Final Report

FEHMARNBELT FIXED LINK
Bird Services (FEBI)

Fauna and Flora – Bats

Bats of the Fehmarnbelt Area – Baseline

E3TR0016 Volume I

Prepared for: Femern A/S
By: DHI / BioConsult SH Consortium
in association with University of Copenhagen and BIOLA

Responsible editor:
FEBI consortium / co DHI
Agern Allé 5
DK-2970 Hørsholm
Denmark

FEBI Project Director: Anders Malmgren Hansen, DHI
www.dhigroup.com

Please cite as:
FEBI (2013). Fehmarnbelt Fixed Link EIA.
Fauna and Flora – Bats
Bats of the Fehmarnbelt Area – Baseline
Volume I
Report No. E3TR0016

Report: 65 pages

May 2013

ISBN 978-87-92416-54-4

Maps:
Unless otherwise stated:
DDO Orthofoto: DDO®, copyright COWI
Geodatastyrelsen (formerly Kort- og Matrikelstyrelsen), Kort10 and 25 Matrikelkort
GEUS (De Nationale Geologiske Undersøgelser for Danmark og Grønland)
HELCOM (Helsinki Commission – Baltic Marine Environment Protection Commission)
Landesamt für Vermessung und Geoinformation Schleswig-Holstein (formerly Landesvermessungsamt Schleswig-Holstein) GeoBasis-DE/LVermGeo SH

Photos:
Max Meyer (Cover page, p 4, p 9-12, p 14-15)

Co-financed by the European Union
Trans-European Transport Network (TEN-T)

Table of contents

Lists of figures and tables are included as the final pages

Note to the reader:
In this report the time for start of construction is artificially set to 1 October 2014 for the tunnel and 1 January 2015 for the bridge alternative. In the Danish EIA (VVM) and the German EIA (UVS/LBP) absolute year references are not used. Instead the time references are relative to start of construction works. In the VVM the same time reference is used for tunnel and bridge, i.e. year 0 corresponds to 2014/start of tunnel construction; year 1 corresponds to 2015/start of bridge construction etc. In the UVS/LBP individual time references are used for tunnel and bridge, i.e. for tunnel construction year 1 is equivalent to 2014 (construction starts 1 October in year 1) and for bridge construction year 1 is equivalent to 2015 (construction starts 1st January).

1 SUMMARY

The present report summarises the results of a study carried out by FEBI with the objective to identify to what extent if any the Fehmarnbelt is used by migratory bats. Some European bat populations are known to migrate between their summer and winter areas (Vauk 1974; Gerell; Ahlén 1997; Skiba 2007). However, the knowledge about the bat species which are supposed to be migrating, their flyways, flight altitudes and distances remains limited. In order to obtain specific data of bat migration intensity, species composition and patterns across Fehmarnbelt, various investigation methods were developed and tested during the autumn migration period in 2009 (August 13 – October 19, 2009). The methods were applied during a survey carried out between April 1 and November 1 in 2010.

Two Scandlines ferries and the vessel used for bird migration radar studies (Arne Tiselius) were equipped with AnaBat SD1 detectors. In addition, a Pettersson D 240x detector was used during personal surveys to record bat calls. In spring 2010 investigations were carried out near the Öresund Bridge to examine bat patterns in the vicinity of a large bridge.

During four nights a kite attached to the radar vessel was used to lift an AnaBat SD1 to an approximate altitude of 60 metres above sea level to examine whether bats use higher altitudes for migration.

On the Danish and German mainland five AnaBat SD1 detectors were installed at selected sites to identify a possible change in species composition during the migration period. In addition personal surveys took place at Fehmarn, Lolland and Gedser coastal sites. 15 bat boxes were installed at Fehmarn and checked during the supposed migration periods.

In total over 104,000 bat calls (not individuals) of 10 species were registered. The most abundant registered species were: Soprano Pipistrelle (*Pipistrellus pygmaeus*), Nathusius' Pipistrelle (*Pipistrellus nathusii*), Common Pipistrelle (*Pipistrellus pipistrellus*), and Noctule (*Nyctalus noctula*). Rarely registered species were: Leisler´s Bat (*Nyctalus leisleri*), Parti-coloured Bat (*Vespertilio murinus*), Barbastelle (*Barbastella barbastellus*), Serotine (*Eptesicus serotinus*), Pond Bat (*Myotis dasycneme*) and Daubenton's Bat (*Myotis daubentonii*).

The ship based investigations provided 237 bat registrations. Thereof the most often recorded bat was Nathusius' Pipistrelle, which is known to be a long-distance migrant from bat ringing studies (Hutterer et al. 2005). The Noctule, also known as a long-distance migrant (Hutterer et al. 2005), was also detected regularly. The Soprano Pipistrelle was identified in relatively high numbers implying that this bat species also migrates across the Fehmarnbelt. The following species were rarely recorded during the offshore surveys: Serotine, Pond Bat and the Common Pipistrelle.

Bat flight altitudes were regularly registered by visual observation. The *Pipistrellus* species were observed flying at altitudes usually between 2-5 metres. Species of the genera *Nyctalus* and *Eptesicus* were usually registered at altitudes between 15-25 m or even higher.

During the offshore survey near the Øresund Bridge the following bat species were registered: Leisler's Bat, Noctule, Parti-coloured Bat, Nathusius' Pipistrelle and Soprano Pipistrelle. In total 23 calls were recorded near the Øresund Bridge. Whether the bats are favouring to cross the Øresund across the open Sea or in the

vicinity of the Bridge could not be examined because no data concerning bat activity could be collected for the structure of the bridge itself. However, the survey shows that bats are crossing the Øresund. Due to the lower number of field nights a comparison to the data collected in the Fehmarnbelt is not expedient.

For the first time shore based and offshore based surveys provided deeper insight in bat behaviour during migration periods in the Fehmarnbelt area. Species which are known to be long-distance migrants and those which are not supposed to be migratory could regularly be observed leaving the shore assumedly to cross the Fehmarnbelt.

The number of bat calls detected differed significantly depending on the method applied. The detector installed at the radar vessel provided better results than the detectors placed on the ferries. Assumedly, because the microphone was installed at a higher altitude above sea level compared to the survey aboard the radar vessel it may have missed the low flying species. During the ship based studies different species could be detected, and the ship based surveys seem to depict the peaks in bat movements or even migration.

The results of this study show that bats do regularly occur in the Fehmarnbelt coastal area and some species are proved to migrate across the Fehmarnbelt. In particular during autumn bats were observed crossing the Fehmarnbelt. There were no indications that bats were using specific migration corridors. It is assumed that bats are crossing the Fehmarnbelt at broad front and that the alignment area of a planned fixed link does not play a special role in bat migration, thus the Fehmarnbelt is considered to be of general importance to bat migration.

2 INTRODUCTION

The scope of investigations during autumn 2009 (ATR ENV030022) and the year 2010 was to examine which bat species, if any, use the Fehmarnbelt for spring and/or autumn migration and to which extent they use it. All bats are protected under the EU Habitat Directive. Furthermore, flight patterns, seasonal variation in occurrence and intensity of migration should be examined during the survey.

It is known by now that some bat populations in Europe are migrating between their summer and winter areas (Vauk 1974; Gerell 1987; Ahlén 1997; Skiba 2007). At the moment the knowledge about bat species which are supposed to be migratory, their flyways, flight altitudes and distances are very limited. Although some species like the Nathusius' Pipistrelle and the Noctule were studied for years no reliable flyways or population sizes could be examined. Particularly in migratory species partial migration commonly occurs. In order to answer some of these questions, some different investigation methods were developed and tested during the autumnal migration period in 2009 (August 13 – October 19, 2009) in the Fehmarnbelt area, including the coastlines of Lolland and Fehmarn. The survey was continued in 2010 covering spring to autumn period (April 1 – November 1, 2010).

The aim of this report is to provide detailed analyses and descriptions of the collected data in order to be able to finally assess the importance of the Fehmarnbelt to bat migration.

3 METHODS AND STUDY SITES

The Table 3-1-Table 3-3 will present a list of the utilized material during the survey including different method types.

3.1 Material

The bat calls were recorded using two different ultrasound detector types: the Pettersson 240x ultrasound detector (Figure 3.1) and the AnaBat SD1 system (Figure 3.2). The range of the detectors depends on the bat species and the flight direction in relation to the direction of the detector's microphone. Some bats like the Noctule can be recorded up to a distance of 100 m while others like the *Pipistrellus*-species can only be recorded up to 40 m.

Pettersson 240x

The Pettersson 240x (Figure 3-1) includes two independent ultrasound conversion systems, the heterodyne and the time expansion system. The heterodyne system converts the previously selected ultrasound range into audible range in real time. The time expansion system works with digital memory which continuously stores 3.4 seconds of sound. The stored signal will be converted into audible sound and played 10 times slower than the original sound source when a button is pressed. Only the bat calls transferred in this format were stored and recorded for further analyses using an MP3-recorder (TrekStor i.Beat Organix 2.0) or comparable equipment. The bat calls recorded with this type of detector were analysed with the real-time spectrogram sound analysis software BatSound (vers. 4) by Pettersson.

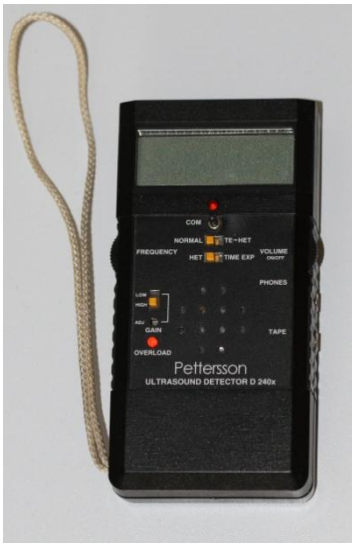


Figure 3-1 Pettersson 240x.

AnaBat SD1

The AnaBat SD1 (Figure 3-2) is meant to monitor bat activity for several weeks, but it can also be used for personal survey if combined with a PDA and the AnaPocket software. The AnaBat SD1 works with the frequency divider system which produces AnaBat-files. It allows choosing between 8, 16 or 32 division. During the investigations the division setting 8 was used. This means that just one wave out of 8 original waves of a bat call was stored. This way the full frequency bandwidth is recorded while the files are kept small. The sensitivity of all AnaBats was adjusted to 5.5. Files were stored on a 2 GB CF-card and analysed with the applied AnaLook program. The disadvantage is that only 12% of a whole bat call can be used for analysis. That is why the identification of species is impossible for *Myotis* and *Plecotus* species. The identification of bats like *Pipistrellus*, *Nyctalus* and *Eptesicus* species is to a large extent possible.

Figure 3-2 AnaBat SD 1.

Table 3-1 Material utilised during the personal survey and the radar vessel survey.

Material -personal survey/radar vessel-
Pettersson D240x (Figure 3.1)
TrekStor i.Beat Organix 2.0 MP-3 Player
Connection cable (D240x to MP-3 Player)
Sennheiser PX 40 Earphones
AnaBat SD1 CF Bat Detector (Figure 3.2)
PDA hp hx2490c
Compactflash GPS BC-337
Connection cable
Hand held spot light

Table 3-2 Material utilised during the Scandlines Ferry survey.

Material -Scandlines Ferry-
AnaBat SD1 CF Detector
CF card
Power supply unit
GPS Smart Antenna SA-320
Extension cable
External microphone system (Figure 3.4)
- Plate of acrylic glass
- Cable straps
- External microphone
- Fixture
- Screws

Table 3-3 Material utilised during the stationary AnaBat survey.

Material -Stationary AnaBat sites-
AnaBat SD1 CF Detector
CF card
Power supply unit/ Motorcycle battery
External microphone system (Figure 3-4)
- Plate of acrylic glass
- Cable straps
- External microphone
- Fixture
- Screws

Table 3-4 Material utilised during the kite survey.

Material -Kite-
AnaBat SD1 CF Detector
CF card
Batteries 4x AA
Mega Power Sled 81
Kite line (65m)
Water- and shockproof box
Snap hook
Duct tape

3.2 Meteorological data

Meteorological data on an hourly basis were provided by the Deutsche Wetterdienst (DWD) for the station of Westermarkelsdorf on Fehmarn.

3.3 Seasons and study sites

Research took place from August 13 – October 19 2009 and from April 2 – November 1 2010. Thereby the survey was focussing on the presumed migration periods. A map showing all study sites is attached in Appendix B

3.3.1 Radar vessel

Bat migration was studied aboard the "Arne Tiselius". In autumn 2009, the vessel was anchoring at two different anchor positions (Figure 3-3) in the Fehmarnbelt. In spring 2010, the anchor position 8 "Hyllekrog" was abandoned. Therefore an anchor position in the middle of the Öresund was added to study in the direct vicinity of the Öresund Bridge. In the autumn of 2010 the survey was continued exclusively at the anchor position 5 "Central Fehmarnbelt". A survey time table of the offshore research is given in Table 3-6.

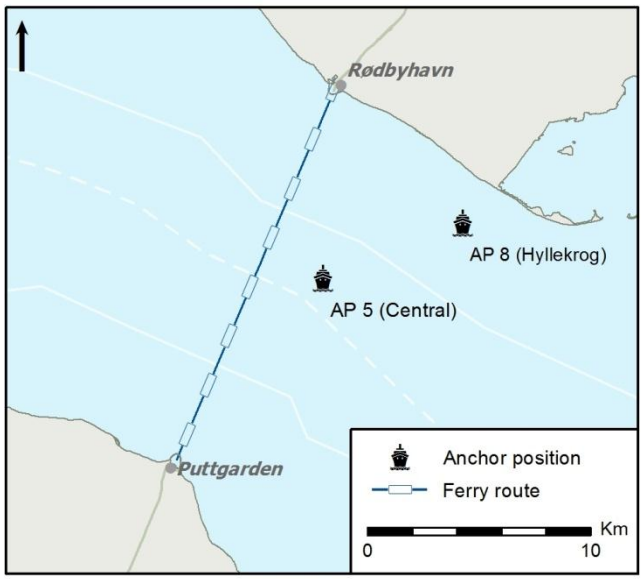


Figure 3-3 Different anchor positions in the Fehmarnbelt.

Both detector types and a handheld spotlight were used during personal surveys which took place in the Fehmarnbelt and in the Öresund. The AnaBat was placed nearby the vessel's side perpendicular to the main supposed migration direction at a height of 2.5 m above sea level. In addition bat calls were recorded with the Pettersson 240x while sitting by the side of the vessel and recording the incoming bat calls with an MP3-Player. During the analysis recordings from both detector types were combined. Additionally, a handheld spotlight was used to follow the bats during their flight across the water surface. Whenever possible, altitudes and flight directions were registered. There were two marine radars running 24 hours/day,

which were in use to study bird migration and not for the detection of bats. Rotating marine radars as used during the bird studies were proven to not significantly influence the activity of bats (Nicholls and Racey 2009). General information on the radar installation is given in Table 3-5.

Table 3-5 Detailed information of the marine Radars.

Radar	Technical specification
Brand	Furuno
Type	FAR2127
Power output [kW]	25 kW
Frequency	9,410 ± 30 MHz (X-band)
Rotational speed [min-1]	24
Antenna length [mm]	2,400

Table 3-6 Survey time table for the offshore investigations; n (AP 5) = 50; n (AP 8) =15; n (Öresund) = 10; n (Transect) = 1.

Date	Site	Date	Site	Date	Site
15.08.2009	AP 5	24.04.2010	AP 5	02.09.2010	AP 5
16.08.2009	AP 5	25.04.2010	AP 5	03.09.2010	AP 5
18.08.2009	AP 8	26.04.2010	Öresund	21.09.2010	AP 5
19.08.2009	AP 5	27.04.2010	Öresund	22.09.2010	AP 5
20.08.2009	AP 5	28.04.2010	Öresund	23.09.2010	AP 5
26.08.2009	AP 5	29.04.2010	Öresund	24.09.2010	AP 5
27.08.2009	AP 5	30.04.2010	Öresund	05.10.2010	AP 5
28.08.2009	AP 8	08.05.2010	AP 5	06.10.2010	AP 5
29.08.2009	AP 8	10.05.2010	Öresund	07.10.2010	AP 5
30.08.2009	AP 5	11.05.2010	Öresund	12.10.2010	AP 5
01.09.2009	AP 5	12.05.2010	Öresund	13.10.2010	AP 5
02.09.2009	AP 8	13.05.2010	Öresund	14.10.2010	AP 5
07.09.2009	AP 5	14.05.2010	Öresund		
08.09.2009	AP 5	16.05.2010	AP 5		
09.09.2009	AP 8	17.05.2010	AP 5		
11.09.2009	Transect	26.05.2010	AP 5		
14.09.2009	AP 5	27.05.2010	AP 5		
15.09.2009	AP 5	29.05.2010	AP 5		
16.09.2009	AP 8				
17.09.2009	AP 8	21.06.2010	AP 5		
18.09.2009	AP 5	22.06.2010	AP 5		
19.09.2009	AP 5	23.06.2010	AP 5		
22.09.2009	AP 8	07.07.2010	AP 5		
23.09.2009	AP 8	08.07.2010	AP 5		
24.09.2009	AP 5	20.07.2010	AP 5		
25.09.2009	AP 5	21.07.2010	AP 5		
26.09.2009	AP 8	22.07.2010	AP 5		
27.09.2009	AP 8				
05.10.2009	AP 8	03.08.2010	AP 5		
06.10.2009	AP 8	04.08.2010	AP 5		
07.10.2009	AP 5	05.08.2010	AP 5		
09.10.2009	AP 8	31.08.2010	AP 5		
10.10.2009	AP 8	01.09.2010	AP 5		

3.3.2 *Personal survey onshore*

In autumn 2009 shore based observations were undertaken at Lolland's and Fehmarn's coastlines (Figure 3-4). During the field nights different sites were surveyed by usage of an AnaBat, the D240x detector and a handheld spotlight at Fehmarn (Katharinenhof, camping ground and Grüner Brink) and Lolland (Hyllekrog (edge) and Rødbyhavn (west)). In spring 2010 shore based observations only took place at Fehmarn's north- and west coast and in autumn 2010 exclusively at Lolland's south coast. During the surveys a small area with interesting guidelines like dikes, hedges or other structures was chosen and observed from sunset until the second third of the night. For analysis recordings both detector types were combined. All recognizable parameters and behaviour (species, flight altitude, and flight direction) were registered. A survey time table (Table 3-7) is added below.

Table 3-7 Survey time table personal survey.

Autumn 2009		**Spring 2010**		**Autumn 2010**	
Date	Site	Date	Site	Date	Site
13.08.2009	Fehmarn	28.04.2010	Wallnau Westermarkelsdorf	11.08.2010	Hyllekrog (edge)
14.08.2009	Lolland	29.04.2010	Westermarkelsdorf	19.08.2010	Hyllekrog (edge)
22.08.2009	Lolland	09.05.2010	Westermarkelsdorf	04.09.2010	Rødbyhavn (east)
23.08.2009	Fehmarn	19.05.2010	Mole (Puttgarden)	05.09.2010	Rødbyhavn (west)
25.08.2009	Fehmarn	22.05.2010	Mole (Puttgarden)	13.09.2010	Hyllekrog (edge)
31.08.2009	Lolland	02.06.2010	Mole (Puttgarden)	29.09.2010	Rødbyhavn (west)
02.09.2009	Fehmarn	03.06.2010	Mole (Puttgarden)	30.09.2010	Rødbyhavn (west)
10.09.2009	Lolland			01.10.2010	Rødbyhavn(west)
11.09.2009	Fehmarn			11.10.2010	Hyllekrog (edge)
20.09.2009	Lolland			11.10.2010	Rødbyhavn (west)
21.09.2009	Fehmarn				
11.10.2009	Fehmarn				
12 nights		7 nights		9 nights	

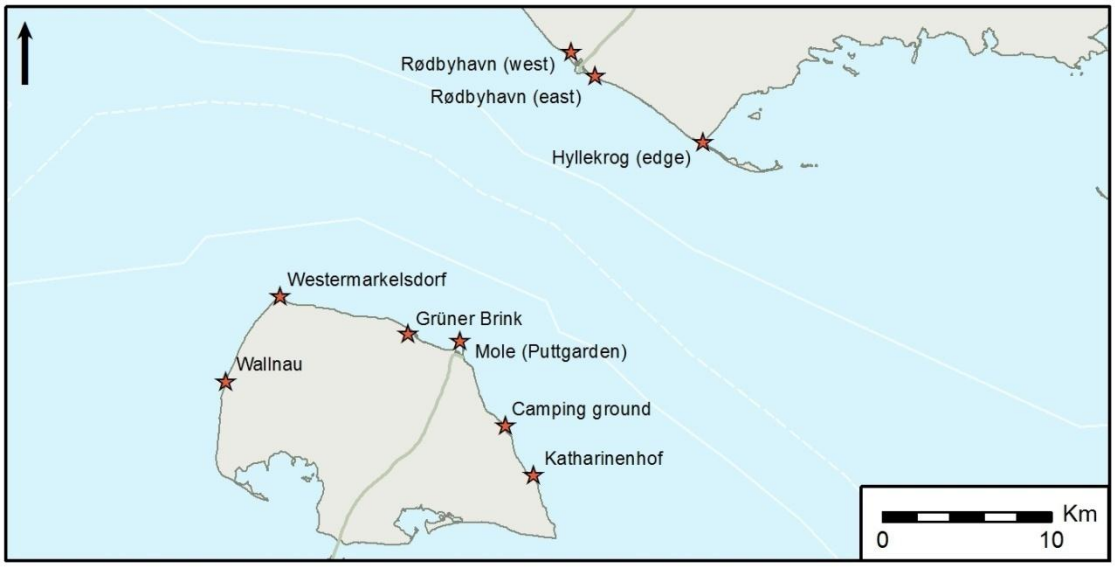


Figure 3-4 Personal investigation sites at Fehmarn and Lolland.

3.3.3 Scandlines Ferries

To survey the vicinity of the planned Fixed Link two Scandlines ferries ("Deutschland" and "Schleswig-Holstein") were equipped with a system including an AnaBat SD1 and a GPS- receiver (Evermore Marine GPS- receiver SA-320) in autumn 2009 (see Figure 3-5). This combination provides geographic coordinates for each recorded bat call. The AnaBat microphone and the GPS-receiver were fixed about 14 m above sea level. The ferries are alternating all night long between Rødbyhavn and Puttgarden (Figure 3-6). To minimise potential noise caused by strong winds, which usually comes from the north-west, the microphone was adjusted in an eastern direction. In spring 2010 an attempt to install the microphone on the "Deutschland" two decks below the old position failed. The reason for this failure can be seen in the ultrasound noise caused by the waves the ferry emitted and also the noise caused by a cooling ventilator of the ferry's engine. In 2010 the only running AnaBat was placed on the ferry "Schleswig Holstein". The periods of investigation are shown in Table 3-8.

Figure 3-5 External microphone system incl. GPS-receiver.

Table 3-8 Survey time table Scandlines ferries "Deutschland" and "Schleswig Holstein".

Ferry	Date	Nights
FS Schleswig Holstein	12.8. - 19.10.2009	73
	28.4. - 01.11.2010	189
FS Deutschland	13.8. - 19.10.2009	72
Total		334

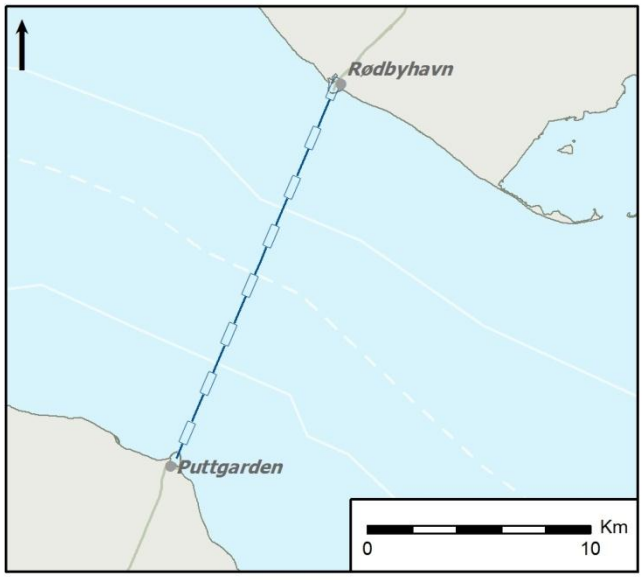


Figure 3-6 Idealised ferry route between Rødbyhavn and Puttgarden.

3.3.4 *Kite*

To examine in which altitudes bats are flying when passing long distances over sea a kite (Mega Power Sled 81) was flown from the radar vessel to raise an AnaBat SD1 (Figure 3-7) to an approximate altitude of 60 m above sea level. The line's length was 65 m. The kite was in use during five nights. During one night (September 10 2009) it was flown from the mainland in Denmark and another four nights from the radar vessel (Table 3-9). The AnaBat was put into a water- and shockproof box to prevent damage. The box was tied up 3 m below the kite (Figure 3-7). In 2010 the survey with a kite was no longer possible, because of a new radar fixture on the vessel's stern whose height reaches a problematic distance to the kite's line.

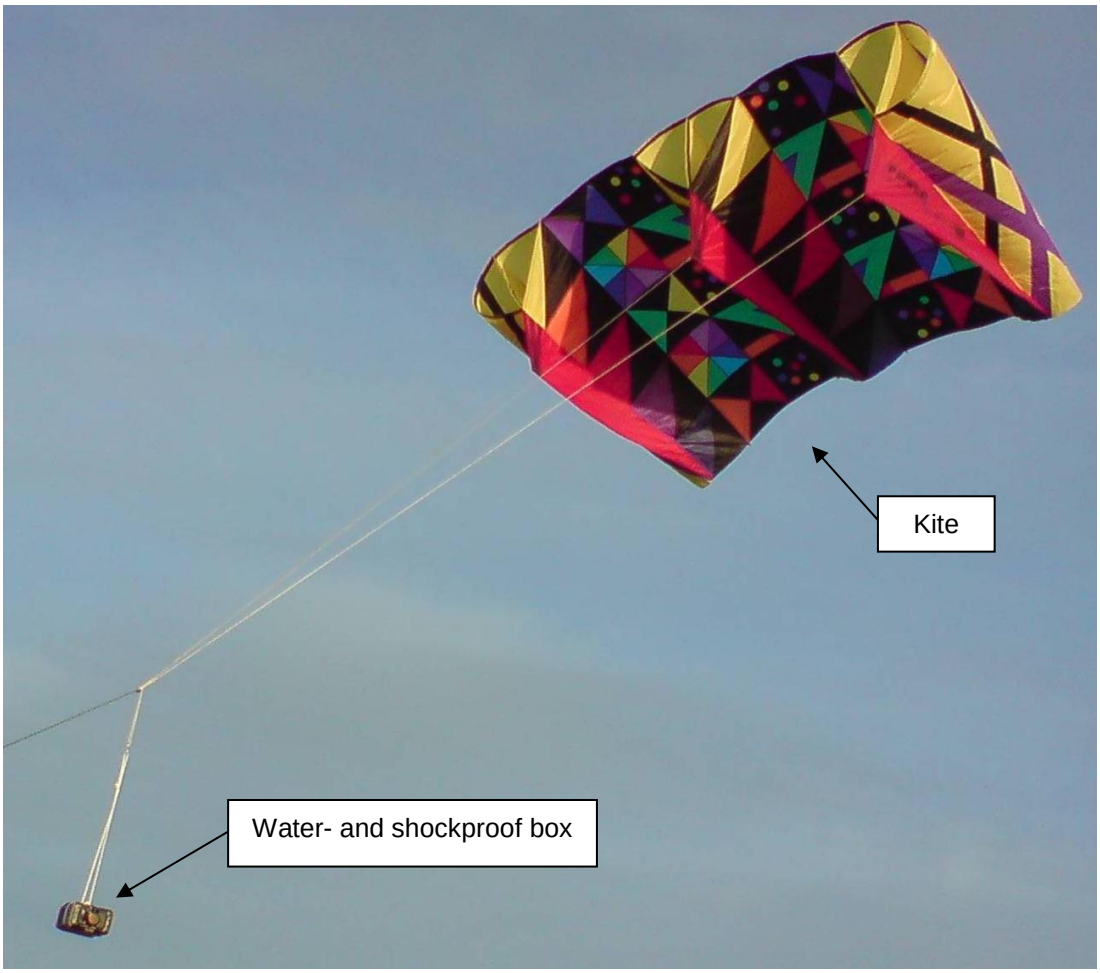


Figure 3-7 *AnaBat SD1 fixed to a kite (Mega Power Sled 81).*

Table 3-9 *Survey time table kite investigations.*

Date	Site	Nights
10.09.2009	Hyllekrog (Lolland)	1
16.09.2009	AP 8 (Hyllekrog)	1
19.09.2009	AP 5 (Central)	1
27.09.2009	AP 8 (Hyllekrog)	1
07.10.2009	AP 5 (Central)	1
Total		5

3.4 Bat box examination

In 2009 15 bat boxes were installed in a coastal wood patch near Katharinenhof and the AnaBat study site "Waldpavillon". The bat boxes were fixed on trees in groups of 3-4. They were installed at a height of 3.5-4 m (Figure 3-8). During migration periods they were examined once a week (Table 3-10). To make the boxes more attractive to the bats their inner rooms were lubricated with a mixture of water and bat excrements. The aim of bat box examination was to catch some specimens to take hair samples for analyses of staple isotopes to reveal the origin of captured bats in cooperation with the Leibniz Institute for Zoo and Wildlife Research.

Table 3-10 Date of examination.

Autumn 2009	Spring 2010	Autumn 2010
12.09.2019	30.03.2010	02.08.2010
21.09.2009	09.04.2010	11.08.2010
29.09.2009	17.04.2010	20.08.2010
11.10.2009	26.04.2010	24.08.2010
19.10.2009	29.04.2010	06.09.2010
	06.05.2010	13.09.2010
	22.05.2010	21.09.2010
	03.06.2010	02.10.2010
		09.10.2010
		17.10.2010

Figure 3-8 Installation of bat boxes near Katharinenhof.

3.5 Stationary detectors

Figure 3-9 External Microphone system.

In 2009, four AnaBats were located at proper sites (Figure 3-10) to monitor species composition during the migration period. Two AnaBats were installed at Fehmarn's coastline at Waldpavillon (Chap. 3.5.1), Grüner Brink (Chap. 3.5.2), one in Lolland at Hyllekrog (Chap. 3.5.4) and another one at Gedser's coastline (Chap. 3.5.6). The AnaBat in Gedser was removed in 2010 and a new site near the Jimi Hendrix Memorial (Chap. 3.5.3) on Fehmarn was installed. In autumn 2010 a new site was added: the quay wall's head of the ferry harbour in Rødbyhavn (Chap. 3.5.5). For all sites an external microphone cable was used in order to achieve a proper investigation area. The way the external microphone-system (Figure 3-9) was fixed was similar at all sites. The subchapters' 3.5.1- 3.5.6 will describe the surroundings of the AnaBat sites. The periods of investigation are shown in Table 3-11.

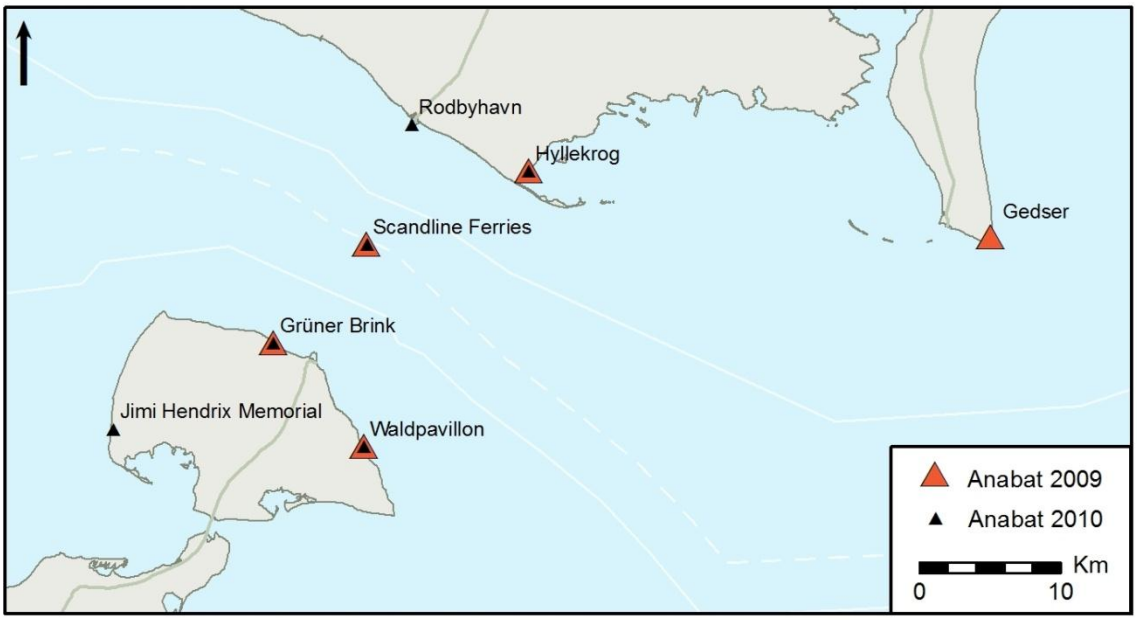


Figure 3-10 AnaBat sites during the survey in the year 2009 and 2010.

Table 3-11 Survey time table of AnaBat sites.

Site	Sample time	Nights	∑ Nights
Waldpavillon (Fehmarn)	23.08.- 18.10.2009 02.04.- 02.06.2010 11.08.- 01.11.2010	58 62 Malfunction	120
Grüner Brink (Fehmarn)	25.08.- 18.10.2009 01.04.- 01.11.2010	55 215	270
Jimi Hendrix Mem. (Fehmarn)	07.04. -01.11.2010	209	209
Hyllekrog (Lolland)	04.09.- 19.10.2009 02.04.- 03.06.2010 12.08.- 11.11.2010	46 63 92	201
Rødbyhavn (Lolland)	19.08.- 01.11.2010	75	75
Gedser (Falster)	15.08.- 18.10.2009	70	70
Total			944

3.5.1 Waldpavillon (Fehmarn)

The AnaBat site near the restaurant "Waldpavillon" (Figure 3-11) was fixed to a fence post next to the cliff line. The microphone was installed in a northeast direction pointing towards the sea. The area can be characterised by a narrow wood patch which follows the coast line, the camping ground in the west and surrounding farmland with hedges and some groves. During autumn 2010 the position of the microphone had to be changed. Because of the constant slide down of the cliff line the fence post that had been used until then could not be utilised anymore. The new position of the microphone was about 15 m north of the old position.

Figure 3-11 AnaBat site "Waldpavillon".

3.5.2 Grüner Brink (Fehmarn)

The "Grüner Brink" is a nature reserve on the north coast of Fehmarn. The area includes wide shallow lakes and small shrub structures. The AnaBat system was fixed next to a caravan surrounded by small bushes (Figure 3-12). The microphone was adjusted with a northeast direction about 15 m from a lake and 300 m from the Baltic Sea.

Figure 3-12 AnaBat site "Grüner Brink".

3.5.3 Jimi Hendrix Memorial (Fehmarn)

The area surrounding this site (Figure 3-14) is characterised by small linear coniferous woodlands, shrubs and wetlands. A campground runs along the coastline to the south. The microphone system was fixed at a height of 1 m on a fence post almost on top of the dike next to a holiday house (Figure 3-13). The distance to the coastline was about 80 m. The microphone was adjusted in a western direction.

Figure 3-13 AnaBat microphone system.

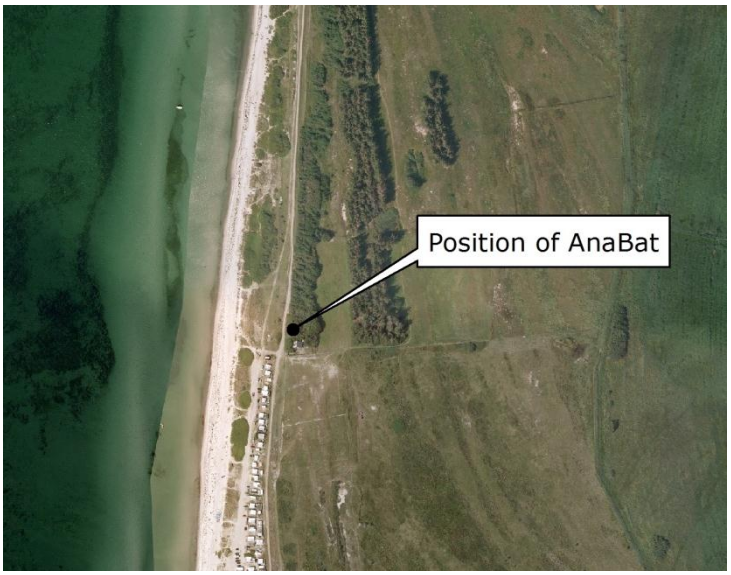


Figure 3-14 AnaBat site "Jimi Hendrix Memorial".

3.5.4 *Hyllekrog (Lolland)*

Hyllekrog is known to be a major leaving point for migrating passerines birds (Kahlert et al. 2007; Skov et al. 2008). The AnaBat was positioned at a pump station about 30 m from the dike. The pump station is surrounded by wetlands including small lakes and shrubs, wood patches and a lagoon (Figure 3-16). By using an external cable the microphone could be fixed on a pole on the dike (Figure 3-15) with a north-east direction to record the bats which supposedly follow the dike during migration. In 2010 the microphone system was fixed about 50 m away from the pump station and the scrub structures in order to avoid recording bat calls emitted by hunting bats. In spring 2010 the microphone was adjusted in a south-western direction and in autumn of the same year in a north-eastern direction.

Figure 3-15 External microphone system at "Hyllekrog".

Figure 3-16 AnaBat site "Hyllekrog".

3.5.5 Rødbyhavn (Lolland)

This AnaBat site is mainly characterised by the Scandlines harbour and the inner harbour with its industrial buildings and a huge silo. The harbour area is surrounded by several small lakes and shrub structures followed by farmland. The microphone was fixed to a pole on the breakwater which was in use to fix sea signs and light installations for the incoming vessels (Figure 3-17). This pole stands on the head of the breakwater about 500 m from the coastline. The direction of the microphone was adjusted into a northeast direction pointing to the shore. Several marine radars are in operation in the vicinity.

Figure 3-17 AnaBat site Rødbyhavn.

3.5.6 Gedser (Gedser)

At the site in Gedser an old tower was used to fix the AnaBat. The AnaBat was installed at the southeast side of the tower 4.5 m above ground. The tower is located next to a lighthouse and the bird ringing station Gedser (Figure 3-18). This small settlement structure is surrounded by farmland. The garden of the ringing station is overgrown with shrubs. A military radar is in use about 600 m to the southeast. The AnaBat was only collecting data during 2009.

Figure 3-18 AnaBat site at Gedser.

4 RESULTS

4.1 Meteorological data

The meteorological data collected by the weather station Westermakelsdorf are shown in the Figure 4-1- Figure 4-3 for the main survey periods in 2009 and 2010. Parameters selected for further analysis are: temperature, wind speed and precipitation. Meteorological data was collected from 00:00 h until 06:00 h local time. For the analysis of the mean night temperature and mean night wind speed data were taken every hour. For the calculation of night precipitation the sum of water accumulated from 18:00 h until 06:00 h next day was used.

