Variation of calls used among all pods of the Southern Resident Killer Whales (*Orcinus orca*)

Laura J. Moe

Beam Reach Marine Science and Sustainability School
Friday Harbor Labs – University of Washington
Fall 2011

Introduction

Most animals communicate in some way, whether it is for feeding or reproducing. Depending on their environment or adaptations, some use visuals, chemical signaling, olfactory senses, as well as tactile senses. For cetaceans, the most practical and useful form of communication is sound. Sight isn't reliable in turbid waters and cannot be used for long distances. Sound not only travels faster in water than it does in the air, but sound also gets absorbed less per kilometer in water than it does in air due to greater density. This enables sound to travel at far greater distances in water (Brennan 2009), which makes this form of communication ideal for all cetaceans, particularly for killer whales.

Killer whales can hear anything within a range of 1 to 100 kHz (Symanksi 1999). They project sounds that are classified as: discernable calls, whistles, and clicks. Whistles are thought to have close-range signaling qualities (Riesch, Ford, & Thompson 2004), while clicks are generally used for echolocation and hunting tactics. The focus here is on killer whale discernable calls, and can be referred to as pulsed calls.

North Eastern Pacific killer whales are separated into three different ecotypes called residents, transients, and offshores. These types are separated due to their social and cultural behaviors, their feeding habits, where geographically they choose to be, and their acoustic distinctions from one another (Ford 1991). Transients have unpredictable patterns of travel, and typically eat mammalian organisms. Offshores are elusive to sightings, but recent reports have said that their diet is mostly pisciverous and includes sharks (K.B. Ford 2011). Resident Killer Whales, the focus of this study, have a predictable range of travel, and their diet typically consists of salmonids (Hanson 2010).

Sixteen pods form the Resident orca population, and these are separated into four acoustically distinct clans (Ford 1991). New pods are generated through divergence of call repertoire of the founding group (Ford 1991). Resident orca pods typically have anywhere from seven to seventeen distinct calls, although on average there are 10.7 different calls per pod (Ford 1991). The southern residents are typically found in the Northeastern Pacific around British Columbia and Washington State in the summer, particularly in the Salish Sea and Puget Sound. Southern residents consist of only one clan, which is classified as the J Clan. This clan consists of 3 pods: J, K, and L; L pod has 41 individuals, J pod has 27, and K pod has 19 (87 individuals total). Because of the long-term stability of the social structure in southern residents, we are able to examine vocal behavior in much more detail than other ecotypes (Ford 1991). These orcas have been intensely studied since the 1970s (Wieland 2007).

Southern Resident Killer Whale calls are classified using an "S" as a prefix for each of the numbered calls to signify that the call is from the southern resident clan. Twenty-five different call types have been formally classified from the southern resident killer whales (Ford 1987). Each pod has unique vocalizations that are more distinctly used within each of the separate pods. The call S1 for example is used exclusively in J pod, according to Wieland, and isn't heard in either K or L pods. Ford in 1991 claimed that both J and K pods used S1. L pod has never been known to use S1. There is typically only crossover usage in only two pods in many of the classified calls. Ford intensely studied killer whale calls and proposed that eight calls have crossover qualities in J and K pods, and five calls have crossover qualities with K and L pods, and merely three calls crossover in all three pods of the southern residents.

Call	Pod		
	J	K	L
S1	x	x	
S2			
i	x		
ii	x		
iii			x
S3	x		
S4	x	x	
S5	x	x	
S6	x	x	x
S7	x	x	
S8			
i	x	x	
ii			x
S9	x		
S10	x	x	x
S12	x		
S13			
i	x		
ii			x
S14	x		
S16		x	x
S17		x	x
S18			x
S19			x
S22			x
S31			x
S33			x
S36			x
S37			
i	x		
ii			x
S40			x
S41	x		
S42	x	x	x
S44	x		
Total	18	10	15

Ford produced this figure in 1991 for his interpretation of types of calls used among Southern Resident Killer Whales. Note the types of calls that are used among all three of the pods: S6, S10, and S42.

