Acta Ichthyologica et Piscatoria 55, 2025, 77–81 | DOI 10.3897/aiep.55.146945

PENSOFT

ACTA ICHTHYOLOGICA ET PISCATORIA

Northernmost Mediterranean record of the silver-cheeked toadfish, *Lagocephalus sceleratus* (Actinopterygii, Tetraodontiformes, Tetraodontidae)

Neven IVEŠA[1], Moira BURŠIĆ[1], Jakov DULČIĆ[2]

1 *Faculty of Natural Sciences, Juraj Dobrila University of Pula, Pula, Croatia*

2 *Institute of Oceanography and Fisheries, Split, Croatia*

https://zoobank.org/E3C17CFE-61B1-4CA8-983D-EC49255BE0D4

Corresponding author: Moira Buršić (moira.bursic@unipu.hr)

Academic editor: Wojciech Piasecki ♦ **Received** 16 January 2025 ♦ **Accepted** 14 February 2025 ♦ **Published** 20 March 2025

Citation: Iveša N, Buršić M, Dulčić J (2025) Northernmost Mediterranean record of the silver-cheeked toadfish, Lagocephalus sceleratus (Actinopterygii, Tetraodontiformes, Tetraodontidae). Acta Ichthyologica et Piscatoria 55: 77–81. https://doi.org/10.3897/aiep.55.146945

Abstract

This study reports the first capture of *Lagocephalus sceleratus* in the northern Adriatic, specifically in Medulin Bay at a depth of 19.7 m. The specimen, a 522 mm male weighing 1330 g, was caught on 13 May 2024. This is the fourth record in the Adriatic and the northernmost one for both the Adriatic and Mediterranean seas. Stomach analysis revealed bivalves, gastropods, sea urchin fragments, and inorganic particles. The further spread of this tetraodontid species in the Adriatic poses ecological and socio-economic risks, such as disruptions to fisheries, biodiversity loss, and threats to marine ecosystems. Effective management requires monitoring, regulation, public education, and citizen science involvement.

Keywords

Lessepsian migrant, Adriatic Sea, Medulin Bay, northernmost occurrence, invasive species

Introduction

Among the new fish arrivals in the Mediterranean, one of the most emblematic is the case of species belonging to the family Tetraodontidae, which includes 19 genera and approximately 130 species (Nelson 2006). Thirteen species of pufferfish have been detected in the Mediterranean Sea, with 11 being non-indigenous. Of these, 11 species have successfully established populations (Ulman et al. 2021a). The silver-cheeked toadfish, *Lagocephalus sceleratus* (Gmelin, 1789), a Lessepsian migrant, is native to the tropical Indian and Pacific Oceans (Ulman et al. 2021b). In the Mediterranean Sea this species was first recorded in 2003 off the southeastern Aegean Sea coast of Turkey (Akyol et al. 2005) and since then, it has quickly spread to other parts of the Mediterranean, reaching as far as Gibraltar and the Black Sea (Deidun et al. 2015; Bilecenoğlu and Öztürk 2018; Galanidi and Zenetos 2019; Azzurro et al. 2020; Gücü et al. 2021; Manilo 2021). The presence of *L. sceleratus* in the Mediterranean is most prominent in the eastern region, with the highest impact along the coasts of Greece, Turkey, Lebanon, Egypt, Cyprus, Malta, and Tunisia. The habitat suitability models predict that *L. sceleratus* is most likely to be found in coastal areas, with high suitability in the eastern Mediterranean, particularly along the coasts of Greece and Turkey. Additional suitable areas include the southern Italian coasts, the strait of Gibraltar, and parts of the western Mediterranean, although some central and western regions show lower suitability. A merged distribution suggests that most of the Mediterranean is suitable for this species, except for certain areas in the central and western basins (Coro et al. 2018).

Besides *L. sceleratus*, the recorded species of the family Tetraodontidae in the Adriatic Sea include the subtropical blunthead puffer, *Sphoeroides pachygaster* (Müller et Troschel, 1848), and the native subtropical oceanic puffer, *Lagocephalus lagocephalus* (Linnaeus, 1758) (see Dulčić and Kovačić 2020). Given their extremely invasive nature and potential risk to human health, monitoring these Tetraodontidae species is crucial for assessing their impact on ecosystems and fisheries. Therefore, the objective of this work was to contribute new records of Tetraodontidae species in the Adriatic Sea, including the northernmost record of *L. sceleratus* in the Mediterranean Sea.

