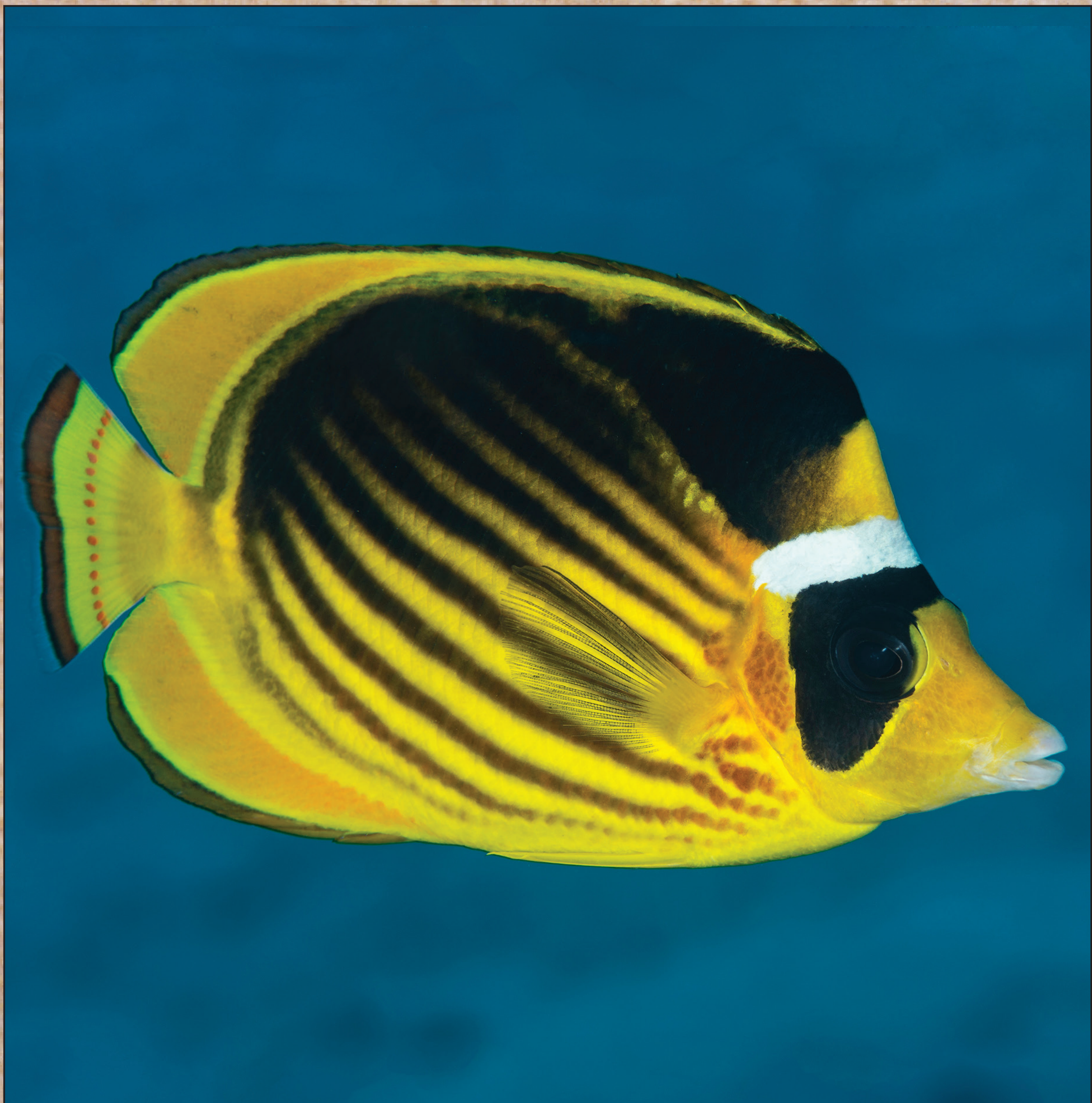
ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 36, 2026, 1



UDK 5 Annales, Ser. hist. nat., 36, 2026, 1, pp. 1-256, Koper 2026 ISSN1408-533X

UDK 5

ISSN 1408-533X
e-ISSN 2591-1783

ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies

Series Historia Naturalis, 36, 2026, 1

KOPER 2026

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

ISSN 1408-533X
e-ISSN 2591-1783
UDK 5
Letnik 36, leto 2026 številka 1

Tisk/*Stampa/Print:* Založništvo PADRE d.o.o.

Izdajatelja/*Editori/Published by:* Zgodovinsko društvo za južno Primorsko - Koper / *Società storica del Litorale - Capodistria*©
Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / *Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente*©

Sedež uredništva/*Sede della redazione/ Address of Editorial Board:* Nacionalni inštitut za biologijo, Morska biološka postaja Piran / *Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran*
SI-6330 Piran /*Pirano*, Fornače/*Fornace* 41, tel.: +386 5 671 2900, fax +386 5 671 2901;
e-mail: annalesSHN@nib.si, *internet:* www.zdjp.si

Redakcija te številke je bila zaključena 20. 06. 2026.

Sofinancirajo/*Supporto finanziario/ Financially supported by:* Javna agencija za znanstveno-raziskovalno in inovacijsko dejavnost Republike Slovenije (ARIS)

Annales - Series Historia Naturalis izhaja dvakrat letno.

Naklada/*Tiratura/Circulation:* 300 izvodov/copie/copies

Revija Annales, Series Historia Naturalis je vključena v naslednje podatkovne baze / *La rivista Annales, series Historia Naturalis è inserita nei seguenti data base / Articles appearing in this journal are abstracted and indexed in:* BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL); Directory of Open Access Journals (DOAJ).

Navodila avtorjem in vse znanstvene revije in članki so brezplačno dostopni na spletni strani https://zdjp.si/en/p/annalesshn/
The submission guidelines and all scientific journals and articles are available free of charge on the website https://zdjp.si/en/p/annalesshn/
Le norme redazionali e tutti le riviste scientifiche e gli articoli sono disponibili gratuitamente sul sito https://zdjp.si/en/p/annalesshn/

OPEN ACCESS

ANNALES · Ser. hist. nat. · 36 · 2026 · 1

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

UDK 5 Letnik 36, Koper 2026, številka 1 ISSN 1408-53 3X
e-ISSN 2591-1783

VSEBINA / *INDICE GENERALE / CONTENTS*

received: 2025-12-16 DOI 10.19233/ASHN.2026.23

HABITAT INSIGHTS FOR THE EUROPEAN POND TURTLE (*EMYS ORBICULARIS*) IN THE COASTAL WETLAND AREA SEČOVLJE SALINA NATURE PARK, SLOVENIA

Kim LEBAN
Most na Soči 112, 5216 Most na Soči, Slovenia
e-mail: kim.leban89@gmail.com

Iztok ŠKORNIK
Sečovlje Salina Nature Park, Parecag 290, 6320 Portorož, Slovenia

Špela ČONČ & Mateja BREG VALJAVEC
Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Novi trg 2, 1000 Ljubljana, Slovenia

Žan KURALT
Genialis d.o.o., Vojkova cesta 63, 1000 Ljubljana, Slovenia

Lenart ŠTAUT, Jure TIČAR, Katarina POLAJNAR HORVAT, Primož GAŠPERIČ & Aleš SMREKAR
Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Novi trg 2, 1000 Ljubljana, Slovenia

Melita VAMBERGER
Senckenberg Naturhistorische Sammlungen Dresden, Museum of Zoology, Königsbrücker Landstraße 159, 01109 Dresden, Germany
e-mail: melita.vamberger@senckenberg.de

ABSTRACT

*A comprehensive study was conducted in the Sečovlje Salina Nature Park, one of the largest coastal brackish areas in Slovenia, to investigate the habitat requirements of the European Pond Turtle (*Emys orbicularis*). During 2019-2020, five female turtles were monitored using GPS solar-powered telemetry transmitters. Based on the high-resolution LiDAR data and spatial analysis, the study aimed to compare the activities of individual turtles on a monthly and hibernation basis across two ecologically distinct but neighbouring areas within the park. The data collected over such a short (monthly) period provides valuable insights into habitat requirements, seasonal spatial dynamics, and the contrasting environmental conditions. The findings contribute essential baseline information for understanding and developing future conservation strategies for this endangered species in coastal brackish wetlands, which tend to be locally specific and vulnerable to numerous human-induced pressures.*

Key words: European Pond Turtle, *Emys orbicularis hellenica,* GPS-telemetry, LiDAR, habitat use, conservation management, coastal wetland

APPROFONDIMENTI SULL'HABITAT DELLA TESTUGGINE PALUSTRE EUROPEA (*EMYS ORBICULARIS*) NELL'AREA UMIDA COSTIERA DEL PARCO NATURALE DELLE SALINE DI SICCIOLE, SLOVENIA

SINTESI

*Gli autori hanno condotto uno studio approfondito nel Parco naturale delle Saline di Sicciole, una delle più grandi aree costiere salmastre della Slovenia, per indagare i requisiti di habitat della testuggine palustre europea (*Emys orbicularis*). Durante il periodo 2019–2020, cinque femmine di tartaruga sono state monitorate mediante trasmettitori GPS a energia solare. Sulla base di dati LiDAR ad alta risoluzione e di analisi* *spaziali, lo studio ha avuto l'obiettivo di confrontare le attività dei singoli individui su base mensile e durante il periodo di ibernazione, in due aree ecologicamente distinte ma confinanti all'interno del parco. I dati raccolti in un periodo relativamente breve (mensile) forniscono informazioni preziose sui requisiti di habitat, sulle dinamiche spaziali stagionali e sulle condizioni ambientali contrastanti. I risultati contribuiscono con informazioni di base essenziali per la comprensione e lo sviluppo di future strategie di conservazione per questa specie minacciata negli ambienti umidi costieri salmastri,*

Parole chiave: testuggine palustre europea, *Emys orbicularis hellenica*, telemetria GPS, LiDAR, uso dell'habitat, gestione della conservazione, zona umida costiera

INTRODUCTION

Knowledge of habitat distribution across space, including changes over time, is crucial to management and conservation initiatives in times of massive biodiversity loss (Böhm *et al.*, 2013). Landscape composition across space has wide-ranging effects on species because it determines the right climatic, elevation, or soil conditions suitable for the physiological requirements of species (Böhm & Popescu, 2016). Habitat loss is one of the leading causes of biodiversity loss. Thus, habitat assessments delineating a critical habitat for the protection or improvement of habitat quality for a species are crucial to conservation.

Compared to other vertebrates, reptiles, especially freshwater turtles, are scarcely represented in landscape ecology (Böhm & Popescu, 2016). While freshwater turtles tend to have narrower habitat requirements than other vertebrates, they still require a relatively large area to meet their diverse needs (Ficetola *et al.*, 2004; Rogner, 2009; Böhm *et al.*, 2013; Lovich *et al.*, 2018). Comparative studies on habitat use (Slavenko *et al.*, 2016) indicate that the required area for normal activity, known as home range (Burt, 1943), of freshwater turtles (species that spend most or a significant amount of time in water), can range from 0.013 ha (*Kinosternon acutum*; Iverson & Vogt, 2011) to up to 327.6 ha (*Trachemys scripta;* Jaeger & Cobb, 2012). Semi-aquatic behavior, which is one of the main characteristics of the genus *Emys*, indicates the need for larger areas based on specific aquatic, riparian, and terrestrial habitat requirements (Ficetola *et al.*, 2004; Mitrus, 2010). Both a location switch and consistent fidelity to specific locations have been observed during daily and seasonal cycles while analysing the main turtle behaviors, such as sun-basking, feeding, mating, egg-laying, overland migrations and hibernation (Lebboroni & Chelazzi, 1991; Kotenko, 2000; Zuffi, 2000; Dall'Antonia *et al.*, 2001; Meeske & Muhlenberg, 2004; Novotný *et al.*, 2004; Ottonello *et al.*, 2005; Ficetola & De Bernardi, 2006; Rogner, 2009; Vignoli *et al.*, 2015; Erdélyi *et al.*, 2019; Marchand *et al.*, 2021). In addition to the behavioral aspects, the complementarity of the habitat use is also strongly correlated with the developmental stage of a species (Lebboroni & Chelazzi, 1991; Cadi *et al.*, 2004; Meeske & Muhlenberg, 2004) and is associated with biotic or physical constraints (Cadi *et al.*, 2004; Meeske & Muhlenberg, 2004; Slavenko *et al.*, 2016), which can vary in the distribution area of a species. Information on habitat requirements for the endangered European Pond Turtle, *Emys orbicularis* (Linnaeus, 1758), is very limited, especially for coastal brackish habitats (Lebboroni & Chelazzi, 1991; Liuzzo *et al.*, 2023). This deficit in information is surprising, as ongoing conservation efforts in coastal wetlands are urgently needed. Conservation management constantly faces numerous conflicts of interest related to humans, especially habitat destruction and fragmentation, invasive species, and climate change, exacerbating challenging conditions during hot and dry summers (Moravec, 2003; Fattizzo, 2004; Broggi & Grillitsch, 2012; Žagar *et al.*, 2013; Standfuss *et al.*, 2016; Ivajnšič *et al.*, 2017).

