From data to information

A start document for setting up a functional blueprint that makes data generated with automatic bat detectors available for a broad use

Limpens, H.J.G.A, V.J.A. Hommersen and M.J. Schillemans

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Auteur:	Limpens, H.J.G.A, V.J.A. Hommersen and M.J. Schillemans
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Gegevens opdrachtgever:	Netherlands Biodiversity Information Facility Postbus 93102
Contactpersoon opdrachtgever	Dr. Niels Raes. NLBIF, node manager

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Contents

1 Introduction

1.1 Background

Bat research has developed significantly in the past decades. New technologies and the enhanced practicality of new generations of ultrasound or bat detectors contributed to this development.

Bat detectors are all about making ultrasound audible and/or recordable. Basically bat detectors have evolved from tuneable heterodyne detectors (narrow band, HET), via frequency division (broad band, FD), time expansion (broad band, TE) to real time ultrasound recording (RT). Especially the last technique innovates bat research through the employment of bat detectors that use automatic triggering and real time recording. Development of high speed soundcards and/or high frequency digitizing of sound have made digital recording in real time possible. Automated triggering has made the employment of stand-alone bat detectors possible.

This automated RT equipment records ultrasonic sounds automatically in reaction on a pre-set trigger (frequency + sound level at certain frequencies). The system is not dependent on a human reacting to an ultrasound event with an active recording, thus creating new opportunities for standardised methods for active and long term data collecting regarding species presence and/or bat activity on a global scale. Involvement of appropriately trained and coordinated volunteers in surveys using broadband RT bat detectors creating increased species coverage and objectivity of species identification, embody the future in developing comprehensive bat monitoring programmes (Barlow et al., 2015). Automatic bat detectors however, generate big amounts of data, especially when combined with large scale utilization in e.g. citizen science projects.

Data storage
Globally there are several organisations/agencies/trusts that carry out citizen science projects targeting bats. All these citizen science projects generate big quantities of data. This big data availability creates new opportunities to generate knowledge on biodiversity patterns. However, the large amount of data also results in challenges in data handling. One main challenge is the data storage. Where are such amounts of data stored? They can be stored on hard drives, resulting in a risk if loss or damage of data. Storage online may reduce such risks. It is, however, not clear where to store such large amounts of data. And new challenges can be found in questions like: Which data to save of delete? Who to allow access to the data? How to secure your data?

Data analysis
Another challenge is that the collected data files/sound files need to be analysed, which is either being done more centralized by the organisations/agencies/trusts that collate the data, or more decentralized by employing volunteers. When the data is analysed by a central organisation this requires a large investment of time by this organisation. On the other hand, this removes the potential

influence of variation in volunteer experience and skills (Barlow et al., 2015; Newson et al., 2015). Data analysed by volunteers create other difficulties, like data not being analysed because of the great amount of time and effort requested from the volunteers, the (relative) lack of experience of the (different) volunteer(s). Training and coordination of volunteers, and the use of standardised methods, have found to be crucial to the success of surveys with volunteers (Newman et al., 2003).

Software
Besides that, the software dealing with processing sound files is developing continuously and fast, ever creating new opportunities e.g. to speed up analysis. Filtering raw data – recorded sound files - is becoming faster and more accurate. There are, however, still (too) many sound files not allocated, or files that are only identified to a genus or group level. It is therefore needed to share experiences with partners that use these software.

Data fragmentation
Another challenge is the fragmentation of generated bat data. Because there is no solid –global- data-infrastructure, data is only shared on a local scale. Most of the time data is only available for project participants and/or is stored only on the hardware of the observer. This creates a situation in which potentially valuable data is not available or accessible for researchers and scientific analysis and/or a wider audience. Also data from different projects is hardly shared.

The challenges regarding automatic generated data, e.g. generated by employing RT recorders, are characteristic for a new generation of biodiversity data: data that is automatically generated and produces big amounts of digital information. Comparable cases are e.g. data generated by the GPS tracking of birds or automatic generated identifications of plankton using plankton recorders. Al such data need to be stored, be comparable with existing information systems and also be usable in the future. The Global Biodiversity Information Facility (GBIF) is globally the most important infrastructure of biodiversity data. An organisation like GLBIF, and their national partners like NLBIF, respond to these new developments, which may be expected to play an increasingly important role in scientific biodiversity research. The approach of this report is therefore to get an overview of the circumstances regarding (RT) bat data and to study which first steps need to be taken to standardise the storage, analysis and interoperability of these data to improve the use of it.

1.2 Goals

Our goals are:
1) To carry out an analysis of problems and opportunities,
2) with a team of people that have experience in processing big amounts of data/analysing sounds files of bats,
3) in which bottlenecks in the data use, data processing and data presentation will be identified and prioritized,
4) and the relevant questions and proposals of solutions of the bottlenecks will be formulated.

The goal of this project is to make a start document for setting up a functional blueprint for a system for data handling that makes data generated with automatic bat detectors available for a broader use. The data should be usable for national and international researchers and volunteers via GLBIF and –where applicable- the (Dutch) National Database Flora and Fauna (NDFF). The start document aims at making progress in creating a usable dataflow that leads to usable data. This would be the first step in setting up a data-infrastructure for big amounts of bat data.

2 Methods

The project is divided in four phases: literature research, consultation by questionnaire, analysis of questionnaire and analysis and synthesis.

2.1 Literature research

In the literature research we studied worldwide initiatives and researches other than the initiatives of the Dutch Mammal Society, regarding bats and big amounts of data. By doing this we can get a first overview of the bottlenecks people are facing regarding this topic. In addition, relevant persons are noted that will be contacted for their input in the questionnaire.

