



What are behavioural response studies ('BRS')?

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Reader

University of Saint Andrews

BRS workshop, SMM 2015, San Francisco

Behavioural response studies

BRS



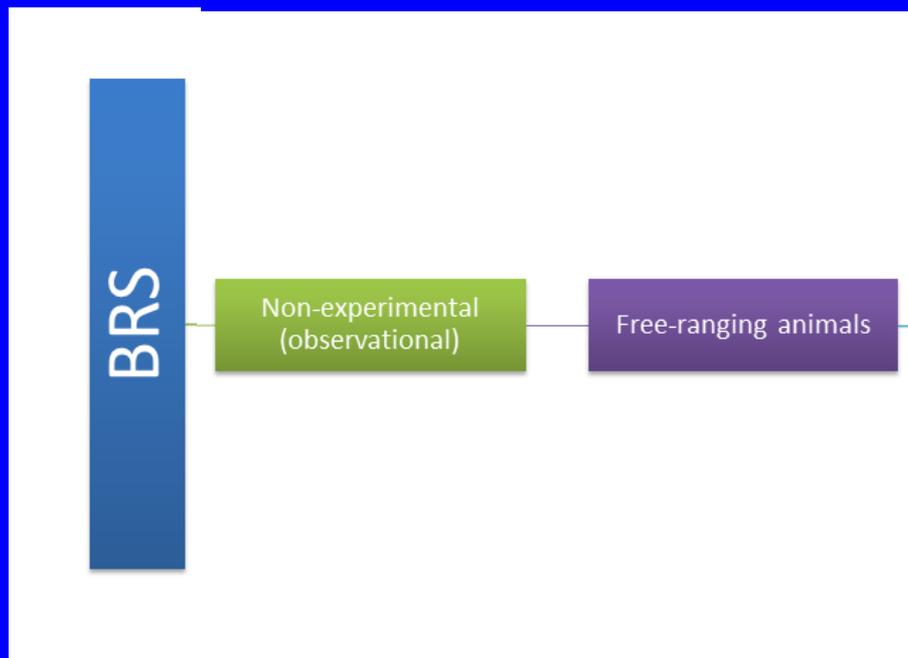
Observations of the behaviour of animals exposed to quantified levels of a disturbance source to:

- 1.) Describe the nature of responses
- 2.) Quantify drivers leading to responses
 - a. 'Dose' drivers
 - b. Context drivers
- 3.) Evaluate biological relevance of responses

Typically requires interdisciplinary approaches:
(biology, statistics, modelling, engineering)

Ideal case

Effects of real disturbance source directly observed:



Measure exposure levels

+

Quantify types of effects

Identify drivers:

- response thresholds
- key context factors

Evaluate biological relevance

Dose-response relationships of harlequin duck behaviour to noise from low-level military jet over-flights in central Labrador

R. IAN GOUDIE* AND IAN L. JONES

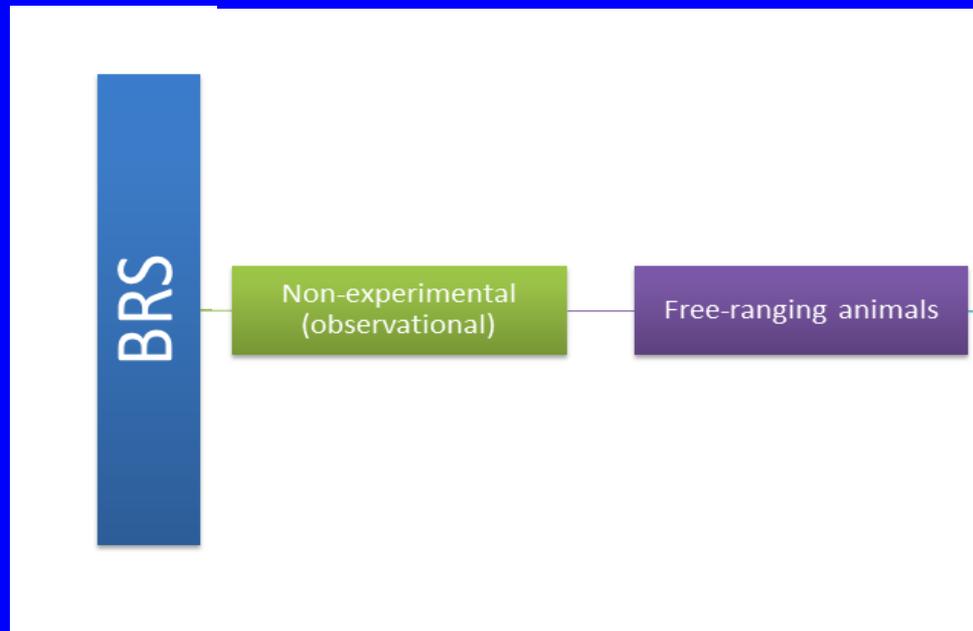
Atlantic Cooperative Wildlife Ecology Research Network, Department of Biology, Memorial University of Newfoundland, St John's, NL, Canada A1B 3X9

Date submitted: 23 January 2004 Date accepted: 29 September 2004



Ideal case

Effects of real disturbance source directly observed:



Dose-response relationships of harlequin duck behaviour to noise from low-level military jet over-flights in central Labrador

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Ideal case

Effects of real disturbance source directly observed:

Measured exposure levels



+

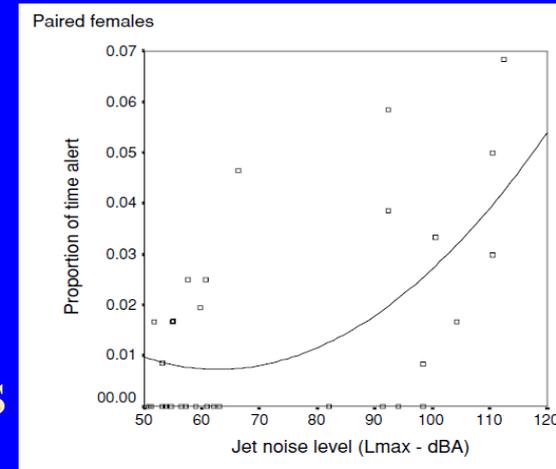
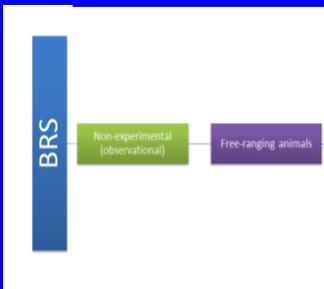
↑ alerting, ↑ agonistic, ↓ courtship

Identify drivers:

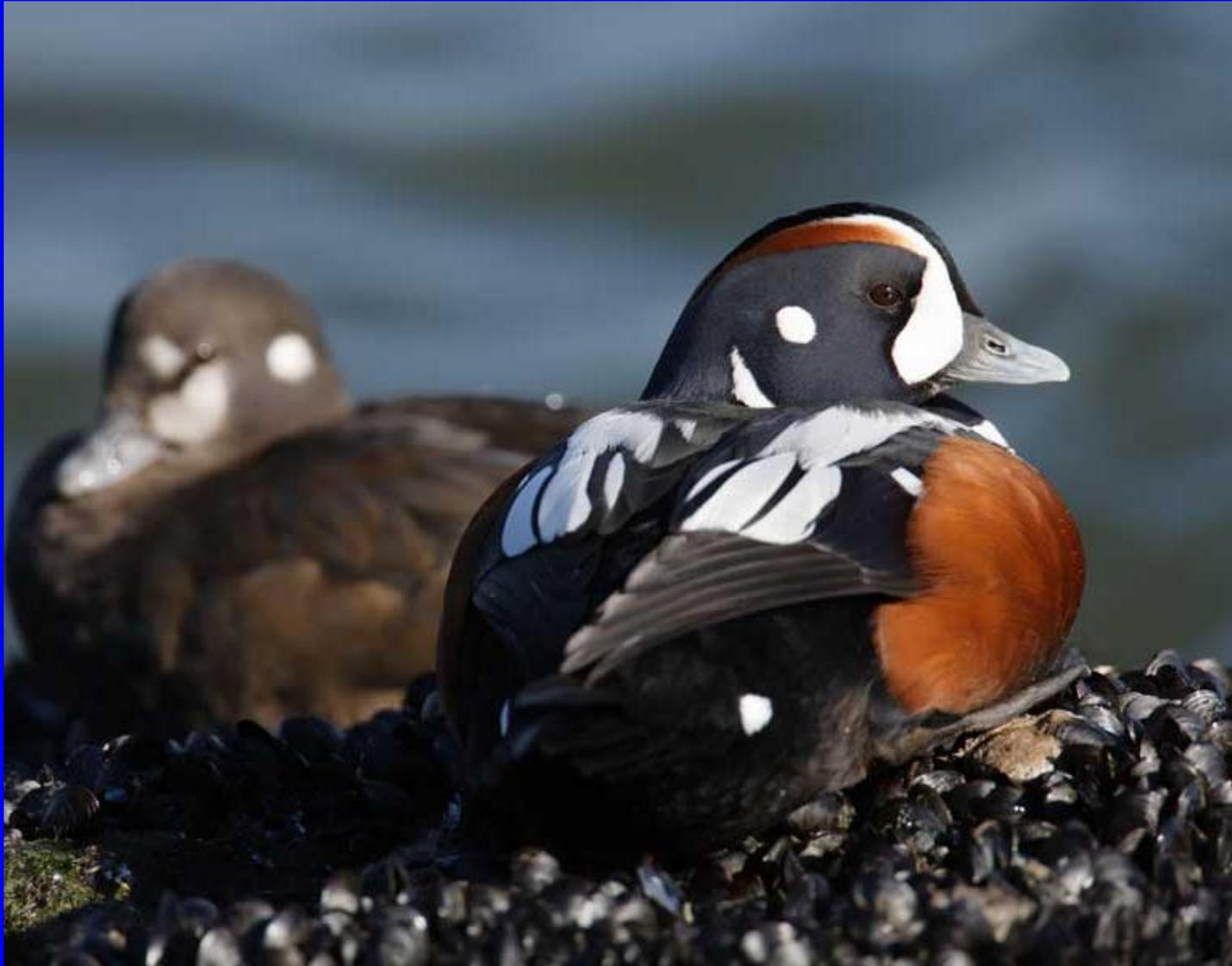
- acoustic threshold: 80 dBA
- females more responsive than males

