Guidelines for consideration of bats in offshore wind farm projects

Authors' list and order to be determined in the end, according to contribution

Foreword

Following Resolution 4.7, approved at the 4th Session of the Meeting of Parties of EUROBATS (Sofia, Bulgaria, 22–24 September 2003), the Advisory Committee of the Agreement was requested to "*assess the evidence of the impacts of wind turbines on bat populations and, if appropriate, to develop guidelines for assessing potential impacts on bats and for the establishment of wind turbines in accordance with the ecological requirements of bat populations*". In response to this request, the Intersessional Working Group (IWG) on Wind Turbines and Bat Populations was established during the 9th Meeting of the Advisory Committee (Vilnius, Lithuania, 17-19 May 2004), and some members of the IWG volunteered to prepare guidelines for assessing potential impacts of wind turbines on bats. The first generic guidelines were adopted at the 5th Session of the Meeting of Parties (Ljubljana, Slovenia, 4–6 September 2006) as an Annex to Resolution 5.6, and published as EUROBATS Publication Series No. 3 (Rodrigues *et al.* 2008). Resolution 5.6, as well as the subsequent Resolution 6.11, approved at the 6th Session of the Meeting of Parties (Prague, Czech Republic, 20–22 September 2010), requested the Advisory Committee to "*keep the generic guidelines updated*". Accordingly, volunteering members of the IWG prepared the revised version of guidelines, which was adopted at the 7th Session of the Meeting of Parties (Brussels, Belgium, 15-17 September 2014) as an Annex to Resolution 7.5, and published as EUROBATS Publication Series No. 6 (Rodrigues *et al.* 2015).

The first generic guidelines aimed primarily to raise awareness about the need to consider bats in wind turbines (WT) development amongst stakeholders, and were a basis for national guidelines that were later published in several countries. The revised version of the guidelines was built upon increased knowledge of the impacts of (onshore) WTs on bats and became widely recognised European best practice on the subject.

Resolution 9.4, approved at the 9th Session of the Meeting of Parties (Brijuni, Croatia, 10–13 October 2022), requested the Advisory Committee to "*update the generic guidelines, now available as EUROBATS Publication Series No. 6, by MoP 10*". Following comprehensive discussions among the IWG members during the 2023-2024 intersessional period, it was decided to split the guidelines into two distinct documents: one focusing on offshore and the other on onshore projects. Furthermore, the development of the offshore project guidelines was considered more urgent, based on substantial scientific knowledge on the topic accumulated since the previous revision. Accordingly, the guidelines for offshore projects have been prepared (this document) and subsequently adopted at the 10th Session of the Meeting of Parties (Valletta, Malta, 10-13 November 2026) as an Annex to Resolution 10.X.

EUROBATS Publication Series No. 6 remains valid for ***onshore wind turbines (WTs)***, whilst new separate onshore project guidelines will be prepared when the increased knowledge justifies the update.

In these guidelines, we tried to compile available evidence related to the effects of ***offshore WTs*** on bats, as well as to identify key knowledge gaps and associated research priorities. Based on the current state of knowledge, recommendations are formulated on pre-construction considerations and surveys, monitoring and mitigating the impacts. For the purpose of these guidelines, we use the term ***offshore WTs*** in a broad sense, to refer to any wind energy installations built at sea, including both developments occurring in inshore waters as well as those further from the coast (i.e. in offshore waters in the strict/legal sense).

According to Resolution 9.4 (and all precedent resolutions), Parties (and non-Party Range States) should adapt generic EUROBATS guidelines to their situation and develop or update their national guidelines accordingly, and ensure their implementation.

Terms highlighted in ***bold and italics*** are included in the Glossary.

1 Introduction

Currently, there are 55 bat species occurring in the EUROBATS area and listed under the Agreement. Bats are protected by law in all European countries. Those occurring in EU countries are protected by the Habitats Directive: all species are listed in Annex IV (species of community interest in need of strict protection) and some of them additionally in Annex II (species of community interest whose conservation requires the designation of special areas of conservation). In addition, most species are listed as Threatened on Red Lists of one or more European countries, in Europe and/or globally (IUCN 2025).

The need to tackle climate change and to find sustainable methods to meet demands for power production are priorities for Europe. Furthermore, there is a growing public and political awareness of the need to reduce dependence on fossil fuels. The commitment to low-emission energy generation has led to the promotion of renewable energy, such as wind power, following Kyoto Protocol and EU Renewable Energy Directive (Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023, amending and/or subsequently repealing Directives 2001/77/EC, 2003/30/EC, 2009/28/EC, Directive (EU) 2018/2001). Further acceleration in wind energy developments is anticipated as a consequence of the framework designed to expedite the permitting process, according to Council Regulation (EU) 2022/2577 of 22 December 2022, amended by Council Regulation (EU) 2024/223 of 22 December 2023.

Environmental Impact Assessment (EIA) is required in all European countries for all projects likely to have significant effects on the environment, including wind energy. In the EU, this requirement is regulated by Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011, amended by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014, on the assessment of the effects of certain public and private projects on the environment. Furthermore, the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) requires parties to assess the environmental impact of certain activities at an early stage of planning, and notify and consult each other on the activities likely to have a significant adverse transboundary impact (Official Journal of the European Communities C 104, 24.4.1992, pp. 7–19). According to Espoo Convention’s Protocol on Strategic Environmental Assessment, these activities explicitly include wind farms, both offshore and onshore (Official Journal of the EU L 308 19.11.2008, pp. 35–49).

Impacts of ***onshore WTs*** on bats are well documented (Rodrigues *et al.* 2015) and include direct killing as the most significant impact (reviewed by Arnett *et al.* 2016 and Lentini *et al.* 2025), but also habitat loss and/or displacement (e.g. Roeleke *et al.* 2016, Barré *et al.* 2018, Ellerbrok *et al.* 2022, Reusch *et al.* 2022, 2023). Conversely, due to practical and methodological difficulties in studying bat behaviour and fatalities in the onshore environment (see section 1.3, the evidence on the impacts of ***offshore WTs*** on bats is still scarce (Hooker *et al.* 2025). However, there is an increasing knowledge on bat offshore activity (which is summarised in section 1.4), and recent evidence on bat behaviour around ***offshore WTs*** (see section 1.5) that indicate that the impacts are likely similar to those around ***onshore WTs***. Therefore, the ***offshore WTs*** are likely to cause bat fatalities, while habitat loss and/or displacement cannot be ruled out in certain contexts (see section 1.5.3).

Since all European bats are protected by international and national legislation, any intentional killing is forbidden by law. Therefore, avoidance, or at least reduction to a minimum, of bat mortality by ***WTs*** is not only a priority for bat conservation, but also a legal obligation in Europe. Accordingly, consideration of bats in the impact assessment of ***onshore WT*** development has become a well-established practice, as well as mitigation and monitoring of impacts, whilst challenging and thus rarely undertaken for ***offshore WTs***. Considering the continuously growing offshore wind energy capacity, and particularly plans and legislation aimed at further rapid growth and acceleration of ***offshore WT*** development, the need to consider bats in ***offshore WT*** development has become evident and urgent. These guidelines aim to promote and facilitate pre-construction considerations and surveys, as well as the monitoring and mitigation of the impacts of ***offshore WTs*** on bats.

1.1 Offshore wind turbine structure and associated risks to bats

Offshore WTs can be divided into two main structural types: fixed support and floating ***offshore WTs*** (Asim *et al.* 2022). Floating wind turbines are more economically viable in deep waters (>60m depth); however, their floating platforms can serve as resting sites for migratory species (i.e. attraction), and this may increase collision risk (Maxwell *et al.* 2022, see section 1.5). Bats may also rest on ***offshore WT*** with fixed support.

The risk of collisions is a function of the number of turbines at a site and the size and design of the turbines. Offshore wind farms often include more turbines than those built onshore (Enevoldsen & Valentine, 2016). Furthermore, ***offshore WTs*** are frequently larger than their onshore counterparts, due to fewer transportation constraints at sea (Bošnjaković *et al.* 2022). While existing rotor diameter of ***offshore WTs*** built in the 2020s can reach 200 meters, current ***offshore WTs*** of the 24 MW class are more than 300 m tall, and for 2030 rotor diameter of 350 m are expected (Bilgili *et al.* 2023, GWEC 2025). An additional feature is that ***offshore WTs*** have very large turbine diameters in relation to their size. As a rule, the space between the sea and the lower rotor blade tip is only 25 m, much less than at larger ***onshore WTs.*** In addition, similar to ***onshore WTs***, ***offshore WTs*** are marked with lights at nacelle height for passing air traffic but, unlike ***onshore WTs***, lights can also be installed at their base for marine traffic.

1.2 Offshore wind energy development in Europe

Europe is a one of the leaders in offshore wind energy, with 37GW of installed capacity in 2025 (WindEurope 2025), largely driven by installations in the United Kingdom (Table 1). The first world commercial offshore wind farm was installed in Denmark in 1991, 1.5 to 3 km off the coast (11 turbines, Vindeby, decommissioned in 2017). Similarly, the world’s first floating wind farm was installed in Scotland in 2017 (Hywind, 5 turbines), 25 km off the coast.

1.2.1 Current state and plans

It is anticipated that by 2030, Europe will have 80 GW of installed offshore capacity, and EU countries will have 45.5 GW (WindEurope 2025). Maps of the offshore wind farms, already installed, under construction and planned, are available online (TGS 4C 2025a, European Commission 2025, WindEurope 2026).

***Table 1**: Overview on the offshore wind energy installed capacity and future projects in Europe. Data collected from WindEurope (2026), TGS 4C (2025a), Government of Norway (2026) and local experts' information.*

Region	Country	Installed capacity (GW)	Installed wind farms	Installed wind turbines	Under construction wind farms	Goal 2050 (GW)[1]
Baltic	Denmark	1.48	10	357	0	7.2
	Germany	1.81	5	309	1	4.1
	Estonia	0	0	0	0	7
	Latvia	0	0	0	0	5
	Lithuania	0	0	0	0	4.5
	Poland	0	0	0	1	17.9
	Finland	0.07	3	19	0	12
	Sweden	0.20	5	80	0	-
Northern seas	Belgium	2.26	11	399	0	8
	Denmark	1.17	7	272	1	35
	Germany	7.28	20	1330	3	65.9
	Ireland	0.03	1	7	0	22
	France	1	2	133	2	15-18
	Netherlands	4.74	10	670	1	70
	United-Kingdom	16.58	45	2878	5	50 [2]
	Norway	0.10	1	11	0	30
Atlantic	Ireland	0	0	0	0	15
	Spain	0.01	2	2	0	0.54-1.56
	France	0.5	1	81	1	21-25
	Portugal	0.03	1	3	0	10
Southern seas	Greece	0	0	0	0	11.8
	Spain	0	0	0	0	0.5-1.5
	France	0.02	1	3	3	6
	Italy	0.03	1	10	0	8.5
	Malta	0	0	0	0	0.35
	Bulgaria	0	0	0	0	2.9
	Croatia	0	0	0	0	3
	Cyprus	0	0	0	0	0.1
	Romania	0	0	0	0	3
	Slovenia	0	0	0	0	0

[1] Data from the Non-binding agreements on goals for offshore renewable generation in 2050. Article 14 (1) of the TEN-E regulation (EU) 2022/869 (2024) (CIRCABC 2024). [2] Goal for 2030.

Baltic sea

Currently, Germany and Denmark are the biggest offshore renewable energy producers in the Baltic Sea (including Kattegat) with about 3.3GW of installed capacity (Table 1). However, other countries such as Poland, Sweden, Estonia and Finland aim to drastically increase their production by 2050 (Table 1).

Northern seas (west)

In the Northern seas (including. North Sea, Celtic Sea, Irish Sea, English Channel), the United Kingdom accounts for more than 16 GW of installed capacity (Table 1) corresponding to 50% of the total European installed capacity. There are major plans for expansion here, as well as in Irish waters. In addition, However, by 2050, Germany and the Netherlands may become the biggest producers (Table 1). So far, wind farms in those areas are mainly fixed but some floating wind farms are developing (TGS 4C 2025b).

Atlantic

In the Atlantic Ocean, only three wind farms are operational so far, but a goal of about 46 GW is expected by 2050 (Table 1). The biggest wind farm is located in the Bay of Biscay, more than 12 km off the French coast. France aims to develop at least four more projects in that area in the next 10 years. In addition, Spain has also one wind turbine (producing 0.005GW) further south in the Atlantic Ocean next to Gran Canaria.

Southern seas

The Southern seas include the Mediterranean Sea and the Black Sea. In 2025, only Italy and France have installed offshore wind farms (Table 1) and plan further development both towards more open areas in the Mediterranean Sea and more closed Adriatic Sea. Greece aims to produce about 12 GW by 2050 (Table 1) in areas close to the islands, mostly in part of the Aegean Sea but also in the Sea of Crete. Most of the projects in the Mediterranean Sea are floating wind farms (LLoret *et al.* 2023, Wawrzynkowski *et al.* 2025) and therefore may have different impacts on biodiversity than fixed structure as in the northern seas. The western part of the Black Sea is currently projected for offshore wind farm development, with World Bank estimates of 3-10 GW developments, potentially using monopiles fixed on the seabed under 75 m depth (World Bank & IFC 2024).

1.2.2 Ambition for further expansion and acceleration

To meet the European Renewable Energy Directive (aim for renewable energy production of 45% of the EU's gross final energy consumption by 2030), deployment will be accelerated, according to Council Regulation (EU) 2022/2577. To that aim, the EU has introduced the renewables acceleration areas (RAAs) that are “areas where the deployment of renewable energy projects of a specific technology is not expected to have significant environmental impacts” (Directorate-General for Energy, 2024). Therefore, by February 2026, Member States have to map areas that can be designated as RAAs for offshore wind farms (European Commission 2025, Directorate-General for Energy & Trinomics 2024). However, projects up until 2028 are already auctioned (WindEurope 2025).

As a result of this acceleration, by 2030, the European Union will have 54 GW of offshore wind energy capacity (corresponding to about 15% of the EU total wind energy capacity) and this number will increase very rapidly (c.f. goal for 2050 Table 1).

1.3 Methods for offshore bat surveys

Surveying bat activity, especially migration, is more complex offshore than onshore, owing to the extreme environmental and logistical challenges. These include isolated locations that are difficult to access, the impacts on equipment of salt water, waves, stormy weather, etc., and the lack of suitable structures to use for observations. Passive acoustic monitoring (PAM) seems to be the most efficient method for general surveys of temporal and spatial variations in bat activity, although the species-specific detection range is very limited (20-60m). The method can be combined with other techniques for more detailed studies of specific occurrences, individual behaviours, flight routes, or collisions. Approaches for such projects include manual observations, infrared cameras, radio tracking, surveys at take-off points, and radar.

Whatever the method, contextual information on weather conditions — wind speed, temperature, rainfall, and air pressure — collected from the nearest meteorological station is vital for interpreting bat activity data at sea. Simultaneous data on bat migration data from close coastal habitats or at possible departure points can also help to explain the results (see section 1.3.2).

When planning monitoring, it is vital to consider inter-annual variability. Preconstruction surveys should span a minimum two years to record potential annual variations in offshore bat activity and migration (BSH 2013, Klop et al. 2024, McKay et al. in press). Continued post-construction surveys and monitoring from offshore structures are also essential to evaluate the collision risk and potential effects of ***offshore WTs***. A review of the current methods is given in Lagerveld et al. (2020) and Mollis et al. (2019).

1.3.1 Passive acoustic monitoring (PAM)

Passive acoustic monitoring is well-established as one of the primary techniques for monitoring bats on- and offshore. It provides a useful index of activity patterns, including geographical, seasonal and diurnal variations (e.g. Bach et al. 2022a; Brabant *et al.* 2019, Brabant *et al.* 2021, Brinkløv *et al.* 2024, 2025, Lagerveld *et al.* 2021, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2026b). Where activity levels are very low, it is possible to infer the passage of individual bats. This situation has been encountered with buoys and some offshore platforms or offshore WTs (Seebens-Hoyer et al. 2026b; Lagerveld et al. submitted). In other cases it is not possible to separate out the activity of individual bats, particularly where there is foraging or exploratory activity, such as on islands or at offshore structures being investigated as roosts.

Bat detectors can be installed at a variety of offshore structures, including buoys, lighthouses, scientific platforms (e.g. Brinkløv et al 2024, Hüppop & Hill 2016, Seebens-Hoyer et al. 2022, 2026b, Solick & Newmann 2021), shipping vessels (Hobbs et al. 2014, Meyer 2011, Seebens et al. 2013), and ***offshore WTs*** (e.g. Brabant et al. 2019, Brinkløv et al 2024, Ecocom 2015, Lagerveld et al. 2014), as well as isolated islands (e.g. Bach et al 2009, 2017, 2022, Jonge Poerink & Haselager 2013, Petersen et al. 2024, Solick & Newmann 2021, True et al. 2021). When using existing static structures, such as ***offshore WTs***, platforms, or lighthouses, detector placement is necessarily restricted to the location of the structure.

Buoys allow more flexibility in positioning, though options may still be limited by shipping routes, areas of special military interest, and construction activities.

