Together for Science and Conservation
WMMC'19
World Marine Mammal Conference
Barcelona 2019

Passive Acoustic Distance Sampling

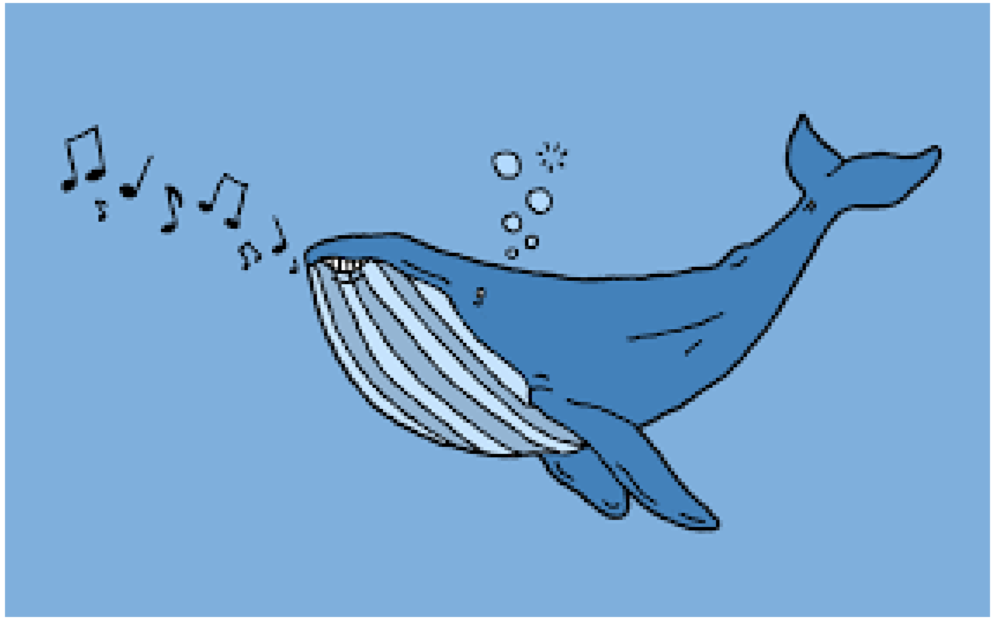
Tiago A. Marques
(Len Thomas & Danielle Harris)

Distance sampling surveys
of marine mammal density and abundance:
from introductory ideas to latest developments


I am possibly the best
marine mammal for
visual surveys ☺!

Visual methods are…

- Dependent on day light
- Dependent on weather
- Temporally restricted (hard to automate recordings, so depends heavily on humans)
- Far from ideal for animals that spend most of their time submerged



But since (most) marine mammals produce ("easily" identifiable) species specific sounds, and these can be identified often further away that visual detections can occur, passive acoustic density estimation has seen huge developments in the last decade.

Here we focus on distance sampling developments, but a range of other applications for passive acoustic data, including major developments in spatially explicit capture recapture methods, have also been developed

BIOLOGICAL REVIEWS
Cambridge Philosophical Society

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doi: 10.1111/brv.12001

Estimating animal population density using passive acoustics

Tiago A. Marques[1,2,*], Len Thomas[1], Stephen W. Martin[3], David K. Mellinger[4], Jessica A. Ward[5], David J. Moretti[5], Danielle Harris[1] and Peter L. Tyack[6]

[1] *Centre for Research into Ecological and Environmental Modelling, University of St Andrews, The Observatory, Buchanan Gardens, Fife, KY16 9LZ, UK*
[2] *Centro de Estatística e Aplicações da Universidade de Lisboa, Bloco C6, Piso 4, 1749-016, Lisboa, Portugal*
[3] *Space and Naval Warfare Systems Center Pacific, 53560 Hull Street, San Diego, CA 92152 USA*
[4] *Cooperative Institute for Marine Resources Studies, Oregon State University and NOAA Pacific Marine Environmental Laboratory, 2030 SE Marine Science Drive, Newport, OR 97365, USA*
[5] *Naval Undersea Warfare Center, 1176 Howell Street, Newport, RI 02841, USA*
[6] *Sea Mammal Research Unit, Scottish Oceans Institute, University of St. Andrews, Fife, KY16 8LB, UK*

Passive acoustic distance sampling

Actually, nothing new there, people have been doing it for many many years with birds!

Ecological Applications, 17(3), 2007, pp. 948–955

FACTORS AFFECTING AURAL DETECTIONS OF SONGBIRDS

MATHEW W. ALLDREDGE,[1,4] THEODORE R. SIMONS,[2] AND KENNETH H. POLLOCK[3]

[1]*North Carolina*

[2]*USGS, North Caro*

[3]*Zoology, Biomathematics,*

Key words: auditory detection; detection probability; observer differences; point counts; singing rate; species difference; warblers.

INTRODUCTION

nt count survey, in which observers record all
en or heard at a point within a specified time
(Ralph et al. 1995), is the most common
g method used in bird population studies

experimental approach to quantify several factors that affect detection probabilities on point count surveys.

Surveys in heavily vegetated habitats rely almost exclusively on auditory detections (Faanes and Bystrak 1981, Scott et al. 1981, Dejong and Emlen 1985), and most use unadjusted counts as an index of population

A key aspect of those forest studies always has been that the focus of the survey, the object of interest, were the animals themselves

Therefore key constraints were animal movement and double counting of animals

Fixed PAM vs. Towed PAM

Line transects

Point transects

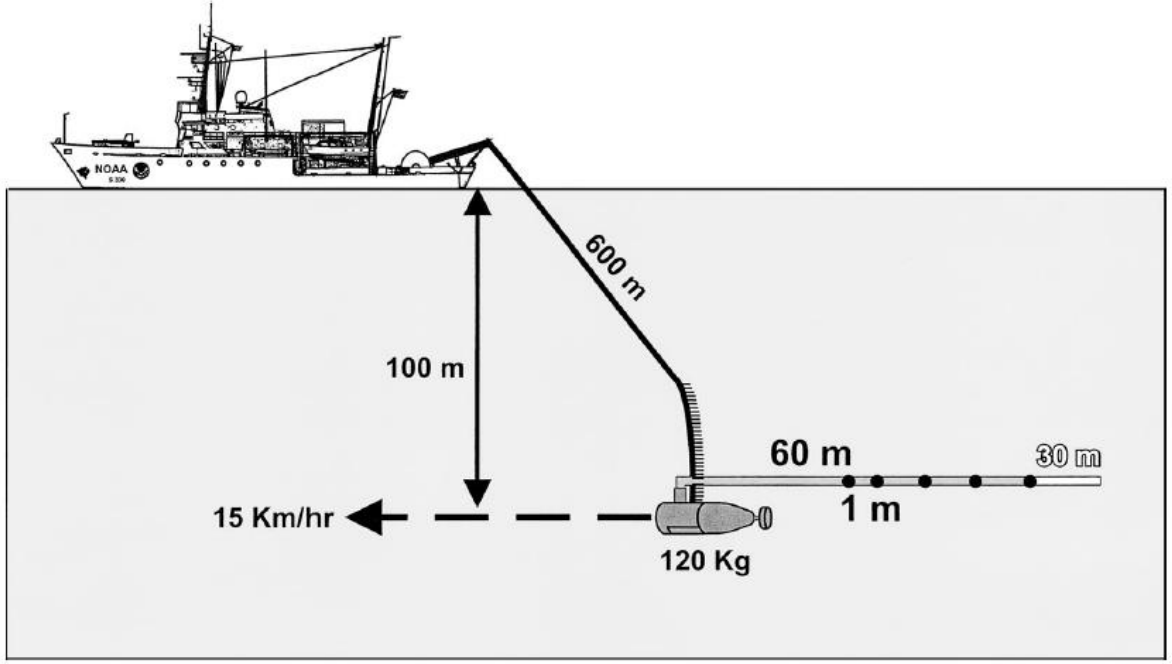


Figure 1. Diagram showing the tow cable, depressor weight, and horizontal hydrophone array used for the acoustic survey (not to scale). The lower 30 m of the tow cable was fared to reduce drag and cable strum. A nylon rope was used to stabilize the last 30 m at the tail of the array.

