Preferential habitat use in the San Juan Islands by Killer Whales based on call rate and bathymetry

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Introduction

Similar to communication among people, animals use communication to convey many signals. Our brains are constantly receiving and interpreting sounds to create the world we perceive around us. That is why so much research focuses on acoustics and their role in the environment. Killer whales, Orcinus Orca, are very acoustic animals and rely on communication to maintain cohesion in their highly social pods. Killer whales also use sound when hunting, in the form of echolocation clicks. (Au et al. 2004) These whales hunt cooperatively in their pods and matrilines and must be able to communicate in order to survive. In the Salish Sea there is increasing noise pollution from boat traffic and other anthropogenic sources. It is important to understand how the Southern Resident Orcas use this environment and which areas are most critical for their ability to communicate if their population is to increase. This distinct population of killer whales is the focus of this paper due to their listing status of endangered in 2005, which was determined after a 17% decline in population size. (NOAA-NMFS 2008) In the recovery plan NOAA identified critical habitat the Orcas use most often. In order to protect their habitat, more critical areas need to be identified and understood. (NOAA-NMFS 2008) This paper focuses on killer whale communication and how it may be affected by bathymetry and in turn transmission loss.

There are many other animals that use sound similar to the Southern Residents, like the White-browed scrubwrens and superb fairy-wrens. These birds listen to each other' s calls and flee if they hear an alarm call signifying that there is a predator nearby (Magrath and Bennet 2012) This study found that birds use communication cooperatively to increase survivorship. Animals also use sound to defend territories or to put on an aggressive display to ward off competitors. (Bradbury and Vehrencamp 1998; Sogge et al. 2003) Similarly Red-Winged black birds use their songs to identify their own species using specific series in their songs. (Beletsky et al. 1980) Bottlenose dolphins also utilize identification series in their calls. (Nakahari and Miyazaki 2011) found that bottlenose dolphins use distinctive vocalizations to identify individuals in pods, as well as a simple contact call to keep in touch with the pod’s location.

The sound that people and animals hear (through the various forms of communication signals that they create) is a result of the oscillation of particles as a wave passes through a medium, such as air or water. (Erbe and Court 2011) Sound is attenuated faster in air than it is in water, which makes aquatic acoustic studies more common. Underwater acoustics are interpreted with a hydrophone, which measures acoustic pressure by detecting a change in ambient hydrostatic pressure caused by a sound wave. (Erbe and Court 2011).

In the water, waves can spread in a spherical or cylindrical model. (Jensen and Kuperman 193) During spherical spreading, a wave will propagate out evenly in all directions like a sphere. Contrastingly cylindrical spreading usually occurs in shallow waters where the wave will bounce off the surface and or the bottom of the ocean and create a cylindrical shape due to the reflection off of those surfaces instead of continuously propagating out in all directions. (Jensen and Kuperman 1983) Spreading is often more complex and can result in a combination of spherical and cylindrical spreading. (Erbe and Court 2011) The type of spreading can also affect the amount of transmission loss. As a sound spreads out there is transmission loss between the source and the received sound levels. Since spherical spreading continues evenly in all directions, more sound energy is lost, whereas in cylindrical spreading sound is contained by the bottom or surface of the ocean and there is lower transmission loss. (Erbe and Court (2011). To measure transmission loss Erbe and Court (2011) use the equation RL (received level)=SL (source level)-TL (transmission loss). This equation will be used to measure transmission loss from spreading experiments and can be impacted by depth, bottom type, and speed of sound in that location. All of these aspects are important when looking at animal communication because they all have the ability to affect the degree to which animals are able to communicate.

The geographic focus of this study is the San Juan Islands and surrounding waters including Haro Strait, Strait of Juan de Fuca, and Swanson Channel. The landscape of an environment can really affect the way sound propagates, especially in the ocean. These islands are acoustically different due to the generally shallow waters, fractured bedrock that make up some of the slopes, and sand/gravel bottom types. The shallow water assumes a cylindrical spreading, which makes for an acoustically interesting area for the Orcas due to the lower transmission loss, which could be why the southern residents prefer the Salish Sea.

