# Bat monitoring for the wind farm Jelinak

## from June to October 2020

Zagreb, April 2021

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| **Project** | **Bat monitoring for the wind farm Jelinak from June to October 2020** |
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| **Client** | Vjetroelektrana Jelinak Ltd. |
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# Contents

# 1 Introduction

Bat monitoring was implemented in the area of the wind farm (WF) Jelinak from June to October 2020. The WF is located in the hinterland of Trogir in Split-Dalmatia County (Figure 1-1). It is in operation since 2013.

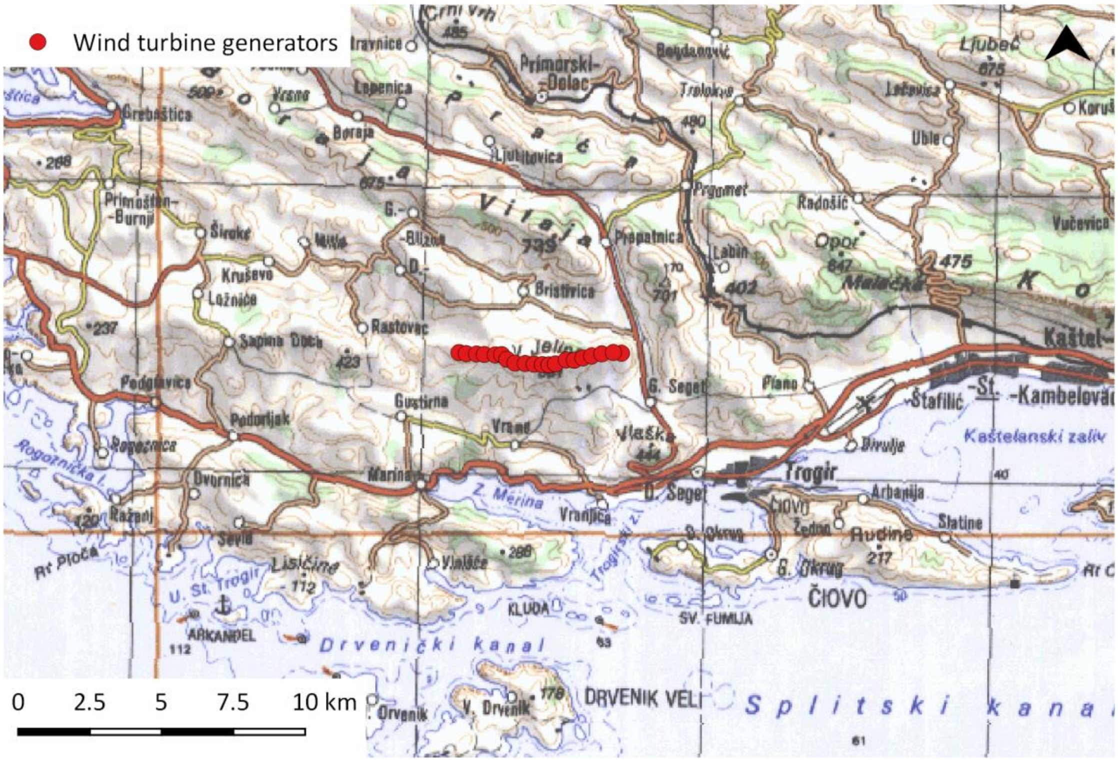



*Figure 1-1. Wind farm location*

The WF facility is comprised of 20 wind turbine generators (WTG's) positioned along access roads (Figure 1-2). Each wind turbine generator consists of a tower, 80 m high, atop which is a nacelle. Rotor blades are attached to the nacelle and measure 82 m in diameter.

During the monitoring, blade feathering and increased cut-in speed were implemented in certain periods at some of the WTG's (Table 1-1).

*Table 1-1. Mitigation mesures implemented during this monitoring*

| Period | Wind turbine generators | Blade feathering | Cut-in speed | Timing |
|---|---|---|---|---|
| 1.-15.7.2020. & 16.-31.8.2020. | WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG10, WTG13, WTG14, WTG16, WTG17, WTG18, WTG20 | yes | 5.0 m/s | 9 pm-3 am |
| 16.7.-15.8.2020. | All except WTG19 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |

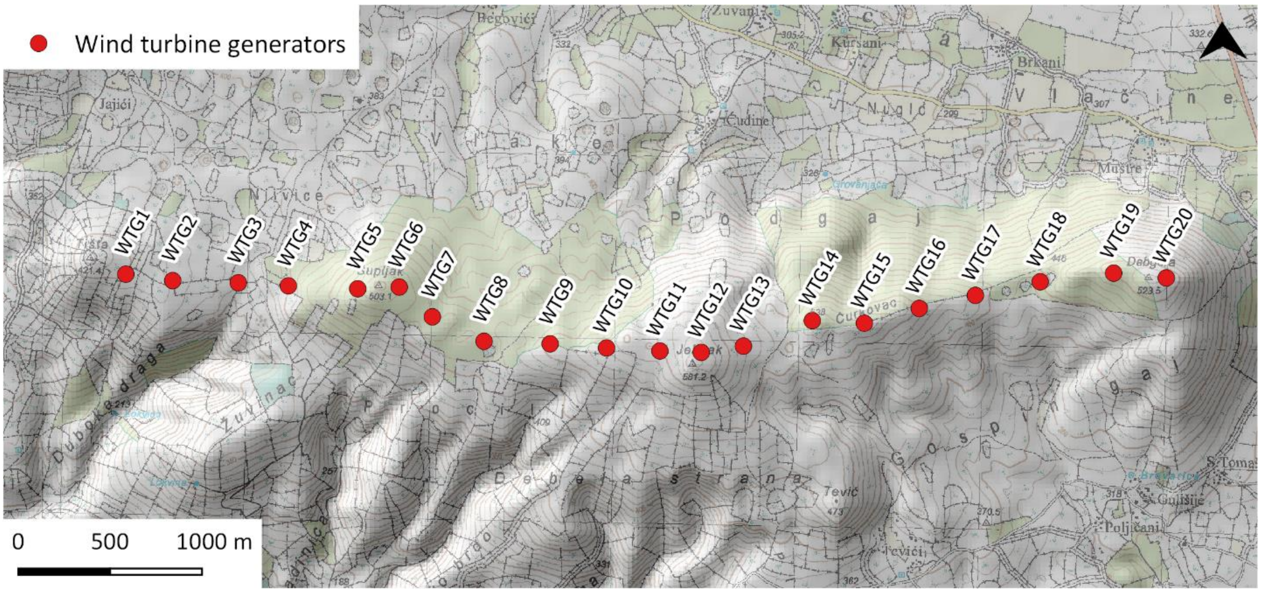



*Figure 1-2. WTG's layout*

WF Jelinak is located in a hilly area, across the peaks Tišta (421.4 m), Šupljak (503.1 m), Dabgora (523.5 m) and Veliki Jelinak (581.2 m). Dominant habitats in the WF area are eastern Adriatic sub-Mediterranean rocky pastures in succession (Figure 1-3). Other present habitats are thermophilous deciduous downy oak (*Quercus pubescens*) coppice and arable land (orchards).

*Figure 1-3. Typical habitat in the WF area*

The monitoring was designed in coordination with monitoring reports from previous years of post-construction monitoring at WF Jelinak, in agreement with Vjetroelektrana Jelinak Ltd. The monitoring included:

- Monitoring of bat collisions;
- Searcher efficiency and carcass persistence trials;
- Monitoring of bat activity using ultrasound detectors (continuous bat call recording at stationary points and peroidic bat call recording on a transect route);
- Data processing and analysis;
- Monthly and final reports.

# 2 Methodology of monitoring

Methodology and dynamics of the monitoring were coordinated with monitoring reports from previous years of post-construction monitoring at WF Jelinak. Implemented methodology was in compliance with EUROBATS guidelines for consideration of bats in wind farm projects (Rodrigues et al. 2014), adjusted to special demands of this project.

Monitoring of bat collisions was implemented from June to October 2020 at all 20 WTG's. In June and September, searches for bat carcasses were carried out every seven days, always two days in a row (June 2$^{nd}$-30$^{th}$ and September 3$^{rd}$-25$^{th}$). In July and August, the searches were carried out every day (July 1$^{st}$-August 31$^{st}$) . In October, carcasses were searched two days in a row in the first week of the month (October 1$^{st}$-2$^{nd}$) (Table 2-1).

Searcher efficiency and carcass persistence trials were conducted in June 2020, at the beginning of monitoring activities. Trials were set up a day before the first two-day carcasses search (June 1$^{st}$). Searcher efficiency trial was conducted during the two-day search (June 2$^{nd}$-3$^{rd}$), while carcass persistence trial was conducted ten consecutive days including the day the test was set up (June 1$^{st}$-10$^{th}$). Searcher efficiency trial was repeated with another survey team in July 2020 (July 7$^{th}$-9$^{th}$), using the same methodology.

Continuous bat call recording was implemented at two stationary points: WTG1 and WTG18. Bat calls were recorded every night from the beginning of June until the end of October 2020 (June 2$^{nd}$-October 31$^{st}$). Peroidic bat call recording along a transect route was carried out in July and August, two times per month for two consecutive days (Table 2-1). Transect route was 7 km long and lasted for around 2 hours and 40 minutes.

*Table 2-1. Monitoring dynamics*

| | | MONITORING OF BAT COLLISIONS | | CONTINUOUS BAT CALL RECORDING | | PERIODIC BAT CALL RECORDING | |
|---|---|---|---|---|---|---|---|
| **YEAR** | **MONTH** | **DATES** | **NUMBER OF SURVEY DAYS PER MONTH** | **DATES** | **NUMBER OF SURVEY NIGHTS PER MONTH** | **DATES** | **NUMBER OF SURVEY NIGHTS PER MONTH** |
| 2020 | June | 2.-3.6., 9.-10.6., 16.-17.6., 23.-24.6., 30.6. | 9 | 2.-30.6. | 20 at WTG1*<br>28 at WTG18* | - | - |
| | July | 1.-31.7. | 31 | 1.-31.7. | 27 at WTG1*<br>31 at WTG18 | 15.-16.7.,<br>29.-30.7. | 4 |
| | August | 1.-31.8. | 31 | 1.-31.8. | 28 at WTG1*<br>30 at WTG18* | 12.-13.8.,<br>24.-25.8. | 4 |
| | September | 3.-4.9., 10.-11.9., 17.-18.9., 24.-25.9. | 8 | 1.-30.9. | 30 at WTG1<br>30 at WTG18 | - | - |
| | October | 1.-2.10. | 2 | 1.-31.10. | 31 at WTG1<br>31 at WTG18 | - | - |

*recording during some nights was interrupted due to a technical issue

## 2.1 Continuous bat call recording on stationary location

Continuous bat call recording was implemented to determine bat presence, species compoisition, abundance, and activity level for all nights in the monitoring period. The recording period started on June 2nd and lasted until October 31st.

Monitoring equipment was placed on WTG's previously defined in the project task, one at each end of the wind farm – WTG1 and WTG18 (Figure 2-1), at the same locations as in previous monitoring years.

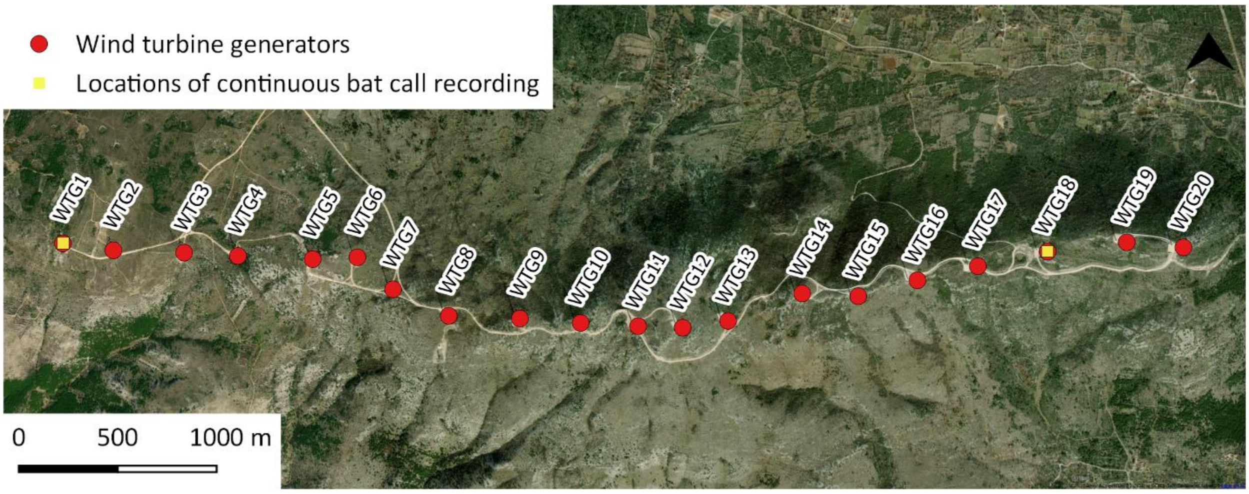



*Figure 2-1. Locations of continuous bat call recording (marked yellow)*

*(Basemap source: www.bing.com/maps/aerial)*

At the beggining of the monitoring period, bat calls were recorded using ultrasound detectors *Elekon BATLOGGER C*. Microphones were set on wind turbine towers at a height of approximately 5 m above the ground, above the tower doors, while the recorders themselves were placed inside the towers. Recordings started 30 min before sunset, and lasted until 30 min after sunrise.

On June 26th, the *Elekon BATLOGGER C* detectors were replaced with ultrasound detectors *Elekon BATLOGGER WE X2* (Figure 2-2), specialized for monitoring at windfarms, which support remote control and have greater storage capacities. Microphones were set higher, at a height of 15 m. They were placed on the skin of the WTG towers, held in place by magnets and tape. Microphone cables were also secured with magnets and tape to prevent strong wind from ripping them off of the tower. The recoders were, once again, placed inside the towers. Recording started 15 min before sunset, and lasted until 15 min after sunrise. All recordings were analysed using *BatExplorer 2*, specialized ultrasound analysis software with use of relevant scientific literature (Russo and Jones 2002; Barataud 2015).

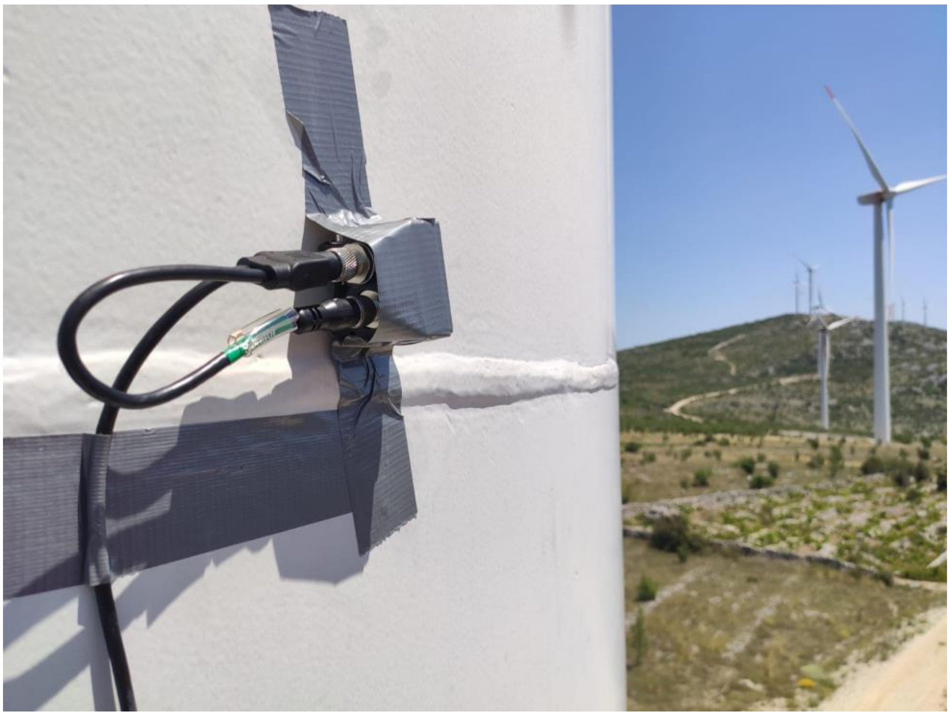


*Figure 2-2. Microphone of ultrasound detector* Elekon WE X2 *set at WTG1*

## 2.2 Periodic bat call recording on a transect route

Periodic bat call recording (bat detector trasect) was used to determine bat presence, species composition, abundance, and activity level in different parts of WF Jelinak. This information also helps identifying key foraging areas, commuting routes, and behaviour of bats in the wind farm area.

Bat detector surveys were carried out during summer months, when bat activity in the wider wind farm area is highest. Surveys were carried out in July and August, two times per month on two consecutive nights. All survey activities were planned and conducted on nights with favourable weather conditions for bats, which means night air temperatures above 10°C, average wind speeds no more than 3 m/s and no precipitation (Appendix I).

The transect route followed access roads between WTG1 and WTG20 and a footpath between WTG4 and WTG5, covering the whole wind farm area (Figure 2-3). The length of the transect was around 7 km. The route was walked at a uniform speed (around 3 km/h) with five-minute-long stationary recording stops at four locations with total duration of the transect route around 2 hours and 40 minutes.

Locations for stationary recording were selected based on habitat and landscape features important for bats, and approximately equally distributed along the transect route. The first one (SR1) was located near WTG2, near orchards. Location SR2 was at the intersection of access roads near WTG7. Location SR3 was in the center of the WF, at WTG10. The final location (SR4) was at the intersection of access roads between WTG17 and WTG18.

Walking speed and duration of stationary recording were defined to ensure completion of the survey within three hours after sunset, a time of peak bat activity. Recording started within 30 minutes after sunset, when activities of some of the present bat species start. To reduce survey bias, the direction in which the transect route was walked was changed for the second day of each two-day survey session.

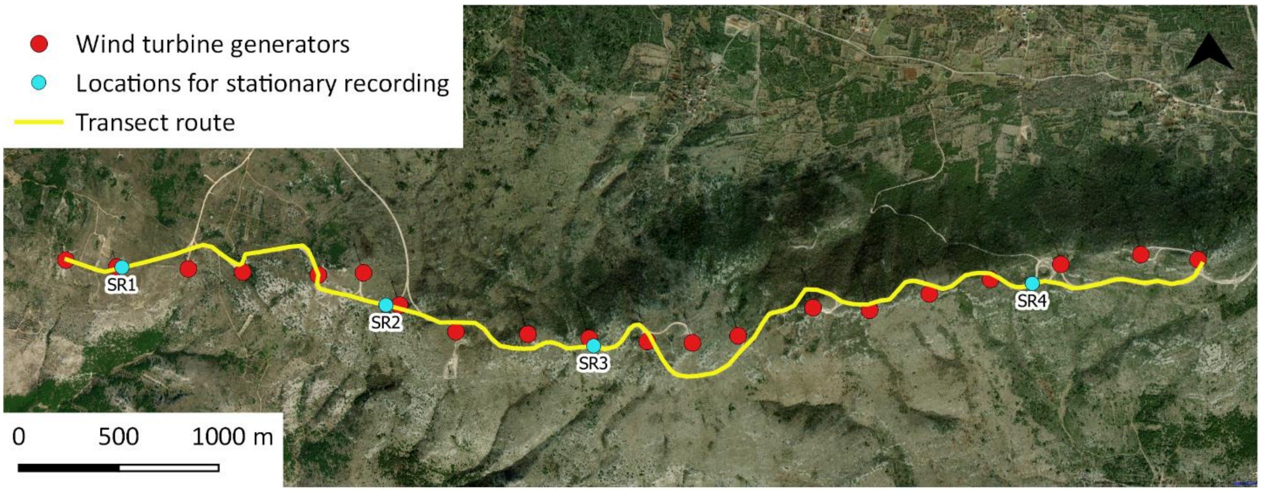



*Figure 2-3. Route of linear transect and locations for stationary recording*

*(Basemap source: www.bing.com/maps/aerial)*

Bat calls were recorded using an ultrasound detector *Elekon BATLOGGER M* which records ultrasound using *time-expansion* (TE) technique (Figure 2-4). Surveyors also played back the bat calls in real time using *heterodyne* (HET) technique which allowed them to "track" the direction of bat flight. All recordings were analysed using *BatExplorer 2*, a specialized ultrasound analysis software, with use of relevant scientific literature (Russo and Jones 2002; Barataud 2015).


*Figure 2-4. Ultrasound detector* Elekon BATLOGGER M

During the bat detector survey along transect routes, the walked path was recorded using handheld GPS devices *Garmin GPSmap 62s* and *Garmin GPSmap 64sx*. Data regarding start and end times, surveyors present, microclimatic conditions (air temperature, wind speed and humidity), number and location of recorded bat calls was entered into a field form (Appendix II). Microclimatic conditions were measured using *Kestrel 4000 Pocket Weather Tracker* at a height 2 m above ground.

## 2.3 Monitoring of bat collisions

Bat collisions were monitored by searching for bat carcasses in a radius of 70 m around each WTG. This is the approximate radius in which bats will most likely fall in regards to WTG dimensions, according to Hull and Muir (2010). Carcasses were searched in the same radius in previous monitoring years.

In June and September, searches for bat carcasses were carried out every seven days, always on two consecutive days. In July and August, the searches were carried out every day. In October, carcasses were searched two consecutive days in the first week of the month.

The searches covered all accessible areas of good visibility within 70 m radius around a WTG (Figure 2-5; Appendix IV). Those areas included: **1)** areas of high visibility – easily accessible areas clear of vegetation, i.e. WTG bases (construction plateaus), access roads and accessible slopes (Figure 2-6); and **2)** areas of moderate visibility – accessible areas covered with low vegetation. Inaccessible areas and those of poor visibility, i.e. difficult terrain and areas covered with high vegetation could not be searched.

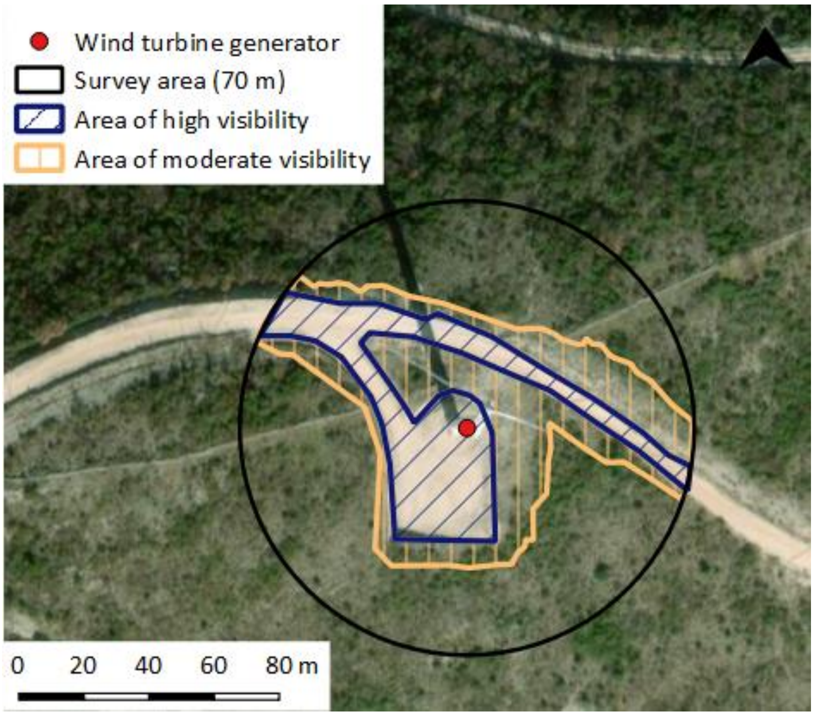



*Figure 2-5. Example of survey area for monitoring of bat collisions*

*(Basemap source: www.bing.com/maps/aerial)*

*Figure 2-6. Example of high (left) and low (right) visibility area*

Each search started within an hour after sunrise, to minimise exposure of carcasses to scavengers. Searchers covered the areas of high visibility by walking across WTG bases and access roads, walked at a slow pace, checking for carcasses for up to 3 meters on both sides of the walking line. In areas of moderate visibility, searchers followed best paths, checking up to 1.5 m on each side. The survey area around each turbine was searched for approximately 15-45 min in total, depending on the searchable area. Each following day , the searchers switched search areas, so that each one was searching the area different than the day before. This also increased the chance of finding carcasses missed by another searcher.

During each search, a track of walked routes was recorded using handheld GPS devices (*GPSMap 62s, GPSMap 64st, Garmin Oregon 650*). Data regarding start and end times, surveyors present in the field, microclimatic conditions and recovered carcasses was entered into a field form (Appendix III). Microclimatic conditions (air temperature, wind speed and relative humidity) were measured using *Kestrel 4000 Pocket Weather Tracker* at a height of 1-2 m above ground.

The discovered carcasses were photographed (Figure 2-7), and their location was recorded using a GPS device. Carcasses were examined and their species, sex, age, state of decay and injuries (if applicable, depending on the state of the carcass) were noted into a field form.


*Figure 2-7. Example of bat carcass photo documentation*

## 2.4 Searcher efficiency trials

It is not likely that all bat carcasses will be found by searchers under WTG's, especially in poorer visibility conditions (Korner-Nievergelt et al. 2011, 2013). Searcher efficiency trials were implemented to find out what proportion of bat carcasses is usually found by searchers, and to later refine the estimation of mortality of bats at wind farm Jelinak.

The trial was set a day before the first two-day search for carcasses (June 1st), and was conducted during the two-day search (June 2nd-3rd). Two teams conducted the trial – one team which set the trial, and another team of two surveyors who searched for carcasses. Twenty bat carcasses, previously kept in 70 % ethanol solution, were placed randomly at WF Jelinak. At each WTG either 0, 1 or 2 carcasses were placed. The number of carcasses at each WTG was determined using a random number generator. Each carcass position was recorded using a handheld GPS device to easily determine if any were removed by scavengers. On June 2nd a team of two surveyors were tasked with performing a regular carcass search without prior knowledge as to where, and how many, bat carcasses were placed the previous day. Carcasses they found were removed from the search area. On June 3rd, the searcher team performed their second regular carcass search, also continuing to search for remaining placed carcasses. In this second search, the searchers switched for search areas, so that each searcher was searching the area different than the day before. This increased the chance of finding carcasses missed by another searcher.

The trial was repeated in the exact same way with another team on July 8th and 9th. Team which set the trial was the same as the first time, while team of two people who searched for carcasses was different. Again, twenty carcasses were placed (on July 7th), after which surveyors performed regular carcass searches.

Results of the trials are shown in chapter 3.4.

## 2.5 Carcass persistence trial

Carcass persistence trial was used to estimate how long bat carcasses persist in the environment before they are removed by other animals such as ants, wasps, birds or foxes. This is important because searching for bat carcasses was not conducted every day in June and September, so the carcasses could have been removed in between searches, before the surveyors could have a chance of finding them. These results were used to refine the estimation of bat mortality at the wind farm.

The trial was was conducted from June 1st until June 9th. Twenty-two fresh mice carcasses were used as bat analogues. They were placed at WF Jelinak on June 1st. At each WTG either 0, 1 or 2 carcasses were placed. The number of carcasses at each WTG was selected using a random number generator. They were randomly placed inside the 70 m radius search area around the WTG's. Their locations were recorded with a handheld GPS device. Each mouse carcass was marked with masking tape with their unique code, and below (or next to) each one, an identical numbered marker was placed attached to a piece of wire which was stuck into the ground (Figure 2-8). Thus, if the carcass was removed, the marker could still be found to confirm the carcass was indeed not at its location. Also, if a mouse carcass was found at a different location it could easily be matched to its original location. The carcasses were placed in late afternoon and were then checked each morning for nine consecutive days. If a carcass was missing, its corresponding marker was found and removed from site.

Results of the trial are shown in chapter 3.5.

*Figure 2-8. Example of a mouse carcass used for carcass persistence trial*

# 3 Monitoring results

## 3.1 Continuous bat call recording

Bat calls were recorded from June 2nd 2020 until October 31st 2020. Not all nights in this period were recorded for both batloggers due to various technical issues. In total there were 136 nights recorded at WTG1 and 150 nights at WTG18, out of althogether 153 nights (Table 2-1).

At WTG1, a total of 78,606 signals were recorded: 7,420 in June, 21,927 in July, 39,863 in August, 10,282 in September and 254 in October. The term "signal" here refers to a single, distinct recording captured by the bat detector that may contain multiple calls of the same bat.

At WTG18, a total of 73,449 signals were recorded: 3,658 in June, 15,724 in July, 39,504 in August, 14,541 in September and 302 in October (Figure 3-1).

