Biodiversity Data Journal 10: e77516
doi: 10.3897/BDJ.10.e77516

Data Paper

An individual-based dataset of carbon and nitrogen isotopic data of *Callinectes sapidus* in invaded Mediterranean waters

Cristina Di Muri[‡,§], Ilaria Rosati[‡], Roberta Bardelli[|], Lucrezia Cilenti[¶], Daniel Li Veli[#], Silvia Falco[¤], Salvatrice Vizzini[|,«], George Nikolaos Katselis[»], Kosmas Kevrekidis[˄], Luka Glamuzina[˅], Giorgio Mancinelli[¦,«,¶]

‡ National Research Council (CNR), Research Institute on Terrestrial Ecosystems (IRET), Lecce, Italy
§ LifeWatch ERIC, Seville, Spain
| University of Palermo, Palermo, Italy
¶ National Research Council (CNR), Institute of Marine Biological Resources and Biotechnologies (IRBIM), Lesina, Italy
# National Research Council (CNR), Institute of Marine Biological Resources and Biotechnologies (IRBIM), Ancona, Italy
¤ University of Valencia, Valencia, Spain
« National Interuniversity Consortium for Marine Sciences (CoNISMa), Roma, Italy
» University of Patras, Mesologhi, Greece
˄ Decentralised Administration of Macedonia Thrace, Kalamaria, Greece
˅ University of Dubrovnik, Dubrovnik, Croatia
¦ University of Salento, Lecce, Italy

Corresponding author: Cristina Di Muri (cristina.dimuri@iret.cnr.it), Giorgio Mancinelli (giorgio.mancinelli@unisalento.it)

Academic editor: Christos Arvanitidis

Received: 02 Nov 2021 | Accepted: 19 Jan 2022 | Published: 25 Jan 2022

Citation: Di Muri C, Rosati I, Bardelli R, Cilenti L, Li Veli D, Falco S, Vizzini S, Katselis GN, Kevrekidis K, Glamuzina L, Mancinelli G (2022) An individual-based dataset of carbon and nitrogen isotopic data of *Callinectes sapidus* in invaded Mediterranean waters. Biodiversity Data Journal 10: e77516. https://doi.org/10.3897/BDJ.10.e77516

Abstract

Background

The characterisation of functional traits of non-indigenous and invasive species is crucial to assess their impact within invaded habitats. Successful biological invasions are often facilitated by the generalist diet of the invaders which can modify their trophic position and adapt to new ecosystems determining changes in their structure and functioning. Invasive

crustaceans are an illustrative example of such mechanisms since their trophic habits can determine important ecological impacts on aquatic food webs. The Atlantic blue crab *Callinectes sapidus* is currently established and considered invasive in the Mediterranean Sea where it has been recorded for the first time between 1947 and 1949. In the last decade, the blue crab colonised most of the eastern and central Mediterranean Sea and the Black Sea and it is currently widening its distribution towards the western region of the basin.

New information

Stable isotope analysis is increasingly used to investigate the trophic habits of invasive marine species. Here, we collated individual measures of the blue crab $\delta^{13}C$ and $\delta^{15}N$ values and of its potential invertebrate prey into a geo-referenced dataset. The dataset includes 360 records with 236 isotopic values of the blue crab and 224 isotopic data of potential prey collected from five countries and 12 locations between 2014 and 2019. This dataset allows the estimation of the trophic position of the blue crab within a variety of invaded ecosystems, as well as advanced quantitative comparisons of the main features of its isotopic niche.

Keywords

invasive species, Atlantic blue crab, transitional water, stable isotope, trophic position, isotopic niche

Introduction

The concern about the impacts of non-indigenous species (NIS) has grown steeply over the past half-century (David et al. 2017), and a large amount of evidence suggests that NIS can alter the structure of natural communities and the integrity of ecosystems causing substantial ecological, economic, and cultural losses, especially in case they become invasive (Invasive Alien Species, IAS hereafter; Anton et al. 2019, see also Thomsen 2020). The impact of IAS is mediated by biotic interactions with the native communities and changes in the ecosystem processes including nutrient dynamics, fluxes of energy, and material cycling (Gallardo et al. 2016, Corrales et al. 2020). The monitoring and assessment of the impact of IAS and the prioritisation of adequate management actions are crucial steps to mitigate and/or limit the potential adverse effects of those species that are more likely to represent a serious threat to native ecosystems (Dick et al. 2017, Cuthbert et al. 2019).

