Preliminary Progress Report on

Southern California Beaked Whale Occurrence from Towed Array Surveys

Kaitlin Frasier, Macey Rafter, John Hildebrand, Simone Baumann-Pickering

Marine Physical Laboratory
Scripps Institution of Oceanography
University of California San Diego
La Jolla, CA 92037

Overview

The goal of our project "Southern California Beaked Whale Occurrence from Towed Array Surveys" is to support the US Navy environmental compliance requirements for monitoring marine mammals. This research effort is performed by the University of California San Diego (UCSD) Scripps Institution of Oceanography (SIO) in La Jolla, CA as part of a larger effort.

Data collected by a shipboard towed array acoustic survey for marine mammals is being analyzed. These data will provide for spatial assessment of Southern California beaked whale occurrence from towed array surveys.

REPORT DOCUMENTATION PAGE	*Form Approved* OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)* 01-2019	2. REPORT TYPE Monitoring report	3. DATES COVERED *(From - To)* 2004 – 2018

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
PRELIMINARY PROGRESS REPORT ON SOUTHERN CALIFORNIA BEAKED WHALE OCCURRENCE FROM TOWED ARRAY SURVEYS	
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
Kaitlin Frasier Macey Rafter John Hildebrand Simone Baumann-Pickering	
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Commander, U.S.Pacific Fleet, 250 Makalapa Dr. Pearl Harbor, HI	
	11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS
Monitoring, passive acoustic analyses, marine mammals, toothed whales, beaked whales, Southern California Range Complex

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON Department of the Navy
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPONE NUMBER *(Include area code)* 808-471-6391

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI-Std Z39-18

Introduction

California Cooperative Fisheries Investigation (CalCOFI) cruises provide the most detailed, spatial and long-term surveys for marine mammals in the Southern California Bight, coincident with the region of the SOCAL Range Complex. They are superior to all other surveys for the SOCAL naval training area as they have excellent spatial coverage, they provide temporal coverage in all seasons, and overall greater numbers of detections provide improved geographic distributional and regional abundance estimates.

Towed array data were collected four times per year over the past fifteen years (2004-2018) during 52 survey cruises. A subset of towed array data was preliminarily screened and showed acoustic detections (clicks and whistles) of a variety of odontocete species' signals. We identified occasional beaked whale acoustic encounters and estimate that there will be a handful of encounters per each cruise. The primary obstacle to performing a detailed analysis is the development of an automated routine to remove echo sounder detections as false detections from echolocation click detections. The subsequent challenges is to identify the few, rare beaked whale signals within the remaining echolocation clicks, dominated by delphinid species. This issue can be successfully addressed because the sonar and odontocete signal characteristics are distinct. We suggest to optimize an automatic detection process and to develop detectors which can be successfully applied to this data set to evaluate beaked whale occurrence across southern California from these towed array surveys.

Current progress:

We have implemented an unsupervised learning algorithm to distinguish between impulse signals associated with echosounders, vessel propeller cavitation, and beaked whale and dolphin echolocation clicks based on differences in their acoustic spectra. This algorithm has been tested on approximately one half of the available CalCOFI towed array recordings (2008-2014), and reliably separates the four signal types at the level of individual signals (e.g. Figure 1). This strategy addresses the first dataset challenge of separating echosounders and other false positives from the beaked whale detections. A key benefit of this approach is that the features of the true and false detections are learned by the algorithm rather than dictated by pre-determined approximations. This is important for towed array data which is collected in a particularly complex, unpredictable near-surface acoustic environment.
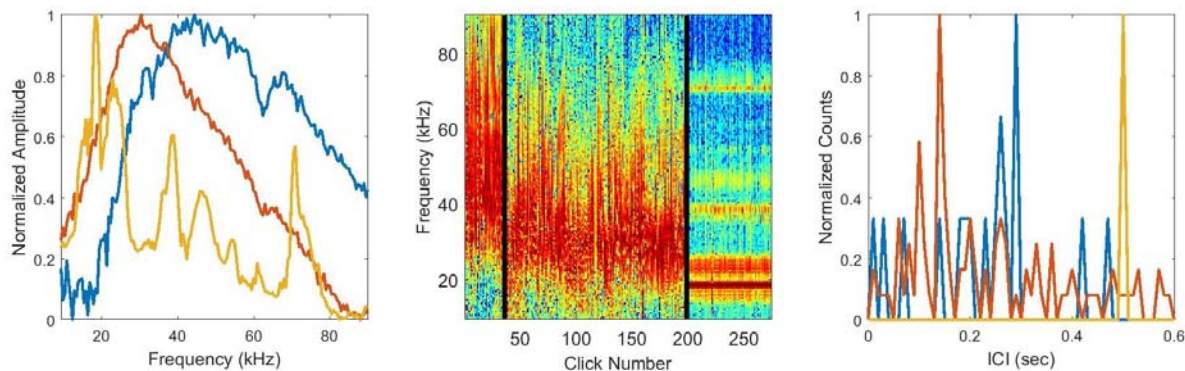
Figure 1. In this example from CalCOFI 2009 data, the unsupervised learning algorithm has reviewed detections in a five minute time window and automatically identified three distinct, recurrent signal types based on spectral features without prior knowledge of the expected categories. Mean spectra of these types are shown on the left-most subplot including beaked whale echolocation clicks (blue), dolphin echolocation clicks (red), and echosounders (yellow). The center subplot shows the concatenated spectra of the detections associated with each type, with black lines delimiting the distinct groupings. The right-most plot shows the inter-click interval (ICI) calculated for each group. Peaks in ICI distributions represent typical cue rates for these signals.

