

**Status of the invasive blue crab *Callinectes sapidus* Rathbun, 1896  
(Brachyura: Portunidae) in Slovenia**

Status invazivne tujerodne modre rakovice *Callinectes sapidus* Rathbun, 1896  
(Brachyura: Portunidae) v Sloveniji

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**Abstract:** Authors present data regarding the presence of the invasive blue crab *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae) based on records gathered from local fishermen. This alien species was firstly recorded in Slovenian coastal waters in March 2019 and it was subsequently found in six other cases in 2019, 2020 and 2021. Crabs were collected or sighted in shallow coastal areas along the Slovenian coast. In addition, authors discussed about the status of the blue crab in marine and coastal habitats of Slovenia.

**Keywords:** Adriatic Sea, *Callinectes sapidus* Rathbun, 1896, invasive species, presence, Slovenia

**Izveček:** Avtorja poročata o prisotnosti modre rakovice *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae) na podlagi podatkov, pridobljenih s strani lokalnih ribičev. Prvič smo to tujerodno vrsto v slovenskem obrežnem morju potrdili marca 2019, potem pa je bila zabeležena še v šestih primerih v letih 2019, 2020 in 2021. Rakovice so bile v vseh primerih ulovljene ali opažene v plitvem obalnem morju vzdolž slovenske obale. Avtorja nadalje razpravljata o statusu modre rakovice v obmorskih in morskih življenjskih okoljih v Sloveniji.

**Ključne besede:** *Callinectes sapidus* Rathbun, 1896, invazivne vrste, Jadransko morje, prisotnost, Slovenija

## Introduction

The blue crab *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae), is considered an economically important species throughout its native area of distribution (Nehring 2011) which comprises the western Atlantic coast from Nova

Scotia to Argentina (Manfrin et al. 2016). Its population supports intensive fishery, which currently supplies over one-third of all US commercial blue crab landings (Miller et al. 2011). It is characterized by early maturity, rapid growth and high reproductive potential, strong swimming capacity and aggressive behaviour and is able to

efficiently exploit available resources in euryhaline and eurytherm environments (Piras et al. 2019). Nowadays, the blue crab is rapidly spreading its distribution worldwide (Mancinelli et al. 2021). During the last decades an expansion of the blue crab has been witnessed in almost all Mediterranean countries (Galil 2011, Cerri et al. 2020). The blue crab is considered as one amongst the most invasive crab species (Streftaris and Zenetos 2006). Up to date it was reported in different habitat types, mainly in coastal lagoons, estuaries and coastal sea. The first record of this species in Europe originated from harbour of Rochefort in France in 1900 (Bouvier 1901). The first evidenced and documented record in the Mediterranean Sea was reported by Giordani Soika (1951) in the Lagoon of Marano and Grado in 1949, however, there are some findings showing that it may arrived already in the 1937 in the Aegean Sea (Nehring 2011). Since then the crustacean started emerging in different areas of the Mediterranean Sea (Cerri et al. 2020). The invasion of the blue crab is aided by warming sea temperatures (Nehring 2011). During the last two decades the records of blue crab specimens have been reported from different localities along the Adriatic coast in its southern (Onofri et al. 2008; Beqiraj and Kashta 2010, Dulčić et al. 2010, 2011, Cilenti et al. 2015), middle (Florio et al. 2008; Castriota et al. 2012) and northern parts (Scaravelli and Mordenti 2007, Manfrin et al. 2016). However, the species is considered established only in southern Croatia, northern Albania and southern Italy (Castriota et al. 2012).

Some authors mentioned different vectors as responsible of Mediterranean introduction of the blue crab, such as dispersal of larvae by ballast water (Nehring 2011, Garcia et al. 2018) or by natural spreading due to its swimming ability (Galil et al. 2002). As it is a highly valued seafood, the possibility of an intentional introduction for aquaculture reasons could not be neglected, as well (Giordani-Soika 1951, Nehring 2011).

