Localizing Vocalizations in southern resident killer whales: A look at Gender Differences

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Introduction

The southern resident killer whales (*Orcinus orca)*, known as J, K, and L pods, forage in the inland and coastal waters of Washington State and British Columbia. The social and acoustic associations characterize the relatedness of this population. A pod is a primary social unit made up of stable matrilines that associate regularly (≥50% of observation time), and emigration of males or females hasn't been observed (Yurk et al., 2002). These stable kin groups are believed to share a unique repertoire of discrete call types; and pods that are acoustically related and share parts of these vocal traditions are called an acoustic clan (Ford, 1991). A community is when pods have frequent associations with one or more pods and have different distributions in relation to other communities (Ford, 1987). Hence, J, K, and L pods socially make up the southern resident community (about 90 whales) and are acoustically know as the J clan, distinguishing them from the northern resident community of 16pods (about 200 whales) and acoustically known as A, G, and R clans (Ford 1991).

Killer whale vocalizations are grouped into three categories, clicks, whistles, and calls. Clicks are very short bursts of sounds (0.1-25ms), characteristically in series (Ford, 1987). Clicks are used as echolocation in the detection and pursuit of prey, as well as during social encounters (Barrett-Lennard et al., 1996). Whistles are tonal in characteristics, commonly with a continuous waveform, which appears in spectrographic analysis as a narrow-band tone with or without harmonics (Thomsen et al., 2000). Whistles are believed to play an important role in the

close range acoustic communication in northern resident killer whales (Thomsen et al., 2002). Calls have been classified as pulsed signals generated at high repetition rates; most fall into distinctive structural categories referred to as discrete calls (Ford, 1987). These discrete calls are the most common sound type during activities when individuals are widely spaced, like in foraging. Suggesting that discrete calls help with cohesion or coordinate with members of the social group (Ford, 1991). These discrete call types are shared among pods, but often seen in different forms specific to each pod or groups of pods. Variability in structure of these discrete calls was common in all categories. Also there appears to be variation in the sound production within madrilènes of pods (Miller and Bain, 2000).

Furthermore, social dynamics and differences between males and females within a pod are quite extensive. For instance, the morphological differences like overall size (adult males ranging in size from 8-9meters and adult females about 7meters), adult males weighing between 10-11 tons and females 7-8 tons (Bigg et al., 1987). While foraging, whales have been seen to swim in percussive arrangements, change to spread out movements of milling, and peripheral males have been seen milling what appears off on their own. (Felleman et al., 1991). Also seen in foraging behavior whales tend to spread out over an area of about 3-10 km^2 and have been seen in different social organizations (Osborne, 1986). When foraging, the pod or subpods are often seen in different spatial arrangements. It has also been documented that adult males dive deeper more often than adult females (Baird et al., 2005). Are these differences in foraging behavior, spatial differences, perceived as minimizing competition for food or are the males scouting for food and then determining where the pod travels next? Thus, I will consider if there are any variations in calls (duration, high and low frequency, change in frequency, and peak amplitude) in regards to gender.

The goal of my study is to localize vocalizations from individuals in the southern resident community with the intent to study gender differences. By localizing the calls of males and focal female matrilines, I hope to understand more about the communication of these animals and might reveal more information about their social organization. Such research is currently relevant due to recent population declines of southern resident killer whales and the recent Endangered Species Act listing (NMFS, 2005). Being able to acoustically recognize individuals would allow acoustic tracking, this is especially important when the winter range is unknown for these animals. Also information on variations in vocalizations among individuals will be useful for description of social roles and acoustic behavior within the population. Are there variations in calls in regards to gender? Do the attributes of male and female calls differ? I hypothesize that the physical measures of those calls will differ from other members or individuals in the pod.

Materials and Methods

Data Collection:

Acoustic and surface behavior observations of the southern residents will take place in the greater Puget Sound region, including the San Juan Islands and adjacent waters around the southern end of Vancouver Island. Fieldwork begins October 2-21, 2006, and one week on land to analyze data will follow. Recordings and observations will be made from a 42' catamaran, known as the Gato Verde. This vessel is propelled primarily by the wind, but can also be powered by twin diesel engines that burn 80% biodiesel. Everyday we will be getting assistance finding the whales using the Whale Watchers' pager system. We will abide by the voluntary Be Whale Wise Guidelines paralleling them and recording when whales are within about 500m of