MARINE MAMMAL SCIENCE, 21(3):429–445 (July 2005)

ESTIMATES OF SPERM WHALE ABUNDANCE IN THE NORTHEASTERN TEMPERATE PACIFIC FROM A COMBINED ACOUSTIC AND VISUAL SURVEY

JAY BARLOW
BARBARA L. TAYLOR
Southwest Fisheries Science Center
8604 La Jolla Shores Drive, La Jolla, California 92037, U.S.A.
jay.barlow@noaa.gov

Sperm whale distribution and seasonal density in the Faroe Shetland Channel

Gordon D. Hastie*, René J. Swift *, Jonathan C.D. Gordon†, George Slesser‡ and William R. Turrell‡

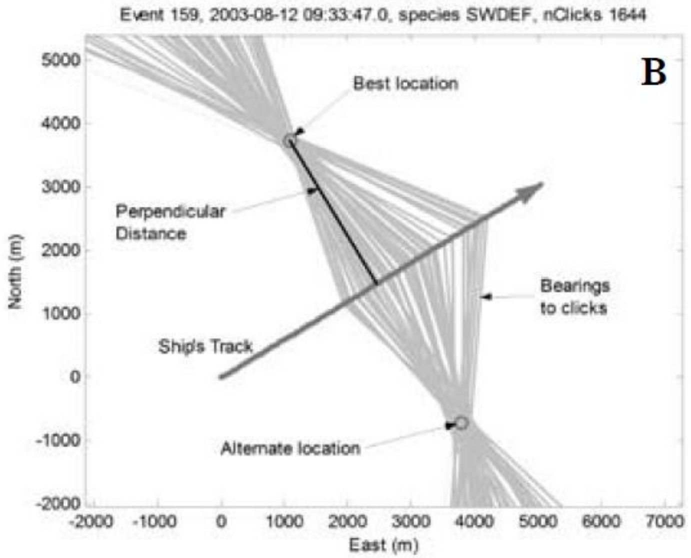


Figure 2. (A) Angle, relative to boat, of the clicks of two sperm whales as the vessel passed by; (B) reconstruction of one whale's position to estimate perpendicular distance.

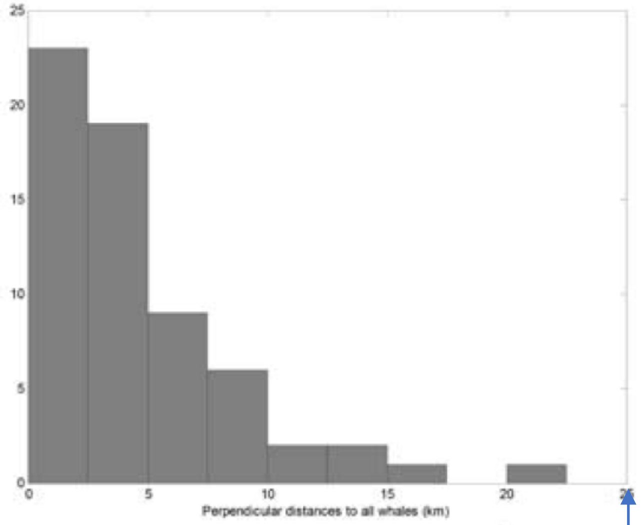


Figure 3. Histogram of perpendicular distances to all located sperm whales.

25km

J. Mar. Biol. Ass. U.K. (2007), **87**, 353–357
Printed in the United Kingdom

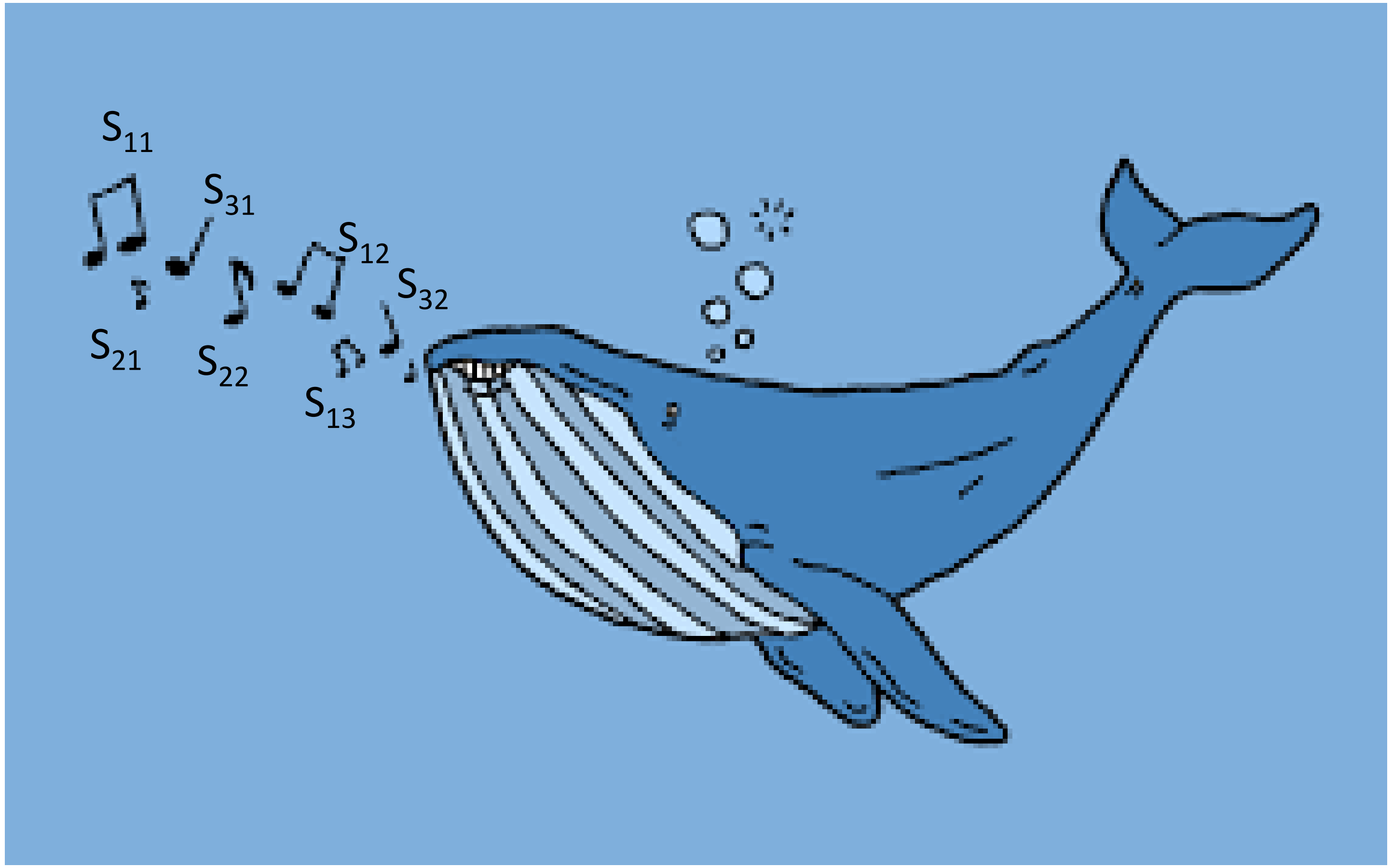
doi: 10.1017/S0025315407054896

Sperm whale abundance estimates from acoustic surveys of the Ionian Sea and Straits of Sicily in 2003

T. Lewis*, D. Gillespie, C. Lacey, J. Matthews, M. Danbolt, R. Leaper, R. McLanaghan and A. Moscrop

'Song of the Whale' Team, International Fund for Animal Welfare, 87–90 Albert Embankment, London, SE1 7UD, UK.
*Corresponding author, e-mail: whalesong@ifaw.org

The use of passive acoustics distance sampling for marine mammals greatly leveraged on switching the focus from animals to cues (here the individual sounds)



So was that something new from acoustics?

