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NOTE

Areal expansion of the box jellyfish *Carybdea marsupialis* (Linnaeus, 1758) towards the Ionian coasts of the Basilicata region (Italy)

Antonio O. Lillo[1, 2, *], Gianvito D'Orlando[1, 2], Giovanna Filippo[1, 2], Salvatore Longo[2], Alessandro Pipino[2], Achille Palma[2] and Teresa Trabace[2]

[1]Environmental Research Foundation of Basilicata Region (FARBAS), Largo C. Azzarà 1, 85100 Potenza, Italy. [2]Metaponto Research Centre, Regional Agency for the Environmental Prevention and Protection of Basilicata (ARPAB), S. S. Jonica 106, 75012 Metaponto, Italy.
ORCID *Antonio O. Lillo* https://orcid.org/0000-0001-7312-2170, *Achille Palma* https://orcid.org/0009-0002-0284-8366

ABSTRACT. The study documents the presence of the box jellyfish *Carybdea marsupialis* in the waters of the Ionian Sea in Italy, which constitutes important data for the knowledge of new areal distribution of this species along the coasts of the Mediterranean basin. *Carybdea marsupialis* belongs to the phylum Cnidaria, class Cubozoa, and is known for its stinging and potentially dangerous stings for humans, making it a species of significant ecological and health interest. The species has previously been observed in other areas of the western Mediterranean, but the report in the Ionian Sea represents an eastward expansion of its distribution range. Results suggest that climate change, influenced by global warming processes and anthropogenic activities, facilitated the expansion of this species into the rest of the Mediterranean Sea. The work highlights the importance of continuous monitoring of indigenous and non-indigenous species and calls for international cooperation to manage any ecological impacts linked to the spread of these marine species.

Key words: Cnidaria, Cubozoa, Mediterranean Sea, sea warming.

Expansión de la distribución de la cubomedusa *Carybdea marsupialis* (Linnaeus, 1758) hacia las costas jónicas de la región de Basilicata (Italia)

RESUMEN. El presente estudio documenta la presencia de la cubomedusa *Carybdea marsupialis* en aguas del Mar Jónico en Italia, lo que constituye un dato importante para el conocimiento de la nueva distribución de esta especie a lo largo de las costas de la cuenca mediterránea. *Carybdea marsupialis* pertenece al Phylum Cnidaria, Clase Cubozoa, y es conocida por sus picaduras urticantes y potencialmente peligrosas para los humanos, lo que la convierte en una especie de gran interés ecológico y sanitario. La especie ya se había observado anteriormente en otras áreas del Mediterráneo occidental, pero el registro en el Mar Jónico representa una expansión hacia el este de su rango de distribución. Los resultados sugieren que el cambio climático, influenciado por los procesos de calentamiento global y las actividades antropogénicas, facilitaron la expansión de esta especie al resto del Mar Mediterráneo. El trabajo destaca la importancia del seguimiento continuo de las especies autóctonas y no autóctonas y hace un llamamiento a la cooperación internacional para gestionar los posibles impactos ecológicos vinculados a la propagación de estas especies marinas.

Palabras clave: Cnidarios, Cubozoa, Mar Mediterráneo, calentamiento del océano.

*Correspondence:
antoniooscar.lillo@gmail.com

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The Mediterranean Sea is recognized as one of the most vulnerable marine ecosystems to climate change, with increasing temperatures, sea level rise

and increasing acidification having a significant impact on marine ecosystems (Giorgi 2006; Somot et al. 2008). Another relevant consequence is the introduction/establishment of new species, often invasive, from warmer waters of the Red Sea or oceans, altering local biodiversity and threatening native species (Bianchi and Morri 2003; Lejeusne et al. 2010). Among the species, *Carybdea marsupialis* (Linnaeus, 1758), a member of the Cnidaria phylum and the Cubozoa class, is one of the species, though not exotic, that have been gradually expanding their distribution area in the Mediterranean Sea (Acevedo 2016). This species is well-known for its capacity to inflict painful stings and for positive phototaxis, making it easily captured by attracting light (Larson 1976; Gershwin et al. 2013).

