Playbacks of predator signals and what might they tell us about responses to sonar

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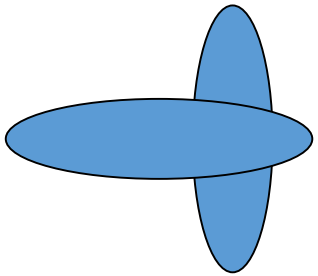
MARINE CONSERVATION ECOLOGY

Overview

- Terrestrial examples of animals responding to predator calls
  - Lots of interception, though dominated by bat-insect and alarm calls (e.g., Cheney & Seyfarth)
  - Features, discrimination, responses
  - Lessons learned
- Examples of killer whale call playback experiments to cetaceans
  - Stimulus types? Controls? Protocols? What can we learn?
- Range vs. RL
- Features of KW calls and sonar signals
- What can we learn from KW playbacks with respect to signal design/choice? Experimental protocol?

Animals may inherit a sensory template for predator detection

- Prey species cannot rely on multiple trials to learn to recognize their predators
- You may not get another chance to learn what the predator looks or sounds like

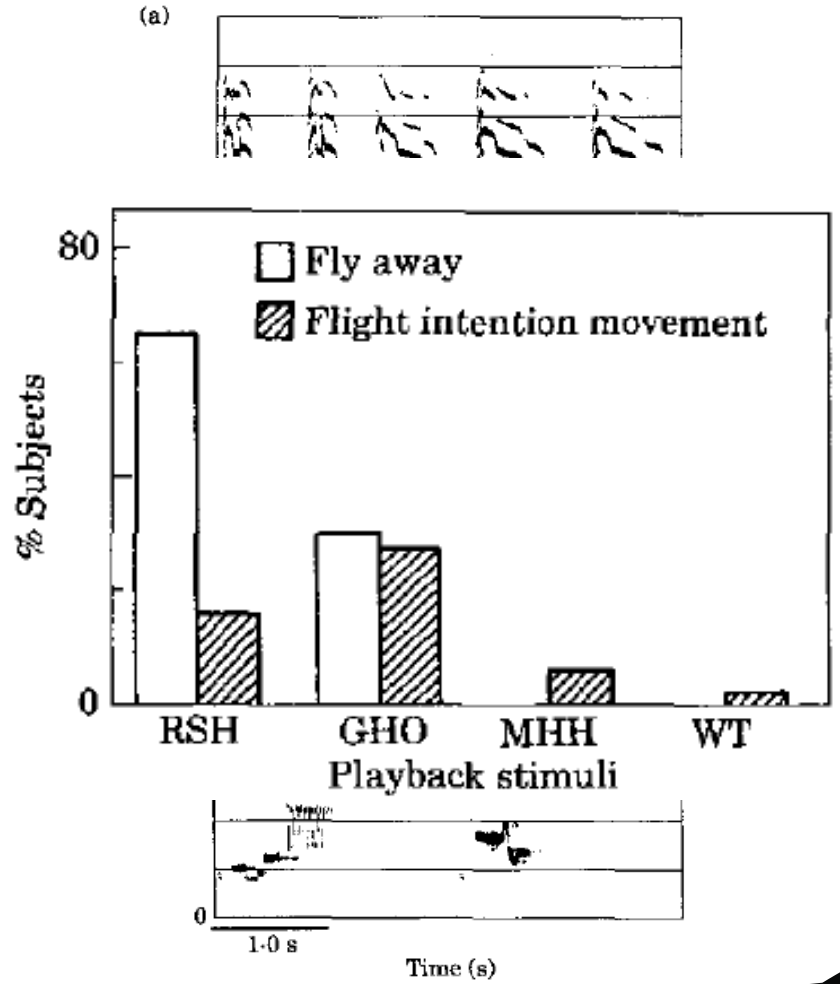


- Visual for birds: Konrad Lorenz 1939, Niko Tinbergen 1948
- Acoustic for marine mammals: Deecke et al. (2002) Nature

Response of crows to predator and non-predator calls

Hauser & Caffrey 1994

- Sounds of:
  - Sympatric predators
  - Allopatric predator
  - Allopatric non-predator, non-competitor
- Lessons learned
  - Some 'all out' responses
  - No response
  - Some equivocal – context, including timing of exposure? Age?



