Behavior and Acoustic correlation: The significance of shared calls in the southern resident killer whales

Juliette Nash 620 University Road, Friday Harbor Laboratories, University of Washington. Friday Harbor, WA 98250. dream.of.orcas@gmail.com 617-510-8335

Literature Review

In the Pacific Northwest the southern resident killer whale population is made up of three distinct pods termed J, K, and L. Pods are comprised of related matrilineal units, and appear to be headed by the eldest female among the matrilines. Numerous studies have been undertaken regarding the surface active behaviors of the northern resident killer whales while other studies have focused on their acoustic behavior. Despite the heavy focus on these two elements, relatively few studies have looked for correlations between the two. The reason for this may be that the results of these studies have suggested that the whales do not link specific behavioral events, such as breaches or spyhops, with specific vocalizations. Many of the whales' sounds are heard across the majority of behavioral states and it is therefore difficult to find any correlations between acoustics and behaviors (Morton 1986). Correlative vocalization & behavior success has been documented with other socially complex societies such as food bray calls in bottlenose dolphins (*Tursiops truncates*) (Janik 2000) and in some male baboon (*Papio cynocephalus)* calls (Fischer etc al. 2002). However, the research done individually on the killer whale behavior and acoustics, has been providing the fundamental information needed to begin answering more questions that regard correlations of the two.

Correlative studies are important for the effective management of any intelligent species, but particularly one as socially complex as the killer whales. The results of these studies, if positive or significant, can lend a great deal of insight when developing management, recovery, or conservation plans. In regard to ethics, correlative studies may help bring about legislation regarding the whale watching industry, and the effect of ocean noise on the whales.

Because the whales spend only 5% of their time each day at the surface and engaging in active surface behaviors (NMFS 2005), behavioral studies have been difficult in the wild. Nonetheless several studies have been done to try to understand what we can readily see the whales engage in, including defining and describing the different oberseved behaviors, behavioral budgets and an overall view of their behavioral ecology (Jacobsen 1986 Osborne 1986, Heimlich-Boran 1988). The most recent advance has been the coding consensus of behaviors which clearly defined the limits and meanings of the descriptive behavioral terminology. This was an effort to eliminate some of the functionality often associated with behaviors that may not have been correct.

Early acoustic research grouped the three pods into an acoustic "clan", where all the whales use the same or similar vocalizations to communicate (Ford 1989, 1991). Further studies showed that killer whale pods within a clan display the communicative elements of vocal dialect, with different pods producing the same sounds in slightly different ways. Dialects vary both between the pods and to a lesser degree within the individual matrilineal units (Ford & Fisher 1983, Deecke 1998, Miller & Bain 2000) of each pod. One study tested two northern resident calls for their stability and fluidity in terms of change and variation over time. Results showed that one call, N9, was remarkably stable and remained significantly unchanged over the course of the 13 year study. The other call, N4, was more fluid and showed a significant change in the call characteristics between the matrilines of the study pod (Deecke et al. 2000).

Miller (2002) showed that vocalizations with two components, a low frequency component and a high frequency component, could be used to relay orientation to conspecifics. His study was on the northern residents and focused primarily on the two most frequently used vocalizations, N4 and N9. Both were found to have a two component structure and be directional in their application – that is to say, the vocalizations sounded differently depending on whether the whales were coming towards a hydrophone array or going away from it. This effect has also been noted by Alexandra Morton (personal communication 2006).

It is currently unknown why some calls remain stable when others do not. For a call such as N9 to remain unchanged for an extended period of time, and to be widely used by the community it must have some significant standing in the communication system and lives of the whales. For the variable, but frequently and widely used call, N4, it must also bear some significance that is highly relevant, but maybe not to the same degree as a more stable call.

This leads to the question of the fundamental principles and factors affecting the whales lives. The first and foremost appears to be the social structure of the community. The killer whales remain in their natal families throughout their lives. These family units are remarkably stable with no members of either sex appearing to naturally disperse (Ford et al. 1994, Morton 2002.). Exceptions to this have existed with two young calves (L98 and A73) who appear to have become separated unintentionally. In the case of A73, the calf was successfully returned to its' matrilineal unit and has remained with her family since. This supports the notion that A73's dispersal had been accidental.

Social cohesion and family bonds can be considered the fundamental element of killer whale society. Synchronization is another highly social and highly integrated part of their lives. Many of the killer whales daily movements, from breathing to traveling to resting are synchronized. When a killer whale is born and goes to take its first breath, it is innately programmed to open it's blowhole at the precise moment its mother does (Morton 1986, 2002). Lastly, the southern residents are fish eaters and studies reveal that their primary prey of choice is salmon – especially the large nutrient rich Chinooks (Ford et al. 1998, NMFS 2005, Ford & Ellis 2006). Because of the need to find large amounts of food each day, foraging can safely be considered a third fundamental that impacts their lives and has the possibility to play a large role in the course of their vocal communications.

