Home range and habitat use of common noctules in the Dutch coastal zone

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Summary

Observations of tagged common noctules up to 12.7 km offshore in August 2019, provided the first evidence that at least some local, non-migrating bats extend their foraging trips to the airspace above the North Sea. These observations triggered Rijkswaterstaat to commission the current study, under the umbrella of the Offshore Wind Ecological Programme (WOZEP), to establish the importance of the maritime habitat for local common noctules living in coastal colonies.

The aim of this study is to assess the home range of both male and female common noctules in two small forests ('t Wildrijk and Ananas) near the coast in the province of North Holland, Dutch mainland. Within the home range, the habitat use and the relative importance of the airspace above the sea are assessed.

To determine home range and habitat use of common noctules, we equipped 56 individuals with GPS tags: 31 females (8 young of the year [YOY] and 23 adults [AD]) and 25 males (13 YOY and 12 AD). Of these, four females (AD) and two males (1 YOY and 1 AD) were tagged twice. Of the resulting 62 'deployments' (i.c. deployed devices) 40 GPS tags with data could be retrieved. On average each recovered deployment yielded six monitored nights (range 1–11), whereas the number of GPS fixes per deployment was on average 29 fixes (range 3–75).

The GPS fixes (n=1145) were used to determine flight paths per tagged individual and per group (YOY and AD females, YOY and AD males). Of these GPS fixes 17 fixes were obtained above sea, of which three occurred close to the Wadden Sea coast and 14 above the North Sea up to 2.7 km from shore.

Home range sizes were estimated using the AKDEc method for 31 individuals. Home range estimates of adult females only were used for the habitat use analysis, since the number of GPS fixes and the number of individuals in the other groups was too small for an analysis of habitat use.

From our current study we conclude:

- that the AKDEc home range of adult female common noctules is on average 45 km^2 and extends not further than a few kilometres onto the North Sea.
- that adult females are almost completely 'terrestrial' and show the least preference for the maritime habitat. When they occur at sea, this is probably driven by specific weather conditions.
- that adult females face low risks of potential negative impacts from offshore wind farms outside the 12 mile zone.
- that home ranges could not reliably be assessed for adult male, young male and young female common noctules due to a lack of data. In comparison to adult females, however, the home range of adult males seem to be larger, while the home ranges of young males and young females are even larger than those of adult males.
- that habitat use could not reliably be assessed for adult males, young males and young females, due to small sample sizes.
- that adult male common noctules face possibly a slightly higher risk in comparison to adult females from offshore wind turbines.
- that young male and young female common noctules face uncertain risk of potential negative impacts from offshore wind farms outside the 12 mile zone
- that our results are valid for Ananas and 't Wildrijk, and extrapolation of these conclusions to home ranges and habitat use of common noctules in other areas in the Netherlands is not necessarily straightforward.

Though outside the scope of this study, our previous bat detector work concluded:

- that common noctules are detected in the offshore wind farms outside the 12 mile zone

To answer remaining questions we recommend:

- to obtain more data from the study area in late summer, put more emphasis on young males, young females, and adult males
- to tag common noctules in other areas, in particular close to the current offshore wind farms.

1 Introduction

1.1 Background

During the execution of the project *Development of instruments for a nature-inclusive energy transition* (KB-36-003-002) in August-September 2018 and 2019, common noctules *Nyctalus noctula* were equipped with multiple tags to calibrate a triangulation algorithm for the Dutch Motus network (Lagerveld *et al* in prep). This algorithm is needed to derive flight paths based on received signals from the Motus receivers. The tagged individuals were equipped with a GPS tag to obtain accurate location fixes, a coded (Motus) VHF tag to obtain simultaneous detections at one or more Motus receivers, and a VHF beeper tag to ensure relocation of the tagged animal, or to find the fallen-off tag-pack in the field.

From this study we learned that some of the nocturnal feeding trips of these common noctules took place above coastal North Sea waters, up to 12.7 km offshore in the end of August 2019 (Lagerveld *et al* in prep). This was the first evidence that at least some local, non-migrating bats venture out offshore during nightly foraging trips in Dutch waters, thus theoretically becoming vulnerable to adverse effects from operational offshore windfarms. This could be even more hazardous taking into account that common noctules fly relatively high, in general well within the rotor swept area (RSA).

Given the observations described, Rijkswaterstaat felt the need to carry out a pilot study within the Offshore Wind Ecological Programme (WOZEP) in order to assess the importance of the maritime habitat for local common noctules living in coastal colonies in more detail.

1.2 Aim of the study

The aim of this study is to assess the home range of male and female common noctules occupying roosts of their breeding colony in two small forests ('t Wildrijk and Ananas) near the coast in the province of North Holland, Dutch mainland. Within the home range the habitat use must be assessed and the relative importance of the airspace above sea determined.

Given that offshore occurrence did appear, we assess up to which distances from shore foraging noctules can be expected and to what extent foraging at sea depends on the weather conditions and the time of the year.

The resulting information is used to estimate the extent of potential negative impacts from offshore windfarms outside the 12 mile zone on local common noctule populations, and if so, under what circumstances these risks would occur.

1.3 Project team

The project team that conducted this study included: employees of Wageningen Marine Research (WMR; Sander Lagerveld, Marinka van Puijenbroek, Bart Noort and Steve Geelhoed); Bionet Natuuronderzoek (René Janssen), and Karina Stienstra and Jan Boshamer.

1.4 Acknowledgements

This study would not have been possible without the help of many other people. Chris van Vliet and Tim Zutt (North Holland Landscape Foundation) gave us access to the Wildrijk and Hidde Bessembinders to duck decoy ‘de Hoop’ near Oudesluis. Marcel Haas (Natuurmonumenten) gave us the opportunity to search for tags on the ground in a restricted area of the Zwanenwater. The heirs of Adam Wit gave us permission to access the garden at the Anna Maria Hoeve next to duck decoy ‘t Zand.

Arnold van den Burg, Wieneke Huls and Dagmar van Nieuwpoort assisted during the nocturnal tagging activities.

Maurice La Haye (Dutch Mammal Society) and Nanneke van der Wal (KNAW) who forms a “Animal Healthfare Desk, who provided a protocol for animal research.

2 Materials and Methods

2.1 Study area

't Wildrijk and Ananas are small forests of respectively 18 ha and 10 ha in the Zijperpolder in North Holland (Dutch mainland), located at 2 and 3 km from the North Sea coastline, respectively (Figure *1*). The area surrounding the forest is dominated by flower bulb cultivation and furthermore characterized by some small scattered villages, the nature reserve Zwanenwater in the dunes and the coastline.

Figure 1. Zijpepolder

't Wildrijk and Ananas have a similar history; they are remnant forest tracks from 17th century, which were once owned by wealthy merchants from Amsterdam, who financed to a large extent the realisation of the polders and had their own rural areas constructed there.

In the 19th century, 't Wildrijk was not in use as an estate any more. It was used as a hunting area and for coppice. In 1940 it was acquired by the North Holland Landscape Foundation. During the Second World War, several bunkers were built in 't Wildrijk in which soldiers who defended the Atlantic Wall, were housed (Belonje 1952). One of these bunkers was converted in the early 1980s to a winter roost for bats. Currently, the most common trees are oak , elm, ash, alder, birch and occasionally beech and linden. 't Wildrijk is well-known for its so-called Stinzen flora.

The Ananas was acquired in 1954 by the Noord Hollandsche Levensverzekering Maatschappij NV, which aimed to develop the area for flower bulb cultivation. Somehow the Ananas forest was not converted to flower bulb fields, but the forest was never maintained (Van Loo 2006). The Ananas is still private property, but currently the North Holland Landscape Foundation is trying to acquire the forest.

Common noctule is a rather scarce species in North Holland north of the North Sea channel. In the 1990s colonies were known at the estate Marquette (Heemskerk), the estates Nijenburg and Ter

Coulster (Heiloo), at Castricum, the Oude Hof and the Bergerbos (Bergen). The total population in this area was estimated at 175–200 animals (Kapteijn 1995). In 2011 a new colony was found in Schoorl by Jan Boshamer.

At ‘t Wildrijk the first common noctule was found in a batbox in 2003. Subsequently, occasional observations occurred throughout the years. In 2015 half of the original wooden flat bat boxes were replaced by Schwegler 2Fn (woodcrete round) bat boxes, subsequently a significant increase in observations occurred. In 2016 a maternity colony was found, and 29 individuals were counted when they left the roost at dusk (Van den Tempel 2016). No data is available from the Ananas forest as systematic research on the occurrence of bats has never been done until August 2019, when a male common noctule equipped with a GPS tag was discovered there in a woodpecker cavity in grey poplar *Populus x canescens*.

2.2 Fieldwork

2.3 Tagging & retrieving tags

All work has been executed under the Nature legislation permit 2018-057682 (Wageningen Marine Research) and the Animal Welfare protocol AVD248002016459 / VZZ-18-005 (Dutch Mammal Society). The methodology applied for all survey techniques and catching was completed with reference to best practice guidance SARS_ CoV_2 protocol 2020 set up by Dutch Mammal Society in cooperation with Vleermuisvangsysteem (VVS).

Bats were caught by different means. The most frequently applied catching method used a box trap which was installed at the entrance of the roost (Figure 2). The animals were caught when they left the roost after dusk. In some cases the catching effort was increased using mist nests (Figure ***3***). Two animals were caught by hand; one while it left the roost during daylight hours and one was found on a fallen tree. When multiple bats were caught at the same time, individual bats were briefly kept in a cotton bag pouch.

Each individual bat was measured, weighed, sexed, aged and the reproductive status (Annex 1) was assessed before tagging (Figure ***4***) as described by Haarsma (2008). The tags used included a GPS tag and a VHF beeper tag. The GPS tag (Pathtrack nanoFix® GEO – MINI 0.86 g) was used to obtain accurate location fixes (typically 5-20 m spatial accuracy). The GPS-tags were no more than 5% of the weight of a bat. Tags were not fitted to pregnant females, or individuals assessed as in poor health. Because tagging disrupts normal night-time activities (and thus potentially causing different behaviour; e.g. Aldridge & Brigham 1988; Kenward 2000), the GPS tags were programmed in such a way that data collection was started the night after the animal had been tagged. GPS location fixes were obtained every 30 minutes from dusk to dawn, and the capacity of the battery generally enabled data collection during 7-8 consecutive nights. Note that GPS-tags need an unobstructed view of the sky to make a location fix. While bats resided in their roost the GPS tag produced null-fixes. Therefore, when a location fix is made, in principle the animal is in flight.

A VHF beeper tag from Telemetrie Service Dessau of the types V1, V3 and V5 (0.28, 0.3 and 0.36 gram respectively) was glued on the GPS tag to ensure relocation of the GPS-tag in order to retrieve the data. The lifespan of the beeper tags used was on average 21 days. Therefore, the tag-pack had to be retrieved after the data-collection of the GPS tag had stopped, but before the lifespan of the beeper tag has ended.

Figure 2. Installing a box trap (photo Jan Boshamer)

Figure 3. Installing the nets (photo Jan Boshamer)

Figure 4. Processing caught bats (photo Sander Lagerveld)

Figure 5. Tagged individual after release (photo Sander Lagerveld)

The first ten animals were tagged using a collar (O'Mara *et al.* 2014), but after finding one dead animal with a rotated collar and tags turned to the abdomen we abandoned this and glued the tags to the area between the shoulder blades using SAUER Hautkleber original. This glue dissolves in a few weeks and in case tags cannot be retrieved, they will fall off automatically. After the bat was tagged, it was released at the location where it was caught, and it could fly away easily (Figure ***5***).

The whereabouts of tagged animals or the location of tags fallen-off were monitored by plane, by car and on foot. We used planes for scanning larger areas (Figure 6), or areas with restricted access. Cars were used to scan from roads (Figure 7). Detections from the air and from roads generally reveal the location of the tag within a few hundred meters. In order to find the actual location of the tagged animal or fallen-off tags, searches on foot are needed (Figure 8).

A few fallen-off tags were found on the ground, but most of them had to be retrieved from the tagged animal or from the bottom of the roost. When a tag was relocated in a roost, we climbed the tree and used a RIGID Micro CA-350 endoscope tree camera to check the location of the tag (Figure 9, Figure 10). When the tag was still attached to the bat, we placed a box trap in order to re-catch the individual to remove the tag. When the tag was lying on the bottom of the roost we retrieved it after the bat(s) had left the roost.

Figure 6. Flightpath of the plane with the approximate location of a relocated tag

Figure 7. Scanning by car (photo Karina Stienstra)

Figure 8. Assessing the actual location of the tag (photo Karina Stienstra)

Figure 9. Climbing trees and checking roosts for bats and dropped GPS tags. (photo Jan Boshamer)

Figure 10. A view from the tree camera (photo René Janssen)

2.4 Data analyses

2.4.1 Flight paths

In addition to the GPS location fixes in flight we included manually made detections of tagged individuals in their roost. The GPS fixes and the roosting location were combined to create maps of their nightly movements and activity patterns, using R 4.0.2 (R Core Team 2020).

2.4.2 Home range

Tracking data is in general autocorrelated, as subsequent location fixes are close in space when time intervals between fixes are short. Methods that ignore this autocorrelation, including the frequently used kernel-density estimator often underestimate the actual home range size (Fleming & Calabrese 2017). In this study we therefore use the area-corrected autocorrelated kernel density estimation (AKDEc) which is implemented in the R-package Cttm (Calabrese *et al.* 2016).

We did not make a priori assumptions on the autocorrelation structure of the data. We used the GPS fixes to assess the home range for each individual. In addition, we only analysed the home range of individuals with more than ten GPS-fixes (31 of the 36 individuals), as the models could not be fitted with fewer than ten observations.

First we created empirical variograms, which show the semi-variance in positions as a function of the time lag separating observations, which shows the autocorrelation structure between time points (Calabrese *et al.* 2016). From the empirical variogram a semi-variance function was fitted. The parameters of this semi-variance function were used as initial parameters in the movement model estimation. In order to calculate the flight range, multiple models were fitted on the data and for each individual the model with the lowest AIC (Akaike information criterion) was selected. The models that were tested were IID, OU, OUΩ, OUF, OUf (Calabrese *et al.* 2016). IID is the most simple model based on the assumption that there is no autocorrelation between GPS points. The OU model corrects for position autocorrelation, but not for velocity autocorrelation. The OUΩ corrects for both position autocorrelation and velocity autocorrelation, but assumes that they are identical and $\Omega > 0$ implements an oscillatory model. The OUf model also assumes that the position autocorrelation and velocity autocorrelation are similar, but $\Omega = 0$. The OUF model is the most complex and includes different corrections for the position autocorrelation and velocity autocorrelation. Table 1 summarizes the differences of the models included in the analysis.

Table 1. Characteristics of the movement models.

Movement model	Position autocorrelation	Velocity autocorrelation	Remarks
Independent identically distributed (IID)	No	No	
Ornstein-Uhlenbeck (OU)	Yes	No	
Oscillatory model (OUΩ)	Yes	Yes	Pos. AC = Vel. AC, $\Omega > 0$
Ornstein-Uhlenbeck f (OUf)	Yes	Yes	Pos. AC = Vel. AC, $\Omega = 0$
Ornstein-Uhlenbeck F (OUF)	Yes	Yes	

Furthermore, we allowed for either isotropic (circular) or anisotropic (elliptical) covariance in the data for each model considered. An isotropic (circular) covariance is used for bats with a symmetric (circular) distribution and an anisotropic (elliptical) distribution for bats with an elongated distribution.

2.4.3 Habitat analysis

Habitat analysis generally involves a comparison between the available habitat .types and the actual use of these habitat types by an organism, or a group of organisms (Manly *et al.* 2002). To quantify the available habitat types, we first defined these using the National Land Use map of The Netherlands (Hazeu *et al.* 2020). This is a grid file that shows the land use of The Netherlands with a spatial resolution of 5x5 m. We used the reference year 2019 for which 48 land use classes were distinguished and merged these land use classes into the 14 habitat types (Annex 2):

1. Fresh water
2. Salt water
3. Built-up area
4. Forest
5. Grassland
6. Agriculture
7. Bulb cultivation
8. Dune vegetation
9. Swamp
10. Orchards
11. Greenhouse farming
12. Heather
13. Salt marsh
14. Open sandy area

The distribution of these 14 habitat types in the northern part of North Holland is shown in Figure 11.

We calculated the relative occurrence of each habitat type and the percentage of GPS fixes per habitat type within the flight range of each individual (Annex 6). In order to assess habitat preferences we used the compositional analysis of habitat use described by Aebischer et al. (1993) using the R -package adehabitatHS 0.3.15 (Calenge 2006). This analysis involved two steps:

1. A test of the overall significance of habitat selection (using a Wilks lambda test).
2. Ranking of the available habitats.

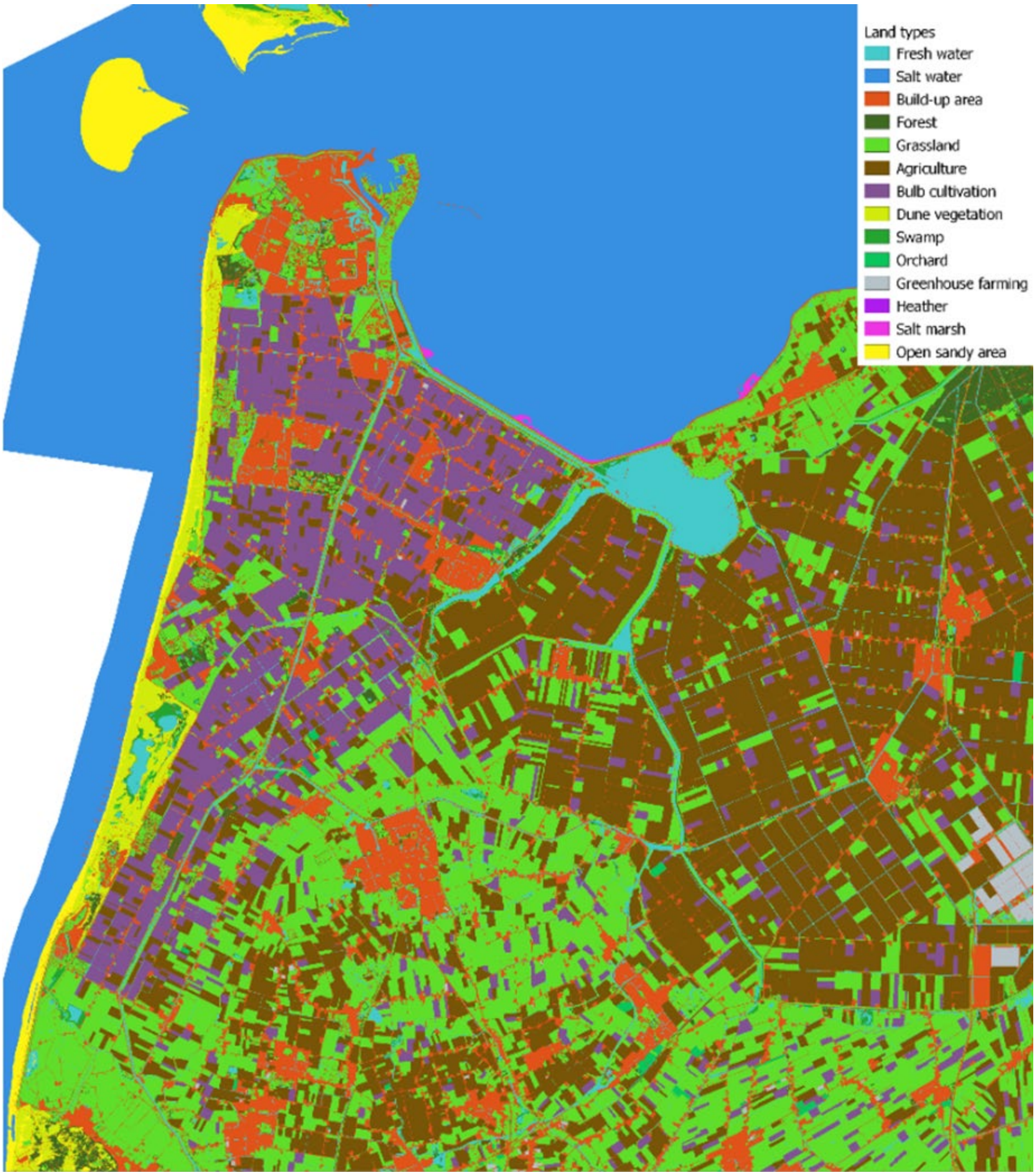


Figure 11. Land use in the northern parts of the province of Noord-Holland. The area shown is larger than the largest individual flight range of the tagged bats

3 Results

3.1 Effort

The fieldwork of this study amounted in total to more than 1000 hours. The majority of the fieldwork was spent searching, trapping and tagging of bats and subsequently retrieving the tags (almost 40% of the time), and scanning for and retrieving tagged individuals (60% of the time). The fieldwork can be divided in two tagging periods. During the first tagging period (June-July), we only tagged adults (AD), since Young of Year (YOY) couldn’t fly yet. In the second period August-September, we tagged adults and Youngs of Year. A summary of the daily activities is shown in Figure 12. The daily logs can be found in Annex 3.

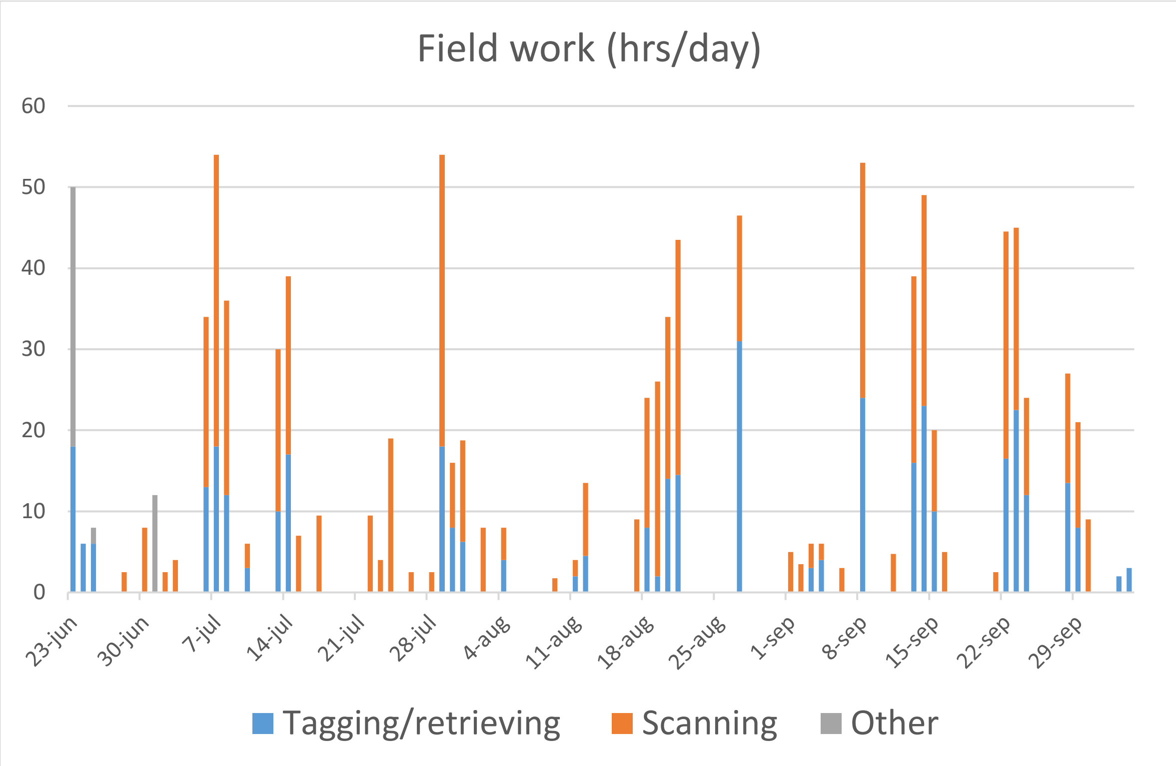


Figure 12. Overview of fieldwork effort (hrs/day) 23 June-4 October 2020.

3.2 Tagged individuals

During this study we tagged 56 individuals: 31 females (8 YOY and 23 AD) and 25 males (13 YOY and 12 AD). Four females (AD) and two males (1 YOY and 1 AD) were tagged twice. All in all resulting in 62 deployed devices, hereafter called deployments. Table 2 shows the deployments of each individual. We obtained data from 40 out of 62 deployments (Table 3): tags of 15 deployments could not be retrieved and the data of seven (recovered) deployments could not be extracted from the GPS due to technical problems. Tags of five adult females from the first catching batch were found back, with the antenna’s bitten off. Twelve tags of the young animals tagged later in the season (n=21) were not recovered. The number of monitored nights per recovered deployment was on average six nights (range 1–11), whereas the number of GPS fixes per deployment was on average 29 fixes (range 3–75).

Table 2. Overview of tagged individuals and deployments per location.

ID	Sex	Age	Released	GPStag	Status	Latitude	Longitude	Location
1	F	AD	23-06-2020 21:00	21742	Lact	52.801	4.726	Ananas - primary roost
			31-07-2020 21:00	56236	Postlac	52.801	4.726	Ananas - primary roost
2	F	AD	23-06-2020 21:10	21746	Lact	52.801	4.726	Ananas - primary roost
3	F	AD	23-06-2020 21:20	21747	Lact	52.801	4.726	Ananas - primary roost
4	F	AD	23-06-2020 21:30	21749	Lact	52.801	4.726	Ananas - primary roost
5	F	AD	23-06-2020 21:40	21749	Lact	52.801	4.726	Ananas - primary roost
6	F	AD	23-06-2020 21:50	21772	Lact	52.801	4.726	Ananas - primary roost
			31-07-2020 21:30	56274	Postlac	52.801	4.726	Ananas - primary roost
7	F	AD	23-06-2020 22:00	21815	Lact	52.801	4.726	Ananas - primary roost
8	F	AD	23-06-2020 22:10	21662	Lact	52.801	4.726	Ananas - primary roost
9	F	AD	23-06-2020 22:20	21881	Lact	52.801	4.726	Ananas - primary roost
10	F	AD	23-06-2020 22:30	21892	Lact	52.801	4.726	Ananas - primary roost
11	M	AD	24-06-2020 23:30	56239	SA1	52.791	4.703	Wildrijk - netting location 1
			08-07-2020 20:10	56278	SA1	52.794	4.706	Wildrijk - NW roost I
12	F	AD	25-06-2020 00:40	56240	3V	52.791	4.703	Wildrijk - netting location 1
13	F	AD	25-06-2020 00:50	56248	Lact	52.791	4.703	Wildrijk - netting location 1
14	F	AD	25-06-2020 00:45	56246	Lact	52.791	4.703	Wildrijk - netting location 1
15	M	AD	08-07-2020 20:30	56275	SA3	52.794	4.706	Wildrijk - NW roost I
16	M	AD	08-07-2020 20:40	56281	SA3	52.794	4.706	Wildrijk - NW roost I
17	M	AD	08-07-2020 20:50	56273	SA3	52.794	4.706	Wildrijk - NW roost I
18	M	AD	30-07-2020 20:00	56231	SA3	52.791	4.703	Wildrijk - W roost I
19	M	AD	30-07-2020 20:10	56226	SA3	52.791	4.703	Wildrijk - W roost I
20	M	AD	30-07-2020 20:20	56282	SA3	52.791	4.703	Wildrijk - W roost I
21	F	AD	31-07-2020 20:15	56233	Postlac	52.801	4.726	Ananas - primary roost
22	M	AD	31-07-2020 23:15	56264	SA3	52.789	4.702	Wildrijk - SW roost II
23	F	YOY	21-08-2020 18:30	56281	SI	52.788	4.704	Wildrijk - batbox 38
24	F	AD	21-08-2020 19:30	56274	SI	52.789	4.702	Wildrijk - SW roost II
25	F	AD	27-08-2020 20:00	56249	V3	52.815	4.736	Stolpen - roost I
			13-09-2020 20:00	56484	V3	52.799	4.727	Ananas - E roost
26	M	YOY	27-08-2020 20:15	56290	SA1	52.791	4.703	Wildrijk - W roost I
			13-09-2020 18:45	56409	SA1	52.799	4.726	Ananas - SE roost
27	F	AD	27-08-2020 20:30	56487	V3	52.815	4.736	Stolpen - roost I
			14-09-2020 19:05	56487		52.798	4.723	Anna's Parck roost
28	M	YOY	27-08-2020 20:30	56232	SA1	52.791	4.703	Wildrijk - W roost I
29	M	YOY	27-08-2020 20:45	56233	SA1	52.791	4.703	Wildrijk - W roost I
30	M	YOY	27-08-2020 21:00	21861	SA1	52.791	4.703	Wildrijk - W roost I
31	F	Ad	27-08-2020 21:10	56278	3V	52.791	4.703	Wildrijk - W roost I
32	M	YOY	27-08-2020 21:20	56285	SA1	52.791	4.703	Wildrijk - W roost I
33	M	YOY	27-08-2020 21:30	56287	SA1	52.791	4.703	Wildrijk - W roost I
34	F	YOY	02-09-2020 20:30	56476	SI	52.789	4.701	Wildrijk - netting location II
35	M	Ad	02-09-2020 21:00	56478	SA2	52.789	4.701	Wildrijk - netting location II
36	M	YOY	08-09-2020 23:00	21815	SA1	52.844	4.767	t Zand - roost
37	M	YOY	08-09-2020 23:00	56246	SA1	52.844	4.767	t Zand - roost
38	M	YOY	08-09-2020 23:00	21749	SA1	52.844	4.767	t Zand - roost
39	F	YOY	08-09-2020 23:00	56273	SI	52.844	4.767	t Zand - roost
40	M	YOY	08-09-2020 23:00	21892	SA1	52.789	4.702	Wildrijk - SW roost I
41	F	YOY	08-09-2020 19:45	56274	SI	52.789	4.702	Wildrijk - SW roost I
42	M	YOY	13-09-2020 19:10	56372	SA1	52.799	4.726	Ananas - SE roost
43	M	YOY	13-09-2020 19:20	56394	SA1	52.799	4.726	Ananas - SE roost
44	M	YOY	13-09-2020 19:30	56381	SA1	52.799	4.726	Ananas - SE roost
45	M	AD	13-09-2020 19:40	56310	SA3	52.799	4.727	Ananas - E roost
46	F	YOY	13-09-2020 19:50	56232	SO	52.799	4.727	Ananas - E roost
47	F	AD	13-09-2020 20:00	56370	3V	52.799	4.727	Ananas - E roost
48	F	YOY	14-09-2020 18:25	56398	SI	52.794	4.722	Ruigeweg 82 - roost
49	F	YOY	14-09-2020 18:50	56254	SI	52.794	4.722	Ruigeweg 82 - roost
50	M	AD	14-09-2020 20:00	56396	SA2	52.794	4.722	Ruigeweg 82 - roost
51	F	AD	14-09-2020 18:50	56290	SI	52.798	4.723	Anna's Parck roost
52	F	AD	14-09-2020 18:55	56368	SI	52.798	4.723	Anna's Parck roost
53	F	AD	14-09-2020 19:00	56485	1V	52.798	4.723	Anna's Parck roost
54	F	AD	14-09-2020 19:05	56437	1V	52.798	4.723	Anna's Parck roost
55	F	YOY	14-09-2020 19:10	56450	SI	52.798	4.723	Anna's Parck roost
56	M	AD	14-09-2020 08:30	56345	SA2	52.814	4.736	Stolpen - roost II

Table 3. Overview of retrieved and non-retrieved deployed tags, June-October 2020.

ID	Sex	Age	GPStag	Tag retrieved	Lat	Long	Location	Nights	GPS fixes
1	F	AD	21742	-	-	-	-	-	-
			56236	-	-	-	-	-	-
2	F	AD	21746	-	-	-	-	-	-
3	F	AD	21747	-	-	-	-	-	-
4	F	AD	21749	06-07-2020 20:15	52.801	4.726	Ananas - primary roost	7	30
5	F	AD	21749	06-07-2020 20:30	52.801	4.726	Ananas - primary roost	6	29
6	F	AD	21772	-	-	-	-	-	-
			56274	04-08-2020 17:00	52.790	4.703	Wildrijk - deployment 37	1	7
7	F	AD	21815	06-07-2020 18:00	52.805	4.738	Ruigeweg 109 - pasture	3	17
8	F	AD	21662	01-07-2020 08:45	52.792	4.705	Wildrijk - batbox 14	7	35
9	F	AD	21881	-	-	-	-	-	-
10	F	AD	21892	06-07-2020 21:00	52.801	4.726	Ananas - primary roost	8	33
11	M	AD	56239	08-07-2020 20:00	52.794	4.706	Wildrijk - NW roost I	1	11
			56278	13-07-2020 18:32	52.825	4.784	Korte Ruigeweg 32 - roost	2	7
12	F	AD	56240	06-07-2020 20:30	52.801	4.726	Ananas - primary roost	8	28
13	F	AD	56248	06-07-2020 20:15	52.801	4.726	Ananas - primary roost	7	33
14	F	AD	56246	06-07-2020 20:10	52.801	4.726	Ananas - primary roost	7	29
15	M	AD	56275	24-07-2020 20:10	52.798	4.723	Anna's Parck roost	11	45
16	M	AD	56281	19-08-2020 15:30	52.829	4.786	Oudesluis E roost	10	75
17	M	AD	56273	13-07-2020 16:00	52.789	4.702	Wildrijk - deployment 19	-	-
18	M	AD	56231	18-08-2020 16:47	52.794	4.722	Ruigeweg 82 - roost	3	26
19	M	AD	56226	20-08-2020 18:00	52.777	4.719	Grote Sloot - cornfield	4	22
20	M	AD	56282	-	-	-	-	-	-
21	F	AD	56233	04-08-2020 17:00	52.791	4.705	Wildrijk - deployment 34	1	3
22	M	AD	56264	21-08-2020 07:00	52.789	4.702	Wildrijk - SW roost II	8	55
23	F	YOY	56281	27-08-2020 19:30	52.815	4.736	Stolpen - roost I	-	-
24	F	AD	56274	27-08-2020 19:30	52.791	4.703	Wildrijk - W roost I	5	14
25	F	AD	56249	13-09-2020 19:30	52.799	4.727	Ananas - E roost	8	26
			56484	22-09-2020 19:15	52.814	4.736	Stolpen - roost II	7	19
26	M	YOY	56290	08-09-2020 19:45	52.791	4.703	Wildrijk - W roost I	4	13
			56409	23-09-2020 19:05	52.829	4.786	Oudesluis E roost	9	65
27	F	AD	56487	14-09-2020 18:30	52.798	4.723	Anna's Parck roost	8	27
			56487	30-09-2020 08:30	52.813	4.684	Zwanenwater - dunes	7	22
28	M	YOY	56232	08-09-2020 19:45	52.789	4.702	Wildrijk - SW roost I	8	30
29	M	YOY	56233	-			-	-	
30	M	YOY	21861	23-09-2020 21:05	52.829	4.785	Oudesluis W roost	6	28
31	F	Ad	56278	13-09-2020 18:15	52.799	4.726	Ananas - SE roost	7	9
32	M	YOY	56285	-			-	-	
33	M	YOY	56287	04-09-2020 16:00	52.790	4.703	Wildrijk - deployment 37-2	1	4
34	F	YOY	56476	-			-	-	
35	M	Ad	56478	08-09-2020 23:15	52.844	4.767	t Zand - roost	-	
36	M	YOY	21815	-			-	-	
37	M	YOY	56246	13-09-2020 20:30	52.799	4.726	Ananas - SE roost	4	45
38	M	YOY	21749	23-09-2020 21:05	52.829	4.786	Oudesluis E roost	3	26
39	F	YOY	56273	23-09-2020 21:05	52.829	4.786	Oudesluis E roost	-	-
40	M	YOY	21892	-			-	-	-
41	F	YOY	56274	-			-	-	-
42	M	YOY	56372	-			-	-	-
43	M	YOY	56394	23-09-2020 21:05	52.829	4.785	Oudesluis W roost	8	90
44	M	YOY	56381	23-09-2020 16:00	52.791	4.703	Wildrijk - W roost I	-	-
45	M	AD	56310	22-09-2020 16:00	52.799	4.727	Ananas - E roost	-	-
46	F	YOY	56232	28-09-2020 19:00	52.803	4.760	Schagerbrug - roost	8	54
47	F	AD	56370	22-09-2020 19:15	52.814	4.736	Stolpen - roost II	7	24
48	F	YOY	56398	28-09-2020 19:00	52.803	4.760	Schagerbrug - roost	7	58
49	F	YOY	56254	24-09-2020 18:15	52.782	4.711	Gunea - roost	1	3
50	M	AD	56396	23-09-2020 19:00	52.794	4.722	Ruigeweg 82 - roost	7	14
51	F	AD	56290	-			-	-	-
52	F	AD	56368	22-09-2020 19:15	52.789	4.702	Wildrijk - SW roost II	7	16
53	F	AD	56485	22-09-2020 19:15	52.814	4.736	Stolpen - roost II	-	-
54	F	AD	56437	22-09-2020 19:30	52.794	4.722	Ruigeweg 82 - roost	7	17
55	F	YOY	56450	22-09-2020 22:00	52.814	4.736	Stolpen - roost II	7	13
56	M	AD	56345	23-09-2020 21:05	52.829	4.786	Oudesluis E roost	9	62

3.3 Roosts

A network of 28 occupied bat roosts was found in the study area (Figure 13). A few roosts were found by listening for social calls and checking batboxes, but the majority were found when scanning for tagged individuals. Ananas and 't Wildrijk contained most roosts, with 3 and 11 roosts respectively. Roosts were mainly found in woodpecker cavities in grey poplars *Populus x canescens*. Furthermore, two roosts were found in crevices in an oak and two in woodcrete Swegler 2Fn bat boxes in 't Wildrijk (Table 4).

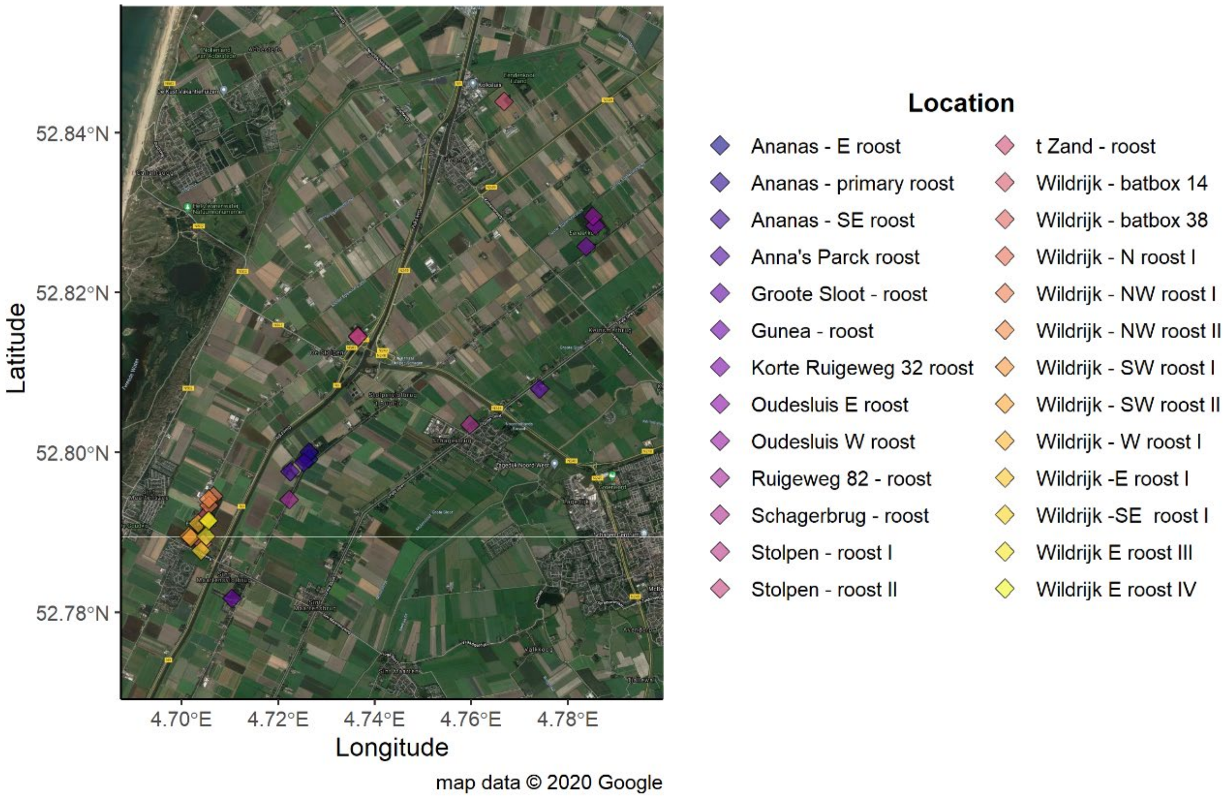


Figure 13. Location of bat roosts in the study area, June-October 2020.

Table 4. Number of bat roosts per type of roost: grey poplar = woodpecker cavity in hybrid populus x canescens *poplars, oak = oak crevices & Bat box = Schwegler 2 FN Bat box.*

Location	Gray Poplar	Oak	Batbox
Ananas	3		
Anna's Parck	1		
Groote Sloot	1		
Gudea Zonnewende	1		
Korte Ruigeweg	1		
Oudesluis	2		
Ruigeweg	1		
Schagerbrug	1		
Stolpen	2		
t Zand	1		
t Wildrijk	11	1	2
Total	24	2	2

3.4 Flight paths

We obtained GPS data from 36 different individuals: 21 females (4 YOY and 17 adult) and 15 males (7 YOY and 8 adult). The actual movements and nocturnal activity pattern of each individual is shown in Annex 4. In general, common noctules perform two foraging flights per night: one soon after dusk comprising on average 1.5–2 hours and one just before dawn which takes in general 0.5–1 hour. In some cases more extensive flight activity was observed.

Figure 14 shows the movement patterns of all adult females (n=17). Flight movements typically occur within a few km from the roost, with a maximum observed distance 11.4 km from the maternity roost. Four individuals were recorded one or more times above the North Sea.
Though the number of recovered tags is low, the flight movements of YOY females (n=4) frequently extend much further away from the colony than those of adult females (Figure 15). One female (ID 48) made an extensive trip lasting four nights up to a distance of 94 km from the maternity roost. During her southbound flight she flew south to Den Haag in the first night, with four location fixes above the North Sea. The second and third night were spent in the area between Den Haag and Rotterdam, and the fourth night she returned to the study area. Another young female (ID 46) was observed above the North Sea once.

The flight movements of males are shown in Figure 16 for adults and in Figure 17 for young animals. In general, adult males (n=8) have flight movements that extend a little bit further than those of adult females. The same holds true for the maximum observed distance of 16.0 km from Ananas. Young males (n=7) show even more extensive flight movements, with a maximum recorded distance 27.5 km from the roost that was used by the tagged animal during that period. Neither YOY nor adult males were recorded above the North Sea. Three young males, however, were recorded above the Wadden Sea north of Wieringen.

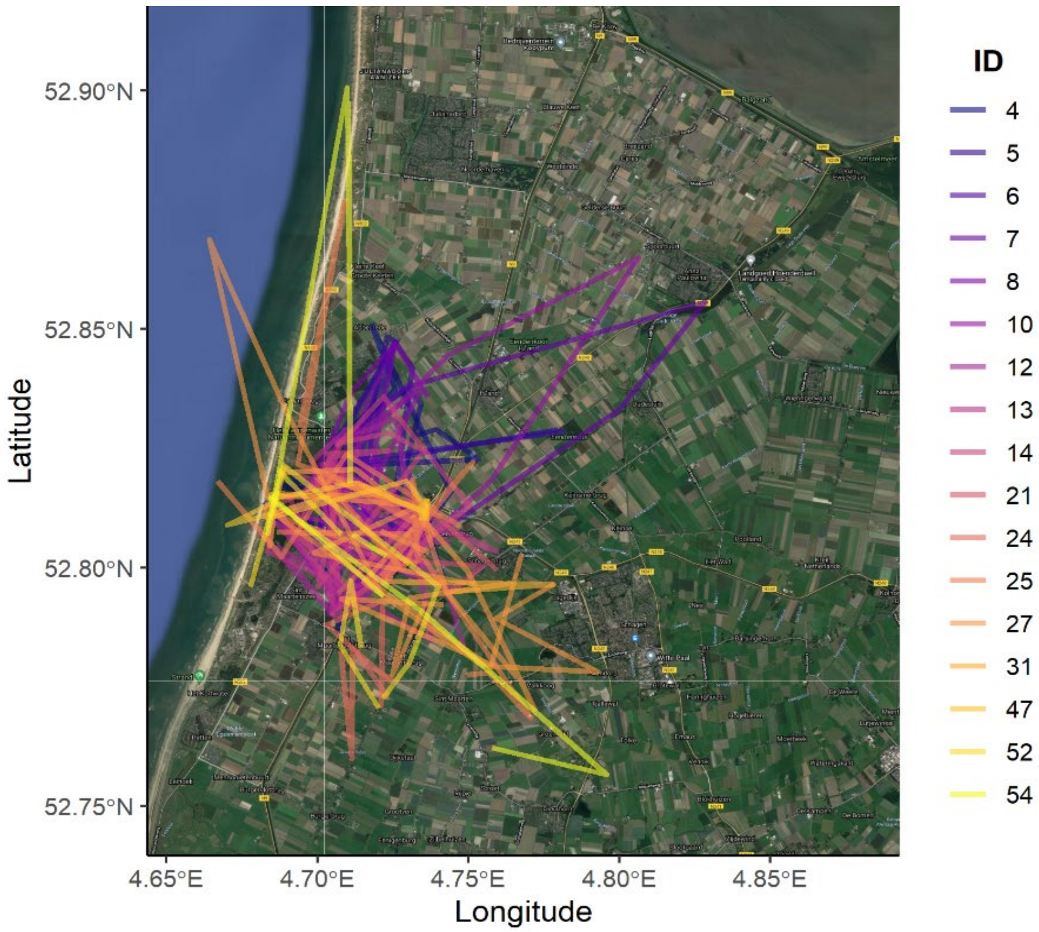


Figure 14. Joint movement pattern adult females (n=17), June-October 2020

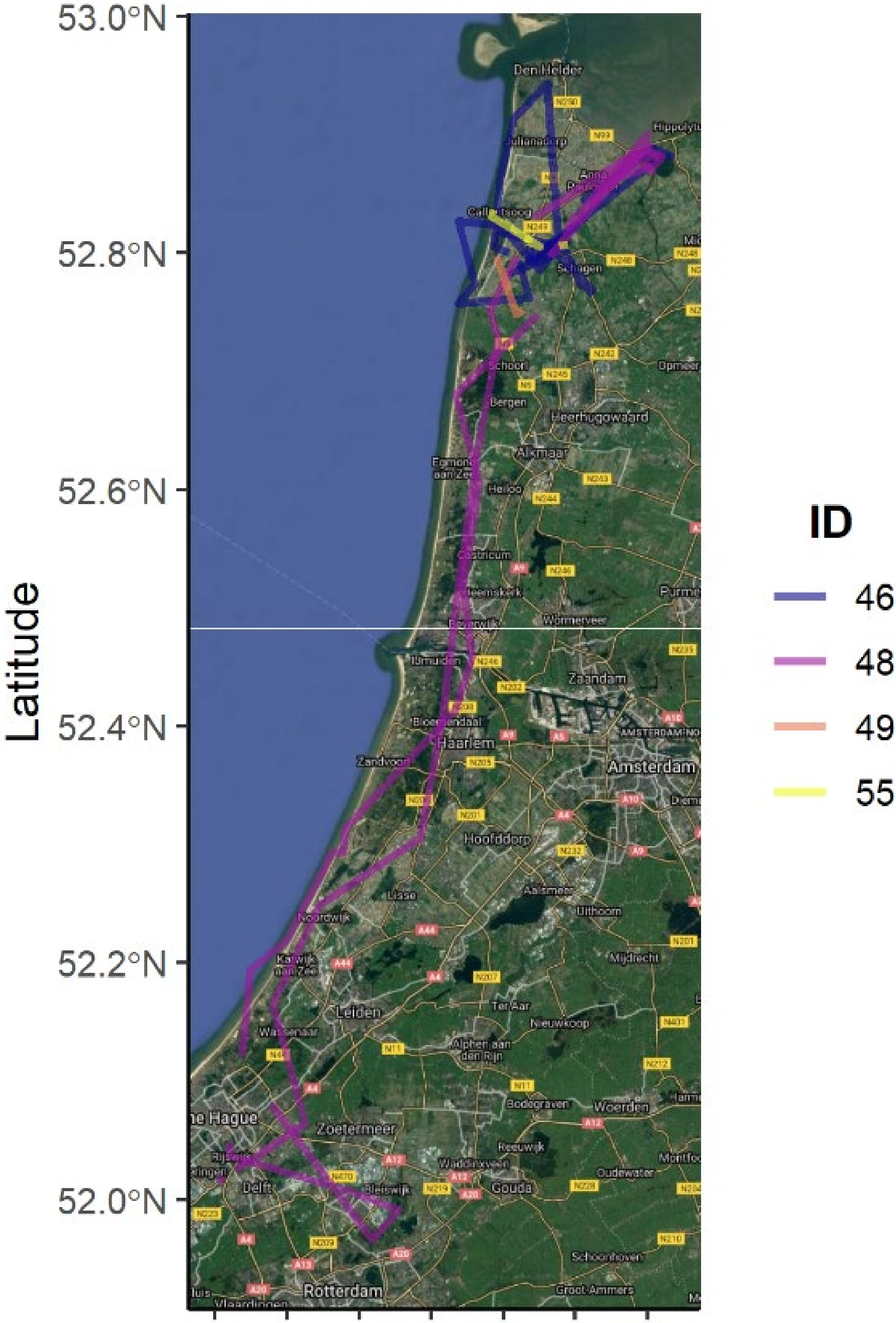


Figure 15. Joint movement pattern YOY females (n=4), June-October 2020

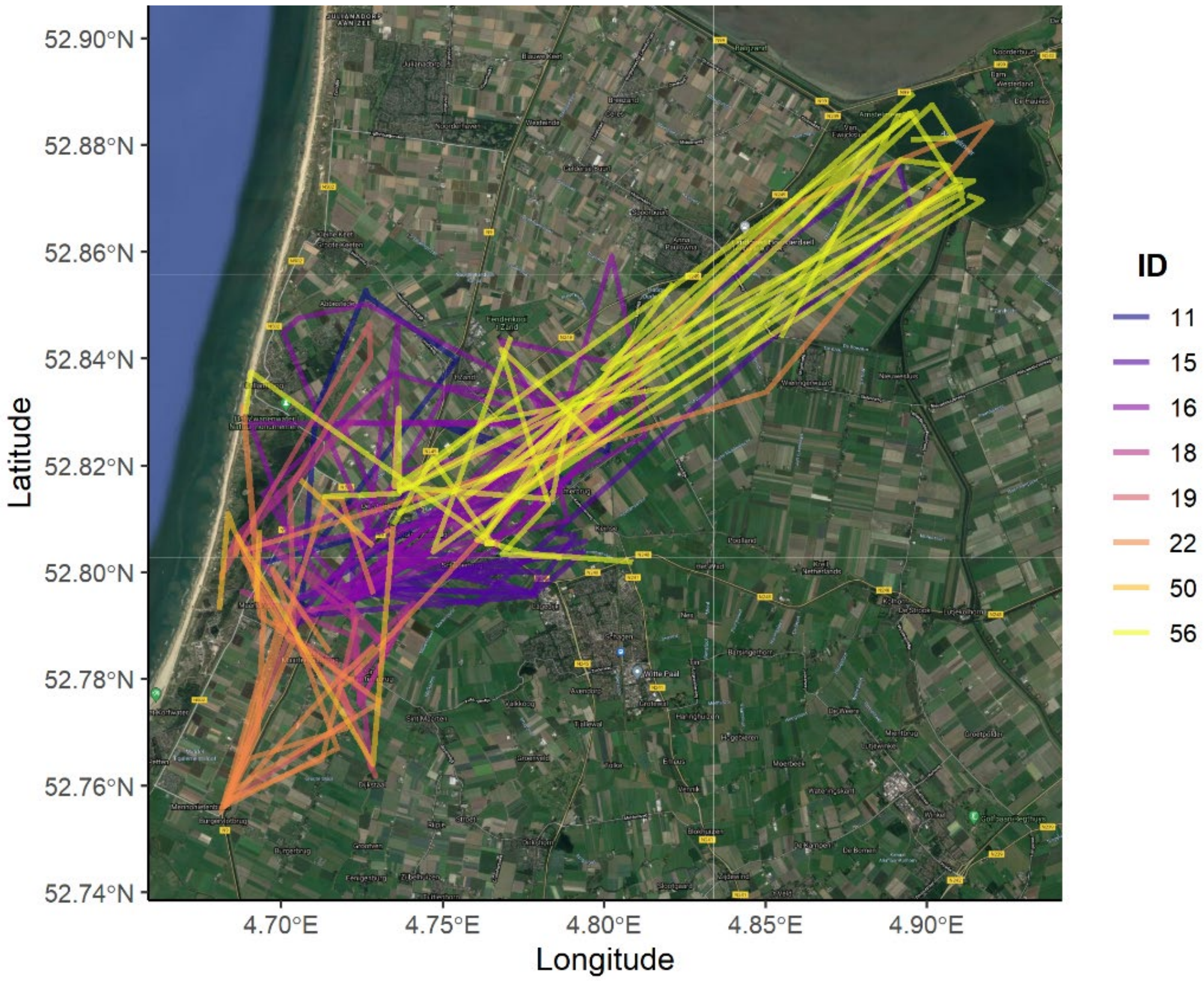


Figure 16. Joint movement pattern adult males (n=8), June-October 2020

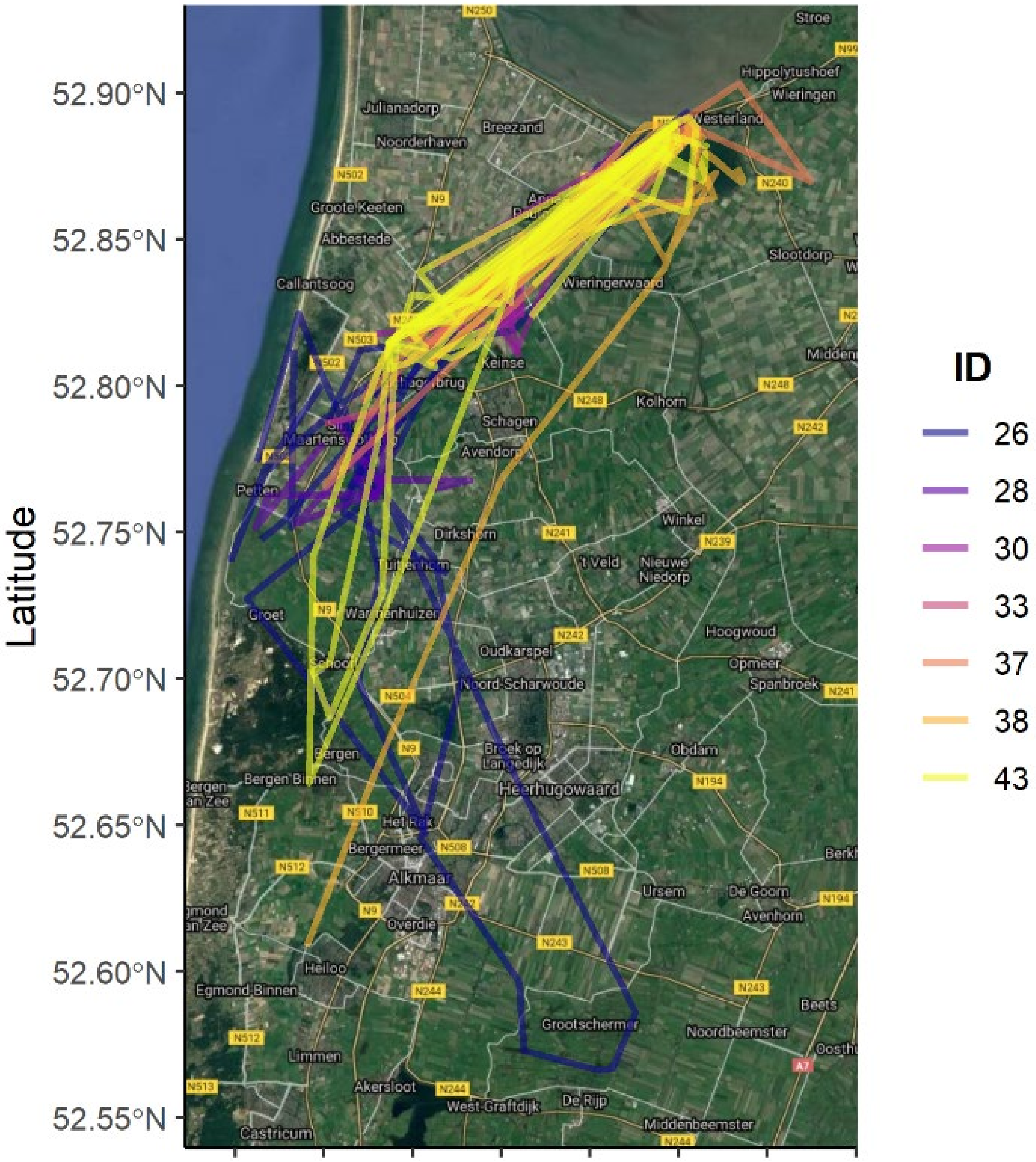


Figure 17. Joint movement pattern YOY males (n=7), June-October 2020

3.5 Home range

AKDEc home range estimations were obtained from all 31 individuals included in the analysis. Maps of the estimated individual home ranges can be found in Annex 5. Table 5 shows the 95% estimated size of the home ranges including the 95% confidence intervals. Furthermore the table shows whether the individual range extends onto the North Sea or onto the Wadden Sea. For 20 individuals the movement pattern shows autocorrelation in both space and velocity (model OUf & OUF). Autocorrelation in space only (model OU) was present in the data of four individuals, whereas the data of seven individuals did not show autocorrelation in their movement pattern (model IDD).

