The Tethys Metadata Interface in PAMGuard

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Tutorial Version 1.1

Learning Outcomes

In this tutorial you wil learn to:

1. Install Tethys and launch the Tethys Server
2. Add a Tethys module to PAMGuard and connect to the Tethys Server
3. Export data from PAMGuard to Tethys, including:
    - Calibration data
    - Deployment data
    - Detections
4. View the exported data both from within PAMGuard and using the Tethys Web client

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1 Glossary

Table 1: Glossary of terms used in this tutorial

Term	Meaning
Tethys	Mother of the Greek river gods. (Also the name of a database system designed to handle metadata from passive acoustic studies).
Tethys Server	Software that you'll run on your computer which controls the database and allows other software to communicate with the database, writing and reading records.
Tethys Database	A set of Tethys data records
Tethys Client	Software that can communicate with the Tethys Server. The two clients you'll use in this tutorial are the Tethys Web client, which runs in a web browser (Chrome, Firefox, etc.) and PAMGuard, though you can also use Matlab, R, and other programming languages to build your own Tethys clients.
PAMGuard	The PAMGuard software, containing a suite of detectors, classifiers and localisers for different sound types.
PAMGuard dataset	Data output from PAMGuard. This generally comprises both a PAMGuard database AND a PAMGuard binary store. A PAMGuard dataset has information from a single device, usually from a single cruise. e.g. if you've been doing surveys from a single vessel over a period or weeks or months, that should generate a single dataset. However, if you'd deployed multiple autonomous recorders, or had two or more vessels out working at the same time, you'd have multiple PAMGuard datasets.
PAMGuard database	One of the data storage systems PAMGuard uses. This is a relational database (usually sqlite) containing information about PAMGuard operation, configuration, and DCL output.
PAMGuard binary store	A set of bespoke data files associated with a PAMGuard dataset. These can contain a lot more detail than the PAMGuard database, provide more rapid data access times, etc.

2 Introduction

In this tutorial, you'll learn how to export data from PAMGuard to a Tethys database and to view the exported data both within PAMGuard and through the Tethys web interface.

PAMGuard is widely used software for the Detection, Classification, and Localisation of animal sounds, particularly marine mammals. PAMGuard can run multiple state of the art algorithms, backed up by a powerful user interface, allowing the user to interact with the detection data.

Tethys is a temporal-spatial database for metadata related to passive acoustic studies. Unlike the PAMGuard databases, which hold a lot of detail about a single dataset, a Tethys database can hold summary data for many projects – that can be every project for you as an individual, your lab, or for multiple labs across a larger organisation.

Both PAMGuard and Tethys are available for free under open source software licenses.

Tethys does not replace existing PAMGuard databases and binary storage system since it's not possible to get the level of detail PAMGuard uses during analysis into a single general database.

However, the intent is that Tethys will contain enough detail for extensive meta-analysis across large temporal and spatial scales, eliminating (or at least minimising) the requirement for researchers to go back to the original PAMGuard data sets.

3 Installation

You can carry out these exercises with any data you like, so long as you have it set up for looking at in the PAMGuard Viewer. We've provided a North Atlantic Right Whale dataset to get you going and the exercises will refer specifically to detectors and operations possible with this dataset. We recommend that you go through the exercises once with our data, then go through them again with your own.

3.1 Software

3.1.1 PAMGuard

This tutorial will work with PAMGuard version 2.02.15 or later, and Tethys version 3.1.

If you are running PAMGuard version 2.02.15 or earlier, you must enable Tethys in PAMGuard by specifying the -smru option as a command line option (Figure 1) when you install PAMGuard.

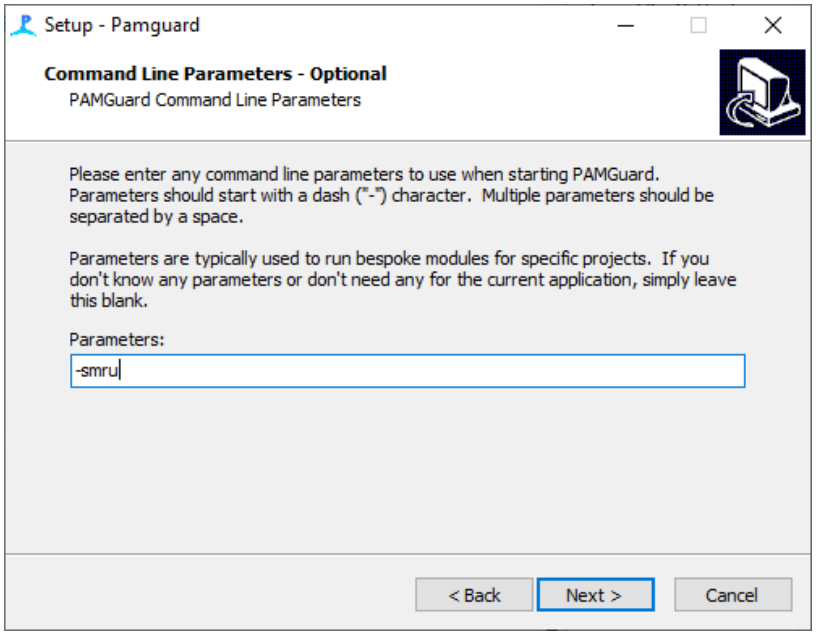


Figure 1: Setting the -smru command line option during installation

3.1.2 Tethys

Download Tethys 3.1 from Zenodo. Two databases are available, **demodb.zip** contains example output from other studies and will allow you to explore all Tethys functionality in full. The smaller **metadata.zip** contains only an empty database. We recommend that you use **demodb** for now, then switch to a blank database when you're ready to start serious work on your own data.

Unzip the database to a location of your choice. The demodb download is approximately 2 GB and it will require about 18 GB on your machine. The vast majority of the size is attributable to the content of the databases that are distributed with the installer.

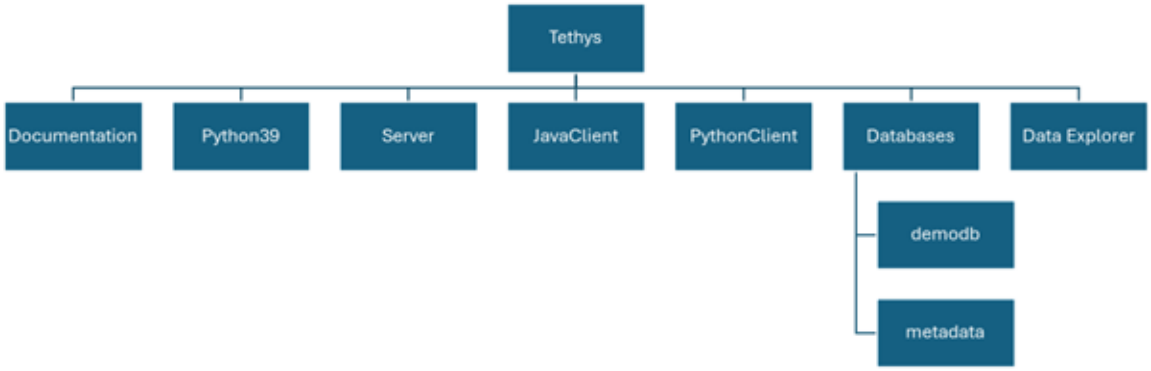


Figure 2: Folder Structure of Tethys

> **Tip**
>
> The unzip functionality that is bundled with Windows can be very slow, if you have a dedicated zip archive manager such as WinRAR or 7Zip we recommend that you use these as they are at least an order of magnitude faster.