2.2 Consultation by questionnaire

The analysis of challenges regarding bats and big amounts of data are further addressed by consulting a maximum of ten researchers having experience with these problems from different points of perspective. People are contacted by questionnaire. The questionnaire mainly deals with (meta) data and data retrieval and storage. The outcome of the response is analysed and described (Chapter 4). This outcome was communicated to the people that gave input for the questionnaire. The analysis of the questionnaire has been synthesised in Chapter 5. This resulted in an advice and conclusions, that will be addressed in Chapter 6.

3 Literature research

Globally there are several organisations/agencies/trusts that carry out citizen science projects regarding bats (Table 2). Apart from two already existing – non acoustic - monitoring networks, the Dutch Mammal Society set up a monitoring network based on acoustic observation of bats targeting population trends of four bat species. Data is collected by volunteers, who each year carry out car (or bike) transects. Species identification is also done by volunteers, who are trained by means of yearly workshops.

Also in Ireland and France citizen science acoustic monitoring projects are carried out, as Bat Conservation Ireland and VigieNature (France) organise car transects for volunteers. In contrast to the Dutch Mammal society, Bat Conservation Ireland analyses the data centralized without the help of volunteers (Roche et al., 2005 and 2011). In France the recordings and identification results are uploaded via a portal. Identification is done by volunteers using (custom) software.

Concerning the UK, Bat Conservation Trust (BCT) has a National Bat Monitoring Program with several ?? acoustic surveys, carried out by volunteers. Data analysis is accomplished by the volunteers themselves, who are trained by means of workshops and online training. BCT also has a partnership project with The Institute of Zoology (IoZ): The Indicator Bats Program (iBats). It aims to develop national bat monitoring programs across the globe (BCT, n.d.). Recordings are provided to volunteers who then identify whether a bat is present, and if so, what species it might be. The same recording is presented to several volunteers. On the basis of this input (especially regarding the presence of a bat in a recording) an algorithm is developed to extract bat calls, which then in turn can be identified to species level (Mac Aodha et al., 2018).

Other citizen science bat projects in the UK involve the Norfolk Bat Survey and the Southern Scotland Bat Survey. These involves surveys in in Norfolk, Southern Scotland and in the Norfolk and Suffolk Brecks, carried out by volunteers. They borrow a bat detector from a Bat Monitoring Centre and collect data in 1 km squares (Norfolk Bat Survey, n.d.; Southern Scotland Bat Survey, n.d.). Initially data were stored on a SD-card and sent by post, but it is now also possible to upload recordings directly. Identification of the species is done using software with a fast feedback to the volunteers.

In America, the Wisconsin Bat Program organises land, water and driving transects for volunteers. Data is saved onto the PDA and analysed in the office (Wisconsin Bat Program, n.d.).

Another bat monitoring program in North America is yet in progress. The North American Bat Monitoring Program (NABat) states that there are currently no national programs to monitor and track bat populations in North America. The aim of the NABat is to provide the architecture for coordinated bat monitoring and to provide managers and policy makers with the information they need on bat population trends (USGS, 2016). Currently (NABat) is using acoustic data gathered from various sources and sampling designs, named ‘ projects’ (Loeb at

al., 2015). Projects may contain sampling form one to a various number of grid cells. Species ID is done by the collector of the data using various types of software. Results are uploaded using a project-database supplied by NABat, collecting the species identification, parameters generated by the software used to identify the species and – possible but not required- the actual recordings.

Data of the Norfolk Bat Survey and the Southern Scotland Bat Survey were analysed by means of a first analysis with the Software SonoChiro (http://www.biotope.fr/fr/innovation/sonochiro), a record filtering in SAS and then manual checking using the software SonoBat (http://www.sonobat.com/) of the files. SonoChiro provided robust results for the majority of the species and recordings were filtered to remove low quality recordings and identifications with low confidence (Newson et al 2015). Currently the data is being analysed using custom software (Tadarida) (https://www.batsurvey.org/species-identification/).

Because of the fragmented data of population status and trends in America, the USGS started in 1994 with the USGS Bat Population Data Project. In this project bat data and publications were synthesized, data was tested for the utility for estimating trends and evaluated for future monitoring programs. The projects product was the bat population data base (USGS, 2017). Currently, USGS scientists want to update , updating and extending the capabilities of this database for better data management, accessibility and utility. Also Bat Conservation International and Washington DC-based NatureServe have formed partners to launch the initiative of a bat database, this is a global database.

The first international symposium on Bat Echolocation methods was organised in 2002 in Austin Texas. This meeting resulted in a handbook on the use of acoustic methods, focussing on the techniques of observation and identification of bats in the field with bat detectors (Brigham et al. 2004). In 2017 in Tucson Arizona the second meeting was organized aiming at an update of the handbook (abstracts: Fenton et al. 2017). The focus in the second meeting was on automated recording and identification of bats. To date a revised version of the handbook is not available.

Table 2. A non-exhaustive Overview of organisations/agencies/trusts that carry out acoustic citizen science surveys on bats and of bat researchers that work with large datasets of bats.

