FINAL REPORT

Bat monitoring for wind farm Jelinak from June to October 2022

Zagreb, April 2023

Project	**Bat monitoring for wind farm Jelinak from June to October 2022**
Documentation	**Final Monitoring Report**
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CONTENTS

1. INTRODUCTION

Bat monitoring was implemented in the area of Wind Farm (WF) Jelinak from June to October 2022. The WF is located in the hinterland of Trogir in Split-Dalmatia County (Figure 1-1). It is in operation since 2013.

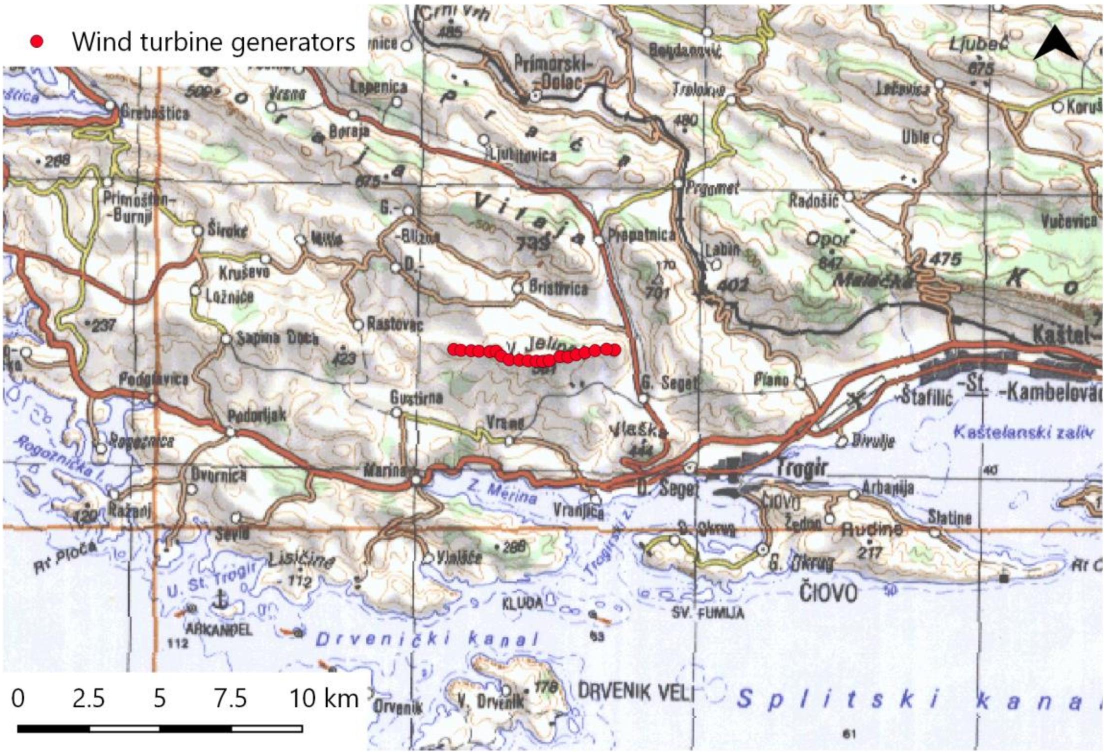


Figure 1-1 Wind farm location

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.

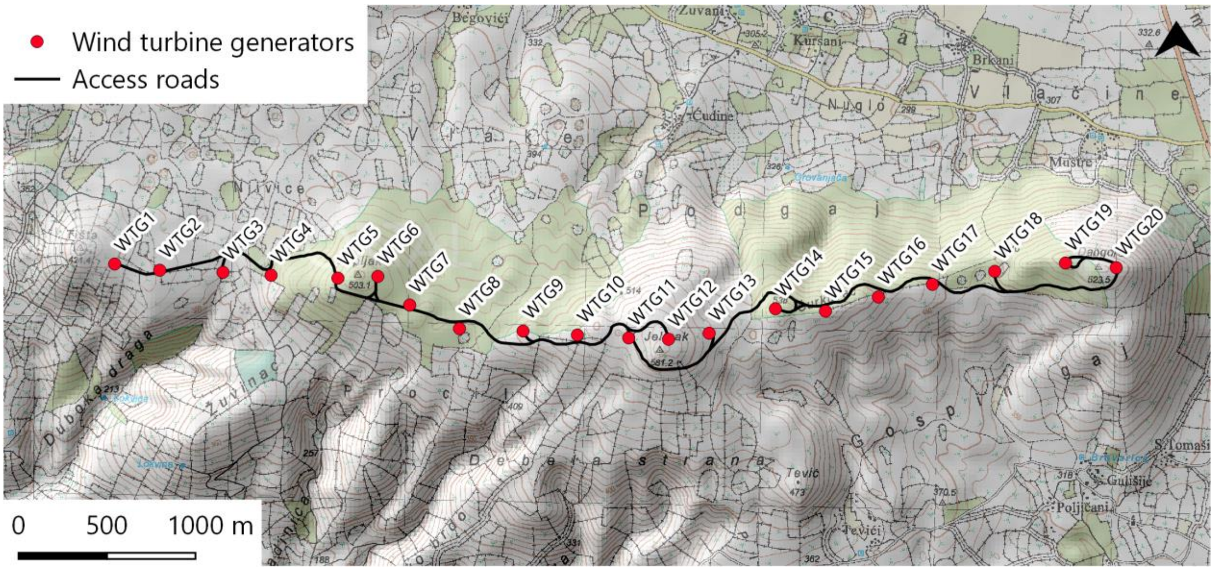


Figure 1-2 Layout of WTG's

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 thermophilus deciduous downy oak (*Quercus pubescens*) coppice and arable land (orchards).

Figure 1-3 Typical habitat in the WF area

During the monitoring, blade feathering (implemented by default at all WTG's) and increased cut-in speed were implemented during pre-determined periods at some of the WTG's (Table 1-1).

Table 1-1 Mitigation measures implemented during monitoring in 2022

PERIOD	WIND TURBINE GENERATORS	BLADE FEATHERING	CUT-IN SPEED	TIMING
1.-15.7.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, 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.	WTG9, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise
	WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG10, WTG12, WTG14	yes	6.0 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until 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 until half an hour after sunrise
1.9.-30.9.	WTG5, WTG8, WTG12, WTG13, WTG16, WTG20	yes	5.0 m/s	from half an hour before sunset until 3 am

Monitoring was designed in accordance with monitoring reports from previous years of post-construction monitoring at WF Jelinak and the project task (Technical Specification). The monitoring included:

- Monitoring of bat collisions
- Searcher efficiency and carcass persistence trials
- Monitoring of bat activity using ultrasound detectors
- Visual monitoring of selected WTG's using thermal imaging sensors
- Data processing and analysis
- Monthly and final reports.

2. METHODOLOGY OF MONITORING

Methodology and dynamics of the monitoring were in accordance with monitoring reports from previous years of post-construction monitoring at WF Jelinak. Implemented methodology followed 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 2022 at all 20 WTG's. In June and September, searches for bat carcasses were conducted every seven or eight days, always two days in a row (June 16th-24th and September 6th-29th). In July and August, the searches were conducted every day (July 1st-August 31st). In October, carcasses were searched two days in a row in the first week of the month (October 5th-6th) (Table 2-1).

Searcher efficiency and carcass persistence trials were conducted in June 2022, at the beginning of monitoring activities. Trials were set up a day before the first two-day carcasses search (June 15th). Searcher efficiency trial was conducted during the two-day search (June 16th-17th), while carcass persistence trial was conducted for ten consecutive days including the day the test was set up (June 15th-24th). Searcher efficiency trial was repeated with another survey team in July 2022 (July 1st-2nd).

Continuous bat call recording was implemented at two stationary points at 15 m hight: WTG3 and WTG18. Bat calls were recorded every night from June 15th until the end of October 2022 (October 31st). At WTG3 an additional microphone was recording bat sounds at nacelle hight from June 22nd until October 31st.

Visual monitoring of bat activity around selected WTG's was carried on July 11th, July 28th, August 12th and August 26th.

Table 2-1 Monitoring dynamics

MONTH	MONITORING OF BAT COLLISIONS		CONTINUOUS RECORDING OF BAT CALLS		VISUAL MONITORING OF BAT ACTIVITY	
	DATES	NUMBER OF SURVEY DAYS PER MONTH	DATES	NUMBER OF SURVEY NIGHTS PER MONTH	DATES	NUMBER OF SURVEY NIGHTS PER MONTH
June	16.-17.6., 23.-24.6.	4	15.-30.6.	15* at WTG3 (15 m), 8* at WTG3 (nacelle), 16 at WTG18	-	-
July	1.-31.7.	31	1.-31.7.	31 at WTG3 (15 m), 31 at WTG3 (nacelle), 31 at WTG18	11.7., 28.7.	2
August	1.-31.8.	31	1.-31.8.	31 at WTG3 (15 m), 31 at WTG3 (nacelle), 31 at WTG18	12.8., 26.8.	2
September	6.-7.9., 13.-14.9., 21.-22.9., 28.-29.9.	8	1.-.30.9.	30 at WTG3 (15 m), 30 at WTG3 (nacelle), 30 at WTG18	-	-
October	5.-6.10.	2	1.-31.10.	31 at WTG3 (15 m), 31 at WTG3 (nacelle), 31 at WTG18	-	-

**during one night (June 23rd/24th) recording was interrupted due to power failure*

2.1. Continuous monitoring of bat activity at stationary points

Continuous recording of bat calls was implemented to determine bat activity level through a longer period. Monitoring equipment was placed on WTG's previously defined in the project task, one at each end of the wind farm: WTG3 and WTG18 (Figure 2-1). At WTG18 bat calls were recorded during previous monitoring years, while the location of the second detector was moved from WTG1 to WTG3 because the latter had consistently highest mortality rates of all WTG's.

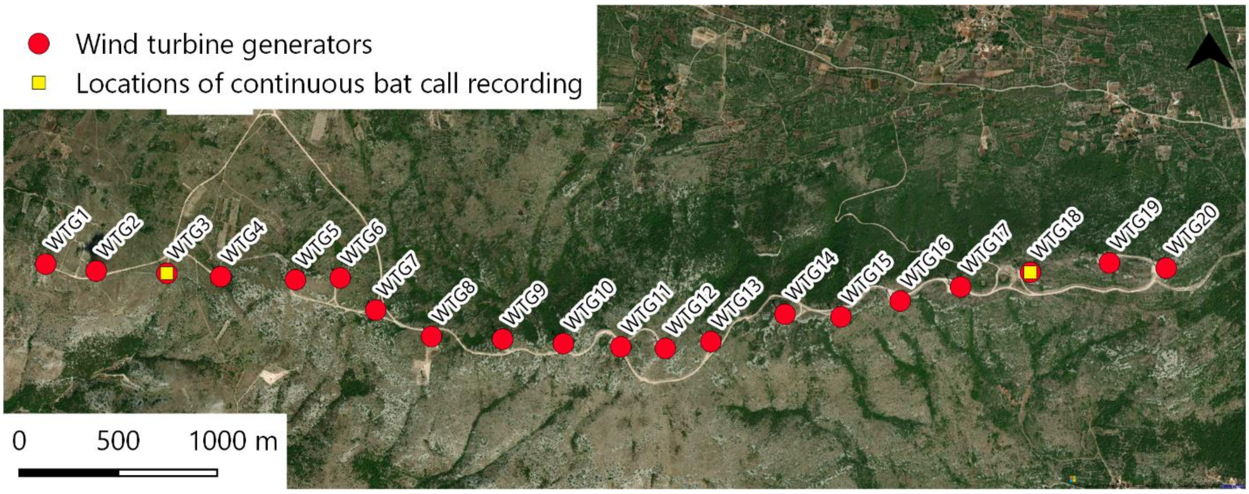


Figure 2-1 Locations of continuous recording of bat calls (Base map: Bing Maps)

Bat calls were recorded using ultrasound detectors *Elekon BATLOGGER WE X2*, specialized for monitoring at windfarms. At both WTG's microphones were set at a height of 15 m. They were placed on the outer plating of the WTG towers, held in place by adhesive tape (Figure 2-2). Microphone cables were secured with construction glue and adhesive tape to prevent strong wind from ripping them off the tower. The recorders were placed inside the towers.

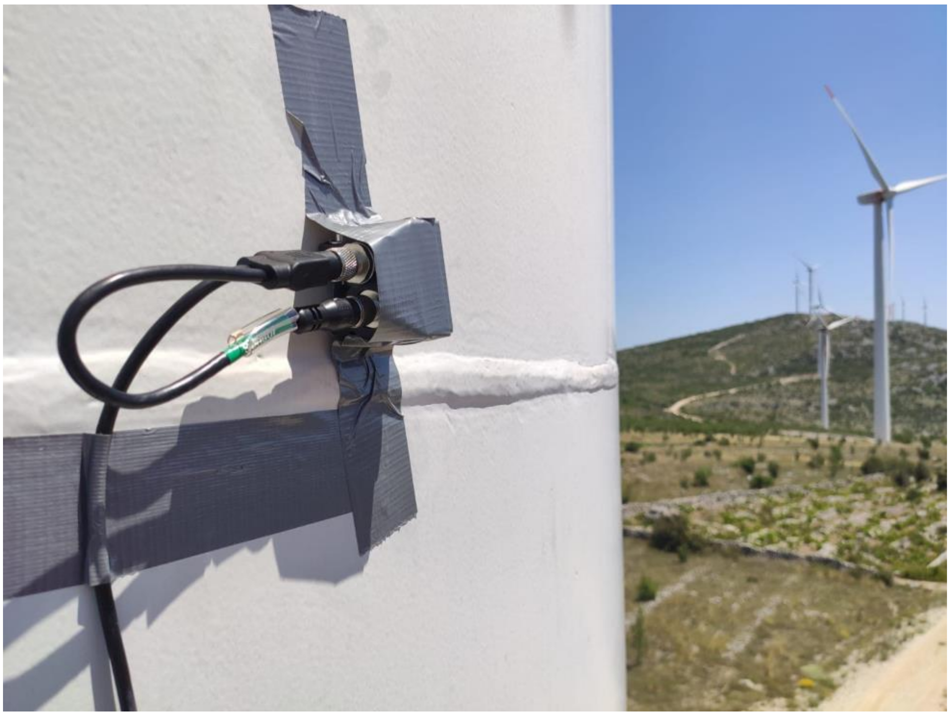


Figure 2-2 Microphone of ultrasound detector *Elekon BATLOGGER WE X2* set at a hight of 15 m

An additional microphone was installed at WTG3 at nacelle hight to gather more information on bat activity in the blade-swept zone. The microphone was attached to a metal tube and fixed under nacelle through a hole in the nacelle itself (Figure 2-3). Microphone cables connected the microphone with the recorder on the inside of the tower.

Figure 2-3 Microphone of ultrasound detector *Elekon BATLOGGER WE X2* set at nacelle hight (Photos: Vjetroelektrana Jelinak Ltd.)

Recording started 15 min before sunset and lasted until 15 min after sunrise. All recordings were analysed using *BatExplorer 2*, a specialized ultrasound analysis software with the use of relevant scientific literature (Russo and Jones 2002; Barataud 2020).

2.2. Visual monitoring of bat activity around selected WTG's

Visual monitoring of bat activity around selected WTG's was carried out using thermal imaging cameras. Observation with thermal imaging sensors is an advanced method of visual tracking which makes it possible to collect precise data and monitor bat passes even in poor visibility and during the night. It was used to obtain data on how bats use the space around the WTG's i.e., to observe height and direction of their flight in relation to turbine blades. This data cannot be obtained by acoustic monitoring, therefore this method serves as a supplementary method to recording of bat calls.

In total five WTG's were selected for visual monitoring: WTG1, WTG2, WTG3, WTG10 and WTG16 (Figure 2-4). When selecting WTG's, care was taken to ensure that these were WTG's with an above-average mortality rate in the last year and that they were distributed in different parts of the WF.

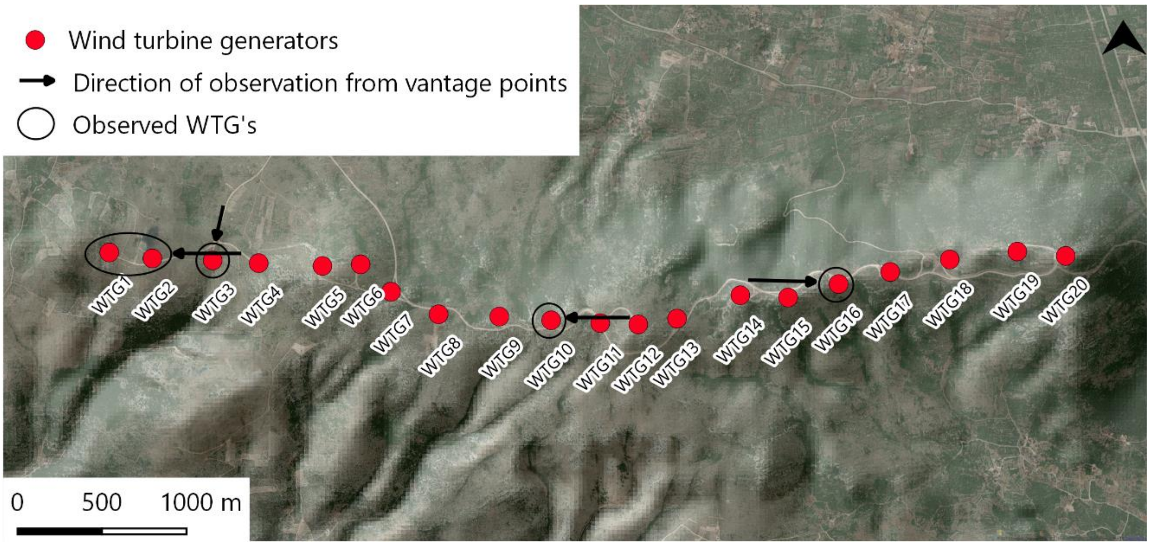
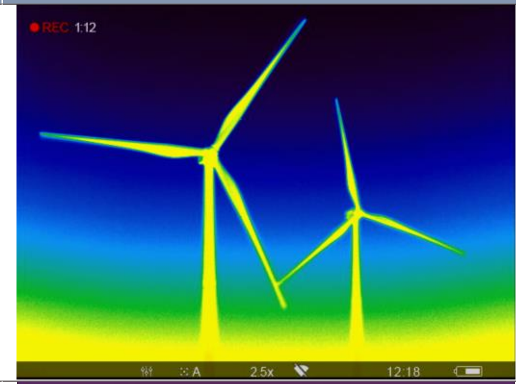
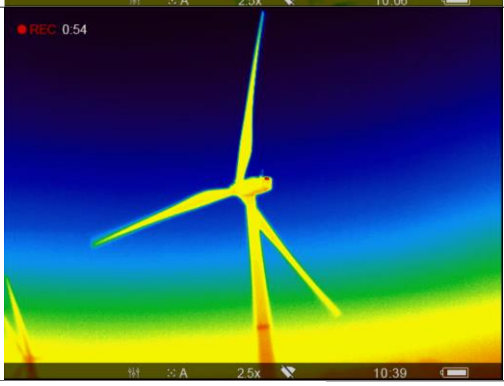


Figure 2-4 Directions and objectives of visual observation (Base map: Bing Maps)

Thermal imaging cameras *Pulsar Accolade LRF XP50* on tripods were used for on-site observation, as well as recording of videos (Figure 2-5). The cameras were set so that the entire blade-swept areas of the selected WTG's were in frame. WTG1 and WTG2 were together in one frame (observed from the same vantage point), while WTG3, WTG10 and WTG16 were each set up in their own frame (Table 2-2). Recording started around half an hour after sunset when a peak in bat activity was expected. Recording of WTG3 lasted for around 3 hours. This WTG was observed the longest since it was the WTG with the highest mortality rate in the previous year. Recording of the other WTG's lasted for 45 minutes each.

Figure 2-5 Thermal imaging camera *Pulsar Accolade LRF XP50* on a tripod

Table 2-2 Frames and times of visual monitoring

WTG's	FRAME	DATE	TIME
WTG1 and WTG2		11.7.2022.	23:27-00:12
		28.7.2022.	20:51-21:35
		12.8.2022.	22:55-23:40
		26.8.2022.	21:15-22:00
WTG3		11.7.2022.	21:05-22:14, 22:49-23:45*
		28.7.2022.	20:49-23:53
		12.8.2022.	20:40-23:40
		26.8.2022.	19:42-22:41
WTG10		11.7.2022.	21:22-22:16
		28.7.2022.	21:45-22:30
		12.8.2022.	21:45-22:30
		26.8.2022.	20:11-20:56
WTG16		11.7.2022.	22:23-23:08
		28.7.2022.	21:57-22:42
		12.8.2022.	20:45-21:30
		26.8.2022.	22:19-23:04

**interruption in recording due to technical issues*

Recorded videos were later reviewed on a computer. Number of bat passes, their direction and position relative to WTG's were noted.

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 regard 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 conducted every seven to eight days, always on two consecutive days. In July and August, the searches were conducted 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 2-6; Appendix II). 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 2-7); 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.

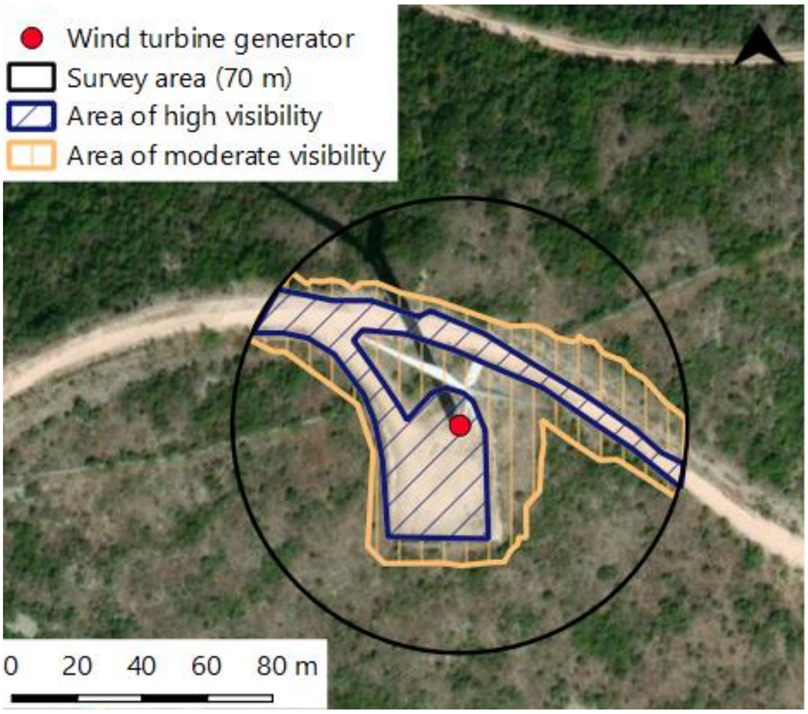


Figure 2-6 Example of survey area for monitoring of bat collisions (Base map source: Bing Maps)

Figure 2-7 Example of high (left) and low (right) visibility area

Search started within an hour after sunrise whenever possible, to minimise exposure of carcasses to scavengers. Searchers covered the areas of high visibility by walking across WTG bases and access roads 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 15-45 min in total, depending on the searchable area. Each following day, the searchers switched their 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 (*Garmin GPSMap 64x, Garmin GPSMap 64st, Garmin Oregon 650, Garmin Oregon 750*). Data regarding start and end times, surveyors present in the field, microclimatic conditions and recovered carcasses was entered into a field form (Appendix I). Microclimatic conditions (air temperature, wind speed and relative humidity) were measured using *Kestrel 4000 Pocket Weather Tracker* and *Kestrel 3000 Environmental Meter* at a height of 1-2 m above ground.

The discovered carcasses were photographed (Figure 2-8), 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 2-8 Example of bat carcass photo documentation

2.3.1. Searcher efficiency trials

It is not likely that all bat carcasses will be found by searchers around WTG's, especially in poorer visibility conditions. 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 WF Jelinak.

The trial was set a day before a regular two-day search for carcasses (June 15th) and was conducted during the two-day search (June 16th-17th). Two teams conducted the trial – one team which set the trial, and another team of two surveyors who searched for carcasses. Thirty freshly defrosted bat carcasses were placed randomly at WF Jelinak. At each WTG either 0, 1, 2 or 3 bat carcasses were placed. The number of carcasses at each WTG was determined using a random number generator (set range 0 – 3). Each carcass position was recorded using a handheld GPS device (*Garmin GPSMap 62s*) and marked with masking tape with a unique code to easily determine if any of the carcasses were removed.

On June 16th, a team of two surveyors was 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 17th, 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 an area different than the day before. This increased the chance of finding carcasses missed by another searcher.

The trial was repeated with another team on July 1st and 2nd, this time with artificial bat carcass substitutes (Figure 2-9). The artificial substitutes ensured lower removal rate i.e., bigger trial sample. The team of two people who searched for carcasses was different then in the first trial. Thirty carcass substitutes were placed on June 30th, after which surveyors performed regular carcass searches.

Results of the trials are shown in chapter 3.4.