Ford's representations of the calls have been used ever since his study in the late 1970s and the early 1980s (Ford 1987), and many have used his interpretation of calls as the guidelines for their studies. However recent studies show variation in Ford's results. Wieland showed that there was nine distinct calls that crossed over all three of the pods in a 2005-2006 acoustic study (excluding unknown and faint calls).
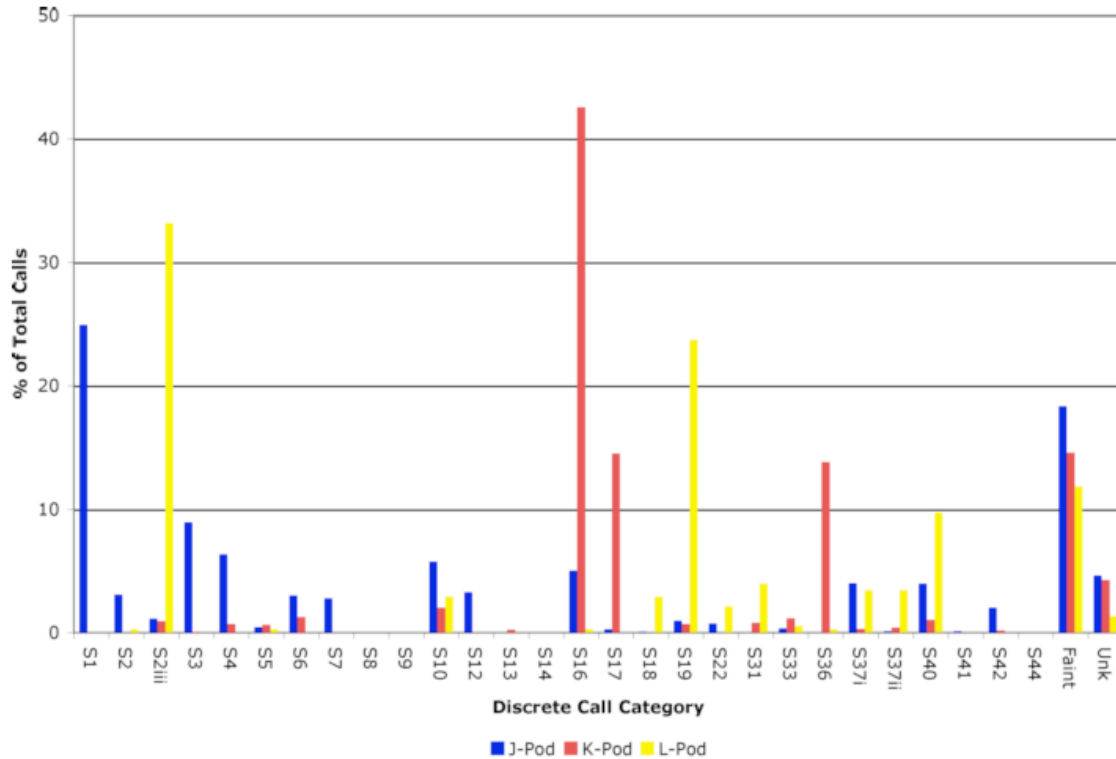
This figure was produced for Wieland's 2007 thesis on Southern Resident Killer Whale acoustics. Note the overlapping call types among all three pods of J Clan: S2iii, S5, S10, S16, S19, S33, S37i and ii, and S40.

Although Ford and Wieland had different data from different times, subtle similarities are present in their results. Both reported that the S10 call was used among all pod types. This suggests that this particular call is a universal gesture. It has also been understood that S10, or otherwise known as V4, is a universal killer whale 'excitement' call, and is used in all cultures of killer whales (Rehn 2010). This can be compared to a laugh or a smile with humans, which means the same thing in every culture: that one is
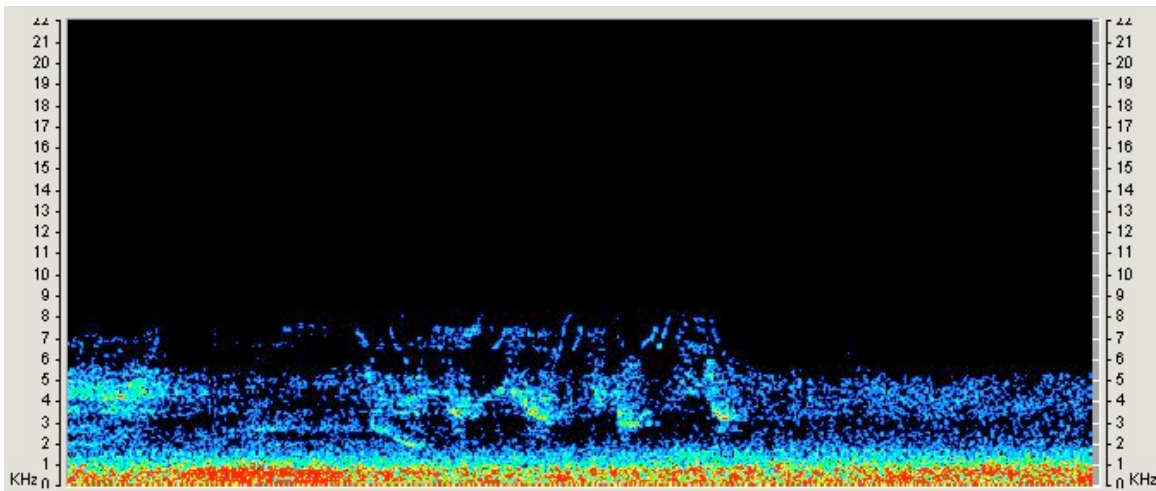
happy.

Fig. 3. The original representation for an S10 call. Ford used this to classify and label S10 calls after it was defined using this particular call. Now also referred to as V4 (Rehn 2010).

The S10 call is prominent in all killer whales, and therefore is believed to be biologically innate to killer whales (Rehn 2010). Biologically innate suggests universality in a behavior, such as a specific call. This study aims to measure differences or similarities in calls that have been shared among all the pods of the southern resident killer whales, such as S19 (Wieland 2007) or S6 (Ford), to see if they too can be considered to be innate within the southern resident clan, or if the calls deviate from one another due to attempted imitations of the calls.