The aim of this contribution is to present all available data regarding the presence of the invasive alien crab in marine and coastal areas of Slovenia and to discuss its current status in the area.

## Material and methods

Blue crab specimens were obtained by local fishermen who caught them in fishing nets or photographed them *in situ*. Blue crabs were captured accidentally from March 2019 to October 2021 in the Slovenian coastal waters. The collected crab specimens were measured by Vernier calliper to the nearest millimetre and weighed with digital balance. The biometric parameters which were measured were the carapace length (CL), carapace width (CW), abdomen length (AL), abdomen width (AW), propodus length (PL), dactylus length (DL), cheliped length (ChL), cheliped width (ChW) and cheliped height (ChH), and rostrum width (RW). The gender was easily assessed through the colour pattern and abdomen characters of specimens. According to the classification of Harding (2003), where blue crabs are divided in three size categories, e.g. small crabs if CW is lower than 80 mm, medium crabs, when CW range from 80 – 120 mm and large crabs, when CW is bigger than 120 mm.

## Results and discussion

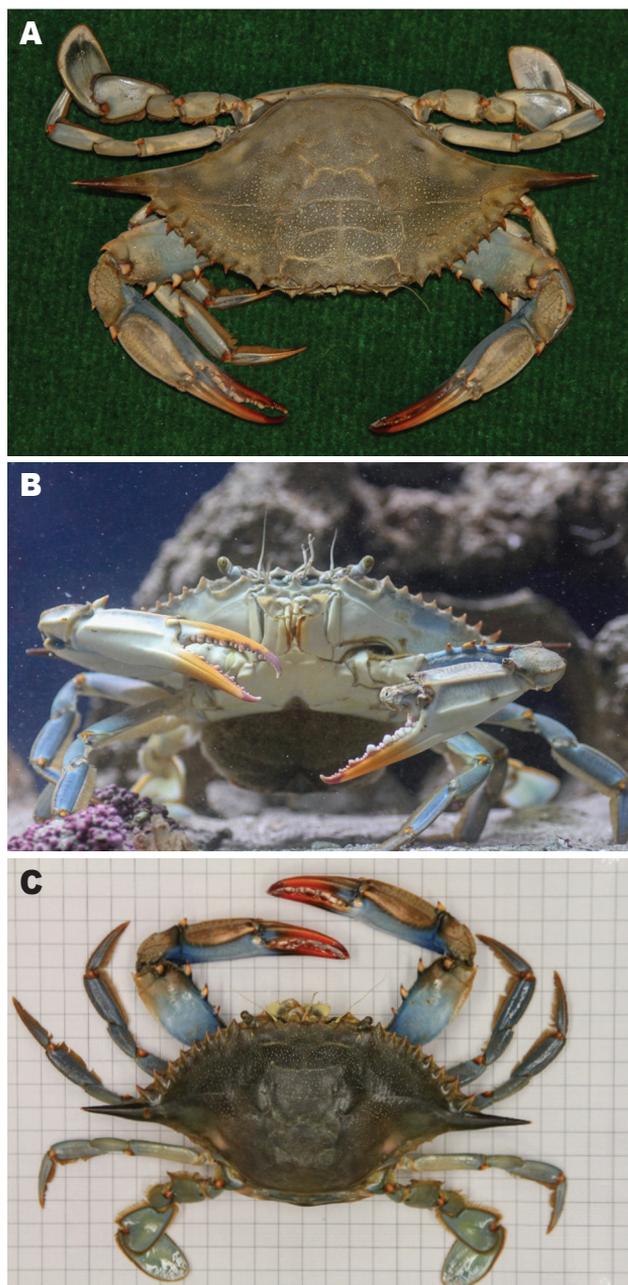
Specimens were collected at seven different localities (Tab. 1, Figs. 1, 2), which were all characterized by their shallowness and muddy bottom. The earliest record of the blue crab originates from Seča (Fig. 2a), in front of the Jernej's canal on 15th March 2019 (Lipej and Rogelja 2021). Altogether 12 specimens were recorded, among which were 10 females and two males. Six specimens (5 females and one male; Fig 3) were collected, while another six specimens were sighted and photographed on 28 July 2020 (Table 1). All specimens were found in the period from March to October. The carapace width ranged between 159.5 mm to 182 mm, while their weight ranged between 173 g and 402 g (Tab. 2). Therefore, all individuals recorded in Slovenia were classified as large sized specimens.