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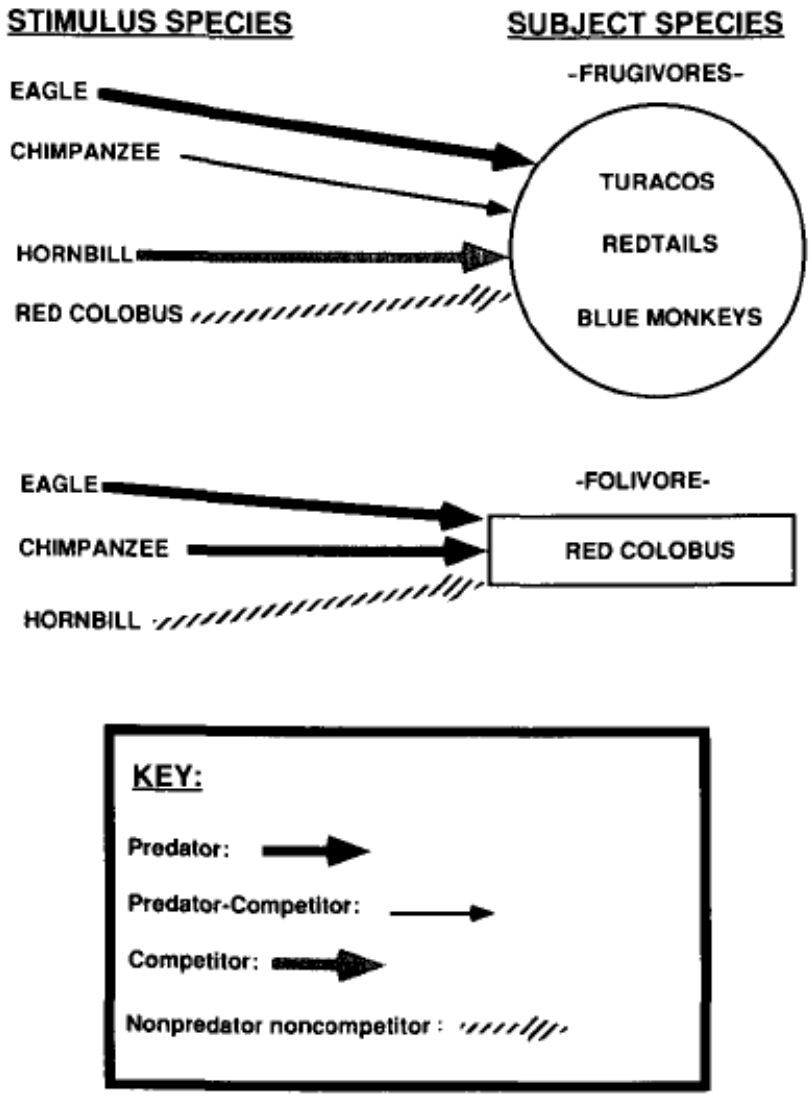
Distinguishing predator from competitor

Hauser & Wrangham 1990

- Measured in foraging monkeys & birds
- Sounds of predators, competitors, sympatric species
- What did we learn:
  - can distinguish predator, even if 'out of place'
  - predator 'overrides' competitor
  - Poly-specific associations reduce vigilance



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Pilot whales and FEK calls

Curé et al 2012

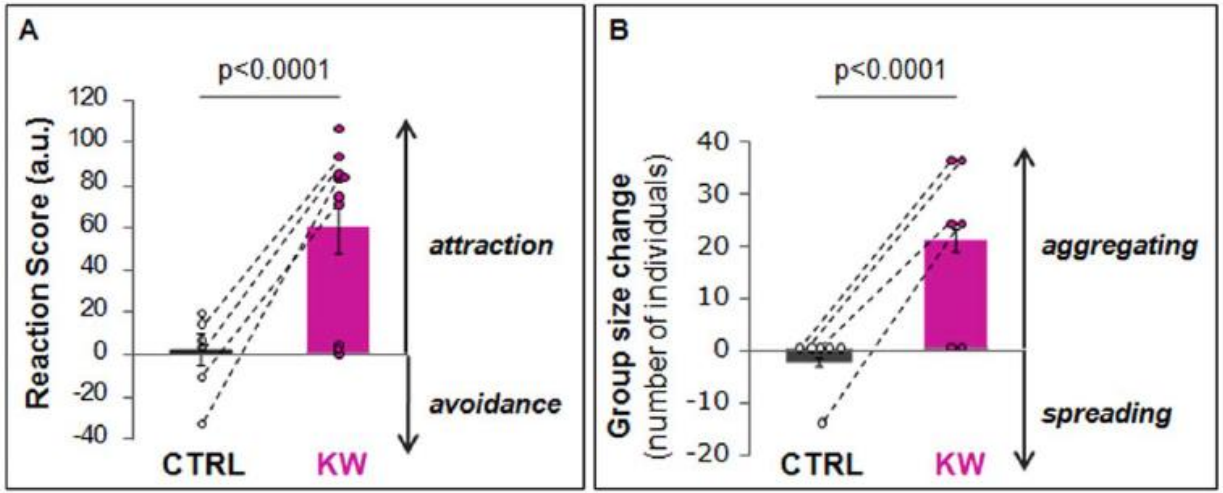

Figure 2. Response of tagged long-finned pilot whales to KW and CTRL playbacks. (A) Reaction scores for KW playbacks (N = 5 whales tested twice, n = 10 trials) and CTRL playbacks (N = 3 whales tested twice, n = 6 trials). Positive values: attraction towards the sound source; negative values: avoidance. Dashed lines link the reaction scores of the same subject. (B) Change of group size during KW and CTRL playbacks (for each stimulus type: N = 3 individuals tested twice, n = 6 trials). Positive values: whales aggregating around tagged animal; negative values: whales spreading. Error bars give mean ± SEM.
doi:10.1371/journal.pone.0052201.g002

- Sounds of sympatric predator/competitor
- Attraction to the source
- Ability to distinguish predator from competitor?
  - Shades of Hauser & Wrangham