PAM from boat transects (see Rodrigues et al. 2015) has been used for studying bat activity (Hobbs et al. 2014, Meyer 2011, Seebens et al. 2013, Kalda pers. comm., Peterson 2016). While vessels that can run a project-specific route may provide some useful data, transects are logistically challenging because of the need for suitable weather windows for safe night time navigation especially where sites are very distant from shore. Like land-based transect surveys, they also have more limited temporal coverage than static bat detector surveys. Another option is to use regular ferries, but often few recordings are obtained with this method (Seebens et al. 2013; Mathews pers. com. (Bay of Biscay and English Channel), Schofield pers. com (Irish Sea)). Reasons for the low productivity of this approach include constraints on the positioning of detectors on large vessels which means that microphones may be high above the water level, but not at levels comparable with the turbine zone of risk; the considerable background noise from engines, air-conditioning units, and wind; and the use of a relatively fixed route which may not coincide with the most important areas for bats. Nevertheless, the method can be helpful in near shore conditions.

PAM surveys at sea level will only record bats near the microphone, which is usually mounted at or below nacelle-height (Ahlén et al. 2009, Hurme et al. 2025, Petersen 2016, Lagerveld et al. 2024, Seebens-Hoyer et al. 2026b). For the detection of activity at higher altitudes of around 100 to 150 m, recorders can be installed at existing ***offshore WTs***, or on masts at platforms (Brabant et al. 2019, Brinkløv et al 2024, Ecocom 2015, Seebens-Hoyer et al. 2026a). Post-construction, bat detectors can be installed at the nacelle and at the service platform. Attempts have been made to overcome the limited air volume surveyed by deploying additional detectors at the nacelle as well as at ground/sea level, or by deploying detectors at varying heights on the turbine tower (e.g. de Jong *et al.* 2021, Brabant *et al.* 2019, Ecocom 2015), or using a variety of existing structures of differing heights (e.g. Lagerveld et al. 2023, Seebens-Hoyer et al. 2026a). However the difficulty of covering a sufficiently large fraction of the rotor-swept area highlighted onshore (Voigt et al. 2021) are even more pronounced offshore.

It is currently unclear how bat acoustic data collected pre- construction relate to collision risks, with varying and non-linear relationships being found in the onshore environment (e.g. Lintott et al. 2016; Voigt et al. 2021), and no data being available from ***offshore WTs***. In some European countries acoustic data are used as part of reactive automated curtailment protocols applied onshore and without a requirement for site-by-site efficacy assessment (e.g. Behr et al. 2023). However, this approach is not permitted in many other countries, in line with Eurobats Resolution 9.4.

In several countries acoustic surveys are used as standard procedure to assess offshore bat activity, e.g. the Netherlands, Denmark and Germany (BSH 2013). Ecological impacts of ***offshore WT*** wind farm developments have also been assessed by using transect surveys from boats and/or acoustic surveys from platforms. However, there has been little research using approaches such as before-after-control impact (BACI), which would be valuable in assessing the impacts of ***offshore WTs*** on bat activity. Consideration must also be given to the very limited statistical power of many surveys to detect differences even if they do exist, owing to the combined effects of low activity levels, the clustering of offshore migration into small periods, and the technological challenges of maintaining continuous long-term monitoring. However, the limited numbers of detections registered offshore, and the limited duration of surveys, means that these approaches have extremely limited statistical power to detect differences even if they truly exist, especially as bat migration offshore occurs highly clustered in only a few nights.

1.3.2 Manual acoustic point counts and visual observations

Manual detector surveys at fixed points likely to be used for departure or return, can provide important evidence on bat migration (Ahlén 1997, Ahlén et al. 2009), particularly if combined with imaging surveys e.g. thermal-imaging. Here it is possible to observe and count bats leaving mainland or island locations, and monitor their flight directions. Ideally, all major exit areas from the coast, and areas where the bats make landfall on the opposite coast, should be monitored. Visual observations, again in combination with bat detectors, can also be made from maritime vessels (Dundarova et al. 2021, Sonntag et al. 2006, Walter et al. 2007). Here, the focus usually lies on recording bat presence, though behaviour of bats at ***offshore WT*** can also be studied (Ahlén et al. 2009, Seebens-Hoyer et al. 2026a).

Another possibility is to tag bats (see section 1.3.4) and track their departure to the sea. By linking these observations and tracks with weather variables, inferences can be made about the conditions associated with offshore migration (Ahlén et al. 2009, Bach et al. 2022b, Lagerveld et al. 2024), and potentially also to develop curtailment strategies for ***offshore WTs***. However, it must be recognised that acoustic records are likely to be limited to low-flying bats, whereas those using high altitudes will be outside the range of the detector (Lagerveld et al. 2024). Tagging and tracking does not have these limits, but is in other ways restricted, e.g. the need of a receiving station network and the need to catch and tag bats (Lagerveld et al. 2024).

1.3.3 GPS-Tracking

Geographical positioning system (GPS) tags give the most precise estimate of animal positions, but tags which transmit their data to satellites, and therefore do not need to be retrieved for data download, are much too large to be applied to most of the any European bat species (excluding *Rousettus aegyptiacus*). Recently developed medium sized tags weighing around 2.0 g can send GPS point data to base stations, avoiding the need for tag retrieval, but the bats need to fly close enough for the data to be transferable, and the tags are too large for most European species. Miniaturised GPS tags (0.7-1.0g) have also been applied, but these rely on the recapture of animals to download the data, and are therefore more suited to assessing local movements in places where roosts are known, than to monitoring long distance movements such as migration and dispersal. There are also ethical and permitting considerations, because of the need for rapid recapture of individuals to remove tags before they fall off. The approach also only provides data for a very short time window (often a single night per bat) and is restricted to environments where there is a reasonable probability of recapture. Nevertheless, useful insights have been gained from miniaturised GPS tags. For example, research using this approach has demonstrated that at least some common noctules *Nyctalus noctula* forage up to 12.7 km offshore from the Dutch coast, though the home ranges of adult females are primarily terrestrial (Lagerveld *et al.* 2021). In Croatia, *Nyctalus lasiopterus* have been recorded flying offshore more than 15 km away from islands and coast, and were regularly using offshore environments during their daily movements (Mazija *et al.* 2025).

Miniaturised GPS tracking devices have also been used to assess bat activity relative to wind turbines in onshore locations. For example, in a coastal region of Germany, *Nyctalus noctula* avoided feeding areas associated with onshore wind turbines, but was attracted to turbines at a local scale when they were situated close to roosts (Reusch *et al.* 2022). *Nyctalus leisleri* have also been found to exhibit a small degree of attraction to turbines, based on results of GPS tracking in German onshore habitats (Scholz et al. 2025). GPS tracking can also give an indication of the 3 dimensional space used by bats in flight. Altitudinal estimates are subject to two to three times more error than horizontal location estimates, but they could nevertheless offer useful data for estimating the likely hazards posed by the rotor swept area. For example, one onshore study found that most flights of *Nyctalus leisleri* were at heights likely to put them at risk from wind turbine blades (Scholz et al. 2025).

1.3.4 Radiotracking and GPS-near systems

Radiotracking using static receiver arrays, such as the ATLAS, Motus, or Celltrack Technologies (CTT) systems (Beardsworth *et al.* 2022; Bijleveld *et al.* 2022; Lagerveld *et al.* 2024, Allan 2026) offer an alternative approach to monitoring bat flight paths. Tags have also recently become available that can monitor long-distance movements autonomously by recording time and estimating locations via existing Internet of Things networks, rather than requiring the construction of a new network of receivers (e.g. Sigfox LoRA, Hurme et al. 2025, Mazija *et al.* 2025, or IoS CTT BlueBat+ tags, Mathews pers com.). These can be boosted, in areas with low network coverage, by additional beacons. In relation to offshore bat activity, they are best deployed to detect long-distance migrations, coastal movements, and the presence of a sea crossing (the tag being detected on either side of the crossing) since opportunities for tag detection in the offshore environment itself are limited. Some of these tags can achieve GPS-close positioning (<100m) (provided they are near a suitable network or beacon); whereas others have a resolution of several kilometers.

1.3.4.1 ATLAS-System

The ATLAS-System (ATLAS = Advanced Tracking and Localization of Animals in real-life Systems) is based on differences in tag-signal arrival at receiver stations of individually coded tags. This system provides GPS-scale precision estimates of animal locations. However, as with GPS tags, the tags are too large for most European bats (minimum size of 0.9g excluding attachment). There is an array of Atlas receivers that intensively monitor an area of 40 x 60km in the Wadden Sea which has been used for ecological studies of bird activity (Bijleveld *et al.* 2022). The authors are only aware of one European study that has deployed them on bats, to investigate the foraging behaviour of common noctules *Nyctalus noctula* in Germany (Roeleke *et al.* 2022). Both of these examples are outside the context of wind energy development.

1.3.4.3 Motus and Static telemetry systems

The Motus Wildlife Tracking System (Taylor *et al.* 2017) uses a network of static radiotracking aerials that are connected to logging devices (‘receiver stations’). When bats pass within range of the receiver, its presence is recorded along with a time-stamp. Although other kinds of static radiotracking networks are available (e.g. stand-alone CTT or Track-IT systems), the key distinguishing feature of the Motus Network is that recorded data is transmitted, following a time-delay, to an online platform. Here, the data can be viewed by other researchers with appropriate access. Hence, it is possible to use the combined array of receivers deployed internationally in order to track large-scale movements.

An advantage of the Motus system is that the tags are of suitable size for use with most European migrating bat species. However, the tag identities are re-used, which has some potential for erroneous results. In addition, the operating frequency commonly used for the network in Europe (150.1MHz) requires large yagi antennas which are prone to wind drag and lightning strike. Although smaller omni-directional antennas can also be used, these have a much smaller detection range. CTT also offers a static receiver system operating on a higher frequency (433MHz). This requires much smaller antennas, less susceptible to wind drag, receivers and has uniquely coded tags. However, the tag sizes are larger meaning that they are only suitable for medium to large European bats. In addition, there are currently few installed receiver stations (whereas this 433MHz is the dominant frequency in North America), making it a less attractive option for large-scale studies in Europe as it would require the installation of new antennae.

The physical installation of receiver stations and antennae is fairly complex. Ongoing technical updates and maintenance are also required (rather than the system being ‘plug-and-play’), which means that long-term funding must be available. These challenges are exacerbated in offshore environments where access can be difficult. There is an extensive network of coastal Motus receivers along the coast of Belgium,the Netherlands and Germany, with smaller numbers in England, France, and Scandinavia, but there are currently very few located offshore. Therefore, to date, research has focused on establishing the presence of offshore movements, and understanding seasonal and weather associations of sea crossings and coastal movements, particularly for Nathusius’ pipistrelle *Pipistrellus nathusii* (e.g. Bach *et al.* 2022b; Lagerveld *et al.* 2021, 2024).

In addition to recording the existence of sea-crossings and coastal movements, static radiotracking systems would be particularly well suited for monitoring activity within wind farms, assessing the distance between the flight path and turbines, and for comparing curtailed and operational blocks. Receiver stations with excellent fields of view could be installed across the wind turbine array, and the normal distance between offshore wind turbines is well within the detectable limit of a radio-tag with a clear line of sight. It would not provide comparable precision to GPS or near-GPS systems, but bat localization to within 200m is possible (Allan 2026). However, to make comparisons between activity in the zone surrounding the turbines and the turbine array, it would be necessary to build additional platforms outside the wind farm on which receivers could be stationed, since identifying the location of individuals by triangulation requires data from at least three receivers.

1.3.4.3 Autonomous GPS-adjacent tags

Tags have recently been developed that make use of existing networks to communicate data and provide GPS-adjacent locational data. LoRa ("Long Range") and IoT ("Internet of things") networks exist for other purposes, and the tags are small, lightweight, and use little power. No additional infrastructure investment is necessarily required from researchers unless network coverage is poor, in which case researchers can boost the network using additional beacons.There is no operator lock-in and the data are secure. However, operation does depend on network coverage. For example, the Sigfox network has been used with great effect to study the movement of Nyctalus species in several European countries (Hurme et al. 2025), but have been less useful in the UK and Ireland, most likely because of network coverage issues. When applied to *Nyctalus leisleri* and *Nyctalus lasiopterus* individuals on an island in Croatia, the results from showed poor spatial resolution. Nevertheless they clearly indicated the directions of bat movements where tags reached networks across the sea, all the way to Italian shore (Mazija *et al.* 2025). Tags are also available that use other IoT networks, including that created by bluetooth-enabled Apple (IoS) devices (CTT BluBat+). In this case, coverage will depend on the density of such products, and is likely to offer very high resolution data in urbanised areas (such as ports and coastal towns), but will be less spatially-precise in rural areas.

1.3.5 Optical and vibration monitoring systems

Optical systems have also been applied to monitor birds, and to a lesser extent, bat activity at wind turbines. These systems are frequently linked to automatic curtailment systems e.g. DT Bird®, Safewind®, Probird®. Changes in pixel contrasts between successive images are used to identify moving objects, and size classification is used to identify objects that could plausibly be the target animal (note that the approach is not able to distinguish species). Three-dimensional (3D) systems which incorporate triangulation of each position provide greater opportunities to understand the location of the animal relative to the blades and therefore identify risky behaviours. Unlike radar and 2-D systems, according to the manufacturers, they are also capable of detecting collisions with a high degree of certainty. However, they require more cameras and greater amounts of data processing, and are therefore more expensive. In addition, there can be large margins of error on position estimates when cameras are placed close to each other, which can be a challenge with the relatively limited space available on an ***offshore WT*** platform. Some systems have been modified and marketed specifically for triggering curtailment for bats (e.g. DT Bat®, Thermal Tracker 3D ® (Matzner *et al.* 2023). These generally use thermal (Long Wave Infra-Red) cameras, because providing sufficient illumination to the rotor-swept area with infra-red lights is difficult, and they also perform better in wet or foggy conditions. However, even with thermal cameras, assessment of the entire rotor swept area is very challenging as the blade tip is often 200m from the base of the wind turbine platform. Cameras with such a long focal length are extremely expensive and have very narrow fields of view, necessitating multiple cameras for adequate coverage of the rotor-swept area. Point-track-and-zoom systems are also being developed, but research is needed to determine how effective these are at 'locking' onto bats and following their movement path, particularly given that views are frequently interrupted by moving rotor blades. There is currently much investment in the development of visual systems. Many are attempting to use AI to identify target objects, sometimes integrated with triggers for shutdown. None of these systems has been formally evaluated using standardised techniques for either bats or birds to assess their detection efficiency or the effectiveness of the triggered curtailment in preventing collisions (Ballester *et al.* 2024). Also, in most offshore scenarios, considerable notice periods (days or longer) are required to implement shutdowns, owing to other overriding considerations such as the maintenance of high-voltage grids. Therefore, while there is potential to trigger mitigation in some particular circumstance, it should not necessarily be assumed that technologies suitable for deployment onshore are applicable offshore (see Chapter 4 for more detail on Mitigation).

Objects colliding with turbine blades create vibrations which potentially can be detected by sensor systems e.g. WT Bird®, ID-Stat®, and WTSU® (Wiggelinkhuizen *et al.* 2010). However, the sensitivity threshold appears to be much higher than would be suitable for detecting bat collisions, and in addition fatalities resulting from barotrauma would be missed.

1.3.6 Radar

The first radar study of bats was done by Bruderer & Popa-Lisseanu (2005), who used a tracking radar to determine European bats species by their wing beat pattern. However, distinguishing bats from birds is complex owing to their morphological and behavioural similarities, especially where activity of swallows and swifts overlaps with that of bats. Weather radar has located migrating common noctule bats crossing the Kalmarsund, Sweden (Ahlén et al. 2009), and scanning radar has been used as a survey technique for assessing the interactions of birds with wind turbines both onshore and offshore.

Radar surveillance techniques have also been proposed to assess the activity of bats at local scales around turbine blades, building on similar applications for birds (e.g. Fijn *et al.* 2015). The wave-length of emitted radio waves determines the resolution and detection range of a radar. Most systems used for wildlife monitoring at wind farms use X-band radar (wavelengths 2.5-3.75 cm) rather than S-band (8–15 cm wavelengths) as its higher resolution means it can detect smaller objects. However, it is more affected by rain and fog, and small non-target species such as insects, must be filtered from the data. Radar loses track of objects in close proximity to moving turbine blades and therefore cannot be used in isolation or to detect collision events. An important challenge in the application of radar technology for bat surveillance is the need to distinguish bats from birds of similar size and wing-beat frequencies. Tests onshore using a portable X-band radar showed good agreement between radar and acoustic techniques in detecting the presence of common noctule *Nyctalus noctula* within the same air-space. The radar was able to detect bats at distances of 665m, meaning that it is well equipped to detect bats within the entire rotor-swept zone (Krapivnitckaia *et al.* 2024). Another onshore test was done on the island in Croatia, using high resolution 3D radar (Robin radars, model Max) in parallel with bat call recording and thermal camera imaging. Recordings provided clear bat flight patterns and at the same time standard methodology provided details on bat species present. This research showed possible opportunities for automated sampling and monitoring tracking seasonal bat migrations and daily movements (Mazija, 2022). Radar was also used to examine the impact of an acoustic deterrent at a wind farm for species ranging in size from *Rousettus aegyptiacus* to *Pipistrellus pipistrellus* at heights of 100m-800m above the ground (BirdScan-MR1 RADAR, Werber *et al.* 2023). Below this altitude, the radar did not provide reliable identification, but effective surveillance was instead conducted using Lidar designed for autonomous vehicles (Livox Horizon). Further research is needed to explore these techniques offshore, where meteorological conditions can be challenging, and to test their efficiency in detecting the species encountered at sea.