Tethys consists of a server program that manages the database, a set of client programs that can communicate with the server, documentation, and the database directory that will either be the demonstration database that contains sample data (demodb) or a blank database (metadata). The programs and data in the zip archive have the folder structure shown in Figure 2. Take a look, particularly at **Documentation**.

PAMGuard sends DCL data to Tethys in a format Tethys can understand directly. If you wish to use other sources, such as importing from spreadsheets or databases, additional software must be installed. See the installation chapter in the Tethys server guide for details. Additional software is also required if you wish the web client to export data in a hierarchical R data format.

To start the Tethys Server, navigate to the folder where you installed the Tethys database and double click on the tethys.bat file. Some system administrators restrict this functionality, and if that does not work, you can open a command line shell and navigate (via the cd command) to Databases\demodb. Type tethys.bat and press enter.

The Tethys server is written in the Python programming language and you are likely to be prompted to allow Python to communicate over the network (Figure 3). Tethys "talks" to client programs on port 9779 and this must be enabled before clients can communicate with Tethys. More information on the firewall is in the Tethys server manual.

After approving the network access, you should see something similar to the following output:

```
[15/May/2024:11:02:51] Welcome to Tethys, 3.1 - Server starting...
No server configuration file at ...\Tethys\ServerDefault.xml (not an error), using internal defaults
Examining logs in ...\databases\demodb\db to verify that database is correct.
Log processing started at 2024-05-15 11:02:51.362099
Cache size set to 1.00 GB
Log processing complete. started at: 2024-05-15 11:02:51.362099 elapsed 0 days 00:00:00.329252
Checkpointing database ...\databases\demodb\db...  checkpoint complete
Cache size set to 1.00 GB
BSDDB environment initialized
```

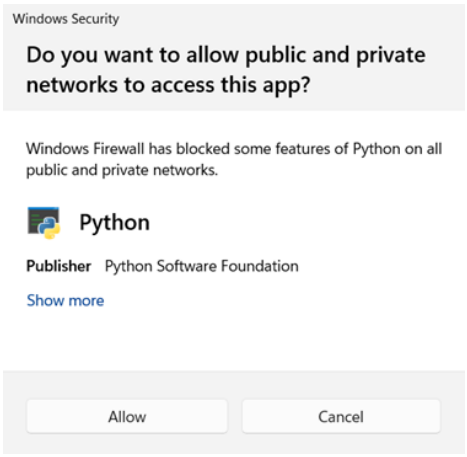


Figure 3: Firewall notice when Tethys starts. Windows is asking permission to allow the database server to communicate over a network port. This is required for the Tethys server to communicate with PAMGuard as well as client tools such as the DataExplorer

```
Starting DB XML in transactional mode
Query cache: 128 GB at C:\Users\marie\AppData\Local\Temp\tethys-build\databases\demodb\diskcache, en
Cannot start R, environment variable "R_HOME" is not set
[15/May/2024:11:02:55] ENGINE Bus STARTING
[15/May/2024:11:02:55] ENGINE Started monitor thread 'Autoreloader'.
[15/May/2024:11:02:56] ENGINE Serving on http://0.0.0.0:9779
[15/May/2024:11:02:56] ENGINE Bus STARTED
[15/May/2024:11:02:57] Web interface at http://vaquita:9779/Client
[15/May/2024:11:02:57] R programming language interface unavailable
```

Next, test that you can communicate with the server. The easiest way to do this is from a web browser. Type localhost:9779/Client into your browser and the web client should load (Figure 4).

Press **Deployments** and you should see the locations of the instrument deployments stored in the demonstration database after a short delay. You may also want to try the following additional steps:

- If you wish to save from the web client in R's data.tree format (requires an R library available from CRAN), you will need to install R on your machine and let Tethys know where to find it. See directions in the Tethys manual (Documentation/Tethys.pdf), section "R installation for data export" (page 9 as of this writing).
- If you are a Matlab user, directions on setting it up are in the Matlab Cookbook in the documentation folder.
- We recommend that you verify that the data explorer is working, follow the instructions in Documentation/DataExplorerManual.pdf to start it.

3.1.3 SQLite Studio

It is not essential to download SQLite Studio, but if you want to easily look inside the PAMGuard database you can download it here. Other SQLite viewers are available, but this is the one we mostly use.

3.2 Data

The dataset we'll be working with is seven days of continuous recordings collected in Cape Cod Bay in 2008 with a Cornell MARU device. These data were prepared for the 2013 DCLDE workshop held in St Andrews. The data have already been processed using two different right whale detectors:

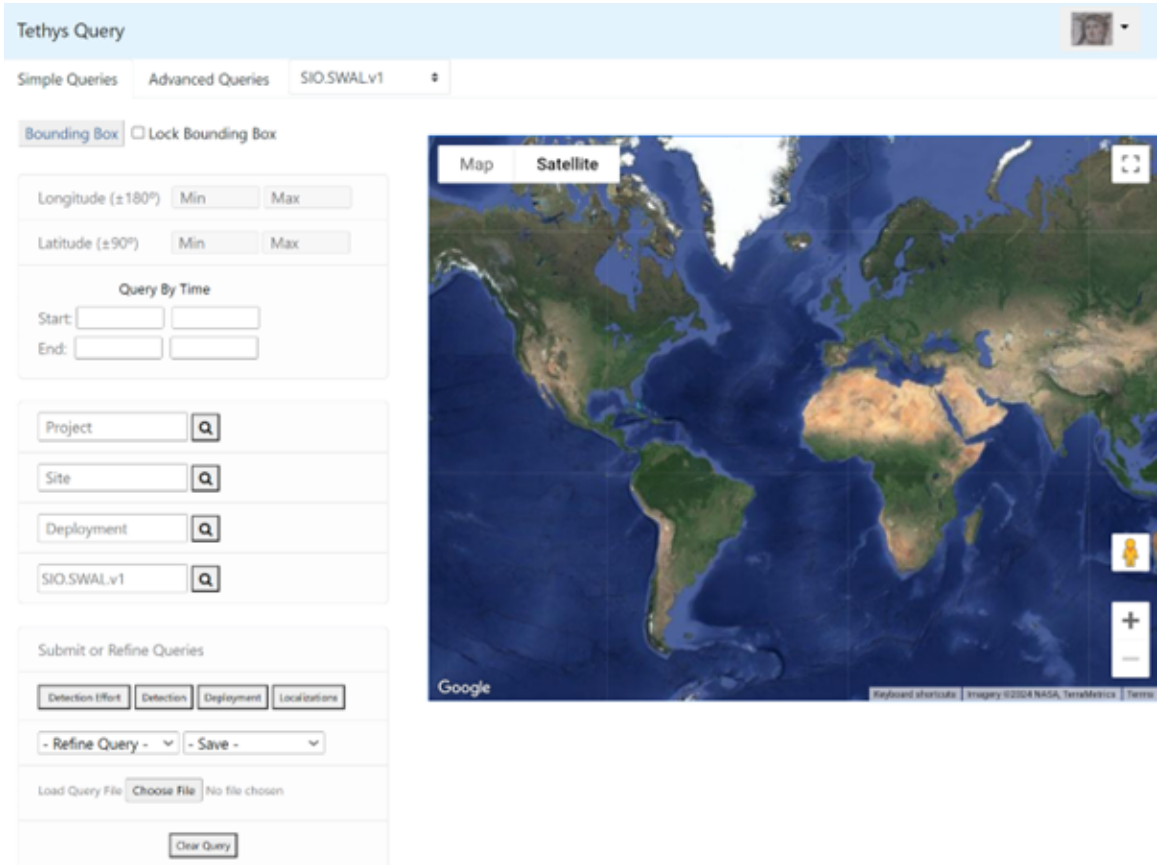


Figure 4: The web client accessible at http://localhost:9779/Client

the Deep Learning detector (Shiu et al. 2020) and the older right whale edge detector (Gillespie 2004). We've also run some noise measurements on the data. Output from the detectors is in both the PAMGuard database and set of binary files which you can download here. Unzip the files into a folder of your choice.

