



CANADIAN
WILDLIFE HEALTH
COOPERATIVE

Guide for Bat Monitoring in Atlantic Canada

March 2021

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**CREATING A WORLD
THAT IS SAFE AND SUSTAINABLE
FOR WILDLIFE AND SOCIETY**



Cover Photo by Jordi Segers

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Section 1. Bat Basics

1.1 The Role of Bats

Bats are mammals in the order of Chiroptera (meaning “hand-wing”). The oldest known fossil record of a bat is over 50 million years old and this ancient species had fully functional wings, similar to modern day bats. Bats live almost everywhere in the world with the exception of the far north, far south, and some off-shore islands. Bats perform extremely important ecosystem services such as insect population control, pollination (1), and seed dispersal (2, 3). Canadian bat diversity includes 8 genera and 19 species, although some of these species are vagrants from the United States and have only been recorded in Canada on a single occasion (*i.e.*, big free-tailed bat, Mexican free-tailed bat, evening bat) (4, 5). Atlantic Canada has seven bat species; four that hibernate and three that migrate (further descriptions in *Section 1.3*). North American hibernating bats are at risk from a fungal disease called white-nose syndrome (WNS). First discovered in 2006, this disease has killed over six million bats, which is the primary reason that three bat species are now federally listed as endangered under the Canadian Species at Risk Act (SARA): little brown myotis, northern myotis, and tri-colored bat. All Canadian bat species are insectivorous and use echolocation, ultrasonic frequency sounds mostly inaudible to the human ear, for orientation and detection and capture of insect prey. Bats, including Canadian species, can live surprisingly long, with the oldest recorded age for a little brown myotis being greater than 30 years old. These bats, however, have a very low reproductive rate, with most species producing only a single pup per year, but a few species can produce up to four pups per litter (4).



Photo by Jordi Segers

Figure 1. Bats perform extremely important ecosystem services such as insect population control.



Photo by Jordi Segers

Figure 2. Hibernating bats are at risk from a fungal disease called white-nose syndrome (WNS).



1.2 The Life Cycle of Bats

Canadian bat species are dependent on insects for food so they must hibernate or migrate south in the winter months when their insect prey is unavailable. Hibernating bats in Atlantic Canada typically enter hibernacula (overwintering sites) for hibernation in September and October and remain there until April or May. Upon emerging from hibernation, these bats migrate to their summering roosts, where males often roost solitary and females form maternity colonies. Fertilisation occurs shortly after emerging from hibernation and between mid-June and mid-July the females give birth, often to a single pup. At approximately 3 to 4 weeks the pups become **volant**, meaning they can fly independently (4, 6). In August, bats leave their summer colonies to visit swarming sites at the entrances of hibernacula. Bats mate at these swarming sites and especially males will visit as many sites as possible. Until hibernation season in September and October, bats spend a lot of time gaining fat reserves. Migratory bats overwinter at southern latitudes where their insect prey remains abundant and migrate north to Canadian latitudes during the spring months. It is unknown how far north most migratory bats move in the summer, but summer records of migratory species exist for Atlantic Canada (7, 8). These bats mate and migrate south during the fall (9). Fertilisation is delayed in females until spring and two to four pups are born usually in mid-June (10, 11).



Photo by Jordi Segers

Figure 3. Maternity colony.

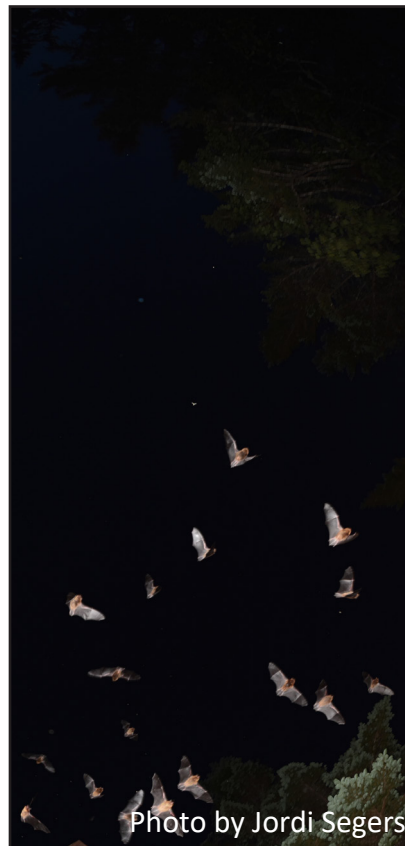


Photo by Jordi Segers

Figure 4. Swarming site.



Photo by Jordi Segers

Figure 5. Hibernaculum.



1.3 Bat Species of Atlantic Canada

1.3.1 Hibernating Bat Species

1.3.1.1 Little Brown Myotis (*Myotis lucifugus*)

Species code: MYLU



Photo by Jordi Segers

Figure 6. Little brown myotis (*Myotis lucifugus*).

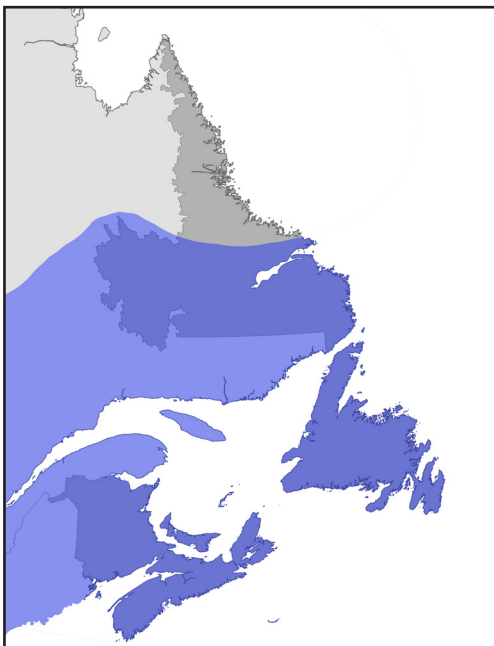


Figure 7. Little brown myotis range (blue indicates confirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)

The little brown myotis is the most widespread bat species in Atlantic Canada and the rest of North America. It is known to occur almost across all of Atlantic Canada except for northern Labrador (4, 6, 12). The little brown myotis is a cavity rooster, and roosts in both natural and human-made roosts. Females can roost in large maternity colonies, sometimes containing more than 1000 individuals (4, 6). Ideal maternity roosts are often found within a kilometre of a water source (4). Little brown myotis are primarily aerial hawkers, meaning they catch their prey in the air, but they are also gleaners, meaning they can capture insects resting on trees and other surfaces. Little brown myotis generally forage throughout the night in areas 1–6 metres (m) above or near water (4, 13), although they have also been observed foraging above the forest canopy, in yards and open clearings, and along streets. Little brown myotis often consume half of their body weight in food each night, but lactating females can eat up to 110% of their body weight in a night (4). They have a varied diet which includes: midges, mosquitoes, moths, spiders, caddisflies, beetles, termites, lacewings, crane flies, wasps, water boatmen, and leaf hoppers (4, 6). Little brown myotis spend their winters hibernating primarily in caves and abandoned mines, but have also been found in a variety of anthropogenic structures including basements of buildings and abandoned wells (4, 14, 15), with optimal conditions of 1–5°C and 70–90% humidity (4, 6). The little brown myotis is a small species weighing 7.0–14.0 grams (g) with a wingspan of 22–27 centimetres (cm) (4).

Federal Species at Risk Act status: Endangered

Atlantic Canada range: New Brunswick (Endangered), Newfoundland and Labrador, Nova Scotia (Endangered), Prince Edward Island



1.3.1.2 Northern Myotis (*Myotis septentrionalis*)

Species code: MYSE

The northern myotis occurs throughout most of Atlantic Canada, but has not been found in northern Labrador (4, 6, 13). The northern myotis generally roosts either solitarily or in small groups, and frequently with other bat species (4, 6). Maternity roosts are usually found in cavities in large trees, although anthropogenic structures may also be used. After the pups are born, the females often leave the maternity colony with their pups, choosing to roost in smaller groups in other cavities, crevices, or under loose bark; changing their roosts every few days. Nursery colonies may also occur in buildings, and are usually less than one kilometre from foraging sites (4). Northern myotis are primarily forest dwelling gleaners, meaning they hunt insect prey from surfaces like branches and leaves, although they are also known to catch insects in flight. Their foraging sites include small ponds, forest canopies, and along paths and roadways (4, 6, 13). They hunt throughout the night very close to the understory vegetation, only 1–3 m from the ground. Northern myotis have varied diet comprised of: flies, moths, beetles, caddisflies, lacewings, leaf hoppers, spiders, and caterpillars. Similar to little brown myotis, northern myotis typically hibernate in caves and mines, but have also been found in basements and abandoned wells (4, 14, 15). The northern myotis is a small brown bat weighing 4.5–10.8 g with a wingspan of 22–26 cm (4).

Federal Species at Risk Act status: Endangered

Atlantic Canada range: New Brunswick (Endangered), Newfoundland and Labrador, Nova Scotia (Endangered), Prince Edward Island



Photo by Jordi Segers

Figure 8. Northern myotis (*Myotis septentrionalis*).

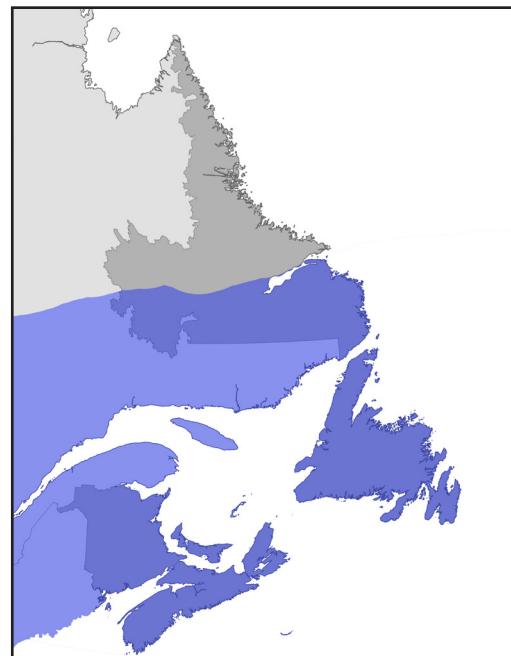


Figure 9. Northern myotis range (blue indicates confirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)



1.3.1.3 Tri-colored Bat (*Perimyotis subflavus*)

Species code: PESU

Eastern Canada is the most northeastern range of the tri-colored bat, and the range of this species in Atlantic Canada is believed to be confined to parts of southern Nova Scotia and the Fundy coast of New Brunswick (16). In the summer, female tri-colored bats roost in small maternity colonies of up to 20 individuals. Maternity roosts are often among lichens in trees or the foliage of deciduous trees (4, 17). Tri-colored bats forage over water and at forest edges throughout the night (4, 16, 18, 19). This bat species typically eats half its body weight in insects per night, but pregnant and lactating females can eat more than their own body weight per night. Their diet consists of small insects, mostly beetles, flies, moths, and leafhoppers. Tri-colored bats typically travel no more than a hundred kilometers between summering sites and their hibernacula as they are not strong long-distance flyers. This species is often the first to enter hibernation in fall and the last to emerge in spring and requires warmer, more stable hibernation temperatures. It weighs 6.0–7.9 g and has a wingspan of 20–26 cm (4). Each hair of the tri-colored bat has a dark, a light, and another dark band, from which it gets its name. Their tri-coloured fur is typically lighter and their forearm skin more pinkish than that of the little brown myotis and northern myotis (4, 20).

Federal Species at Risk Act status: Endangered

Atlantic Canada range: New Brunswick (Endangered), Nova Scotia (Endangered)



Photo by Jordi Segers

Figure 10. Tri-colored bat (*Perimyotis subflavus*).

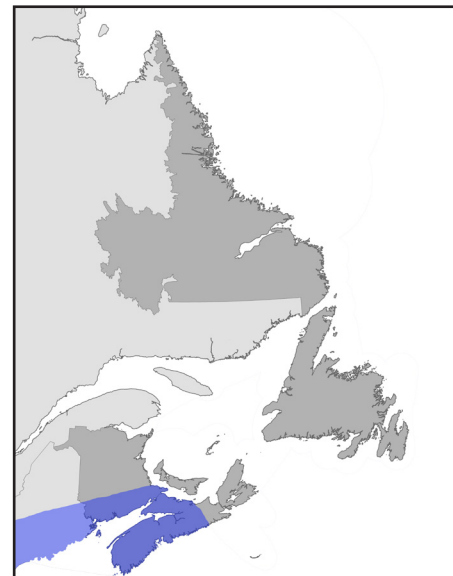


Figure 11. Tri-colored bat range (blue indicates confirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)



Photo by Jordi Segers

Figure 12. Big brown bat (*Eptesicus fuscus*).

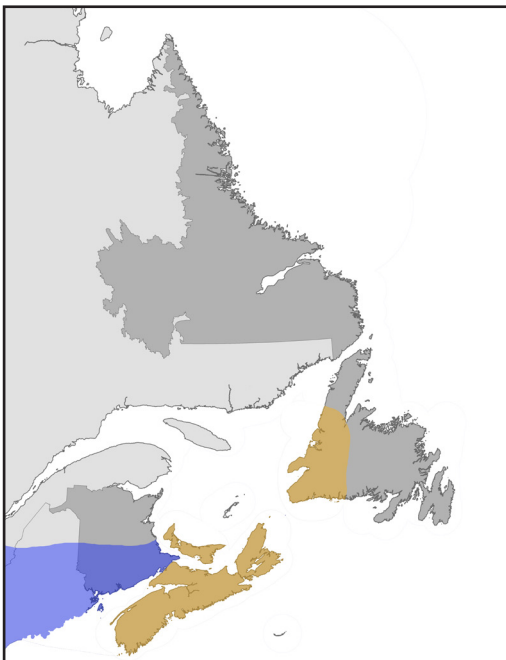


Figure 13. Big brown bat range (blue indicates confirmed range and yellow indicates unconfirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)

1.3.1.4 Big Brown Bat (*Eptesicus fuscus*)

Species code: EPFU

The distribution of the big brown bat spans most of North America, but in Atlantic Canada this species is only found in southern New Brunswick, remaining unconfirmed in Prince Edward Island, Nova Scotia, and Newfoundland and Labrador. In the summer, big brown bats roost individually or in small numbers in tree cavities, under loose bark, in rock crevices, and in anthropogenic structures. Big brown bats forage 6–10 m above the ground, emerging from their roosts just after sunset, to feed continuously throughout the night (4, 6). Upon emerging for an evening, big brown bats will first find a water source to rehydrate (4). Female big brown bats often form maternity colonies in anthropogenic structures in eastern Canada (4, 6). Big brown bats feed on a wide variety of insects including moths, beetles, caddisflies, flies, mosquitoes, mayflies, stoneflies, and ants. In the winter, they can typically be found hibernating in caves, mines, deep rock crevices, and heated buildings. The big brown bat resembles both the little brown myotis and the northern myotis, but it is approximately twice as heavy (4, 6) and when flying, its wings beat much more slowly. Its weight is 15.0–29.6 g and they have a wingspan of 32–39 cm (4).

Federal Species at Risk Act status: Not listed

Atlantic Canada range: New Brunswick, Newfoundland (possible range), Nova Scotia, Prince Edward Island (possible range)



1.3.2 Migratory Bat Species

1.3.2.1 Hoary Bat (*Lasiurus cinereus*)

Species code: LACI

The hoary bats range extends through most of North America, including southern Canada (4, 21). In Atlantic Canada it is known to occur regularly in mainland Nova Scotia and New Brunswick, though comparatively few records exist for Prince Edward Island, Newfoundland, and Cape Breton Island (4, 8, 22). This species has not been detected in Labrador. The hoary bat is the largest bat in Canada and is a migratory species (4). This species generally roosts in trees, often high in the branches hidden by leaves, but also in tree hollows or in bark crevices. Male hoary bats are solitary roosters and females roost only with their offspring. Gestation begins in the spring, usually resulting in twins, however, a litter can have anywhere between one and four pups. In the northern portion of their range, pups are born in mid to late June, and pups become volant after approximately four weeks (4, 6). Hoary bats tend to emerge to forage approximately an hour after sunset, which is slightly later than most other Canadian bat species (4, 6). The length of the foraging period depends on prey availability; around lights hoary bats may only hunt for one or two hours, whereas in light-free areas they often hunt for the entire night (4). Foraging takes place high above clearings or over water. Hoary bats consume a wide range of insects, including: moths, beetles, flies, grasshoppers, termites, dragonflies, and wasps (4, 6). Hoary bats migrate in groups, generally from mid-August to October. It is presumed that most hoary bats fly far enough south in the winter that they do not have to hibernate, although some bats may hibernate for short periods in the cooler regions of their wintering grounds. Females often fly farther east and north than the males during migration to summer habitat (6). The hoary bat has a very distinctive appearance due to the colouration of its fur. The fur on its body is a combination of dark brown, black, and grey with light and dark bands which make the fur look frost-tipped (“hoary”). Around the face, its fur is a yellowish-brown colour, and the nose, mouth, and ear edges are very dark, almost black. The hoary bat weighs 25.0–35.7 g with a wingspan of 24–41 cm (4).

Federal Species at Risk Act status: Not listed

Atlantic Canada range: New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island



Photo by Jordi Segers

Figure 14. Hoary bat (*Lasiurus cinereus*).

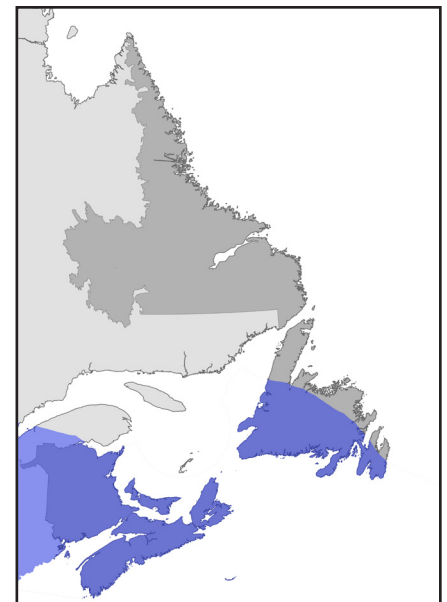


Figure 15. Hoary bat range (blue indicates confirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)



Photo by Jordi Segers

Figure 16. Eastern red bat (*Lasiurus borealis*).

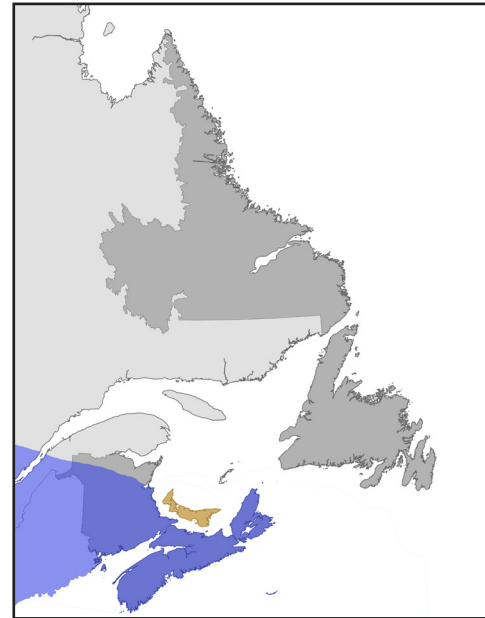


Figure 17. Eastern red bat range (blue indicates confirmed range and yellow indicates unconfirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)

1.3.2.2 Eastern Red Bat (*Lasiurus borealis*)

Species code: LABO

The eastern red bat is known to occur in Nova Scotia and New Brunswick, but has not been confirmed in Prince Edward Island, and has not been detected Newfoundland and Labrador (4, 8). The eastern red bat is a solitary species that roosts in mixed-hardwood forests and relies on its colour to blend in with foliage. Eastern red bats give birth to one to five pups, averaging at three, in the summer. Eastern red bats have a highly diverse diet of flying and non-flying insects, including moths, mosquitoes, beetles, lacewings, flies, flying ants, termites, crickets, cicadas, and ground beetles (4). Although this species is a migratory bat, flying south for the winter, they are known to hibernate in areas with a milder climate than found in most of Canada. Males and females migrate at different times, with females initiating both their spring and fall migration earlier than males. The eastern red bat is recognisable by its characteristic reddish-orange fur with black or white tips on its back and black wings. Males are more bright red than females. This species weighs 10.0–17.4 g and has a wingspan of 28–33 cm (4).

Federal Species at Risk Act status: Not listed

Atlantic Canada range: New Brunswick, Nova Scotia, Prince Edward Island (possible range)



1.3.2.3 Silver-haired Bat (*Lasionycteris noctivagans*)

Species code: LANO

Similar to the eastern red bat, the silver-haired bat is known to occur in New Brunswick and Nova Scotia, but has not been definitively confirmed in Prince Edward Island or Newfoundland (4, CWHC Atlantic, unpublished data). This species has not been detected in Labrador. In most locations in Canada this bat species is predominantly encountered during its spring and fall migration and is less often observed at its summer foraging and birthing locations. This bat species is found in a diverse array of habitats but always remains close to trees, especially old growth forests (4). The silver-haired bat is a tree-roosting species, and individuals may change their roost sites regularly. During migration, silver-haired bats day-roost in holes, tree crevices, old trees with furrowed bark, and along buildings. Silver-haired bats are often the first species in an area to begin foraging each evening, with foraging starting just after sunset, and foraging habitat includes treetops or above water (4, 6). This species has an opportunistic diet and eats a wide variety of prey including: moths, beetles, flies, mosquitoes, leafhoppers, cicadas, flying ants, termites, midges, and occasionally even spiders or bees (4, 6). This bat species has very dark fur that looks almost black with silver tips. This species weighs 5.7–16.7 g and has a wingspan of 27–31 cm (4).

Federal Species at Risk Act status: Not listed

Atlantic Canada range: New Brunswick, Newfoundland (possible range), Nova Scotia, Prince Edward Island (possible range)



Photo by Jordi Segers

Figure 18. Silver-haired bat (*Lasionycteris noctivagans*).

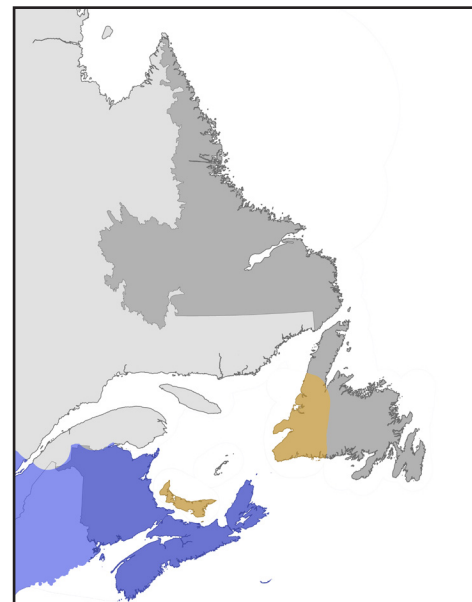


Figure 19. Silver-haired bat range (blue indicates confirmed range and yellow indicates unconfirmed range).

Image adapted from Naughton (2012) with recent regional observations (2020)



Table 1. The range of bat species in the Atlantic provinces (through visual record).

Bat Species	New Brunswick	Newfoundland and Labrador	Nova Scotia	Prince Edward Island
Little brown myotis (<i>Myotis lucifugus</i>)	YES	YES	YES	YES
Northern myotis (<i>Myotis septentrionalis</i>)	YES	YES	YES	YES
Tri-colored bat (<i>Perimyotis subflavus</i>)	YES	NO	YES	NO
Big brown bat (<i>Eptesicus fuscus</i>)	YES	UNCONFIRMED ¹	UNCONFIRMED ¹	UNCONFIRMED ¹
Silver-haired bat (<i>Lasionycteris noctivagans</i>)	YES	UNCONFIRMED ¹	YES	UNCONFIRMED ¹
Hoary bat (<i>Lasiurus cinereus</i>)	YES	YES	YES	YES
Eastern red bat (<i>Lasiurus borealis</i>)	YES	NO	YES	UNCONFIRMED ¹

1. Unconfirmed means that the species has been acoustically detected but cannot be confirmed due to uncertainty in acoustic species identification.





Section 2. North America Bat Monitoring Program

2.1 What is the North American Bat Monitoring Program (NABat)?

In 2015, the United States Department of Agriculture (USDA) released *A Plan for the North American Bat Monitoring Program (NABat)* (23). This multiagency and multinational program was constructed to standardise the monitoring of the 47 bat species in Canada and the United States of America. The need for standardised monitoring arose because of the necessity to address the questions about population declines associated with the emergence of WNS. While the original goal of the monitoring program was to gather information pertinent to the impact of WNS on bat populations, its design is also suitable for investigating the potential effects of wind energy development, climate change, and other causes of habitat loss on bat populations (23). Listed below are the purpose, mission, goals, and objectives of NABat, taken as direct excerpts from *A Plan for the North American Bat Monitoring Program (NABat)* (23):

NABat Purpose: Create a continent-wide program to monitor bats at local to rangewide scales that will provide reliable data to promote effective conservation decisionmaking and the long-term viability of bat populations across the continent.

NABat Mission: Provide the biological, administrative, and statistical architecture for coordinated bat population monitoring to support regional and range-wide inferences about changes in the distributions and abundances of bat populations facing current and emerging threats, and to provide guidance for monitoring at the local scale.

NABat Goals:

1. Develop and maintain a long-term continental program to monitor bat distributions and indices of abundance at rangewide, regional, and local scales.
2. Provide regular analyses and reporting on the status and trends of bat populations to inform managers and policymakers so that they can manage bat populations effectively.

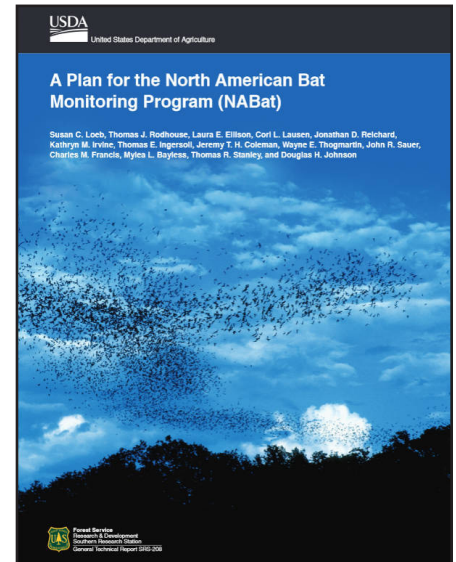


Figure 20. *A Plan for the North American Bat Monitoring Program (NABat)* (23).



Figure 21. The NABat Mission includes monitoring bat populations facing emerging threats.



NABat Objectives:

1. Provide the infrastructure needed for a coordinated bat monitoring program across national, State, Provincial, tribal/ aboriginal, and private lands boundaries.
2. Provide a centralised database to house and manage data collected under the NABat program as well as additional data on bats of North America.
3. Define a statistically robust continent-wide sampling framework for the collection of bat monitoring data.
4. Provide recommended field protocols for colony count and acoustic monitoring data collection.
5. Provide statistical analyses of status and trends in populations at national and regional scales using the most appropriate and robust methods available.
6. Provide periodic “State of North America’s Bats” reports that assess the status and trends of bats in relation to current and emerging threats.
7. Continually assess the monitoring program and adjust protocols, sampling designs, and analyses as necessary.

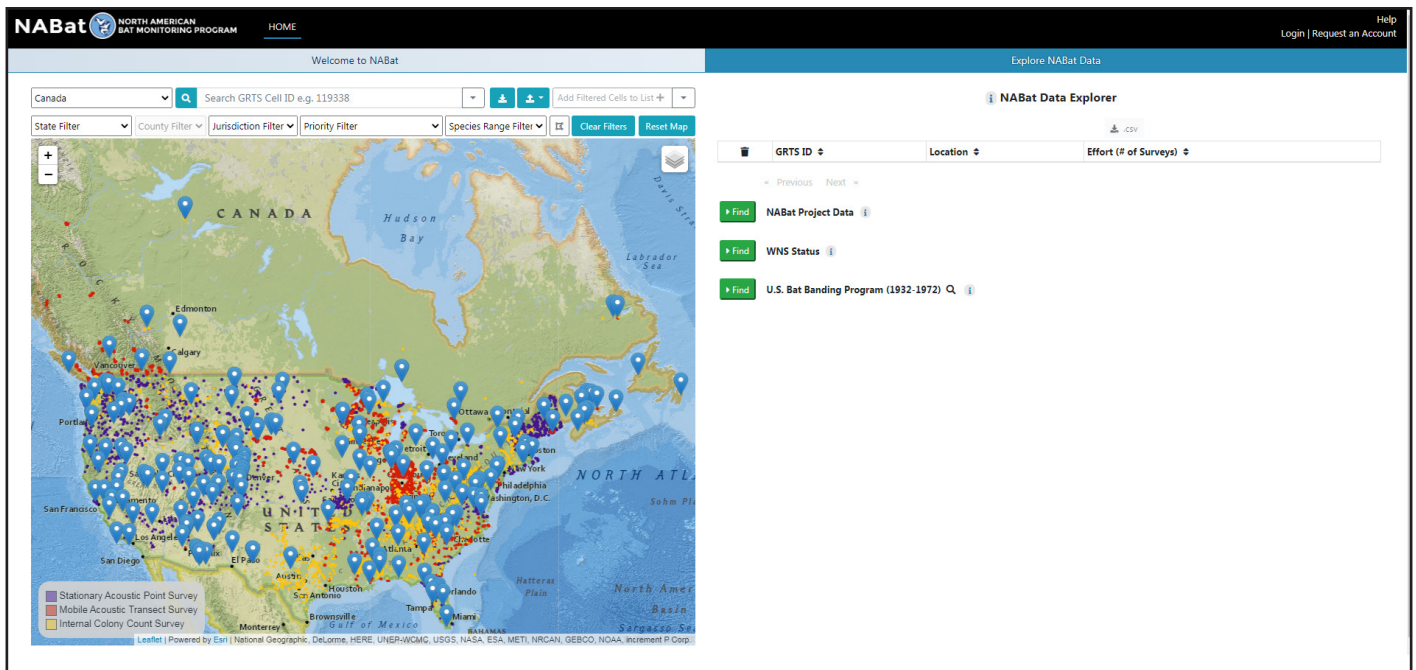


Figure 22. NABat objectives include defining a statistically robust continent-wide sampling framework for the collection of bat monitoring data.



2.2 NABat Monitoring Methods

NABat provides consistent monitoring methods, which include: colony counts, standardised grids, and acoustic surveys, in addition to other types of monitoring (23).

2.2.1 Acoustic Surveys

Acoustic surveys are used to identify the presence of bats in an area by recording their echolocation calls. Echolocation enables bats to create a mental map of their surroundings, which allows deft flight in complete darkness without relying on strong night vision. During flight, bats emit **calls** or pulses at high speed that are projected into the environment. When the sound waves of these calls come into contact with an object, they are reflected back to the bat. The bat processes these reflected sounds to help it form a mental map. These calls are usually a higher frequency than humans are capable of hearing; the upper limit of human hearing falls between 12-20 kHz, depending on a variety of factors (24), however, the high frequency limit of most people is well below this frequency range. Therefore, to monitor bats based on their calls, the calls have to be recorded with special microphones that can detect high frequency sounds. Subsequently, these calls are analysed using special computer software to create an image of the call, called a **spectrogram**, which can be used to obtain information on bat species and behaviour.

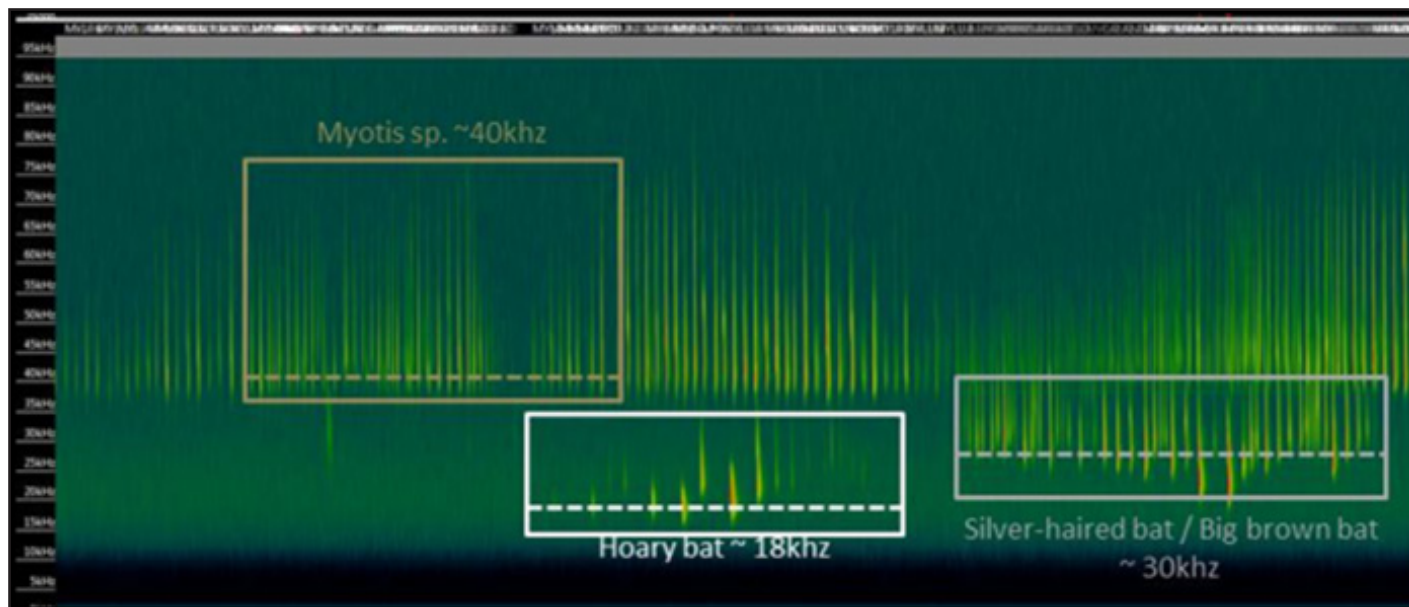


Figure 23. Example spectrogram with multiple bat species.



NABat acoustic surveys are broken down into stationary point surveys and mobile transects (23). Most acoustic surveys are conducted during the summer, when bats are active, but before pups become volant; for Atlantic Canada this is from **June 1st until July 31st**. By consistent monitoring of only adult bat populations without the pups, it allows for consistency and comparability between datasets and trends over time. Ideally, all acoustic surveys should be done during a period of good weather, which is defined as: clear weather (no rain or fog), low wind speed (less than 10 km/h), and temperatures above 10°C (23). All acoustic surveys should be conducted at least once per year to allow for between-year comparisons of statistical trends.

Acoustic survey data have a very important limitation: while bat calls can be identified to species or categorical groups, they cannot be determined to originate from an individual animal, and thus no inference can be made about population size. Acoustic surveys for bats provide information about magnitude of bat activity or relative abundance of bats between sampling periods (number of **bat passes** recorded with mobile surveys). Thus, an increase or decrease in acoustic bat activity should not be interpreted as an increase or decrease in population numbers without the use of additional, more robust survey methods targeted at population counts (*i.e.*, colony counts).



Photo by Tessa McBurney

Figure 24. Stationary point survey.



Photo by Tessa McBurney

Figure 25. Mobile transect.



2.2.1.1 Stationary Point Surveys

Stationary point surveys involve placing 2-4 bat detectors in specific types of habitat for a monitoring period of 4-7 nights, with the detectors set to record 30 minutes before sunset until 30 minutes after sunrise. If the monitoring period is a week, try for at least four nights of good weather (as defined in *Section 2.2.1*) during the monitoring period. Stationary point surveys are better able to control factors that could influence the quality and quantity of the recordings than mobile transects. They also remove the habitat bias from sampling along roadways that is inherently associated with mobile transects (23). However, the primary limitation of stationary point surveys is that they cannot be used to estimate the relative abundance of bat species. For example, due to the passiveness of the data collection, it cannot be determined whether 10 recorded bat passes came from 10 separate bats, 1 bat flying by the detector 10 times, or something in between. Thus, it is very important to recognise that stationary point surveys can only be used to measure bat activity, not relative abundance (23).

Stationary point surveys provide data on:

- Species Magnitude of Activity
- Species Distribution
- Species Richness
- Species Habitat Use
- Species Presence/Absence

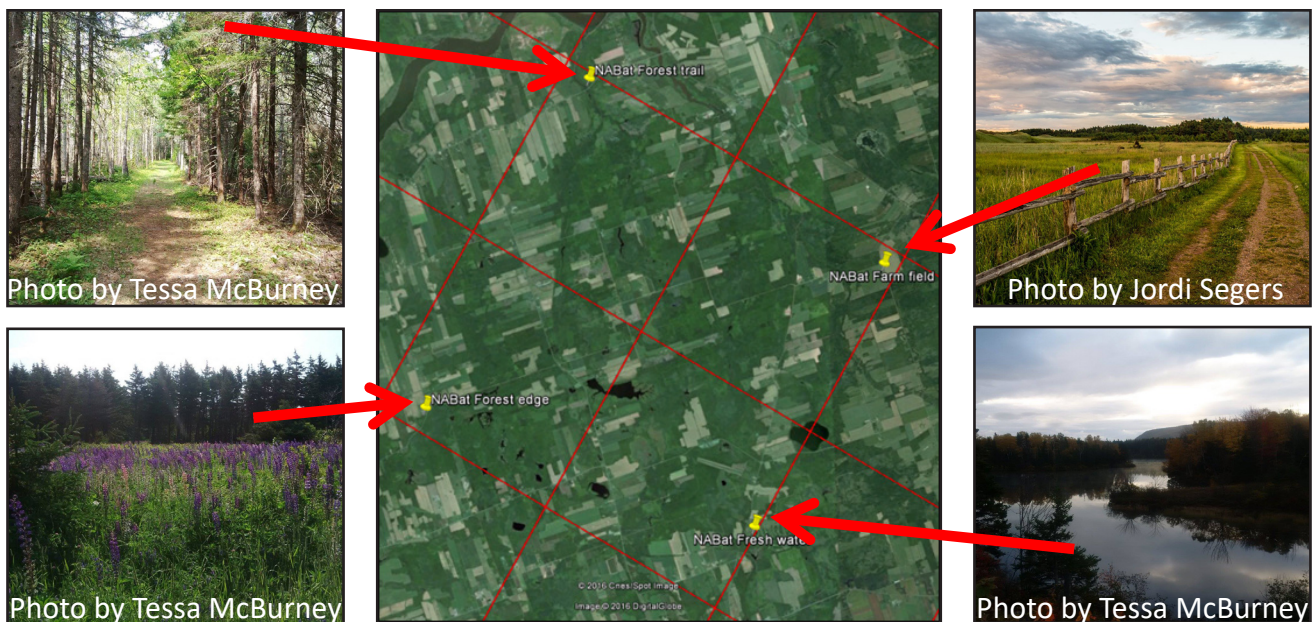


Figure 26. Place 2-4 bat detectors at specific types of habitat over several nights.



Table 2. Stationary point survey equipment.

Equipment	Number Required
acoustic recorders	2-4
omnidirectional/hemidirectional microphone (includes microphone cable and foam microphone cover (if necessary))	2-4
4 D batteries	8-16 (4 per recorder, may need to replace)
SDHC or SDXC memory cards	2-8 (depending on number of anticipated gigabytes)
chains and locks with keys (to secure recorders)	2-4 (1 per recorder)
ultrasonic calibrator	1
Global Positioning System (GPS)	1
compass	1
duct tape or zip wires (to secure microphone cables)	variable
datasheet	1





2.2.1.2 Mobile Transects

Mobile transects involve driving a vehicle at a slow speed along a set route with a microphone fixed to the exterior of the vehicle, so that bat passes can be recorded while in motion. The mobile transects are driven consistently at a consistent speed of 32 km/h. The commuting flight speed of the majority of bat species is less than 32 km/h, thus the vehicle is travelling faster than a bat during mobile transects, and as a result, each bat pass is assumed to represent a single individual. Due to bat passes being indicative of the actual number of bats recorded, mobile transect data can be used to estimate relative abundance of bats. However, there may be a bias in species representation as some bat species may be under- or overrepresented depending on their preference for using roadside habitat. There are no specific habitat requirements for these surveys, and the roads can be surrounded by many different kinds of habitat including: agricultural areas, wetlands, forested areas, and even residential areas or small towns. NABat recommends starting the mobile transect 45 minutes after sunset (23); however, research in Atlantic Canada has demonstrated that bats are more frequently recorded between 22:00-23:00, consistent with a survey start time of approximately an hour to an hour and 15 minutes after sunset, depending on the survey date (25). The driving transects are conducted during the same period that the GRTS cell is being monitored via stationary point surveys (23). Optimally, two mobile transects will be done a year to increase accuracy in abundance estimates, however, this is not a requirement.



Photo by Tessa McBurney

Figure 27. Mobile transect set-up.

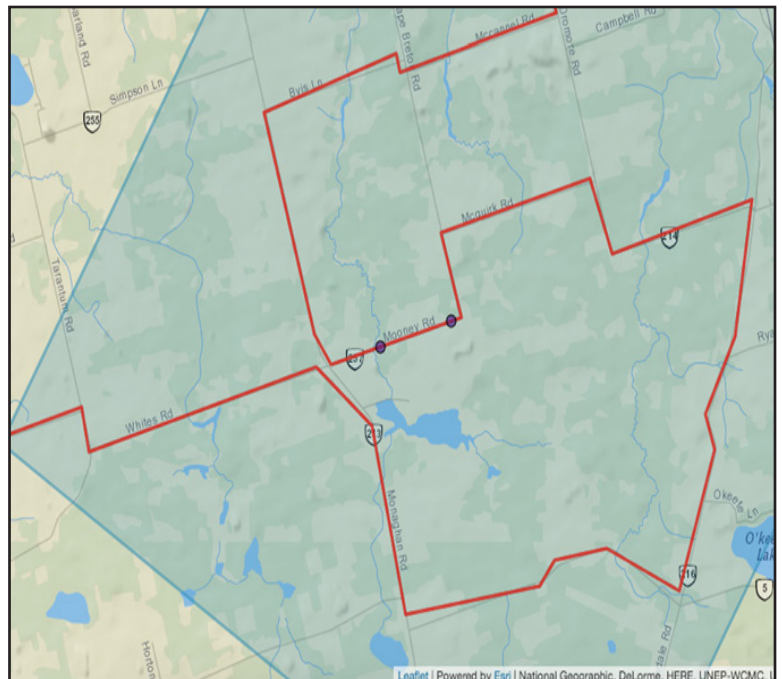


Figure 28. Mobile transect route.



The NABat protocol provides the following mobile transect recommendations (23):

1. Transects are driven consistently at 32 km/h, while still practicing road safety and following traffic rules (e.g., stop signs).
2. The roads used in the surveys should be secondary (provincial highways/county) roads or tertiary (county/forest) roads, with as few stops as possible.
3. Transects should be between 25-48 km in length and fit within a 100 km² GRTS cell.
4. The road cannot cross back on itself (be less than 100 m from another section of the transect) in an effort to prevent bats from being counted more than once, which would bias the abundance estimates.
5. There should be a minimum of three metres between the vehicle and the tree canopy, and roads surrounded by dense forested corridors and low-hanging canopy should not be used to prevent the recorded bat passes from being affected by high clutter.
6. Driving transects should always be conducted on a night with suitable weather conditions (see *Section 2.2.1*).
7. Directional microphones are preferred by NABat to reduce road noise being recorded by the microphones, which may impact the quality of the recorded bat passes. However, research conducted in Atlantic Canada in recent years has indicated that omnidirectional microphones record higher quality, and a higher number, of bat passes (25). Thus, multi-directional microphones (omnidirectional or hemidirectional) are recommended for mobile transects.

Mobile transects provide data on: Species Relative Abundance Estimates

Species Distribution

Species Composition

Species Presence/Absence

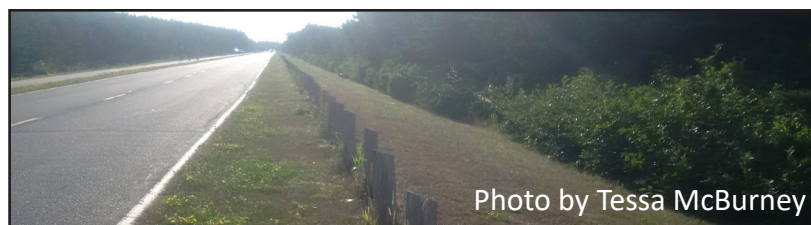


Figure 29. The roads used in the surveys should be secondary (provincial highways/county) roads or tertiary (county/forest) roads, with as few stops as possible.



Table 3. Mobile transect equipment.

Equipment	Number Required
acoustic recorder	1
omnidirectional/hemidirectional microphone (includes microphone cable and foam microphone cover (if necessary))	1
4 D batteries	4 (may need to replace)
SDHC or SDXC memory cards	1-2 (depending on number of anticipated gigabytes)
ultrasonic calibrator	1
Global Positioning System (GPS) (suggested but not mandatory)	1
method to secure microphone to vehicle	1
vehicle	1
datasheet	1





2.2.2 Colony Counts

While colony counts may be the best survey method for gathering data on bat population size and trends, it is important to remember that it provides population estimates at best. Colony counts rely on two factors: availability (that the bats are present during the survey) and detectability (that the bats are able to be observed during the survey). There will always be variation in these factors depending on a number of variables: weather conditions, observer experience, roost characteristics, the individual bat, etc. While these variables cannot be completely controlled, thus, providing only a population estimate, it is important to keep colony counts as consistent as possible (23).

2.2.2.1 External Roost Counts

External roost counts are also referred to as emergence surveys and are comprised of counting bats as they are leaving and re-entering their roost site. Emergence surveys provide reliable estimates of bats at a particular roost, are fairly simple to do, and cause minimal disturbance to the bats (23). In Atlantic Canada, emergence surveys, or external roost counts, are also sometimes called colony counts, because they are typically used to count the number of bats in a maternity colony during the summer.



Photo by Tessa McBurney

Figure 30. Colony counts rely on availability (that the bats are present during the survey).



Photo by Tessa McBurney

Figure 31. External roost counts are comprised of counting bats as they are leaving and re-entering their roost site.



NABat recommends that the emergence survey should start half an hour before sunset (23), however, 15 minutes before sunset has been found to be sufficient in Atlantic Canada (CWHC Atlantic, unpublished data). The emergence survey continues until at least an hour after sunset to ensure that all bats have left their roost. One person should be placed at every corner of the building so that all sides of the building can be observed at the same time. This is easiest with at least four people but it can still be accomplished with a minimum of two individuals positioned to ensure that the entire building can be observed at the same time. It is important that each observer only watches their own specific area of the building and there is no overlap in the areas being monitored; otherwise the same bat may be counted twice by two different people. Bats are counted both leaving and entering the roost; the bats counted entering the roost will be subtracted from the total that left the roost to prevent recounting of the same individual. If bats are possibly present in multiple structures on the property, have enough individuals involved to properly monitor each structure so population estimates are accurate. Each person should stand as close to the building as possible to get a good view, while still making sure that the entire side of the structure is visible. The emergence survey should also be conducted on a night with good weather (i.e., no rain, winds less than 10 km/h, and temperatures higher than 10°C) because in adverse weather conditions bats may not leave their roost. Try to minimise other factors that may prevent bats from leaving the roost, such as loud noises or bright lights (23). The emergence survey is completed (23):

- an hour after sunset if no bats have been observed exiting the building,
- when no bats are observed exiting the building for at least 10 minutes after the last bat emerged, or
- if sufficient light is no longer available to allow observation of bats exiting the building.

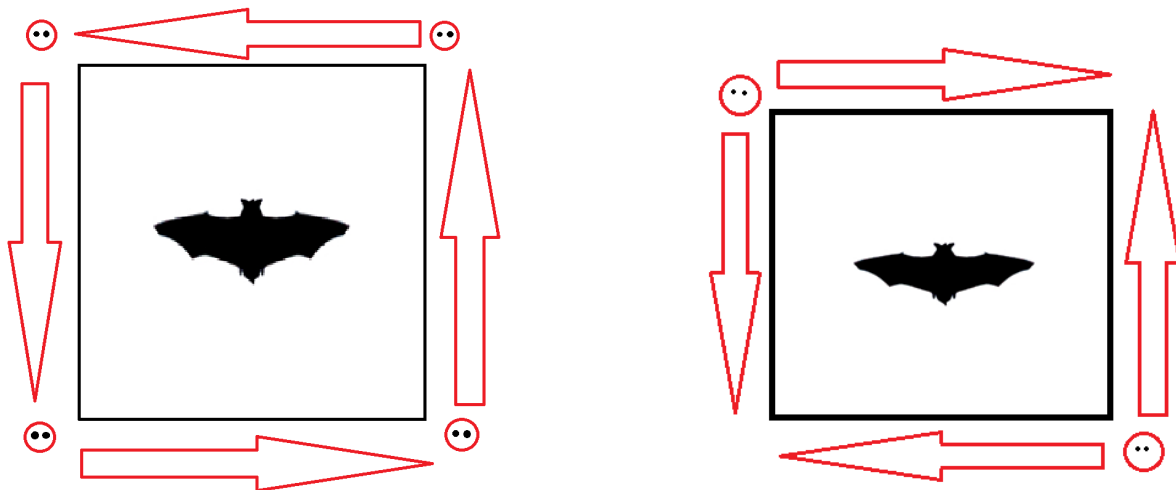


Figure 32. Diagrams of how best to conduct an emergence survey with four people (left; depicted as circles) and two people (right). The arrows are the direction(s) each person is looking.

Image by Tessa McBurney



External roost counts should be done at least once during the period of June 1st-July 31st; before the pups become volant. If this standardised method is used over multiple years, it can give reliable data on whether the adult population remains stable or changes over time. The more times an emergence survey is done for a given roost site during this period, the more reliable the population estimate is for that roost, so multiple surveys are encouraged (but not required). Although not outlined in the NABat protocol, it can also be helpful to do another roost count during the period of August 1st-August 31st, once the pups have become volant. If a count is done both early and late in the summer, the latter count allows for the number of pups born that summer (reproductive output) to be estimated, which provides useful information on recovery of bat populations post-WNS. If the external roost count occurs in a NABat GRTS cell where acoustic monitoring is also being done, the count and acoustic monitoring should be done during the same period.

Using only visual methods for external roost counts does not allow for species identification (ID). If determination of species presence/absence in a roost site is necessary, then the emergence survey will need to be combined with a stationary point acoustic survey. The stationary point survey will give a potential indication of species presence/absence in a roost, but it will not be definitive because a bat flying nearby could be recorded even though it does not roost at that site. While stationary point survey methods in combination with external roost counts provide information on potential species presence/absence in a roost, it will not give the species composition of a population because stationary point acoustic surveys can only measure the activity of the bat species present and not their abundance.

External roost counts provide data on: Population Abundance Estimates

Roost Characteristics



Photo by Tessa McBurney

Figure 33. If determination of species presence/absence in a roost site is necessary, then the emergence survey will need to be combined with a stationary point acoustic survey.



2.2.2.2 Internal Roost Counts

NABat colony counts may include internal roost counts of both maternity colonies and hibernacula (23). Hibernacula are considered critical habitat and entering these sites (if it is even safe to enter in consideration of occupational health and safety standards) requires special permitting, risks spreading the fungus that causes WNS and potentially exposing bats to SARS-CoV-2. Maternity colonies suitable for colony counts are often in residential, privately owned buildings, and internal counts at these sites come with their own inherent health risks. Due to these reasons, we will not be encouraging those reading this document to participate in internal roost counts, unless they are done in close collaboration with the provincial or federal agency responsible for the bat species being monitored.



Photo by Jordi Segers

Figure 34. Hibernacula are considered critical habitat and entering these sites requires special permitting.

Internal roost counts provide data on:

Population Abundance Estimates

Species Distribution

Species Composition

Species Richness

Species Evenness

Species Diversity

Species Presence/Absence

Sex Ratio

Roost Characteristics

Pseudogynoscus destructans (Pd) Presence
(with additional collection)



Section 3. Equipment Set-up and Deployment

3.1 Site Selection

3.1.1 NABat GRTS Cell Selection

NABat has developed a prioritisation of monitoring areas (a probabilistic sampling framework) across all of North America to ensure data collection is accomplished in a manner allowing for robust statistical analysis on a continental scale while also permitting flexibility to select field sites that are practical and biologically relevant. The NABat sampling frame is based on a spatially balanced 10x10 km (100 km²) grid system which covers North America, and each individual grid cell has a priority value assigned to it. The high priority cells are selected through a combination of randomisation and spatial balance (NABat constructed the grid using the generalised random-tessellation stratified (GRTS) survey design algorithm). When selecting a monitoring location, identify all 10x10 km GRTS cells within the geographical area to be monitored and assess suitability of cells for acoustic monitoring starting with the highest priority cell (lowest number) within that area (e.g., National park, private property, provincial land, watershed area). Some cells might be unsuitable because of legalities, inaccessibility, hazards, or unsuitable habitat. In those cases, assess the next GRTS cell in order of priority until enough appropriate GRTS cells are identified for monitoring (23). The [NABat website](#) has a GRTS cell selection tool, which is further explained in their [guidance documents](#) as well as in a [tutorial video](#). This tool allows users to create a new project through the Partner Portal and select GRTS cells to monitor based on sites within their survey jurisdiction that are not already being surveyed by others.

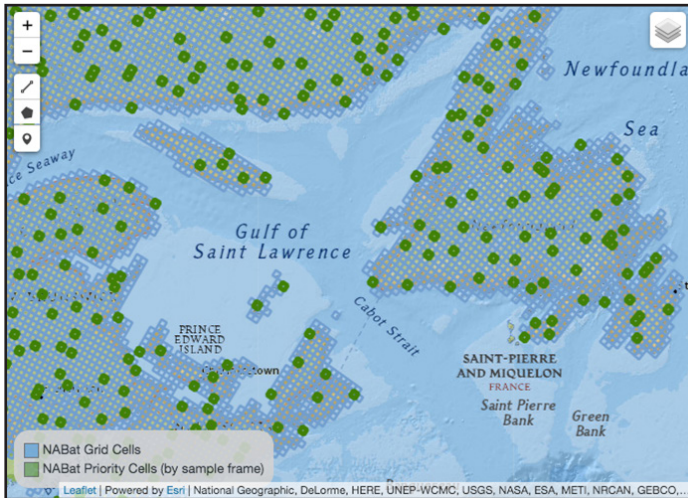


Figure 35. NABat 10x10 km GRTS cells throughout part of Atlantic Canada.

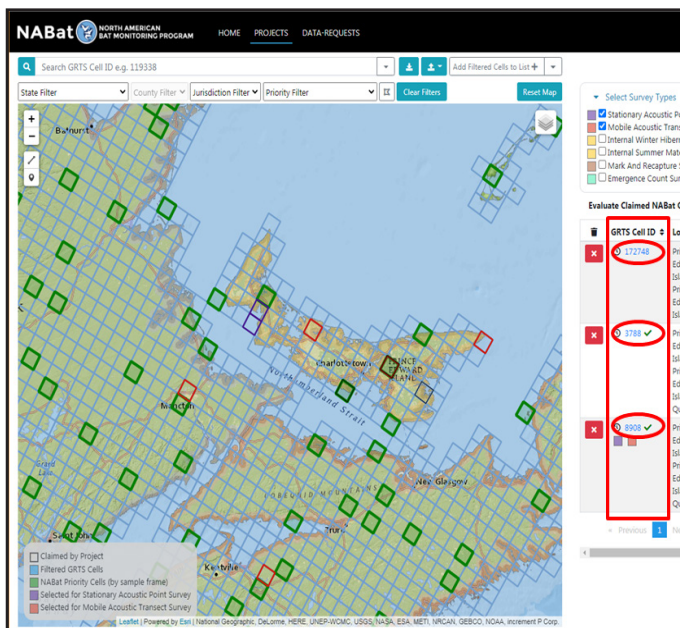


Figure 36. Each individual GRTS cell has a priority value; the high priority cells are outlined in green.



To use this tool:

Step 1- Navigate to the **NABat partner portal** and login.

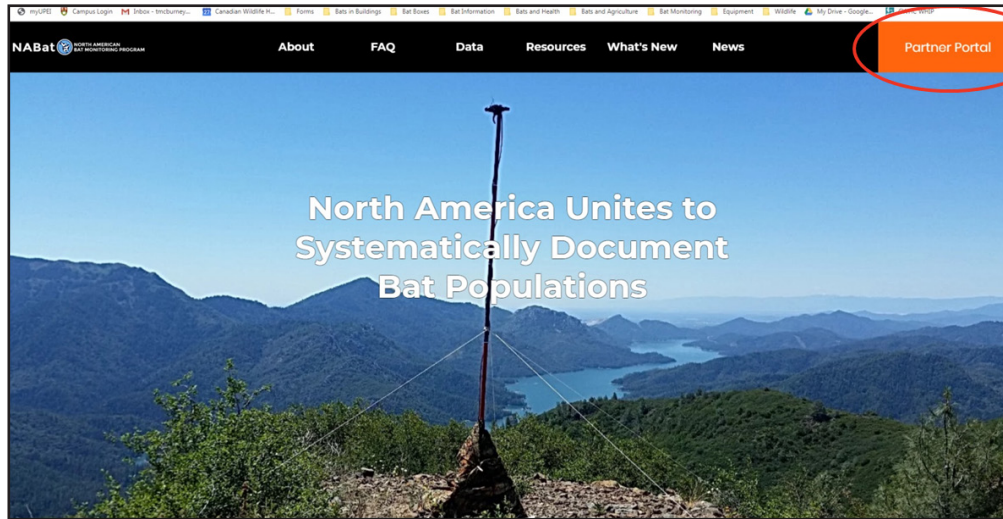


Figure 37. NABat partner portal (Step 1).

Step 2- If a project is not created yet go to *Section 4.2.2* for detailed instructions. If the project is already created, select it under the “Projects” tab at the top of the page.

Step 3- On the project page click on the grey “Cell Selection Tool” button at the top right of the page.

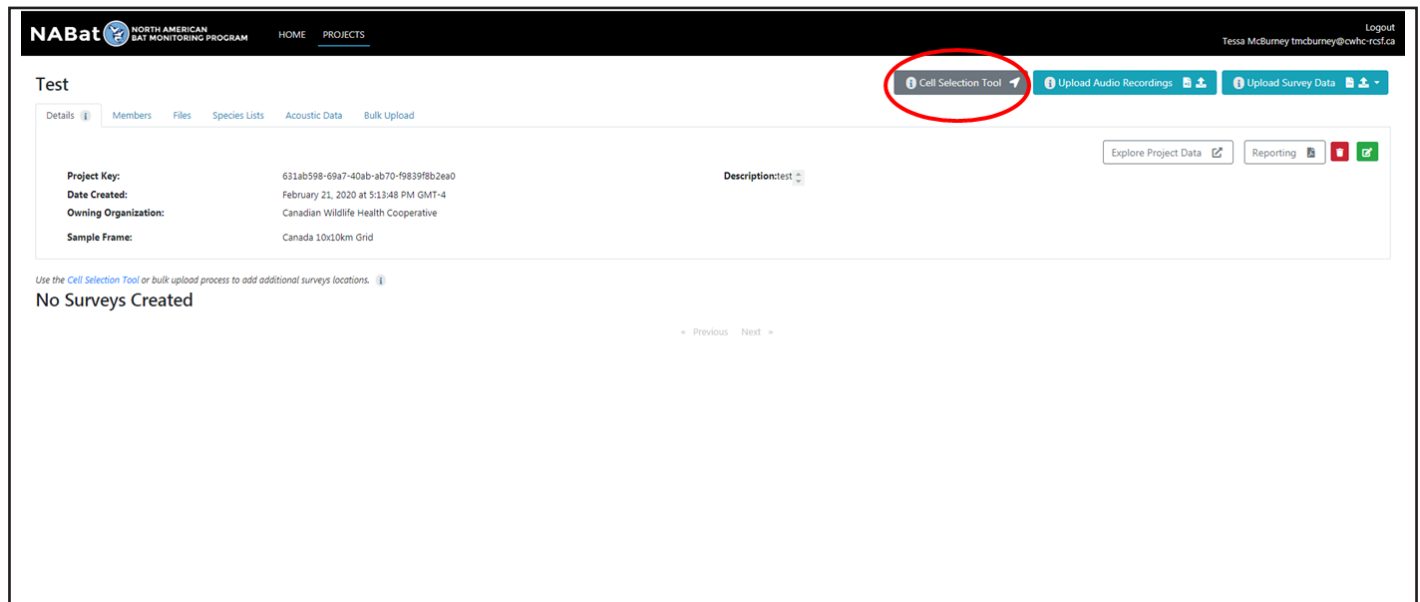


Figure 38. Click on the grey “Cell Selection Tool” button (Step 3).



Step 4- If Canada is designated, begin by selecting the appropriate province under "Select State". Optionally, this can be narrowed down by selecting county or division under "Select County", selecting a jurisdiction level and preset NABat priorities.

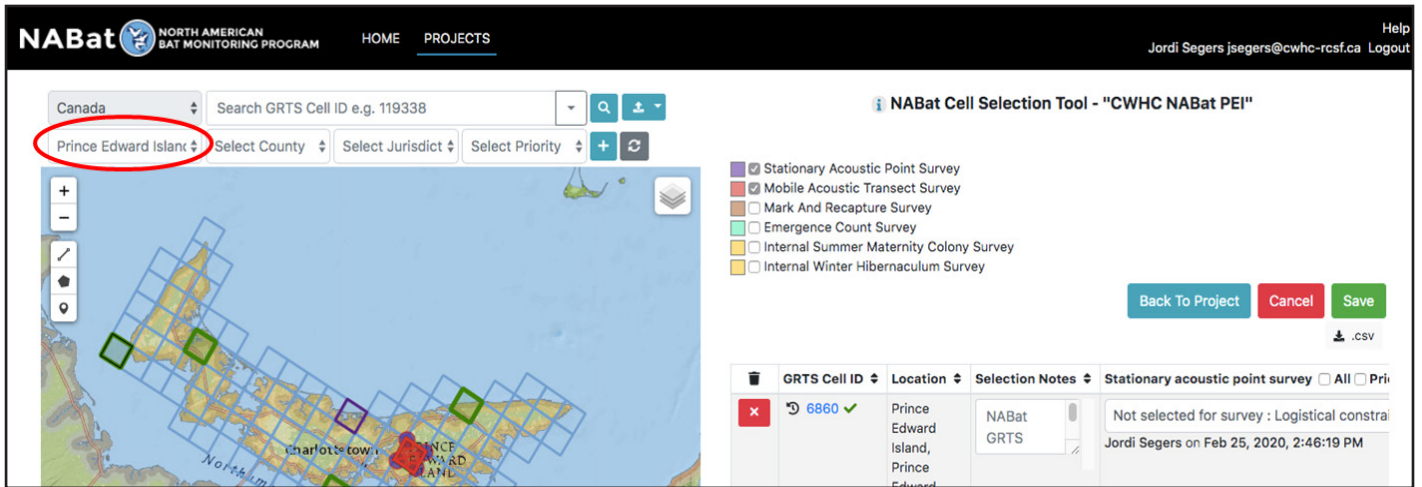


Figure 39. Select the appropriate province under "Select State" (Step 4).

Step 5- Finally, add check marks to the types of monitoring of interest in (e.g., "Stationary Acoustic Point Survey", "Mobile Acoustic Transect Survey", "Internal Summer Maternity Colony Survey", etc.). Click the + button to add all selected cells to the table.

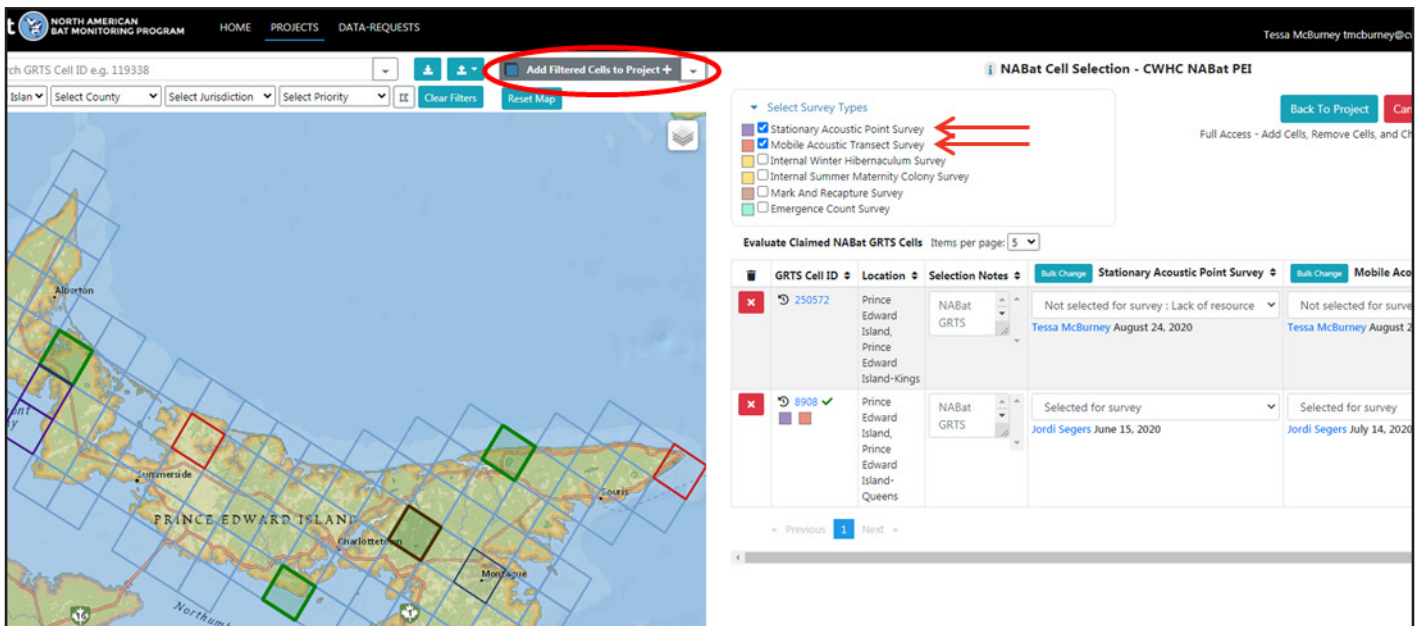


Figure 40. Add check marks to the types of monitoring of interest (Step 5).



Step 6- The table can be sorted based on GRTS Cell ID and other headers by clicking on the arrows next to the header names. Clicking on cells on the map will also bring that particular cell to the top of the table. In the table, find the appropriate cell(s) of choice and select “Selected for survey” for the types of monitoring that will be done in that/those cell(s). Different reasons can be selected why cells are not chosen for survey. Alternatively, click the red button with the “x” to remove cells that are not applicable.

The screenshot shows a map of Prince Edward Island with a grid of GRTS cells. A table on the right lists cells with their GRTS Cell ID, Location, Selection Notes, and Stationary acoustic point survey status. A dropdown menu is open over the table, listing reasons for not selecting a cell for survey:

- Not selected for survey : No Permission
- Not selected for survey : Absence of >25km roads for mobile transects
- ✓ Not selected for survey : Lack of resources
- Not selected for survey : Not safe
- Not selected for survey : Logistical constraints
- Selected for survey
- Selected as oversample (i.e., backup grid cell)

 A red arrow points to the 'Logistical constraints' option in the table.

Figure 41. The table can be sorted based on GRTS Cell ID and other headers by clicking on the arrows next to the header names (Step 6).

Step 7- Click the green “Save” button at the top of the table to complete the cell selection procedure.

*Note: The table shows which cells are already being monitored. If the cell of interest is already being monitored, consider collaboration with the monitoring group/person. Contact details (email address) are provided in the table.

The screenshot shows the NABat web application interface. The 'Save' button at the top right of the table is circled in red. The interface shows a map of Prince Edward Island and a table of GRTS cells with columns for Stationary Acoustic Point Survey, Mobile Acoustic Transect Survey, and Emergence Count Survey.

Figure 42. Click the green “Save” button at the top of the table to complete the cell selection procedure (Step 7).



3.1.2 Habitat Selection

Each GRTS cell can be sub-divided into four 5x5 km quadrants (to see these quadrants, check the box for “Alaska & Canada 5km Grid Cells” in the NABat cell selection tool) to deploy up to four stationary acoustic bat detectors. Consider the species present in the monitoring area and choose sites that are most likely used by bats (*e.g.*, feeding areas, commuting corridors, roost sites, etc.). Ideally each stationary detector in each quadrant monitors for bat activity in a different habitat type. Detectors should be placed in areas that maximise the number and quality of recorded bat echolocation calls. For example: when monitoring with two detectors, deploy them at a forest edge and a wetland and when monitoring with four detectors add a field and hedgerow monitoring site.

When choosing specific monitoring sites, think about practicality as well as the questions that need to be answered with the monitoring data that are collected. Consider the different habitat types that different bat species are attracted to. For example, does the diversity of bat species need to be determined or is the purpose to monitor species at risk bats? If questions relate to the presence of silver-haired bats, choose old-growth forest habitat; if questions relate to the presence of hoary bats, consider mounting the microphone on a high pole.

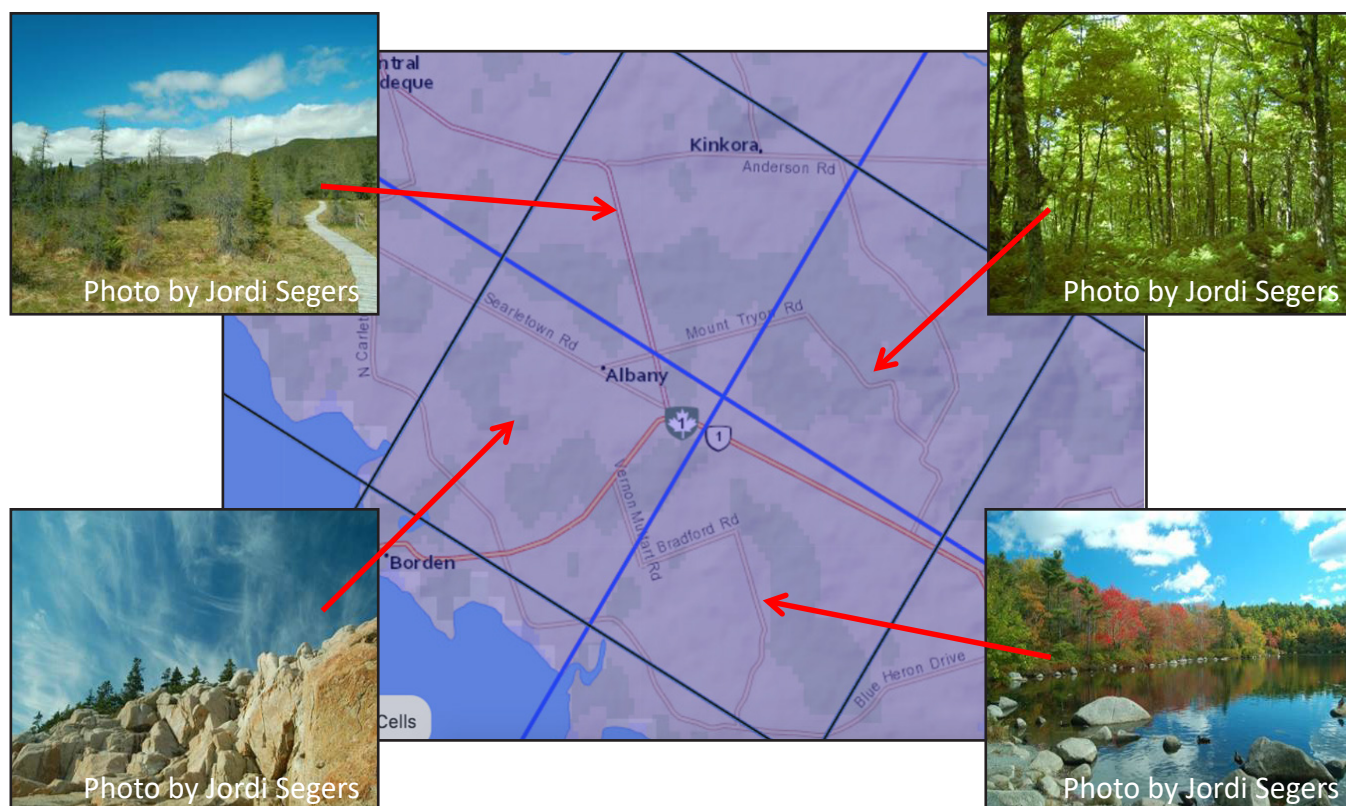


Figure 43. Each GRTS cell can be sub-divided into four 5x5 km quadrants.



3.1.3 Species-specific Monitoring

As can be observed in *Section 1.3*, diverse bat species have unique life histories. Due to this, there is not a “one size fits all” method for monitoring bat populations. Depending on the species that is targeted, certain aspects of the monitoring protocol may have to be adjusted or particular methods of monitoring discounted all together.

3.1.3.1 Stationary Point Surveys

The species targeted by a stationary point survey may dictate the habitat chosen for monitoring. For example, northern myotis is a highly forest-dependent species, as they use the forest interior for both foraging and roosting (23, 26). Therefore, if northern myotis is the targeted species, the GRTS cell will have to be selected, and acoustic detector deployment tailored, to fit the habitat requirements of this species. A further complicating factor is that northern myotis are “whispering bats”, meaning their echolocation calls are relatively low in intensity (loudness). This makes their calls difficult to record using acoustic detectors, especially in high cluttered habitat, which includes the closed canopy forested areas where they typically forage (23). Due to this, northern myotis can be a challenging species to target using stationary point surveys. The northern myotis provides a good example of the need to ensure the life history of the target species is reviewed prior to selecting the GRTS cell and deploying the acoustic detectors, so that the appropriate monitoring strategies are chosen for successful detections.



Photo by Tessa McBurney

Figure 44. The species targeted by a stationary point survey may dictate the habitat chosen for monitoring.



Photo by Jordi Segers

Figure 45. Northern myotis is a highly forest-dependent species and can be challenging to target using stationary point surveys.



3.1.3.2 Mobile Transects

The NABat protocol acknowledges that a disadvantage to using mobile transects is that certain species may be over- or underrepresented depending on their habitat preferences (23). Underrepresented species may include *Myotis* species (spp.), which are frequently not detected by mobile transect methods (27). That is not to say that mobile transects should not be used to monitor *Myotis* spp., however, it is important to keep this in mind when interpreting survey results.

Habitat selection is also important when selecting the mobile transect route. Although the NABat protocol specifies that mobile transects can successfully take place in a variety of habitats, certain habitat types have been found to be more successful than others for recording bat passes during mobile transects. For example, a higher number of bat passes have been recorded on transect routes with permanent water sources, than routes with high density urban populations (28). Additionally, some bat species have been found to avoid open areas, including farmland and pastures (29, 30). Since many bat species exhibit a preference for commuting along linear corridors, such as woodland edges (29), the selection of a route with such habitat features could increase the probability of recording bats.

3.1.3.3 Colony Counts

While colony counts are an excellent method to assess little brown myotis and big brown bat populations, they are a less effective strategy to monitor populations of other species. Lasiurine bat species, *i.e.*, hoary bats and eastern red bats, do not form summer and winter colonies, but rather prefer to roost solitarily. Silver-haired bats do form small colonies, but as a tree-roosting bat species, these are difficult to locate and often are not accessible. Thus, colony counts are not an appropriate monitoring method for these species. Options for monitoring these bat species include acoustic surveys and mist-netting (not under the NABat protocol) when applicable. These types of surveys will allow for determination of species distribution and habitat occupancy, but will not necessarily give a strong indication of population numbers (23).



Photo by Jordi Segers

Figure 46. *Myotis* species may be underrepresented when using mobile transects.



Photo by Jordi Segers

Figure 47. Colony counts are not appropriate for monitoring Lasiurine bat species, including hoary bats.



3.2 Equipment Types

Many bat detectors are available, ranging in ease of use, technical capability, and price. For the purpose of this document we will focus on the **Wildlife Acoustics Song Meter SM4Bat FS** detector. This bat detector can be used with a variety of microphone types, including the omnidirectional SMM-U1 microphone (records in all directions (approximately 360°)) and the hemidirectional SMM-U2 microphone (roughly records in a range of 180°). Accessories can be purchased, including a microphone directional horn, which narrows the directional response of the microphone so that the microphone only records in the direction it is pointed in (a range of approximately 100°). Other detector brands, models, and microphones can be used for acoustic monitoring of bats, but because different equipment has a different sensitivity in recording bat calls, monitoring should be done using detectors and microphones of the same or comparable models within a single GRTS cell to ensure data consistency and comparability.



Figure 48. Wildlife Acoustics Song Meter SM4Bat FS detector.

Image from Wildlife Acoustics

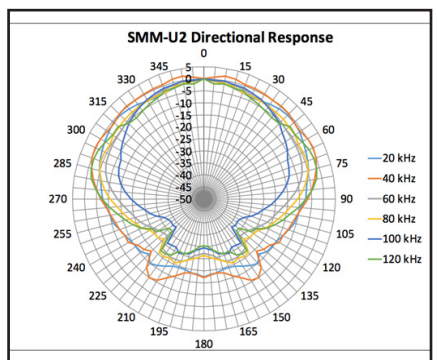
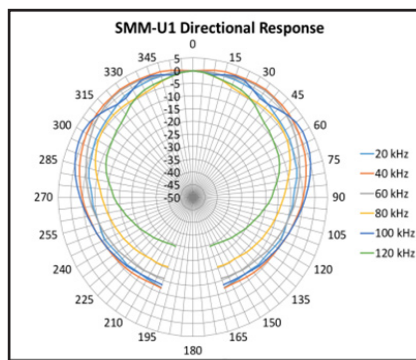
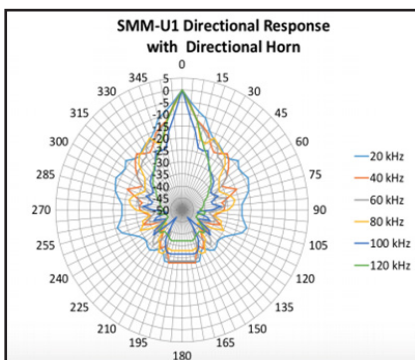


Figure 49. Directional response of three of Wildlife Acoustics microphone types: directional microphone horn (left), omnidirectional microphone (centre), hemidirectional microphone (right).

Images from Wildlife Acoustics



3.3 Equipment Set-up

3.3.1 SM4Bat Detector Set-up for Stationary Point Surveys

Step 1- Insert batteries: Open the front, protective cover of the detector to expose the front screen panel and press down on the indentation between the two SD card slots to open the front panel and reveal the battery compartment. Insert four D batteries in the compartment and close the front panel.

Step 2- Turn on: Turn on the detector by flipping the black switch on the top right side of the detector from “EXT” to “INT”. The detector is now operating on the internal power source of the D batteries and the screen will come on.

Step 3- Insert SD card: Insert a SD card in SLOT A (a second card may be inserted into SLOT B as a back-up or as a card for data overflow, but this is optional). Based on prior NABat monitoring conducted in Atlantic Canada, it is recommended to use at least one SD card with 32 GB storage capacity (or higher).

Due to operating system and setting variation when formatting memory cards with a computer, which can cause SD card reading issues for the acoustic detector, we recommend formatting memory cards with the SM4BAT detector before deployment.

*Note: Ensure any data from a previous deployment is digitally stored elsewhere before formatting the SD card.

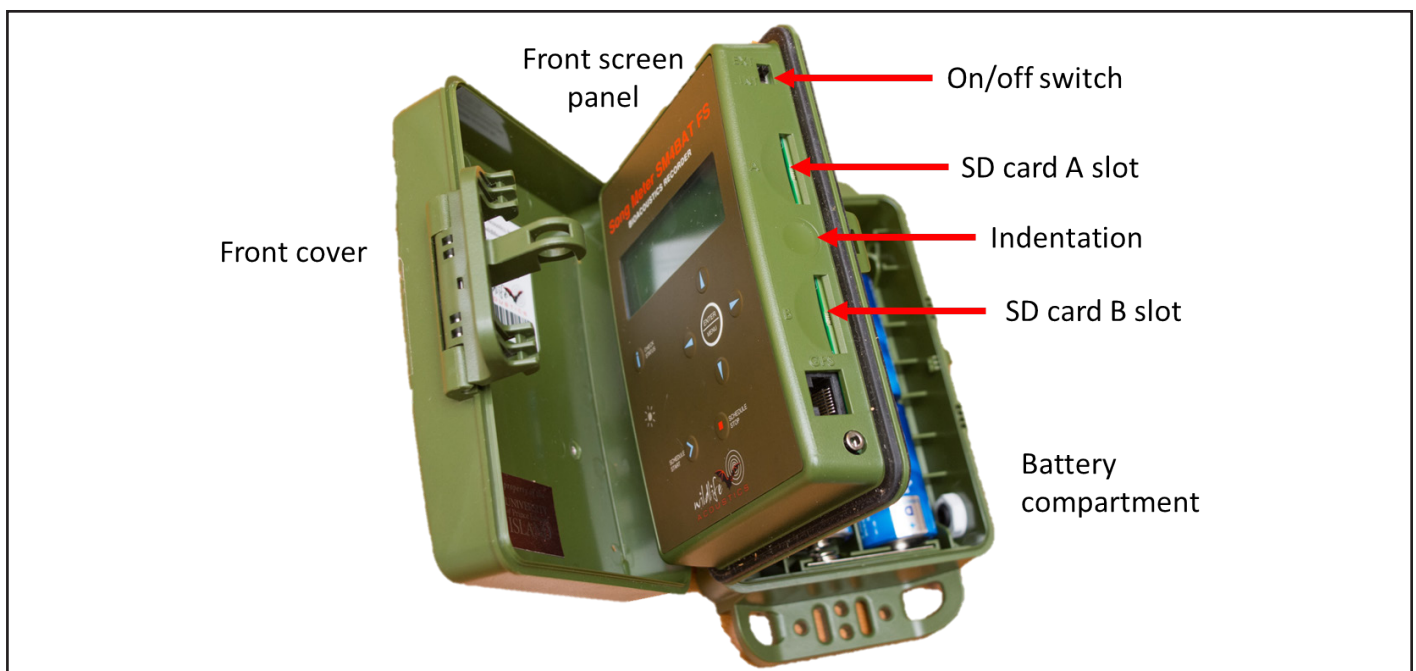


Figure 50. SM4Bat FS detector compartments.



Figure 51. SM4Bat FS “Enter/Menu” button.

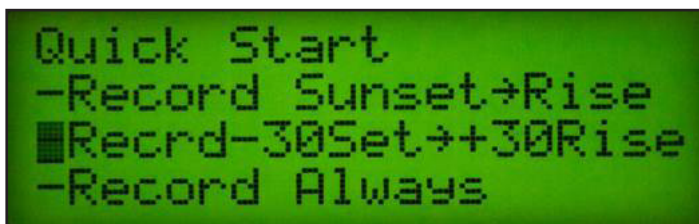


Figure 52. Set recording schedule (Step 4).

Format SD cards: Under “Main Menu” press the downwards arrow button until it is on “Utilities”, then press the “Enter/Menu” button. Again, using the downward arrow button, scroll down to “Format all cards” and then press the “Enter/Menu” button. It will ask for confirmation: scroll down and select “Yes” with the “Enter/Menu” button. The detector screen should now read “Formatting all cards...” and will list the SD card slots where it formatted cards when the action is completed (it will say whether it is “Done” or whether there was no SD card in that slot). Press the left arrow button to get back to the “Main Menu”.

Step 4- Set recording schedule: SM4Bat detectors should be set up to record for the entire duration of the nights selected for the survey period. NABat recommends starting recording 15 minutes before sunset until 15 minutes after sunrise. However, the SM4Bat has a simple detector setting to start recording 30 minutes before sunset and end recording 30 minutes after sunrise. For simplicity, the 30 minute setting will be described in detail, but if users wish to save some battery power, the 15 minute setting can be applied. Whichever setting is used, ensure consistency among all sites.

Using the arrow keys on the front panel, move the black cursor to “Quick Start” and press the “Enter/Menu” button. Use the down arrow to move the black cursor to the “Recrd-30Set->+30Rise” option. Press the right arrow or “Enter/Menu” button to confirm this setting. Press the left arrow button to go back.

*Note: If the detector goes to sleep, press the Check Status button to wake it up again. If it says “recording”, press the “Schedule Stop” button to return to the “Main Menu”.



Step 5- Set audio settings: Move the black cursor to “Settings” and press the “Enter/Menu” button. Move the black cursor to “Audio” and press the “Enter/Menu” button. Enter the recommended NABat settings specified in *Table 4*, if not already selected. To select a setting, move the black cursor over to the options using the right arrow button and scroll up and down using the arrow buttons to select the setting of choice. Once selected, press the right arrow button to save the setting and continue.

*Note: If the left arrow button is pressed, the setting will revert to the standard setting).

Once all of the audio settings have been entered, press the left arrow button to return to the other settings.

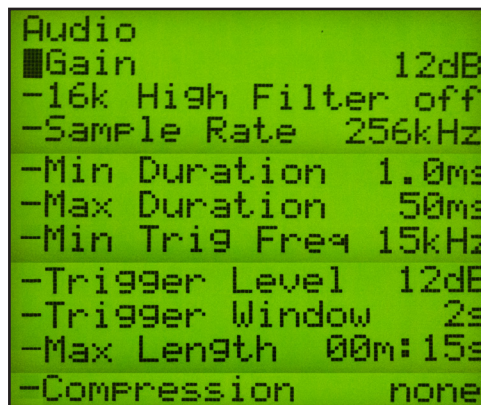


Figure 53. Set audio settings (Step 5).

Table 4. Wildlife Acoustics SM4Bat Detector Settings for Stationary Point Surveys

Specification	Setting
Gain	12 dB (decibel)
16k high filter	OFF
Sample rate	256 kHz (kilohertz)
Min duration	1.0 ms (milliseconds)
Max duration	50 ms (milliseconds)
Min trigger freq	15 kHz (kilohertz)
Trigger level	12 dB (decibel)
Trigger window	2 s (seconds)
Max length	00m:15 s (seconds)
Compression	None



Step 6- Set date and time: Move down using the arrow button to the “Date and Time” option and select it using the “Enter/Menu” button. If the date is incorrect, change it using the arrow buttons. Likewise, if the time is incorrect for the time zone, change it using the arrow buttons. Once the correct date and time are selected, press the right arrow key to save the choice. Press the left arrow key to return to “Settings”.

*Note: The “Rise and Set” times are automatically updated after the correct coordinates are added in the “Location” settings. To verify that these times are correct, check them after updating the “Location” settings. The “Rise and Set” times will change automatically throughout the season as the daylight lengthens and shortens. For example, on July 6th, 2020 the “Rise” time is 05:28 and the “Set” time is 21:06.

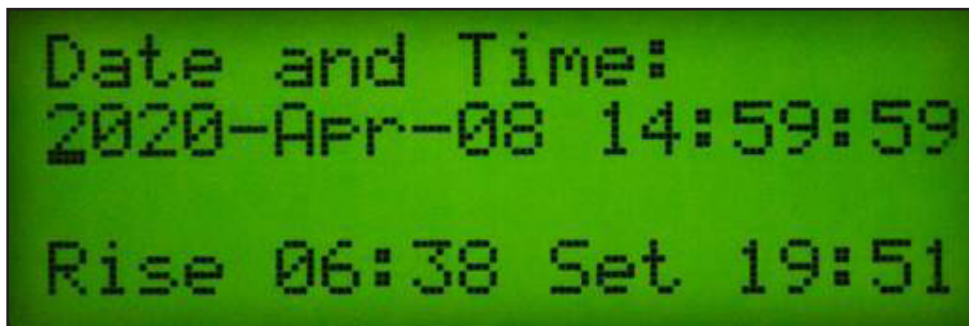


Figure 54. Set date and time (Step 6).

Step 7- Set location: Move down using the arrow button to “Location” and push the “Enter/Menu” button to select it. The top “Prefix” option can remain as is because it represents a unique identification number for the detector, or it can be changed based on the preference of the user. Next, press down to “Latitude” to set the correct coordinates for the site of deployment. Press the left arrow and then hold down the up or down arrows to select a number for “Latitude”. Once the correct Latitude has been entered, press the right arrow to save these settings. Then move down to “Longitude” and repeat the process for “Latitude”.

*Note: Ensure the correct hemispheric direction is next to the numeric coordinates which in Canada is west (W) for longitude and north (N) for latitude.



Figure 55. Set location (Step 7).



Step 8- Set time zone: Still in “Location Settings”, scroll down to “Timezone”. The “Timezone” can be selected by choosing a number with the down arrow. Once the correct number is selected, move with the right arrow to save the choice. Go back to the “Settings” using the left arrow.

*Note: The Universal Time Coordinated (UTC) time zone relative to Daylight Savings Time should also be set correctly under Location Settings. The Maritime Provinces and most of Labrador use Atlantic Time at UTC -3 during Daylight Savings Time and -4 during standard time. Newfoundland and southeastern Labrador are on Newfoundland Time at UTC -2 ½ during Daylight Savings Time and -3 ½ during standard time.

Step 9- Set sunrise/sunset type: Move down to “Sunrise/Sunset Type” and select it using the “Enter/Menu” button. Next to “Solar” it should say “sunrise/set”, if not, select this option using the arrow keys and press the right arrow to save. Double check that the indicated times at the bottom of the screen are correct for the current date and location, then press the left arrow button to return to Settings.



Figure 56. Set sunrise/sunset type (Step 9).

Step 10- Set LED indicator: Press the down arrow to the “LED Indicator” option (skip “Delay Start” and “Battery Cutoff”), and select this option using the “Enter/Menu” button. Press the left arrow button to move past “Mode” and select “5 minutes only”, and then press the right arrow to save.

*Note: This choice is optional and is a matter of preference to save battery life and make the detector less noticeable when deployed in the field.

Press the left arrow button to return to “Settings”, and the left arrow again to exit “Settings” and return to the “Main Menu”.



Step 11- Export schedule and settings: Press the down arrow to navigate to “Schedule” and select it using the “Enter/Menu” button. Press the down arrow again to navigate to “Export Sched+Setts” and select it using the “Enter/Menu” button. The screen should say “Stand by...” and then “Schedule Exported” before returning automatically to the “Schedule Settings”.

*Note: This is optional but will export all of the recently input schedule settings to the SD card, that way the card can be used to share schedule settings between detectors.

*Note: Not all of the settings will transfer, so each setting should be checked each time.

*Note: When exporting/importing schedules, the following settings do not transfer:

Date and Time: Time

Location: Latitude
Longitude
Timezone

Every other setting should transfer, but should be checked for verification.

Use the left arrow key to return to the “Main Menu”.

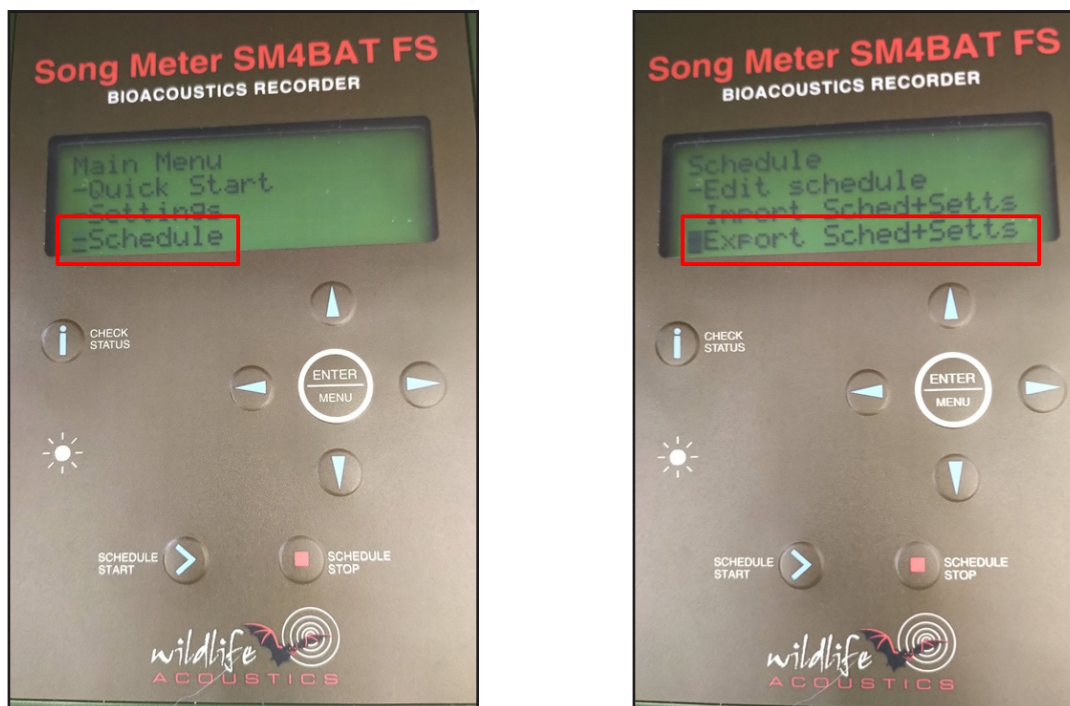


Figure 57. Export the schedule and settings (Step 11).