… not really ☺!

Cue counting: using whale blows to estimate whale abundance (needs a blow rate production)

Minke whale abundance estimation from the NASS 1987 and 2001 aerial cue–counting surveys taking appropriate account of distance estimation errors

David L. Borchers[1], Daniel G. Pike[2], Thorvaldur Gunnlaugsson[3] and Gísli A. Víkingsson[3]

[1] *RUWPA, The Observatory, University of St Andrews, Fife, KY16 9LZ, United Kingdom*
[2] *1210 Ski Club Road, North Bay, Ontario, P1B 8E5, Canada*
[3] *Marine Research Institute, P.O. Box 1390, IS-121, Reykjavík, Iceland*

ABSTRACT

We estimate the abundance of minke whales (*Balaenoptera acutorostrata*) from the Icelandic coastal shelf aerial surveys carried out as part of the 1987 and 2001 North Atlantic Sightings Surveys (NASS). In the case of the 1987 survey, the probability of detecting animals at distance zero ($g(0)$) is very close to 1 but there is substantial random measurement error in estimating distances. To estimate abundance from these data, we use methods which assume $g(0)=1$ but which include a distance measurement error model. In the case of the 2001 survey, measurement errors were sufficiently small to be negligible, and we use double platform methods which estimate $g(0)$ and assume no measurement error to estimate abundance. From the 1987 survey, we estimate abundance to be 24,532 animals, with 95% CI (13,399; 44,916). From the 2001 NASS survey data, minke whale abundance is estimated to be 43,633 animals, with 95% CI (30,148; 63,149).

Borchers, D.L., Pike, D.G., Gunnlaugsson, Th. and Víkingsson, G.A. 2009. Minke whale abundance estimation from the NASS 1987 and 2001 aerial cue–counting surveys taking appropriate account of distance estimation errors. *NAMMCO Sci. Publ.* 7:95-110.

Estimating cetacean population density using fixed passive acoustic sensors: An example with Blainville's beaked whales

First output from DECAF project

Tiago A. Marques[a] and Len Thomas
Centre for Research into Ecological and Environmental Modelling, The Observatory, University of St Andrews, St Andrews KY16 9LZ, Scotland

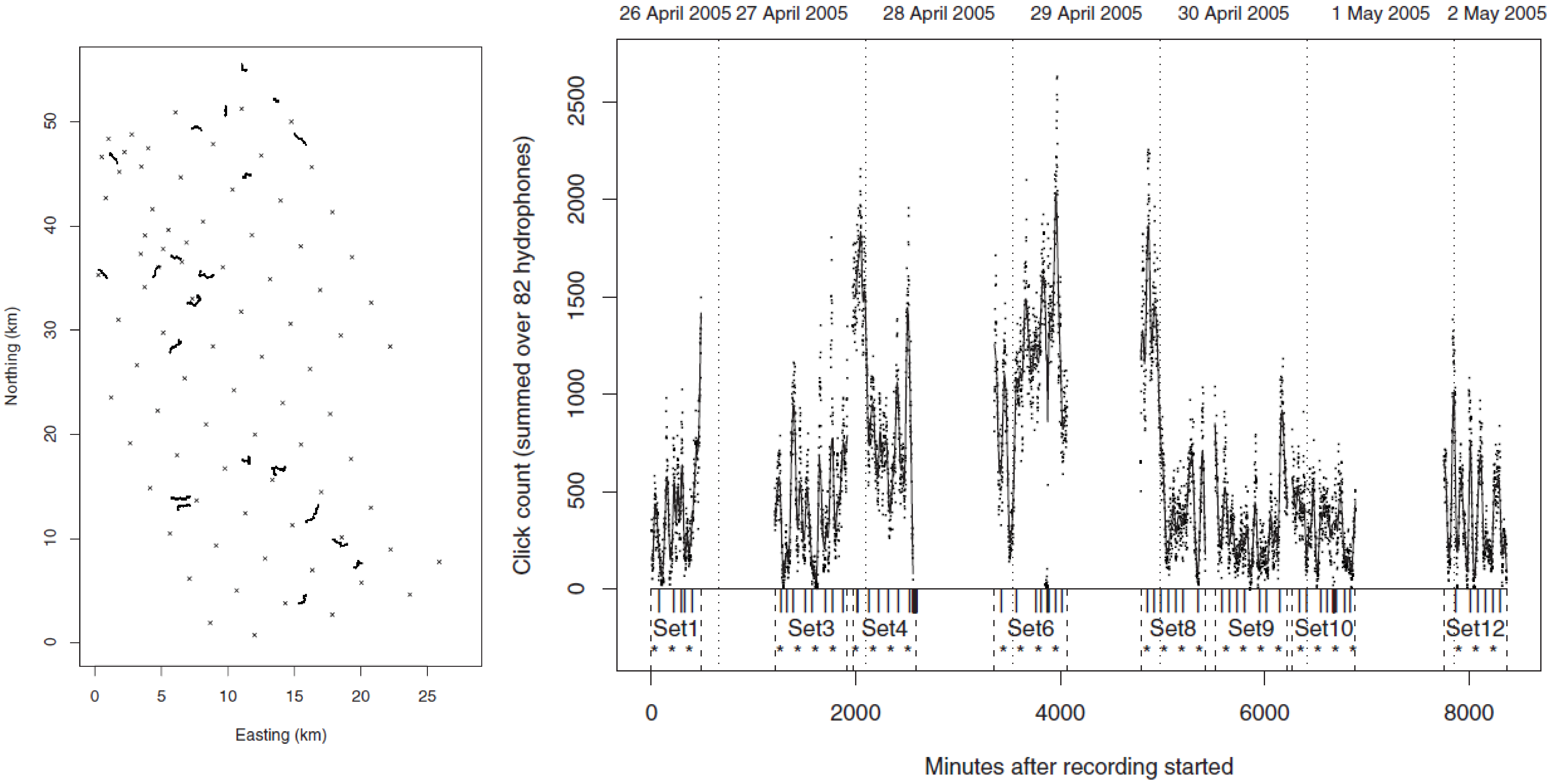
Jessica Ward and Nancy DiMarzio
Naval Undersea Warfare Center Division, 1176 Howell Street, Newport, Rhode Island 02841

Peter L. Tyack
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

(Received 2 December 2008; revised 3 February 2009; accepted 5 February 2009)

Methods are developed for estimating the size/density of cetacean populations using data from a set of fixed passive acoustic sensors. The methods convert the number of detected acoustic cues into animal density by accounting for (i) the probability of detecting cues, (ii) the rate at which animals produce cues, and (iii) the proportion of false positive detections. Additional information is often required for estimation of these quantities, for example, from an acoustic tag applied to a sample of animals. Methods are illustrated with a case study: estimation of Blainville's beaked whale density over a 6 day period in spring 2005, using an 82 hydrophone wide-baseline array located in the Tongue of the Ocean, Bahamas. To estimate the required quantities, additional data are used from digital acoustic tags, attached to five whales over 21 deep dives, where cues recorded on some of the dives are associated with those received on the fixed hydrophones. Estimated density was 25.3 or 22.5 animals/1000 km^2, depending on assumptions about false positive detections, with 95% confidence intervals 17.3–36.9 and 15.4–32.9. These methods are potentially applicable to a wide variety of marine and terrestrial species that are hard to survey using conventional visual methods. [DOI: 10.1121/1.3089590]

