The Use of Behavioral Response Study Data in the Development of Behavioral Risk Functions for the US Navy

E. Elizabeth Henderson, Dorian Houser, Jim Finneran, And Keith Jenkins

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Talk Outline

- Background
  - Previous US Navy BRFs
  - Definition of "significant" behavioral responses
  - Dose-dependent vs context-dependent responses

- Review of new data
  - Data standards for inclusion
  - Field studies
  - Captive studies

- Development of risk functions
  - Statistical issues
  - Model development
  - Example BRF

- Looking to the future

EIS Phase I/II BRFs

- Limited data sources
  - Finneran TTS study
  - Nowacek right whale alarm
  - Shoup killer whale

- Based on SURTASS LFA curve

- Two curves
  - Mysticete
  - Odontocete/everything else
  - Both had 50% at 160 dB

- Step functions
  - Harbor porpoise – 120 dB
  - Beaked whales – 140 dB
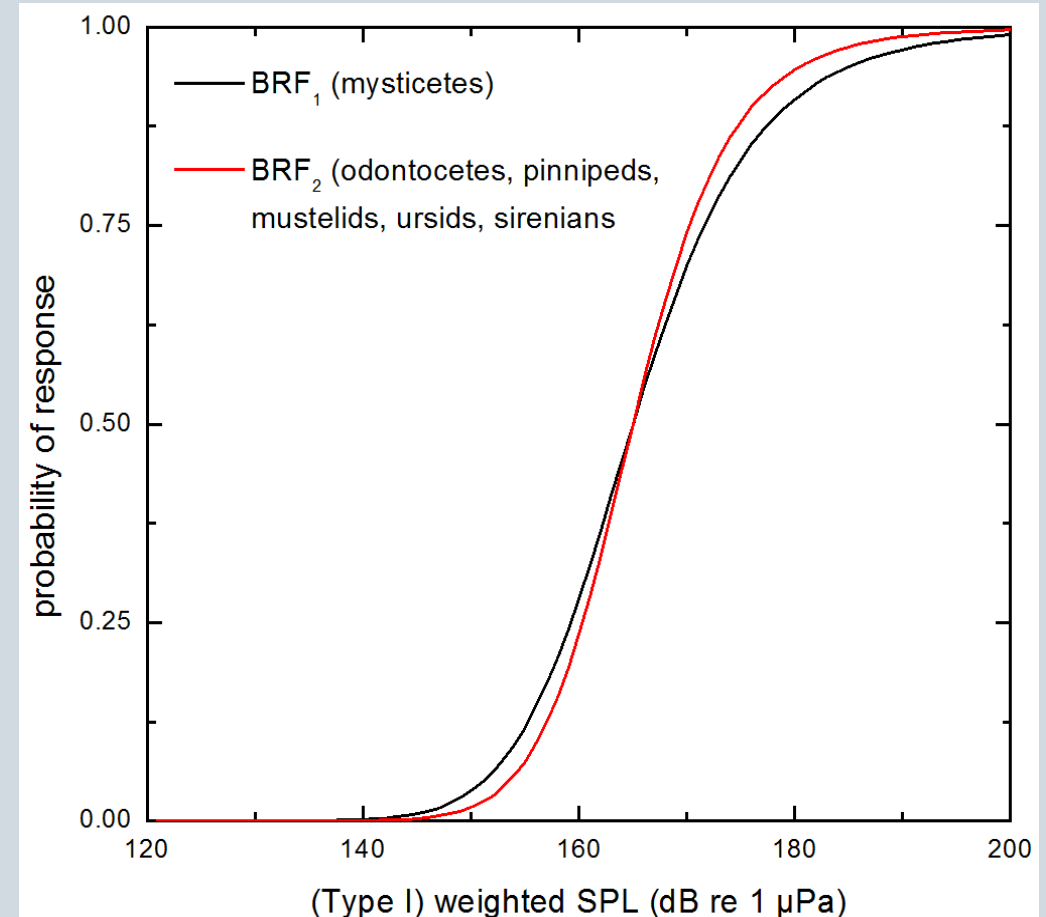
"Significant" Behavioral Responses

Under the Marine Mammal Protection Act, for military readiness activities, such as Navy training and testing, behavioral 'harassment' is:

"any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, *to a point where such behavioral patterns are abandoned or significantly altered*." (Section 315(f) of Public Law 107–314; 16 U.S.C. 703 note)

What is abandonment or significant alteration?

