Relationship between Vocalizations and Social Activity in Southern Resident Killer Whales, *Orcinus Orca*

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Literature Review: The killer whale, also referred to as the Orca whale is the largest member of the Delphinidae family. Within the species Orca, three distinct groups exist: offshores, transients, and residents (Holt 2008). Orcas as a species make several types of calls. These include clicks, whistles, and pulsed calls. Although considerable work has been done on pulsed calls in Orcas, less is known about the use of whistles in Killer Whales. The reason for the predominance of literature on pulsed calls is because clicks require high frequency equipment and whistles are not as commonly made by wild Orcas. A whistle is a tonal sound with an average bandwidth of 4.5 kHz, an average dominant frequency of 8.3 kHz (Thomsen et al. 2001). Clicks on the other hand are used for echolocation. Clicks can be made singularly or in click trains (Holt 08). They are relatively short, broadband, and range in frequency from 8 to 80 kHz (Au 2004). The most common call orcas use is the pulsed call which can contain harmonics up to 30 Hz (Ford 1989). The source levels of the calls often range from 135 to 168 dB re 1µPa (Miller 2006).

Of the studies done with whistles in resident killer whales, differences exist between Northern Resident Killer Whales and Southern Resident Killer Whales. Studies done with the Northern Residents showed that the whistle was primarily used during socializing (Thomsen et al. 2002). During the course of the study researchers found that

whistles were used 43% of the time during socializing events as opposed to 29% and 28% for discrete and variable calls respectively (Thomsen et al. 2002). The full statistics from Thomsen et al's study can be seen in table 1.

Behavioural category/ sounds	Socializing (12/15/33)	Social-travelling (16/18/49)	Foraging (5/17/31)	Mixed foraging (10/10/21)	Slow-travelling (7/14/22)	Mixed slow-travelling (7/8/14)	Travelling (5/5/7)
Whistles	43%	26%	3%	6%	6%	2%	2%
Discrete calls	29%	54%	94%	85%	85%	89%	96%
Variable calls	28%	20%	3%	9%	9%	9%	2%

Table 1: Results from Thomsen et al. study on Northern Residents

However, in a 2006 study done by Colleen Barry, a former student of Beam Reach, on Southern Resident Killer Whales off of San Juan Island, she found that whistles were used least frequently during socializing events (Barry 2006). Research has suggested vocal differences in the different populations and ecotypes of orcas (Ford 1991) and these conflicting results support those findings. Although the Northern Residents and Southern Residents habitat sometimes overlap, this supports the theory that they are still distinct populations.

Apart from whistles there has also been work done on the behavior of the southern resident killer whales. Nicole Lee, a 2005 Beam Reach student, studied the correlation between breaches and vocalization (Lee 2005). She found that within one minute of a breach, the call most often heard is S10 (Lee 2005). However, the correlation between S10 and breach was not sufficient to say that there was a strong relationship between S10 and breaching.

Another study done comparing behaviors to vocalizations was Heather Hooper's 2007 study *Discrete Call-Type and Behavioral Event Associations of Southern Resident Killer Whales (Orcinus orca) in the Salish Sea.* Heather looked at the call types made in

association with specific behavioral events including peckslap, breach, change of direction, tailslap, and porpoising. Her study showed many different calls used within a two minute period of these specific events (Hooper 2007). In addition to these studies, a 2006 research project done by Juliette Nash examined a link between killer whale acoustics and killer whale behavior. Unfortunately, Juliette's results were inconclusive (Nash 2006).

When doing behavioral work it is important to define various behaviors such as social behaviors for the purposes of the research project. Most socialization definitions are very similar in nature. Socializing is tactile interactions between two or more orcas. The individual behaviors of socializing can vary greatly from percussive events such as breaching and tailslapping, to physical contact, such as rubbing, rolling over, and sexual interactions, as well as acoustic calls such as whistles or pulsed calls. During social interactions the group is stationary or nearly stationary (Bain 1986, Barry 2006, Nash 2006, Thomsen 2002). It is also important to note that the entire group of orcas might not be socializing at the same time. Sometimes only a smaller group of orcas socialize while the others display other behaviors nearby (NMFS 2008). The purpose of these definitions is to clearly separate observed behaviors in the wild into specific categories. Another of the categories that is defined is social travel which is traveling at a fairly constant rate and course (Barry 2006, Thomsen 2002).

