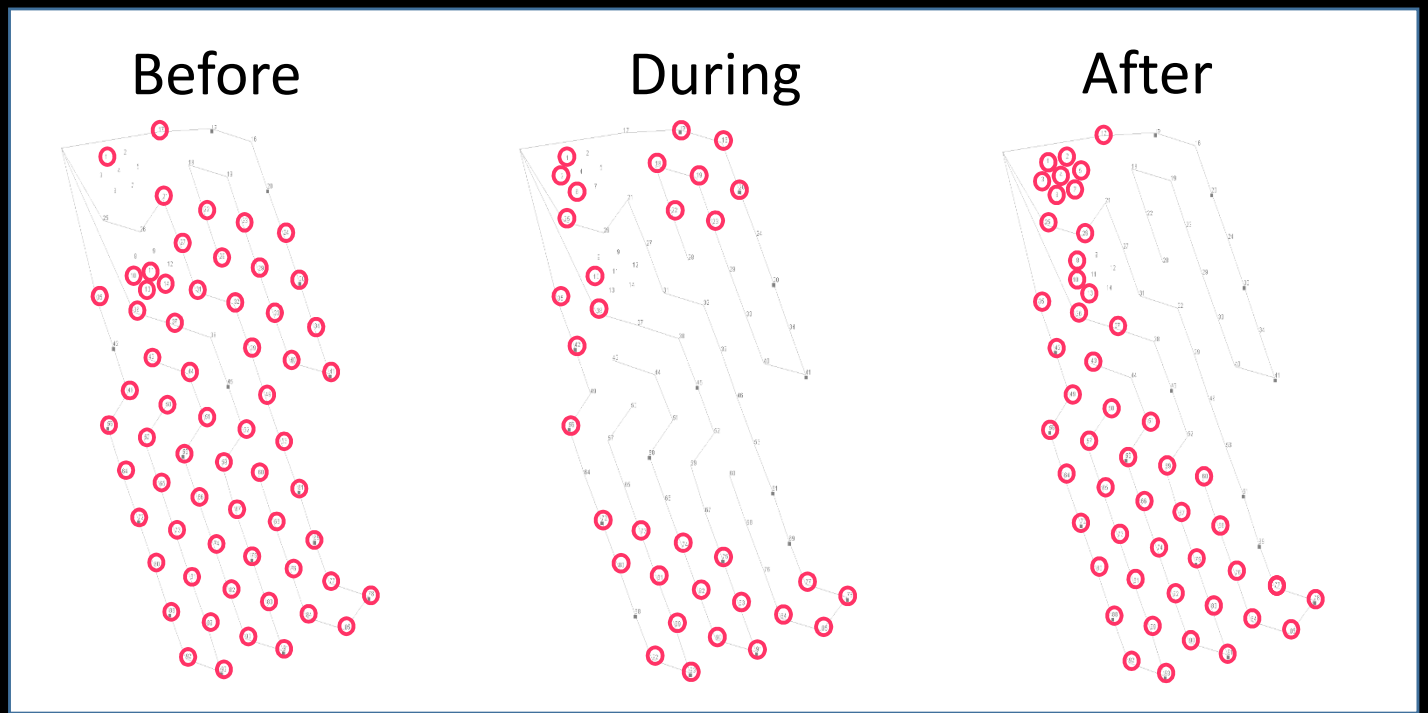






PAM-based localization and tracking

- Arrays of hydrophones can localize and sometimes track animals or groups
- Localization example: AUTEC SCC studies on groups of diving Blainville's beaked whales. Tyack et al. (2011)



Temporal view

- McCarthey et al. (2001)