Box jellyfish are characterized by a transparent cubic bell and four tentacles containing stinging cnidocytes. *Carybdea marsupialis* has the bell that can reach dimensions of about 3-4 cm in length. From the lower edge of the latter, four long tentacles extend, equipped with cnidocytes, stinging cells that the jellyfish uses both to capture prey and to defend itself (Acevedo 2016). The life cycle of this box jellyfish is complex and includes two main stages: the polyp stage and the medusa stage. In the polyp stage, the organism is sessile and attaches itself to marine substrates. During the medusa stage, however, *C. marsupialis* is vagile and actively moves in water, behaving as an efficient predator (Bordehore et al. 2023). This mobility distinguishes box jellyfish from the classic jellyfish we are used to, which are often passively transported by marine currents (Gershwin et al. 2013). *Carybdea marsupialis* is an active predator and feeds on small fish and crustaceans that it immobilizes using its stinging tentacles. Its stinging power is capable of causing intense pain, skin irritation and, in extreme cases, systemic reactions such as nausea, dizziness and breathing difficulties in humans (Rottini et al. 1995; Avian et al. 1997; Peca et al. 1997; Di Camillo et al. 2006). However, it is not as dangerous as the Australian box jellyfish, for example the famous *Chironex fleckeri*, which has caused numerous deaths (Hamner et al. 1995; Bailey et al. 2005; Bentlage et al. 2009; Keesing et al. 2016). *Carybdea marsupialis* has been reported in several areas of the Mediterranean Sea, mainly western, where an increasing presence of stable populations has occurred (Katsanevakis et al. 2014) probably due to water warming and ecological changes (Morandini et al. 2014). This is evidenced in recent years by new records of other individuals of the phylum Cnidaria, for example *Porpita porpita*, in the Mediterranean Sea basin along the Italian coasts (Lillo et al. 2019, 2024). The species *C. marsupialis* prefers warm and temperate waters and is frequently found close to the coasts. It has been reported in massive numbers in Tunisia, Spain and the Italian coasts in the Adriatic Sea (Bordehore et al. 2011; Boero 2013; Gueroun et al. 2015). No reports exist for the Ionian side of the Basilicata region in the Global Biodiversity Information Facility dataset or in some bibliographic works (GBIF 2024).

The scientific community has become interested in *C. marsupialis* in recent decades due to an increase in the number of sightings in Mediterranean regions such as Spain and Italy (Acevedo 2016), raising concerns about the impact on local marine biodiversity (Boero 2013). This article describes the first record of *C. marsupialis* in the coastal area of the municipality of Policoro, an important tourist resort on the Gulf of Taranto in the Basilicata region, characterized by sandy beaches and medium-deep waters. The appearance of *C. marsupialis* in the Ionian waters of Basilicata represents an expansion of its known range to date, suggesting changes in environmental dynamics and warming of the Mediterranean Sea.

The first sighting of the species *C. marsupialis* in Basilicata was recorded on September 8, 2024, inside the port of Policoro, called Marinagri (40,2052° N-16,7306° E) (Figure 1). Individuals were found during night hours near two boats placed at a distance of 10 m from each other. In the following 48 h, two inspections were conducted inside other areas of the port to verify the presence

