ENERGINET ELTRANSMISSION A/S

KATTEGAT

TECHNICAL REPORT - BATS

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PROJECT NAME: KATTEGAT
PROJECT NO.:
DATE: 02-10-2024
VERSION: 5.0
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DESCRIPTION: TECHNICAL REPORT FOR BATS

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SUMMARY

INTRODUCTION

In order to accelerate the expansion of Danish offshore wind production, it was decided with the agreement on the Finance Act for 2022 to offer an additional 2 GW of offshore wind for establishment before the end of 2030. In addition, the parties behind the Climate Agreement on Green Power and Heat 2022 of 25 June 2022 (hereinafter Climate Agreement 2022) decided), that areas that can accommodate an additional 4 GW of offshore wind must be offered for establishment before the end of 2030. Most recently, a political agreement was concluded on 30 May 2023, which establishes the framework for the Climate Agreement 2022 with the development of 9 GW of offshore wind, which potentially can be increased to 14 GW or more if the concession winners – i.e. the tenderers who will set up the offshore wind turbines – use the freedom included in the agreement to establish capacity in addition to the tendered minimum capacity of 1 GW per tendered area.

In order to enable the realization of the political agreements on significantly more energy production from offshore wind before the end of 2030, the Danish Energy Agency has drawn up a plan for the establishment of offshore wind farms in three areas in the North Sea, the Kattegat and the Baltic Sea respectively.

The area for Kattegat Offshore Wind Farm (OWF) is located in Kattegat, approximately 20 kilometer east of Djursland and approximately 30 kilometers north of Zealand. The area for the OWF is approximately 122 km^2. The Kattegat OWF will be connected to land via subsea cables making landfall close to Grenaa.

This report presents the results of the bat survey for the proposed areas Kattegat OWF from the first year between March 2023 and November 2023. The second-year survey program will be undertaken from April 2024 – November 2024.

EXISTING DATA AND KNOWLEDGE

Bat species can be divided into three groups depending on their typical migration distances. Some bats are sedentary and only rarely move more than a few kilometres from their breeding and roosting sites. Other species are short distance migrating bats with a moving range up to around 100 kilometres, typically between a breeding site or a summer roosting site to a winter roosting and hibernation site. Most bats of Northern Europe belong to this group. The third group is long distance migrating bats, typically migrating between a few hundred kilometres and several thousand kilometres. The long-distance migrating bats are considered the species most vulnerable to offshore wind farms.

It is generally presumed that most migrating bats avoid crossing long distances over the sea. Therefore, the main migration routes are expected to follow land and coast until sea crossing cannot be avoided. In Northern Europe large numbers of bats are known to migrate from Finland, the Baltic countries, and Sweden to Holland, Belgium, Northern France and even the southern parts of England.

There are few studies on bat migration over the Kattegat between Denmark and Fennoscandia and most of them are not publicly available. This is the case for two projects in Swedish part of northern Kattegat (Poseidon and Vidar) and Swedish Kattegat S near Anholt. Also, no bat survey were carried out prior or post to the construction of Anholt Offshore Windfarm in the Danish part of Kattegat.

Two species of bats, common noctule and nathusius pipistrelle, are most likely to migrate through the pre investigation area in larger numbers, because both species are known to migrate long distance and both species are present in large populations in Sweden.

METHODOLOGIES

In spring 2023 (late March-early April) bat detectors were installed on the island Hesselø and Djursland peninsula, Sjællands Odde peninsula and two places along the west coast of Sweden and on fourteen buoys in the southern part of Kattegat. This report focusses mainly on the eight buoys within the pre-investigation area for Kattegat OWF and the detectors on coast of Djursland. The bat detectors recorded the ultrasound from bats in the vicinity of the detector and saved the recording for later analysis. The range of the recording varies between different bat species. Large bat, like common noctule and parti-colored bat can be recorded up to 100 meters from the detector, whereas smaller bat will only be recorded when they are within a distance below 50 meters. In the pre-investigation areas of Kattegat OWF five detectors on buoys were active in spring and summer 2023 whereas eight detectors on buoys were active in autumn 2023.

RESULTS

The spring pattern of common noctule activity on the coastal area of Djursland West og the pre-investigation area shows no clear migration patterns. Most activity is in summer and indicate an important breeding area in some of the coastal forest. Very few recordings of common noctule on Hesselø in spring also indicates that there is limited migration of noctules. In late summer and early autumn there is still some activity on the coast of Djursland and more activity on Hesselø. This may indicate some level of migration in autumn from mid-August to mid-April. However, the migrating animals might be mixed with local feeding animals from Djursland and maybe even from Northern Zealand.

Nathusius pipistrel is the only species with a rather clear migration pattern. On Djursland the spring migration starts in late April and continue until early June. The migration on Hesselø seem to be slightly earlier, from mid-April to mid-May. This difference may indicate that the bats observed on Hesselø are not arriving from Djursland but more likely from Northeast Zealand. The pattern on Hesselø fits better with the patterns observed on the island Hallands Väderö near the Swedish coast. Nathusius pipistrels along the Swedish coast are expected to arrive from Zealand.

Soprano pipistrel is common in all coastal areas around the pre-investigation area but shows no clear patterns of migration.

Parti-colored bat is not common on Djursland and shows no clear patterns of migration. The species has the main distribution in Northern Zealand, and the high activity on Hesselø in late April may originate from animals from Zealand.

The bat detectors on the offshore buoys generally recorded less bats than on the land-based detector. In spring 2023 nathusius pipistrel was recorded only four times and only on the westernmost buoy. Parti-coloured bat was recorded only in late summer on two buoys. Common noctule, and soprano pipistrel were not recorded on the buoys in spring.

In autumn the numbers of bat recordings per buoy were higher. The buoys with large numbers of records are situated between 10 and 30 km from the coast of Djursland. The majority of the records are from early September and especially the night after 9th September.

The records per buoy range from 3 to 20 per season. The average bat recording per buoy, when corrected for detector failure, is 13.8 per year. This is higher than similar figures from the Baltic Sea south of Bornholm where a similar survey was carried out for the Energy Island project I 2022 and 2023. The buoys at Bornholm recorded in average 5.3 bats per buoy per season. Also, similar survey in Hesselø east of the planned Kattegat OWF area shows less recordings of bats with an average of only 2.3 per buoy.

Most bat species prefer to fly over the sea in the dark hours where the risk from predators is lower. This is confirmed by the pattern shown in this data, only very few common noctules are recorded by bat detectors outside the dark part of night.

The number of bat recordings are compared to the information on the weather condition estimated by the MetOcean buoy. This direct relation was only possible to do in the late summer and autumn due to the installation of the MetOcean buoys from 21 July 2023.

The bats prefer to fly in low wind speeds. Of all bat recordings 95 percent were recorded when windspeeds (measured 12 meters above sea level) were less than 6 m/s. This measurement might represent the conditions in the surrounding of the bat detectors and therefore could be considered as the preference for the recorded bat.

If the number of bat records are compared to the wind speed around a theoretical nacelle 150 meters above sea level most bat records would still be below 6 m/s. Based on the estimates from the MetOcean buoys 88 percent of the bat records are below 6 m/s in 150 meter above sea level.

All nights with bat observation in 2023 had temperatures higher than 16 C, except one night in October with one observation of a common noctule (temperature 12.2 C measured at the MetOcean buoy).

CONCLUSIONS

Based on data from the 1st year of bat survey in the southern part of Kattegat it is concluded that during spring migration from mid-April to mid-May several bat species occur. This indicates some kind of migration in the area, most likely from Jutland to Sweden.

In late summer and early autumn, in nights with high temperature and low wind speed, bats from Djursland (Jutland) use the southern part of Kattegat for feeding. Most likely related to the presence of large insects over the open sea. This feeding behaviour seems to be restricted to nights with wind speeds below 6 m/s and temperatures higher than 16 C.

The data collection will continue in 2024, and this will provide more information on the pattern and the magnitude of the migration and the feeding patterns of bats from the surrounding coastal areas.

INTRODUCTION

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The area for Kattegat Offshore Wind Farm (OWF) is located in Kattegat, approximately 20 kilometer east of Djursland and approximately 30 kilometers north of Zealand. The area for the OWF is approximately 122 km^2. The Kattegat OWF will be connected to land via subsea cables making landfall close to Grenaa.

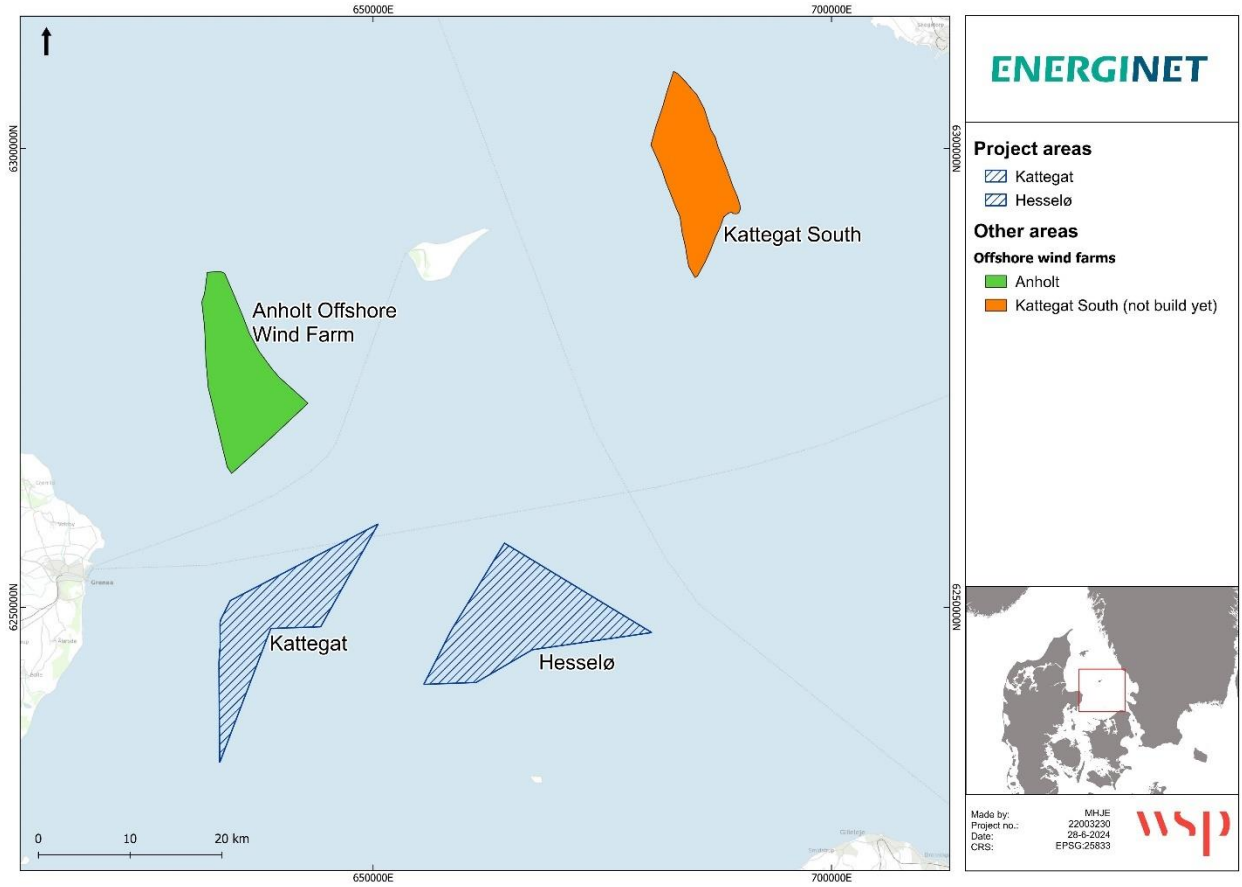

Figure 1 - Overview of offshore wind project in southern Kattegat

Bat migration across the offshore areas of Denmark is poorly known and to date there is no existing data from the southern part of Kattegat available. Due to the planning of several new offshore wind farms in this area, there is a need for information on bat migration and behaviour in the area as baseline for the environmental impact and risk assessment.
To support the environmental impact assessments for the future offshore wind farm projects a bat monitoring program was initiated by Energinet in spring 2023. The program will run for two years, and this technical report is based only on the first-year data collected in 2023.

A similar program of bat monitoring is undertaken for the nearby Hesselø OWF area (see map (Figure 1). This report is focused on the data collected for Kattegat OWF, but in relation to future impact assessments data from the larger area should also be considered.

EXISTING DATA AND KNOWLEDGE

BAT MIGRATION

Bat species can be divided into three groups depending on their maximum migration distance (Figure 2). Some bats are sedentary and only rarely move more than a few kilometres from their breeding and roosting sites. Other species are short distance migrating bats with a moving range up to around 100 kilometres, typically between a breeding site or a summer roosting site to a winter roosting and hibernation site. Most bats of Northern Europe belong to this group. The third group is long distance migrating bats, typically migrating between a few hundred kilometres and several thousand kilometres. The long-distance migrating bats are considered the species most vulnerable to offshore wind farms (Rydell et al. 2010, Voigt et al. 2012 Lehnert et al. 2014, Arnett et al. 2016, Kruszynski et al. 2020).

It is generally presumption that most migrating bats avoid crossing long distances over the sea. Therefore, the main migration routes are expected to follow land and coast until sea crossing cannot be avoided. In Northern Europe large numbers of bats are known to migrate from Finland, the Baltic countries, and Sweden to Holland, Belgium, Northern France and even the southern parts of England.

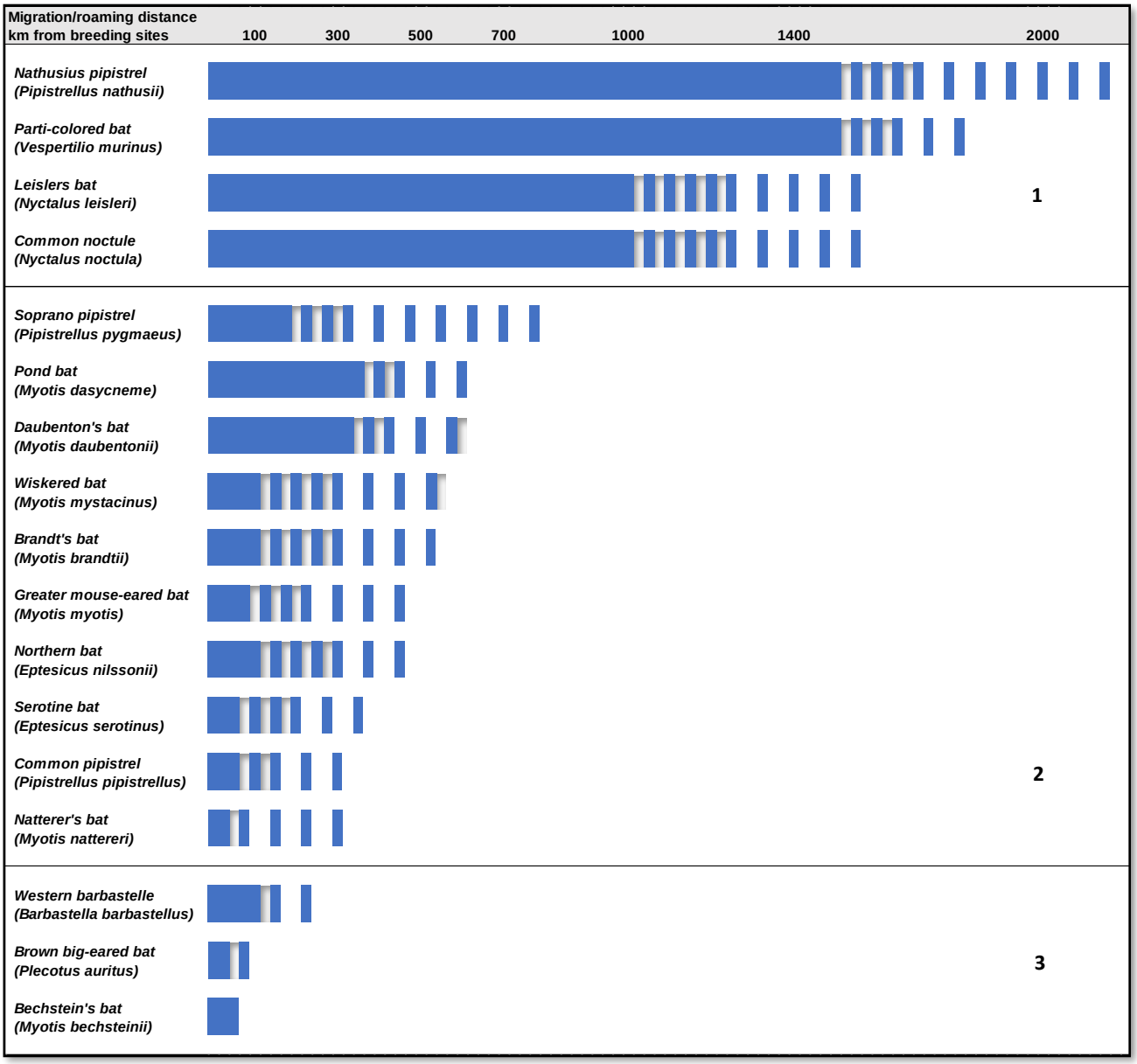

Figure 2 – General distance of migration and roaming for bat species found in Denmark. Figure from Christensen & Hansen 2023 (Translated from Danish). Based on sources: Baagøe 2001, Pētersons 2004, Hutterer et al. 2005, Dietz et al. 2011, Baagøe & Jensen 2007, Alcalde et al. 2021 a.o.

