Hibernating bats along the Dutch coast

Kees Mostert[1], Jan Piet Bekker[2] & Kees Kapteyn[3]

[1] Palamedesstraat 74, NL-2612 XS Delft, the Netherlands, email: kmos@xs4all.nl
[2] Zwanenlaan 10, NL-4351 RX Veere, the Netherlands
[3] Vogelwaarde 11, NL-2036 GD Haarlem, the Netherlands

Abstract: Hibernating bats along the coast of the Dutch provinces of Noord-Holland, Zuid-Holland and Zeeland are described from the first counts in the early 1960s until the winter of 2020, with an emphasis on trends since 1990. The main hibernacula complexes are located in the Natura 2000 dune areas of Meijendel-Berkheide and Kennemerland-Zuid, the Noord-Holland dune area, Kapittelduinen, Voorne and Schouwen. The inner dunes of the remaining coastal areas and the Delta also contain significant numbers. Until now, no hibernating bats have been found on the Wadden Islands. In most areas the numbers counted have increased strongly, though a large part of this may be due to hibernacula being better protected from disturbance. Much of the increase in bats counted is due to a strong increase in the numbers of Daubenton's bat (*Myotis daubentonii*), which is by far the most numerous hibernating species along the Dutch coast (around three quarters of the total), with record numbers counted over the last few winters. Pond bats (*M. dasycneme*) are the second most populous species (around 13%), hibernating in bunkers between IJmuiden and Hoek van Holland. During the winter of 2019, a maximum of 682 animals of this species were counted, of which 578 were in Meijendel-Berkheide. This Natura 2000 area is by far the most important hibernating area for the pond bat in the Netherlands. Brown long-eared bats (*Plecotus auritus*) and whiskered bats (*M. mystacinus*) account for around (8% and 5% resp.) of the total each with up to 400-300 respectively counted per year. Their numbers can fluctuate strongly, and the later species is mostly found in the dune area between The Hague and Wassenaar. Natterer's bats (*M. nattereri*) hibernate in modest numbers (just 1%) of several dozen (41-86) animals each year along the Dutch coast between IJmuiden and The Hague and on the islands of Schouwen, Walcheren and Goeree. The most important complex for this species is the Kop van Schouwen, with several dozen winter visitors. The remaining of the twelve hibernating bat species found hibernating in the coastal area during this period are Geoffroy's bat (*M. emarginatus*), greater mouse-eared bat (*M. myotis*), common pipistrelle (*Pipistrellus pipistrellus*), Nathusius' pipistrelle (*P. nathusii*), serotine (*Eptesicus serotinus*), barbastelle (*Barbastella barbastellus*) and grey long-eared bat (*Pl. austriacus*). The figures from the counts are compared with the national trend, calculated by Statistics Netherlands (CBS), which shows an increase in the numbers of most species, but less pronounced than the numbers recorded in these censuses. In the last ten years there has been a decline and/or fluctuations in the numbers of some species counted, notably the whiskered bat, Natterer's bat and the brown long-eared bat. In the first case this may be due to milder winters leading this species to hibernate in tree hollows, etc. In the later case it reflects a national decline in numbers. A long term comparison between bunkers that are privately managed and those managed by nature conservation agencies shows that the latter are more effective in attracting increasing bat populations.

Keywords: Dutch coast, hibernating bats, Natura 2000, bunkers, bat trends, whiskered bat, Natterer's bat, Daubenton's bat, pond bat, brown long-eared bat.

Introduction

The Dutch coastal zone covers three Provinces, (from north to south) Noord- and Zuid-Holland and Zeeland. Ecologically it contains the outer dunes, and the inland dune area of the mainland dunes, together with the islands of Zeeland and Zuid-Holland and the former estuaries in the Delta area. Scattered over this area are hundreds of sites in which bats hibernate (figure 1). Many of these sites are bunkers from World War II that formed a defence against an Allied attack. There are also a few bunkers on the Wadden Islands, but since no hibernating bats have yet been found there, this area is not considered further here.

The first count of bats in hibernacula along the Dutch coast dates from 1963 when the Middenduin ice-cellar near Overveen was visited. From 1967, an increasing number of abandoned ice cellars were established as hibernacula for bats, using patio blocks, and counted including Landgoed Waterland and Belvedere. Ten years later, Huis te Manpad (1977; years in brackets after a location indicate the first count in this particular hibernaculum) and the Elswout estate (1979) were added.

The first incidental counts in Zuid-Holland were made in 1968, when three whiskered bats (*Myotis mystacinus*) were found in the burial vault at Warmond and one whiskered bat (van Wijngaarden et al. 1971) and a pipistrelle (notes of Mr. Wey, SBB) in the Prins Hendrik fort in Ooltgensplaat. The first annual counts in the coastal area took place in 1977 in the bunker complexes near Meijendel (Lina et al. 2022, in this issue).

This contribution provides an overview of all the known hibernacula of bats along the Dutch coast. Although the entire history of hibernating bats along the Dutch coast is outlined, the emphasis is on the period starting in the 1990s. Since then, most sites have been counted annually, enabling an estimation of annual trends.

In this paper, the coastal area is subdivided

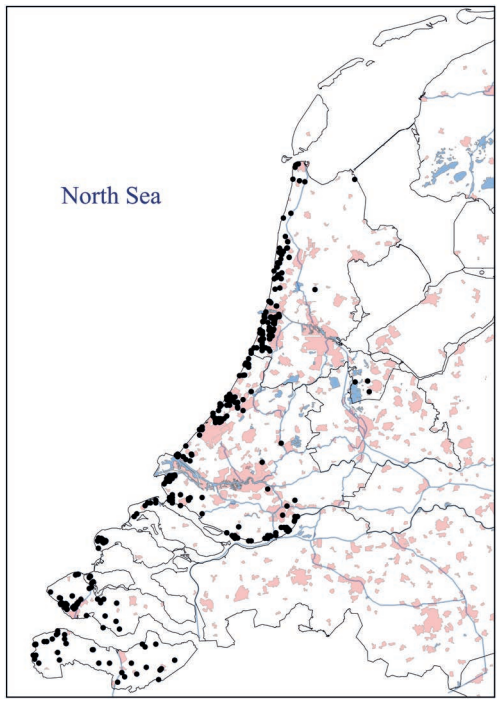

Figure 1. Hibernacula of bats along the Dutch coast and in the delta region.

Figure 2. Broken lintel ceiling with hibernating Daubenton's bats, Haamstede. *Photo: Kees Mostert.*

into 17 subareas and the results of the bat counts/surveys are discussed from north to south, based on these sub-areas. This is followed by a general picture for the entire Dutch coast, followed by a separate discussion of all the bat species encountered. We then compare developments in the coastal area with the national trend, calculated by the Netwerk Ecologische Monitoring (NEM) since 1986 (La Haye et al. 2022, in this issue). Finally, the relationships between summer roosts and hibernacula and the opportunities and threats facing different bat species are discussed.

Descriptions of winter quarters

Types of sites in the coastal area

The majority of the sites with hibernating bats along the Dutch coast consist of bunkers in the dune area (92%). Groups of bunkers at a short distance from each other ('complexes') are present in the Noord-Holland dune area (Castricum-IJmuiden), Kennemerland-Zuid (IJmuiden-Noordwijk), Meijendel and Berkheide, the Staelduinse Bos and Hoek van Holland (Kapittelduin), Voorne, Goeree, Schouwen and Walcheren. These complexes, sometimes have underground tunnel systems connecting various bunkers with each other. Some bunkers still remain in the inner dune area although most were removed shortly after the Second World War. The bunkers are mostly made of reinforced concrete with a wall thickness ranging from 50 cm up to two metres. The thickness of the ceilings can be up to three and a half metres. There are many different types of bunkers, from small artillery bunkers, '*tobroeks* ', to large bunkers, consisting of several rooms. In general, it is easy to investigate these bunkers quite thoroughly. The spaces are clearly arranged and the places to hide in the different types of bunkers can be found in predictable places. Bats are regularly found in air and ventilation shafts that are closed off from above and in cable ducts. The flat ceilings and walls are easy to view and the recesses for support beams at different heights are also easy to inspect. Special mention should be made of the lintels, consisting of four tubes, with which the ceiling is covered. A number of bat species have a preference for the spaces in partially broken lintels (figure 2) (Bekker 2019). These constructions were used in ammunition bunkers on Goeree, in four storage bunkers in the Slotbos Haamstede and in six air raid shelters in Oranjezon.

In most hibernation sites, bats hide in crevices and holes, preferring closed air vents, cracks and crevices behind, for example, loose plaster. The original windows and doors are often bricked up. In a number of bunkers, measures have been taken to improve the indoor climate.

A total of 819 hibernacula have been used by bats in the coastal region, of which 203 are in Noord-Holland, 474 in Zuid-Holland and 142 in Zeeland (figure 3). In the inner dune area, there are a small number of ice cellars on country estates, where bats hibernate. There are eight ice cellars in Kennemerland-Zuid in Noord-Holland. The ice cellar in Middenduin near Overveen is particularly popular among hibernating bats. In the 1980s, inventories were started in the ice cellars at the Duin en Kruidberg, Nova Zembla (1983) and Midden-Herenduin (1986) estates. In Zuid-Holland there are three ice cellars in the inner dune area, at Wittenburgh, the Horsten and Endegeest. However, the Horsten is closed off (but accessible to bats) and no bats have so far been found in Endegeest. Of particular interest is the ice cellar on the Dordwijk estate in Dordrecht, which was first counted in 1981. The only ice cellar in Zeeland (in Middelburg) was bricked up in the 1980s and is therefore inaccessible to bats. Besides ice cellars, there are a limited number of other underground storage sites (e.g. potato cellars) where bats hibernate, such as in Zeeuws-Vlaanderen.

On the islands of Zuid-Holland and in Zeeland there are several forts and ruins where hibernating bats have been found

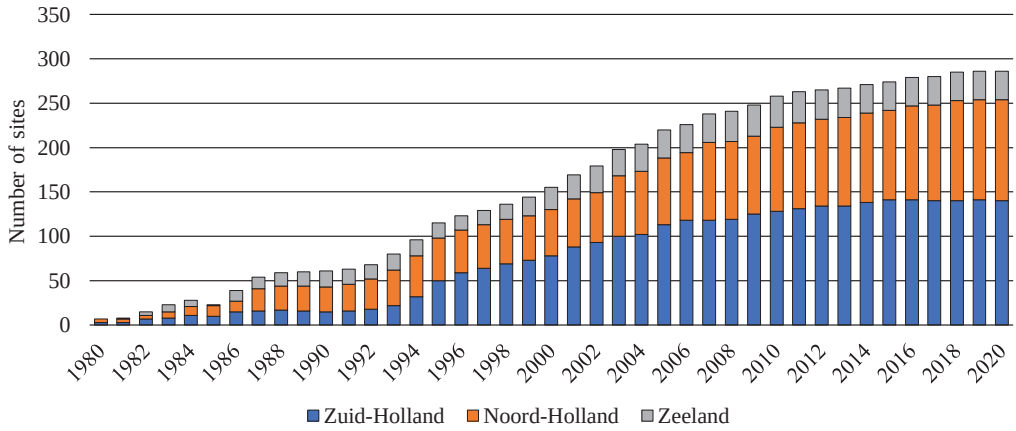

Figure 3. The number of surveyed bat hibernacula along the Dutch coast (sites with no bats or occasionally with a few animals are not taken into account).

in the cellars or in closed corridors. These are: Fort Nieuwenhoorn on Voorne, Fort Hoeksche Waard, Fort Rammekens, the Keldermanspoort near Hulst and the Stenen Beer near Sluis. There are two sites, the Ruïne van Brederode and the Dom van Veere, where hundreds of pipistrelles hibernated in some years in the higher parts of the buildings. These hibernating groups of pipistrelles are not considered further in this article because the vast majority spend the winter mainly in cavity walls or similar places (Kapteyn 1997). Other hibernation sites include several artificial caves on estates in the inner dune area in Zuid-Holland and three drainage sluices and a lime kiln in Zeeuws-Vlaanderen.

