

ANNALES

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





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Series Historia Naturalis, 36, 2026, 1

ISSN 1408-533X
e-ISSN 2591-1783

UDK 5

Letnik 36, leto 2026 številka 1

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Založništvo PADRE d.o.o.

Izdajatelj/Editori/Published by:Zgodovinsko društvo za južno Primorsko - Koper / Società storica del Litorale - Capodistria®
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e-mail: annalesSHN@nib.si, internet: www.zdjp.si

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

**Sofinancirajo/Supporto finanziario/
Financially supported by:**

Javna agencija za znanstveno-raziskovalno in inovacijsko dejavnost Republike Slovenije (ARIS)

Annales - Series Historia Naturalis izhaja dvakrat letno.**Naklada/Tiratura/Circulation:** 300 izvodov/copie/copies

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

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RAPID INCREASE IN RECORDS OF THE INVASIVE SILVER-CHEEKED TOADFISH *LAGOCEPHALUS SCCELERATUS* (GMELIN, 1789) IN THE ADRIATIC SEA

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ABSTRACT

The silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789) is a highly invasive Lessepsian migrant causing major ecological and socio-economic impacts in the Mediterranean Sea. Although the species was previously rare and sporadic in the Adriatic Sea, this study documents a sudden increase in its records between late March and early May 2026. Data were obtained from recreational and professional fisheries and validated through morphological identification and satellite-derived sea surface temperature (SST) data. Five new records were reported during this period, with four documented within less than two weeks along the eastern Adriatic and Albanian coasts, representing the highest number of records recorded over such a short interval in the region. SST values ranged from 14.69 °C to 15.68 °C. These findings indicate an increasingly regular presence, likely linked to sea warming.

Key words: *Lagocephalus sceleratus*, Adriatic Sea, Lessepsian migration, invasive species, climate change, range expansion

RAPIDO AUMENTO DELLE SEGNALAZIONI DEL PESCE PALLA ARGENTEO INVASIVO *LAGOCEPHALUS SCCELERATUS* (GMELIN, 1789) NEL MAR ADRIATICO

SINTESI

Il pesce palla argenteo, *Lagocephalus sceleratus* (Gmelin, 1789), è un migrante lessepsiano altamente invasivo che provoca impatti ecologici e socioeconomici significativi nel Mediterraneo. Sebbene la specie fosse in precedenza rara e presente solo sporadicamente nell'Adriatico, lo studio documenta un improvviso aumento delle sue segnalazioni tra fine marzo e inizio maggio 2026. Durante questo periodo sono state registrate cinque nuove segnalazioni, di cui quattro documentate in meno di due settimane lungo le coste dell'Adriatico orientale e dell'Albania, rappresentando il più alto numero di osservazioni registrato in un intervallo di tempo così breve nella regione. I valori di SST variavano da 14,69 °C a 15,68 °C. Questi risultati indicano una presenza sempre più regolare della specie, probabilmente collegata al riscaldamento del mare.

Parole chiave: *Lagocephalus sceleratus*, Adriatico, migrazione lessepsiana, specie invasiva, cambiamento climatico, espansione dell'areale

INTRODUCTION

Hundreds of marine species have entered the Mediterranean Sea from the Red Sea and the Indian Ocean through the Suez Canal, establishing populations primarily in its eastern basin and progressively spreading toward other regions. This phenomenon, known as Lessepsian migration, is now considered the largest marine biological invasion in the world. The influx of non-indigenous species, together with the introduction of warmer and more saline waters from the Red Sea – further amplified by ongoing climate change – is driving substantial alterations in the structure and composition of Mediterranean marine biodiversity. Increasing sea temperatures are creating more favourable conditions for thermophilic Lessepsian migrants, facilitating their establishment and expansion. The Adriatic Sea, as the northernmost and one of the coldest sub-basins of the Mediterranean, has historically acted as a barrier to the spread of such species. However, recent environmental changes, including rising temperature and salinity (Terzić *et al.*, 2025), indicate that this barrier is weakening. Until the beginning of the 21st century, only eight Lessepsian fish species had been recorded in the Adriatic Sea since the 1800s (Dulčić *et al.*, 2004), most of them along the eastern coast. Over the last two decades, however, this number has nearly doubled, with at least 15 species now reported, several of which show an increasing frequency of occurrence (Dulčić & Dragičević, 2023).