Unlike in male blue crab, sexual maturity in females is established at the terminal moult, during which the coloration of the abdomen darkens and its shape changes from triangular to semi-circular presumably to provide a larger surface area for brooding eggs (Van Engel 1958,



**Figure 1:** Map of the Slovenian coastal sea and adjacent waters of the Gulf of Trieste. Black points denote the records of the blue crab in the area. Legend: 1. Jernej's channel, Seča, 2. Strunjan, 3. In front of the Sečovlje Salina, 4. Chanell in the Sečovlje salina, 5. Fiesa, 6. Piran and 7. Pacug.

**Slika 1:** Zemljevid slovenskega obalnega morja in okoliških voda. Črne pike označujejo lokalitete, kjer so bile potrjene modre rakovice. Legenda: 1. Jernejev kanal, Seča, 2. Strunjan, 3. Pred Sečoveljskimi solinami, 4. Kanal v Sečoveljskih solinah, 5. Fiesa, 6. Piran in 7. Pacug.



**Figure 2:** Blue crabs, recorded in the marine waters of Slovenia. (A) - female blue crab, captured on 15 March 2019, (B) - An ovigerous female, recorded on 9 April 2020, (C) - female, captured recorded on 16 October 2019.

**Slika 2:** Modre rakovice, ulovljene v slovenskih morskih vodah. (A) - samica, ujeta 15 marca 2019, (B) - ovi-gerna samica, ujeta 9. aprila 2020, (C) - samica, ujeta 16. oktobra 2019.



**Figure 3:** A male specimen of the blue crab, captured at 14 October 2021 in Pacug.

**Slika 3:** Samec modre rakovice, ujet 14 oktobra 2021 v Pacugu.

Jivoff et al. 2007). Based on these characteristics all five collected females are considered as sexually mature. Females have the only opportunity to mate immediately after the pubertal moult. They store the spermatophores containing sperm and can therefore produce multiple broods over several years, reaching 1 – 3 broods in temperate waters and up to 7 in tropical waters per year (Hines et al. 2003). The female collected on 9th April 2020 (Fig. 2b) and kept in the tank developed an egg mass beneath its aprons that was firstly noticed on 9th July 2020. The eggs were already brown and got darker in the period of four days, showing that the egg development was reaching its final stage. The egg mass was not noticed before as the female was less active and buried in the sand during the day. On 13th July the female was preventively translocated to a quarantine tank where it was kept until the release of larvae, so no accidental escape of larvae to the sea could be possible. On 17th July the female was returned to the aquarium in the public area.

The majority of specimens were caught in shallow waters on sedimentary bottom or in estuaries and channels. As an opportunistic species the blue crab is able to tolerate wide oscillations of temperature and salinity, typical conditions of brackish waters and adjacent eurytherm and euryhaline habitats (Piras et al. 2019). Such environment is characterized by low number of native

species and seems to offer many non occupied ecological niches (Nehring 2006, 2011). Brackish waters are also in general known as environments where alien species are very successful in term of colonisation (Paavola et al. 2005).