Materials and methods

On 13 May 2024, a *Lagocephalus sceleratus* specimen was caught by a recreational angler operating from a boat anchored between two small islets, Ceja and Trumbuja, in Medulin Bay (northern Adriatic, southern Istria, 44°47′24″N, 13°55′43″E) (Fig. 1). The fish was caught at a depth of 19.7 m at around 18:00 h, with a sea surface temperature of 17.63°C. Pieces of chicken were used as bait. Upon being hauled onto the boat, the fish immediately inflated and produced clicking sounds. The specimen was subsequently transported to the Laboratory of the Faculty of Natural Sciences in Pula for further analysis. The examination included species identification, weighing, measuring (total and standard length), macroscopic determination of sex through gonadal analysis, and stomach content analysis to assess dietary habits.

Results and discussion

The caught specimen of the silver-cheeked toadfish was determined to be a male and had a total length of 522 mm (standard length of 433 mm) and weight of 1330 g (Fig. 2). The first specimen of *L. sceleratus* in the Adriatic Sea was caught in October 2012. This occurred on the northern side of Jakljan Island in the southern Adriatic, Croatia (Sulić-Šprem et al. 2014). Additional records in the Adriatic followed, in 2013 near Tribunj (Dulčić et al. 2014 and in 2014 near Vodice from the eastern middle Adriatic (Dulčić et al. 2014).

In 2014, the species was also recorded on the Italian side of the Adriatic, near Trani in the Puglia region, southwestern Adriatic (Carbonara et al. 2017). This was the fifth recorded sighting of *L. sceleratus* in the Adriatic Sea and the fourth along its eastern side. It also represents the northernmost occurrence of this species in both the Adriatic and the entire Mediterranean Sea (Fig. 3).

The stomach and its contents were carefully removed, but identifying prey items was generally limited to higher taxonomic levels given that the pufferfish's beak-like jaws crush food so thoroughly that prey is rarely recognizable at the species level. Despite this, the analysis did reveal bivalve shells, gastropod shells, fragments of sea urchin skeletons, and particles of inorganic material (Fig. 4). *Lagocephalus sceleratus* has a formidable dentition that allows them to occupy a broad ecological niche, preying on both pelagic and benthic organisms, including those with armor-like exteriors like crustaceans, sea urchins, and barnacles (Ulman et al. 2021a).

In Medulin Bay, *L. sceleratus* was caught at a depth of 19.7 m, which corresponds to the depth range at which it is most commonly caught (Özbek et al. 2017). The spread of Tetraodontidae in the Adriatic Sea poses unpredictable risks, making it crucial to continue collecting biological data on these invasive species to better understand their future ecological impact. While it is evident that the biodiversity profile in the Mediterranean Sea is changing, the extent to which warm-water species will affect the trophic web and marine ecosystem functioning remains uncertain and is under constant evaluation. The growing presence of *L. sceleratus* in coastal regions poses a direct threat to tourism, especially in areas frequented by swimmers. This invasive species is

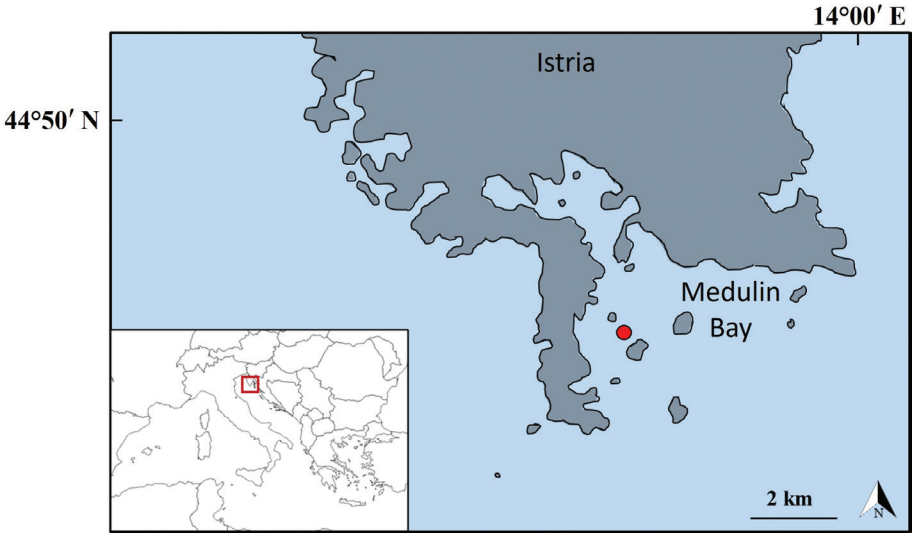

Figure 1. The area in the northern Adriatic Sea where *Lagocephalus sceleratus* was caught, Medulin Bay, southern Istria, Croatia. Red dot indicates the exact location (44°47′24″N, 13°55′43″E).