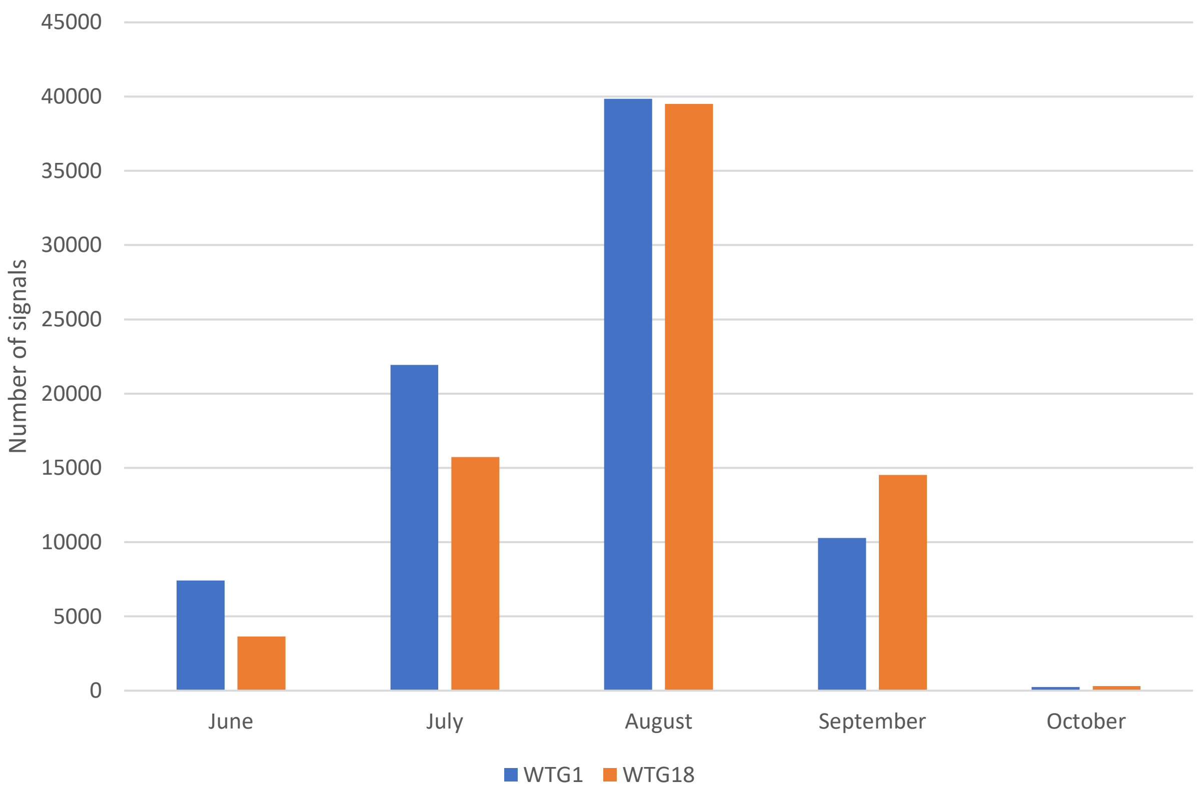



*Figure 3-1. Total number of signals per month for both continuous recording devices*

Signals were identified to genus level, or species level in case of *Eptesicus serotinus, Hypsugo savii*, *Miniopterus schreibersii* and *Tadarida teniotis* for which no other species from the same genus occur in the WF Jelinak area. Signals belonging to genus *Pipistrellus* were by far the most common accounting for 95.24 % of all recorded activity. Second most common was *H. savii* with 2.09 % of all signals. *T. teniotis* signals accounted for 1.71 % af all signals and all other species/genera were below 1 % of total signals (Table 3-1).

*Table 3-1. Number of signals per species/genera*

| SPECIES | NUMBER OF SIGNALS WTG1 | WTG18 | TOTAL | % |
|---|---|---|---|---|
| ***Pipistrellus* sp.** | 75862 | 68969 | 144831 | 95.24 % |
| ***Hypsugo savii*** | 1028 | 2155 | 3183 | 2.09 % |
| ***Tadarida teniotis*** | 1063 | 1541 | 2604 | 1.71 % |
| ***Nyctalus* sp.** | 495 | 291 | 786 | 0.52 % |
| ***Myotis* sp.** | 111 | 293 | 404 | 0.27 % |
| ***Eptesicus serotinus*** | 66 | 139 | 205 | 0.13 % |
| ***Miniopterus schreibersii*** | 0 | 23 | 23 | 0.02 % |
| ***Plecotus* sp.** | 1 | 36 | 37 | 0.02 % |
| ***Rhinolophus hipposideros*** | 1 | 0 | 1 | 0.001 % |
| ***Rhinolophus euryale*** | 0 | 2 | 2 | 0.001 % |
| **TOTAL** | **78627** | **73449** | **152076** | |

*Pipistrellus* species were the most common of all recorded groups, as stated above, and their activity outnumbered that of any other groups on most nights, even in June and Ocotber when it was at its lowest. Their peak of activity was in August (Figure 3-2).

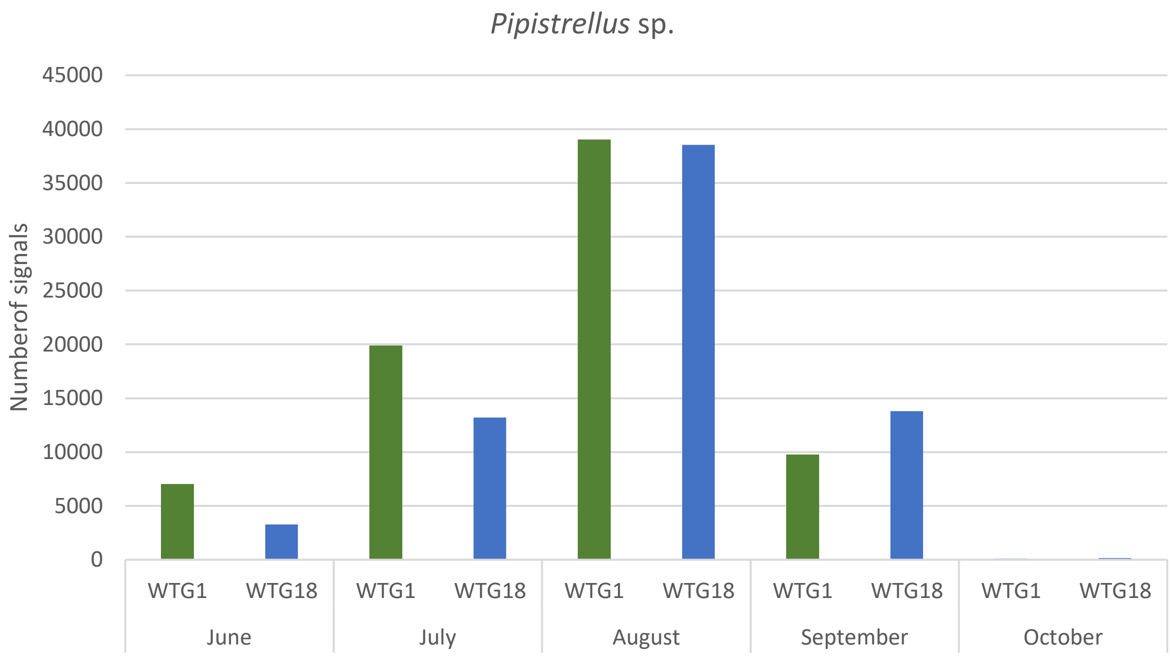



*Figure 3-2. Number of signals per month for* Pipistrellus *sp.*

Species *H. savii*'s peak activity was in July and August and it was much more pronounced at WTG18 location than at WTG1. After August, activity of this species dropped significantly at both locations (Figure 3-3).

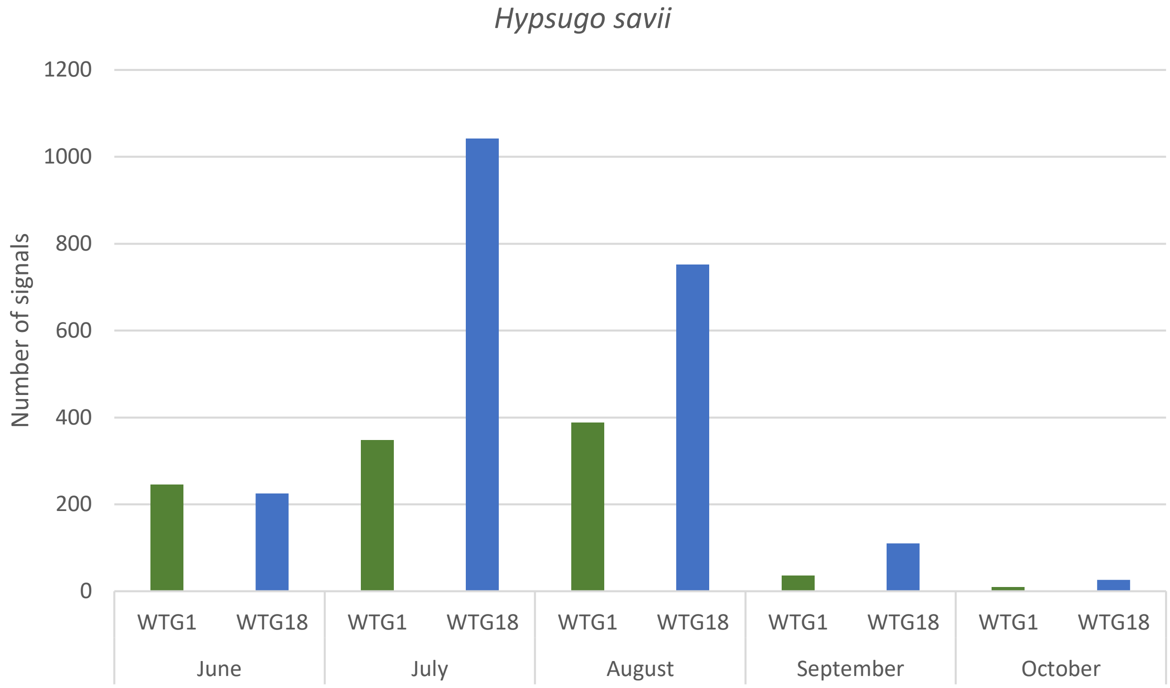



*Figure 3-3. Number of signals per month for* Hypsugo savii

*Tadarida teniotis* was the third most represented species/genus. Its signals were recorded during each month of monitoring and at both locations. There was a clear peak of activity in July but the activity remained high during August and September as well (Figure 3-4).

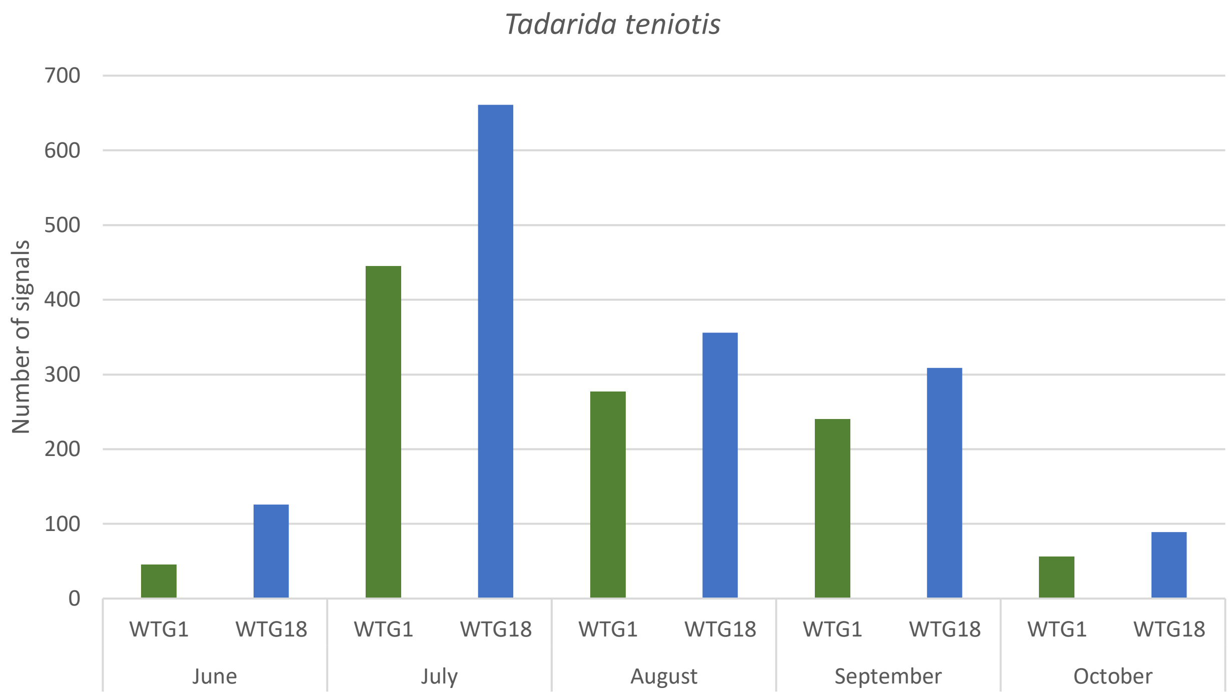



*Figure 3-4. Number of signals per month for* Tadarida teniotis

*Nyctalus* species were recoded more frequently at WTG1 than at WTG18. At both locations a peak of their activity was recorded in September (Figure 3-5).

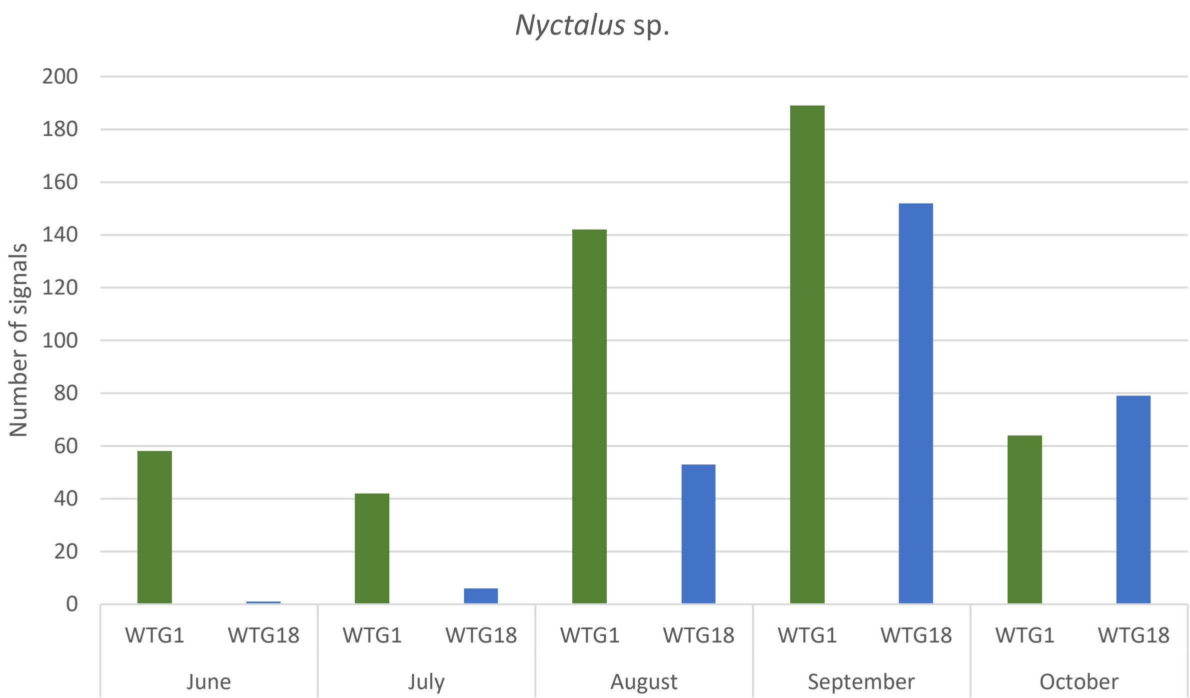



*Figure 3-5. Number of signals per month for* Nyctalus *sp.*

Species of genus *Myotis* were recorded infrequently and showed different peaks of activity when the two recording locations are compared. More *Myotis* signals (293) were recorded at WTG18 and the peak was in August, while just over a third of that (111) was recorded at WTG1. Peak activity at WTG1 was in July (Figure 3-6).

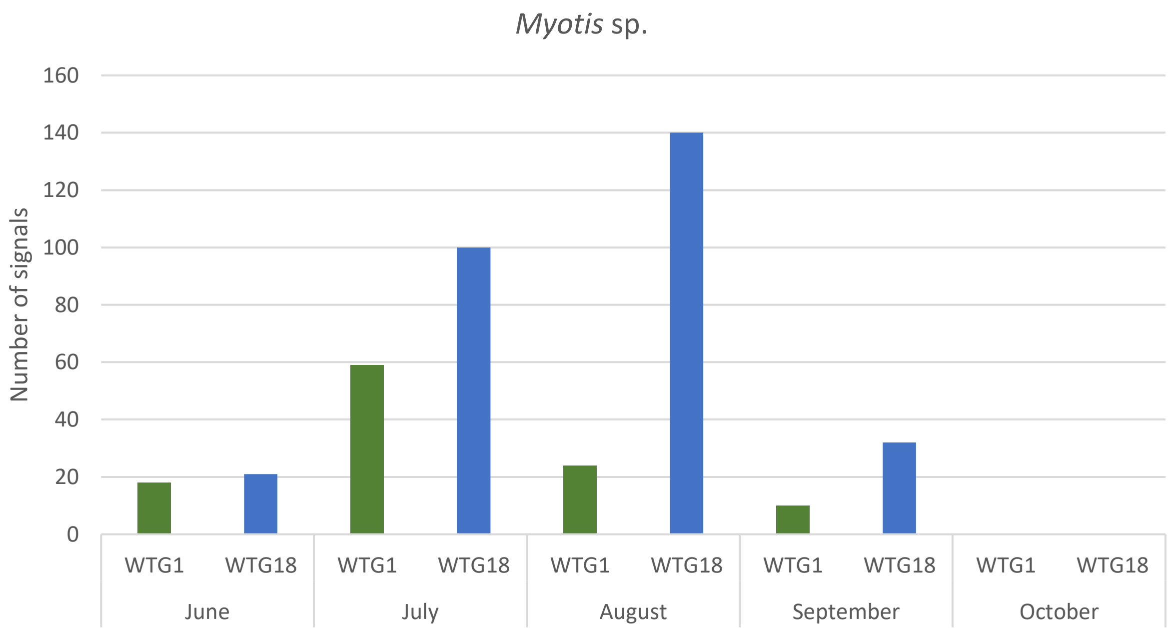



*Figure 3-6. Number of signals per month for* Myotis *sp.*

Species *Eptesicus serotinus* accounted for 0.13 % of total signals and had a peak of activity in September with 131 of the total 205 signals recorded during that month (Figure 3-7).

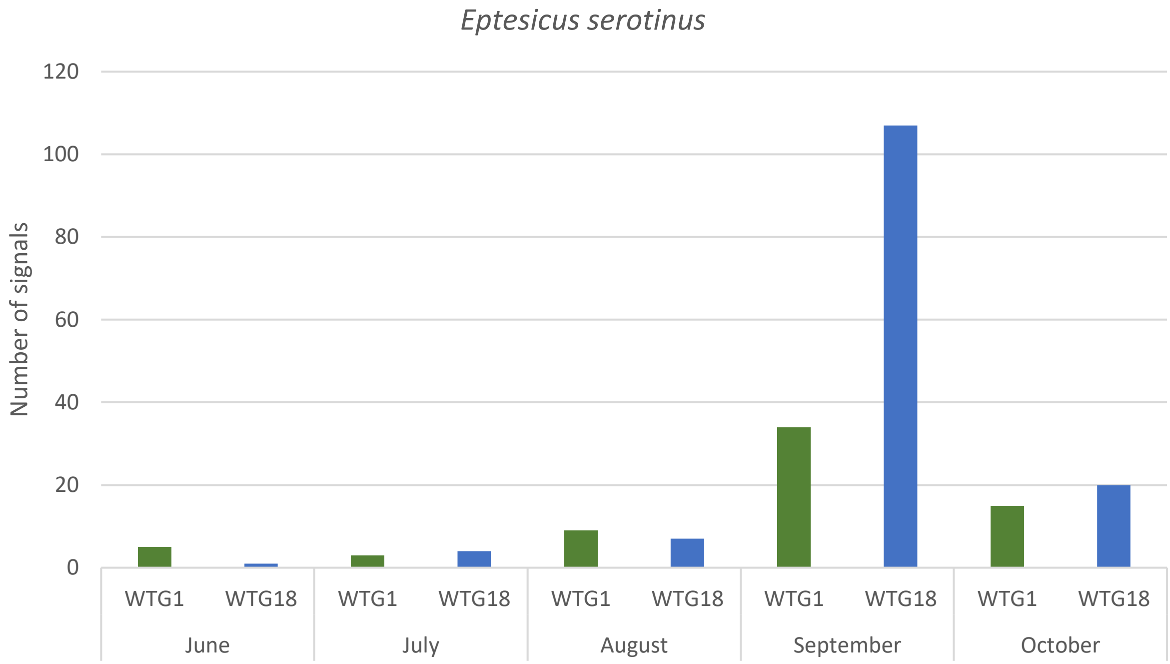



*Figure 3-7. Number of signals per month for* Eptesicus serotinus

Species *Miniopterus schreibersii* was only recorded at WTG18 location and very rarely, so there is not enough data to draw conlcusions on its activity at WF Jelinak, but the trend suggests a peak of activity later in the season (Figure 3-8).

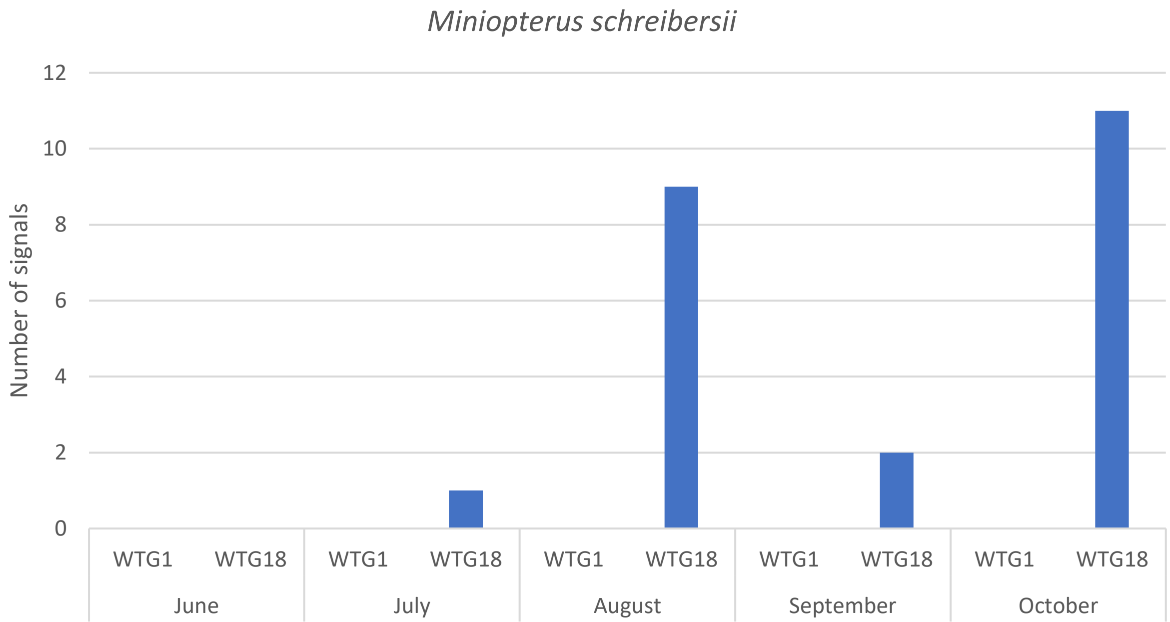



*Figure 3-8. Number of signals per month for* Miniiopterus schreibersii

*Plecotus* species were only recorded 37 times in total, and only once at WTG1. Peak activity at WTG18 came in September and October (Figure 3-9).

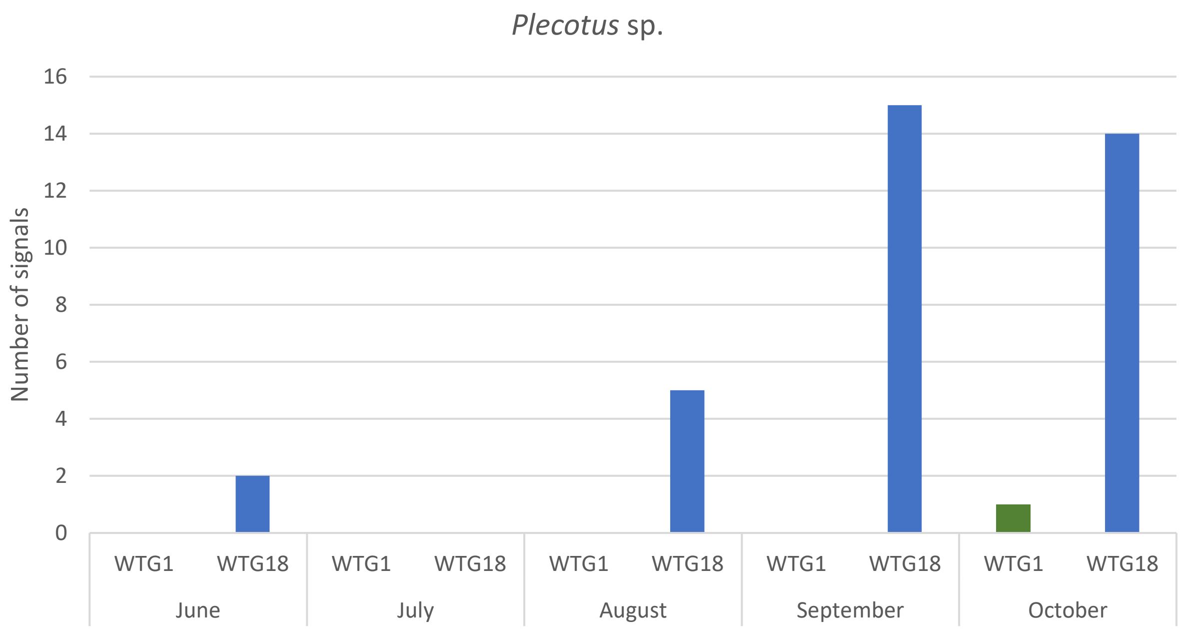



*Figure 3-9. Number of signals per month for* Plecotus *sp.*

Signals belonging to *Rhinolophus* species were only recorded three times, twice at WTG18 and once at WTG1. All three signals were from late July. Two signlas were identified as *Rhinolophus hipposideros*, and the third one as *Rhinolophus euryale*.

### 3.1.1 Bat activity through the night

Bat activity was analyzed for evaluation of changes in activity distribution throught the night as well. The data is presented in one-hour intervals for each month of survey and for each recording location.

In June, activity was consistently beginning after 9 PM. Peak activity differed between the two recording locations, with WTG1 having a pronounced peak around 11 PM and WTG18 showing a first peak around midnight and another one, after 3 AM. No activity was recorded after 6 AM (Figure 3-10).

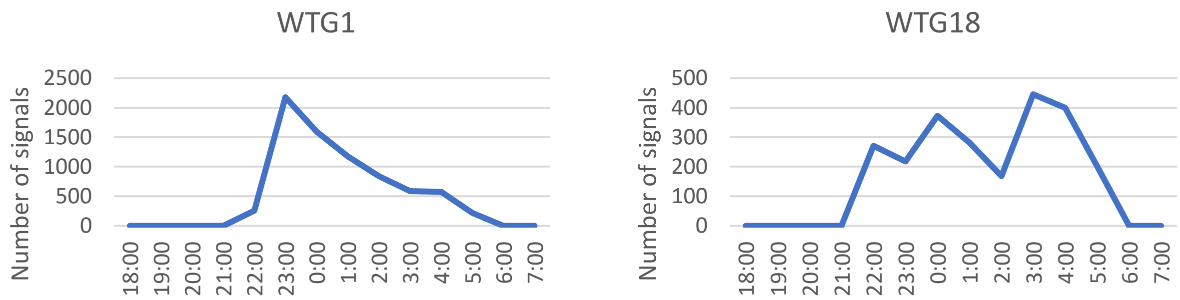



*Figure 3-10. Hourly bat activity in June for both recording locations*

In July the beginning of activity started around 9 PM and both recording locations showed, in this period, a very pronounced peak of activity in the first two hours. After 11 PM there is a drop in activity, but it still remains above June's peak activity to around 3 AM. No signals were recorded after 6 PM (Figure 3-11).