PACS number(s): 43.30.Sf, 43.80.Ka [WWA] Pages: 1982–1994



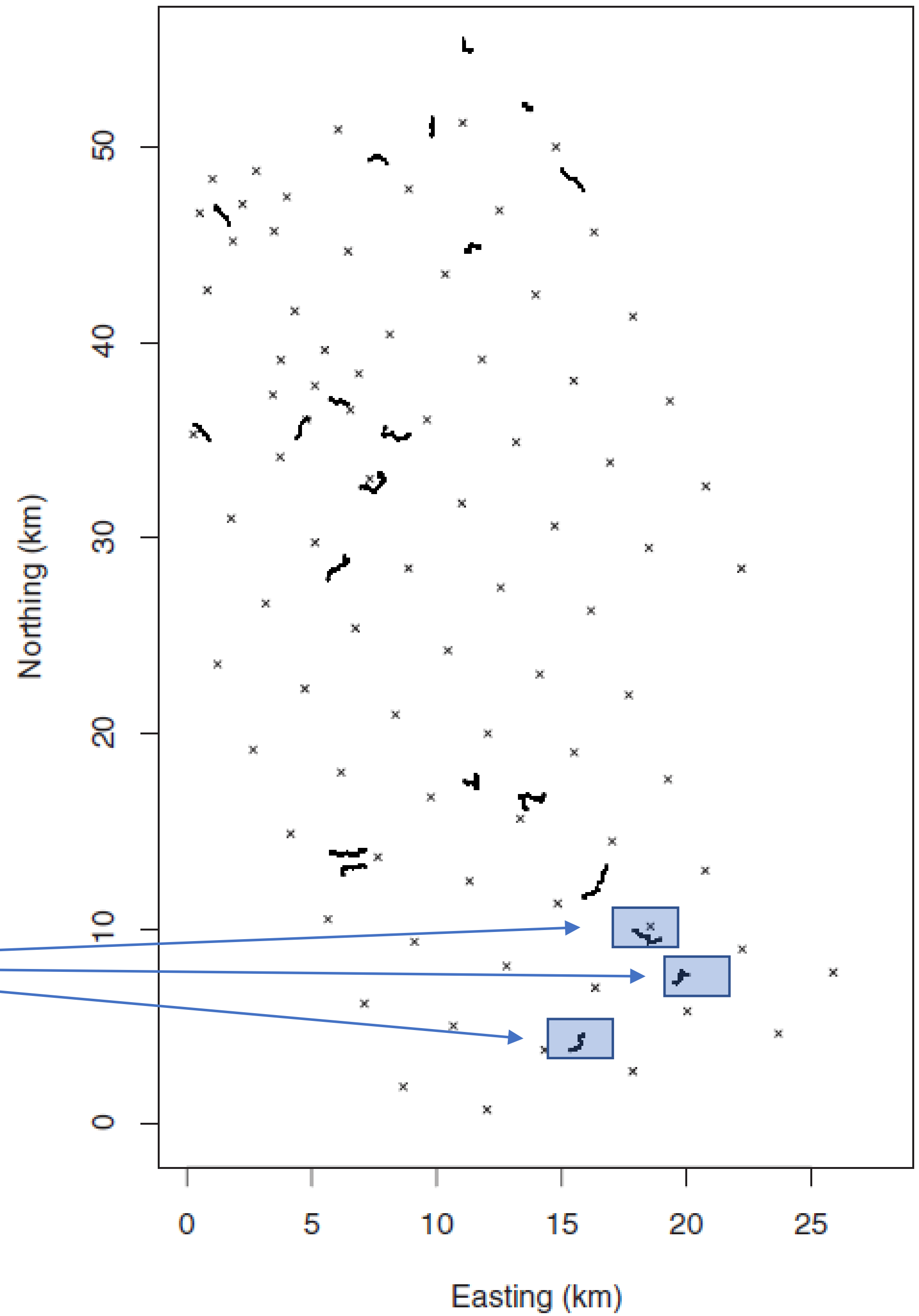
Northing (km)
Easting (km)
26 April 2005
27 April 2005
28 April 2005
29 April 2005
30 April 2005
1 May 2005
2 May 2005
Click count (summed over 82 hydrophones)
Set1
Set3
Set4
Set6
Set8
Set9
Set10
Set12
Minutes after recording started

song unit, echolocation click, etc. Considering Eq. (2), an estimate of density $\hat{D}$ from the n_c detected cues over a time period T (and additional information detailed below) can be obtained by

$$\hat{D} = \frac{n_c(1-\hat{c})}{K\pi w^2 \hat{P} T \boxed{\hat{r}}}, \tag{3}$$

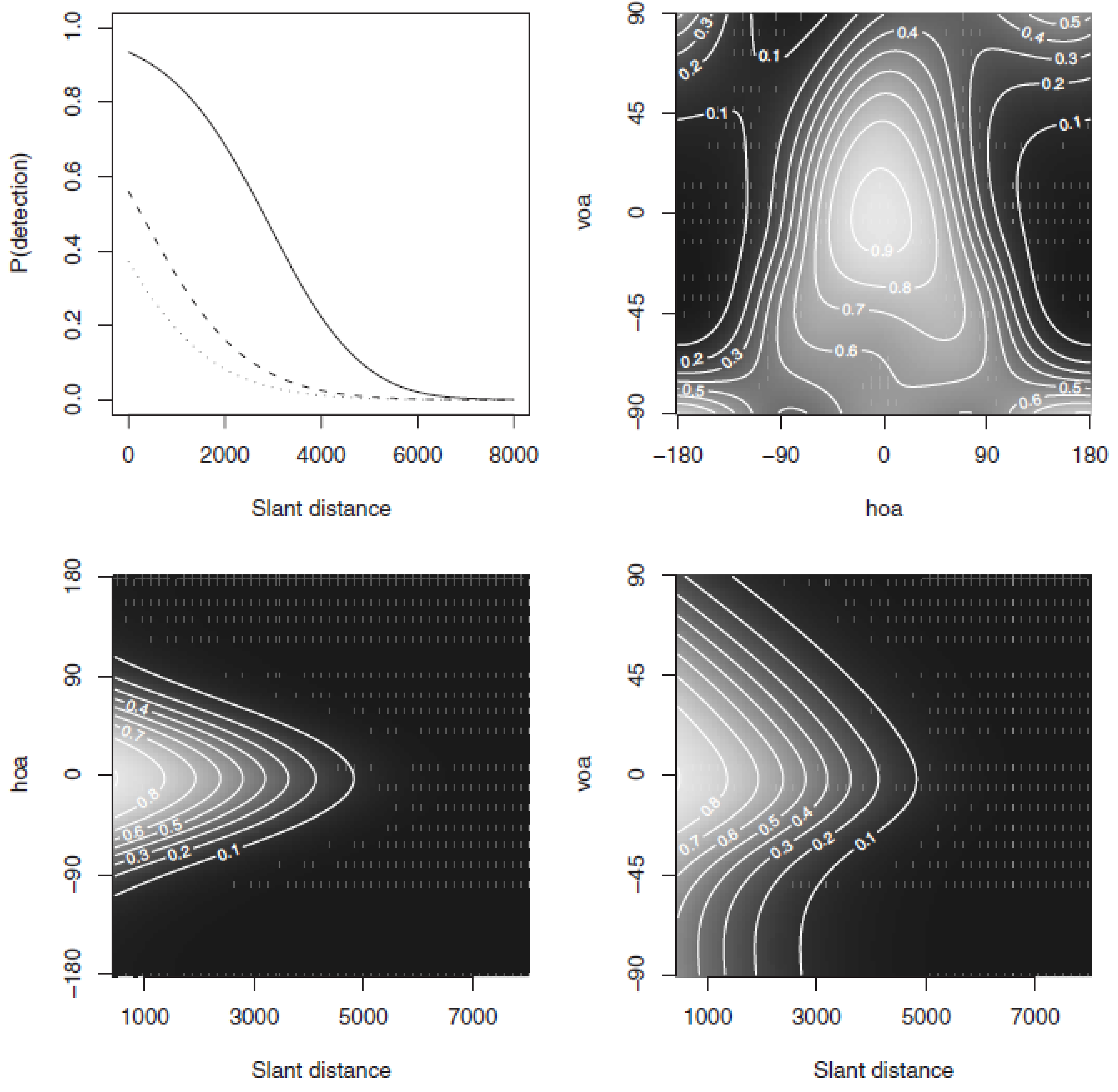
where w is the distance away from the hydrophones beyond which cues are assumed to not be detected, $\hat{P}$ is the estimated average probability of detecting a cue made within distance w, $\hat{r}$ is the estimated cue production rate, $\hat{c}$ is the estimated proportion of false positive detections, and K is the number of replicate sensors used.