The Atlantic blue crab (*Callinectes sapidus* Rathbun, 1896) is considered one of the worst invasive species in the Mediterranean Sea owing to its impact on local biodiversity, fisheries, and aquaculture (Streftaris and Zenetos 2006). The Atlantic blue crab (hereafter blue crab) was first recorded in Europe at the start of the past century (Bouvier 1901) and appeared in the Mediterranean Sea between 1947 and 1949 (Giordani Soika 1951, Serbetis 1959). Over the last decade, the blue crab has spread almost ubiquitously in the eastern and central Mediterranean Sea and in the Black Sea, and it is currently widening its distribution towards the western sectors of the basin (Mancinelli et al. 2017a, Mancinelli et al. 2021).

The blue crab is an opportunistic omnivore, feeding on a variety of food sources from plants and detritus, to molluscs, arthropods (including conspecifics), polychaetes, and fish (Belgrad and Griffen 2016). Similar to other IAS, such trophic plasticity represents a key adaptive feature explaining the establishment success of the blue crab in non-native ecosystems and its impact on invaded food webs (Mancinelli et al. 2017b). However, while the crucial role played by the blue crab in regulating the structure and functioning of native food webs is well recognised, the number of studies investigating the trophic role of this invader in non-native ecosystems is remarkably lower (Mancinelli et al. 2017b, but see Kampouris et al. 2019 for a counter-example). In native coastal ecosystems, the blue crab acts as a keystone species by regulating the carbon cycle and prey/predator abundance through both bottom-up and top-down interactions (Altieri et al. 2012, Pugesek et al. 2013). Thus, understanding how the trophic ecology of this taxon shapes benthic food webs in invaded ecosystems is crucial for an accurate assessment of its impact.

Stable isotope analysis of $\delta^{13}C$ and $\delta^{15}N$ has become an increasingly popular methodology in studies focusing on food web structure and functioning. Specifically, $\delta^{13}C$ can trace the flow of matter and nutrients from basal to higher trophic levels and $\delta^{15}N$ can clarify trophic interactions (Fry 2006). In addition, even though species-specific physiological or metabolic factors can influence $\delta^{15}N$ values (Tibbets et al. 2007; Doi et al. 2017), $\delta^{15}N$ is commonly used to infer the species trophic position within food webs (Post 2002). In fact, as the trophic level increases, the nitrogen enriches predictably in its heavier isotope ^{15}N due to the preferential excretion of the lighter isotope ^{14}N (Minagawa and Wada 1984; Post 2002). Noticeably, the assessment of the effects of non-indigenous species on native communities is one of the first applications of stable isotope analysis in invasion ecology (Mitchell et al. 1996). Mancinelli and Vizzini (2015)reviewed the advantages and limitations of the method for identifying and quantifying the ecological impact of invasive species, clearly emphasising how the estimation of invasive species trophic position, using stable isotopes, can be successfully used for assessing direct predatory impacts, as well as community-scale effects on the whole trophic structure. For the blue crab, recent evidence indicated substantial variability in its trophic level across closely-located coastal ecosystems and size-related shifts in individual trophic position within invaded food webs (Mancinelli et al. 2016, Mancinelli et al. 2017b). Ultimately, these studies demonstrate the utility of stable isotope analysis in detecting changes in food web structure after the invasion; an advanced understanding of such trophic interactions can, in turn, help to predict and quantify the impact of biological invasions on aquatic food webs (Jackson et al. 2012).