Step 12- Calibrate microphone: Under the Utilities menu, microphone calibration settings can be found. Use this in conjunction with the Wildlife Acoustics Ultrasonic Calibrator for Ultrasonic Microphones (sold separately). This calibrator emits an ultrasonic signal that can be used to test the sensitivity of ultrasonic microphones. Microphones should be tested before each field season, before each deployment if possible, and when troubleshooting is required (to test whether microphone sensitivity loss can be ruled out as an issue). Navigate to “Calibrate Mic” under “Utilities”. Set the ultrasonic calibrator to “CAL” (calibrate), it will now emit a constant 40 kHz tone.

Place the SMM-U2 microphone (connected to the SM4Bat detector) flat on the calibrator; slide it forward until it touches the switches. If the SM4Bat calibrator screen reads -47 dB or higher (less negative, closer to 0) the microphone passed the sensitivity test. If it reads below -47 (more negative) than it should not be used and should be replaced or repaired.



Figure 58. Calibrate microphone (Step 12).



Figure 59. Hemidirectional microphone calibration.

Image from Wildlife Acoustics

The SM4 detector set-up is now complete, if the detector is not being deployed until a later date, the detector can be turned off by moving the black switch on the top right of the detector to “EXT” to save battery life. If detectors are to record on the day of deployment, ensure that – “Delay Start” is not enabled (-enable “No” next to the “Delay Start” option). If detectors are deployed prior to the date that recording starts, a delay start can be set.

For more details on SM4Bat and other detectors, see the [NABat Guide to Acoustic Detector Settings](#).



3.3.2 SM4Bat Detector Set-up for Mobile Transects

Step 1- Insert batteries: Open the front, protective cover of the detector to expose the front screen panel and press down on the indentation between the two SD card slots to open the front panel and reveal the battery compartment. Insert four D batteries in the compartment and close the front panel.

Step 2- Turn on: Turn on the detector by flipping the black switch on the top right side of the detector from “EXT” to “INT”. The detector is now operating on the internal power source of the D batteries and the screen will come on.

Step 3- Insert SD cards: Insert a SD card in SLOT A (a second card may be inserted into SLOT B as a back-up or as a card for data overflow, but this is optional). Based on prior NABat monitoring conducted in Atlantic Canada, it is recommended to use at least one SD card with 32 GB storage capacity (or higher).

Due to operating system and setting variation when formatting memory cards with a computer, which can cause SD card reading issues for the acoustic detector, we recommend formatting memory cards with the SM4Bat detector before deployment.

*Note: Ensure any data from a previous deployment is digitally stored elsewhere before formatting the SD card.

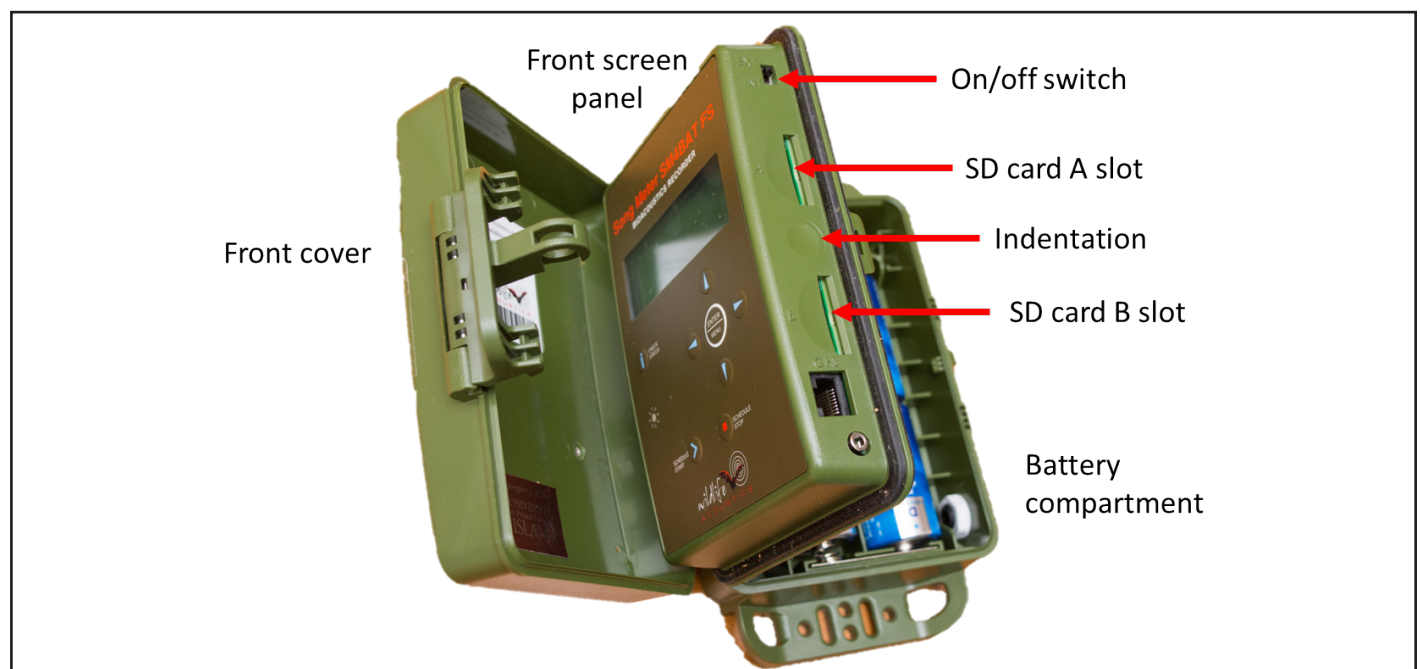


Figure 60. SM4Bat FS detector compartments.



Format SD cards: Under “Main Menu” press the downwards arrow button until it is on “Utilities”, then press the “Enter/Menu” button. Again, using the downward arrow button, scroll down to “Format all cards” and then press the “Enter/Menu” button. It will ask for confirmation: scroll down and select “Yes” with the “Enter/Menu” button. The detector screen should now read “Formatting all cards...” and will list the SD card slots where it formatted cards when the action is completed (it will say whether it is “Done” or whether there was no SD card in that slot). Press the left arrow button to get back to the “Main Menu”.

Step 4- Set recording schedule: When setting up the SM4Bat for mobile transects, the detector can be set up to record always. Using the arrow keys on the front panel, move the black cursor to “Quick Start” and press the “Enter/Menu” button. Use the down arrow to move the black cursor to the “Record Always” option. Press the right arrow or “Enter/Menu” button to confirm this setting. Press the left arrow button to go back.

*Note: Since a mobile transect is always conducted after sunset and before sunrise, the “Recrd-30Set->+30Rise” can be used instead of the “Record Always” setting. Whichever setting is chosen, the recording time must be manually initiated when starting the mobile transect.

*Note: If the detector goes to sleep, press the Check Status button to wake it up again. If it says “recording”, press the “Schedule Stop” button to return to the “Main Menu”.



Figure 61. SM4Bat FS “Enter/Menu” button.

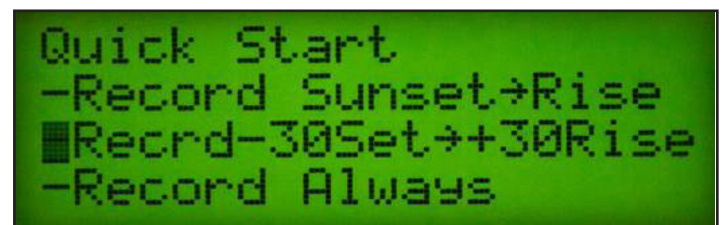


Figure 62. Set recording schedule (Step 4).



Step 5- Set audio settings: Move the black cursor to “Settings” and press the “Enter/Menu” button. Move the black cursor to “Audio” and press the “Enter/Menu” button. Enter the recommended NABat settings specified in *Table 5*, if not already selected. To select a setting, move the black cursor over to the options using the right arrow button and scroll up and down using the arrow buttons to select the setting of choice. Once selected, press the right arrow button to save the setting and continue.

*Note: If the left arrow button is pressed, the setting will revert to the standard setting).

Once all of the audio settings have been entered, press the left arrow button to return to the other settings.

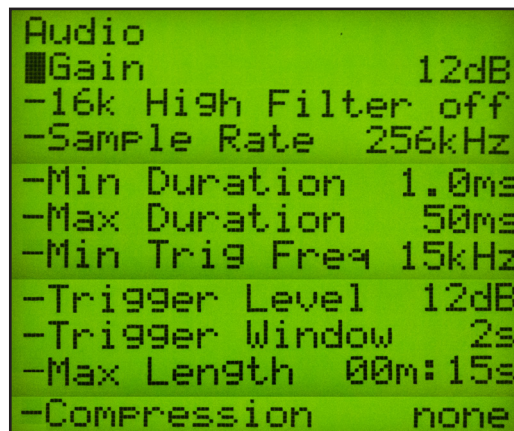


Figure 63. Set audio settings (Step 5).

Table 5. Wildlife Acoustics SM4Bat Detector Settings for Mobile Transects

Specification	Setting
Gain	12 dB (decibel)
16k high filter	OFF
Sample rate	256 kHz (kilohertz)
Min duration	1.0 ms (milliseconds)
Max duration	50 ms (milliseconds)
Min trigger freq	15 kHz (kilohertz)
Trigger level	12 dB (decibel)
Trigger window	2 s (seconds)
Max length	00m:15 s (seconds)
Compression	None



Step 6- Set date and time: Move down using the arrow button to the “Date and Time” option and select it using the “Enter/Menu” button. If the date is incorrect, change it using the arrow buttons. Likewise, if the time is incorrect for the time zone, change it using the arrow buttons. Once the correct date and time are selected, press the right arrow key to save the choice. Press the left arrow key to return to “Settings”.

*Note: The “Rise and Set” times are automatically updated after the correct coordinates are added in the “Location” settings. To verify that these times are correct, check them after updating the “Location” settings. The “Rise and Set” times will change automatically throughout the season as the daylight lengthens and shortens. For example, on July 6th, 2020 the “Rise” time is 05:28 and the “Set” time is 21:06.



Figure 64. Set date and time (Step 6).

Step 7- Set location: Move down using the arrow button to “Location” and push the “Enter/Menu” button to select it. The top “Prefix” option can remain as is because it represents a unique identification number for the detector, or it can be changed based on the preference of the user. Next, press down to “Latitude” to set the correct coordinates for the site of deployment. Press the left arrow and then hold down the up or down arrows to select a number for “Latitude”. Once the correct Latitude has been entered, press the right arrow to save these settings. Then move down to “Longitude” and repeat the process for “Latitude”.

*Note: Ensure the correct hemispheric direction is next to the numeric coordinates which in Canada is west (W) for longitude and north (N) for latitude.



Figure 65. Set location (Step 7).



Step 8- Set time zone: Still in “Location Settings”, scroll down to “Timezone”. The “Timezone” can be selected by choosing a number with the down arrow. Once the correct number is selected, move with the right arrow to save the choice. Go back to the “Settings” using the left arrow.

*Note: The Universal Time Coordinated (UTC) time zone relative to Daylight Savings Time should also be set correctly under Location Settings. The Maritime Provinces and most of Labrador use Atlantic Time at UTC -3 during Daylight Savings Time and -4 during standard time. Newfoundland and southeastern Labrador are on Newfoundland Time at UTC -2 ½ during Daylight Savings Time and -3 ½ during standard time.

Step 9- Set sunrise/sunset time: Move down to “Sunrise/Sunset Type” and select it using the “Enter/Menu” button. Next to “Solar” it should say “sunrise/set”, if not, select this option using the arrow keys and press the right arrow to save. Double check that the indicated times at the bottom of the screen are correct for the current date and location, then press the left arrow button to return to Settings.



Figure 66. Set sunrise/sunset type (Step 9).

Step 10- Set LED indicator: Press the down arrow to the “LED Indicator” option (skip “Delay Start” and “Battery Cutoff”), and select this option using the “Enter/Menu” button. Press the left arrow button to move past “Mode” and select “5 minutes only”, and then press the right arrow to save.

*Note: This choice is optional and is a matter of preference to save battery life.

Press the left arrow button to return to “Settings”, and the left arrow again to exit “Settings” and return to the “Main Menu”.



Step 11- Export schedule and settings: Press the down arrow to navigate to “Schedule” and select it using the “Enter/Menu” button. Press the down arrow again to navigate to “Export Sched+Setts” and select it using the “Enter/Menu” button. The screen should say “Stand by...” and then “Schedule Exported” before returning automatically to the “Schedule Settings”.

*Note: This is optional but will export all of the recently input schedule settings to the SD card, that way the card can be used to share schedule settings between detectors.

*Note: Not all of the settings will transfer, so each setting should be checked each time.

*Note: When exporting/importing schedules, the following settings do not transfer:

Date and Time: Time

Location: Latitude
Longitude
Timezone

Every other setting should transfer, but should be checked for verification.

Use the left arrow key to return to the “Main Menu”.

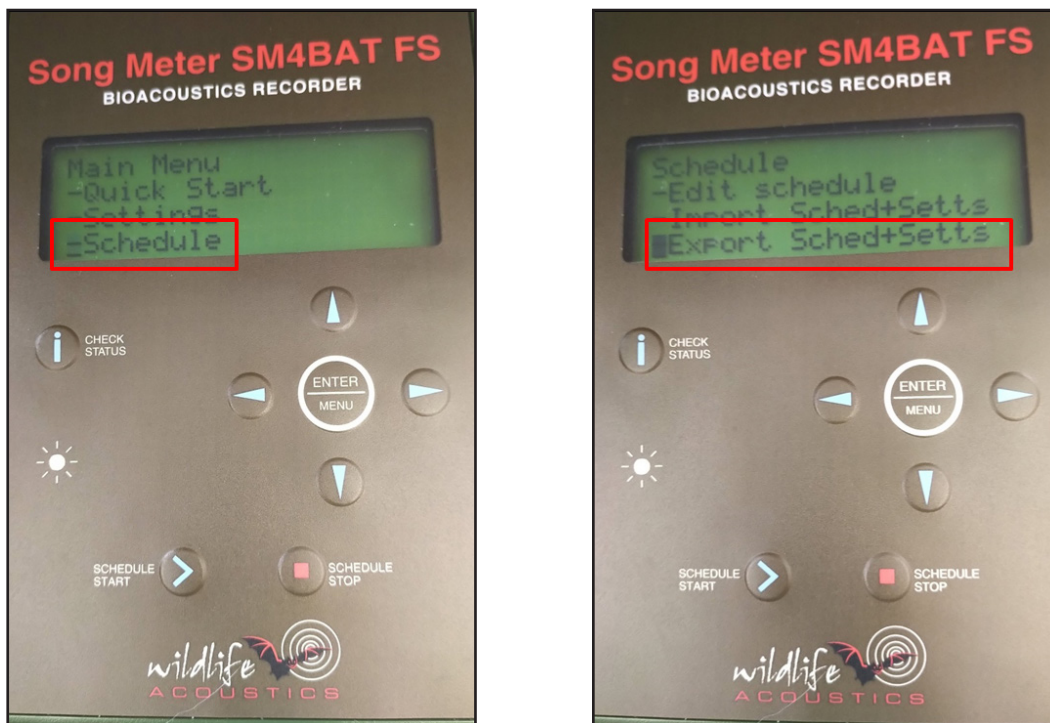


Figure 67. Export the schedule and settings (Step 11).



Step 12- Calibrate microphone: Under the Utilities menu, microphone calibration settings can be found. Use this in conjunction with the Wildlife Acoustics Ultrasonic Calibrator for Ultrasonic Microphones (sold separately). This calibrator emits an ultrasonic signal that can be used to test the sensitivity of ultrasonic microphones. Microphones should be tested before each field season, before each deployment if possible, and when troubleshooting is required (to test whether microphone sensitivity loss can be ruled out as an issue). Navigate to “Calibrate Mic” under “Utilities”. Set the ultrasonic calibrator to “CAL” (calibrate), it will now emit a constant 40 kHz tone.

Place the SMM-U2 microphone (connected to the SM4Bat detector) flat on the calibrator; slide it forward until it touches the switches. If the SM4Bat calibrator screen reads -47 dB or higher (less negative, closer to 0) the microphone passed the sensitivity test. If it reads below -47 (more negative) than it should not be used and should be replaced or repaired.



Figure 68. Calibrate microphone (Step 12).



Figure 69. Hemidirectional microphone calibration.
Image from Wildlife Acoustics

The SM4 detector set-up is now complete, if the detector is not being deployed until a later date, the detector can be turned off by moving the black switch on the top right of the detector to “EXT” to save battery life.

For more details on SM4Bat and other detectors, see the [NABat Guide to Acoustic Detector Settings](#).



3.4 Field Deployment

3.4.1 Detector Field Deployment for Stationary Point Surveys

Bat echolocation calls change in high clutter areas (places with many obstacles such as branches) both due to how sound echoes off of surfaces as well as due to bats changing the way they echolocate when there is more clutter in the environment. To ensure high quality bat echolocation calls are recorded that can be identified to species with a high degree of certainty it is important to choose monitoring sites strategically. Microphones should be positioned 3 to 5 meters from any clutter (such as trees, hedges, walls). Microphones should also be placed more than 1.4 meters above the ground and **kept horizontal (if water resistant, like the SMM-U2)** or angled down at 45 degrees (if not waterproof, like the SMM-U1). For security, we recommend that detectors are locked onto poles or trees. Set up detectors before deployment but do not start detectors until fully deployed and ensure the microphone cable is properly plugged in. Finally, turn the power switch to “INT” to switch the detector on and press the “SCHEDULE START” button. The detector screen will indicate “Going to sleep until...”, which time should be 30 minutes before sunset.

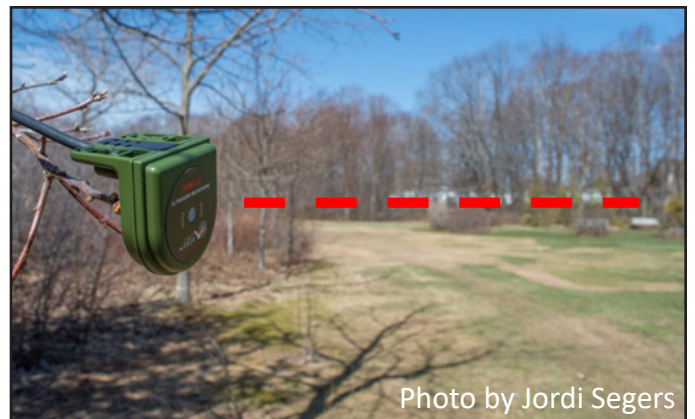
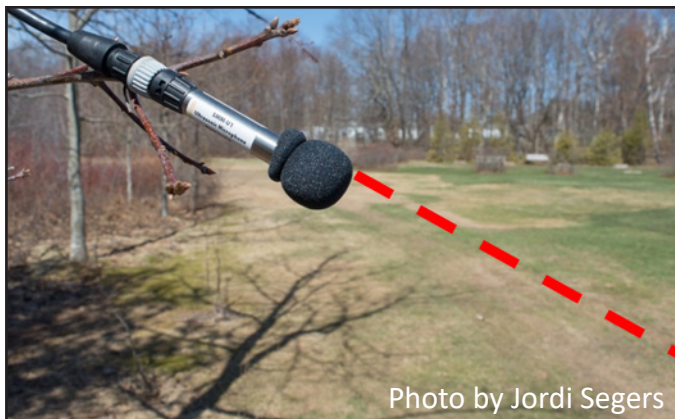


Figure 70. Microphone field deployment: omnidirectional microphone (left) and hemidirectional microphone (right).

3.4.1.1 SM4Bat Detector Field Check for Stationary Point Surveys

Step 1- Select the “CHECK STATUS” button. If functioning properly it should say “Going to sleep until the activation date at the pre-set time (30 minutes before sunset)”.

Step 2- While the “CHECK STATUS” screen is still open on the detector screen; select the “SCHEDULE STOP” button. This will stop the current schedule and allow access to the “Main Menu”.

Step 3- The screen should now be on the “Main Menu”. Again, select the “CHECK STATUS” button. This will show the status of the memory cards, microphone, and batteries.



3.4.1.1.1 Microphone

The microphone information should read as “Mic: U2”, which means that the microphone cable is connected to the detector in the MIC socket. If it reads “Mic: NA”, the microphone cable is not connected properly and will need to be connected before recording can begin.

*Note: If the microphone is not connected properly to the microphone cable, but the cable is connected properly to the detector, the microphone status will still read as “Mic: U2”, however, no recording will be able to take place. Periodically check that the microphone is properly attached to the microphone cable.

3.4.1.1.2 Battery

The battery life will read as “Bat: x.x V”. Generally, new D batteries will have a voltage of anywhere between 6.1 and 6.5. In order for the detector to properly record the bat calls, **the battery should not fall anywhere below a minimum of 4.5 V**. In order to change the batteries, open up the internal section of the detector by placing pressure on the round indentation on the side.

3.4.1.1.3 SD Cards

The SM4 has two SD card slots, SDA and SDB. Next to the name of the slot will be the amount of data captured on the memory card in gigabytes (GB). For example, if it reads “SDA: 1/64”, this means that there is a 64 GB memory card in slot A with approximately 1 GB of data. Anything below 1 GB will read as 0 GB, but this does not necessarily mean that there is no data on the memory card. If there is no memory card placed in the slot it will read “EMPTY”. There must be at least one memory card in a slot in order to record data. When changing a memory card, pop the memory card out of the slot on the side of the detector by first gently pressing the SD card until it pops out and then replacing the removed SD card with a new memory card. After changing the memory card ensure that the detector can properly read the card by again selecting the “CHECK STATUS” button. Next to the slot that the card was placed in, it should read 0/64.

*Note: Ensure the new SD card has been reformatted (described in *Section 3.3.1. Step 3*).

*Note: If changing to a new memory card, it may be desirable to export the schedule and settings from the detector on to the new memory card. This is not necessary, but will allow the schedule to be shared with another detector or to be saved as a computer file; the schedule will be easily transferable via the SD card. Saving the schedule and settings to a SD card can be done by going into “Main Menu”, “Schedule”, “Export Sched+Setts” and selecting the “Enter/Menu” button.

Additionally, it may be beneficial to quickly review the detector settings to ensure that the settings are the same after changing a SD card or the batteries (the settings should not change, this is just a precaution).



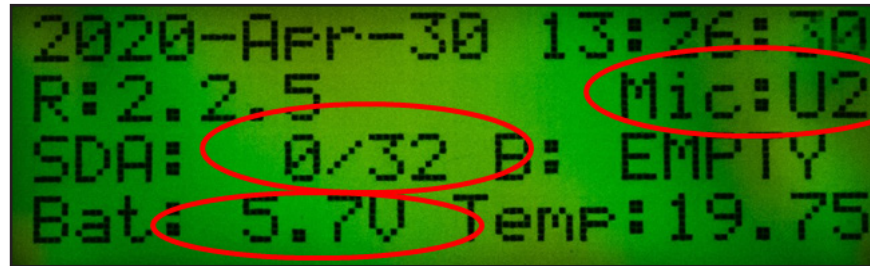


Figure 71. Microphone, battery, and SD card status (Step 3).

Step 4- After the microphone has been checked, and the batteries and SD card have been checked and/or changed, the detector is ready to re-start its schedule. Select the “SCHEDULE START” button and the detector will go to sleep again.

*Note: If there is no attached microphone cable or SD card inside a slot, a warning will be given at this point).

Now, if the “CHECK STATUS” button is selected it should again say, “Going to sleep until the activation date at the pre-set time (30 minutes before sunset)”.

Now the detector field check is complete.



Figure 72. Select the “SCHEDULE START” button and the detector will go to sleep again (Step 4).



3.4.2 Detector Field Deployment for Mobile Transects

It is highly recommended that a GPS track is created with a GPS unit during the mobile transect. Unless the GPS Module for SM4 detectors is used, a separate, hand-held GPS unit can be used. Consult the user manual of the GPS unit to determine how to activate and save tracks. When using an external GPS, ensure the SM4Bat time settings are exactly the same as the time indicated by the GPS (which is always accurate) for later cross referencing. If no GPS unit is available a mobile transect can still be conducted with data associated to a GRTS cell. The NABat website has a tool that automatically estimates the location of mobile transect bat detections based on time and transect route. See *Section 4.8.2.1* in this document on how to enter the mobile route into the NABat database.

*Note: A SM3BAT detector recording in WAC mode with a GPS attached will create a track log. Similarly, if a Titley Scientific detector (Swift, Express, Walkabout) is being used, these units have a transect mode which will automatically log the track in addition to embedding waypoints of recordings into file metadata.

The acoustic detector remains inside the vehicle and the plastic cover can be kept open for visual monitoring by the passenger. The microphone will have to be mounted outside the vehicle, pointing straight up. While there are no ready-made rigs to mount microphones on a car, custom rigs can be easily made with pieces of wood or plastic, held in place by sunroof or passenger window of the vehicle. Ensure that the microphone projects entirely above the highest point of the vehicle, so that the sides of the vehicle cannot block any sounds from reaching the microphone.

Set up detectors before deployment but do not start detectors until fully deployed and ensure the microphone cable is properly plugged in. Finally, turn the power switch to “INT” to switch the detector on and start recording by pressing the “SCHEDULE START” button. Wait to start recording until the mobile transect has commenced to prevent potentially recording bat passes that should not be included in the mobile transect data analysis. When the “SCHEDULE START” button is pressed, the detector will start recording immediately. The screen should say “Preparing to record” with the current date and time at the top of the screen. Underneath it will say “CONTINUOUS”, which indicates that it will record continuously until the schedule has been stopped. Then “Preparing to record” will change to “Currently Recording” and below it will either say “ARMED” (the detector is primed to begin recording as soon as the microphone is triggered), “TRIGGERED” (a recording has been triggered), or “PREPARING” (the detector is saving the recorded file to the SD card). At the end of the mobile transect press the “SCHEDULE STOP” button to stop recording.



Figure 73. SM4Bat GPS unit.

Image from Wildlife Acoustics



3.5 Site Data

Ancillary data should be collected, including: deployment location (including GRTS cell ID), habitat type, detector and microphone identifiers, microphone height, and microphone orientation (see *Sections 7.1 and 7.2*). [Metadata sheets](#) with additional fields can be downloaded from the NABat website.

3.6 Common Deployment Issues and Troubleshooting

3.6.1 “DIRTY” SD Cards

Sometimes when SM4 Bat detectors are retrieved, the SD card status reads as “dirty”. This indicates that there was a power issue when the detector was writing data to the memory card, most likely caused by discharged batteries, and the detector has protected the memory card from losing any of the data already stored on it (becoming corrupt) by preventing any more changes to be made to those data. Thus, no more data is stored after the power issue occurred, but any data saved before the interruption will be secured and accessible on the card. Always use new alkaline batteries or fully charged rechargeable batteries when deploying detectors to minimise risk of cards become write-protected due to a sudden loss of power.

3.6.2 High Clutter Habitat

Data containing fragmented bat calls are hard to read. Therefore, as described earlier, microphones should be placed in areas with low clutter and no reflective surfaces. If leaves, branches, or other clutter are near the microphone, and thus between the microphone and the bats, only fragments of calls might be recorded, making it very hard to identify species. Similarly, flat, reflective surfaces create multiple echoes of a bat echolocation call, which can make species ID difficult. Place microphones away from clutter and reflective surfaces to increase the recording quality of bat echolocation calls, which makes species ID easier.



Photo by Tessa McBurney

Figure 74. If leaves, branches, or other clutter are near the microphone only fragments of calls might be recorded.



3.6.3 Microphone Sensitivity

If no data were recorded during deployment, use the Wildlife Acoustics Ultrasonic Calibrator for Ultrasonic Microphones (see *Section 3.3.1. Step 12*) to test whether the microphone is faulty. This test cannot account for improperly connected microphones or cables during deployment.

*Note: SMM-U1 microphones require a slightly different setup for calibration than SMM-U2 microphones. Consult the SM4Bat user manual for these details.

3.6.4 Firmware Update

Always ensure that the SM4Bat detector is operating with the latest firmware version, this decreases chances of errors due to incompatibility with new brands or models of SD cards or other bugs caused by the detector. The current firmware version can be read from the main screen of the SM4Bat detector, reading, for example: “R:2.2.5”. Visit <https://www.wildlifeacoustics.com/account/downloads/firmware> and log in to download the latest firmware version. Copy the file to an SD card (in the top layer of the directory, *i.e.*, not in any folder). Insert the card into the SM4Bat. Navigate to “Main Menu”, “Utilities”, “-Firmware Update”. Select the Firmware file and give the detector a moment to finalise the update. Check on the main screen if the firmware version is indeed updated by pressing the “CHECK STATUS” button.



Figure 75. Always ensure that the SM4Bat detector is operating with the latest firmware version.

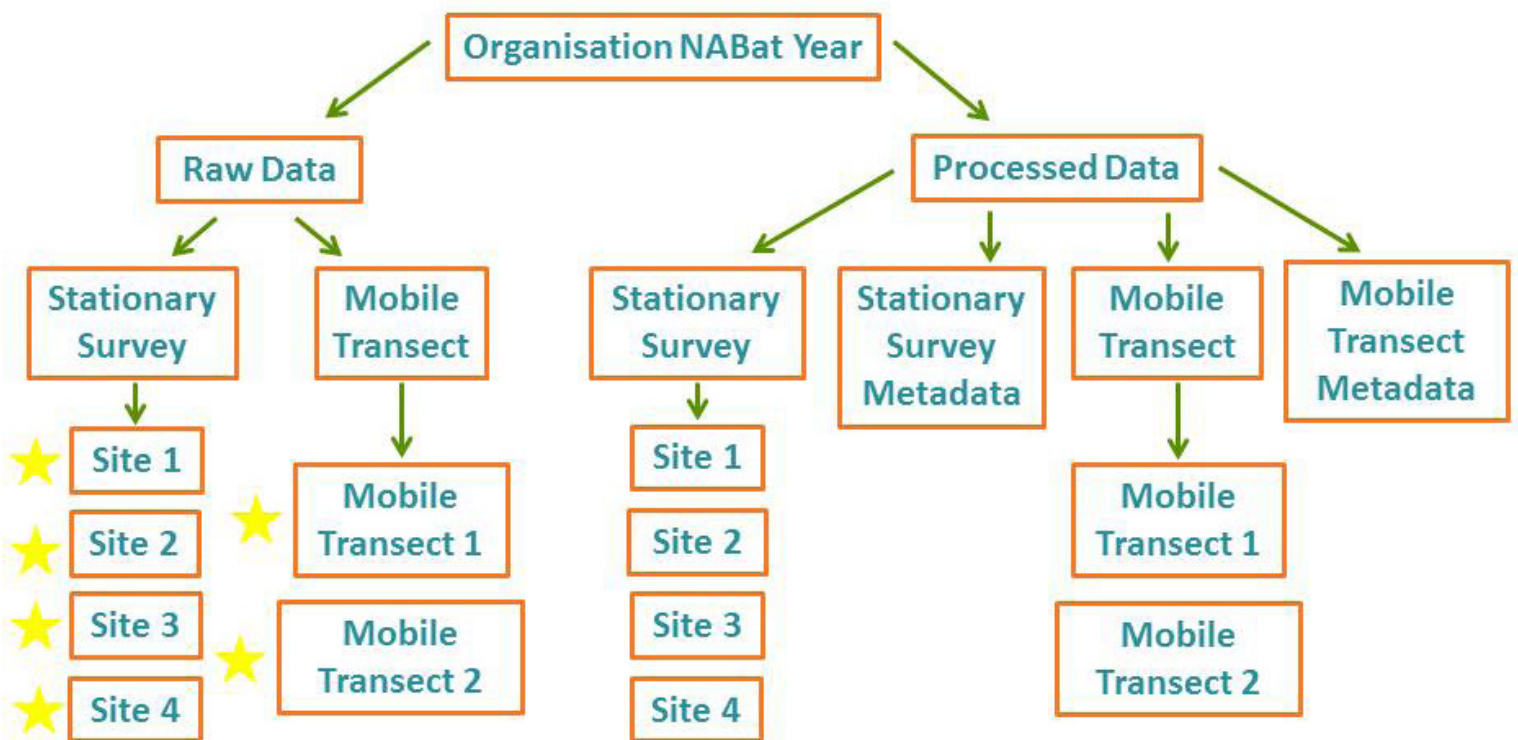


Figure 76. File folder organisational system for acoustic data. The stars indicate the file folders where the raw data are stored.





4.1.2 Transferring Data from Detector to Computer

When the bat detectors are retrieved from the field, it is time to transfer the acoustic data from the SD card(s) in the detector onto a computer hard drive for backup storage and data analysis. As a precautionary measure, first shut the detector off by switching the black switch on its top right side from INT to EXT. The batteries can also be removed at this time if the detector is not to be used again in the near future. All of the data are recorded on a SD card, so the SD card(s) can simply be removed from the SD slot(s) in the detector and inserted into a SD slot in a computer. The SD card should show up on the computer directory (in the list of devices) as a SD card drive under “Computer”. Simply click on this drive to see the available data. These data can subsequently be copied to another folder on the computer, and ideally backed up on a secondary device (e.g., external hard drive) if possible. When the data are uploaded to the NABat website, they can also be safely accessed online. After the data are safely copied to a computer and verified to be in good condition, reformat the SD card in the detector (see *Section 3.3.1 Step 3*). Use the organisational system created in *Section 4.4.1* to sort and store the data.

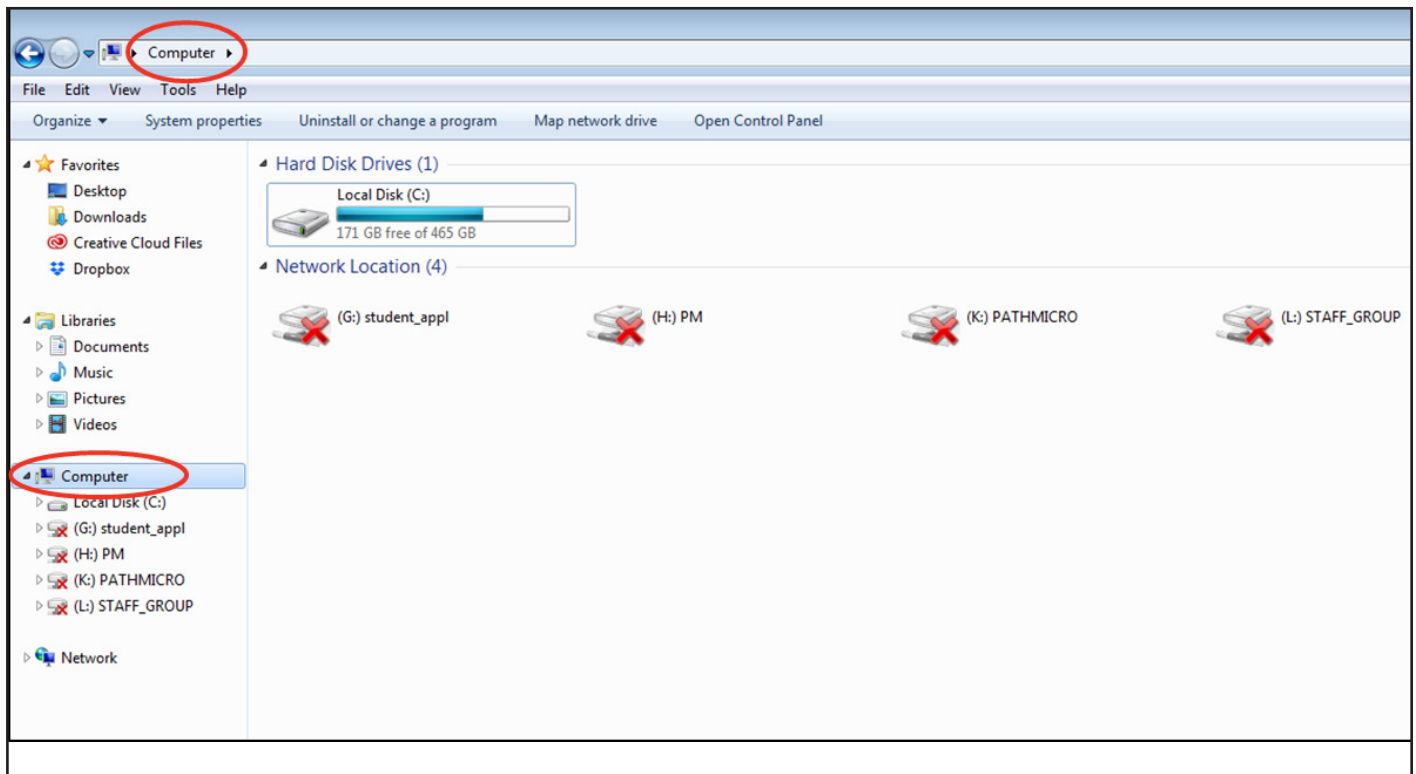


Figure 77. Transfer the acoustic data from the SD card(s) onto a computer.



4.2 Introduction to the NABat Website

4.2.1 Creating a NABat Account

To upload the data to the NABat website, first request an account. Go to the [NABat website](#) and select the orange “Partner Portal” button at the top right of the page.

*Note: Use Google Chrome or Mozilla Firefox as the internet browser. The images below show the NABat website using Google Chrome. If Mozilla Firefox is used, the layout of the website will be slightly different.

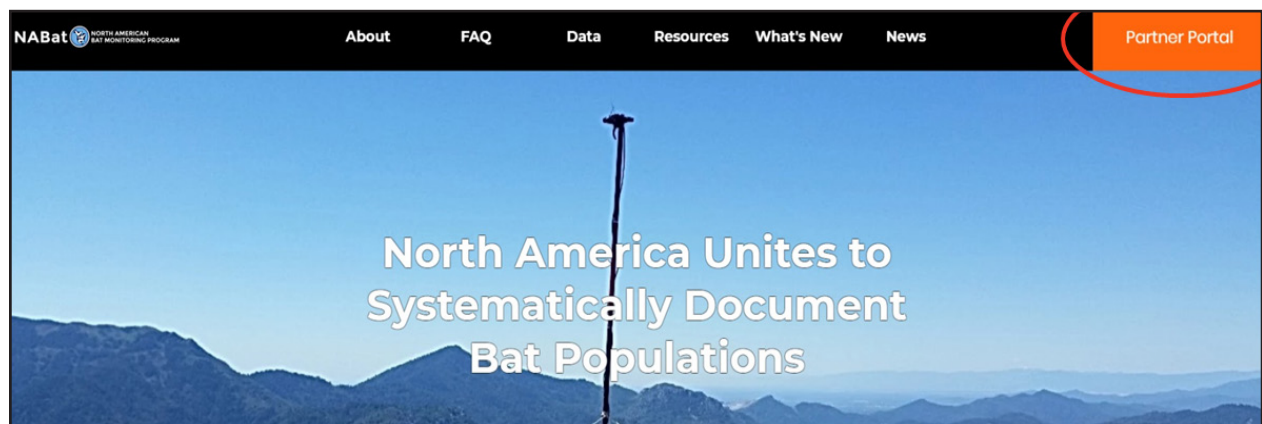


Figure 78. Go to the NABat website and select the orange “Partner Portal” button at the top right of the page.

This progresses to a page where “Login/Request an Account” is at the top right of the screen.

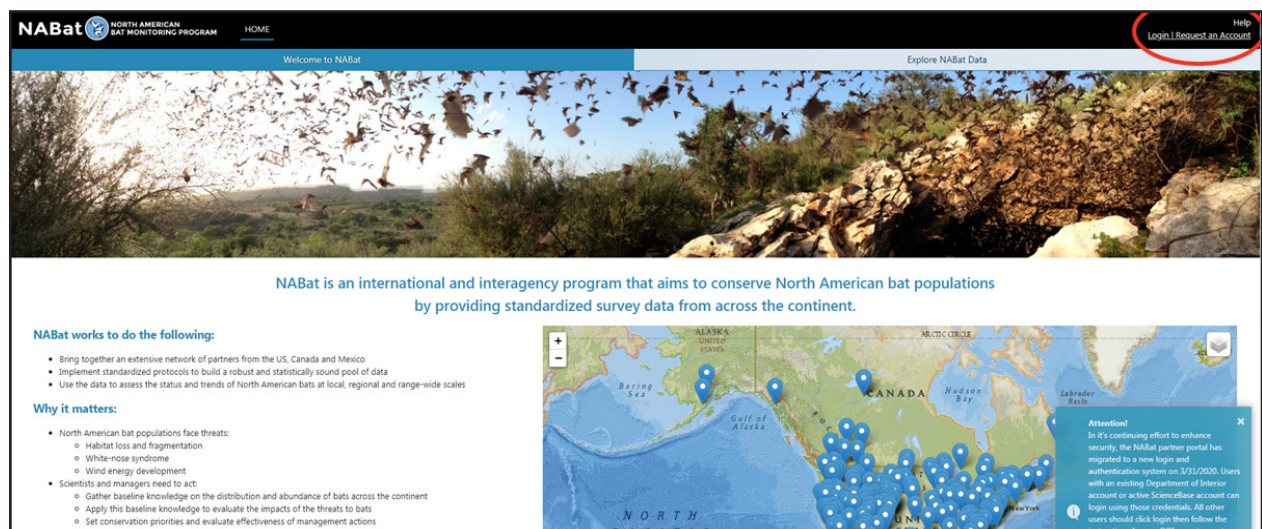


Figure 79. This progresses to a page where “Login/Request an Account” is at the top right of the screen.



Click on “Login/Request an Account” and on the new screen go to the “Non-DOI users” section and click the link.

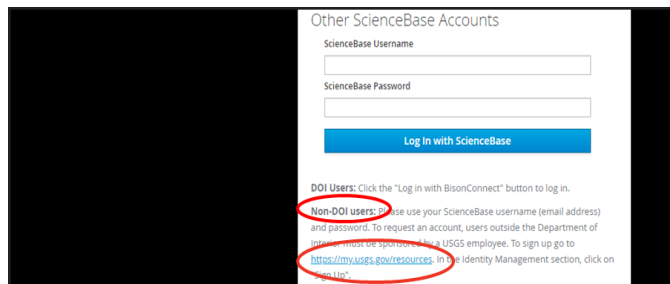


Figure 80. Click on “Login/Request an Account”.

This will open a new page where there are several fields that must be completed. For the Sponsor (USGS email) field use the following e-mail address: breichert@usgs.gov.

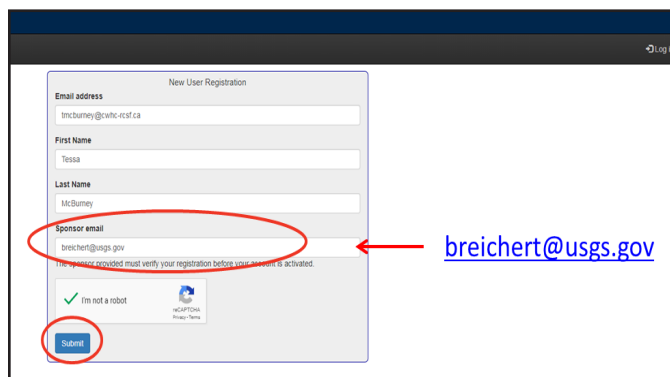


Figure 81. Complete the fields.

Once the sponsor approves the account, an e-mail will be sent to the e-mail address associated with the account. Click on the link in the e-mail.

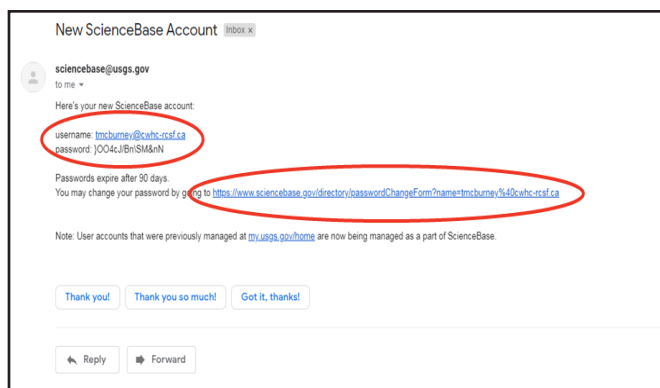


Figure 82. Click on the link in the e-mail.



Put the username included in the e-mail (e-mail address) and the temporary password given in the e-mail, before clicking the “Login” button.

Username: e.g., joe@usgs.gov

Password:

DOI users: Please use your ScienceBase username (email address) and Active Directory password.

Non-DOI users: Please use your my.usgs.gov username (email address) and password. To request an account, users outside the Department of Interior must be sponsored by a USGS employee. To sign up, [go here](#).

I've forgotten my password.

- Non-DOI users can reset their password [here](#)
- For help with Active Directory credentials, DOI users can contact the USGS Service Desk at 703-648-HELP (4357) or [USGS Service Desk Web Page](#) (requires USGS intranet access)

WARNING TO USERS OF THIS SYSTEM

This computer system, including all related equipment, networks, and network devices (including Internet access), is provided by the Department of the Interior (DOI) in accordance with the agency policy for official use and limited personal use. All agency computer systems may be monitored for all lawful purposes, including but not limited to, ensuring that use is authorized, for management of the system, to facilitate protection against unauthorized access, and to verify security procedures, survivability and operational security. Any information on this computer system may be examined, recorded, copied and used for authorized purposes at any time. All information, including personal information, placed or sent over this system may be monitored, and users of this system are reminded that such monitoring does occur. Therefore, there should be no expectation of privacy with respect to use of this system. By logging into this agency computer system, you acknowledge and consent to the monitoring of this system. Evidence of your use, authorized or unauthorized, collected during monitoring may be used for civil, criminal, administrative, or

Figure 83. Put the username included in the e-mail (e-mail address) and the temporary password given in the e-mail.

This will open another webpage where the password for the account can be changed. In the “Current password” field, type the password provided in the e-mail above, and then create a new password using the two fields below. Click on the blue “Save” button to save the new password.

USGS
science for a changing world

ScienceBase-Directory People Organizations Help

Change Password for tmcburney@cwhc-rcaf.ca

Current Password

New Password

Confirm New Password

ScienceBase-Directory Version: 3.2.2 | Report a Problem | For General Contact/Questions | ScienceBase Notify
Build Version: 3.2.1-3-g53d77eb (2020-03-03 07:41)

DOI Privacy Policy | Legal | Accessibility | Site Map | Contact USGS

U.S. Department of the Interior | DOI Inspector General | White House | E-gov | No Fear Act | FOIA

Figure 84. Click on the blue “Save” button to save the new password.



This opens another page saying that the password change was successful.

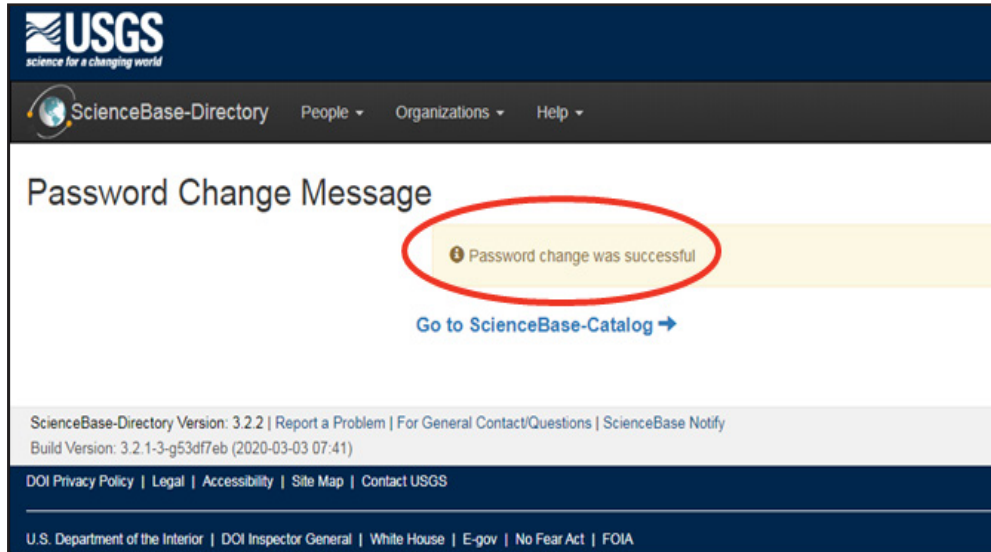


Figure 85. This opens another page saying that the password change was successful.

Go back to the NABat login [page](#) and enter the e-mail address and new password under “Other ScienceBase Accounts”, and click the blue “Log In with ScienceBase” button. Once this is done, login is possible.

*Note: ScienceBase now requires a password change every 90 days.

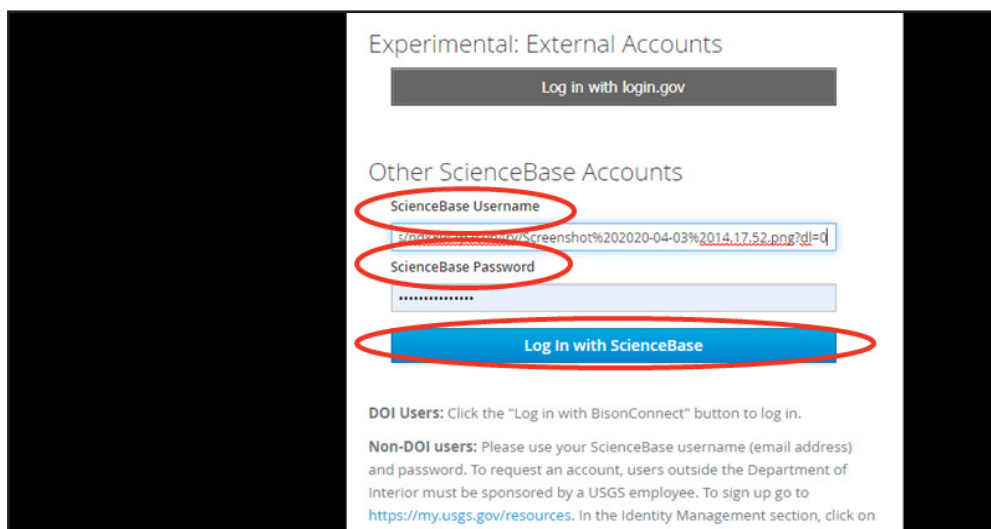


Figure 86. Enter the e-mail address and new password under “Other ScienceBase Accounts”.



4.2.2 Creating a NABat Project

Go back to the above [website](#) and select “Login” at the top right. Enter the username and password created in Section 4.2.1 and select the green “Login” button below. This should automatically bring up “Projects”, but if not, then select “Projects” next to “Home” at the top left side of the page. The first time data are uploaded to NABat, a new project will have to be created. Select the “Add New Project” button to the right above the map.

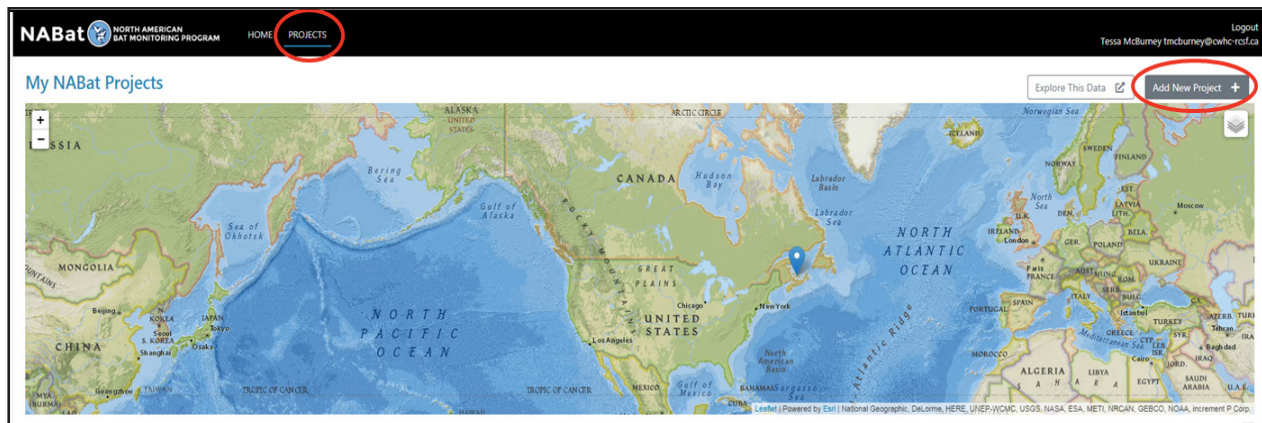


Figure 87. Select the “Add New Project” button to the right above the map.

On the new page, fill in all of the required fields.

*Note: The “Owning Organization” field cannot be edited. If the desired organisation is not already in the dropdown list, please contact Dane Smith (danesmith@contractor.usgs.gov) with the name and address of the new organization and ask that it be added to the list.

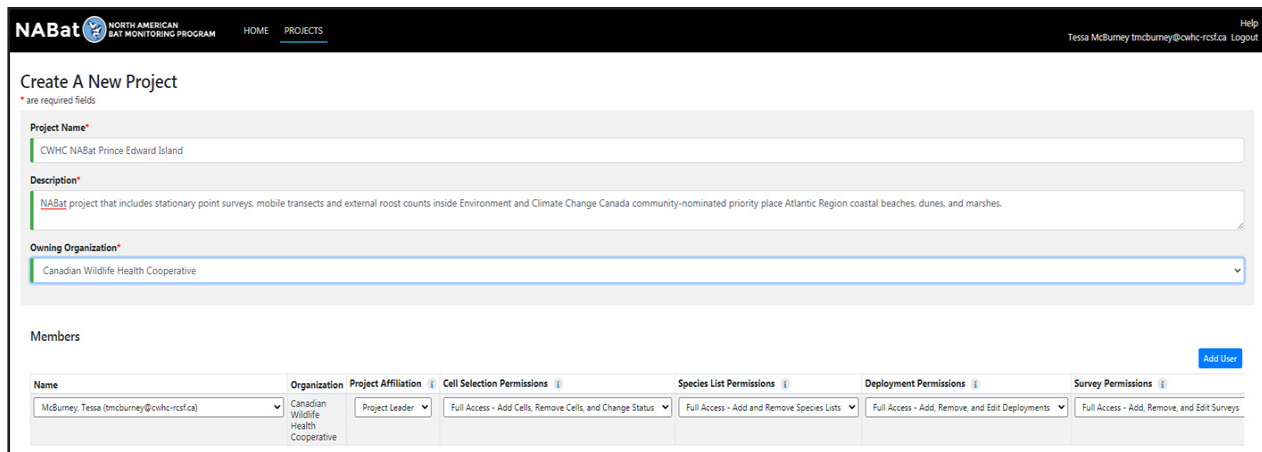


Figure 88. On the new page, fill in all of the required fields.



Under “Members” add every person that should be able to access and upload the data. Under “Project Affiliation” the Project Leader and other contributors (e.g., biologists, researchers) can be designated.

*Note: Ensure that at least one individual is designated as a Project Leader.

New people can be added by selecting the blue “Add User” button on the right. At this point, the provincial coordinator should also be added so they are able to access the data. Under the four “Permissions” columns it can be indicated how much access each individual has to various aspects of the project. Provincial coordinators should be given Full Access in each category.

Figure 89. Under “Members” add every person that should be able to access and upload the data.

Under “GRTS Selection” select the appropriate option under “Sample Design” (likely the “NABat: Survey locations were established following the NABat sample design.” option). Under “Grid Sample Frame” select “Canada 10x10km Grid”.

Figure 90. For “Sample Frame” select “Canada 10x10km Grid”.



One of the benefits of NABat, as previously discussed, is that they use the uploaded data to internally conduct assessments of bat species across North America. A new feature of the website is to give the option to also have the data available for public access. It is recommended that “Never do” is selected, or that the public access drop-down lists are left blank until there is consultation with a provincial biologist. The first permission is to allow public access to location coordinates for caves, mines, and roosts, which are extremely sensitive sites for bat recovery and often occur on private land. These data should not be shared without the permission of provincial biologists. After completion of the public access section, select the blue “Proceed to Cell Selection” at the bottom right.

Figure 91. It is recommended that “Never do” is selected until there is consultation with a provincial biologist.

Now, if the Canada sample frame was properly selected, a map of Canada is shown and there is a drop-down list of Canadian provinces when “Select State” is chosen. Select the province of interest, which will place a blue NABat grid over the province of choice (it may appear as solid blue until the map is zoomed in on, either by scrolling with the mouse or selecting the “+” button at the top left of the map).

Figure 92. Select the province of interest.



To see the NABat priority monitoring cells for the province, select the white button with grey squares in the top right of the map, and select “NABat Priority Cells (by state/province)” from the drop-down list. Now, the NABat priority monitoring cells should appear highlighted in green. Another useful layer from the drop-down list is “NABat Project Locations”, which will show all current NABat projects on the map with blue pins if it is selected from the drop-down list. Select the monitoring cell (specifications can be filled in above the map to narrow down the search, or the map can be zoomed in on by double clicking on a cell). More than one site can be selected if the NABat site spans two of the GRTS cells (just click on both cells). To reset the map, select the red “Cancel” button at the right of the screen.

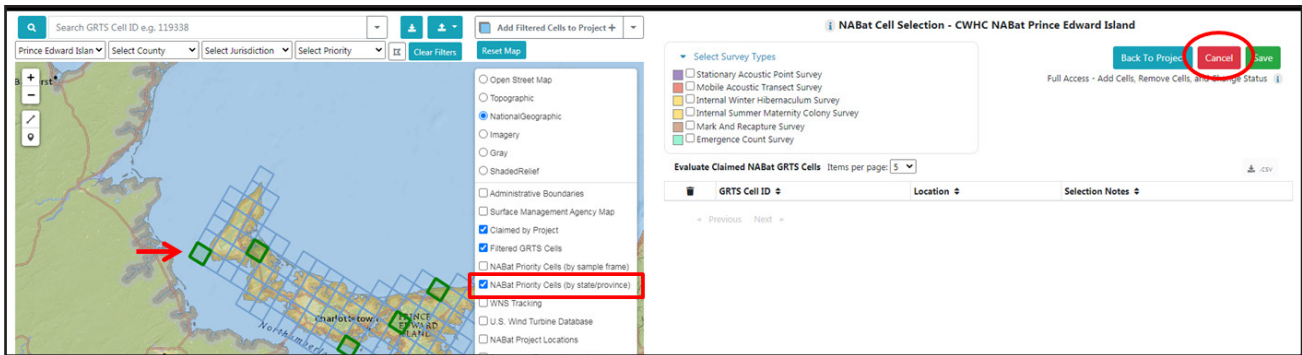


Figure 93. To see the NABat priority monitoring cells for the province, select the white button with grey squares in the top right of the map, and select “NABat Priority Cells (by state/province)” from the drop-down list.

When a cell is selected, it shows up to the right of the map with a “GRTS Cell ID”. Above, the types of monitoring done at the site can be selected next to the coloured boxes. Select next to the purple box for stationary point surveys, select next to the pink box for mobile transects, and next to the green box for emergence counts. Now next to the GRTS Cell ID new columns will appear, depending on the type of monitoring that was selected.

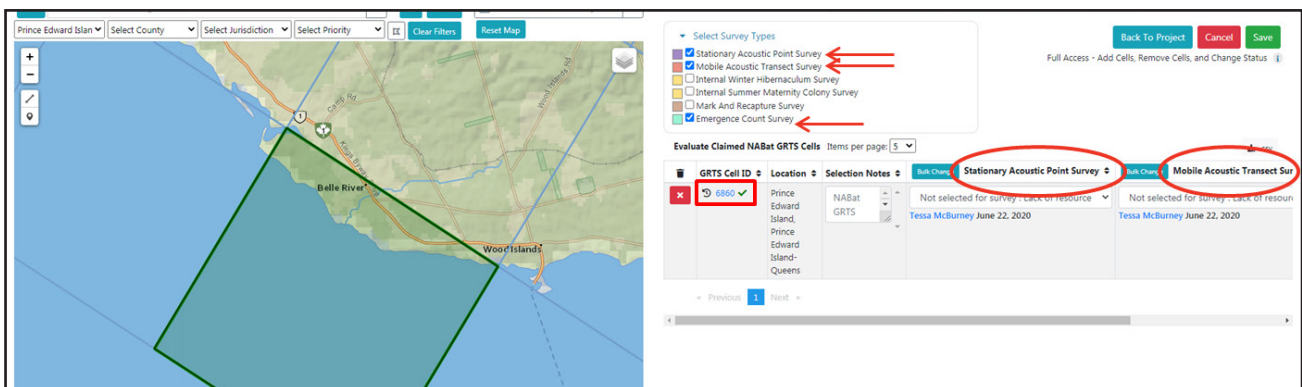


Figure 94. The types of monitoring done at the site can be selected next to the coloured boxes.



If stationary acoustic point surveys were conducted, under this column, select "Selected for survey". Do this for every type of monitoring that was done at this site. If a required column is not there, check the appropriate box above next to the coloured boxes. If a specific type of survey was unable to be done in the GRTS cell, this can be specified here as well. For example, if a mobile transect was unable to be conducted because there was not a suitable length of roadway, still select the Mobile Acoustic Transect Survey next to the pink box, but then under the Mobile Acoustic Transect Survey column select "Not selected for survey : Absence of >25km roads for mobile transects" from the drop-down list.

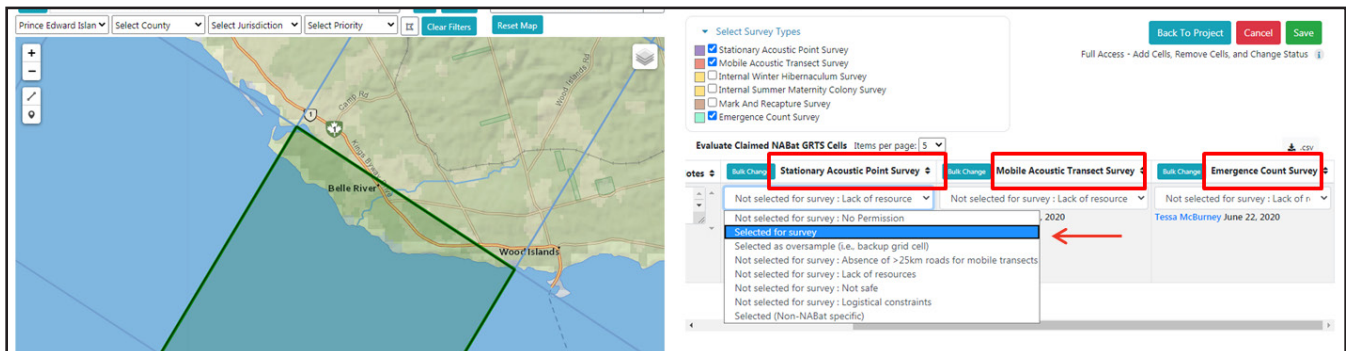


Figure 95. Select "Selected for survey" for every type of monitoring that was done at this site.

Next select the green "Save" button above the project information to establish and save the project.

*Note: If no survey type is selected for a cell (i.e., none of the coloured boxes are selected), the chosen GRTS cell will not save to the project even after selecting the "Save" button before moving to another page. If this happens, within the desired project the "Proceed to Cell Selection" button will have to be selected again and the GRTS cell will have to be re-selected, this time ensuring that at least one survey type is chosen using the coloured boxes.

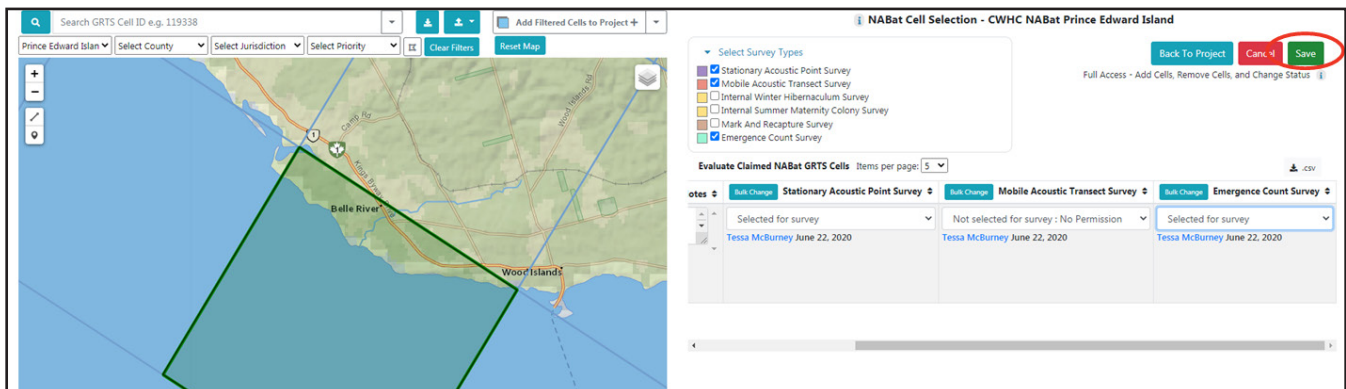


Figure 96. Next select the green "Save" button above the project information to establish and save the project.



If for some reason a mistake is made that cannot be changed and that project needs to be deleted, go to the “Projects” page, and click on the project that needs to be deleted. Once this is done, click on the small, red button with a trash can icon, next to “Reporting”, and when asked for confirmation of whether the project should be deleted, select the red “Delete” button at the bottom of the pop-up window. That will remove the project.

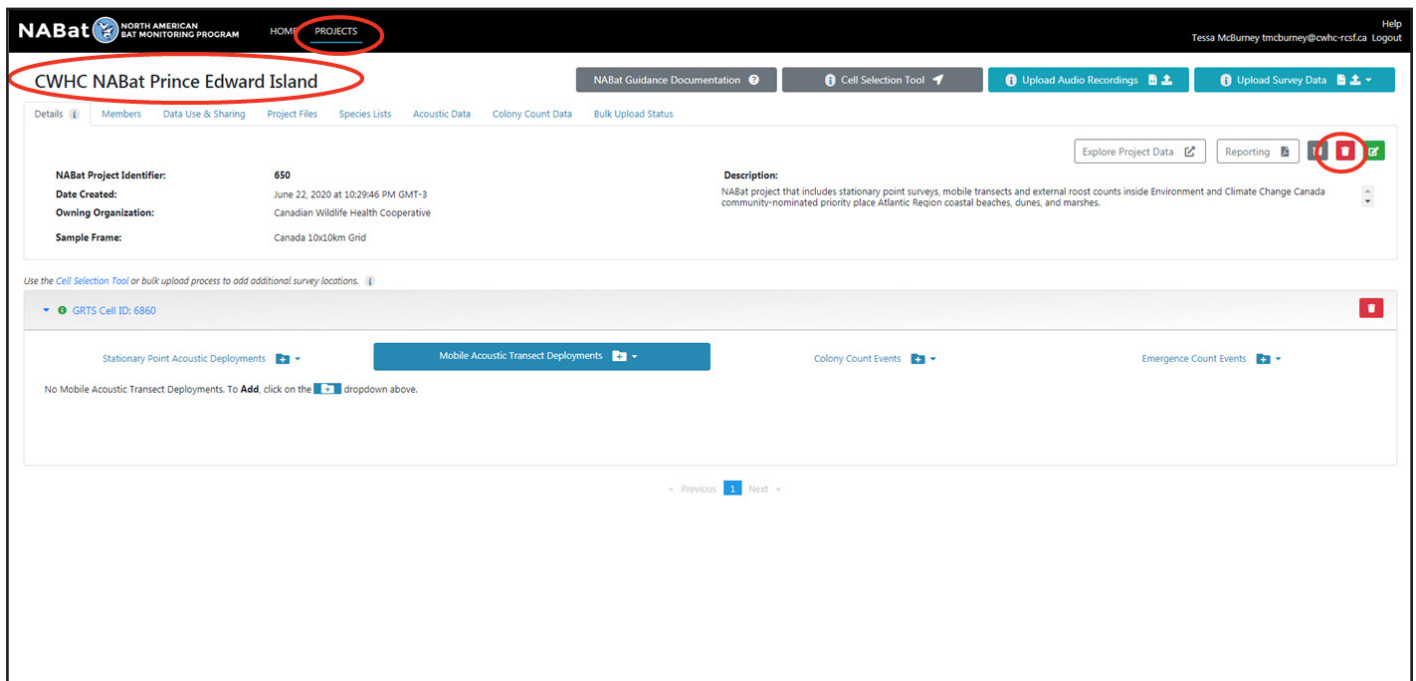


Figure 97. If for some reason a mistake is made that cannot be changed and that project needs to be deleted, click on the small, red button with a trash can icon.



4.3 Spectrogram Software

4.3.1 Introduction to Kaleidoscope

There are many great software options available for reading acoustic data, including Sonobat, Analoow, Anabat Insight, Bat Call Identification (BCID), and Kaleidoscope. Each program has its strengths and weaknesses for analysing bat acoustic data, so if purchasing software, do research and select the program that best suits the needs of the project. For the purposes of this training guide, one program was selected as an example for practical reasons, and thus, only Wildlife Acoustics Kaleidoscope software will be described within this guide. This software program was chosen because a free version is available, it is able to directly analyse both full spectrum and zero-cross files (described in *Section 4.3.2*), and there is a statistically-based auto identification option that can be **purchased**.

To download the free Kaleidoscope software, go to the Wildlife Acoustics **website**, where it is necessary to first create an account. Click on “My Account” on the top of the page, which opens the Log In page.

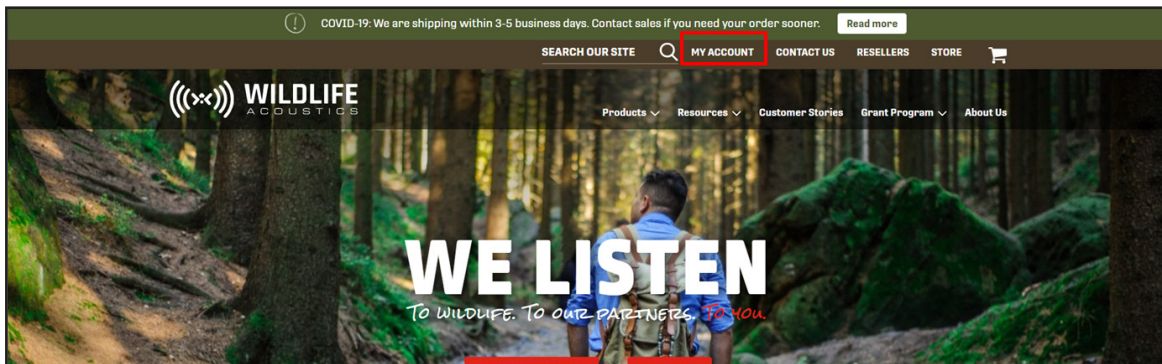


Figure 98. Click on “My Account” on the top of the page, which opens the Log In page.

Select the “Request Account / Reset Password” button.

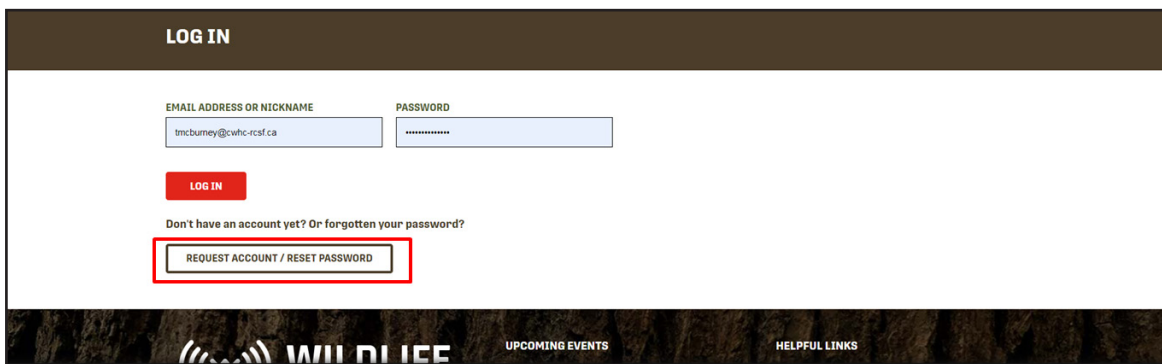


Figure 99. Select the “Request Account / Reset Password” button.



Then add an e-mail address, and select the box agreeing to terms of use before clicking the red “Create New Account” button. An e-mail will be sent with a link to a webpage where all the required fields must be filled in before selecting the “Create Account” button at the bottom of the page. The registered e-mail account and new password will enable login into the “My Account” page.

Figure 100. All the required fields must be filled in before selecting the “Create Account” button at the bottom of the page.

When logged in, select the “Resources” tab at the top of the webpage and scroll down to and select “Downloads” (first option from top).

Figure 101. Select the “Resources” tab at the top of the webpage.



On the new page, click on the Kaleidoscope icon.

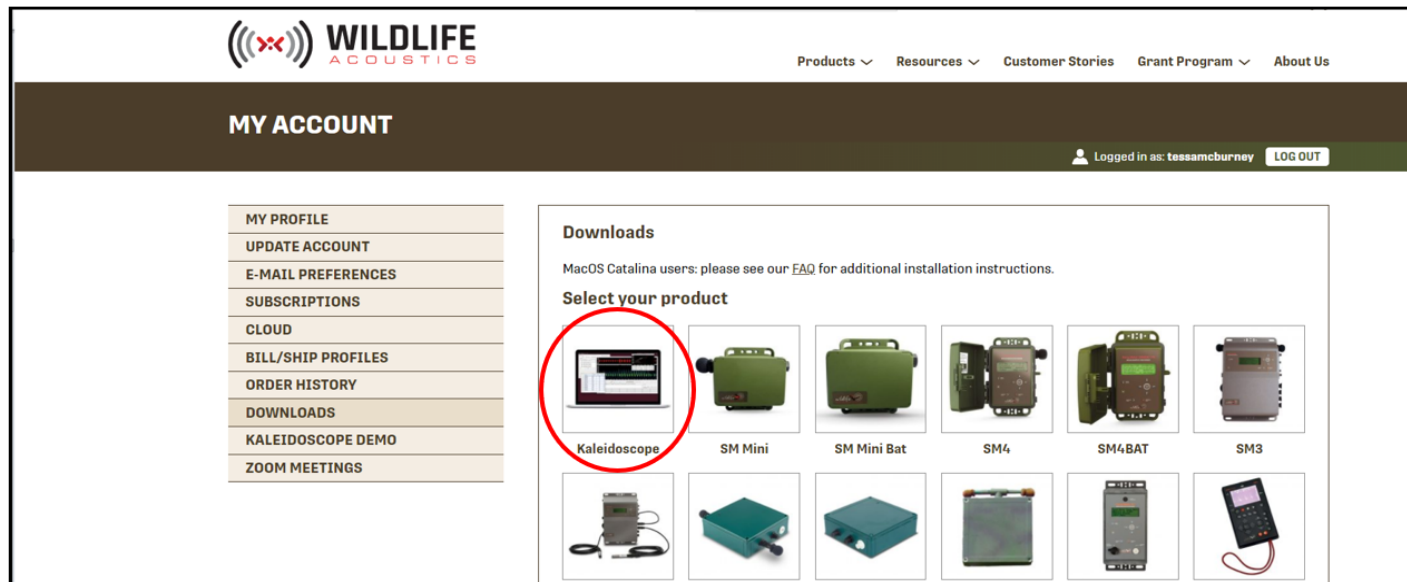


Figure 102. Click on the Kaleidoscope icon.

On the Downloads page, first select the desired computer operating system at the top of the box by clicking on the red "PICK OS" button.

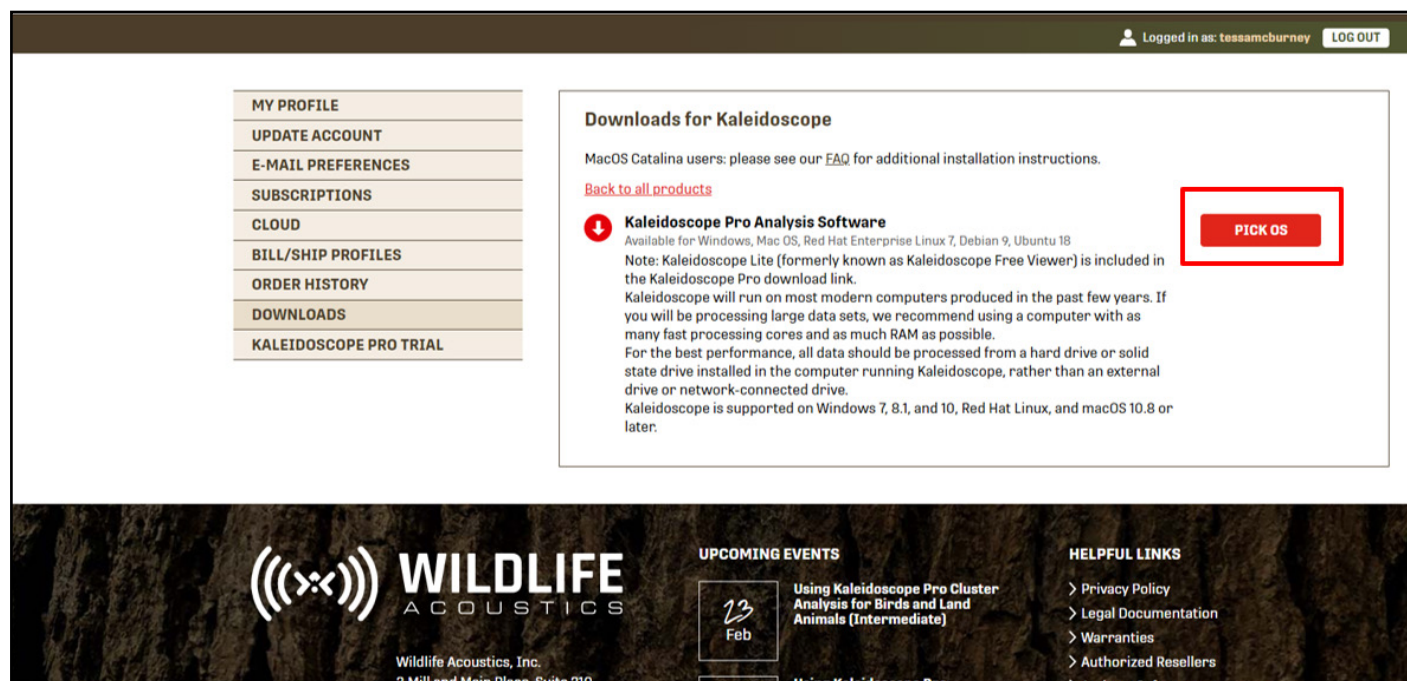


Figure 103. Select the desired computer operating system.



Then click the “VIEW” button next to the appropriate icon (Windows, Mac OS, etc.).

Operating System	Latest Version	Release Date	Action
Windows	5.3.5 (22 older versions available)	Released 2020-08-24, approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifiers for MYOSEP only	VIEW
Mac OS	5.3.5	Released 2020-08-24, approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifiers for MYOSEP only	VIEW
Debian 9	5.3.5	Released 2020-08-24 approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifier for MYOSEP only	VIEW
Ubuntu 18	5.3.5	Released 2020-08-24 approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifiers for MYOSEP only	VIEW
Red Hat	5.3.5	Released 2020-08-24, approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifiers for MYOSEP only	VIEW

Figure 104. Then click the “VIEW” button next to the appropriate icon (Windows, Mac OS, etc.).

Next, select the latest version of software in the “DOWNLOAD VERSION” dropdown, check the box below, and click on the dark grey “DOWNLOAD” button. Follow the usual computer prompts for downloading and installing a program.

MacOS Catalina users: please see our [FAQ](#) for additional installation instructions.

[Back to list](#)

Kaleidoscope Pro Analysis Software

Released 2020-08-24, approved by U.S.F.W.S. using 5.1.0 classifiers with balanced setting for MYOSOD/MYOSEP surveys or 5.2.1 classifiers for MYOSEP only

Latest Version: **5.3.5**

Older versions: 22 older versions available [VIEW](#)

Platform: Windows

Filename: KaleidoscopeInstaller-5.3.5.exe

Download

DOWNLOAD VERSION
5.3.5 (latest version) ▼

EXPORT CERTIFICATION FOR KALEIDOSCOPE PRO ANALYSIS SOFTWARE

I understand that this software is subject to U.S. export controls and that the export or reexport of this software may require a license from the U.S. Government.

I certify that I am not located in, or a citizen or permanent resident of, Cuba, Iran, North Korea, Syria or the Crimea Region of Ukraine. I am not listed on the U.S. Consolidated List (see <https://www.export.gov/csl-search>). I do not own 50% or more of any entity listed on the Consolidated List. I will not ship, transfer, or transmit this software (directly or indirectly) to any of the above named regions, to citizens or permanent residents of the above named regions, to any persons or entities listed on the U.S. Consolidated list, or to any person or entity who owns more than 50% or more of any entity listed on the Consolidated List.

By checking this box, I am certifying the truthfulness of my response

[DOWNLOAD](#)

Figure 105. Click on the dark grey “DOWNLOAD” button.



*Note: Kaleidoscope Version 5 or later required for this guide.

*Note: To assess the difference between the free Kaleidoscope version and the Kaleidoscope Pro version, there is a 14-day free trial of the professional software. On the Downloads page, select the “Kaleidoscope Demo” bar on the left side of the page. Once under “Kaleidoscope Demo”, select the “Start 14-Day Trial” at the bottom of the page to get a Kaleidoscope Demo license. Open the already downloaded Kaleidoscope software on the computer and select “License” at the top right, and then “Install demo or permanent license”. Lastly, enter the Wildlife Acoustics account e-mail address and the Demo license that was given above, and select the “Activate” button on the bottom left to start the free 14-day trial.

The free Kaleidoscope software has two parts: the converter (*Section 4.4*) and the viewer (*Section 4.3.3*). Clicking on the desktop shortcut on the computer will open the converter. Opening a recorded audio file will automatically open that file in the viewer. Ensure “Bat Analysis Mode” is always selected in the Kaleidoscope converter for bat acoustic monitoring.

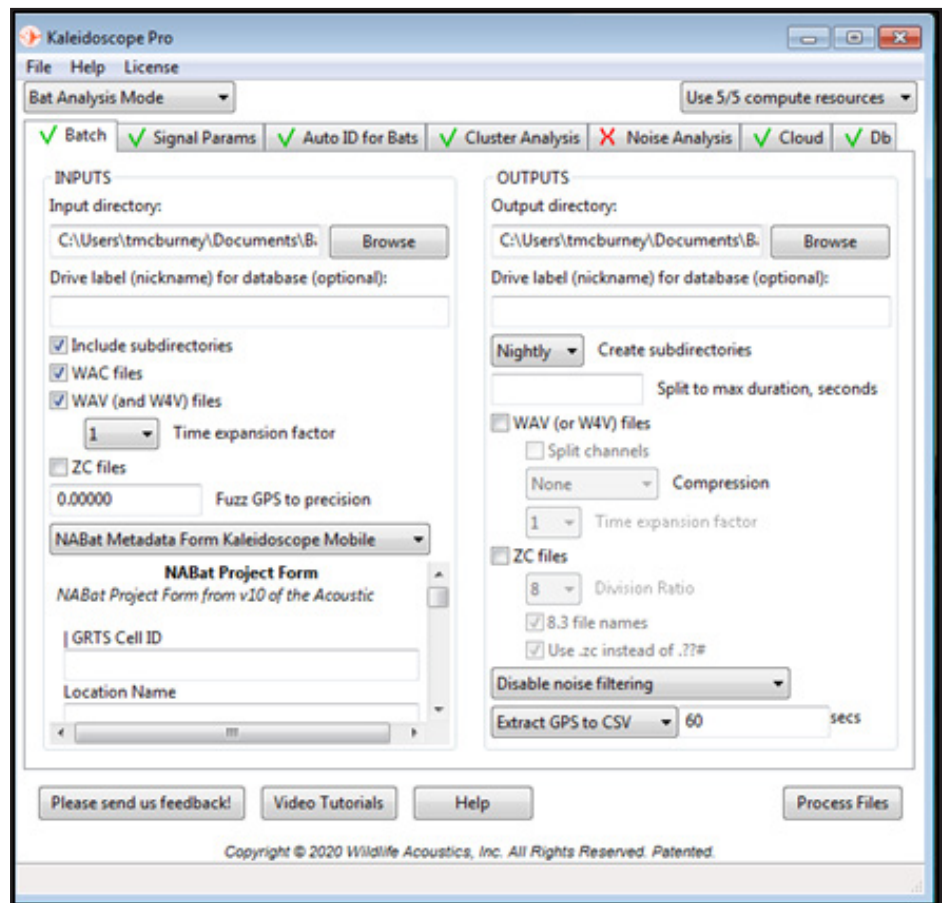


Figure 106. Kaleidoscope converter.

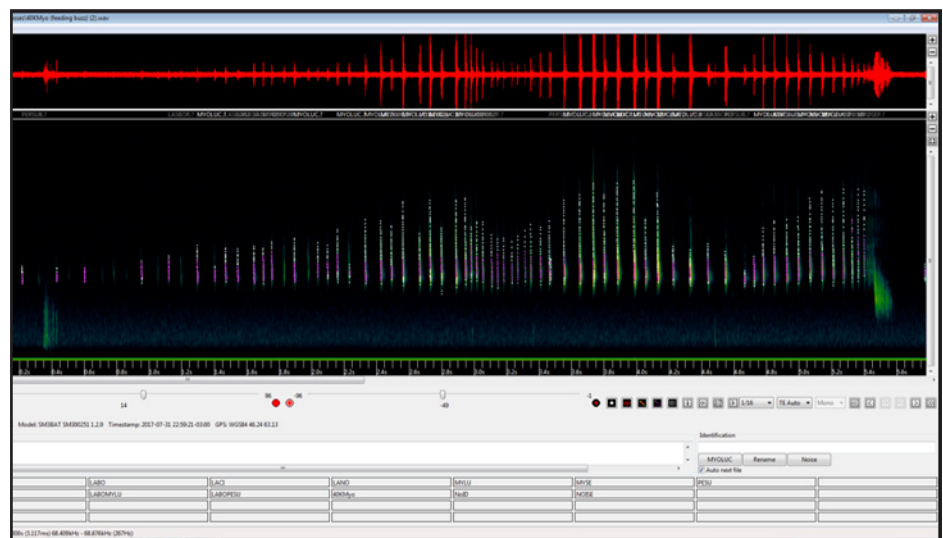


Figure 107. Kaleidoscope viewer.



4.3.2 Full Spectrum vs. Zero-cross Analysis

Acoustic data can be recorded and read in full spectrum or zero-crossing formats. Some detector types can be set to record in either format.

*Note: Full spectrum format can be converted to zero-crossing format afterward, but not the other way around. It is recommended that all data are recorded and stored in full spectrum and converted with Kaleidoscope to both full spectrum and zero-crossing for convenience of data analysis. SD memory cards with appropriate data storing capacity should be used with acoustic detectors, typically at least 32 GB.

4.3.2.1 Full Spectrum Analysis (FS)

Full spectrum recording means the full spectral composition of sound is recorded and results in an audio file format that captures the highest resolution of audio file for further analysis. This permits a higher level of detail to be read from these files, but files are also larger in size. Full spectrum files often can contain feeding buzzes, harmonics, and capture calls emitted by multiple bats at the exact same time. Full spectrum audio files recorded with the SM4Bat FS have a .wav or .wac file extension.

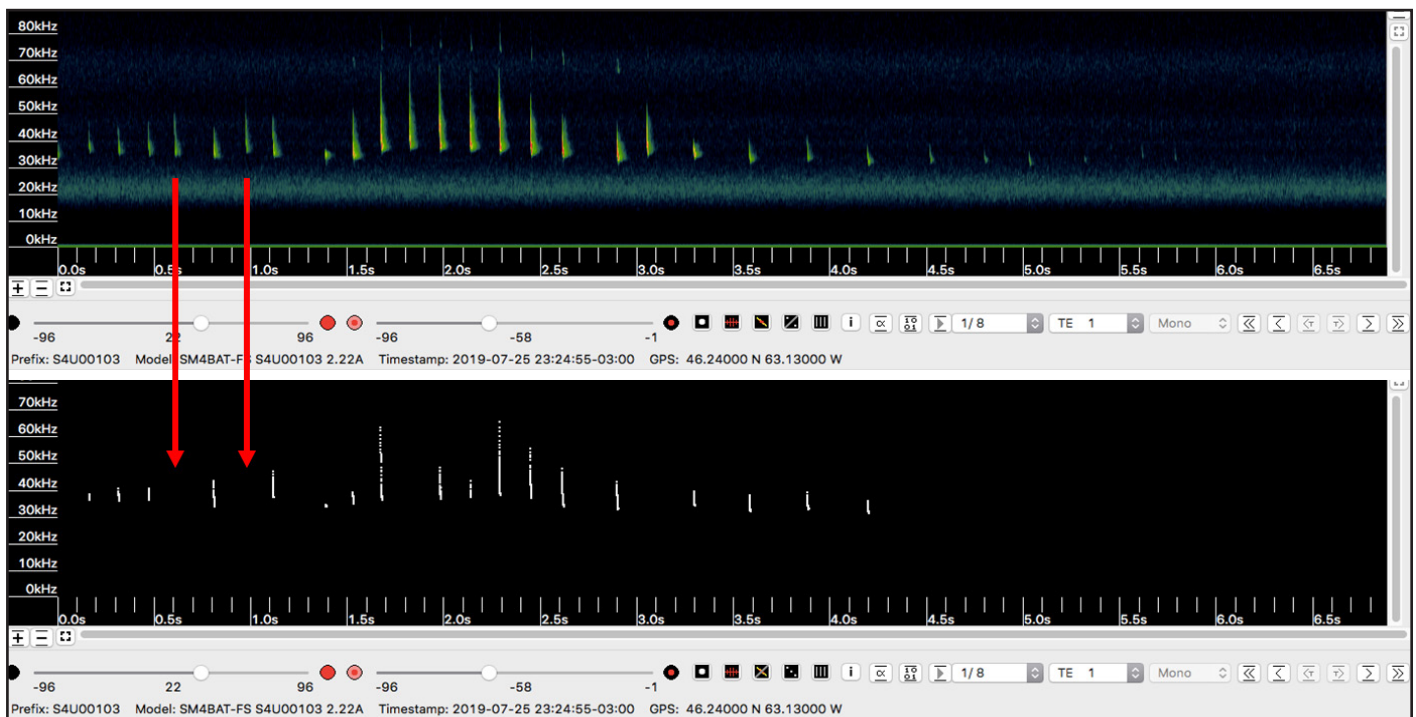


Figure 108. Image demonstrating full spectrum (above) permits a higher level of detail than zero-cross (below). Several pulses recorded in FS are not visible in ZC.



4.3.2.2 Zero-cross Analysis (ZC)

Zero-cross recording results in an audio file format that only captures the frequency of the sound recorded at any time with the highest amplitude (the “loudest”) and a direct measure of amplitude is lost. The fundamental nature of zero-crossing is to record sounds of higher amplitude than the ambient noise (*e.g.*, sounds from wind blowing grass, insects, rain, etc.). This method of data collection results in file sizes that are only a fraction of full spectrum files (about 1/1000th), but there is less detail retained in the stored file. Zero-cross audio files typically do not capture feeding buzzes and do not contain harmonics or calls emitted by quieter bats at the exact same time. Call signatures can also become more fragmented when the recorded amplitude (loudness) of the sounds was not sufficient, making it harder to interpret the bat species. Zero-cross audio files recorded with the SM4Bat FS have a .zc file extension.

Although Kaleidoscope allows the viewing of full spectrum data, its underpinning analysis is based entirely on zero-cross analysis, thus, for the purposes of calculations and measurements, Kaleidoscope can only use frequencies that are louder than the underlying noise (*i.e.*, zero-cross audio files).



Figure 109. Image demonstrating full spectrum (above) permits a higher level of detail than zero-cross (below). The harmonics recorded in FS are not visible in ZC.



4.3.3 Using the Kaleidoscope Viewer

The Kaleidoscope viewer displays a spectrogram with time (ms) on the horizontal axis (x-axis) and frequency (kHz) on the vertical axis (y-axis).

