Acoustic Monitoring of Cetaceans off Angola in West Africa

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Abstract

The coastal waters near Angola comprise a region of high cetacean diversity, but little is known about the distribution of species in the area. As part of the Wildlife Conservation Society's Ocean Giants Program, underwater acoustic data was continuously collected over one year's period using fixed marine acoustic recording units (MARUs), with particular interest in expanding present knowledge of humpback whales (*Megaptera novaeangliae*) populations. While computer-automated detection programs have been designed and implemented during analysis of this data, their efficacy has not been fully explored and quantified. This project focuses on verifying the sensitivity of current detection methods calibrated for humpback vocalizations by comparison of manual presence/absence assessment with detector output. We also intend to review specific cases in which the computer program appears to lose time or is unable to detect common signals within song, and provide suggestions for how false negatives may occur and how detection protocols can be improved.

Figure 1: Humpback whale

Introduction

Many cetacean species are known to produce complex vocalizations that function as communications between social groups and aid in navigating the environment, foraging for food, and attracting mates . Sound, which travels through water at approximately 4x the speed of sound in air, is the primary channel of communication for cetaceans as visibility is low and unreliable in marine conditions. In particular, Humpback whales (*Megaptera novaeangliae*) produce a wide array of 'social sounds' during intraspecies interactions, with males also producing complex 'song' that act as breeding displays [1]. These vocalizations can be recorded using active and passive acoustic monitoring techniques and analyzed for a wealth of information concerning species identification, abundance, migration patterns, and behavior [2,3].

Because humpbacks and other whale species are sensitive to sounds within their vocalization range, anthropogenic noise pollution from oil and gas exploration and development as well as shipping traffic may have detrimental effects on individual and population health. It is critical to accurately monitor cetacean spatial and temporal distribution in areas that may be subject to current and future sources of anthropogenic noise.

The coastal waters near Angola represent one region of overlap between industrial interests and significant cetacean ranges, but the area has been poorly studied. Preliminary research has found the highest cetacean species diversity in West Africa [4]. In 2011, five marine acoustic recording units (MARUs) were deployed in a fixed pattern off the coast of Cabinda, an exclave of Angola. Acoustic data was collected for three 4-month periods, analyzed for whale vocalizations using a computer-automated detection program, and manually checked for false positive identifications [5]. However, this two-step signal processing procedure is imperfect and has been observed anecdotally to produce false negatives during both extended periods of dense, close-range song and for vocalizations within-song. This project aims to quantify detector sensitivity by comparison of manual presence/absence assessment with detector output, and to review specific periods of missed detections in order to suggest explanations and improvements to the detection method.

Figure 2: Location of MARU deployment

Methods & Materials

This project utilizes passive acoustic data gathered during the first 4-month deployment of five MARUs placed off the coast of Cabinda, an exclave of Angola. During the period of October 2011 to January 2012, the MARUs were set to record in the lower frequency range of 0-1000 Hz in order to focus on humpback vocalizations. Acoustic data from 4 of the 5 MARUs was processed by a computer-automated detection program, mainly calibrated for humpback song and social sounds , and then manually verified as positive detections. In the assessment of presence/ absence, 4 hours during every other day of the deployment were manually reviewed visually and aurally using the Raven software for humpback song and compared to detections within that hour by the computer program. Extended periods of missed song were noted for further analysis.