There is much variation in estimated home range (minimum 12 km^2 and maximum 16698 km^2) and there are marked differences between the age classes and the sexes (Table 6). Adult females and males have the smallest ranges, whereas young animals have the most extensive range. The size of the estimated home range, however, depends on the number of GPS fixes. Except for adult females, these

home ranges are obviously bigger with increasing numbers of fixes (Figure 18). The estimated home ranges for adult females remain in the same order of magnitude, irrespective of the number of GPS fixes.
The estimated home range was restricted to land for a small proportion of the individuals. For most individuals the estimated home range extends onto the sea, either onto the North Sea, or the Wadden Sea or onto both (Table 7), but it is restricted to a few kilometres from the coast. The estimated home range of only one individual (ID 48: YOY female) extends beyond the 12 mile zone (Annex 5).

Table 5. Optimal model (see 2.4.2 for explanation of the used models), 95% AKDEc home range, 95% confidence intervals and detected at North Sea or Wadden Sea (Y/N).

ID	Sex	Age	optimal model	model_name	area [km²]	area CI [km²]	North Sea	Wadden Sea
4	F	AD	OUf isotropic	1. 4 - OUf isotropic	40.91	25.65 - 59.68	Y	N
5	F	AD	OUf isotropic	10. 5 - OUf isotropic	54.62	32.84 - 81.86	Y	N
7	F	AD	OUf anisotropic	20. 7 - OUf anisotropic	73.76	34.34 - 127.98	Y	N
8	F	AD	OU anisotropic	27. 8 - OU anisotropic	27.77	17.11 - 40.95	N	N
10	F	AD	OUf anisotropic	33. 10 - OUf anisotropic	40.25	26.21 - 57.25	Y	N
11	M	AD	OU anisotropic	40. 11 - OU anisotropic	99.1	48.63 - 167.23	Y	N
12	F	AD	IID anisotropic	46. 12 - IID anisotropic	32.68	21.55 - 46.1	Y	N
13	F	AD	IID isotropic	54. 13 - IID isotropic	27.27	18.65 - 37.49	Y	N
14	F	AD	OUf isotropic	62. 14 - OUf isotropic	37.15	22.49 - 55.41	Y	N
15	M	AD	OUf anisotropic	70. 15 - OUf anisotropic	59.07	41.73 - 79.37	N	N
16	M	AD	OUf anisotropic	76. 16 - OUf anisotropic	69.56	53.73 - 87.41	N	N
18	M	AD	IID isotropic	83. 18 - IID isotropic	32.78	21.21 - 46.82	Y	N
19	M	AD	OUf anisotropic	90. 19 - OUf anisotropic	49	27.08 - 77.31	Y	N
22	M	AD	OUf anisotropic	97. 22 - OUf anisotropic	110.2	76.1 - 150.51	Y	N
24	F	AD	IID isotropic	104. 24 - IID isotropic	11.94	6.36 - 19.26	N	N
25	F	AD	IID isotropic	112. 25 - IID isotropic	78.71	57.19 - 103.62	Y	N
26	M	YOY	OUF anisotropic	118. 26 - OUF anisotropic	611.32	441.96 - 807.73	Y	Y
27	F	AD	OUf anisotropic	122. 27 - OUf anisotropic	53.43	36.95 - 72.89	Y	N
28	M	YOY	OU isotropic	129. 28 - OU isotropic	44.4	28.68 - 63.5	N	N
30	M	YOY	OUf anisotropic	137. 30 - OUf anisotropic	62.09	37.4 - 92.92	N	Y
37	M	YOY	OUf anisotropic	144. 37 - OUf anisotropic	104.08	73.32 - 140.13	N	Y
38	M	YOY	OUf anisotropic	151. 38 - OUf anisotropic	600.69	258.27 - 1085.13	Y	Y
43	M	YOY	OUf anisotropic	158. 43 - OUf anisotropic	250.54	185.81 - 324.79	N	Y
46	F	YOY	OUf anisotropic	165. 46 - OUf anisotropic	201.44	143.32 - 269.28	Y	Y
47	F	AD	OU anisotropic	172. 47 - OU anisotropic	12.24	6.48 - 19.81	Y	N
48	F	YOY	OUF anisotropic	178. 48 - OUF anisotropic	16697.75	4851.1 - 35732.78	Y	Y
50	M	AD	IID isotropic	182. 50 - IID isotropic	40.29	21.45 - 64.96	Y	N
52	F	AD	IID anisotropic	189. 52 - IID anisotropic	26.84	15.07 - 41.96	Y	N
54	F	AD	OUf anisotropic	195. 54 - OUf anisotropic	117.93	60.88 - 193.52	Y	N
55	F	YOY	OUf anisotropic	202. 55 - OUf anisotropic	22.54	10.68 - 38.75	Y	N
56	M	AD	OUf anisotropic	209. 56 - OUf anisotropic	141.68	103.74 - 185.43	Y	Y

Table 6. AKDEc home range, sigma (standard deviation) and number of individuals per sex and age class.

Sex	Age	Average AKDEc [km²]	sigma [km2]	n
F	AD	45	29	14
	YOY	5641	9576	3
M	AD	75	38	8
	YOY	279	264	6

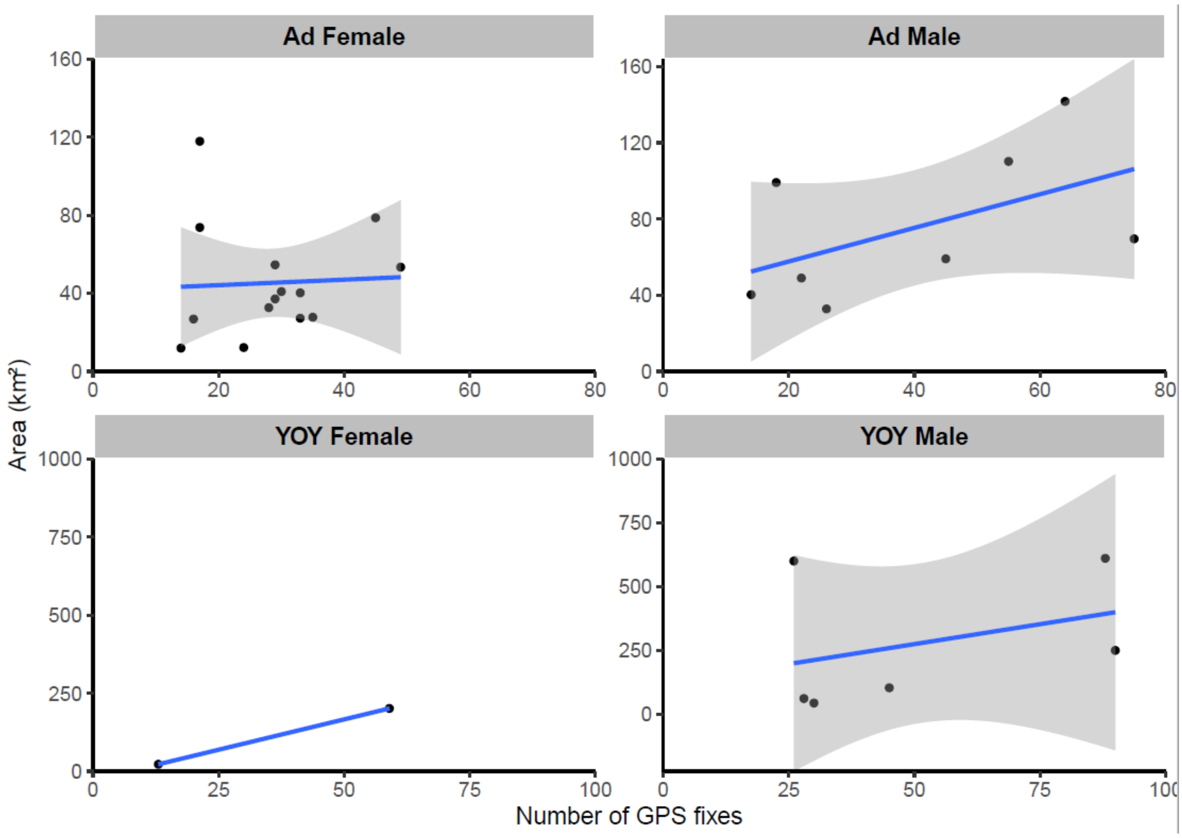


Figure 18. Estimated home range per sex and age class as a function of the number of GPS fixes. ID 46 (YOY female) with an estimated flight range of 16698 km² has been omitted from this figure. Note the different scales of young and adult individuals.

Table 7. Extent of the AKDEc home range onto sea.

		Flight range extends onto				
Sex	**Age**	**North Sea**	**Wadden Sea**	**North Sea & Wadden Sea**	**Exclusively on land**	**Total**
F	AD	12			2	14
	YOY	1		2		3
M	AD	5		1	2	8
	YOY		3	2	1	6
Total		18	3	5	5	31

3.6 Occurrence above sea

A total of 17 GPS fixes were obtained above sea (1.5% of the data, n=1145), of which three occurred close to the Wadden Sea coast north of Wieringen and 14 above the North Sea up to 2.7 km from shore. Only females (2 YOY and 4 adult) were recorded above the North Sea, whereas only males (3 YOY) were recorded above the Wadden Sea. Flight heights ranged between 19–32 m above the Wadden Sea and between 24–250 m above the North Sea (*Table **8***).

The North Sea records occurred during the nights of 14 and 15 September 2020 and during these nights a large proportion of the tagged animals was recorded above sea. The weather during these nights was characterized by high temperatures, gentle easterly winds and high atmospheric pressure (Table 9).
At September 14th we obtained data from five individual bats, of which three had flown above the North Sea and one above the Wadden Sea. During the night of September 15th we obtained data from 11 individual bats, of these four were recorded above the North Sea.

Table 8. GPS flight height recorded above the North Sea and Wadden Sea. Note that heights are regularly inaccurately assessed by a GPS [1].

Area	ID	Sex	Age	Date	Time [UTC]	Latitude	Longitude	Height [m]
Wadden Sea	38	Male	YOY	10-09-2020	19:00	52.89	4.88	19
	37	Male	YOY	12-09-2020	20:00	52.90	4.93	32
	26	Male	YOY	14-09-2020	22:30	52.89	4.90	25
North Sea	25	Female	AD	14-09-2020	19:00	52.82	4.67	250
	47	Female	AD	14-09-2020	19:30	52.81	4.67	48
	46	Female	YOY	14-09-2020	19:30	52.76	4.64	232
					20:30	52.83	4.64	89
				15-09-2020	19:30	52.86	4.70	-25 [1]
	27	Female	AD	15-09-2020	19:00	52.87	4.66	84
	48	Female	YOY	15-09-2020	22:00	52.31	4.48	24
					22:30	52.29	4.48	95
					23:00	52.29	4.46	164
					23:30	52.22	4.40	198
					00:30	52.19	4.35	92
	54	Female	AD	15-09-2020	19:00	52.90	4.71	48
	55	Female	YOY	15-09-2020	18:00	52.84	4.69	52
					19:00	52.83	4.68	31

Table 9 Weather conditions 14-15 September 2020 at Airport De Kooij (source KNMI)

Weather parameter	14-09-2020	15-09-2020
Average temperature [C]	18.4	20.3
Maximum temperature [C]	25.4	25.8
Minimum temperature [C]	12.4	16.5
Wind direction [degree]	84	45
Average wind speed [m/s]	2.7	2.6
Average Air pressure [mB]	1023	1019
Sunshine [h]	11.6	11.5
Precipitation [mm]	0	0
Average humidity [%]	84	84
Clouds	partial	half

3.7 Habitat analysis

The availability and the use of each habitat type was quantified for each individual with its home range (n =31, Annex 6). The dataset does not include GPS fixes from the habitat types *Greenhouse farming*, *Heather* and *Salt marsh* and only one GPS fix from the habitat type *Orchards.* Therefore, these four habitat types were not included in the analysis, leaving ten habitat types for the analysis.

We performed the habitat analysis exclusively for adult females, because in the other functional groups (YOY females, adult and YOY males) the estimated home range depends on the number of location fixes and the number of individuals per group is small.

A selection test of the ten remaining habitat types revealed a significant habitat selection (p= 0.0000085, Lambda=0.0585592 df=9) for adult females. The habitat analysis (***Table 10***) clearly shows that *Fresh water* is the most preferred habitat, followed in descending order by *Built-up area*, *Grassland*, *Dune vegetation* and *Swamp*. The analysis showed no preference for the habitat types *Forest*, *Flower bulbs*, *Open sandy area*, *Agriculture* and *Salt water*. The least preferred habitat is therefore *Salt water,* i.c. the North Sea and the Wadden Sea.

Table 10. Ranking matrix of habitat types. At the intersection of the row i and of the column j, there is a "+" when the habitat i is more used than the habitat in the column, and "-" otherwise. When the difference is significant, the sign is tripled. For instance on the first row habitat type fresh water is more used than built-up area and grassland, but the difference is not significant, hence the '+'. Fresh water is used significantly more than for instance forest and bulb vegetation, hence the '+++'.

Habitat type	Fresh water	Built-up area	Grassland	Forest	Bulb vegetation	Dune vegetation	Swamp	Open sandy area	Agriculture	Salt water
Fresh water	0	+	+	+++	+++	+++	+++	+++	+++	+++
Built-up area	-	0	+	+	+++	+++	+++	+++	+++	+++
Grassland	-	-	0	+	+++	+++	+++	+++	+++	+++
Forest	---	-	-	0	+	+	+	+++	+++	+++
Bulb vegetation	---	---	---	-	0	+	+++	+++	+++	+++
Dune vegetation	---	---	---	-	-	0	+	+	+	+++
Swamp	---	---	---	-	---	-	0	+	+	+++
Open sandy area	---	---	---	---	---	-	-	0	+	+++
Agriculture	---	---	---	---	---	-	-	-	0	+++
Salt water	---	---	---	---	---	---	---	---	---	0

4 Discussion

Common noctule is a migratory species, in particular in Eastern Europe. Females are known to cover distances up to 1600 km between summer and winter areas, whereas males do not migrate, or only do so over short distances (Dechmann *et al.* 2017; Lehnert *et al.* 2018). The exact timing, flight routes and the magnitude of this annual migration are poorly understood. Populations are not known to migrate from England in the winter and records from Orkney, Shetland and North Sea installations are regarded as vagrants from Europe (Mackie & Racey 2008), some perhaps originating from Scandinavia (Petersen *et al.* 2014). In the Netherlands common noctule is considered a partial migrant; only a small proportion of the population migrates (Sluiter & Van Heerdt 1966; Kapteyn 1995). There are no indications that the population in our study area is migratory. At least a large proportion of the population, including several well-marked individuals, is year-round present in our study area (unpublished data WOZEP telemetry project).

Common noctule is primarily a tree-roosting bat, but sometimes the species is found in buildings as well. Like other bat species, common noctule uses a network of roosts and regularly switches between these roosts. In April females form maternity colonies, which disintegrate again in July after the young have become independent. During summer the males reside nearby, either individually or in small groups. In August the mating season starts and adult males defend their territories and try to attract both adult and juvenile females to their mating roost. Juvenile males and sexually inactive adult males are also tolerated in these roosts. Males do not reproduce in their first year (Sluiter & Van Heerdt 1966).

The colonies at Wildrijk and Ananas are no exception to the general pattern. The primary roost at Ananas was exclusively occupied by adult females and their young. Scattered throughout the study area we found roosts occupied by one or more males, accompanied by adult females, and by juvenile males and females later in the season. Juvenile males are known to leave the colony and settle elsewhere (Sluiter & Van Heerdt 1966). This is reflected in the genetic population structure of common noctules in Europe which indicates a high dispersal rate of males (Petit & Mayer 1999). Furthermore juvenile males are more likely to disperse than juvenile females (Petit *et al.* 2001). This difference in dispersal behaviour may explain the difference in the retrieval-rate of the GPS deployments in this study: juvenile males 50% (n=10), adult males 92% (n=13), juvenile females 71% (n=7) and adult females 76% (n=25) (Table 3). Note that the retrieval rate of adult females was highly influenced by antennas bitten off (paragraph 3.2).

Foraging usually takes place within a few kilometres from the roost (Kronwitter 1988; Kapteyn 1995, Roeleke *et al.* 2016)., but distances up to 26 km have been reported (Kronwitter 1988). Our study shows also most flight activity within a few kilometres from the roost, and maximum distances of approximately 11 and 16 km for adult females and adult males respectively. Differences in distances from the roost are also reflected in the estimated AKDEc home ranges. On average adult females had a home range of 45 km^2 (sigma = 29 km^2, n=14) and this range did not change much over time, between the maternity period and the mating season. The AKDEc home range of adult males was larger: on average 75 km^2 (sigma = 38 km^2, n=8), also without obvious seasonal variation. Juveniles generally flew further away from the colony. Maximum distances of up to 27.5 km for juvenile males and 94 km for juvenile females were recorded. It seems unlikely that these distant flights should be regarded as regular foraging flights. Instead, these flights could be exploratory flights prior to the actual dispersal. Estimated AKDEc home ranges of juvenile males were on average 279 km^2 (sigma = 264 km^2, n=6) and of juveniles females on average 5641 km^2 (sigma = 9576 km^2, n=3) The average flight range of juvenile females is highly influenced by one individual with a range of 16698 km^2; neglecting this observation results in an average range of 112 km^2 (sigma = 127 km^2, n=2).

According to Seaman *et al.* (1999), home range estimates should be based on at least 30 and preferably on more than 50 location fixes. Of our estimated home ranges 15 were based on 10-29 location fixes, nine on 30-49 location fixes and seven on 50 or more location fixes. The estimated home ranges of both adult and young males, as well as juvenile females are likely to be negatively biased as the size of the estimated home range clearly shows a relation with the number of location fixes. For adult females there was no obvious dependency between the number of location fixes and the size of the home range. Furthermore, the home range estimation of adult females is based on a larger sample size (n=14) and therefore we consider this home range estimate reliable. More data are needed in order to obtain reliable home range estimates for adult and young males, as well as for juvenile females.

The habitat analysis clearly revealed habitat preferences by adult female common noctules. The preference for fresh water, built-up areas, grassland and swamp is in line with the most important known foraging habitats in the Netherlands (Kapteyn 1995, Limpens *et al.* 1997), and in Germany (Roeleke *et al.* 2016 and 2018). Our study indicates that dune vegetation is also important. Salt water was the least preferred habitat. In other words, terrestrial habitats are preferred and the marine habitat is avoided. Although we could not perform a statistical analysis on the habitat use of the other groups (adult and young males, and young females), there seem to be no obvious differences between adult males and females in the use of the marine environment. These groups rarely venture out to sea, and estimated home ranges extend only a few kilometres offshore. Young males and females have larger home ranges, with the estimated home range of one individual (YOY female ID 46) exceeding beyond the 12 mile zone (where offshore wind development takes place). Bat detector research in offshore wind farms confirms that common noctules are occasionally present in Offshore Wind farm Egmond aan Zee (September 2012), Princess Amalia Wind Farm (September 2014 and 2016) and Luchterduinen (August 2016) (Jonge Poerink *et al.* 2013, Lagerveld *et al.* 2015 and 2017). Note, however, that only a small proportion (approximately 15%) of the recorded 'Nyctaloids' (including Nyctalus, Vespertilio, Eptesicus species) were identified to species level and that generally high-flying species such as common noctules can be missed by the bat detector (Voigt et al. 2021). Furthermore there are two records from gas production platforms close to the North Sea coast of the Dutch Wadden Sea islands (6 and 11 km) in September 1994 and 1996 (Boshamer & Bekker 2008).

Despite the avoidance shown by the habitat analysis, this study indicates that common noctules do occur offshore and that this probably coincides with certain weather conditions. During two subsequent days in September 2020 with high temperatures (max 25°C) and easterly winds, 60% and 36% of the tagged animals (n=5 and 11) were recorded at sea, respectively. These animals were detected up to 2.7 km from land. The same phenomenon also occurred in autumn 2018 and 2019, when offshore activity off the coast of North Holland occurred during similar weather conditions. Amongst the individuals recorded offshore, one adult male reached a distance from shore of 12.7 km 2019 (Lagerveld *et al*. in prep). It seems plausible that insect availability over the sea may explain the presence of common noctules at the North Sea (cf. Ahlén *et al.* 2009). High temperatures trigger insect activity and easterly winds may drift these insects offshore. Furthermore, migrating insects can also fly in large numbers over sea, increasing the offshore insect availability (Chapman *et al.* 2004; Drake *et al.* 2012).

Roosts of common noctules near the Dutch coast are located in wooded areas between Oostvoorne in South Holland and our study area in North Holland. Coastal colonies are absent from Zeeland, Friesland, Groningen and the Wadden Sea Islands (Broekhuizen *et al.* 2016). Roosts are found up to 600 m from the North Sea coast; the actual coastline is avoided. The environmental characteristics and group composition of each roost may differ from those in our study area, potentially resulting in roost-specific behaviour. Animals from a roost near rich feeding areas can exhibit short foraging trips, whilst animals from a similar-sized roost at a greater distance need to travel further to find sufficient food. Therefore individuals roosting at other locations can show different behaviour, have different home ranges and different habitat use, in comparison to the individuals in our study area. These potential differences make it difficult to extrapolate our findings to other areas. A study in southern Sweden, for example, revealed frequent use of the maritime environment. By tracking bats with a radar system during 18 nights from July to October in 2005 and 2006, noctules were regularly found foraging regularly at sea and repeatedly returning to the same land areas again before dawn. Moreover they apparently flew long distances from the coast to forage (Ahlén *et al.* 2009). Though the situation in Sweden differs from the Netherlands, e.g. the Baltic Sea is brackish and more sheltered than the North Sea, Ahlén *et al.* (2009) demonstrate that local common noctules are capable of exploiting resources above sea.

Apart from spatial differences between colonies, bats behave differently during their yearly cycle as already sketched by Sluiter & Van Heerdt (1966). Furthermore, juveniles alter their behaviour before dispersal, and migratory animals, from more inland populations, physiologically prepare for migration. This can lead to seasonal changes in home range size, amount and duration of foraging sessions, and selection of different foraging habitats (e.g. Dechmann *et al.* 2014).

5 Conclusions and recommendations

From our current study we conclude:

- that the AKDEc home range of adult female common noctules is on average 45 km^2 and extends not further than a few kilometres onto the North Sea.
- that adult females are almost completely ‘terrestrial’ and show the least preference for the maritime habitat. When they occur at sea, this is probably driven by specific weather conditions.
- that adult females face low risks of potential negative impacts from offshore wind farms outside the 12 mile zone.
- that home ranges could not reliably be assessed for adult male, young male and young female common noctules due to a lack of data. In comparison to adult females, however, the home range of adult males seem to be larger, while the home ranges of young males and young females are even larger than those of adult males.
- that habitat use could not reliably be assessed for adult males, young males and young females, due to small sample sizes.
- that adult male common noctules face possibly a slightly higher risk in comparison to adult females from offshore wind turbines.
- that young male and young female common noctules face uncertain risk of potential negative impacts from offshore wind farms outside the 12 mile zone
- that our results are valid for Ananas and ‘t Wildrijk, and extrapolation of these conclusions to home ranges and habitat use of common noctules in other areas in the Netherlands is not necessarily straightforward.

Though outside the scope of this study, our previous bat detector work concluded:

- that common noctules are detected in the offshore wind farms outside the 12 mile zone

To answer remaining questions we recommend:

- to obtain more data from the study area in late summer, put more emphasis on young males, young females, and adult males
- to tag common noctules in other areas, in particular close to the current offshore wind farms.

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. This certificate is valid until 15 December 2021. The organisation has been certified since 27 February 2001. The certification was issued by DNV GL.

References

Aebischer, N.J., Robertson, P.A. & Kenward, R.E., 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74(5): 1313-1325.

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

Aldridge, H.D.J.N. & Brigham, R.M., 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% "rule" of radiotelemetry. Journal of Mammalology 69: 379–382.

Belonje, J., 1952. Het Wildrijk in de Zijpe. Drukkerij Meijer, Wormerveer.

Broekhuizen, S., Thissen, J., Spoelstra, K., Canters, K. & Buys, J., 2016 Atlas van de Nederlandse Zoogdieren; herkenning, verspreiding & leefwijze. KNNV Uitgeverij

Boshamer, J.P.C. & Bekker, J.P., 2008. Nathusius' pipistrelles (*Pipistrellus nathusii*) and other species of bats on offshore platforms in the Dutch sector of the North Sea. Lutra 51: 17-36.

Calabrese, J.M., Fleming, C.H., & Gurarie, E., 2016. ctmm: An r package for analyzing animal relocation data as a continuous-time stochastic process. Methods in Ecology and Evolution 7(9): 1124-1132.

Calenge, C., 2006. The package 'adehabitat' for the R software: a tool for the analysis of space and habitat use by animals. Ecological Modelling 197: 516–519.

Chapman, J.W., Reynolds, D.R., Smith, A.D., Smith, E.T. & Woiwod, I.P., 2004. An aerial netting study of insects migrating at high altitude over England. Bulletin of Entomological Research 94: 123-136.

Drake, V.A. & Reynolds, D.R., 2012. Radar entomology: observing insect flight and migration. Cabi, Wallingford, UK.

Dechmann, D.K., Wikelski, M., Varga, K., et al., 2014. Tracking post-hibernation behavior and early migration does not reveal the expected sex-differences in a "female-migrating" bat. PLOS ONE 9: e114810.

Dechmann, D.K.N., Wikelski, M., Ellis-Soto, D., Safi, K., O'Mara, M., 2017. Determinants of spring migration departure decision in a bat. Biol. Lett. 13, 20170395.

Fleming, C.H. & Calabrese, J.M., 2017. A new kernel-density estimator for accurate home-range and species-range area estimation, Methods in Ecology and Evolution 8(5): 571-579. DOI: 10.1111/2041210X.12673.

Haarsma, A-J., 2008. Manual for assessment of reproductive status, age and health in European Vespertilionid bats. Electronic publication, version 2. Zoogdiervereniging, Arnhem, The Netherlands.

Hazeu, G.W., Vittek, M., Schuiling, R., Bulens, J.D., Storm, M.H., Roerink, G.J. & Meijninger, W.M.L., 2020. LGN2018: Een nieuwe weergave van het grondgebruik in Nederland. Wageningen.

Jonge Poerink, B., Lagerveld, S. & Verdaat, H., 2013. Pilot study Bat activity in the Dutch offshore wind farms OWEZ and PAWP 2013. IMARES report C026/13.

Kapteyn, K., 1995. Vleermuizen in het landschap. Schuijt & Co. Haarlem.

Kenward, R.E., 2007. A manual for Wildlife tracking. Academic press. ISBN 0-12-404242-2

Kozhurina, E.I., 1993**:** Social organization of a maternity group in the noctule bat**,** *Nyctalus noctule* (Chiroptera: Vespertilionidae). Ethology 93: 89-104.

Kronwitter, F., 1988. Population structure, habitat use and activity patterns of the noctule bats *Nyctalus noctula* Schreb. 1774 (Chirpotera, Vespertilionidae) revealed by radio-tracking. Myotis 26: 23–85.

Lagerveld, S., Gerla, D., van der Wal, J.T., de Vries, P., Brabant, R., Stienen, E., Deneudt, K., Manshanden, J. & Scholl, M., 2017. Spatial and temporal occurrence of bats in the southern North Sea area. Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C090/17; 52 p.

Lagerveld, S., Jonge Poerink B. & de Vries P., 2015. Monitoring bat activity at the Dutch EEZ in 2014. Den Helder, IMARES, (Report / IMARES Wageningen UR C094/15).

Lehnert, L.S., Kramer-Schadt, S., Teige, T., Hoffmeister, U., Popa-Lisseanu, A., Bontadina, F., ... & Voigt, C.C., 2018. Variability and repeatability of noctule bat migration in Central Europe: evidence for partial and differential migration. Proceedings of the Royal Society B, 285(1893), 20182174.

Limpens, H., Mostert, K., Bongers, W., 1997. Atlas van de Nederlandse vleermuizen; onderzoek naar verspreiding en ecologie. KNVV.

Manly, B.F.J., McDonald, L.L., Thomas, D.L., McDonald, T.L. & Erickson, W.P., 2002. Resource Selection by Animals: Statistical Design and Analysis for Field Studies. 2nd edn. Kluwer Academic Publishers: Dordrecht, The Netherlands.

O'Mara, M.T., Wikelski, M. & Dechmann, D.K., 2014. 50 years of bat tracking: device attachment and future directions. Methods in Ecology and Evolution 5(4): 311-319.

Petersen, A., Jensen, J.K., Jenkins, P., Bloch, D. & Ingimarsson, F., 2014. A review of the occurrence of bats (Chiroptera) on islands in the North East Atlantic and on North Sea installations. Acta Cropterologica 16: 169-195.

Petit, E. & Mayer, F., 1999. Male dispersal in the noctule bat (*Nyctalus noctula*): where are the limits? Proceedings of the Royal Society of London B: Biological Sciences 266: 1717–1722. doi:10.1098/rspb.1999.0837

Petit, E., Balloux, F. & Goudet, J., 2001. Sex-biased dispersal in a migratory bat: a characterization using sex-specific demographic parameters. Evolution 55(3): 635-640.

R Core Team. 2020 R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Roeleke, M., Blohm, T., Kramer-Schadt, S., Yovel, Y., & Voigt, C.C., 2016. Habitat use of bats in relation to wind turbines revealed by GPS tracking. Scientific reports 6(1): 1-9.

Roeleke, M., Teige, T., Hoffmeister, U., Klingler, F., & Voigt, C.C., 2018. Aerial-hawking bats adjust their use of space to the lunar cycle. Movement Ecology 6(1): 1-10.

Sluiter, J.W. & Van Heerdt P.F., 1966. Seasonal habits of the noctule bat (*Nyctalus noctula*). Arch. Neerl. Zool. 16: 423-439.

Van Loo, L.F., 2006. 'Graaf Bentinck' of grootgrondbezitters in de Zijpe. ZHB 2006-03. Historische Vereniging "De Zijpe"

Van den Tempel, C., 2016. Uitgebreid leefgebied Rosse vleermuis in Noord-Holland. De Levende Natuur 117(6): 262.

Voigt, C.C., Russo, D., Runkel, V., & Goerlitz, H.R., 2021. Limitations of acoustic monitoring at wind turbines to evaluate fatality risk of bats. Mammal Review.

Justification

Report C057/21
Project Number: 4315100149

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Mardik Leopold
Researcher

Signature:

Date: 5 July 2021

Approved: Tammo Bult
Director

Signature:

Date: 5 July 2021

Annex 1: reproductive status bats

Source: www.vleermuizenvangen.nl, assessed 18-05-2021

Epi- Epiphyseal growth plates
1. Epiphyseal gaps not yet sealed. Three translucent regions can be seen in the joint: the space between the bones, and the two epiphyseal plates on either side. Joint is still long and thin.
3. Intermediate joining visible.
4. Epiphyseal gap nearly closed; joints thicker and nearly rounded
5. Epiphyseal gap closed and no longer translucent. Only the gap between the two bones is still translucent. Joints thicker and rounded.
Age – Estimation of age
- Juv.- Juvenile (2-3 months).
- Sub.-Subadult, sexual immature (between 3 and 15 months).
- Ad.- Adult, sexual mature (between 3 months and unknown number of years).
- Ab. Avr. Above average (clearly older than other individuals of same species. The exact age of such an individual will depend on specie specific trades as well on geographical related variables).

Dentition
Wear – Dental wear
1. No wear, canines still pointed.
2. No wear on molars, only slight wear on premolars and canines.
3. All teeth including molars slightly worn (also already visible from the front).
4. Chewing surfaces of molars clearly worn, canines flattened.
5. Chewing surfaces severely worn (almost flat), canines maximally half their original size.

Plaque – Dental plaque
1. No plaque, or only maximally on one molar.
2. Yellow plaque in crevices of and between (pre-)molars, black discolouration on maximally one tooth.
3. Yellow or black plaque present in the crevices and edges of most teeth, but plaque does not continue uninterrupted along the edges of more than two teeth.
4. Narrow black or (partially) yellow line of plaque along the entire tooth row.
5. Broad black band of plaque along the entire tooth row.

Sexual status makes – Males
Ts- Testes
The testes progressively expand and descend towards the tail. In Rhinolophus and Nyctalus, testes expand but do not descend. The size of the testes varies from 1 to 5. At category 5 the testes is very large and swollen.

Epi. Size – Size of the epididymes. The epididymes descend from the body cavity along the uropatagium; in Myotis extending along (almost) the entire first vertebra of the tail. Upon reaching sexual maturity for the first time, the epididymes do not reascend and remain temporary elongated. After the mating season the epididymes appear empty. The size and shape of the epididymes varies largely between species. Pipistrelles have very round epididymes that decend to a much lesser degree than those of the Myotis species. The size of the epididymes varies from 1 to 5. At category 1 the epididymides are still in the body cavity. At category 5 the epididymides is completely descended and long.

Epi. Filling – Filling of the epididymis
The degree of filling of the epididymes is measured in 5 percentage classes. Often a dark tip is visible in the epididymes when an individual has been previously sexually active, in this case the epididymes size is scored a class higher than the epididymes filling.

1 - Completely empty, 0%.
2 - Barely filled, 25%.
3 - Moderately filled, 50%.
4 - Almost completely filled 75%, epididymes begin to swell.
5 - Completely filled (100%) Epididymes clearly swollen
Epi. Color – Color of the caudae epididymis
The pigmentation of the (tunica vaginalis in front of the) caudae epididymes diffuses as they expand. Animals that were previously sexually active therefore have lighter epididymes than juveniles or subadults. There is a large amount of variation between species. For example, Geoffrey's bat also has very dark epididymes in adults, whereas those of Pipistrellus can be very light, also in juveniles. Often the tip of the epididymes remains dark in adult bats, the Color of this tip should not be taken into account when scoring.

Reproductive status males

SI - Sexual immature. Juvenile male which shows no signs of sexual activity. Testes not swollen, epididymes still in body cavity. The caudae epididymes heavily pigmented.
SA1 – Sexual status 1. The early stage of spermatogenesis. Testes swollen, but epididymes not descended and without filling.
SA2 - Sexual status 2. The beginning the testes regression and the descending and swelling of the epididymes.
SA3 – Sexual status 3. The last stage of spermatogenesis activity. The epididymes are fully swollen and the testes is regressed.
SM – Sexual mature. After the mating season. Male without enlarged testes or filled epididymes, but with clearly descended epididymes and diffuse pigmentation of the caudae epididymes.

Reproductive status marks females

MG - Mammary glands. Mammary glands are visible under the skin surrounding the nipple as a light-yellow or white discoloration. The size of the mammary glands, when measured along the anteroposterior axis, varies from 1 cm to 2,5 cm. Possible swelling of the mammary glands should be noted in the remarks field.
1. Mammary glands not visible, skin around the nipple the same Color as that on the stomach
2. Mammary glands visible, maximal diameter approximately 1 cm.
3. Mammary glands visible, maximal diameter approximately 1.5 cm.
4. Mammary glands visible, maximal diameter approximately 2 cm.
5. Mammary glands visible, maximal diameter approximately 2.5 cm.

Reproductive status female.

This category can be assessed by investigating the following characteristics: the nipple, hair in nipple area and the the area immediately surrounding the nipple. The nipple area always remains completely bald. Some hair remains on the nipple itself, and during the lactation period this sticks together in a tuft. When assessing baldness, the amount of hair in the immediate area surrounding the nipple is scored. During the lactation period the nipple clearly discolors due to callous formation, this discoloration can be whitish, yellowish, or dark brown.
- S.I – Sexual immature. Female that is not pregnant. Nipple not enlarged, Color same as surrounding skin. No bald patch around the nipple, and the surrounding hairs have (almost) the same length, colour, and structure as the surrounding hair.
- Preg. – Pregnant. Abdomen swollen and hard. Stomach slightly pear-shaped.
- H.Preg. - Highly pregnant, abdomen clearly swollen and hard. Stomach clearly pear-shaped, release immediately.
- Lac – Lactating. (Strongly) enlarged nipple as a result of current lactation period. Clearly visible mammary glands. Color of the nipple clearly different from that of the surrounding skin. Bald patch around the nipple, hairs on the nipple sometimes stuck together in a single tuft.
- P.lact – Post lactating. Female that has lactated previously in the season. Strongly enlarged nipple. Immediately after the lactation period the hair starts to regrow, these hairs are short, grey and clearly different in structure from the surrounding hairs.

- 1V - Female which has clearly lactated in at least one previous year, but is not currently pregnant nor lactating. Small, but enlarged (wart-like) nipple due to lactation in the past. Color clearly different from that of the surrounding skin, hairs in the immediate area of the nipple are still slightly different in color and structure from surrounding hairs, but not grey. Hair density is also lower.
- 3V - Female which has clearly lactated in at least one previous year, but is not currently pregnant nor lactating. Enlarged (wart-like) nipple due to lactation in the past. Color clearly different from that of the surrounding skin, hairs in the immediate area of the nipple are still slightly different in Color and structure from surrounding hairs, but not grey. Hair density is also lower.
- 5V - Female which has clearly lactated in several previous years, but is not currently pregnant nor lactating. Strongly enlarged, wart-like nipple due to multiple years of lactation. Color clearly different from that of the surrounding skin, hairs in the immediate area of the nipple are still slightly different in color and structure from surrounding hairs, but not grey. Hair density is also lower.

Annex 2: Habitat categories

Source: https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksinstituten/Environmental-Research/Faciliteiten-tools/Kaarten-en-GIS-bestanden/Landelijk-Grondgebruik-Nederland/Versies-bestanden/LGN2019.htm, assessed 20-04-2021

Category	Code	Subcategory
Agriculture	2	Maize
	3	Potatoes
	4	Beets
	5	Grain
	6	Other agricultural crops
Build-up area	18	Buildings in a primarily built-up area
	19	Buildings in a secondary built-up area
	20	Forest in a primarily built-up area
	23	Grass in primarily built-up area
	24	Bare land in a built-up area
	25	Roads and railways
	26	Buildings in rural areas
	27	Other land use in rural areas
Bulb vegetation	10	Flower bulbs
Dune vegetation	32	Dunes with low vegetation
	33	Dunes with high vegetation
	34	Duinheide
	46	Grass in coastal area
Forest	11	Deciduous forest
	12	Coniferous forest
	22	Forest in secondary built-up area
	40	Forest in high moor area
	43	Forest in swamp area
Fresh water	16	Fresh water
Grassland	1	Agricultural grass
	28	Grass in secondary built-up area
	45	Natural grasslands
	47	Other grass
Greenhouse farming	8	Greenhouse horticulture
Heather	36	Heather
	37	Moderately grazed
	38	Highly grazed heather
Open sandy area	31	Open sand in coastal area
	35	Open drifting sand and / or river sand
Orchards	9	Orchards
	61	Nurseries
	62	Fruit farms
Salt marsch	30	Salt marshes
Salt water	17	Salt water
Swamp	39	High bog
	41	Other swamp vegetation
	42	Reed vegetation
	321	Shrub vegetation in high moor area (low)
	322	Shrub vegetation in swamp area (low)
	323	Other shrub vegetation (low)
	331	Shrub vegetation in upland moor area (high)
	332	Shrub vegetation in swamp area (high)
	333	Other shrub vegetation (high)

Annex 3: Fieldwork effort

(JB: Jan Boshamer, Avdb = Arnold van den Burg, WH = Wieneke Huls, RJ: René Janssen, LK = Lonneke Klein-Aarts, SL: Sander Lagerveld, BN: Bart Noort, KS: Karina Stienstra)

Start [UTC]	End [UTC]	Activities	Crew
2021-06-23 10:00	2021-06-24 03:00	• Check batboxes Wildrijk and listening for social calls • Listening for social calls Ananas, found maternity roost • Trapping 26 females with boxtrap at maternity roost Ananas, tagged 10 individuals • Trapping with mist nets in Wildrijk, tagged 3 females and 1 male	JB, RJ, SL, KS
2021-06-24 17:00	2021-06-24 23:00	• Check batboxes Wildrijk and listening for social calls • Trapping with mist nets in Wildrijk	RJ,
2021-06-25 16:00	2021-06-25 22:00	• Check batboxes Wildrijk and listening for social calls • Scanning for tagged individuals on foot, 1 located including an untagged individual • Unsuccessful attempt to catch untagged individual with boxtrap	RJ, JB
2021-06-28 10:00	2021-06-26 12:30	• Scanning for tagged individuals on foot Wildrijk (4 located)	KS
2021-06-30 07:30	2021-06-30 11:30	• Scanning for tagged individuals Wildrijk on foot (4 located) and Ananas (1 located)	JB, KS
2021-07-01 07:30	2021-07-01 13:30	• Scanning for tagged individuals Wildrijk on foot (6 located, 1 tag retrieved from individual in batbox) and Ananas (1 located) • Listening for social calls , one additional roost found Wildrijk	JB, KS
2021-07-02 10:00	2021-07-02 12:30	• Scanning for tagged individuals by car: area covered between Noorderhaven and Wildrijk, Callantsoog and Korte Ruigeweg (1 located Korte Ruigeweg)	JB
2021-07-03 06:30	2021-07-03 08:30	• Scanning for tagged individuals by car: area covered between Schagerbrug and Burgerbrug, Belkmerweg and Ruigeweg • Scanning for tagged individuals on foot Ananas (2 located)	JB, KS
2021-07-06 13:30	2021-07-06 24:00	• Scanning for tagged individuals by car: area covered between de Stolpen and St Maartensvlotbrug, Belkmerweg and Ruigeweg, and subsequently scanning for tagged individuals on foot Korte Ruigeweg (1 found dead), Ananas (2 located) and Wildrijk (1 located) • Check batboxes Wildrijk and listening for social calls • Unsuccessful attempt to catch tagged individual with boxtrap in Wildrijk • Trapping 35 females with boxtrap at maternity roost Ananas, 4 tags retrieved from tagged animals, 1 tag retrieved with magnet from roost.	JB, RJ, BN, KS
2021-07-07 09:00	2021-07-07 21:00	• Plane charter at Texel airport in order to scan from the air, last minute cancellation just before take-off (installed equipment under the wing eventually not allowed). • Scanning for tagged individuals by car: area covered between de Stolpen and St Maartensvlotbrug, Belkmerweg and Korte Ruigeweg, and subsequently scanning for tagged individuals on foot Wildrijk (1 located). Due to bad weather irresponsible to install boxtrap.	JB, RJ, KS

Start [UTC]	End [UTC]	Activities	Crew
2021-07-08 12:00	2021-07-08 24:00	• Plane charter at Middenmeer airport and scanning from the air during a two hour flight. A large area covered between Julianadorp and Petten & Callantsoog to Schagen. 3 animals found (1 at duck decoy Oudesluis and 2 located at Wildrijk). Scanning on foot the Wildrijk revealed two separate locations with one tagged animal each. • Unsuccessful attempt to catch tagged individual with boxtrap 1 at Wildrijk • Successful attempt to catch tagged animal and 2 others with boxtrap 2 (all 3 receive tag). • Trapping with mist nets in Wildrijk, 1 individual tagged.	JB, RJ, KS
2021-07-10 09:00	2021-07-10 12:00	• Scanning for tagged individuals by car: area covered between Anna Paulowna and St Maartensvlotbrug, Belkmerweg and Oudesluis. 1 located in duck decoy Oudesluis and 1 at Wildrijk.	JB, BN
2021-07-13 14:00	2021-07-13 24:00	• Check batboxes Wildrijk. • Scanning for tagged individuals by car: area covered between Oudesluis and St Maartensvlotbrug, Belkmerweg and Ruigeweg. 1 located in duck decoy Oudesluis and 1 at Wildrijk, 1 located at Anna's parck and 1 located at Korte Ruigeweg. • Succesful attempt to catch tagged animal with boxtrap Korte Ruigeweg (tag retrieved). • Caught tagged animal Wildrijk by hand (found weakened at tree trunk), and tag retrieved. Animal was taken into care and released two days later when it was recovered. • Trapping with mist nets in Wildrijk, 2 females captured, not tagged (female biased dataset).	JB, RJ, KS
2021-07-14 11:00	2021-07-14 22:00	• Check batboxes Wildrijk. • Scanning for tagged individuals by car: area covered between Oudesluis and St Maartensvlotbrug, Belkmerweg and Korte Ruigeweg, Robbenoordbos and Dijkgatsbos. 1 located in duck decoy Oudesluis and 1 located at Anna's Parck. • Unsuccessful attempt to catch tagged individual with boxtrap at Anna's Parck. • Trapping with mist nets at Ananas, 1 female captured, not tagged (female biased dataset).	JB, RJ, BN, KS
2021-07-15 11:00	2021-07-15 14:30	• Scanning for tagged individuals on foot: Noorderhaven and Ananas.	JB, KS
2021-07-17 11:00	2021-07-17 15:45	• Check batboxes Wildrijk. • Scanning for tagged individuals on foot: Wildrijk • Scanning for tagged individuals by car: area covered between Noorderhaven and Ewijcksluis and Wildrijk and St Maarten	JB, KS
2021-07-22 11:00	2021-07-22 15:45	• Check batboxes duck decoy Callantsoog. • Scanning for tagged individuals on foot Wildrijk. • Scanning for tagged individuals by car: area covered between Callantsoog and Schagerbrug, Camperduin and Burgerbrug	JB, KS
2021-07-23 11:00	2021-07-23 13:00	• Scanning for tagged individuals by car: area covered between Wieringen and duck decoy Oudesluis.	JB, KS
2021-07-24 11:00	2021-07-24 21:00	• Scanning for tagged individuals by car: area covered between de Stolpen and St Maartensvlotbrug , Belkmerweg and Korte Ruigeweg. • Scanning for tagged individuals on foot: Wildrijk, Ananas and Anna's parck (1 located) • Succesful attemp to catch tagged animal with boxtrap Anna's parck (tag retrieved)	JB, KS

Start [UTC]	End [UTC]	Activities	Crew
2021-07-26 11:00	2021-07-26 13:30	• Scanning for tagged individuals by car: area covered between Anna Paulowna, St Maartensvlotbrug, Belkmerweg and Korte Ruigeweg • Scanning for tagged individuals on foot: Ananas and Anna's Parck	KS
2021-07-28 10:00	2021-07-28 12:30	• Scanning for tagged individuals on foot: Wildrijk, (4 located)	KS
2021-07-29 08:00	2021-07-30 02:00	• Scanning for tagged individuals on foot Schoorlse Duinen • Scanning for tagged individuals on foot Ananas & Anna's Parck • Check batboxes Wildrijk. • Scanning for tagged individuals on foot Wildrijk • Trapping with mist nets at Wildrijk.	JB, RJ, BN, KS
2021-07-30 14:00	2021-07-30 22:00	• Check batboxes Wildrijk. • Scanning for tagged individuals on foot Wildrijk • Tree climbing and checking known roosts with treecamera (3 untagged individuals found) • Trapping 3 males with boxtrap, all tagged	JB, RJ
2021-07-31 17:30	2021-07-31 23:40	• Tree climbing and checking known roosts Wildrijk with treecamera • Trapped with boxtrap 1 Wildrijk (1 male tagged) • Tree climbing and checking known roosts Ananas with treecamera • Trapping with boxtrap 2 Ananas (3 females tagged)	JB, RJ, KS
2021-08-02 11:00	2021-08-02 15:00	• Scanning for tagged individuals on foot Wildrijk (5 found)	JB, KS
2021-08-04 15:00	2021-08-04 19:00	• Scanning for tagged individuals by car duck decoy Oudesluis • Scanning for tagged individuals by car Ananas & Anna's Parck • Checking bat boxes Wildrijk • Scanning for tagged individuals on foot Wildrijk (3 located of which 2 were retreived from the forest floor)	BN, KS
2021-08-09 08:30	2021-08-09 10:15	• Scanning for tagged individuals by car duck decoy Oudesluis (1 located) • Scanning for tagged individuals by car Ananas & Anna's Parck • Checking bat boxes Wildrijk • Scanning for tagged individuals on foot Wildrijk (1 located)	KS
2021-08-11 07:30	2021-08-11 09:30	• Scanning for tagged individuals by car duck decoy Oudesluis (1 located) • Obtained access duck decoy Oudesluis	SL, KS
2021-08-12 06:30	2021-08-12 11:00	• Scanning for tagged individuals on foot duck decoy Oudesluis (1 located), social calls heard in the same roost • Scanning for tagged individuals on foot Wildrijk (1 located)	JB, BN, KS
2021-08-17 07:00	2021-08-17 11:30	• Checking bat boxes Wildrijk • Scanning for tagged individuals on foot Wildrijk	JB, KS
2021-08-18 07:00	2021-08-18 17:00	• Scanning for tagged individuals on foot duck decoy Oudesluis (1 located) • Scanning for tagged individuals on foot Ananas & Anna's Parck • Scanning for tagged individuals on foot Wildrijk (1 located), unsuccessful attempt to retrieve (fallen-off) tag from roost • Plane charter airport Middenmeer. Scanning for tagged individuals from the air (2 additional tags located in the fields). 1 tag retrieved later from the ground, 1 tag could not be found.	JB, RJ, BN, KS
2021-08-19 07:00	2021-08-19 17:00	• Unsuccesful attempt to locate remaining tag in the field • Scanning for tagged individuals by car: area covered between Oudesluis and Burgerbrug, Belkmerweg and Korte Ruigeweg (1 located duck decoy Oudesluis, 1 located Wildrijk) • Scanning for tagged individuals on foot duck decoy 't Zand	JB, RJ, KS