Among these, the silver-cheeked toadfish *Lagocephalus sceleratus* (Gmelin, 1789) is of particular concern, not only due to its potential impact on native biodiversity but also because of the risks it poses to human health. This invasive Lessepsian migrant is native to the tropical Indo-Pacific region. Following its entry into the Mediterranean via the Suez Canal, it was first recorded in 2003 off the southeastern Aegean coast of Turkey (Akyol *et al.*, 2005). Since then, *L. sceleratus* has undergone rapid and continuous range expansion, colonising large parts of the eastern and central Mediterranean, reaching the Strait of Gibraltar, and extending into the Black Sea (Milazzo *et al.*, 2012; Azzuro *et al.*, 2020; Ulman *et al.*, 2021). The species is a generalist carnivorous predator, feeding on crustaceans, fish, and cephalopods. Its maximum reported weight outside the Mediterranean is 7 kg (Smith & Heemstra, 1986), whereas in the Mediterranean, individuals weighing 8–9 kg have been documented (Ulman *et al.*, 2022), with unconfirmed reports of specimens reaching up to 10–12 kg along the Turkish coast (Ulman *et al.*, 2021).

The species is of particular concern due to its ecological and socio-economic impacts. Being a voracious predator with few natural enemies, particularly in the Mediterranean, it can disrupt and alter local food webs. Additionally, its strong dentition causes considerable damage to fisheries. It has already been observed that *L. sceleratus* causes substantial economic losses,

particularly in the small-scale fishing sector, through depredation on fish entangled in fishing gear, as well as extensive damage to fishing equipment, for example by biting and severing parts of netting or hooks on longlines. These interactions result in increased labour and equipment costs for the fisheries sector, in addition to catch losses (Ünal & Bodur, 2017). Moreover, the presence of highly poisonous tetrodotoxin (TTX) in its tissues, including the muscles, skin, and specific organs, makes the fish highly toxic and posing a serious risk to human health if consumed. In fact, there have already been several reported cases of fatal poisoning (Ulman *et al.*, 2021, 2022).

In the Adriatic Sea, *L. sceleratus* has historically been considered a rare and sporadic visitor. The first documented record dates back to October 2012, when a single female specimen was caught by beach seine near Jakljan Island in the southern Adriatic (Sulić Šprem *et al.*, 2014). This was followed by a limited number of additional records between 2013 and 2014, when two specimens were reported from the central-eastern Adriatic (Dulčić *et al.*, 2014). Another record of *L. sceleratus* was reported from the western Adriatic coast, Italy, in 2014 (Carbonara *et al.*, 2017), and later from Albanian waters in 2019 (Kousteni *et al.*, 2019). The most recent record, which also represents the northernmost occurrence in the Mediterranean, was reported in May 2024 from Medulin Bay in the northern Adriatic (Iveša *et al.*, 2025).

Despite these observations, the species has appeared only intermittently over a period of more than a decade. The present study reports these new findings and discusses their implications in the context of ongoing environmental changes and potential shifts in species distribution patterns.

MATERIAL AND METHODS

Data on new occurrences of *Lagocephalus sceleratus* were collected opportunistically during March and in May 2026 through a combination of direct reports from recreational fishers and professional fishing activities. Each record included information on capture location, date, fishing gear used, and, where available, morphometric data (total length and weight). Species identification was performed based on external morphological characteristics following standard taxonomic descriptions (Smith & Heemstra, 1986), including body shape, coloration, and the distinctive silver lateral band.

