

Up Close and Personal: Recording Humpback Whale Song at Close Ranges (10-50m)

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Abstract: Male humpback whales (*Megaptera novaeangliae*) produce long, complex vocalizations consisting of a hierarchically-structured sequence of distinctive broadband ‘units’, each of a few seconds’ duration. The function of this “song” remains unclear. Singers are often observed in a stationary position with their body inclined downwards while vocalizing for about 10-12 minutes. The posture is suggestive of the singer attempting to optimize song propagation, but without calibrated measurements of the sound speed profile, source characteristics, range and orientation to the singer at close range, such ideas are difficult to test. Previous recordings have been made at considerable distance, where absorption, multipath and other propagation effects are imposed on the signal and the orientation to the singer is unknown. Prior recordings are also usually of low bandwidth. Recent work, however, has suggested that, close to the singer, song units may contain significant energy up to 20 kHz. The Acoustic Research Laboratory, Tropical Marine Science Institute at the National University of Singapore in collaboration with the Kewalo Basin Marine Mammal Laboratory of the University of Hawaii have deployed two types of acoustic recording systems in close proximity to singers in addition to CTD casts taken by the US Geological Survey. The first acoustic system is a digital video camera in an underwater

housing with built-in hydrophone, recording at 44.1 kSa/s and operated by rebreather divers who are able to simultaneously ascertain both orientation and range to the singer using an ultrasonic depthsounder. The second is a custom-built self-contained high-frequency system with four hydrophones in an array that recorded at 250 kSa/s per channel. Both systems provide extremely high signal-to-noise ratio (typically 60 dB) calibrated recordings without propagation artifacts. Individual song units have been analyzed for power spectral density. Results indicate that most of the energy is located below 5 kHz with occasional harmonics up to 8 kHz. Individual units from a 6-minute sequence of 134 units were classified into 12 types with four classes containing 80% of the units. Comparisons of the power spectral densities within and across the four most common classes were conducted. Variations within classes were found to be within 7 dB when normalized for total power. Differences between the classes were small (up to 5dB) in the range of 500-1800 Hz and larger (up to 14dB) in the range from 1800-3500 Hz. The high-frequency recording system provides independent verification within the overlapping frequency range of both systems as well as information about the frequency content above 22 kHz up to 120 kHz.