Variations in S6, S10, and S19 calls in Southern Resident Killer Whales (*Orcinus orca*)

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Question

Do S6, S10, and S19 calls have variations that are specific enough to be set apart by pod?

Methods

A. Killer Whale Recordings

Recordings were collected from all three of J Clan's pods (J, K, and L). A 42' electric biodiesel hybrid catamaran, Gato Verde, was used to deploy a four hydrophone array consisting of Lab40 models from LabCore Systems with a flat response between .1 and 10 kHz. Cruises took place from September 19th to the 29th and October 2nd to the 13th. Recordings were taken from September 27th for J Pod, October 4thfor L Pod, and October 12th for K Pod. High resolution photos were taken during recordings and were used for pod identification. Our location remained in Haro Straight for the majority of the both cruises.

B. Acoustic and Statistical Analysis

Recordings were digitized using SoundDevices at 44.1 kHz and were analyzed using RavenPro1.4. Audacity was used to crop individual S6, S10, and S19 calls from the raw data. To reduce human error while taking measurements, each call was measured three times. The average was taken for all parameters measured using RavenPro 1.4 beta version build 38 (2003-2010: Cornell Lab of Ornithology, Ithaca, New York). Of S19 calls, 55 were quantified from L pod, 40 from J pod, and 25 from K pod. 40 S6 calls from J pod and 33 S6 calls from K pod were collected. Of S10 calls, 42 were counted for J pod, and 28 for K and L pods.

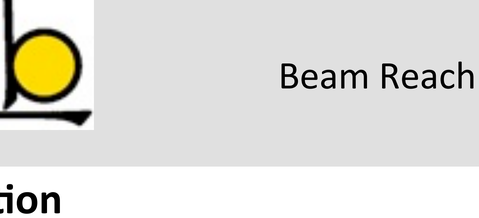


Fig. 1. S6 call from J Pod taken on September 27th, 2011. Colored lines demonstrate parameters measured: high frequency (upper yellow), low frequency and duration (both lower yellow), delta frequency (orange), peak frequency or frequency containing most power (green), frequency 95% or frequency at which 95% of the energy is contained (blue), max time or time containing most power (white), and center time or time when 50% of the energy is reached through the call (black).

S6

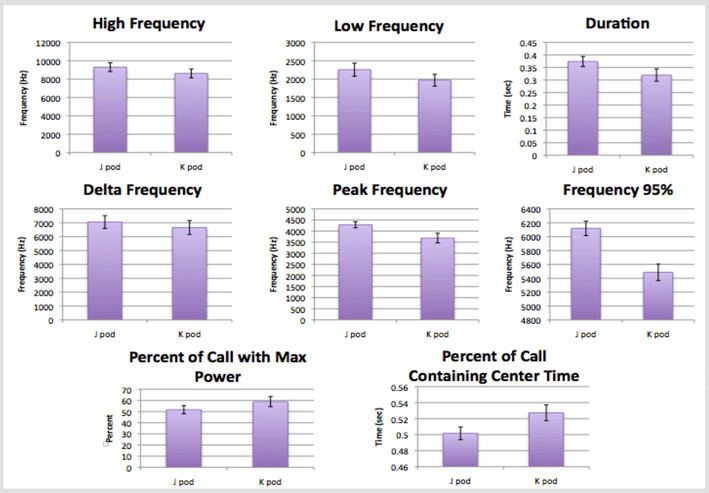


Fig. 2. The means of S6 parameters for J pod and K pod. L pod was eliminated due to insignificant sample size. Significant factors include

Abstract

In killer whales (*Orcinus orca*), vocal calls appear to be an important aspect of communication. Preferences of prey, travel patterns, and vocal "dialects" are distinguishing features among the different ecotypes of northeast pacific killer whales. Fish eating resident killer whales frequently associate with other whales outside their own pod. A vocally distinct clan may contain up to eight pods. Although clans are classified by their vocal similarities, pods within the same clan only share a fraction of another's repertoire. Southern Resident Killer Whales (SRKW) consist of three pods in a single clan. The S10, S6, and S19 calls have all been claimed to be calls that are shared between all pods of the SRKW: J, K, and L. This study investigates whether or not variations in common calls are pod specific in SRKW. In fall of 2011, A towed underwater hydrophone array was used to record calls of SRKW specifically for this study. L Pod's S19 calls are significantly different from J pod S19 calls in both high frequency and delta frequency. They also consist of a high frequency not present in the majority of J and K S19 calls. Little variation in S6 calls existed between J and K pods. J pod's S10 calls showed a significant variation from K or L pods due to a distinct click train directly prior to the call.