OFFSHORE BAT SURVEYS IN SOUTHERN KATTEGAT

There are few studies on bat migration over the Kattegat between Denmark and Fennoscandia and most of them are not public available. This is the case for two projects in Swedish part of northern Kattegat (Poseidon and Vidar) and Swedish Kattegat S near Anholt. Also, no bat survey was carried out prior or post the construction of Anholt Offshore Windfarm in the Danish part of Kattegat. The most relevant, and available, information is the survey carried out for Sejerø Nearshore Wind Farm in 2014 (Figure 3)

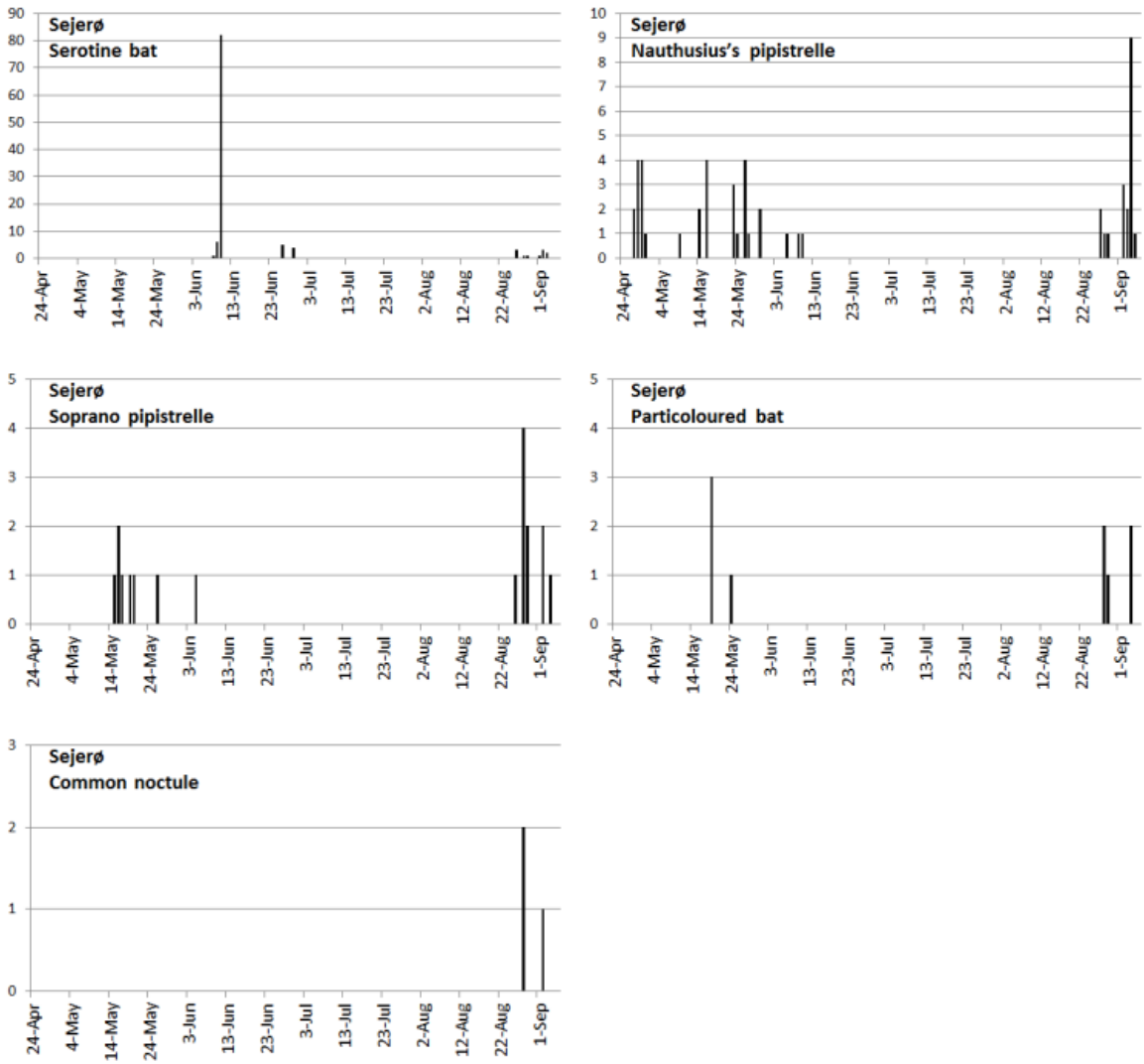

Figure 3 – Bat recordings from Sejerø 2014 (Daily totals). Data collected for Sejerø Bugt Nearshore Wind Farm.

BAT SPECIES MIGRATING THROUGH SOUTHERN KATTEGAT IN LARGER NUMBERS

Two species of bats, common noctule and nathusius pipistrelle, are most likely to migrate through the pre investigation area in larger numbers, because both species are known to migrate long distance and both species are present in large populations in Sweden (Wesling et al. 2020), Finland (Tidenberg 2019), and the Baltic countries (Eurobat 2014).

COMMON NOCTULE (NYCTALUS NOCTULA)

Common noctule is widespread and common in Denmark (Møller et al. 2013) and Sweden (De Jong et al. 2020, Wesling et al. 2020) (Figure 4). The Swedish population is estimated to 130,000 individuals (Wesling et al 2020).

Common noctule is a typical migratory bat species. Populations from north-eastern Europe are known to migrate southwest in autumn, thus covering distances of up to 1,000 km. Due to the weather conditions, western populations tend to be more sedentary (Lehnert et al. 2018).
Common noctule occur in small numbers in coastal bat survey in the southern Kattegat (Figure 3) and it is expected that the common noctule migrates through the pre investigation area.

Figure 4 - Distribution of common noctule (Source: EUROBAT).).

NATHUSIUS PIPISTRELLE (PIPISTRELLUS NATHUSII)

Nathusius pipistrelle is widespread and common in Denmark (Møller et al. 2013) and Sweden (De Jong et al. 2020) and the distribution in the region also include the Baltic countries and southernmost Finland (Figure 5). The nathusius pipistrelle undertakes a seasonal long-distance migration, usually from northeast to southwest Europe.
Existing data from offshore surveys in Kattegat shows nathusius pipistrelle to be a frequent species.

Figure 5 - Distribution of nathusius pipistrelle (Source: EUROBAT).).

BAT SPECIES MIGRATING THROUGH SOUTHERN KATTEGAT IN SMALL NUMBERS

PARTICOLOURED BAT (VESPERTILIO MURINUS)

Particolored bat is common in the northern part of the island Zealand (Denmark) (Møller et al. 2013). Particolored bat has a scattered distribution in Sweden (De Jong et al. 2020). Particoloured bat is a long-distance migratory species, and the species might occur in the marine pre-investigation area in small numbers.

LEISLERS BAT (NYCTALUS LEISLERII)

Leislers bat is only recorded a few times on in Denmark (Møller et al. 2013) and is very rare in Sweden (De Jong et al. 2020). Large numbers of Leislers bats are not expected in southern Kattegat.

NORTHERN BAT (EPTESICUS NILSSONII)

Northern bat is common in Sweden (De. Jong et al. 2020, Wesling et al. 2020) but rare in Denmark (Møller et al. 2013). Although northern bat appears to be a sedentary species, ring recoveries have shown that they occasionally fly longer distances. None of the previous offshore surveys in Kattegat recorded northern bats and it is therefore not expected that the species will occur in in southern Kattegat.

SEROTINE BAT (EPTERSICUS SEROTINUS)

Serotine bat is a common species in most part of Denmark (Møller et al. 2013). In Sweden the species is rather rare and only found in the southernmost part of the country (De Jong et al. 2020). Serotine bat is rather sedentary and the distance between summer and winter roosts tends to be small. It is therefore not expected that the species will occur in significant numbers in the pre-investigation area.

SOPRANO PIPISTRELLE (PIPISTRELLUS PYGMAEUS)

Soprano pipistrelle is widespread and common in Denmark (Møller et al. 2013) and in southern Sweden (De Jong et al. 2020). Due to its abundance and occurrence in Denmark and southern Sweden it is likely that a small number of soprano pipistrelle may migrate through the southern Kattegat.

COMMON PIPISTRELLE (PIPISTRELLUS PIPISTRELLUS)

Common pipistrelle is widespread and common in southern parts of Denmark (Møller et al 2013) and found scattered in southern Sweden (De Jong et al 2020). Common pipistrelle is a rather sedentary species, with summer and winter roosts often less than 20 km apart. However, long distance migrations have also been recorded. It is possible that a small number of common pipistrelle may migrate through southern Kattegat.

POND BAT (MYOTIS DASYCNEME)

Pond bat is rather common in the northern parts of Jutland (Møller et al. 2013) but rare in Sweden (De Jong et al. 2020). Large number of migrating pond bats are not likely to occur in the pre-investigation area.

DAUBENTON'S BAT (MYOTIS DAUBENTONII)

Daubenton's bat is common in Denmark (Møller et al 2013) and in Sweden (De Jong et al. 2020). Daubenton's bat is a migrant species and is known to fly up to 150 km between roosts. The migration seems however, primary to be over land along rivers and lakes. Daubentoni’s bat is rarely observed offshore, and large number are not expected in southern Kattegat.

BRANDT'S BAT (MYOTIS BRANDTII)

Brandt's bat is widespread and common in Sweden (De. Jong et al. 2020) but rare in Denmark (Møller et al 2013). Brandt's bat is an occasional migrant, but the distances covered are usually no more than 40 km. Large numbers of Brandt's bat in the southern Kattegat are considered unlikely.

WHISKERED BAT (MYOTIS MYSTACINUS)

Whiskered bat is common and widespread in Sweden (De Jong et al. 2020) but not recorded in Denmark outside Bornholm in the Baltic Sea (Møller et al. 2013). Whiskered bat is an occasional migrant, but the distances covered are usually small. Large number of whiskered bat in southern Kattegat is considered unlikely.

BAT SPECIES UNLIKELY TO MIGRATE IN SOUTHERN KATTEGAT

WESTERN BARBASTELLE (BARBASTELLA BARBASTELLUS)

Western barbastelle is only recorded in the southern part of Zealand and the islands in southern Denmark (Møller et al. 2013) and is rare in Sweden (De Jong et al. 2020). Western barbastelle is largely a sedentary species; the distance between summer and winter roosts are usually below 40 km. Occurrences in the offshore parts of Kattegat far away from the coast are therefore considered unlikely.

BROWN BIG-EARED BAT (PLECOTUS AURITUS)

Brown big-eared bat is common and widespread in Denmark (Møller et al. 2013) and Sweden (De Jong et al. 2020). Brown big-eared bat is a very sedentary species. Occurrences over the sea in Kattegat far away from the coast is considered unlikely.

GREATER MOUSE-EARED BAT (MYOTIS MYOTIS)

Greater mouse-eared bat is a regional migrant, whose movements between traditional summer and winter roosts usually range from 50 to 100 km. It is only regularly breeding south of the Baltic Sea (BfN 2008) and there are only very few records from Sweden (de Jong et al. 2020). Because Kattegat is situated outside the main distribution area of the species (Dietz et al. 2011), it seems unlikely that the species will occur in the pre-investigation area.

NATTERER'S BAT (MYOTIS NATTERI)

Natterer's bat is common and widespread in Sweden (De Jong et al. 2020) and scattered in Denmark (Møller et al 2013). Natterer's bat is generally considered a sedentary species; however, some individuals are known to have covered long distances. Occurrence of natterer's bat in Kattegat are considered unlikely.

TIMING OF BAT MIGRATION OVER THE SOUTHERN KATTEGAT

Unfortunately, only few systematic studies of migrating bats have been carried out in Kattegat region. Therefor the expected timing of the bat migration is extrapolated from general knowledge from Denmark and Sweden. The spring migration is expected to start in April and continue until early June and the autumn migration is starting in August and may continue until late October.

CLIMATE CHANGE AND THE TIMING OF BAT MIGRATION

The timing of the bat migration is obviously linked to the presence of the specific types of insects which are the main feeding source for each bat species. Change in winter temperature and change in the timing of spring and autumn may influence the insect abundance and occurrences. Exactly how this influence the timing of the bat migration and how quickly the bats will adapt to the changed conditions are not known. However, an 8-year data series from Falsterbo, in southernmost Sweden, indicates a change in the migration time for nathusius bat from a median of the autumn migration in late August 2012 to late September 2019 (Bach 2021).
It is likely that especially the autumn migration is highly sensitive to change in temperature during August, September, and October. Generally, it could be considered that the bats will stay longer in their breeding areas if there are plenty of insects to feed on. The migration in spring is less predictable because the bats do not know, the conditions at the end destination and the timing of the exit from the wintering areas is predominantly driven by other factors such as day length.

FEEDING DURING BREEDING SEASON

During the summer most bats are located at or in close proximity to their breeding sites feeding on the abundance of insect within this area. However, when the weather is suitable some bat species also forage at sea, and even far from the coast. Exactly how far out the bats feed and how often they feed over the sea is not documented. It is expected that most activity occur along the coast where most insects are found, and less far away from the coast.

METHODOLOGY

In spring 2023 (late March-early April) bat detectors were installed on the island Hesselø, on the island Hjelm and Djursland peninsula, Sjællands Odde peninsula and two places along the west coast of Sweden and on fourteen buoys in the southern part of Kattegat (Figure 6 & Figure 7). This report focusses mainly on the eight buoys within the pre-investigation area for Hesselø OWF and the detectors on coast of Djursland. The results from the rest of the coastal detectors are provided in Appendix II. The bat detectors recorded the ultrasound from bats in the vicinity of the detector and saved the recording for later analysis. The range of the recording varies between the different bat species. Large bat, like common noctule and parti-colored bat can be recorded up to 100 meters from the detector, whereas smaller bat only can be recorded when they are within a distance below 50 meters. In the pre-investigation areas of Kattegat OWF five detectors on buoys were active in spring and summer 2023 whereas eight detectors on buoys were active in autumn 2023.

OFFSHORE BUOY BASED SURVEY

A total of eight bat detectors have been attached to C-pod buoys used for the marine mammal survey by WSP (Figure 6). The detectors collect recordings of all bats passings on 8 positions (Figure 7, Figure 8**Error! Reference source not found.Error! Reference source not found. Error! Reference source not found.Error! Reference source not found.**) in the pre-investigation areas in spring, summer, and autumn (1st of April to 31st of October) in 2023. The position of the buoys ranges from 10 km up to 40 km from the coast of Jutland, Zealand and Sweden.

Figure 6 - Automatic bat detector mounted on a buoy used for the C-POD station in the marine mammal survey.

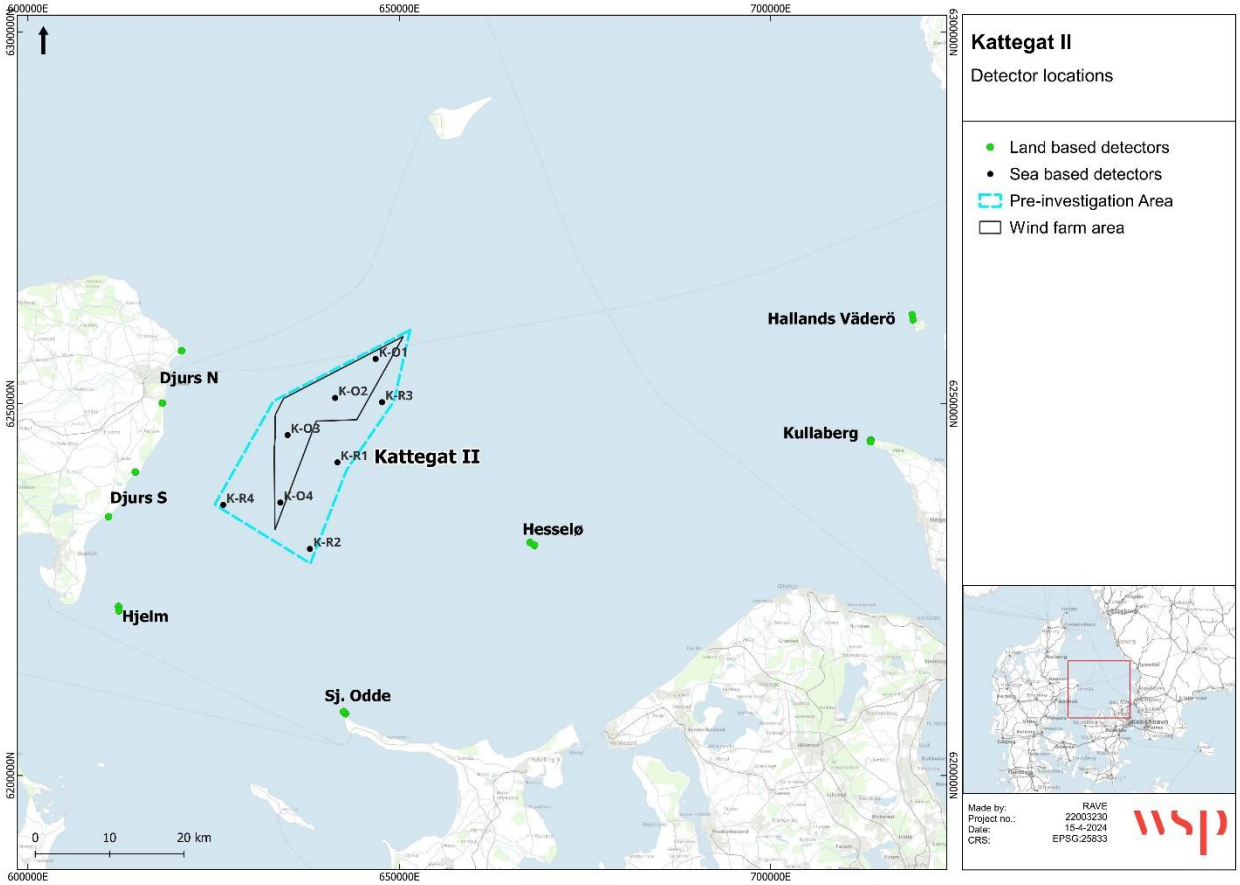

Figure 7 - Map showing the position of the buoys used for the survey. Bat detectors on Djursland, Hjelm, Sjællands Odde, Hesselø, Kullen and Hallands Väderö. (green dots) and on eight buoys located within the pre-investigation area for Kattegat Offshore Wind (black dots)

K-O1															
K-O2															
K-O3															
K-O4															
K-R1															
K-R2															
K-R3															
K-R4															
	mar-23		apr-23		may-23		jun-23		jul-23		aug-23		sep-23		oct-23

Figure 8- Deployment-time (green) of each of the 8 bat detectors. Green bars indicate that the detector runs without failure (For detector number see Figure 7).

OFFSHORE VESSEL BASED SURVEY

The survey vessel Skoven has been visiting the survey areas for different purposes throughout the survey period in 2023. A bat detector has been installed on the vessel (Figure 9). The bat detector was programmed to record completely independent with no assistance from the staff onboard the vessel. The bat detector recorded the ultrasound from bats around the vessel and saved the recording for later analysis. The bat detector also recorded the position of the vessel and the time. Weather conditions (wind direction, wind speed and temperature were taken from the vessels logbook). The vessel-based bat surveys included data collection from March 2023 to October 2023.

