The reaction of Southern resident orca to sensitive frequencies produced by nearby vessels

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Literature Review

The killer whale (*Ornicus orca*) is the largest cetacean in the dolphin family Delphinidae. There are three different types of whale pods, or matrilineal family groups, in the northeastern Pacific Ocean commonly known as resident, transient, and offshore orcas. Typically, residents tend to be more vocal than the other types, particularly when foraging and socializing with other members of the pod. There are four resident pods that are named the Northern, Southern, Southern Alaska, and Western Alaska residents corresponding to the locations of their residency.

All of these pods use echolocation for communication and prey location in an array of three categories of vocalizations: clicks, whistles, and calls (Holt, 2008). Often, the ambient noise levels in their aquatic environment reach levels that mask certain frequencies of important echolocation calls. The variant frequency level of each call is dependent on the individual sending or receiving the call but is essential for survival. There is relatively little data concerning the vocal changes of the Southern residents according to specific frequency levels from surrounding vessels.

This study, therefore, will focus on the frequency and levels of measurable noise from vessels in the immediate area during a call period. The suggested frequency range of source levels created by boats is 0.1 to 15 kiloHertz (kHz) (Veirs, 2005), while the sensitive hearing range for orca is typically 20 kHz (Szymanski 1999). By collecting whale calls and measuring specific frequencies, we will be able to discern the most sensitive range of hearing for the Southern resident whales. The vessel noise information will then be analyzed with the whales' call behavior during that time. Any information on the sensitive frequency range of the orca pod associated with data on their vocal reactions to frequencies within that range will be instrumental in defining vessel regulations. If successful, it will support the need for specific vessel frequencies to be eliminated from the orca habitat altogether. The impact of certain frequencies on the orca and their habitat is a mystery that we are hoping to begin to solve.

It has been well documented for most of these pods that ambient noise produced by vessels impact their call behavior. Historically, whales have displayed several avoidance tactics including the avoidance of boats (Watkins 1986; Beach and Weinrich 1989), longer dives (Erbe 2002 quoting Blane and Jaakson 1994), path deviation, variable swimming speeds (Williams 2009), and observable avoidance strategies (Erbe 2002). Scheville in 1968 also claimed that the changes in whale behaviors and vocalizations are due to the noise produced by the boats, as opposed to the mere presence of a moving object.

Subsequently, researchers have invested in quantifying and qualifying these observations according to variables such as amplitude of the sound (Holt et al. 2008), distance from the vessel (Erbe, 2002), changes in whale behavior (Lusseau, 2009), and inhibition effects of the whales (Williams, 2009). Holt et al. (2008) observed that killer whales increase their call amplitude by 1 decibel (dB) for every 1 dB increase in background noise levels within a particular call type. This call type was the S1 call which is typical in the Southern residents. It is likely that the residents are responding to a noise increase near their sensitive frequency range, so this study will focus on the impacts that boat frequencies have on the S1 call, while also noting behavioral changes near particularly high noise levels at sensitive frequencies.

Similar impacts of ambient noise have been discovered and recorded in animals with equivalent echolocation abilities. Vocalization level changes have been observed by Schiefele et al. in beluga whales along the St. Lawrence River in 2005. Wieland made similar observations that the masking noise stimulated compensation behaviors of increased vocalizations in belugas and great tits in a similar manner to orca whale compensations. She also recorded that bottlenose dolphins whistle at a higher rate due to vessel noise (2009).

It is clear that increased noise levels in the environment affect the animals that rely on echolocation for communication and prey detection. With increased masking effects over time, it is imperative that studies discover realistic means to manage their populated environment. Although the Southern residents compensate in a variety of ways, few studies have recorded a critical frequency range for Southern residents or the compensation mechanisms used to overcome ambient noise within that range.

Masking noise compensation is dependent on the frequency and loudness of the call. Trained beluga whales are able to communicate at high masking levels as long as the major frequency component of the call is audible (Erbe 2000). Also, belugas have been observed altering their call frequencies in order to compensate for masking noise at a given noise level (Wieland, 2009). In addition, Humpback whales commonly increase their call duration when low frequency sonar is in the acoustical area (Wieland, 2009). Taking these compensations to vessel frequencies into consideration, this study will attempt to find the vocalization changes of the Southern resident pod and analyze the data for a frequency of particular vocalization impact.

A recent study by Andrew Foote and Jeffrey Nystuen (2008) analyzed the variable frequency in calls between ecotypes of killer whales. They found that in the Northeastern Pacific region, the three “ecotypes” of killer whales are able to live in a close proximity by using a range of frequencies for different types of prey. The offshore whales have a significantly higher frequency minimum than the residents, who in turn have higher frequency ranges than the transients. These levels are related to their prey specifications, meaning that different frequency levels within the environment would have different impacts on the type of orca in the area. Our study will focus on vessel frequency impacts specifically on the Southern residents, who, according to Foote, have a medium frequency range. It is expected that vessels will have a range of frequencies and that the vocalization changes with also vary. Foote noted (2008) that the low frequency ship noises (typically between 0 and 10 kHz) can mask entire components of killer whale calls.

Since frequency ranges can vary by call type, we will separate call types into three categories of whistles, calls, and clicks and focus primarily on the common S1 calls. This is a mid-frequency and highly utilized call which is likely to show mid-frequency compensation mechanisms. Once an observable vessel frequency range is established, vocal reactions of the whales to various noise levels within that frequency range will be recorded and analyzed for any changes. If possible, the study will categorize the spectral properties of vessel noise into narrowband or broadband, as well as low, medium, and high frequencies. The hypothesis is that the pod (or individuals) will have stronger behavioral reactions to increased ambient noise within a more sensitive frequency range. When this range is specified and supported with statistically significant data, law-makers will have the necessary information to establish practical vessel restrictions to create a better environment for the Southern residents within the Salish sea and beyond.

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