Finally, the data were analysed and nights with unsuitable weather conditions were assessed. Unsuitable weather conditions are characterised by a precipitation above 1mm, a mean night temperature below 8 °C or a mean night wind speed above 8 m/s. These figures are the result of the analyses of the weather parameters in regard to the recorded bat activity at the radar vessel (see Chap. 4.2).

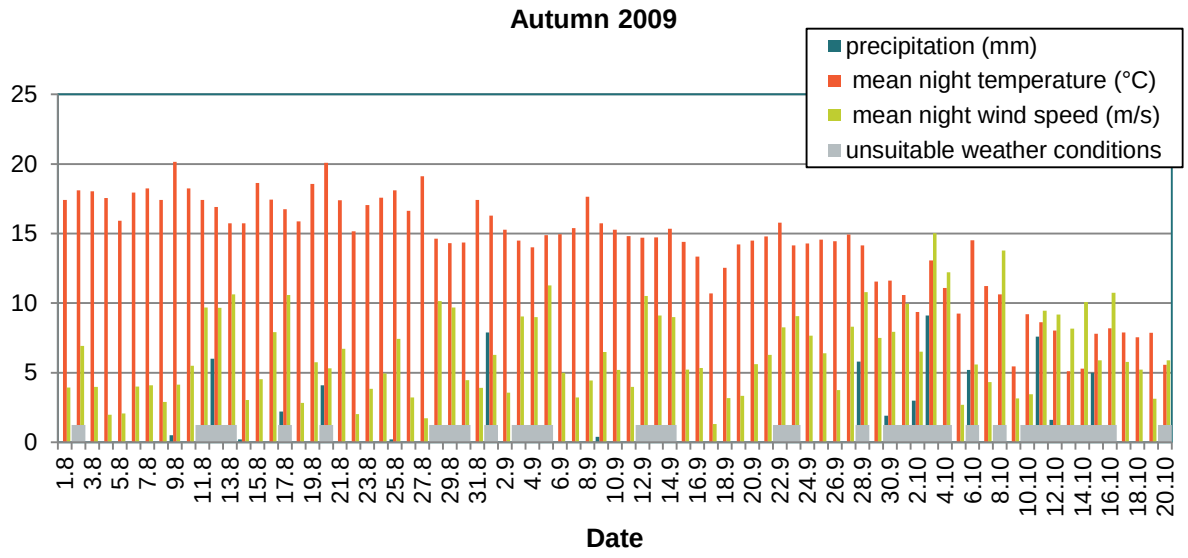


Figure 4-1 Weather parameters (precipitation, mean night temperature, mean night wind speed and unsuitable weather conditions) at Westermakelsdorf in the autumn of 2009.

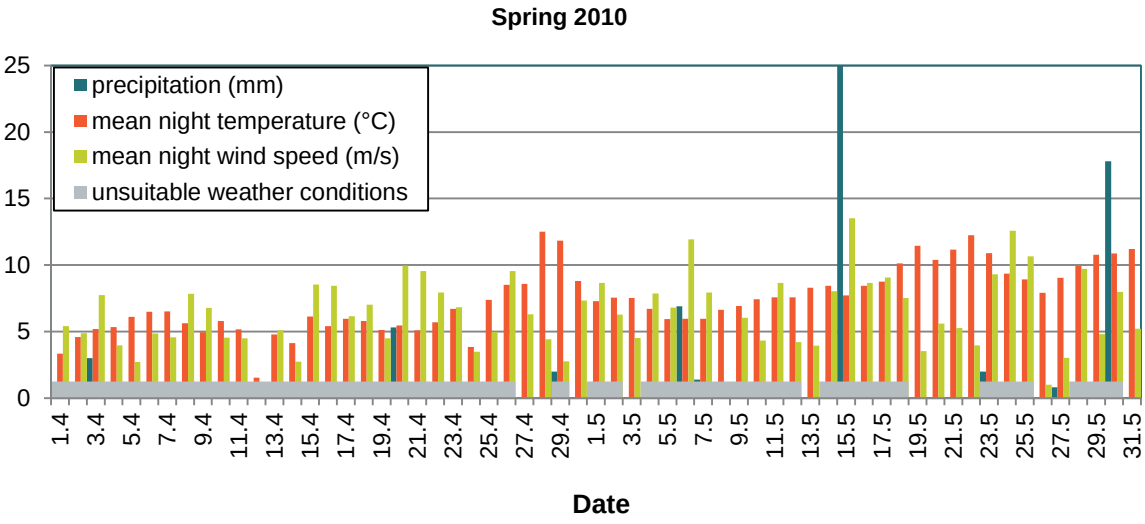


Figure 4-2 Weather parameters (precipitation, mean night temperature, mean night wind speed, unsuitable weather conditions) at Westermakelsdorf in spring 2010.

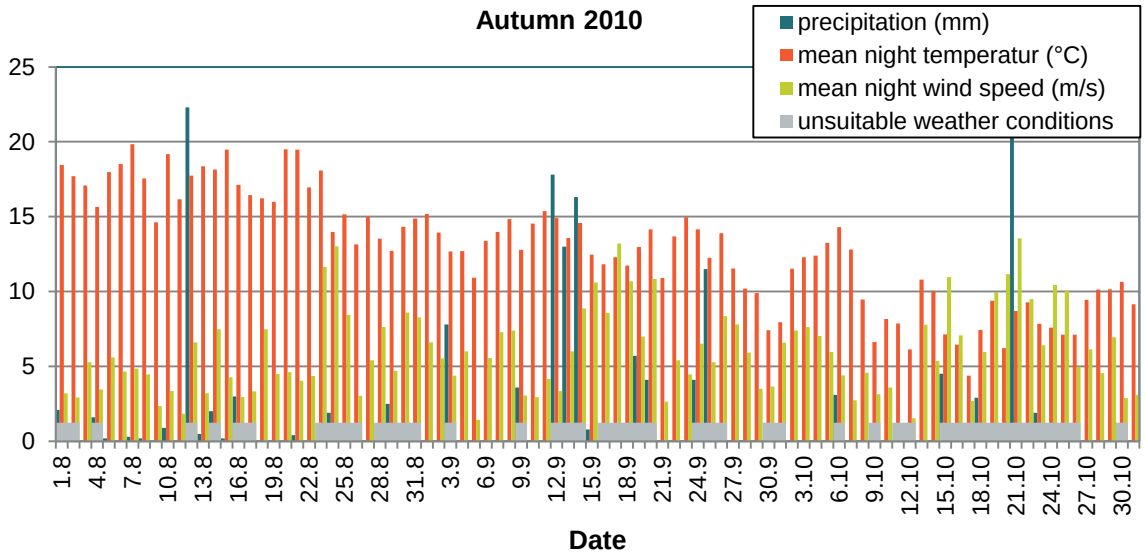


Figure 4-3 Weather parameters (precipitation, mean night temperature, mean night wind speed, unsuitable weather conditions) at Westermakelsdorf in autumn 2010.

4.2 Bat activity in relation to meteorological parameters

The following Chapters 4.2.1-4.2.3 will present the results of the analyses of the detected bat activity during the radar vessel survey in regard to the weather data provided by the weather station Westermarkelsdorf. The weather station is about 18.5 km (AP 5) – 25.5 km (AP 8) away from the different vessel's anchor positions, which means that the weather conditions may differ from the measured data in Westermakelsdorf.

4.2.1 Wind speed

Figure 4-4 shows that bat activity mostly occurred offshore at wind speeds below 7 m/s with the highest counts during wind speeds below 6.5 m/s. The highest activity occurred at 6.5 m/s. One contact was registered during one night with an averaged wind speed of approximately 9 m/s.

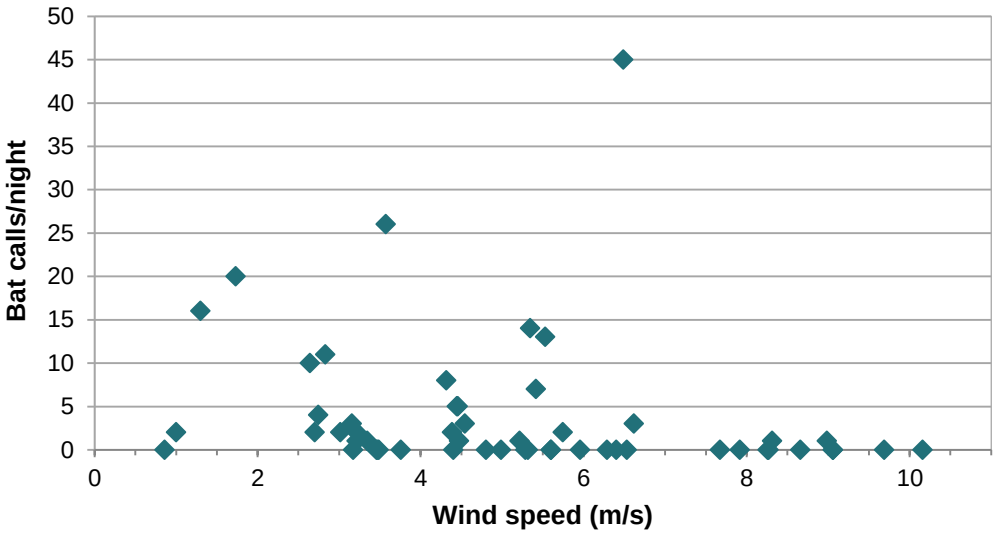


Figure 4-4 Distribution of bat activity in regard to wind speed in m/s; number of bat calls n = 211.

4.2.2 Bat activity in regard to precipitation

The bat activity dropped to nearly zero when the nights were rainy. The highest activity was recorded during nights with no or nearly no precipitation (Figure 4-5). During the survey three contacts were registered during nights with a precipitation above 1 mm.

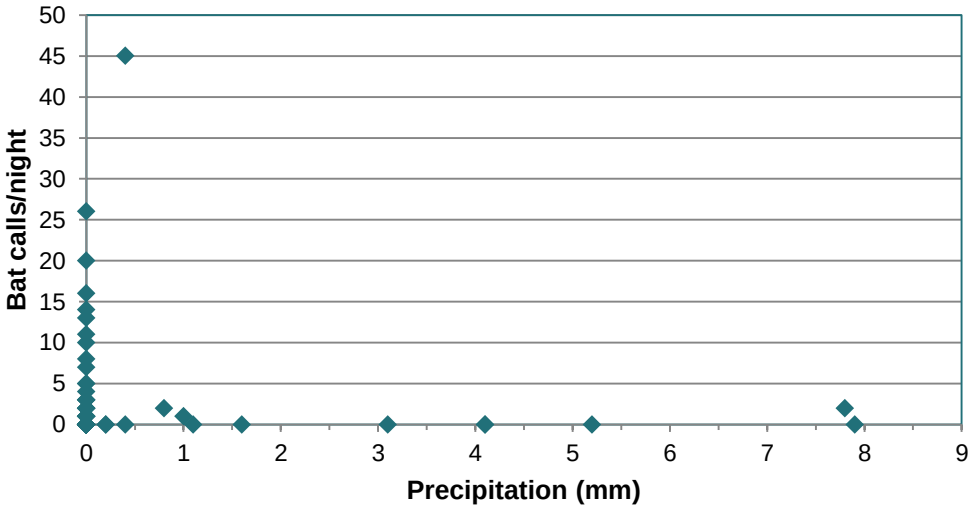


Figure 4-5 Distribution of bat activity in regard to precipitation in mm; number of bat calls (n = 211)

4.2.3 Bat activity in regard to temperature

The highest bat activity (95% of all recorded bat calls) was registered during nights with a mean temperature above 10°C (Figure 4-6). Three contacts were registered during one night with a mean temperature of 5.5 °C.

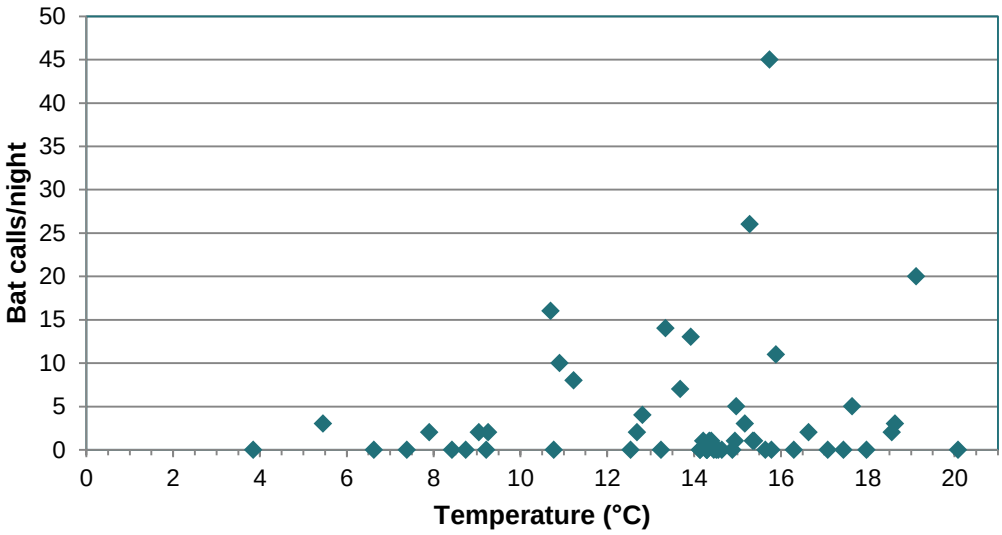


Figure 4-6 Distribution of bat activity in regard to temperature in °C; number of bat calls n = 211.

4.3 Bat data

All recorded bat calls were analysed using current identification literature (Skiba 2009; Dietz et al. 2007). In some cases, particularly the AnaBat-files, it was not possible to come to a clear identification. All AnaBat-files were analysed with the added AnaLook software. Calls recorded by the Pettersson 240x were analysed using the BatSound 4 software. The analysis was made on a call layer, which does not represent the number of individual bats.

Expected species inventory

Based on other studies and a consultation with the "Arbeitsgemeinschaft Fledermausschutz in Schleswig-Holstein" (AGF), Matthias Göttsche, an expected species inventory list for Fehmarn was deduced. The results of this consultation are shown in Table 4-1.

Table 4-1 List of expected species inventory at Fehmarn by (AGF).

Species	Scientific classification	Status
Brown long-eared Bat	*Plecotus auritus*	verified
Serotine	*Eptesicus serotinus*	verified
Noctule	*Nyctalus noctula*	verified
Leisler´s Bat	*Nyctalus leisleri*	verified
Parti-coloured Bat	*Vespertilio murinus*	verified
Nathusius' Pipistrelle	*Pipistrellus nathusii*	verified
Common Pipistrelle	*Pipistrellus pipistrellus*	verified
Soprano Pipistrelle	*Pipistrellus pygmaeus*	verified
Natterer's Bat	*Myotis natteri*	supposed
Pond Bat	*Myotis dasycneme*	verified during migration across the Fehmarnbelt
Daubenton's bat	*Myotis daubentonii*	verified

Protection status
The protection status and the abbreviations used during analyses of the registered species are shown in Table 4-2.

Table 4-2 Species abbreviations and protection status of registered bats according to the EU Habitat Directive.

Species	Scientific classification	Abbreviation.	Annex II (FFH)	Annex IV (FFH)
Barbastelle	*Barbastella barbastellus*	Bbar	+	+
Serotine	*Eptesicus serotinus*	Eser	-	+
Noctule	*Nyctalus noctula*	Nnoc	-	+
Leisler´s Bat	*Nyctalus leisleri*	Nlei	-	+
Parti-coloured Bat	*Vespertilio murinus*	Vmur	-	+
Nathusius' Pipistrelle	*Pipistrellus nathusii*	Pnat	-	+
Common Pipistrelle	*Pipistrellus pipistrellus*	Ppip	-	+
Soprano Pipistrelle	*Pipistrellus pygmaeus*	Ppyg	-	+
Pond Bat	*Myotis dasycneme*	Mdas	+	+
Daubenton's Bat	*Myotis daubentonii*	Mdau	-	+
Genera/ group classification				
Nnoc, Nlei, Eser, Enil, Vmur		NYC		
Pnat, Ppip, Ppyg		Pspec.		
Indeterminable *Myotis* call		MYO		
Indeterminable bat call		Chiro.		

4.4 Radar vessel

During the whole survey in 2009 and 2010 a total of 214 bat calls from six bat species (Figure 4-7) could be recorded on board the radar vessel in the Fehmarnbelt. 93% of all recorded calls could be determined to species level showing a precise picture of the bat fauna in the Fehmarnbelt. The most recorded bat species was Nathusius' Pipistrelle accounting for 63% of all bat calls recorded. This was followed by the Soprano Pipistrelle with 17% of all calls. Common Pipistrelle was recorded four times. Ten bat calls could only be identified to a genus level and must be labelled as "Pspec". Pond Bat was recorded once and three calls of Serotine could be recorded during the survey. The Noctule could be recorded 12 times, while there were ten indefinable "NYC" calls. Several sightings of *Pipistrellus* species (48) and *Nyctalus* species (7) could be made using a strong flashlight showing the bats flying into the supposed migration direction. The *Pipistrellus* species were generally seen flying about 2-5 m above the sea level. The *Nyctalus* species normally used higher altitudes between 15-25 m or even higher. The bat contacts were usually very short (10 sec) which means that the bats just passed the vessel. Sometimes they circled the vessel before flying into a certain direction mostly into the supposed migration direction. Three times a Nathusius' Pipistrelle and once a Noctule were observed feeding or hunting around the ship.

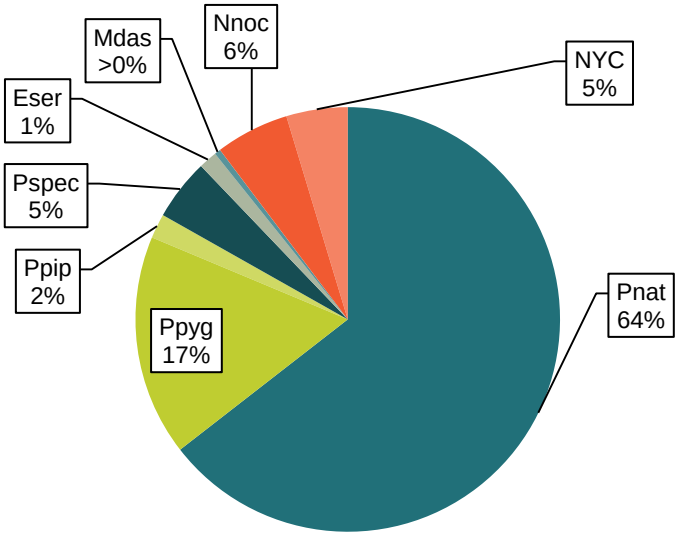


Figure 4-7 Species composition Fehmarnbelt (AP5 + AP8) in 2009 and 2010; n = 214.

4.4.1 Species composition autumn 2009

In autumn 2009 163 bat calls could be recorded (Figure 4-8). The majority of calls (118) were recorded at the anchor position 8 "Hyllekrog". A number of 44 calls could be recorded at the anchor position 5 "Central". While six species and one group could be recorded at AP 8 just 5 species were recorded at AP 5. The percentage of the most frequent recognised species (Pnat, Ppyg, Nnoc) was nearly the same at both anchor positions. At anchor position 8 "Hyllekrog" one identification of the Pond Bat could be made.

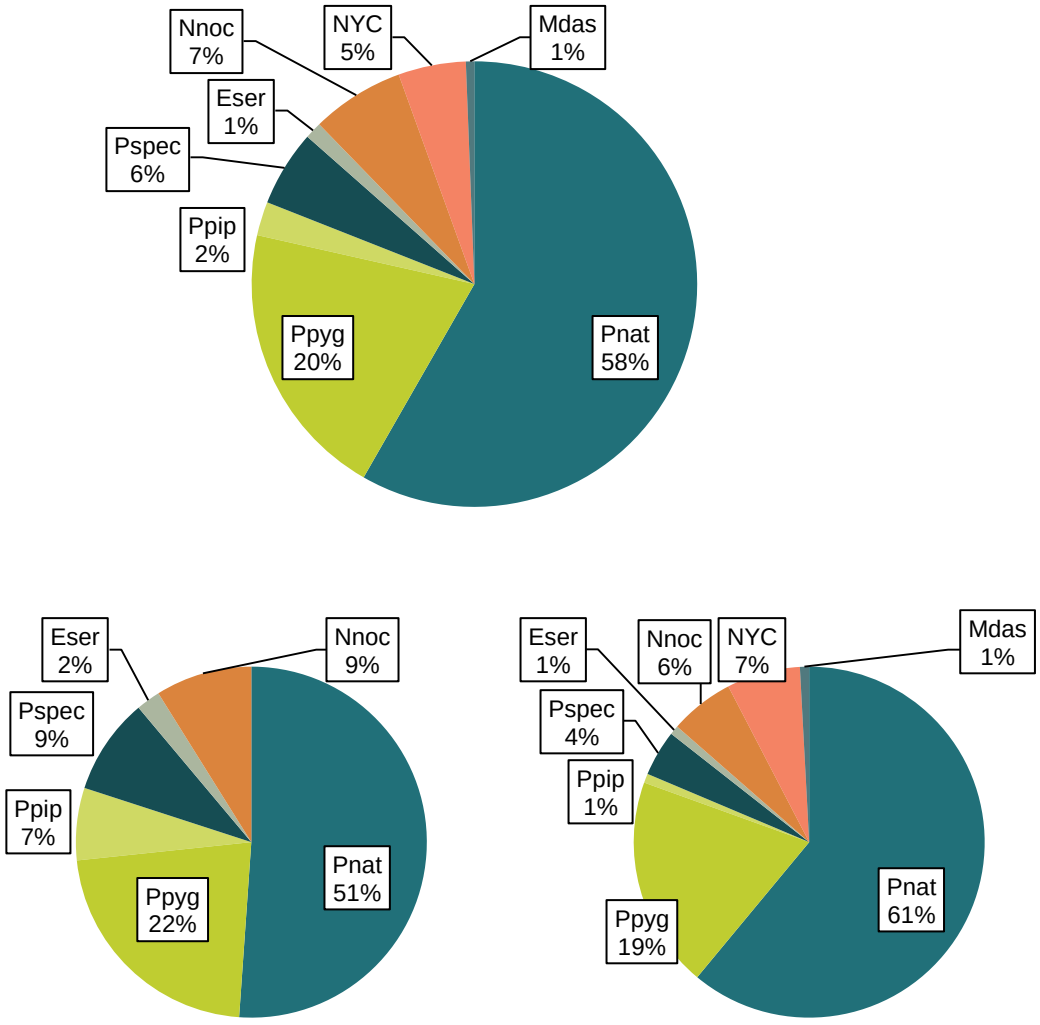


Figure 4-8 Species composition in the Fehmarnbelt AP 5 + AP 8 (top); n = 163, at AP 5 (bottom left); n = 45 and AP8 (bottom right); n = 118 in autumn 2009.

4.4.2 *Activity autumn 2009*

Pipistrellus genus

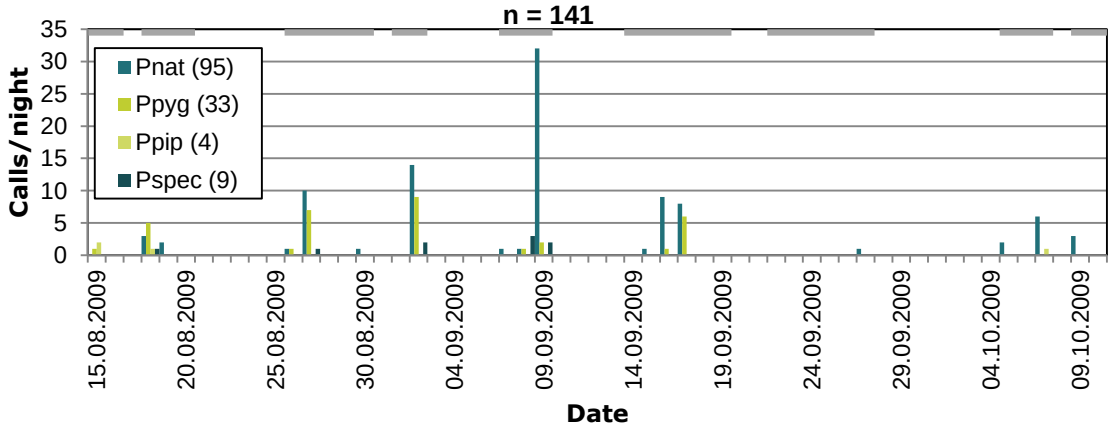


Figure 4-9 Activity of Pipistrellus species in autumn 2009 in the Fehmarnbelt. Recordings from both anchor positions (AP 5 + 8). Nights of observation are indicated in grey on the upper axis.

The Pipistrellus genus showed different activity peaks for every species (Figure 4-9). The activity of Nathusius' Pipistrelle peaked on the 9th of September. This species was recorded during the whole survey. The Soprano Pipistrelle's activity peaked September 2. This species was not registered from mid-September till the end of the survey. Because of a lack of registrations the Common Pipistrelle showed no recognisable peak. The following figures show the activity of the Pipistrellus genus divided into the different anchor positions AP 5 (Figure 4-10) and AP 8 (Figure 4-11).

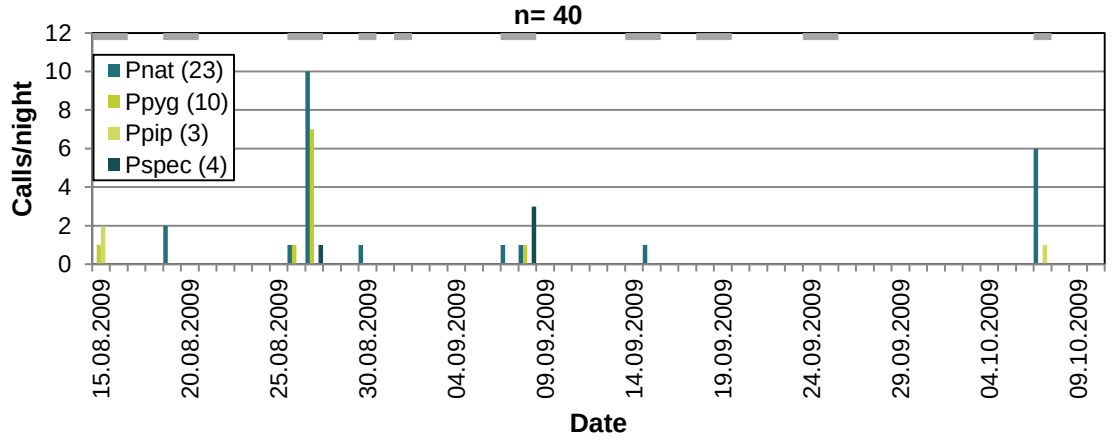


Figure 4-10 Activity Pipistrellus species autumn 2009 in the Fehmarnbelt. Recordings from anchor position AP 5. Nights of observation are indicated in grey on the upper axis.

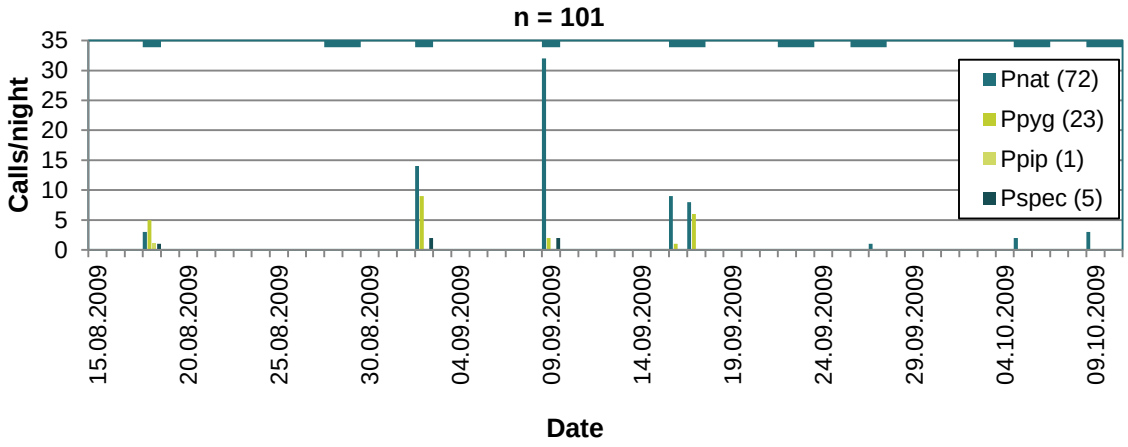


Figure 4-11 Activity Pipistrellus species autumn 2009 in the Fehmarnbelt. Recordings from anchor position AP 8. Nights of observation are indicated in grey on the upper axis.

Summary *Pipistrellus* genus

The Nathusius' Pipistrelle was registered the most at AP 8. From the last decade of September till the end of the first week of October this species was registered sporadically, which was caused by unsuitable weather conditions during this time (see Figure 4-1).

The Soprano Pipistrelle did not occur offshore anymore from the beginning of the third decade of September.

The Common Pipistrelle's activity was wide spread and showed no recognisable peak during the survey.

***Myotis-/Nyctalus-/Eptesicus* genera**

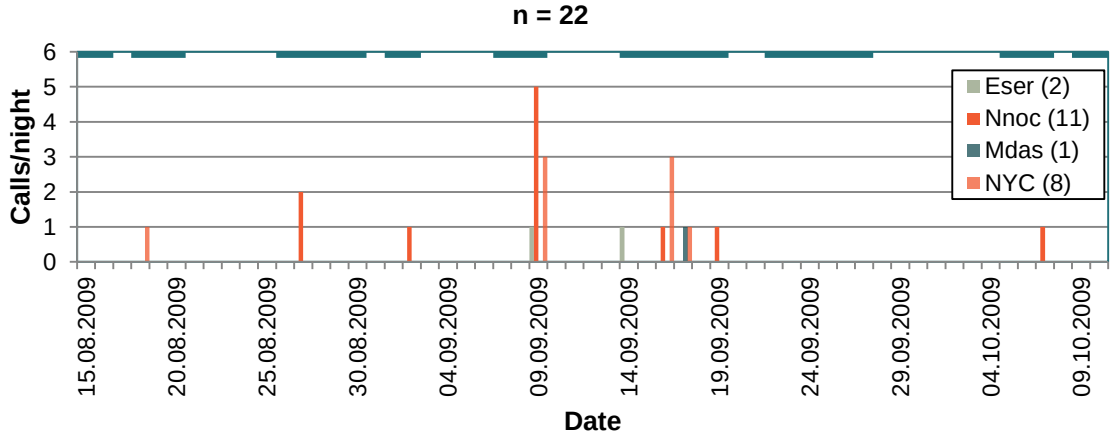


Figure 4-12 Activity Myotis-/Nyctalus-/Eptesicus species autumn 2009 in the Fehmarnbelt. Recordings from both anchor positions (AP 5 + 8). Nights of observation are indicated in grey on the upper axis.

The Noctule showed a peak of activity on September 9. The Serotine was first recorded during the second week of September and a second registration was made on September 14. The Pond Bat was detected on September 17. The following figure shows the activity of the Noctule, the Serotine, the "NYC" group and the Pond Bat at the different anchor positions AP 5 and AP 8 (Figure 4-13).

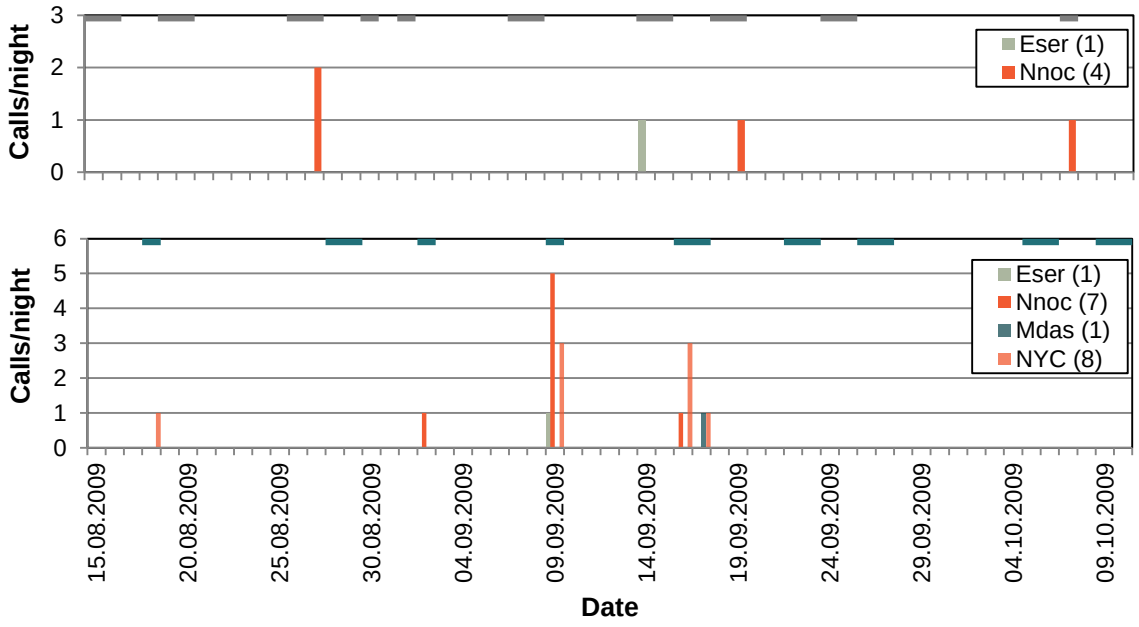


Figure 4-13 Activity of Myotis-/Nyctalus-/Eptesicus species in autumn 2009 in the Fehmarnbelt. Recordings from anchor position AP5 (top); n = 5 and AP8 (bottom); n = 17. Nights of observation are indicated in grey on the upper axis.

Summary *Myotis-/Nyctalus-/Eptesicus* genera
Most of the Noctule registrations were made at AP 8.

Activity of the Serotine was registered during the second week of September only.

The Pond Bat exclusively occurred in mid-October at AP 8.

4.4.3 Species composition spring 2010

Fehmarnbelt
In the Fehmarnbelt four bat calls could be recorded during eight nights of investigation. The Nathusius' Pipistrelle was recorded three times and additionally one indeterminable Pipistrellus call was recorded. Because of unsuitable weather conditions (see Figure 4-2) the activity was very scarce. That is why no charts will be shown for the spring time survey in the Fehmarnbelt.

Öresund

In spring 2010 23 bat calls from five species and one group have been recorded during ten nights of investigation in the Öresund (Figure 4-14). The Nathusius' Pipistrelle was the bat most recorded. The Leisler's Bat was recorded five times. The Soprano Pipistrelle and the Nyctalus-group were both registered three times. At least two recordings could be made of the Noctule and the Parti-coloured bat.

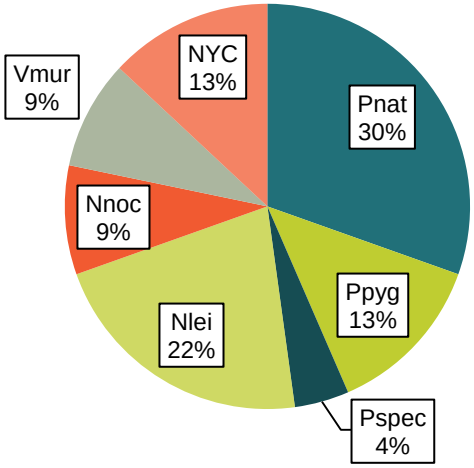


Figure 4-14 Species composition in Öresund in spring 2010; n = 23.

4.4.4 Activity spring 2010

Öresund

The Nathusius' Pipistrelle could be identified during both the investigative periods. Due to restrictions of the survey time a peak of activity could not be found. The Soprano Pipistrelle could be registered three times May 11. One call could only be allocated to the *Pipistrellus* group.

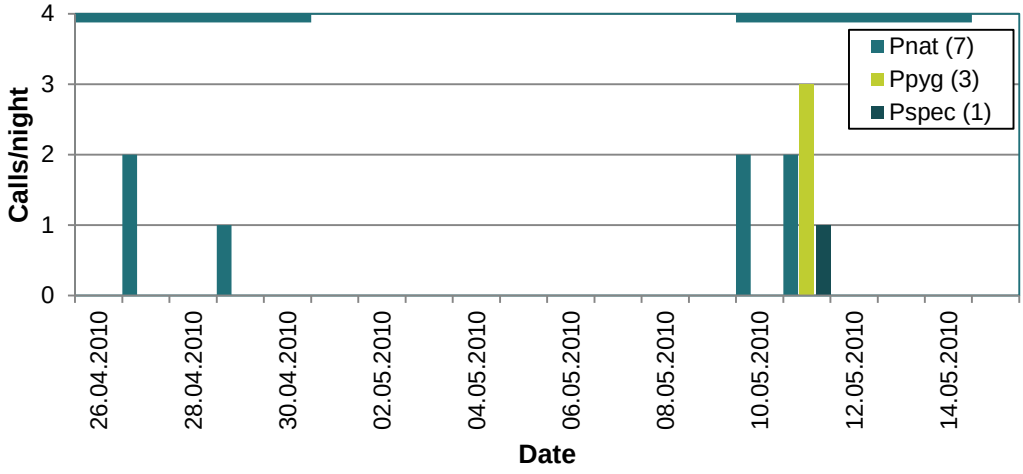


Figure 4-15 Activity of Pipistrellus species in spring 2010 in the Öresund. Recordings from different anchor positions and drifting intervals. Nights of observation are indicated in grey on the upper axis.

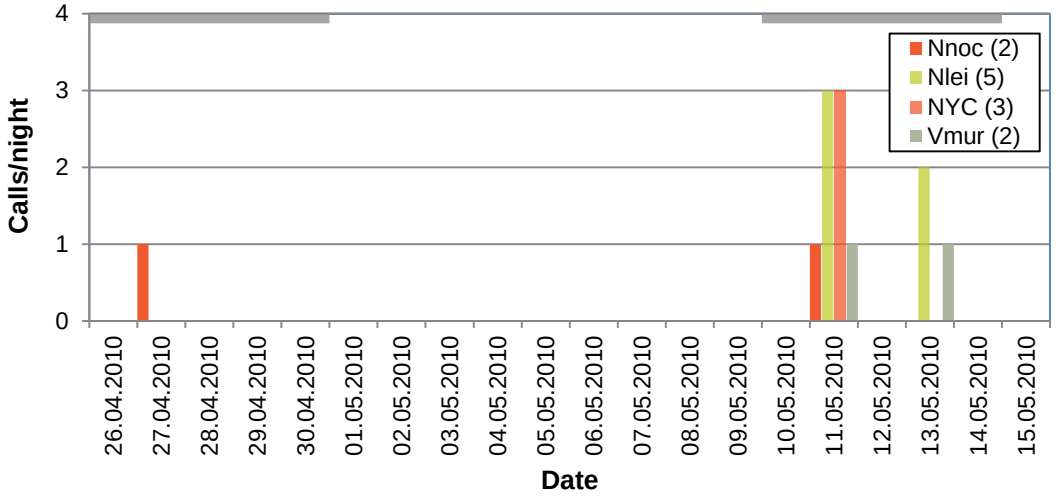


Figure 4-16 Activity of Nyctalus-, Vespertilio species spring 2010 in the Öresund. Recordings from different anchor positions and drifting intervals. Nights of observation are indicated in grey on the upper axis.

The Leisler's Bat's activity was registered just a few days before the mid of May. The Noctule was recorded during both surveys. Every survey registered one contact. The Parti-coloured Bat was detected during the survey the second week of May. Three bat calls were indeterminable and had to be labelled as "NYC".