In Slovenia, the European Pond Turtle is an endangered and fully protected native turtle species (Official Gazette of the Republic of Slovenia, No. 46/2004, with amendments; Habitat Directive, 1992; Bern Convention, 1979; Official Gazette of the Republic of Slovenia, No. 82/02, with amendments). According to Vamberger *et al.* (2015), the Slovenian populations match the morphological and genetic characteristics of the two subspecies: *E. o. orbicularis* and *E. o. hellenica*. The nominate subspecies *E. o. orbicularis* inhabits a wide range of Slovenia, whereas the subspecies *E. o. hellenica* is more closely restricted to the Mediterranean climate and is present in the Slovenian part of Istria and its hinterland (Vamberger *et al.*, 2015; Žagar *et al.*, 2019). One of the major *E. o. hellenica* populations inhabit the Istrian coastal wetland area Sečovlje Salina (Fritz, 2003; Tome, 2003). In 2003, the population in Sečovlje Salina with the Dragonja River estuary was estimated to represent 1-5 % of the Slovenian population according to limited findings (Škornik, 1990-1991; Tome, 1996, 2003). Despite several recent studies (Škornik, 2005; Vamberger, 2009; Torkar, 2012; Budak, 2013; Torkar & Ferjančič, 2013; Ferjančič & Škornik, 2018; 2019), some biological aspects, such as habitat use, remain under-researched across the entire distribution range. Furthermore, our knowledge of the habitat use of other Slovenian *E. o. hellenica* populations in coastal brackish areas (Leban *et al.*, 2021) or internal riverine and marshy plains (Pekolj *et al.*, 2021; Lipovšek & Vamberger, 2021) remain incomplete. This lack of knowledge hinders the adequate protection and management of this species.

Telemetry is an essential method for collecting data on habitat requirements using tracking devices based on various technologies (Joo *et al.*, 2020; Crane *et al.*, 2021). VHF (very high frequency) radiotelemetry is common in terrestrial reptile research and seems to be the predominant tracking method for valuable insight into habitat requirements, also for freshwater turtles with semi-aquatic behavior (Crane *et al.*, 2021). Automated or GPS (Global Positioning System) logging devices remain relatively rare in reptile research despite the growing popularity in the last decade also as a cost- and time-efficient approach (Joo *et al.*, 2020; Crane *et al.*, 2021; Čonč *et al.*, 2022). Furthermore, for studying the movements of freshwater turtles, GPS-telemetry enables more accurate delineation of movement paths, reveals the timing of movements between habitats, and allows data collection without researcher interference with the turtle's movements (Christensen & Chow-Fraser, 2014). However, all recent studies on tracking the movements of *Emys orbicularis* are based on radiotelemetry (Mascort & Budo, 2017; Drechsler *et al.*, 2018; Escoriza *et al.*, 2020; Horváth *et al.*, 2021; Liuzzo *et al.*, 2023), including research conducted in Slovenia (Vamberger & Kos 2011; Pekolj *et al.*, 2021).

We used GPS telemetry, high-resolution LiDAR, and spatial data to gain valuable insights into the utilization of aquatic and terrestrial habitats by the European pond turtle in the protected coastal wetland of Sečovlje Salina. Individual turtle activities and habitat use were compared on a monthly basis during the active season and during hibernation to obtain detailed and accurate information on habitat requirements. One of the main objectives of this study was also to estimate the differences in the spatial ecology of turtles living in different environments within the protected area. The data collected over such a short timeframe (monthly) provides valuable insights for understanding and developing future conservation strategies for this endangered species in coastal brackish wetland environments, which are locally specific and vulnerable to numerous human-induced environmental pressures.

MATERIAL AND METHODS

Study area

The field study was conducted in the Sečovlje Salina Nature Park (~ 45°29′ N, 13°37′ E; hereafter: SSNP), located in the southwestern part of Slovenia, the southernmost stretch of the Piran Bay (northern Adriatic coast) at the Dragonja River mouth (Fig. 1). Based on the physical-geographical classification of Europe accounting for climate, rocks, soil characteristics, the area belongs to the Mediterranean region (Perko *et al.*, 2021). The approximately 674-ha large, protected area with no settlements or inhabitants was established at the state level in 2001. As a typical saline ecosystem with marine, hypersaline, brackish, and freshwater environments, SSNP hosts numerous rare, threatened, and endemic species and is considered to have significant national and international value (Škornik, 2012; Turk, 2019; Official Gazette of the Republic of Slovenia, No. 48/04, with amendments; Official Gazette of the Republic of Slovenia, No. 111/04, with amendments). Following the Habitat Directive (Habitat Directive, 1992), two Natura 2000 sites in the SSNP have also been designated for conservation of *Emys orbicularis*: the Sečoveljske soline in estuarij Dragonje (site code: SI3000240) and the Kanal Sv. Jerneja (site code: SI3000239). The base of the Salina is covered with up to a 90-m thick layer of sediments (Ogorelec *et al.*, 1981). The hinterland of the SSNP is represented by a predominantly flat Dragonja river valley, with a simple geological structure composed of flysch rocks, limestone, and fluvial deposits (Čonč, 2020). Higher altitudes surrounding the SSNP consist of flysch hills in the west and northwest and a karst plateau in the east (Čonč, 2020; Stepišnik, 2022). The climatic conditions are coastal sub-Mediterranean, with an average annual temperature of 13.8 °C and average annual precipitation of 958 mm (Ogrin *et al.*, 2023).

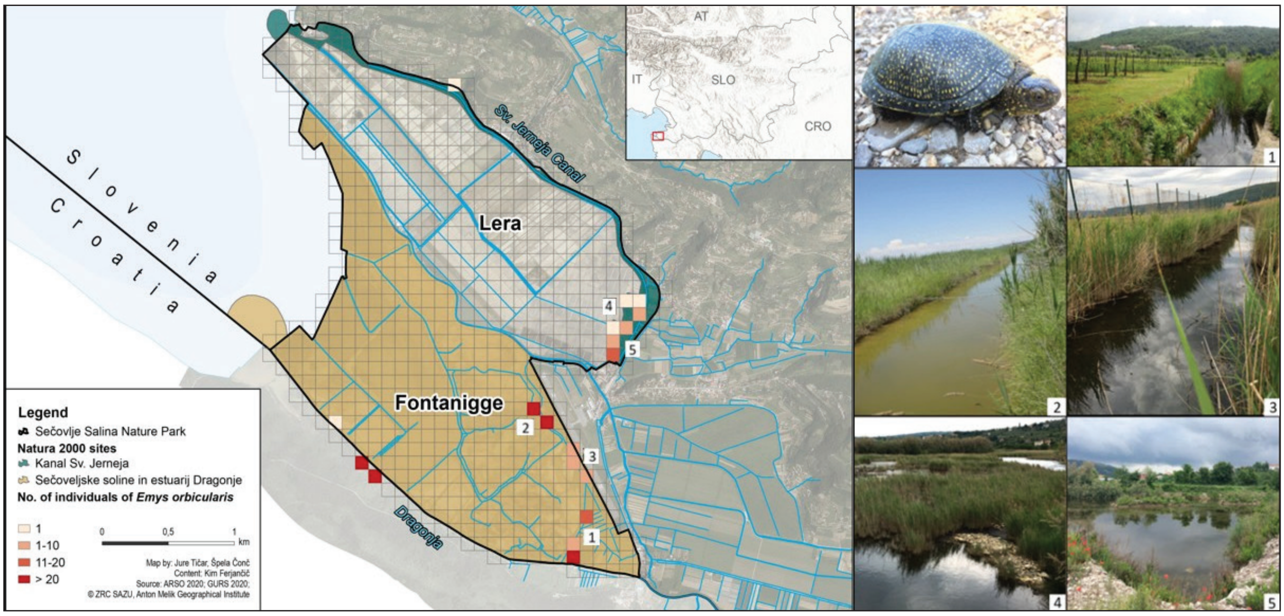


Fig. 1: The number of captured European Pond Turtle** (E. orbicularis) **in the Sečovlje Salina Nature Park and its hinterland (according to Polajnar Hrovat** et al.**, 2022). 1 – Stojbe Ditch; 2 – Alto ditch; 3 – Airport ditch; 4 – larger marsh in the Mining area; 5 – pond in the Mining area.
Sl. 1: Število ujetih močvirskih sklednic** (E. orbicularis) **v Krajinskem parku Sečoveljske soline z zaledjem (po Polajnar Hrovat in sod., 2022). 1 – kanal Stojbe; 2 – kanal Alto; 3 – kanal Letališče; 4 – večje močvirje na območju Rudnika; 5 – bajer na območju Rudnika.

The SSNP is divided arbitrarily into connected Lera and Fontanigge areas, with delineated smaller areas that primarily represent specific aquatic or terrestrial habitats (Škornik, 2012). This study followed the same site separation and focused on parts of the SSNP with the highest occurrence of *Emys orbicularis*. These parts include the marshy brackish so-called Mining area (also known as "Korea") in the southeastern part of the Lera area and the southern Salina edge of the Fontanigge area, which has artificial drainage brackish ditches, especially in the Stojbe, Alto, and Airport areas (Fig. 1). In the Mining area (maximum water surface up to 3.5 ha), turtles were found in two smaller, mostly open ponds or in a larger, densely vegetated marsh. Some shallow parts of the marsh can dry out in summer. The upper part of the nearby canal Sv. Jerneja is also considered as a part of this "pond-like" Lera area (hereafter: Lera area). Based on occasional measurements, the salinity ranged between 2.00-14.97 PSU, depending on the season and water level. The "canal-like" Fontanigge area (hereafter: Fontanigge area) consists mostly of shallow ditches with well-vegetated banks. The Stojbe ditch may dry out during summer, while the Alto and Airport ditches have a more stable hydroperiod. The salinity in these two ditches could rise to 40 PSU during the summer months. The banks around the Alto ditch were repaired multiple times to prevent saltwater intrusions, and a new shallow brackish water surface was created in 2019 (Škornik, 2012; Ferjančič & Škornik, 2018; I. Škornik, pers. comm.). *Phragmites australis* is a dominant plant in all areas where turtles mainly occur. It usually coexists with other halophytic aquatic (*e.g.*, *Ruppia cirrhosa*) and riparian plant communities (*e.g.*, *Suaeda maritima, Juncus maritimus, Carex extensa*); in some places, it is often replaced by *Arundo donax* (Kaligarič, 1990; Jogan, 2001; Škornik, 2012).

Trapping and GPS tracking

Five females captured during regular monitoring using baited funnel traps were selected for telemetry: three in the Lera area and two in the Fontanigge area (Ferjančič & Škornik, 2019). The sites of the captured turtles were recorded using a handheld GPS device (Garmin). All females were measured, weighed, photographed, aged (Meeske, 2006; Vamberger & Kos 2011), and marked by marginal notching (Kuchling, 1987). They were also palpated to detect the presence of eggs (Vamberger *et al.*, 2017). Solar-powered telemetry transmitters (Milsar RadioTag-14; Anonymous, 2024b) were attached to the anterior upper carapace margin of each female using an epoxy plumber (Pattex Epoxy Kit). As the weight of the RadioTag-14 transmitter was less than 5% of the female body mass, the influence of the tag was considered minimal (Knapp

& Abarca, 2009; Bayrakçı *et al.*, 2021). The tagged females were released into the water at the capture site within 30 minutes.

The telemetry data was collected from the first half of April 2019 until the end of June 2020. Data were automatically downloaded on a weekly basis using a radio download feature (base station) based on Milsar software (Anonymous, 2024b) without the need to recapture the turtle. The maximum range for downloading data in the line of sight (with no obstacles between the base station and transmitter) was estimated to be less than 3 km. The data collection intervals were set between 5 and 15 min. The variables recorded by the telemetry transmitters with estimated error < 10 m (Milsar, *pers. comm.*) were latitude, longitude, time, and date (Appendix 1).

Home range, movements, and habitat use

The analysis of home range, movement, and habitat use was based on separate monthly telemetry data obtained during the period of activity and grouped hibernation months during the period of hibernation. These periods were not defined in advance based on the observations but rather determined accordingly to the gathered telemetry data. Telemetry data of turtles were not pooled but analysed separately. All applied analyses were based on the same gathered data of cleaned (expert's decision) tracking locations. Only turtles with available tracking data for both years, including those for hibernation, were considered representative and used in all analyses. Information from tracked females with less available data was used solely for comparison purposes.

Home ranges were calculated using the Minimum Convex Polygon (MCP; Mohr, 1947) and Kernel Density Estimation (KDE; Worton, 1989), which are the most frequently used geometric methods in reptile home range studies (Crane *et al.*, 2021). The home range sizes for the entire study period were calculated using the Minimum Convex Polygon (MCP) method, employing both 100% of all telemetry records (hereafter: MCP 100%) and 95% of the records (hereafter: MCP 95%). To allow comparison with similar studies, the home range for the entire study period was also estimated using the 95% counter level by the KDE method (hereafter: KDE 95%). A fixed bivariate normal KDE with h_{ref} as the smoothing factor (default reference bandwidth) was used for the KDE calculation. For monthly and hibernation home range size calculations, only the MCP 95% method was used, as it has been used in the literature for *Emys orbicularis* (Cadi *et al.*, 2004; Thienpont *et al.*, 2004; Liuzzo *et al.*, 2023). All calculations were conducted in R (version 4.3.1; R Core Team, 2023) using the packages "adehabitatHR" and "adehabitatLT" (Calenge, 2006, 2023) with sp (Pebesma & Bivand, 2005) and sf (Pebesma, 2018) for the spatial data processing. As home range size estimations did not meet the parametric assumptions, the Aligned Rank Transform (ART) ANOVA test was used to examine the effect of months and to test the difference between areas. Furthermore, the interaction between months and areas was also investigated (Wobbrock *et al.*, 2011; Kay & Wobbrock, 2023). The relationship between the number of locations and home range was analysed using Spearman Correlation (Drechsler *et al.*, 2018; Liuzzo *et al.*, 2023).