Radar-based automatic shut-down systems, triggered by the presence of large birds, such as eagles, within the wind farm, have also been developed for use onshore (e.g. McClure *et al.* 2021; May *et al.* 2012). These are less applicable in offshore environments where longer-periods are usually required because of the requirements of maintaining net stability, although there is potential to explore whether individual turbines could be curtailed. For example, a radar-based automated curtailment system is in development supported by the Dutch Research Council (the BatGuardian System). The performance of radar detection systems, and the detectable range, depends on the size of the animal, the tortuosity of the flight path, and interference from other features (e.g. flicker from wind turbine blades) (May *et al.* 2017). Therefore, although well-developed radar systems exist for bird monitoring, they are not usually deployed for bats, and the relevant data are frequently discarded early in the processing pipeline.

1.3.7 Carcass searches

Carcass searches, as conducted onshore, are not possible in offshore environments. Only a fraction of the carcasses will remain on the small platform under the turbine, and even this small percentage of carcasses may be blown away by strong winds and waves or consumed by scavengers before being detected. However, during turbine maintenance, technicians can find carcasses on the wind turbine structure, such as the floating platform or the turbine access platform. These observations are opportunistic and cannot be used *per se* to estimate collision fatality rates. However, they can give a rough idea of species that can be at risk in the area. Beach surveys near ***offshore WTs*** could also be of interest to find bats that could have been killed by direct collision or barotrauma (as has been applied to birds e.g. Newton & Little 2009). To complete this survey, search efficiency and carcass persistence need to be tested, as well as the effect of wind and current on deposition. In addition, carcasses need to be examined to determine whether the death was caused by a collision.

1.4 Current knowledge on offshore bat migration and activity in Europe

Prior to the development of ***offshore WTs***, knowledge concerning bat presence at sea was largely limited to anecdotal visual observations from vessels, without any dedicated research effort (Mackiewicz & Backus, 1956; van Deusen, 1961). This lack of data can be attributed to the largely terrestrial nature of bats—an order for which suitable foraging habitat offshore has been considered unlikely —and to the historically limited understanding of bat migratory movements.

European bat species move between summer and winter habitats with some species undertaking long-distance migrations, generally following a northeast to southwest direction, and sometimes including offshore environments (Hutterer *et al.* 2005, Kruszynski *et al.* 2020, Alcalde *et al.* 2021). Nonetheless, compared to birds, research on bat migration in Europe remains limited and is largely based on recoveries of banded individuals (Hutterer *et al.* 2005). Recently, data have also been collected using different methods such as acoustic recordings (Bat Migration Europe 2026), radiotracking, and analysis of stable isotopes (e.g. Hurme *et al.* 2025, Kruszynski *et al.* 2021, Lagerveld *et al.* 2024, Merlet *et al.* 2025, Wright et al. 2020). Bats may also forage (presumably on crustaceans or aerial plankton) over the sea many kilometres from the coastline (e.g. Ahlén et al. 2009, Lagerveld & Mostert 2023). Nonetheless, given the challenge of tracking bats at sea, it is difficult to understand their activity offshore.

Most of the current knowledge on offshore bat occurrence has been gained by studies in central and northern Europe, where bats mainly use the offshore regions for migration (Ahlén 1997, Ahlén *et al.* 2009, Bach *et al.* 2017, 2022b, Brabant *et al.* 2020, 2021, Lagerveld & Mostert 2023, Lagerveld *et al.* 2014, 2021, 2023, 2024, Meyer 2011, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022, 2026a, b, Skiba 2007 etc.). Especially nearshore areas may also be used for foraging throughout the warm season (Ahlén *et al.* 2009, Lagerveld & Mostert 2023, Seebens *et al.* 2013). Where land masses or islands lie rather close to each other, commuting and foraging may also occur, in summer as well as spring and autumn (Lagerveld & Mostert 2023, Meyer 2011, Seebens-Hoyer *et al.* 2022, Seebens *et al.* 2013).

1.4.1 Bat migration at sea: species and regions

In Europe, long-distance migrants include: the Nathusius' pipistrelle (*Pipistrellus nathusii*), the parti-coloured bat (*Vespertilio murinus*), the common noctule (*Nyctalus noctula*) and the Leisler's bat (*Nyctalus leisleri*). Banding data have shown that these migrants can travel 800 to 1400 km between their summer and hibernation areas (Alcalde *et al.* 2013, Kalda *et al.* 2019, Masing *et al.* 1999, Tájek & Tájková, 2021, Van Heerdt & Sluiter 1965), and more than 2,000 km for the longest flights of Nathusius' pipistrelle (Alcalde *et al.* 2021, Vasenkov *et al.* 2022). Other species, such as the Eurasian Serotine (*Eptesicus serotinus*), Northern bat (*Eptesicus nilssonii*), Common Pipistrelle (*Pipistrellus pipistrellus*), Soprano Pipistrelle (*Pipistrellus pygmaeus*) and some *Myotis* species, may also migrate several hundred kilometres. They are occasionally recorded in offshore environments, though much less frequently than other species (Ahlén et al. 2009, FEBI 2013, Bach et al. 2017, Seebens-Hoyer et al. 2021, Brinkløv et al. 2025). It should also be noted that some widely-used automated acoustic identification programmes appear to under-identify species, including *Eptesicus*, *Vespertilio* and *Nyctalus* species, particularly where there is significant background noise (Smeele et al. 2026).

Bat migrations across large open waters are known from Northern Europe, including the Baltic Sea, North Sea and the English Channel (BRL & Biotope 2017, Fritzen 2014, 2015, Gaultier *et al.* 2020, Hüppop *et al.* 2019, Jarzembowski 2003,; Lagerveld *et al.* 2024, Petersen *et al.* 2014, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022, 2026b) and the Mediterranean Sea (Amengual *et al.* 2007, Ramos Pereira *et al.* 2009). While bats cross the German part of the Southern Baltic in a broad front, but still with clearly higher concentrations in the western parts, in the German Bight (North Sea) the intensity of bat activity decreases with increasing distance to the coast (Seebens-Hoyer *et al.* 2022, 2026b). In Kalmarsund and Öresund (both about 15-20 km wide) up to 11 bat species have been observed (Ahlén *et al.* 2009, Hüppop *et al.* 2019). Some evidence also suggests that bats can cross the Bay of Biscay: bats were detected at an offshore French wind farm, located more than 12 km off the coast (Parc éolien en mer de St-Nazaire, O-Geo 2024) and on islands close to this area (Ouvrard & Fortin 2014). In addition, bats were also detected by acoustic recorders installed on boats, in the southern part of the Bay of Biscay (Dorémus *et al.* 2023) suggesting a migratory route to Spain. Reported bat occurrence for each sea is presented in Table 2.

***Table 2**: Occurrence of bat species at European seas and their European conservation status according to the IUCN Red List. X = regularly, (X) = occasionally.*

	Baltic Sea	**North Sea**	**English Channel**	**Bay of Biscay**[1]	**Mediterranean Sea**[1]	**Black Sea**[1]
Nyctalus noctula (LC)	X	(X)	(X)	(X)	(X)	X
Nyctalus leisleri (LC)	(X)	X	X	X	X	X
Nyctalus lasiopterus (VU)					X	X
Cnephaeus serotinus (LC)	(X)	(X)	(X)	X		X
Cnephaeus nilssonii (LC)	X	(X)				
Vespertilio murinus (LC)	X	(X)				X
Pipistrellus nathusii (LC)	X	X	X	X	X	X
Pipistrellus pygmaeus (LC)	X	(X)	(X)	(X)	(X)	X
Pipistrellus pipistrellus (LC)	X	X	X	X	(X)	X
Pipistrellus kuhlii (LC)			X	X		X
Hypsugo savii (LC)					(X)	(X)
Miniopterus schreibersii (VU)					X	(X)
Tadarida teniotis (LC)					X	
Myotis dasycneme (VU)	(X)					
Myotis daubentonii (LC)	(X)					
Myotis brandtii/mystacinus (LC)	(X)					
Myotis capaccinii (VU)					X	

[1] *Observations in the Bay of Biscay and southern seas are lacking; other species may be present.*

Some studies suggest that bat occurrence is highest along the coast, where migratory activity is concentrated (Brabant *et al.* 2021, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022: in the German North Sea), and gradually declines offshore with increasing distance from shore. However, this pattern has not been consistently confirmed in other investigations (Sjollema *et al.* 2014, Lagerveld *et al.* 2023, Seebens-Hoyer *et al.* 2022: in the southern Baltic Sea), particularly in contexts involving sea-crossings (between landmasses). Lagerveld *et al.* (2023), for example, reported the highest predicted occurrence approximately equidistant between the British Isles and the Netherlands, nearly 100 km from the nearest coast. A gradient appears to occur when a marine area is not directly on the migration route between two parallel landmasses, meaning that bats can choose either to shorten the route or to follow the coastline. This is the case, for example, in the German Bight (between Denmark and Netherland). Here, we can see that the activity decreases with increasing distance to the landmasses (Seebens-Hoyer et al. 2022, 2026b). In contrast, as explained above, a uniform distribution appears to occur when the marine area in question lies between two parallel or nearly parallel landmasses (e.g. between Germany and Sweden (Seebens-Hoyer et al. 2002, 2026b), meaning that crossing bats are present along the entire route between the landmasses—from near the coast to far from the coast—in order to cross the marine area.

1.4.2 Nathusius' Pipistrelle

The Nathusius' Pipistrelle (*Pipistrellus nathusii*) is the most commonly studied migratory bat species, and some leaving and landfall points have been identified (Lagerveld *et al.* 2024). In the Baltic and North seas, overall, spring migration occurs from April until Mid June (Bach *et al.* 2017, Bach *et al.* 2022a, Jarzembowski 2003, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022), while in the northern part of the Baltic Sea from mid of May until mid of June (Fritzén pers. comm). Autumn migration occurs from August to October, with a peak in September (Ahlén *et al.* 2009, Jarzembowski 2003, Lagerveld *et al.* 2021, 2023, Petersons 2004, Russ *et al.* 2001, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022). Nathusius' Pipistrelle activity at sea, during the night, does not usually start immediately at sunset, but depending on the site location and weather, may start a few hours later (Bach *et al.* 2022b, Lagerveld *et al.* 2014, 2023, Seebens-Hoyer et al. 2022). During autumn migration, Bach *et al.* (2022b) found that bats were flying at a speed from 4 to 8 m/s, similar to findings inland (6.9 m/s, Troxell *et al.* 2019). In addition, to date, Nathusius migration is mainly observed at low wind speed, warm temperature (>15°C) and east-northeasterly tailwinds (Brabant *et al.* 2021, Lagerveld *et al.* 2021, 2024) but this knowledge may come from bias of the monitoring methods (e.g. distribution of Motus receivers and intensity of tagging). Most studies (Ahlén *et al.* 2009, Brabant *et al.* 2021, Lagerveld *et al.* 2021, Seebens-Hoyer *et al.* 2022) found migrating bats in rather low heights. Most of these studies rely on acoustic data which, for methodological reasons, only monitored comparatively low altitudes of up to around 100 m (hub height). When activity was recorded simultaneously in different heights, the activity decreased with height (Brabant et al. 2019, Seebens-Hoyer et al. 2026b). Lagerveld *et al.* (2024) calculated the flight altitudes on the basis of tracking data using flight speed from radio transmitters and wind data. They suggest that bats select flight altitudes with favourable wind conditions (up to 10 m/s tailwind), achieving migration ground speeds twice their own flight speed), which occurred several hundreds meters high. Which proportion of the offshore migrating bats are using such high altitudes and why is still unclear.

Although Nathusius' Pipistrelle migration has been studied in the north of Europe, peer-reviewed studies from other parts of Europe are very scarce. To the best of our knowledge, only one study reported direct evidence of the species in the Black Sea (Dundarova *et al.* 2021), but reports for offshore oil and gas platforms have shown that the animals migrates within the area as well, usually during late autumn and early spring, alongside dispersions of Kuhl's Pipistrelle (see section 1.4.3). Other reports also mentioned this species in the Atlantic Ocean, i.e. Bay of Biscay (Jodet & Marmim 2023, Ouvrard & Fortin 2014, O-GEO 2024, Pessato *et al.* 2024).

1.4.3 Other species offshore migration, movements and foraging

Most of the knowledge on Common Noctule (*Nyctalus noctula*) migration comes from the North Sea and Baltic Sea regions (Ahlén *et al.* 2009, Lagerveld *et al.* 2014, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022, 2026b), similar to that of Nathusius' pipistrelle. However, Noctules are much less common there. Spring migration starts later than in pipistrelles (beginning in May) and lasts until mid June (Seebens-Hoyer *et al.* 2022). Rydell *et al.* (2014) reported migration in autumn from August throughout October, without any clear difference from the Nathusius' migration (see also Seebens-Hoyer *et al.* 2022). In western Estonia, Common Noctules have been observed crossing the sea also during spring migration (Kalda pers. comm.). In addition, radar observations have shown that this species flies low at sea, although some can fly over 40 m high (Ahlén *et al.* 2009). A recent study shown that, Nyctalus spp., like pipistrelles, were mostly recorded at low altitudes, but seem to occur at higher altitudes a little more often than Nathusius´pipistrelles (Seebens-Hoyer et al. 2026a; note that only altitudes up to around 100 m were surveyed). Inland, Common Noctule migration is triggered by warm temperatures and low precipitation, although migration can also occur under less optimal conditions; migration at several hundred meters of height - measured directly using accelerometers - and in wind speeds up to 11 m/s was also recorded (Hurme *et al.* 2025). High altitude foraging has been observed in migrating bats crossing the open sea (e.g. Ahlén *et al.* 2009, Lagerveld & Mostert 2023, Solick and Newman 2021). Common Noctules have also been found foraging over the German Wadden Sea (Reusch et al. 2022).

Other long-distance migrant species such as the Leisler's Bat (*Nyctalus leisleri*) and the Parti-Coloured Bat (*Vespertilio murinus*) have been sighted over the Baltic, North and Black seas and found on offshore oil and gas installations (Russ 2001, Ahlén *et al.* 2009, Boshamer & Bekker 2008, Brabant *et al.* 2016, Dundarova *et al.* 2021, Hüppop & Hill 2016, Hüppop *et al.* 2019, Petersen *et al.* 2014, Seebens-Hoyer *et al.* 2022, Skiba 2007, Sonntag *et al.* 2006, Vauk 1974, Walter *et al.* 2007), and Leisler's Bat has also been recorded in the Bay of Biscay (Jodet & Marmim 2023, Ouvrard & Fortin 2014, O-GEO 2024, Pessato *et al.* 2024). In the north Adriatic Sea of Croatia, Giant Noctule (*Nyctalus lasiopterus*) clearly shows a tendency to follow the coastal line when migrating over the sea (Mazija *et al.* 2025). However, information on the migration period and weather conditions influencing the activity of these species at sea is lacking throughout Europe.

Movements of Kuhl's Pipistrelle (*Pipistrellus kuhlii*) have been sighted in the Black Sea oil rigs (Figure 1) with entire colonies at more than 120 km offshore, which can suggest that Crimea and Dobrogea areas may be linked by dispersion episodes (Oceanic 2022).

Figure 1. Bats that came from the open sea during daylight hours searching for shelter on oil rigs in the Black Sea

Migrating and foraging Pond Bats (*Myotis dasycneme*), Daubenton's bats (*Myotis daubentonii*) and Soprano Pipistrelles (*Pipistrellus pygmaeus)*, the species not regarded as long-distance migrants, are also often recorded during summer over the Baltic and Wadden Sea, mostly nearshore but also on remote islands, occasionally with high activity (Ahlén 1997, Ahlén *et al.* 2009, FEBI 2013, Seebens *et al*. 2013, Seebens-Hoyer *et al.* 2022, Brinkløv *et al*. 2025, Geidnert 2025, Klang 2026). Five bat species, including Daubenton's bats, have been found flying 2 km off the coast in mid-June in the German Baltic Sea (Seebens et al. 2013).

Seasonal bat movements across the Mediterranean, particularly in spring and autumn, are documented (Amengual et al. 2007; Ramos Pereira et al. 2009), although offshore movements on a local scale remain poorly understood in the region. Regular occurrence of only maternity colonies of *Rhinolophus* and *Plecotus* species on Adriatic islands, while only occasionally a very few hibernating individuals have been found (Mazija pers. comm.), indicates connectivity with mainland habitats and populations.

1.5 Bats and offshore wind turbines

1.5.1 Interactions and behaviour

Migrating bats cross large open water bodies in spring and autumn, potentially encountering multiple offshore wind farms along their routes. Observations from Sweden show that bats regularly explore ***offshore WTs*** upon encountering them (Ahlén *et al.* 2009). In such cases, bats have been observed flying up and down the turbine, possibly looking for roost sites and, if food is available, they were observed to start foraging (Ahlén *et al.* 2009). These observations are in accordance with results of a behavioural study at the offshore wind farm Baltic 1 in Germany (Pommeranz pers. comm., Seebens-Hoyer *et al.* 2026a). Another study in Germany shows that offshore migrating bats usually just pass small structures as buoys but stay for longer periods and show exploratory behaviour at larger and more complex offshore structures such as platforms and lighthouses (Seebens-Hoyer *et al.* 2022, 2026a). These findings are confirmed by the few existing studies at ***offshore WTs*** (Brabant *et al.* 2019, Ecocom 2015). In both studies, bat detectors were installed at nacelle height and at the service platform, but only 10% of the activity occurred at nacelle height. Similar results were found in a study by Seebens-Hoyer *et al*. (2026a) where bat activity at heights from 10-100m was investigated at the research platform FINO II in the Baltic Sea.