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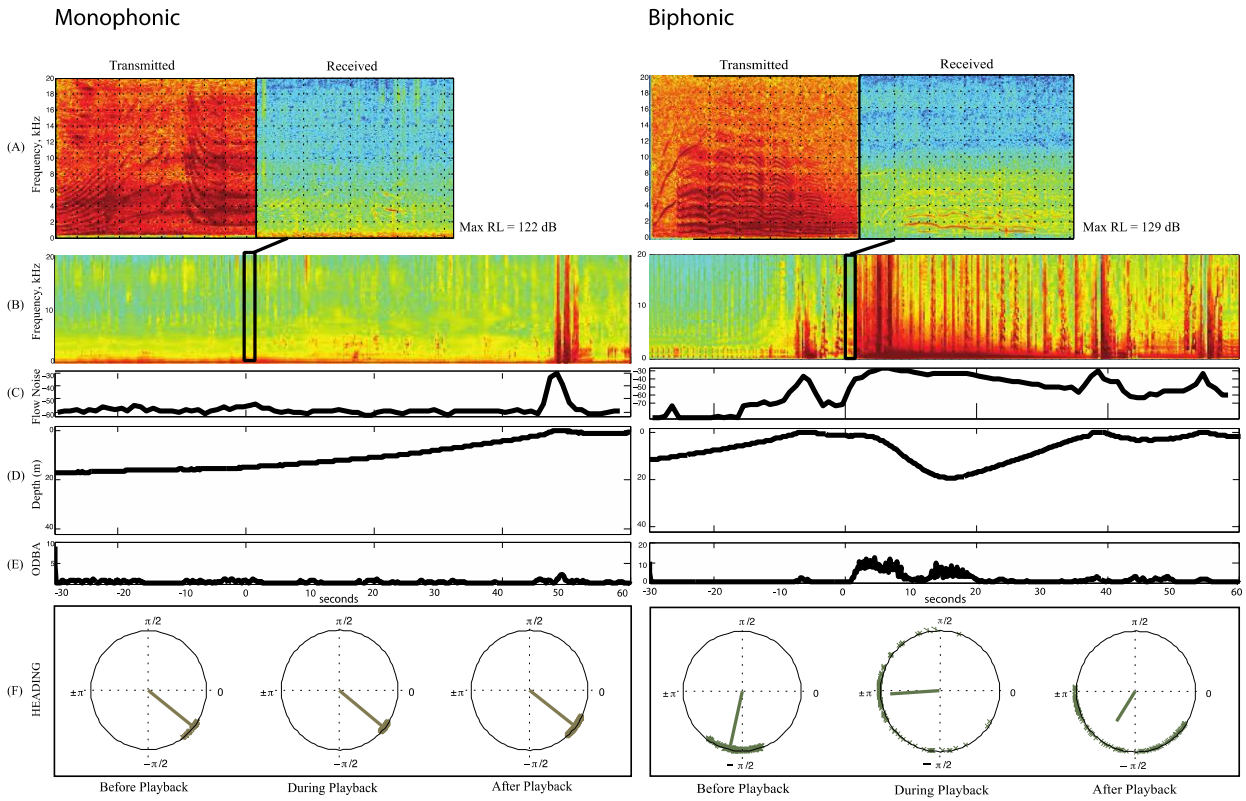
Differential response in pilot whales to MEK calls

- Single stimulus, repeated
- Short duration exposure
- Stationary source
- Controls



Read et al., unpubl

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Male sperm whales…

Curé et al 2013

- Increased sociality in typically asocial animals
  - Some increase group size
  - Coda production
- Cease foraging
- Differential response, e.g., sw10_160?
- Response to control