The first step was to apply these tests to the southern residents, who have not been the focus of acoustic behavior studies. Because killer whales tend to use their vocalizations in a wide variety of behaviors attempts to find correlates have so far been largely unsuccessful. My goal was to figure out which calls might be significant to the southern resident killer whales, and what these significant calls were correlated with. A review of Ford's call catalog revealed that the southern resident pods share only three calls, S6, S10, and S42. It is assumed that these calls are significant to the population based on the principle that they are shared between the pods. Spectrogram analysis has revealed that both S10 and S42 are two component calls and therefore have the potential to be emitted directionally by the signaler and may reveal information or orientation to kin or other receivers (Miller 2002). There are many examples of calls shared between two pods, but those are not focused on in this study, as the assumption is that they are not as significant to the population as a whole. It is possible that some of these calls are shared by all three pods and have not been recorded as doing so.

The first of these shared calls, S6, is a single-component call that appears to be stable amongst the pods – although no studies have been done to show stability over time. Analysis in Raven™ showed that this call is relatively simple in structure, and is occasionally accompanied by echolocation creaks. The call is frequently produced repetitiously and samples have been obtained where one whale repeats the call twice, is answered with the same call, and then repeats it a third time. For these reasons I will be looking for the S6 call in regard to social cohesion. As a simple, single component call it does not carry the orientation information that a two-component call carries, not is it directional in nature. If a group of whales were trying to maintain cohesion while out of visual range, but not engaging in synchronized or organized behavior they may not necessarily need to convey that level of detailed information and a single component call may be sufficient. In reference to the echolocation creak that sometimes occurs in the first syllable of the S6 call, and the repetition of the call, I will offer that those two features allow one member to use echolocation to find the whale it might be calling to. Repetition also lends itself to making oneself easier to see through use of sound. I would expect to hear this sound used frequently, except when the whales are in a tight formation, or resting.

The second call, S10, is a high pitched two-component call which has a great deal of variation both between the three pods and within them. Interestingly, 93% of the samples that were obtained had echolocation clicks, creaks, or buzz trains. Sometimes one call sample had several of these elements. Samples that were missing elements were all very brief and high in amplitude, which may have caused echolocation to be drowned out or cut off. High degrees of variation and large amounts of echolocation lend support to the notion that this call might be used in regard to foraging. Foraging definitions for this study are consistent with Jacobsen (1986). High degrees of variation may also decrease the calls communicative significance, but this has not yet been tested. I am expecting to find this call used immediately prior to foraging, within two minutes, during foraging, and immediately after foraging, within two minutes. Because not all foraging occurs at the surface, S10 will also be acceptable when heard along with echolocation creaks which are often associated with hunting salmon (Morton, 2002). I do not expect to hear S10 when the whales are not visibly or audibly, via echolocation creaks, foraging.

The third shared call, S42 is another two-component call, although notably more stable than S10. The structure of the call in spectral analysis also seemed to be less complex than S10 and occurred at a much lower pitch. There is variation between the pods, with J & K being the most similar. L pod appears to only use the first two syllables of the call, while omitting the third. None of the samples I had of S42 contained echolocation features, which suggests that it is likely not used for foraging. As a two-component call it may relay orientation information or other signals to conspecifics (Miller 2002). I will be looking for this call in respect to synchronized changes in group travel direction. This call may be heard frequently, as synchronized behaviors are common, but for this study I am primarily interested in using change of travel direction as an apparent and relatively simple event to measure and sample. This is the only call of these three that I would expect to see associated with a behavior event as opposed to a behavioral state or formation. I would expect to see an increase in the call rate of S42 immediately prior to and during a change in group direction.

Methods

The research platform is a 14m long sailing catamaran with a quiet hybrid diesel-electric motor. Acoustic data will be recorded from a single towed hydrophone through a custom amplifier with the gain set on low, and onto a Marantz stand-alone recorder from the moment whales are within sight and a general behavioral state can be detected. Acoustic recordings will continue until the whales are too distant for behavioral state or travel direction to be observed. Acoustic range for this study is estimated to be about 2km away from the platform.

Surface behaviors will be recorded using a Zire21 Palm PDA, equipped with customized software from Dr. Jim Ha. The pod or pods within the acoustic range of 2km will be identified and the general group behavioral states will be recorded. Scans of the behavioral states will be recorded every five minutes. The level of group spread will also be recorded. In this study group spread is defined as whales in tight, less than16m of distance between one whale and another, close formation or loose and spread, defined in this instance as any distance greater than 16m. These parameters were set by considering the underwater visibility range in the San Juans and Haro Straight region, which is on average, 10m.

During all encounters with the whales attempts will be made through photo identification to identify the pods and as many individual whales that are part of the focal group as possible. Photos will be taken with a Sony Cybershot D-H5 camera along with several other cameras used by other researchers on the platform.