Tag	Date	Number of Dives	Dives for $g(y)$
Md296	23 Oct 2006	3	3
Md227	15 Aug 2007	6	0
Md245	2 Sep 2007	4	3
Md248a	5 Sep 2007	4	4
Md248b	5 Sep 2007	4	3
Total		21	13



Each click produced by a tagged whale was detected, or not, in the surrounding hydrophones

We don’t know the distances to detected clicks, but we can model the detection probability and get a detection probability!

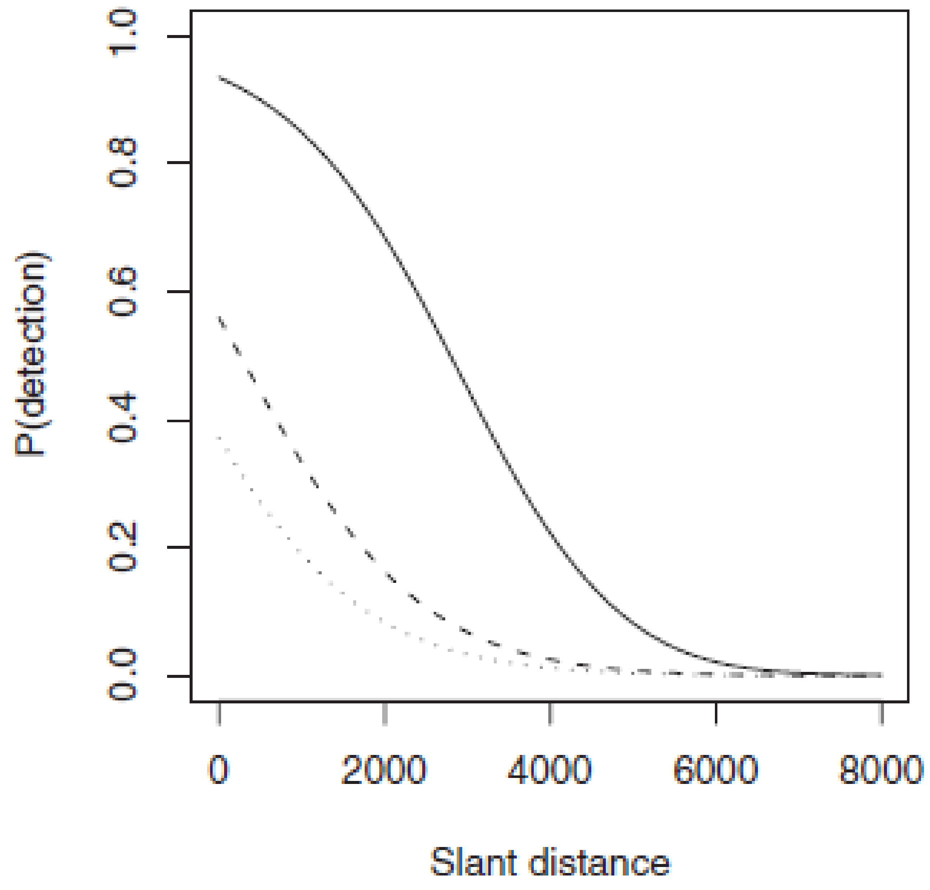


Exactly the same detection function concept, just estimated with a different type of data (detected vs. non detected, i.e. a logistic regression)

Why not straightforward distance sampling?

Because distances could not be directly obtained from the detected sounds.

Well… not often… but sometimes they can!



From echolocation clicks to animal density—Acoustic sampling of harbor porpoises with static dataloggers

Line A. Kyhn[a)]
Department of Bioscience, Aarhus University, Frederiksborgvej 399, DK-4000 Roskilde, Denmark

Jakob Tougaard
Department of Bioscience, Aarhus University, DK-4000 Roskilde, Denmark

Len Thomas
Centre for Research into Ecological and Environmental Modeling, University of St. Andrews, St Andrews, KY16 9LZ, Scotland

Linda Rosager Duve
Department of Animal Science, Aarhus University, DK-8830 Tjele, Denmark

Joanna Stenback
Nyckelvägen 18, 554 72 Jönköping, Sweden

Mats Amundin
Kolmården Djurpark, SE-618 92, Kolmården, Sweden

Geneviève Desportes
GDnatur, DK-5300 Kerteminde, Denmark

Jonas Teilmann
Department of Bioscience, Aarhus University, DK-4000 Roskilde, Denmark

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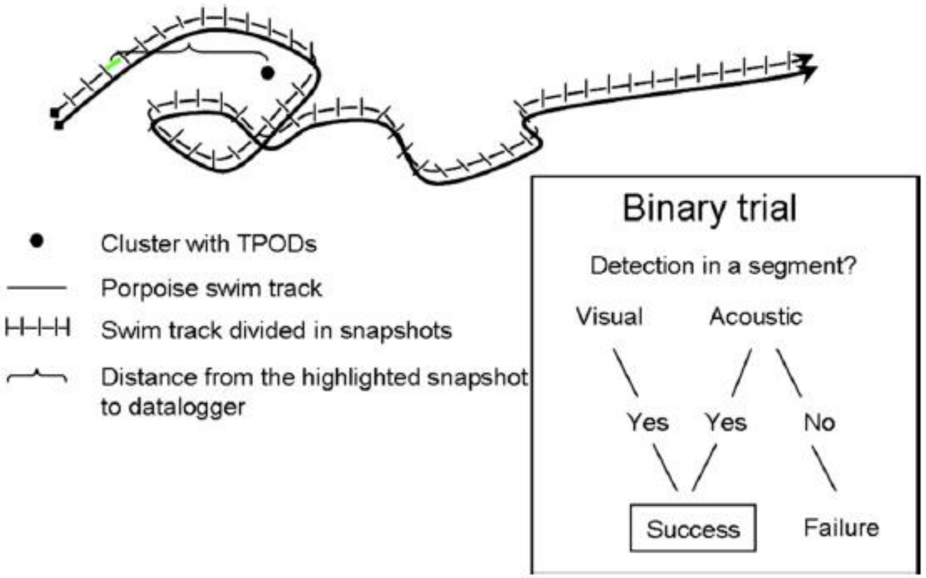