General description

Purpose: This dataset collates available geo-referenced and individual-based isotopic values ($\delta^{13}C$ and $\delta^{15}N$) of *C. sapidus* and its potential animal prey in Mediterranean waters. The isotopic values, included in the dataset, are expressed in delta notation (‰ deviation from atmospheric nitrogen and from Pee Dee Belemnite [PDB] limestone used as standards for N and C, respectively) and $\delta^{15}N$ or $\delta^{13}C = [(R_{Sample}/R_{Standard}) - 1] \times 1000$, where $R = {}^{15}N/{}^{14}N$ or ${}^{13}C/{}^{12}C$. The analytical precision of measurements for all $\delta^{13}C$ and $\delta^{15}N$ values was 0.2‰ as calculated by the standard deviation of replicates of the internal standards. This dataset can be used for a variety of comparative analyses including the calculation of the trophic position of the crab and/or metrics and descriptors of its isotopic niche, and it was conceived as one of the input files for the Functional biogeography of invaders workflow of the LifeWatch ERIC Internal Joint Initiative. Specifically, the analytical workflow aims at identifying climatic predictors of the trophic position of two invasive crustaceans, i.e. the blue crab *C. sapidus* and the Louisiana crayfish *Procambarus clarkii*. For *P. clarkii*, the workflow runs on an aggregated dataset resolved at population scale, whereas for *C. sapidus*, two datasets can be used as input files to run the analyses: (i) an aggregated dataset at the population scale similar to the one built for *P. clarkii* and (ii) an individual-based dataset with isotopic values of single specimens as described in the present article. All datasets include isotopic information for potential prey to allow the estimation of the trophic position of the invasive species under analysis.

Project description

Title: LifeWatch ERIC Internal Joint Initiative - Functional biogeography of invaders: the case of two widely distributed omnivorous crustaceans (https://bit.ly/iji-crustaceans).

Personnel: Cristina Di Muri, Giorgio Mancinelli, Ilaria Rosati, Lucia Vaira

Study area description: Coastal and transitional areas of the Mediterranean Sea colonised by *C. sapidus*. The westernmost records are located in Spain, the northernmost in Croatia, the easternmost in Turkey, and the southernmost in Greece. The majority of records lie in Italy.

Design description: The dataset contains geographical and temporal information on the sampling event including country, location, geographical coordinates, type of habitat, year, and month or season in which the sampling occurred. Biological features of the species included are also specified, such as the invasive or native nature of the species for each location and the prey-predator relationship. Such attributes, together with $\delta^{13}C$ and $\delta^{15}N$ values, can be used for downstream analyses including the calculation of the blue crab trophic position, which can be estimated using two different approaches. The first method estimates the trophic position using the following equation:

$$\text{Trophic Position } \delta^{15}N = (\delta^{15}N_{Consumer} - \delta^{15}N_{Baseline})/\Delta^{15}N + \lambda$$

This equation is a generalisation of the formula presented in Jepsen and Winemiller (2002), where $\delta^{15}N_{Consumer}$ is the nitrogen isotopic value of the blue crab, $\Delta^{15}N$ is the trophic level fractionation of $\delta^{15}N$, $\delta^{15}N_{Baseline}$ and λ are the nitrogen isotopic value and the trophic level of the baseline species (e.g. for *Phorcus turbinatus*, λ = 2). Alternatively, the blue crab trophic position can be estimated using a Bayesian approach implemented in the R package tRophicPosition (Quezada-Romegialli et al. 2018, R Core Team 2021). In this case, the original $\delta^{13}C$ and $\delta^{15}N$ values can be back-estimated using mean values, standard deviations, and sample size for each location and species and assuming a normal distribution.

Sampling methods

Study extent: The literature search for compiling this dataset ended on 31st April 2021.

Sampling description: The online platforms ISI Web of Science and Scopus were searched using multiple search criteria including the terms "*Callinectes sapidus*" and "stable isotopes" in conjunction with "non-indigenous", "alien", "invasive", "Mediterranean Sea", and "Black Sea". The results were integrated with those obtained by querying Google Scholar using the same search criteria, together with the corresponding terms in Spanish or Portuguese (e.g. "jaiba azul", "cangrejo azul", "siri azul") in order to access additional literature published in languages other than English. Google Scholar search results were saved using the freeware Publish or Perish ver. 7.27.2849 (Harzing 2007).