All telemetry data collected for each turtle were used to create trajectories, which are defined as the paths connecting the relocations of the tracked turtles. The daily mean distances traveled were analysed based on the distance parameter of the created trajectory. The trajectories were created in R (version 4.3.1; R Core Team, 2023) using the package "adehabitatLT" (Calenge, 2006, 2023; Paterson, 2018). The Mann-Whitney test was used to evaluate differences in mean monthly/hibernation movement distances between the Lera and the Fontanigge areas.

Turtle habitat use was analysed based on 11 predictor covariates, which were categorized into two groups: topographical and environmental/anthropogenic (Appendix 2). All variables were mapped and analysed in ArcGIS Pro 3.0.3 (ESRI, Redlands, CA, USA). Calculation of topographical predictors was based on the spatial analysis of a high-resolution digital terrain model (hereafter: DTM; 1 m × 1 m). To create a DTM, LiDAR data obtained from aerial laser scanning was used, consisting of a cloud of ground points (LAS files) provided by the Slovenian Environment Agency (ARSO). The aspect, slope, solar radiation (SR), Topographic Wetness Index (TWI), Terrain Ruggedness Index (TRI), and Vector Ruggedness Measure (VRM) were calculated based on the LiDAR-derived DTM. Values of topographical predictors were categorized into five classes based on Jenks' natural breaks (1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high). Environmental/anthropogenic predictors were also included: length of waterway and cycling path, area of lentic and lotic water bodies, and land use categories (Appendix 2). Data were provided by the Ministry of Agriculture, Forestry, and Food (MKGP, 2023), Municipality of Piran, and Slovenian Water Agency (DRSV). Habitat use was analysed separately for the Lera and the Fontanigge areas based on all gathered telemetry data for a given turtle (MCP 100 % for the entire study period). Each turtle's location was associated with the covariate range/category. Statistically significant differences in habitat use were tested on a monthly/hibernation basis. Due to the data not meeting parametric assumptions, a non-parametric Chi-Square test with *post hoc* residual analysis and Kruskal-Wallis tests with *post hoc* Mann-Whitney tests were used. To account for differences between months and compared turtles, a sequentially rejective Bonferroni test was applied in all *post hoc* analyses (Holm, 1979; Delucchi, 1993). Although Chi-square tests were conducted on frequency data, the results are presented as proportions to facilitate interpretation. All statistical analyses were carried out using SPSS (IBM SPSS Statistics 21), with an alpha level set at 0.05.

RESULTS AND DISCUSSION

General observations of GPS-telemetry

During the study, five females in a good state of health (no detected physical or locomotory abnormalities), with straight-line carapace lengths ranging from 128 to 162 mm and body mass from 383 to 670 g, were tracked using GPS telemetry (Appendix 1). A total of 8597 GPS tracking locations were collected, with varying tracking frequencies. Some tags only produced one location per day or none for several consecutive days, presumably because the transmitters did not transmit data when the turtles were submerged underwater. The locations were recorded over at least 414 days for each turtle. The tracking frequency ranged from 1 to 48 locations per day. Only two turtles with available data for both years, including those for hibernation, were considered representative and used in all analyses: the adult female named Berta (tag number: 999003) and the adult female named Nevija (tag number: 999006). Berta, with an average tracking frequency of 16 locations per day with received signal (April 2019-June 2020; 4038 locations over 193 days with received signal) was set as representative for the Lera area and Nevija, with an average tracking frequency of 20 locations per day with received signal (May 2019-June 2020; 3440 locations over 155 days with received signal) was set as representative for the Fontanigge area. Data from other tracked females (Alta, Loredana, and Rudica), with available telemetry data for 2-4 months, were used for comparison purposes only (Appendix 1).

The months of activity and the hibernation period were set based on the GPS telemetry. In the Lera area, the end of the activity period was determined based on the most recent data downloaded from Berta in 2019 (19/11/2019), which indicated that the activity period concluded around mid-November 2019. The start of the active period in 2020 was most likely in the beginning of April (n_{GPS} = 313; 3/04/2020-30/04/2020) because only a few GPS locations were obtained at the end of February (n_{GPS} = 5; 26/02/2020-28/02/2020) and at the beginning of March (n_{GPS} = 4; 3/03/2020-08/03/2020). The highest number of locations was obtained in July (n_{GPS} = 1,299). In the Fontanigge area, the last datum downloaded by Nevija in 2019 was at the beginning of September (11/09/2019), while the first received signal in 2020 was from the beginning of March (03/03/2020). The low number of GPS locations obtained in March (n_{GPS} = 20; 03/03/2020-20/3/2020) most likely indicates the start of the active period at the beginning of April (n_{GPS} = 515; 05/04/2020-30/04/2020), similar to the Lera area. The highest number of recorded locations was in June (n_{GPS} = 1189). The results from the telemetry data for both the active (from April to the first half of November in Lera and from April to August in Fontanigge) and hibernation (from the second half of November to March in Lera and from September to March in Fontanigge) periods are quite different from those of the central part of Slovenia. Vamberger & Kos (2011) reported that the period of activity of the European Pond Turtle in Ljubljansko barje starts from late February to early March, and the hibernation period from around the second half of October to the beginning of November. Despite expectations of an early end to the hibernation period in 2020 due to favorable weather conditions, especially higher air temperatures and prolonged sunshine compared to the long-term average (1999-2020; Anonymous, 2024a), it is most likely that the tracked turtle's activity resumed at the beginning of April.

Home range

The calculated home range sizes (Tab. 1) during the entire study period were generally larger in Fontanigge (26.3 ha according to 100% MCP and 7.9 ha/5.0 ha according to 95% MCP/KDE) compared to Lera (23.3 ha according to 100% MCP and 4.6 ha/4.4 ha according to 95 % MCP/KDE). Furthermore, the estimated MCP 95% during the activity period was also larger in Fontanigge (2.0 ± 1.92 ha) compared to Lera (1.8 ± 1.36 ha). The opposite was observed for the hibernation period, with a larger home range estimated in Lera (0.9 ha according to 95% MCP) compared to Fontanigge (0.1 ha according to 95% MCP). Additionally, the monthly MCP 95% based on pooled data from all turtles was smaller than the sizes of individual representative turtles in both areas. There was no statistically significant difference in the home range size estimates between the two areas ($F = 2.51$, $p = 0.139$) or among months ($F = 2.86$, $p = 0.063$). However, the interaction between the area and months was statistically significant ($F = 3.33$, $p = 0.041$), indicating that monthly variation in home

Tab. 1: Home range size estimations for the representative European Pond Turtles** (E. orbicularis) **in the Lera (turtle Berta) and in the Fontanigge (turtle Nevija) in the Sečovlje Salina Nature Park. Results are presented for the entire study period (2019-2020) and monthly/hibernation period based on Minimum Convex Polygon (MCP) and Kernel Density Estimation (KDE) methods. *href as the reference default bandwidth. **All tracked females.

Tab. 1: Ocene velikosti domačega okoliša dveh izbranih samic močvirske sklednice** (E. orbicularis) **na območjih Lere in Fontanigg v Krajinskem parku Sečoveljske soline. Rezultati so prikazani za celotno obdobje raziskave (2019–2020) ter za mesečno/hibernacijsko obdobje na podlagi metod minimalnega konveksnega poligona (MCP) in metode jedrne gostotne ocene (KDE). *href kot referenčna privzeta širina pasu. **Vse sledene samice.

Method	Period	Lera area	Fontanigge area
MCP 100% (ha)	entire study period	23.28	26.27
MCP 95% (ha)	entire study period	4.62	7.93
KDE 95% (ha)*	entire study period	4.40 (h_{ref} = 14.29)	5.02 (h_{ref} = 15.27)
Monthly MCP 95% (ha)	activity period	1.77 ± 1.36 (0.05-3.92)	1.98 ± 1.92 (0.14-5.21)
Hibernation MCP 95% (ha)	hibernation period	0.87	0.11
Monthly MCP 95% - all turtles (ha)**	activity period	1.36 ± 1.32 (0.05-3.92)	1.80 ± 1.86 (0.08-5.21)

range size differs between Lera and Fontanigge. *Post-hoc* pairwise comparisons (Holm-adjusted) did not identify any statistically significant differences between specific area–month combinations (all $p > 0.05$), suggesting that the significant interaction likely reflects subtle, area-specific seasonal trends. The correlation between the size of the home range and the number of locations for turtles with >10 locations was positive and strongly significant (n = 25; Spearman Correlation Test, R = 0.88, $p < 0.001$).

The difference in home range sizes between areas could be attributed to the different habitat features. The smaller home ranges based on 95% locations (MCP 95%) in the pond/swamp Lera area (Tab. 1) are probably associated with a more stable hydroperiod, a greater variety of nearby aquatic habitats with predominant stagnant water bodies, and the possibility of retreating in deeper water compared to the ditch/canal Fontanigge area. Another contributing factor could be the lower salinity in the Lera area, with a maximum salinity level of 15 PSU (Ferjančič & Škornik, 2018). Previous research reports occasions with salinity levels as high as 40 PSU in almost all ditches in the Fontanigge area, with captured turtles found in water with salinity levels up to 30 PSU (Ferjančič & Škornik, 2018). These salinity levels are among the highest ever recorded for this species (Lebboroni & Chelazzi, 1991; Liuzzo *et al.*, 2023). However, it is important to note that these observations were based on limited data within SSNP (Ferjančič & Škornik, 2018), and detailed salinity monitoring could offer further valuable insights into the salinity tolerance of this species. Additionally, when considering the mechanism of adaptation to brackish or salty environments (Agha *et al.*, 2018), it would be beneficial to increase the number of tracked individuals or extend the tracking period to confirm whether the behavioral pattern of the population in SSNP corresponds with recent findings on the behavioral ecology of the Venetian *Emys orbicularis* population, which suggests that turtles tend to avoid brackish environments during hibernation and prefer higher salinities during active periods (Liuzzo *et al.*, 2023). Limited findings suggest that turtles in the Fontanigge area prefer the same brackish aquatic habitats throughout the year, despite the availability of nearby water bodies with lower salinity (Dragonja and Drnica canal, Stojbe ditch; Ferjančič & Škornik, 2018). Furthermore, the estimations based on the KDE 95 % in both areas were different from those of the other turtle populations in Slovenia (6.57 ha; Vamberger & Kos, 2011). This result may suggest limited suitable habitat conditions nearby compared to the Ljubljansko barje. It is likely that the turtles inhabited a significant part of the Dragonja River valley in the past and were forced to find smaller secondary habitats on the edge of the salt pans after the extensive land reclamation interventions.

Home range estimations indicate that turtle Berta in the Lera area utilized a wider variety of water habitats compared to turtle Nevija in the Fontanigge area. During its active period, Berta

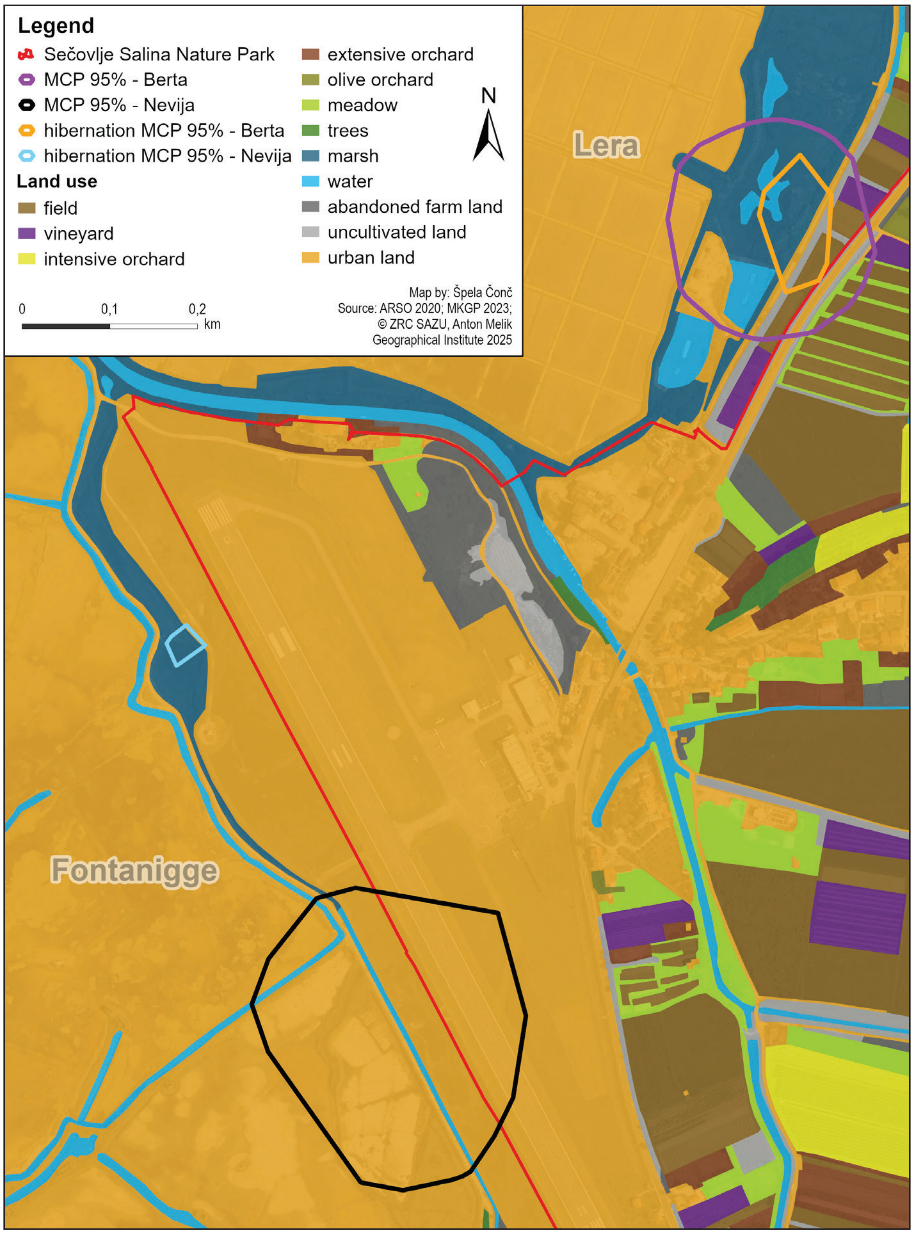


Fig. 2: Home range areas for the representative European Pond Turtles (*E. orbicularis*) obtained from 95 % of locations calculated with the Minimum Convex Polygon method in Lera (turtle Berta) and in Fontanigge (turtle Nevija) in the Sečovlje Salina Nature Park.
Sl. 2: Območja domačega okoliša dveh izbranih samic močvirske sklednice (*E. orbicularis*), izračunana iz 95 % lokacij z metodo minimalnega konveksnega poligona (MCP), na območjih Lere in Fontanigg v Krajinskem parku Sečoveljske soline.