Figure 2. Specimen of *Lagocephlus sceleratus* (♂) from Medulin Bay, Croatia.

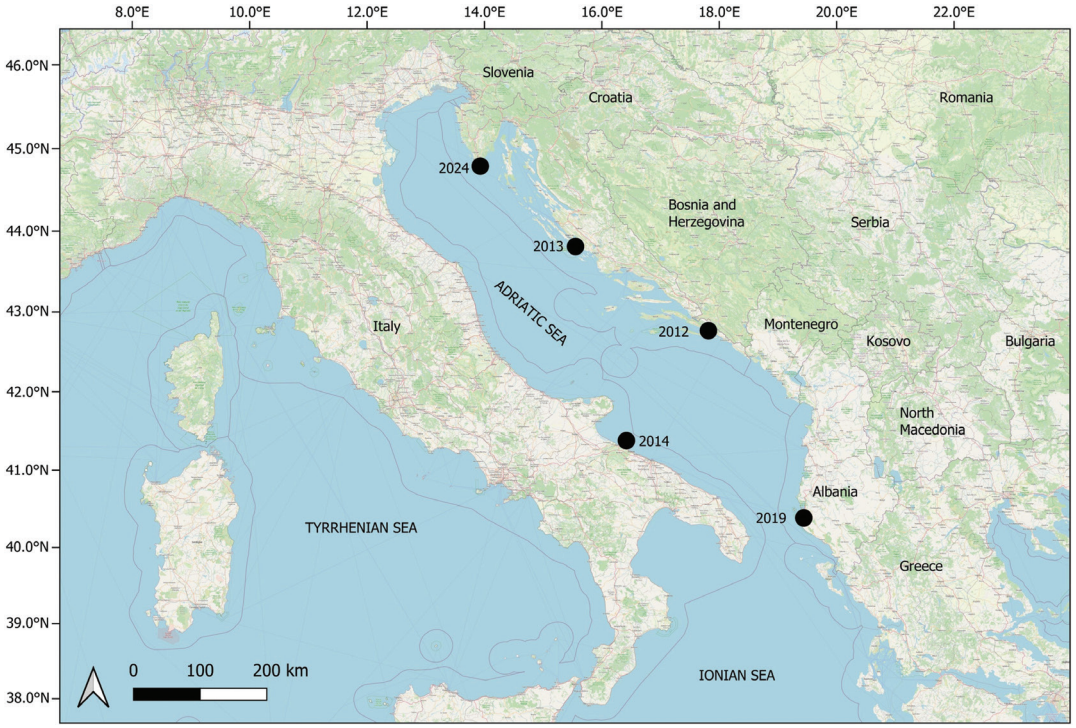

Figure 3. Adriatic records of *Lagocephalus sceleratus*. **2012** = Sulić-Šprem et al. (2014); **2013** = Dulčić et al. (2014); **2014** = Carbonara et al. (2017); **2019** = Kousteni et al. (2019); **2024** = presently reported study (Base map: OpenStreetMap contributors 2024, styled in QGIS).

known for its aggressive behavior, with reported cases of bites causing significant injuries. Alarmingly, recent evidence from the southern and eastern Mediterranean shows that these bites can result in severe injuries, such as partial amputations of fingers (Sümen and Bilecenoğlu 2019). Although such cases are rare, they highlight the potential danger this species poses to humans. These risks not only create safety concerns for swimmers but also threaten the image and appeal of tourist destinations, potentially leading to economic losses in local tourism and related industries. Effective management and public awareness are crucial to mitigate these impacts (Ulman et al. 2024).