Methods

Recordings will be collected from all three of J Clan's pods. Individual calls obtained will be isolated into separate sound files. Non-archival calls will be obtained in a couple different ways: from a stationary hydrophone array, and a mobile hydrophone array. A three hydrophone stationary array located at Lime Kiln Point State Park is used for data collection on San Juan Island. A 42' sailing catamaran called the Gato Verde will also be used for this study. The Gato Verde provides a mobile four hydrophone array that is weighted to a depth below the surface to reduce flow noise of calls. Hydrophones in both locations consist of a Reson high frequency hydrophone, which has a flat response between .1 and 100 kHz, which useful for picking up orca clicks. The remaining hydrophones consist of the Lab40 model from LabCore Systems, which is less sensitive than the Reson, but useful for picking up audible calls. Cruises will take place on September 18th to the 28th and October 2nd to the 13th throughout the Salish Sea. Before recording, base point average, or the sensitivity of the hydrophones, will be set depending on decibel level of calls and/or background noise.

Ideal encounters consist of individual pods (not mixed pods) to maximize confirmation on call origin. If pods are to be encountered intermingling, recordings will take place, and data for localization will ensue. This requires photo identification to determine which pod an individual came from, and the orientation of the animal in relation to the hydrophone array on the Gato Verde, and time in which the animal was sighted. The call will then be localized through a program called Ishmael (Mellinger) to

determine which direction the call came from. If calls can be placed confidently to their origin, they will be used for this study.

Killer Whale calls are classified based on certain criteria. All call types can vary in frequency, call rate, duration, and amplitude. Different orca calls in particular are discernable with a human ear and are visually unique with the usage of spectrograms (Wieland 2010). The use of spectrograms will be used predominantly in this study. These will be obtained through software called Audacity (Audacity Team) by uploading sound files and putting them in spectrum form. Sampling rate will be set to 96000 to sharpen the visualization of calls and increase accuracy of measurements.

An equal number of high quality individual calls will be classified from each pod. Archival calls as well as calls obtained by myself will be considered. The calls must meet quality criteria of having minimal background noise, high enough amplitude to easily distinguish frequencies from, be visually distinct on a spectrogram, and confirmation on which pod the call came from through localization and photo identification. Programs such as Audacity and Raven Pro (2003-2010: Cornell Lab of Ornithology, Ithaca, New York) will be used to analyze the maximum and minimum frequencies, the delta frequencies, and the duration of each call. Maximum and minimum frequencies will be recorded for calls that are actively used among all three of the pods. These will each be recorded and put into a table showing their variances. From this, the mean maximum and minimum frequency from each pod will be recorded and put into a bar graph. Similar analyzing strategies will be done with frequency delta (the frequency range) for each of the pods and put either into a scatter plot or a graph. Duration will also be done similarly and will most likely be put into a bar graph to maximize visual contrast. Duration can

vary over time (Wieland 2007) and therefore recordings must be taken from a similar

time range, preferably most recent findings that meet the above criteria. Another option is

to use two different sets of time ranges to maximize results.

References

Audacity Team (2008): Audacity (Version 1.3.13-beta)[Computer program]. Retrieved August 2011, from http://audacity.sourceforge.net/

Brennan, C.W. 2009. Basic Acoustic Theory. R2 Sonic.

Foote, A., Nystuen, J. 2008. Variation in call pitch among killer whale ecotypes. Journal of the Acoustical Society of America 123(3): 1747-1752.

Ford, John K.B. et al. 1987. A catalogue of underwater calls produced by killer whales (Orcinus orca) in British Columbia.

Ford, John K. B. 1991. Vocal traditions among resident killer whales (Orcinus orca) in coastal waters in British Columbia.

Ford, John K.B. et al. 2011. Shark predation and tooth wear in a population of northeastern Pacific killer whales. Aquatic Biology 11: 213-224.

Hanson, M., Baird, R., Ford, J. et al. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research 11: 69-82.

Mellinger, Dave. Ishmael: Localizing/tracking. NOAA/PMEL VENTS Program Hathfield Marine Resources Studies. Leader in Developing Ocean Observational Systems.

Rehn, N., Filatova, O., Durban, J. et al. 2010. Cross-cultural and cross-ecotype production of a killer whale 'excitement' call suggests universality. Die Naturwissenschaften 98(1): 1-6.

Riesch, R., Ford, J., Thomsen, F. 2006. Stability and group specificity of stereotyped whistles in resident killer whales, Orcinus orca, off British Columbia.

Szymanski, Michael D. et al. 1999. Killer whale (Orcinus orca) hearing: auditory brainstem response and behavioral audiograms. Journal of the Acoustical Society of America 106(2):1134-1141.

Thomsen, F., Franck, D., Ford, J. 2000 Characteristics of whistles from the acoustic repertoire of resident killer whales (Orcinus Orca) off Vancouver Island, British

Columbia. Journal of the Acoustical Society of America 109(3) 1240-1246.

Wieland, Monika. 2001. Repertoire usage of the Southern Resident Community of Killer Whales (Orcinus orca) (Master's thesis). Reed College, Portland, OR.