was observed in a larger marsh, a smaller pond, ditches along the salterns' edge, and the canal Sv. Jerneja. During the hibernation period, Berta was primarily seen in the larger marsh and canal Sv. Jerneja. In contrast, Nevija in the Fontanigge area was active in the ditches of the Alto and Airport regions, as well as in a shallow water pool along the Alto's ditch. During its hibernation period, Nevija was found only in the upper part of the ditch in the Airport area (Fig. 2). Notably, the home ranges of the two turtles did not overlap during either the active or the hibernation periods, despite previous observations of movements between areas (Ferjančič & Škornik, 2018).

Due to the limitations of acquiring tracking data, the size and location of the home range during hibernation should be carefully interpreted. Only a limited number of locations were identified between October and March. The estimated home range size during hibernation obtained from 95% of locations in the Lera area is comparable with estimates from France (0.74 ha; Thienpont *et al.*, 2004). On the other hand, the estimates in Fontanigge, obtained using the same method, are more comparable with estimates from Italy (mean ± 1 SD: 0.13 ± 0.11 ha; Liuzzo *et al.*, 2023). In Lera, the location of Bertas' home range during hibernation coincided with its home range during the activity period, like the observations of Novotný *et al.* (2008) observed in Slovakia. However, in Fontanigge, turtle Nevija migrated at least 300 m away from its active season site to hibernate in deeper waters, which resembles the findings of Thienpoint *et al.* (2004) in France (Fig. 2). Our findings indicate that turtles in SSNP do not concentrate only in one area to hibernate, as suggested by Vamberger and Kos (2011) in the Ljubljana marsh area. Therefore, identifying both the period and the sites selected for hibernation is crucial for the species' long-term survival, especially due to observed aggregation during hibernation and high site fidelity to the overwintering site (Schneeweiss *et al.*, 1998; Meeske, 2000; Mazanaeva & Orlova, 2004; Thienpont *et al.*, 2004; Vamberger & Kos, 2011).

Movement results

The mean distances traveled per day were quite similar in both areas (n = 7477; Mann-Whitney U = 6920991; p = 0.81). The calculated mean daily distances during the entire study period were slightly longer for the turtle Berta in Lera (ranging from 12.23 ± 8.14 m to 49.63 ± 18.35 m) compared to those of the turtle Nevija in Fontanigge (ranging from 11.04 ± 12.98 m to 38.67 ± 59.60 m; Fig. 3). For both turtles, the longest mean distance traveled per day was calculated for March. A slight peak in the mean distance traveled per day was observed in June (≈ 30 m), followed by a notable increase in the autumn for both turtles (>30 m). Turtle Berta in Lera exhibited longer daily mean distances in October and November, while turtle Nevija in Fontanigge only in September. The maximum distance traveled in a day was recorded for turtle Berta in June (560.02 ± 45.58 m) and for turtle Nevija in

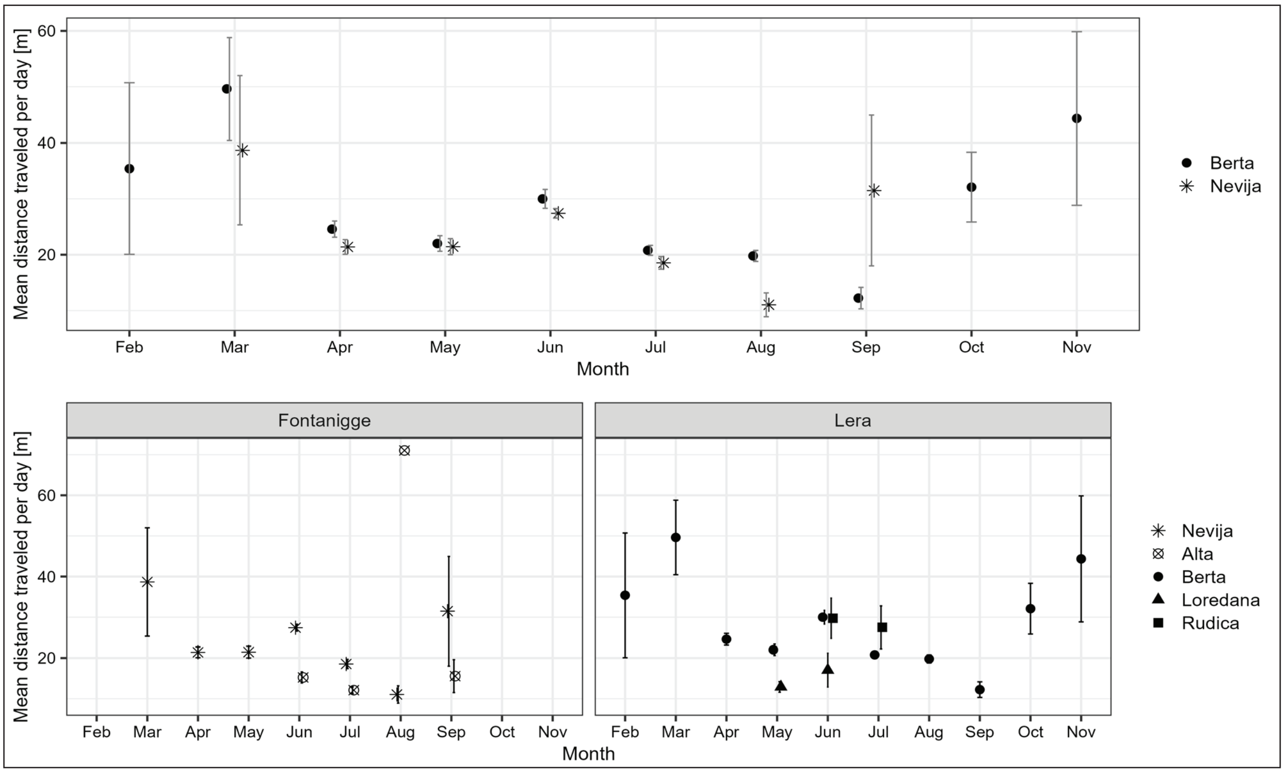


Fig. 3: Mean distance traveled per day with standard deviation for European pond turtles** (E. orbicularis) **in Lera and Fontanigge in the Sečovlje Salina Nature Park.
Sl. 3: Povprečna dnevna prepotovana razdalja s standardnim odklonom pri močvirskih sklednicah** (E. orbicularis) **na območjih Lere in Fontanigg v Krajinskem parku Sečoveljske soline.

September (585.44 ± 89.35 m). In addition, the monthly mean distances traveled per day were shorter compared with other turtles for almost all months (ranging from 12.10 ± 13.09 m to 29.74 ± 22.70 m; Fig. 3).

A comparable mean distance traveled per day was calculated in both areas, despite the differences in home range (Tab. 2). The longest mean distance traveled per day in March should be interpreted with caution due to the limited number of locations during that month, which is still considered part of the hibernation period. It is assumed that the turtles primarily traveled underwater during this time. Our movement results are partly comparable with those obtained by Cadi *et al*. (2004), especially when considering the long-range movement in May and June obtained for the French population in La Serre (maximum: 520 m). Similar longest traveled distances were also reported by Liuzzo *et al*. (2023) for the Venetian population in Italy (546.64 m). The movements of turtles in our study partly resemble those observed in eastern Spain, specifically in the Albufera de Valencia Natural Park (Drechsler *et al*., 2018), where a peak in movement was observed in spring (March and April) and later again in July.

Habitat use

The analysis of habitat use for both representative females in each area revealed differences between months of the active season and the hibernation period for almost all topographical and environmental/anthropogenic covariates (Appendix 3). In Lera, the most important terrestrial land use categories for Berta were fields, uncultivated land, and urban land (each with over 1% use in all months/hibernation). Among the aquatic categories, for each month and the hibernation period, the highest number of locations was assigned to the marsh. Berta was observed every month in both lentic and lotic waters, except during hibernation (present only in the lotic waters), with the latter being predominantly selected. The highest percentage of Berta's locations assigned to waterway was recorded in September (11%), whereas in all other months, it was lower than 4%.

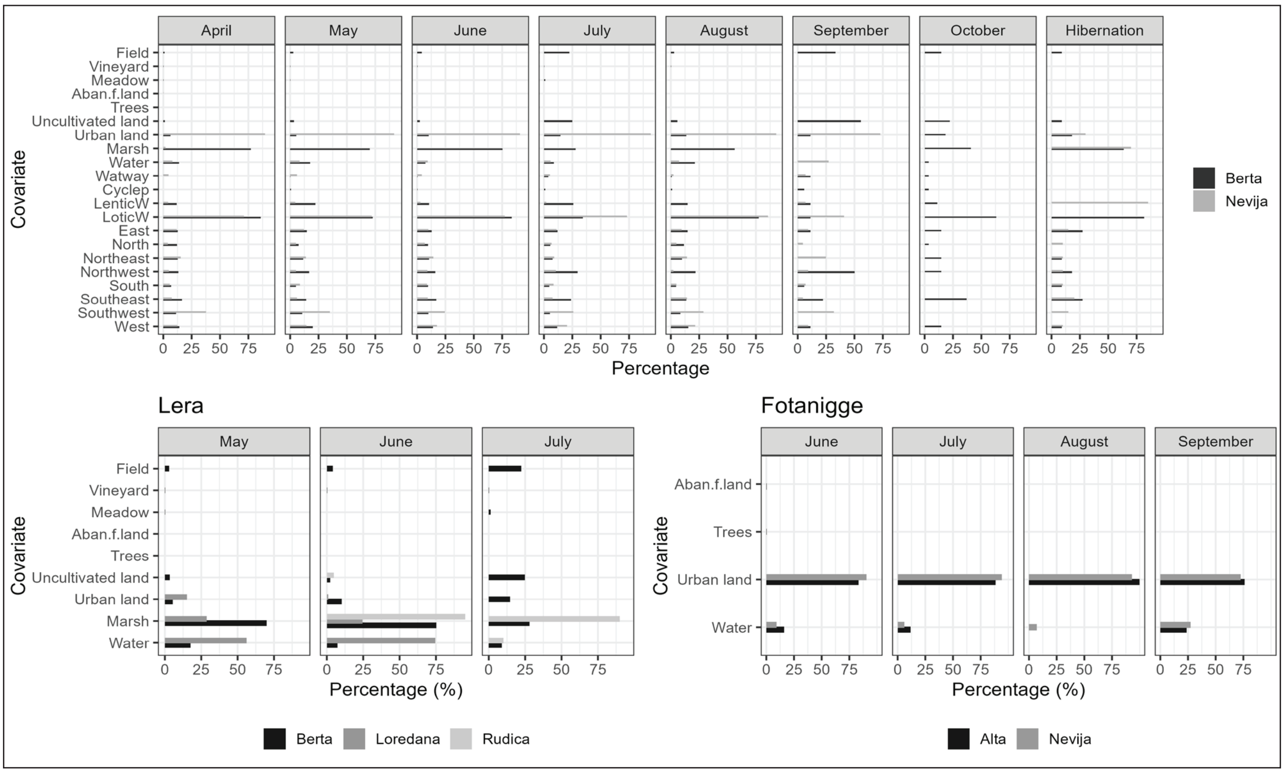


Fig. 4: The monthly/hibernation proportions of the covariate categories/range for European pond turtles** (E. orbicularis) **in Lera and Fontanigge in the Sečovlje Salina Nature Park. Aban.f.land - Abandoned farmland; LenticW – Lentic Water, LoticW – Lotic water, Watway – Waterway, Cyclep – Cycling path.
Sl. 4: Mesečni in hibernacijski deleži kategorij oziroma razponov kovariat pri močvirskih sklednicah** (E. orbicularis) **na območjih Lere in Fontanigg v Krajinskem parku Sečoveljske soline. Aban.f.land – opuščena kmetijska zemljišča; LenticW – stoječe vode; LoticW – tekoče vode; Watway – vodotok; Cyclep – kolesarska pot.