Evaluate biological relevance

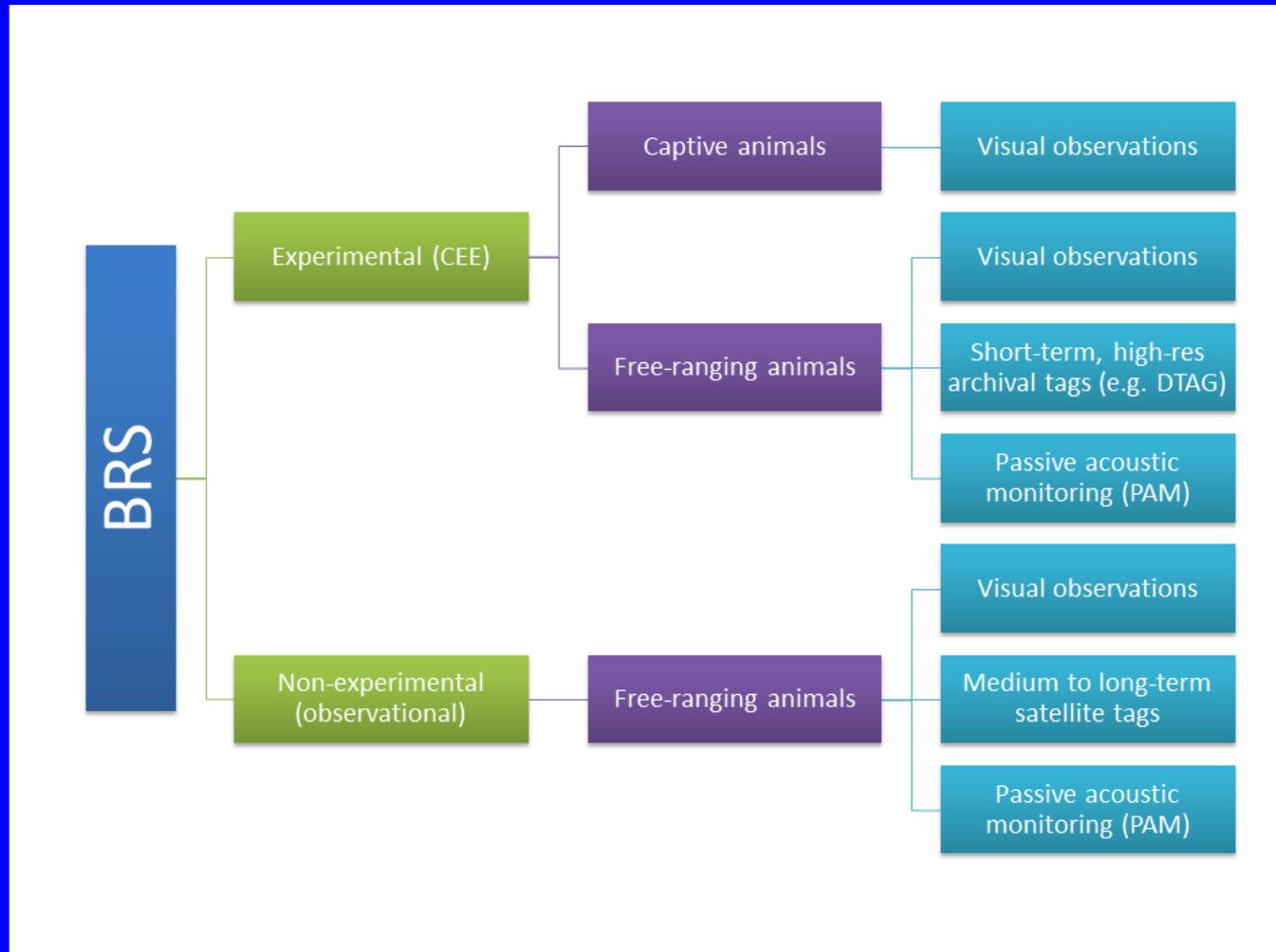
- chronic exposure → negative consequences ☹️



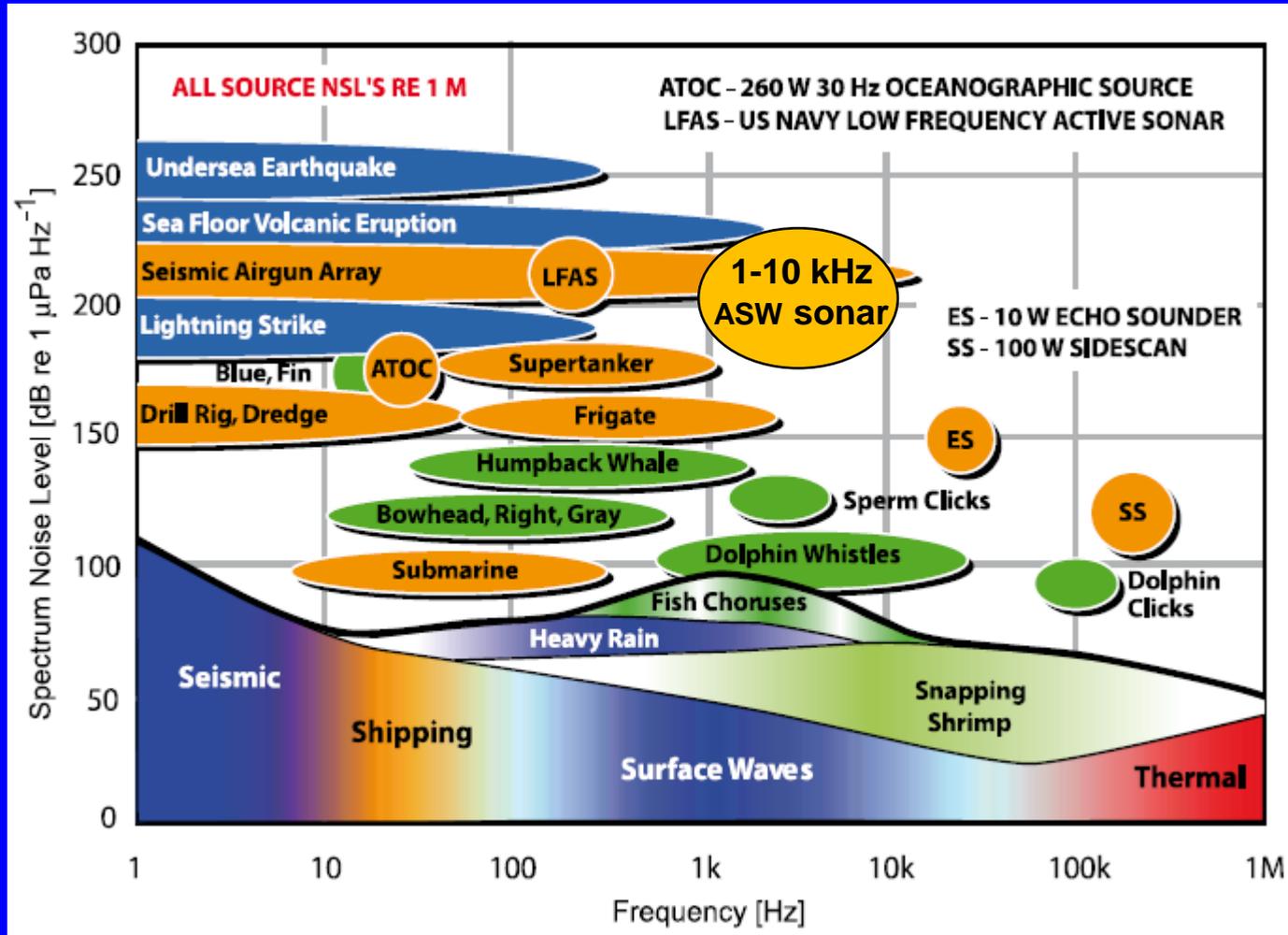
Risk assessment ducks → marine mammals



BRS approaches marine mammals and noise



marine mammals and noise



Adapted from Boyd et al., 2008 ESF Marine Board – Oxford 2005

Navy sonar and whales recognition of a hazard



navy sonar may impact behaviour /
physiology in a harmful way



Beaked whales being removed from the beach after a
mass stranding, Canary Islands, 2002

Haro Strait, 2003



ICES, 2005; NRC, 2005; IACMST, 2006;
Nowacek *et al.*, 2007; Southall *et al.*,
2007; 2009; Boyd *et al.*, 2008



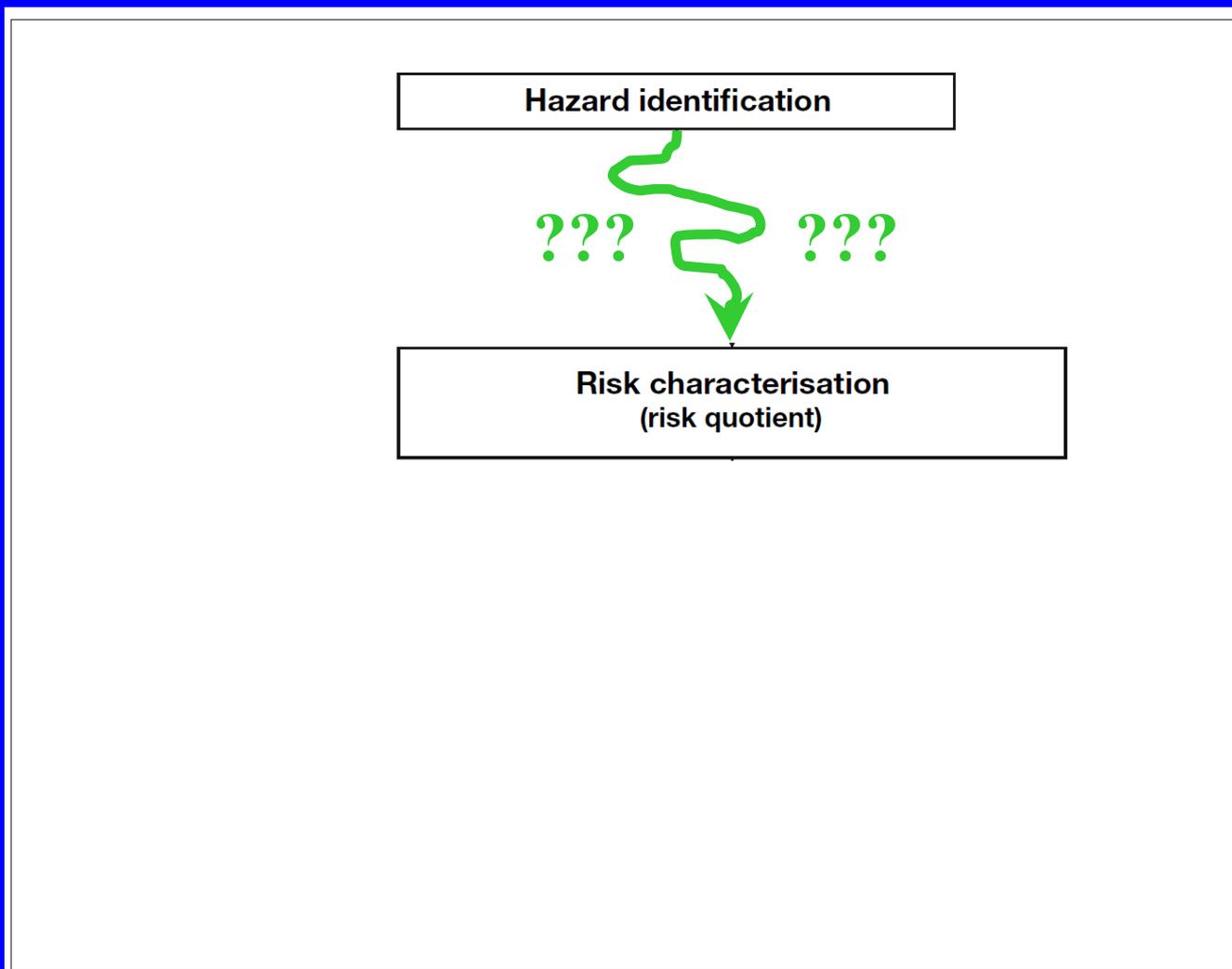
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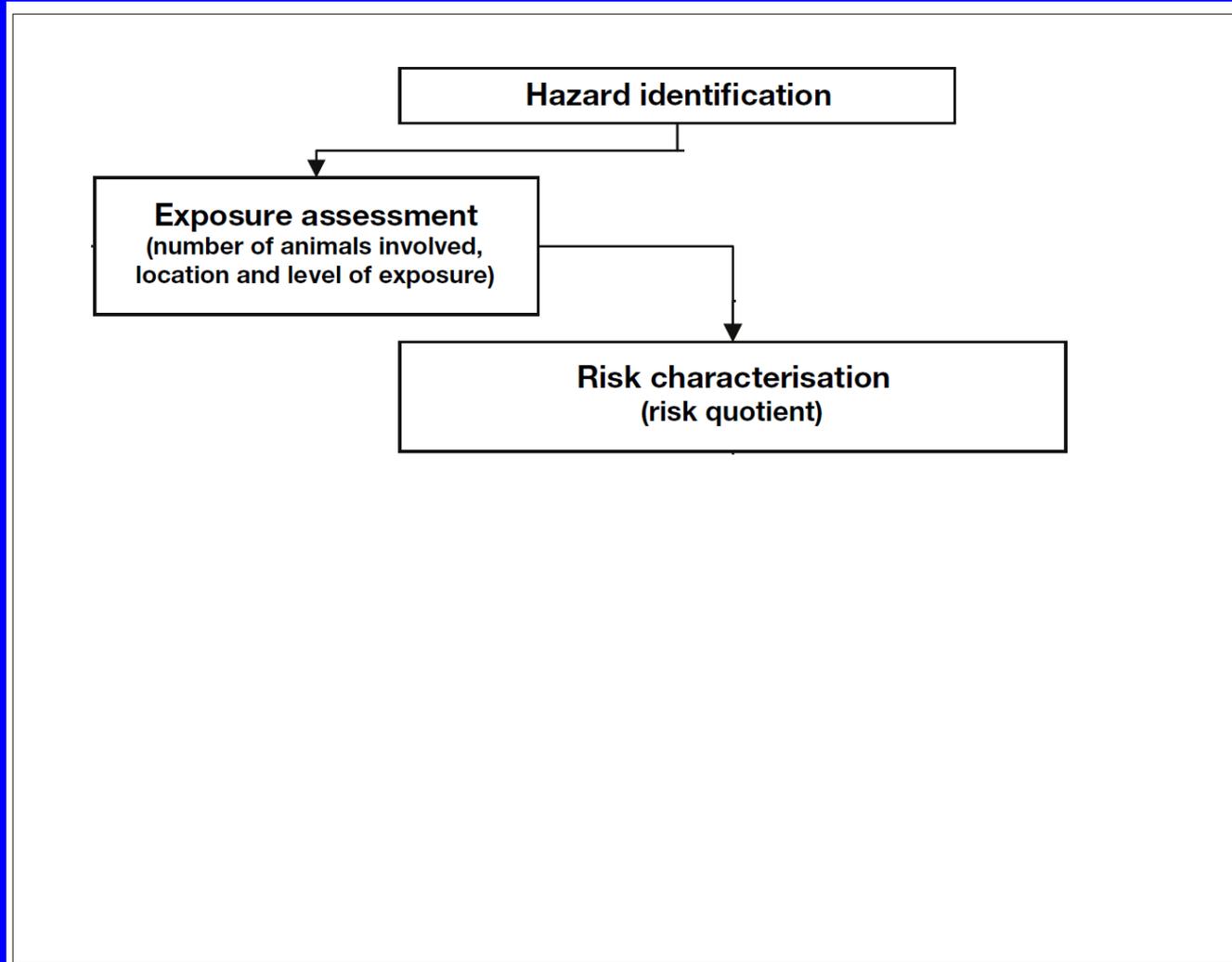
FILE 8.04.01 (Inst 3/5-01)

