Correlation between vocalizations and breaching in the Southern Resident Killer whales

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Abstract

One of the key questions humans would ask killer whales, if given the chance, would be “What are you trying to communicate to me?” Throughout the years humans have been able to link vocalizations to behaviors in many different animal species. There have been a few successful attempts in Killer whales. For instance, echolocation, a series of high frequency clicks emitted by whales for calculating the distance to an object has been found to occur when Killer whales are foraging (Lennard *et al,.* 1996a.). My curiosities led me to wonder if there were other behaviors that could be linked to vocalizations. I chose breaching, one of the most mysterious behaviors they perform. Using a linear hydrophone array, an amplifier, a recording device, and software designed for analyzing sound, I recorded and analyzed the vocalizations that were made one minute before and after I observed a breach. I found the most frequent call made was S10. My observations were made over a five week sailing excursion (Sept. 26 – Oct. 28) along the west side of San Juan Island, Washington. My study focused on the Southern Resident Killer whale pods J, K and L.

Introduction

Killer whale background

The southern resident killer whale population consists of three pods: J, K, and L. Currently, these whales are being considered for listing as threatened under the U.S Endangered Species Act. In Canadian waters the southern residents have already been declared endangered. One probable cause of why their existence is in jeopardy is due to the language barrier that separates humans and whales. If the communication whales use, through sounds and behaviors, were better understood humans could respond more efficiently to their needs.

History of breaching

Aerial displays, such as breaching, are one of the most captivating and mystifying activities the southern residents engage in. Imagining something so massive hurl their entire body out of the water is unfathomable to most.

(Breach observed on October 21, 2005. Photo by Scott Veirs)

Though these whales have been studied for the last twenty five years, it is not known why breaching occurs. However, there are many theories that try to explain the event. One theory offers foraging as an explanation, proposing that the whales are using a strategic technique of emerging from the water and falling to stun their prey. Another hypothesis presents breaching as being an indication of annoyance intended for boats, or other pod members. A form of socializing behavior or “play” is another explanation for this activity. According to Ford *et al*., (1994), various aerial displays such as breaching, spy hopping, tail slapping, and flipper slapping are behaviors seen during socializing. But, perhaps the most sensible approach is the speculation of it not occurring for any one specific reason, but due to a combination of all the above mentioned.