Having the wav files is not essential for the completion of the exercises, but it's good to have them, or at least to know where they are. Wav files are available as part of the DCLDE 2013 workshop dataset. You will need the zipped archive NOPPWavFiles.zip. Download the files into a folder of your choice.

4 Launch PAMGuard Viewer

The PAMGuard Tethys module is only available in Viewer Mode.

To get started, launch PAMGuard viewer mode, when it asks for a database, navigate to the NARWExample.sqlite3 database that you downloaded. When you launch the viewer, it will ask for the location of the PAMGuard database (Figure 5) and then the PAMGuard binary store (Figure 6). By default, it will probably look for these files where I had them stored on my computer and you'll have them somewhere else, so navigate carefully to the correct database file and binary store folder.

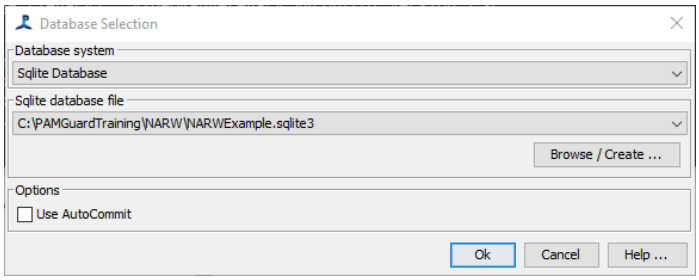


Figure 5: PAMGuard Viewer database selection

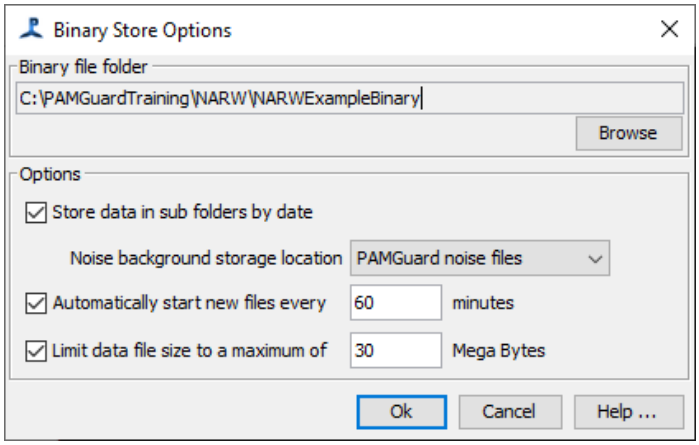


Figure 6: Selecting the binary storage location

> **Tip**
>
> Did you know that if you right click on the database file, you'll get an option to open the database in the PAMGuard Viewer from Windows Explorer (Figure 7).

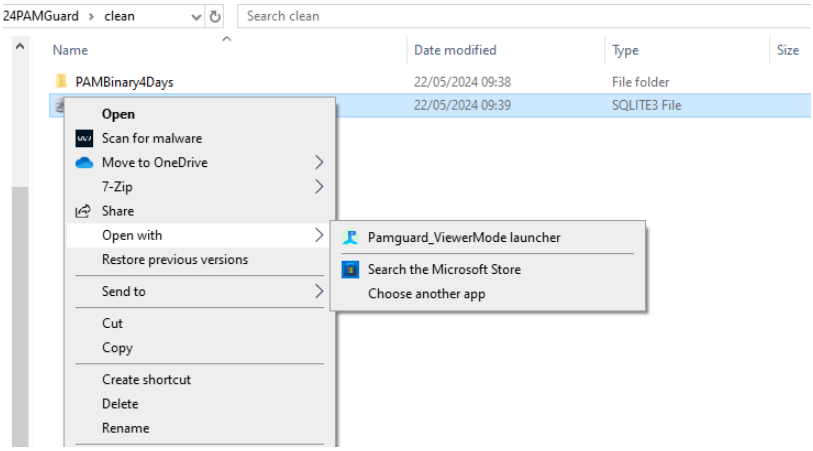


Figure 7: Menu Command to open the database

If you've downloaded the raw recording files, you can tell PAMGuard where to find these from the Settings / Sound Acquisition menu (Figure 8). Note that having the raw audio available at this point isn't essential.

Have a quick scroll through the data and you should be able to see both the DL detections, which appear as a shaded rectangle over the full bandwidth of the spectrogram (Figure 9), and the edge detections which show the outlines of the sounds. You'll probably notice that there are more DL detections than there are edge detections. This is because the DL detector is better than the edge detector as shown in (Shiu et al. 2020).

5 Add the Tethys Module

To communicate with Tethys, you'll first have to add the PAMGuard Tethys module. This is available in the File / Add Modules / Utilities menu. If you can't find it, then you've an old version of PAMGuard, or you've not followed the PAMGuard installation instructions in Section 3.1.1 properly and set the -smru option (Figure 1).

The first time you run you may get a security warning (Figure 10). Say OK to everything. If you don't have admin rights, you may have difficulties here !

Once the Tethys module is added, go to the Tethys tab, the PAMGuard display should look like (Figure 11a).

If the top area of the display is coloured orange (Figure 11b), then it means the Tethys server is not running properly or that PAMGuard is failing to communicate with it. Start the server according to the instructions above and read the installation document. Once the server is running, the PAMGuard display will be a normal grey colour. If you can't get this to work, ask for help.

5.1 Project Information

A key goal of Tethys is accurate recording of project metadata. This includes obvious information such as hydrophone calibrations and locations of data, but also includes more nuanced information such as the motivation for the project deployment and who the responsible person for the data is. For example, many density estimation methods require that data are sampled at random locations in space (either through random instrument deployment or track-line layout), so if the data were deliberately targeting known hot-spots, they may not be suitable for density estimation, and users of the Tethys database will need to know this. Additional project information data entry fields have been added to PAMGuard in support of Tethys integration and should now be filled in. This

