Beluga whale (*Delphinapterus leucas*) vocalizations from the eastern Beaufort Sea population

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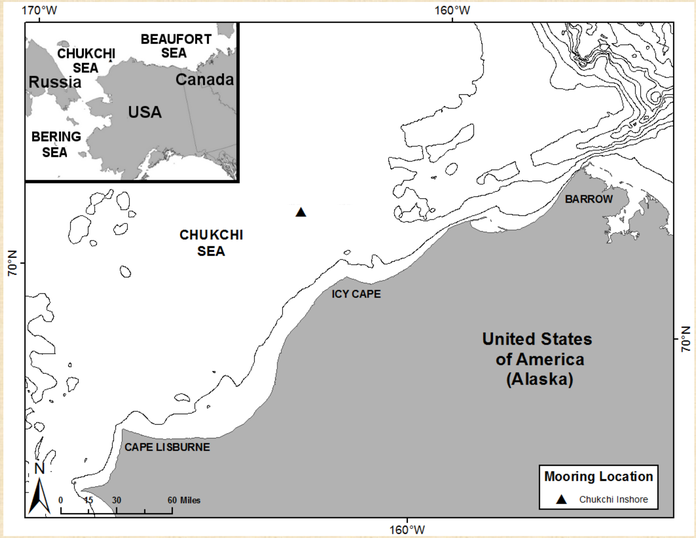
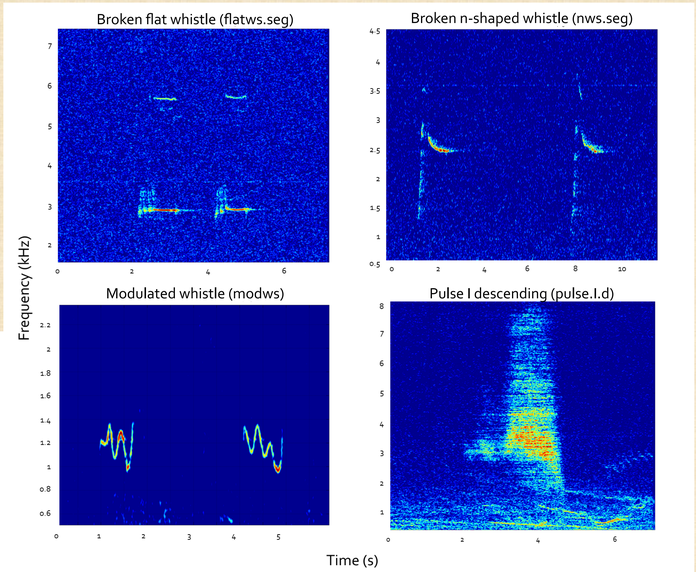
Abstract

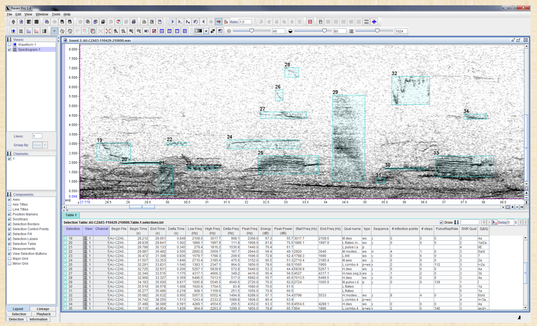
Graded call systems are challenging to categorize in a meaningful way. Beluga whales, *Delphinapterus leucas*, are notoriously vocal with multiple call types that blend from one type into another on a continuum of calls. Here, we present the first description of spring 2011 vocalizations from the eastern Beaufort Sea beluga population using both a non-parametric classification tree analysis (CART) and a Random Forest analysis. Twelve frequency and duration measurements were made on 1019 calls, and resulted in 34 different call types with 83% agreement in classification for both CART and Random Forest analyses. This high-level of agreement in classification with a manual classification of calls into 36 categories provides a robust set of methods for analyzing graded call systems. Further, these methods provide a more comprehensive analysis of data collected through passive acoustic monitoring methods, where calls cannot be attributed to individuals, and thus the amount of pseudo-replication of calls from individuals is unknown. This study provides a description of the partial vocal repertoire of the eastern Beaufort Sea beluga population, which can be used for understanding beluga population structure in the rapidly changing Arctic.