S19

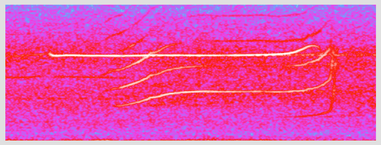


Fig. 3. A spectrogram of an S19 call taken from L-pod on October 4th, 2011 off Turn Point in Haro Straight. Note the upper powerful frequency that begins the majority of L Pod's S19 calls.

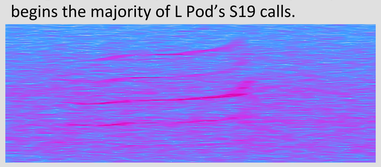


Fig. 4. A spectrogram of an S19 call taken from J Pod on September 27th, 2011 in Haro Straight. Note the lack of the powerful upper frequency that is present in the figure above.

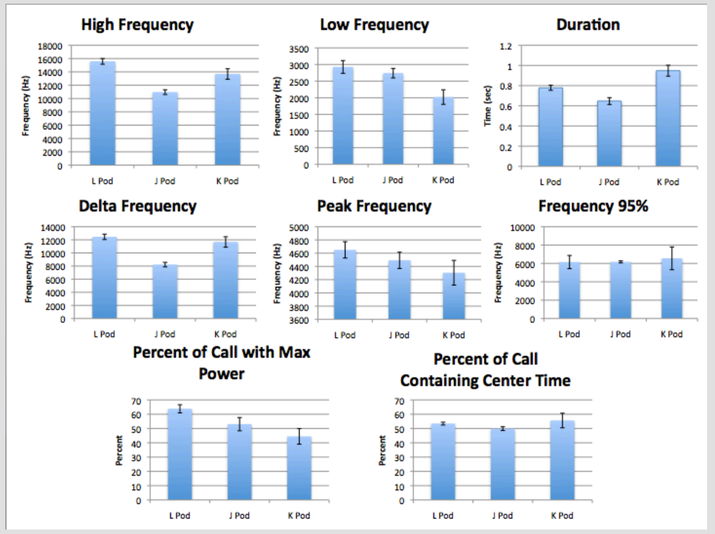


Fig. 5. The means of S19 parameters for each pod in Fall 2011. Significant parameters include high frequency and duration for all the pods, delta frequency between J and K pods and J and L pods, low frequency between K and other pods, and percent of call with max power between K and L pods.

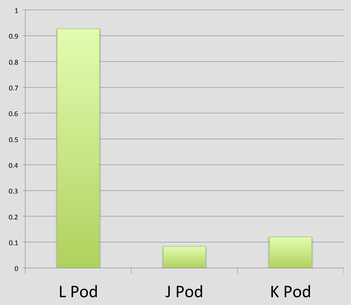


Fig 6. Percentage of S19 calls containing a distinct powerful high frequency at the beginning of the call for each pod (L pod – 92%, J pod – 8%, and K pod – 12%) in fall of 2011.

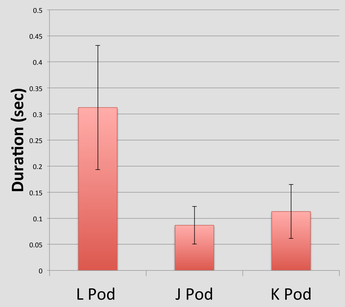


Fig. 7. Mean durations and standard deviations from the time high frequencies in J, K, and L pod S19 calls begin to the time lower harmonics begin in the S19 call.