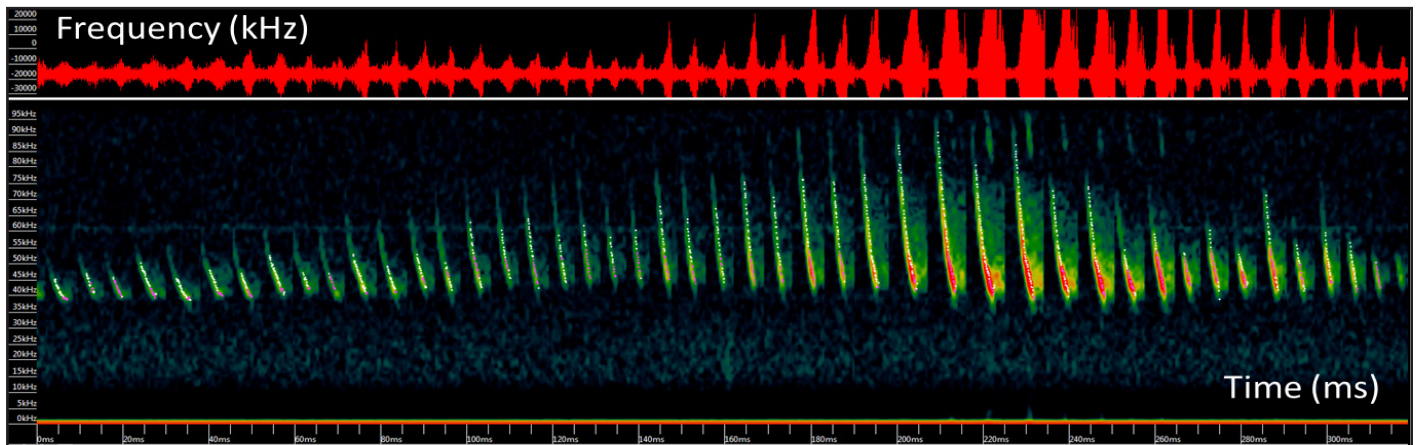


Figure 110. Time (ms) on the horizontal axis (x-axis) and frequency (kHz) on the vertical axis (y-axis).

If the mouse is hovered over the spectrogram, white horizontal lines appear. By right-clicking on the mouse button, two horizontal lines can be created and placed at frequencies that are helpful for data analysis. For example, these lines can be used as a quick guide to screen calls for species ID (e.g., set a line at 35 kHz to quickly determine if it is a high or low frequency bat).

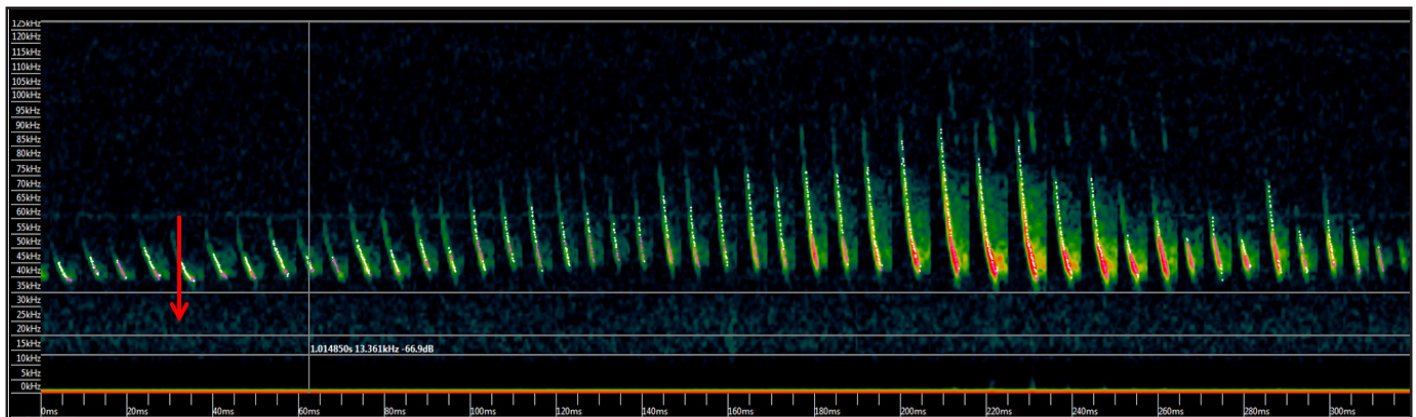


Figure 111. Right-clicking on the mouse button creates two horizontal lines.

Described below are various buttons with different functions within the Kaleidoscope viewer. It is important to experiment with these buttons to determine the settings that work best while interpreting data.

Additionally, to get the full picture that allows for complete understanding of the file being analysed, it can be helpful to switch between the different functions while looking at a single file. There is a list of keyboard short-cut keys for some of these buttons (see *Section 7.3*).



4.3.3.1 Toggle Zoom Buttons

Zoom in on the horizontal and vertical axes by pressing the zoom “+” and “-” buttons next to the axis. Pressing the zoom button that forms a square will automatically zoom out to the maximum axis for that file. Shortcut keys have preset zoom levels (see *Section 7.3*).

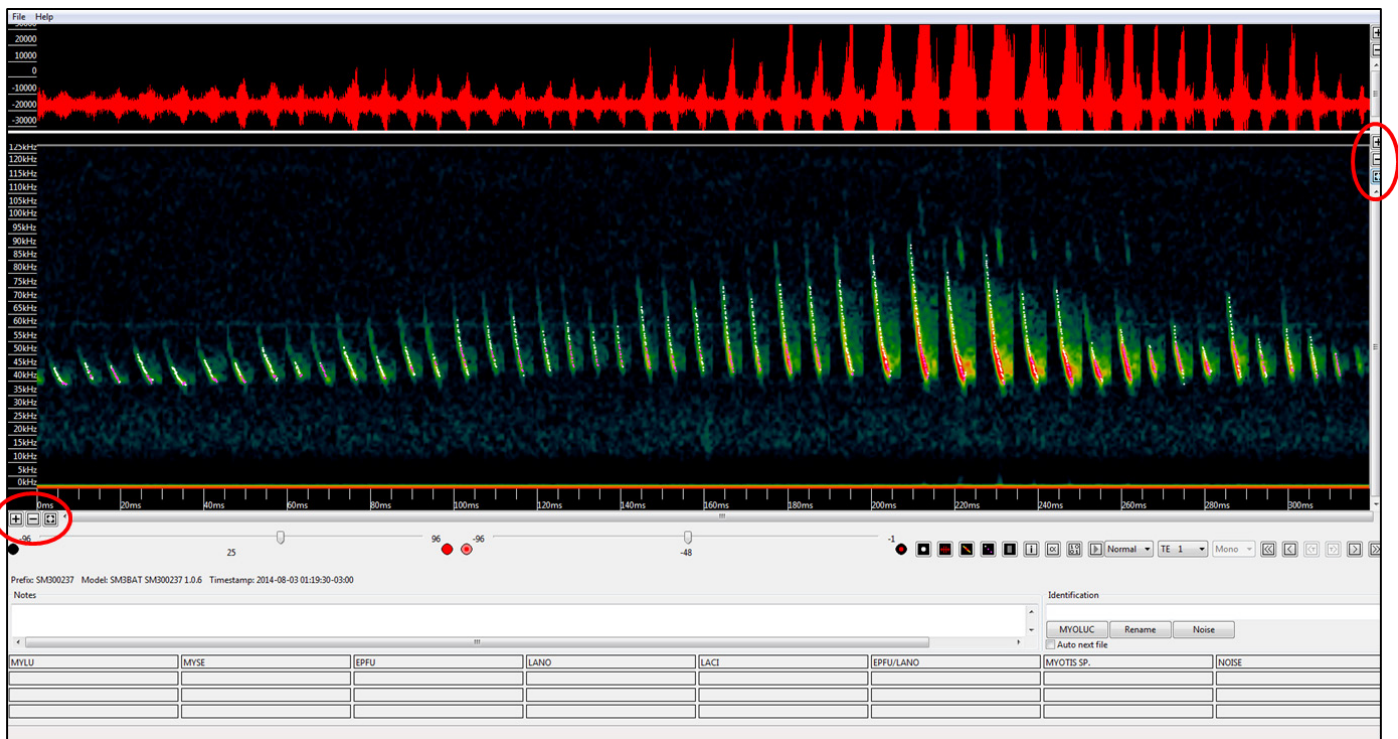


Figure 112. Toggle zoom buttons.



4.3.3.2 Display Adjustment Sliders

The display adjustment slider on the left controls the brightness of the spectrogram. Increase the value (positive integers) to better see high frequency calls that do not show up in zero-cross. The display adjustment slider on the right controls the contrast of the spectrogram. Adjust this depending on how fuzzy the spectrogram appears (generally slide to the right, towards “-1”).

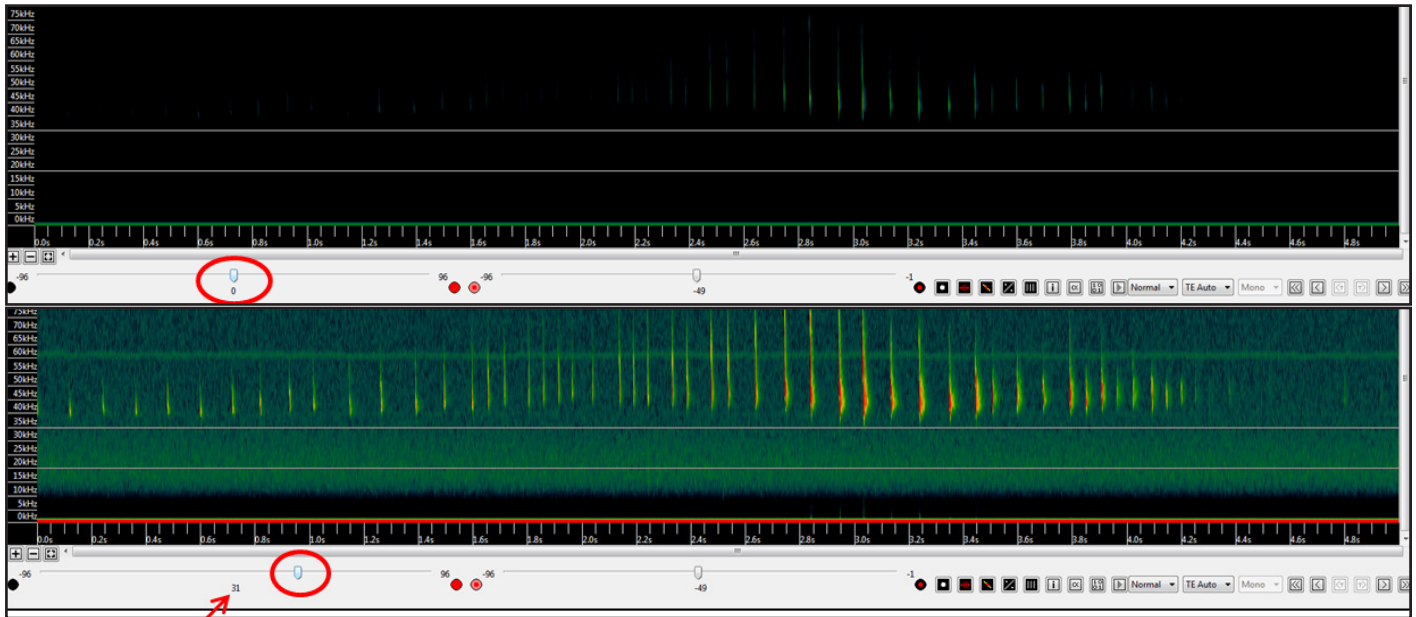


Figure 113. The display adjustment slider on the left controls the brightness of the spectrogram.

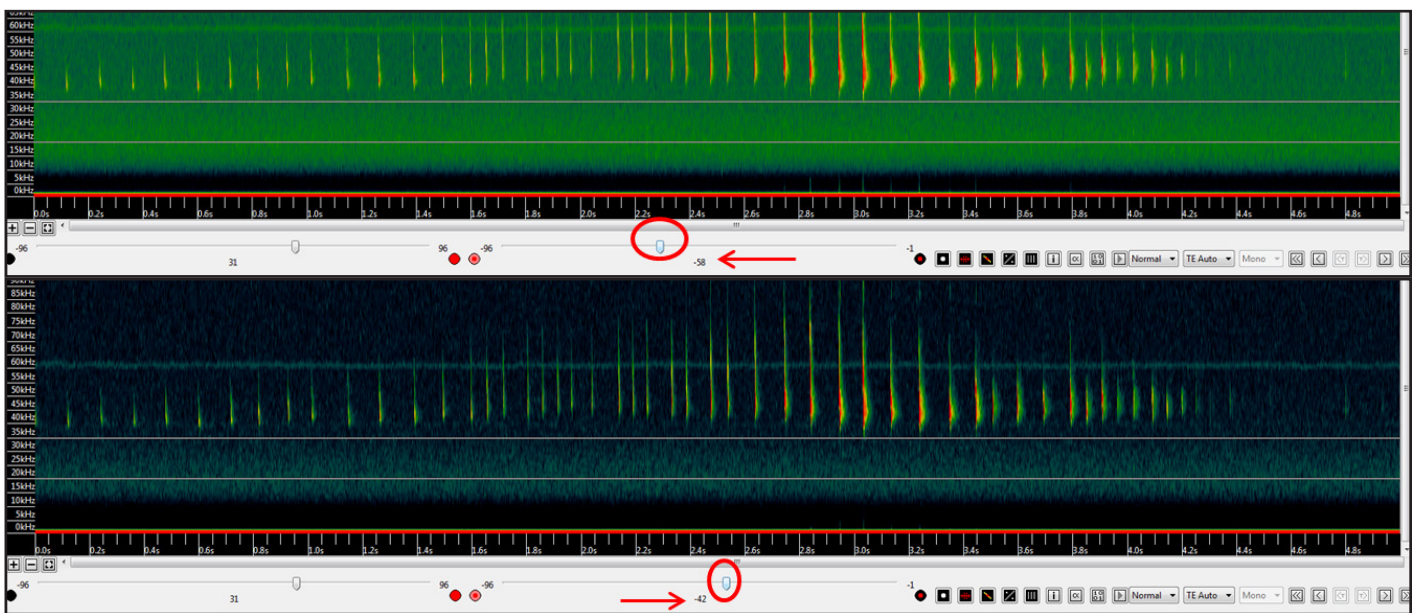


Figure 114. The display adjustment slider on the right controls the contrast of the spectrogram.



4.3.3.3 Toggle Inverse Video

The toggle inverse video button changes the background of the calls from black to white. Black is the standard choice.

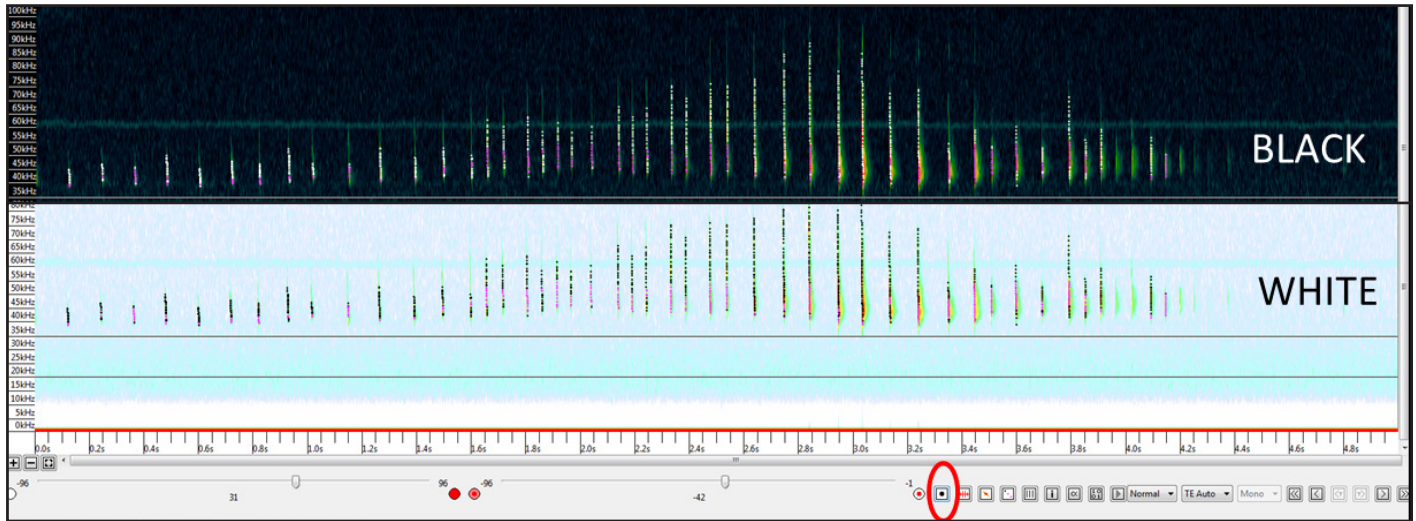


Figure 115. The toggle inverse video button changes the background from black (above) to white (below).

4.3.3.4 Toggle Waveform Log/Linear View

This controls the appearance of the red oscillogram at the top of the Kaleidoscope viewer. Use log view (where the vertical axis is between -30000 and 30000).

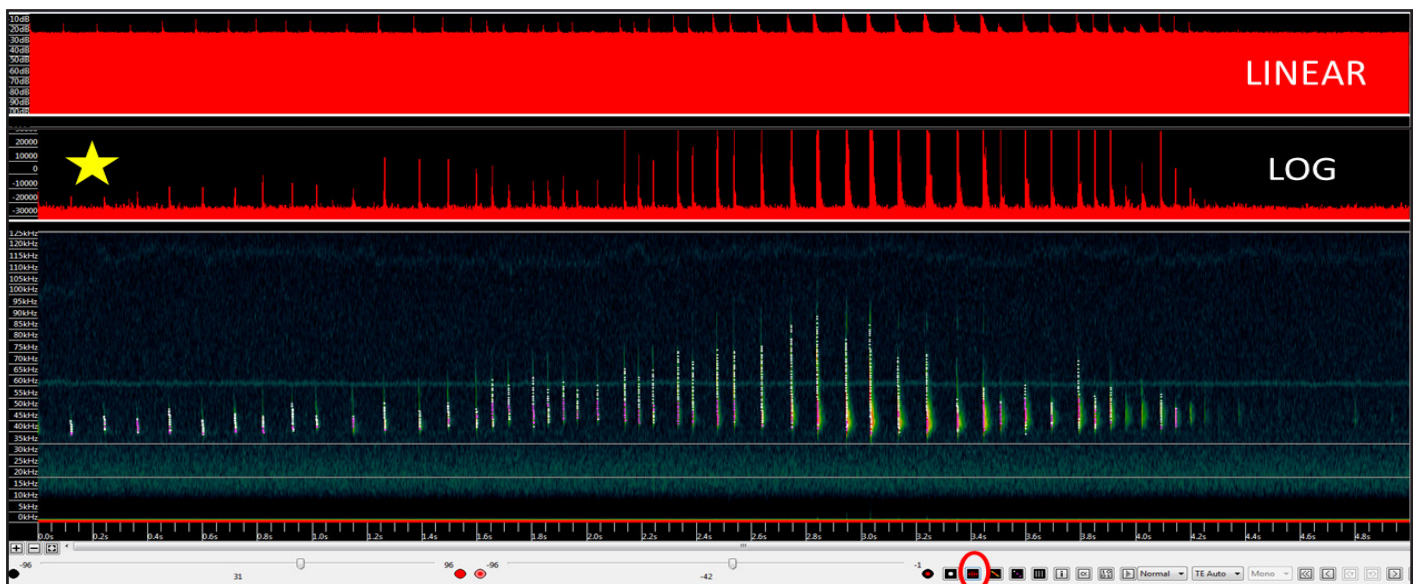


Figure 116. The oscillogram can be changed between linear view (above) and log view (below).



4.3.3.5 Toggle Full Spectrum View

This button turns off full spectrum analysis mode. Some individuals find it faster to go through files only looking at zero-cross, but information is lost (often the higher frequency parts of the calls) if the calls are not also examined under full spectrum. Toggle this on and off depending on personal preference.

*Note: Full spectrum resolution can be adjusted by changing the FFT (Fast Fourier Transform) and WIN (Window) SIZE settings. If the pulses appear fuzzy or cut off try increasing the FFT and WIN SIZE. In the Kaleidoscope viewer window go to “File”, “FFT Settings”, and change the FFT SIZE and WIN SIZE. WIN SIZE should generally be 50% (half) of the FFT SIZE.

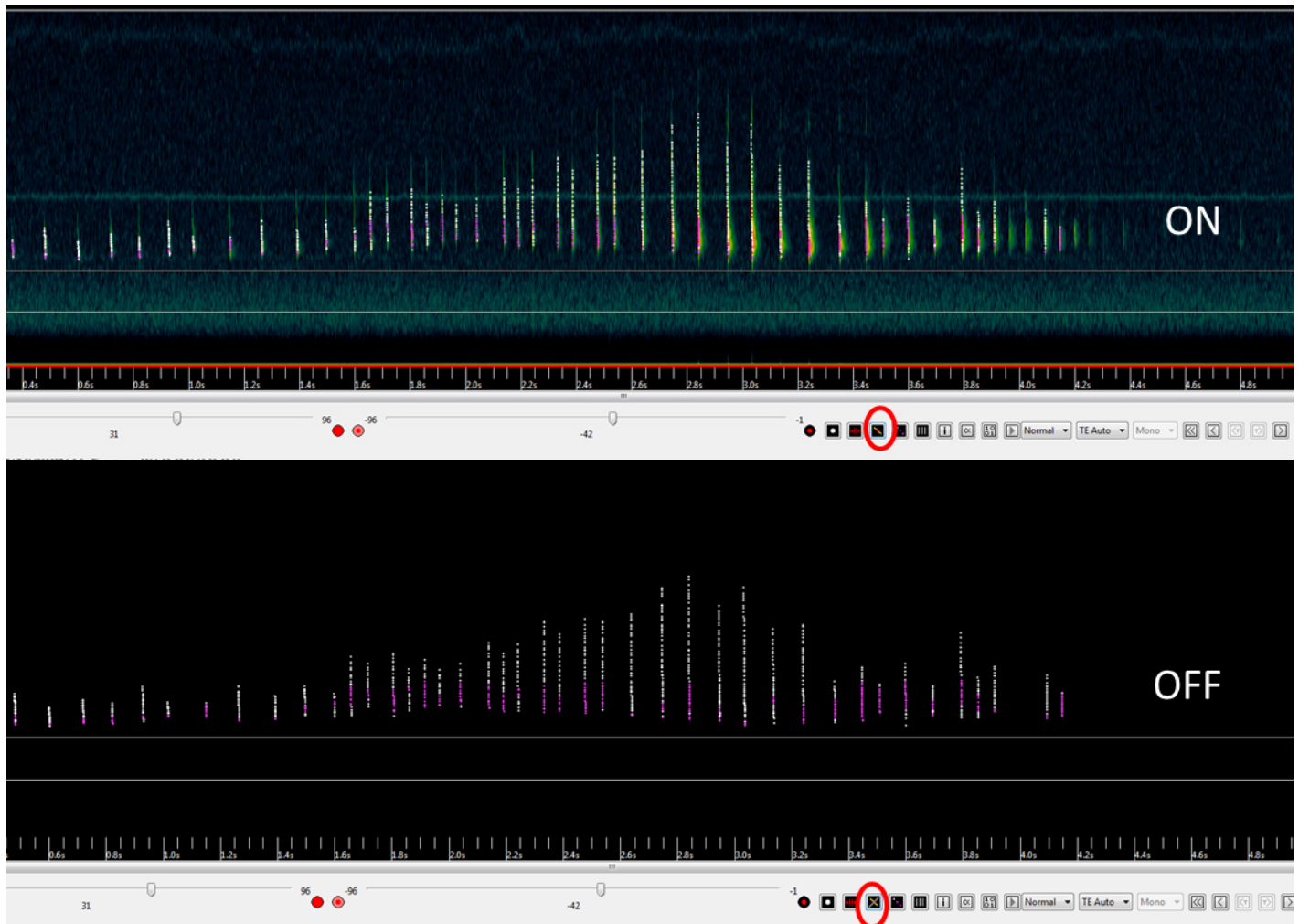


Figure 117. Full spectrum view can be turned on (above) and off (below).



4.3.3.6 Toggle Zero-cross View

This button gives three options: no zero-cross analysis, standard zero-cross analysis (all white), and zero-cross analysis highlighting the call body which is purple, while the rest of the pulse is white. All calls should be examined under zero-cross, and the species ID should be made using zero-cross frequencies (not full spectrum).

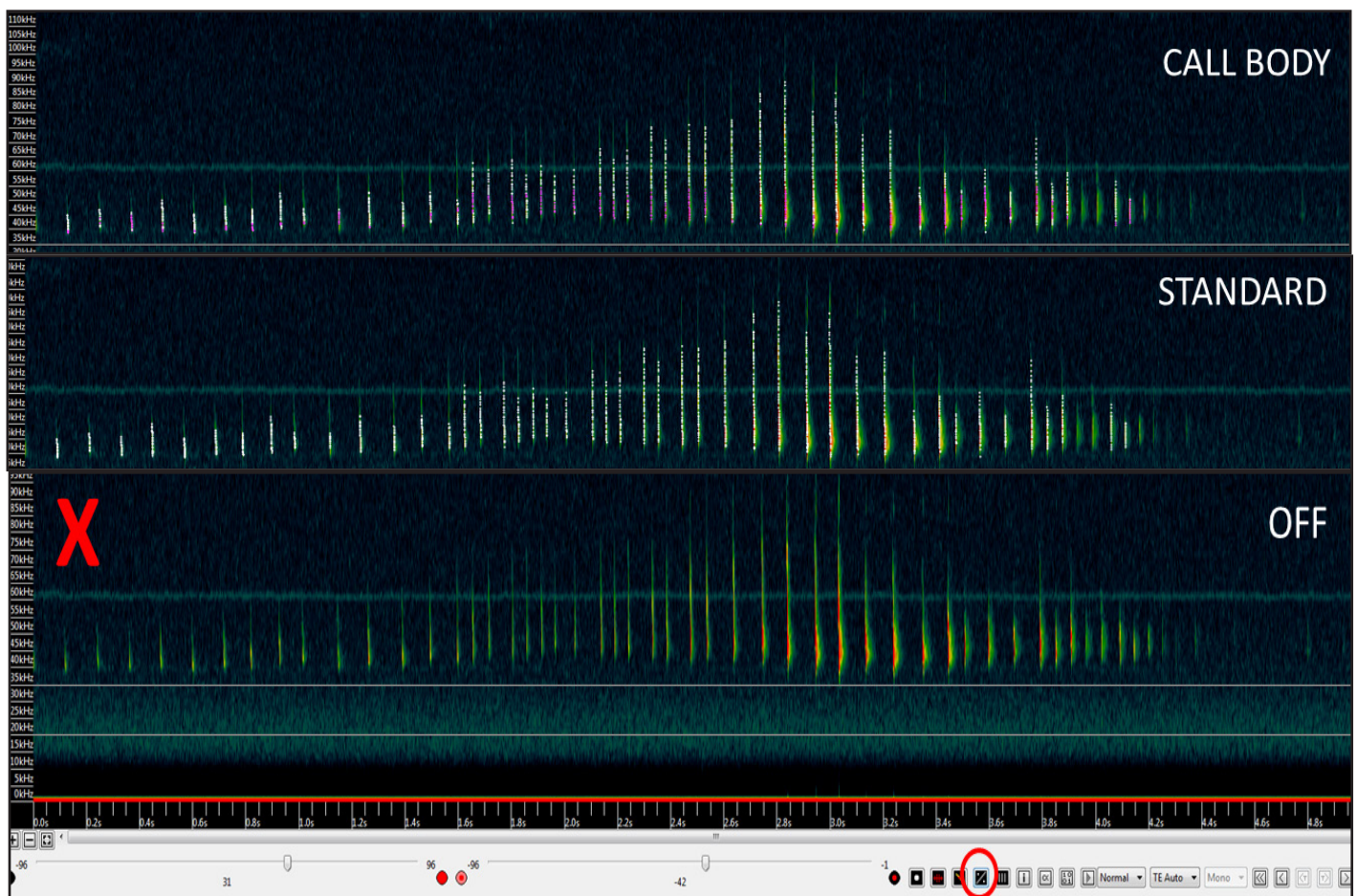


Figure 118. Zero-cross view has three options: call body (above), standard (centre), and off (below).



4.3.3.7 Toggle Normal/Compressed Time View

This button changes between normal and compressed time view. Normal time view is the **call sequence** displayed in real time. Compressed time view displays the call sequence with the **time between calls** (TBC) (see *Section 4.7.1.5*) removed. It is important to look at the sequence in normal time to get full understanding of what is happening in the spectrogram. For example, it will allow determination of whether there is more than one bat of the same species within a single file, or will display information about irregular spacing of calls that may help with species ID. It is also important to look at the sequence in compressed time view because it gives a better idea of the shape of the calls that may also help with species ID.

*Note: It is possible to zoom in on the calls in normal time view, but the toggle function is easier.

*Note: In compressed time, only zero-cross pulses show up.

*Note: When using compressed time, ensure the x-axis (time) is kept consistent so that the call shape is comparable between sequences. A general recommendation is to have the x-axis maximum set at approximately 160 ms.

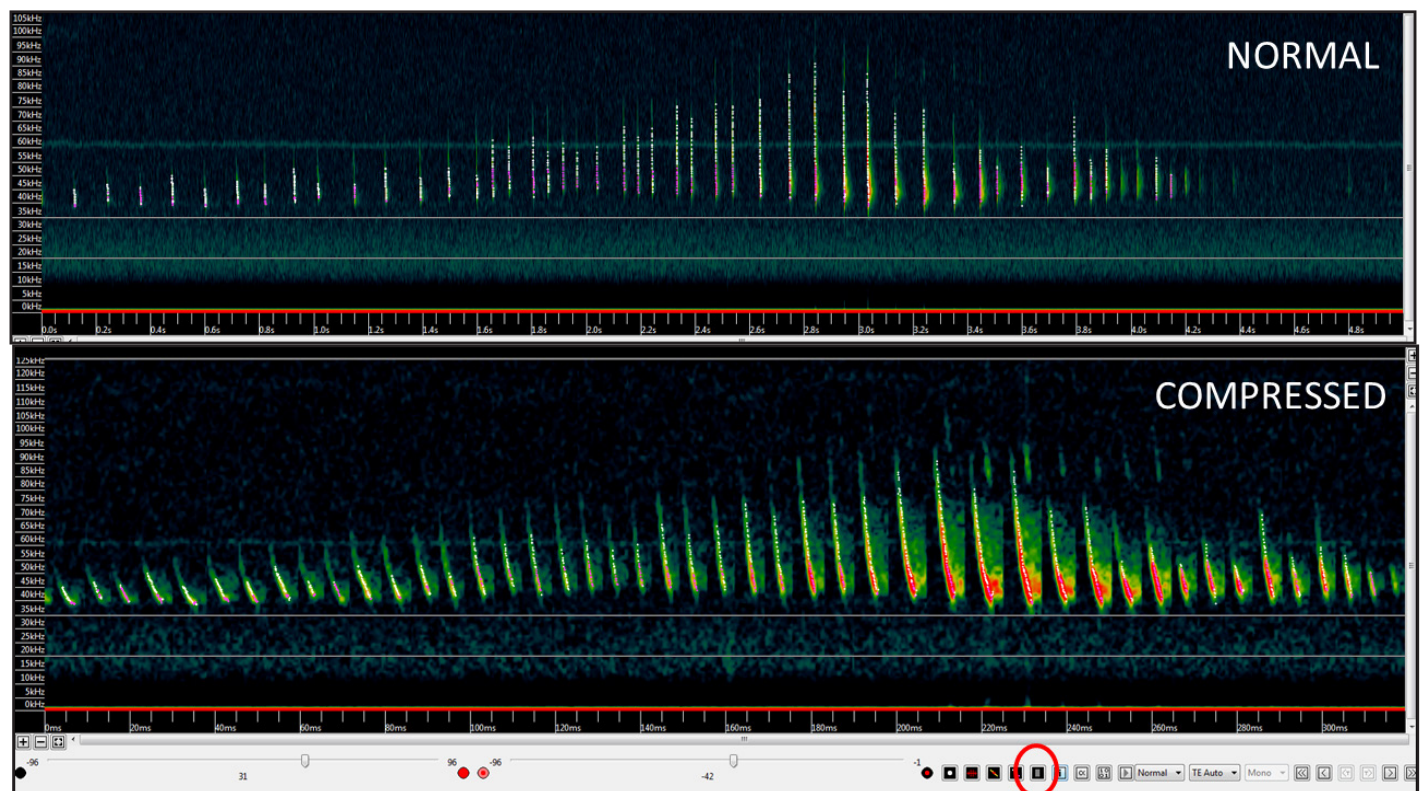


Figure 119. Toggle between normal time view (above) and compressed time view (below).



4.3.3.8 Toggle Linear/Log Frequency View

This button changes the frequencies on the x-axis from linear to logarithmic. The standard setting is linear frequency view.

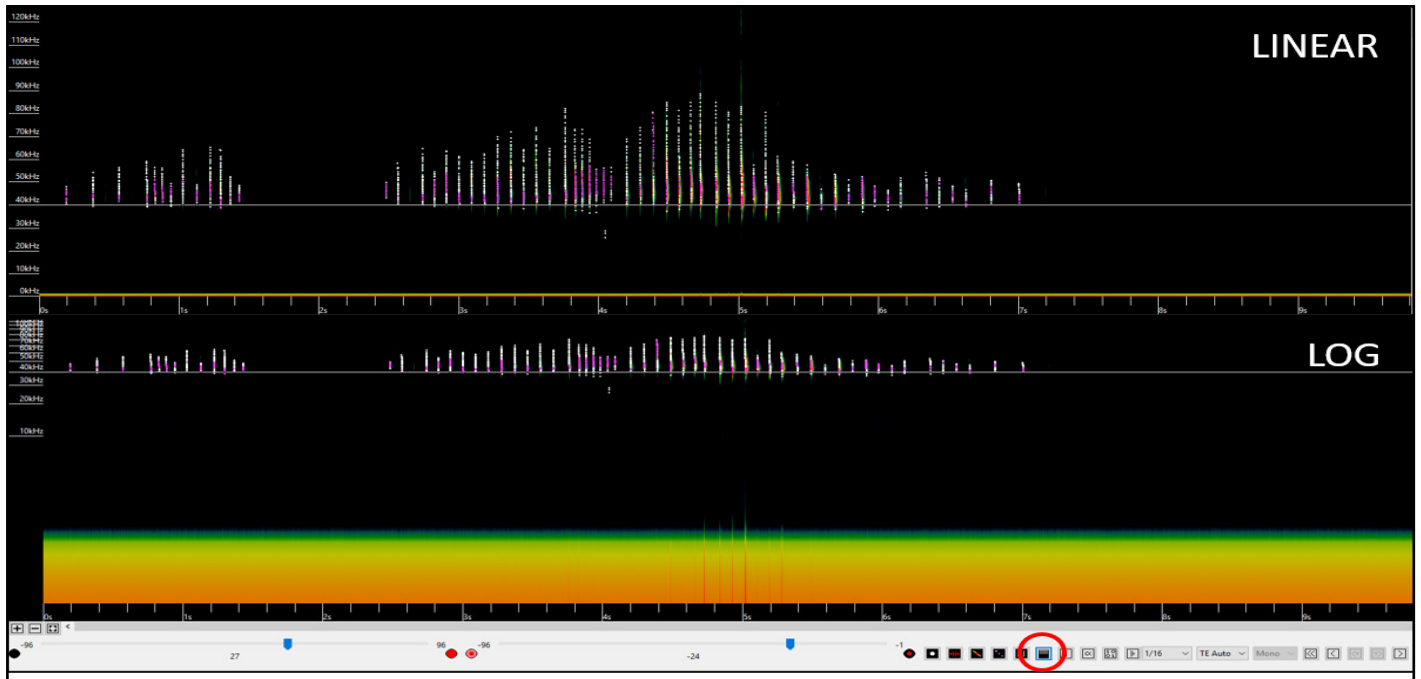


Figure 120. Toggle between linear (above) and logarithmic (below) frequencies.

4.3.3.9 Toggle Auto ID

This button turns the auto ID function on and off; however, the free software without auto ID capabilities does not have this feature enabled.

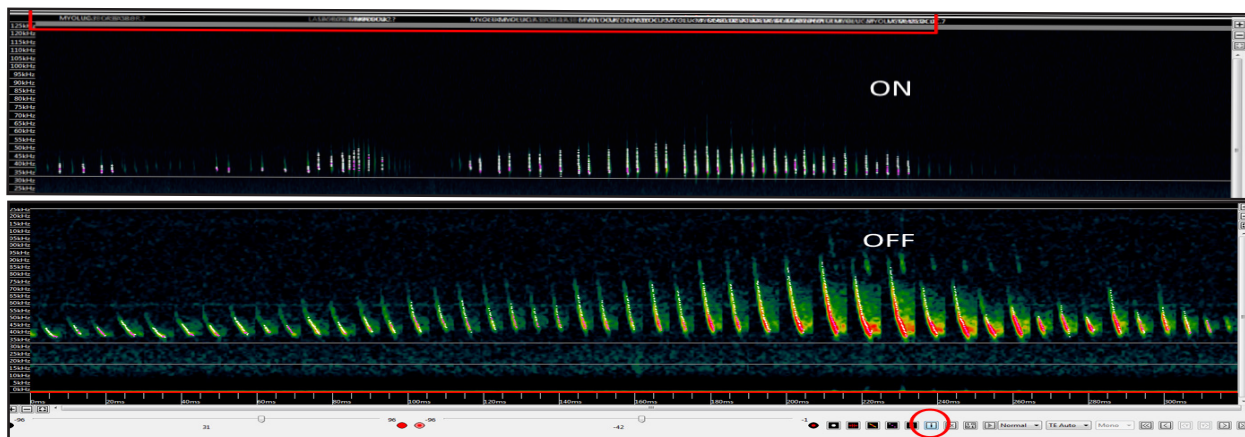


Figure 121. Turn the auto ID function on (above) and off (below).



4.3.3.10 Analyze View/Selection

By selecting this button, a Kaleidoscope viewer analysis window is created with several useful calculations to help with species ID. Many of these terms are described below in *Section 4.7.1*. Use this button to calculate the S_c or any other value required for ID purposes. If no specific pulse is selected when clicking on this button, the values will be representative for the all of the pulses currently observed within the viewer window (*i.e.*, the average). To calculate the average for the ENTIRE recorded sequence, ensure that the whole sequence can be seen in the viewer window (use normal time view and the x-axis toggle zoom button). Alternatively, if the left mouse button is held down, a little white box can be drawn around a single pulse within the sequence, and then the values within the analysis window will reflect those calculated only for that specific pulse. To remove the white box, left click on the spectrogram.

*Note: When looking at the S_c of a sequence, compare the calculated S_c of the sequence with the S_c of some individual pulses. The calculated average S_c for a sequence is sometimes not accurate because of poor quality pulses that result in artificially negative slopes.

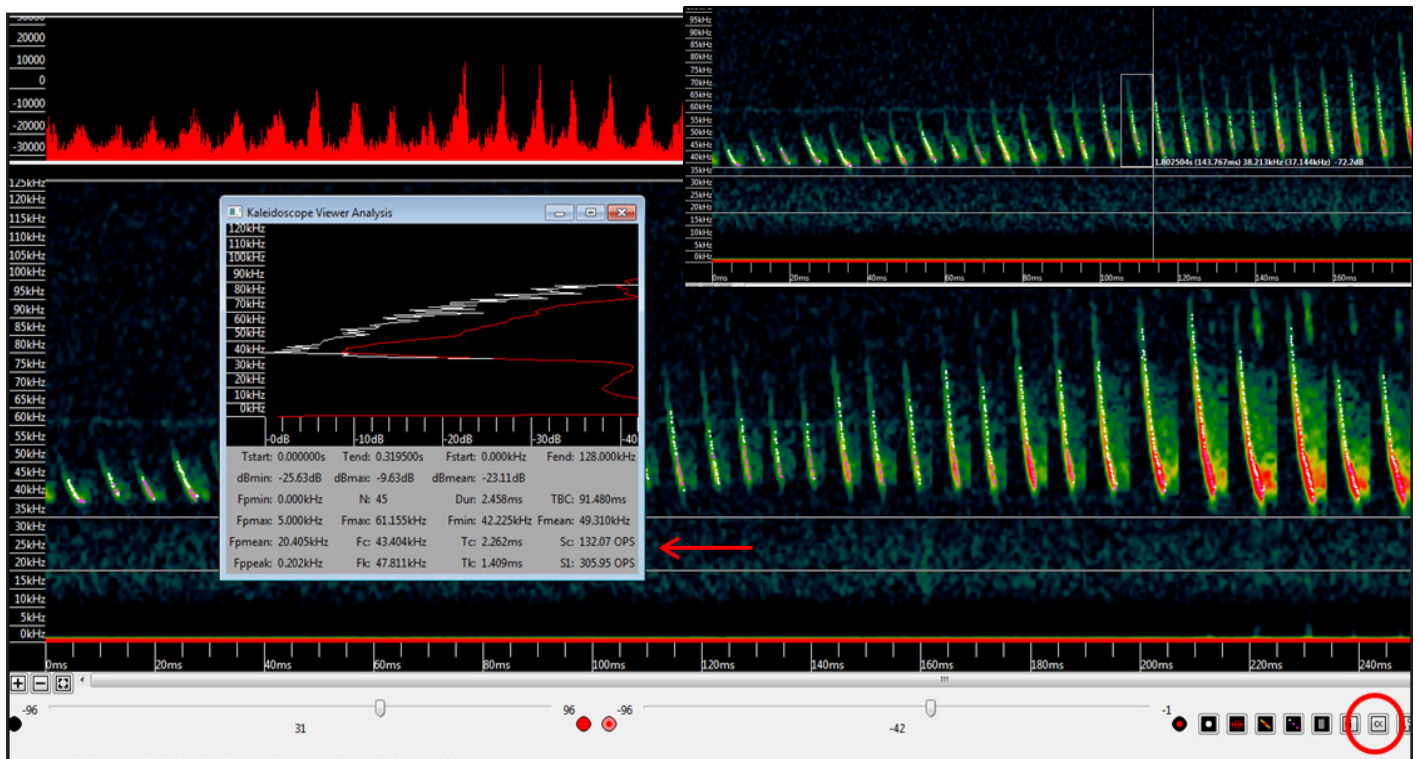


Figure 122. A Kaleidoscope viewer analysis window is created with several useful calculations.



4.3.3.11 Toggle Show/Hide Metadata Panel

This either reveals or hides the panel at the bottom of Kaleidoscope viewer. With the manual ID methods (see *Section 4.6*) recommended within this guide the metadata panel will need to be used and thus should be shown.

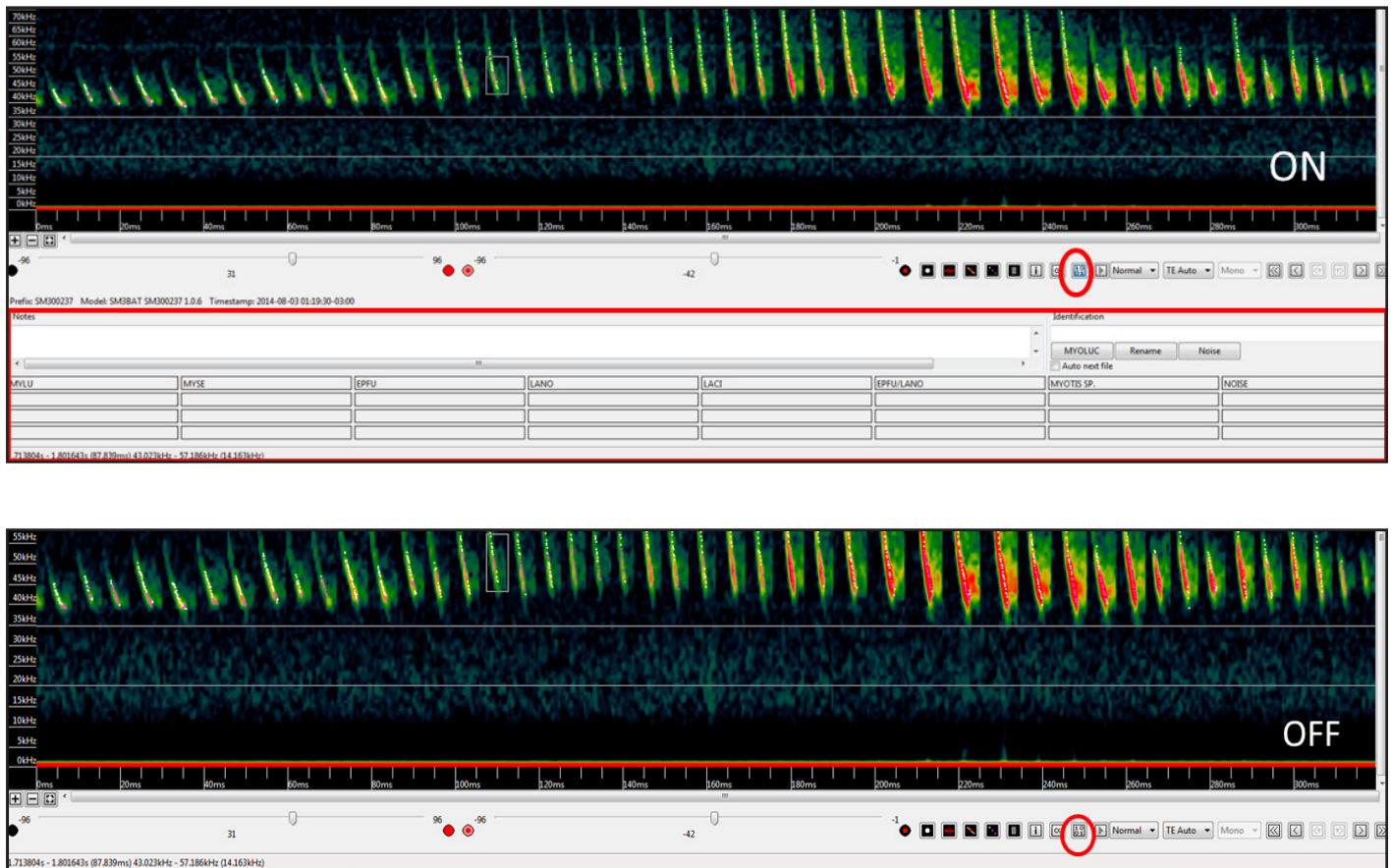


Figure 123. Select to either reveal (above) or hide (below) the metadata panel.



4.3.3.12 Play Sound

This feature will allow audible play back of the spectrogram. To hear the recording in real time but at a lower frequency so it is audible, select the “Normal” setting from the drop-down list and click on the play “arrow”. The “Normal” setting is too fast to hear bat calls, but it will allow for determination if an insect or another object is creating noise in the file. To slow down a bat call so it is audible for humans, select either the “1/8” or “1/16” option. Remember, the call will be slower in normal time than in compressed time. If specific pulses are not selected in the white box, then the entire sequence will play from the beginning. To play a specific section or pulse of interest, draw a white box (described in *Section 4.3.3.9*) around the target selection with the mouse and press play. To remove the white box left click on the spectrogram with the mouse.

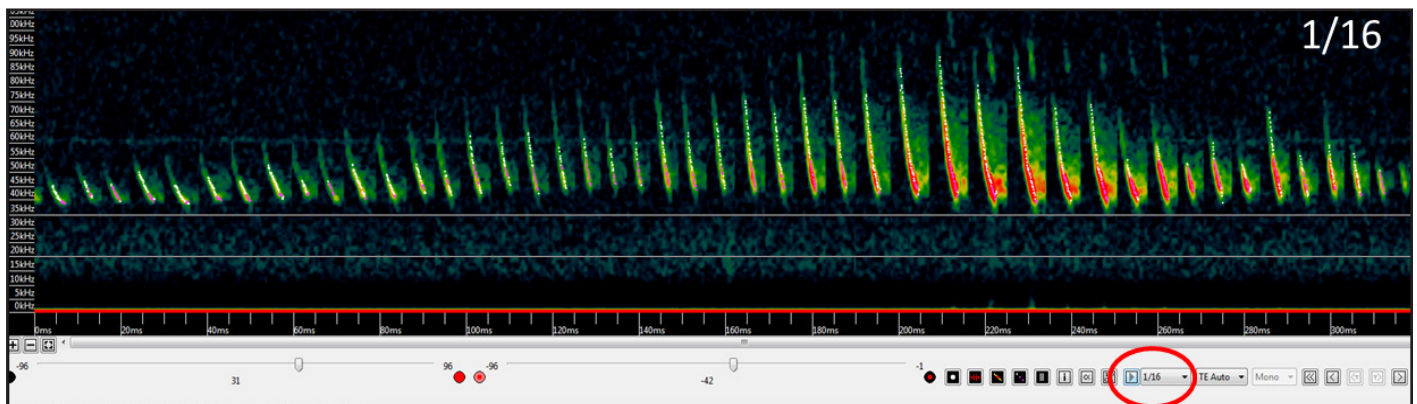
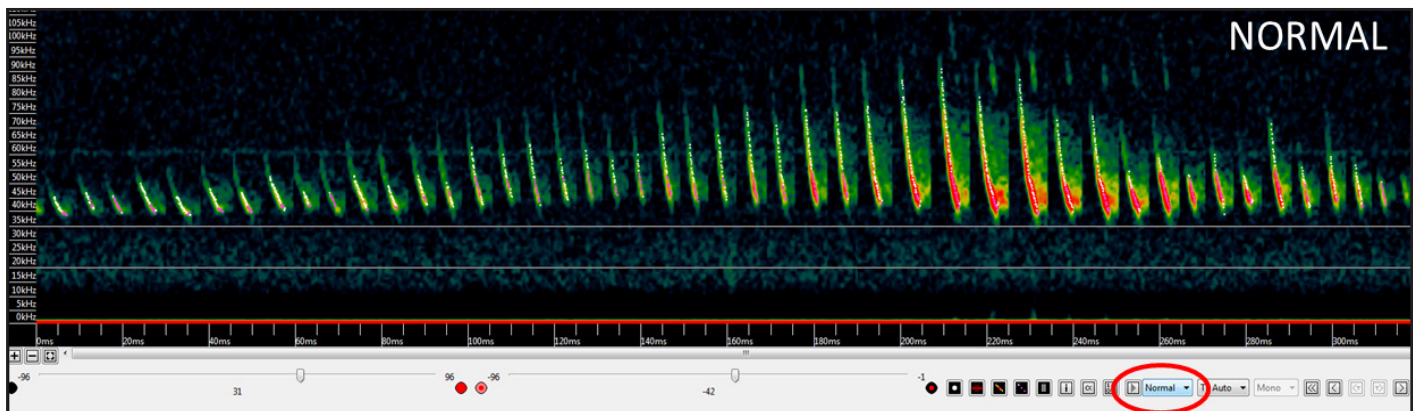


Figure 124. To hear the recording in real time select “Normal” (above) and to slow down the audio select “1/8” or “1/16” (below).



4.3.3.13 Time Expansion Factor (TE)

The Time Expansion (TE) Factor can generally be kept on automatic, “TE Auto”

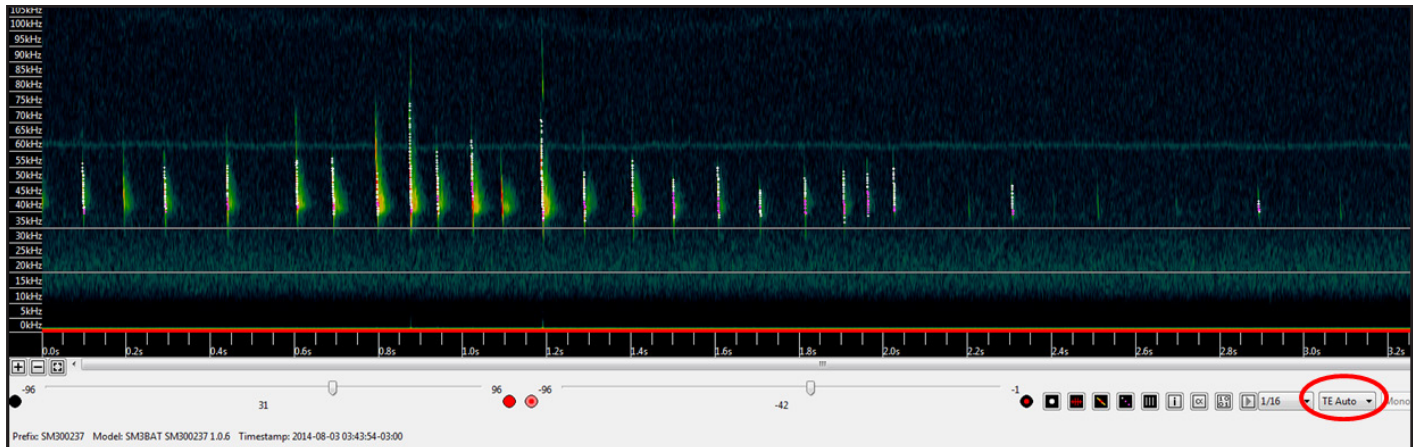


Figure 125. The Time Expansion (TE) Factor can generally be kept on auto, “TE Auto”.

4.3.3.14 Microphone Channel

The drop-down list next to TE Factor should be greyed out on “Mono” if only one microphone channel was used for recording, but this preference can be changed in the Kaleidoscope converter window (see *Section 4.4 Step 11*) if other recording techniques were used.

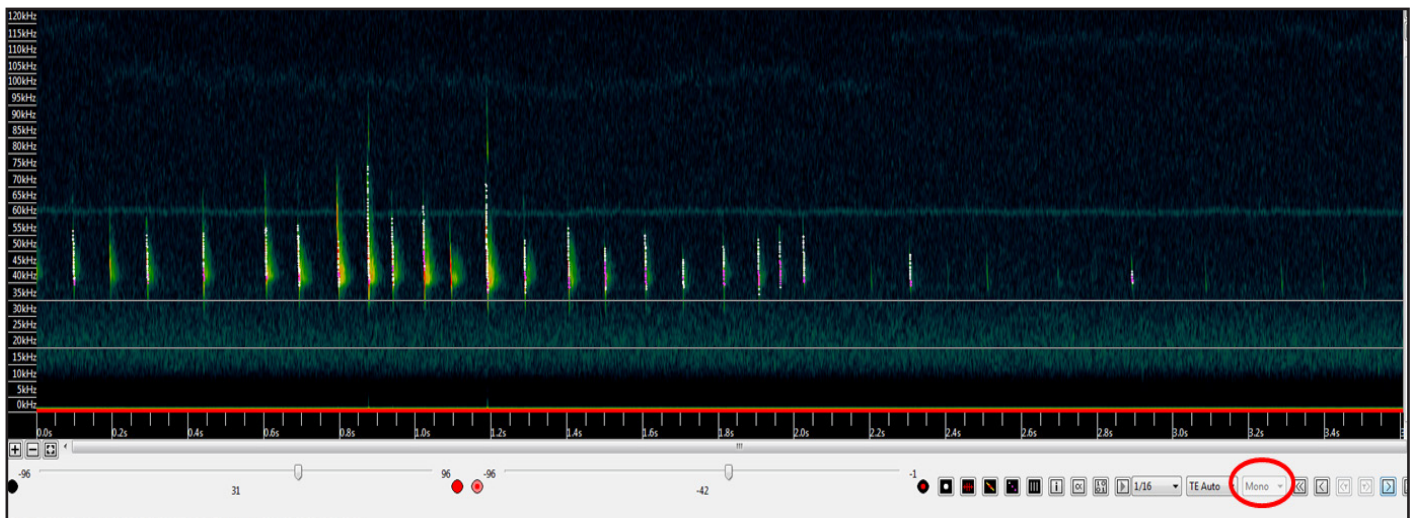


Figure 126. The drop-down list next to TE Factor should be greyed out on “Mono” if only one microphone channel was used for recording.



4.3.3.15 Arrow Buttons

The single line arrow buttons can be used to switch between acoustic files within the same file folder, select the right single line arrow to go to the next file and the left single line arrow to go to the previous file. Alternatively, click on the spectrogram (*i.e.*, ensure one of the function buttons is not still selected, the buttons are highlighted in blue when they are selected) and press the bottom arrow on the keyboard to go to the next file and the top arrow on the keyboard to go to the previous file. The double line arrows allow for switching between folders within a folder. So, although all acoustic files for a single NABat quadrant site will be separated into individual folders based on monitoring nights, by selecting the right double line arrow to go to the next folder or the left double line arrow to go to the previous folder, it is possible to switch between the monitoring night folders.

*Note: If it was decided to create two sets of files, zero-cross only files and full spectrum files that can also be examined with zero-cross analysis in Kaleidoscope, ensure only one set of files is analysed (ideally, the full spectrum files) so the same acoustic files are not examined twice (*i.e.*, as full spectrum and zero-cross), and as a result, the number of bat sequences overcounted.

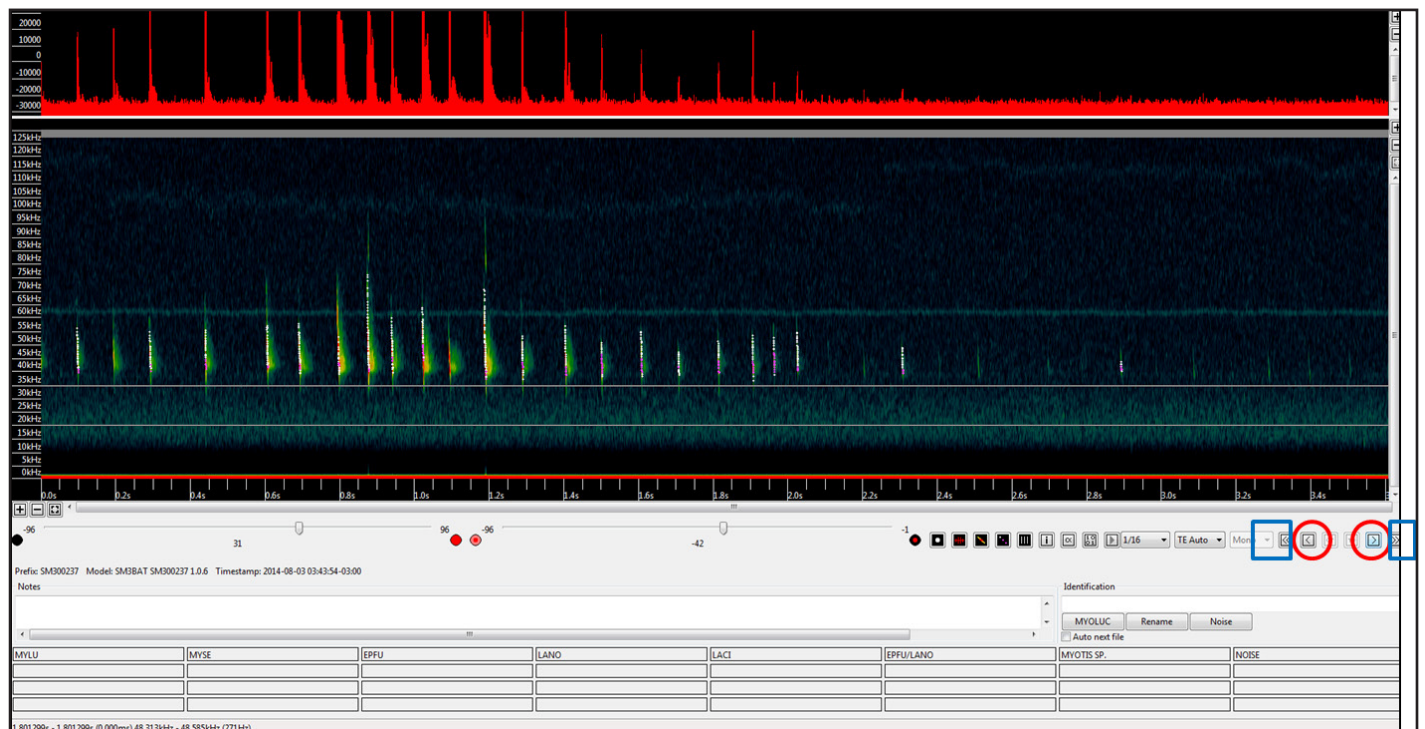


Figure 127. The single line arrow buttons (red circles) can be used to switch between acoustic files within the same file folder and the double line arrows (blue squares) allow for switching between folders within a folder.



4.4 Creating Metadata for Stationary Point Survey Acoustic Files

To upload acoustic data to the NABat website, metadata will need to be included. The simplest way to do this is to follow the steps as outlined below; before the data are manually identified:

Step 1- Download the following NABat metadata forms for Kaleidoscope at this [website](#):

NABat_Metadata_Form_Kaleidoscope_Stationary.xml

NABat_Stationary_Meta_Output_Only_KPRO.xml

The screenshot shows the USGS ScienceBase-Catalog interface. The breadcrumb trail is: ScienceBase Catalog → North American Bat Monitoring... → NABat Metadata Files → NABat Metadata Forms for A... The page title is "NABat Metadata Forms for Auto ID Software". Under "Attached Files", there is a table of files with download icons and file sizes. Two files are highlighted with red boxes:

File Name	Size
NABat_Metadata_Kaleidoscope_to_SonoBat.xml	3.35 KB
NABat_Metadata_Form_SonoBat_3.xml	3.38 KB
NABat_Metadata_Form_SonoBat_4.xml	3.35 KB
NABat_Mobile_Meta_Output_Only_KPRO.xml "Transect Metadata Form (Output Only)"	10.62 KB
NABat_Stationary_Meta_Output_Only_KPRO.xml "Stationary Metadata Form (Output Only)"	11.24 KB
NABat_Metadata_Form_SonoBat_Mobile.xml	2.85 KB
NABat_Metadata_Form_Kaleidoscope_Stationary.xml	20.92 KB
NABat_Metadata_Form_Kaleidoscope_Mobile.xml	17.72 KB

Figure 128. Download the NABat metadata forms for Kaleidoscope (Step 1).

Step 2- Create a species list for the monitoring area. A species list is connected to a NABat website account. If a user has already created a species list and wants to use the same list again, move on to *Step 3*. To create a new species list, follow the instructions below:



4.4.1 Creating a Species List

Go the NABat Projects [page](#), and select the project. At the top of the project screen, select the “Species Lists” tab.

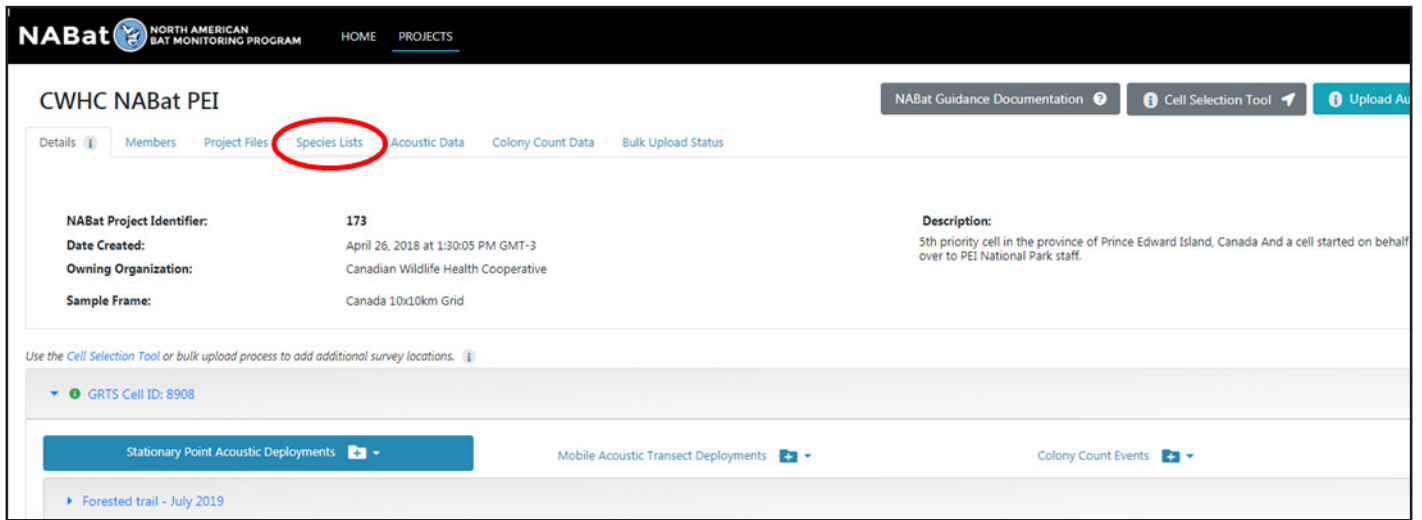


Figure 129. At the top of the project screen, select the “Species Lists” tab.

On this page, click on the green “Manage Classifiers” button (looks like an editing button with a pencil) on the right.

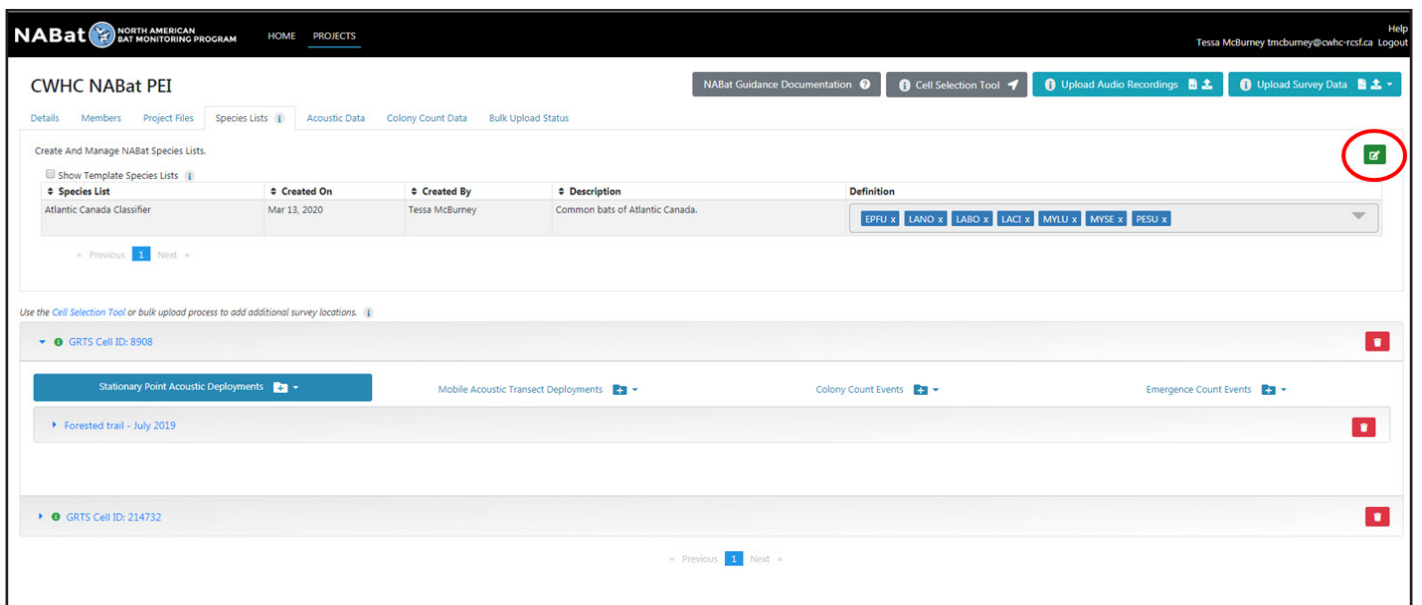


Figure 130. Click on the green “Manage Classifiers” button.



Then select the grey “Add +” button.

Species List	Created On	Created By	Description	Definition
Atlantic Canada Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Atlantic Canada.	EPU x LANO x LABO x LACT x MYLU x MYSE x PESU x

Figure 131. Select the grey “Add +” button.

Now there are some fields to fill out. In the first field, create a name for the new classifier (e.g., PE Classifier, Cape Breton Classifier, etc.).

Species List	Created On	Created By	Description	Definition
PE Classifier	Mar 13, 2020	Tessa McBurney	Common Bats of the Pacific Northwest.	Select Species to Include
Atlantic Canada Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Atlantic Canada.	EPU x LANO x LABO x LACT x MYLU x MYSE x PESU x

Figure 132. In the first field, create a name for the new classifier.



Then add a classifier “Description” (e.g., Common bats of Prince Edward Island.).

Species List	Created On	Created By	Description	Definition
PE Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Prince Edward Island.	Select Species to Include
Atlantic Canada Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Atlantic Canada.	EPPU x LANO x LABO x LACI x MYLU x MYSE x PESU x

Figure 133. Add a classifier “Description”.

Lastly, add a “Definition”, which is the list of species to be included in the classifier. This is accomplished by clicking on the box next to the four letter abbreviation of each species to be added; when this is done, the species name should appear in a blue box in the “Definition” field. If a species needs to be removed, click the white “x” in the corner of the blue box for that particular species.

Species List	Created On	Created By	Description	Definition
PE Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Prince Edward Island.	EPPU x <input type="checkbox"/> Select All Search <input checked="" type="checkbox"/> EPPU <input type="checkbox"/> EUMA <input type="checkbox"/> EUFL <input type="checkbox"/> EUPE <input type="checkbox"/> EUUN <input type="checkbox"/> IDPH <input type="checkbox"/> LANO
Atlantic Canada Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Atlantic Canada.	EPPU x LANO x LABO x LACI x MYLU x MYSE x PESU x

Figure 134. Add a “Definition”, which is the list of species to be included in the classifier.



Once all of the desired species for the classifier have been selected, click the green “Save” button on the top right to save the species list; it will now be available for use in the Kaleidoscope metadata form. If a classifier needs to be deleted, select the green “Manage Classifiers” button, and then in the trash can column next to the classifier designated for deletion, select the red “X” button, and when asked “Are you sure?”, select the red “Delete” button below to complete this action.

The screenshot shows the NABat web application interface for the 'CWHC NABat PEI' project. The top navigation bar includes 'HOME' and 'PROJECTS'. The main content area is titled 'CWHC NABat PEI' and contains a table of classifiers. The 'Save' button is circled in red.

Species List	Created On	Created By	Description	Definition	
Atlantic Canada Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Atlantic Canada.	EPPU x LANO x LABO x LACI x MYLU x MYSE x PESU x	X
PE Classifier	Mar 13, 2020	Tessa McBurney	Common bats of Prince Edward Island.	EPPU x	X

Figure 135. Click the green “Save” button on the top right to save the species list.



Step 3- Open the Kaleidoscope converter software by clicking on the desktop icon.

*Note: These directions require Kaleidoscope Version 5 or later.

Step 4- Ensure that at the top of the Kaleidoscope converter window “Bat Analysis Mode” is selected from the drop-down list.

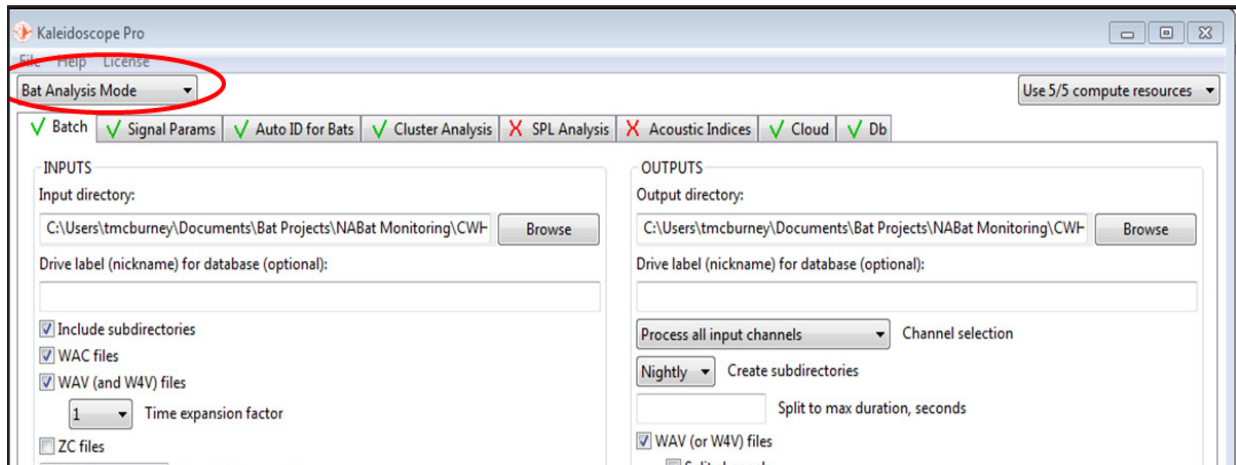


Figure 136. Ensure “Bat Analysis Mode” is selected from the drop-down list (Step 4).

Step 5- Under “INPUTS” “Input directory:” click on the “Browse” button, and select the file folder of ONE of the stationary point survey sites from within the Raw Data subfolder.

Step 6- Under “OUTPUTS” “Output directory:” click on the “Browse” button, and select the matching file folder for the stationary point survey site within the Processed Data subfolder.

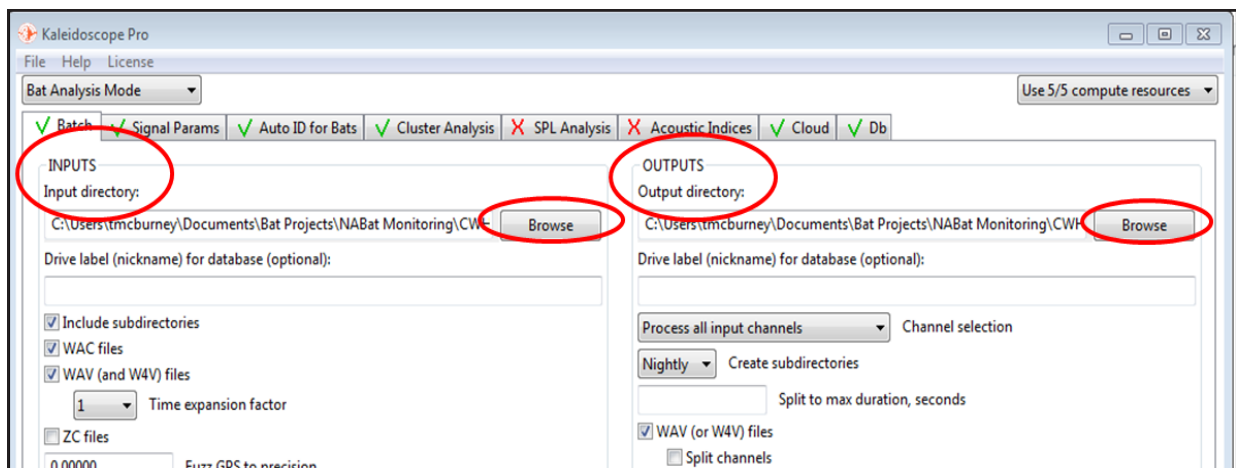


Figure 137. Select file folders for “Input directory” and “Output directory” (Steps 5 and 6).



Step 7- Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” and select the following file that was downloaded in *Step 1*:

NABat_Metadata_Form_Kaleidoscope_Stationary.xml

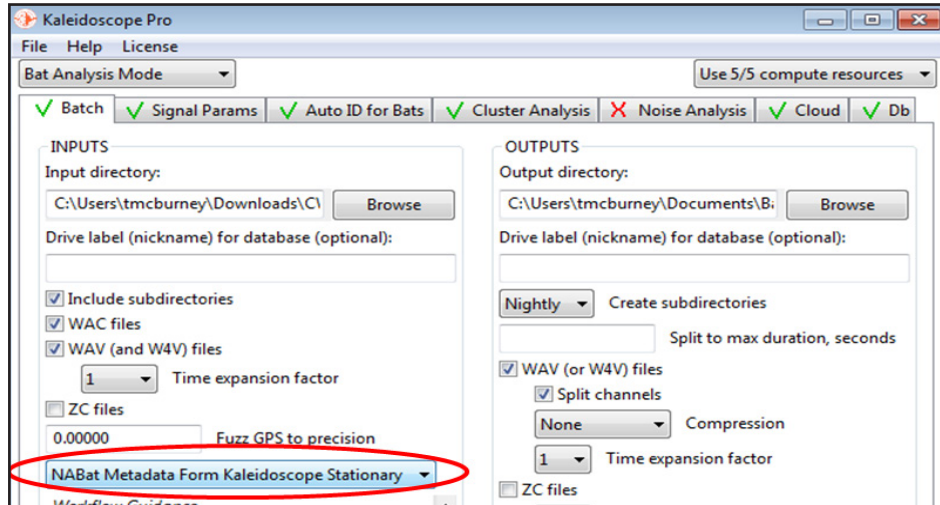


Figure 138. Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” (Step 7).

Step 8- The NABat metadata form will now appear in the Kaleidoscope window under “NABat Project Form”, requiring completion of the fields below (hover the mouse over individual fields for more information):

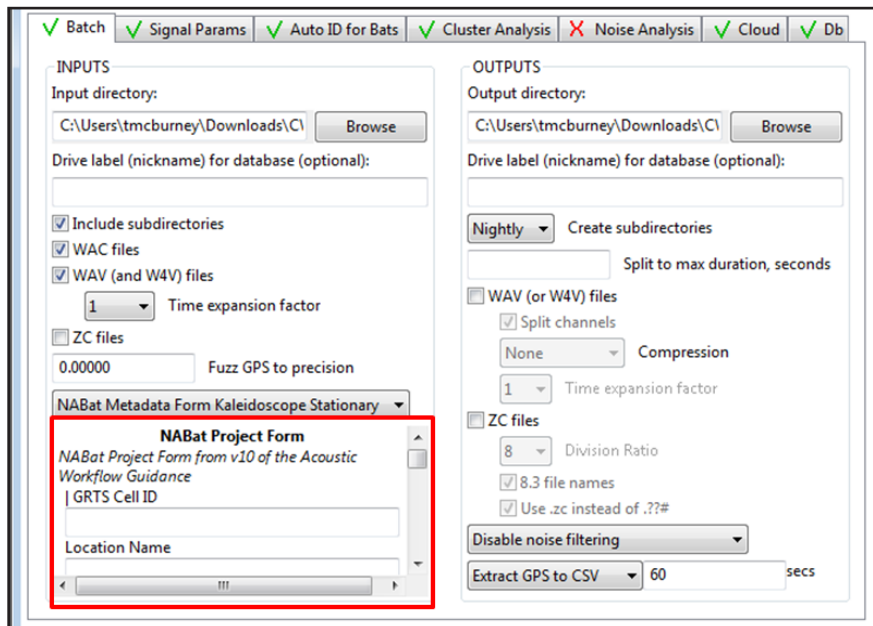


Figure 139. The NABat metadata form will appear under “NABat Project Form” (Step 8).



- **GRTS Cell ID** (the NABat GRTS Cell ID)

The screenshot shows the NABat software interface with various settings. The 'GRTS Cell ID' field is highlighted with a red box and contains the value '8908'. The interface includes sections for 'INPUTS' and 'OUTPUTS' with various checkboxes and dropdown menus.

Figure 140. The NABat metadata form “GRTS Cell ID” field.

- **Location Name** (use a unique identifier for the stationary point site; e.g., Forested Trail; does NOT have a maximum of 6 letters)

The screenshot shows the NABat software interface with various settings. The 'Location Name' field is highlighted with a red box and contains the value 'Farm'. The interface includes sections for 'INPUTS' and 'OUTPUTS' with various checkboxes and dropdown menus.

Figure 141. The NABat metadata form “Location Name” field.



- **Latitude** (decimal degrees)
- **Longitude** (decimal degrees)

The screenshot shows the NABat metadata form with the following settings:

- Batch:
- Signal Params:
- Auto ID for Bats:
- Cluster Analysis:
- Noise Analysis:
- Cloud:
- Db:

INPUTS

Input directory: C:\Users\tmcburney\Downloads\C\ Browse

Drive label (nickname) for database (optional):

Include subdirectories

WAC files

WAV (and W4V) files

Time expansion factor: 1

ZC files

Fuzz GPS to precision: 0.00000

NABat Metadata Form Kaleidoscope Stationary

Latitude Decimal Degrees: 46.2858

Longitude Decimal Degrees: -62.78935

OUTPUTS

Output directory: C:\Users\tmcburney\Downloads\C\ Browse

Drive label (nickname) for database (optional):

Nightly Create subdirectories

Split to max duration, seconds:

WAV (or W4V) files

Split channels

Compression: None

Time expansion factor: 1

ZC files

Division Ratio: 8

8.3 file names

Use .zc instead of .??#

Figure 142. The NABat metadata form “Latitude” and “Longitude” fields.

- **Survey Start Time** (YYYY-MM-DDThh:mm:ss; e.g., 2020-06-12T20:30:00; *use 24h time)
- **Survey End Time** (YYYY-MM-DDThh:mm:ss; e.g., 2020-06-13T06:30:00; *use 24h time)

The screenshot shows the NABat metadata form with the following settings:

- Batch:
- Signal Params:
- Auto ID for Bats:
- Cluster Analysis:
- Noise Analysis:
- Cloud:
- Db:

INPUTS

Input directory: C:\Users\tmcburney\Downloads\C\ Browse

Drive label (nickname) for database (optional):

Include subdirectories

WAC files

WAV (and W4V) files

Time expansion factor: 1

ZC files

Fuzz GPS to precision: 0.00000

NABat Metadata Form Kaleidoscope Stationary

Survey Start Time: 2014-07-20T20:33:00-03:00

Survey End Time: 2014-08-04T06:12:00

OUTPUTS

Output directory: C:\Users\tmcburney\Downloads\C\ Browse

Drive label (nickname) for database (optional):

Nightly Create subdirectories

Split to max duration, seconds:

WAV (or W4V) files

Split channels

Compression: None

Time expansion factor: 1

ZC files

Division Ratio: 8

8.3 file names

Use .zc instead of .??#

Disable noise filtering

Figure 143. The NABat metadata form “Survey Start Time” and “Survey End Time” fields.



• Software Type

If using the free version of Kaleidoscope (i.e., not using Auto ID), fill this field with “No Auto ID”.

If using the professional version of Kaleidoscope (i.e., with Auto ID), version of Kaleidoscope currently in use in the following format: Kaleidoscope #.#.x (e.g., Kaleidoscope 5.1.x).

*Note: To find the version of Kaleidoscope currently in use, select “Help” from the menu bar at the top of the Kaleidoscope converter window, then click “About” from the drop-down list and under “Kaleidoscope” it will list the current version.

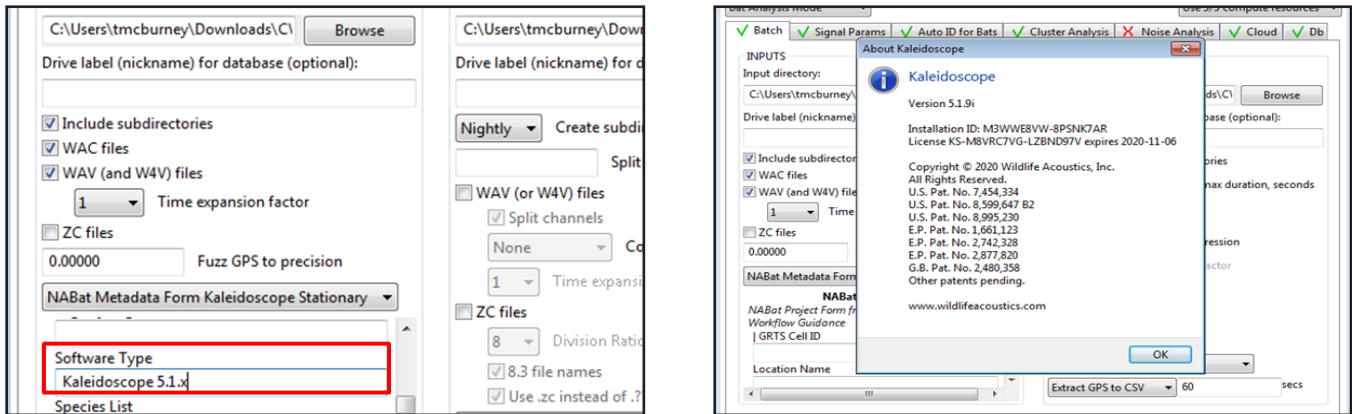


Figure 144. The NABat metadata form “Software Type” field.

• Species List (see Section 4.4.1 for more information)

There are additional fields that can be filled in if the information was collected during the surveys, but only the above fields are required.

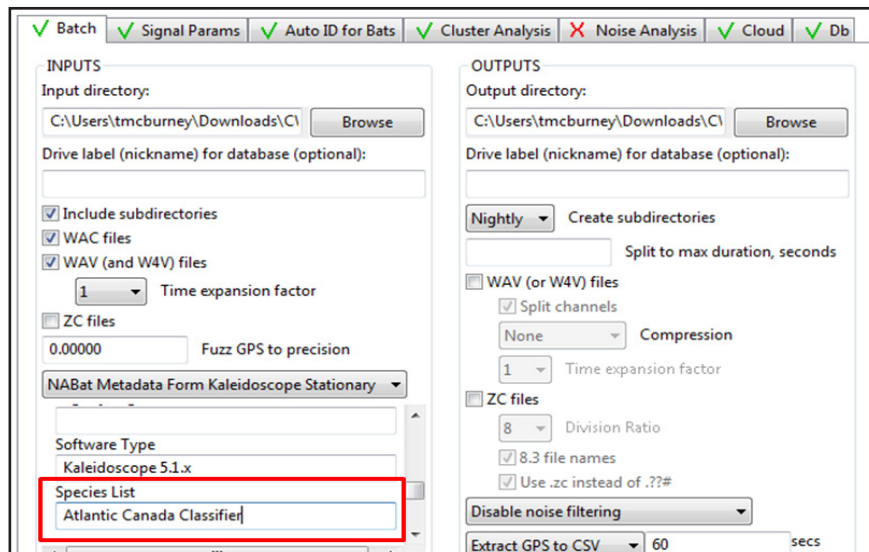


Figure 145. The NABat metadata form “Species List” field.



Step 9- After filling out the required fields and any desired additional fields, next to “Create subdirectories”, select “Nightly” from the drop-down list.

*Note: Selecting “Nightly” for subdirectories will automatically organise all of the acoustic data into folders by recording night. If this is not desired, select “None” instead of “Nightly”.

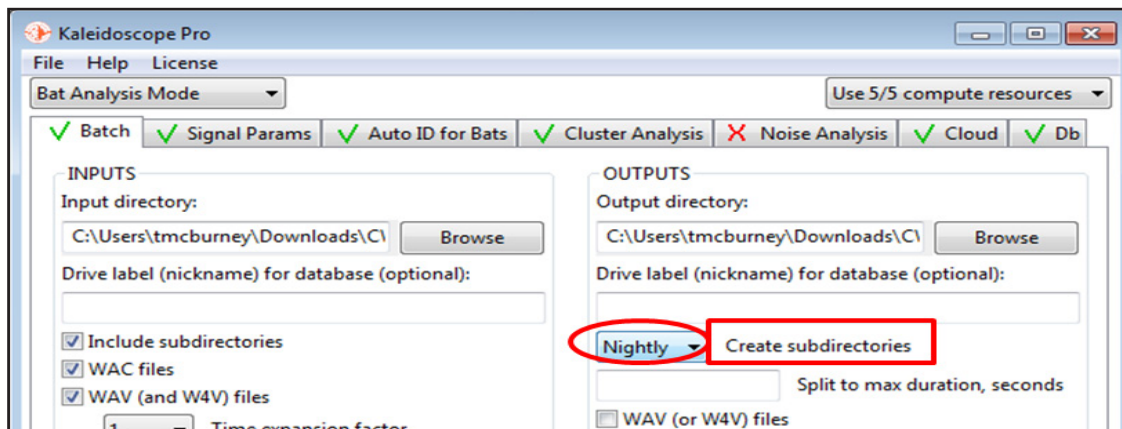


Figure 146. Next to “Create subdirectories”, select “Nightly” (Step 9).

Step 10- Select the box next to “WAV files”.

*Note: By creating .wav files, the files can be analysed in Kaleidoscope under both full spectrum and zero-cross analysis, which is recommended. If zero-cross only files are desired, process the data with the box next to “ZC files” selected instead.

Step 11- Under “WAV”, unselect the box next to “Split channels” if only one microphone was used to collect the acoustic data.

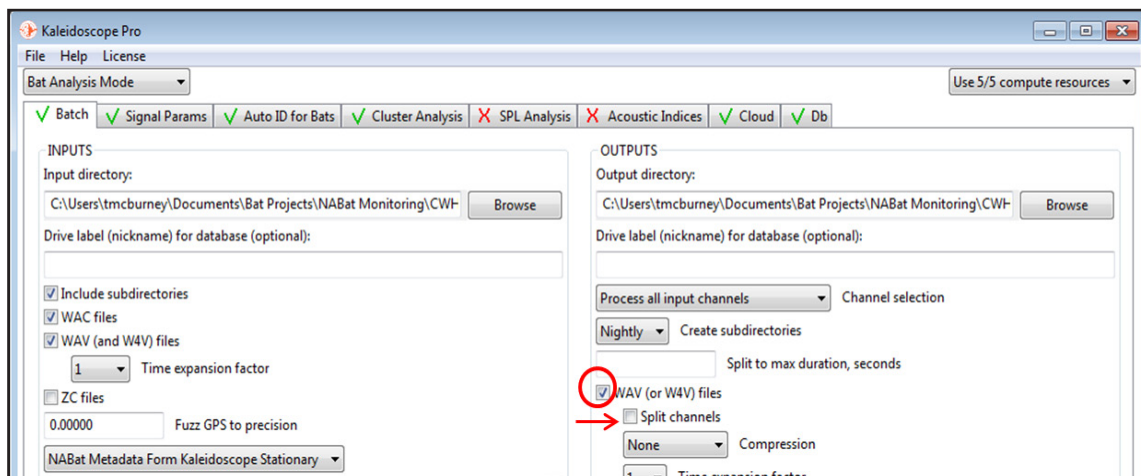


Figure 147. Select the box next to “WAV files” (Step 10) and under “WAV”, unselect the box next to “Split channels” (Step 11).



Step 12- Select “Move noise files to NOISE subfolder” from the drop-down list.

*Note: This will move all the files that the Kaleidoscope software screens as NOISE into a separate subfolder. All of these files should still be manually identified to ensure they are NOISE, but moving them to a subfolder can make sorting these files easier.

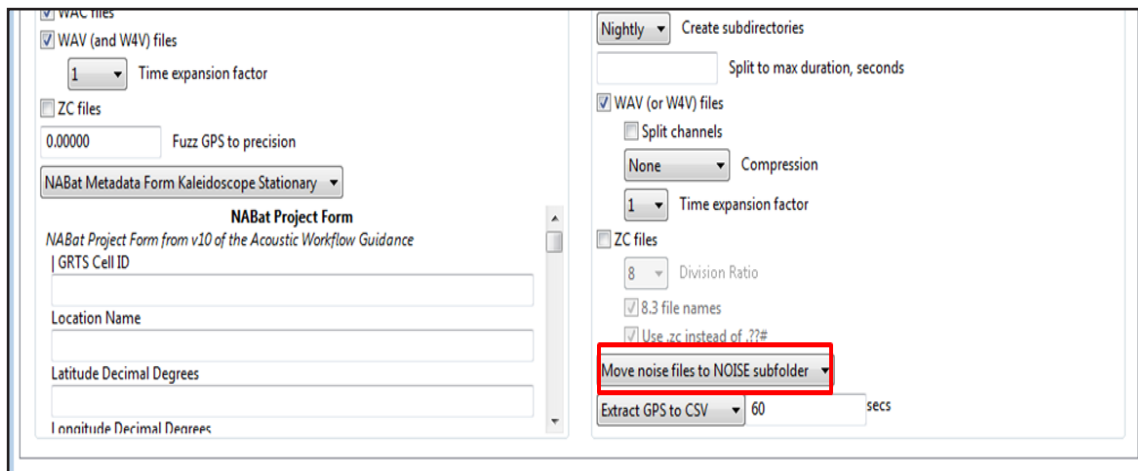


Figure 148. Select “Move noise files to NOISE subfolder” from the drop-down list (Step 12).

Step 13- Select “Extract GPS to CSV” from the dropdown. In the box next to this, the frequency of waypoint extraction can be specified in seconds. Change as desired, or leave on the standard “60 secs”.

*Note: This setting will result in a gps.csv with an associated waypoint for each recorded file. If a gps.kml is preferred so that the GPS file can be opened directly in Google Earth, select “Extract GPS to KML” from the dropdown. It is also possible to select “Extract GPS Disabled”, if no separate GPS file is desired.

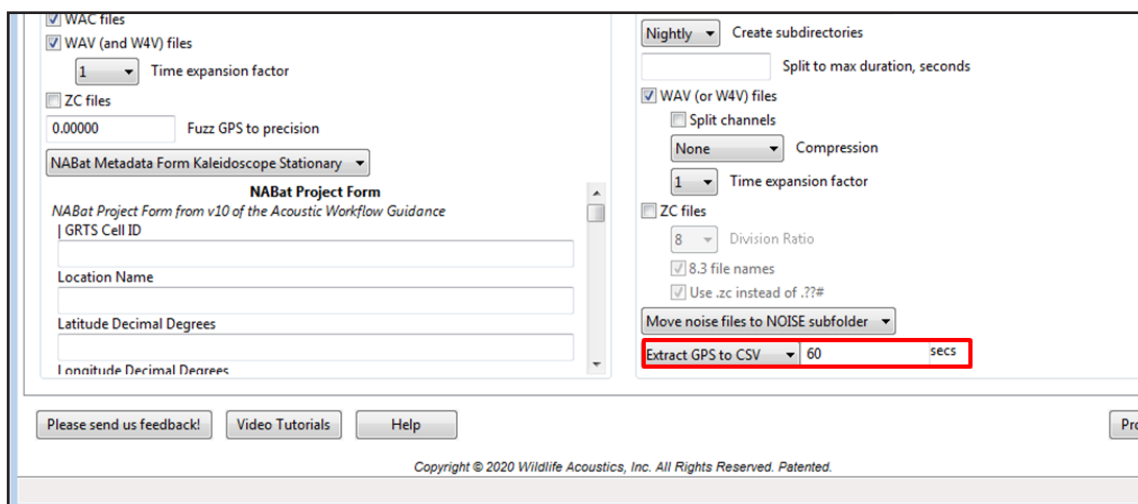


Figure 149. Select “Extract GPS to CSV” from the dropdown (Step 13).