Migrating bats have also been detected at a floating wind turbine in the Bay of Biscay, 14 km of the French coast (Pessato *et al*. 2024), and are regularly rescued from the platforms of ***offshore WTs*** in south-east England (John Puckett, Kent Bat Group, pers com. 2025). We know that the structures of floating wind turbines are used as resting places for birds, increasing wind farm attractiveness (Maxwell *et al.* 2022, see section 1.1). While it has not been demonstrated yet, we can also expect bats to be attracted to this structure to seek refuge, as has been observed on boats and offshore platforms (Boshamer & Bekker, 2008, Russ *et al.* 2001, Seebens-Hoyer *et al.* 2022).

Migrating bats may also be attracted to ***offshore WTs*** (Ahlén *et al.* 2009, Boshamer & Bekker 2008, Seebens-Hoyer 2022, 2026b). In some cases insects have also been observed accumulating around these structures, presumably attracting bats foraging on them (Ahlén *et al.* 2009). At an offshore wind farm in the North Sea, Brabant *et al.* (2021) reported instances in which bats appeared to explore the area and/or engage in foraging behavior, as indicated by the emission of characteristic feeding buzzes. The authors suggest that such behaviors could elevate collision risk. Feeding buzzes have also been recorded in a low fraction (c. 5%) of calls recorded at 13 offshore platforms in the North Sea (Lagerveld pers comm. 2025). Comparable foraging activity was observed by Willmott *et al.* (2023) around two turbines located 42 km offshore from Virginia, using a combined video and thermal imaging system. Bats were seen foraging in the vicinity of turbines, which also attracted large numbers of insects. Notably, most foraging events occurred when the turbine blades were stationary.

While in several countries ***offshore WT*** have on-demand lights, e.g. in Germany wind turbines are equipped with lights per safety standards: usually red lights at the nacelle are required to make them visible to air traffic and white/yellow lights at the base of the turbine for marine traffic and maintenance. Although the red lights at wind farms can be seen for several kilometres (Bará & Lima 2024) it is not clear whether bats are attracted by such light at sea. However, studies inland or on the coast, show that some species, such as *Pipistrellus* species can be attracted to white and green lights (Barré *et al.* 2023, Voigt et al. 2017) and red, but not warm-white lights (Voigt et al. 2018), impacting their migration by positive phototaxis, independently of the presence of insects (Voigt *et al.* 2017). Seebens-Hoyer *et al.* (2026b) did not find any evidence for light attraction offshore when comparing the bat activities recorded acoustically at unlit and lit buoys nearby.

1.5.2 Flight height

Although flight height is a critical parameter for assessing fatality risk, few studies have addressed this issue at ***offshore WTs*** specifically (Brabant *et al.* 2019, Willmott *et al.* 2023, Seebens-Hoyer *et al.* 2026a). Regardless of the survey method employed (visual observations, cameras or acoustic detectors), it is often difficult to capture the full potential range of bat flight heights owing to technical challenges. For instance, the detection range of an acoustic detector for Nathusius' pipistrelle is up to 20-25 m (Weber et al. 2018, Runkel 2020), which is insufficient to cover possible flight heights from low above sea level to several hundred kilometres or even only the entire exposure zone of an ***offshore WT*** which may have a rotor of reaching 200-300 m diameter. Similarly it can be difficult to obtain sufficient resolution to determine flight heights. Bat flight heights at sea vary considerably across studies. Using video recordings, Willmott *et al.* (2023) reported a median flight height of 98 m (range: 40–130 m) for North American species. Comparably, off the U.S. Atlantic coast, Eastern Red Bats (*Lasiurus borealis*) have been estimated to fly at 100–200 m and even above 200 m (Hatch *et al.* 2013). In Europe, several studies report predominantly low flights when surveying bat activity up to around 100 m: Brabant *et al.* (2019) recorded acoustically bats flying at platform and nacelle height (93 m) at a North Sea offshore wind farm and the observed rate was substantially lower (0.02 bats/night) at nacelle height than that recorded near the base of turbines (16 m; 0.18 bats/night). Ecocom (2015) had similar findings. Flight heights of less than 10 m were recorded for the majority of Nathusius´Pipistrelles and Noctules observed from the coast in the Baltic Sea (Ahlén *et al.* 2009), and 3–20 m for Nathusius' pipistrelles in the North Sea (Boshamer & Bekker, 2008; Lagerveld *et al.* 2014). Seebens-Hoyer *et al.* (2026a) found 75 % of the bat activity recorded with microphones in four heights (10 m, 33 m, 66 m, 100 m) at the lowest microphone. In Europe, bats have been shown to rapidly gain altitude when approaching vertical structures such as ships, lighthouses, or wind turbines (Ahlén *et al.* 2009), highlighting the importance of in situ studies conducted specifically in offshore wind farm sites. Remarkably, Lagerveld et al. (2025) showed that the best fitting model of migration activity of radio-tagged Nathusius'pipistrelles includes tailwind speed at 100m height. That European bats were observed predominantly at lower altitudes in most studies may therefore be an effect of the methods applied. Studies using techniques capable of directly surveying bats simultaneously at all altitudes from low to several hundred meters above sea level (e.g. radar, if further developed) are therefore urgently needed.

1.5.3 Possible impacts

Europe has large-scale offshore wind farm development plans, particularly in the North, Baltic and Mediterranean Seas (Lloret *et al.* 2023; see Table 1). Given the evidence for bat migration and for their activity around offshore installations, this future expansion is anticipated to have a medium to high negative impact on at least some European bats (Seebens-Hoyer *et al.* 2022, 2026b; Brabant *et al.* 2020; Lagerveld & Mostert 2023; Wawrzynkowski *et al.* 2025). According to the precautionary principle, efforts must be taken to avoid further damage to the conservation status of European bats arising from ***offshore WT*** developments, especially as the species of concern are already declining (e.g. BfN 2025).

Onshore WTs kill bats regularly (e.g. O'Shea *et al.* 2016; Arnett *et al.* 2016; Rydell *et al.* 2010a; Voigt *et al.* 2015), sometimes in very high numbers (e.g. Rnjak *et al.* 2023; Mar Salguero *et al.* 2023). Offshore, no data are yet available on specific numbers of fatalities: currently, there are neither established suitable methods to monitor bat fatalities at ***offshore WTs***, nor other validated methods to observe or detect colliding bats. Based on offshore observations of bat flight heights outside wind farm contexts, accurately assessing collision risk remains challenging. However, several studies on this topic have found some evidence to suggest that the fatality risk might be high at several ***offshore WT*** sites (Ahlén *et al.* 2009, Brabant *et al.* 2019, Gaultier *et al.* 2020, Hüppop *et al.* 2019, Lagerveld *et al.* 2021, Rydell *et al.* 2014, Seebens-Hoyer *et al.* 2022, 2026b). Therefore, the main impact of ***offshore WTs*** on bats are undoubtedly **fatalities** from collision with the wind turbine blades and barotrauma (Ahlén *et al.* 2009, Brabant *et al.* 2019, 2021, Lagerveld *et al.* 2021, 2024, Seebens-Hoyer *et al.* 2022, Skiba 2007).

Displacement (i.e. indirect habitat loss caused by avoidance) or direct habitat loss (through destruction/degradation of important habitat features) have been found to occur at ***onshore WTs*** (Barré *et al.* 2018, Reusch *et al.* 2022, Roeleke *et al.* 2016). Currently there is no evidence that habitat loss is as important offshore. However, much is still to be learned about migration patterns, as well as foraging offshore in some areas (e.g. the Black, North and Baltic Seas), and therefore the potential importance of displacement should not yet be ruled out.

The type and magnitude of impacts of offshore wind energy facilities will depend on the ecological context. For example, the Black Sea is small, comparable to a large lake. It also includes extensive areas of sand dunes and shallow waters, particularly near the Danube Delta, and is surrounded by optimal bat habitats with limestone and mature woodland. Here, planned ***offshore WTs*** will be mostly located in shallow waters (World Bank & IFC 2024), some close to the shore and near the Danube Delta Biosphere Reservation. Therefore developments here will potentially affect not only migratory species, but also local resident bat populations feeding at, or transiting through, large open spaces.

Further most offshore wind energy developments will have impacts that are transboundary, and careful attention must be paid to the cumulative impacts that accrue when migratory bats encounter multiple different WT installations along their route.

2 General aspects of the planning process

Given the climate targets agreed upon in the European Union (EU) and partner states (EEA) for a more sustainable future and independent energy source, offshore wind energy will play a vital part and is set to scale up to 300 GW by 2050 (see section 1.2). The EU has recognized that wind energy development struggles with complex permitting application procedures and has adopted an accelerated development approach in 2022 for land installations, simplifying some aspects of the environmental permitting procedures. This in turn raised concerns about the proper assessment of cumulative negative impacts on a regional scale.

Future offshore wind energy projects will most likely undergo an accelerated permitting process, as an incentive for the high project costs and for the lack of protected natural areas. Each member state or partner non-EU-member state will rely on national maritime spatial plans (MSP) and international collaboration will be encouraged for a more streamlined energy production strategy.

Bats regularly migrate in offshore or coastal areas across Europe and frequently use stopover points on any stationary installations or ships (see section 1.4), thus ***offshore WTs*** will continue to have a negative impact on bats (see section 1.5.3), with potential upscaling of negative cumulative effects. Therefore, <u>bats should be considered early on and at a higher level of national and/or regional planning procedures</u> when designating priority areas for wind energy in offshore environments. Distribution mapping is a recommended approach to identify areas likely to be particularly sensitive at regional and national planning level (see section 3.1).

Understanding bat movements is key within spatial planning and environmental impact assessment process, allowing for proper and timely avoidance and mitigation measures to be planned and implemented. Cautionary principle should be applied in areas lacking detailed bat movement data, and MSPs should include bats as a mandatory evaluation component for the entirety of the given area. The absence of evidence (i.e. the lack of existing scientific data) must not be misinterpreted as evidence of absence (i.e. bat activity in a given area) and cannot be used as an argument to exclude bats from offshore planning consideration. In areas where large-scale offshore bat studies lack, a preliminary survey should inform distribution mapping prior to the comprehensive pre-construction surveys (see section 3.1).

National authorities need to implement environmental assessment procedures for ***offshore WT*** project proposals using tools like maritime spatial plans (MSP). For EU member states, these fall under the Directive 2014/89/EU that states the avoidance of transboundary risks. This should be considered even if member states do not have specific legislation for areas that fall into their territorial waters or the exclusive economic zone (EEZ). The assessments need to apply even if the proposed project sites are not within protected natural areas, as all bats are protected under the Habitats Directive, EUROBATS Agreement and other international agreements and the potential cumulative impacts can have far reaching consequences. Bat movements need to be thoroughly studied for each ***offshore WT*** project (see Chapter 3), which may or may not be part of a formalised, legal SEA or EIA process, to specifically tailor efficient on site-specific avoidance or mitigation measures (see Chapter 4), especially in understudied migratory pathways.

Offshore wind energy projects are large-scale developments, often financed by international financial institutions. Their strict regulations and thorough environmental due diligence follow best-practice guidelines to minimize investment risks and prevent unforeseen environmental impacts. Thus, a key component of that process needs to include consideration for potential negative impacts on bats.

These guidelines offer support for that process, in the absence of (or in concert with) other regulations which can be widely interpreted using national case-by-case adaptation of the EU Directive and the EUROBATS Agreement. They should be considered as best practice for the current state of knowledge.

During the SEA and EIA, the standard mitigation hierarchy must be followed: avoidance of the impact, mitigation of the existing impact and, finally, compensation of the residual effects if necessary. Pre-construction studies should be undertaken prior to the project installation for at least two consecutive seasons, and the monitoring should continue during the entire construction period and within all the operational and disassembly stages (see Chapter 3).

2.1 Site selection phase

Offshore areas do not generally offer roosts for bats, thus **avoidance** in the planning stage based on roost proximity or feeding grounds will be difficult to assess. While also considering the proximity from the nearest offshore fixed installations or land masses, this stage needs to focus on established and potential bat flight paths, as determined by prior studies, and by the EIA monitoring (see Chapter 3). Offshore bat movement studies have been rarely performed independently from large development projects such as ***offshore WTs*** or oil and gas, as the costs for these procedures are often very high. This in turn has generated sporadic observations, which are not particularly useful for the EIA assessment, as the observations need to be site specific and their timeline needs to consider all the relevant periods for the bat activity within the area. Modelling the potential flight paths is also an option within this stage in some locations, as data already exists for certain areas such as the North Sea, including from existing ***offshore WT*** projects. This step also needs to consider maritime freight routes and other ship movements, and existing fixed installations, such as oil and gas platforms, fishery, defence and existing ***offshore WT*** infrastructure, as bats will use these areas for stop over, feeding, and even roosting in some cases. Distribution and activity maps produced by either large-scale studies or preliminary pre-construction surveys will best inform site selection (see section 3.1 and Table 3).

2.2 Construction phase

The negative impact of ***offshore WTs*** on bats will start within the construction phase, as some species of bats will be attracted to a temporary shelter and potential feeding grounds created by development. Along with these, other guidelines need to be considered (e.g. Voigt et al. 2018). The EIA should consider the impacts from construction and propose mitigation and monitoring, as needed.

2.3 Operational phase

Following turbine installation, bats may change their behaviour i.e., some species will most likely use the ***offshore WTs*** as a stopover point or a feeding ground during migration (see section 1.5.1), and the main impact are fatalities (see section 1.5.3). Thus, **mitigation measures** will be key for optimal fatality reduction at ***offshore WTs***. Standard carcass searches are impossible at ***offshore WTs*** (see section 1.3.7). Therefore, it is imperative that ***offshore WTs*** implement blade feathering, higher turbine cut-in wind speeds and/or shutting down turbines during sensitive migratory periods (see section 4.2.1). The EIA needs to include the requirement of post-construction monitoring that will properly assess the impact on bats during the operational phase (see section 3.2) and enable adaptive management where applicable. Planning and operational permits and/or conditions should include clear mitigation and monitoring requirements, according to EIA.

3 Impact assessment and monitoring

Given that bats are protected under both international and national legislation across all European countries, and due to possible impacts of the ***offshore WTs*** on bats and fatality risk particularly (see section 1.5.3), bats must be investigated and considered to evaluate the potential effects of ***offshore WT*** projects on bat populations and determine the significance of the anticipated impacts.

The impacts of wind farms are a function of the degree to which bats are exposed to turbines, the severity of the impacts on individuals, and the importance of fatalities or behavioural perturbations to populations (Figure 2). Measuring any of these features is challenging, and, in the onshore environment, most attention has focused on measuring exposure risks and individual impacts, particularly collision fatalities, whereas impacts on populations are largely unknown. Conditions in the offshore environment mean that all forms of ecological monitoring are more difficult than onshore, and fatality surveys are not yet possible, except at floating offshore turbines.

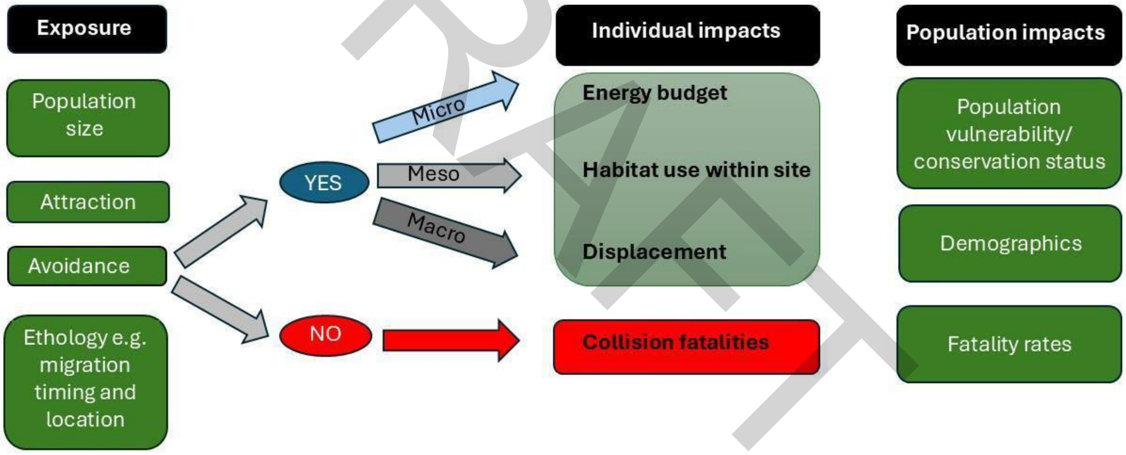

Figure 2. *Framework for considering the impacts of wind turbines on bats. Factors modifying the scale of exposure or population impacts are shown in green.*

It can be assumed that at least migratory bat species are found in the area of all European offshore regions lying between two landmasses with up to 150 km distance to the nearest landmass (compare Brabant *et al.* 2019, Brinkløv et al. 2025, Lagerveld et al. 2023, Seebens-Hoyer et al. 2026b). In regions bordering only one landmass, regular occurrence of bats is to be expected up to 75 km from the nearest landmass (Brabant et al. 2019, Seebens-Hoyer et al. 2026, Solick *et al.* 2021). In all these areas where regular occurrence of migratory or resident bats is expected, pre- and post-construction monitoring and impact assessments on bats are required for all ***offshore WT*** projects, if investigations of the bat occurrence at the site have not been done within the last three years.

The general procedure should follow all steps listed in Table 3 and includes a broad-scale offshore study prior to traditional (pre- and post-construction) monitoring and impact assessment. The following guidance is to be understood as methodological standards for monitoring and impact assessments of ***offshore WTs*** development in Europe according to the current state of knowledge and research. The project developers must nevertheless fulfil the existing formal requirements to comply with national, European and international legislations with and without regard to the ***EIA*** and Strategic Environmental Assessment (***SEA***) regulations.