Biological Conservation 226 (2018) 42–53

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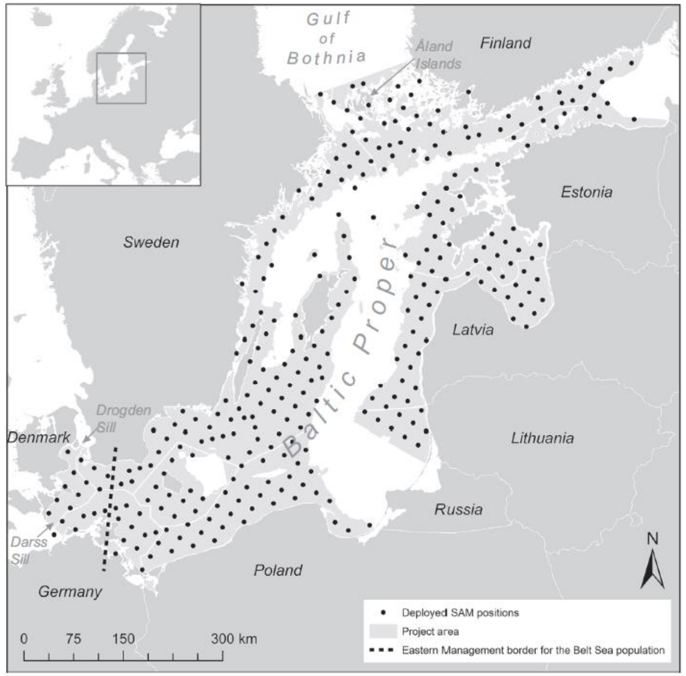
journal homepage: www.elsevier.com/locate/biocon

Basin-scale distribution of harbour porpoises in the Baltic Sea provides basis for effective conservation actions

Ida Carlén[a,b,*], Len Thomas[c], Julia Carlström[a,1], Mats Amundin[d,2], Jonas Teilmann[e], Nick Tregenza[f], Jakob Tougaard[e], Jens C. Koblitz[g,3,4], Signe Sveegaard[e], Daniel Wennerberg[d], Olli Loisa[h], Michael Dähne[g], Katharina Brundiers[g], Monika Kosecka[i,5], Line Anker Kyhn[e], Cinthia Tiberi Ljungqvist[d,6], Iwona Pawliczka[i], Radomil Koza[i], Bartlomiej Arciszewski[i], Anders Galatius[e], Martin Jabbusch[g], Jussi Laaksonlaita[h], Jussi Niemi[h], Sami Lyytinen[h], Anja Gallus[g], Harald Benke[g], Penina Blankett[j], Krzysztof E. Skóra[i], Alejandro Acevedo-Gutiérrez[k]



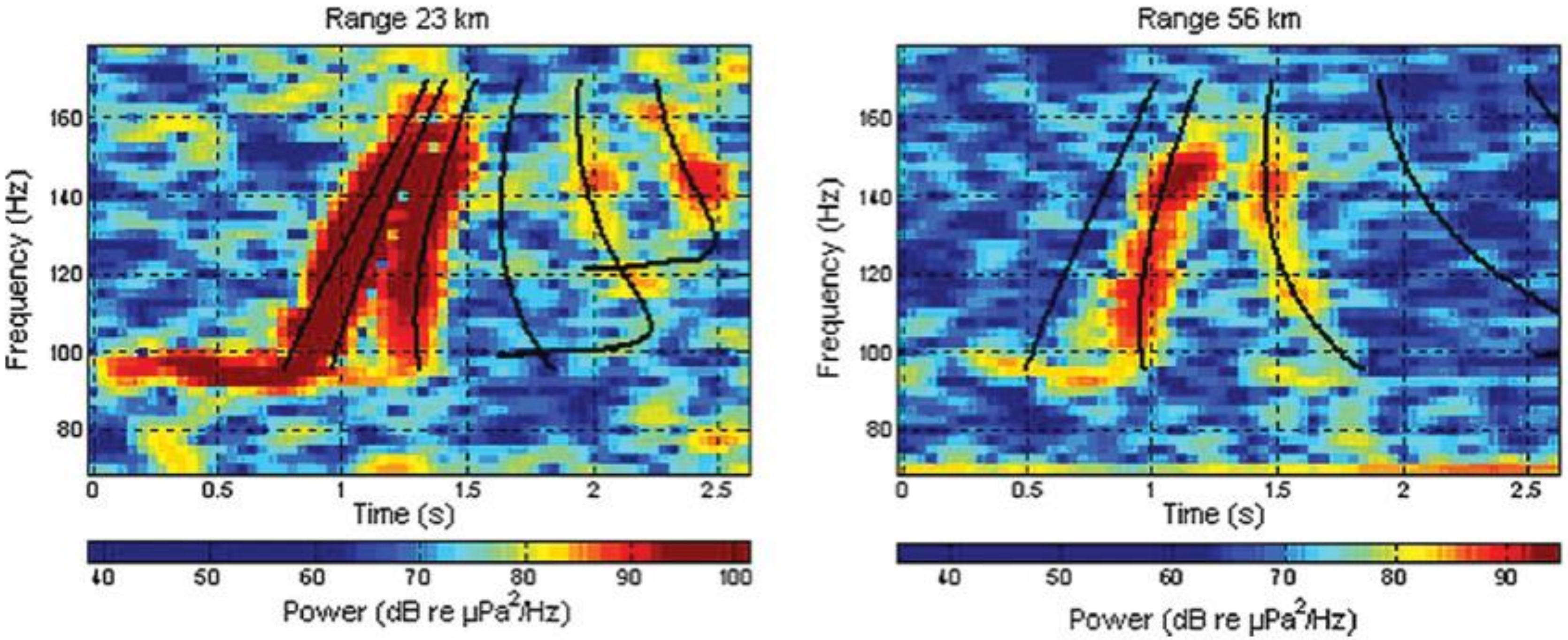


FIG. 3. (Color online) Spectrograms of a single right whale call received on two easternmost ARPs (site C and D), with overlaid normal mode arrivals of synthetic call based on range estimates, given above each call. Figure adapted with permission from Wiggins *et al*. (2004) in Canadian Acoustics.

Vol. 13: 163–172, 2011
doi: 10.3354/esr00325

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published online March 9

OPEN ACCESS

Estimating North Pacific right whale *Eubalaena japonica* density using passive acoustic cue counting

Tiago A. Marques[1,2,*], Lisa Munger[3], Len Thomas[1], Sean Wiggins[3], John A. Hildebrand[3]

[1]Centre for Research into Ecological and Environmental Modelling, The Observatory, Buchanan Gardens, University of St Andrews, St Andrews KY16 9LZ, UK

[2]Centro de Estatística e Aplicações da Universidade de Lisboa, Bloco C6, Piso 4, Campo Grande, 1749-016 Lisboa, Portugal

[3]Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Drive, La Jolla, California 92093-0205, USA

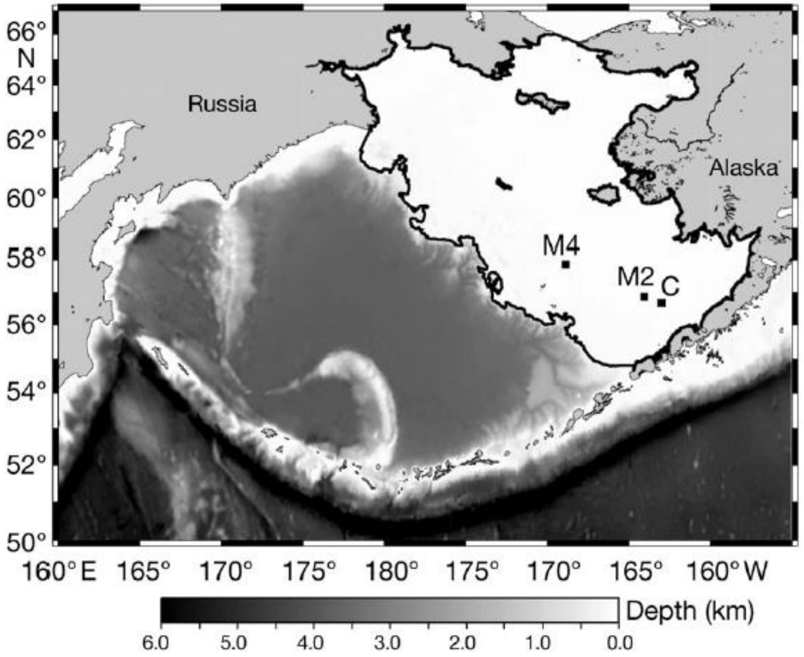


Fig. 1. Bering Sea, with location of sensors (C, M2, and M4) shown. Land masses are light gray. The eastern Bering Sea shelf is outlined with a thick black line including the 200 m depth contour along its western edge. Bathymetry data were taken from Amante & Eakins (2009)