Step 14- Select the “Signal Params” tab at the top and next to “(kHz) Minimum and Maximum Frequency Range” ensure the range is from 15-120 kHz.

*Note: The frequency range selected in the Kaleidoscope converter controls the basic frequency settings in the Kaleidoscope viewer. For example, if the minimum frequency of interest is set to 40 kHz, then when using the viewer, no frequencies below 40 kHz will be recognised by the program. This means that in compressed time view no bat pulses will be observable (*i.e.*, the screen will be completely grey) if all of the frequencies with the highest amplitudes are below 40 kHz. However, the entire recording will still be observable in normal time view, which adds to the importance of viewing each file in normal time view before switching over to compressed time view to more closely inspect the pulses.

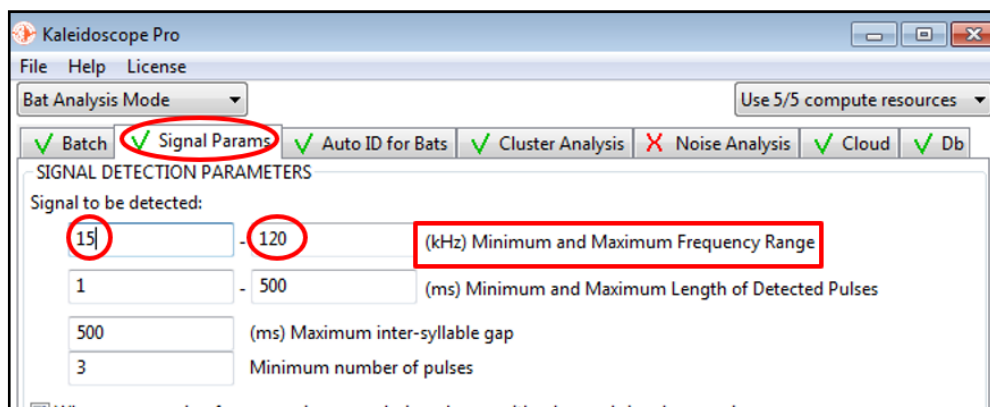


Figure 150. Next to “(kHz) Minimum and Maximum Frequency Range” ensure the range is from 15-120 kHz (Step 14).

Step 15- Next to “(ms) Minimum and Maximum Length of Detected Pulses” confirm the range is 1-500 ms.

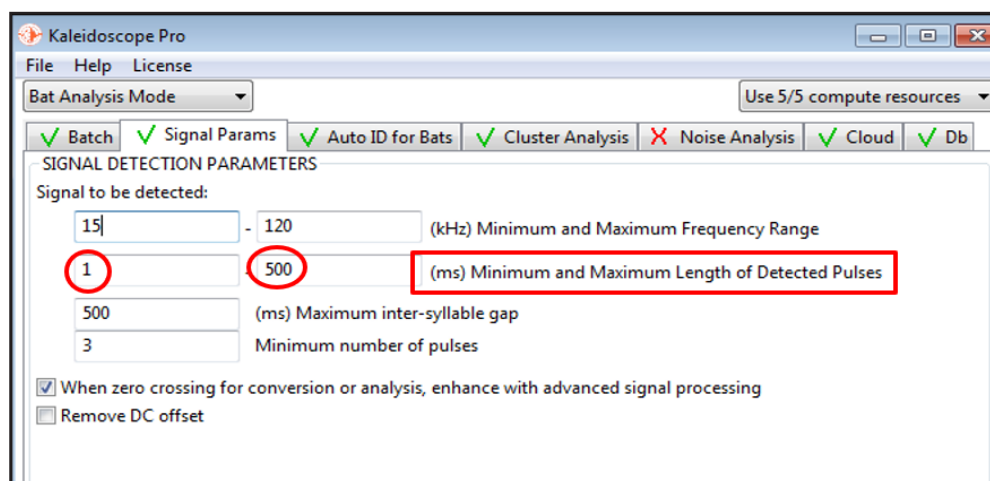


Figure 151. Next to “(ms) Minimum and Maximum Length of Detected Pulses” confirm the range is 1-500 ms (Step 15).



Step 16- Still under “Signal Params”, next to “Minimum number of pulses” enter 3.

If using Auto ID, go to *Step 18*.

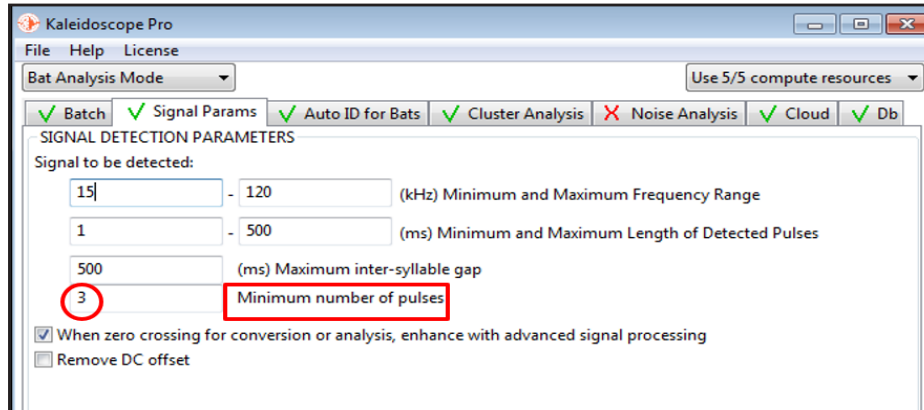


Figure 152. Next to “Minimum number of pulses” enter 3 (Step 16).

Step 17- If not using Auto ID, under “Signal Params”, next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”, uncheck the box.

If not using Auto ID, go to *Step 20*.

Step 18- If using Auto ID, still under “Signal Params” tab, select the box next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”.

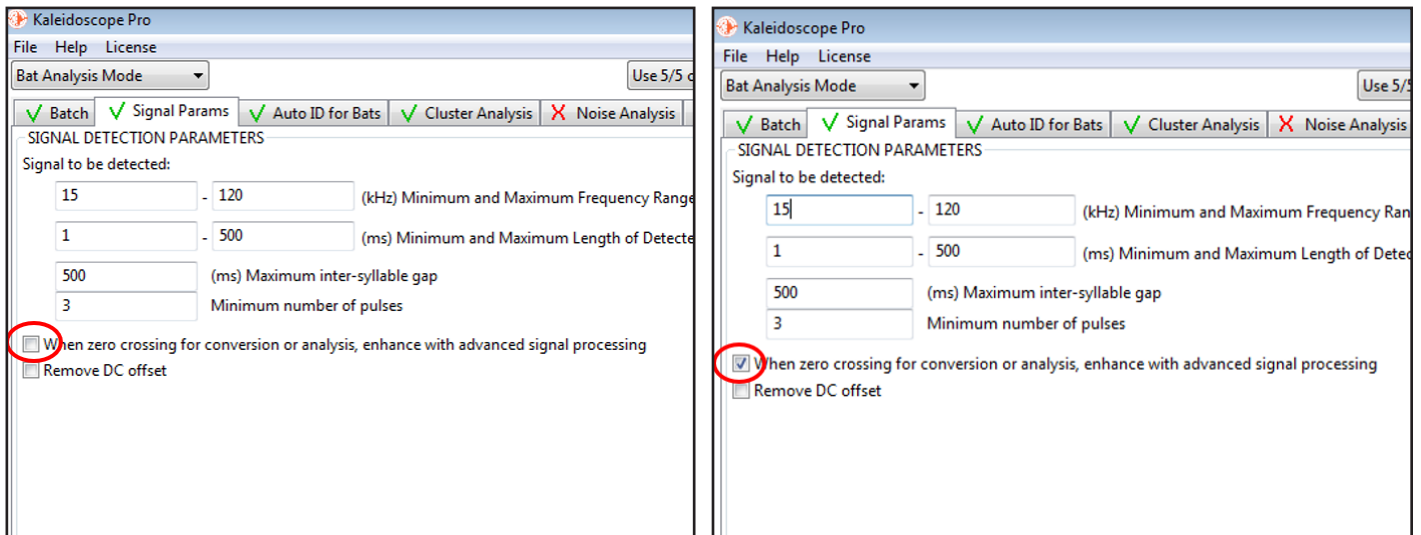
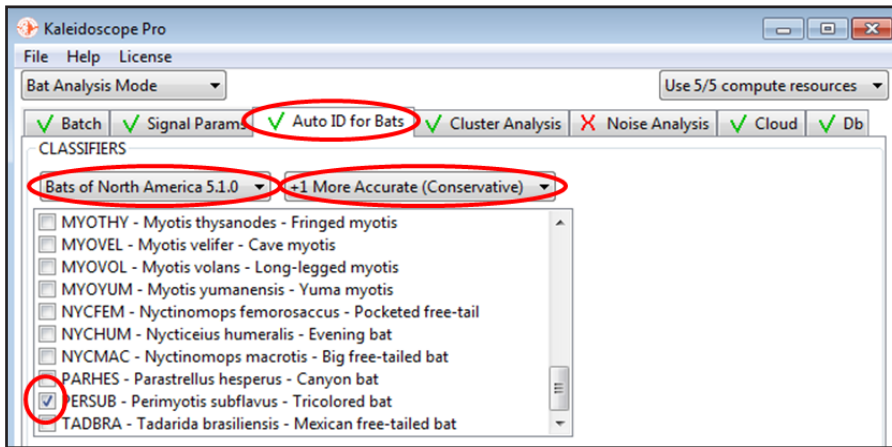


Figure 153. If not using Auto ID, next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”, uncheck the box (Step 17) (left). If using Auto ID, select the box (Step 18) (right).



Step 19- If using Auto ID, under the “Auto ID for Bats” tab select “Bats of North America 5.1.0” (or most recent version). Ensure the drop-down list next to this is on “+1 More Accurate (Conservative)”. Next, select the SAME species that were already added to the Species List for the metadata classifier list above (Step 2). If the standard Atlantic Canada Classifier is being used, choose the following bats by selecting the box next to the name: EPTFUS, LASBOR, LASCIN, LASNOC, MYOLUC, MYOSEP, PERSUB.



- EPTFUS
- LASBOR
- LASCIN
- LASNOC
- MYOLUC
- MYOSEP
- PERSUB

Figure 154. If using Auto ID, under the “Auto ID for Bats” tab select “Bats of North America 5.1.0” (Step 19).

Step 20- Go back to the “Batch” tab and select the “Process Files” button on the bottom right.

*Note: Due to changing some of the default settings, Kaleidoscope may ask about a few of the chosen settings before proceeding. If all of the changes are the same as those made above, then click “Okay” to start processing the files.

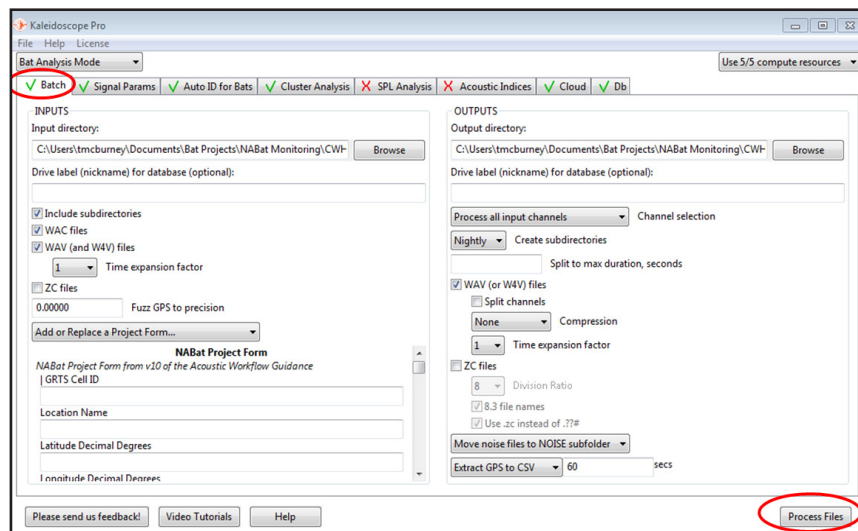


Figure 155. Select the “Process Files” button (Step 20).



*Note: When Kaleidoscope processes the raw acoustic data, it automatically will create the following for the designated stationary point survey site in the processed data folder:

- the **processed audio files** within a “Data” folder (files automatically designated as NOISE are in a “NOISE” subfolder within the “Data” folder)
- **log.txt** (this file keeps a record of each step of the file processing and can be used for diagnostics if an error occurs)
- **settings.ini** (this file keeps a record of the settings used in the Kaleidoscope converter window during data processing)

These settings can be reloaded into the Kaleidoscope converter by opening the converter and selecting “File”, “Load Settings”, and then selecting the desired settings.ini file.

- **gps.csv** (this file contains the GPS data for each file if the “Extract GPS to CSV” setting was selected, if the “Extract GPS to KML” setting was selected, this file will be gps.kml, if the “Extract GPS Disabled” was selected, there will be no GPS file)
- **meta.csv** (this file contains all of the metadata that were entered in the NABat metadata form in the Kaleidoscope converter window, in addition to providing a list of all the files recorded within that stationary point survey site, this spreadsheet is where the manual ID for each file will be added)

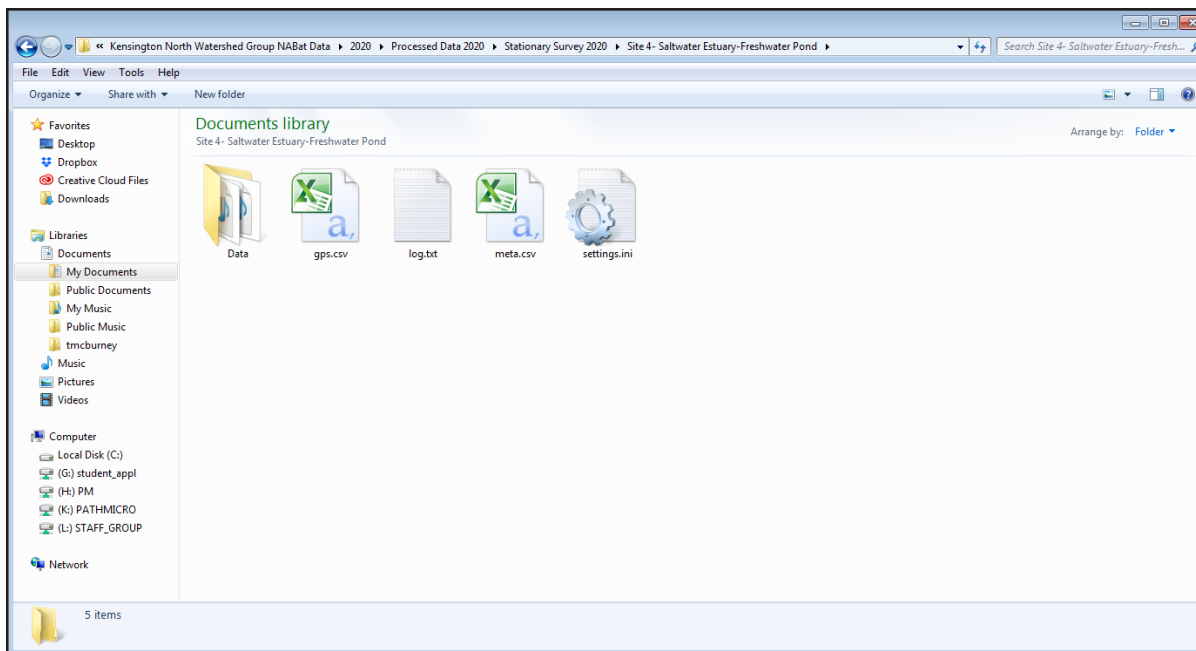


Figure 156. When Kaleidoscope processes the raw acoustic data, it automatically will create new files.



If the Pro Version of the Kaleidoscope software is used for data processing, two other files will be created after data processing:

- **idsummary.csv** (this file gives a summary of the number of files recorded for each species on each monitoring night using Auto ID classification)
- **id.csv** (this file provides a list of all of the files recorded within that stationary point survey site, and includes averages of call parameter values for each file in addition to the auto ID given for each file, this spreadsheet is where the manual ID for each file will be added if using the Pro Version of the Kaleidoscope software)

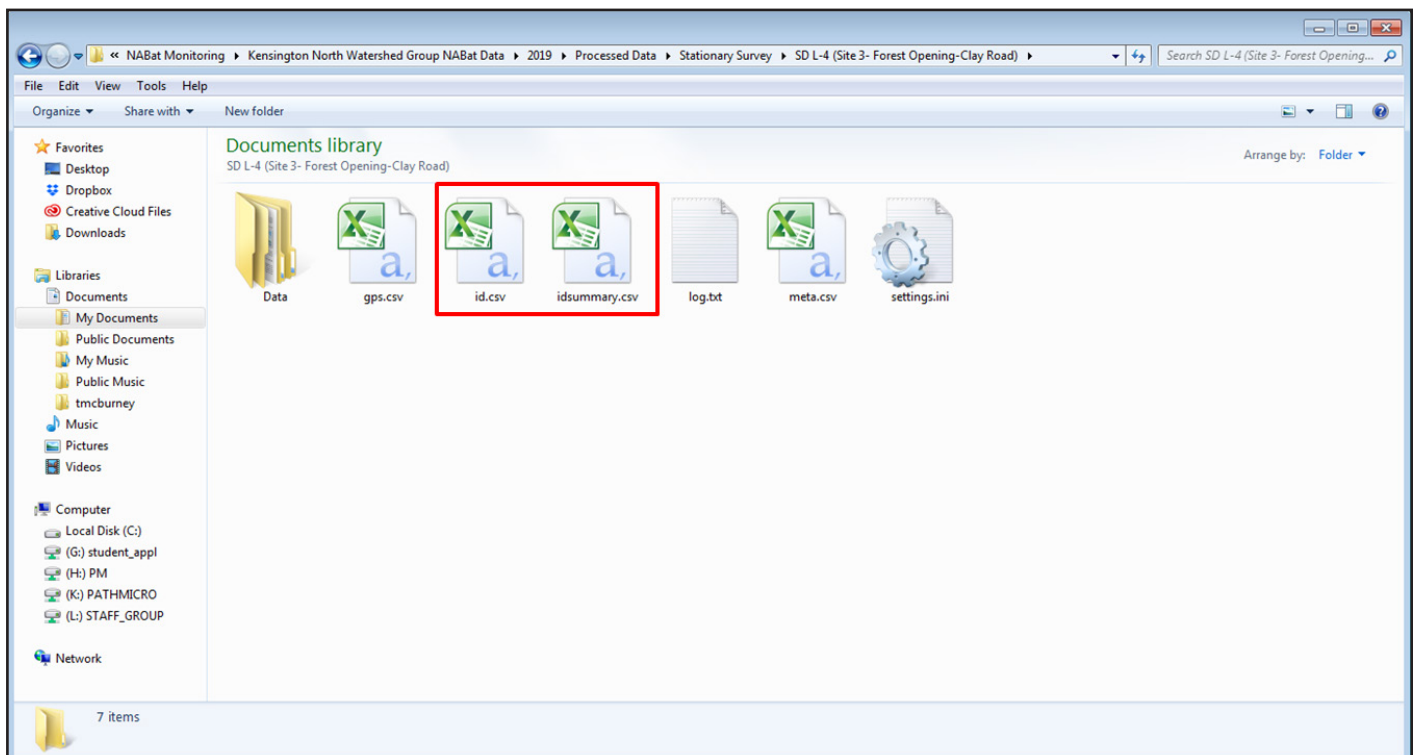


Figure 157. If the Pro Version of the Kaleidoscope software is used for data processing, two other files will be created after data processing.

Step 21- Go back and repeat all of the steps above for the other stationary point survey file folders that contain the acoustic data for the remaining stationary point survey monitoring sites included in this NABat GRTS cell.

Step 22- After all of the stationary point survey data have been processed; the next task will be manually identifying the files.



4.5 Creating Metadata for Mobile Transect Acoustic Files

To upload acoustic data to the NABat website, metadata will need to be included. The simplest way to do this is to follow the steps as outlined below; before the data are manually identified:

Step 1- Download the following NABat metadata forms for Kaleidoscope at this [website](#):

NABat_Metadata_Form_Kaleidoscope_Mobile.xml

NABat_Mobile_Meta_Output_Only_KPRO.xml

The screenshot shows the USGS ScienceBase-Catalog interface. The breadcrumb trail is: ScienceBase Catalog → North American Bat Monitori... → NABat Metadata Files → NABat Metadata Forms for A... The main heading is "NABat Metadata Forms for Auto ID Software". Under "Attached Files", there is a table of files:

File Name	Size
NABat_Metadata_Kaleidoscope_to_SonoBat.xml	3.35 KB
NABat_Metadata_Form_SonoBat_3.xml	3.38 KB
NABat_Metadata_Form_SonoBat_4.xml	3.35 KB
NABat_Mobile_Meta_Output_Only_KPRO.xml "Transect Metadata Form (Output Only)"	10.62 KB
NABat_Stationary_Meta_Output_Only_KPRO.xml "Stationary Metadata Form (Output Only)"	11.24 KB
NABat_Metadata_Form_SonoBat_Mobile.xml	2.85 KB
NABat_Metadata_Form_Kaleidoscope_Stationary.xml	20.92 KB
NABat_Metadata_Form_Kaleidoscope_Mobile.xml	17.72 KB

Figure 158. Download the NABat metadata forms for Kaleidoscope (Step 1).

Step 2- Create a species list for the monitoring area. A species list is connected to a NABat website account. If a user has already created a species list and wants to use the same list again, move on to *Step 3*. To create a new species list, follow the instructions in *Section 4.4.1*.



Step 3- Open the Kaleidoscope converter software by clicking on the desktop icon.

*Note: These directions require Kaleidoscope Version 5 or later.

Step 4- Ensure that at the top of the Kaleidoscope converter window “Bat Analysis Mode” is selected from the drop-down list.

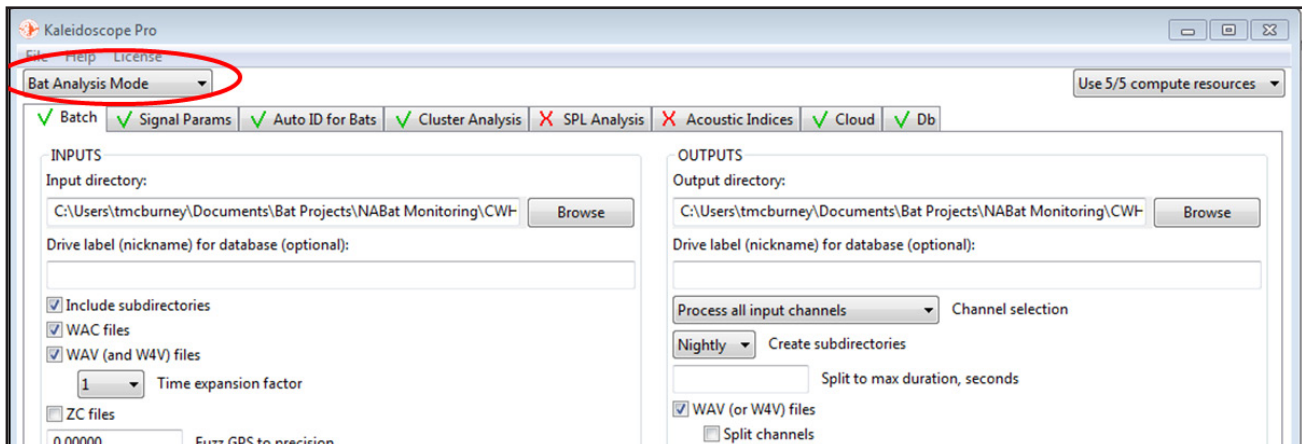


Figure 159. Ensure “Bat Analysis Mode” is selected from the drop-down list (Step 4).

Step 5- Under “INPUTS” “Input directory:” click on the “Browse” button, and select the file folder of ONE of the mobile transects from within the Raw Data subfolder.

Step 6- Under “OUTPUTS” “Output directory:” click on the “Browse” button, and select the matching file folder for the mobile transect within the Processed Data subfolder.

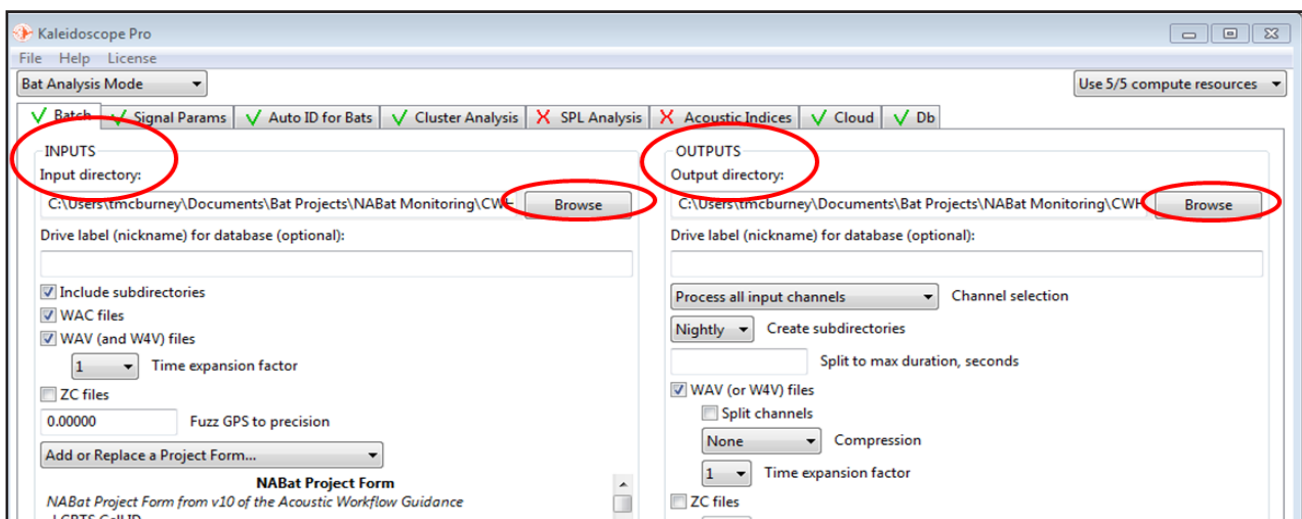


Figure 160. Select file folders for “Input directory” and “Output directory” (Steps 5 and 6).



Step 7- Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” and select the following file that was downloaded in *Step 1*:

NABat_Metadata_Form_Kaleidoscope_Mobile.xml

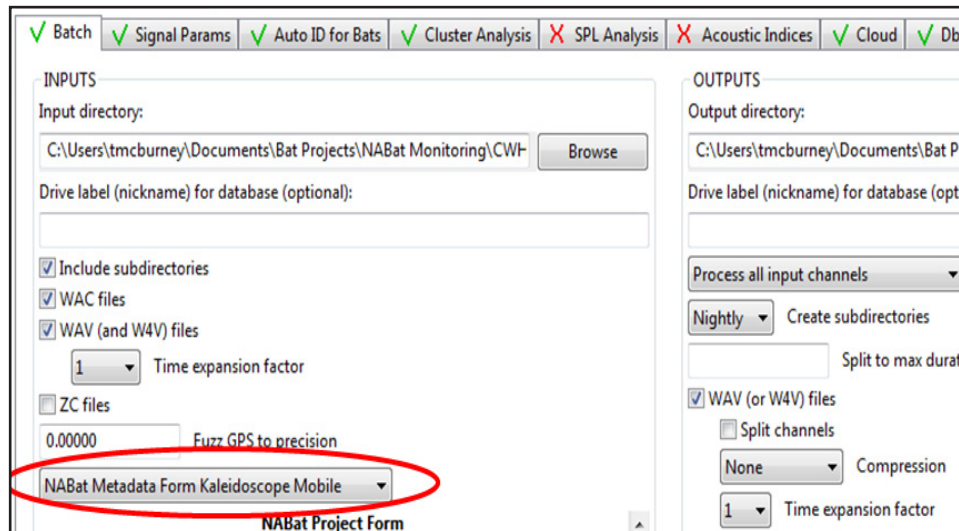


Figure 161. Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” (Step 7).

Step 8- The NABat metadata form will now appear in the Kaleidoscope window under “NABat Project Form”, requiring completion of the fields below (hover the mouse over individual fields for more information):

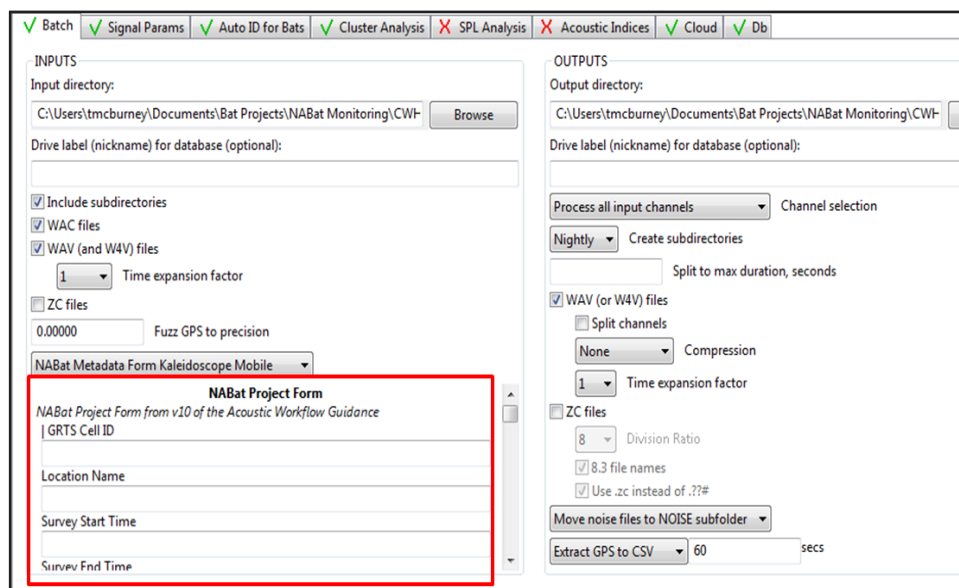


Figure 162. The NABat metadata form will appear under “NABat Project Form” (Step 8).



- **GRTS Cell ID** (the NABat GRTS Cell ID)

*Note: If no GPS was used during the mobile transect, leave the field for GRTS Cell ID blank.

The screenshot shows the NABat Project Form interface. At the top, there are several tabs: Batch (checked), Signal Params (checked), Auto ID for Bats (checked), Cluster Analysis (checked), SPL Analysis (unchecked), Acoustic Indices (unchecked), Cloud (checked), and Db (checked). The main area is divided into INPUTS and OUTPUTS sections. In the INPUTS section, the 'GRTS Cell ID' field is highlighted with a red box and contains the value '8908'. Other fields include 'Input directory' (C:\Users\tmcburney\Documents\Bat Projects\NABat Monitoring\CWF-), 'Drive label (nickname) for database (optional)', 'Include subdirectories' (checked), 'WAC files' (checked), 'WAV (and W4V) files' (checked), 'Time expansion factor' (1), 'ZC files' (unchecked), 'Fuzz GPS to precision' (0.00000), and 'NABat Metadata Form Kaleidoscope Mobile' (selected). The OUTPUTS section includes 'Output directory', 'Drive label (nickname) for database (optional)', 'Process all input channels' (Nightly), 'Create subdirectories', 'Split to max duration', 'WAV (or W4V) files' (checked), 'Split channels' (unchecked), 'Compression' (None), 'Time expansion factor' (1), 'ZC files' (unchecked), and 'Division Ratio' (8).

Figure 163. The NABat metadata form GRTS Cell ID field.

- **Location Name** (enter a descriptive and original name for the route, e.g., Donagh Road Route)

The screenshot shows the NABat Project Form interface, similar to Figure 163. The 'GRTS Cell ID' field is now filled with '8908'. The 'Location Name' field is highlighted with a red box and contains the value 'Farm'. Other fields in the INPUTS section are the same as in Figure 163. The OUTPUTS section includes 'Output directory', 'Drive label (nickname) for database (optional)', 'Process all input channels' (Nightly), 'Create subdirectories', 'Split to max duration', 'WAV (or W4V) files' (checked), 'Split channels' (unchecked), 'Compression' (None), 'Time expansion factor' (1), 'ZC files' (unchecked), and 'Division Ratio' (8). There are also checkboxes for '8.3 file names' and 'Use .zc instead of .??#', both of which are checked.

Figure 164. The NABat metadata form Location Name field.



- **Survey Start Time** (YYYY-MM-DDThh:mm:ss; e.g., 2020-06-12T20:30:00; *use 24h time)
- **Survey End Time** (YYYY-MM-DDThh:mm:ss; e.g., 2020-06-13T06:30:00; *use 24h time)

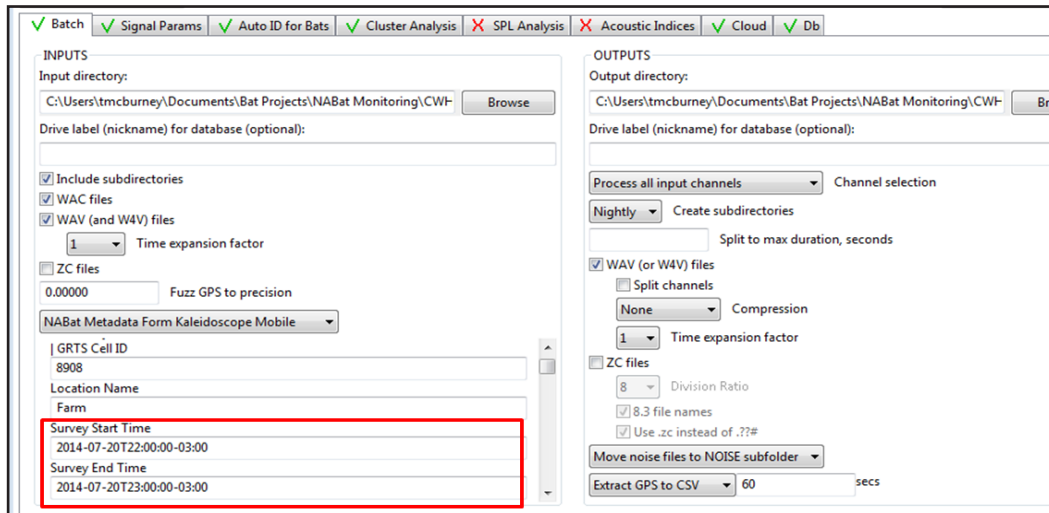


Figure 165. The NABat metadata form Survey Start Time and Survey End Time fields.

• **Software Type**

If using the free version of Kaleidoscope (i.e., not using Auto ID), fill this field with “No Auto ID”.

If using the professional version of Kaleidoscope (i.e., with Auto ID), version of Kaleidoscope currently in use in the following format: Kaleidoscope #.#.x (e.g., Kaleidoscope 5.1.x).

*Note: To find the version of Kaleidoscope currently in use, select “Help” from the menu bar at the top of the Kaleidoscope converter window, then click “About” from the drop-down list and under “Kaleidoscope” it will list the current version.

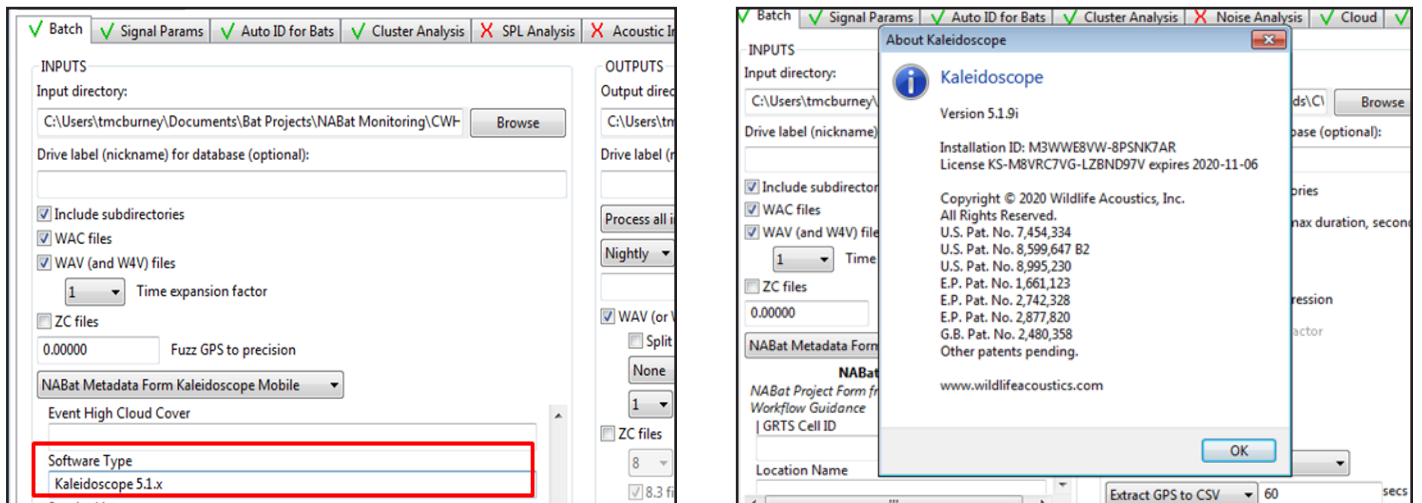


Figure 166. The NABat metadata form Software Type field.



- **Species List** (see *Section 4.4.1* for more information)

There are additional fields that can be filled in if the information was collected during the surveys, but only the above fields are required.

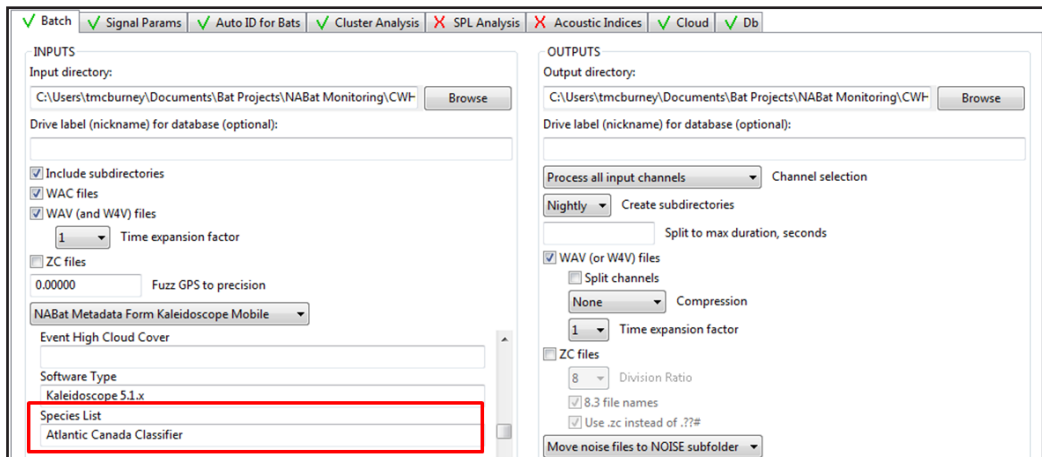


Figure 167. The NABat metadata form Species List field.

Step 9- After filling out the required fields and any desired additional fields, next to “Create subdirectories”, select “Nightly” from the drop-down list.

*Note: Selecting “Nightly” for subdirectories will automatically organise all of the acoustic data into folders by recording night. If this is not desired, select “None” instead of “Nightly”.

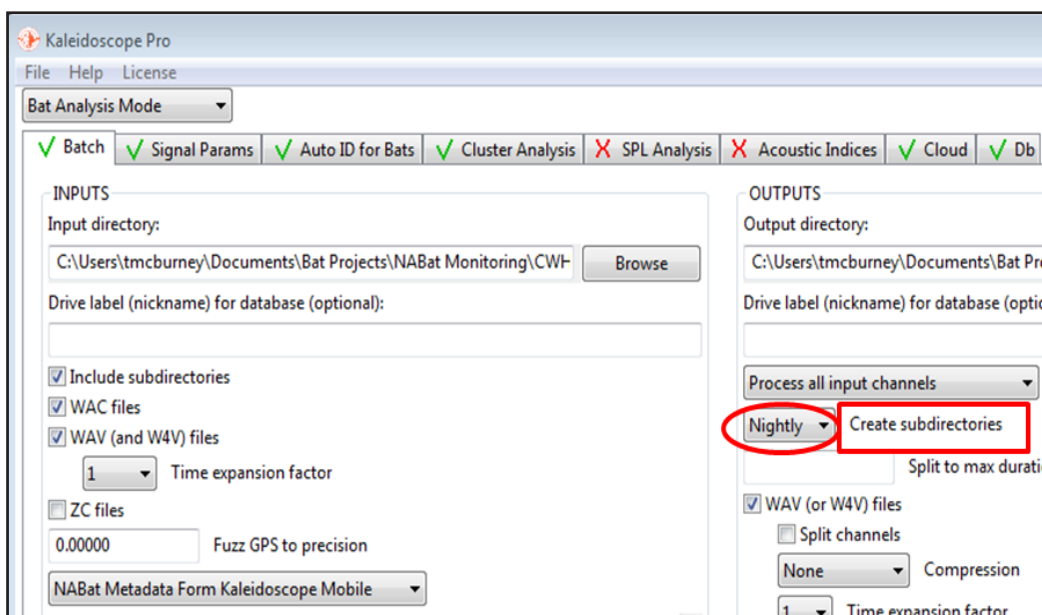


Figure 168. Next to “Create subdirectories”, select “Nightly” (Step 9).



Step 10- Select the boxes next to “WAV files”.

*Note: By creating .wav files, the files can be analysed in Kaleidoscope under both full spectrum and zero-cross analysis, which is recommended. If zero-cross only files are desired, process the data with the box next to “ZC files” selected instead.

Step 11- Under “WAV”, unselect the box next to “Split channels” if only one microphone was used to collect the acoustic data.

The screenshot shows the Kaleidoscope software interface. At the top, there are tabs for various analysis options: Batch (checked), Signal Params (checked), Auto ID for Bats (checked), Cluster Analysis (checked), SPL Analysis (unchecked), Acoustic Indices (unchecked), Cloud (checked), and Db (checked). The main interface is divided into INPUTS and OUTPUTS sections. In the INPUTS section, the 'Include subdirectories', 'WAC files', and 'WAV (and W4V) files' checkboxes are checked. The 'ZC files' checkbox is unchecked. In the OUTPUTS section, the 'WAV (or W4V) files' checkbox is checked, and the 'Split channels' checkbox is unchecked. A red circle highlights the 'WAV (or W4V) files' checkbox, and a red arrow points to the 'Split channels' checkbox.

Figure 169. Select the box next to “WAV files” (Step 10) and under “WAV”, unselect the box next to “Split channels” (Step 11).

Step 12- Select “Move noise files to NOISE subfolder” from the drop-down list.

*Note: This will move all the files that the Kaleidoscope software screens as NOISE into a separate subfolder. All of these files should still be manually identified to ensure they are NOISE, but moving them to a subfolder can make sorting these files easier.

The screenshot shows the Kaleidoscope software interface. The 'NABat Project Form' is visible, with fields for 'GRTS Cell ID', 'Location Name', 'Latitude Decimal Degrees', and 'Longitude Decimal Degrees'. The 'OUTPUTS' section is also visible, with the 'WAV (or W4V) files' checkbox checked and the 'Split channels' checkbox unchecked. The 'Move noise files to NOISE subfolder' option is selected in the drop-down list. A red box highlights the drop-down list.

Figure 170. Select “Move noise files to NOISE subfolder” from the drop-down list (Step 12).



Step 13- Select “Extract GPS to CSV” from the dropdown. In the box next to this, the frequency of waypoint extraction can be specified in seconds. Change as desired, or leave on the standard “60 secs”.

*Note: This setting will result in a gps.csv with an associated waypoint for each recorded file. If a gps.kml is preferred so that the GPS file can be opened directly in Google Earth, select “Extract GPS to KML” from the dropdown. It is also possible to select “Extract GPS Disabled”, if no separate GPS file is desired.

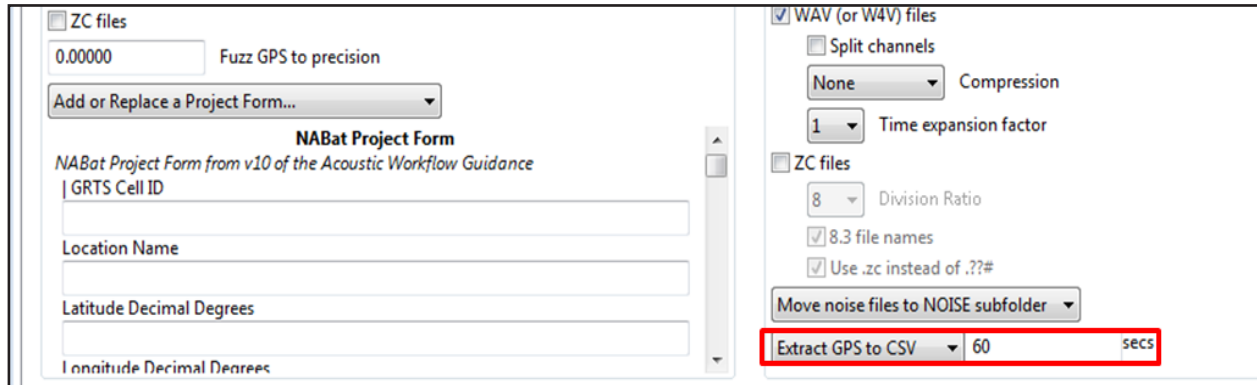


Figure 171. Select “Extract GPS to CSV” from the dropdown (Step 13).

Step 14- Select the “Signal Params” tab at the top and next to “(kHz) Minimum and Maximum Frequency Range” ensure the range is from 15-120 kHz.

*Note: The frequency range selected in the Kaleidoscope converter controls the basic frequency settings in the Kaleidoscope viewer. For example, if the minimum frequency of interest is set to 40 kHz, then when using the viewer, no frequencies below 40 kHz will be recognised by the program. This means that in compressed time view no bat pulses will be observable (*i.e.*, the screen will be completely grey) if all of the frequencies with the highest amplitudes are below 40 kHz. However, the entire recording will still be observable in normal time view, which adds to the importance of viewing each file in normal time view before switching over to compressed time view to more closely inspect the pulses.

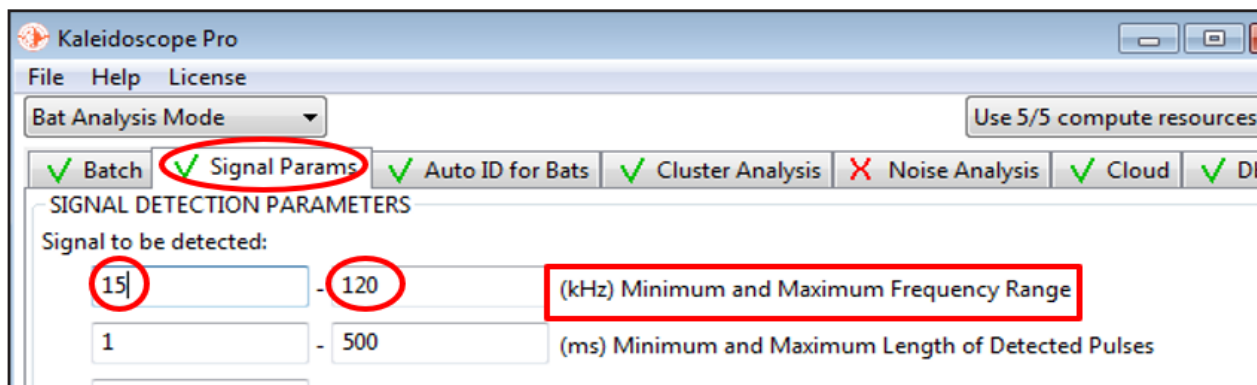


Figure 172. Next to “(kHz) Minimum and Maximum Frequency Range” ensure the range is from 15-120 kHz (Step 14).



Step 15- Still under “Signal Params”, next to “(ms) Minimum and Maximum Length of Detected Pulses” confirm the range is 1-500 ms.

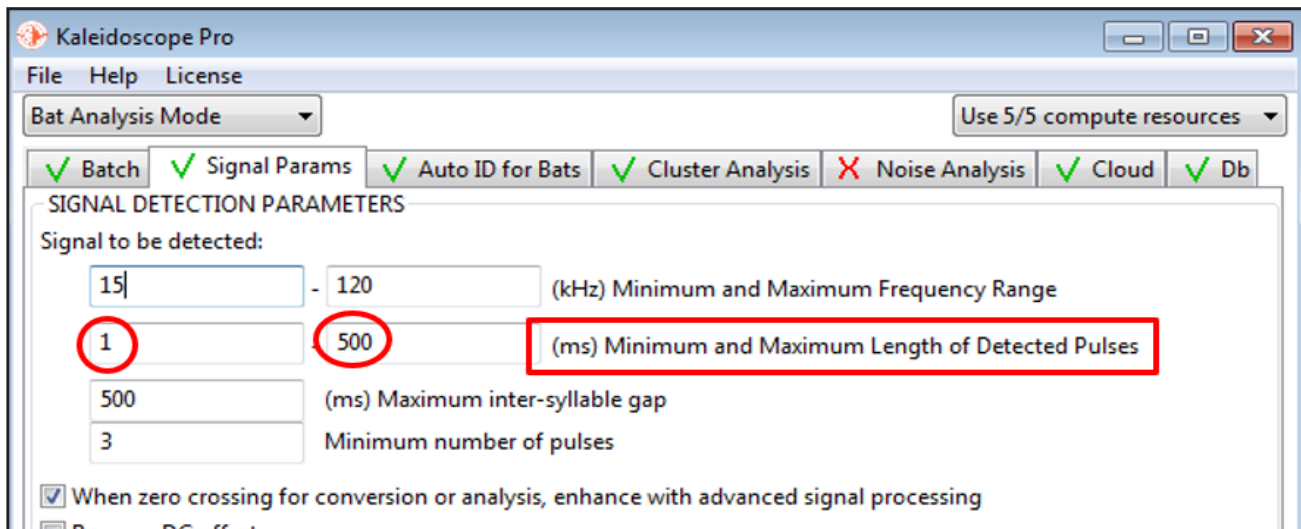


Figure 173. Next to “(ms) Minimum and Maximum Length of Detected Pulses” confirm the range is 1-500 ms (Step 15).

Step 16- Still under “Signal Params”, next to “Minimum number of pulses” enter 3.

If using Auto ID, go to *Step 18*.

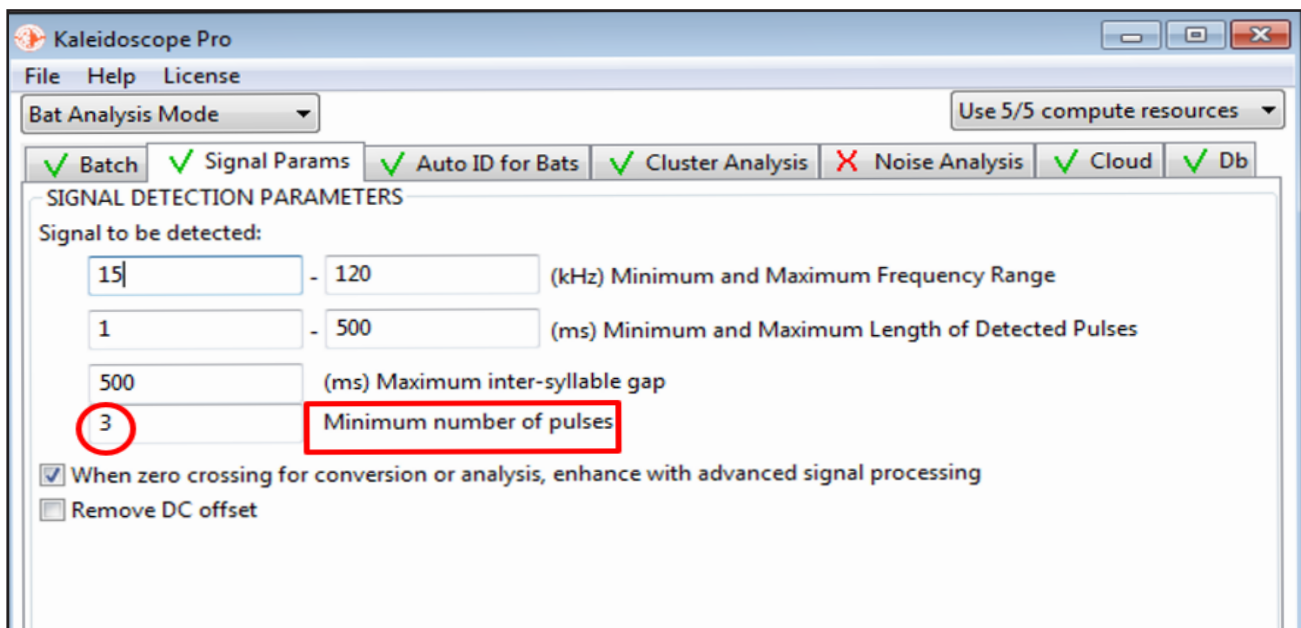


Figure 174. Next to “Minimum number of pulses” enter 3 (Step 16).



Step 17- If not using Auto ID, under “Signal Params”, next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”, uncheck the box.

If not using Auto ID, go to *Step 20*.

Step 18- If using Auto ID, still under “Signal Params” tab, select the box next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”.

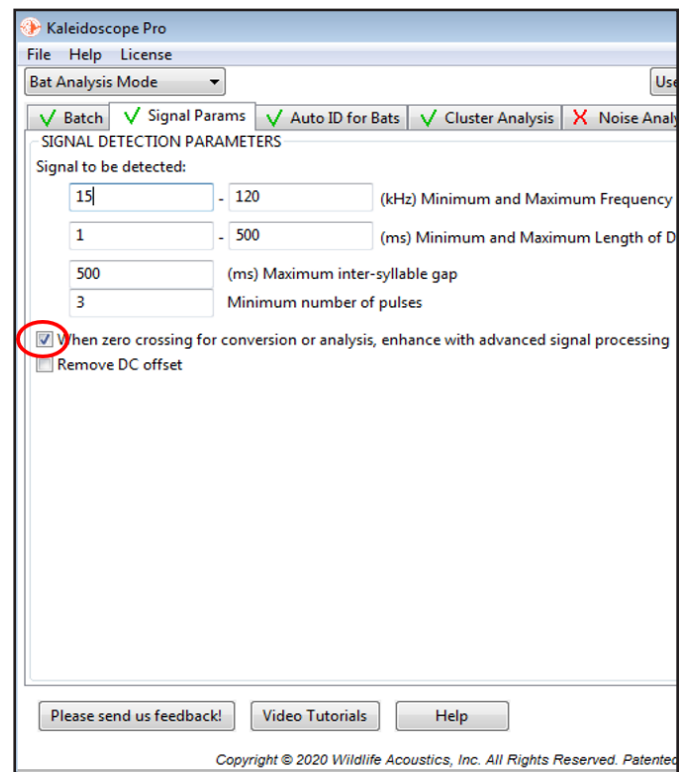
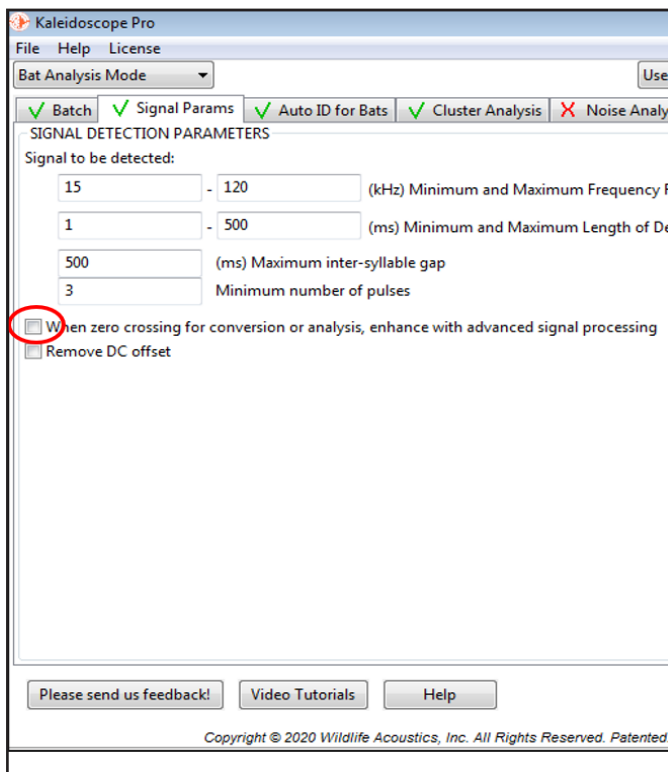
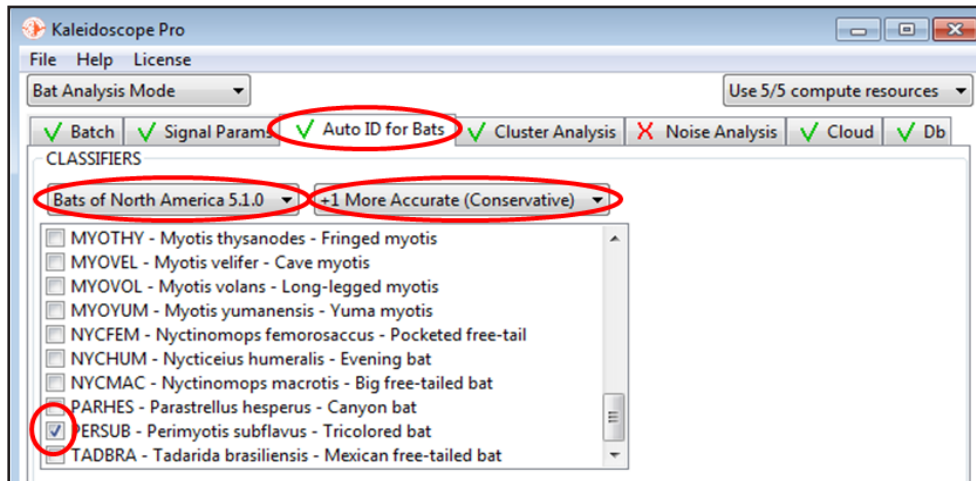


Figure 175. If not using Auto ID, next to “When zero-crossing for conversion or analysis, enhance with advanced signal processing”, uncheck the box (Step 17) (left). If using Auto ID, select the box (Step 18) (right).



Step 19- If using Auto ID, under the “Auto ID for Bats” tab select “Bats of North America 5.1.0” (or most recent version). Ensure the drop-down list next to this is on “+1 More Accurate (Conservative)”. Next, select the SAME species that were already added to the Species List for the metadata classifier list above (Step 2). If the standard Atlantic Canada Classifier is being used, choose the following bats by selecting the box next to the name: EPTFUS, LASBOR, LASCIN, LASNOC, MYOLUC, MYOSEP, PERSUB.



- EPTFUS
- LASBOR
- LASCIN
- LASNOC
- MYOLUC
- MYOSEP
- PERSUB

Figure 176. If using Auto ID, under the “Auto ID for Bats” tab select “Bats of North America 5.1.0” (Step 19).

Step 20- Go back to the “Batch” tab and select the “Process Files” button on the bottom right.

*Note: Due to changing some of the default settings, Kaleidoscope may ask about a few of the chosen settings before proceeding. If all of the changes are the same as those made above, then click “Okay” to start processing the files.

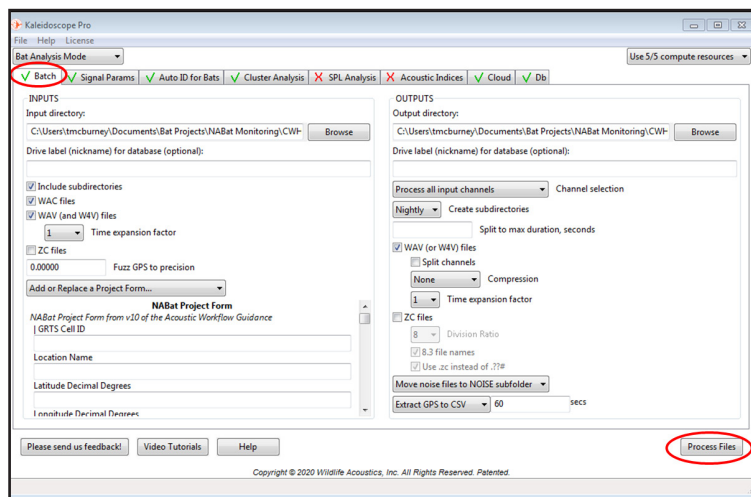


Figure 177. Select the “Process Files” button (Step 20).



*Note: When Kaleidoscope processes the raw acoustic data, it automatically will create the following for the designed mobile transect in the processed data folder:

- the **processed audio files** within a “Data” folder (files automatically designated as NOISE are in a “NOISE” subfolder within the “Data” folder)
- **log.txt** (this file keeps a record of each step of the file processing and can be used for diagnostics if an error occurs)
- **settings.ini** (this file keeps a record of the settings used in the Kaleidoscope converter window during data processing)

These settings can be reloaded into the Kaleidoscope converter by opening the converter and selecting “File”, “Load Settings”, and then selecting the desired settings.ini file.

- **gps.csv** (this file contains the GPS data for each file if the “Extract GPS to CSV” setting was selected, if the “Extract GPS to KML” setting was selected, this file will be gps.kml, if the “Extract GPS Disabled” was selected, there will be no GPS file)
- **meta.csv** (this file contains all of the metadata that were entered in the NABat metadata form in the Kaleidoscope converter window, in addition to providing a list of all the files recorded within that stationary point survey site, this spreadsheet is where the manual ID for each file will be added)

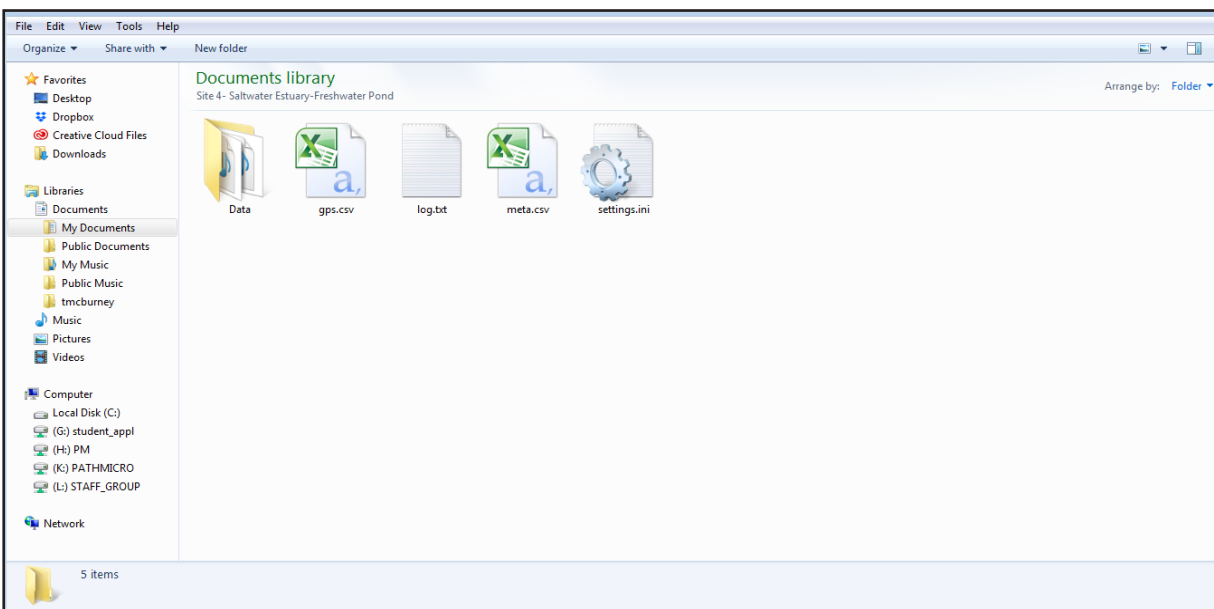


Figure 178. When Kaleidoscope processes the raw acoustic data, it automatically will create new files.



If the Pro Version of the Kaleidoscope software is used for data processing, two other files will be created after data processing:

- **idsummary.csv** (this file gives a summary of the number of files recorded for each species on each monitoring night using Auto ID classification)
- **id.csv** (this file provides a list of all of the files recorded within that stationary point survey site, and includes averages of call parameter values for each file in addition to the auto ID given for each file, this spreadsheet is where the manual ID for each file will be added if using the Pro Version of the Kaleidoscope software)

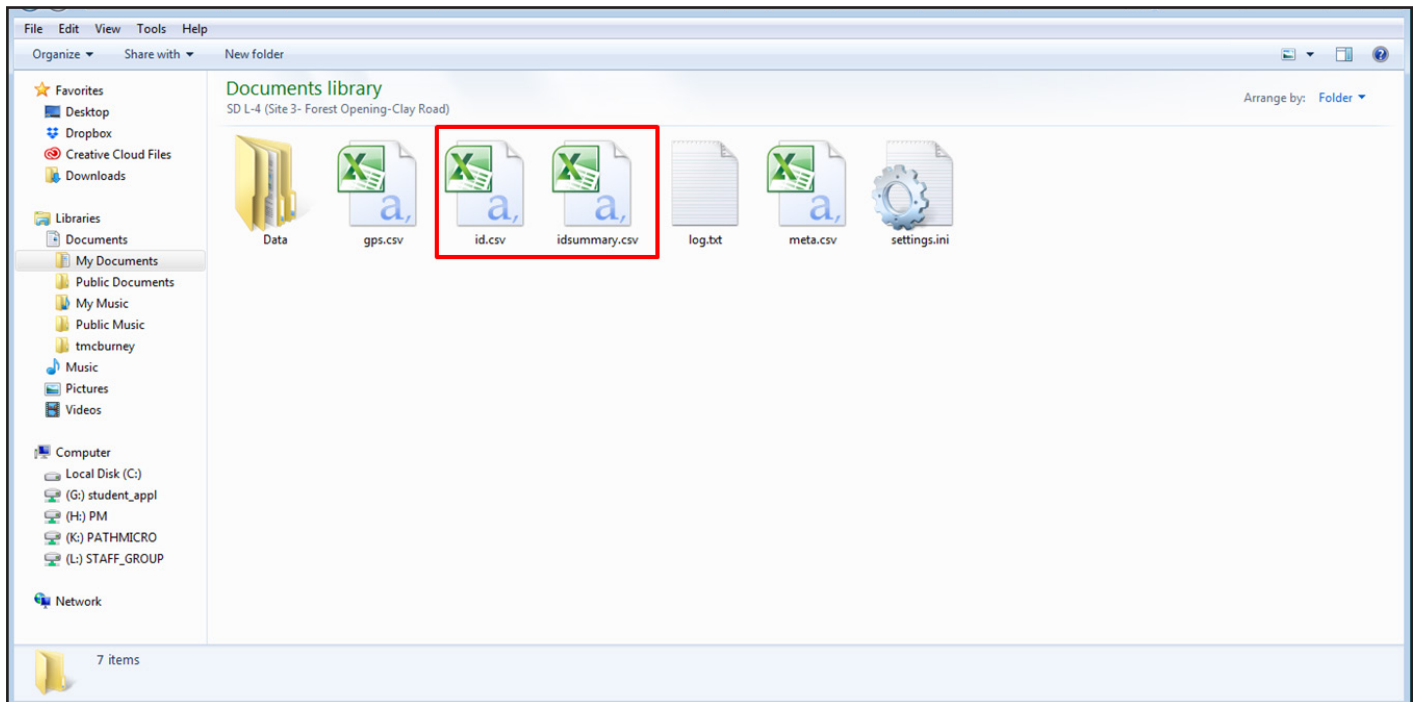


Figure 179. If the Pro Version of the Kaleidoscope software is used for data processing, two other files will be created after data processing.

Step 21- Go back and repeat all of the steps above if there are any other mobile transect file folders that contain acoustic data for mobile transects conducted within this NABat GRTS cell.

Step 22- After all of the mobile transect data have been processed; the next task will be manually identifying the files.



4.6 Opening and Manually Identifying Files in Kaleidoscope

There are two ways to open and manually identify acoustic files: **1. Kaleidoscope Free Version**

2. Kaleidoscope Pro Version

4.6.1 Kaleidoscope Free Version

This method works with the free version of Kaleidoscope software. To manually identify files in Kaleidoscope, first open the files using the Kaleidoscope converter window. The results table must NOT be open to use this method.

To open a file using the Kaleidoscope converter window, go to “File” and “Open...”.

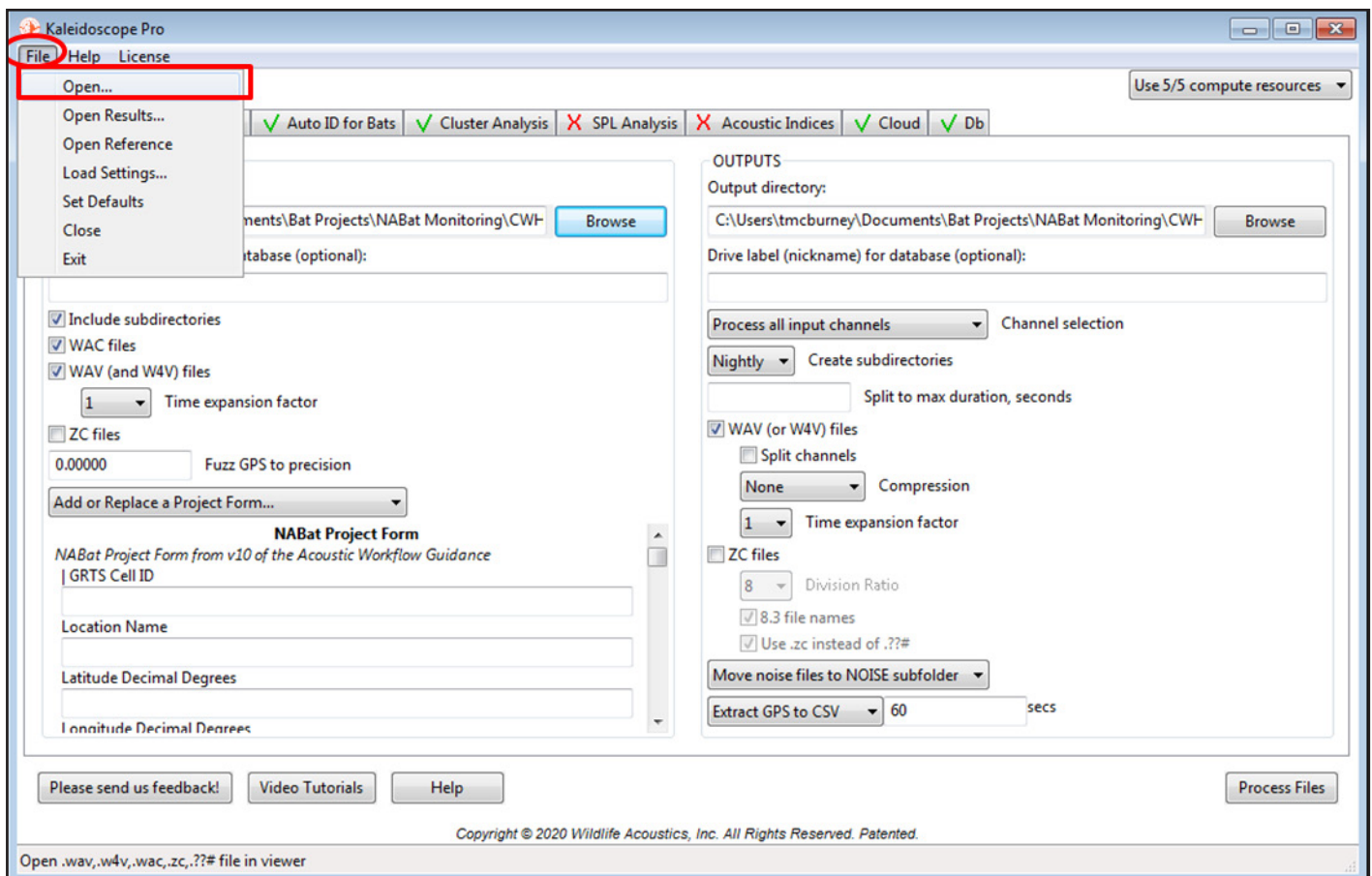


Figure 180. To open a file using the Kaleidoscope converter window, go to “File” and “Open...”.



Select the first file of the desired monitoring night within the stationary point survey site subfolder from within the Processed Data subfolder. This should open the first file within the Kaleidoscope viewer window. To switch between monitoring night folders within a stationary point survey site, use the double line arrow button in Kaleidoscope.

*Note: Do NOT select the “Process Files” button or all of the data that have already been processed will be overwritten and all of the information will have to be re-entered in the metadata form.

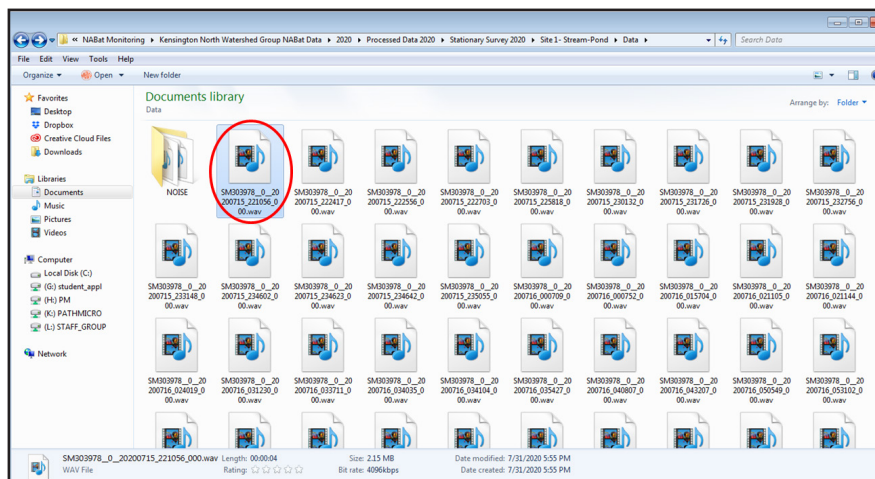


Figure 181. Select the first file of the desired stationary point survey site subfolder.

The next task will be to create manual ID labels. To create a manual ID label, right click one of the grey boxes at the bottom of the screen, so that it is highlighted in white.

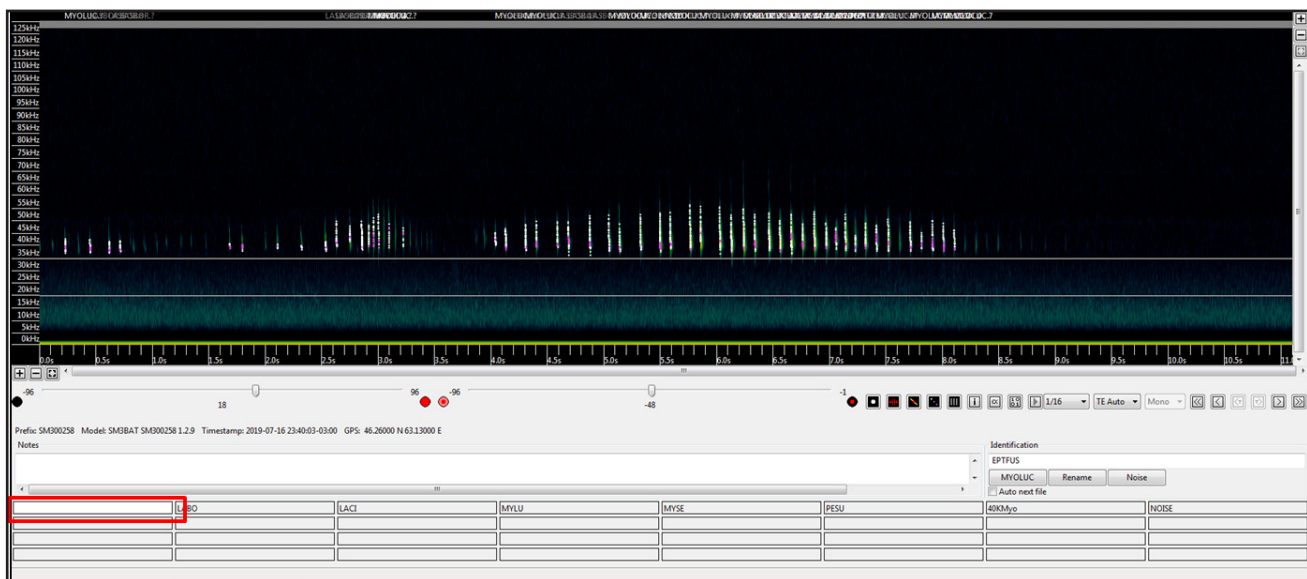


Figure 182. To create a manual ID label, right click one of the grey boxes at the bottom of the screen.



Type the desired label into the box. Do this for all necessary species labels in the region using the four-letter NABat species codes and codes for common groupings (see *Table 6 and 11*). Now that the ID labels have been created, everything has been set up to start manually identifying the acoustic files.

*Note: These manual ID labels will remain in the Kaleidoscope viewer for future use, unless they are changed or deleted.

EPFU	LABO	LACI	MYLU	MYSE	PESU	40KMyo	NOISE

Figure 183. Type the desired label into the box.

As the files are analysed, click on the label that appropriately describes the file and hit the enter button on the keyboard. If the file has multiple bat passes, select the correct label for one of the sequences and go to *Section 4.7.3.14* for more information. The selected manual ID label should be seen in the white “Identification” field in the bottom right of the viewer window. For efficiency, the “Auto next file” box underneath “Identification” can be selected. If this box is selected, once the desired species/grouping label has been pressed, Kaleidoscope will automatically add the chosen ID label to the “Identification” field and move to the next acoustic file in that folder. Proceed until all files within the folder have been manually identified.



Figure 184. For efficiency, the “Auto next file” box underneath “Identification” can be selected.



*Note: It is also important to manually identify the files Kaleidoscope screens as NOISE. If Kaleidoscope created a “NOISE” subfolder for each monitoring night, open the first file within the “NOISE” subfolders by double-clicking on the file and manually identify the files as described above.

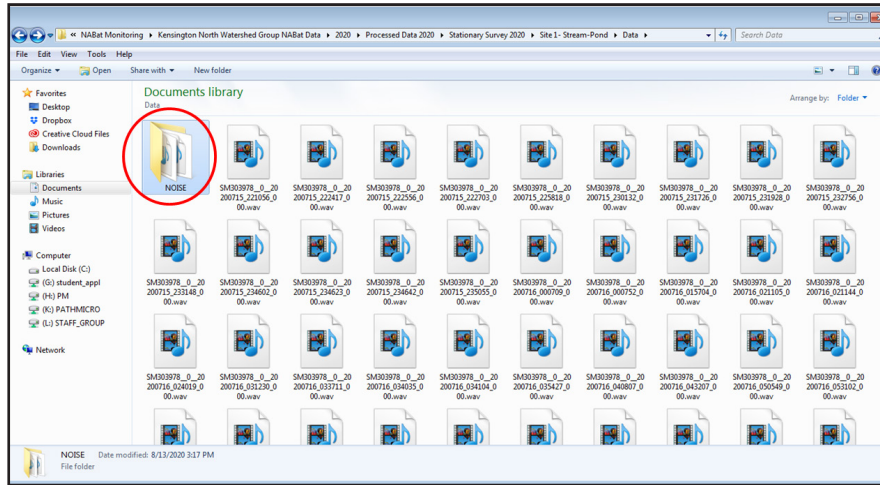


Figure 185. It is also important to manually identify the files Kaleidoscope screens as NOISE.

If this method is used, the “Manual ID” column should be automatically populated when the metadata file is created (see Section 4.8.1 Step 7). However, the “Manual ID” column in the meta.csv will NOT automatically populate. To fill in the column in the meta.csv spreadsheet, the manual IDs can be copied from the metadata file once it is created and added manually to the meta.csv. If data are transferred from one spreadsheet to another, it is crucial that both spreadsheets are sorted the same way to prevent mislabelling of files.

AUTO ID*	PULSES	MATCHIN*	MATCH R*	MARGIN	ALTERNAT*	ALTERNAT N	Fc	Sc	Dur	Fmax	Fmin	Fmean	TBC	Fk	Tk	S1	Tc	Qual	FILES	MANUAL ID	GID	USE
2	NoID	11	0	0	0		11	39.966	-0.25	58.189	40.73	39.236	39.998	489.29	39.965	12.713	-9.35	43.498	13.39	40KMYC		
3	NoID	5	0	0	0	MYOLUC LASBOR	5	45.079	129.8	2.534	55.512	42.224	47.691	538.44	50.465	0.688	318.67	1.909	1.86	1		
4	MYOLUC	16	12	0.75	0.318302	LASBOR PERSUB	16	43.21	87.56	3.74	58.491	41.161	47.516	160.59	48.837	1.652	418.49	3.338	2.52	1		
5	MYOLUC	35	23	0.657	0.140781	MYOSEP LASBOR	35	42.978	158.4	3.077	61.605	37.374	47.111	128.39	49.943	0.974	475.62	2.261	9.47	1		
6	MYOLUC	20	11	0.55	0.184712	MYOSEP LASBOR	20	38.63	83.68	3.345	52.208	36.812	42.583	164.341	41.484	1.798	318.9	2.924	3.76	1		
7	MYOLUC	28	24	0.857	0.300425	LASBOR PERSUB	28	38.082	57.9	4.437	51.387	36.859	41.939	170.255	40.745	2.385	291.34	3.962	5.3	1		
8	MYOLUC	25	18	0.72	0.29775	LASBOR	25	38.631	62.9	4.783	53.019	36.574	42.643	200.984	41.386	2.532	219.79	4.156	5.46	1		
9	MYOLUC	9	6	0.667	0.221883	LASBOR MYOSEP	9	38.901	76.91	3.924	51.855	36.912	42.57	229.304	41.866	2.02	377.76	3.35	2.17	1		
10	MYOLUC	22	18	0.818	0.289946	LASBOR	22	38.545	69.39	4.846	55.452	36.142	43.087	141.052	41.756	2.486	340.65	4.161	4.04	1		
11	MYOLUC	20	17	0.85	0.366944	LASBOR PERSUB	20	38.771	63.99	3.858	49.792	38.15	42.432	133.881	41.39	2.175	279.24	3.564	3.31	1		
12	MYOLUC	12	9	0.75	0.280812	LASBOR MYOSEP	12	39.507	85.99	3.206	49.578	38.038	42.711	128.839	43.127	1.421	264.97	2.846	2.14	1		
13	MYOLUC	30	24	0.8	0.30732	LASBOR MYOSEP	30	38.222	72.21	5.031	57.266	36.463	43.91	135.595	41.269	3.132	374.3	4.629	6.12	1		
14	MYOLUC	26	22	0.846	0.319296	LASBOR	26	39.276	66.29	4.2	52.103	37.73	43.012	134.144	41.927	2.311	304.68	3.707	4.37	1		
15	MYOLUC	38	30	0.789	0.306426	LASBOR MYOSEP	38	39.07	86.57	4.4	58.227	36.862	44.758	123.075	42.634	2.463	391.43	3.884	8.04	1		
16	MYOLUC	26	24	0.923	0.376821	MYOSEP LASBOR	26	39.926	114.05	4.27	63.932	37.862	46.62	102.88	44.33	2.489	542.12	3.878	5.31	1		
17	MYOLUC	31	26	0.839	0.311206	MYOSEP PERSUB	31	41.694	71.52	4.21	56.903	40.039	45.996	152.107	45.596	2.041	318.72	3.748	7.06	1		
18	NoID	31	0	0	0		31	42.939	98.63	3.54	59.295	41.052	47.715	121.72	48.072	1.519	426.25	3.14	6.85	1		
19	MYOLUC	20	16	0.8	0.290615	LASBOR PERSUB	20	41.559	73.88	3.869	56.996	39.957	46.161	137.115	45.054	2.07	374.64	3.468	3.84	1		
20	MYOLUC	14	11	0.786	0.226219	LASBOR	14	41.407	105.24	3.489	56.243	38.468	45.716	127.302	47.434	1.217	436.26	3.029	2.89	1		
21	NoID	34	0	0	0		34	42.019	94.51	3.951	57.51	40.525	46.744	139.503	47.257	1.732	318.97	3.558	7.61	1		
22	MYOLUC	33	23	0.697	0.348932	LASBOR PERSUB	33	41.823	69.78	4.355	56.783	40.246	46.237	113.571	46.586	1.888	313.65	3.903	5.94	1		
23	NoID	12	0	0	0		12	42.511	73.66	3.89	53.84	41.102	46.045	123.831	47.344	1.415	278.82	3.451	2.25	1		
24	MYOLUC	30	30	1	0.432676	LASBOR PERSUB	30	40.135	84.2	4.763	61.789	38.427	46.601	111.424	44.463	2.802	414.76	4.318	6.64	1		

Figure 186. The “Manual ID” column in the meta.csv will NOT automatically populate.



Both spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar (under the “Home” tab) and selecting “Custom Sort”.

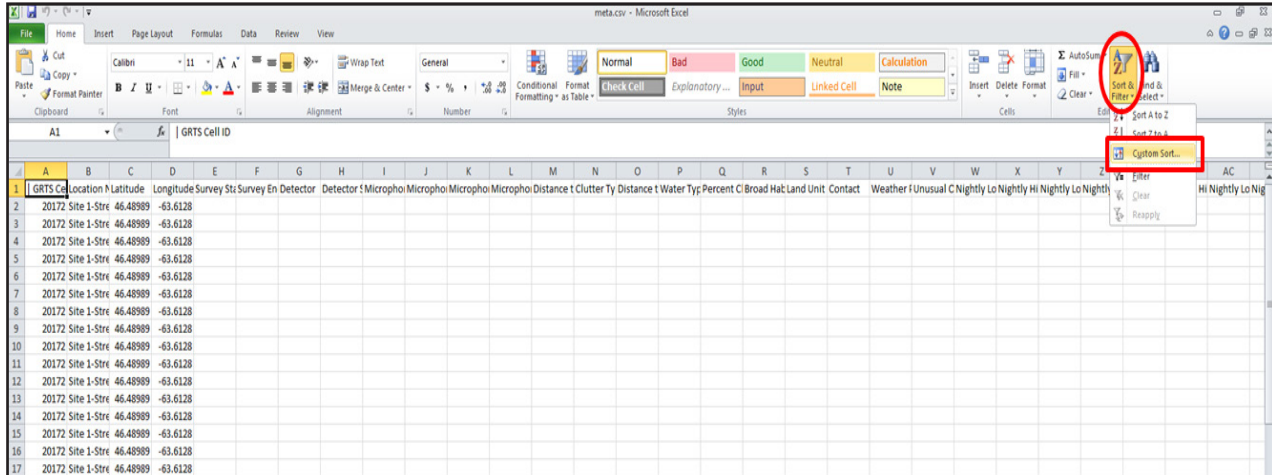


Figure 187. The spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar.

In the “Column” “Sort by” field select “Audio Recording Name (*wav *zc)” from the drop-down list, in the “Sort On” field select “Values”, and in the “Order” field select “A to Z”, and then click “OK”. This should sort the rows in the meta.csv spreadsheet to match the rows in the metadata file; however, this should be verified to prevent mislabelling of files. Once both spreadsheets are identically sorted, copy the “Manual ID” column from the metadata.csv and paste it in the appropriate section of the “Manual ID” column in the meta.csv.

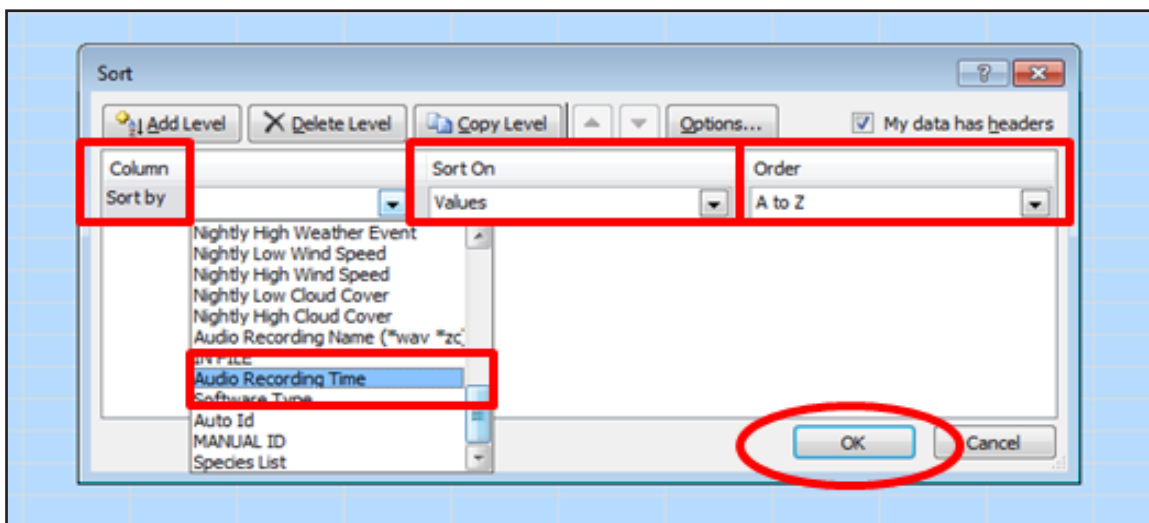


Figure 188. In the “Column” “Sort by” field select “Audio Recording Name (*wav *zc)” from the drop-down list.



4.6.2 Kaleidoscope Pro Version

This method requires the pro version of Kaleidoscope software. To manually identify files in Kaleidoscope, first open the files using the Kaleidoscope converter window. The results table must be open to use this method.

If the Pro Version of the Kaleidoscope software is used for data processing, once processing has completed, the first file should open automatically. If the window has already been closed (*i.e.*, if files were processed from multiple sites or surveys at one time), follow the steps below:

To open a file using the Kaleidoscope converter window, under INPUTS “Input directory:” click on the “Browse” button, and select the file folder of the desired stationary point survey site from within the Raw Data subfolder.

*Note: If the SM4 detector created a “Data” subfolder, it may be necessary to select the “Data” subfolder from within the folder of the desired site.

Under OUTPUTS “Output directory:” click on the “Browse” button, and select the matching file folder for the stationary point survey site within the Processed Data subfolder.

*Note: If Kaleidoscope created a “NOISE” subfolder, select the “NOISE” subfolder from within the folder of the desired site. If there is no “NOISE” folder, but the SM4 detector created a “Data” subfolder, select the “Data” subfolder from within the folder of the desired site.

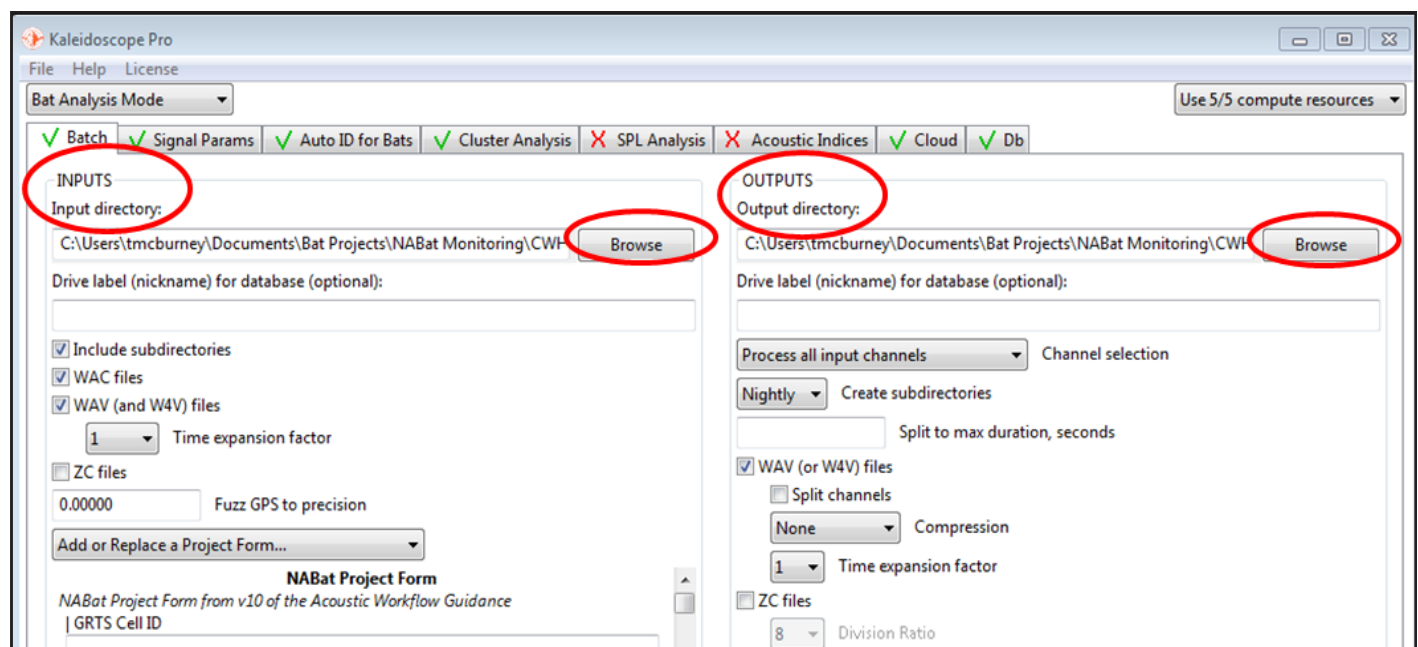


Figure 189. Select file folders for “Input directory” and “Output directory”.