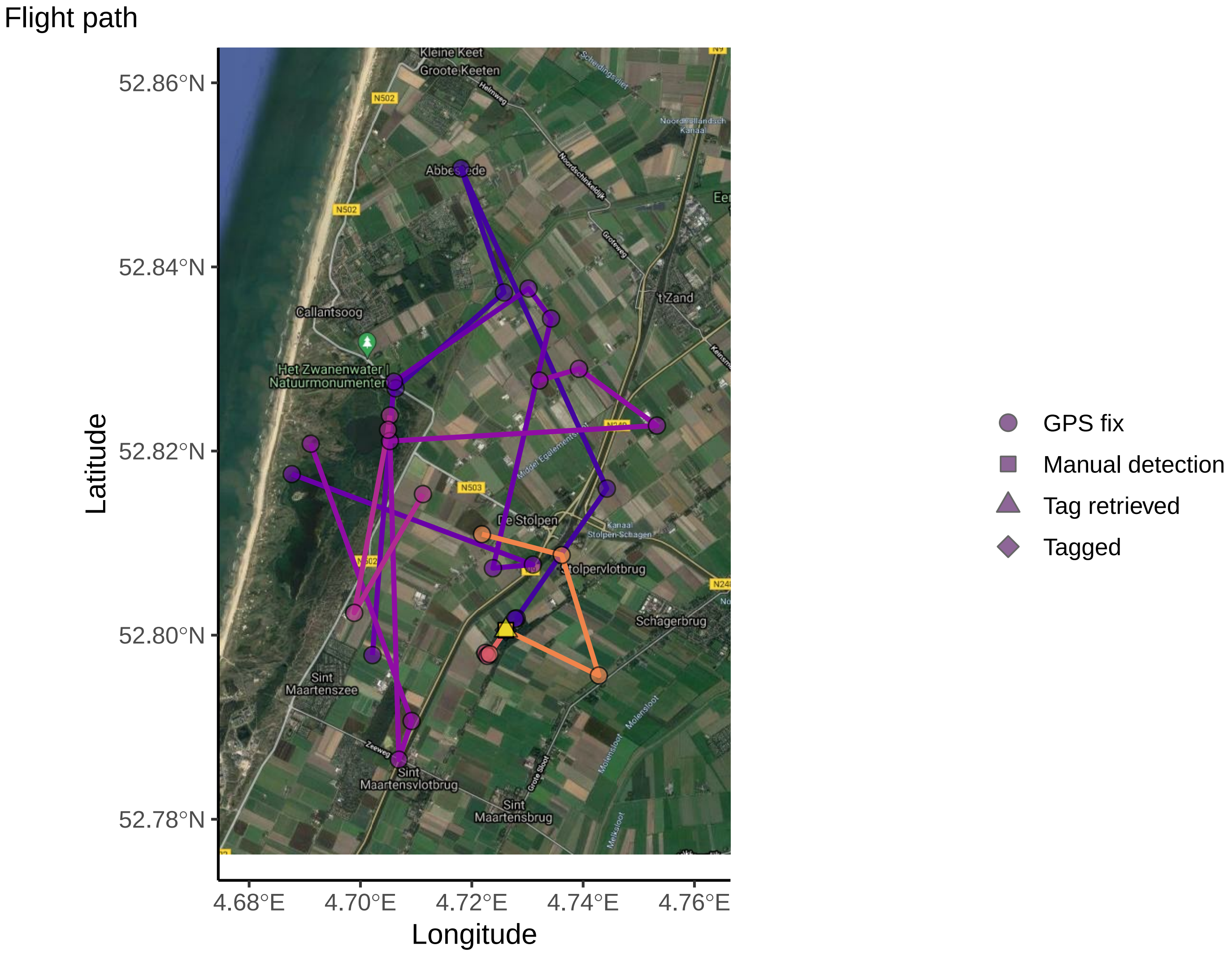
Start [UTC]	End [UTC]	Activities	Crew
2021-08-20 09:00	2021-08-20 17:00	• Plane charter airport Middenmeer. Scanning from the air for remaining tag in the field, obtained more accurate location, tag retrieved later from cornfield. • Scanning for tagged individuals on foot duck decoy Oudesluis (1 located). Treeclimbing and fallen-off tag found with treecamera in roost and retrieved.	JB, RJ, KS, LK
2021-08-21 07:00	2021-08-21 21:30	• Checking bat boxes Wildrijk (1 female tagged) • Scanning for tagged individuals on foot Wildrijk (1 located), fallen-off tag found with treecamera in roost and retrieved. • Tree climbing and checking known roosts Wildrijk with treecamera, two roosts with bats found. • Trapping with boxtrap 1 Wildrijk (1 female tagged), 3 escaped. • Trapping with boxtrap 2 Wildrijk (1 male tagged)	JB, RJ, KS
2021-08-27 07:00	2021-08-27 21:30	• Scanning for tagged individuals by car: area covered between de Stolpen and St Maartensvlotbrug, Belkmerweg and Korte Ruigeweg (1 located de Stolpen,1 located Wildrijk) • Trapping with boxtrap 1 de Stolpen (1 tag retrieved, 2 individuals tagged) • Trapping with boxtrap 2 Wildrijk (2 tags retrieved, 7 individuals tagged)	JB, WH, RJ
2021-09-01 07:00	2021-09-01 12:00	• Scanning for tagged individuals by car: area covered between Julianadorp and St Maartensvlotbrug, Callantsoog and duck decoy 't Zand. • Scanning on foot Wildrijk (4 located) • Scanning on foot duck decoy 't Zand, (1 located at farm nearby).	KS
2021-09-02 19:00	2021-09-02 22:30	• Trapping with mist nets in Wildrijk (1 male 1 female tagged)	JB
2021-09-03 14:00	2021-09-03 17:00	• Scanning for tagged individuals by car: area covered between Julianadorp and St Maartensvlotbrug, Callantsoog and duck decoy 't Zand (3 located at farm 't Zand, 4 at Wildrijk and 3 at Ananas) • No trapping due to bad weather	JB, RJ
2021-09-04 15:00	2021-09-04 17:00	• Scanning for tagged individuals on foot (4 located of which 1 fallen-off tag retrieved from forest floor)	RJ, BN, KS
2021-09-06 14:00	2021-09-06 16:00	• Scanning for tagged individuals by car: area covered between Julianadorp and St Maartensvlotbrug, Callantsoog and duck decoy 't Zand (2 located at farm 't Zand, 2 at Wildrijk and 1 at Ananas)	JB, KS
2021-09-08 06:30	2021-09-08 23:30	• Scanning for tagged individuals on foot Noorderhaven, duck decoy Callantsoog, duck decoy 't Zand (1 located), Ruigeweg (1 located), Ananas (2 located) and Wildrijk (2 located). • Trapping with boxtrap 1 Wildrijk (5 animals caught, 2 tags retrieved, 2 new individuals tagged). • Trapping with boxtrap 2 farm 't Zand (13 animals caught, 4 tagged, 1 fallen-off tag retrieved from roost) • Trapping with mist nets in Wildrijk	JB, RJ, SL, DvN, KS
2021-09-11 08:30	2021-09-11 13:15	• Scanning for tagged individuals by car: area covered between Julianadorp and St Maartensvlotbrug, Belkmerweg and duck decoy 't Zand (2 located at farm 't Zand, 2 at Wildrijk and 7 at Ananas)	KS

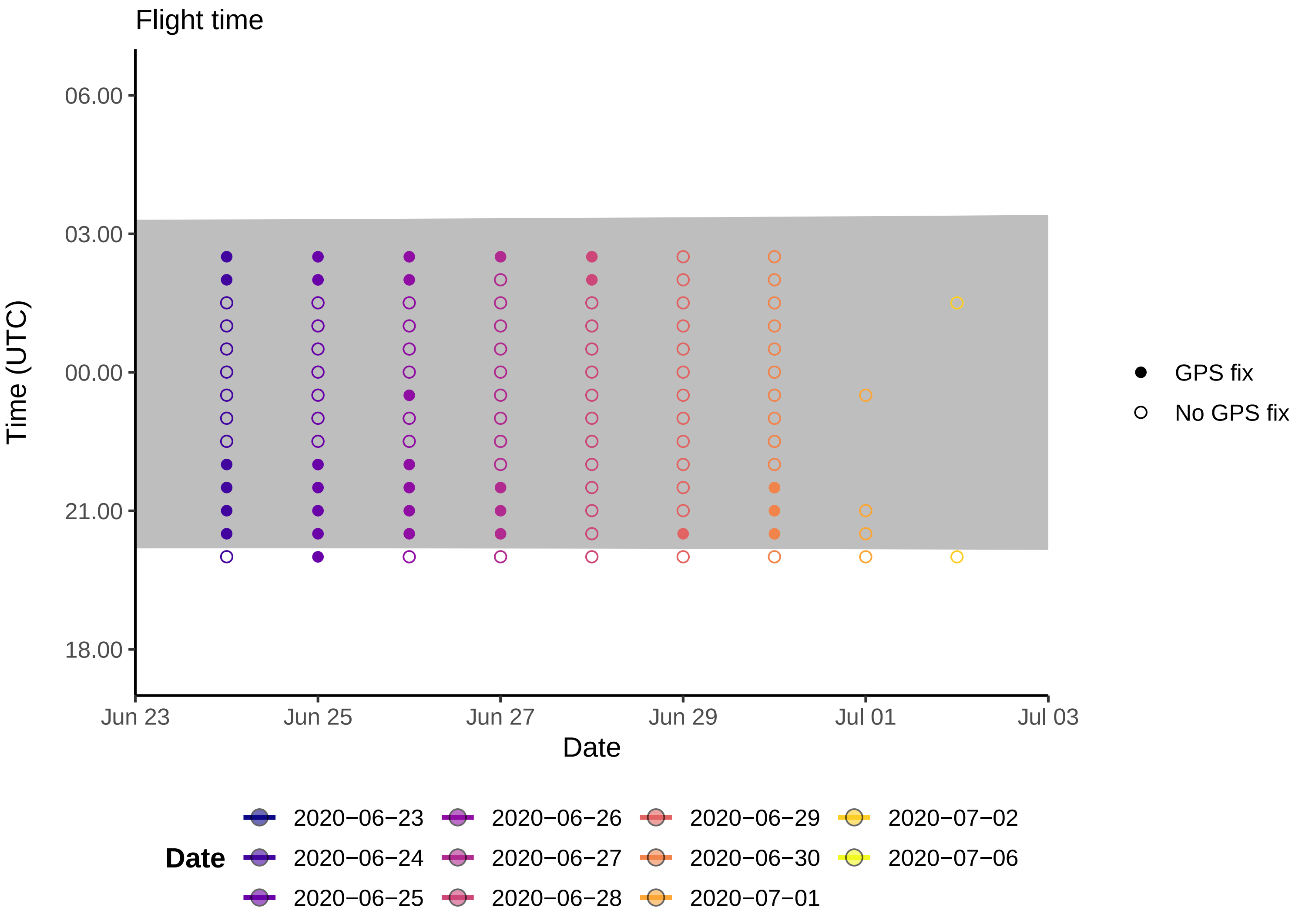
Start [UTC]	End [UTC]	Activities	Crew
2021-09-13 08:00	2021-09-13 23:00	• Scanning for tagged individuals by car: area covered between Julianadorp and St Maartensvlotbrug, Belkmerweg and duck decoy 't Zand (1 at duck decoy Oudesluis and 8 at Ananas) • Scanning for tagged individuals on foot Ananas, (2 roosts with respectively 1 and 7 tagged individuals). • Trapping with boxtrap 1 Ananas (4 animals caught, 1 tag retrieved, 4 individuals tagged (including previously tagged animal). • Trapping with boxtrap 2 Ananas (6 animals caught , several escaped, 1 tagged individual released, 1 tag retrieved, 4 individuals tagged (including previously tagged animal)	JB, RJ, SL, KS
2021-09-14 08:00	2021-09-14 23:00	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (1 at Grote Sloot, 2 de Stolpen, 3 Wildrijk, 1 Ananas • Tree climbing and checking known roost de Stolpen, one individual emerged from roost and was caught by hand and tagged. • Scanning for tagged individuals on foot Ananas, (1 fallen-off tag retrieved from the forest floor, 1 located at roost), Anna's Parck (1 located), Korte Ruigeweg (1 located) • Trapping with boxtrap 1 Ananas (1 caught, tag retrieved). • Trapping with boxtrap 2 Anna's Parck (6 animals caught 1 tag retrieved, 6 individuals tagged (including previously tagged animal) • Trapping with boxtrap 3 Korte Ruigeweg (4 animals caught 1 tag retrieved, 4 individuals tagged (including previously tagged animal)	AvdB, JB, RJ, SL, KS
2021-09-15 07:00	2021-09-15 12:00	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (2 at Grote Sloot, 1 at and St Maartensvlotbrug 4 at de Stolpen, 3 Ruigeweg, 1 Ananas, 1 duck decoy t Zand, 1 Korte Ruigeweg)	JB, RJ, SL, KS
2021-09-16 07:00	2021-09-16 12:00	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (2 located at Ananas, 3 located Ruigeweg, and 1 located Wildrijk)	KS
2021-09-21 13:00	2021-09-21 15:30	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (1 located at Ananas, 2 located at Grote Sloot, 2 located at the Stolpen, 2 located duck decoy Oudesluis, 5 located Ruige Weg, and 2 located Wildrijk)	KS
2021-09-22 06:30	2021-09-22 23:00	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (1 located at Ananas, 2 located at Grote Sloot, 3 located at the Stolpen, 2 located duck decoy Oudesluis, 5 located Ruigeweg, and 2 located Wildrijk) • Scanning for tagged individuals on foot Ananas, (1 fallen-off tag retrieved from roost) • Trapping with boxtrap 1 Wildrijk (1 caught, tag retrieved). • Trapping with boxtrap 2 de Stolpen (4 animals caught 3 tags retrieved) • Trapping with boxtrap 3 Ruige Weg (several escaped)	JB, RJ, KS

Start [UTC]	End [UTC]	Activities	Crew
2021-09-23 06:30	2021-09-23 23:00	• Scanning for tagged individuals on foot Wildrijk, 1 fallen-off tag retrieved from the forest floor • Scanning for tagged individuals by car Ananas, Anna's Parck, Ruigeweg (1 located), Grote Sloot (2 located) • Scanning for tagged individuals on foot duck decoy Oudesluis (4 located) • Tree climbing and checking known roost Oudesluis with treecamera, 1 fallen-off tag retrieved • Trapping with boxtrap 1 duck decoy Oudesluis (7 caught, 1 tag retreived). • Trapping with boxtrap 2 duck decoy Oudesluis (8 caught, 2 tags retrieved). • Trapping with boxtrap 3 Ruige Weg (1 caught, tag retrieved)	JB, RJ, SL, KS
2021-09-24 08:30	2021-09-24 20:30	• Scanning for tagged individuals by car: area covered between Breezand and St Maartensvlotbrug, Belkmerweg and Schagerbrug (2 located at St Maartensvlotbrug and 2 located at Grote Sloot). • Trapping with boxtrap 1 St Maartensvlotbrug (4 caught, 1 tag retrieved, 1 tag apparently fallen-off in crevices). • Trapping with boxtrap 2 Grote Sloot (2 tagged animals escaped)	JB, RJ
2021-09-28 06:30	2021-09-28 20:00	• Scanning for tagged individuals by car: area covered between de Stolpen and St Maartensvlotbrug, Belkmerweg and Schagerbrug (2 located at Grote Sloot) • Last-minute cancellation of chartered plane from Airport Middenmeer due to bad weather. • Trapping with boxtrap Grote Sloot (2 tagged animals caught, tags retrieved)	JB, RJ
2021-09-29 06:30	2021-09-29 20:00	• Scanning for tagged individuals by car: area covered between van Ewijcksluis and St Maartensvlotbrug, Belkmerweg and Ruigeweg. • Plane charter airport Middenmeer. Scanning for tagged individuals from the air during 2 hours. 1 tag located in Zwanenwater	JB, RJ, SL, KS
2021-09-30 06:30	2021-09-30 11:00	• Scanning on foot for tags Zwanenwater, eventually found fallen-off in the dunes close to the beach.	JB, KS
2021-10-03 10:00	2021-10-03 12:00	• Scanning for tagged individuals by car: area covered between Julianadorp and Petten, Callantsoog to 't Zand	SL
2021-10-04 08:00	2021-10-04 11:00	• Scanning for tagged individuals by car: area covered between Bakkum and Petten, Camperduin and Burgervlotbrug	SL

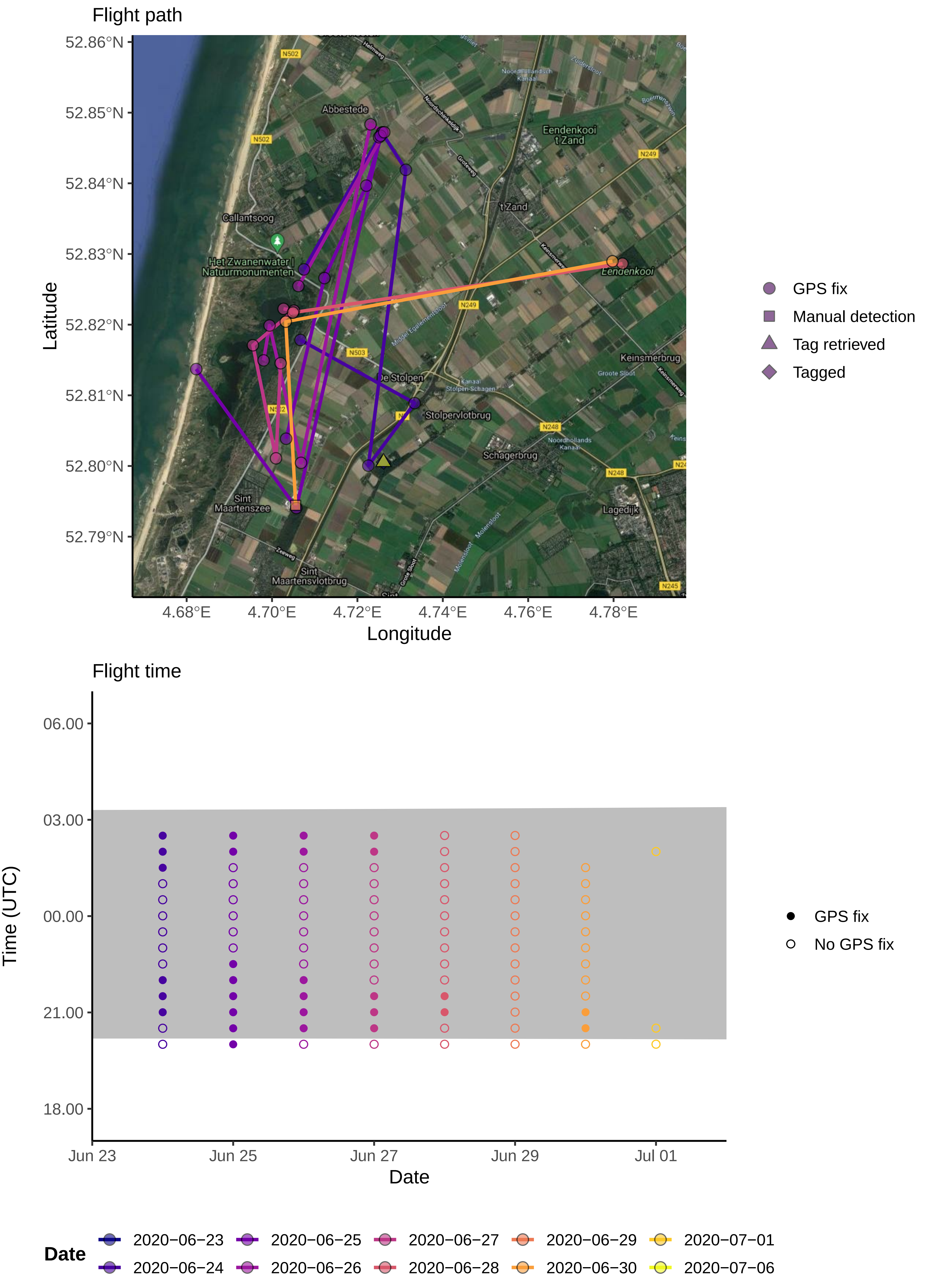
Annex 4: Flightpaths

Common noctule, ID = 4, Female, Ad

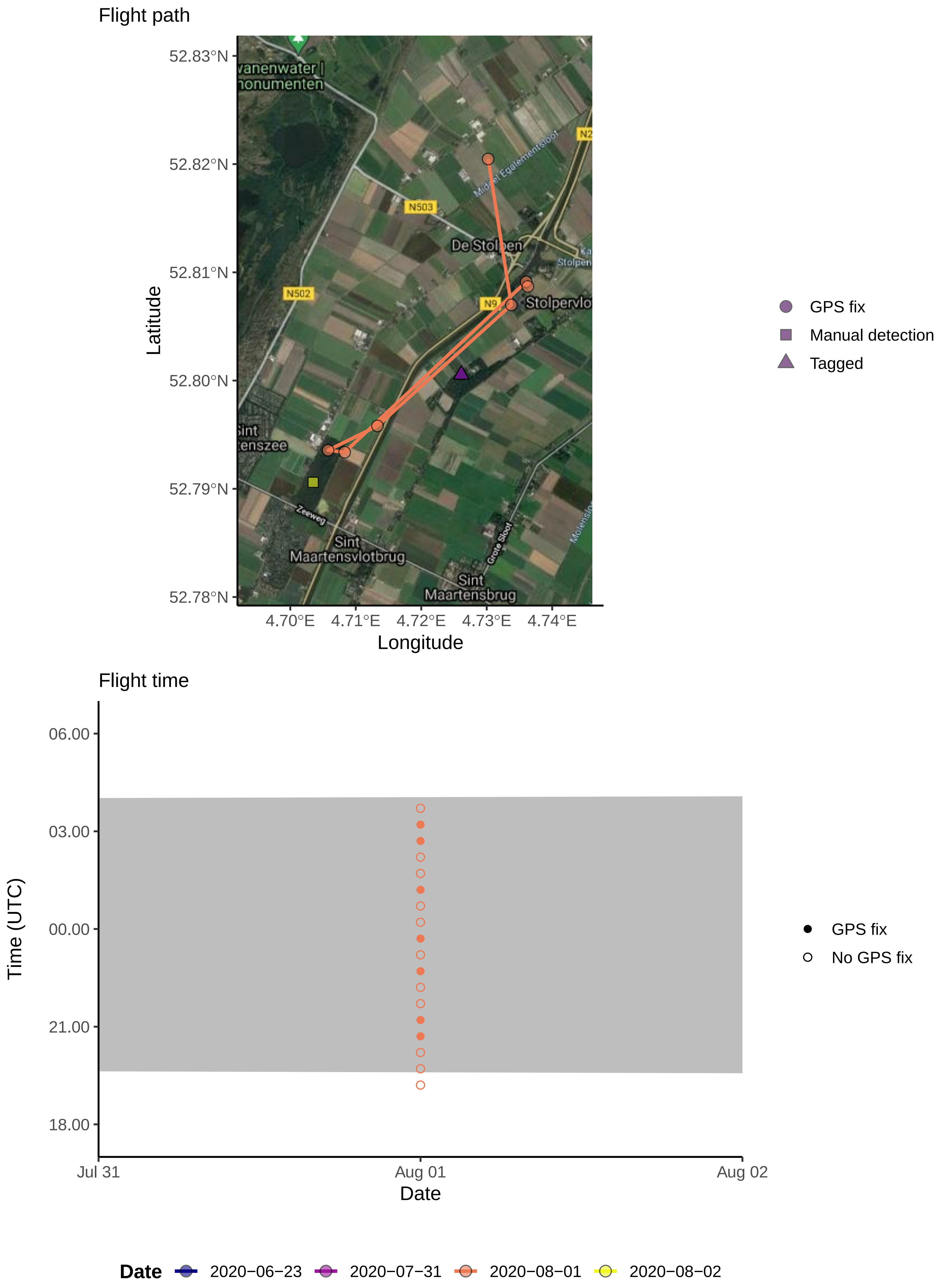




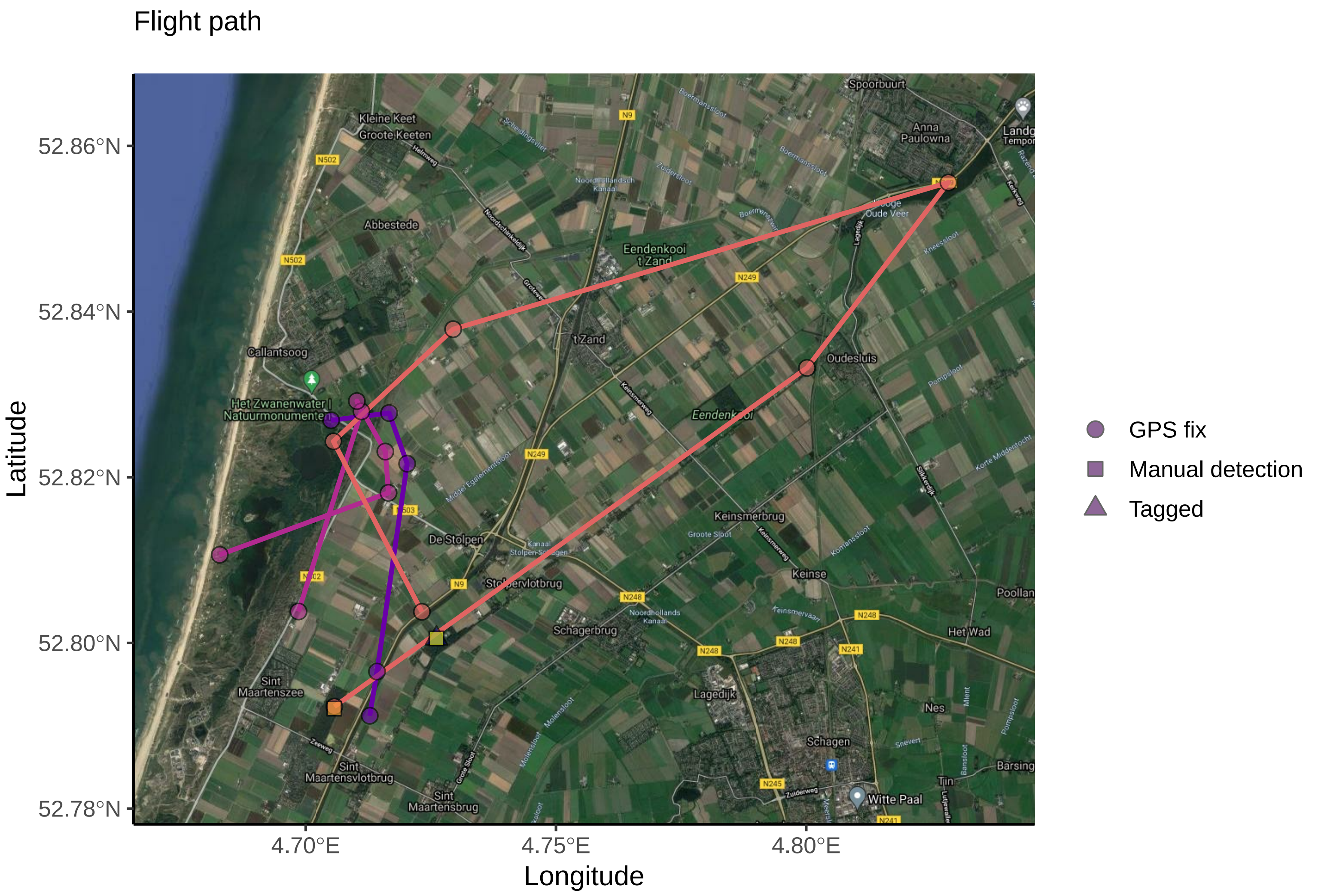
Common noctule, ID = 5, Female, Ad

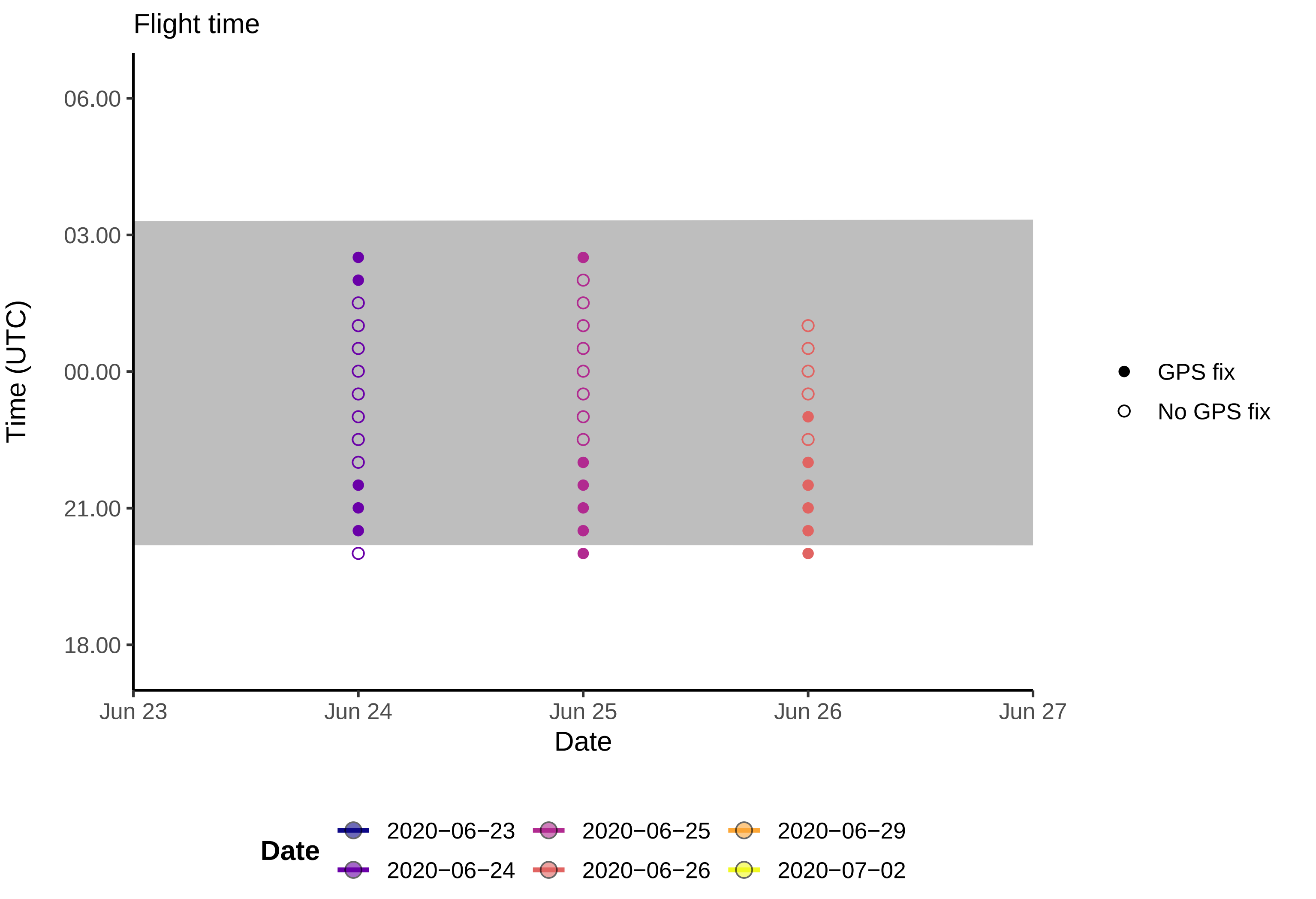


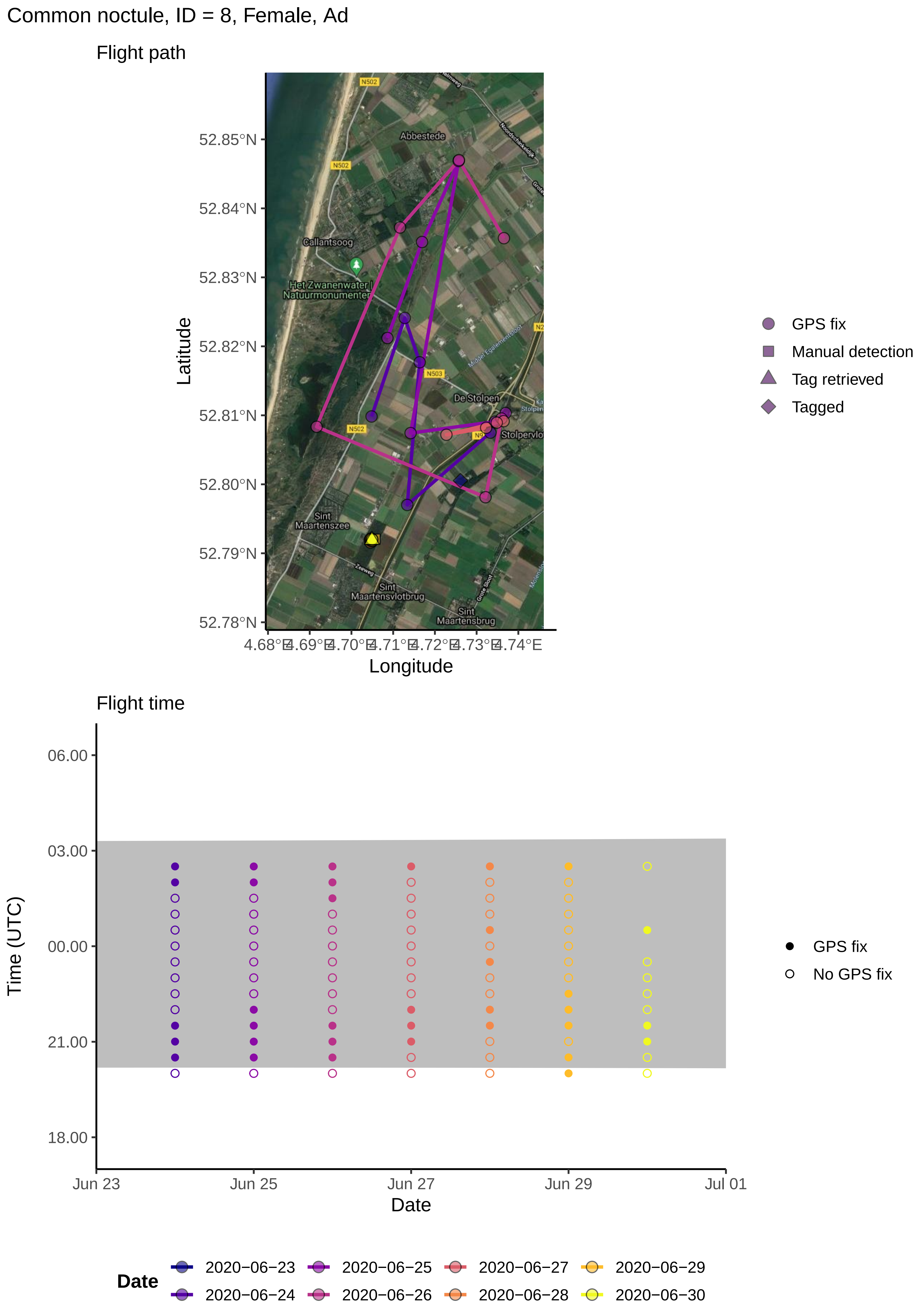
Common noctule, ID = 6, Female, Ad



Common noctule, ID = 7, Female, Ad

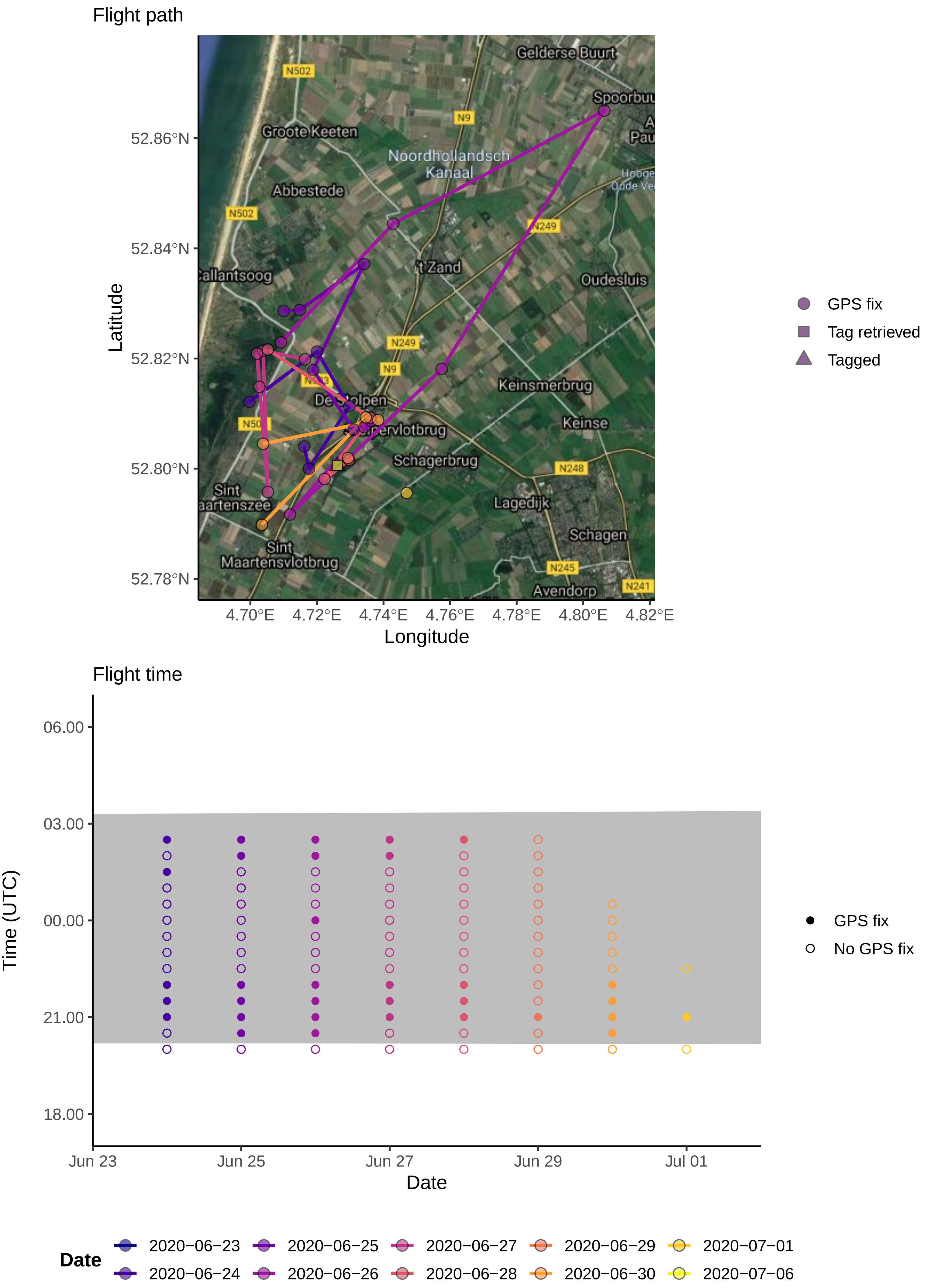


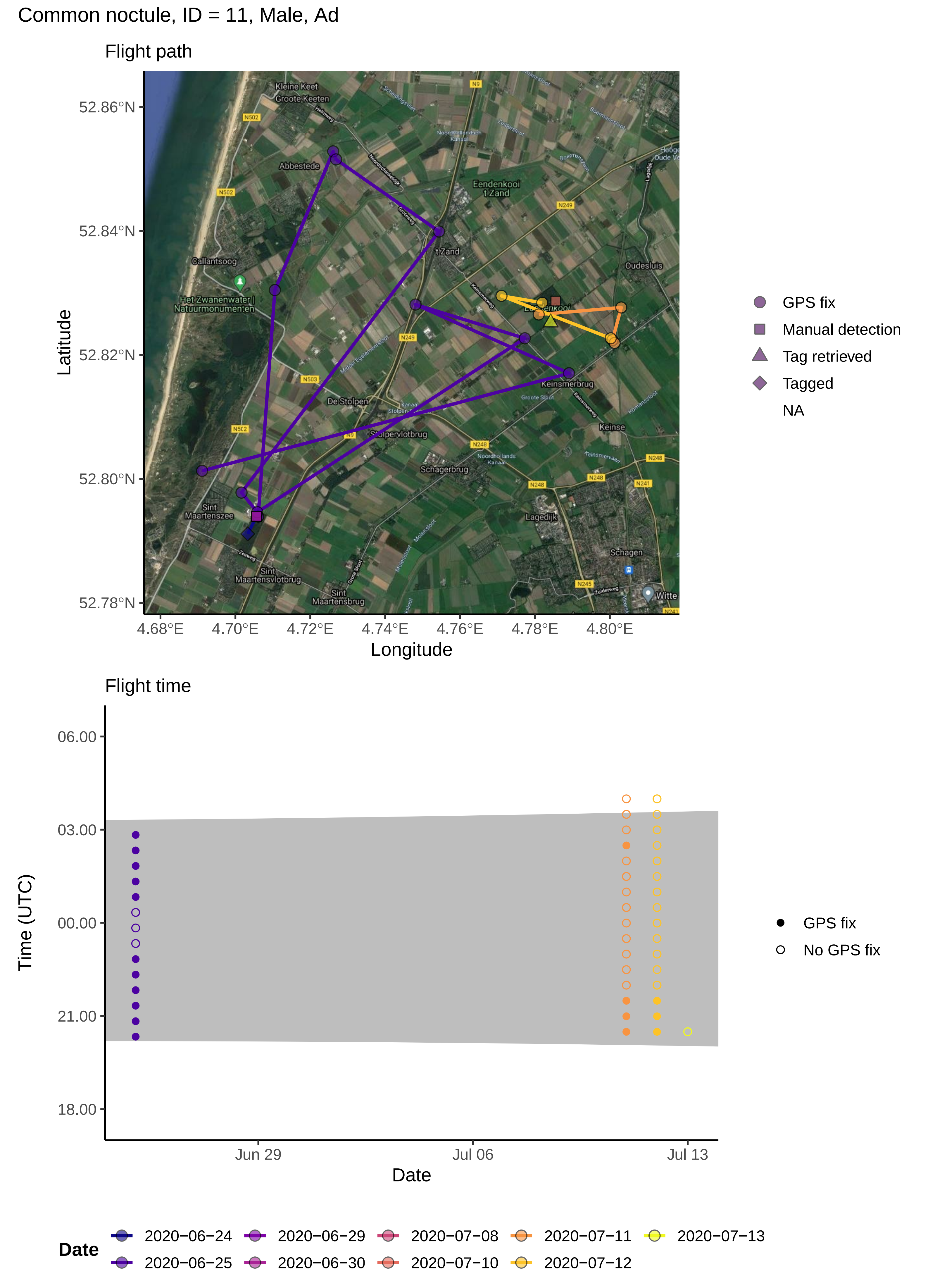




Common noctule, ID = 8, Female, Ad
Flight path
Latitude
52.85°N
52.84°N
52.83°N
52.82°N
52.81°N
52.80°N
52.79°N
52.78°N
Longitude
4.68°E
4.69°E
4.70°E
4.71°E
4.72°E
4.73°E
4.74°E
Abbestede
Callantsoog
Het Zwanenwater | Natuurmonumenten
De Stolpen
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
N502
N503
GPS fix
Manual detection
Tag retrieved
Tagged
Flight time
Time (UTC)
06.00
03.00
00.00
21.00
18.00
Date
Jun 23
Jun 25
Jun 27
Jun 29
Jul 01
GPS fix
No GPS fix
Date
2020−06−23
2020−06−24
2020−06−25
2020−06−26
2020−06−27
2020−06−28
2020−06−29
2020−06−30

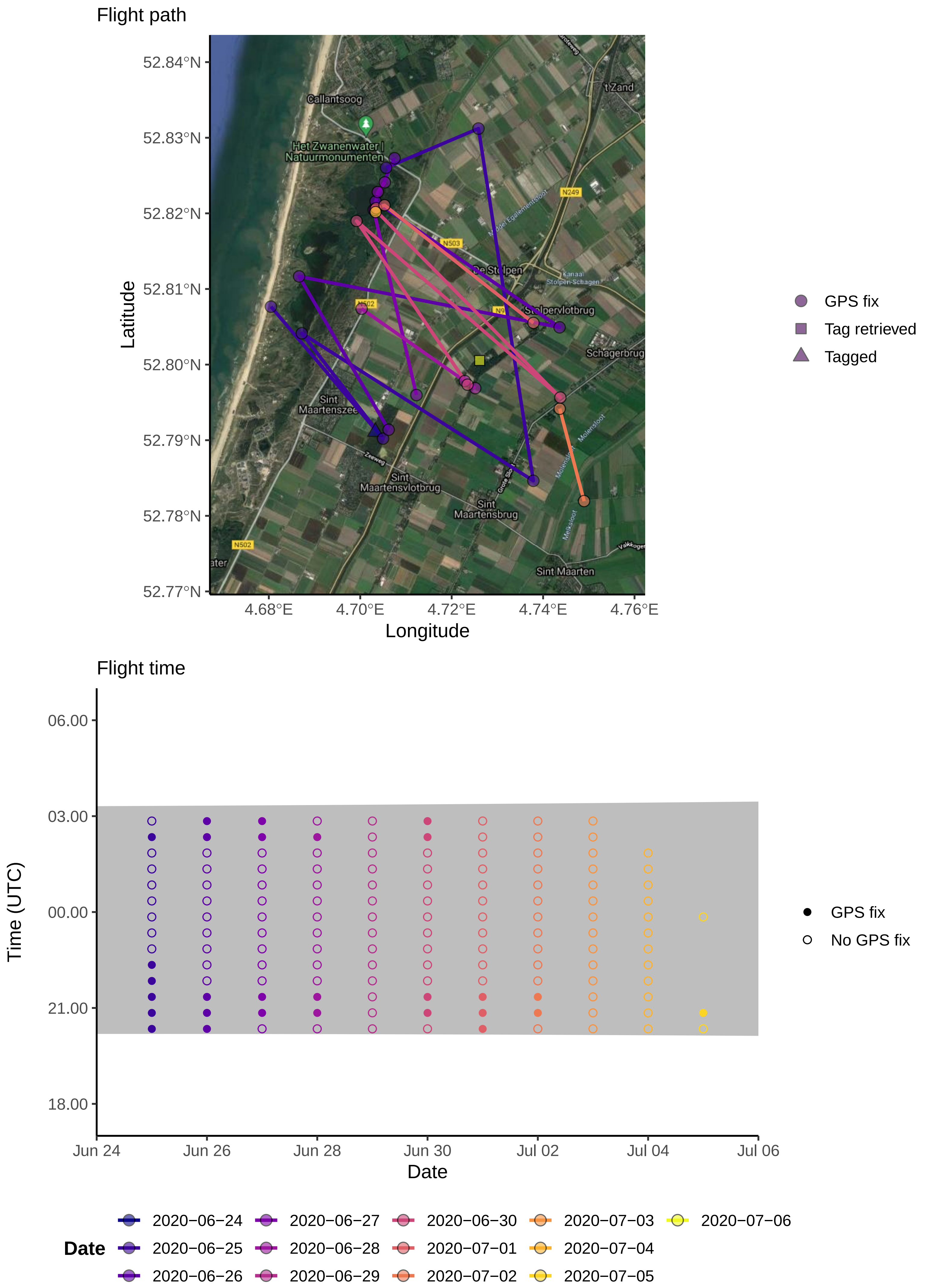
Common noctule, ID = 10, Female, Ad



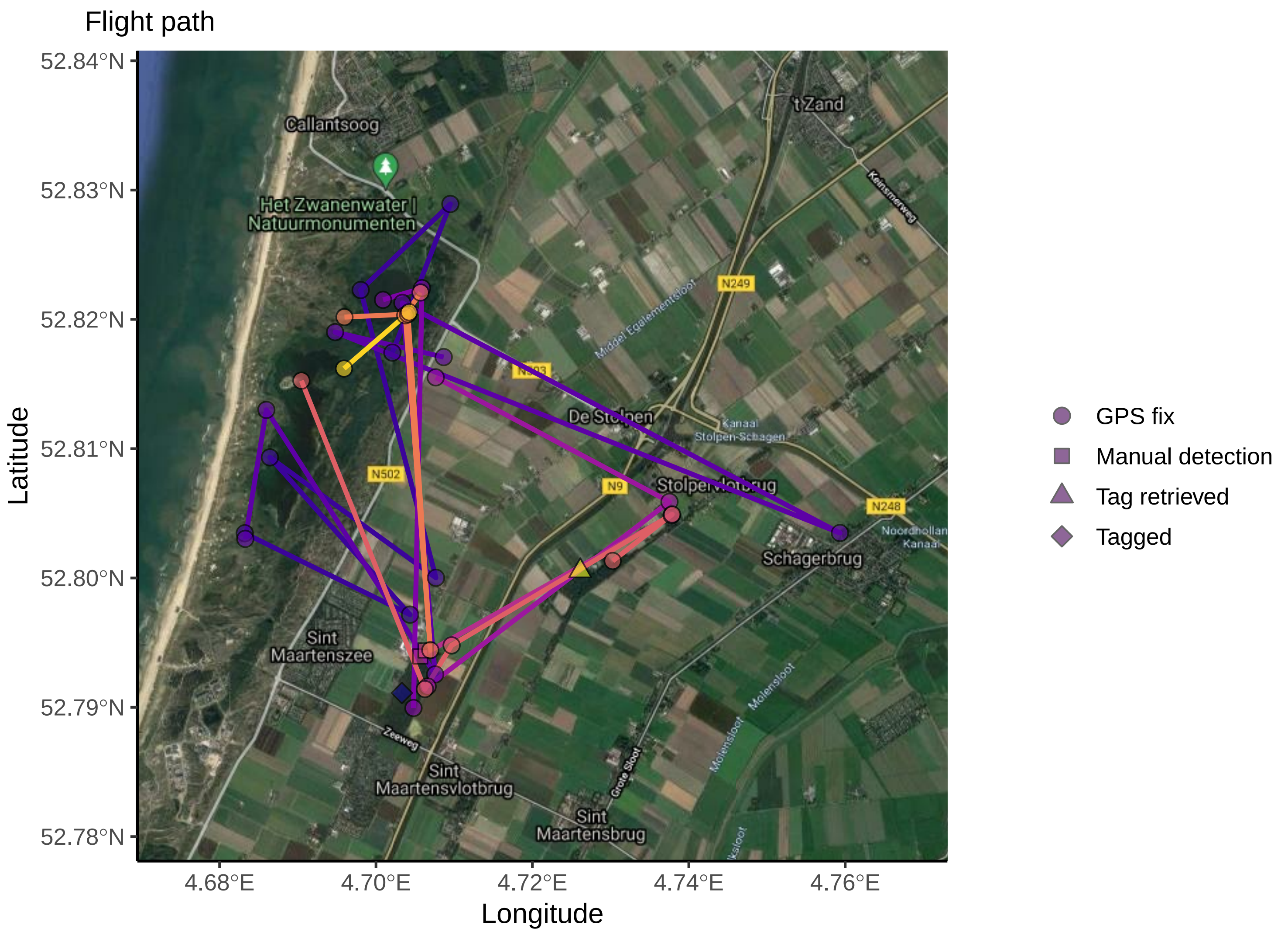


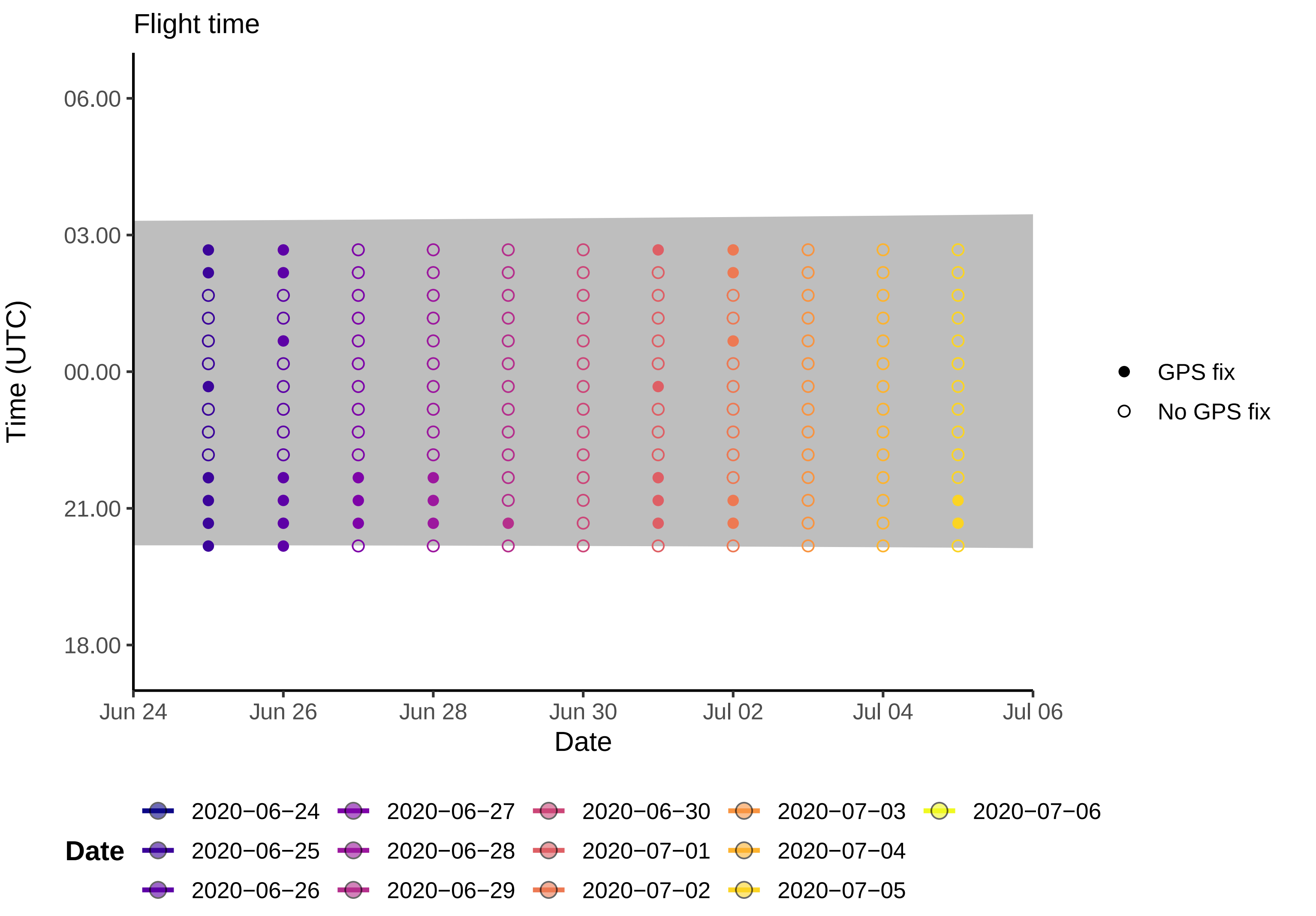
Common noctule, ID = 11, Male, Ad
Flight path
Latitude
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
4.78°E
4.80°E
Longitude
Kleine Keet
Groote Keeten
Abbestede
Eendenkooi
t Zand
Callantsoog
Het Zwanenwater | Natuurmonumenten
Oudesluis
De Stolpen
Stolpervlotbrug
Keinsmerbrug
Keinse
Schagerbrug
Lagedijk
Schagen
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
Witte
GPS fix
Manual detection
Tag retrieved
Tagged
NA
Flight time
Time (UTC)
06.00
03.00
00.00
21.00
18.00
Jun 29
Jul 06
Jul 13
Date
GPS fix
No GPS fix
Date
2020−06−24
2020−06−25
2020−06−29
2020−06−30
2020−07−08
2020−07−10
2020−07−11
2020−07−12
2020−07−13