Figure 9 - Automatic bat detector (in front) mounted on the survey vessel Skoven.

COASTAL (ONSHORE) SURVEY

The land-based detector was mounted trees along the coast of Djursland, on Sjællands Odde peninsula, along the Swedish coast and on two small island in Southern Kattegat The specific position was selected on spot with high possibility for feeding bat if any bat were present on the areas. These coastal detector provide important information on the potential of migrating bats and the likelihood for feeding bats on the neighbouring sea. (Figure 10**).** For the result see also appendix II

Figure 10 – Bat detector mounted on a pine tree near the coast south of Grenå (Djursland)

ANALYSIS

The detectors mounted on buoys were the SeaBat model used for other projects offshore in Denmark. Both detectors are based on the AudioMoth technology and were setup to record all bat activity from half hour before sunset to half hour after sunrise. The recordings were divided into 5 seconds recordings separated by 10 seconds' pause. The sorting of the recording was made by the software Kalaidoscope. The range of the recording depends on the species of bats. Loud speaking bat like common noctule may be recorded up to 100 meters from the detector, whereas small and more silent bats may be recorded up to less than 50 meters from the recorder. Due to these differences, the amount of recording of different species cannot be compared directly.
The basic measure is recordings per night. The number of recordings cannot be translated into number of individuals. However, large activity and a high number of recordings per night may indicate more individuals.

DATA AND RESULTS

GENERAL COASTAL (ONSHORE) PATTERNS

The patterns of the bat activity measured on the coastal detectors are shown in Appendix 2. Often the patterns found on these coastal positions are a mixture of local and migrating bats. However, some general patterns for each of the species during 2023 can be highlighted.

The spring pattern of common noctule activity on the coastal area of Djursland west of the pre-investigation area shows no clear migration patterns. Most activity is in summer and indicate a breeding area in some of the coastal forests. Very few record of common noctule on Hesselø in spring also support the impression of a very limited migration of noctules. In late summer and early autumn there is still some activity on the coast of Djursland and more activity on Hesselø. This may indicate some level of migration in autumn from mid-August to mid-April. However, the migrating animals might be mixed with local feeding animals from Djursland and maybe even from Northern Zealand.

Nathusius pipistrel is the only species with a rather clear migration pattern.

On Djursland the spring migration starts in late April and continue until early June. The migration on Hesselø seem to be slightly earlier, from mid-April to mid-May. This difference may indicate that the bats observed on the island Hesselø are not arriving from Djursland but more likely from Northeast Zealand. The pattern on Hesselø fits better with the patterns observed on the island Hallands Väderö near the Swedish coast. Nathusius pipistrels along the Swedish coast are expected to arrive from Zealand.

Soprano pipistrel is common in all coastal areas around the pre-investigation area but shows no clear patterns of migration.

Parti-colored bat is not common on Djursland and shows no clear patterns of migration. The species has the main distribution in Northern Zealand, and the activity on Hesselø in late April might be bats flying over from Zealand.

GENERAL OFFSHORE PATTERNS

The bat detectors on the offshore buoys generally recorded less bats than on the land-based detector (see Appendix 2) In spring 2023 nathusius pipistrel was recorded four times only on the westernmost buoy (K-R4), 11th May, 14th May, 22nd May and 24th May). Parti-coloured bat was recorded only in late summer on two buoys (K-O4 and K-R1). Common noctule, daubenton's bat and soprano pipistrel were not recorded on the buoys in spring.

In autumn the numbers of recordings per buoy were considerable higher (Figure 11). The buoys with large number of records are situated between 10 and 30 km from the coast of Djursland. A majority of all records are from early September and especially the night after 9th September.

The records per buoy range from 3 to 20 per season (Figure 11). The average bat recording per buoy, when corrected for detector failure, is 13.8 per year This is higher than similar figures from the Baltic Sea south of Bornholm where a similar survey was carried out for the Energy Island project I 2022 and 2023 (Christensen 2024a). The buoys at Bornholm recorded in average 5.3 bats per buoy per season. Also, similar survey in Hesselø east of the present project shows less recordings of bats with an average of only 2.3 per buoy (reports in prep. for Hesselø offshore wind farm pre-investigation areas).

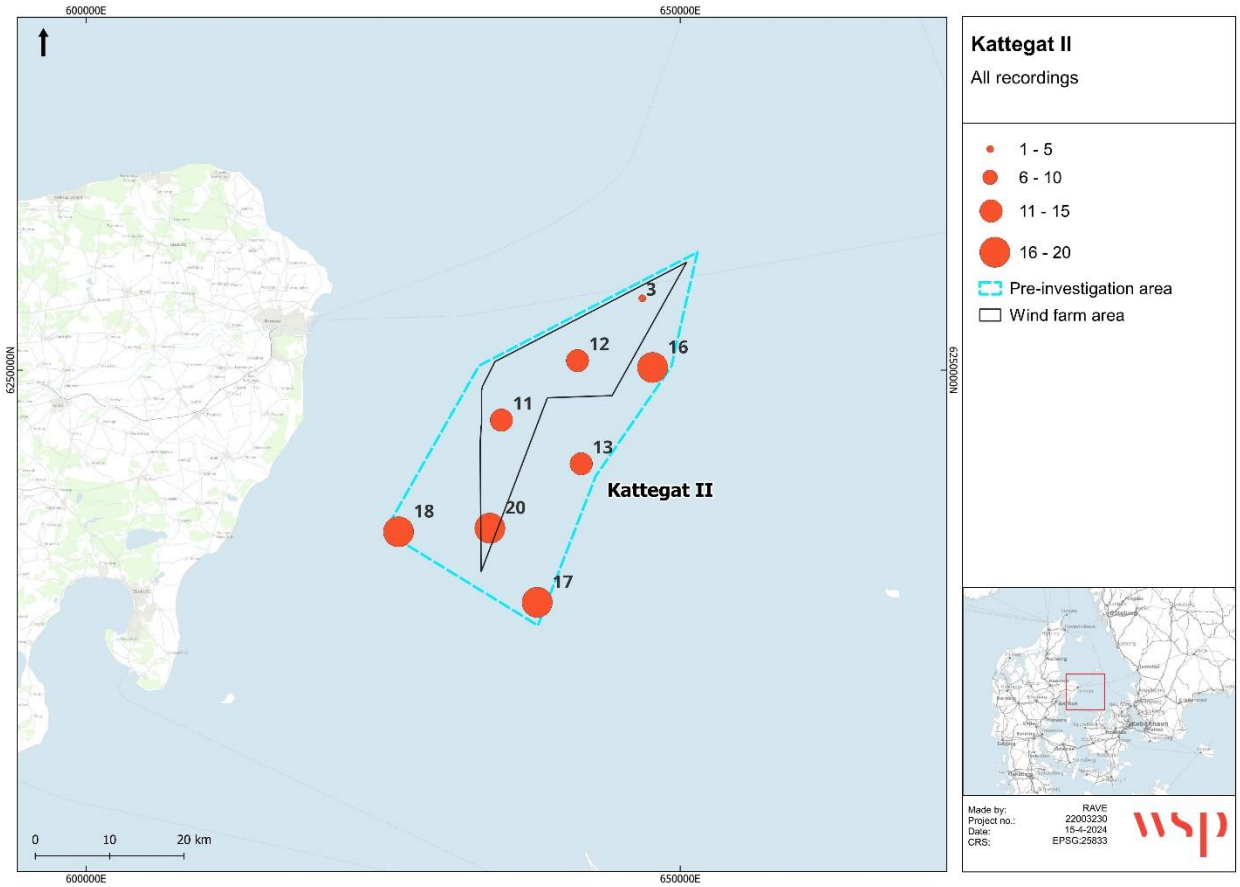

Figure 11 - *Number of bat recordings per buoy in 2023*

Compared to a similar survey on the wind turbine in the existing Kriegers Flak OWF the present study shows lower number (Christensen 2024b). In 2023 the average recording of bats around the wind turbines 184.3. This may indicate some attraction by the wind turbines.

SEASONAL VARIATION IN OBSERVATIONS

OFFSHORE OBSERVATIONS

Most of the recordings on the buoys were from the night after 9th and 10th September (Figure 12). The weather these nights was exceptionally warm (temperate above 16 C) and with very low wind speed (<5 m/s) (Figure 16).

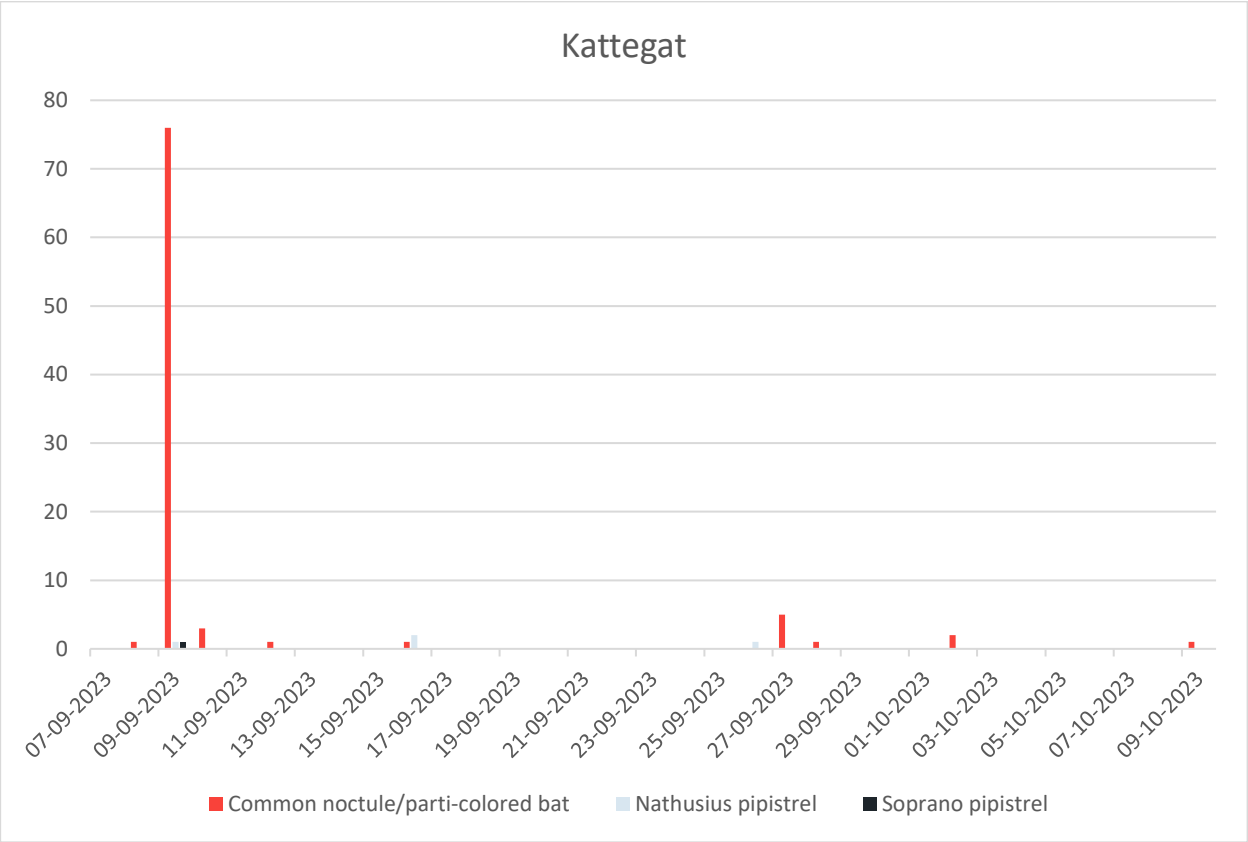

Figure 12 - *Total number of bat recordings (from 8 buoys) per night in autumn 2023.*

Recordings at coastal areas

TIME OF OFFSHORE OBSERVATIONS

Most bat species prefer to fly over the sea when it is dark and the risk from predators is lower (Figure 13). Only very few common noctules are recorded outside the dark part of night.

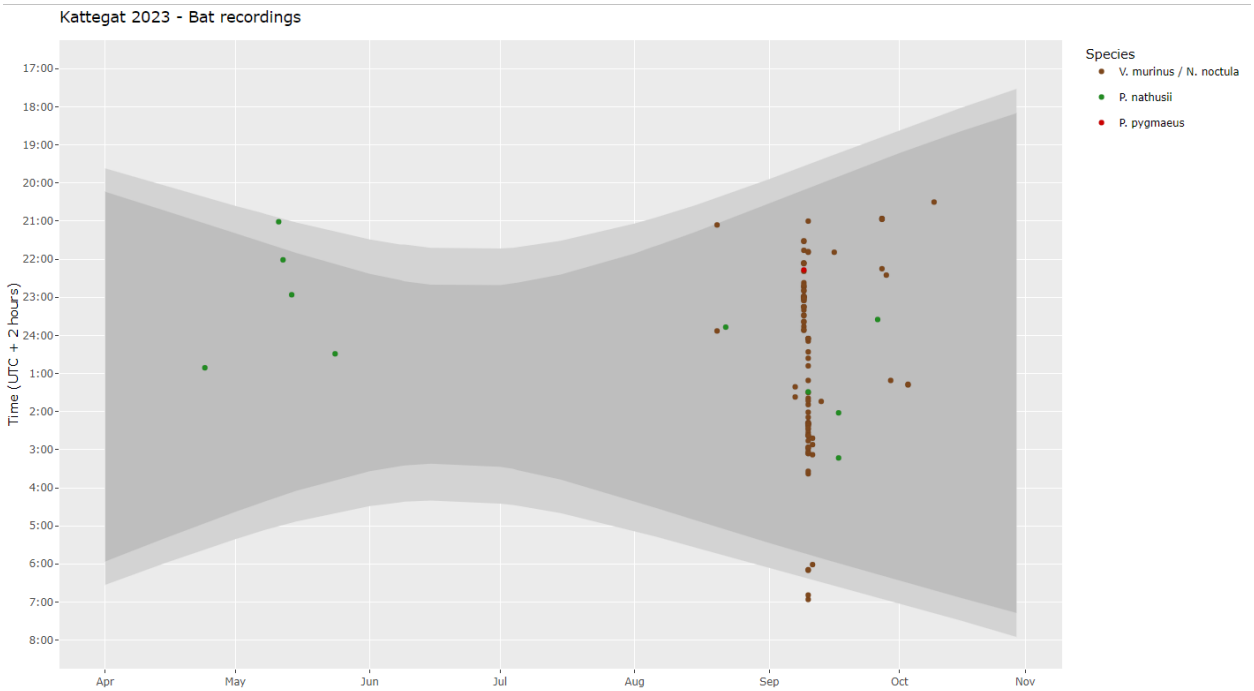

Figure 13 - Time of the bat recordings on the buoy-based detectors in 2023. Shaded areas indicate the nights. Pale shading indicates the dusk from sun set to the sun is more than 6 degrees under the horizon and similar in the morning until sunrise (see suninfo.dk for more information)

OFFSHORE OBSERVATIONS AND WEATHER CONDITIONS

The number of bat recordings are compared to the information on the weather condition estimated by the metocean buoy. This direct relation was only possible to do in the late summer and autumn due to the installation of the MetOcean buoys from 21 July 2023.
The bats also prefer to fly in low wind speed (Figure 14). 95 percent of all bats are recorded when the windspeeds measurements in 12 meters hight were less than 6 m/s. This measurement might represent the conditions in the surrounding of the bat detectors and therefore could be considered as the preference for a typical bat.
If the number of bat records are compared to the wind speed around a theoretical nacelle in 150 meters hight most bat records will still be below 6 m/s. Based on the estimates from the MetOcean buoys 88 percent of the bat records are below 6 m/s in 150 meters hight over the sea (Figure 15)

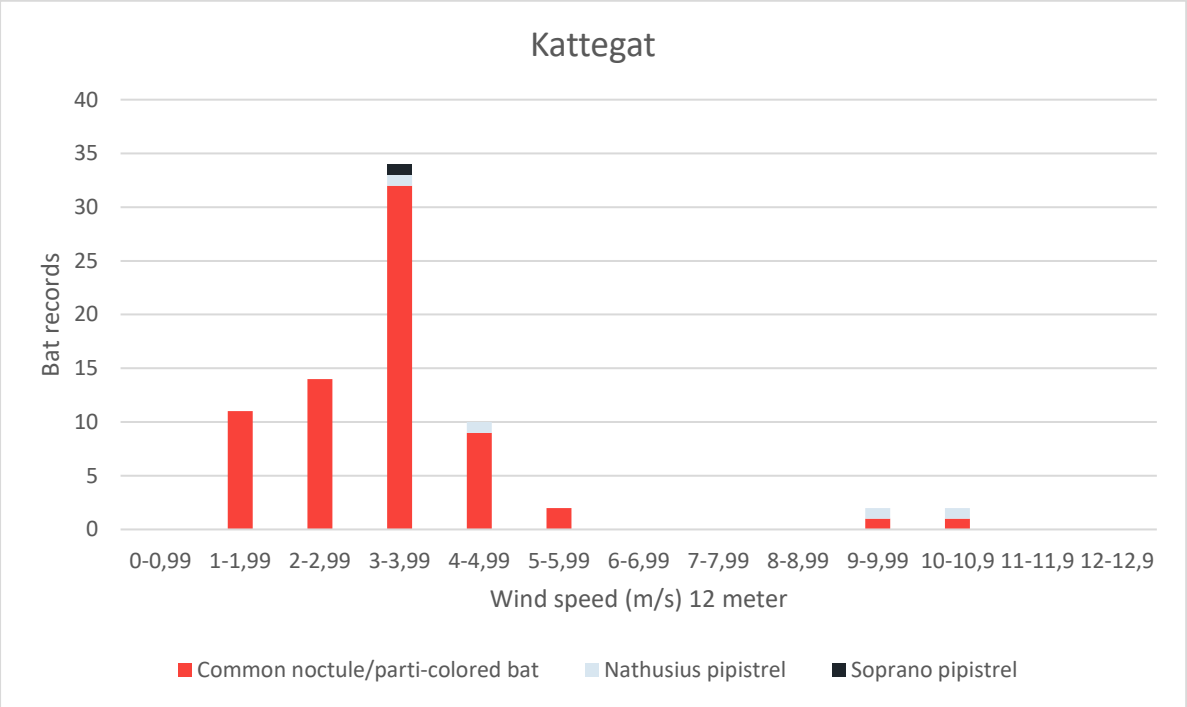

Figure 14 – *Relation between number of bat recordings on the 8 buoy-based detectors and windspeed (m/s) in 12 meter above the sea level, estimated by the MetOcean buoy in*