Figure 2-9 Example of an artificial bat carcass substitute

2.3.2. 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 insects, birds, or mammals. 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 had a chance of finding them. These results were used to refine the estimation of bat mortality at the wind farm.

The trial was conducted from June 15th until June 24th. A total of 30 freshly defrosted mice carcasses were used as bat analogues. They were placed at WF Jelinak on June 15th. At each WTG either 0, 1, 2 or 3 carcasses were placed. The number of carcasses at each WTG was selected using a random number generator (set range 0-3). They were randomly placed inside the 70 m radius around the WTG's. Their locations were recorded with a handheld GPS device (*Garmin GPSMap 62s*). 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 or attached to nearby plants (Figure 2-10). Thus, if the carcass were 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 the afternoon and were then checked each morning for nine consecutive days. If a carcass was missing, its corresponding marker was recovered and removed from the site.

Results of the trial are shown in chapter 3.5.

Figure 2-10 Example of a mouse carcass with markers used for carcass persistence trial

3. RESULTS

3.1. Continuous monitoring of bat activity at stationary points

Bat calls were recorded from June to October with three microphones at two stationary points (two microphones at WTG3 and one at WTG18). In total there were 408 nights recorded at both WTG3 and WTG18 (Table 2-1).

Highest number of bat passes was recorded at nacelle hight at WTG3, a total of 58,985 (Figure 3-1). The term "pass" here refers to a single, distinct recording captured by the bat detector that may contain multiple calls of the same bat. There were 2,468 passes recorded in June, 28,160 in July, 25,096 in August, 1,995 in September and 1,266 in October (Figure 3-2).

At a 15 m hight at WTG3, a total of 36,739 passes were recorded. There were 1,375 passes in June, 10,762 in July, 17,848 in August, 5,077 in September and 1,677 in October.

At a 15 m hight at WTG18, a total of 43,425 passes were recorded, which is more than at WTG3. There were 2,591 passes recorded in June, 13,652 in July, 24,001 in August and 3,181 in September. There was no activity recorded in October. These results are similar to those in 2021 (52,760 passes), with slightly higher number of recordings in July, and slightly lower in the other months (Figure 3-3).

Total bat activity at a 15 m hight increased from June to August, after which it decreased in September and October, same as has been observed in 2021. This activity trend reflects bat annual cycle – females give birth in late spring, and by the end of July or August juveniles can actively fly, increasing bat activity in summer months. As temperatures drop through September, so does the activity of bats. At nacelle hight, activity was at its peak in July. It was higher than at 15 m from June to August, then lower in September and October.

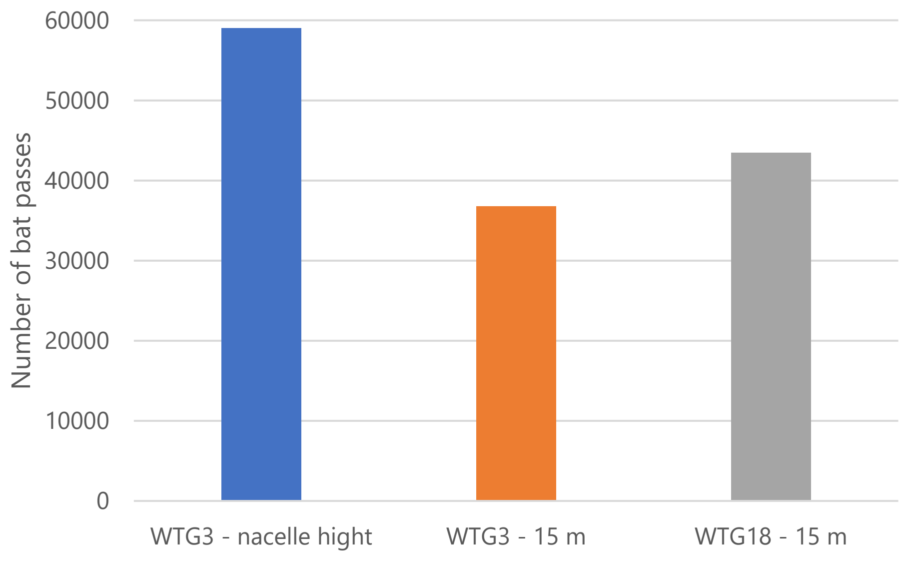


Figure 3-1 Total number of bat passes recorded at stationary points

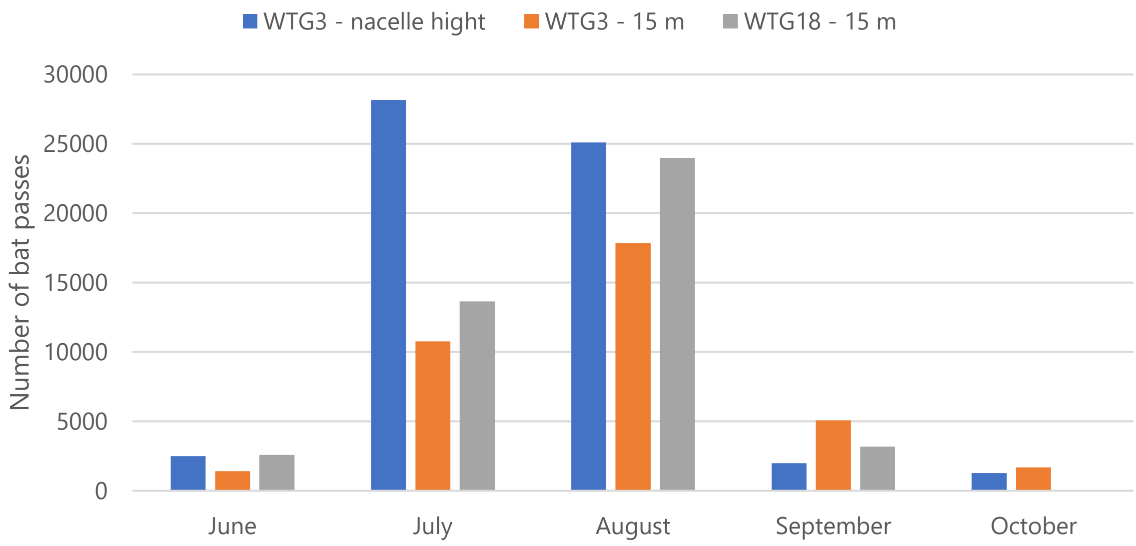


Figure 3-2 Total number of bat passes per month recorded at stationary points

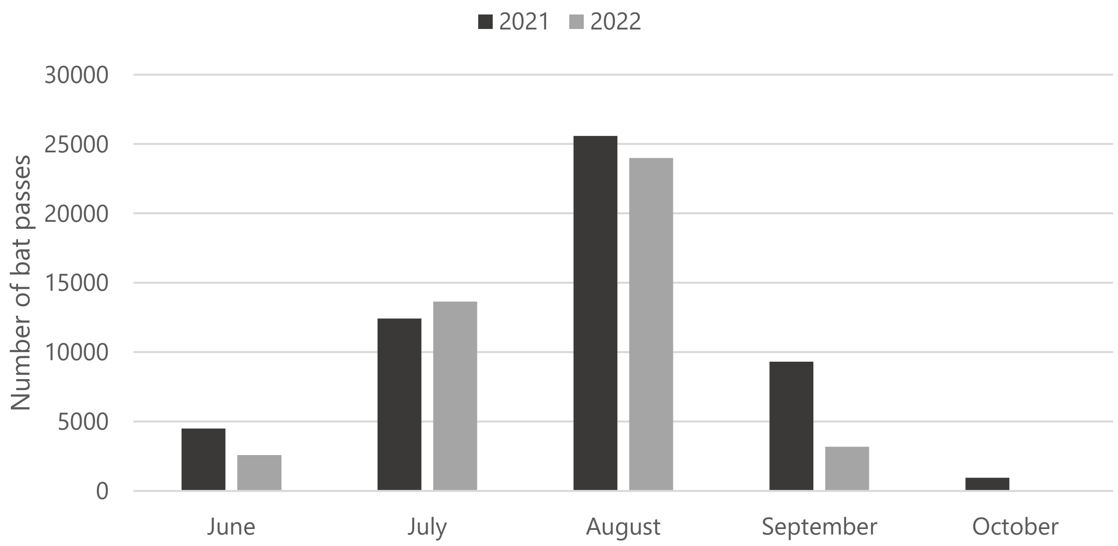


Figure 3-3 Comparison of total recorded bat activity at WTG18 in 2021 and 2022

Significantly higher bat activity at nacelle height than at 15 m, especially in July provides a new insight into bat activity during the periods of highest recorded mortality, recorded in previous years. It is apparent that local populations prefer foraging closer to turbine blades during the summer months, possibly as a reaction to changing activity patterns of their prey. This puts them at a higher risk of collision with turbine blades. Increased cut-in speed in this period should prevent most collisions but some bats still get killed, possibly due to sheer number of foraging/migrating bats in the area.

3.1.1. Bat activity through the night

Bat activity was analysed for evaluation of changes in activity distribution through the night. The data is presented in 1-hour intervals for two recording nights in each month for each recording location. Selected recording nights represent the dates in first and second half of each month with highest bat activity.

At VA18, in June there were two distinct peaks of bat activity during the night, first one in the first two hours after sunset and second one approximately two hours before sunrise (Figure 3-4 and Figure 3-5).

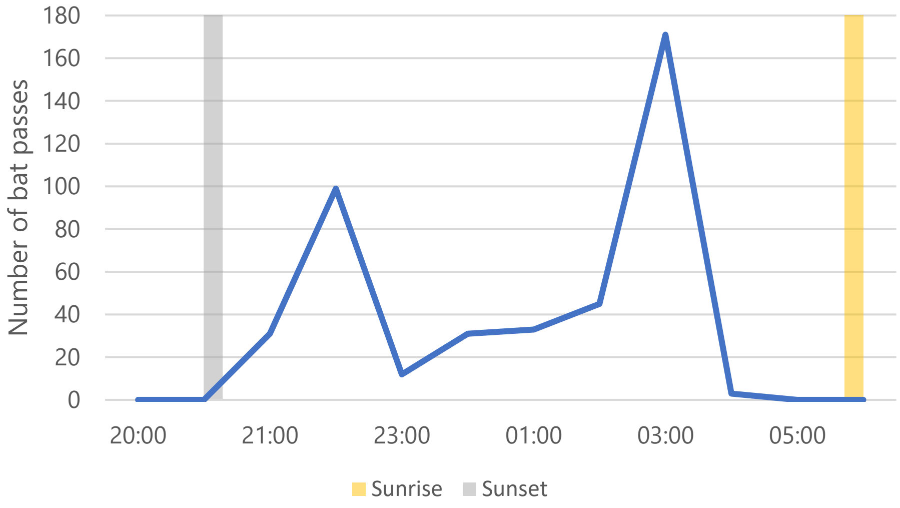


Figure 3-4 Number of bat passes through the night for June 19th at WTG18

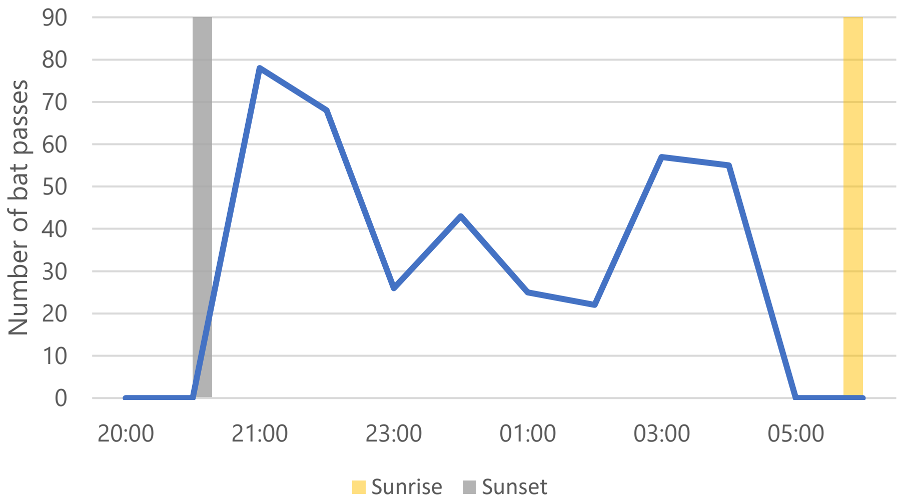


Figure 3-5 Number of bat passes through the night for June 30th at WTG18

In July the second peak is much less pronounced or even absent and by the end of the month most of the bat activity was recorded much later after sunset (Figure 3-6 and Figure 3-7).

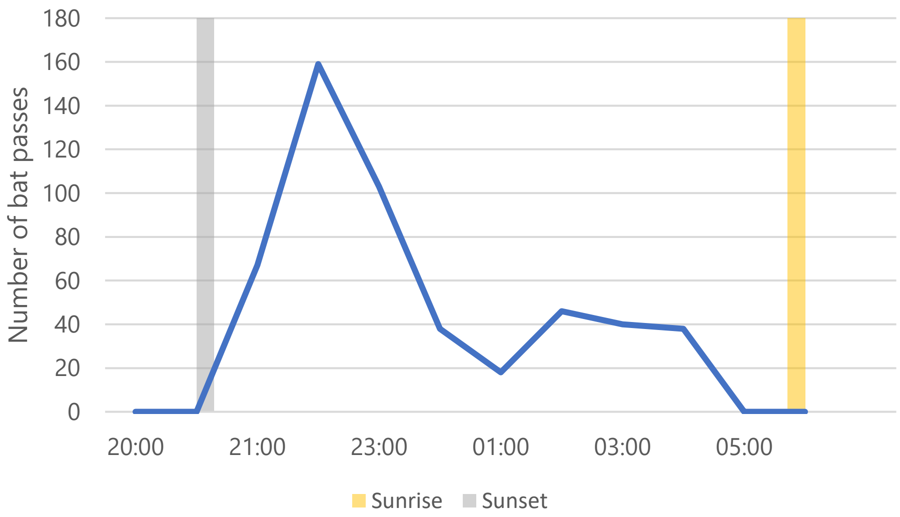


Figure 3-6 Number of bat passes through the night for July 16th at WTG18

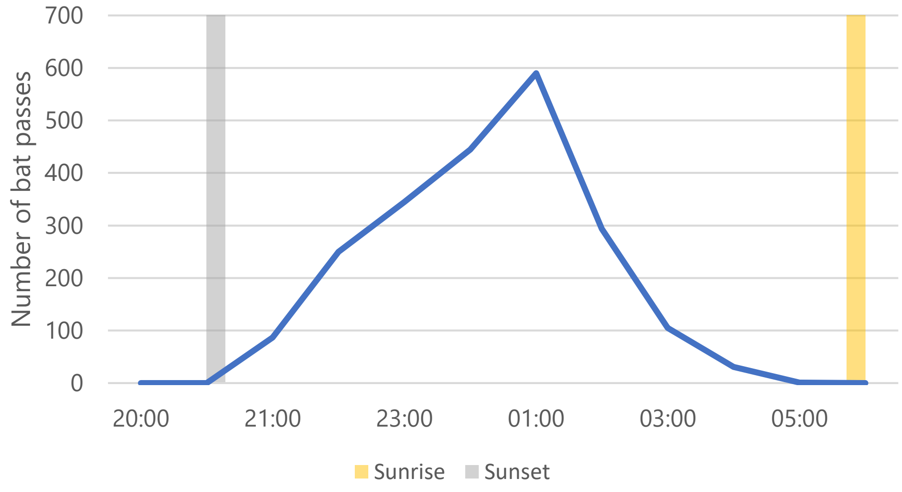


Figure 3-7 Number of bat passes through the night for July 29th at WTG18

In August, both activity peaks are once again apparent with either one being more pronounced than the other in a changing pattern from one night to the next (Figure 3-8 and Figure 3-9).

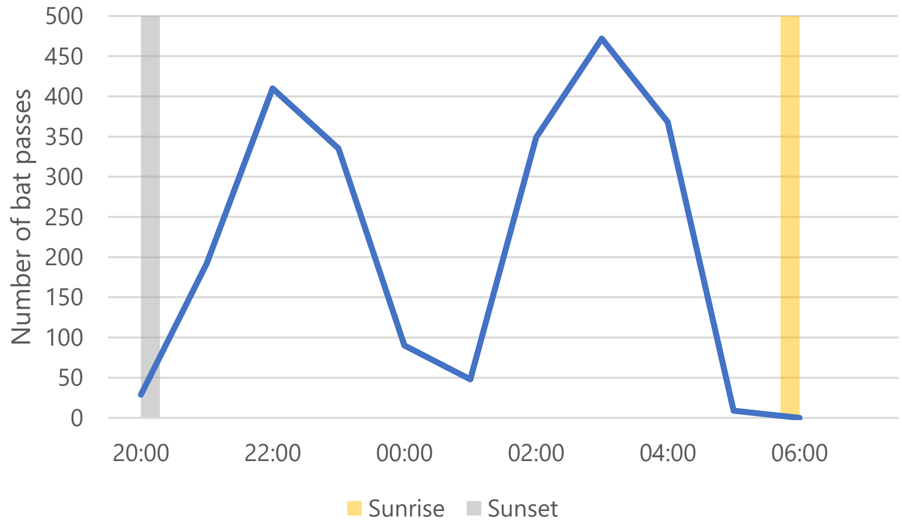


Figure 3-8 Number of bat passes through the night for August 12th at WTG18

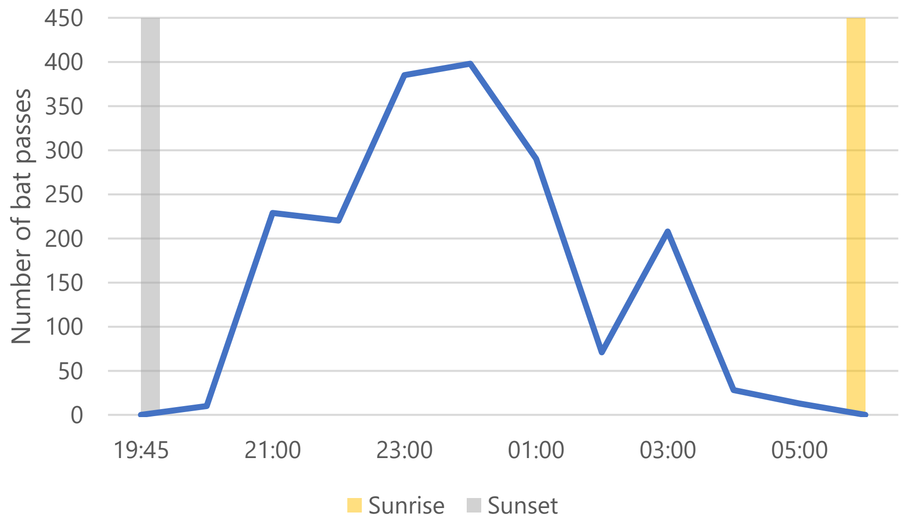


Figure 3-9 Number of bat passes through the night for August 25th at WTG18

In September, most nights had a pattern of one more pronounced activity peak (Figure 3-11), sometimes with a slight interruption (Figure 3-10).

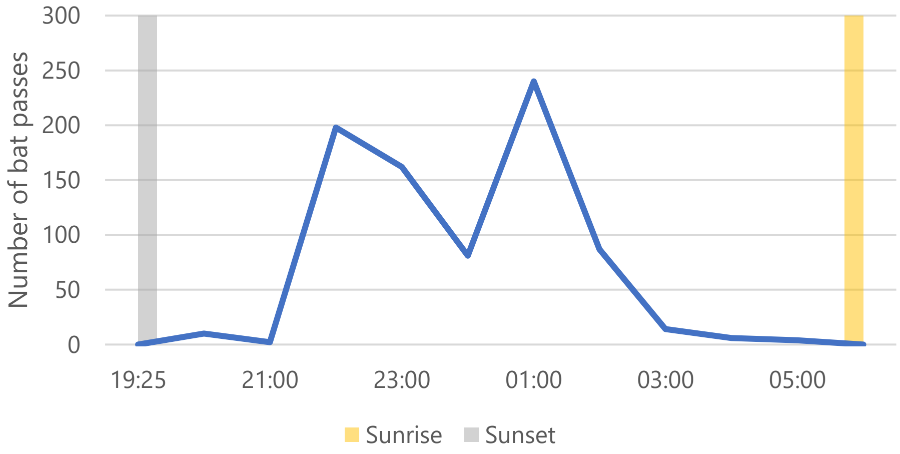


Figure 3-10 Number of bat passes through the night for September 6th at WTG18

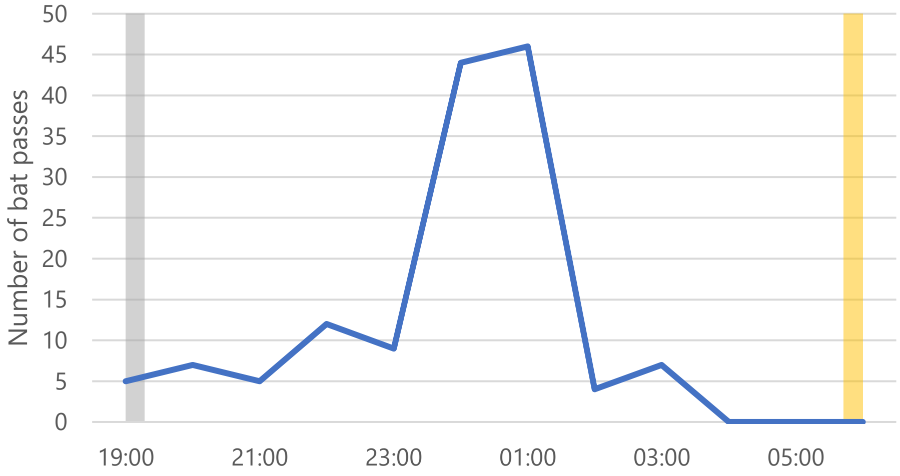


Figure 3-11 Number of bat passes through the night for September 18th at WTG18

Activity data for WTG3 doesn't show two distinct peaks at the beginning and end of the night in June as observed at WTG18, rather having a single peak either early or late in the night (Figure 3-12 and Figure 3-13).

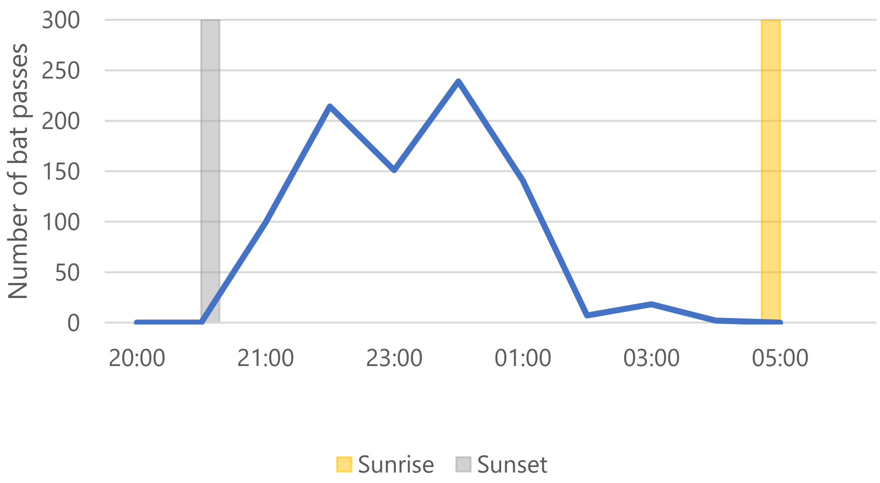


Figure 3-12 Number of bat passes through the night for June 24th at WTG3

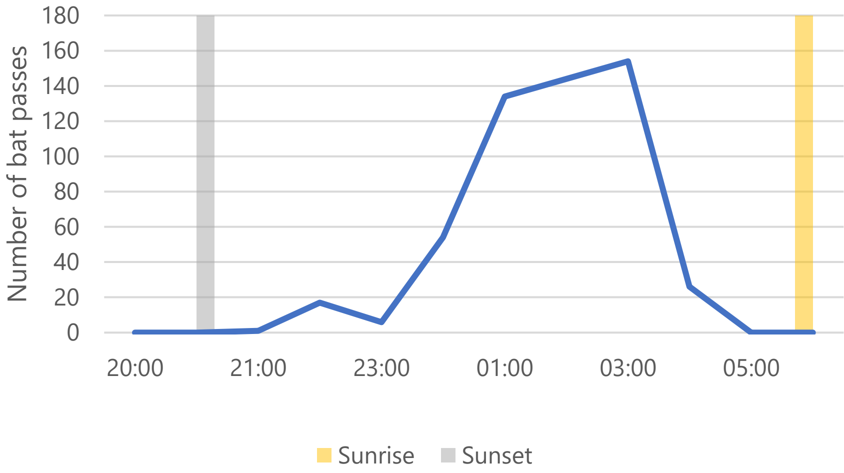


Figure 3-13 Number of bat passes through the night for June 26th at WTG3

In July at WTG3, there was an overall high level of activity, most of it occurring roughly in the middle of the night (Figure 3-14 and Figure 3-15).