Common noctule, ID = 12, Female, Ad



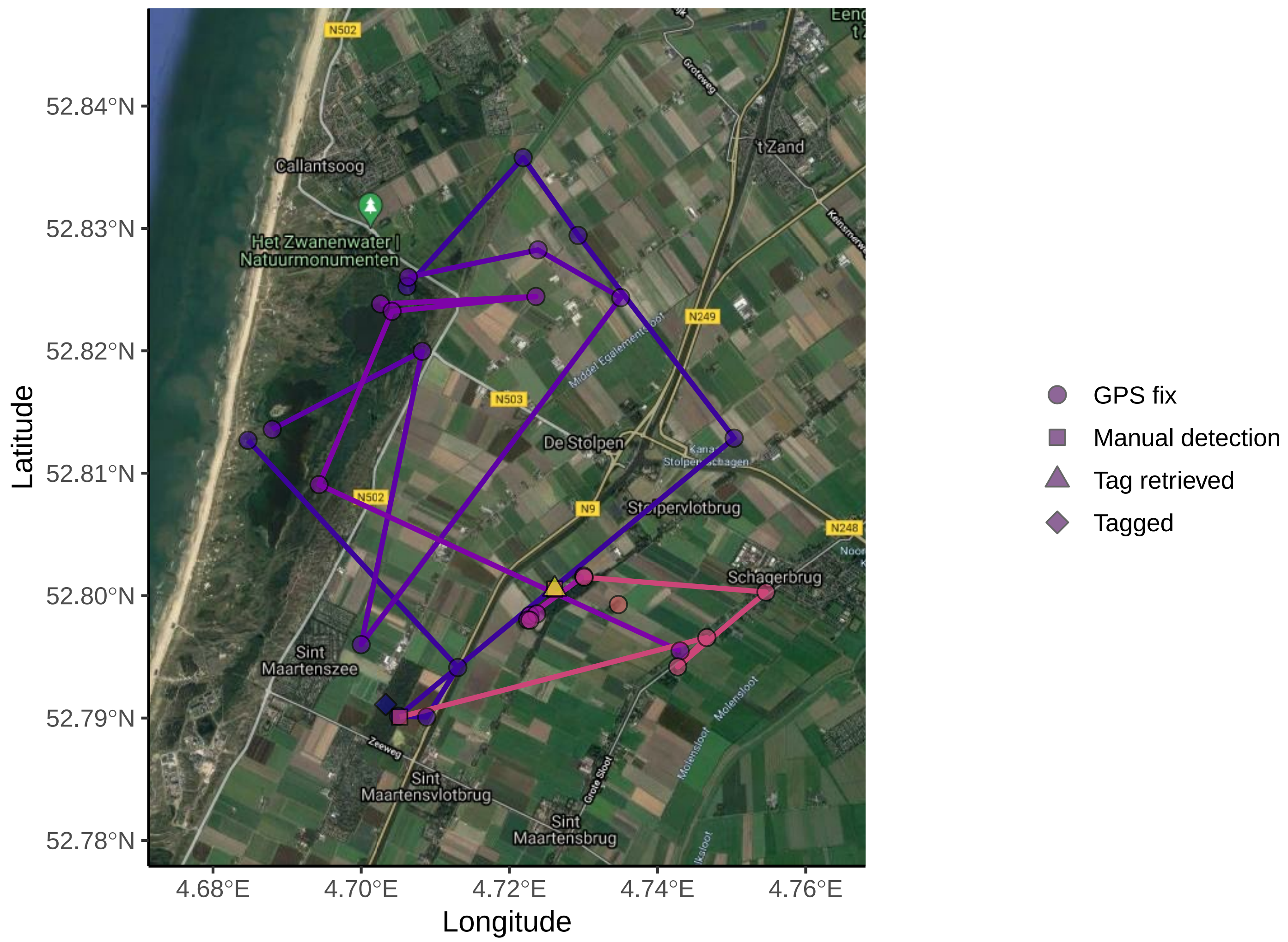
Common noctule, ID = 13, Female, Ad



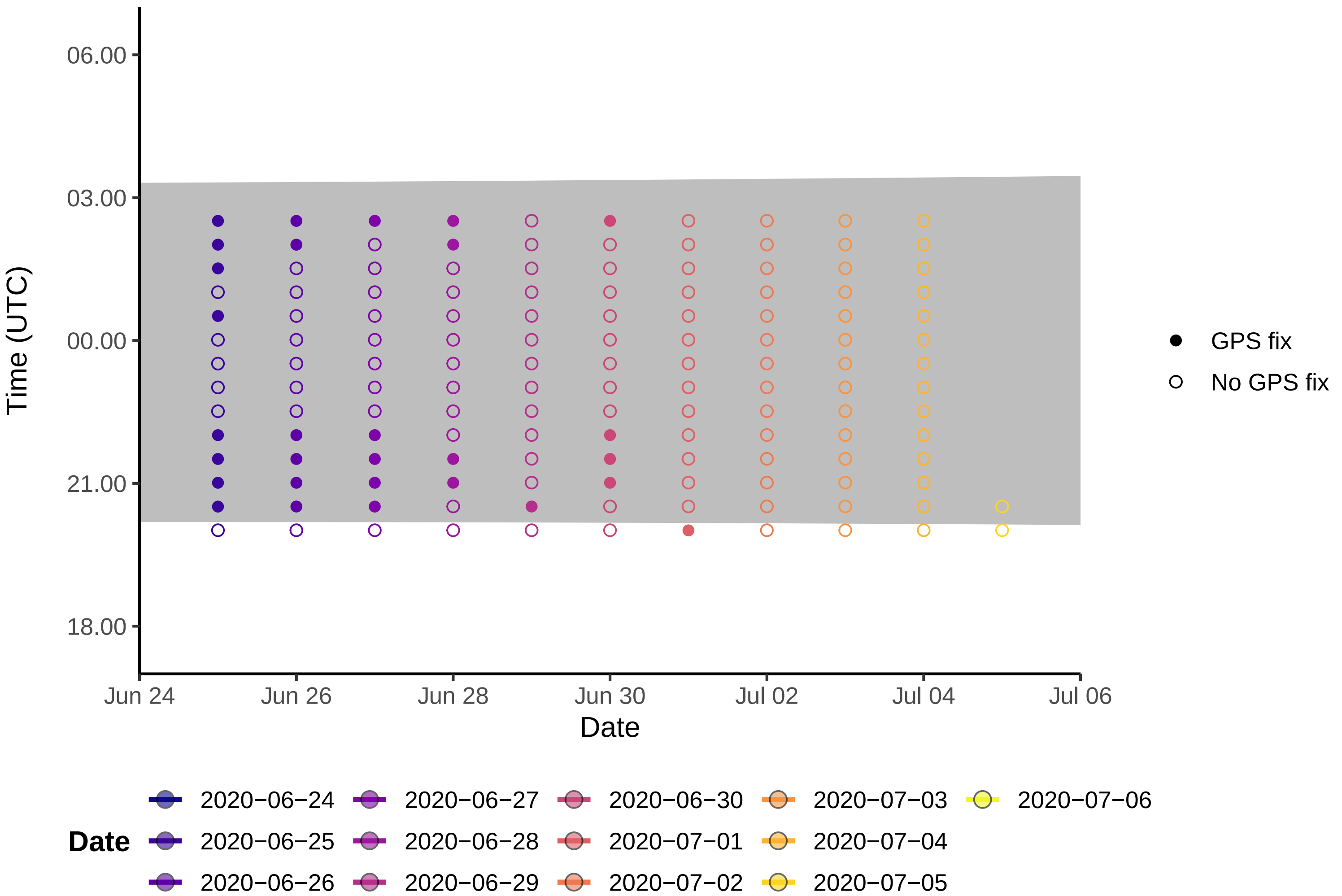


Common noctule, ID = 14, Female, Ad

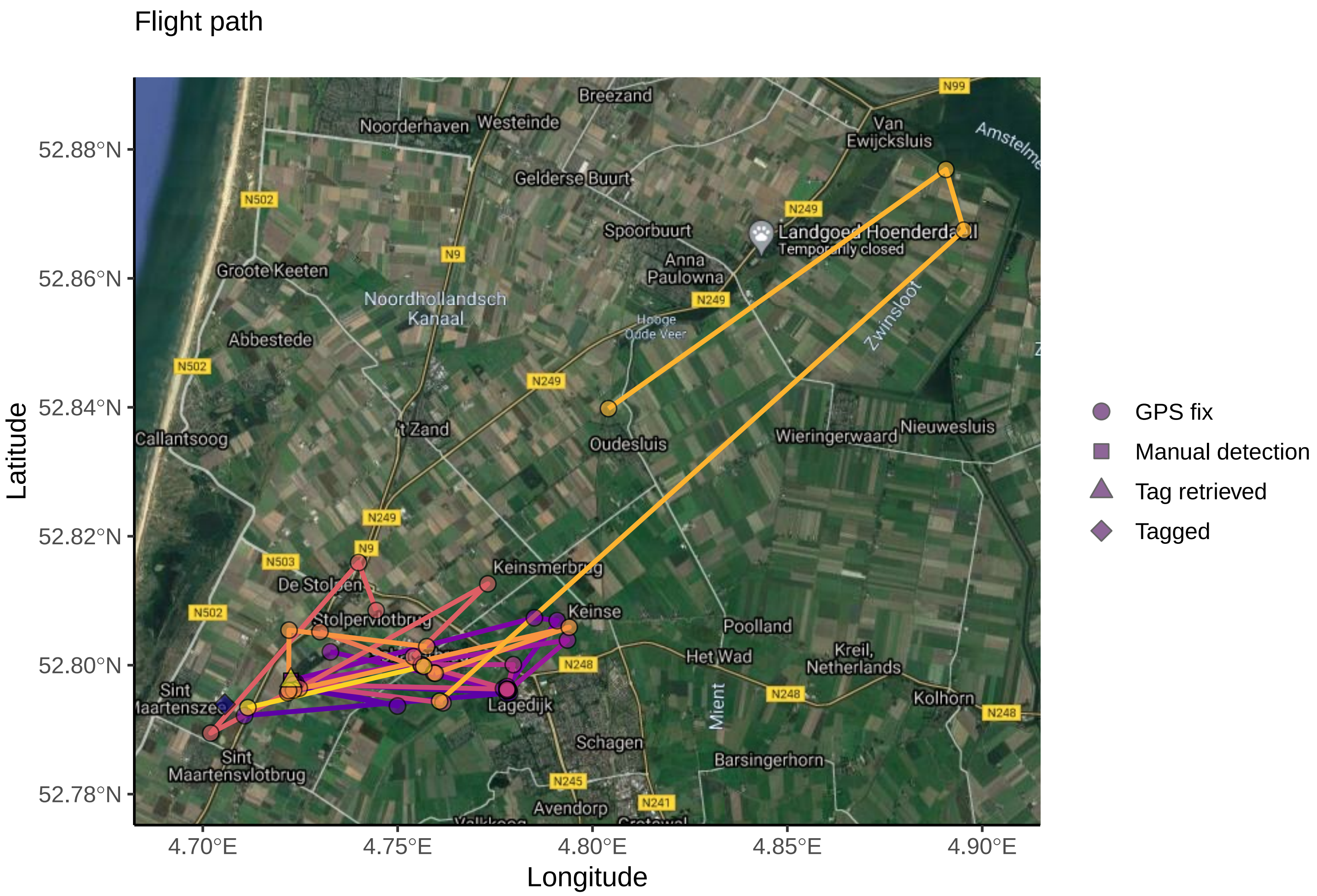
Flight path

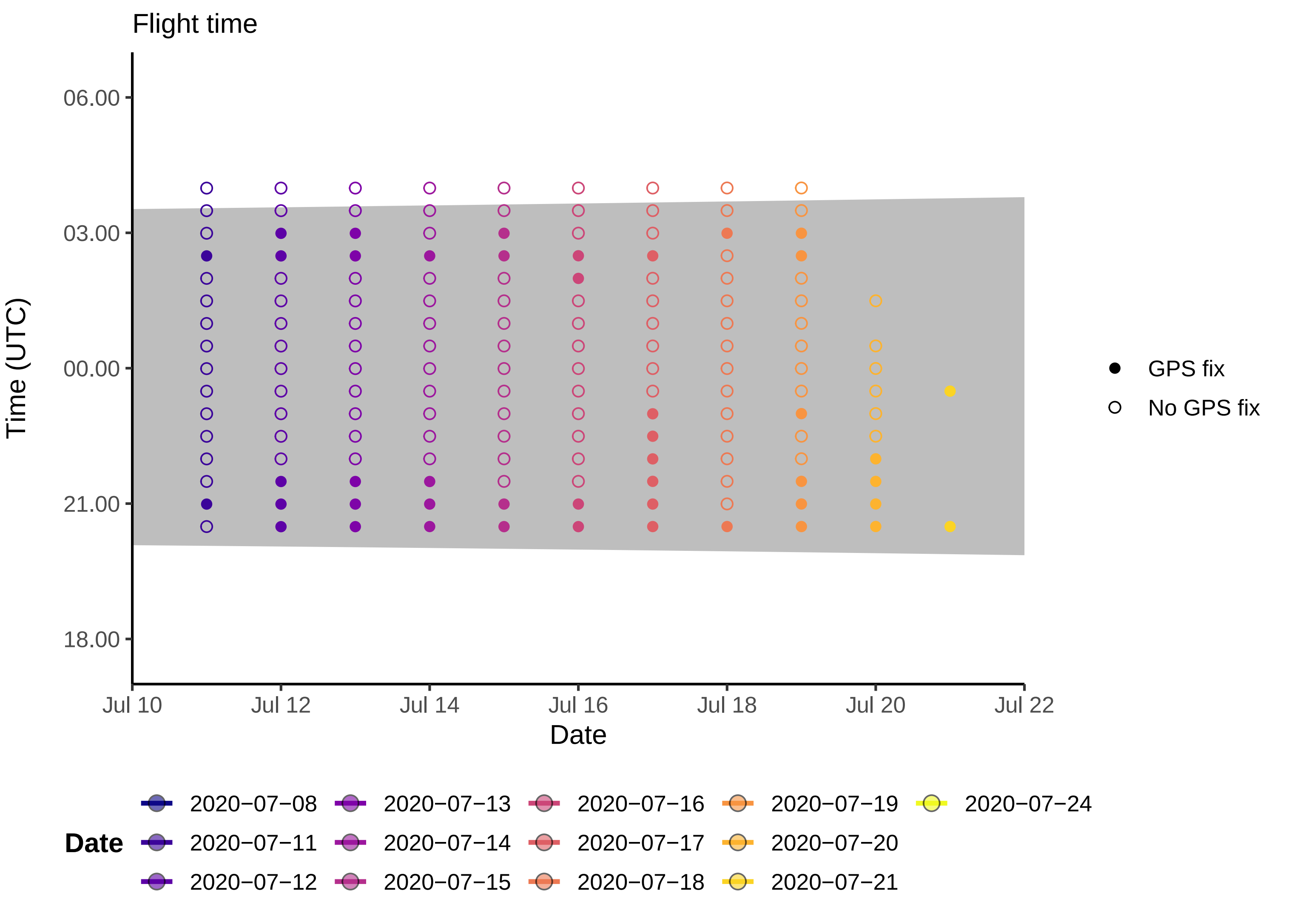


Flight time

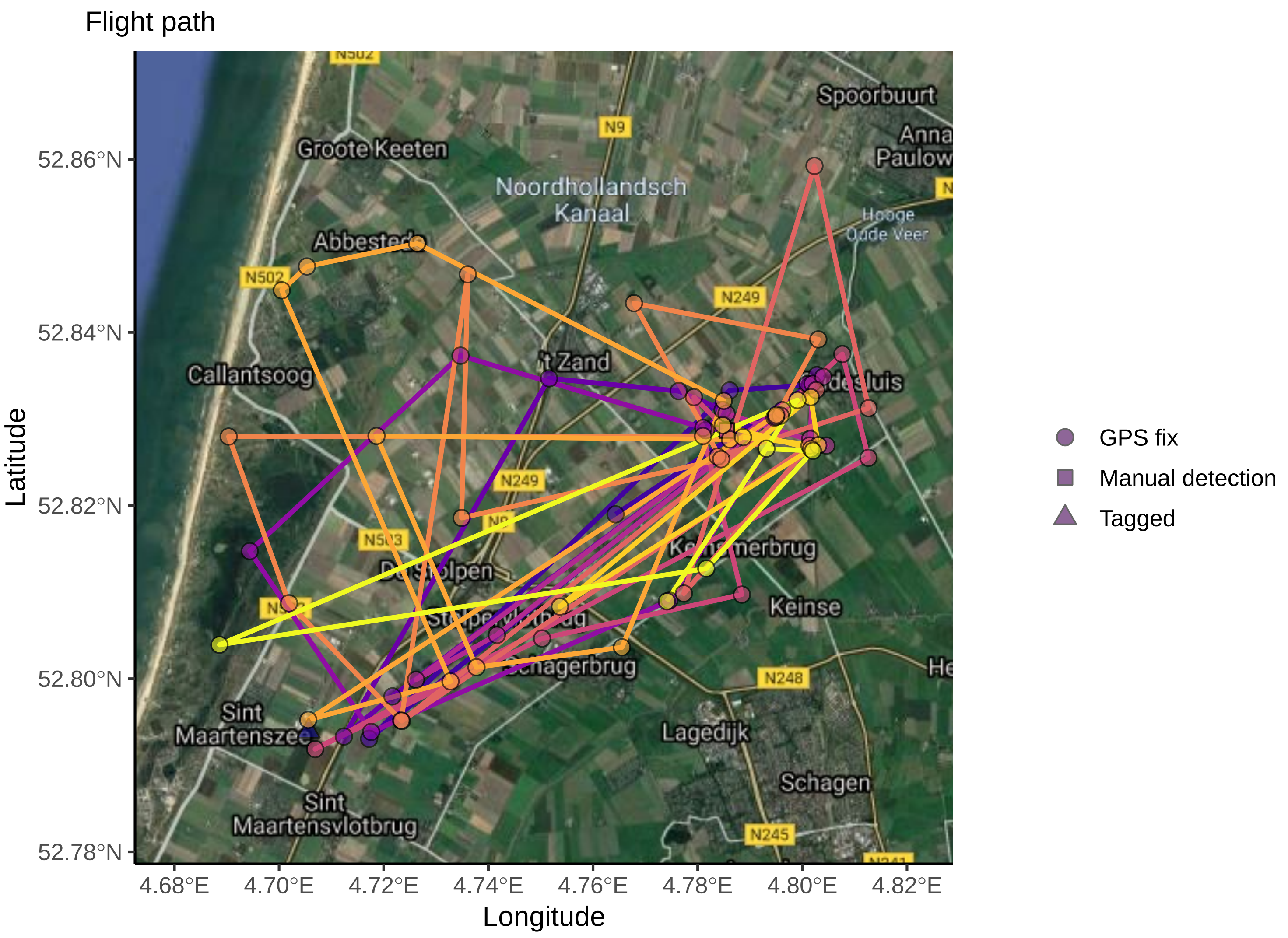


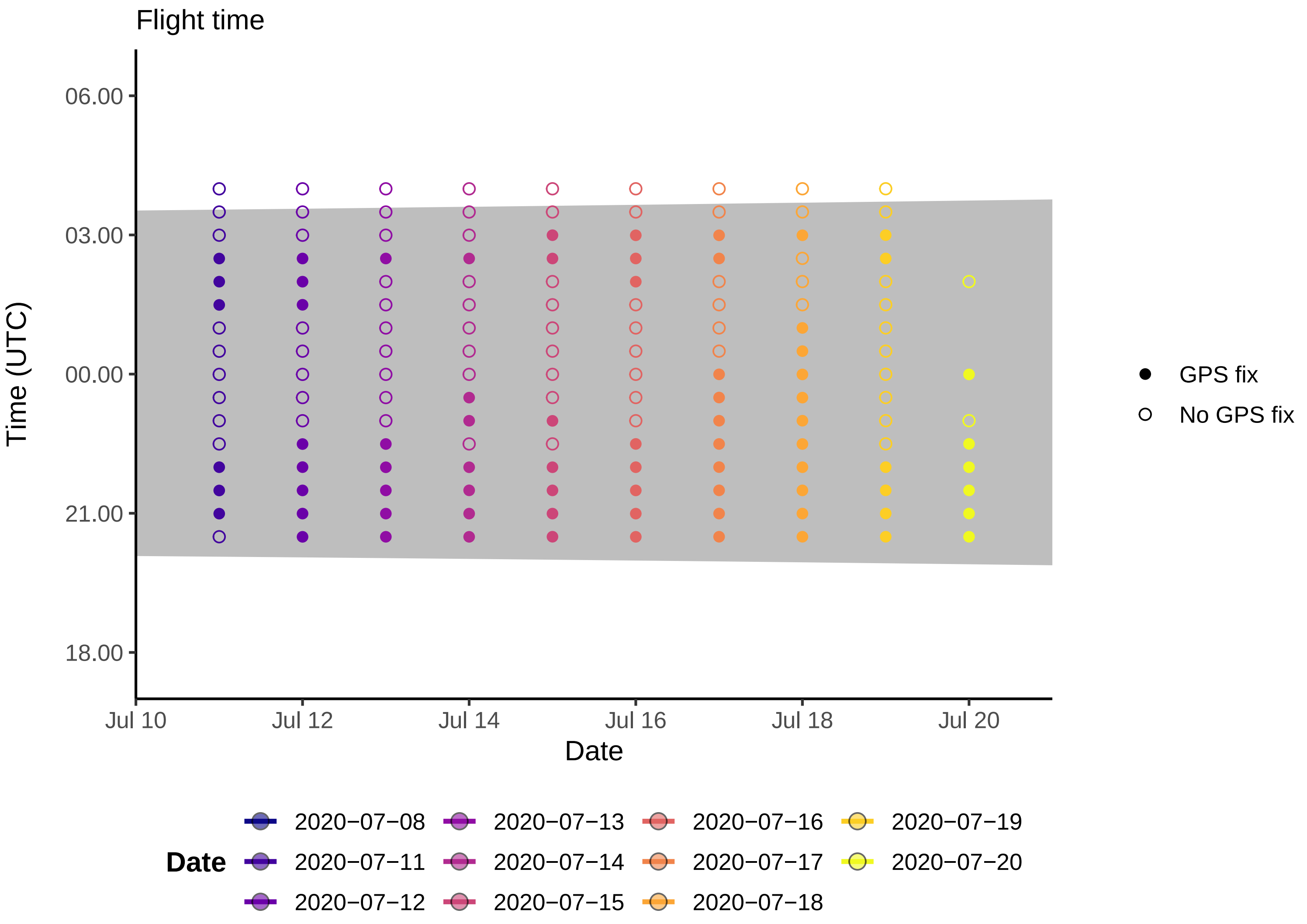
Common noctule, ID = 15, Male, Ad



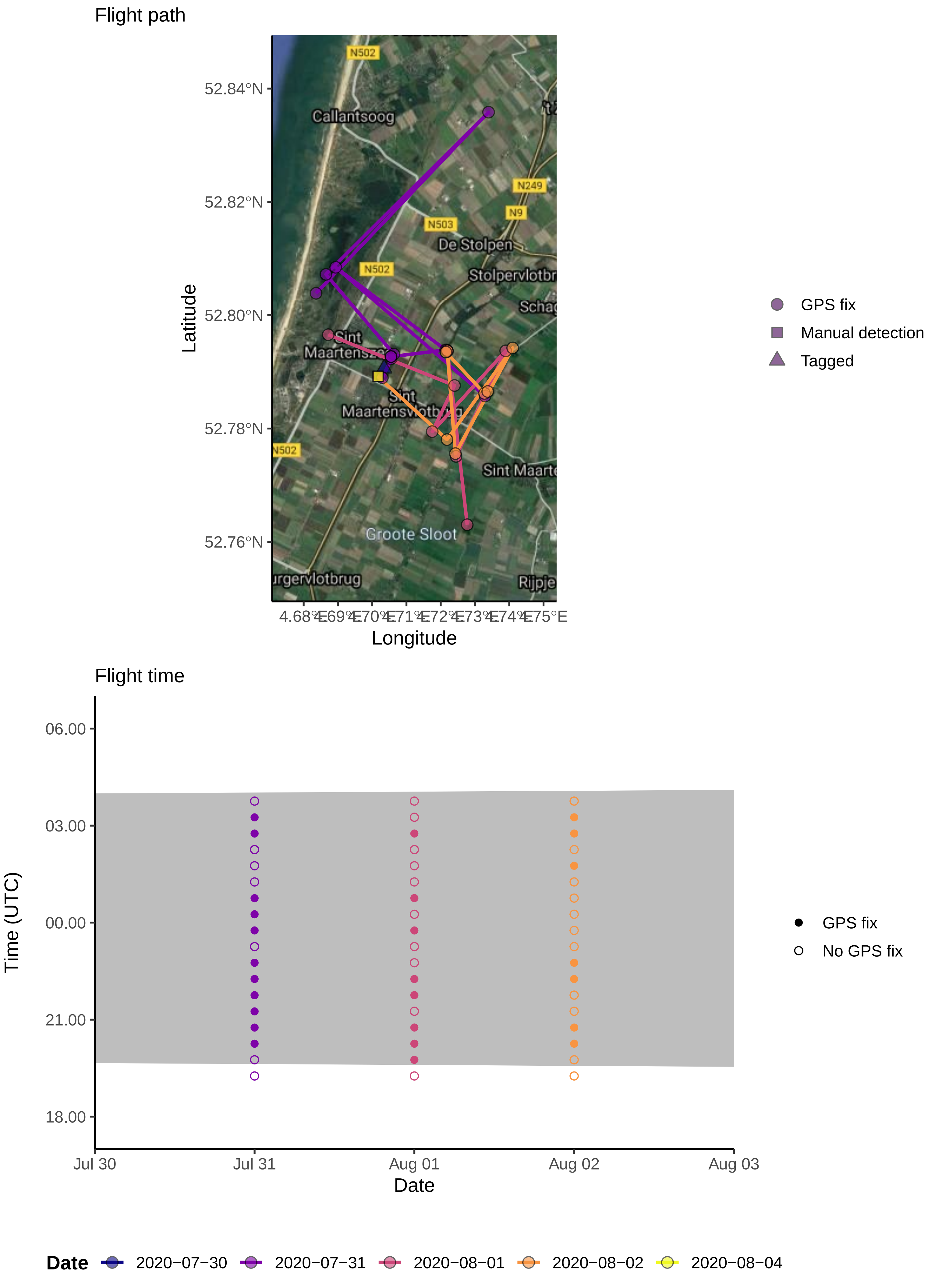


Common noctule, ID = 16, Male, Ad

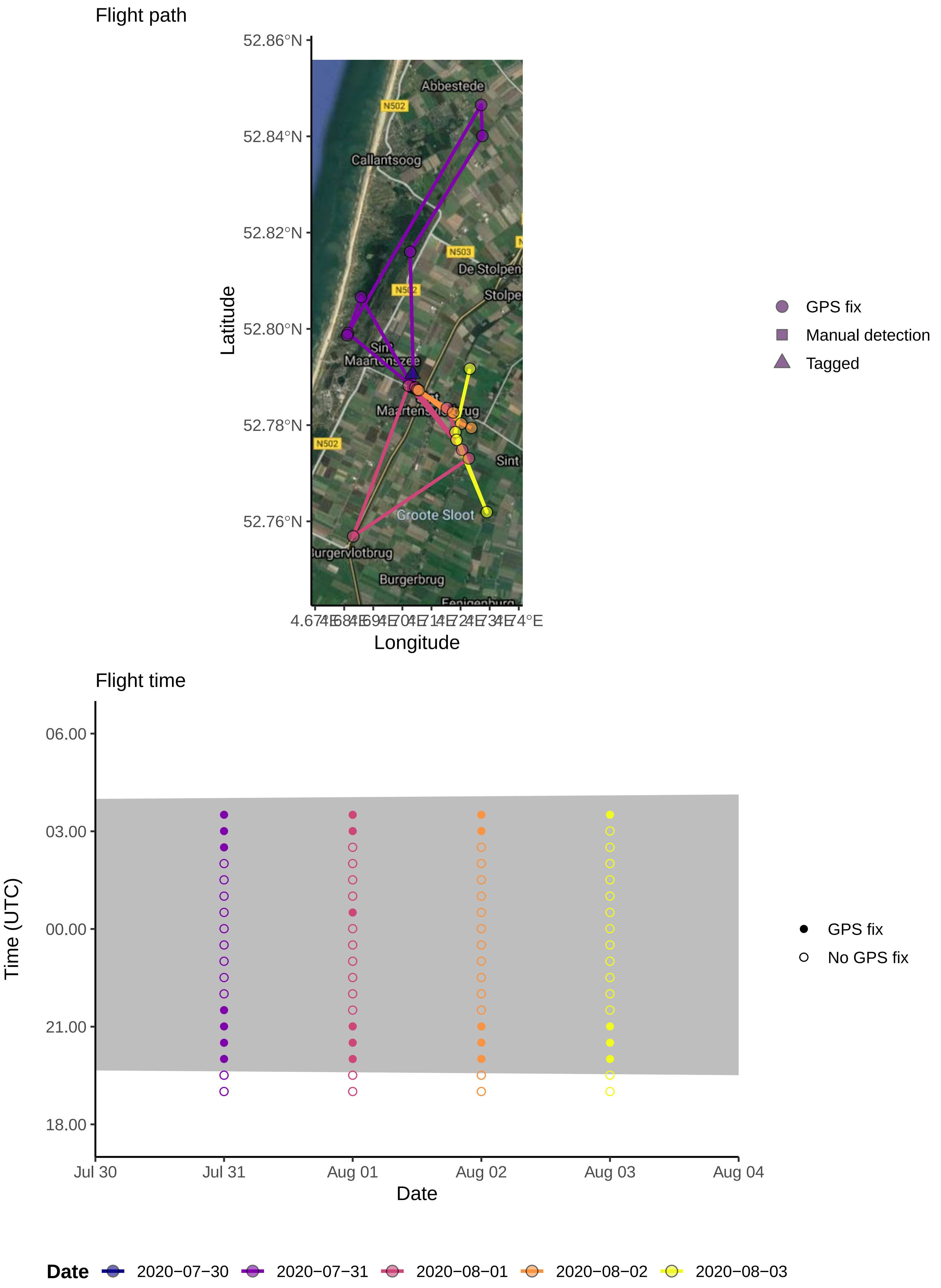




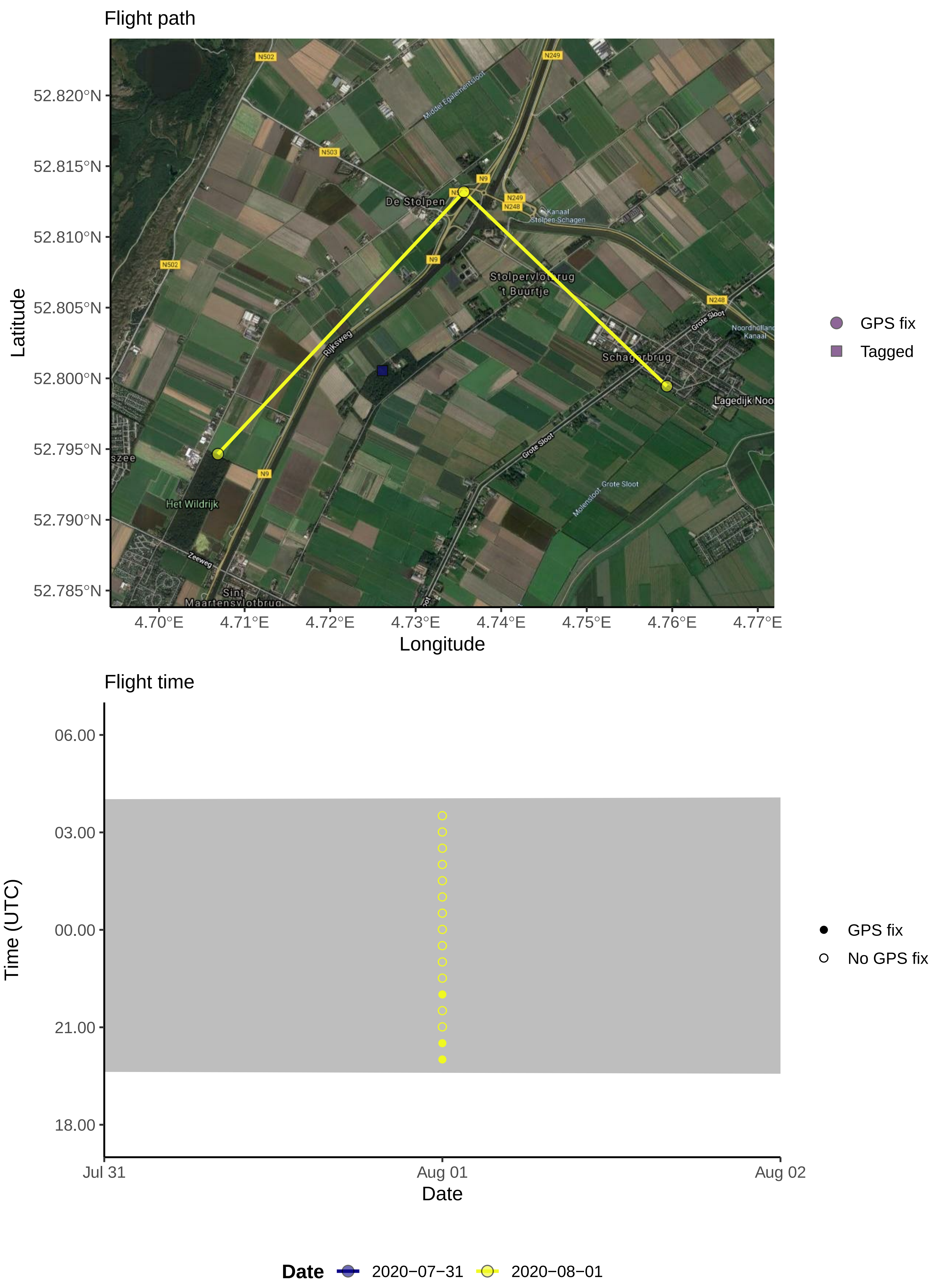
Common noctule, ID = 18, Male, Ad



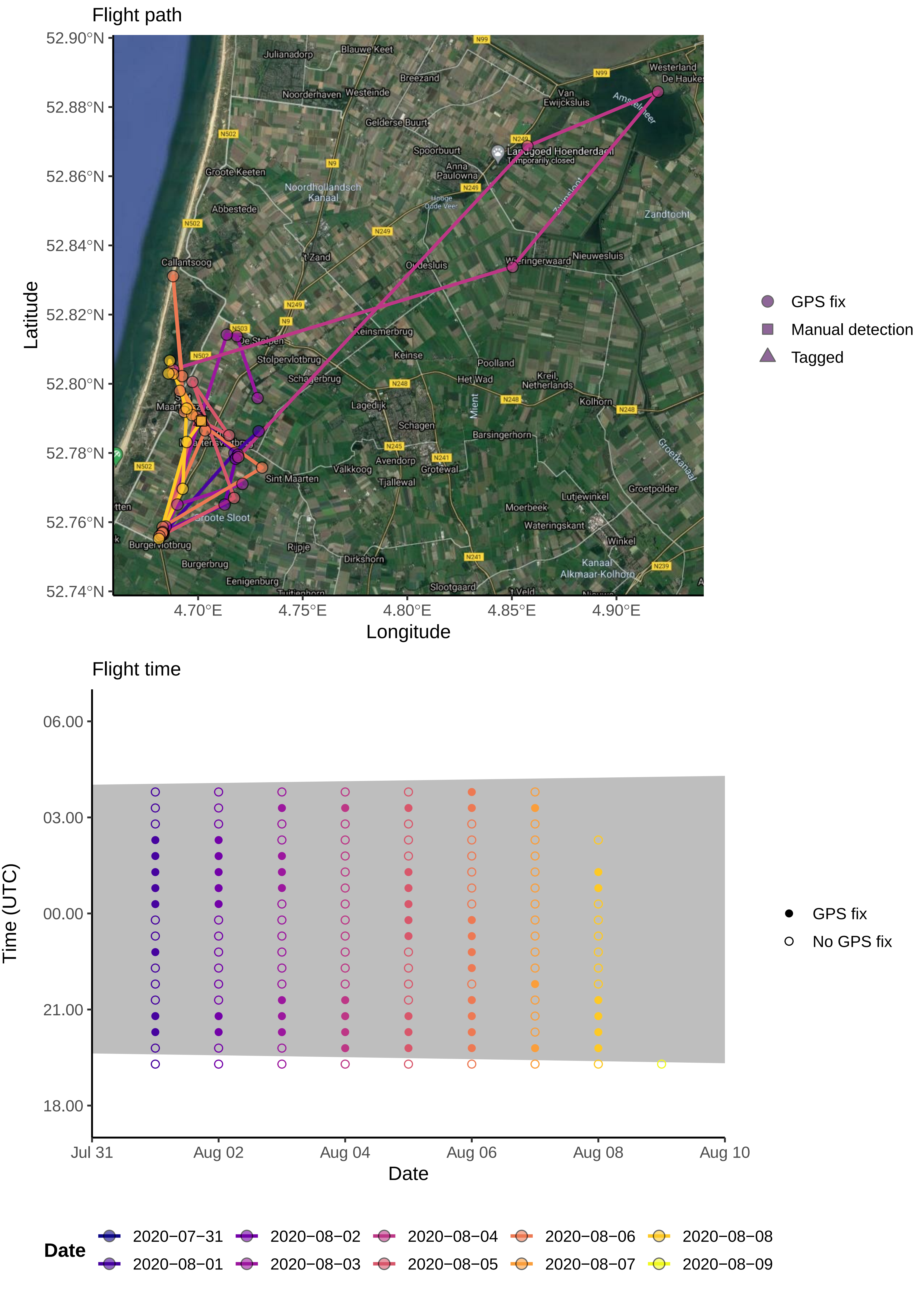
Common noctule, ID = 19, Male, Ad



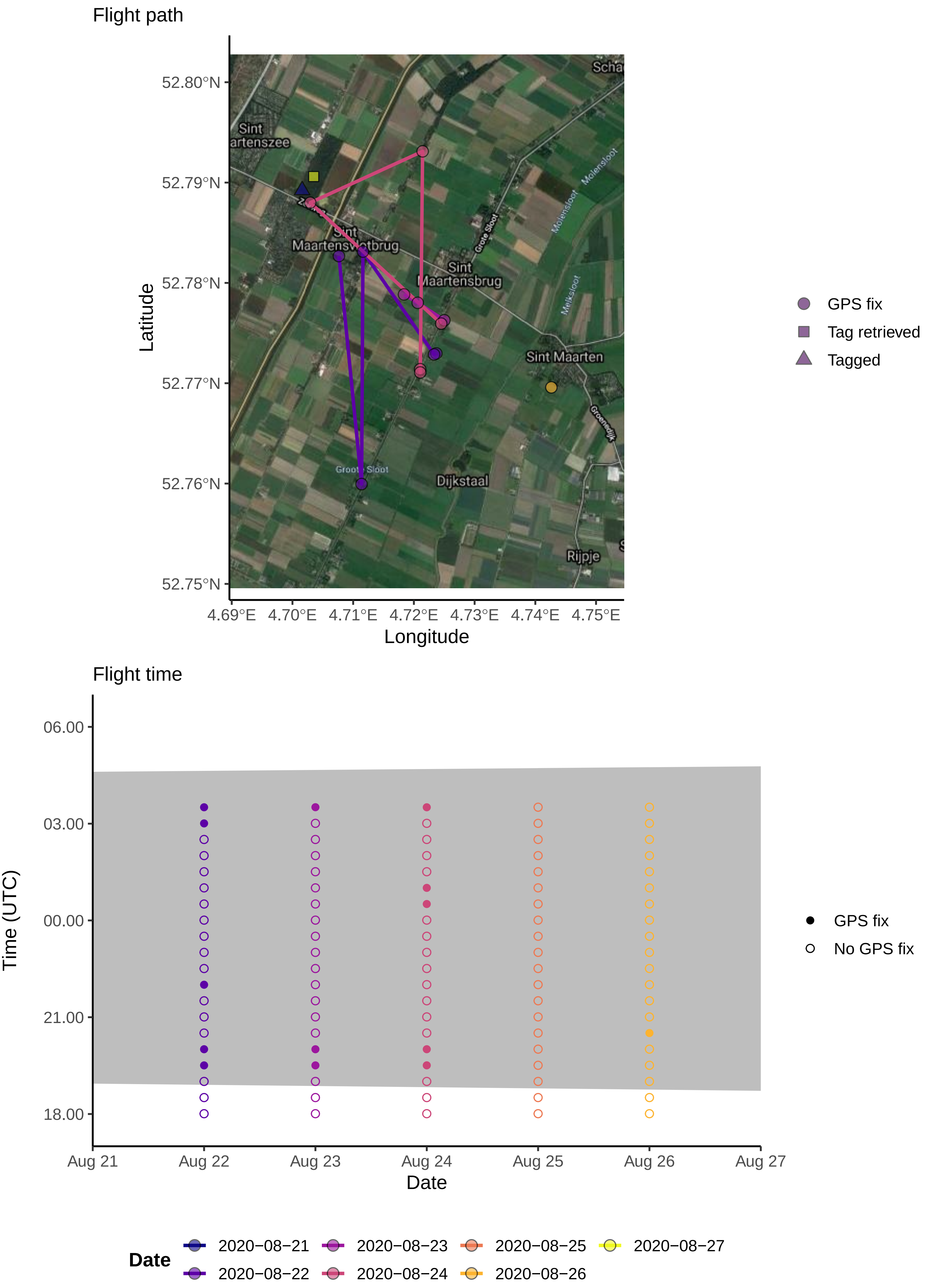
Common noctule, ID = 21, Female, Ad



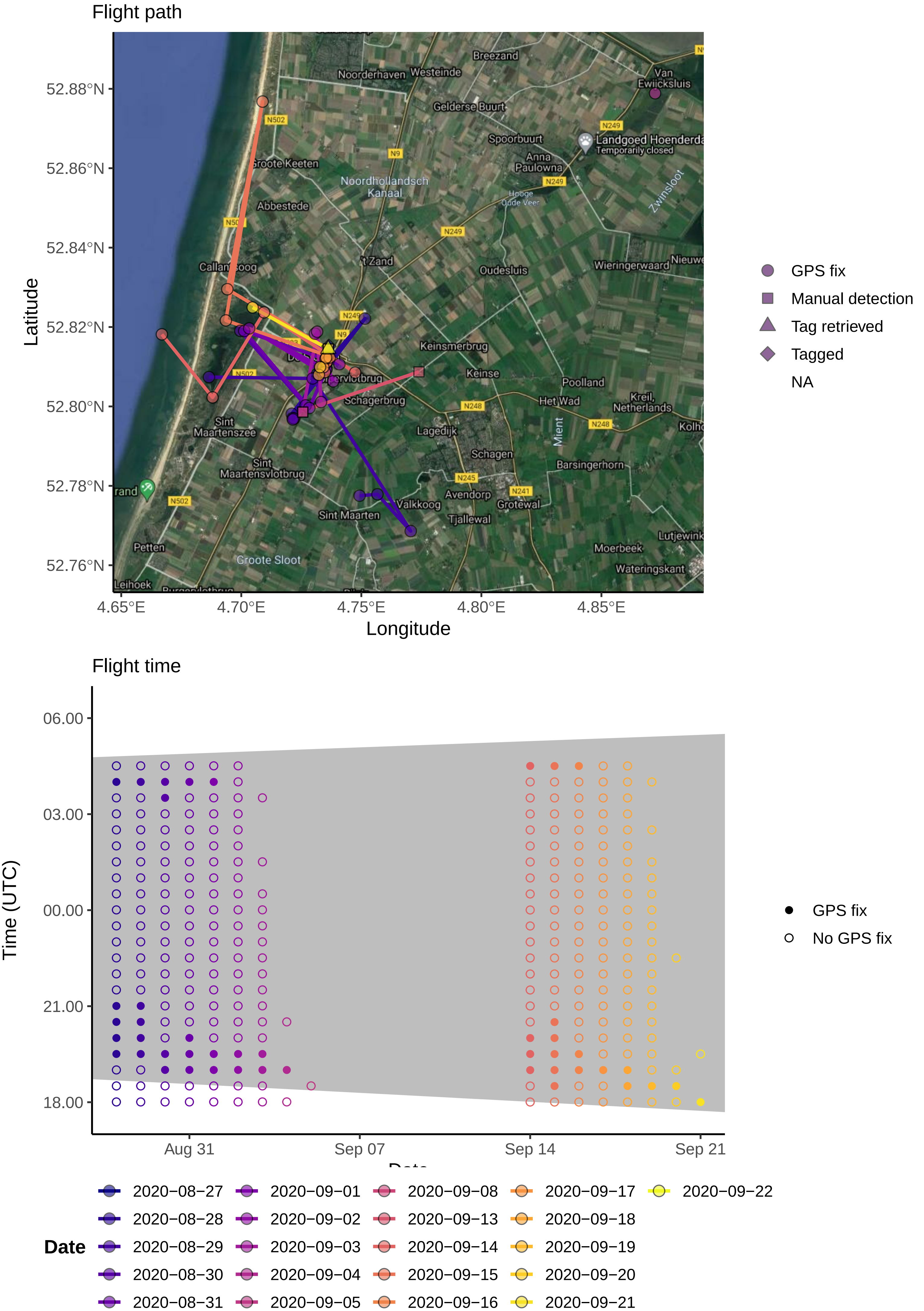
Common noctule, ID = 22, Male, Ad



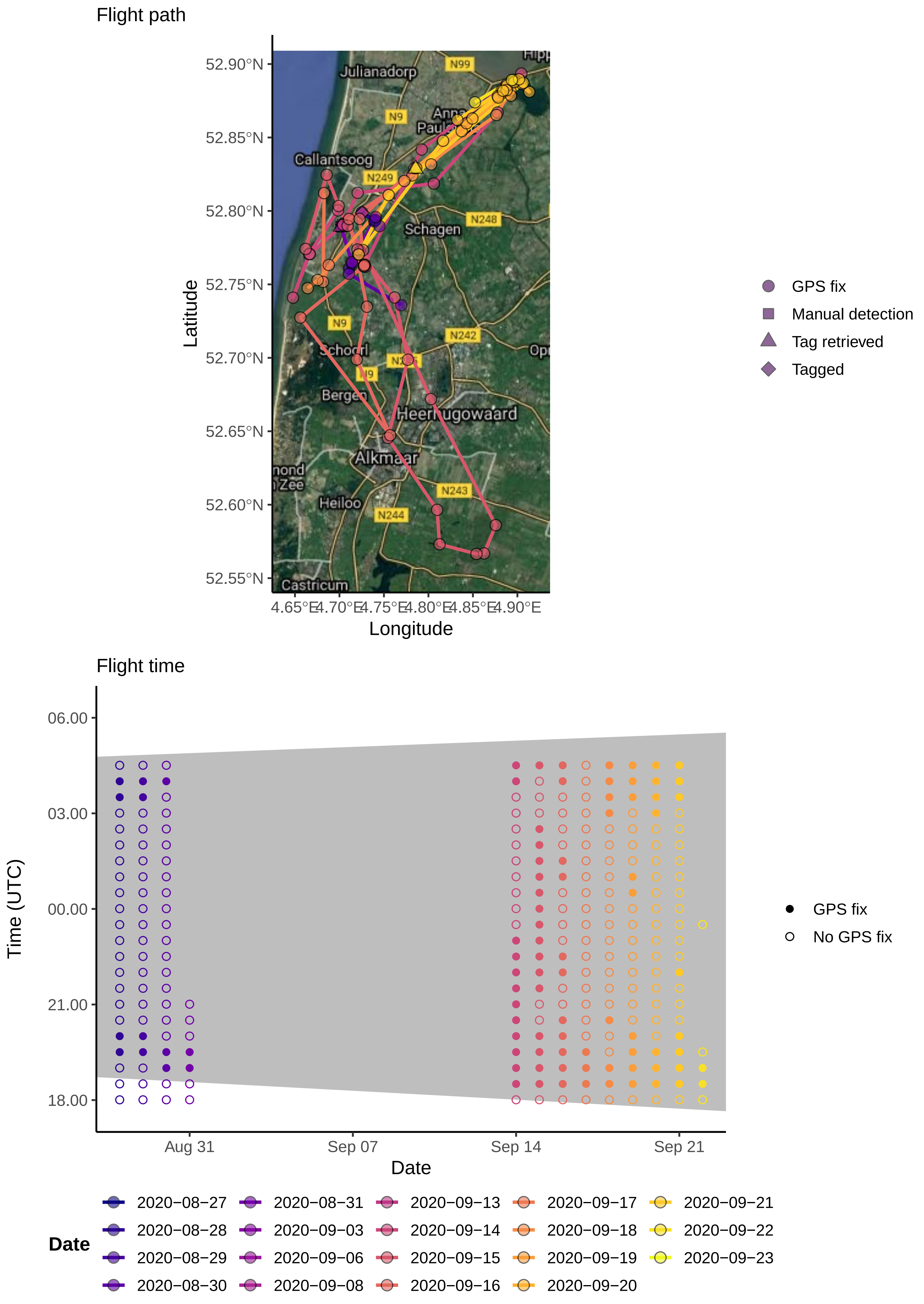
Common noctule, ID = 24, Female, Ad



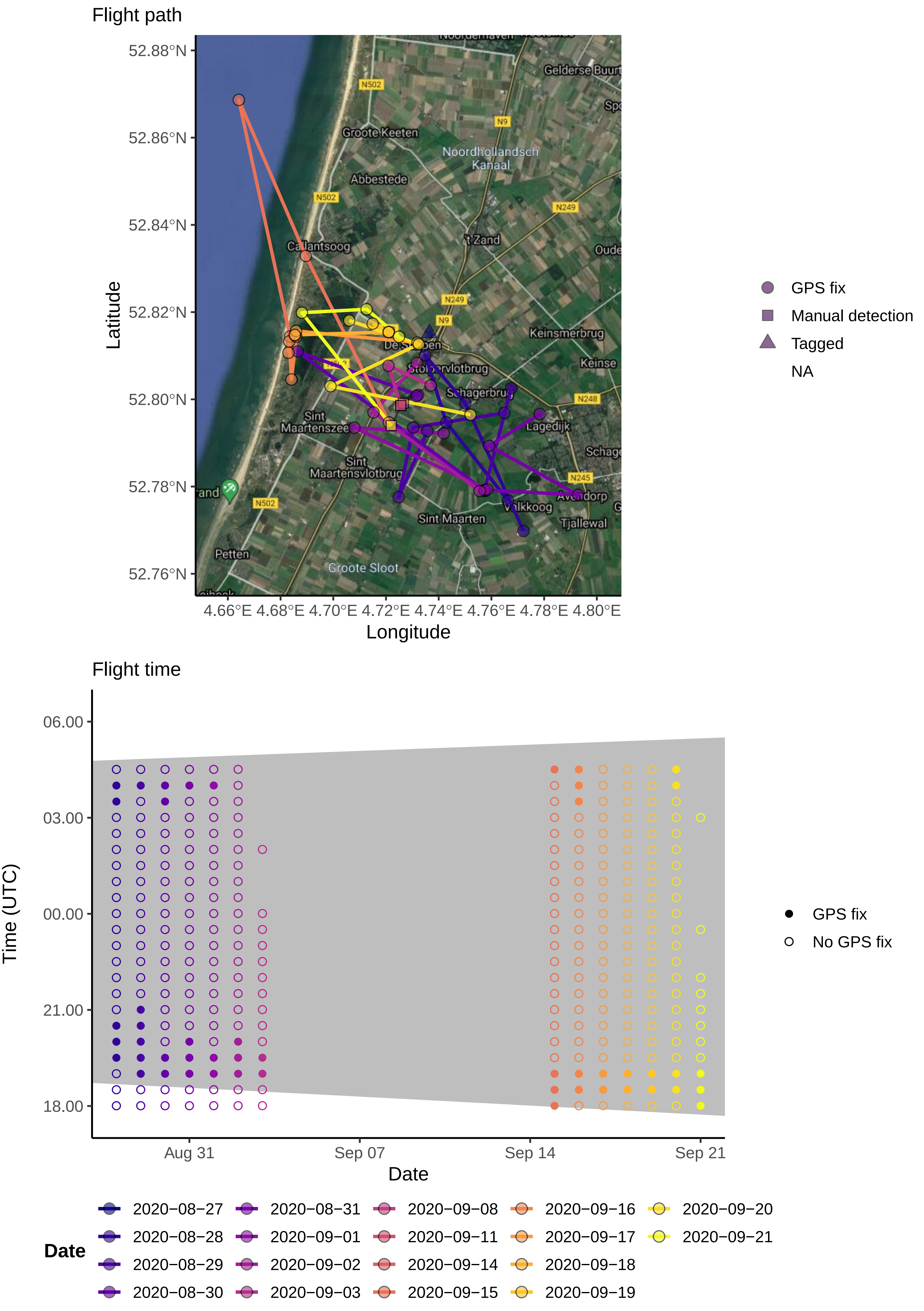
Common noctule, ID = 25, Female, Ad



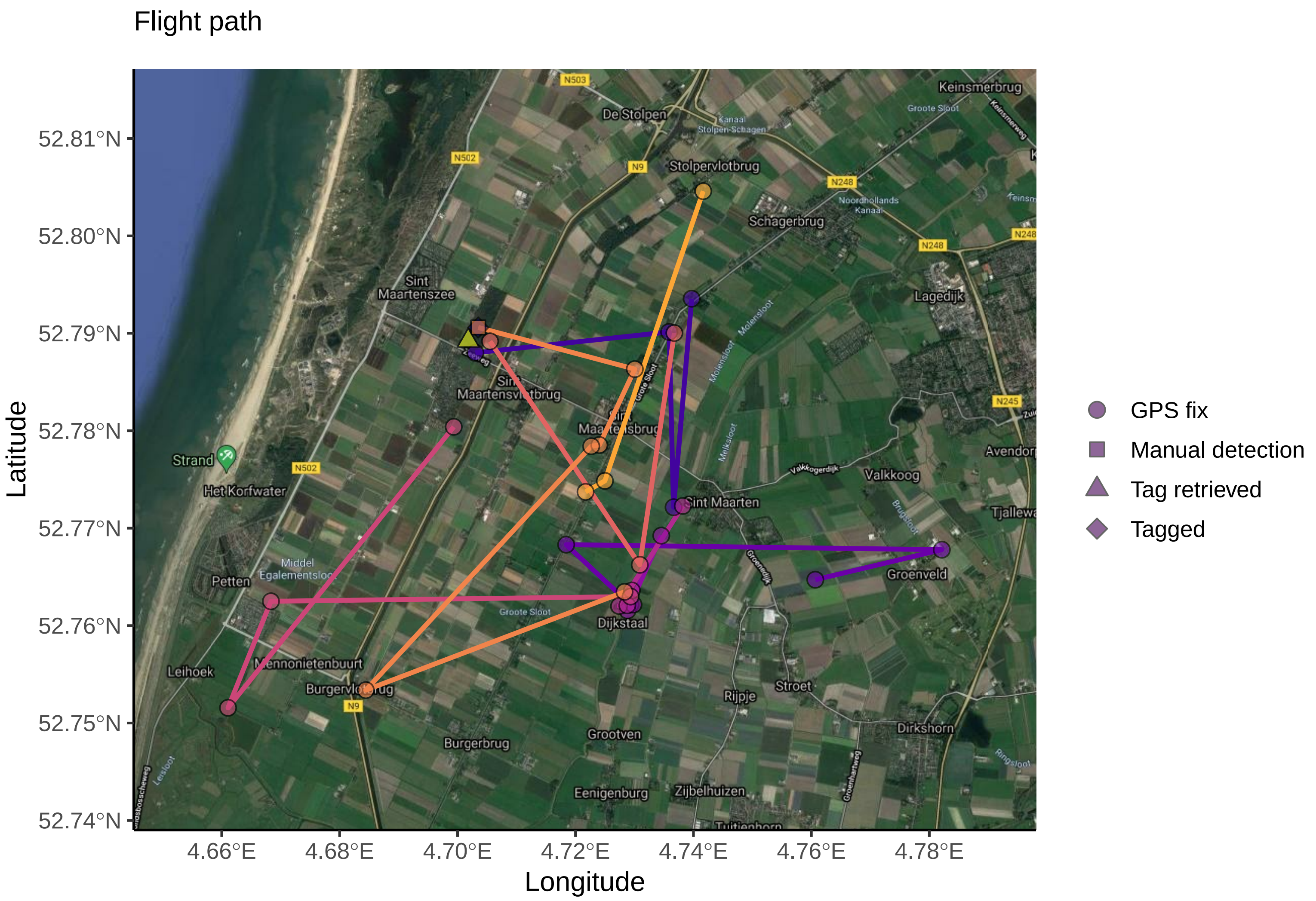
Common noctule, ID = 26, Male, YOY

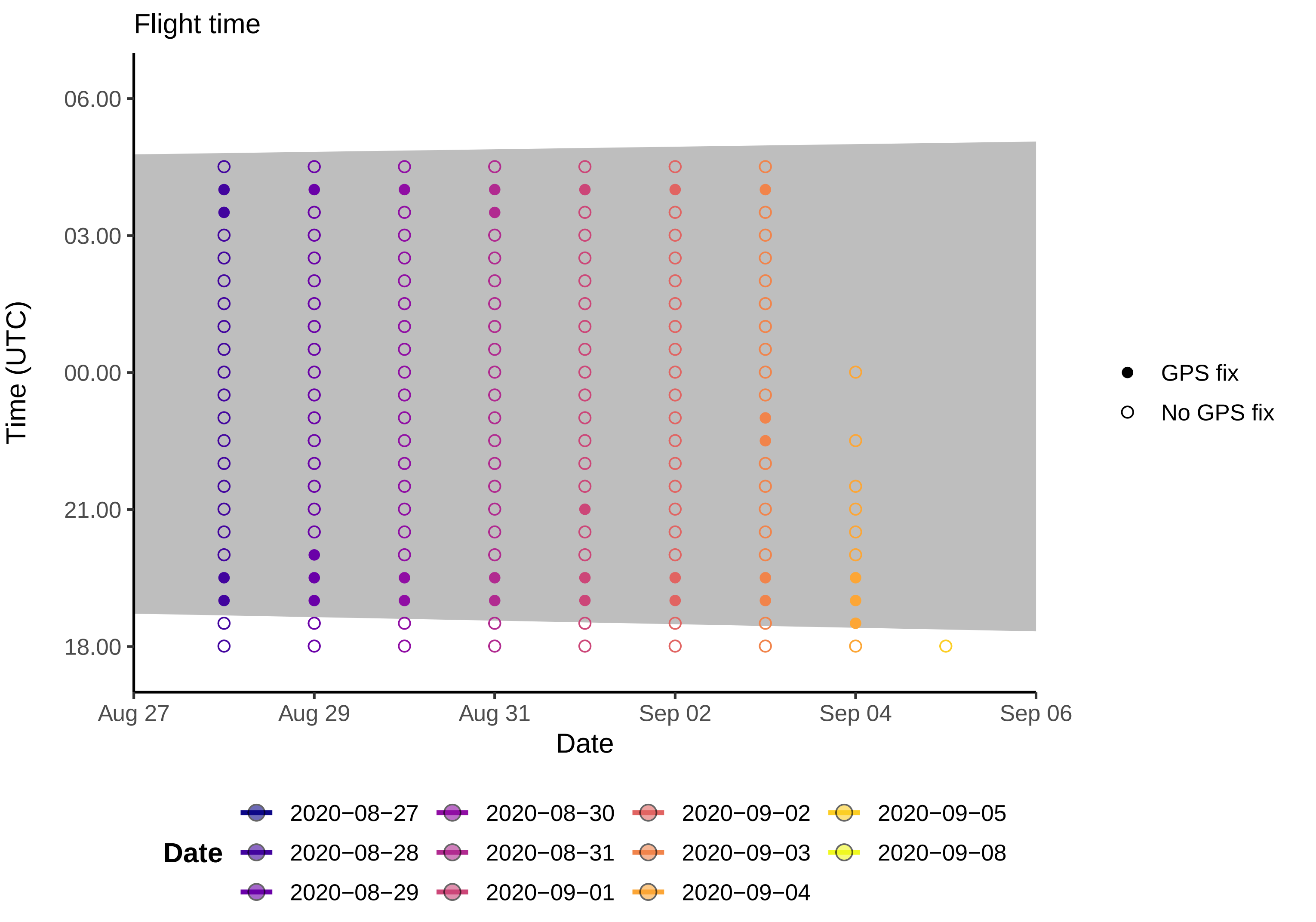