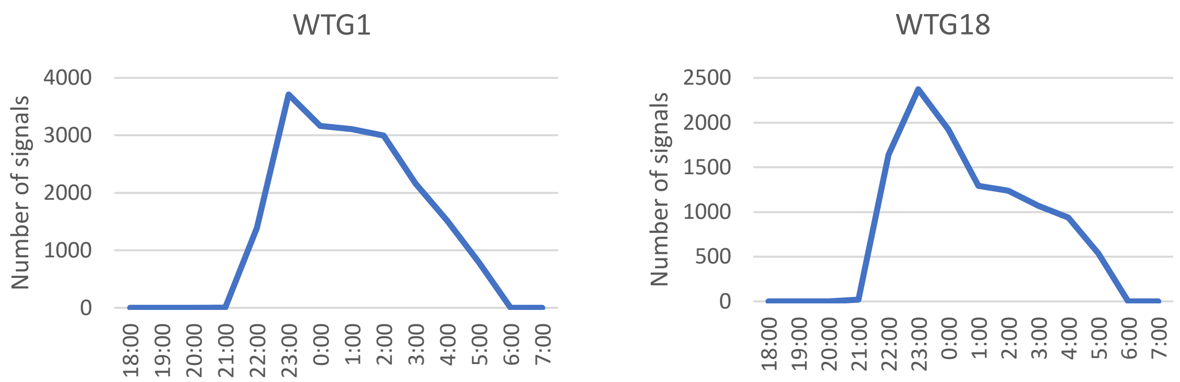



*Figure 3-11. Hourly bat activity in July for both recording locations*

In August, with the shortening of day, bat activity was started around 8 PM. Peak activity at both locations was still around 11 PM to midnight, but the drop in activity after that was not as sharp as in July and there is even a noticeable second peak around 3 AM to 4 AM. Activity also ended later and signals were recorded even after 6 AM (Figure 3-12).

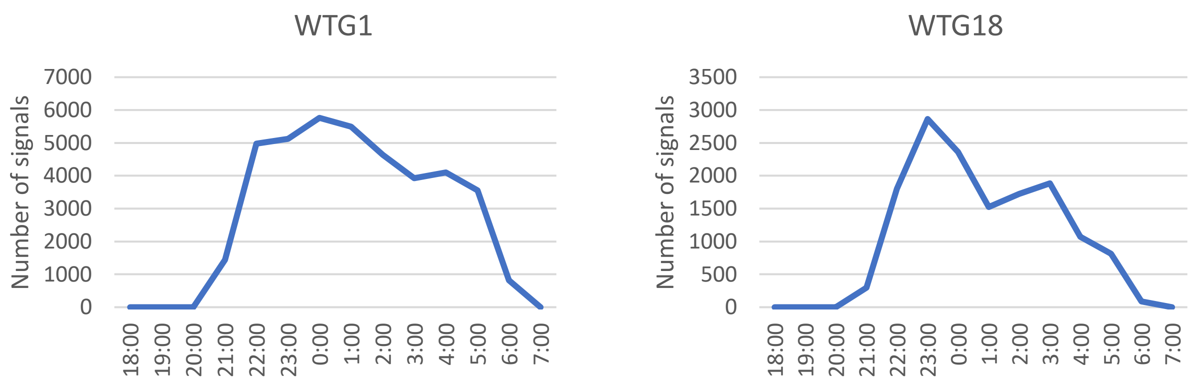



*Figure 3-12. Hourly bat activity in August for both recording locations*

Increasingly shorter days in September meant that the start of bat activity in September moved to even earlier than 7 PM. There was no clear peak around 11 PM like in previous months but, instead, bat activity remained very high from about 9 PM up until midnight. Dropoff after the peak is gradual. As in August, there was a second peak of activity recorded, with some difference between the two recording locations – around 2 AM at WTG1 and around 3 AM at WTG18. The second peak at WTG18 was also more pronounced but ultimately similar in total number of signals, as WTG1 showed much higher levels of activity in this period (Figure 3-13).

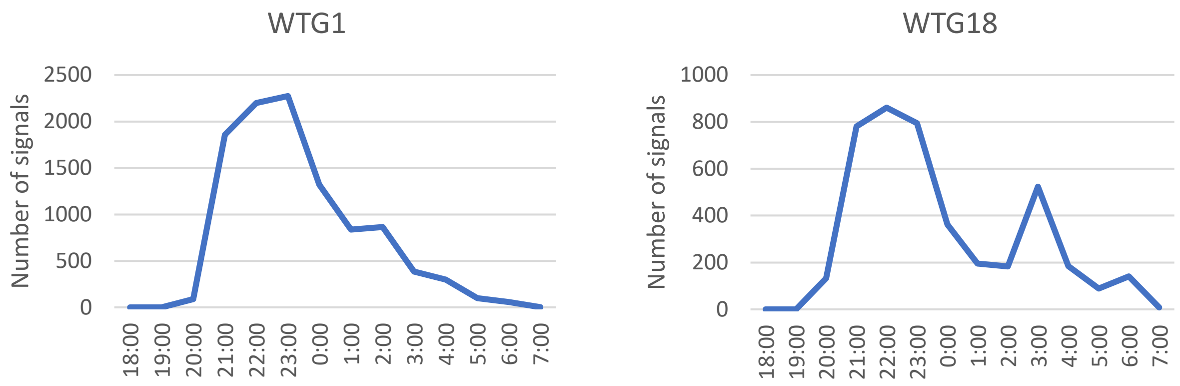



*Figure 3-13. Hourly bat activity in September for both recording locations*

In October the period of bat activity extends throughout the night and bat signals start even before 6 PM and last up until 7 AM. A peak was still evident within the first three hours but was now moved to around 8 PM (WTG1) and 9 PM (WTG18). Dropoff after the peak is sharper than in the previous two months but there were occasional secondary peaks, more prounounced at WTG1 location (Figure 3-14). As the total activity was low, these trends might not be as accurate as for the previous months.

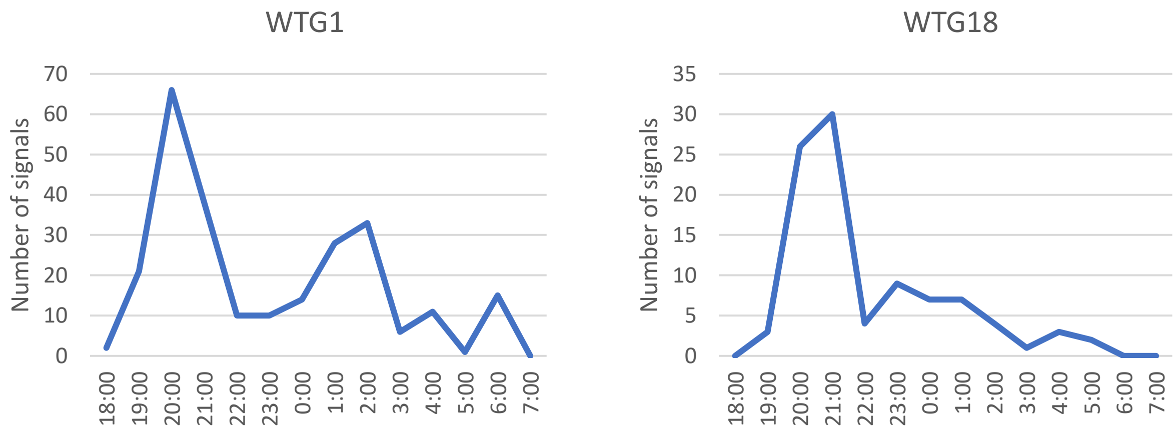



*Figure 3-14. Hourly bat activity in October for both recording locations*

### 3.1.2 Bat activity in relation to wind speed

Data on wind measurements at nacelle height from July to September 2020 was provided by Vjetroelektrana Jelinak Ltd. As expected, bat activity was found to be dependent on wind speed in the WF area.

Figure 3-15 shows total bat activity for each night in July, August and September plotted against average nightly wind speeds for the same period. Bat activity spiked whenever night wind speeds dipped below 4 m/s and, conversely, when the wind was stronger, especially when faster than 6 m/s, bat activity dropped. The same can be observed for each of recorded species/genera (Figure 3-16).

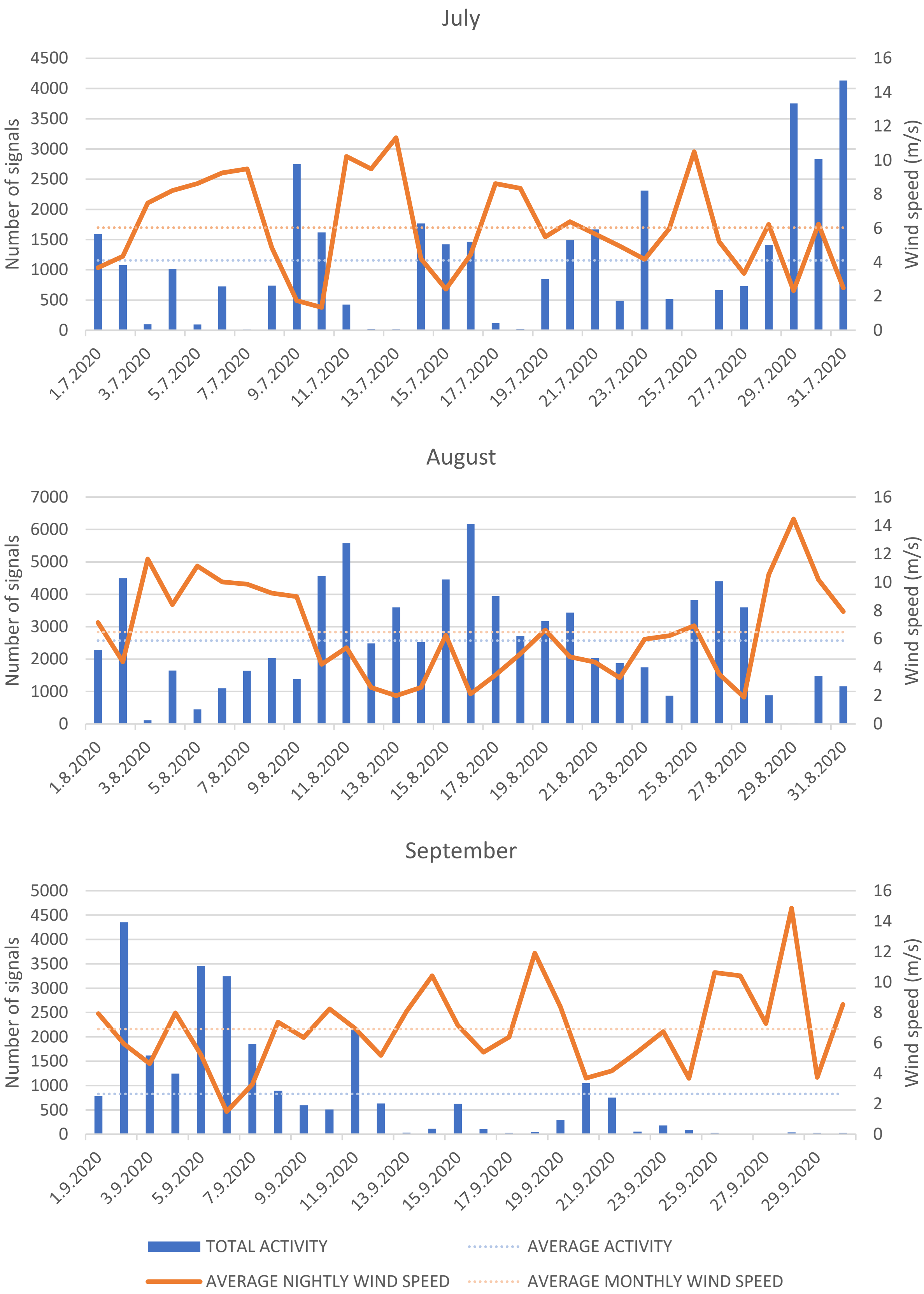
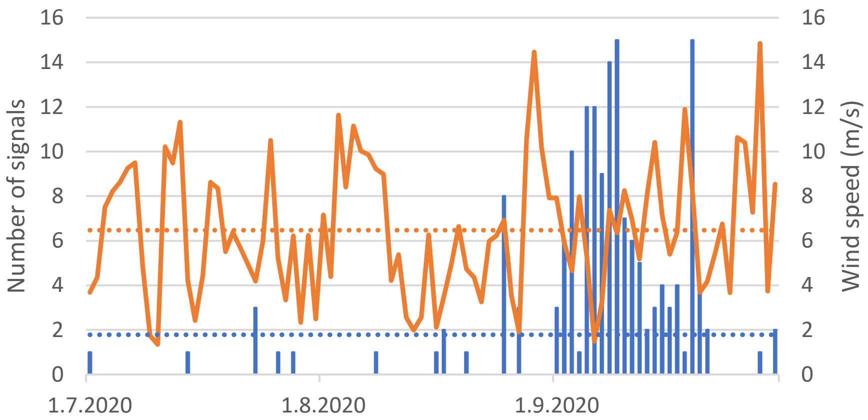
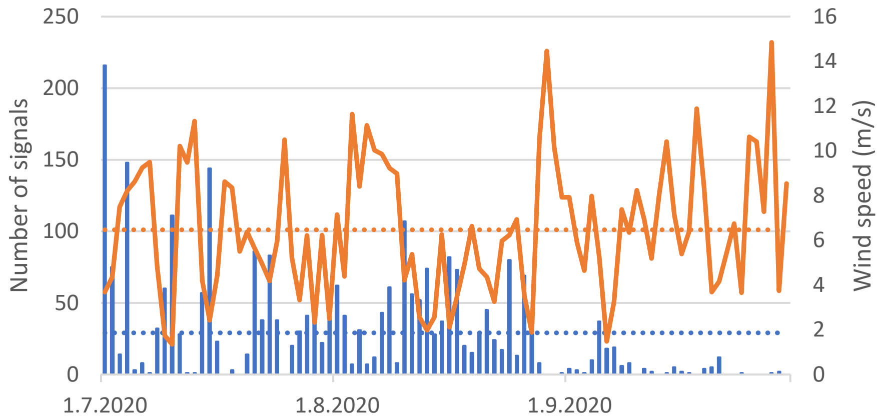



*Figure 3-15. Total bat activity per night and average night wind speed for July, August and September 2020*

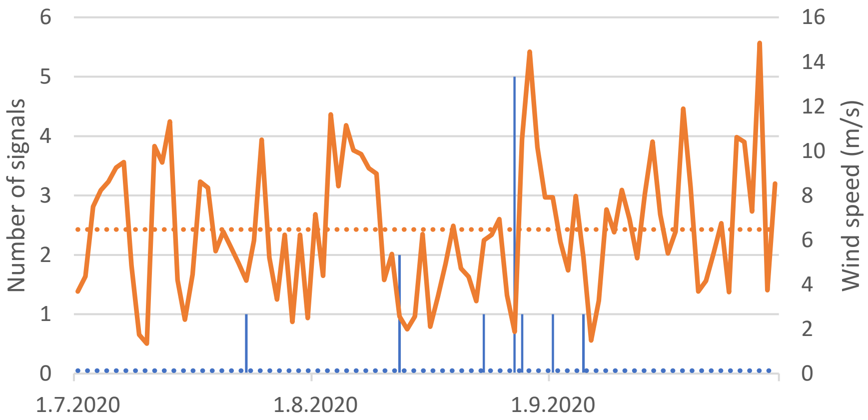
*Eptesicus serotinus*



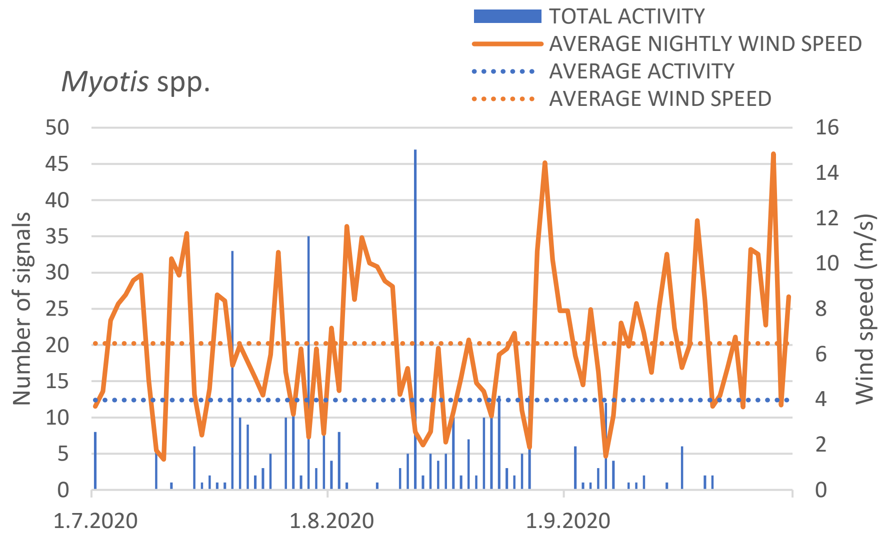

*Hypsugo savii*




*Miniopterus schreibersii*




*Myotis* spp.



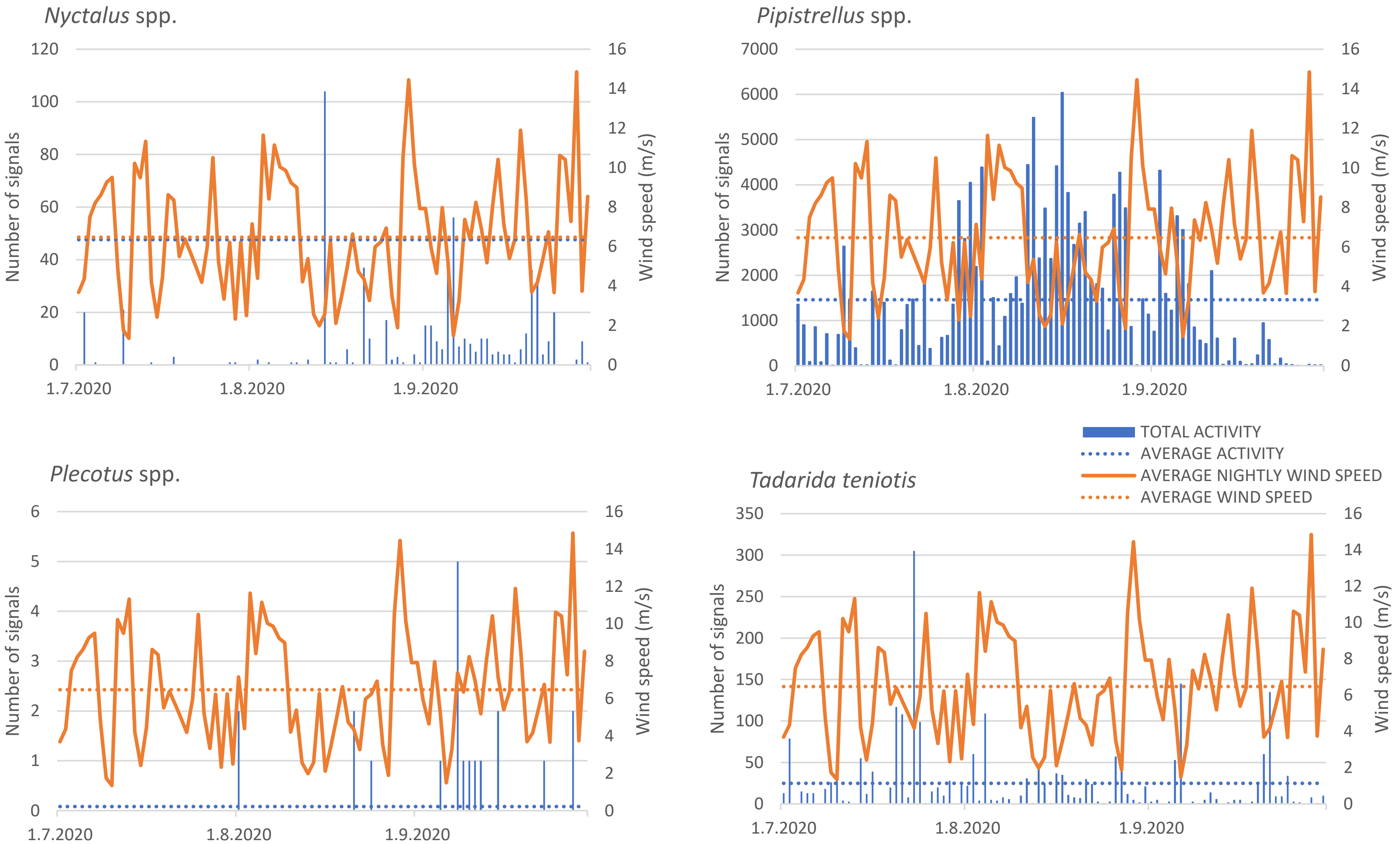



*Figure 3-16. Bat activity per species and per night of recording and average night wind speed*

In July and August, most activity (66.54 % and 57.54 %, respectively) was recorded at wind speeds below 5 m/s, while in September a majority of activity was recorded up to wind speeds of 6 m/s. At winds speeds above 7 m/s, only 7.12 % of signals in July, 17.80 % in August and 18.68 % in September were recorded (Table 3-2, Figure 3-17).

There were 11 nights with average wind speed over 7 m/s in July, meaning 92.88 % of all signals were recorded in 20 days. In August the number of days with high winds increased to 12 meaning that 82.20 % of all signals were recorded in 19 days. There were 14 nights with winds over 7 m/s in September which meant that 81.32 % of all signals were recorded in just 16 days. In September the fewest number of days with wind speeds below 4 m/s (5) and below 5 m/s (7) were recorded. Therefore, bats active during that period needed to forage even in less favourable conditions.

*Table 3-2. Percantage of total calls for July, August and September at different wind speeds*

| MONTH | PERCENTAGE OF TOTAL CALLS | | | | NUMBER OF NIGHTS WITH AVERAGE WIND SPEED > 7 m/s |
|---|---|---|---|---|---|
| | < 4 m/s | < 5 m/s | < 6 m/s | < 7 m/s | |
| **July** | 44.66 % | 66.54 % | 76.87 % | 92.88 % | 11 |
| **August** | 35.89 % | 57.54 % | 66.72 % | 82.20 % | 12 |
| **September** | 25.24 % | 34.79 % | 69.47 % | 81.32 % | 14 |

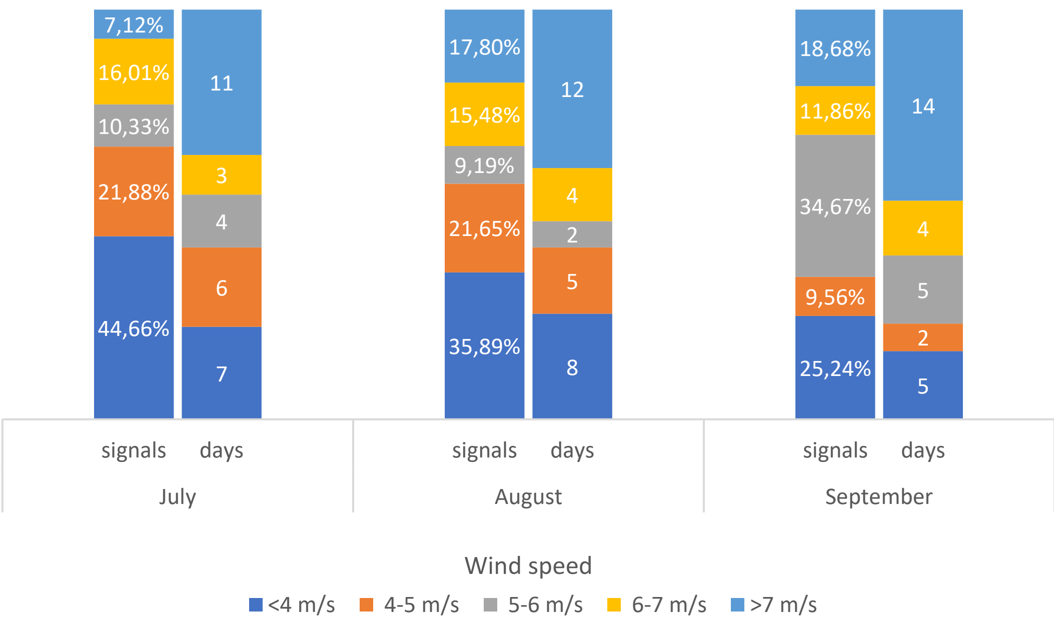



*Figure 3-17. Percentage of total calls and number of days for different wind speeds per month*

Analysis of the data on bat activity in relation to wind speed shows that in more than 50 % of cases bats were active when wind speed was not optimal (> 3 m/s). But, when comparing wind speeds measured at nacelle height and at 2 m above ground, it is found that wind speed at nacelle height can be up to 12 m/s higher (on average 4 m/s). So, it is possible that during nights when wind speeds at nacelle height were not optimal, wind speeds near ground were lower and more favourable for bat activity.

## 3.2 Periodic bat call recording on a transect route

During eight nights in July and August, 958 signals were recorded in total. Most of the signals (more than 80 %) belonged to *Pipistrellus kuhlii* and *Pipistrellus kuhlii*/*P. nathusii*, marked as such since these two species sometimes couldn't be distinguished by this method of identification. However, considering dominantly open habitats in the wind farm area, it is more likely those signals belonged to *Pipistrellus kuhlii*, since *Pipistrellus nathusii* prefers deciduous forests, forest edges and riparian areas where it usually follows linear landscape elements (Kyheröinen et al. 2019). With *Hypsugo savii*, more than 95 % of the recorded signals belonged to these three species. The rest of the recorded species were *Tadarida teniotis*, *P. pipistrellus*, *P. pygmaeus*, *Rhinolophus ferrumequinum*, *R. euryale*, *Miniopterus schreibersii* and genus *Myotis* (Figure 3-18, Table 3-3). A proportion of recorded species' activity is comparable to activity recorded at stationary points.

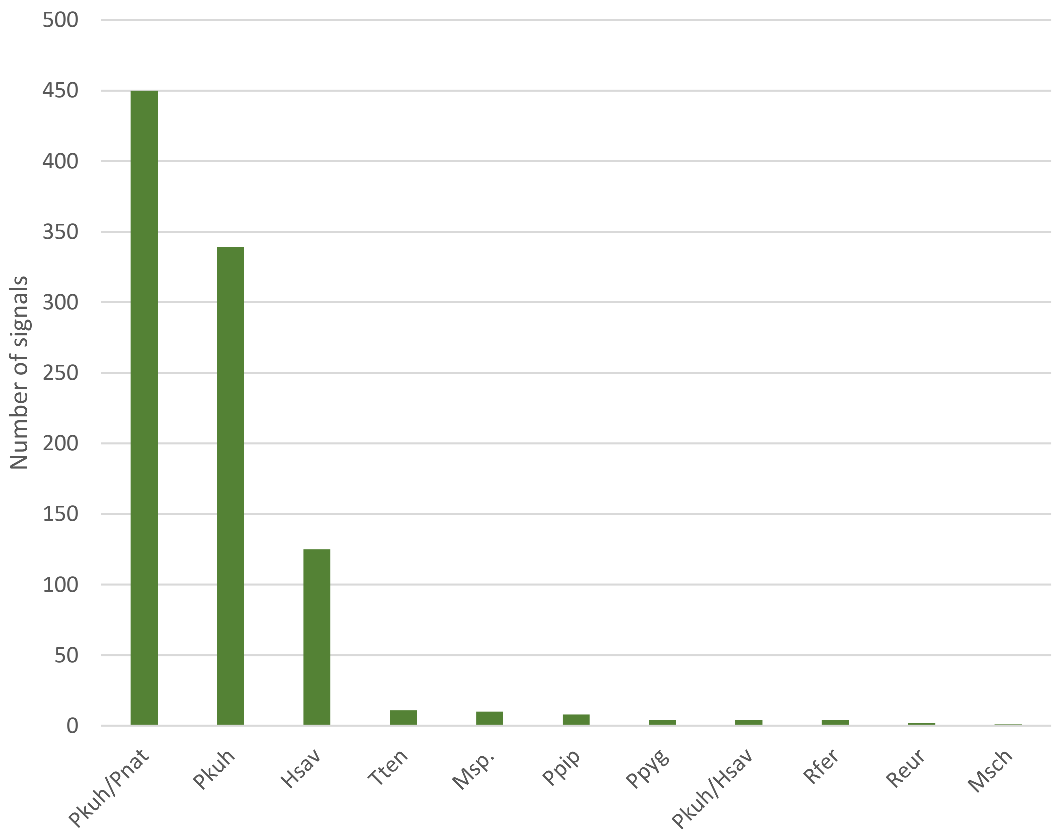



*Figure 3-18. Number of calls per species recorded during periodic bat call recording on a transect route*

*(Pkuh* = Pipistrellus kuhlii*, Pnat* = Pipistrellus nathusii*, Hsav* = Hypsugo savii, *Tten* = Tadarida teniotis, *Msp.* = Myotis *spp., Ppip* = Pipistrellus pipistrellus*, Ppyg* = Pipistrellus pygmaeus*, Rfer* = Rinolophus ferrumequinum*, Reur* = Rinolophus euryale, *Msch* = Miniopterus schreibersii*)*

*Table 3-3. Number of signals per species recorded during periodic sounds recording on a transect route*

| SPECIES | NUMBER OF BAT SIGNALS | | | | | | | | TOTAL | PROPORTION |
|---|---|---|---|---|---|---|---|---|---|---|
| | 15.07.2020. | 16.07.2020. | 29.07.2020. | 30.07.2020. | 12.08.2020. | 13.08.2020. | 24.08.2020. | 25.08.2020. | | |
| ***Pipistrellus kuhlii/Pipistrellus nathusii*** | 39 | 4 | 76 | 59 | 49 | 109 | 109 | 5 | **450** | **47.0 %** |
| ***Pipistrellus kuhlii*** | 33 | 44 | 88 | 36 | 33 | 55 | 41 | 9 | **339** | **35.4 %** |
| ***Hypsugo savii*** | 15 | 7 | 42 | 5 | 6 | 24 | 24 | 2 | **125** | **13.0 %** |
| ***Tadarida teniotis*** | - | - | - | - | - | 3 | 8 | - | **11** | **1.1 %** |
| ***Myotis* sp.** | - | 3 | 1 | - | 3 | - | 1 | 2 | **10** | **1.0 %** |
| ***Pipistrellus pipistrellus*** | - | 4 | - | 1 | - | - | 2 | 1 | **8** | **0.8 %** |
| ***Pipistrellus pygmaeus*** | - | - | - | 4 | - | - | - | - | **4** | **0.4 %** |
| ***Pipistrellus kuhlii/Hypsugo savii*** | 2 | 2 | - | - | - | - | - | - | **4** | **0.4 %** |
| ***Rhinolophus ferrumequinum*** | - | 1 | 1 | 2 | - | - | - | - | **4** | **0.4 %** |
| ***Rhinolophus euryale*** | - | - | - | - | - | 1 | 1 | - | **2** | **0.2 %** |
| ***Miniopterus schreibersii*** | - | - | - | - | - | - | 1 | - | **1** | **0.1 %** |
| **TOTAL** | **89** | **65** | **208** | **107** | **91** | **192** | **187** | **19** | **958** | |

To get more accurate quantification of bat activity, an activity index adjusted with detectability coefficient was used.