Motivation for breach studies

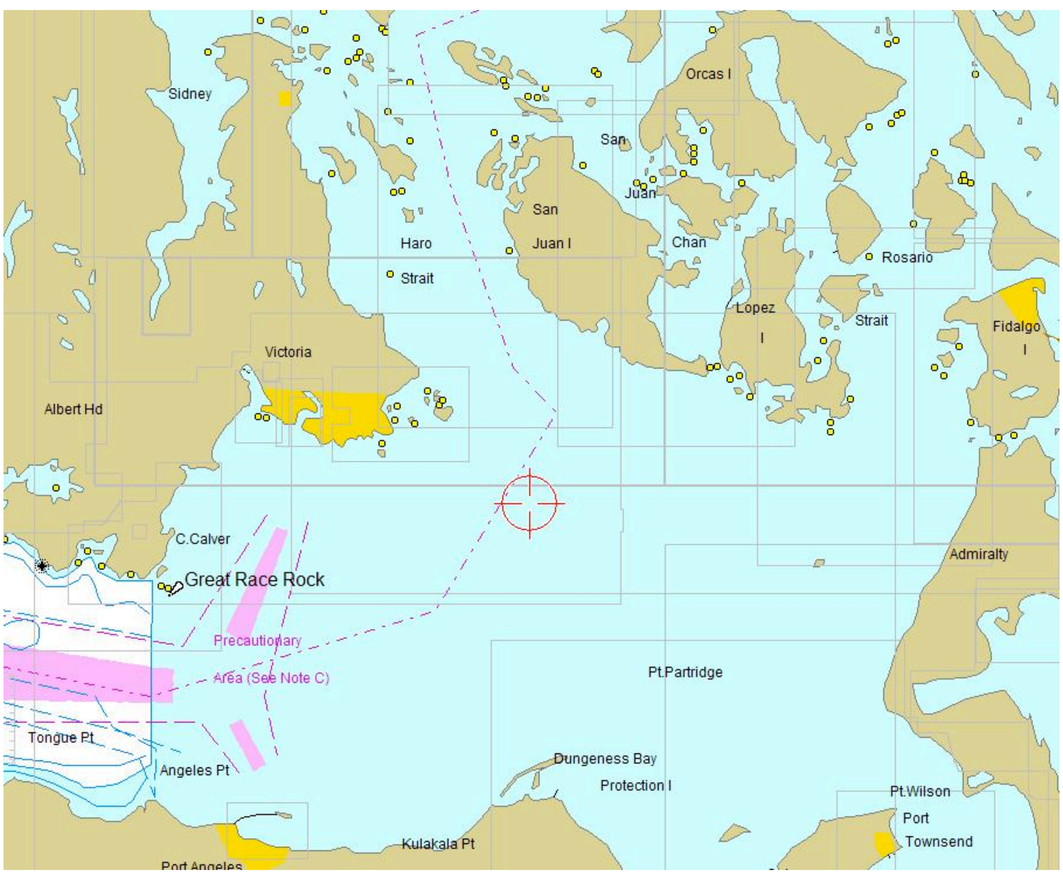
The activities of the resident killer whales are typically grouped into four broad categories: foraging, traveling, resting, and socializing (Ford et al., 1994). While socializing, whales employ a wide range of highly variable squeaks, squawks, and whistles (Ford *et al.,* 1994). Closely related, studies done in captivity on killer whales have shown that when playing (tactile behavior) both adults and calves emit an array of squeaks, squeals and whistles (Vanessa Williams, WDCS, 2001). This led me to a curiosity about what vocalizations are made specifically during breaching, no matter what explanation for that activity was correct. Just as echolocation has been linked to foraging, I questioned if there was a correlation of calls that only occurred when breaching. In addition, I wondered if I could verify the theory past researchers have made reporting socializing behavior being associated with high frequency vocalizations.

Expected outcomes

My experiment was designed to record vocalizations and analyze the sounds I heard at the time a breach occurred. I expected to find a particular vocalization/s that correlated with the activity of breaching. I also anticipated finding vocalizations that were not correlated to breaching, but were present at the time it occurred. I believe either one provides useful knowledge. Another expectation I had was that the breaches observed during socializing behavior would be associated with calls that have high-frequency components, such as squeaks, squawks, and whistles. This expectation stemmed from past research that had reported socializing behavior as being associated with high frequency calls.

Dates of recordings and observations

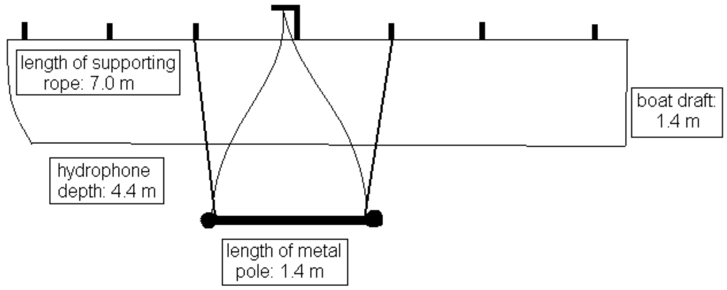
All observations and recordings were taken during a five week sailing excursion on the Gato Verde, a 42 foot catamaran, from September 26, 2005 to October 28, 2005. The majority of the observations were made approximately from 12-5pm. The observation sites ranged from the west side of San Juan Island (Haro Straight) to the mouth of the Straight of Juan de Fuca. (**see map below**)