The locations of the hibernacula

The first bat counts of hibernation sites along the Dutch coast took place in the mid-1960s. From the second half of the 1970s onwards, the bats in several sites were counted annually and since the 1990s approximately 140 up to 280 are counted annually.

In the vicinity of Den Helder and Callantsoog, there are a small number of sites in the coastal area. These are the Hospitaal St. van Den Helder (1987), Julianadorp (1988), Wildrijk (1991), Pettemerduin Korfwater (1994), the Julianadorp aan Zee bunkers (2009), the ammunition bunker behind Huisduinen (2015) and the dog training bunker at Streepjesberg (2018).

The vast majority of these sites are located in the Noord-Hollands Duinreservaat and Schoorlse Duinen near Bergen (1992) and the Wimmenummerduinen near Egmond (1994), while Klimweg Schoorl (1983) and Abdij Egmond-binnen (1993) are more remotely located.

There are many bunkers in the subarea south of the Noordzeekanaal down to Noordwijk (in Zuid-Holland) particularly in the Kennemerland-Zuid dune area, including in the Amsterdamse Waterleidingduinen (hereinafter AWD) (see Lange et al. 2022, in this issue). To the south of this, in the vicinity of Noordwijk, there is a large bunker complex and a few small bunkers. In the 1980s, counting started at Duin en Kruidberg, Nova Zembla (1983), Klimweg Schoorl (1983), Kraansvlak A and B, Kennemerduinen (1983), Landgoed Leyduin (1984), AWD (1986), Midden-Herenduin (1986) and Landgoed Beeckesteijn (1989). The first counts of the bunkers north of Noordwijk were done in 1982 and the Ruïne van Brederode has been counted since the early 1990s.

In Meijendel and Berkheide, between The

Figure 4. Above-ground bunker Staelduinse Bos, Hoek van Holland. *Photo: Kees Mostert.*

Hague and Katwijk, there are a number of large bunker complexes, namely Delfland-bunker, the DWL bunker, Wassenaarse Slag, Uilenbosch and Moffenslag. These complexes are among the most important hibernacula for bats along the Dutch coast, especially for the pond bat (*Myotis dasycneme*). Lina et al. (2022, in this issue) provide an extensive overview of trends in these large bunker complexes. In addition, there are a number of small bunkers scattered throughout the area with small numbers of bats. The first counts took place here in the late 1970s when most of the sand was dug out of the bunkers. In 1993 and 1995 the small bunkers near Zwarte Pad and the Klip were first counted, as well as a number of bunkers in Berkheide.

In the inner dune area, bunkers are to be found on the Nieuw-Leeuwenhorst estate (1994), the Zuidwijk Estate (2000), the Maaldrift defence site near Wassenaar (1999) and private bunkers on the Wassenaar estates (1996). Bunker complexes on the Clingendael Estate (1995) and in Rijksdorp (1998) and Valkenburg (1997) harbour large numbers of bats. Some locations have become part of the built-up area of The Hague, including a tennis club (2001), a park and Arendsduin Estate and the Ockenburgh Cemetery (both 1999). Some other estates such as the Voordes in Rijswijk have bunkers, but bats are only sporadically seen there.

In the Westduinpark (1998), near The Hague, there is a complex of dozens of small bunkers with a long corridor. As this narrow dune area is very close to The Hague and Scheveningen, the bunkers attract a number of unwanted visitors. Since the late 1990s, a number of these bunkers have been closed off to improve their suitability for hibernating bats.

The first census in Hoek van Holland was conducted in 1981. The Kapittelduinen dune area, a Natura 2000 site, which lies between Hoek van Holland, the Staelduinse Bos and the Nieuwlandse Dijk contains a number of bunkers and there are some more just outside the site in the Galgeweg. Hoek van Holland has both a large network of corridors and a number of small bunkers. The Staelduinse Bos contains many dozens of above-ground bunkers and the Nieuwlandse Dijk has a number of small bunkers, which are regularly broken into (figure 4). The Hoek van Holland dune area and the Staelduinse Bos were both previously owned by the Ministry of Defense, and ownership of these areas was transferred to Het Zuid-Hollands Landschap in the late

Table 1. Number of sites and complexes per subarea with hibernation sites which are counted annually. Also shown is first the winter season in which the vast majority of hibernating bats (>90%) were counted in these sites.

	Number of sites	Complexes	>90% of bats counted since
Den Helder-Callantsoog	7	4	1993
NH Duinreservaat [& Schoorlse Duinen]	43	14	1994
Wimmenummerduinen	11	1	2001
AWD	47	6	1987
Remaining Kennemerland-Zuid	95	26	1992
Noordwijk	24	5	2005
Meijendel-Berkheide	103	18	1986
Binnenduin Den Haag-Wassenaar	58	11	1998
Westduinpark	23	7	2005
Kapittelduinen	83	15	1986
Dunes of Voorne	119	24	1996
Dunes of Goeree	25	8	1994
Hoeksche Waard	21	6	2005
Eiland van Dordrecht	18	7	2001
Kop van Schouwen	65	8	1986
Manteling Walcheren	47	13	2000
Zeeuws-Vlaanderen	30	10	2002

1980s and early 1990s. The first counts were made here in 1981 and 1986 respectively.

In the remaining Delta area (Hoeksche Waard and the Eiland van Dordrecht, both 2000) a number of casemates can be found along the dikes of Haringvliet and Hollands Diep. Some of these sites are equipped for hibernating bats.

The first counts on Voorne took place in 1982 at Wasserman, Haringvlietdam and polder Quack. The dunes of Voorne contain a large number of small bunker complexes, of which Wasserman, the Biberbunker, Hesterhof and the Bernhard complex (1994) are the most important for hibernating bats. The inner dune area also has several dozen privately owned bunkers. Since the mid-1990s, the number of sites counted has increased sharply.

On Goeree (2001) there are a number of scattered small bunkers, in the inner dune area of Oostduinen, the Punt van Goeree and along the Grevelingendijk near the Preekhilpolder (Mostert 2005).

In the province of Zeeland, the first count was carried out in the Stenen Beer near Sluis in 1981. In the following years, Fort Rammekens (1982), the former boarding school in Sluis (1982), the Kop van Schouwen (1983), Groede and the Keldermanspoort near Hulst (1985) were also counted. Since the late 1980s, these hibernation sites have been visited annually.

In the Kop van Schouwen, a large number of bunkers in the Slotbos Haamstede and scattered bunkers in the adjacent dune area are used as hibernacula.

A few suitable hibernation sites have been counted on Walcheren since the 1980s: Fort Rammekens, the bunkers at Valkenisse (1986) and Oranjezon (1988). Since 1998, the bunkers in the Toorenvliet Park and some old sewer ditches in Middelburg have also been counted regularly. The counts here have been more complicated because a number of bunkers were regularly broken open and then closed again, so some bunkers were not always accessible for counting. A number of scattered above-ground bunkers in the arable areas have also been included in the annual count. Since 1999, six bunkers along the Onrustweg

in Noord-Beveland (directly bordering Walcheren) have also been counted.

In the 1980s, a small number of suitable hibernation sites were discovered in Zeeuws-Vlaanderen, including the former boarding school St. Joseph in Sluis which was in use until 1944 after which it fell into disrepair. The demolition of the building only started in 1990 and in 1995 the cellars were also demolished. A number of hibernation sites are no longer accessible for research or are no longer suitable, such as the Suatieluis Reigersbosch and the Keldermanspoort near Hulst.

Table 1 shows the number of sites and complexes per subarea and the first year when hibernating bats were counted in these sites, allowing for a reliable trend calculation. The number of counted sites has increased over the years, especially until around 2010, after which the trend levelled off (figure 3). The increase was mainly caused by bunkers that had previously been buried under a layer of sand being exposed and dug open by bunker searchers.

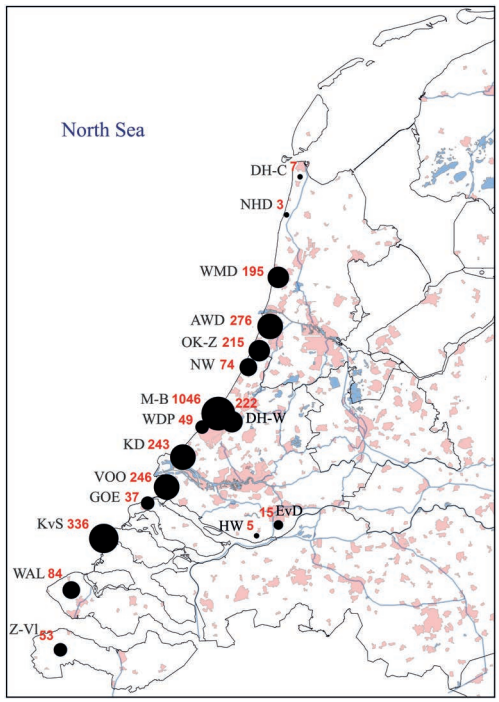

Figure 5. The average number of annual hibernating bats per subarea over the period 1990-2020.

Results

First, we discuss the number of hibernation sites per subarea (from north to south) and the average number and species of hibernating bats within them. These subareas are arranged as much as possible by Natura 2000 area. We then go on to present the population trend for each species along the entire Dutch coast, showing both the absolute numbers counted and the trends, both for the coastal zone and the Netherlands a whole (calculated by Statistics Netherlands (CBS)).

Number of sites and bats per subarea

Most sites in the coastal area are found in the mainland dunes, especially in the inner dune area between IJmuiden and The Hague (figure 1). A large number of hibernation sites can also be found in the dune areas of the Zuid-Holland and Zeeland Islands. The Hoeksche Waard and the Eiland van Dordrecht have a number of casemates along the dikes of the former sea inlets of Haringvliet and Hollands Diep, which are also considered part of the coastal area.

The division into areas is based on the Natura 2000 areas as much as possible. From north to south these are: Den Helder-Callantsoog, Noord-Hollands Duinreservaat and Schoorlse Duinen, Kennemerland-Zuid, Meijendel-Berkheide, Westduinpark, Solleveld & Kapittelduinen, Voorne, Goeree, Schouwen and Walcheren. Areas that are not designated as Natura 2000 sites are the inner dune of The Hague-Wassenaar, the inner dune near Haarlem, the Hoeksche Waard, Eiland van Dordrecht and Zeeuws-Vlaanderen.

In most subareas the numbers of bats has increased significantly since 1980, mainly

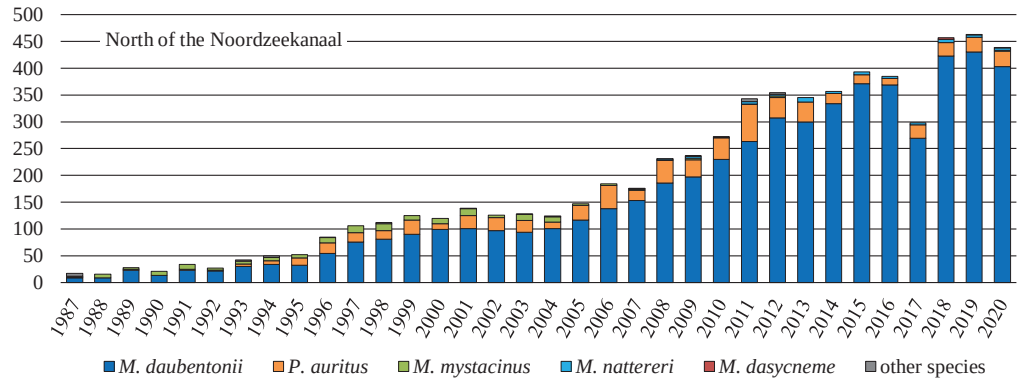

Figure 6. Number of hibernating bats north of the Noordzeekanaal (excluding Wimmenummerduinen).