Quality control: Only records with defined locations whose accuracy was checked using Google Earth were included in the dataset; geographic coordinates were converted to decimal degrees when not originally specified as such. The taxonomic check was performed using the World Register of Marine Species.

Step description: The blue crab preys preferentially on bivalves (Hines 2007); accordingly, this taxonomic group was chosen as a reference for the selection of baseline species included in the dataset. *M. galloprovincialis* was generally used in the dataset given the almost ubiquitous distribution in Mediterranean marine coastal waters. If not available, other bivalves and herbivorous gastropods occurring at the study sites were chosen. On only one occasion, the omnivorous polychaete (*Alitta succinea*) was used as the baseline species. The trophic level of prey species was assigned, based on their trophic habits as follows: bivalves' trophic position = 2 (filter feeders); gastropod *Phorcus turbinatus* trophic position = 2 (herbivore; Aslan and Polito 2021); polychaete *A. succinea* trophic position = 2.78 (omnivore; Jumars et al. 2015, Como et al. 2018). Both *M. galloprovincialis* and *Arcuatula senhousia* are filter feeders and their diets mainly rely on phytoplankton and suspended particulate matter (Inoue and Yamamuro 2000, Ezgeta-Balić et al. 2014); hence, in agreement with the Sea Around Us database, we assumed for both taxa a trophic position = 2. However, it has been also repeatedly indicated that zooplankton can be included in the diet of *M. galloprovincialis* depending on local conditions, as well as on seasonal variations in resource availability (Ezgeta-Balić et al. 2012, Peharda et al. 2012). Our dataset is freely downloadable and the trophic position of *C. sapidus* prey can be modified according to the user's specific needs and/or if and when more updated information becomes available. Within our dataset a considerable variation in individual δ^{15} N values occur for *M. galloprovincialis* as well as for other baseline species (i.e. *Phorcus turbinatus*). Such variation could be due to individual-scale differences in feeding habits, ontogeny, and metabolism (Tibbets et al. 2007, Doi et al. 2017). The user is, therefore, free to calculate the trophic position of *C. sapidus* by adopting, for example, the grand mean of the δ^{15}N values or any other estimation of central tendency (e.g. mode or median). Alternatively, individual δ^{15}N values of baseline taxa can be selected by eliminating the outliers or by choosing only a subset of the specimens included (e.g. the lower quartile of the isotopic distribution).

Geographic coverage

Description: The dataset gathers isotopic values of different Mediterranean areas colonised by *C. sapidus* including seven study sites in Italy, two study sites in Greece, and one study site in Croatia, Spain, and Turkey (Fig. 1, Table 1). The westernmost records are located in Spain (39.00494; -0.148602), the northernmost in Croatia (43.027423; 17.436056), the easternmost in Turkey (40.157275; 25.96473), and the southernmost in Greece (38.961748; 20.815487).

Table 1.

List of locations included in the dataset with names, countries, ecosystem types, and years in which the sampling events occurred. The last column states the source from which the information was extracted.

Location ID	Location name	Country	Habitat	Sampling year	Reference
1	Gandia	Spain	Estuary	2016	De Giorgi et al. (2022)
2	Alento	Italy	Estuary	2019	Li Veli et al. (2022)
3	Lesina	Italy	Lagoon	2016	De Giorgi et al. (2022)
4	Mar Piccolo	Italy	Lagoon	2014	Mancinelli et al. (2017b)
5	Torre Colimena	Italy	Lagoon	2014	Mancinelli et al. (2017b)
6	Spunderati	Italy	Lagoon	2014	Mancinelli et al. (2017b)
7	Acquatina	Italy	Lagoon	2016	Mancinelli et al. (2017b)
8	Alimini	Italy	Lagoon	2014	Mancinelli et al. (2017b)
9	Parila	Croatia	Lagoon	2015	Mancinelli et al. (2016)
10	Pogonitsa	Greece	Lagoon	2016	De Giorgi et al. (2022)
11	Loudias	Greece	Coastal	2016	De Giorgi et al. (2022)
12	Gökçeada	Turkey	Lagoon	2017	Aslan and Polito (2021)

