Using bioacoustics for field survey

Carlos Abrahams

c.abrahams@bakerconsultants.co.uk
@abr_eco

bakerconsultants
ECOLOGYDESIGNINNOVATION

NOTTINGHAM TRENT UNIVERSITY

Bioacoustics

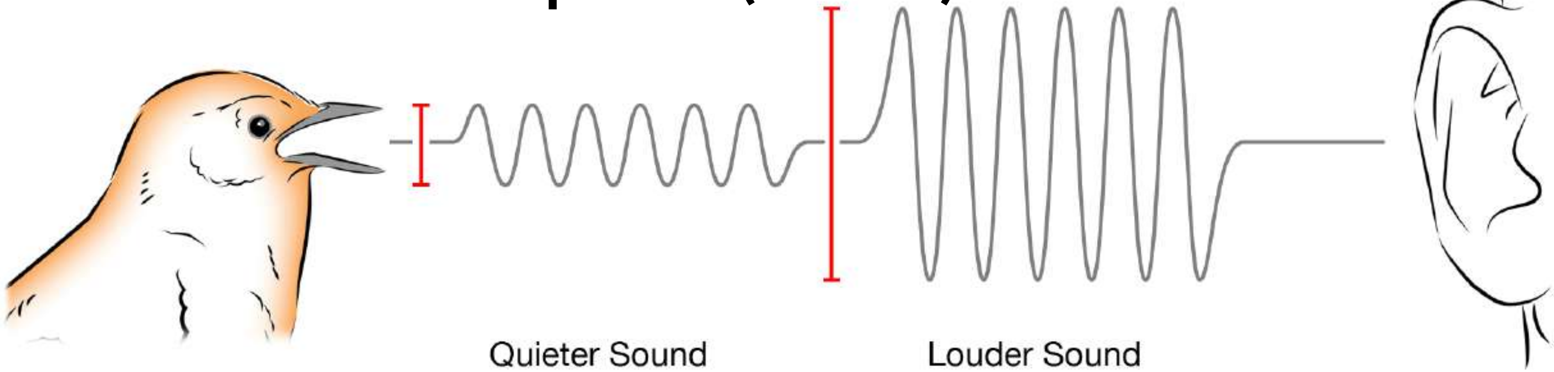
1. What is it?
2. Why use it?
3. Bat, whale & bird surveys
4. Case studies

BIOACOUSTICS
An old/new tool for ecologists?

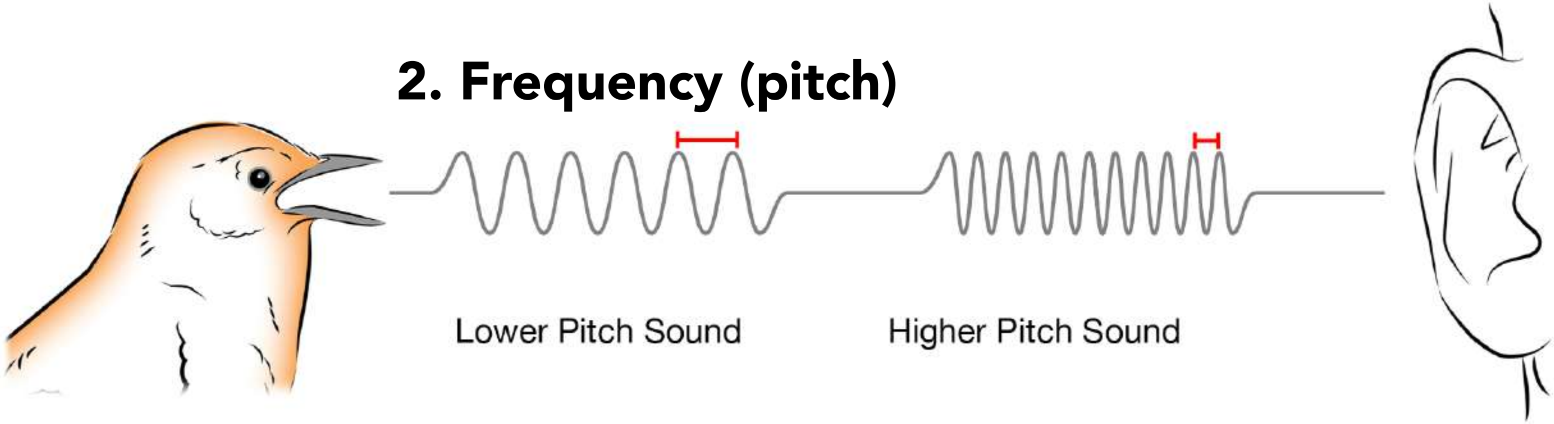
@abr_eco

Sound =

1. Amplitude (volume)

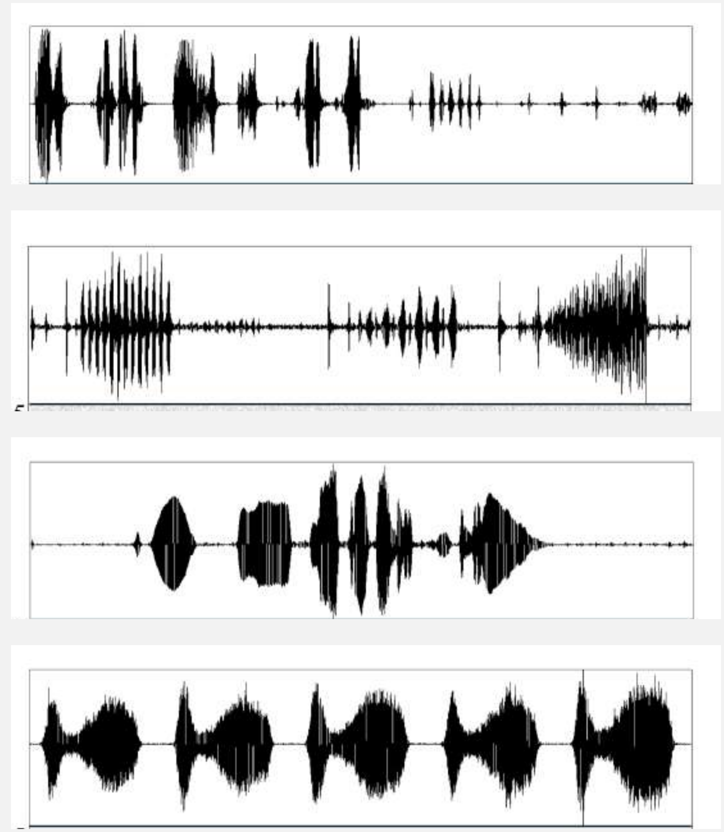


2. Frequency (pitch)



Amplitude:

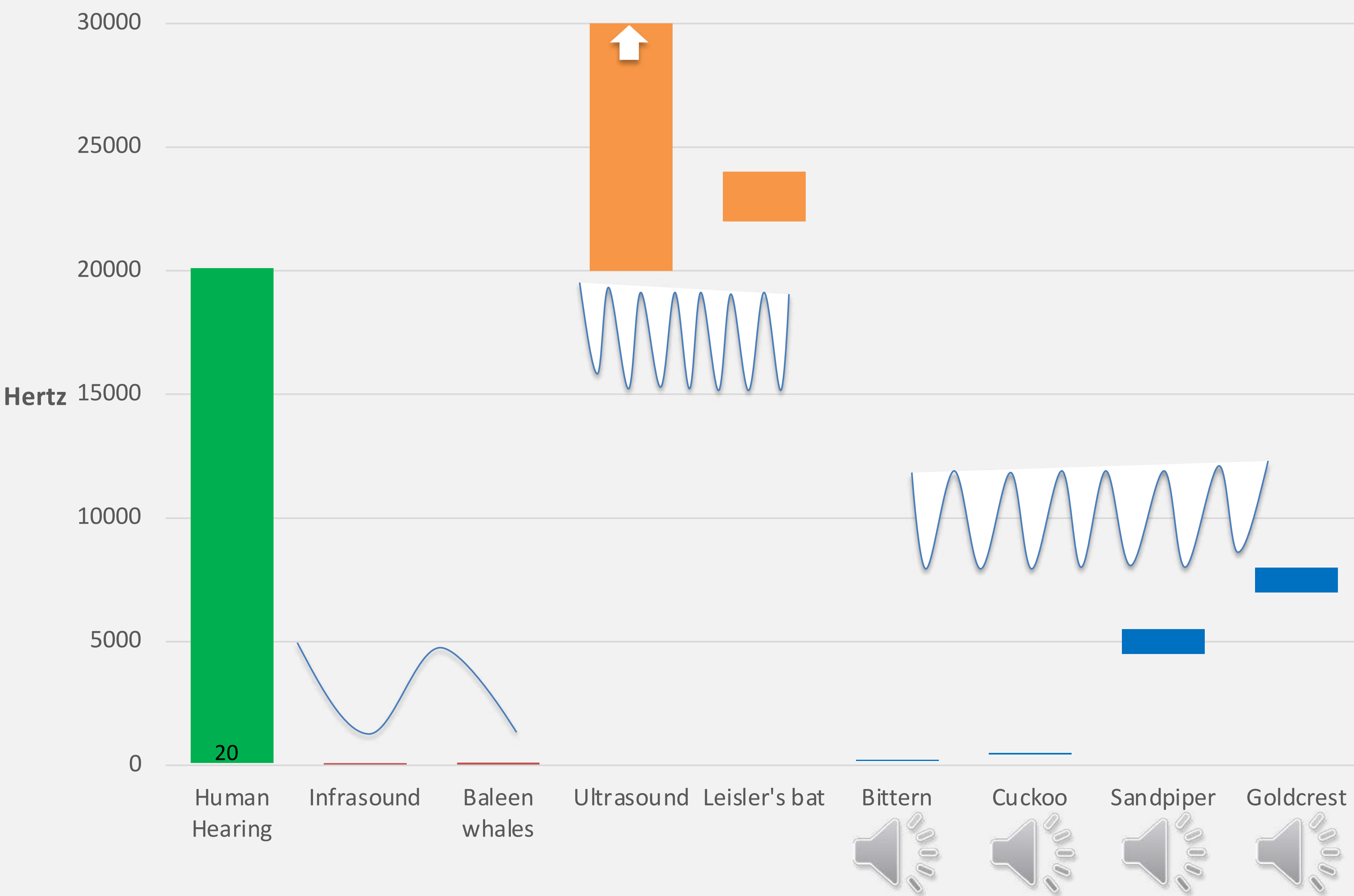
Faintest audible	**0.1 dB**
Whisper	**20 dB**
Conversation	**60 dB**
Nightingale song	**85 dB**
Power saw	**110 dB**
White bellbird	**125 dB**
Jet engine/howler monkey	**140 dB**
Blue whale	**188 dB**



North Island kaka
Marsh wren
Western meadowlark
Kakapo

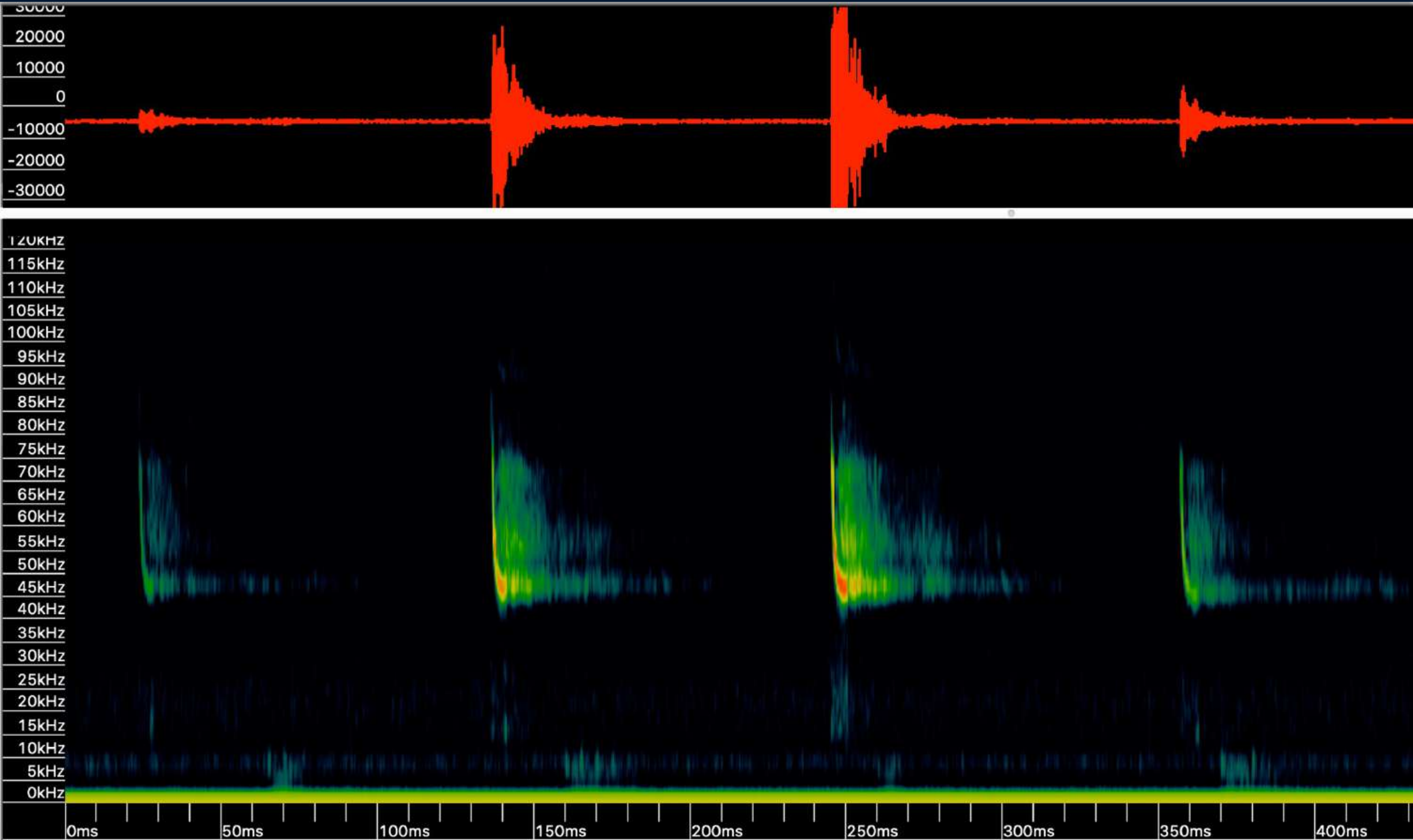
Priyadarshani N, Marsland S, Castro I, Punchihewa A (2016) Birdsong Denoising Using Wavelets. PLoS ONE 11(1): e0146790.
https://doi.org/10.1371/journal.pone.0146790