The first record of *C. sapidus* in the northernmost part of the Adriatic Sea originated before seventy years (Giordani Soika 1951), however, only recently new findings were discovered in the area (Manfrin et al. 2016). Such records were reported only during the past five years. It is reasonable to speculate that the blue crab arrived in Slovenian waters from the Italian part of the Gulf of Trieste where it was recently discovered in Marano and Grado Lagoon (Manfrin et al. 2016). The second possibility is that the species came from the south, *i.e.* from Istria, where it is considered as frequent from Savudrija to Pula (Sladonja, personal communication), although there are no published records in that regard. However, Gljuščić (2019) in his Master thesis mentioned a case of the blue crab finding in the vicinity of Šćuza lagoon, near Pomer bay in southern Istria. The third possibility is that the blue crabs recruited to the Gulf of Trieste and Slovenian waters as settled larvae from ship's ballast waters (Manfrin et al. 2016).

**Table 1:** Occurrence of the blue crab in Slovenian coastal waters.**Tabela 1:** Pojavljanje modre rakovice v slovenskih obalnih vodah.

N	Date	Locality	GPS position		Depth	
			N	E	(m)	Ind.
1	15.03.2019	Jernej's canal	45.50055556	13.58416667	6	1♀
2	16.10.2019	Strunjan	45.535630	13.601313	5	1♀
3	09.04.2020	Portorož	45.48138889	13.58777778	3	1♀
4	28.07.2020	Sečovlje salina	45.48472222	13.59388889	1	5♀,1♂
5	13.09.2021	Fiesa	45.52750000	13.57888889	9	1♀
6	03.10.2021	Piran	45.52555556	13.56694444	4	1♀
7	14.10.2021	Pacug	45.526111	13.590278	3	1♂

Taking into account recently published data of Benabdi et al. (2019) and Shaiek et al. (2021) the occurrence of *C. sapidus* is so far confirmed in 18 out of the 23 countries surrounding the Mediterranean Sea. Since the species was recently confirmed also in Slovenian waters (Lipej and Rogelja 2021), Slovenia represents the 19th country. On the basis of regular monitoring of non-indigenous species in marine waters of Slovenia up to date at least 57 non-indigenous species were reported in the Slovenian part of the Adriatic Sea (Orlando Bonaca et al. 2020, Mavrič et al. 2021). Among them the blue crab is the only alien crab. Since in the close proximity other alien crab species were recorded, such as *Callinectes danae* (Mizzan 1993), *Dyspanopeus sayi* (Mizzan 1995) and *Rhitropanopeus harrisii* (Mizzan and Zanella 1996) from the northern Adriatic lagoons, *Hemigrapsus sanguineus* from waters off Rovinj (Schubart 2003) and *Eriocheir sinensis* (Bettoso and Comisso, 2015) from the Lagoon of Grado and Marano, some of them could be recorded in Slovenia in nearby future.

According to some authors (Nehring 2011) the blue crab may benefit from global warming. It has been hypothesized that as global temperatures rise, blue crabs will probably experience a northward range expansion (Johnson 2015), which facilitate their colonisation and dispersion in new environments (Nehring 2011).

Although the blue crab was recorded in three successive years in Slovenian coastal waters it is still not possible to consider the species as an established one. In fact, all findings were recorded in the warmer period of the year. Due to the low winter temperatures, the species is probably not able to survive such harsh conditions occurring in winter. However, there are some evidences from the estuary of the Neretva river where “muddy” individuals, which may emerged after overwintering buried in the sediments, were observed (Mancinelli et al. 2016).

In its native area, the Chesapeake Bay, the average winter temperatures on the sea bottom reach 3.4 °C. Rome et al. (2005) showed that significant mortality may not occur unless water temperatures drop significantly below 3° C for an extended period of time. Since the average winter temperature in the Slovenian sea is higher, with the average in the coldest month of February 7.3° C and minimal 6.3° C (ARSO, 2019), the blue crab could be able to over-winter in the studied area.