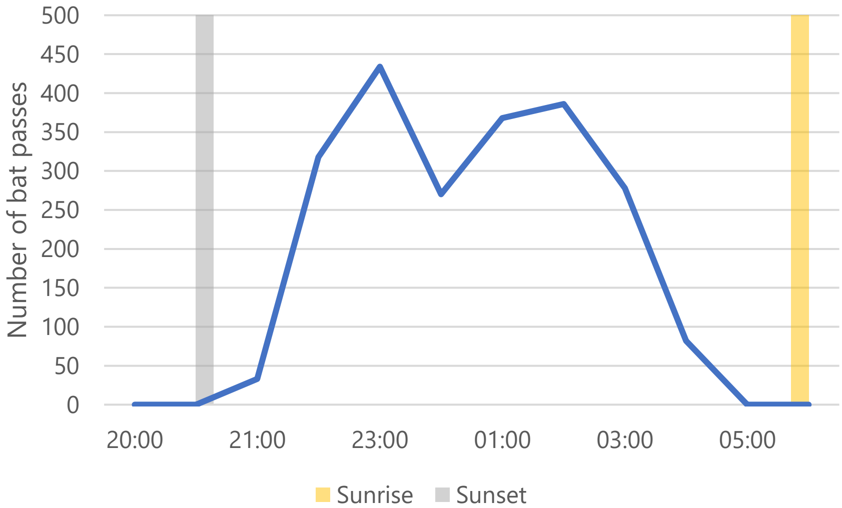


Figure 3-14 Number of bat passes through the night for July 2nd at WTG3

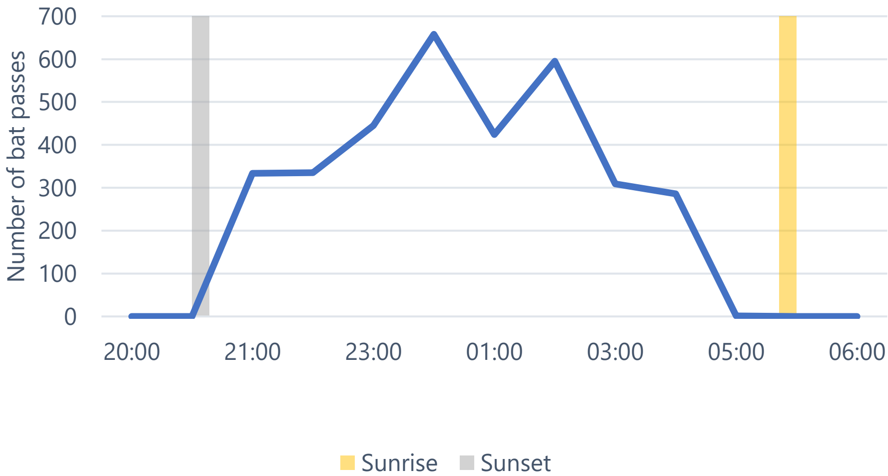


Figure 3-15 Number of bat passes through the night for July 24th at WTG3

Similar activity pattern was observed in early August at WTG3 as was in July. Activity rapidly rises after sunset and remains high through most of the night (Figure 3-16). Later in the month the activity is more spread out in two distinct peaks (Figure 3-17).

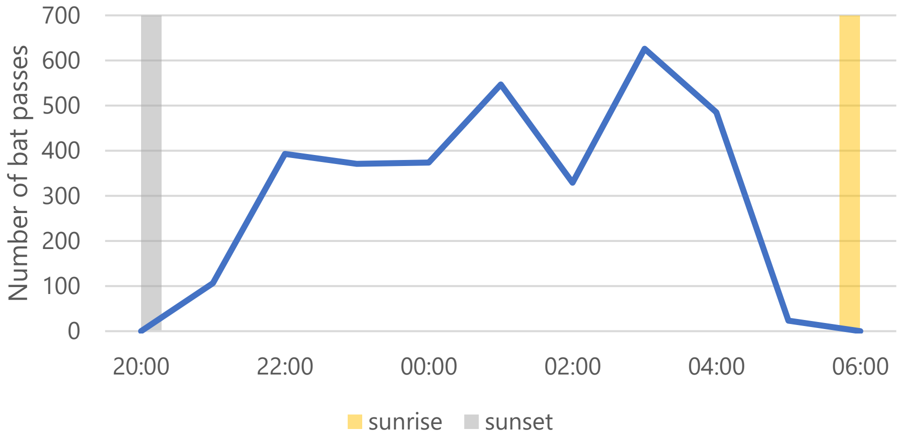


Figure 3-16 Number of bat passes through the night for August 2nd at WTG3

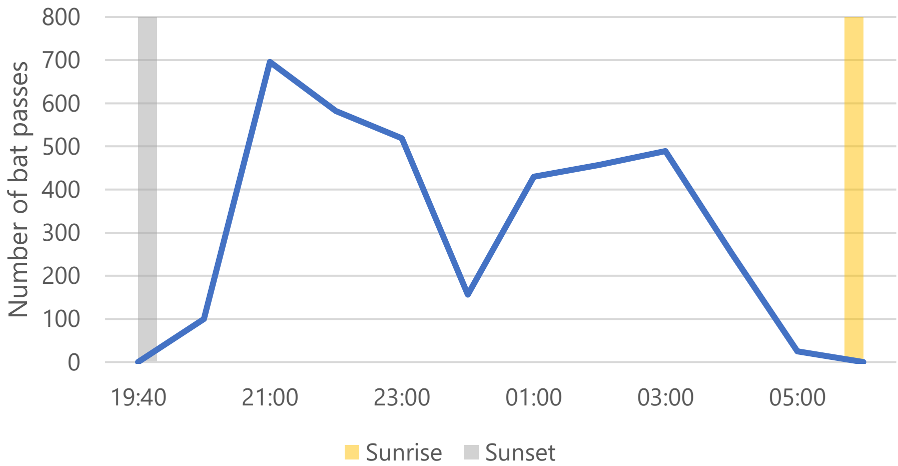


Figure 3-17 Number of bat passes through the night for August 17th at WTG3

In September at WTG3, most of activity was recorded in the first part of the night, with a sharp drop in activity after the first two hours after sunset (Figure 3-18 and Figure 3-19).

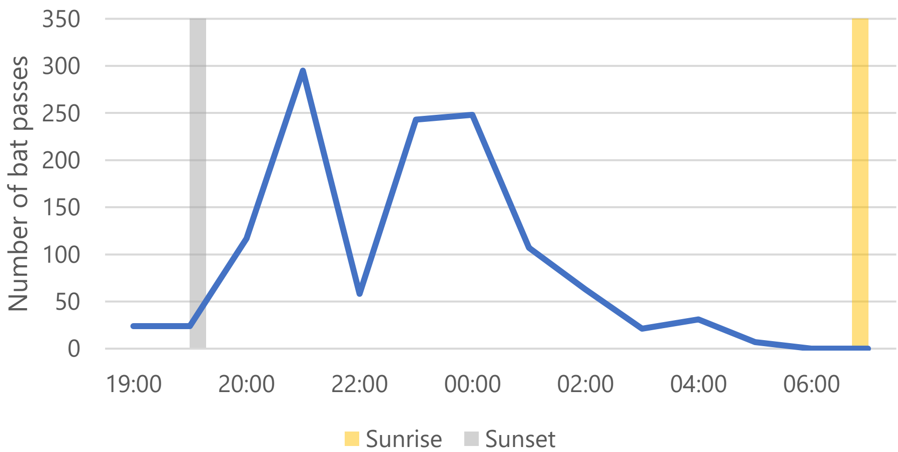


Figure 3-18 Number of bat passes through the night for September 3rd at WTG3

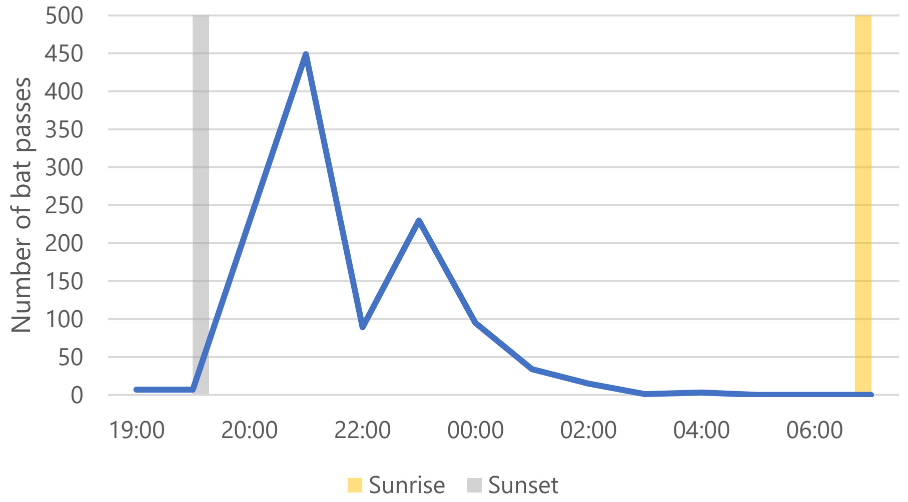


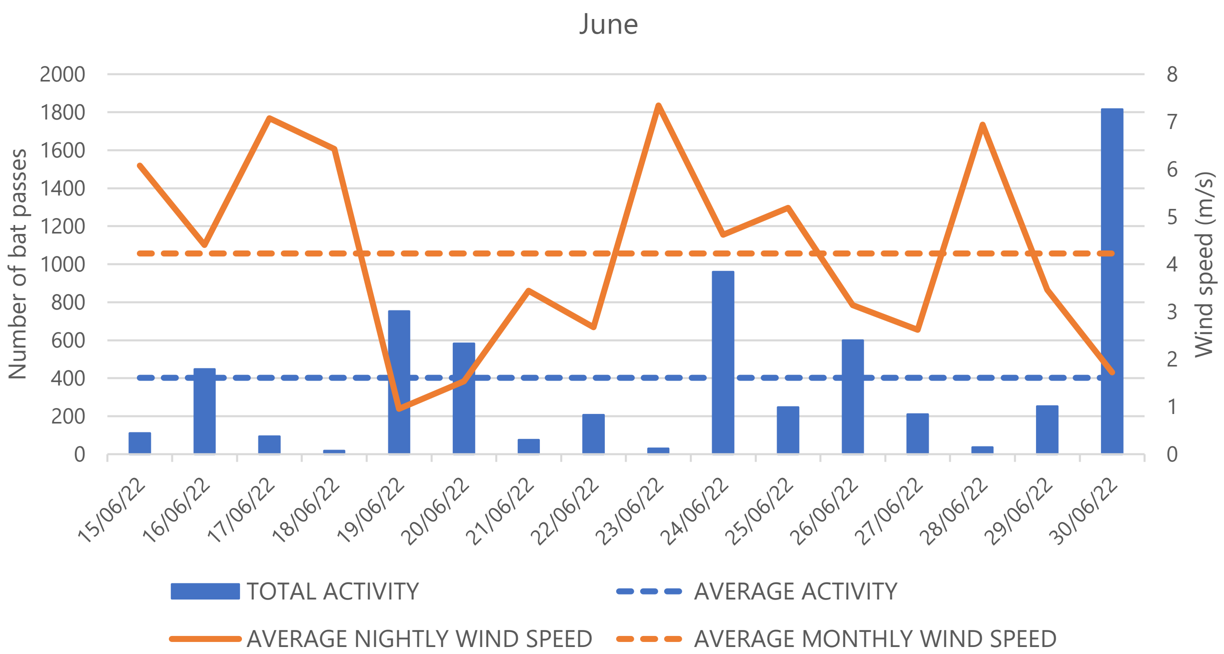
Figure 3-19 Number of bat passes through the night for September 7th at WTG3

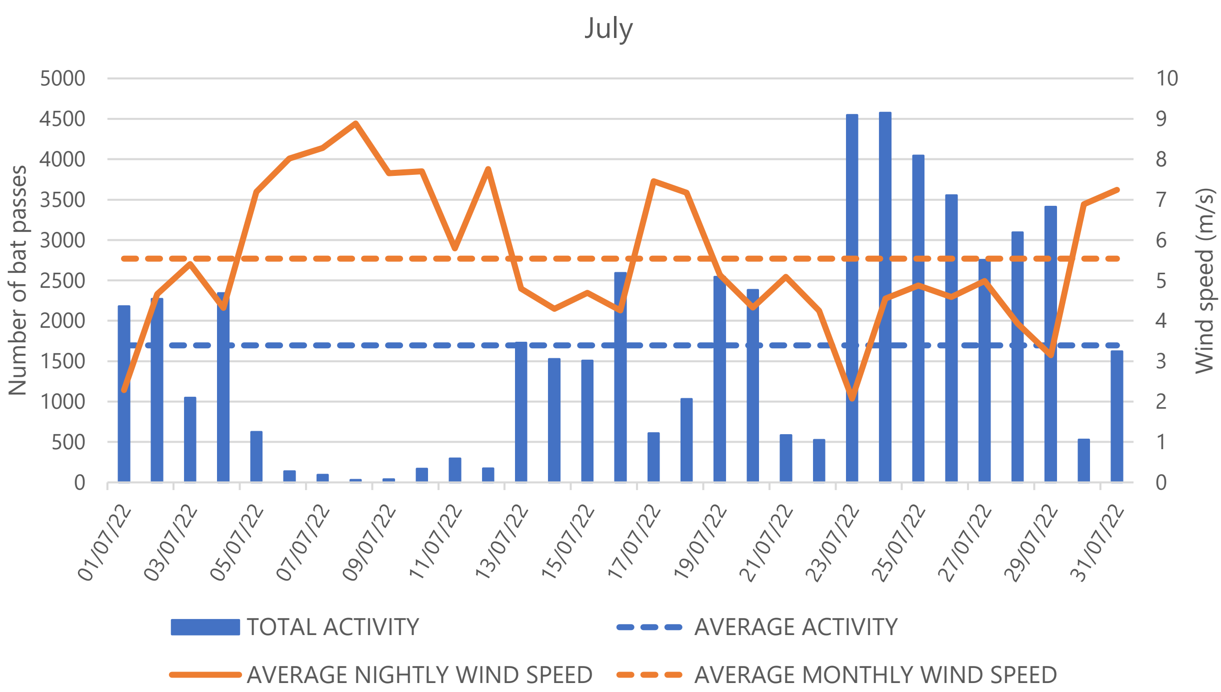
Main result of this analysis is that in July and August, when most of the fatalities happen, bat activity levels remain high throughout the night. Mitigation measures in case of severe bat mortality need to consider that there can be no safe time to stop increased cut-in speed before sunrise.

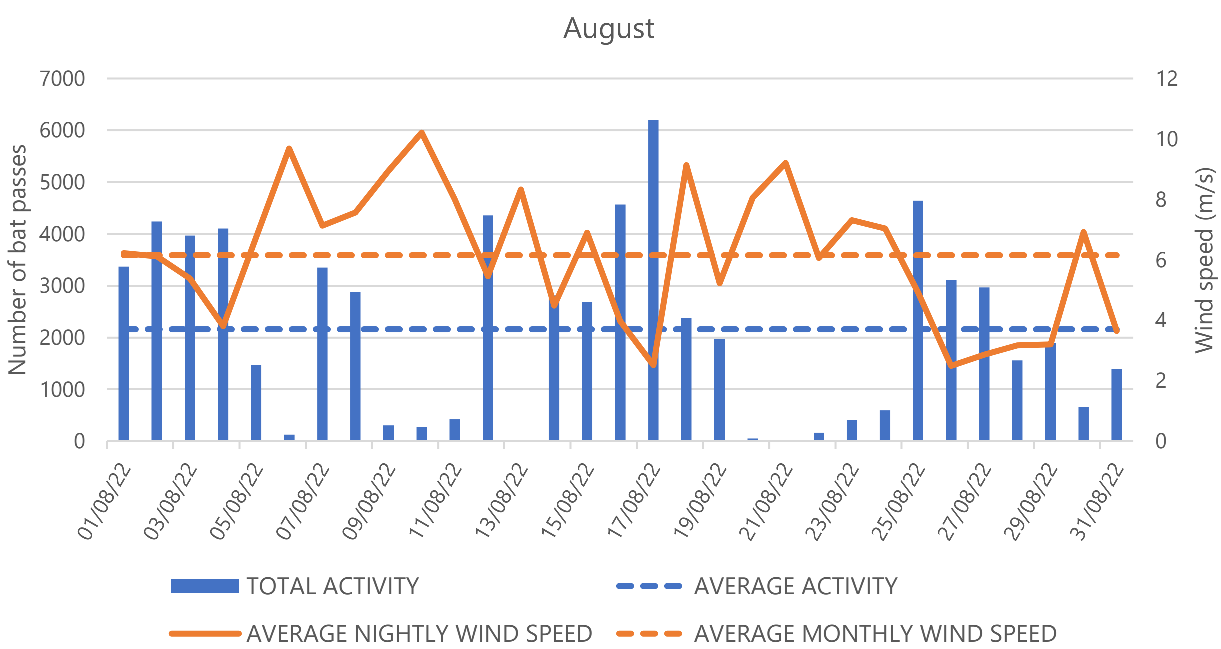
3.1.2. Relation of bat activity and wind speed

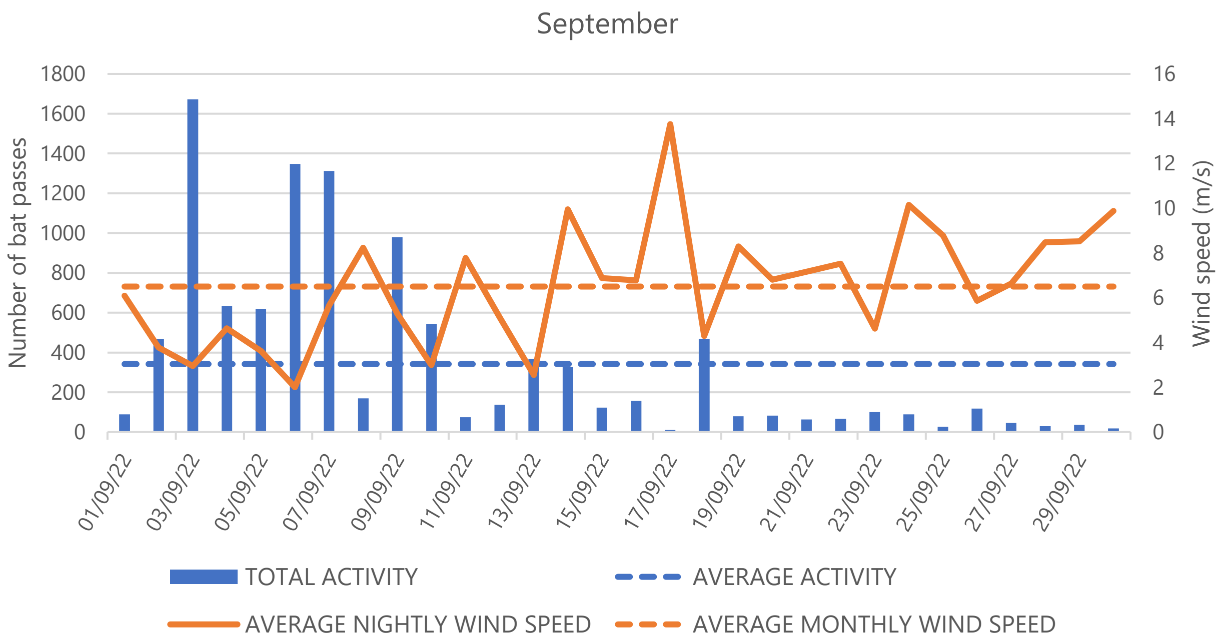
Data on wind measurements at nacelle height from June to October 2022 was provided by Vjetroelektrana Jelinak Ltd. When plotted against bat activity for each night, it shows there is a clear dependence of bat activity on nightly wind speed. Activity spikes are present at nights of lower average wind speed, while at nights with higher average wind speed activity decreased (Figure 3-20). This trend was apparent in the previous year of monitoring as well.

In August, activity was the highest on August 17th when wind speed was the lowest, but when wind speeds became higher, activity dropped, as expected. In July however, a peak of activity was recorded on July 23rd when wind speed was the lowest, but after wind speeds became higher, activity remained high, probably because it didn't exceed an average of 5 m/s. It is also possible that the activity was increased due to the greater number of juvenile bats.




July
Number of bat passes
Wind speed (m/s)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
9
8
7
6
5
4
3
2
1
0
01/07/22
03/07/22
05/07/22
07/07/22
09/07/22
11/07/22
13/07/22
15/07/22
17/07/22
19/07/22
21/07/22
23/07/22
25/07/22
27/07/22
29/07/22
31/07/22
TOTAL ACTIVITY
AVERAGE ACTIVITY
AVERAGE NIGHTLY WIND SPEED
AVERAGE MONTHLY WIND SPEED


August
Number of bat passes
Wind speed (m/s)
7000
6000
5000
4000
3000
2000
1000
0
12
10
8
6
4
2
0
01/08/22
03/08/22
05/08/22
07/08/22
09/08/22
11/08/22
13/08/22
15/08/22
17/08/22
19/08/22
21/08/22
23/08/22
25/08/22
27/08/22
29/08/22
31/08/22
TOTAL ACTIVITY
AVERAGE ACTIVITY
AVERAGE NIGHTLY WIND SPEED
AVERAGE MONTHLY WIND SPEED



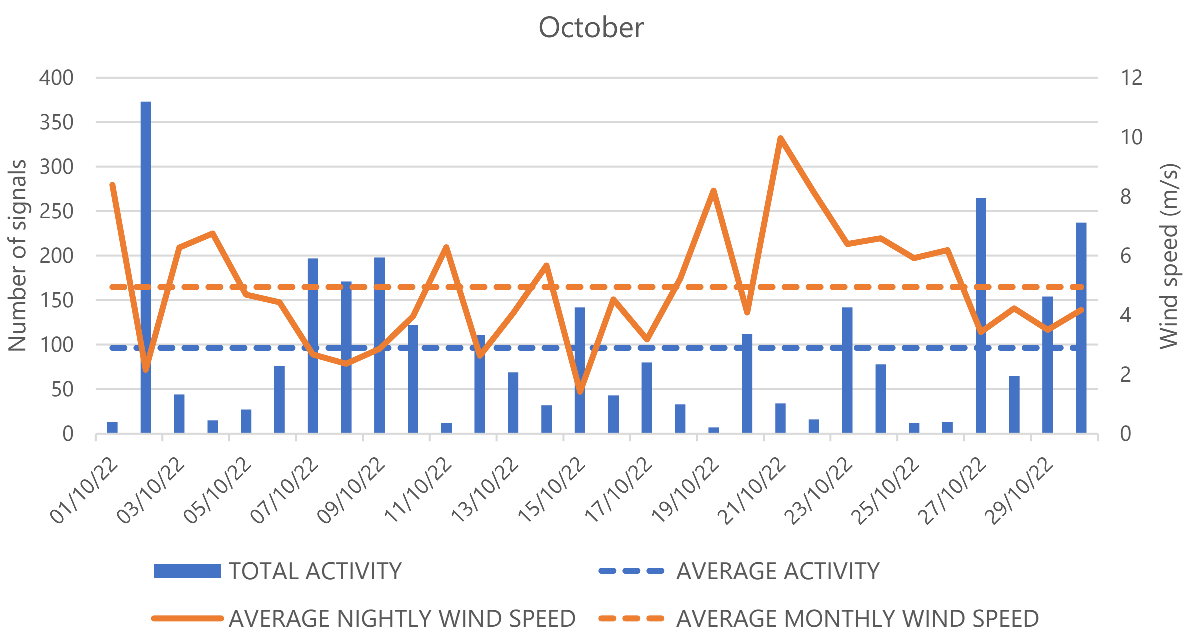


Figure 3-20 Total bat activity per night and average night wind speed for June, July, August, September and October

In June, July, September and October, more than half of the activity was recorded at wind speeds below 5 m/s, while in August bats were active at slightly higher wind speeds. At winds speeds above 7 m/s, which are considered least favourable for bats, less than 10 % of activity was recorded, except in August (Table 3-1, Figure 3-21).

There were two nights with average wind speed over 7 m/s in June, meaning that 87 % of all activity accounts to 14 days of survey. In July, the number of days with high winds increased to ten, meaning that 70 % of activity was recorded in 21 days. Foraging conditions were the least favourable in August and September, when there were twelve days with average wind speeds above 7 m/s. In total around 60 % of activity was recorded in days that had average wind speeds below 7 m/s. In October there were four days with average wind speed above 7 m/s, meaning that 90 % of activity was recorded during lower wind speeds.

Analysis of the data on bat activity in relation to wind speed shows that in July there were only four nights with wind speeds under 4 m/s. Also, in August there was a high number of nights with very high wind speeds (> 6 m/s). This could have forced bats to be active and forage in non-optimal conditions. It should be taken into consideration that wind speed measured at nacelle height is usually significantly higher than it is closer to the ground. Therefore, it is possible that even though wind speed at nacelle height was not optimal, wind speeds near the ground were lower and more favourable for bat activity.

