Lessons learned from sonar BRS: methodological implications for studies with other anthropogenic sound sources

Brandon L. Southall

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SOCAL-BRS Team

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ESR Co-authors: (P. Tyack, P. Miller, D. Nowacek)

Workshop Organizers (notably C. Harris)

Overview & Talk Outline

- Many talks thus far have illustrated progress in various areas regarding sonar BRSs.
- *Goal*: integrate observations across studies (emphasis on experimental) to identify key considerations for BRSs with other sources

1. *Operational and Logistical Issues*
2. *Emergent Research Considerations*
3. *Analytical Approaches*

Operational and Logistical Issues

Factors driving increased operational size of BRSs

- Most studies (esp. CEEs) inherently require multidisciplinary tools and skills – and thus field/analysis/support teams
- Increasingly clear need to match context with real operations

Factors driving reduced operational size of BRSs

- Simple funding realities as approaches have matured
- Demonstrated successes of leaner field teams with ability to adapt to changes in both schedules, field conditions

Optimize approach to balance these, given site- and species-specific considerations

Emergent Research Considerations: Importance of Baseline Data, Controls

Need a representative understanding of baseline (undisturbed) behavior to interpret response

- How much? Depends on species-typical traits
- Increasingly capable longer-term tags can provide key baseline information on selected behavioral parameters (informed interaction of methods on different scales)

Experimental controls (different approaches) within CEEs critical in publishing defensible results

- Observational studies lack real controls, but can address some of the same issues with information about periods of exposure/no exposure

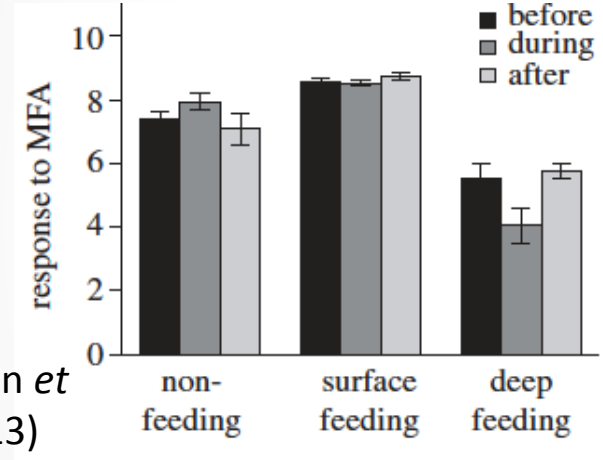
Emergent Research Considerations: Species-Specific Factors Affecting Design

- Life History Factors (*e.g.*, broad distribution, seasonality)
- Group Size
- Natural Response to Threat (*e.g.*, predators)
- Variability Within and Between Behavioral States
- Relative Novelty/Familiarity with Sound Source

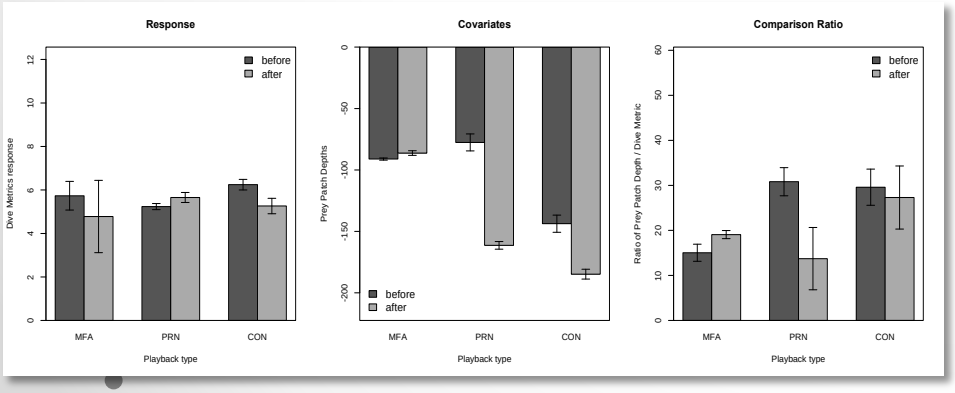
Emergent Research Considerations: Context-Dependent Factors (1)

Behavioral State, Prey Distribution, Source Range

SOCAL-BRS blue whale examples



Goldbogen *et al.*, (2013)