Frequency:

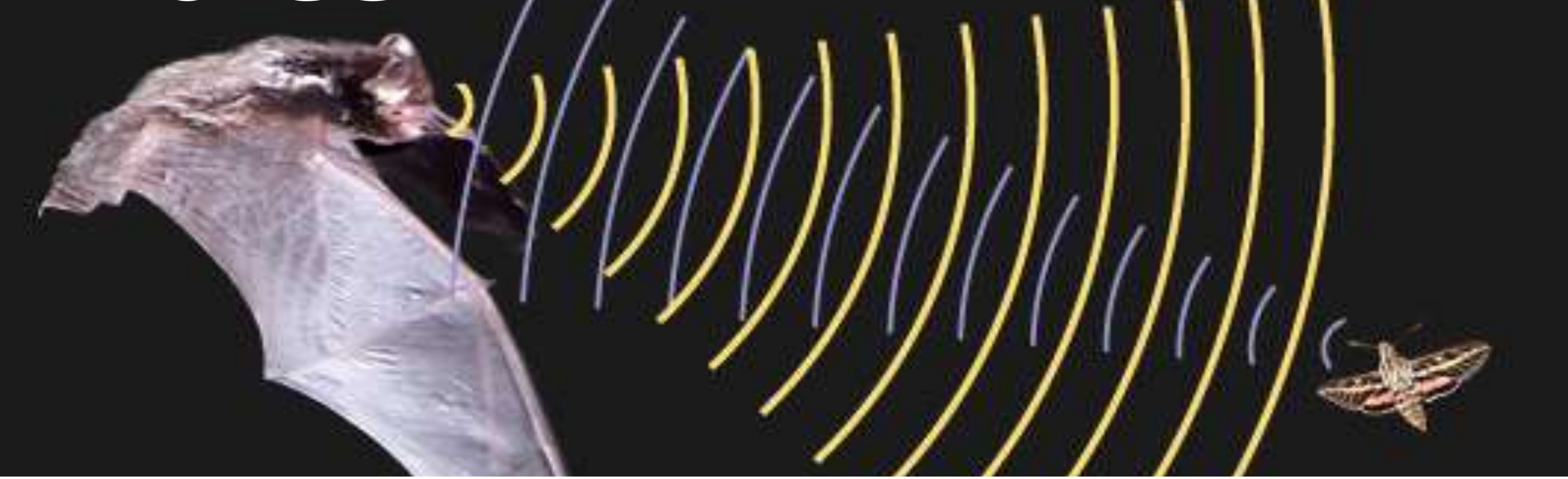


@abr_eco

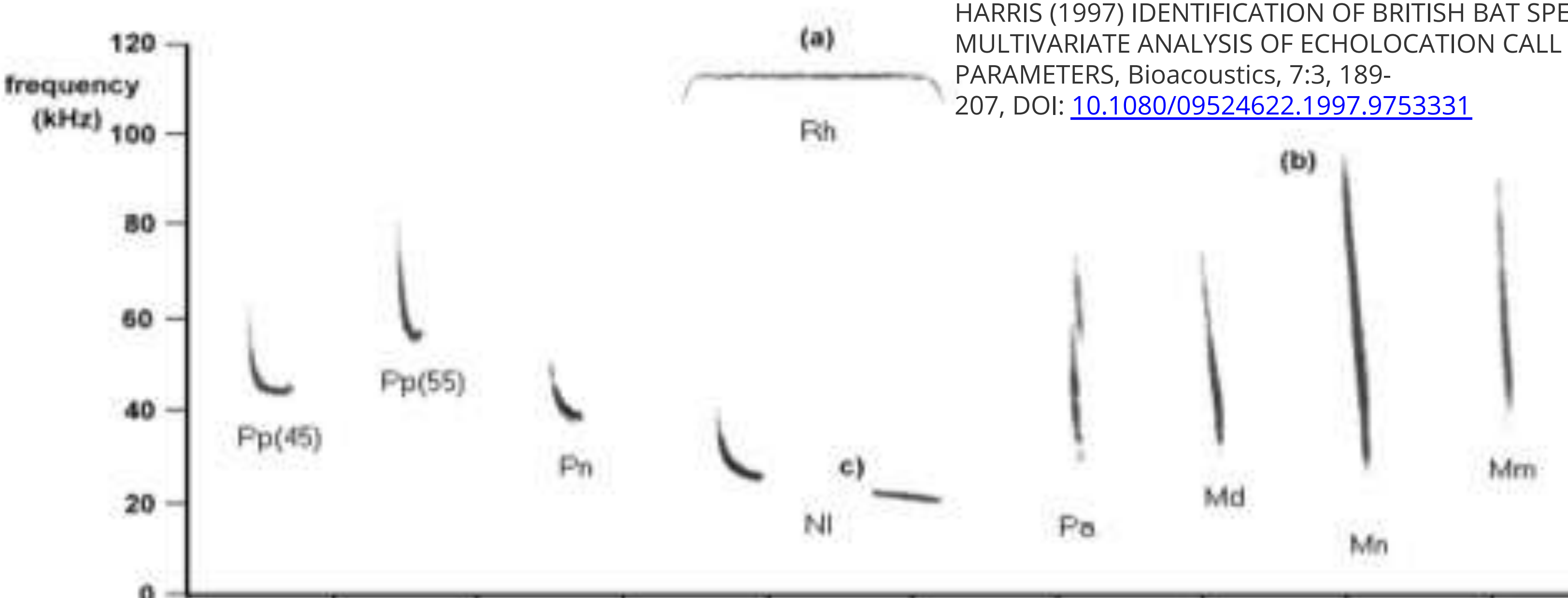
Spectrogram

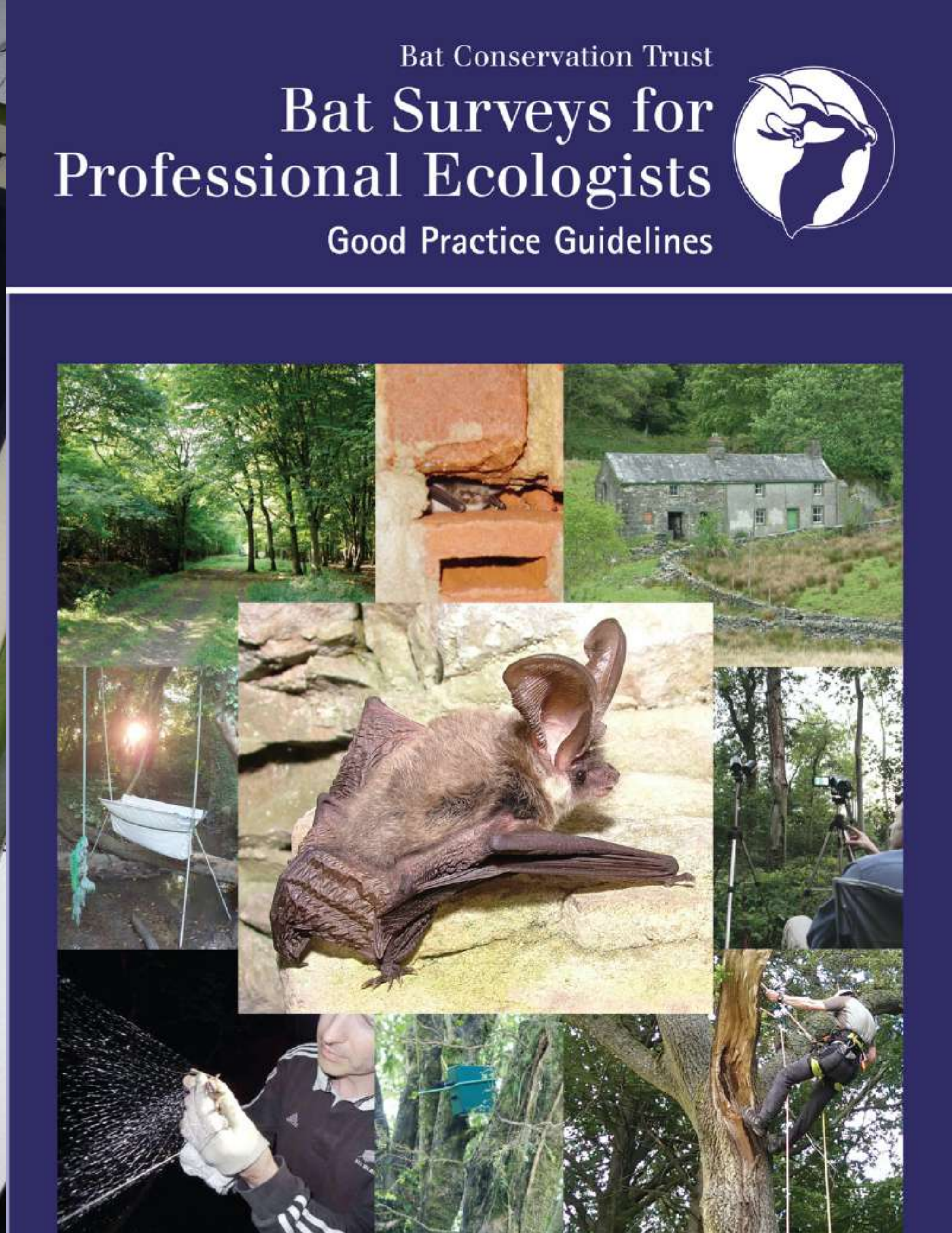


Bats



NANCY VAUGHAN, GARETH JONES & STEPHEN HARRIS (1997) IDENTIFICATION OF BRITISH BAT SPECIES BY MULTIVARIATE ANALYSIS OF ECHOLOCATION CALL PARAMETERS, Bioacoustics, 7:3, 189-207, DOI: 10.1080/09524622.1997.9753331