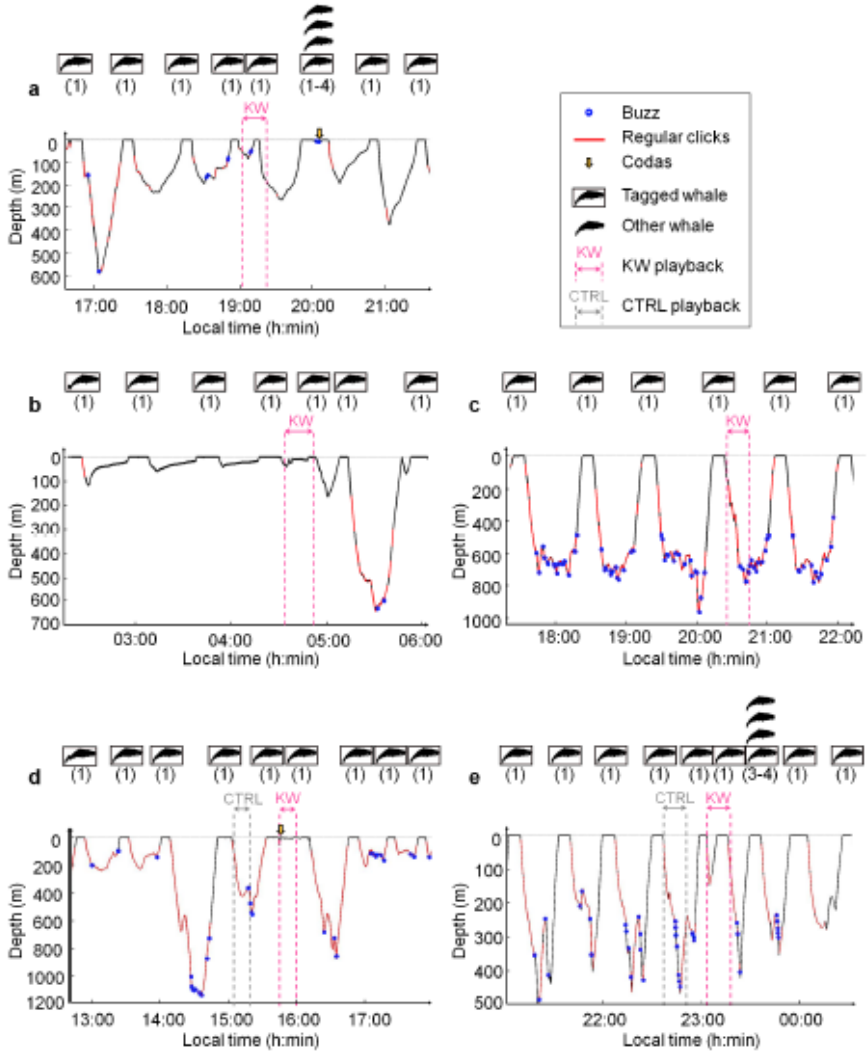

Figure 2 | Time-depth profile of tagged whales sw09_141a (a), sw09_142a (b), sw09_160a (c), sw10_149a (d) and sw10_150a (e) during baseline, CTRL and KW playbacks. The diving periods highlighted in red correspond to clicking activity, the blue circles represent emission of buzzes, and the yellow arrows indicate production of codas. For each surfacing phase, the range of group size is shown between brackets.

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Humpback whales exposed to MEK calls

Curé et al 2015

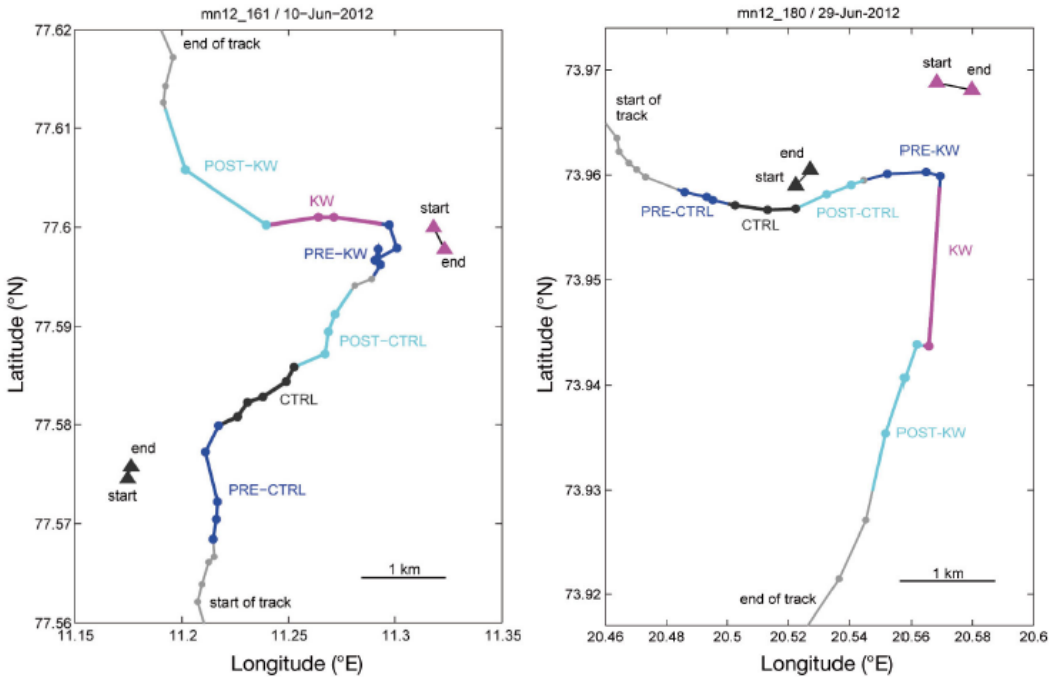

Fig. 1. Horizontal track of tagged humpback whales *Megaptera novaeangliae* mn12_161a (left) and mn12_180a (right) during control (CTRL; dark grey) and mammal-eating killer whale *Orcinus orca* (KW; magenta) sound playbacks. The whale track during the PRE and POST exposures is shown in blue and cyan, respectively. Corresponding colour-coded triangles represent the position of the sound source at start and end of playback

- Changes in foraging behavior
- Group type specific response
- Speed response during 'post' period
- Response to control

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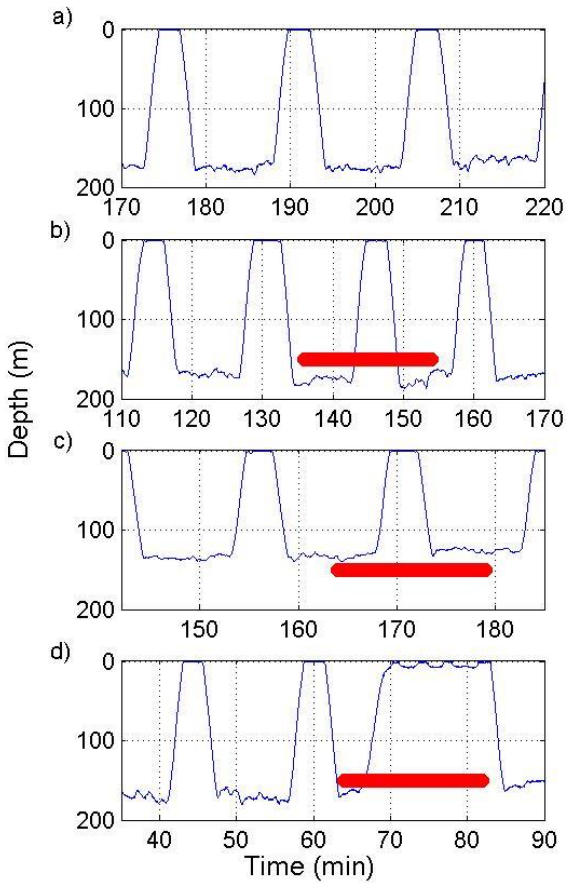