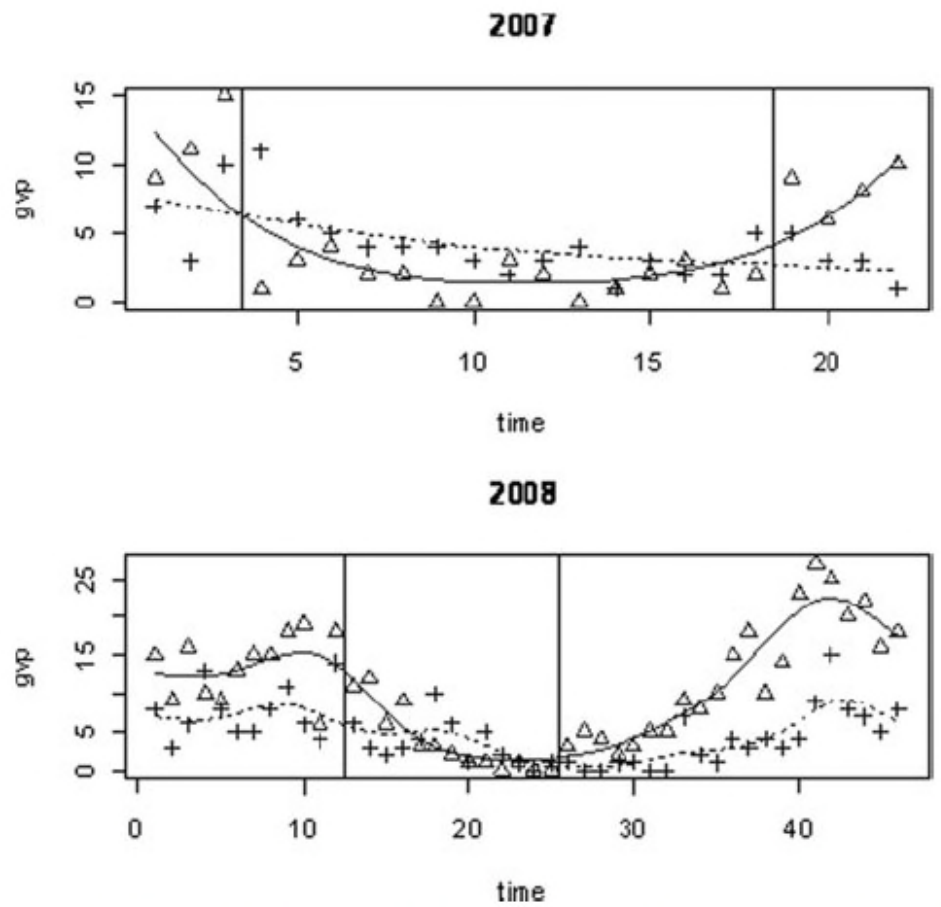
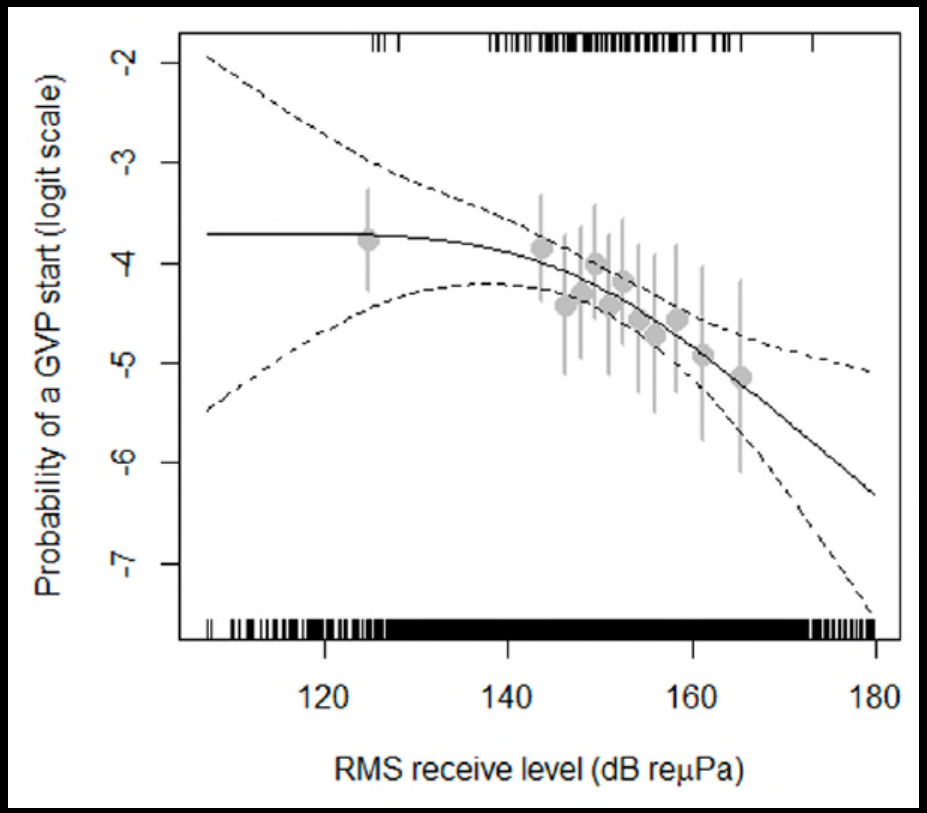
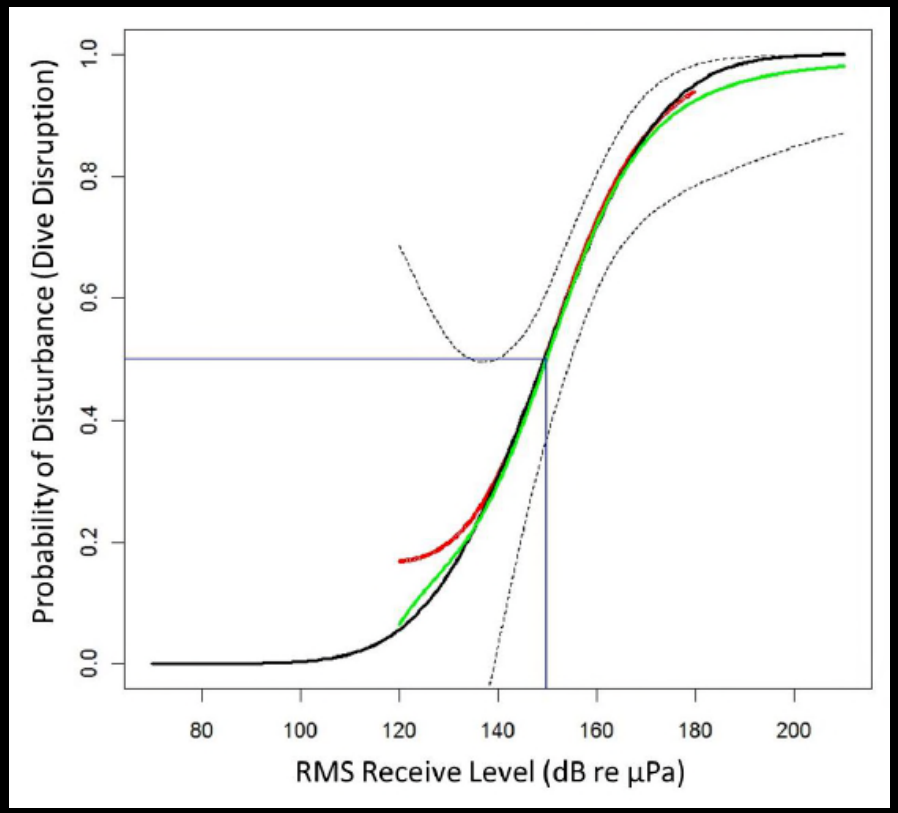