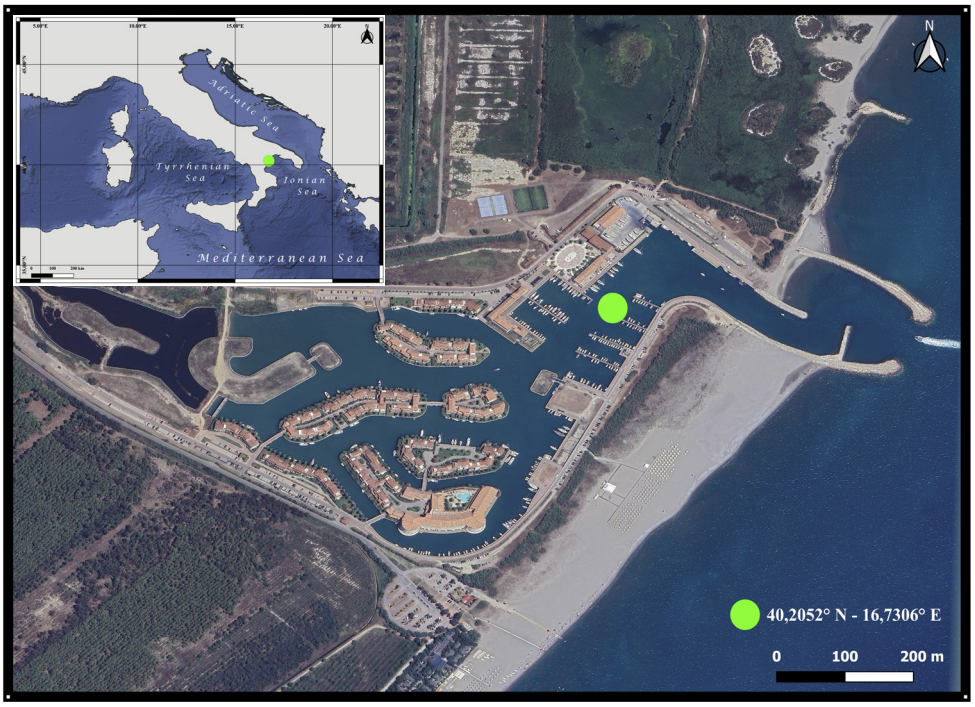

Figure 1. *Carybdea marsupialis* record in the port of Policoro (Basilicata, southern Italy).

of other individuals. The specimens were identified inside the port at depths between 1 m and 5 m. Observations were conducted visually during the night hours and during the day. Individuals were not collected but only photographed and inspected through visual census for identification. During the observation period, five specimens of *C. marsupialis* were detected (Figure 2 A). All individuals had a cube-shaped bell, transparent with light whitish shades and a diameter of between 4 and 5 cm (Figure 2 B and 2 C). Tentacles, long and transparent, extended up to about 10-15 cm in length (Acevedo 2016). These observations represent the first documented record of *C. marsupialis* in the Ionian Sea waters of Basilicata, a significant event for the region. Although populations of this species have been reported in other areas of the Mediterranean, such as Spain, France and the Adriatic and Tyrrhenian coasts of Italy (Boero et al. 2008), this finding represents a new geographical expansion of the known range of this species in Italian waters.

The appearance of *C. marsupialis* in the Lucanian Ionian waters could be the result of human transportation of the larvae by ballast waters (Zangaro et al. 2024) and various environmental factors, including global warming and changes in marine currents that favor the movement of species (Canepa et al. 2017). Recent studies have highlighted that the increase in temperatures of the Mediterranean Sea facilitates the proliferation of exotic species, especially during the summer period (CIESM 2001). One of the consequences of sea warming is the shift in the distribution area of thermo-tolerant species that have the potential to create interspecific interactions by altering food web structures and ecosystem processes (Mancini et al. 2022). In areas with a strong tourist vocation such as the city of Policoro, the presence of this jellyfish could negatively influence seaside tourism if the species were to establish a sedentary population (Mariottini and Pane 2010). This jellyfish is known for its urticating stings, which can cause painful