Methods

Instruments used for acoustic observation

I recorded southern resident killer whale vocalizations using two hydrophones arranged on a contraption our team called the “Ears” (**see below)**



EARS

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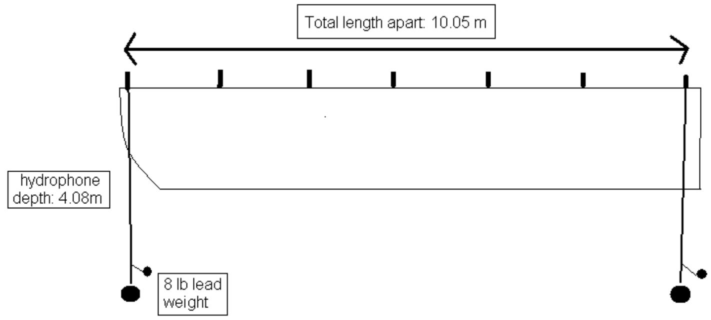
The ears were assembled by using a 1.4 meter metal pole that lay horizontally with a hydrophone attached on each end. To keep the hydrophones parallel to the boat we secured an approximately 7.0 meter long rope to each end of the hydrophone array and led to widely spaced stanchions on the port side of the catamaran. Consistent checks were made during observations to insure that the array was kept parallel to the boat for accurate bearing readings. The rope was also used for transferring the weight from the hydrophones to the boat. The hydrophones were deployed at a depth of 3.08 meters below the draft (bottom of the keel) on the port side, resulting in a hydrophone depth of 4.4 meters beneath the water’s surface. To control flow noise and cable vibrations we wrapped the pole in pipe insulation. We also lashed an “elbow” shaped pipe to a stanchion located in the middle of the hydrophone array so that the hydrophone cords could be held away from the boat, preventing them from hitting against the boat. This linear array was used for the first half of my data collection.

An adjustment was made to the “Ears” during the third week of field research by removing the metal pole centering the two hydrophones and extending the length between each hydrophone. The new ears, the “Elephant Ears”, measured 10.05 meters apart and were attached to the bow and stern cleats on the port side of the boat (**see below**).



Elephant Ears

The hydrophone cables were attached to a rope with an 8 pound lead weight on the end, keeping the hydrophones vertical in the water at a depth of 4.08 meters.

The hydrophones were connected to an amplifier which offered two gains settings: times 10, being the highest, and times one, being the lowest. We determined which gain setting was appropriate by monitoring levels of ambient and anthropogenic background sounds, and assessing how they affected the quality of the vocalization recordings.

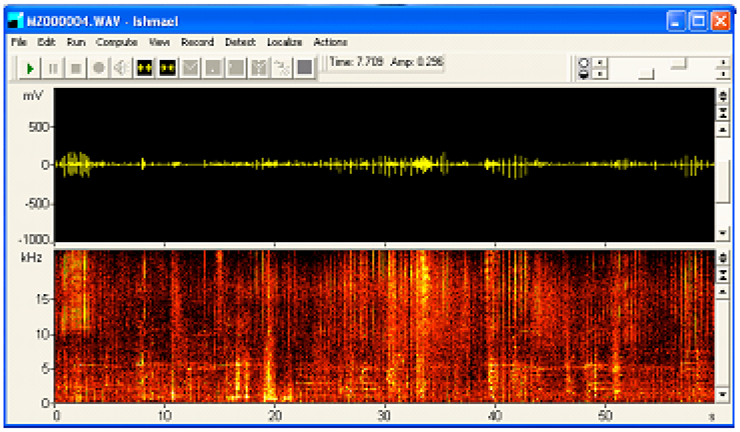
After the sounds were amplified, they were transmitted to the Marantz, a sound recording device that retains up to fifty minutes of sound data in one minute increments, giving each observation up to fifty minutes of data sound files per flash memory card. The Marantz also offered a gain setting, which was adjusted according to background noise to reduce the amount of saturation in the sound files. The gain was set half way between the minimum and maximum settings. After each session the files were downloaded for data analysis. The time stamp on the Marantz was in sync with the time on the GPS.