Figure 4. The results of the GAM (solid line) fit to the GVPs within the range boundaries (diamond), and the GAM (dashed line) fit to GVPs on edge hydrophones (plus). The *x*-axis represents the number of 5 h time increments. The plots are divided by vertical lines into the time periods before, during and after sonar operations.

SCC Dose-response function

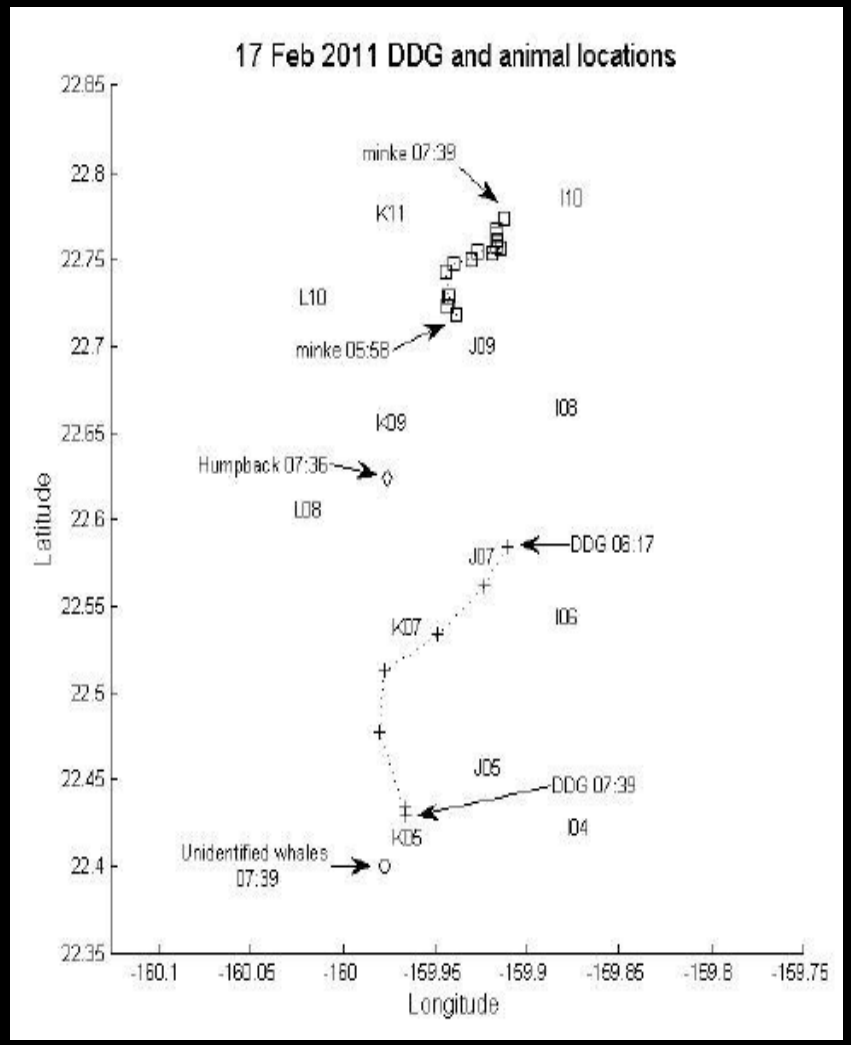
- Moretti et al. (2014)