Initiatives	websites	Names/ contacts	Description
iBats (Indicator bats Program)	http://www.bats.org.uk/pages/ibatsprogram.html	Kit Stoner, Kate Jones	Monitoring bats worldwide by means of transects
Norfolk bat survey	http://www.batsurvey.org/norfolk/	Stuart Newson	Monitoring bats throughout Norfolk by means of three survey locations in 1km-square. Detectors are borrowed and returned to Bat Monitoring Centres.
Southern Scotland Bat survey	http://www.batsurvey.org/scotland/	Stuart Newson	Monitoring bats throughout Southern Scotland by means of three survey locations in 1km-square. Detectors are borrowed, returned and analysed by southern Scotland bat survey.
The Breckland Bat Project	http://www.batsurvey.org/projects-in-suffolk/breckland_bats/	James Parry	Monitoring bats throughout Suffolk and Breckland by means of three survey locations in 1km-square. Detectors are borrowed, returned and analysed by the Breckland bat society.
University of Exeter, researcher	http://biosciences.exeter.ac.uk/staff/index.php?web_id=Paul_Lintott	Paul Lintott	PhD on bats
Bat Conservation Ireland	www.batconservationireland.org	Tina Aughney	Car based monitoring: 28 x 30km squares are surveyed by car.
Vigie Chiro	http://vigienature.mnhn.fr/page/vigie-chiro	Christian Kerbiriou, Jean François Julien & Yves Bas	Car based monitoring, counts in 2x2 km squares, stations in 2x2 km squares
Wisconsin Bat Program	http://wiatri.net/Inventory/Bats/volunteer/acoustic.cfm		Car, walking and canoe based transects
North American Bat Monitoring Program (NABat)	https://www.fort.usgs.gov/science-tasks/2457	Patty Stevens	Objectives: 1) provide the architecture for coordinated bat monitoring to support inferences about trends in bat populations and abundances, and 2) provide managers and policy makers with information on bat population trends.
USGS Bat Population Data Project	https://my.usgs.gov/bpd/	Bill Rainey	Creating one big database for bat data in the United States
Bat conservation trust	http://www.bats.org.uk/pages/batmonitoring.html	Katherine Boughey (Monitoring & Science Manager)	Several monitoring projects, like iBats and National Bat monitoring study.
Bat Conservation international	http://www.batcon.org/our-work/initiatives/launch-a-global-bat-database	Dave Waldien, Mylea Bayless, Wynifred Frick	Launch a Global Bat Database
University of Naples		Danilo Russo	Researcher of bats
Swiss Federal Institute for Forest, Snow and Landscape Research	http://www.wsl.ch/info/mitarbeitende/obrist	Martin Obrist	Researcher of bats
Swiss Bat Bioacoustics Group SBBG	http://www.fledermaus-be.ch/	Elias Bader	Researcher of bats

4 Questionnaire

The questionnaire is displayed in Appendix I and has been sent to 25 persons dealing with automatic generated data of bats and large datasets worldwide. Of these 25, eight persons (Table 3) gave their input for the questionnaire.

From the view point of data flow architecture, the questionnaire targeted questions regarding what and how (meta)data is collected and retrieved and how such data is finally stored. As a basis for a deeper level of interpretation of the received feedback, also details where asked concerning recording, species identification and monitoring/observation design.

Table 3. People that gave their input for the questionnaire.

Initiatives/organisations/bat researchers	Name of person that gave input for questionnaire
Norfolk bat survey / Southern Scotland Bat survey	Stuart Newson
Vigie Chiro	Yves Bas
North American Bat Monitoring Program (NABat)	Brian Reichert
Swiss Federal Institute for Forest, Snow and Landscape Research	Martin Obrist
NIOO-KNAW/ Dutch bat researcher	Kamiel Spoelstra
Dutch bat researcher	Niels de Zwarte
Dutch bat researcher	Jasja Dekker
Dutch bat researcher	Sander Lagerveld

5 Analysis of consultation by questionnaire

Out of the eight respondents three are dealing with nationwide and/or regional data. Five respondents mainly deal with data concerning several (larger or smaller) projects. Appendix II gives an overview. When we take the DMS acoustic monitoring scheme into account there would be a fourth respondent dealing with nationwide data and the number of respondents is then nine.

In the analysis we focus on four aspects relevant for dataflow architecture:

1. Methods of transfer and storage of data
2. Method of recording
3. Identification of species
4. Metadata

Method of transfer and storage of data

Data collected in the field is generally transferred to a central location by physical means (e.g. hard drive, SD-card) or via file transfer. In four[1] cases data is transferred using a portal or interface for uploading. Mostly raw data is transferred (e.g. recordings), in three cases a species ID is also transferred along with the raw data.

Data is mainly stored locally or via a SAN. When dealing with nationwide monitoring schemes between 1 to 8 TB of storage per year is being used, and a yearly increase (of unknown magnitude) is expected.

Method of recording

Automated bat detectors are always used. Brands of bat detectors and microphones and their settings differ greatly. Across respondents different types of triggers are used. Mostly full spectrum 'time expanded' or real time recordings are being used.

Identification of species

When only recordings are transferred the identification process is obviously done centrally. When species identification is done by the collectors of the data (mainly volunteers) the software to do the identification is provided or freely available. These are mainly software packages that run locally, although in France the call extraction from the recordings is a local facility whose outcome is then identified to species via an internet based tool. In the Norfolk scheme a recent facility is offered where recordings are uploaded directly to a central processing computer that generated a fast –partial- outcome of species, which is fed back to the collector. Previously data was transferred by posting SD-cards.

In all cases species identification is done using automated software. And in almost all cases the result of the automatic identification software is validated by hand vetting. Hand vetting is used on a sample of the data. The sample is either chosen according to species group or to confidence level as indicated by the used software. Sample size is not given.

1

Identification mostly tries to target the species level, but this is not always attainable. Several respondents group species together when identification to species level is not possible. Most used are Myotis-group (genus), Nyctalus-Serotinus-Vespertillio-group (guild) and the Plecotus-group (genus).

As recordings may also hold various non-bat sounds (artificial or other biota), a process of scrubbing (extracting only the recordings with bat calls, or only bat calls from recordings) is very important. A too strict process will also exclude recordings with bat calls (false negatives), giving a false number of recordings (or calls). A too loose process would give many 'false positives' which are falsely regarded as bats (a species or a group).

Among the respondents the process of scrubbing is either done using settings of the recording device (triggers) of by filtering recordings afterwards. There is no clear preference indicated by the respondents.

Metadata

Metadata which is retrieved alongside the actual recordings almost always includes coordinates, date and time, used-IDs, data on the settings of the recording device, data about the sampling point, data on call or recording quality and specifics of used classifiers and filters.