Common noctule, ID = 27, Female, Ad

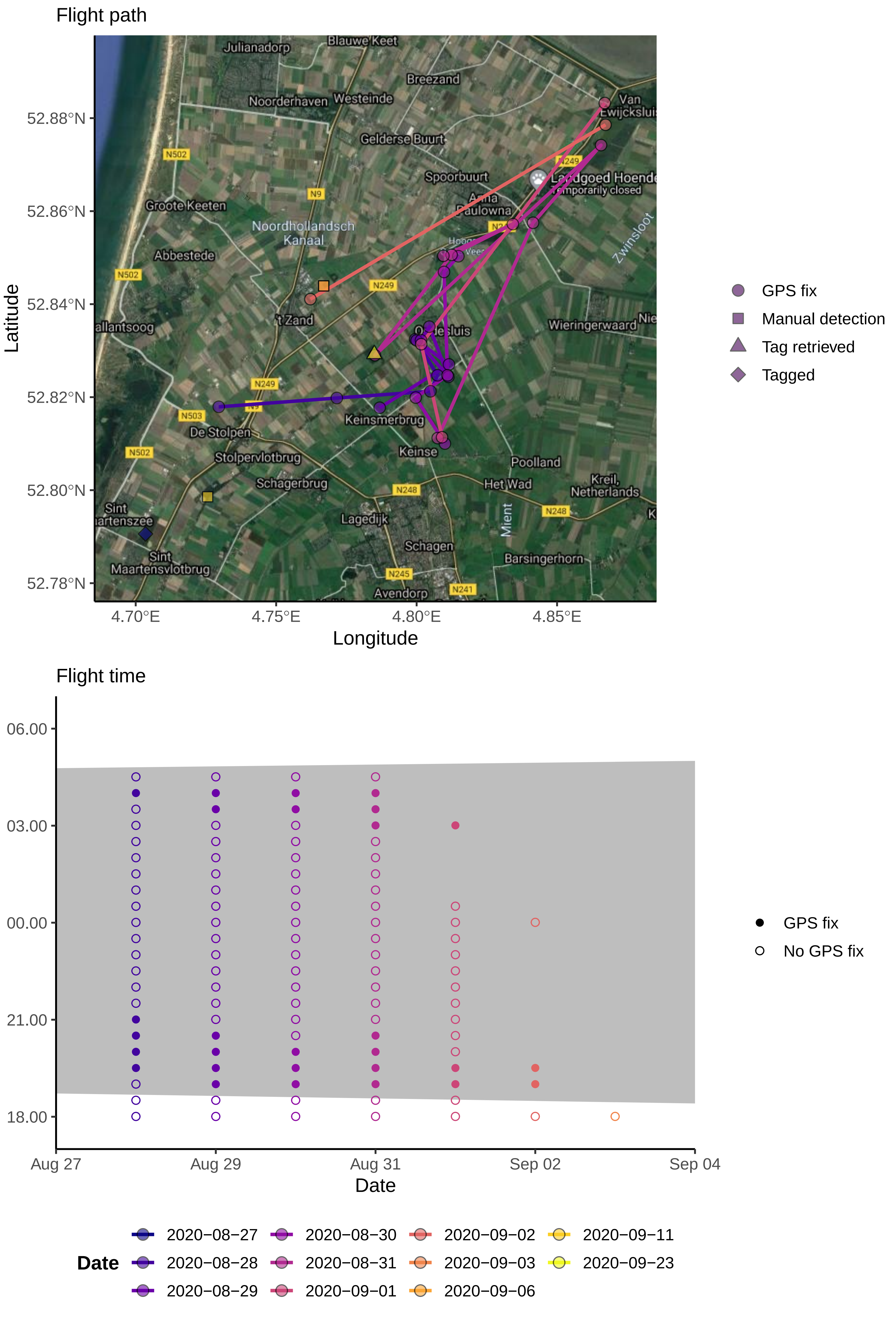


Common noctule, ID = 28, Male, YOY



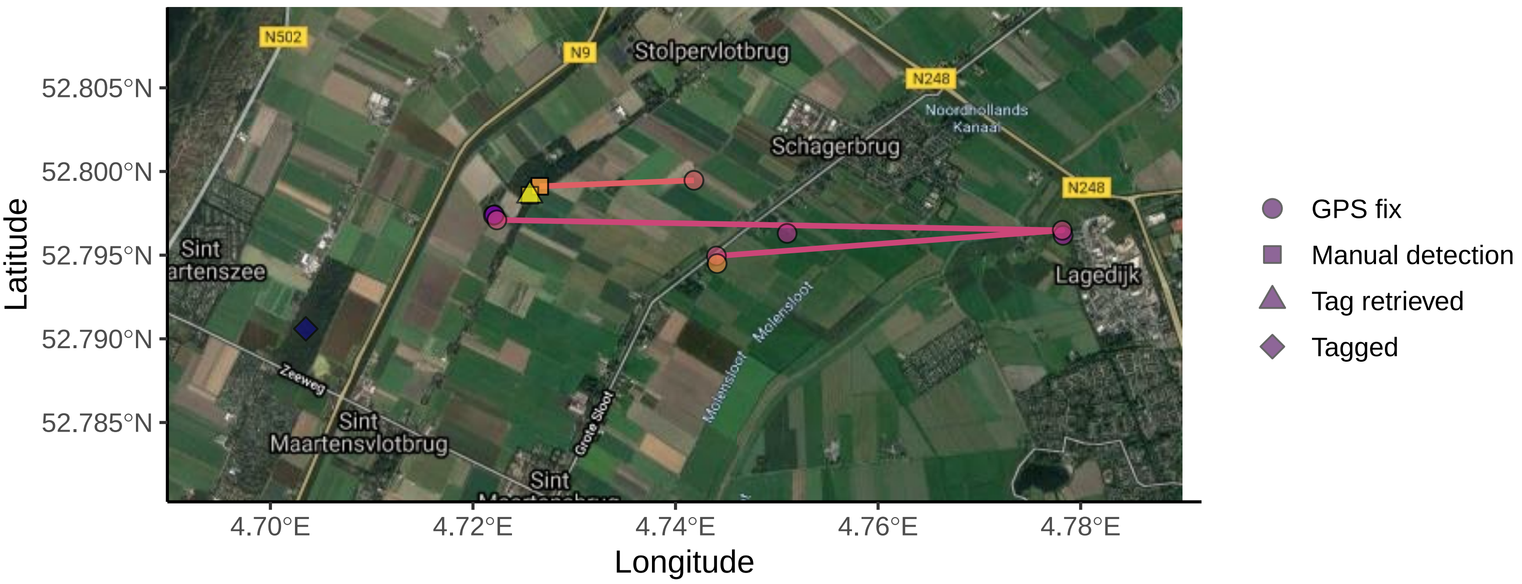


Common noctule, ID = 30, Male, YOY

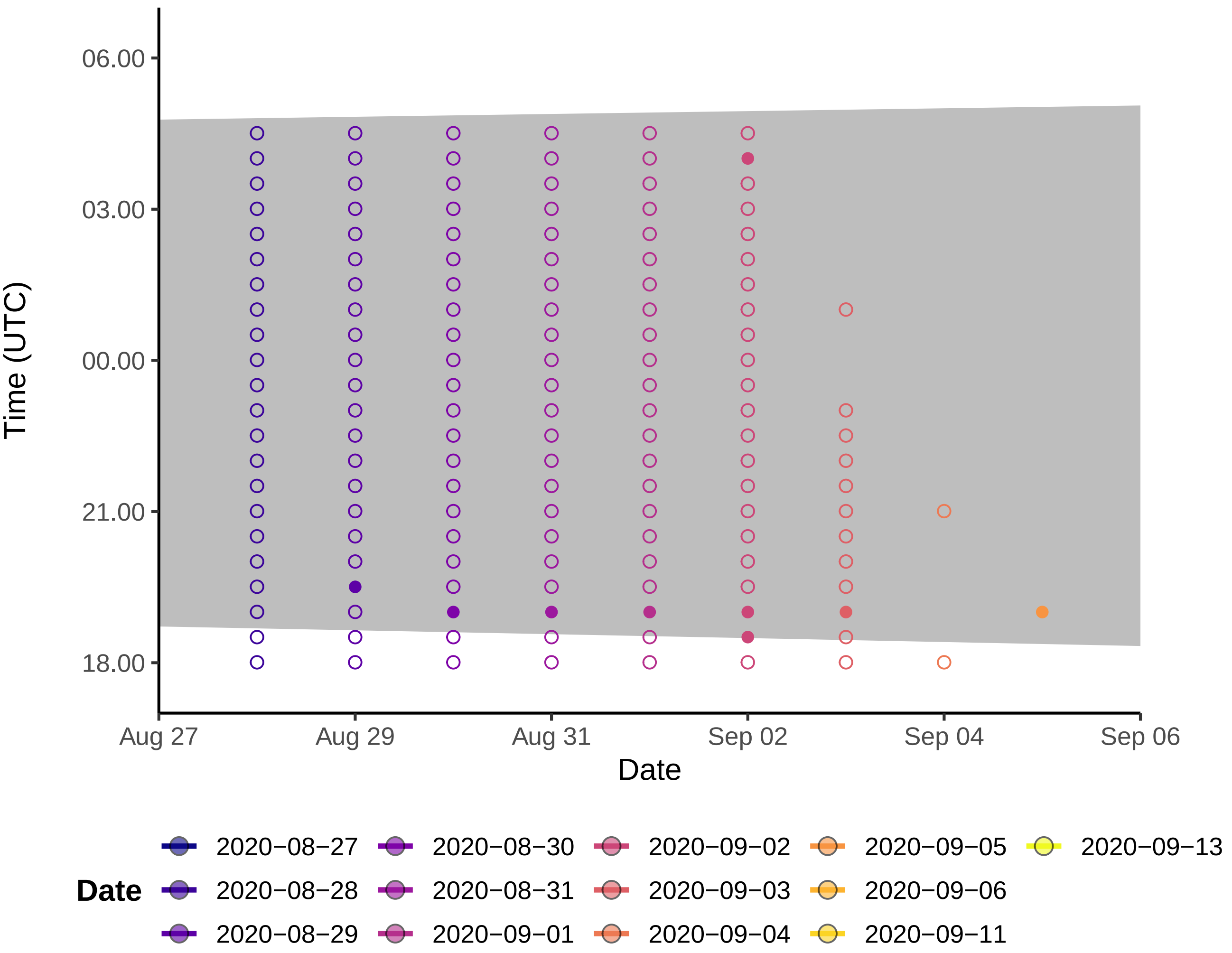


Common noctule, ID = 31, Female, Ad

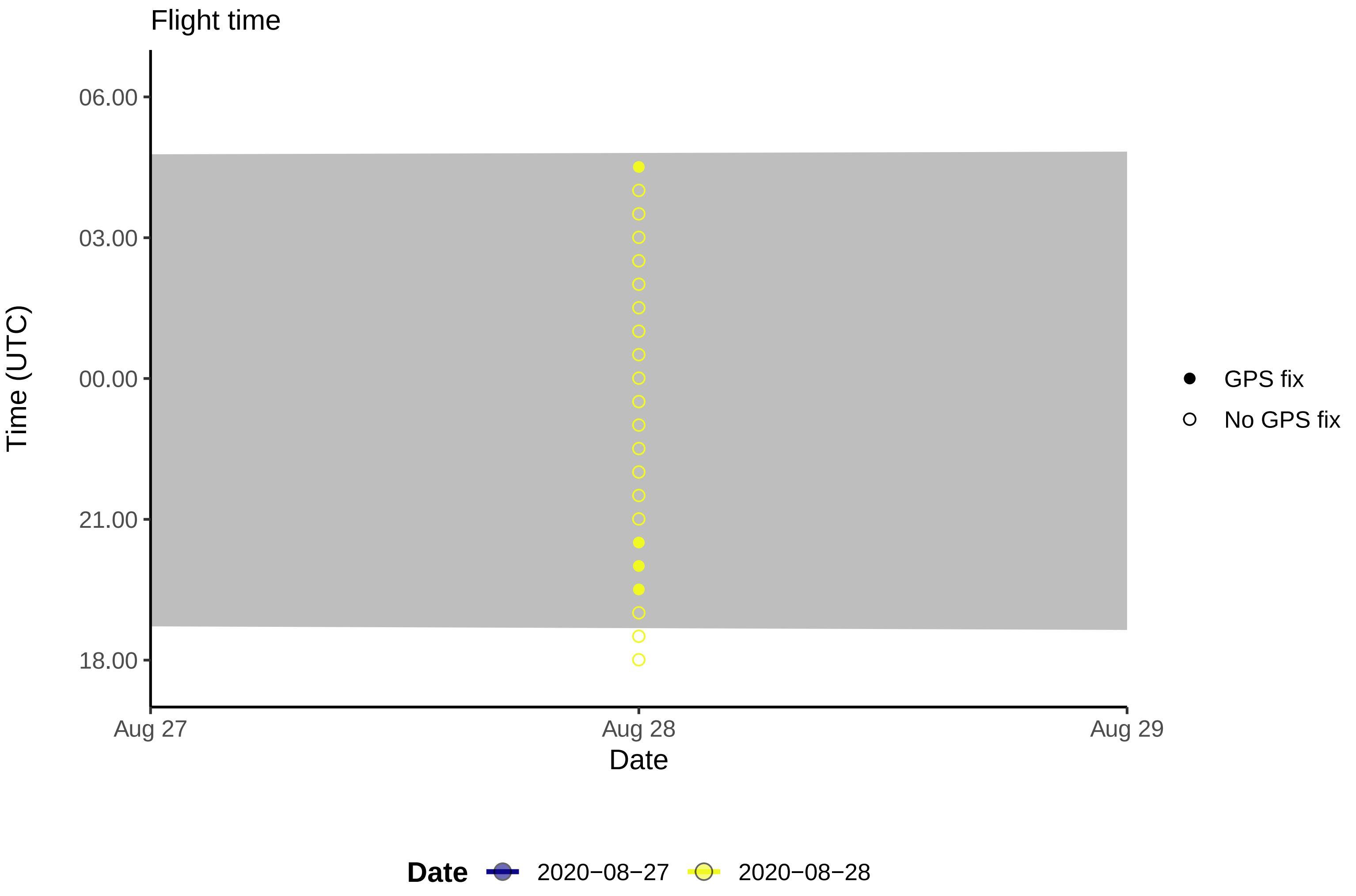
Flight path



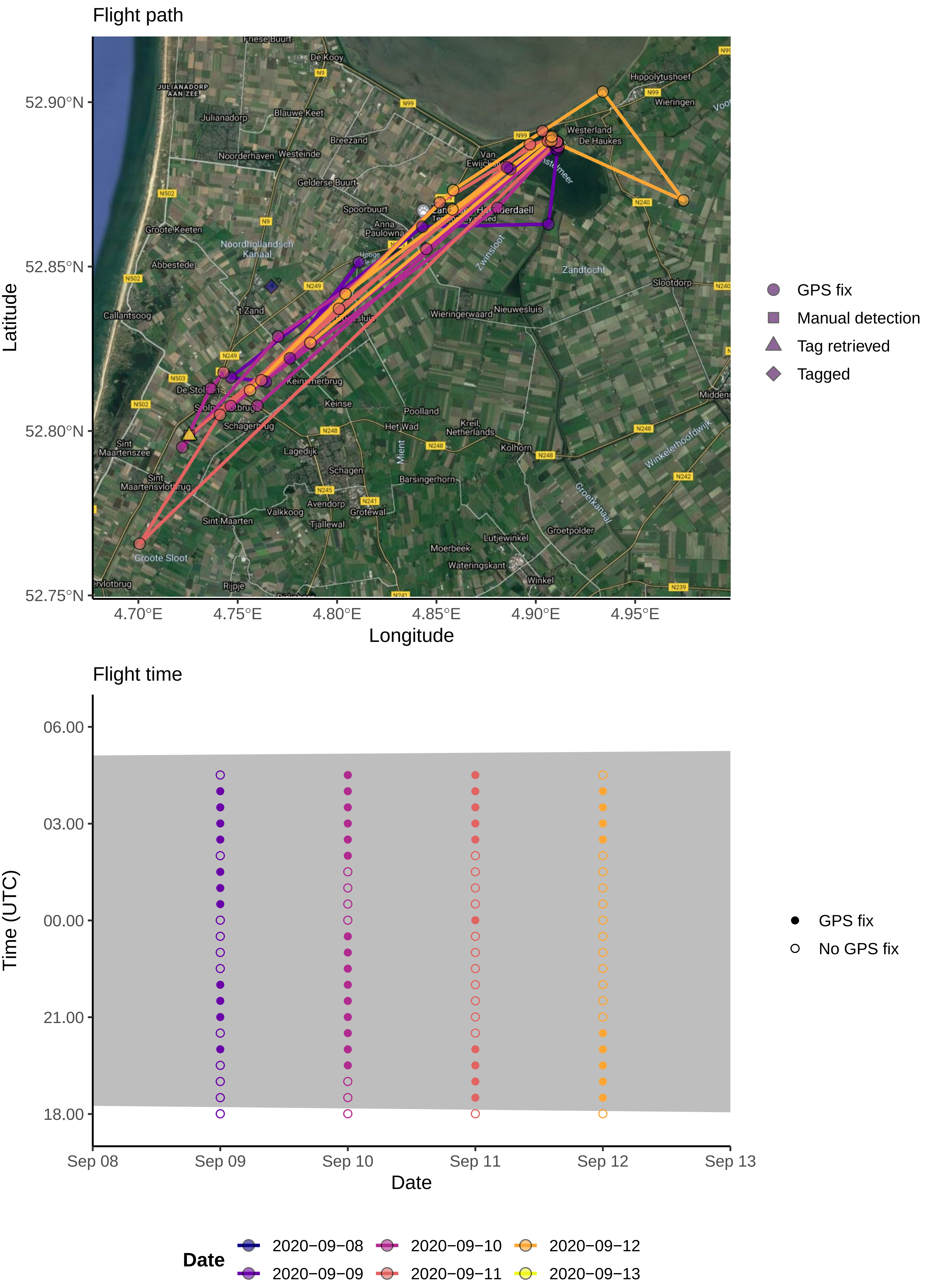
Flight time



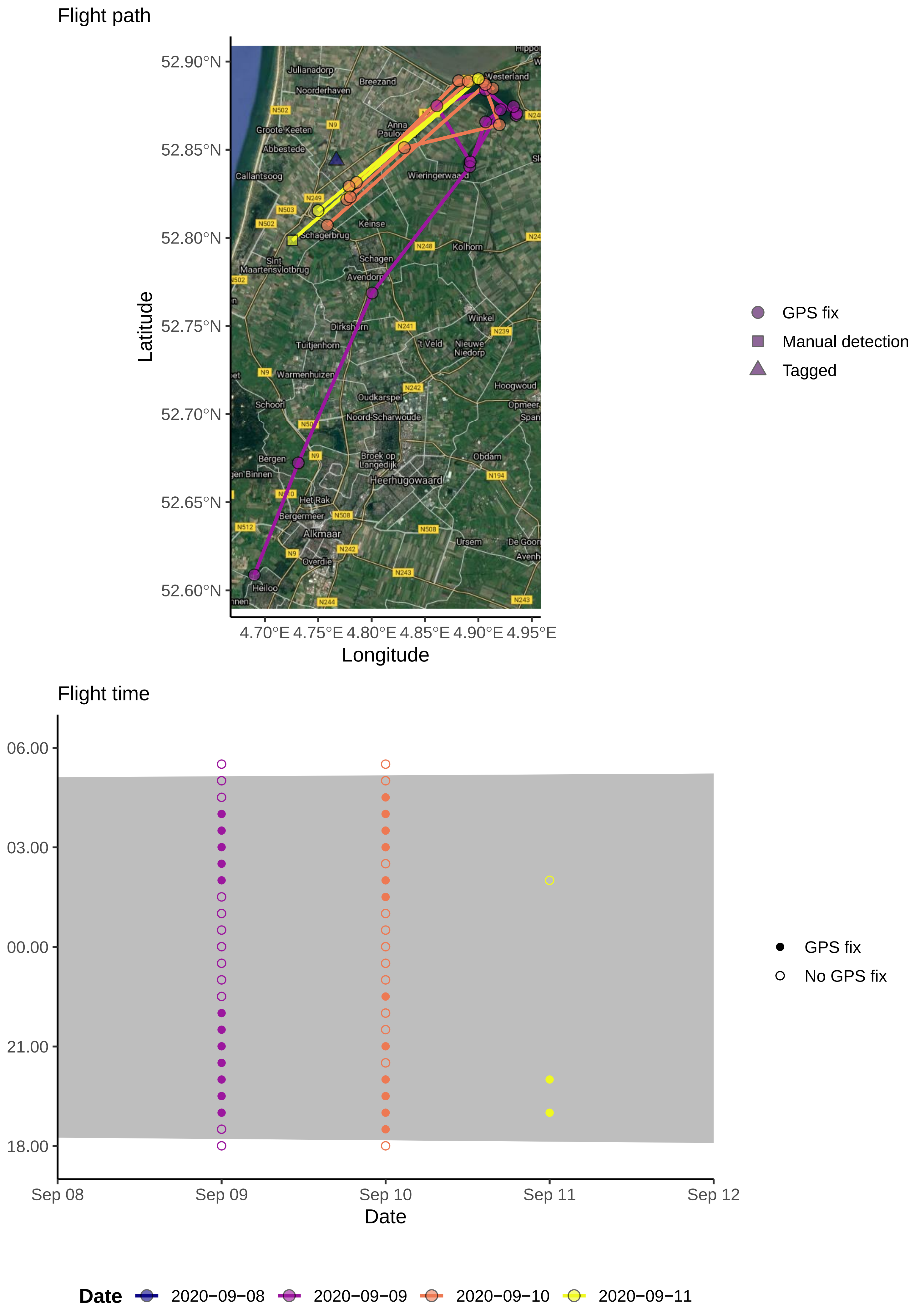
Common noctule, ID = 33, Male, YOY



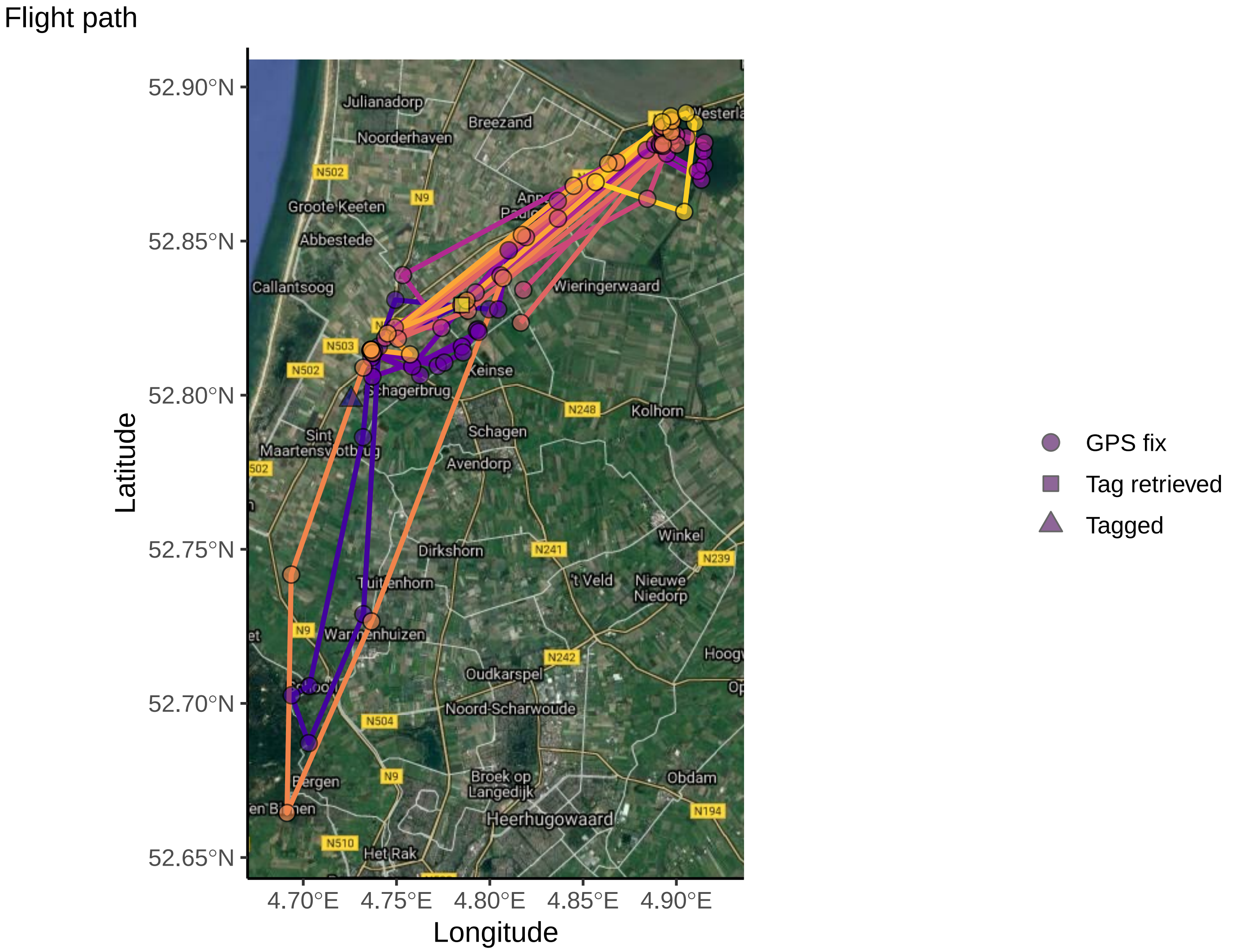
Common noctule, ID = 37, Male, YOY

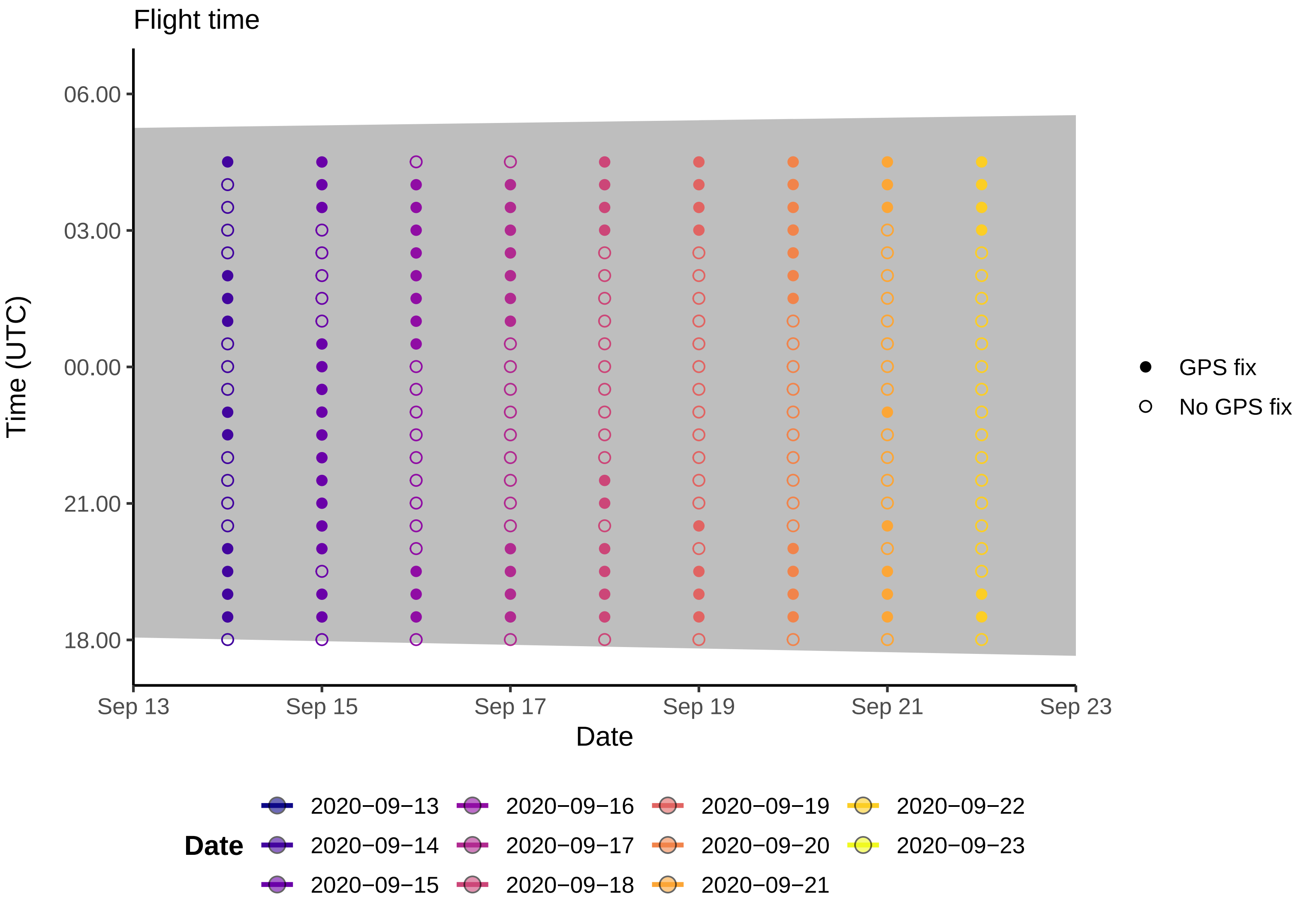


Common noctule, ID = 38, Male, YOY

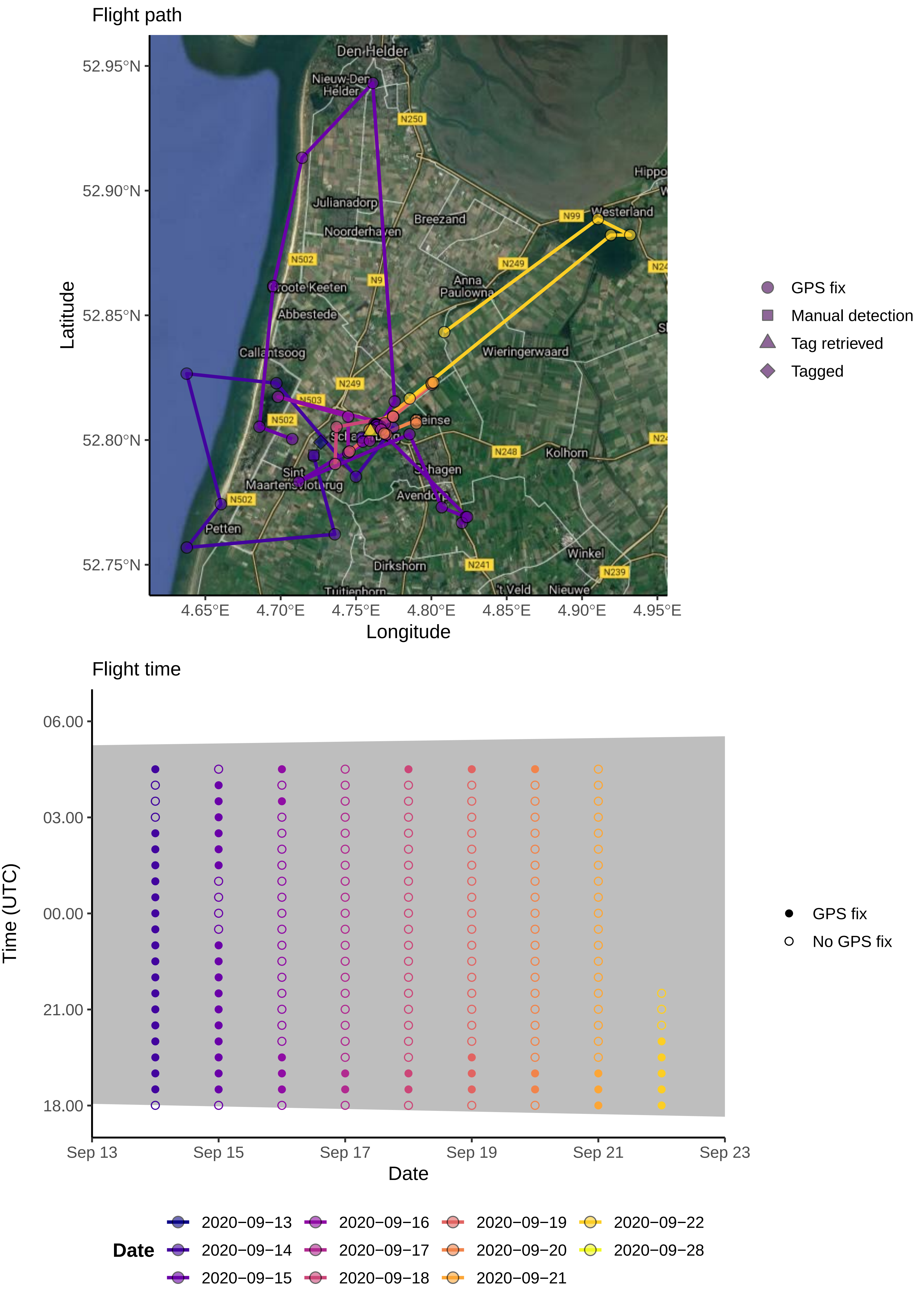


Common noctule, ID = 43, Male, YOY

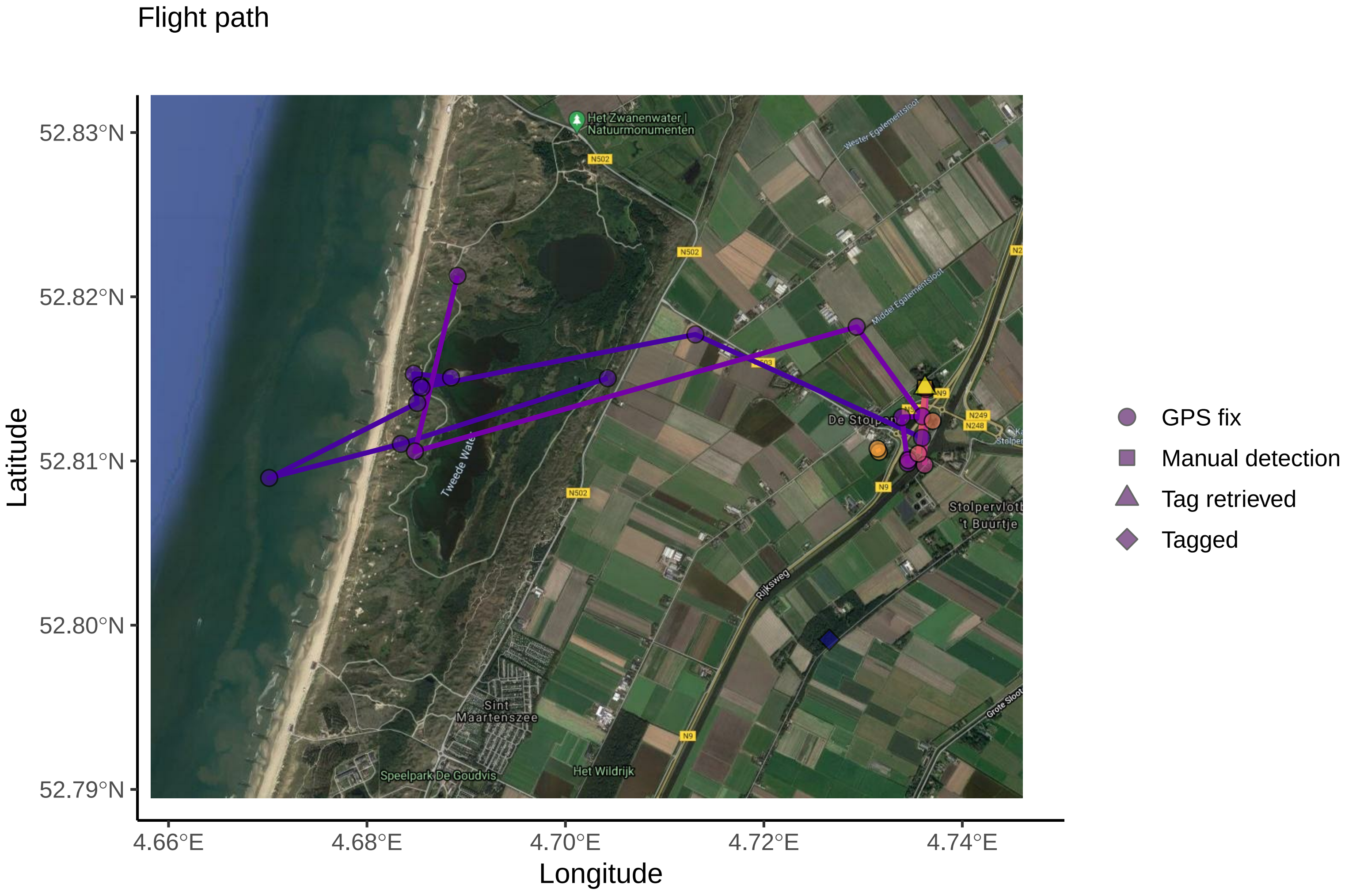


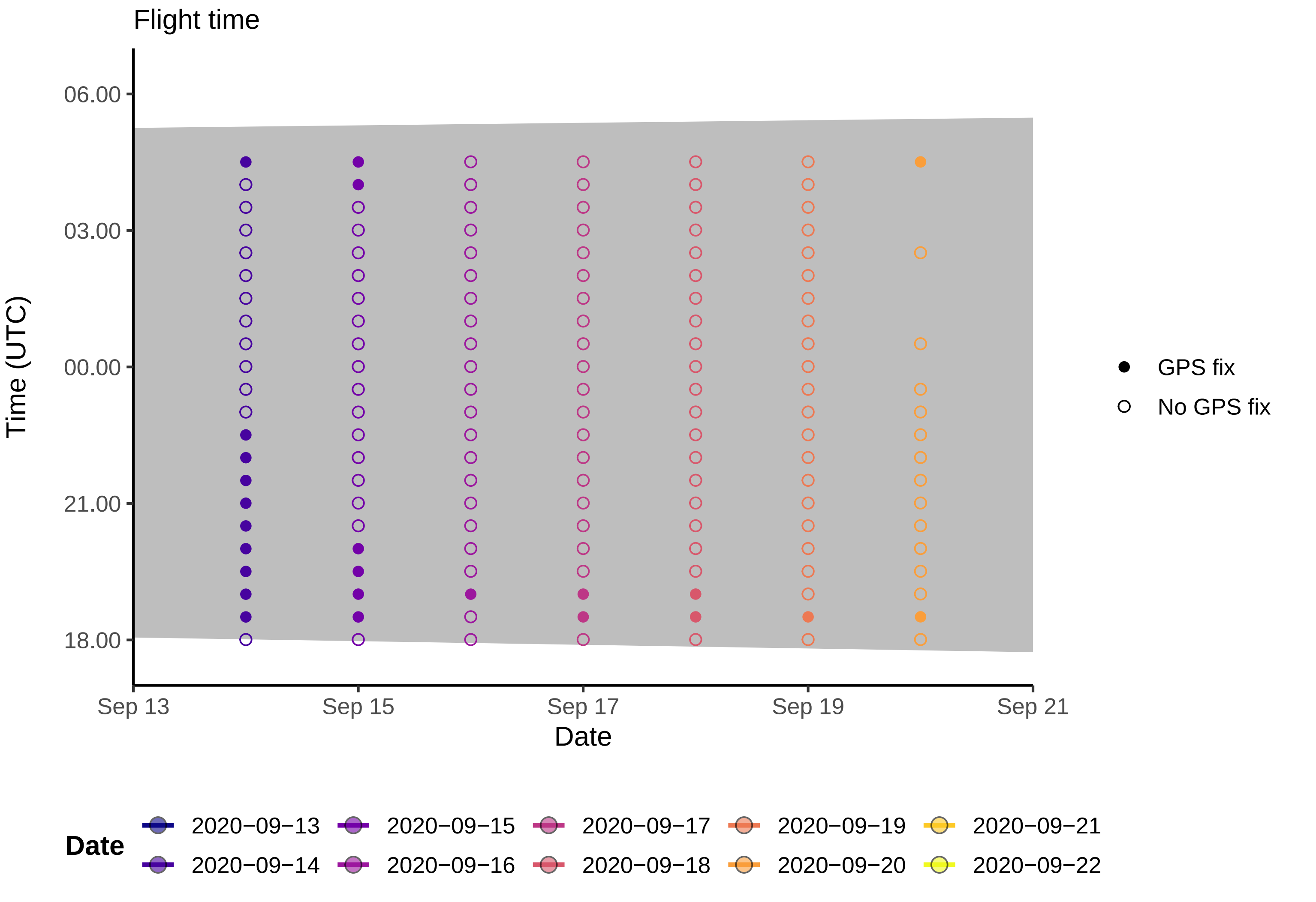


Common noctule, ID = 46, Female, YOY

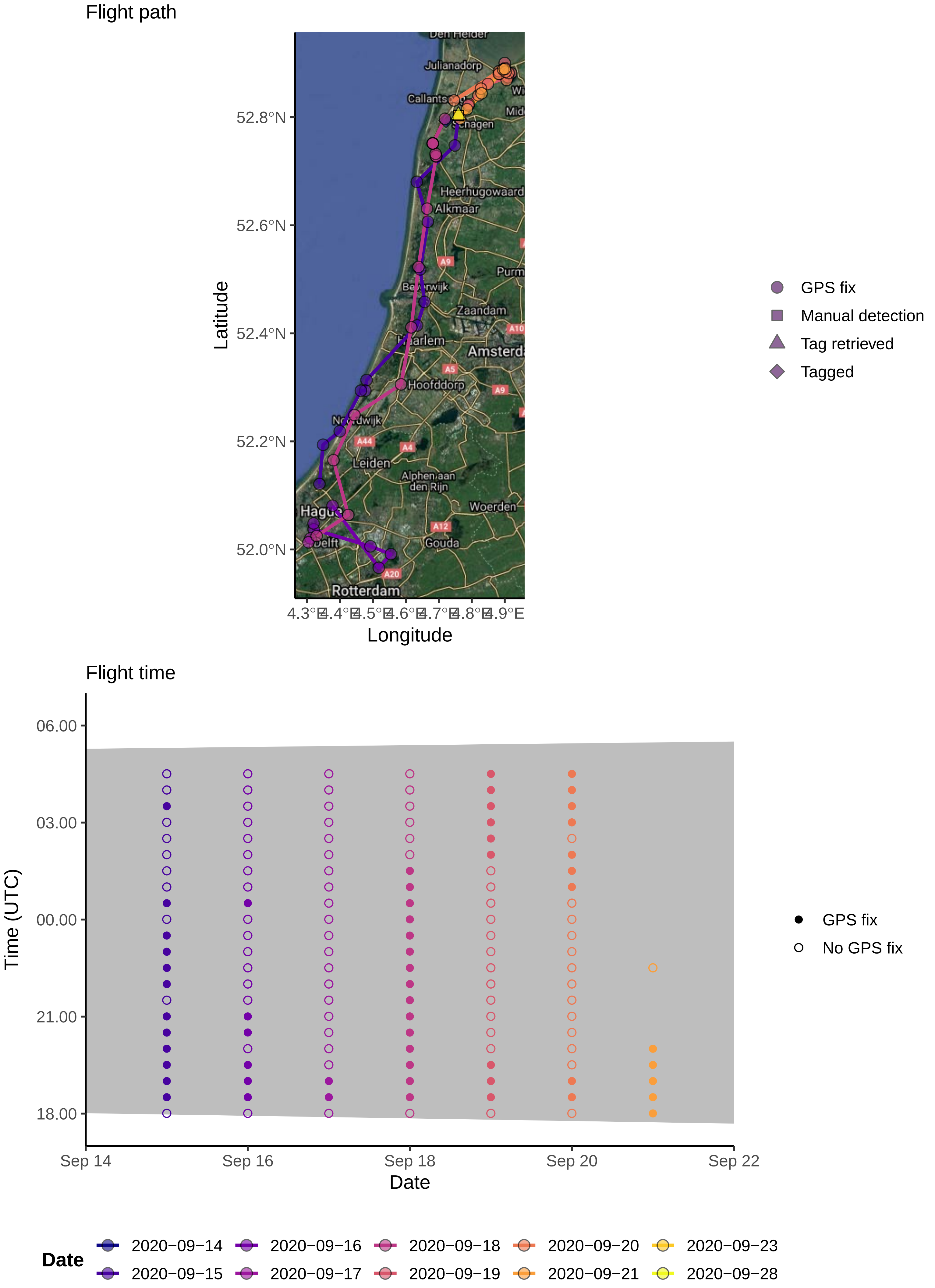


Common noctule, ID = 47, Female, Ad



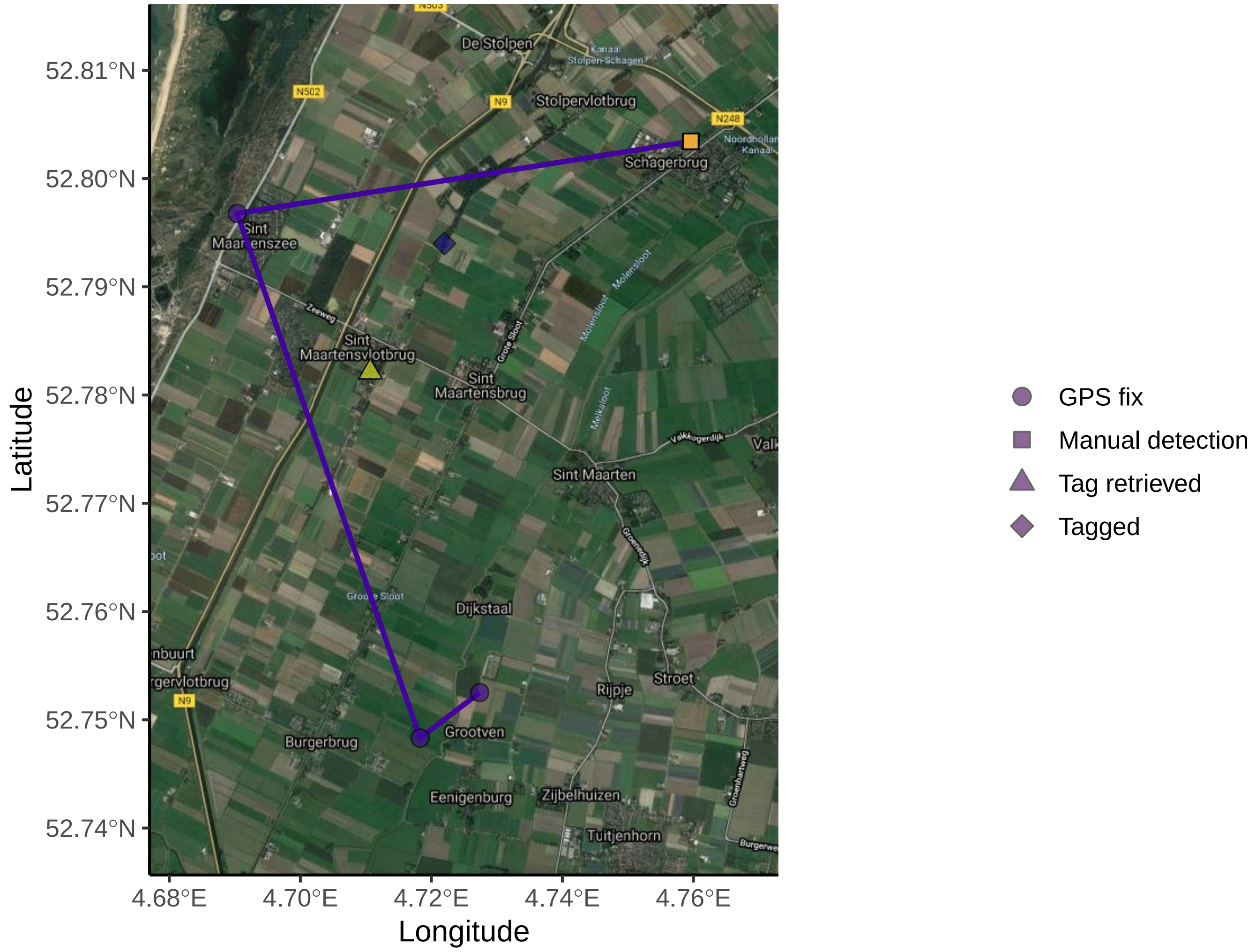


Common noctule, ID = 48, Female, YOY

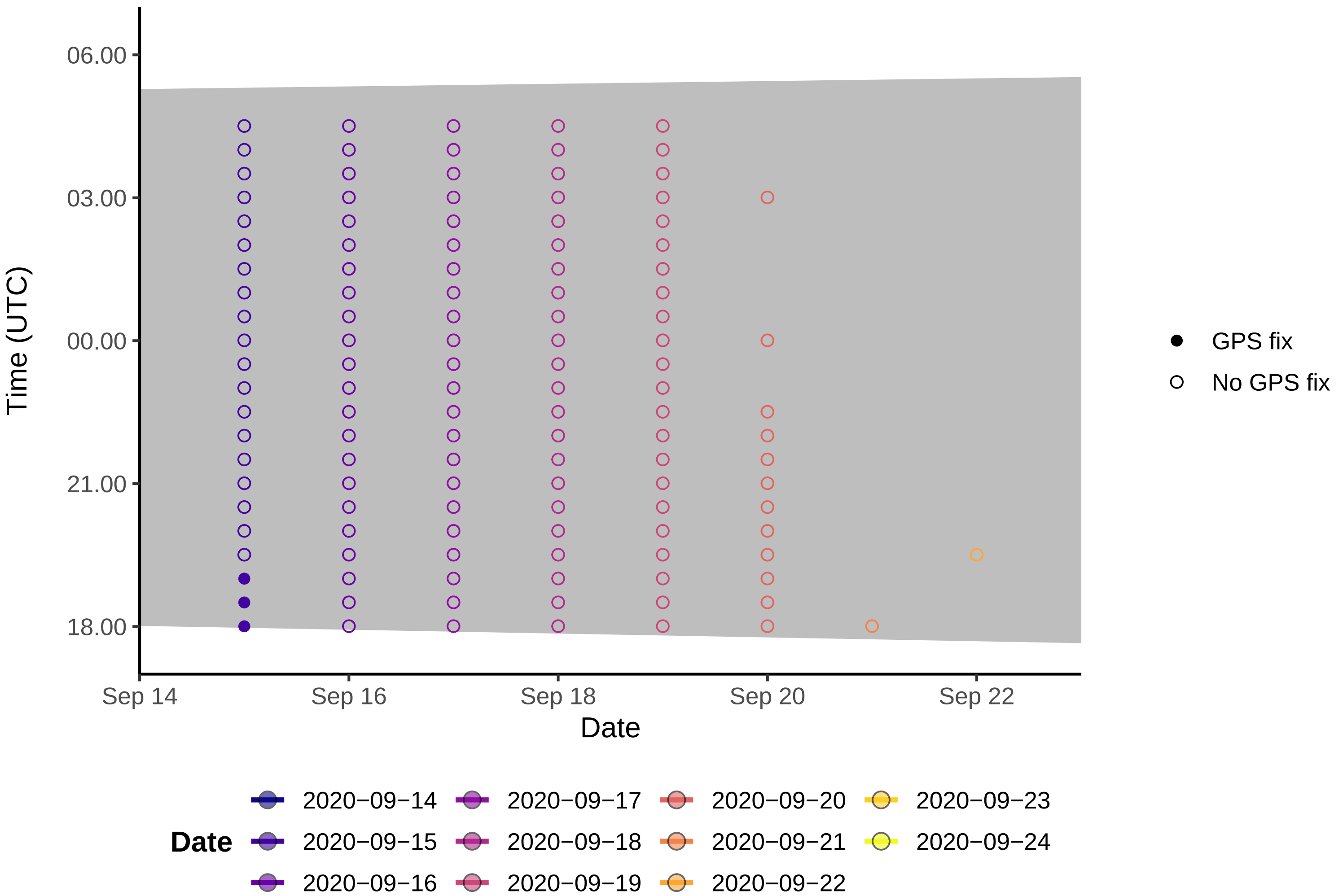


Common noctule, ID = 49, Female, YOY

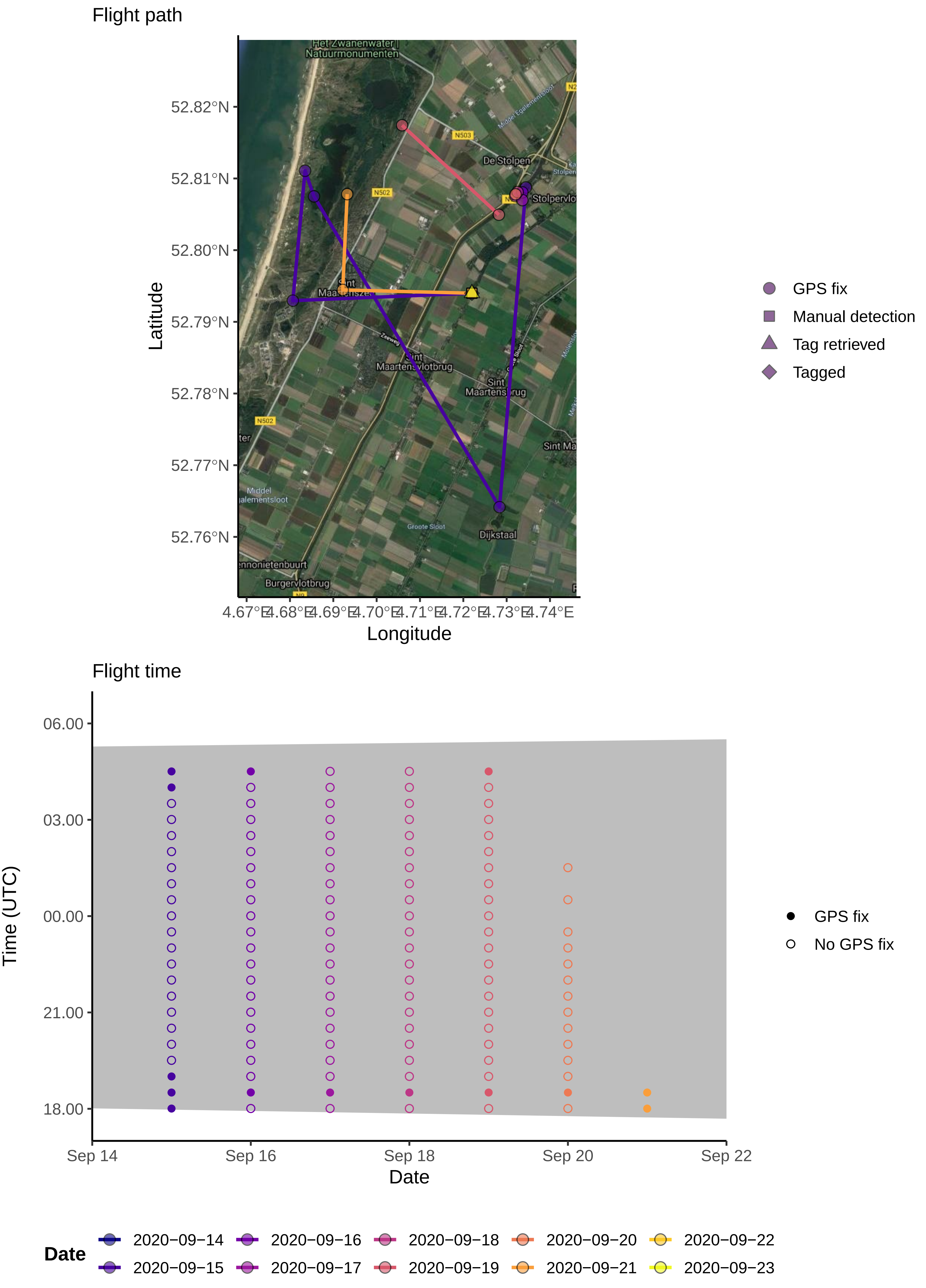
Flight path



Flight time