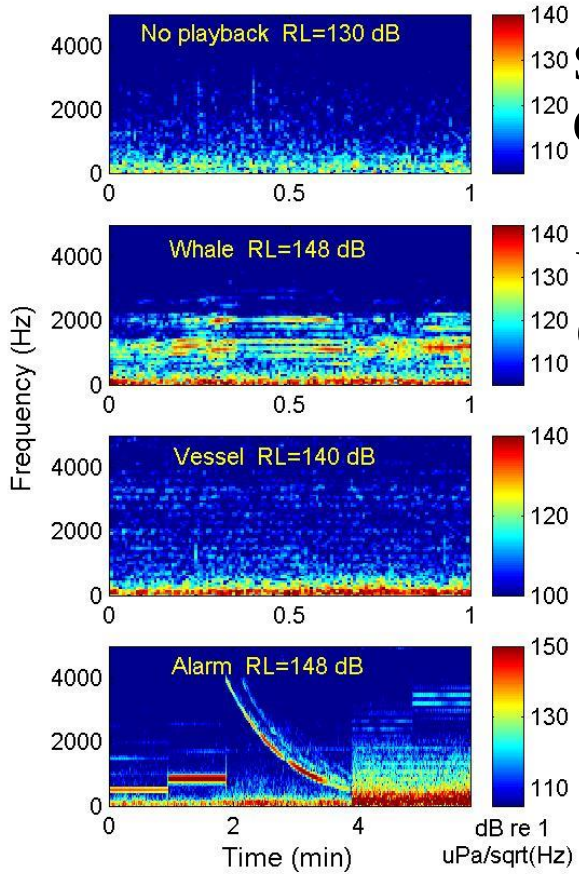

Silent Control

Whale Calls

Vessel Noise

Alerting Control

Right whales exposed to 'annoying' sounds

Nowacek et al. 2004

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Blue Whale Response Probability Functions

Southall *et al*. (*in prep*) used recurrent event survival analysis to determine relationship between exposure dose (cSEL) and p(resp) for different severity levels, individual behavioral state, and source-animal range

- Prelim results removed from presentation, will hopefully be published in final form late 2016.

Context (behavioral state; source range) determines p(resp) as much or more than exposure RL in blue whales

‘Nonlinear’ features of killer whale calls

Tyson et al. 2007

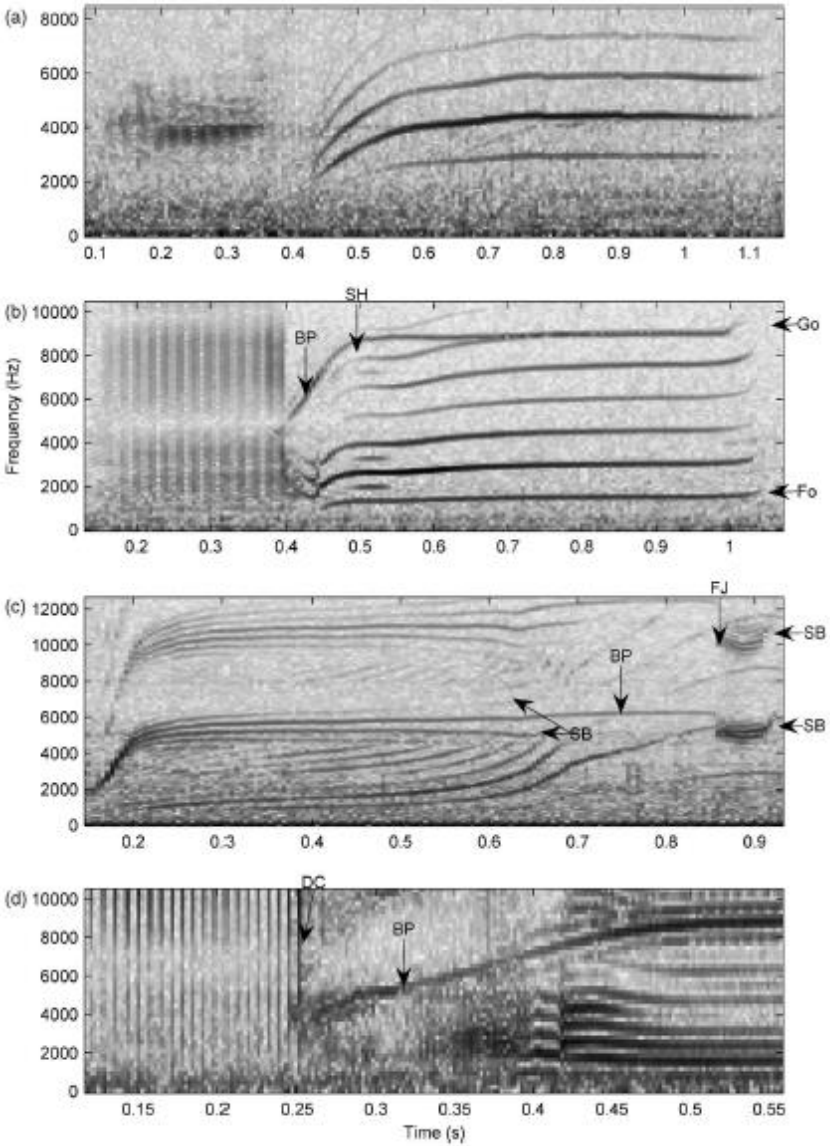
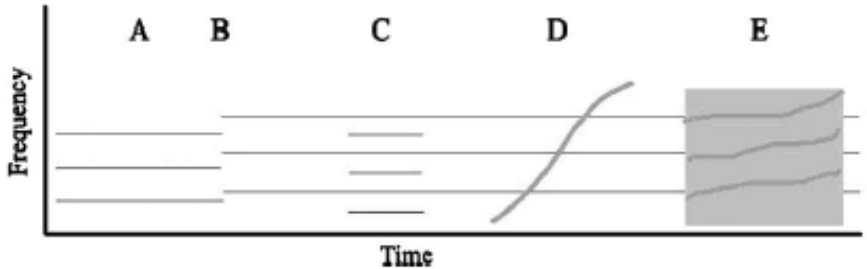
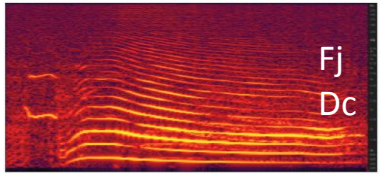