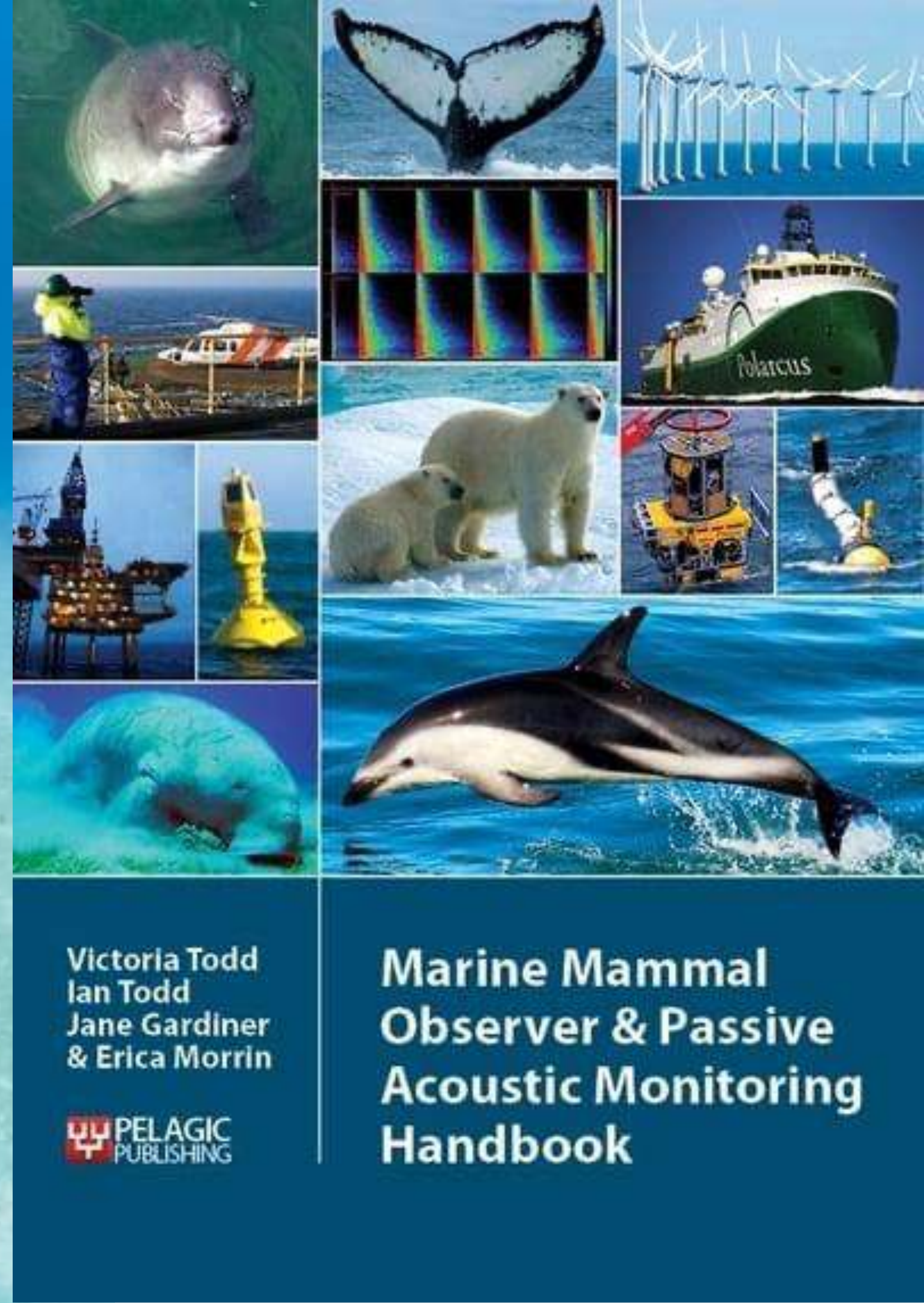




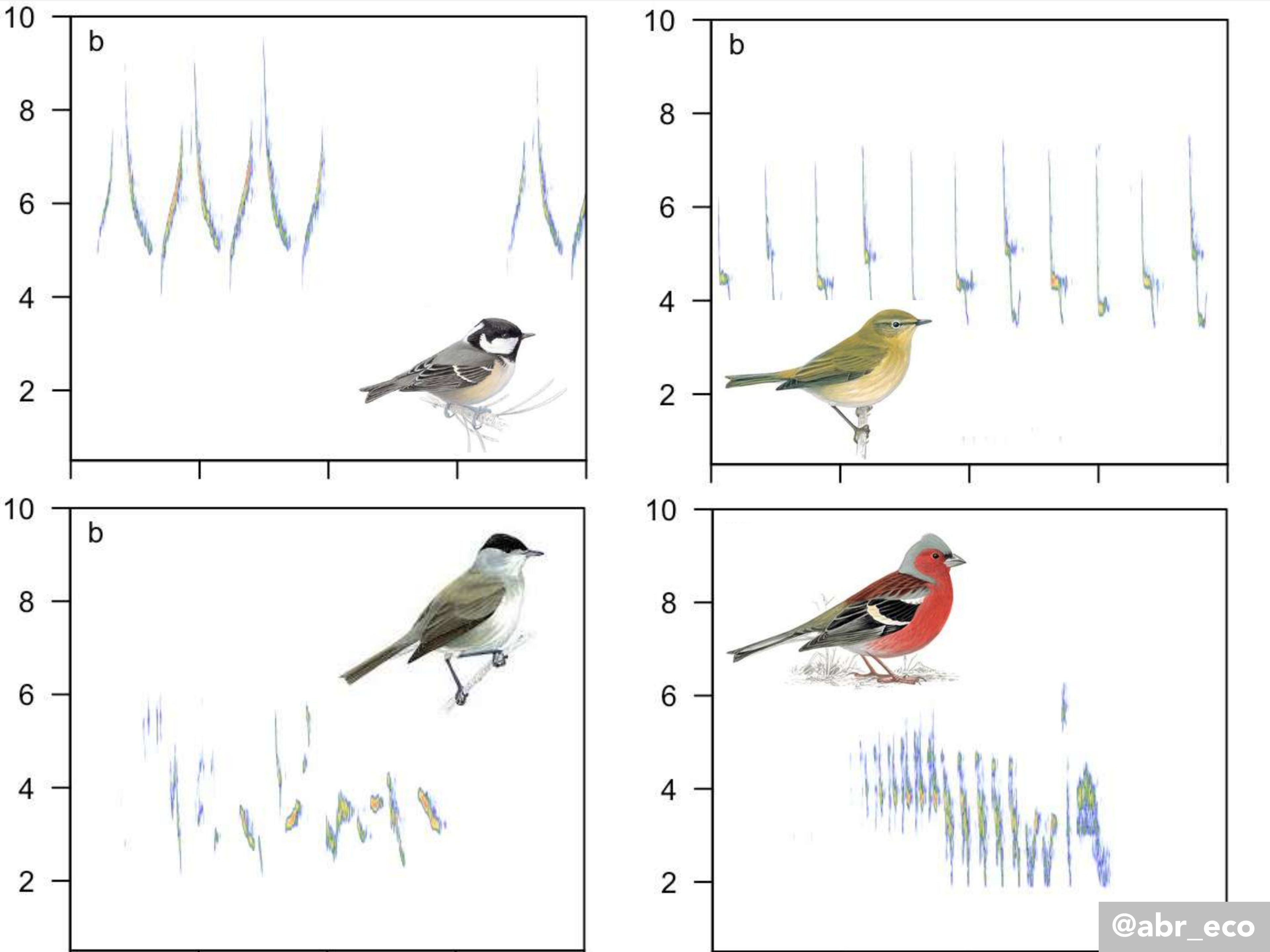
https://www.bats.org.uk/resources/guidance-for-professionals/bat-surveys-for-professional-ecologists-good-practice-guidelines-3rd-edition


Whales
@abr_eco


@abr_eco

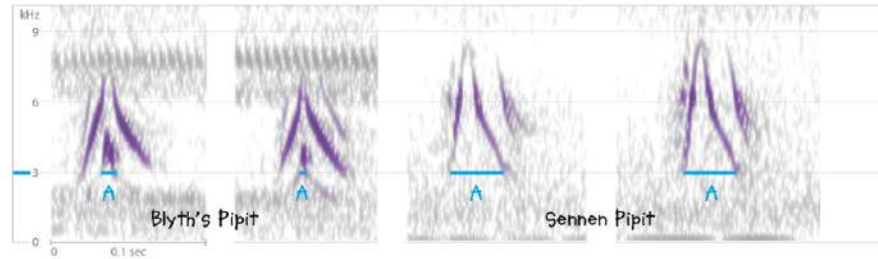

Polarcus
Victoria Todd
Ian Todd
Jane Gardiner
& Erica Morrin
PELAGIC PUBLISHING
Marine Mammal Observer & Passive Acoustic Monitoring Handbook


BIRDS?
Or amphibians,
invertebrates,
terrestrial mammals,
fish...?
@abr_eco



10
8
6
4
2
b
10
8
6
4
2
b
10
8
6
4
2
b
10
8
6
4
2
@abr_eco

Call identification of Europe's first Paddyfield Pipit



Sonagram showing measurement A, the span of the fundamental at 3 kHz. **Blyth's Pipit** *Anthus godlewskii* (left two calls)Baga fields, Goa, India, 10 November 2001 (*Killian Mullarney*) 01.011.KM.02835.01; and **Sennen pipit** *Anthus* (right two calls) Sennen, Cornwall, England, 24 October 2019 (*Mashuq Ahmad*).

Blyth's Pipit *Anthus godlewskii* Goa, India, November 1997. In Goa, Richard's Pipit *A richardi*, Blyth's Pipit and Paddyfield Pipit *A rufulus* all occur together, and it is an excellent place to

Paddyfield Pipit *Anthus rufulus* Goa, India, November 1997. Sketch with description of calls (*Killian Mullarney*)

Mystery pipit *Anthus* Sennen, Cornwall, England, 3 November 2019 (*Mashuq Ahmad*).

Bioacoustics: why use it?

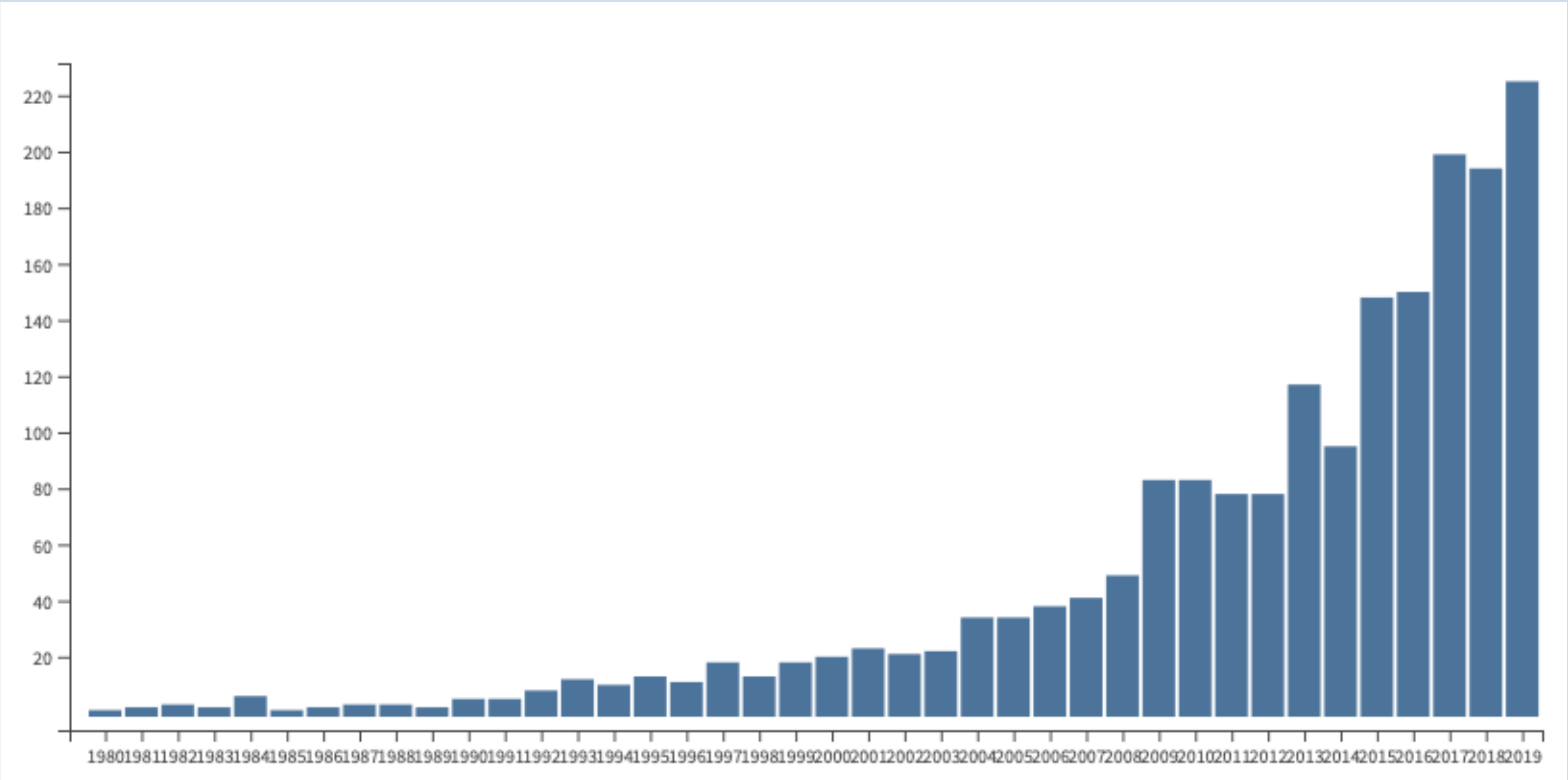
Box 1.

Advantages of bioacoustics	Grade 10=major; 1=minor
Long-duration data capture	7.3
Ability to **repeatedly listen** to and re-analyse data	7.1
Permanent raw data record	6.9
Greater **standardisation** in data collection	6.3
Quality assurance opportunities, with ID verification	6.0
Reduced **subjectivity** and observer **bias**	5.7
Less **disturbance** to surveyed birds	4.5
Opportunities to **share raw data**	4.3
Less reliance on **availability** of expert surveyors	3.5
H&S – avoids **night-time** work, reduces visits to **remote** areas	3.4

