Analysis of Call Type Repetition in the Southern Resident Killer Whales

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Introduction

Killer whale (*Orcinus orca*) are the largest member of the dolphin family (*Delphinidae*) (Baird 2002). Killer whales are seen throughout the entire world's oceans, but in only a few locations can they be found reliably in protected waters. One such area is off the coast of British Columbia and Washington State, where the whales have been studies intensively since the 1970's. Through field identification of the individuals by means of natural markings on the dorsal fin and saddle patch, the whales of the Pacific Northwest are among the best-known cetacean populations (Ford 1991).

The killer whales of the Pacific Northwest are classified into three types. Offshore killer whales, exactly as their name suggests, spend the majority of their time out at sea and are rarely encountered (Center for Whale Research 2007). The other two types, transients and residents are primarily coastal. Transients are marine mammal eating killer whales and travel in groups of 1-7 members, as opposed to residents, which feed primarily on fish and live in stable family groups containing 5-50 individuals (Ford 1991). The resident killer whale populations are split into northern and southern communities. The communities are then further split into pods, and although pods within communities associate, pods of different communities do not (Ford 1987).

Each pod of resident killer whales is made up of the smallest social unit called a matrilineal group, which compromises individuals related by matrilineal descent from a single living female (Ford 1991). Matrilineal groups rarely spend more than a few hours apart. The long-term stability of killer whale social structure has provided the opportunity to examine in detail the vocal behaviors of pods over extended periods (Ford 1991). There is evidence that resident pods have repertoires of discrete calls that are consistent over several years and that these repertoires differ amongst pods (Ford 1991).

Killer whales have a complex communicative system. Their repertoire is made up for three vocalizations; clicks, whistles and discrete calls (Ford 1989). Clicks are short broadband pulses of sound, which are used for echolocation during foraging and navigation (Ford 1989). Whistles are pure sounds with little harmonic structure (reference). Although dolphins use whistles regularly in their repertoire, killer whales are rarely seen producing whistles (Ford 1987). The third type of vocalization is discrete calls, which are the main focus of this study.

Discrete calls have a harmonic structure and can be identified by the human ear due to their unique tonal structure, or by spectrograms. Ford (1987) published a catalogue of discrete calls of northern and southern residents, as well as transients. In Ford's research, he identified 26 discrete call types for southern residents. In his later research, it became apparent that pods had group-specific dialect, and each pod had a distinct repertoire of 7-17 call types (Ford 1989)

What is not understood is whether the vocalizations going on between members of communities are actual communication. In a study on semantic combinations in primate calls, putty-nosed monkeys *Cercopithecus nictitans stampflii* were found to respond to playback calls of what researchers thought to be warning calls (Arnold & Zuberbuehler 2006). It was found that the playback calls generally initiated the group to move on to another area. Not many direct links have been made between discrete call types and behavior for the SRKW, therefore the reasoning behind many call types is unknown. Some studies have associated discrete call types with broad behaviors such as foraging and socializing, but many call types are heard regardless of the behavior involved.

Problem statement

A primary interest of researchers is to establish whether killer whales are communicating to a degree that humans are able to interpret. If scientists are able to show evidence of killer whale communication that is dependent on their survival, conservationists will be able to put forth-convincing arguments toward their protection. The aim of this study is to identify whether a three-sequence natural grouping occurs during the vocalizations of southern resident killer whales (SRKW). I hypothesize that a three-sequence grouping

will be evident, and based on previous studies by Ford (1989) and Weiland (2007), that a repetition of the same call type will be evident. My research will add to ongoing research on killer whale vocalizations. Ford's (1987) call catalogues of the SRKW will aid in the visual identification of call types recorded in my study, as will the spectrograms presented in Weiland (2007). My findings of three-call sequence natural groupings can be compared to the results of Monikas (2007) two-call sequence natural groupings.

Literature Review

Ford (1987) catalogues 77 discrete call types, and 37 subtype calls of killer whale pods along the coast of British Columbia. This data forms the basis for analyses of vocal differentiation and the population structure of killer whales in British Columbia. Ford (1987) uses representative spectrograms and descriptive statistics of some physical parameters of the discrete calls. Given that my recordings will solely be based on southern residents, Ford's catalogues will be used to compare spectrograms of my data in order to identify which calls have been recorded. Once the calls are identified, I will be able to distinguish sequences that may be occurring.