Resources utilized for visual observation

While observing the southern resident killer whales visually, I used a behavioral observation data sheet. On this sheet I recorded: the date of the observation, starting time of the Marantz file, exact time breaching occurred, gain setting, end time of observation, and file name of the sound files downloaded. My watch and others were synchronized to the GPS time for precise readings. Other Beam Reach members assisted by calling out the time and of a breach they had witnessed. Beam Reach members also helped with downloading files and deploying the ears. All data sheets were printed on water-proof paper for foul weather observations.

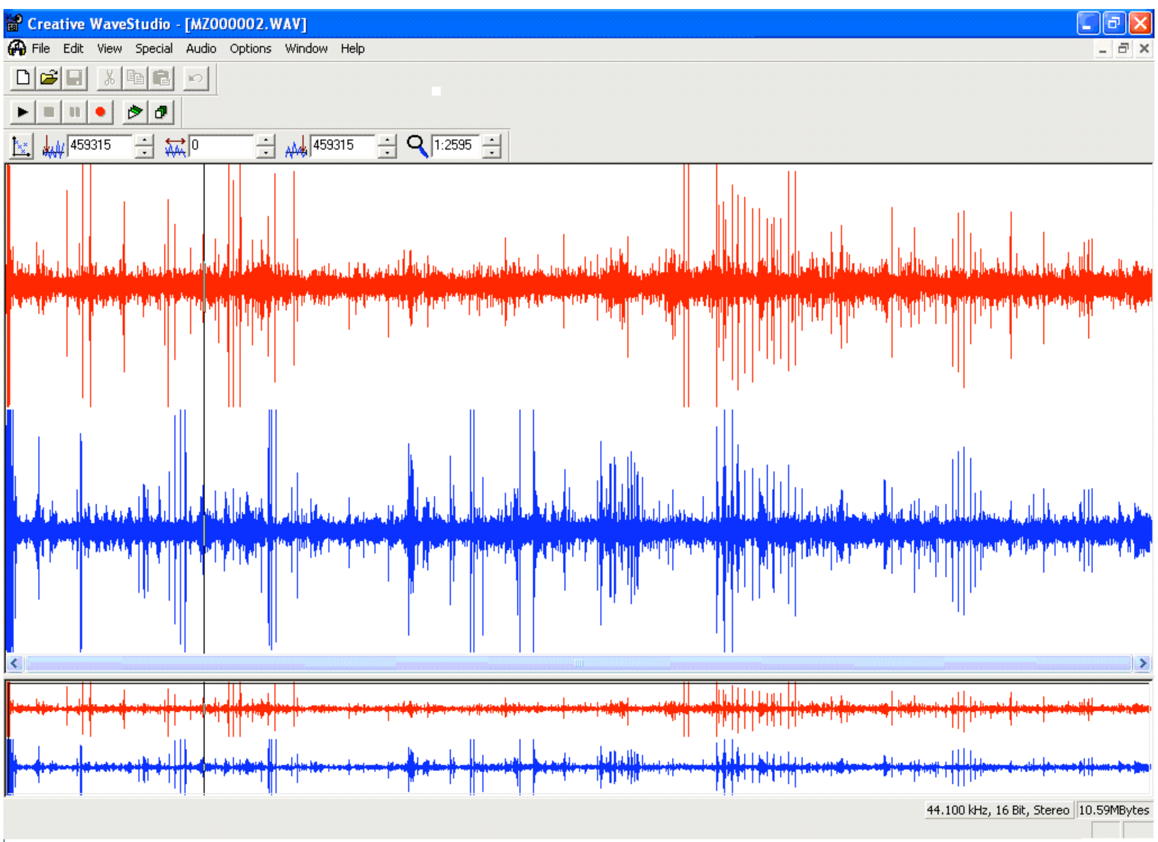
Software applied for data analysis

To analyze both the acoustic and behavioral observations, I used the software Ishmael 1.0, Creative Wave Studio, and Call Tutor. Ishmael, a program produced by David Mellinger, is used for localizing sound. I did not use this software for localization purposes; however, I did use it to review the vocalizations and spectrograms of the sounds that were recorded (**see below**).



