Surface behaviors of Southern Resident killer whales: Are they responding to vessel noise?

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INTRODUCTION

The Southern Resident killer whales *(Orcinus orca)* have been added as an endangered species fairly recently. They were declared "depleted" under the Marine Mammal Protection Act in 2003 and captures in the 1970s put a dent in population numbers. A combination of threats, such as dams being placed and sonar being developed have put these whales in a delicate position. Funding has been allocated to get a better understanding of the species and with their listing to the Endangered Species Act it should increase. A possible threat to the killer whales is the noise produced by vessel traffic because they use sound to communicate, navigate, and detect predators and prey. Marine mammals may try to avoid loud sound sources up to tens of kilometers away (Richardson, et al., 1995). There is currently no data on permanent hearing loss due to reported and prolonged noise exposure in marine mammals (Erbe, 2002).

Whale watching boats have increased over the years and so has the acoustical compensation from killer whales to account for it (Foote et al. 2004, Fig. 1). Haro Strait, the primary summer region for Southern Resident killer whales, has relatively high vessel traffic due to a key shipping lane. Commercially the

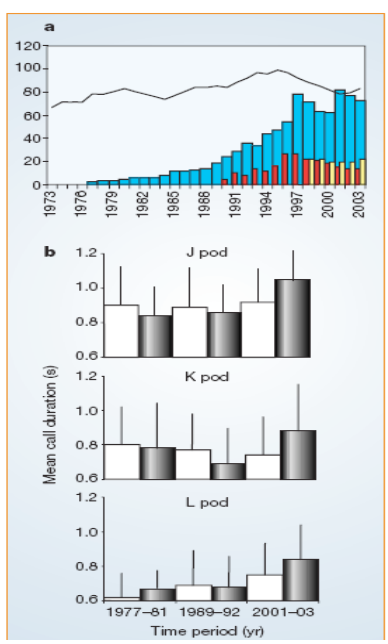

Figure 1 Effect of whale-watcher boat noise on calls made by killer whales.
a, Boat and whale numbers are shown for the period between 1973 and 2003. Solid line, size of whale population; blue bars, number of active commercial boats per year; red bars, average number of boats following whales, measured from shore base (Lime Kiln Lighthouse, San Juan Island, Washington state; data for 1990–2003 only); yellow bars, average number of vessels following whales, measured using boat-based observations (1998–2003 only).
b, Call duration in seconds for the three pods (termed J, K and L) recorded in the presence (black) and absence (white) of boats for each time period (error bars show 1 s.d.). (Foote et al. 2004)

strait is serving the needs of two countries, Canada and United States. With that come high amounts of cargo ships for economic purposes: oil, clothing, automobiles, electronics, etc. National Security is present by the Navy from both countries. Sonar exercises are common from military vessels and have been known to affect cetaceans in the past. “High energy, mid-range, mid-frequency sonars” have been linked to mass strandings of beached whales (NRC, 2003). Other commercial vessels in the water come from the fishing industry, commuter vessels (ferry) and the whale-watching industry. There is also personal vessel traffic used for recreational uses and research. Whale watch guidelines have been put in place to assist in whale-watching vessels to view the whales at a 100 yard distance. These guidelines are voluntary and may not always be followed by personal vessels.

Marine Mammals ears physically bear a resemblance to land mammal ears except they lack the external fleshy lobes that land mammals tend to posses. The ocean has always had some amount of noise, which may have led to the evolution of marine mammal hearing to be toughened for ‘natural’ aquatic noise. That compensation has been shown in research that marine mammals have developed broader hearing ranges (NRC, 2003). Killer whales use high frequency echolocation to scout for prey and their surroundings. When foraging on prey, the pulses are shorter and more frequent. While foraging the whales can echolocate to navigate the bathymetry for vessels around them using pulses that go a further distance. Outboard-powered vessels operating at full speed produce estimated RMS sound-pressure levels of about 160-175 decibels with reference to one micro Pascal at one meter (dB re 1 _Pa hereafter) (Bain 2002, Erbe 2002). Inflatables with outboard engines are slightly “louder” than rigid-hull powerboats with inboard or stern-drive engines (Erbe 2002). Results from Grabstein (2006) showed that large vessels produce a significantly smaller fraction of their acoustic power at high frequencies than small craft, and that the shape of a vessel's spectrum level (power vs frequency) is more closely related to vessel type rather than weight or speed. A slow motorboat at 100m sounds the same as when it travels at a fast speed 500m away (Bain (pers. comm.).