Sea surface temperature (SST) data corresponding to the observation period were obtained from publicly available satellite datasets (Copernicus Marine Service), allowing for a comparison of thermal conditions across the recorded locations.

All records were georeferenced and mapped to assess their spatial distribution along the Adriatic coastline.

RESULTS AND DISCUSSION

In March 2026, four new records of *L. sceleratus* were documented within a period of less than two weeks, with an additional fifth record from 1 May, representing a notable increase compared to the previously sporadic occurrence pattern in the Adriatic Sea (Fig. 1).

The first specimen was recorded in the southern Adriatic. Shortly thereafter, a second individual was observed near Split in the central-eastern Adriatic. A third specimen was captured a few days later by a recreational angler in the nearby Makarska area at a depth of approximately 40 m (Fig. 2). The fourth record originated from the Karaburun Peninsula (Bay of Vlorë, Albania), where a specimen measuring 45 cm in total length and weighing approximately 1 kg was accidentally caught using a trammel net. The fifth record was also reported from the Bay of Vlorë on 1 May, where a recreational angler caught a specimen measuring 55 cm in length and weighing 2.65 kg. Sea surface temperatures during the observation period ranged from 14.69 °C in the central-eastern Adriatic, near the recording locations, to 15.68 °C in the southern Adriatic near the Bay of Vlorë.

These records span a broad latitudinal gradient along the eastern Adriatic coast and represent the highest number of observations reported within such a limited time interval in this region. The sudden increase in records of *L. sceleratus* in the Adriatic Sea sharply contrasts with the previous sporadic pattern observed between 2012 and 2024. The detection of five individuals within a short period of time, across a wide geographic area, may indicate a shift from occasional occurrence toward a more regular presence.

One possible explanation for this pattern is the ongoing warming of the Adriatic Sea, which is part of a broader and well-known trend affecting the Mediterranean basin. As a thermophilic species, *L. sceleratus* is likely to benefit from rising sea temperatures, which may facilitate both its survival during winter months and its northward expansion. Although the recorded sea surface temperatures during the 2026 study period have still been relatively moderate, they can nevertheless reflect increasingly favourable environmental conditions compared to previous decades, particularly during late winter and early spring, periods that were historically more limiting for such species.

Additionally, the clustering of records could be linked to increased detectability rather than a true population increase. Enhanced awareness among fishers and the growing use of digital communication platforms may contribute to improved reporting of rare or unusual species. Nevertheless, the spatial distribution and narrow temporal window of these observations suggest that ecological drivers are likely the primary cause of this pattern rather than reporting bias alone. The Adriatic Sea has traditionally been considered less susceptible to Lessepsian invasions compared to the



Fig. 1. Previous locations of *Lagocephalus sceleratus* records in the Adriatic Sea between 2012 and 2024 (●) and locations of records between late March and early May 2026 (★).

Sl. 1. Lokacije predhodnih najdb vrste *Lagocephalus sceleratus* v Jadranskem morju med letoma 2012 in 2024 (●) in lokacije najdb med koncem marca in začetkom maja 2026 (★).

eastern Mediterranean, primarily due to its lower temperatures and semi-enclosed nature. However, recent studies indicate that this barrier may be weakening. For instance, the rapid expansion of other thermophilic invasive species, such as the devil firefish, *Pterois miles* (Bennett, 1828), demonstrates that the Adriatic is becoming increasingly suitable for species of tropical origin (Bakiu *et al.*, 2024). The northernmost record of *L. sceleratus* from Medulin Bay (Iveša *et al.*, 2025), together with the present findings, further supports this trend and suggests a progressive northward shift in species distribution.