FIG. 3. Spectrograms of representative killer whale vocalizations exhibiting nonlinear phenomena (note: spectrograms are zoomed in on for better resolution). (a) Stable limit cycle (SLC) following the characteristic introductory buzz. (b) Introductory buzz then biphonation (BP) in the form of a nonparallel band and subharmonics (SH); G_o is the high frequency component, F_o is the low frequency component. (c) Nonparallel BP with sidebands (SB) appearing around the G_o and a frequency jump (FJ) to a lower frequency with SB's being produced at a new lower rate. (d) Introductory buzz followed by deterministic chaos (DC, initiation indicated by arrow) and then a transition into a nonparallel BP and a SLC.



Oo-2



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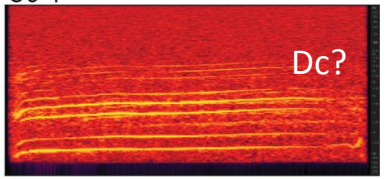
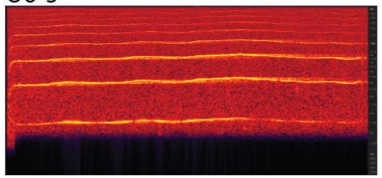
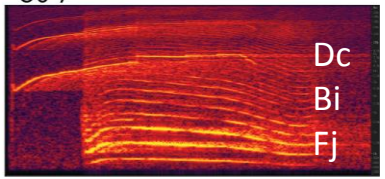


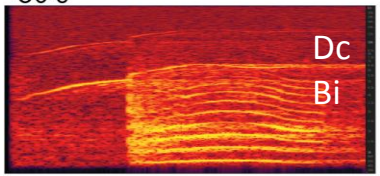
Oo-5



*Oo-7



*Oo-8



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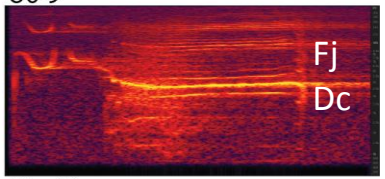
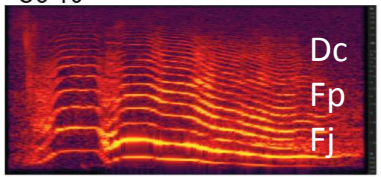
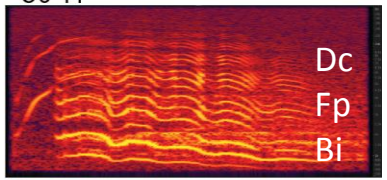


*Oo-10



*Oo-11



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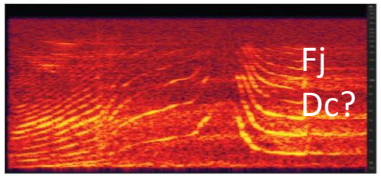

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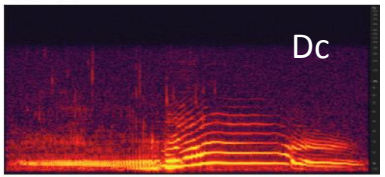

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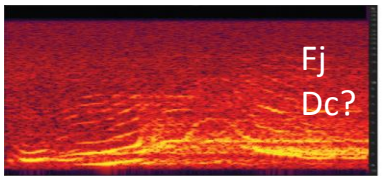
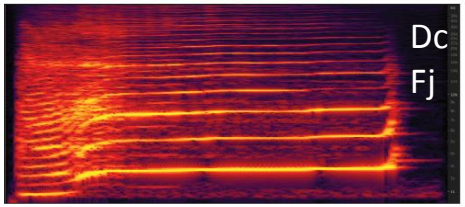
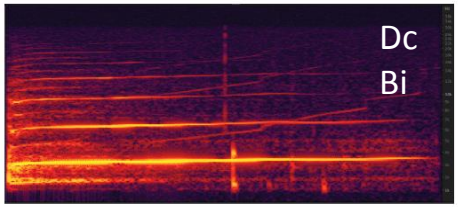


Gm-1



Gm-5



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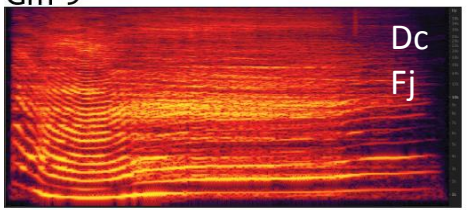