Berta was occasionally observed near or on the cycling path almost every month (0.4-5.6% of locations), except in April and during hibernation. Most of Berta's locations were documented in the northwest-facing areas during the summer months (July-September) and in the southeast-facing areas during almost all other months. During hibernation, the assigned locations mostly faced to the southeast and east, and during May to the west (Fig. 4). Throughout the year, Berta predominantly used locations with high solar radiation, very low slope and ruggedness, and locations with low potential for water accumulation (TWI). However, it is important to note that throughout the active season and hibernation, a wide range of values was observed for all these topographical covariates, ranging from very low to very high classes, even for the solar radiation (Fig. 5). In Fontanigge, most of Nevija's terrestrial locations during active months were assigned to urban land (>73%). Among the aquatic categories, the highest number of locations was assigned to water. Almost every month, Nevija was observed in both lotic and lentic waters, with the latter being predominantly selected. Lentic water was the only habitat assigned for hibernation. The highest percentage of Nevija's locations assigned to waterway was recorded in September (7%), whereas in all other months, it was lower than 6%. During the study, Nevija was not observed near or on the cycling path. Nevija's locations were mostly in the southwest-facing areas, with less variation in assigned slope values between months compared to Lera (Fig. 4). Some similarities with Lera were observed regarding the topographical covariates (*e.g.*, solar radiation, slope, and potential for water accumulation), although Nevija's locations were more often assigned to even gentler slopes and less rugged terrain. Overall, the range of assigned values for topographical covariates was narrower compared to Lera, with most falling within four classes (Fig. 5).

The monthly analysis of habitat use considering all females also revealed differences among months for almost all topographical and environmental/anthropogenic covariates in both areas (Chi-Square > 4.34 with $p < 0.03$ and Mann Whitney $> 2,136.0$

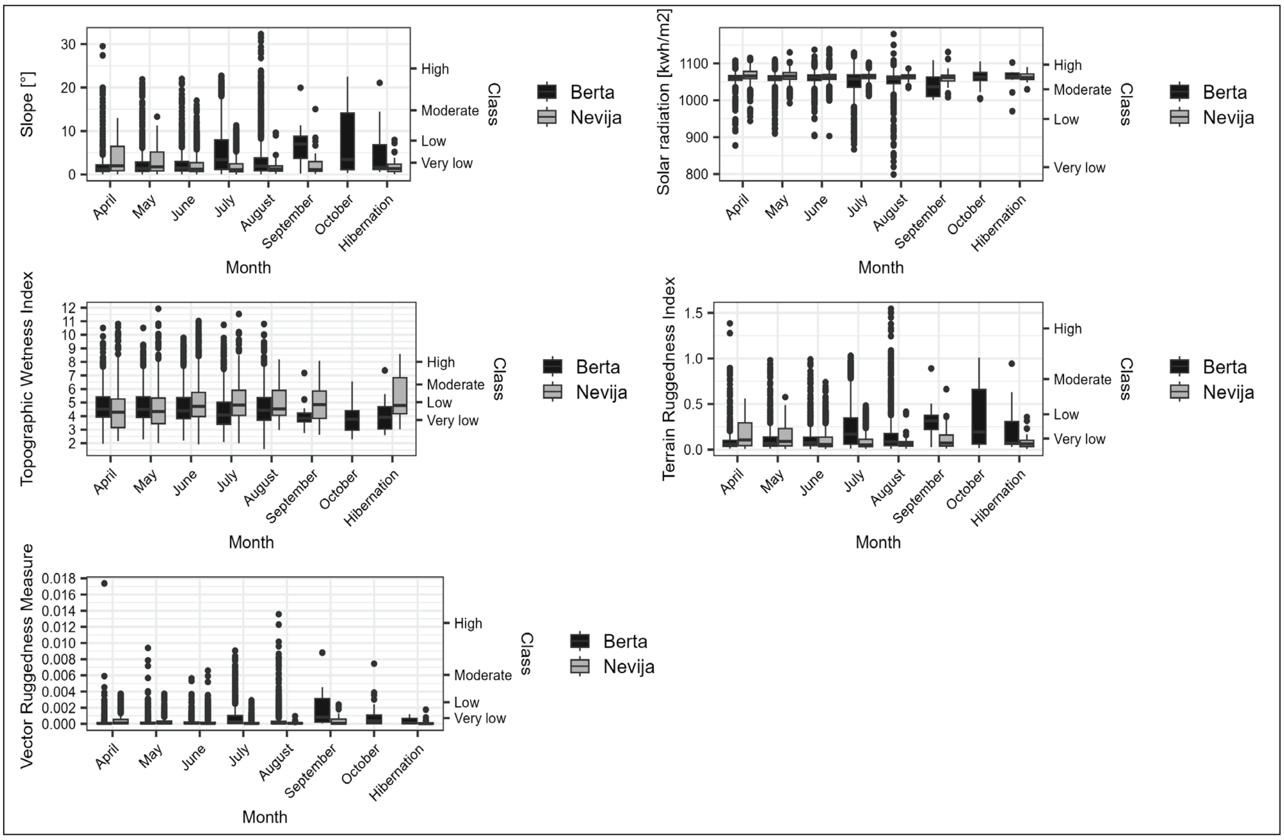


Fig. 5: Box plots of topographic covariates for European pond turtles** (E. orbicularis) **in Lera and Fontanigge in the Sečovlje Salina Nature Park.

Sl. 5: Box-ploti topografskih kovariat pri močvirskih sklednicah** (E. orbicularis) **na območjih Lere in Fontanigg v Krajinskem parku Sečoveljske soline.

with $p < 0.001$). Interestingly, the land use categories assigned in June and July for two other females with palpated eggs differed from those of the representative females (Fig. 4).

In both areas, the highest percentage of terrestrial locations was assigned to the urban area land category. In our study, this category primarily consists of the saline system, which includes gravel paths, saline fields, and the overgrown or cultivated banks of water habitats or embankments next to the saline fields. These surfaces within urban areas are believed to be very important for *Emys orbicularis*, as previous observations have also shown egg laying in some parts (Ferjančič & Škornik, 2018; 2019). However, the available data for this land use category do not accurately distinguish between the saline system and other infrastructure types also included in this category, such as airports, tourist areas, or other concrete surfaces. Therefore, the results should be interpreted with caution. Based on our results, we suggest that a more detailed delineation (*e.g.*, remote detection based on high-resolution aerial imagery) of land categories within the saline system (*e.g.*, gravel paths, reedbed) would substantially improve the understanding of the turtles' habitat requirements. Furthermore, such detailed identification would allow for more targeted management and protection measures.

All terrestrial locations assigned to Berta and Nevija, along with urban land, can be considered as potential egg-laying sites (Fig. 4), especially field, uncultivated land, and meadow land use categories in Lera, as well as the abandoned farmland in Fontanigge. Although only a few of Berta's locations were tracked in the vineyard land category, nesting of *Emys orbicularis* was confirmed there in one of the previous years. The locations of other females with palpated eggs were also assigned to the land categories: trees and uncultivated land (Fig. 4). Nesting sites similar to those suggested for egg-laying in our study were also observed in Slovakia (Novotný *et al.*, 2004). It seems that the closeness of fields and uncultivated land categories, besides urban land, is significant for turtles during short-term reactivation, either immediately after hibernation, most likely between February and March, or even earlier. In addition to analysing terrestrial habitats, Berta was often (1% of locations; n = 35) observed on the cycling path (Fig. 4). Furthermore, our analysis showed that turtles use suitable habitats also outside the SSNP, including agricultural areas on the other side of the road. Both lotic and lentic waters are considered important in both areas. As shown in this study, turtles can be observed crossing the cycling path, exposing them to bicycles and other small vehicles that may cause injury or mortality. Frequent daily use of the cycling path by visitors, tourists, and locals can also disturb turtles during basking, migration, or egg-laying. Because the cycling path represents one of the intensively used tourist infrastructures within or near the SSNP, we highlight the need to assess its potential negative impact and to compare it with other infrastructure types, such as gravel paths.

The analysis based on topographical factors indicated that both turtles tended to prefer areas with high solar radiation, low or very low slope and ruggedness, as well as low potential for water accumulation. However, a wide range of values for these characteristics was observed on a monthly basis and during hibernation, indicating the need for a diverse range of habitat features. Similarly, a significant diversity was also documented for the assigned aspect during the study period. No specific pattern could be identified for the assigned values for any of the topographical factors, whereas the most similar values between months/hibernation period was observed for solar radiation (Fig. 5). The assigned values for some topographical covariates (*e.g.*, aspect and slope) can mostly be compared only to values obtained from the presence records of *Emys orbicularis* and no particular deviation from those was observed (Kornilev *et al.*, 2017).

CONCLUSIONS

As already pointed out by Liuzzo *et al.* (2023), quantitative data on the habitat requirements of the threatened European Pond Turtle in saline ecosystems are urgently needed to evaluate which areas are indispensable for the species and what measures can improve habitat suitability. Our research focused on the predominantly brackish habitats in the SSNP, where the subspecies *Emys o. hellenica* lives (Vamberger *et al.* 2015). Recent data have shown a low number of younger individuals (Ferjančič & Škornik, 2018; 2019; 2021) and highlighted several threats, including the intensive use of agricultural land, park visitors deviating from marked paths (Škornik, 2016; 2017; 2018; 2019; 2020), the introduction of alien turtle species (*Trachemys scripta*; Krofel *et al.*, 2009; Torkar, 2012; Ferjančič & Škornik, 2018; 2019; Žagar *et al.*, 2019), and inappropriate timing of management measures in aquatic habitats. Due to limited funding and the observation that males and females in similar habitats do not show significant differences in movement distance and home range (Slavenko *et al.*, 2016; Liuzzo *et al.* 2023), our research focused only on females living in the Fontanigge and Lera areas, where turtles are most abundant in the SSNP (Fig. 1), which also allowed us to study reproductive behavior, as successful long-term reproduction is crucial for species conservation (Zuffi, 2000;

Ficetola *et al.*, 2004; Fritz & Chiari, 2013). Based on a comprehensive literature review, our study is among the first to use GPS transmitters on this semiaquatic turtle species (Cadi *et al.*, 2004; Meeske & Muhlenberg, 2004; Novotný *et al.*, 2004, 2008; Thienpont *et al.*, 2004; Vamberger & Kos, 2011; Perez-Santigosa *et al.*, 2013; Mignet *et al.*, 2014; Mascort & Budo, 2017; Drechsler *et al.*, 2018; Escoriza *et al.*, 2020, Horváth *et al.*, 2021; Liuzzo *et al.*, 2023). A comprehensive dataset of locations was gathered using solar-powered GPS telemetry (Appendix 1). Due to limited GPS signals when the turtles are underwater, this dataset does not provide a complete understanding of their habitat requirements throughout the year. To address this issue, it is recommended to use a solar-powered GPS system that is supplemented with an additional source of energy (for example, batteries), especially during the hibernation period, to enhance data collection. Furthermore, high-resolution LiDAR-derived topographic covariates (1 m × 1 m) were used to maximize spatial precision and minimize potential bias in habitat-use analysis, even considering minor inaccuracies (estimated errors are <10 m, depending on habitat type; Anonymous, 2024b) in GPS data. The high-resolution spatial data were retained rather than generalized, as this approach better corresponds to reality and reflects fine-scale habitat relationships (Čonč *et al*. 2024). Given the flat and homogeneous terrain of the SSNP, the small GPS error was considered acceptable (Cochrane *et al.*, 2019). While acknowledging these strengths, the study also recognizes the need to address GPS telemetry limitations in future analysis (Čonč *et al*. 2024). Temporal inconsistencies in solar-powered transmitter data (*e.g.*, when submerged underwater) and the limited number of tracked turtles were identified as the main issues, rather than spatial inaccuracy. Although the chosen method provided valuable insights into turtle habitat use, a habitat selection analysis (*e.g.*, Krupiński *et al.*, 2021) could offer a more detailed understanding of environmental preferences, if consistent data become available.

Our results, based on 95 % of locations, clearly show that the European Pond Turtle *E. o. hellenica* in SSNP requires around 4 ha in the Lera area and at least 5-8 ha in the Fontanigge area of diverse suitable aquatic and adjacent terrestrial sites to fulfil all its main biological needs. It is important to note that the method chosen to estimate home range size can impact the results (Walter *et al.*, 2015; Silva *et al.*, 2020). Therefore, to ensure comparable results, outcomes from multiple method datasets are considered. Our results not only show the difference on a monthly/hibernation basis regarding the required area for normal freshwater turtle activity (home range), movements, and habitat use, but also highlight the need for distinct conservation management on a smaller scale. This conclusion is evident in the two adjacent but different Lera and Fontanigge areas inside SSNP.