6 Synthesis and advice

From the literature research it is obvious that the use of automatic bat detectors is growing and a lot of organisations face the related challenges in different ways. We have to be aware that only a relatively small number of people responded to the questionnaire and thus have to be careful when interpreting the outcome.

There is a marked difference in how respondents are dealing with data between respondents running one or several, larger or smaller project(s) and those who deal with nationwide of regional (monitoring)schemes).

Advancement of identification software is fast, as is the development of automatic bat detectors. Both are decreasing in cost and growing in choice.

This implies that the use of different makes of software and devices is also growing. It is foreseeable that volunteers will increasingly use their own automatic bat detector(s) to record bats while working in a monitoring scheme, instead of using only one type which is provide by the project. This implies that they can and will also collect data on an ad-hoc basis.

At the same time, it seems clear that a recording system used nowadays might be obsolete in a few years. This is a serious concern for strictly regulated monitoring schemes, in which often – for the necessary methodical rigidity - only one system of detection and recording is used.

Method of transferral and storage

There seems to be a trend towards uploading calls or recordings, instead of physical transferral of data (e.g. hard disks, SD-cards), especially when dealing with nationwide or regional monitoring schemes. However, one party mentioned that the amount of data collected was growing too fast and they were thinking of reversing to sending physical devices and/or doing local scrubbing (removing all non-bats sound from the recordings) and then performing an upload.

Also it is clear that when dealing with nationwide, or even continent-wide data, a wish and need exists for a central database to store the data (including metadata). Mostly data is stored on a SAN, which makes it easy to manage and add storage capacity when needed. However, it is also foreseeable that when the datasets become very large, searching such datasets will become more strenuous. The storage facility will have to facilitate these searchers.

Method of recording

With strictly regulated monitoring schemes, mostly dealing with population trends not based on occupancy methods, systems for detection and recording, as well as the way they are used are also strictly regulated. But when dealing with distribution data and ad-hoc data recordings systems and the way they were employed will all differ. Using the full potential of distribution data will almost always include dealing with different systems for detection and recording, modes of employing and used trigger settings. This indicates the necessity of also transferring metadata about devices, usage and settings.

Identification

Species identification is always handled by software, rather than manually.

Recently it has become clear that using software has important limitations (among others Russo and Voigt, 2016). Although the accuracy of the software is increasing and call extraction can be improved (for example see Mac Oadha et al., 2018), errors will persist. These errors might be false positives (where a recording is assigned a species identification while there is no bat pulse), false negatives (a bat pulse is present in the recording, but no species identification is assigned) or misidentification (a species identification is assigned but the recording in is reality of a different species; in quantitative analysis these would also add to the false negatives).

Traditionally these errors are counteracted by hand vetting. This is indeed indicated by all respondents. Hand vetting however involves much time, depending on the sample taken to be hand vetted. The sample size is not given by the respondents to the questionnaire. From literature it is clear that various sample sizes are used. Sample sizes are based on a fixed percentage of all recordings, a fixed percentage of recordings stratified towards species that are difficult to identify using acoustics, a fixed percentage of recordings stratified towards quality of recordings (e.g. S/N) or a mix of the before mentioned.

However, dealing with errors can also be based on the confidence level given by the software used to identify the species in a recording, by setting an explicit fault tolerance (Barré et al. 2019). Barré et al. (2019) show that the degree of hand vetting needed thus can be significantly decreased. Furthermore they show that when not taking errors into account analysis on ecological relationships between species presence or abundance and environmental parameters or landscape features, will lead to false conclusions.

This implies that when dealing with large datasets (of different sources) one should always take the confidence level of the ID into account, and that it is highly likely that this decreases the time needed for hand vetting. On turn, this implies that metadata of the software used (e.g. settings and confidence levels) should be available. It also implies that after recordings (raw data) and species identifications are made available by observers, these metadata still needs to be available for ID validation (hand vetting) and for dealing with errors and error levels.

We can distinguish three modes to deal with the species ID process:

1) Decentralized: for example, NABat and the Dutch monitoring scheme.
   Collectors handle the species identification process themselves.
   Both recordings (raw data) and species ID (processed data) are transferred.
   This implies well trained collectors and transferral of metadata of the identification process (e.g. outcome of the automatic identification software including confidence levels and settings). It also implies that identification software is available for collectors.
   After recordings and identification data is retrieved, a validation process is needed to
   a) ensure identification is reliable and done with comparable assumptions

(e.g. confidence levels given by software, across different sources of data
b) deal with expected errors of the software used.
When dealing with many different sources of data (and thus also with many different recording devices and different software used for identification) metadata about the used devices and software becomes of paramount importance.
When dealing with volunteers, a particular concern is that feedback should be presented regarding whether the identification supplied by the volunteer was indeed accurate. This ensures a learning effect. An important advantage of this decentralized fashion is that capacity is being generated among volunteers for dealing with acoustic data. This enables them to then also collect and report acoustic data on an ad-hoc fashion.

2) Centralized: for example, Ireland. Collectors send the recordings to a central location. There the identification process is handled. Feedback to collectors is done after processing the recordings. A major advantage is that the identification process can be tightly regulated and controlled. Making is easier to deal with errors. However, there is no or little learning effect for volunteers, which might also effect whether volunteers will stay involved in such schemes.

3) Mixed Mode: for example, France and UK. Collectors send the recordings to a central location. There the identification process is handled. In the case of France, collectors see output via an internet tool. In the UK, collectors receive a quick response concerning at least the common species and/or easily identified species and receive full information afterwards. As identification is done centrally is can be well controlled and regulated. There is no real learning effect, but volunteers receive feedback quickly, which is important to keep them involved.