Table 3: *General bat monitoring procedure steps*

phase	**tool**	**product**	**decision**
Step 1: spatial planning	Broad-scale study offshore study (a) national research program (b) preliminary survey (if national research program is missing)	density map (presenting data on bat occurrence and activity)	- low- to mid-level occurrence: ***offshore WT*** development potentially possible in an area - high-level occurrence: ***offshore WT*** development not possible in an area
Step 2: approval 1	pre-construction monitoring/survey	environmental impact assessment	type and extent of mitigation measures during the first post-construction survey
Step 3: approval 2	post-construction monitoring	impact assessment	type and extent of site specific mitigation measures
Step 4: approval 3	repetition post-construction monitoring every 5 years	impact assessment	type and extent of ongoing mitigation measures

3.1 Broad-scale offshore monitoring: national research programs and preliminary surveys

Broad-scale studies to try to identify offshore regions with regular bat activity are strongly advised, resulting in a density map as a standard output (see Brinkløv et al. 2025, Seebens-Hoyer et al. 2026b). Such studies may timely reduce the impacts on bats by ***offshore WT*** development. Preliminary density maps should inform the designation of areas where no *offshore WT* should be installed due to bat protection issues, and areas where *offshore WT* deployment is potentially possible. In areas where bat activity has been shown to be low project developers can have more confidence that impacts on bats will be low and thus expect minor yield losses due to minor mitigation measures. It is also important to recognise that bat behaviour may change post-construction, owing either to general inter-annual changes in flightpaths or specific attraction to the WTs. Maps should be regularly updated with new knowledge. When predictive models are used, maps should be associated with uncertainty at each grid cell. Uncertainty can be measured using the coefficient of variation (ratio of the standard deviation to the mean), the higher the value, the greater the dispersion around the mean, and the less reliable the prediction is (e.g. Wade et al. 2016, Canonne et al. 2025).

In areas where a national/regional offshore bat study is lacking, a broad-scale preliminary offshore survey prior to the comprehensive pre-construction survey is strongly recommended to compensate for regions' limited background knowledge of bat populations. Like national bat research programs, preliminary studies should be able to show whether ***offshore WTs*** can be built, or whether minor or major mitigation measures are likely to be needed.

Broad-scale offshore studies, either as research programs or as preliminary studies, should also enable the project developers to anticipate to what extent mitigation measures such as blade feathering, higher cut-in wind speeds and shutting down turbines temporarily are likely to be necessary (noting the potential for bat activity to change post-construction and therefore to require increased levels of mitigation).

A preliminary survey in addition to a pre-construction survey may follow the described routine of pre-construction surveys described below, but could e.g. be undertaken for one year only (as it is in addition to the pre-construction survey lasting minimally 2 years). If the requirements of the pre-construction survey are met, the preliminary survey can replace the first survey year of the pre-construction survey. A preliminary survey cannot replace surveys associated with the impact assessment and the post-construction monitoring in its entirety.

Site and region-specific knowledge on how weather influences bat activity is critical to determine potential energy yield losses caused by curtailment in the pre-survey phase.

As part of the preliminary study, existing knowledge from the project area and at regional and international level has to be compiled.

3.2 Pre- and post-construction monitoring and impact assessment

The aim of the pre-construction survey is to build up knowledge about all relevant aspects of offshore bat occurrence in the area proposed for development, while post-construction monitoring focuses on the impacts of the ***offshore WTs*** on bats. The impact assessments of both pre- and post-construction surveys assess the impacts of the ***offshore WT*** development on bats and propose/define site-specific mitigation measures and post-construction monitoring programs. Therefore, knowledge of the occurrence of different bat species in the project area is necessary. Such knowledge must be obtained by surveys directly in the project area within a relevant timescale.

Examples of national bat research programmes

The Netherlands. *Studies on bats in the North Sea have been carried out since 2012, and since 2016 as part of the Dutch Offshore Wind Ecological Programme (WOZEP). The focus lies on acoustic long-term surveys at up to 14 stations, mainly* ***offshore WTs*** *(e.g. Lagerveld et al. 2021, 2023). Numerous automatic VHF radiotelemetry stations (Motus network) have been installed and hundreds of bats radio-tagged to study the North Sea migration routes (Lagerveld et al. 2024, 2025).*

United Kingdom*. Initiated by collaborative research with the Netherlands, automatic VHF radiotelemetry stations (Motus network) have been installed, mainly on the East coast of southern England. More than 300* Pipistrellus nathusii *bats have been tagged, some of which have been detected crossing to the Netherlands and Germany (Lagerveld et al. 2024, 2025). There are also ongoing acoustic surveys on parts of the English coastline, particularly in the south.*

Germany. *Studying bat migration offshore began in 2016, with a strong focus on acoustic long-term survey at 13 stations in the North and Baltic Seas mainly at buoys and platforms (Seebens-Hoyer et al. 2022, 2026a, b). Further work includes behavioral observations in an offshore wind farm, and radiotracking bats (Bach et al. 2022b). These studies have also led to sensitivity mapping to risk that* ***offshore WTs*** *pose to bats.*

Denmark. *An intense research program began in 2023 with acoustic monitoring at buoys,* ***offshore WTs*** *and at the coast in several regions (e.g. Brinkløv et al. 2024) which also led to sensitivity mapping the risk that* ***offshore WTs*** *pose to bats in the study region (Brinkløv et al. 2025, Smeele et al. 2026).*

France*: Monitoring of bats in the Atlantic Ocean (i.e. bay of Biscay) and the English Channel started in 2023 as part of a national programme called MIGRATLANE. More than 40 sites, along the coast, on islands or on structures at sea (e.g. Fecamp mast) have been equipped with acoustic recorders. In addition, acoustic surveys have been carried out on research vessels or ferries. Results of this programme are planned for 2027. In 2021, a similar programme started in the Mediterranean Sea (MIGRALION) but mainly focused on birds.*

Finland/ Sweden: *Bat migration monitoring began in 2018 with radio-tracking of* Pipistrellus nathusii *in Northern Finland (Schneider & Fritzén, 2020). So far over 100 bats have been radio-tracked and the first results will be published in 2026. In parallel this was extended with widespread acoustic monitoring within the project Bat Migration Across the Baltic Sea (BAMBI) led by the Swedish University of Agricultural Sciences and University of Helsinki. Over 100 remote islands and lighthouses have been equipped with acoustic detectors with early results indicating broad-front seasonal movements of bats across the Baltic Sea.*

In general, approaches to monitor bats and assess the impacts of ***offshore WTs*** should be based on site-specific offshore surveys, no matter if they may or may not be part of a formal/legal ***EIA*** or ***SEA*** process prior to or after construction. Impact assessments shall provide site-specific information and therefore need to be undertaken directly in the project area. Studies from areas outside the project area always have limitations regarding their significance for the project area. Surveys carried out on land may provide additional information, especially on the activity of possible take-off points, but land-based surveys can under no circumstances replace offshore surveys.

Following standardized procedures and making the data openly available is prerequisite to gain comparability among different studies and to be able to assess cumulative effects. The complete survey data and its metadata (sampling method and effort) should be made publicly available, according to EUROBATS Resolution 9.4, to enable estimation of cumulative effects in subsequent impact assessments.

To ensure fulfilment of minimum quality standards, it is essential that “relevant authorities dealing with the assessment reports possess the appropriate resources and capacities to be able to assess and evaluate the results of those studies”, according to EUROBATS Resolution 9.5, and that bat experts carrying out assessment are adequately experienced and skilled, according to EUROBATS Resolution 8.10 .

3.2.1 General principles of monitoring and impact assessment

The aim of the (pre- and post-construction) survey is to achieve a detailed site-specific understanding of the spatio-temporal occurrence of bats, species composition, their activity and, if possible, to estimate the number of migrating individuals (population level). Then, based on these insights, the type and scope of required mitigation measures can be plausibly concluded, including their fine-tuning. The fine-tuning can be achieved by gaining a deep understanding of the factors correlating with bat occurrence, especially wind speed, wind direction, air temperature, and lunar phase, resulting in targeted mitigation measures. The development of a post-construction monitoring program (methodological concept for post-construction survey) for the first or further operating phase should also be part of the pre-construction assessment (see Table 3).

The (monitoring) survey and impact assessment should at least provide detailed site-specific information on the following aspects:

(a) Spatio-temporal occurrence and activity of bats

(b) Estimated number of offshore occurring bats (potentially affected population) where it is possible to make such inferences (see section 3.2.9)

(c) Species composition

(d) Weather conditions and moon phase

A comprehensive post-construction monitoring scheme focuses both on activity levels and mortality rates. The post-construction monitoring can only achieve understanding of the impacts of the ***offshore WT*** on bats if it takes into account the pre-construction status. Therefore, carrying out impact assessments prior to construction is absolutely necessary. The activity monitoring will also help understand the results of the mortality monitoring and vice versa.

An important aspect is to improve the predictability of activity and collision risk, as this is key for effective mitigation (see Chapter 4).

3.2.2 Goals of the impact assessment

The impact assessment must consider the following aspects using reliable data:

- review of existing data (see section 3.2)
- occurrence and activity of bats in the project area (species-specific, to the finest possible taxonomic resolution)
- phenology of bats in the project area (species-specific, to the finest possible taxonomic resolution)
- analysis of the correlation between bat activity and weather conditions and moon phase in the project area (species-specific, to the finest useful taxonomic resolution)
- usage of the project area in the context of migration, foraging and commuting
- assessment of cumulative effects
- suitability of the project area for ***offshore WT*** development, if not addressed as part of a broad-scale offshore study
- requirement for and extent of necessary bat protection and mitigation measures
- concept for first or ongoing post-construction monitoring

3.2.3 Review of existing data

Existing knowledge from the project area and at regional and international level has to be compiled.

This includes intensive search for:

- publications and reports (survey, impact assessment, research and other reports, grey literature)
- species distribution maps
- databases and information on bird migration routes, as bats and birds often use the same routes.

Likewise, available data and information can be requested from:

- local, national and international (e.g. Global Biodiversity Information Facility - GBIF) databases
- local, national and international bat and nature conservation groups

- local, national and international nature conservation and renewable energy authorities
- relevant research organizations like universities and research institutes
- consultants that worked in the area or the region.

3.2.4 Timing of the survey

The monitoring must cover the complete offshore activity period (migration and summer period), therefore the study period should start earlier and continue for longer.

In central and northern Europe surveying from the beginning of the spring migration to the end of the autumn migration period usually is sufficient (see Table 4). In southern Europe, and possibly also elsewhere, bat activity is possible throughout the year, including the offshore environment and therefore the survey should cover the whole year (Citation).

Due to the weather-dependent shift in migration periods and general variation between bat activity between years, full pre-construction and post-construction surveys must both cover at least two years, and ideally three or more years. Depending on the results, it may be necessary to continue monitoring for additional years. It should be considered that, due to climate change, migration periods may shift (earlier in spring, later in autumn), so that the study periods might have to be adopted throughout the years.

If there are more than three years between the survey and the construction of the turbines, repetition of the survey is required.

***Table 4:** Typical activity period in different marine regions*

MONTH	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
REGION												
Baltic Sea				🟨	🟨	🟨	🟨	🟨	🟨	🟨		
Bay of Biscay			🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨		
Mediterranean Sea	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Black Sea			🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	
North Sea				🟨	🟨	🟨	🟨	🟨	🟨	🟨		

Usually, surveying the activity from half an hour before sunset to at least one hour after sunrise is sufficient. However, in more northern areas, the survey should also cover the morning hours. In all areas bats may also fly at daylight occasionally.

A survey limited to short periods of time is unsuitable to survey bats offshore. Migratory bats occur more frequently in short periods of time (very clumped occurrence). If no data is collected during such a phase of increased activity, the study does not reflect the occurrence of bats in the area. Continuous survey throughout the period in which bats are active in the offshore area is therefore mandatory for pre-survey and survey assessment in ***offshore WT*** projects to achieve a reliable result from the impact assessment.

3.2.5 Passive acoustic monitoring as standard method

Only limited methods applicable offshore enable continuous monitoring of species-specific bat occurrence and activity (see section 1.3). Automatic acoustic surveys are well established under offshore conditions and provide continuous monitoring (see section 1.3.1). Therefore, automatic acoustic surveys have become an established standard to survey bats in ***offshore WT*** projects.

Radar (see section 1.3.6) and optical and electronic imaging techniques (see section 1.3.5) are developed and should also be capable of being used for monitoring in future, after having been proven for bats in direct comparison with established acoustic methods.

Radio telemetry is an important supplementary method to gain further information on the movements of individuals and therefore migratory routes (see section 1.3.4). Manual acoustic point counts and visual observations can also provide valuable supplementary information (see section 1.3.2).

3.2.6 Requirements of ultrasound devices used for offshore surveys

Using appropriate ultrasound devices is crucial for acoustic surveys in the context of impact assessments (see Parsons & Szewczak 2009). Only full-spectrum real-time ultrasound devices allowing precise species identification should be used. The systems used should be calibratable to ensure sufficient sensitivity. Because the microphones can wear out very quickly under offshore conditions, only detector systems with test signal generators, that allow the microphone sensitivity to be checked, should be used. The microphones must be serviced or replaced at the latest when their sensitivity decreases, but at least once a year.

Offshore equipment is vulnerable to the harsh conditions of being left at sea for long periods. Extra precautions should especially be taken to protect microphones deployed at offshore sites. For example, microphones can be embedded 2-5 cm deep in a tube with a diameter of minimum 7 cm (e.g. a PU tube, see Figure 3). The microphones must in no case be embedded in a narrower tube and/or deeper, or be covered, as this narrows the detection range and therefore reduces detection possibility. At mounting heights of up to 6 m, e.g. at buoys, the microphone should be aligned horizontally (see Figure 8). For a higher installation, e.g. on platforms, the microphone should be aligned at an angle of approximately 45° to the water surface (see Figure 3). The microphones must not be covered by foils or other materials, as this increases attenuation, changes the frequency response and reduces drying off. Commercially available microphones are also durable enough offshore to be used for acoustic surveys without any extra protection.

Figure 3: *Bat detector (microphone) installation on a platform*

Example: Technical features of two acoustic systems suitable for offshore surveys

Only calibratable devices with reference signal generators that record in real time should be used. Examples of devices with suitable specifications are provided in the table below.

	bat bioacoustictechnology GmbH	ecoObs GmbH
detector system	Computer-based system consisting of a computer unit (Batmode 2s or 2s+), a ultrasound detector unit called UltraSoundGate (e.g. 116Hnbm) and microphones with microphone heating and reference signal generator (microphone disk GM50, microphone capsule FG-DT50, e.g.). outdoor-switch box, battery and solar panels available, if needed	Mobiles System bestehend aus Batcorder mit Erweiterungsset und Solarpanel (batcorder 3.1, Box Set mit Extension 4.0 inkl. Mikrofonscheibe, GSM-Modul, Schutzbox, Bleigel-Akku, Solarpanel); ggf. Pelibox.
size	outdoor-switch box consisting computer and detector units, battery and charge controller: 500 x 500 x 250mm. two solar panels: 2x 1060 x 570 mm.	Box with batcorder, battery and charge controller: 300 x 240 x 190 mm solar panel 160 x 140 mm
requirements for the location	power supply or room for two relatively large solar panels	-

special features	Up to 4 microphones can be operated in parallel, the recordings are recorded on the computer unit The microphones are available with microphone heating, which extends their service life. Microphones with capsule protection for offshore use are available, which are designed to extend durability (e.g. GM50+, first trial 2025)	one system per microphone needed.
Remote control and remote enquiry	Wireless remote desktop access is possible via the integrated 4G LTE mobile radio module, or alternatively via the Ethernet connection if there is appropriate network coverage at the installation site.	Sending of status messages and control via SMS-possible with mobile phone reception. Measurement data can be downloaded via USB interface (e.g. Ethernet connection).
Attachment to WTGs	Variant 1: Complete device on external bracket. Can be attached using brackets and clamps or straps or mounting magnets. Power from tower (Schuko) or from solar panels on platform. Variant 2: Complete device in the tower, guidance of the microphone on cables up to > 100 m outside possible. Microphones can be attached using holders and clamps or straps or mounting magnets.	Complete device on external bracket. Can be attached using brackets and clamps or straps or mounting magnets.
Maintenance	At least annual maintenance or annual replacement of the microphones is required (only deploy new/maintained microphones shortly before recording begins).	
Software settings	BSH (2013)	Brinkmann et al(2011)

3.2.7 Measuring weather conditions

As offshore bat migration often correlates with weather parameters (see section 1.4), information on the weather conditions, especially wind speed, wind direction and air temperature must be collected along with bat surveys. In some areas, a correlation between bat migration and the moon phase has been shown (Lagerveld 2021), therefore moon phase and cloud cover data should also be included. This is particularly important because weather conditions and the moon phase may be needed to define targeted mitigation measures such as blade feathering, higher cut-in wind speeds and shutting down turbines temporarily.

Weather conditions, especially wind speed, vary greatly with height. It is therefore important that the weather data, like the bat activity data, must be measured at a certain height and that the height of measurement is noted and always clearly presented.

3.2.8 Sound file and data analysis

The sound files should be analysed semi-automatically and manually to species or species group level using the software related to the ultrasound device and relevant literature (e.g. Barataud 2015, Russ 2012, Skiba 2009). The bat activity should be quantified to eliminate recording differences of different detector systems, for example in minute intervals with bats (minute in which at least one bat call occurs) (Seebens-Hoyer et al. 2026b).