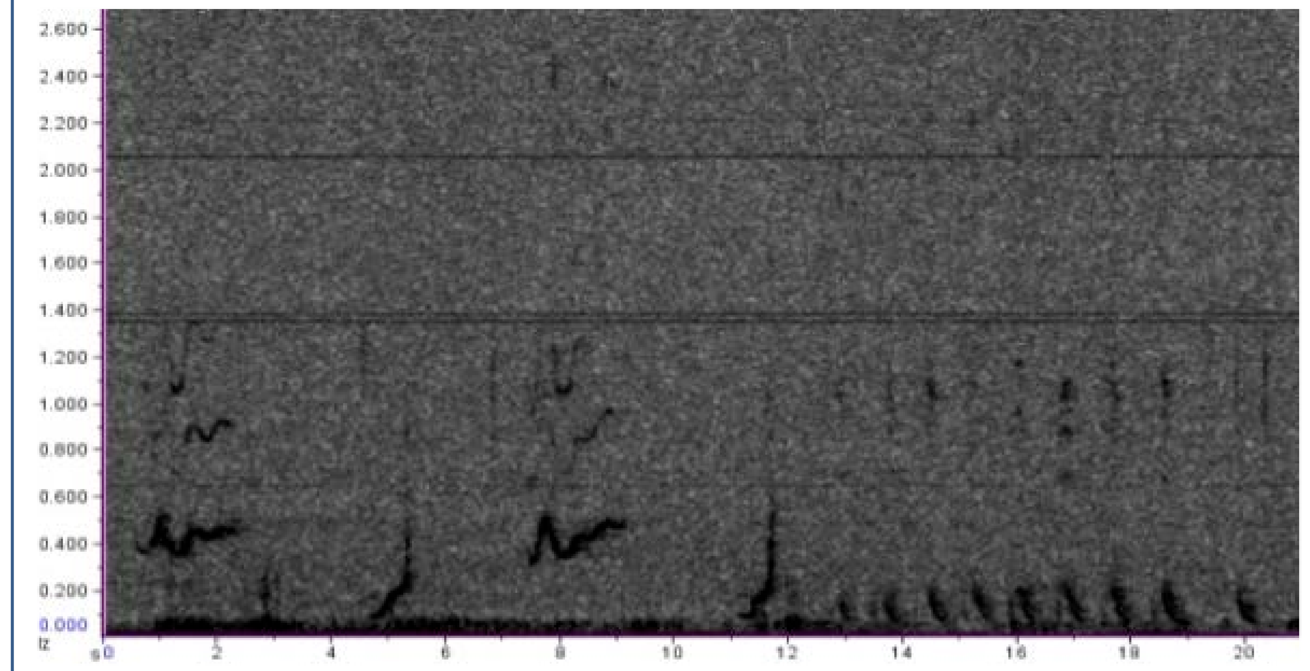

Figure 3: Sample of humpback song

Preliminary Results and Discussion

Within an hour, the automated detection method is largely capable of correctly identifying humpback song, which commonly occurs in extended patterns that last for hours rather than isolated bursts. While the detector may fail to identify far-off song, with stronger signals it appears unlikely that the detector will consistently miss every element in a string of consecutive vocalizations. When interpretation of acoustic data only requires confirmation of presence/absence, this slightly decreased sensitivity may not have significant effects on study results.

There appear to be several periods of approximately 15-30 minutes over the deployment in which the detector entirely fails to identify obvious song. These instances may represent a defect in detector programming, and these periods will be further investigated. Within periods of dense song, the detector may miss single vocalizations between those marked positive. These false negatives may be a consequence of detector protocol, which bases its assessments on signal power within the neighborhood of the signal in order to account for fluctuations in general noise in the environment.

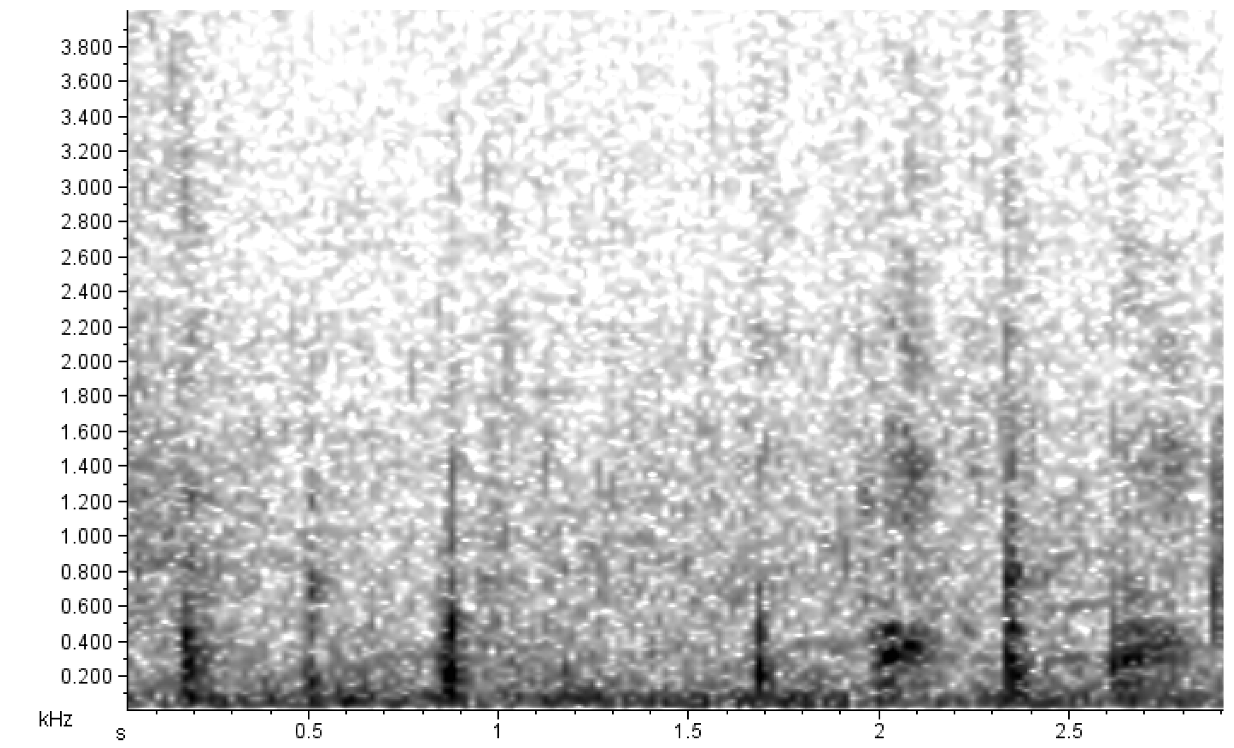

Figure 4:Humpback social sounds (snorts, pulses)

References

1.Noad, M.J., et al., *Cultural revolution in whale songs.* Nature 2000. **408**: p. 538.

2.Oswald, J.N., J. Barlow, and T.F. Noriss, *Acoustic identification of nine delphinid species in the eastern tropical pacific ocean.* Marine Mammal Science, 2003. **19**(1): p. 20-37.

3. Marques, T.A., et al., *Estimating cetacean population density using fixed passive acoustic sensors: an example with Blainville's beaked whales.* J Acoustic Soc Am, 2009. **125**(4): p. 1982-94.

4. Weir, C.R., *A review of cetacean occurrence in West African waters from the Gulf of Guinea to Angola.* Mammal Review, 2010. **40**(1): p. 2-39.

5. Cerchio, S., et al., *Humpback whale singing activity off northern Angola: an indication of the migratory cycle, breeding habitat and impact of seismic surveys on singer number in Breeding Stock B1.* 2013.

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