@abr_eco

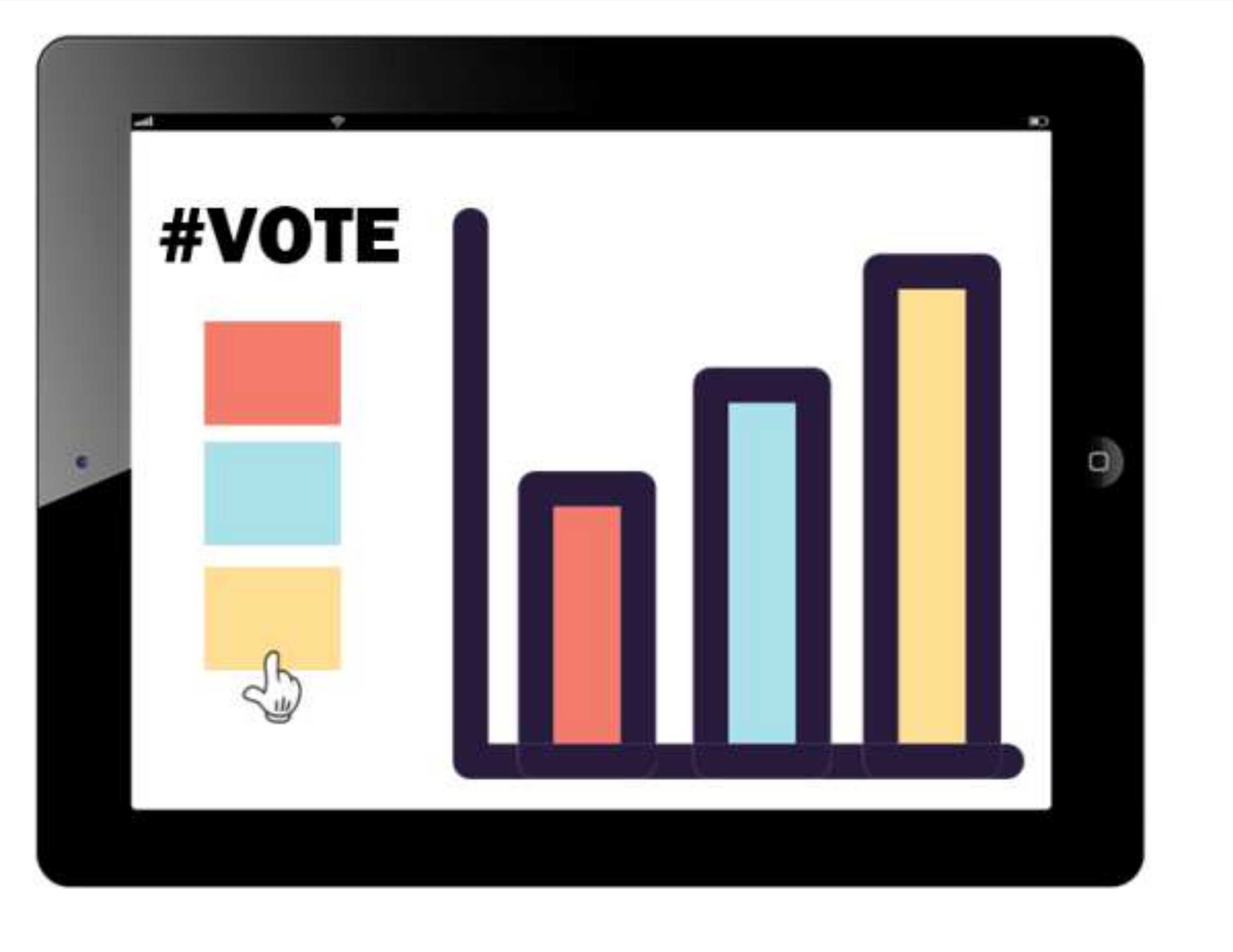
MAN vs. MACHINE

Increasing scientific interest



@abr_eco

Chat – Barriers to use?

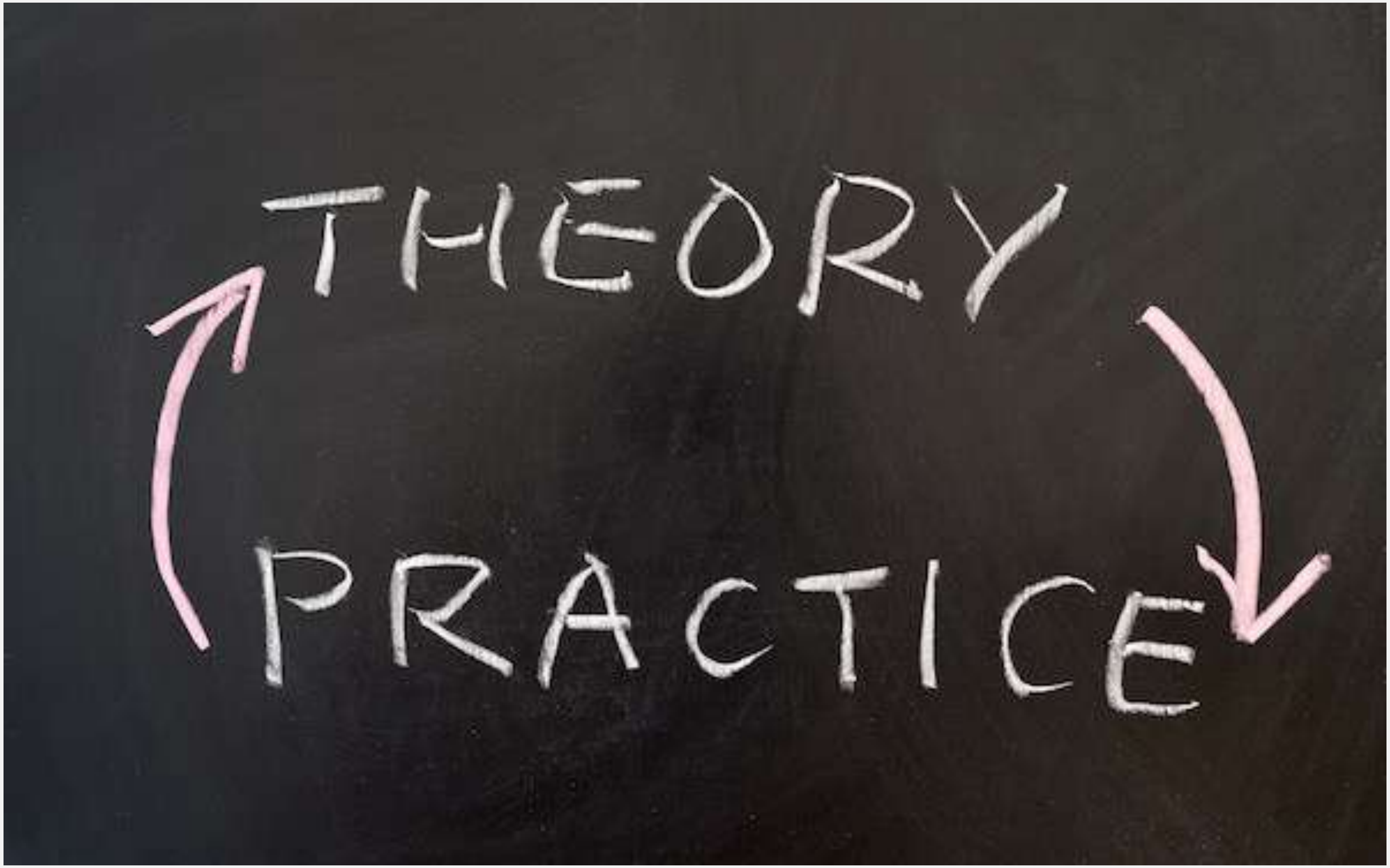


Bioacoustics: why not use it?

Disadvantages of bioacoustics	Grade 10=major; 1=minor
Capital **cost** of equipment	7.1
Need for improvements in **automated classification** systems	6.7
Lack of **expertise/skills** in bioacoustics	6.0
Reduced ability to cover a wide **spatial area** compared to transects	5.9
Data storage requirements	5.5
Potential for **loss of data** if units fail	5.1
Availability of **hardware/software**	4.8
Comparability with established methods	4.8
No **visual recording** of birds	4.8
The method is not yet widely **proven/accepted**	4.3

@abr_eco

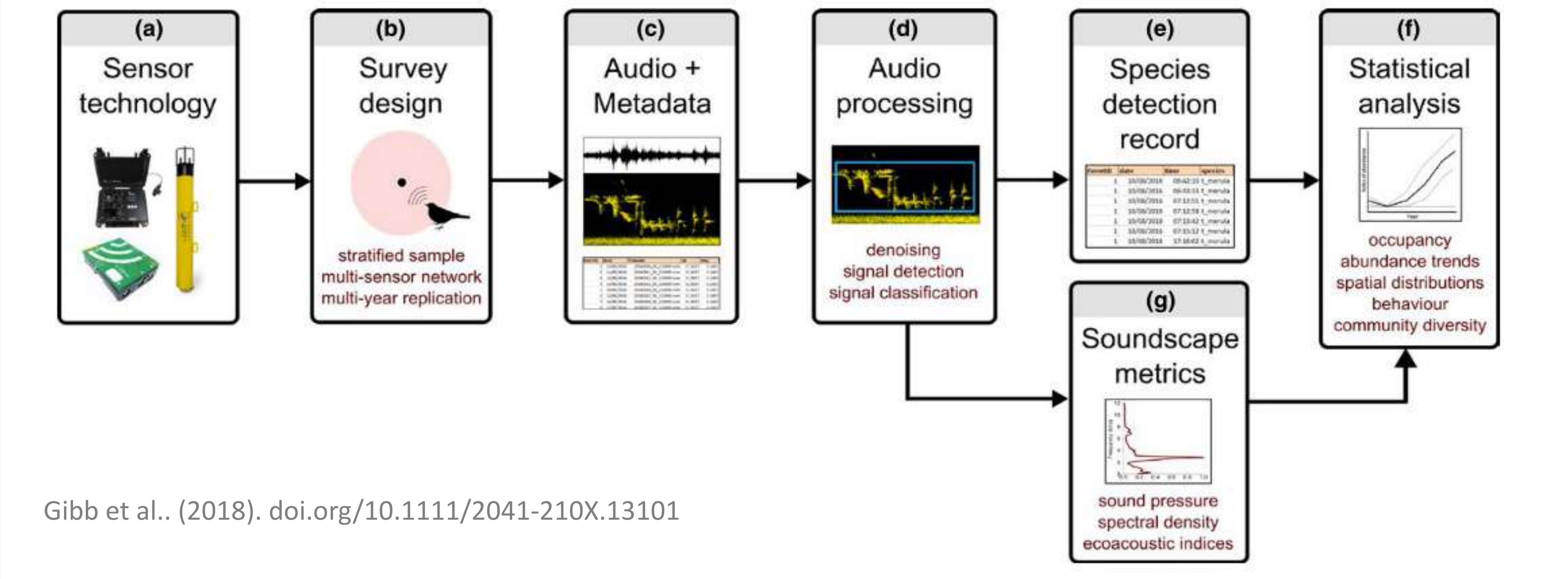
Urgent need for knowledge transfer (both ways) and practical conservation-based implementation…



See the WWF Acoustic Monitoring Guidelines here:
https://www.wwf.org.uk/sites/default/files/2019-04/Acousticmonitoring-WWF-guidelines.pdf

Key Stages in Bioacoustics Process

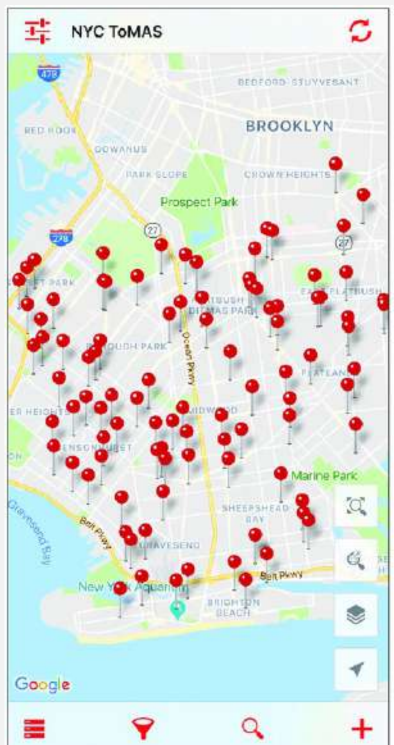
1. Sound data capture
2. Metadata capture
3. Data storage/archive
4. Data processing/analysis
5. Outputs



Gibb et al.. (2018). doi.org/10.1111/2041-210X.13101

Metadata recording

- At the start of each deployment, record the date/time, surveyor name, sampling location and recorder/microphone identifiers.
- Photographs of location and setup should be taken.
- Weather conditions during the survey period should also be recorded.



GUANO Field name
GUANO|Version
Filter HP
Filter LP
Firmware Version
Hardware Version
Humidity
Length
Loc Accuracy
Log Elevation
Loc Position
Make
Model
Note
Original Filename
Samplerate
Serial
Species Auto ID
Species Manual ID
Tags
TE
Temperature Ext
Temperature Int
Timestamp

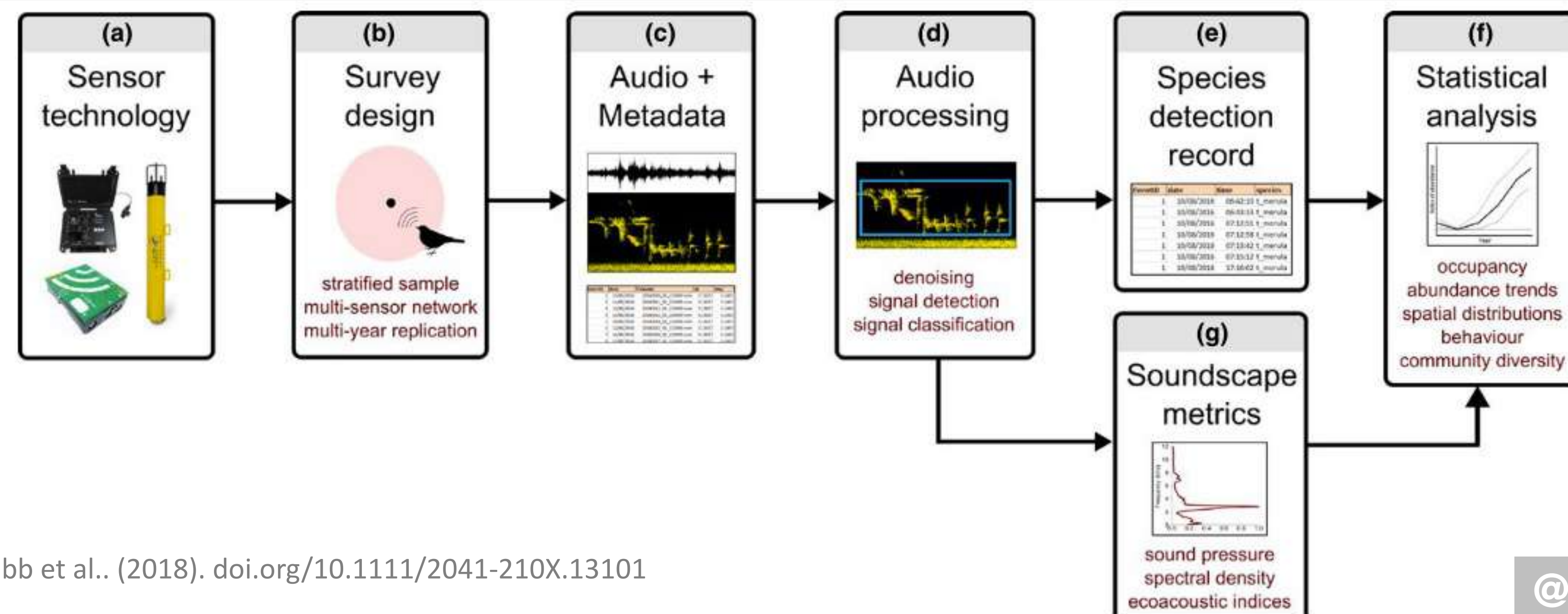
The following example is the embedd
recording made with a Pettersson D1

```
GUANO|Version:  1.0

Timestamp:  2012-03-29T03:58:(
Species Auto ID:  MYLU
Species Manual ID:  Myosod
Tags:  hand-release, voucher,
Note:  Hand release of male In
TE:  1
Samplerate:  500000
Length:  6.5
Filter HP:  20.0
Make:  Pettersson
Model:  D1000X
Loc Position:  37.1878016 -86.
Loc Accuracy:  20
Loc Elevation:  228.6

SB|Version:  3.4
SB|Classifier:  US Northeast
SB|DiscrProb:  0.913
SB|Filter:  20kHz Anti-Katydic

PET|Gain:  80
PET|Firmware:  1.0.4 (2009-11-
```

Data analysis methods

- Identify the presence/absence of each species in one minute audio samples and calculate the proportion of samples in which each species is recorded.
- Provide a summary of species observations per day or sampling event.
- If using any automated recogniser or clustering process, then the error rates should be checked and reported, so that the quality of the recogniser can be properly assessed.