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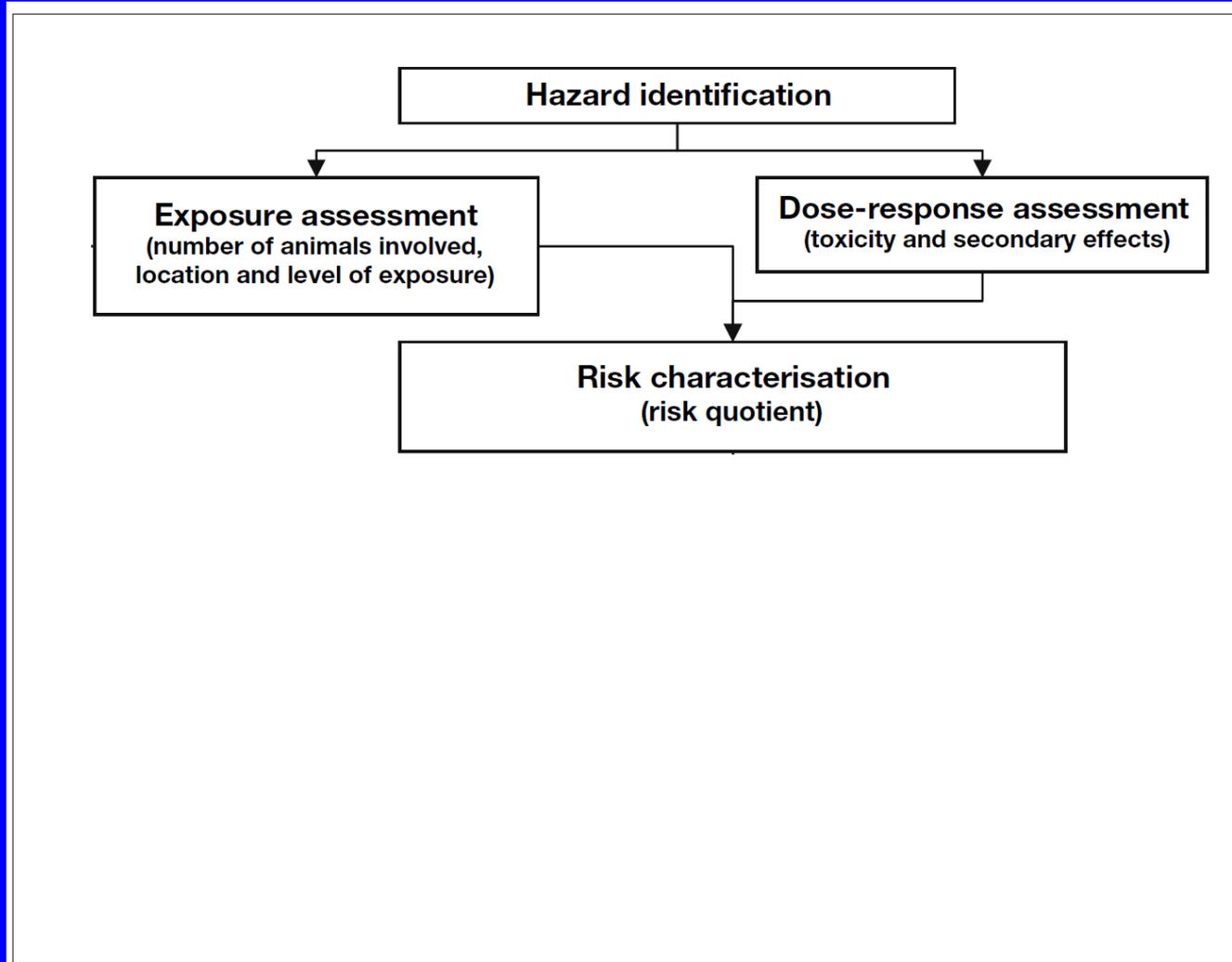
How to assess risk?



