Determining call rate and use in matriarch southern resident killer whales of the Salish Sea: Do matriarchs vocalize more frequently and use certain calls more than non-matriarchs?

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INTRODUCTION

The killer whale, *Orcinus orca*, is a highly social top predator. In the waters surrounding Washington state and the greater Puget Sound there, are three types of killer whales: resident, transient, and offfshore. Each group has slight differences in physical characteristics making them easily identifiable to the trained eye. Killer whales are resource specialists, and each group of whales has specialized on hunting prey most suitable for their geographic range. Transient killer whales, which specialize on marine mammals as a prey source, are typically seen in waters off the coast of Washington. Offshores usually stay in deeper waters off the Pacific Northwest and specialize in hunting fish, while residents live in coastal waters spring through fall and specialize on salmon (and other fish) as sources of prey (Ford et. al 2000). While their habitats overlap, genetic analysis has determined that transients and residents are genetically isolated (Ford et al. 2000). Because of their large pod size and coastal distribution, residents are the most commonly encountered of the groups. The resident whales have been divided into two distinct populations known as the northern residents (primarily inhabiting waters near northern Vancouver Island to southeastern Alaska) and the southern residents (primarily inhabiting waters around the southern tip of Vancouver Island and the greater Puget Sound area) (Ford et al. 2000). This study will focus on southern resident killer whales, (hereafter referred to as southern residents or SRKW's) in the waters in and around the San Juan Islands.

Natural markings and subtle differences between killer whales, such as variation of saddle-patch coloration (the area of lighter color just behind the dorsal fin), dorsal fin, and tail-fluke shape, have made it possible for photographic identification and cataloguing of individuals over the last three decades (Bigg et al. 1990, Olesiuk, 1990). Catalogue organization usually consists of the oldest whale- the matriarch- at the top of the page and her offspring below in order of increasing age from left to right (Ford et al. 2000). This method of individual identification has provided the basis for in-depth studies on association and

movement patterns for southern resident killer whales over the past thirty years (summarized by Hoelzel et al. 2007). As cataloguing efforts continue, there is more and more certainty about lineage. There is some degree of uncertainty however, as some relationships had to be surmised at the onset of the study. Of the 299 resident whales (northern and southern) catalogued, the mothers of 208 (70%) are positively known; probable mothers are known for 46 whales (15%) and possible mothers are known for 15 (5%); 10% are completely unknown (Ford et al. 2000).

Southern resident killer whales have complex social structures, which rely on older female members of the group (matriarchs) to maintain social organization (Bigg et.al 1990). Matrilines are groups of closely related individuals linked by maternal descent. An older female, or matriarch, represents the top tier of the matriline (Ford et. al 2000). As many as four generations may exist in one matriline. Groups of related matrilines (who likely share a common maternal ancestor) join together to form pods (Ford et. al, 2000). The SRKW population consists of three pods known as J, K, and L pods. Pods with similar dialects are thought to be more closely related (Ford 1991). In 1991 Ford (1991) suggested that similarity in vocal repertoire reflects matrilineal relatedness and grouped pods with shared call types into acoustic clans. Several studies have looked and classified existing vocal repertoires for all orca pods in the Pacific Northwest region (Miller et al 1999; Spong et al 2005; Nousek et al 2006). These vocal repertoires have varying degrees of similarity based on relatedness. Recent studies have recorded calls from identified pods and described pod-specific repertoires of 7-17 call types (Ford, 1991).

In an aquatic environment where light degrades quickly but sound travels well, cetaceans rely on acoustic means to communicate and maintain contact with each other under water (Myrberg 1980). Much research has been done on killer whale acoustics to establish vocal repertoires for pods (Miller et al 1999; Deecke et al 2005; Nousek et al 2006). There is mounting evidence that killer whale calves learn vocalizations through mimicry rather than genetic inheritance (Janik & Slate 1997; Bain 1988). Since matriarchs are at the top tier of social organization in the killer whale society, it is important to study their vocal repertoire and frequency of calls in the SRKW society. It has been determined in African elephants that the oldest female individuals in groups have the greatest ability to discriminate between familiar and unfamiliar contact calls; that would likely mean greater survivorship for social groups led by older females

than younger ones (McComb et al 2001). If this is true among SRKW's, then the matriarch is an invaluable member of the group.

An example of pod hierarchy in the SRKW population would be that of the J pod. The J pod consists of four matrilines headed by the J2, J8, J16, and J9 matriarchs (Ford 2000). The above-mentioned individuals each are at the top tier of their own matrilines, being the mother, grandmother, and sometimes great-grandmother to anywhere from three to seven individuals. J2, J8, J16, and J9 are likely related through some matrilineal connection (sisters or maternal cousins). Together the J2, J8, J16, and J9 matrilines form the J pod consisting of 19 animals (Ford 2000). In the SRKW population, the J pod occasionally associates with the K and L pods forming a clan composed of all three pods (this clan is known at the J-clan) (Ford et al.2000). Through acoustic analysis, J and L pods have been shown to be more closely related to each other than either is to the L pod (Ford et al. 2000). This study will investigate the possibility that matriarchs communicate more frequently than other individuals. If this is true, documentation of acoustic variation at the different levels of social organization for the J-clan could prove to be rooted in matriarchical delineation.