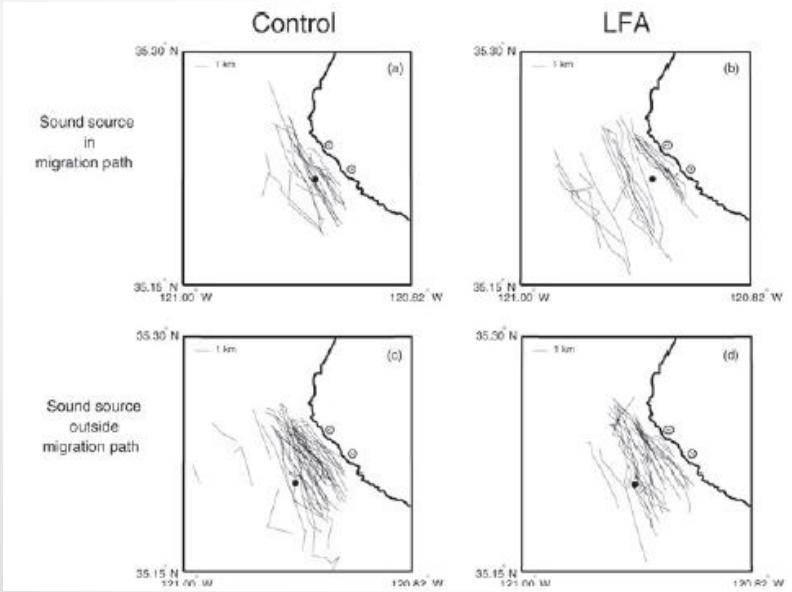


Friedlaender *et al.*, (in press)

Emergent Research Considerations: Context-Dependent Factors (2)

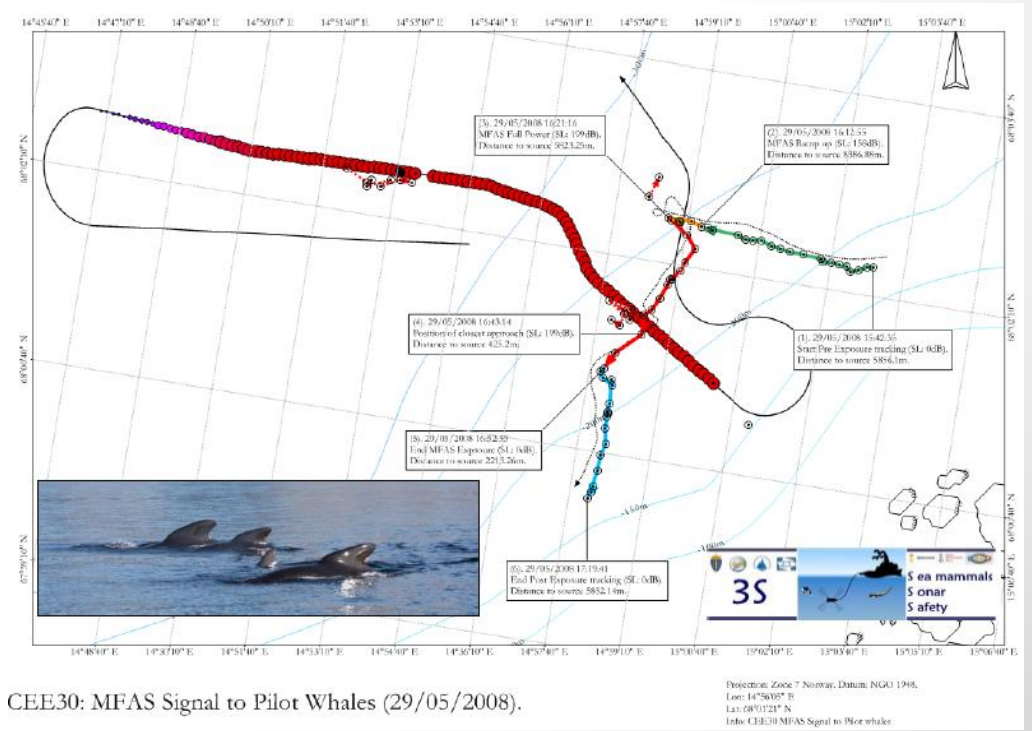
Spatial Orientation of Source-Receiver

Stationary Source



Courtesy Buck and Tyack; published in Ellison *et al.*, (2012)