Table 3-1 Percentage of bat passes for June, July, August, September and October at different wind speeds

LOATION	MONTH	PERCENTAGE OF TOTAL BAT PASSES					NUMBER OF NIGHTS WITH AVERAGE SPEED > 7 m/s
		< 4 m/s	4-5 m/s	5-6 m/s	6-7 m/s	> 7 m/s	
TOTAL (WTG3 and WTG18)	**June**	69.85 %	21.87 %	3.84 %	2.55 %	1.90 %	2
	July	25.17 %	56.68 %	8.51 %	1.01 %	8.63 %	10
	August	38.54 %	11.14 %	15.39 %	18.81 %	16.12 %	12
	September	48.93 %	11.73 %	24.83 %	4.84 %	9.67 %	12
	October	62.67 %	21.74 %	2.66 %	10.51 %	2.42 %	4
WTG3	**June**	68.41%	28.13%	2.55%	0.08%	0.83%	3
	July	22.47%	60.85%	7.17%	8.41%	1.10%	6
	August	29.80%	19.15%	26.63%	11.55%	12.87%	9
	September	43.96%	8.74%	17.80%	14.99%	14.51%	14
	October	59.38%	17.97%	10.58%	2.04%	10.02%	6
WTG18	**June**	71.98%	12.58%	7.87%	6.45%	1.12%	1
	July	26.51%	52.87%	10.01%	0.69%	9.92%	10
	August	33.56%	14.95%	25.77%	7.62%	18.10%	14
	September	59.98%	23.67%	6.79%	3.87%	5.69%	11
	October	0.00%	0.00%	0.00%	0.00%	0.00%	5

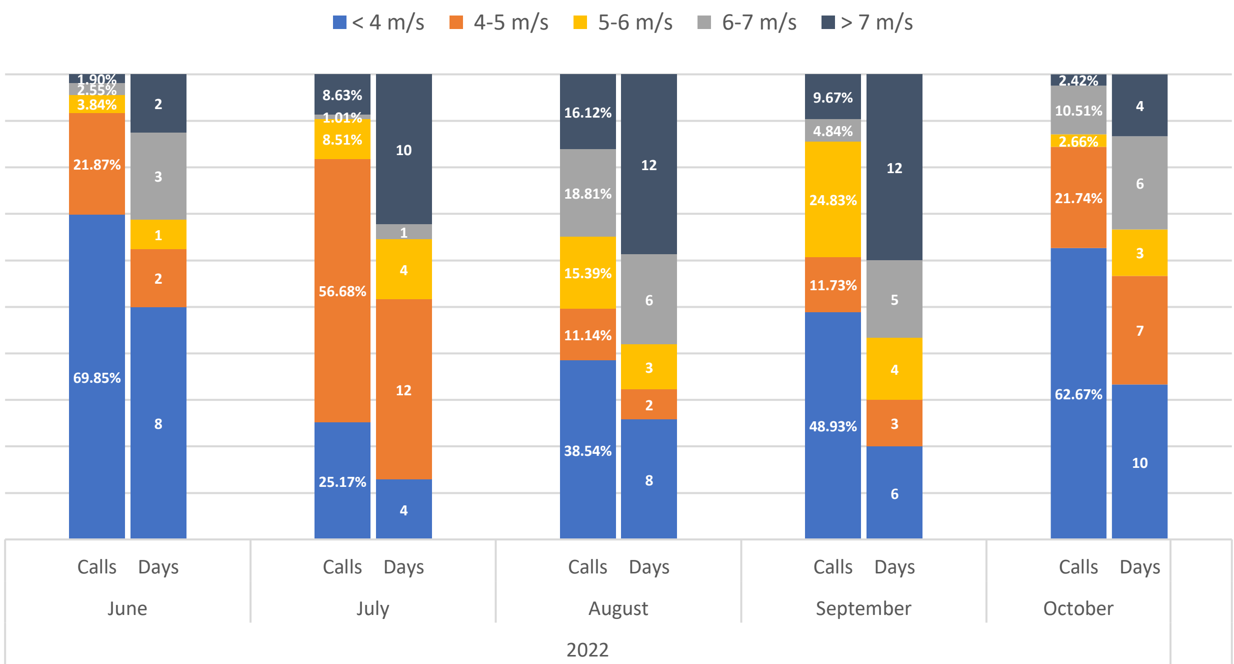


Figure 3-21 Percentage of total bat passes and number of days for different wind speeds per month at WTG3 and WTG18

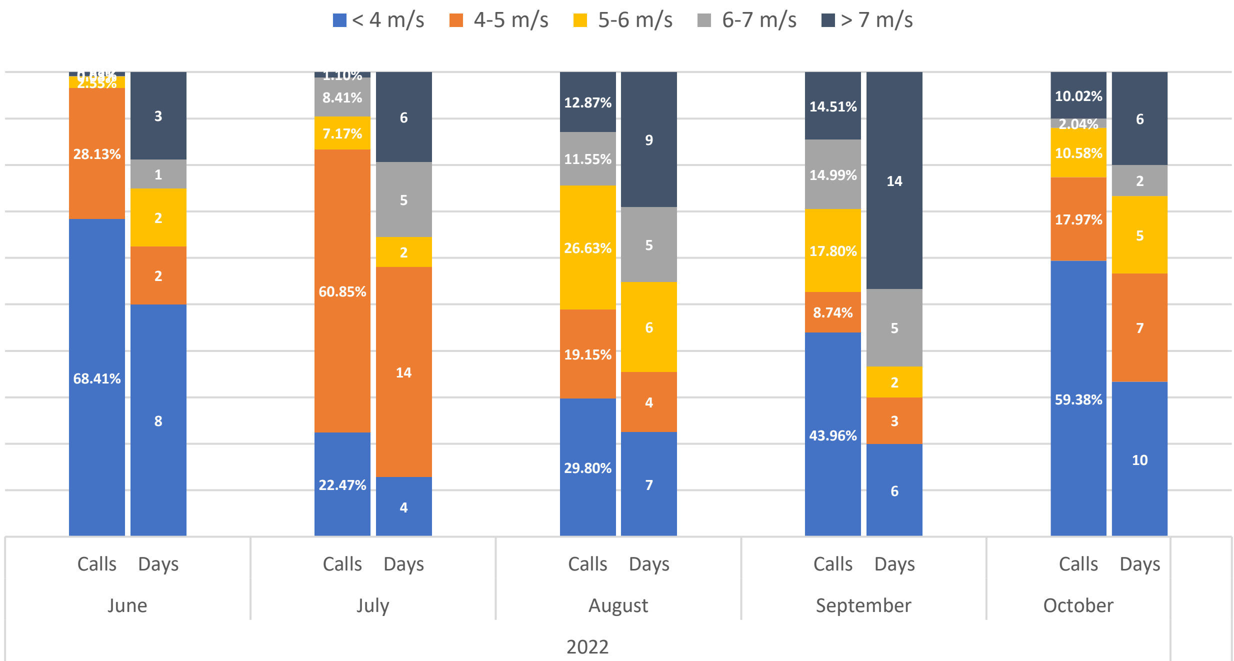


Figure 3-22 Percentage of total bat passes and number of days for different wind speed per month at WTG3

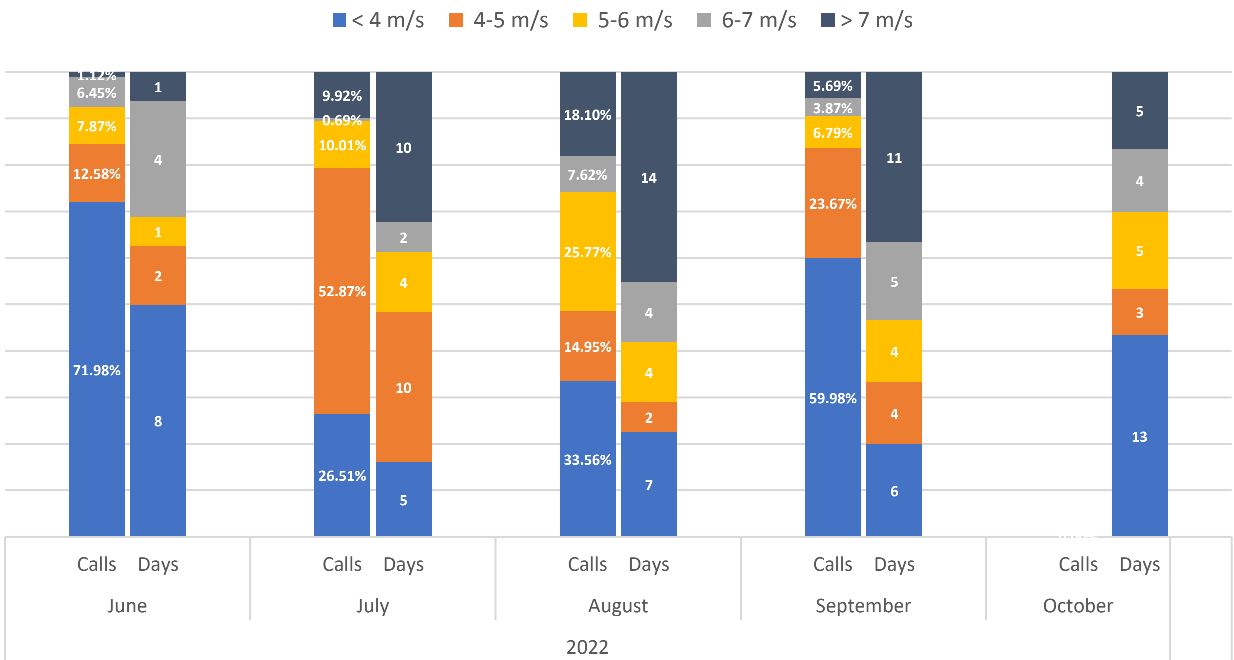


Figure 3-23 Percentage of total bat passes and number of days for different wind speed per month at WTG18

3.2. Visual monitoring of bat activity around selected WTG's

Bat activity around five WTG's (WTG1, WTG2, WTG3, WTG10 and WTG16) was monitored in July and August using thermal imaging cameras. In total 170 bat passes were observed, most of them around WTG3, which was observed longer than the other WTG's (Table 3-2, Figure 3-24).

Table 3-2 Number of bat passes observed with thermal imaging cameras

DATE	NUMBER OF BAT PASSES				
	WTG1 and WTG2	WTG3	WTG10	WTG16	TOTAL
11.7.2022.	14	2	3	18	**37**
28.7.2022.	0	34	21	1	**56**

DATE	NUMBER OF BAT PASSES				
	WTG1 and WTG2	WTG3	WTG10	WTG16	TOTAL
12.8.2022.	2	12	2	2	**18**
26.8.2022.	6	31	5	17	**59**
TOTAL	**22**	**79**	**31**	**38**	**170**

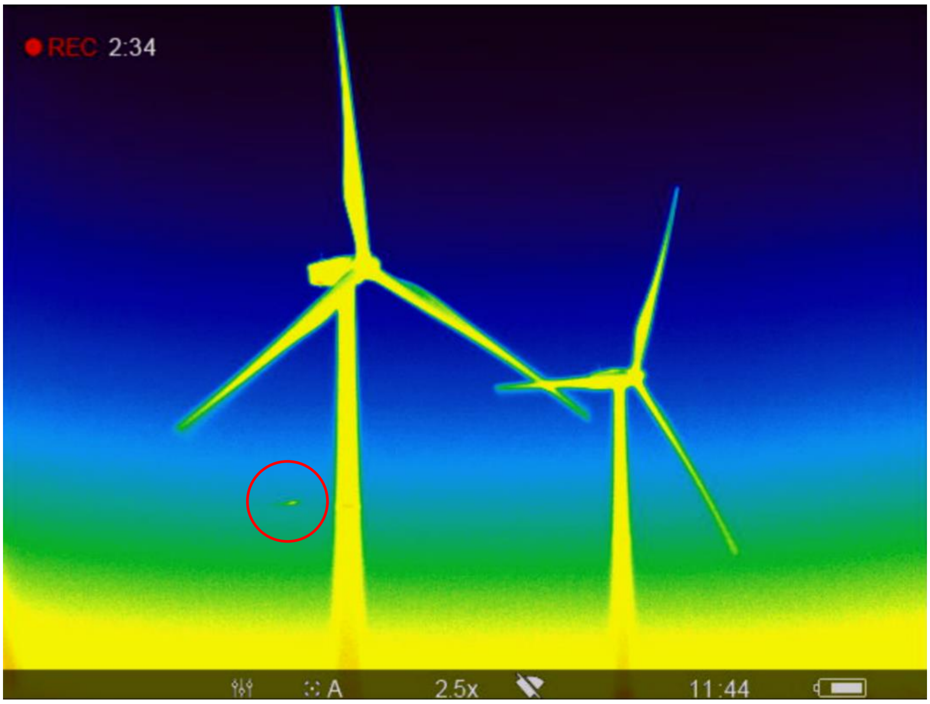


Figure 3-24 Bat (circled) near WTG2 as seen with a thermal imaging camera

Bat passes which were close to camera i.e., far from the observed WTG's were excluded from further analysis. Direction of flight and position relative to WTG's were noted (Table 3-3).

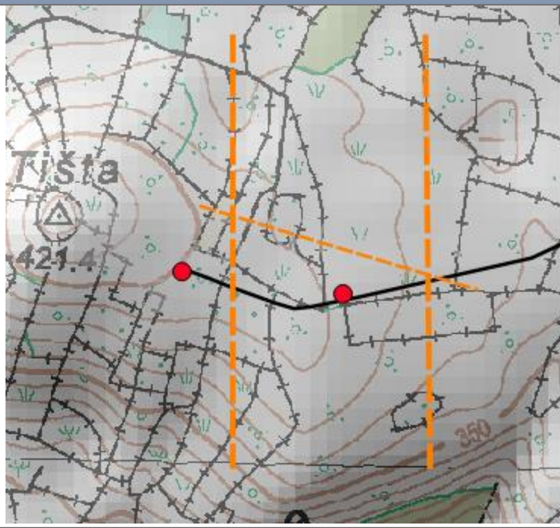
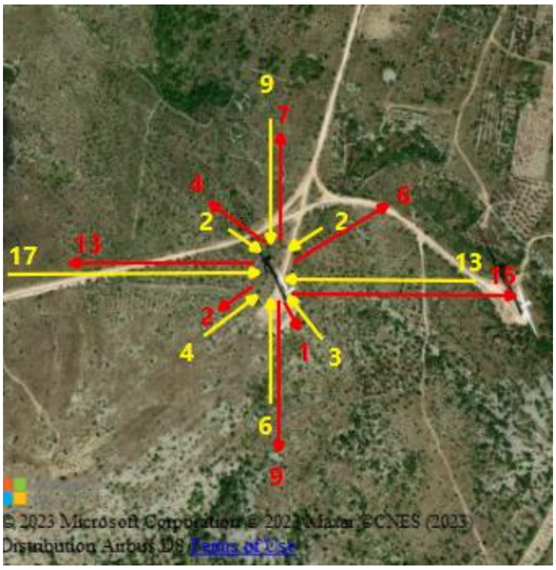
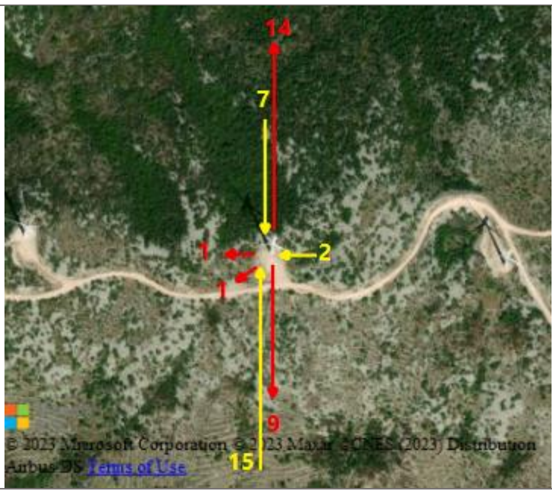
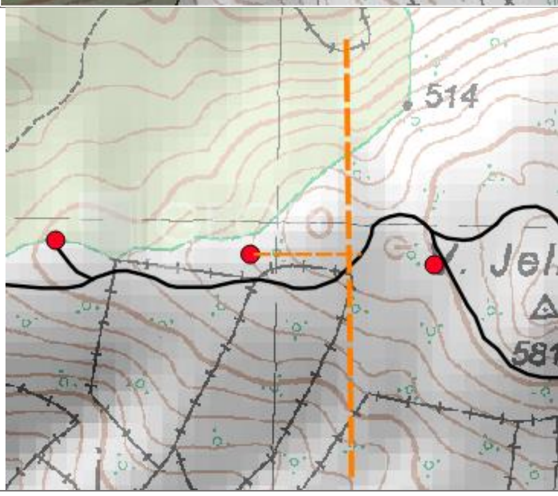
Around WTG1 and WTG2 bats were mostly flying south-north and southeast-northwest. It is possible that they were avoiding the peak Tišta in the west. No passes were noted in or from that direction. Also, almost all passes occurred east of WTG's; five east of WTG1, seven east of WTG2 and only one north of the WTG's. It is possible however that passes east of the WTG's were more visible because they were closer to the vantage point.

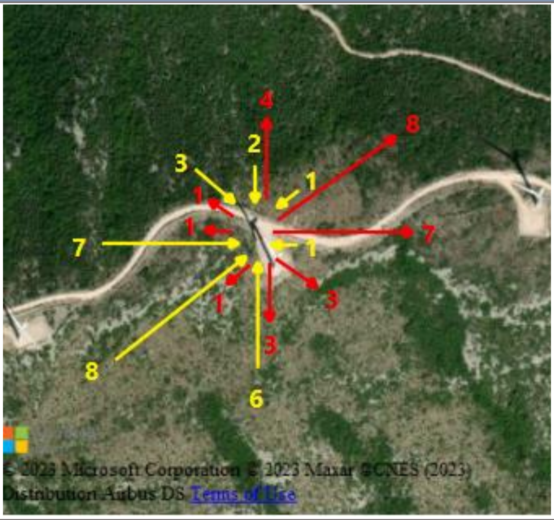
Around WTG3 bat passes in all directions were noted and they were the most numerous among the observed WTG's. Bats were mainly flying east-west, followed by south-north. This supports a presumption discussed in the previous monitoring reports that bats are migrating along the Duboka draga valley located south of WTG3 and dispersing in all directions around WTG3 as it is the lowest part of the WF. Most of the passes were observed north of the WTG; 45 passes north, six east and one west. Again, it is possible that passes north of the WTG's were more visible because they were closer to the vantage point, but terrain north of the WTG is flatter and access roads pass on that side, so those could also be attractive features for bat activity.

Around WTG10 bats were mainly flying south-north, possibly avoiding the Veliki Jelinak peak. This is consistent with the results of bat call recording along a linear transect carried out during previous years of monitoring, which showed low bat activity at the peak. All passes for which position relative to the WTG could be determined were noted east of the WTG, closest to the vantage point.

Around WTG16 bats were observed flying in all directions. The largest number of bats were flying southwest-northeast, followed by east-west and south-north. There's an area of more dense shrubby vegetation north of the access road which passes along the southwest-northeast line, so it might be that bats are often following the road along the vegetation edge. Most of the passes were observed west of the WTG; 17 west, four south, four north and two east. The reason for that could be that those passes were closer to the vantage point, but also that, when looking from the vantage point, the access road and coppice edge stretch west and north relative to WTG16.

Table 3-3 Directions of bats passes observed with thermal imaging cameras

WTG's	OBSERVED DIRECTIONS OF BAT PASSES (towards and from the observed WTG's)	MAIN DIRECTIONS OF BAT PASSES (thinner lines = less bat passes)
WTG1 and WTG2		
WTG3		
WTG10		

WTG's	OBSERVED DIRECTIONS OF BAT PASSES (towards and from the observed WTG's)	MAIN DIRECTIONS OF BAT PASSES (thinner lines = less bat passes)
WTG16		

In most of the cases bats were flying linearly past WTG's, but in a few cases they were circling around them. Bats were observed to be circling around turbine blades (twice at WTG1 and WTG2 and once at WTG3, WTG10 and WTG16 each), nacelle (once at WTG3) and tower (twice at WTG3). It can be concluded that bats are not in a risk of collision while circling around WTG's, but rather when flying linearly past WTG's, among which WTG3 is probably at the most frequent flying route.

Bat passes observed around WTG3 were compared to recordings of bat calls recorded at the same time at that WTG. In this way, the possible species of observed bats could be determined. According to the recordings of the microphone at the nacelle hight, most of the bat passes possibly belonged to *Pipistrellus kuhlii* (18) or *Pipistrellus kuhlii / nathusii* (7), and a few possibly belonged to *Hypsugo savii* (3). Recordings recorded with another microphone, set at 15 m hight, showed similar results regarding species composition (possibly 19 passes of *Pipistrellus kuhlii*, 9 of *Pipistrellus kuhlii / nathusii*, 2 of *Hypsugo savii*, and 1 of *Miniopterus schreibersii / Pipistrellus pygmaeus*).

3.3. Monitoring of bat collisions

Bat carcasses were found from the second half of June until the first half of September. In total, 58 carcasses were found. The carcasses belonged to at least four bat species: *Pipistrellus kuhlii* (23), *Hypsugo savii* (22), *Nyctalus noctula* (1) and *Vespertilio murinus* (1). Eleven carcasses were in too poor a condition for identification (nine were noted as Chiroptera sp., one as *Pipistrellus* sp. and one as *Hypsugo savii / Pipistrellus* sp.) (Table 3-4). Chiroptera sp. were classified as smaller bat species (e.g., *Pipistrellus* sp., *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 2004). The carcasses in poor condition were all found in July, when they were the most exposed to insects such as wasps and ants (Figure 3-25), as well as to faster tissue decay due to higher ambient temperatures.

All the species found are considered to have a high collision risk with WTG's because they fly and forage in open space, high above the vegetation (Rodrigues et al. 2014). This was also confirmed by visual observations of the blade-swept zone combined with acoustic monitoring – almost all of the observed bat passes for which species can be assumed belonged to the individuals of *Pipistrellus kuhlii* (/ *nathusii*) and *Hypsugo savii*. Most of the carcasses had no apparent external injuries, which could mean that barotrauma was a possible cause of death. Bats experience barotrauma when encountering vortices at blade tips, which can lead to haemothorax (Baerwald et al. 2008). Some of the carcasses had fractures of wing bones (forearm, upper arm, scapula, phalanx). The fractures were most probably a consequence of collision with turbine blades, but it is possible that some were a result of the fall or that they were run over by vehicles after the fall.

The complete list of bat carcasses found with their description is in Appendix III.

Table 3-4 Number of bat carcasses found per species per month

SPECIES	NUMBER OF CARCASSES					
	June	July	August	September	October	TOTAL
Chiroptera sp. (FA < 36 mm)	0	9	0	0	0	**9**
Hypsugo savii	2	18	2	0	0	**22**
Nyctalus noctula	0	0	0	1	0	**1**
Pipistrellus kuhlii	0	20	3	0	0	**23**
Pipistrellus sp.	0	1	0	0	0	**1**
Hypsugo savii / Pipistrellus sp.	0	1	0	0	0	**1**
Vespertilio murinus	0	0	1	0	0	**1**
TOTAL	**2**	**49**	**6**	**1**	**0**	**58**

Figure 3-25 Wasps scavenge on a bat carcass

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). All recorded species are listed as Appendix IV species of the Council Directive 92/43/EEC (Habitat Directive), i.e. species of community interest in need of strict protection, both within and outside Natura 2000 sites. Also, they are protected by the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats,

1979) as strictly protected species (Appendix II). 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 3-5 Protection and IUCN status of bat species found dead in the WF area

SPECIES	ORDINANCE ON STRICTLY PROTECTED SPECIES[1]	IUCN WORLD[2]	IUCN CROATIA[3]	HABITATS DIRECTIVE (APPENDIX NO.)[4]	BERN CONVENTION (APPENDIX NO.)[5]
Hypsugo savii	SP	-	-	IV	II
Nyctalus noctula	SP	LC	-	IV	II
Pipistrellus kuhlii	SP	LC	-	IV	II
Vespertilio murinus	SP	LC	-	IV	II

***SP** = strictly protected species; **LC** = least concerned species*

*(Sources: **1** - Ordinance on Strictly Protected Species, Official Gazette 144/13, 73/16; **2** - IUCN Red List of Threatened Species; **3** - Antolić et al. 2006; **4** - European Council Directive 92/43/EEC; **5** - 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 WTG2. The second highest number (8) was at the WTG5. Five carcasses were found at WTG11, four at WTG1, WTG3, WTG8 and WTG10 each, three at WTG7, WTG15 and WTG17 each, two at WTG4, WTG9, WTG13 and WTG19 each and one at WTG14, WTG16 and WTG18 each. Higher number of carcasses than average (2.9) was found at ten WTG's (WTG1, WTG2, WTG3, WTG5, WTG7, WTG8, WTG10, WTG11, WTG15, WTG17) (Table 3-6, Figure 3-26).

Mortality was recorded at five out of 18 WTG's with implemented mitigation measures in the first half of July, 15 out of 18 in the second half of July, three out of 18 in the first half of August and one out of 18 in the second half of August. In September, mortality was not recorded at WTG's with implemented mitigation measures.