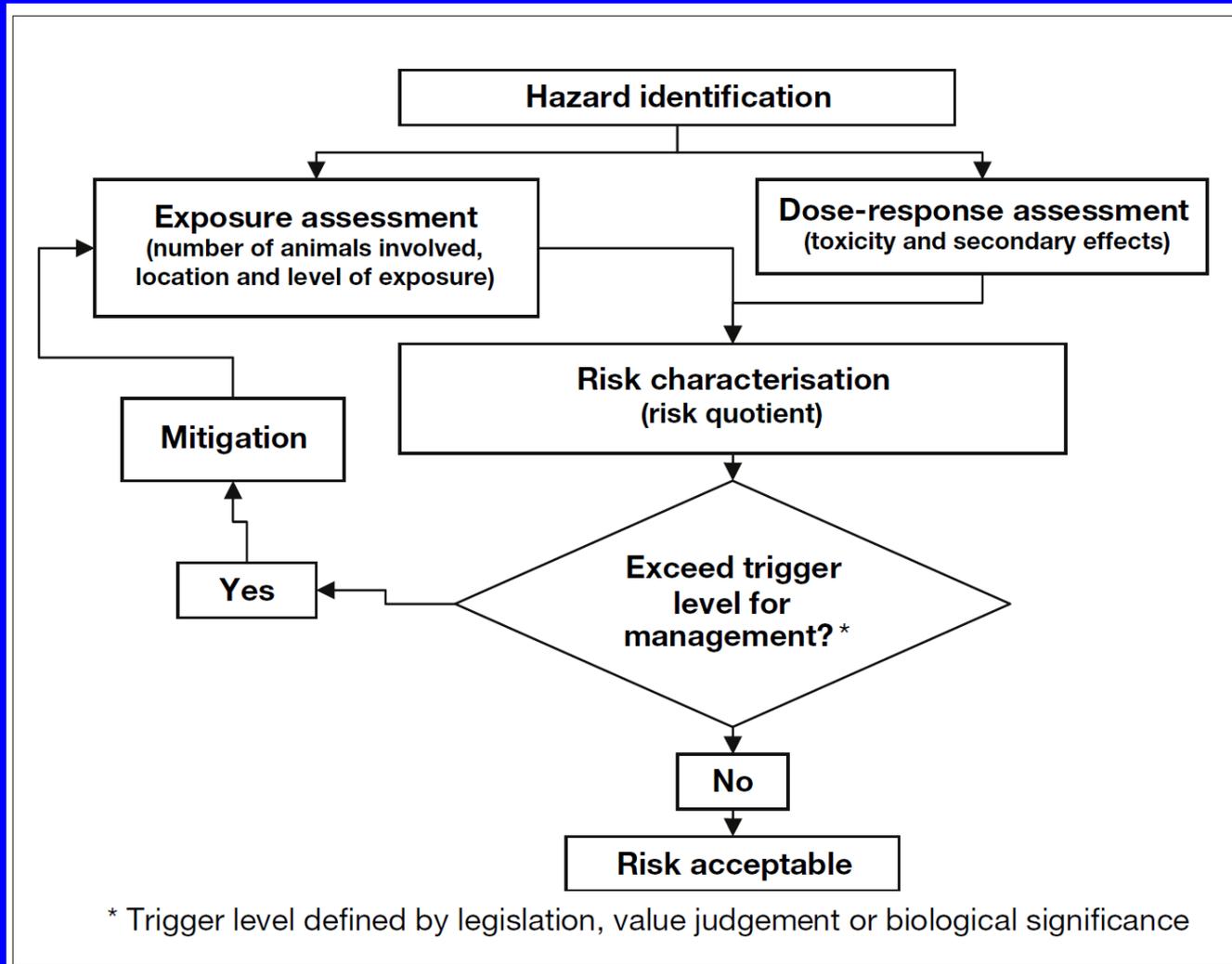
Risk assessment framework



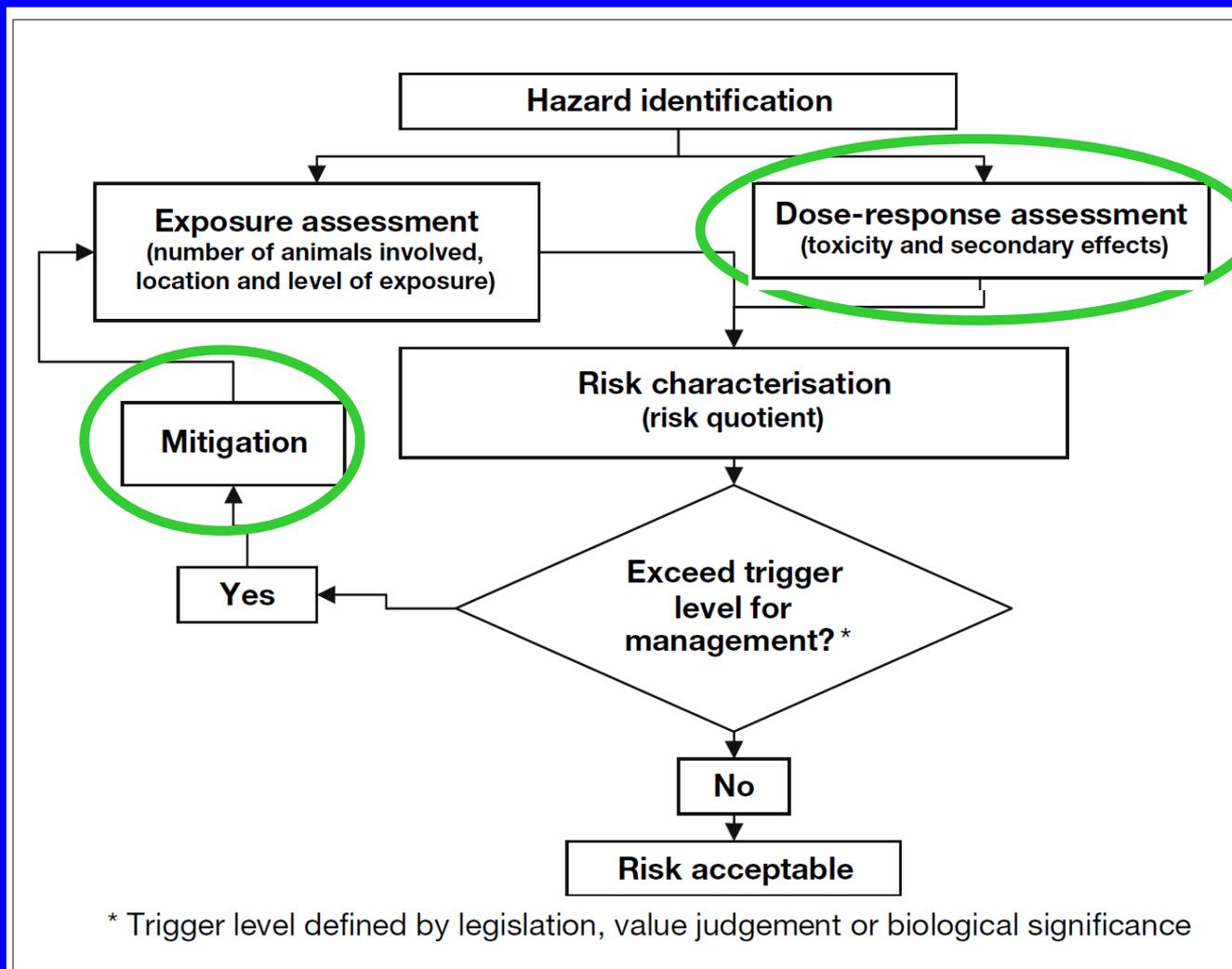
Risk assessment framework



Risk assessment framework



Addressed by BRS



BRS approaches

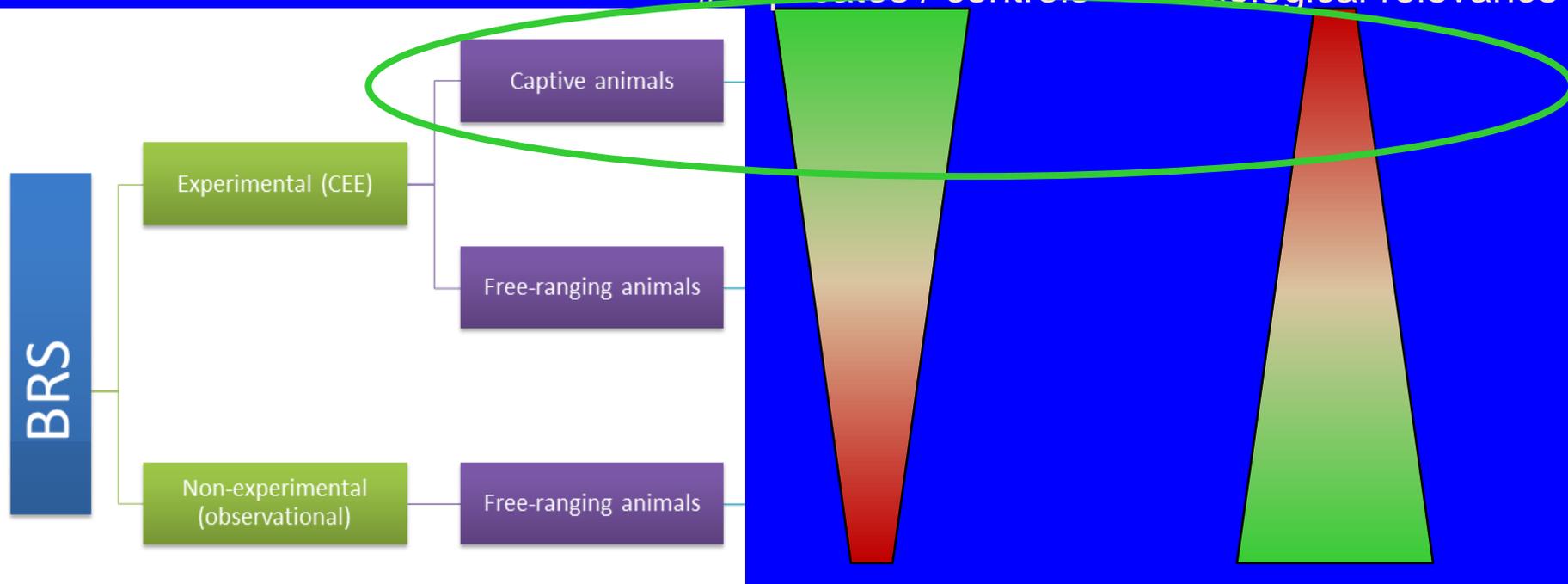


Experimental control

- individual histories
- ease of observation
- # replicates / controls

Relevant context

- response types
- natural drivers
- biological relevance



BRS approaches

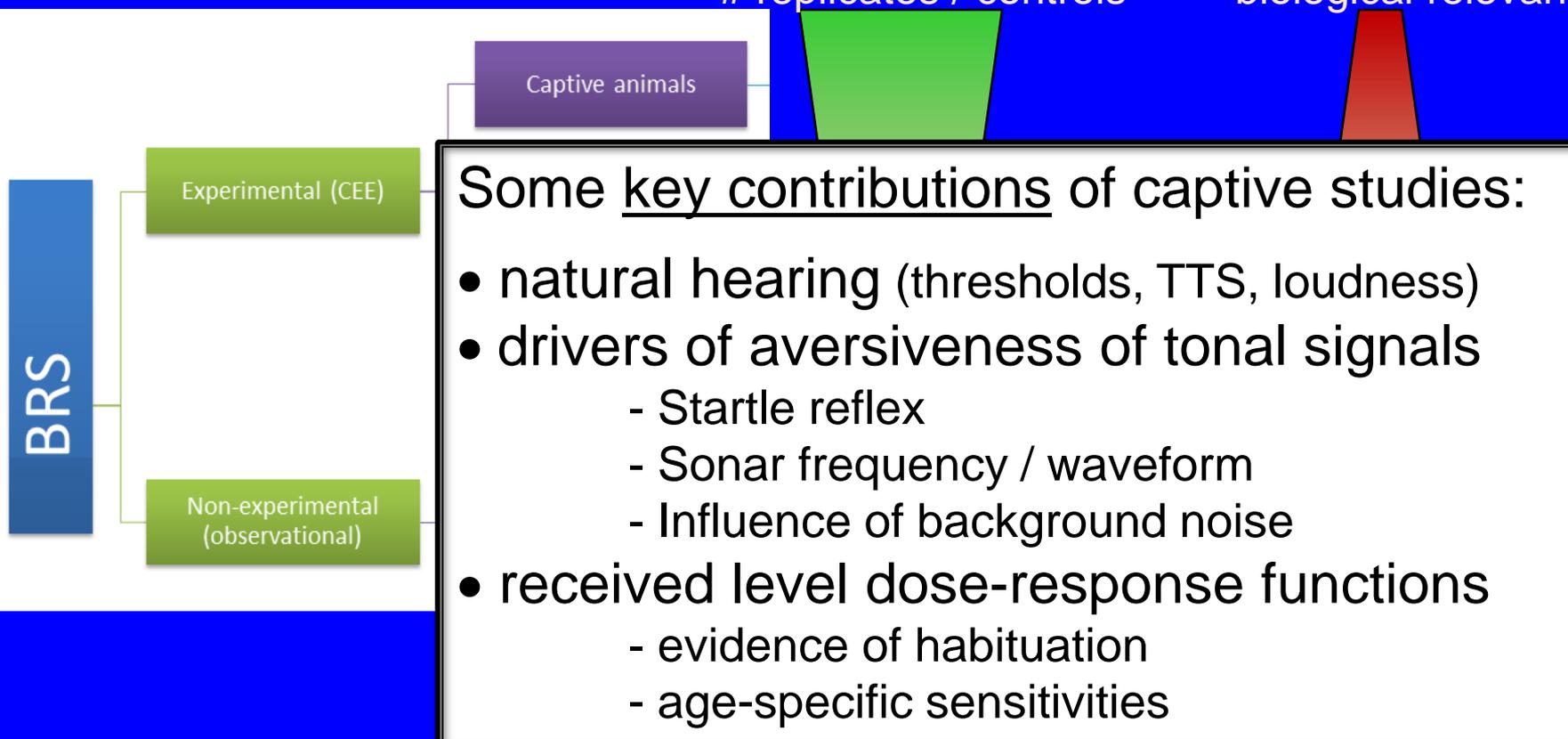


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e.g. Symanski et al., 1999; Gotz & Janik, 2010, 2011;
Kastelein et al. 2011, 2013; Houser et al. (2012, 2013)