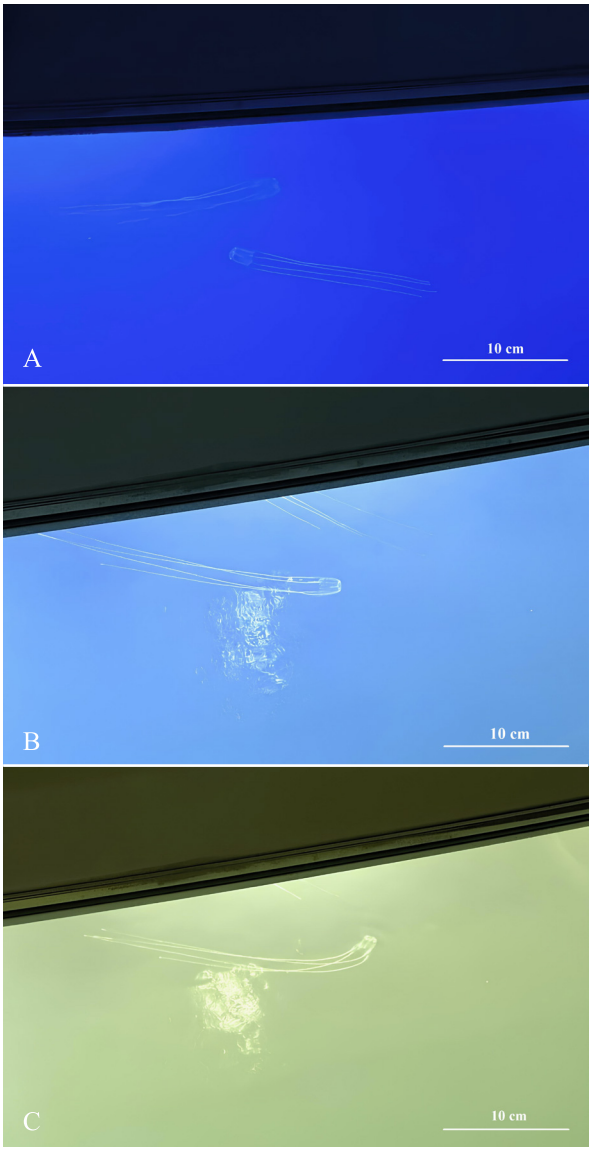

Figure 2. *Carybdea marsupialis* specimens found in Policoro (Basilicata, Italy). A) Two specimens of the box jellyfish. B) and C) Show clearly one individual of *Carybdea marsupialis* followed by the tips of tentacles of another one hidden by the boat.

irritation and, in extreme cases, acute allergic reactions that require medical intervention. Ecologically, the expansion of *C. marsupialis* could alter local marine food webs. This box jellyfish feeds on small fish and zooplankton, and a significant increase in its population could impact local fish stocks. At the same time, the increase in jellyfish populations is often related to the decrease of their natural predators, such as sea turtles and large pelagic fish, species that are increasingly threatened by human activities. In addition, the species seem to be favored by the high ratio of anthropogenic nutrients and human activities such as coastal constructions (Acevedo 2016). In fact, a high number of sightings of the species come from areas close to ports and marinas, which indicates that coastal constructions can be suitable settlement substrates for the planulae of the species (Bordehore et al. 2011; Boero 2013; Gueroun et al. 2015; Zammit et al. 2015). The increasing presence of *C. marsupialis* in the Mediterranean raises questions about the future of marine ecosystems and the impact of climate change. The increase in water temperature could further favor the expansion of this species in areas where it was previously rare or absent. Furthermore, the phenomenon of jellyfish blooms, a massive increase in population, can have significant ecological consequences by altering food webs. The appearance of these phenomena is seen as a potential indicator of state change in marine ecosystems (Graham and Kroutil 2001; Mills 2001; Purcell 2005; Purcell et al. 2007; Richardson et al. 2009), attributed not only to natural but also to anthropogenic conditions (Purcell et al. 2007; Dong et al. 2010). Another factor to consider is the variation of marine currents, which could have transported the larvae of *C. marsupialis* to new geographical areas, such as the Ionian coast of Basilicata. Indeed, as cited in the work of Petrosillo et al. (2023), a rotation of the current at variable depths is noted at the extreme eastern side of the Ionian Gulf, inducing a vortex structure in the summer months. It is known that jellyfish in the planktonic phase are highly susceptible to passive transport by currents facilitating the geographical dispersion. Alterations in marine currents could also have contributed to the dispersion of larvae or adult jellyfish from the western regions of the Mediterranean towards the Ionian Sea of Basilicata. The expansion

of these species is under the attention of the scientific community as it requires in-depth monitoring and study to evaluate the long-term effects of their increase in the waters of the Mediterranean Sea. 'Citizen science' can help to contribute to the detection and monitoring of rare or alien species in aquatic environments (Tiralongo et al. 2020). Citizens, expert fishermen or simple sea lovers can be very useful in recognizing species considered relevant to track changes in the biodiversity of the Mediterranean Sea (Tiralongo et al. 2020). This is evidenced by the Citizen science project 'Alienfish' where the involvement of sea users and expert fishermen has allowed the detection of both indigenous and non-indigenous rare species in recent years (Tiralongo et al. 2019). The same was carried out by the Regional Agency for Environmental Protection of the Basilicata Region (ARPAB), which started a reporting campaign regarding the alien hydrozoan *P. porpita*, inviting all bathers in the area to participate, to monitor its presence along the Italian coasts (https://www.arpab.it/2024/07/17/avete-visto-questa-specie-in-mare-e-lidrozoo-marino-porpita-porpita/).