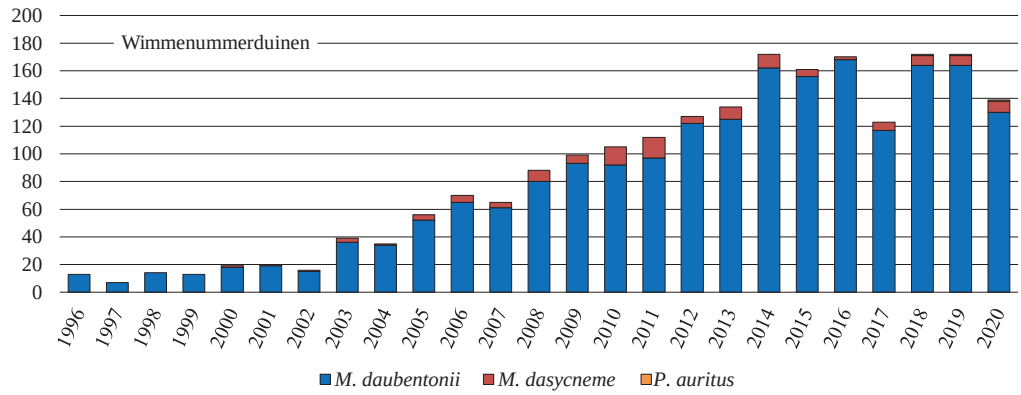

Figure 7. Number of hibernating bats in the Wimmenummerduinen (Castricum).

due to an increase in Daubenton's bat (*Myotis daubentonii*). Year on year changes in the absolute numbers of hibernating bats counted are not strictly comparable as an indicator of the total bat population as many new sites were found and/or included in the counts in the 1980s and 1990s. However, the index values calculated by Statistics Netherlands (CBS) also show an increase in the numbers of most species, although somewhat less pronounced than the increase in absolute numbers.

The average numbers of hibernating bats per year for the period 1990-2020 are presented in figure 5. This shows that the most important areas on the Dutch coast for hibernating bats are Kennemerland-Zuid and the AWD, Meijendel-Berkheide, Kapittelduinen (Staelduinse Bos and Hoek van Holland), Voorne and Schouwen. The results in the Natura 2000 areas and other subareas are explained in more detail below.

Dunes north of the Noordzeekanaal

The coastal strip between Den Helder and Callantsoog, the Noord-Hollands Duinreservaat and the Schoorlse Duinen, forms an almost continuous dune area north of the Noordzeekanaal. The numbers of bats counted since 1987 shows a clear upward trend (figure 6). In the vicinity of Den Helder, initially only a few brown long-eared bats (*Plecotus auritus*) hibernated, while Daubenton's bats were also found

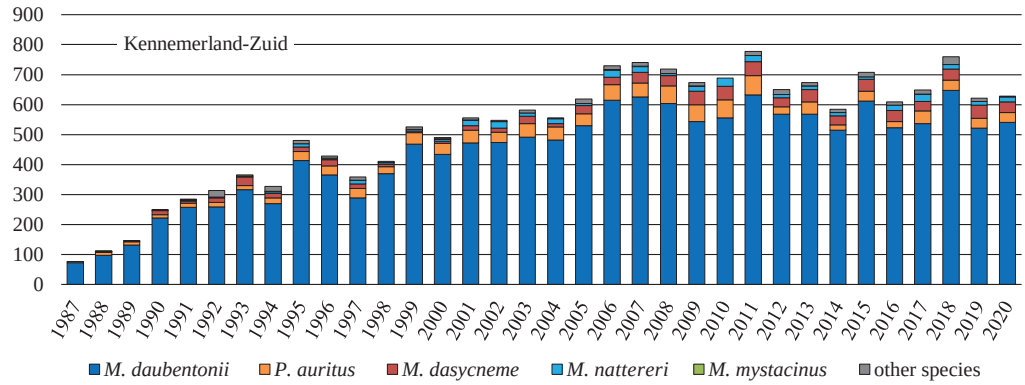

Figure 8. Number of hibernating bats in Kennemerland-Zuid (IJmuiden-Noordwijk including the AWD).

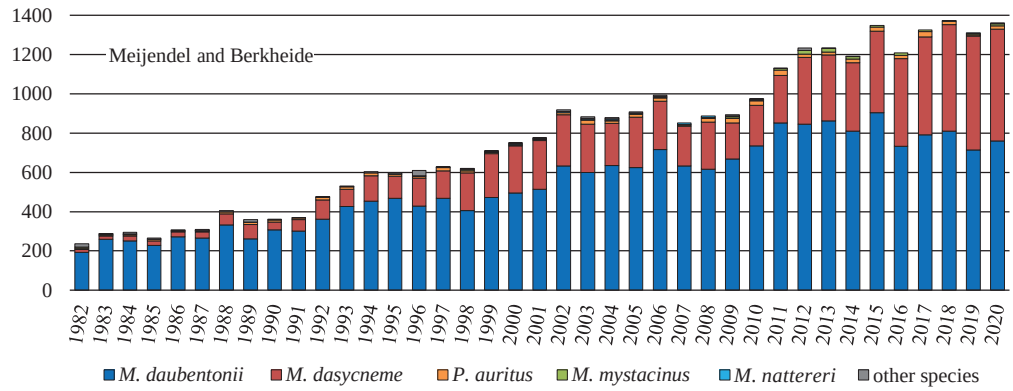

Figure 9. Number of hibernating bats in the Meijendel and Berkheide Natura 2000 area.

in the vicinity of Callantsoog. In recent years, more bats have been counted in the Wildrijk, with 30 Daubenton's bats and three brown long-eared bats in 2019.

The numbers of bats in the Wimmenummerduinen, in the south of the subarea, have increased rapidly since 1996 (figure 7). However, an increase has also been noted at other sites, with several Natterer's bats and a single pond bat counted in recent years. In recent years, the whiskered bat has disappeared as a regular hibernating visitor from Schoorl and Egmond-binnen.

There are two other sites in the vicinity of Beverwijk. The allotment garden complex near Beverwijk was counted from 1998 to 2016. Small numbers of Daubenton's bats and brown long-eared bats hibernated there every year but since 2014, no bats have been found there. The Forteiland near IJmuiden was only counted in 1997 and 1998. This resulted in one to four whiskered bats, seven to eleven Daubenton's bats, a pond bat and a brown long-eared bat. No counts were made in other years.

Kennemerland-Zuid (IJmuiden-Noordwijk including the AWD)

The number of hibernating bats in this part of the coastal zone increased from 249 in 1990 to 778 in 2011, followed by a slight downward trend (figure 8). The pond bat and brown long-eared bat show a sustained increase with maximum numbers in 2011 of 47 and 64 animals respectively, since then the numbers have

fluctuated somewhat. The same goes for Natterer's bat, which increased to a maximum of 27 animals in 2010, but whose numbers have fluctuated since. The whiskered bat has always been scarce (up to four animals), and in recent years has not been spotted hibernating.

The large bunker complex near Noordwijk has been examined for bats since 2005, after having being closed for years. The number of bats counted increased from seven in 2005 to 33 in 2020.

Meijendel and Berkheide

There is a central complex of bunkers at Meijendel en Berkheide and a small number of bunkers spread around. These have been investigated since 2000 and dozens of hibernating bats are counted each year (figure 9; see also Lina et al. 2022, in this issue). This is the only place in the coastal zone where a greater mouse-eared bat has been spotted hibernating since 2014 (figure 10).

The inner dune area of The Hague and Wassenaar

Up to 400 bats hibernate here (figure 11) and the large number of whiskered bats (100-150) is striking. This makes it the most important stronghold for this species in the coastal area of the Netherlands. There has also been an increase in the number of pond bats here (figure 12).

There are a few known ice cellars in the Horsten, Wittenburgh and Endegeest and a few artificial caves on the estates of Berensteyn and Backershagen, In addition, there is an underground space under a church building, a lime kiln in Katwijk and a burial vault in Warmond. The ice cellar in the Horsten was opened once, in 1995, following a restoration, when eight Daubenton's bats were counted. Apart from this, this site has not been counted.

Westduinpark

Since the late 1990s, the number of hibernating Daubenton's bats in the Westduinpark near The Hague has increased almost every year (figure 13). Initially there were a few dozen, but in 2013, 100 Daubenton's bats were counted for the first time and also four

Figure 10. Greater mouse-eared bat, Meijendel, The Hague. *Photo: Kees Mostert.*

Figure 12. Hibernating pond bat, The Hague. *Photo: Kees Mostert.*

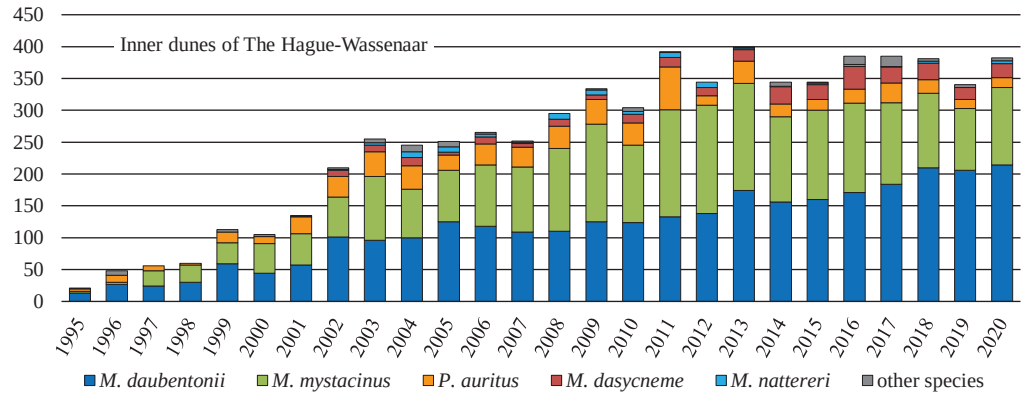

Figure 11. Number of hibernating bats in the inner dune area of The Hague-Wassenaar.

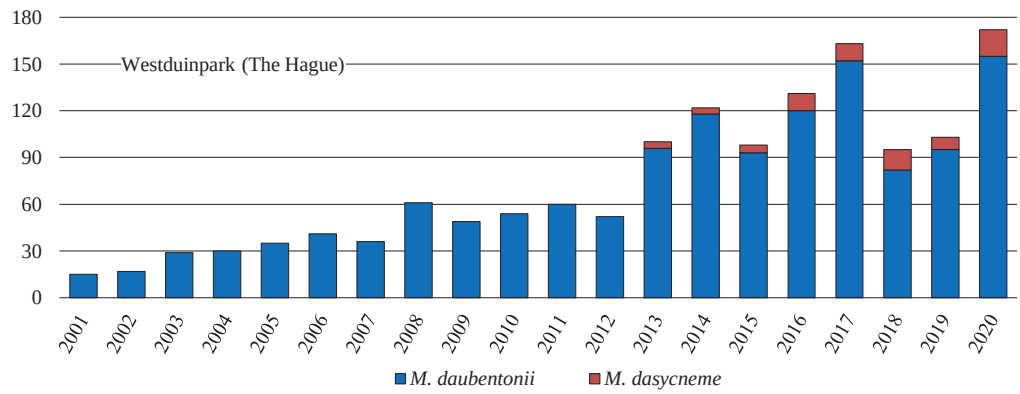

Figure 13. Number of hibernating bats in the Westduinpark near The Hague.

hibernating pond bats were found here for the first time. In the winter of 2020, a total of 172 hibernating bats were counted, the largest count during the whole period: 155 Daubenton's bats and 17 pond bats. This makes the Westduinpark an important hibernation site for Daubenton's bats and increasingly, for the pond bat. It is the only dune area where only two bat species have been observed during the study period.

