Scripps Institution of Oceanography, 16th July 2009

Location: Scripps Seaside Forum; cell A9 on map at http://tinyurl.com/n67kct
Scientific coordinators: John Hildebrand (jhildebrand@ucsd.edu), Len Thomas (len@mcs.st-and.ac.uk)

Talk timings: First talk (tutorial): 40 minutes + 20 for questions; Subsequent talks: 20 minutes + 10 for questions; 45 minutes for open discussion before close.

Agenda

Session chair: John Hildebrand.
08:45 Late registration
09.00 Opening and welcome. John Hildebrand.

10:45 Coffee.

Session chair: Jay Barlow.
11:00 Estimating beaked whale density from single hydrophones by means of propagation modelling. Elizabeth Küsel.
11:30 Density estimates from long-term autonomous recorders. John Hildebrand
12:00 Estimating whale abundance using sparse hydrophone arrays. Danielle Harris.
12:30 Lunch

Session chair: Sean Wiggins.
14:00 Estimates of the percentage of sperm whales missed on combined visual and acoustic surveys in the eastern Pacific Ocean. Jay Barlow.
15:00 Passive Acoustics as a Tool for Density Estimation of Delphinids: Great Potential and Great Limitations. Shannon Rankin.

15:30 Coffee.

Session chair: Len Thomas.
16:15 Open Discussion: What do we know about estimating density?; Where next?
17:00 Close.

No-host dinner that evening at venue TBA.
Abstracts

Review of methods for estimating cetacean density from passive acoustics.

Len Thomas and Tiago Marques

CREEM, University of St Andrews, St Andrews, Scotland.

For the past two years, we have been working on a large collaborative project, with the soothing acronym “DECAF”, to develop general methods for estimating whale density from fixed underwater hydrophones. We start by introducing distance sampling based methods and contrasting visual surveys against acoustic surveys. We then give an overview of the potential approaches, and show how the methods available for any particular circumstance are constrained by the hydrophone configuration (e.g., number, placement and sensor characteristics), whale behaviour (vocal, social and movement) and sound propagation through water, as well as what is known from auxiliary data, or can be assumed, about these things. We illustrate the talk with various applications, mostly based on data from US Navy testing ranges.

Estimating beaked whale density at AUTEC using tagged whale data.

Tiago A. Marques¹, Jessica Ward², Len Thomas¹, Nancy DiMarzio³, Peter L. Tyack³, David Moretti³ and Steve Martin⁴

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We give a case study of cue-based estimation of cetacean density from a sparse array of hydrophones. Detection probability and cue (click) rate are estimated from a sample of whales fitted with acoustic tags, and this is then used to convert number of detected foraging clicks of Blaineville’s beaked whale over 6 days at the US Navy AUTEC range into an estimate of density. The amount of false positives is accounted for by manually screening a sample of the 6 day data set. Wind speeds were lower during the tagging study than the 6 day period, and we demonstrate how a correction can be estimated for the additional ambient noise and its effect on detectability.
Estimating beaked whale density from single hydrophones by means of propagation modeling

Elizabeth T. Küsel¹, David K. Mellinger¹, Len Thomas², Tiago Marques², David Moretti³ and Jessica Ward³

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The objective of this study is to estimate the spatial density of cetaceans from isolated sensors by using propagation modeling to estimate the probability of detecting an animal as a function of its distance from each receiving sensor. The target species is Blainville’s beaked whale (Mesoplodon densirostris) and the study area is the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Tongue of the Ocean, Bahamas. In order to develop a general method that can be applied to any situation in which isolated hydrophones are deployed, our analysis is based on information available in the literature for this species. (Although DTAGs were deployed on some whales in this area, our approach is to disregard the DTAG data so as to have a method applicable to other situations in which DTAG data are not available.) A ray-tracing acoustic propagation model is used to estimate the environmental transmission loss as a function of depth and range in the vicinity of a single-hydrophone receiver. The computed transmission loss is compared to ambient noise levels and source level distributions to estimate the detection probability as a function of range. The analysis is repeated for each hydrophone inside the study area whether or not clicks were detected. A discussion of the parameters needed for the detection model, based on the sonar equation, will be presented. This includes the assumptions about source level and beam pattern for Blainville’s beaked whales from literature review, as well as characterization of the detection threshold. The detection probability function is then combined with the total number of clicks detected and the average click rate to estimate beaked whale spatial density. This study provides a relevant comparison to both the detection function and the spatial density of whales derived empirically from the DTAG data by Marques et al. (2009).
Density Estimates from Long-Term Passive Acoustic Monitoring