Table 3-6 Number of bat carcasses found per month under each WTG (WTG's with implemented mitigation measures are marked yellow)

WTG	NUMBER OF CARCASSES								
	JUNE 2ND HALF	JULY 1ST HALF	JULY 2ND HALF	AUGUST 1ST HALF	AUGUST 2ND HALF	SEPTEMBER 1ST HALF	SEPTEMBER 2ND HALF	OCTOBER 1ST HALF	TOTAL
WTG1	-	-	4	-	-	-	-	-	**4**
WTG2	-	2	4	1	2	-	-	-	**9**
WTG3	-	-	3	1	-	-	-	-	**4**
WTG4	-	1	1	-	-	-	-	-	**2**
WTG5	-	-	7	1	-	-	-	-	**8**
WTG6	-	-	-	-	-	-	-	-	**0**
WTG7	-	1	1	-	1	-	-	-	**3**
WTG8	-	-	4	-	-	-	-	-	**4**
WTG9	-	-	2	-	-	-	-	-	**2**
WTG10	-	1	3	-	-	-	-	-	**4**
WTG11	-	-	4	-	-	1	-	-	**5**
WTG12	-	-	-	-	-	-	-	-	**0**
WTG13	-	-	2	-	-	-	-	-	**2**
WTG14	1	-	-	-	-	-	-	-	**1**
WTG15	-	-	3	-	-	-	-	-	**3**
WTG16	-	-	1	-	-	-	-	-	**1**
WTG17	1	1	1	-	-	-	-	-	**3**
WTG18	-	-	1	-	-	-	-	-	**1**
WTG19	-	-	2	-	-	-	-	-	**2**
WTG20	-	-	-	-	-	-	-	-	**0**
TOTAL	**2**	**6**	**43**	**3**	**3**	**1**	**0**	**0**	**58**

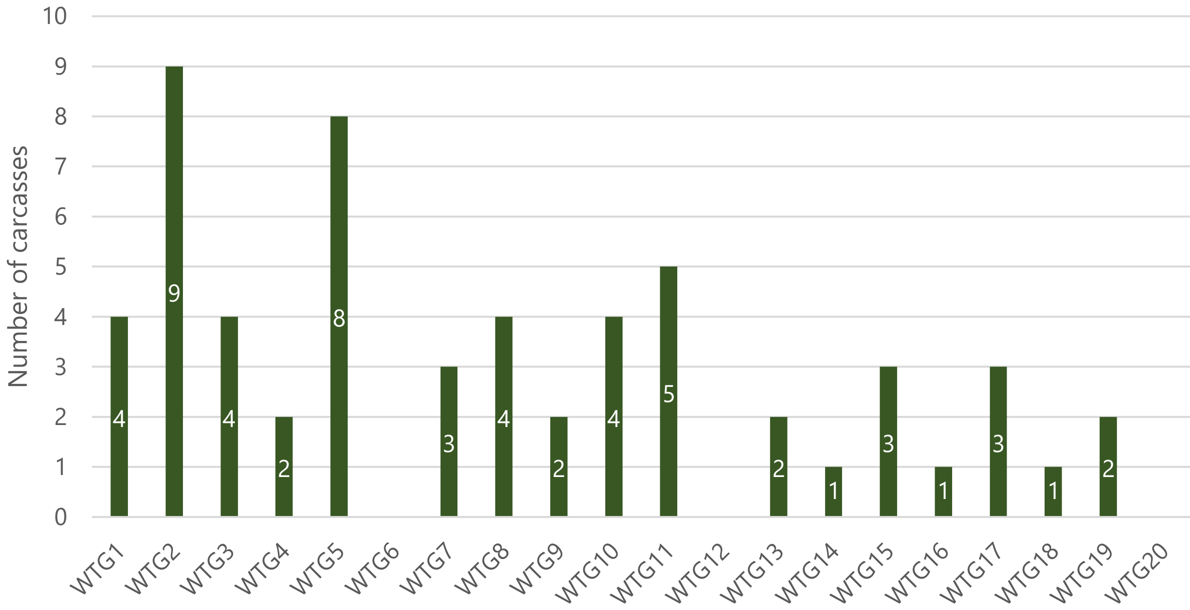


Figure 3-26 Number of bat carcasses found at each WTG

3.3.2. Bat mortality per month

The largest number of carcasses was found in July (49), more precisely in the second half of July (43), followed by August (Figure 3-27, Figure 3-28).

Individuals of *Hypsugo savii* were found from June to August, but mostly in July. Carcasses of *Pipistrellus kuhlii* were found in July and August. This is likely because females give birth in late May and in June, and juveniles can actively fly by the end of July or in August. Adults also begin mating in August. Therefore, during this period bat activity is at its peak. During the end of July and in August, carcasses of 22 juvenile and one subadult individuals were found. Most of them of them were *Hypsugo savii* (12), but there were also *Pipistrellus kuhlii* (8) and unidentified small bat species (3). Also, there were 21 adult females among the found carcasses (8 *Hypsugo savii* and 11 *Pipistrellus kuhlii*), some of them in the period when bats in the area raise their young. Two *Hypsugo savii* females found in June were lactating. Females gathered in maternity colonies, as well as juveniles, often forage closer to their roosts which may indicate that the WF area is within their foraging area. *Pipistrellus* and *Hypsugo* species are often found near human settlements, and they rarely have daily migrations over great distances, so the maternity colonies or other roosts may be located in the nearby settlements (Bristivica, Blizna).

In September, mating continues, and autumn migrations take place. A female individual of *Vespertilio murinus* was found in late August, while a subadult individual of *Nyctalus noctula* was found in early September. Both species are migratory, and potential autumn migrations of *Nyctalus* spp. were identified in previous years of monitoring as well.

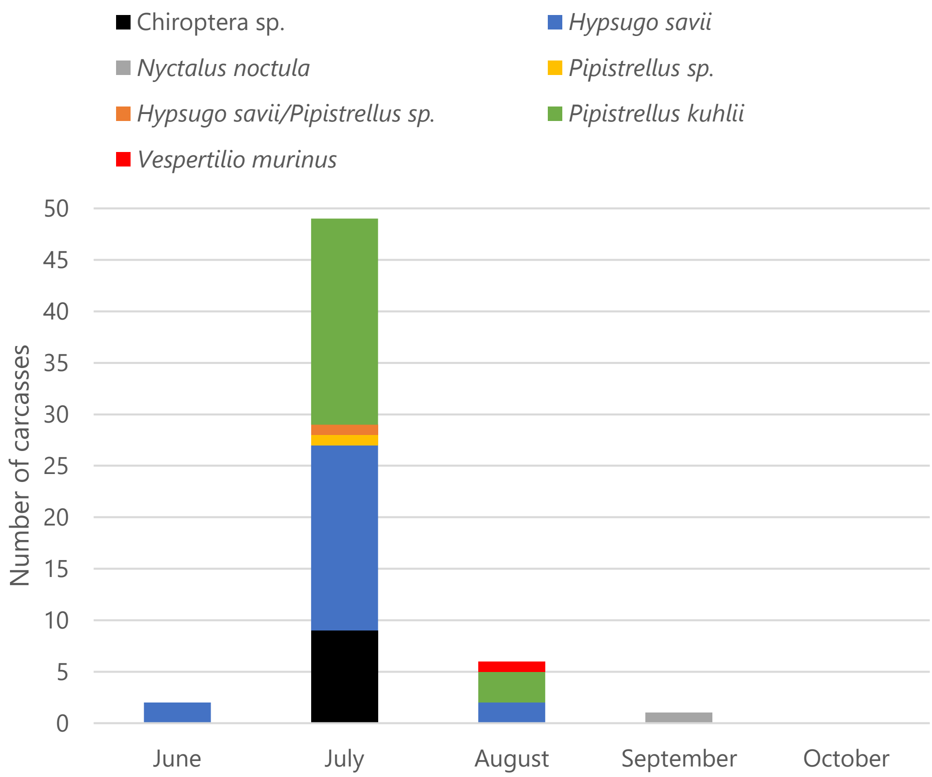


Figure 3-27 Number of bat carcasses found per species per month

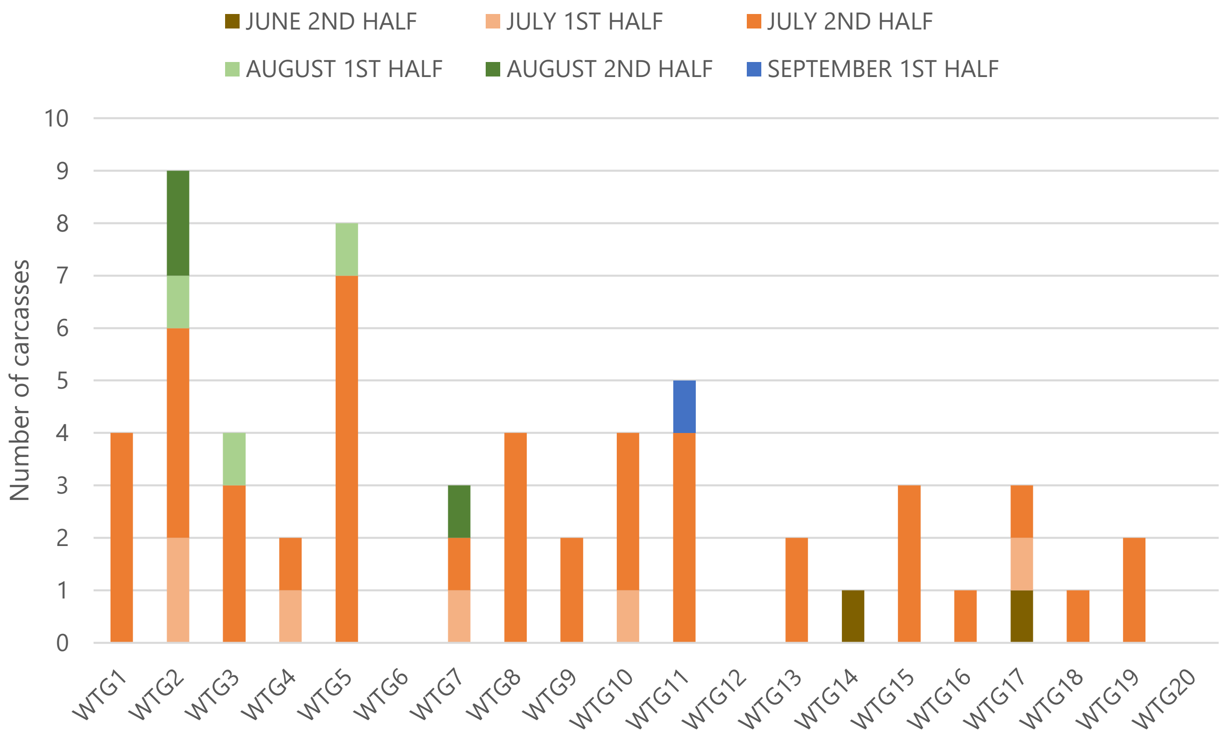


Figure 3-28 Number of bat carcasses found at each WTG per half a month

3.3.3. Bat mortality in relation to activity

Bat carcasses were usually found after nights of higher bat activity, meaning that bat mortality increases with an increase of bat activity (Figure 3-29). The biggest number of bat carcasses was found during the first peak of very high activity in July.

It has to be pointed out that the relation cannot 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.

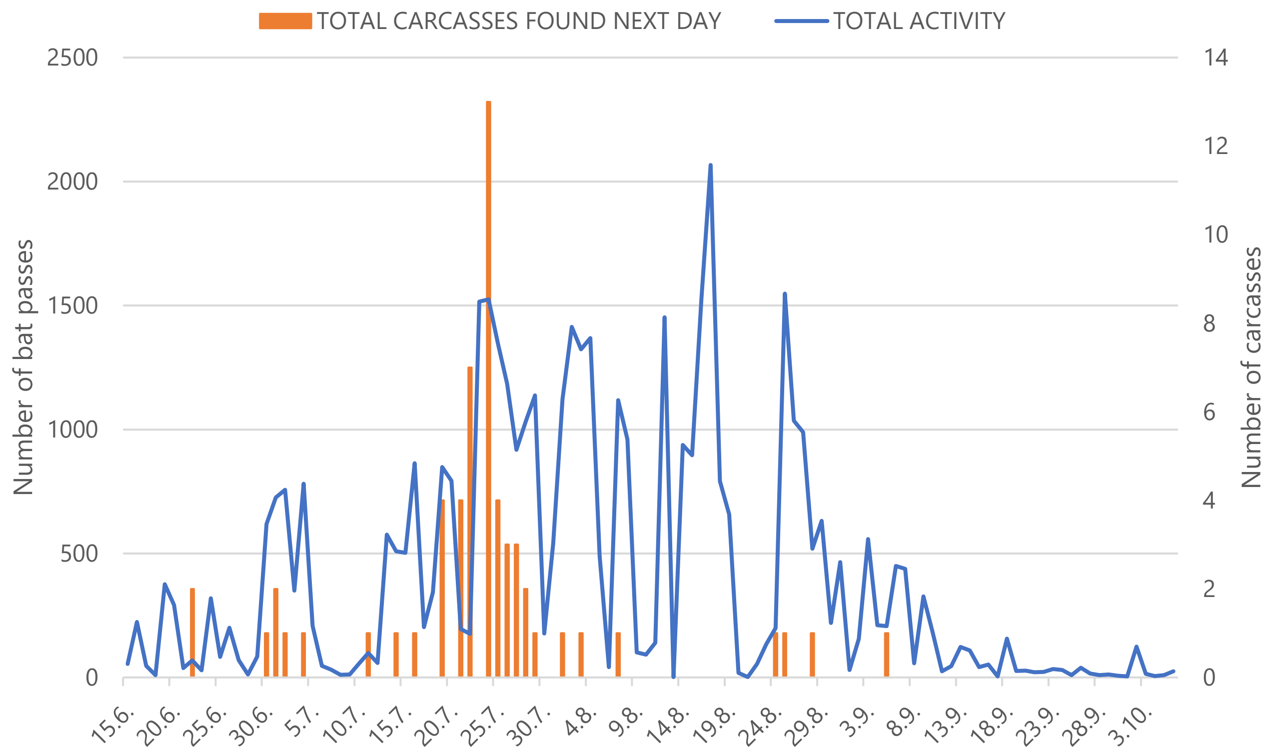


Figure 3-29 Corelation of bat activity and mortality (daily searches only in July and August)

3.3.4. Bat mortality in relation to wind speed

Bat mortality was generally higher in nights with lower wind speed (Figure 3-30). This is in accordance with previous conclusion that mortality increases with an increase of bat activity since bat activity was generally higher in nights when wind speed was lower.

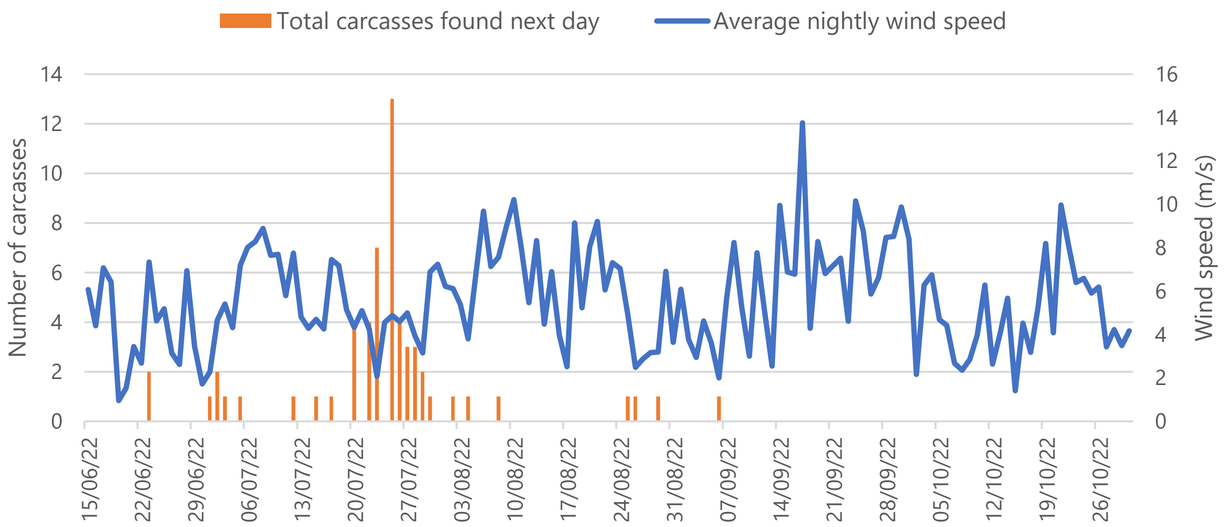
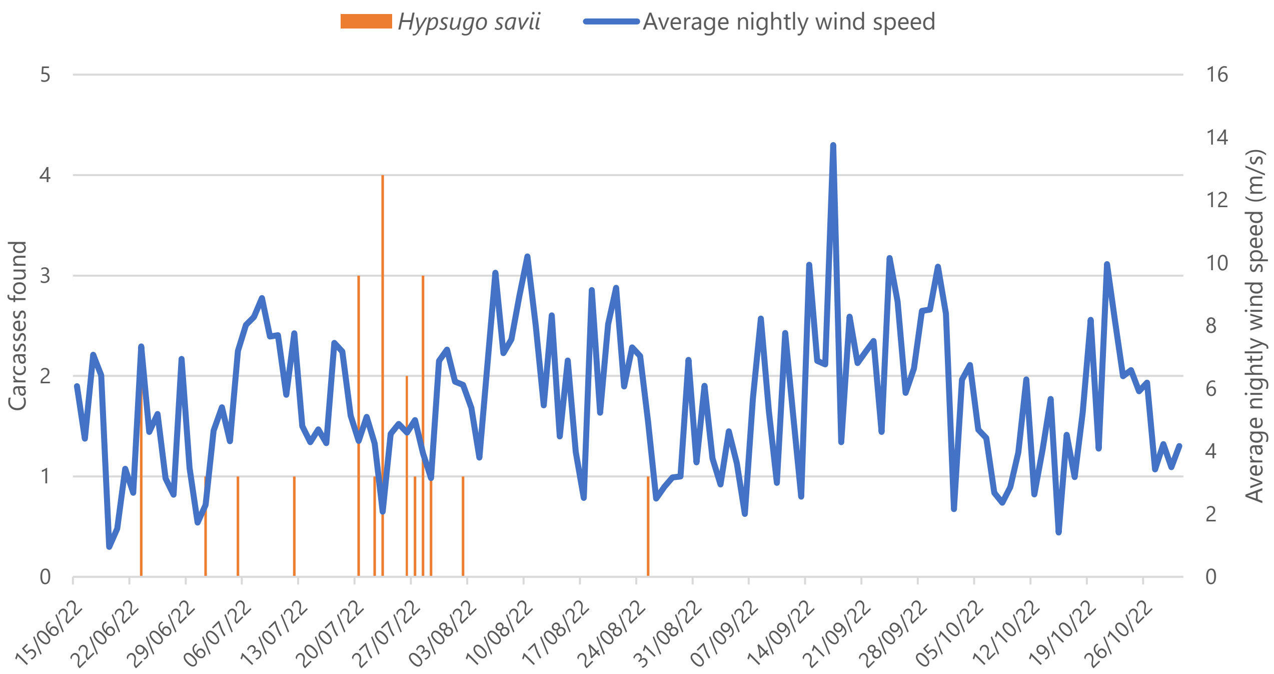
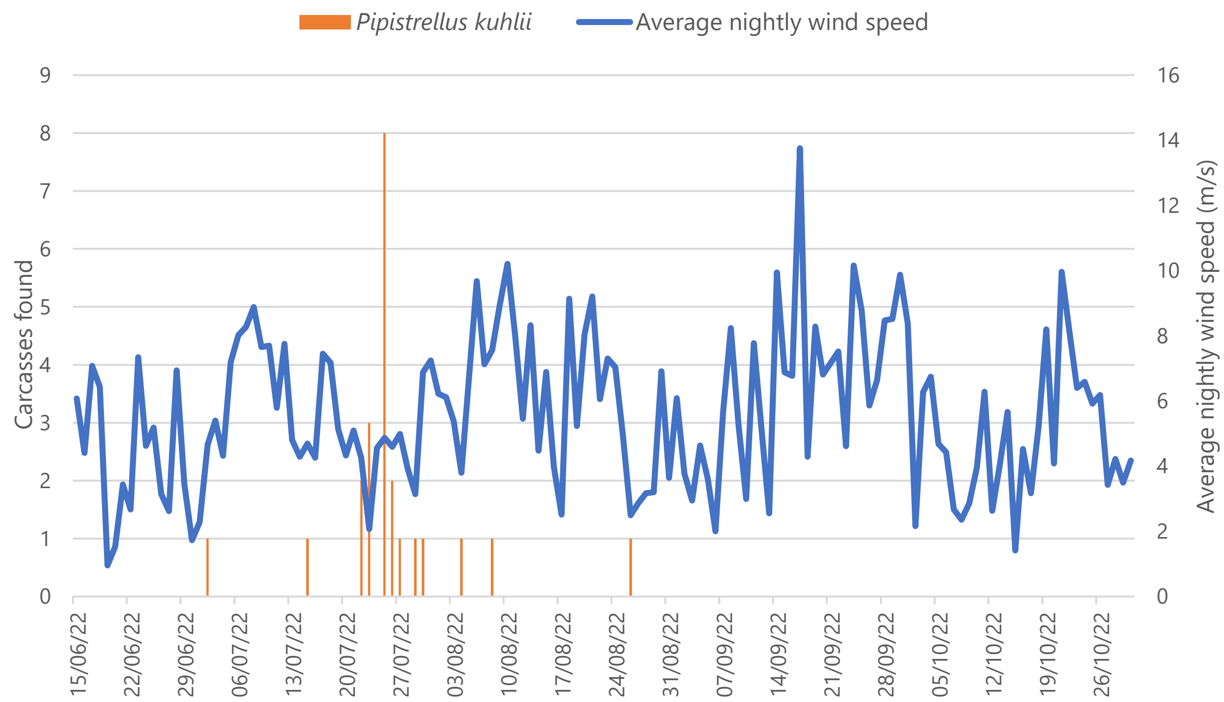


Figure 3-30 Corelation of bat mortality and activity (daily searches in only in July and August)

Mortality of each taxon individually also shows correlation with lower wind speed (Figure 3-31).


Hypsugo savii
Average nightly wind speed
Carcasses found
Average nightly wind speed (m/s)
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
15/06/22
22/06/22
29/06/22
06/07/22
13/07/22
20/07/22
27/07/22
03/08/22
10/08/22
17/08/22
24/08/22
31/08/22
07/09/22
14/09/22
21/09/22
28/09/22
05/10/22
12/10/22
19/10/22
26/10/22


Pipistrellus kuhlii
Average nightly wind speed
Carcasses found
Average nightly wind speed (m/s)
0
1
2
3
4
5
6
7
8
9
0
2
4
6
8
10
12
14
16
15/06/22
22/06/22
29/06/22
06/07/22
13/07/22
20/07/22
27/07/22
03/08/22
10/08/22
17/08/22
24/08/22
31/08/22
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28/09/22
05/10/22
12/10/22
19/10/22
26/10/22

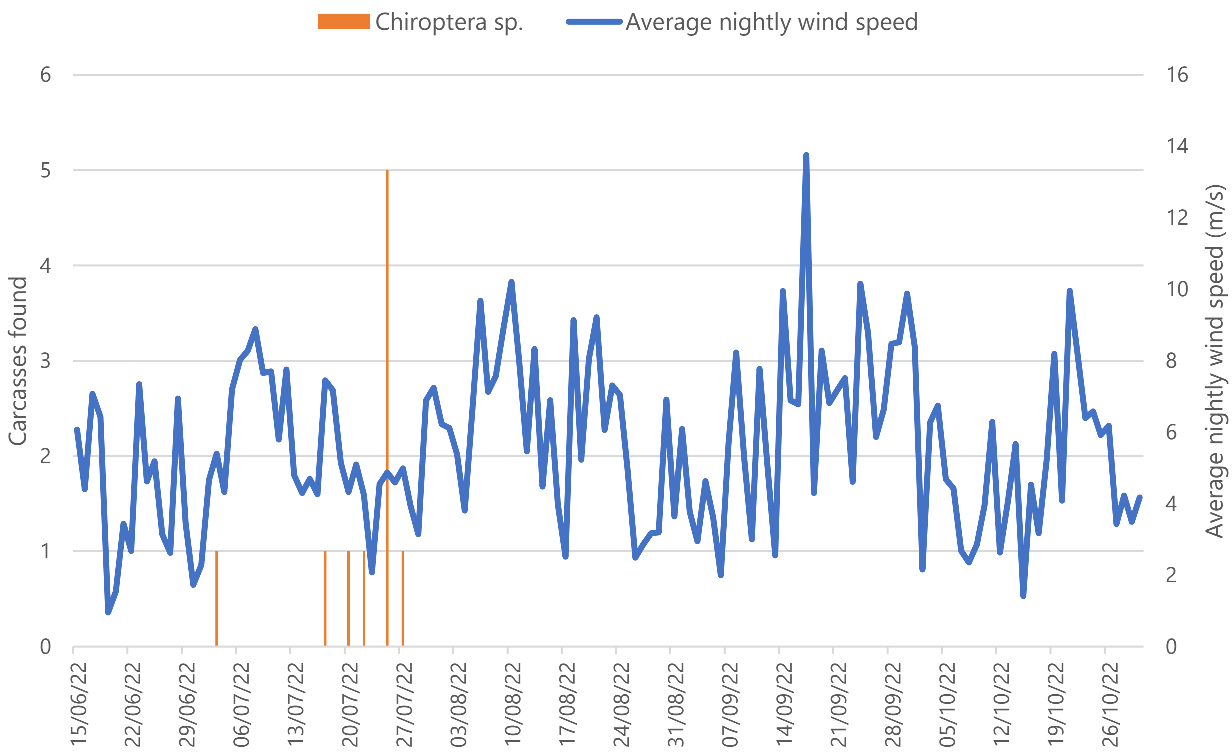

Figure 3-31 Relation of mortality and average wind speed for different species and groups (daily searches only in July and August)

Average wind speed at nacelle height in nights directly preceding the days when bat carcasses were found was 4.5 m/s (Figure 3-32), which is below average wind speed for the whole period of survey. It should be noted that lower wind speed is not the cause of increased bat mortality neither is it dangerous for them – this correlation is due to the increase of bat activity and therefore more interactions with WTG's.