"Significant" Behavioral Responses

➢ Southall et al. 2007 scale
  ➢ Modified by 3S in 2011
  ➢ 0 – 9, in three groups

➢ Adapted this approach
  ➢ Three categories
    ➢ **Low** – unlike to disrupt an individual to point of significant alteration or abandonment
      ➢ E.g. startle response, change in respiration, change in heart rate, change in group spacing/synchrony
    ➢ **Moderate** – responses that could become significant if sustained over a long duration
      ➢ E.g. alteration in migration paths, behavioral states, dive profile, cessation of breeding or foraging behavior, avoidance
      ➢ *What constitute a "long duration"?*
    ➢ **High** – possible immediate consequences to growth, survivability or reproduction
      ➢ E.g. long-term or permanent abandonment of important area, prolonged separation of females/dependent offspring, flight, stranding

# "Significant" Behavioral Responses

Captive studies

➢Low

➢changes in swim direction or orientation to sound source, small changes in respiration

➢Moderate to high

➢annoyance or aggressive behavior, moderate to prolonged avoidance of sound source

➢refusal to participate, loss of behavioral control

Dose- vs Context-based Responses

➤ At higher amplitude levels, received level may be a good predictor of response

➤ At lower levels, many contextual factors may be more important
  ➤ proximity
  ➤ experience
  ➤ behavioral state
  ➤ group composition

➤ Distance used to set max range to effects
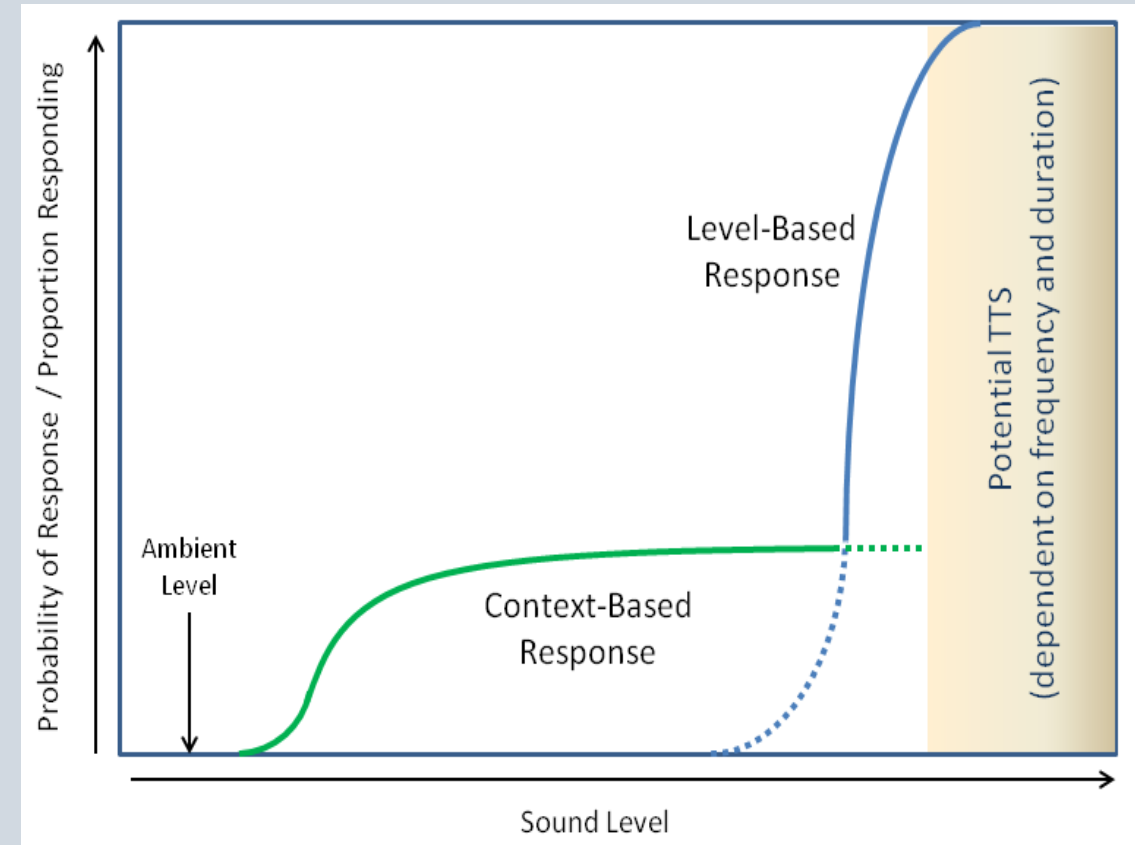
e.g. Ellison et al. 2011