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Acoustic monitoring is often complimentary to visual approaches for the study of marine mammal populations. When acoustic and visual techniques are compared, they often reveal different aspects (behavioral, spatial, or temporal) of the population under study. Long-term, passive acoustic monitoring provides a means for estimating densities of marine mammals over seasonal and longer time scales. Acoustic-based density estimation requires information both on detection range, which is dependant upon source levels and propagation characteristics, and on calling rates, which may be dependent upon behavioral state (e.g. foraging, breeding). An example is presented for north Pacific right whale density estimation in the Bering Sea using passive acoustic monitoring of “upsweep” calls. Another example is presented for Cuvier’s beaked whale density estimation in the southern California region, based on detection of their echolocation pulses.

Estimating whale abundance using sparse hydrophone arrays.

Danielle Harris (1), Len Thomas (1), John Hildebrand (2), Sean Wiggins (2), John Harwood (1)

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The aim of this PhD project is to develop statistical methods to produce absolute whale abundance estimates from data recorded by sparse hydrophone arrays, illustrated by several case studies.

The main methodology used will be based on point transect sampling, a form of distance sampling, which is commonly used to estimate bird abundance. However, the use of acoustic data from sparse arrays causes the measurement of distances to the detected animals – a key element of distance sampling - to be problematic. In addition, some of
the main assumptions of point transect methods are violated. Therefore, alternative approaches to these problems will be investigated.

In this presentation, two of the case studies currently being worked on will be described. The first case study involves blue whale (Balaenoptera musculus) vocalisations which have been recorded at Diego Garcia, part of the Chagos Archipelago in the Indian Ocean, by International Monitoring System hydrophone stations. These stations are primarily used to detect nuclear explosion test activity but also record low frequency cetacean vocalisations.

The second case study is based on fin whale (Balaenoptera physalus) vocalisations recorded by ocean bottom seismometers used to study tsunamis in the Atlantic Ocean.

**Estimates of the percentage of sperm whales missed on combined visual and acoustic surveys in the eastern Pacific Ocean.**

Jay Barlow and Shannon Rankin

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Abundance estimation from line-transect surveys commonly assumes that all animals on the trackline are detected. For long-diving species, such as sperm whales, this assumption is commonly violated. Marine mammal surveys were conducted in the eastern tropical Pacific in 2000-2002, with visual observers searching by 25X binoculars and acousticians aurally monitoring two elements of a towed hydrophone array. Visual and acoustic teams were independent and did not learn of detections made by the other team until after the animals had passed abeam. Data from 186 visual and acoustic detections were used to estimate the fraction of whales missed by each method. Many of the 178 acoustic detections were at greater distances than could be seen by the visual observers. Based on Palka’s direct-duplicate method, the percentages of missed trackline groups were 37% and 21%, respectively, for visual and acoustic methods. Assuming these two detection methods are independent, the percentage missed by both groups is 8%. If, as expected, the likelihood of detection is inversely related for visual detections (at the surface) and acoustic detections (typically diving), the percentage missed by both team would be less than 8%. Acoustic detections greatly reduce the fraction of missed animals, but by itself, this method cannot reliably estimate group sizes and still misses some groups. A combination of acoustic and visual methods is recommended for sperm whale surveys.
Integration of Automated Acoustic Detection Methods into Towed-Array Surveys for Marine Mammals