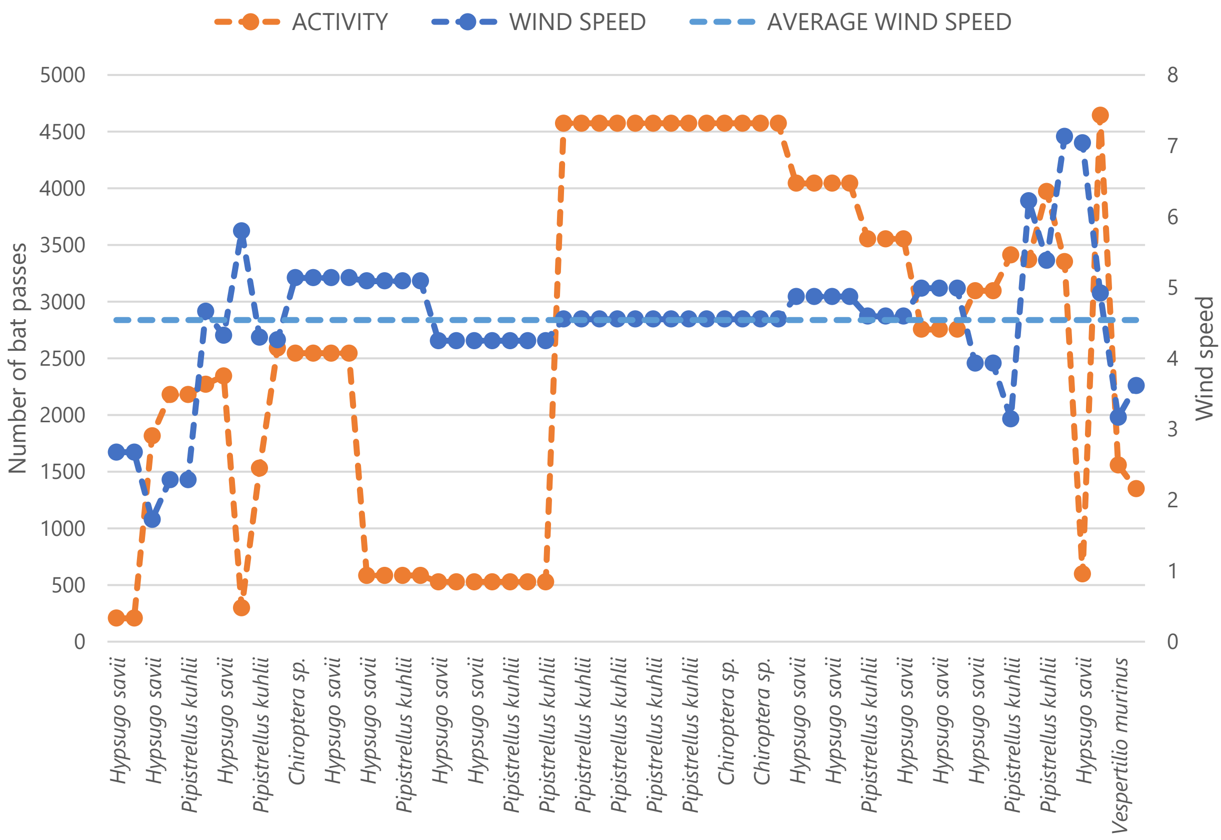

Figure 3-32 Wind speed and activity in the night before the carcass was found for each discovered bat carcass

3.3.5. Bat mortality in relation to mitigation measures

During 2022 blade feathering and increased cut-in speed were implemented during some periods at selected WTG's (Table 1-1). It is assumed that collisions of bats with WTG's do not occur when these mitigation measures are implemented. This was confirmed by the mortality monitoring. Bat carcasses were found only after nights when no mitigation measures were implemented at the corresponding WTG, or when mitigation measures were implemented for some time during the night, but then wind speed exceeded the mitigation measure threshold and the turbine blades were rotating again, thus posing a risk for bats (Table 3-7).

In 24 cases collisions occurred when the cut-in speed was 6.0 m/s, in 15 cases when it was 5.0 m/s, and in five cases when it was 5.5 m/s. In five cases only blade feathering was implemented. In one case (July 2nd) wind speed was not above the defined cut-in speed (5.5 m/s), but the measure was not implemented during the whole night (only from 9 pm until 3 am), and also the speed data are from different WTG's that the one under which the bat carcass was found, so it is possible that wind speed at that WTG exceeded the cut-in speed sometime during the night. When no mitigation measures were implemented, in two cases wind speed exceeded 5.5 m/s, while in three cases it exceeded 6.0 m/s. Therefore, most collisions occurred on the nights when cut-in speed was 6.0 m/s.

In the cases of *Pipistrellus kuhlii* and *Hypsugo savii*, the highest cut-in speed (6.0 m/s) was sometimes not high enough to prevent collisions. In the case of *Vespertilio murinus*, it was 5.5 m/s, while *Nyctalus noctula* was found at the WTG which had only blade feathering implemented during that night.

Table 3-7 Bat carcasses found, wind speeds measured the night before and implemented increased cut-in speed

DATE	WTG	SPECIES	NIGHTLY WIND SPEED (m/s)*	INCREASED CUT-IN SPEED
23/06/2022	WTG17	*Hypsugo savii*	0.2-5.7	no
23/06/2022	WTG14	*Hypsugo savii*	0.2-5.7	no
01/07/2022	WTG17	*Hypsugo savii* (older carcass)	0.3-4.1	the individual collided some other night
02/07/2022	WTG4	*Pipistrellus* sp. (older carcass)	0.2-5.2	the individual collided some other night
02/07/2022	WTG2	*Pipistrellus kuhlii*	0.2-5.2	part of the night (9 pm-3 am); also, wind speed could have been higher at WTG2
03/07/2022	WTG2	Chiroptera sp.	0.5.-10.4	part of the night (< 5.5 m/s, 9 pm-3 am)
05/07/2022	WTG10	*Hypsugo savii*	0.5-8.3	part of the night (< 5 m/s, 9 pm-3 am)
12/07/2022	WTG7	*Hypsugo savii*	2.3-8.9	part of the night (< 5.5, 9 pm-3 am)
15/07/2022	WTG11	*Pipistrellus kuhlii*	0.3-9.5	part of the night (< 5 m/s, 9 pm-3 am)
17/07/2022	WTG16	Chiroptera sp.	0.5-9.1	part of the night (< 5 m/s)
20/07/2022	WTG19	Chiroptera sp.	2.0-9.1	no
20/07/2022	WTG15	*Hypsugo savii*	2.0-9.1	part of the night (< 5 m/s)
20/07/2022	WTG9	*Hypsugo savii*	2.0-9.1	part of the night (< 5 m/s)
20/07/2022	WTG3	*Hypsugo savii*	2.0-9.1	part of the night (< 6 m/s)
22/07/2022	WTG13	*Hypsugo savii*	0.4-8.9	part of the night (< 5 m/s)
22/07/2022	WTG10	Chiroptera sp.	0.4-8.9	part of the night (< 6 m/s)

DATE	WTG	SPECIES	NIGHTLY WIND SPEED (m/s)*	INCREASED CUT-IN SPEED
22/07/2022	WTG9	*Pipistrellus kuhlii*	0.4-8.9	part of the night (< 5 m/s)
22/07/2022	WTG5	*Pipistrellus kuhlii*	0.4-8.9	part of the night (< 6 m/s)
23/07/2022	WTG1	*Hypsugo savii* (2), *Pipistrellus kuhlii*	0.4-8.4	part of the night (< 6 m/s)
23/07/2022	WTG3	*Hypsugo savii*	0.4-8.4	part of the night (< 6 m/s)
23/07/2022	WTG5	*Pipistrellus kuhlii*	0.4-8.4	part of the night (< 6 m/s)
23/07/2022	WTG10	*Hypsugo savii*	0.4-8.4	part of the night (< 6 m/s)
23/07/2022	WTG15	*Pipistrellus kuhlii*	0.4-8.4	part of the night (< 5 m/s)
25/07/2022	WTG1	*Pipistrellus kuhlii*	2.0-6.7	part of the night (< 6 m/s)
25/07/2022	WTG2	*Pipistrellus kuhlii*	2.0-6.7	part of the night (< 6 m/s)
25/07/2022	WTG5	*Pipistrellus kuhlii* (4)	2.0-6.7	part of the night (< 6 m/s)
25/07/2022	WTG7	*Pipistrellus kuhlii*	2.0-6.7	part of the night (< 6 m/s)
25/07/2022	WTG8	*Pipistrellus kuhlii*, Chiroptera sp.	2.0-6.7	part of the night (< 6 m/s)
25/07/2022	WTG11	Chiroptera sp.	2.0-6.7	part of the night (< 5 m/s)
25/07/2022	WTG13	*Pipistrellus* sp. / *Hypsugo savii*	2.0-6.7	part of the night (< 5 m/s)
25/07/2022	WTG15	Chiroptera sp.	2.0-6.7	part of the night (< 5 m/s)
25/07/2022	WTG17	Chiroptera sp.	2.0-6.7	part of the night (< 5 m/s)
26/07/2022	WTG19	*Hypsugo savii*	0.4-7.4	no
26/07/2022	WTG18	*Pipistrellus kuhlii*	0.4-7.4	part of the night (< 5 m/s)
26/07/2022	WTG10	*Hypsugo savii*	0.4-7.4	part of the night (< 6 m/s)
26/07/2022	WTG2	*Pipistrellus kuhlii*	0.4-7.4	part of the night (< 6 m/s)
27/07/2022	WTG4	*Pipistrellus kuhlii*	0.5-7.5	part of the night (< 6 m/s)
27/07/2022	WTG8	Chiroptera sp.	0.5-7.5	part of the night (< 6 m/s)
27/07/2022	WTG11	*Hypsugo savii*	0.5-7.5	part of the night (< 5 m/s)
28/07/2022	WTG8	*Hypsugo savii*	0.9-12.1	part of the night (< 6 m/s)
28/07/2022	WTG3	*Hypsugo savii*	0.9-12.1	part of the night (< 6 m/s)
28/07/2022	WTG2	*Hypsugo savii*	0.9-12.1	part of the night (< 6 m/s)
29/07/2022	WTG2	*Hypsugo savii*	0.3-7.0	part of the night (< 6 m/s)
29/07/2022	WTG11	*Pipistrellus kuhlii*	0.3-7.0	part of the night (< 5 m/s)
30/07/2022	WTG5	*Pipistrellus kuhlii*	0.3-10.9	part of the night (< 6 m/s)
02/08/2022	WTG5	*Hypsugo savii*	2.2-9.4	part of the night

DATE	WTG	SPECIES	NIGHTLY WIND SPEED (m/s)*	INCREASED CUT-IN SPEED
				(< 6 m/s)
04/08/2022	WTG3	*Pipistrellus kuhlii*	2.5-8.8	part of the night (< 6 m/s)
08/08/2022	WTG2	*Pipistrellus kuhlii*	2.6-12.6	part of the night (< 6 m/s)
25/08/2022	WTG7	*Hypsugo savii*	2.2-10.7	part of the night (< 5.5 m/s)
26/08/2022	WTG2	*Pipistrellus kuhlii*	0.9-9.1	part of the night (< 5.5 m/s)
29/08/2022	WTG2	*Vespertilio murinus*	0.5-6.2	part of the night (< 5.5 m/s)
06/09/2022	WTG11	*Nyctalus noctula*	0.1-7.3	no

**measured at WTG3 and WTG18*

3.4. Searcher efficiency trial

Out of 30 bat carcasses placed for the June trial, on the first day of search eight carcasses were found, while 14 were already removed by scavengers. On the second day, two more carcasses were found, and four more carcasses were removed. After two days the search team found 10 of 12 available bat carcasses (83.33 %) (Table 3-8).

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

CARCASS CODE	WTG	Day 1	Day 2
B1	WTG1		
B2	WTG2		
B3	WTG3		
B4	WTG5		
B5	WTG6		
B6	WTG8		
B7	WTG8		
B8	WTG8		
B9	WTG10		
B10	WTG10		
B11	WTG10		
B12	WTG11		
B13	WTG11		
B14	WTG11		
B15	WTG12		
B16	WTG12		
B17	WTG12		
B18	WTG13		
B19	WTG13		
B20	WTG15		
B21	WTG15		
B22	WTG16		
B23	WTG16		

CARCASS CODE	WTG	Day 1	Day 2
B24	WTG17		
B25	WTG17		
B26	WTG18		
B27	WTG18		
B28	WTG18		
B29	WTG19		
B30	WTG20		
TOTAL FOUND		**8/16**	**2/4**

Green = carcass found; orange = carcass not found; grey = carcass missing

The trial was repeated in July with 30 artificial bat carcass substitutes and a different survey team. This time no artificial bat carcass substitutes were removed, while the trial showed comparable results regarding searcher efficiency. On the first day, 16 carcass substitutes were found, while on the second day, seven more carcasses were found. After two days the search team found 23 of 30 bat carcass substitutes (76.67 %) (Table 3-9).

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

CARCASS CODE	WTG	Day 1	Day 2
B1	WTG1		
B2	WTG1		
B3	WTG1		
B4	WTG2		
B5	WTG3		
B6	WTG3		
B7	WTG4		
B8	WTG5		
B9	WTG6		
B10	WTG6		
B11	WTG7		
B12	WTG8		
B13	WTG8		
B14	WTG9		
B15	WTG11		
B16	WTG11		
B17	WTG13		
B18	WTG13		
B19	WTG13		
B20	WTG14		
B21	WTG14		
B22	WTG15		
B23	WTG15		
B24	WTG16		
B25	WTG17		

CARCASS CODE	WTG	Day 1	Day 2
B26	WTG18		
B27	WTG18		
B28	WTG18		
B29	WTG19		
B30	WTG20		
TOTAL FOUND		**16/30**	**7/14**

Green = carcass found; orange = carcass not found

Since the second 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. Estimated efficiency was 38 – 66 % (median 52 %; 95 % confidence intervals).

3.5. Carcass persistence trial

Out of 30 placed mouse carcasses, four were removed during the first night after placement (after half a day). Ten carcasses were found to be missing after two nights (after 1.5 days), five carcasses after three nights (after 2.5 days) and three carcasses after four nights (3.5 days). One carcass was removed after five nights (4.5 days), after six (5.5 days) and after seven (5.6 days) each. After eight nights (6.5 days) there were two carcasses removed. After 9 nights (8.5 days) there was still three carcasses remaining (Table 3-10; Figure 3-33). Average carcass persistence was 2.83 days.

Table 3-10 Results of the carcass persistence trial

CARCASS CODE	WTG	DAYS OF PERSISTENCE									
		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
M1	WTG2	+	+	+	+	+	+	+	+	+	> 8.5
M2	WTG3	+	+	+	-						2.5-3.5
M3	WTG3	+	+	+	+	+	+	+	-		6.5-7.5
M4	WTG4	-									< 0.5
M5	WTG4	+	+	-							1.5-2.5
M6	WTG4	+	-								0.5-1.5
M7	WTG5	-									< 0.5
M8	WTG5	+	+	+	+	+	+	+	+	+	> 8.5
M9	WTG6	+	+	+	+	+	+	-			5.5-6.5
M10	WTG7	+	+	+	-						2.5-3.5
M11	WTG7	+	+	+	-						2.5-3.5
M12	WTG7	+	+	+	+	+	-				4.5-5.5
M13	WTG8	+	+	+	+	+	+	+	-		6.5-7.5
M14	WTG8	+	+	+	+	+	+	+	+	+	> 8.5
M15	WTG8	+	-								0.5-1.5
M16	WTG9	+	-								0.5-1.5
M17	WTG10	+	-								0.5-1.5
M18	WTG12	+	-								0.5-1.5
M19	WTG13	+	+	-							1.5-2.5

CARCASS CODE	WTG	DAYS OF PERSISTENCE									
		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
M20	WTG14	+	-								0.5-1.5
M21	WTG14	+	-								0.5-1.5
M22	WTG15	+	-								0.5-1.5
M23	WTG15	-									< 0.5
M24	WTG15	+	+	-							1.5-2.5
M25	WTG16	+	+	-							1.5-2.5
M26	WTG17	-									< 0.5
M27	WTG17	+	-								0.5-1.5
M28	WTG18	+	+	-							1.5-2.5
M29	WTG19	+	-								0.5-1.5
M30	WTG20	+	+	+	+	-					3.5-4.5
NUMBER OF MISSING CARCASSES		**4**	**10**	**5**	**3**	**1**	**1**	**1**	**2**	**0**	

Green = carcass found; orange = carcass not found

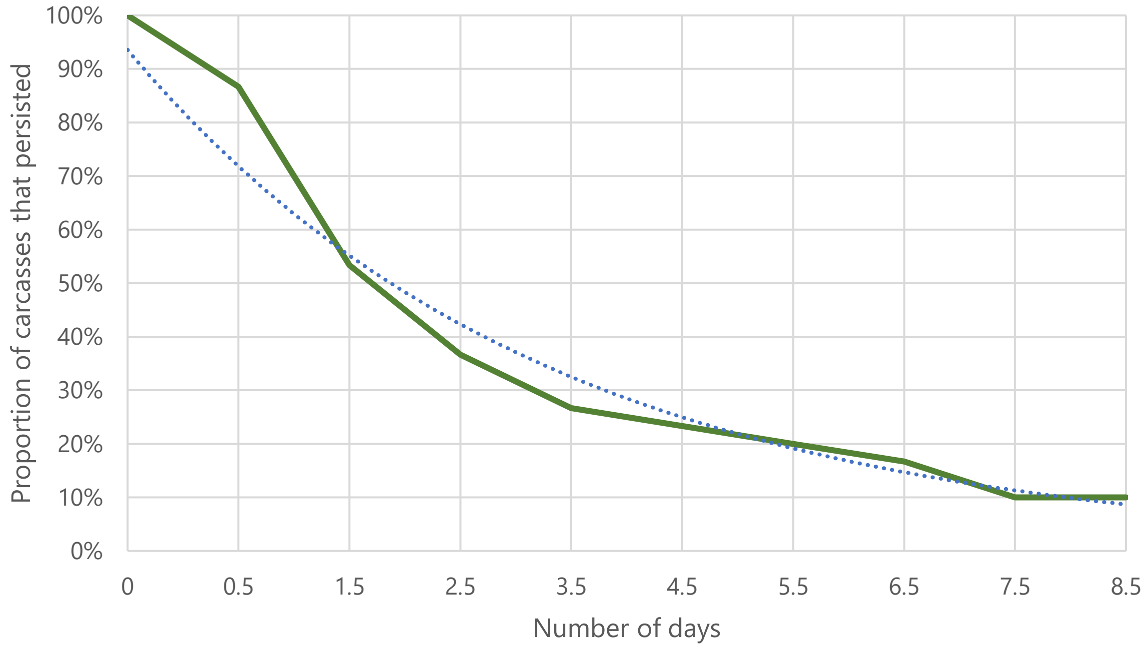

Figure 3-33 Carcass persistence according to the trial (trendline shown dotted)

Mortality estimator GenEst (USGS 2018) was used to estimate carcass persistence based on the trial results. Estimation for average carcass persistence (median) was 1.8 days (95 % confidence intervals; Figure 3-34).

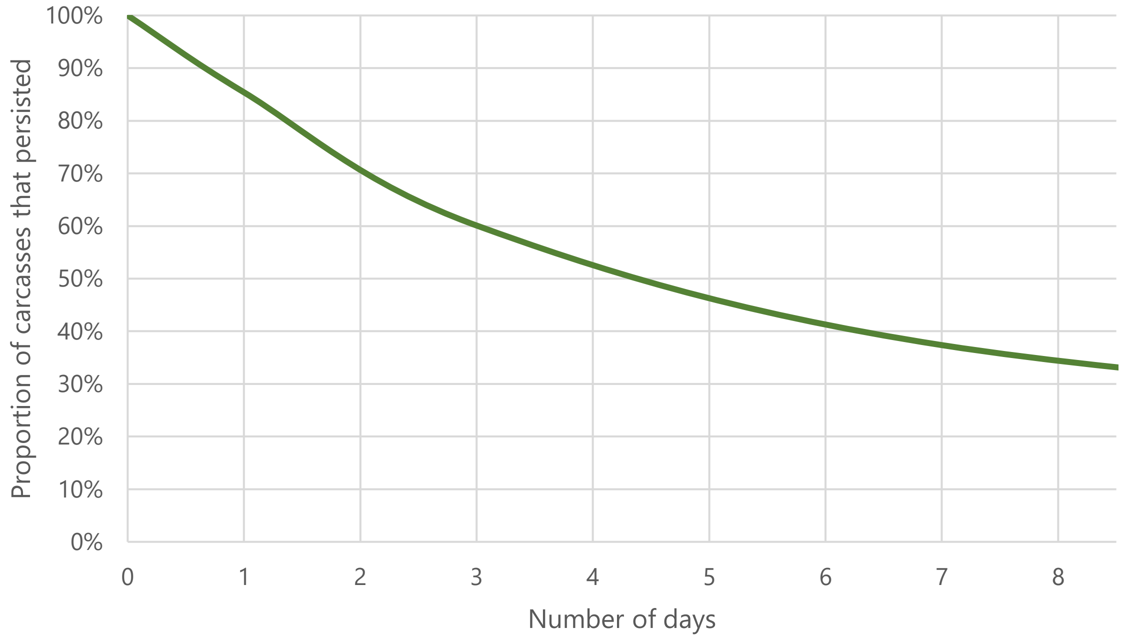

Figure 3-34 Carcass persistence according to GenEst

3.6. Estimation of mortality

To estimate total mortality at WF Jelinak, the number of carcasses found during monitoring of bat fatalities was corrected for searched area, carcass persistence, searcher efficiency and distance from WTG. Mortality estimator GenEst (USGS 2018) was used, which is the best available statistical mortality estimator (Rabie et al. 2021).

Since only accessible areas of good (high and moderate) visibility were searched within 70 m buffers around WTGs, 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 up 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 II; Table 3-11).

Table 3-11 Average density weight proportion per turbine

WTG	AVERAGE DWP	WTG	AVERAGE DWP
WTG1	18.57 %	**WTG11**	29.43 %
WTG2	20.55 %	**WTG12**	19.53 %
WTG3	14.30 %	**WTG13**	19.62 %
WTG4	17.92 %	**WTG14**	17.84 %
WTG5	17.45 %	**WTG15**	24.57 %
WTG6	18.38 %	**WTG16**	21.55 %
WTG7	25.81 %	**WTG17**	25.49 %
WTG8	23.66 %	**WTG18**	18.91 %
WTG9	15.83 %	**WTG19**	20.54 %
WTG10	21.13 %	**WTG20**	23.28 %

For the estimation of total mortality GenEst uses:

- Carcass observations (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 16th to October 6th 2022 was 338.48 – 676.57 (median 473.36; 95 % confidence intervals).

GenEst mortality estimator doesn't account for distance of carcasses from WTG. That adjustment is important in total mortality estimation because 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) and are spread over increasingly greater areas at greater distances from WTGs (Huso and Dalthorp 2014).