Data used for Phase III BRF

➢ Standards used for inclusion:
  - ➢ Observations of responses paired with RL estimates
  - ➢ Primary study objective = behavioral response to sonar/sonar-like sounds

➢ Data from Phase I/II
  - ➢ Still included Nowacek right whale alarm
  - ➢ Dropped Finneran TTS study
    - ➢ responses were secondary, animals were trained for high noise levels
  - ➢ Dropped Shoup killer whale incident
    - ➢ No actual measured RL (prop modeled only), not an intentional behavioral response so observations were ad hoc

Data used for Phase III BRF – Field Studies

- 3S and 3S2
  - killer whales, pilot whales, sperm whales
  - humpback whales, northern bottlenose whale, minke whale

- SoCal BRS
  - blue whales, Cuvier's beaked whales, Baird's beaked whale

- AUTEC BRS
  - Blainville's beaked whales

- SURTASS LFA
  - humpback whales, blue whales, (gray whales)

- Moretti risk function
  - Blainville's beaked whales

Data used for Phase III BRF – Captive Studies

➢ Houser et al. 2013a; 2013b
  ➢ bottlenose dolphin
  ➢ California sea lion

➢ Götz et al. 2011
  ➢ grey seal

➢ Kvadsheim et al 2010
 ➢ hooded seal

Data used for Phase III BRF - Responses

➤ Discussed response results with researchers/authors

➤ Used new definitions of "significant" responses
  ➤ If response lasted duration of exposure, considered "High"
    ➤ exception – mother/calf separation

➤ Confidence score given to all responses (0, 0.5, 1)
  ➤ High confidence in all but 4 exposures
    ➤ Two humpback whales (authors had low confidence in response)
    ➤ One pilot whale (response was based on prediction of more dives)
    ➤ One sperm whale (motivation of movement unclear)