BRS approaches

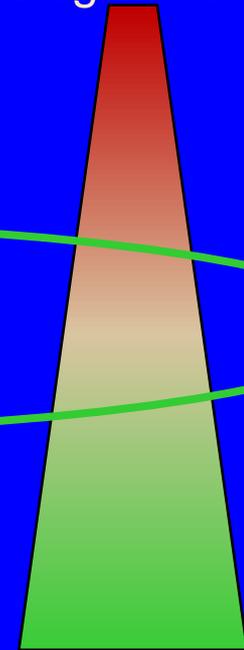
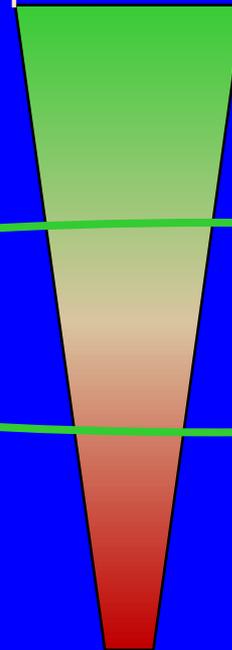
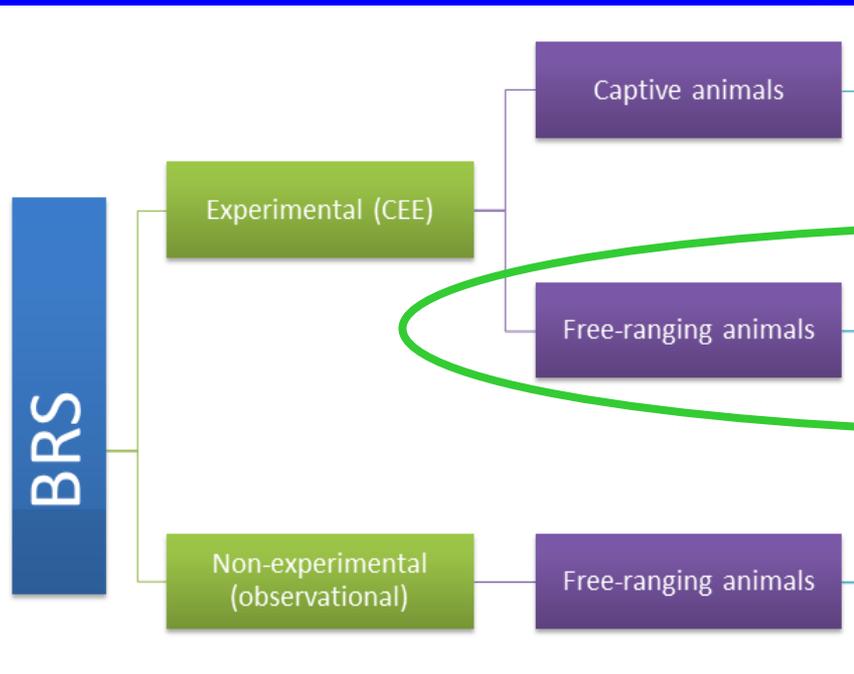


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BRS of free-ranging cetacea (studying effects of sonar)



	<u>AUTEC</u>	<u>3S (Norway)</u>	<u>SOCAL</u>
Period:	2007-2009	2006-2015	2010-ongoing
Species:	<i>Odontoceti</i>	<i>Odontoceti</i> <i>Mysticeti</i>	<i>Odontoceti</i> <i>Mysticeti</i>
Ziiphidae:	<i>Mesploplodon</i>	<i>Hyperoodon</i>	<i>Ziphius</i> , <i>Berardius</i>
Source:	3-4 kHz, 53C	1-2 & 6-7 kHz	3-4 kHz, 53C
<u>all studies used source level ramp-up</u>			
	stationary	towed, approach	stationary real Navy 53C
Controls:	pre-exposure PRN killer whale	pre-exposure no-sonar killer whale	pre-exposure PRN = pseudo-random noise no-sonar

BRS experiments: free-ranging cetaceans



Tag a random
'representative'
whale subject



Tagged focal whale
visual observations:
- location &
- social context
- mitigation



1-2 kHz
'LFAS'

214 dB max source level



Sonar source

tagging difficult species often a limiting factor in BRS

desirable to be able to tag any whale within a species



Dtag deployed onto northern bottlenose whale
at 15m distance using ARTS launching system

Dtag: critical tool for BRS



Thanks to: Mark Johnson



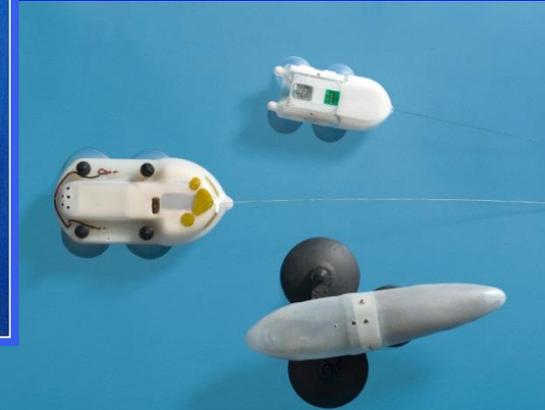
- Suction cups / release timer
- Rechargeable battery
- Radio beacon / recovery
 - marks a 'focal individual'

Movement sensors

- underwater behaviour
- enable track reconstruction

Audio sensors

- record sonar signal (**'dose'**)
- acoustic / movement behaviour



Dtag: critical tool for BRS



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Socrates source



1-2 kHz

'LFAS'

