An acoustic and behavioral analysis of the southern resident killer whales of British Columbia: How does gender and age affect behavior states and discrete calls?

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The southern resident killer whale community of British Columbia is made up of three pods that collectively make up 90 individuals (Center for Whale Research 2007). A pod is defined as a social unit in which the whales spend at least 50% of their time together (Ford et al. 2000). They socialize regularly, share acoustic calls, and the pods made up of tightly knit matrilines. The offspring in these resident pods have never been seen to disperse from their mothers. Pods that share acoustic similarities belong to clan. The J, K, and L pods which make up the southern resident community share some discrete calls, which place them in J clan (Ford et al. 2000). Although they have some acoustic similarities, there are calls that are pod specific. It is unknown if there are any that are individually specific calls, although a study has shown that there does not seem to be signature whistles (Riesch et al. 2005).

The goal of this study is to 1- localize killer whale calls in order to identify specific individuals and investigate whether calls are gender and/or age specific and 2- to collect surface behavior data in order to distinguish whether there are behavioral differences between genders and different age classes. The answers to these questions are relevant to the current management plans for the southern residents. It would be advantageous to have the ability to distinguish gender acoustically because it would provide insight into the male: female ratio when the whales are out of sight. It would also

be beneficial to distinguish the types of calls transmitted from calves to mothers in order to establish how anthropogenic noise could affect their communication.

It is unknown whether behavior and acoustic differences between genders are prevalent in killer whales. Killer whales produce three types of sounds: clicks, whistles and calls (Saultilis et al. 2005). Whistles are tonal sounds that last about 1.8 seconds and have an average frequency of 8.3 kHz (NMFS 2006). Discrete pulsed calls are the most common type of vocalization of the southern residents. Call frequencies are generally between 1-6 kHz, but can extend up to 30 kHz (NMFS 2006). Although it is unknown whether discrete calls differ between gender or age, there is evidence that the range of frequency is related to body size (May-Collado et al. 2007). It is believed that a large factor in intraspecific variation could be related to a morphological constraint such as body size or mass. There is a great size variation in the toothed whales, *Odontoceti* is correlated with minimum frequency (May-Collado et al. 2007). The larger toothed whales have a greater range in reference to low frequencies when in comparison to smaller toothed whales (May-Collado et al. 2007). This may indicate that adult male killer whales are able to produce lower frequency calls due to sexual dimorphism, as males are approximately 10 meters whereas females range from 6-8 meters (Baird 2006).

It also may be possible that there are sounds or calls produced more frequently, or solely by males. These sex-specific acoustics have been proven in various animals such as the sperm whale and many species of birds (Jaquet et al. 2001, Alcock et al. 1998). In an isolated population of transient killer whales in southern Alaska, it is known that lone males make loud, discrete calls that last from 1-4 s, which is significantly longer than their average hunting call (Saulitis et al. 2005). These calls are thought to send

multiple pieces of information during long distance communication (Saulitis et al. 2005). Although the social behaviors of resident and transient killer whales differ greatly, it indicates that there is a possibility that the southern resident males also have distinct calls. Foreman (2006) also found the southern resident males have lower frequency fundamentals and shorter calls than females. Due to these data I hypothesize that the southern resident adult males will produce calls more frequently, at lower frequencies, and have calls that are somewhat distinct from the rest of the population.

Along with sex-specific calls, there may also be sexually specific behavior, which has been found in other delphinids (Kaplan et al. 2007). A population of over 600 bottlenose dolphins (*Tursiops truncatus*) in Western Australia exhibits a behavior known as contact swimming in which one dolphin places a pectoral fin on the flank of another dolphin (Connor et al. 2005). Two adult females exhibit this behavior even when they are in a group dominated by males (Connor et al. 2005). It is thought that since this position looks much like a mom and her calf, it is more commonly found in females because they provide parental care and males do not (Connor et al. 2005).

My second study question asks whether age plays a role in the behavior and acoustics of the southern residents. The birth of a killer whale is a group event for the whole pod (Baird 2002). The acoustic behaviors of three northern resident matrilines were observed after births of calves (Weib et al. 2005). All pods increased their family-specific call rates, and showed a very high rate of excitement calls, all of which peaked in the days followed by the birth, and then dropped back to normal levels approximately two weeks after (Weib et al. 2005). It is known that infants learn their calls from their mothers, and tend to vocalize less in their first year of birth (Baird 2002). Infants tend to

separate (more than 16 m) from their mothers more than once an hour (Baird 2002). One fourth of their time is spent either playing with siblings or by themselves (Baird 2002). During these times, are they communicating with their mothers and with other members of the pod? If they are in contact with their mother, what kind of calls are they producing?

Tactile behaviors in Atlantic Spotted dolphins, *Stenella frontalis* have been proven to vary greatly with age class, mostly in regards to petting and rubbing (Kaplan et al. 2007). Juveniles engage in these behaviors much more frequently than adults (Kaplan et al. 2007). They also tend to play with other juveniles that are of the same sex (Kaplan et al. 2007). With this in mind, do juvenile killer whales exhibit certain behaviors more frequently than adults? I hypothesize that juvenile killer whales exhibit more tactile behaviors than adults.

