Application of Density Estimation Methods to Datasets from a Glider

Elizabeth Thorp Küsel and Martin Siderius
Portland State University
Electrical and Computer Engineering Department
1900 SW 4th Ave.
Portland, OR 97201
phone: (503) 725-3223 fax:(503) 725-3807 email: siderius@pdx.edu

David K. Mellinger and Sara Heimlich
Oregon State University
Cooperative Institute for Marine Resources Studies
2030 SE Marine Science Dr.
Newport, OR 97365
phone: (541) 867-0372 fax: (541) 867-3907 email: David.Mellinger@oregonstate.edu

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http://www.ece.pdx.edu/Faculty/Siderius.php

LONG-TERM GOALS

This is a new project that started in August 2013 and the long-term goal is to extend the use of population density estimation methods based on detections of marine mammal vocalizations to datasets collected by a moving platform. The moving platform under consideration is an electric underwater glider, which offers the potential of surveying a larger area than a fixed, single sensor. The glider also has the potential to surface and transmit data using a satellite modem. Moreover, fitting the glider with two hydrophones, one on each wing can provide bearings to vocalizing animals. Density estimation from glider datasets will be developed by looking at some of the species known to occur off the central Oregon coast, such as humpback and sperm whales as well as different dolphin species.

OBJECTIVES

The objective of this research is to extend existing methods for cetacean population density estimation from fixed passive acoustic recordings to datasets recorded from a moving platform, in particular using an underwater glider. Instead of using datasets previously recorded for different applications, the current project will benefit from data collections designed specifically for density estimation purposes, with combined environmental sampling provided by the glider's Conductivity, Temperature and Depth (CTD) sensor. The central Oregon coast, where experiments and data collection will take place, is an easily accessible area for both project teams (PSU and OSU) working on this project with known occurrence of many marine mammal species, ranging from

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pinnipeds, to baleen whales, cetaceans and dolphin species (Carretta *et al*., 2009). Extensive oceanographic (Pierce *et al*., 2012) as well as noise characterization (Haxel *et al*., 2011) has also been performed in this area, providing possible support data for the current project's data analysis. Because gliders offer low-cost, all-weather, remote-area operation, it is our goal to extend its usability to population density estimation surveys offering another tool to aid those involved in marine mammal research, monitoring, and mitigation planners.

APPROACH

Approach to Estimating Population Density from a Glider Dataset

The dataset to be used in the current project will be recorded off the coast of Newport OR, by using a Teledyne Webb Research electric glider (Webb *et al*., 2001) owned by PSU's NEAR Lab. The glider is fitted with two hydrophones on the tips of its wings and a digital acoustic monitoring (DMON) instrument inside of the glider's scientific bay. The glider can dive to a maximum depth of 200 meters, driven in a saw-tooth vertical profile by variable buoyancy. Two-week glider deployments will be performed at four times of the year out to the shelf break to compare presence and population density of animals over the four seasons. By sampling the near shore, continental shelf, and shelf break, cetacean habitat use characterization will also be performed.

The methodology employed in this study to estimate the population density of marine mammals off Newport, OR, will be based on the works of Zimmer *et al*. (2008), Marques *et al*. (2009), and Küsel *et al*. (2011) and the recent results presented by Ainslie (2013) with regards to call bandwidth as well as approaches for correctly modeling broadband calls being currently addressed by the project's PIs. Required steps for a cue counting approach, where a cue has been defined as a clicking event (Küsel *et al*., 2011), to density estimation from data recorded by single, fixed sensors are summarized in Figure 1.

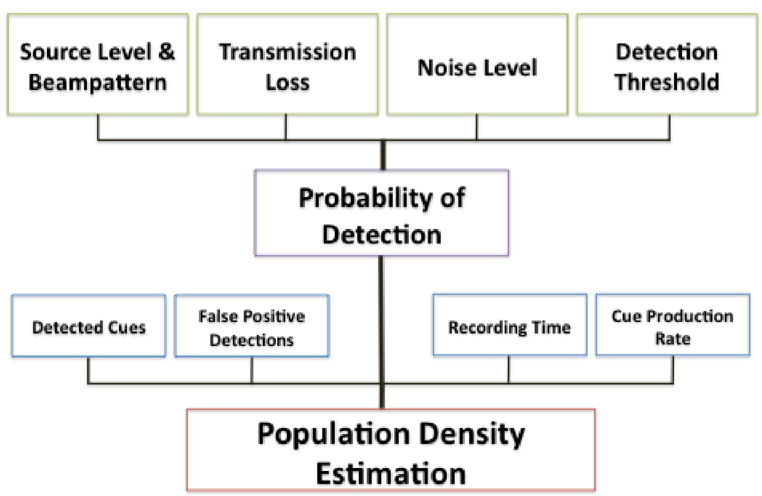

Figure 1. Flow chart with the required steps for estimating the population density of a species.

Fitting the glider with two recording sensors, instead of one, provides the opportunity to investigate other density estimation modalities (Thomas and Marques, 2012), such as individual or group counting. In this sense, bearings to received sounds on both hydrophones will be computed in a similar way as has been presented by Lewis *et al*. (2007) using a towed hydrophone array. The analysis of one and two sensors will also provide data with which to compare different density estimation methodologies.

The choice of target species will be largely dependent on the dataset obtained after a glider mission. Systematic compilation of marine mammal data present in the area, noting the observation time of year, from literature, stock assessments, visual observations, and acoustic sensors can aid in realizing what species will be expected during a given field experiment. The required animal acoustic behavior (source level, beampattern, and cue production rate from Fig. 1) will come from information available in the literature and from available acoustic tags. Acoustic transmission loss will be computed using an acoustic propagation model chosen based on the call frequency content; Bellhop (Porter and Bucker, 1987) for high frequency calls, or RAM (Collins, 1993) for low frequencies (< 1000 Hz). From literature information on the target species' diving behaviors when emitting sounds, a 3D random distribution of simulated animals will be created taking into account their orientations with respect to the glider. The probability of detecting a cue as a function of distance from the hydrophone is necessary to estimate a detection function for each call type, or for each species. This can be accomplished by measuring the signal-to-noise ratio (SNR) of detected calls from a subsample of the data set and then estimating the proportion of those within an SNR bin that were detected. We further simulate the SNR of randomly distributed calls along the glider track by using the sonar equation with estimated ambient noise levels from the data set, and transmission loss calculated by a propagation model.

WORK COMPLETED

A preliminary glider test was performed at Waldo Lake, in central Oregon, on September 20th, 2013, to evaluate operational functions, such as communications and mission performance. Waldo Lake is one of the deeper lakes in Oregon State, with very clear waters, providing a good environment to test the glider before ocean deployments.

RESULTS

Figure 2 shows the location of the glider test at Waldo Lake, OR, in September, 2013 and the location of the modifications to the glider putting the hydrophones on the wings. Such test was important to check on the glider operation and logistics in order to plan future ocean deployments off Newport accordingly.

Figure 2. Location of Waldo Lake, OR and preparations for glider deployment, which took place on September 20th, 2013. On the right, making sure hydrophones are in place on the wings.

IMPACT/APPLICATIONS

We expect to develop a density estimation method that can be applied to acoustically-equipped ocean gliders, making data from such gliders applicable for a wider range of applications – before-during-after exposure studies, seasonal distribution measurement, population estimates, etc. The application of recently developed density estimation methods to different data sets and marine mammal species also provides opportunities to improve the methodology and make it more general. By improving our capabilities for monitoring marine mammals we hope to contribute to minimizing and mitigating the impacts of man-made activities on these marine organisms.

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