The data should be presented at least as follows (see example plots in Figures 4-6):

- bat activity over the year
- bat activity over the year and night hours
- bat activity and wind speed
- bat activity and wind direction
- bat activity and air temperature
- bat activity and lunar phase

For each aspect, a graph for the different species and a graph with all bat registrations should be given. The study period and times without survey should be graphically indicated. For all weather correlations the frequency of the weather factor should be indicated. For all correlations the value at which 95% of the activity is achieved should be indicated.

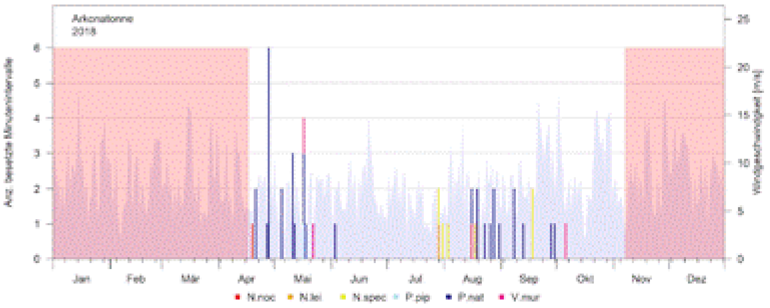

__Figure 4:__ Example plot: activity over the year, species in different colors, periods not surveyed in red

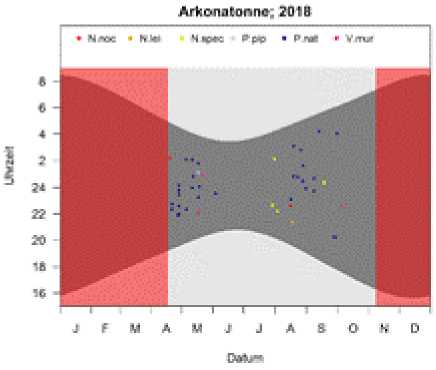

Figure 5: *Example plot: activity over the year and night hours, species in different colors, periods not surveyed in red*

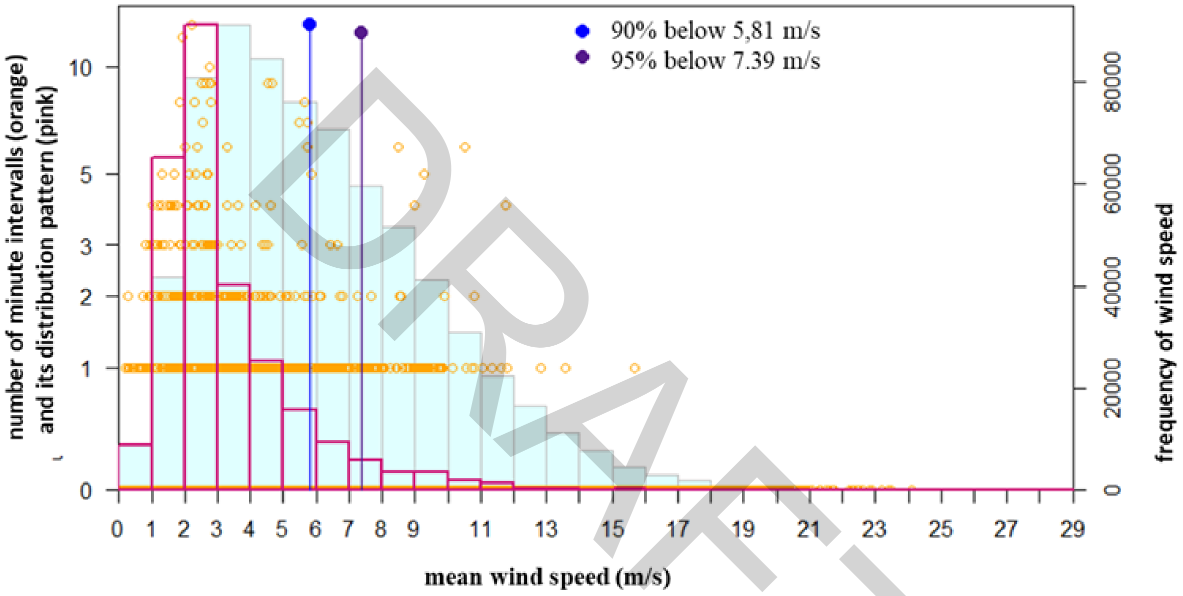

Figure 6: *Example plot: activity at wind speed (orange cycles and pink columns), frequency of different wind speeds (blue columns), value at which 95 % and 90% of the bat activity is recorded in magenta resp. in blue.*

3.2.9 Estimated number of bats (bat migration traffic rates)

To get an idea of the bat populations at sea, the bat migration traffic rate (estimated number of bats per year passing a one km line perpendicular to the general suspected migration direction) can be estimated in some circumstances from acoustic data. In well-surveyed regions where bat migration appears to be consistent in direction and location, a method for extrapolating acoustic data into individuals and subsequently the bat migration traffic rate is described in Seebens-Hoyer et al. (2026b) and explained in principle below. The technique is applicable if there are no resident bats present and the observed bat activity is rather low (bats are only passing, and extensive hunting, commuting and other behavior resulting in multiple recording of individuals is usually missing). The method is not applicable on islands. Such requirements lead to distinct temporal activity patterns. It also depends on assumptions of homogeneity of activity across a region. Individual bats can be separated using a certain separator extracted from the data, e.g. 20 minutes without bat activity. As a result, activities and activity clusters separated by a minimum of 20 minutes without bat activity represent and are counted as different individuals . Based on the mean detectable range of the calibrated bat detector, a minimum annual bat migration traffic rate can be calculated from the individual numbers. The bat migration traffic rate represents the bat potentially affected by ***offshore WTs*** in a certain area.

The bat migration traffic rate can be used to define threshold values to inform spatial planning and mitigation measures. For example, in Germany, areas with bat migration traffic rates of more than 1,000 bats per km per year are recommended to remain free of ***offshore WTs***, while values of more than 300 bats per km and year would require avoidance and mitigation measures (Seebens-Hoyer et al. 2026b).

3.2.10 Reporting

The target group of an impact assessment and monitoring report on bats is usually not very familiar with bats, so basic aspects of the ecology and biology of the subject should be explained.

The report must also include a detailed description of implemented methodology (study design, survey area, ultrasound devices type and settings, microphone sensitivity, precise timing of deployment, etc.), including images of the ultrasound systems in use. Limitations of the method should be clearly explained.

The acoustic data should be presented as indicated (see section 3.2.8). In addition, the raw data should be described (number of minute intervals with bats per species and year, phenology, etc.). The wind speed and air temperature at which 95 % of the activity occurs (species-specific and across all species) should also be specified. The bat migration traffic rate should be presented, as applicable (see section 3.2.9).

All possible impacts must be considered (see section 1.5.3) and plausibly assessed. Cumulative effects must also be addressed. All existing and planned ***offshore WTs*** likely to cumulate impacts should also be taken into consideration, including those beyond neighbouring and/or EU member states, wherever relevant.

Avoidance and mitigation measures must be presented in detail and justified. A concept for the post-construction monitoring program must be included in pre-construction impact assessment reports.

3.2.11 Pre-construction survey design

At least three survey sites for smaller wind farms (up to 10 km longest diameter) and at least one survey site per each 5 km for larger wind farms (more than 10 km longest diameter) along a line crosswise to the presumed migration route (e.g. crosswise between two landmasses) are recommended (see Figure 7). One survey site should be positioned at each end of the proposed development area, the rest of the survey sites in the middle (see Figure 7). Additional survey sites at all edges of the wind farm area must be maintained when a 7.5 km to the next survey site is exceeded.

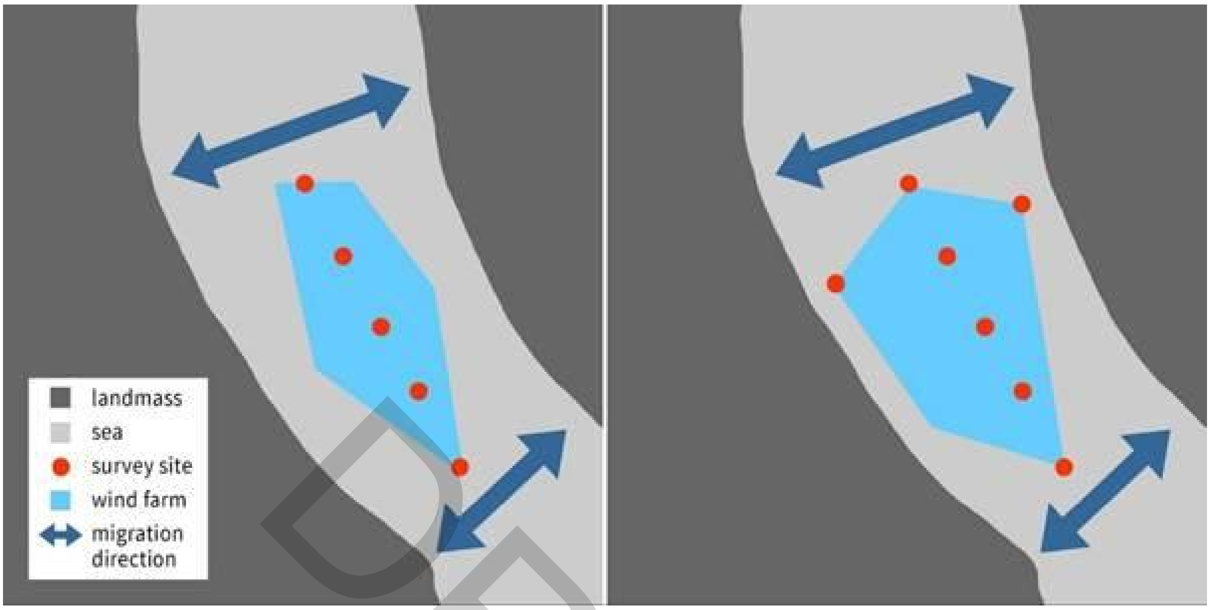

Figure 7: Principle sketch (example) for survey designs

Survey sites are very limited offshore. Suitable supporting structures for the ultrasound devices must be installed before the construction of ***offshore WTs***. The structures should be positioned according to the requirements defined in the pre-survey or survey phase. Therefore buoys, which can be freely positioned, are recommended (Brinkløv et al. 2025, Seebens-Hoyer et al. 2022, 2026a, b). Once platforms and ***offshore WTs*** are built, the ultrasound devices can be mounted on these (e.g. Brabant *et al.* 2019, Lagerveld *et al.* 2023), if positions are suitable.

Larger buoys with heights of three to ten meters above sea level are especially well-suited for carrying ultrasound devices offshore (see Figure 8). They can be placed specifically in the project area and remain there for the whole study period. Another possibility is to use ships or other objects to carry the ultrasound devices. It must be considered that only dark or very small, illuminated objects like buoys, but not illuminated ships, are appropriate for impact assessment surveys to get an insight into baseline (unaffected by development) occurrence.

Figure 8: *Bat detector on a 4 m- buoy*

3.2.12 Post-construction survey design

Since conventional carcass searches are not possible offshore (see section 1.3.7), monitoring should focus on the acoustic bat activity first and foremost. Acoustic activity surveys are an established method to gain long-term automatic data on the bat occurrence, while activity in the rotor-swept area can provide useful insights into the risks posed to bats. In Germany, acoustic data are used as a basis for estimating fatalities and designing mitigation (e.g. Behr et al. 2023), but this approach is not permitted in many other countries (see section 1.3.1).

Due to the large size of ***offshore WTs*** relative to the comparatively short detection range of bat detectors (see section 1.5.2), acoustic monitoring is required at least at nacelle height and simultaneously at about 30m above of the lower rotor blade tip (Bach et al. 2020, Seebens-Hoyer et al. 2022). Additional monitoring heights in between are recommended.

For monitoring the activity at nacelle height the microphone must point downwards to the blade zone, enabling a relatively large coverage of the blade zone and protection from weather at the same time (see Rodrigues et al. 2015). For monitoring the activity at height of the lower rotor blade tip the microphone should be attached to the tower about 30 m above the lower rotor blade tip, pointing as well downwards to the blade zone.

It should be noted that, in areas with high bat activity, shutdowns during times of high bat activity may be required already during the monitoring years to prevent the killing of bats. For example, in central and northern Europe such periods are usually mid-April to end of May and mid-August to the end of September, whenever wind speed is rather low (7 m/s at 10 m above sea level, see Seebens-Hoyer et al. 2026b, and 8-10 m/s at nacelle height, see Elmeros et al. 2024).

3.2.13 Mortality monitoring

To date, it is not possible to determine the mortality of bats at ***offshore WTs***. Carcass searches are impossible offshore (see section 1.3.7) and other methods still lack suitable validation (see sections 1.3.5 and 1.3.6).

4 Avoidance, mitigation and compensation

Impact assessment (including formal ***EIA***) must be undertaken to evaluate the potential effects of ***offshore WT*** projects on bat populations. Where significant adverse effects are predicted, the assessment must propose effective measures to first avoid, and, where avoidance is not feasible, to mitigate these impacts, and finally to compensate for any residual effects. The design of appropriate avoidance, mitigation, and compensation measures for any ***WT*** development depends fundamentally on knowledge of bat species presence, distribution, and activity patterns, as determined through targeted pre-construction surveys conducted as part of the impact assessment. Such measures must also be adapted to the specific characteristics of each development site and, in many cases, to the ecological requirements of individual species. Consequently, site-specific and species-specific approaches are essential. The effectiveness of implemented avoidance, mitigation, and compensation measures should be systematically monitored, and adaptive management should be applied where necessary. This is particularly relevant for ***offshore WTs***, where strong attraction effects may occur due to structural and lighting features (Rydell 2015), potentially leading to increased bat presence and activity during the operational phase compared with pre-construction conditions.

4.1 Avoidance

In ***offshore WT*** contexts, the location of turbines is expected to be a major determinant of bat mortality, with fatalities varying substantially both within a given region and among turbines within the same wind farm (Rydell *et al.* 2010a; Piorkowski & O'Connell, 2010). Thus, preventive spatial planning remains the most effective strategy to reduce bat fatalities, benefiting both conservation and project efficiency. Considering bat activity during early project phases—screening and scoping—enables the identification and avoidance of high-risk areas. Even at the strategic planning level, where authorities designate suitable zones for wind farm development, potential impacts on bats should be explicitly considered. In onshore contexts, the EUROBATS Guidelines (Rodrigues *et al.* 2015) recommend avoiding turbine installation in areas of high bat activity, such as key foraging habitats (e.g., woodlands, wetlands, hedgerows) or near roosts, particularly for species and populations that are more vulnerable to disturbance and collision risks.

Predicting high-risk areas based on established bat migration routes is critical for guiding spatial planning and turbine siting, particularly offshore, where the focus is on mapping migratory corridors and activity zones (Brinkløv et al. 2025, Lagerveld *et al.* 2023, Seebens-Hoyer et al. 2026b), as the marine environment generally serves only as a marginal foraging habitat (see section 1.4).

Beyond anecdotal records, dedicated offshore studies have now confirmed the presence of several bat species, particularly migratory ones, along coastlines and farther offshore (see section 1.4). Moreover, bats have been regularly detected both within operational offshore wind farms and in areas targeted for future developments (see section 1.5; Ahlén et al. 2009, Brabant et al. 2019, 2021, Lagerveld et al. 2021, 2023, Seebens-Hoyer et al. 2026b, Solick & Newman 2021). These emerging data on spatial distribution patterns, especially if they have led to sensitivity maps (Brinkløv et al. 2025, Seebens-Hoyer et al. 2026b) may provide valuable input for the spatial planning of future ***offshore WT*** projects.

We therefore recommend avoiding the development of offshore wind farms wherever intense bat migration occurs offshore. Considering the diversity of European marine environments (including the Baltic Sea, North Sea, English Channel, Atlantic Ocean, Mediterranean Sea, and Black Sea) and the current absence of consensus regarding the spatial determinants of bat occurrence and activity -except within maritime strait- we underscore the pivotal role of monitoring embedded within environmental impact assessments and targeted research programs, in elucidating spatial determinants and informing effective mitigation strategies.

4.2 Mitigation

4.2.1 Blade feathering in offshore context

Implementing operational mitigation measures, such as feathering turbine blades during periods favoring offshore bat migration, represents an effective approach to reducing collision risk and associated fatalities. In onshore context, increasing the wind speed at which turbines begin generating electricity, a mitigation measure known as curtailment, can significantly reduce bat fatalities (Arnett *et al.* 2011, Behr *et al.* 2017, Martin *et al.* 2017, Mantoiu *et al.* 2020, Smallwood and Bell 2020, Whitby *et al.* 2024, Bennett *et al.* 2022, Rabie *et al.* 2022, Barré *et al.* 2023). Additional variables, such as ambient temperature, can be used to refine curtailment algorithms (Martin *et al.* 2017). Beyond traditional threshold-based approaches (e.g. wind speed, temperature), emerging algorithmic methods including large set of environmental variable (Barré *et al.* 2023); or even integrating information on bat acoustic activity (Behr et al. 2023, Voigt *et al.* 2024) have been proposed to dynamically model collision risk and optimize turbine operation accordingly. Although our understanding of the spatial distribution of bats at sea remains incomplete, substantial progress has been made in identifying the temporal drivers of their occurrence. Research has advanced in characterizing migratory movements — including seasonal and diel phenology, migratory flow directions — and in determining the environmental factors influencing bat presence offshore, particularly meteorological conditions (see section 1.4; Brabant *et al.* 2019; Lagerveld *et al.* 2021, 2023, 2024; Seebens-Hoyer et al. 2022, 2026a; Smith *et al.* 2016; Willmott *et al.* 2023). Such knowledge provides a crucial foundation for the development of effective mitigation strategies and the design of efficient curtailment schemes aimed at minimizing bat mortality at wind turbines.