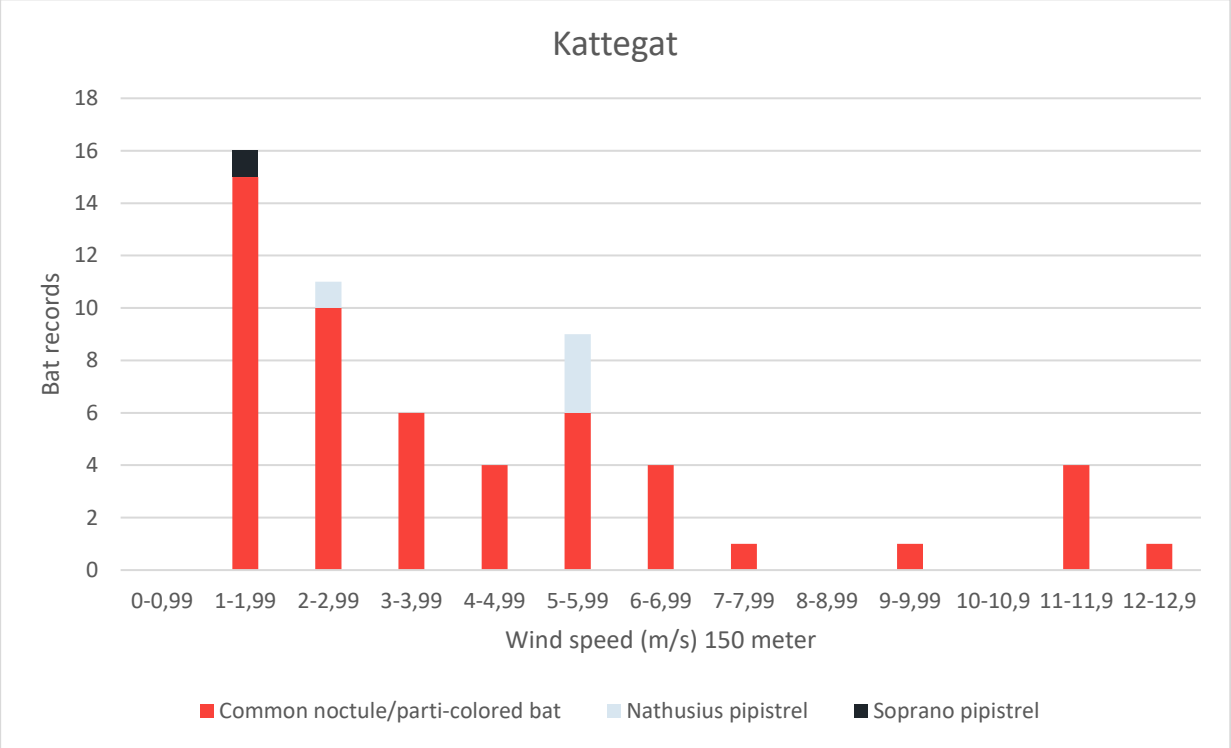

Figure 15 – *Relation between number of bat recordings on the 8 buoy-based detectors and windspeed (m/s) in 150 mter above the sea level, estimated by the MetOcean buoy in*

All nights with bat observation in 2023 had temperatures higher than 16 degrees Celsius, except one night in October with one observation of a common noctule (temperature 12.2 C measured at the MetOcean buoy).

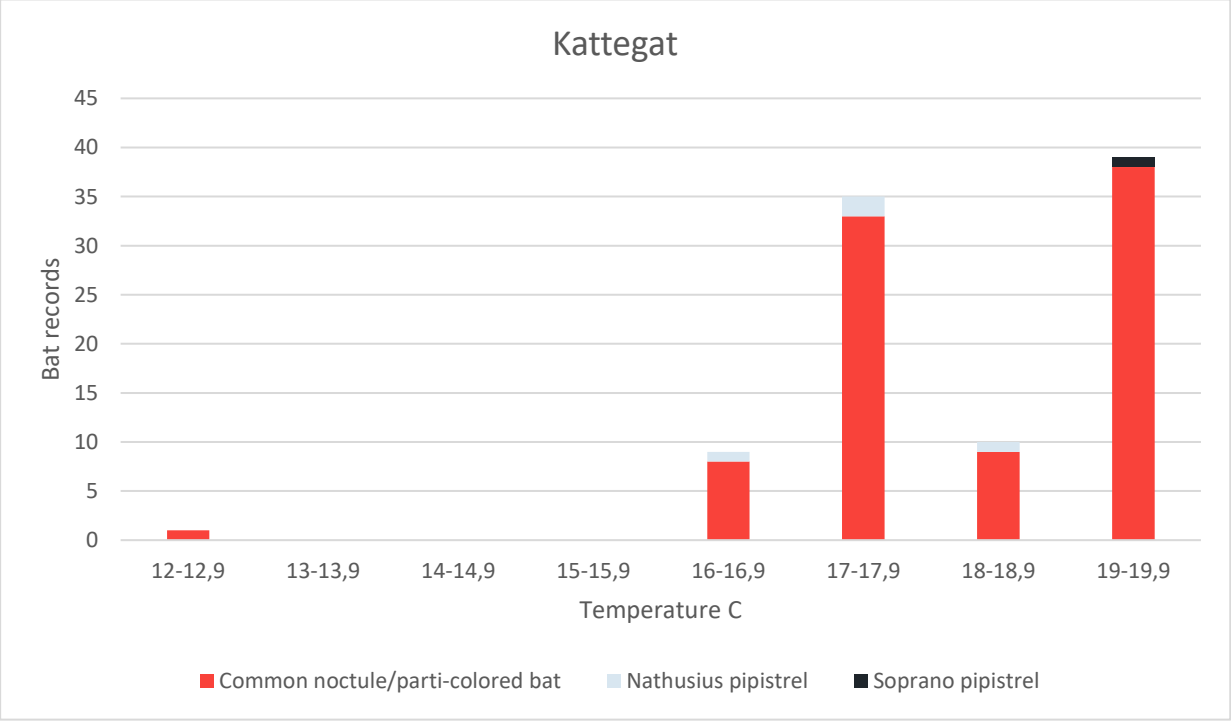

Figure 16 – Relation between the number of bat observations and the temperature (Data from MetOcean buoy)

STATUS

The reason for the large number of bat recordings in early September nights may not be related to migration. It is more likely that the occurrences are linked to feeding behaviour of the larger bat species such as common noctule and particolored bat. In late summer and early autumn species of large moths are known to migrate and aggregate in large number and it is likely that the bats are feeding on these insects. The patterns shown on (Figure 11) also indicate that these bats are flying out from the east coast of Djursland. The theory of feeding behaviour as the main driver for the presence offshore is supported by many feeding buzzes (ultra-sounds with indication of feeding behaviour, see Figure 17) on the recordings from the detectors on the buoys.

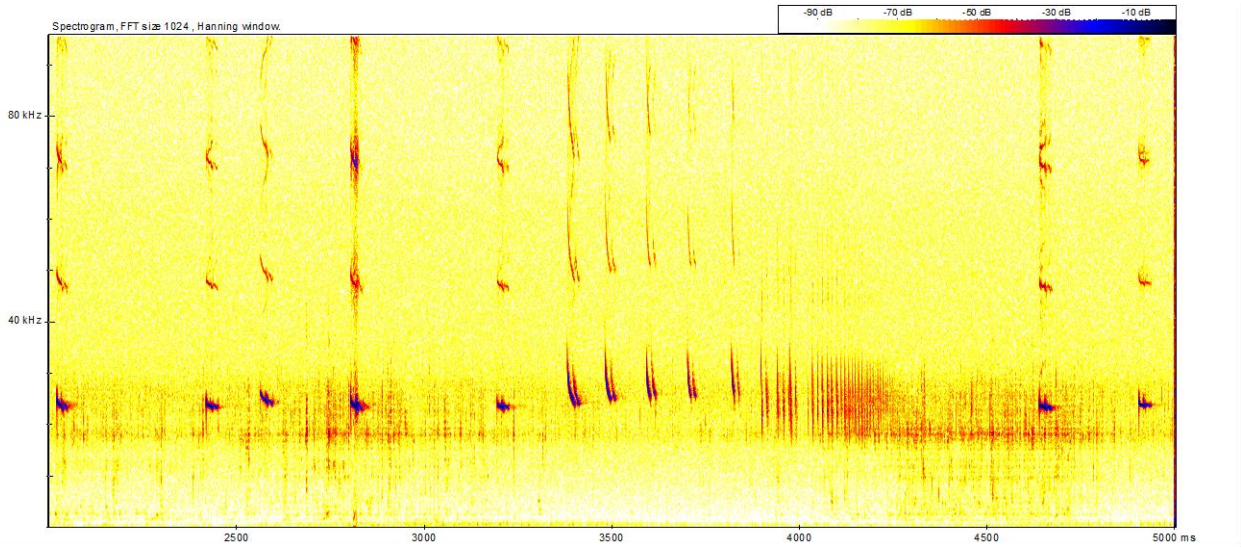

Figure 17 – *Recording of common noctule with feeding buzzes SeaBat08 (Buoy K-O2), 9th September* *2023, 22:59. The first part of the recording shows navigation signal only. The second half of the recording shows signals 'zooming' in on prey.*

In the interpretation of the results, it is very important not to compare number of recordings of the offshore buoy-based detector with the number of the recordings from the land-based detector. The buoys are placed on the open sea and the bats are just passing by. Due to the relatively small range of the detectors for smaller bats (under 100 meters) and the low number of buoys in a large area, the expected number of bat records will be lower.

CONCLUSION

Based on data from 1st year survey in the southern part of Kattegat it is concluded that during spring migration from mid-April to mid-May several bat species occur. This indicates some kind of migration in the area, most likely from Jutland to Sweden.

In late summer and early autumn, in nights with high temperature and low wind speed, bats from Djursland (Jutland) use the southern part of Kattegat for feeding. Most likely related to the presence of large insects over the open sea. This feeding behaviour seems to be restricted to night with wind speed below 6 m/s and temperatures higher than 16 degrees C.

The data collection will continue in 2024, and this will provide more information on the pattern and the magnitude of the migration and the feeding patterns of bats from the surrounding coastal areas.

DATA AND KNOWLEDGE GAPS

Monitoring of bat activity on open sea is a challenge, due to harsh weather condition and risk of damages from fishing and shipping activities. Therefor is failure on some detector unavoidable. During the survey in spring and early summer the several detectors had failures and therefor this part of the survey is based on information from relative few detectors.

The information on migrating bat in southern Kattegat is done for the first time. Therefor direct comparing to other similar studies in the area is impossible. Information collected in a similar setup exists for projects the Baltic Sea and in Northern part of Kattegat. However, none of the survey data are publicly available.

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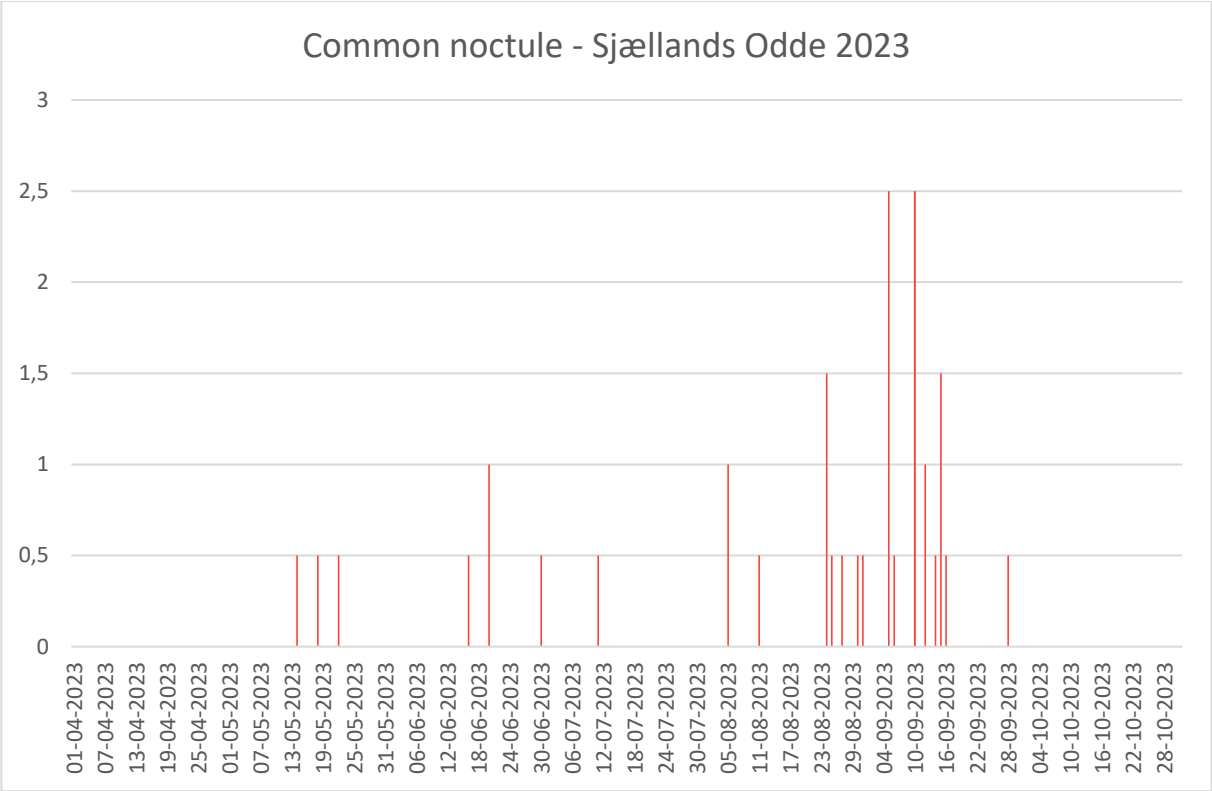
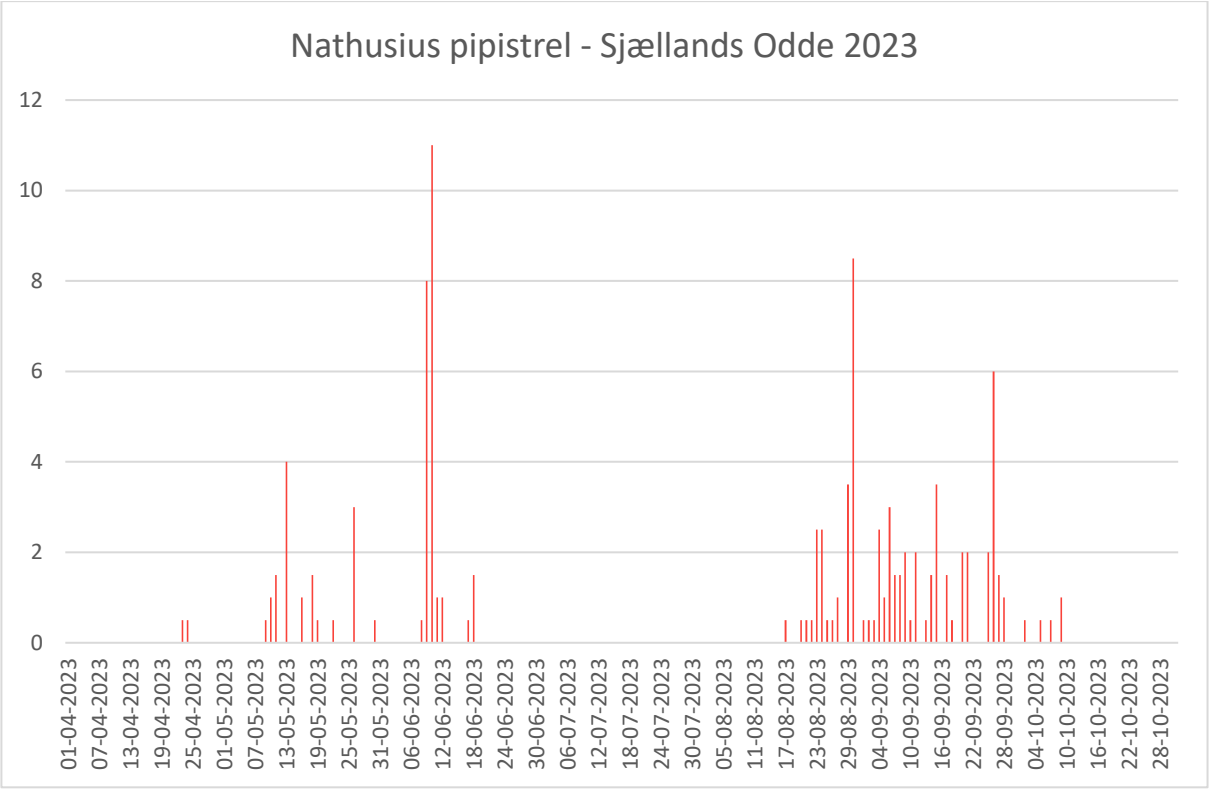
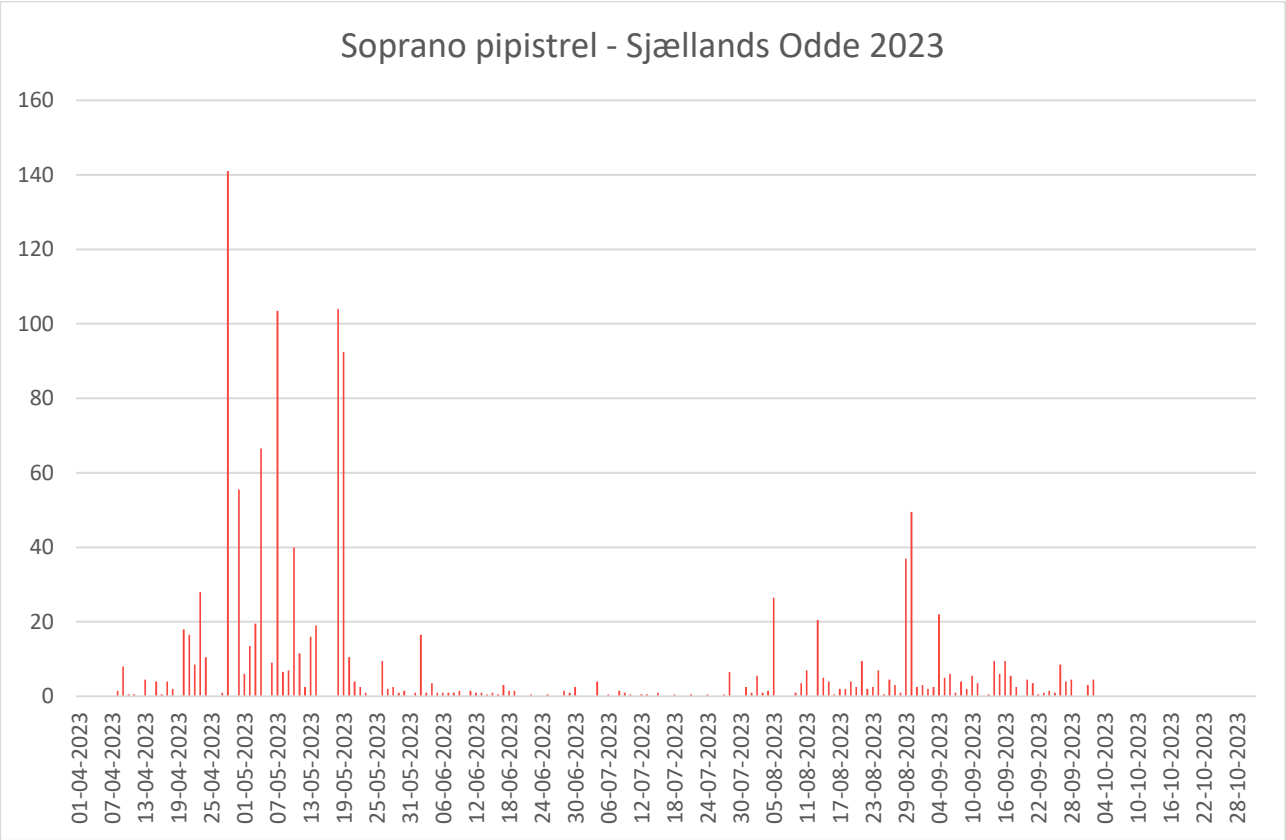
APPENDIX 1 – SPECIES DISTRIBUTION