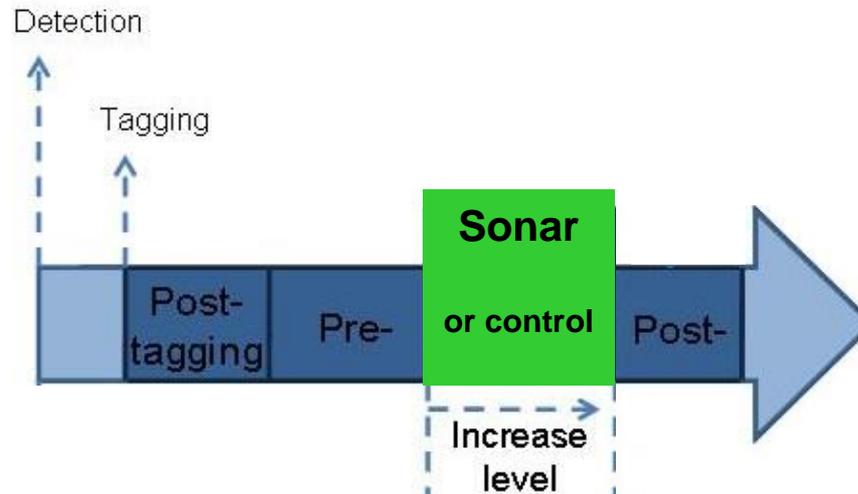
214 dB max source level



BRS

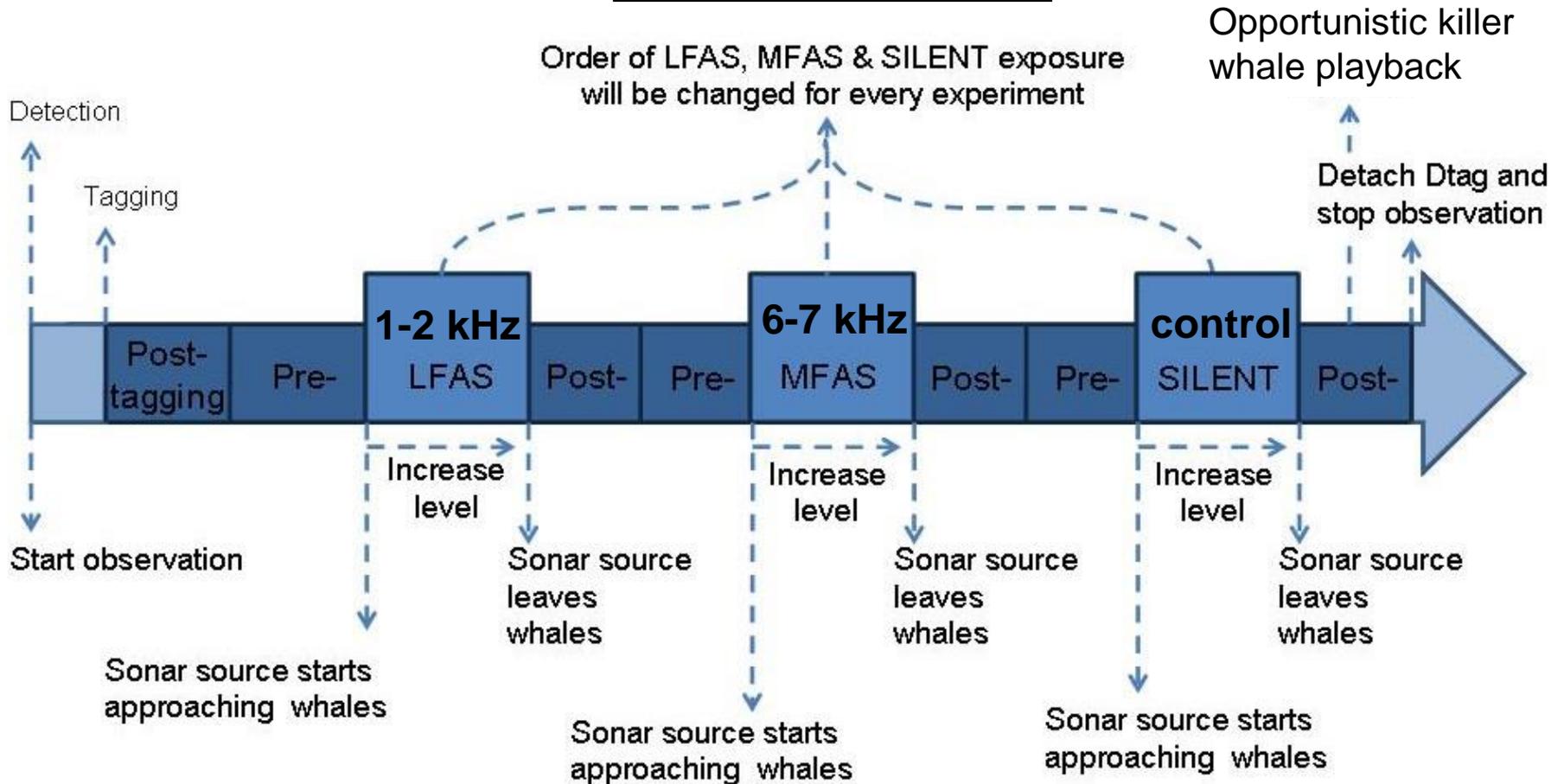
Experimental design

simple version



Experimental design

complex version





BRS

data - analysis

Rich observations

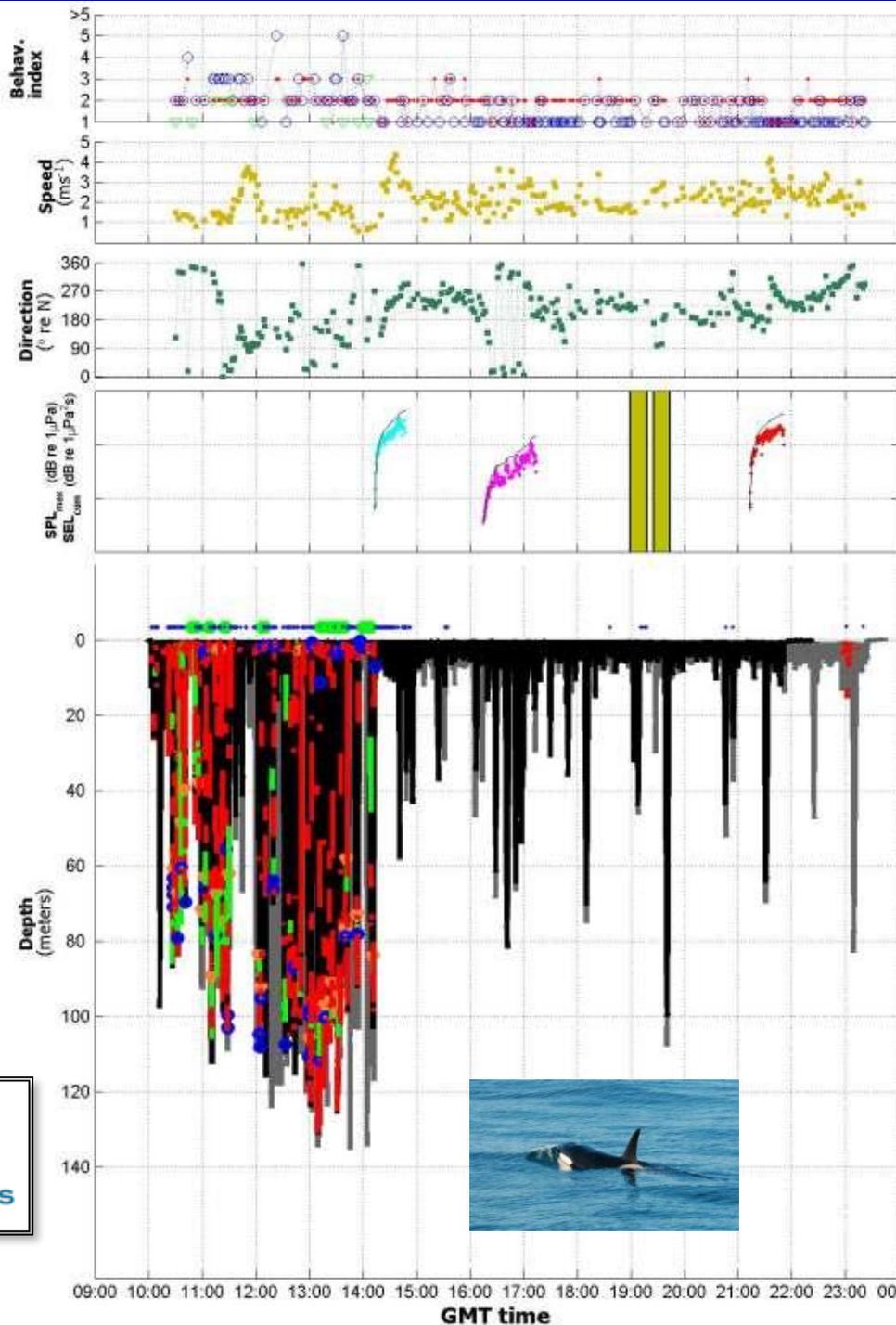
- natural behaviour patterns
- multi-variate, time-series
- cross / auto-correlation

Typically small # subjects

- most species <10

Analytical challenge!!!

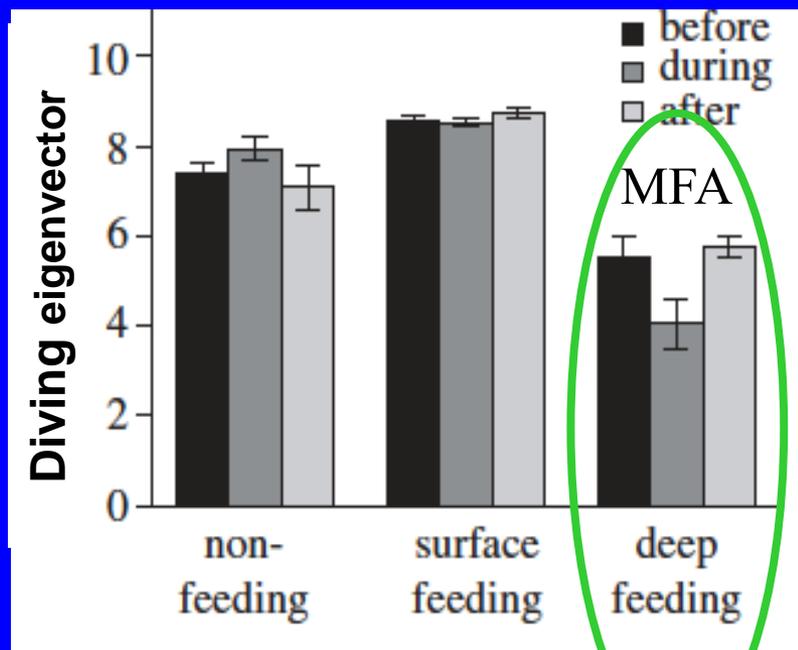
MOCHA
 MULTI-STUDY OCEAN ACOUSTICS HUMAN EFFECTS ANALYSIS



BRS data – analysis treatment blocks

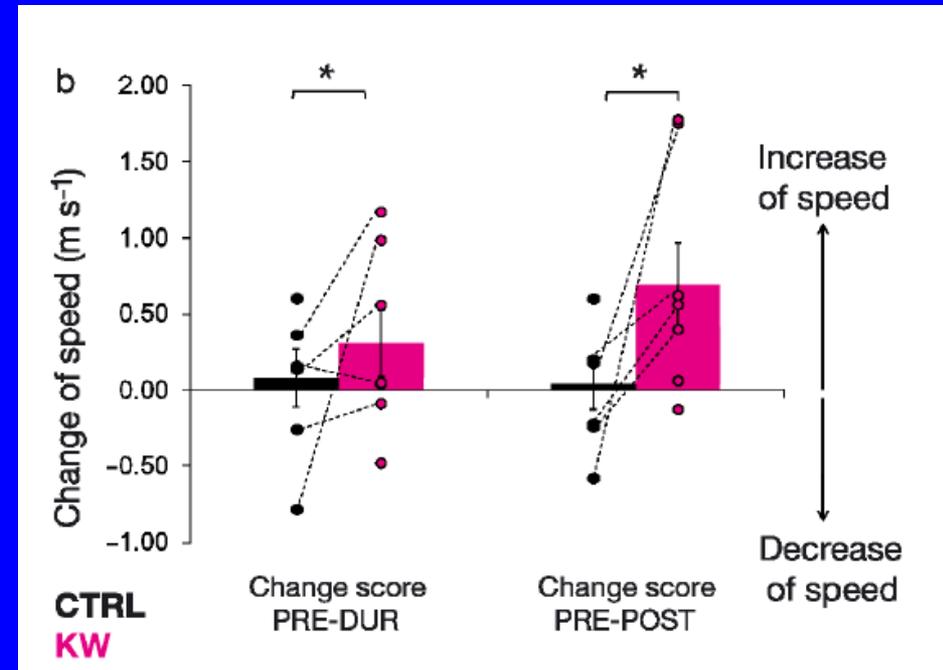
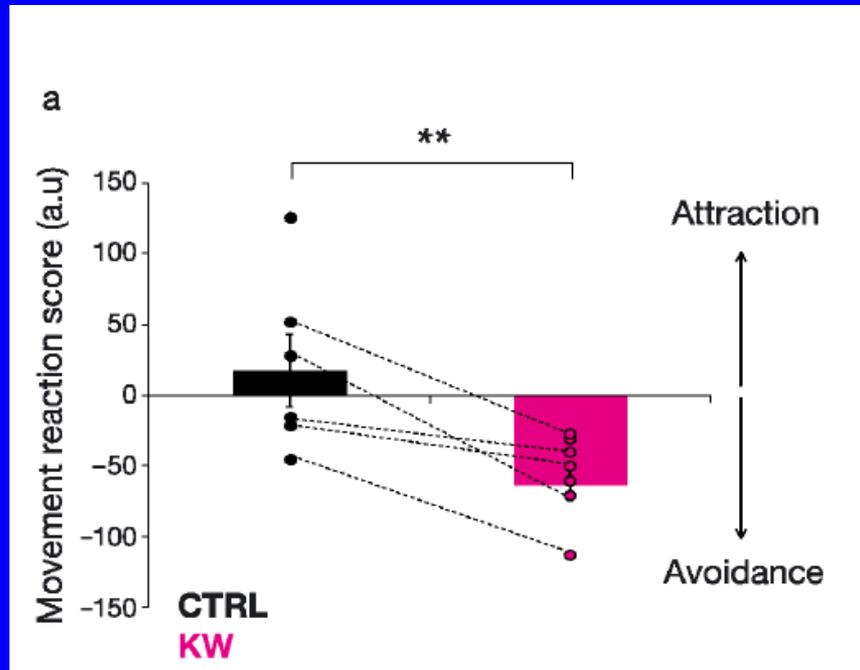


Tagged blue whale in SOCAL-BRS project (Taken under NMFS permit #14534, J. Calambokidis). Taken from SEA-inc.net website, with permission



Goldbogen et al., 2013

BRS data – analysis treatment blocks



Humpback whale responses to
killer whale sounds

Cure et al., 2015

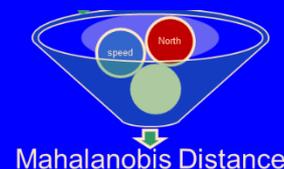
BRS data – analysis dose-response



Response threshold detection: identify sound level associated with a response

Case-by case analyses:

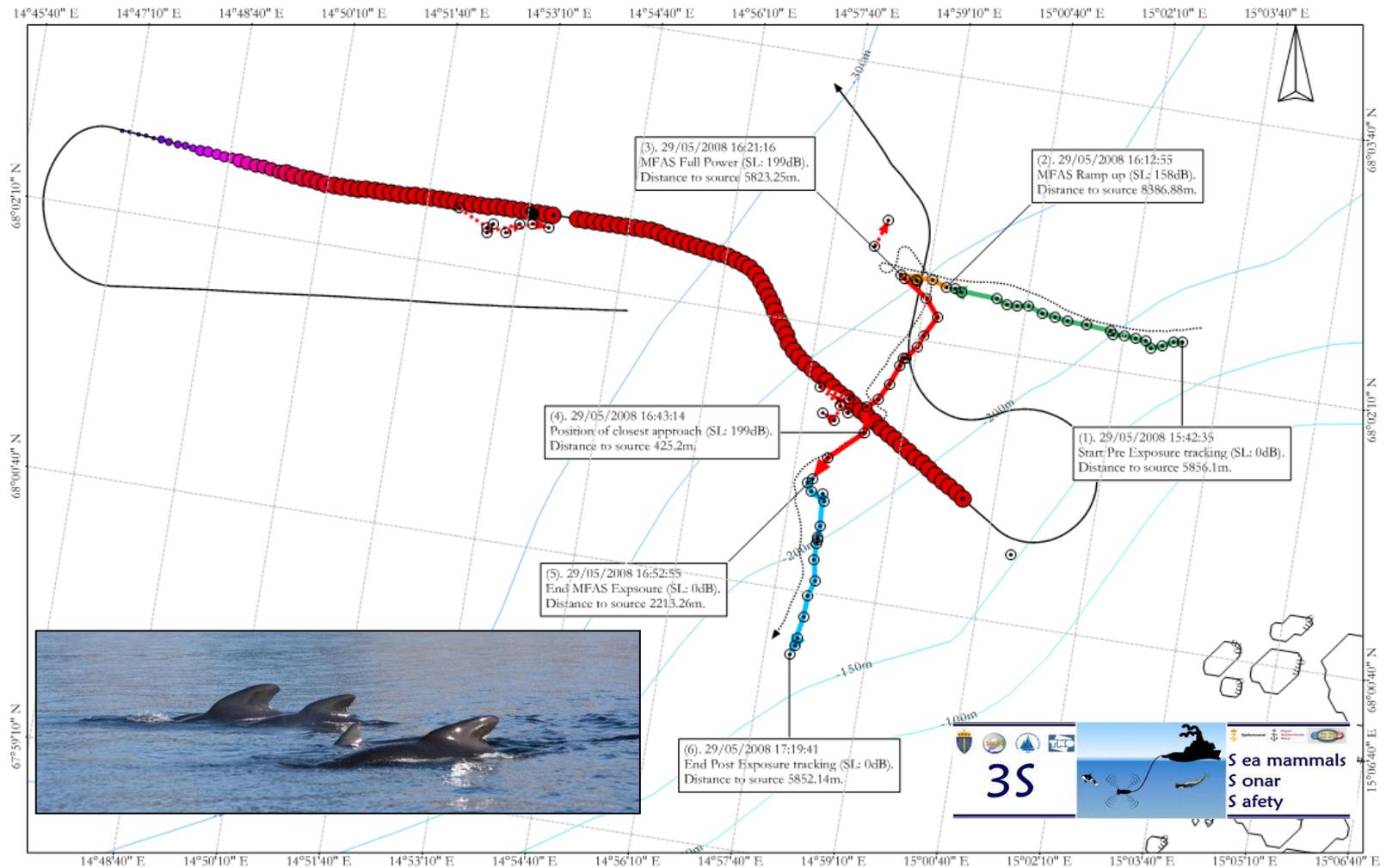
- Quantitative: time-series break-point analysis
- Descriptive: expert-identification