The data collected by month during the active season and during the hibernation period is extremely important for avoiding any invasive mechanical interventions, such as mulching machines, in the terrestrial areas inside the SSNP and its surroundings, especially because turtles were also observed outside the park (Fig. 2). It is essential to prevent or minimize any disturbances (MESP, 2024), particularly during the nesting season (until the eggs hatch). Based on our findings and previous observations, this nesting period is expected to occur from late June to the end of July and again from late August until early November. Furthermore, it is important to avoid the use of heavy machinery during the suggested hibernation months, from September/October until April, when the end of hibernation is suggested. The period should be extended until the end of April due to the confirmed spring emergence of hatchlings (Budak, 2013; Ferjančič & Škornik, 2021). Limitations during this time frame are particularly important because it is suggested that turtles in SSNP do not hibernate in just one area; other hibernation areas still need to be discovered. The long-term continuity of such a study, including also males and younger individuals, is crucial for preserving all hibernation areas. It would be essential to incorporate the preservation of suitable hibernation areas into the Natura 2000 Management Program as another key management strategy for species conservation (MESP, 2024). During the active months when turtles spend the most time in aquatic habitats, it is important to perform maintenance works on banks (mowing, clearing, or thinning of vegetation) and interventions (dredging and silting) according to the mosaic principle. Any interventions in water habitats during the suggested hibernation period should be prevented. Moreover, our research emphasizes the significance of placing information boards and road signs along the cycling path in the SSNP, which will help to notify park visitors and hikers about the presence of the European Pond Turtle and the potential for turtles crossing the road. Given the presence of turtles on the SSNP's opposite side of the road (Fig. 2), it is crucial to create a safe passage to reduce injuries and fatalities caused by vehicles. These incidents have already been documented. Additionally, the lower part of the Dragonja River valley, which is represented by the floodplains of both the Dragonja and Drnica rivers, could also play a crucial role in conserving the European Pond Turtle within the SSNP's hinterland. In this unprotected lowland area (approximately 758 ha), extending nearly to the village of Dragonja and the western border of the Natura 2000 area Slovenska

Istra (site code: SI3000212), turtles could be found in the main channel of the Dragonja River (Budak, 2013; Tome, 2003). Additionally, the channeled bed of the Drnica River, along with the larger canals and smaller ditches on reclaimed land, may also represent potential habitats. Although data on turtle presence have not yet been systematically collected, gathering this information will be essential for the successful long-term conservation of the species. It would also be important to follow the proposed management requirements of the species (MESP, 2024) and the suggested use of machinery in this area of the park's hinterland.

Our findings can strengthen the existing management (MESP, 2024) and guide conservation efforts to protect not only the European Pond Turtle but also other endangered species, thereby preserving essential ecological processes and components of biodiversity in SSNP. The role of the European Pond Turtle in SSNP should be seen as a potential symbol of sustainable development (Polajnar *et al.*, 2022). Its existence emphasizes the significance of connecting aquatic and terrestrial habitats (Bodie & Semlitsch, 2000; Cadi *et al.*, 2004) and contributes to ecosystem services, such as seed dispersal, nutrient cycling, and carbon storage (Lovich *et al.*, 2018). The intention of the study was also to point out the importance of wetland conservation and to encourage sustainable management based on a participatory approach to link the conservation goals with the social aspect and local economic development (Polajnar *et al.*, 2022; Smrekar *et al.*, 2022).

ACKNOWLEDGEMENTS

Fieldwork was conducted with the permit released by the Ministry of Environment and Spatial Planning (35601-50/2020-4). The authors would like to thank all those who gave us valuable advice and comments. Special thanks to Dr. Andraž Šuligoj and Sašo Sever for the help with the statistics. The research was financially supported by the Slovenian Research and Innovation Agency (P6-0101). We would also like to thank the three anonymous reviewers for their suggestions, which have improved the manuscript.

Appendix 1: Summary of telemetry data of European Pond Turtles** (E. orbicularis) **tracked in the Sečovlje Salina Nature Park. *Minimum time interval. / No data.
Priloga 1: Povzetek telemetričnih podatkov močvirskih sklednic** (E. orbicularis)**, sledenih v Krajinskem parku Sečoveljske soline. *Minimalni časovni interval. / Ni podatkov.

Information/Turtle name	**Rudica**	**Berta**	**Alta**	**Loredana**	**Nevija**
Id of telemetry tag	999001	999003	999004	999005	999006
Straight-line carapacial length (mm)	133.17	162.00	128.07	148.14	137.30
Body mass (g)	403	670	383	526	426
Age	4.class	4. class	3. class	5. class	4. class
Sex	Female	Female	Female	Female	Female
Eggs presence	yes	no	yes	no	no
Deployment date	11.06.2019	18.04.2019	11.06.2019	24.05.2019	26.05.2019
Last downloaded data	13.07.2019	04.06.2020	14.09.2019	18.06.2019	29.06.2020
Telemetry time interval	120*min	15 min	5 min	5 min	10 min
Number of locations	31	4038	832	256	3440
Number of locations in 2019	31	3419	832	256	1796
Number of locations in 2020	/	619	/	/	1644
Number of tracking days with data	18	193	36	12	155
Number of tracking days in 2019	18	129	36	12	61
Number of tracking days in 2020	/	64	/	/	94

Appendix 2: Characteristics of predictor covariates used for the habitat use analysis by the European Pond Turtle** (E. orbicularis) **in the Sečovlje Salina Nature Park. *Values of covariates where categories are listed were defined based on Jenks natural breaks (1 = very low. 2 = low. 3 = moderate. 4 = high. 5 = very high). **A) Slovenian Environment Agency (ARSO - Agencija RS za okolje), B) Slovenian Water Agency (DRSV), C) Ministry of Agriculture, Forestry and Food (MKGP), and D) Municipality of Piran.

Priloga 2: Značilnosti kovariat, uporabljenih pri analizi rabe habitata močvirske sklednice** (E. orbicularis) **v Krajinskem parku Sečoveljske soline. Vrednosti kovariat, kjer so podane kategorije, so bile določene z metodo Jenksovih naravnih prelomov (1 = zelo nizko; 2 = nizko; 3 = zmerno; 4 = visoko; 5 = zelo visoko).A) Agencija Republike Slovenije za okolje (ARSO), B) Direkcija Republike Slovenije za vode (DRSV), C) Ministrstvo za kmetijstvo, gozdarstvo in prehrano (MKGP) in D) Občina Piran.

Covariate		**Range or category***	**Description**	**Data source****
Topographical	**Aspect**	North: 337.5 - 22.5 Northeast: 22.5 - 67.5 East: 67.5 - 112.5 Southeast: 112.5 - 157.5 South: 157.5 - 202.5 Southwest: 202.5 - 247.5 West: 247.,5 - 292.5 Northwest: 292.5 - 337.5	Area [m^2] of aspect categories in each HR indicating the compass direction the surface faces at that location.	A)
	Slope [°]	1: 0.00 - 2.68 2: 2.684 - 7.77 3: 7.77 - 14.74 4: 14.749 - 24.39 5: 24.395 - 68.35	Area [m^2] of steepness of the slope categories in each HR.	A)
	Solar radiation [kwh/m^2]	1: 366.49 - 818.70 2: 818.71 - 949.34 3: 949.344 - 1,029.74 4: 1,029.74 - 1,096.73 5: 1,096.73 - 1,220.67	Area [m^2] of incoming solar radiation from a raster surface category in each HR.	A)
	Topographic Wetness Index (TWI)	1: 0.20 - 3.72 2: 3.72 - 5.03 3: 5.03 - 6.34 4: 6.34 - 8.00 5: 8.00 - 15.39	Area [m^2] of topographic wetness categories as an estimation of water accumulation locations in an area with elevation differences in each HR.	A)
	Terrain Ruggedness Index (TRI)	1: 0.00 - 0.12 2: 0.12 - 0.39 3: 0.39 - 0.77 4: 0.77 - 1.33 5: 1.33 - 6.16	Area [m^2] of terrain ruggedness categories as measure of the difference in elevation values from a center cell and eight cells directly surrounding it in each HR.	A)
	Vector Ruggedness Measure (VRM)	1: - 0.00 - 0.0007 2: 0.0007 - 0.003 3: 0.003 - 0.006 4: 0.006 - 0.01 5: 0.01 - 0.05	Area [m^2] of terrain ruggedness categories as the variation in 3-D orientation of grid cells within a neighborhood calculated in each HR.	A)
Environmental/ anthropogenic	**Waterway [m]**	0 - 839.89	Length of waterways in each HR.	B)
	Lentic water [m2]	0 - 40,088.71	Area [m^2] of waterways in each HR.	B)
	Lotic water [m2]	0 - 13,053.33	Area [m^2] of waterbodies in each HR.	B)
	Land use	1100 - Field 1190 - Greenhouse 1211 - Vineyard 1221 - Intensive orchard 1222 - Extensive orchard 1230 - Olive orchard 1300 - Meadow 1410 - Abandoned farm land 1500 - Trees 1600 - Uncultivated land 3000 - Urban land 4220 - Marsh 7000 - Water	Area of land use categories in each HR.	C)
	Cycling path [m]	0 - 237.24	Length of cycling paths in each HR.	D)

Appendix 3: The percentages/average values of the covariate categories/range during the entire study period (2019-2020) of the representative European Pond Turtle** (E. orbicularis) **in the Lera (turtle Berta) and in the Fontanigge (turtle Nevija) in the Sečovlje Salina Nature Park. n = number of locations assigned to environmental/anthropogenic or topographical covariate range/category. *Pearson Chi-Square/Mann Whitney. / No data

Priloga 3: Odstotki/povprečne vrednosti kategorij/razponov kovariat v celotnem obdobju raziskave (2019–2020) za izbrani samici močvirske sklednice** (E. orbicularis) **na območju Lere (želva Berta) in Fontanigg (želva Nevija) v Krajinskem parku Sečoveljske soline. n = število lokacij, dodeljenih posameznim okoljskim, antropogenim ali topografskim razponom oziroma kategorijam kovariat. Pearsonov hi-kvadratni test/Mann-Whitneyjev test. / Ni podatkov.

Covariate	Lera				Fontanigge			
	2019-2020	n	Statistics*	Significance (p)	2019-2020	n	Statistics*	Significance (p)
% of Land use category								
Field	9.41	380	1273.464	< 0.001	0.00	0	1395.361	< 0.001
Vineyard	0.20	8			0.00	0		
Meadow	0.47	19			0.00	0		
Abandoned farm land	0.02	1			0.06	2		
Trees	0.02	1			0.00	0		
Uncultivated land	10.75	434			0.00	0		
Urban land	11.22	453			90.50	3113		
Marsh	54.93	2218			0.73	25		
Water	12.98	524			8.71	300		
% of all locations								
Lentic water	18.20	64	109.342	< 0.001	3.80	132	368.645	< 0.001
Lotic water	64.60	736	843.248	< 0.001	74.20	2550	99.223	< 0.001
Waterway	1.60	2600	75.040	< 0.001	4.60	158	5.718	0.456
Cycling path	0.99	35	16.527	0.021	/	0	/	/
% of Aspect range								
East	13.22	534	260.360	< 0.001	10.74	368	110.982	< 0.001
North	8.59	347			6.09	210		
Northeast	9.91	400			13.78	474		
Northwest	21.47	867			7.92	272		
South	5.94	240			8.18	281		
Southeast	18.13	732			8.39	289		
Southwest	8.30	335			28.32	975		
West	14.44	583			16.57	571		
Mean value								
Slope (°)	Low (3.90)	4038	312.997	< 0.001	Very low (2.63)	3440	99.89	< 0.001
Solar radiation (kwh/m^2)	High (1053.21)	4038	49.594	< 0.001	High (1063.89)	3440	32.634	< 0.001
Topographic Wetness Index	Low (4.59)	4038	117.898	< 0.001	Low (4.88)	3440	75.57	< 0.001
Terrain Ruggedness Index	Low (0.180)	4038	348.054	< 0.001	Low (0.122)	3440	107.95	< 0.001
Vector Ruggedness Measure	Low (0.00055)	4038	329.952	< 0.001	Very low (0.00029)	3440	76.425	< 0.001

HABITATNE ZNAČILNOSTI MOČVIRSKE SKLEDNICE (*EMYS ORBICULARIS*) V KRAJINSKEM PARKU SEČOVELJSKE SOLINE, SLOVENIJA

Kim LEBAN
Most na Soči 112, 5216 Most na Soči, Slovenia
e-mail: kim.leban89@gmail.com

Iztok ŠKORNIK
Sečovlje Salina Nature Park, Parecag 290, 6320 Portorož, Slovenia

Špela ČONČ & Mateja BREG VALJAVEC
Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Novi trg 2, 1000 Ljubljana, Slovenia

Žan KURALT
Genialis d.o.o., Vojkova cesta 63, 1000 Ljubljana, Slovenia

Lenart ŠTAUT, Jure TIČAR, Katarina POLAJNAR HORVAT, Primož GAŠPERIČ & Aleš SMREKAR
Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Novi trg 2, 1000 Ljubljana, Slovenia

Melita VAMBERGER
Senckenberg Naturhistorische Sammlungen Dresden, Museum of Zoology, Königsbrücker Landstraße 159, 01109 Dresden, Germany
e-mail: melita.vamberger@senckenberg.de

POVZETEK

*V Krajinskem parku Sečoveljske soline (KPSS), enem največjih obalnih somornih mokrišč v Sloveniji, smo izvedli obsežno raziskavo habitatnih zahtev (območje razširjenosti, premike in rabo habitata) sladkovodne vrste želve močvirske sklednice (*Emys orbicularis*). V letih 2019- 2020 smo opremili pet samic z GPS-oddajniki na sončno energijo. Z uporabo visoko-ločljivih LiDAR podatkov ter podrobne prostorske analize smo primerjali aktivnosti posameznih želv na mesečni ravni in v času hibernacije, in sicer na dveh ekološko različnih sosednjih območjih znotraj parka, kjer je vrsta prisotna v največjem številu. Podatki, zbrani v tako kratkem (mesečnem) obdobju, zagotavljajo dragocen vpogled v habitatne zahteve, sezonsko dinamiko rabe prostora ter razlike v okoljskih razmerah. Rezultati predstavljajo pomembno izhodišče za oblikovanje ciljno usmerjenih naravovarstvenih ukrepov za ohranjanje te ogrožene vrste želve v obalnih somornih mokriščih, ki so pogosto krajevno specifična in izpostavljena številnim vplivom človeka.*

Ključne besede: Močvirska sklednica, *Emys orbicularis hellenica*, GPS-telemetrija, LiDAR, raba habitata, naravovarstveni ukrepi, obalno mokrišče

REFERENCES

Agha, M., J. Ennen, D. Bower, A. Nowakowski, S. Sweat & B. Todd (2018): Salinity tolerances and use of saline environments by freshwater turtles: Implications of sea level rise. Biol. Rev., 93(3), 1634–1648.