To be added after 2024 field season

APPENDIX 2 – OBSERVATIONS PER NIGHT



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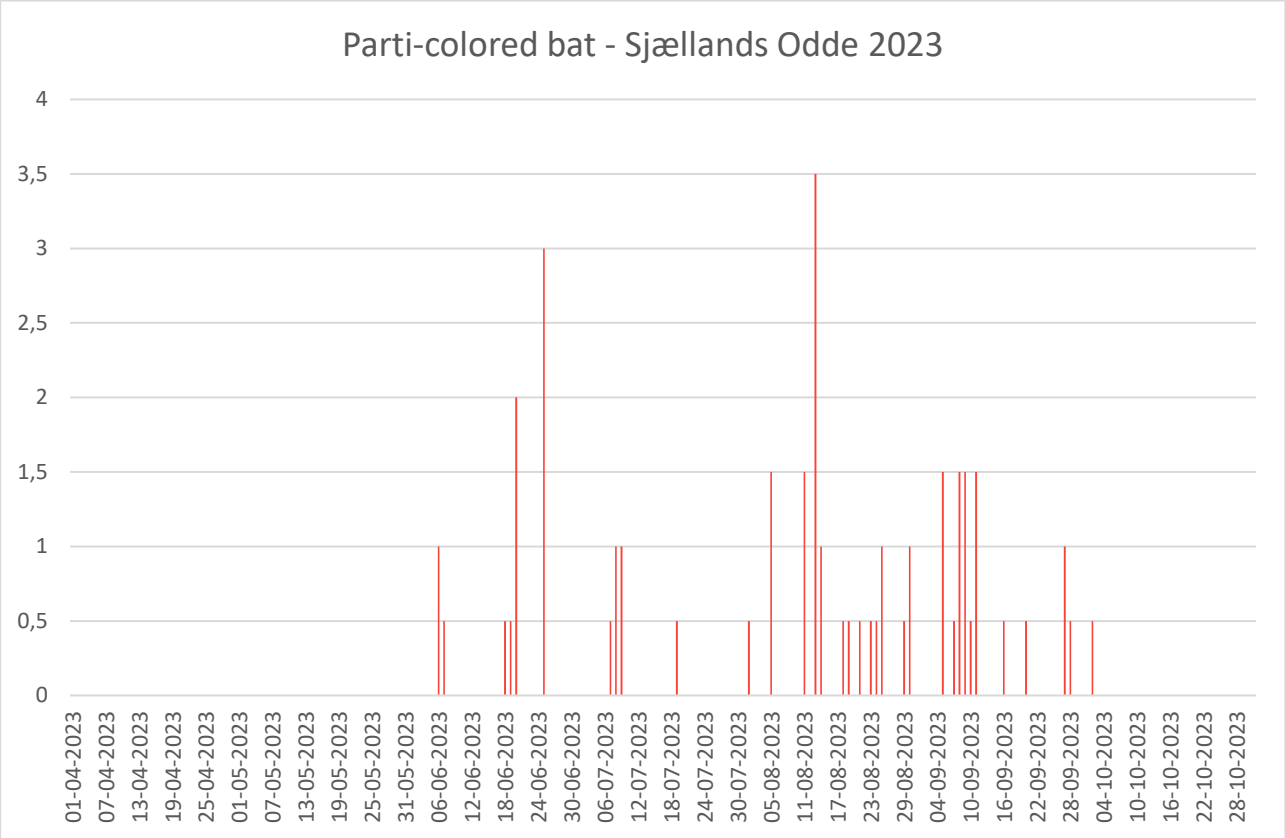
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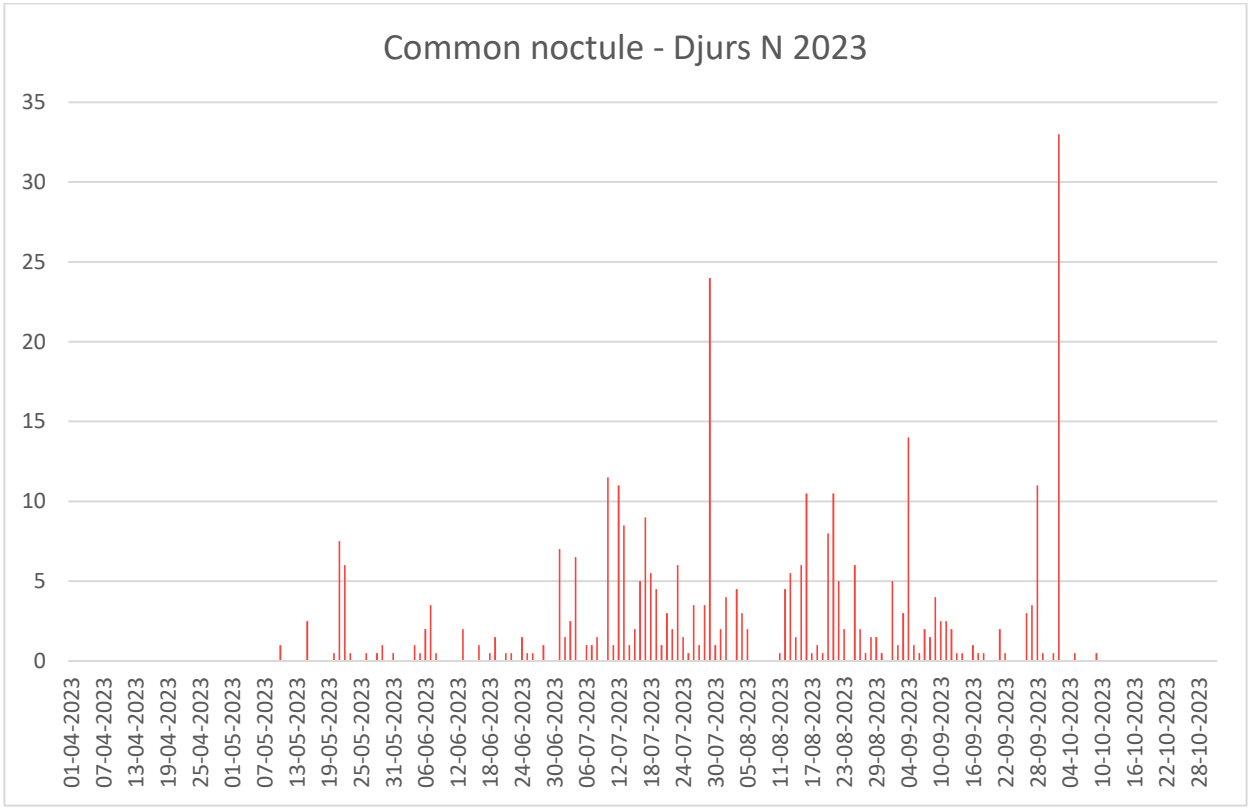
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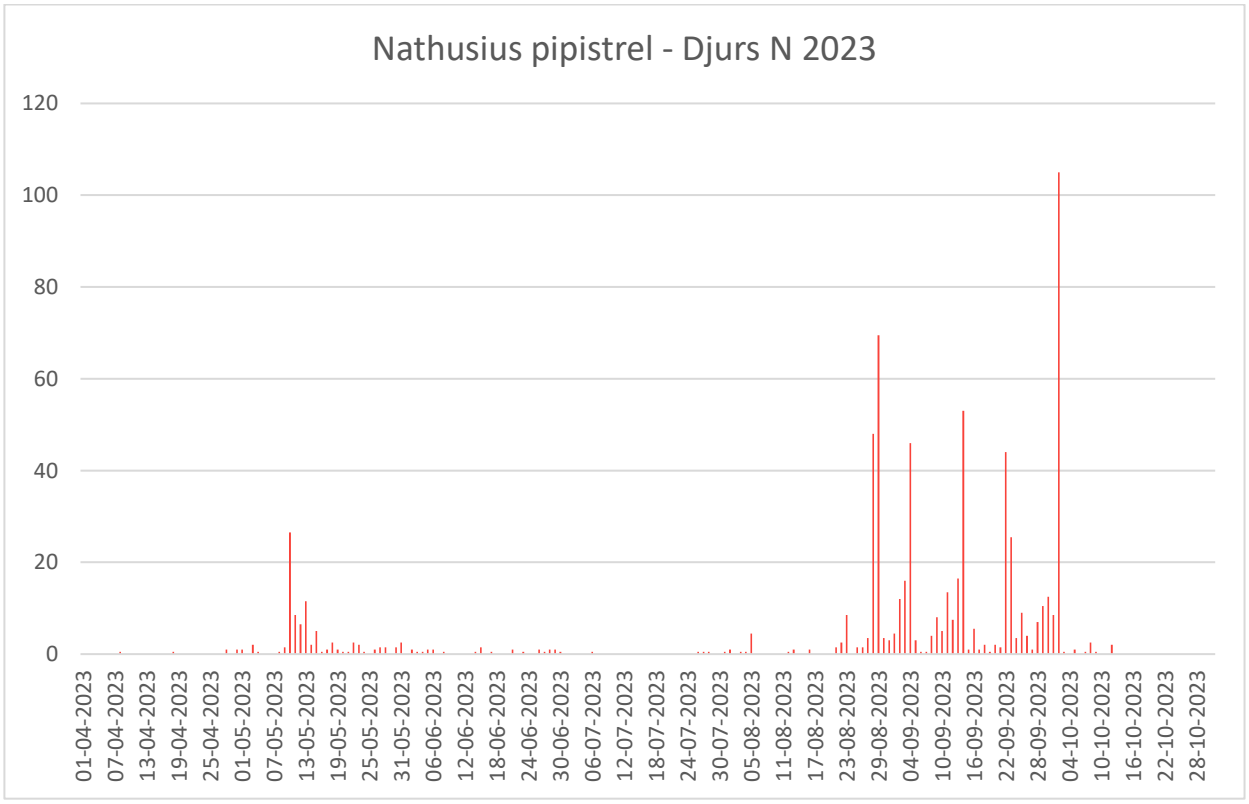
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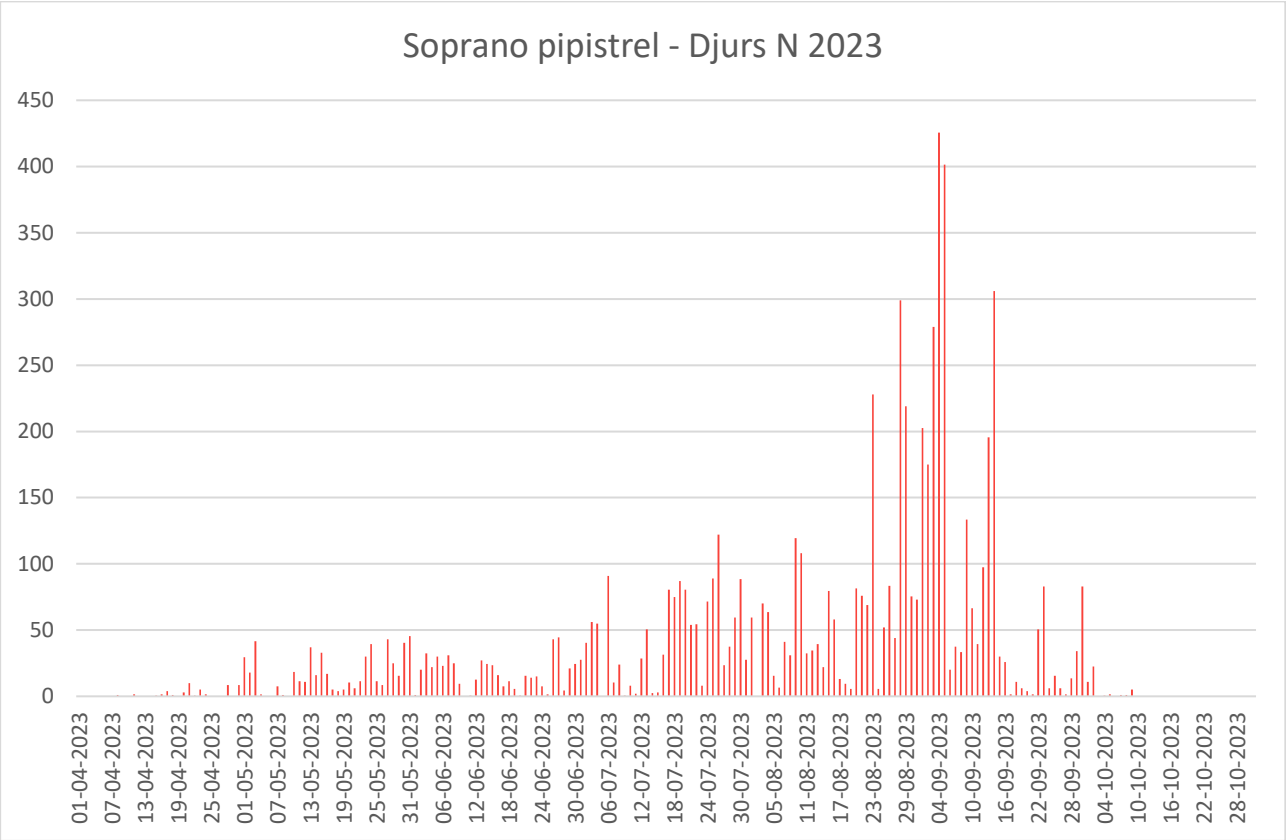
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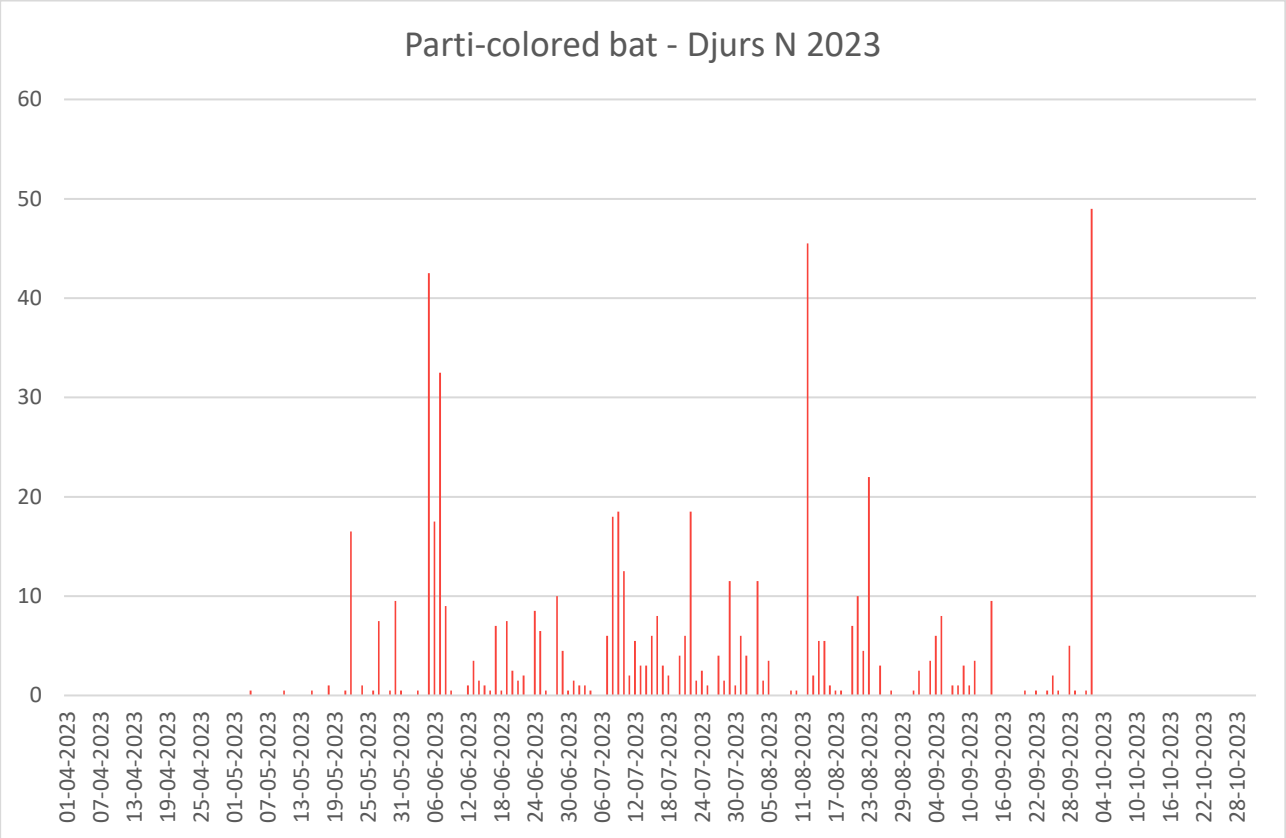
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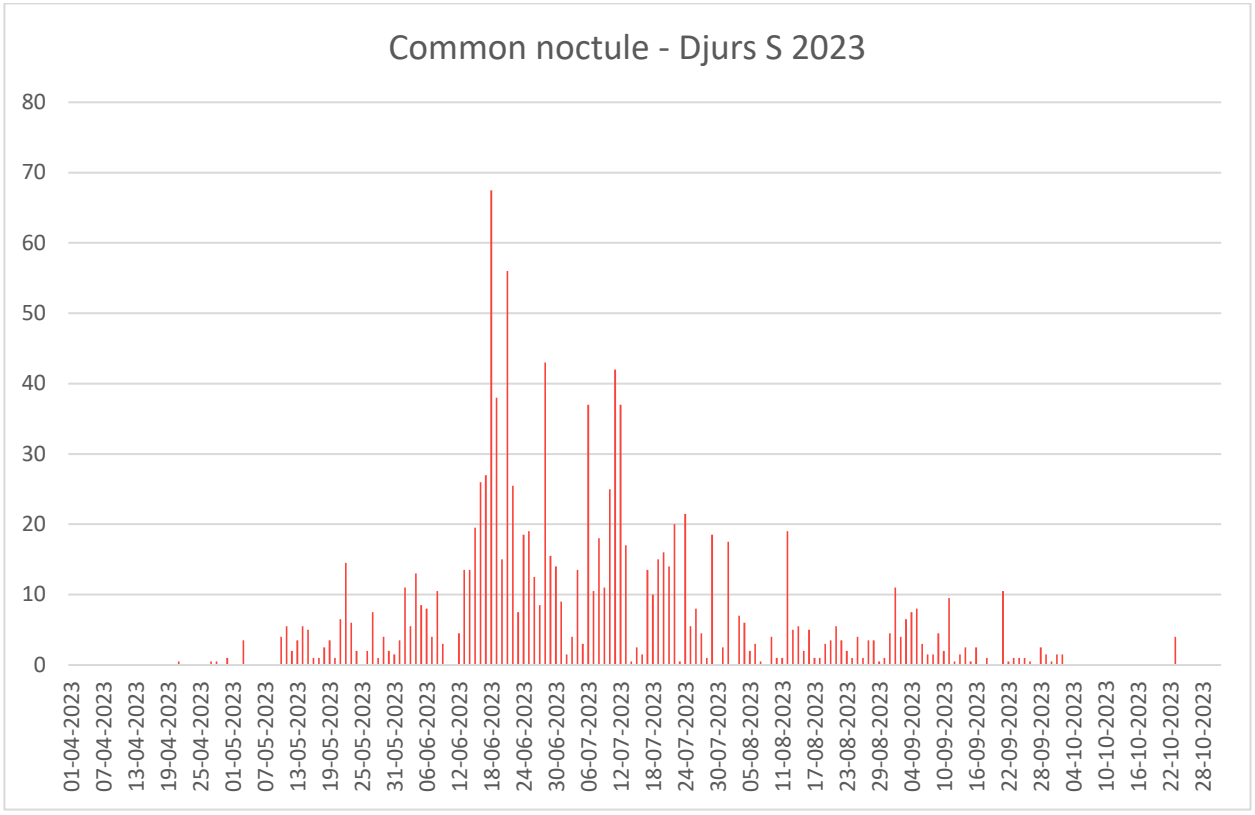