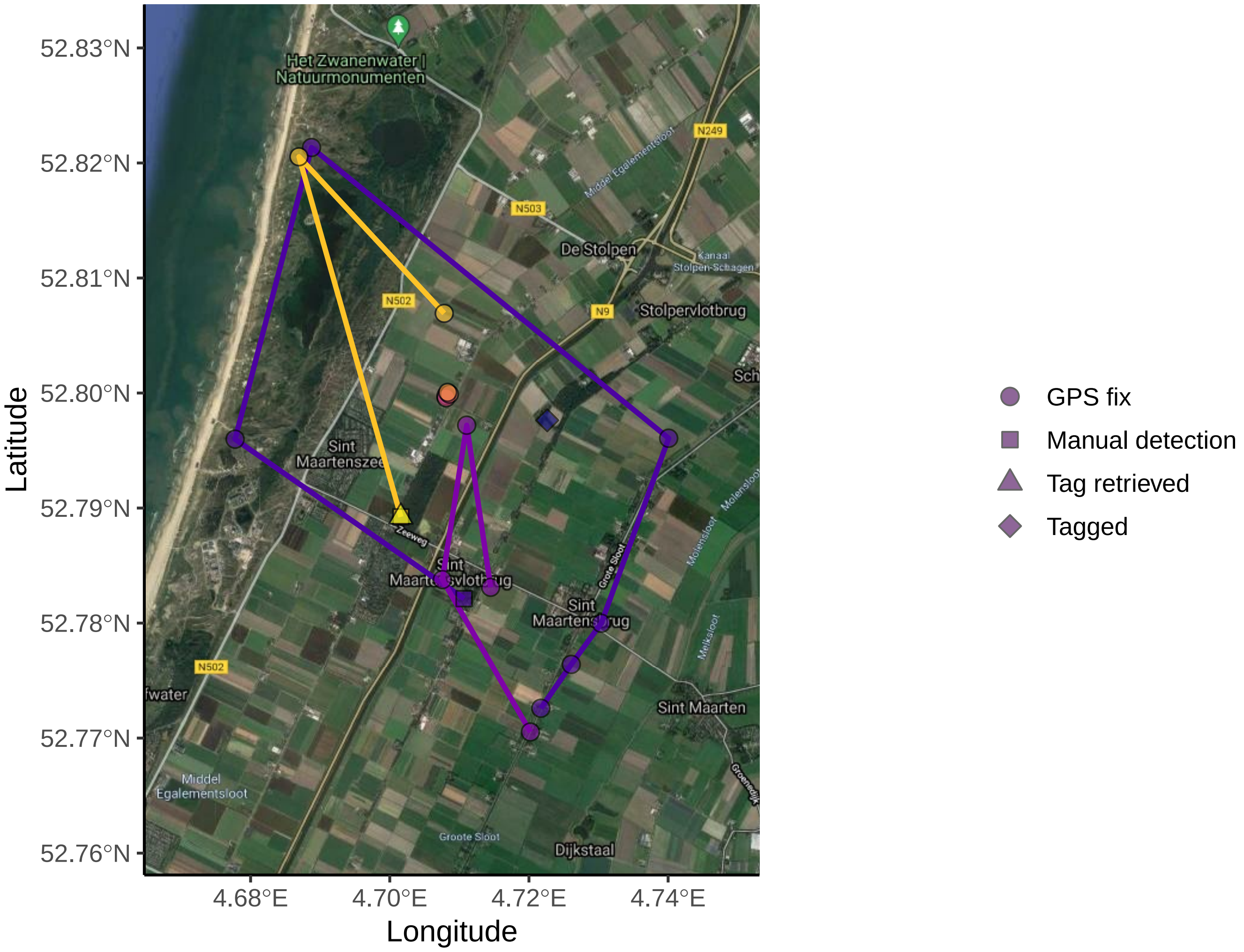


Common noctule, ID = 50, Male, Ad

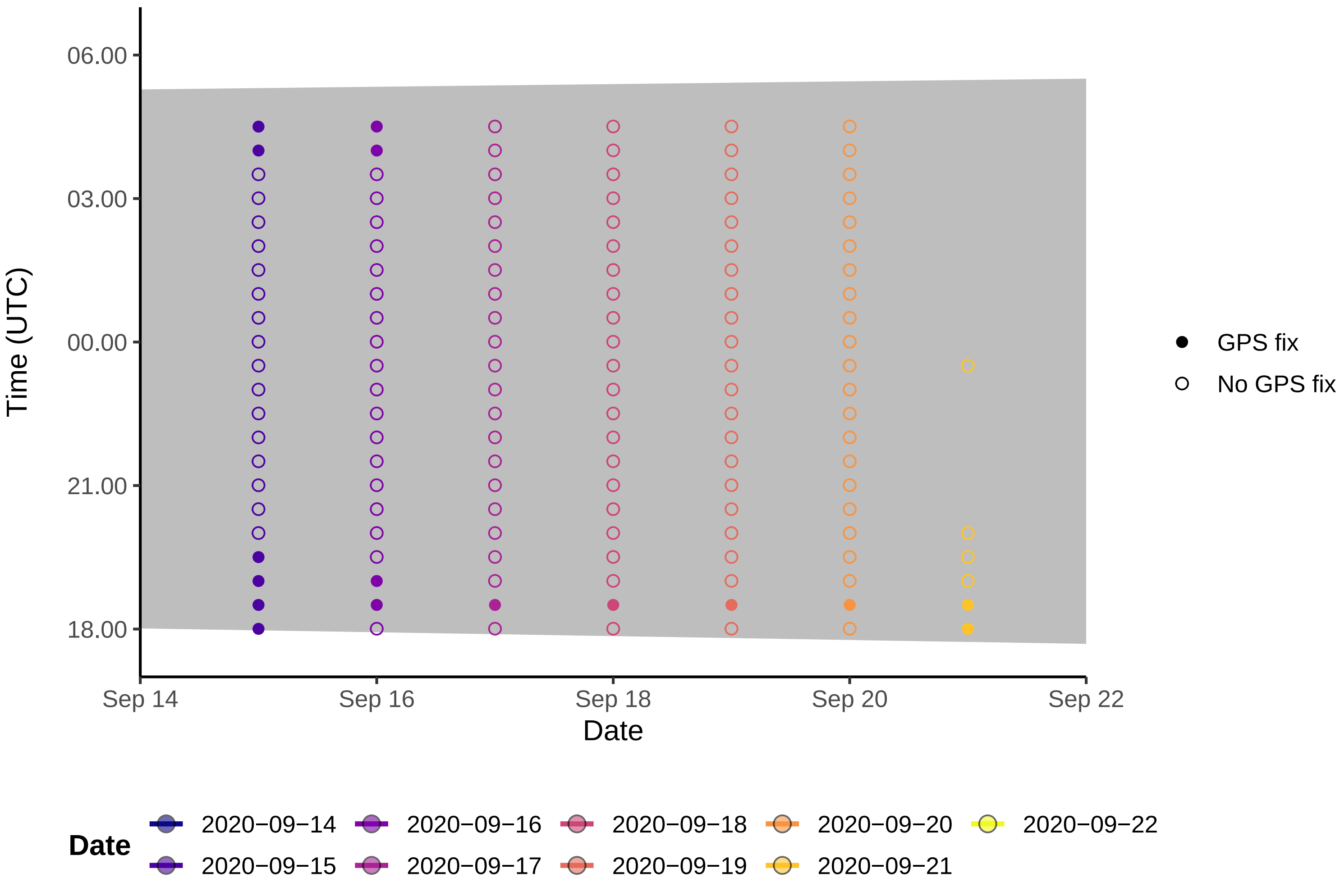


Common noctule, ID = 52, Female, Ad

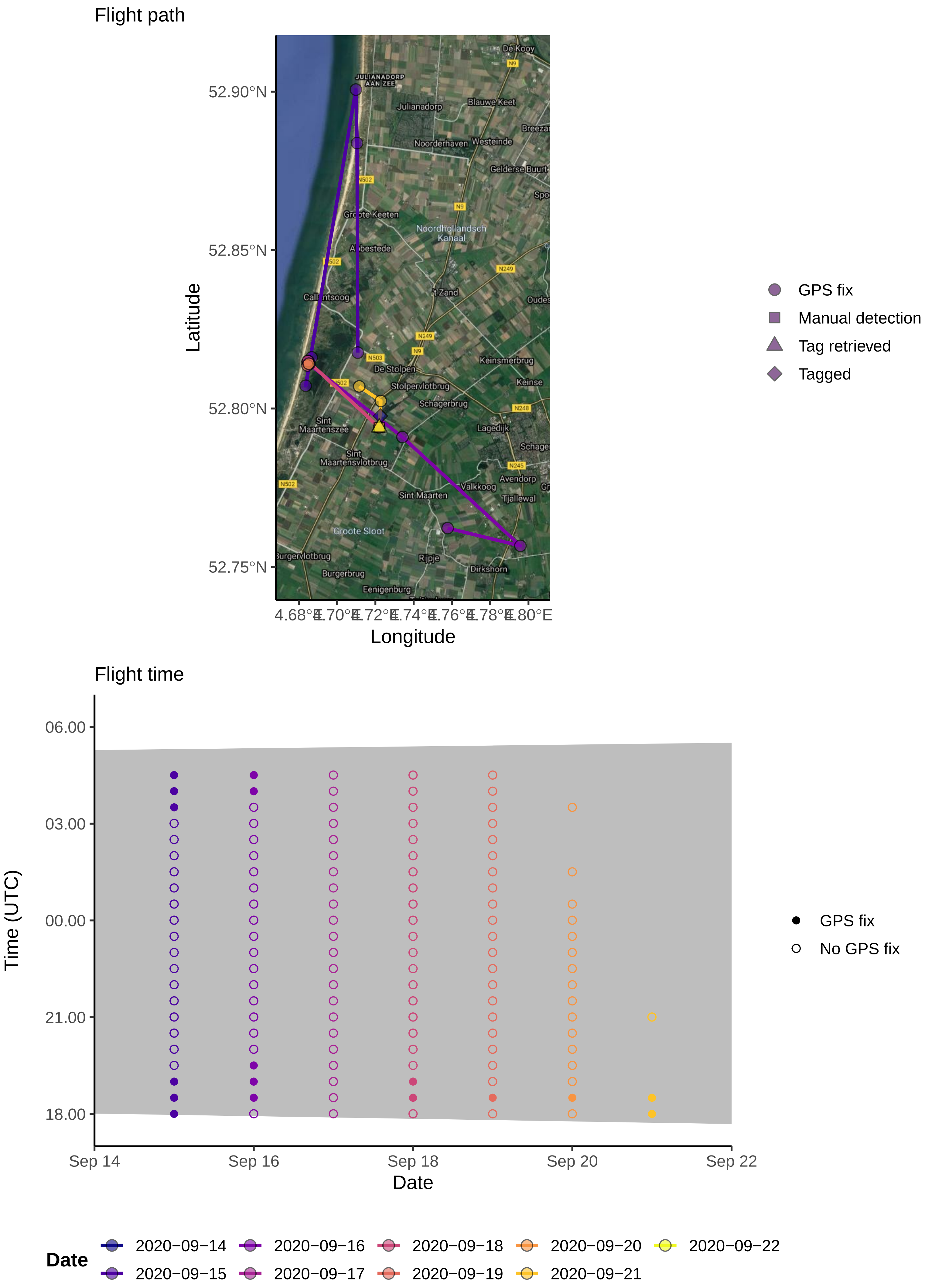
Flight path



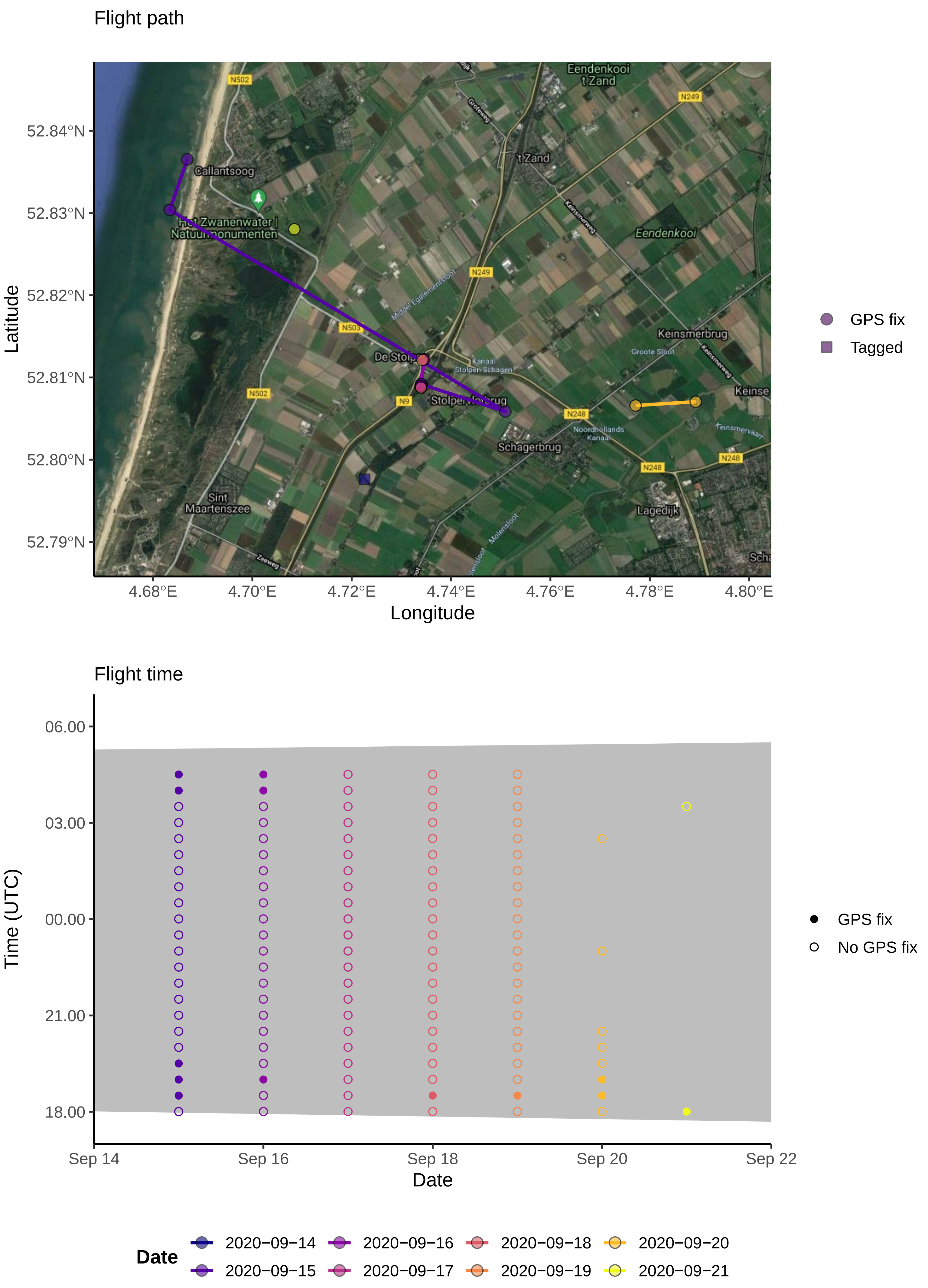
Flight time



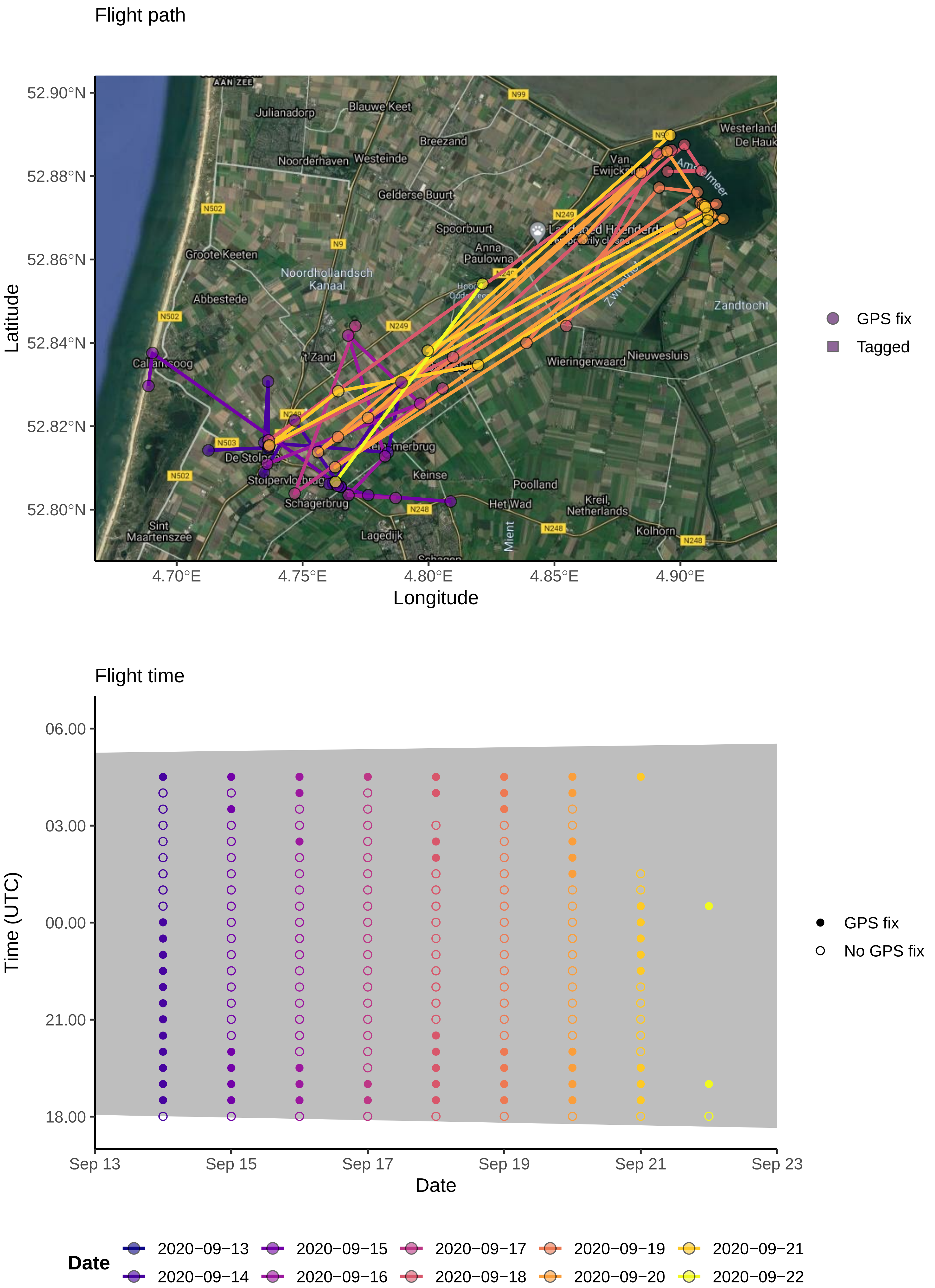
Common noctule, ID = 54, Female, Ad



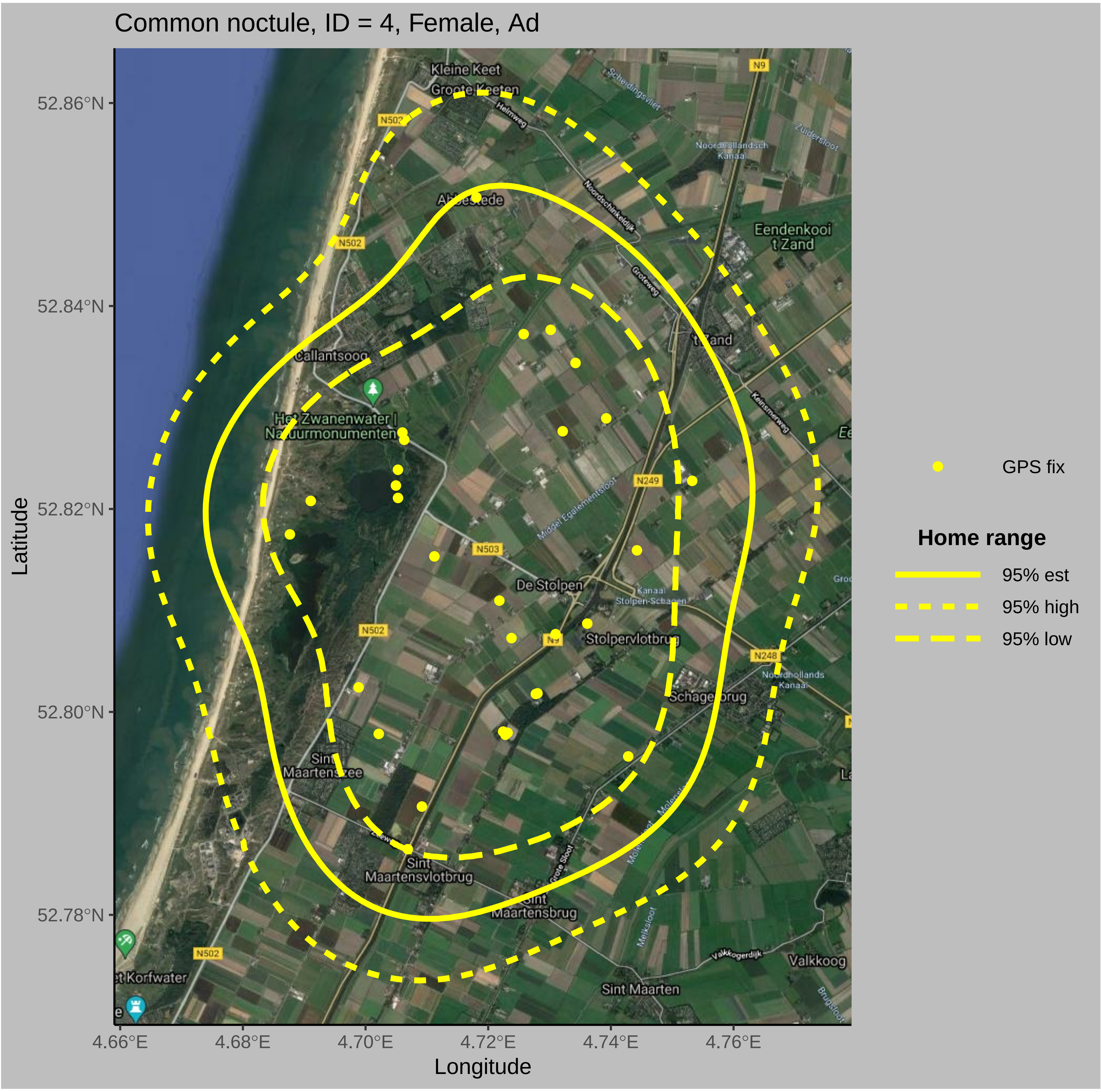
Common noctule, ID = 55, Female, YOY

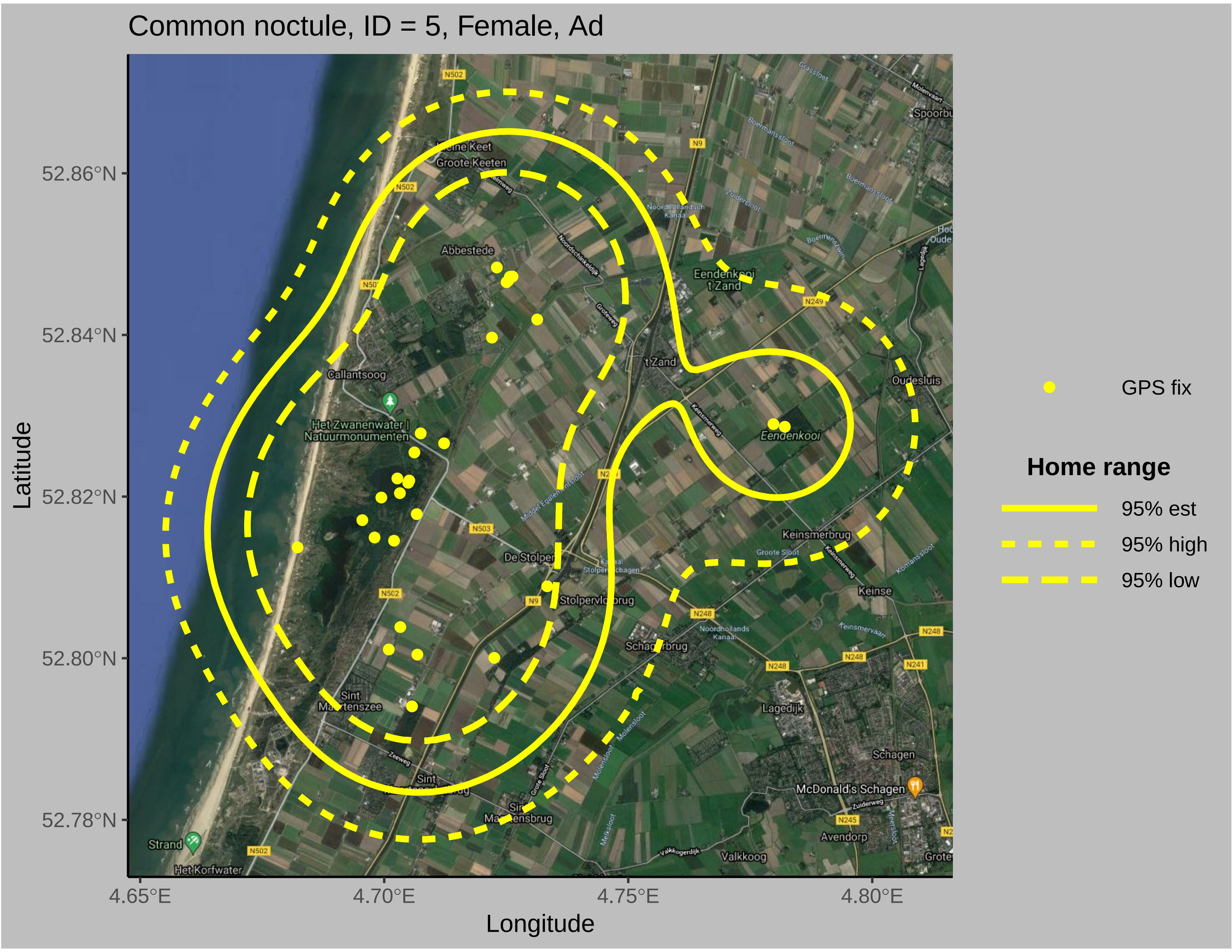


Common noctule, ID = 56, Male, Ad

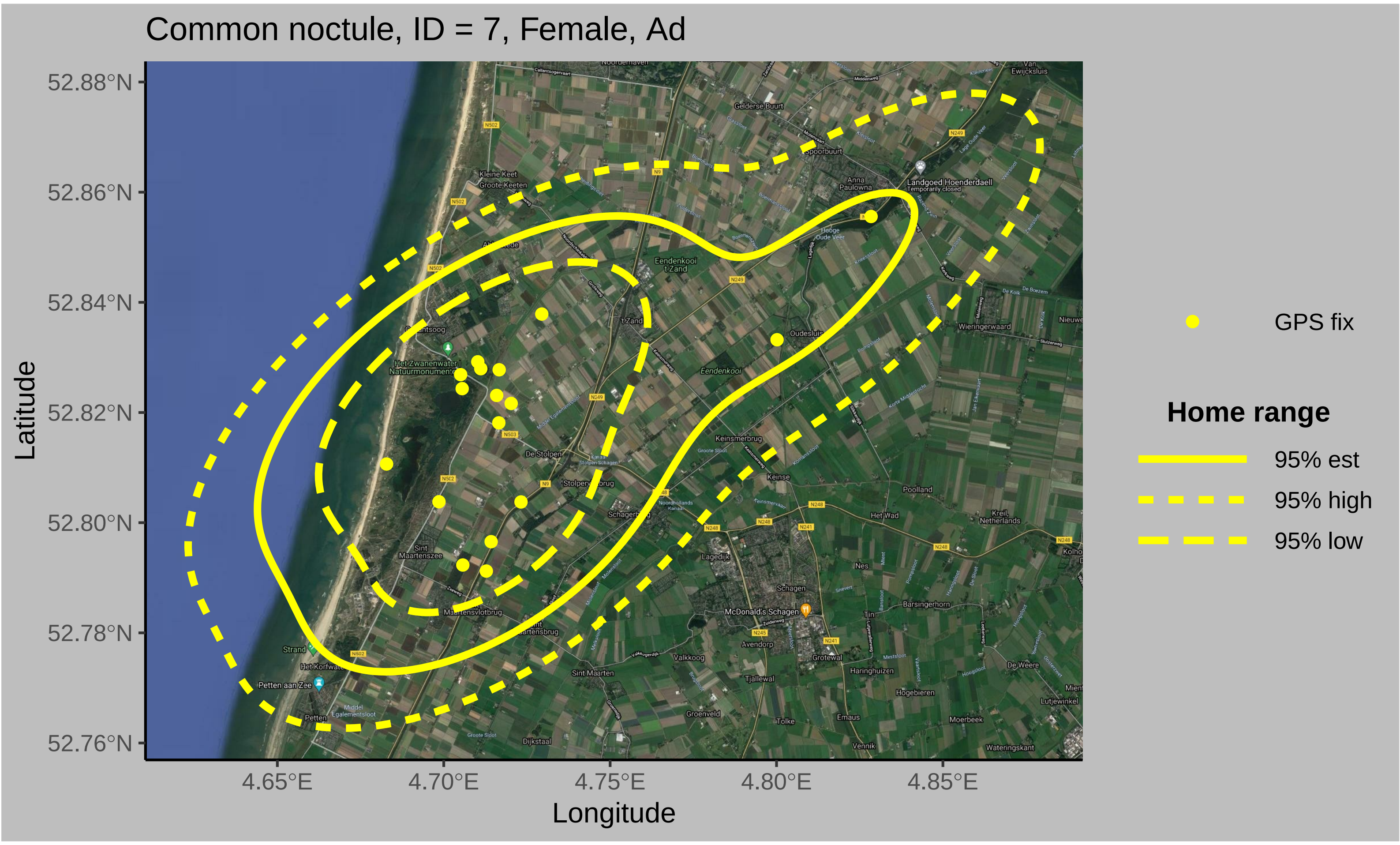


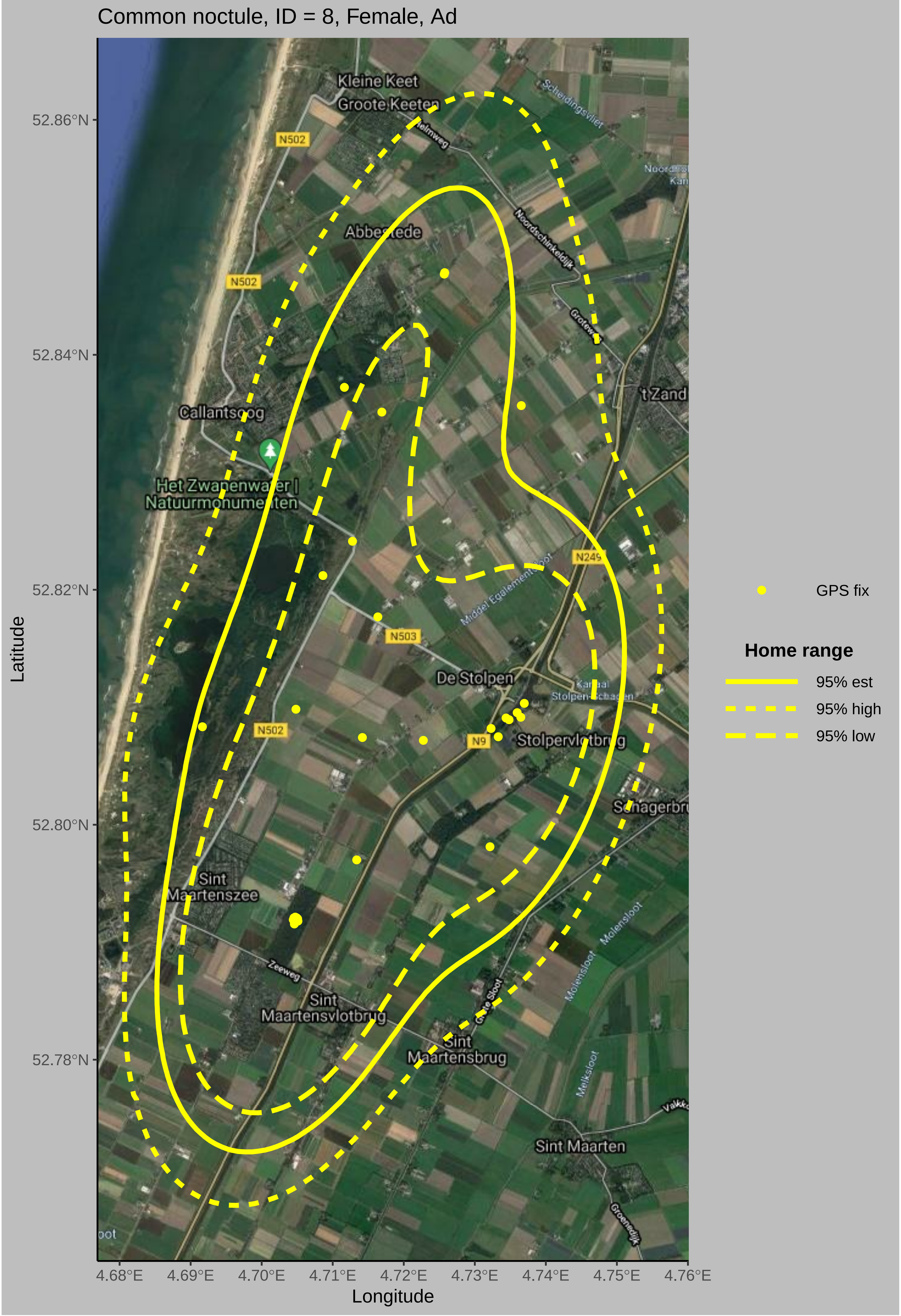
Annex 5: Home range


Common noctule, ID = 4, Female, Ad
Latitude
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
Longitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
GPS fix
Home range
95% est
95% high
95% low

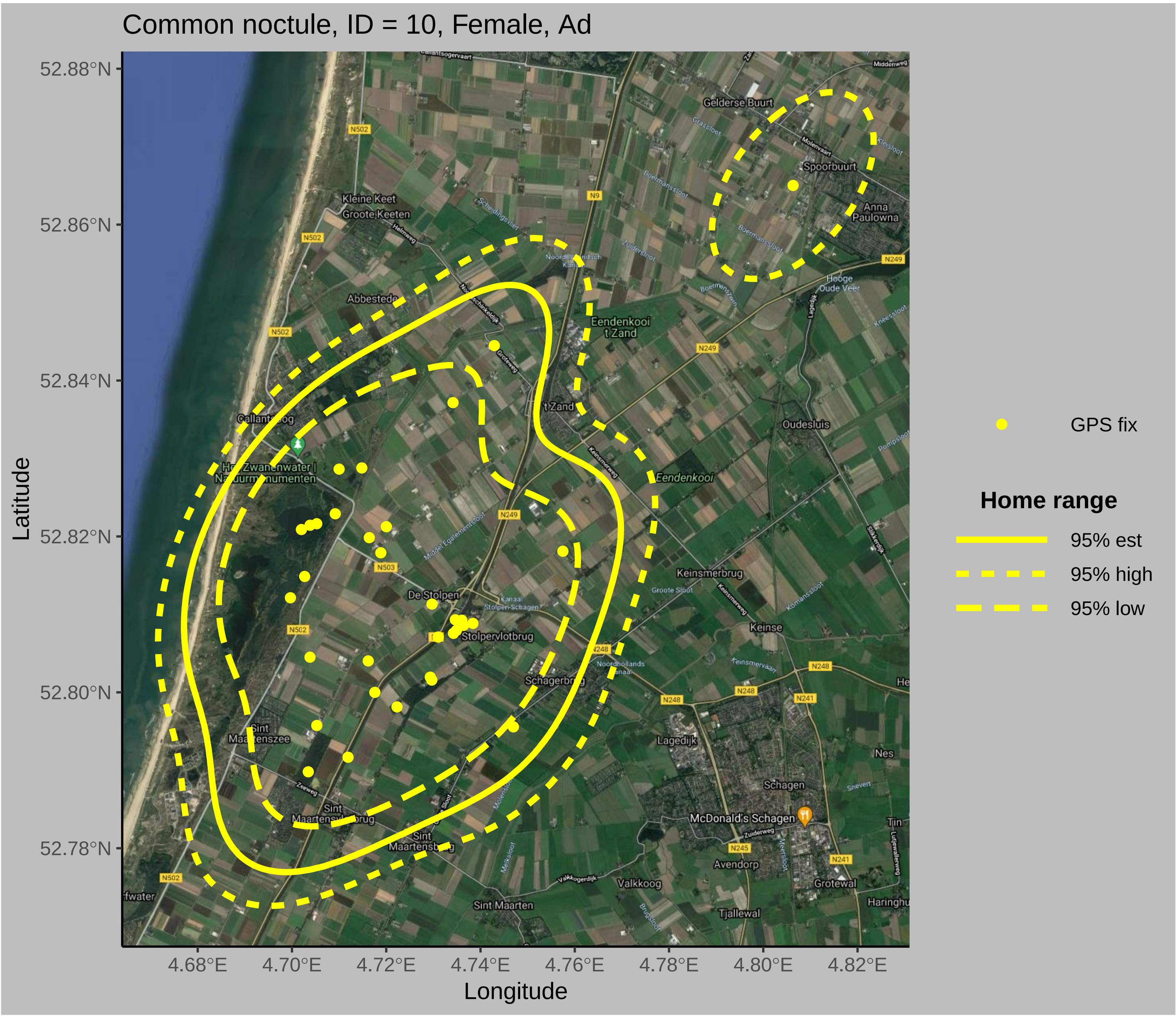


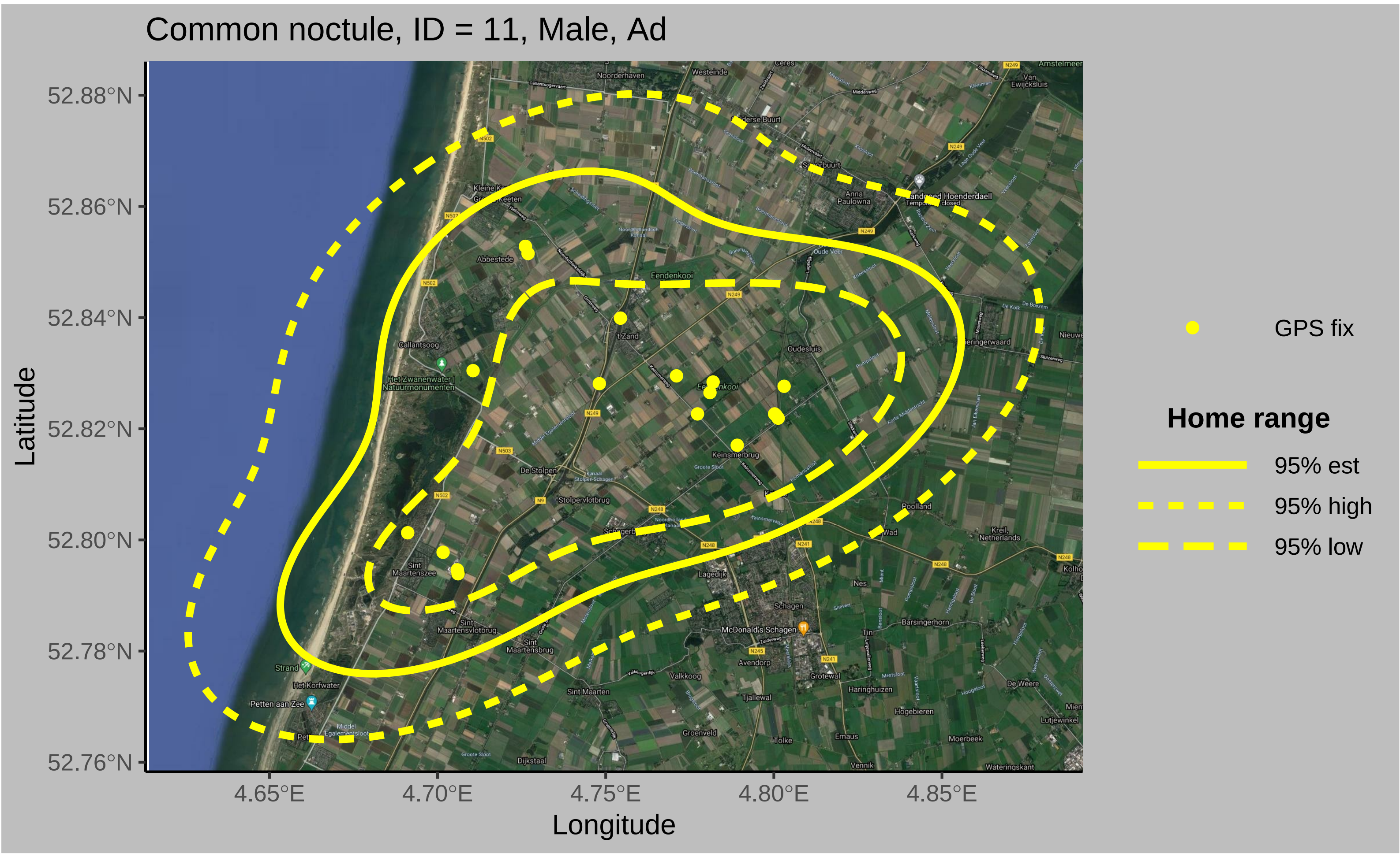
Common noctule, ID = 5, Female, Ad
Latitude
Longitude
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
4.65°E
4.70°E
4.75°E
4.80°E
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 7, Female, Ad
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