Moving Source

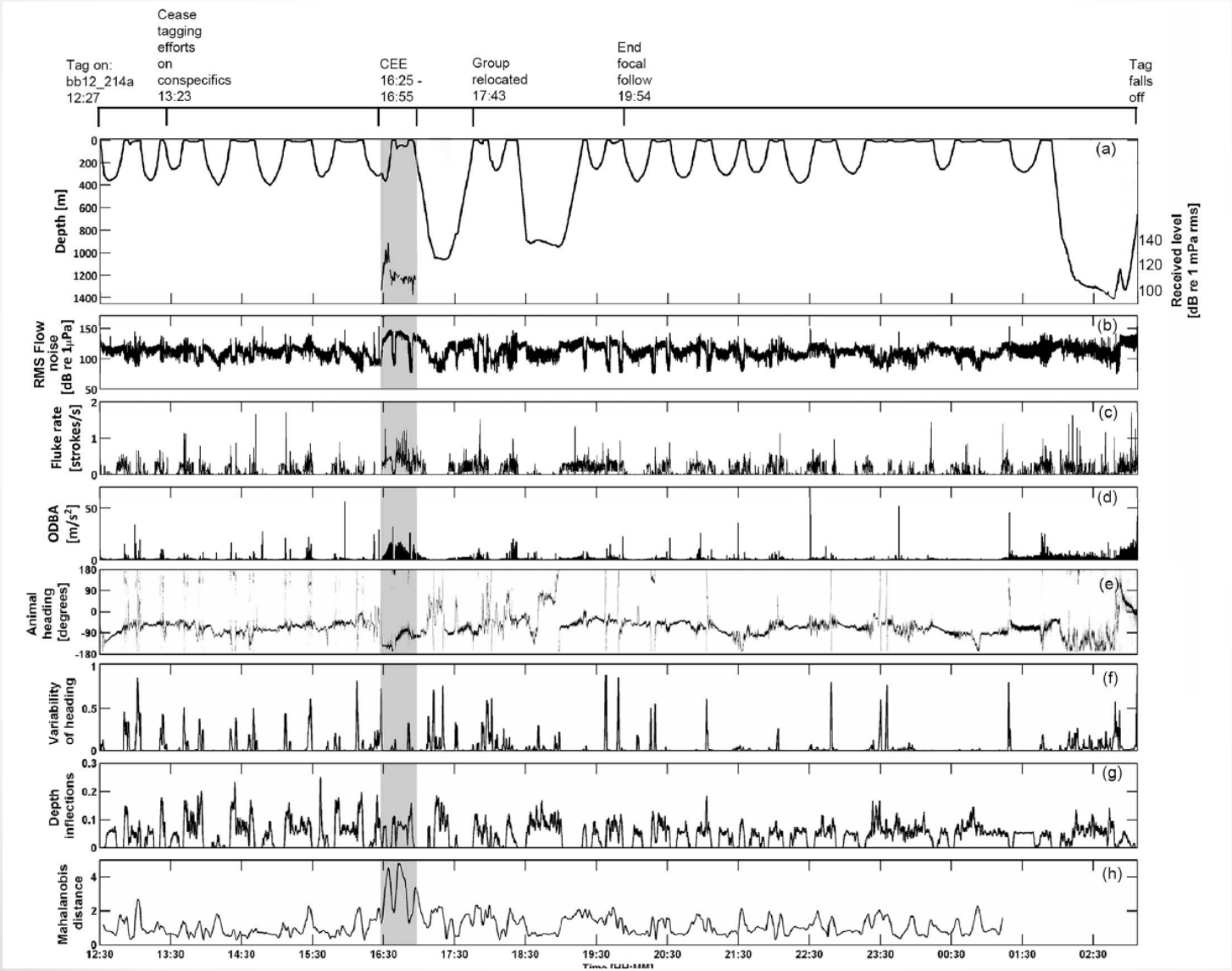


Courtesy 3S (P. Miller)

Analytical Methods

MOCHA
MULTI-STUDY OCEAN ACOUSTICS HUMAN EFFECTS ANALYSIS

Multivariate data require multivariate analyses



Stimpert *et al.*, (2014)

Analytical Methods

Complimentary Analyses – Comprehensive Insight

MOCHA
MULTI-STUDY OCEAN ACOUSTICS HUMAN EFFECTS ANALYSIS

Harris *et al.*, (2016)

Group (*Across-Individuals*) Response Analyses

- Principal component analyses (PCAs) and generalized additive mixed models (GAMMs)
- Hidden Markov Models (HMM) – Behavioral State Switching

Within-Individual Response Analyses

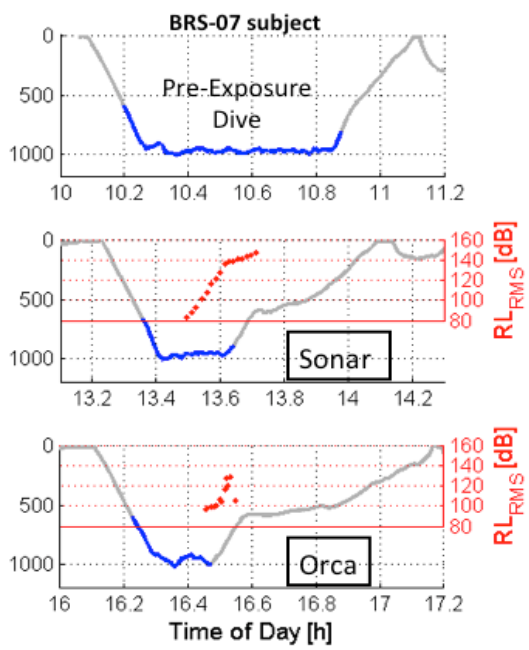
- General Estimating Equations (GEEs)
- Mahalanobis Distance
- Expert Severity Scoring – Event Survival Analysis