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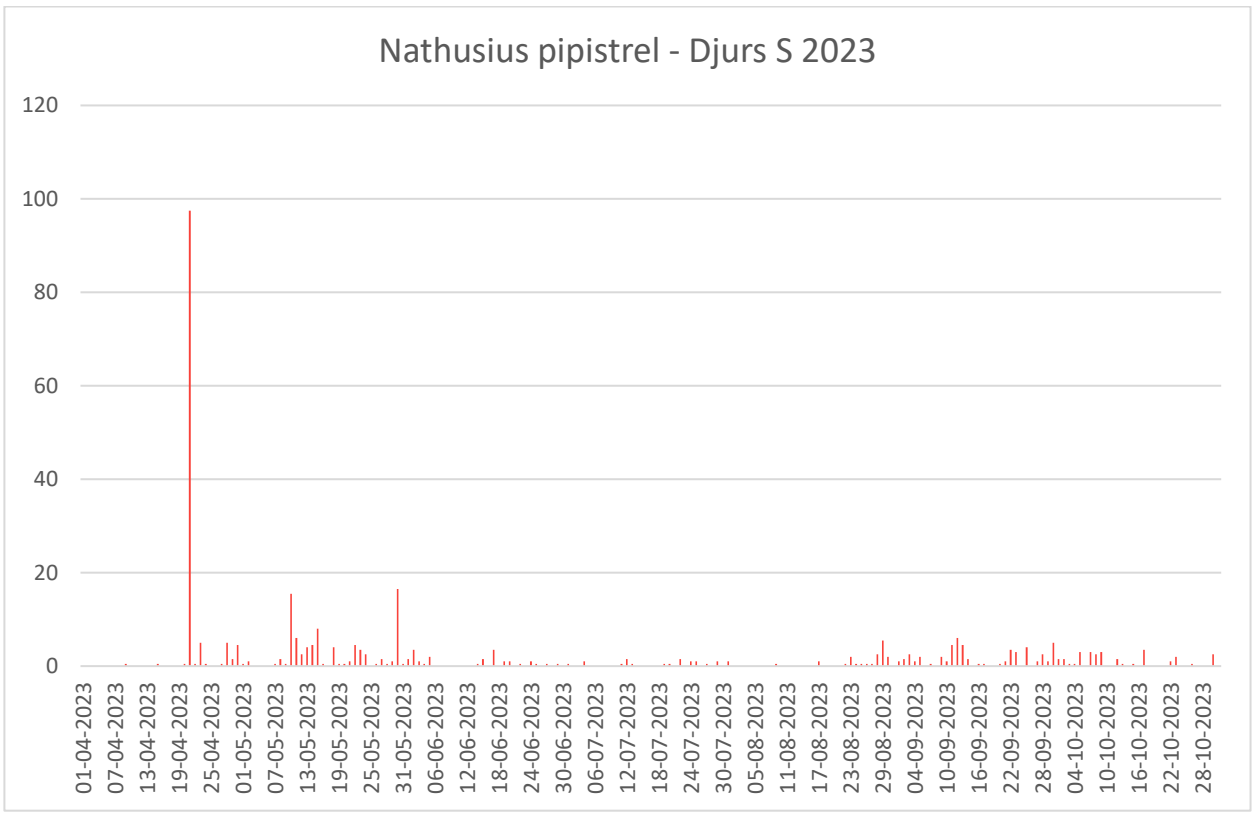
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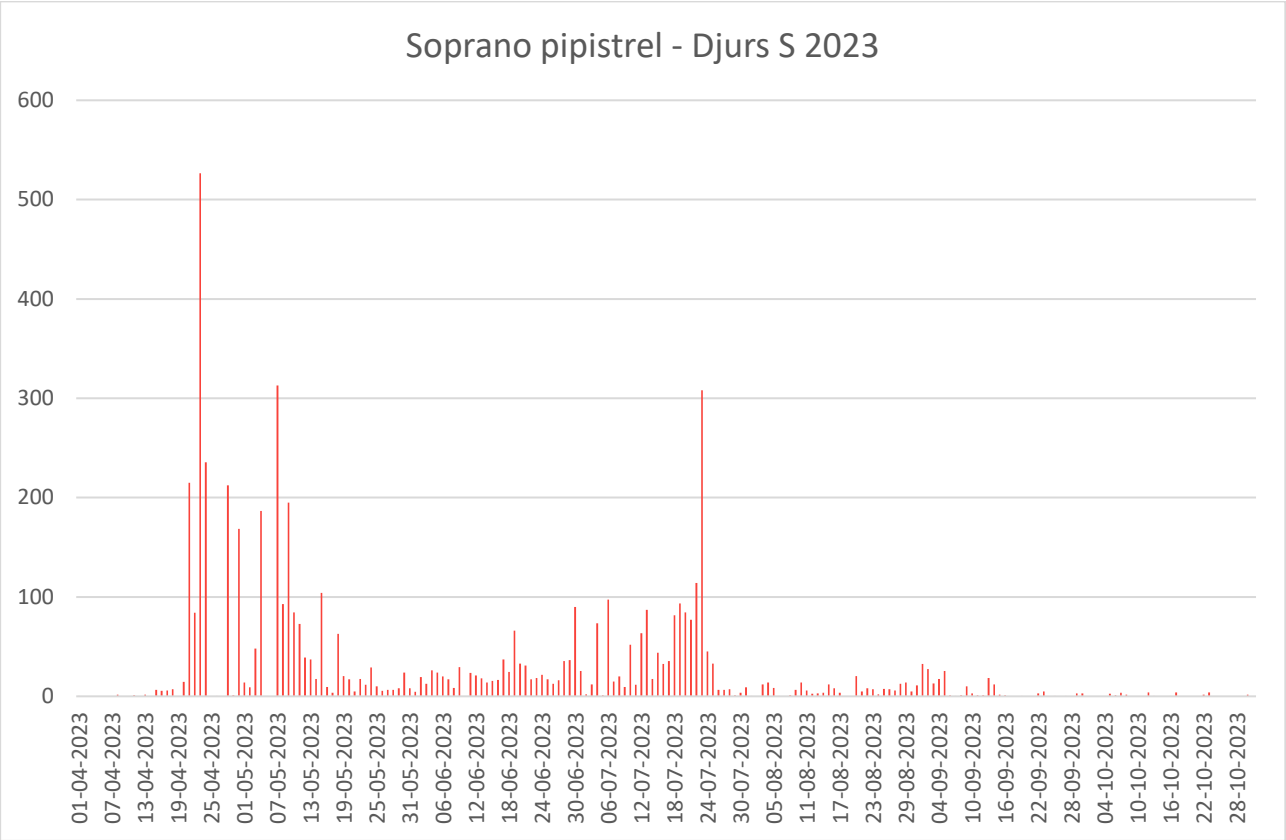
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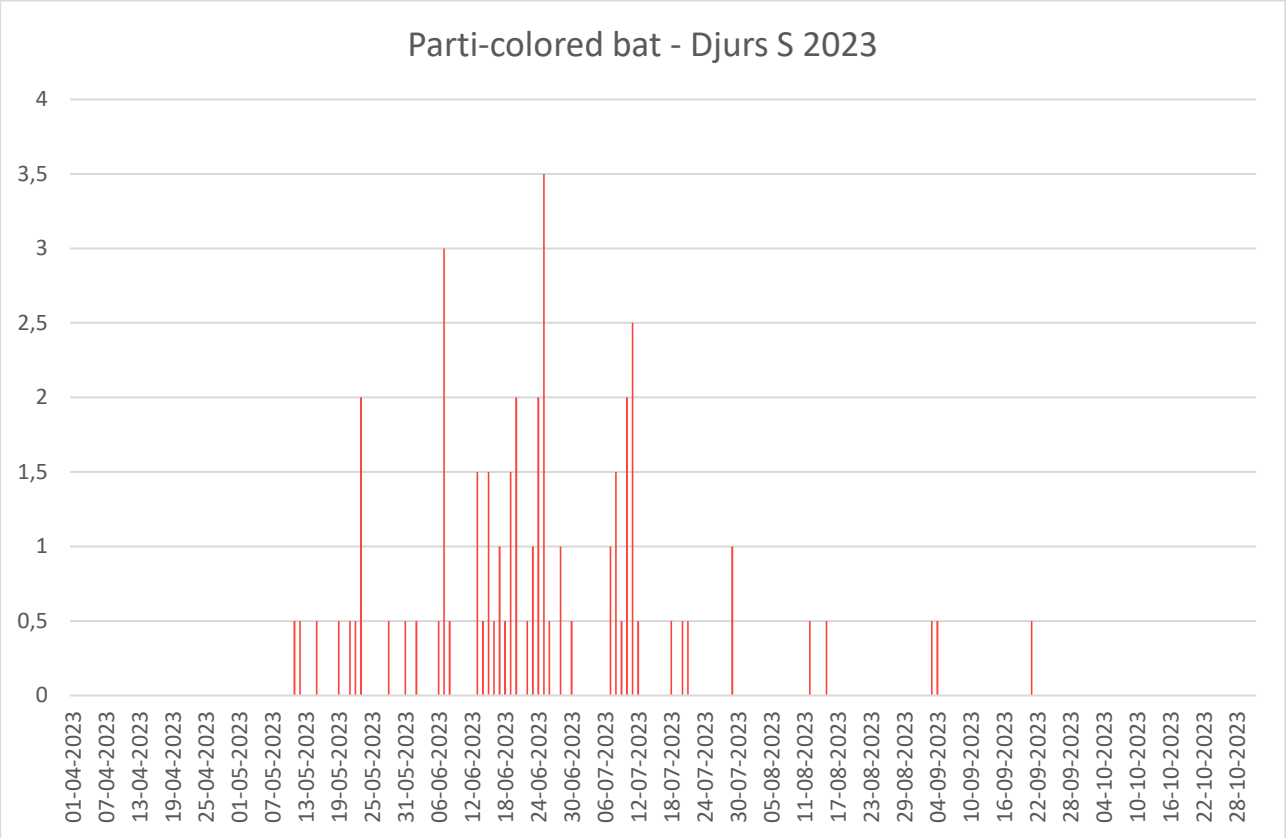
Parti-colored bat - Djurs S 2023
4
3,5
3
2,5
2
1,5
1
0,5
0
01-04-2023
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13-04-2023
19-04-2023
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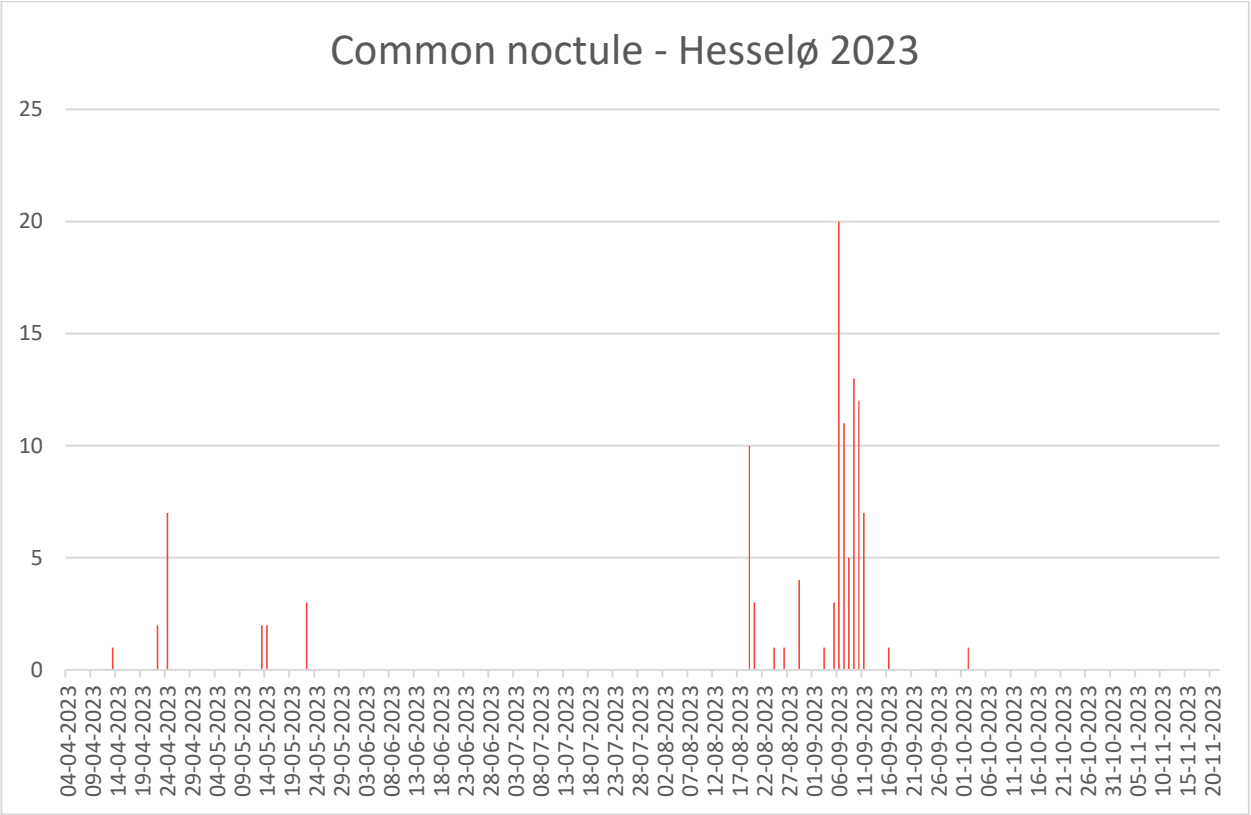
Common noctule - Hesselø 2023
25
20
15
10
5
0
04-04-2023
09-04-2023
14-04-2023
19-04-2023
24-04-2023
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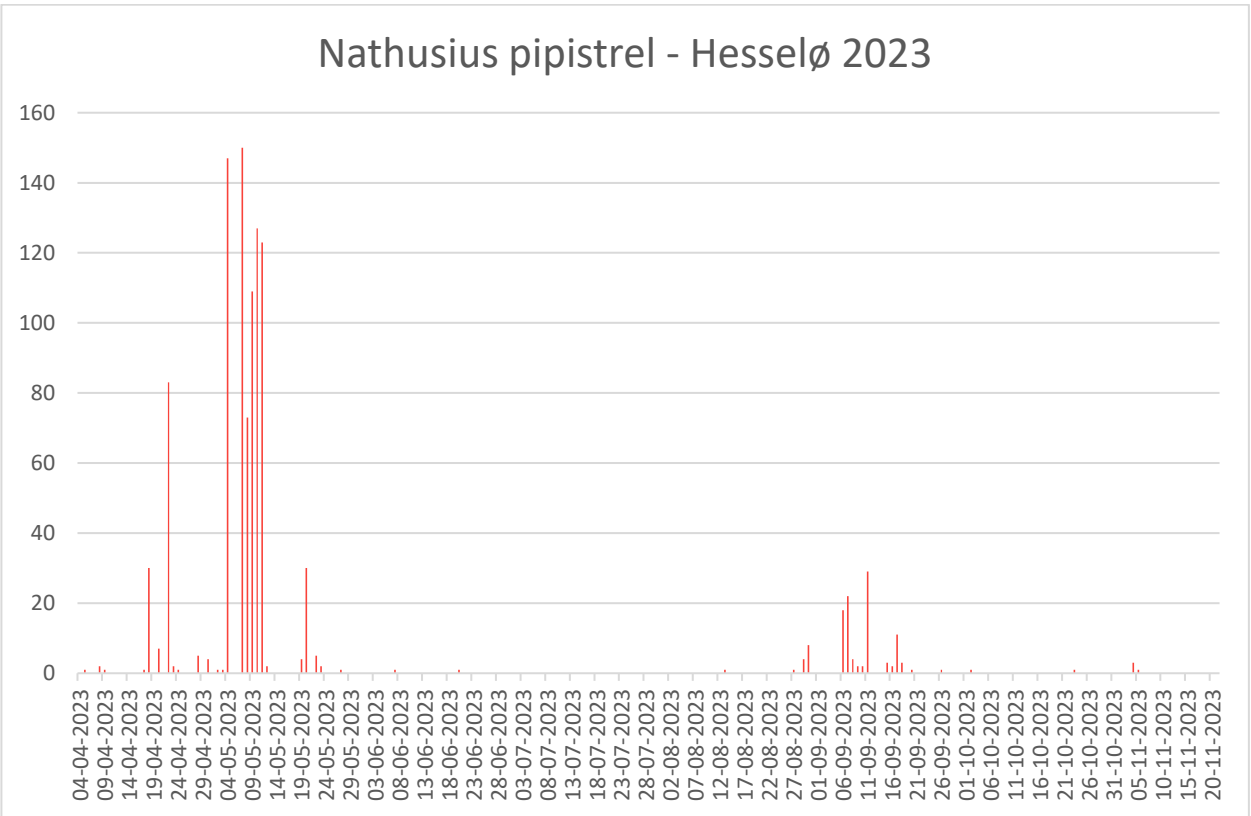
20-11-2023


