Anthropogenic Noise: Does an Increase of Boats Cause Decreased Vocalization Rates in Killer Whales (Orcinus orca)?

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Literature Review

Resident killer whales inhabit the Pacific waters of North America. They are divided into four populations called Southern, Northern, Southern Alaska and Western Alaska (NMFS 2008). Residents forage on fish and reside in stable pods ranging from 10-60 individuals (Ford et al. 2000). The Southern Residents, which preside in coastal waters of Oregon, Washington and British Columbia during the summer months, have been listed as endangered under the Endangered Species Act in 2005 (NMFS 2008). The community of Southern Resident killer whales (SRKW) is divided into three pods; J, K and L. Although Northern and Southern Residents have an overlap in habitat, the two groups do not interact with each other (Ford et al. 2000).

The organization of orca groups is built on the matriline in which a mother and her young stay together throughout their lives (Ford et al. 2000). Matrilines have been seen to maintain a close knit group of up to five generations and individuals rarely separate for multiple hours at a time (Ford et al. 2000). A grouping of closely related matrilines composes a pod. The relatedness of matrilines or pods can often be determined by the degree of similarity in their acoustic calls (NMFS 2008).

Vocalizations in killer whales are a way of connecting families with a shared culture, along with the practical uses of foraging and navigating (Ford et al. 2000). Orca acoustic communication is comprised of three parts: pulsed calls, whistles and echolocation clicks. Pulsed calls are the most common type of communication which typically last less than two seconds. The calls often range in tone while whistles remain fairly constant (NMFS 2008). Clicks on the other hand are bursts of ultrasonic sound that are often grouped together to form 'click trains' (NMFS 2008).

The strong social family ties cause limited interactions with other killer whale populations. This places them in a perilous position when alterations arise in their habitat since there is such a small gene pool in the population (Guimaraes et al. 2007). A sharp decline of the population in the late 1990s and the susceptibility for a pod or a significant fraction of its population to continue to decline caused orcas to be listed as endangered. The fragile state that the orca population is in has created a heated debate of what effects boat noise has on orcas.

The background noise caused by ships and boats can make it much more difficult for killer whales to detect and discriminate messages from one another (Foote et al. 2004). Ship noise is an incredibly loud sound source created by humans which is able to mask an entire omnidirectional component of an orca call with its wide broadband (Foote 2008). Orcas have their most sensitive hearing at 20 kHz (Szymanski 1999). Although boat sources range due to time of day and season, the frequency range of source levels created by boats is .1-15 kHz (Veirs 2005). Although the anthropogenic noise people create falls below the optimum hearing range of orcas, it is still within their hearing range of 1-100 kHz (Szymanski 1999).

The vocalizations are crucial to the stability of matrilines and the pod as a whole (Parsons 2009). Limited communication could cause the tightly organized and efficient pods or matrilines to exert more effort when travelling together (Holt 2009).

Problem Statement

Human fascination with the Southern Resident population of killer whales has created some issues for the orca. Once a group of orcas are noticed by an individual boater, the word spreads across the radio and phone lines and within minutes multiple boats are trying to get a view of the whales. Verbal communication between people is not even necessary for people to become aware that whales are near by. The whale watching industry has easily identifiable boats, and if a few of those boats are seen heading in the same direction, it is a good indication for other boaters that orcas have been sighted. This massive influx of boats around the killer whales in the Salish Sea creates an inability for the orcas to travel without human interruption. These and other anthropogenic noises make it difficult for the vocal community of orcas to communicate.

Vocalization between individuals is thought to be crucial in maintaining social cohesion in traveling and development of young. The masking of the pulsed calls of orcas by noise created by boats can affect the orca population in a couple of different ways. The competition of noise has been shown to cause a higher repetition of calls and an increase in call amplitude in order to be heard (Holt 2009). An increase in call duration has also been noted as boat numbers rise (Foote 2004). This extra effort does not come without a price. The extra energy it takes to compete with anthropogenic noise may not be beneficial to a population with a dwindling prey source. Energy constraints could cause the SRKW to be much less vocal than it would prefer. An increase in the

number boats causes a change in swimming patterns which enhances the energy expenditure (Kreite 2002). The extra energy use in travel could end up minimizing the amount of phonation in the pod.

The purpose of the study is to monitor a possible change in behavior caused by the additional sound created by humans. As more people partake in boating, ambient noise increases (Holt 2009). The quantity of boats is not the only factor involved, because as boating speed increases, so does the noise it creates (Erbe 2002). The type and size of the boat along with the style of engine also impacts the noise level projected into the water (Erbe 2002).

A lack of vocalization, while less subtle than louder and longer calls, could produce equally harmful effects. A deficiency of phonation between individuals makes traveling as a cohesive unit more difficult and less efficient energetically. The possibility of such significant alterations to the orcas lifestyles caused me to ask: does anthropogenic noise cause SRKW to forego communications to avoid the competition with the surrounding sounds?

Methods

Data will be obtained while onboard the 42 foot sailing catamaran, Gato Verde, from May 10, 2009 through May 31, 2009. A linear four hydrophone array will be deployed from the port side of the stern of the catamaran. The Lab Core Array has four hydrophones that are ten meters apart from its neighbor. It is to be towed while the Gato Verde maintains a speed under two knots. This is done in order to minimize the flow noise so it will not add to the ambient noise. In order to keep the linear array under the surface of the water, a 4.54 kg weight is tied to the cable of the hydrophones. This allows

the hydrophones to remain submerged and in a localized place in the water column. All recordings will be taken with Sound Devices 702 and analyzed with the computer program Audacity. Ambient noise will be calculated by isolating a part of the recording that are void of calls, whistles or clicks and is representative of the sound file as a whole. To determine significance in the data, a regression will be applied to all variables.

Vocalization and ambient noise are not the only factors involved though. Another aspect of the research is to monitor the behavioral states of the Southern Residents. The behavioral states will be separated according to the NOAA behavior workshop (NOAA 2004). The five behavioral states of killer whales are: rest, travel, forage, play and milling. Orcas are considered at rest when they are moving at slow speeds, while remaining close to one another and very directional. Resting also consists of flank or non-linear orientation and a lack of percussive events. Travel on the other hand is defined by the directional nature of the whales, while everything else can vary. Speeds, orientation and proximity to one another can change while traveling. Foraging is hard to identify since much of the hunting is done beneath the surface. The key to determine foraging is with lunge and chase events. Play can occur with any orientation, speed or proximity, but usually involves interactions with objects, such as kelp, or with other individuals. Milling is recognized by slow to medium repeated nondirectional movements of a non-linear orientation.

Distinguishing between behavioral states will remove a source of ambiguity of the call rates. If it is found that orcas communicate more frequently due to a specific behavior state, than it will not be confused as resulting from ambient noise.

The pod of whales will be identified using photo identification methods. This enables any variations between the pods to be measured. The number of whales will also be noted because as the number of whales increase, the probability of communication increases. Once again, this additional data collected will ensure that the results calculated will pertain to ambient noise and not other factors.

I expect there to be a decrease in pulsed call rates as ambient noise increases. The energetic effort required to continue to communicate with higher ambient noise diminishes the rewards.

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