4.4.5 Summer 2010

In summer 2010 two bat calls were recorded during eight nights of observation in the Fehmarnbelt. One call of Nathusius' Pipistrelle on June 23 and one NYC call on July 21 were registered. Because of the lack of activity no activity charts will be shown for the spring time survey in the Fehmarnbelt.

4.4.6 Species composition autumn 2010

In autumn 2010 45 bat calls were recorded at AP 5 "Central" during 14 nights of observation. Nathusius' Pipistrelle was recorded the most (39 calls). Three calls of Soprano Pipistrelle, one Noctule, one Serotine and one indeterminable NYC call were also recorded.

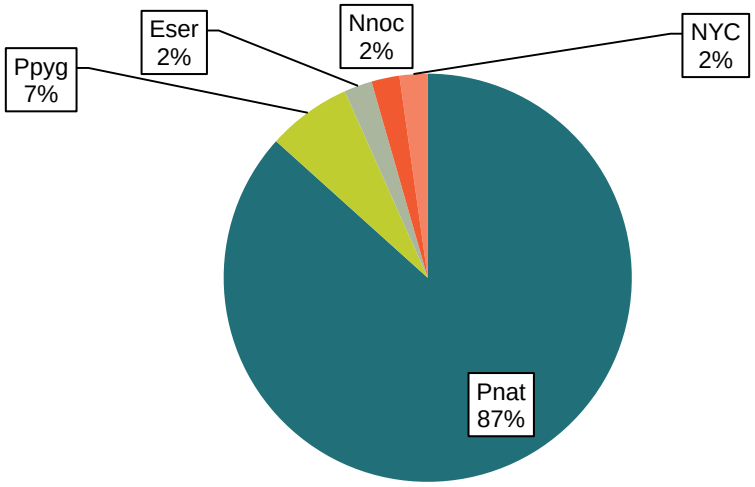


Figure 4-17 Species composition at AP 5 in autumn 2010; n = 45.

4.4.7 Activity autumn 2010

Pipistrellus genus

In autumn Nathusius' Pipistrelle was first registered early September. A survey in August did not register any activity of this species. The latest contact was recorded on October 13. There were two days, September 2 and September 21, when the activity increases up to 10 calls per night. The Soprano Pipistrelle was registered early September exclusively.

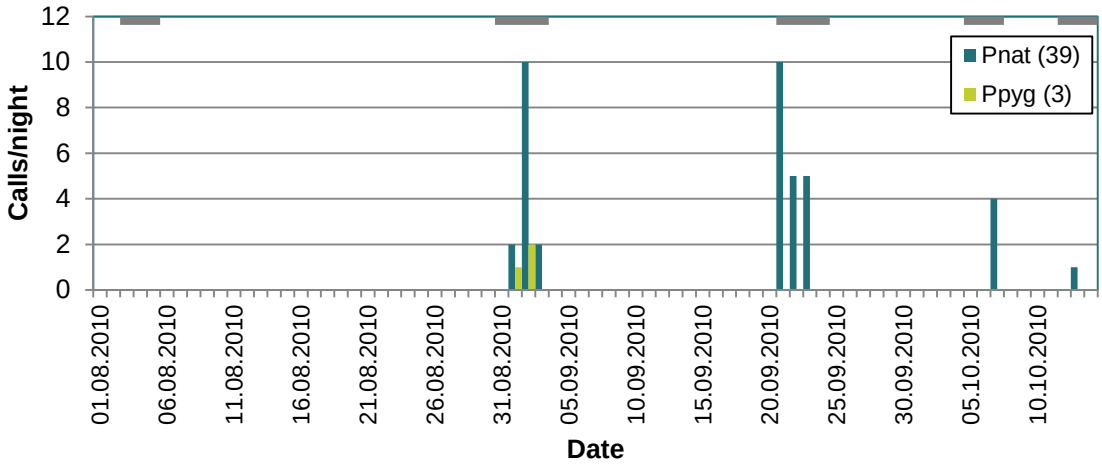


Figure 4-18 Activity Pipistrellus species autumn 2010 in the Fehmarnbelt. Recordings from anchor position 5. Nights of observation are indicated in grey on the upper axis.

***Nyctalus*- and *Eptesicus*- genera**

In autumn 2010 three registrations of the *Nyctalus*- and *Eptesicus* genera were made. The Noctule and the Serotine were both recorded once during the night of September 22. Additionally, one contact of the NYC-group was recorded on September 2.

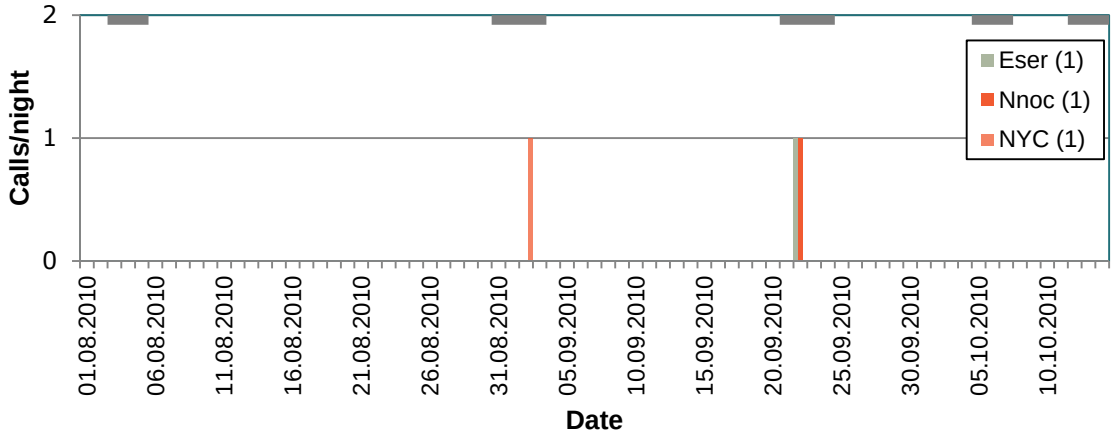


Figure 4-19 Activity of the Nyctalus-/Eptesicus species in autumn 2010 in the Fehmarnbelt. Recordings from AP 5. Nights of observation are indicated in grey on the upper axis.

4.5 Personal survey

During 29 nights of personal survey in 2009 and 2010 1,003 bat calls of nine species and two groups could be recorded. 83% of all recorded calls could be determined to species level showing a precise picture of the shore sided bat fauna. The majority of undetermined calls belong to the *Pipistrellus* genus, furthermore clarifying that no relevant species were missed during the survey. The tables below show how many contacts of which species could be registered during the survey at different sample areas. The tables present the accumulated results of the Pettersson 240x and the AnaBat SD1 detectors which were in use during the personal survey. The personal observation allowed distinguishing between migrating and hunting behaviour. These observations were also added in Table 4-3 - Table 4-12 (see comments). The following abbreviations were used in this Chapter: ind.=Individual/s; transfer=directional flight into a certain direction; NE=north-east etc.

4.5.1 Autumn 2009

Table 4-3 Personal survey at Katharinenhof in autumn 2009 (n = 235).

Date	Pnat	Ppyg	Ppip	Pspec	Nnoc	Comments
13.08.	6	24	54	30	-	1 ind. Pnat mating/ several ind. Ppip hunting/ several ind. Ppyg hunting + 5 ind. transfer
23.08.	-	-	-	-	-	-
25.08.	3	3	1	-	-	1 ind. Pnat mating/2 ind. Ppyg transfer
02.09.	1	3	1	-	-	1 ind. Pnat mating/ 2 ind. Ppyg transfer
11.09.	1	1	3	-	1	1 ind. Pnat mating/ 1 ind. Ppyg transfer/ Nnoc transfer
21.09.	7	8	82	6	-	Several ind. Ppip hunting/ 5 ind. Pnat SE/ 3 ind. Ppyg S
11.10.	-	-	-	-	-	Abort>>Rain
Total	18	39	141	36	1	

Data from the personal survey near Katharinenhof are presented in Table 4-3.

Table 4-4 Personal survey at Grüner Brink in autumn 2009 (n = 10).

Date	Pnat	Ppip	Pspec	Eser	Comments
13.08.	-	-	1	-	-
23.08.	1	-	-	-	1 ind. Pnat SW
25.08.	-	2	-	-	hunting
02.09.	-	-	-	2	transfer
20.09.	-	2	-	-	hunting
21.09.	-	2	-	-	hunting
Total	1	6	1	2	

Data from the personal survey at the Grüner Brink are presented in Table 4-4.

Table 4-5 Personal survey at camping ground in autumn 2009 (n = 47).

Date	Pnat	Ppyg	Ppip	Pspec	Nnoc	Comments
13.08.	-	-	-	-	-	
23.08.	-	-	-	1	-	
25.08.	3	2	-	-	1	1 ind. Pnat S/ 2 ind. Ppyg transfer
02.09.	2	2	3	-	-	All ind. SE
11.09.	4	12	2	-	1	9 ind. Ppyg+2 ind. Pnat SE/ 1 ind. Pnat hunting/ 1 ind. Nnoc transfer
21.09.	2	9	-	-	-	5 ind. Ppyg S/ 1 ind. Pnat S
29.09.	-	-	-	-	-	Abort >>Rain
11.10.	2	1	-	-	-	1 ind. Pnat hunting/ 1 ind. Pnat S
Total	13	26	5	1	2	

Data from the personal survey near the camping ground are presented in Table 4-5.

Table 4-6 Personal survey at Rødbyhavn (west) in autumn 2009 (n = 24).

Date	Pnat	Ppyg	Nnoc	NYC	MYO	Comments
14.08.	2	1	-	-	-	2 ind. Pnat S/ 1 ind. Ppyg S
31.08.	1	7	5	-	2	3 ind. Ppyg transfer + 2 ind. Ppyg S/ 1 ind. Pnat S/ 3 ind. Nnoc transfer
10.09.	2	-	1	1	-	1 ind. Pnat S/ 1 ind. Nnoc transfer
20.09.	-	2	-	-	-	2 ind. Ppyg transfer
Total	5	10	6	1	2	

Data from the personal survey at Rødbyhavn (west) are presented in Table 4-6.

Table 4-7 Personal survey at Hyllekrog in autumn 2009 (n = 171).

Date	Pnat	Ppyg	Ppip	Pspec	Nnoc	NYC	MYO	Eser	Comments
22.08.	9	28	2	9	2	2	-	11	Several ind. Ppyg hunting + 3 ind. Ppyg S/ 5 ind. Pnat SW/ 2 ind. Eser hunting/ 2 ind. Nnoc transfer
31.08.	3	9	2	-	-	-	1	-	1 ind. Pnat S/ 3 ind. Ppyg S
10.09.	7	37	7	-	1	1	-	-	Several ind. Ppyg hunting + 4 ind. Ppyg S/ 3 ind. Pnat S/ 1 ind. Nnoc transfer
20.09.	3	36	-	-	-	1	-	-	Several ind. Ppyg hunting + 2 ind. Ppyg S/ 1 ind. Pnat S
Total	22	110	11	9	3	4	1	11	

Data from the personal survey at Hyllekrog are presented in Table 4-7.

4.5.2 Spring 2010

Table 4-8 Personal survey at Wallnau in spring 2010 (n = 11).

Date	Pnat	Ppip	Nnoc	NYC	Eser	Comments
28.04.	5	1	3	1	1	2 ind. Pnat NE/ 2 ind. Nnoc hunting
Total	5	1	3	1	1	

Data from the personal survey at Wallnau are presented in Table 4-8.

Table 4-9 Personal survey at the Mole (Puttgarden) in spring 2010 (n = 39).

Date	Pnat	Ppyg	Pspec	Nlei	NYC	Comments
19.05.	14	-	1	-	1	9 ind. Pnat NE
22.05.	13	1	-	-	-	5 ind. Pnat NE
02.06.	8	-	-	1	-	3 ind. Pnat NE/ 1 ind. Nlei NE
03.06.	-	-	-	-	-	
Total	35	1	1	1	1	

Data from the personal survey at the Mole (Puttgarden) are presented in Table 4-9.

Table 4-10 Personal survey at Westermarkelsdorf in spring 2010 (n = 18).

Date	Pnat	Pspec	Nnoc	Comments
28.04.	1	1	-	
29.04.	15	-	1	10 ind.Pnat NE/ 1 ind. Nnoc transfer
09.05.	-	-	-	
Total	16	1	1	

Data from the personal survey at Westermarkelsdorf are presented in Table 4-10.

4.5.3 Autumn 2010

Table 4-11 Personal survey at Hyllekrog in autumn 2010 (n = 394).

Date	Pnat	Ppyg	Ppip	Pspec	Nnoc	NYC	Mdau	MYO	Bbar	Vmur	Eser	Comments
11.08.	55	145	15	49	39	9	1	34	-	-	1	Several ind. Ppyg hunting +5 ind. Ppyg S/ 9 ind. Pnat S/ several Nnoc hunting/ 1 ind. Eser transfer
19.08.	3	6	-	2	-	-	-	-	-	-	-	1 ind. Pnat S/ 3 ind. Ppyg S
13.09.	4	1	-	-	-	-	-	-	-	-	-	"2 ind. Pnat S
11.10.	7	13	-	6	-	-	-	-	3	1	-	3 ind. Pnat S/ 4 ind. Ppyg S
Total	69	165	15	57	39	9	1	34	3	1	1	

Data from the personal survey at Hyllekrog are presented in Table 4-11.

Table 4-12 Personal survey at Rødbyhavn (west) during autumn 2010 (n = 38).

Date	Pnat	Ppyg	Pspec	Nnoc	NYC	Mdau	MYO	Comments
04.09.	9	3	2	8	-	3	-	5 ind. Pnat S/ 3 ind. Nnoc S
29.09.	2	1	-	1	2	-	-	1 ind. Pnat S/ 1 ind. Ppyg transfer/ 1 ind. Nnoc transfer
30.09.	2	1	-	-	-	-	-	1 ind. Pnat S
01.10.	1	-	-	-	-	-	-	1 ind. Pnat S
11.10.	-	-	-	-	-	-	3	AnaBat in Rødbyhavn
Total	14	5	2	9	2	3	3	

Data from the personal survey at Rødbyhavn (west) are presented in Table 4-12.

Table 4-13 Personal survey at Rødbyhavn (quay wall) during autumn 2010 (n = 16).

Date	Pnat	Ppyg	Pspec	Nnoc	Mdau	MYO	Eser	Comments
05.09.	2	1	2	6	3	1	1	2 ind. Pnat S/ 2 ind. Nnoc S
Total	2	1	2	6	3	1	1	

Data from the personal survey at Rødbyhavn (west) are presented in Table 4-13.

Table 4-14 Personal survey all stations (n = 1,003).

Species / Site	Pnat	Ppyg	Ppip	Pspec	Eser	Nnoc	Nlei	NYC	MYO	Mdau	Vmur	Bbar	Total
Katharinenhof 2009	18	39	141	36	-	1	-	-	-	-	-	-	235
Grüner Brink 2009	1	-	6	1	2	-	-	-	-	-	-	-	10
Camping ground 2009	13	26	5	1	-	2	-	-	-	-	-	-	47
Rødbyhavn (west) 2009	5	10	-	-	-	6	-	1	2	-	-	-	24
Hyllekrog 2009	22	110	11	9	11	3	-	4	1	-	-	-	171
Wallnau 2010	5	-	1	-	1	3	-	1	-	-	-	-	11
Mole (Puttgarden) 2010	35	1	-	1	-	-	1	1	-	-	-	-	39
Westermarkels-dorf 2010	16	-	-	1	-	1	-	-	-	-	-	-	18
Hyllekrog 2010	69	165	15	57	1	39	-	9	34	1	1	3	394
Rødbyhavn (west) 2010	14	5	-	2	-	9	-	2	3	3	-	-	38
Rødbyhavn (Quay wall) 2010	2	1	-	2	1	6	-	-	1	3	-	-	16
Total	200	357	179	110	16	70	1	18	41	7	1	3	1,003

4.6 Scandlines ferry

Species composition
Overall 62 bat calls from four different species and three groups (Figure 4-20) were recorded by the AnaBats fixed on the Scandlines ferries "Deutschland" and "Schleswig Holstein". The majority of the recorded bat calls (36) cannot be identified to species level and must be labelled as "NYC". Six calls could be identified as Noctule. The dominant *Pipistrellus* species was the Nathusius' Pipistrelle (19 recordings) followed by one Soprano Pipistrelle and one Common Pipistrelle. Also one call of the *Myotis* genus could be recorded.

It can be pointed out that the number of recorded bats did not reach the level which was recorded at the radar vessel. Nevertheless, this method proved the occurrence of bats in the Fehmarnbelt.

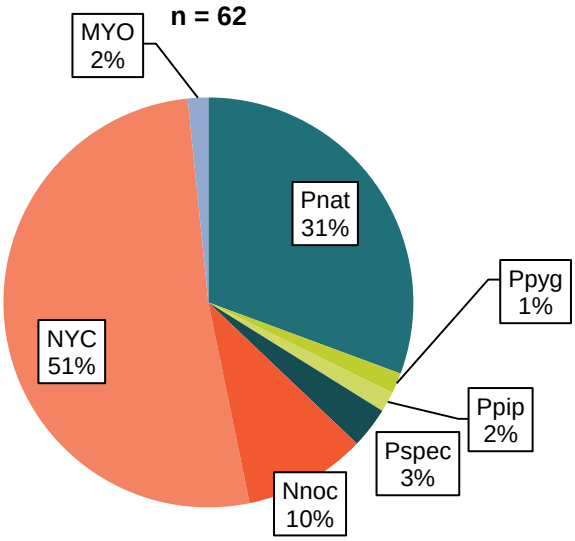


Figure 4-20 Species composition on Scandlines ferries 2009 and 2010.

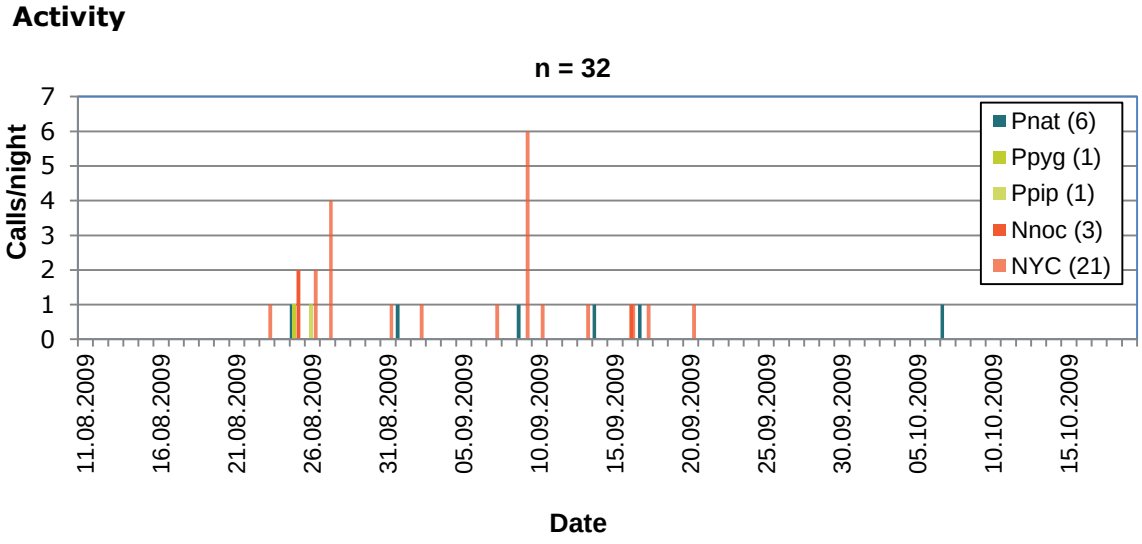


Figure 4-21 Activity of recorded bats along the ferry route between Rødbyhavn and Puttgarden during autumn 2009.

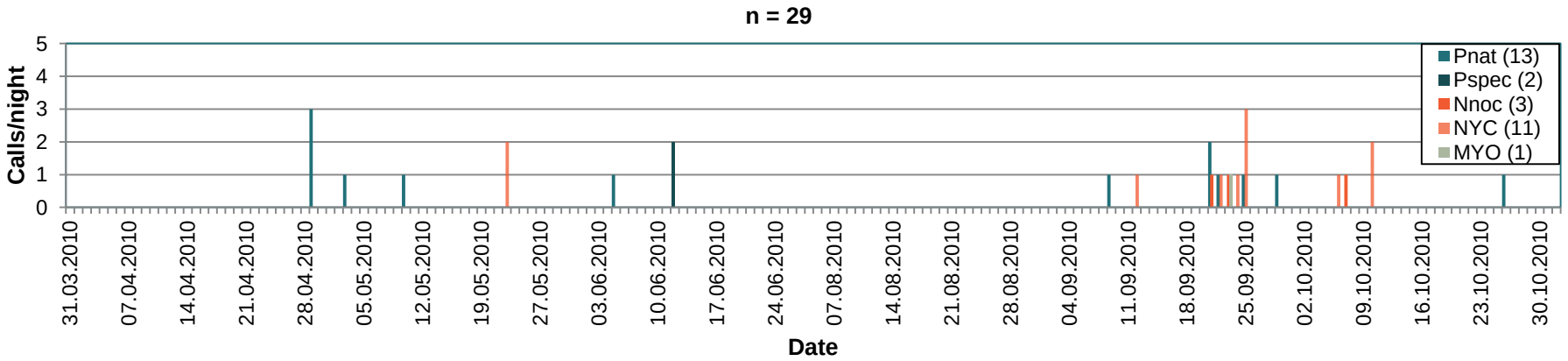


Figure 4-22 Activity of recorded bats along the ferry routes between Rødbyhavn and Puttgarden during 2010.

During the autumn bats recorded on the ferries occurred over a long period of time from the third decade of August till the beginning of October in 2009. In autumn 2010 the activity lasted from the first week of September till the end of October. During spring the first bats were recorded at the end of April and then occasionally until June. But it turned out that the majority of bats occurred in the autumn (Figure 4-21 and Figure 4-22).

Allocations of bat calls
The calls were recorded wide spread over the navigation route between Rødbyhavn and Puttgarden (see Figure 4-23).

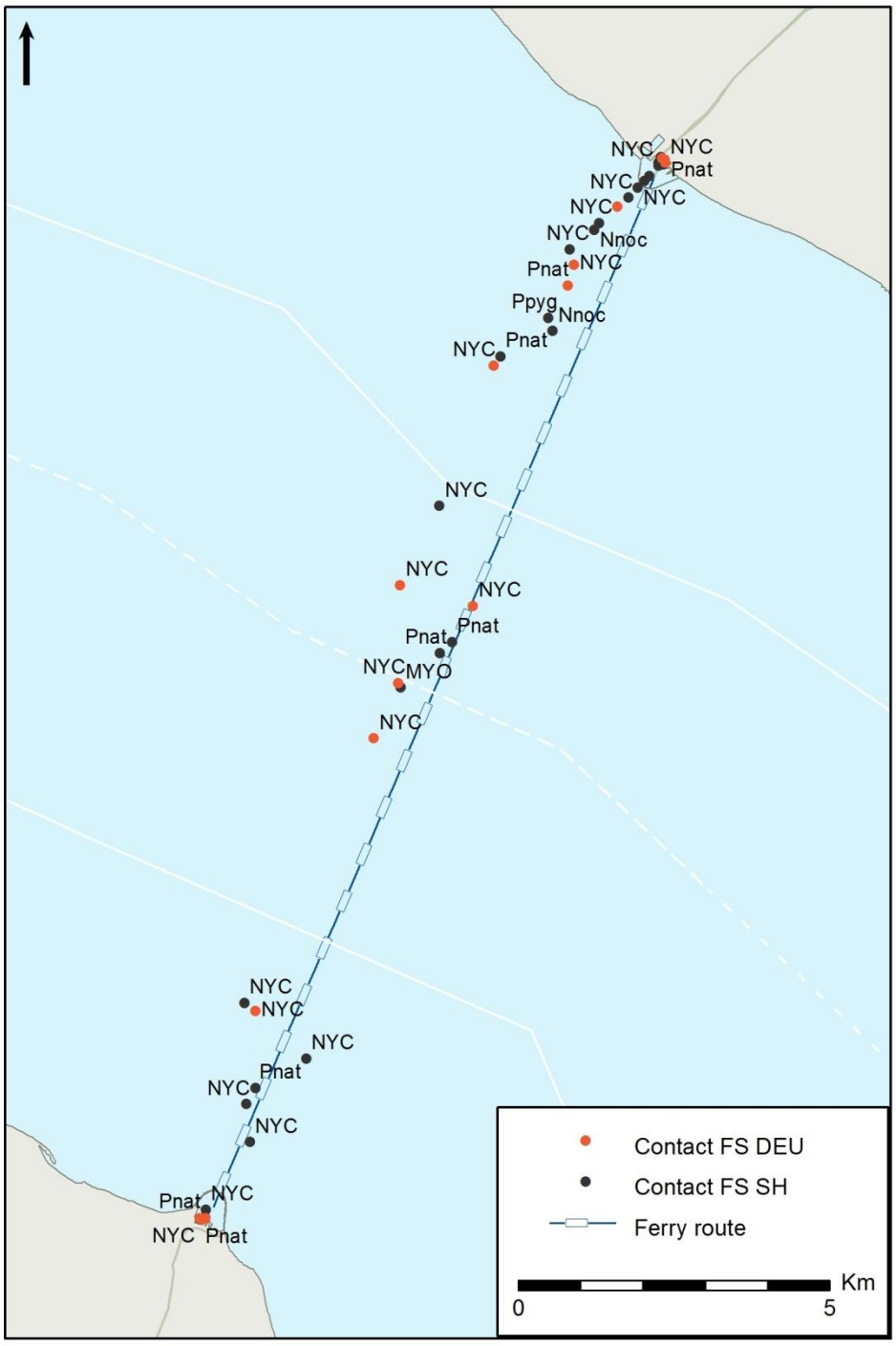


Figure 4-23 Bat contacts recorded by AnaBats installed at the Scandlines ferries in 2009 and 2010. Illustrations of all bat contacts recorded by the AnaBats installed on the ferries "Schleswig Holstein" and "Deutschland". Additionally the abbreviations of the registered species are applied.

4.7 Kite

During four nights the AnaBat was raised by a kite from the radar vessel. Two Noctules could be recorded. The recordings were made on September 19, 2009 and

October 7, 2009. The kite was raised once from the Danish mainland at Hyllekrog and recorded three Noctules and one indeterminable "NYC"-call. It can be pointed out that solely bats of the *Nyctalus* genus were recorded by this method. (Figure 4-24).

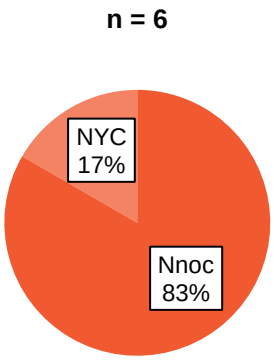


Figure 4-24 Species composition AnaBat raised with kite.

4.8 Bat box examination

The bat boxes where checked 23 times during the supposed migration periods during autumn 2009 and spring and autumn 2010, but the examination yielded no results. The bat boxes were always empty and showed no evidence of bat activity.

4.9 Stationary AnaBat sites

The results from the stationary AnaBat sites are summarised in Table 4-15. 87% of all recorded bat calls could be determined to species level. Showing a clear picture of shore sided bat fauna. Some of the AnaBat sites differ significantly in the number of recorded calls per night and also in species composition. There were sites which recorded only a hundred calls while at other sites thousands of calls were recorded during the same time interval.

Table 4-15 Summarised results from the different stationary AnaBat sites. The number of field nights is attached to the site in brackets.

Species/ Site	Pnat	Ppip	Ppyg	Pspec	Eser	Nnoc	Nlei	NYC	MYO	Bbar	Chiro	Total
Hyllekrog (160)	20,348	2,467	27,288	6,944	-	1,473	1	573	1,475	33	117	60,719
Gedser (70)	716	8,334	210	143	-	-	-	24	8	-	-	9,435
Grüner Brink (270)	1,135	142	38	230	1	29	-	538	15	-	8	2,136
Wald-pavillon (120)	9,288	7,040	8,596	2,843	1	20	4	57	7	-	3	27,859
Jimi Hendrix Memorial (209)	1,307	74	84	160	-	56	-	428	18	-	13	2,140
Rødbyhavn (75)	150	3	16	8	-	36	-	25	1	-	4	243
Total	32,232	18,060	36,232	10,328	2	1,614	5	1,645	1,524	33	145	102,532

4.10 Activity of migratory bats

The activity of the two bat species (Nathusius' Pipistrelle, Noctule) that are known to be migratory is shown in diagrams, which include one migration period starting with autumn 2009 followed by spring and autumn 2010 at the different AnaBat sites. Additionally the phenological activity of the Soprano Pipistrelle will be shown. It is not absolutely clarified whether these species are migratory. The data for some species (e.g. Pond Bat, Serotine and Common Pipistrelle) were scarce which caused that the activity of these species could not be illustrated.

The number of bat calls recorded per night will be shown for the before appointed species. Some sites are presented combined into one diagram. All diagrams cover the same time span on the horizontal axis to allow for comparison, although some detectors may have been in operation a few days longer or shorter than presented in the bar charts (for exact survey intervals see chapter 3.5). The vertical axis is scaled different in each diagram.

4.11 Nathusius' Pipistrelle

The diagrams below show the Nathusius' Pipistrelle calls recorded at the different sites on Lolland, Fehmarn and in the Fehmarnbelt (Figure 4-25 – Figure 4-35).

4.11.1 Autumn 2009

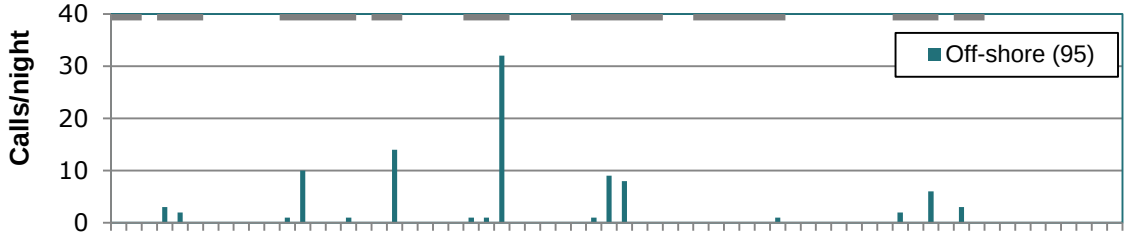


Figure 4-25 Activity of Nathusius` Pipistrelle in autumn 2009 in the Fehmarnbelt. Recordings from both anchor positions (AP 5 + 8). Nights of observation are indicated in grey on the upper axis.

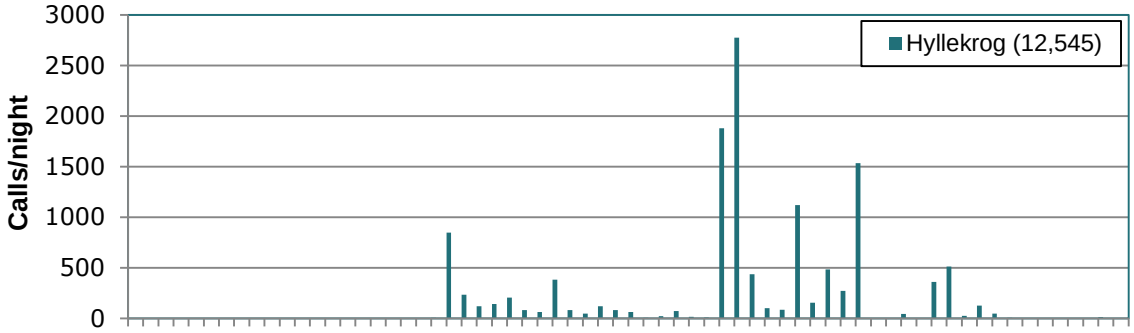


Figure 4-26 Activity of Nathusius` Pipistrelle in autumn 2009 from Hyllekrog.

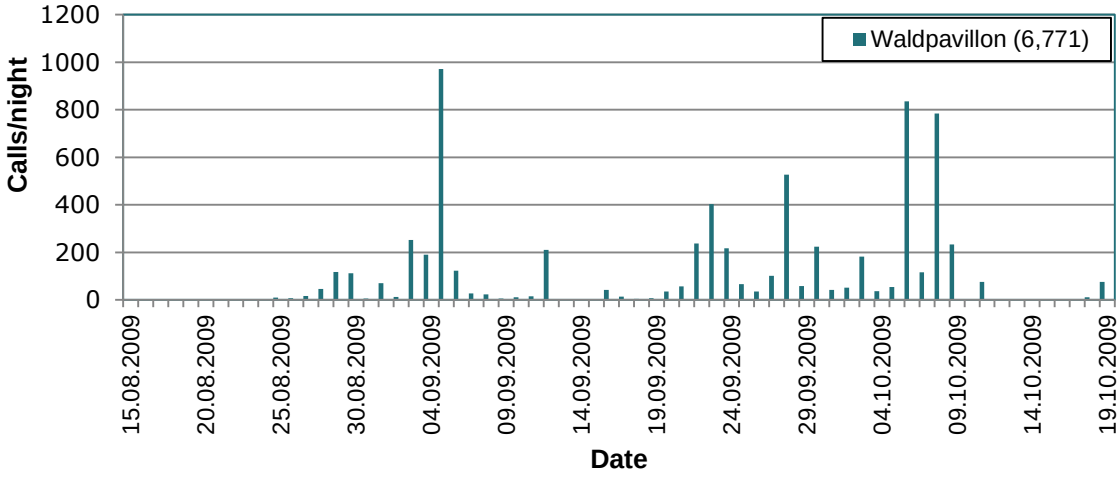


Figure 4-27 Activity of Nathusius` Pipistrelle in autumn 2009 from Waldpavillon.

In the Fehmarnbelt the recorded peak of activity was recorded September 9 (Figure 4-25). The development of the activity registered increases continuously until the peak followed by a drawn-out decrease.

At Hyllekrog the first peak was registered in the beginning of September, the second was recorded from the end of September until October 2. The last call was recorded October 11 (Figure 4-26).

At Waldpavillon two periods of high activity were found, the first during the night of September 5 and the second at the end of the first September week (Figure 4-27).

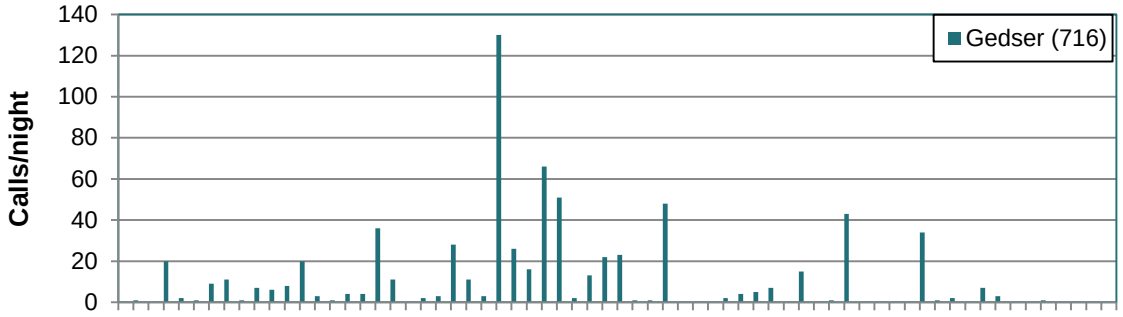


Figure 4-28 Activity of Nathusius` Pipistrelle in autumn 2009 from Gedser.

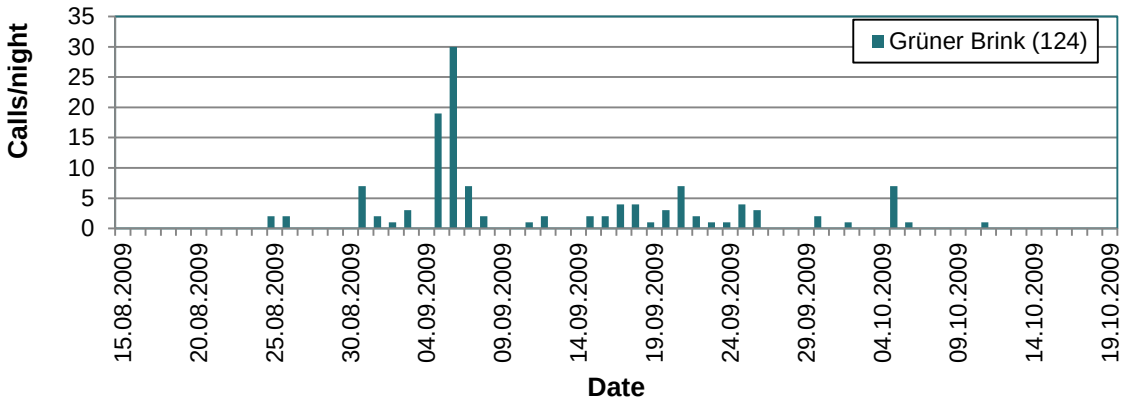


Figure 4-29 Activity of Nathusius` Pipistrelle in autumn 2009 from Grüner Brink.

In Gedser the activity was the highest around September 9 (Figure 4-28). From mid-August the activity continuously increased till the peak and thereafter slowly decreased until mid-October. Highest activity at Grüner Brink (Figure 4-29) was reached during the night of September 6. The Nathusius' Pipistrelle could be registered regularly in low numbers until the end of the first decade of October.

4.11.2 Spring 2010

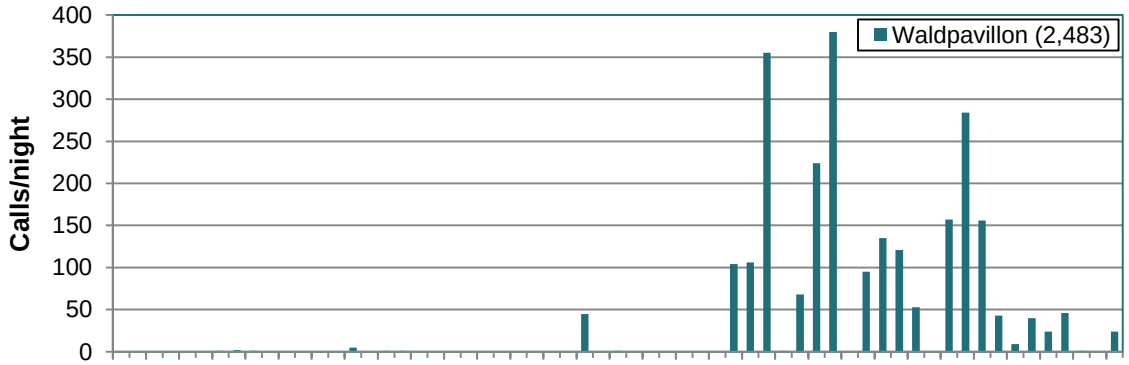


Figure 4-30 Activity of Nathusius` Pipistrelle spring 2010 from Waldpavillon.