Nathusius pipistrel - Hesselø 2023
160
140
120
100
80
60
40
20
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04-04-2023
09-04-2023
14-04-2023
19-04-2023
24-04-2023
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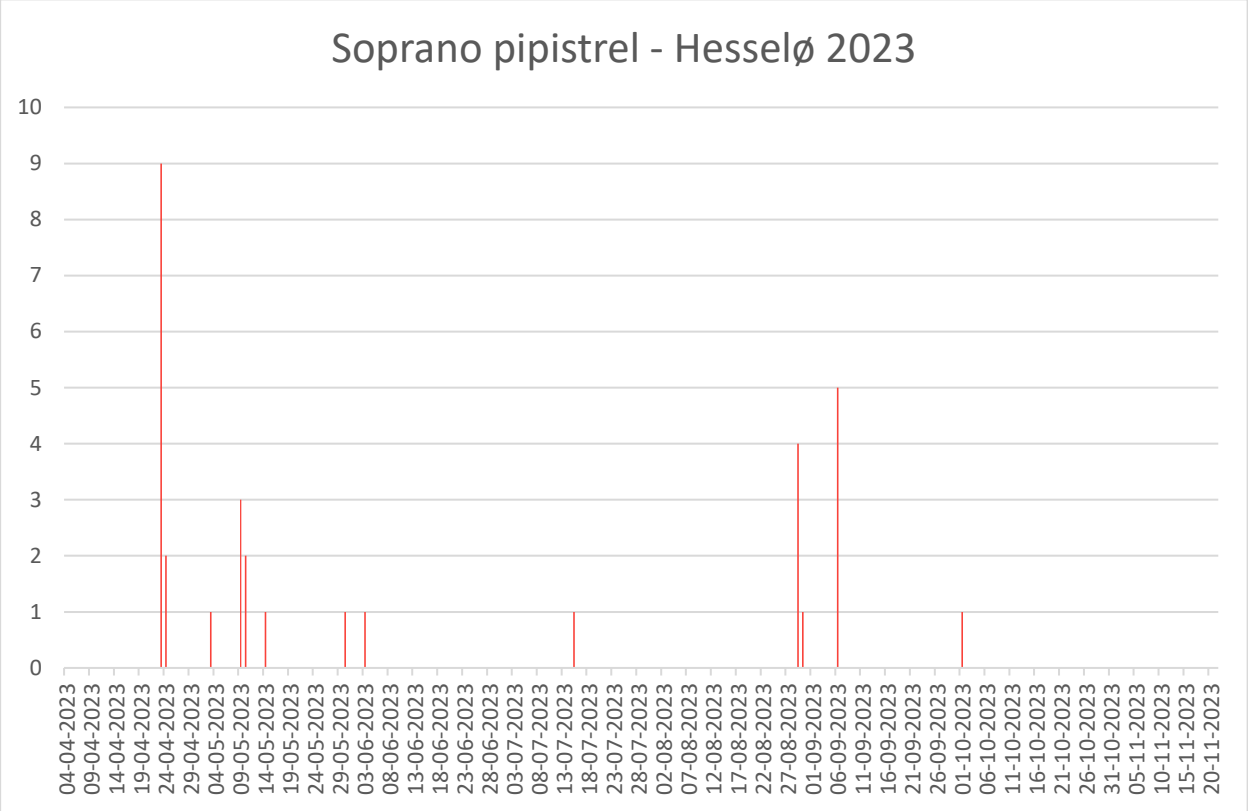
Soprano pipistrel - Hesselø 2023
10
9
8
7
6
5
4
3
2
1
0
04-04-2023
09-04-2023
14-04-2023
19-04-2023
24-04-2023
29-04-2023
04-05-2023
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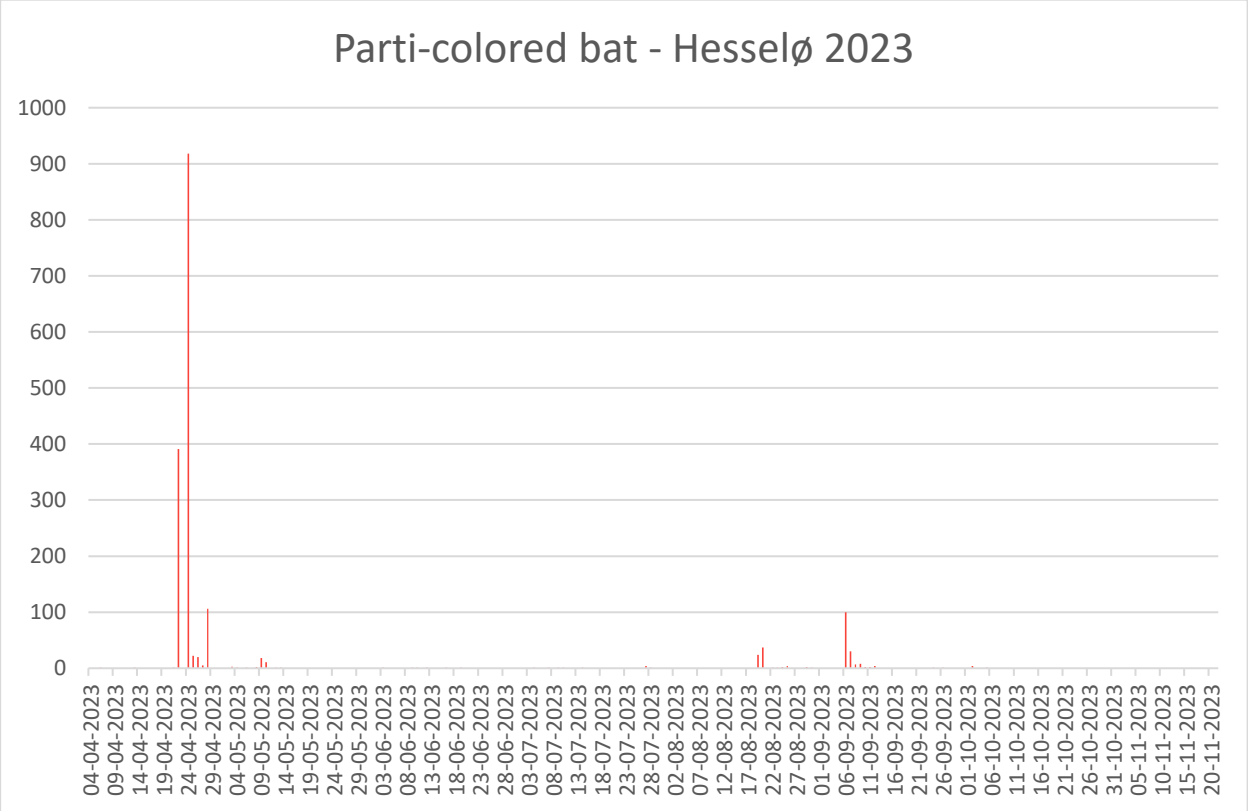
Parti-colored bat - Hesselø 2023
1000
900
800
700
600
500
400
300
200
100
0
04-04-2023
09-04-2023
14-04-2023
19-04-2023
24-04-2023
29-04-2023
04-05-2023
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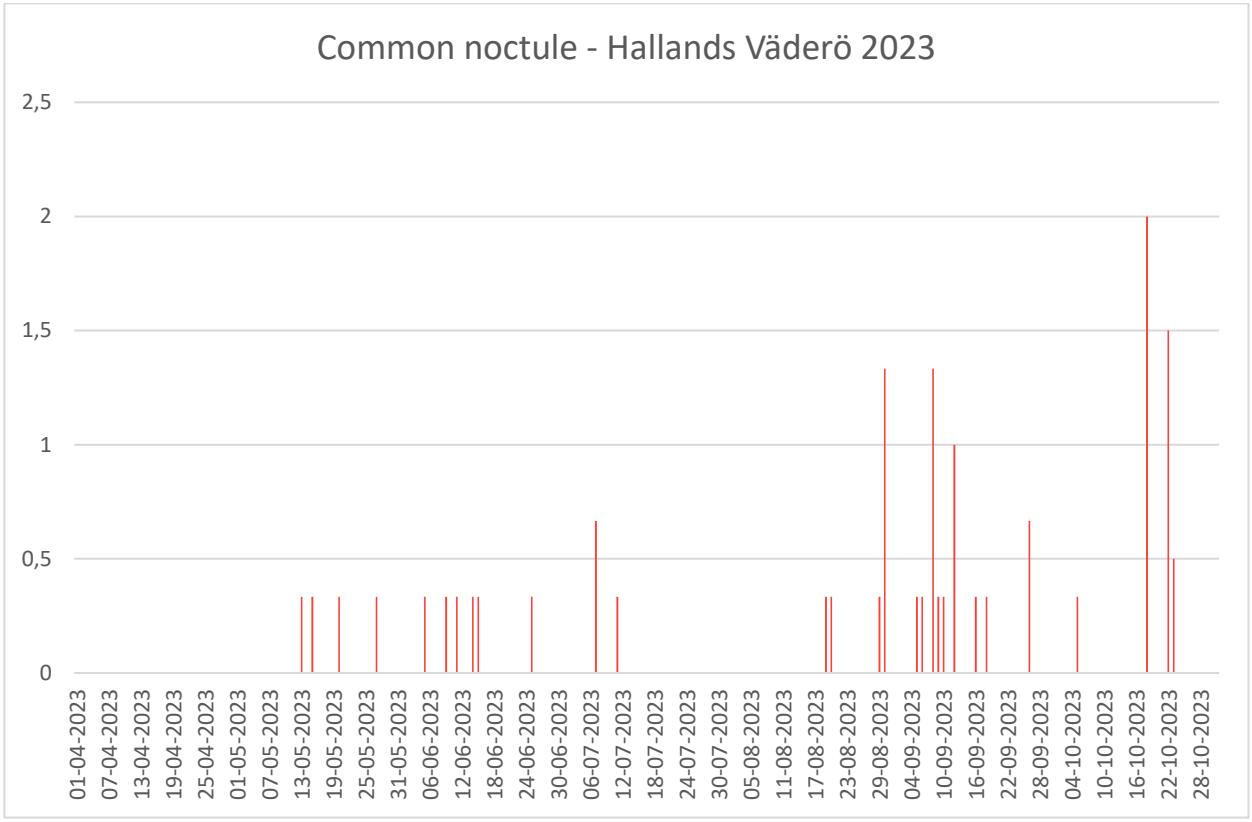
Common noctule - Hallands Väderö 2023
2,5
2
1,5
1
0,5
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
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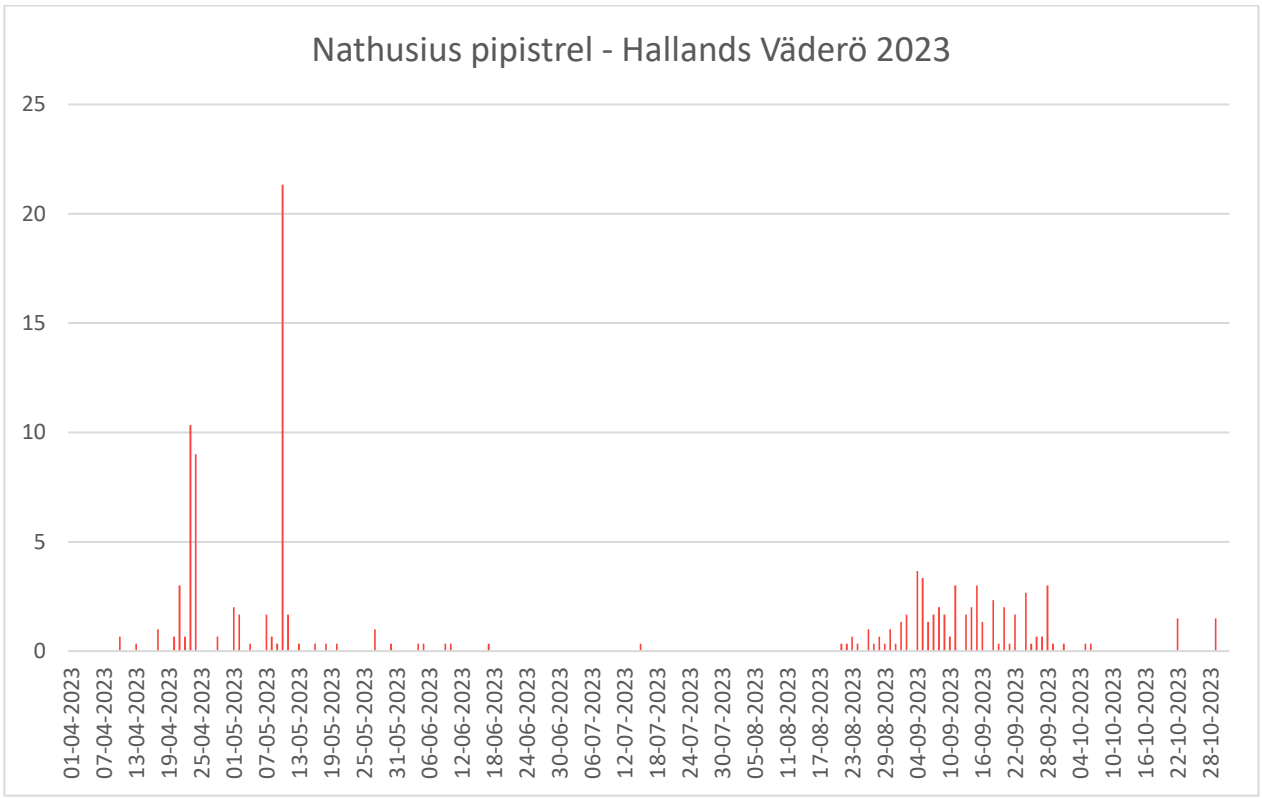
Nathusius pipistrel - Hallands Väderö 2023
25
20
15
10
5
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
07-05-2023
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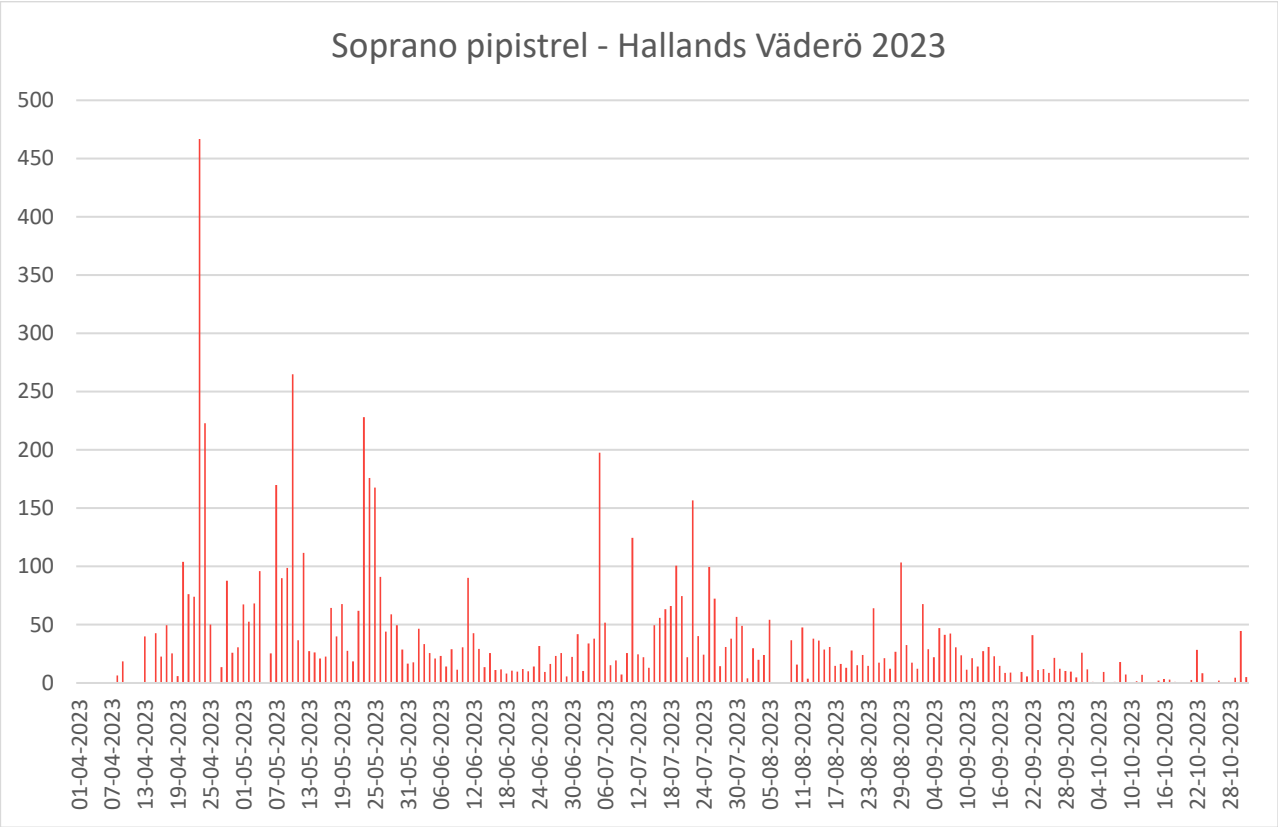
Soprano pipistrel - Hallands Väderö 2023
500
450
400
350