The arrival of this invasive alien crab in the waters off Slovenia was expected since it was previously recorded in the immediate vicinity at Italian sites (see Manfrin et al. 2016) and could be attributed to higher water temperatures. Although only few records have been reported to us so far, the local occurrence and the further dispersion of this species deserve to be cautiously monitored,

**Table 2:** Biometrical parameters, measured on the collected specimens of blue crab, recorded in the coastal waters of Slovenia. All measurements are in millimetres.

**Tabela 2:** Biometrični parametri, izmerjeni na zbranih primerkih modre rakovice, ulovljenih v slovenskih obalnih vodah. Vse meritve so izražene v milimetrih.

Date	15. 03. 2019	16. 10. 2019	9. 04. 2020	13. 09. 2020	3. 10. 2021	14. 10. 2021
Sex	♀	♀	♀	♀	♀	♂
Weight (g)	173	234	188	287	189	402
Carapace width	182	186	174	170.5	159.5	172
Carapace length	68.5	73.5	69	74	65	78.5
Rostrum width	36	38	36.1	45	39	46.5
Abdomen length	51	50	49	47	47	55
Abdomen width	55	55	54	55.5	52	54.5
Right chelipod length	74	82.5	75.5	83.9	72	112.1
Left chelipod length	76	80	77.5	80	63	109
Right propodus length	33	36	30	35.5	31.5	37.5
Left propodus length	31	33.5	32	33	26.5	44.2
Right chelipod height	24.4	26.5	20	30.3	15	34.5
Left chelipod height	20.5	22.5	23	23	18.5	30
Right dactylus length	39.5	41	38	43	34.8	34
Left dactylus length	39	40	-	42	33.1	55.2
Right chelipod width	17.5	19	15	20.8	18	25
Left chelipod width	16	17	16.5	18	13	23

especially in order to gain data on the functional role that this taxon could play within benthic food webs in Mediterranean coastal habitats. According to Mancinelli et al. (2017) the blue crab can prey on a wide spectrum of native crab and fish or compete with them, which could inflict potentially high ecological impacts on the native biota. Since in its native area of distribution the blue crabs plays a major role in energy transfer within the food web of estuaries and lagoons, it may also be responsible for certain impacts in the invaded environments.

## Povzetek

Modra rakovica *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae) je med najbolj invazivnimi vrstami rakovic, ki so jo doslej potrdili v 19 od 23 sredozemskih držav. Prvič smo to tujerodno vrsto v slovenskem obrežnem morju potrdili marca 2019, potem pa je bila za-beležena še v šestih primerih v letih 2019, 2020 in 2021. Skupaj je bilo popisanih 12 primerkov, od katerih je bilo 10 samic in dva samca. Vse najdbe pa izvirajo iz toplejšega dela leta. Rakovice so bile v vseh primerih ulovljene ali opažene v evrihalinih in evritermih življenjskih okoljih v plitvem obalnem morju vzdolž slovenske obale. Gre za oportunistično vrsto, ki je zmožna tolerirati velika nihanja temperature in slanosti, ki

so značilna za brakične vode. Premer karapaksa rakovic je bil med 159.5 mm in 182 mm, telesna masa pa je bila med 173 g and 402 g. Čeprav je bila modra rakovica doslej najdena le na manjšem številu lokalitet, je njeno pojavljanje in razširjanje smiselno spremljati, še posebej z vidika pridobivanja podatkov o funkcionalni vlogi, ki jo ima ta vrsta v pridenem prehranjevalnem spletu sredozemskih obrežnih habitatov.