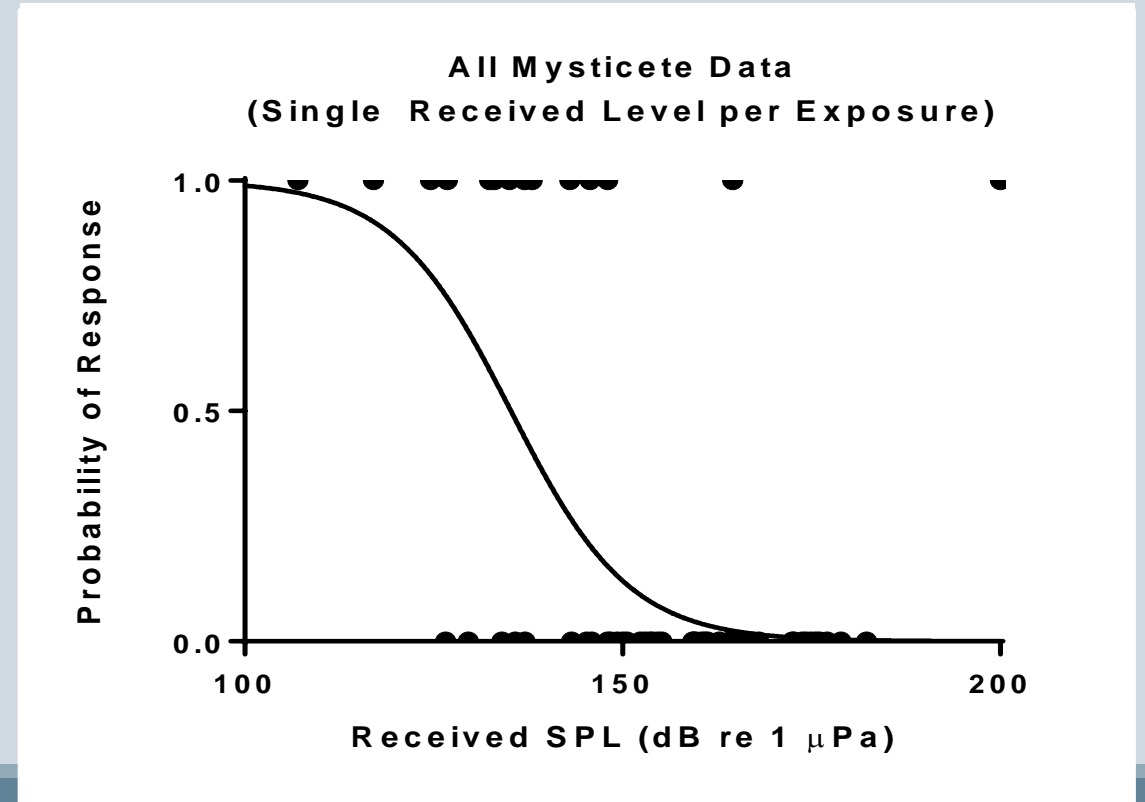# Development of Risk Functions - Issues

- Disparate data
  - field vs captive studies
  - Tag ping history vs single exposure levels
  - Moretti risk function

- Statistical issues
  - Pseudoreplication
    - Tag Data
    - Repeated exposures of some individuals
  - Sample size

- Wide range of response RLs

- Proximity of sound source/vessels

Development of Risk Functions – Fitting Data

➢ Received levels at response (or max received level) Only
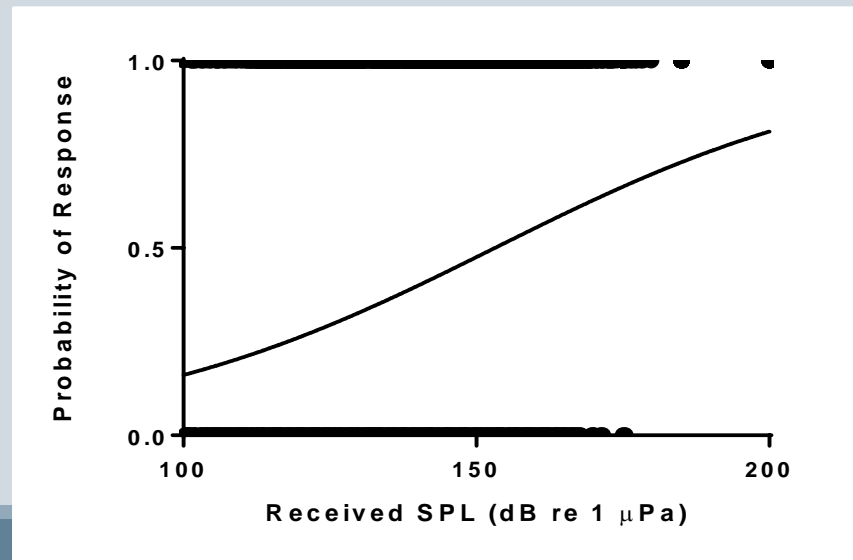 ➢ Responses/No Responses across all received levels
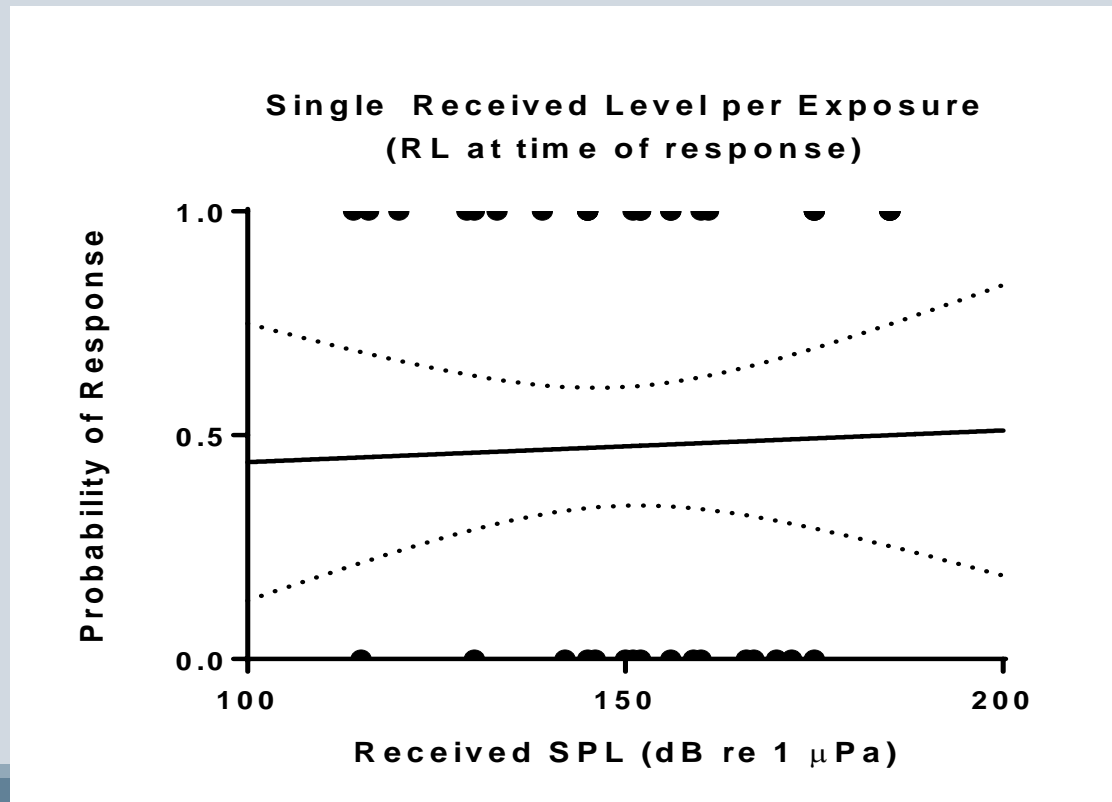
Odontocetes

