

## T. Aran Mooney: (Marine Mammal) Temporal Resolution

### Odontocete Auditory Temporal Resolution

Localization of sounds is perhaps the most important function of hearing and identifying a sounds location is often aided by temporal cues. I am investigating how fast various species can receive and process short sounds and the comparative relationship between marine species. We've looked the temporal processing and its relationship to hearing and echolocation. The papers are summarized below.

#### Finless porpoise



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Auditory temporal resolution and evoked responses to pulsed sounds for the Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*)

Temporal cues are important for some forms of auditory processing, such as echolocation. Among odontocetes (toothed whales, dolphins, and porpoises), it has been suggested that porpoises may have temporal processing abilities which differ from other odontocetes because of their relatively narrow auditory filters and longer duration echolocation signals. This study examined auditory temporal resolution in two Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*) using auditory evoked potentials (AEPs) to measure: (i) rate following responses and modulation rate transfer function for 100 kHz centered pulse sounds and (ii) hearing thresholds and response amplitudes generated by individual pulses of different durations. The animals followed pulses well at modulation rates up to 1250 Hz, after which

response amplitudes declined until extinguished beyond 2500 Hz. The subjects had significantly better hearing thresholds for longer, narrower-band pulses similar to porpoise echolocation signals compared to brief, broadband sounds resembling dolphin clicks. Results indicate that the Yangtze finless porpoise follows individual acoustic signals at rates similar to other odontocetes tested. Relatively good sensitivity for longer duration, narrow-band signals suggests that finless porpoise hearing is well-suited to detect their unique echolocation signals.

Mooney, TA, Li, SH, Ketten, DK, Wang, K, and Wang D. 2011. Auditory temporal resolution and evoked responses to pulsed sounds for the Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*). *Journal of Comparative Physiology A*. 197:1149–1158. doi: 10.1007/s00359-011-0677-y



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#### Wild white-beaked dolphin

Auditory temporal resolution of a wild white-beaked dolphin (*Lagenorhynchus albirostris*)

Adequate temporal resolution is required across taxa to properly utilize amplitude modulated acoustic signals. Among mammals, odontocete marine mammals are considered to have relatively rapid temporal resolution, which is a selective advantage when processing fast traveling underwater sound. However, multiple methods used to estimate auditory temporal resolution have left comparisons among odontocetes and other mammals somewhat vague. Here we present the estimated auditory temporal resolution of an adult male white-beaked dolphin, (*Lagenorhynchus albirostris*), using auditory evoked potentials and click stimuli. Ours is the first of such studies performed on a wild dolphin in a capture-and-release scenario. The white-beaked dolphin

followed rhythmic clicks up to a rate of approximately 1125-1250 Hz, after which the modulation rate transfer function (MRTF) cut-off steeply. However, 10% of the maximum response was still found at 1450 Hz indicating high temporal resolution. The MRTF was similar in shape and bandwidth to that of other odontocetes. The estimated maximal temporal resolution of white-beaked dolphins and other odontocetes was approximately twice that of pinnipeds and manatees, and more than ten-times faster than humans and gerbils. The exceptionally rapid temporal resolution abilities of odontocetes are likely due primarily to echolocation capabilities that require rapid processing of acoustic cues.

Mooney, TA, Nachtigall, PE, Taylor, KA, Rasmussen, MH, and Miller, LA. 2009. Auditory temporal resolution of a wild white-beaked dolphin (*Lagenorhynchus albirostris*). *Journal of Comparative Physiology A*. 195:375-384.

#### Risso's dolphin

Rapid auditory evoked responses and high temporal resolution in a Risso's dolphin, *Grampus griseus*



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Toothed whales and dolphins (Odontocetes) are known to echolocate, producing short, broadband clicks and receiving the corresponding echoes, at extremely rapid rates. Auditory evoked potentials (AEP) and broadband click stimuli were used to determine the modulation rate transfer function (MRTF) of a neonate Risso's dolphin, *Grampus griseus*, thus estimating the dolphin's temporal resolution, and quantifying its physiological delay to sound stimuli. The Risso's dolphin followed sound stimuli up to 1000 Hz with a second peak response at 500 Hz. A weighted MRTF reflected that the animal followed a broad range of rates from 100-1000 Hz, but beyond 1250 Hz, the animal's hearing response was simply and onset/offset response. Similar to other

mammals, the dolphin's AEP response to a single stimulus was a series of waves. The delay of the first wave, P1, was 2.76 ms and the duration of the multi-peaked response was 4.13 ms. The MRTF was similar in shape to other marine mammals, except that the response delay was among the fastest measured. Results predicted that the Risso's dolphin should have the ability to follow clicks and echoes while foraging up to an extremely close range.

Mooney TA, Nachtigall PE, Yuen MMY. 2006. Temporal resolution of the Risso's dolphin, *Grampus griseus*, auditory system. *Journal of Comparative Physiology A*. 192: 373-380.



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### Cephalopod auditory temporal resolution...?

We've been examining if and how squid can follow individual pulsed sounds and the maximum rate they can follow.

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