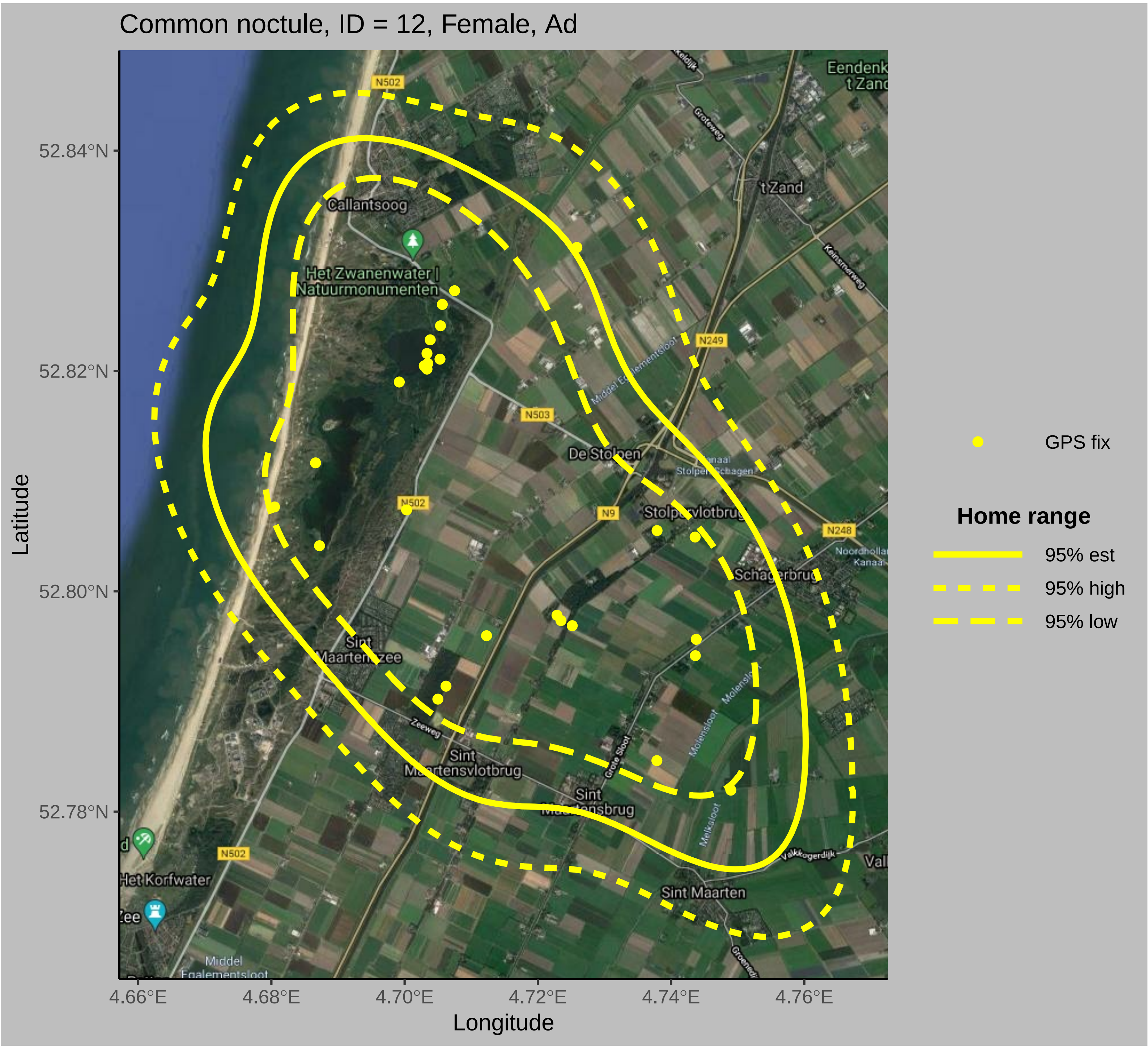


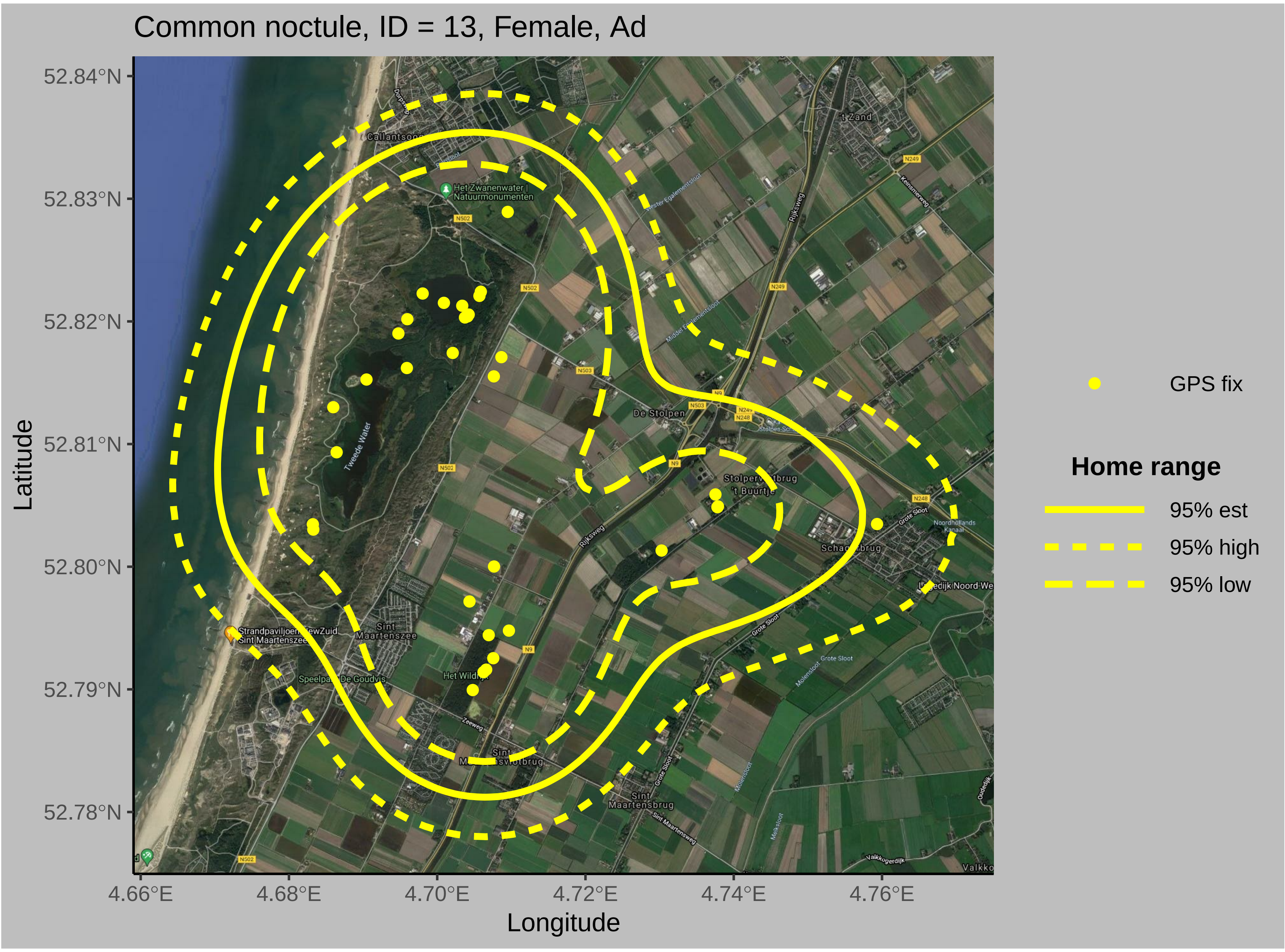
Common noctule, ID = 8, Female, Ad
Latitude
Longitude
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
4.68°E
4.69°E
4.70°E
4.71°E
4.72°E
4.73°E
4.74°E
4.75°E
4.76°E
GPS fix
Home range
95% est
95% high
95% low
Kleine Keet
Groote Keeten
Abbestede
Callantsoog
Het Zwanenwater | Natuurmonumenten
De Stolpen
Stolpervlotbrug
Schagerbrug
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
Sint Maarten
't Zand
N502
N503
N249
N9

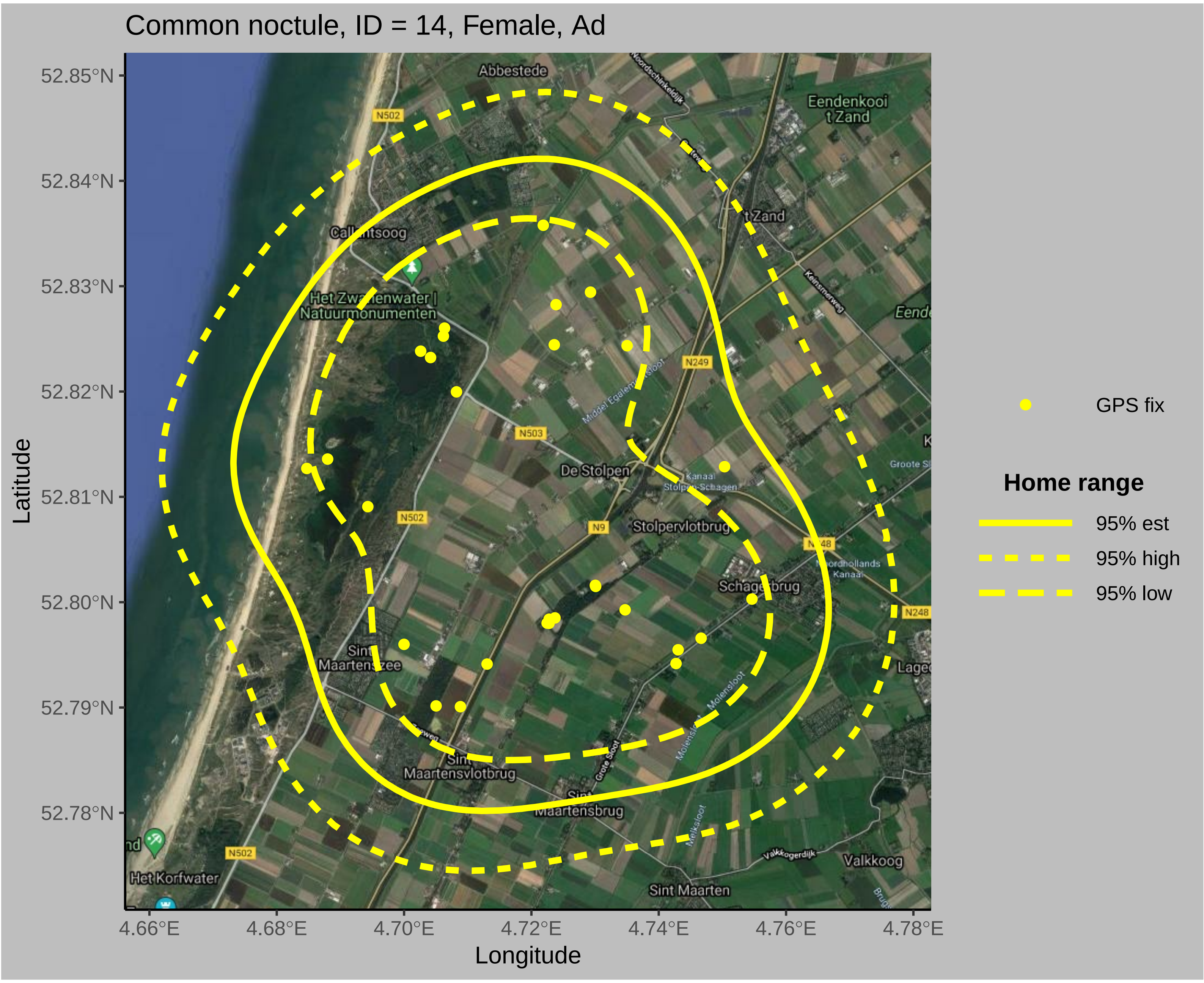

Common noctule, ID = 10, Female, Ad
Latitude
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
Longitude
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
4.78°E
4.80°E
4.82°E
GPS fix
Home range
95% est
95% high
95% low
Gelderse Buurt
Spoorbuurt
Anna Paulowna
Kleine Keet
Groote Keeten
Abbestede
Eendenkooi
't Zand
Oudesluis
Callantsoog
Eendenkooi
De Stolpen
Stolpervlotbrug
Keinsmerbrug
Keinse
Schagerbrug
Lagedijk
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
Schagen
McDonald's Schagen
Avendorp
Valkkoog
Sint Maarten
Tjallewal
Grotewal
Nes
N502
N9
N249
N503
N248
N245
N241



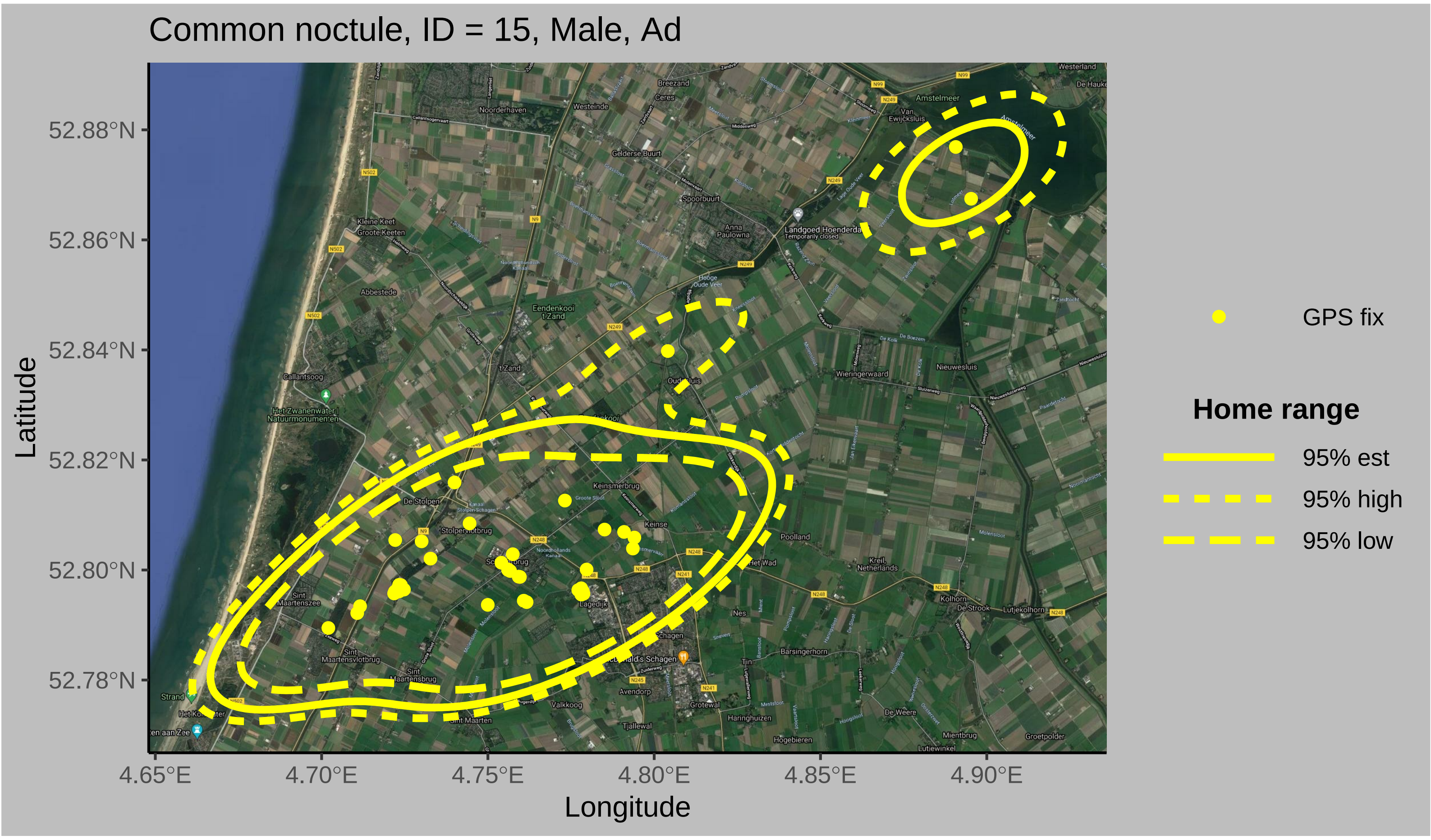
Common noctule, ID = 11, Male, Ad
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

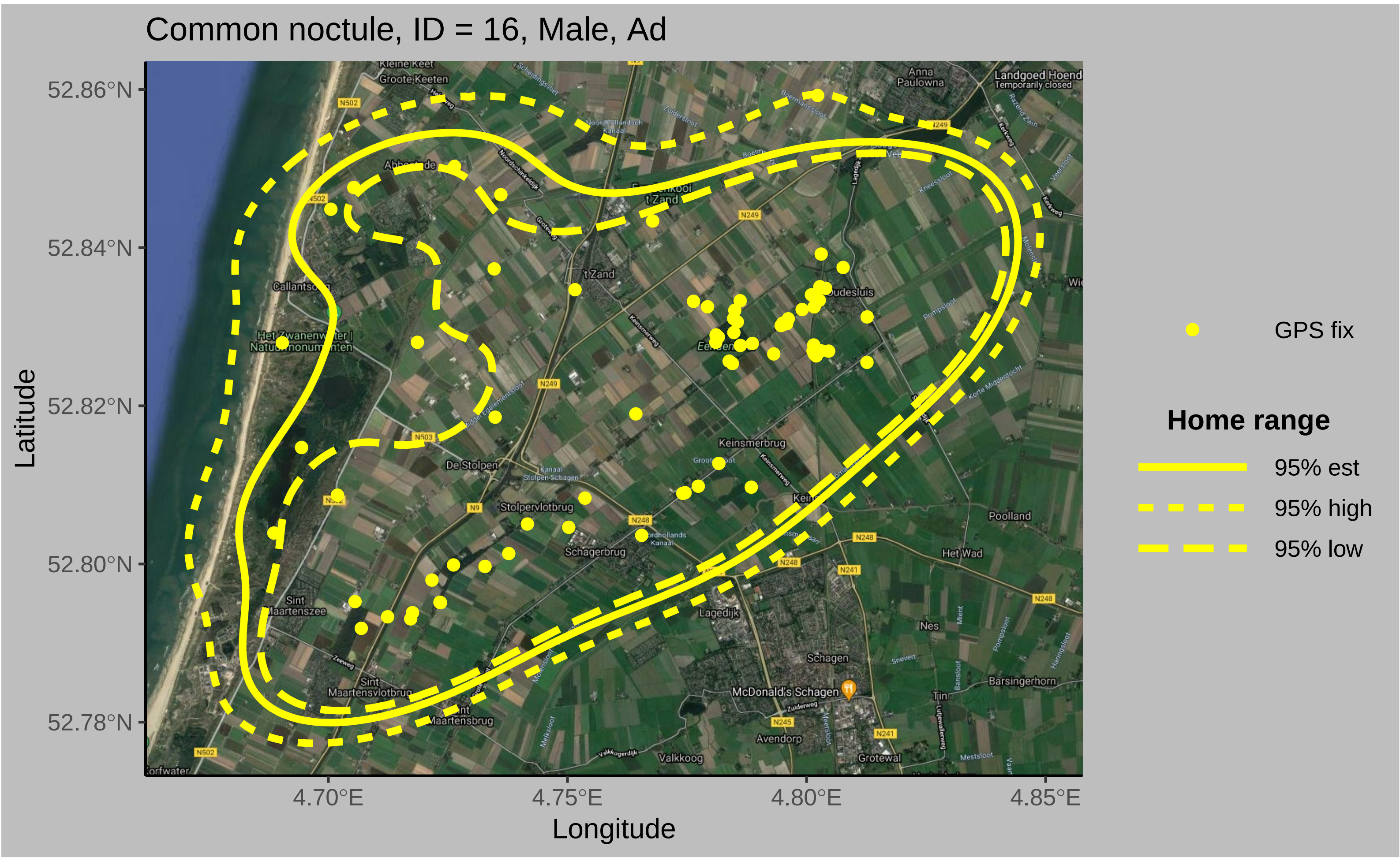

Common noctule, ID = 12, Female, Ad
52.84°N
52.82°N
52.80°N
52.78°N
Latitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

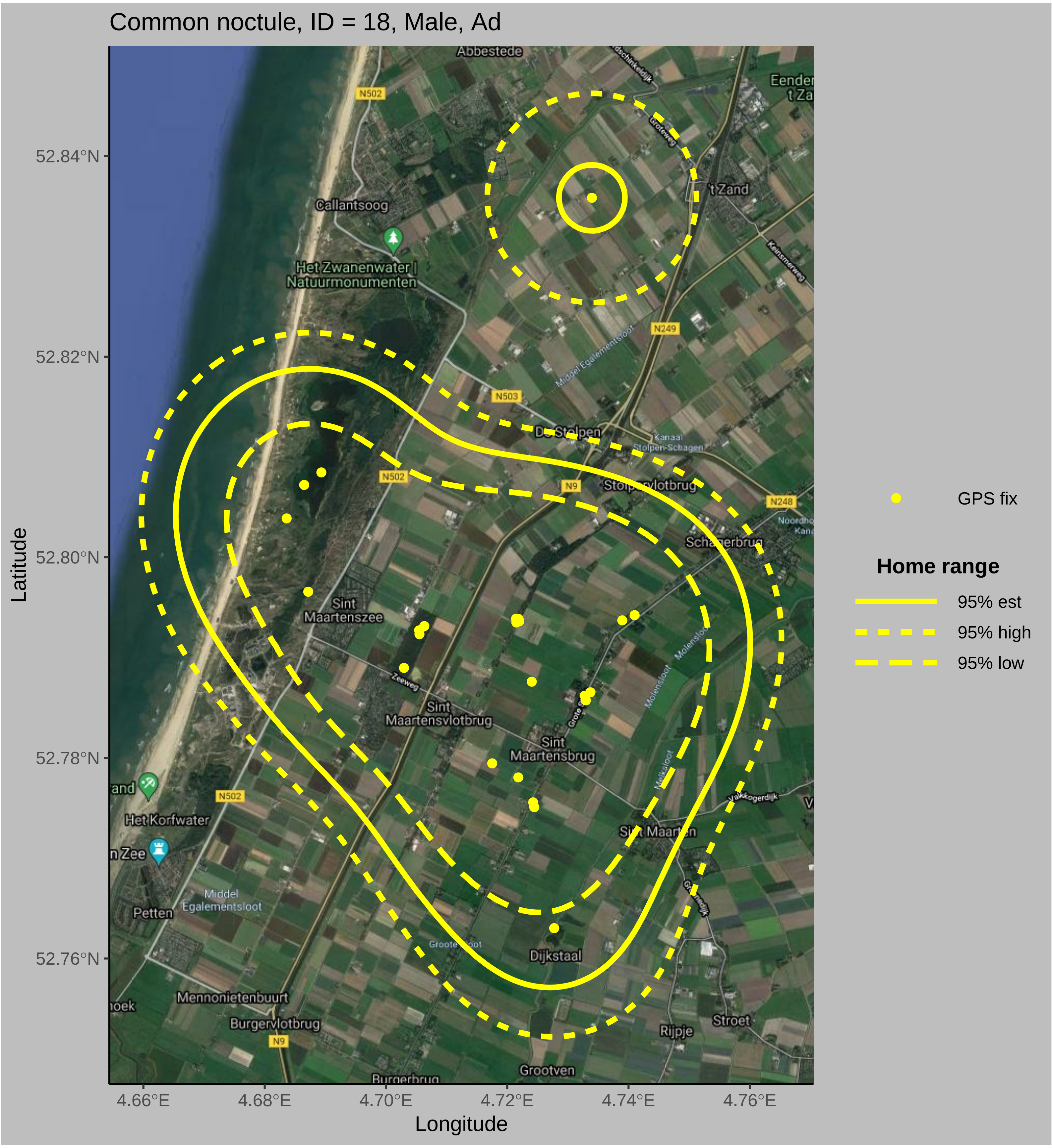

Common noctule, ID = 13, Female, Ad
52.84°N
52.83°N
52.82°N
52.81°N
52.80°N
52.79°N
52.78°N
Latitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
Longitude
GPS fix
Home range
95% est
95% high
95% low



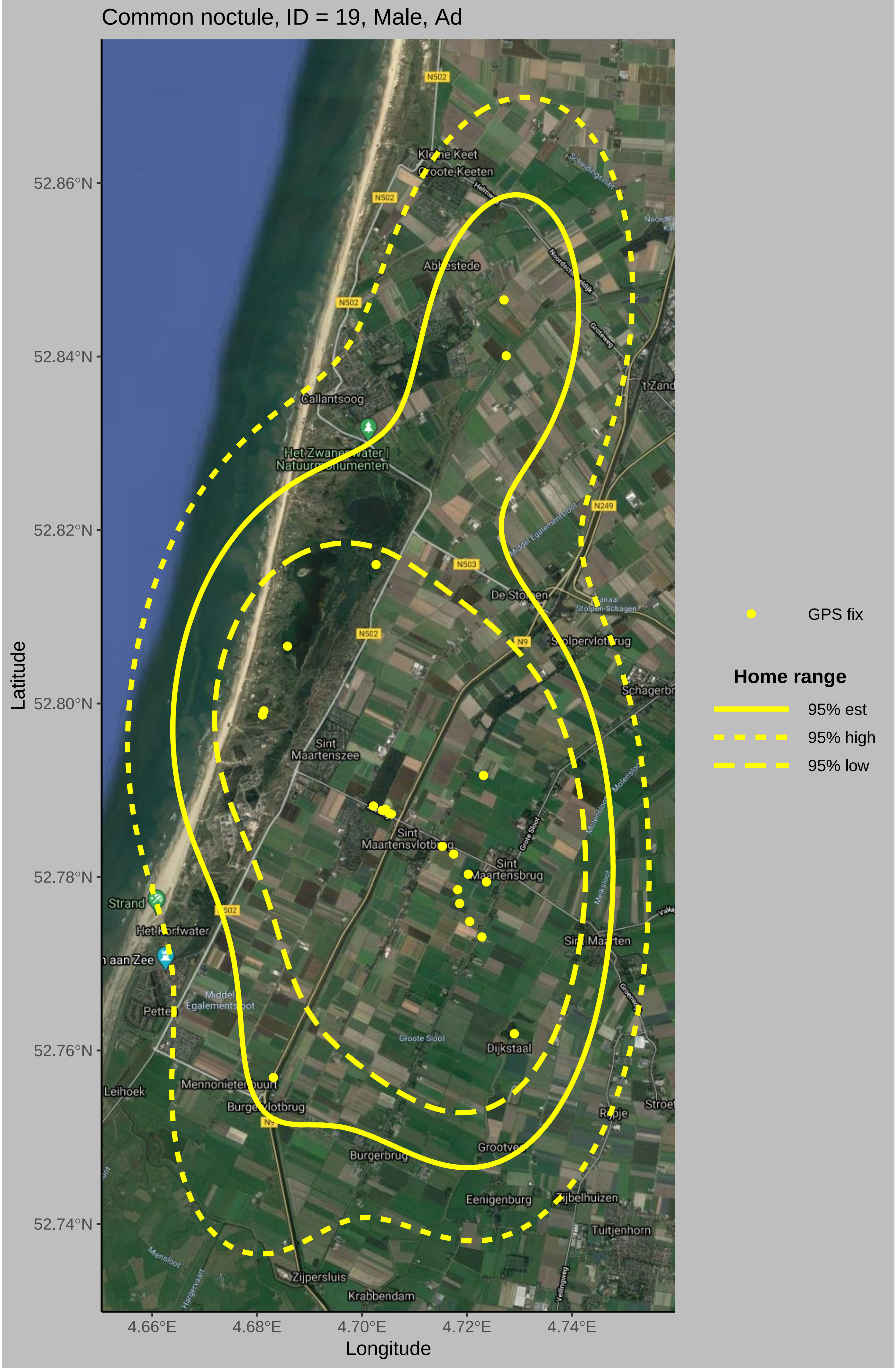
Common noctule, ID = 14, Female, Ad
Latitude
Longitude
52.85°N
52.84°N
52.83°N
52.82°N
52.81°N
52.80°N
52.79°N
52.78°N
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
4.78°E
GPS fix
Home range
95% est
95% high
95% low
Abbestede
Eendenkooi t Zand
Callantsoog
Het Zwanenwater | Natuurmonumenten
De Stolpen
Stolpervlotbrug
Schagerbrug
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
Het Korfwater
Sint Maarten
Valkkoog
N502
N503
N249
N9
N248

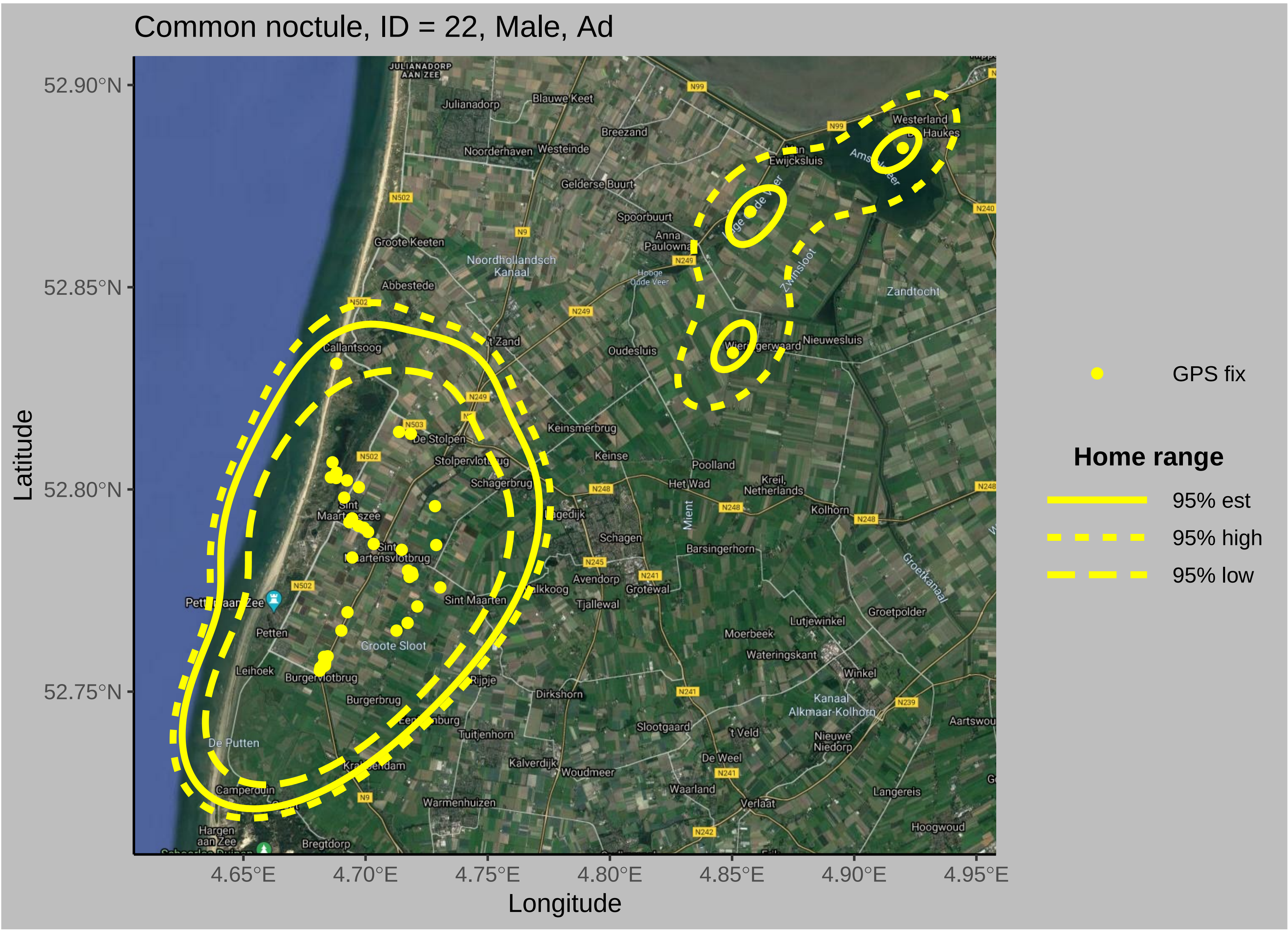

Common noctule, ID = 15, Male, Ad
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
Longitude
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 16, Male, Ad
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
Latitude
4.70°E
4.75°E
4.80°E
4.85°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

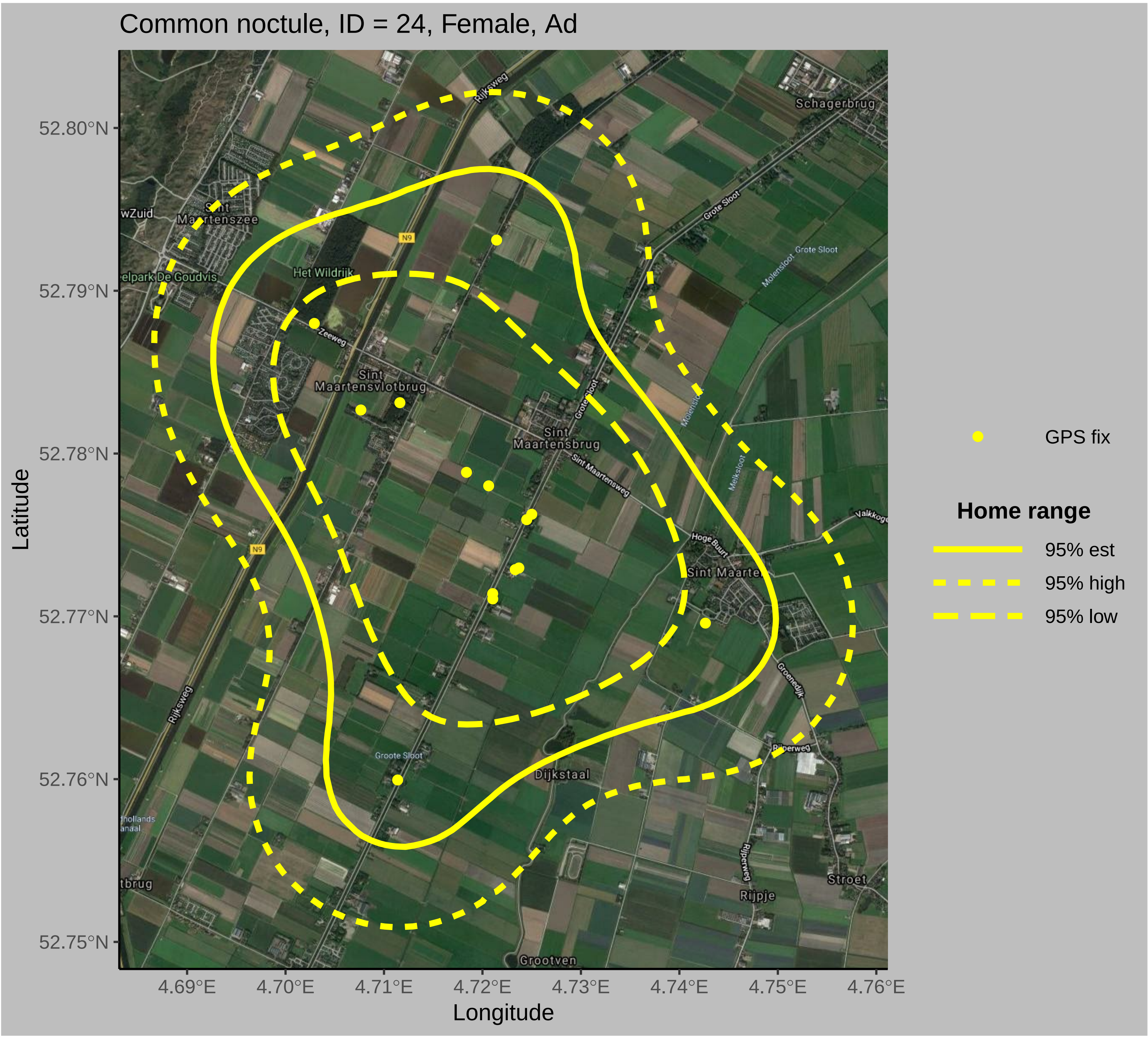


Common noctule, ID = 18, Male, Ad
Latitude
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
Longitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
GPS fix
Home range
95% est
95% high
95% low
Callantsoog
Het Zwanenwater | Natuurmonumenten
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
De Stolpen
Stolpervlotbrug
Schagerbrug
Dijkstaal
Petten
Mennonietenbuurt
Burgervlotbrug
Grootven
Rijpje
Stroet
Abbestede
Het Korfwater

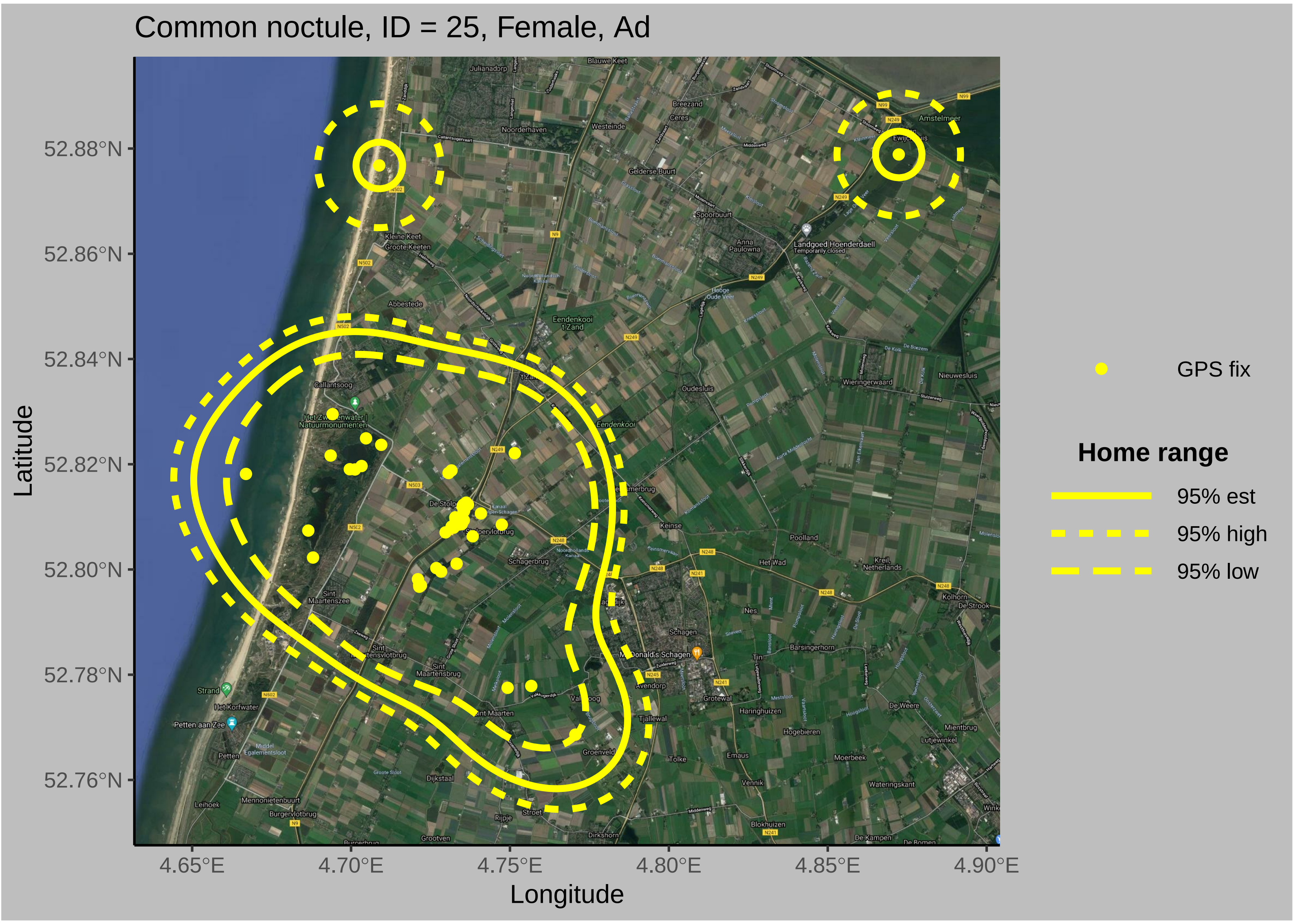

Common noctule, ID = 19, Male, Ad
Latitude
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
52.74°N
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

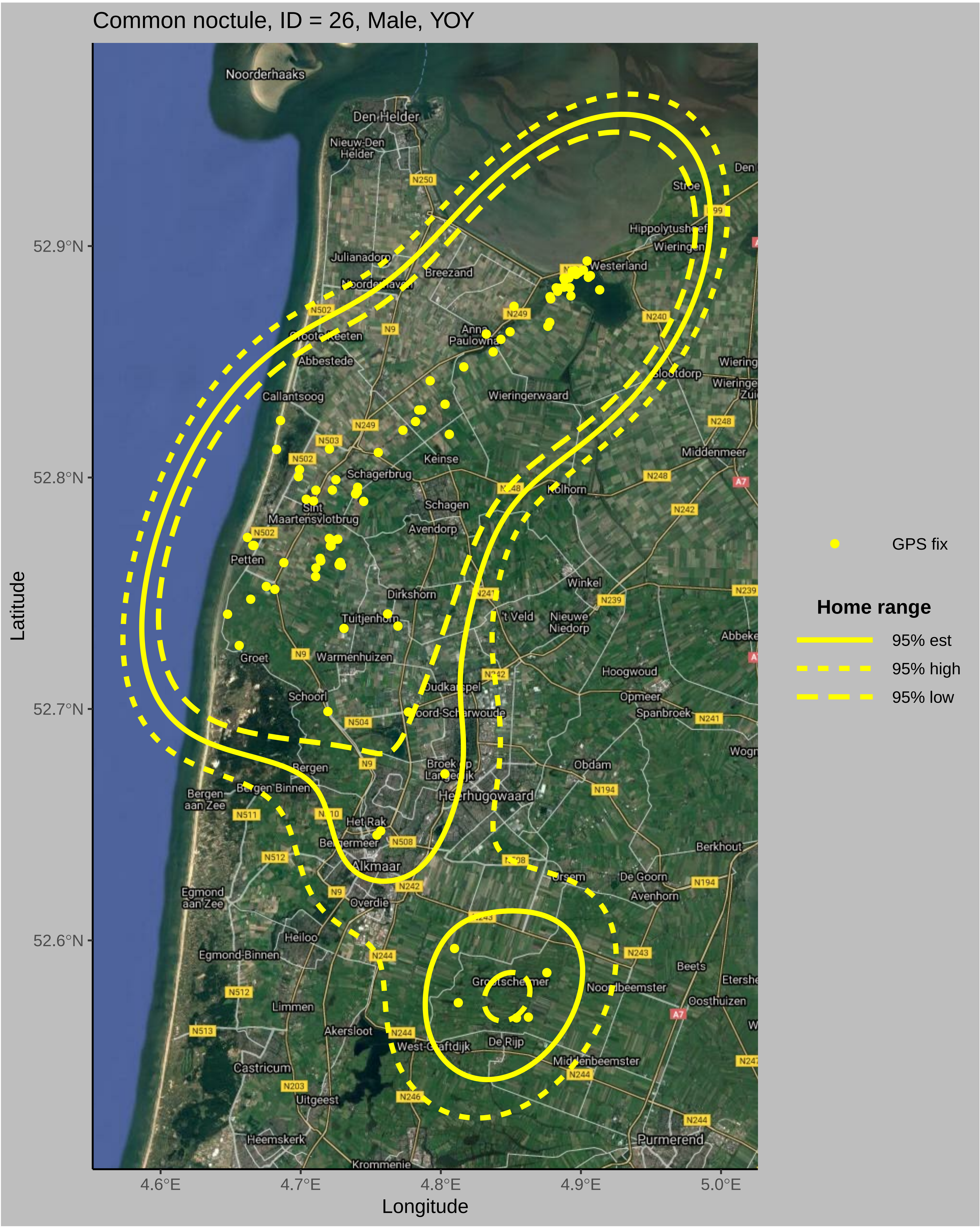


Common noctule, ID = 22, Male, Ad
52.90°N
52.85°N
52.80°N
52.75°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
4.95°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

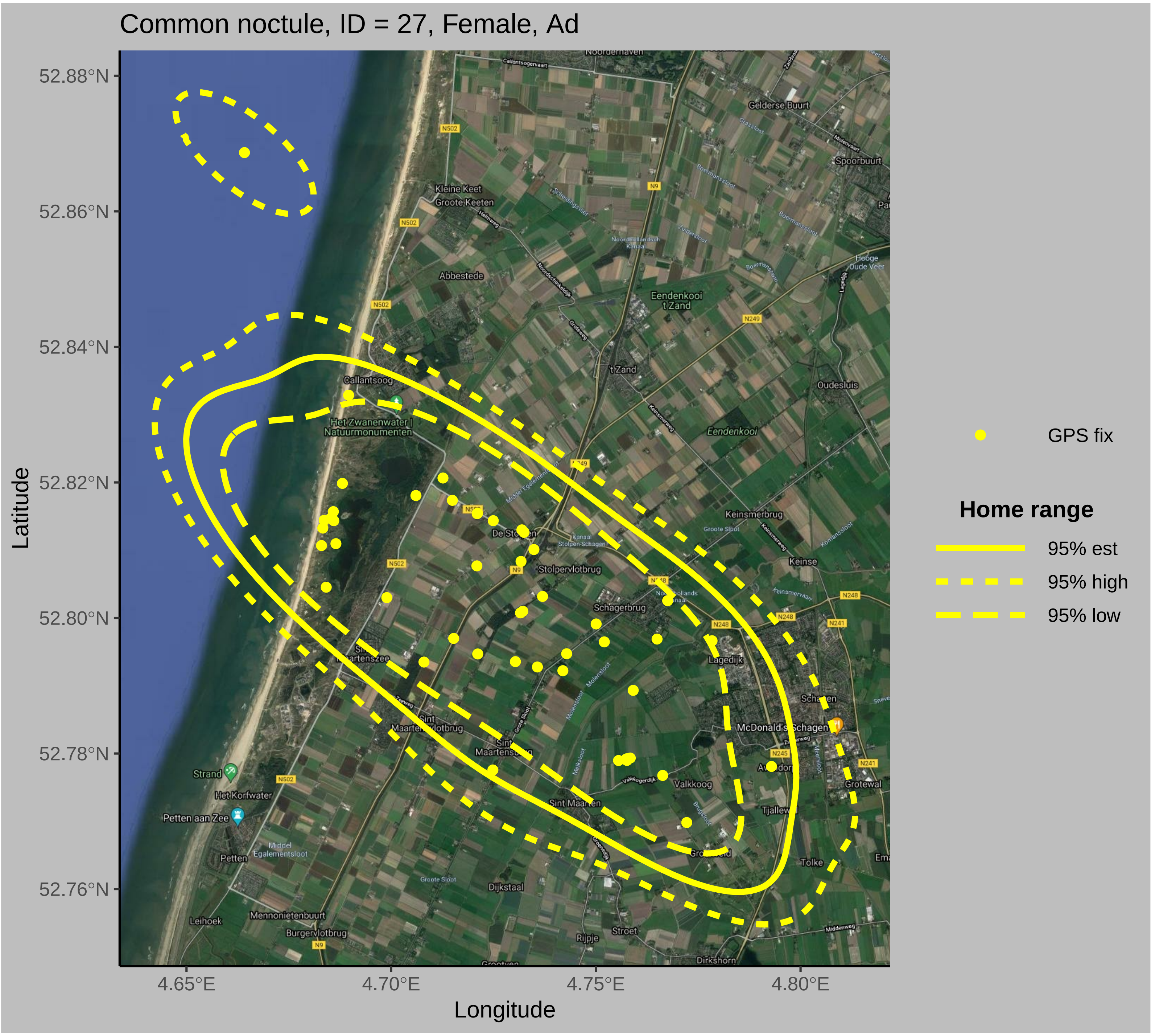


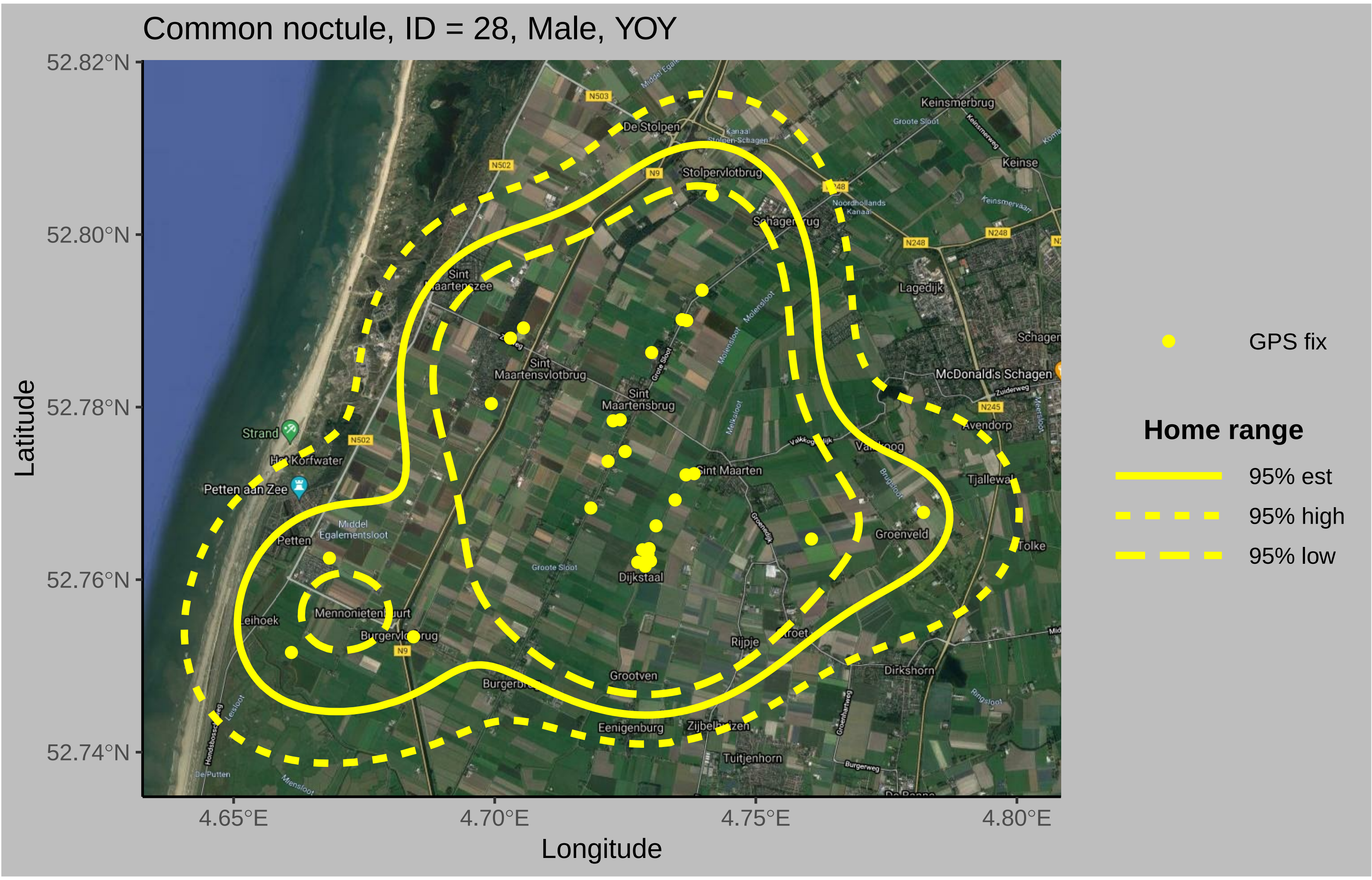
Common noctule, ID = 24, Female, Ad
Latitude
Longitude
52.80°N
52.79°N
52.78°N
52.77°N
52.76°N
52.75°N
4.69°E
4.70°E
4.71°E
4.72°E
4.73°E
4.74°E
4.75°E
4.76°E
GPS fix
Home range
95% est
95% high
95% low
Schagerbrug
Sint Maartenszee
Het Wildrijk
Sint Maartensvlotbrug
Sint Maartensbrug
Dijkstaal
Grootven
Rijpje
Stroet

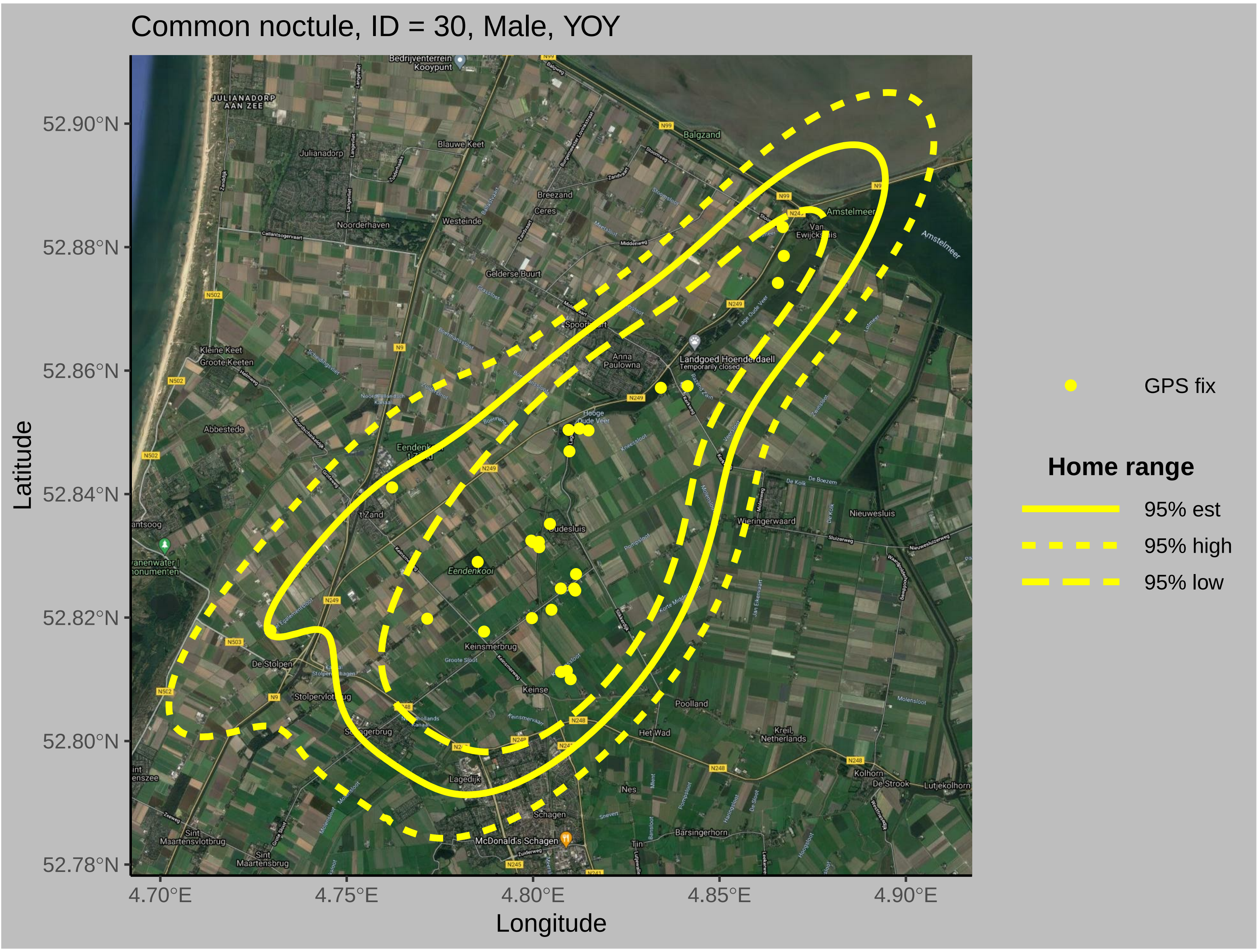

Common noctule, ID = 25, Female, Ad
Latitude
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
Longitude
GPS fix
Home range
95% est
95% high
95% low