300
250
200
150
100
50
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
07-05-2023
13-05-2023
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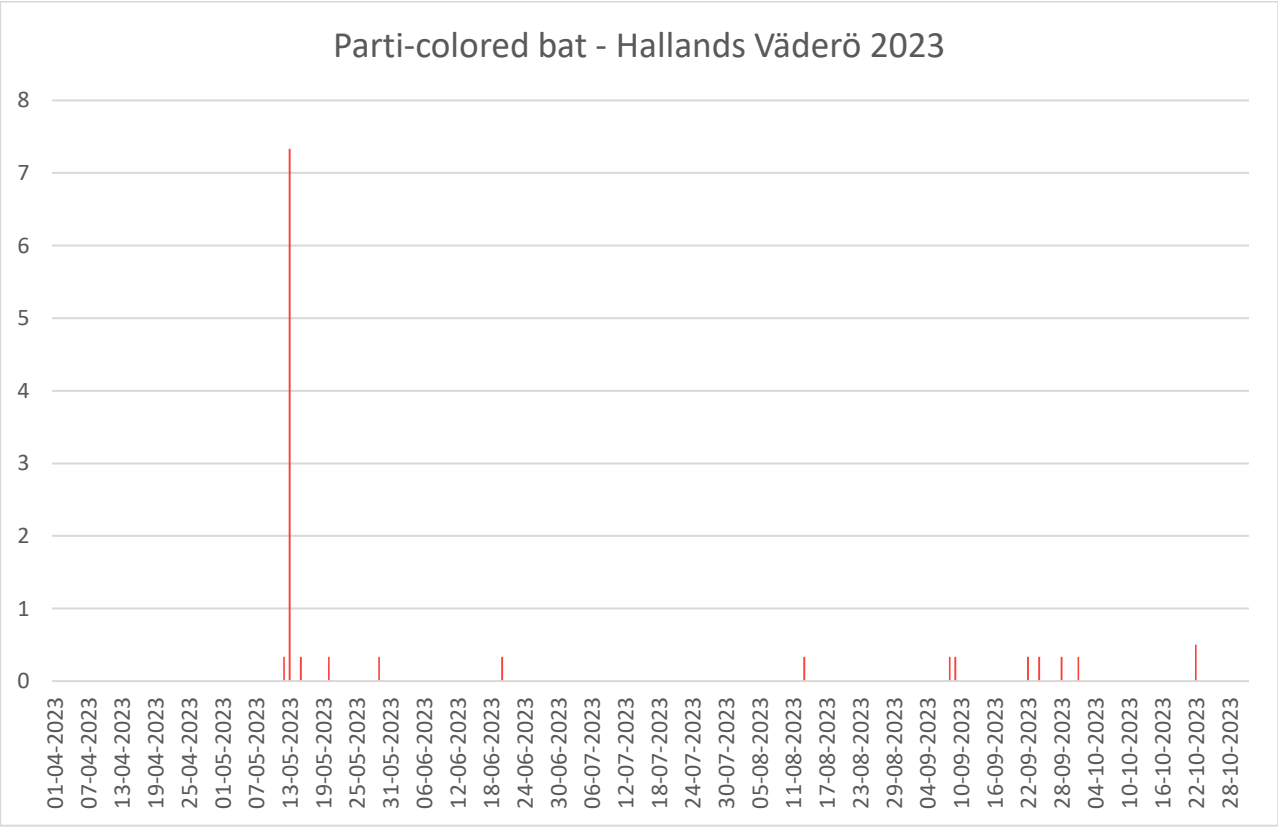
Parti-colored bat - Hallands Väderö 2023
8
7
6
5
4
3
2
1
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
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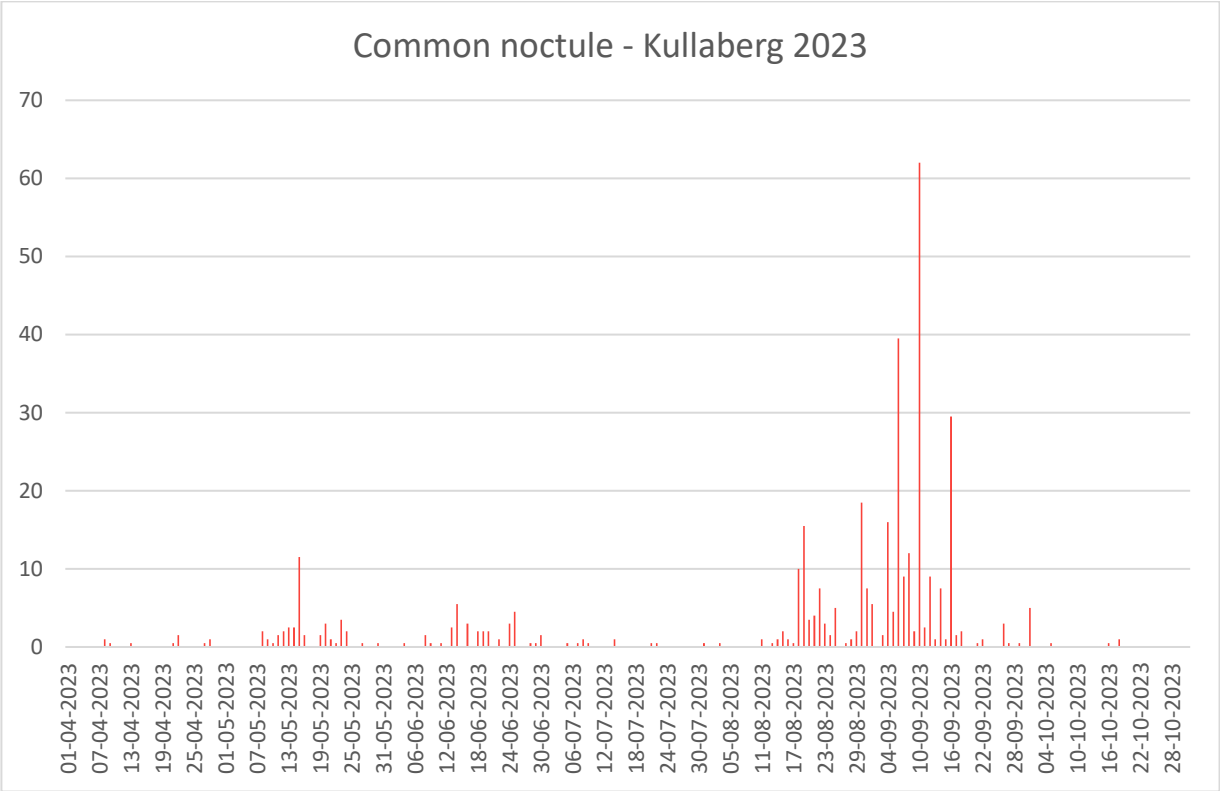
Common noctule - Kullaberg 2023
70
60
50
40
30
20
10
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
07-05-2023
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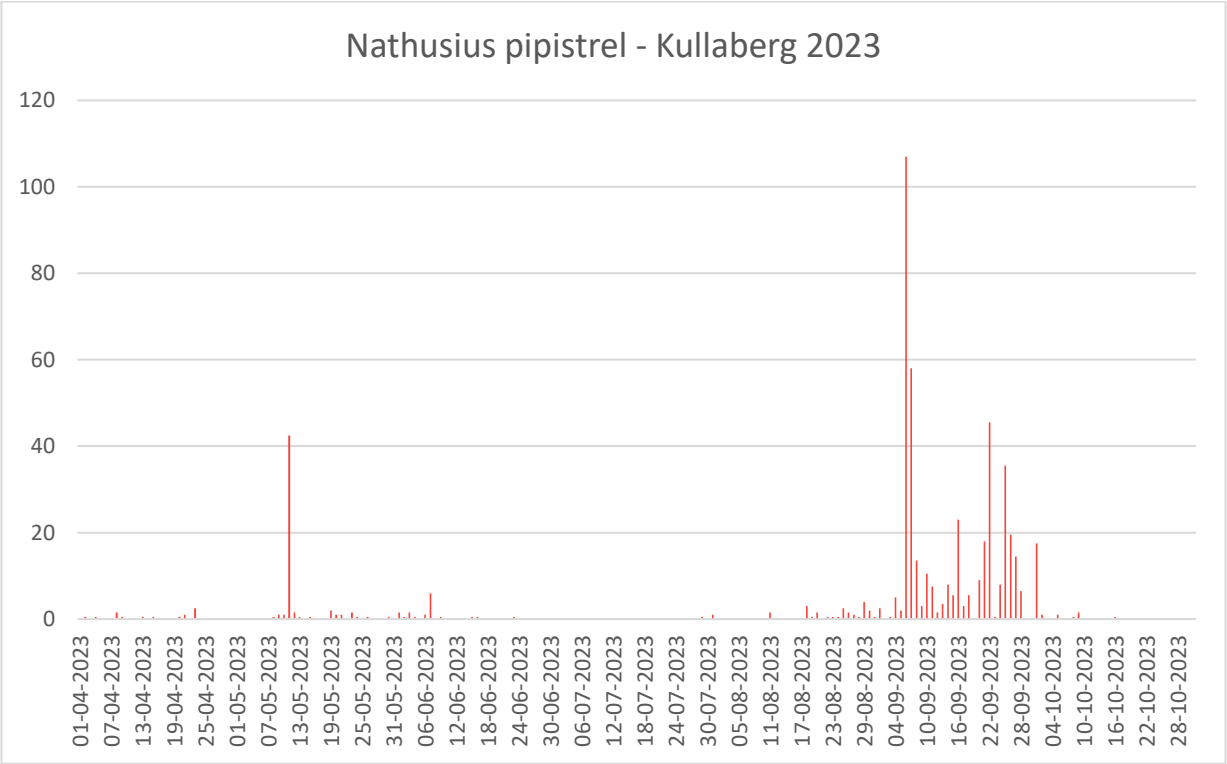
Nathusius pipistrel - Kullaberg 2023
120
100
80
60
40
20
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
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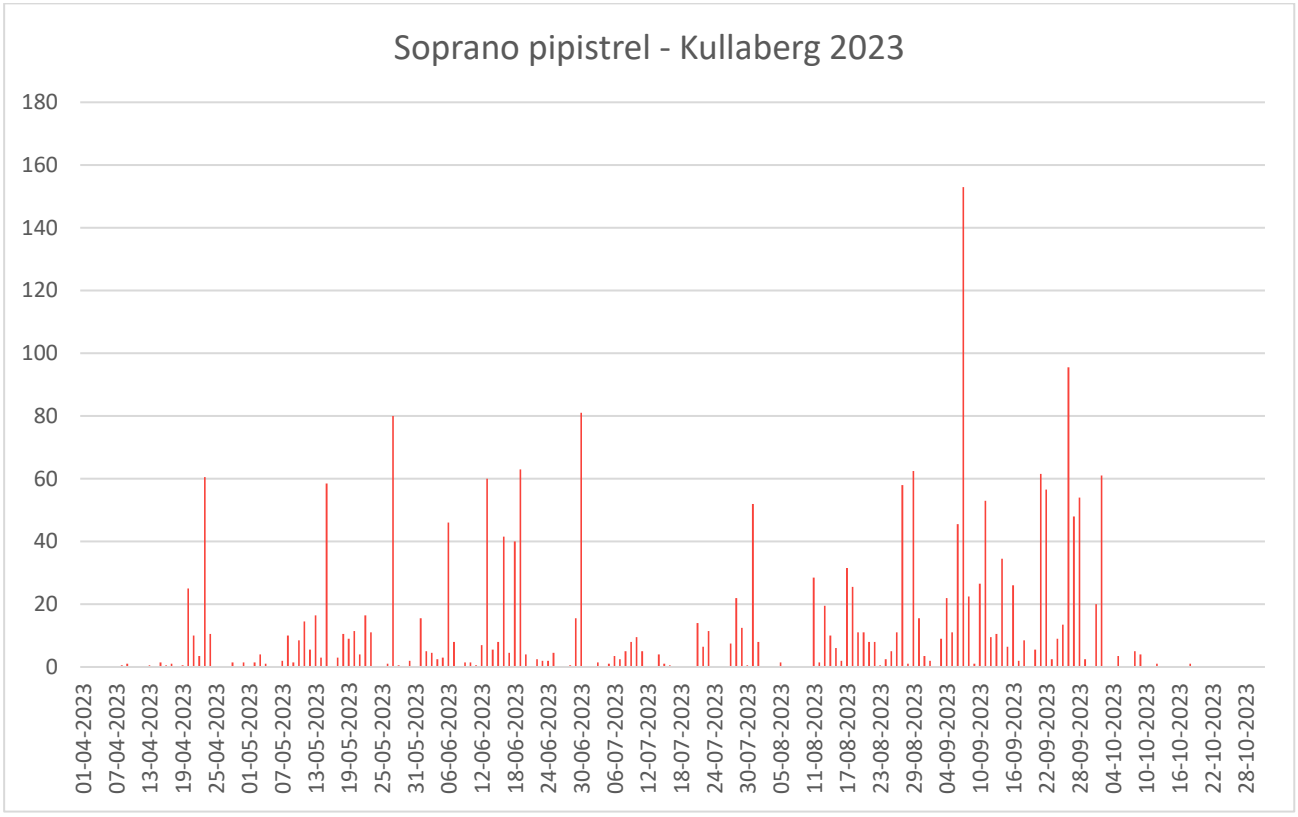
Soprano pipistrel - Kullaberg 2023
180
160
140
120
100
80
60
40
20
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
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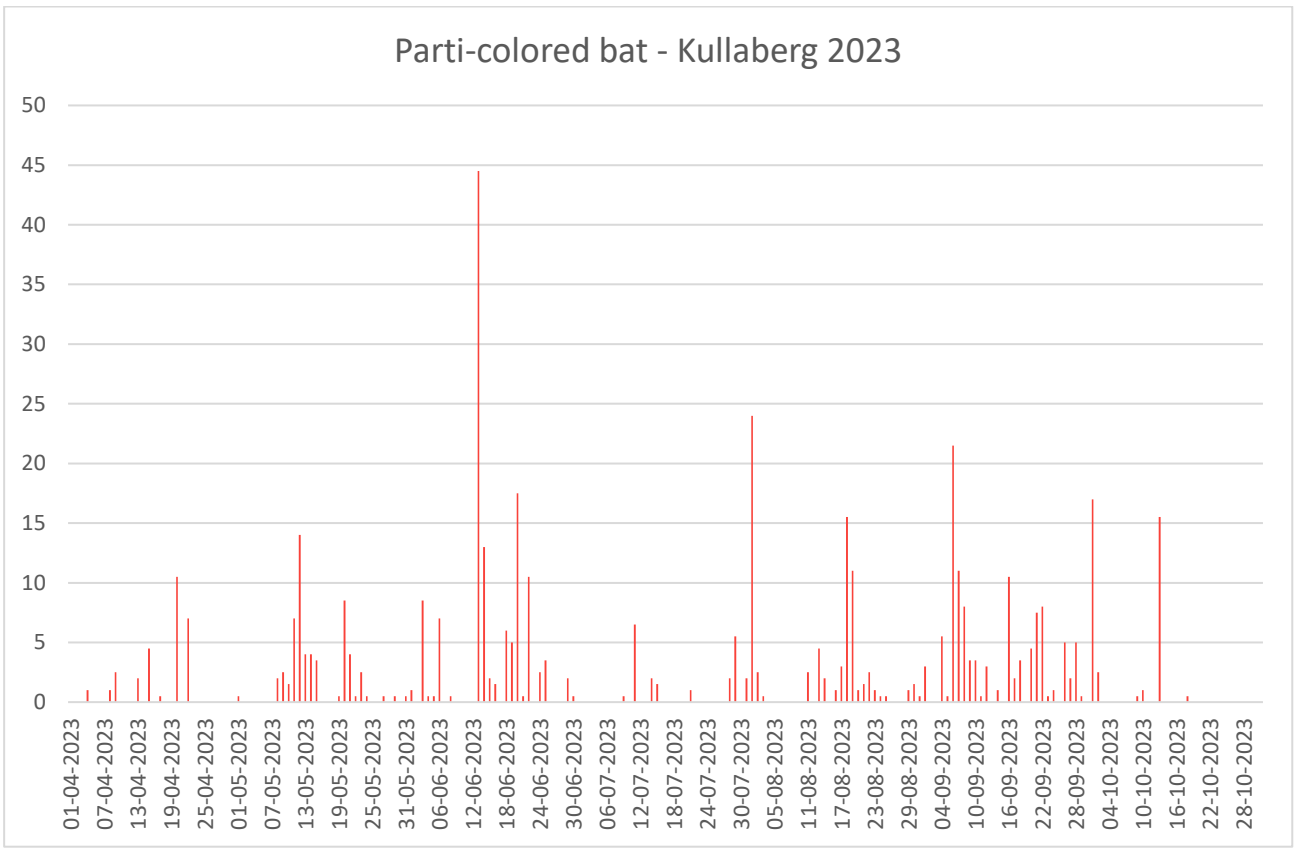
Parti-colored bat - Kullaberg 2023
50
45
40
35
30
25
20
15
10
5
0
01-04-2023
07-04-2023
13-04-2023
19-04-2023
25-04-2023
01-05-2023
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