Mysticetes

Development of Risk Functions – Fitting Data

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  ➢ Responses/No Responses across all received levels

➢ All exposure data (e.g. response/no response to every ping or exposure trial)

  ➢ BRS/3S data dominated dataset; still response across all RLs

  ➢ High pseudoreplication and autocorrelation issues
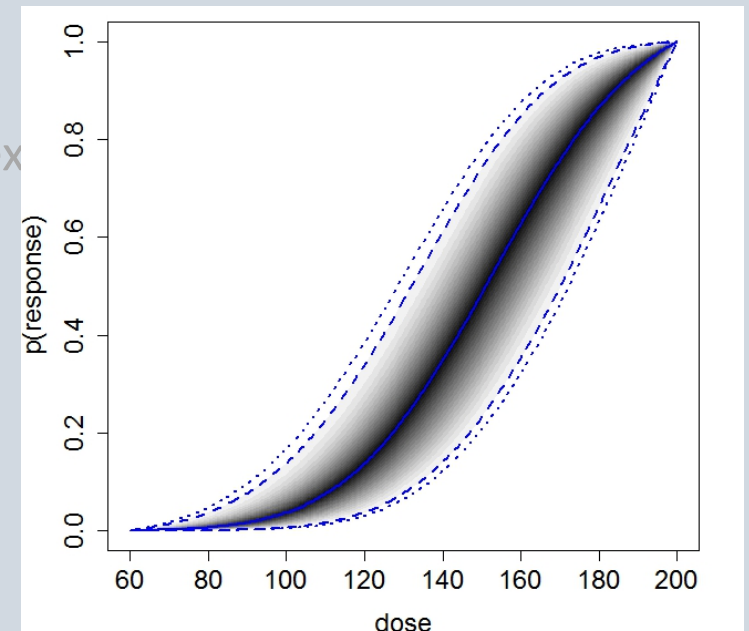
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➢Bayesian dose response function
  ➢ Similar results/issues as traditional sigmoidal or asymmetric functions