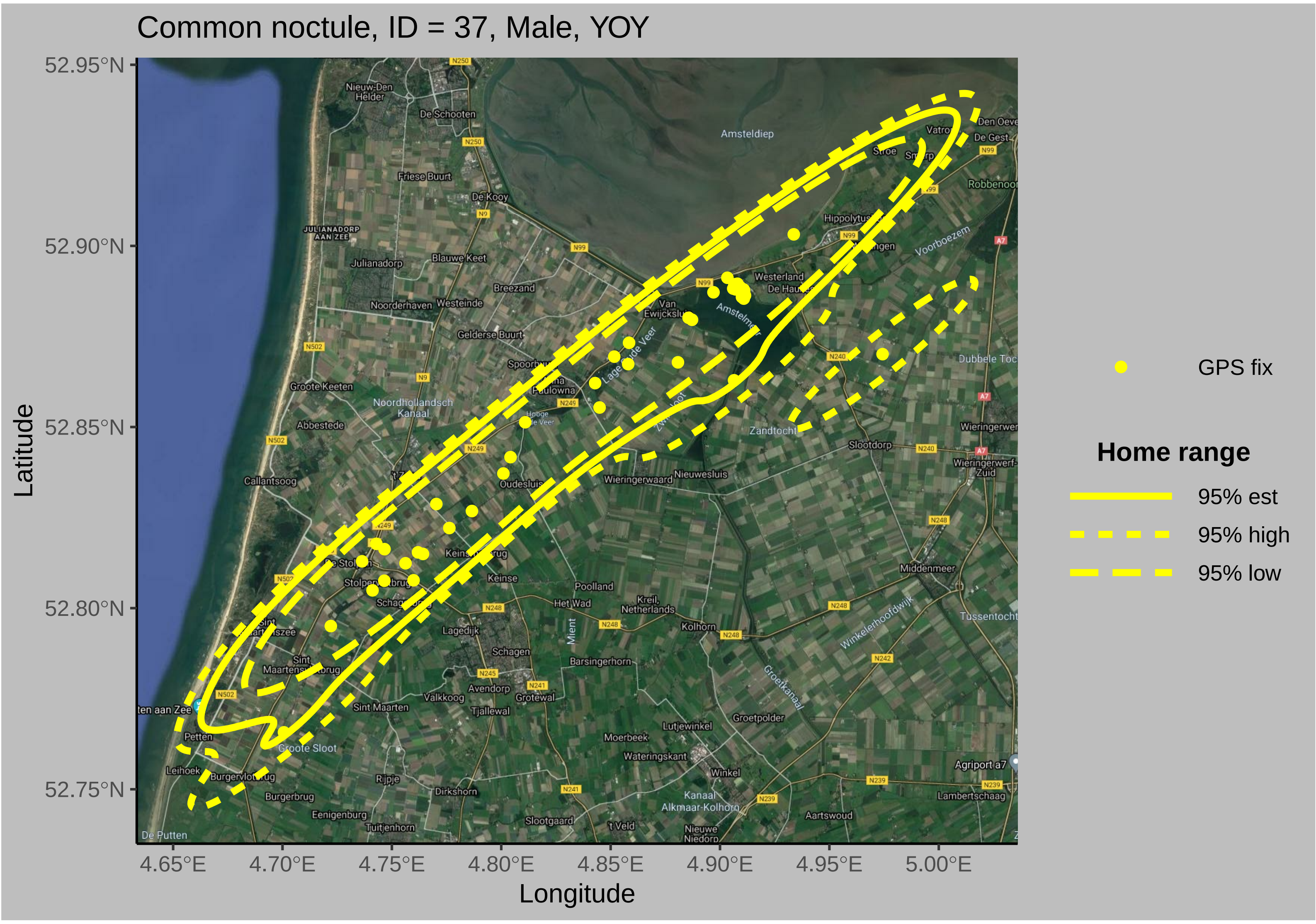
Common noctule, ID = 26, Male, YOY
Latitude
52.9°N
52.8°N
52.7°N
52.6°N
4.6°E
4.7°E
4.8°E
4.9°E
5.0°E
Longitude
GPS fix
Home range
95% est
95% high
95% low
Noorderhaaks
Den Helder
Julianadorp
Breezand
Callantsoog
Schagerbrug
Schagen
Keinse
Wieringerwaard
Westerland
Middenmeer
Kolhorn
Petten
Winkel
Dirkshoorn
Groet
Warmenhuizen
Schoorl
Hoogwoud
Opmeer
Bergen
Obdam
Heerhugowaard
Alkmaar
Heiloo
Limmen
Akersloot
Castricum
Uitgeest
Heemskerk
De Rijp
Purmerend


Common noctule, ID = 27, Female, Ad
Latitude
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
4.65°E
4.70°E
4.75°E
4.80°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

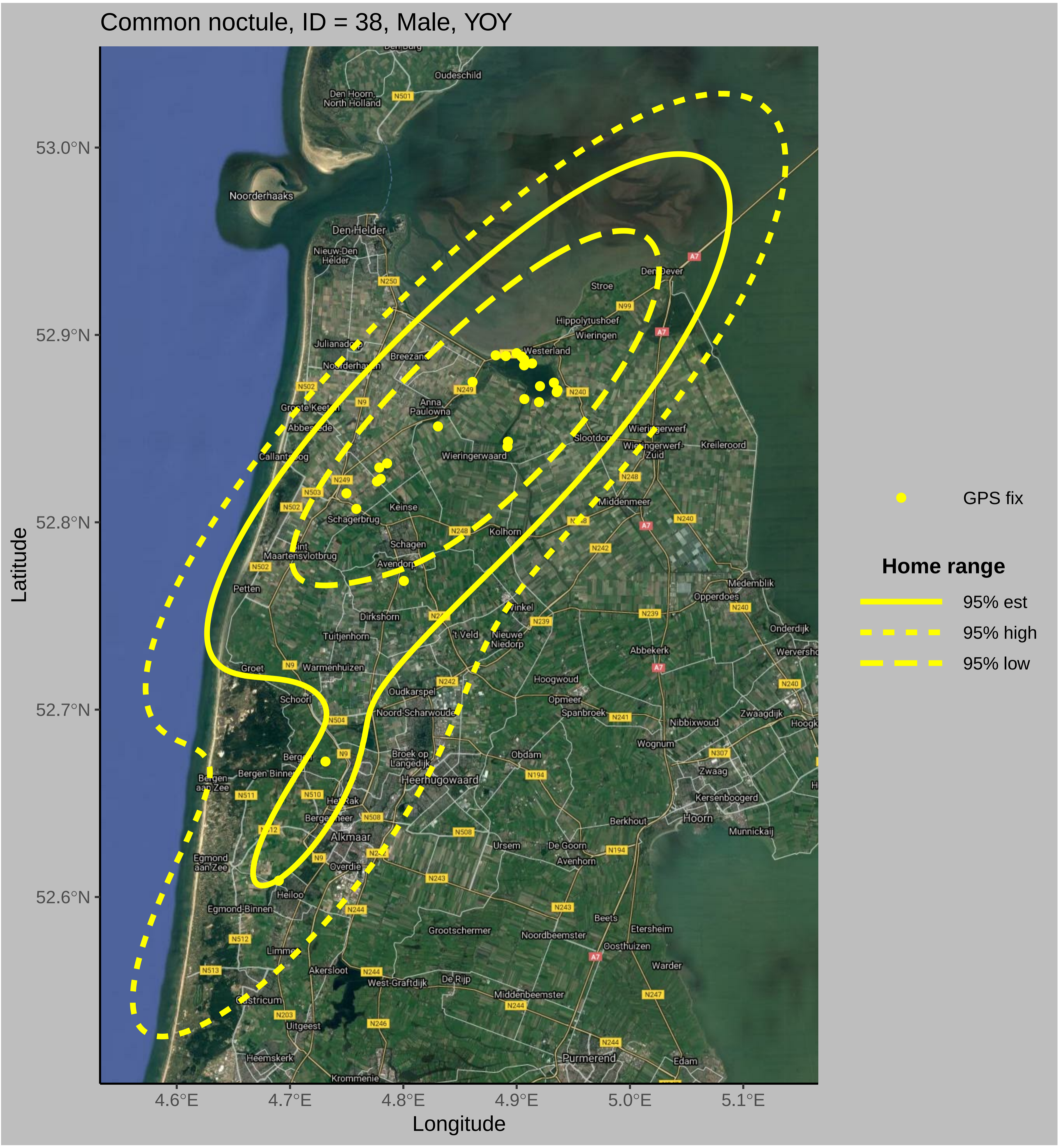

Common noctule, ID = 28, Male, YOY
52.82°N
52.80°N
52.78°N
52.76°N
52.74°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
Longitude
GPS fix
Home range
95% est
95% high
95% low



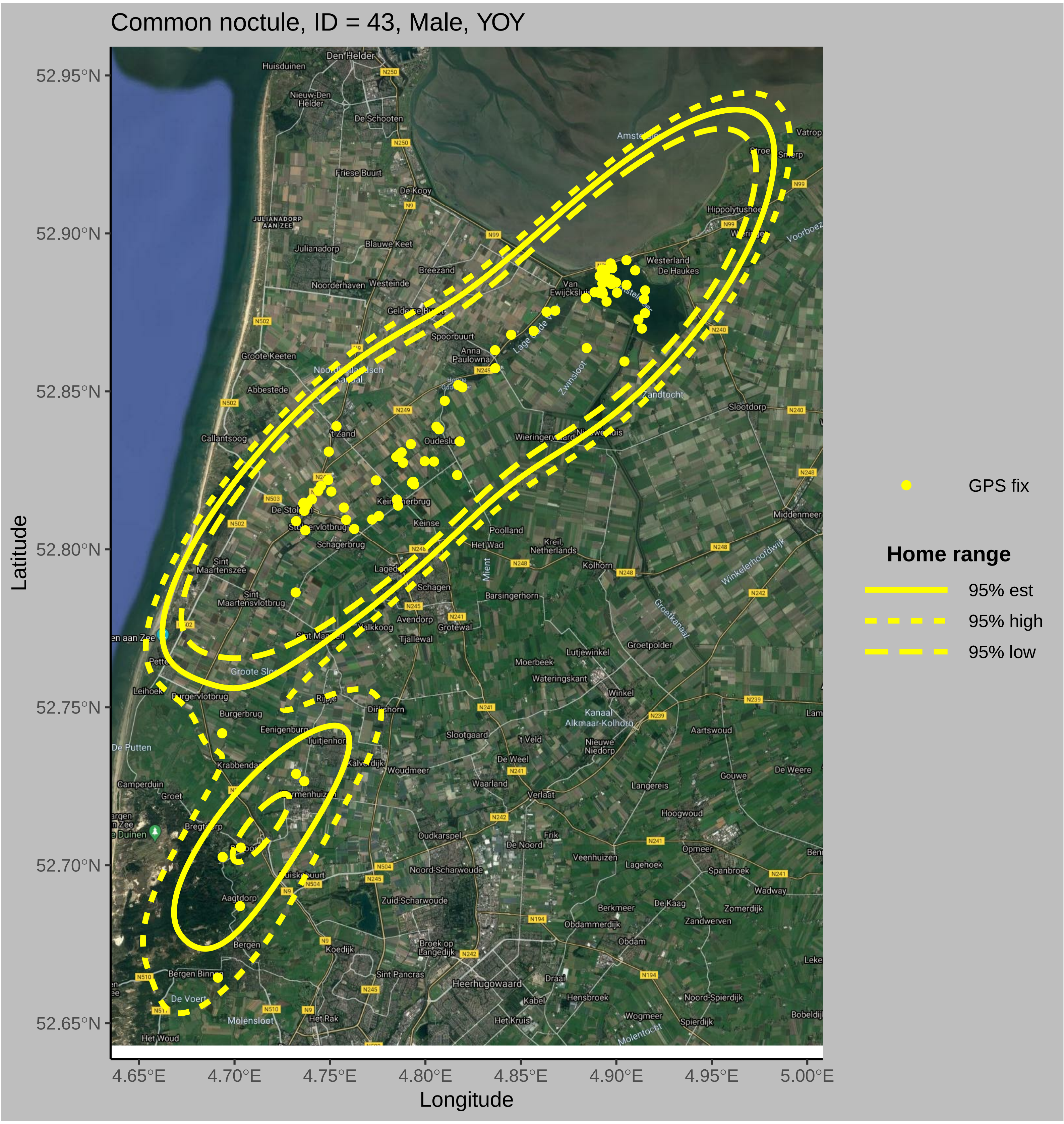
Common noctule, ID = 30, Male, YOY
Latitude
52.90°N
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
Longitude
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
GPS fix
Home range
95% est
95% high
95% low

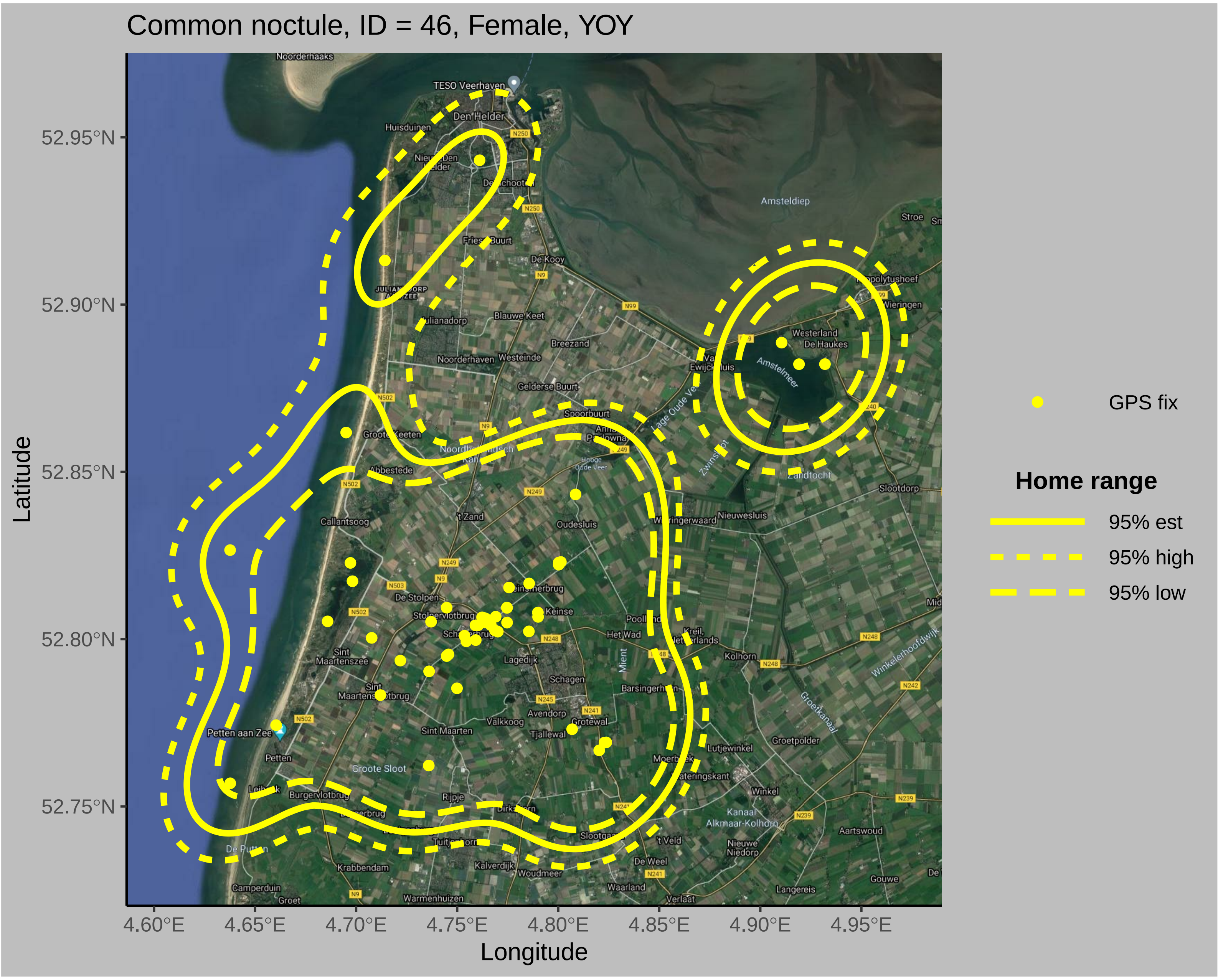


Common noctule, ID = 37, Male, YOY
52.95°N
52.90°N
52.85°N
52.80°N
52.75°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
4.95°E
5.00°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

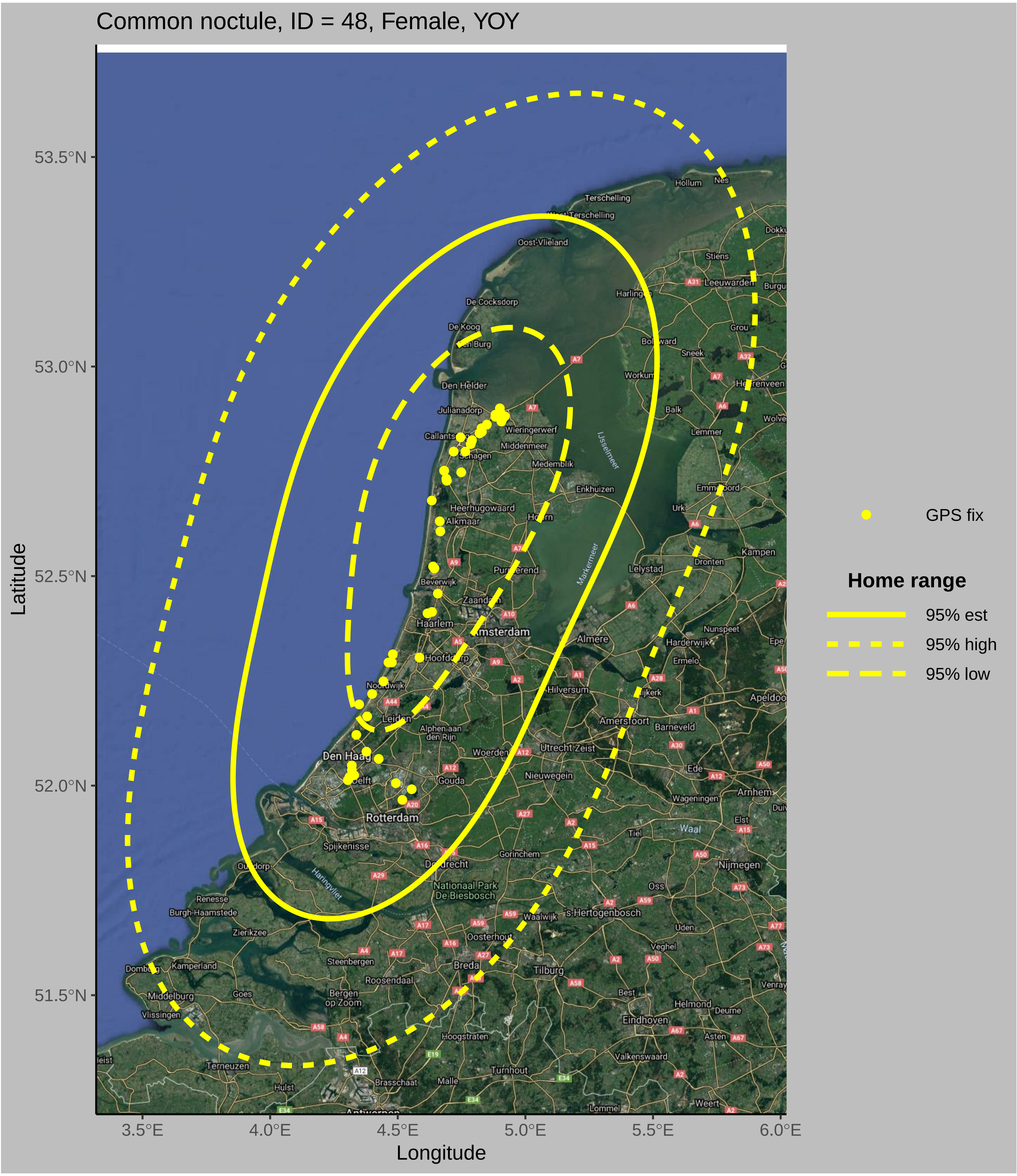


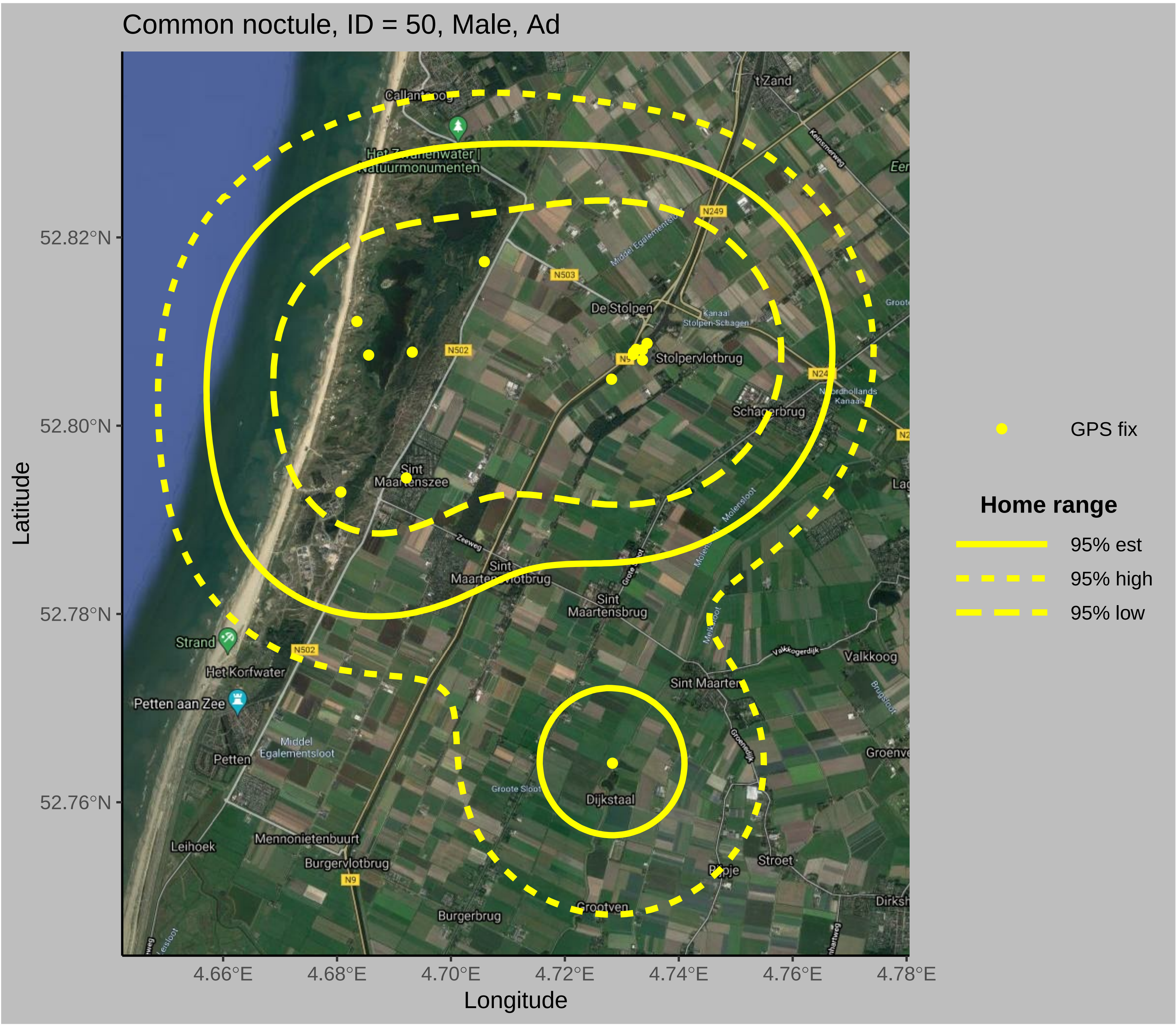
Common noctule, ID = 38, Male, YOY
Latitude
53.0°N
52.9°N
52.8°N
52.7°N
52.6°N
4.6°E
4.7°E
4.8°E
4.9°E
5.0°E
5.1°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

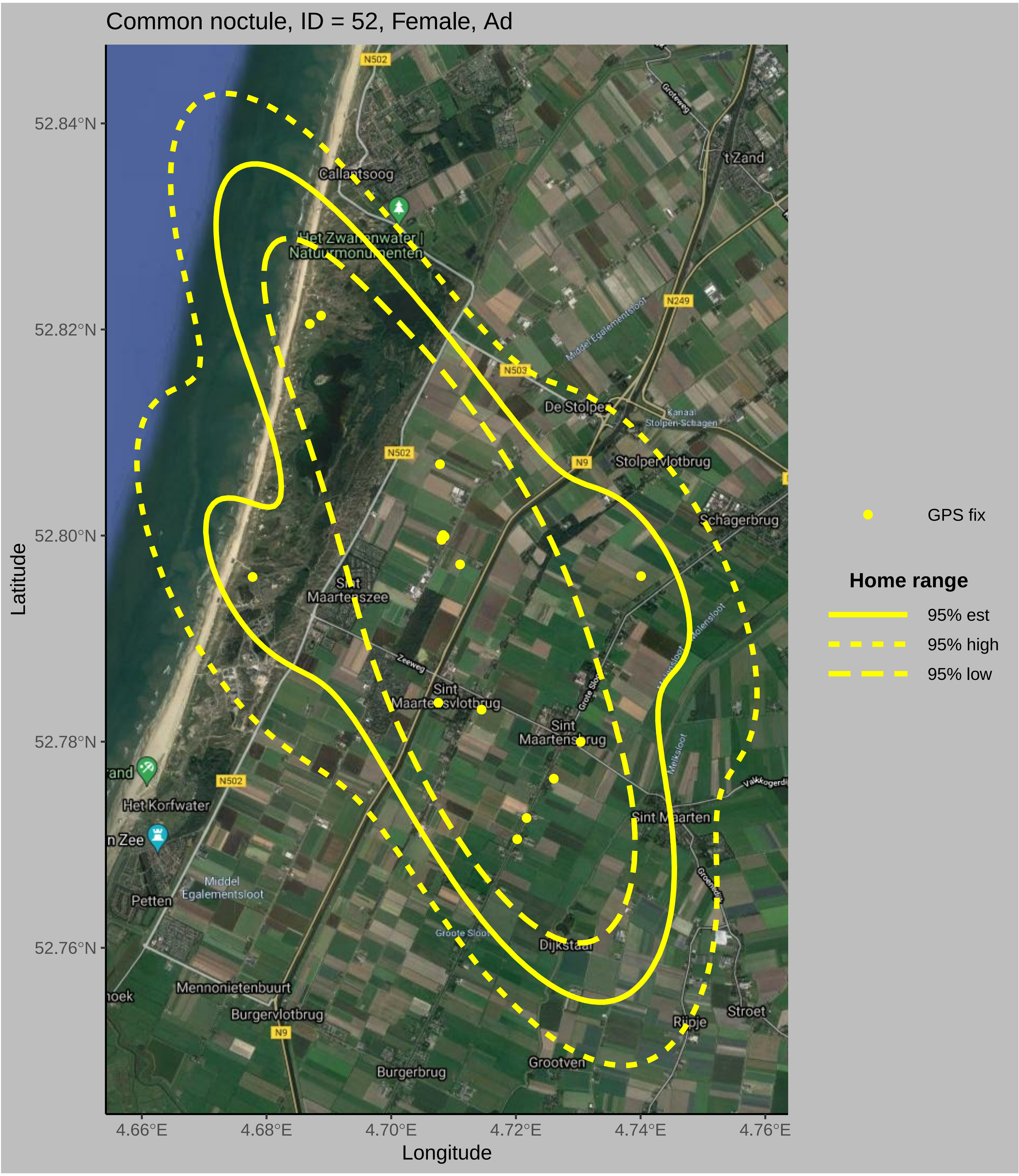

Common noctule, ID = 43, Male, YOY
Latitude
52.95°N
52.90°N
52.85°N
52.80°N
52.75°N
52.70°N
52.65°N
Longitude
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
4.95°E
5.00°E
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 46, Female, YOY
Latitude
Longitude
52.95°N
52.90°N
52.85°N
52.80°N
52.75°N
4.60°E
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
4.95°E
GPS fix
Home range
95% est
95% high
95% low

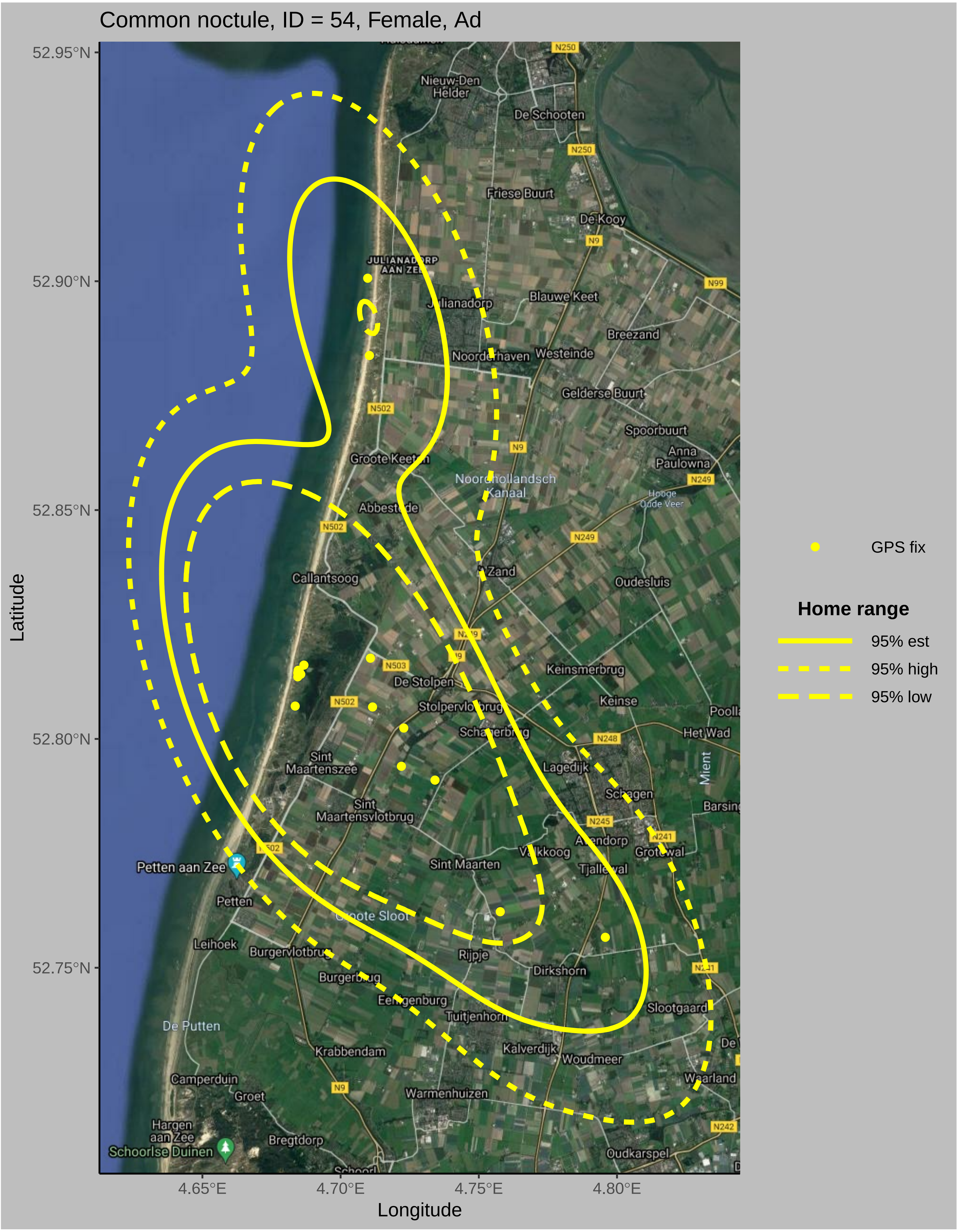

Common noctule, ID = 47, Female, Ad
Latitude
52.825°N
52.820°N
52.815°N
52.810°N
52.805°N
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
Longitude
GPS fix
Home range
95% est
95% high
95% low

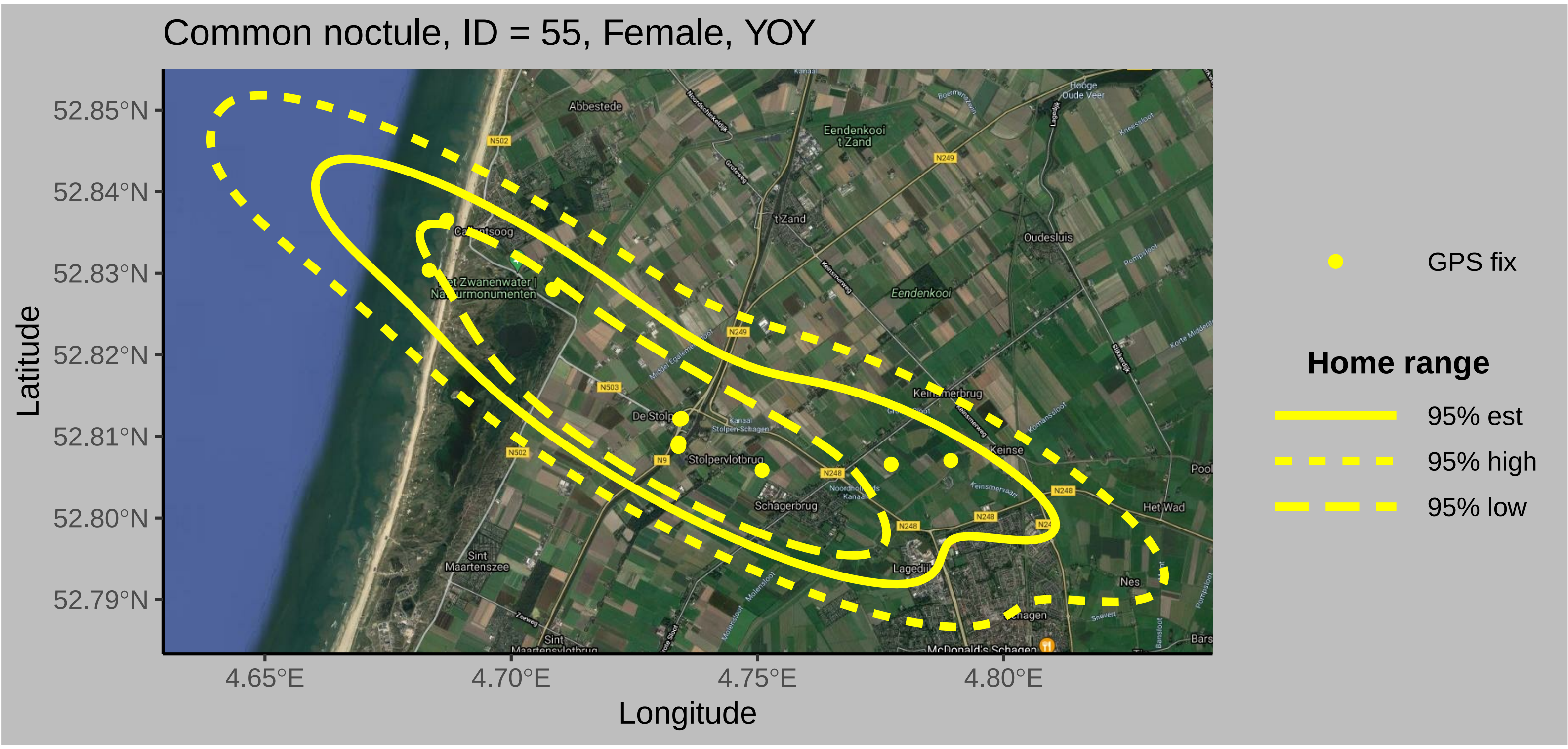

Common noctule, ID = 48, Female, YOY
53.5°N
53.0°N
52.5°N
52.0°N
51.5°N
Latitude
3.5°E
4.0°E
4.5°E
5.0°E
5.5°E
6.0°E
Longitude
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 50, Male, Ad
52.82°N
52.80°N
52.78°N
52.76°N
Latitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
4.78°E
Longitude
GPS fix
Home range
95% est
95% high
95% low
Callantsoog
't Zand
De Stolpen
Stolpervlotbrug
Schagerbrug
Sint Maartenszee
Sint Maartensvlotbrug
Sint Maartensbrug
Sint Maarten
Valkkoog
Strand
Het Korfwater
Petten aan Zee
Petten
Middel Egalementsloot
Dijkstaal
Groote Sloot
Leihoek
Mennonietenbuurt
Burgervlotbrug
Burgerbrug
Grootven
Stroet
N502
N503
N249
N9

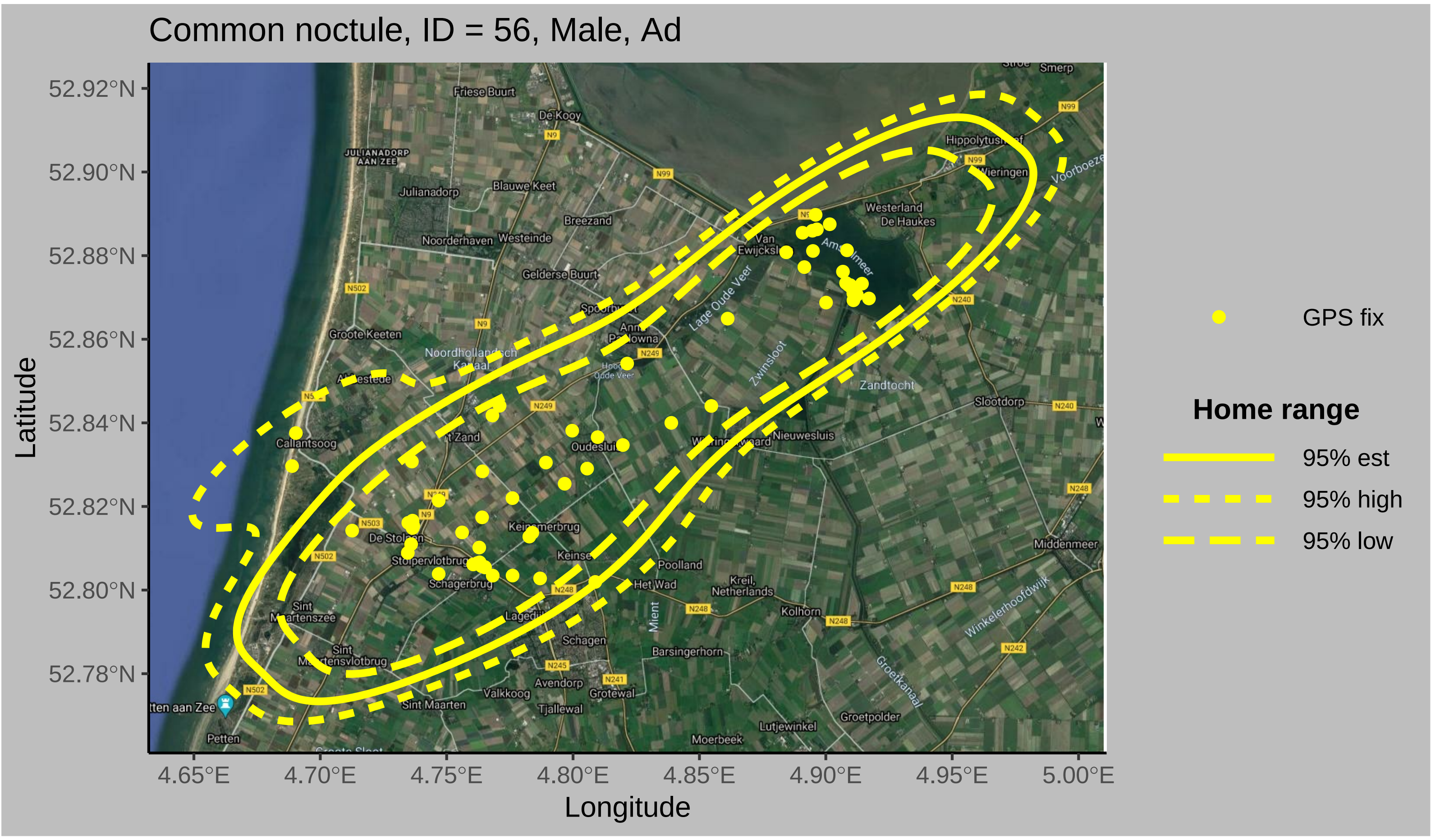


Common noctule, ID = 52, Female, Ad
52.84°N
52.82°N
52.80°N
52.78°N
52.76°N
Latitude
4.66°E
4.68°E
4.70°E
4.72°E
4.74°E
4.76°E
Longitude
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 54, Female, Ad
52.95°N
52.90°N
52.85°N
52.80°N
52.75°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
Longitude
GPS fix
Home range
95% est
95% high
95% low
Nieuw-Den Helder
De Schooten
Friese Buurt
De Kooy
Julianadorp aan Zee
Julianadorp
Blauwe Keet
Breezand
Noorderhaven
Westeinde
Gelderse Buurt
Spoorbuurt
Anna Paulowna
Groote Keeten
Noordhollandsch Kanaal
Abbestede
Zand
Oudesluis
Callantsoog
De Stolpen
Stolpervlotbrug
Keinsmerbrug
Keinse
Schagerbrug
Het Wad
Sint Maartenszee
Lagedijk
Schagen
Sint Maartensvlotbrug
Petten aan Zee
Petten
Sint Maarten
Tjallewal
Groote Sloot
Leihoek
Burgervlotbrug
Rijpje
Dirkshorn
Burgerbrug
Eenigenburg
Tuitjenhorn
Slootgaard
De Putten
Krabbendam
Kalverdijk
Woudmeer
Camperduin
Groet
Warmenhuizen
Waarland
Hargen aan Zee
Schoorlse Duinen
Bregtdorp
Oudkarspel



Common noctule, ID = 55, Female, YOY
52.85°N
52.84°N
52.83°N
52.82°N
52.81°N
52.80°N
52.79°N
Latitude
4.65°E
4.70°E
4.75°E
4.80°E
Longitude
GPS fix
Home range
95% est
95% high
95% low


Common noctule, ID = 56, Male, Ad
Latitude
Longitude
52.92°N
52.90°N
52.88°N
52.86°N
52.84°N
52.82°N
52.80°N
52.78°N
4.65°E
4.70°E
4.75°E
4.80°E
4.85°E
4.90°E
4.95°E
5.00°E
GPS fix
Home range
95% est
95% high
95% low

Annex 6: Availability and use of habitat types

Availability [%]

ID	Fresh water	Salt water	Build-up area	Forest	Grassland	Agriculture	Bulb vegetation	Dune vegetation	Swamp	Orchards	Greenhouses	Heather	Salt marsh	Open sandy area	Percentage
4	4.64	3.86	11.69	2.75	17.46	10.76	36.28	9.14	2.34	0.49	0.05	0.00	0.00	0.56	100.00
5	4.05	10.65	10.76	2.56	16.85	9.31	33.26	9.45	1.93	0.10	0.04	0.00	0.00	1.03	100.00
7	3.77	15.33	10.65	2.26	15.21	13.06	29.79	7.02	1.53	0.35	0.03	0.00	0.00	1.00	100.00
8	3.39	0.00	10.29	3.43	18.69	13.11	42.81	5.96	2.01	0.28	0.04	0.00	0.00	0.01	100.00
10	4.68	1.09	10.88	2.64	17.72	11.28	38.61	9.72	2.34	0.61	0.05	0.00	0.00	0.38	100.00
11	3.32	5.19	10.54	1.86	24.25	17.77	28.94	5.74	1.21	0.28	0.03	0.00	0.00	0.87	100.00
12	4.67	8.21	10.53	2.34	19.57	11.30	27.42	12.27	2.54	0.14	0.03	0.00	0.00	0.97	100.00
13	5.64	8.02	9.65	2.50	13.07	9.98	30.31	16.41	3.21	0.19	0.03	0.00	0.00	0.99	100.00
14	4.83	3.55	11.33	2.72	19.32	10.80	33.55	10.42	2.43	0.41	0.05	0.00	0.00	0.59	100.00
15	4.86	0.00	14.95	1.74	33.99	17.43	23.97	2.32	0.21	0.43	0.01	0.00	0.00	0.09	100.00
16	3.93	0.00	11.72	2.10	25.81	18.63	32.23	3.70	1.40	0.39	0.03	0.00	0.00	0.07	100.00
18	4.05	6.14	9.85	1.94	25.93	15.64	25.61	8.97	1.07	0.10	0.02	0.00	0.00	0.70	100.00
19	3.74	5.41	9.26	2.00	21.90	16.58	29.63	8.79	1.80	0.11	0.04	0.00	0.00	0.74	100.00
22	3.93	17.03	9.29	1.47	28.08	12.61	18.18	5.69	1.22	0.18	0.05	0.00	0.00	2.29	100.00
24	2.36	0.00	12.33	2.64	37.15	18.94	26.05	0.00	0.24	0.26	0.02	0.00	0.00	0.00	100.00
25	3.75	14.32	10.41	1.76	23.67	13.56	22.75	7.14	1.37	0.37	0.06	0.00	0.00	0.83	100.00
26	4.82	20.99	13.34	2.48	26.21	17.72	10.54	2.24	0.75	0.09	0.08	0.00	0.08	0.68	100.00
27	4.09	14.43	12.94	1.42	25.91	13.43	18.04	7.40	1.54	0.22	0.02	0.00	0.00	0.55	100.00
28	2.72	0.00	10.55	1.50	35.81	25.03	23.07	0.22	0.79	0.14	0.16	0.00	0.00	0.00	100.00
30	6.31	2.16	14.18	1.28	25.42	28.36	20.53	0.00	1.19	0.37	0.03	0.00	0.16	0.00	100.00
37	9.44	7.64	12.45	1.69	22.54	24.22	19.88	0.65	0.88	0.27	0.02	0.00	0.31	0.01	100.00
38	5.27	21.94	10.16	1.83	25.48	21.69	11.37	0.99	0.61	0.08	0.06	0.00	0.11	0.40	100.00
43	6.60	10.78	13.11	3.78	23.36	20.91	18.24	1.98	0.65	0.18	0.07	0.00	0.18	0.18	100.00
46	5.43	18.54	11.84	1.26	26.55	16.72	14.88	2.84	0.71	0.12	0.06	0.00	0.09	0.95	100.00
47	7.88	17.87	7.56	0.79	9.52	5.71	32.60	13.62	2.50	1.11	0.03	0.00	0.00	0.82	100.00
48	12.96	47.67	11.51	1.31	16.00	6.15	1.19	1.26	0.63	0.29	0.57	0.00	0.04	0.43	100.00
50	4.36	14.03	9.94	1.80	17.52	11.22	26.12	11.47	2.04	0.44	0.03	0.00	0.00	1.02	100.00
52	4.89	7.93	8.82	2.08	21.22	15.57	23.13	13.30	2.16	0.00	0.01	0.00	0.00	0.90	100.00
54	2.31	30.57	8.54	1.23	20.07	13.03	15.97	6.09	0.81	0.10	0.07	0.00	0.00	1.22	100.00
55	3.98	12.96	13.72	1.02	25.45	8.33	23.39	7.72	2.14	0.62	0.03	0.00	0.00	0.66	100.00
56	9.30	3.67	11.68	1.52	24.34	26.25	19.27	2.41	0.94	0.20	0.02	0.00	0.23	0.16	100.00
	5.03	10.64	11.11	1.99	22.71	15.33	24.44	6.29	1.46	0.29	0.06	0.00	0.04	0.62	100.00

Use [%]

ID	Fresh water	Salt water	Build-up area	Forest	Grassland	Agriculture	Bulb vegetation	Dune vegetation	Swamp	Orchards	Greenhouses	Heather	Salt marsh	Open sandy area	Percentage
4	6.67	0.00	10.00	0.00	16.67	3.33	46.67	10.00	6.67	0.00	0.00	0.00	0.00	0.00	100.00
5	27.59	0.00	10.34	6.90	24.14	6.90	10.34	6.90	3.45	0.00	0.00	0.00	0.00	3.45	100.00
7	0.00	0.00	11.76	5.88	29.41	0.00	35.29	11.76	5.88	0.00	0.00	0.00	0.00	0.00	100.00
8	5.71	0.00	17.14	42.86	5.71	5.71	14.29	8.57	0.00	0.00	0.00	0.00	0.00	0.00	100.00
10	15.15	0.00	18.18	3.03	18.18	3.03	30.30	9.09	3.03	0.00	0.00	0.00	0.00	0.00	100.00
11	5.56	0.00	22.22	5.56	50.00	0.00	11.11	5.56	0.00	0.00	0.00	0.00	0.00	0.00	100.00
12	25.00	0.00	3.57	7.14	21.43	3.57	14.29	21.43	3.57	0.00	0.00	0.00	0.00	0.00	100.00
13	15.15	0.00	12.12	9.09	15.15	0.00	21.21	27.27	0.00	0.00	0.00	0.00	0.00	0.00	100.00
14	24.14	0.00	6.90	3.45	13.79	3.45	34.48	6.90	6.90	0.00	0.00	0.00	0.00	0.00	100.00
15	13.33	0.00	8.89	4.44	37.78	6.67	28.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
16	1.33	0.00	21.33	5.33	41.33	2.67	24.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
18	11.54	0.00	34.62	19.23	11.54	3.85	11.54	3.85	3.85	0.00	0.00	0.00	0.00	0.00	100.00
19	13.64	0.00	4.55	13.64	27.27	18.18	18.18	4.55	0.00	0.00	0.00	0.00	0.00	0.00	100.00
22	10.91	0.00	30.91	0.00	25.45	5.45	20.00	5.45	0.00	0.00	0.00	0.00	0.00	1.82	100.00
24	7.14	0.00	21.43	7.14	35.71	14.29	14.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
25	15.56	2.22	20.00	2.22	22.22	4.44	13.33	15.56	2.22	0.00	0.00	0.00	0.00	2.22	100.00
26	25.00	1.14	15.91	6.82	28.41	12.50	6.82	3.41	0.00	0.00	0.00	0.00	0.00	0.00	100.00
27	2.04	2.04	22.45	0.00	28.57	6.12	18.37	14.29	4.08	0.00	0.00	0.00	0.00	2.04	100.00
28	10.00	0.00	20.00	10.00	23.33	20.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
30	14.29	0.00	25.00	7.14	32.14	14.29	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
37	44.44	2.22	15.56	2.22	11.11	11.11	13.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
38	42.31	3.85	3.85	0.00	26.92	15.38	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
43	37.78	0.00	15.56	1.11	30.00	6.67	6.67	0.00	1.11	1.11	0.00	0.00	0.00	0.00	100.00
46	25.42	5.08	13.56	3.39	35.59	3.39	6.78	3.39	1.69	0.00	0.00	0.00	0.00	1.69	100.00
47	12.50	4.17	16.67	4.17	20.83	0.00	8.33	29.17	4.17	0.00	0.00	0.00	0.00	0.00	100.00
48	24.14	8.62	20.69	3.45	24.14	6.90	3.45	6.90	1.72	0.00	0.00	0.00	0.00	0.00	100.00
50	28.57	0.00	7.14	0.00	35.71	0.00	0.00	21.43	7.14	0.00	0.00	0.00	0.00	0.00	100.00
52	6.25	0.00	12.50	0.00	25.00	0.00	37.50	18.75	0.00	0.00	0.00	0.00	0.00	0.00	100.00
54	0.00	5.88	11.76	0.00	17.65	0.00	17.65	29.41	11.76	0.00	0.00	0.00	0.00	5.88	100.00
55	23.08	15.38	15.38	0.00	30.77	0.00	7.69	0.00	7.69	0.00	0.00	0.00	0.00	0.00	100.00
56	40.63	0.00	7.81	1.56	18.75	10.94	17.19	0.00	0.00	0.00	0.00	0.00	0.00	3.13	100.00

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