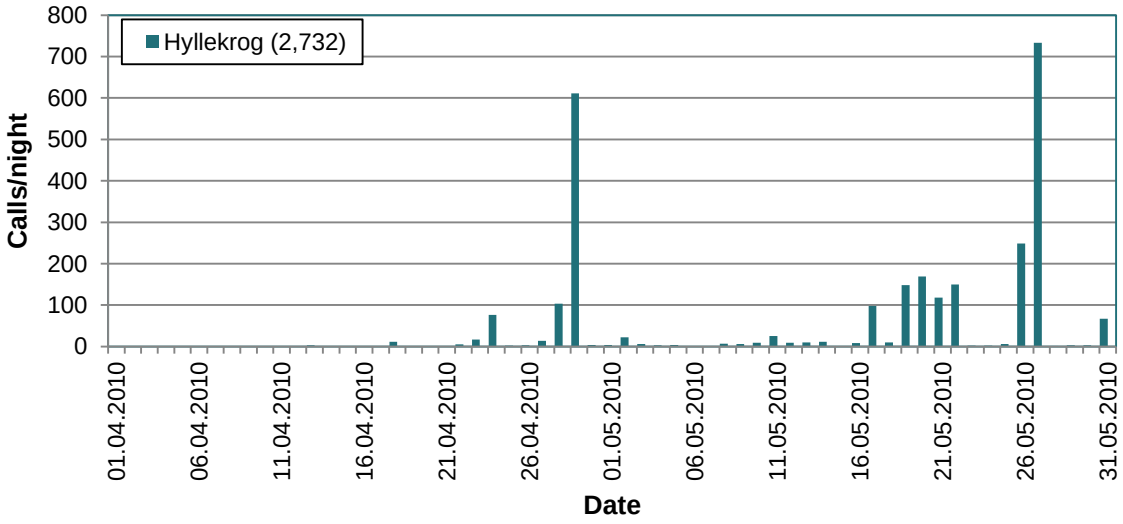


Figure 4-31 Activity of Nathusius` Pipistrelle spring 2010 from Hyllekrog.

At Waldpavillon a period of high activity was registered from the end of the first week of May until the beginning of the last week of May. Thereafter the activity decreased until the end of the survey (Figure 4-30).

The activity at Hyllekrog showed two peaks, the first at the end of April and the second slowly built up from mid-May and peaked on May 27. Periods of no activity during April and May might be related to unsuitable weather conditions (see Chapter 4.1) (Figure 4-31).

4.11.3 Autumn 2010

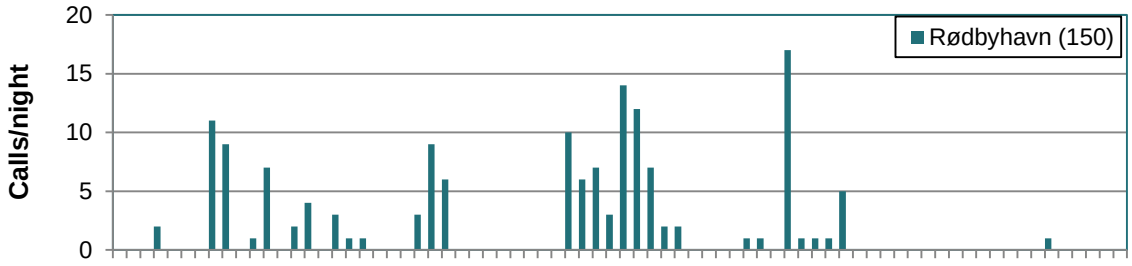


Figure 4-32 Activity of Nathusius` Pipistrelle during autumn 2010 from Rødbyhavn.

The AnaBat installed at the quay wall in Rødbyhavn registered the highest activity during the night of October 7 with 17 calls. Activity was registered regularly, but in low numbers with a period of no activity between September 13 and September 21 attributable to unsuitable weather conditions. Following a period of no activity after October 12 one call was recorded on October 26 (Figure 4-32).

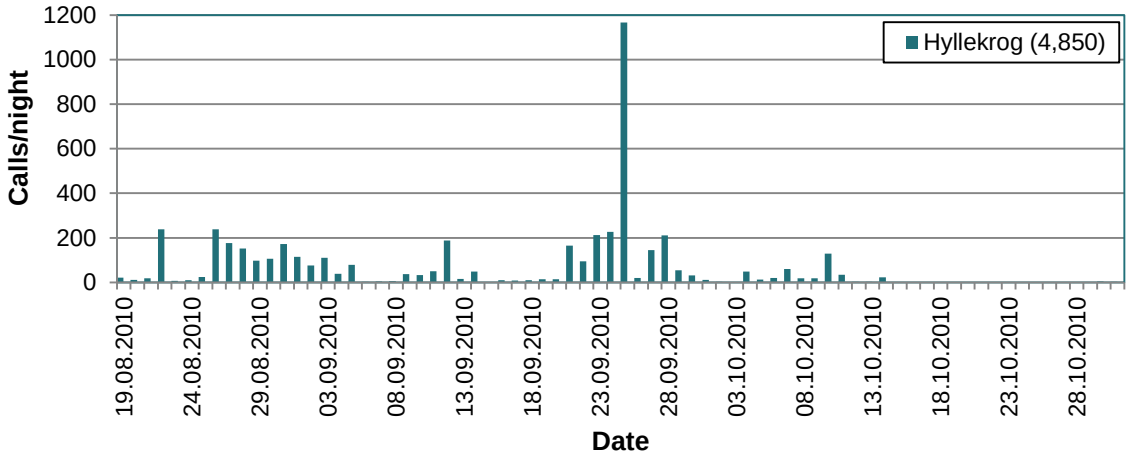


Figure 4-33 Activity of Nathusius` Pipistrelle autumn 2010 from Hyllekrog.

At Hyllekrog the highest activity level was recorded during the night of September 25. In comparison to the year 2009 the activity peak occurred almost at the same time (Figure 4-33).

4.11.4 Spring till Autumn 2010

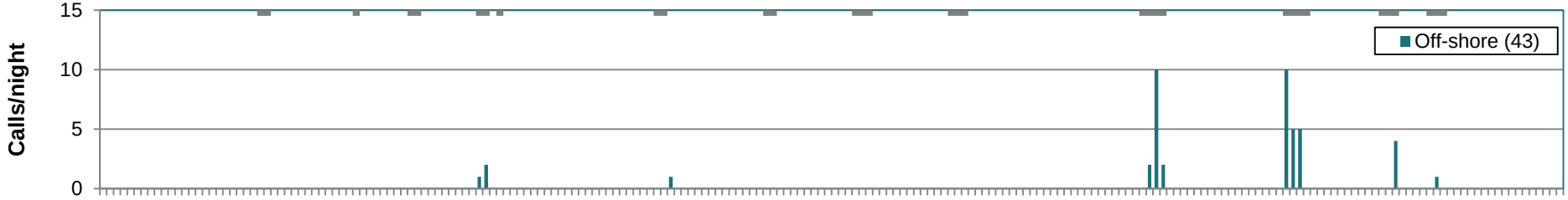


Figure 4-34 Activity Nathusius` Pipistrelle 2010 at anchor position 5.

During the springtime offshore survey the Nathusius' Pipistrelle was first registered at the end of May. In the summer it was observed once on June 23. In comparison to the low spring and summer activity the autumnal survey generally shows more activity. Two activity peaks were recorded in mid-August and at the end of September (Figure 4-34).

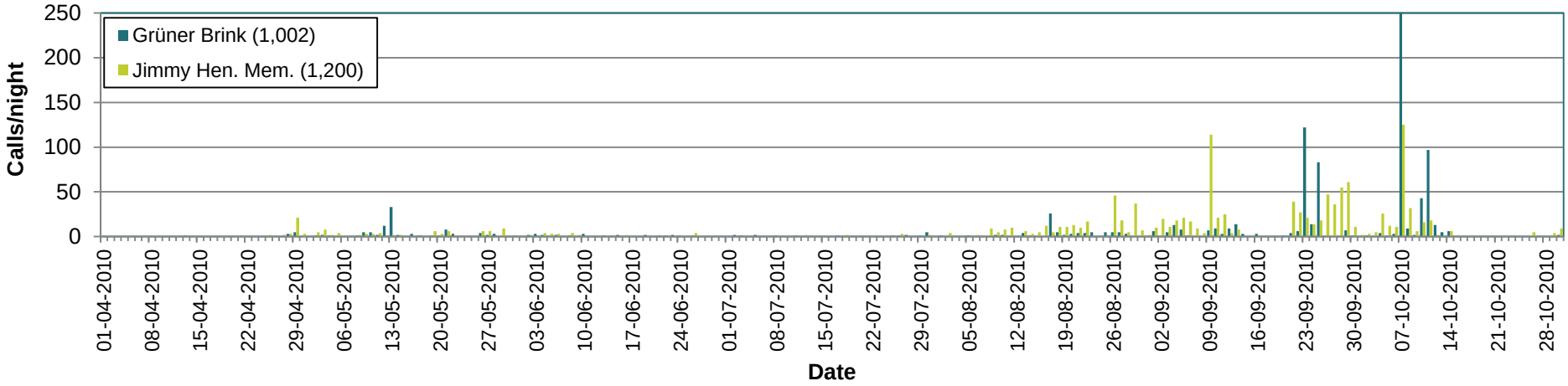


Figure 4-35 Activity Nathusius` Pipistrelle 2010 at Jimi Hendrix Memorial and Grüner Brink.

The activity charts of the sites Grüner Brink and Jimi Hendrix Memorial (Figure 4-35) both show a period of low activity during May followed by a period of hardly any activity during the summer including the months of June and July. In early August the activity increases till the peak of activity was reached in the first decade of October. At Jimi Hendrix Memorial a second activity peak was detected in early September. Thereafter a period of seven days showed no activity caused by bad weather (see Chapter 4.1). After mid-October hardly any activity was recorded.

4.11.5 Summary

In general it can be summarised for all sites that the activity of the Nathusius' Pipistrelle was higher during the autumnal surveys.

The first Nathusius' Pipistrelle was recorded in mid-April, but activity increased drastically towards the end of April. The period of high activity in the springtime lasted until the beginning of June. The continuously recording AnaBats thereafter registered a period of very low activity during the summer. These findings are supported by the offshore surveys during the summer with only one recorded call. In early August the activity of Nathusius' Pipistrelle increased again and peaked between the last decade of September and the end of the first decade of October. At some sites a second activity peak was found in the first decade of September. From mid-October the allocations of the Nathusius' Pipistrelle were very scarce.

4.12 Noctule

The diagrams below show the Noctule calls recorded at the different sites in Lolland, Fehmarn and in the Fehmarnbelt (Figure 4-36 – Figure 4-43).

4.12.1 Autumn 2009

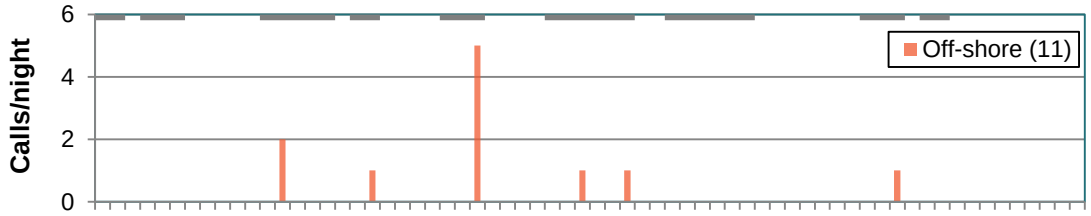


Figure 4-36 Activity Noctule autumn 2009 in the Fehmarnbelt. Recordings from both anchor positions (AP 5 + 8). Nights of observation are indicated in grey on the upper axis.

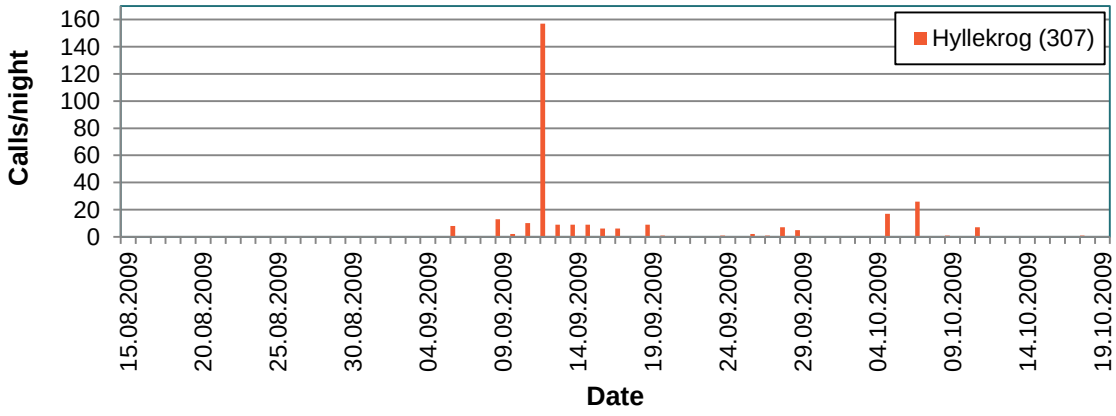


Figure 4-37 Activity of Noctule autumn 2009 from Hyllekrog.

The offshore survey registered the activity peak September 9 (Figure 4-36). Thereafter the Noctule was registered occasionally until the end of the first week of October.

The activity of the Noctule at Hyllekrog was the highest on September 12. On October 5 and 7 the activity rose again but did not reach the level which was achieved in mid-September. After that registrations of the Noctule were scarce.

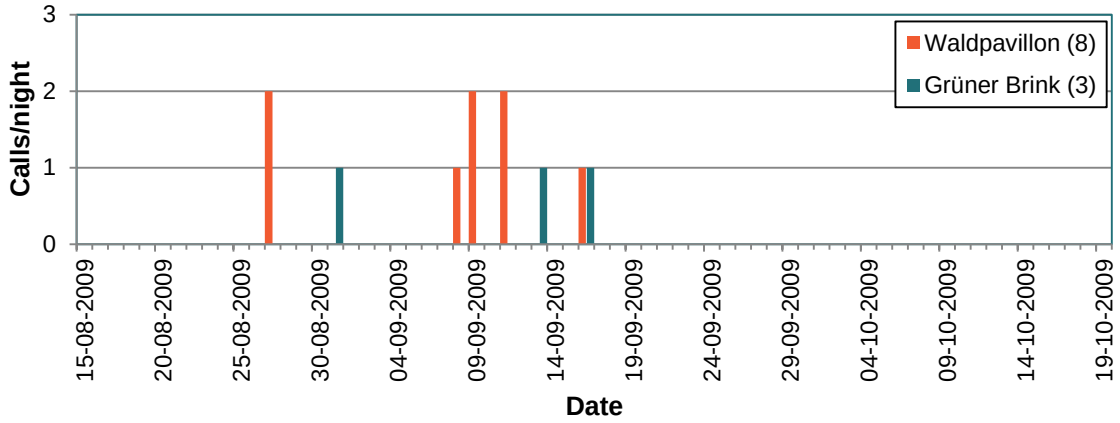


Figure 4-38 Activity of Noctule in autumn 2009 from Waldpavillon and Grüner Brink.

At the sites Waldpavillon and Grüner Brink the Noctule's activity was rather low. Only 11 recordings were made during the survey. Activity was detected between the end of August and mid-September (Figure 4-38).

4.12.2 Spring 2010

The offshore survey did not register the Noctule during the spring.

Activity of the Noctule first occurred mid-April at Hyllekrog (Figure 4-39). Later on the activity increased till the end of May and peaked on May 27.

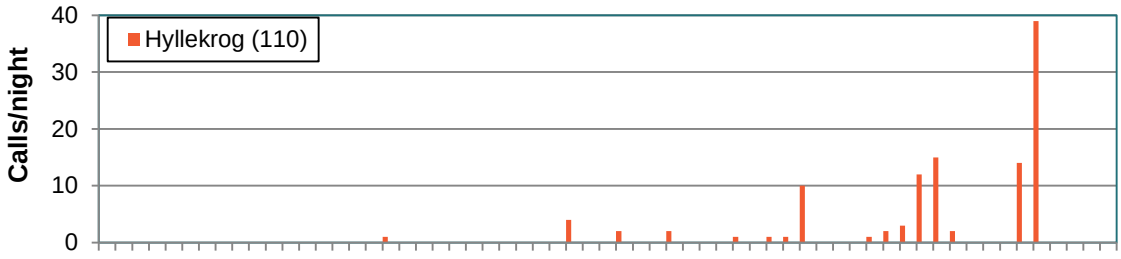


Figure 4-39 Activity of Noctule in spring 2010 from Hyllekrog.

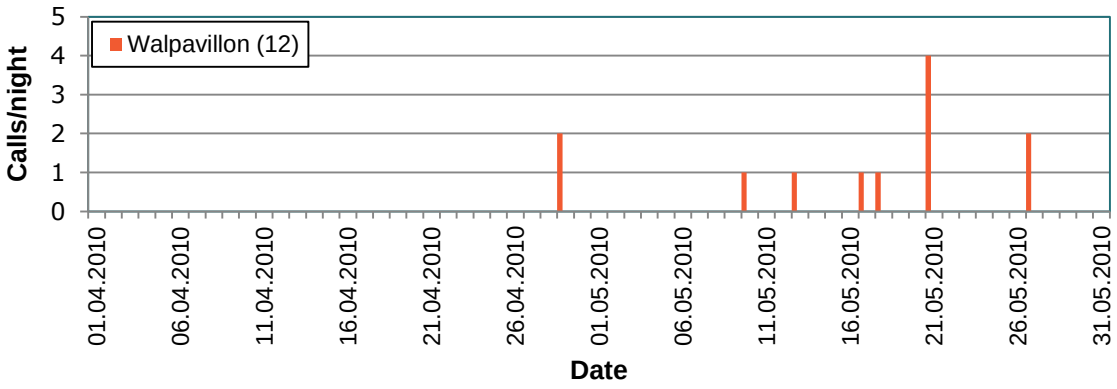


Figure 4-40 Activity of Noctule in spring 2010 from Waldpavillon.

At Waldpavillon only a few calls were recorded (Figure 4-40). This species was first recorded at the end of April and occurred sporadically till the end of May. A peak was identified on May 21.

4.12.3 Autumn 2010

During the offshore survey in autumn 2010 the Noctule was observed once on September 22.

The AnaBat in Rødbyhavn registered a peak of the Noctules activity during the last week of August (Figure 4-41). Until the end of the survey the activity was rather low and only two small ascents of activity were registered in the beginning of the last decade of September and at the end of first decade of October.

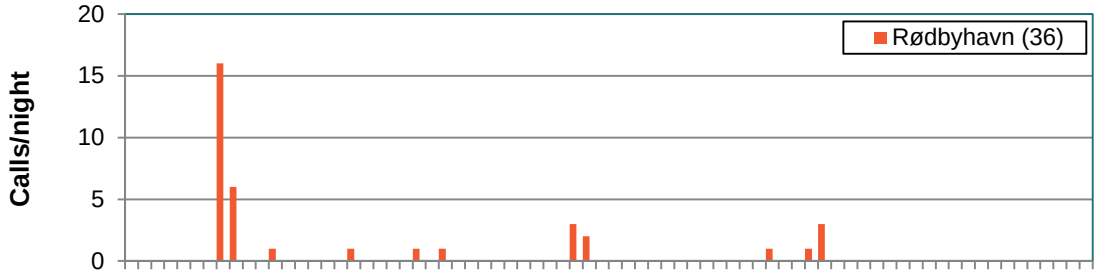


Figure 4-41 Activity of Noctule in autumn 2010 from Rødbyhavn.

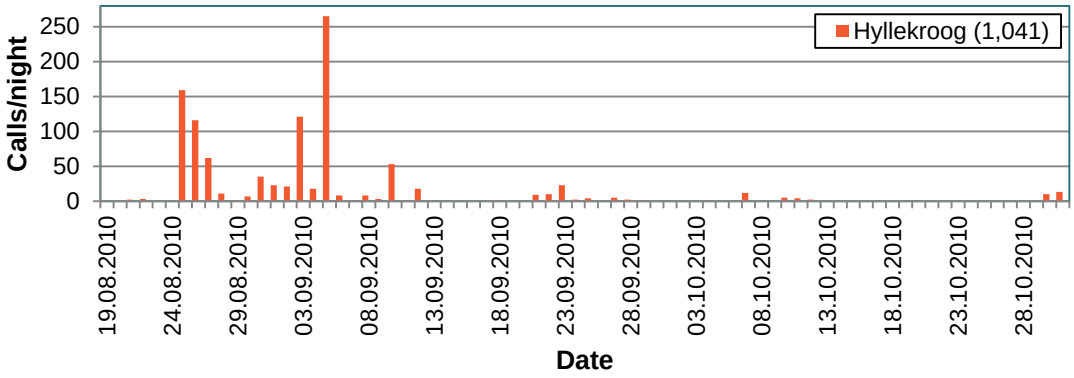


Figure 4-42 Activity of Noctule in autumn 2010 from Hyllekrog.

During autumn this species occurred regularly and the activity peaked during the last week of August and the first week of September (Figure 4-42). Then the activity decreases and only few registrations were made. The last recording which is not displayed in the bar chart of the Noctule was made November 1.

4.12.4 Spring till autumn 2010

At the sites Grüner Brink and Jimi Hendrix Memorial the Noctules activity started April 28 (Figure 4-43). The activity in the spring was quite low. During summer the Noctule could be identified twice at Jimi Hendrix Memorial. At Grüner Brink it was not registered during the summer. The activity increased again during the beginning of August and peaked between the end of August and the first half of September. Thereafter the activity decreased again. The last recording was made October 10 at Grüner Brink.

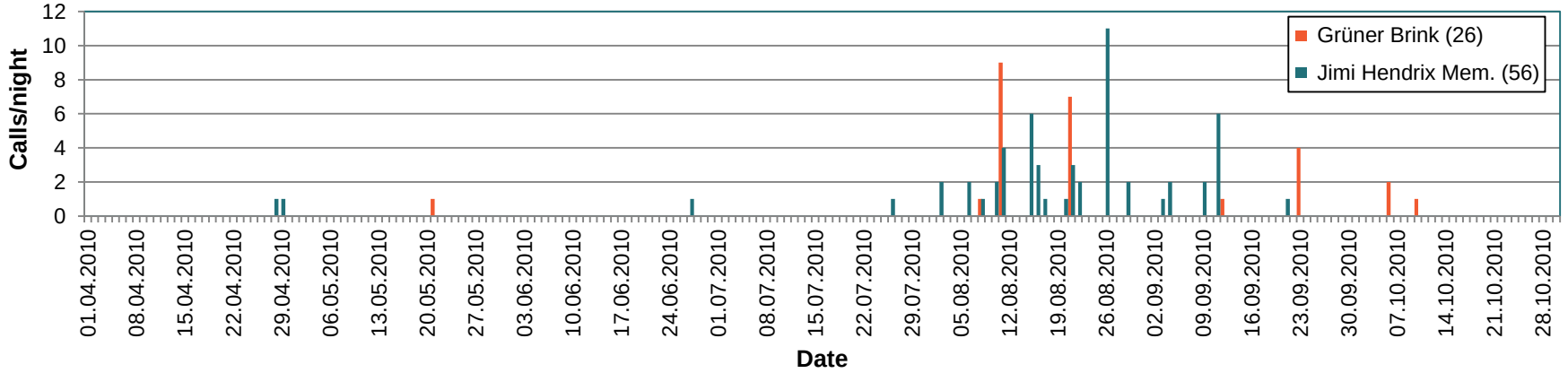


Figure 4-43 Activity of Noctule 2010 from Jimi Hendrix Memorial and Grüner Brink.

4.12.5 Summary

The Noctule was registered at all sites during the surveys in 2009 and 2010. Especially during the springtime the activity of the Noctule was rather low in comparison to the registered activity during the autumnal surveys.

The first recording of the Noctule was made during the night of April 18 at Hyllekrog. Late April this species was recorded at all stationary AnaBat sites, but registrations were scarce at the sites Grüner Brink and Jimi Hendrix Memorial. However, it was not recorded during the springtime offshore-survey. The continuously recording AnaBats registered only two contacts during the summer, including the months of June and July. Furthermore, it was not registered during the summer offshore-survey. At the beginning of August the activity of the Noctule increased at all sites in 2009 and 2010 and the main periods of high activity were found between the end of August and the first half of September at the Danish sites. The last Noctule was registered November 1 at Hyllekrog in 2010. At the sites located at Fehmarn's coastlines the main periods of activity were found during the end of August until mid-September in 2009 and in 2010 between the beginning of August and mid-September. The last identification was made October 10 in 2010.

4.13 Soprano Pipistrelle

The diagrams below show the Soprano Pipistrelle calls recorded at the different sites on Lolland, Fehmarn and in the Fehmarnbelt (Figure 4-44 – Figure 4-52).

4.13.1 Autumn 2009

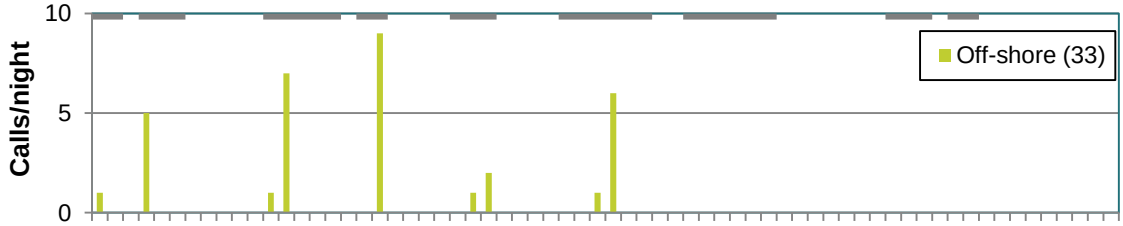


Figure 4-44 Activity of Soprano Pipistrelle autumn 2009 in the Fehmarnbelt. Recordings from both anchor positions (AP 5 + 8. Nights of observation are indicated in grey on the upper axis.

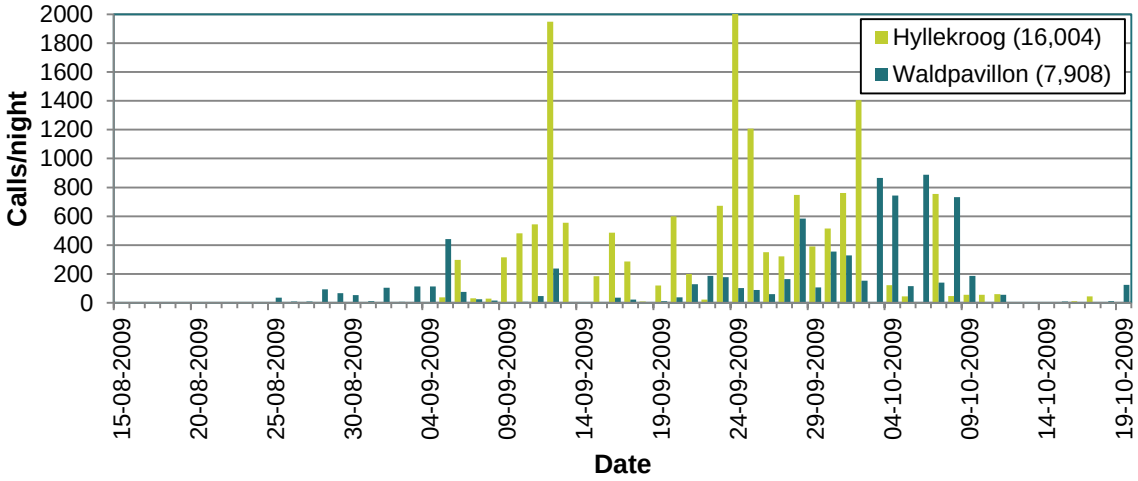


Figure 4-45 Activity of Soprano Pipistrelle autumn 2009 from Hyllekrog and Waldpavillon.

In autumn 2009 the Soprano Pipistrelle was registered regularly during the offshore-survey (Figure 4-44). The last recordings were made during the night of September 17. The peak of activity of this species with regard to the radar vessel was registered at September 2.

At Hyllekrog the Soprano Pipistrelle was commonly recorded (Figure 4-45). From the beginning of the survey till early October high activity was registered apart from some days with unsuitable weather conditions, during which the activity decreased (see Chapter 4.1). The last recordings at Hyllekrog were made during the night of October 19.

At the site Waldpavillon the Soprano Pipistrelle could also be registered regularly in high numbers (Figure 4-45). A small activity peak was recorded during the first week of September. Thereafter, a period of low activity followed. During a period beginning at the end of September till the end of the first decade of October high activity was regularly registered at this site. During the last survey night the species could still be recorded.

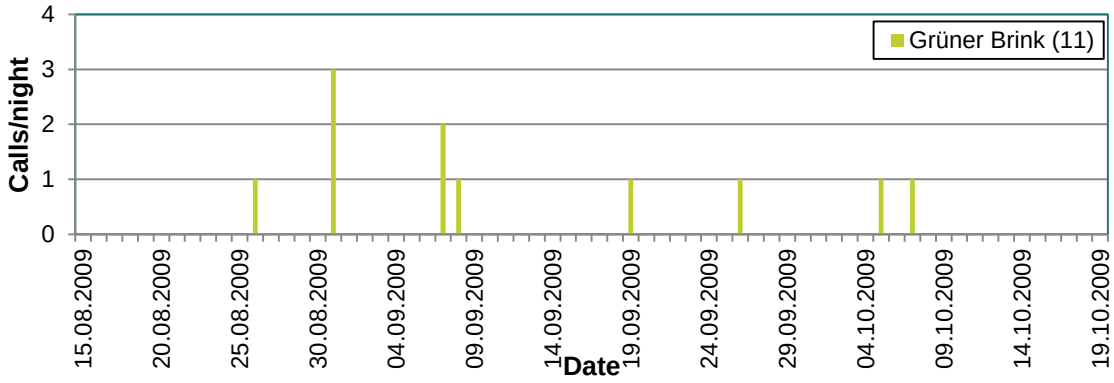


Figure 4-46 Activity of Soprano Pipistrelle autumn 2009 from Grüner Brink.

At the site Grüner Brink the activity of the Soprano Pipistrelle (Figure 4-46) was lower than at the sites described above. The scattered registrations were made between the end of August and the end of the first week of October. The peak of activity is represented by a night with three registrations of the Soprano Pipistrelle.

4.13.2 Spring 2010

During the offshore survey in the spring no Soprano Pipistrelles were registered.

The first Soprano Pipistrelle was registered at Waldpavillon during the night of April 8 (Figure 4-47). Followed by a month of hardly any activity because of unsuitable weather conditions until the end of the first week of May (see Chap. 4.1). Thereafter the Soprano Pipistrelle was regularly registered and the activity peaked during the night of May 23. The activity did not reach the dimension of activity level in autumn 2009. Subsequently, the activity decreases again till the end of the spring survey.

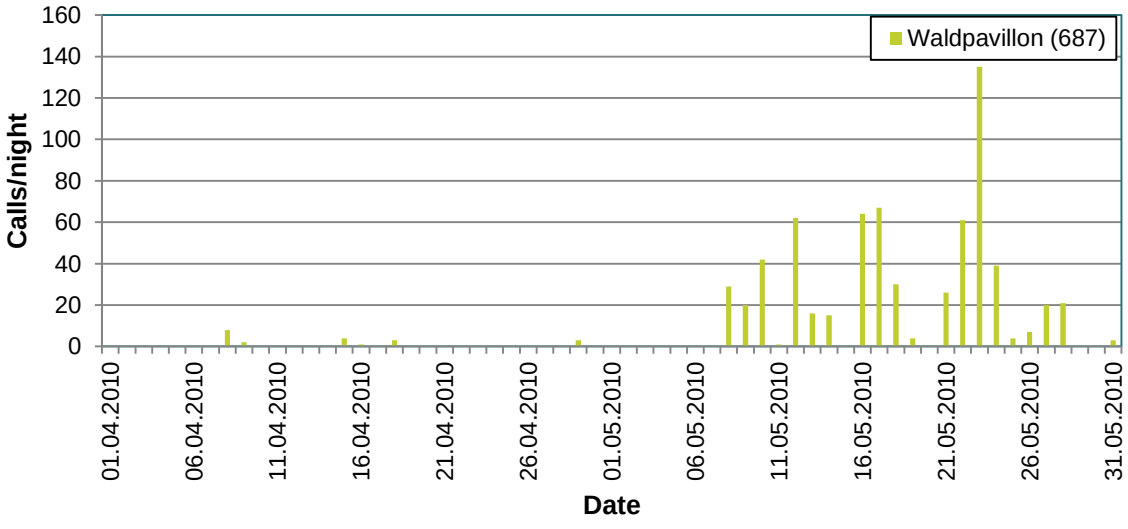


Figure 4-47 Activity of Soprano Pipistrelle in spring 2010 from Waldpavillon.

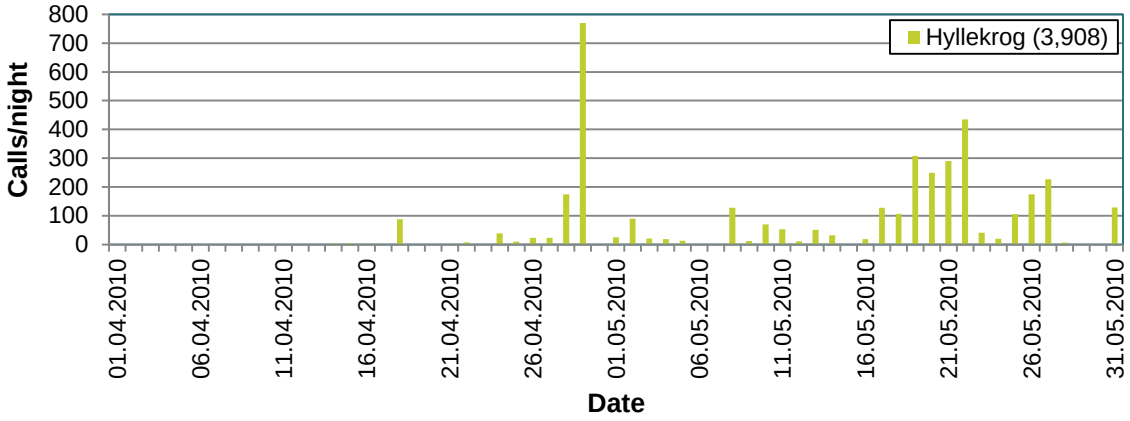


Figure 4-48 Activity of Soprano Pipistrelle in spring 2010 from Hyllekrog.

During the spring two activity peaks were registered at Hyllekrog (Figure 4-48). The first was recorded during the night of April 29 and the second followed after a period of lower activity at the beginning of the second half of May with the peak during the night of May 22.

4.13.3 Autumn 2010

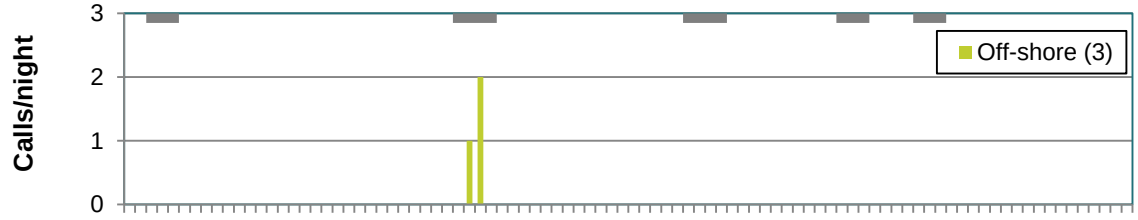


Figure 4-49 Activity of Soprano Pipistrelle autumn 2009 in the Fehmarnbelt. Recordings from anchor position AP 5. Nights of observation are indicated in grey on the upper axis.

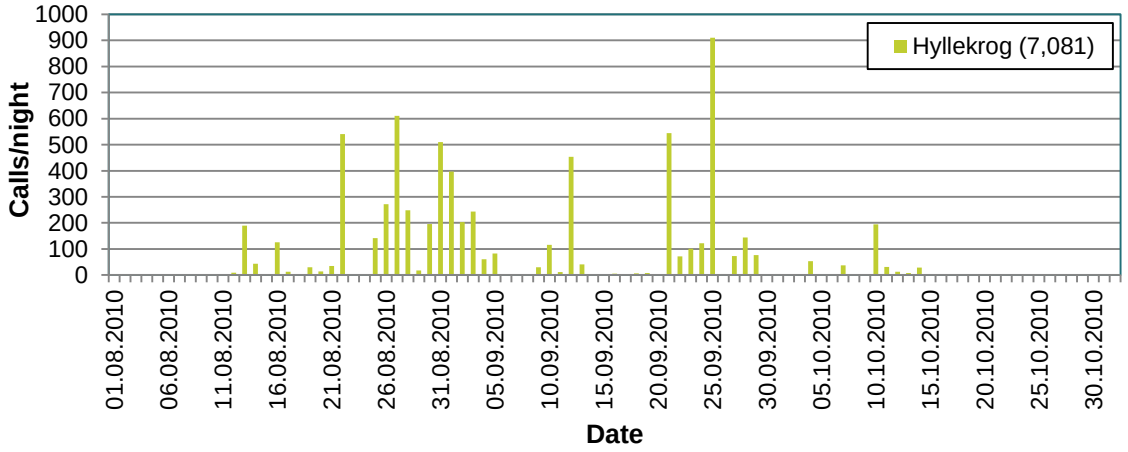


Figure 4-50 Activity of Soprano Pipistrelle in autumn 2010 from Hyllekrog.

The Soprano Pipistrelle was registered three times during autumnal offshore survey. Calls were only recorded during the second autumn survey at the beginning of September (Figure 4-49).

Although the differences were not as huge as in autumn 2009 the comparison of surveys at Hyllekrog proved again that the activity level during autumn is higher than in the spring. The analysis of bat calls showed multiple periods of no activity assumedly caused by periods of unsuitable weather conditions (see Chapter 4.1). During the beginning of the survey the activity level was low but increased rapidly during the night of August 22 (Figure 4-50). After this activity peak, which was

interrupted by two days of no activity also assumedly caused by unsuitable weather, the activity increased and remained nearly stable till September 5. Three days of no activity followed. Thereafter activity showed a peak September 12. A week of low activity caused by unsuitable weather followed. Then, the activity increased again and the highest peak during the autumn survey at this site was recorded September 25. A small ascent was registered at the end of the first decade of October. Subsequently the activity decreased and the last recording, which is not displayed in the bar chart of the Soprano Pipistrelle, was made November 1.

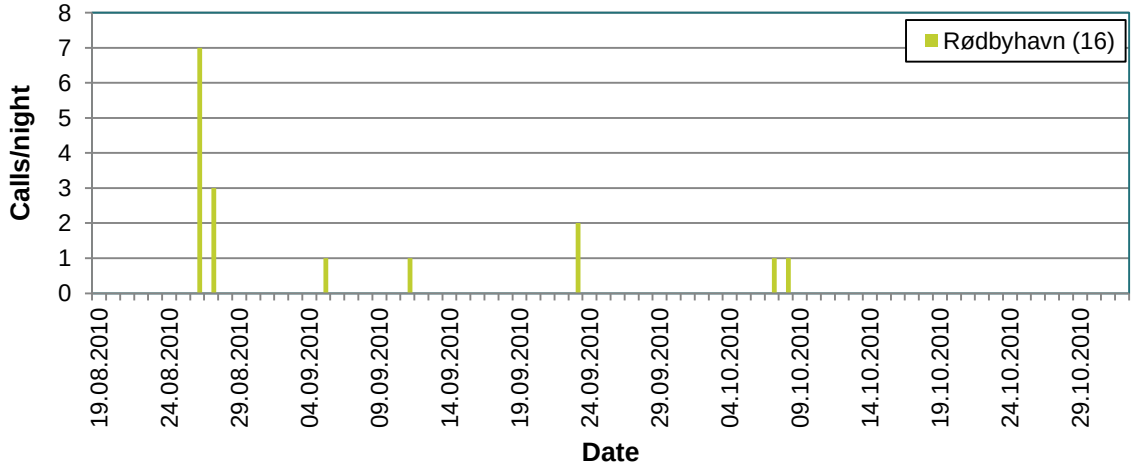


Figure 4-51 Activity of Soprano Pipistrelle in autumn 2010 from Rødbyhavn.

