Boat noise and its effects on the frequency of individual killer whale calls

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Killer whales are structured around cultural matralines (Springer, A.M, et. Al., 2003) The Northeastern Pacific killer whales have been classified as three different ecotypes, which are the transients, the offshores, and the residents. This distinction has been made due to their geographic locations, feeding preferences, and social, as well as cultural differences (Ford, J, K, B. 1991). Recently, a population of killer whales known as the Southern Residents have gained an increasing amount of attention. The Southern resident killer whale population is comprised of three pods - J, K, and L. As defined by Braird and Whitehead, a pod is a group of individuals that are commonly seen together, and associate with each other at least 50% of the time (Braird, R. W. and Whitehead, H. 2000). Pod sizes can range from 3 to 50 individuals, and the Southern Resident Killer whale pods primarily feed on fish (Braird, R.W. and Whitehead, H. 2000). These Southern Resident killer whales are most commonly seen from June – October off the coast of British Columbia, and waters adjacent to Washington State (Ford, J. K. B., 1991). In November of 2005, under the Endangered Species Act, NOAA (National Oceanic and Atmospheric Administration) Fisheries listed this keystone predator, as endangered (NOAA, 2011). Increasing efforts have been made to protect the dwindling population of the Southern Resident Killer Whales, due to their importance as a cultural icon. Washington State, the U.S., and Canadian federal government have also classified the southern resident orcas as an endangered species. There are three threats to the Southern Resident Killer Whales that have been identified by NOAA. These threats are declining salmon abundance (particularly Chinook salmon), exposure to toxic pollutants, and the presence of vessels and the noise

effluence that they create in the underwater homes of these prominent hunters (WDFW 2011). According to Erbe's model, behavioral reactions were linked to boats within 400 m of killer whales (Erbe, C. 2002). This model suggests that Southern Resident Killer Whales change their behavior in response to underwater noise disturbances from boat engines. These behavioral changes include faster swimming, less time foraging, changes in dive duration, moving into the open ocean, and using less predictable routes of travel (Holt, M. M., 2008). According to a study performed in 2004 by Foote and colleagues, all three pods (J, K, and L) of Southern Resident killer whales made longer call durations in the presence of boats, which further indicates that these whales adjust their behavior to compensate for anthropogenic noise once it reaches a threshold level (Foote, A.D., et. al. 2004). It is known that the most sensitive hearing range for killer whales is 20 kHz (Szymanski, M.D., et. al., 1999).

According to NOAA, killer whales primarily depend on their advanced hearing ability and evolved vocalizations to find food, traverse through their ever-changing environment, and convey information with other members of their pod (NFSC, 2011). Lesage, V., and colleagues determined that small rapid motorboats and large slow - moving ferries both induced changes in the calls of St. Lawrence belugas (Lesage, V., 1999). This resulted in changes in beluga call rates, increased call repetition, increased call duration, and increase frequency ranges which belugas used to vocalize (Lesage, V., 1999). In addition to this study, Holt, and colleagues found that whales increase their call source by 1 dB as background noise levels increased by 1 dB level.

Since these studies indicate that there could be a relationship between boat noises and call rates, this experiment is designed to test the hypothesis that if underwater noise created by

vessel traffic reaches the noise threshold of killer whales (20 kHz), then the rate at which an individual call is made will have a greater frequency.

Materials and Methods

This experiment will be carried out using both a stationary array of hydrophones located at Lime Kiln and a mobile linear array of hydrophones which will be pulled behind a 42 – foot catamaran named the Gato Verde.

Stationary Hydrophone Array

The Lime Kiln north array hydrophones are stationary, and will be used to record killer whale calls when boats are present, as well as absent. This array consists of both 3 Labcore hydrophones and 1 Reson hydrophone. The Lime Kiln North array consists of 4 hydrophones arranged in a "U" shape. The hydrophone measurements are taken from a point of origin (metal post) in front of the light house. Respectively these hydrophones will be called H1, H2, H3, and H4, based on their proximity to the point of origin, with the hydrophones closest to the point of origin receiving the lowest number. H1 is a Reson high frequency hydrophone, which is used to hear high frequency flat responses between .1 and 100 kHz. H1 is specifically good at picking up Orca click. H2, H3, and H4 are Labcore hydrophones, which are less sensitive than H1, and are used to hear audible calls. There are 2 hydrophones that are co-located, and have been measured at a distance (x) of approximately -26m south of the point of origin, and a distance (y) of approximately -2m west of the point of origin, and a depth (z) of approximately -9m below the water surface. These hydrophones will be called H1 and H2 for the purpose of this study, and are more proximal to the other two hydrophones. Hydrophone 3 (H3) has been measured at

a distance (x) of -33m South of the point of origin, a distance (y) of 1 m West of the point of origin, and a depth of -10m below the waters surface. Hydrophone 4 (H4) has been measured at a distance (x) of -41m South of the point of origin, a distance(y) of 0m West of the point of origin, and a depth (z) of approximately -13 m below the water's surface. H4 is currently the most distal hydrophone from the point of origin in working condition.