Once the INPUTS and OUTPUTS have been selected, go to “File” and “Open results” at the top of the Kaleidoscope converter window. Select the id.csv file from the desired site and select “Open”.

*Note: If the chosen OUTPUTS is the “Data” subfolder, it may be necessary to go back a folder to find the appropriate id.csv file.

*Note: Do NOT select the “Process Files” button or all of the data that have already been processed will be overwritten and all of the information will have to be re-entered in the metadata form.

This will open the first file in the Kaleidoscope viewer window. It should also automatically open the results table.

*Note: If an error window pops up with “Unable to find either the output file or the input file”, select “Browse Output (local)” and manually select the desired first file within the Raw Data subfolder (this should be the first file listed in the results table that automatically opened). Then select “Browse Input (local)” and manually select the matching file within the Processed Data subfolder. Once “Open” is selected, this should automatically open the desired file in the Kaleidoscope viewer window and the results table should also still be open.

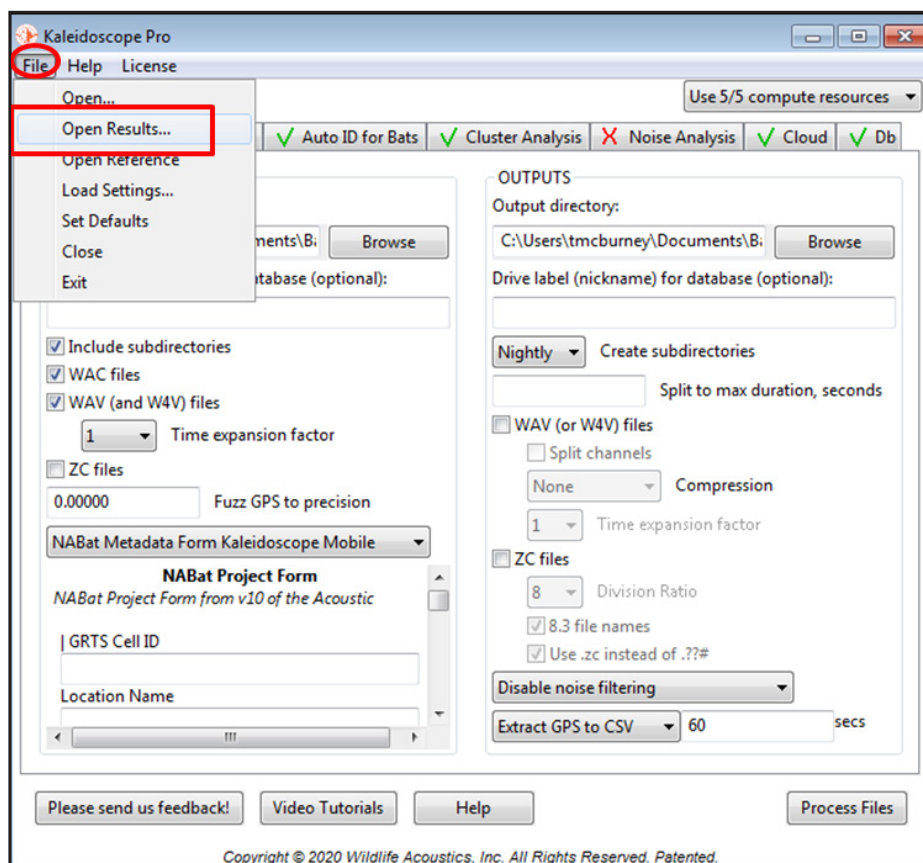


Figure 190. Go to “File” and “Open results” at the top of the Kaleidoscope converter window.



The results table can have a variety of columns, but for manual ID purposes, it is necessary to have the file name under “IN FILE” (this should show up automatically) and a “MANUAL ID” column.

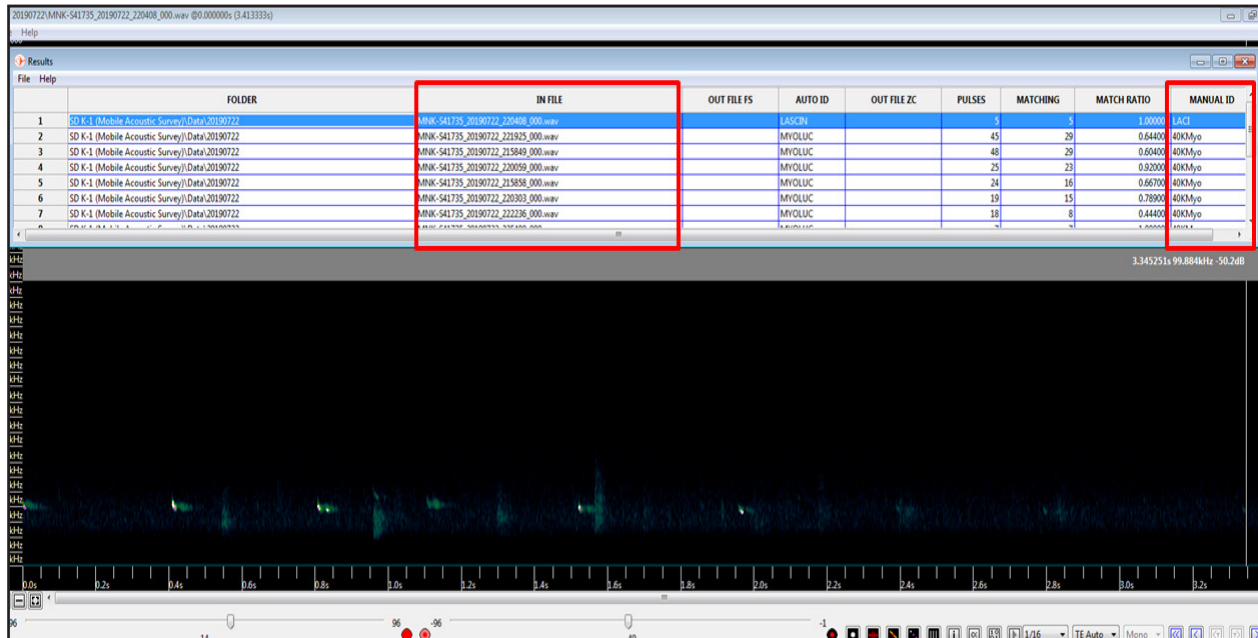


Figure 191. It is necessary to have the file name under “IN FILE” and a “MANUAL ID” column.

If these columns are not automatically there, in the results table go to “File” and “Edit columns...”.

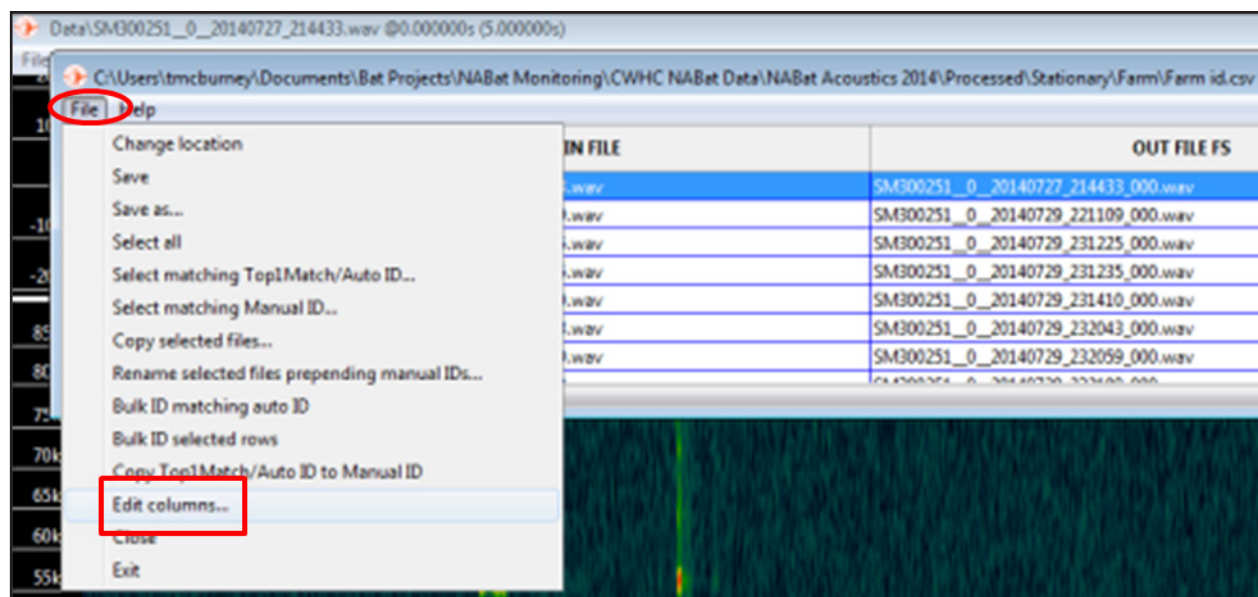


Figure 192. In the results table go to “File” and “Edit columns...”.



Select “Show” next to the desired column name. Then click “OK” at the bottom.

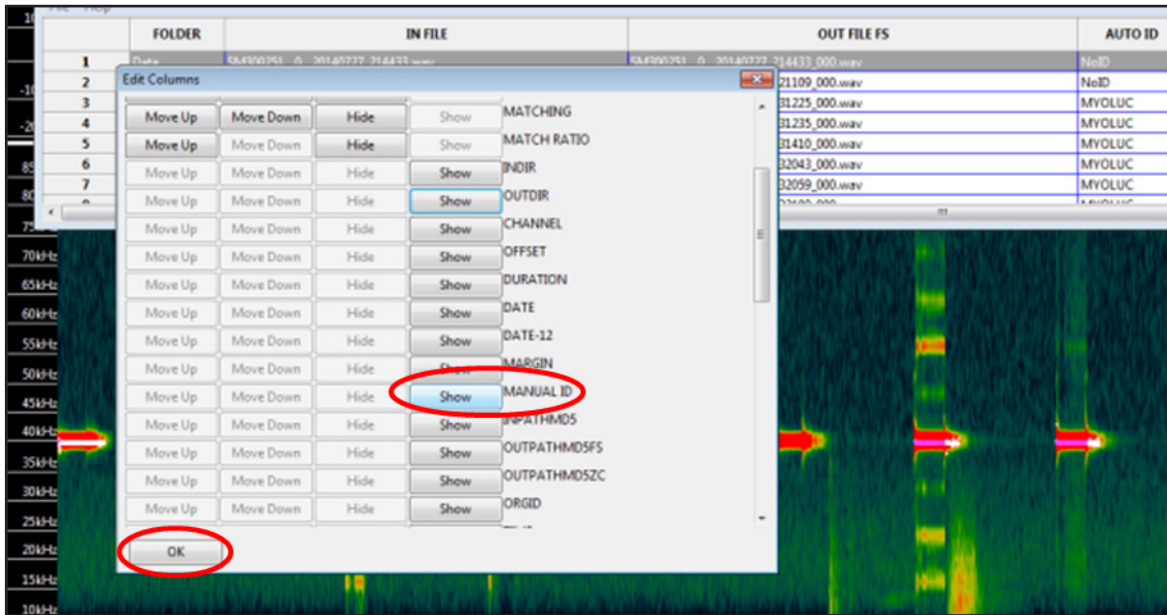


Figure 193. Select “Show” next to the desired column name.

The above instructions will result in the first acoustic file opening in the Kaleidoscope viewer window. The files are sorted the same way they are in the id.csv spreadsheet, by Auto ID label. The next task will be to create manual ID labels. To create a manual ID label, right click one of the grey boxes at the bottom of the screen, so that it is highlighted in white.

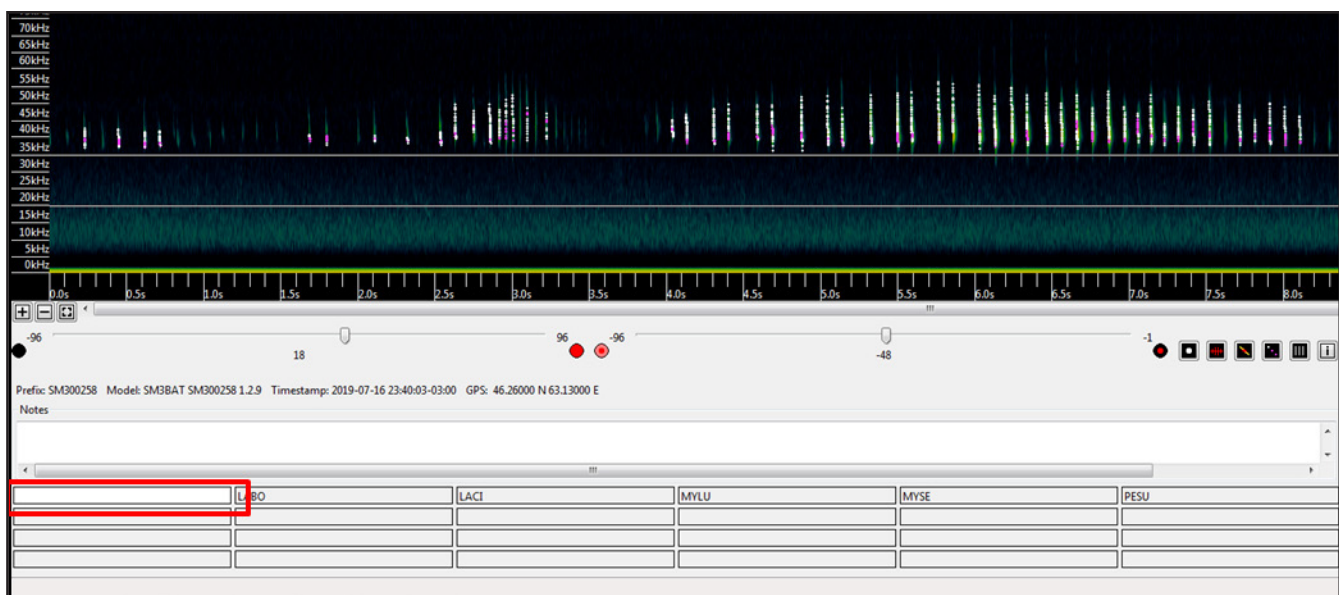


Figure 194. To create a manual ID label, right click one of the grey boxes at the bottom of the screen.



Type the desired label into the box. Do this for all necessary species labels in the region using the four-letter NABat species codes and codes for common groupings (see *Table 6 and 11*). Now that the ID labels have been created, everything has been set up to start manually identifying the acoustic files.

*Note: These manual ID labels will remain in the Kaleidoscope viewer for future use, unless they are changed or deleted.

EPFU	LABO	LACI	MYLU	MYSE	PESU	40KMyo	NOISE

Figure 195. Type the desired label into the box.

As the files are analysed, click on the label that appropriately describes the file and hit the enter button on the keyboard. If the file has multiple bat passes, select the correct label for one of the sequences and go to *Section 4.7.3.14* for more information. The selected manual ID label should now automatically populate the row for that file in the open results table. For efficiency, the “Auto next file” box underneath “Identification” can be selected. If this box is selected, once the desired species/grouping label has been pressed, Kaleidoscope will automatically add the chosen ID label to the results table and move to the next acoustic file in that folder.

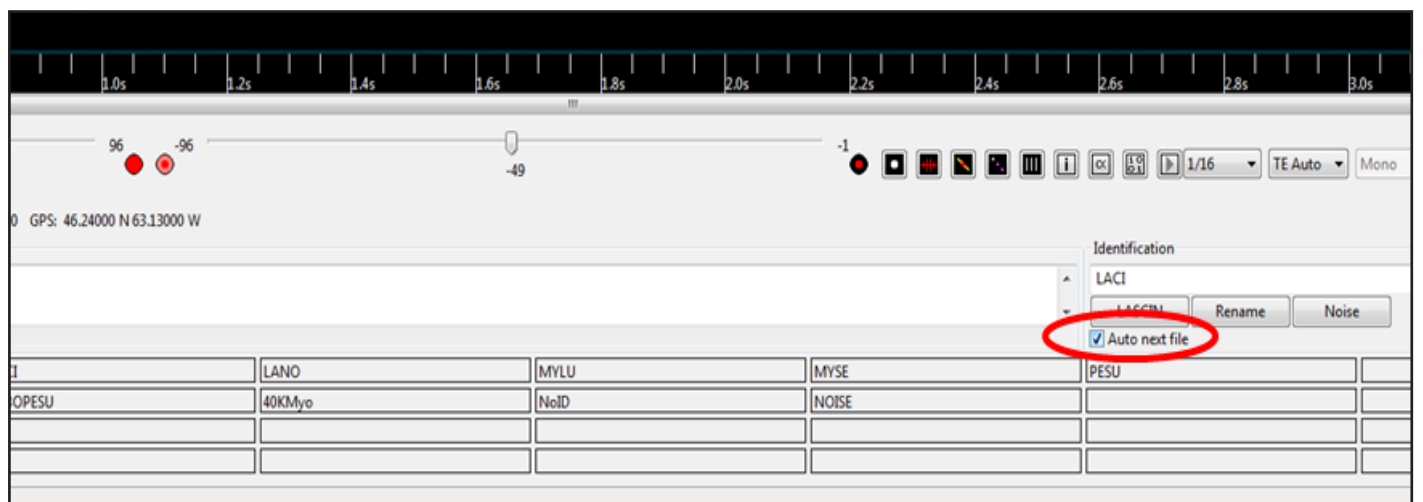


Figure 196. For efficiency, the “Auto next file” box underneath “Identification” can be selected.



To re-open a specific file, simply click on the row of the desired file in the results table.

Once all of the files within a folder have been analysed, SAVE the results table by going to “File” and “Save” in the results spreadsheet. Alternatively, save the results spreadsheet frequently to prevent losing any of the manual IDs.

*Note: If the results table is NOT saved, the “MANUAL ID” column in the id.csv spreadsheet will not automatically populate, and all of the manual IDs will be lost.

*Note: When the results table is saved, it will overwrite any information that has been manually typed into the id.csv spreadsheet. If there is a desire to make notes about the files as they are analysed, create a new spreadsheet or keep the notes in an alternative location.

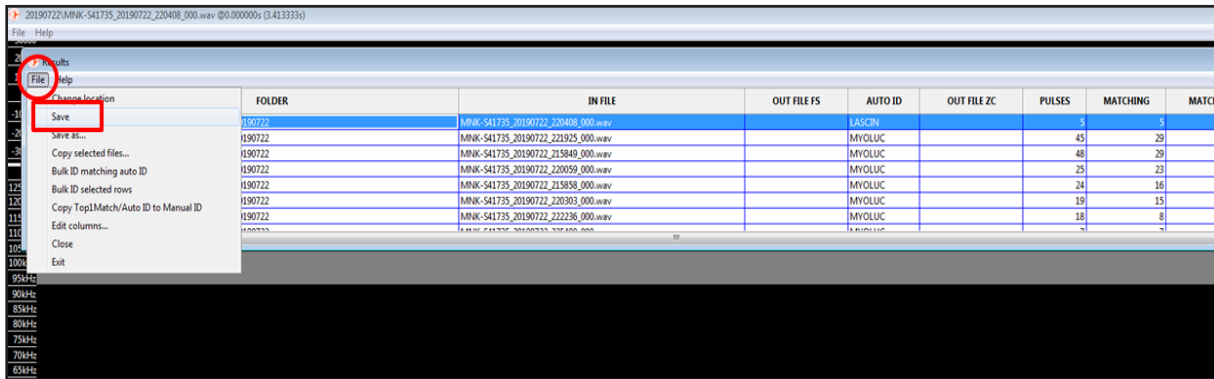


Figure 197. Save the results table by going to “File” and “Save” in the results spreadsheet.

If this method is used, the Manual ID column should be automatically populated when the metadata file is created (see Section 4.8.1 Step 7).

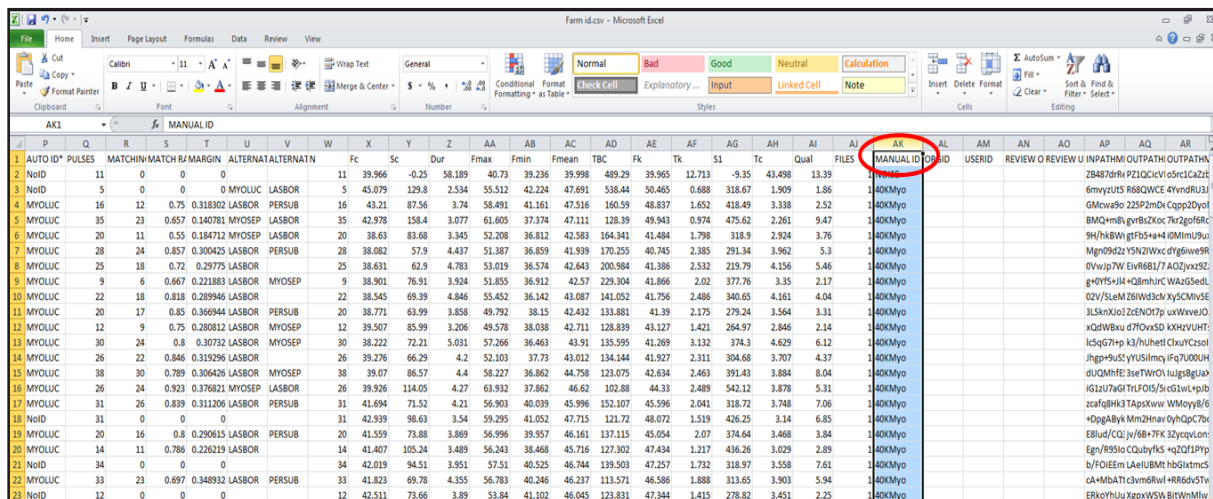


Figure 198. The “Manual ID” column in the metadata file should be automatically populated.



4.7 Spectrogram Analysis

4.7.1 Basic Acoustic Terminology

The following terms are used when reading and interpreting spectrograms. Ensure the terms listed below are understood:

4.7.1.1 Spectrogram Terminology

Spectrogram: an image displaying sound waves

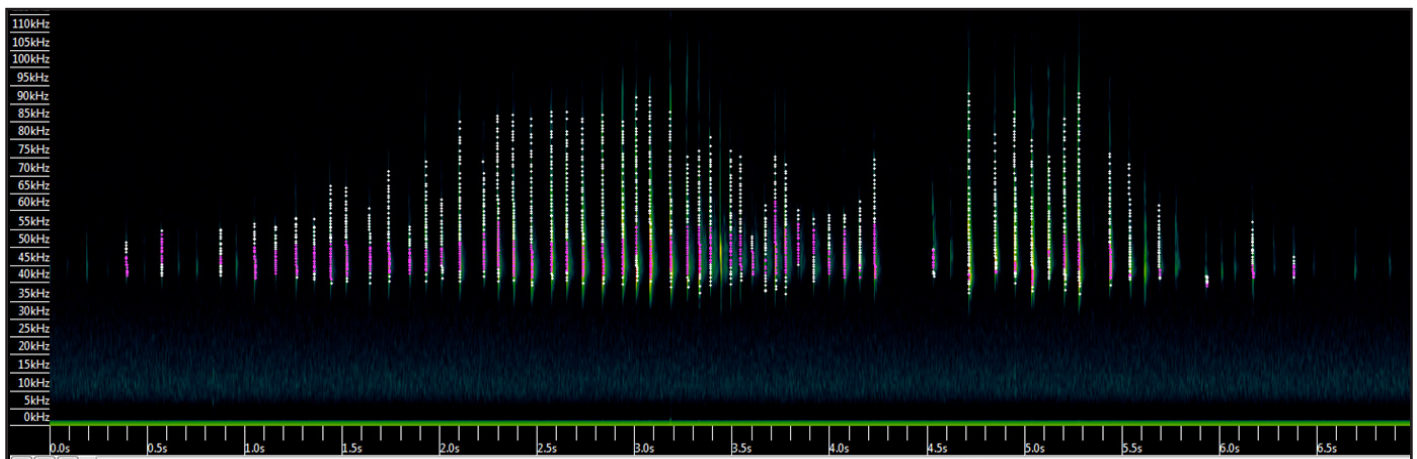


Figure 199. Example spectrogram.

Call/Pulse: each separate line of sound on a spectrogram (usually sweeps from high to low frequency) (23); represents a single echolocation call of a bat

(Call) Sequence: a series of calls/pulses that can be visualised in a spectrogram

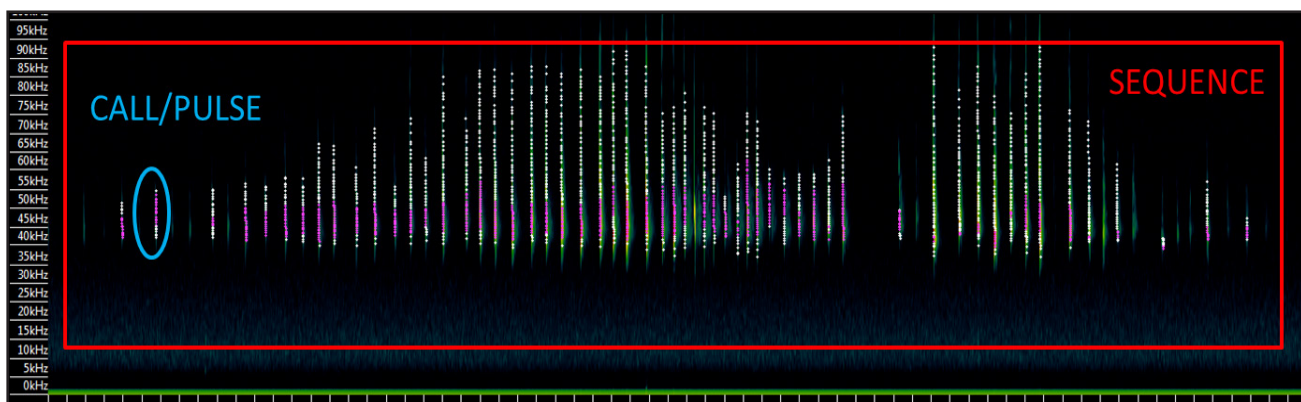


Figure 200. The difference between a call/pulse (blue circle) and a (call) sequence (red square).



Bat pass:

Bat pass is the unit of measurement commonly used when calculating species magnitude of activity (stationary point surveys) or species relative abundance estimates (mobile transects). NABat defines a bat pass as a sequence of calls/pulses that are separated by at least two seconds (23). By having the detector trigger window set to “two seconds” (see *Table 4*), this should ensure that each separate recorded file constitutes a separate bat pass. However, there are several conditions that need to be considered when manually identifying spectrograms, and designating files as bat passes:

1. Sometimes files are of poor quality (depending on recording conditions), and even though the detector made a file, the file quality is not sufficient to be confident in identifying the calls as those of a bat. Thus, in order for a file to be designated as a bat pass; it should have **at least three discernible bat calls/pulses in zero-cross (NOT full spectrum)**.

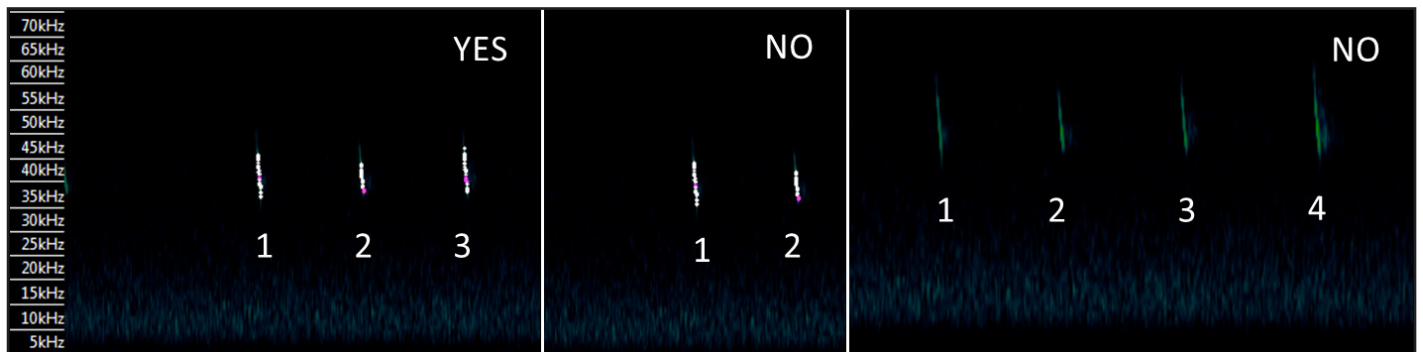


Figure 201. A bat pass; it should have at least three discernible bat calls/pulses in zero-cross, like in the image on the left; the image in the centre and to the right are not bat passes.

2. Sometimes more than one bat is recorded in a single file. There may be identifiably more than one bat of a single species, or multiple bats of multiple species. In these cases, a single file may include more than one bat pass.

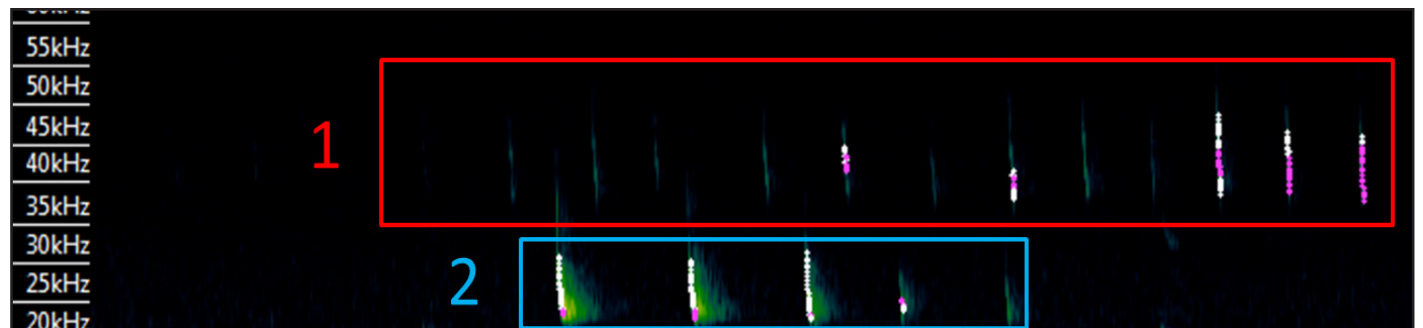


Figure 202. Sometimes more than one bat is recorded in a single file; this image has two bat passes (highlighted in red and blue).



4.7.1.2 Call Morphology Terminology

Call body: the part of call with the lowest slope, the flattest part of call (after the knee)

Knee/Elbow: a bend in the call that is sometimes present, and can be either indistinct (smooth, rounded) or distinct (sharp, angular)

Tail/Toe: a hook on the end of the call that is sometimes present after the **call body**, and can be either upturned or downturned

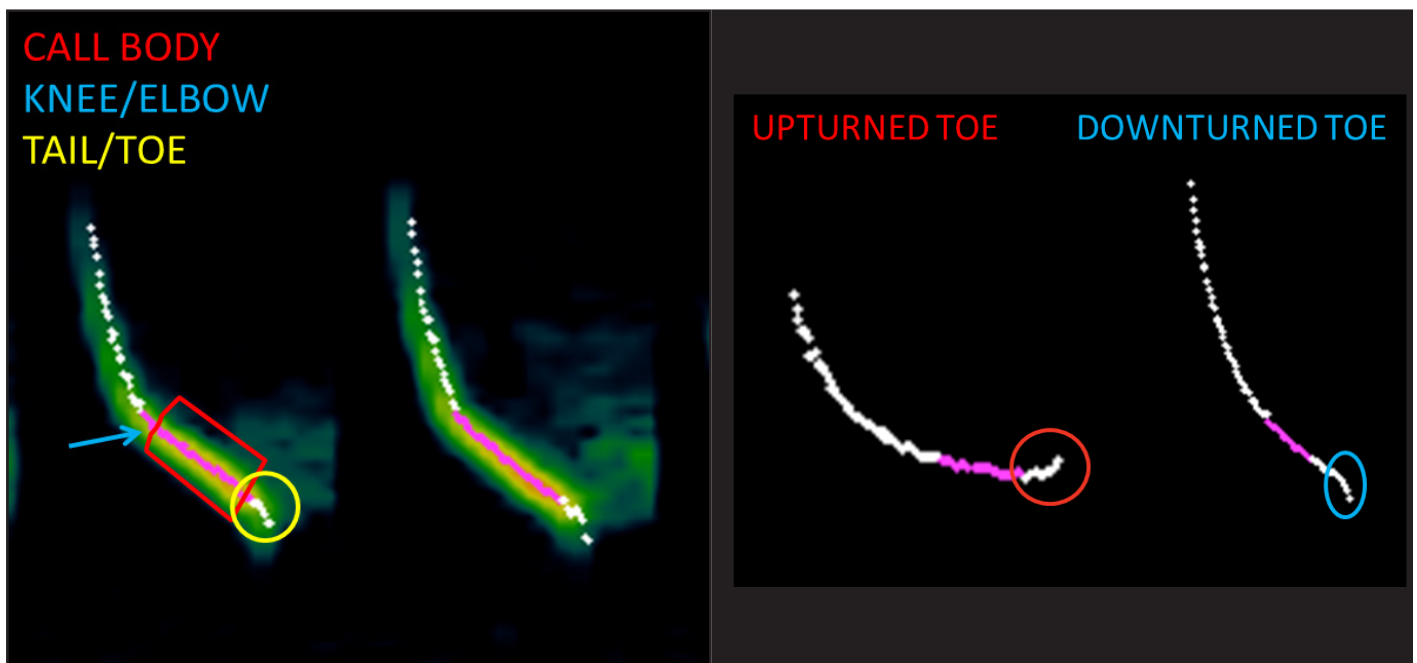


Figure 203. Parts of a call may include: a call body (red), a knee/elbow (blue), and a tail/toe (yellow); a tail/toe can either be upturned (red) or downturned (blue).



4.7.1.3 Frequency Terminology

Characteristic frequency (F_c): the average frequency of the call body (kHz)

Minimum frequency (F_{min}): the lowest frequency of the call (kHz)

Maximum frequency (F_{max}): the highest frequency of the call (kHz)

(not always observable because higher frequency sound waves cannot travel as far in the air)

Knee frequency (F_k): the average frequency of the knee (kHz)

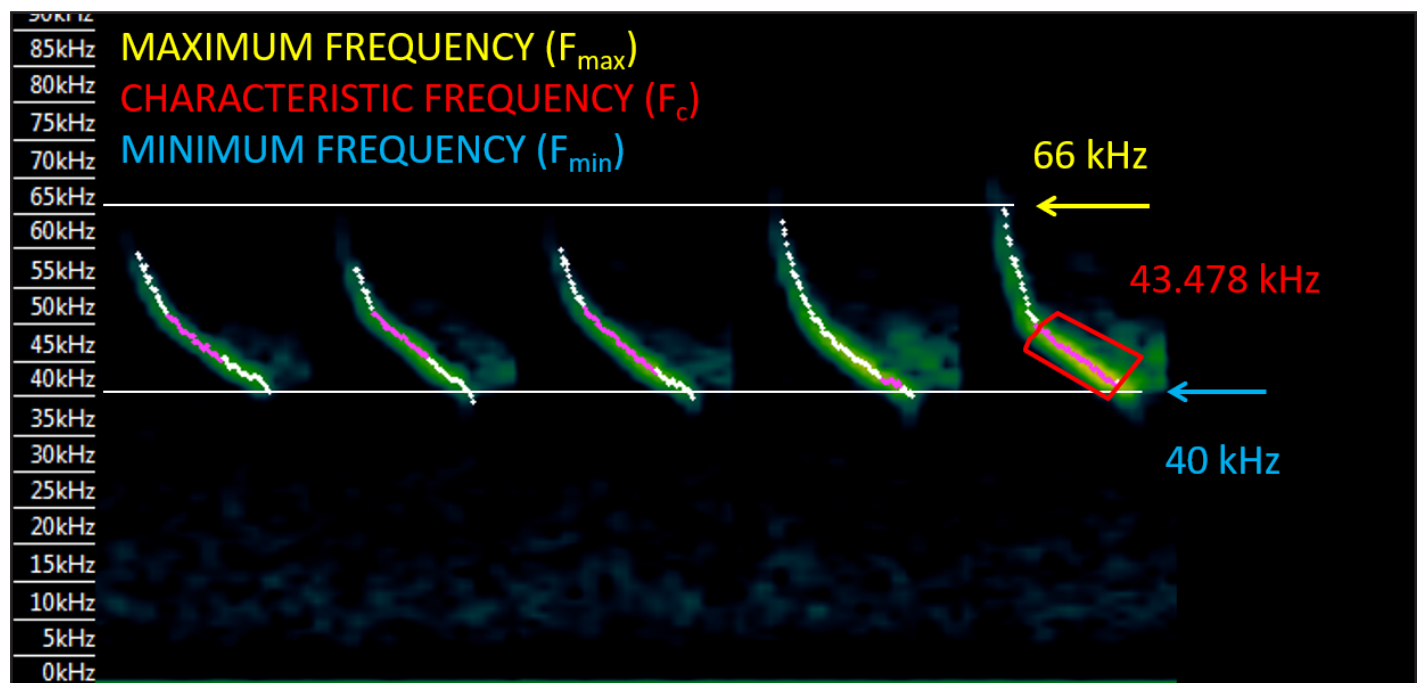


Figure 204. Every call has: a maximum frequency (yellow), a characteristic frequency (red), and a minimum frequency (blue).



4.7.1.4 Slope Terminology

Call body slope (S_c): the slope of the call body (also considered the characteristic slope of the call) (OPS)

If the call is flat, it will have a low S_c (0-1 OPS), if the call is steep, it will have a high S_c (800-1000 OPS).

Initial slope (S_1): the slope of the call above the knee (OPS)

Octaves per second (OPS): unit used to measure call slope

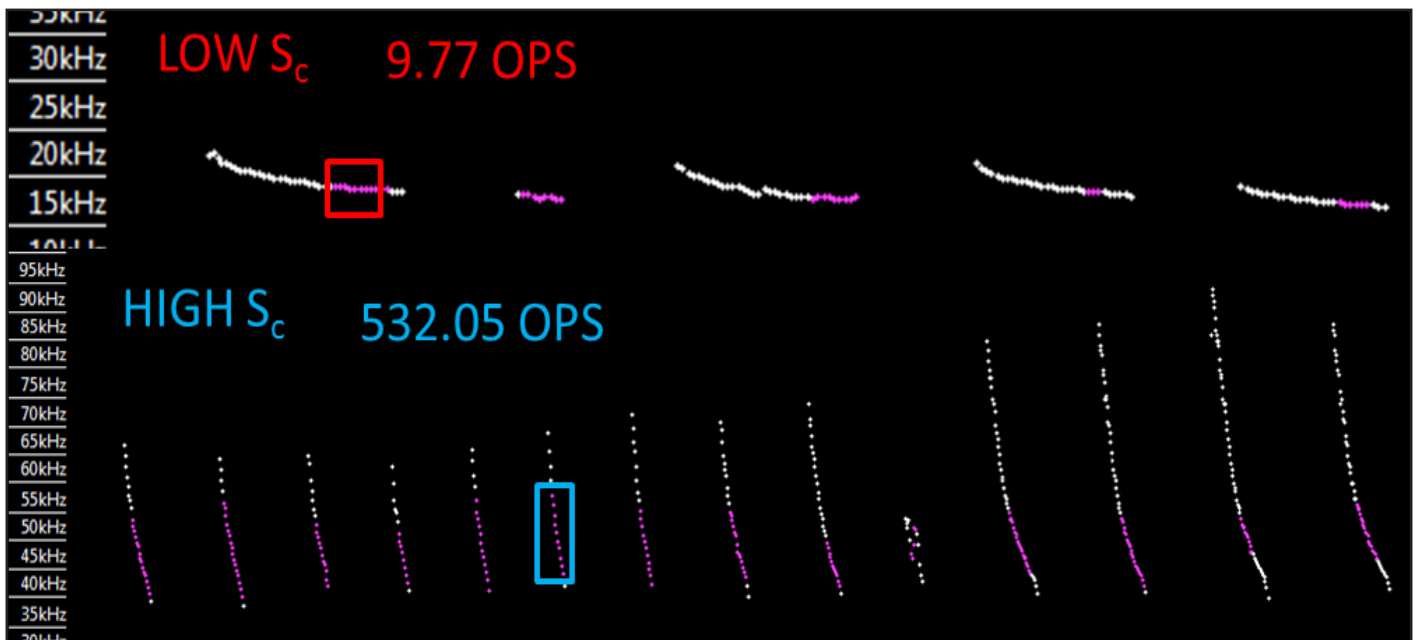


Figure 205. A call can have a low call body slope (red) or a high call body slope (blue).



4.7.1.5 Additional Terminology

Duration (Dur): the length of time of a pulse (ms)

Time between calls (TBC): the length of time between pulses (ms)

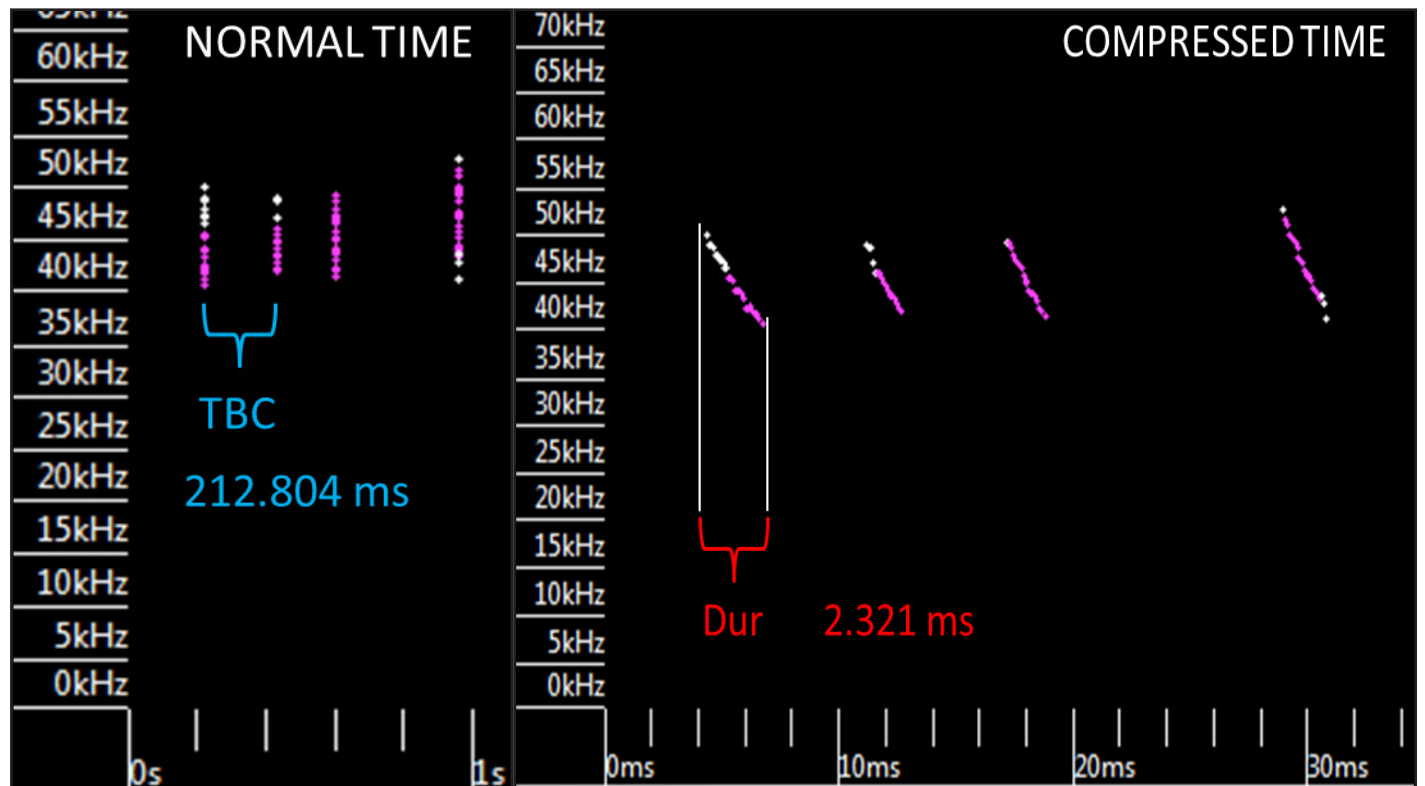


Figure 206. Time between calls (blue) is the length of time between pulses, whereas duration (red), is the length of time of a single pulse.



4.7.2 Echolocation Basics

Bats echolocate by producing pulses of sound (call/pulse). These pulses are separated by periods of quiet (TBC) during which the bat listens for the echoes that allow it to form a mental map of its surroundings. Bats are able to produce both high and low frequency calls. The low frequency calls that humans are capable of hearing are often social calls. The high frequency calls (out of the range of human hearing) may also be social calls, but are more often echolocation calls. Echolocation calls are predominantly used for navigation and foraging. Depending on the habitat that is being sampled, it may be more common to get foraging calls (*e.g.*, wetland habitat) or navigation calls (*e.g.*, commuting corridor). A significant amount of information can be determined from a spectrogram of bat calls. The calls have distinctive characteristics of appearance based on: the species, the habitat in which the call is made, and the purpose of the call (bat behaviour). When examining a spectrogram, knowledge, attention, and care are required for proper interpretation. For bat species ID, echolocation calls are predominantly used, or more specifically, the search phase of the echolocation sequence (see *Section 4.7.2.1.2*).



Photo by Jordi Segers

Figure 207. Calls have distinctive characteristics of appearance based on the species and the purpose of the call.



Photo by Tessa McBurney

Figure 208. Calls have distinctive characteristics of appearance based on the habitat in which the call is made.



4.7.2.1 Bat Behaviour and Echolocation

4.7.2.1.1 Social Calls and Echolocation

As described in *Section 2.2.1*, bats typically use echolocation calls when flying, to help them create an image of their surroundings because they are often moving in darkness. While there is some indication that bats receive information from other bats through echolocation calls, bats primarily communicate through “social calls” (31). These calls are not necessary to create a mental map of their surroundings, and so function very differently from echolocation calls (32). Social calls can be lower in frequency, and humans can hear some of these calls, which sound like a chattering noise. Sometimes calls on a spectrogram may resemble bat echolocation calls, but they may be uncharacteristic in some ways; maybe the frequency is lower than expected, or perhaps the calls jump around in an unusual way. It is possible that these may be social calls, but they are often difficult to properly identify because they do not follow the typical echolocation patterns used to identify bat calls to species. If a social call sequence can be confidently identified as a bat but cannot be identified to species or common grouping, it should be labelled as “NoID”. If there is uncertainty that a recorded sequence represents a bat pass, it is best to identify the file as “NOISE”.

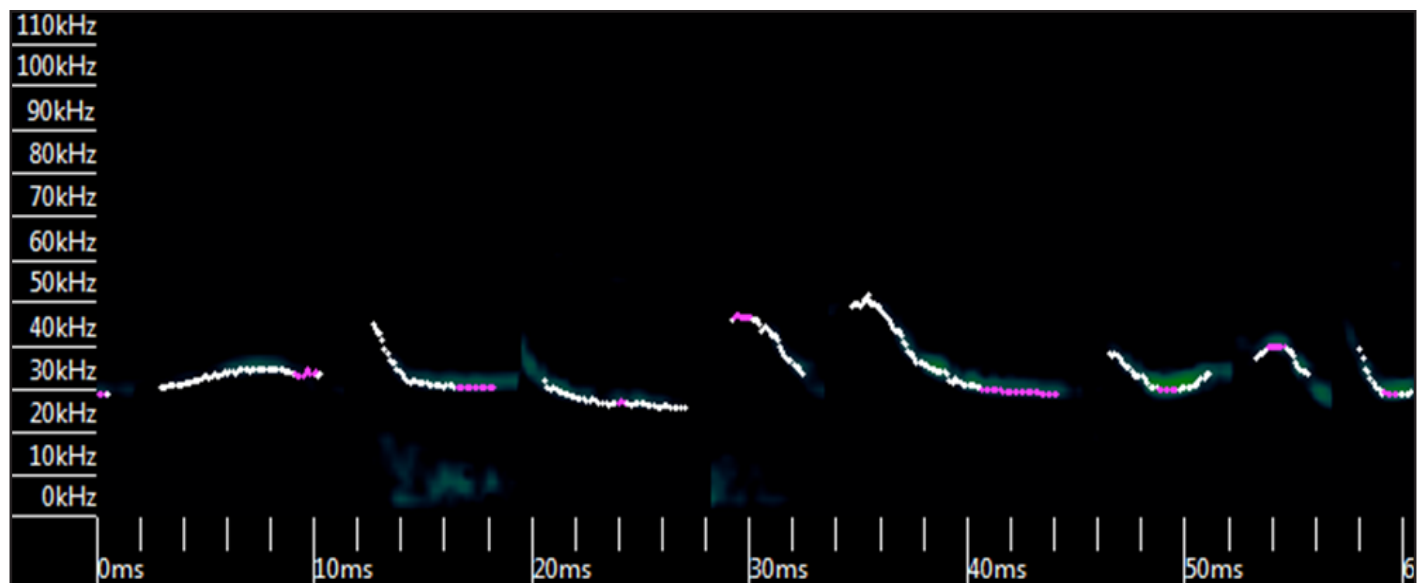


Figure 209. Social calls are often difficult to properly identify because they do not follow the typical echolocation patterns used to identify bat calls to species.



4.7.2.1.2 Echolocation Sequence Phases

There are three typical phases that may be observed in a bat echolocation sequence: the **search phase**, the **approach phase**, and the **terminal phase** (“buzz”). While the three phases tend to follow the same general order (*i.e.*, search, approach, terminal), they are not always sequential depending on the success of the bat, *e.g.*, if there is a failed phase, the bat may return to the previous phase. If the three phases successfully reach their conclusion, the bat may start over again in the first phase (the search phase). Bat calls often look considerably different depending on the phase (33):

1. Search phase*

The search phase is when a bat is flying around sending out echolocation calls to navigate its surroundings or to search for prey. These calls are fairly consistent and evenly spaced, and thus, **the search phase is the best phase to examine when identifying bat calls to species.**

2. Approach phase

The approach phase occurs when a bat has detected echoes reflecting off an object and responds to the object, which may be a surface (*e.g.*, the ground), a tree, another bat, or prey. The bat will approach the object to verify whether or not it is something to eat. These calls will be spaced more closely together (shorter TBC), have a steeper slope (faster change in frequencies) and will sweep through a greater range of frequencies. Approach phase calls may also vary in frequency, often tending toward higher frequencies which allow for better object resolution and distance calculations.

3. Terminal phase (“buzz”)

The terminal phase, also called a “buzz” or “feeding buzz” is made when a bat is sufficiently close to the object of interest and has determined it is prey it will attempt to eat, or water it will attempt to drink (“drinking buzz”). These calls are very close together, usually increase in frequency, and often have a very steep slope. Often the terminal phase is not recorded because it may be of lower amplitude given that the bat is very close to its target at this point in time, or the bat may stop echolocating entirely right before it captures its prey.

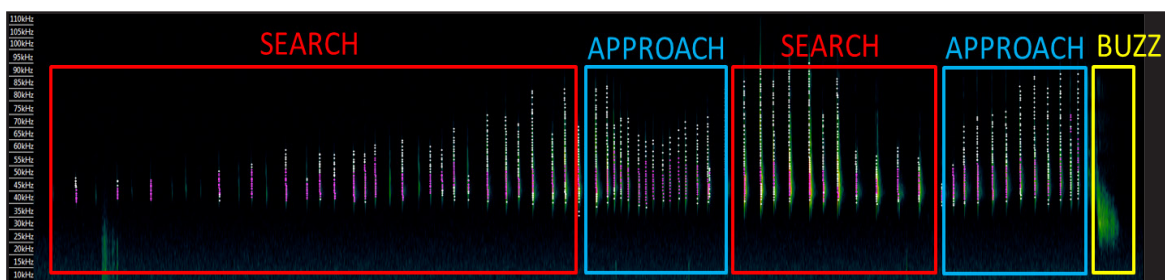


Figure 210. There are three typical phases that may be observed in a bat echolocation sequence: the search phase (red), the approach phase (blue), and the terminal phase (“buzz”) (yellow).



4.7.2.2 Habitat and Echolocation

4.7.2.2.1 Effect of Clutter

The type of habitat a bat is flying in can affect the shape of a call in a variety of ways. The first habitat consideration is the degree of clutter present. Habitat can be categorised as high, moderate, or low clutter. “Clutter” is simply the amount of material in the environment that can reflect back an echolocation call. For example, a high clutter habitat would be a dense forest, where all of the leaves and branches would be considered clutter. A low clutter habitat may be an open field, where nothing is obstructing the flight, or echolocation calls, of the bat. High clutter habitat results in calls that generally have a steeper slope, a shorter **duration**, a higher frequency, and a greater change in frequency (long frequency sweeps). In contrast, a low clutter habitat results in calls with a lower slope, longer duration, lower frequency, and smaller change in frequency (short frequency sweeps). Outside of very specific situations, **it is easier to distinguish between bat species in low clutter habitat because there is generally more species variation in lower clutter calls (33).**

Figure 211. Habitat can be categorised as high (above), moderate (centre), or low clutter* (below).



Bats can also be categorised by the type of habitat they are most likely to occupy. There are bat species found more frequently in high clutter habitats, and these species are often slower when flying, emit more calls closer together (*i.e.*, short TBC), and have calls with a higher frequency, lower amplitude (“whispering bats”), shorter duration, and steeper slope. Bats predominantly found in high clutter habitats fly more slowly because they must navigate through a landscape with a large number of obstacles. The characteristics of their calls relate to maximising the information received from echolocating within a short time frame, *i.e.*, to avoid collisions in the high clutter environment. Their calls are lower in amplitude because the bats are echolocating close to the objects in the environment, and by lowering the amplitude of their calls they can reduce the confusion that comes from excessive reflecting off of these objectives. The northern myotis is an example of a species that predominantly occupies high clutter habitat. In contrast, bat species more frequently found in low clutter habitats are generally fast fliers and not as maneuverable. These species emit calls spread further apart (*i.e.*, long TBC) and their calls have the following characteristics: lower frequency, higher amplitude, longer duration, and lower slope (*i.e.*, flat calls). Bat species found mainly in low clutter habitats are often faster when flying because they are flying in the open, which allows them to fly faster without the danger of collision with objects in the environment. These bat species also use echolocation calls that are higher in amplitude to compensate for the potentially long distance their calls may have to travel before reflecting off of an object. Migratory bats, such as hoary bats, are typically found in low clutter environments (33).



Figure 212. Bat species can also be categorised by the type of habitat they are most likely to occupy; the northern myotis (left) is a high clutter bat species and the hoary bat (right) is a low clutter bat species.



4.7.2.2.2 Effect of Reflection

There are two types of reflections that can be recorded in addition to a bat pulse: **specular echoes** and **diffuse echoes**.

Specular echoes are those that are reflected off a smooth surface, such as water or a rock. Specular echoes appear on a spectrogram as a second bat call that immediately follows the original bat call. The two calls are often almost identical in appearance, but sometimes the second call can be slightly shorter. It is important to check the calls in both normal time view and compressed time view, because if the calls are only examined in compressed time view, a specular echo can sometimes be interpreted as a file with two bat sequences. However, when examined in normal time view, it will be apparent that the second call immediately follows the first call and it is a reflection, rather than the call of a second bat (33).

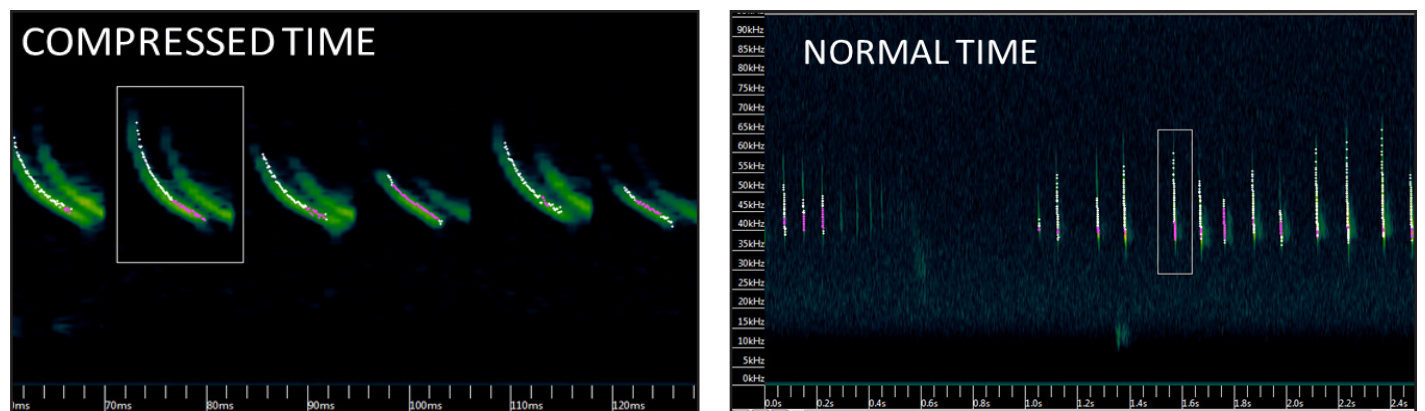


Figure 213. Example of specular echoes in compressed time (left) and real time (right).

A diffuse echo is reflected off a rough surface, such as a tree. Rather than resembling the appearance of a second bat call, the reflected sound is scattered, and appears as unspecific noise following the original bat call on the spectrogram (33).

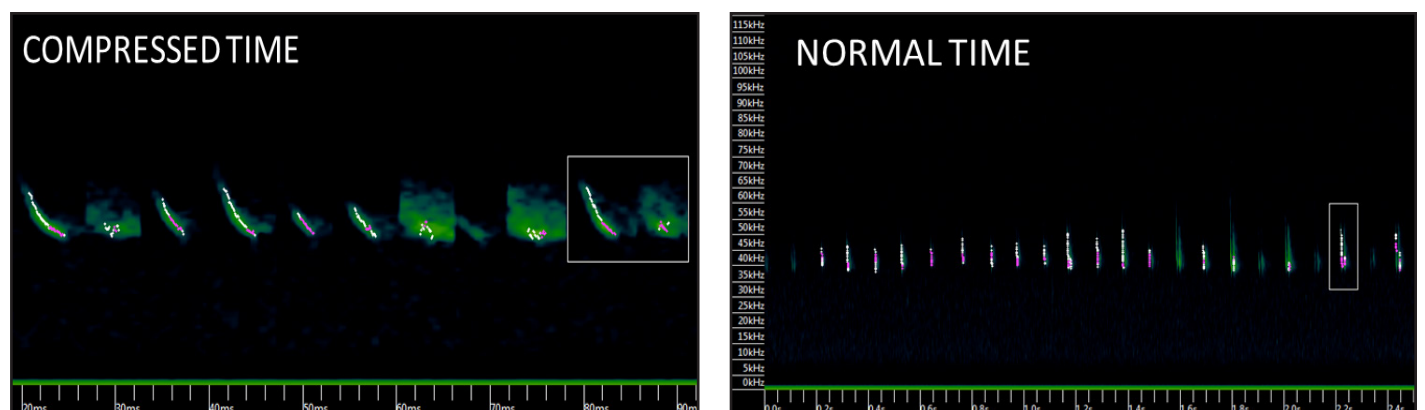


Figure 214. Example of diffuse echoes in compressed time (left) and real time (right).



4.7.2.3 Harmonics and Echolocation

Harmonics also should be considered when analysing spectrograms. Harmonics are sounds where the frequency will change by a certain number of steps. An example of harmonics is octaves in music, where each octave is a different harmonic level. The first harmonic, also called the fundamental harmonic, is the harmonic with the lowest frequency. The second harmonic is two times the frequency of the first harmonic. The third harmonic is three times the frequency of the first harmonic, and so on. For example, if the fundamental harmonic is 25 kHz, the second harmonic is 50 kHz and the third harmonic is 75 kHz. The harmonic with the most energy (*i.e.*, highest amplitude) is called the dominant harmonic, and this is usually the fundamental harmonic. When examining spectrograms, a second line or even third line of calls may be observed directly above calls made at a lower frequency. If the higher lines of calls are located directly above the lowest line of calls, and are at even intervals (*i.e.*, at two and three times the F_{min} of the lowest line of calls), then this may be indicative of harmonics produced by an individual bat rather than the calls of two or three separate bats. Harmonics are almost exclusively identified in full spectrum analysis (versus zero-cross). The calls of the harmonics should be perfectly aligned above each other when analysing calls in normal time view (33).



Figure 215. Example of harmonics at 25-50 kHz in compressed time (above) and normal time (below).



4.7.3 Bat Species Identification

As mentioned in *Section 1.3*, there are seven bat species that have been documented across Atlantic Canada (please refer to *Table 1* to determine which bat species have been detected in the province being monitored). For the purposes of acoustic analysis, bats in Atlantic Canada can be placed into two general categories: high frequency bat species ($F_c \geq 35$ kHz) and low frequency bat species (F_c 15-30 kHz). Low frequency bat species include: the hoary bat, the silver-haired bat, and the big brown bat. High frequency bat species include: the little brown myotis, the northern myotis, the tri-colored bat, and the eastern red bat.

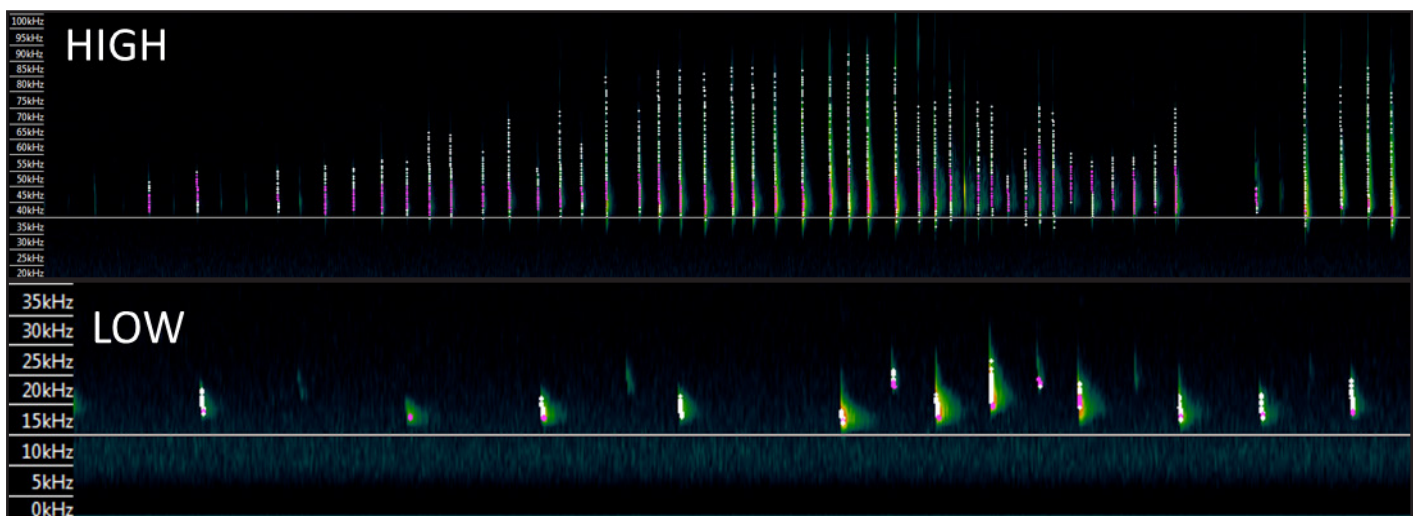


Figure 216. Bats in Atlantic Canada can be placed into two general categories: high frequency bat species ($F_c \geq 35$ kHz) (above) and low frequency bat species (F_c 15-30 kHz) (below).

When analysing spectrograms, it is recommended that each file is viewed initially in normal time view. This will show whether the file has one or multiple bat passes. Remember that compressed time view removes the TBC so that more pulses can be viewed on a single screen for analysis. Without being able to examine the TBC, it can be difficult to determine the true pattern of the sequence (*e.g.*, if there is more than one bat, or if the bat is in the approach or terminal phase of the echolocation sequence). After viewing the file in normal time view, the file should be viewed in compressed time view, which allows each pulse to be viewed in more detail, which is imperative for species ID. In compressed time view the viewer display will show grey where there are no pulses strong for zero-cross analysis. While normal time view will show all of the information that was recorded, compressed time view only shows the signals that are stronger than the ambient noise (*i.e.*, zero-cross audio files). The zero-cross signals that show up in compressed time view are the only ones that can be analysed by the program (*e.g.*, for measurements, calculations, auto ID, etc.).

*Note: When identifying bat call sequences, **remember to use call sequences recorded in low clutter habitat and to primarily look at the search phase of the echolocation sequence.** There is only one situation where it may be appropriate to use high clutter habitat to identify bat species, specifically the northern myotis (see *Section 4.7.3.9*).



4.7.3.1 Strengths and Limitations of Acoustic Identification of Species

While analysing acoustic recordings of bat echolocation calls provides a valuable opportunity to gain insight into species presence and magnitude of activity, the limitations of this technique of species ID should be considered. Additionally, a conservative approach should be applied to species ID because it reduces the potential for confusing results, especially in relation to data on the presence of species. Some species, like the hoary bat, have highly characteristic echolocation calls that are relatively easily recognised and distinguished from other species, especially in Atlantic Canada. However, species more closely related to each other, such as the little brown myotis and northern myotis, sometimes have incredibly similar echolocation call characteristics that make it challenging to reliably separate these species for ID purposes. Furthermore, even some species that are not closely related to one another have significantly overlapping echolocation call characteristics (*e.g.*, the big brown bat and the silver-haired bat), resulting in only being able to confidently identify call sequences to species in very specific circumstances. If not confident in identifying a bat to a particular species, it is preferable to be conservative and assign that particular bat sequence to the appropriate common grouping (described in *Table 11*).



Figure 217. Some bat species that are not closely related to one another have significantly overlapping echolocation call characteristics, such as the big brown bat (left) and the silver-haired bat (right).



4.7.3.2 Little Brown Myotis (*Myotis lucifugus*) (MYLU)

The little brown myotis is typically described as a “40 kHz *Myotis*”, which simply means that it is a *Myotis* spp. with a standard call F_c of 35-40 kHz. There are several *Myotis* spp. that have this distinguishing call characteristic. Depending on the habitat, little brown myotis can actually echolocate as low as 30 kHz, but this would be in low clutter, or open, environments. In high clutter habitat, the F_{max} of the little brown myotis can go as high as 100-110 kHz. The little brown myotis pulse has a distinctive **knee** that results in the calls having a curved appearance (6, 33, 34).

Typical F_c : 35-40 kHz

Similar species: Northern myotis

Eastern red bat

Tri-colored bat

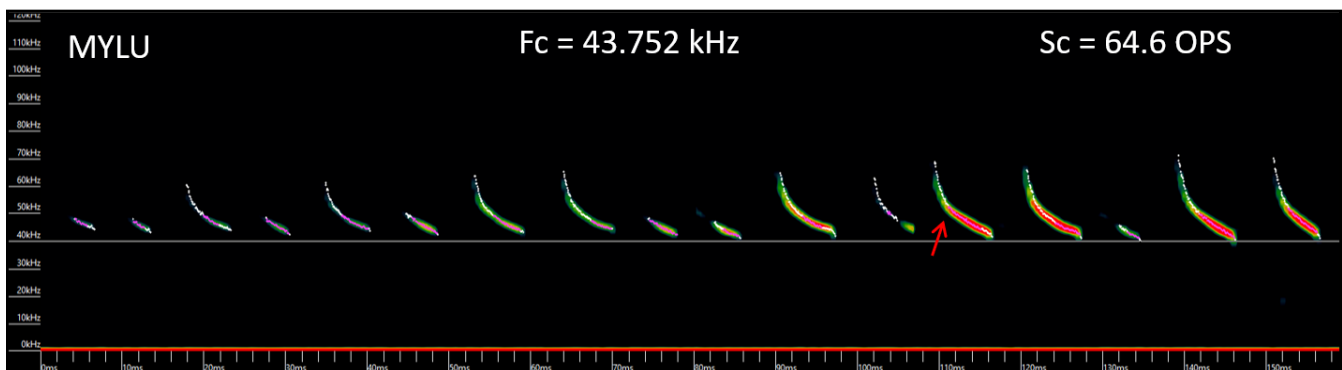


Figure 218. The little brown myotis pulse has a distinctive knee that results in the calls having a curved appearance.

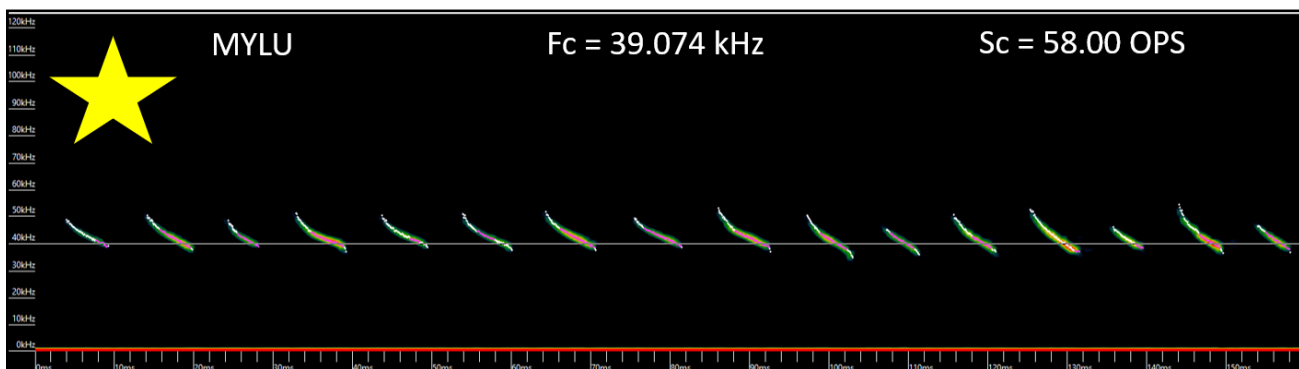


Figure 219. Characteristic little brown myotis sequence.



4.7.3.3 Northern Myotis (*Myotis septentrionalis*) (MYSE)

The northern myotis is another “40 kHz *Myotis*” species. Having adapted for echolocating in high clutter conditions, the northern myotis is known as a “whispering bat”, which means they often emit echolocation calls that are low in intensity, which are more suited for navigating high clutter environments. Due to this, their call shape is fairly long and steep, regardless if they are flying in high or low clutter habitats. Their calls have almost no knee present; they are almost vertical and straight. In high clutter habitat, the F_{\max} of the northern myotis can go as high as 120 kHz. Their call F_c is often 35-40 kHz but can exceed this (6, 33, 34).

Typical F_c : 35-40 kHz

Similar species: Little brown myotis

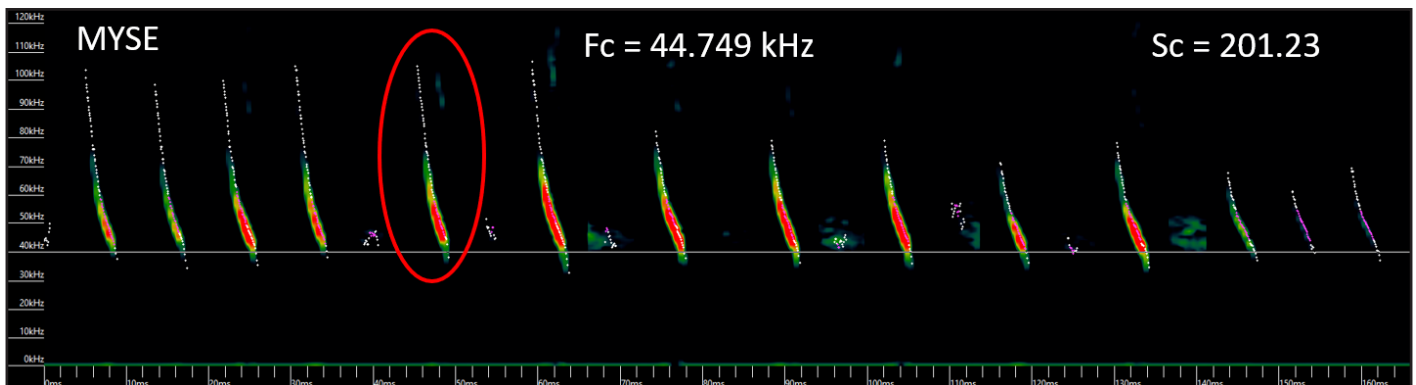


Figure 220. The northern myotis pulse has almost no knee present; it is almost vertical and straight.

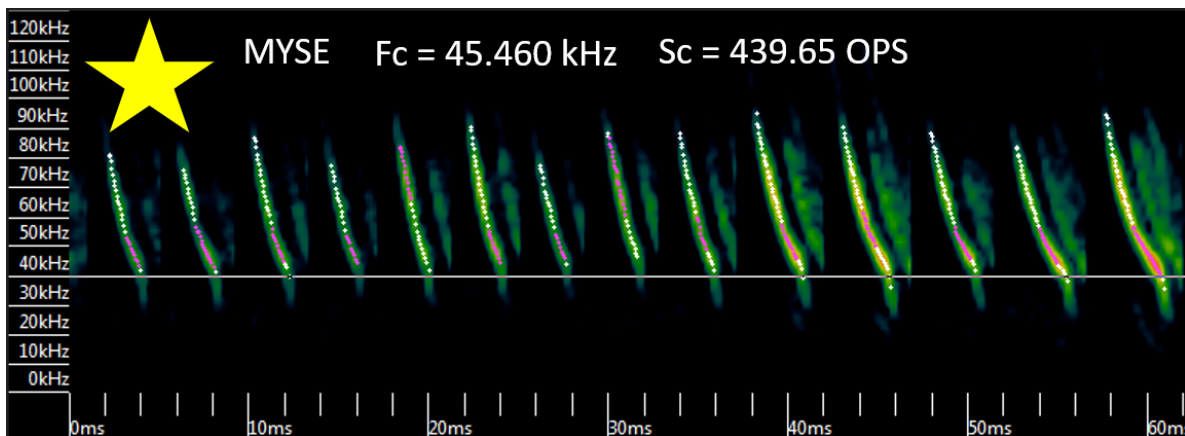


Figure 221. Characteristic northern myotis sequence.

Image from Toby Thorne



4.7.3.4 Tri-colored Bat (*Perimyotis subflavus*) (PESU)

The tri-colored bat is a high frequency bat species with a typical F_c of 40-45 kHz, but it can drop down to 35 kHz (34). Due to overlapping frequencies with LABO and 40 kHz *Myotis* spp., tri-colored bat calls can sometimes be confused with these species, especially when their calls are made in high clutter habitat. However, tri-colored bat calls made in low clutter environments are fairly distinctive when they present as consistent, flat calls with an extremely low slope (8-27 OPS) around 40 kHz (35). Occasionally, the calls also display a **toe** that sweeps downwards, sometimes resulting in the pulse having a flat “s-shape”. Tri-colored bat call sequences are very consistent, with the F_c of each pulse being approximately the same kHz. Their calls can also have a very rounded, hooked appearance where an upturned toe is present (around 40 kHz) (34).

Typical F_c : 40-45 kHz

Similar species: Eastern red bat

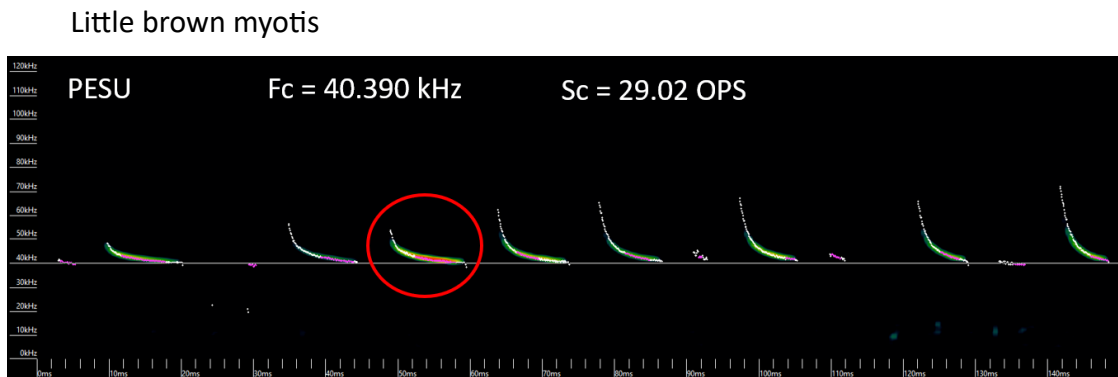


Figure 222. Tri-colored bat calls can occasionally display a toe that sweeps downwards, resulting in the pulse having a flat “s-shape”.
Image from Mersey Tobeatic Research Institute

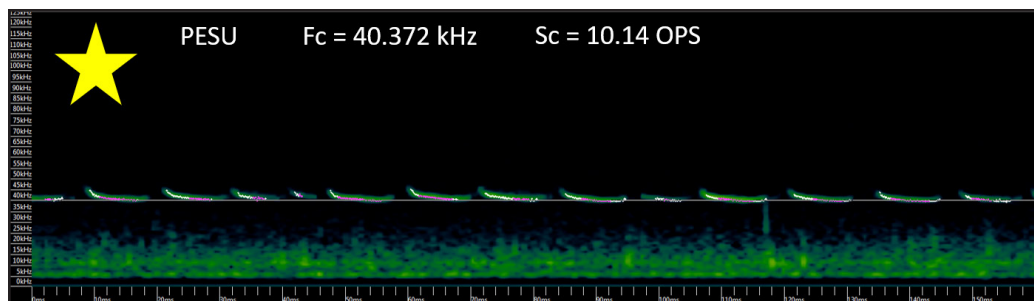


Figure 223. Characteristic tri-colored bat sequence.
Image from Mersey Tobeatic Research Institute



4.7.3.5 Eastern Red Bat (*Lasiurus borealis*) (LABO)

The eastern red bat belongs to the *Lasiurus* bat genus, which we commonly refer to as “Lasiurines”. Lasiurines have very distinctive call characteristics which include an **undulating** pattern (*i.e.*, the F_{\min} does not remain consistent in a call sequence). Additionally, the shape of the call frequently presents in a hooked appearance, sometimes even at higher frequencies, which can be the result of a distinctive upturned toe. The F_c is usually 30-40 kHz, but it can be as low as 28 kHz in low clutter habitat and even exceed 45 kHz in high clutter habitat. At low frequencies (in low clutter habitat), calls can have a S_c that approaches flat (*i.e.*, low slope), but eastern red bats produce extremely steep calls (*i.e.*, high slope) in high clutter habitat. The eastern red bat is a high frequency bat species (33, 34).

Typical F_c : 30-40 kHz

Similar species: Tri-colored bat

Little brown myotis

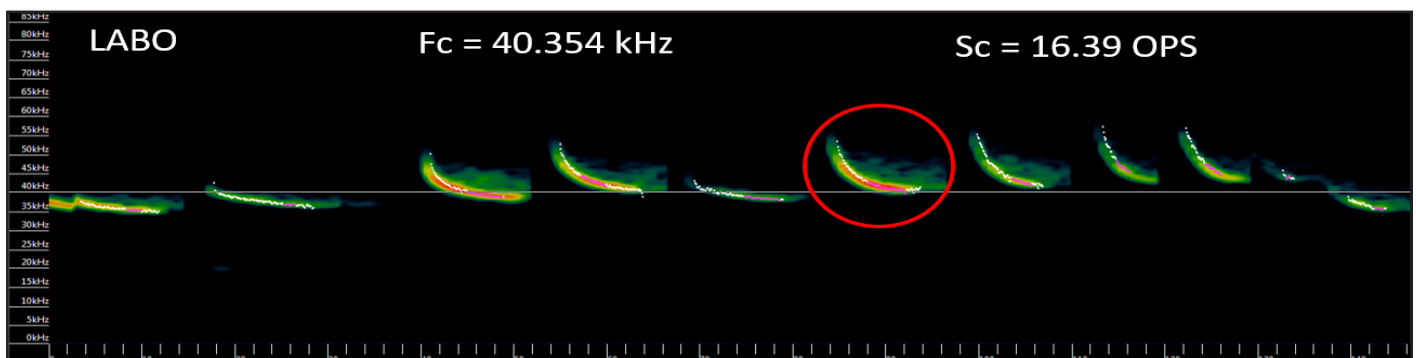


Figure 224. The shape of the eastern red bat call frequently presents in a hooked appearance, which can be the result of a distinctive upturned toe.

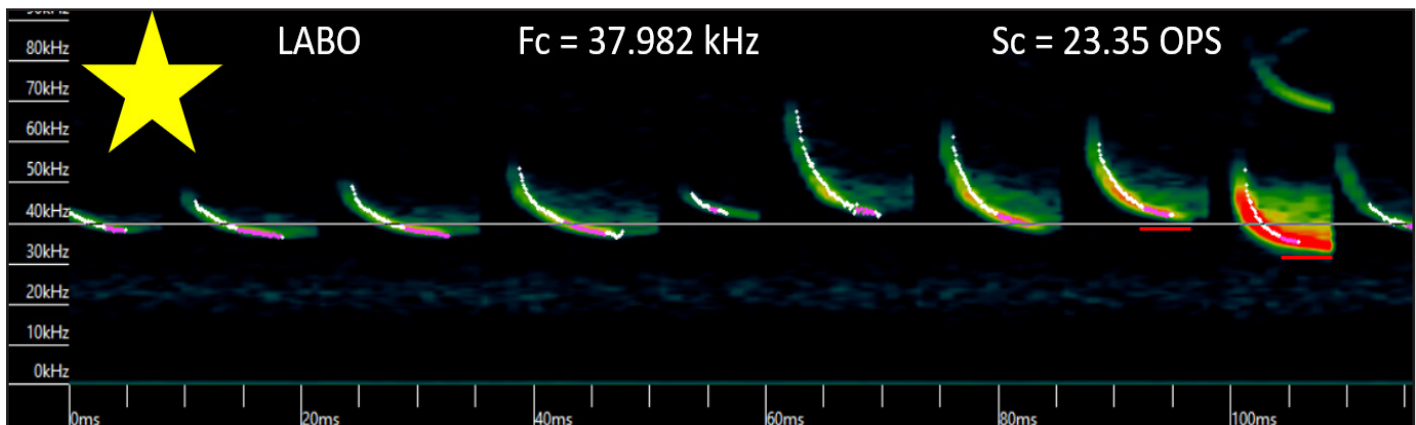


Figure 225. Characteristic eastern red bat sequence.



4.7.3.6 Hoary Bat (*Lasiurus cinereus*) (LACI)

The hoary bat is another Lasiurine species, meaning its call also has an undulating pattern that frequently exhibits a hooked appearance with an upturned toe. The F_c is 15-30 kHz, making the hoary bat a low frequency bat species. Calls with an F_c above 30 kHz are considered high clutter calls for a hoary bat, and thus they have a high slope. Hoary bat calls in low clutter habitat typically have a F_c below 20 kHz and a characteristically flat appearance (*i.e.*, a low slope), with less obvious undulation (33, 34).

Typical F_c : 15-30 kHz

Similar species: None

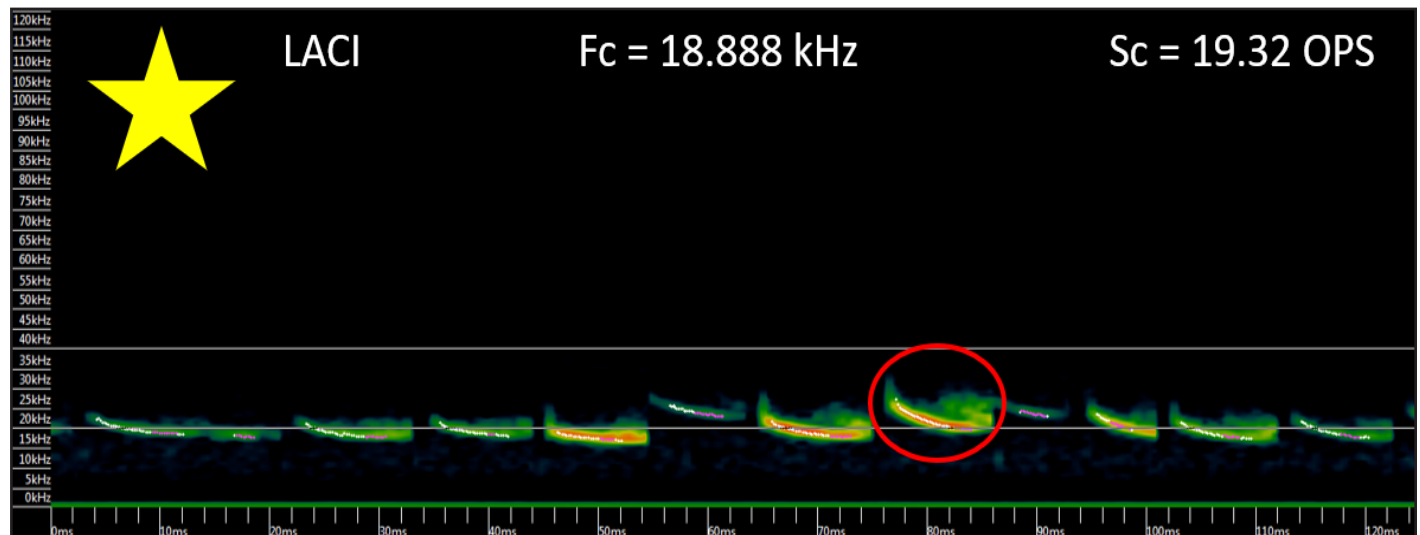


Figure 226. Characteristic hoary bat sequence.



4.7.3.7 Silver-haired Bat (*Lasionycteris noctivagans*) (LANO)

The silver-haired bat is another low frequency bat species. The F_c of their calls is 25-30 kHz, although the F_{min} can drop to 23 kHz in low or moderate clutter habitat. The F_{max} of their calls typically do not go higher than 50-55 kHz. Silver-haired bat calls in a sequence tend to have a fairly consistent F_{min} and toes can either be upturned or downturned. The main distinguishing characteristic of silver-haired bat calls is that they are flat and non-undulating around 25 kHz (33, 34).

Typical F_c : 25-30 kHz

Similar species: Big brown bat

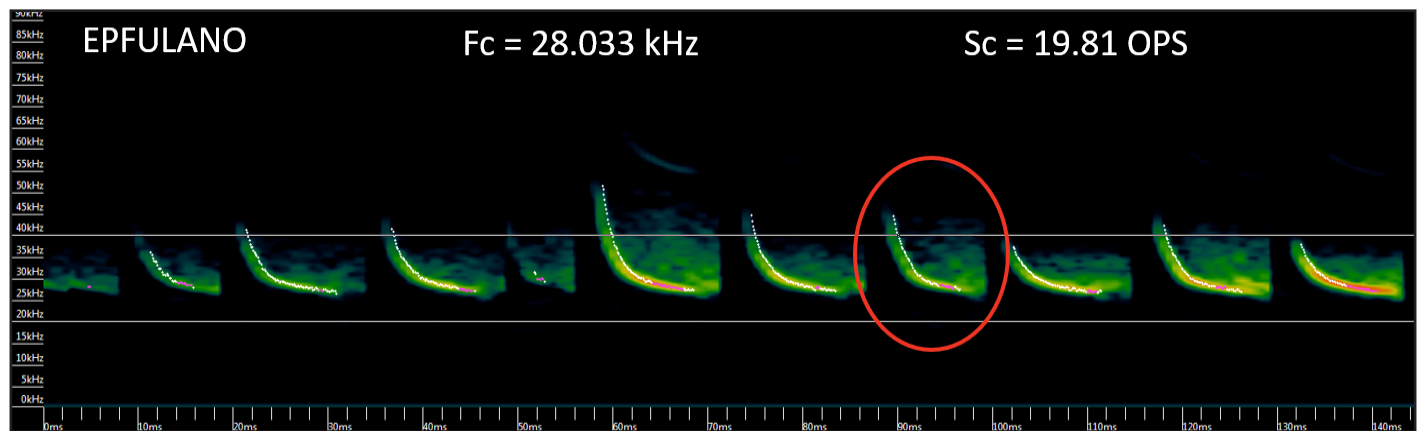


Figure 227. Silver-haired bat calls can have toes that are either upturned (as in the image) or downturned.

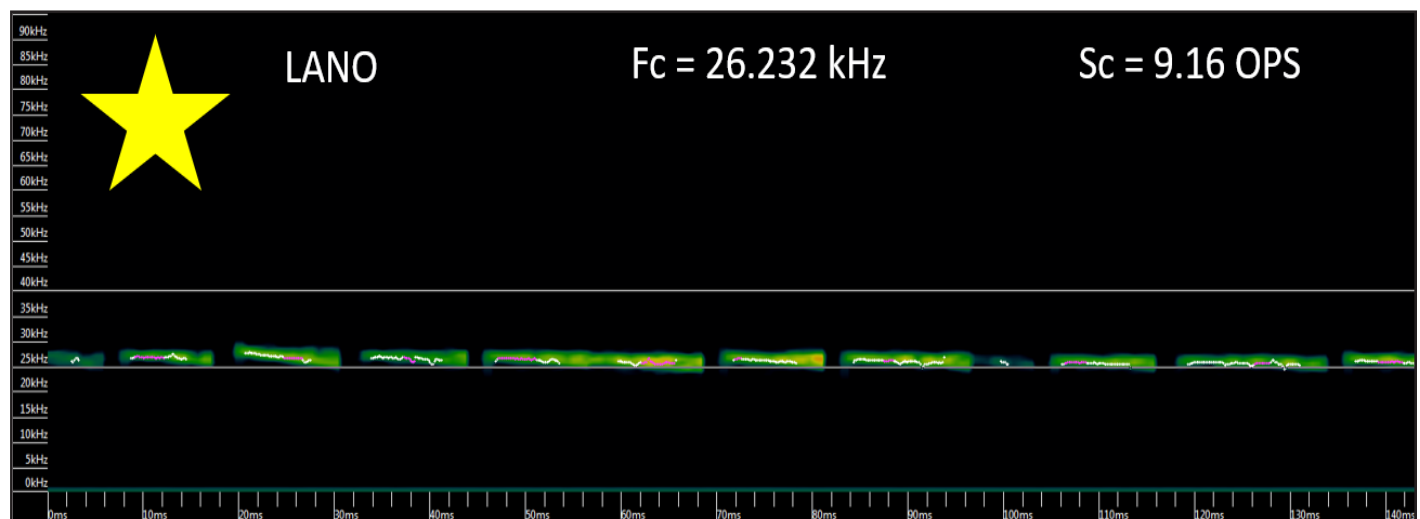


Figure 228. Characteristic silver-haired bat sequence.



4.7.3.8 Big Brown Bat (*Eptesicus fuscus*) (EPFU)

The big brown bat is also a low frequency bat species. Commonly, the F_c of their calls is 25-30 kHz, but the F_{min} may be as low as 20 kHz in low clutter environments. The F_{max} of their calls can go above 60 kHz. Big brown bat calls in a sequence have a consistent F_{min} , and even their flattest pulses have a slope greater than 5 OPS (*i.e.*, the pulses are never flat). Calls often have a smooth (not too prominent) knee, and can end in an upturned toe, resulting in a slightly hooked appearance, or a downturned toe, resulting in an “s-shape” (33, 34).