Anonymous, (2024a): https://meteo.arso.gov.si/met/sl/app/webmet/#webmet==8Sdwx2bhR2cv0WZ0V2bvEGcw9ydlJWblR3LwVnaz9SYtVmYh9iclFGbt9SaulGdugXbsx3cs9mdl5WahxXYyNGapZXZ8tHZv1WYp5mOnMHbvZXZulWYnwCchJXYtVGdlJnOn0UQQdSf (Accessed 21 April 2024).

Anonymous, (2024b): https://milsar.com/products/radio-tag-14.html (Accessed 21 April 2024).

Bayrakci, Y., D. Ayaz & L. Luiselli (2021): Determining home range, habitat use changes throughout time, and the threats of an endangered freshwater turtle (*Rafetus euphraticus*) in Turkey. Aquat. Conserv.: Mar. Freshw. Ecosyst., 31(10), 3276–3290.

Bodie, J.R. & R. Semlitsch (2000): Spatial and temporal use of foodplain habitats by lentic and lotic species of aquatic turtles, Oecologia, 122, 138–146.

Böhm, M. & D. Popescu (2016): Landscape ecology, biogeography, and GIS methods. In: Dodd K., (ed.): Reptile ecology and conservation: a handbook of techniques. First edition, Oxford University Press, Oxford, pp. 298–314.

Böhm, M., B. Collen, J.E.M. Baillie, P. Bowles, J.S. Chanson, N.A. Cox, G.A. Hammerson, M.D. Hoffmann, S.R. Livingstone, M. Ram, A.G.J. Rhodin, S.N. Stuart, P.P. Van Dijk, B.E. Young, L.E. Afuang, A.L. Aghasyan, A.M. García, C. Aguilar, R.D. Ajtić & G.R. Zug (2013): The conservation status of the world's reptiles. Biol. Conserv., 157, 372–385.

Broggi, M.F. & H. Grillitsch (2012): The European Pond Terrapin *Emys orbicularis hellenica* (Valenciennes 1832) in the Aegean: Distribution and threats. Herpetozoa, 25, 47–58.

Budak, V. (2013): Studio della popolazione di testuggine palustre (*Emys orbicularis*) lungo il fiume Dragonja-Dragogna. Graduation thesis, Università degli studi di Trieste, Trieste, 144 pp.

Burt, W.H. (1943): Territoriality and home range concepts as applied to mammals. J. Mammal., 24, 346–352.

Cadi, A., M. Nemoz, S. Thienpont & P. Joly (2004): Home range, movements, and habitat use of the European pond turtle (*Emys orbicularis*) in the Rhone-Alpes region, France. Biologia, 59(14), 89–94.

Calenge, C. (2006): The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. Ecol Modell., 197, 516–519.

Christensen, R. & P. Chow-Fraser (2014): Use of GPS loggers to enhance radio-tracking studies of semi-aquatic freshwater turtles. Herpetol. Conserv. Bio., 9, 18–28.

Cochrane, M.M., D.J., Brown, & R.A. Moen (2019): GPS technology for semi-aquatic turtle research. Diversity, 11(3), 34.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Communities, L 206, 22 July 1992, pp. 7–50.

Council of Europe (1979): Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Bern, 19 September 1979. European Treaty Series – No. 104.

Crane, M., I. Silva, B.M. Marshall & C.T. Strine (2021): Lots of movement, little progress: a review of reptile home range literature. PeerJ, 9, e11742.

Čonč, Š. (2020): Pomen varovanja vročih točk geodiverzitete za ohranitev biotske pestrosti na območju Nature 2000 v dolini reke Dragonje. Geografski vestnik, 92(2), 9–28.

Čonč, Š., T. Oliveira, R. Portas, R. Černe, M. Breg Valjavec & M. Krofel (2022): Dolines and Cats: Remote Detection of Karst Depressions and Their Application to Study Wild Felid Ecology. Remote Sens., 14(3), 656, 16 pp.

Čonč, Š., T. Oliveira, E. Belotti, L. Bufka, R. Černe, M. Heurich, M. Breg Valjavec & M. Krofel (2024): Revealing functional responses in habitat selection of rocky features and rugged terrain by Eurasian lynx (*Lynx lynx*) using LiDAR data. Landsc. Ecol., 39(7), 121.

Dall'Antonia, L., M. Lebboroni, S. Benvenuti & G. Chelazzi (2001): Data loggers to monitor activity in wild freshwater turtles. Ethol. Ecol. Evol., 13(1), 81–88.

Davidson, N.C. (2014): How much wetland has the world lost? Long-term and recent trends in global wetland area. Mar. Freshw. Res., 65, 934–941.

Delucchi, K. L. (1993): On the use and misuse of chisquare. In: Keren, G. & C. Lewis (eds.): A handbook for data analysis in the behavioral sciences, Vol. 2. L. Erlbaum Hillsdale, N.J., pp. 294–319.

De Solla, S.R., R. Bondurianski & R.J. Brooks (1999): Eliminating autocorrelation reduces biological relevance of home range estimates. J. Anim. Ecol., 68, 221–234.

Drechsler, R.M., L.M. Fernández, M. Lassalle & J. Monrós (2018): Movement patterns and home range sizes of translocated European pond turtles (*Emys orbicularis*, Linnaeus, 1758) in eastern Spain. Herpetol. Conserv. Biol., 13, 1–9.

Erdélyi, G., B. Szabó & I. Kiss (2019): Basking activity pattern of the European pond turtle, *Emys orbicularis* (Linnaeus, 1758) in Babat valley (Gödöllő, Hungary). Herpetozoa, 32, 221–227.

Escoriza, D., M. Franch, S. Ramos, P. Sunyer & D. Boix (2020): Demographics and survivorship in the European Pond Turtle (*Emys orbicularis*): A 31-year study. Herpetol Conserv Bio., 15, 41–48.

Fattizzo, T. (2004): Basic morphological data and notes on natural history and conservation of a population of *Emys orbicularis* in southern Apulia (Carovigno, Salento). Ital J Zool., 2, 191–193.

Ficetola, G.F. & F. De Bernardi (2006): Is the European "pond" turtle *Emys orbicularis* strictly aquatic and carnivorous? Amphibia-Reptilia, 27, 445–447.

Ficetola, G.F., E. Padoa-Schioppa, A. Monti, R. Massa, F. De Bernardi & L. Bottoni (2004): The importance of aquatic and terrestrial habitat for the European pond turtle (*Emys orbicularis*): implications for conservation planning and management. Can. J. Zool., 82(11), 1704–1712.

Ferjančič, K. & I. Škornik (2018): Monitoring populacije močvirske sklednice (*Emys orbicularis*. Linnaeus 1785) v Krajinskem parku Sečoveljske soline, Seča, 60 pp.

Ferjančič, K. & I. Škornik (2019): Močvirska sklednica. In: Naravovarstveni monitoring Sečoveljskih solin, Priloga letnemu poročilu KPSS, SOLINE Pridelava soli d. o. o., Seča, pp. 58–61.

Ferjančič, K. & Škornik I. (2021): Močvirska sklednica. In: Naravovarstveni monitoring Sečoveljskih solin, Priloga letnemu poročilu KPSS, SOLINE Pridelava soli d. o. o., Seča, pp. 54–59.

Fritz, U. (2003): Die Europäische Sumpfschildkröte. Laurenti-Verlag, Bielefeld, 224 pp.

Fritz, U. & Y. Chiari (2013): Conservation actions for European pond turtles – a summary of current efforts in distinct European countries. Herpetol. Notes, 6(1), 105–163.

Holm, S. (1979): A simple sequentially rejective multiple test procedure. Scand. J. Statist., 6, 65–70.

Horváth, E., M. Martvoňová, S. Danko, P. Havaš, P. Kaňuch & M. Uhrin (2021): Distribution range and population viability of *Emys orbicularis* in Slovakia: a review with conservation implications. J. Nat. Conserv., 44, 141–161.

Ivajnšič, D., L. Lipej, I. Škornik & M. Kaligarič (2017): The sea level rise impact on four seashore breeding birds: the key study of Sečovlje Salina Nature Park. Climatic Change., 140, 549–562.

Iverson, J.B. & R.C. Vogt (2011): *Kinosternon acutum* Gray 1831 – Tabasco Mud Turtle, Montera, Chechagua de Monte. In: Rhodi, A.G.J., P.C.H. Pritchard, P.P van Dijk, R.A. Saumure, K.A. Buhlmann, J.B. Iverson & R.A. Mittermeier (eds.): Conservation Biology of Freshwater Turtles and Tortoises: A compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Res. Monogr., 5, 062.1-062.6.

Jaeger, C.P. & V.A. Cobb (2012): Comparative spatial ecologies of female painted turtles (*Chrysemys picta*) and red-eared sliders (*Trachemys scripta*) at Reelfoot Lake, Tennessee. Chelonian Conserv. Biol., 11, 59–67.

Jogan, N. (2001): Ali je *Ruppia cirrhosa* (Petagna) *grande* edini slovenski predstavnik tega rodu? Annales, Ser. Hist. Nat, 11(2), 289–292.

Joo, R., S. Picardi, M. Boone, T. Clay, S. Patrick, V. Romero-Romero & M. Basille (2020): A decade of movement ecology. 20202006.00110.

Kaligarič, M. (1990): Botanična podlaga za naravovarstveno vrednotenje slovenske Istre. Varstvo narave, 16, 17–44.

Kay, M. & J. O. Wobbrock (2023): *ARTool: Aligned Rank Transform for Nonparametric Factorial ANOVAs*. R package version 0.11.1. Available at: https://CRAN.R-project.org/package=ARTool (Accessed 21 May 2025).

Knapp, C.R. & J.G. Abarca (2009): Effects of radio transmitter burdening on locomotor ability and survival of iguana hatchlings. Herpetologica, 65(4), 363–372.

Kornilev, Y., G. Popgeorgiev, B. Naumov, A. Stoyanov & N. Tzankov (2017): Updated distribution and ecological requirements of the native freshwater turtles in Bulgaria. Acta Zool. Bulg., Supplement, 10, 65-76 + i-xvii.

Komac, B., M. Pavšek & M. Topole (2020): Climate and Weather of Slovenia. In: Perko, D., R. Ciglič, M. Zorn, (eds.): The Geography of Slovenia. World Regional Geography Book Series. Springer, Cham, Switzerland, pp. 71–89.

Kotenko, T.I. (2000): The European Pond turtle (*Emys orbicularis*) in the Steppe Zone of the Ukraine. Kataloge des OÖ. Landesmuseums, 149, 87–106.

Krofel, M., V. Cafuta, G. Planinc, M. Sopotnik, A. Šalamun, S. Tome, M. Vamberger & A. Žagar (2009): Razširjenost plazilcev v Sloveniji: pregled podatkov, zbranih do leta 2009. Natura Sloveniae, 11(2), 61–99.

Krupiński, D., D. Kotowska, M.R. Recio, M. Żmihorski, P. Obłoza, & P. Mirski (2021): Ranging behaviour and habitat use in Montagu's Harrier Montagu's Harrier (*Circus pygargus*) in extensive farmland of Eastern Poland. J. Ornithol., 162, 325–337.

Kuchling, G. (1987): Fortpflanzung der Europäischen Sumpfschild-kröte *Emys orbicularis*, unter der natürlichen Klimabedingungen Wiens. ÖGH-Nachrichten, Wien, 10(11), 33–36.

Leban, K., B. Rakar & D. Stavber (2021): Močvirska sklednica (*Emys orbicularis*) v Naravnem rezervatu Škocjanski zatok – Poročilo za leto 2020. DOPPS, Koper, 33 pp.

Lebboroni, M. & G. Chelazzi (1991): Activity patterns of *Emys orbicularis* L. (Chelonia Emydidae) in central Italy. Ethol. Ecol. Evol., 3, 257–263.

Lipovšek, G. & M. Vamberger (2021): Močvirska sklednica (*Emys orbicularis*) v območju Natura 2000 Slovenska Istra (SI3000212). Končno poročilo. Projekt LIFE-IP NATURA.SI (LIFE17 IPE/SI/000011). EMYS. Ekološke raziskave in svetovanje, Gregor Lipovšek s. p., Pako, 24 pp.