SPECIES	Number of wav files
BLUE TIT	20369
BLACKBIRD	17493
ROBIN	4584
GREAT TIT	3561
WREN	3536
Mixed species chorus	1713
CARRION CROW	1358
TREECREEPER	1341
CHIFFCHAFF	1240
GREAT TIT, BLACKBIRD	766

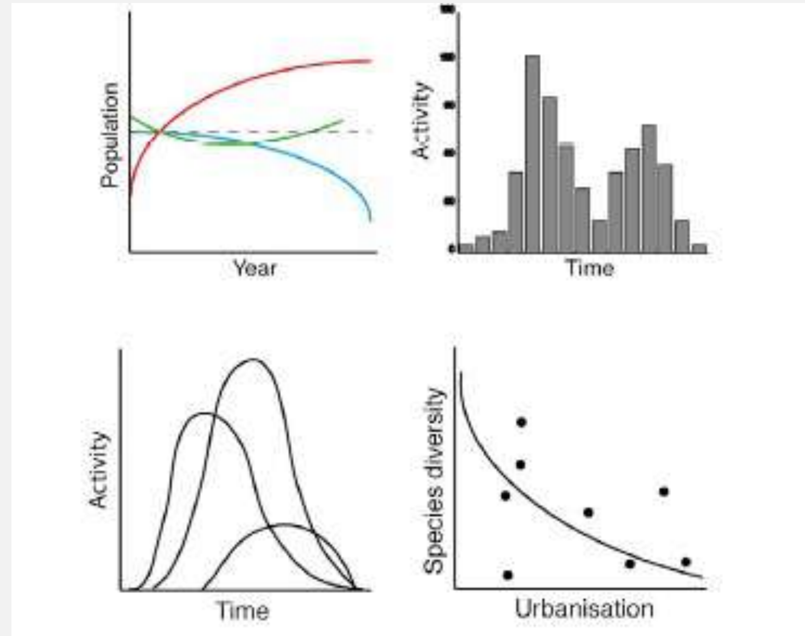


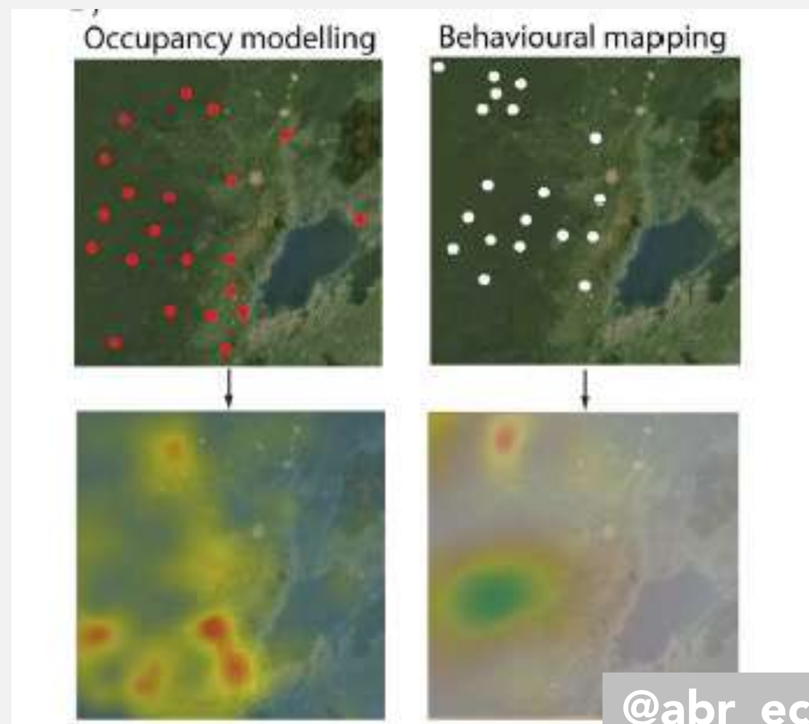
Gibb et al.. (2018). doi.org/10.1111/2041-210X.13101

@abr_eco

Outputs

- Presence/absence
- Species lists
- Temporal patterns
- Spatial patterns
- Density/population
- Individuals

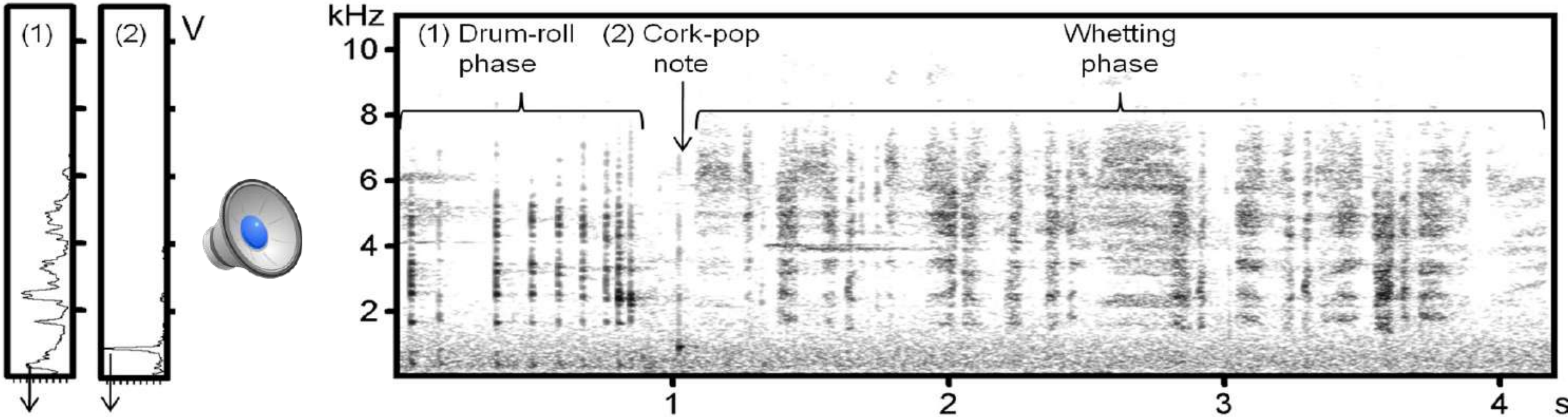




Gibb et al.. (2018). doi.org/10.1111/2041-210X.13101

Analysis approaches: species case studies

- –Capercaillie
- –Nightjar
- –Heathland birds



Fundamental Frequencies

Laiolo et al. (2011) Mechanisms Underlying the Bioindicator Notion: Spatial Association between Individual Sexual Performance and Community Diversity. PLoS ONE 6(7): e22724. https://doi.org/10.1371/journal.pone.0022724

SURVEY

@abr_eco

BIRD STUDY, 2018
https://doi.org/10.1080/00063657.2018.1446904

Check for updates

A first test of unattended, acoustic recorders for monitoring Capercaillie *Tetrao urogallus* lekking activity

Carlos Abrahams[a,b] and Matthew J. H. Denny[c]

[a]Baker Consultants, Matlock, UK; [b]Biosciences Department, School of Science and Technology, Nottingham Trent University, Nottingham, UK; [c]Denny Ecology, Cambridge, UK

ABSTRACT
Capsule: Automated acoustic recording can be used as a valuable survey technique for Capercaillie *Tetrao urogallus* leks, improving the quality and quantity of field data for this endangered bird species. However, more development work and testing against traditional methods are needed to establish optimal working practices.

ARTICLE HISTORY
Received 5 June 2017
Accepted 22 November 2017

Journal of Ornithology
https://doi.org/10.1007/s10336-019-01649-8

ORIGINAL ARTICLE

Check for updates

Comparison between lek counts and bioacoustic recording for monitoring Western Capercaillie (*Tetrao urogallus* L.)

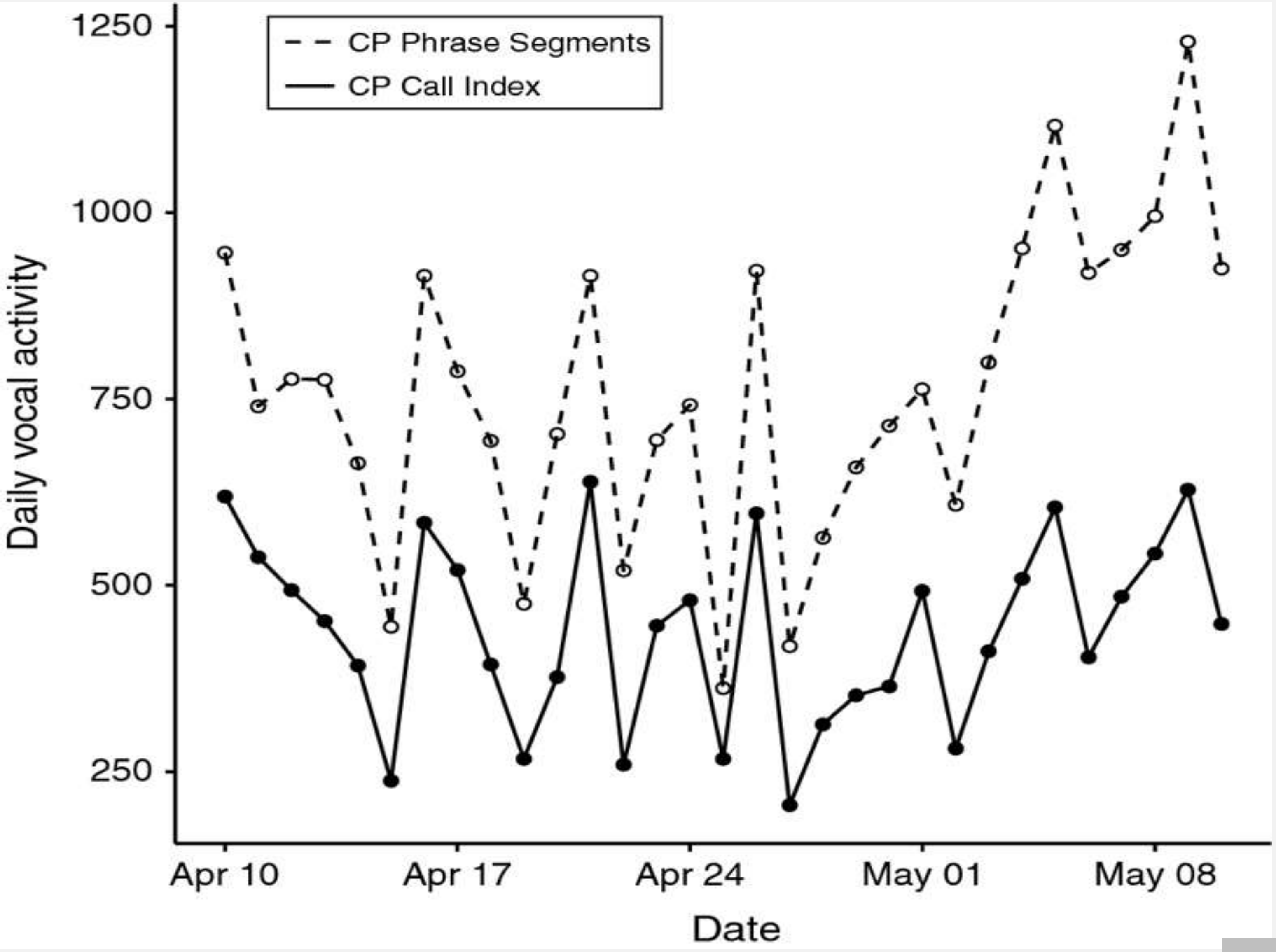
Carlos Abrahams[1,2]

Open Access!