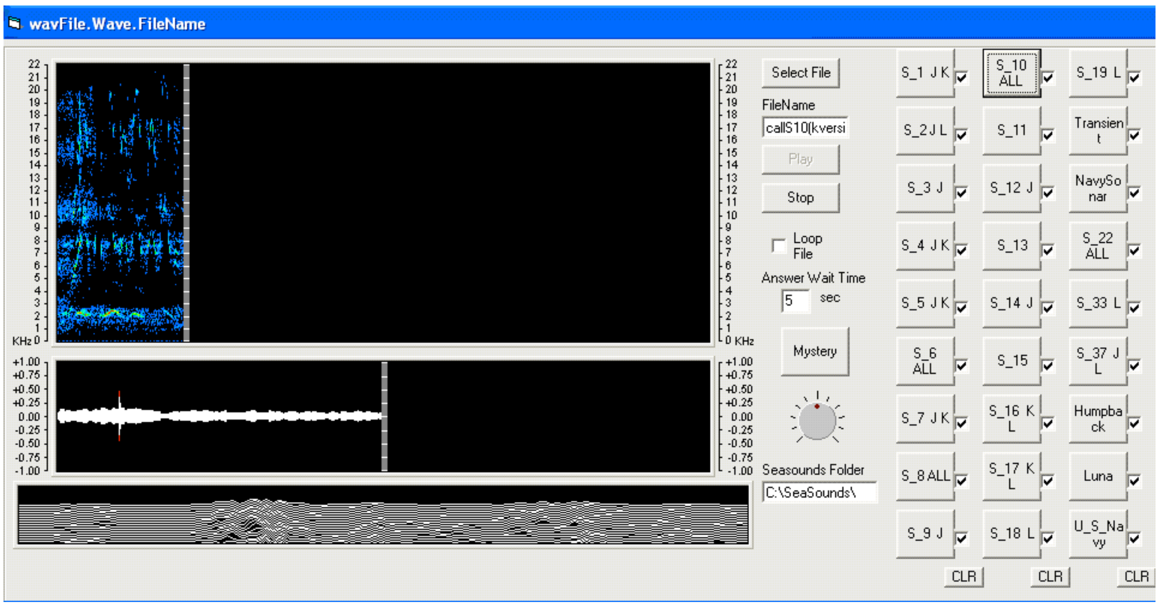
(This is an image of the computer program "Ishmael" used to review vocalizations and view spectrograms. The screen presents frequency (Y axis) over time (X axis), as well as a spectrogram to show low and high frequencies.)

Creative Wave Studio is a computer program that graphs amplitude over time of sound files. I used Creative Wave Studio to listen to the sound files that were recorded (**see below**).



(This is an image of the computer program "Creative Wave Studio." This is showing the graphing of amplitude (Y axis) over time (X axis) of sound files.)