At the site Rødbyhavn recordings of the Soprano Pipistrelle were scarce (Figure 4-51). The highest activity was registered at the beginning of the survey during the night of August 26. Thereafter only scattered registrations were made. The last recording of the Soprano Pipistrelle was registered October 8.

4.13.1 Spring till autumn 2010

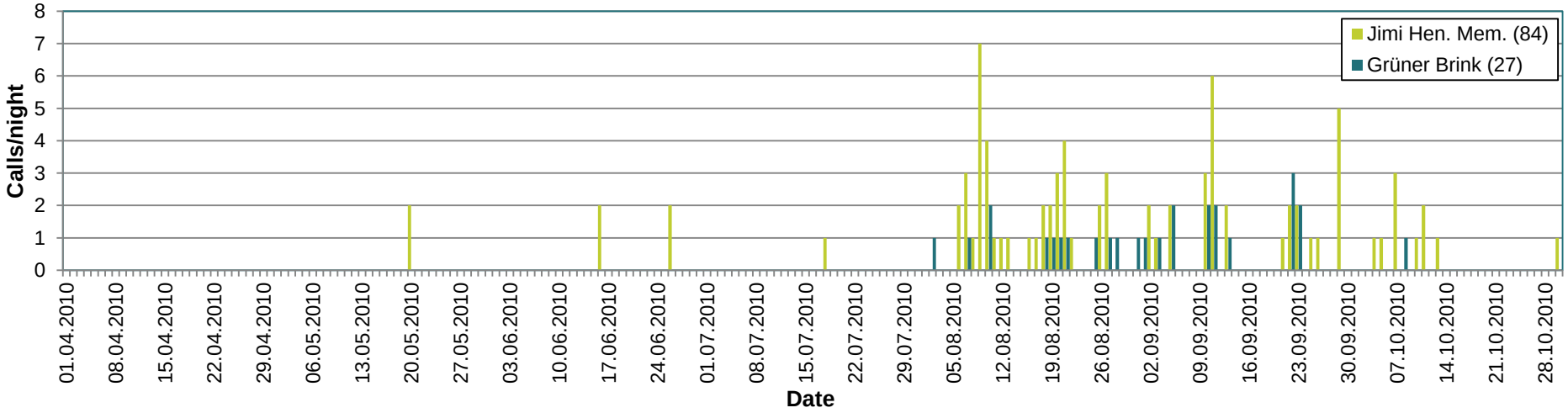


Figure 4-52 Activity of Soprano Pipistrelle 2010 from Jimi Hendrix Memorial and Grüner Brink.

During the survey the AnaBat installed at Jimi Hendrix Memorial recorded nearly three times more registrations compared to Grüner Brink. The continuously recording AnaBats only registered two contacts of the Soprano Pipistrelle during the spring. Both recordings were made at Jimi Hendrix Memorial during the night of May 20. Registrations (5) during the summer were also scarce. In the beginning of August the number of recordings increased at both sites, but it can also be categorised as rare. From the beginning of August till mid-October the Soprano Pipistrelle was registered more or less regularly. Small distinct peaks were detected at Jimi Hendrix Memorial: August 9, September 11 and September 29. At the site Grüner Brink the recordings during autumn were very scattered. A little ascend was noticed September 22. The last recordings were registered at Jimi Hendrix Memorial October 30 and at Grüner Brink October 8 (Figure 4-52).

It was noticed that the Soprano Pipistrelle's activity was lower during the springtime survey. During the offshore survey in the spring this species was not registered. The first registration in spring was recorded April 8 at the site Waldpavillon. Presumably caused by the unsuitable weather conditions particularly during April but in alleviated form also in May regular activity of the Soprano Pipistrelle occurred not until the end of April. At Hyllekrog two activity peaks were registered: first, at the end of April and second after mid-May. The constantly recording AnaBats at Jimi Hendrix Memorial and at Grüner Brink registered almost no activity during the summer. Activity was registered regularly but in low numbers till the beginning of August and lasted till mid-October at the aforementioned sites. In contrast to the offshore survey in autumn 2009 the Soprano Pipistrelle was only registered in low numbers. As in autumn 2009 two periods of high activity were registered at Hyllekrog (see Figure 4-45 and Figure 4-50). During autumnal surveys in 2009 and 2010 the activity ended, occasionally registration excluded, after mid–October.

5 DISCUSSION

Current literature presents references that bats are crossing wide areas of open water like the North or the Baltic Sea (Vauk 1974, Ahlén 1997, Skiba 2007, Ahlén et al. 2009). Long-distance migrants like Nathusius' Pipistrelle or the Noctule fly across the Baltic Sea from southern Sweden to Germany or the Netherlands (Ahlén 1997, Hutterer et al. 2005, Ahlén et al. 2009). Ahlén et al. (1997) assume based on personal observations at Gotland that even bat populations of Estonia and its neighbouring states migrate towards a route from Estonia to Gotland (Sweden), Öland (Sweden), Falsterbo (Sweden) and finally pass over Gedser (Denmark) to Poland or even to Lolland and across the Fehmarnbelt (Ahlén et al. 2009). These studies are based on the assumption that migration routes of bats are alike the migration routes of birds.

For the area of Fehmarn two studies were carried out which came to similar statements. A report of a study concerning the construction of the road B 207 concluded that at Fehmarn the activity of bats during autumn rises (Schumann 2009), and additionally a thesis points out that the activity of migratory bats rises during migration periods at Fehmarn (Klöcker 2002).

5.1 Methodical verification of migration

5.1.1 Problem definition: activity/migration

With the stationary AnaBat detectors bat activity can be observed. The data provided by the AnaBat allows allocating the recorded calls to the respective species. However, it cannot determine the number of individuals or flight patterns. These can only be observed in personal (on- and offshore) surveys. This means that it is not possible to separate individuals using the AnaBat detectors. Activity can be measured in calls/night or calls/hour. For example ten bat calls of one species were recorded during one night of observation. It is not possible to extract information if the same bat was flying ten times in the detector's range or if ten migrating individuals of the same species passed the detector's range.

In order to deal with this problem one can analyse phenological occurrence (see Popa-Liseanu & Voigt 2009, Fleming & Eby 2003, Holland & Wikelski 2009) and intensity of registered species at the different stationary AnaBat sites. The occurrence or absence of species during some seasonal periods at the study sites can be a hint for migration. Also the intensity of activity during periods of occurrence and its phenology can provide hints for migration. Migration is difficult to prove due to the uncertainties of the variables like potential variation in seasonal and areal occurrence of resident bats (Fleming & Eby 2003) and the before mentioned problems. Other methods of verifying migration are the banding of bats (see Hutterer et al. 2005) or radio tracking bats during their flight which might be difficult at the open sea. A third possibility would be radar-tracking with a radar comparable to the "Superfledermaus" (Bruderer & Popa-Lisseanu 2005).

Existing classifications of European bat fauna name the known migratory bat species. These classifications were deduced from the results of banding data. "Long-distant migrants" are: Leisler's Bat, Noctule, Nathusius' Pipistrelle, and the Parti-coloured bat. These species regularly fly 3,000 - 4,000 km in one return flight from their breeding areas to their hibernation roosts (Hutterer et al. 2005). Another category is "regional migrant". These species are migrating distances up to 800 km. These species are: Barbastelle, Northern Bat, Common Pipistrelle and Pond Bat (Hutterer et al. 2005). These classifications provide a list of species, which are of special concern for the analysis of migration in this study.

Verification of migration
In case of the offshore investigation species which occurred offshore are treated as migrating. However Ahlén et al. 2007 observed local bats feeding offshore as rarely observed during this study. Accordingly some bat registrations might originate from local bats that feed offshore. If directional flight towards the main supposed migration direction (autumn = southwards/ spring = northwards) can be observed in personal surveys this is considered as further confirmation of the migration hypothesis. Furthermore, occurrence and absence analyses showing characteristic absence during the summer of a species is also considered as further indication for migration.

5.1.2 Abundance of migrating bats

The abundance of bats which are migrating across the Fehmarnbelt can only be extrapolated using the data collected by the AnaBats installed at the Scandlines ferries and the data registered at the radar vessel with regard to the range of the detectors and finally multiplied with the length of the Fehmarnbelt. In detail, the range for the detection of *Pipistrellus* genus is about 30 m and for *Nyctalus* genus between 100 and 150 m and *Eptesicus* genus about 70-90 m (Skiba 2009). Radar studies in the Kalmarsund point out that the detector investigations are able to register a small proportion of the whole contingent of migrating bats (Ahlén et al., 1997).

Even in the analyses of night acoustic data of the much more thoroughly researched bird migration the registered calls were not used for estimation of abundances.

Finally, there are a lot of variables which cannot be considered in this study, for example the flying altitude of migrating bats when crossing the open sea is not conclusively researched. A radar study in Kalmarsund revealed that the majority of migrating bats use altitudes below 40 metres, while some were registered in altitudes up to 180 m (Ahlén et al. 2007). A survey carried out at Falsterbo (Sweden) using a thermal camera revealed that larger bats fly at altitudes of up to 1,200 m (Ahlèn et al. 2007). The effect of the vessel itself is also unknown. Bats might either head for the vessel attracted by lights, insects or the structure of the vessel itself or they could avoid vessels at the open sea.

To assess if the Fehmarnbelt plays an important role for the bat migration a comparison between the potential population size of each species of importance and the actual number of bats crossing the Fehmarnbelt is needed. As of now, no reliable information about population sizes of European bats is available. Since the methods used in this study do not allow reliable accounting for the number of bats migrating across the Fehmarnbelt the importance of the Fehmarnbelt for bat migration cannot be assessed precisely. However, migration as such can be detected with the applied methods.

5.2 Analyses of bat activity data

The following passages will discuss the results of the bat data recorded by the stationary AnaBat sites, the results given by the offshore investigations including the radar vessel and the Scandlines ferries and the results of the personal investigations from the coastlines.

5.2.1 Nathusius' Pipistrelle

The Nathusius' Pipistrelle was registered during the survey in high numbers and at all sites especially during the migration period in the autumn but also in the spring (see chapter 4.11). It is known to be a local species which is breeding in Denmark (Baagøe 2001) and also in the northern parts of Scandinavia (Dietz et al. 2007).

The species is also known to be a long-distance migrant (Hutterer et al. 2005). Two long-distance flights from south Sweden to Germany and the Netherlands have been recorded (Hutterer et al. 2005).

The Nathusius' Pipistrelle was the most commonly detected species during the offshore surveys. The fact that this species was regularly identified on the radar vessel flying in south or south-west directions during the autumnal migration period can be considered an indication that this species is migrating across the Fehmarnbelt. Surveys carried out by Ahlén et al. (2009) in the years 2005, 2006 and 2008 show an occurrence of the Nathusius' Pipistrelle in the open waters of Kattegat, Øresund and Kalmarsund. During 38 field nights 112 Nathusius' Pipistrelles were registered by Ahlén et al. (2009). 138 Nathusius' Pipistrelles were registered during 73 field nights of this study. Due to differences in the methods applied a reliable comparison of the intensities of migrating Nathusius' Pipistrelles is not realistic. Differences can be found in the bat's behaviour. Ahlén et al. (2009) regularly observed hunting bats during offshore surveys. This behaviour was rarely observed during the survey in the Fehmarnbelt. During the coastal personal surveys the Nathusius' Pipistrelle was regularly observed leaving land and flying towards the supposed main migration direction.

Additionally, analysis of the activity data of the stationary AnaBat sites (see Chap. 4.11) yields indication for migration. The activity of Nathusius' Pipistrelle over the course of the year 2010 at the sites Grüner Brink and Jimi Hendrix Memorial showed a typical pattern for a migrating species with high activity in the spring and autumn and nearly no activity in the summer. During a study carried out for the EIA concerning the construction of the B 207 a higher level of activity of the Nathusius' Pipistrelle was measured during the migration periods (Schumann et al. 2009). This indicates that Nathusius' Pipistrelle passes the Fehmarnbelt region during spring on its way to the breeding areas in the north and during autumn on its way to wintering grounds in the south.

At the stationary AnaBat site at Hyllekrog high activity was registered especially during autumnal migration periods. Nathusius' Pipistrelle was regularly observed feeding but also leaving land at this site. It can be assumed that bats accumulated there. This is supported by the overall higher number of bat contacts which were registered at anchor position 8, south of Hyllekrog. This is furthermore confirmed by a study in Kalmarsund; Ahlén et al. (2009) "observed greater levels of bat activity at sea adjacent to known departure points […]". Another explanation for bat aggregation at Hyllekrog might be the occurrence of high insect densities provided by the large wetlands at Hyllekrog.

The migration period during spring is a short event occurring over a span of only a few days (Strellkov 1969). This can be seen as a reason for the comparatively low activity and occurrence during spring time. Ahlén et al. (2009) also described that bat migration in spring is "[...]widely dispersed and [bats] do not arrive in concentrated flyways."

The autumnal migration period is longer and can occur over several weeks (Strellkov 1969; Ahlén 1997). The autumnal high activity may be caused by additional individuals including females and young bats that are migrating to southern areas. This finding is supported by other studies which also registered a rising activity during the autumn migration period (Klöcker 2002; Schumann 2009).

Overall the data proves that this species is migrating across the Fehmarnbelt. The assessment of migration intensity is, in regard to the aforementioned problems, not precise. The Nathusius' Pipistrelle was the most commonly registered species during the offshore survey. This species seems to be the species which must be

taken into account when it comes to the impact assessment of the Fehmarnbelt Bridge.

5.2.2 Noctule

The Noctule was registered regularly at nearly all sites, but not as often as the Nathusius' Pipistrelle. The species is breeding in Denmark (Baagøe 2001) and southern parts of Scandinavia (Dietz et al. 2007). The species is also known to be a long-distance migrant (Hutterer et al. 2005). Two long-distance flights from south Sweden to Germany were registered (Hutterer et al. 2005).

During the offshore surveys it was registered regularly, in particular during the supposed migration periods in autumn. Ahlén et al. (2007) regularly observed this species heading out to the open sea at the south coast of Sweden. Ahlén et al. (2009) registered the Noctule 277 times during their study in the Baltic Sea. A reliable comparison to the study in the Fehmarnbelt, which registered the Noctule 12 times, is not possible. The fact that the Noctule was also registered during the offshore surveys in the Fehmarnbelt implies that this species uses the Fehmarnbelt for migration.

There also seems to be an accumulation at the AnaBat site at Hyllekrog shown by high activity during the autumn 2009 and 2010. Hyllekrog seems to be a stopover area for the Noctule or they might accumulate there when unsuitable weather does not allow crossing the Fehmarnbelt. Additionally high abundances of insects might cause the high activity of Noctules at Hyllekrog. A closer view at the results of two anchor positions supports the idea of accumulation in the Hyllekrog area. The recordings of the Scandlines ferries show that the Noctules were also using the vicinity of the ferry routes to hop over to Fehmarn. Therefore it can be assessed that the Noctule crosses the Fehmarnbelt in a broad corridor. The lower number of registrations of the Noctule in relation to the Nathusius' Pipistrelle might be the result of higher altitudes the Noctules may use. Additionally some calls of the Noctule might only be determined into the "NYC" group. A study which used a thermal camera during a survey at Falsterbo revealed larger bats, presumably Noctules, in altitudes up to 1,200 m (Ahlèn et al. 2007). Additionally, the kite investigations showed that the Noctule is using higher altitudes.

In conclusion it can be stated that the Noctule migrates across the Fehmarnbelt. The Noctule seems to use the whole width of the Fehmarnbelt with some areas of higher intensity like Hyllekrog.

5.2.3 Soprano Pipistrelle

The Soprano Pipistrelle occurs in Denmark (Baagøe 2001) and the southern parts of Scandinavia (Dietz et al. 2007). The species has also local populations in the eastern parts of Schleswig-Holstein. Seasonal migration of this species is not yet clarified but expected in particular for the northern Scandinavian populations (Hutterer et al. 2005; Skiba 2009). The longest reported distance (775 km) from Germany to Croatia was proved by Ohlendorf (Ohlendorf, notice in writing). Some long-distance flights might be mixed up with those of the Common Pipistrelle because the Soprano Pipistrelle was first identified in 1999 by DNA-analysis (Barrat et al. 1997) and most of the banded Common Pipistrelles were banded before that.

The species was the second most registered during the offshore surveys. Additionally, the species was observed several times leaving the shore towards the main supposed migration direction. This leads to the assumption that this species migrates across the Fehmarnbelt. It was registered at all sites during the survey with a high proportion of all recorded calls at the AnaBat sites Hyllekrog and Waldpavillon. During the study in Kalmarsund the Soprano Pipistrelle "was the most numerous bat found at departure sites and over the ocean" (Ahlén et al. 2009).

Despite some rare registrations during the summer the results of the continuously recording AnaBats also supported the assumption that this species is migratory in the greater area of Fehmarn. Within a small geographical range bats of the same species and the same population can show partial migration or even sex-biased migration which is common in bats (Fleming & Eby 2003). Commonly, females of migratory species are flying longer distances than males (Fleming & Eby 2003). This might also be an explanation for late registrations in autumn and occasional registrations during the summer.

Finally, it can be stated that the Soprano Pipistrelle crosses the Fehmarnbelt for migration.

5.2.4 Serotine

The Serotine is a resident species in Denmark (Baagøe 2001) and the southern parts of Sweden (Dietz et al. 2007). Hutterer et al. (2005) described this species as a regional migrant which includes migration or dispersal flights of up to 800 km. No banding data are published which show that the Scandinavian populations of the Serotine migrate to Central Europe. The banding data are insufficient for general categorisations (Hutterer et al. 2005).

The Serotine was registered in 2009 and in 2010 during the offshore surveys which documents that this species crosses the Fehmarnbelt on rare occasions during dispersal flights or migration. A flight direction of the Serotine was not registered.

Therefore it cannot be conclusively assessed if the Serotine regularly crosses the Fehmarnbelt for migration.

5.2.5 Common Pipistrelle

The Common Pipistrelle is described by Baagøe (2001) as a common bat in Denmark. In most cases this species seems to be sedentary in Europe (Hutterer et al. 2005). But it can be assumed that it is partially migratory or even sex-biased migratory. No ringing data are published which shows that Scandinavian populations of the Common Pipistrelle migrate to Central Europe. Some registered long-distance flights might be mixed-up with those of Soprano, or Nathusius' Pipistrelle (Hutterer et al. 2005, Dietz et al. 2007).The data recorded at the different stationary AnaBat sites are showing low activity during the summer which may be emitted by a local population. A rising of activity was also registered during migration periods in the spring and autumn (see appendix). The higher level during the migration period can be assessed as an indication for migration. Directional flights were registered twice during a personal survey at the camping ground.

During the offshore surveys observations of the Common Pipistrelle were scarce (three registrations) and no flight directions could be observed.

Due to the low number of offshore recorded calls this species cannot be finally determined concerning its migration classification and will not be assessed further.

5.2.6 Pond Bat

Baagøe (2001) specified the Pond Bat as a rare species in Denmark with a geographical emphasis on dispersion in Jutland. It also occurs in the southern parts of Sweden (Dietz et al. 2007). "The Pond Bat is considered to be a facultative migrant covering middle to long range distances, with known displacements from 10 to 300 km" (Hutterer et al. 2005). The species is listed in Annex II of the Habitat Directive.

There was one single registration of this bat during the offshore survey in 2009. During the offshore survey in 2010 this species was not recorded. During the

survey from the radar vessel some individuals may be missed because a permanent clicking which sounds like *Myotis* calls was emitted by a cooling pump of the vessels engine.

Ahlén et al. (2009) observed the Pond Bat 118 times. They registered this species hunting and foraging in the Baltic Sea. This behaviour was not registered in the Fehmarnbelt. There are some hibernation roosts of the Pond Bat in Schleswig Holstein (e.g. Segeberger Kalkberghöhle) (Naturschutzbund n.d.), which might be a possible destination for the Pond Bat when crossing the Fehmarnbelt.

The single observation and the above-mentioned problems in detecting this species do not allow for a reliable assessment of the intensity in the use of the Fehmarnbelt.

5.3 Assessment of importance of the Fehmarnbelt for bat migration

Just one other study dealing with offshore detection of bats in the Baltic Sea exists, which shows that offshore investigation of bats is a new field needing further investigations. This study was carried out in the areas of Kattegat, Øresund and Kalmarsund (Ahlén et al. 2009). Due to methodical differences this study is not comparable with the data provided by this study.

The results recorded by the study verify bat migration across the Fehmarnbelt. Out of a total community of 16 species in Denmark (Baagøe 2001) and an expected species inventory of 11 species at Fehmarn (Leguan GMBH 2011) a number of six species (Nathusius' Pipistrelle, Noctule, Soprano Pipistrelle, Serotine, Pond Bat and Common Pipistrelle) could be identified in the Fehmarnbelt during offshore surveys. With exception of the Pond Bat all of these species were also detected onshore. The onshore investigations additionally detected the Leisler's Bat, Parti-coloured Bat, Barbastelle and Daubenton's Bat. However, observations of these species were scarce. The Leisler's Bat, Parti-coloured Bat and Barbastelle are also known to be migratory, while the Daubenton's Bat is categorised being not migratory (Hutterer et al. 2005). The fact that the Leisler's Bat, Parti-coloured Bat and Barbastelle were not detected offshore and rarely detected during the shore-sided surveys shows the low relevance of these species in the Fehmarnbelt area. Three species (Nathusius' Pipistrelle, Noctule, and Soprano Pipistrelle) were found to migrate regularly across the Fehmarnbelt. Due to the scarcity of data the Serotine, Pond Bat and Common Pipistrelle could not be finally assessed. There are hints for migration of these species in seasonal occurrence, but a proof for regular migration could not be delivered.

An accumulation of bats was observed at the coast and offshore at Hyllekrog. The results given by the AnaBats installed on the Scandlines ferries, which collected bat data in the direct vicinity of the planned fixed link, do however not indicate higher migration intensities in the corridor. Thus, it can be summarised that the direct vicinity of the planned fixed link does not play a crucial role for inter-regional migration and long-distance migration.

Nevertheless, the Fehmarnbelt is crossed by migratory bats during their seasonal movements. An absolute number of bats passing the Fehmarnbelt cannot be extrapolated due to the lack of detailed knowledge of the nature of bat migration and the behaviour of the different species (see Chapter 5.1). From the available data it cannot be concluded in which direction the Fehmarnbelt is crossed by migrating bats. It is considered to be unlikely that bats are aware of the shortest land to land connection between Lolland and Fehmarn and thus it is unclear

whether there is directed migration between these islands. Instead it is considered to be more likely that bats behave like songbirds during nocturnal migration which cross the sea at broad front. According to the fact that bats were detected at all offshore sites including Scandlines ferry survey and radar vessel survey it is considered that bat migration occurs in broad front across the waters of the Fehmarnbelt. The occurrence of broad front offshore migration might be a result of the inexistence of guidance structures in the sea areas as well as inexistence of guiding structures at coastal areas, like peninsulas, which might concentrate bat migration before crossing sea areas. Broad front migration of bats at sea is also confirmed by a master thesis carried out on the islands Wangerooge, Mellum and Neuwerk, located in the North Sea (Frey 2010). Additionally Ahlèn et al. (2007) found that bats occurred offshore all over the strait between Denmark and Sweden (Öresund) which also confirms broad front migration across open waters. Furthermore, several incidental observations of bats during bird surveys carried out for offshore wind farm projects in the Baltic Sea (Walter et al. 2005; several unpublished sightings, meeting BSH 2012) prove the occurrence of bats in offshore areas especially during migration phases in spring and autumn, indicating that bat migration occurs in broad front.

6 EVALUATION OF THE IMPORTANCE OF FEHMARNBELT FOR BAT MIGRATION

The following chapter will assess the importance of the Fehmarnbelt with regard to bat migration. The assessment will be done based on the data collected during the offshore surveys (Scandlines ferries and Radar vessel). The three most common species (Nathusius´ Pipistrelle, Soprano Pipistrelle and Noctule) will be treated. Due to scarcity of data concerning the other species (Serotine, Common Pipistrelle and Pont Bat) these seem to play a subordinated role and will not be assessed further. An assessment of the importance of the Fehmarnbelt based on a four grade scale is not done because it lacks current knowledge about biology of migration and reliable schemes to assess the recorded migration intensities. To assess the importance of the Fehmarnbelt a two grade scale will be used.

Criteria
Table 6-1 clarifies the two grade importance level scale and the appending criteria.

Table 6-1 Importance level and criteria.

Importance level	Criterion
Special	Special migration corridor between Lolland and Fehmarn.
General	Bat migration between Lolland and Fehmarn is proven, but no indication of special migration corridor.

Evaluation of importance
For the three regarded species (Nathusius´ Pipistrelle, Soprano Pipistrelle and Noctule) the importance of the Fehmarnbelt is concluded to be general importance as the results of the study indicate some migration but no special corridor in the area.

Table 6-2 Evaluation of importance.

Species	Importance level	Explanatory statement
Nathusius' Pipistrelle	General	Migration was proven, but no hint for a special migration corridor was found. For more detailed information see chapter 5.2.1.
Noctule	General	Migration was proven, but no hint for a special migration corridor was found. For more detailed information see chapter 5.2.2.
Soprano Pipistrelle	General	Migration was proven, but no hint for a special migration corridor was found. For more detailed information see chapter 5.2.3.

7 CONCLUSION

The data of the migration study 2009 and 2010 show that bats of at least six species were identified in the open waters of the Fehmarnbelt. Three species could be assessed to cross the open water regularly in the same way as has been recorded from several other places in the western Baltic Sea (Ahlén et al. 2009, Baagøe & Jensen 2007, and Klöcker 2002), eastern Baltic Sea (Ahlén et al. 2009) and North Sea (Hüppop 2009; Bach et al. 2009). A first assessment of these recordings is that it seems that they follow the typical migration routes of birds. On land it is known that bats often follow rivers, coastlines etc. on their migration (Bach et al. 2008, Furmankiewicz 2009). On a local level they use linear structures for orientation (Verboom 1998). Due to inexistence of guiding structures and the fact that bat observations were made at all offshore sites it is considered that the bats perform a broad front migration during their flight across the open sea.

The results from this study indicate that bats migrate across the Fehmarnbelt at broad front with concentrations at a few points on land as, for example, outside Hyllekrog. This means that there is no special concentration of migrating bats at sea in the area of the planned fixed link.

Assessing the importance of the Fehmarnbelt for bat migration is difficult, because there are only a few bat migration studies in Europe dealing with netting (Petersons 1990, 2004) or detector surveys (e.g. Bach et al. 2009, Ciechanowski et al. 2010; Furmankiewicz & Kucharska 2009), particularly at sea (Ahlén et al. 2009; Hüppop 2009). Taking into account the numbers of bats found at sea, the activity on land, in particular at Grüner Brink, together with the location (guiding structures along the coast at Gedser, Wallnau and the east coast of Fehmarn) and the importance for bird migration it is concluded that the Fehmarnbelt is of general importance for bat migration.

8 REFERENCES

Ahlén, I. (1997). Migratory behavior of bats at south Swedish coasts. Zeitschrift für Säugetierkunde (62), 375-380.

Ahlén, I., Bach, L., Baagøe, H. J., Pettersson, J. (2007). Bats and offshore wind turbines studied in southern Scandinavia. Report 5571, Swedish Environmental Protection Agency, Stockholm.

Ahlén, I., Bach, L., Baagøe, H. J. (2009). Behavior of Scandinavian bats during migration and foraging at sea. Journal of Mammalogy, 90(6), 1318–1323.

Baagøe, H. J. (2001). Danish bats (Mammalia: Chiroptera): Atlas and analysis of distribution, occurrence and abundance. (Z.M. Copenhagen, Ed.) Steenstrupia. 26(1), 1-117.

Baagøe, H.J., JENSEN, T.S. (2007). Dansk pattedye atlas. Gyldendal, Copenhagen.

Bach, L. & R. Rahmel (2007). Offshore-Windenergieanlagen und Fledermäuse. In: PETERS, W. et al. (2007). Berücksichtigung von Auswirkungen auf die Meeresumwelt bei der Zulassung von Windparks in der ausschließlichen Wirtschaftszone. Endbericht eines Forschungsvorhabens, gefördert aus Mitteln des Bundesumweltministeriums (FKZ 0329949). Berlin.

Bach, L. , Bach, P., Helge, A., Maatz, K, Schwarz, V., Teuscher, E., Zöllner, J. (2009). Fledermauszug auf Wangerooge – erste Ergebnisse aus dem Jahr 2008. – Natur- und Umweltschutz (Zeitschrift Mellumrat) Band 8, Heft 1, 10-12.

Barrat, E. M., Deaville, R., Burland, T. M., Bruford, M. W., Jones, G., Racey, P. A. & Wayne, R. K.(1997). DNA answers the call of pipistrelle bat species. Nature 387,138-139.

Bruderer, B. & Popa-Lisseanu, A. G. (2005). Radar data on wingbeat frequencies and flightspeeds of two bat species. Acta Chriopterologica 7, 73-82

Ciechanowski, M. , Zajac, T., Zielinska, A., Dunajski, R. (2010). Seasonal activity patterns of seven vespertilionid bat species in Polish lowlands. – Acta Threriologica 55(4), 301-314.

Dietz, C. , Helversen Von, O., Nill, D. (2007). Handbuch der Fledermäuse Europas und Nordwestafrikas. Stuttgart: Kosmos.

Fleming, T. H., Eby, P. (2003). Ecology of bat migration, 156-208. In: Bat ecology (Kunz, T. H. and Fenton, M. B. eds.). University of Chicago Press, Chicago, Illinois.

Furmankiewicz, J., Kucharska, M. (2009). Migration of bats along a large river valley in southwester Poland. Journal of Mammalogy, 90(6), 1310–1317.

Gerell, R. (1987). Do Swedish bats migrate? Fauna och flora (Stockholm). 82, 79-83.

Holland, R. A. & Wikelski, M.(2009). Studying the migratory behaviour of individual bats: Current techniques and future directions. Journal of Mammology, 90(6), 1324-1329

Hüppop, O., Hill, R., Hüppop, K., Jachmann, F. (2009). Auswirkungen auf den Vogelzug, Begleitforschung im Offshore-Bereich auf Forschungsplattformen in der Nordsee. FINOBIRD final report, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Bonn.

Hutterer, R., Ivanova, T., Meyer-Cords, C., Rodrigues, L. (2005). Bat Migration in Europe. Bat Migration in Europe - A Review of Banding Data and Literature , 111. (B. f. (BfN), Ed.).

Kahlert, J., Petersen, I.K. & Desholm, M. (2007): Effects on birds of the Rødsand 2 offshore wind farm: Environmental Impact Assessment. NERI report.

Klöcker, T. (2002). Vergleichende Untersuchung wandernder Fledermausarten in zwei Untersuchungsgebieten Schleswig-Holsteins, 137.

Leguan GMBH (2011): Feste Fehmarnbeltquerung, deutsche Festlandseite - Biologische Untersuchungen. Report to Femern A/S, 608.

Nicholls, B., & Racey, P. (2009). The Aversive Effect of Electromagnetic Radiation on Foraging Bats—A Possible Means of Discouraging Bats from Approaching Wind Turbines. Aberdeen, Untited Kingdom. PLoS ONE 4(7): e6246. doi:10.1371/journal.pone.0006246

Nicholls, B., & Racey, P. (2007). Bats Avoid Radar Installations: Could Electromagnetic Fields Deter Bats from Colliding with Wind Turbines? Aberdeen, Untited Kingdom.

Petersons, G. (1990). Die Rauhautfledermaus, *Pipistrellus nathusii* (Keyserling & Blasius, 1839), in Lettland: Vorkommen, Phänologie und Migration. Nyctalus 3, 81-98.

Petersons G. (2004). Seasonal migrations of north-eastern populations of Nathusius‘ bat *Pipistrellus nathusii* (Chiroptera). Myotis, 29-56.

Popa-Lisseanu, A.G., Voigt, C.C. (2009). Bats on the move. Journal of Mammalogy, 90(6), 1283–1289.

Schumann, M. (2009). Vierstreifiger Ausbau der B 207 zwischen Heiligenhafen. Report. Preez: Landesbetrieb für Straßenbau und Verkehr SH.

Skiba, R. (2007). Die Fledermäuse im Bereich der Deutschen Nordsee unter Berücksichtigung der Gefährdungen durch Windenergieanlagen (WEA). Nyctalus (N.F.), 12:199-220.

Skiba, R. (2009). Europäische Fledermäuse- Kennzeichen, Echoortung und Detektoranwendung. Hohenwarsleben: Westarp Wissenschaftenverlagsgeslel-lschaft.

Skov, H., Jensen, N. E., Durinck, J., Jensen, B. P., Leonhard, S. (2008). Rødsand 2 land migration. Baseline autumn 2008. DHI report to E.ON.

Strellkov, P. P. (1969). Migratory and stationary bats (Chiroptera) of the European part of the Soviet Union. Acta Zoologica (14), 393-440.

Vauk, G. (1974). Fledermausbeobachtungen auf der Insel Helgoland. Zeitschrift für Säugetierkunde, 39, 133-135.

Verboom, B. (1998). The use of edge habitats by commuting and foraging bats. – IBN Scientific Contributions 10, 120.

Walter, G., Matthes H. & JOOST M. (2007). Fledermauszug über Nord- und Ostsee – Ergebnisse aus Offshore-Untersuchungen und deren Einordnung in das bisher bekannte Bild zum Zuggeschehen. Nyctalus (N.F.) 12, 221-233.

Internet sources

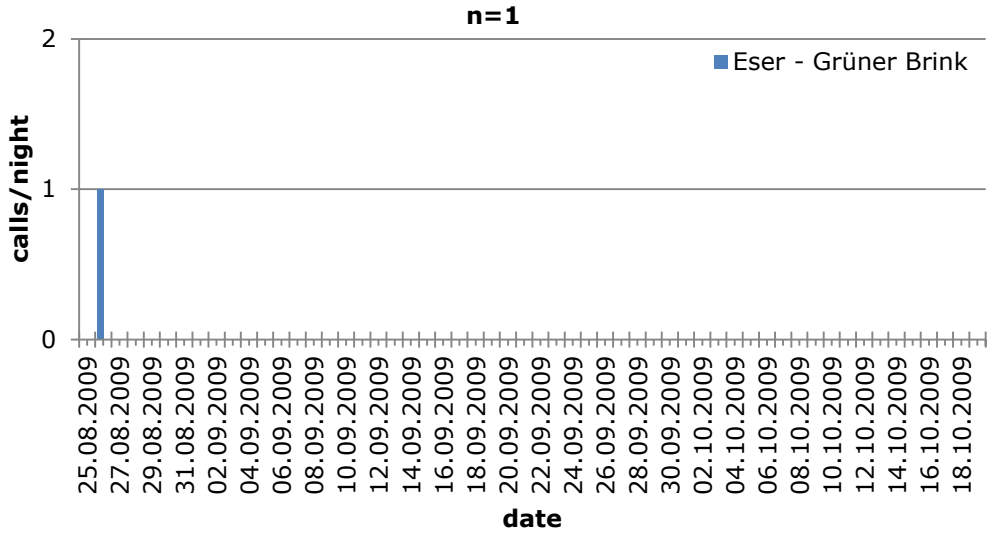
Naturschutzbund (NABU)(n.d.). Teichfledermaus. [http://schleswig-holstein.nabu.de/naturvorort/fledermaeuse/fledermausarteninschleswig-holstein/03056.htm, accessed January 7 2011]