Received: 12 May 2018 / Revised: 3 September 2018 / Accepted: 1 March 2019

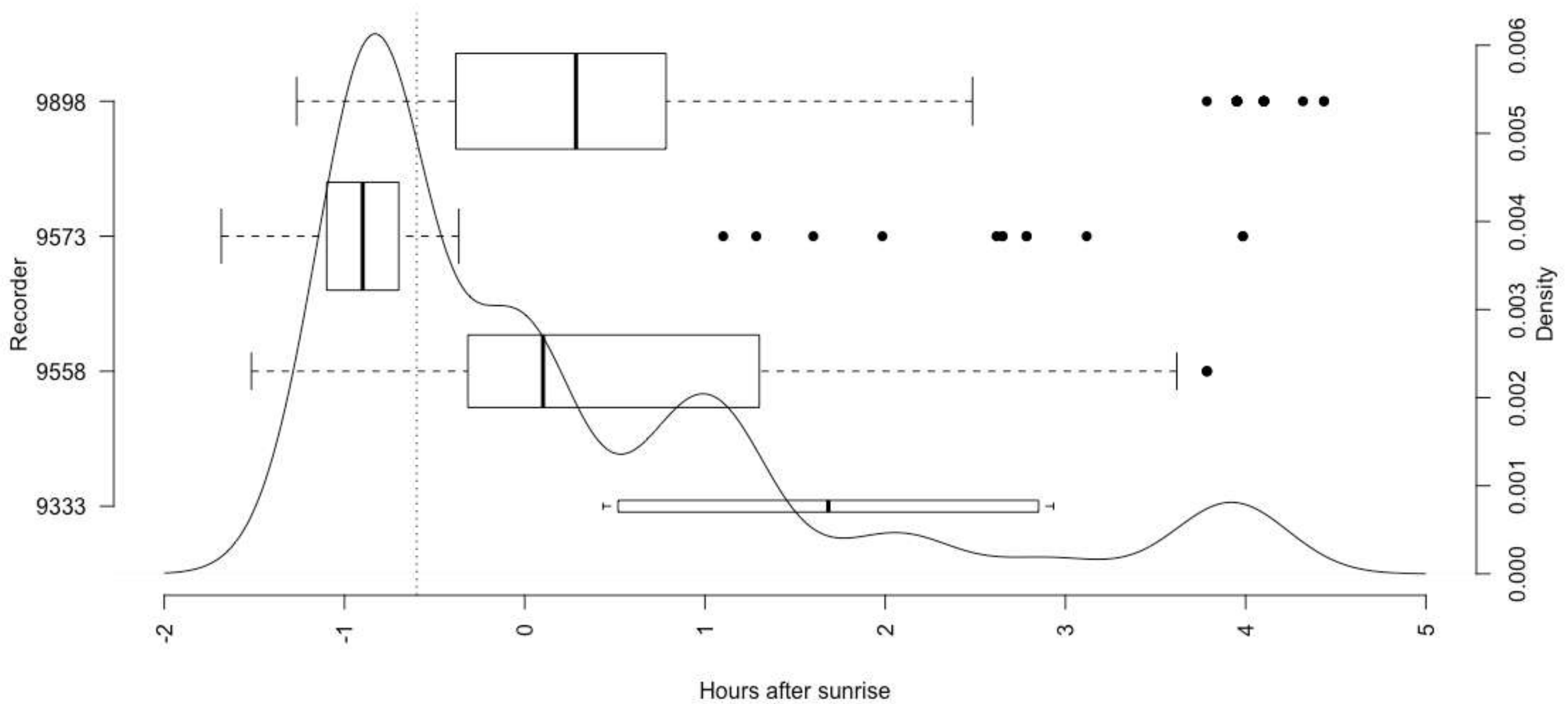
@abr_eco

RESULTS:
Call activity varies between dates



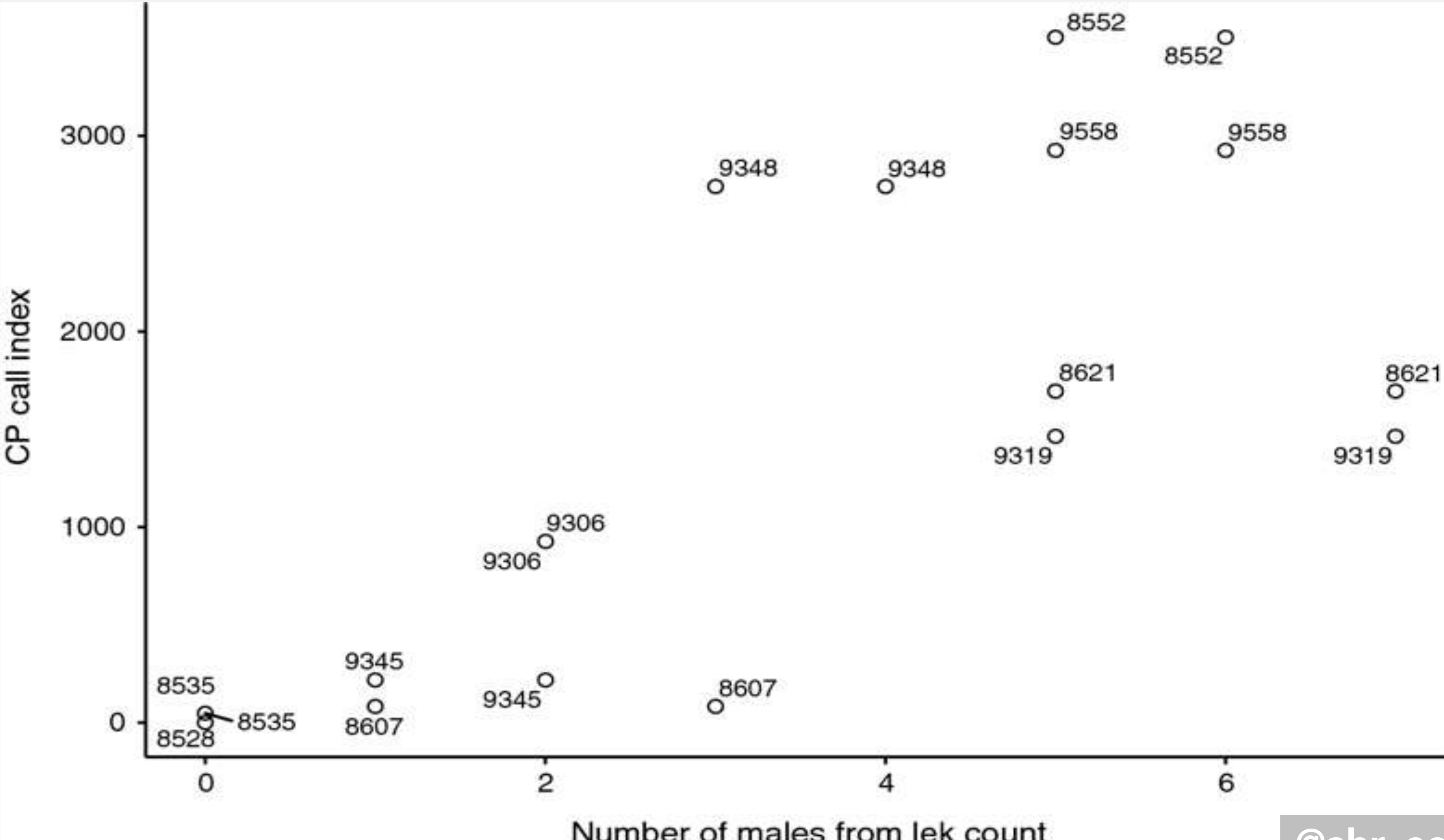
@abr_eco

RESULTS:
Call activity has a pre-dawn peak



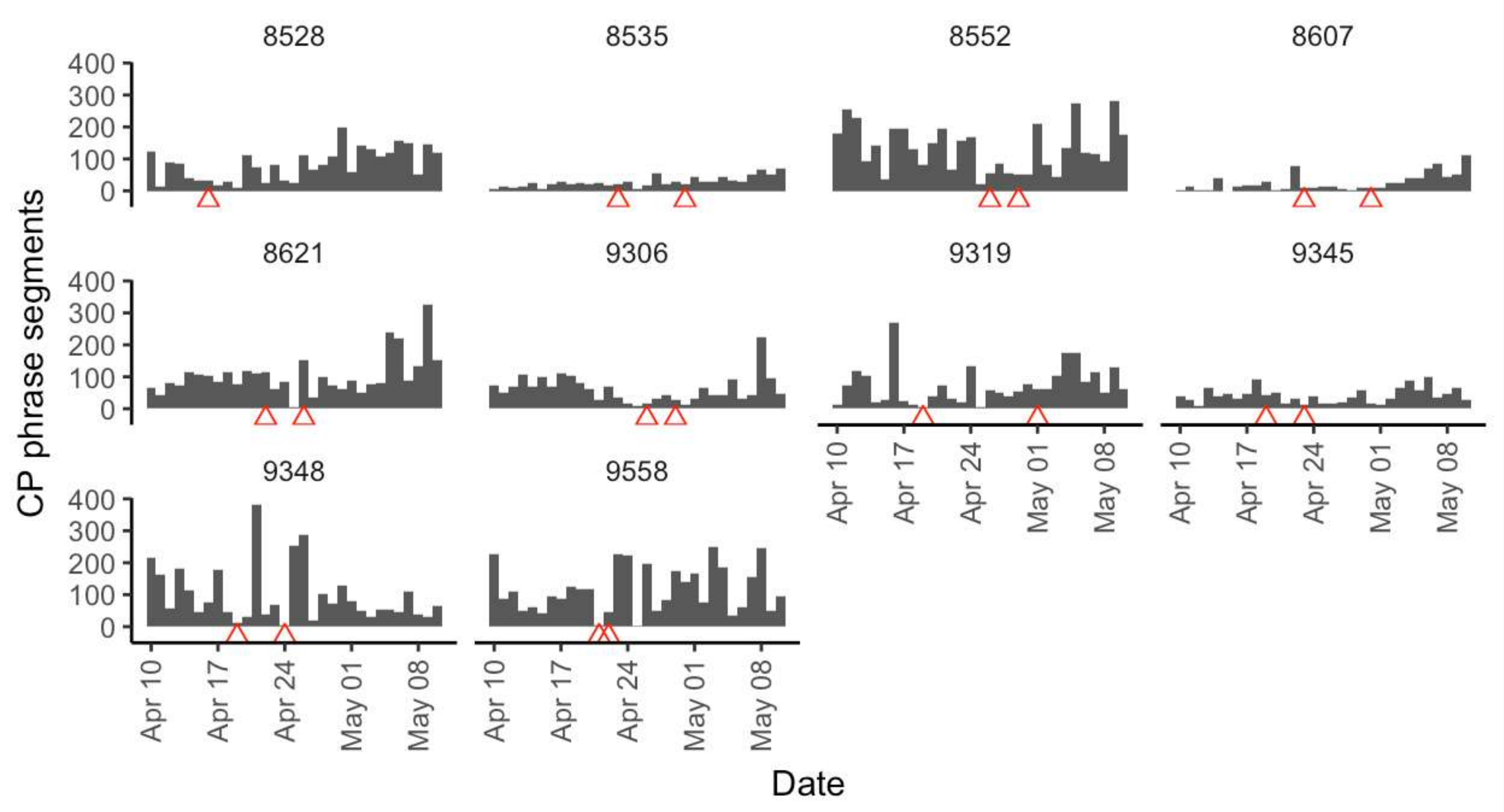
@abr_eco

RESULTS:
Call activity is related to numbers



@abr_eco

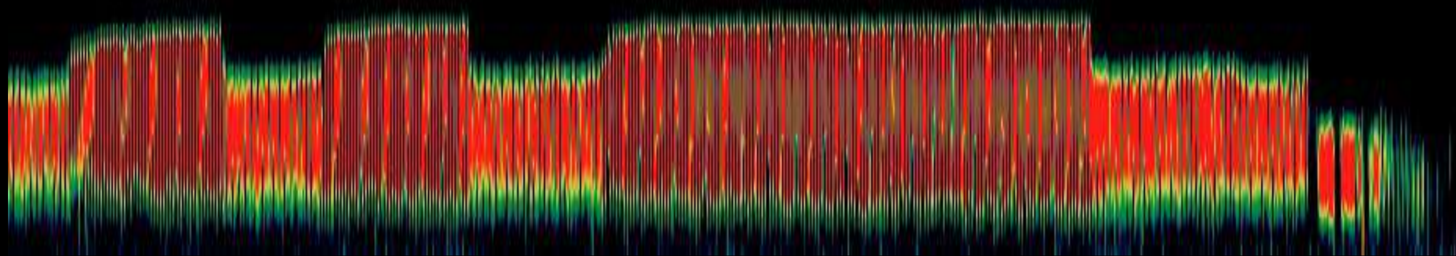
RESULTS:
Surveyors may cause disturbance?



Δ = Dates with human surveyors conducting lek counts

@abr_eco

HEATHLAND BIRDS



@abr_eco


@abr_eco

Two nightjar song types: paired and unpaired?