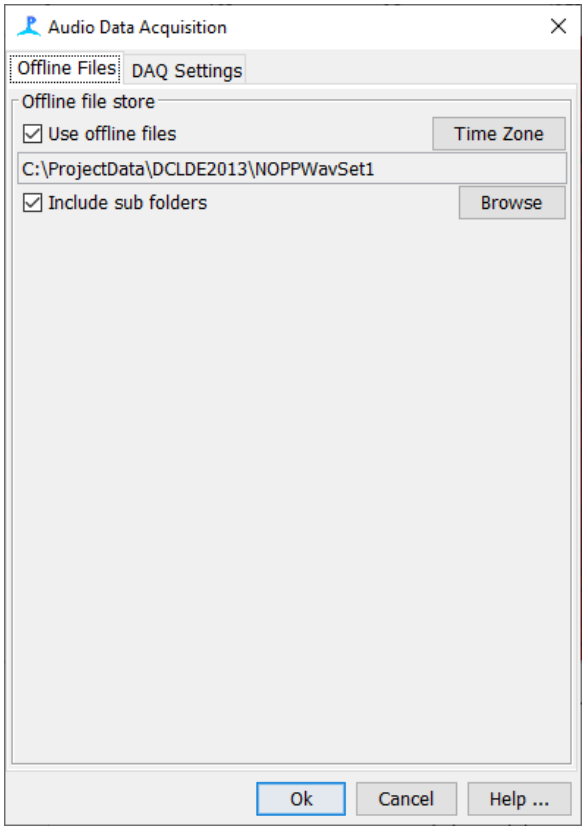


Figure 8: Setting the sound file location

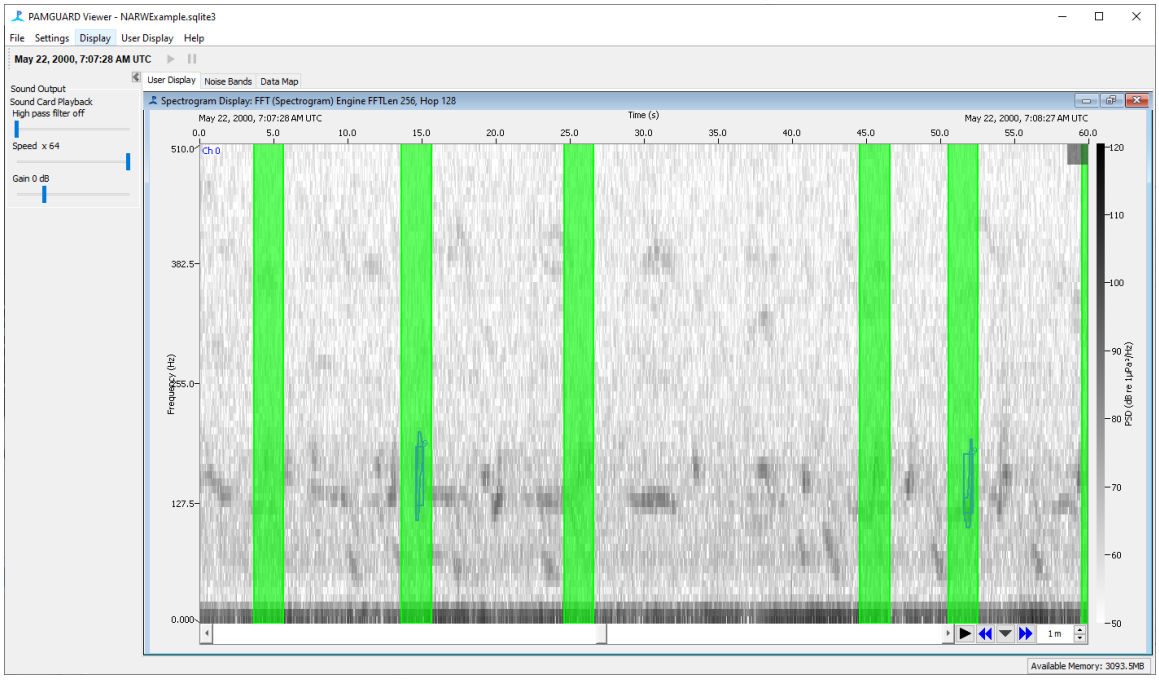


Figure 9: Viewing data in the PAMGuard spectrogram. The green bands are detections from the Deep Learning detector. The smaller marks are from the Right Whale Edge Detector

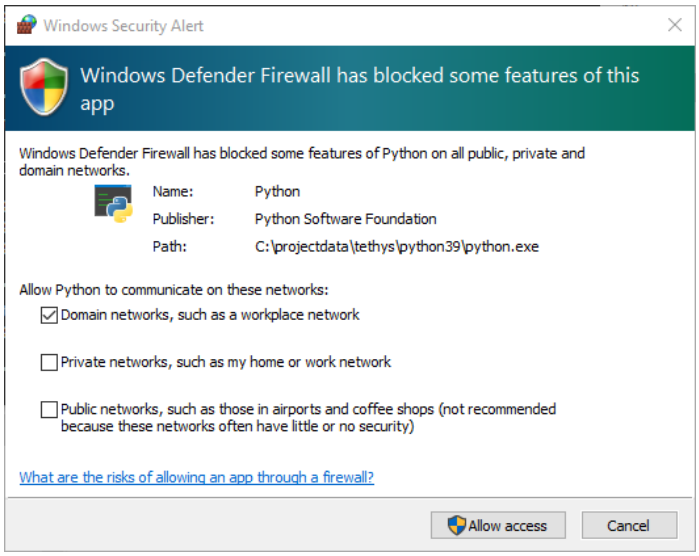
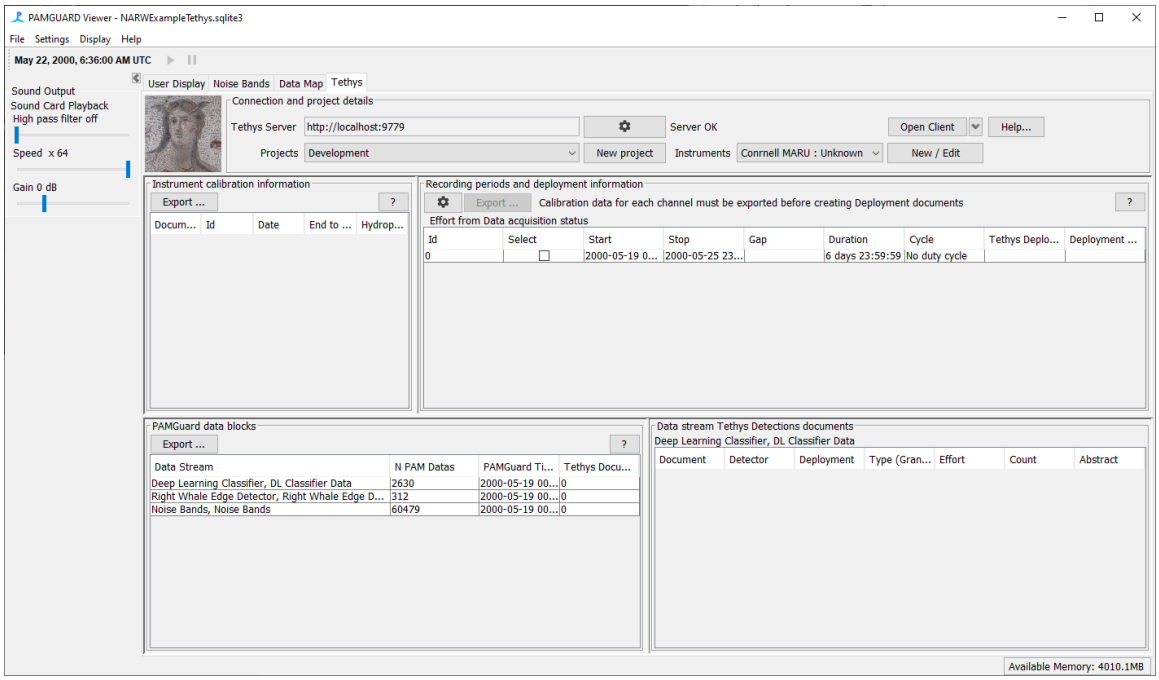
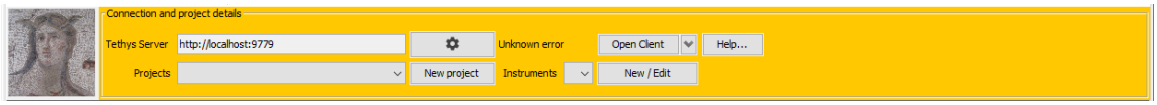