Kapittelduinen (Hoek van Holland and Staelduinse Bos)

The counts in Hoek van Holland in the 1980s initially yielded relatively few bats (5-16 animals), with 26 animals in 1988. When the regular winter census was resumed in 1994, 58 bats were counted and then the number increased to 97 animals in 1999 (figure 14). Since then, a period of regular break-ins has caused a sharp decline in numbers. Only when intensive measures were taken to prevent disturbances did the annual counts increase again. Since 2011, the pond bat has been encountered almost annually.

The first count in the Staelduinse Bos in 1986 yielded 23 bats. The number increased from 38 to 97 animals between 1992 and 1993, partly due to the efforts of the volunteer fire brigade, which made a number of bunkers much more humid. Subsequently, the number of bats counted grew further to several hundred per year (figure 15). Several dozen bats also hibernate along the Galgeweg and the

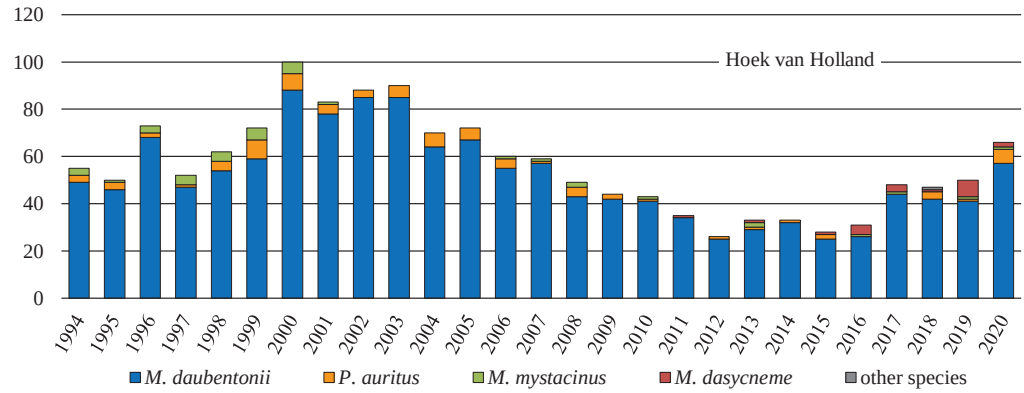

Figure 14. Number of hibernating bats in Hoek van Holland.

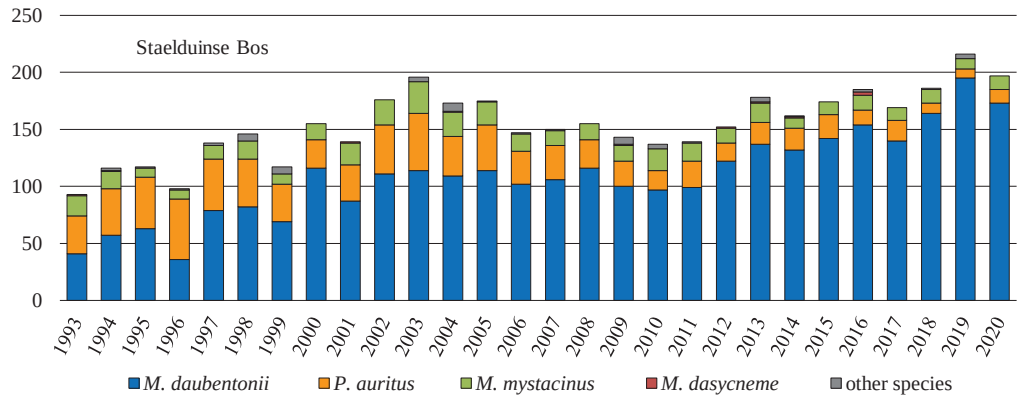

Figure 15. Number of hibernating bats in the Staelduinse Bos.

Nieuwlandse Dijk. In recent years, the number of pond bats has clearly increased in these sites. However, the number of whiskered bats and, especially, the number of brown long-eared bats has decreased over the years (figure 15). The largest numbers of these species were counted in 1994 (18 whiskered bats) and 1995 (53 brown long-eared bats). For many years a maternity colony of brown long-eared bats was present in summer and occasionally a solitary Daubenton's bat (Mostert 1990a).

The dunes of Voorne

The dunes of Voorne have a large number of small bunker complexes, of which Wasserman, the Biber bunker, Hesterhof and the Bernard complex are the most important for hibernating bats. In the inner dune area, there are also several dozen bunkers that are privately owned.

During the 2020 census, 441 bats were found in the dunes of Voorne, including 389 Daubenton's bats, 42 brown long-eared bats and seven pipistrelles (figure 16). This makes it clear that the winter habitats in the dunes of Voorne are an important hibernating spot for bats on the Dutch coast. The whiskered bat has not been seen hibernating here since 2013.

Goeree

The number of bats counted on Goeree has fluctuated between 37 and 56 each year since 2000 (figure 17). The bats found are mainly Daubenton's bats (30-50 animals) and some

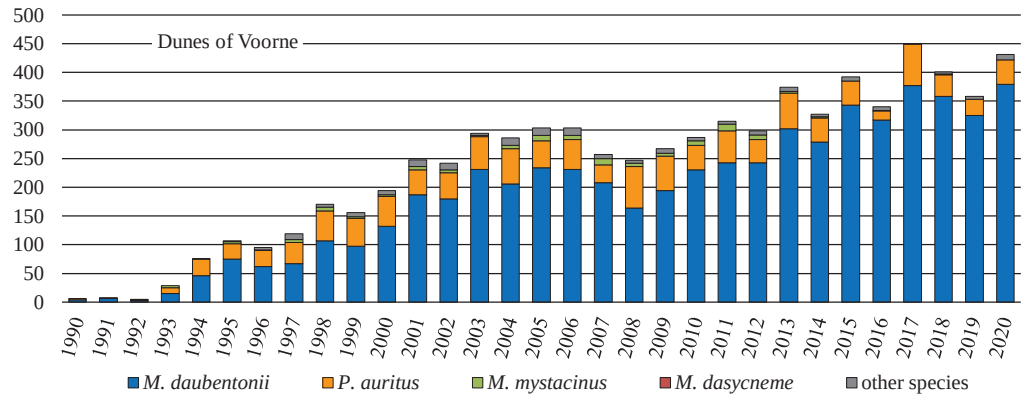

Figure 16. Number of hibernating bats in the dunes of Voorne.

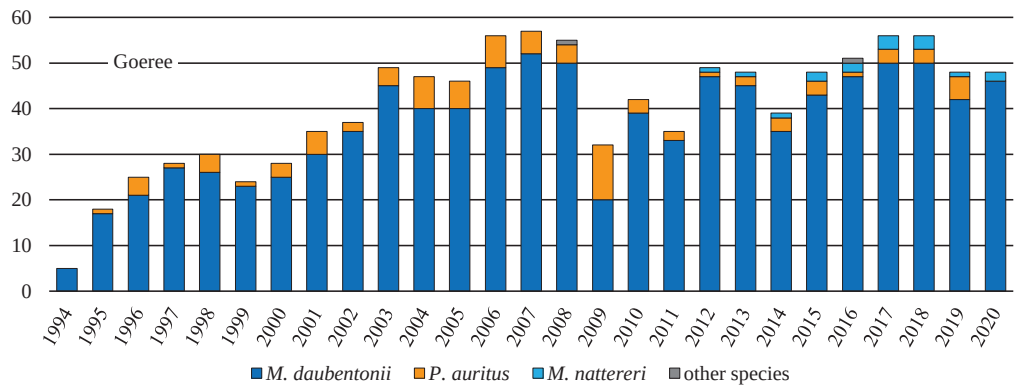

Figure 17. Number of hibernating bats on Goeree.

brown long-eared bats (up to seven animals). Since 2012, Natterer's bat has become a regular hibernator here, although the numbers remain modest (one to three animals). Other species have not yet been recorded here.

The remaining Delta area

In the Hoeksche Waard and on the Eiland van Dordrecht there are a number of casemates along the dikes of the Haringvliet and the Hollands Diep. Some of these sites are suitable for hibernating bats, mainly lodging brown long-eared bats. In most years a few whiskered bats were counted in the ice cellar on the Dordwijk estate, but since its restoration a few years ago no further animals have been found there.

In the casemates and bunkers on the dikes, there is a relatively small number of brown long-eared bats, whose numbers are increasing slowly but surely. Since 1994 more sites are visited in the winter, including the Tong and Zuidplaat. More and more bunkers appear to be used as hibernating quarters. The first Daubenton's bat was reported in 2001, and their number had grown to nine individuals by the 2020 census.

The first count in the Hoeksche Waard took place in 2000. So far, only hibernating brown long-eared bats have been found there, with less than ten individuals in most years, except in 2015, when 15 individuals were counted (figure 18).

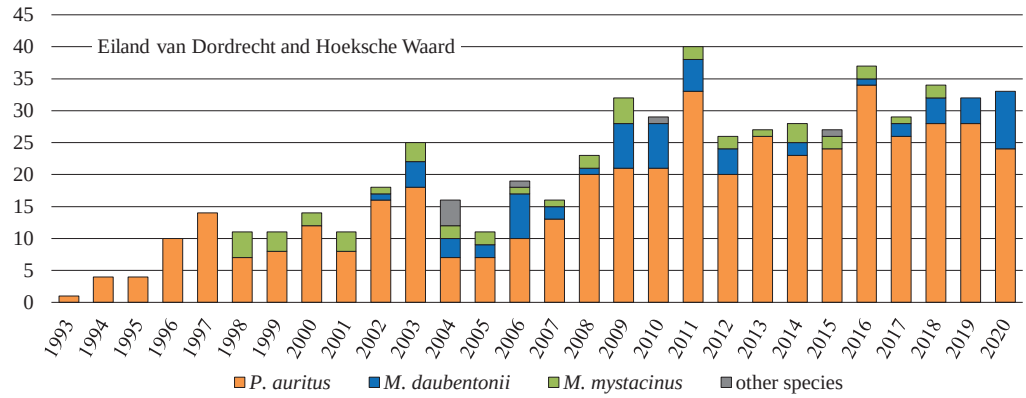

Figure 18. Number of hibernating bats on the Eiland van Dordrecht and the Hoeksche Waard.

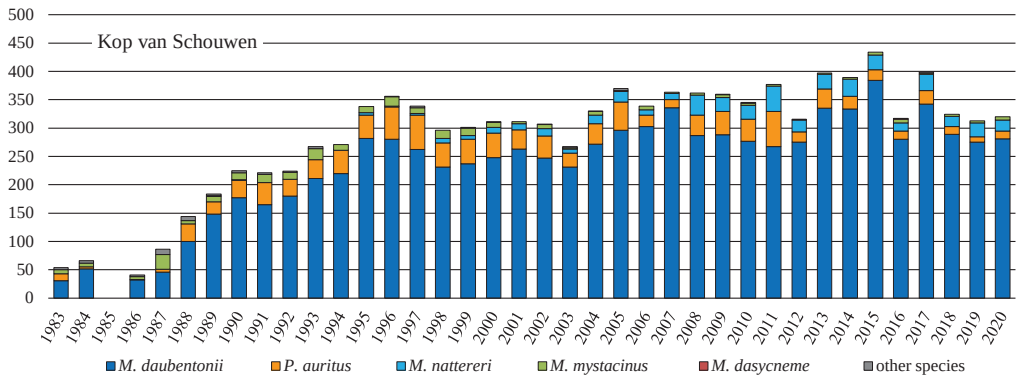

Figure 19. Number of hibernating bats on the Kop van Schouwen.