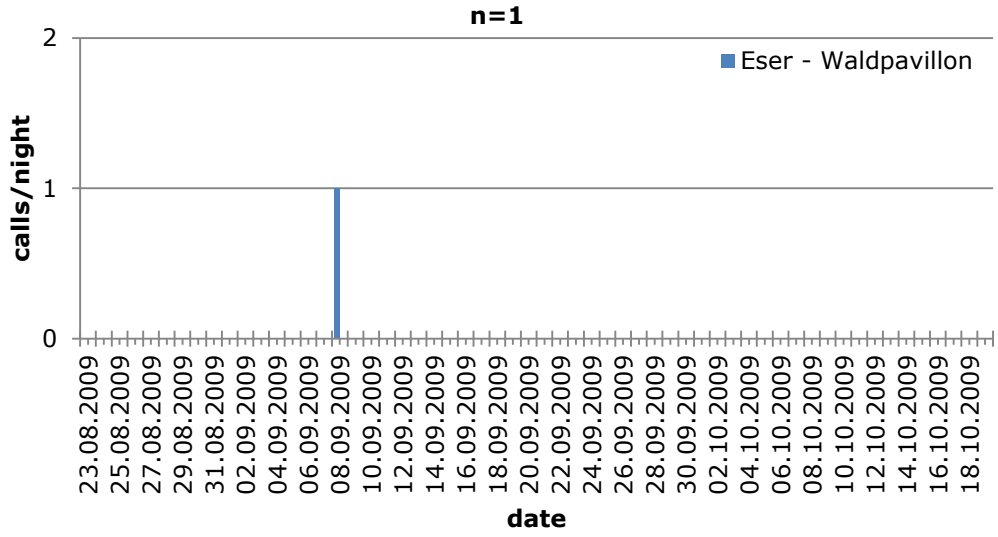
List of figures

List of tables

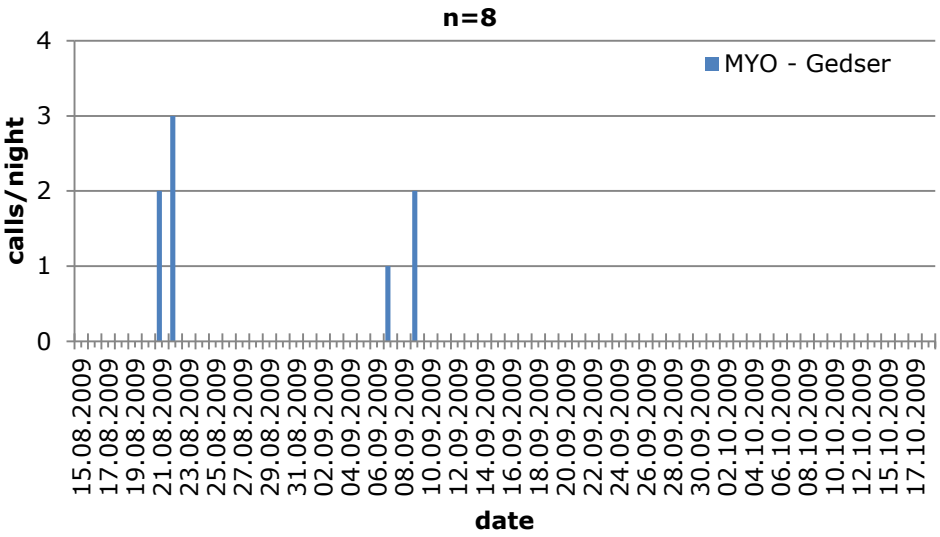
APPENDIX A – BAT RECORDINGS

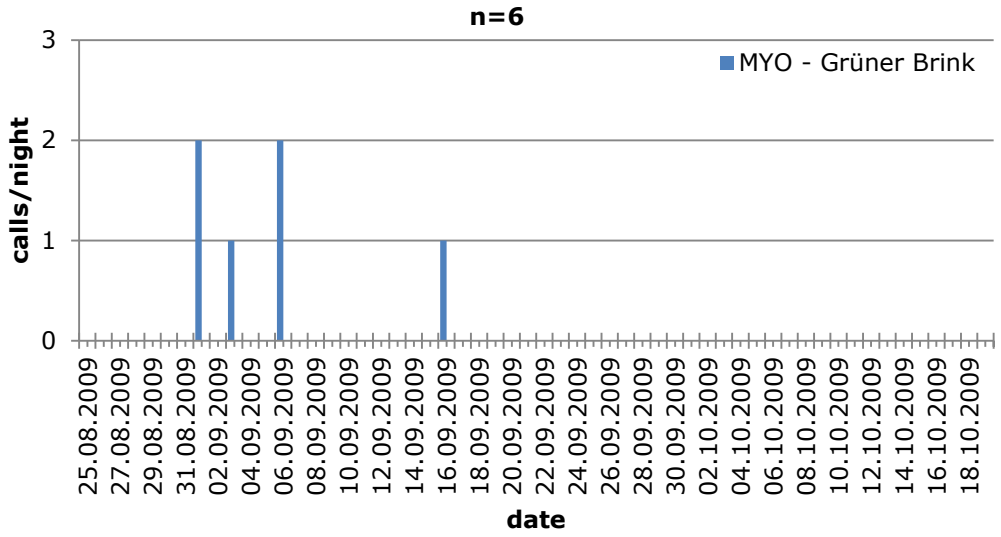
Eser - 2009

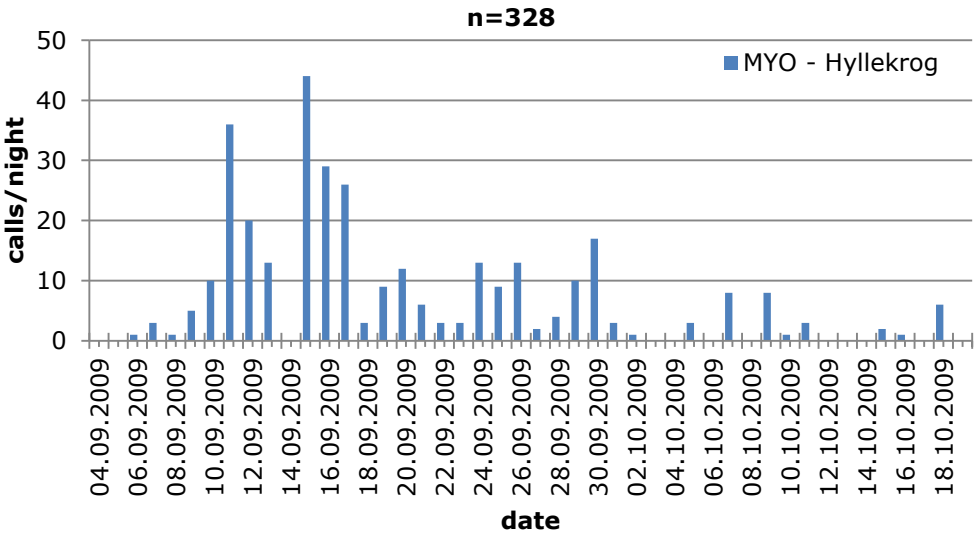


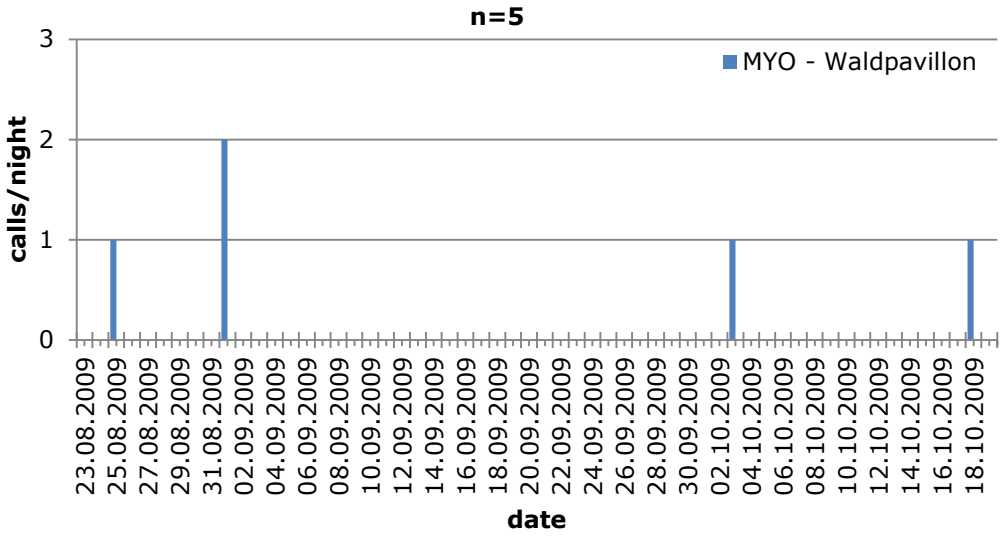


MYO – Autumn 2009

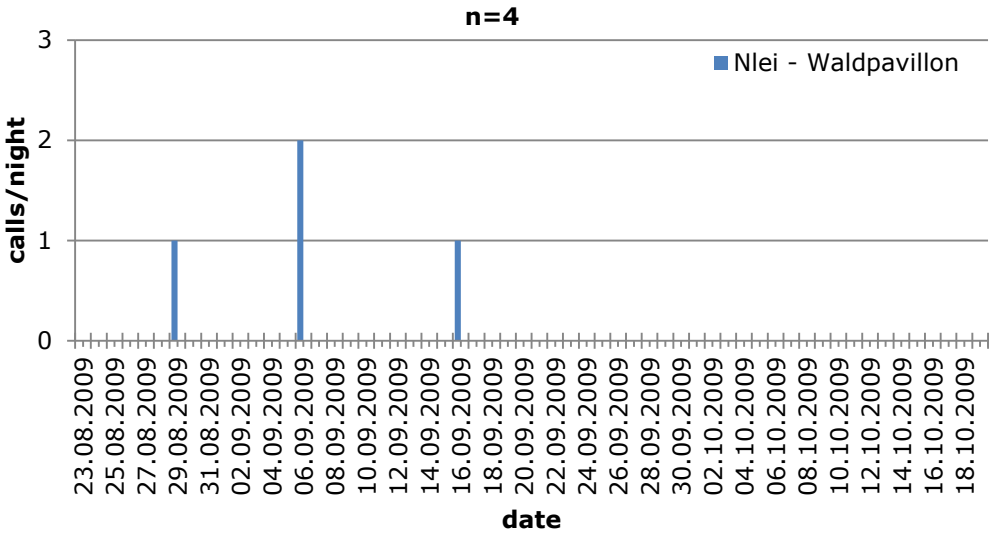




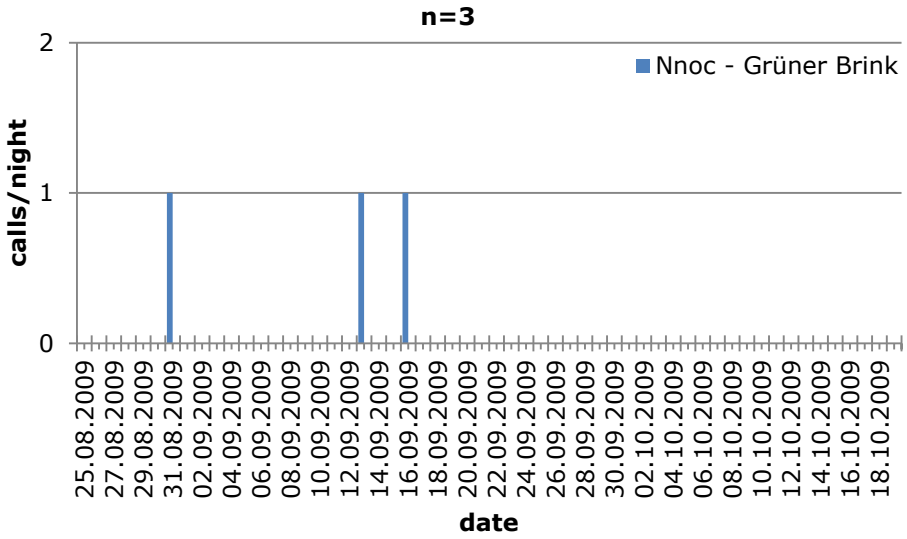


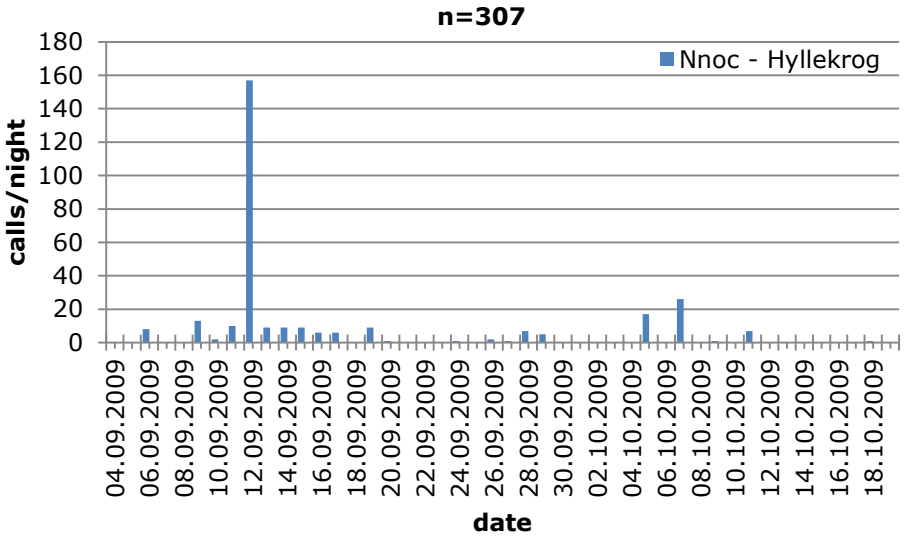


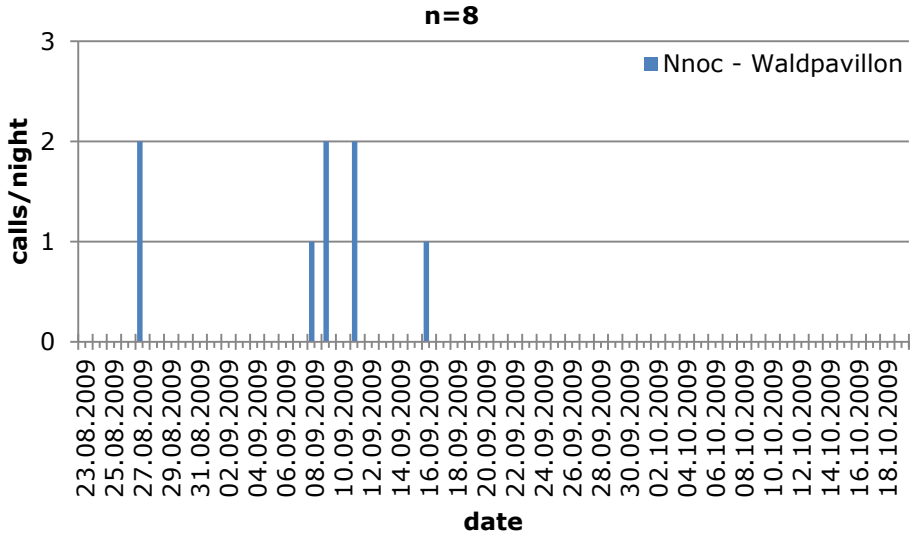
Nlei – Autumn 2009



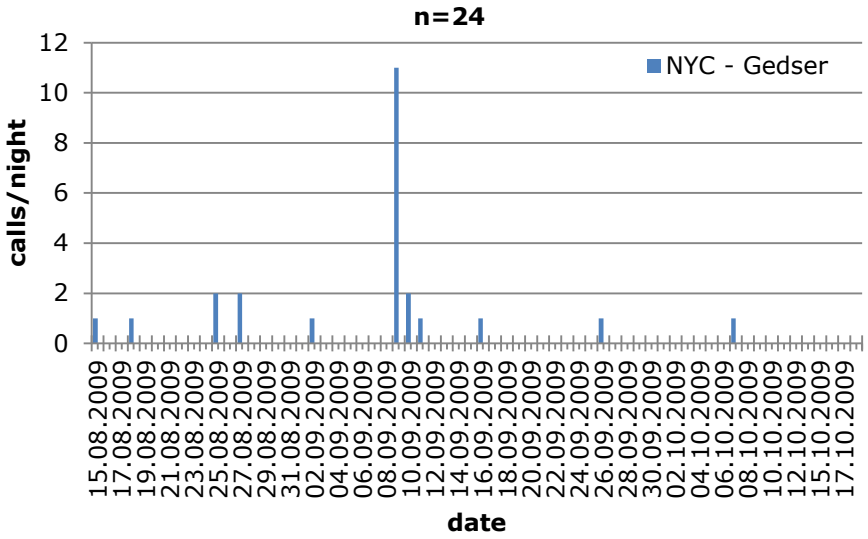
Nnoc – autumn 2009

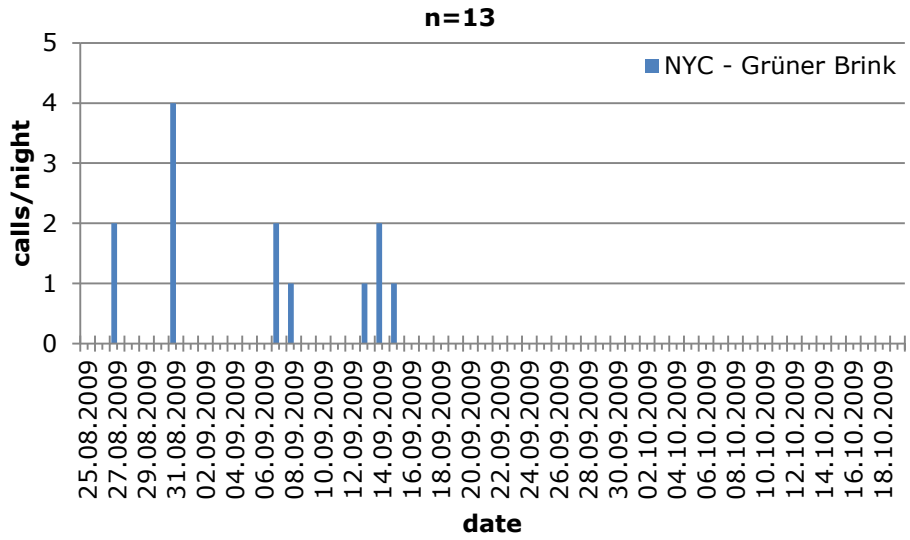


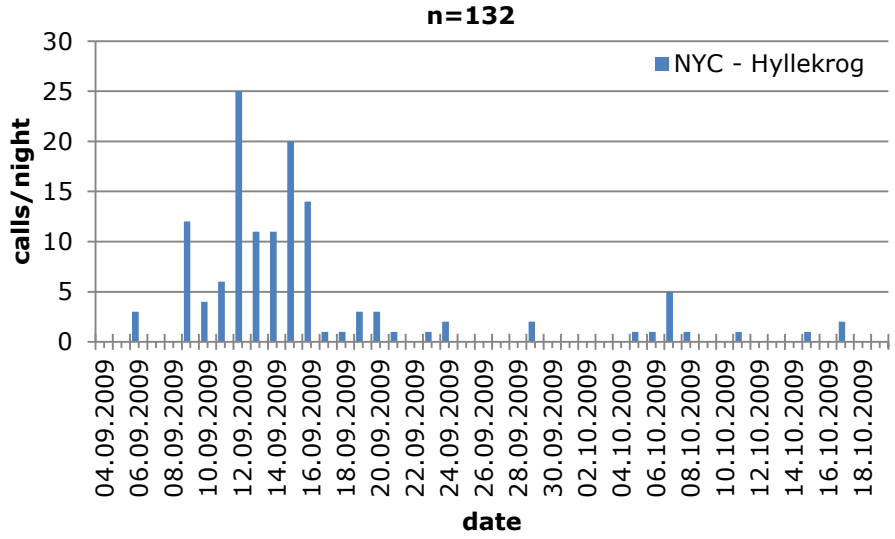


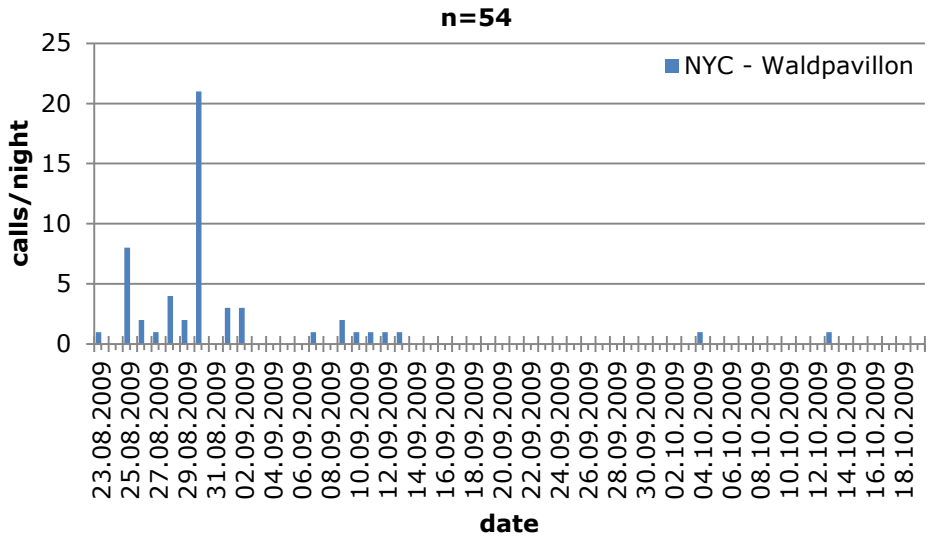


NYC – autumn 2009

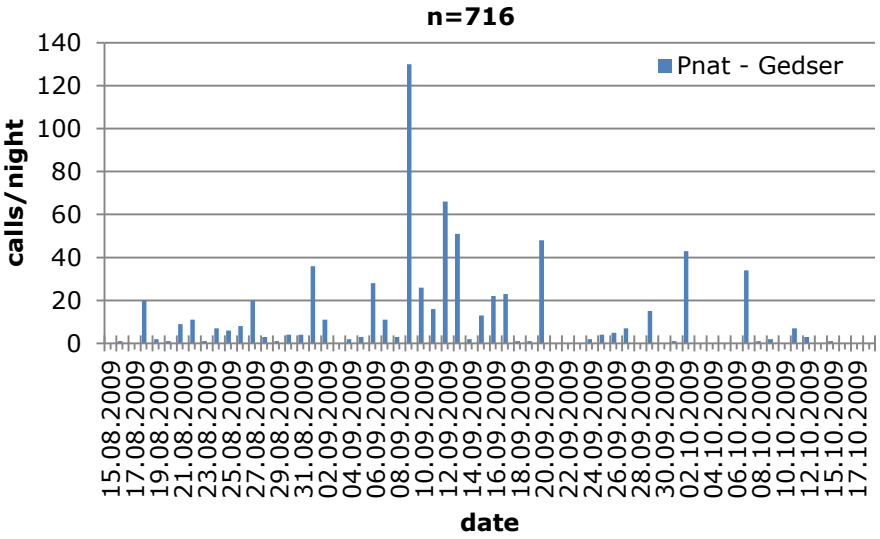


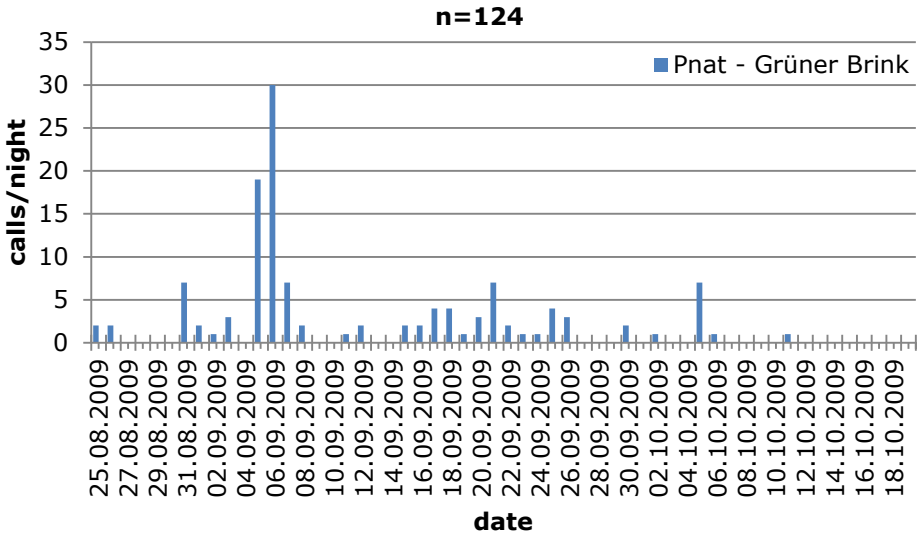


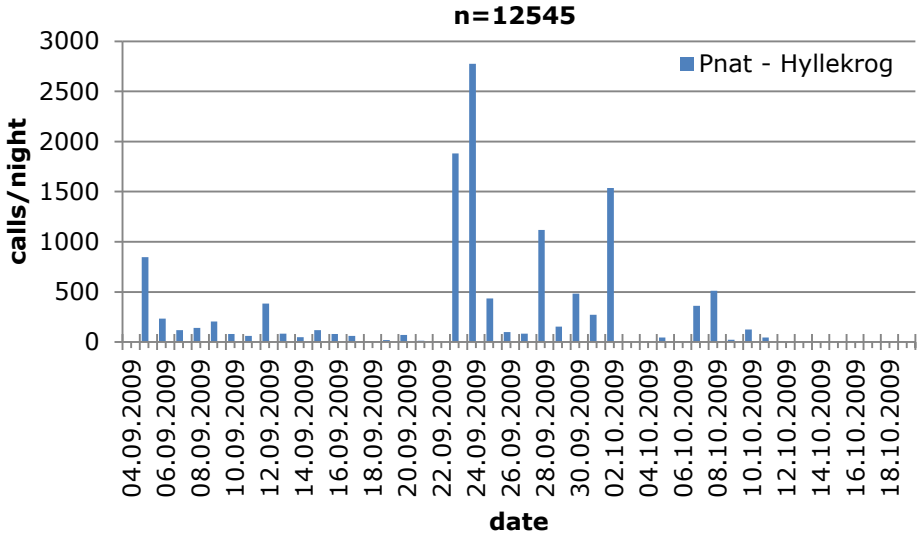


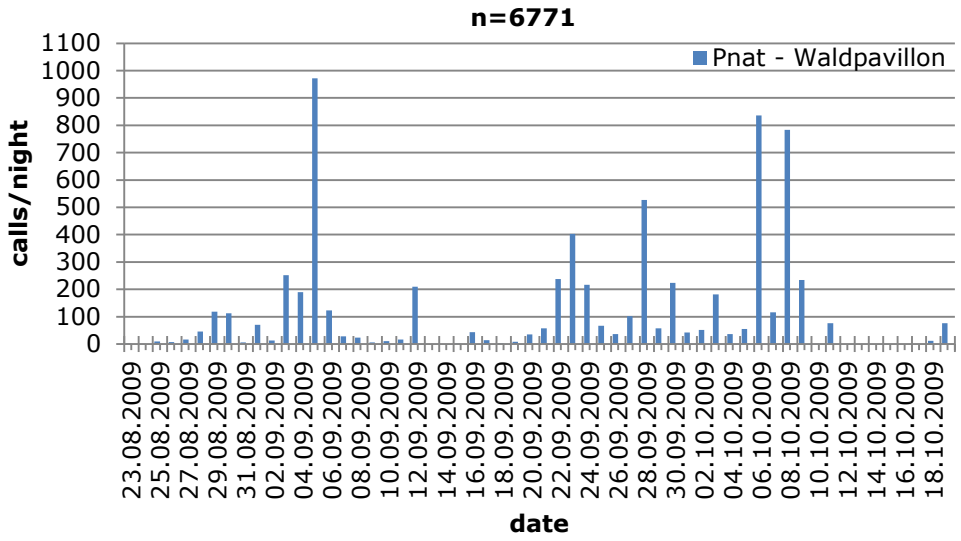

n=54
NYC - Waldpavillon
calls/night
25
20
15
10
5
0
23.08.2009
25.08.2009
27.08.2009
29.08.2009
31.08.2009
02.09.2009
04.09.2009
06.09.2009
08.09.2009
10.09.2009
12.09.2009
14.09.2009
16.09.2009
18.09.2009
20.09.2009
22.09.2009
24.09.2009
26.09.2009
28.09.2009
30.09.2009
02.10.2009
04.10.2009
06.10.2009
08.10.2009
10.10.2009
12.10.2009
14.10.2009
16.10.2009
18.10.2009
date

Pnat – Autumn 2009

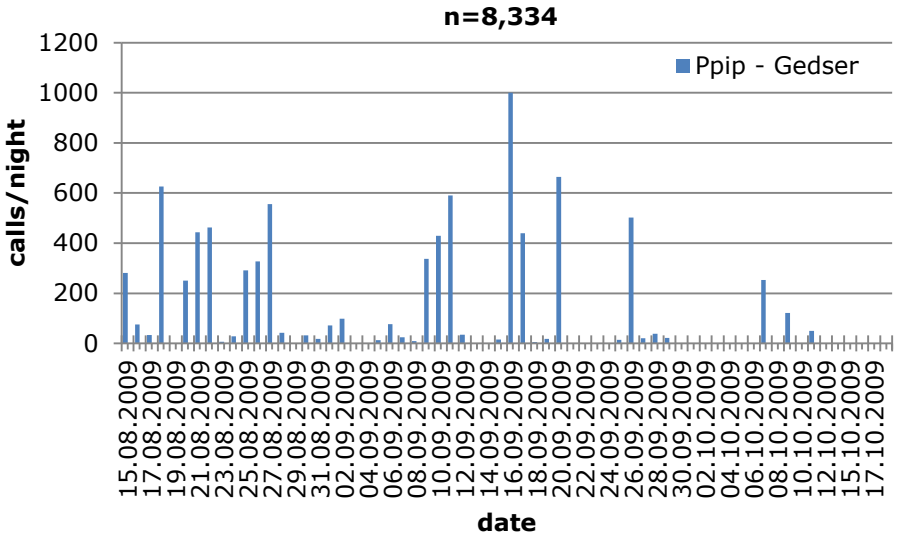


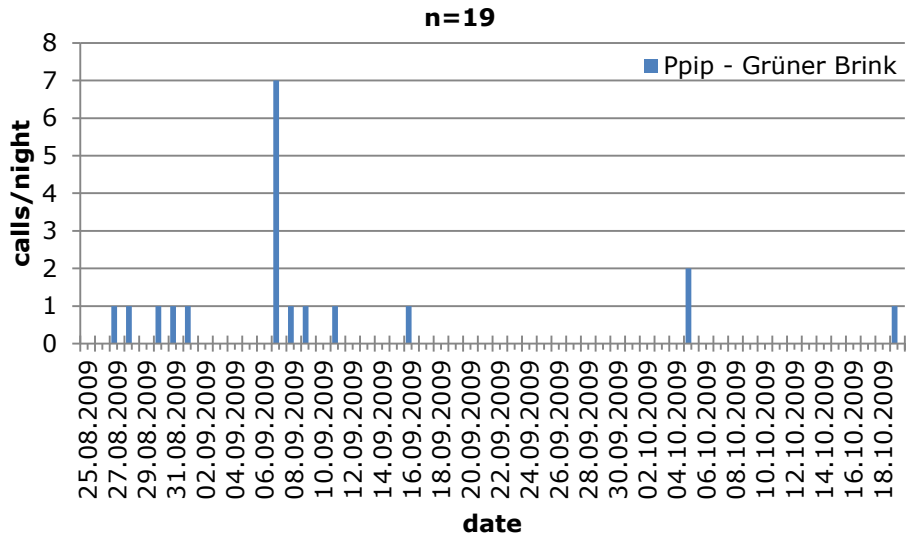


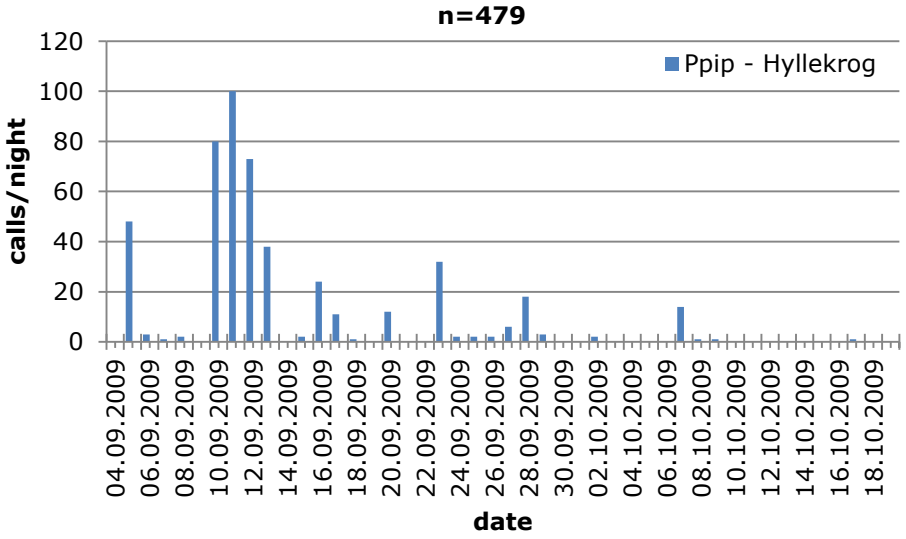


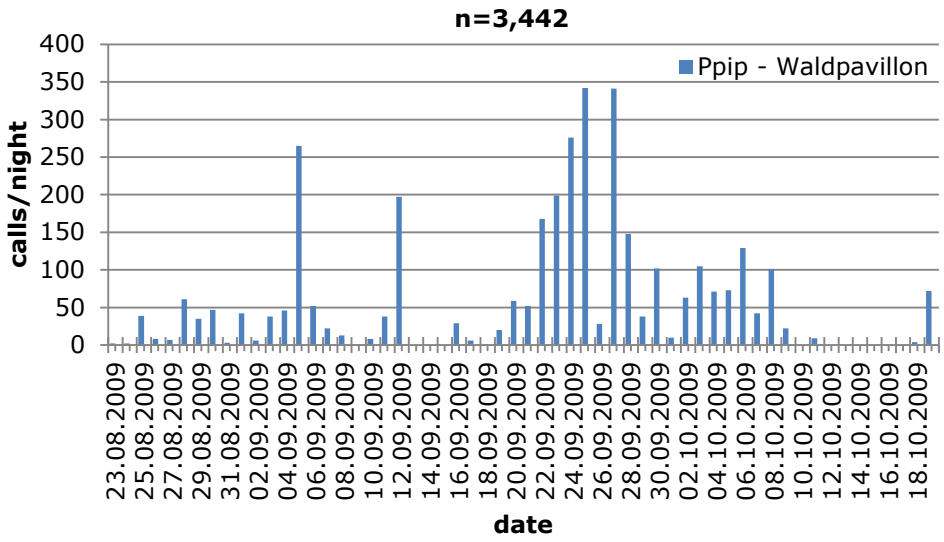

n=6771
Pnat - Waldpavillon
calls/night
1100
1000
900
800
700
600
500
400
300
200
100
0
23.08.2009
25.08.2009
27.08.2009
29.08.2009
31.08.2009
02.09.2009
04.09.2009
06.09.2009
08.09.2009
10.09.2009
12.09.2009
14.09.2009
16.09.2009
18.09.2009
20.09.2009
22.09.2009
24.09.2009
26.09.2009
28.09.2009
30.09.2009
02.10.2009
04.10.2009
06.10.2009
08.10.2009
10.10.2009
12.10.2009
14.10.2009
16.10.2009
18.10.2009
date

Ppip – autumn 2009

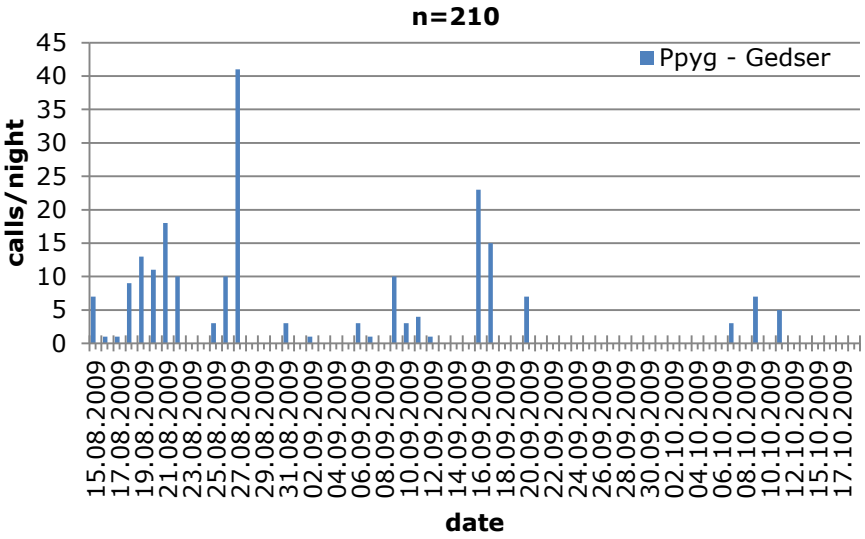


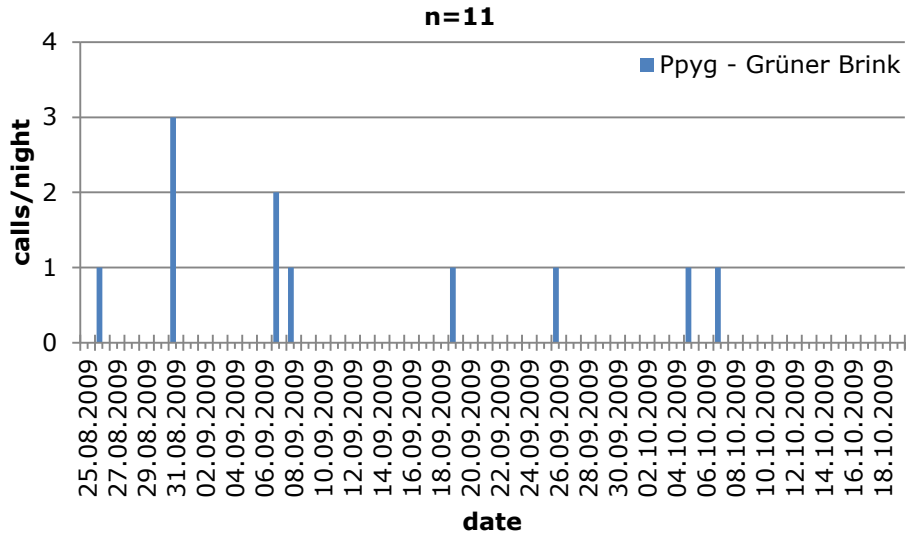


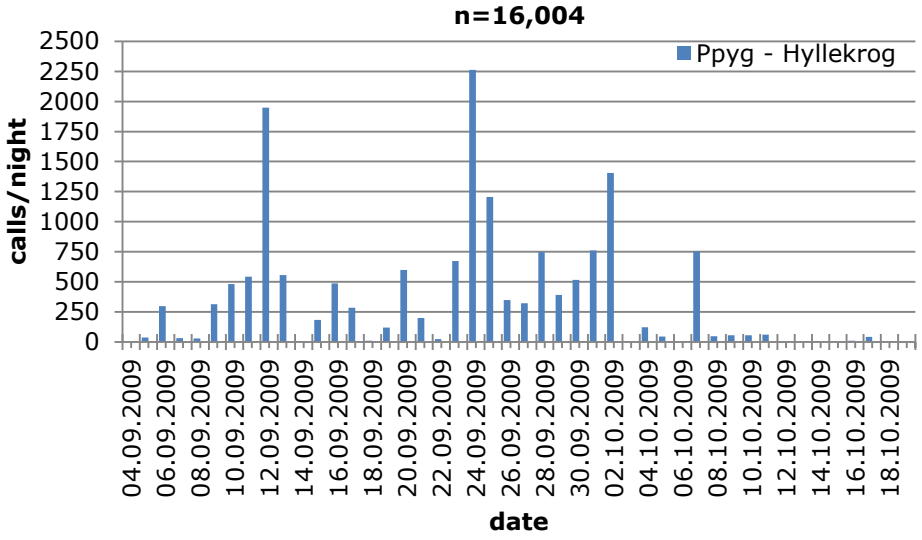


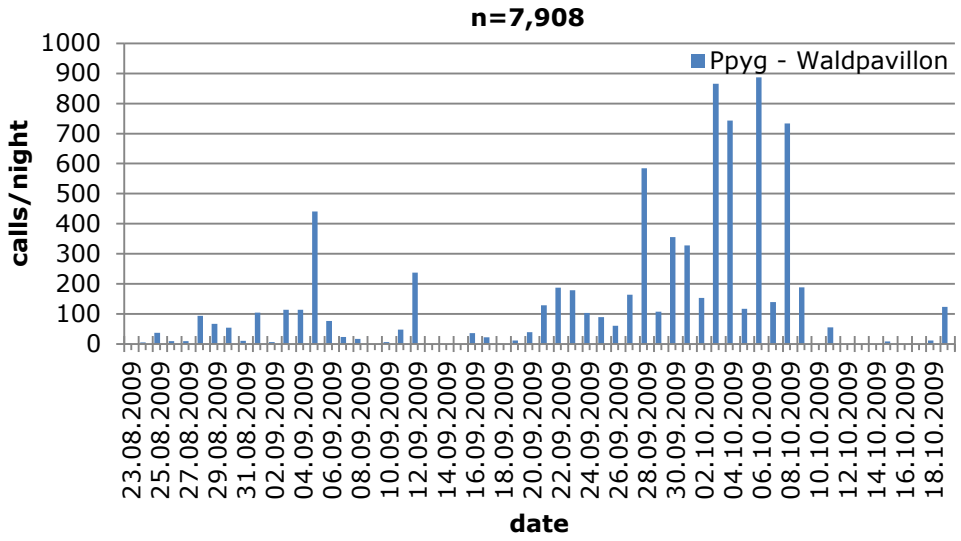

n=3,442
Ppip - Waldpavillon
calls/night
400
350
300
250
200
150
100
50
0
23.08.2009
25.08.2009
27.08.2009
29.08.2009
31.08.2009
02.09.2009
04.09.2009
06.09.2009
08.09.2009
10.09.2009
12.09.2009
14.09.2009
16.09.2009
18.09.2009
20.09.2009
22.09.2009
24.09.2009
26.09.2009
28.09.2009
30.09.2009
02.10.2009
04.10.2009
06.10.2009
08.10.2009
10.10.2009
12.10.2009
14.10.2009
16.10.2009
18.10.2009
date