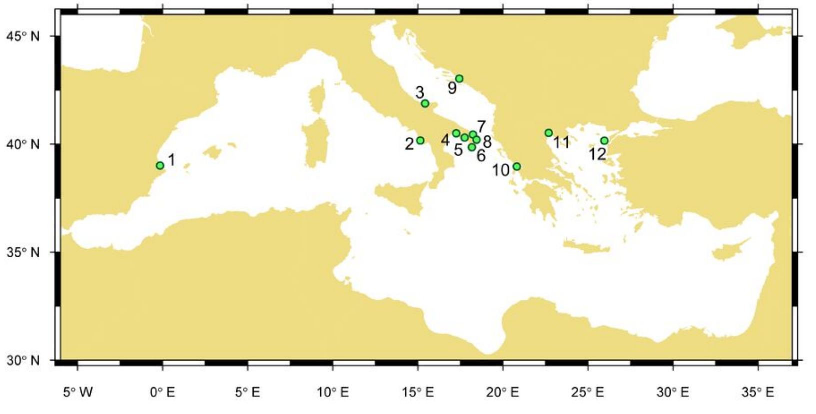

Figure 1. doi

Map of the Mediterranean sites included in the dataset. The study sites represent coastal and transitional systems where established populations of *Callinectes sapidus* were investigated.

Coordinates: 38.96175 and 43.02742 Latitude; -0.1486 and 25.96473 Longitude.

Taxonomic coverage

Description: The dataset is a collection of individual-based isotopic values belonging to *C. sapidus* and its potential prey including: *P. turbinatus*, *A. succinea*, *Arcuatula senhousia*, and *M. galloprovicialis*.

Taxa included:

Rank	Scientific Name	Common Name
species	*Alitta succinea*	Pile worm
species	*Arcuatula senhousia*	Asian date mussel
species	*Callinectes sapidus*	Blue crab
species	*Mytilus galloprovincialis*	Mediterranean mussel
species	*Phorcus turbinatus*	Turbinate monodont

Usage licence

Data resources

Data package title: An individual-based dataset of carbon and nitrogen isotopic data of *Callinectes sapidus* in invaded Mediterranean waters.

Resource link: https://doi.org/10.48372/9CD2907F-8F44-4DF6-9070-6B21E1991B94

Number of data sets: 1

Data set name: An individual-based dataset of carbon and nitrogen isotopic data of *Callinectes sapidus* in invaded Mediterranean waters.

Download URL: https://dataportal.lifewatchitaly.eu/view/urn%3Auuid%3Ae869c2cc-2011-461d-99cc-8d6d642b1624

Data format: csv

Description: A description of the dataset format is provided below. The dataset attributes were labelled using standard glossaries harvested from Darwin Core, LifeWatch ERIC Ecoportal, and NERC Vocabulary Server.

Column label	Column description
catalogNumber	An identifier (preferably unique) for the record within the dataset or collection.
country	The name of the country or major administrative unit in which the Location occurs.
locality	The specific description of the place.
habitat	A category or description of the habitat in which the Event occurred.
eventDate	The date-time or interval during which an Event occurred.
decimalLatitude	The geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location. Positive values are north of the Equator, negative values are south of it.
decimalLongitude	The geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic centre of a Location. Positive values are east of the Greenwich Meridian, negative values are west of it.
establishmentMeans	Statement about whether an organism or organisms have been introduced to a given place and time through the direct or indirect activity of modern humans (https://dwc.tdwg.org/em/#dwcem_e).

scientificName	The full scientific name, with authorship and date information, if known. When forming part of an Identification, this should be the name in lowest level taxonomic rank that can be determined. This term should not contain identification qualifications, which should instead be supplied in the IdentificationQualifier term.
trophicRole	Statement specifying whether the species is a predator or a prey.
carbon-13	A value of the isotope of the chemical element carbon, expressed in permil (‰).
nitrogen-15	A value of the isotope of the chemical element nitrogen, expressed in permil (‰).
trophicLevel	Any of the feeding levels through which the passage of energy through an ecosystem proceeds; examples are photosynthetic plants, herbivorous animals, and microorganisms of decay.