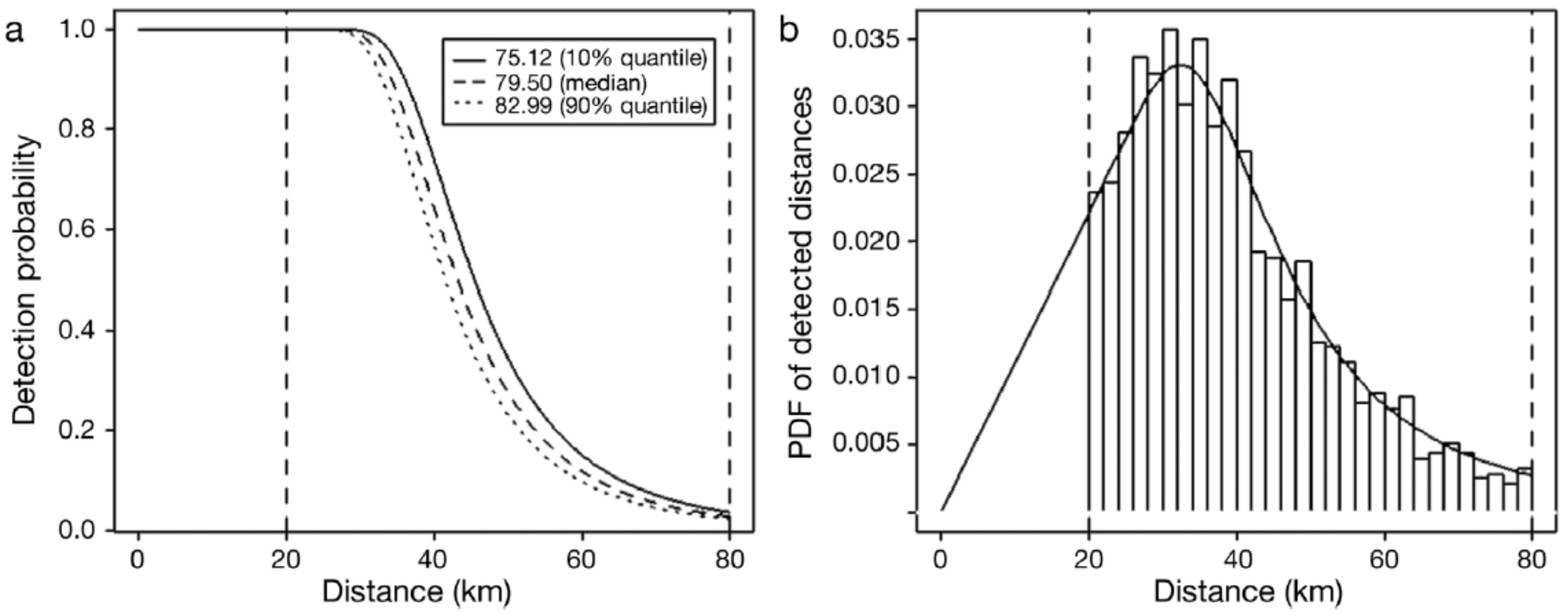


Fig. 2. Distances to detected right whale calls and fitted model: (a) shows the detection function (as a function of distance, for 3 values of the noise covariate, namely the 10, 50, and 90% quantile of the observed distribution) and (b) corresponds to the probability density function (PDF) of detection distances, and goodness-of-fit could be judged based on this plot. Vertical dashed lines represent the left and right truncation distances

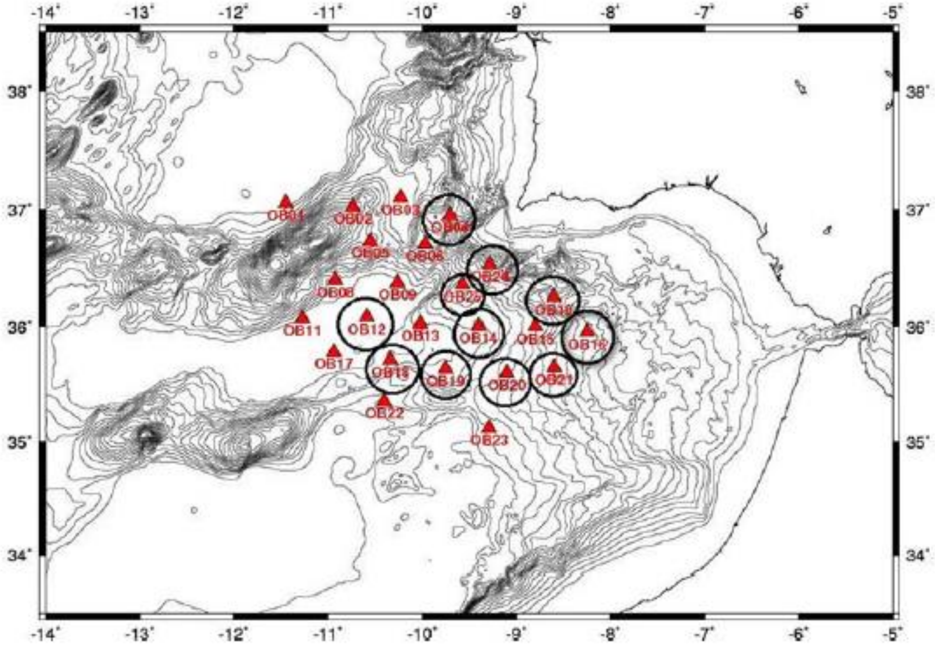
Big No No's!

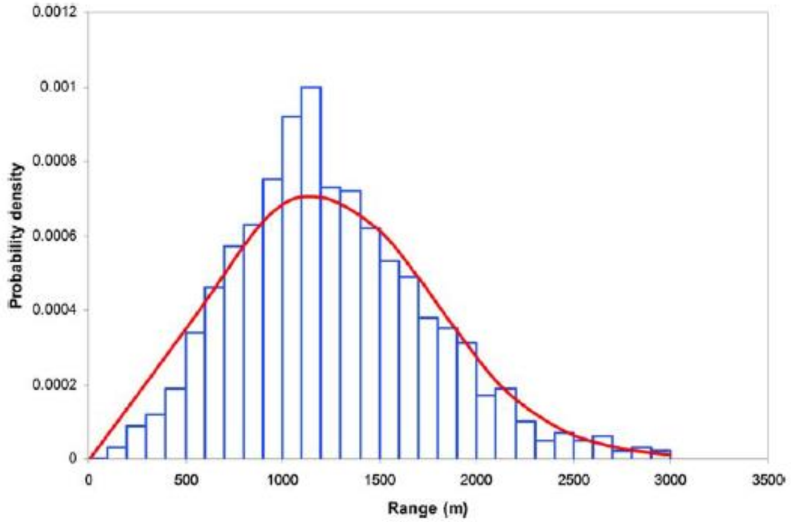
3 sensors…

Cue rate from another time and another place

Implications for right whale management

This study presents the first abundance estimate for North Pacific right whales based on acoustic data, and is strikingly similar to the numbers recently estimated by other authors (Wade et al. 2011) using mark-recapture techniques for photographic and genetic data.