According to current data, increased presence and distribution of *L. sceleratus* in the Adriatic Sea is concerning. In some Mediterranean coastal areas, after less than a decade since its first detection, *L. sceleratus* has become an increasingly significant portion of small-scale coastal fishing catches, leading to significant socio-economic repercussions. In response, proposed management measures in the invaded areas include designing more robust fishing gear, modifying fishing tactics during periods of frequent *L. sceleratus* presence, and exploring its commercialization (Christidis et al. 2024). The primary control recommendation for decision-makers is to prioritize the targeted removal

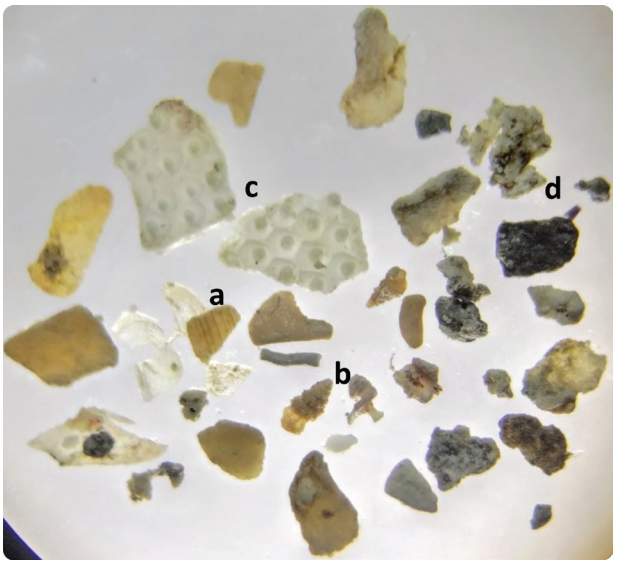

Figure 4. Different types of prey found in the stomach of the captured individual of *Lagocephalus sceleratus* in Medulin Bay. **a** = bivalve shells, **b** = gastropod shells, **c** = fragments of sea urchin skeletons, **d** = particles of inorganic material.

of the species during its spawning period. The Adriatic Sea's current that flows north–northwest along Albania and Croatia, reaching the Istrian Peninsula, where it turns and flows southeast along Italy system, aids the movement of larvae and juvenile fish, potentially facilitating the spread of species into new areas. Moreover, the waters of Medulin Bay share oceanographic features with the Kvarner area, with deeper waters and slightly higher bottom temperatures than the northern Adriatic along the western Istrian coast. While the shallow northern Adriatic shelf produces denser water, Kvarner Bay undergoes more frequent bottom layer renewal, occurring annually instead of the longer cycles in other deep Adriatic basins (Pranić et al. 2024). Such oceanographic conditions could be more favorable for allochthonous thermophilic species, some of which have already been recorded in the nearby area (Iveša et al. 2024). As a coastal nation, Croatia faces significant health and ecological risks from the invasive species *L. sceleratus*, necessitating a coordinated and proactive response. To mitigate these risks, strict regulations must be enacted and effectively enforced to prevent the marketing and consumption of this highly toxic species. At the same time, education and training programs for medical staff, tourism workers, marine recreation professionals, and the general public are essential to raise awareness and ensure preparedness for potential encounters.

While the EU addresses invasive species management through Regulation (EU) No. 1143/2014 (European Union 2014), the regulation largely excludes marine invasive species, focusing instead on freshwater and terrestrial ecosystems due to scientific uncertainties and legal challenges. In Croatia, national policies cover only aquarium-related marine species and neglect wild marine species like *L. sceleratus*, creating significant gaps in management efforts. Adding marine species to EU frameworks is further complicated by their economic importance to fisheries, which conflicts with conservation goals that aim to restrict their use and trade.

To bridge these gaps, targeted efforts are required at both national and local levels. The Directorate of Fisheries should take the lead in educating fishers about the risks associated with *L. sceleratus*. Information campaigns through workshops, digital platforms, and printed materials can help fishers safely handle accidental catches while minimizing harm to ecosystems and human health. Additionally, public education campaigns and stakeholder training programs will enhance preparedness and reduce the likelihood of health hazards or ecological damage, especially in vulnerable areas like the Adriatic Sea. A comprehensive, cohesive approach is vital to ensure that scientific recommendations are effectively translated into actionable policies and practices.

Finally, this study also underscores the importance of citizen science in the early detection and monitoring of invasive species. Local fishermen and marine enthusiasts have already played a crucial role in the timely detection of both previous and recent records of *L. sceleratus* in Croatian waters.