Killer whales, *Orcinus Orca,* are the largest members of the Delphinidae family and occupy more regions in the world than any other dolphin species. (Leatherwood and Dahlheim 1978) While there is only one recognized species there are several ecotypes of killer whales. (Ford et al. 1999) have identified three types resident, transient and offshore. They can be distinguished by physical and behavioral characteristics such as foraging patterns, spatial distribution, saddle patch shape, and dorsal fin shape. Ongoing photo-identification studies have been able to identify all members of the southern resident pods J, K, and L, as well as many members of the transients that frequent these waters. Less is known about the offshore whales since they are frequently on the move and are farther from shore and away from good observation sites. (Ford and Ellis 1999) These whales can also be identified by their food preferences. Residents feed on fish alone, while transients are more opportunistic and will feed on marine mammals. It is assumed that the offshore whales feed on mammals as well. (Bigg et al. 1987) One unique trait of killer whales globally, is that they all communicate with unique pod-specific calls. There are 22 distinct calls for the southern residents in general, with more calls identifying each pod. (Ford 1987)

It is important to understand how killer whales utilize their habitat and the importance their favorite locations play in their ability to communicate and maintain pod cohesion. From what is known about the way sound travels and the bathymetry of the Salish Sea in conjunction with killer whale communication, Orcas will communicate with a higher call rate in locations with a lower transmission loss where spreading can be affected by depth, bottom type and the speed of sound. Alternatively Orcas may also be communicating less frequently in areas with low transmission loss since they do not need to repeat their calls in order to be heard to compensate for a higher transmission loss. The goal of this paper is to measure sound speed profiles and characterize bathymetric types of the Southern Resident Killer Whales' favorite locations based on (Hauser et al. 2007) and inversely locations they rarely frequent in order to understand if they preferentially use certain locations to ease communication problems.

Methods

Data will be collected from the 42' catamaran the Gato Verde as well as the dinghy the Gatito from late April to late May. Archived data will also be incorporated into the study to make the data more robust. In order to identify areas for data collection, the San Juans were divided into 5 major areas where the Southern Residents are most likely to be seen: salmon bank, south of salmon bank(offshore), west side of San Juan Island, north of San Juan Island near Boundary Pass and Swanson Channel if possible, and the south side of Lopez Island. Data will also be collected in areas where the whales do not generally frequent such as: inland bays, and the islands above Orcas island such as Sucia, and San Juan channel.

Acoustic data will be collected with a 4 hydrophone array (for call rate) and single calibrated hydrophone for spreading experiments. The spreading experiments will be done from the Gatito 100m away from the Gato Verde, subject to change dependent on sea state and boat traffic. These experiments will be done using an underwater speaker connected to an ipod playing tones of varying frequencies. First a CTD will be deployed to understand the construction of the water in that location, and to check for the possibility of a duct as well, which would affect the speed of sound. (Erbe and Court 2011) If there is a duct, then a spreading experiment will be done with the speaker lowered to middle of the duct and compared to a time when there is no minimum or maximum. When Killer Whales are present acoustic data will be recorded using dual time-synchronized recorders (Sound Devices 702 model) as well as a GPS location of the whales to go back and examine the bathymetry later. The location will be downloaded from Captain Todd's GPS. The study will be looking at the rate of all Southern Resident calls and the data will be normalized by number of whales present. All surface behavior observations will be taken according to NOAA behavior workshop from 2004. Rate of calls will be determined by counting number of calls per minute and then potentially averaged over the whole encounter. Time permitting, individual call use proportions will be calculated for all calls used during that encounter as well as general call rate for all calls together. This will attempt to look at whether certain calls are used more often in similar areas.

The final paper will include a bar graph of location vs. call rate, scatter plot of call rate vs. averaged sound speed from profile in all locations, table of bathymetric categorizations, and a plot of SRKW calls vs. transmission loss from spreading experiment.

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