Acknowledgements

The authors thank all the Italian, Croatian, Greek, and Spanish colleagues who have contributed to the data collection and Lucia Vaira (LifeWatch ERIC) for her assistance with the data and metadata publications.

Author contributions

Cristina Di Muri: conceptualisation, data analysis, writing - final review and editing.

Ilaria Rosati: dataset formatting and quality check - final review and editing.

Roberta Bardelli and Salvatrice Vizzini: dataset creation, stable isotope analysis - final review and editing.

Lucrezia Cilenti, Daniel Li Veli, Silvia Falco, George Katselis, Kosmas Kevrekidis, and Luka Glamuzina: sample collection - final review and editing.

Giorgio Mancinelli: conceptualisation, formal analysis, methodology, writing - original draft, final review and editing.

References

- Altieri AH, Bertness MD, Coverdale TC, Herrmann NC, Angelini C (2012) A trophic cascade triggers collapse of a salt-marsh ecosystem with intensive recreational fishing. Ecology 93 (6): 1402-1410. https://doi.org/10.1890/11-1314.1
- Anton A, Geraldi NR, Lovelock CE, Apostolaki ET, Bennett S, Cebrian J, Krause-Jensen D, Marbà N, Martinetto P, Pandolfi JM, Santana-Garcon J, Duarte CM (2019) Global ecological impacts of marine exotic species. Nature Ecology & Evolution 3 (5): 787-800. https://doi.org/10.1038/s41559-019-0851-0

- Aslan H, Polito MJ (2021) Trophic ecology of the Atlantic blue crab *Callinectes sapidus* as an invasive non-native species in the Aegean Sea. Biological Invasions 23: 2289-2304. https://doi.org/10.1007/s10530-021-02506-7
- Belgrad BA, Griffen BD (2016) The influence of diet composition on fitness of the blue crab, *Callinectes sapidus*. PLOS One 11: 0145481. https://doi.org/10.1371/journal.pone.0145481
- Bouvier EL (1901) Sur un *Callinectes sapidus* M. Rathbun Trouvé à Rochefort. Bulletin du Muséum d'Histoire Naturelle Paris 7: 16.
- Como S, Velde G, Magni P (2018) Temporal variation in the trophic levels of secondary consumers in a Mediterranean coastal lagoon (Cabras lagoon, Italy). Estuaries and Coasts 41 (1): 218-232. https://doi.org/10.1007/s12237-017-0265-7
- Corrales X, Katsanevakis S, Coll M, Heymans JJ, Piroddi C, Ofir E, Gal G (2020) Advances and challenges in modelling the impacts of invasive alien species on aquatic ecosystems. Biological Invasions 22 (3): 907-934. https://doi.org/10.1007/s10530-019-02160-0
- Cuthbert RN, Dickey JW, Coughlan NE, Joyce PW, Dick JT (2019) The Functional Response Ratio (FRR): advancing comparative metrics for predicting the ecological impacts of invasive alien species. Biological Invasions 21 (8): 2543-2547. https://doi.org/10.1007/s10530-019-02002-z
- David P, Thebault E, Anneville O, Duyck PF, Chapuis E, Loeuille N (2017) Impacts of invasive species on food webs: a review of empirical data. Advances in Ecological Research 56: 1-60. https://doi.org/10.1016/bs.aecr.2016.10.001
- De Giorgi R, Cilenti L, Falco S, Katselis G, Kevrekidis K, Papadia P, Fanizzi FP, Mancini F, Bardelli R, Vizzini S, Mancinelli G (2022) Trace metals in five Mediterranean populations of the invasive Atlantic blue crab *Callinectes sapidus*: do variations in trophic position matter? Submitted to Journal of Applied Ecology.
- Dick JT, Laverty C, Lennon JJ, Barrios-O'Neill D, Mensink PJ, Robert Britton J, Médoc V, Boets P, Alexander ME, Taylor NG, Dunn AM, Hatcher MJ, Rosewarne PJ, Crookes S, MacIsaac HJ, Xu M, Ricciardi A, Wasserman RJ, Ellender BR, Weyl OL, Lucy FE, Banks PB, Dodd JA, MacNeil C, Penk MR, Aldridge DC, Caffrey JM (2017) Invader relative impact potential: a new metric to understand and predict the ecological impacts of existing, emerging and future invasive alien species. Journal of Applied Ecology 54 (4): 1259-1267. https://doi.org/10.1111/1365-2664.12849
- Doi H, Akamatsu F, González A (2017) Starvation effects on nitrogen and carbon stable isotopes of animals: an insight from meta-analysis of fasting experiments. Royal Society Open Science 4 (8). https://doi.org/10.1098/rsos.170633
- Ezgeta-Balić D, Najdek M, Peharda M, Blažina M (2012) Seasonal fatty acid profile analysis to trace origin of food sources of four commercially important bivalves. Aquaculture89-100. https://doi.org/10.1016/j.aquaculture.2011.12.041
- Ezgeta-Balić D, Lojen S, Dolenec T, Žvab Rožič P, Dolenec M, Najdek M, Peharda M (2014) Seasonal differences of stable isotope composition and lipid content in four bivalve species from the Adriatic Sea. Marine Biology Research 10 (6): 625-634. https://doi.org/10.1080/17451000.2013.833338
- Fry B (2006) Stable Isotope Ecology. 521. Springer, New York. https://doi.org/10.1007/0-387-33745-8