Conclusion

The spread of *Lagocephalus sceleratus* in the Adriatic highlights the growing challenges of invasive tetraodontid species in the Mediterranean. Its northernmost capture stresses the need for monitoring and management. The presence of *L. sceleratus* disrupts native species, alters food webs, and threatens marine ecosystems. Addressing these challenges requires regulatory measures, targeted removal, and public education. Public awareness campaigns and training programs for coastal communities and recreational fishers are essential. Engaging local communities through citizen science, like mobile apps for sighting reports, will enhance early detection and management of Invasive Alien Species (IAS), helping mitigate ecological and socio-economic threats to Mediterranean biodiversity.

Acknowledgments

Authors are thankful to fishermen Mr Anton Vidovič and Mr Mario Lazarić for providing a specimen and data about catch.

Funded by the European Union – NextGenerationEU through the project Coastal fish (and other marine organisms) communities: status, challenges and pressures, acronym PRIMOS.

References

Akyol O, Ünal V, Ceyhan T, Bilecenoglu M (2005) First confirmed record of *Lagocephalus sceleratus* (Gmelin, 1789) in the Mediterranean Sea. Journal of Fish Biology 66(4): 1183–1186. https://doi.org/10.1111/j.0022-1112.2005.00667.x

Azzurro E, Bariche M, Cerri J (2020) The long reach of the Suez Canal: *Lagocephalus sceleratus* (Gmelin, 1789) an unwanted Indo–Pacific pest at the Atlantic gate. BioInvasions Records 9(2): 204–208. https://doi.org/10.3391/bir.2020.9.2.05

Bilecenoğlu M, Öztürk B (2018) Possible intrusion of *Lagocephalus sceleratus* (Gmelin, 1789) to the Turkish Black Sea coast. Journal of the Black Sea/Mediterranean Environment 24(3): 272–276.

Carbonara P, Kolitari J, Đurović M, Gaudio P, Ikica Z, Kroqi G, Milone N, Spedicato MT (2017) The presence of Tetraodontidae species in the Central Mediterranean: An update from the southern Adriatic Sea. Acta Adriatica 58(2): 325–338. https://doi.org/10.32582/aa.58.2.11

Christidis G, Batziakas S, Peristeraki P, Tzanatos E, Somarakis S, Tserpes G (2024) Another one bites the net: Assessing the economic impacts of *Lagocephalus sceleratus* on small-scale fisheries in Greece. Fishes 9(3): e104. https://doi.org/10.3390/fishes9030104

Coro G, Vilas LG, Magliozzi C, Ellenbroek A, Scarponi P, Pagano P (2018) Forecasting the ongoing invasion of *Lagocephalus sceleratus* in the Mediterranean Sea. Ecological Modelling 371: 37–49. https://doi.org/10.1016/j.ecolmodel.2018.01.007

Deidun A, Fenech-Farrugia A, Castriota L, Falautano M, Azzurro E, Andaloro F (2015) First record of the silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789) from Malta. BioInvasions Records 4(2): 139–142. https://doi.org/10.3391/bir.2015.4.2.11

Dulčić J, Kovačić M (2020) Ihtiofauna Jadranskoga mora. Golden marketing – Tehnička knjiga; Institut za oceanografiju i ribarstvo, Zagreb/Split, 680 pp.

Dulčić J, Dragičević B, Antolović N, Sulić-Šprem J, Kolíl'ul V, Grgičević R (2014) Additional records of *Lobotes surinamensis*, *Caranx crysos*, *Enchelycore anatina*, and *Lagocephalus sceleratus* (Actinopterygii) in the Adriatic Sea. Acta Ichthyologica et Piscatoria 44(1): 71–74. https://doi.org/10.3750/AIP2014.44.1.09

European Union (2014) Regulation (EU) No. 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union, L 317, 4.11.2014, 35–55.

Galanidi M, Zenetos A (2019) EU risk assessment of *Lagocephalus sceleratus*. State of knowledge, evaluation and criteria, data needs/formats and management. In: Langar H, Ouerghi A (Eds) Proceedings of the 1st Mediterranean Symposium on the Non-Indigenous Species, Antalya, Turkey, January 2019. SPA/RAC publi., Tunis, 45–50.