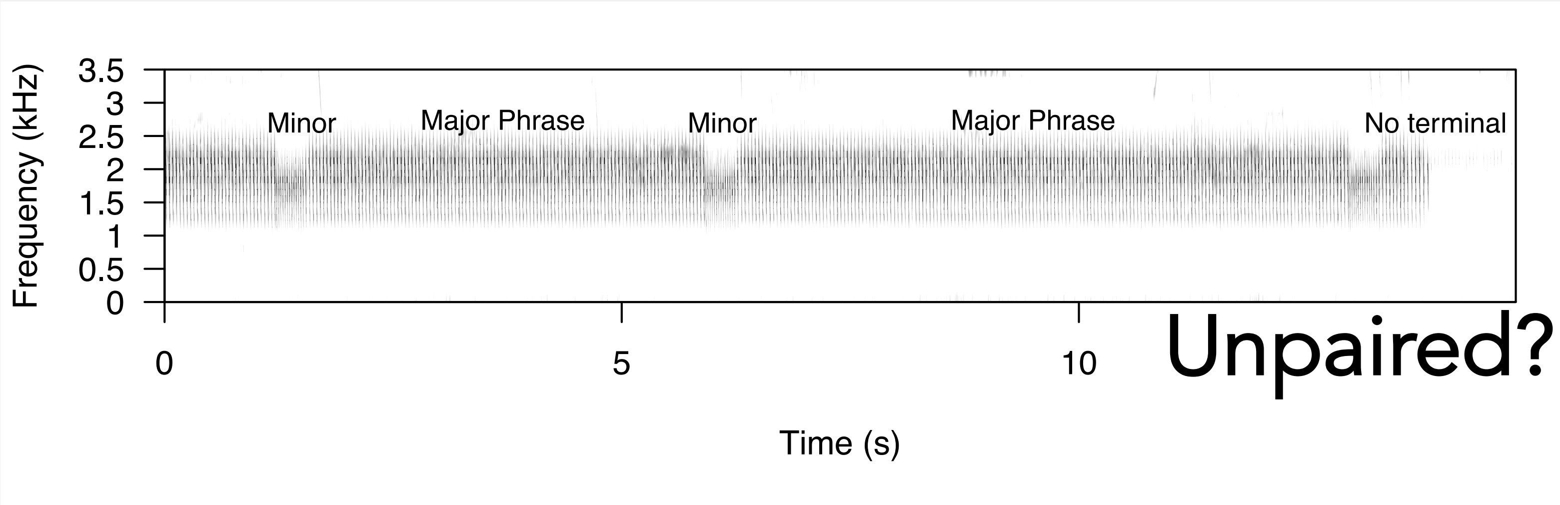


Figure 1. Spectrogram (acoustic frequency plotted against time) showing the major and minor phrases, the principal constituents of male nightjar song. This is Song Type I, without a terminal phrase, ending abruptly on either a minor phrase or a major phrase.

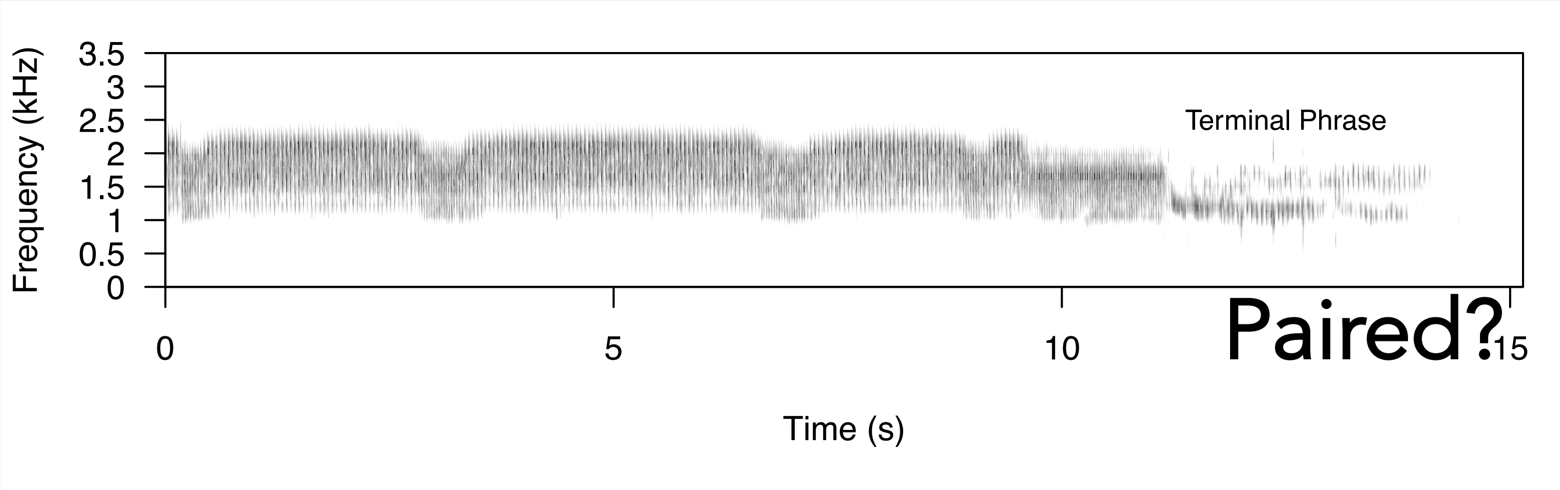


Figure 2. Spectrogram showing male nightjar Song Type II, with a terminal phrase. The terminal phrase may be preceded by either a minor phrase or a major phrase.

Ecological Indicators 112 (2020) 106131

Contents lists available at ScienceDirect

Ecological Indicators

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

Combining bioacoustics and occupancy modelling for improved monitoring of rare breeding bird populations

Carlos Abrahams[a,b,1], Matthew Geary[c,2]

[a] Baker Consultants Ltd, West Platform, Cromford Station, Cromford Bridge, Matlock, Derbyshire DE4 5JJ, United Kingdom
[b] Nottingham Trent University, Clifton Campus, Nottingham NG11 8NS, United Kingdom
[c] Conservation Biology Research Group, Department of Biological Sciences, University of Chester, Parkgate Rd, Chester CH1 4BJ, United Kingdom

ARTICLE INFO

Keywords:
Acoustic ecology
Autonomous recorder
Bird survey
Heathland
Occupancy model

ABSTRACT

Effective monitoring of rare and declining species is critical to enable their conservation, but can often be difficult due to detectability or survey constraints. However, developments in acoustic recorders are enabling an important new approach for improved monitoring that is especially applicable for long-term studies, and for use in difficult environments or with cryptic species.

Bioacoustic data may be effectively analysed within an occupancy modelling framework, as presence/absence can be determined, and repeated survey events can be accommodated. Hence, both occupancy and detectability estimates can be produced from large, coherent datasets. However, the most effective methods for the practical detection and identification of call data are still far from established. We assessed a novel combination of automated clustering and manual verification to detect and identify heathland bird vocalizations, covering a period of six days at 44 sampling locations.

Occupancy (Ψ) and detectability (p) were modelled for each species, and the best fit models provided values of: nightjar $\Psi = 0.684$, $p = 0.740$, Dartford warbler $\Psi = 0.449$, $p = 0.196$ and woodlark $\Psi = 0.13$, $p = 0.996$. Including environmental covariates within the occupancy models indicated that tree, wetland and heather cover were important variables, particularly influencing detectability.

The protocol used here allowed robust and consistent survey data to be gathered, with limited fieldwork resourcing, allowing population estimates to be generated for the target bird species. The combination of bioacoustics and occupancy modelling can provide a valuable new monitoring approach, allowing population trends to be identified, and the effects of environmental change and site management to be assessed.

1. Introduction

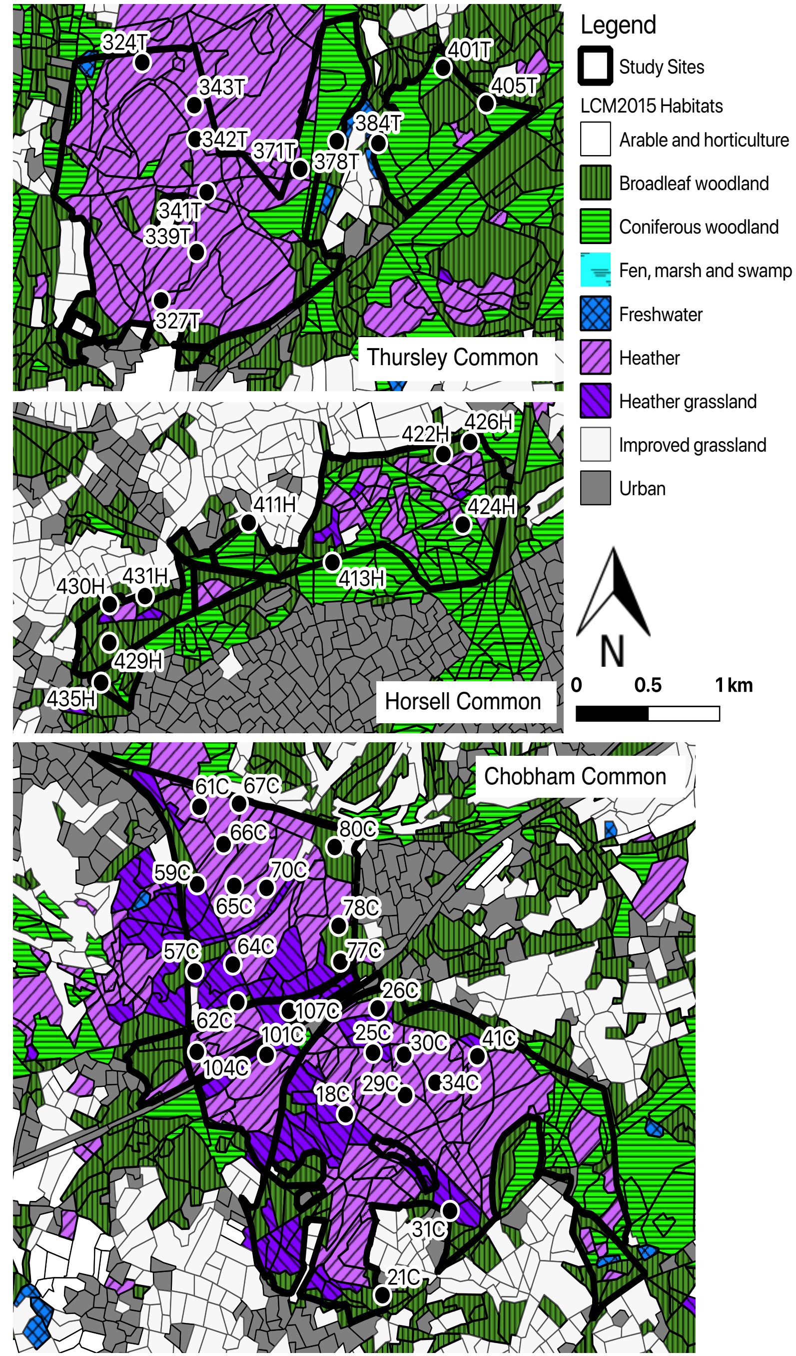
1.1. Bioacoustics for Biodiversity monitoring

Biodiversity monitoring is central to nature conservation, allowing species status to be evaluated or assessments to be made of biological responses to environmental changes (Pereira and Cooper, 2006). Long-term monitoring of designated nature conservation sites is particularly needed to identify population trends and inform management planning efforts, especially in the context of factors such as climate change and habitat loss/severance (Noss, 1990; Furnas and Callas, 2015). However, existing monitoring practices and protocols are often sub-optimal, especially in terms of unbiased spatial coverage, sampling effort optimization, the statistical use of the data, and the lack of repeated sampling (Schmeller et al., 2012).

We assessed the potential to improve the existing monitoring methods currently used on sites that are internationally important for their breeding bird populations. The most common methods for monitoring of bird numbers and distributions are transect or point count surveys by human observers. These have recognised disadvantages, such as observer bias, the availability of skilled/experienced surveyors (Brandes, 2008; Celis-Murillo et al., 2009; Rempel et al., 2005; Sedláček et al., 2015), and the infrequent and short-term nature of survey visits (Shonfield and Bayne, 2017; Zwart et al., 2014). In response to these issues, passive acoustic monitoring is increasingly being used as an alternative monitoring technique. This method uses automated recording units, which can be deployed in the field for days or weeks at a time to capture animal sounds. The advantages of this approach include the production of a standardised, long-duration, permanent dataset and record of species identification, which can be repeatedly analysed and

E-mail address: c.abrahams@bakerconsultants.co.uk (C. Abrahams).
[1] ORCID id: 0000-0003-0301-5585.
[2] ORCID id: 0000-0003-0951-6110.