Ppyg -autumn 2009

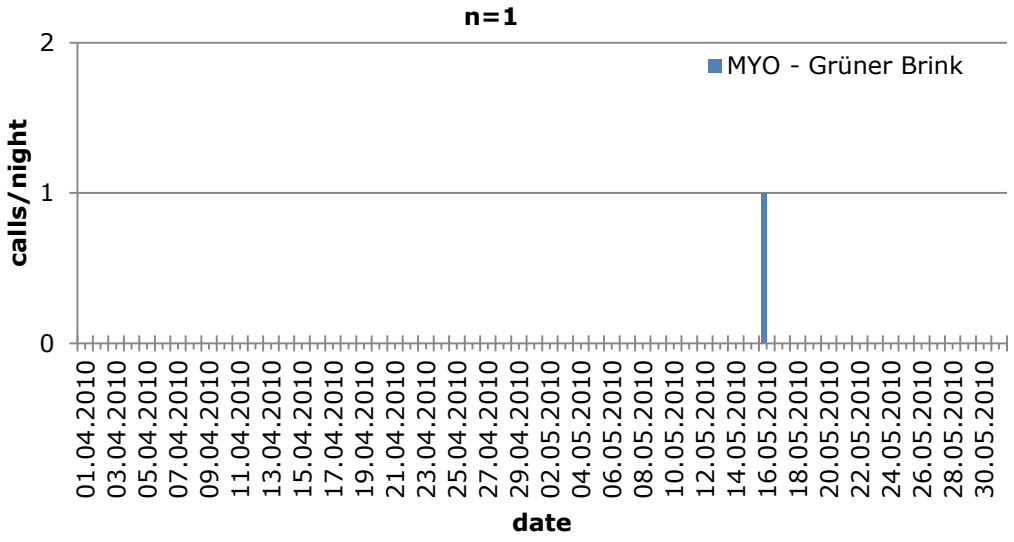


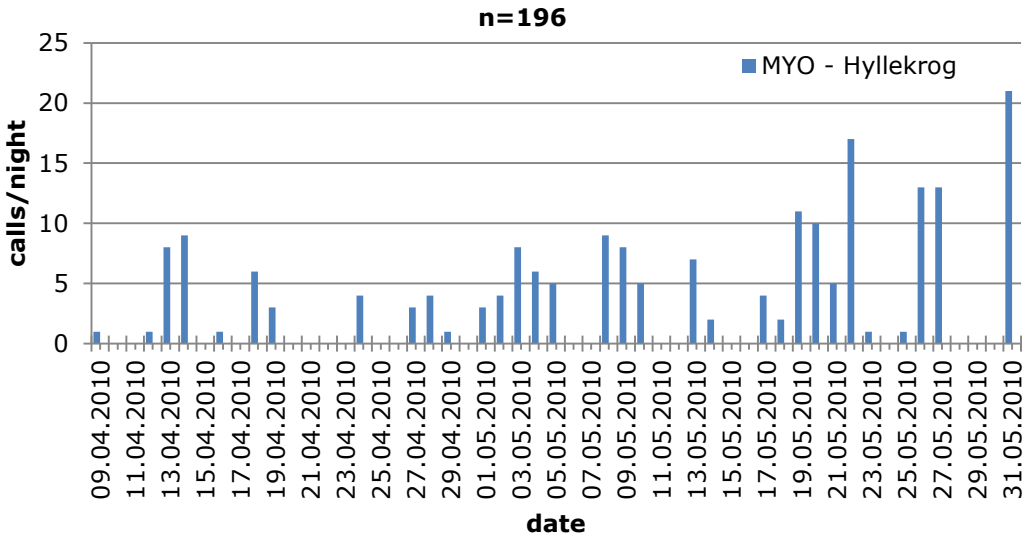


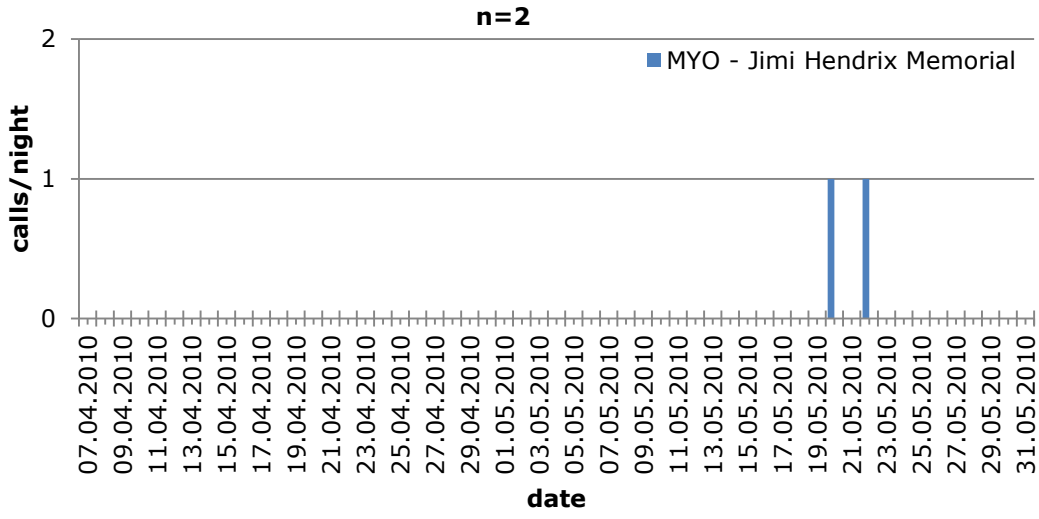


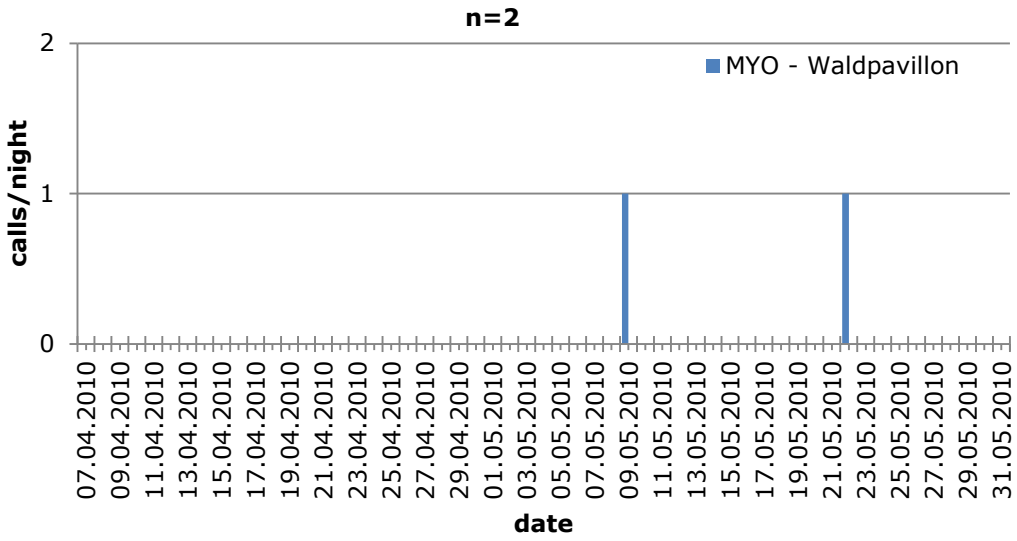

n=7,908
Ppyg - Waldpavillon
calls/night
1000
900
800
700
600
500
400
300
200
100
0
23.08.2009
25.08.2009
27.08.2009
29.08.2009
31.08.2009
02.09.2009
04.09.2009
06.09.2009
08.09.2009
10.09.2009
12.09.2009
14.09.2009
16.09.2009
18.09.2009
20.09.2009
22.09.2009
24.09.2009
26.09.2009
28.09.2009
30.09.2009
02.10.2009
04.10.2009
06.10.2009
08.10.2009
10.10.2009
12.10.2009
14.10.2009
16.10.2009
18.10.2009
date

MYO - Spring 2010

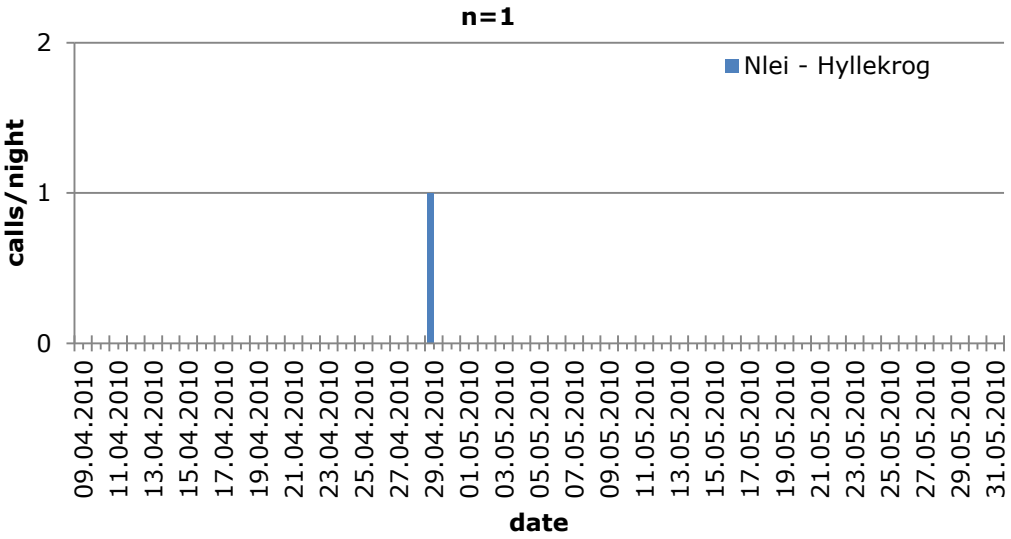




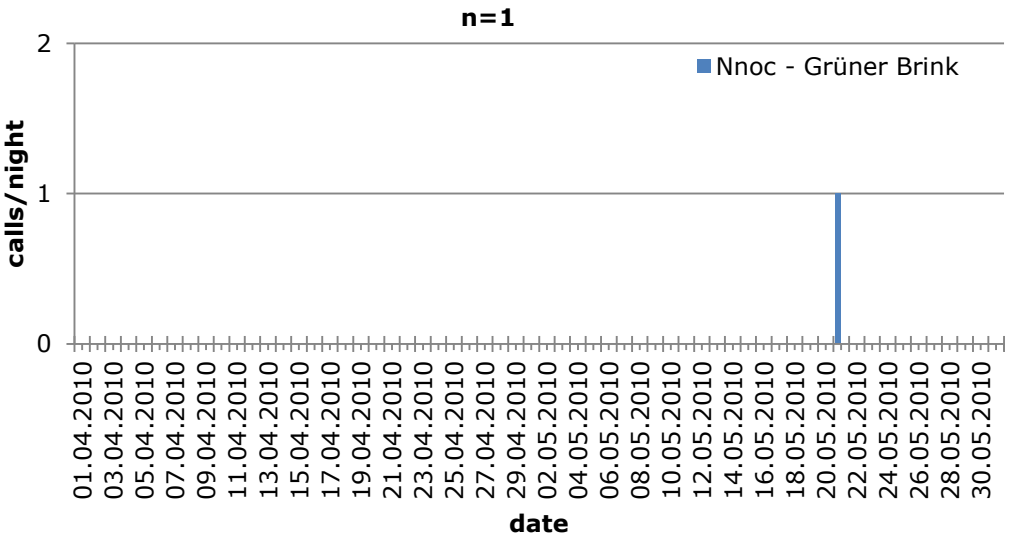


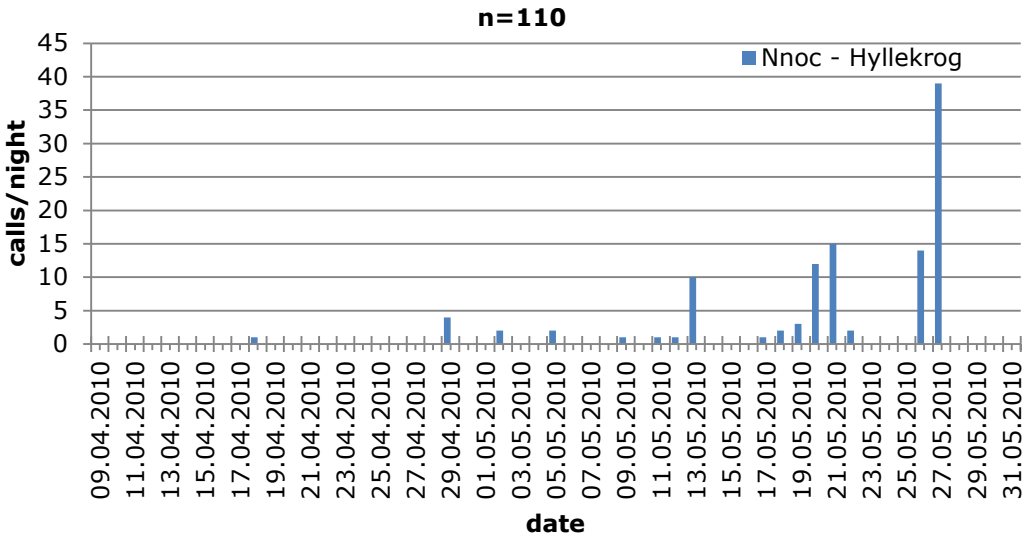

n=2
MYO - Waldpavillon
calls/night
2
1
0
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

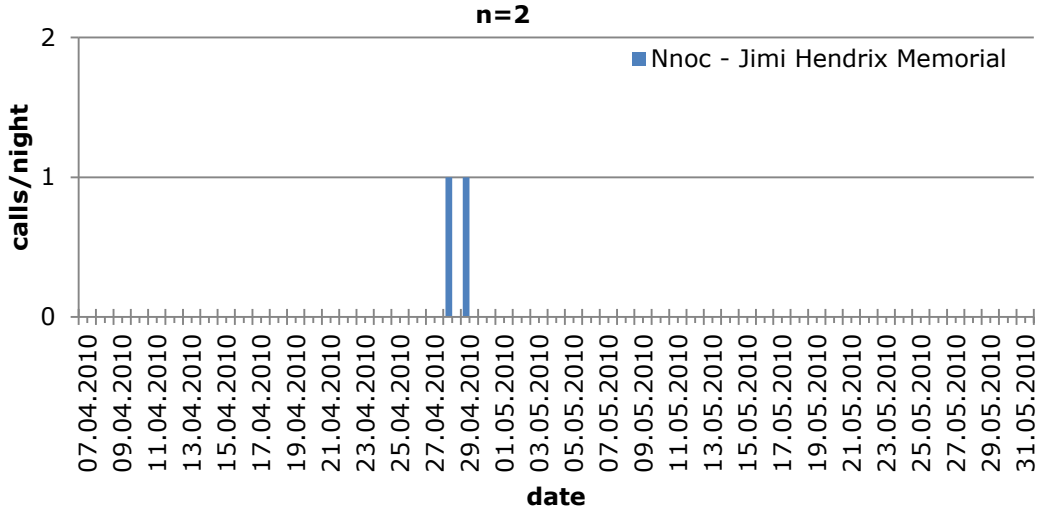
Nlei - Spring 2010

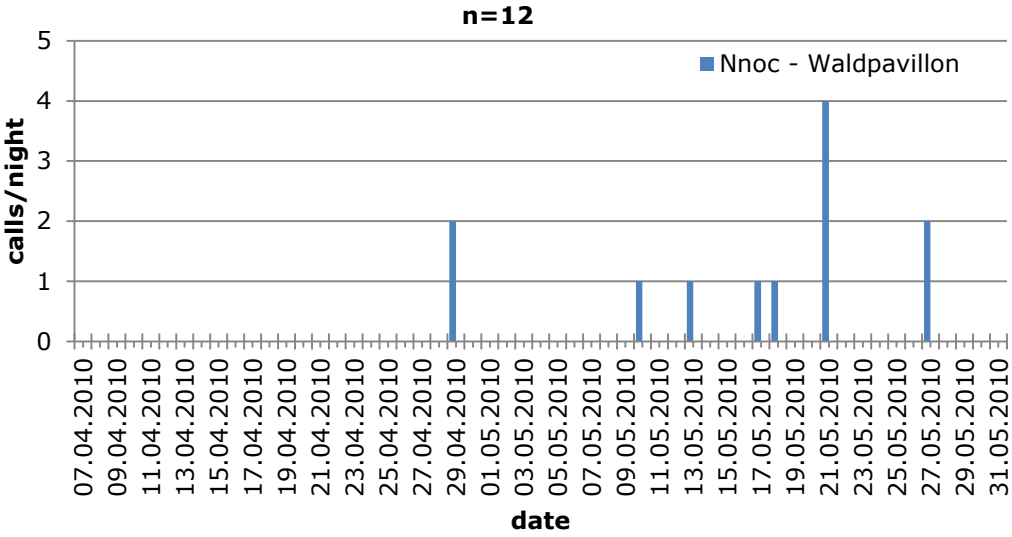


Nnoc - Spring 2010

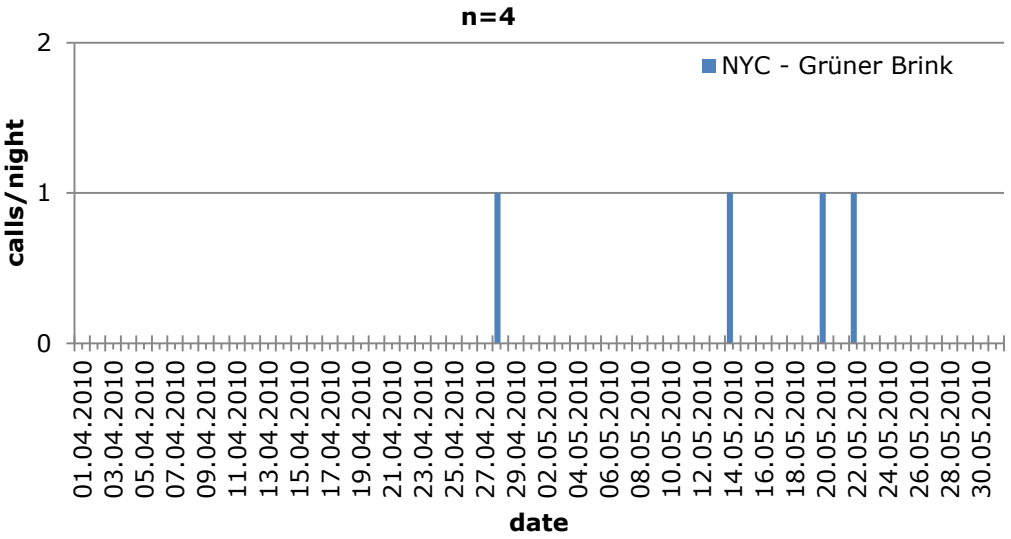


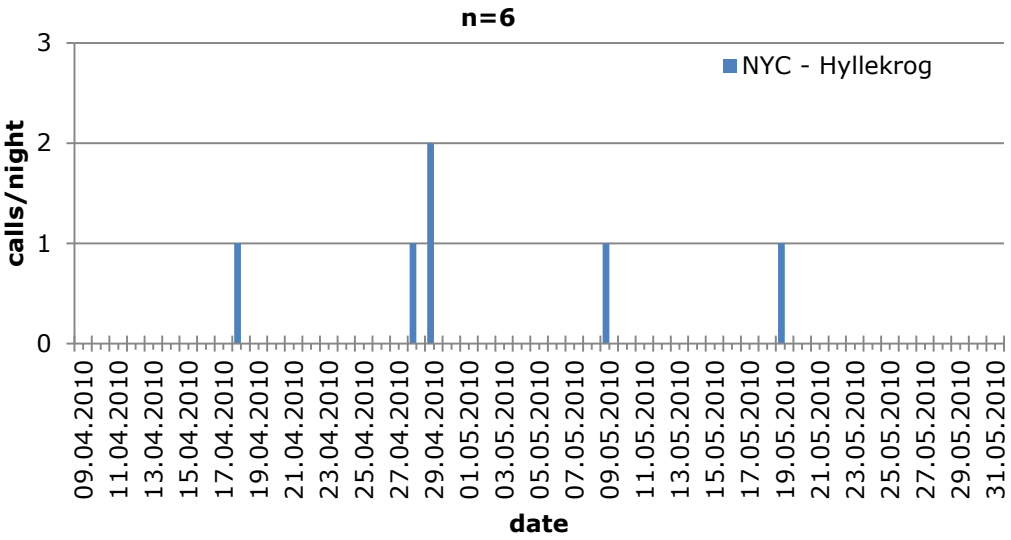

n=110
Nnoc - Hyllekrog
calls/night
0
5
10
15
20
25
30
35
40
45
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

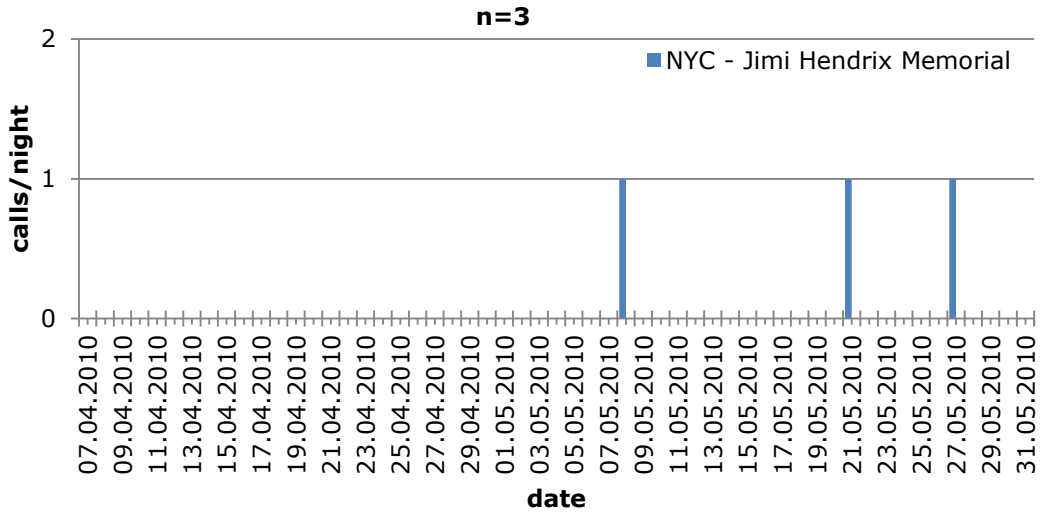

n=2
Nnoc - Jimi Hendrix Memorial
calls/night
0
1
2
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

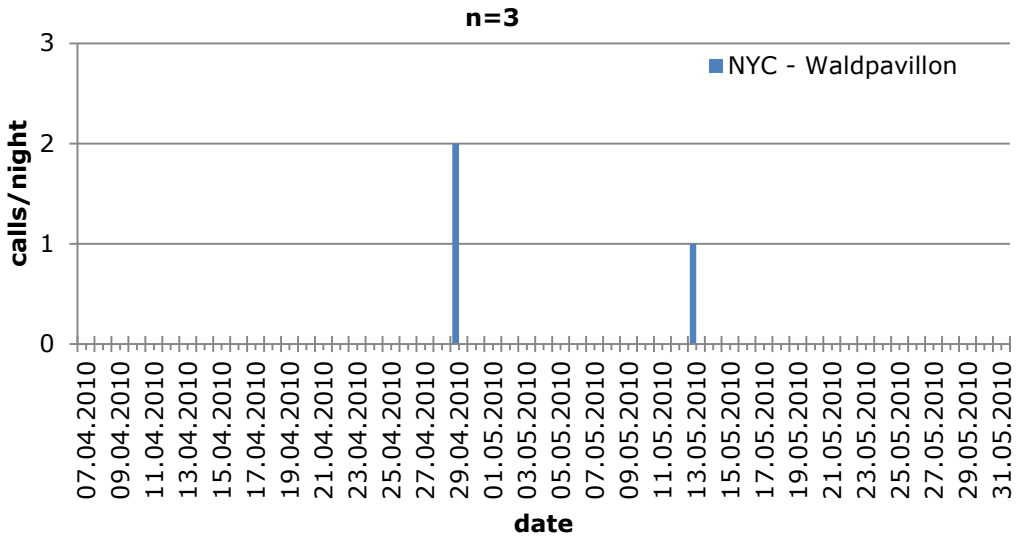

n=12
Nnoc - Waldpavillon
calls/night
0
1
2
3
4
5
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

NYC - Spring 2010

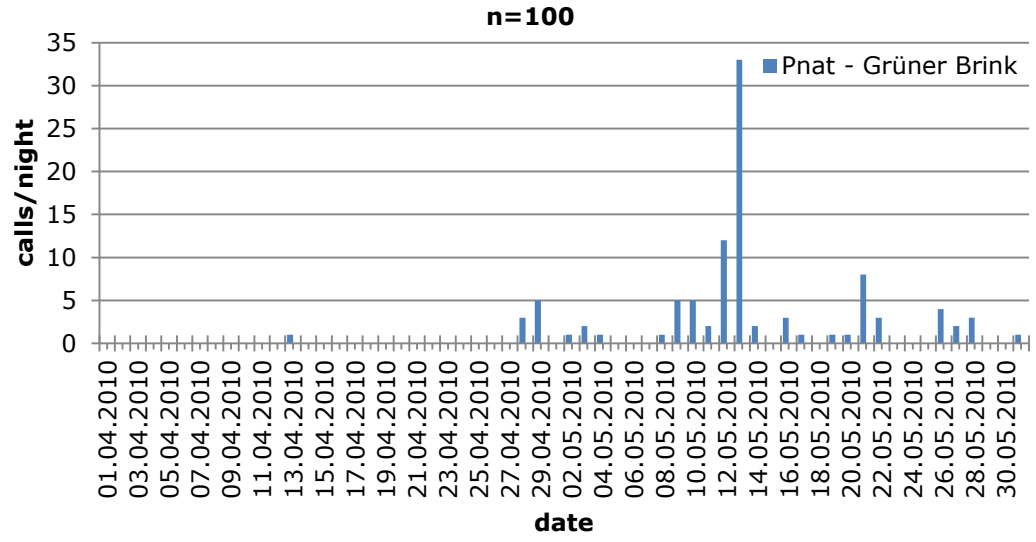


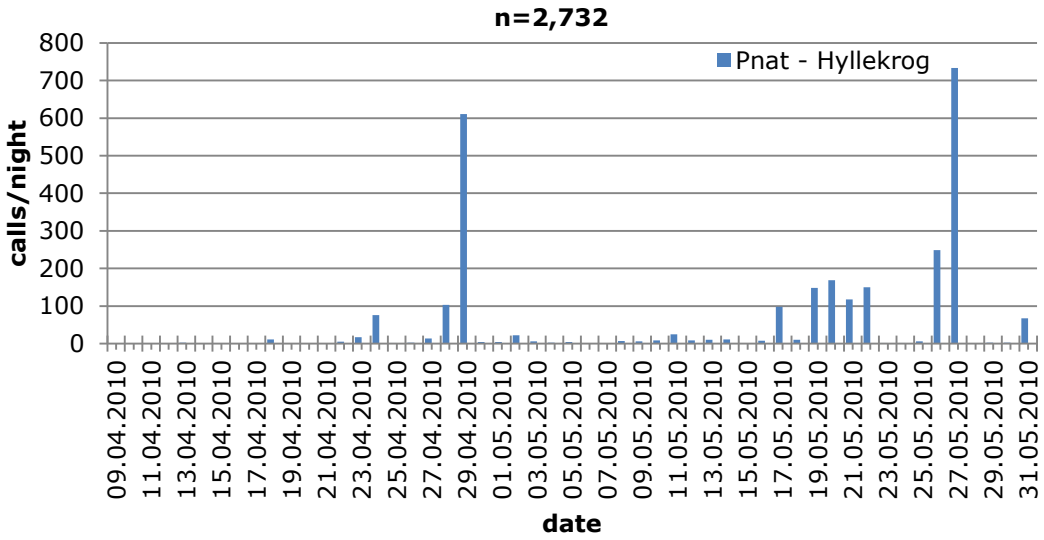


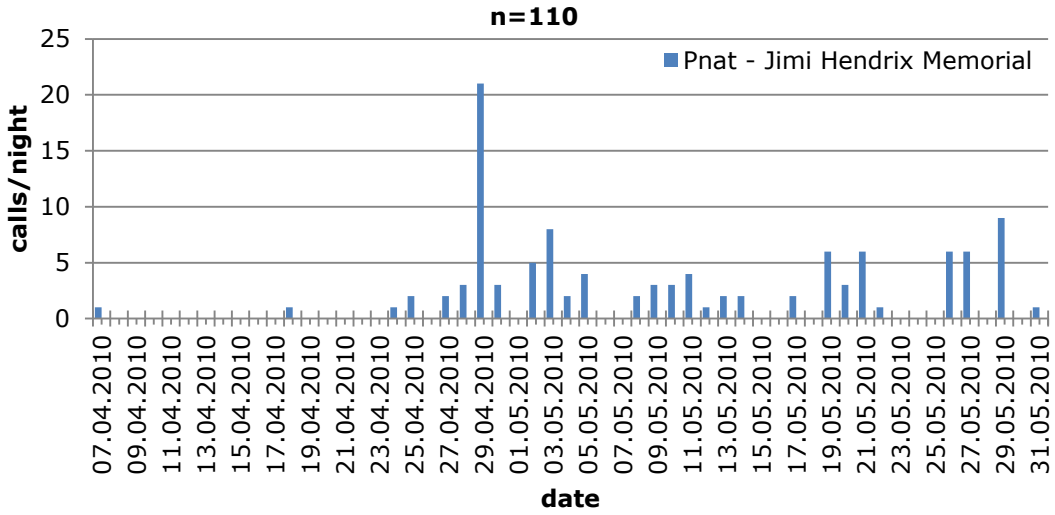


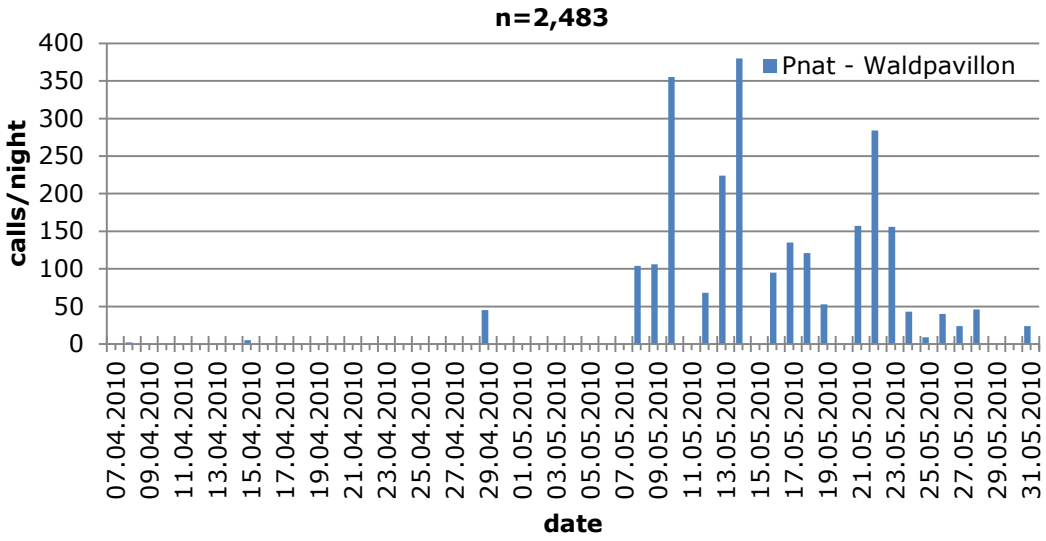

n=3
NYC - Waldpavillon
calls/night
0
1
2
3
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

Pnat - Spring 2010

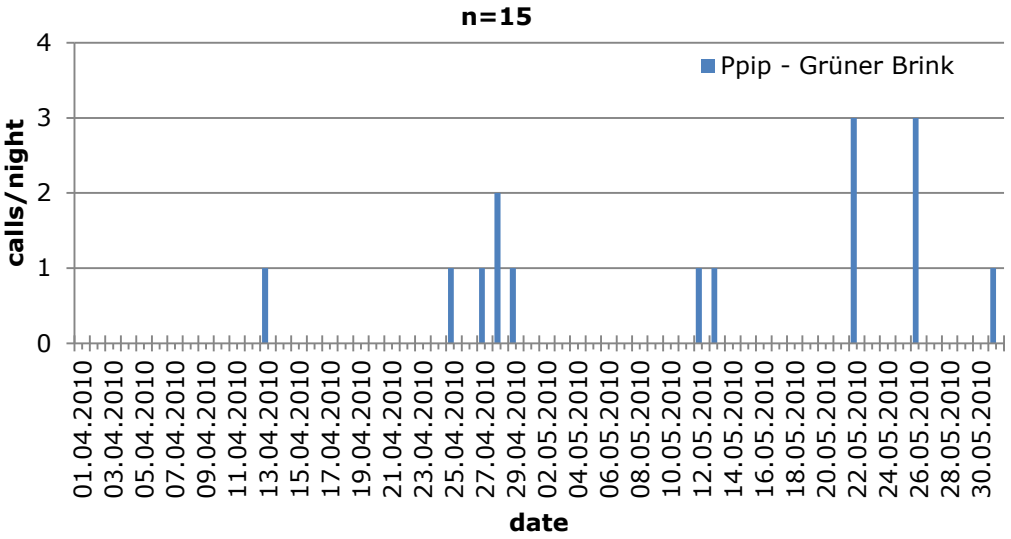


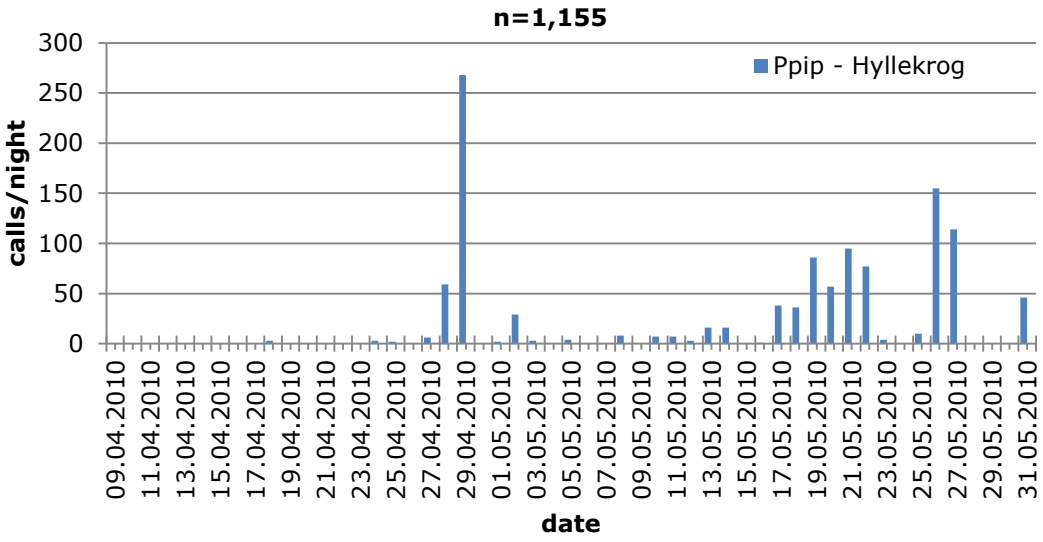


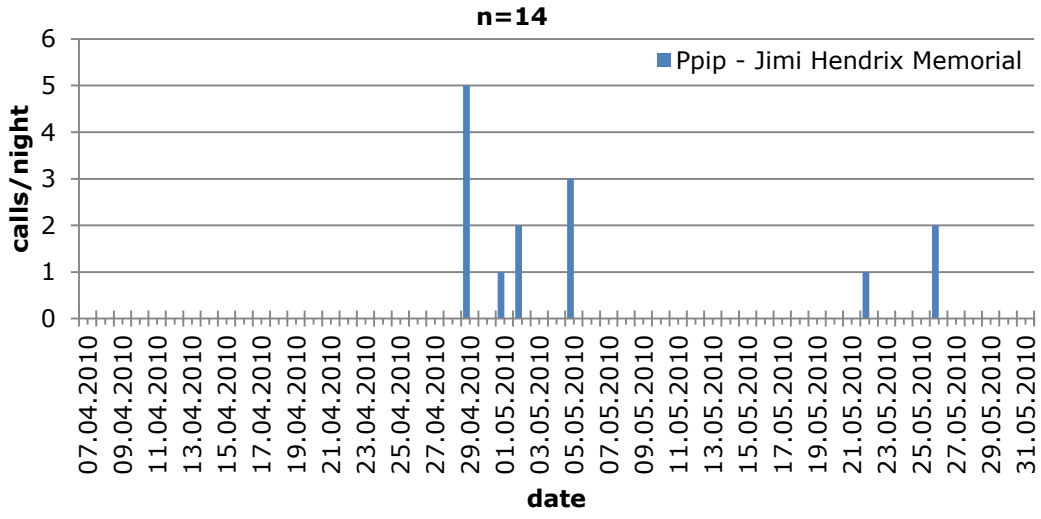


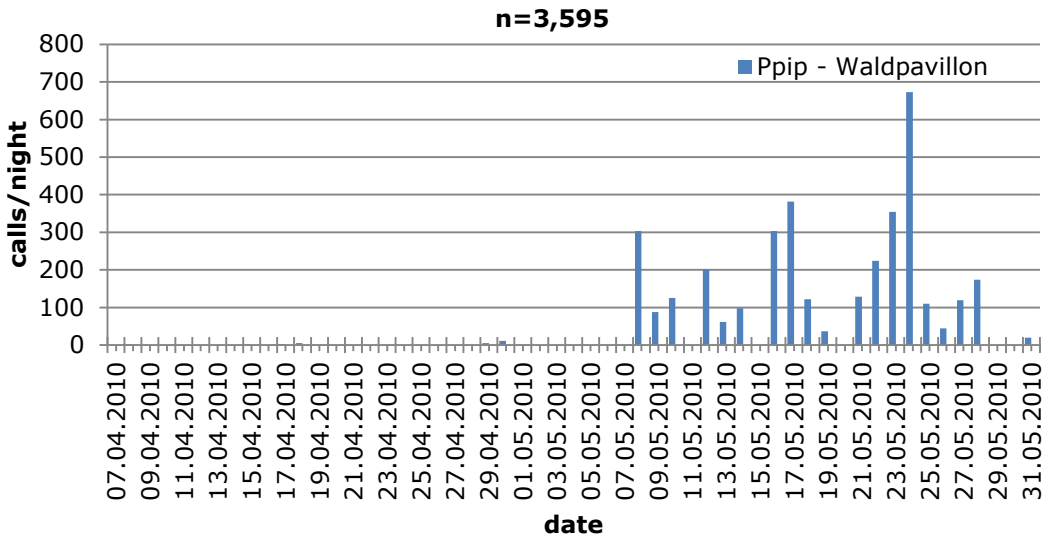

n=2,483
Pnat - Waldpavillon
calls/night
400
350
300
250
200
150
100
50
0
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