Mobile Hydrophone Array

In addition to using the Lime Kiln North array of hydrophones, I am also using a linear array of 4 Labcore hydrophones, which will be pulled behind a 42 foot catamaran, named the Gato Verde. These hydrophones will be calibrated by _____ to establish a baseline, and are spaced 10 m apart, as they are pulled behind the Gato Verde at a speed of approximately 2 knots, so that the noise produced by water flowing over the hydrophones will be reduced. A _# kg_____weight will be attached to these hydrophones as well to insure that they remain under water while the Gato Verde is in motion.

To determine whether the rate of an individual call is being made more frequently when there is more noise pollution due to vessel traffic, the 4 hydrophone array will record the total number of calls made by killer whales per minute when there are no boats present. This will be done to establish a baseline for the rate at which individual killer whale calls are made. The same procedure will be employed when boats are present to determine if there is an effect on the total number of whale calls per minute. Boats will be counted every minute when killer whales are present to determine if there is a correlation between the number of boats present and the frequency of an individual call. A spread equation will be used to quantify the distance of the boats from the killer whale. This procedure will help determine the relationship between the

amount of boat traffic, and the number of killer whale calls made every minute. Audacity will be used to measure the amplitude of boat noises. This procedure will determine whether the boat noises have reached the noise threshold of the killer whales. Once this is determined, Audacity will again be used to determine the call rate of killer whale calls. The rate will then be calculated (#of individual calls/minute).

The number of boats present will be determined using radar which is located on the Gato Verde.

Boats will be considered present if they are within 400 meters of the Gato Verde when whale calls are heard through the hydrophones. This distance was chosen because the current law for vessel traffic around killer whales requires that boaters within 400 m of the killer whales reduce their speed. However, as noted in Erbe's paper, killer whales may still alter their behavior when boats are within 400 m(Erbe, C. 2002). The type of boat will also be recorded to determine if there is a relationship between the kind of boat(s) present, and the call rate of an individual whale call. It is probable that there will be more calls made by the Southern Resident Killer Whales when there are more killer whales present. In consideration of this factor, the number of killer whales in a given area will be determined through photographing, and identifying which pod (J, K, or L) is present when the calls are recorded. Therefore, calls that are recorded when the killer whales are not visible will be omitted from the data, and killer whales will only be considered present when a visual identification or number of individuals can be confidently secured.

References Page

Braird, R. W., and Whitehead, H. 2000. Social Organization of mammal – eating killer whales: group stability and dispersal patterns.

Erbe, C. 2002. Underwater noise of whale – watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18 (2): 394 – 418.

Foote, A.D., R.W. Osborne, and A.R. Hoezel. 2004. Whale-call response to masking boat noise. NATURE 428(6986):910.

Ford, John K. B. 1991. Vocal traditions among resident killer whales (Orcinus orca) in coastal waters of British Columbia. Can. Zoology 60: 1454-1483.

Holt, Marla M., M. "Sound exposure and Southern Resident Killer Whales: A review of current knowledge and data gaps." *NMFS-NWFSC*. (2008): 59. Print.

Lesage, V., et. Al. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence river estuary, Canad. Marine Mammal Science 15 (1): 65 – 84.

Springer, A. M., et.al. 2003. Sequential megafaunal collapse in North Pacific Ocean: An ongoing legacy of industrial whaling? 100 (21) 12223 – 12228.

Szymanski, M.D., K. Kiehl, S. Pennington, S. Wong, and K.R. Henry. 1999. Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. Journal of the Accoustical Society of America 106(2):1134-1141.

Alaska FisheriesScience Center National Marine Fisheries Service. *National Marine Mammal Laboratory*. Alaska, Print. <http://www.afsc.noaa.gov/nmml/education/cetaceans/killer.php>.

NOAA. *Endangered Species Act Status of Puget Sound Killer Whales*. Seattle: Department of Commerce, 2011 . Print. <http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/>.

Washington Department of Fish & Wildlife. *Orca Whale Management*. Olympia: Washingon, 2011. Print. <http://wdfw.wa.gov/conservation/orca/>.