- Gallardo B, Clavero M, Sánchez MI, Vilà M (2016) Global ecological impacts of invasive species in aquatic ecosystems. Global Change Biology 22 (1): 151-163. https://doi.org/10.1111/gcb.13004
- Giordani Soika A (1951) Il *Neptunus pelagicus* (L.) nell'alto Adriatico. Natura 42 (1-2): 18-20.
- Harzing AW (2007) Publish or Perish. ver. 7.27.2849. URL: https://harzing.com/resources/publish-or-perish
- Hines AH (2007) Ecology of juvenile and adult blue crabs. In: Kennedy VS, Cronin LE (Eds) The blue crab: *Callinectes sapidus*. Maryland Sea Grant College, College Park, Maryland, 565-654 pp.
- Inoue T, Yamamuro M (2000) Respiration and ingestion rates of the filter-feeding bivalve *Musculista senhousia*: implications for water-quality control. Journal of Marine Systems 26 (2): 183-192. https://doi.org/10.1016/s0924-7963(00)00053-1
- Jackson MC, Donohue I, Jackson AL, Britton JR, Harper DM, Grey J (2012) Population-level metrics of trophic structure based on stable isotopes and their application to invasion ecology. PlOS One 7 (2): 31757. https://doi.org/10.1371/journal.pone.0031757
- Jepsen DB, Winemiller KO (2002) Structure of tropical river food webs revealed by stable isotope ratios. Oikos 96 (1): 46-55. https://doi.org/10.1034/j.1600-0706.2002.960105.x
- Jumars PA, Dorgan KM, Lindsay SM (2015) Diet of worms emended: an update of polychaete feeding guilds. Annual Review of Marine Science 7: 497-520. https://doi.org/10.1146/annurev-marine-010814-020007
- Kampouris TE, Porter JS, Sanderson WG (2019) *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae): an assessment on its diet and foraging behaviour, Thermaikos Gulf, NW Aegean Sea, Greece: evidence for ecological and economic impacts. Crustacean Research 48: 23-37. https://doi.org/10.18353/crustacea.48.0_23
- Li Veli D, Lillo AO, Lago N, Specchiulli A, Scirocco T, Cilenti L, Bardelli R, Vizzini S, Mancinelli G (2022) The invasive *Callinectes sapidus* in the Tyrrhenian Sea: a baseline assessment of the trophic position of a newly-recorded population from the Campania region (Italy). Submitted to Marine Pollution Bulletin.
- Mancinelli G, Vizzini S (2015) Assessing anthropogenic pressures on coastal marine ecosystems using stable CNS isotopes: state of the art, knowledge gaps, and community-scale perspectives. Estuarine Coastal and Shelf Science 156: 195-204. https://doi.org/10.1016/j.ecss.2014.11.030
- Mancinelli G, Glamuzina B, Petrić M, Carrozzo L, Glamuzina L, 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: 634-643. https://doi.org/10.12681/mms.1724
- Mancinelli G, Raho D, Zotti M, Alujević K, Guerra MT, Vizzini S (2017a) Trophic flexibility of the Atlantic blue crab *Callinectes sapidus* in invaded coastal systems of the Apulia region (SE Italy): a stable isotope analysis. Estuarine Coastal and Shelf Science 198: 421-431. https://doi.org/10.1016/j.ecss.2017.03.013
- Mancinelli G, Chainho P, Cilenti L, Falco S, Kapiris K, Katselis G, Ribeiro F (2017b) The Atlantic blue crab *Callinectes sapidus* in southern European coastal waters: distribution, impact and prospective invasion management strategies. Marine Pollution Bulletin 119: 5-11. https://doi.org/10.1016/j.marpolbul.2017.02.050