A recent development is the collaboration between BTO, BCT, University College London and Oxford University: together they try to develop and end-to-end system of recording-automated identification-feedback (https://www.bats.org.uk/our-work/national-bat-monitoring-programme/british-bat-survey). An integral part of this system is also the automated feedback to users.

Metadata

As discussed, metadata should not only deal with information about the recording and sample site itself (location, data, time et cetera) but also with information about the recording device and settings and if appropriate of the identification process (software used, confidence levels of identification, settings etc.)

Implications for the Netherlands

- The evolution of automatic detectors results in an increasing number of volunteers using their private detector and/or recording device. These observers will use their personal equipment for regulated monitoring schemes as well as for their 'personal projects', leading to standardised as well as to ad-hoc data.
- There is an implicit wish for capacity building (learning).
- It is to be expected that a currently used device might become obsolete in a relatively short period.
- When working towards a database which involves data from different schemes, sources and regions (or on a larger scale even countries) it involves different devices and settings used for collecting data and for the identification process.

In this context it seems most appropriate to use a mixed and/or decentralized model for data collection and identification.

Depending on the amount of data to be expected, a mixed model might involve large computing power to be able to quickly give feedback to volunteers. The need for a central location for either the primary identification process (e.g. assigning a species to a recording), or the validation process, is no different for a mixed or decentralized model.

Ideally – to facilitate different types of volunteers and/or different levels of experience in performing species ID - it should be possible that volunteers can send in only recordings and receive identification information in return (mixed model), parallel to a facility to do and check their own identification (decentralized model).

It seems most appropriate however to organize both path ways (the facility to send in recordings, as well as the facility to do and check one's own identification) centrally (per country, monitoring scheme or project).

When looking at the Netherlands, the NDFF is a central location where data concerning bat (and other) species from various sources is made available to different parties. Data is being added via ad-hoc observations (either waarneming.nl, telmee.nl, lower governmental bodies [e.g. municipalities] or consulting parties) and of structured survey and monitoring schemes (NEM).

Ad-hoc data is to be validated, as using software may lead to misidentifications in that data (of unknown magnitude). When dealing with data that has been analysed for species identification with software, it is of paramount importance that not only the outcome of the analysis, but also metadata of the recording device and settings and of the software used are transferred. Without that information a true validation is not possible and there will be no certainty that the species identification has been done correct. Not being able to validate data may in turn lead to data not being used and/or invalid information being used.

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8 Bijlages

Appendix I: Questionnaire

I) Appendix I: Questionnaire

Instruction for the questionnaire of the NLBIF project dealing with automatic generated data on bat acoustics.

The project for which we are looking for your input and cooperation is dealing with how to handle the data stream generated through the projects working with auto acoustic recording and auto ID of acoustic bat signals.

Please answer the questions we posed in the different tabs in this Excel table questionnaire. Many questions are written in the so called 'closed' format. We would like to invite you however, to answer in full text. Also we would like to invite you to point out topics we are missing.

The information needed to try and improve the handling of the data stream of such bat research projects, is primarily connected to the topics:

A metadata (Table 4)
B data retrieval, management and storage (Table 5)

So please address the questions in their specific excel-tabs.

In case you are not the right person to fill in the excel tabs, would you please let us know whom we should address with this first questionnaire and possible more detailed questionnaires?

Please let us know whether we could contact you again to look at some more detailed questions in a next phase of the project.

If you know of any published literature dealing with data handling bat data could you pls. supply the reference
We supply extra tabs dealing with details. It might be helpful to also try and answer the questions in the excel-tabs dealing with:

C recording bats
D species ID, and
E observation - monitoring design

These tabs are not required the primary aim of our project, but provide useful further insights. We leave it at your discretion whether or not you fill out these tabs.

Table 4. Tab A of questionnaire: metadata

WHICH METADATA ARE RECORDED, OR DEDUCIBLE FROM RAW DATA?	Please indicate correct choice by background colour	
Metadata		
Are you recording and storing metadata?	Yes	No
Are you using a custom made format, for encoding of metadata ?	Yes	No
Are you using a freely available format?	Yes	No
Other,….		
Date and time of recording?	Yes	No
Location coordinates?	Yes	No
Metadata recording	Yes	No
Is this information available from your software?	Yes	No
Registered weather data	Yes	No
Is this information available from your recording?	Yes	No
Data on equipment & observer	Yes	No
Are you recording and storing ..		
specifics and ID of your recording unit ?	Yes	No
name observer (+ observer team)?	Yes	No
specific of material (incl. mic and sensitivity, and settings of automatic detectors)	Yes	No
Other,….		
Metadata on sample point	Yes	No
Metadata on sample session / recording session	Yes	No
Metadata on ID-proces	Yes	No
Are you recording and storing ..		
specifics of identifying person/party/software	Yes	No
Are you recording and storing ..	Yes	No
specifics on call quality?	Yes	No
specifics on type/version/year of classifier?	Yes	No
specifics on used filter settings?	Yes	No
used reference material?	Yes	No
Other,….		
How do you link metadata - (ultra)sound recording - raw data and processed data?		