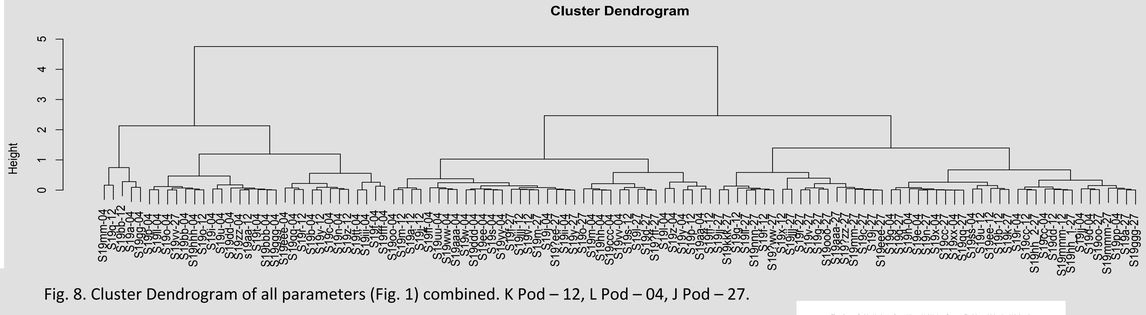
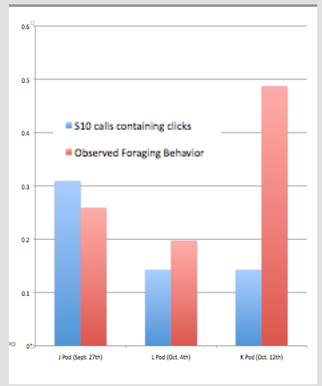


Fig. 8. Cluster Dendrogram of all parameters (Fig. 1) combined. K Pod – 12, L Pod – 04, J Pod – 27.

S10



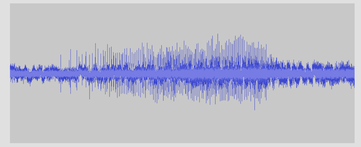


Fig. 10. A waveform view of a click train prior to an S10 call taken from J Pod .

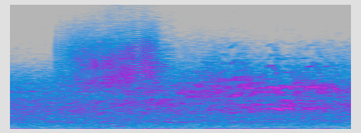


Fig. 11. A spectrogram view of the same click train prior to an S10 call.

Fig. 9. This figure represents the percentage of S10 calls within each pod that contained consistent click trains (represented by the blue bars). These consistencies were compared to percentage of observed foraging for each day (represented by the red bars).

Results & Discussion

Vocal similarities is what makes the SRKW a distinct clan. S6 and S10 calls have been observed throughout the pods since John Ford defined calls in the 1970's and 1980's. S19 calls have only recently been thought be shared among all pods of the SRKW. Each call had a distinction from others by pod in certain criteria in this study. Significant variation within the calls are as follows:

S6

- The peak frequency, or the frequency containing the most power, is significantly greater in J pod than in K pod (Fig. 2).
- Center time, or the point in time of the call at which the samples divided into two time intervals of equal energy, is significant: J pod uses energy quicker in S6 than K pod (Fig. 2).

S19

- High frequency differences are significant in all pods (L-15.6 kHz, J-10.9 kHz, K-13.7 kHz) (Fig. 5).
- Duration differences are significant in all the pods (L=0.778s J=.646s K=.948s) (Fig. 5).
- J has a significant difference in delta frequency (change in frequency) from L (12.5 kHz) and K (11.7 kHz) pods (Fig. 5).
- Percent of call containing max power was significant between L pod (63.8%) and K pod (44.5%) (Fig. 5).
- All parameters (fig. 1) to create a dendrogram and show scattered groupings (Fig. 8).

S10

- There were consistent click trains prior to S10 calls (Fig.10, Fig. 11) and those that don't have click trains prior to the call (Fig. 9).
- Percentage of observed foraging times for each day was graphed with the presence of clicks prior to S10 calls and exhibit little to no relationship (Fig. 9).

Whether variations in calls is due to pod specific deviations or other factors such as bathymetry or sample size is unknown. Sample size in this study was limited in order to eliminate the speculation of call variations through time. Variations in power parameters may be significantly offset by background noise such as passing vessels, clicks, and distant killer whale calls.

Conclusion

Variations in S6, S10, and S19 calls were all present throughout individual pods. Beginnings of pod specificity of these variations are suggested throughout S6 and S10 calls, and particularly in S19 calls in SRKW. The S19 call in L pod is significantly set apart from the samples collected from K and J pods. Similar research can be done with archive data to investigate whether or not these trends are consistent.

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