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Currently, passive acoustic surveys of cetaceans require specially trained personnel to monitor hydrophone signals in real-time. While effective, this method is time-consuming and costly. Automated detection of cetacean vocalizations would be a valuable tool during acoustic line-transect surveys, allowing for detection when experienced technicians are unavailable. This technique significantly reduces effort and removes sources of human error and bias in detection ability. PAMGUARD 1.0 Core software was evaluated for use in automated detection of cetacean acoustic signals. Three different detector configurations of PAMGUARD were evaluated. This work shows that the majority of whistle and click events can be detected using PAMGUARD software. All of the PAMGUARD trials were capable of detecting whistles and clicks of cetacean species with varying success. These techniques were field-tested at sea during a recent Southwest Fisheries Science Center (SWFSC) marine mammal survey. Automated detection of beaked whales and Dall’s porpoise was especially successful during this survey which is noteworthy because these are species that are difficult to see in less-than-perfect survey conditions. This study has demonstrated the feasibility of using automated methods for detections of marine mammals in real-time during acoustic line transect surveys and results indicate that integration of these survey methods may result in increased accuracy of abundance estimation for visually elusive species.
Passive Acoustics as a Tool for Density Estimation of Delphinids: Great Potential and Great Limitations

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The use of passive acoustics to estimate cetacean density will depend on reliable and precise detection, localization, species identification, and group size estimation. For delphinids, in particular, there are significant complications that must be addressed before useful results can be obtained. We examine data from eight years of combined visual and acoustic line-transect surveys to evaluate the efficacy of using passive acoustics for estimation of density estimation and/or population abundance of delphinids. We find great variation in the detection and localization of dolphin species using towed hydrophones, and we will discuss the potential impact of this variation on density estimation. Acoustic species identification and group size estimation are considerably more complicated than detection and localization, and we evaluate alternative approaches to address each issue. Examination of two acoustic species identification programs, ROCCA (for whistles) and PAMGUARD (for echolocation clicks), show that each method is useful for different species, and some combination of the two may be optimal for groups that produce both types of sounds. Group size estimation using acoustic detections alone may never be possible given the variability in vocal activity of dolphins. Alternative methods to determine group size are considered. Finally, we examine the role that acoustics may play in dolphin population surveys given these practical limitations.
Estimating minke whale boing density at Pacific Missile Range Facility, Hawaii

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Acoustic data from the Pacific Missile Range Facilities bottom mounted hydrophones are being utilized in the DECAF (Density Estimation of Cetaceans using Acoustic Fixed sensors) project as an application of density estimation methodology using real world data. Automated techniques have been developed to detect and classify sounds as Minke whale ‘boing’ vocalizations. Multiple boing detectors (Ishmael whistle based, Matlab versions and a C code version) have been evaluated on a test subset of data previously analyzed by a retired acoustic intelligence analyst. DECAF will use the C code detector running in the Marine Mammal Monitoring on Navy Ranges (M3R) system to perform density estimation on a larger set of PMRF data. Methods are under development to associate auto-detected boing vocalizations across 24 spatially separated hydrophones to individual boings by utilizing features of the signals (levels and boing frequency in the band 1350Hz-1440Hz), and temporal/spatial patterns of detections. While localization is possible for some cases, the method being used for density estimation only requires association of boings to individual boings.

The proposed analyses for estimating density from the resulting data is based on spatially explicit capture recapture (SECR) methods. Outputs of the signal processing will be organized as “capture histories”, i.e. for each produced boing, a vector of length 24 indicating if it was detected or not at each of PMRF hydrophones. Both a likelihood-based and a Bayesian-based approach are envisaged. Some preliminary results based on simulated data are presented, and some of the potential issues involved are discussed.

This work is the result of multiple DECAF team members contributions, Len Thomas (CREEM), David K. Mellinger (OSU), and NUWC team members David Moretti, Ronald Morrissey, Nancy DiMarzio and Susan Jarvis.