The discovery of *C. marsupialis* in the Policoro area represents an important signal for the monitoring of marine biodiversity in the Ionian Sea. This sighting extends the known range of the species and highlights the need for monitoring to study the evolution of the species in Italian waters. Furthermore, it is essential to develop awareness campaigns aimed at bathers, tourism operators and fishermen to prevent possible incidents related to jellyfish stings. *C. marsupialis* along the coasts of Basilicata represents a new important data for the geographical distribution of the species in the Mediterranean. The stabilization of this species in the Lucanian Ionian waters is driven mainly by the sea warming and conventional marine currents of the Mediterranean Sea, and in particular port waters may play a significant role on this process. This is because, in addition to providing artificial substrates, they have the characteristic of being rich in nutrients necessary for the development and growth of the polyp and medusoid phase of some jellyfish species (Duarte et al. 2013). As a result, larvae can settle in these areas by following this gradient enriching resident biofouling communities (Chiu et al. 2008). Given the potential impact on public health and the local ecosystem, it is necessary to continue to carefully monitor the box jellyfish population in the region and study the dynamics of their blooms to better understand their causes and effects. Some science platforms in Europe region are available for these purposes, such as the website https://observation.org. The Mediterranean Science Commission (CIESM) through the 'Jellywatch' program in 2008 collects information on the distribution, size and sightings of jellyfish in the Mediterranean Sea in order to continuously update the expansion of the species (Saygin 2017).

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Author contributions

Antonio O. Lillo: conceptualization; methodology; software; validation; formal analysis; investigation; resources; data curation; writing-original draft; writing-review and editing; visualization; supervision; project administration. Teresa Trebace: validation; visualization; supervision. Gianvito D'Orlando: investigation; resources; writing-original draft; writing-review and editing; visualization; supervision. Giovanna Filippo: visualization. Salvatore Longo: visualization. Alessandro Pipino: visualization. Achille Palma: visualization; supervision.

REFERENCES

Acevedo M. 2016. Biology, ecology and ecophysiology of the box jellyfish *Carybdea marsupialis* (Cnidaria: Cubozoa) [PhD thesis]. Barcelona: Polytechnic University of Catalunya. 129 p.

Avian M, Budri N, Rottini Sandrini L. 1997. The nematocysts of Carybdea marsupialis Linnaeus, 1758 (Cubozoa). In: den Harlog JC, editor. Proceedings of the 6th International Conference on Celenterate Biology. The Leeuwenhorst, Noordwijkerhout, The Neherlands. 16-21 July 1995. Leiden: Nationaal Natuurhistorisch Museum p. 21-26.

Bailey PM, Bakker AJ, Seymour JE, Wilce JA. 2005. A functional comparison of the venom of three Australian jellyfish-*Chironex fleckeri*, *Chiropsalmus* sp., and *Carybdea xaymacana*-on cytosolic Ca_2^+, haemolysis and *Artemia* sp. lethality. Toxicon. 45 (2): 233-242.

Bentlage B, Peterson AT, Cartwright P. 2009. Inferring distributions of chirodropid box-jellyfishes (Cnidaria: Cubozoa) in geographic and ecological space using ecological niche modeling. Mar Ecol Prog Ser. 384: 121-133.

Bianchi CN, Morri C. 2003. Global sea warming and "tropicalization" of the Mediterranean Sea: biogeographic and ecological aspects. Biogeographia. 24 (1): 319-327.

Boero F. 2013. Review of jellyfish blooms in the Mediterranean and Black Sea. Studies and Reviews. General Fisheries Commission for the Mediterranean. 92. Roma: FAO. 53 p.

Boero F, Bouillon J, Gravili C, Miglietta MP, Parsons T, Piraino S. 2008. Gelatinous plankton: irregularities rule the world (sometimes). Mar Ecol Prog Ser. 356: 299-310.

Bordehore C, Fuentes VL, Atienza D, Barberá C, Fernandez-Jover D, Roig M, Acevedo-Dudley MJ, Canepa AJ, Gili JM. 2011. Detection of an unusual presence of the cubozoan *Carybdea marsupialis* at shallow beaches located near Denia, Spain (southwestern Mediterranean). Mar Biodivers Rec. 4: e69.