Table 5. Tab B of the questionnaire: data retrieval and storage

DATA COLLECTION, RETRIEVING DATA FROM PARTICIPANTS AND DATA STORAGE	Please indicate correct choice by background colour	correct choice!		
Does the data concern a specific project or multiple projects?	Specific	Multiple		
Does the data concern a single observer/party or multiple observers/parties	Single	Multiple		
Is there a facility to reanalyse data?	Yes	No		
Other, ……..				
With wat technique, process and in which form are data retrieved ..				
How is the data transferred?	Portal	(physical exchange of) Storage Device	File transfer (e.g. wetransfer, shared disks)	
Other, ……..				
hat data is transferred?	Raw Only (e.g. all recordings)	Scrubbed Raw (all noise and non-target species data removed)	ID only	ID and recordings
Are the potential biological sounds in the cast away retrieved and stored?	Yes	No		
Other, …				
If scrubbed data is used				
At what stage and by what party is the data scrubbed?	Before retrieval, by observer, facility (e.g. software) provided	Before retrieval, by observer, no facility provided	After retrieval of data (centrally)	
Other, ……..				
Validation				
Validation done?	Yes	No		
Is all data validated or a sample of it?	All	Sample		
Done by observers?	Yes	No		

If done by observers: is facility (e.g. software) provided by you?	Yes	No	
If facility is provided: does the facility operate locally (e.g. downloaded software) or on network (e.g. internet)	Locally	Network	
Done after retrieval (centrally)?	Yes	No	
If done centrally: only via software, only by hand vetting or by software and hand vetting	software only	manually only	combination
Storage			
Are you storing data (including and especially raw data e.g. recordings) on (local or SAN) hard disks or in the cloud?	SAN/Local	Cloud	
What was the reason for this choice?			
Remarks			
Who is presently managing the collated data?			
How is future management of the collated data secured?			
Other, ….			
Who is providing storage capacity for you/for your project			
How is future storage capacity for your data secured?			
Other, ….			
What is the average storage capacity you currently need for e.g. 1 year of data?			
Can you give an estimate of how this required capacity will develop in the near future?			
Other, ….			
What technique do you use to retrieve stored data?			
How many times/year do you retrieve stored data?			

II) Appendix II

Summary interpretation of questionnaire acoustic auto-data bats

8 respondents – not always everybody responded to every question. Dutch Mammal Society excluded in below summary

WHICH META DATA ARE RECORDED, OR DEDUCIBLE FROM RAW DATA?		
Meta data	yes	
Are you recording and storing meta data?	7/8	7/8 store meta data
Are you using a custom made format, for encoding of meta data?	4/8	4/8 use a custom made; those who don't use custom made use freely available format
Are you using a freely available format?	5/8	5/8 use freely available format; 1/8 uses both custom and freely available
Date and time of recording?	1/8	1/8 doesn't store date and time; why?
Location coordinates?	8/8	8/8 store location coordinates
Meta data recording	4/8	4/8 store meta data of the recording itself; not everyone understands what metadata on recording is/our question needs definition
Is this information available from your software?	4/8	4/8 have data available from software
Registered weather data	6/8	6/8 store weather data; question needs definition
Is this information available from your recording?	6/8	3/8 store from recording; 1/8 collects his own data; 1/8 uses data from weather station
Data on equipment & observer	5/8	5/8 store data on equipment
Are you recording and storing..		
Specifics and ID of your recording unit?	8/8	

Name observer (+ observer team)?	7/8	
specific of material (incl. mic and sensitivity, and settings of automatic detectors)	7/8	
Meta data on sample point	7/8	
Meta data on sample session / recording session	7/8	questions needs definition
Meta data on ID-process	5/8	1/8 stores in associated access database file
Are you recording and storing ..		
specifics of identifying person/party/software	7/8	
Are you recording and storing ..		
specifics on call quality?	5/8	
specifics on type/version/year of classifier?	7/8	
specifics on used filter settings?	6/8	
used reference material?	6/8	question needs definition
How do you link meta data - (ultra)sound recording - raw data and processed data?		self-written software; database, manually, data base pointing to file location. E.g. guano

➔ Start using broader protocol for storage of meta data
➔ Start using software and storing that are compatible

DATA COLLECTION, RETRIEVING DATA FROM PARTICIPANTS AND DATA STORAGE		
	multiple	specific
Does the data concern a specific project or multiple projects?	4/8	1/8
Does the data concern a single observer/party or multiple observers/parties	4/8	1.8
Is there a facility to reanalyse data?		
Other, ……..		
With wat technique, process and in which form are data retrieved ..		
How is the data transferred?	file transfer, physical device and portal	
Other, ……..		
What data is transferred?	4/8 raw; 1/8 scrubbed; 1/8 ID	
Are the potential biological sounds in the cast away retrieved and stored?	2/8 yes. 1/8 no;	needs definition
Other, …		
If scrubbed data is used		
At what stage and by what party is the data scrubbed?	4/8 before retrieval and software provided; 1/8 after retrieval	
Other, ……..		

Validation		
Validation done?	6/8 yes; also dependent on research question	
Is all data validated or a sample of it?	1/8 sample; also dependent on question	
Done by observers?	7/8 by observer	
If done by observers: is facility (e.g. software) provided by you?	4/0 software provide, 1/8 no software provided	
If facility is provided: does the facility operate locally (e.g. downloaded software) or on network (e.g. internet)		
Done after retrieval (centrally)?	4/8 validation after retrieval; 1/8 wish to develop this to standardize validation	
If done centrally: only via software, only by hand vetting or by software and hand vetting	5/8 combi software and hand vetting; 1/8 manual	
Storage		
Are you storing data (including and especially raw data e.g. recordings) on (local or SAN) hard disks or in the cloud?	6/8 SAN/local; 2/8 cloud (incl. combi cloud/SAN/local); distant storage temp on tape	
What was the reason for this choice?	predictability, convenience, , price, government compliance, price, amount of data, location of the software analysis, backup; step to cloud is anticipated,	
Remarks		
Who is presently managing the collated data?	person/organisation managing the project	
How is future management of the collated data secured?	1/8 organisation, 1/8 successor; 4/8 only storage secured	