The northern and southern resident killer whales have home ranges that greatly overlap, yet they belong to different acoustic clans and do not seem to interact (Riesch et al. 2005). Since the clans have specific dialects, and within clans there are pod specific calls, it seems possible that there are gender, age, or even individual calls that could be localized and identified. If these whales show age and gender specific communication, it could also be possible that they exhibit specific behaviors that coincide with their calls. I hypothesize that there are definitive differences between the call rates and behavior of males and females, and between different age classes.

Materials and Methods

I will be collecting two different sets of data, one for acoustic behavior and the other for surface behavior. All data will be collected aboard the *Gato Verde*, a 42' electric

powered catamaran, in the inland waters surrounding the San Juan Islands, Washington. The recordings and behavioral data will only be collected from the J, K, and L southern resident pods. We will be following the Whale Watch Guidelines in order to ensure a minimal impact on the whales (The Whale Museum 2006).

For the acoustic part of my study, I will be analyzing the call rates of males, females, and different age groups to assess if there are differences. In order to collect this data, a four channel hydrophone array (Lab Core) will be deployed behind the boat. The gain will be set at 37dB and the samples per second at 44,100. The array will continuously record when whales are present. While the whales are within our sight, a focal group will be chosen. The group of whales closest to the boat will be chosen so it will be easier to photo identify the individual whales in the group. However, lone whales or whales in small groups will take priority in order to increase accuracy of localization. When whales are present, the bearing of the animal in regards to the boat will be calculated using a protractor. The distance of the whale from the boat will be taken using a range finder (Newcon Optic), and pictures will be taken for later identification.

The acoustic data will be analyzed using the program Ishmael 1.0 (David Mellinger) which localizes calls through the hyperbolic method by producing a bearing to the whale and location in regards to the hydrophone array. The coordinates for the location produced by Ishmael will be put into Excel (Microsoft) and compared to the bearing and location that was recorded with the protractor and range finder. From the Ishmael coordinates, the distance can be calculated using the Pythagorean Theorem. The value produced is the distance, and from that number we can obtain the bearing in radians, which is defined by sin=opposite/hypotenuse. The value in radians is then

converted into degrees, which allows it to be compared to the bearing and distance obtained on the boat. If the bearing is within 15 degrees and the distance is within 50 meters, the data will be accepted and used for localization. The error range chosen for the degree and distance is due to potential large human error when using the protractor and estimating the distance of whales when I am unable to use the range finder. If data is accepted, the localized animal will be identified.

Once the localization to a specific animal is complete, the call rate will be analyzed during a one minute interval because our sound files are spliced into one minute files. The statistical test used to analyze my data will be the T-test. Hopefully, it will be possible to localize individuals of different sexes and age groups. My results will then indicate how call rates differ between these groups.

The second question of my study involves the differences in surface behaviors between genders and different age groups. The behavioral states that will be used are taken from Ford et. al 2000 and listed in Table 1.

Foraging	Traveling	Resting	Socializing
includes feeding or searching for food. It Is the most common activity. The pod is usually spread out with small subpods that are generally swimming together. There are usually 2-3 short dives made, followed by a loner diver (1-3 minutes). Foraging is thought to compromise 65% of the southern resident behavior.	Traveling is considered when a group of whales is consistently swimming in a specific direction. Usually there is a tight formation, and there cannot be ay signs of feeding or searching for food. They usually travel faster than when they forage, and they often surface and dive simultaneously. They are usually very vocal while traveling.	This behavior is very easily recognized because the whales swim slowly, in a tightly knit group, usually abreast. While swimming abreast, the offspring usually surround their mother. They are very quiet and make longer dives. Resting is thought to make up 13% of southern resident behavior.	Socializing includes many different physical interactions, displays, and percussive events. Socializing behavior includes sexual interactions, kelping, aerial displays (breaching, tail slapping, spyhopping, etc.) This is thought to account for 15% of the southern resident's time.

I will record the behavior and take pictures for later identification. Each whale can be identified by their distinguishable saddle patch shape, dorsal fin shape, and specific nicks or scratches. The Orca Survey has left and right identification pictures of each whale and the pictures I take will be identified using this guide (The Center for Whale Research 2007). My observation period will be in ten minute intervals, and during these periods the focal group's behavioral state will be recorded. The surface behavior data will be organized by creating a table that includes the duration of the 10 minute interval, behavior, gender, bearing, distance, and identification. Gender between adults is very easily distinguishable due to the different sizes and shapes of the dorsal fin. The total duration (seconds) that each individual has spent in the four different behavioral sates will then be calculated. After the individuals are grouped by sex and age, total durations for each behavior will be averaged to obtain a final result that will indicate the proportion of time that males, females, and juveniles spend in the different states (Tables 2 & 3). The T-test test will also be used to analyze the behavioral data.

Date	Time	Bearing to whale	~Distance	Behavior	Gender	ID	Notes

Figure 2. The data that will be taken in 10 minute intervals while whales are present.

	Traveling	Socializing	Milling	Foraging
Male Adult				
Female Adult				
Juvenile				

Figure 3. The proportion of time that males, females, and juveniles spend in different behavior states will be calculated and compared.

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