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## References

- ARSO, 2019. Naše okolje, Mesečni bilten Agencije RS za okolje, Ministrstvo za okolje in prostor, Agencija Republike Slovenije za okolje, letnik XXVI, številka 3.
- Benabdi, M., Belmahi, A.E., Grimes, S., 2019. First record of the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 (Decapoda: Brachyura: Portunidae) in Algerian coastal waters (southwestern Mediterranean). *BioInvasions Records*, 8, 119-122.
- Beqiraj, S., L. Kashta, 2010. The establishment of blue crab *Callinectes sapidus* Rathbun, 1896 in the Lagoon of Patok, Albania (south-east Adriatic Sea). *Aquatic Invasions*, 5, 219-21.
- Bettoso, N., G. Comisso, 2010. First record of the Chinese mitten crab (*Eriocheir sinensis*) in the Lagoon of Marano and Grado (northern Adriatic Sea). *Annales series historia naturalis*, 25, 29-34.
- Bouvier, E.L., 1901. Sur un *Callinectes sapidus* M. Rathbun trouvé à Rochefort. *Bulletin du Museum D'Histoire Naturelle*, 7, 16-17.
- Castriota, L., Andaloro, F., Costantini, R., A.D. Ascentiis, 2012. First record of the Atlantic crab *Callinectes sapidus* Rathbun, 1896 (Crustacea: Brachyura: Portunidae) in Abruzzi waters, central Adriatic Sea. *Acta Adriatica*, 53, 467-71.
- Cerri, J., Chiesa, S., Bolognini, L., Mancinelli, G., Grati, F., et al., 2020. Using online questionnaires to assess marine bio-invasions: A demonstration with recreational fishers and the Atlantic blue crab *Callinectes sapidus* (Rathbun, 1986) along three Mediterranean countries. *Marine Pollution Bulletin*, 111209.
- Cilenti L., Paziienza, G., Scirocco, T., Fabbrocini, A., D'Adamo, R., 2015. First record of ovigerous *Callinectes sapidus* (Rathbun, 1896) in the Gargano Lagoons (south-west Adriatic Sea). *BioInvasions Records*, 4, 281-287.
- Dulčić, J., Dragičević, B., Lipej, L., 2010. New record of the Blue Crab, *Callinectes sapidus* Rathbun, 1896, (Decapoda: Brachyura) in the Adriatic Sea. *Annales, Series Historia Naturalis*, 20, 23-28.
- Dulčić, J., Tutman, P., Matic-Skoko, S., Glamuzina, B., 2011. Six years from first record to population establishment: The case of the blue crab, *Callinectes sapidus* Rathbun, 1896 (Brachyura, Portunidae) in the Neretva river delta (South-Eastern Adriatic Sea, Croatia). *Crustaceana*, 84 (10), 1211-1220.
- Florio, M., Breber, P., Scirocco, T., Specchiulli, A., Cilenti, L., Lumare, L., 2008. Exotic species in Lesina and Varano lakes: Gargano National Park (Italy). *Transitional Waters Bulletin* 2, 69-79.
- Galil B., C. Froglija, Noël P., 2002. CIESM Atlas of Exotic Species in the Mediterranean. In: Briand F, editor. *Crustaceans: decapods and stomatopods*, vol. 2. Monaco: CIESM Publishers; 2002.
- Galil, B.S., 2011. The alien Crustaceans in the Mediterranean Sea: An Historical Review. p. 377-401. In: *In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts*. Galil, B.S., Clark, P.F., Carlton, J.T. (Eds). Springer-Verlag, Berlin-Heidelberg.