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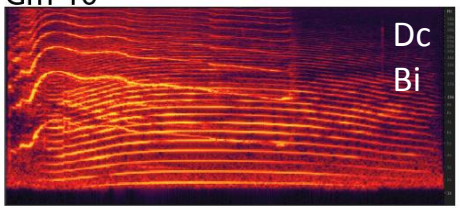

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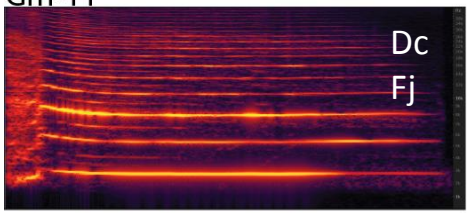

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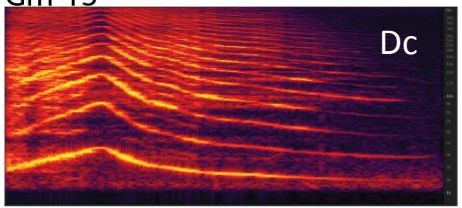
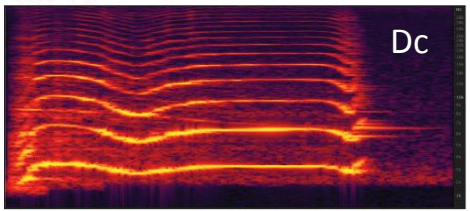


Gm-15



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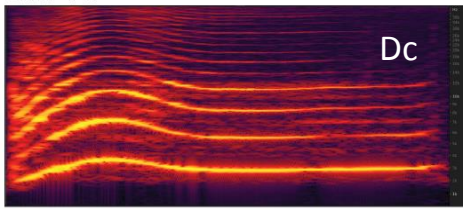
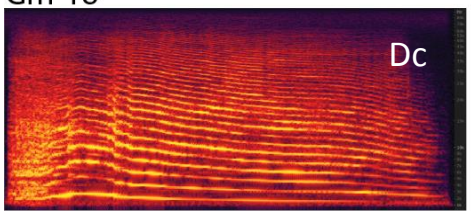


Gm-18



REVIEW

Calls out of chaos: the adaptive significance of nonlinear phenomena in mammalian vocal production

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biology letters
Biol. Lett. (2012) 8, 189–192
doi:10.1098/rsbl.2011.0832
Published online 5 October 2011
Animal behaviour

Scared and less noisy: glucocorticoids are associated with alarm call entropy

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What is the sound of fear? Behavioral responses of white-crowned sparrows *Zonotrichia leucophrys* to synthesized nonlinear acoustic phenomena

Ellen K. BLESDOE[1], Daniel T. BLUMSTEIN[1, 2*]

SUBHARMONICS, BIPHONATION, AND DETERMINISTIC CHAOS IN MAMMAL VOCALIZATION

I. WILDEN[1], H. HERZEL[2*], G. PETERS[3] AND G. TEMBROCK[1]

biology letters
Biol. Lett. (2011) 7, 47–49
doi:10.1098/rsbl.2010.0537
Published online 21 July 2010
Animal behaviour

The function of nonlinear phenomena in meerkat alarm calls

Simon W. Townsend[1,2,*] and Marta B. Manser[1,2]

The Sound of Arousal: The Addition of Novel Non-linearities Increases Responsiveness in Marmot Alarm Calls

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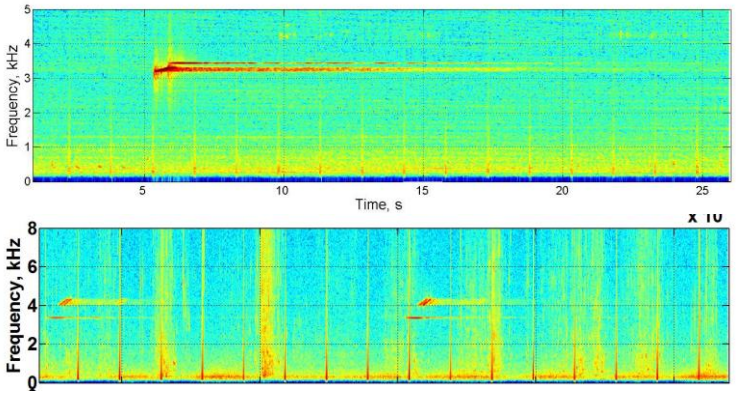
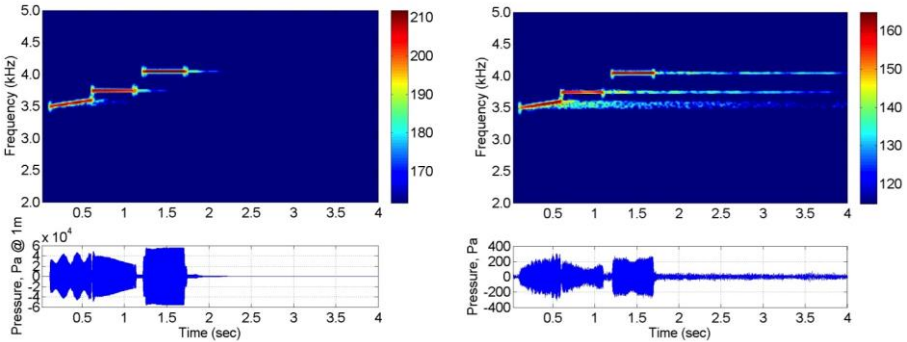
Features of KW calls and MFAS



Two-element MFAS signal from a 53C surface vessel (top) and from a helicopter dipping sonar (bottom), from SOCAL.