Typical F_c : 25-30 kHz

Similar species: Silver-haired bat

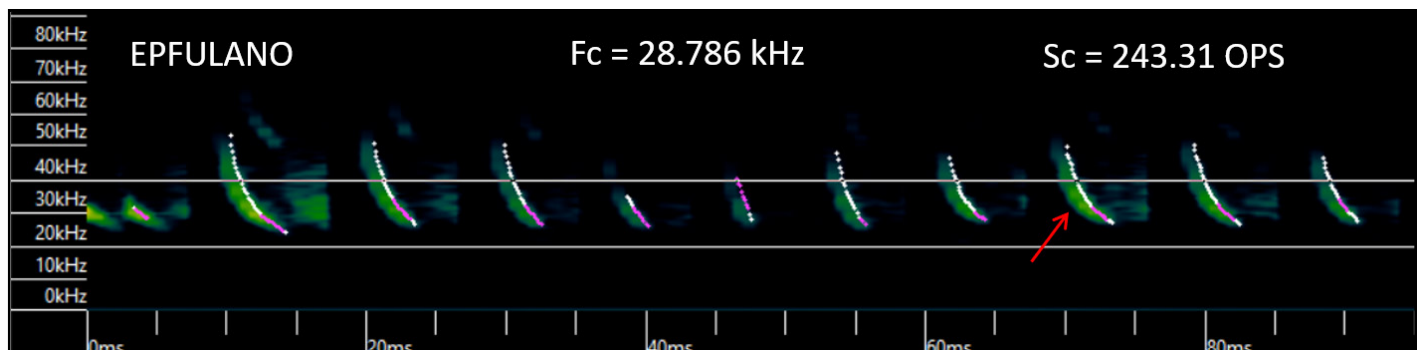


Figure 229. Big brown bat calls often have a smooth (not too prominent) knee.

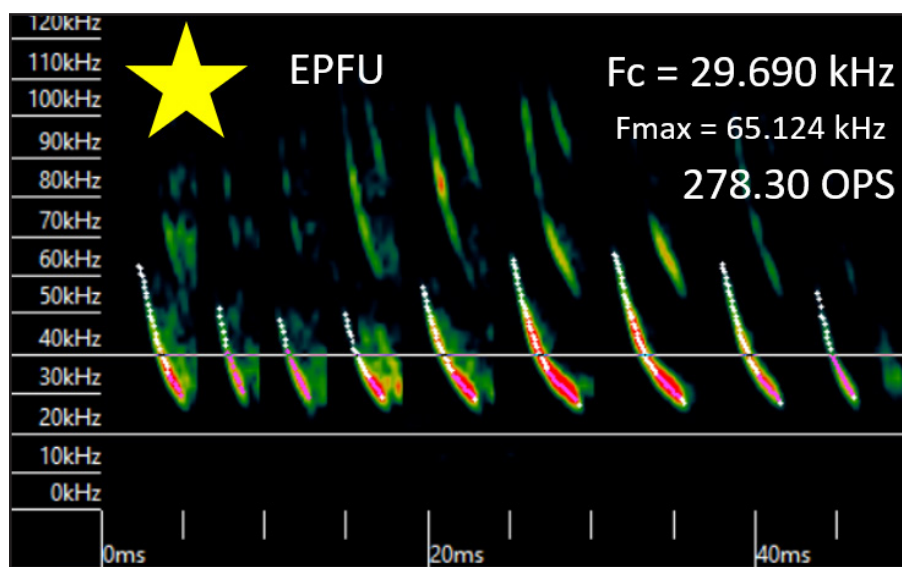


Figure 230. Characteristic big brown bat sequence.



The NABat species codes are four-letter codes comprised of the first two letters of the genus name and the first two letters of the species name (e.g., *Myotis lucifugus* is **MYLU**) (23).

Table 6. NABat Species Codes

Common Name	Scientific Name	Code
Little brown myotis	<i>Myotis lucifugus</i>	MYLU
Northern myotis	<i>Myotis septentrionalis</i>	MYSE
Tri-colored bat	<i>Perimyotis subflavus</i>	PESU
Eastern red bat	<i>Lasiurus borealis</i>	LABO
Hoary bat	<i>Lasiurus cinereus</i>	LACI
Silver-haired bat	<i>Lasionycteris noctivagans</i>	LANO
Big brown bat	<i>Eptesicus fuscus</i>	EPFU



Figure 231. The NABat species codes are four-letter codes comprised of the first two letters of the genus name and the first two letters of the species name.

Photos by Jordi Segers



4.7.3.9 Little Brown Myotis vs. Northern Myotis

In most cases, when recording passively, it is virtually impossible to distinguish little brown myotis calls from northern myotis calls. While there is some confusing overlap between these two species, this is generally true because it can be difficult to determine the exact degree of clutter that the bat is responding to while echolocating. Unless any of the specific criteria outlined below are met, a call sequence with a consistent F_{min} , a $S_c > 80$ OPS, and a F_c of 35-45 kHz should be identified as **40KMyo** if recorded in low clutter habitat. In high clutter habitat, it may be necessary to identify a sequence as **HighF** unless there are specific distinguishing characteristics of a particular species (35).

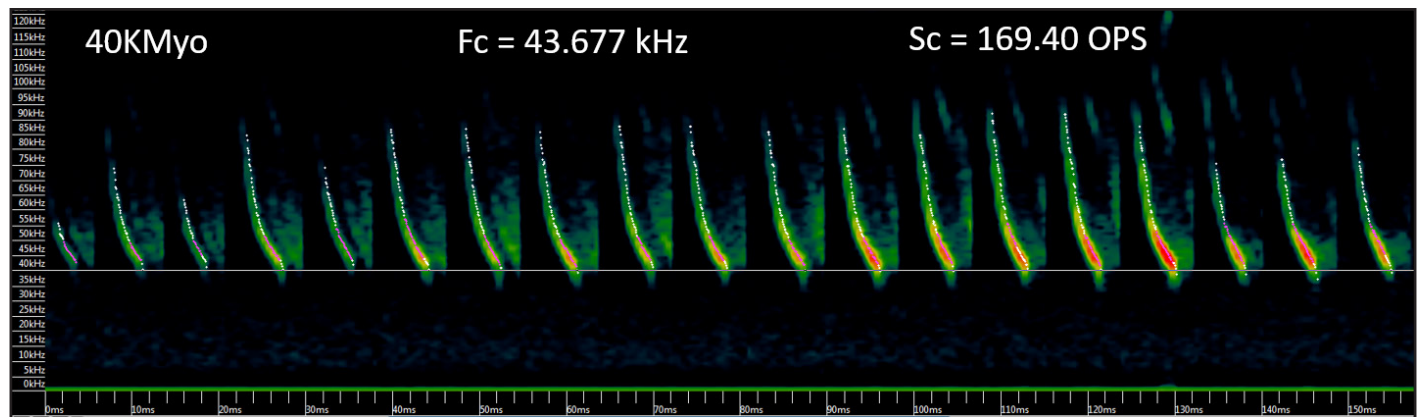


Figure 232. It is virtually impossible to distinguish little brown myotis calls from northern myotis calls, in these cases the calls should be identified as **40KMyo**.



However, in very specific low clutter habitat conditions, it may be possible to differentiate between these *Myotis* spp. In low clutter habitat in areas where PESU is not known to occur, if the F_{\min} is consistent, the S_c of the call sequence is $25 \leq 80$ OPS, and the F_c is 35-45 kHz, then the call sequence can be identified as **MYLU**. In low clutter habitat in areas where PESU is known to occur, if the F_{\min} is consistent, the S_c of the call sequence is $50 \leq 80$ OPS, and the F_c is 35-45 kHz, then the call sequence can be identified as **MYLU** (35). The presence of a distinct elbow in the call can be indicative of MYLU, so this feature may be helpful as a visual cue, but cannot be quantified, so should not be used as a concrete way to distinguish between these species.

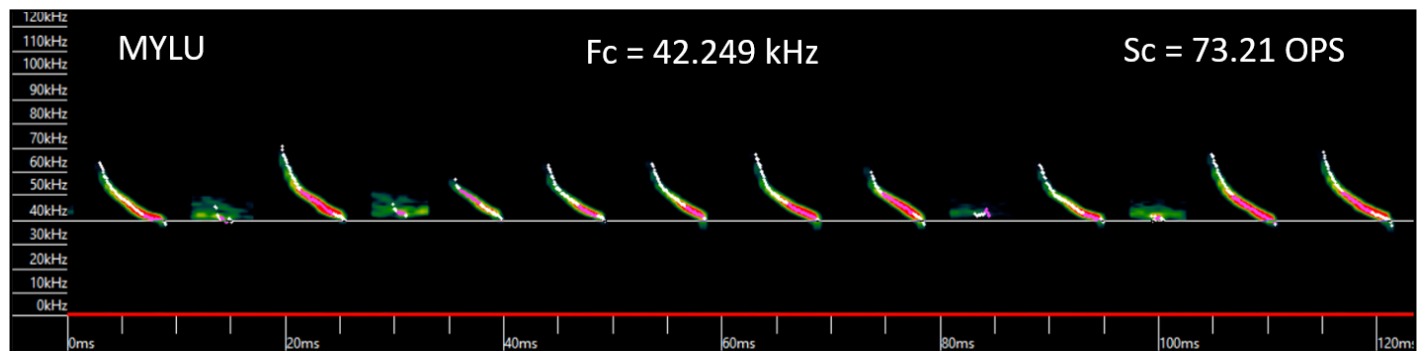


Figure 233. In low clutter habitat, if the S_c of the call sequence is $50 \leq 80$ OPS, then the call sequence can be identified as **MYLU**.

Conversely, if the F_{\min} is consistent, the S_c is ≥ 200 OPS, and the F_c is 35-45 kHz, the call sequence can be identified as **MYSE** in low clutter habitat (35).

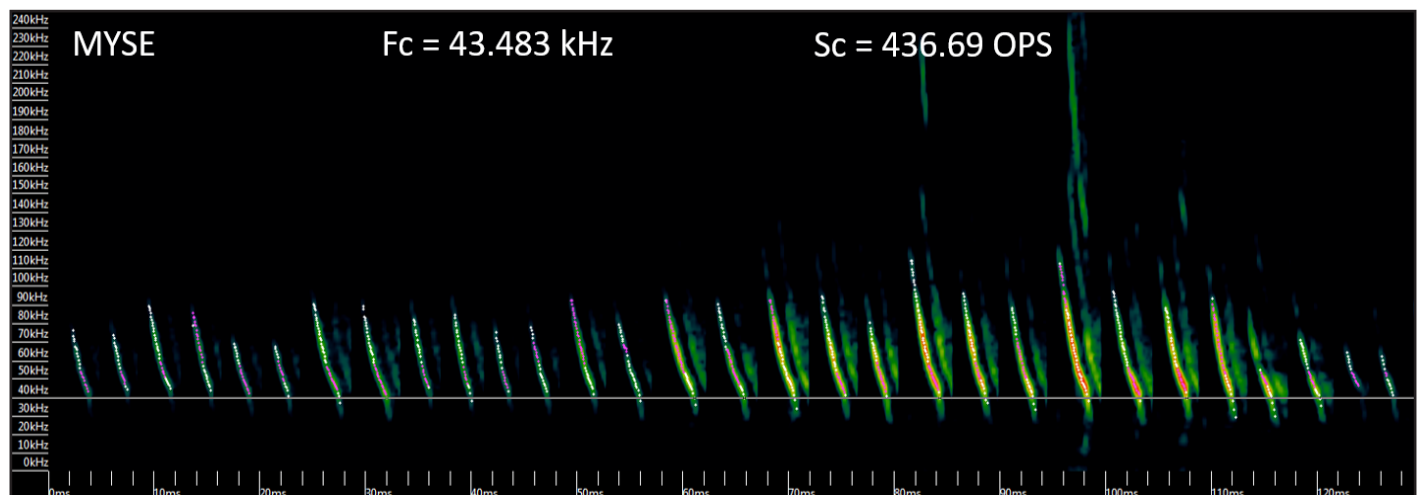


Figure 234. In low clutter habitat, if the S_c is ≥ 200 OPS, the call sequence can be identified as **MYSE**.
Image from Toby Thorne



In high clutter habitat, there is also a specific situation where it may be possible to distinguish between MYSE and MYLU. If the F_{max} is ≥ 118 kHz, the bat is likely **MYSE**, because the F_{max} for MYLU in high clutter habitat is generally only 100-110 kHz (33, 34). It is not possible to use F_{max} as a method for identifying MYLU in high clutter habitat because it is impossible to rule out MYSE without knowing how close the bat is to the microphone (*i.e.*, the microphone may not pick up the higher frequencies that are indicative of MYSE if the bat is far away from the microphone, so the while the call may appear to be MYLU based on a lower F_{max} , the bat is MYSE in actuality).

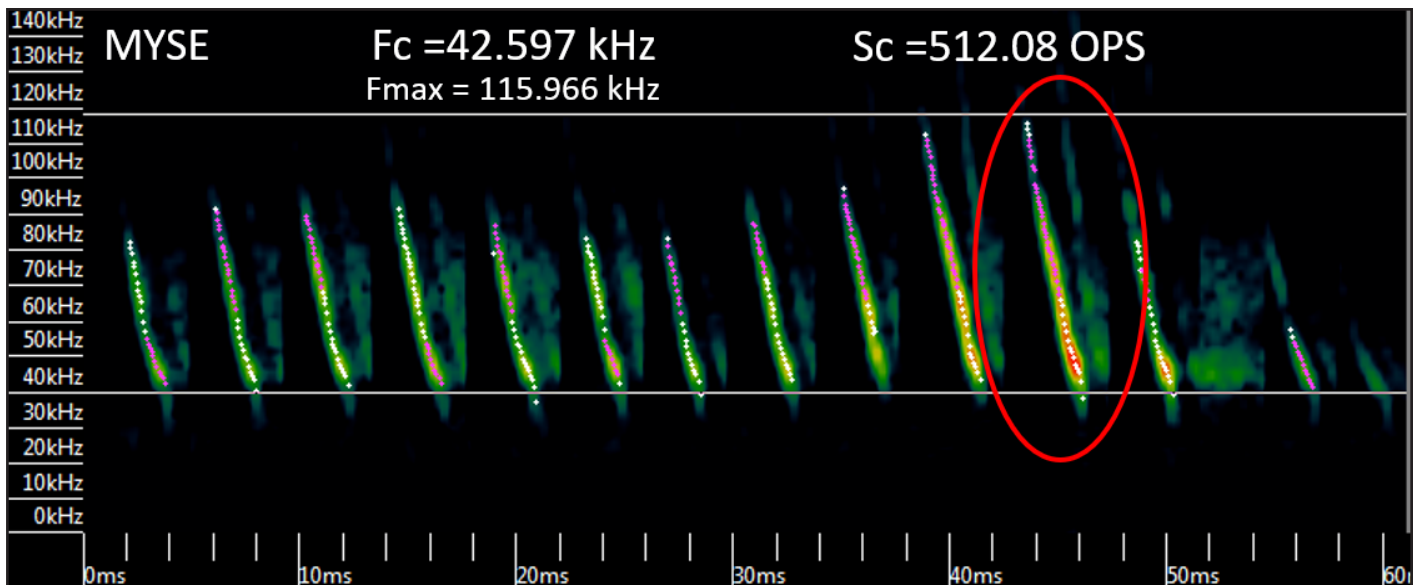


Figure 235. In high clutter habitat, if the F_{max} is ≥ 118 kHz, the bat is likely **MYSE**.

Image from Toby Thorne

Table 7. Call identification features for little brown myotis versus northern myotis.

Call Features	Little Brown Myotis (MYLU)	Northern Myotis (MYSE)
Low clutter habitat : S_c 25-50 \leq 80 OPS	YES	NO
Low clutter habitat : S_c \geq 200 OPS	NO	YES
High clutter habitat : F_{max} \geq 118 kHz	NO	YES



4.7.3.10 Eastern Red Bat vs. Little Brown Myotis

In high clutter environments, eastern red bat calls can sometimes be mistaken for those of little brown myotis. Eastern red bat calls made in high clutter habitat do not show as much of the undulation typical of Lasiurines, and also do not exhibit the characteristic hook shape. In high clutter habitat, it may be necessary to identify a sequence as **HighF** unless there are specific distinguishing characteristics of a particular species (35). In low clutter environments confusion may arise when attempting to interpret short, poor quality call sequences with few pulses, because in these cases LABO undulation may not be obvious. In low clutter habitat in areas where PESU is not known to occur, where short sequences have no undulation or slight undulation, an F_c of approximately 35-45 kHz, and a S_c 25<50 OPS, then the sequence can be identified as **LABOMYLU** (33, 34, 35). In low clutter habitat in areas where PESU is known to occur, if short sequences have no undulation or slight undulation, a F_c of approximately 35-45 kHz, and a S_c 25<50 OPS then the sequence can be identified as **HighF** (35).

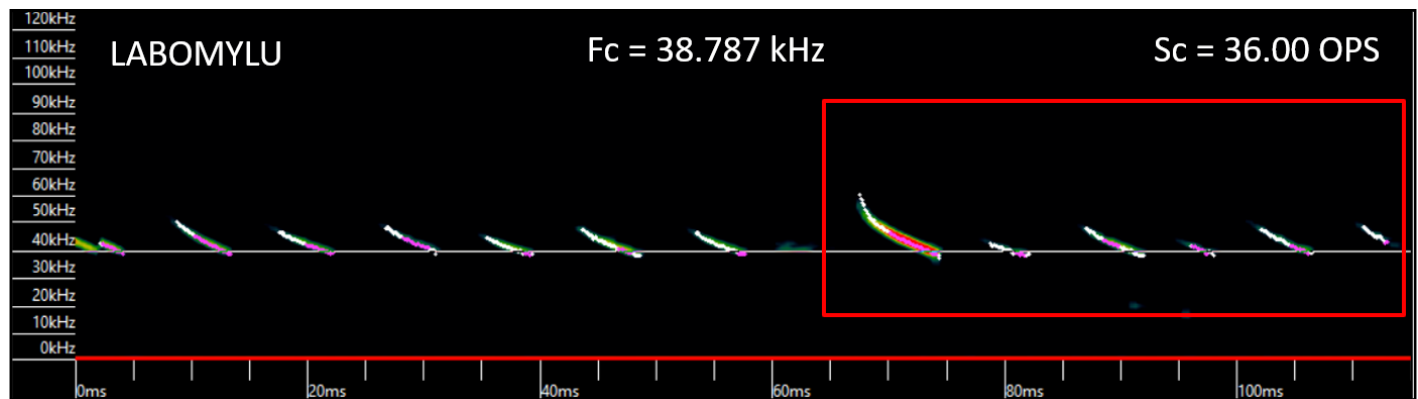


Figure 236. Confusion between LABO and MYLU may arise when attempting to interpret short, poor quality sequences, in which case the sequence can be identified as **LABOMYLU**.

Image from Toby Thorne



In moderate and low clutter habitat, it is typically not too difficult to differentiate between LABO and MYLU. MYLU calls made in moderate and low clutter environments often exhibit a distinctive knee, in comparison to LABO calls which often have a hooked appearance in similar habitat.

Whereas MYLU calls maintain a fairly consistent F_{\min} , the F_{\min} of LABO calls changes sporadically with their undulating call pattern. In low clutter habitat, if the calls are undulating and have an F_c of $28 < 45$ kHz, then the sequence can be identified as **LABO** (the calls may also be hooked but it is not definitive characteristic). Alternatively, in low clutter habitat in areas where PESU is not known to occur, if the F_{\min} is consistent, the S_c of the call sequence is $25 \leq 80$ OPS, and the F_c is 35-45 kHz, then the call sequence can be identified as **MYLU**. In low clutter habitat in areas where PESU is known to occur, if the F_{\min} is consistent, the S_c of the call sequence is $50 \leq 80$ OPS, and the F_c is 35-45 kHz, then the call sequence can be identified as **MYLU** (35).

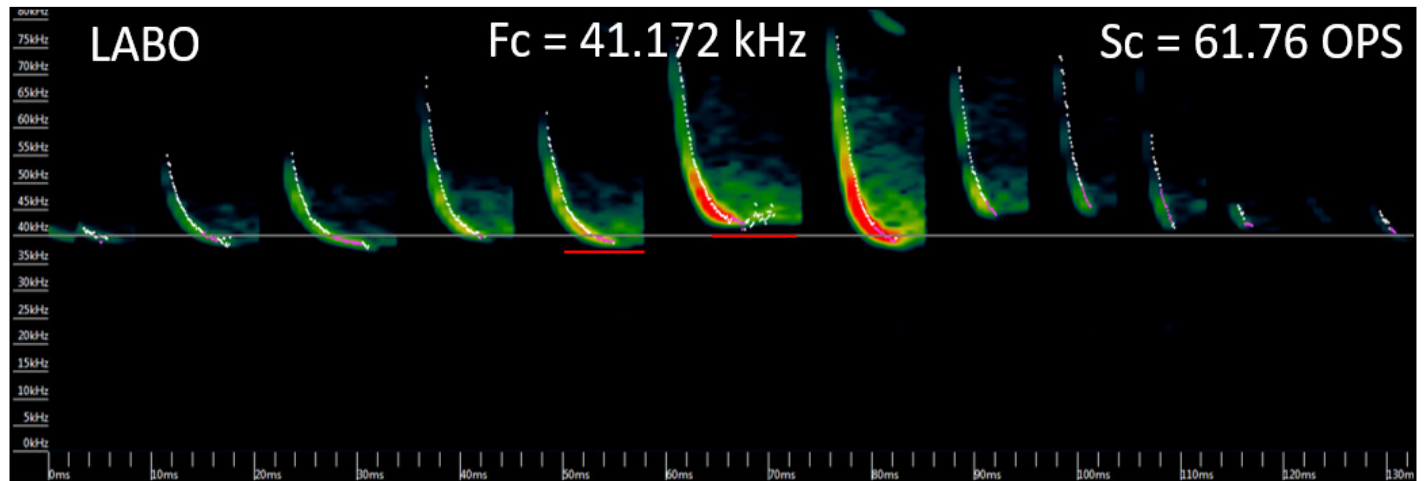


Figure 237. The F_{\min} of LABO calls changes sporadically with their undulating call pattern.

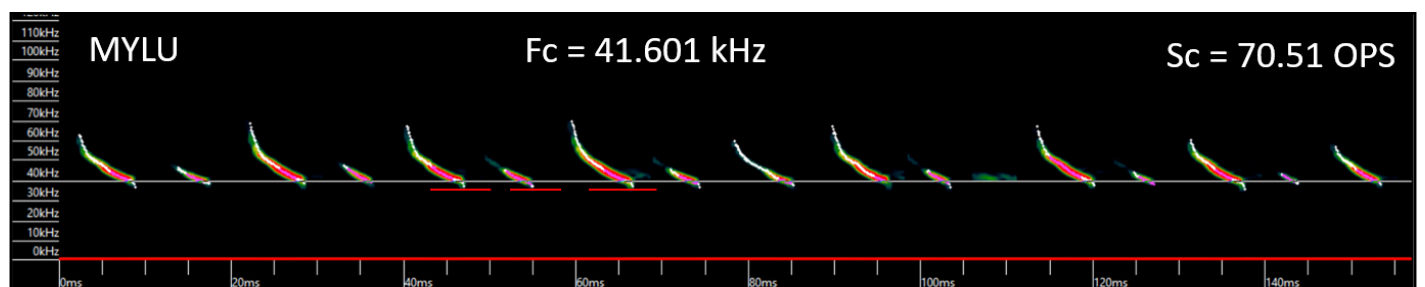


Figure 238. MYLU calls maintain a fairly consistent F_{\min} .



The slope of LABO calls is generally much lower than that of MYLU calls. In low clutter habitat in an area where PESU is not known to occur, even if the pulses have no undulation or slight undulation, if the S_c is <25 OPS and the F_c is $30 < 45$ kHz, then the sequence can be identified as **LABO**. Alternatively, in low clutter habitat in an area where PESU is known to occur, even if the pulses have no undulation or slight undulation, if the S_c is <25 OPS and the F_c is $30 < 35$ kHz, then the sequence can be identified as **LABO**. In low clutter habitat regardless if PESU may be present or not, even if the pulses have slight undulation, if the S_c of the call sequence is $50 \leq 80$ OPS, and the F_c is $35-45$ kHz, then the call sequence can be identified as **MYLU** (35).

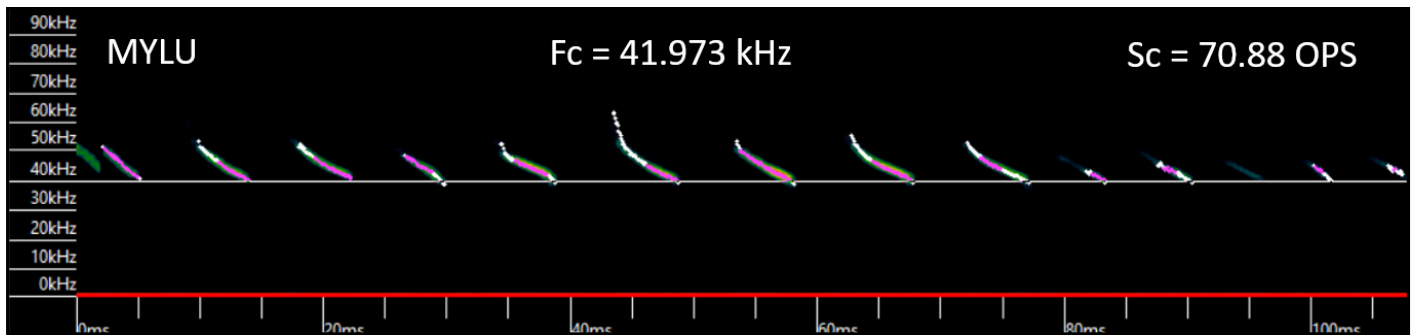
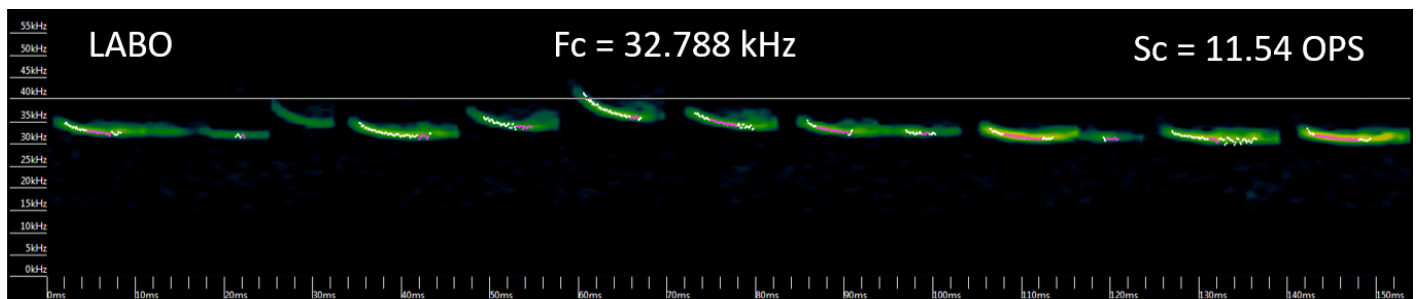


Figure 239. If the S_c is <25 OPS and the F_c is $30 < 35$ kHz then the sequence can be identified as **LABO**; if the S_c of the call sequence is $50 \leq 80$ OPS and the F_c is $35-45$ kHz then the call sequence can be identified as **MYLU**.

Table 8. Call identification features for eastern red bats versus little brown myotis.

Call Features	Eastern Red Bat (LABO)	Little Brown Myotis (MYLU)
Undulating F_{min}	YES	NO
Consistent F_{min}	NO	YES
$S_c < 25$ OPS	YES	NO
$S_c \geq 50$ OPS	NO	YES



4.7.3.11 Eastern Red Bat vs. Tri-colored Bat

Difficulties in differentiating between eastern red bats and tri-colored bats also predominantly arise in high clutter habitats, where the typical features of Lasiurine calls are not always apparent. In these circumstances, eastern red bat calls may not show F_{\min} undulation or their characteristic hooked appearance. In high clutter habitat, it may be necessary to identify a sequence as **HighF** unless there are specific distinguishing characteristics of a particular species (35). In low clutter habitat, both PESU and LABO may also exhibit calls with a rounded, hooked appearance, leading to confusion between these two species. In low clutter habitat, if short sequences have no undulation or slight undulation, a F_c of approximately 35-45 kHz, and a $S_c < 25$ OPS, the sequence can be identified as **LABOPESU**, due to the inability to identify the sequence to species (33, 34, 35). In low clutter habitat, if short sequences have no undulation or slight undulation, a F_c of approximately 35-45 kHz, and a $S_c 25 < 50$ OPS, then the sequence can be identified as **HighF** (35).

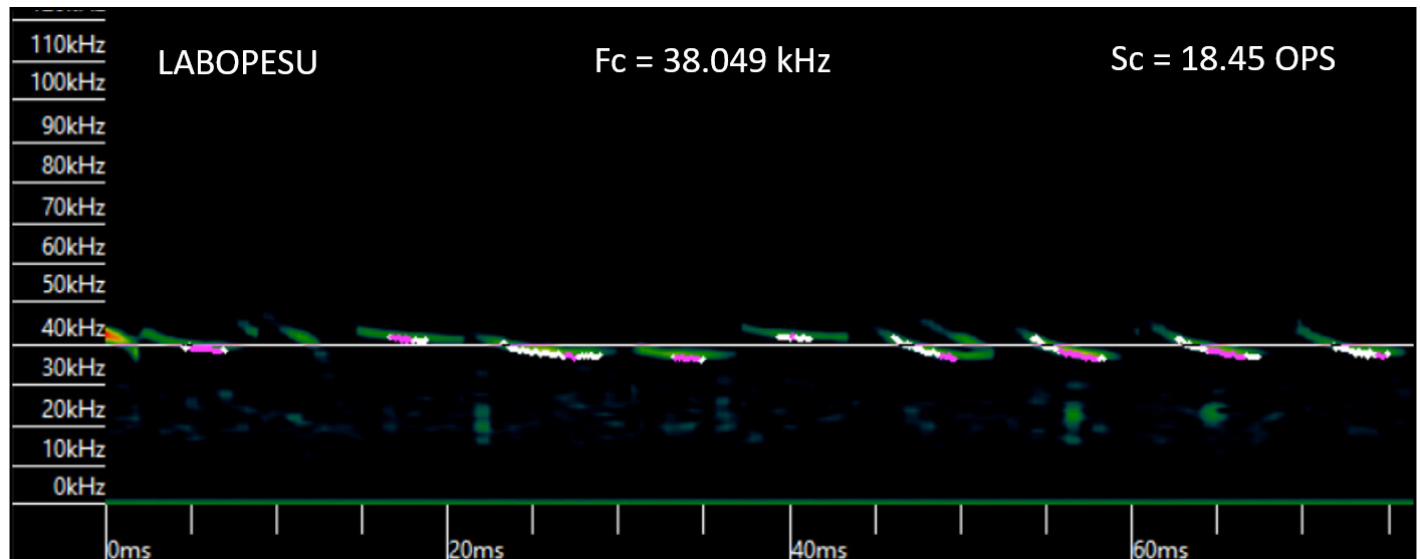


Figure 240. Confusion between LABO and PESU may arise when attempting to interpret short, poor quality sequences, in which case the sequence can be identified as **LABOPESU**.



In moderate and low clutter habitat, LABO calls will often have an undulating F_{min} allowing for easier identification of species. In comparison, PESU calls will maintain a regular and consistent F_{min} . In low clutter habitat, if the calls are undulating and have an F_c of $28 < 45$ kHz, then the sequence can be identified as **LABO**.

Additionally, LABO calls may have an F_c as low as 28 kHz, whereas the lowest F_c of a PESU call is generally 35 kHz. Therefore, in low clutter habitat, even if the pulses have no undulation or slight undulation, if the F_c is 30-35 kHz and the S_c is < 25 OPS then the sequence can be identified as **LABO** (33, 34, 35).

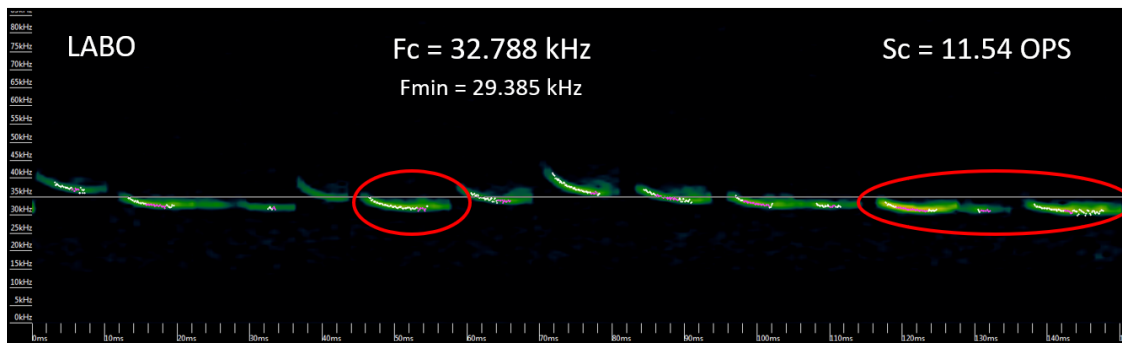


Figure 241. LABO calls will have an undulating F_{min} and may have a F_c 30-35 kHz.

In low clutter habitat, if the calls have a consistent F_{min} , are approaching flat with a $S_c \leq 20$ OPS, and have a F_c of approximately 35-45 kHz, the sequence can be identified as **PESU** (16, 35, 36, Lori Phinney, personal communication).

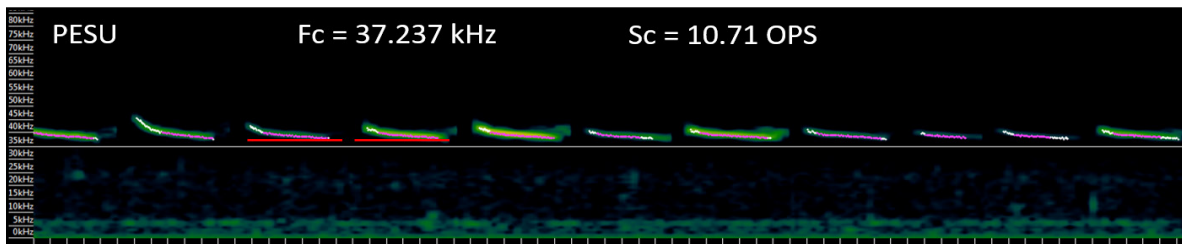


Figure 242. In low clutter habitat, if the calls have a consistent F_{min} , are approaching flat with a $S_c \leq 20$ OPS, and have a F_c of approximately 38-45 kHz, the sequence can be identified as **PESU**.

Image from Mersey Tobeatic Research Institute

Table 9. Call identification features for eastern red bats versus tri-colored bats.

Call Features	Eastern Red Bat (LABO)	Tri-colored Bat (PESU)
Undulating F_{min}	YES	NO
Consistent F_{min}	NO	YES
F_c 30<35 kHz	YES	NO
$S_c \leq 20$ OPS at F_c 38-45 kHz	NO	YES



4.7.3.12 Big Brown Bat vs. Silver-haired Bat

In high clutter habitat, it may be necessary to identify a sequence as **LowF** unless there are specific distinguishing characteristics of a particular species (35). In low clutter habitat, if calls present as consistent (*i.e.*, not undulating) with a F_c of approximately 25-30 kHz, a $S_c > 15$ OPS, a $F_{\min} > 23$ kHz, and a $F_{\max} < 60$ kHz, then it will not be possible to differentiate between big brown bat and silver-haired bat calls, and the sequence should be identified as **EPFULANO** (33, 34). Occasionally in low clutter habitat it may be impossible to rule out LACI if it is a very short sequence with little or no undulation and a F_c of approximately 25-30 kHz, in which case the sequence should be identified as **LowF**.

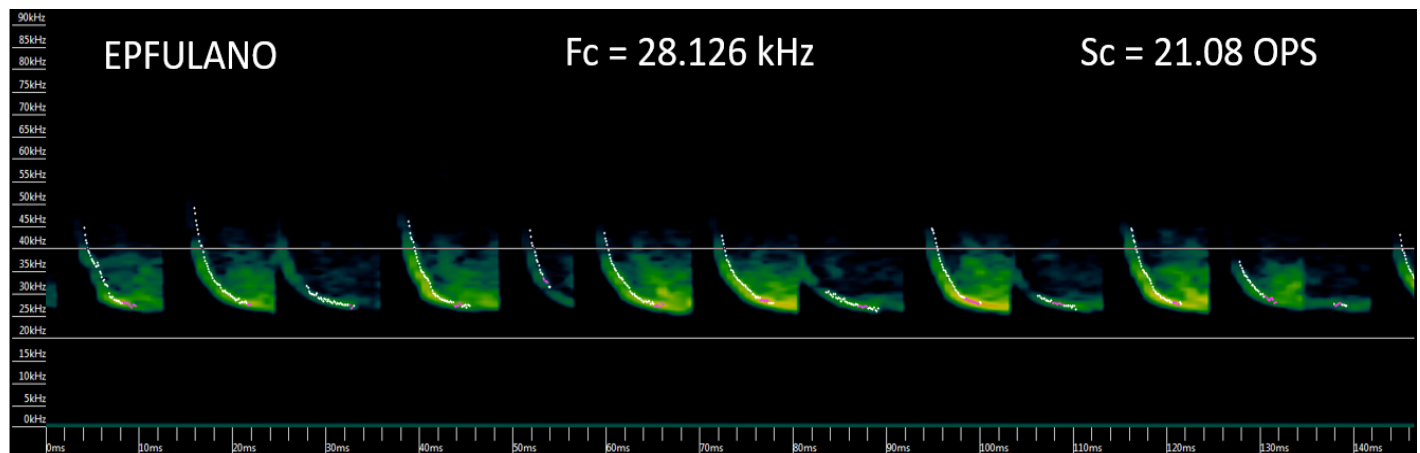


Figure 243. In low clutter habitat, if calls present as consistent (*i.e.*, not undulating) with a F_c of 25-30 kHz, a $S_c > 15$ OPS, a $F_{\min} > 23$ kHz, and a $F_{\max} < 60$ kHz, then the sequence should be identified as **EPFULANO**.



However, in low clutter habitat, if the calls have a consistent F_{min} and are essentially flat with a low slope ($S_c \leq 15$ OPS) at a F_c of approximately 25-30 kHz, the sequence can be identified as **LANO**, because EPFU calls typically do not have a low slope (33, 34).

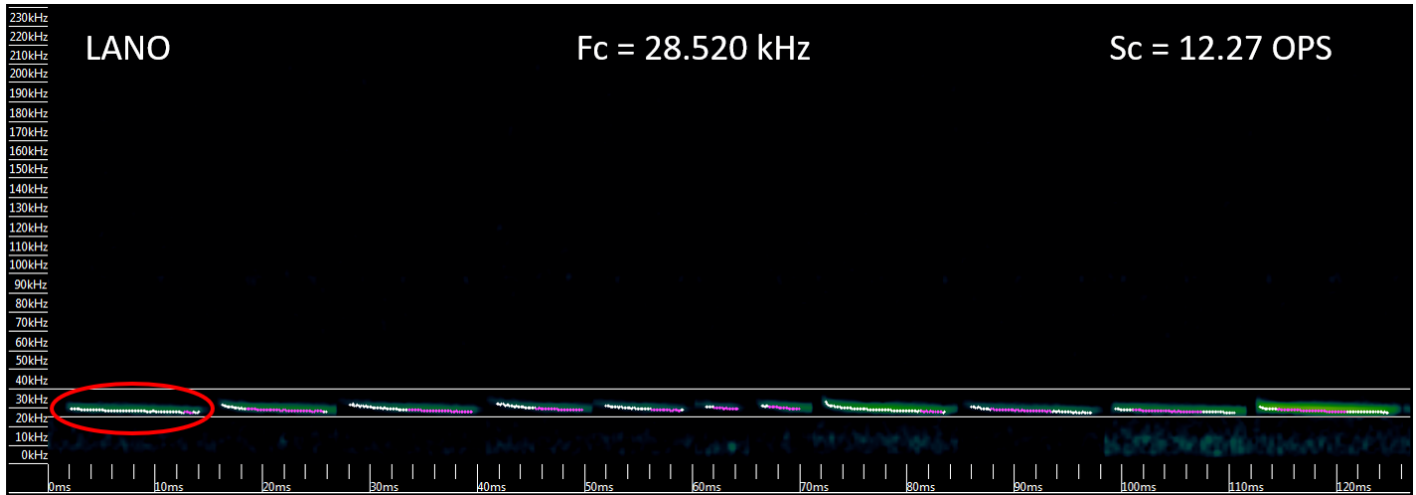


Figure 244. If the calls are consistent and are essentially flat with a low slope ($S_c \leq 15$ OPS) at a F_c of approximately 25-30 kHz, the sequence can be identified as **LANO**.

Big brown bats have a larger range in frequency than silver-haired bats, which allows for additional differentiation techniques. In low clutter habitat, if the calls have a consistent F_{min} , the F_c is approximately 25-30 kHz, and the F_{max} of the pulse is >60 kHz, the sequence can be identified as **EPFU**, because LANO calls typically do not have an $F_{max} > 55$ kHz (33, 34).

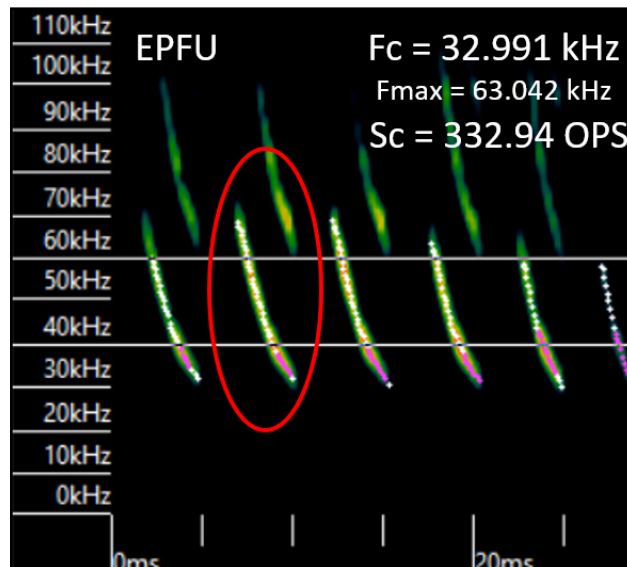


Figure 245. If the calls are consistent, the F_c is approximately 25-30 kHz, and the F_{max} of the pulse is >60 kHz, the sequence can be identified as **EPFU**.



Alternatively, in low clutter habitat, if the calls have a consistent F_{min} , the F_c is approximately 25-30 kHz, and the F_{min} of the pulse is <23 kHz, the sequence can be identified as **EPFU**, because LANO calls generally do not have an F_{min} <23 kHz (33, 34).

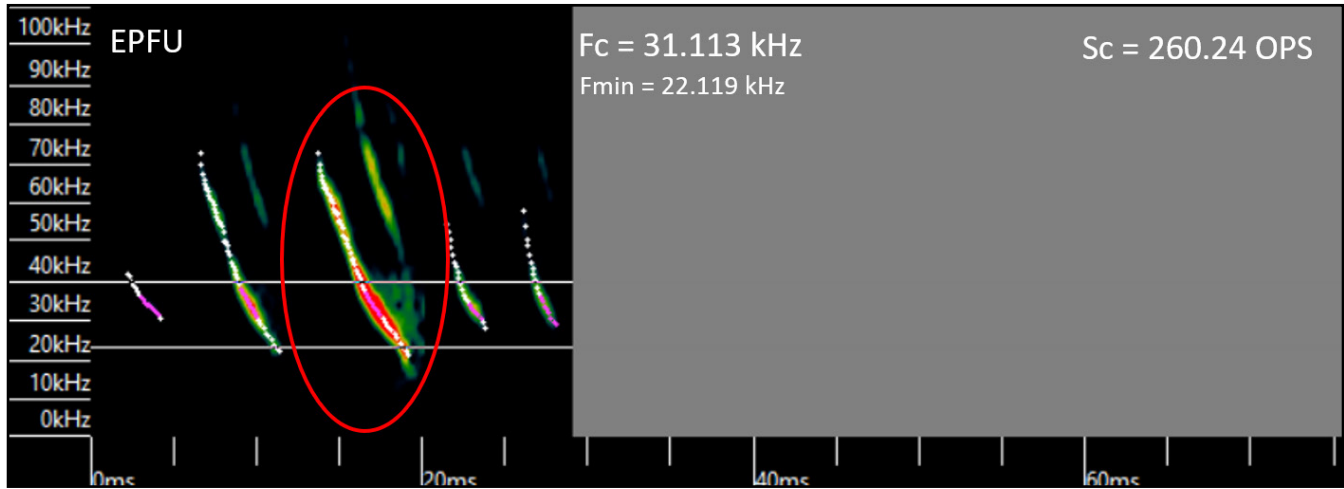


Figure 246. If the calls are consistent, the F_c is approximately 25-30 kHz, and the F_{min} of the pulse is <23 kHz, the sequence can be identified as **EPFU**.

Table 10. Call identification features for big brown bats versus silver-haired bats.

Call Features	Big Brown Bat (EPFU)	Silver-haired Bat (LANO)
$S_c \leq 15$ OPS at F_c 25-30 kHz	NO	YES
$F_{max} > 60$ kHz	YES	NO
$F_{min} < 23$ kHz	YES	NO

Table 11. NABat Codes for Common Groupings

Common Names	Code
Hoary bat/big brown bat/Silver-haired bat	LowF
Big brown bat/Silver-haired bat	EPFULANO
Eastern red bat/Tri-colored bat/Little brown myotis/Northern myotis	HighF
Eastern red bat/Little brown myotis	LABOMYLU
Eastern red bat/Tri-colored bat	LABOPESU
Little brown myotis/Northern myotis	40KMyo



4.7.3.13 Non-bat Files

If a file does not appear to include data that resemble bat calls, then it should be identified as **NOISE**. This includes files that are: too short of a sequence to be considered a bat pass (less than three pulses in ZC), fractionated calls of poor quality that cannot be readily identified as bat calls, recordings of other animals (birds, insects, etc.), or mechanical/environmental sounds.

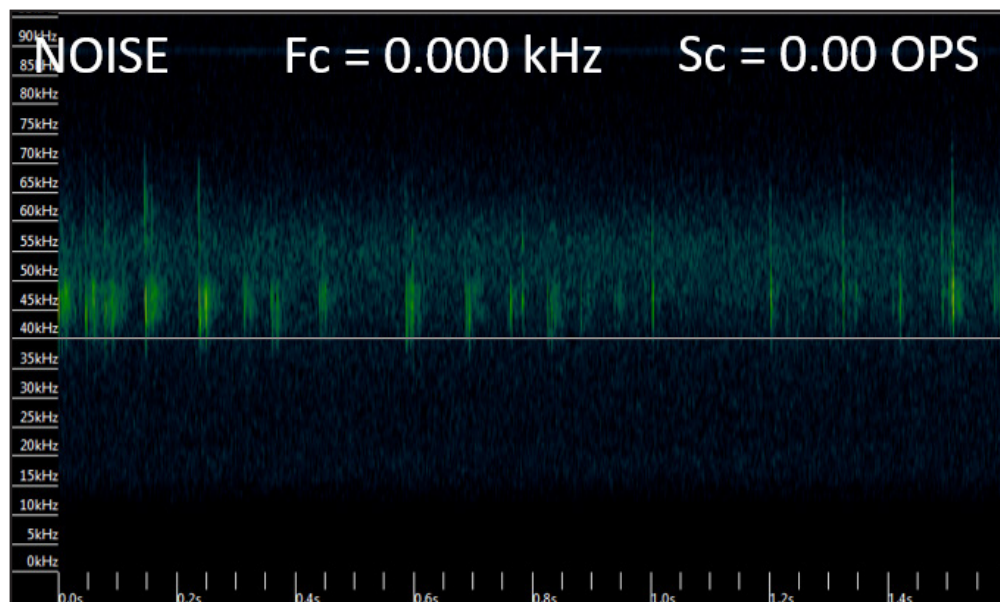
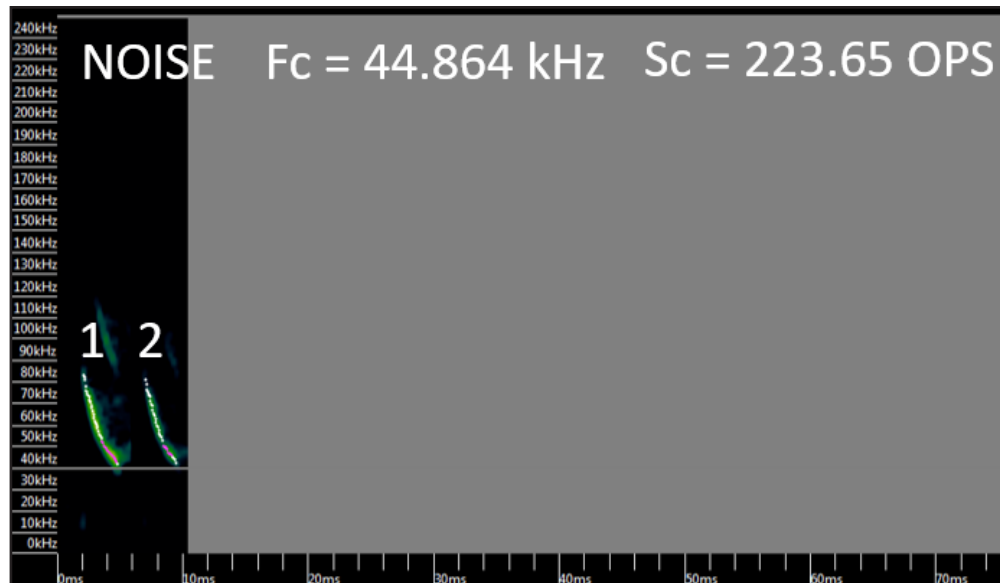


Figure 247. **NOISE** includes files that have less than three pulses in ZC; the image above only has two pulses in ZC, and the image below has many pulses in FS but no pulses in ZC.

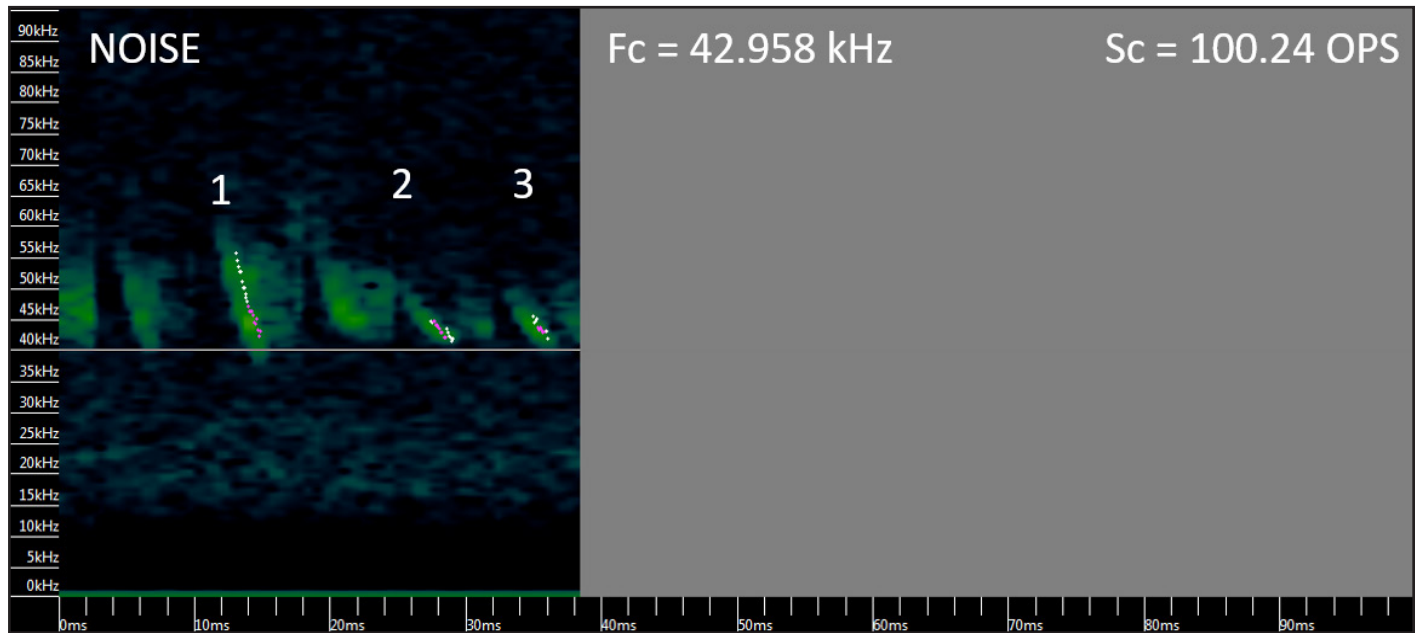


Figure 248. NOISE includes files with fractionated calls of poor quality that cannot be readily identified as bat calls.

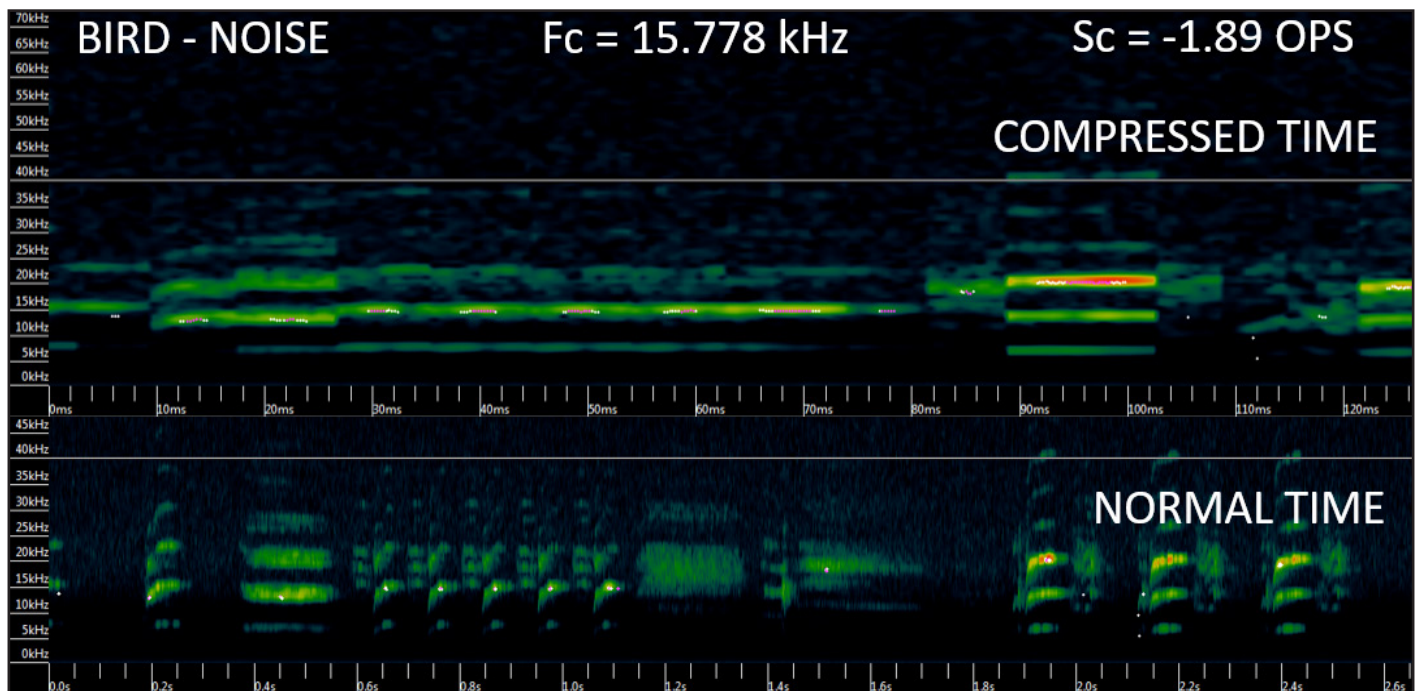


Figure 249. NOISE includes recordings of other animals, such as birds (as in this file) and insects.

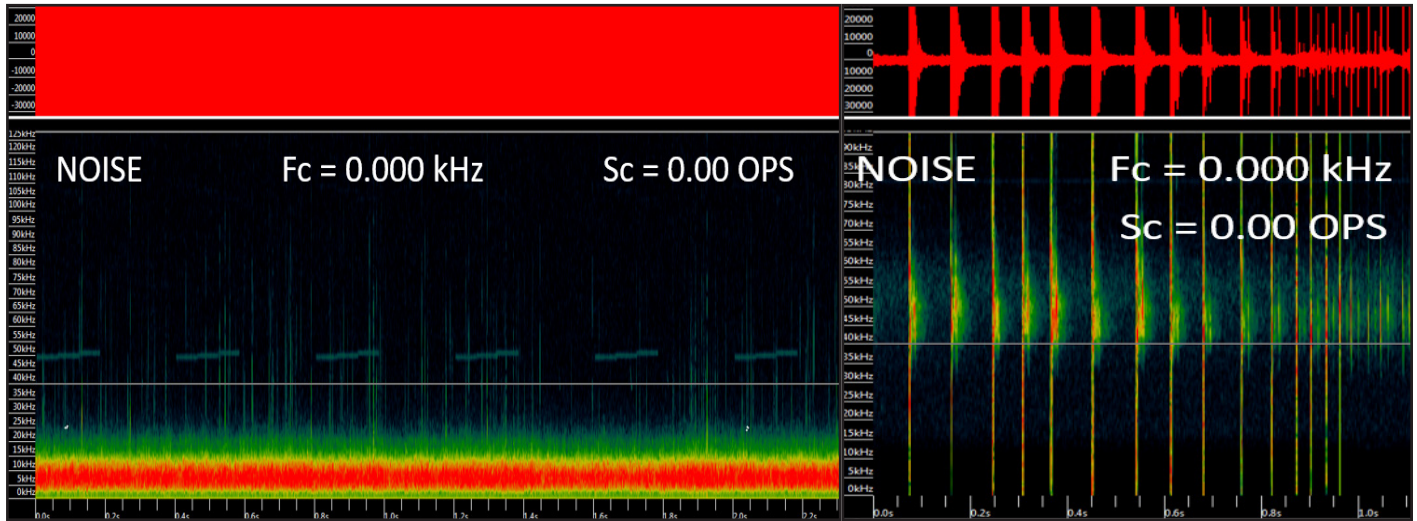


Figure 250. NOISE files which include mechanical/environmental sounds.

If the file appears to contain bat calls, the calls cannot be identified to species or common group, then the file can be identified as **NoID**.

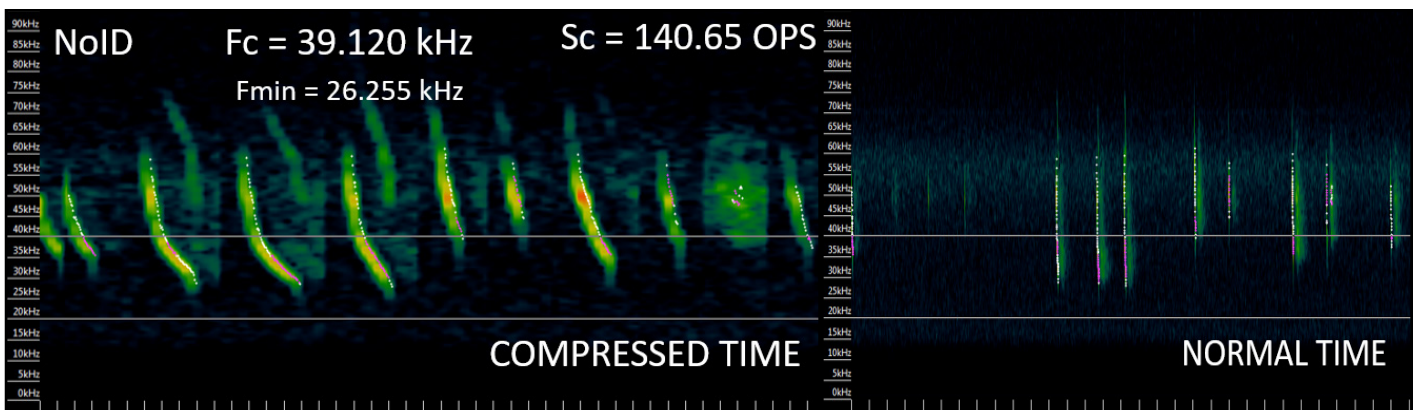


Figure 251. If the file appears to contain bat calls, the calls cannot be identified to species or common group, then the file can be identified as **NoID**.



4.7.3.14 Multi-bat Files

Sometimes a single recorded file will have the calls of more than one bat in it. Follow the instructions below when identifying these files:

1. Stationary Point Surveys

- a. Calls of two or more bats of the same species/species group:

If two or more bat calls of the same species or species group are identified in one file, then that file should be simply labelled with the species name or species group name. It is not necessary to capture every call sequence of the same species because stationary point survey data are used primarily for species presence/absence, thus the number of call sequences per species is not required for any calculations.

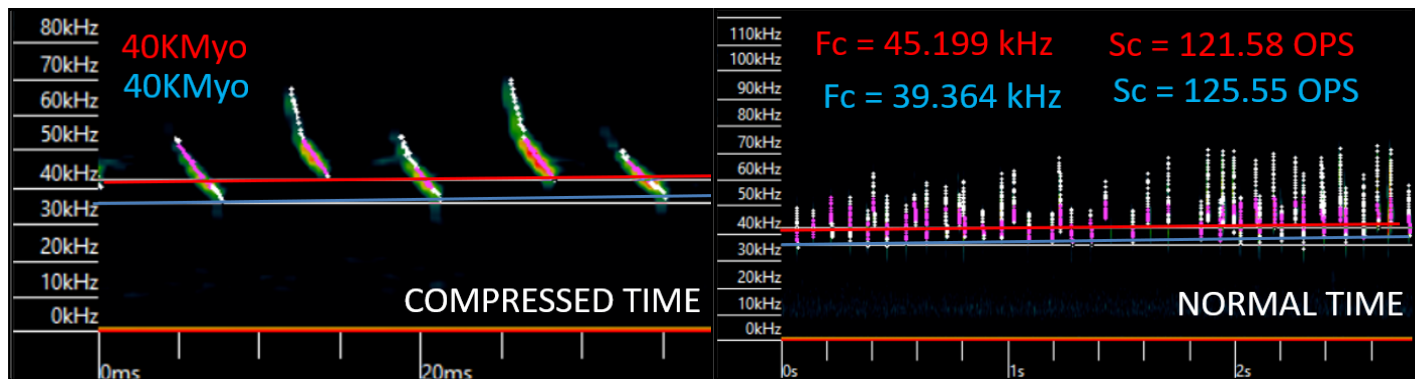


Figure 252. A file may contain calls of two or more bats of the same species/species group.

- b. Calls of two or more bats of different species/species groups:

If two or more bat calls of separate species or species groups are identified in one file, add a single additional row to represent each species or species group identified within the file. Copy all of the other data from the original file row into the new row(s); the only difference being the manual ID.

*Note: These rows will have to be manually added into both the meta.csv and the metadata.csv file created in Section 4.8.1.

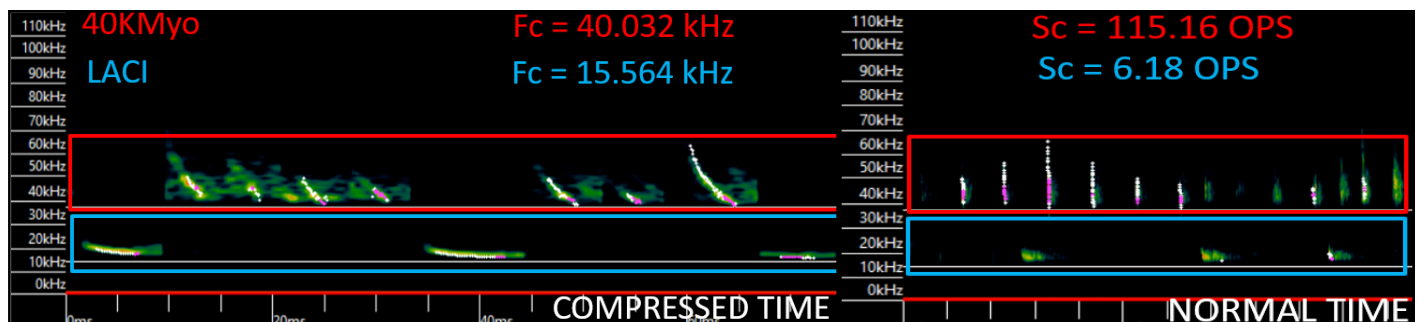


Figure 253. A file may contain calls of two or more bats of different species/species groups.



2. Mobile Transects

Two or more bats of the same species/species groups OR two or more bats of different species/species groups:

Mobile survey data can be used to calculate species relative abundance, so it is important that each bat is recorded individually, regardless of species or species group. Therefore, every bat recorded in a file requires a new row in the spreadsheet with all of the data from the original row copied to the new row. Ensure the manual ID species name is correct for each new addition to the spreadsheet.

*Note: These rows will have to be manually added into both the meta.csv and the metadata.csv file created in *Section 4.8.1*.

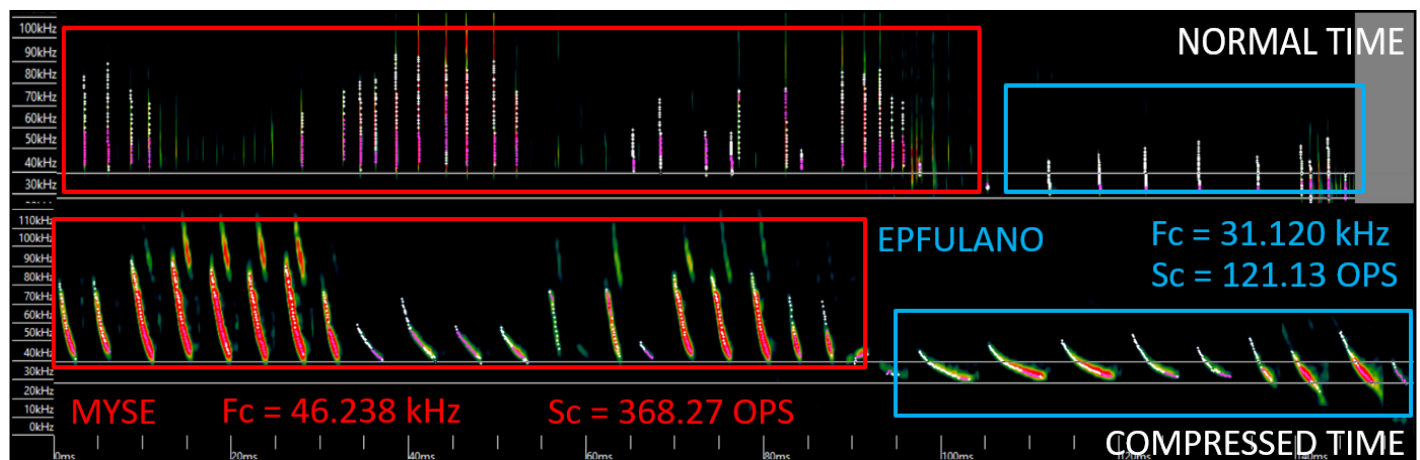


Figure 254. A file may contain calls of two or more bats of different species/species groups.

4.8 Uploading Data to the NABat Website

4.8.1 Uploading Stationary Point Survey Acoustic Data

When all of the files for a GRTS cell have been manually identified, the data can be uploaded to the NABat website.

Step 1- Open the Kaleidoscope converter.

Step 2- Under the “Batch” tab, under INPUTS “Input directory:” click on the “Browse” button, and select the file folder for ALL of the stationary sites from within the Processed Data folder (the Stationary Survey subfolder).

Step 3- Under OUTPUTS “Output directory:” click on the “Browse” button, and select the Stationary Survey Metadata subfolder within the Processed Data subfolder.

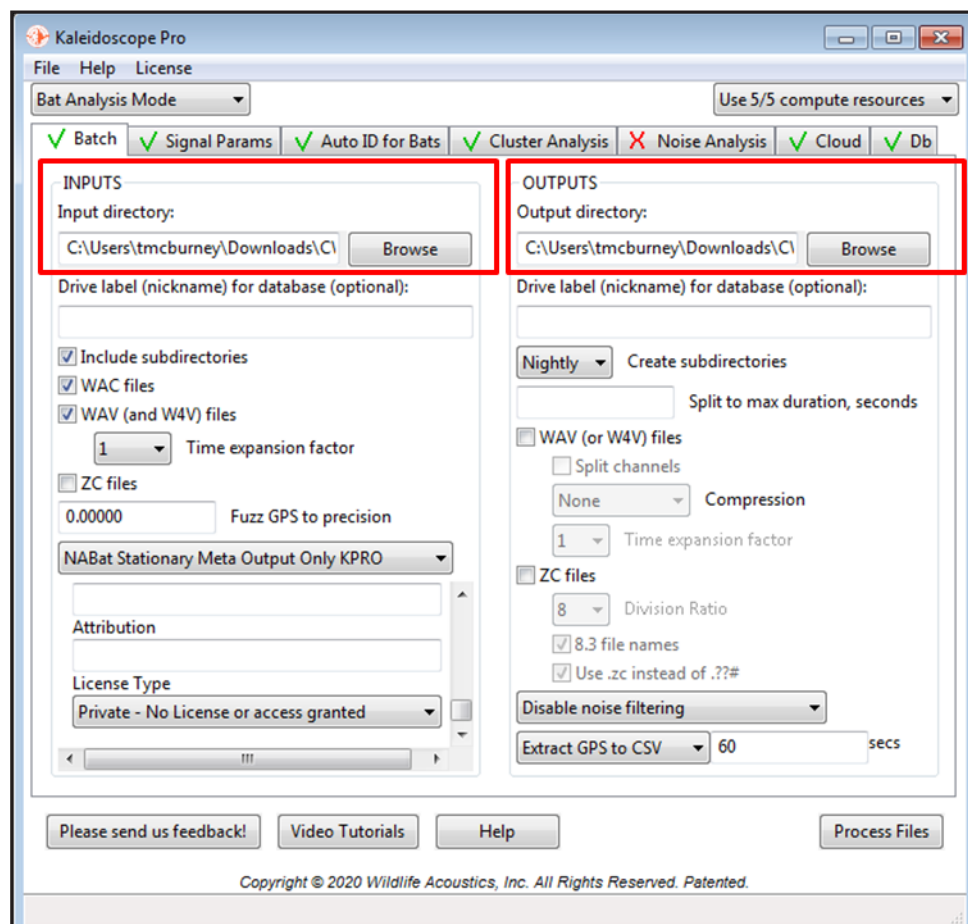


Figure 255. Select file folders for “Input directory” and “Output directory” (Steps 2 and 3).



Step 4- Next, change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” and select the file that was downloaded in *Section 4.4 Step 1*:

NABat_Stationary_Meta_Output_Only_KPRO.xml

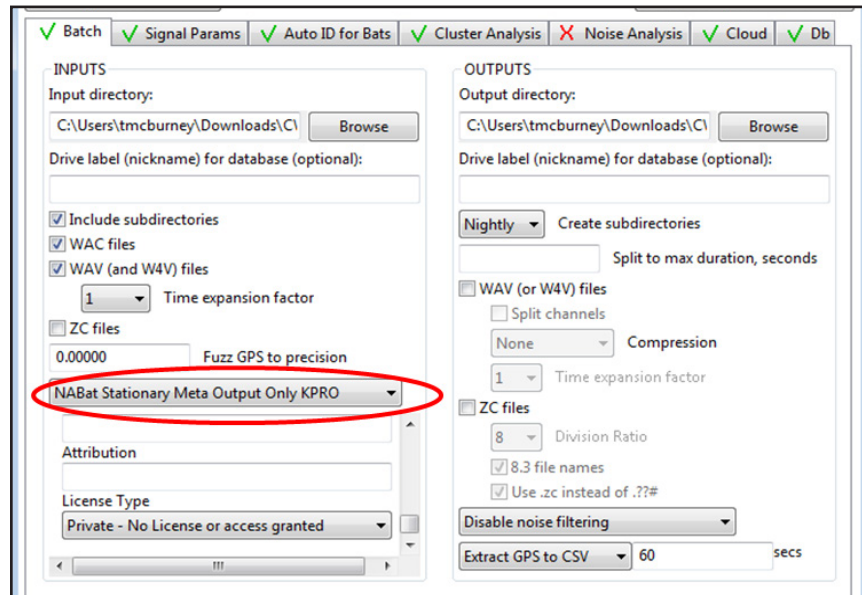


Figure 256. Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” (Step 4).

Step 5- Then next to “WAV” and “ZC files”, UNSELECT both boxes so additional acoustic data files are not created.

Step 6- Select the “Process Files” button on the bottom right.

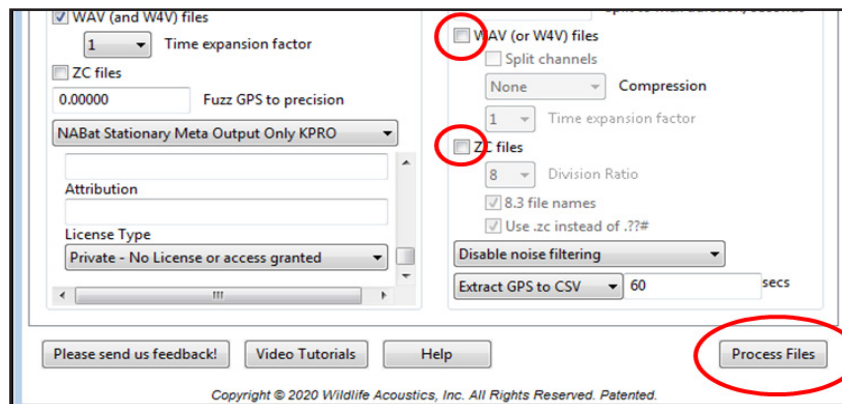


Figure 257. Unselect the boxes next to “WAV” and “ZC files” (Step 5), and select the “Process Files” button on the bottom right (Step 6).



*Note: When Kaleidoscope processes the meta output file, it automatically will create the following in the stationary survey metadata folder:

- **log.txt** (this file keeps a record of each step of the file processing and can be used for diagnostics if an error occurs)
- **settings.ini** (this file keeps a record of the settings used in the Kaleidoscope converter window during data processing)

These settings can be reloaded into the Kaleidoscope converter by opening the converter and selecting “File”, “Load Settings”, and then selecting the desired settings.ini file.

- **gps.csv** (this file contains the GPS data for each file if the “Extract GPS to CSV” setting was selected, if the “Extract GPS to KML” setting was selected, this file will be gps.kml, if the “Extract GPS Disabled” was selected, there will be no GPS file)
- **meta.csv** (this file contains all of the metadata that were entered in the NABat metadata form in the Kaleidoscope converter window, in addition to providing a list of all the files recorded within that stationary point survey site, this spreadsheet is where the manual ID for each file will be added)

*Note: This meta.csv file is referred to elsewhere in the document as metadata.csv to distinguish the file from the other meta.csv file created when the data are processed through Kaleidoscope.

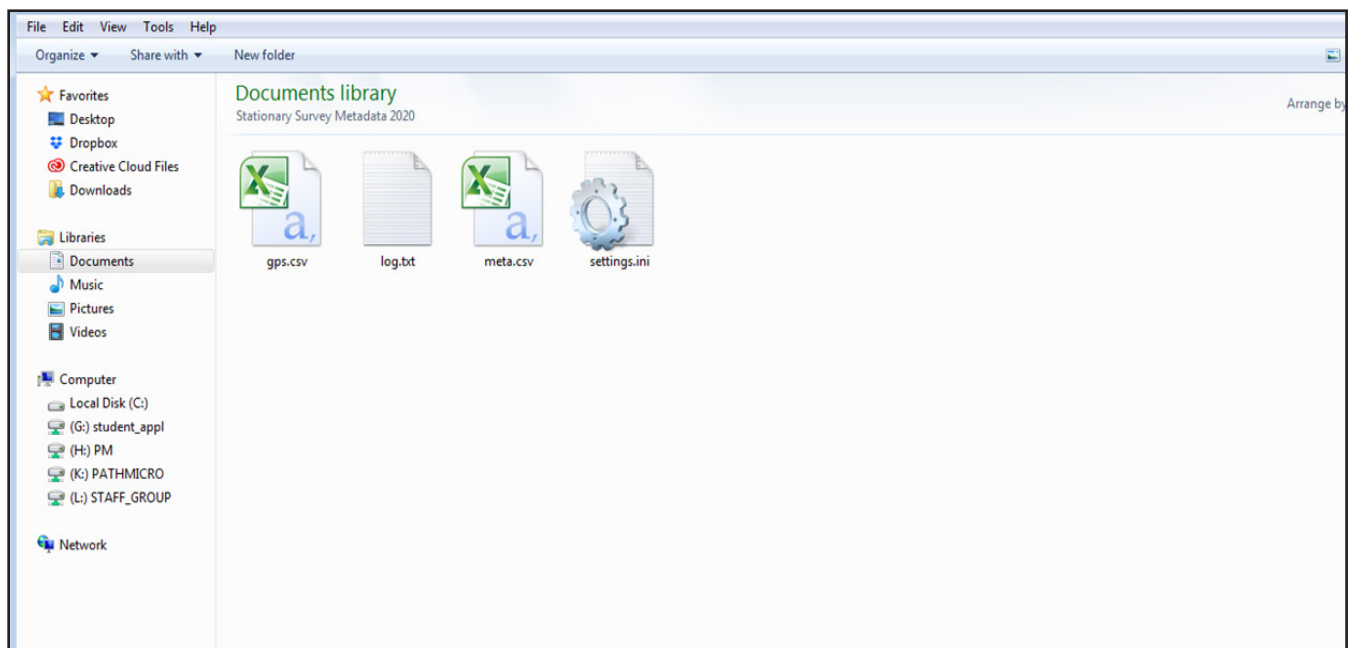


Figure 258. When Kaleidoscope processes the meta output file, it automatically will create new files.



If the Pro Version of the Kaleidoscope software is used for data processing, one other file will be created after data processing:

- **db-batch.wdb** (this file is used to upload metadata to a database, but this file will not be used for uploading data to the NABat database)

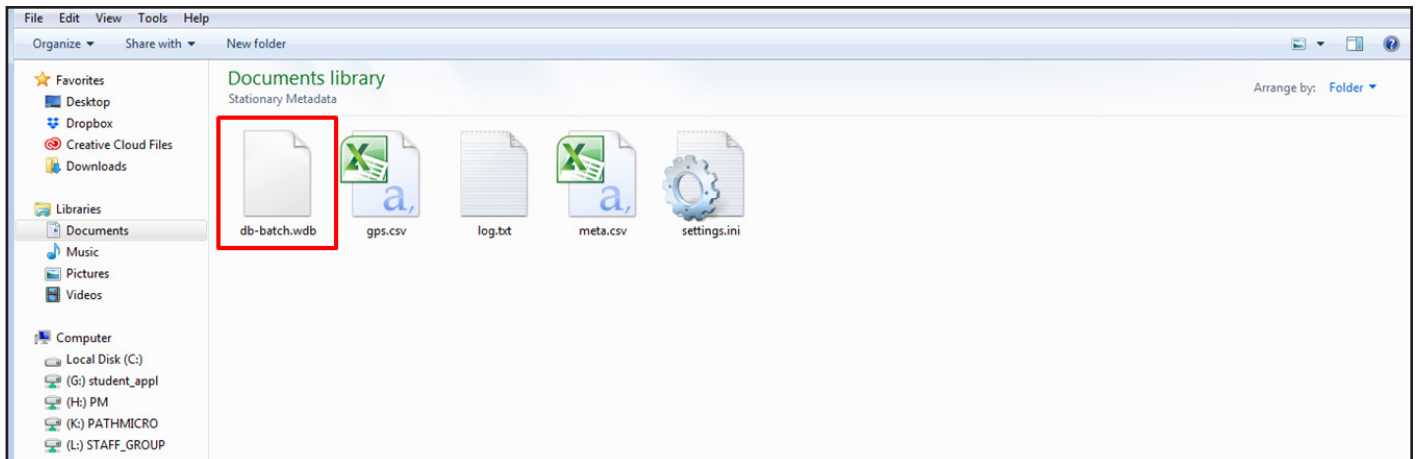


Figure 259. If the Pro Version of the Kaleidoscope software is used for data processing, one other file will be created after data processing.

Step 7- The new metadata file is now created. To review the file, open the metadata.csv in the Stationary Survey Metadata subfolder, and ensure that all of the columns, including manual ID, are filled in correctly.

*Note: If there are multi-bat files ensure that all of the necessary rows have been added (see Section 4.7.3.14).

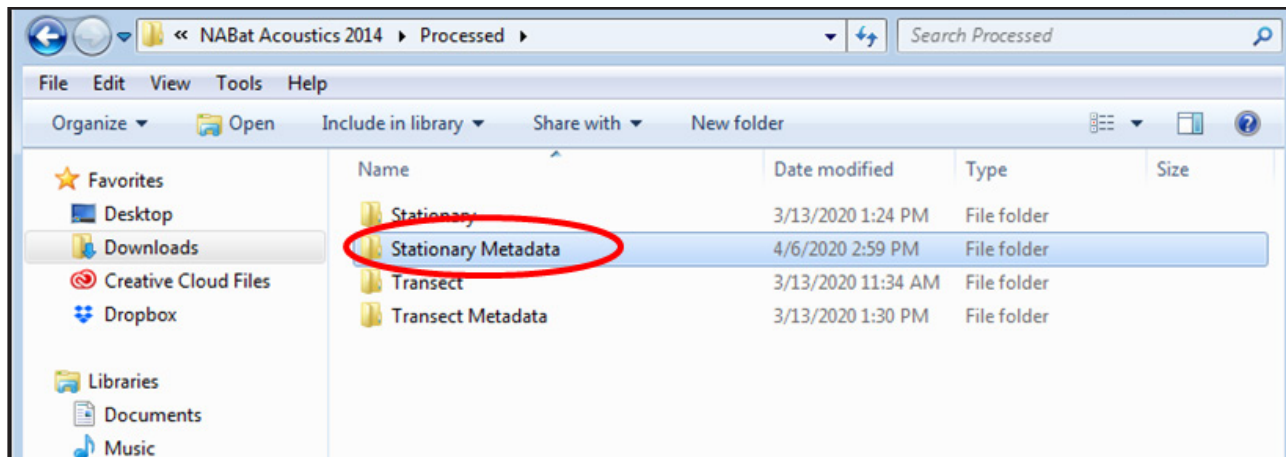


Figure 260. To review the file, open the metadata.csv in the Stationary Survey Metadata subfolder (Step 7).



Regardless if Kaleidoscope Free Version or Kaleidoscope Pro Version were used to manually identify the files, the Manual Id column in the metadata file should have filled in automatically. If some of the manual IDs are missing, those manual IDs will have to be either cut and pasted from the id.csv spreadsheet into the metadata spreadsheet (Kaleidoscope Pro Version), or the file will have to be re-opened in the Kaleidoscope viewer window and the manual ID found in the “Identification” field and then manually typed into the metadata spreadsheet (Kaleidoscope Free Version). If data are transferred from one spreadsheet to another, it is crucial that both spreadsheets are sorted the same way to prevent mislabelling of files. Both spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar (under the “Home” tab) and selecting “Custom Sort”.

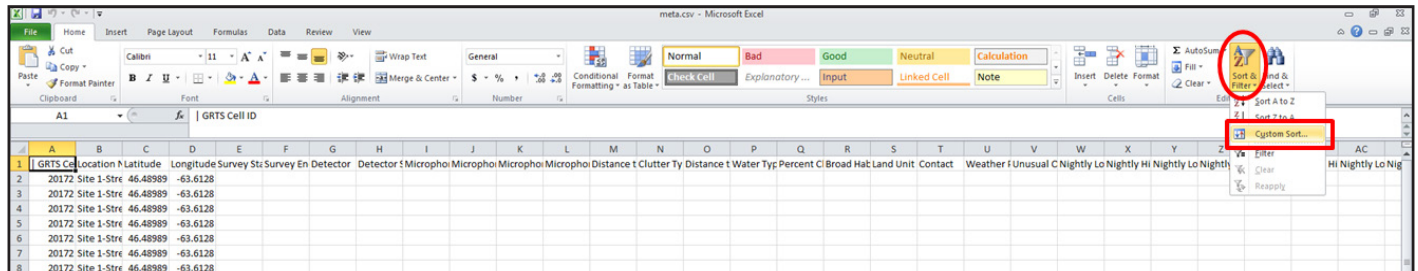


Figure 261. The spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar.

In the “Column” “Sort by” field select “Audio Recording Name (*wav *zc)” from the drop-down list, in the “Sort On” field select “Values”, and in the “Order” field select “A to Z”. This should sort the rows in the meta.csv spreadsheet to match the rows in the metadata file; however, this should be verified to prevent mislabelling of files. Once both spreadsheets are identically sorted, simply copy the MANUAL ID column from the meta.csv and paste it in the appropriate section of the Manual Id column in the metadata.csv.

*Note: If using the Kaleidoscope Pro Version, the id.csv should be sorted by “IN FILE” in the “Sort by” field.

*Note: The metadata file for stationary point surveys contains file information for ALL of the stationary point survey sites. When copying and pasting manual IDs, ensure that the manual IDs from a certain site are added to the correct site in the metadata file.

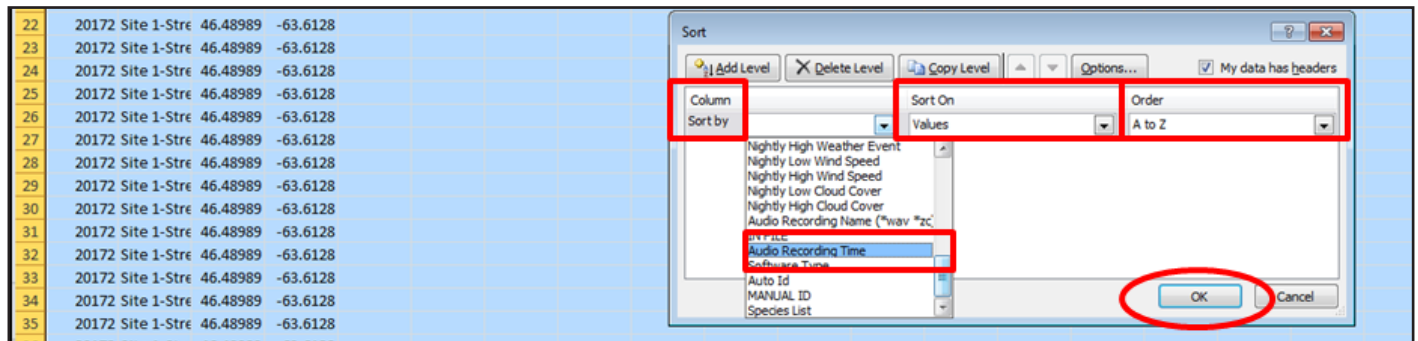


Figure 262. In the “Column” “Sort by” field select “Audio Recording Name (*wav *zc)” from the drop-down list.



Step 8- Rename the metadata.csv with a descriptive and original name that will NOT be able to be duplicated (e.g., CWHC NABat Stationary Survey 2020).

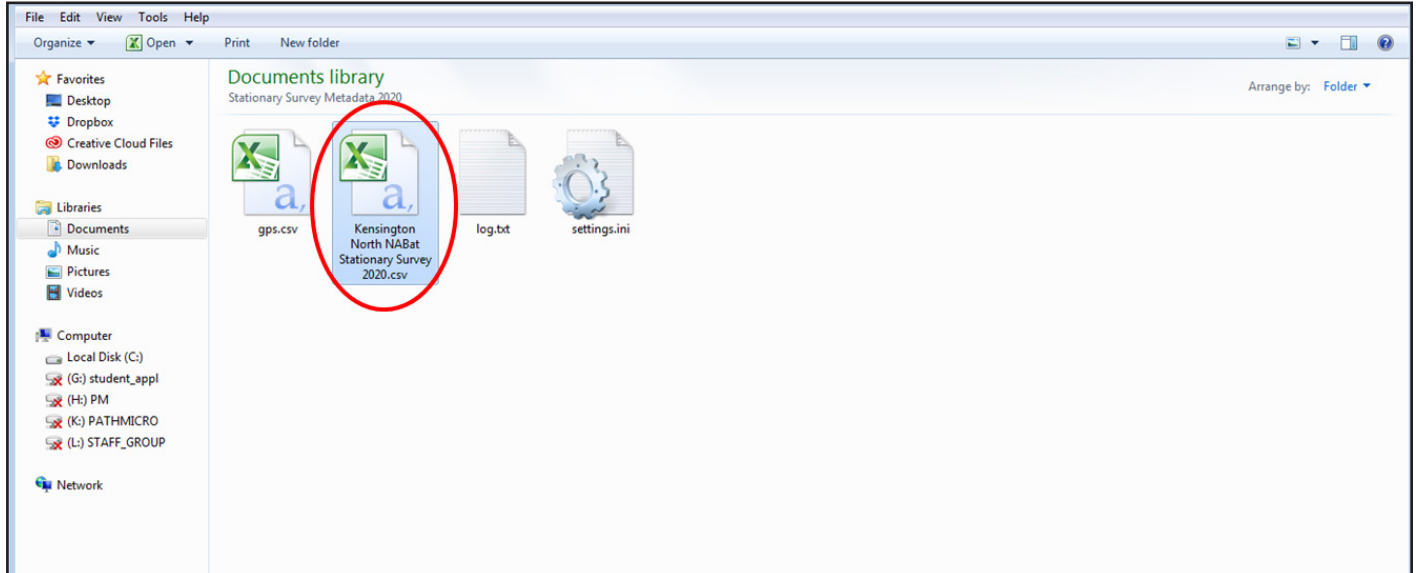


Figure 263. Rename the metadata.csv with a descriptive and original name (Step 8).

Step 9- Go to the NABat Projects page and select the project created in Section 4.2.2 from the table at the bottom of the page.

Step 10- On the new page, click the turquoise “Upload Survey Data” button in the top right corner.

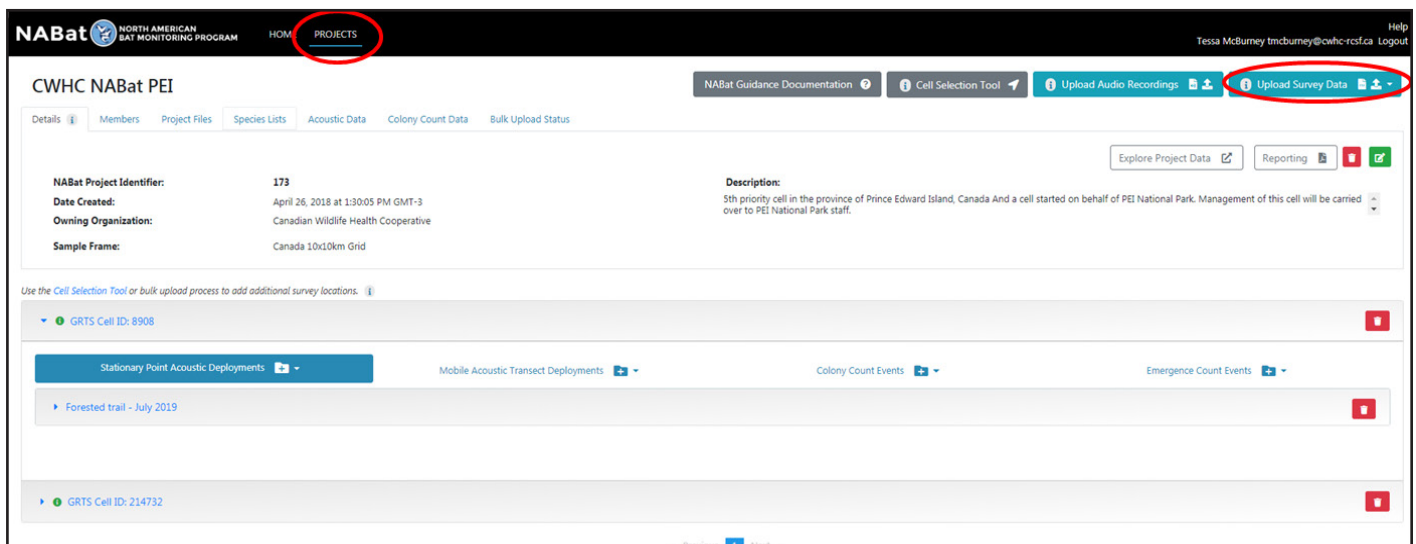


Figure 264. Click the turquoise “Upload Survey Data” button in the top right corner of the page for the desired project (Step 10).



Step 11- Select “Stationary Acoustic Point”.