- Mancinelli G, Bardelli R, Zenetos A (2021) A global occurrence database of the Atlantic blue crab *Callinectes sapidus*. Scientific Data 8 (1): 1-10. https://doi.org/10.1038/s41597-021-00888-w
- Minagawa M, Wada E (1984) Stepwise enrichment of 15N along food chains: further evidence and the relation between δ15N and animal age. Geochimica et Cosmochimica Acta 48 (5): 1135-1140. https://doi.org/10.1016/0016-7037(84)90204-7
- Mitchell MJ, Mills EL, Idrisi N, Michener R (1996) Stable isotopes of nitrogen and carbon in an aquatic food web recently invaded by *Dreissena polymorpha* (Pallas). Canadian Journal of Fisheries and Aquatic Sciences 53 (6): 1445-1450. https://doi.org/10.1139/f96-053
- Peharda M, Ezgeta-Balić D, Davenport J, Bojanić N, Vidjak O, Ninčević-Gladan Ž (2012) Differential ingestion of zooplankton by four species of bivalves (Mollusca) in the Mali Ston Bay, Croatia. Marine Biology 159 (4): 881-895. https://doi.org/10.1007/s00227-011-1866-5
- Post DM (2002) Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology 83 (3): 703-718. https://doi.org/10.1890/0012-9658(2002)083
- Pugesek BH, Baldwin MJ, Stehn T (2013) The relationship of blue crab abundance to winter mortality of Whooping Cranes. The Wilson Journal of Ornithology 125 (3): 658-661. https://doi.org/10.1676/12-159.1
- Quezada-Romegialli C, Jackson AL, Hayden B, Kahilainen KK, Lopes C, Harrod C (2018) tRophicPosition, an R package for the Bayesian estimation of trophic position from consumer stable isotope ratios. Methods in Ecology and Evolution 9 (6): 1592-1599. https://doi.org/10.1111/2041-210X.13009
- R Core Team (2021) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/
- Serbetis C (1959) Un nouveau crustacé commestible en mer Egeé *Callinectes sapidus* Rath. (Decapod. Brach.). General Fisheries Council for the Mediterranean (GFMC), Proceedings and Technical papers 5: 505-507.
- Streftaris N, Zenetos A (2006) Alien marine species in the Mediterranean-the 100 ‘worst invasives’ and their impact. Mediterranean Marine Science 7 (1): 87-118. https://doi.org/10.12681/mms.180
- Thomsen MS (2020) Indiscriminate data aggregation in ecological meta-analysis underestimates impacts of invasive species. Nature Ecology & Evolution 4 (3): 312-314. https://doi.org/10.1038/s41559-019-0851-0
- Tibbets T, Wheeless L, del Rio CM (2007) Isotopic enrichment without change in diet: an ontogenetic shift in δ15N during insect metamorphosis. Functional Ecology https://doi.org/10.1111/j.1365-2435.2007.01342.x