There are many parallels between the structure of African elephant society and killer whales of the Pacific Northwest. Determination that matriarchs in killer whale populations indeed vocalize more often than other members of the group would expand on our knowledge of pod structure and the importance of matriarchs. Since it has already been established that vocalizations are learned throughout life, it would make sense that older females have the more acquired knowledge (having longer spans than males) and would therefore be the most beneficial individuals to a pod (Janik & Slate 1997, Foote et al. 2006). This would firmly establish the importance of matriarchs to the pod and the subsistence of orca populations. The considerations for conservation based on that alone are immense.

(proposed) METHODS AND EXPDERIMENTAL DESIGN

Data collection will be a joint effort of students working on the *Gato Verde*, a biodiesel sailing catamaran, between August 27 and October 20, 2007 in the waters surrounding the San Juan Islands in the greater Puget Sound area of the Salish Sea. Hydrophones will be dropped off the stern end of the boat and recordings will be made of southern resident killer whales in the area. Calls will be recorded and later

analyzed to determine the location of the source relative to the boat. In addition, photo records will be taken to identify animals and match them with hydrophone recordings to identify which animal made particular calls. Since estimated age and identity of all animals is known, statistical analysis will determine the number of calls made by each individual. Comparison of call rate made by identified matriarchs versus call rate of other animals will determine if social status correlates with call rate.

The five students aboard the *Gato Verde* are studying various aspects of killer whale acoustics; for this reason we will be able to work together in collecting data and each person will be responsible for various aspects of the data collection. The first person will be responsible for locating an individual whale to focus on and ensure that all individuals are recording data on the same whale. That person will also record social behaviors of the focal animal. A second person will be responsible for listening to the hydrophones to record when calls are made (to make data sorting easier). A third student will be responsible for recording the bearing of the individual whale it is decided to focus on as well as the approximate number of whales in the group at the time of recording. Bearing will be estimated with the use of a standard protractor. A final individual will be responsible for finding the distance of the focal animal using a Newcon Optikc x9; LRM 2000PRC range finder (if the animal is out of range a visual estimate will be made by range finding near-by boats and getting an estimate of the distance to the whale).

As mentioned above, we will record various parameters to identify individual whales and localize their calls from the recordings made. To record calls, a Lab Core hydrophone will be deployed and recordings of killer whales in the area will be made. Peak sensitivity is about 5000 Hz and it's down 30dB at about 200 Hz and 10,500 Hz. Two Sound Devices are used to record calls; they record at flat from 10 Hz to 40 KHz (to .1, -0.5dB). The sampling rate is 44,100 samples/sec and the gain is 37dB. The hydrophone array is a series of four hydrophones connected together and attached to a digital sound recorder onboard the *Gato Verde*. To ensure that the hydrophone is deep enough to avoid surface turbulence and interference, an eight pound weight is attached to the end closest to the boat (after the fourth hydrophone is deployed). Hydrophone specifics such as distance between hydrophones are entered into *Ishmael*. We will deploy the hydrophones as soon as whales are seen in the general vicinity.

Once the appropriate data has been recorded, I will localize calls and match them to individuals. To determine the position of the whale, we will take a picture of a relatively isolated individual and record

the time, bearing (of animal relative to boat), and approximate distance from the boat to the animal at that particular moment. An estimate of the number of individuals in the group will also be made at the time of recording to normalize the number of calls made by individuals of the entire group. Doing this will control for calls not matched to a particular individual and normalize the number of calls per individual. To localize calls, we will use a program called Ishmael 1.0 (David Mellinger). In *Ishmael,* we will open the file and match calls with whales that were at a certain distance and bearing to the corresponding time in the field. Once we have the call open, we will ask *Ishmael* to localize the call and compare the result with the parameters recorded in the field. If the results in *Ishmael* are consistent with the data recorded, the results will be included in analysis. We will accept the data if *Ishmael* gives a bearing of within 15 degrees of the estimated bearing and a distance within 50 meters of the estimated distance.

Variation in saddle-patch coloration and dorsal fin characteristics will be used to identify individuals. Comparisons will be made with the Center of Whale Research's (2007) Identification catalogue of southern resident killer whales. Individuals will be identified and correlated with a particular call based on the location of that whale at a particular time and the localization of a call at the same time.

After I have matched certain individuals with particular calls, I will separate the matriarchs calls' from other animals and determine if the matriarchs have vocalized more frequently than other animals and/or if they use particular calls more than other members of the pod. After a whale is identified and localized to be the source of a particular call, I will note how many calls that individual made per minute. I will then add up the total number of calls made by matriarchs and compare this number with the total number of calls made by all individuals. I will compare the amount of calls matriarchs made with their proportion of the population. For example, if matriarchs are 25% percent of the population of SRKW's, and are making 50% of calls, then I know that they are vocalizing more than other individuals. I will use a t-test to determine if there is significant difference in calling rate between the two groups (matriarchs and non-matriarchs). My hypothesis is that there will be a significant difference and that matriarchs will have a higher call rate than non-matriarchs.

The final analysis I will make will be the difference in use of call type. It may be possible that matriarchs are using particular calls more than other individuals are. For that analysis, I will need to identify each type of call being made. To identify calls, I will refer to John Ford's (1987) SRKW call

catalogue. After identifying each call type, I will compare the number of times matriarchs use each call compared with other animals (by graphing the calls). A t-test will be used for this analysis to see if there is a significant difference in calls being made by matriarchs versus calls being made by non-matriarchs.

Sample size will depend on our ability to track whales and record individual animals suitable for acoustic isolation. In order to ensure replicability, animals will be recorded at random and attention will be paid to relative pod structure at the time of recording. In order to attain data as error-free as possible, data of calls will only be accepted into the data-analyses with certain knowledge of who the source producer is.

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