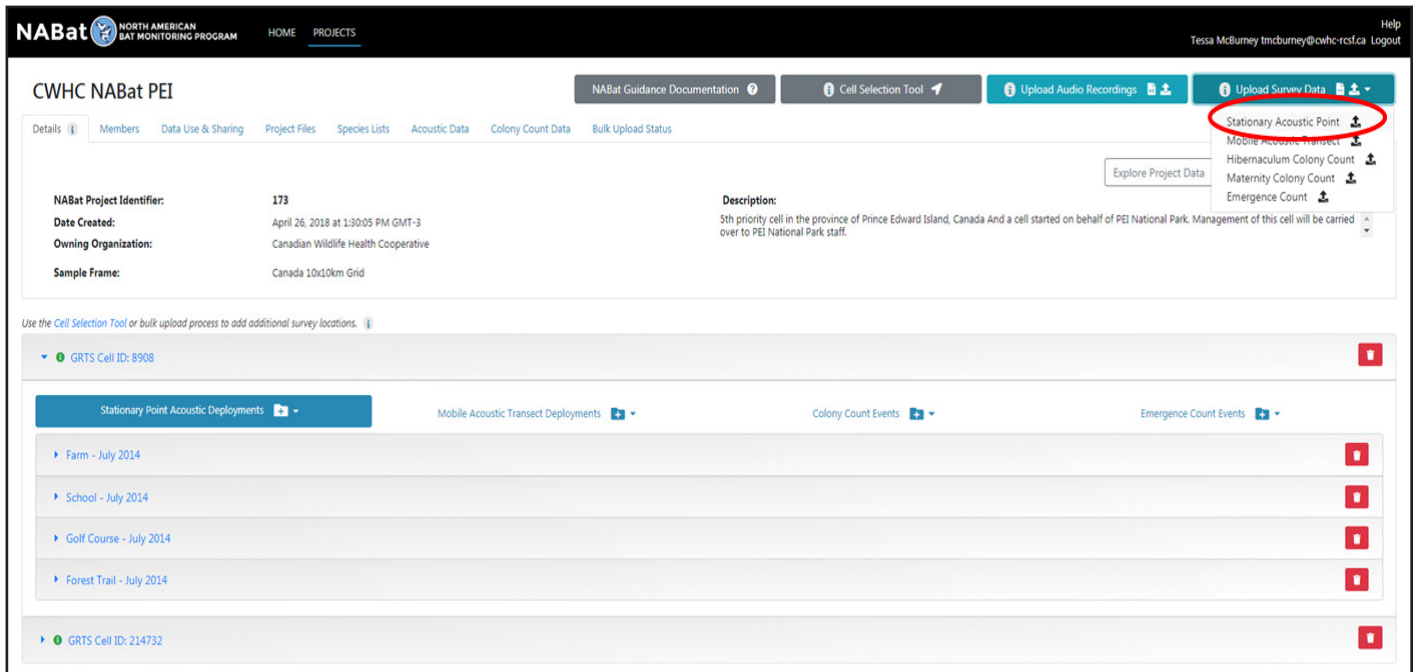


Figure 265. Select “Stationary Acoustic Point” (Step 11).

Step 12- Select the “Full Metadata” button.

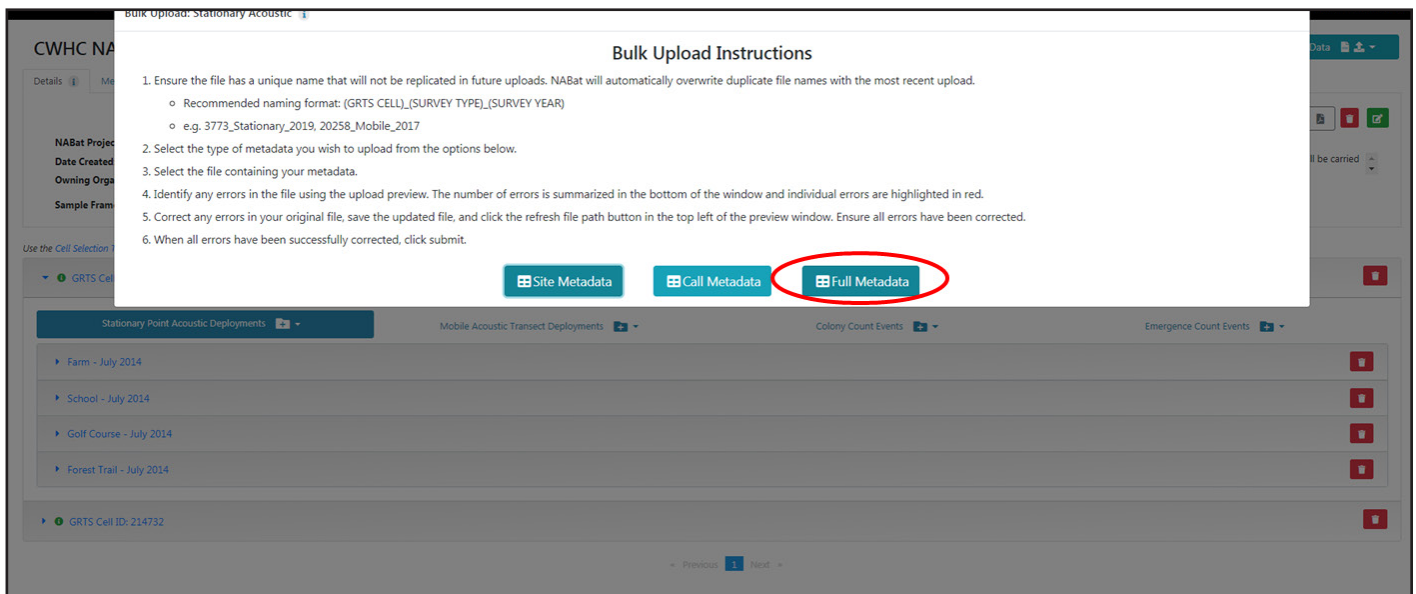


Figure 266. Select the “Full Metadata” button (Step 12).



Then the blue “Select File” button in the bottom right.

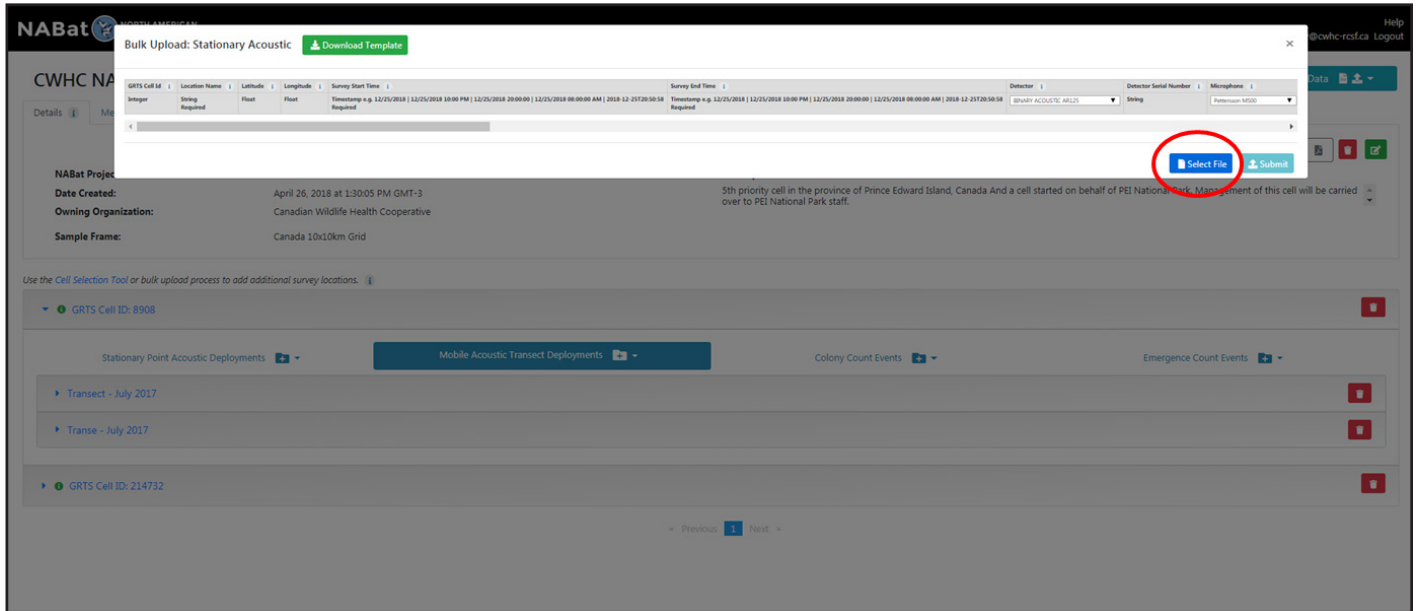


Figure 267. Then the blue “Select File” button in the bottom right (Step 12).

Step 13- Select the metadata.csv file that was renamed in *Step 8*.

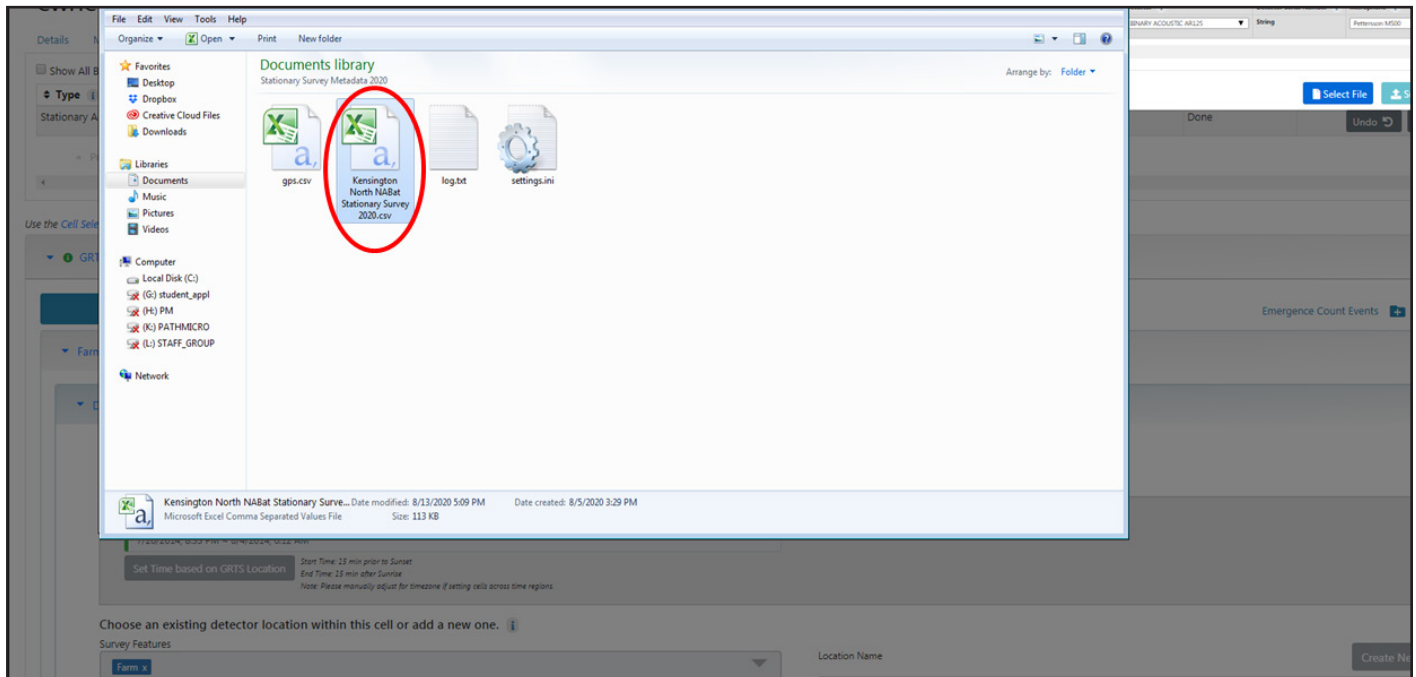


Figure 268. Select the metadata.csv file that was renamed in *Step 8* (Step 13).



This will result in a bulk upload table. It will assess the first 300 rows of data for errors, which can be seen at the bottom “Document Preview: Discovered # error(s) in # row(s).”

Document Preview: Discovered 1 error(s) in 102 row(s) ✓ Matched 38 Column(s) ✗ Missing 0 Column(s) ⚠ 0 Extra Column(s)

Figure 269. The bulk upload table will assess the first 300 rows of data for errors.

In the bulk upload table the errors are shown in red.

Document Preview: Discovered 1 error(s) in 102 row(s) ✓ Matched 38 Column(s) ✗ Missing 0 Column(s) ⚠ 0 Extra Column(s)

Figure 270. In the bulk upload table the errors are shown in red.



The drop-down list under the column title can be clicked to see examples of how the column should be formatted.

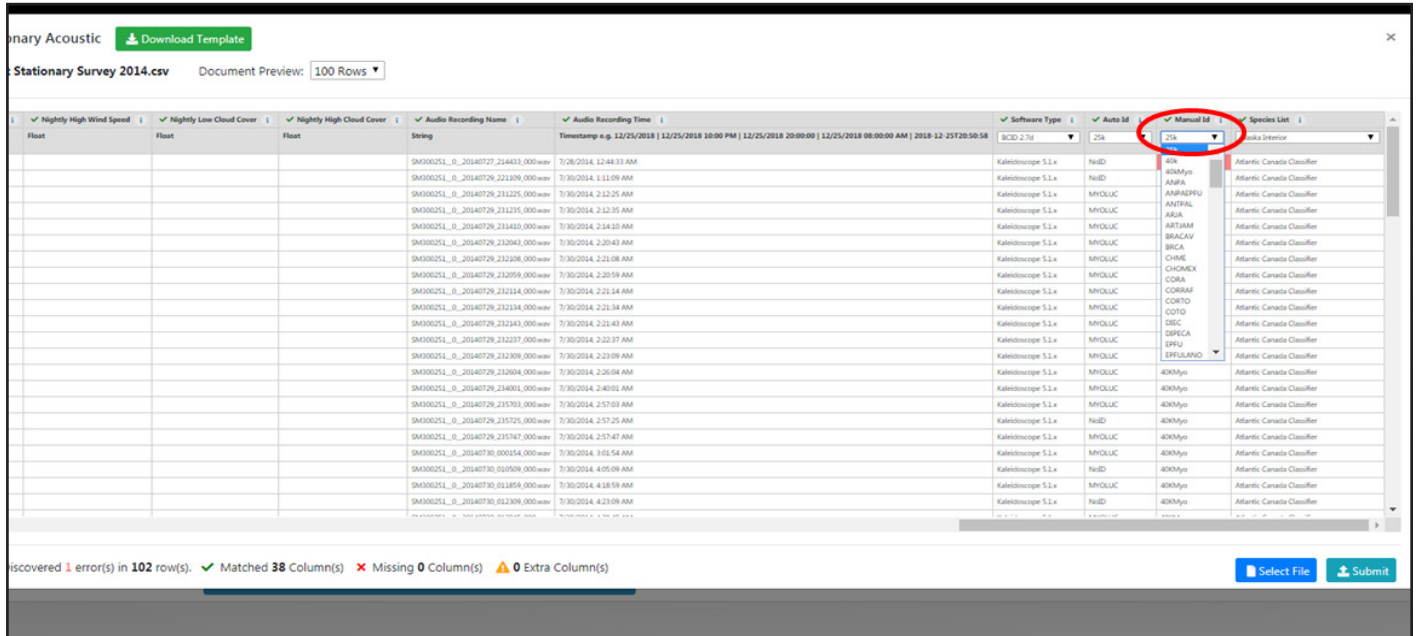


Figure 271. The drop-down list under the column title can be clicked to see examples of how the column should be formatted.

The bottom of the bulk upload table will also indicate if any columns are missing.

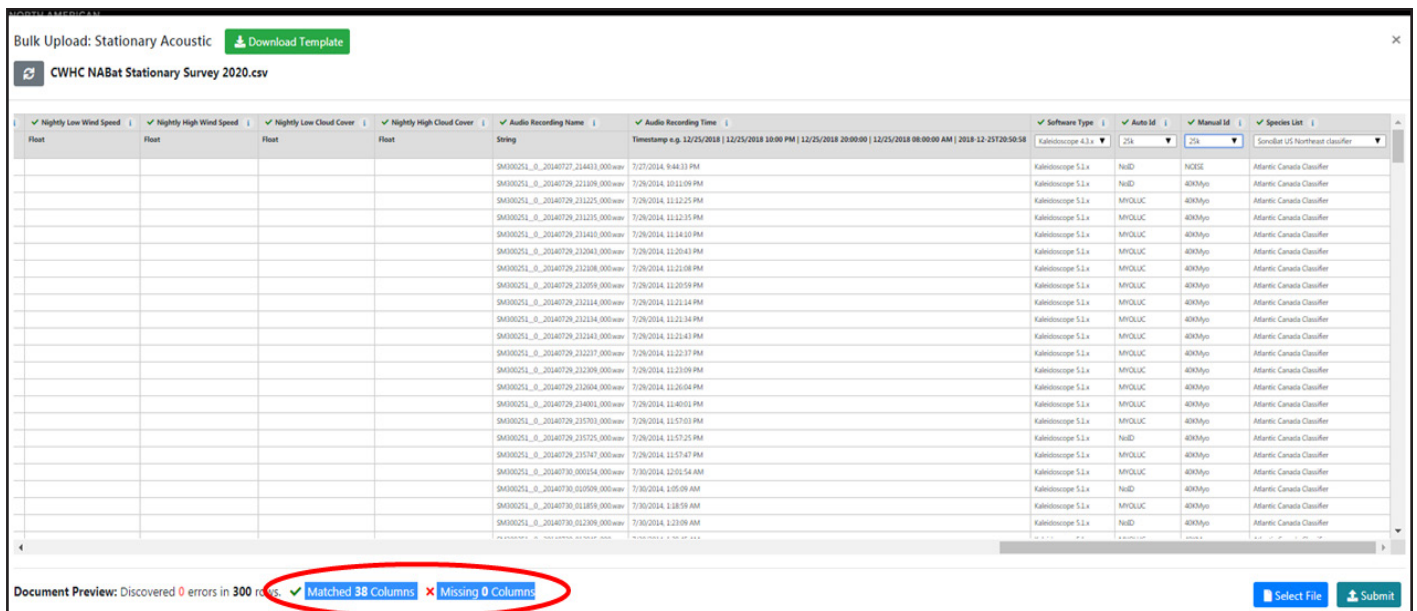


Figure 272. The bottom of the bulk upload table will also indicate if any columns are missing.



Either go back into the metadata file to fix the errors now (recommended) or submit the files and fix the errors afterwards.

Step 14- When the data are ready to be submitted, click on the teal “Submit” button in the bottom right corner of the bulk upload table and it will indicate if there are any more issues with the data after they are submitted.



Figure 273. When the data are ready to be submitted, click on the teal “Submit” button in the bottom right corner of the bulk upload table (Step 14).

Step 15- At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload. Click the blue hyperlink in the “Errors Found” column to download a .csv highlighting the location of the errors in the metadata sheet. It is crucial to fix these errors, because NABat will ignore any data with errors, and that data will not be uploaded to the website. To delete a metadata.csv with errors, find the file in the table under the “Bulk Upload Status” tab and select the grey “Undo” button under the “Action” column. Once the errors are corrected in the original metadata.csv sheet, re-upload the metadata.csv sheet as described in Steps 9-15.

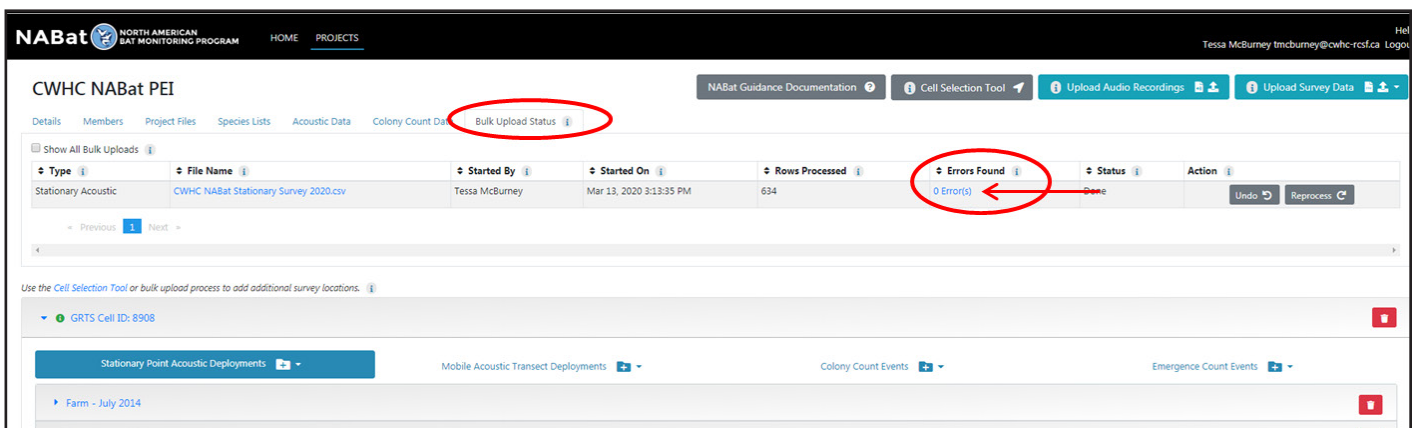


Figure 274. At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload (Step 15).



When this is completed and no errors are identified, the survey sites and accompanying uploaded data will be under the “Stationary Point Acoustic Deployments” tab. Under each site there are other tabs that can be selected:

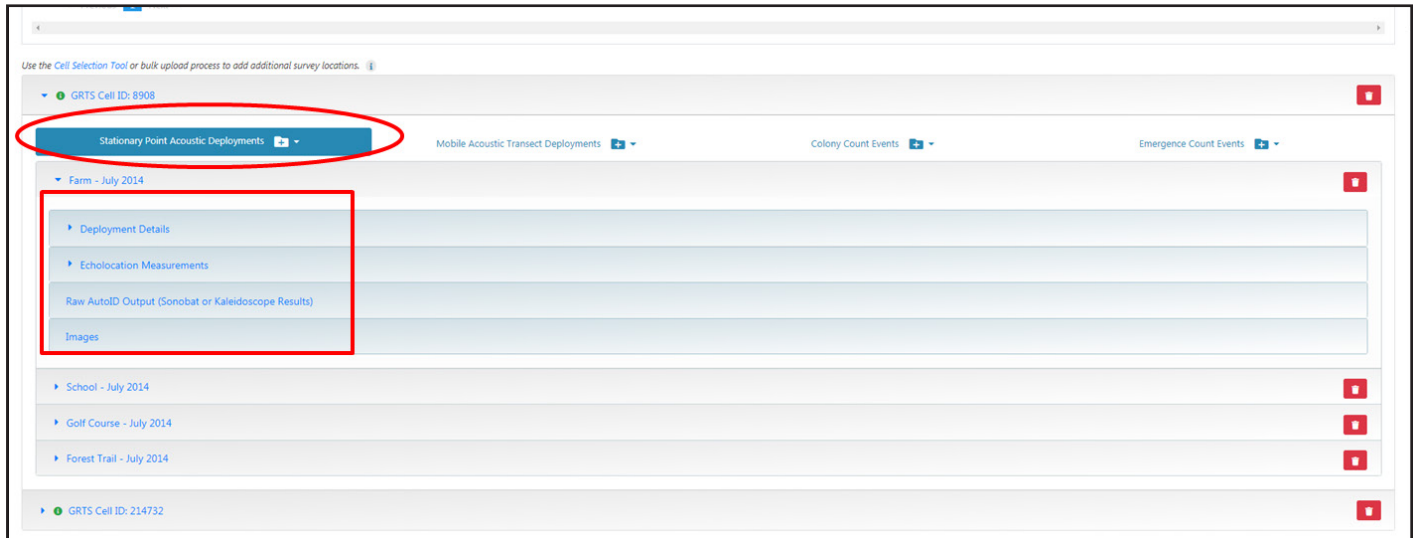


Figure 275. The survey sites and accompanying uploaded data will be under the “Stationary Point Acoustic Deployments” tab.

- “**Deployment Details**” has all of the information that was submitted about equipment deployment, including equipment type and placement.

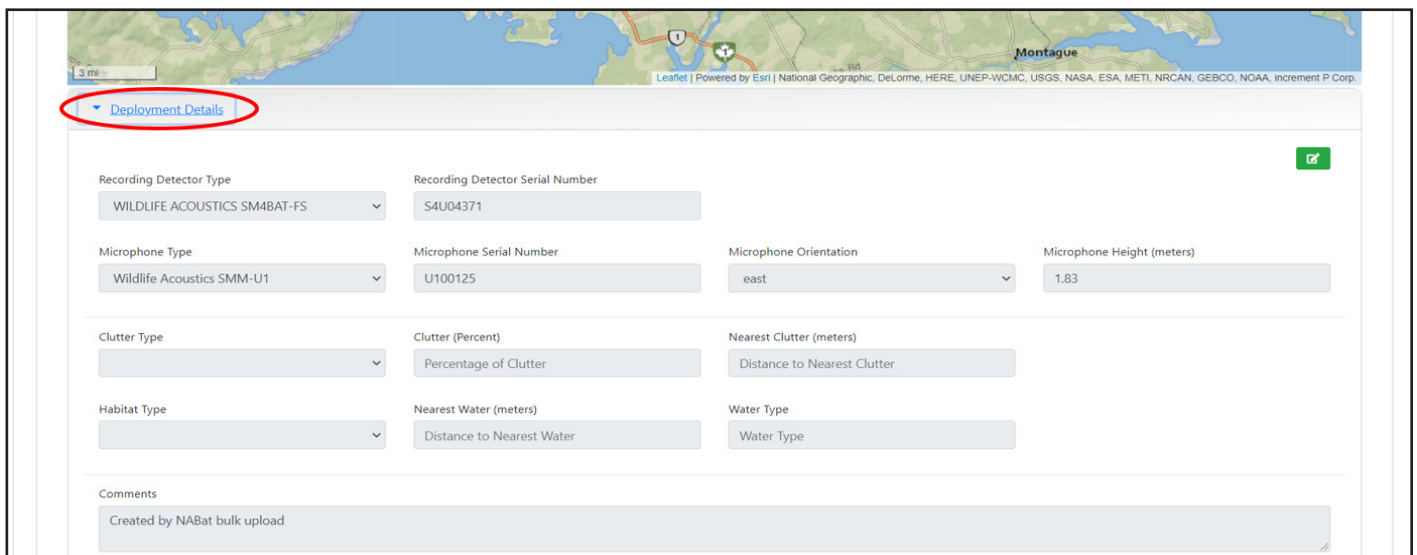


Figure 276. “**Deployment Details**” has all of the information that was submitted about equipment deployment.



- “Echolocation Measurements” gives a summary about the acoustic files and species.

Stationary Point Acoustic Deployment Values

Auto ID	Manual ID	Species
7	0	Lasiurus borealis (LABO) Eastern red bat
1	1	Lasiurus cinereus (LAC) Hoary bat
298	0	Myotis lucifugus (MYLU) Little brown bat
0	1	Not a bat (NOISE) Not a bat
88	0	(NoID) Bat but no grouping or user-defined category applies
0	392	(40kMyo) Various species of Myotis with pulses that have a minimum frequency in the range of 35-40 kHz

Audio Recording	Recording Time	Software	Species List	Species (Auto ID)	Species (Manual ID)
SM300251_0_20140727_214433_000.wav	7/27/2014, 9:44:33 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	(NoID) Bat but no grouping or user-defined category applies	Not a bat (NOISE) Not a bat
SM300251_0_20140729_221109_000.wav	7/29/2014, 10:11:09 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	(NoID) Bat but no grouping or user-defined category applies	(40kMyo) Various species of Myotis with pulses that have a minimum freq
SM300251_0_20140729_231225_000.wav	7/29/2014, 11:12:25 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	Myotis lucifugus (MYLU) Little brown bat	(40kMyo) Various species of Myotis with pulses that have a minimum freq
SM300251_0_20140729_231235_000.wav	7/29/2014, 11:12:35 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	Myotis lucifugus (MYLU) Little brown bat	(40kMyo) Various species of Myotis with pulses that have a minimum freq
SM300251_0_20140729_231410_000.wav	7/29/2014, 11:14:10 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	Myotis lucifugus (MYLU) Little brown bat	(40kMyo) Various species of Myotis with pulses that have a minimum freq
SM300251_0_20140729_232043_000.wav	7/29/2014, 11:20:43 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	Myotis lucifugus (MYLU) Little brown bat	(40kMyo) Various species of Myotis with pulses that have a minimum freq
SM300251_0_20140729_232059_000.wav	7/29/2014, 11:20:59 PM	Kaleidoscope (S.L.x)	Atlantic Canada Classifi	Myotis lucifugus (MYLU) Little brown bat	(40kMyo) Various species of Myotis with pulses that have a minimum freq

Figure 277. “Echolocation measurements” gives a summary about the acoustic files and species.

- The “Raw AutoID Output (Sonobat or Kaleidoscope Results)” tab allows uploading of the original Kaleidoscope meta.csv output with the other uploaded data. Click on the turquoise “Upload Raw AutoID Files” on the right and select the appropriate files. As they are all automatically named meta.csv by Kaleidoscope, before uploading the files ensure they are given a unique name so they can be associated with the appropriate deployment site.

Raw AutoID Output (Sonobat or Kaleidoscope Results)

Upload/Share Raw AutoID Files

File Name	Size	Last Modified
Farm id.csv	20,154 KB	Mar 13, 2020, 6:00:37 PM

Upload Raw AutoID Files

Figure 278. The “Raw AutoID Output (Sonobat or Kaleidoscope Results)” tab allows uploading of the original Kaleidoscope meta.csv output.



- Under the “**Images**” tab photos of the site and site set-up can be uploaded, which is recommended. Select the turquoise “Upload Deployment Images” button on the right.

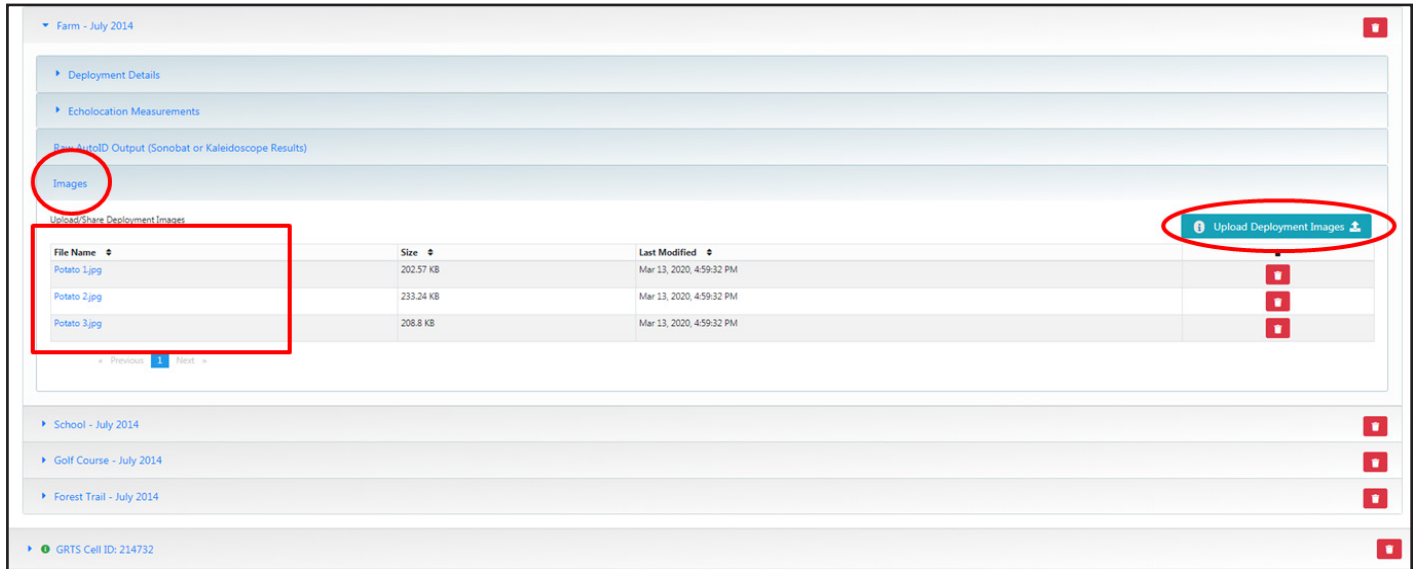


Figure 279. Under the “**Images**” tab photos of the site and site set-up can be uploaded.

Then choose the blue “Select Files” button. Select the image files to be uploaded and then select the green “Upload” button on the bottom right of the pop-up window.

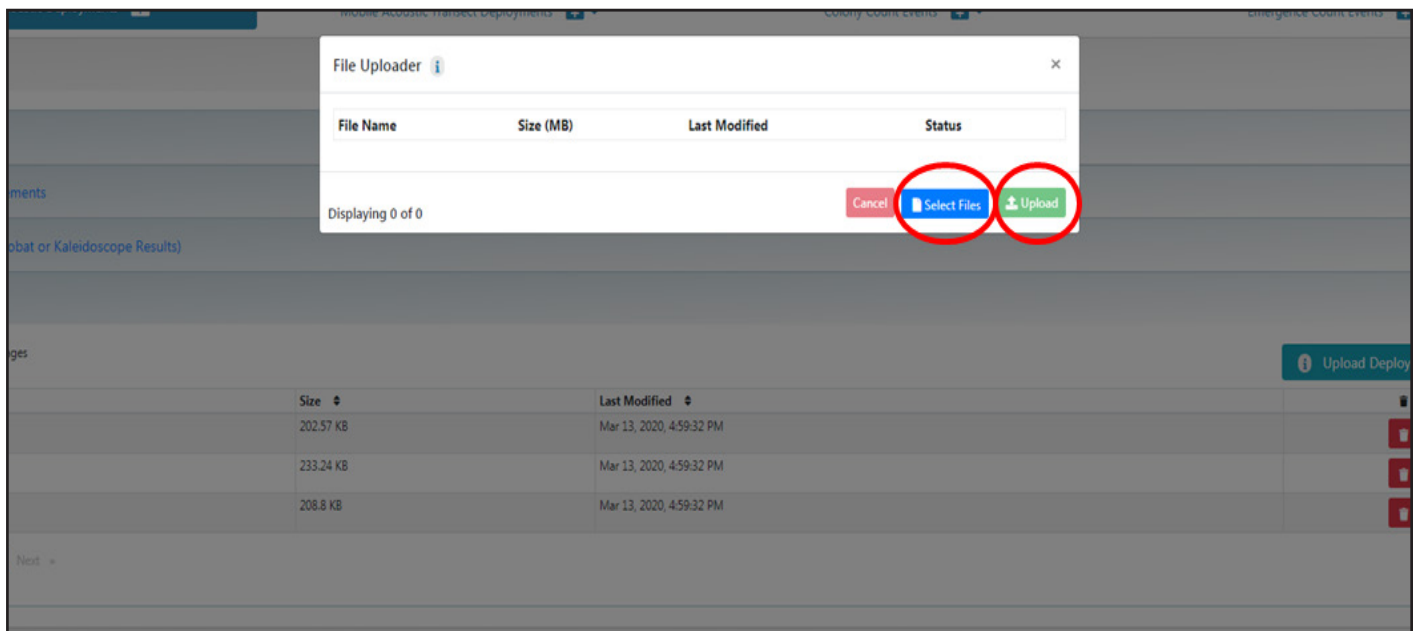


Figure 280. Choose the blue “Select Files” button, select the image files to be uploaded, and then select the green “Upload” button on the bottom right of the pop-up window.



Another option is to upload acoustic files directly to the NABat website. This is good practice because it creates a back-up for all of the acoustic data files and enables other individuals working on the same project to access the files. Under “Projects” select the teal “Upload Audio Recordings” button on the top right of the page.

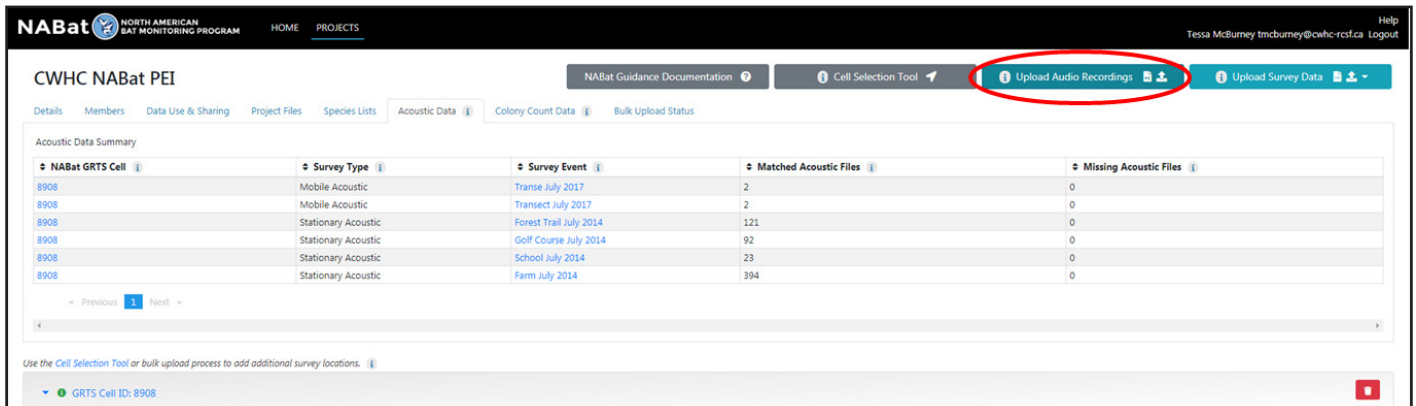


Figure 281. To upload acoustic files, under “Projects” select the teal “Upload Audio Recordings” button on the top right of the page.

Select the blue “Select Files” button and choose all of the processed NABat audio files to be uploaded to the project. It will take time for the files to upload, so select a small number of files at a time (*i.e.*, not thousands of files at one time) to process. Once all of the files are chosen, select the green “Upload” button on the bottom right of the window.

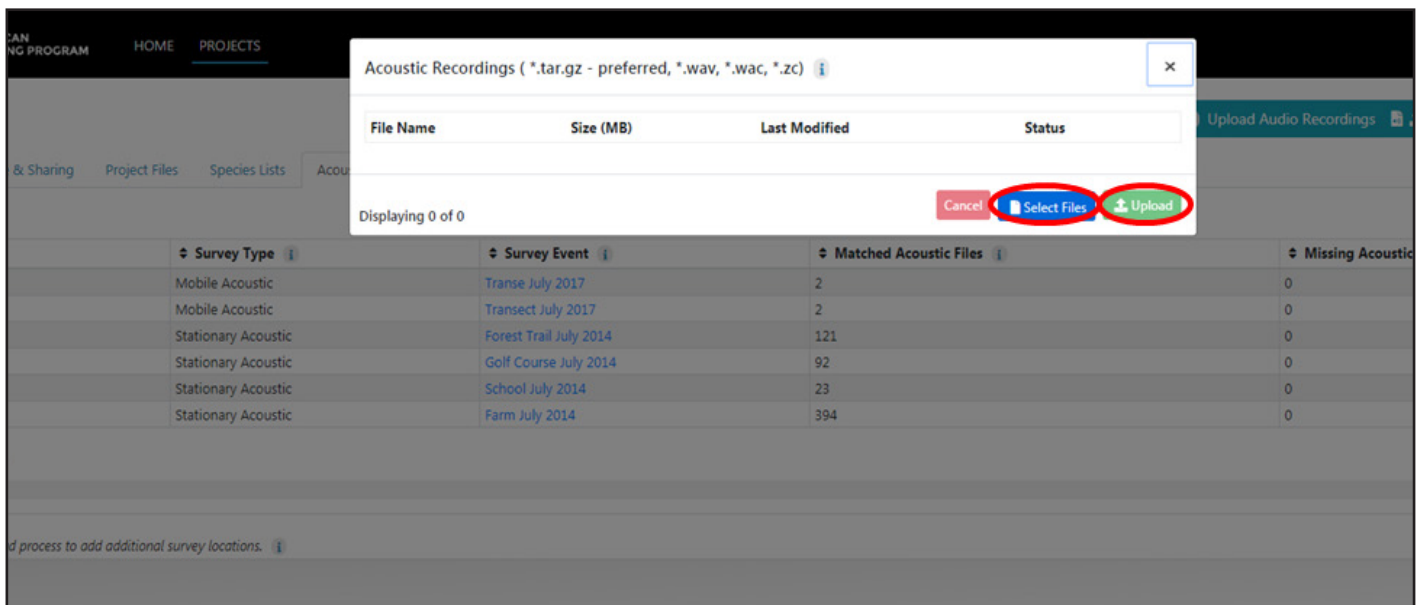


Figure 282. Select the blue “Select Files” button, and once all the files are chosen, select the green “Upload” button on the bottom right of the window.



When the data are all successfully uploaded, the website will automatically match the acoustic data file with the metadata sheet that was previously uploaded with all of the file names. To access a file, click on the survey site tab of interest in under “Stationary Point Acoustic Deployments” and then select the “Echolocation Measurements” tab. The file names in the table should now be blue (hyperlinks).

*Note: If the raw audio files are uploaded, the acoustic file will not be automatically matched to the file names. Upload the processed audio files.

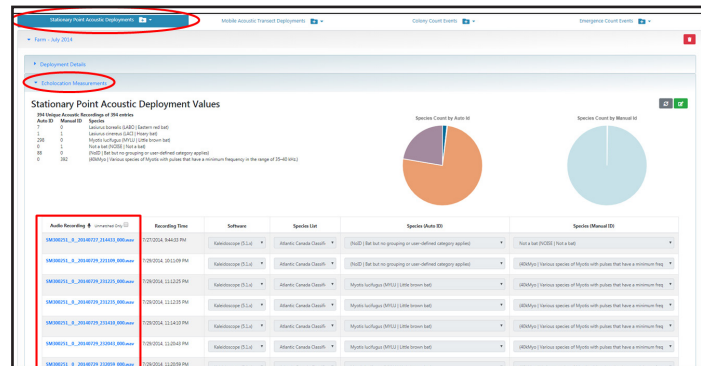


Figure 283. When the data are all successfully uploaded, the website will automatically match the acoustic data file with the metadata sheet that was previously uploaded with all of the file names.

When a blue file name is clicked, it will automatically download the file to the computer and the file will then be able to be examined with Kaleidoscope.

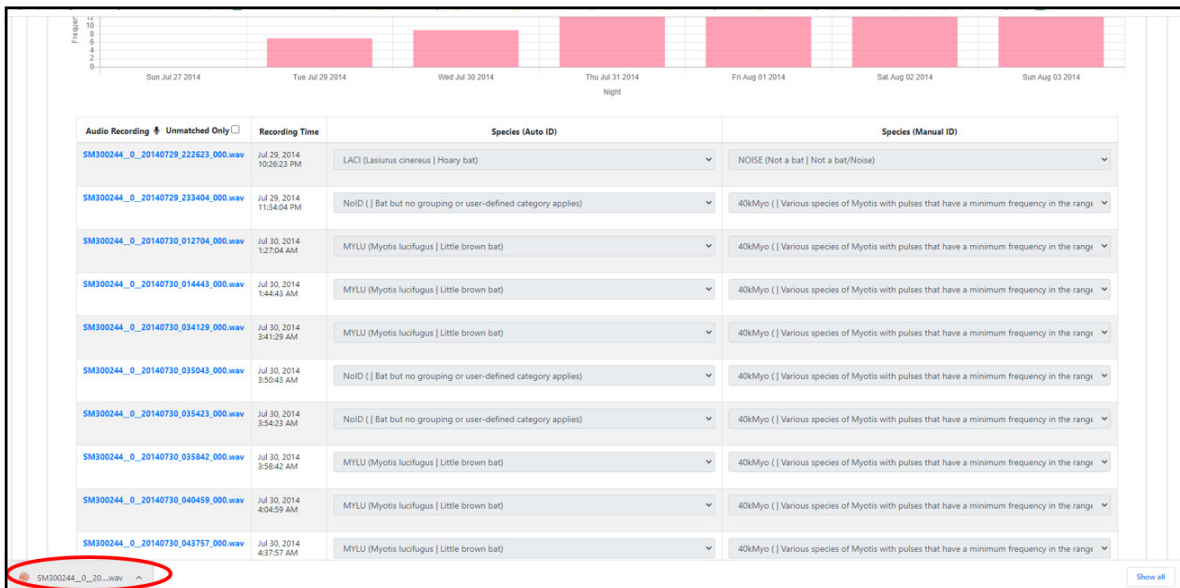


Figure 284. When a blue file name is clicked, it will automatically download the file to the computer and the file will then be able to be examined with Kaleidoscope.



4.8.2 Uploading Mobile Transect Acoustic Data

When all of the files for a GRTS cell have been manually identified, the data can be uploaded to the NABat website.

Step 1- Open the Kaleidoscope converter.

Step 2- Under the “Batch” tab, under INPUTS “Input directory:” click on the “Browse” button, and select the file folder for ALL of the mobile transects from within the Processed Data subfolder (the Mobile Transect subfolder).

Step 3- Under OUTPUTS “Output directory:” click on the “Browse” button, and select the Mobile Transect Metadata subfolder within the Processed Data subfolder.

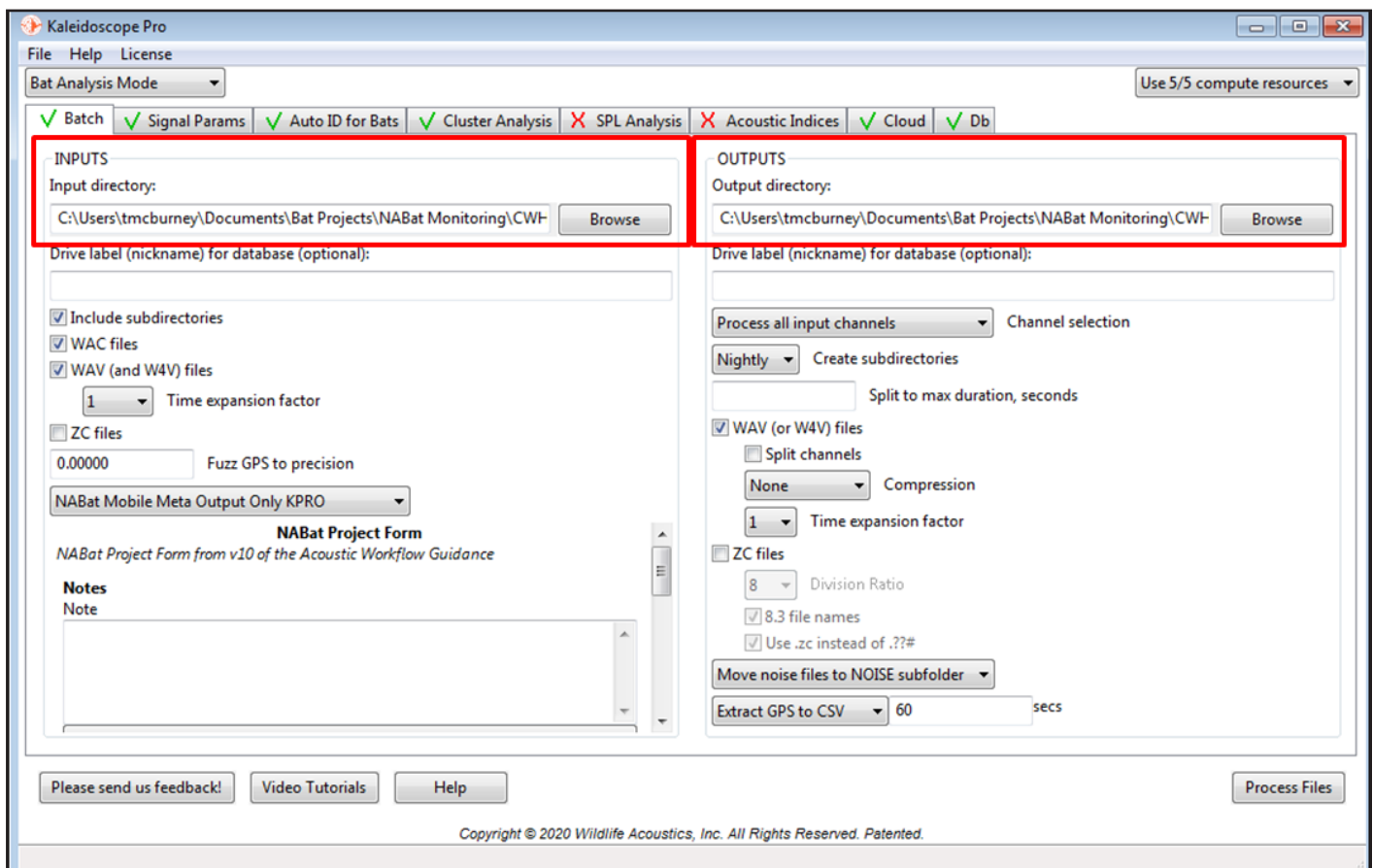


Figure 285. Select file folders for “Input directory” and “Output directory” (Steps 2 and 3).



Step 4- Next, change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” and select the file that was downloaded in *Section 4.4 Step 1*:

NABat_Mobile_Meta_Output_Only_KPRO.xml

Figure 286. Change the drop-down list from “Default Project Form” to “Add or Replace a Project Form” (Step 4).

Step 5- Then next to “WAV” and “ZC files”, UNSELECT both boxes so additional acoustic data files are not created.

Step 6- Select the “Process Files” button on the bottom right.

Figure 287. Unselect the boxes next to “WAV” and “ZC files” (Step 5), and select the “Process Files” button on the bottom right (Step 6).



*Note: When Kaleidoscope processes the meta output file, it automatically will create the following in the mobile transect metadata folder:

- **log.txt** (this file keeps a record of each step of the file processing and can be used for diagnostics if an error occurs)
- **settings.ini** (this file keeps a record of the settings used in the Kaleidoscope converter window during data processing)

These settings can be reloaded into the Kaleidoscope converter by opening the converter and selecting “File”, “Load Settings”, and then selecting the desired settings.ini file.

- **gps.csv** (this file contains the GPS data for each file if the “Extract GPS to CSV” setting was selected, if the “Extract GPS to KML” setting was selected, this file will be gps.kml, if the “Extract GPS Disabled” was selected, there will be no GPS file)
- **meta.csv** (this file contains all of the metadata that were entered in the NABat metadata form in the Kaleidoscope converter window, in addition to providing a list of all the files recorded within that stationary point survey site, this spreadsheet is where the manual ID for each file will be added)

*Note: This meta.csv file is referred to elsewhere in the document as metadata.csv to distinguish the file from the other meta.csv file created when the data are processed through Kaleidoscope.

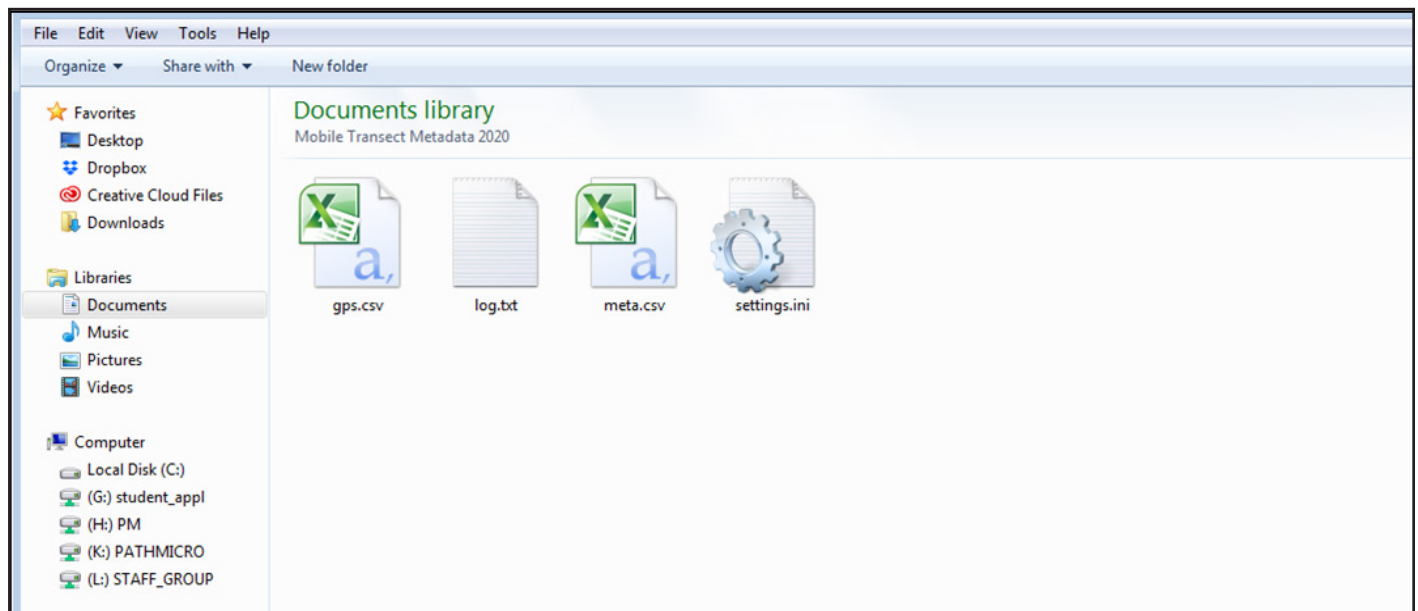


Figure 288. When Kaleidoscope processes the meta output file, it automatically will create new files.



If the Pro Version of the Kaleidoscope software is used for data processing, one other file will be created after data processing:

- **db-batch.wdb** (this file is used to upload metadata to a database, but this file will not be used for uploading data to the NABat database)

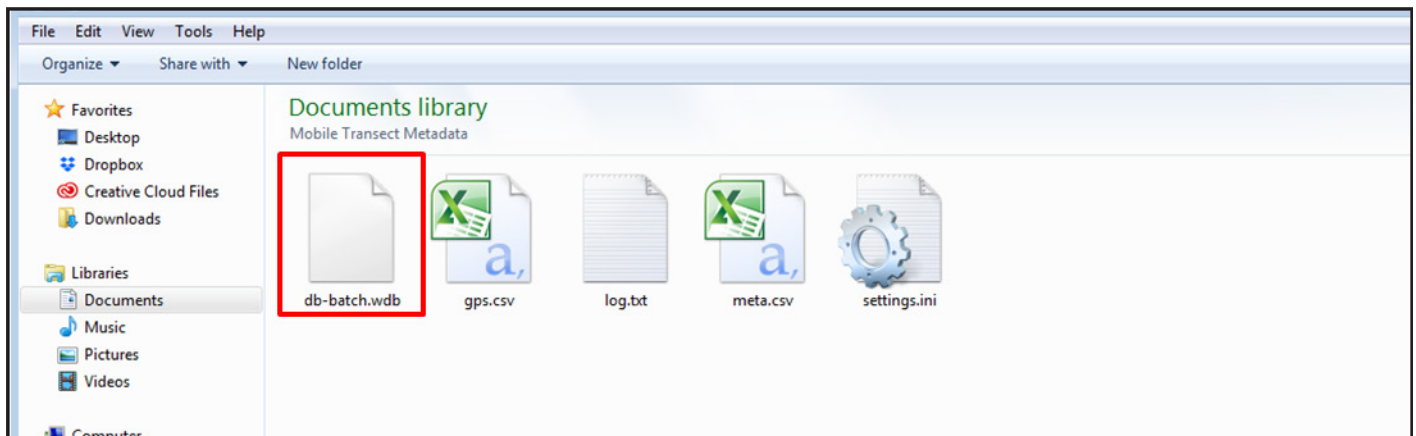


Figure 289. If the Pro Version of the Kaleidoscope software is used for data processing, one other file will be created after data processing.

Step 7- The new metadata file is now created. To review the file, open the metadata.csv in the Mobile Transect Metadata subfolder, and ensure that all of the columns, including manual ID, are filled in correctly.

*Note: If there are multi-bat files ensure that all of the necessary rows have been added (see *Section 4.7.3.14*).

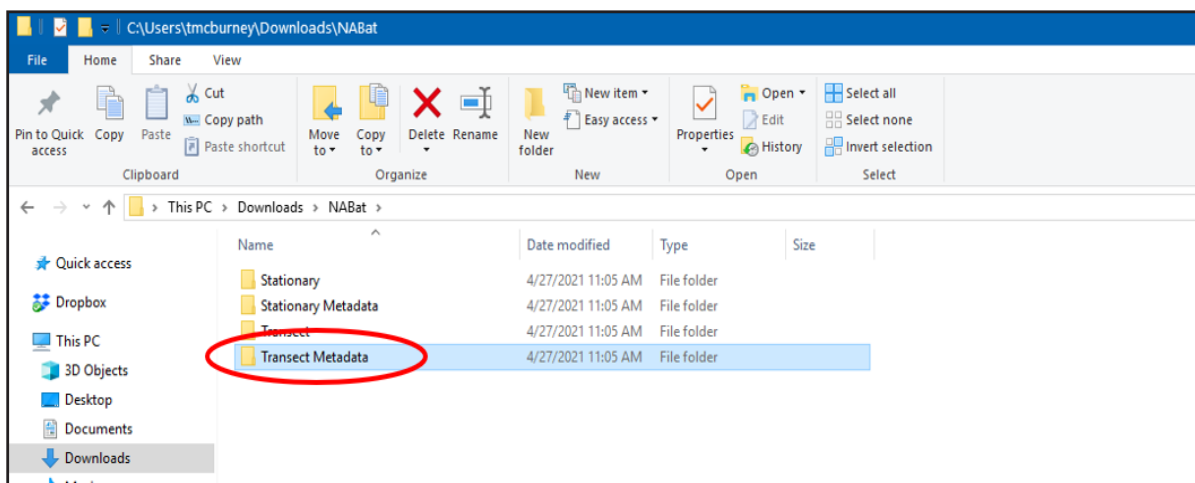


Figure 290. To review the file, open the metadata.csv in the Mobile Transect Metadata subfolder (Step 7).



Regardless if Kaleidoscope Free Version or Kaleidoscope Pro Version were used to manually identify the files, the Manual Id column in the metadata file should have filled in automatically. If some of the manual IDs are missing, those manual IDs will have to be either cut and pasted from the id.csv spreadsheet into the metadata spreadsheet (Kaleidoscope Pro Version), or the file will have to be re-opened in the Kaleidoscope viewer window and the manual ID found in the “Identification” field and then manually typed into the metadata spreadsheet (Kaleidoscope Free Version). If data are transferred from one spreadsheet to another, it is crucial that both spreadsheets are sorted the same way to prevent mislabelling of files. Both spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar (under the “Home” tab) and selecting “Custom Sort”.

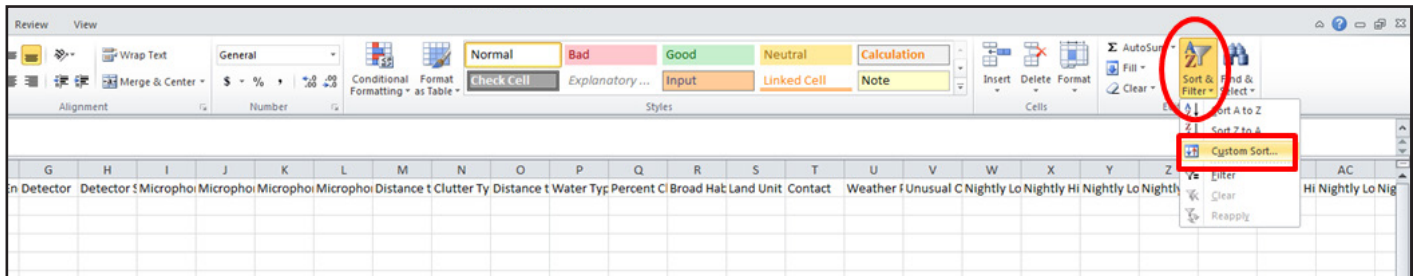


Figure 291. The spreadsheets can be sorted appropriately by clicking on the “Sort & Filter” button on the tool bar.

In the “Column” “Sort by” field selecting “Audio Recording Name (*wav *zc)” from the drop-down list, in the “Sort On” field selecting “Values”, and in the “Order” field selecting “A to Z”. This should sort the rows in the meta.csv spreadsheet to match the rows in the metadata file; however, this should be verified to prevent mislabelling of files. Once both spreadsheets are identically sorted, simply copy the MANUAL ID column from the meta.csv and paste it in the appropriate section of the Manual Id column in the metadata.csv.

*Note: If using the Kaleidoscope Pro Version, the id.csv should be sorted by “IN FILE” in the “Sort by” field.

*Note: The metadata file for mobile transects contains file information for ALL of the mobile transects. When copying and pasting manual IDs, ensure that the manual IDs from a certain mobile transect are added to the correct mobile transect in the metadata file.

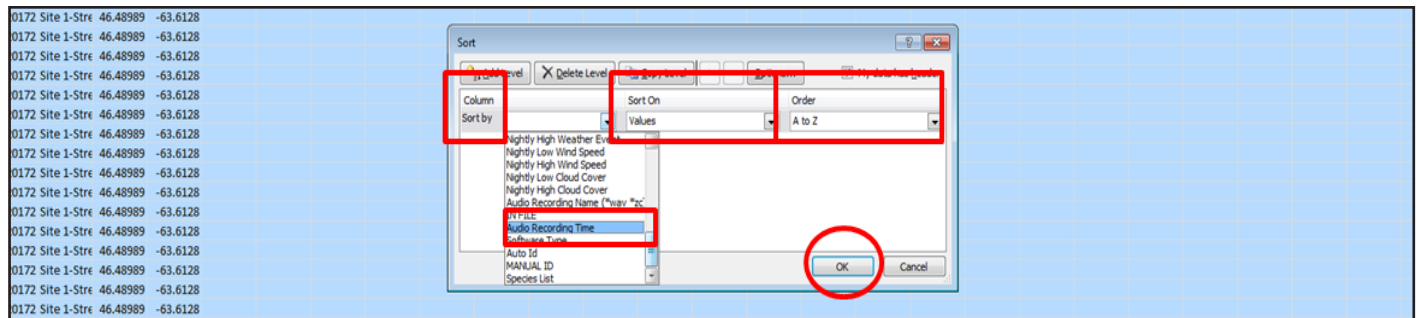


Figure 292. In the “Column” “Sort by” field select “Audio Recording Name (*wav *zc)” from the drop-down list.



Step 8- If the latitude and longitude of the calls were recorded with an external GPS unit, these locations must be manually added to the bulk metadata spreadsheet. Consult the manual of the GPS unit on how to download the location file, typically in the form of a text file with a column for date and time, latitude, and longitude. Cross-reference the times of recorded and manually identified bat passes in the meta.csv with the times, latitudes, and longitudes from the GPS text file and manually copy these data into the metadata file.

AD	AE	AF
Latitude	Longitude	Audio Recording T
46.44444	-63.22222	20-07-21T21:37:00
		20-07-21T21:40:00
		20-07-21T21:44:00
		20-07-21T21:54:00
		20-07-21T21:54:00
		20-07-21T21:57:00
		20-07-21T21:58:00
		20-07-21T21:59:00
		20-07-21T21:59:00
		20-07-21T22:07:00
		20-07-21T22:22:00
		20-07-21T22:23:00
		20-07-21T22:30:00
		20-07-21T22:33:00
		20-07-21T22:33:00
		20-07-21T22:45:00
		20-07-21T22:46:00
		20-07-21T22:50:00
		20-07-21T22:51:00
		20-07-21T22:56:00
		20-07-21T23:00:00

Figure 293. If the latitude and longitude of the audio files were recorded with an external GPS unit, these locations must be manually added to the bulk metadata spreadsheet (Step 8).

If no GPS was used, leave the fields for GRTS, latitude, and longitude blank (if any of these fields were automatically populated, delete the values but keep the column headers), and consult Section 4.8.2.1 below on how to save transect routes before the data have been uploaded.

AD	AE	AF
Latitude	Longitude	Audio Recording T
		20-07-21T21:37:00
		20-07-21T21:40:00
		20-07-21T21:44:00
		20-07-21T21:54:00
		20-07-21T21:54:00
		20-07-21T21:57:00
		20-07-21T21:58:00
		20-07-21T21:59:00
		20-07-21T21:59:00
		20-07-21T22:07:00
		20-07-21T22:22:00
		20-07-21T22:23:00
		20-07-21T22:30:00
		20-07-21T22:33:00
		20-07-21T22:33:00
		20-07-21T22:45:00
		20-07-21T22:46:00
		20-07-21T22:50:00
		20-07-21T22:51:00
		20-07-21T22:56:00
		20-07-21T23:00:00

Figure 294. If no GPS was used, leave the fields for GRTS, latitude, and longitude blank (Step 8).



4.8.2.1 Saving Mobile Transect Routes

For NABat to use the full potential of submitted mobile transect data, the transect route that was driven should be recorded. The route can be easily drawn using the NABat “Mark a transect route” tool.

Navigate to the desired project using the “Projects” tab then select the “Details” tab.

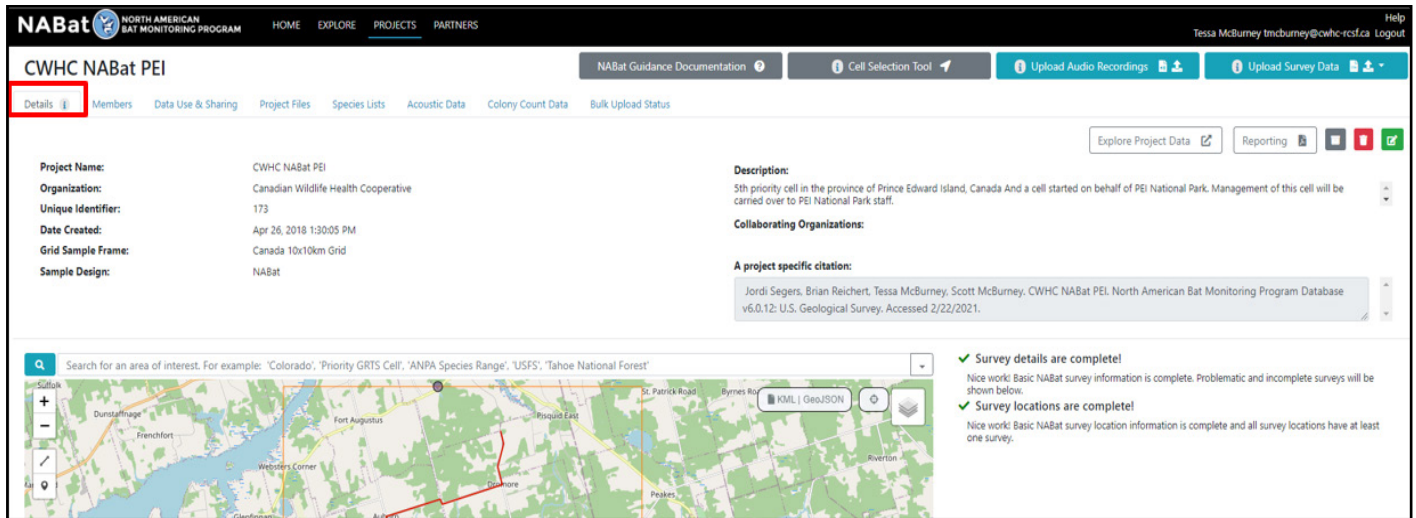


Figure 295. Navigate to the desired project using the “Projects” tab then select the “Details” tab.

In the top left corner of the map, click on the diagonal line icon to make a transect route.

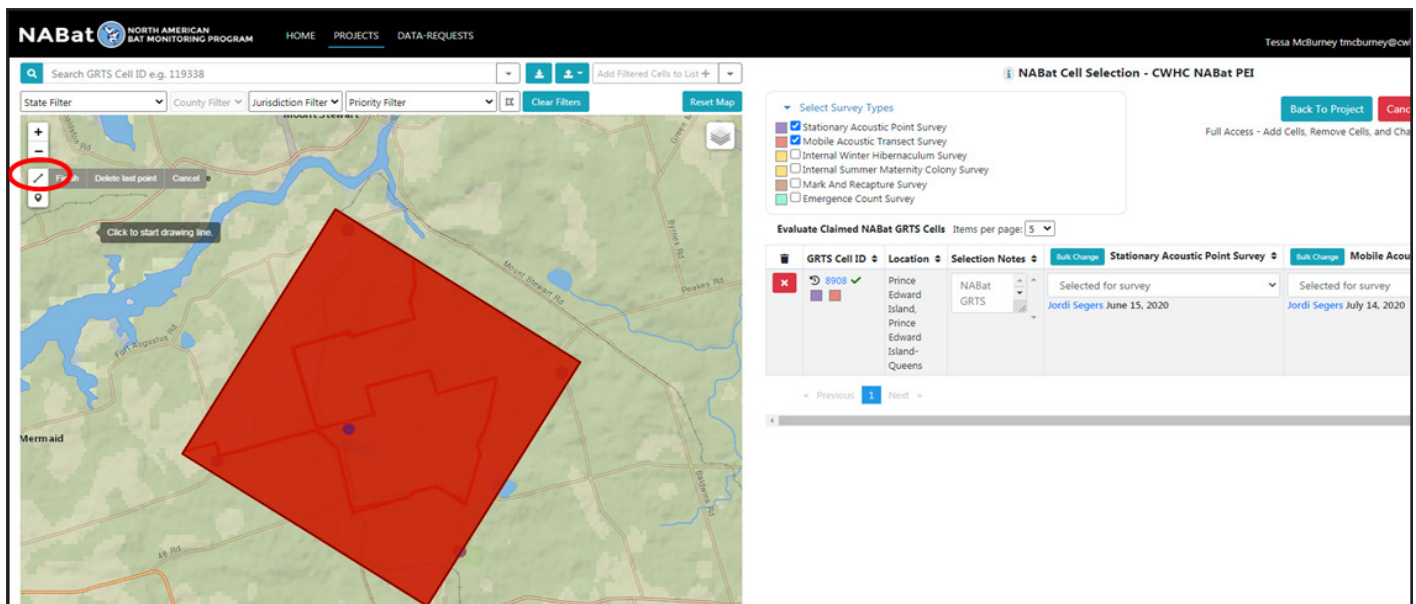


Figure 296. In the top left corner of the map, click on the diagonal line icon to make a transect route.



Next, click on the map where the transect begins to drop a marker. Then click at each point on the map where the transect makes a turn, including bends in the road, as this tool does not automatically detect the placement of roads.

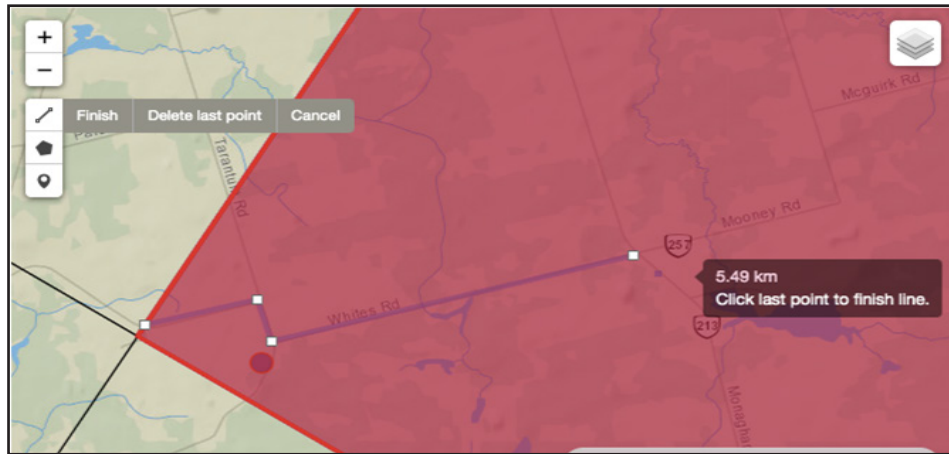


Figure 297. Click on the map where the transect begins to drop a marker, and then click on each point on the map where the transect makes a turn.

When the full transect is drawn, click on “Finish” or click again on the last marker of the drawn transect.

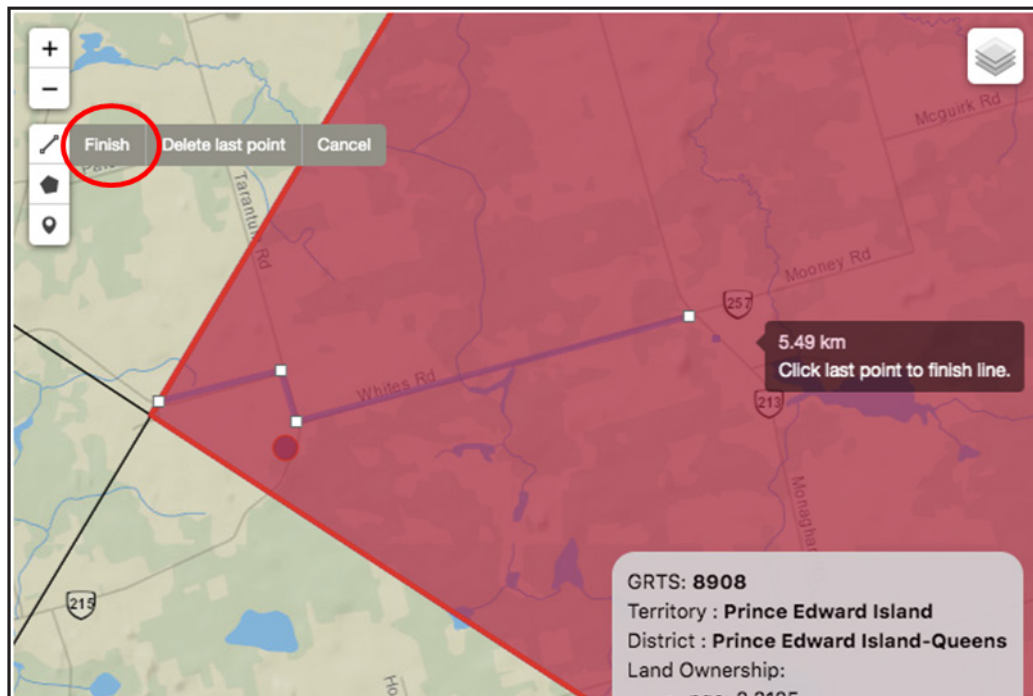


Figure 298. When the full transect is drawn, click on “Finish”.



Name the transect route the same as the “Location Name” in the applicable metadata file to ensure it is linked to this metadata. Provide an optional description, and set “Location Type” to “Transect Route”. Once the fields are all filled out, select the green “Save” button.

The screenshot shows a mobile application interface for creating a transect route. A map in the background displays a red transect route. A white form is overlaid on the map, containing the following fields: Name (Transe), Description (CWHC NABat mobile survey Location), Location Type (Transect Route), GRTS Cell(s) (8908), Created On (2020-04-20T17:23:), Full Length (m) (37157.42), and a green Save button. The form is titled 'Name' and has a close button in the top right corner.

Figure 299. Fill out the transect route fields and then select the green “Save” button.

The transect route will appear under the “Deployment Details” tab for the mobile transect once the data are uploaded.

*Note: Location data, including GRTS, latitude, and longitude fields should be kept blank in the metadata.csv if this tool is used to estimate where bat passes were recorded.

*Note: Ensure that the transect is drawn as described above BEFORE survey data are uploaded to the website. If not, the acoustic files will not be associated with the drawn route, and the bat passes will not appear on the route map.

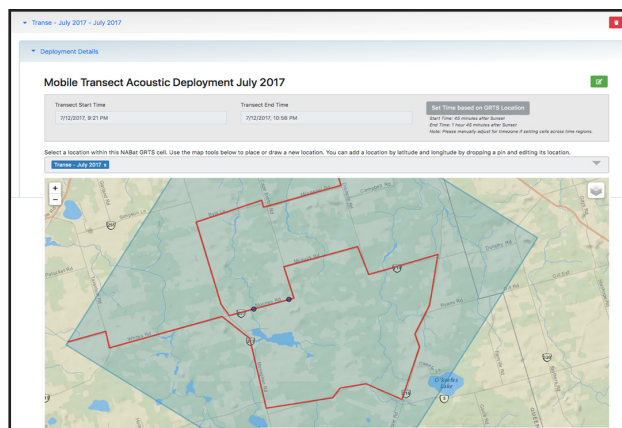


Figure 300. The transect route will appear under the “Deployment Details” tab for the mobile transect once the data are uploaded.



Step 9- Rename the metadata.csv with a descriptive and original name that will NOT be able to be duplicated (e.g., CWHC NABat Mobile Transect 2020).

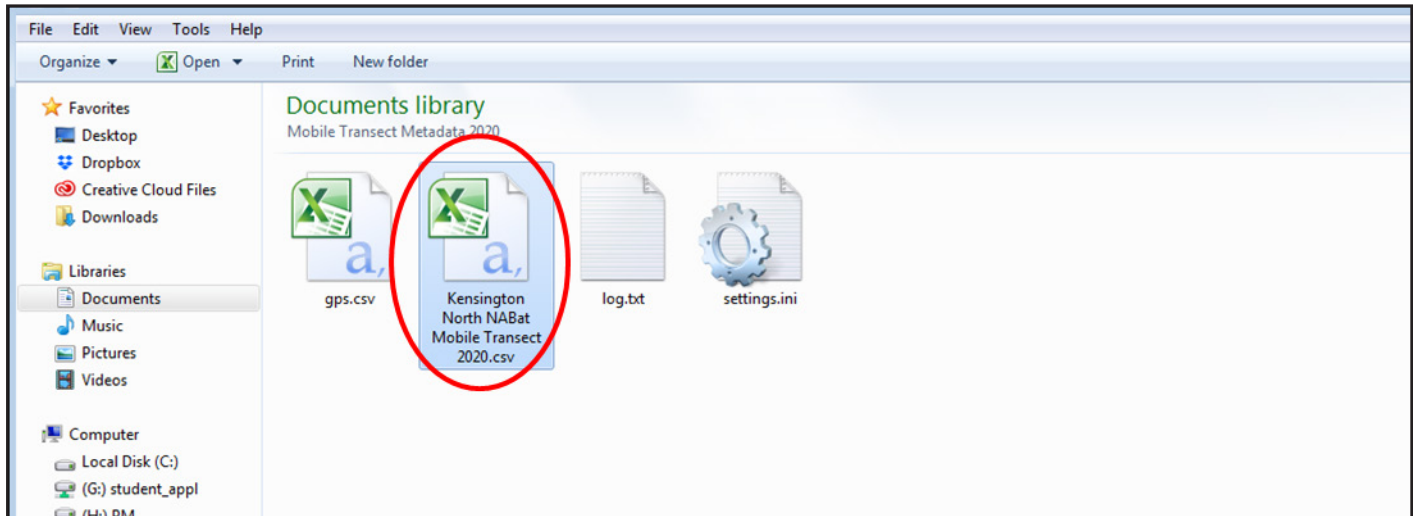


Figure 301. Rename the metadata.csv with a descriptive and original name (Step 9).

Step 10- Go to the NABat Projects [page](#) and select the project created in *Section 4.2.2* from the table at the bottom of the page.

Step 11- On the new page, click the turquoise “Upload Survey Data” button in the top right corner.

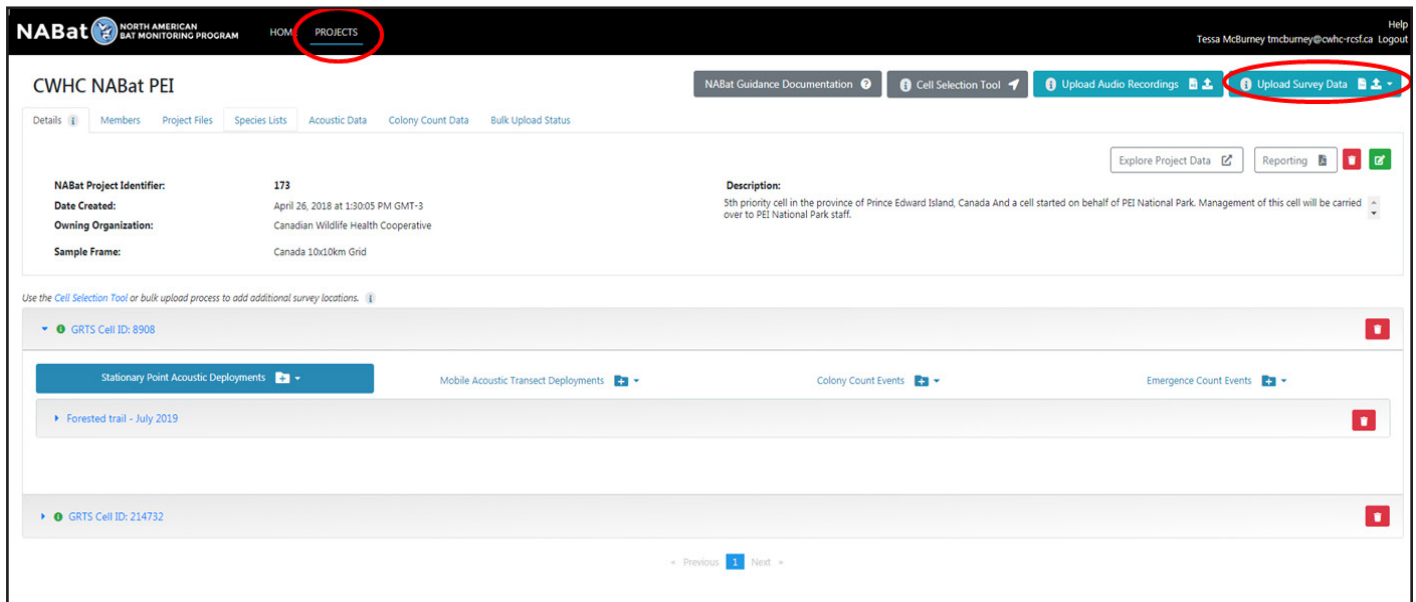


Figure 302. Click the turquoise “Upload Survey Data” button in the top right corner of the page for the desired project (Step 11).



Step 12- Select “Mobile Acoustic Transect”.

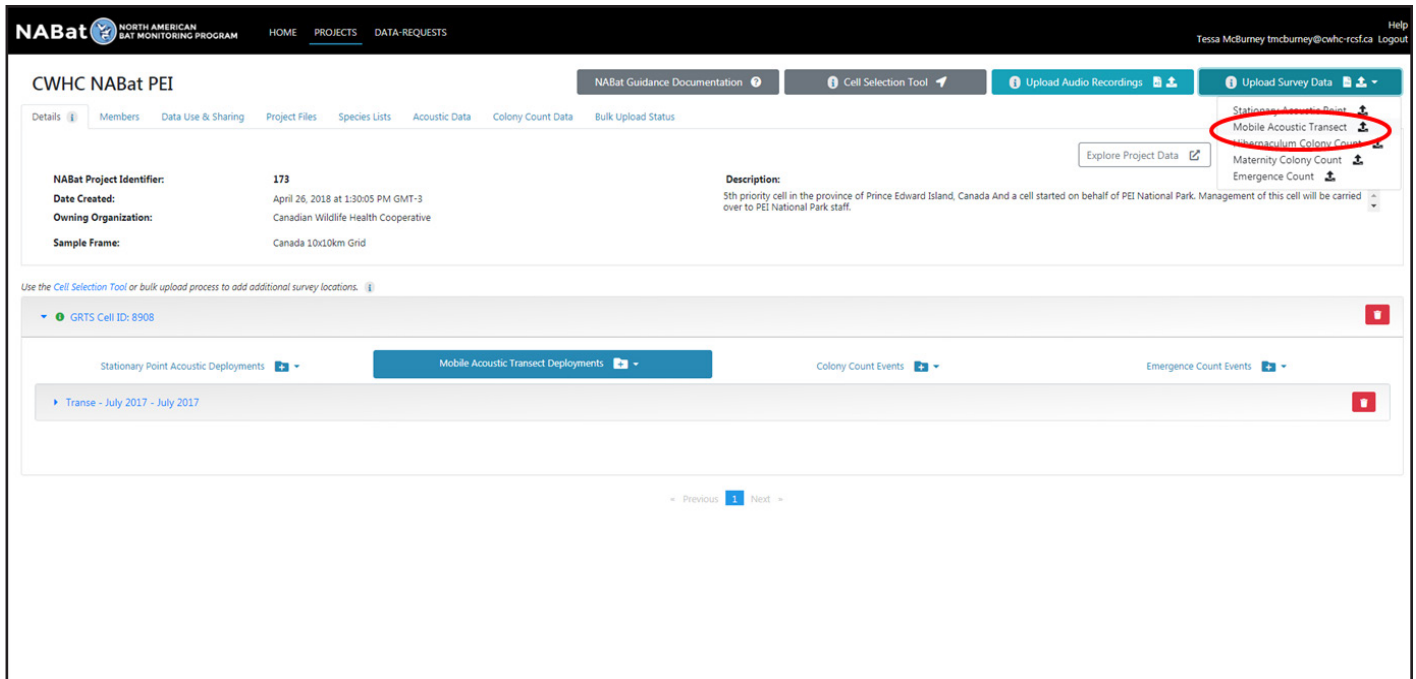


Figure 303. Select “Mobile Acoustic Transect” (Step 12).

Step 13- Select the “Full Metadata” button.

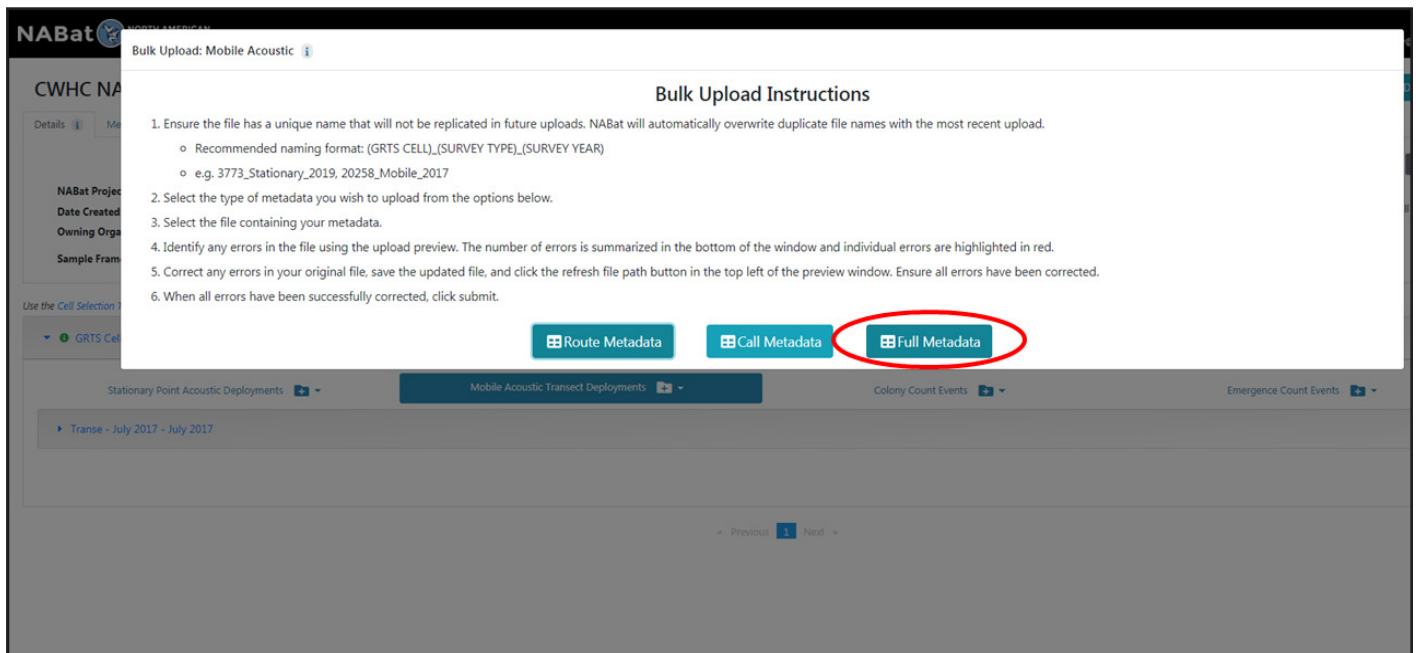


Figure 304. Select the “Full Metadata” button (Step 13).



Then choose the blue “Select File” button in the bottom right.

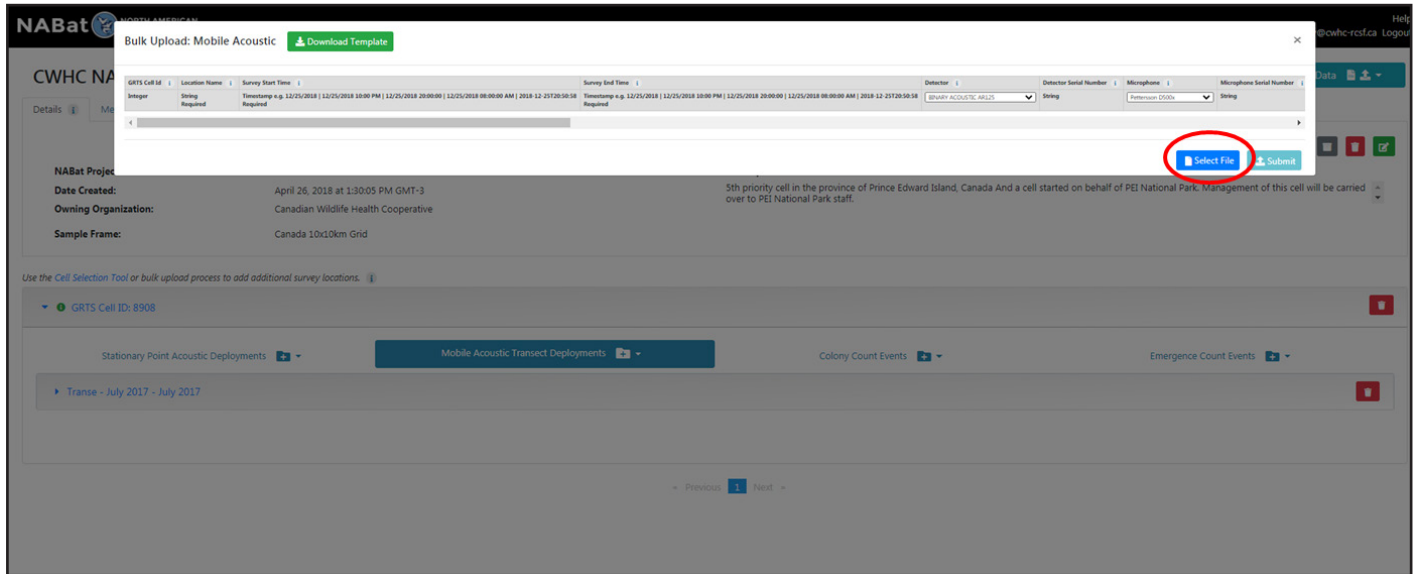


Figure 305. Then the blue “Select File” button in the bottom right (Step 13).

Step 14- Select the metadata.csv file that was renamed in *Step 9*.

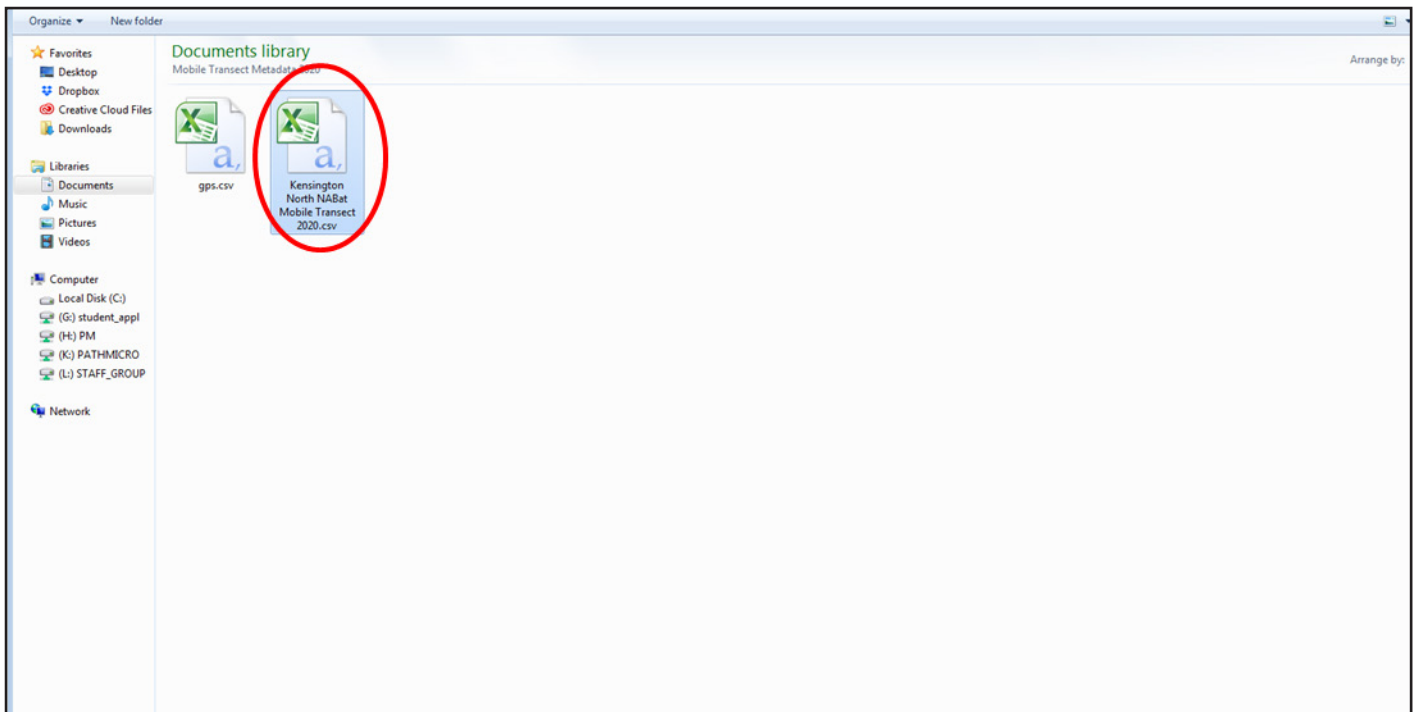


Figure 306. Select the metadata.csv file that was renamed in *Step 9* (Step 14).