https://doi.org/10.1016/j.ecolind.2020.106131
Received 4 September 2019; Received in revised form 17 January 2020; Accepted 22 January 2020



https://doi.org/10.1016/j.ecolind.2020.106131

Fig 2. Number of target species phrases recorded per day

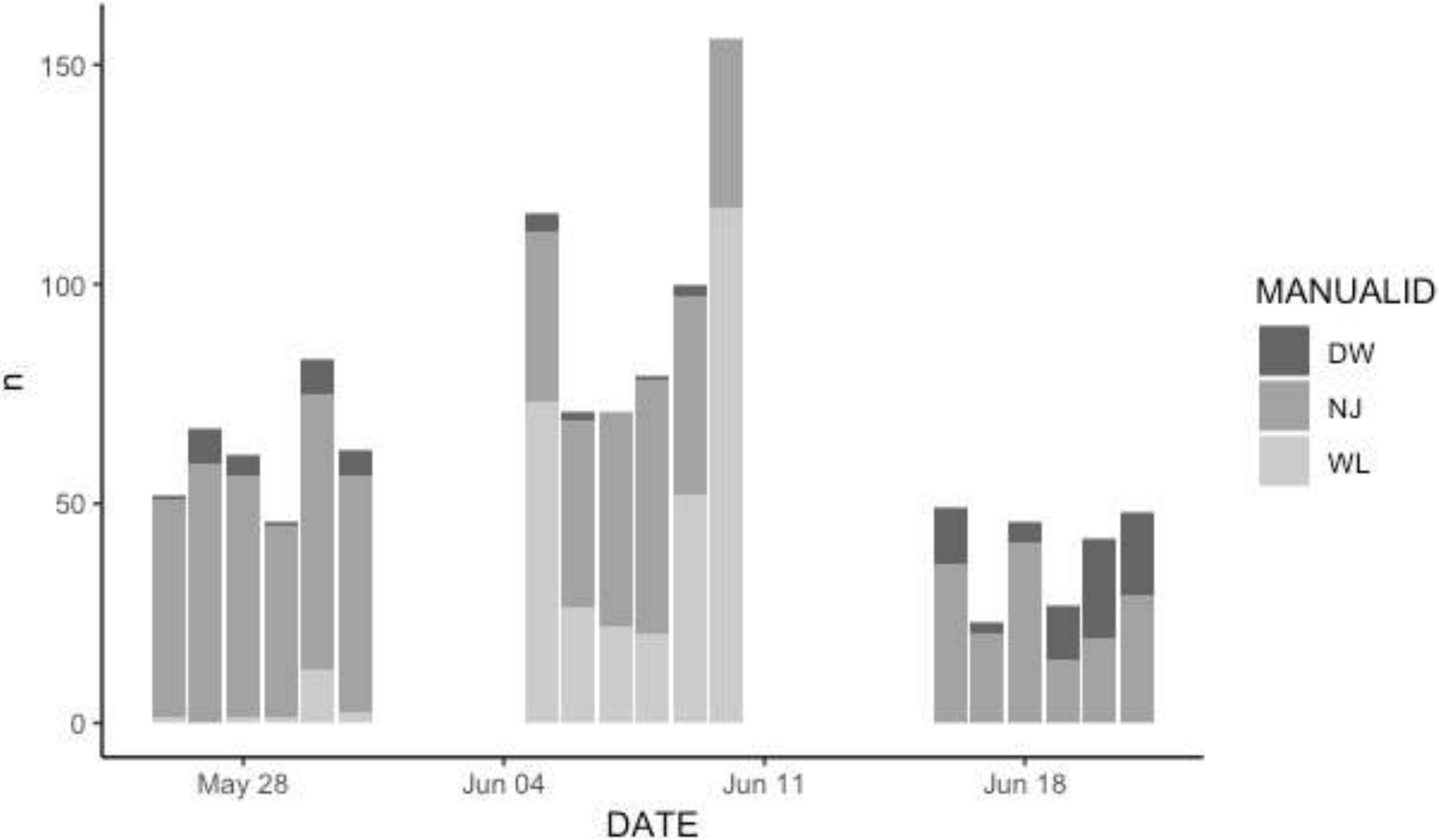
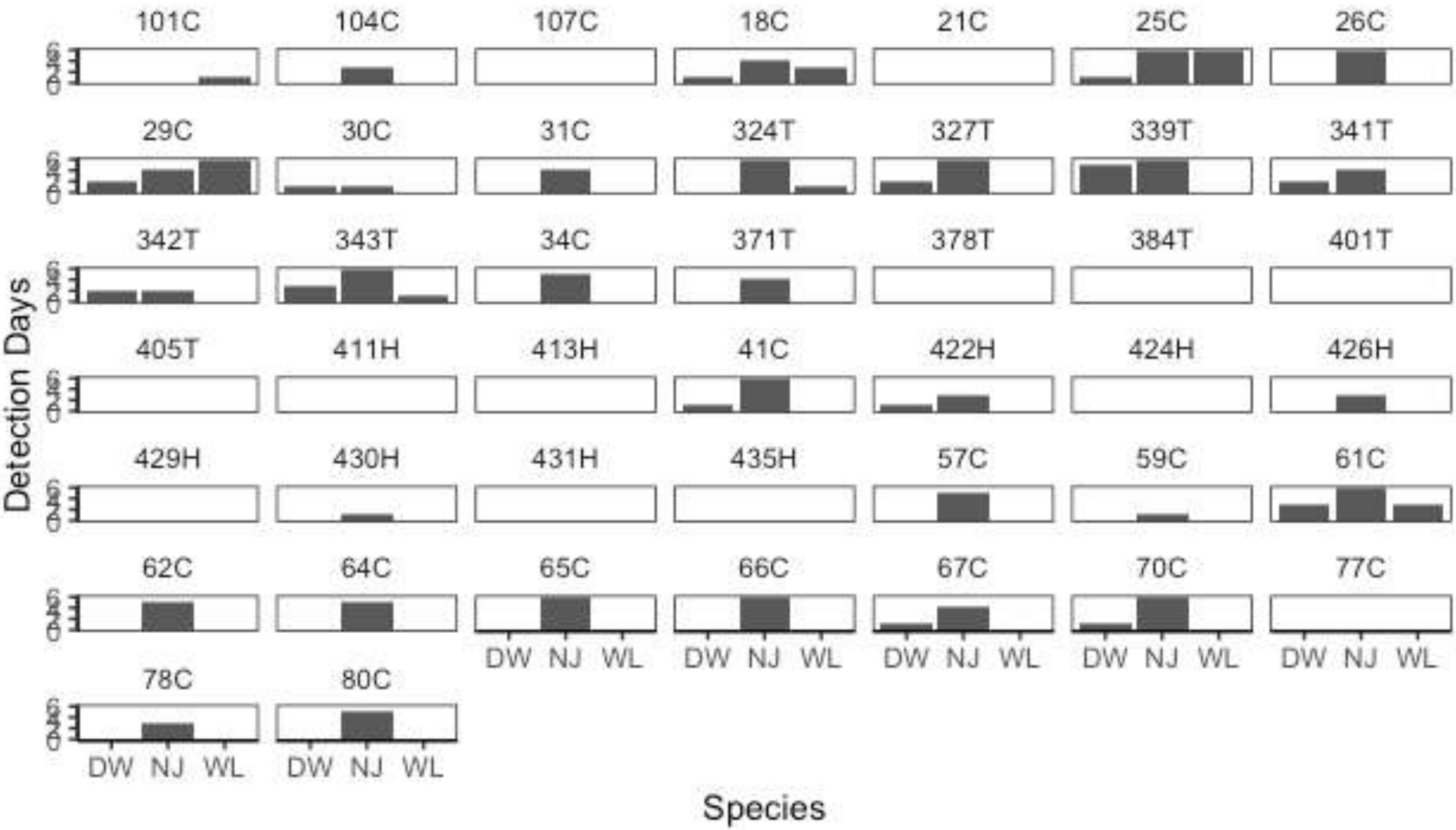
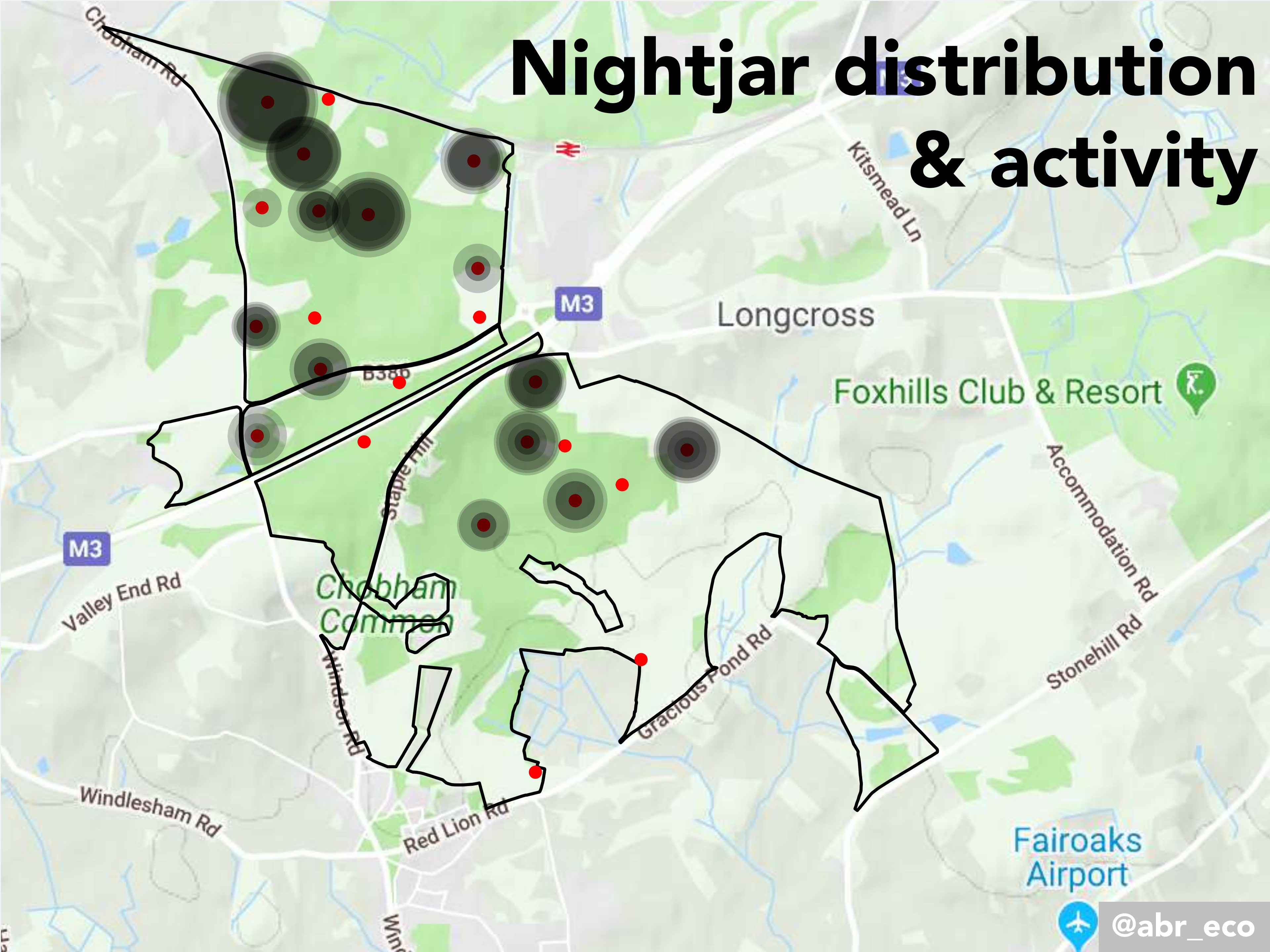


Fig 3. Number of detection days for each species at each site



Nightjar distribution & activity



@abr_eco

Bioacoustics: Better survey

- ➢Longer-term data
- ➢More consistent data
- ➢More sites, less effort
- ➢Synchronised recording
- ➢Less disturbance?

@abr_eco

Resources

Cornell Lab
Wildlife Sound Recording Soc.
www.xeno-canto.org
www.soundapproach.co.uk

How to
Search for medi
Download medi
Request media
Credit media
› Record audio
Why wave (.wa
Record with sm
Manage files an
Prepare and upl
recordings
Prepare and upl
photos
Choose recordi
Get started with
Identify birds

The Macaulay Library is here to help you meet the challenges of recording birds and other animals in the wild. This page contains tips on how to maximize the quality of your recordings. Be sure to check out our informational videos at the bottom of this page.

Some Recent Reviews

- Merchant, N. D., Fristrup, K. M., Johnson, M. P., Tyack, P. L., Witt, M. J., Blondel, P., & Parks, S. E. (2015). Measuring acoustic habitats. *Methods in Ecology and Evolution*, *6*(3), 257–265. https://doi.org/10.1111/2041-210X.12330
- Shonfield, J., & Bayne, E. M. (2017). Autonomous recording units in avian ecological research: current use and future applications. *Avian Conservation and Ecology*, *12(1)*(1), 14. https://doi.org/10.5751/ACE-00974-120114
- Darras, K., Batáry, P., Furnas, B., Fitriawan, I., Mulyani, Y., & Tscharntke, T. (2017). Autonomous bird sound recording outperforms direct human observation: Synthesis and new evidence, 1–37. https://doi.org/10.1101/117119
- Gibb, R., Browning, E., Glover-Kapfer, P., & Jones, K. E. (2018). Emerging opportunities and challenges for passive acoustics in ecological assessment and monitoring. *Methods in Ecology and Evolution*, (October). https://doi.org/10.1111/2041-210X.13101
- Sugai, L. S. M., Silva, T. S. F., Ribeiro, J. W., & Llusia, D. (2019). Terrestrial Passive Acoustic Monitoring: Review and Perspectives. *BioScience*, *69*(1), 5–11. https://doi.org/10.1093/biosci/biy147
- Desjonquères, C, Gifford, T, Linke, S. Passive acoustic monitoring as a potential tool to survey animal and ecosystem processes in freshwater environments. *Freshwater Biology*. 2020; 65: 7–19. https://doi.org/10.1111/fwb.13356
- Sugai, L.S.M., Desjonquères, C., Silva, T.S.F. and Llusia, D. (2020), A roadmap for survey designs in terrestrial acoustic monitoring. Remote Sens Ecol Conserv. doi:10.1002/rse2.131
- Kitzes, J., & Schricker, L. (2019). The Necessity, Promise and Challenge of Automated Biodiversity Surveys. *Environmental Conservation*, *46*(4), 247–250. https://doi.org/10.1017/s0376892919000146


I ❤️ bioacoustics
@abr_eco