Figure 10: Windows security warning you'll get the first time you run Tethys



(a) The Tethys tab panel with a successful server connection

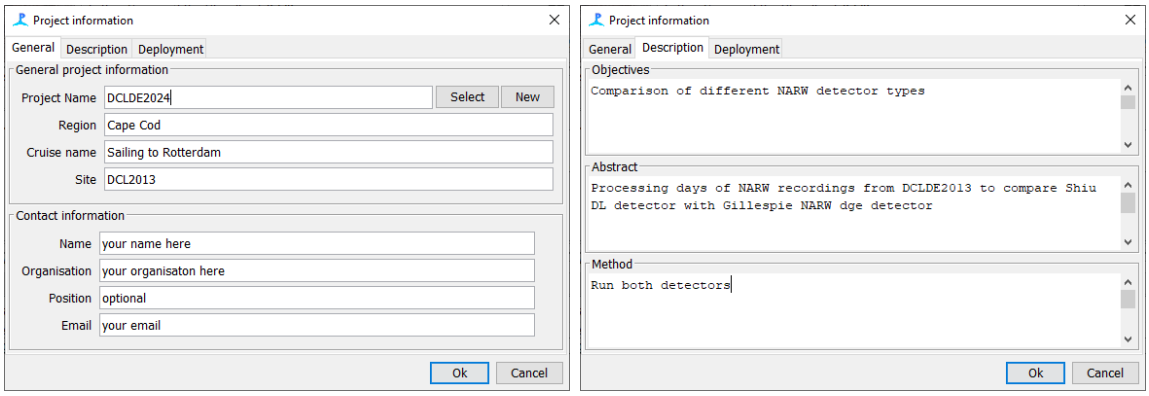


(b) The tethys panel in error state when it is unable to connect to the Tethys server

Figure 11: The Tethys Tab Panel in PAMGuard. This is where you interract with Tethys to export and view data

information is available in the Settings / Project Information menu, or can be filled out as you export data to Tethys.

The project information follows the schema laid out in (Roch et al. 2016) and you are encouraged to fill in as much as possible. Since this is just a test, fill the data as shown in Figure 12. Note that it's worth filling in the project metadata for all PAMGuard projects, even if you don't use Tethys. Do it at the start of your project while it's still fresh in your mind.



(a) General information

(b) Project description

Figure 12: PAMGuard dialog for project information.

In the 'Deployment' tab, set it to "Use start and end times of collected audio data"

Obviously, for 'real' data, you'd enter a lot more detail at this point.

> No promises, but there is no harm in asking ...
>
> At this point in the software development, it's a really good time to make suggestions. Do you want the boxes for project information to be bigger ? How much text do you want to put into them ? Should you be copying in your entire cruise research protocol ?

5.2 Hydrophone / Instrument information

The hydrophone calibration and location information have already been set in the PAMGuard database, but the discerning among you may notice the additional "Instrument Type" and "Instrument Id" fields in the hydrophone array configuration (Figure 13). These are required by Tethys and, along with the project name, are used to link Tethys data to PAMGuard data whenever the PAMGuard configuration is opened with the Tethys database module in the future. These are part of PAMGuard whether you use Tethys or not, and you're encouraged to fill them in to keep a record of what you've been doing.

6 Tethys Data Export

There are four main types of Tethys document:

Calibrations – information about the individual hydrophones used.

Deployments – information about deployment locations, dates, motivations, etc.

Detections – detections (or noise measurements) found within the data.

Localizations – localisations of detected sounds in one, two or three dimensions.

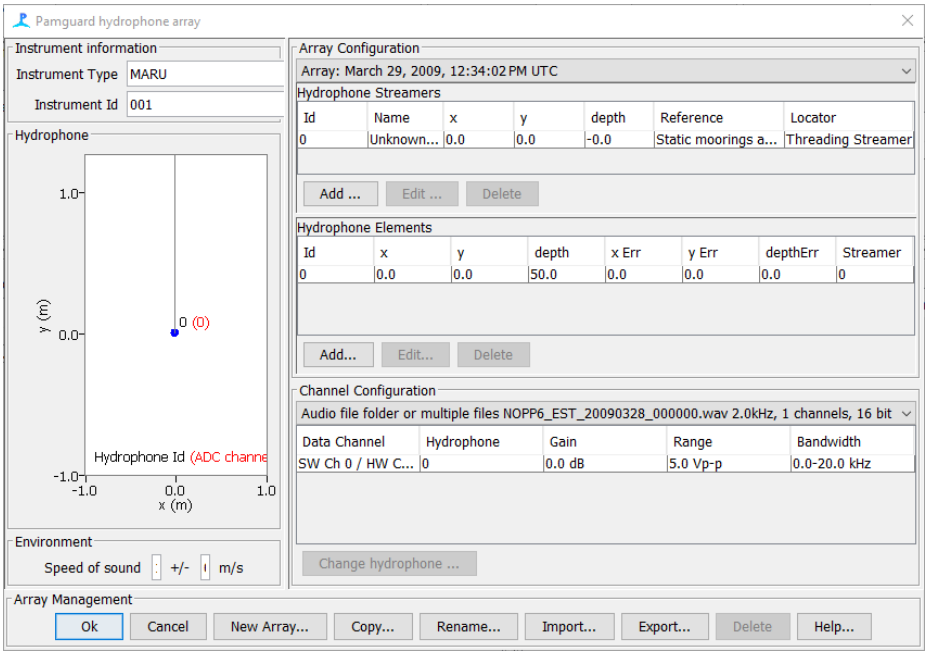


Figure 13: The PAMGuard Array Manager dialog

These should be exported in order so that the Deployments can reference the Calibrations and the Detections can reference the Deployments, etc.