- Garcia, L., Pinya, S., Colomar, V., París, T., Puig, M., Rebassa, M., Mayol, J. 2018. The first recorded occurrences of the invasive crab *Callinectes sapidus* Rathbun, 1896 (Crustacea: Decapoda: Portunidae) in coastal lagoons of the Balearic Islands (Spain). *Bioinvasion records*, 7(2), 191-196.
- Giordani Soika, A., 1951. Il *Neptunus pelagicus* (L.) nell'Alto Adriatico. *Natura*, 42, 18–20.
- Gljuščić, E., 2019. Alien marine flora and fauna in harbors and adjacent areas along Istrian peninsula. Univerza na Primorskem, Fakulteta za matematiko, naravoslovje in informacijske tehnologije, Koper, pp. 1-79.
- Harding, J.M., 2003. Predation by blue crabs, *Callinectes sapidus*, on rapa whelks, *Rapana venosa*: possible natural controls for an invasive species. *Journal of Experimental Evidence Marine Biology and Ecology*, 297, 161-177.
- Hines, A. H., Jivoff, P. R., Bushmann, P. J., van Montfrans, J., Reed, S. A., Wolcott, D. L., Wolcott, T. G., 2003. for sperm limitation in the blue crab, *Callinectes sapidus*. *Bulletin of Marine Science*, 72(2), 287-310.
- Jivoff, P. R., Hines, A. H., Quackenbush, S., 2007. Reproduction and embryonic development. Blue crab: *Callinectes sapidus*. In: Kennedy, V.S. and Cronin, L.E. (Eds.): *The Blue Crab: Callinectes Sapidus*, Maryland Sea Grant College, pp. 255-298.
- Johnson D.S., 2015. The savory swimmer swims north: a northern range extension of the blue crab *Callinectes sapidus*? *Journal of Crustacean Biology*, 35(1), 105-10.
- Lipej, L., M. Rogelja, 2021. The blue crab *Callinectes sapidus* Rathbun, 1896 reaches Slovenia. New Alien Mediterranean Biodiversity Records. Collective Article. *Mediterranean Marine Science*, 22(3)(in press).
- Mancinelli, G., Glamuzina, B., Petrić, M., Carozzo, M., Glamuzina, B. Zotti, M., Raho, D., Vizzini, S. 2016. The trophic position of the Atlantic blue crab *Callinectes sapidus* Rathbun 1896 in the food web of Parila Lagoon (South Eastern Adriatic, Croatia): a first assessment using stable isotopes. *Mediterranean Marine Science*, 17/3, 634-643.
- Mancinelli, G., Chainho, P., Cilenti, L., Falco, S., Kapiris, K., Katselis, G., Ribeiro, F., 2017. On the Atlantic blue crab (*Callinectes sapidus* Rathbun 1896) in southern European coastal waters: Time to turn a threat into a resource? *Fisheries Research*, 194, 1-8.
- Mancinelli, G., Bardelli, R., Zenetos, A., 2021. A global occurrence database of the Atlantic blue crab *Callinectes sapidus*. *Scientific reports*, 8, 111.
- Manfrin, C., Comisso, G., Dall'Asta, A., Bettoso, N., Chung, J.S., 2016. The return of the Blue Crab, *Callinectes sapidus* Rathbun, 1896, after 70 years from its first appearance in the Gulf of Trieste, northern Adriatic Sea, Italy (Decapoda: Portunidae). *Check List*, 12, 1-7.
- Mavrič, B., Orlando-Bonaca, M., Fortič, A., Francé, J., Mozetič, P., Slavinec, P., Pitacco, V., Trkov, D., Vascotto, I., Zamuda, L.L., Lipej, L., 2021. Spremljanje vrstne pestrosti in abundance tujerodnih vrst v slovenskem morju (*Monitoring of diversity and abundance of non indigenous species in Slovenian Sea*). Končno poročilo, junij 2021. Poročila 195. Morska Biološka Postaja, Nacionalni Inštitut za Biologijo, Piran [In Slovenian].
- Miller, T. J., Wilberg M. J., Colton A. R., Davis G. R., Sharov A. F., et al., 2011. Stock assessment of blue crab in Chesapeake Bay. UMCES Technical Report Series TS614.11. University of Maryland Center for Environmental Science. Cambridge, MD.
- Mizzan L., 1993. Presence of swimming crabs of the genus *Callinectes* (Stimpson) (Decapoda, Portunidae) in the Venice Lagoon (North Adriatic sea - Italy): first record of *Callinectes danae* Smith in European waters. *Bollettino del Museo civico di storia naturale di Venezia*, 42, 31-43.
- Mizzan L., 1995. Notes on the presence and diffusion of *Dyspanopeus sayi* (Smith, 1869) (Crustacea, Decapoda, Xanthidae) in the Venetian Lagoon. *Bollettino del Museo civico di storia naturale di Venezia*, 44, 121129.
- Mizzan L., Zanella L., 1996. First record of *Rhithropanopeus harrisi* (Gould, 1841) (Crustacea, Decapoda, Xanthidae) in the Italian Waters. *Bollettino del Museo civico di storia naturale di Venezia*, 46, 109-122.

