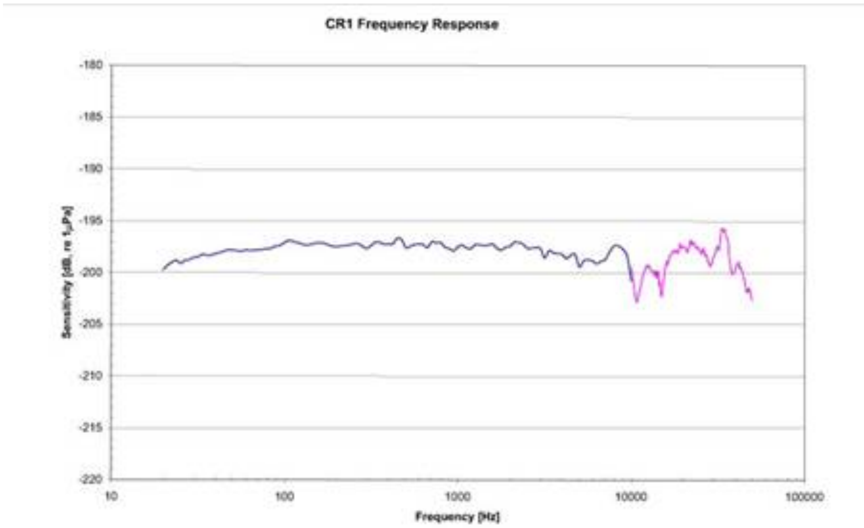
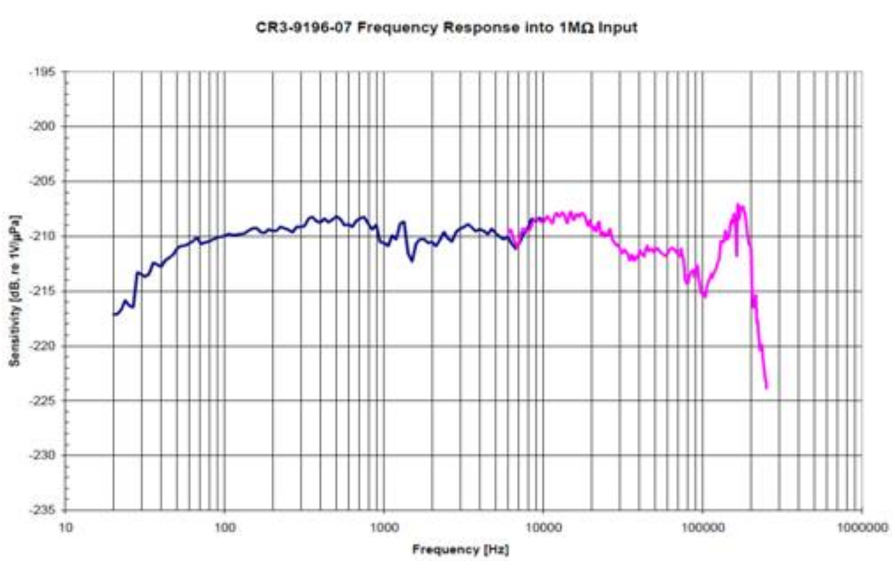
Descriptions of the 96 kHz and 500 kHz Recording Systems

The .wav files collected in the Peruvian Amazon basin were recorded using two systems. The majority of the recordings between 2007-2013 were recorded using a Cetacean Research Technology CR1 Hydrophone and Microtrack 24/96 digital tape recorder. Sample rates used were 96 kHz/second yielding a useful frequency range of about 46 kHz. The hydrophone sensitive curve is included below.



In addition a prototype Dolphin Recording System (DRS) was tested in the same Amazonian region in 2012. The system consisted of a Cetacean Research Technology CR 3 Hydrophone, a Reson preamp and an IOTech Personal Daq/3000 Series digital acquisition system. Recording sample rates were set at 400 or 500 kHz/second yielding recordings up to about 195 to 230 kHz. Below is the CR 3 Hydrophone response curve.