Bordehore C, Manchado-Pérez S, Fonfría ES. 2023. Swimming ability of the *Carybdea marsupialis* (Cnidaria: Cubozoa: Carybdeidae): implications for its spatial distribution. BioRxiv. DOI: https://doi.org/10.1101/2023.05.06.539705

Canepa A, Fuentes V, Bosch-Belmar M, Acevedo M, Toledo-Guedes K, Ortiz A, Durá E, Bordehore C, Gili J-M. 2017. Environmental factors influencing the spatiotemporal distribution of *Carybdea marsupialis* (Lineo, 1978, Cubozoa) in South-Western Mediterranean coasts. PLoS ONE. 12 (7): e0181611.

Chiu JMY, Zhang R, Wang H, Thiyagarajan V, Qian PY. 2008. Nutrient effects on intertidal community: from bacteria to invertebrates. Mar Ecol Prog Ser. 358: 41-50.

[CIESM] Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée. 2001. Gelatinous zooplankton outbreaks: theory and practice. Naples: CIESM Workshop Monographs. no. 14. 112 p.

Di Camillo C, Bo M, Puce S, Tazioli S, Bavestrello G. 2006. The cnidome of *Carybdea marsupialis* (Cnidaria: Cubomedusae) from the Adriatic Sea. J Mar Biol Assoc UK. 86 (4): 705-709.

Dong Z, Liu D, Keesing JK. 2010. Jellyfish blooms in China: dominant species, causes and consequences. Mar Pollut Bull. 60 (7): 954-963.

Duarte CM, Pitt KA, Lucas CH, Purcell JE, Uye SI, Robinson K, Brotz L, Decker MB, Shuterland KR, Malej A, et al. 2013. Is global ocean sprawl a cause of jellyfish blooms? Front Ecol Environ. 11 (2): 91-97.

[GBIF] Global Biodiversity Information Facility. 2024. Global distribution map of *Carybdea marsupialis.* [accessed 2024 Sep 10]. https://www.gbif.org.

Gershwin LA, Richardson AJ, Winkel KD, Fenner PJ, Lippmann J, Hore R, Avila-Soria G, Brewer D, Kloser RJ, Steven A, Condie S. 2013. Biology and ecology of *Irukandji jel-*

lyfish (Cnidaria: Cubozoa). Adv Mar Biol. 66. 1-85. DOI: https://doi.org/10.1016/B978-0-12-408096-6.00001-8

Giorgi F. 2006. Climate change hot-spots. Geophys Res Lett. 33 (8): L08707. DOI: https://doi.org/10.1029/2006GL025734

Graham WM, Kroutil RM. 2001. Size-based prey selectivity and dietary shifts in the jellyfish, *Aurelia aurita*. J Plankton Res. 23 (1): 67-74.

Gueroun SKM, Acevedo MJ, Kéfi-Daly Yahia O, Deidun A, Fuentes VL, Piraino S, Daly Yahia MN. 2015. First records of *Carybdea marsupialis* proliferation (Cnidaria: Cubozoa) along the eastern Tunisian coast (Central Mediterranean). Ital J Zool. 82 (3): 430-435.

Hamner WM, Jones MS, Hamner PP. 1995. Swimming, feeding, circulation and vision in the Australian box jellyfish, *Chironex fleckeri* (Cnidaria: Cubozoa). Mar Freshwat Res. 46 (7): 985-990.

Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Cinar ME, Oztürk B, Grabowski M, Golani D, Cardoso AC. 2014. Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. Aquat Invasions. 9 (4): 391-423.

Keesing JK, Strzelecki J, Stowar M, Wakeford M, Miller KJ, Gershwin LA, Liu D. 2016. Abundant box jellyfish, *Chironex* sp. (Cnidaria: Cubozoa: Chirodropidae), discovered at depths of over 50 m on western Australian coastal reefs. Sci Rep. 6 (1): 22290.

Larson RJ. 1976. Cubomedusae: feeding-functional morphology, behavior and phylogenetic position. In: Mackie GO, editor. Coelenterate ecology and behavior. Boston: Springer. p. 237-245.

Lejeusne C, Chevaldonné P, Pergent-Martini C, Boudouresque CF, Pérez T. 2010. Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. Trends Ecol Evol. 25 (4): 250-260.