The **activity index** was calculated following methodology proposed in Miller 2001. The index uses the time unit of one minute in which bat activity is observed. Therefore, one minute of recording time represents one count of activity of a certain species. The one-minute time unit is short enough to reflect small changes in bat activity, while reducing some effects that might distort quantification of the actual level of activity. One of the causes of these effects is the difference between calls of different bat species. While some bats, for example *Pipistrellus* spp., *Myotis* spp. and *Nyctalus* spp., emit a higher number of short calls during a search phase, others, like *Tadarida teniotis*, use fewer but longer pulses. Accordingly, if one individual of each species was foraging during a one-minute period, less calls of the latter would be recorded, though the level of activity was the same. The other effect is caused by the difference between individuals in flight behaviour near a bat detector. Bats can fly in different directions and at different distances from the detector. When an individual briefly ventures outside the detector's range and then returns, it causes an interruption in recording, so it appears as several separate signals. The method described by Miller reduces these effects and allows a more accurate comparison of each species' relative contribution to activity during the survey.

The activity index was calculated by counting the number of one-minute periods in which a certain species was recorded (i.e. deducting repeated signals of the same species during the same minute) (Table 3-4). The activity index reduced the number of signals by more than two thirds for species with the most number of signals.

The activity index was additionally adjusted with **detectability coefficient**. The detectability coefficient is used because, depending on their ecology, different bat species emit calls of different intensity. Signals emitted with increased intensity have a larger detection range, i.e. species emitting such signals can be detected at greater distances from the bat detector. The detectability coefficient was therefore, derived from the detection range, applying higher values to less detectable and lower values to more detectable species. By multiplying the number of signals or activity index with the coefficient, the level of activity of the different species is assessed in case they emitted signals with the same detection probability:

*adjusted activity index = activity index * detectability coefficient*

Detectability coefficients for bats in an open to a semi-open environment as described by Barataud (2015) were used for the adjustment. Barataud classifies *Rhinolophus* and most of *Myotis* species into a group with weak intensity of signal emission, some *Myotis* spp., *Pipistrellus* spp. and *Miniopterus* spp. into a group with medium intensity emission, *Hypsugo savii* into a group with strong intensity of emission and *Tadarida teniotis* into a group with very strong intensity of emission. For signals which could not be identified as one particular species, arithmetic mean of activity indicies of possible species was taken as activity index value. The proportion of activity of species with strong intensity of emission (*Hypsugo savii, Tadarida teniotis*) decreased, while the precantage of species with weak intensity (*Rhinolophus ferrumequinum*, *Rhinolophus euryle*, *Myotis* sp.) increased (Table 3-4).

For the purpose of activity assessment comparable between different time periods, activity index per hour was calculated for all species of each survey conducted. The index per hour is equal to adjusted activity index multiplied by one hour (60 minutes) and divided by duration of a survey (in minutes):

*activity index per hour = adjusted activity index * 60 min / survey duration (min)*

**Mean activity index per hour** is the arithmetic mean of indices calculated in an observed time period. Mean activity index per hour for all surveys reflects the share of total activity expressed by the adjusted activity index (Table 3-4, Figure 3-19).

*Table 3-4. Total number of signals, activity index, adjusted activity index and mean activity index per hour for bat species recorded during periodic sounds recording on a transect route*

| SPECIES | NUMBER OF SIGNALS | ACTIVITY INDEX* | DETECTABILITY COEFFICIENT** | ADJUSTED ACTIVITY INDEX | MEAN ACTIVITY INDEX / HOUR |
|---|---|---|---|---|---|
| ***Pipistrellus kuhlii/Pipistrellus nathusii*** | **450** (47.0 %) | **264** (44.2 %) | 1.00 | **264.00** (46.2 %) | **109.49** (46.5 %) |
| ***Pipistrellus kuhlii*** | **339** (35.4 %) | **214** (35.8 %) | 1.00 | **214.00** (37.4 %) | **87.51** (37.2 %) |
| ***Hypsugo savii*** | **125** (13.4 %) | **90** (15.1 %) | 0.63 | **56.70** (9.9 %) | **23.16** (9.8 %) |
| ***Tadarida teniotis*** | **11** (1.1 %) | **5** (0.8 %) | 0.17 | **0.85** (0.1 %) | **0.37** (0.2 %) |
| ***Myotis* sp.** | **10** (1.0 %) | **7** (1.2 %) | 1.81 | **12.65** (2.2 %) | **5.16** (2.2 %) |
| ***Pipistrellus pipistrellus*** | **8** (0.8 %) | **6** (1.0 %) | 1.00 | **6.00** (1.0 %) | **2.47** (1.0 %) |
| ***Pipistrellus pygmaeus*** | **4** (0.4 %) | **2** (0.3 %) | 1.00 | **2.00** (0.3 %) | **0.81** (0.3 %) |
| ***Pipistrellus kuhlii/Hypsugo savii*** | **4** (0.4 %) | **3** (0.5 %) | 0.82 | **2.45** (0.4 %) | **0.99** (0.4 %) |
| ***Rhinolophus ferrumequinum*** | **4** (0.4 %) | **3** (0.5 %) | 2.50 | **7.50** (1.3 %) | **2.97** (1.3 %) |
| ***Rhinolophus euryale*** | **2** (0.2 %) | **2** (0.3 %) | 2.50 | **5.00** (0.9 %) | **2.15** (0.9 %) |
| ***Miniopterus schreibersii*** | **1** (0.1 %) | **1** (0.2 %) | 0.83 | **0.83** (0.1 %) | **0.36** (0.2 %) |
| **TOTAL** | **958** | **597** | | **571.97** | **235.43** |

*(Source: *according to Miller 2001; **Barataud 2015)*

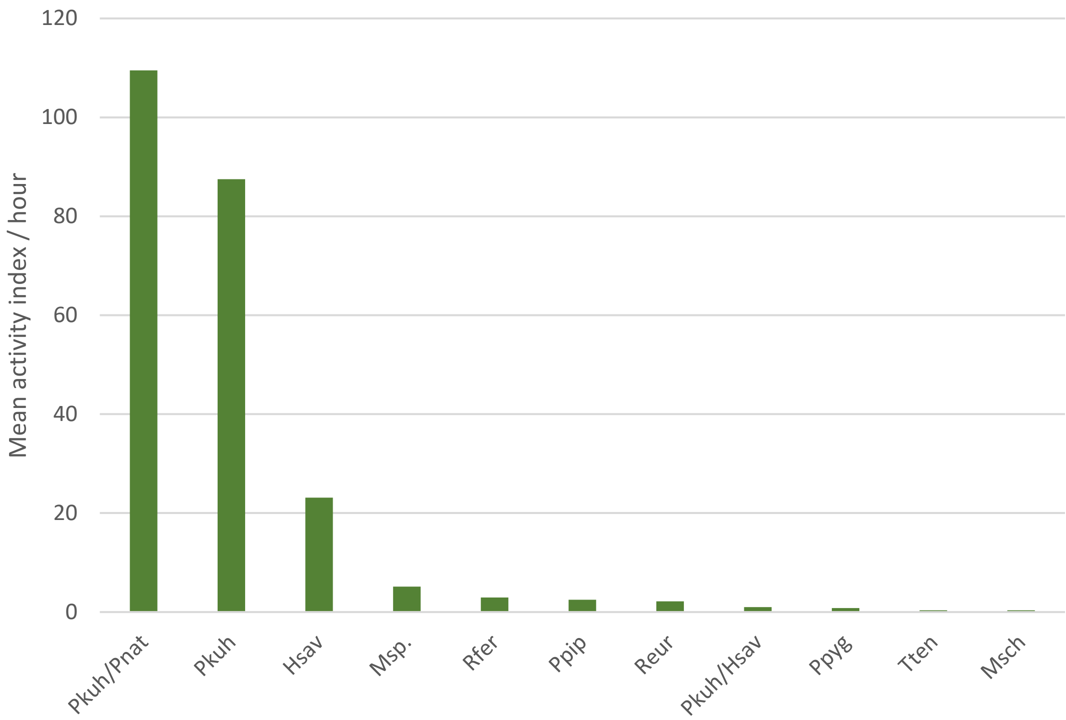



*Figure 3-19. Mean activity index per hour for bat species recorded during bat call recording on a transect route*

(*Pkuh* = Pipistrellus kuhlii*, Pnat* = Pipistrellus nathusii*, Hsav* = Hypsugo savii, *Msp.* = Myotis *spp., Ppip* = Pipistrellus pipistrellus*, Rfer* = Rinolophus ferrumequinum*, Reur* = Rinolophus euryale, *Ppyg* = Pipistrellus pygmaeus*, Tten* = Tadarida teniotis, *Msch* = Miniopterus schreibersii*)*

The highest bat activity was recorded west of Veliki Jelinak peak, between WTG10 and WTG11, especially at the location of stationary recording SR3 at WTG10. Activity was also high at the location of stationary recording SR1, near orchards and WTG2 (Figure 3-20-Figure 3-22).

The lowest activity was recorded around the peak Dabgora, in the area of WTG19 and WTG20. Low activity was also regularly recorded at the east slope of Veliki Jelinak, between WTG12 and WTG14. A reason could be that WTG12, WTG14 and WTG19 are located further from the main access road, i.e. from the transect route. It was observed that bat activity was generally higher around WTG's than in the surrounding area, beacause they often circle around WTG towers, above the manipulative plateau.

Wind speed and direction at each WTG was analysed. At WTG1, WTG11, WTG19 and WTG20, which are positioned at the highest altitudes around peaks Pišna, Veliki Jelinak and Dabgora, wind speed was always higher than the average wind speed on all WTG's (Figure 3-23). That is likely why low activity was recorded around WTG1, WTG19 and WTG20.

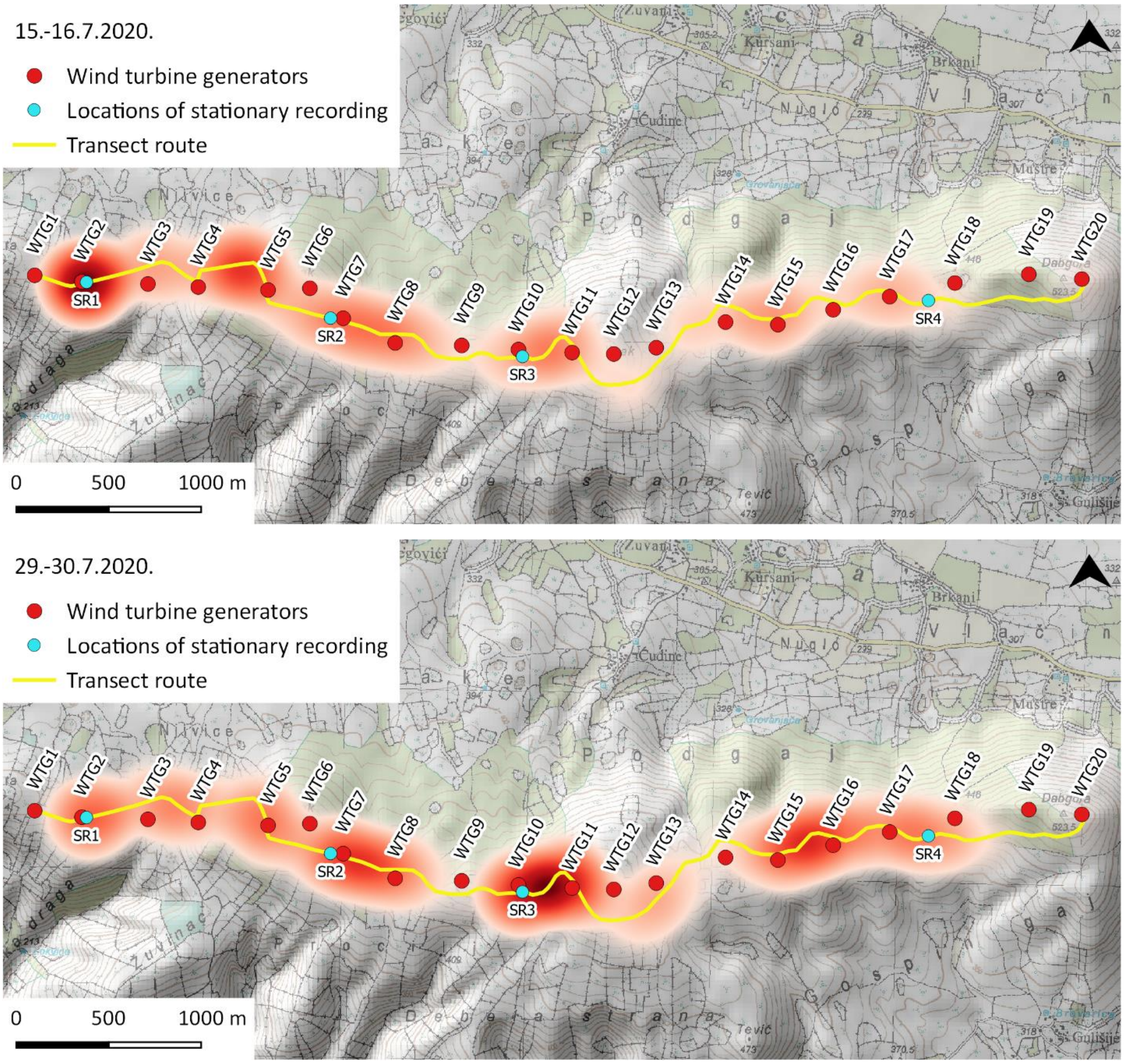



*Figure 3-20. Heatmap of bat activity along the transect route in July*

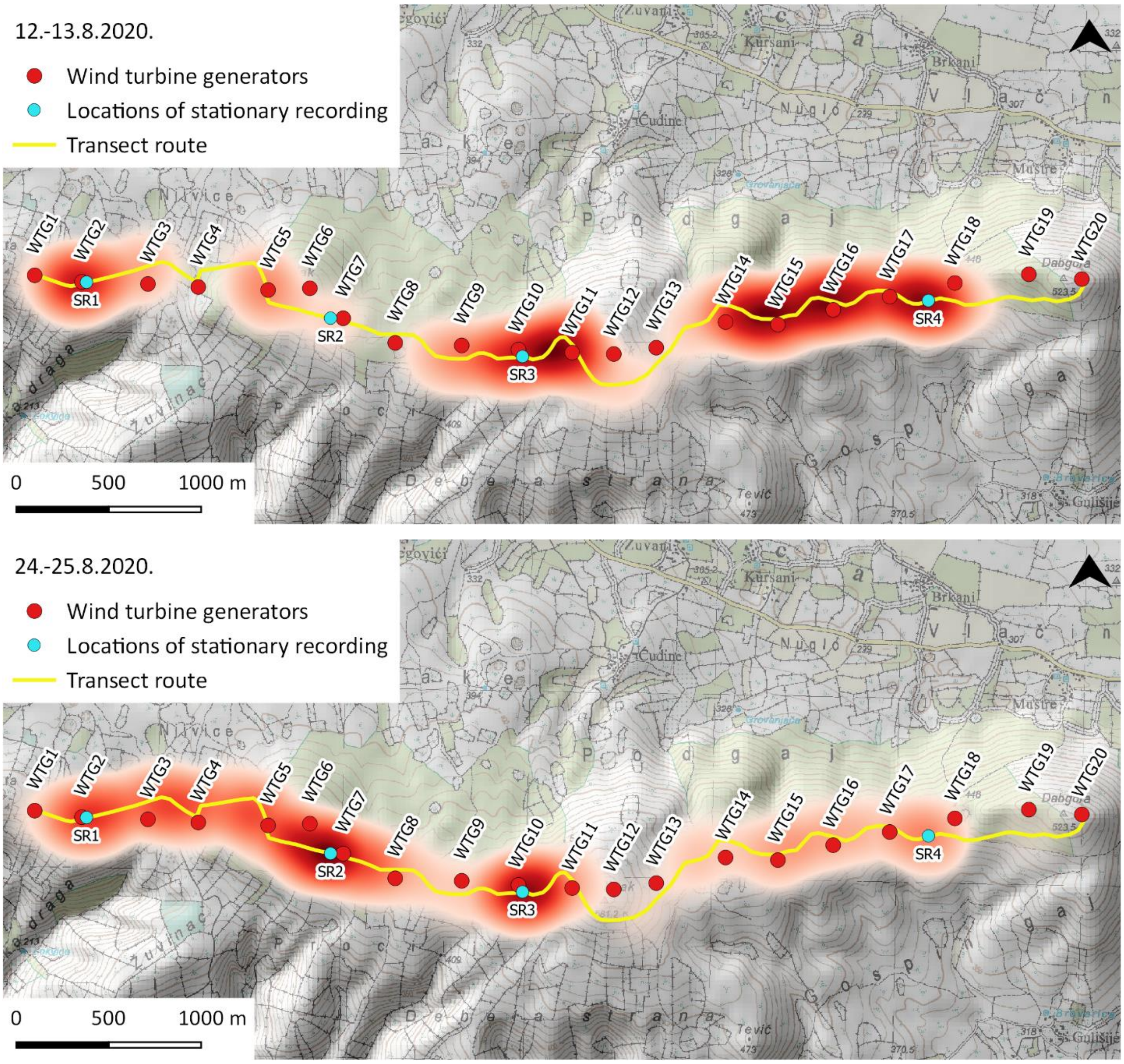



*Figure 3-21. Heatmap of bat activity along the transect route in August*

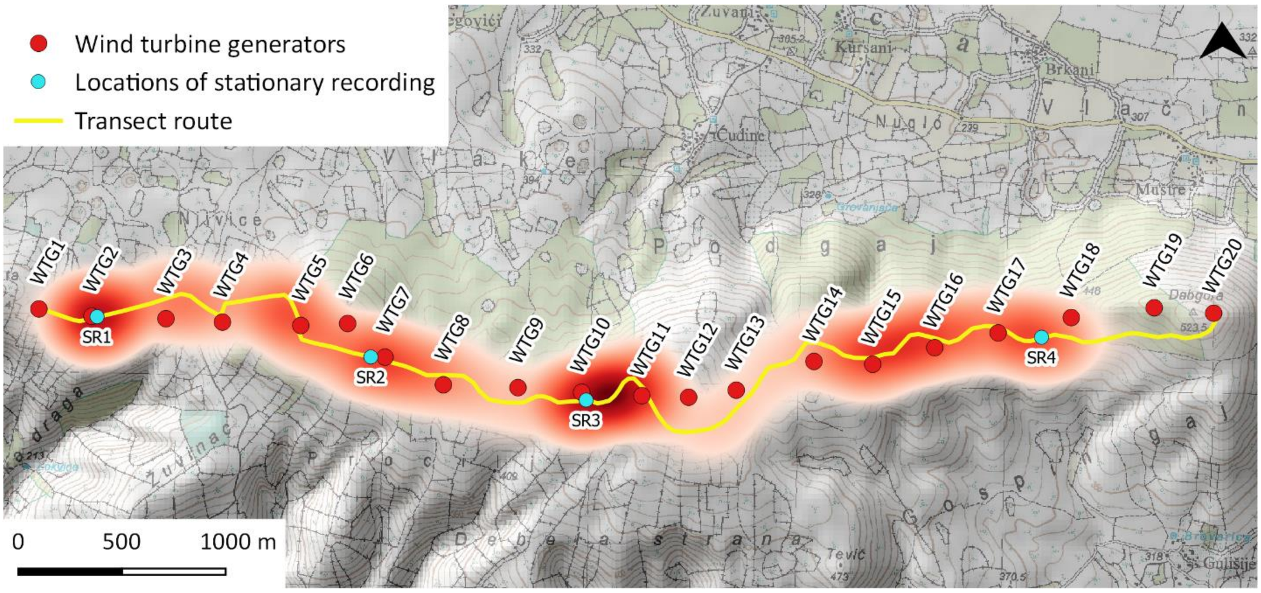



*Figure 3-22. Heatmap of total bat activity along the transect route*

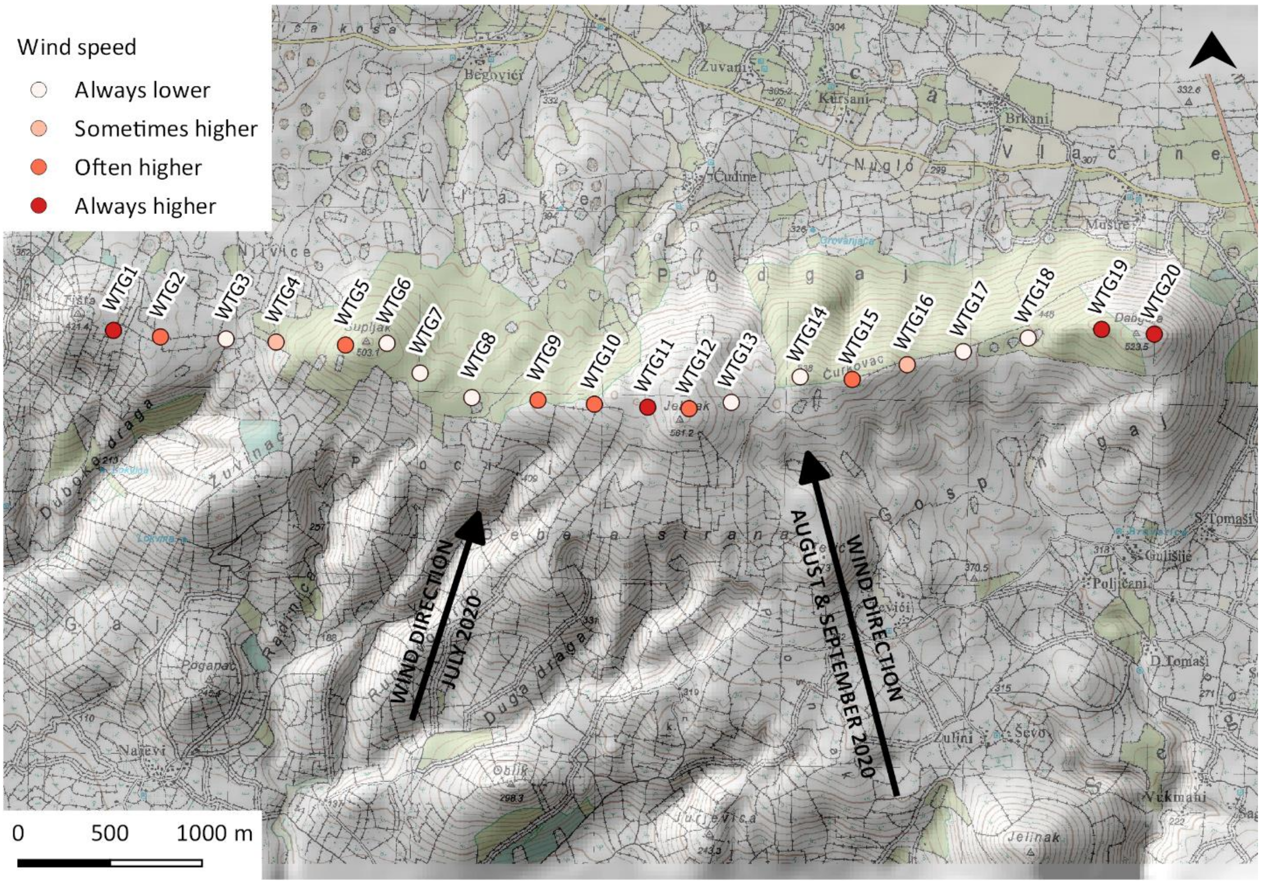



*Figure 3-23. Wind speed at each WTG in regards to average wind speed of all WTG's and average wind direction recorded at nacelle height*

## 3.3 Monitoring of bat collisions

Bat carcasses were found during every month of the survey, except in October. In total, 54 carcasses were found. The carcasses belonged to at least six different bat species: *Pipistrellus kuhlii* (24), *Hypsugo savii* (12), *Pipistrellus pipistrellus* (3), *Nyctalus leisleri* (3), *Nyctalus noctula* (1) and *Tadarida teniotis* (1). Ten carcasses were in too poor a condition for identification (noted as Chiroptera spp.) (Table 3-5). Those were classified as smaller bat species (e.g. *Pipistrellus* spp., *Hypsugo savii*) based on the lengths of their forearms (FA < 36 mm), which is one of the main morphological features in bat species identification (Dietz and von Helversen 2014). All of the carcasses in poor condition were discovered in the midsummer (July and August), when carcasses were the most exposed to ants and wasps (Figure 3-24), as well as to faster tissue decay due to higher ambient temperatures.

All species found are rated as to be of high collision risk with WTG's, some of them because they fly and forage in open space (*Pipistrellus* spp., *Hypsugo savii*), while some migrate long distances at high altitude (*Nyctalus* spp., *Tadarida teniotis*). In contrast, bats species which fly close to vegetation (gleaning bats) have a lower risk of colliding with WTG's (e.g. *Myotis* spp., *Rhinolophus* spp.) (Rodrigues et al. 2014).

*Table 3-5. Number of bat carcasses found regarding bat species*

| SPECIES | NUMBER OF CARCASSES | | | | | |
|---|---|---|---|---|---|---|
| | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER | TOTAL |
| ***Pipistrellus kuhlii*** | - | 7 | 16 | 1 | - | **24** |
| ***Hypsugo savii*** | 1 | 4 | 6 | 1 | - | **12** |
| **Chiroptera sp. (FA < 36 mm)** | - | 6 | 4 | - | - | **10** |
| ***Pipistrellus pipistrellus*** | - | - | 3 | - | - | **3** |
| ***Nyctalus leisleri*** | - | - | - | 3 | - | **3** |
| ***Nyctalus noctula*** | - | - | - | 1 | - | **1** |
| ***Tadarida teniotis*** | - | - | - | 1 | - | **1** |
| **TOTAL** | **1** | **17** | **29** | **7** | **0** | **54** |

*Figure 3-24. Ants and wasps scavange on bat carcasses*

Most of the carcasses had no apparent external injuries, which could mean that barotrauma was possible cause of death. Bats experience barotrauma when encountering vorticies at blade tips, which can lead to hemothorax (Baerwald 2008). Some of the carcasses had fractures of wing bones (forearm, upper arm, shoulder, elbow). The fractures were most probably a consequence of collision with turbine blades, but it is possible that some individulas were run over by vehicles after the fall.

The complete list of bat carcasses found with their description is in Appendix V of this document.

All bat species in Croatia are strictly protected by law (Ordinance on Strictly Protected Species, Official Gazette 144/13, 73/16; based on the Nature Protection Act, Official Gazette 80/13, 15/18, 14/19, 127/19).

*Nyctalus leisleri* is a nearly threatened (NT) species in Croatia according to IUCN. All recorded species are listed as Appendix IV species, i.e. animal and plant species of community interest in need of strict protection, both within and outside Natura 2000 sites (Appendix IV of the Council Directive 92/43/EEC – Habitats Directive) and are protected by the Bern Convention (Appendix II – strictly protected species and Appendix III – protected species of the Convention on the Conservation of European Wildlife and Natural Habitats, 1979) (Table 3-6). Accordingly, a strict protection regime must be implemented for all present bat species as a priority in bat conservation, as well as a legal obligation.