Special attention must be paid to the fact that short-term shutdowns, which are common practice for onshore wind turbines, regularly cannot be applied offshore. The main reasons are (i) the extreme mechanical stresses that repeated shutdowns place on these large turbines and (ii) that offshore wind farms generate considerably more electricity and shutdowns at the farm level can therefore lead to instability in the power grids—especially when several farms are shut down, as is to be expected in the event of mass migration. For this reason, shutdown times for ***offshore WTs*** are set in advance, i.e., 24 to 48 hours in advance (e.g. Ministerie van Economische Zaken 2016), in cases where such orders have been implemented in practice. Accordingly, predictions of bat migration events must take the required time periods into account. Even when the required level of protection has been achieved, it must be taken into account that shutdowns cannot be carried out *ad hoc*.

4.2.1.1 Temporal dynamics of bat occurrence

Current evidence indicates that the presence of bats at sea occurs predominantly during the autumn migration period, corresponding to the post-nuptial dispersal phase. Most detections in Europe are concentrated between mid-August and early November (see section 1.4). Interannual patterns in offshore occurrence have been addressed in few studies (Brabant *et al.* 2021, Lagerveld *et al.* 2023, Seebens-Hoyer et al. 2022), confirming the consistency of autumnal migration but revealing significant year-to-year fluctuations in detection rates. Brabant *et al.* (2021) and Seebens-Hoyer et al. (2022) suggested that such variability may reflect weather-dependent effects, with adverse conditions delaying or suppressing migratory movements in some years.

The majority of research has focused on nocturnal activity, as acoustic monitoring devices are typically programmed to operate during nighttime hours, occasionally extending to twilight periods. However, continuous monitoring off the coast of Virginia (USA) combining acoustic and video data revealed that 45% of detections occurred during daylight (Willmott *et al.* 2023). Similarly, Solick & Brown, (2021) reported a predominance of diurnal detections along the U.S. East Coast, although the visual nature of their dataset introduces potential methodological bias. Evidence from the North Sea further suggests that migratory crossings may extend over several nights, with bats frequently observed in the late morning and presumed to roost on offshore structures during the day (Lagerveld *et al.* 2023, Seebens-Hoyer *et al.* 2022).

Although curtailment strategies have not yet been broadly adopted in offshore wind operations, unlike in onshore contexts, the growing body of offshore data now enables the formulation of practical and scientifically grounded curtailment settings. Finally, it is important to note that, while there is consensus that curtailment measures reduce bat mortality, there is also agreement that these measures have, to date, never fully eliminated bat fatalities (Baerwald *et al.* 2009; Arnett *et al.* 2011; Voigt *et al.* 2015; Whitby *et al.* 2024).

4.2.1.2 Meteorological parameters influencing bat occurrence at sea

Bat activity at sea generally declines with increasing wind speed. Brabant *et al.* (2019) reported that 80.5% of *P. nathusii* detections occurred when wind speed did not exceed 5 m/s measured 10 m above sea level, and that no individuals were recorded when wind speed exceeded 13.4 m/s. Similarly, Lagerveld *et al.* (2021) found that during 67% of nights with *P. nathusii* detections, wind speeds were below 5 m/s measured 10 m above sea level; in 31% of cases they ranged between 5 and 8 m/s, and in only 2% of cases did they exceed 8 m/s. In the southern Baltic Sea Seebens-Hoyer et al. (2026b) recorded most bats at 8 to 9 m/s, measured 10 m above sea level, while in the German North Sea most bats occurred at or below 6 - 7 m/s. On the U.S. East Coast, Willmott *et al.* (2023) observed that bat activity declined sharply above 6 m/s (at nacelle height) and remained minimal above 10 m/s, with no detections recorded when wind speeds exceeded 16 m/s.

Several studies have also reported a positive correlation between bat presence and higher air temperatures (Brabant *et al.* 2021; Lagerveld *et al.* 2021, 2023; Willmott *et al.* 2023). Lagerveld *et al.* (2021) noted that only 11% of *P. nathusii* detections occurred on nights with mean temperatures below 15 °C, whereas 50% were recorded between 15 °C and 18 °C, and

39% when mean temperatures exceeded 18 °C (all during autumn migration). Brabant *et al.* (2021) reported a mean temperature of 16.0 °C for nights with *P. nathusii* detections, compared to 14.9 °C across the entire study period (also autumn migration only). Willmott *et al.* (2023) detected bats near turbines within a temperature range of 20–24 °C (what season?). It has to be taken into account that especially in autumn, this might be a general seasonal effect rather than a dependency between migration and temperature. In spring, when nighttime temperatures are often still in the single digits, temperature can play a limiting role. The threshold value for a significant increase in bat sightings in spring is 10°C for the German North Sea and 9°C for the German Baltic Sea (Seebens-Hoyer et al. 2026a).

In contrast, other factors commonly associated with bat activity in onshore context —such as moon phase, cloud cover, atmospheric pressure, precipitation, and visibility—appear to have limited or inconsistent effects in offshore context. Lagerveld *et al.* (2023) nevertheless observed that *P. nathusii* migratory activity tended to decrease between the full moon and the last quarter, and then increase again just before the new moon. The relationship with atmospheric pressure remains more ambiguous: Brabant *et al.* (2021) found a positive correlation in offshore environments, whereas studies conducted in terrestrial contexts have reported both positive and negative responses (Bender & Hartman, 2015; Smith *et al.* 2016; Baerwald & Barclay, 2014; Dechmann *et al.* 2017).

Several studies have suggested a positive relationship between migration departures from land and the presence of tailwind aligned with the direction of travel for *P. nathusii* (e.g. Lagerveld et al. 2024; Petersons 2004). However, in other cases, wind direction has been found to have little association with migration when wind speeds were low (Sebens-Hoyer et al. 2026a).

Overall, these results highlight the key role of wind speed and temperature in shaping offshore bat activity, while other meteorological factors appear to have more limited or context-dependent effects. The consistency of these patterns with observations from onshore wind farms (Barré *et al.* 2023; Behr *et al.* 2017; Martin *et al.* 2017; Voigt *et al.* 2024) further underscores their generality across environments.

4.2.2 Raising the lower rotor sweep point

The altitude distribution provides another starting point for mitigation measures. Despite all the uncertainty due to the restricted heights surveyed in available studies (see section 1.5.2) - a high proportion of bats fly at rather low altitudes and bat activity decreases with altitude in studies surveying up to 100 m (Brabant *et al.* 2019, Lagerveld *et al.* Seebens-Hoyer *et al.* 2026a). Therefore, raising the lower rotor sweep point could reduce the proportion of bats occurring in the rotor area and thus being at risk of collision with the rotor blades. On the other hand, it is unknown whether and to what extent bats migrate at altitudes of more than 100 m above the sea. Lagerveld et al. (2024) found evidence that bats migrate at an altitude of several hundred meters above the English Channel. That proportion of bats could be directly endangered by their flying altitude or by 'diving' into the wind farm from above. For these animals, an increase in the rotor area could increase the risk. Additionally, increasing the lower rotor sweep height may raise the risk of bird collisions in passerine migration areas, underscoring the importance of considering the entire flying fauna community.

The chance to protect bats by raising the rotor sweep point highlights that studying the flight altitudes during offshore migration from water surface to several hundred meters is highly important.

4.2.3 Optimizing nocturnal aviation lighting as a mitigation strategy

Bats may be attracted or repelled by the illumination of offshore structures with artificial light at night (ALAN). There is no empirical data available on the long-distance effect of ALAN on offshore migrating bats yet, but several authors hypothesize the existence of a lure effect. Rydell & Wickman (2015) suggested that the activity of bats observed at an ***offshore WT*** located 4 km from the coast of Gotland Island in the Baltic Sea may be associated with attraction induced by the turbine's illumination and by the presence of insects themselves drawn to the light (Rydell *et al.* 2010b). This hypothesis has subsequently been corroborated in onshore settings, where Larnoy *et al.* (in prep) found that bat activity at turbines illuminated only when aircraft were detected—thereby substantially reducing the duration of turbine lighting—was markedly lower than at sites near turbines illuminated throughout the night, and comparable to that observed at control sites. Voigt et al. (2017, 2018) found attraction to ALAN of Nathusius´pipistrelles migrating along the coast. In an onshore wind farm context, Larnoys et al. (2026) showed that bat acoustic activity was overall higher at sites located near wind turbines continuously illuminated throughout the night than at control sites, across all functional guilds. Activity recorded near wind turbines equipped with an aircraft detection lighting system was overall lower than that observed near continuously illuminated turbines, and comparable to control sites. These findings suggest that part-night lighting could help reduce the attractiveness of wind turbines to bats.

On the other hand, Seebens-Hoyer et al. (2026b) did not find any differences in the bats simultaneously recorded at an unlit buoy and a lit platform in the southern Baltic Sea. These findings suggest that attraction behavior towards wind turbines, which may increase collision risk, may be associated with the structure itself or/and with aviation lighting on turbines (Rydell et al. 2014). We therefore advocate for the experimental assessment of this lighting reduction mitigation measure on ***offshore WTs***, with the objective of minimizing bat attraction and thereby mitigating collision risk.

4.2.4 Deterrents

No deterrents have (yet) been proven to be effective at preventing bats from approaching ***WTs***, let alone to reduce bat fatalities at operating ***WTs*** (e.g. Arnett et al. 2016). Although various technologies and approaches were tested over the years (mostly onshore) - acoustic, mostly ultrasonic (e.g. Arnett et al. 2013, Romano et al. 2019, Weaver 2020, Gilmour et al. 2020), visual (light), texture (e.g. Bennett & Hale 2018), and electromagnetic, mostly radar (e.g. Gilmour et al. 2020), occasionally combined with curtailment (e.g. Good et al. 2022, Clerc et al. 2025), studies to date revealed inconsistent effectiveness. Also, the impact of such measures on other wildlife has to be considered. Therefore, although research into deterrents may have potential, currently they cannot be considered as a ***mitigation*** strategy to avoid bat fatalities.

4.3 Compensation

The implementation of offset measures to compensate for impacts that cannot be avoided or reduced is a legal requirement in the European Union (McGillivray, 2012). Offsets are intended to provide population resiliency by restoring or creating habitat for species at high risk of collision (Regnery *et al.* 2013). In onshore context, several approaches have been proposed as compensation measures, such as creation of new wetland habitats as foraging habitats for bats, or provision of new roost structures, (Peste *et al.* 2015). To our knowledge, the effectiveness of most of these proposed measures has not been validated (Berthinussen *et al.* 2021). Currently, there is a lack of evidence on effective compensation measures for wind turbine casualties and habitat loss. The possibility to compensate for fatalities is, at best, questionable, given the inherently low growth rates of bat populations (resulting from low fecundity, litter sizes rarely exceeding one offspring, and delayed onset of reproduction) (Barclay & Harder, 2003; Barclay *et al.* 2011). Therefore, avoidance and mitigation measures are essential to minimize conflicts between ***offshore WT*** development and bat conservation!

5 Research priorities

There are important knowledge gaps in the field of bat ecology and conservation that future research should prioritize. We outline here those knowledge gaps and highlight potential collaborations, existing and advancing technologies and techniques that will help to address those areas of research.

Knowledge on species distributions, bat population sizes and dynamics at local, regional and international scales is generally lacking in most of Europe, although some regions including the U.K. (Barlow *et al.* 2015; Mathews et al. 2018; 2020) and Catalonia (Torre *et al.* 2021) have developed extensive monitoring programmes. We emphasize that understanding local and broadscale bat ecology, ideally through national and international monitoring programs, would be integral to best understanding how to proceed with most core issues related to these knowledge gaps. In particular, accurate regional scale bat species distribution maps and knowledge of intermediate and long-distance migrations would radically improve the ability of stakeholders to make informed management decisions. In the context of climate change, these resources are increasingly important to develop and regularly update across Europe. (Belluardo et al, 2026; Festa *et al.* 2023; Fialas *et al.* 2025)

5.1 Understudied regions

There are regions in Europe for which there is disproportionately less knowledge of bat populations and migration (see section 1.4). It will be important to address such data gaps in order to realise the broader goals of these guidelines. Important understudied areas include Black and Mediterranean seas but also the Irish Sea, Atlantic Ocean, North Sea (northern expanses of the North Sea, along the coast of Scotland and Norway) and the Baltic Sea. Identifying migratory pathways on land, including headlands, in the Fennoscandia, northern U.K., the Baltic, Balkans and Mediterranean will be critical for better understanding the risks that ***offshore WT*** development pose to European bat populations (Gaultier *et al.* 2020; Massaad *et al.* 2022).

5.2 Improving knowledge on migration routes and foraging offshore

A clearer understanding of migratory pathways (see section 1.4) is essential for assessing and mitigating the risks that ***offshore WT*** development may pose to bats, as this knowledge underpins both effective conservation planning and responsible placement of future infrastructure. Open and edge space foraging bats capable of intermediate and long distance movements are among the species most likely to experience direct fatalities at offshore wind facilities (Rydell et al. 2010a, Voigt et al. 2024). Certain linear features and landscape elements are likely to act as important migratory pathways, such as waterways, ridgelines, coastlines, and headlands. Identifying sensitive routes that are highly trafficked is a critical step for guiding current and future research efforts (see section 3.1), particularly in areas where offshore development may intersect with migration. These coastal land features may in future prove to be useful indicators of where development should be avoided. They also provide strategic locations for capturing and radio tagging or GPS tagging bats to better understand their migratory movements. While landscape elements can act as migratory corridors in some regions, research from the Baltic Sea and other well-studied parts of northern Europe shows that bat migration during autumn and spring, particularly *Pipistrellus nathusii,* occurs as broad front movements (Wood pers. comm.; Seebens-Hoyer et al. 2006b, 2022; Brinkløv et al. 2021; Lagerveld et al. 2021b).

When migratory bat activity is diluted across wide areas and over extended time periods, mitigation strategies for ***offshore WTs*** must be adapted to reflect these more diffuse patterns. For example, in such situations, blanket curtailment would be likely to be ineffective while imposing substantial costs on operators, and highly precise curtailment would risk underestimating true levels of activity and potential impacts.

Furthermore, we should consider that impacts from ***offshore WTs*** may not be limited to the migratory period or to migratory species (see section 1.4.3). Currently it is unclear how to calculate the risk that offshore wind farms pose to bats in relation to their distance to the coast throughout Europe. However, the area within 20 km from the coast has been identified as highly sensitive in Denmark (Brinkløv et al. 2025). Future research should consider the importance of near shore foraging areas to bats and how this relates to risk posed by offshore wind farms located in these areas should also be more carefully studied.

5.3 Attraction and displacement behaviours

Coupled to the need to better understand spatial patterns of migration, we still lack fundamental knowledge about how bats interact with ***offshore WTs*** (see section 1.5.1). From research on land, we know that different bat species can be either attracted or displaced by windfarms (Roeleke et al. 2016, Richardson et al. 2021, Reusch et al. 2022), but we currently lack comparable data for the offshore environment. The attractive effect of windfarms may partly be due to lighting (see section 4.2.3), and we recommend more experimental approaches to evaluate whether modifying lighting can reduce attractiveness for bats. We also still lack fundamental knowledge on flight height at sea and how this may influence interactions with wind turbines (see section 1.5.2). Studies conducted in coastal areas indicate that bats usually fly at relatively low altitudes (Ahlén et al. 2009, Brabant, 2019), but other studies have predicted that bat flight at altitudes over 400 m is plausible (Laegerveld et al. 2024), and it is possible that bats flying over open sea may fly higher to benefit from favourable tail winds at these altitudes (Hüppop and Hill, 2016). Studying bat flight at altitude over the sea is logistically and methodologically difficult but existing marine infrastructure could be utilised. Future research should consider that there are numerous existing structures in coastal and offshore areas that could be used for various data collection efforts, often from the energy (Fowler *et al.* 2020, Martins *et al.* 2023) and military (Fazia *et al.* 2024) sectors. Abandoned oil rig platforms could, for example, provide important infrastructure for Motus stations and acoustic monitoring sites, especially with regards to establishing baseline data before ***offshore WTs*** expand across European seas.

5.4 Monitoring collisions and mortality

Currently there are no standardized or well tested methods for monitoring bat collisions or estimating fatalities at ***offshore WTs***. There is a great deal of potential in using acoustics in combination with cameras and/or multiple sensor systems to address these needs (Lagerveld *et al.* 2020, Newman *et al.* 2024, Brinkløv *et al.* 2025). These methods could be especially practical for informing “smart curtailment” strategies (Newman *et al.* 2024). However, these techniques will need to be thoroughly tested and made easily available before they can be included in official guidance. An overview of existing technologies with associated reports and scientific literature can be found at Tethys (see also section 1.3.5). There is exciting potential to integrate passive acoustic monitoring with long range infrared and thermal cameras, together with AI algorithms, to detect, identify and assess risk of bats approaching and colliding with turbines in real time (Happ et al. 2021, Weaver et al. 2025). Research and development in this field must account for how bats flying offshore may echolocate less frequently and with quieter calls, making acoustic monitoring alone unlikely sufficient for accounting for bat activity and potential risk of collision (Solick & Newman 2021).