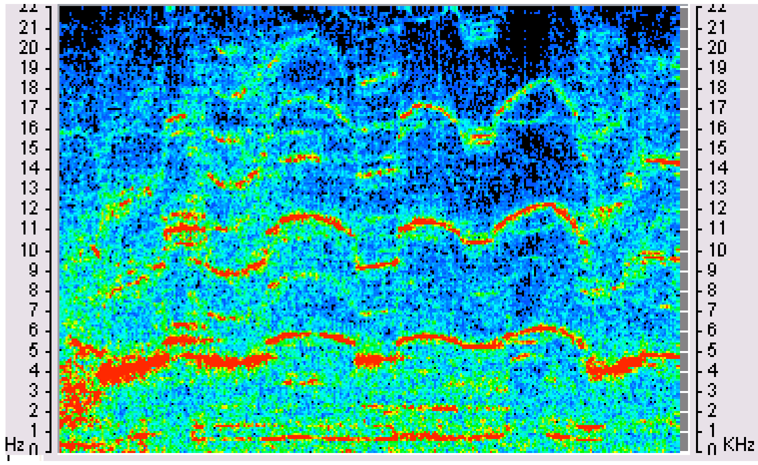
Call Tutor, created by Val Veirs, was developed for the purpose of learning a variety of killer whale vocalizations. I used Call Tutor to compare calls I heard while listening from the sound recordings to already stereotyped calls on the program, thereby attempting to find a positive match and identify a call I had heard (**see below**).



(A picture of the computer program "Call Tutor" used to learn calls and compare spectrograms. The gray buttons on the right show the calls available to listen to repeatedly as needed.)

Results

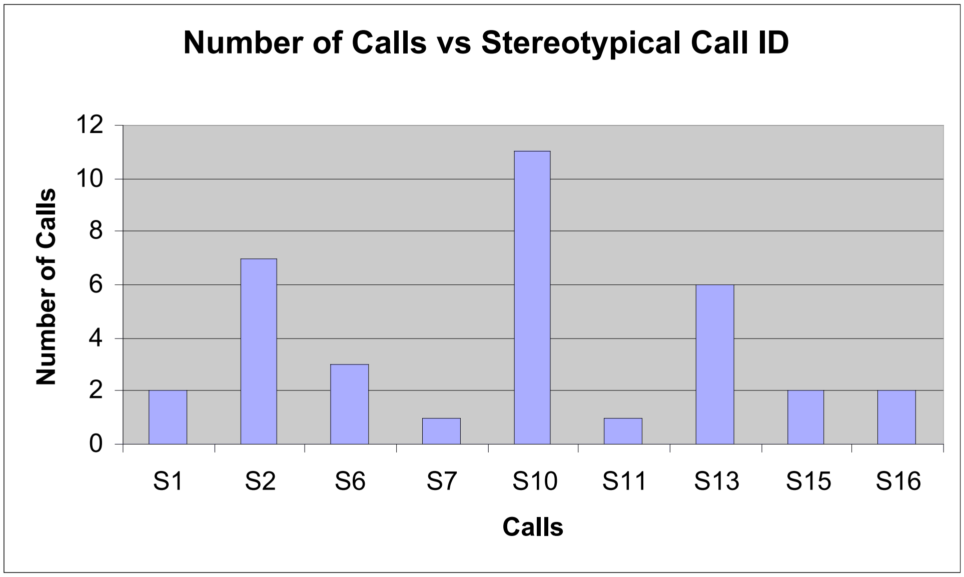
From the 18 breaches I observed, I found that S10 was the most used call one minute before and after a breach occurred (**see spectrogram below.**)



(Spectrogram of S10 call.)