Liuzzo, M., S. Borella, D. Ottonello, V. Arizza & S. Malavasi (2023): Comparing activity and space patterns of the European pond turtle, *Emys orbicularis* (L., 1758) in a Venice Lagoon wetland area: implications for conservation planning and management. Amphib-reptil., 44(2), 153–166.

Lovich, J.E., J.R. Ennen, M. Agha & J.W. Gibbons (2018): Where have all the turtles gone and why does it matter? BioScience 68, 771–791.

Mazanaeva, L. & V. Orlova (2004): Distribution and ecology of *Emys orbicularis* in Daghestan, Russia. In: Fritz U., P. Havaš (eds.). Proceedings of the 3rd International Symposium on *Emys orbicularis*, Biologia, 59(14), 47–53.

Marchand, T., A-S. Le Gal & J-Y. Georges (2021): Fine scale behavior and time-budget in the cryptic ectotherm European pond turtle *Emys orbicularis*. PloS one, 16(10), 21 pp.

Mascort R. & J. Budó (2017): The European PondTurtle, *Emys orbicularis* (L., 1758), in the River Ter Basin (North East Iberian Peninsula): 40 Years of Conservation. Acta Zool Bulg., 10, 91–104.

Meeske, A.C.M. (2000): Habitat requirements of the European pond turtle (*Emys orbicularis*) in Lithuania. In: Proceedings of the 2nd International Symposium on Emys orbicularis, Chelonii 2, 27–32.

Meeske, A.C.M. (2006): Die Europäische Sumpfschildkröte am Nördlichen Rand ihrer Verbreitung in Litauen. Supplement der Zeitschrift für Feldherpetologie 11, Laurenti Verlag, 160 pp.

Meeske, A.C.M. & M. Muhlenberg (2004): Space use strategies by a northern population of the European pond turtle. *Emys orbicularis*, Biologia, 59(14), 95–101.

Mignet, F., T. Gendre, D. Reudet, F. Malgoire, M. Cheylan & A. Besnard (2014): Short-term evaluation of the success of a reintroduction program of the European pond turtle: The contribution of space-use modeling. Chelonian Conserv. Biol., 13, 72–80.

MESP (Ministry of the Environment and Spatial Planning) (2024): Natura 2000 Management Programme. Government of the Republic of Slovenia, Ljubljana. https://natura2000.gov.si/natura-2000/natura-2000-v-sloveniji/program-upravljanja/ (Accessed 27.10.2025)

Mitrus, S. (2010): Is the European pond turtle *Emys orbicularis* strictly aquatic? Habitats where the turtle lives in central Europe. Acta Herpetol., 5(1), 31–35.

Mohr, C.O. (1947): Table of equivalent populations of North American small mammals. Am. Midl. Nat., 37(1), 223–249.

Moravec, J. (2003): Some notes on the population of dwarfed *Emys orbicularis* from Pag (Croatia). Cas Nar Muz Praze Rada Prirodoved, 172(1-4), 55–60.

Novoa, V., O. Rojas, R. Ahumada-Rudolph, K. Sáez, P. Fierro & C. Rojas (2020): Coastal Wetlands: Ecosystems Affected by Urbanization? Water, 12, 698, 18 pp.

Novotný, M., S. Danko & P. Havaš (2004): Activity cycle and reproductive characteristics of the European pond turtle (*Emys orbicularis*) in the Tajba National Nature Reserve, Slovakia. Biologia, (59), 113–121.

Novotný, M., S. Danko, A. Burešová, I. Majláth & P. Havaš (2008): European pond turtle hibernation in southeastern Slovakia: a preliminary report. Rev. Esp. Herp. 22, 139–147.

Official Gazette of the Republic of Slovenia, No. 82/02. https://pisrs.si/pregledPredpisa?id=ODRE1883 (Accessed 27.10.2025)

Official Gazette of the Republic of Slovenia, No. 46/04. https://pisrs.si/pregledPredpisa?id=URED2386 (Accessed 27.10.2025).

Official Gazette of the Republic of Slovenia, No. 48/04. https://pisrs.si/pregledPredpisa?id=URED629 (Accessed 27.10.2025).

Official Gazette of the Republic of Slovenia, No. 111/04. https://pisrs.si/pregledPredpisa?id=PRAV6035 (Accessed 27.10.2025).

Ogrin, D., B. Repe, L. Štaut, D. Svetlin & M. Ogrin (2023): Podnebna tipizacija Slovenije po podatkih za obdobje 1991-2020. Dela, 59, 5–89.

Ogorelec, B., M. Mišic, A. Šercelj, F. Cimerman, J. Faganeli & P. Štegnar (1981): Sediment sečoveljske soline, Geologija, 24, 180–216.

Ottonello, D., S. Salvidio & E. Rosecchi (2005): Feeding habits of the European pond terrapin *Emys orbicularis* in Camargue (Rhóne delta, Southern France). Amphib. Reptil., 26, 562–565.

Pebesma, E. (2018): Simple Features for R: Standardized Support for Spatial Vector Data. The R Journal, 10(1), 439–446.

Pebesma, E. & R. Bivand (2005): Classes and methods for spatial data in R. R News, 5(2), 9–13.

Paterson, J.E. (2018): Analyzing telemetry data in R: creating trajectories. https://jamesepaterson.github.io/jamespatersonblog/02_trackingworkshop_trajectories (Accessed 15 January 2024).

Pekolj, A., M. Vek & G.Lipovšek (2021): Terenska raziskava močvirske sklednice (*Emys orbicularis*) z metodo telemetrije na območju opuščenih glinokopov bilje z določitvijo območij gnezdenja (JN št. 201-103/2019): končno poročilo. Herpetološko društvo - Societas herpetologica slovenica: 21 pp.

Pérez-Santigosa, N., J. Hidalgo-Vila & C. Díaz-Paniagua (2013): Comparing Activity Patterns and Aquatic Home Range Areas Among Exotic and Native Turtles in Southern Spain. Chelonian Conserv. Biol., 12, 313–319.

Perko, D., R. Ciglič & M. Hrvatin (2021): Landscape macrotypologies and microtypologies of Slovenia. Acta Geogr. Slov., 61, 7–89.

Polajnar Horvat, K., P. Gašperič, K. Leban, J. Tičar & A. Smrekar (2022): Participatory Approach to Wetland Governance: The Case of The Memorandum of Understanding of the Sečovlje Salina Nature Park. Sustainability, 14(16), 20 pp.

R Core Team (2023): R: A Language and Environment for Statistical Computing (Version 4.3.1). Vienna: R Foundation for Statistical Computing.

Rogner, M. (2009): European pond turtle (*Emys orbicularis*). Edition Chimaira 4. Frankfurt am Main, 270 pp.

Schneeweiss, N., B. Andreas & N. Jendretzke (1998): Reproductive ecology data of the European pond turtle (E*mys o. orbicularis*) in Brandenburg, Northeast Germany. In: Fritz, U., U. Joger, R. Podloucky & J. Servan (eds.): Proceedings of the EMYS Symposium Dresden 96, Mertensiella, Nr. 10, 227 pp.

Silva, I., M. Crane, B.M. Marshall & C.T. Strine (2020): Reptiles on the wrong track? Moving beyond traditional estimators with dynamic Brownian Bridge Movement Models. Mov Ecol, 8(43), 13 pp.

Slavenko, A., Y. Itescu, F. Ihlow & S. Meiri (2016): Home is where the shell is: predicting turtle home range sizes. J Anim Ecol, 85, 106–114.

Smrekar, A., P. Gašperič, J. Tičar, & K. Polajnar Horvat (2023): Aktivno vključevanje deležnikov v upravljanje zavarovanih območij: primer mokrišča Krajinski park Sečoveljske soline. Geografski Vestnik, 95(1), 77–97.

Standfuss, B., G. Lipovšek, U. Fritz & M. Vamberger (2016): Threat or fiction: is the pond slider (*Trachemys scripta*) really invasive in Central Europe? A case study from Slovenia. Conserv. Genet., 17, 557–563.

Stepišnik, U. (2022): Ponorni kontaktni kras Zrenjskega ravnika, Istra, Hrvaška Dela, 58.

Škornik, I. (1990-1991): Želve – miroljubne stoletnice, Proteus 53, 54–59.

Škornik, I. (2005): Naravovarstveni monitoring Sečoveljskih solin v letu 2005, Seča, SOLINE Pridelava soli d.o.o., 67 pp.

Škornik, I. (2012): Favnistični in ekološki pregled ptic Sečoveljskih solin. Ljubljana. Schwartz print d.o.o., pp. 9–45.

Škornik, I. (2016): Naravovarstveni monitoring Sečoveljskih solin 2015. Seča, SOLINE Pridelava soli d.o.o., 96 pp.

Škornik, I. (2017): Naravovarstveni monitoring Sečoveljskih solin 2016. Seča, SOLINE Pridelava soli d.o.o., 100 pp.

Škornik, I. (2018): Naravovarstveni monitoring Sečoveljskih solin 2017. Seča, SOLINE Pridelava soli d.o.o., 116 pp.

Škornik, I. (2019): Naravovarstveni monitoring Sečoveljskih solin 2018. Seča, SOLINE Pridelava soli d.o.o., 126 pp.

Škornik, I. (2020): Naravovarstveni monitoring Sečoveljskih solin 2019. Seča, SOLINE Pridelava soli d.o o., 104 pp.

Thienpont, S., A. Cadi, R. Quesada & M. Cheylan (2004): Overwintering habits of the European pond turtle (*Emys orbicularis*) in the Isère department (France), Biologia, Bratislava, 59(14), 143–147.

Torkar, G. (2012): Načrt izvajanja monitoringa močvirske sklednice v Sečoveljskih solinah: poročilo. EGEA. Zavod za naravo, Ljubljana, 8 pp.

Torkar, G. & K. Ferjančič (2013): Močvirska sklednica (*Emys orbicularis* (Linnaeus. 1758)) v Krajinskem parku Sečoveljske soline. Rezultati raziskave v letu 2013. Ljubljana. EGEA. Zavod za naravo, 27 pp.

Tome, S. (1996): Pregled razširjenosti plazilcev v Sloveniji. Annales, Ser. Hist. Nat., 3, 217–228.

Tome, S. (2003): Strokovna izhodišča za vzpostavljanje omrežja Natura 2000: močvirska sklednica *Emys orbicularis* (Linnaeus. 1758), Ljubljana, 11 pp.

Turk, R. (2019): Varstvo narave – zavarovana območja. In: Pavšič J., M. Gogala, A. Seliškar (eds.): Slovenska Istra I: ellenicat, rastlinstvo, živalstvo in naravovarstvo, Slovenska matica, Ljubljana, pp. 411–422.

Vamberger, M. (2009): European pond turtle (*Emys orbicularis*) in Slovenia. In: Rogner M. (eds): European pond turtle (*Emys orbicularis*). Edition Chimaira 4, Frankfurt am Main, pp. 190–192.

Vamberger, M. & I. Kos (2011): First observations on some aspects on the natural history of European pond turtles *Emys orbicularis* in Slovenia. Bologia, 66(1), 170–174.

Vamberger, M., G. Lipovšek, A. Šalamun, M. Cipot, U. Fritz & M. Govedič (2017): Distribution and population size of the European pond turtle *Emys orbicularis* in Ljubljansko barje. Slovenia. Vertebr. Zool., 67(2), 223–229.

Vamberger, M., H. Stuckas, F. Sacco, S. D'Angelo, M. Arculeo, M. Cheylan, C. Corti, M. Lo Valvo, F. Marrone, M. Wink & U. Fritz (2015): Differences in gene flow in a twofold secondary contact zone of pond turtles in southern Italy (Testudines: Emydidae: *Emys orbicularis galloitalica. E. o. ellenica. E. trinacris*), Zoologica Scripta, 44(3), 1–17.

Vignoli, L., M.A. Bologna, S. Manzini, L. Rugiero & L. Luiselli (2015): Attributes of basking sites of the European pond turtle (*Emys orbicularis*) in central Italy. Amphibia-Reptilia, 36(2), 125–131.

Zuffi, M. A. L. (2000): Conservation biology of the European pond turtle *Emys orbicularis* (L.) in Italy, Staphia, 69, 219–228.

Žagar, A., M. Vamberger & T. Genov (2019): Plazilci. In Pavšič J., M. Gogala & A. Seliškar (eds.): Slovenska Istra I: Neživi svet. Rastlinstvo. Živalstvo in naravovarstvo. Slovenska matica, Ljubljana, pp. 363–373.

Žagar, A., V. Cafuta, K. Drašler, T. Jagar, M. Krofel, M. Luznik, E. Ostanek, V. Petkovska, G. Planinc, M. Sopotnik & M. Vamberger (2013): A review of eleven short-term reptile surveys in the western Balkans, Hyla, 1, 3–18.

Walter, W.D., D.P. Onorato & J.W. Fischer (2015): Is there a single best estimator? Selection of home range estimators using area-under-the-curve. Mov. Ecol., 3(10), 11 pp.

Wobbrock, J.O., L. Findlater, D. Gergleand & J.J. Higgins (2011): The aligned rank transform for nonparametric factorial analyses using only ANOVA procedures. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11), 143–146.

Worton, B. J. (1989): Kernel methods for estimating the utilization distribution in home-range studies. Ecology, 70(1), 164–168.