Build dose-response function from thresholds

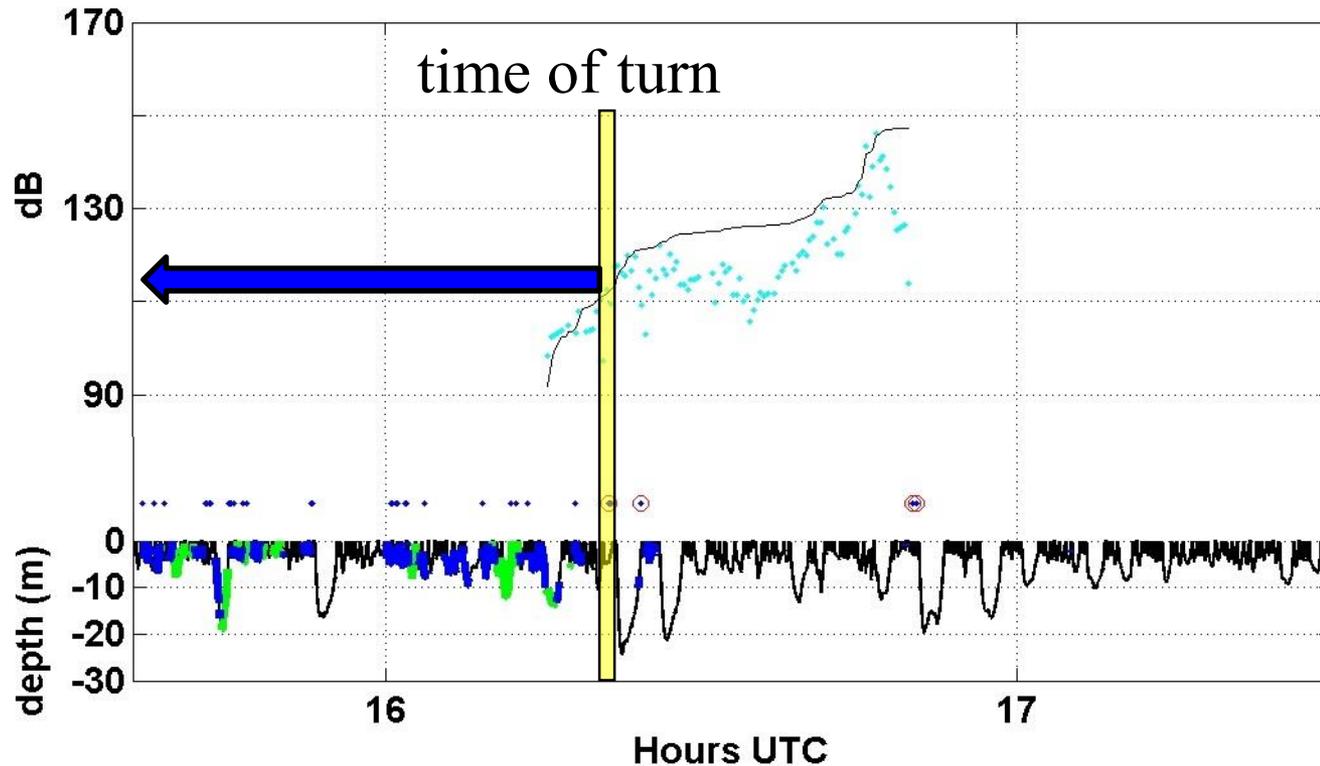
BRS experiment

gm08_150c 6-7 kHz sonar



CEE30: MFAS Signal to Pilot Whales (29/05/2008).

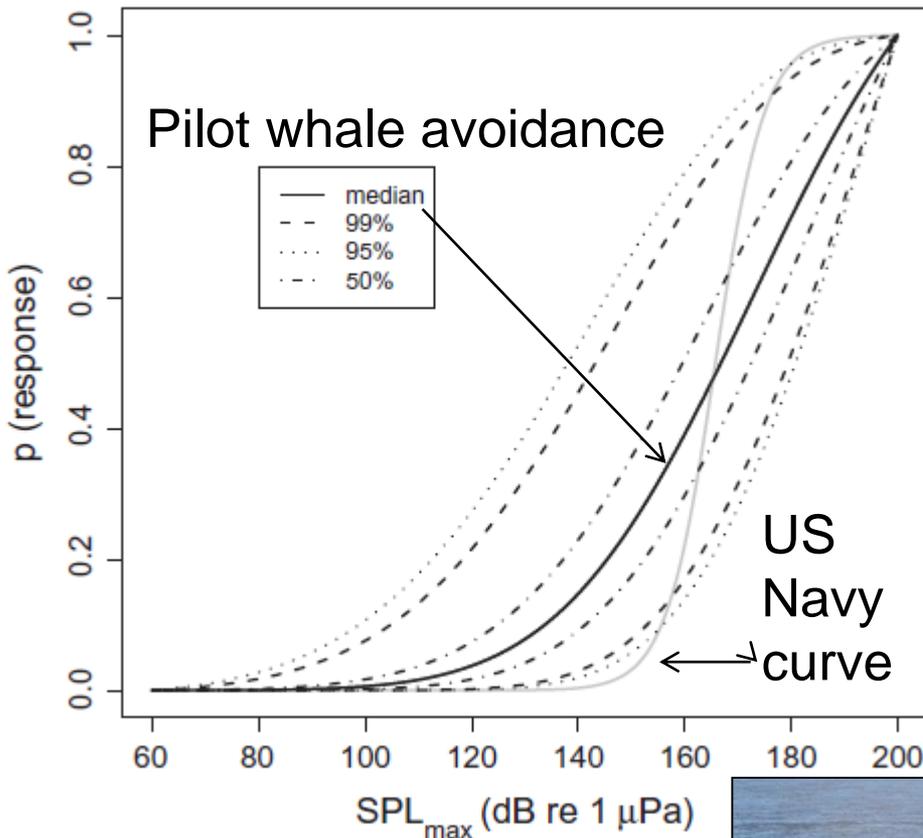
BRS experiment received level 'dose' escalation



gm08_150c: 6-7 kHz



Dose-response function from dose-escalation thresholds



Uncertainty due to:
- between and within
individual variation

(unexplained context factors)



BRS approaches

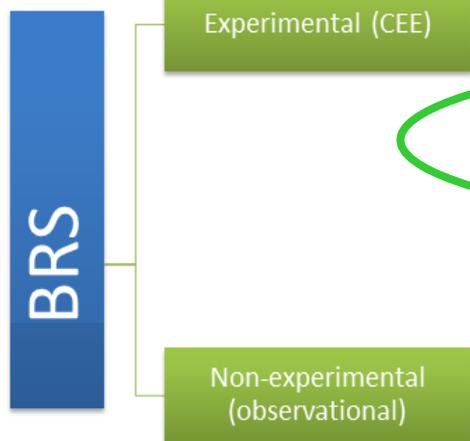


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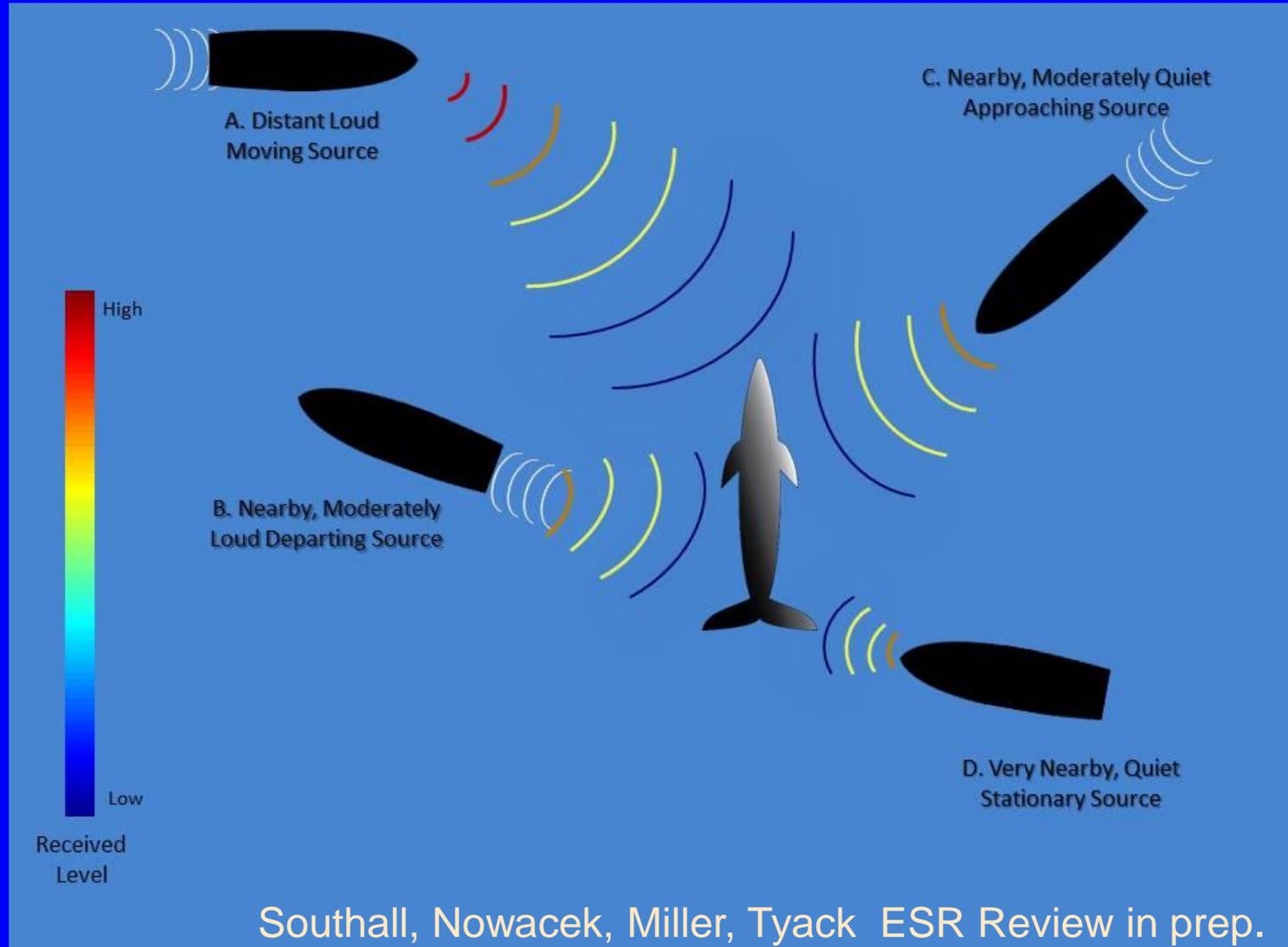