*Table 3-6. Protection and IUCN status of bat species found dead in the WF area*

| SPECIES | ORDINANCE ON STRICTLY PROTECTED SPECIES | IUCN WORLD | IUCN CROATIA | HABITATS DIRECTIVE (APPENDIX NO.) | BERN CONVENTION (APPENDIX NO.) |
|---|---|---|---|---|---|
| ***Pipistrellus kuhlii*** | SP | LC | - | IV | II |
| ***Hypsugo savii*** | SP | - | - | IV | II |
| ***Pipistrellus pipistrellus*** | SP | LC | - | IV | III |
| ***Nyctalus leisleri*** | SP | LC | NT | IV | II |
| ***Nyctalus noctula*** | SP | LC | - | IV | II |
| ***Tadarida teniotis*** | SP | LC | - | IV | II |

***SP** = strictly protected species; **LC** = least concerned species; **NT** = nearly threatened species*
*(Sources: Ordinance on Strictly Protected Species, Official Gazette 144/13, 73/16; IUCN Red List of Threatened Species; Antolić et al. 2006; European Council Directive 92/43/EEC; European Council Convention on the Conservation of European Wildlife and Natural Habitats, 1979)*

### 3.3.1 Number of carcasses per WTG

Regarding WTG's, the highest number of carcasses (9) was found at WTG3. The second highest number (6) was at adjacent WTG2. At WTG8 five carcasses were found, at WTG7, WTG12 and WTG19 four, at WTG4, WTG5 and WTG14 three, at WTG1, WTG6, WTG9 and WTG13 two, and at WTG11, WTG16, WTG17, WTG18 and WTG20 one. At WTG10 and WTG15 no carcasses were found. In total 9 WTG's had mortality higher than average (WTG2, WTG3, WTG4, WTG5, WTG7, WTG8, WTG12, WTG14, WTG19; average 2.7) (Figure 3-25).

At WTG's with the highest number of carcasses (WTG3 and WTG2), the carcasses were found in July and August (Figure 3-26).

Mortality was recorded at two out of 14 WTG's with implemented mitigation measures in the first half of July, eight out of 19 in the second half of July, seven out of 19 in the first half of August and eight out of 14 in the second half of August (Table 3-7).

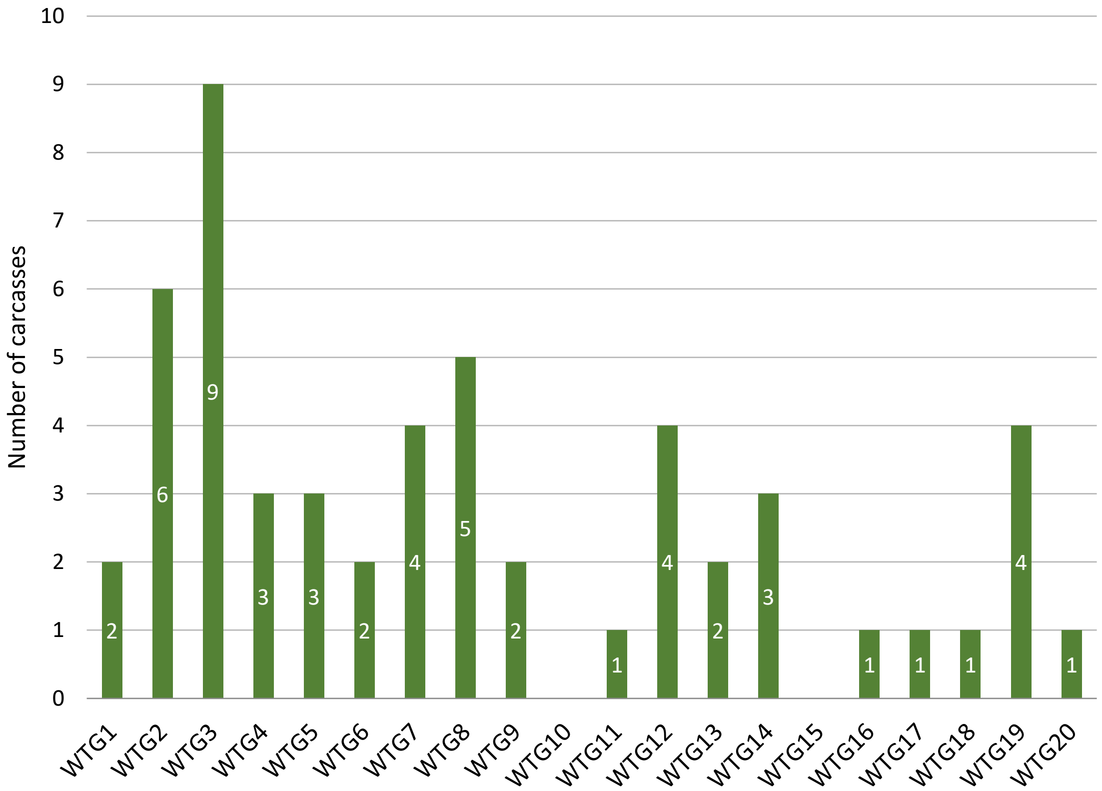



*Figure 3-25. Number of bat carcasses found at each WTG*

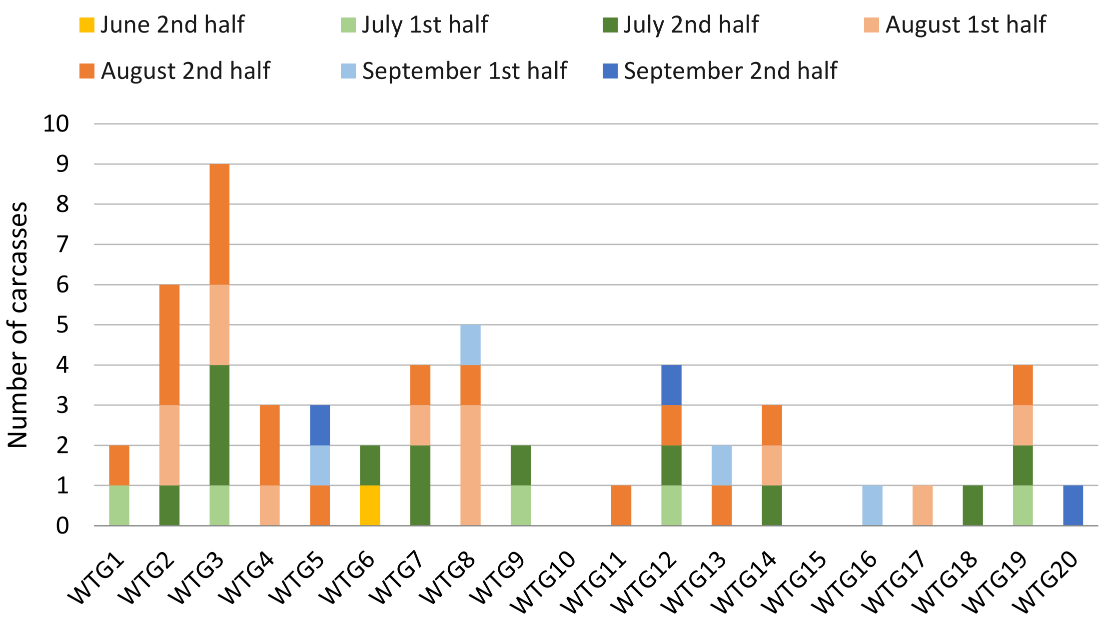



*Figure 3-26. Number of bat carcasses found at each WTG per half a month*

*Table 3-7. Number of bat carcasses found per month at each WTG*

| WTG | NUMBER OF CARCASSES JUNE | JULY 1st HALF | JULY 2nd HALF | AUGUST 1st HALF | AUGUST 2nd HALF | SEPTEMBER 1st HALF | SEPTEMBER 2nd HALF | OCTOBER | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| WTG1 | - | 1 | - | - | 1 | - | - | - | 2 |
| WTG2 | - | - | 1 | 2 | 3 | - | - | - | 6 |
| WTG3 | - | 1 | 3 | 2 | 3 | - | - | - | 9 |
| WTG4 | - | - | - | 1 | 2 | - | - | - | 3 |
| WTG5 | - | - | - | - | 1 | 1 | 1 | - | 3 |
| WTG6 | 1 | - | 1 | - | - | - | - | - | 2 |
| WTG7 | - | - | 2 | 1 | 1 | - | - | - | 4 |
| WTG8 | - | - | - | 3 | 1 | 1 | - | - | 5 |
| WTG9 | - | 1 | 1 | - | - | - | - | - | 2 |
| WTG10 | - | - | - | - | - | - | - | - | 0 |
| WTG11 | - | - | - | - | 1 | - | - | - | 1 |
| WTG12 | - | 1 | 1 | - | 1 | - | 1 | - | 4 |
| WTG13 | - | - | - | - | 1 | 1 | - | - | 2 |
| WTG14 | - | - | 1 | 1 | 1 | - | - | - | 3 |
| WTG15 | - | - | - | - | - | - | - | - | 0 |
| WTG16 | - | - | - | - | - | 1 | - | - | 1 |
| WTG17 | - | - | - | 1 | - | - | - | - | 1 |
| WTG18 | - | - | 1 | - | - | - | - | - | 1 |
| WTG19 | - | 1 | 1 | 1 | 1 | - | - | - | 4 |
| WTG20 | - | - | - | - | - | - | 1 | - | 1 |
| **TOTAL** | **1** | **5** | **12** | **13** | **16** | **4** | **3** | **0** | **54** |

*WTG's with implemented mitigation measures are marked* ***yellow***

### 3.3.2 Bat mortality per month

Most of the carcasses were found in July and August, with a maximum in August (29 carcasses). In June and September less carcasses were found, while at the beginning of October there were no findings (Table 3-5). These numbers reflect entirely the recorded bat activity (Figure 3-1).

Species found from the end of June until August were *Pipistrellus* spp. and *Hypsugo savii*, while in September other species were also found (*Nyctalus* spp. and *Tadarida teniotis*) (Figure 3-27).

Activity of *Pipistrellus* spp. and *Hypsugo savii* was the highest in July and August, same as mortality. This is likely because females give birth in late May and in June, and juveniles can actively fly by the end of July or August. Adults begin mating in August, therefore, during this period bat activity is at its peak. During the end of July and in August, carcasses of juvenile and subadult individuals of *Pipistrellus* spp. and *Hypsugo savii* were found. Also, there were 27 adult females among the found carcasses, some of them in the period when bats in the area possibly raise their young. Females gathered in maternity colonies, as well as juveniles, often forage closer to their roost which may indicate that the WF area is within their foraging area. We often find *Pipistrellus* and *Hypsugo* species near human settlements, and they rarely have daily migrations over great distances, so the maternity colonies or other roosts may be located in nearby settlements (Bristivica, Blizna).

In September mating continues and autumn migrations take place. Activity was high, but not as high as in July and August. Activity of *Nyctalus* spp., on the other hand, was at its peak, which indicates that this species migrates in autumn in higher abundances across the WF area. One individual of *Tadarida teniotis* found dead in September was subadult, thus more sensitive to collision. It is possible that mitigation measures in July and August efficiently reduced mortality of less abundant species like *Nyctalus* spp. and *Tadarida teniotis*.

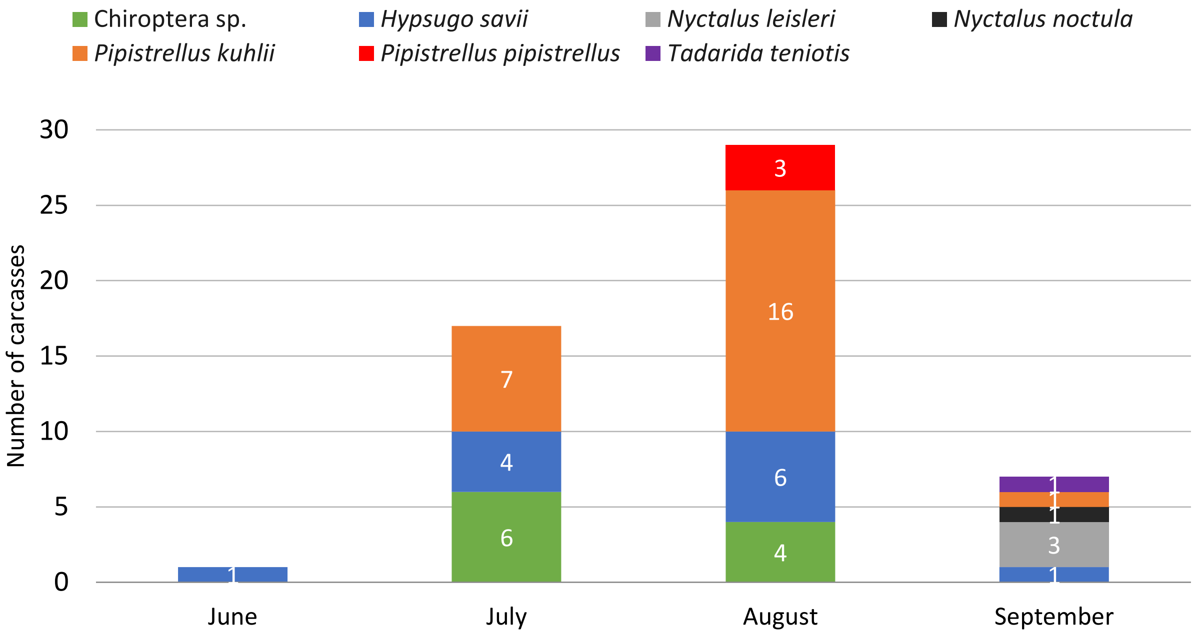



*Figure 3-27. Number of bat carcasses found per species per month*

### 3.3.3 Bat mortality in relation to activity

It is evident that bat mortality was to some extent related to bat activity. The number of bat carcasses found usually increased after nights with higher activity (Figure 3-28). The relation can't be completely reliable because bat activity was recorded only at two locations, so activity around other WTG's could have been different in the same period.

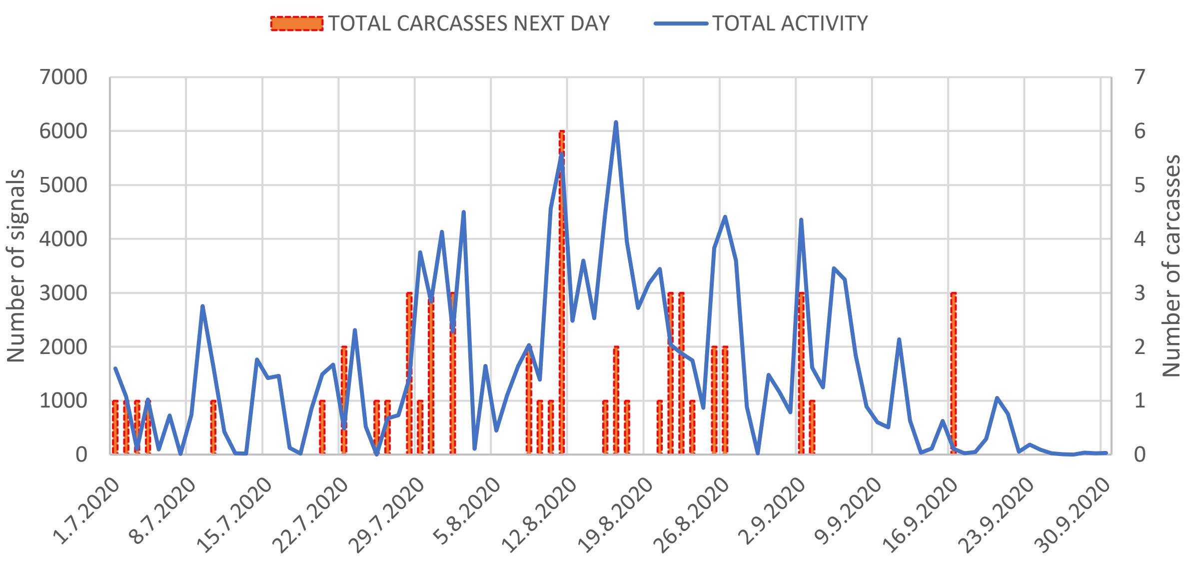



*Figure 3-28. Relation of bat mortality and activity (! No daily searches in September)*

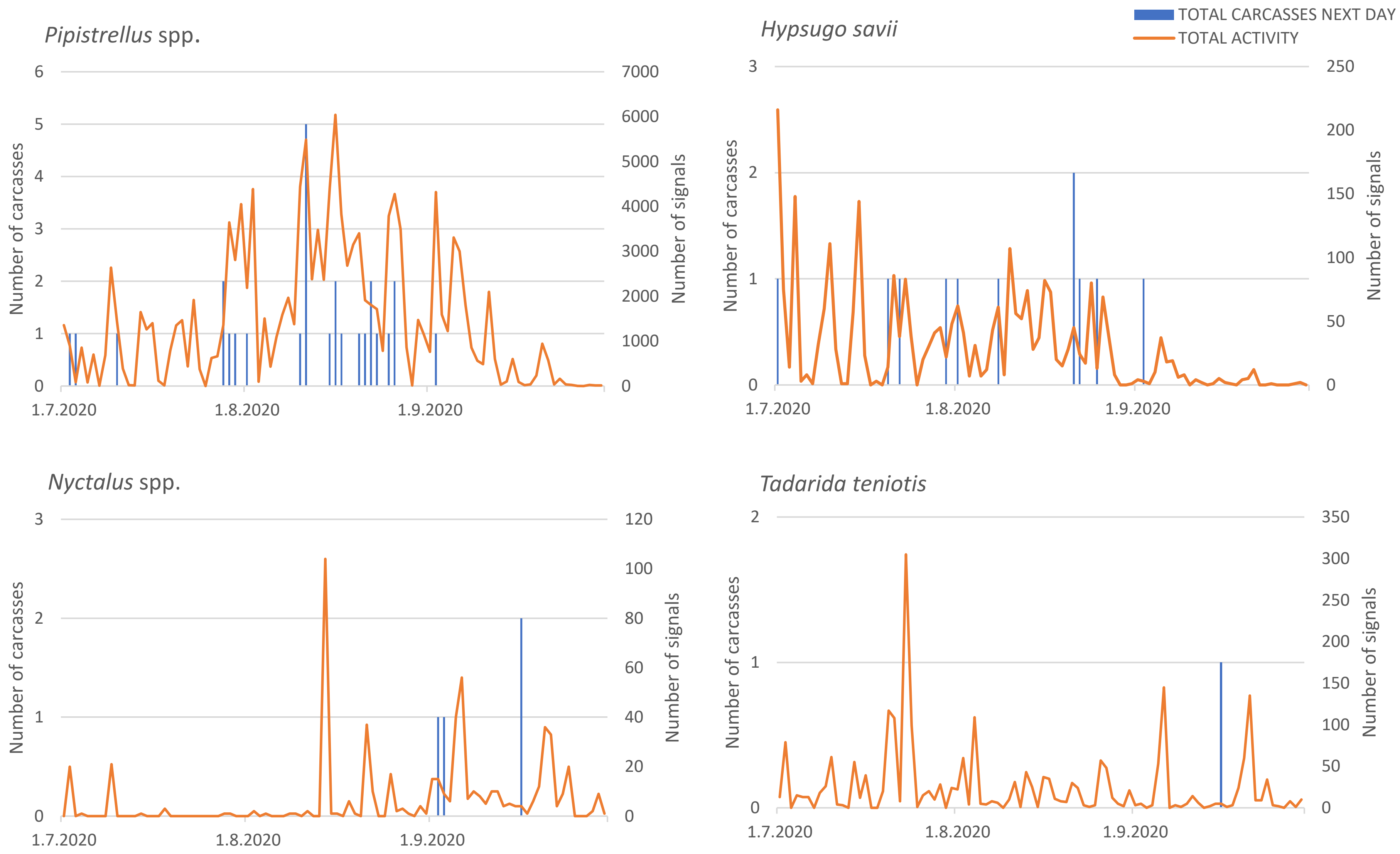



*Figure 3-29. Relation of activity and mortality for four different taxa whose carcasses were found (! No daily searches in September)*

When comparing activity and mortality for different species/groups, only for *Pipistrellus* spp. is the relation between activity and mortality obvious. This is most likely due to the number of found carcasses which is much smaller for other taxa and insufficient for a clear trend to show (Figure 3-29).

### 3.3.4 Bat mortality in relation to wind speed

In regards to wind speed, mortalty was usually higher when wind speeds were lower (Figure 3-30).

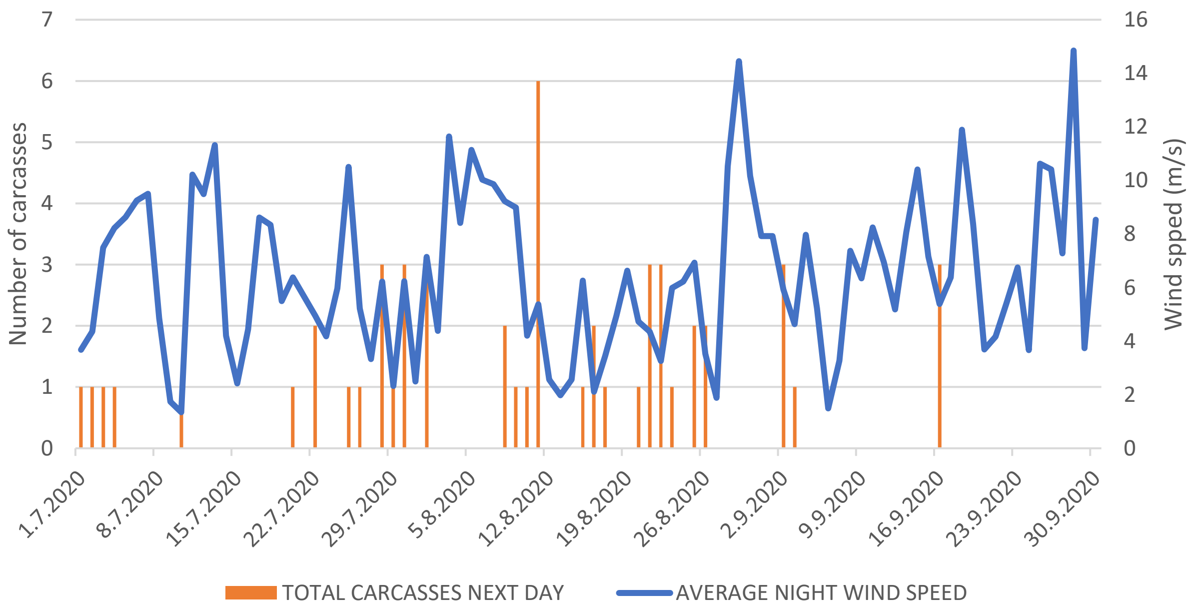



*Figure 3-30. Relation of bat mortality and wind speed (! No daily serches in September)*

Average wind speed at nacelle height in nights directly preceding the days when bat carcasses were found was 5.43 m/s (median 5.37 m/s). Bat activity was usually high in those nights with some exceptions. The trend follows those established in this report, that bat activity is generally higher when the wind speeds are lower.

*Pipistrellus* species consistently suffered collisions at lower wind speeds (Figure 3-35). When comparing activity for larger bat species for which carcasses were found (*Nytalus* spp. and *Tadarida teniotis*), however, no such correlation was found, because variations were not significant enough (Figure 3-32).

It is important to note that the number of fatalities does not increase at lower wind speeds only because those speeds are more dangerous for bats, but primarely because the bat activity is higher and there are more individuals interacting with WTG's.

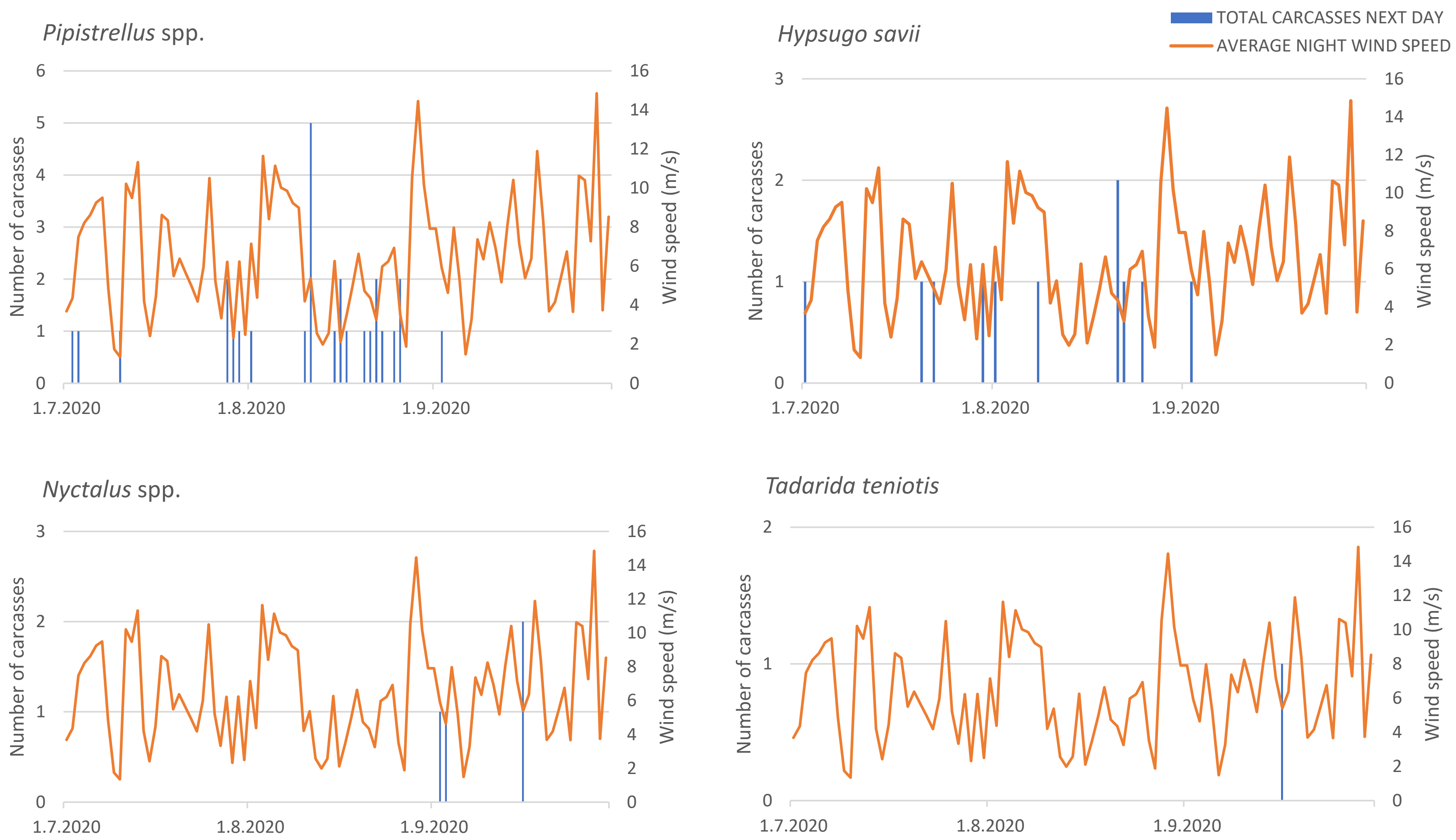



*Figure 3-31. Relation of mortality and average wind speed for four different taxa whose carcasses were found (no daily searches in September)*

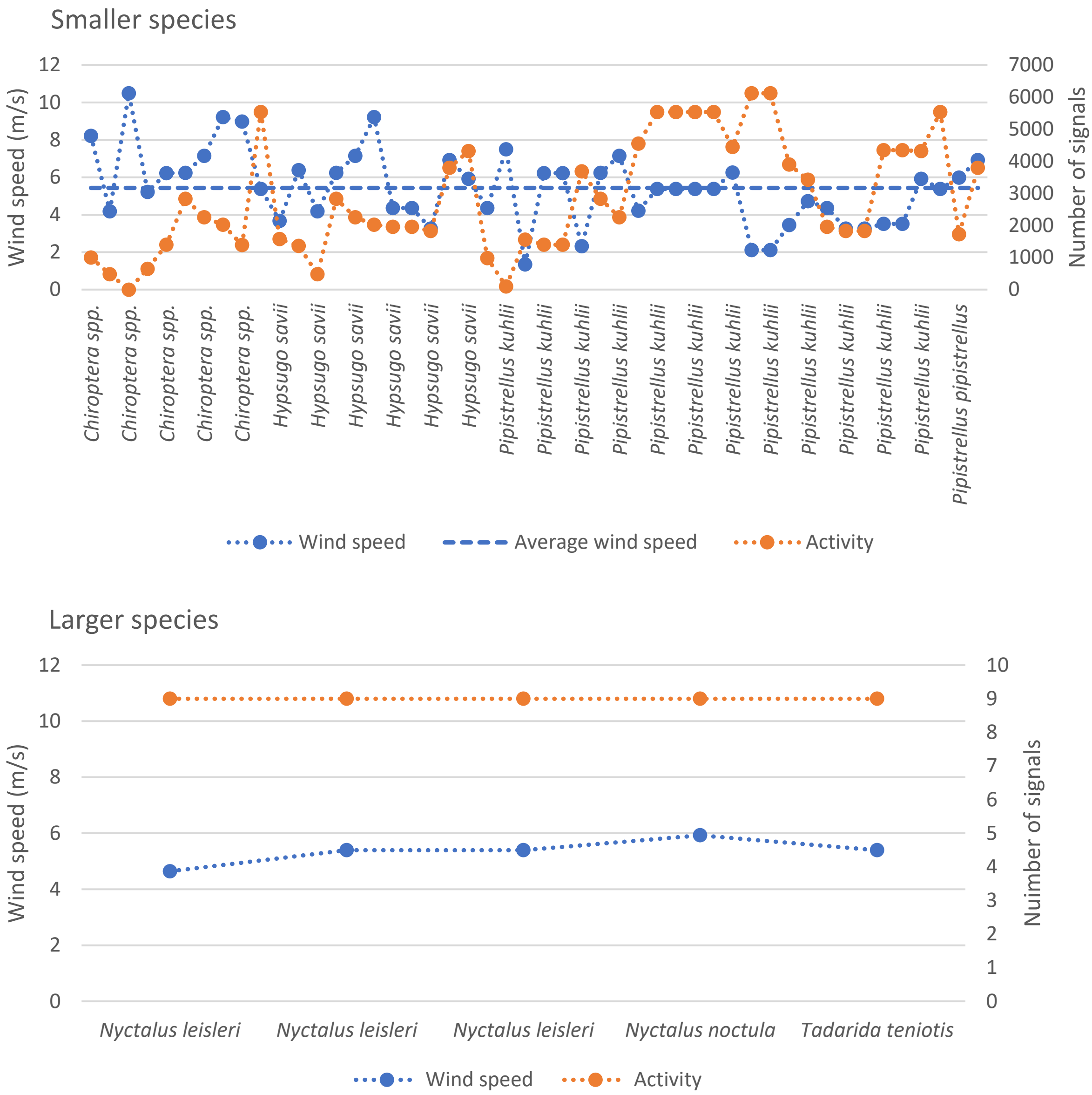



*Figure 3-32. Wind speed and activity in the night before the carcass was found for each discovered bat carcass*

## 3.4 Searcher efficiency trial

Out of 20 placed bat carcasses during the June trial, 12 were found on the first day of search (60 %), and four more on the second day (80 % in total) (Table 3-8).