Tracking

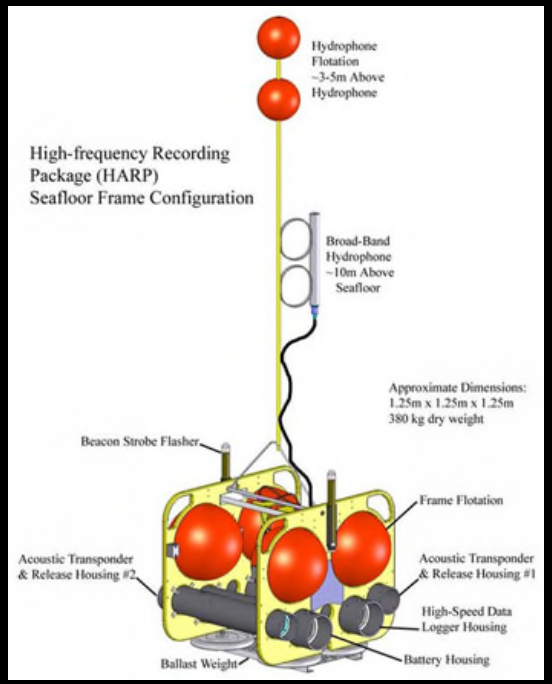
- In general, PAM is not ideal for monitoring individual-level responses
- But tracking of vocalizing animals is possible in some cases
- Example: Martin and Kok (2011) Minke, PMRF