Methods

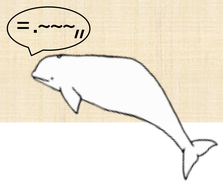
- Data: eastern Chukchi Sea spring peak 23 Apr- 6 May 2011
  - AURAL (Autonomous Underwater Recorder for Acoustic Listening)
  - 'Inshore' 40 mile
  - 16 kHz
- Measuring calls: Raven
  - Frequency
  - Duration
- Call type classification
  - Subjective classification
  - Random Forest
  - CART (Classification and Regression Tree)

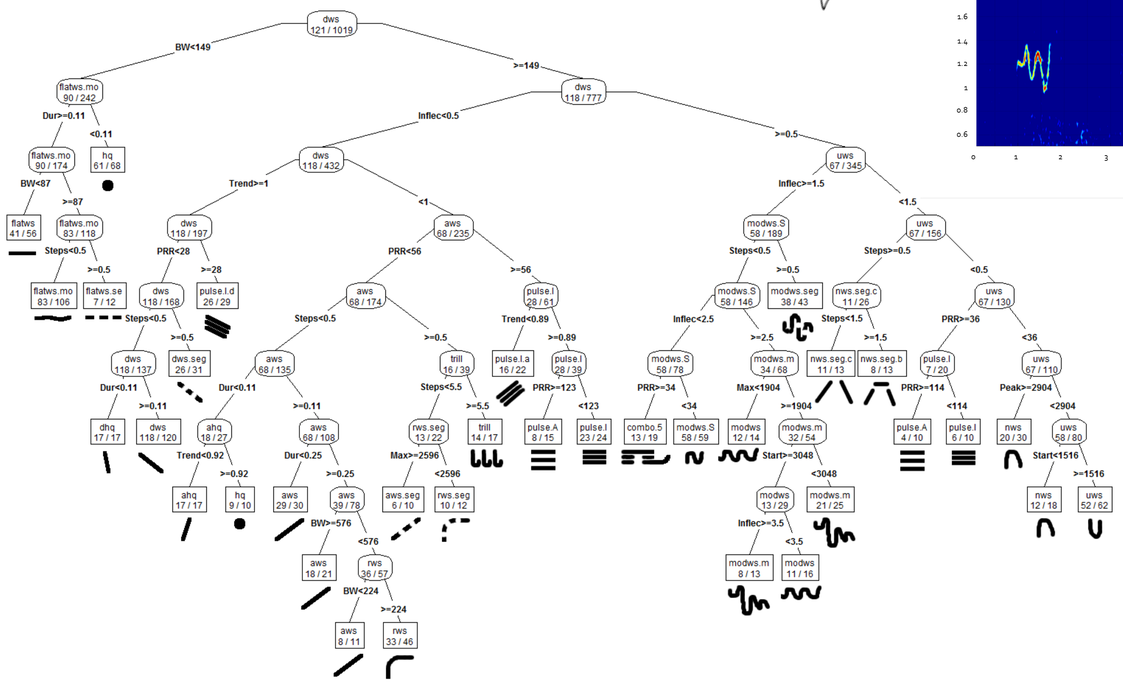


Measurement	Abbreviation	Description
Duration (s)	Dur	Length of call
Minimum frequency (Hz)	Min	Minimum frequency
Maximum frequency (Hz)	Max	Maximum frequency
Start frequency (Hz)	Start	Start frequency
End frequency (Hz)	End	End frequency
Bandwidth (Hz)	BW	Max – Min frequency
Peak frequency (Hz)	Peak	Frequency of the spectral peak
Frequency range (ratio)	Range	Ratio of max/ min frequency
Frequency trend (ratio)	Trend	Ratio of start/end frequency
Inflections	Inflec	Number of reversals in slope
Steps	Steps	Number of breaks for broken whistles
Pulse repetition rate (/s)	PRR	For pulsed calls

Classification tree of Beaufort Sea beluga calls

Variables and criteria used at each split in the tree are listed. Terminal node boxes display the total number of correct classifications.





Abbreviations: a=ascending, hq=high squeak, ws=whistle, seg=broken, a letter (e.g., .b) after seg=variant number of broken whistle, d=descending, mod=modulated, S=s-shaped, n=n-shaped, r=r-shaped, u=u-shaped. e.g., nws.seg.c=n-shaped broken whistle type c

Results

- 36 subjective call types in 17 major categories
  - Whistles: seven major contour categories
  - Pulsed/noisy calls: five major call categories
  - Combined calls: six call types
- 34 CART & Random Forest categories
- Classification success:
  - CART 83%
  - Random Forest 83%
  - Out-Of-Bag error rate = 16.78%

Conclusions

This study provides the first description of the vocal repertoire of the eastern Beaufort Sea beluga population during its spring migration through the northeastern Chukchi Sea.

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