Kop van Schouwen (Slotbos Haamstede and the adjacent dune area)

The Slotbos Haamstede on Schouwen is by far the most important hibernation area in Zeeland, with several hundred hibernating bats each year. In the adjacent dune area there are also small numbers of bats in a few scattered bunkers. The first census took place here in 1983, finding 54 bats. After measures to protect the hibernacula were taken, the count increased sharply in the second half of the 1980s to 228 animals in 1990 and then to 358 animals in 1996. Since then, the count has started to fluctuate annually at a high level, peaking in 2005 (370 animals) and 2017 (383 animals). Daubenton's bat accounted for most of the growth in numbers. Initially, the number of brown long-eared bats counted also increased to a high number of 61 animals in the winter of 1997, but since then has declined steadily, with only 10-13 hibernating animals in recent years (figure 19). The number of whiskered bats has also decreased slowly, with only three to six animals in recent winters. The first Natterer's bat in the Slotbos Haamstede was noticed in 1990 and four specimens were counted in 1995. Since then, the numbers have increased annually to several dozen hibernating individuals, with a peak in the winter of 2011 of 45 hibernating individuals. Hibernating pond bats were found twice and once, in 2017, a single Geoffroy's bat (figure 20) (Mostert & Bekker 2017).

Figure 20. Geoffroy's bat, Haamstede. *Photo: Kees Mostert.*

Walcheren

Oranjezon is now the preferred location for hibernating bats on Walcheren. The first count took place here in 1988. Until the mid-1990s, a small number of brown long-eared bats were found here, although the number remained below 20 animals. Since 2000, the number of bats has steadily increased, to more than a hundred animals in recent years. The largest increase was among Daubenton's bats. The number of brown long-eared bats initially increased to 21 in the winter of 2010, after which the numbers started to fluctuate. The first Natterer's bat was seen here in the winter of 2002 and nine individuals were counted during the 2020 census (figure 21).

Fort Rammekens, with some water cellars, was one of the first sites on Walcheren where small numbers of bats were found when counting began in 1982. In the 1990s, less than ten bats were usually counted although there 18 in 1999. From 2005 the numbers increased to several dozen animals, with a maximum of 41 Daubenton's bats and one brown long-eared bat in the winter of 2007.

The bunkers at Valkenisse have been counted since the mid-1980s. At the time it sheltered some Daubenton's bats and whiskered bats and an occasional Natterer's bat. In the 1990s, the numbers started to increase to a limited extent, reaching a maximum of 20 animals in 2008 (14 Daubenton's bats and six brown long-eared bats).

Small numbers of Daubenton's bats have been counted periodically since the 1990s in Toorenvlietpark in Middelburg. A maximum of 21 Daubenton's bats (in 2011) and of three brown long-eared bats were counted (in 2007 and in 2018). Occasionally, a few bats hibernated in the sewer ditches of Middelburg, including a Natterer's bat in 1999; since 2001 no more animals have been found here.

Since the 1990s, several scattered, aboveground bunkers in the fields on Walcheren have been periodically surveyed, and a few hibernating Daubenton's bats and brown long-eared bats occasionally observed along the Strandweg and Koudekerkseweg. Over the last 20 years, more of these bunkers have been counted, such as those on the Lageweg, Verbrande Hofweg, Abeelseweg and Groeneweg, Westkapelle and Buttinge. Because of this, the number of bats counted has increased somewhat. Every year several dozen hibernating bats are encountered, with a maximum of 42 Daubenton's bats and ten brown long-eared bats in the winter of 2008.

Adjacent to Walcheren, a few hibernating Daubenton's and brown long-eared bats have also been found on Noord-Beveland along the Onrustweg in recent winters.

Zeeuws-Vlaanderen

In the 1980s, a small number of suitable hibernation sites were known about in Zeeuws-Vlaanderen. Since then, a number of them have disappeared (the former boarding school near Sluis), are no longer accessible for research, but still suitable for bats (the Suatiesluis Reigersbosch) or are no longer suitable, such as the Keldermanspoort near Hulst.

There is no clear trend in the numbers of

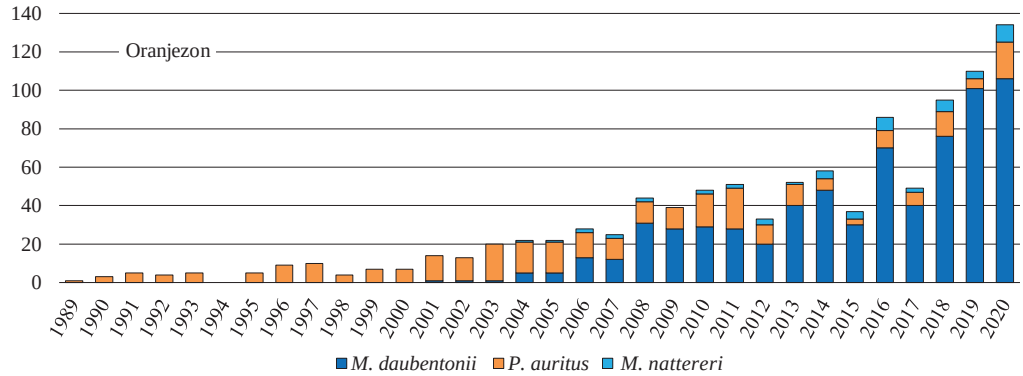

Figure 21. Number of hibernating bats in Oranjezon (Walcheren).

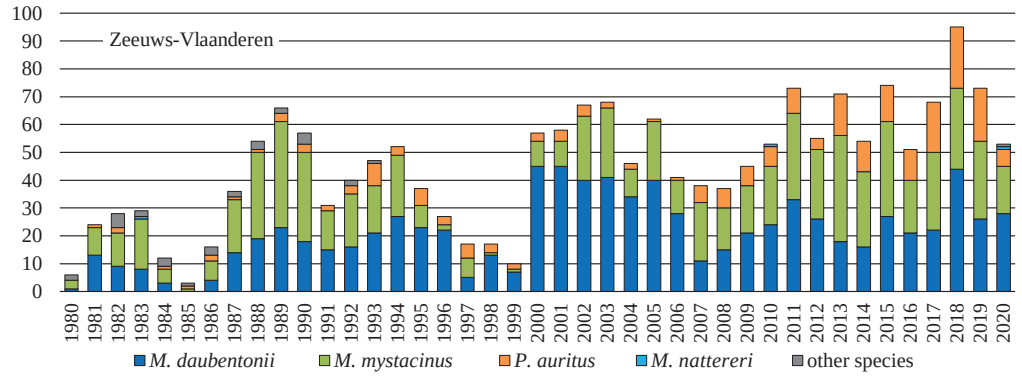

Figure 22. Number of hibernating bats in Zeeuws-Vlaanderen.

hibernating bats here (figure 22). In most years, several dozen Daubenton's bats, whiskered bats and brown long-eared bats are present, scattered across a varying number of sites.

In the 1980s the ruins at Sluis accommodated small numbers of bats (8-21) in the cellars, including whiskered bats (up to 14), Daubenton's bats (up to eight) and brown long-eared bats (up to three). A small number of barbastelles (*Barbastella barbastellus*) hibernated there every year, with a maximum of five animals in 1982 (figure 23). In the 1980s and early 1990s, this was the only winter population of this species in the Netherlands (Glas 1986, Bekker & Mostert 1995). Twice, in 1983 and 1985, a hibernating grey long-eared bat (*Plecotus austriacus*) was found here, its only known hibernating location along the Dutch coast (Glas 1986). The ruins were demolished in 1994.

In the Suatiesluis Reigersbosch a maximum of 14 hibernating animals were counted in the period 1988-1991. The first Daubenton's bat was found in 2007 in the Suatieluis Vlaamsekreek, after it was restored in 2001. Since then, a maximum of nine whiskered bats (2015) and three brown long-eared bats (2011) have been found here. In the Hellegat Suatieluis, which has been visited since 2004, one brown long-eared bat was observed during the first visit.

A small and varying number of bats, between 10 and 20 animals, in most years, hibernate in the Stenen Beer near Sluis. In 1989, 32 animals were counted. During the 2020 census, 15 animals were counted, including a Natterer's bat. This species has only twice before been counted in Zeeuws-Vlaanderen, in 1981 and 1982, at the same site. Most years between 2 and 14 whiskered bats are counted here, with a peak

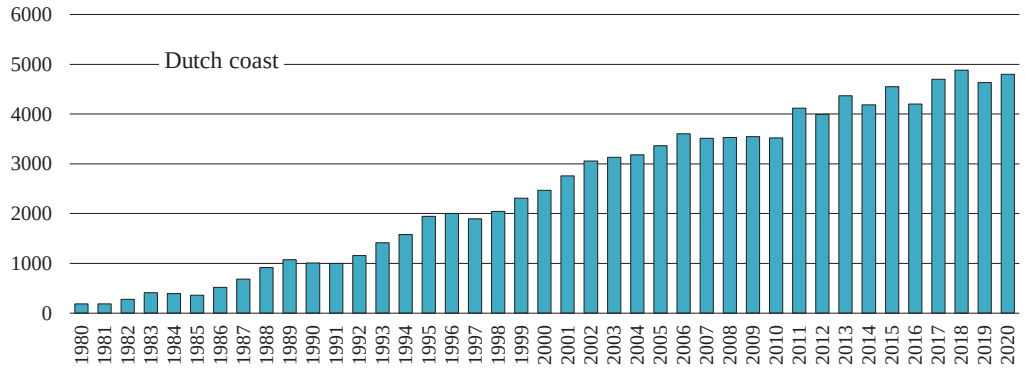

Figure 24. Number of hibernating bats along the Dutch coast.

Figure 23. Barbastelle, Sluis, Zeeuws-Vlaanderen. *Photo: Dick Klees.*

of 18 animals in 2013.

The first bat (a whiskered bat) was identified in the bunker complex northwest of Groede in 1982, but it was only from 1994 that more bats were counted in the bunkers every year. The number grew to 41 animals in 2002 and then decreased to 18 animals by the 2020 census. In 1998, the bunker complex was redesigned and made more suitable for bats. Whiskered bats have always had a significant share in this complex with three to nine animals annually, and 16 and 15 animals in 2017 and 2018, respectively.

The Keldermanspoort has accommodated a number of whiskered bats (a maximum of twelve animals) for many years. Since its restoration in 2000, its significance for bats has diminished. In 2006, 13 whiskered bats were counted, but since 2010 only a few animals have been seen and none since 2015.

In the 1990s scattered bunkers were counted at Breskens, Sluis and Oostburg, with occasional whiskered and brown long-eared bats being spotted. In the last 20 years, a larger number of bunkers spread across Zeeuws-Vlaanderen have been counted, including Retranchement, Axelse Vlakte and Tragel-west. Small numbers of bats are counted here every year: whiskered bat (up to seven), Daubenton's bat (up to six) and brown long-eared bat (up to 12). In the other sites, which have mainly only been counted since 2008, the number of bats has slowly increased from 12 in 2008 to a maximum of 38 animals in 2018 and 2019. The proportions of whiskered bats, Daubenton's bats and brown long-eared bats has remained about the same.