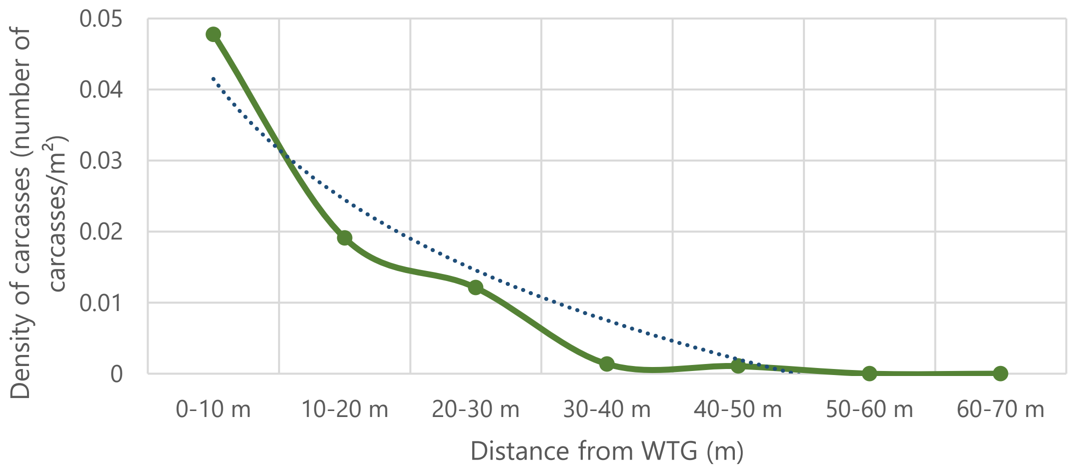

Figure 3-35 Density of carcasses found in regard to distance from WTG (trendline shown dotted)

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. 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):

$$f(d) = 1/[1 + y_0^{-1}(1 - y_0)^{1-d}]$$

where $y_0 = 0.05$ and d = distance from WTG.

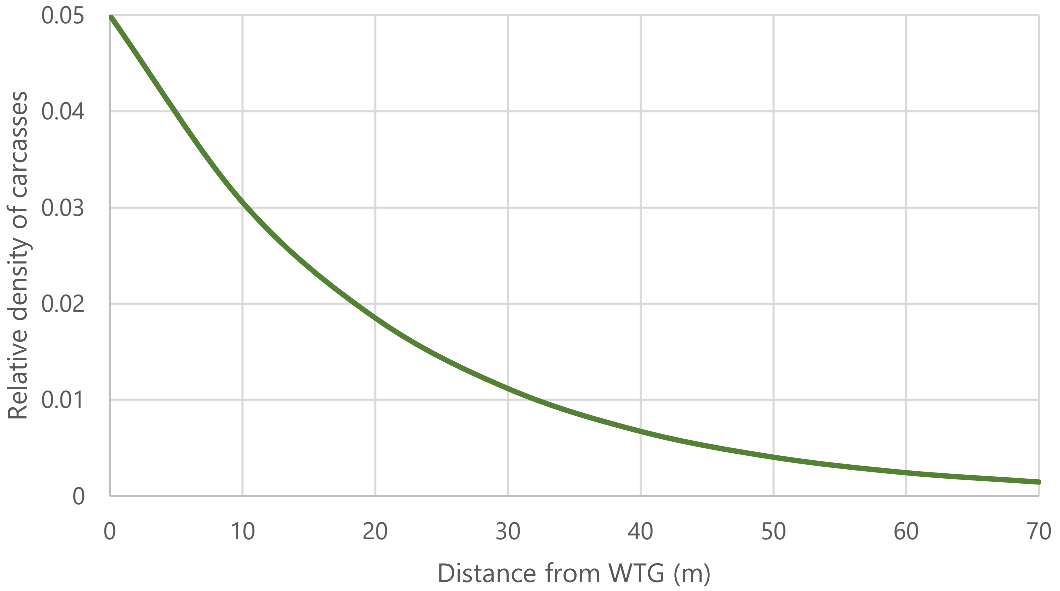

Figure 3-36 Empirical DL05 distribution of fatalities (Huso and Dalthorp 2014)

Locations of discovered carcasses were sorted into 10-meter groups (rings or annuli) 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. The decrease of carcass density with distance from a WTG is reflected in the coefficients (Table 3-12).

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 corrected estimated number of bat fatalities is **86**.

Table 3-12 Correction of estimated bat fatalities for distance of carcasses from WTG's

10-m ring	Ring area (m^2)	Proportion of ring area	Number of carcasses found	Estimated number of fatalities	Distribution coefficient*	Corrected estimated number of fatalities
0 – 10 m	314	2 %	15	9.66	1.00	10
10 – 20 m	942	6 %	18	28.97	0.61	18
20 – 30 m	1,571	10 %	19	48.31	0.37	18
30 – 40 m	2,199	14 %	3	67.62	0.22	15
40 – 50 m	2,827	18 %	3	86.93	0.13	11
50 – 60 m	3,456	22 %	0	106.28	0.08	9
60 – 70 m	4,084	27 %	0	125.59	0.05	6
TOTAL	**31,379**	**100 %**	**58**	**1,288.22**		**86**

** based on Huso and Dalthorp 2014*

3.6.1. Estimations of mortality per WTG

GenEst can also estimate mortality for each WTG. The results of those estimations, as well as estimations corrected for distance of carcasses from WTG are shown below (Table 3-13, Figure 3-37).

The highest mortality was estimated for WTG2 and WTG5. Average number of fatalities was 4, which means that estimated mortality was above the average at nine WTG's (WTG1, WTG2, WTG3, WTG4, WTG5, WTG8, WTG10, WTG11, WTG17).

Table 3-13 Estimated number of fatalities per WTG

WTG	Carcasses found	GenEst estimation	Corrected estimation
WTG1	4	31.65	6
WTG2	9	69.81	13
WTG3	4	42.26	8
WTG4	2	31.26	6
WTG5	8	66.87	12
WTG6	0	0	0
WTG7	3	17.07	3
WTG8	4	25.03	5
WTG9	2	18.5	3
WTG10	4	28.88	5
WTG11	5	31.25	6
WTG12	0	0	0
WTG13	2	14.75	3
WTG14	1	17.15	3
WTG15	3	17.96	3
WTG16	1	6.76	1
WTG17	3	29.36	5
WTG18	1	7.83	1
WTG19	2	14.13	3
WTG20	0	0	0

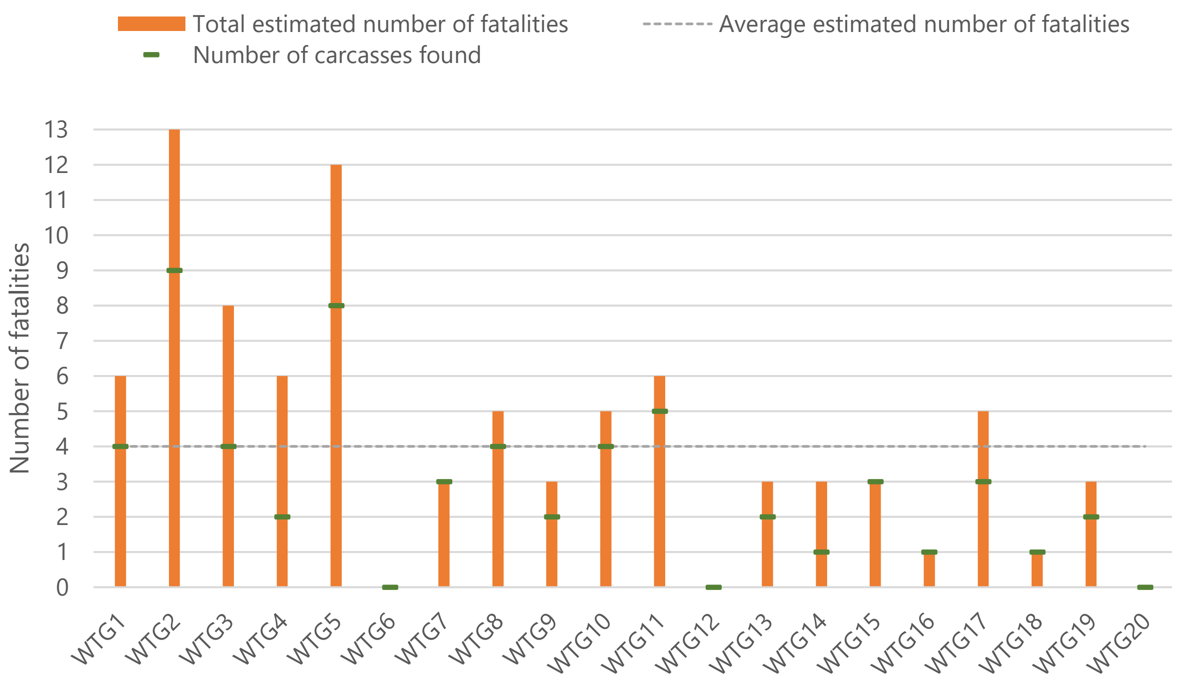

Figure 3-37 Comparison of number of found bat carcasses and mortality estimations per turbine

3.6.2. Comparison of mortality with previous years

The number of bat carcasses found at WF Jelinak during all monitoring years (2013, 2014, 2015, 2016, 2017, 2020, 2021 and 2022) was compared (Figure 3-38, Figure 3-39). Field effort for monitoring of bat collision differed between years. Survey dynamics and the number of WTG's surveyed were not the same (Table 3-14), and search dogs were used in some surveys. Also, different modes of wind farm operation (i.e., mitigation measures) were implemented each year (Table 3-15). However, mortality survey design in 2022 was the same as in 2021, which allowed a direct comparison of the monitoring results.

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 rates 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 dynamics 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. In 2021 almost the same number of bat carcasses was found as in 2020. In 2022 number of found carcasses was slightly higher.

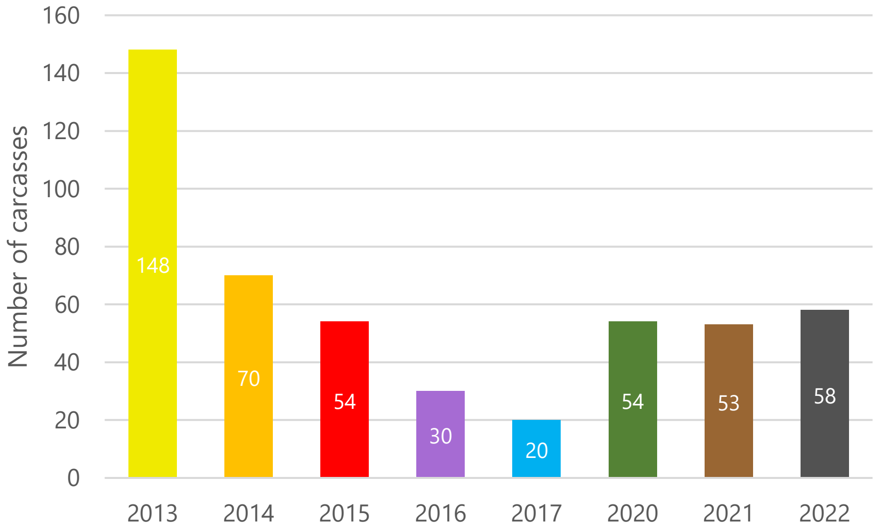

Figure 3-38 Number of bat carcasses found at WF Jelinak in 2013, 2014, 2015, 2016, 2017, 2020, 2021 and 2022

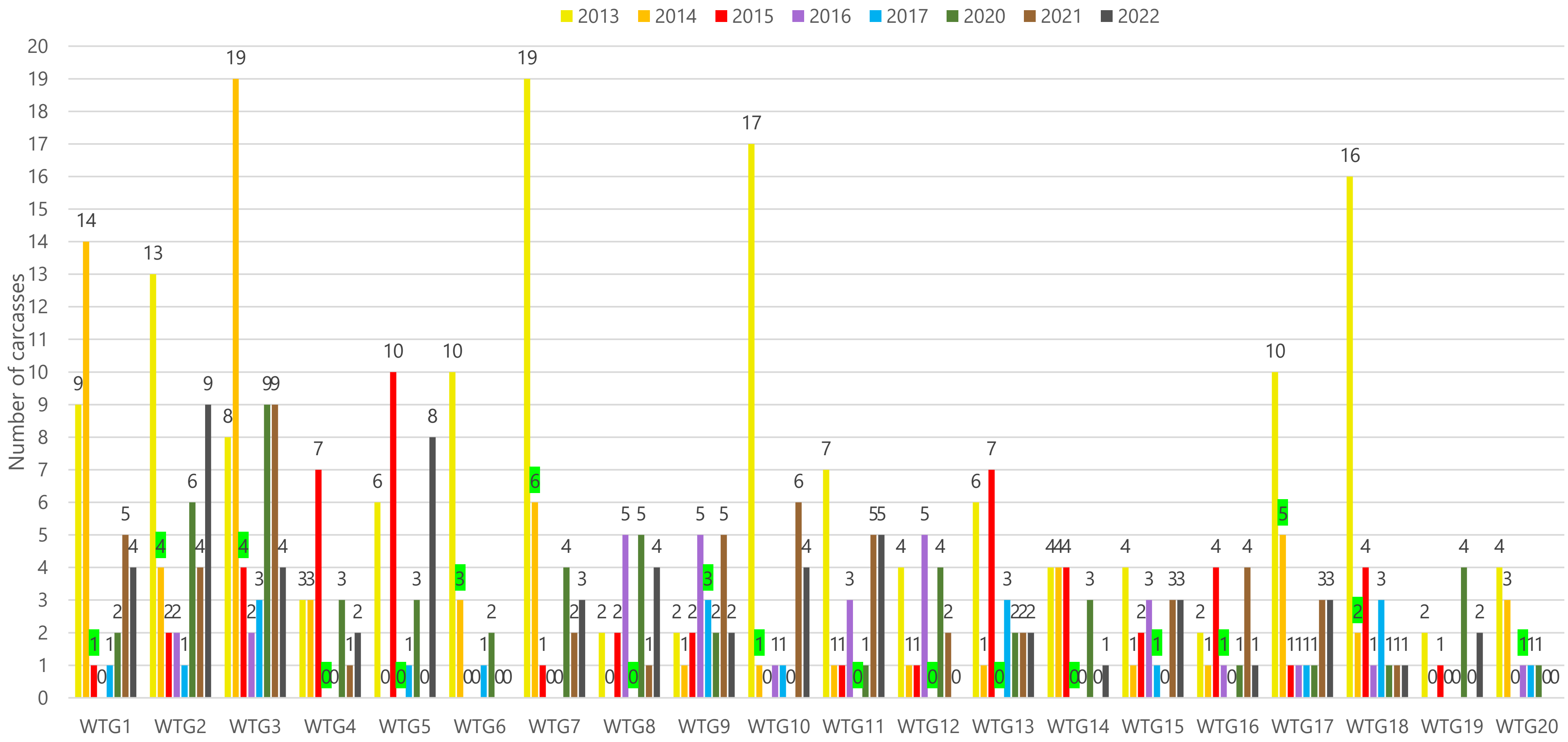

Figure 3-39 Number of bat carcasses per WTG found at WF Jelinak in 2013, 2014, 2015, 2016, 2017, 2020, 2021 and 2022 (number of carcasses when mitigation method was introduced is marked green)

Table 3-14 Survey dynamics for monitoring of bat collisions at WF Jelinak in 2013, 2014, 2015, 2016, 2017, 2020, 2021 and 2022

MONTH	SURVEY DYNAMICS							
	2013	2014	2015	2016	2017	2020	2021	2022
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	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	every day	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	every day	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	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	1 two-day search	1 two-day search

Table 3-15 Mitigation measures implemented at WF Jelinak in 2013, 2014, 2015, 2016, 2017, 2020, 2021 and 2022

PERIOD	WTG'S	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 until 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 until 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 until half an hour after sunrise
1.-15.7.2021.	WTG1, WTG10, WTG13, WTG17, WTG18	yes	5.0 m/s	9 pm-3 am
1.-15.7.2021.	WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14	yes	5.5 m/s	9 pm-3 am
16.7.-15.8.2021.	WTG1, WTG10, WTG13, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise
16.7.-15.8.2021.	WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14	yes	5.5 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.2021.	WTG1, WTG10, WTG13, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.2021.	WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14	yes	5.5 m/s	from half an hour before sunset until half an hour after sunrise
1.-30.9.2021.	WTG5, WTG8, WTG12, WTG13, WTG16, WTG20	yes	5.5 m/s	from half an hour before sunset until 3 am
1.-15.7.2022.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	9 pm-3 am
1.-15.7.2022.	WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14	yes	5.5 m/s	9 pm-3 am
16.7.-15.8.2022.	WTG9, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise

PERIOD	WTG'S	BLADE FEATHERING	CUT-IN SPEED	TIMING
16.7.-15.8.2022.	WTG1, WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG10, WTG12, WTG14	yes	6.0 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.2022.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.2022.	WTG2, WTG3, WTG4, WTG5, WTG6, WTG7, WTG8, WTG12, WTG14	yes	5.5 m/s	from half an hour before sunset until half an hour after sunrise
1.-30.9.2022.	WTG5, WTG8, WTG12, WTG13, WTG16, WTG20	yes	5.0 m/s	from half an hour before sunset until 3 am

WTG3, which had the highest mortality in 2021, did not have the highest mortality in 2022. It was the neighbouring WTG2 instead. Surprisingly, WTG5 had no mortality recorded in 2021, but had the second highest mortality in 2022 (Figure 3-40 and Figure 3-41).

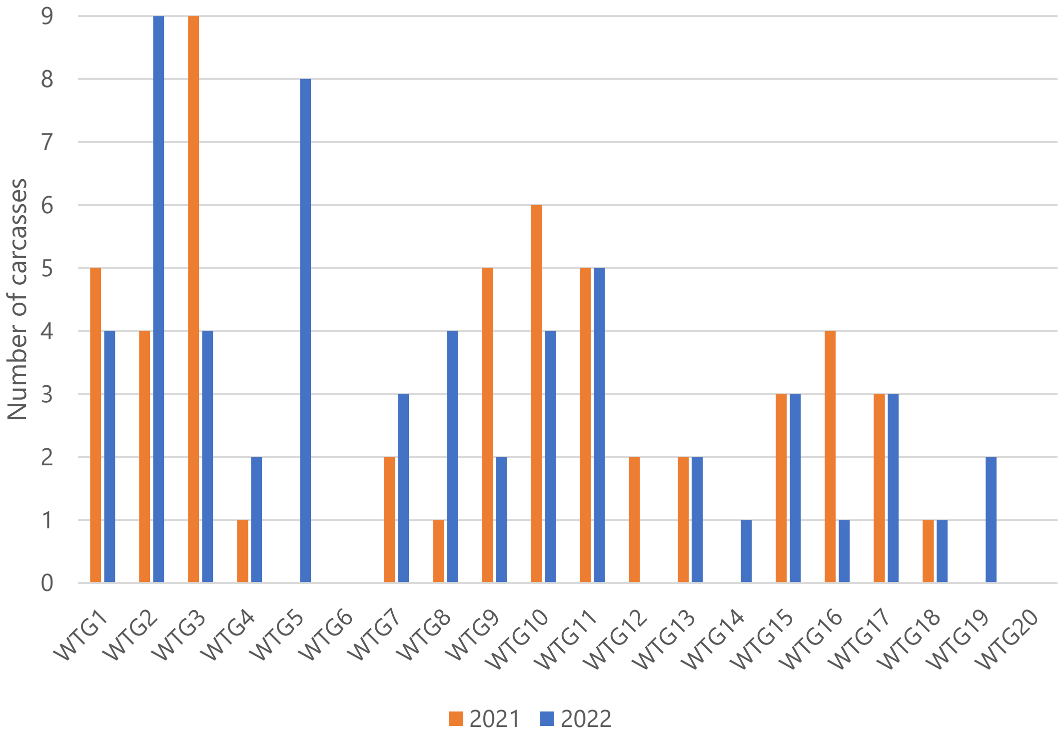

Figure 3-40 Number of bat carcasses found in 2021 and 2022 per WTG

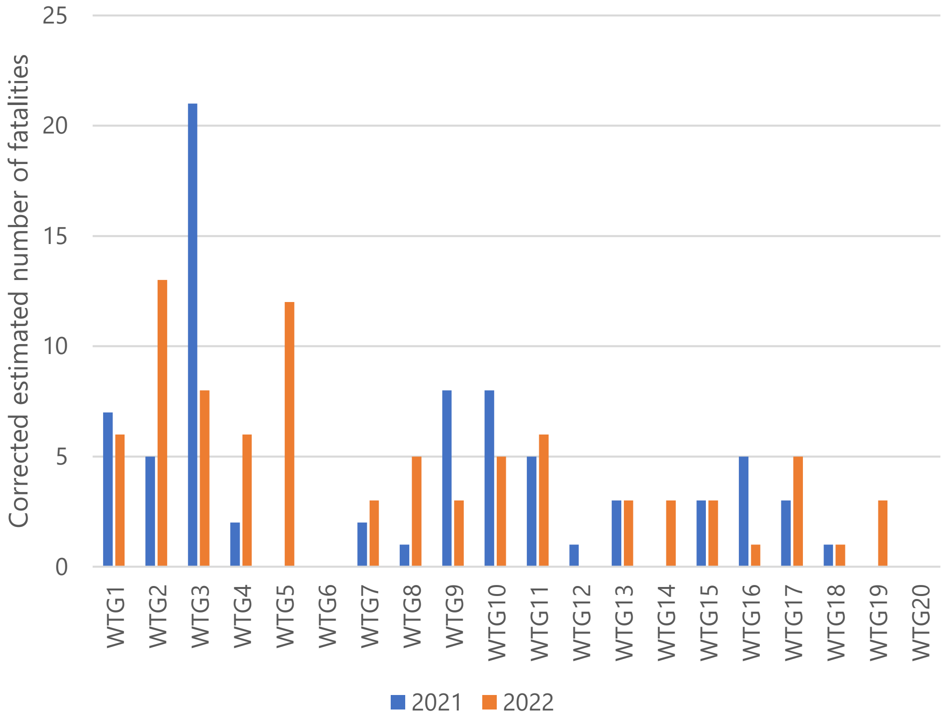

Figure 3-41 Corrected estimated number of bat fatalities in 2021 and 2022 per WTG

4. MITIGATION MEASURES PROPOSAL

Due to a relatively high estimated mortality at WF Jelinak, which represents a negative impact on local bat populations, mitigation measures are proposed to minimise those impacts 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.

Results showed that mitigation measures which were implemented in 2021 were largely efficient in the first half of July, second half of August and in September, but in the second half of July and the first half of August bat mortality was high. Unlike a few previous years of monitoring, WTG3 did not have the highest mortality rate, although visual observations and stationary recording at the nacelle hight showed that bats are flying at that location more frequently than the other monitored locations. Instead, WTG2 had the highest mortality rate, which is the neighbouring WTG. They are both located in the lowest part of the WF and are more suitable for bat activities, therefore pose more risk for collisions. The second highest mortality was at WTG5, which had zero or very low mortality in previous years and is likely coincidental and doesn't reflect an overall pattern for that location.

Most of the collisions occurred when mitigation measures were implemented, which means that the implemented cut-in speed was not high enough to prevent it. To further improve prevention of bat mortality, alteration of mitigation measures is proposed for WTG2 and WTG3 in the second half of July and the first half of August, when cut-in wind speed is proposed to be 6.5 m/s (Table 4-1).

Table 4-1 Proposal of further mitigation measures

PERIOD	WIND TURBINE GENERATORS	BLADE FEATHERING	CUT-IN SPEED	TIMING
1.-15.7.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, 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.	WTG9, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until half an hour after sunrise
	WTG1, WTG4, WTG5, WTG6, WTG7, WTG8, WTG10, WTG12, WTG14	yes	6.0 m/s	from half an hour before sunset until half an hour after sunrise
	WTG2, WTG3	yes	6.5 m/s	from half an hour before sunset until half an hour after sunrise
16.-31.8.	WTG1, WTG9, WTG10, WTG11, WTG13, WTG15, WTG16, WTG17, WTG18	yes	5.0 m/s	from half an hour before sunset until 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 until half an hour after sunrise
1.9.-30.9.	WTG5, WTG8, WTG12, WTG13, WTG16, WTG20	yes	5.0 m/s	from half an hour before sunset until 3 am

5. SUMMARY

The bat monitoring program for wind farm Jelinak was conducted from June 2022 to October 2022. Monitoring was designed in coordination with monitoring reports from previous years of post-construction monitoring at WF Jelinak and the project task.

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 visual monitoring of bat activity around selected WTG's.

Continuous bat call recording was implemented on two WTG locations. Three microphones were set up. Bat detectors were set up to continuously record bat calls each night from June to October. A total of 58,985 bat passes were recorded. Bat activity was found to be highest in July and August, and lowest in October. Correlation of bat activity with wind speed was analysed and it was found that bat activity decreased with increasing wind speeds. Visual observation showed that bats are not in a risk of collision while circling around WTG's, but rather when flying linearly past WTG's, among which WTG3 is probably at the most frequent flying route.

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 58 carcasses were found. They belonged to at least four bat species: *Pipistrellus kuhlii* (23), *Hypsugo savii* (22), *Nyctalus noctula* (1) and *Vespertilio murinus* (1). Eleven carcasses were in too poor a condition for identification (nine were noted as small Chiroptera sp., one as *Pipistrellus* sp. and one as *Hypsugo savii* / *Pipistrellus* sp.). Searcher efficiency and carcasses persistence trials were implemented as well, in order to estimate the total number of fatalities. Search results were then analysed and corrected for carcass persistence, searcher efficiency, proportion of searched area, and distance from WTG. Estimation using GenEst estimator tool show a total estimated mortality of 86 bats.

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. Therefore, mitigations measures were proposed, that build upon the measures implemented earlier, as well as methodology for further monitoring.