*Table 3-8. Results of the searcher efficiency trial in June*

| PLACED CARCASS | WTG | CARCASSES FOUND | |
|---|---|---|---|
| | | FIRST SEARCH | SECOND SEARCH |
| **1** | WTG2 | + | / |
| **2** | WTG3 | - | + |
| **3** | WTG4 | + | / |
| **4** | WTG4 | - | - |

| PLACED CARCASS | WTG | CARCASSES FOUND FIRST SEARCH | SECOND SEARCH |
|---|---|---|---|
| **5** | WTG5 | - | + |
| **6** | WTG6 | + | / |
| **7** | WTG7 | - | + |
| **8** | WTG9 | - | - |
| **9** | WTG10 | + | / |
| **10** | WTG10 | + | / |
| **11** | WTG11 | + | / |
| **12** | WTG13 | - | + |
| **13** | WTG13 | + | / |
| **14** | WTG14 | + | / |
| **15** | WTG15 | + | / |
| **16** | WTG16 | - | - |
| **17** | WTG18 | + | / |
| **18** | WTG19 | + | / |
| **19** | WTG20 | - | - |
| **20** | WTG20 | + | / |
| **TOTAL** | | **12/20 (60 %)** | **16/20 (80 %)** |

The trial repeated in July with another survey team showed similar results. Out of 20 placed bat carcasses, 2 were removed (probably by scavengers) before they could be found by searchers. Out of the remaining 18 carcasses, 10 were found on the first day of search (56 %), and five more on the second day, which means 18 were found in total (83 %) (Table 3-9).

*Table 3-9. Results of the searcher efficiency trial in July*

| PLACED CARCASS | WTG | CARCASSES FOUND FIRST SEARCH | SECOND SEARCH |
|---|---|---|---|
| **1** | WTG2 | + | / |
| **2** | WTG3 | - | + |
| **3** | WTG3 | + | / |
| **4** | WTG5 | - | - |
| **5** | WTG5 | - | - |
| **6** | WTG6 | - | + |
| **7** | WTG8 | + | / |
| **8** | WTG9 | - | - |
| **9** | WTG9 | / | / |
| **10** | WTG10 | + | / |
| **11** | WTG12 | + | / |
| **12** | WTG12 | - | + |
| **13** | WTG13 | + | / |
| **14** | WTG13 | - | + |
| **15** | WTG14 | - | + |
| **16** | WTG15 | / | / |
| **17** | WTG16 | + | / |
| **18** | WTG17 | + | / |
| **19** | WTG28 | + | / |
| **20** | WTG20 | + | / |
| **TOTAL** | | **10/18 (56 %)** | **15/18 (83 %)** |

Since the first trial had a larger sample of carcasses, those results were used for further analyses. Mortality estimator GenEst (USGS 2018) was used to estimate searcher efficiency based on the trial results. Searchers successfully found 16 mice carcasses out of 20, which resulted in 38-79 % efficiency (95 % confidence intervals; median 60 %) as estimated by GenEst.

## 3.5 Carcass persistence trial

Out of 22 placed mouse carcasses, two were removed during the first night after placement (after half a day). Four carcasses were found to be missing after two nights (after 1.5 days), while most carcasses (6) were missing after three nights (after 2.5 days). From the 4th to 8th night, one to three carcasses were removed. After eight nights there were only two carcasses remaining (Table 3-10**Error! Reference source not found.**). Average number of days of carcass persistence was 3 (Figure 3-33).

*Table 3-10. Results of the carcass persistence trial*

| PLACED CARCASS | WTG | DAYS OF PERSISTENCE<br>Day 1 (0.5) | Day 2 (1.5) | Day 3 (2.5) | Day 4 (3.5) | Day 5 (4.5) | Day 6 (5.5) | Day 7 (6.5) | Day 8 (7.5) | Day 9 (8.5) | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WTG2 | + | - | | | | | | | | 0.5-1.5 |
| 2 | WTG2 | + | + | + | + | - | | | | | 3.5-4.5 |
| 3 | WTG3 | + | + | + | - | | | | | | 2.5-3.5 |
| 4 | WTG4 | + | + | + | + | - | | | | | 3.5-4.5 |
| 5 | WTG6 | + | + | + | + | + | + | + | - | | 6.5-7.5 |
| 6 | WTG7 | + | + | - | | | | | | | 1.5-2.5 |
| 7 | WTG7 | + | + | - | | | | | | | 1.5-2.5 |
| 8 | WTG8 | + | + | + | + | + | - | | | | 4.5-5.5 |
| 9 | WTG8 | + | + | + | + | + | - | | | | 4.5-5.5 |
| 10 | WTG9 | - | | | | | | | | | < 0.5 |
| 11 | WTG9 | + | + | - | | | | | | | 1.5-2.5 |
| 12 | WTG11 | + | + | - | | | | | | | 1.5-2.5 |
| 13 | WTG11 | + | + | + | + | + | + | + | + | + | > 8.5 |
| 14 | WTG12 | + | + | - | | | | | | | 1.5-2.5 |
| 15 | WTG14 | - | | | | | | | | | < 0.5 |
| 16 | WTG16 | + | + | - | | | | | | | 1.5-2.5 |
| 17 | WTG17 | + | - | | | | | | | | 0.5-1.5 |
| 18 | WTG18 | + | - | | | | | | | | 0.5-1.5 |
| 19 | WTG18 | + | + | + | + | - | | | | | 3.5-4.5 |
| 20 | WTG19 | + | - | | | | | | | | 0.5-1.5 |
| 21 | WTG20 | + | + | + | - | | | | | | 2.5-3.5 |
| 22 | WTG20 | + | + | + | + | + | + | + | + | + | > 8.5 |
| NUMBER OF CARCASSES MISSING | | 2 | 4 | 6 | 2 | 3 | 2 | 0 | 1 | 0 | |

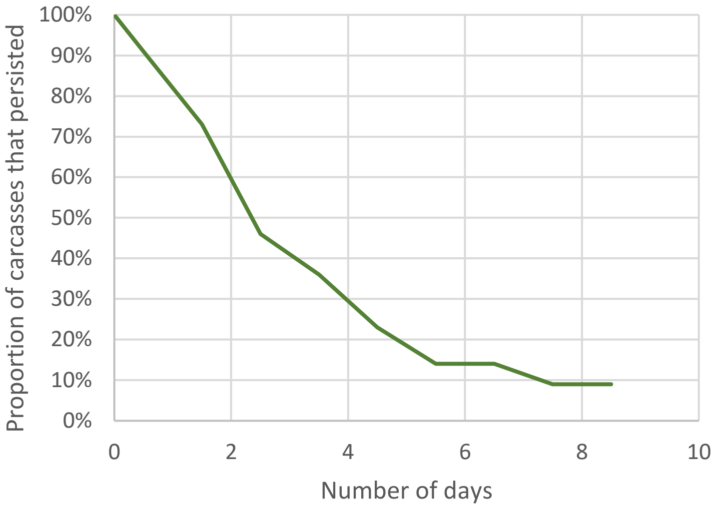



*Figure 3-33. Carcass persistence according to the trial*

Mortality estimator GenEst (USGS 2018) was used to estimate carcass persistence based on the trial results. Estimation for average carcass persistence was 2.4 days (median) (Figure 3-34).

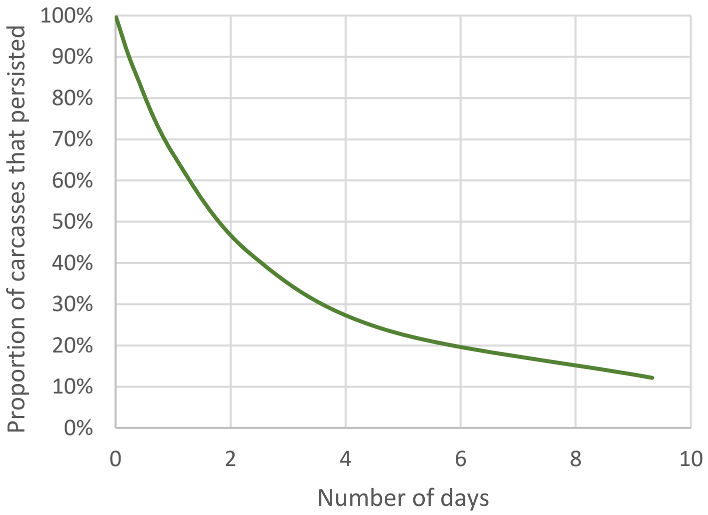



*Figure 3-34. Estimated carcass persistence according to GenEst*

## 3.6 Estimation of mortality

To estimate total mortality at wind farm Jelinak, the number of carcasses found during monitoring of bat collisions was corrected for searched area, carcass persistence, searcher efficiency and distance from WTG. Two mortality estimators were used: Huso (Huso et al. 2018) and GenEst (USGS 2018).

Since only accessible areas of good (high and moderate) visibility were searched within 70 m buffers around WTG's, correction for the searched area had to be made. It was necessary to extrapolate the number of estimated fatalities based on carcasses found in searched areas to unsearched areas. To get that estimation, the size (proportion) of a searched area within the total survey area was calculated, i.e. density weight proportion (DWP). The size of the searched area around a WTG was calculated by summing the total size of high visibility area, and the size of area of moderate visibility up to 1,5 m on both sides of the line walked, based on GPS tracks recorded during all surveys (Appendix IV; Table 3-11).

*Table 3-11. Average density weight proportion per turbine*

| WTG | AVERAGE DWP |
|---|---|
| **WTG1** | 15.22 % |
| **WTG2** | 18.36 % |
| **WTG3** | 13.05 % |
| **WTG4** | 16.62 % |
| **WTG5** | 15.59 % |
| **WTG6** | 15.66 % |
| **WTG7** | 23.60 % |
| **WTG8** | 20.24 % |
| **WTG9** | 14.25 % |
| **WTG10** | 18.40 % |
| **WTG11** | 27.10 % |
| **WTG12** | 17.66 % |
| **WTG13** | 19.00 % |
| **WTG14** | 15.24 % |
| **WTG15** | 22.18 % |
| **WTG16** | 19.48 % |
| **WTG17** | 22.82 % |
| **WTG18** | 16.78 % |
| **WTG19** | 18.65 % |
| **WTG20** | 20.05 % |
| **TOTAL** | **18.50 %** |

For the estimation of total mortality **Huso** estimator uses:

- Carcass observations data (results of carcass searches);

- Searcher efficiency (trial results);

- Carcass persistence (trial results);

- Proportion of searched area (DWP).

The estimated number of bat fatalities from June to October 2020 was **261-702** (95 % confidence intervals; median 432). Huso estimatior requires regular search dynamics, so estimations were made for three different periods (June, July-August, September), which were then summed up (Table 3-12).

For the estimation of total mortality **GenEst** uses:

- Carcass observations data (results of carcass searches);
- Search dynamics (timetable of carcass searches);
- Searcher efficiency (trial results);
- Carcass persistence (trial results);
- Proportion of searched area (DWP).

The estimated number of bat fatalities from June to October 2020 was **360-780** (95 % confidence intervals; median 512).

*Table 3-12. Number of fatalities estimated by Huso and GenEst estimators (95 % confidance intervals)*

| ESTIMATOR | PERIOD | ESTIMATED NUMBER OF FATALITIES |
|---|---|---|
| Huso | JUNE | 7-12 (median 9) |
| | JULY-AUGUST | 220-608 (median 371) |
| | SEPTEMBER | 34-82 (median 52) |
| | TOTAL | **261-702 (median 432)** |
| GenEst | TOTAL | **368-780 (median 512)** |

Both mortality estimators don't account for distance of carcasses from WTG. That adjustment is important in total mortality estimation because collided bats are not equally likely to fall anywhere in the 70 m radius but are, instead, increasingly likely to fall closer to WTG towers (Figure 3-35). That is because carcasses are more likely to fall closer to WTG's and because carcasses are spread over greater areas at greater distances from WTG's (Huso i Dalthorp 2014).

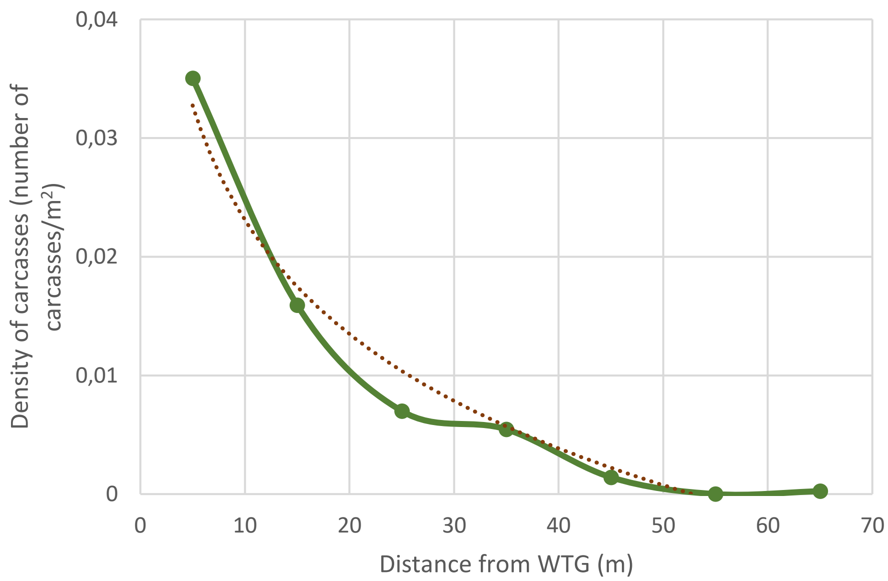



*Figure 3-35. Density of carcasses found in regard to distance from a WTG*

When enough data is available to estimate the change in carcass density with distance, a case-specific model can be used to estimate carcass fall distributions. However, when data is not sufficient, such as in this case, empirical models are a better solution (Huso and Dalthorp 2014, Korner-Nievergelt et al. 2019). For that adjustment the **DL05 estimator** (Huso and Dalthorp 2014) was used. It is based on the assumption that relative density of carcasses decreases as a simple linear logistic function of distance from WTG (Figure 3-36).

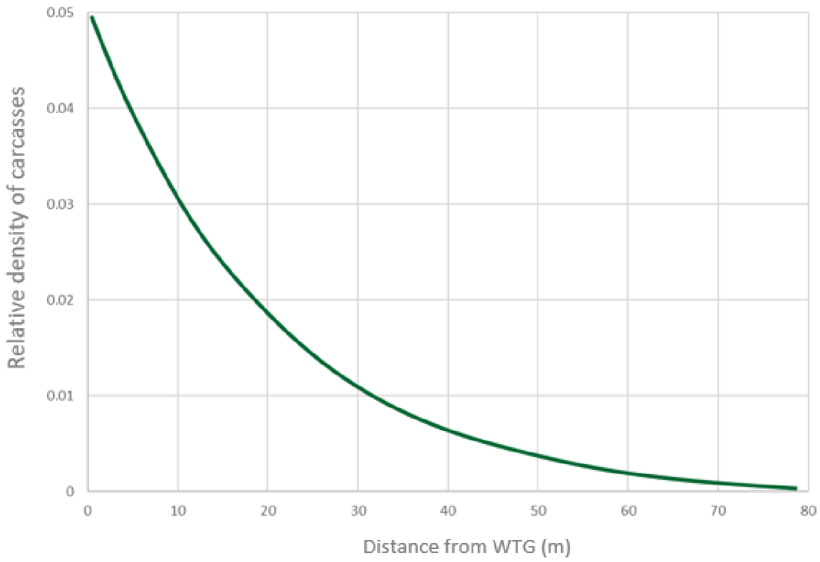



*Figure 3-36. Empirical DL05 distribution of fatalities (Huso and Dalthorp 2014)*

Locations of discovered carcasses were sorted into 10-meter groups (rings) according to distance from a WTG tower (0-10 m, 10-20 m, etc.). To then adjust for distribution of carcasses, coefficients for each distance category were used. The coefficients were derived from the modelled simple linear logistic function. Decrease of carcass density with distance from a WTG is reflected in the coefficients (Table 3-13).

The estimated number of bat fatalities within each 10-meter group was calculated by multiplying the number of carcasses proportional to the area size of the corresponding 10-meter ring with distribution coefficient.

*estimated number of fatalities = number of fatalities adjusted regarding share of area size * distribution coefficient*

To reach the **final estimate of bat fatalities** at WF Jelinak, estimated numbers of carcasses for each 10-meter group were summed up. Once the equation is applied, a total estimated number of bat fatalities is **76** according to **Huso**, and **90** according to **GenEst** (Table 3-13).

*Table 3-13. Correction of estimated bat fatalities for distance of carcasses from WTG*

| 10-m RING | RING AREA ($m^2$) | PROPORTION OF RING AREA | ESTIMATED NUMBER OF FATALITIES | | DISTRIBUTION COEFFICIENT* | CORRECTED ESTIMATED NUMBER OF FATALITIES | |
|---|---|---|---|---|---|---|---|
| | | | Huso | GenEst | | Huso | GenEst |
| **0-10 m** | 314 | 1.56 % | 9 | 10 | 1 | 9 | 10 |
| **10-20 m** | 941 | 4.68 % | 26 | 31 | 0.6 | 16 | 19 |
| **20-30 m** | 1568 | 7.80 % | 44 | 52 | 0.4 | 18 | 21 |
| **30-40 m** | 2195 | 10.92 % | 62 | 73 | 0.2 | 12 | 15 |
| **40-50 m** | 2823 | 14.05 % | 79 | 94 | 0.1 | 8 | 9 |
| **50-60 m** | 3459 | 17.21 % | 97 | 115 | 0.08 | 8 | 9 |
| **60-70 m** | 4081 | 20.31 % | 115 | 136 | 0.05 | 6 | 7 |
| **TOTAL** | **15393** | **100 %** | **432** | **512** | | **76** | **90** |

*(Source: *based on Huso and Dalthorp 2014)*

### 3.6.1 Estimation of mortality per WTG

GenEst can also estimate mortality for each WTG. The results of those estimations, as well as estimatons corrected for distance of carcasses from WTG is shown below (Table 3-14).

*Table 3-14. Estimated number of fatalities per WTG*

| WTG | GenEst ESTIMATION | CORRECTED ESTIMATED NUMBER OF FATALITIES |
|---|---|---|
| **WTG1** | 19 | 3 |
| **WTG2** | 49 | 9 |
| **WTG3** | 102 | 18 |
| **WTG4** | 25 | 4 |
| **WTG5** | 38 | 7 |
| **WTG6** | 20 | 4 |
| **WTG7** | 24 | 4 |
| **WTG8** | 39 | 7 |
| **WTG9** | 20 | 4 |
| **WTG10** | 0 | 0 |
| **WTG11** | 5 | 1 |
| **WTG12** | 40 | 7 |
| **WTG13** | 17 | 3 |
| **WTG14** | 29 | 5 |
| **WTG15** | 0 | 0 |
| **WTG16** | 9 | 2 |
| **WTG17** | 6 | 1 |
| **WTG18** | 8 | 1 |
| **WTG19** | 31 | 5 |
| **WTG20** | 14 | 2 |

The final assessment of bat mortality per turbine resulted in two WTG's having higher number of assessed fatalities than other WTG's (WTG3 and WTG2). Five more WTG's had higher mortality than average (WTG5, WTG8, WTG12, WTG14 and WTG19; average 4.43) (Figure 3-37).

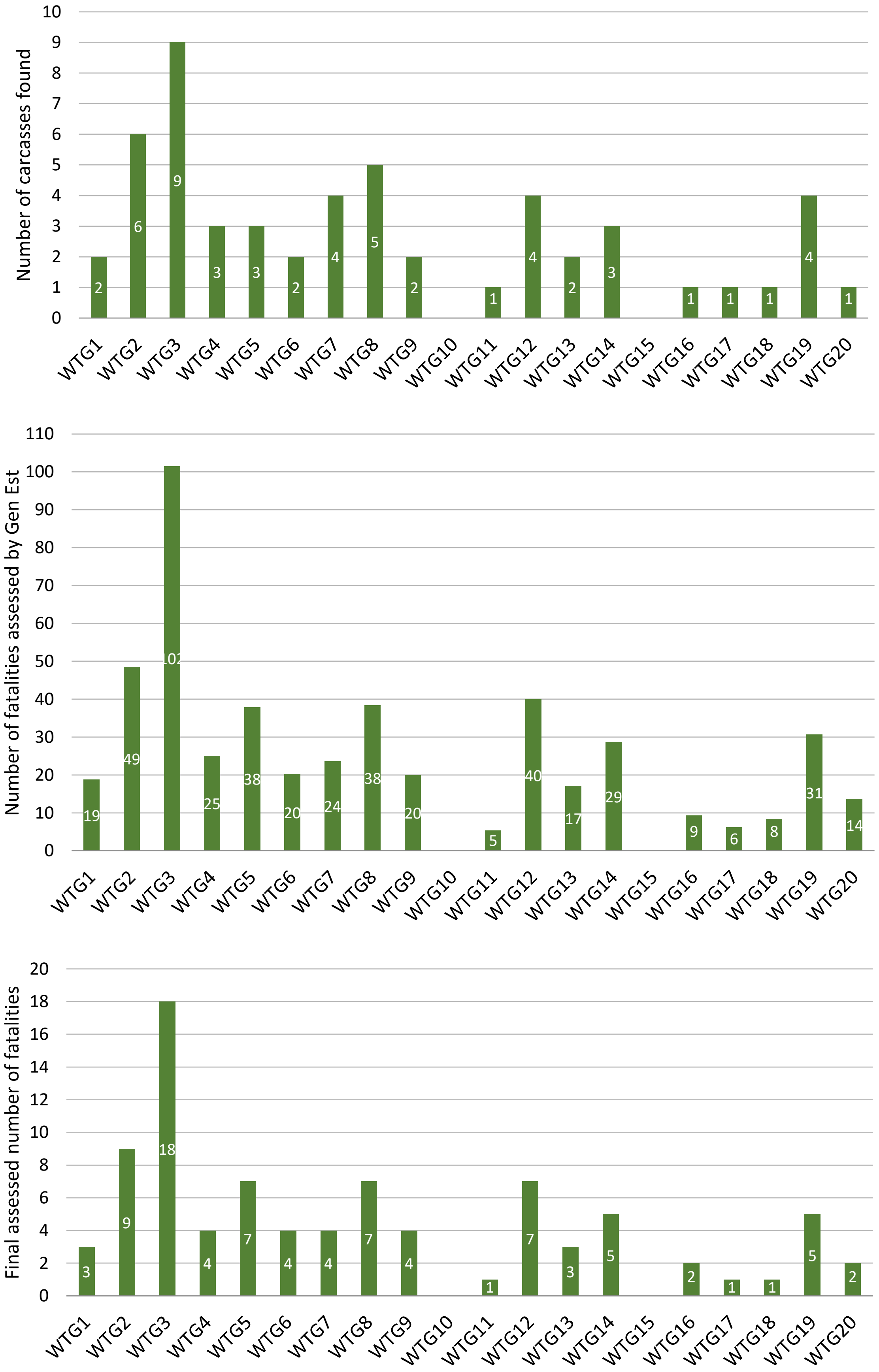



*Figure 3-37. Comparason of mortality estimations per turbine*

Bat mortality was compared to bat activity, wind speed and mode of operation of WTG's (Figure 3-38). The highest number of fatalities found (9) and assessed (18) was at WTG3 which is located in continuation of the Duboka draga valley characterized by low wind speeds and is surrounded by orchards. It is close to the location of stationary recording SR1 at which high bat activity was recorded. Because of high bat activity, applied mitigation measures weren't enough to significantly prevent bat collisions. The second highest number of fatalities was at adjacent WTG2. At WTG8 five carcasses were found. At that WTG low wind speeds were also measured, and south of the WTG there are orchards and a building to which a road leads, which may direct bats from south towards the WTG. Bat carcasses were also found when mitigation measures were applied. Above average mortality was also assessed at WTG5, WTG12, WTG14 and WTG19. For these WTG's, it can only be concluded that at WTG19 collisions occured probably because no mitigation measures were implemented. It seems that relation between bat activity, wind speed and bat mortality are in some cases evident (like for the WTG's with the highest mortality), while in some cases not.

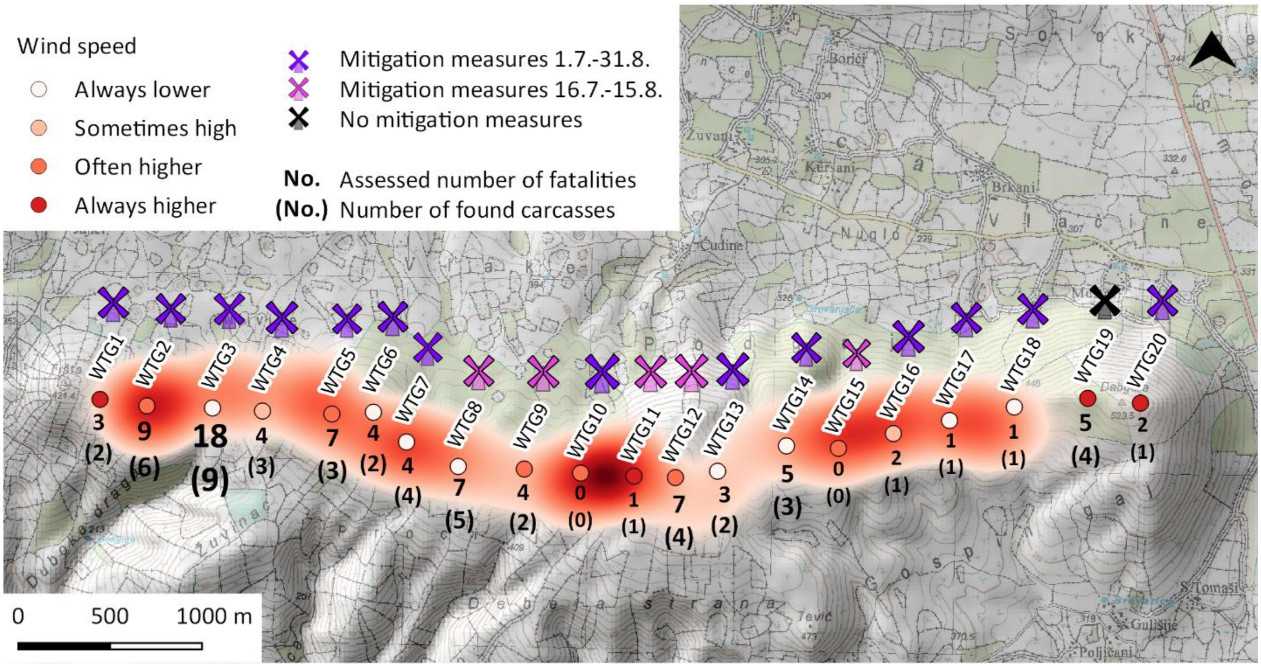



*Figure 3-38. Bat mortality compared to bat activity, wind speed and mode of operation of WTG's*

### 3.6.2 Comparison of mortality with previous years

The number of bat carcasses found at wind farm Jelinak during all monitoring years (2013, 2014, 2015, 2016, 2017 and 2020) was compared (Figure 3-39, Figure 3-40). It should be emphasized that field effort for monitoring of bat collision differred between years. Survey dynamics and the number of WTG's surveyed was were not the same (Table 3-15), and search dogs were used in some surveys. Also, different modes of wind farm operation (i.e. mitigation measures) were implemented each year (Table 3-16).