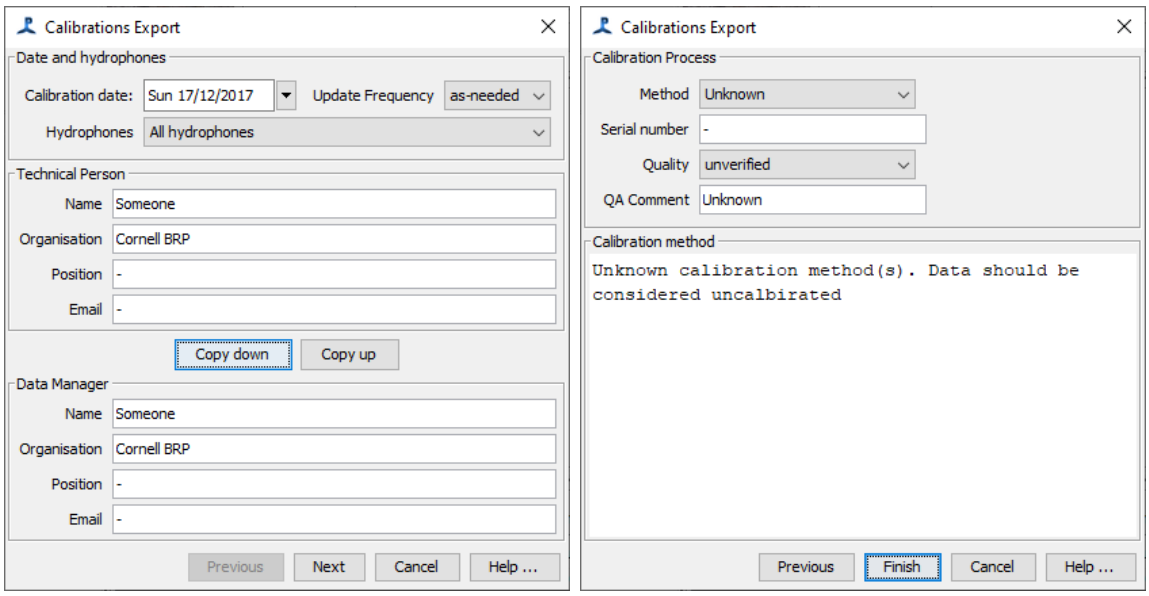
> No promises, but there is no harm in asking ...
>
> What types of calibration data do you have for your own studies ? Will it fit into these data fields or do you require something different ?

For each type of data, there is an export Wizard. Ideally, you should know what to put in most of the data fields, but if you're exporting older data may not be able to do this fully – for example, we've no idea how the data we're using in this example were calibrated, let alone the serial number of the device used in the calibration. (Hopefully, the data owners do know that, but we've not had time to dig that information out). Going forwards, these are all things you should be noting down for every one of your projects if you want the data to be useful in years to come. Honesty is essential though: if the system was not calibrated, then say so !

6.1 Export the Calibrations

(in this case there is only one hydrophone, so it's a 'calibration') fill in as much information as you can in the dialog panels (Figure 15). You'll get either a popup window telling you that the export has succeeded, or an error message.

> See what you've exported so far
>
> If you want to, at this point, skip to Section 7 below and look at what you've exported to Tethys using either the Tethys Client or the internal PAMGuard tools.



(a) Calibration date and contact information

(b) Calibration process details

Figure 14: Calibration information dialog

6.2 Export the Deployments

Here you'll get a chance to review the project information that you entered earlier. This is critical information since any future analysis will probably want to know the motivations behind the data collection. For example were instruments laid out at random as part of a density estimation study, or were you targeting an area known as a whale hot-spot anyway.

Data Locations: This will default to the folders on your computer that currently hold the sound files, the database, and the binary store. If you can, change these to where permanent copies of the data are stored, e.g. the server address or DOI for the raw audio files you've used as in Figure 15a, (or perhaps for your data it's the name of a cupboard full of hard drives in a dusty basement?). People may want to find these data long after the computer you're currently using has been recycled.

6.3 Export Detections and Localizations

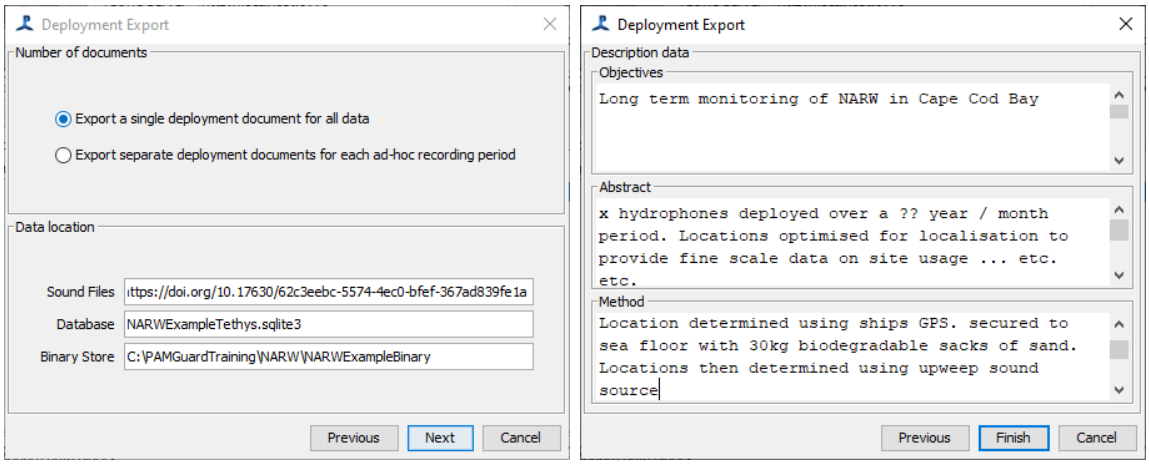
6.3.1 Species Codes

PAMGuard will not allow you to export data to Tethys until you've correctly defined species information for your detections.

Tethys uses ITIS Taxonomic Serial Numbers (TSN's) from the database at https://www.itis.gov/. These are numeric codes for every known species at all taxonomic levels, e.g. you can have a code at the species level (e.g. 180517 is for dens beaked whale), the Genus (180506 is for Mesoplodon), the Family (770799 is for Hyperoodontidae) all the way up to Animalia (202423). This is important, since some detectors / classifiers really might be working at the species level, for others you may just know that it's clicks or whistles from an Odontocete (180404) but have no idea which species it actually is.

Thinking of odontocetes raises another issue: Many odontocetes make several types of call, for instance clicks, whistles, and burst pulse sounds and you'll probably want to distinguish between them in your database. Therefore, Tethys detections have both a compulsory ITIS species code AND an optional *call type*.

Fortunately, you don't need to learn these species coded by heart or go to the ITIS website to look



(a) Data locations (b) Deployment details entry

Figure 15: PAMGuard dialogs for entering essential information about the deployment. Tell people where to find the data, which should ideally be an online archive rather than a folder on a computer that may not exist in a years time. also say Where, why, and how the data were collected. Knowing the motivation behind the data collection is essential in understanding statistical models using those data.

them up (it's a bit slow) since they are all already in the Tethys database you're working with and PAMGuard can search for them.

Different PAMGuard detectors have different numbers of species defined. For instance, the click detector has a 'default' species that clicks will be assigned to, which you'll probably set to Odontocete, but if you're familiar with the click detector, you'll know that you can define any number of species classifiers which may be for different anthropogenic sounds as well as for different species of marine mammal.

In the lower left panel of the PAMGuard display, titled "PAMGuard data blocks", right click on the first row in the table "Deep Learning Classifier, DL Classifier Data" and select "Species info …" to open the species code dialog. For the DL classifier, there are only two classes: not right whales (or "Noise") and Right Whales. The detector is designed to only detect up-calls, so your species dialog should look similar to Figure 16.

Have a play around. Click on the 'find button' and use the species search dialog (Figure 17) yourself. Try typing 'right whale' into the search term and you'll get a list of 13 different codes with right whale in their name (I didn't expect that many either – I though there were three). Select the one you want and press OK.

> **Note**
>
> Putting these codes into multiple similar projects can get a bit tiresome. It's not possible to make a "standard" translation between the codes that PAMGuard detector use and ITIS since everyone sets up PAMGuard in a different way. However, I am thinking about "Export" and "Import" buttons on these dialogs so that you can move the TSN translations between your own projects more efficiently.