- Nehring, S., 2006. Four arguments why so many alien species settle into estuaries, with special reference to the German river Elbe. *Helgoland Marine Research*, 60, 127–134.
- Nehring S., 2011. Invasion history and success of the American crab *Callinectes sapidus* Rathbun in European coastal waters. In: Galil B.S., Clark P.F., Carlton J.T. (eds), *In the wrong place: alien marine crustaceans - distribution, biology and impacts*. *Invading Nature - Springer Series in Invasion Ecology*, 6, 607–624.
- Onofri, V., Dulčić, J., Conides, S. Matić-Skoko et al., (2008): The occurrence of the blue crab, *Callinectes sapidus* Rathbun, 1896 (Decapoda, Brachyura, Portunidae) in the eastern Adriatic (Croatian coast). *Crustaceana*, 81 (4), 403-409.
- Orlando-Bonaca, M., Fortič, A., Francé, J., Lipej, L., Mavrič, B., Mozetič, P., Slavinec, P., Pitacco, V., Trkov, T. Vascotto, I., Zamuda, L.L., 2020. Spremljanje vrstne pestrosti in abundance tujerodnih vrst v slovenskem morju (*Monitoring of diversity and abundance of non indigenous species in Slovenian Sea*). Drugo fazno poročilo, junij 2020. Poročila 192. Morska Biološka Postaja, Nacionalni Inštitut za Biologijo, Piran, 60 [In Slovenian]
- Paavola, M., Olenin, S. and Leppakoski, E., 2005. Are invasive species most successful in habitats of low native species richness across European backish water seas? *Estuarine, Coastal and Shelf Science*, 64, 738-750.
- Piras, P., Esposito, G., Meloni, D., 2019. On the occurrence of the blue crab *Callinectes sapidus* (Rathbun, 1896) in Sardinian coastal habitats (Italy): a present threat or a future resource for the regional fishery sector? *BioInvasions Records*, 8, 1, 134-141.
- Rome, M. S., Young-Williams, A. C., Davis, G. R., Hines, A. H., 2005. Linking temperature and salinity tolerance to winter mortality of Chesapeake Bay blue crabs (*Callinectes sapidus*). *Journal of Experimental Marine Biology and Ecology*, 319(1-2), 129-145.
- Scaravelli, D., Mordenti, O., 2007. Segnalazioni faunistiche. *Quaderni di Studi Naturali, Romagna*, 24, 155-160.
- Schubart, C. D., 2003. The East Asian shore crab *Hemigrapsus sanguineus* (Brachyura: Varunidae) in the Mediterranean Sea: an independent human-mediated introduction. *Scientia Marina*, 67 (2), 195–200.
- Shaiek, M., El Zrelli, R., Crocetta, F., Mansour, L., Rabaoui, L., 2021. On the occurrence of three exotic decapods, *Callinectes sapidus* (Portunidae), *Portunus segnis* (Portunidae), and *Trachysalambria palaestinensis* (Penaeidae), in northern Tunisia, with updates on the distribution of the two invasive portunids in the Mediterranean Sea. *BioInvasions Records*, 10(1), 158-169.
- Streftaris, N. and Zenetos, A., 2006. Alien marine species in the Mediterranean - the 100 'Worst Invasives' and their impact. *Mediterranean Marine Science*, 7, 87-118.
- Van Engel, W. A., 1958. The blue crab and its fishery in Chesapeake Bay. Part 1. Reproduction, early development, growth and migration. *Commercial fisheries review*, 20(6), 6.