Development of Risk Functions - Solutions

➤ All individuals and exposures used
  ➤ Each exposure was contextually different
  ➤ Maximize available data

➤ Response binned by 10-dB
  ➤ Single value per individual/exposure per bin
  ➤ Equalize contributions across individuals/studies

➤ Proportion taken of final bin values

➤ Biphasic dose response function
  ➤ Captures context-based and dose-response values
  ➤ Reaches 0 and 1 without forcing
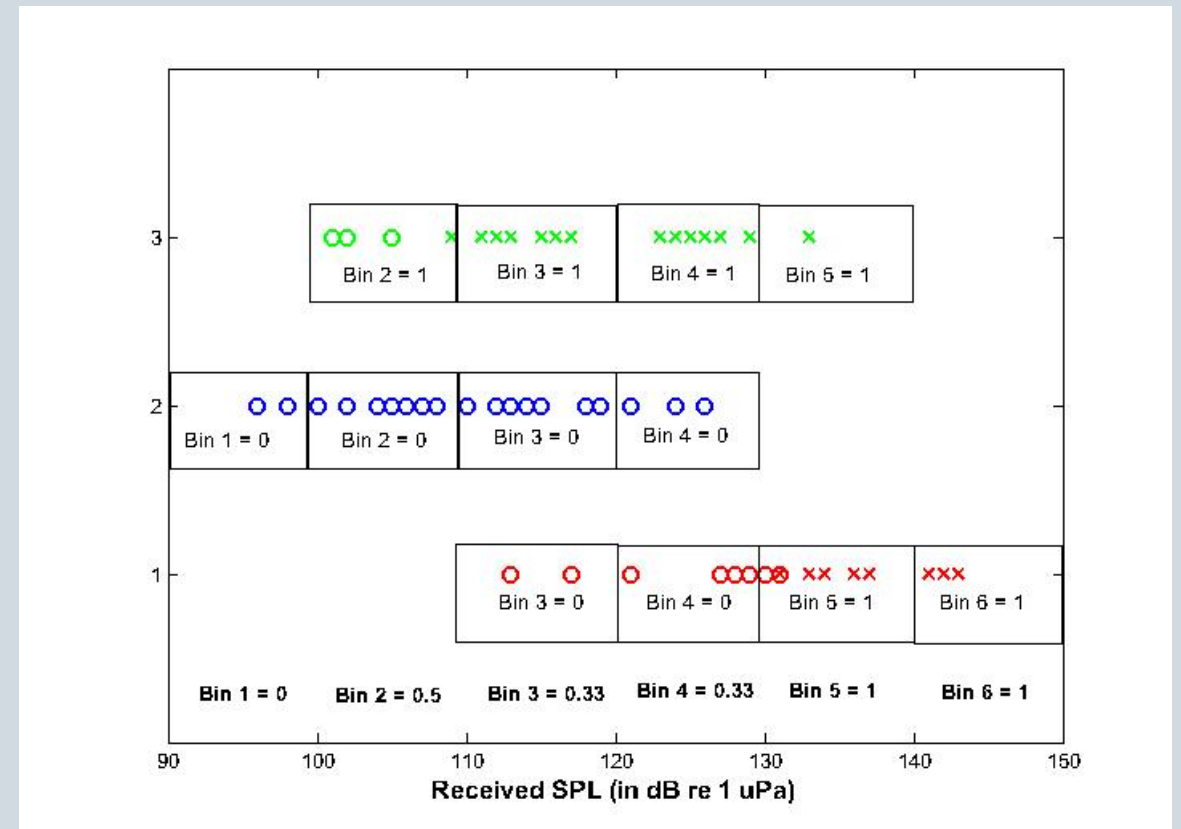
Phase III BRFs

➢ Odontocete

➢ Mysticete

➢ Pinniped

➢ Beaked whales

➢ Harbor porpoise – step function

Future Development

➢ More data on responses at different proximities, behavioral states, etc.

➢ Can develop more complex models to incorporate contextual factors
  ➢ Proximity
  ➢ Behavioral state
  ➢ Source movement
  ➢ Exposure duration

➢ Improve understanding of long-term consequences/repeated exposures
  ➢ Integrate this information into BRFs as well