Lillo AO, D'Orlando G, Filippo G, D'Amore A, Longo S, Palma A, Trabace T. 2024. Occurrence of the blue button *Porpita porpita* along the Italian Ionian and Tyrrhenian coasts. Mar Fish Sci. 37 (4): 667-671. DOI: https://doi.org/10.47193/mafis.3742024010707

Lillo AO, Tiralongo F, Tondo E. 2019. New records of *Porpita porpita* (Linnaeus, 1758) (Cnidaria: Hydrozoa) in the Mediterranean Sea. Nat Eng Sci. 4 (3): 293-298.

Mancini F, Lillo AO, Bardelli R, Vizzini S, Mancinelli G. 2022. Variation in the stable isotope trophic position of the bluefish *Pomatomus saltatrix* (Linnaeus, 1766) from two Mediterranean sites: insights from a global meta-analysis. Mediterr Mar Sci. 23 (4): 850-863.

Mariottini GL, Pane L. 2010. Mediterranean jellyfish venoms: a review on scyphomedusae. Mar Drugs. 8 (4): 1122-1152.

Mills CE. 2001. Jellyfish blooms: are populations increasing globally in response to changing ocean conditions? Hydrobiologia. 451: 55-68.

Morandini AC, Stampar SN, Kubota S. 2014. Mass occurrence of the cubomedusa *Copula sivickisi* (Cnidaria: Cubozoa) at Seto Harbor, Shirahama, Wakayama, Japan, in summer of 2013; a possible recent example of global warming. Publ Seto Mar Biol Lab. 42: 108-111.

Peca G, Rafanelli S, Galassi G, Di Bartolo P, Bertini S, Alberani M, Beccari G. 1997. Contact reactions to the jellyfish *Carybdea marsupialis*: observation of 40 cases. Contact Dermatitis. 36 (3): 124-126. DOI: https://doi.org/10.1111/j.1600-0536.1997.tb00392.x

Petrosillo I, Scardia Scardia AMS, Ungaro N, Specchiulli A, Fanelli G, Centoducati G, De Serio F, Carlucci R, Valente D, Barbone E, et al. 2023. Towards sustainable marine spatial planning of aquaculture. Ecol Indic. 154: 110542.

Purcell JE. 2005. Climate effects on formation of jellyfish and ctenophore blooms: a review. J Mar Biol Assoc UK. 85 (3): 461-476.

Purcell JE, Uye SI, Lo WT. 2007. Anthropogenic causes of jellyfish blooms and their direct consequences for humans: a review. Mar Ecol Prog

Ser. 350: 153-174.

Richardson AJ, Bakun A, Hays GC, Gibbons MJ. 2009. The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. Trends Ecol Evol. 24 (6): 312-322.

Rottini G, Gusmani L, Parovel E, Avian M, Patriarca P. 1995. Purification and properties of a cytolytic toxin in venom of the jellyfish *Carybdea marsupialis*. Toxicon. 33 (3): 315-326.

Saygin Ö. 2017. On the occurrence of blue button, *Porpita porpita* (Cnidaria: Hydrozoa) from Levantine coast of Turkey. Nat Eng Sci. 2 (2): 33-36.

Somot S, Sevault F, Déqué M, Crépon M. 2008. 21st century climate change scenario of the Mediterranean using a coupled atmosphere-ocean regional climate model. Glob Planet Change. 63 (2-3): 112-126. DOI: https://doi.org/10.1016/j.gloplacha.2007.10.003

Tiralongo F, Lillo AO, Tibullo D, Tondo E, Martire CL, D'Agnese R, Mcali A, Mancini E, Giovos I, Coco S, Azzurro E. 2019. Monitoring uncommon and non-indigenous fishes in Italian waters: One year of results for the AlienFish project. Reg Stud Mar Sci. 28: 100606.

Tiralongo F, Crocetta F, Riginella E, Lillo AO, Tondo E, Macali A, Mancini E, Russo F, Coco S, Paolillo G, Azzurro E. 2020. Snapshot of rare, exotic and overlooked fish species in the Italian seas: a citizen science survey. J Sea Res. 164: 101930.

Zangaro F, Pinna M, Specchia V. 2024. Environmental DNA as early warning for alien species in Mediterranean coastal lagoons: implications for conservation and management. Diversity. 16 (9): 525.