In 2013 mitigation measures were not implemented, so the number of carcasses found was the highest, despite less field effort than in the following years. In 2014, the number of fatalities was significantly lower, most likely because of implementation of mitigation measures on WTG's with highest mortality in 2013. At WTG's which were searched more frequently (every day from June to September), more carcasses were found. Mitigation measures were therefore implemented on additional WTG's in 2015, which resulted in further reduction of mortality. In 2015 every-day searches were introduced at all WTG's during July and August, so a high number of carcasses were found at some WTG's which were not that frequently searched in previous years. That resulted in implementation of mitigation measures at more additional WTG's in 2016. Mortality was then reduced even more, and was the lowest in 2017, when mitigation measures were implemented at almost all WTG's. During 2020, search dinamics and mitigation measures remained the same as in 2017, but the number of carcasses found was higher. Higher mortality in 2020 when compared to 2017 can be due to different search dynamics and/or different bat activity between the two years.

Results from continuous bat call recording cannot be directly compared to the results from previous monitoring surveys at WF Jelinak. For 2014, the results are presented only for the whole period of monitoring and not per month, which made the comparison impossible, since surveys were carried out during different period of time than during this survey (from June 26$^{th}$ until November 14$^{th}$). In 2015, 2016 and 2017, total bat acitvity was measured as „activity in seconds“, a method incompatible with the recording method used during this survey.

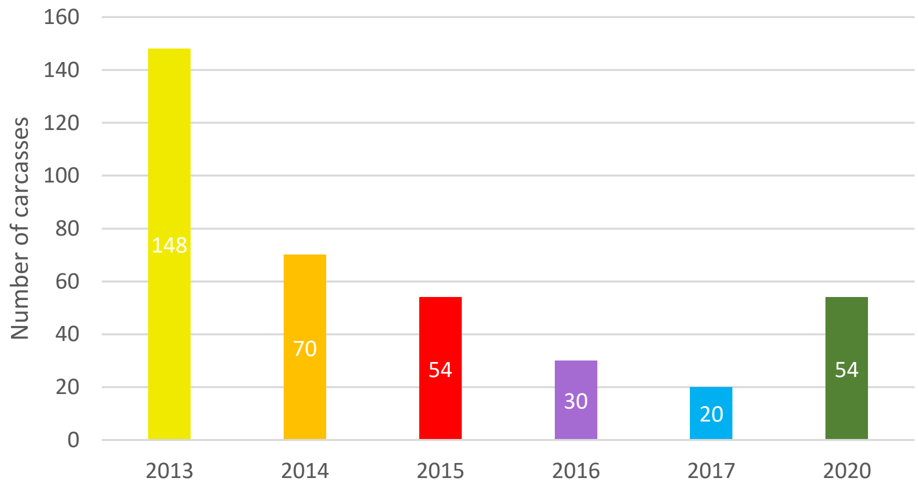



*Figure 3-39. Number of bat carcasses found at wind farm Jelinak in 2013, 2014, 2015, 2016, 2017 and 2020*

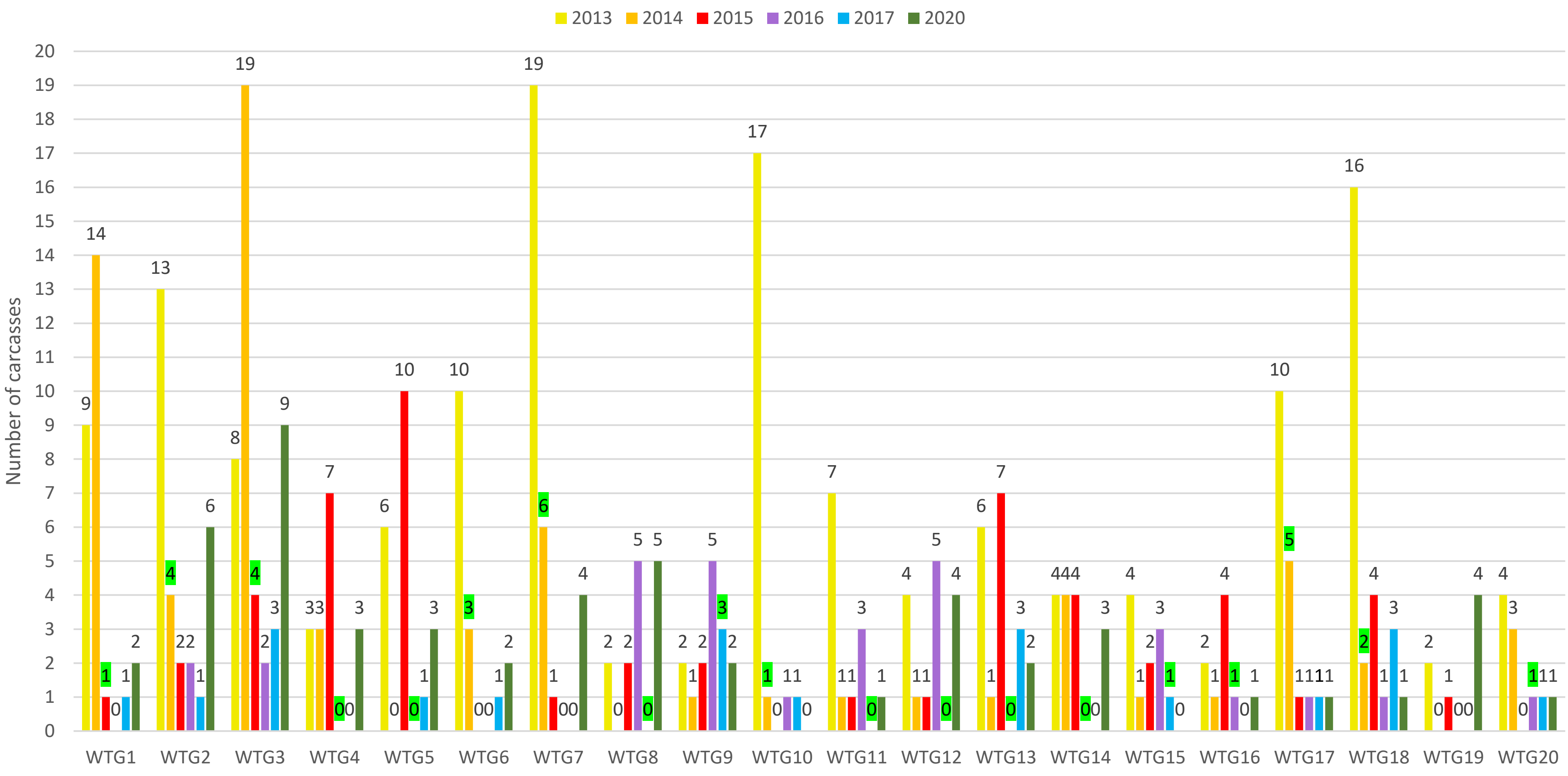



*Figure 3-40. Number of bat carcasses per WTG found at wind farm Jelinak in 2013, 2014, 2015, 2016, 2017 and 2020*

*(Number of carcasses when mitigation method was introduced is marked **green**)*

*Table 3-15. Survey dinamics for monitoring of bat collisions at WF Jelinak in 2013, 2014, 2015, 2016, 2017 and 2020*

| MONTH | SURVEY DINAMICS | | | | | |
|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2020 |
| **March** | 2 x | 2 x | - | - | - | - |
| **April** | 2 x | 2 x | - | - | - | - |
| **May** | 2 x | 2 x | - | - | - | - |
| **June** | 2 x | 2 x | 2-day searches every 7 days | 2-day searches every 7 days | 2-day searches every 7 days | 2-day searches every 7 days |
| **July** | 2 x | 2 x all WTG's + every day at WTG1, WTG2, WTG3, WTG6, WTG7, WTG10, WTG14, WTG17 and WTG18 | every day | every day | every 3 days | every day |
| **August** | 2 x | 2 x all WTG's + every day at WTG1, WTG2, WTG3, WTG6, WTG7, WTG10, WTG14, WTG17 and WTG18 | every day | every day | every 3 days | every day |
| **September** | 2 x | every day at WTG1, WTG2, WTG3, WTG6, WTG7, WTG10, WTG14, WTG17 and WTG18 | 2-day searches every 7 days | 2-day searches every 7 days | 2-day searches every 7 days | 2-day searches every 7 days |
| **October** | 2 x | - | 2-day searches every 7 days | 1 two-day search | 1 two-day search | 1 two-day search |

*Table 3-16. Mitigation measures implemented at WF Jelinak in 2013, 2014, 2015, 2016, 2017 and 2020*

| Period | Wind turbine generators | Blade feathering | Cut-in speed | Timing |
|---|---|---|---|---|
| **1.7.-30.9.2014.** | WTG2, WTG6, WTG7, WTG10, WTG17, WTG18 | | 5.0 m/s | from one hour before sunset until 3 hours after sunset |
| **1.7.-31.8.2015.** | WTG1, WTG2, WTG3, WTG6, WTG7, WTG10, WTG17, WTG18 | | 5.0 m/s | 9 pm-3 am |
| **1.7.-15.7.2016. & 16.8.-31.8.2016.** | WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG10, WTG13, WTG14, WTG16, WTG17, WTG18, WTG20 | yes | 5.0 m/s | 9 pm-3 am |
| **16.7.-15.8.2016.** | WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG10, WTG13, WTG14, WTG16, WTG17, WTG18, WTG20 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |
| **1.7.-15.7.2017. & 16.8.-31.8.2017.** | WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG10, WTG13, WTG14, WTG16, WTG17, WTG18, WTG20 | yes | 5.0 m/s | 9 pm-3 am |
| **16.7.-15.8.2017.** | All except WTG19 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |
| **1.-15.7.2020. & 16.-31.8.2020.** | WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG10, WTG13, WTG14, WTG16, WTG17, WTG18, WTG20 | yes | 5.0 m/s | 9 pm-3 am |
| **16.7.-15.8.2020.** | All except WTG19 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |

# 4 Mitigation measures proposal

Due to a relatively high estimated mortality at WF Jelinak, which represents a negative impact on local bat populations, mitigiation measures are proposed to minimise those impact to an acceptable level. The only mitigating measures that have been proven effective in Europe are blade feathering and increase of cut-in wind speed (Rodrigues at al. 2014). Blade feathering is the rotation of turbine blades at 90° to prevent them from turning when the wind speed is below the cut-in threshold. Increased cut-in wind speed is the delay in the start of the power production process until the wind speed is at a pre-defined point.

Blade feathering is important for preventing collisions of small bat species, which are the most common species in the WF area and are most active when wind speeds are relatively low (up to 3 m/s). At WF Jelinak, blade feathering below 3 m/s is the default mode of operation of WTG's (Table 4-1).

*Table 4-1. Blade feathering implemented at WF Jelinak*

| PERIOD | WIND TURBINE GENERATORS | BLADE FEATHERING |
|---|---|---|
| 1.1.-31.12. | all WTG's | 0-3 m/s |

In 2020, mitigation measures (blade feathering and cut-in speed increased to 5.0 m/s) were implemented at 14 WTG's from July 1st until August 31st, and at 5 more WTG's from July 16th until August 15th (Table 1-1). Only at WTG19 were no mitigation mesures implemented. The measures were implemented during the whole night between July 16th and August 15th, while before and after that period the measures were implemented from 9 pm until 3 am.

Most of the bat carcasses (37/54) were found after nights when mitigation measures were implemented. All of the carcasses belonged to small bat species (*Pipistrellus* spp., *Hypsugo savii*), which are more active during lower wind speeds, so it is assumed that mitigation measures were to some point effective in reduction of bat mortality. However, most carcasses were found after nights with wind speeds slightly above 5.0 m/s (5.3-5.4 m/s), which means that cut-in speed should also be slightly higher.

Eight carcasses were found in the second half of August, when the mitigation measures lasted until 3 am. It was observed that bat activity in August didn't significantly drop before morning hours (around 6 am), which means the collisions also potentially occured after 3 am, when there were no mitigation measures.

A significant number of carcasses (7) was also found in September, which could be mitigated with mitigation measures.

Therefore, mitigation measures should be amended to increase cut-in speed at the WTG's with highest recorded mortality to 5.5 m/s. This includes the whole implementation period from July 1st to August 31st. Also, all measures should be implemented throughout the entire night from July 16th until August 31st. Additional mitigation measure to be implemented in September is also proposed. The six WTG's with recorded mortality in September should have cut-in speed increased to 5.5 m/s for the duration of the month. Implementation of this measure is proposed from 30 minutes before sunset to 3 am to target larger bat species which are active earlier in the night. Carcasses of larger bat species, such as *Tadarida teniotis* and *Nyctalus* spp., were most common among all the fatalities in September. Proposed mitigation measures could lead to significant declines of bat fatalities.

Some WTG's were assessed to pose a lower collision risk for bats (Table 4-2). When looking at the results from all monitoring years, those WTG's had the lowest number of recorded fatalities. Even though at some of those WTG's mitigation measures were implemented in some periods, bat mortality was assessed to be relatively low even before the start of mitigation measure implementation. It is proposed to implement blade feathering at those WTG's (already implemented in the WF operation protocol), with no additional mitigation measures.

*Table 4-2. Lower risk WTG's*

| WIND TURBINE GENERATORS | NUMBER OF BAT CARCASSES | | | | | | AVERAGE MORTALITY | AVERAGE MORTALITY WITHOUT MEASURES |
|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2020 | | |
| WTG9 | 2 | 1 | 2 | 5 | 3 | 2 | 2.50 | 2.75 |
| WTG11 | 7 | 1 | 1 | 3 | 0 | 1 | 2.17 | 3.00 |
| WTG15 | 4 | 1 | 2 | 3 | 1 | 0 | 1.83 | 2.50 |
| WTG16 | 2 | 1 | 4 | 1 | 0 | 1 | 1.50 | 2.33 |
| WTG19 | 2 | 0 | 1 | 0 | 0 | 4 | 1.17 | 1.17 |
| WTG20 | 4 | 3 | 0 | 1 | 1 | 1 | 1.67 | 2.33 |

Numbers in red = no mitigation measures

Numbers in green = cut-in speed 5.0 m/s

Based on the above stated conclusions on bat fatalities, the mitigation measures protocol should be as described in the Table 4-3 (additional to blade feathering implemented by default at all WTG's).

It is recommended to continue the monitoring programs in following years, which would determine the impact of the new mitigation measures plan on bat population protection but also on energy production. When compared to the overall monitoring results and especially those from 2020, mitigation measures could further be optimised and planned in more details. The survey design for future monitoring should be the same as in 2020 to enable direct comparisons and a proper assessment of the mitigation measures effectiveness.

*Table 4-3. Proposed additional mitigation measures*

| PERIOD | WIND TURBINE GENERATORS | BLADE FEATHERING | CUT-IN SPEED | TIMING |
|---|---|---|---|---|
| 1.-15.7. | WTG1, WTG10, WTG13, WTG17, WTG18 | yes | 5.0 m/s | 9 pm-3 am |
| | WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14 | yes | 5.5 m/s | 9 pm-3 am |
| 16.7.-15.8. | WTG1, WTG10, WTG13, WTG17, WTG18 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |
| | WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14 | yes | 5.5 m/s | from half an hour before sunset untill half an hour after sunrise |
| 16.-31.8. | WTG1, WTG10, WTG13, WTG17, WTG18 | yes | 5.0 m/s | from half an hour before sunset untill half an hour after sunrise |
| | WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14 | yes | 5.5 m/s | from half an hour before sunset untill half an hour after sunrise |
| 1.9.-30.9. | WTG5, WTG8, WTG12, WTG13, WTG16, WTG20 | yes | 5.5 m/s | from half an hour before sunset untill 3 am |

# 5 Summary

The bat monitoring program for wind farm Jelinak was conducted from June 2020 to October 2020. Monitoring was designed in coordination with monitoring reports from previous years of post-construction monitoring at WF Jelinak, in agreement with Vjetroelektrana Jelinak Ltd.

Wind farm Jelinak is located in Split-Dalmatia County, in Trogir hinterland and consists of 20 wind turbine generators (WTG's). Surrounding habitats include eastern Adriatic sub-Mediterranean rocky pastures, thermophilous deciduous downy oak coppice and arable land (orchards).

Impact of the wind farm on bats was monitored by monitoring of bat collisions and bat activity. Bat collisions were monitored by searching for bat carcasses at WTG bases, while bat activity was monitored by continuous bat call recording at stationary locations and periodic bat call recording along a transect route.

Continuous bat call recording was implemented on two WTG locations. Bat detectors were set up to continuously record bat calls each night from June to October. A total of 152,076 signals were recorded. Over 95 % of those were identified to belong to the species of genus *Pipistrellus*. Bat activity was found to be highest in August and lowest in October. Correlation of bat activity with wind speed was analyzed and it was found that bat activity decreased with increasing wind speeds.

Periodic bat call recording along the transect route was conducted in July and August, twice each month for two continuous days. The transect route passed along the access road connecting all WTG's. Most of the recorded bat signals were found to belong to species of genus *Pipistrellus*, as well as to *Hypsugo savii*.

Searching for bat carcasses was implemented every seven days for two consecutive days in June and September, every day in July and August, and once for two consecutive days in October. A total of 54 carcasses were found. They belonged to six bat species: *Pipistrellus kuhlii* (24), *Hypsugo savii* (12), *Pipistrellus pipistrellus* (3), *Nyctalus leisleri* (3), *Nyctalus noctula* (1) and *Tadarida teniotis* (1). An additional 10 carcasses could not be identified to a species level, but are considered to belong to either genus *Pipistrellus* or *H. savii* due to their forearm size. Searcher efficiency and carcasses persistence trials were implemented as well, in order to estimate the total number of fatalities. Search results were then analyzed and corrected for carcass persistence, searcher efficiency, proportion of searched area, and distance from WTG. Estimations using two different estimator tools, Huso and GenEst, show a total estimated mortality of 76 and 90 bats, respectively.

The number of found bat carcasses, as well as estimations of total mortality, when compared to bat activity and recorded wind speeds, indicated a possible negative impact of the WF on bat populations, especially at WTG's with highest mortality. Therefore, mitigations measures were proposed, that build upon the measures implemented earlier, but focusing on WTG's with highest estimated mortalitiy numbers, and on most sensitive periods for bat populations.

# 6 References

## 6.1 Regulations

1. Convention on the Conservation of European Wildlife and Natural Habitats, 1979
2. Council Directive 92/43/EEZ
3. Law on Ratification of the Agreement on the Protection of Bats in Europe (EUROBATS), Official Gazette 06/00
4. Nature Protection Act, Official Gazette 80/13, 15/18, 14/19, 127/19
5. Ordinance on Strictly Protected Species, Official Gazette 144/13, 73/16
6. Regulation on the ecological network and the responsibilities of public institutions for the management of ecological network areas, Official Gazette 80/19

## 6.2 Literature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## 6.3 Internet sources


1. IUCN Red List of Threatened Species. https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species (Accessed: January 2021)

# 7 Appendix

*Appendix I. Microclimatic conditions recorded during periodic sounds recording on a transect route*

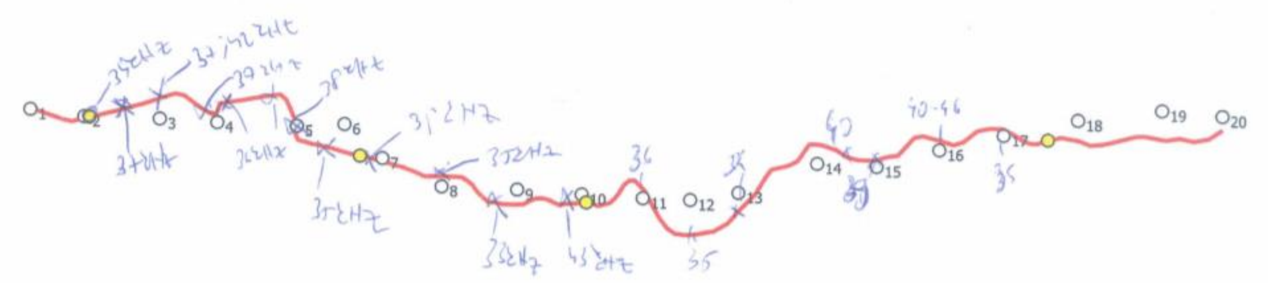
| SURVEY DATE | START TIME | END TIME | AIR TEMPERATURE (°C) | | WIND SPEED (m/s) | | AIR HUMIDITY (%) | | WEATHER CONDITIONS |
|---|---|---|---|---|---|---|---|---|---|
| | | | START | END | START | END | START | END | |
| 15.7.2020. | 21:05 | 23:33 | 20.9 | 17.7 | 0.0 | 1.4 | 68.9 | 72.1 | mostly clear |
| 16.7.2020. | 21:10 | 23:39 | 20.9 | 19.4 | 2.9 | 2.0-2.3 | 66.1 | 83.3 | clear |
| 29.7.2020. | 20:53 | 23:30 | 28.2 | 26.9 | 0.8 | 1.5 | 46.0 | 46.5 | clear |
| 30.7.2020. | 20:50 | 23:19 | 27.4 | 25.9 | 2.6-3.1 | 1.7 | 45.2 | 63.1 | clear |
| 12.8.2020. | 20:30 | 22:53 | 26.0 | 23.3 | 1.7 | 1.6 | 55.8 | 60.4 | clear |
| 13.8.2020. | 20:33 | 22:53 | 25.6 | 25.9 | 1.1 | 0.7 | 55.9 | 55.8 | clear |
| 24.8.2020. | 20:16 | 22:35 | 27.1 | 23.9 | 1.3-2.2 | 0.8 | 53.6 | 63.7 | partly cloudy |
| 25.8.2020. | 20:13 | 22:43 | 21.2 | 21.0 | 2.9-3.3 | 1.8-3.9 | 65.9 | 62.3 | clear |

*Appendix II. Example of a field form for periodic sounds recording on a transect route*

*Monitoring šišmiša - VE Jelinak 2020*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DATUM: 29.7.2020. | VRIJEME POČETKA: 20:53 | | | | VRIJEME ZAVRŠETKA: 23:30 | | |
| PRISUTNI ISTRAŽIVAČI:<br>1. [illegible]<br>2. [illegible] | VREMENSKE PRILIKE | | | | MIKROKLIMATSKI UVJETI | | |
| | bez oblaka | X | lagana kiša | | POČETAK | | ZAVRŠETAK |
| | malo oblaka | | kiša | | Vrijeme: 20:57 | | Vrijeme: 23:32 |
| NAPOMENE: | djelomično oblačno | | nevrijeme | | T (°C): 28,2 | | T (°C): 26,9 |
| | oblačno | | magla | | H (%): 46,0 | | H (%): 46,5 |
| | NAPOMENA: | | | | Vjetar (m/s): 0,8 | | Vjetar (m/s): 1,5 |

SNIMANJE PO TRANSEKTU




| | | |
|---|---|---|
| ST_2 | vrijeme: 21:00 - 21:05 | vjetar (m/s): 0,5 |
| ST_6-7 | vrijeme: 21:38 - 21:43 | vjetar (m/s): 0,0 |
| ST_10 | vrijeme: 22:03 - 22:08 | vjetar (m/s): 0,0 |
| ST_17-18 | vrijeme: 23:09 - 23:14 | vjetar (m/s): 1,3 |

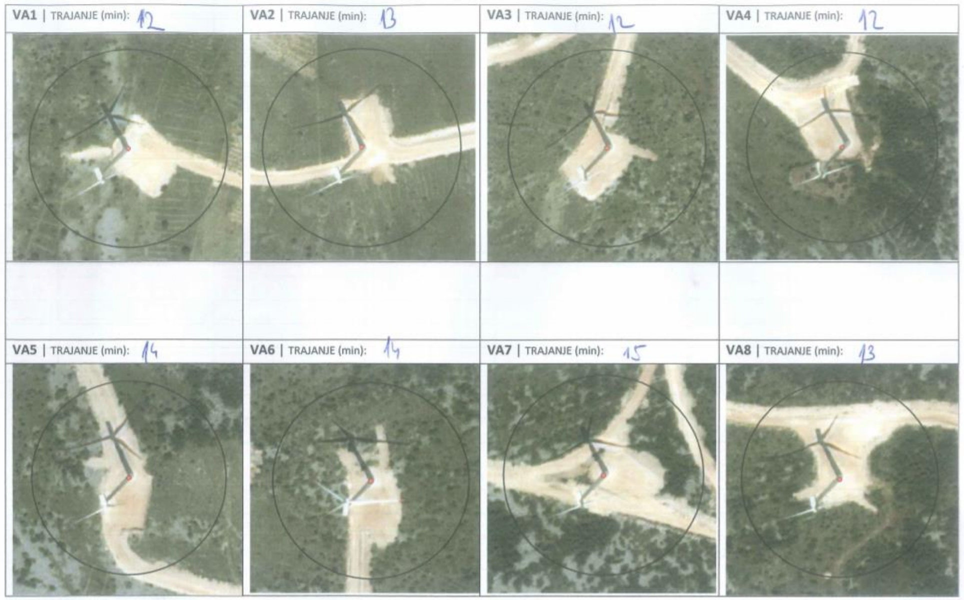
## *Appendix III. Example of a field form for monitoring of bat collisions*

*Monitoring smrtnosti - VE Jelinak*

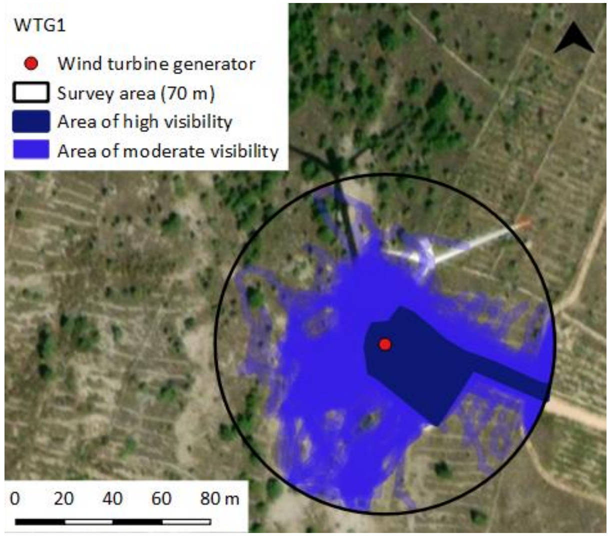
| DATUM: 17.9.2020. | | PRISUTNI ISTRAŽIVAČI: MARTA MIKULIĆ LOVIE TASSOR | | |
|---|---|---|---|---|
| MIKROKLIMATSKI UVJETI | POČETAK | vrijeme: 7:14 | T (°C): 22,4 | H (%): 55,0 | vjetar (m/s): 0 |
| | ZAVRŠETAK: | vrijeme: 12:58 | T (°C): 29,7 | H (%): 42,7 | vjetar (m/s): 1,9 – 2,8 |

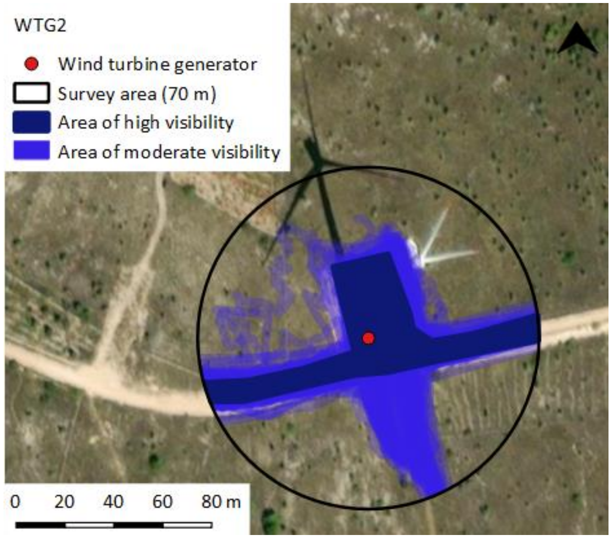
| R.BR. | ŠIFRA NALAZA | VA | VRSTA | SPOL | DOB | FA | OZLJEDE | STANJE | NAPOMENE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 632MM | 5 | Hsav | | AD | 41,68 | / | polusvjež | jeli ga ose |
| 2 | 1278 LT | 12 | H sav | ♀ | AD | 42.44 | / | SVJEŽ | |
| 3 | 633MM | ~~20~~ 19 | T ten | ♀ | SAD | 59.08 | / | SVJEŽ | |