While these emerging new approaches could eventually provide high-resolution information needed for operational mitigation, an additional challenge lies in how such data can be used offshore. Although curtailment is widely used on land to reduce wildlife collisions, short-term shutdowns offshore are far more challenging (see section 4.2.1). Using real-time bat detections to instruct curtailment is not feasible, as taking turbines offline without notice can contribute to instability in the offshore grid (Brabant & Degraer 2023). Instead, there is a need to shift toward predictive models of bat activity that provide operators with sufficient lead time to plan required curtailment. This type of proactive approach has already been successfully implemented in the Netherlands for birds using predictive activity models (Brabant & Degraer 2023), and developing comparable methods for bats should be a priority.

5.5 Technological developments

To advance our understanding of bat migration, it is essential to evaluate the effectiveness and feasibility of emerging radio-tagging technologies such as ATLAS (Beardsworth et al. 2022), while simultaneously expanding the existing Motus network into under-studied regions of Europe. At present, most Motus stations are concentrated in the southern North Sea and the English Channel, with smaller clusters in both the northern and southern Baltic Sea. Priority expansion areas include the northern North Sea, central Baltic, Mediterranean, Black Sea, Irish Sea, and the Atlantic Ocean, where coverage remains insufficient to effectively track migratory movements (www.motus.org).

Motus stations are often operated through national or regional initiatives, therefore greater international collaboration is strongly encouraged to strengthen and coordinate the network across Europe. Funding mechanisms that explicitly support cross-border cooperation such as COST Action grants, which have previously facilitated international research on bats and climate change (Fialas et al. 2025), should be actively pursued. COST Action initiatives and other similar collaborations that consolidate the expertise, knowledge, equipment, capital and administration needed for continued monitoring of bat movements will be extremely valuable to ***offshore WT*** operations. International collaboration on the regional (i.e., Baltic, Nordic, Iberian, Mediterranean, etc.) and international scale will be integral to maintaining and advancing bat migration research in Europe long term, particularly with regards to the Motus network. There is great potential for Motus partners in Europe to develop broadscale monitoring networks where collaborators can complement each other’s efforts, share resources for building and maintaining stations, and work together to secure sustainable funding for these efforts. Furthermore, efforts such as Motus will directly benefit bird and even insect monitoring efforts.

There are rapid technological developments which may also offer alternatives to static radiotracking networks. These include tags that exploit existing Internet of Things (Hurme et al. 2025), Bluetooth beacon networks (Farine et al. 2024) and Wifi coverage (Wild et al. 2023) to obtain positions and transmit data. Users can potentially boost coverage by installing their own beacons, and research testing the effectiveness and accuracy of these approaches in monitoring movements at sea, as well as in identifying coastal departure and landfall points is warranted. There is also progress with miniaturising GPS tags (Gauld et al. 2023), though it is unlikely that satellite transmission of data is achievable in the near future owing to battery power requirements, and therefore they can be most usefully deployed in coastal areas where there there is a reasonable probability of achieving data downloads from beacons or through recapture of tagged individuals.

Aside from tagging, acoustics are also widely used as a method to monitor bat activity in offshore and coastal regions (see Section 1.3.1), and studies often examine the effects of weather on seasonal patterns of bat activity. However, the low statistical power of small-scale studies, combined with the low detection rates of migratory bats, often makes it difficult to draw robust conclusions about the influence of environmental drivers. Compiling large scale datasets, including via meta-analysis (Richter, 2026) and data collected from Environmental Impact Assessments, would substantially increase statistical power and improve our ability to understand continental scale movements of migratory bats (Roemer, 2024).

Combining datasets is not straightforward. Acoustic data recorded with different devices, using different settings, and analysed with various software platforms, each introducing its own sources of error, can be challenging to integrate (Roemer et al. 2025). For this reason, it is essential that acoustic metadata are made accessible and, ideally, standardised to allow for reliable re-analysis (Lopez Baucells et al. 2025). Such bioacoustic data coupled with detailed meta-data and study design descriptions would be extremely valuable if shared and made available to other researchers (Brinkløv *et al.* 2023). Research priorities in this field must include open science principles and should consider building upon existing data whenever possible. However, storing large acoustic datasets remains costly, and initiatives that support long term archiving of such data should be encouraged and utilised by bat researchers (Lopez Bosch et al. 2024).

6 Content of national guidelines

According to the Resolution 9.4, Parties, non-Party Range States and other stakeholders, including nongovernmental organizations are called to “develop and ensure implementation of national guidance following EUROBATS Publication Series No. 6” and “ensure that impact assessment procedures and post-construction monitoring follows either EUROBATS guidelines, or where they are more stringent, national guidelines“. According to the same resolution, the Secretariat and the Advisory Committee were requested to “update the generic guidelines, now available as EUROBATS Publication Series No. 6” (i.e. this document when considering ***offshore WT*** projects, until it is replaced by a new version).

While these EUROBATS guidelines provide an important and necessary foundation, national guidelines are vital to ensure that survey and monitoring protocols, impact assessments and mitigation measures for bats for ***offshore WT*** projects are both scientifically sound and practically applicable within the unique natural and regulatory landscapes of each country or region, leading to more effective and enforceable conservation outcomes throughout the entire range of the Agreement. National guidelines are the ones that can ensure that the principles of the international guidelines are applied effectively, enabling adaptation of general recommendations to specific local conditions. Accordingly, there are several key elements which should be taken into consideration when developing national guidelines:

1. **Implementation of EUROBATS guidelines**: National guidelines should be based on the principles contained in the related EUROBATS Guidelines (i.e. this document).
2. **Adaptation to local environments**: National guidelines should be specific to the local environment, adapting general EUROBATS Guidelines to national and regional conditions, for example, accounting for variations in climate, topography, bat fauna biodiversity.
3. **Addressing national legislation**: National guidelines should be aligned with national and, for EU Parties, also EU regulations and administrative practices, integrated into the national system of environmental impact assessments to ensure they are observed and applied.
4. **Flexibility and updates**: National guidelines can include some adjustments in comparison to EUROBATS Guidelines if they are based on specific national or regional conditions. They should also be updated regularly to keep them consistent with the most recent version of the EUROBATS recommendations and the current state of knowledge.
5. **Specific content**: National guidelines should cover at least pre-construction surveys, impact assessments and post-construction monitoring, but also include other components depending on the requirements of a particular state, such as specific national or regional conditions and legislation, experience requirements for bat experts, term glossaries, administrative procedures etc.
6. **Standardization and comparability**: National guidelines can standardize the scope of data that must be submitted to authorities, along with the data organisation, presentation and storage, ensuring that results are comparable between countries or regions.
7. **Transboundary considerations**: While national guidelines should not contradict international guidelines, they can affect the choice of research methods and data specificity, recognizing that bats migrate across borders and may experience transboundary impacts.

The EUROBATS Publication Series No 6 “Guidelines for consideration of bats in wind farm projects – Revision 2014” was published in 2015. The effort in translating the guidelines in multiple languages made them more accessible in a wide number of countries. Still, a review of existing national guidelines in 2017 Report of the EUROBATS Intersessional Working Group on Wind Turbines and Bat Populations and subsequent annual reports up to 2023 indicated that national guidelines across Parties and non-Party Range States vary in significant extent, with their existence still lacking in some countries. Differences are observed in their compliance with EUROBATS Guidelines, general scope and level of legal obligation. A particular problem is the lack of specific instructions for considering bats in both planned and existing ***offshore WT*** projects. Some guidelines specifically related to offshore wind farms have already been published (e.g. BSH 2013). Still, this document is the first to offer more comprehensive information and recommendations on this topic. The lack of evidence, and the difficulty in collecting that evidence, has posed a problem for the organisations tasked with ensuring that the environmental impacts of offshore development are minimised and mitigated for appropriately. Insufficient knowledge on this topic is also recognized within paragraph 6 of Resolution 9.4 which calls to "promote research in the offshore environment in order to enhance monitoring techniques, improve understanding of impacts, and identify potential solutions, also in collaboration with research conducted on other taxa." To ensure equally effective protection of bats throughout the entire range of the Agreement, it is essential that national guidelines also show awareness of this problem, meeting certain standards in considering bats in planned and existing offshore wind farms based on the resolutions of the Parties and the most current scientific knowledge.

While recommendations mentioned so far might appear prescriptive, the following sub-chapters analyse them in more detail, outlining minimum requirements for national guidelines and identifying areas in which a range of solutions on national level may be appropriate.

6.1 Format of the national guidelines

Although the Resolution 9.4 clearly calls for Parties to develop national guidelines for considering impacts of ***onshore*** and ***offshore WTs*** on bats, it does not prescribe specific format required for the national guidelines. Thus, various acceptable solutions exist based on a state's preferences. Guidelines may appear as:

a) A standalone document focused solely on bats and offshore wind farms or wind farms in general,
b) A chapter within broader environmental impact assessment guidelines, or
c) A section in general guidelines for assessing the impacts of various development projects on bats.

Although it is acceptable to create separate guidelines specialized for ***offshore WTs***, it is still advisable to include them in the same document that provides guidelines for considering bats in ***onshore WT*** projects. This would ensure consistency required across similar aspects such as addressing national regulations, current state of knowledge, experience requirements for bat experts, even standardization on data collection and analysis in cases when similar methods are used for a larger national data base (e.g. acoustic monitoring at turbine nacelles). In any case, individual guidelines should not lead to an unjustified reduction in the quality of the assessment for any type of wind farm. They should also require adequate research and assessments regardless of the number of wind turbines included in a wind farm, since cumulative effect of several single wind turbines can equal the impact of a large wind farm. In some cases, developing several regional guidelines instead of one national document is acceptable, provided that sufficient consistency is also maintained.

6.2 Stakeholders involved in the development of guidelines

Parties should select the appropriate authority or organization to develop national guidelines. They can be developed by specialized non-governmental organizations, research institutions, governmental nature conservation units or individual experts. In the best case scenario, all stakeholders with high experience in bat research, monitoring and conservation, as well as wind farm impact assessments on a national or regional level, should be involved at some point of the development process. However, since implementation of the provisions of the Resolution and nature protection on the national scale is the duty of competent state authorities of a given Party, these authorities should officially adopt national guidelines and formalize their use after making sure that the applied guidelines agree with the current knowledge and the general EUROBATS Guidelines.

6.3 Compliance of national guidelines with EUROBATS Guidelines

The EUROBATS Guidelines encompass both specific and general recommendations. National guidelines may either repeat specific recommendations or simply state that the specific recommendations in the EUROBATS Guidelines should be followed. In parts where the EUROBATS recommendations are too general, the national guidelines should offer more detailed guidance. They can also address issues not covered by EUROBATS Guidelines. Some adjustments are possible to adapt the EUROBATS Guidelines to local requirements, bat activity and species composition in each country and region as well as current knowledge. These modifications should be based only on informed decisions and justified in the guidelines. Having that in mind, some adjustments are acceptable if justified by:

a) Special national or regional conditions (for example, by excluding acoustic surveys during winter in regions with temperatures below 0 degrees Celsius).
b) Current scientific knowledge (for example, incorporating new, widely accepted methods that improve research effectiveness even if they are not yet included in the current version of the EUROBATS Guidelines).

According to Resolution 9.4, the EUROBATS Secretariat and the Advisory Committee are responsible for compiling relevant information, including methods to assess the impact of wind power generation on bat populations and updating the generic guidelines. National guidelines, therefore, must be regularly updated to remain consistent with the latest EUROBATS recommendations. Although a fixed update schedule may be adopted, guidelines should ideally be updated as necessary, particularly after revisions to the EUROBATS Guidelines. Each version should be clearly dated or numbered.

6.4 Key components of national guidelines

National guidelines should at least cover pre-construction impact assessments (including surveys) and post-construction monitoring, with established minimum survey scopes and methods as outlined by general EUROBATS Guidelines. They should be embedded within environmental impact assessment regulations and, for EU Parties, must also comply with EU legislation. Since one of their key assignments is to adapt general guidelines to national and regional conditions and regulations, it is advisable that they contain additional information and guidelines for this purpose, including:

a) climatic and weather conditions that affect the timing of the bat activity season,

b) present bat fauna (species composition, distribution and abundance, threats, vulnerability to collisions with wind turbines, times and routes of migration etc.),

c) regulations and legislation regarding specific requirements concerning research, reports and impact assessment procedures (e.g., differences in research scope for the purposes of Strategic Environmental Assessments (SEA), Environmental Impact Assessments (EIA) and Appropriate Assessments (AA) for Natura 2000 sites), taking in mind that research scope may be more general at strategic planning stages and become increasingly detailed as the permitting process advances, with the complete impact assessment analysis finished before a final decision to allow a wind farm construction is issued.

Additional guidance can be included to coordinate similar efforts of neighbouring countries to recognize transboundary impacts on migrating bat populations. Although national guidelines may influence choices in research methods and reporting, they should not contradict each other.

If mitigating measures and principles of their application are included in the national guidelines, special consideration needs to be addressed to mitigation measures noted by the relevant Resolution of the Meeting of the Parties. In line with paragraph 18 of Resolution 9.4., it is noted that the use of blade feathering below the cut in speed, elevating turbine cut-in wind speed and shutting down turbines are the only mitigation measures which so far have proved to be effective in reducing bat mortality at wind turbines. Guidelines should acknowledge that wind farm construction can alter bat behavior and should specify how curtailment measures can be adjusted based on observed bat activity. Depending on the findings, mitigation can be tightened, relaxed, or even extended to include temporary turbine shutdowns during periods of high bat activity. This approach supports adaptive management and helps improve existing mitigation measures. National guidelines should also ensure that the results of post-construction monitoring are sent to appropriate authorities responsible for nature conservation and can be used by specialists for collective analyses and improvement of national and EUROBATS guidelines.

Other components can also be incorporated in the national guidelines, depending on the requirements of a particular state, such as:

a) Qualification and experience requirements for personnel and bat experts conducting pre-construction surveys, post-construction monitoring, data analysis and/or impact assessments,

b) Special requirements for pre-construction surveys and post-construction monitoring (e.g. additional data sources, equipment, spatial coverage, organisation and presentation of collected data, data format and storage),

c) Additional pre-construction survey and post-construction monitoring efforts beyond the minimum scope in specific critical areas,

d) Glossaries of terms,

e) Lists of supplementary literature,

f) Contacts for advisory organizations,

g) Administrative procedures if these issues are not regulated by national or regional law.

6.5 Balancing adaptability and consistency at regional and local level

National guidelines should align with EUROBATS Guidelines while adapting to local conditions, such as bat activity, migration, and environmental sensitivities. They must also ensure coordination with authorities at all levels to address transboundary impacts and maintain regulatory consistency. National guidelines should complement the general EUROBATS Guidelines to adapt to local conditions, whether in relation to bat activity, species migration patterns, or environmental sensitivities. Still, at the same time they should ensure effective coordination with local, regional, and international authorities to address transboundary impacts and maintain regulatory consistency. In most cases, national guidelines apply to the entire country, whether it is a Party or a non-Party Range State. However, in larger states, regional or administrative units may adopt different guidelines. Some European countries have different offshore administrative units. These units are often defined by maritime zones or regions and can vary depending on the country's territorial waters, exclusive economic zones, and regional maritime regulations for better management of marine resources, environmental protection, and offshore development projects. For this reason, it is important to have in mind that offshore wind farms can affect multiple jurisdictions, especially in countries with regional coastal management systems or international boundaries (e.g., neighbouring countries with shared seas). Authorities responsible for implementing EUROBATS Guidelines and bat conservation should strive for consistency across regions. Ideally, a national framework of uniform guidelines should be established, accommodating regional differences where necessary (e.g., standardized research methods with region-specific variations in data collection timing or interpretation).

As a rule, guidelines developed for one state should not be applied in another, particularly if this results in a narrower research scope or less rigorous criteria for data interpretation. Guidelines from another state may only be used in the following cases:

a) If the state conducting the assessment has not yet developed or adopted national guidelines. In this case, guidelines from the most ecologically similar state may be applied.
b) To expand the scope of research beyond national guidelines for scientific or comparative purposes. This includes cases such as cross-border impact assessments near national borders.

6.6 Ensuring Implementation of Guidelines

By integrating national guidelines into local planning, permitting, and enforcement processes, Parties should ensure that national guidelines are not merely recommendations but legally binding and enforceable for developers and regulators, as required by Resolution 9.4. For EU states and candidates, strict adherence to the latest national guidelines aligns with Directive 2011/92/EU on assessing the environmental effects of public and private projects and Directive 2001/42/EC on assessing the environmental effects of plans and program, which require that assessments reflect the current state of knowledge and assessment methods. National guidelines should specify methods that align with these standards. They also must comply with other relevant international and EU laws, such as the Marine Strategy Framework Directive 2008/56/EC, and other conservation and biodiversity agreements.

It is unacceptable for ***offshore WTs*** to be approved without an impact assessment when national guidelines exist – whether officially recommended by relevant authorities or informally endorsed by NGOs. To maintain quality assurance, it is essential to establish uniform standards for evaluating ***SEA***, ***EIA*** and Appropriate Assessment (AA) reports. Only reports that fully comply with national guidelines should be approved, though studies with a broader scope or more rigorous interpretation of results may also be accepted.

7 Conclusions and further work

This document summarizes relevant current knowledge on offshore bat activity and interactions with WTs. Accordingly, it sets out generic guidelines for the planning process, impact assessment, monitoring and mitigation to take account of the effect of ***offshore WTs*** on bats, as requested Resolution 9.4. Additionally, it summarizes relevant research priorities. It is by no means exhaustive and requires regular updates and further development, particularly within the regional/national contexts, according to Resolution 9.4. Regular updates of the state of art will be provided in the IWG comprehensive reports available online, while the guidance document itself will be updated as needed.

The impacts of ***offshore WTs*** on bats should be investigated further, particularly in order to find and improve solutions to monitor and minimise the impacts, as requested Resolution 9.4.

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