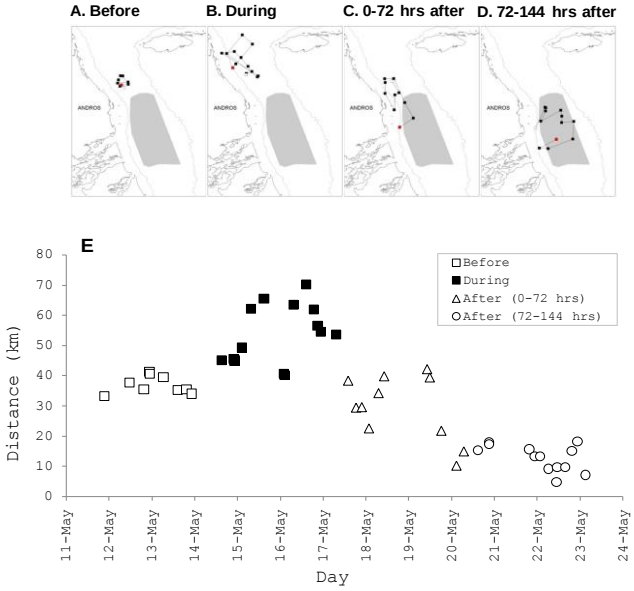
Multiple methods in SOCAL-BRS blue whales (5!) where large N (46 CEEs)

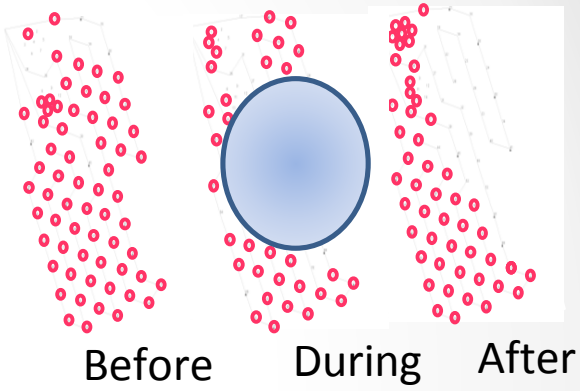
Southall et al: MONDAY 1330 (Imperial A)

Analytical Methods

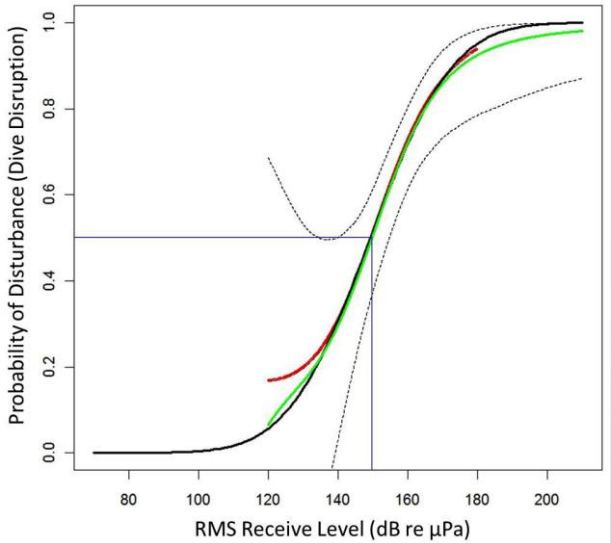
Complimentary Methods – Comprehensive Insight







Tyack *et al.*, (2011)



Moretti *et al.*, (2014)

Taking BRSs to Scale

- Increasing use of full scale (actual) sources
- Test potential response over larger source-animal range
  - Range-RL interaction in terms of p(resp)
- Extend temporal sampling
  - CEE results can inform testable hypotheses to be evaluated with targeted monitoring with longer-term tags/hypotheses
  - Multi-scale methods for both experimental and observational monitoring
  - Importance of medium-duration, high-resolution tags (Calambokidis – SOCAL blue whale example shown)

Synthesis – Key Considerations from Lessons Learned (Field Studies)

- Optimize Field Configurations – Maximize Adaptability
- Understand Baseline Behavior
- Study (or at least measure) Contextual Factors & RL
  - Behavioral State
  - Source-Animal Spatial Relationships
  - Don't Have to Measure/Understand Every Combination
  - Risk Assessment and Mitigation: Different Processes
- Use Complimentary (multi-scale) Methods and Analyses
  - Dynamic interaction and overlap between shorter-term, high-resolution and longer-term low resolution methods