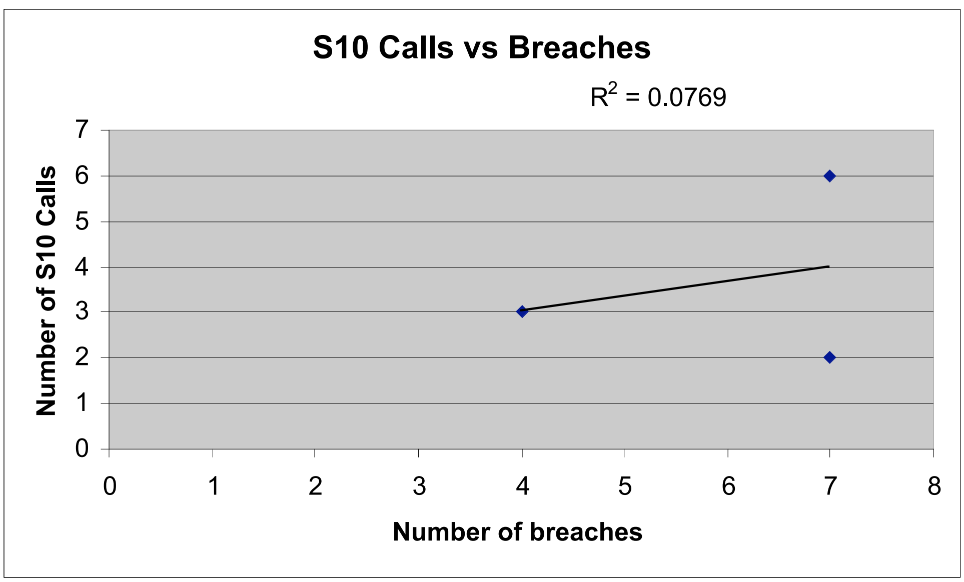
While doing acoustic analysis, I heard a total of eleven S10 calls throughout three observations. Other calls I heard included: S1, S2, S7, S11, S13, S15, and S16, but were not frequent enough to find a correlation. (**See figure 1 below.**) Using Excel to fit a line to three observations, I found that the S10 call showed a correlation coefficient (R squared value) of 0.0769 (1 being the correlated, 0 being uncorrelated (**see figure 2 below.**)

Figure 1:



(This histogram shows the stereotyped calls (as identified by Ford, J.K.B.1991.) on the X axis and the number of stereotyped calls that were made on the Y axis.)

Figure 2:



(This figure shows the number of breaches (X axis) and S10 calls (Y axis) that were observed during three separate observations.)

Discussion

Patterns and trends

While doing this research I found that throughout the one minute increments of sound recordings I listened to there were many different calls. Although S10 calls occurred most frequently during observations, and showed somewhat of a trend, I found there not to be a consistent call when breaching occurred. This may be for the reason that the whales could have been engaged in different activities during the three observations that were made, or that there simply aren't certain calls related to breaching.

I did find a pattern while I was observing them behaviorally. I found that the days it was raining the whales seemed more active. On one rainy day I observed a calf breach five times after a female (presumably its mother or another adult female in the pod) had breached. Also during that observation I witnessed eleven breaches, more than double what I had witnessed the day before that had sunny and calm weather conditions. S10 was the dominant call heard during the rainy observation.

I found what past researchers (Ford, Ellis and Balcomb., 1994, and, Williams, V., 2001.) theorized about socializing whales emitting a wide range of highly variable squeaks, squawks, and whistles to be true. The one observation taken while raining, verified their theories, in my opinion. I believe the whales seen that day were socializing, or "playing". The majority of the vocalizations I observed acoustically from that day were high frequency calls.

I also noticed a pattern of breaching. I observed more often than not two breaches take place in a row. The majority of the observations I took were made during the day, however I did not see or hear any breaches during night observations.

My theory

Upon completion of my experiment, I found that although lots of calls were made during the time breaching occurred there was no strong correlation between a particular call and breaching. However, I believe this could be due to the whales' behaviors and vocalizations being contextual. For a behavioral analogy, when a human jumps it could be for joy, to express madness, or simply for no reason at all. Accompanying the jump could be such vocalizations as "Hooray!", "Oh no!", or no vocalizations what so ever. My belief is that the whales do not breach merely because they are foraging, socializing, or any other behavior. I believe they behave and vocalize as sporadically and uncoordinated as humans do.

Future studies

Experiments such as this are just one step into further linking behaviors with vocalizations, and an even smaller step in a great voyage: providing humans with a better understanding of what the whales are communicating. Future studies of specific behaviors and vocalizations using localization would also be beneficial by enabling precise location of a sound. Knowing this would allow knowledge of what specific animal, or group of animals were emitting sounds related to breaching or other particular behaviors.

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