Other, ….	availability of funding might impair future accessibility	
Who is providing storage capacity for you/for your project	5/8 research organisation; 1/8 personal budget	
How is future storage capacity for your data secured?	5/8 research organisation; 1/8 personal budget	
Other, ….		
What is the average storage capacity you currently need for e.g. 1 year of data?	3/8 : 1 to 2 TB; 1/8 5 TB; 8 - 10 TB; 1/8 not determined	
Can you give an estimate of how this required capacity will develop in the near future?	Growth is anticipated, but no ideas on how much; doubling.in the next years..	
Other, ….		
What technique do you use to retrieve stored data?	custom software; queries; MongoDB; data warehouse;	
How many times/yr. do you retrieve stored data?	bandwidth very rarely - weekly	

AUTOMATED ACOUSTIC OBSERVATION/MONITORING OF CHIROPTERA	
Are you using (automated) acoustic techniques to study animal species?	
Which species are you studying with manual and/or automated acoustic techniques	7/7 all (regional) species; marine mammals
Which manual and/or automated acoustic technique are you using for what species?	
Are you using automated acoustic techniques for non-bat species that might also record bat species?	5/7 concentrate on bats; 2/7 also birds and or grasshoppers
Which technique targeting non-bat species might also record bats species?	
Are your techniques capturing only the low-frequency non-ultrasound part of bat echolocation and social sounds	7/7 lower frequencies up to ultrasound frequencies
What frequency bandwidth is captured?	range: 0-5 for lower and 156 to 190 for upper
Are your techniques capturing only the high-frequency ultrasound part of bat echolocation and social sounds	7/7 lower frequencies up to ultrasound frequencies
What frequency bandwidth is captured?	
Are your techniques capturing ''the whole band width'' used by bats?	7/7 whole bandwidth
What frequency bandwidth is captured?	
Other,..	

Are you using (automated) acoustic techniques to study animal species?	
Are you using a custom made ultrasound recording device/bat detector?	7/7 use existing brand, but testing of custom made is ongoing
Are you using a custom made ultrasound sensitive microphone?	7/7 use existing brand, but testing of custom made is ongoing
What is the frequency response curve of the microphone?	2/7 have or provide info on frequency response
Other,	
Are you using an industry made, of the shelf, ultrasound recording device/bat detector?	7/7 use available brand
Are you using an industry made, of the shelf, ultrasound sensitive microphone?	7/7 use available brand
What is the frequency response curve of the microphone?	2/7 are considering the frequency response curve
Other,	
What brand and type(s) of ultrasound detector are you using?	Pettersson, Batlogger, Batcorder, Wildlife Acoustics SM2 and SM4, Anabat
What brand and type(s) of ultrasound detector are you using for automated recording?	tranquillity transect and D240x for active transects
Other,	
What technique are you using to make ultrasound recordable?	
TE / sample	
Are you using a **frequency trigger** for the recording?	
What frequency is used as the trigger and why?	TE / Sample : not very much used + no info on settings

Are you using an **amplitude trigger** for the recording?	no use of amplitude trigger
What amplitude is used as the trigger and why?	
Other,	
Is the influence of different trigger settings tested?	
Is there an influence on numbers of recordings, numbers of calls per recording and/or numbers of recorded species?	
Other,	
What is the **% of sampled time** per second?	
Other,	
Real Time (full spectrum recording)	
Are you using a **frequency trigger** for the recording?	No frequency triggers used? No combination of amplitude/frequency triggers?
What frequency is used as the trigger setting and why?	frequency triggers also for bird recording
Are you using an **amplitude trigger** for the recording?	
What amplitude is used as the trigger setting and why?	6dB SNR SM2BAT trigger + equivalence for other devices
Other,	time/frequency trigger; advanced crest
Frequency division?	preference for full spectrum
Are you using a **frequency trigger** for the recording?	
What frequency is used as the trigger setting and why?	

Are you using an **amplitude trigger** for the recording?	
What amplitude is used as the trigger setting and why?	
What sample rate is used for the digitalisation of the recording?	
Other,	
What brand and type of microphone are you using?	different brands; also as standard with detector brand
What frequency bandwidth is captured by the combination of detector and microphone?	Standard as with detector + special for grasshoppers birds and bats...
What is the frequency response curve of the microphone?	
What is the directionality of the microphone in response to the frequency?	
Other,	
What is the relative sensitivity of the set up for different species?	
Has the relative sensitivity for different species been tested?	
With artificial ultrasound? With play back of recorded species?	
With different bat species flying towards the microphone?	
Other,	
Has the influence of weather conditions on the sensitivity and samples volume been tested, or taken into account?	
What is the influence of air humidity on your set up?	no practical consideration to influence air humidity on set up
What is the influence of air temperature on your set up?	influence of temp is not understood; but used as covariate
What is the influence of wind speed on your set up?	

What is the influence of wind direction on your set up?	
What is the influence of relative wind speed on you set up? E.g. In case of transects (car, bicycle...)	relative wind speed - more noise lower recording quality

SPECIES IDENTIFICATION - species ID (relevant for automated recording)	
What ultra sound recording type and information density is used for ID?	
Are you using full spectrum real time recordings for ID	5/7 yes FS/RT
Are you using full spectrum 'time expanded' recordings for ID	3/7 yes TE
Are you using zero-crossing analysis, frequency division recording for ID?	1/7 yes FD/ZC
Are you using zero-crossing analysis on full spectrum recordings for ID?	1/7 ZC/FD on FS/RT
Other,	
ID level	
Are you targeting ID to the species level?	1/7 not on species level; 5/7 yes when possible
Are you targeting ID to the level of higher taxa?	5/7 yes to higher taxon (genus or species group), if necessary
If so, are you differentiating between the species and species groups?	2/7
Other,	
Which species are ID'd to species level?	none - all where possible/all excluding Plecotus; and with varying confidence levels
Which species - species group are ID'd to group level?	pragmatic approach ; N/E/V; Pspec or specific combination, Mspec of specific combination, Mspec+Plec
Other,	
What are the higher taxa, groups you are using (genus, species pairs or groups)?	pragmatic approach ; N/E/V; Pspec or specific combination, Mspec of specific combination, Mspec+Plec