the vessel. So, when we encounter whales we will take a GPS way point at the time of deployment of the towed hydrophone array, which will be used to assist in localizing the calls of focal animals. There will be continuous recording throughout the time we see whales. The array of four hydrophones will be in linear formation and attached to the starboard hull of the catamaran. The total length of this array is 52.60m. The distance from the stern of the boat to each of the hydrophones is 19.1 m, 27.97m, 36.83m, and 46.18m respectively. The estimated depth of the array is approximately 2m. Hydrophone #2 was calibrated using a National Institutes of Standards and Technology hydrophone. When whales are present, I will be located at the bow of the boat with my clipboard, PDA (palm Tungsten E and software provided by Dr. James Ha, University of Washington), clipboard with paper and pencil backup for observational data, watch, bearing chart, binoculars, laser range finder, and an assistant with a camera. I will not collect surface data if the whales are in close/ tight knit groups. Opportunistically, when whales are spread out I will choose my focal groups to get acoustic and surface behaviors. My focal groups will consist of lone males or more than one male traveling together and a matriline with primarily only females that are acoustically isolated from other pod members. To decrease the possibility that my sample was dominated by one vocalizing individual, I will try to conduct at least another recording sessions of each focal group with more than one individual (Miller and Bain, 2000). Once I find my focal groups, I will find the bearing from the center of the boat (which I will have to adjust when analyzing ISHMAEL'S bearing), and determine their distance, either exact distance with a range finder or do an estimate. Then I will count the number of individuals in the focal group (time stamped in the PDA). If the focal animal/s are not identified at the time of surface recording, we will photograph each focal group and document in writing which frame on the camera matches the calls recorded. We will later use the Center for Whale

Research Field Guide, 2006 color edition. The last observation recorded in the PDA will be the predominant behavior state, as sited below (Osborne, 1986). When our data collection has ended I will take another GPS way point, bring in the array, and prepare the sound recording for acoustic analysis.

Behavior States:

Resting: Often a tight cluster of whales moving slowly often in synchronized formations. Traveling at speeds around 1-2 kn. Stationary resting, known as logging, are when whales hover at the surface of the water (up to 1.5 min. at a time).

Traveling: Directional movement at a steady pace (+3.5 kn) over a minimum distance of 2-3 km. Staying together as a pod, not necessarily synchronized, however it does occur.

Foraging/milling: Loose forward orienting; non-directional milling; percussive activity; spread out over a 3-10 km^2 region; sometimes sudden bursts of energy that appears like chasing.

Surface Active: Explosive surface acrobatics (breaches, porpoising, and cartwheels). There are also other low level activities such as tail lobs, pectoral slaps, dorsal fin slaps, spyhops, and any other splashing behavior. When whales are seen manipulating seaweed or any other object.

Other: This is a category where a behavior might be difficult to put into a category. Sexual behavior or courtship are a few examples that might fit into this category.

Data Analysis:

Information collected on my PDA (numbers in focal group, bearing, distance, predominant behavior state, and Pod I.D.) will be downloaded and transferred to my data file stored in excel (Appendix 1). I will take the time in which my focal group was isolated by

distance from the rest of the pod and go to my vocalization recordings. The hydrophone array will be attached to a red box, where the National Instruments Board took the output from the four channels of the hydrophone array into a laptop. Series of sound files, which will be time stamped and stored every 10 minutes, will be used to record the data using a software program known as ISHMAEL 1.0. To localize, this program calculates the algorithm for the time delay to each phone; produces a bearing to the animal/s and an estimated location using phone pairs and the hyperbolic method. I will only look for calls to localize within 5 minutes of the time I saw an isolated focal group . Once I am confident of the call/s within that window, will I go on to analyze the structures of the calls. Vocalizations in which consistent angles to the sound source could not be verified with this program's locations will be thrown out. Vocalizations recorded from a localized source will be measured to estimate the variation in the call characteristics within a single individual (male) or small group (females). I will use a software program called Raven version 1.2.1. to analyze the structure of the calls (sampling rate of 22050 samples per second, and using an FFT rate of 512). Measurements of the minimum, maximum, and change in frequencies, call duration, and amplitude will be taken from each of the localized sample vocalizations. To statistically analyze the variations in calls I will use a t-test to determine if each of the physical measures of calls varies with gender.

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Appendix 1: Data Sheet

Date:							
GPS way pt							
Pod							
# of indiviudals							
Photo I.D.							
Bearing							
Distance							
Predominant group behav							
File #							
Min. frequency							
Max. frequency							
Change in frequency							
Call duration							
Amplitude							
Other							