

Occurrence of repetitive vocal pattern ‘signals’ in *Orcinus orca*.

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Orcinus orca are the largest whale in the *Delphinidae* family. They are classified into three distinct ecotypes in the northeastern Pacific Ocean: transients, offshore and residents. Each ecotype is distinct in their behavior, morphology, ecology, and vocalization repertoire (NMFS 2008, Ford 1991).

Residents can be identified by a slightly more curved dorsal fin tip, their occurrence in stable groups, fish focused diet, and unique vocalization repertoire. Residents have a very complex social structure consisting of four levels. The smallest, the matrilineal group, consists a female and her offspring for up to four generations. Next are pods, the most commonly occurring group, which consist of closely related matrilines who spend the majority of their time together (NMFS 2008, Ford 1991). The next largest are clans, one or more pods who share similar dialects and ancestry. The largest are communities, clans and pods that regularly associate with each other regardless of matrilineal relatedness (NMFS 2008, Ford 1987, Ford 1991).

On the west coast of the US and Canada there are 4 different communities, southern residents, northern residents, southern Alaska residents and western Alaska residents (NMFS 2008, Ford 1991, 1987). The southern residents will be the focus of this study.

Orcas have a complex social structure which is theorized to be the reason for their advanced communication. There are three categories of vocalizations: clicks, whistles, and pulsed calls (Ford 1991, 1987).

Clicks are very short bursts of sound that often are produced in a series called a click train. These click trains are used mostly for navigation and foraging, but since they

also occur during social interaction it is thought that they may serve a communicative function as well (Barrett-Lennard et al. 1996 in NMFS 2008).

Whistles are continual tonal calls with harmonics that last from a range of about .06 - 18.3 seconds. They have a high average dominant frequency of 8.3kHz and among the southern residents, are most commonly used both during foraging and socializing (NMFS 2008, Ford 1987).

Pulsed calls are made by a string of pulses so close together that it sounds like a single tone. They last from 50 milliseconds - 10 seconds long and have an average frequency ranging from 1-6kHz (Ford 1987, NMFS 2008). These calls are broken into three categories: discrete, variable, and aberrant (Ford 1987).

Discrete calls are categorized by being highly structured and having repeated occurrences. It is thought that their function is to help maintain group identity and contact. Variable calls are categorized as random unrepeated discrete calls and aberrant calls are calls that differ from other pulsed calls (Ford 1987, 1991).

Orcas' complex social structure is mirrored in the existence of dialects that exist between clans, pods and matriline. Dialects are categorized as differences in vocal repertoires and acoustics (Ford 1991).

Because light doesn't travel very far in water but sound does, it is theorized that marine animals must rely on sound to keep in communication with each other (Myberg 1980 in Miller et al. 2004). Vocalizations are very important when studying marine mammal behavior because observing their behavior can be extremely difficult. As one of the only ways scientists are able to research free-ranging orcas, decoding the information in sounds is very important to understanding their both their communication and behavior.

Both Bigg et al. (1987) and Ford (1987, 1991) thought that discrete pulsed calls were significant because of the frequent occurrences and their importance in dialect differences. Recently Reich et al. (2005) looked for and found discrete whistles. Both

Thomson et al. (2001) and Reisch et al. (2005, 2002) found that orca whistles are much more complex than previously suspected, and most commonly occur during socializing behavior leading them to believe that, like discrete pulsed-calls, they are important to communication.

Miller (2004) found that orcas exhibit call-typing behavior, in which after one whale calls, another will often respond with the same or very similar call. He also found that of the one or two most frequent calls produced, a significant percent of the time, those calls occur in series. Weiland (2007) found something similar, that the most frequent call had patterns of repetition. She also discovered that, although they are much more repetitive than human language, orca calls are not random.

Like Weiland (2007) and Miller (2004), Morton (1986) studied sequence patterns in vocalizations as well as the correlation of sounds and behavior. She concluded that when the frequency of calls were measured during different behavior states, there were correlations between behaviors and calls. She also suggests that there is a high degree of order in 'sound sequencing' and found that a sound that she called 'F1' was frequently repeated at both the start and stop of 'conversations'.

Although Morton (1986) found this 'F1' occurrence, no further study on the existence of repetitive calls appearing at the beginning and end of 'conversations' in free-ranging orcas has been pursued. This, as well as the question of other repetitive call patterns existing in relation to behavior, warrants further study as knowledge of patterns in vocalizations may allow biologists to better understand behavioral trends and patterns as well as group cohesion and decision-making.

I want to address these issues by answering the following questions: Do repetitive call patterns occur at the beginning and end of 'conversations'? Does this phenomenon occur during other behavior?

To investigate these questions I will test the following two hypotheses: Orcas' 'conversations' begin and end with a repetition sequence or 'signal'. Other behaviors, like foraging and traveling, also begin and end with a 'signal'.

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