# ACOUSTIC AND VISUAL TRACKING REVEALS DISTRIBUTION, SONG VARIABILITY AND SOCIAL ROLES OF HUMPBACK WHALES IN HAWAIIAN WATERS

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By

Adam S. Frankel

Dissertation Committee:

Louis M. Herman, Chairperson
Alexander Malahoff
Craig R. Smith
Dixon Stroup
Joseph R. Mobley, Jr.

This dissertation is dedicated to my parents, Patricia M. Frankel and Alan Arby Frankel, Ph.D.. I wish that he were here to see the next Dr. Frankel.

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# Abstract

Acoustic and visual methods were used to track and observe humpback whales off Hawai'i. Chapter 3 found 62 singing whales were located acoustically in water depths from 10 to 305 fathoms. This indicates that singers are not confined within the 100 fathom contour, although near shore waters had a higher density of singers. The relative bearings from one singer to another indicated that singers predominantly oriented and moved away from other singers. A negative relationship was found between change-in-separation and the initial distance between singers, thus singers close to another were more likely to increase their separation. These observations suggest that 4 km is the preferred minimum spacing between singers off Northwestern Hawai'i. Some singers actively swam while singing and others continued singing while affiliating with or being joined by other whales. The correlation between breaching and the cessation of singing suggests that the sounds of aerial behavior can convey information to other whales.

Humpback whales song has been characterized as having the same structure shared by all individuals simultaneously. Chapter 4 found that the songs of individual whales were significantly different from one another at the level of the song unit. Significant differences were found in the duration, bandwidth, lowest frequency, frequency of peak amplitude and the source level of different singers. The implication of these findings is that these small scale differences allow for the possibility of assessment of the song and the singer by other animals.

The opposite end of the acoustic sensory modality was examined in Chapter 5. Whales responded to playbacks of biological and synthetic sounds. An empirically determined measurement of sound transmission loss allowed the received sound levels to be estimated when the stimulus was presented. The lowest sound level that produced a response was 102 dB re 1 μPa. This corresponds to a 16 dB signal-to-noise ratio. This

value is probably an underestimate of the response threshold and certainly an underestimate of their hearing threshold.

Taken together, these findings reported here suggest the need to expand the traditional interpretations of singing humpback whales as obtained from visual observations alone.