To date, we have used this algorithm to identify distinct categories of signals within a subset of towed array detection data (Figure 2). Our next step is to train a neural network using these categories to sequentially identify the false detections across the entire dataset, and flag them for removal. The remaining candidate beaked whale signals will then be further examined to identify clear beaked whale events.
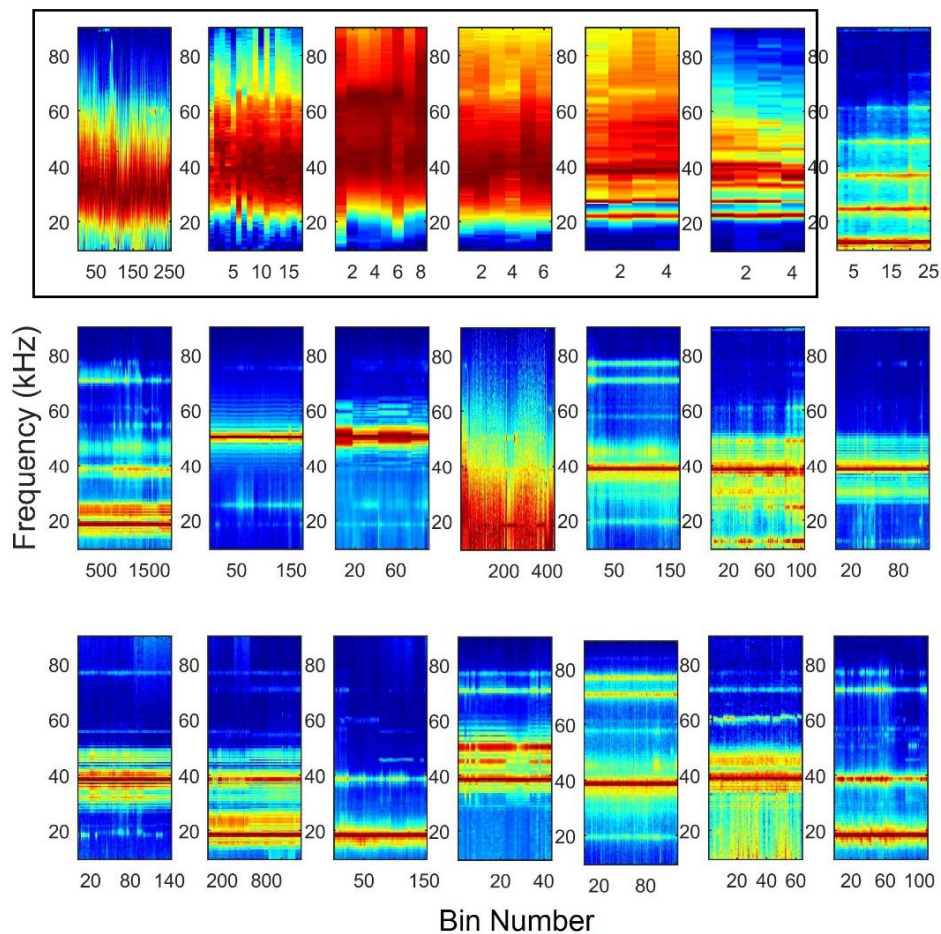
Figure 2. Categories of marine mammal and anthropogenic signals detected in the CalCOFI towed array dataset from 2008-2014. Black box on top row indicates marine mammal (dolphin and beaked whale echolocation click) categories. All other categories represent different types of echosounders and propeller noise which often obscure other signals of interest within the dataset.