Gücü AC, Ünal V, Ulman A, Morello EB, Bernal M (2021) Management responses to non-indigenous species in the Mediterranean and the Black Sea in the face of climate change. In: Bahri T, Vasconcellos M, Welch DJ, Johnson J, Perry RI, Ma X, Sharma R (Eds) Adaptive management of fisheries in response to climate change. FAO Fisheries and Aquaculture Technical Paper No. 667. FAO, Rome, 161–176. https://doi.org/10.4060/cb3095en

Iveša N, Brajković A, Piria M, Buršić M (2024) The northernmost record of *Percnon gibbesi* (H. Milne Edwards, 1853) in the Mediterranean Sea. BioInvasions Records 13(3): 767–776. https://doi.org/10.3391/bir.2024.13.3.15

Kousteni V, Bakiu R, Benhmida A, Crocetta F, Di Martino V, Dogrammatz IA, Doumpas N, Durmishaj S, Giovos I, Gökoğlu M, Huseyinoglu M, Jimenez C, Kalogirou S, Kleitou P, Lipej L, Macali A, Petani A, Petović S, Prato E, Fernando R, Sghaier Y, Stancanelli B, Teker S, Tiralongo F, Trkov D (2019) New Mediterranean biodiversity records 2019. Mediterranean Marine Science 20(1): 230–247. https://doi.org/10.12681/mms.19609

Manilo L (2021) Alien fishes in the Black Sea waters of Crimea (Ukraine). Geo&Bio 20(20): 79–101. https://doi.org/10.15407/gb2010

Nelson JS (2006) Family Tetraodontidae—puffers. In: Nelson JS (Ed.) Fishes of the world. John Wiley and Sons, Hoboken, New Jersey, 456–457.

OpenStreetMap contributors (2024) OpenStreetMap data. Retrieved on 15 December 2024 from https://www.openstreetmap.org

Özbek E, Çardak M, Kebapçioglu T (2017) Spatio-temporal patterns of abundance, biomass and length of the silver-cheeked toadfish *Lagocephalus sceleratus* in the Gulf of Antalya, Turkey (Eastern Mediterranean Sea). Turkish Journal of Fisheries and Aquatic Sciences 17(4): 725–733. https://doi.org/10.4194/1303-2712-v17_4_08

Pranić P, Denamiel C, Vilibić I (2024) Kilometer-scale assessment of the Adriatic dense water multi-decadal dynamics. Journal of Geophysical Research: Oceans 129(10): e2024JC021182. https://doi.org/10.1029/2024JC021182

Sulić-Šprem J, Dobroslavić T, Kožul V, Kuzman A, Dulčić J (2014) First record of *Lagocephalus sceleratus* in the Adriatic Sea (Croatian coast), a Lessepsian migrant. Cybium 38(2): 147–148. https://doi.org/10.26028/CYBIUM/2014-382-005

Sümen S, Bilecenoğlu M (2019) Traumatic finger amputation caused by *Lagocephalus sceleratus* (Gmelin, 1789) bite. Journal of Black Sea/Mediterranean Environment 25: 333–338. https://blackmeditjournal.org/wp-content/uploads/9-20193_333-338.pdf

Ulman A, Yildiz T, Demirel N, Canak O, Yemişken E, Pauly D (2021a) The biology and ecology of the invasive silver-cheeked toadfish (*Lagocephalus sceleratus*), with emphasis on the Eastern Mediterranean. NeoBiota 68: 145–175. https://doi.org/10.3897/neobiota.68.71767

Ulman A, Harris H, Doumpas N, Al Mabruk S, Akbora D, Azzurro E, Bariche M, Çiçek BA, Deidun A, Demirel N, Fogg AQ, Katsavenakis S, Kletou D, Kleitou P, Papadopolou A, Ben Souissi B, Hall-Spencer JM, Tiralongo F, Yildiz T (2021b) Low pufferfish and lionfish predation in their native and invaded ranges suggests human control mechanisms may be necessary to control their Mediterranean abundances. Frontiers in Marine Science 8: e670413. https://doi.org/10.3389/fmars.2021.670413

Ulman A, Abd Rabou AFN, Al Mabruk S, Bariche M, Bilecenoğlu M, Demirel N, Galil BS, Hüseyinoğlu MF, Jimenez C, Hadjioannou L, Kosker AR, Peristeraki P, Saad A, Samaha Z, Stoumboudi MT, Temraz TA, Karachle PK (2024) Assessment of human health impacts from invasive pufferfish (attacks, poisonings and fatalities) across the Eastern Mediterranean. Biology 13(4): 208. https://doi.org/10.3390/biology13040208