The National Marine Fisheries Service (NMFS) has done work to categorize and code the specific behaviors in killer whales. Their findings were published in the 2004 workshop on Killer Whale behavior. Key distinctions that they make in their paper include subcategorizing play behavior into three subcategories. These subcategories are

object play, social interactive play, and solitary play. Object play is anything with inanimate objects such as kelp or logs. Social interactive play can include touching, breaching, or percussive events such as tailslaps and breaches (NMFS 2004). They also come up with a key definition of directionality for the purpose of defining traveling behavior. They refer to directionality as being less than or equal to 90 degrees of the whales previous direction of travel. Likewise any movements which are greater than 90 degrees from the previous direction of travel will be considered non-directional (NMFS 2004).

Other categories of behavior described by NMFS are rest, travel, forage and milling (NMFS 2004). Rest consists of the whales being close together, traveling at slow speeds if at all, and lacking percussive events. In foraging behavior the whales can be in tight or loose formations, traveling at various speeds, and often including behaviors like chasing, lunging, and porpoising. Traveling can be directional movement in any direction at any speed and the whales could be grouped close or spread out wide. Milling is repeated non-directional movement over any distance usually at slow or medium speeds (NMFS 2004).

Behavioral studies with other cetacean species in the pacific have had similar definitions of social behavior. A study in 1986 on the behavior of Gray Whales in the Bearing Sea defined social behavior for the Gray Whales as being within one-half body length of each other and interacting with each other (Wursig 1986). For example if they were oriented towards each other at close range they would be considered socializing.

Problem Statement: Despite extensive studies on orca acoustics, there are still a great many mysteries about what various acoustic calls mean. Further complicating our understanding of orca acoustics is the fact that each of the various pods have their own unique dialect (Ford 1991). This was shown in the conflicting results of two acoustical studies of orcas. The first done by Thomsen showed that northern resident killer whales use whistles predominately during socializing activity. However, as mentioned above another study done in 2006 by Colleen Barry showed that southern residents use whistles during socializing activity the least. This leads to the question; if southern residents don't whistle as often during socializing, what calls do they make, and are they different from the calls made during periods of non-social behavior?

Previous studies have shown differences in calls by each separate pod of orcas and between the different types of orcas. Exploring what southern residents do in place of whistles during socializing might help us understand more about those pod-specific dialects. Furthermore, exploring the question of call usage by southern resident killer whales would give us a better and deeper understanding of them as a species. The fact is there is still a great deal about killer whales as a species and southern residents specifically that is not well understood. We know that they are a highly social species, but why they perform specific behavioral events such as breaches is still beyond our understanding. By studying their acoustics in addition to their behavior we might begin to get a window into their world. This information could then be used to better understand their natural existence and how our presence on the water threatens that existence.

Since the Southern Residents, like all Killer Whales, are highly social species it is logical to assume that socializing provides an important part of their existence. When

orphaned they often try and find new social interactions like Luna did near Gold River after getting separated from her pod. She tried to associate with humans and boaters until her death in 2006. Understanding social activity better will give us a better understanding to their social structure, group cohesion, customs and traditions, and larger traits on a whole. In the future a better understanding of social behavior and the whales need for it might help avoid another tragedy like was seen with Luna.

For the purposes of this study, social activity will be defined as any tactile interactions between two or more orcas such as rubbing, rolling over, and sexual displays, as well as aerial displays and percussive events over a prolonged period of time while being stationary or nearly stationary. This definition was formulated after looking at similar definitions by other behavioral studies. For the purposes of this study there will also be a separate behavioral definition for social travel. Social travel will be defined as swimming at a consistent speed and course with occasional social events while being grouped closely together.

After defining these behaviors and examining previous literature I was led to the follow question: Is there a relationship between vocalizations and social activity in southern resident killer whales?