Griffen (2004) examined discrete calls of a solitary southern resident, L98, to determine if the individual was producing discrete calls. Acoustic analysis revealed L98 used three main discrete calls while in Nootka Sound. In this study the three calls were compared to the southern resident killer whale common calls S1, S36 and S19. Interestingly, S1 and S19 are commonly used calls of K pod, however S36 is a commonly used call of L pod. When L98 was a calf, he was often seen spending time with a matriarch of L pod, K18. Therefore evidence indicates that southern killer whale calves learn their dialect through mimicry from other whales. As the purpose of Griffen's (2004) study was to determine discrete calls, the methodology in this study is comparable to a theory I wish to use in my own research. She used hydrophones to collect recordings and spectrograms to identify calls. It will also be interesting to compare data from Griffen's (2004) research on one member of L pod, to the data I collect on other members of L pod, and analyze any differences in selected parameters of the calls.

Weiland (2007) analyzed discrete call types of SRKW. The aim of her study was to identify which calls are used by what pods, the frequency of call usage by each pod, and the mean duration of each call. The second part of her study was to analyze sequential patterns, and make a cross species comparison using Zipfs statistics and the published data of McCowan (1991, 2002). She predicted that call type usage, frequency of call usage, and mean duration of each call type will be different between past recordings (Ford's 1978-1983) and present (Weiland 2005 and 2006). The second part of Weiland's (2007) research predicted that there would be a sequential structure in the SRKW discrete call communicative system. This part of her research is particularly to me as I predict that a three-sequence pattern can be identified in the repertoire of discrete calls in SRKW.

Methods

In the field

The purpose of this study is to identify whether SRKW have specific call sequence in their repertoire. I hypothesize that a three-sequence grouping will be evident. The data targeted during this study are discrete calls vocalized by the SRKW (J, K and L pods). No pod specification will be made during this study. All recordings will be made from the *Gato Verde*, off the coast Washington State, during an eight-week study during the months of August, September and October. The *Gato Verde* is a 42-foot catamaran, with an electric-biodiesel fueled engine. The battery pack enables the *Gato Verde* to motor silently for up to 3 hours continuously. When extended motoring is required, the on-board biodiesel generator provides enough electricity to power the electric motors. This makes it possible to motor silently whilst recording vocalizations, as well as minimizing disturbances on the whales. I'll be using a hydrophone array (Lab Croe Systems of Olympia Washington), with four hydrophones spaced at 10-m intervals and deployed at a depth of 3 m. The focus of this study is the discrete calls of the SRKW, therefore any recordings of whistles and clicks will not be analysed. The hydrophone will be hooked into an amplifier that converts analogue into digital and records files onto a laptop through a program called 'Oval Locator'. A colleage, Anne Harman, will be listening to calls in real time and recording relevant information onto a constructed data sheet. There will be no set distance that SRKW must be from the hydrophone for recordings to be

valid, however only clear recordings, where call types are discernable by ear will be used in this study. All other data will be discarded. Overlapping calls between whales will not be used in this study. Recordings will be made opportunistically when whales are present.

In the lab

Programs used in analysis of recorded calls will be Call Tutor (Beam Reach 2006, Designed by Val Veirs) and Ishmael 1.0 (mobysoft.org). Call Tutor is a sound displaying program, which has a library of preselected calls which allows you listen to specific southern resident calls. Call Tutor will be used to compare calls from the recordings to assist in identification. Ishmael 1.0 will be used to display the sound recording with spectrograms which will further aided in the identification of calls. The visuals displayed in Ishmael 1.0. will also aid in identifying a 'call sequence'. A '3-call sequence' is defined as three calls 'grouped' together visually on the spectrogram. The calls must have a spacing of less than 2.5 seconds. Comparison to Ford's (1987) call catalogue using spectrogram comparison will also aided in the identification of the calls. When a '3-call sequence' was identified, the information was recorded on a matrix table (see Table 1.) Information will also be recorded on the duration of the sequence and the duration of the intervals in between calls (see Table 2).

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