Numbers of hibernating bats along the Dutch coast

Every year, several thousand bats hibernate in the coastal area of the Netherlands. Since the first censuses in the second half of the 1970s, the number of animals counted has steadily grown. In 1980, there were only a few hundred animals, in 1990 more than 1000, in 2002 more than 3000 animals were counted, in 2010 more than 3400 and in 2020 almost 5000 animals (figure 24). This increase is partly due to the ever-increasing number of sites being surveyed, partly to the closure of a large number of

Table 2. Trends of hibernating bat species over the study periods (source: Statistics Netherlands (CBS)).

	Coast trend 1986-2020	Coast trend 2009-2020	National trend 1986-2020	National trend 2011-2020
M. mystacinus	Moderate increase	Moderate decrease	Moderate increase	Moderate decrease
M. nattereri	Strong increase	Stable	Strong increase	Moderate increase
M. daubentonii	Moderate increase	Moderate increase	Moderate increase	Moderate increase
M. dasycneme	Strong increase	Strong increase	Moderate increase	Moderate increase
P. auritus	Moderate increase	Moderate decrease	Moderate increase	Moderate decrease

sites, making more suitable for bats and, possibly, also due to an actual population increase of the species found. The individual contribution of these factors on the growth in numbers of bats counted cannot be deduced from the research methodology and the results.

A total of twelve species of bats were found hibernating in the coastal area during the period: whiskered bat, Geoffroy's bat, Natterer's bat, greater mouse-eared bat, Daubenton's bat, pond bat, common pipistrelle, Nathusius' pipistrelle, serotine, barbastelle, brown long-eared bat and grey long-eared bat. Daubenton's bat has the largest share of the counted animals (76%), followed by the pond bat (10%), long-eared bat (8%), whiskered bat (5%) and Natterer's bat (1%).

Daubenton's bat is by far the most numerous hibernating species in bunkers, cellars and other structures along the Dutch coast: between 2010 and 2020, between 2730 to 3740 animals were counted in the annual censuses. For other species in the past decade, between 320 and 670 pond bats, 170-430 brown long-eared bats, 170-310 whiskered bats and 41-86 Natterer's bats have been counted in hibernation along the Dutch coast. The trends are predominantly positive, although during the last decade, the whiskered bat and brown long-eared bat have declined in numbers.

Numbers and trends by species

Figures 25 to 29 show the number of counted hibernating bats along the Dutch coast bats by species and compares these figures with the indexed values calculated by Statistiscs Netherlands (CBS) for both the Dutch coast and for the whole of the Netherlands. The index is the ratio to indicate the development of a bat species based on the same winter hibernacula (also calculated by the CBS). In these figures, the number of bats counted is indicated on the left y-axis and the index values in percentages are indicated on the right y-axis. For all trends 1986 is the starting year (index value=100; except for Natterer's bat, for which the starting year is 1987). More recent trends of the hibernating bat species over the period 1986 to 2020 and over a recent period are shown separately: along the coast (2009-2020) and the national trend (2011-2020) (table 2).

Whiskered bat (Myotis mystacinus)

Several hundred whiskered bats hibernate in the sites studied along the Dutch coast, with between 170 and 310 animals counted annually in the past decade. Since the 1990s, the number of animals counted initially increased until the winter of 2011. Since then, there has been a remarkable decline, with the species abandoning more and more areas where it previously occurred in small numbers (figure 25).

The trend along the coast shows a moderate increase from 1986 to 2012, although in the last census year (2020) there was a moderate decrease (table 2). This is reflected by, the national trend which also shows a less pronounced increase from 1986-2012, and in the last period (2012-2020) a less pronounced decrease.

Most whiskered bats on the coast hibernate

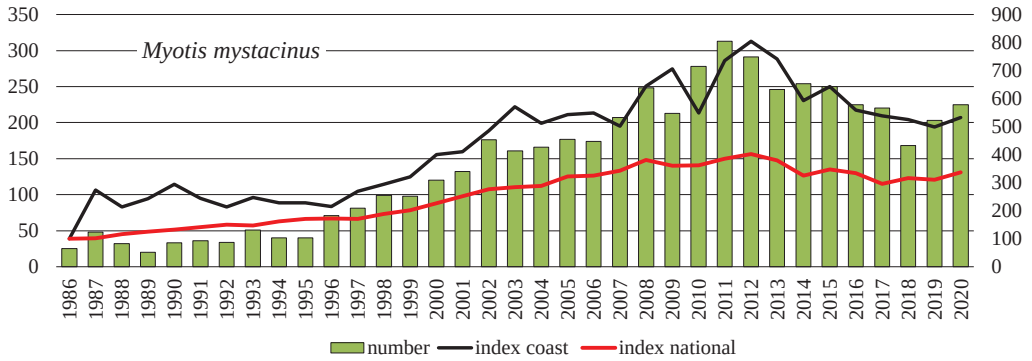

Figure 25. Number and index of hibernating whiskered bats along the Dutch coast compared with the national index (NEM/CBS). Explanation: numbers of columns shown on the left Y-axis, indexes in percentages on the right Y-axis; the percentages of both trends are based on 1986 numbers.

in the inner dune area between The Hague and Wassenaar, where the count increased to 212 in 2008 (Mostert et al. 2009). The most popular locations are the eastern edge of Berkheide, Rijksdorp, Valkenburg, the Wittenburgh ice cellar and Clingendael. In the adjacent dune area of Meijendel-Berkheide, small numbers, of up to 15 animals have been found.

In the Kapittelduinen (Staelduinse Bos and Hoek van Holland) several dozen specimens have been counted annually since the 1990s (22 in 2001) with a total of 15 animals in 2020. In addition, Zeeuws-Vlaanderen also still accommodate hibernating specimens in the Keldermanspoort, Groede, Breskens and the Stenen Beer at Sluis, Retranchement and a few other small sites. The highest counts here were of 38 animals (in 1990 and 2013).

The whiskered bat is rare or even absent in other areas of the Dutch coast, such as the AWD, the Westduinpark near The Hague, on Goeree, Walcheren and in the vicinity of Noordwijk. In other areas, such as in the coastal area of Noord-Holland and on Voorne, the species has declined or even disappeared.

North of the Noordzeekanaal, the whiskered bat initially hibernated in small numbers (up to 13 animals annually), mainly in the vicinity of Schoorl and Egmond-Binnen and occasionally near Bergen. Between 2005 and 2013, a maximum of three animals were found there, but since then numbers have increased again. In the vicinity of Haarlem, the whiskered bat is no longer found every year (three reports in the past ten years), while before 2010, up to five animals were found annually. There have also been declines on the islands of Zuid-Holland and Zeeland. On Voorne a small number of animals were counted annually in hibernation sites (with a maximum of nine animals in 2005), but the species has not been found in the last five years. On Schouwen, the number of animals has been limited to three or four specimens in the last few winters.

In the period 1998-2001, a broader research programme was conducted into the twin species *M. mystacinus* and *M. brandtii*, which included the coastal area of the Netherlands (Mostert et al. 2005). It is difficult to distinguish between the two species: the characteristics of the dentition are useful and Brandt's bat has a lighter coloured ear base. In the winters of 1999, 2000 and 2001, 134 whiskered bats were identified throughout the Netherlands, of which 29 were in Zuid-Holland, 9 in Noord-Holland and 12 in Zeeland (Mostert et al. 2005). Since observations of Brandt's bat in the Netherlands are almost completely limited to the border area with Germany, we assume that only *M. mystacinus* hibernates in the Dutch coastal area.

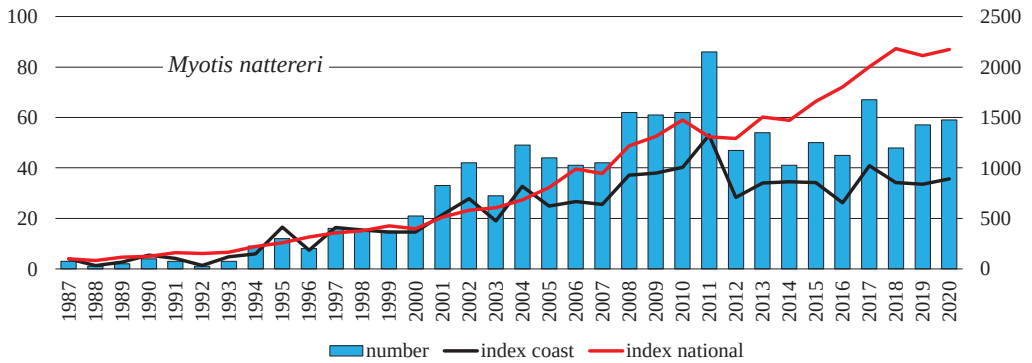

Figure 26. Number and index of hibernating Natterer's bats (*M. nattereri*) along the Dutch coast compared with the national index (NEM/CBS). Explanation: see caption fig. 19.

Natterer's bat (Myotis nattereri)

Natterer's bat hibernates in modest numbers of several dozen animals (annually between 41-86 animals) along the Dutch coast between IJmuiden and The Hague and on Schouwen, Walcheren and Goeree. Both the numbers and the indexed values show an increase (figure 26). Along the coast bat numbers increased from 1987 until 2011 but then dipped and have fluctuated since then. This is in contrast to the national trend, which shows a strong increase over the entire period; with the exception of 2010-2012 (table 2).

In the area between IJmuiden and The Hague, the first hibernating Natterer's bats were noticed in the IJskelder Middenduin near Haarlem (three animals in 1970) and in the large bunker complexes near Wassenaar (occasionally one or two animals in the 1980s). In the 1990s, the numbers of Natterer's bats began to increase annually and they were found in more locations. In the years 2001-2012 there were between 22 and 36 animals in the area. Since then, the number has decreased somewhat, but 25 animals were counted again in the winter of 2020. Since 2008, Natterer's bat has established itself as a hibernator north of the Noordzeekanaal, with up to eight specimens in recent years at various locations around Castricum and Egmond.

In Zeeland, Natterer's bats were occasionally encountered in the 1980s on Schouwen, Walcheren and Zeeuws-Vlaanderen. However, they only got a foothold in 1995 when four animals were found on Schouwen and the number has continued to increase every year since then. In 2011, a record 45 animals were counted, but since then the number has fluctuated at around 18-24 animals. This makes Schouwen the most important stronghold for this species along the Dutch coast. Possibly under the influence of this increase, the first specimen was found on nearby Goeree in the winter of 2011, and up to three specimens have hibernated here annually since then (Mostert 2011). The species has also been spotted a few times in Zeeuws-Vlaanderen; a hibernating animal was found in the Stenen Beer near Sluis during the 2020 census.