Some contributions of experimental (wild):

- Description of diverse responses
 - across a wide range of species
 - 'negative' controls confirm sonar was driver
- Linkage of responses to measured 'dose'
 - some at surprisingly low received levels
 - dose-response functions produced
- Importance of context on response
 - behavioural state affects responsiveness
 - high levels of unexplained variation
- Predator playbacks as 'positive' control
 - responses are more consistent & stronger
 - 'yard-stick' for biological relevance

Context is important

- experimental vs real sonar exposure -



tradeoffs w/ BRS approaches

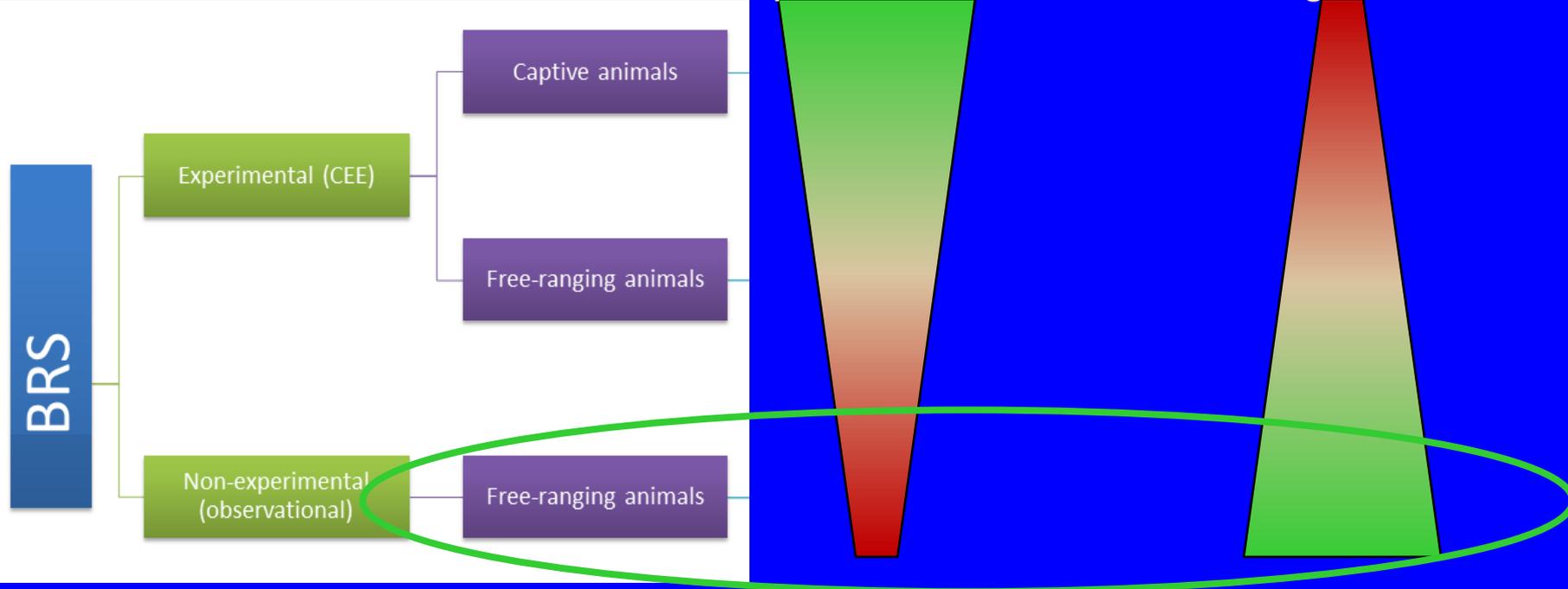


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experiments ~ observations

effects of sonar



Tagged whale experiment:
avoidance & cessation of clicking:

MFA: 138 dB re $1\mu\text{Pa}$

Orca: 98 dB re $1\mu\text{Pa}$

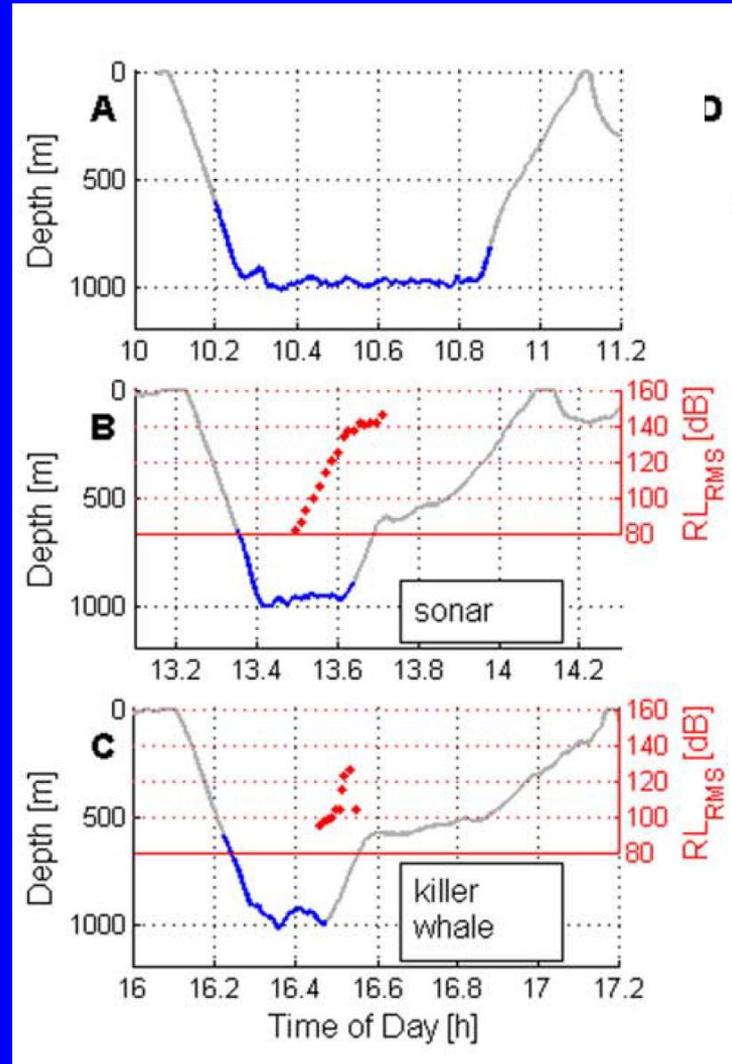
PRN: 142 dB re $1\mu\text{Pa}$

OPEN ACCESS Freely available online

PLoS one

Beaked Whales Respond to Simulated and Actual Navy Sonar

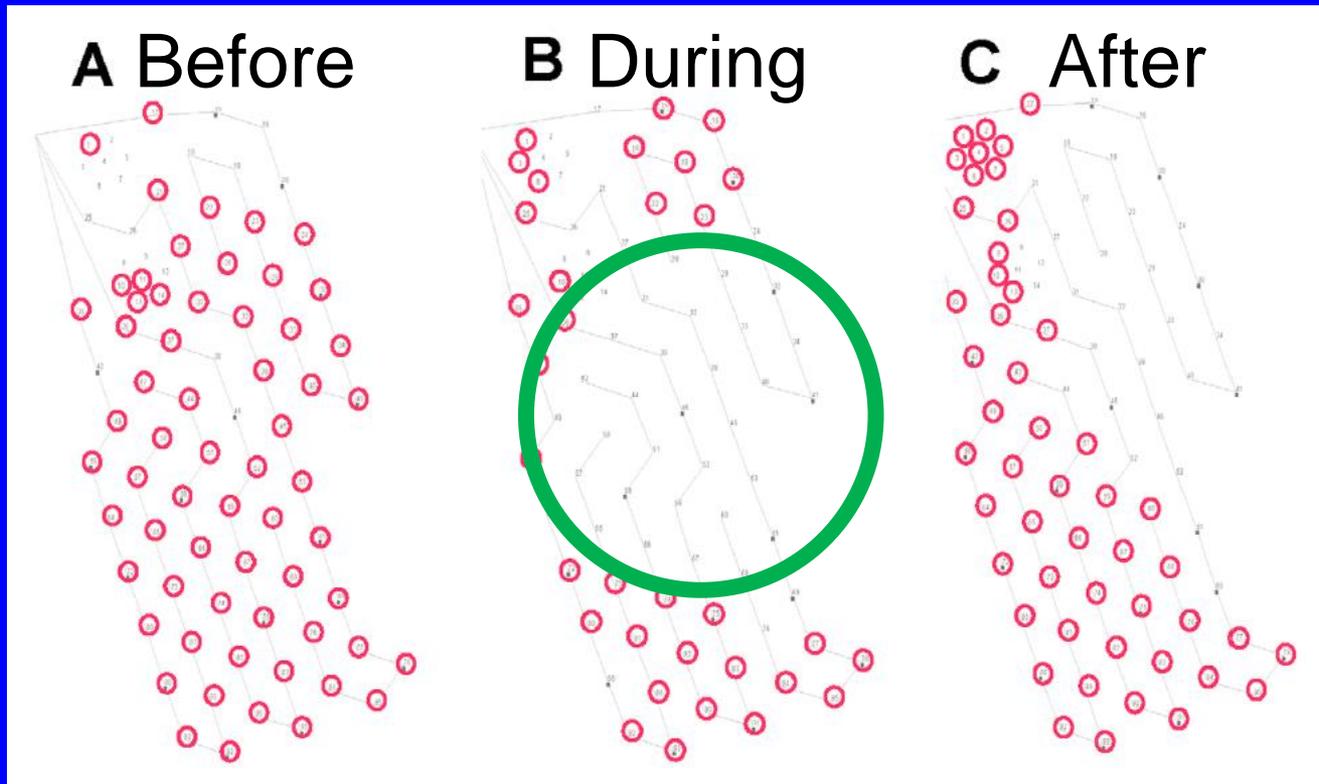
Peter L. Tyack^{1*}, Walter M. X. Zimmer², David Moretti³, Brandon L. Southall^{4,5}, Diane E. Claridge⁶, John W. Durban⁷, Christopher W. Clark⁸, Angela D'Amico⁹, Nancy DiMarzio³, Susan Jarvis³, Elena McCarthy³, Ronald Morrissey³, Jessica Ward³, Ian L. Boyd¹⁰



experiments ~ observations effects of sonar



Click detections during real sonar



BRS approaches

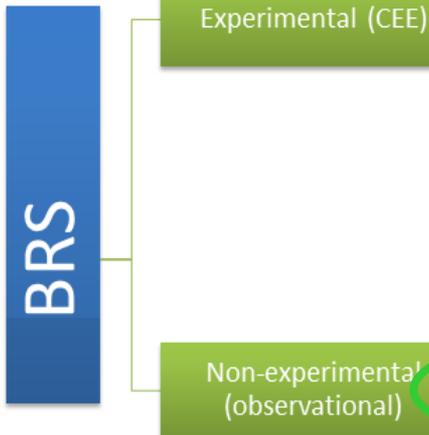


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Observations of real exercises

- Have been successful, but rare to date
 - multiple methods and logistics challenges
- Important to describe real outcomes
 - context issues less important
 - exposure levels represent actual values
- Are a high priority for future research
 - require novel methods (tagging / acoustics)
 - linking to experiments can help design
 - require good-will of navies

THANK YOU!!



Effects on marine mammals “zones of influence”