The indirect effects of anthropogenic sound on marine mammals via effects on their predators, prey and other critical habitat elements are largely uninvestigated (NRC, 2003). Underwater sounds can be generated by engines, dredging, drilling, construction, seismic testing and sonar (Richardson et al. 1995). Anthropogenic sound has caused the killer whales to adjust their behavior to acoustically compensate once it reaches a threshold level (Foote et al. 2004). Acoustical compensation has been seen in other species, such as the great tits overcoming urban noise with a higher minimum frequency song (Slabbekoorn and Peet, 2003). Foote et al. (2004) found that the Southern Resident Killer Whale population increased the duration of their calls by 10-15% as vessel traffic increased over three decades. Movements of killer whales have also appeared to be affected by boats within 100m and 400m (Bain, pers. comm.). Lusseau (2003) stated, for cetaceans, there is an increase in time spent underwater as a vertical avoidance of boats. This is a typical response in cetaceans and has been likened to predator avoidance strategies.

The NMFS (2005) summarized that some studies have linked vessels with short-term behavioral changes in Northern and Southern Resident killer whales. Avoidance tactics often vary between encounters and the sexes, with the number of vessels present and their proximity, activity, size, and "loudness" affecting the reaction of the whales (Williams et al 2002). Williams et al. (2002)

demonstrated significant behavioral responses of male resident killer whales at received levels of approximately 116dB. Whether it is the presence and activity of the vessel, the sounds of the vessel or a combination of these factors it is not currently fully understood (NMFS, 2005). It is not known how current anthropocentric noise has affected the killer whales hearing and if it is stressing the whales to behave differently or if they have grown accustomed to a certain level. As a first step to addressing these uncertainties, I propose to consider descriptive studies of the effect of vessel noise on surface behavior. Specifically, I will test if the amount of vessel noise in the area has an effect on the killer whales call rate(?) and surface behavior.

METHODS AND MATERIALS

Study Area

During the months of September and October 2006 I will conduct a randomized survey in the Salish Sea surrounding the San Juan Islands and South Vancouver Island aboard the 'Gato Verde', a 42-foot catamaran, powered by wind and a quiet biodiesel engine. I will physically record surface behavior, number of boats motored or idling, total number of whales, and surface behavior.

Definitions

Surface behavior is to include all actions performed by killer whales during visual time at the surface of the water, including but not limited to states (foraging, play, etc.) and events (breeching, tail slaps, change in bearing, distance, time during surfacing, etc) (Appendix 1). Behavioral events will be taken as a secondary source of data, depending on the sample size. Foraging is characterized by a loose forward orienting formation with subgroups and individuals occasionally varying their progress and engaging in non-directional milling activity (Osborne, 1986). Long, dorsal ended dives with non-directional travel will also be considered as foraging, especially in males. Vessel is referred to as all man-made devices that have the ability to make noise in the water (this excludes kayaks and does not exclude aircraft). Inactive is characterized by a tight, slow moving group (1-2 kn) with all individuals in simultaneously surfacing within a few meters of immediate neighbor or touching. Socialize is characterized by behavioral events and is not in accord with any other category. Travel is characterized as directional movement at a steady energetic pace (+3.5 kn) and an absence of any novel surface events. Sexual behavior is categorized by visualization of a penis.