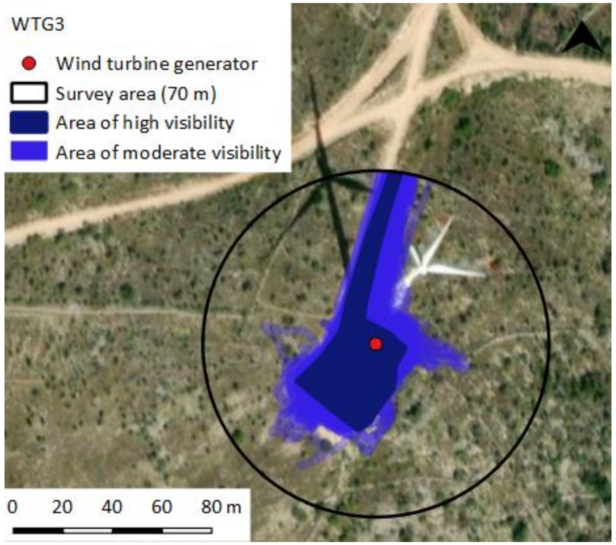
*Monitoring smrtnosti - VE Jelinak*

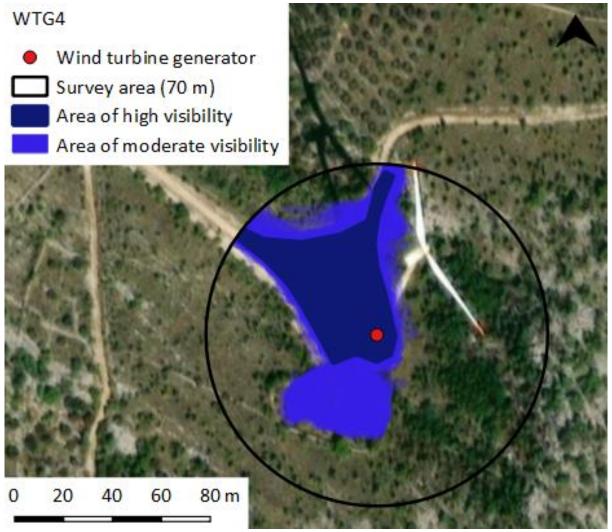


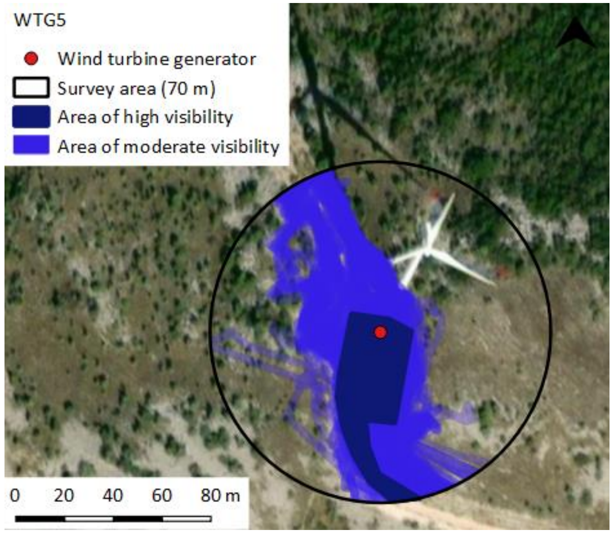
*Appendix IV. Areas searched for bat carcasses around each WTG (darker blue indicates more frequent searches)*

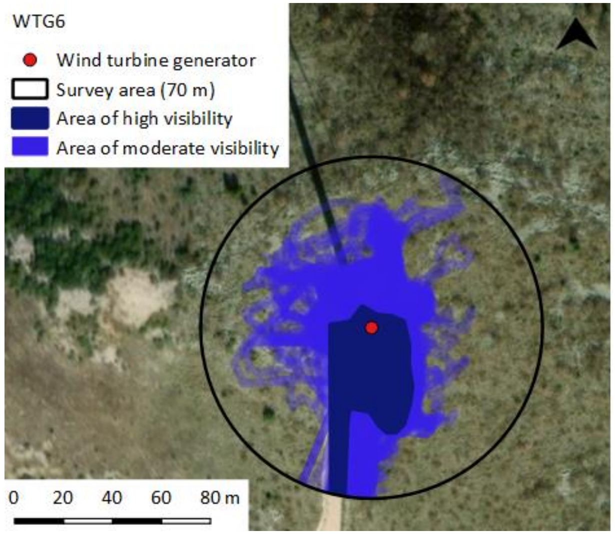


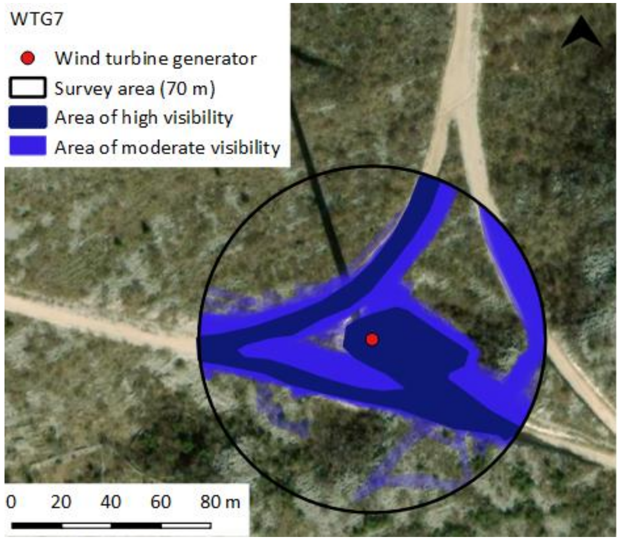



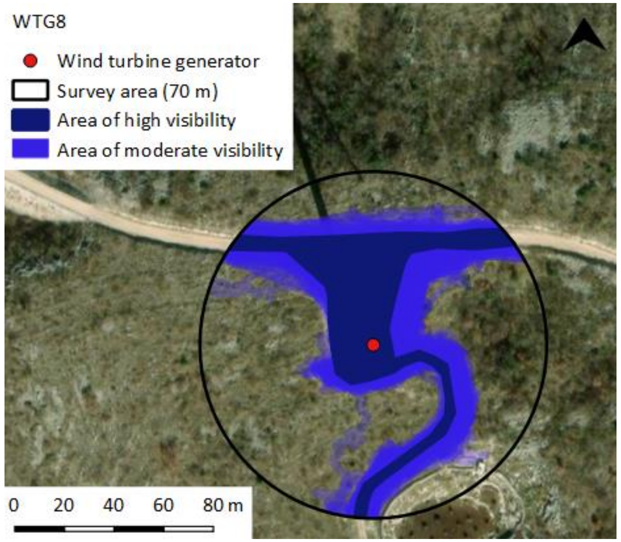



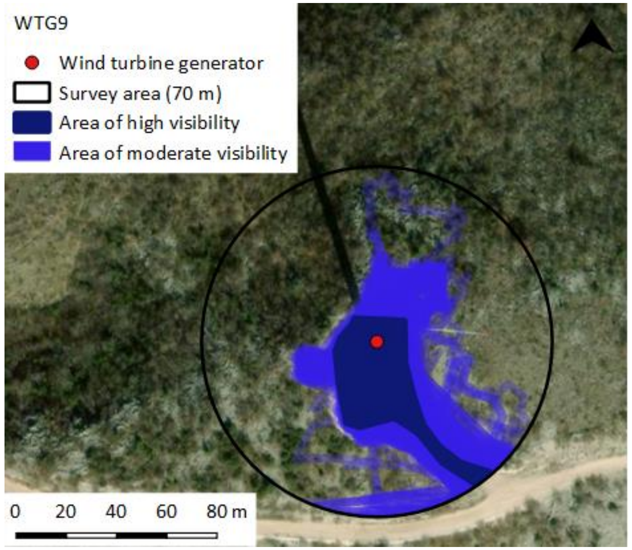



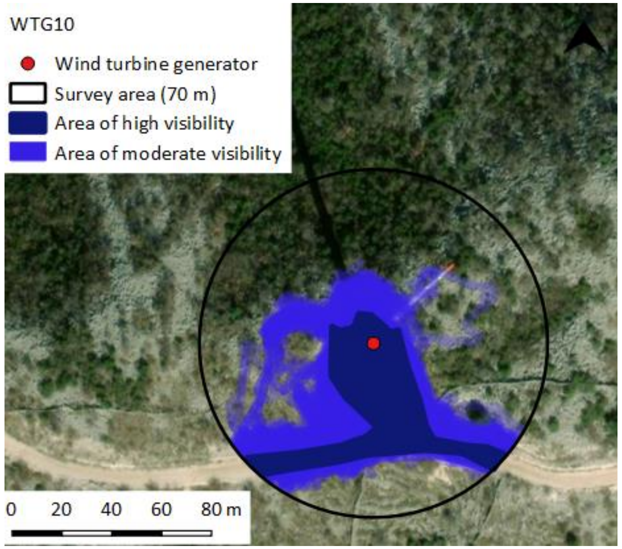



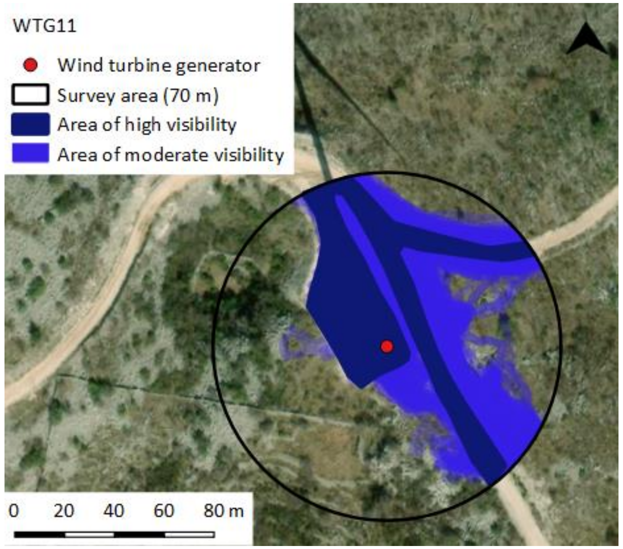



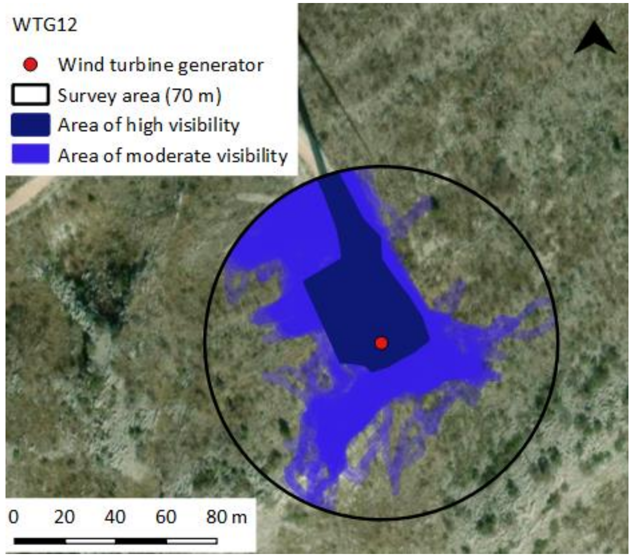

WTG7
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

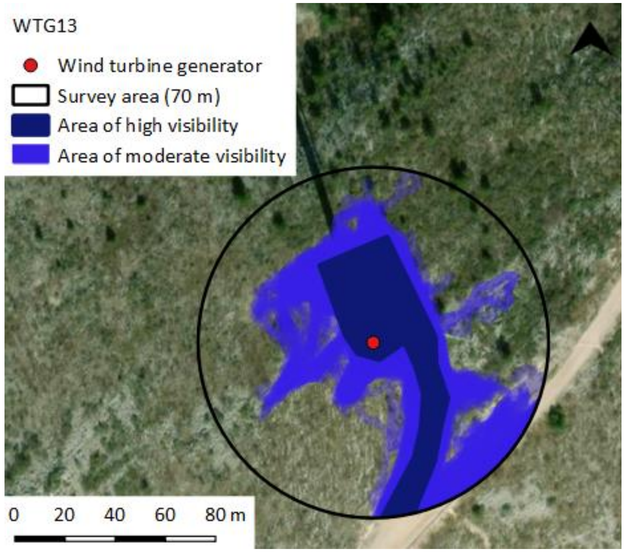

WTG8
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

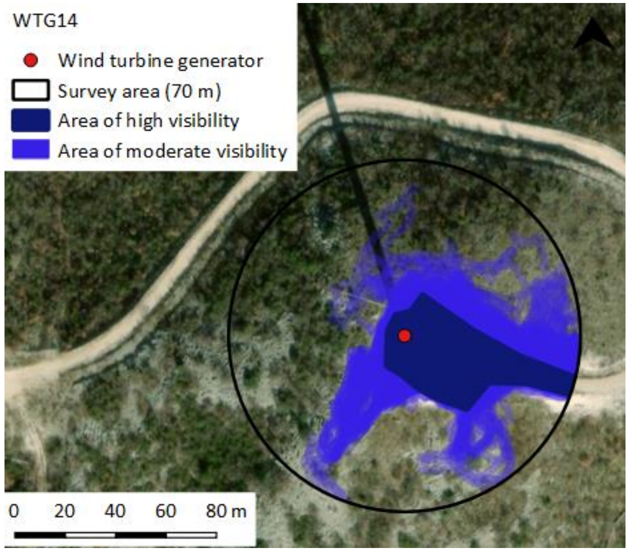

WTG9
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

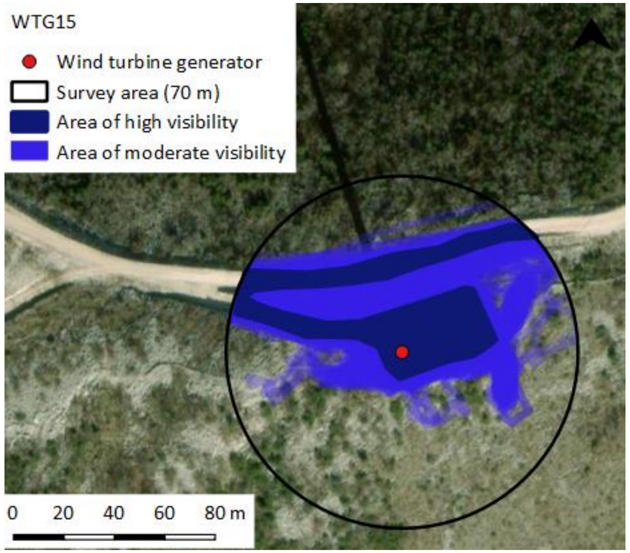

WTG10
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

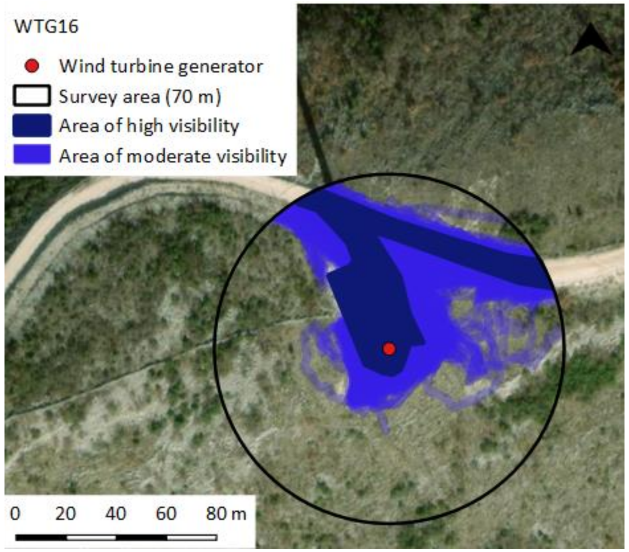

WTG11
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

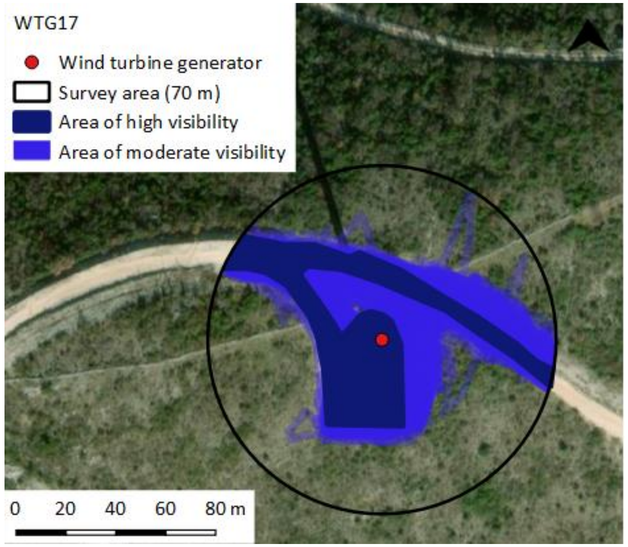

WTG12
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

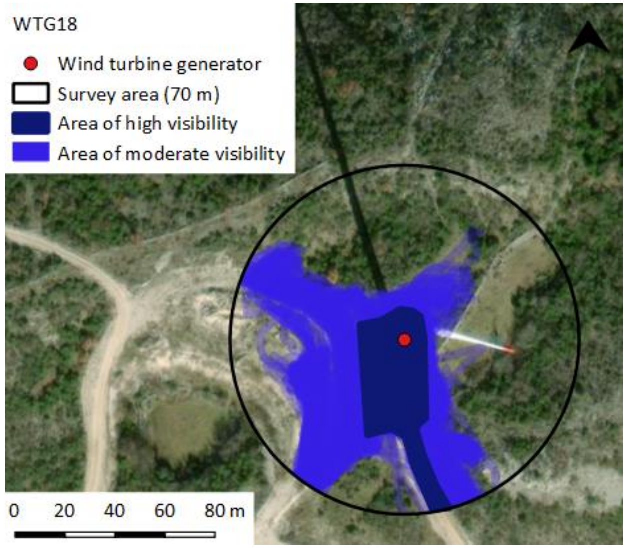

WTG13
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

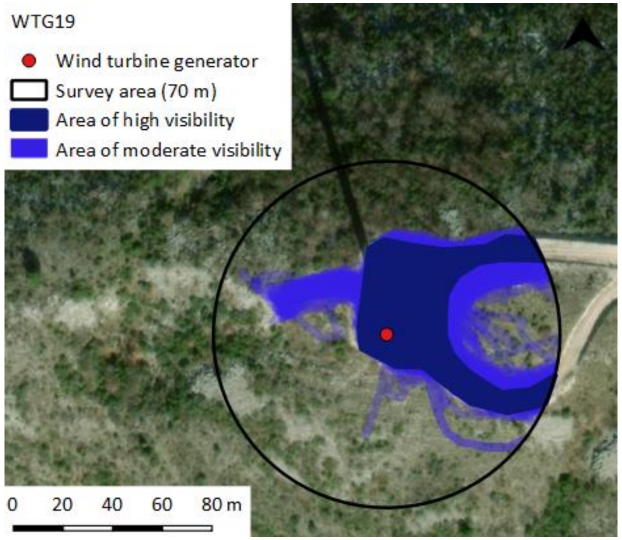

WTG14
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

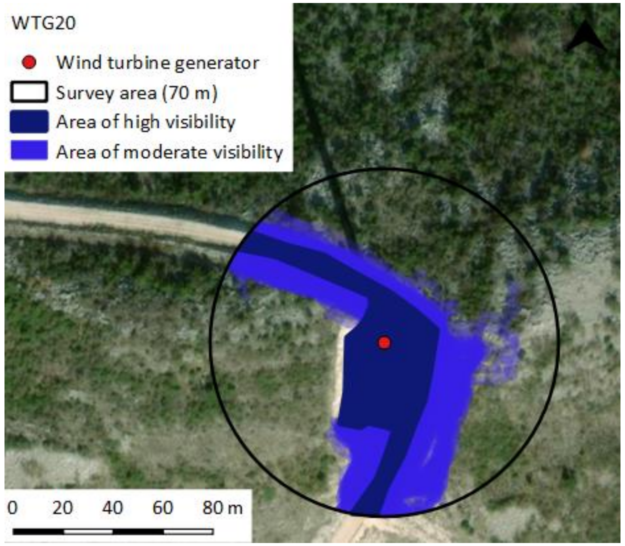

WTG15
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m


WTG16
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m


WTG17
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m


WTG18
Wind turbine generator
Survey area (70 m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

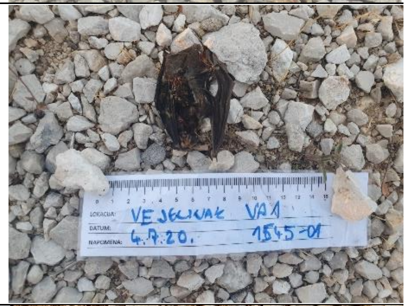


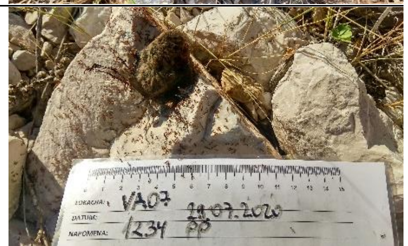

*(Basemap source: www.bing.com/maps/aerial)*

*Appendix V. Carcasses found during monitoring of bat collision*

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 24.6.2020. | WTG6 | *Hypsugo savii* | Male | Adult | 33.30 | Torn right wing membrane | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 2.7.2020. | WTG19 | *Hypsugo savii* | - | Adult | 32.29 | - | Half-dry |   |
| 3.7.2020. | WTG9 | *Pipistrellus kuhlii* | Male | Adult | 33.11 | - | Dry |   |
| 4.7.2020. | WTG1 | *Pipistrellus kuhlii* | - | Adult | 35.10 | - | Half-dry |   |
| 5.7.2020. | WTG3 | Chiroptera sp. | - | - | 33.35 | Broken left forearm | Half-dry |   |

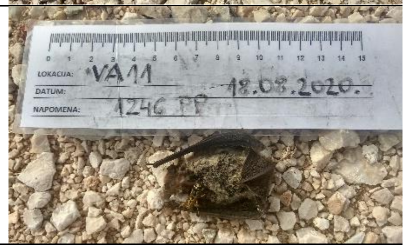
| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 11.7.2020. | WTG12 | *Pipistrellus kuhlii* | Male | Adult | 34.03 | - | Fresh |  |
| 21.7.2020. | WTG3 | *Hypsugo savii* | Female | Adult | 33.17 | - | Fresh |  |
| 23.7.2020. | WTG9 | Chiroptera sp. | - | Adult | 34.65 | - | Fresh |  |
| 23.7.2020. | WTG18 | *Hypsugo savii* | - | Adult | 34.05 | - | Fresh |  |
| 26.7.2020. | WTG2 | *Pipistrellus* sp. / *Hypsugo* sp. | Female | Adult | 35.21 | - | Fresh |  |

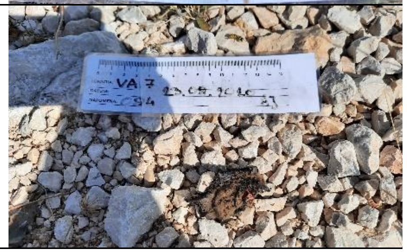
| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 27.7.2020. | WTG3 | *Pipistrellus* sp. / *Hypsugo* sp. | Female | Adult | 33.95 | broken right forearm | Fresh |  |
| 29.7.2020. | WTG3 | *Pipistrellus kuhlii* | Female | Juvenile | 36.42 | - | Fresh |  |
| 29.7.2020. | WTG6 | *Pipistrellus kuhlii* | Female | Adult | 34.95 | - | Fresh |  |
| 29.7.2020. | WTG7 | Chiroptera sp. | Female | Adult | 34.17 | broken right upper arm | Fresh |  |
| 30.7.2020. | WTG19 | *Pipistrellus kuhlii* | Female | Adult | 34.11 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 31.7.2020. | WTG7 | *Hypsugo savii* | Female | Adult | 34.59 | - | Fresh |  |
| 31.7.2020. | WTG14 | Chiroptera sp. | - | Juvenile | 33.48 | - | Fresh |  |
| 31.7.2020. | WTG12 | *Pipistrellus kuhlii* | Male | Subadult | 33.41 | - | Fresh |  |
| 2.8.2020. | WTG2 | *Hypsugo savii* | Female | Adult | 34.64 | - | Fresh |  |
| 2.8.2020. | WTG3 | *Pipistrellus kuhlii* | Female | Adult | 33.94 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 2.8.2020. | WTG7 | Chiroptera sp. | Female | Adult | 33.77 | - | Fresh |  |
| 9.8.2020. | WTG3 | Chiroptera sp. | - | Adult | 33.27 | - | Fresh |  |
| 9.8.2020. | WTG2 | *Hypsugo savii* | Female | Adult | 34.44 | - | Fresh |  |
| 10.8.2020. | WTG4 | *Pipistrellus* sp. / *Hypsugo* sp. | Male | - | 33.02 | - | Fresh |  |
| 11.8.2020. | WTG5 | *Pipistrellus kuhlii* | - | Adult | 34.93 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 12.8.2020. | WTG8 | *Pipistrellus kuhlii* | Male | Adult | 33.34 | - | Fresh |  |
| 12.8.2020. | WTG8 | *Pipistrellus pipistrellus* | Male | Subadult | 33.93 | broken shoulder | Fresh |  |
| 12.8.2020. | WTG8 | *Pipistrellus kuhlii* | Female | Adult | 34.69 | - | Fresh |  |
| 12.8.2020. | WTG14 | *Pipistrellus kuhlii* | Female | Adult | 34.27 | - | Fresh |  |
| 12.8.2020. | WTG17 | *Pipistrellus kuhlii* | Male | - | 33.00 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 12.8.2020. | WTG19 | Chiroptera sp. | - | Juvenile | 34.79 | - | Fresh |  |
| 16.8.2020. | WTG3 | *Pipistrellus kuhlii* | Female | Adult | 34.91 | - | Fresh |  |
| 17.8.2020. | WTG13 | *Pipistrellus kuhlii* | Female | Adult | 45.07 | - | Fresh |  |
| 17.8.2020. | WTG4 | *Pipistrellus kuhlii* | - | Adult | 33.57 | - | Fresh |  |
| 18.8.2020. | WTG11 | *Pipistrellus kuhlii* | Female | Adult | 34.63 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 21.8.2020. | WTG8 | *Pipistrellus kuhlii* | Male | Adult | 33.74 | - | Fresh |  |
| 22.8.2020. | WTG4 | *Hypsugo savii* | - | Subadult | 34.64 | - | Fresh |  |
| 22.8.2020. | WTG2 | *Hypsugo savii* | Female | Adult | 33.99 | - | Fresh |  |
| 22.8.2020. | WTG3 | *Pipistrellus kuhlii* | Female | Adult | 35.06 | - | Fresh |  |
| 23.8.2020. | WTG7 | *Pipistrellus kuhlii* | Female | Adult | 33.73 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 23.8.2020. | WTG14 | *Pipistrellus kuhlii* | Female | Adult | 34.55 | - | Fresh |  |
| 23.8.2020. | WTG19 | *Hypsugo savii* | Female | Adult | 34.06 | - | Fresh |  |
| 24.8.2020. | WTG2 | *Pipistrellus pipistrellus* | Female | Adult | 33.83 | Broken left elbow | Fresh |  |
| 26.8.2020. | WTG2 | *Pipistrellus pipistrellus* | Male | Adult | 31.69 | - | Fresh |  |
| 26.8.2020. | WTG3 | *Hypsugo savii* | Female | Adult | 33.66 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 27.8.2020. | WTG1 | *Pipistrellus kuhlii* | - | - | 33.89 | - | Fresh |  |
| 27.8.2020. | WTG12 | *Pipistrellus kuhlii* | Female | Adult | 33.91 | - | Fresh |  |
| 3.9.2020. | WTG5 | *Pipistrellus kuhlii* | Male | Adult | - | - | Fresh |  |
| 3.9.2020. | WTG8 | *Nyctalus noctula* | Female | Adult | 54.83 | - | Fresh |  |
| 3.9.2020. | WTG13 | *Hypsugo savii* | Male | Adult | 33.13 | - | Fresh |  |

| DATE | WTG | SPECIES | SEX | AGE | FA (mm) | INJURIES | STATE OF CARCASS | PHOTO |
|---|---|---|---|---|---|---|---|---|
| 4.9.2020. | WTG16 | *Nyctalus leisleri* | Female | Adult | 42.86 | - | Fresh |  |
| 17.9.2020. | WTG5 | *Nyctalus leisleri* | - | Adult | 41.68 | - | Half-dry |  |
| 17.9.2020. | WTG12 | *Nyctalus leisleri* | Female | Adult | 42.44 | - | Fresh |  |
| 17.9.2020. | WTG20 | *Tadarida teniotis* | Female | Subadult | 59.08 | - | Fresh |  |