Applying distance sampling to fin whale calls recorded by single seismic instruments in the northeast Atlantic

Danielle Harris[a)]
Centre for Research into Ecological and Environmental Modelling, The Observatory, Buchanan Gardens, University of St. Andrews, St. Andrews, Fife, KY16 9LZ, United Kingdom

Luis Matias
Instituto Dom Luiz, Universidade de Lisboa, Lisbon, Portugal 1749-016

Len Thomas
Centre for Research into Ecological and Environmental Modelling, The Observatory, Buchanan Gardens, University of St. Andrews, St. Andrews, Fife, KY16 9LZ, United Kingdom

John Harwood
Scottish Oceans Institute, Institiud Chuantan na h-Alba, East Sands, St Andrews, KY16 8LB, Scotland, United Kingdom

Wolfram H. Geissler
Alfred-Wegener-Institut für Polar- und Meeresforschung, Am Alten Hafen 26, D-27568 Bremerhaven, Germany

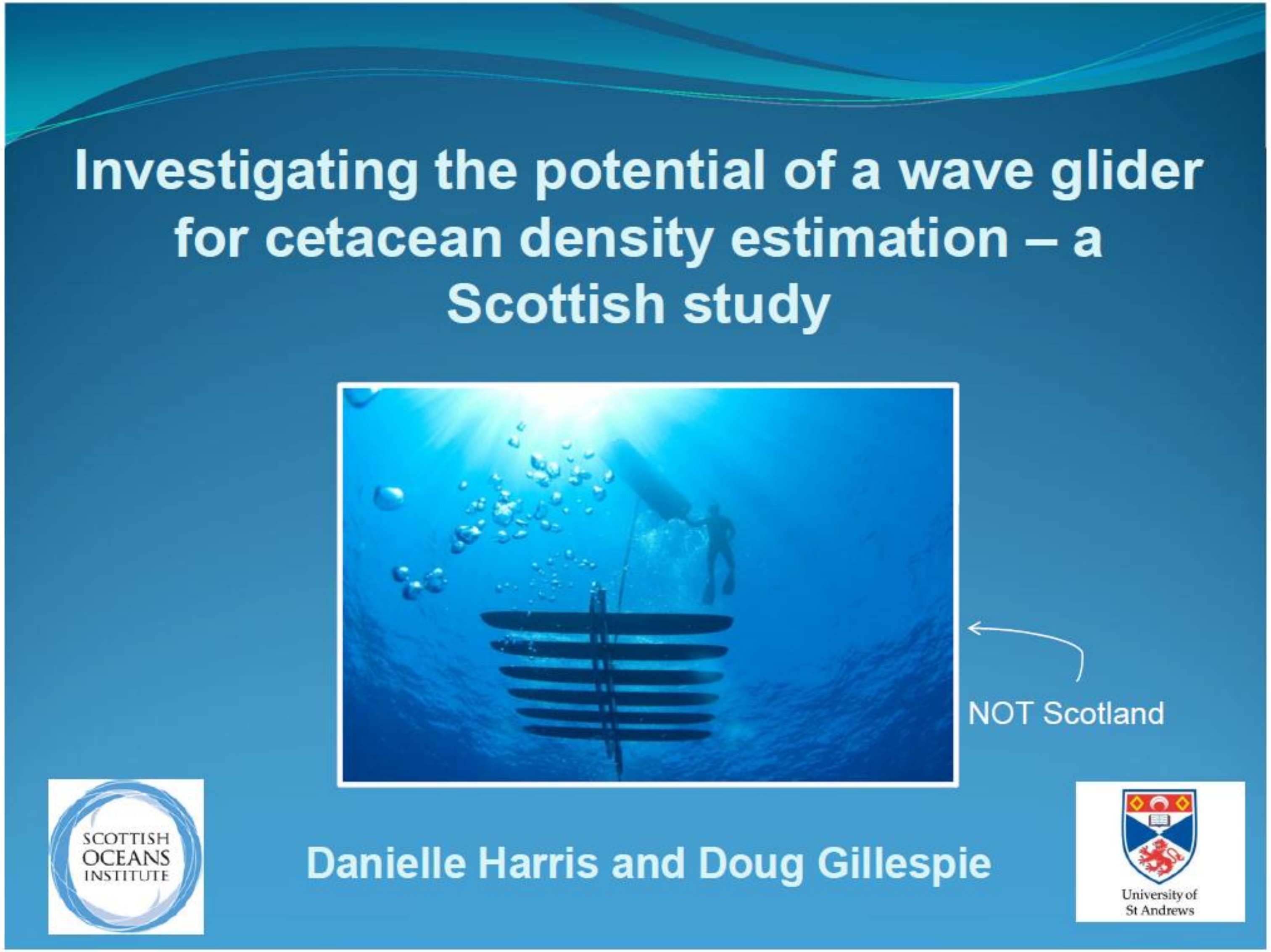
(Received 30 June 2012; revised 25 July 2013; accepted 12 August 2013)

Automated methods were developed to detect fin whale calls recorded by an array of ocean bottom seismometers (OBSs) deployed off the Portuguese coast between 2007 and 2008. Using recordings collected on a single day in January 2008, a standard seismological method for estimating earthquake location from single instruments, the three-component analysis, was used to estimate the relative azimuth, incidence angle, and horizontal range between each OBS and detected calls. A validation study using airgun shots, performed prior to the call analysis, indicated that the accuracy of the three-component analysis was satisfactory for this preliminary study. Point transect sampling using cue counts, a form of distance sampling, was then used to estimate the average probability of detecting a call via the array during the chosen day. This is a key step to estimating density or abundance of animals using passive acoustic data. The average probability of detection was estimated to be 0.313 (standard error: 0.033). However, fin whale density could not be estimated due to a lack of an appropriate estimate of cue (i.e., vocalization) rate. This study demonstrates the potential for using a sparse array of widely spaced, independently operating acoustic sensors, such as OBSs, for estimating cetacean density. *© 2013 Acoustical Society of America.*

[http://dx.doi.org/10.1121/1.4821207]

PACS number(s): 43.30.Sf, 43.80.Ka [JJF] Pages: 3522–3535

Gliders and drifters – not as fast as a line transect, not as slow as a point transect



ongoing work related to methods development

Monday
December 09, 2019

3:00 PM - 3:15 PM

3:00 PM

3:15 PM

Abundance estimation for Mesoplodon beaked whale species using drifting acoustic recorders. (147)

Part of session: *Hearing and Passive Acoustic Monitoring*

Room 112

Talks

Authors

Jay Barlow
Researcher
NOAA/SW Fisheries Science Center

Jeff Moore
Research - government
NOAA - SW Fisheries Science Ctr

Jennifer Keating McCullough
Sr. Passive Acoustics Associate
JIMAR/PIFSC/NOAA

Emily T. Griffiths
Ocean Associates Inc.

Take Home Messages

Passive acoustics can have significant advantages over visual based methods, especially for deep divers

Passive acoustic monitoring of marine mammals is now routinely applied, but density estimates still not routinely implemented

Distance sampling is a go-to method if distances to sounds can be obtained (or detection function estimated any other way – experiments and sound propagation models)

Both towed systems and bottom mounted systems being routinely used, but drifting buoys and gliders likely to catch up soon

Key issue (for cue based methods) is lack of knowledge about cue rate production – if you are interested on this come talk to me about ACCURATE