Selection of Data

Auxiliary data will be taken at the start and end of each data collection, such as temperature, cloud over, wind speed/sea state and GPS waypoints. Once whales are in acoustic and observable range (~600m), a count will be done on vessels. Vessel count included moving (motoring or idling) boats within 450m of the whales. Large ships were counted once in visual range at any distance from the whales. All data will be time stamped using a PDA (Palm Tungsten E) and software provided by James Ha of University of Washington. Boats were marked as motoring or idled, by their size and personal or commercial. The distance of whales closest to the Gato Verde and number of whales will be recorded as categorical (0m-100m, 101m-200m, 201m-400m, 400m>). An identification of the pod will be taken when possible. Once vessel counts have been done, ten minutes of whale behavior will be taken on the cluster of whales closest to the Gato Verde. Behavioral states and events will be observed with the definitions from above and time stamped. States will be collected as duration and events will be done as a count. A single hydrophone array will be pulled at the stern end of the 'Gato Verde' to capture all noise from whales and vessels and recorded onto a Marantz. Time will be manually recorded once sound has started recording and ended. Digital camera and video cameras will be used to help identify the whale pods when possible. (Total number of visual whales will be used for call rate if someone else is taking that data).

Acoustical Monitoring

Files will be recorded in ten-minute increments. Acoustical data will be analyzed by using Raven 1.2 software to produce spectrograms of vocalizations and vessel noise with a sampling rate of 44.1 kHz. A one-minute time sample will be taken in coincidence of the start time from the vessel count. Whale vocalizations will be spliced from the one-minute sample in order to receive RMS amplitude of vessels. The one-minute sample will be extended beyond and before the vessel count time to ensure 60 seconds of vessel noise has been obtained. The one-minute not spliced sample will be used to get a call rate (or percentage) of whale calls.

Data Analysis

I would like to see if there is a relationship with the number of moving vessels and the amount of noise. The statistical test used will be a correlation to see if there is a linear relationship between vessel noise and number of moving vessels. To test surface behavior against vessel noise, I will take a mean on the RMS from prior and after the behavior is observed and test it against the behavioral states. I believe I will be able to show a significant difference in the behavioral states and vessel noise. Al data will be tested for normality. I will also hope to be able to test if there is a vocal response to vessel noise and hope to show there is not a significant difference by using an ANOVA. I would like to test number of behavioral events with vessel noise with a correlation. Overall, I am hoping to show vessel noise has little effect on the Southern Resident killer whales, if any at all.

LITERATURE CITED

Bain, D. E. 2002. A model linking energetic effects of whale watching to killer whale *(Orcinus orca)* population dynamics. Friday Harbor Laboratories, University of Washington, Friday Harbor, Washington.

Bain, D. E. 2006. personal communication.

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 18:394-418.

Foote, A., R. Osborne and A. Hoelzoel. 2004. Whale-call response to masking boat noise. Nature, 428: 910.

Grabstein, M. 2006. A comparison of received noise levels to source type, speed and distance in the Haro Strait of Washington State. Ph.D. thesis, Colorado College, Colorado.

Osbourne, R.W. in Behavioral biology of killer whales. B. Kirkevold and J.S. Lockard Eds (Liss, New York, 1986) p211-249

Jelinski D.E., Krueger C.C., Duffus D.A., 2002, Geostatistical analyses of interactions between killer whales *(Orcinus orca)* and recreational whale-watching boats. Appl. Geogr. 22, 393-411.

Lusseau, David. 2003. Male and female bottlenose dolphins *Tursiops spp*. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. Marine Ecology Progress Series 257:267-274.

National Marine Fisheries Service (NMFS). 2005. Proposed Conservation Plan for Southern Resident Killer Whales *(Orcinus orca)*. National Marine Fisheries Service, Northwest Region, Seattle, Washington. 183 pp.

National Research Council (NRC). 2003. Ocean Noise and Marine Mammals. The National Academic Press, Washington DC.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, California.

Slabbekoorn H, Peet M. 2003. Birds sing at a higher pitch in urban noise. Great tits hit the high notes to ensure that their mating calls are heard above the city's din. Nature 424: 267.

Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4:305-310.