L. sceleratus has been reported to be rapidly expanding across a variety of Mediterranean habitats, often becoming locally abundant in newly colonised areas (Ulman *et al.*, 2021, 2022). Previous predictive studies have already indicated that suitable habitats for this species are likely to increase in the Adriatic Sea under future climate scenarios. Using a modelling approach, D'Amen and Azzurro (2020) projected that, by 2050, most of the Adriatic Sea could become suitable for the species, with the possible exception of the northernmost areas, which currently face lower invasion risk due to less favourable environmental conditions. Similar conclusions were reached in a recent study based on species distribution models



Fig. 2. A specimen of *Lagocephalus sceleratus* caught on 22 March 2026 near Makarska.
Sl. 2. Primerek vrste *Lagocephalus sceleratus*, ulovljen 22. marca 2026 v bližini Makarske.

(SDMs) (Weterings *et al.*, 2026), which also emphasised that completely halting the spread of *L. sceleratus* in the Mediterranean is no longer a realistic goal, given the species' established populations and rapid expansion. Instead, the authors advocate for adaptive management and mitigation strategies, including increased public awareness regarding the species' toxicity.

Given the well-documented ecological impacts of *L. sceleratus*, as well as its potential risks to fisheries and human health, the observed increase in records in the Adriatic Sea warrants particular attention. Continued and systematic monitoring is essential to determine whether this pattern reflects the early stages of population establishment or a temporary influx of individuals. In this context, the integration of citizen science data with validated scientific observations represents a valuable approach for improving early detection and tracking the spread of invasive species. Furthermore, targeted monitoring efforts, particularly in areas where repeated records are now emerging,

could help clarify whether local reproduction is occurring, which would indicate a more advanced stage of establishment.

At present, it remains unclear whether *L. sceleratus* has established a self-sustaining population in the Adriatic Sea, as has already been documented for *Pterois miles*. However, the increasing frequency of records, including those reported in this study, suggests that such a scenario may become increasingly likely in the near future.

ACKNOWLEDGMENTS

This research was funded by the European Union (NextGenerationEU) under the Croatian Recovery and Resilience Plan 2021–2026 (NRRP), through the University of Split institutional project "Anthropogenic Impact on the Sustainability of Coastal Marine Ecosystems - AIME; IP-UNIST-52" approved by the Ministry of Science, Education, and Youth of the Republic of Croatia.

HITRO NARAŠČANJE POJAVOV INVAZIVNE SREBRNOPROGE NAPIHOVALKE
LAGOCEPHALUS SCELERATUS (GMELIN, 1789) V JADRANSKEM MORJU*Alen SOLDÓ*Department of Marine Studies, University of Split, Croatia
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POVZETEK

Srebrnoproga napihovalka *Lagocephalus sceleratus* (Gmelin, 1789) je močno invazivna lesepska selivka, ki povzroča velike ekološke in družbeno-ekonomske posledice v Sredozemskem morju. Ta vrsta je bila v Jadranskem morju prej redka in občasna, pričujoča raziskava pa ugotavlja nenaden porast najdb med koncem marca in začetkom maja 2026. Podatke sta avtorja pridobila iz ljubiteljskega in gospodarskega ribolova ter potrdila s pomočjo morfološke identifikacije in satelitskih podatkov o temperaturi morske gladine (SST). V tem obdobju je bilo zabeleženih pet novih najdb, od katerih so bile štiri dokumentirane v manj kot dveh tednih vzdolž vzhodne jadranske in albanske obale, kar predstavlja največje število zabeleženih pojavov v tako kratkem času na tem območju. Vrednosti SST so se gibale med 14,69 °C in 15,68 °C. Te ugotovitve so v nasprotju s sporadičnimi pojavljanji, zabeleženimi med letoma 2012 in 2024, ter nakazujejo premik k rednejši prisotnosti, kar je najverjetneje povezano z naraščanjem temperatur morja, ki ugodno vplivajo na toploljubne vrste.

Ključne besede: *Lagocephalus sceleratus*, Jadransko morje, lesepska selitev, invazivna vrsta, podnebne spremembe, širjenje areala

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