Acoustic Challenges in the Amazon Environment

Physical
Environmental factors in the Amazon River basin, such as frequent heavy rain, submerged trees, floating vegetation, bank proximity, river debris, flow noise at the hydrophone face and varying riverbed substrates, impact the recordings. Additionally, surface and bottom reflected echoes and reverberations are common in areas with water depths ranging from 3 to 10 meters in the tributaries where the majority of *Inia* have been recorded by us and up to 50 meters in the main Amazon channel. Finally, anthropogenic interference from both powered river craft and noise from riverside human activities are also frequently encountered.

Biological
Inia acoustics are challenging to analyze due to complications associated with sampling in a turbid, complex and shallow water environment. First, visual counts of dolphins present during recordings are difficult to ascertain due to the typically opaque Amazonian habitat, along with the dolphins' unpredictable and low profile surfacing behavior characterized by a small dorsal hump. Additional observational confusion is encountered due to the lack of fused cervical vertebrae that permit *Inia* to bend into a "U", such that the flukes are next to the rostrum. Thus, a single dolphin may appear as two animals, as depicted below. Consequently, the number of vocalizing dolphins in each sample are only estimates, and may not be accurate (see Gomez-Salazar et al. 2012 for similar challenges).

Furthermore, some of the recordings also include the sympatric tucuxi (Sotalia *fluviatilis).* Although these two species are morphologically different, there is some overlap in acoustic signaling. *Inia* are comparatively larger than *Sotalia,* characterized by lengths of up to 255 cm for males and 215 cm for females, whereas *Sotalia* grow to approximately 152 cm. While both species emit clicks, only *Sotalia* are known to produce pure tone whistles. However, *Inia* also generate short duration squeals.

Unique *Inia* Morphology and Physiology
Inia has a large pronounced melon and a long narrow cylindrical rostrum. Observations of *Inia* show that the species has a unique ability to change the shape and orientation of the rostrum and melon (Penner & Murchison, 1970). Transmitting and receiving acoustical energy and processing are not well understood, although the physiological components for *Inia* acoustics has been described (Keiten, 1997). Sexual dimorphism and age related size/weight are also factors that could affect the bioacoustic properties and require further investigation.

(Best, R.C. & da Silva, V.M.F., 1993. Inia geoffrensis. *Mammalian Species*. 426, 1-8.)
This figure illustrates the long length of the *Inia* rostrum.

DRS and Microtrack Recording Log

In addition to the previously described environmental conditions, the DRS prototype experienced significant self-generated electronic noise which reduced the signal to noise ratio significantly. While deployed in the natural habitat electronic interference was caused by poor grounding and wetted connections. Although these problems were common in the 2012 Amazonian recordings, a number of .wav files were captured that showed click frequency components up to the maximum Nyquist criteria.

Furthermore, in the 2012 Amazonian recordings gain settings in the DRS prototype system were varied in an attempt to compensate for the wide amplitude range of dolphin signals and environmental background noise. Because much of the energy recorded was ultrasonic, system clipping (overloading) was encountered. No automatic gain control (AGC) was incorporated in either the DRS or Mictrotrack systems.

In 2013 the DRS and the Microtrack systems were deployed to Mosquito Lagoon on the Indian River Florida where *Tursiops* were recorded simultaneously with the two systems. DRS noise reduction measures were mostly successful and much improved SNRs were experienced. However, gain settings were manipulated between recordings.

Summary

Despite the shortcomings, this system did provide evidence of broad and narrow band pulsed signals up to approximately 240 kHz for both species. Furthermore, simultaneous recordings were made using the Microtrack digital recorder sampling at 96 kHz.

The accompanying Spread Sheet documents each recording.

References

Gomez-Salazar, C., Trujillo, F., Portocarrero-Aya, M., & Whitehead, H. 2012. Population, density estimates, and conservation of river dolphins (Inia and Sotalia) in the Amazon and Orinoco river basins. Marine Mammal Science. 28(1), 124-153.
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Keiten, D.R. 1997. Structure and function in whale ears. *Bioacoustics*, *The International Journal of Animal Sound and its Recordings.* Vol. 8, pp. 103-135

Penner, R.H. & Murchison, A.E. 1970. Experimentally demonstrated echolocation in the Amazon River porpoise, Inia geoffrensis (Blainville). Naval Undersea Research and Development Center, Ocean Sciences Department. June 1970.