Daubenton's bat (Myotis daubentonii)

Daubenton's bat is by far the most numerous hibernating species in bunkers, cellars and other hibernation sites along the Dutch coast, with up to 3740 animals counted in the last decade. More than three quarters of all hibernating bats along the Dutch coast are Daubenton's bats, whether in Noord- or Zuid-Holland, Zeeland and sites in the dune area, in the inner dunes or elsewhere. Since the start of the censuses in the 1970s, the numbers of this species constantly increased, with the highest count in recent winters (figure 27). Both the numbers and the indexed values show a moderate

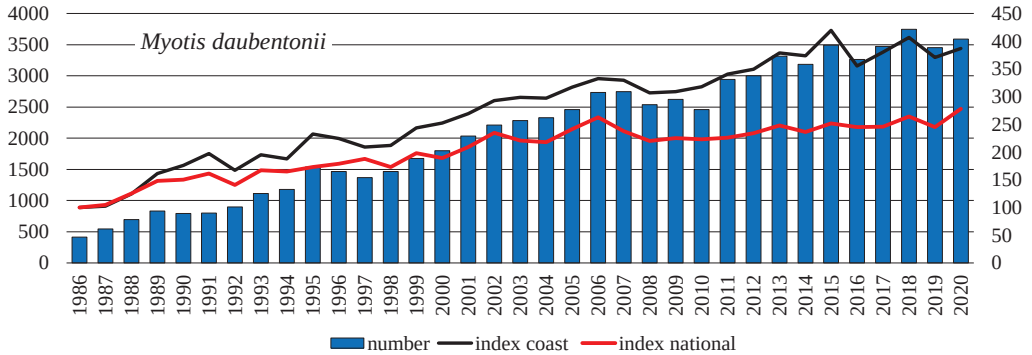

Figure 27. Number and index of hibernating Daubenton's bats (*M. daubentonii*) along the Dutch coast compared with the national index (NEM/CBS). Explanation: see caption fig. 19.

increase throughout the period 1986-2020, but the increase in the indexed values along the coast is stronger than nationally (figure 27). The increase in the numbers of hibernating bats along the coast (figure 24) is largely due to the increase of this species.

The most important strongholds of this species along the coast are Meijendel-Berkheide (maximum 1032 counted specimens in 2015), Schouwen (maximum 384 in 2015), Voorne (maximum 379 in 2020), Staelduinse Bos and Hoek van Holland (298 in 2020), AWD (222 in 2012) and Egmond-Bergen (430 in 2019).
Not only have the numbers of Daubenton's bat increased, but it has also appeared in an increasing number of sites where it was initially absent, such as Wildrijk and on the Eiland van Dordrecht. Only brown long-eared bats were counted in the bunkers at Oranjezon from 1989, until the first Daubenton's bat was reported in 2001. Twenty years later, 106 specimens were counted.

Pond bat (Myotis dasycneme)
The pond bat hibernates in large numbers in bunkers between IJmuiden and The Hague. This makes the species, the second most common bat species, after Daubenton's bat, accounting for 10% of hibernating bats on the Dutch coast. During the winter of 2019, a record number of 682 animals were counted, of which 578 were found in Meijendel-Berkheide (figure 28). This Natura 2000 area is by far the most important hibernating area for the pond bat in the whole of the Netherlands. In the same year, smaller numbers were counted in the adjacent inner dune area (20 animals), the area around Noordwijk (19), Westduinpark (17) and Kapittelduin (11). Smaller numbers also hibernate in neighbouring Noord-Holland, in Kennemerland-Zuid (44 animals).

Both the numbers and the indexed values show a strong increase in the period 1986-2020, with the increase in these values along the coast being stronger than nationally (figure 28). The trend along the coast has shown a strong increase since 1987, and in the period 2009-2020 (table 2). The national trend shows a moderate increase over the entire period and over the past decade (table 2, see also La Haye & van der Meij 2022, in this issue).

The species is virtually absent north of the Noordzeekanaaal and on the Zuid-Holland and Zeeland islands. Only a few incidental hibernating specimens have been found on Schouwen (two animals in 1989 and one in 2016), in the dunes of Voorne (one animal in 2018), in the Wimmenummerduinen (one animal in 2019 and in 2020), at Wijk aan Zee (two animals in 2018) and at Egmond aan Zee (one annual hibernating animal in 2018-2020).

In Meijendel-Berkheide, the species has continued to increase, from a few dozen animals in the 1980s to a maximum of 588 animals in recent years. In the AWD (counted since 1986), the species has been found

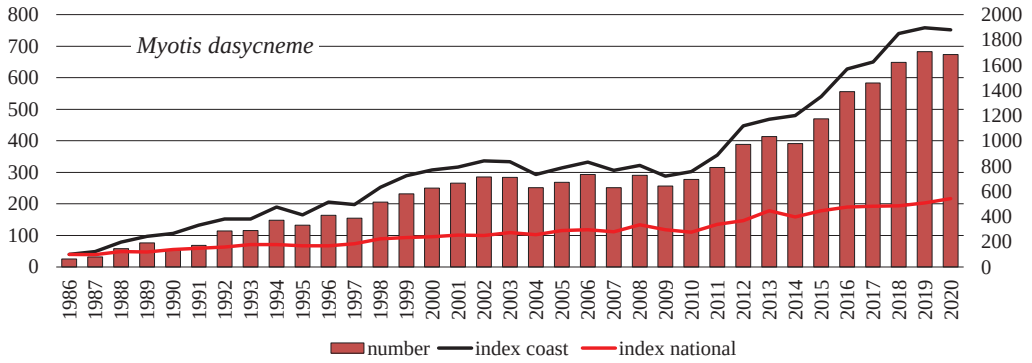

Figure 28. Number and index of hibernating pond bats (*M. dasycneme*) along the Dutch coast compared with the national index (NEM/CBS). Explanation: see caption fig. 19.

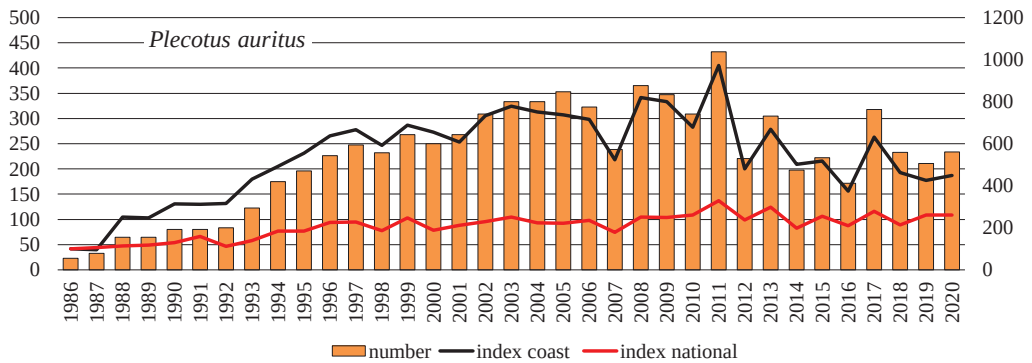

Figure 29. Number and index of hibernating brown long-eared bats (*P. auritus*) along the Dutch coast compared with the national index (NEM/CBS). Explanation: see caption fig. 19.

annually in increasing numbers since 1999, with up to 22 individuals in 2019. In recent years, the pond bat has continued to expand both southwards and northwards. Hibernating pond bats are now regularly encountered in the Westduinpark, Hoek van Holland and the Staelduinse Bos.

Brown long-eared bat (Plecotus auritus)

The brown long-eared bat is the third most numerous hibernating species along the Dutch coast. The number of brown long-eared bats account for 8% of the total and though the numbers can fluctuate strongly there are, as a rule, generally several hundred hibernators (with a maximum of 430 in the winter of 2011) (figure 29). The brown long-eared bat is the most widely distributed bat species along the coast, and hibernates in many small sites where other species are absent. Over the past decade, the number of animals in a number of subareas has declined. However, it is possible that this is partly due to milder winters, which may lead more animals to hibernate in tree holes and other habitats (Mostert 1997, Bekker 2022, in this issue).

The development of the numbers and the indexed values of brown long-eared bats showed a steady increase (with occasional dips) until 2011, after which the numbers spotted declined sharply (again with fluctuations): in 2011 there were almost 450 individuals spotted, in 2020 it was less than 200. The national index also increased between 1986 and 2011 but has decreased slightly since then, again with fluctuations (figure 29 and table 2).

After an initial increase in some subareas in the 1990s, the numbers have declined noticeably. In the 1990s, 50 specimens were counted in the Staelduinse Bos, but in recent years only up to twelve specimens have been found there. The casemates in the Hoeksche Waard and the harbour on the Eiland van Dordrecht house several dozen brown long-eared bats and there has been modest increase in the numbers counted there. In Haamstede, the highest number of 61 animals was counted in 1995, while in recent years a maximum of 14 animals were counted.

Other species

There are some bat species that have been reported occasionally in winter quarters along the Dutch coast: Geoffroy's bat (*Myotis emarginatus*), greater mouse-eared bat (*Myotis myotis*), common pipistrelle (*Pipistrellus pipistrellus*), Nathusius' pipistrelle (*Pipistrellus nathusii*), serotine (*Eptesicus serotinus*), barbastelle (*Barbastella barbastellus)* and grey long-eared bat.

Geoffroy's bat was found hibernating in 2016 in the bunkers in the Slotbos Haamstede on Schouwen (Mostert & Bekker 2017) and seems to be an occasional hibernator there. There is also an older report of two animals collected in September 1953 in the Kennemerduinen (Kapteyn 1995).

A greater mouse-eared bat was found hibernating on 2 February 2001 in the bunker in the Oostduinpark in The Hague. Since 2014 one hibernating animal has been present in one of the bunkers at Meijendel. Only two other hibernating cases are known of: in the Nova Zembla ice cellar near Duin- en Kruidberg, in 1984 and 1991.

Although the common pipistrelle is by far the most numerous bat species in the Netherlands, this species is only exceptionally found in hibernation sites such as bunkers, (ice) cellars and fortresses, apart from the hundreds of specimens that were recorded in the Ruïne van Brederode in several years. In Zuid-Holland, its hibernation is limited to a few dry bunkers in the inner dune area of Voorne, with up to five hibernating in most years and a maximum of 14 specimens in the winter of 2004. There are also incidental reports from the Staelduinse Bos and Berkheide. In Zeeland, up to two animals were regularly reported from Fort Rammekens, once in 1987 in Sluis and once in 2020 in Groede. In the 1990s there was a large winter roost behind wooden beams in the church tower of Veere. A maximum of 95 animals were counted in 1991.

Nathusius' pipistrelle is sometimes found during the winter census. Since 2014, the species has been counted annually in small numbers (up to seven animals) in the bunkers at Zuidwijk; in the winter of 2017, twelve animals were found. There are also incidental reports, from Clingendael (one in 2003), Berkheide (one in 2005-2007) and the Staelduinse Bos (one in 2017).

Up to five serotines were found hibernating annually between 1984 and 2005 in the gatehouse of Elswout and a solitary hibernating animal was found in the Ruïne van Brederode in 2007 and 2018. In Zeeland, a few solitary hibernating specimens were spotted in the church tower of Veere in 1986-1990, 2000 and 2003 and in the Keldermanspoort near Hulst in 1992.

In the 1980s and early 1990s, the barbastelle hibernated annually in the former boarding school near Sluis, where up to five specimens were counted. The last sighting was in 1994. This site has since been destroyed. Since then, the species has not been found in Zeeuws-Vlaanderen, and has not been spotted hibernating in the Netherlands. A hibernating grey long-eared bat was found twice in the same former boarding school, in the 1983 and 1985.

Conclusions and discussion

General trends along the coast

The trend in numbers of hibernating bats along the Dutch coast shows a remarkable growth since the 1990s (see figure 24). Since 1995,

this is only to a limited degree a result of an increasing number of counted sites (see figure 3). Daubenton's bat is by far the most numerous hibernating species along the Dutch coast, accounting for over three-quarters of the number of hibernating animals. The increase in the number of bats shown in figure 24 is therefore largely the result of an increase in this species. Since the 1970s, the number of Daubenton's bats has continued to increase, with the highest count in the last few winters. The pond bat only hibernates in large numbers in bunkers between IJmuiden and The Hague, with a maximum of 682 animals in the winter of 2019. In recent years there has been an expansion of the population in both a southerly and northerly direction and pond bats have become regular hibernators in the Westduinpark, Hoek van Holland, the Staelduinse Bos and also north of the Noordzeekanaal.

The number of whiskered bats initially grew from the 1990s until the winter of 2012, but since then there has been a marked decline. They have abandoned more and more subareas, such as the coastal area of Noord-Holland and Voorne, where the species previously occurred in small numbers.