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6.3. Internet sources

1. Bing Maps (2023): Bing Areal. www.bing.com/maps/aerial
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7. APPENDIX

Appendix I Example of a field form for monitoring of bat collisions

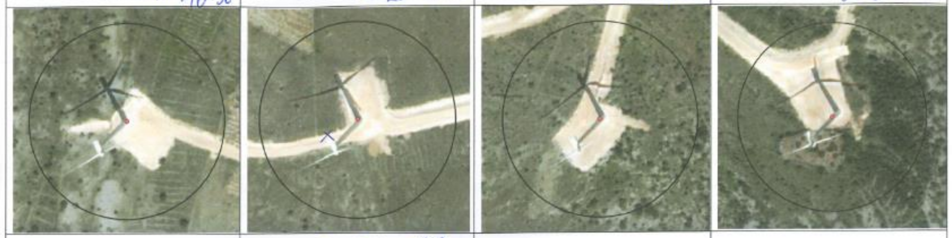
Monitoring smrtnosti - VE Jelinak

DATUM: 26.7.2022.	PRISUTNI ISTRAŽIVAČI: ZLATAN TROKIĆ, DORA KRAJ			
MIKROKLIMATSKI UVJETI — POČETAK	vrijeme: 5:10	T (°C): 26,8°C	H (%): 27%	vjetar (m/s): 2,3 - 2,7m/s
MIKROKLIMATSKI UVJETI — ZAVRŠETAK:	vrijeme: 10:56	T (°C): 31,9 °C	H (%): 48.1 %	vjetar (m/s): 3,9-4.8

R.BR.	ŠIFRA NALAZA	VA	VRSTA	SPOL	DOB	FA	OZLJEDE	STANJE	NAPOMENE
1.	148DK	19	Hsav	♀	AD	33,84	/	SVJEŽ	
2.	091ZT	ØVA18	Pkuh	♂	JUV	34,63	/	—"—	
3.	092ZT	VA10	Hsav	♀	JUV	36.00	/	SVJEŽ	
4	DK149	VA2	Pkuh	♀	AD	34,45	/	SVJEŽ	

Monitoring smrtnosti - VE Jelinak

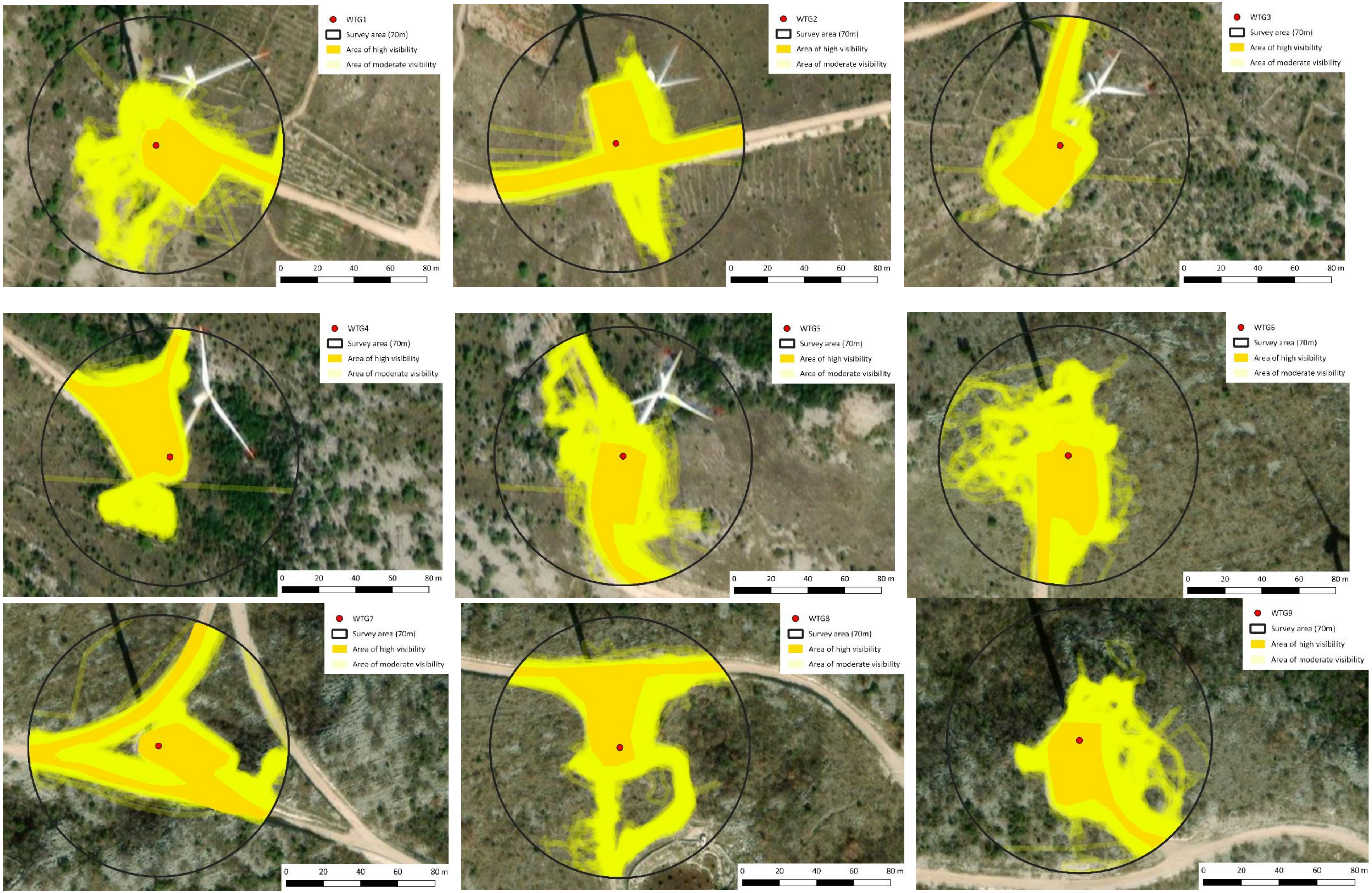
VA1 | TRAJANJE (min): 10:41-10:56	VA2 | TRAJANJE (min): 10:25-10:40	VA3 | TRAJANJE (min): 10:05-10:20	VA4 | TRAJANJE (min): 9:48-10:03

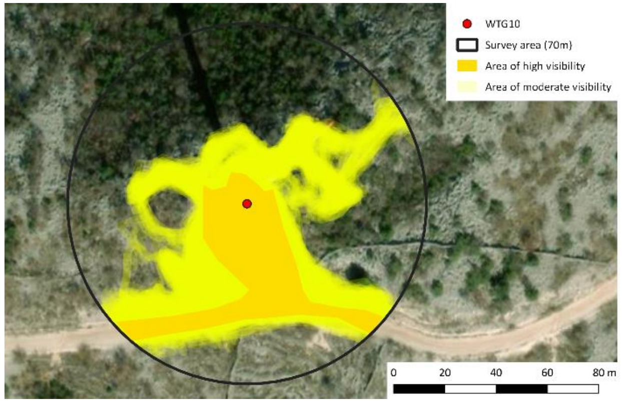


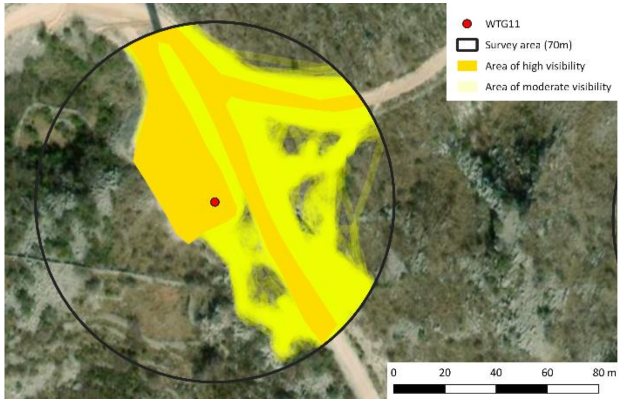
	NALAZ DK149		

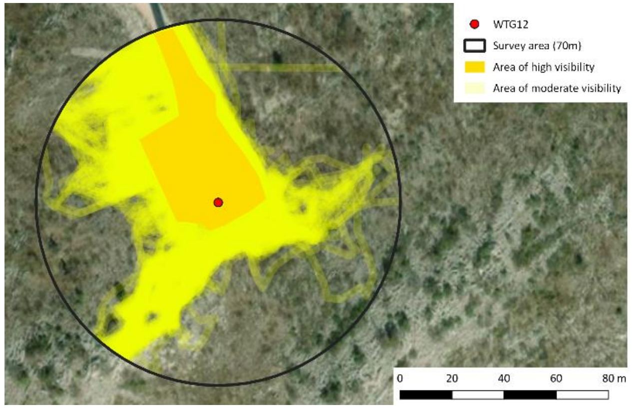
VA5 | TRAJANJE (min): 9:26-9:41	VA6 | TRAJANJE (min): 9:09-9:24	VA7 | TRAJANJE (min): 8:52-9:07	VA8 | TRAJANJE (min): 8:36-8:51

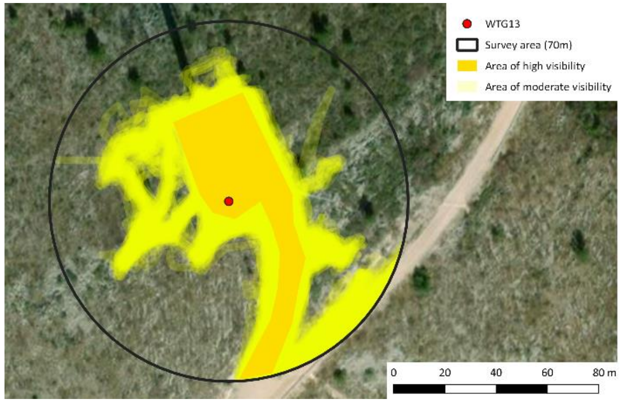
Appendix II Areas searched for bat carcasses around each WTG (darker yellow indicates more frequent searches) (Base map: Bing Maps)

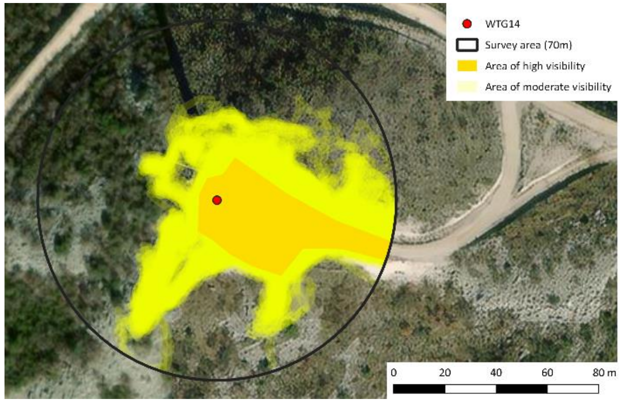


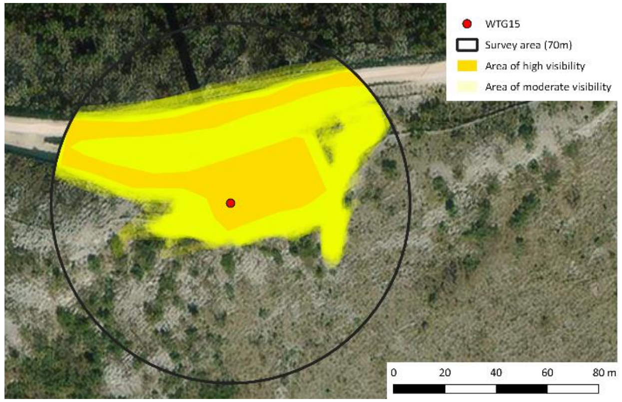

WTG10
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

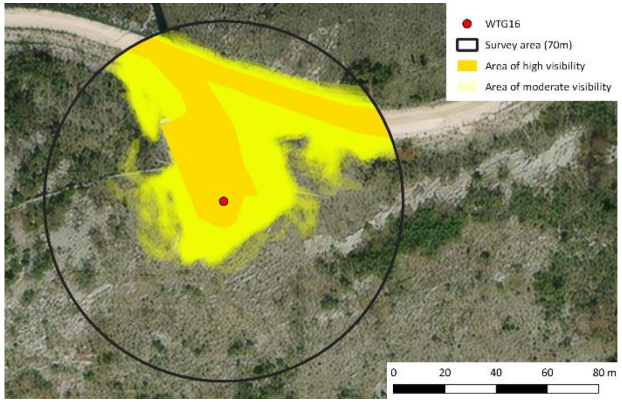

WTG11
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

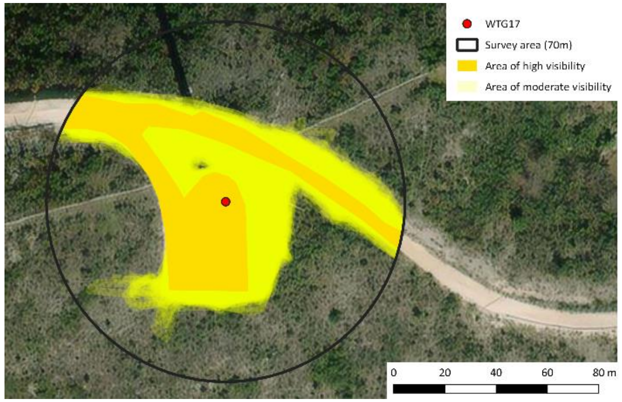

WTG12
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

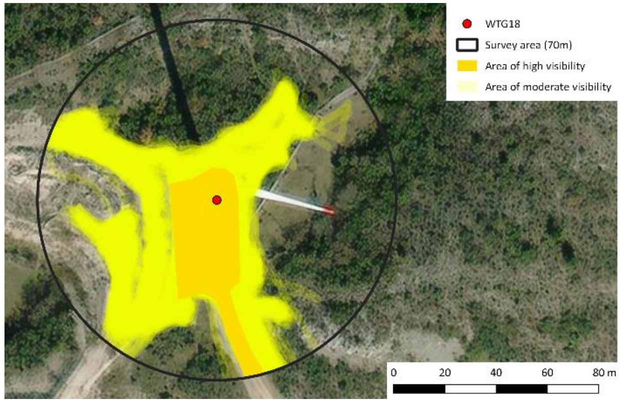

WTG13
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

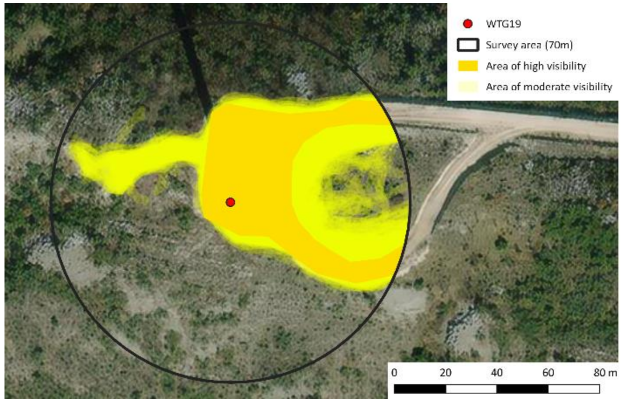

WTG14
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

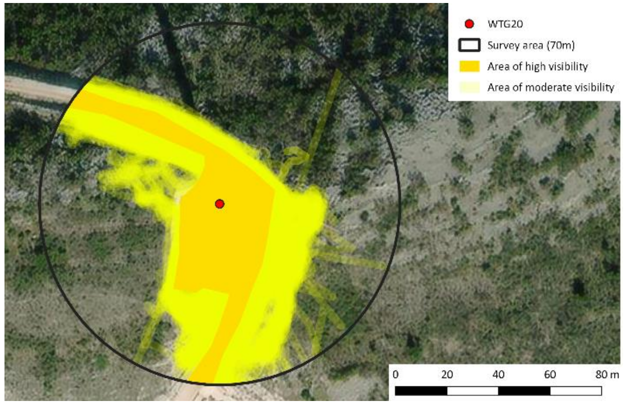

WTG15
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m


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


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


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


WTG19
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m


WTG20
Survey area (70m)
Area of high visibility
Area of moderate visibility
0 20 40 60 80 m

Appendix III Carcasses found during monitoring of bat collisions

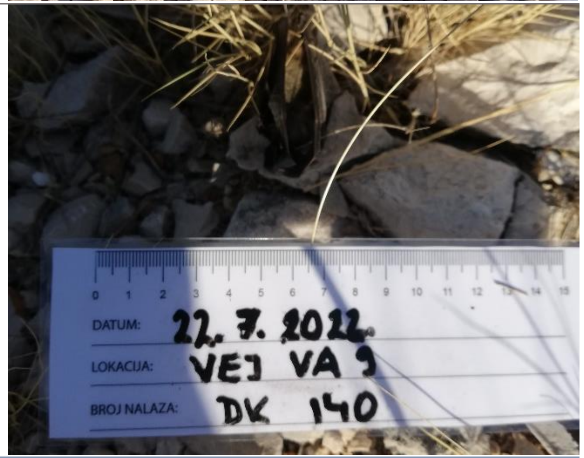
DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
23.6.2022.	WTG14	*Hypsugo savii*	Female	Lactating adult	33.64	No	Fresh	
23.6.2022.	WTG17	*Hypsugo savii*	Female	Lactating adult	34.21	Fracture of left phalanx	Fresh	
1.7.2022.	WTG17	*Hypsugo savii*	Female	Adult	35.02	No	Older	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
2.7.2022.	WTG4	*Pipistrellus* sp.	-	Adult	34.10	No	Older	
2.7.2022.	WTG2	*Pipistrellus kuhlii*	Male	Adult	34.13	No	Fresh	
3.7.2022.	WTG2	Chiroptera sp.	-	-	30.32	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
5.7.2022.	WTG10	*Hypsugo savii*	Female	Adult	34.51	No	Fresh	
12.7.2022.	WTG7	*Hypsugo savii*	Female	Adult	34.57	Wound on left scapula	Fresh	
15.7.2022.	WTG11	*Pipistrellus kuhlii*	Female	Adult	34.45	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
17.7.2022.	WTG16	Chiroptera sp.	Female	Adult	34.87	No	Fresh	
20.7.2022.	WTG19	Chiroptera sp.	-	Juvenile	33.78	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
20.7.2022.	WTG15	*Hypsugo savii*	Female	Adult	34.32	Fractures of both forearms	Fresh	
20.7.2022.	WTG9	*Hypsugo savii*	Female	Juvenile	33.47	No	Fresh	
20.7.2022.	WTG3	*Hypsugo savii*	Male	Juvenile	30.96	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
22.7.2022.	WTG13	*Hypsugo savii*	Male	Juvenile	34.78	No	Fresh	
22.7.2022.	WTG10	Chiroptera sp.	-	Juvenile	35.04	No	Fresh	
22.7.2022.	WTG9	*Pipistrellus kuhlii*	Male	Adult	33.57	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
22.7.2022.	WTG5	*Pipistrellus kuhlii*	Male	Juvenile	33.63	No	Fresh	
23.7.2022.	WTG1	*Hypsugo savii*	Female	Juvenile	35.24	No	Fresh	
23.7.2022.	WTG1	*Pipistrellus kuhlii*	Female	Adult	35.98	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
23.7.2022.	WTG1	*Hypsugo savii*	Female	Juvenile	34.59	No	Fresh	
23.7.2022.	WTG3	*Hypsugo savii*	Male	Adult	33.26	No	Fresh	
23.7.2022.	WTG5	*Pipistrellus kuhlii*	Male	Adult	33.80	No	Fresh	

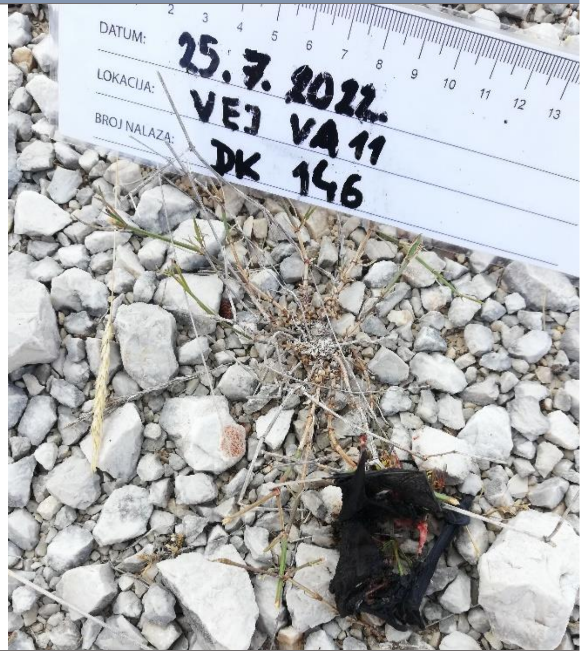
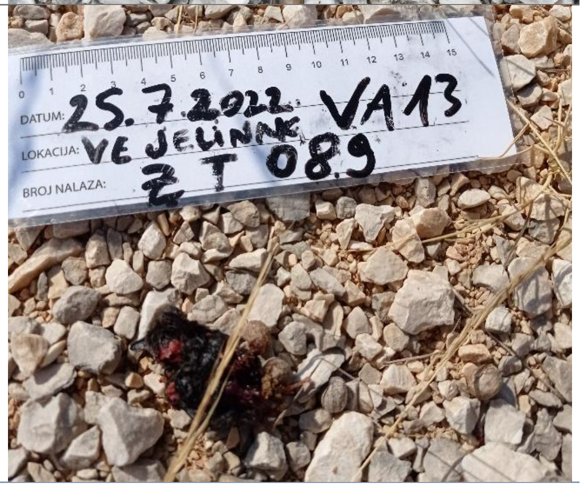
DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
23.7.2022.	WTG10	*Hypsugo savii*	Female	Juvenile	34.00	No	Fresh	
23.7.2022.	WTG15	*Pipistrellus kuhlii*	-	Adult	33.44	No	Fresh	
25.7.2022.	WTG1	*Pipistrellus kuhlii*	Female	Lactating adult	32.95	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG2	*Pipistrellus kuhlii*	Female	Adult	34.78	No	Fresh	
25.7.2022.	WTG5	*Pipistrellus kuhlii*	Female	Adult	32.98	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG5	*Pipistrellus kuhlii*	Female	Juvenile	35.19	No	Fresh	
25.7.2022.	WTG5	*Pipistrellus kuhlii*	Female	Adult	35.74	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG5	*Pipistrellus kuhlii*	Female	Adult	33.36	No	Fresh	
25.7.2022.	WTG7	*Pipistrellus kuhlii*	Male	Juvenile	34.20	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG8	*Pipistrellus kuhlii*	Female	Juvenile	31.94	No	Fresh	
25.7.2022.	WTG8	Chiroptera sp.	Female	-	32.72	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG11	Chiroptera sp.	-	Juvenile	34.97	No	Fresh	
25.7.2022.	WTG13	*Pipistrellus sp. / Hypsugo savii*	-	-	-	-	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.7.2022.	WTG15	Chiroptera sp.	Female	-	33.33	No	Fresh	
25.7.2022.	WTG17	Chiroptera sp.	-	-	33.36	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
26.7.2022.	WTG19	*Hypsugo savii*	Female	Adult	33.84	No	Fresh	
26.7.2022.	WTG18	*Pipistrellus kuhlii*	Male	Juvenile	34.63	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
26.7.2022.	WTG10	*Hypsugo savii*	Female	Juvenile	36.00	No	Fresh	
26.7.2022.	WTG2	*Pipistrellus kuhlii*	Female	Adult	34.45	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
27.7.2022.	WTG4	*Pipistrellus kuhlii*	Female	Juvenile	33.68	No	Fresh	
27.7.2022.	WTG8	Chiroptera sp.	-	-	-	-	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
27.7.2022.	WTG11	*Hypsugo savii*	Female	Juvenile	34.73	No	Fresh	
28.7.2022.	WTG8	*Hypsugo savii*	Male	Adult	33.85	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
28.7.2022.	WTG3	*Hypsugo savii*	Female	Juvenile	33.36	No	Fresh	
28.7.2022.	WTG2	*Hypsugo savii*	Female	Juvenile	35.90	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
29.7.2022.	WTG2	*Hypsugo savii*	Female	Juvenile	34.06	No	Fresh	
29.7.2022.	WTG11	*Pipistrellus kuhlii*	Female	Adult	34.54	No	Fresh	
30.7.2022.	WTG5	*Pipistrellus kuhlii*	Female	Subadult	34.51	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
2.8.2022.	WTG5	*Hypsugo savii*	Female	Juvenile	34.34	No	Fresh	
4.8.2022.	WTG3	*Pipistrellus kuhlii*	Female	Juvenile	34.51	No	Fresh	
8.8.2022.	WTG2	*Pipistrellus kuhlii*	Female	Adult	34.98	No	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
25.8.2022.	WTG7	*Hypsugo savii*	Female	Adult	33.86	No	Fresh	
26.8.2022.	WTG2	*Pipistrellus kuhlii*	Female	Adult	34.94	No	Fresh	
29.8.2022.	WTG2	*Vespertilio murinus*	Female	Adult	44.26	Fracture of right upper arm	Fresh	

DATE	WTG	SPECIES	SEX	AGE	FA (mm)	VISIBLE INJURIES	STATE OF CARCASS	PHOTO
6.9.2022.	WTG11	*Nyctalus noctula*	Female	Subadult	55.48	Fracture of right upper arm	Fresh