6.3.2 Export the Data

Once the species codes are all in place, you can export the detections by pressing the "Export …" button.

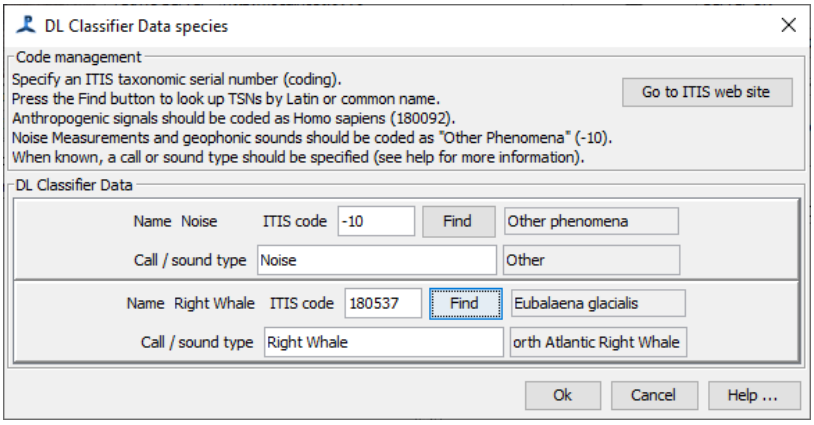


Figure 16: PAMGuard dialog for setting up ITIS species codes. Some PAMGuard modules may only have a single species, others, such as output from click and whistle classifiers may have many different species set by the user. Each internal species name within PAMGuard must be associated with an ITIS code

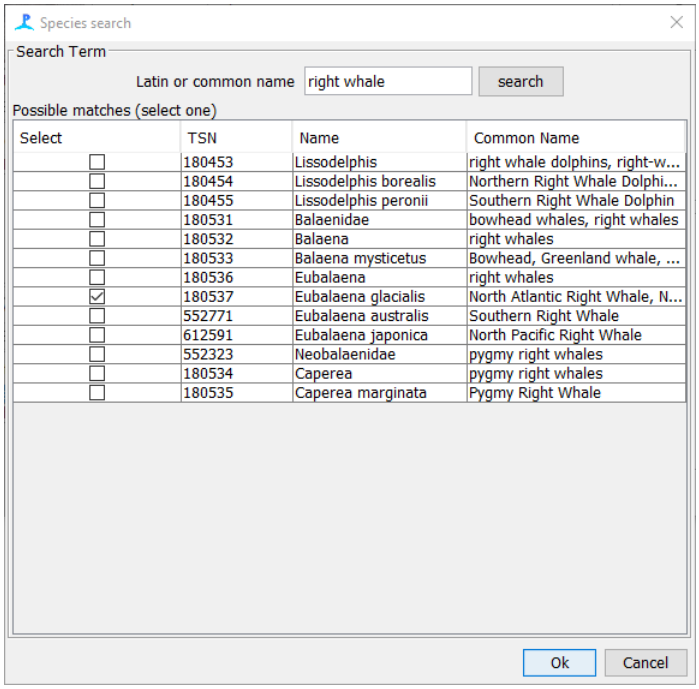
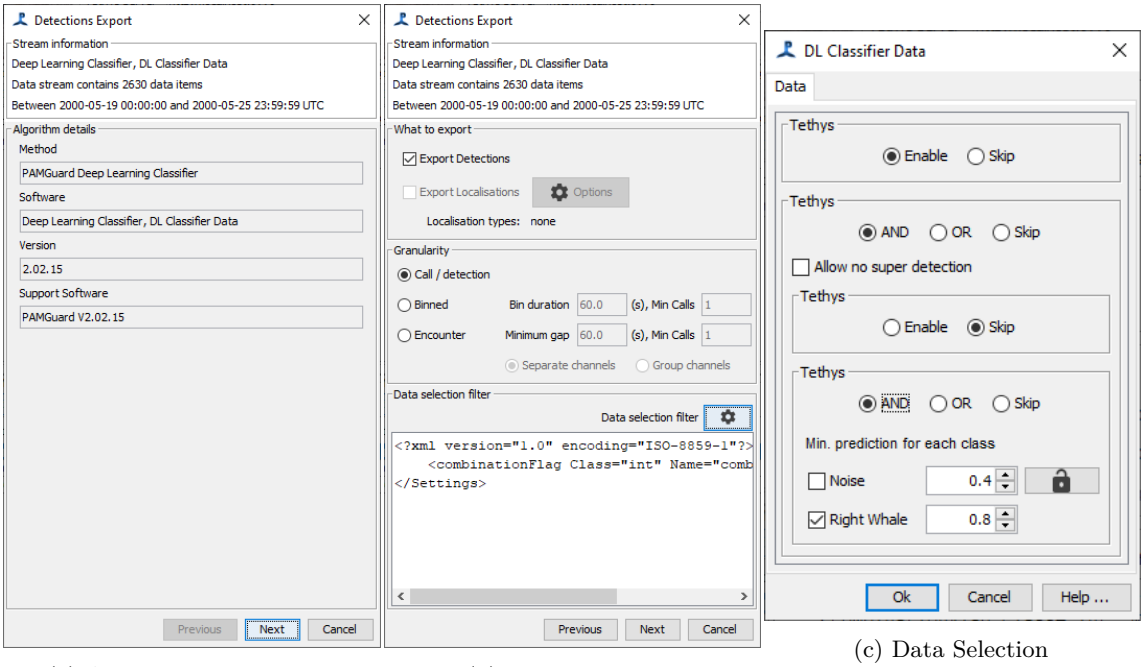
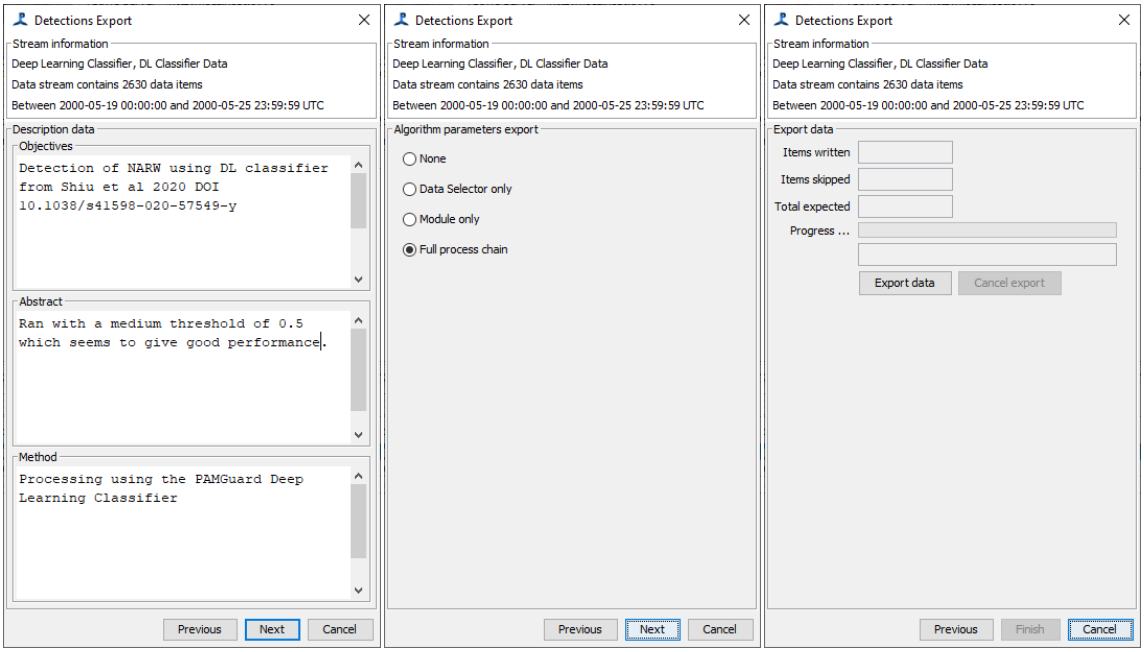


Figure 17: The PAMGuard ITIS Species code search dialog



(a) Automatic Information (b) What to export (c) Data Selection



(d) Details about the data (e) Algorithm parameters (f) Export progress

Figure 18: Pages of the Detection and Localization export wizard.