Ppip - Spring 2010

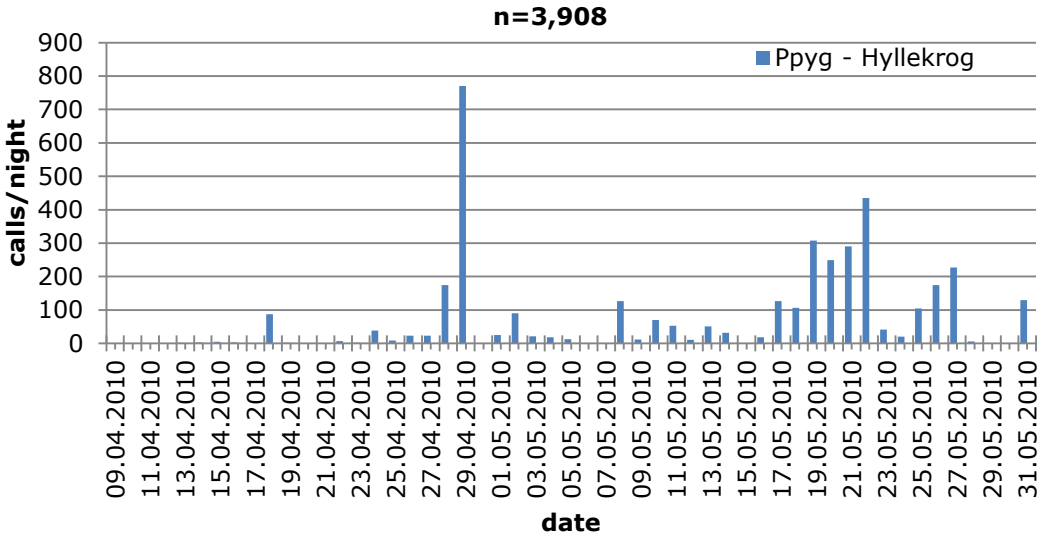


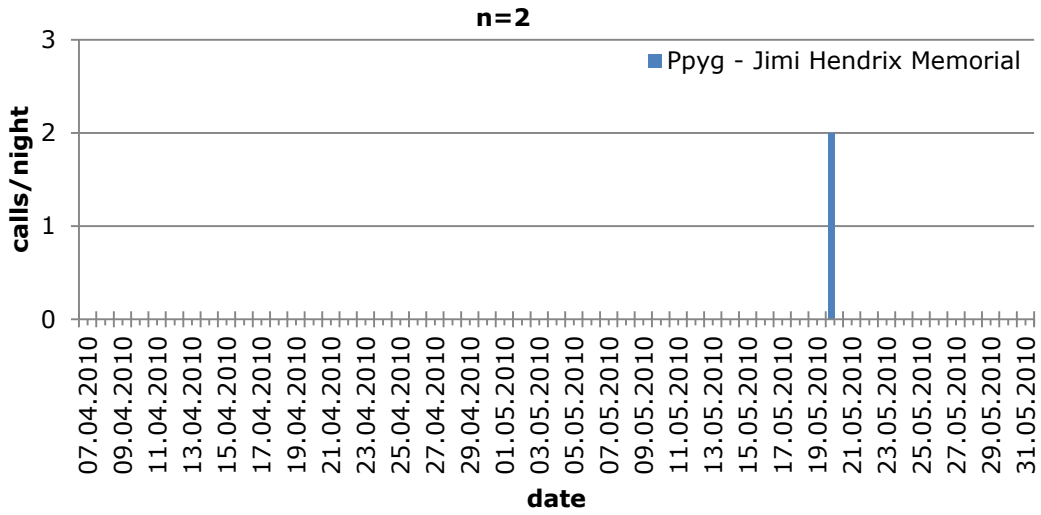


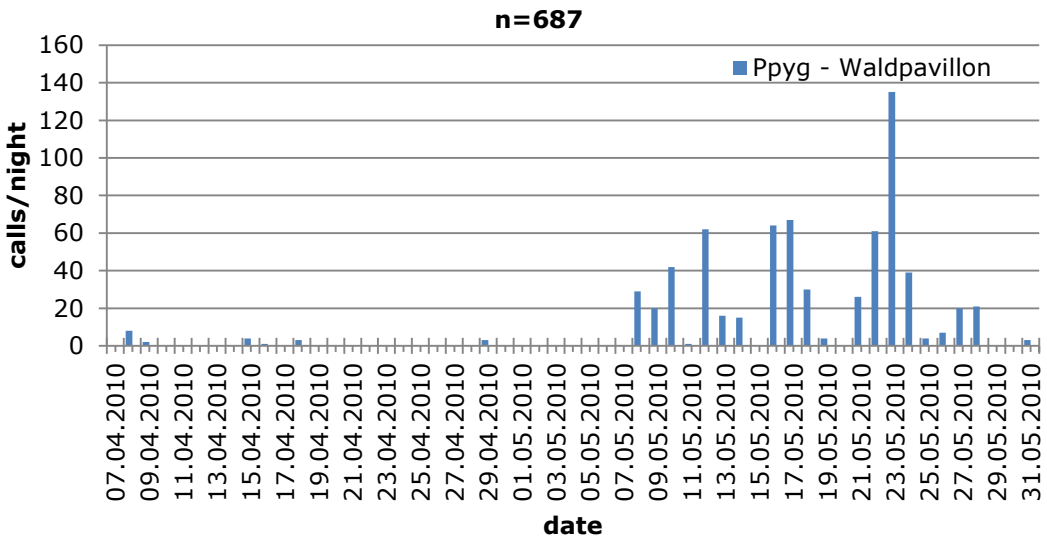



n=3,595
Ppip - Waldpavillon
calls/night
800
700
600
500
400
300
200
100
0
07.04.2010
09.04.2010
11.04.2010
13.04.2010
15.04.2010
17.04.2010
19.04.2010
21.04.2010
23.04.2010
25.04.2010
27.04.2010
29.04.2010
01.05.2010
03.05.2010
05.05.2010
07.05.2010
09.05.2010
11.05.2010
13.05.2010
15.05.2010
17.05.2010
19.05.2010
21.05.2010
23.05.2010
25.05.2010
27.05.2010
29.05.2010
31.05.2010
date

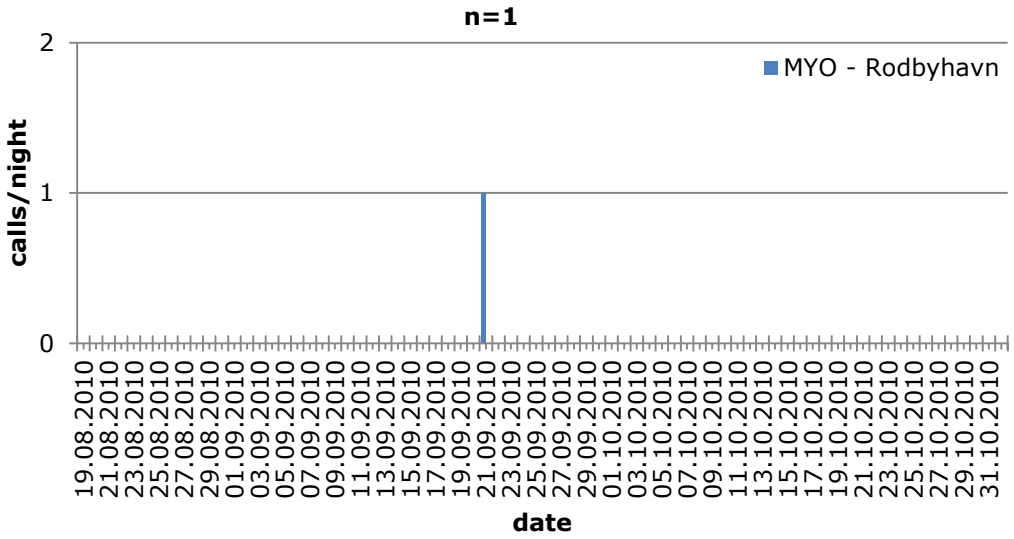
Ppyg - Spring 2010

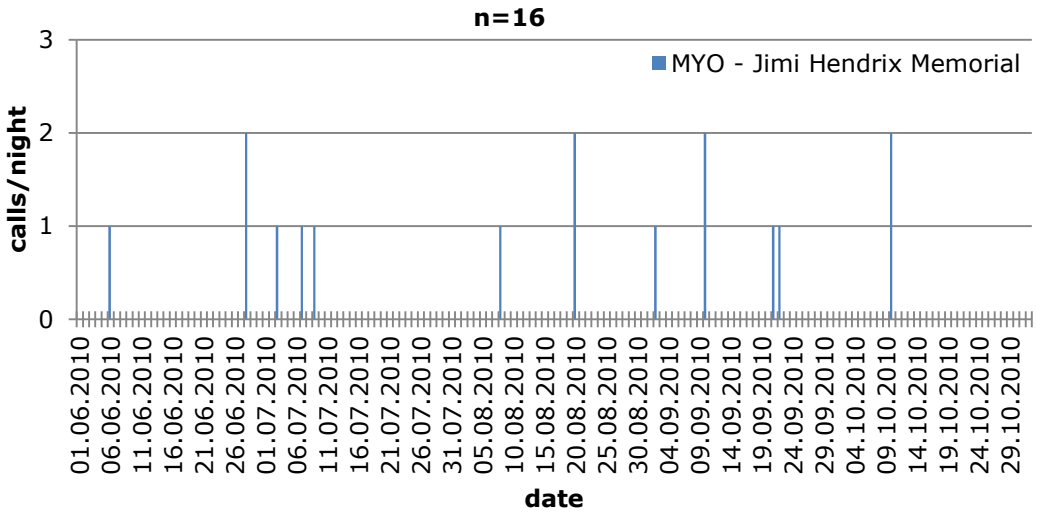




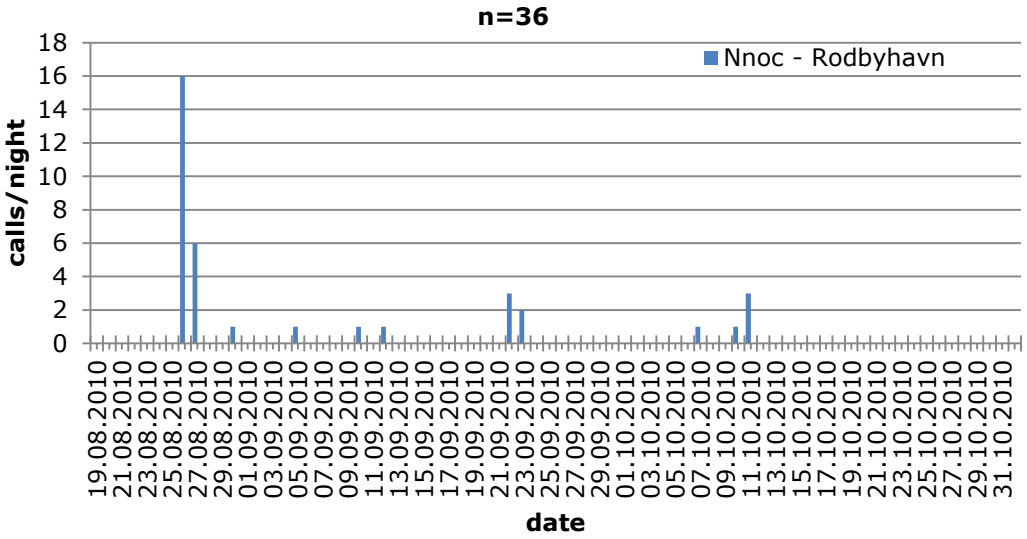


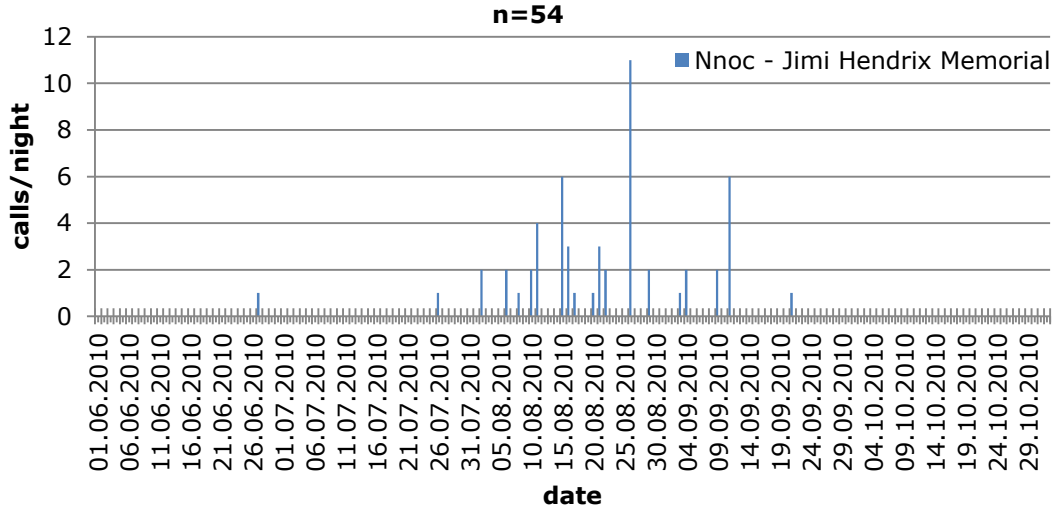
MYO - Autumn 2010

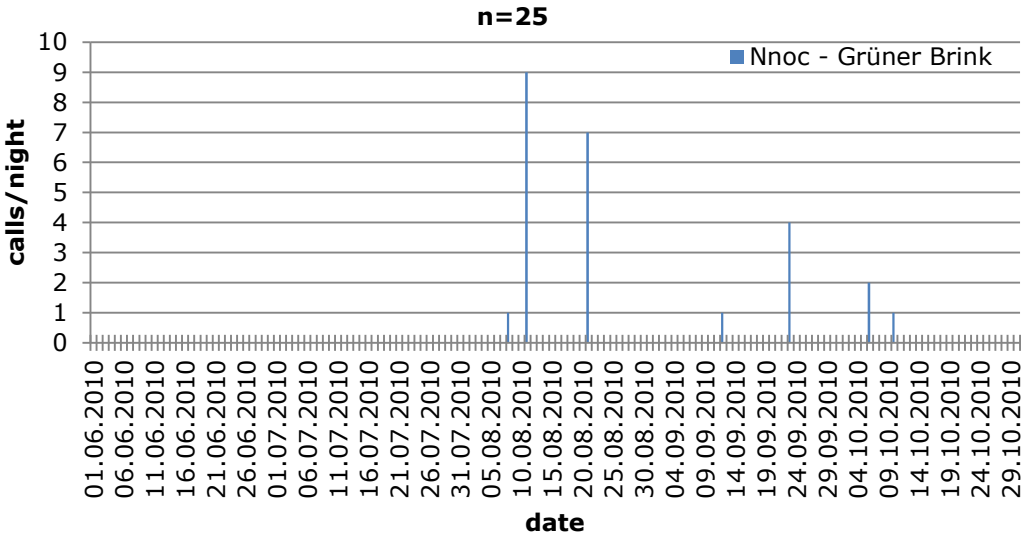




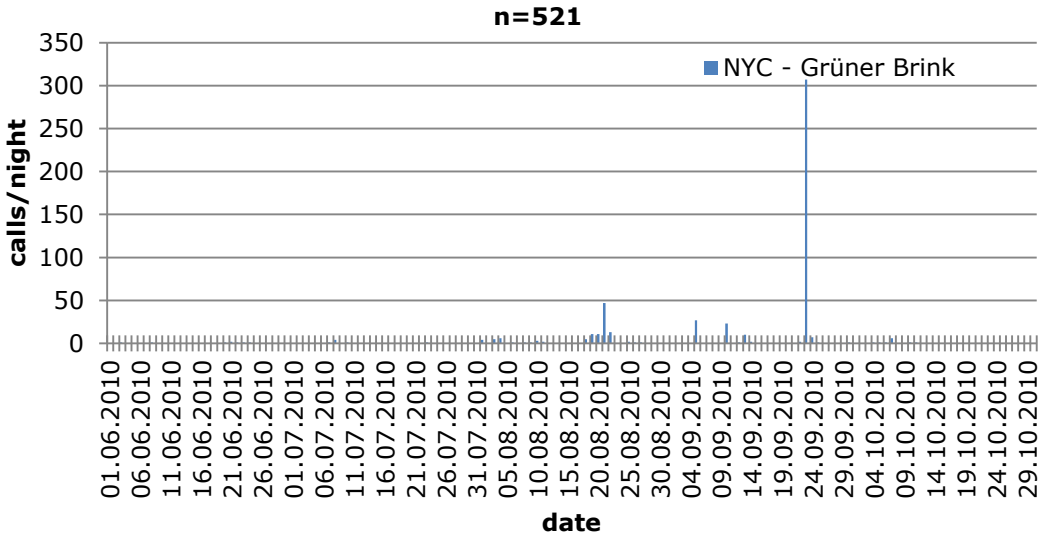
Nnoc - Autumn 2010

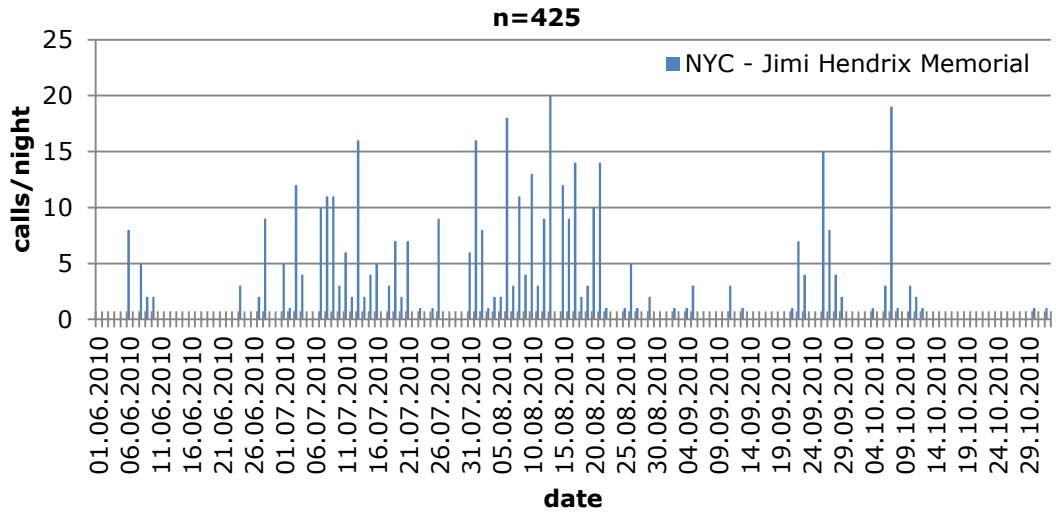


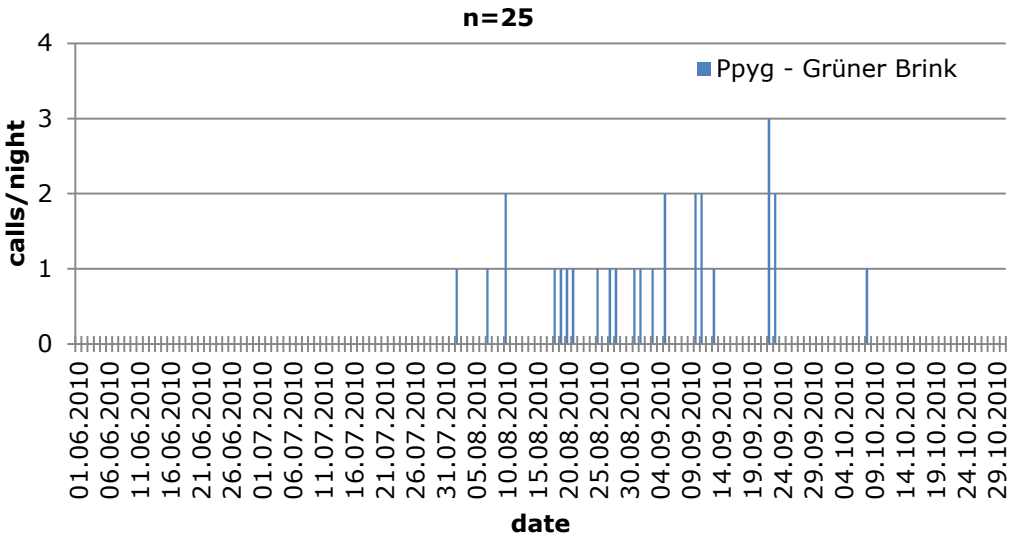




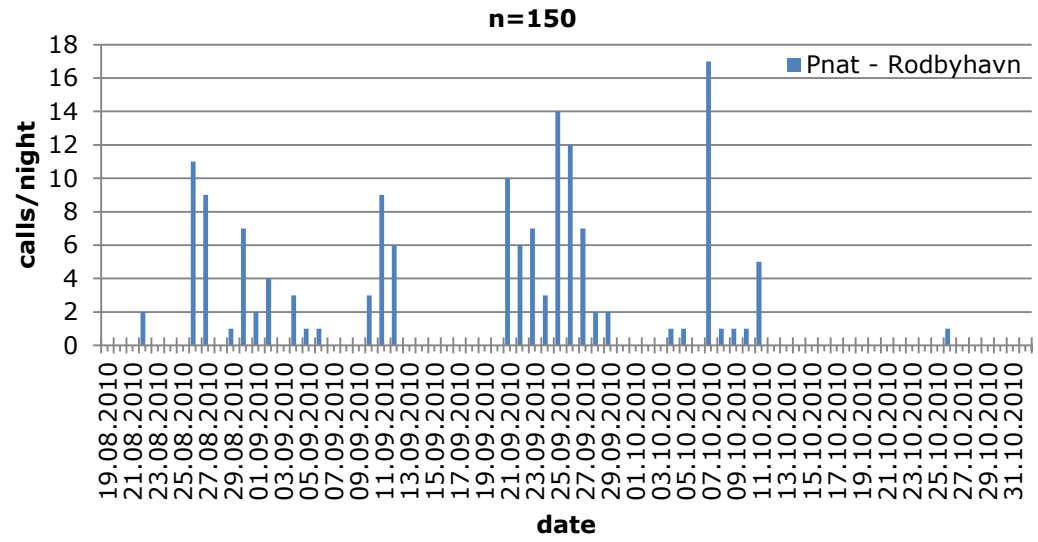
NYC - Autumn 2010

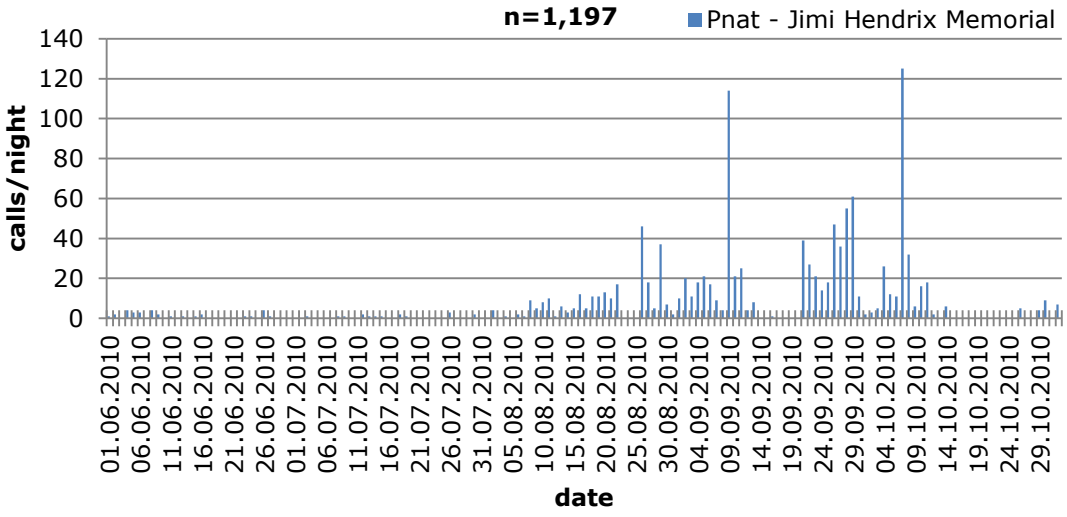


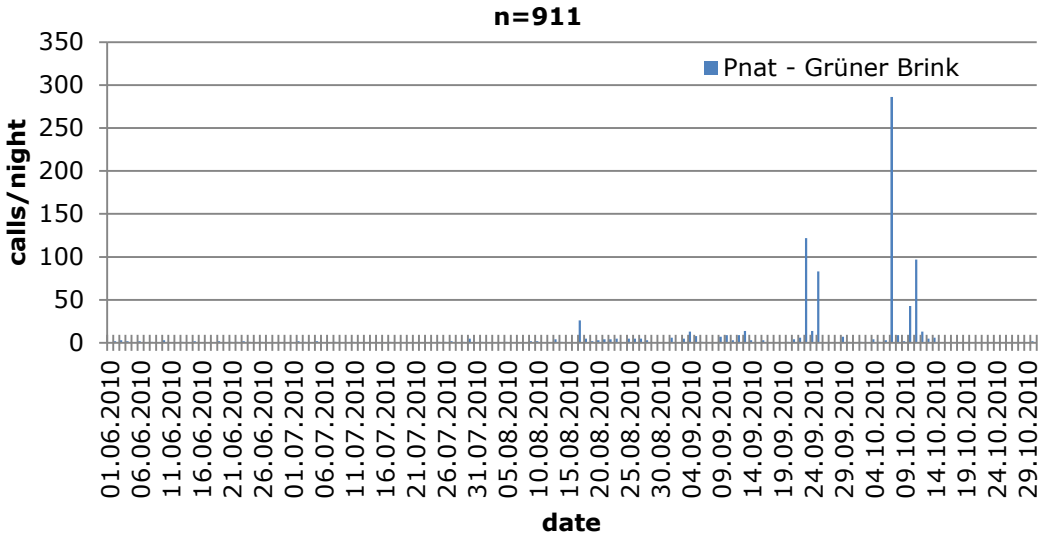



n=25
Ppyg - Grüner Brink
calls/night
0
1
2
3
4
01.06.2010
06.06.2010
11.06.2010
16.06.2010
21.06.2010
26.06.2010
01.07.2010
06.07.2010
11.07.2010
16.07.2010
21.07.2010
26.07.2010
31.07.2010
05.08.2010
10.08.2010
15.08.2010
20.08.2010
25.08.2010
30.08.2010
04.09.2010
09.09.2010
14.09.2010
19.09.2010
24.09.2010
29.09.2010
04.10.2010
09.10.2010
14.10.2010
19.10.2010
24.10.2010
29.10.2010
date

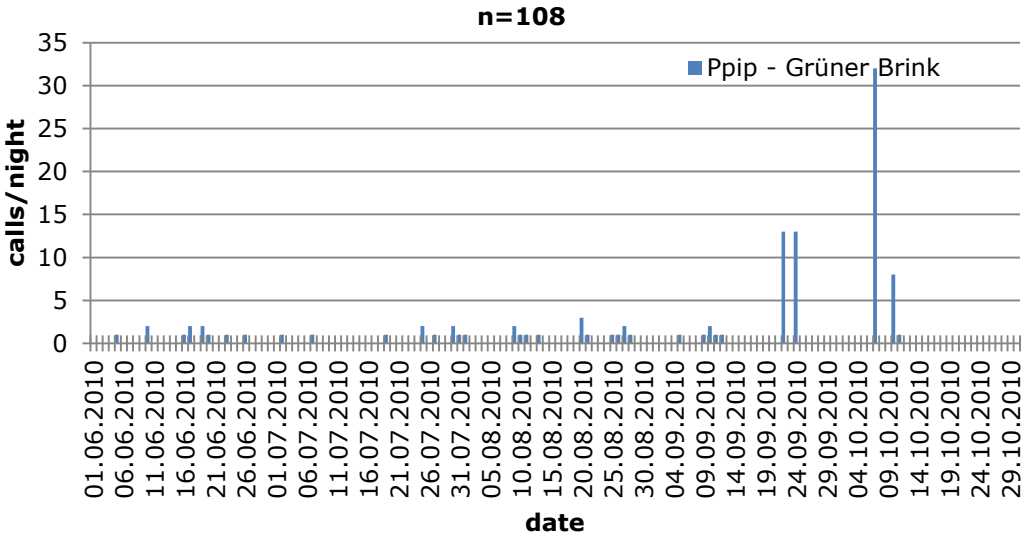
Pnat - Autumn 2010

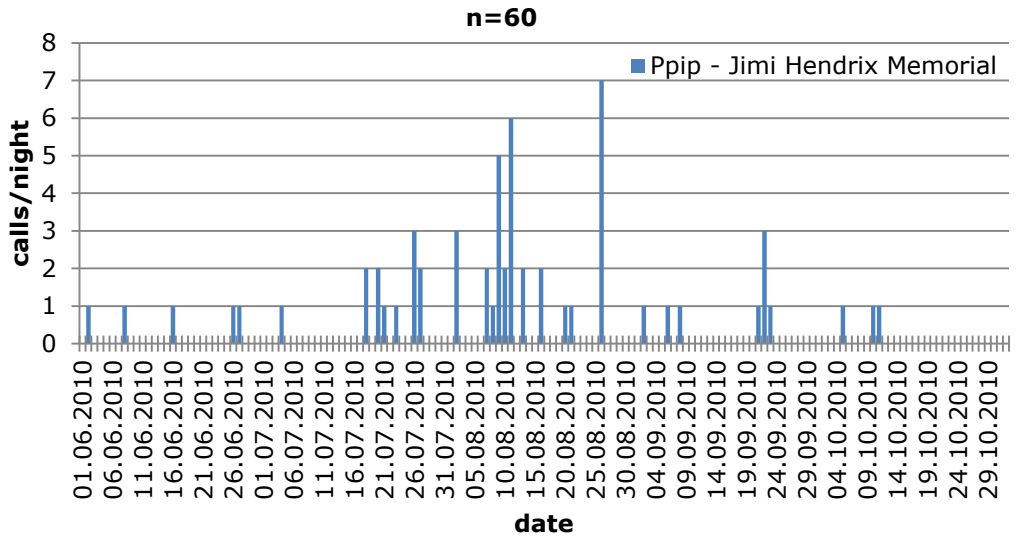


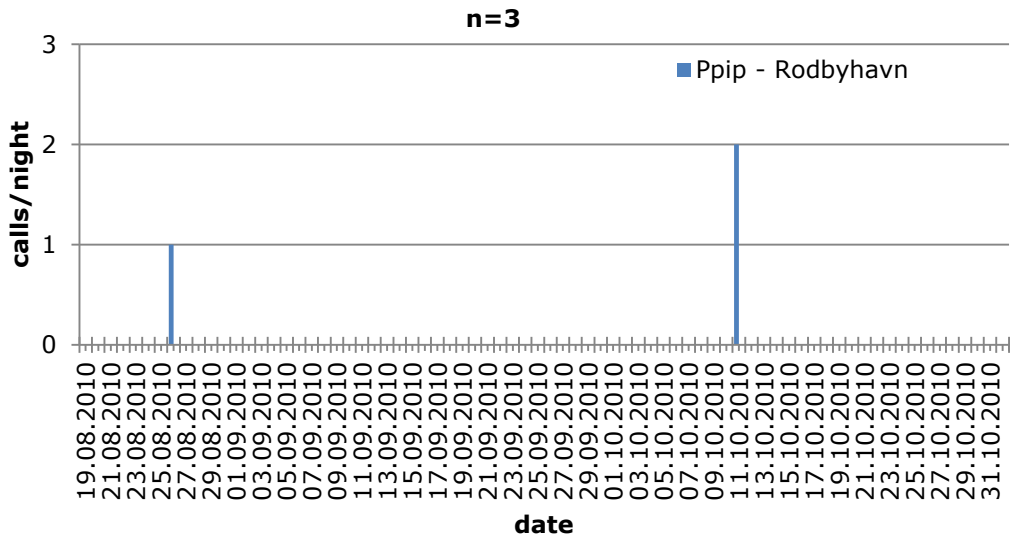




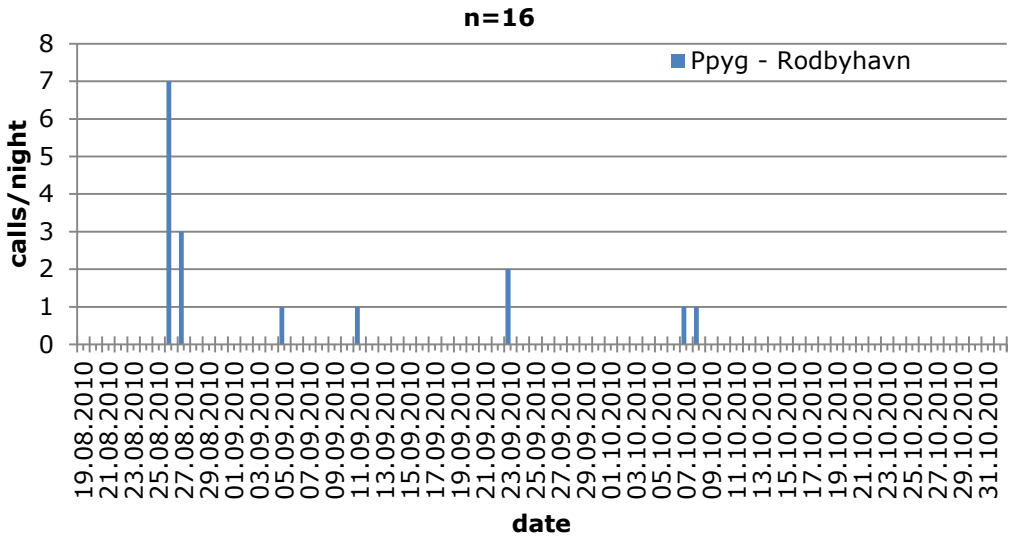
Ppip - Autumn 2010

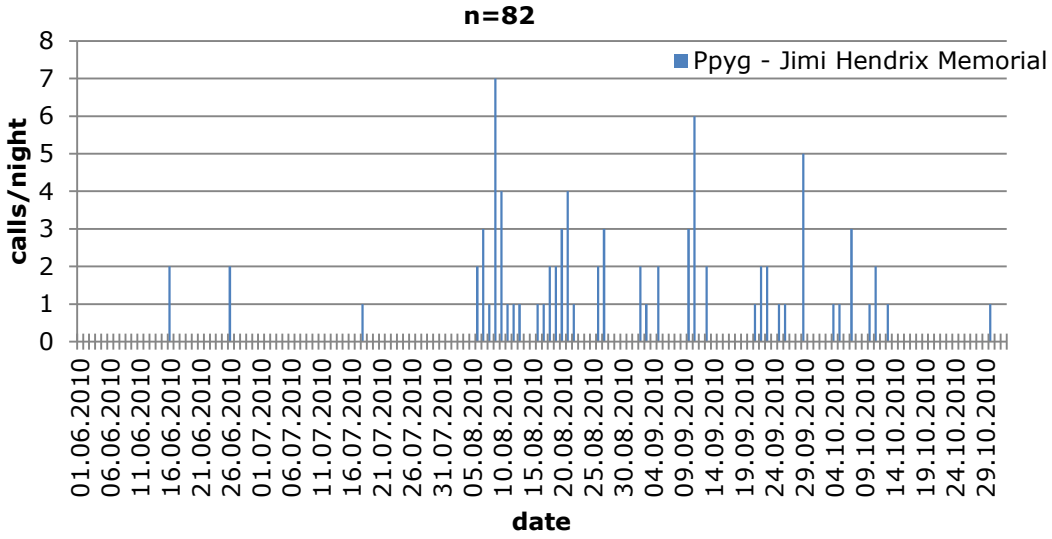


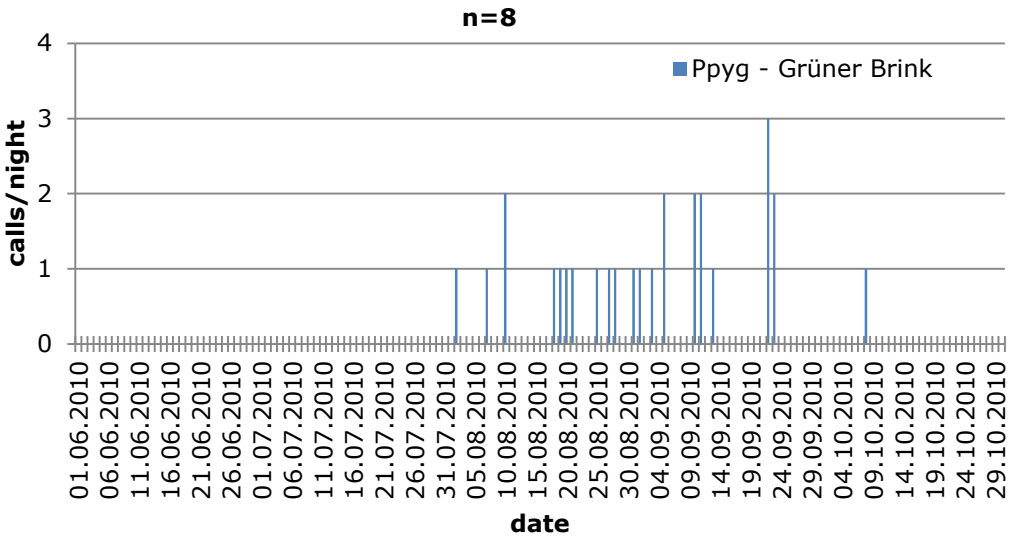


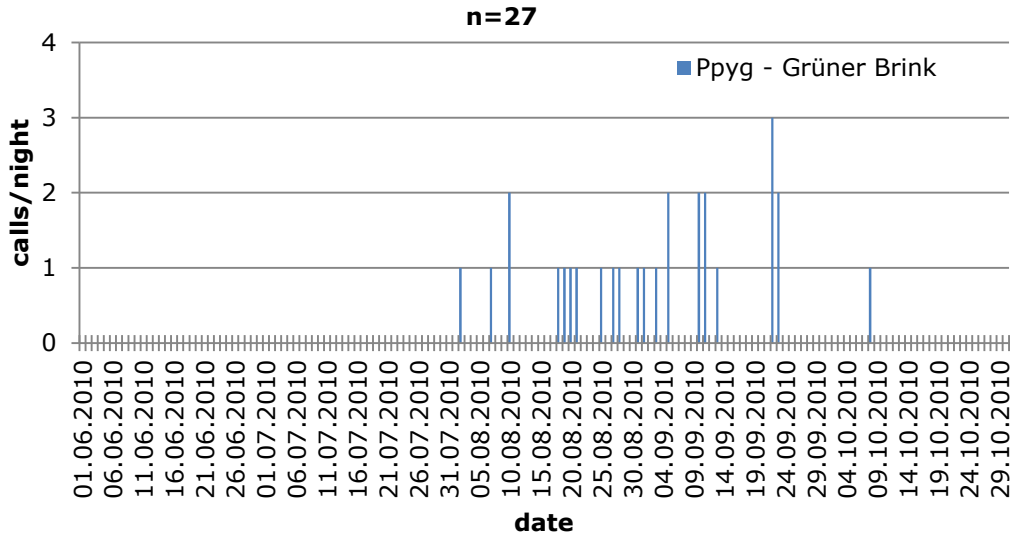


Ppyg - Autumn 2010






n=8
Ppyg - Grüner Brink
calls/night
0
1
2
3
4
01.06.2010
06.06.2010
11.06.2010
16.06.2010
21.06.2010
26.06.2010
01.07.2010
06.07.2010
11.07.2010
16.07.2010
21.07.2010
26.07.2010
31.07.2010
05.08.2010
10.08.2010
15.08.2010
20.08.2010
25.08.2010
30.08.2010
04.09.2010
09.09.2010
14.09.2010
19.09.2010
24.09.2010
29.09.2010
04.10.2010
09.10.2010
14.10.2010
19.10.2010
24.10.2010
29.10.2010
date


n=27
Ppyg - Grüner Brink
calls/night
0
1
2
3
4
01.06.2010
06.06.2010
11.06.2010
16.06.2010
21.06.2010
26.06.2010
01.07.2010
06.07.2010
11.07.2010
16.07.2010
21.07.2010
26.07.2010
31.07.2010
05.08.2010
10.08.2010
15.08.2010
20.08.2010
25.08.2010
30.08.2010
04.09.2010
09.09.2010
14.09.2010
19.09.2010
24.09.2010
29.09.2010
04.10.2010
09.10.2010
14.10.2010
19.10.2010
24.10.2010
29.10.2010
date

APPENDIX B – MAP OF STUDY SITES