Data will be analyzed during the evenings or other times when whales are not present, and will be done so in a timely fashion. The PDA data will be transferred to an excel sheet on a Toshiba Satellite laptop, and will be briefly reviewed for quality assurance. This will then be filed until after the acoustic recordings are analyzed to avoid bias. Acoustic recordings will be studied in their entirety, with much analysis occurring in Raven ™ where a spectral image can accompany playback to make finding the three calls easier. Call rate of S6, S10, and S42 per 5 minutes will be determined, and once the acoustic files for an observation have been analyzed, the surface behavioral data will be overlaid to look for correlations between call rate and group spread (S6), foraging (S10), and known changes of group direction (S42).

Data obtained during super pod encounters or other occasions where the whales are spread within the acoustic range but their behavioral states cannot be obtained, due to sea or weather conditions will be analyzed separately to maintain data integrity.

Works Cited

Bain, D. E. 1986.Acoustic behavior of *Orcinus:* sequences, periodicity, behavioral correlations and an automated technique for call classification. In: *Behavioral Biology of Killer Whales* (ed. By B.C. Kirkevold & J. S. Lockard), pp335-371. New York: A. R. Liss.

Deecke, V. 1998. Stability and change of killer whale (*Orcinus orca*) dialects. M.Sc. Thesis, University of British Columbia.

Deecke, V., J.K.B. Ford, P. Spong. 2000. Dialect change in resident killer whales: implications for vocal learning and cultural transmission. *Animal Behavior,* **69**, 395-405.

Fischer, J., K. Hammerschmidt, D.L. Cheney, R.M. Seyfarth. 2002. Acoustic features of male baboon loud calls: Influences of context, age and individuality. *Journal of the Acoustical Society of America,* **111,** 1465-1474.

Ford, J. K. B., H. D. Fisher. 1983. Group-specific dialects of killer whales (*Orcinus orca*) in British Columbia. In: *Communication and behavior of whales* (ed. By R. Payne), pp.129-161. Boulder, Colorado: Westview Press.

Ford, J.K.B 1987. A catalogue of underwater calls produced by killer whales (*Orcinus orca*) in British Columbia. Can. Data Rep. *Fish. Aquat. Sci*. No. 633.

Ford, J.K.B 1989. Acoustic behavior of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. *Canadian Journal of Zoology,* **67**, 727-745.

Ford, J. K. B. 1991. Vocal traditions among resident killer whales (*Orcinus orca*) in coastal waters of British Columbia, Canada. *Canadian Journal of Zoology,* **69**, 1454-1483.

Ford, J.K.B, G.M Ellis, K.C. Balcomb. 1994. Killer whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. UBC Press, Vancouver, British Columbia.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R.S. Palm, K. C. Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales (Orcinus orca) in coastal British Columbia and adjacent waters. *Canadian Journal of Zoology,* **76**, 1456-1471.

Heimlich-Boran, J. R. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. *Canadian Journal of Zoology,* **66**, 565-578.

Jacobsen, J. K. 1986. The behavior of *Orcinus orca* in Johnston Strait, British Columbia. In: *Behavioral Biology of Killer Whales* (ed. By B.C. Kirkevold & J. S. Lockard), pp135-185. New York: A. R. Liss.

Janik, V.M. 2000. Food-related bray calls in wild bottlenose dolphins (*Tursiops truncates*). *Proceedings of the Royal Society B*, **267**, 923-927.

Miller, P. J. 2002. Mixed Directionality of killer whale stereotyped calls: a direction of movement cue? *Behavioral Ecology and Sociobiology*, **52**, 262-270.

Miller, P. J. O., D.E. Bain. 2000. Within-pod variation in the sound production of a pod of killer whales, *Orcinus orca*. *Animal behavior,* **60**, 617-628.

Morton, A. B. 2002. *Listening to whales: what the orcas have taught us.* First edition. Ballantine books/Random house, New York, NY.

Morton, A. B., J. C. Gale, R. C. Prince. 1986. Sound and behavior correlations in captive *Orcinus orca*. In: *Behavioral Biology of Killer Whales* (ed. By B.C. Kirkevold & J. S. Lockard), pp303-333. New York: A. R. Liss.

National Marine Fisheries Service. 2004. *A consensus coding scheme for killer whale behavior.* SRKW Behavior Workshop, NOAA NMFS NFSC, Seattle WA.

National Marine Fisheries Service. 2005. *Proposed conservation plan for southern resident killer whales (Orcinus orca).* National Marine Fisheries Service, Northwest Region, Seattle, Washington.

Osborne, R. W. 1986. A behavioral budget of Puget Sound killer whales. In: *Behavioral Biology of Killer Whales* (ed. By B.C. Kirkevold & J. S. Lockard), pp211-249. New York: A. R. Liss.