This will result in a bulk upload table. It will assess the first 300 rows of data for errors, which can be seen at the bottom "Document Preview: Discovered # error(s) in # row(s)."

Document Preview: Discovered 1 error(s) in 102 row(s). ✓ Matched 38 Column(s) ✗ Missing 0 Column(s) ⚠ 0 Extra Column(s)

Select File Submit

Figure 307. The bulk upload table will assess the first 300 rows of data for errors.

In the bulk upload table the errors are shown in red.

Matched 38 Column(s) ✗ Missing 0 Column(s) ⚠ 0 Extra Column(s)

Select File Submit

Figure 308. In the bulk upload table the errors are shown in red.



Either go back into the metadata file to fix the errors now (recommended) or submit the files and fix the errors afterwards.

Step 15- When the data are ready to be submitted, click on the teal “Submit” button in the bottom right corner of the bulk upload table and it will indicate if there are any more issues with the data after they are submitted.

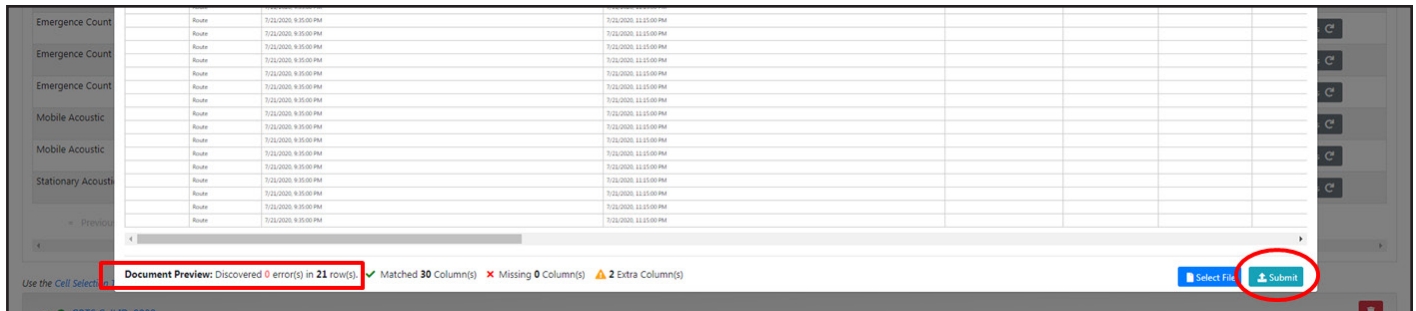


Figure 311. When the data are ready to be submitted, click on the teal “Submit” button in the bottom right corner of the bulk upload table (Step 15).

Step 16- At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload. Click the blue hyperlink in the “Errors Found” column to download a .csv highlighting the location of the errors in the metadata sheet. It is crucial to fix these errors, because NABat will ignore any data with errors, and that data will not be uploaded to the website. To delete a metadata.csv with errors, find the file in the table under the “Bulk Upload Status” tab and select the grey “Undo” button under the “Action” column. Once the errors are corrected in the original metadata.csv sheet, re-upload the metadata.csv sheet as described in Steps 9-15.

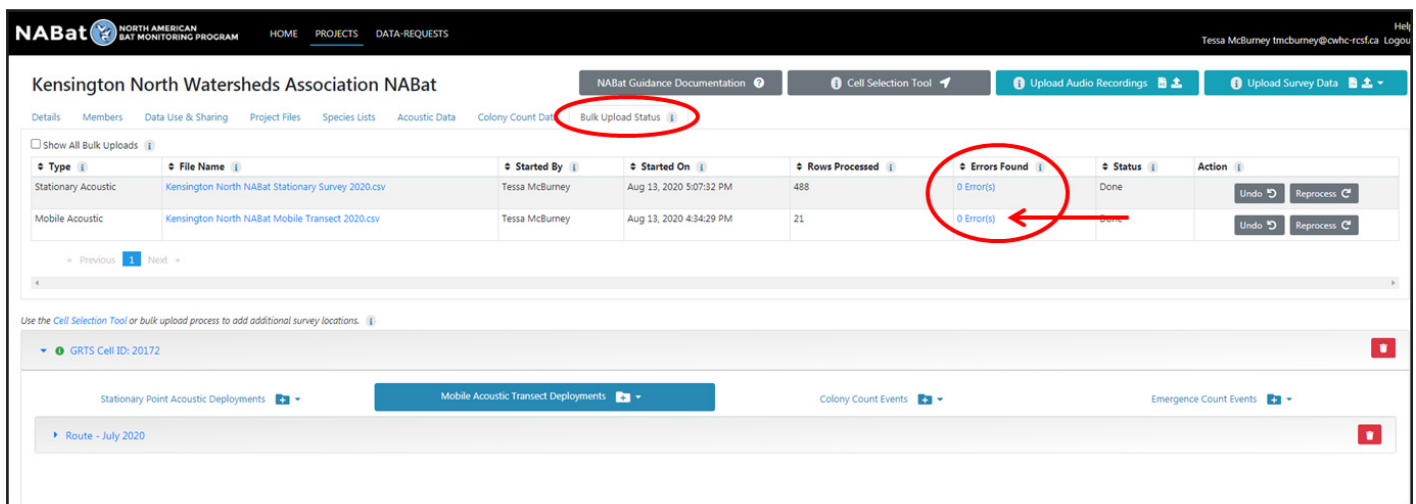


Figure 312. At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload (Step 16).



When this is completed and no errors are identified, the survey location(s) and accompanying uploaded data will be under the “Mobile Acoustic Transect Deployments” tab. Under each site there are other tabs that can be selected:

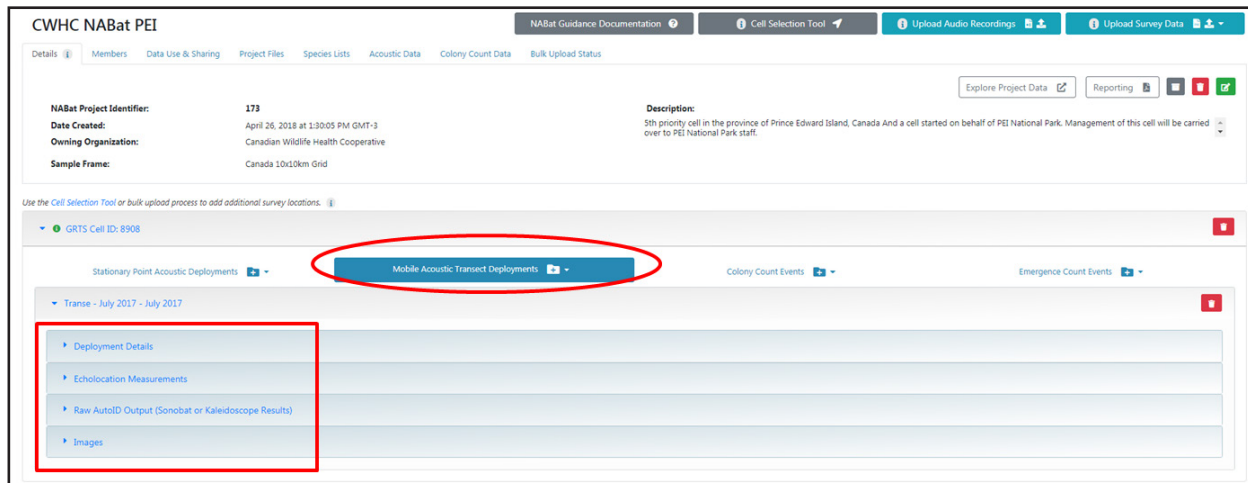


Figure 313. The survey location(s) and accompanying uploaded data will be under the “Mobile Acoustic Transect Deployments” tab.

- “**Deployment Details**” has all of the information that was submitted about equipment deployment, including equipment type and placement.

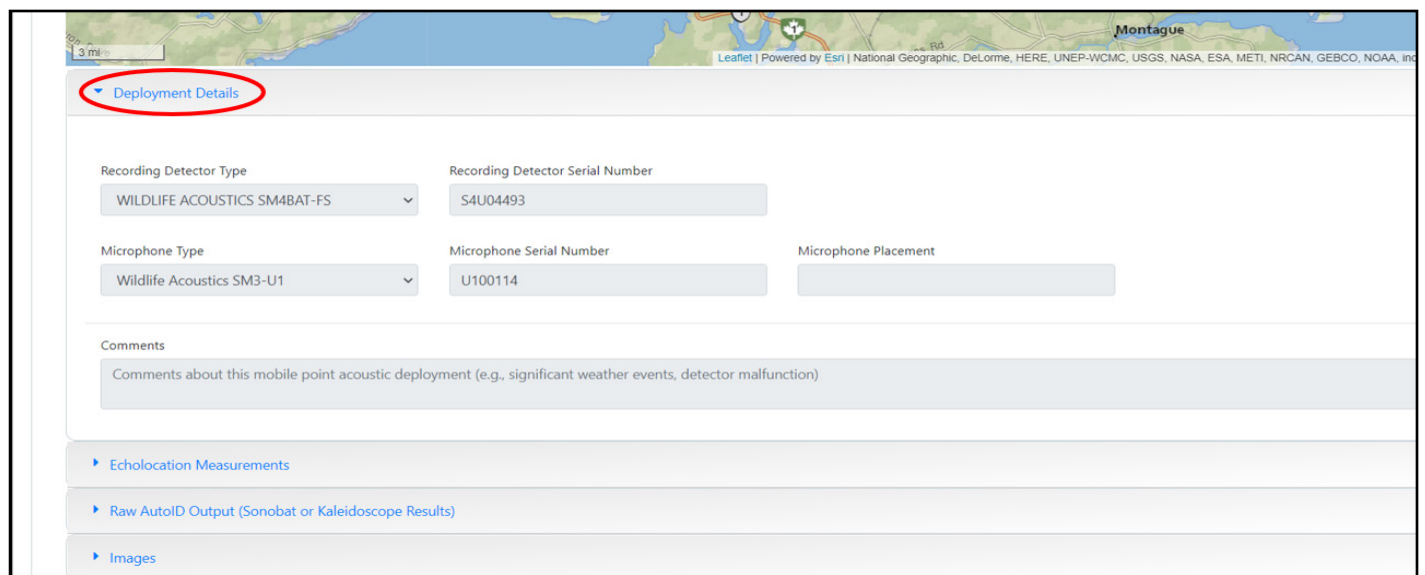


Figure 314. “**Deployment Details**” has all of the information that was submitted about equipment deployment.



- “Echolocation Measurements” gives a summary about the acoustic files and species.

Audio Recording	Recording Time	Latitude	Longitude	Software	Species List	Species (Auto ID)	Species (Manual ID)
SM300254_0+1_20170712_222513.wav	7/12/2017, 10:25:13 PM	46.2722050214502	-62.8741092547621	Kaleidoscope (4.5.0)	Atlantic Canada Class	Myotis lucifugus (MYLU Little brown bat)	(40kMyo Various species of Myotis with p...
SM300254_0+1_20170712_222828.wav	7/12/2017, 10:28:28 PM	46.2696240295644	-62.8871887819102	Kaleidoscope (4.5.0)	Atlantic Canada Class	Myotis lucifugus (MYLU Little brown bat)	(40kMyo Various species of Myotis with p...

Figure 315. “Echolocation Measurements” gives a summary about the acoustic files and species.

- The “Raw AutoID Output (Sonobat or Kaleidoscope Results)” tab allows uploading of the original Kaleidoscope meta.csv output with the other uploaded data. Click on the turquoise “Upload Raw AutoID Files” on the right and select the appropriate files. As they are all automatically named meta.csv by Kaleidoscope, before uploading the files ensure they are given a unique name so they can be associated with the appropriate deployment site.

File Name	Size	Last Modified
Farm id.csv	200.4 KB	Mar 13, 2020, 6:00:37 PM

Figure 316. The “Raw AutoID Output (Sonobat or Kaleidoscope Results)” tab allows uploading of the original Kaleidoscope meta.csv output.



- Under the “**Images**” tab photos from the equipment set-up for the mobile transect can be uploaded, which is recommended. Select the turquoise “Upload Deployment Images” button on the right.

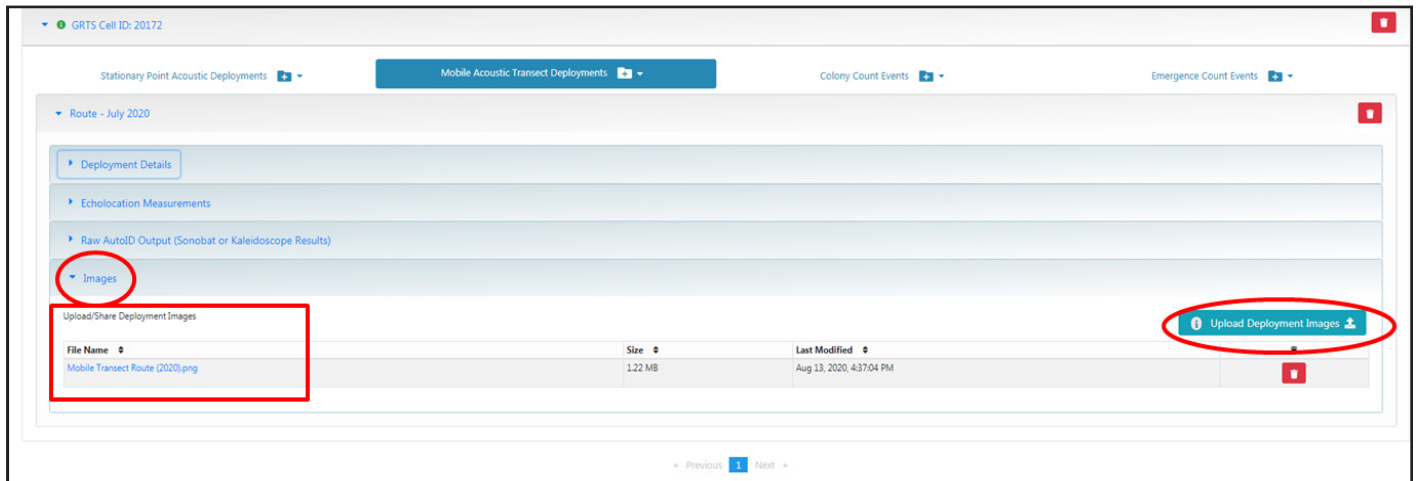


Figure 317. Under the “**Images**” tab photos from the equipment set-up for the mobile transect can be uploaded.

Choose the blue “Select Files” button. Select the image files to be uploaded and then select the green “Upload” button on the bottom right of the pop-up window.

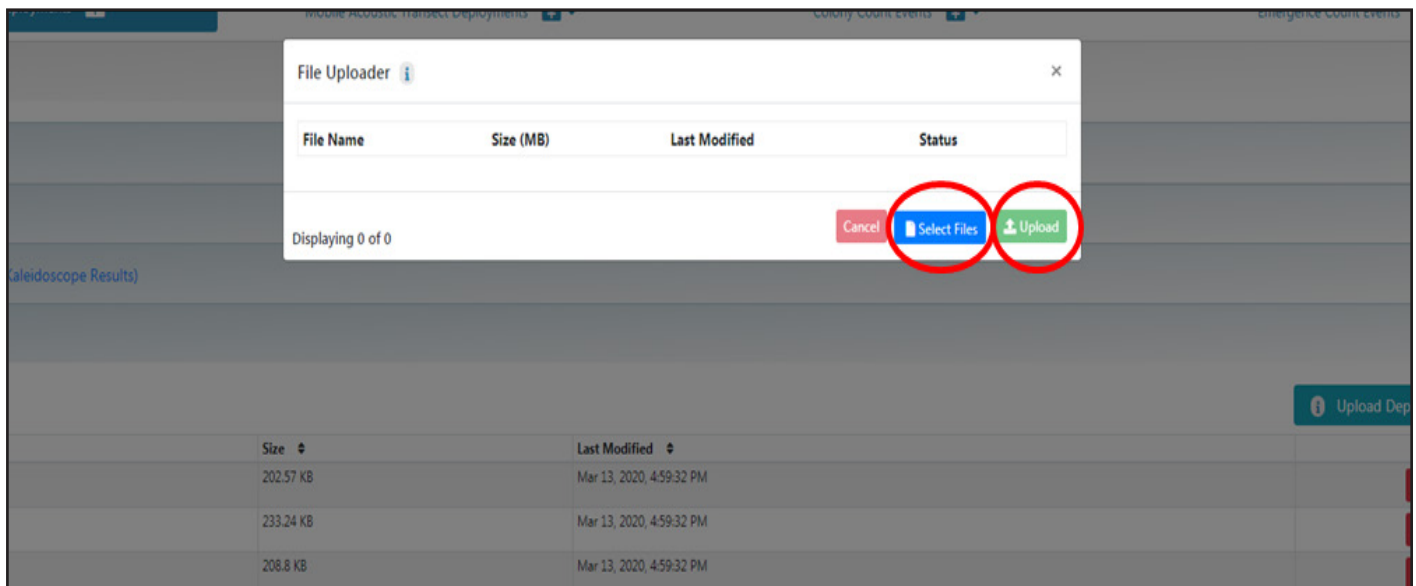


Figure 318. Choose the blue “Select Files” button, select the image files to be uploaded and then select the green “Upload” button on the bottom right of the pop-up window.



Another option is to upload acoustic files directly to the NABat website. This is good practice because it creates a back-up for all of the acoustic data files and enables other individuals working on the same project to access the files. Under “Projects” select the teal “Upload Audio Recordings” button on the top right of the page.

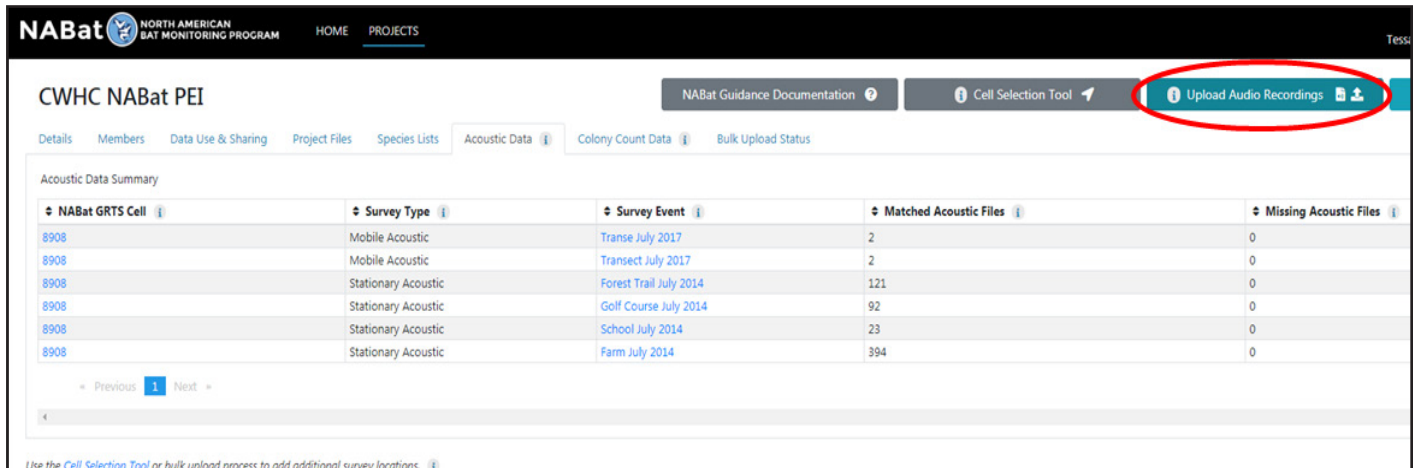


Figure 319. To upload acoustic files, under “Projects” select the teal “Upload Audio Recordings” button on the top right of the page.

Select the blue “Select Files” button and choose all of the processed NABat audio files to be uploaded to the project. It will take time for the files to upload, so select a small number of files at a time (*i.e.*, not thousands of files at one time) to process. Once all of the files are chosen, select the green “Upload” button on the bottom right of the window.

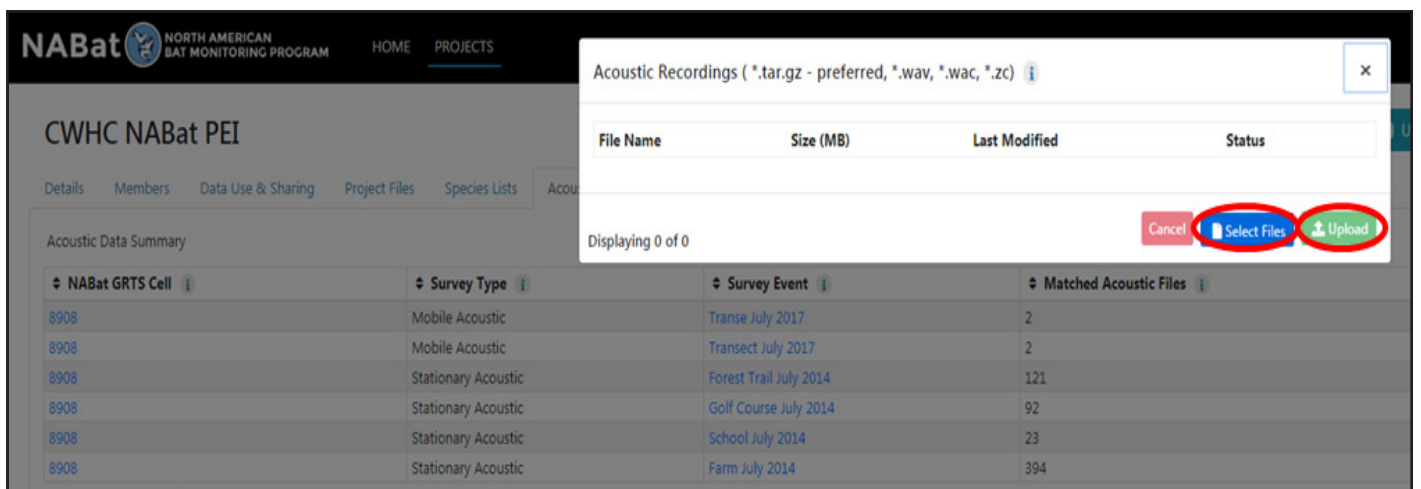


Figure 320. Select the blue “Select Files” button, and once all the files are chosen, select the green “Upload” button on the bottom right of the window.



When the data are all successfully uploaded, the website will automatically match the acoustic data file with the metadata sheet that was previously uploaded with all of the file names. To access a file, click on the mobile transect tab of interest in under “Mobile Acoustic Transect Deployments” and then select the “Echolocation Measurements” tab. The file names in the table should now be blue (hyperlinks).

*Note: If the raw audio files are uploaded, the acoustic file will not be automatically matched to the file names. Upload the processed audio files.

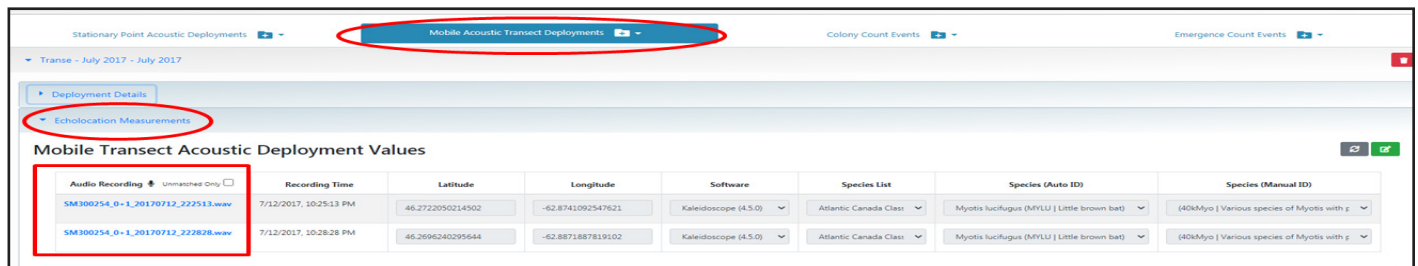


Figure 321. When the data are all successfully uploaded, the website will automatically match the acoustic data file with the metadata sheet that was previously uploaded with all of the file names.

When a blue file name is clicked, it will automatically download the file to the computer and the file will then be able to be examined with Kaleidoscope.

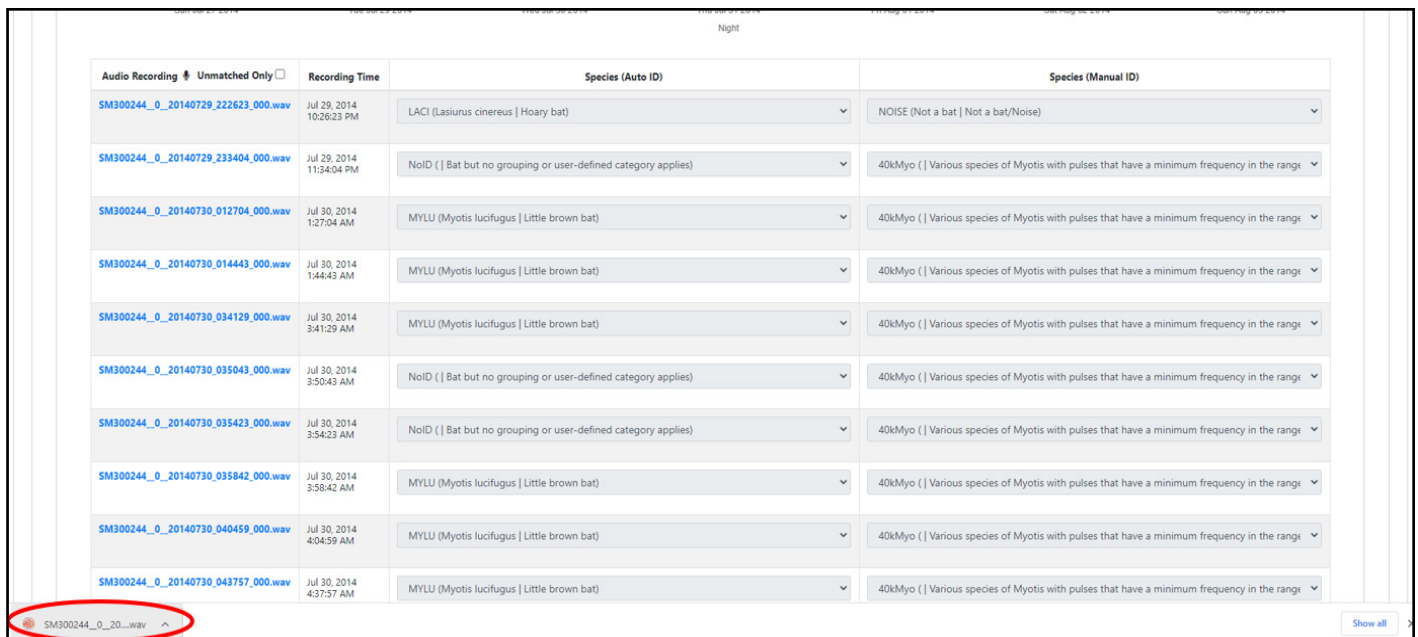


Figure 322. When a blue file name is clicked, it will automatically download the file to the computer and the file will then be able to be examined with Kaleidoscope.



4.8.3 Uploading Emergence Count Data

Follow the steps below to upload emergence count (*i.e.*, external roost count/emergence survey) data.

Step 1- Go to the NABat Projects [page](#) and select the project created in *Section 4.2.2* from the table at the bottom of the page.

Step 2- On the new page, click the turquoise “Upload Survey Data” button in the top right corner and select “Emergence Count”.

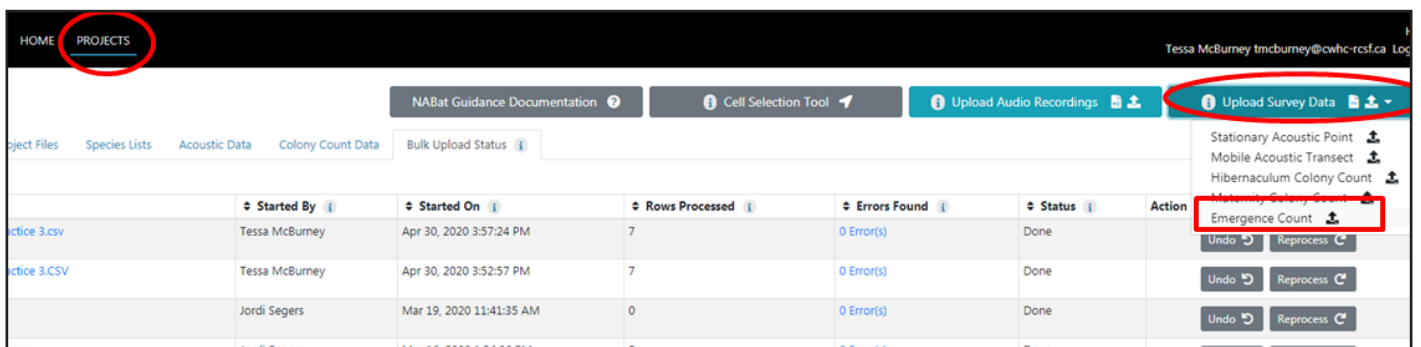


Figure 323. Click the turquoise “Upload Survey Data” button in the top right corner of the page for the desired project and select “Emergence Count” (Step 2).

Step 3- Select the turquoise “Full Metadata” button at the bottom of the window.

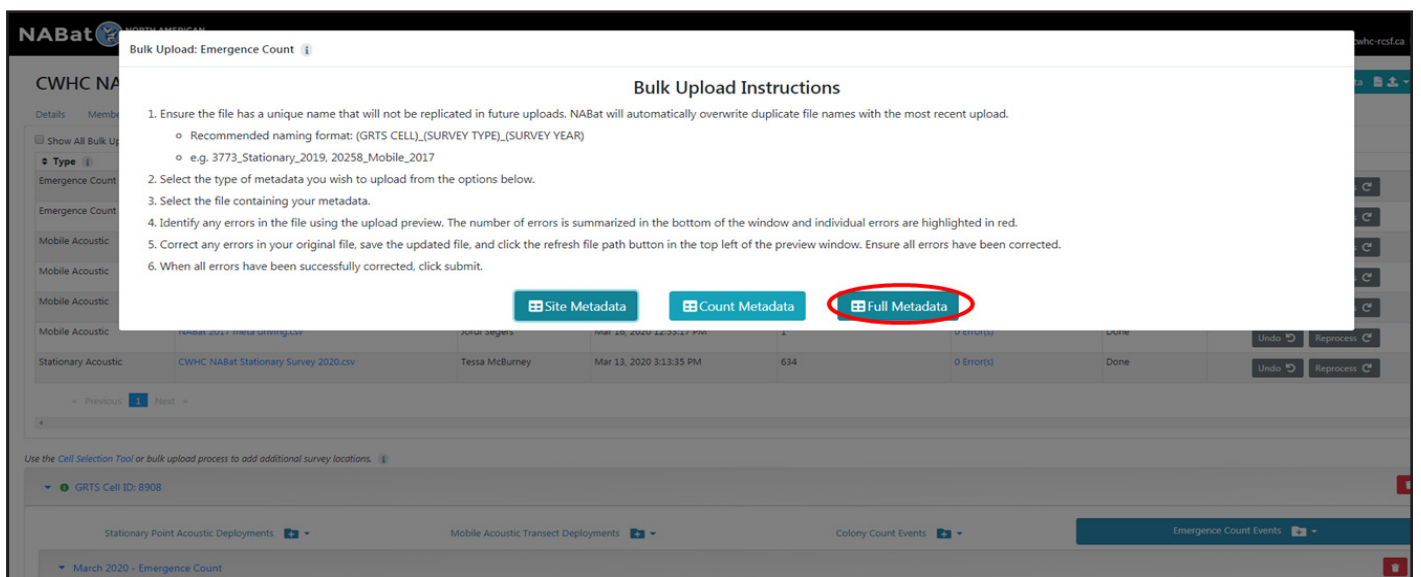


Figure 324. Select the “Full Metadata” button (Step 3).



Step 4- Download the data spreadsheet template by clicking on the green “Download Template” at the top left of the window. The spreadsheet should be renamed with a descriptive and original name that will NOT be able to be duplicated (e.g., CWHC NABat Emergence Counts 2020).

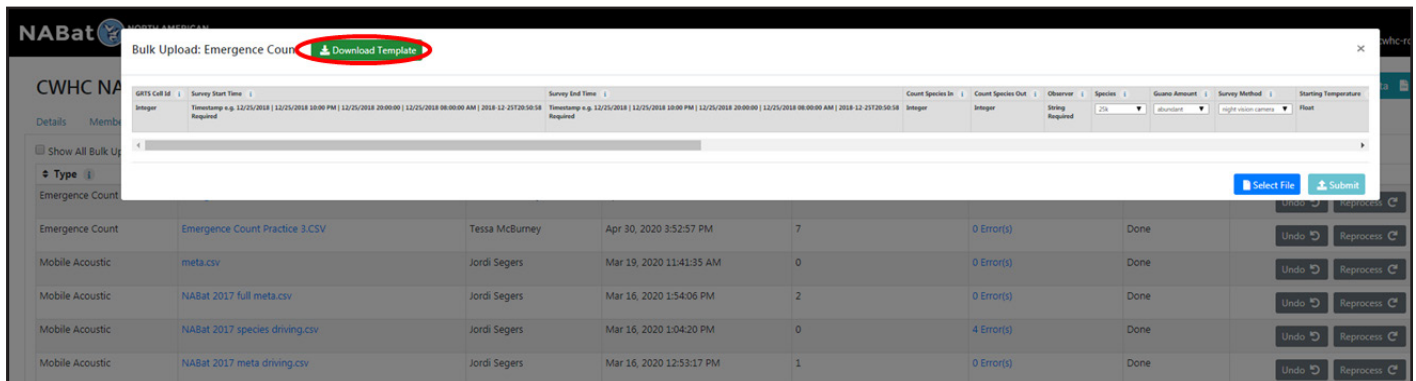


Figure 325. Download the data spreadsheet template by clicking on the green “Download Template” at the top left of the window.

Step 5- Fill in the columns with data collected during the emergence counts. All of the emergence count data collected within a single GRTS Cell can be entered into the one spreadsheet. Each row will contain data for a separate emergence count. The following columns are required:

- **GRTS Cell ID**
- **Location Name**
- **Latitude**
- **Longitude**
- **Survey Start Time**
- **Survey End Time**
- **Observer** (if more than one observer, separate names with “/”)
- **Species** (use NoID unless you are able to confirm to species or species group)
- **Count Species Out** (*Count Species In is not required by NABat but should be included)

The other columns can be filled out before uploading the datasheet or the data can be added afterwards by editing the emergence count under the “Emergence Count Details” tab.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
GRTS Cell ID	Location Name	Latitude	Longitude	Survey Start Time	Survey End Time	Observer	Exit Identifier	Roost Location	Broad Habitat	Roost Type	Roosting Level	Roost Exit	Seasonal Use	Maternity	Aspect
Integer	String -Rec	Float	Float	Timestamp	Timestamp	String -Rec	String	historical	agriculture	artificial	rc	String	Integer	fall roost	post volan east
GRTS ID	A user-def	Latitude in	Longitude	Time when	Time when	Name of p	Enter the e	Please indi	Broad hab	Please ent	Describe w	How many	Please indi	If you indi	Indica
8908	106 Wisen	46.26401	-62.882	2020-07-1	2020-07-1	Tessa McBurney/Jordi Segers/Scott McBurney									
8908	870 Simps	46.29621	-62.9242	2020-07-1	2020-07-1	Tessa McBurney/Jordi Segers									

Figure 326. Fill in the columns with data collected during the emergence counts.



Step 6- When the datasheet is completed, go back to the website and click the blue “Select File” button with the bulk emergence count data upload window and select the datasheet renamed in *Step 4*. This will result in a bulk upload table. It will assess the first 300 rows of data for errors, which can be seen at the bottom “Document Preview: Discovered # error(s) in # row(s).” In the bulk upload table the errors are shown in red and the drop-down list under the column title can be clicked to see examples of how the column should be formatted. The bottom of the bulk upload table will also indicate if any columns are missing. Either go back into the metadata file to fix the errors now (recommended) or submit the files and fix the errors afterwards.

Step 7- When the data are ready to be submitted, click on the teal “Submit” button in the bottom right corner of the bulk upload table. The “Bulk Upload Status” tab will indicate if there are any more issues with the data after they are submitted.

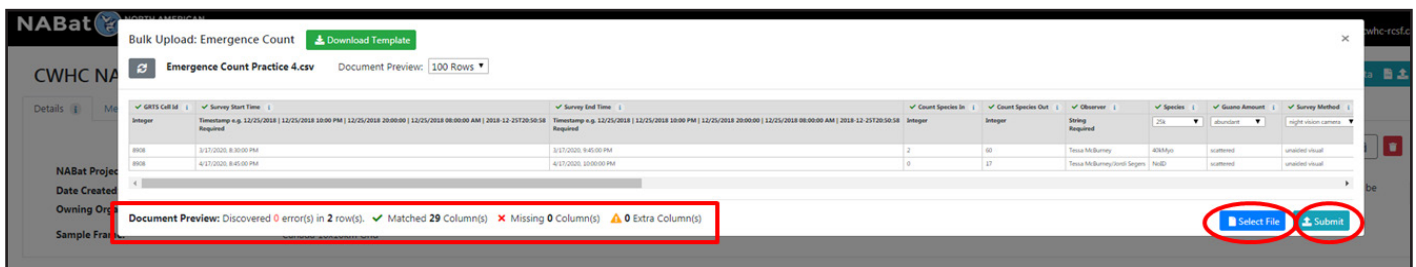


Figure 327. When the datasheet is completed, go back to the website and click the blue “Select File” button (Step 6), and then click on the teal “Submit” button in the bottom right corner of the bulk upload table to submit the data (Step 7).

Step 8- At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload. Click the blue hyperlink in the “Errors Found” column to download a .csv highlighting the location of the errors in the uploaded spreadsheet. It is crucial to fix these errors, because NABat will ignore any data with errors, and that data will not be uploaded to the website. Once the errors are corrected in the original spreadsheet, re-upload the spreadsheet as described in *Steps 6-7*.

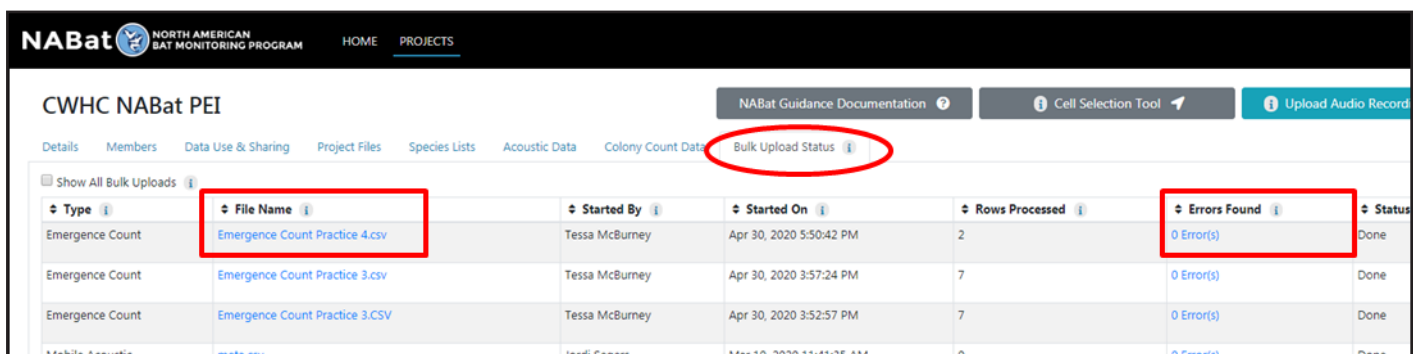


Figure 328. At the top of the page under “Show All Bulk Uploads” or “Bulk Upload Status” will be a row with information about the recent upload (Step 8).



When this is completed and no errors are identified, the survey location(s) and accompanying uploaded data will be under a separate tab under the blue “Emergence Count Events” tab. The emergence counts are automatically named based on their survey date.

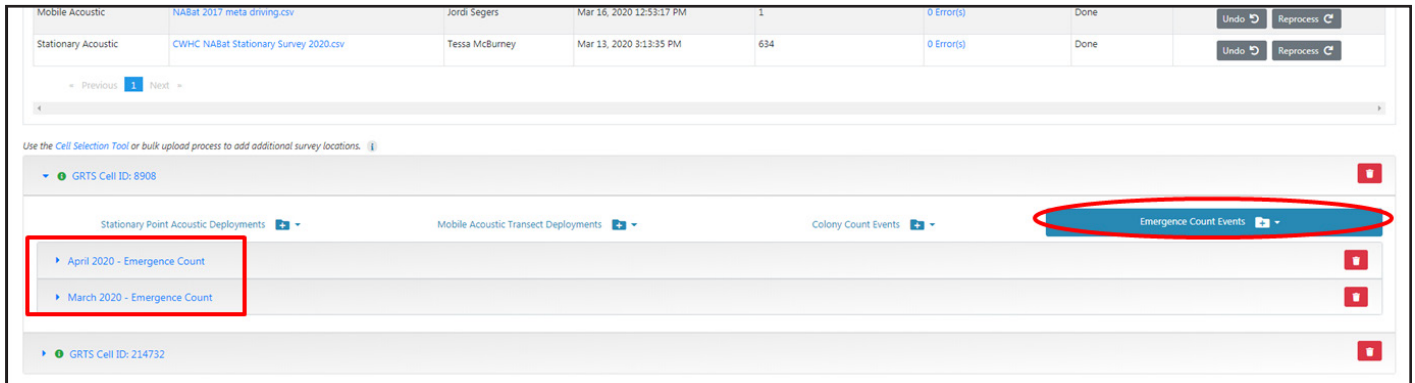


Figure 329. The survey location(s) and accompanying uploaded data will be under the “Emergence Count Events” tab.

Each emergence count event will have the following tabs that can be selected:

- The “**Emergence Count Details**” tab will include all of the information submitted about the site location(s), survey weather conditions, and will also show a map with the survey location (if the location data were entered). This is also where additional details can be added about the survey if columns were skipped when filling out the data spreadsheet.

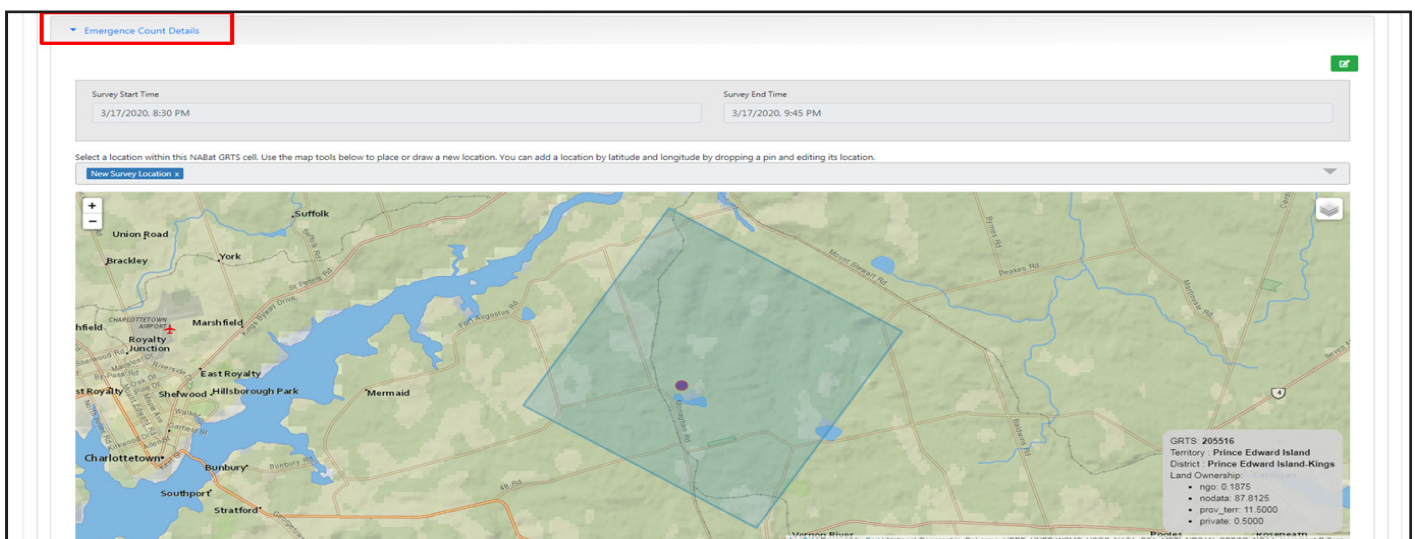


Figure 330. “**Emergence Count Details**” will have all of the information that was submitted about the site location(s).



- The “**Emergence Count Values**” tab will list details about the bats counted during the survey, including the count numbers.

Species	Observer(s)	Species In	Species Out
Various species of Myotis with pulses that have a minimum frequency in the range of 35-40 kHz - 40kMyo	Tessa McBurney	2	60

Figure 331. “**Emergence Count Values**” will list details about the bats counted during the survey, including the count numbers.

- The “**Raw Species Count Data**” tab allows datasheets that have different fields than those required by NABat to be uploaded. If data from emergence surveys were recorded on other datasheets, those datasheets can be uploaded here. Additionally, if any acoustics were recorded while conducting the emergence survey, this tab is where the original Kaleidoscope meta.csv datasheet can be uploaded. Click on the turquoise “**Upload Raw Count Files**” on the right and select the desired files. Ensure the files all have unique names before they are uploaded.

File Name	Size	Last Modified
Emergence Count Summary (2018).xlsx	75.73 KB	Mar 16, 2020, 4:00:31 PM

Figure 332. The “**Raw Species Count Data**” tab allows uploading of other datasheets or the original Kaleidoscope meta.csv output if any acoustics were recorded.



- Under the “**Images**” tab photos of the site can be uploaded, which is recommended. Select the turquoise “Upload images and videos” button on the right and choose the blue “Select Files” button. Select the image files to be uploaded and then select the green “Upload” button on the bottom right of the pop-up window.

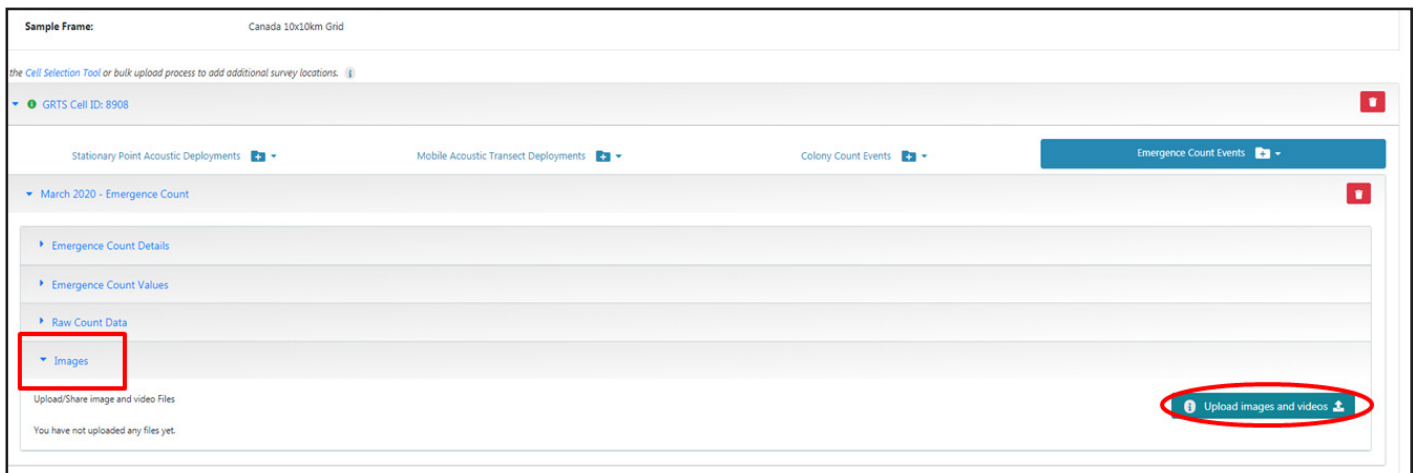


Figure 333. Under the “**Images**” tab photos of the site can be uploaded.

If an emergence count event needs to be deleted, click on the “Emergence Count Events” tab. Next to the event designated for deletion, select the red trash can button. When asked “Are you sure?” select the red “Delete” button.

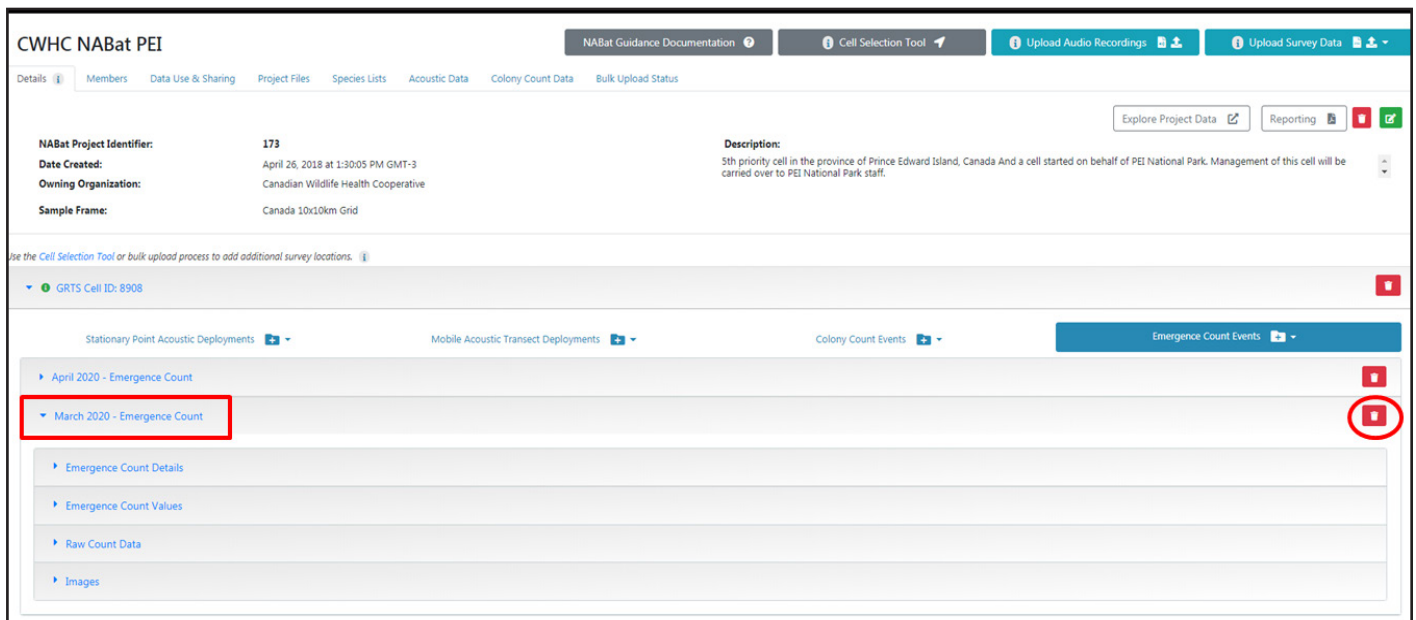


Figure 334. If an emergence count event needs to be deleted, select the red trash can button.



4.8.4 Exploring Data on the NABat Website

Once data are uploaded to the NABat website, take the time to explore the data presentation features of the website. On the “Project” tab for accessible projects, under the “Details” tab, select “Explore Project Data” at the top right of the page.

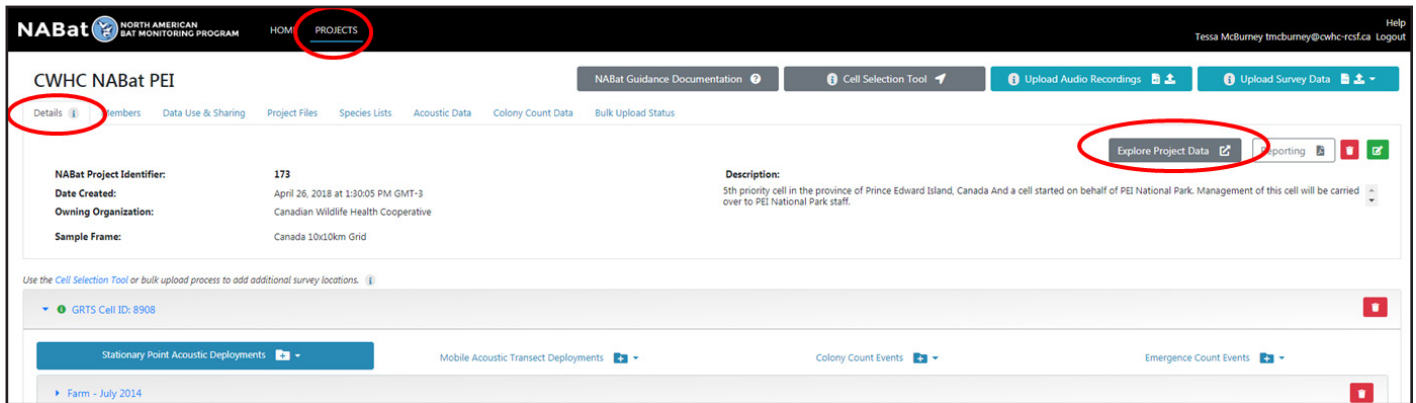


Figure 335. On the “Project” tab for accessible projects, under the “Details” tab, select “Explore Project Data” at the top right of the page.

Here there are several visual aids for viewing the uploaded data. This will provide different options for categorising data in both chart and table form, which are available for download.

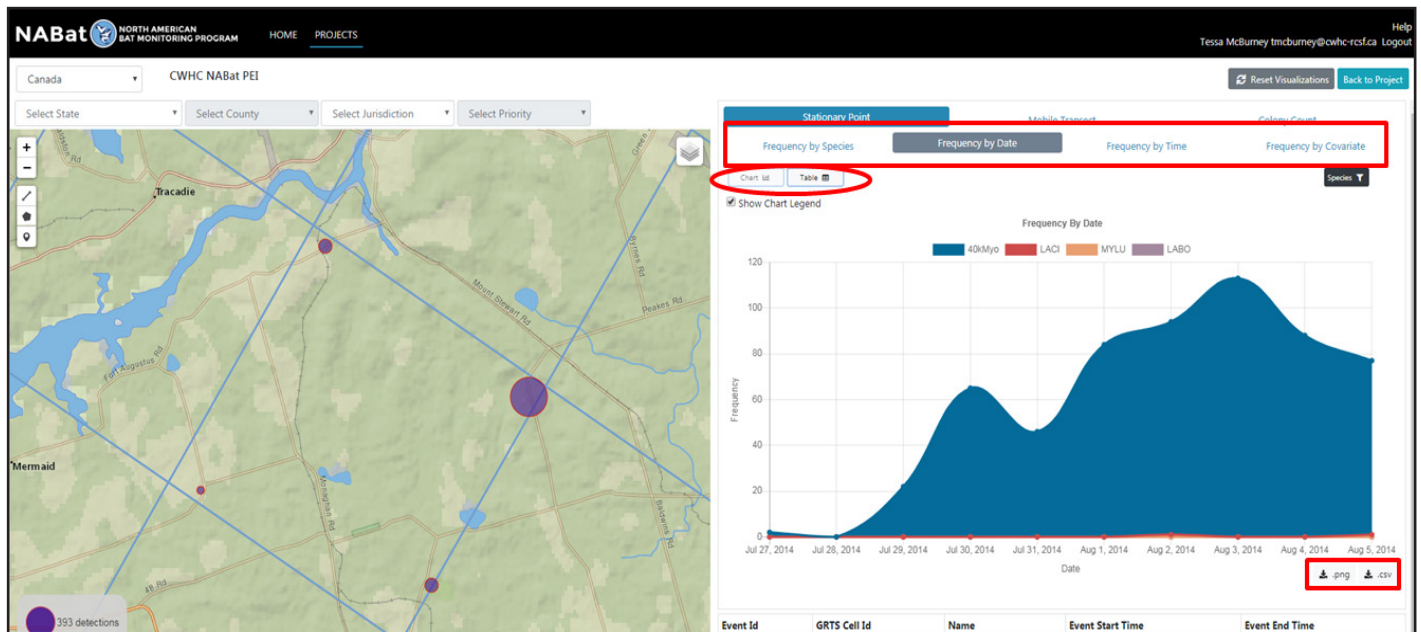


Figure 336. There are several visual aids for viewing the uploaded data.



Select the type of survey on the top right of the page (Stationary Point or Mobile Transect, there is no option for emergence surveys). If Stationary Point is selected, the map on this page will show the number of detections at each of the stationary point survey sites. For site-specific visuals, select the desired site from the table at the bottom of the page.

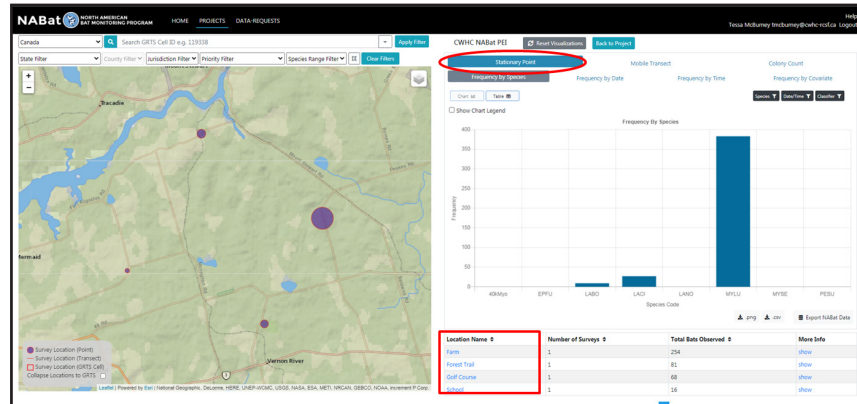


Figure 337. If Stationary Point is selected, the map on this page will show the number of detections at each of the stationary point survey sites, or for site-specific visuals, select the desired site from the table at the bottom of the page.

Select the grey “Reset Visualizations” button at the top of the page to go back to a summary of all sites.

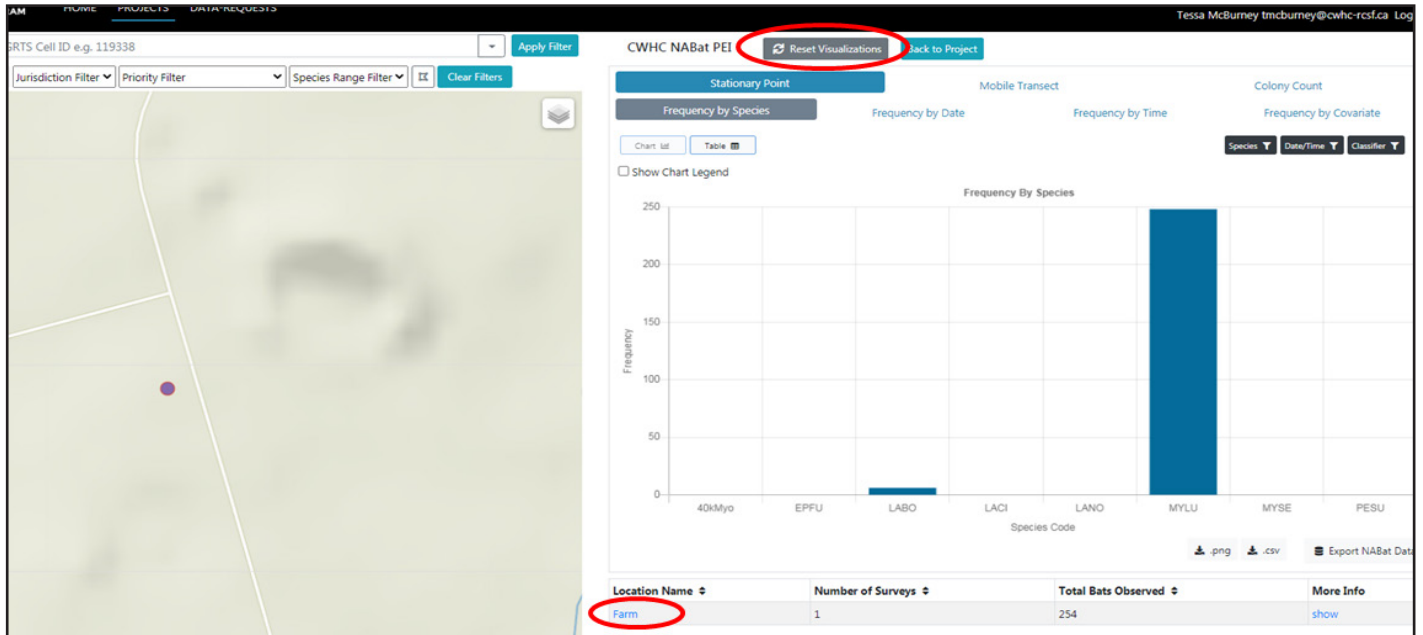


Figure 338. Select the grey “Reset Visualizations” button at the top of the page to go back to a summary of all sites.



To see the mobile transect detections on the map, select “Mobile Transect” and then the desired survey from the table at the bottom of the page.

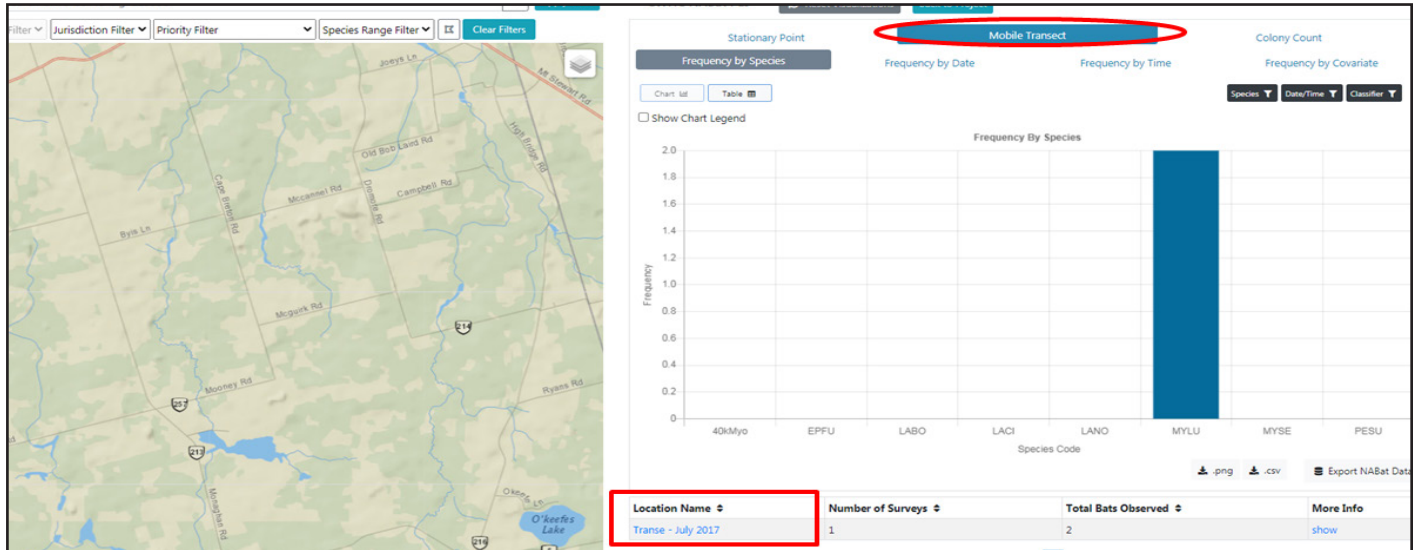


Figure 339. To see the mobile transect detections on the map, select “Mobile Transect” and then the desired survey from the table at the bottom of the page.

If multiple mobile transects were conducted, select the grey “Reset Visualizations” button at the top of the page to go back to a summary of all surveys.

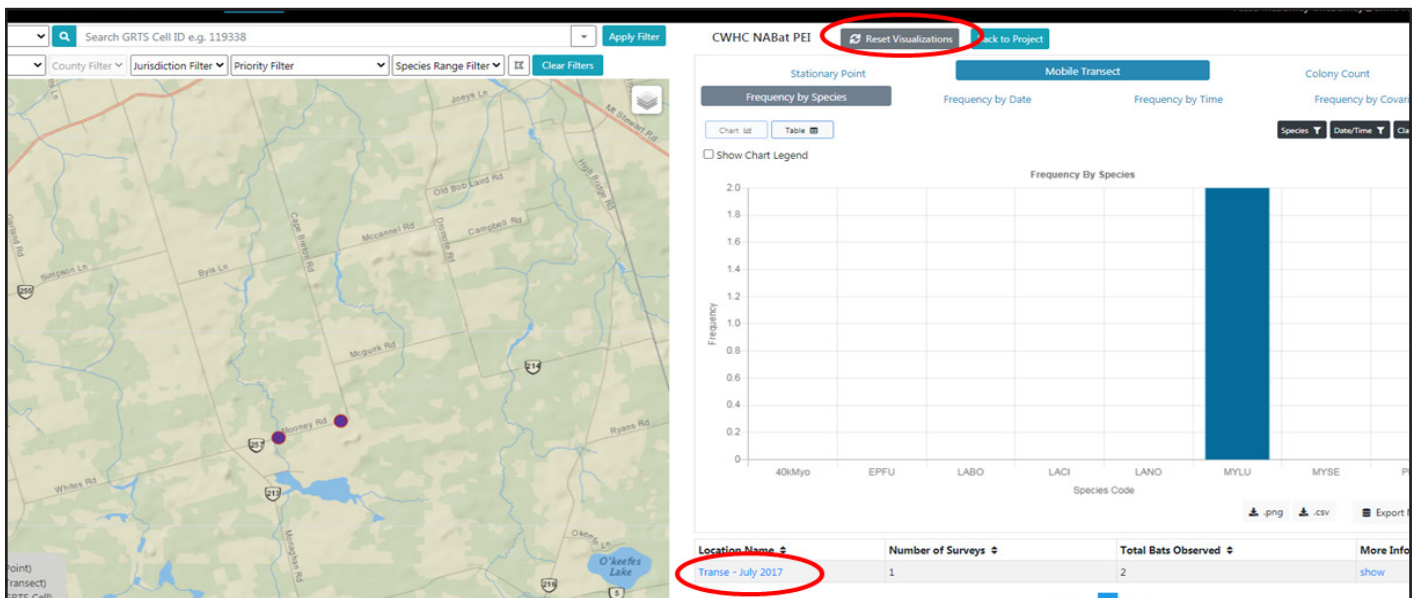


Figure 340. If multiple mobile transects were conducted, select the grey “Reset Visualizations” button at the top of the page to go back to a summary of all surveys.



4.9 NABat Consistency and Data Sharing

A temporal revisit design is used to evaluate the survey effort over time in each sampling unit (*i.e.*, each GRTS cell), and ensures that site-level replication occurs at regular time intervals. The NABat temporal revisit design uses the “always revisit” model, where it is recommended that the same GRTS cells are surveyed every year for acoustic surveys, including both stationary point surveys and mobile transects, and external roost counts. Internal roost counts (which are not encouraged without close collaboration with provincial or federal agencies) should be conducted every year or every second year. NABat chose the “always revisit” temporal revisit design because it is considered optimal for detecting trends, it has high statistical power, and it has already been used for successful temporal trend detection of bat populations within the U.S. Additionally, this study design allows for some flexibility in regard to missing data. If a GRTS cell was not monitored in a particular year, resulting in the loss of data from that year, that GRTS cell can still be accommodated within NABat analyses framework. As long as the missing data are random and unbiased (*i.e.*, the same GRTS cell does not lack data collection for multiple years in a row), the data can still be included in future NABat analyses (23).

The power of NABat monitoring is the trends that can be observed over prolonged periods of collecting and submitting monitoring data. Gathering a single year of data will not be sufficient to answer long-term questions about the bat populations being monitored, and a minimum of five years of data collection should occur prior to using bat activity as a measure of populations-level trends.



Figure 341. The power of NABat monitoring is the trends that can be observed over prolonged periods of collecting and submitting monitoring data.



The other benefit of NABat monitoring is its monitoring network. By sharing any data with NABat online, it will allow that data to be included in continental-wide monitoring for trends in bat populations. However, since the data are also incredibly useful for local and regional-scale monitoring and analysis, it is very important to share data on an annual basis directly with provincial government agencies responsible for conservation and management of bat populations:

4.9.1 New Brunswick

Department of Natural Resources and Energy Development

Forest Planning and Stewardship Branch

506-453-3826



4.9.2 Newfoundland and Labrador

Department of Fisheries, Forestry and Agriculture

Forestry and Wildlife Branch

709-637-2025

4.9.3 Nova Scotia

Department of Lands and Forestry

Wildlife Division, Biodiversity Programme

902-679-6091

biodiversity@novascotia.ca

4.9.4 Prince Edward Island

Department of Environment, Energy and Climate Action

Forests, Fish and Wildlife Division

902-368-4683





Section 5. Resources

Document should be cited as the following:

McBurney, T. S. and J. L. Segers. 2021. Guide for Bat Monitoring in Atlantic Canada. Tech. Rep. Charlottetown, PE: Canadian Wildlife Health Cooperative, Canadian Wildlife Health Cooperative Atlantic Office. 233 p.

5.1 Definitions

Approach phase: echolocation sequence phase where a bat has detected echoes reflecting off an object and approaches the object

Bat pass: the unit of measurement commonly used when calculating species magnitude of activity or species relative abundance estimates; at least three discernible bat calls/pulses in zero-cross (NOT full spectrum)

Call/Pulse: each separate line of sound on a spectrogram (usually sweeps from high to low frequency); represents a single echolocation call of a bat

Call body: the part of call with the lowest slope, the flattest part of call (after the knee)

Call body slope (S_c): the slope of the call body (also considered the characteristic slope of the call) (OPS)

Characteristic frequency (F_c): the average frequency of the call body (kHz)

Clutter: the amount of material in the environment that can reflect back an echolocation call

Diffuse echo: an echo that is reflected off a rough surface, such as a tree

Duration (Dur): the length of time of a pulse (ms)

Initial slope (S_1): the slope of the call above the knee (OPS)

Knee/Elbow: a bend in the call that is sometimes present, and can be either indistinct (smooth, rounded) or distinct (sharp, angular)

Knee frequency (F_k): the average frequency of the knee (kHz)

Maximum frequency (F_{max}): the highest frequency of the call (kHz)

Minimum frequency (F_{min}): the lowest frequency of the call (kHz)



Octaves per second (OPS): unit used to measure call slope

Search phase: echolocation sequence phase where a bat is flying around sending out echolocation calls to navigate its surroundings or to search for prey

(Call) Sequence: a series of calls/pulses that can be visualised in a spectrogram

Spectrogram: an image displaying sound waves

Specular echo: an echo that is reflected off a smooth surface, such as water or a rock

Tail/Toe: a hook on the end of the call that is sometimes present after the call body, and can be either upturned or downturned

Terminal phase (buzz): echolocation sequence phase where a bat is sufficiently close to an object of interest and has determined it is prey it will attempt to eat, or water it will attempt to drink

Time between calls (TBC): the length of time between pulses (ms)

Undulation: the F_{\min} does not remain consistent in a call sequence (it moves up and down in frequency)

Volant: able to fly



Figure 342. A specular echo is an echo that is reflected off a smooth surface, such as water or a rock.



Section 6. References

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Section 7. Appendix

7.1 Data for Stationary Point Surveys

Data Fields	Description	Example
Project Name	The NABat Project Name is defined by the user when creating an NABat Project	CWHC NABat 2020
Site name	A user-defined name of the specific location (or point) where a detector was deployed within a single grid cell	Tabby Pond
GRTS Cell ID	NABat GRTS ID number of the cell where the survey was conducted	8908
GPS coordinates (latitude)	Decimal degrees (DD)	46.262668
GPS coordinate (longitude)	Decimal degrees (DD)	-63.134469
Surveyor organisation	Name of organisation (if applicable)	Canadian Wildlife Health Cooperative
Surveyor names	The name(s) of survey participant(s)	Tessa McBurney Jordi Segers
Surveyor years of experience	Number of years of experience with survey type	Five (TM) Seven (JS)
Survey type	Name of NABat survey type	Stationary point survey
Survey date(s)	Monitoring period	June 1st -June 7th, 2020
Activation start date	YYYY-MM-DD Date when detector was activated to start recording (*Note: not deployment date)	2020-06-01
Activation start time	HH:MM:SS Time when detector was activated to start recording (*Note: not deployment time) (should be 30 minutes before sunset) (use 24-hour clock)	20:42:00



Activation end date	YYYY-MM-DD Date when detector was activated to end recording (*Note: not retrieval date)	2020-06-07
Activation end time	HH:MM:SS Time when detector was activated to end recording (*Note: not retrieval time) (should be 30 minutes after sunrise) (use 24-hour clock)	05:36:00
Deployment date	YYYY-MM-DD Date when detector was deployed	2020-06-01
Deployment start time	HH:MM:SS Time when detector was deployed	12:30:00
Retrieval date	YYYY-MM-DD Date when detector was retrieved	2020-06-08
Retrieval end time	HH:MM:SS Time when detector was retrieved	10:25:00
Habitat type	Broad habitat type(s) of site	wetland
Moonrise/moonset times	For each monitoring night (use 24-hour clock) **select the times that fit for the night monitoring period (not the day); the moonset time may be on the next day Data can be found here	June 1st - 15:49/3:42
		June 2nd - 17:08/4:09
		June 3rd - 18:27/4:39
		June 4th - 19:47/5:15
		June 5th - 21:03/5:59
		June 6th - 22:13/6:51
		June 7th - 23:12/7:51
Sunrise/sunset times	For each monitoring night (use 24-hour clock) Data can be found here	June 1st - 5:24/20:57
		June 2nd - 5:23/20:58
		June 3rd - 5:23/20:58
		June 4th - 5:22/20:59
		June 5th - 5:22/21:00
		June 6th - 5:21/21:01
		June 7th - 5:21/21:01



Nightly temperature (°C)	For each monitoring night (use Celsius) Data can be found here	June 1st - 14.0
		June 2nd - 12.9
		June 3rd - 17.9
		June 4th - 23.5
		June 5th - 24.1
		June 6th - 17.2
		June 7th - 14.2
Nightly relative humidity (RH) (%)	For each monitoring night Data can be found here	June 1st - 43
		June 2nd - 100
		June 3rd - 92
		June 4th - 56
		June 5th - 70
		June 6th - 100
		June 7th - 60
Nightly wind speed (km/h)	For each monitoring night Data can be found here	June 1st - 35
		June 2nd - 55
		June 3rd - 48
		June 4th - 39
		June 5th - 50
		June 6th - 21
		June 7th - 33
Nightly wind direction	Cardinal direction The wind direction in tens of degrees can be found here Convert tens of degrees to cardinal direction here (*first multiply by 10)	June 1st - WSW
		June 2nd - ESE
		June 3rd - S
		June 4th - SW
		June 5th - S
		June 6th - N
		June 7th - SW
Average survey cloud cover (%)	Percent of sky covered by clouds *Data cannot be collected post-survey	June 1st - 12
		June 2nd - 87
		June 3rd - 100
		June 4th - 80
		June 5th - 0
		June 6th - 5
		June 7th - 10



Moon phase/percent illumination (%)	For each monitoring night (moon phase with the percent illumination of the moon) Moon phase can be found here Percent illumination can be found here	June 1st - Waxing gibbous (76)
		June 2nd - Waxing gibbous (85)
		June 3rd - Waxing gibbous (93)
		June 4th - Waxing gibbous (98)
		June 5th - Full moon (100)
		June 6th - Waning gibbous (99)
		June 7th - Waning gibbous (96)
Any significant weather event	Describe in as much detail as necessary Some data can be found here , but should record data during the monitoring period to ensure all data are captured	Thunderstorm (June 6th)
Detector model #	# found on the detector	S4U03784
Microphone #	# found on the microphone	U100133
Microphone orientation (°)	1-360°	45.5°
Microphone direction	Cardinal direction	NNE
Distance from microphone to ground (m)	Height (meters) of microphone above ground	2.3
Distance from microphone to clutter (m)	Distance (meters) between microphone and nearest clutter (e.g., vegetation, buildings, or other structure)	3.2
Site photos	At least one photo should be taken of each site set-up (ideally, multiple photos will be taken to show what the site looks like in every direction)	yes
Comments	Any additional comments	When retrieved, the SD card had 1/64 GB of data and the battery was at 6.2 V.



7.2 Data for Mobile Transects

Data Fields	Description	Example
Project Name	The NABat Project Name is defined by the user when creating an NABat Project	CWHC NABat 2020
GRTS Cell ID	NABat GRTS ID number of the cell where the survey was conducted	8908
GPS coordinates start (latitude)	Decimal degrees (DD)	46.190971
GPS coordinates start (longitude)	Decimal degrees (DD)	-62.939959
GPS coordinates end (latitude)	Decimal degrees (DD)	46.395345
GPS coordinates end (longitude)	Decimal degrees (DD)	-63.193990
Surveyor organisation	Name of organisation (if applicable)	Canadian Wildlife Health Cooperative
Surveyor names	The name(s) of survey participant(s)	Tessa McBurney Jordi Segers
Surveyor years of experience	Number of years of experience with survey type	Five (TM) Seven (JS)
Survey type	Name of NABat survey type	Mobile transect
Survey date(s)	Monitoring period	June 4th, 2020
Activation start date	YYYY-MM-DD Date when detector was activated to start recording	2020-06-04
Activation start time	HH:MM:SS Time when detector was activated to start recording (use 24-hour clock)	22:00:00
Activation end date	YYYY-MM-DD Date when detector was activated to end recording	2020-06-04
Activation end time	HH:MM:SS Time when detector was activated to end recording (use 24-hour clock)	23:15:00
Habitat type	Broad habitat type(s) of transect	wetland, forest – conifer, agriculture



Moonrise/moonset times	Use 24-hour clock **select the times that fit for the night monitoring period (not the day); the moonset time may be on the next day Data can be found here	19:47/5:15
Sunrise/sunset times	Use 24-hour clock Data can be found here	5:22/20:59
Average survey temperature (°C)	Use Celsius (average for the length of the survey) Data can be found here	23.5
Average survey relative humidity (RH) (%)	Average for the length of the survey Data can be found here	56
Average survey wind speed (km/h)	Average for the length of the survey Data can be found here	8
Average survey wind direction	Cardinal direction (average for the length of the survey) The wind direction in tens of degrees can be found here Convert tens of degrees to cardinal direction here (*first multiply by 10)	SW
Average survey cloud cover (%)	Percent of sky covered by clouds *Data cannot be collected post-survey	40
Moon phase/percent illumination (%)	Moon phase with the percent illumination of the moon Moon phase can be found here Percent illumination can be found here	Waxing gibbous (98)
Any significant weather event	Describe in as much detail as necessary Some data can be found here , but should record data during the monitoring period to ensure all data are captured	None; clear weather



Detector model #	# found on the detector	S4U03785
Microphone #	# found on the microphone	U100134
Microphone orientation (°)	1-360°	0.0/360.0
Distance from microphone to ground (m)	Height (meters) of microphone above ground	1.5
Set-up photos	At least one photo should be taken of set-up (ideally, multiple photos will be taken to show what the set-up and transect route looks like)	yes
Comments	Any additional comments	Had to briefly stop at a stop sign to avoid traffic (22:14).



Photo by Darlene Weeks

Figure 343. Participating in bat research is fun.



7.3 Keyboard Shortcuts for Kaleidoscope Viewer (28)

Shortcut Key	Function
Down arrow	Next file
Up arrow	Previous file
Shift-down arrow	Next folder
Shift-up arrow	Previous folder
Right arrow	Scroll forward 1/10th screen width
Left arrow	Scroll backward 1/10th screen width
Shift-right arrow	Scroll forward one screen width
Shift-left arrow	Scroll backward one screen width
Space bar	Play .wav file
r	Reload file
0	Accept auto ID label
1-8	Selects the corresponding manual ID label from the top row of customisable labels (1 = left, 8 = right)
+ OR z	Zoom-in x-axis
- OR Z	Zoom-out x-axis
=	Zoom to maximum axis for that file
.	Toggle zero-cross view
/	Toggle full spectrum view
Control-manual ID label (or corresponding # key)	Adds manual ID labels to manual ID field, can add multiple species, automatically separates with “;” (temporarily disables “Auto next file” option)

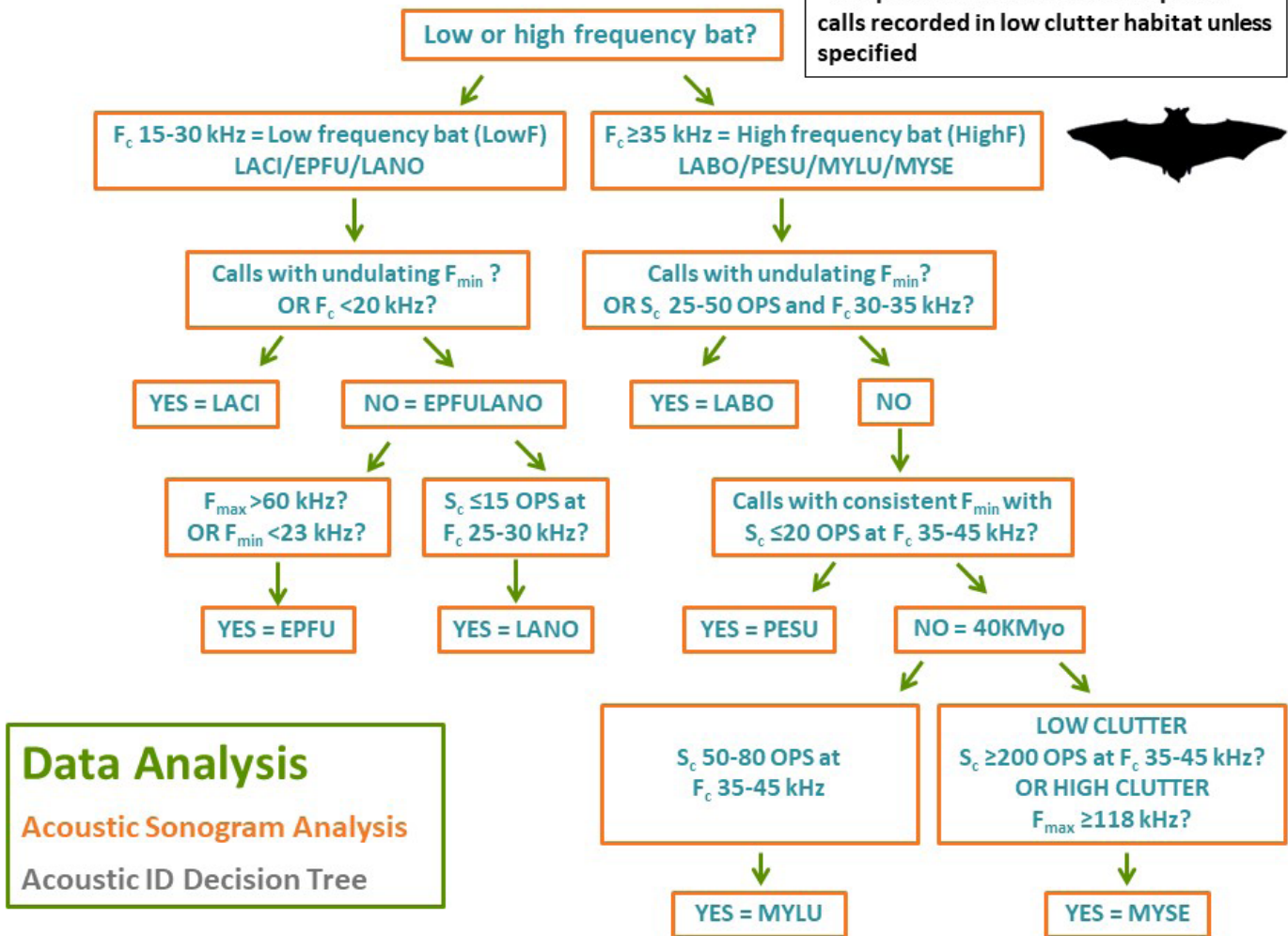




7.4 Acoustic Identification Decision Tree



*Call parameters are for search phase calls recorded in low clutter habitat unless specified

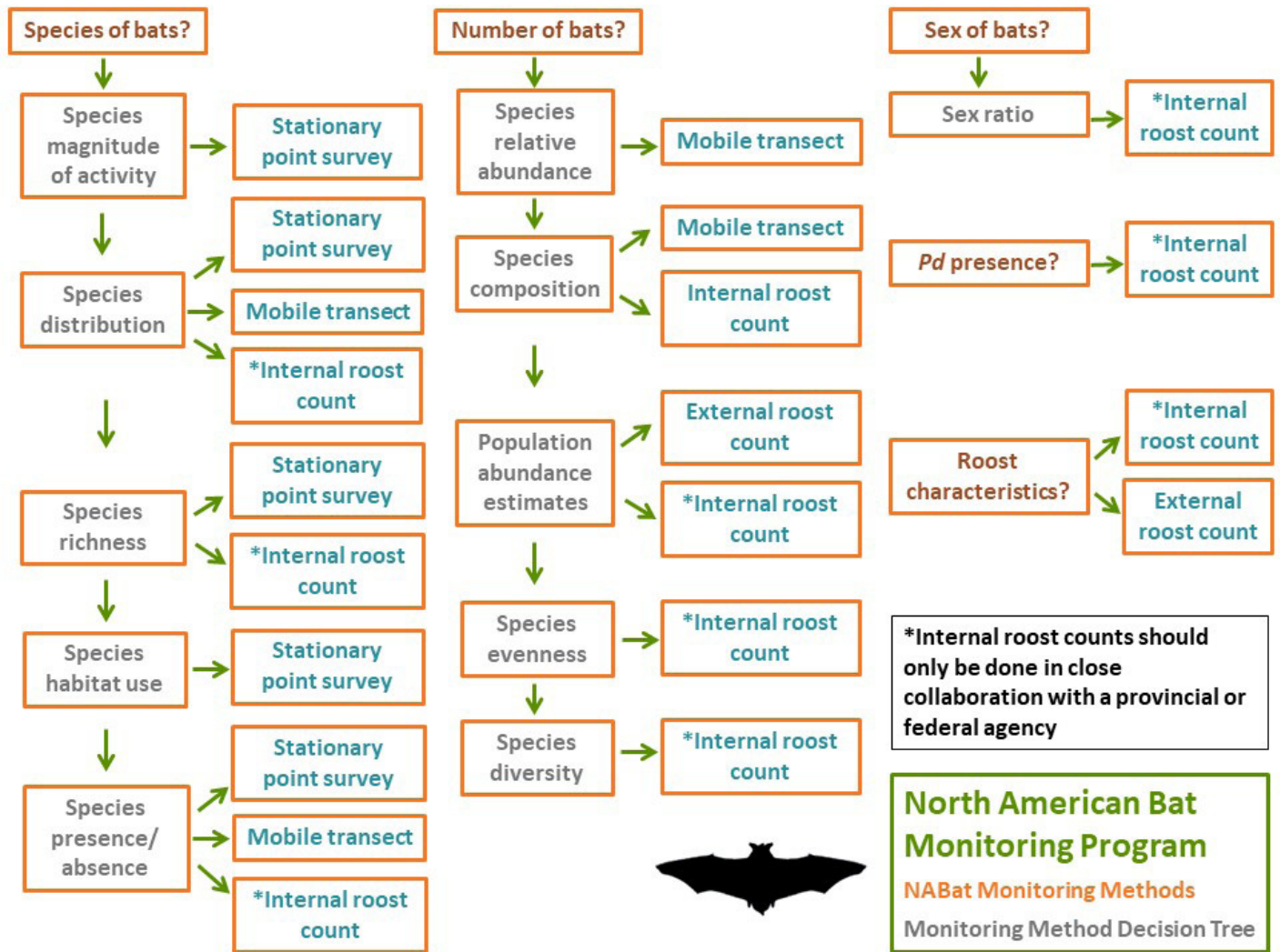


Data Analysis
Acoustic Sonogram Analysis
Acoustic ID Decision Tree



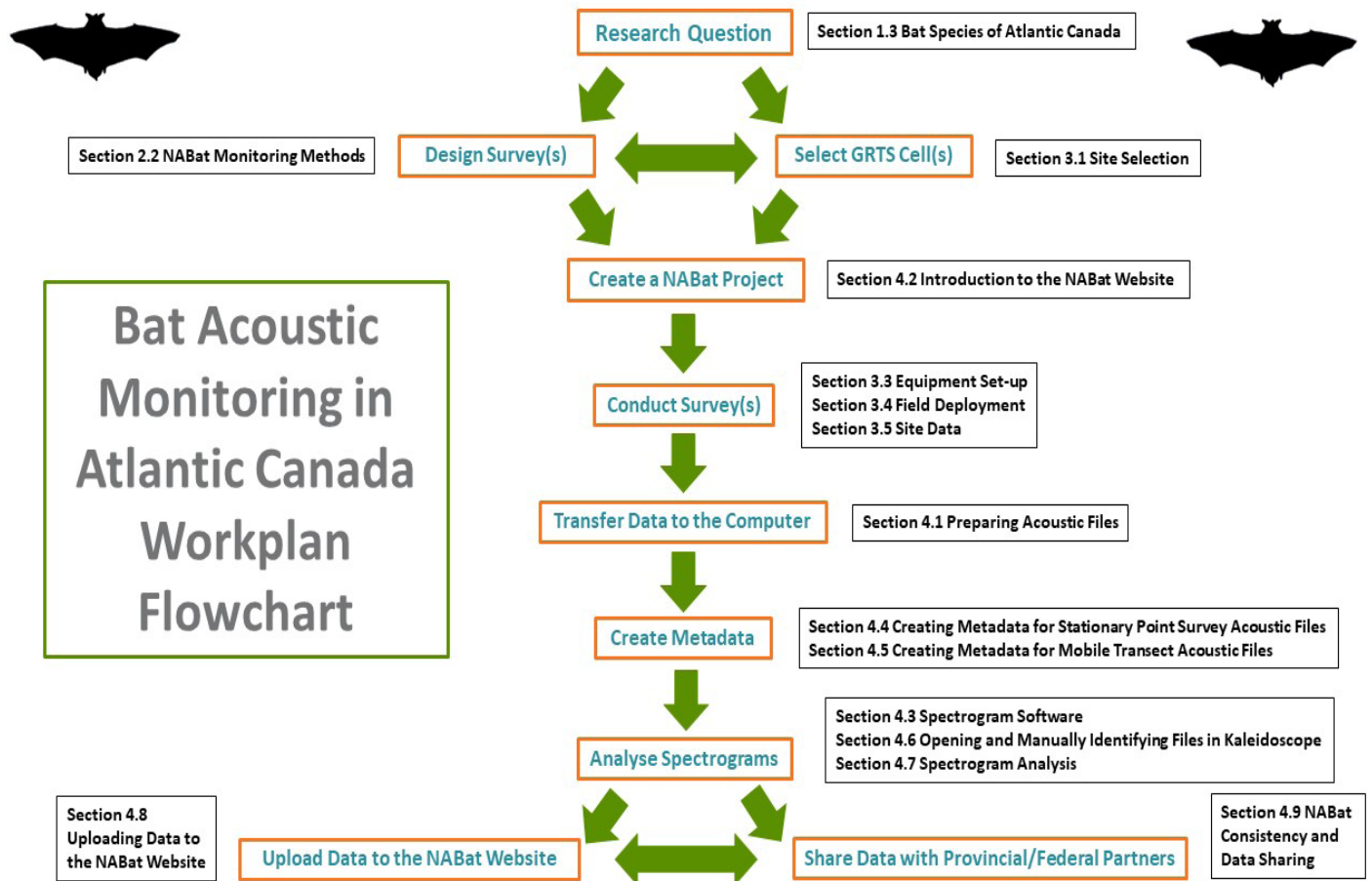


7.5 Monitoring Method Decision Tree





7.6 Acoustic Workplan Flowchart





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