Other,	
Are you differentiating between recording qualities when differentiating between ID levels?	3/7 no differentiation between recording quality for ID's; 3/7 yes and impact on confidence level; relying on ID by observer
Other,	
Are you working with social calls in ID?	5/7 also use social calls; 1/7 does not - depending on research design
Are you working with bat passes/pulse train in ID?	5/7 yes pulse train
Other,	
ID approach	
Is species ID performed by a human observer?	3/7 ID by human. 2/7 ID human for validation; 1/7 no
Is species ID from your own data collection handled by you?	ID own recordings; cross verification; others when necessary and available
Is species ID for different observation sessions by multiple observers/teams centralized via a single expert/smaller team of experts?	sometimes ID is centralized, but often also ID by decentral groups
Is species ID for different observation sessions by multiple observers/teams decentralized via different observers/teams?	sometimes ID is centralized, but often also ID by decentral groups
Are ID's generated in a decentralized approach checked via a single expert/smaller team of experts?	3/7 no later check by independent specialist; samples checked by independent...
Other,	
Is species ID done through a classifier using automated bat ID software?	6/6 use classifier auto ID software
Are you using sound parameters for the ID?	6/6 use sound parameters
Are you using visual parameters on the call shape?	4/6 also use visual parameters

Other,	
Are you using your own custom made software?	3/6 use custom made software; custom made can also be freely available; own input in library for classifier
Are you using software available on the market?	5/7 use software from market
What software brand and version are you using?	
Other,	
Are you using a 'multiple auto-analyses' approach combining different software?	2/7
What combination of software packages (brand, version) are you using?	
Other,	
Are you using software that is offered as a package with the detector brand and/or type?	2/6 use software that is package with detector 4/6 use different software
Other,	
Classifiers / filter settings	
Are you scrubbing your data with a custom made ''noise filter''?	2/6 use some level of scrubbing, but scrubbing is also seen to lose ''other'' data;
Other,	
Are you using a custom made classifier (set of filter criteria)?	5/7
Other,	
Are you using a general classifier, available from the market?	3/7

Are you using a regional classifier, available from the market?	3/7
Are you knowledgeable on the filter settings for you classifier?	3/7 + not relevant
Other,	
Are you using manual vetting of (a sample of) ID's?	2/7
Are you using manual vetting on a random sample?	3/7 + stratified in relation to difficulty
Are you using manual vetting on a selected sample of 'difficult species'?	4/7
Other,	All Auto-IDs are verified by human observer
What is the S/R ratio used to identify the presence of a 'bat call' in the recording	4/7 + relation to background noise + no/working with period trigger + quality index
Are you purposely using this particular S/N ratio?	4/7 + fine tuning towards optimum
Do the classifier and/or software allow you to freely choose S/N settings?	5/7 + use standard setting
Do the classifier and/or software require you choose a specific dB value, specific S/N setting?	no
Other,	
Are you knowledgeable of what general % of calls you will be missing as a result of the selected settings?	
Other,	
Are you knowledgeable of what % of calls you will be missing for specific species?	3/7 needs definition
Are you knowledgeable of the relative % of calls you will be missing for the different species?	3/7
Other,	

What % of ID confidence are you taking as accurate enough for the ID?	40 - 70 % + hand vetting
Is this dependent on the species?	4/7 + relative abundance of species in a region in relation to potential species group
What % of ID confidence are you taking as accurate enough for the ID of different species?	depending on species
Other,	
Reference libraries	
Are you storing you own - ground-truthed - recordings of species to a reference library?	3/7 + subject that needs improvement
Which reference libraries are you using?	personal libraries, and published libraries, Barataud
Other,	
In general a higher S/N ratio results in less false positives, but more false negatives in the number of calls recognized in the recordings.	The issue of the relation of S/N with less or more false positives in 'ID' – versus - ` number of recognised bat calls in recording' needs more discussion
Using a lower S/N ratio leads to more false positives, and less false negatives.	

OBSERVATION DESIGN / MONITORING DESIGN		
What is the unit of one sample session/recording session (day/evening/night, transect, month, ..)?	2/7	interval
Other…		
Are you recording on **fixed points**?	6/7	+ depending on project
What is the duration of a sampling/recording session?	4 min - 15 nights	bandwidth + depending on project
What is the time of beginning / ending of a sampling session?		
Other…		
On what height(s) are you recording?		
Other,		
Are you recording on **transects?**	3/7	consider fixed versus transect
What is the length of the transect?	3/7	couple of 100 m to 20 km
What is the time of beginning / ending of the transect?	3/7	30 - 45 min after + 15 min before
Other…		
Are you continually moving while following the transect	3/7 + 1/7	yes + no
What is the way of moving (car, bicycle, on foot, boat, ..)	3/7	by car and on foot
What is the (targeted) speed at which you are moving?	3/7	20 - 25 km, standing while recording, 3 km hour
Other…		
Are you also doing **point counts on the transect**?	1/7	

What is the number of point counts on the transect?	> 10	
What is the duration of one point count session?	> 15 min	
Are the point count sessions on fixed preselected locations?	1/7	depending on project
Other…		
Are you recording while freely **roaming** through study area?	1/7	
Other…		
Are you recording in one sample session or visit?	3/7	needs definition
Or are you performing repeats?	5/7	
How many repeats are you using?	2 to > 10	depending on project
Other…		
Are you registering numbers of calls?	6/7	
Are you registering bat passes, pulse trains?	5/7	
Are you registering numbers of recordings (e.g. Wav-files)?	6/7	
How are you dealing with auto correlation of recordings?	5/7	fitting models with random terms; temporal clumping in 5 min; spatial clumping within 1 km
Other…		