Simulated MFAS signal recorded at the source (A) and on a tag attached to a blue whale off SOCAL (B)

- Frequency jumps?
- Biphonation?
- Propagation effects?

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MARINE CONSERVATION ECOLOGY

- Synthesizing what we have learned from marine mammals and others about responses to predator calls *vis a vis* sonar…
  - Some predator signals evoke differential responses – why?
    - Age and/or sex class?
    - Previous exposure? E.g., naval ranges
    - Social factors, e.g., who is currently with you? What is your social structure?
    - Allopatric predators – different response?
    - Recognition of predator vs. competitor
    - Acoustic differences of allopatric predators
  - Evidence for generalizing or is the test of a small number of exemplars?
  - Two 'fight' species take flight…?
  - Distance to potential predator matters
    - Ability of animals to resolve range vs. RL
  - Ability to resolve MEKs from FEKs?
  - Features of KWs signals that cause alarm?
    - Multiple nonlinear dynamics? Combinations?
    - Significance to the killer whales?
    - Similarities to sonar?

What can we learn about our experimental protocols…

- What are the best stimuli?
  - Synthetic? Altered? Sympatric vs allopatric?
- What are the best control stimuli
  - Noise?
  - Non-threatening sympatric species?
  - Conspecifics?
  - Silence?
- Duration of exposure
- Source – stationary vs. moving
- Ever present pseudoreplication…

"If we knew what we were doing, it wouldn't be called 'research', would it?"….Einstein

Thanks to all who contributed, hope it sparks some discussion

Tyack, Miller, Curé, Read, Bowers, Southall, Janik, Sayigh, Quick, Deecke, Thomas, DeRuiter, Harris, etc…

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‘Nonlinear’ dynamics in **right whale** calls

Tyson et al. 2007

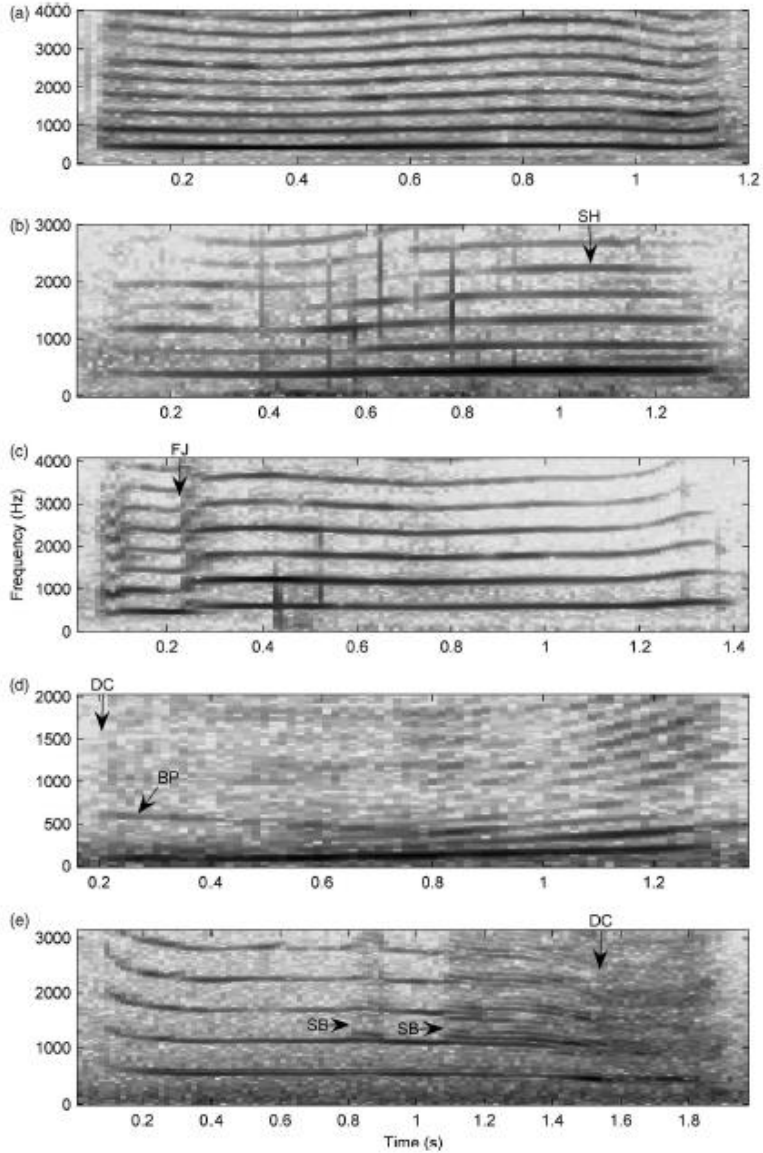

FIG. 2. Spectrograms of representative right whale vocalizations exhibiting nonlinear phenomena (note: spectrograms are zoomed in on for better resolution). (a) Stable limit cycle (SLC). (b) SLC then initiation of subharmonics (SH) indicated by arrow. (c) SLC then a frequency jump (FJ) to a higher frequency. (d) Deterministic chaos (DC, initiation indicated by arrow) with an embedded nonparallel biphonation (BP), then a transition to a SLC. (e) SLC then BP in the form of sidebands (SB) being produced twice, the second time transitioning into DC.

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