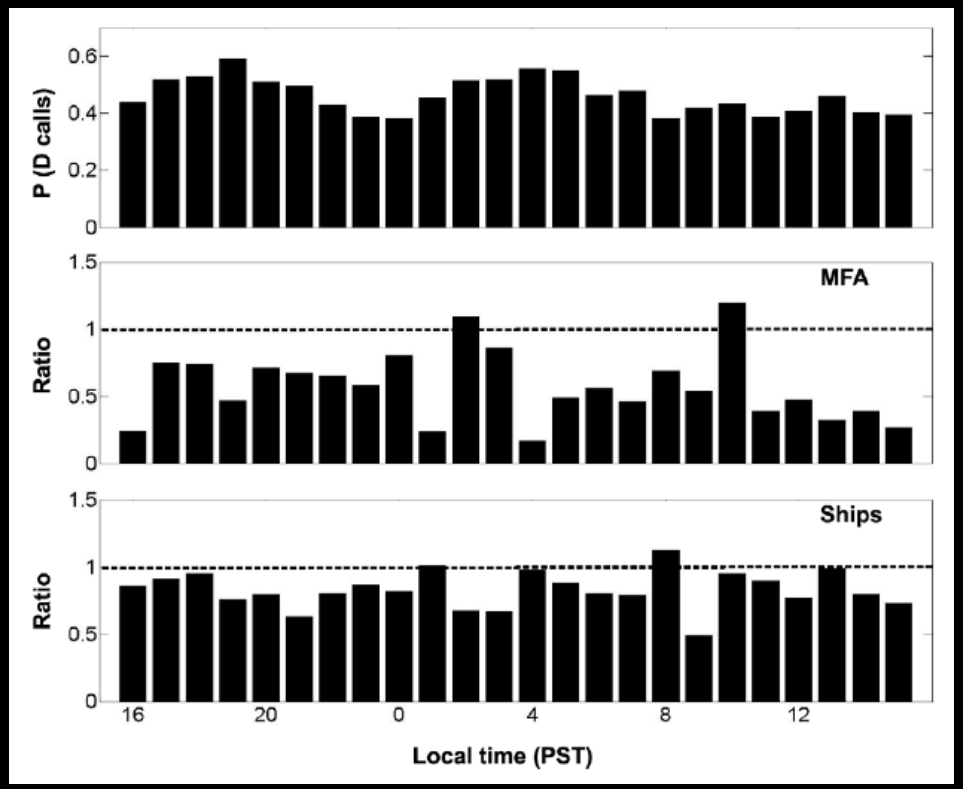


PAM detection only

Hildebrand lab. Blue whale calls, S. California.

- McKenna (2011) PhD. ship noise.
- Melcón et al. (2012)[1]





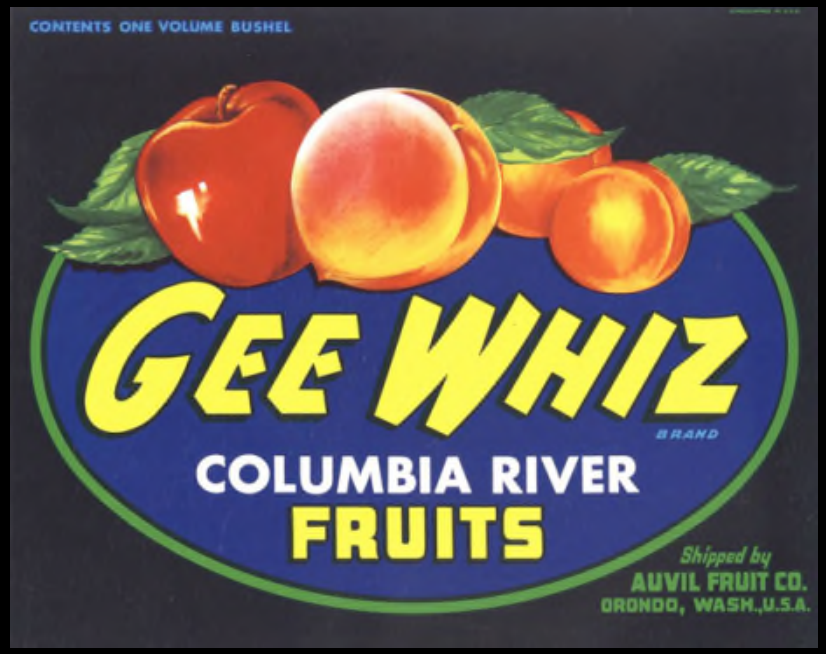
[1]PLoS One7(2): e32681. doi:10.1371/journal.pone.0032681

PAM detection only

- Oswald et al. (2014) Delphinids and
  Charif et al. (2014) large whales, N. Carolina & Florida
- Methods development on a small test dataset

1. Is the probability of detecting vocalizations different in the presence of sonar? (All)
2. Given there is a vocalization, does the signal type (whistle, click or buzz) change in the presence of sonar? (Pilot whales, DEUO)
3. Do the characteristics of whistles change in the presence of sonar? (Pilot whales, DEUO)
4. Does the duration of vocalizations change in the presence of sonar? (Minke)