Again, this will take you through several pages of a "Wizard", as shown in Figure 18 where you'll enter more information. The first page (Figure 18a) is filled in automatically with information about the detector and the PAMGuard version you're running.

The second page, Figure 18b is much more interesting, where you'll chose whether you export Detections, Localizations, or both. If you're doing both, it's a good idea to do them at the same time so that the Localizations document can easily cross reference to the Detections. (Note that these data don't have any localizations, so that options is not available.) You'll also select the **Granularity** which can be "Call", "Binned", or "Encounter". Note that if you're exporting localizations, then only "Call" granulatity is allowed.

"Call": If you select call, then every single call in your dataset will be exported to Tethys. This is probably OK for baleen whales, where data rates are not too high, but we'd advise against trying to export too many millions of clicks from an odontocete dataset.

"Binned": This exports counts of data in fixed time intervals of your choosing which could be seconds or days. If you like C-POD like porpoise positive minutes, this is the option for you. For data with a high call rate it's certainly a good way of getting a summary of your detections into Tethys without overloading it. Note that if more than one species (see the species codes section above) is present within a time interval, then an entry will be made in the database for each different species for each time bin.

"Encounter": This option searches for groups of sounds close together in time and saves a record with the start and end time of the encounter along with a count of the number of calls within that time period.

For Binned and Encounter export you can also choose to separate individual channels. This might make sense if your hydrophones are spatially very far apart so that you're getting different animals detected on each one. It's your data and it's up to you.

Data Selection filters

Some PAMGuard outputs (not all) have a data selection filter. These are used by multiple PAMGuard components and are generally quite bespoke for each detector. For example, in this example, the Deep Learning data selector (Figure 18c) has been set to only export data with a score of 0.8 or more, which is a subset of the data since the detector was set to save detections with a score of 0.4 or more.

The data selector in the click detector allows you to select by click type (if you're using a click classifier) and whether clicks are assigned to a click train. The click data selector is used on various displays and also to filter input to the click train detector. Similarly, the right whale edge detector allows you to select by the 'score' of the detection, which is on a scale of 1 (nothing like a right whale) to 11 (very right whale like). If there is a data selector, then information about it will be shown at the bottom of the granularity page and is also written to Tethys as part of the algorithm description.

Detections information (more abstracts and stuff) Figure 18d

This again ? Didn't you enter this for the Deployment document you created ? Yes, but it's important since the motivations behind your analysis have to be captured separately from the motivations behind the overall study. For example, the deployment may have been to survey all baleen whale species over a period of months using a randomized instrument layout suitable for density estimation, but the analysis may have only concentrated on a single species on calm weather days when boat surveys had already confirmed that animals were present. Think about what someone trying to use these data may need to know and enter it here.

Algorithm Parameters Figure 18e

Here you can select the information about the processing that took place in PAMGuard that will be exported to Tethys. It will be written to the top of each Detections document in xml format. The

options are reasonably self explanatory: for instance for the right whale edge detector, if you select 'Full Process Chain', you'll get all of the settings not just of the detector, but the FFT module feeding it, and the acquisition module feeding the FFT (and a decimator or any other modules upstream of the detector). The easiest way to understand this is to generate some outputs and take a look at what's in the XML. Generally, we'd recommend outputting the "Full Process Chain". It's a bit verbose, but does give a complete record of how PAMGuard was set up for processing the data – which is one of the key goals of Tethys.

Export the Data Figure 18f

The last page of the Wizard has the "Export data" button, which will generate the Tethys records and write them to the database.

Large datasets

Exporting very large datasets can take a very long time and may even bring down the system with memory overflows. We're still working on how to manage this and any feedback will be welcome.

You should experiment with exporting data in different ways: Try the different granularities and see what you get. See what difference there is in the data recorded from two detectors.

7 Viewing and Managing the Data

7.1 The Tethys Web Client

By far the most versatile way to view data is to use the Web based client developed by Marie Roch. You'll have seen instructions on how to launch this with the Tethys installation instructions. To make life easy, instead of typing 'localhost:9779/Client' into your web browser, you can just hit the 'Open Client' button at the top of the PAMGuard display.

7.2 viewing in PAMGuard

7.2.1 List of Documents

To the right of the 'Open Client' button, there is a small drop down arrow. This will show a menu that takes you to lists of Tethys documents (all documents of a particular type in the database) which can be either in the web browser, or within PAMGuard. Try both, using the 'Show in PAMGuard' option to switch between browser view and PAMGuard view.

7.2.2 View a Single Document

To check the output of a single document, the easiest thing to do is to simply right click on it in the PAMGuard display and select 'Display document …' and a window will appear with the XML text of the document.

7.3 Deleting Data

We all make mistakes (Well, I do!). The displays in PAMGuard will generally show a pop-up menu with a delete option which will remove any documents from the database.

7.4 Exporting

Similarly, there is an option to save individual documents as XML text documents.

8 Error Reporting and Feedback

This is new software, hot out of the mines, so expect a few teething problems. We really value feedback and information on errors since that's the only way we can rectify problems. If there is an error writing a document, you should get a big clear pop-up window saying that the document failed to write. In the corner of that window is a 'Copy' button which will copy the text of the error into the systems clipboard. Please do that and paste it into an email to us at info@pamguard.org.

Another really helpful thing you can do at this point is to also get a copy of the XML document that PAMGuard was attempting to write to the Tethys database. Prior to writing to the database, these are held in a temporary folder and they are deleted when you exit PAMGuard. The folder can be tricky to find (on my system it's in C:\Users\dg50\Pamguard\PAMGuardTethys) but there is a menu item 'open temp document folder' at the bottom of the documents menu (the one next to the 'Open client' button) and also in the Settings / Tethys menu. If you can attach a copy of the document that caused an error to an email to us, then we'll be able to understand the error and hopefully fix it. Finally, if you've not found it before, PAMGuard logs the terminal output in a set of files in the user/Pamguard folder (mine is C:\Users\dg50\Pamguard). You can get to this from the main PAMGuard help menu. The files may look as though they are full of total garbage, but it's meaningful to us and can help us to debug any problems effectively and efficiently.

At time of writing (late 2024) there is still time to influence the final Tethys interface in PAMGuard, so we welcome your feedback. Please send any comments or suggestions to pamguard@st-andrews.ac.uk.

9 Acknowlegements

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