Natterer's bat initially increased in numbers, but numbers have stagnated since 2010. Numbers of brown long-eared bat have also declined somewhat in the last decade. This is possibly partly due to the milder winters, as a result of which bats, particularly brown long-eared bats, more often hibernate in trees and other roosts. In summary, three of the five main hibernating species have shown a stagnation in growth or decline between 2011 and 2020.

In the 1970s, 1980s and sometimes later, many sites were closed to unauthorized persons and converted into bat roosts, reducing disturbance and making the quarters more suitable for hibernating bats. The trends calculated by the NEM / Statistics Netherlands (CBS), show progress for most species, although somewhat less strongly than on the basis of absolute numbers.

The question is whether the adjustments are the only reason for the increase or would the numbers have otherwise increased in the sites concerned? This question that cannot be answered. What is certain is that the modified sites contribute to a favourable conservation status for the species that hibernate there.

Relationship between winter quarters and maternity roosts

The extent to which the hibernating bats in the coastal area are related to the maternity colonies in the hinterland, especially the wooded inland dune area, is an intriguing question.

In the past few decades dozens of colonies of Daubenton's bats have been found in the inner dune area. Most colonies have been found in old deciduous trees; old country estates with many oaks and beech trees in a water-rich environment are especially suitable sites. The water catchment areas in the dunes near The Hague, Haarlem and Castricum are important foraging areas for bats. In the 1990s, the summer population of Daubenton's bats in the inland dune area in the west of the Netherlands was estimated at 1800 to 2000 adults (Mostert 1990b, 1993, Limpens et al. 1997). In the years 2015-2020 it was estimated to be at least 2500-3300 adult animals (table 3).

In Noord-Holland the summer population of Daubenton's bat was estimated at 1100 to 1400 individuals in the early 1990s, of which 900-1150 were in the inner dune area (Kapteyn 1995). The most northern colony in the dune area was found in Schoorl. More recent estimates are not available. However, the hibernation counts imply that the size of the summer population has probably increased.

In the inner dune area of Zuid-Holland, there have been 1150-1600 adult Daubenton's bats in recent years (Mostert 2011, 2012, 2020). The largest colony was 177 animals in Ockenburgh near The Hague. All the estates in and around The Hague were intensively examined in both 2009-2011 and 2015-2017 (Mostert 2012, Mostert & van der Kuil 2020).

Table 3. Number of colonies of Daubenton's bats in the inner dune area of the western Netherlands

	number of colonies	population size	min.-max.
Province of Noord-Holland			
Noord-Hollands Duinreservaat	8	10	300-400
Kennemerland-Zuid	15	20	600-750
Behind Polder Area	6	8	200-250
Province of Zuid-Holland			
Kennemerland-Zuid ZH	3	3	100-150
Leiden and surroundings	3	3	100-150
The Hague-Wassenaar	4	7	300-450
The Hague and surroundings	10	16	450-500
Delft	1	1	50-50
Staelduinse Bos	2	2	50-100
Voorne	3	3	100-150
Province of Zeeland			
Schouwen	3	4	150-150
Walcheren	2	3	50-100
Zeeuws-Vlaanderen	2	3	50-100
Total	*28*	*73*	*2500-3300*

In the first period, 16 maternity colonies were found with an estimated 350-400 Daubenton's bats, (largely based on counts of fledglings) and there were an estimated 450-500 adults in the second period. So, both the number of bats and the number of colony sites have increased.

On the islands of Zeeland, colonies have been found in the wooded inner dune of Schouwen and Walcheren (Mostert 1991). In addition the species has also been found in small numbers in the canals of old towns such as Zierikzee, Goes and Middelburg, although no colonies have been found there. A bat box in the Veerse Bos was once used as a maternity roost (Bekker 1990). Colonies also have been found in Zeeuws-Vlaanderen near Aardenburg and along the fortifications of Sluis and an unconfirmed sighting in the vicinity of Hulst. Two breeding colonies of Daubenton's bats were found in Aardenburg with 88 and at least 35 animals (Mostert 2017). In Zeeland, 250-350 Daubenton's bats are estimated to be present in the summer.

It is likely that a vast majority of the hibernating Daubenton's bats in the coastal area (2730-3740) spend the summer on the estates of the inner dune area (estimated 2500-3300 animals, see table 3). Reports of banded specimens suggest the same. In August 1990, 28 sub-adult Daubenton's bats were banded at the Overvoorde estate in Rijswijk (Mostert 1990b). In the following years, several banded animals were found in hibernation sites in the dune area. In January 1991, a banded animal was found in one of the bunkers in the Staelduinse Bos, 12 km southwest of the summer location. A second banded specimen was found in a bunker along the Galgeweg in Westland, about 8 km southwest of the banding site (Mostert 1993). In December 1993 and December 1994, two banded Daubenton's bats were found in the bunkers of Hoek van Holland (14 km southwest of the banding site). In December 1995 there was one specimen and in December 1996 three. The last banded specimen was found in December 1997. In total, at least five different individuals were found during the hibernation counts.

Some whiskered bats have also been observed in the wooded inner dunes. Most observations in Noord-Holland are from the area of Bergen and Haarlem; however, no

colonies or roosts have been found here. In the peat meadow area, up to 40 whiskered bats have been observed in West-Friesland, in Ilpendam and Abbekerk (15-20 animals), but since 2004 and 2010 these colonies have been abandoned. Based on old observations (Kapteyn 1995), droppings were collected from bats at five churches, in Aartswoud, Hoogwoud, Wognum, Spanbroek and Benningbroek (van den Tempel & Veldhuijzen van Zanten 2020). DNA from whiskered bats was found in all five attics. However, as the church attics were never cleaned, the droppings found may have been very old. Visual observations of whiskered bats were also made in two churches, in Opperdoes and in Spanbroek.

In Zuid-Holland, small colonies of the whiskered bat were known in Oostvoorne (under a roof moulding) and in the Staelduinse Bos (in a hollow oak). However, both colonies have not been present for a long time.

On Zuidwijk estate near Wassenaar a pregnant female whiskered bat was caught in 2006, but no roost was found (Achterkamp 2012). In June 2012, another attempt was made to find roosts by catching and tracking animals with transmitters. This led to the identification of three different roosts for an adult female within a radius of 1600 m from the first location. However, it did not lead to a maternity colony. Only a few foraging animals have been spotted around The Hague and Wassenaar and there are no recent reports from Zeeland.

In 2013, a group of six Natterer's bats were caught on the Elswout estate near Haarlem, including a female that had recently suckled a young and a young animal. Animals were also recorded in this environment with a bat detector (Hoogenboom et al. 2014). For the time being, this is the only known report of a colony of this species in the coastal area.

Between 1986 and 1993, the summer population of brown long-eared bats in Noord-Holland was estimated to be around 250-500 adults (Kapteyn 1995). Hoogenboom et al. (2014) estimate the summer population of brown long-eared bats in the same area to have been between 60 and 150 animals in the period 1994-2014. However, these numbers may be an underestimate, as the species is difficult to detect due to its soft sonar.

In Zuid-Holland the brown long-eared bat is known to occur in the summer in estate forests in the inner dunes and in a number of church buildings, especially in the east of the province. The population is estimated at 150 to 300 animals.

In Zeeland, the number of colonies of brown long-eared bats is limited (Bekker et al. 2010). In the Slotbos Haamstede, four small colonies, with a total of 23 animals, were found in trees (Mostert 2017) and in bat boxes on the Goudplaat (Noord-Beveland). In the Veerse Bos two colonies of approximately 30 and 20 animals were counted. Including specimens counted in church attics, the estimate for Zeeland thus amounts to 100 to 150 animals.

It is likely that the maximum summer population of brown long-eared bats along the entire coast, is around 600 individuals, which exceeds the maximum hibernating number of 430. This difference may be explained as brown long-eared bats also use other types of winter quarters.

The relationship between the hibernating pond bats and colonies of males has been demonstrated through banding. This relationship is discussed among others by Haarsma & Tuitert (2009) .

Opportunities and threats

Hibernacula in the immediate vicinity of aging woodland areas, generally offer good opportunities for various bat species. The felling of old trees and the removal of dense undergrowth around bunkers may be the cause of a temporary decline in the numbers of counted hibernating bats (for example on Schouwen).

Intact bunkers in the dune areas of the Staatsbosbeheer, Natuurmonumenten or those of the three Landschappen (Noord-Holland,

Zuid-Holland and Zeeland) are usually well protected. Most of the complexes are not accessible to unauthorized persons and many bunkers frequented by bats in the winter are closed with steel doors or a fence. In many cases, these measures have resulted in a higher occupancy of hibernating bats. Nevertheless, a large number of bunkers are still entered by unauthorized people. The frequent breaking open and disruption of sites remains a source of constant concern, especially when fireworks are set off (for example in Hoek van Holland). Indications of overnight stays are regularly found and in a few cases bunkers are used as a base for poaching.

There are also indications that partial opening until late summer or autumn for other management objectives has a detrimental effect on hibernating bats.

A number of bunkers, built on unstable ground, are slowly sinking into the clay soil (for example on Walcheren). There are also some bunkers in dynamic dune areas that are gradually being covered by drifting sand (for example on Schouwen).

A comparison between bunkers on Voorne that are managed privately and by nature conservancy agencies point out that the former category shows a less favourable long term trend in bat numbers than the later. Changes of ownership and the bunkers being used for other purposes are the main causes of this.

Acknowledgements: Our thanks go to the many people who have helped with or coordinated (often for many years in a row) the winter counts: Gerben Achterkamp, Piet Admiraal, Ben van As, Sebastiaan Bakker, Ernest Bekker, Hans Bekker, Klaas van den Berg, Fons Bongers, Suzanne Boon, Menno van den Bos, Jan Boshamer, P.W.M. Bijnsdorp, Lucien Calle, Suzanne Cosijn -Boon, Rob van Dam, Jan Alewijn Dijkhuizen, Rogier Dijkstra, Vilmar Dijkstra, M. Dirkson, Mark Dobbelaar, Sandra Dobbelaar, Linda Doedens, Bernard van Duinen, Marina Fijten, Dick Groenedijk, Rob and Alexandra Haan, Anne-Jifke Haarsma, Anton van Haperen, Adrie van Heerden, N. Hogeweg, Nanning-Jan Honigh, Dorien Hoogeboom, Merijn Hoogendoorn, Klaas Kaag, Leon Kelder, Guido Keijl, Dick Klees, Luc Knijnsberg, Tjeerd Kooij, Rene Kriek, Rudy van der Kuil, Sander Lagerveld, Maarten Laming, Rogier Lange, Peter Lina, Ruud Luntz, Gerrit Makelaar, Han Meerman, Xander Meijers, Anton van Meurs, Veronique van Meurs, Bart Noort, Walter Oosterom, Marlous Pauw, F. Richter, Ton van Rijn, Ester Rodriguez, Ina Roels, Martijn van Schie, Ton and Kees van Schie, Evelien Spijkman, Bert Stam, Karina Stienstra, Carola van der Tempel, Eric Thomassen, Kees Timmermans, Piet Veel, Susanne van der Veer, Fenneke van de Vegte, Jowien van de Vegte, Huub Veldhuijzen van Zanten, Job van der Veldt, Joost Verbeek, Monique Versloot, Petra Vlaming, Floor van der Vliet, John van Vliet, Aldo Voûte, Sjakel Wesemael, Alex Wieland, Jeroen Willemsen, Richard Witte, Hans Wondergem, Jan Wondergem, E. Zeilstra and Annemieke van Zuijlen.

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Received: 16 December 2021
Accepted: 29 March 2022