Methods slide



Generalized Estimating Equations

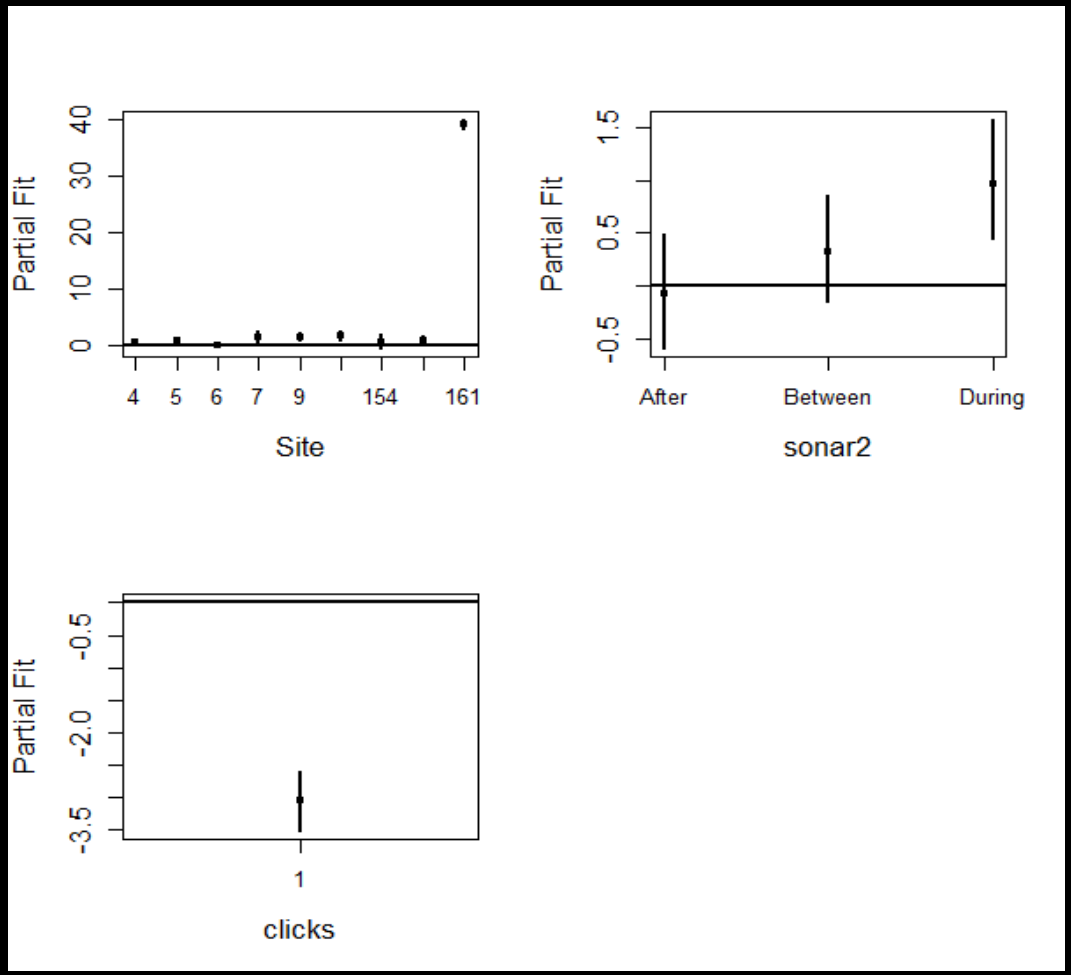
Hidden Markov Models

Potential covariates

Covariate	Description	Unit
Sonar	Before / During / Between / After	--
s(Time)	Time of day	Seconds
Site	Site numbers	--
s(Sonarlag)	Time lag since last sonar	Seconds
Location	JAX or OB	--
s(Peak frequency)	--	Hz
s(Length of sonar event)	--	Minutes
s(Mean ping interval)	--	Seconds
s(SDEV ping interval)	--	Seconds
s(Mean repetition rate)	--	Pings/seconds
s(SDEV repetition rate)	--	Pings/seconds
s(Mean peak frequency)	--	Hz
s(SDEV minimum frequency)	--	Hz
s(SDEV maximum frequency)	--	Hz
Presence of sonar ping type	3 sonar ping types x 3 lengths	--

Example result
DEUO – whistles | encounter

Site



Sonar

Presence of clicks

(Note – these are on logit scale)

… see also Hom-Weaver poster on Minke whales

Population-level studies

- PAM potentially enables cost-effective density monitoring for some species over large areas and long time scales
- Comparative approach for assessing population consequence of disturbance (PCoD)
- Caveat: demographic studies also have an important role (e.g., photo-ID based) – population size may appear healthy but an area may be a sink

Discussion: What have observational studies using PAM ever done for me?

- Triage: is there an effect?
  - Long-term, large scale detection studies
- Dose (acoustic) response
  - Dispersed arrays can show spatial and temporal patterns, dose-response
- Population consequence
  - Comparative DE studies
- Avoidance response
  - Individual tracking
- Increased effectiveness of tagging studies
- Won't work for all situations!
- Don't (typically) follow individuals.
- Conclusion - A useful tool alongside others

The future

- Lots of past data to be mined
- Better baselines
- Monitoring response around large-scale real-world exercises off Navy ranges
- Long-term comparative density estimation studies
- Leveraging general increase in knowledge of MM bioacoustics