Methods: All observations will be made aboard the *Gato Verde,* a biodiesel-electric hybrid catamaran. Using its electric motors we will be able to record the Southern Residents with little to no acoustic interference from the research vessel. Trailing from the stern of the boat we will have a hydrophone array consisting of three LONS hydrophones off of the port stern. We will also have a high-frequency Cetacean Research

Technologies hydrophone trailing off of the starboard stern of the boat to record high frequency vocalizations made by the whales. A full diagram of the hydrophone array set up can be seen in figure 1.

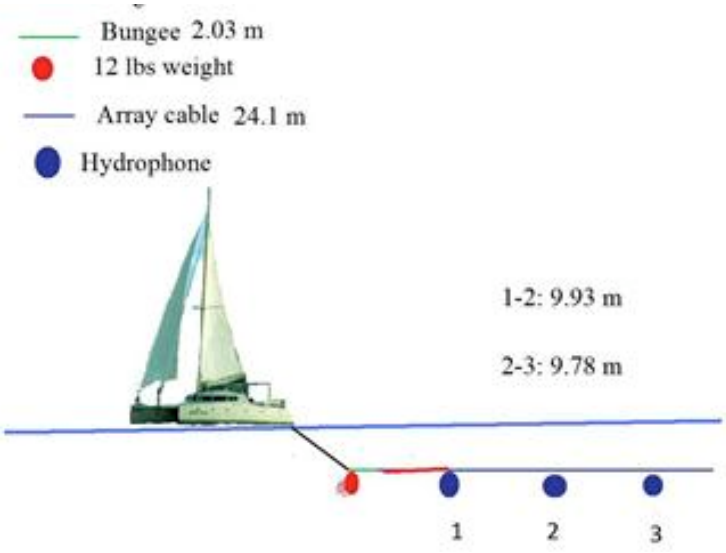

Figure 1: The hydrophone array trailing behind the *Gato Verde.* Photo courtesy of Dominique Walk

As you can see the distance of the whole cable is 24.1 meters and the distance from hydrophone 1 to hydrophone 2 and hydrophone 2 to hydrophone 3 is 9.93 and 9.78 meters respectively. Also, a weight will be deployed with the array to keep it below the surface. The recordings will be made at 44.1 kHz, 16 bit sampling rate.

During Killer Whale sightings I will also be on deck making behavioral observations. I will be observing what behavioral state or states they are in during our time with them as well as behavioral events such as breaches. The behavioral states I will be interested in are social, social travel, and non-social. I will be using a digital stopwatch to record times elapsed. Acoustic recordings will be made on two Sound Devices 702 solid state digital recorders set up in a master-slave format. Latitude and Longitude information will also be recorded using a GPS unit. Behavioral notes made during the sightings will be noted on a data sheet which can be seen in appendix A. I will also be

using several types of cameras to make photo documentation of the social events and 7 X 35 binoculars to assist during observations.

After recording all the data I will perform acoustic analysis on a Dell Inspiron 1200 laptop using several types of acoustic analysis software. I will be using Audacity and Syrinx for data analysis, as well as Ishmael for localizing calls from social groups. During analysis I will be looking at several factors between social and non-social periods. I will be measuring the peak frequencies of the calls made to see if the whales vocalize at a different frequency at times of socializing much like a human voice might change pitch when excited or scared. I will also be measuring call rates to see if the vocalize more less or about the same between socializing and non socializing events. Lastly, I will analyze the recordings by call type to see if the whales use certain call types more during one type of behavioral state than another. Part of this will be looking at call sequences to see if there are any changes or certain sequences used predominately during certain types of behavior.

Behavioral Data Sheets

Date: **Sighting Number:**

Time Recording Start: _____ Lat: _____
Time Recording Stop: _____ Long: _____
Waypoint: _____ Location: _____

Behavior at beginning of recording: _____

Social Start:							
Social Stop:							

Type of Social Behavior: **Social ___** **Social Travel ____**

Pod: **J____** **K_____** **L____**

Percussive Events Recorded: **Breach _____** **Pectoral Slap _____**
Tail Slap_____ **Other_____**

Number of Whales in Social Group: _____

Number of Whales Present overall: _____

File(s) Name: _____

Photos: _____

Video: _____

Conditions: _____

Notes:

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