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SHORT COMMUNICATION

Unexpected occurrence of the Japanese amberjack *Seriola quinqueradiata* in the Mediterranean Sea: First record and possible introduction pathways

Francesco Tiralongo[1,2,3]*, Cataldo Licchelli[4], Anna Maria Pappalardo[1], Giada Santa Calogero[1], Venera Ferrito[1], Francesco Denitto[4,5] and Antonio Terlizzi[6]

[1] *Department of Biological, Geological, and Environmental Sciences, University of Catania, Catania, Italy*
[2] *National Research Council, Institute of Marine Biological Resources and Biotechnologies, Messina, Italy*
[3] *Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, Avola, Italy*
[4] *Hydracoop, Fisheries and Aquaculture Research Institute, Lecce, Italy*
[5] *Associazione Salento Sommerso, Lecce, Italy*
[6] *Department of Life Sciences, University of Trieste, Trieste, Italy*

Francesco Tiralongo and Cataldo Licchelli are co-first authors.

Abstract: The introduction of non-indigenous species (NIS) into the Mediterranean Sea represents a growing ecological concern, driven by multiple vectors including shipping, aquaculture, and climate-mediated range expansions. In this study, we report the first Mediterranean record of the Japanese amberjack *Seriola quinqueradiata* Temminck & Schlegel, 1845 (Carangidae), a species native to the northwestern Pacific Ocean. A specimen was captured by an angler on 13 February 2026 along the coast of Nardò (Ionian Sea, Italy), near Zone C of the Porto Cesareo Marine Protected Area. Species identification was confirmed through an integrative taxonomic approach combining morphological examination and mitochondrial COI gene barcoding. A second specimen, likely belonging to the same species, was captured shortly thereafter in the same area. The most plausible introduction pathways were discussed. This finding highlights the importance of continuous monitoring of marine biodiversity, particularly through the integration of citizen science and fisheries observations, which are essential for the early detection of rare and potentially invasive species.
Keywords: non-indigenous species; Ionian Sea; Carangidae; Pacific Ocean; global warming; biological invasions; citizen science

Sažetak: NEOČEKIVANA POJAVA JAPANSKOG GOFA *SERIOLA QUINQUERADIATA* U SREDOZEMNOM MORU: PRVI ZABILJEŽENI NALAZ I MOGUĆI PUTEVI UNOSA VRSTE. Unos alohtonih vrsta (NIS) u Sredozemno more predstavlja rastući ekološki problem, potpomognut različitim vektorima unosa, uključujući pomorski promet, akvakulturu i širenje areala uslijed klimatskih promjena. U ovom radu izvještavamo o prvom nalazu japanskog gofa *Seriola quinqueradiata* Temminck & Schlegel, 1845 (Carangidae) u Sredozemnom moru, vrste prirodno rasprostranjene u sjeverozapadnom dijelu Tihog oceana. Jedan primjerak ulovljen je od strane rekreativnog ribolovca 13. veljače 2026. godine uz obalu mjesta Nardò (Jonsko more, Italija), u blizini Zone C Zaštićenog morskog područja Porto Cesareo. Identifikacija vrste potvrđena je integrativnim taksonomskim pristupom koji je uključivao morfološku analizu i barkodiranje mitohondrijskog gena COI. Na istom području ubrzo nakon prvog, ulovljen je i drugi primjerak, koji je vjerojatno pripadao istoj vrsti. U radu se raspravlja o najvjerojatnijim putevima unosa ove vrste. Ovaj nalaz naglašava važnost kontinuiranog praćenja morske bioraznolikosti, osobito kroz integraciju građanske znanosti i opažanja iz ribarstva, koji su ključni za rano otkrivanje rijetkih i potencijalno invazivnih vrsta.
Ključne riječi: alohtone vrste; Jonsko more; Carangidae; Tihi ocean; globalno zatopljenje; biološke invazije; građanska znanost

INTRODUCTION

The Mediterranean Sea is widely recognized as a hotspot for biological invasions, with the increasing occurrence of non-indigenous species (NIS) driven by multiple introduction pathways, including shipping, aquaculture, and climate-mediated range expansions (Zenetos *et al*., 2022). These processes are contributing to profound changes in biodiversity patterns, community structure, and ecosystem functioning across the basin (Galanidi *et al*., 2023; Michail *et al*., 2026).

Within this context, large pelagic predators of the family Carangidae are characterized by high dispersal capabilities and ecological plasticity, traits that may facilitate both natural range expansions and human-mediated introductions. The genus *Seriola* includes several commercially important species with wide geographical distributions, often associated with coastal and pelagic

**Corresponding author*: francesco.tiralongo@unict.it
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environments and capable of long-distance migrations influenced by oceanographic conditions such as temperature and currents (Furukawa *et al*., 2020; Bacheler *et al*., 2022; Tone *et al*., 2022; Park *et al*., 2024).

Seriola quinqueradiata Temminck & Schlegel, 1845, commonly known as the Japanese amberjack, is a pelagic species native to the northwestern Pacific Ocean, where it supports major fisheries and represents one of the most important aquaculture species, particularly in Japan (Brudeseth *et al*., 2013; Ikegami *et al*., 2025). Its natural distribution extends from the East China Sea to the coastal waters of Japan, including both the Pacific Ocean and the Japan Sea (Tian *et al*., 2012; Furukawa *et al*., 2020). The species exhibits complex life-history traits, including early-life association with drifting seaweed, which acts as a dispersal and nursery habitat (Sakakura and Tsukamoto, 1997; Uehara *et al*., 2006; Sassa *et al*., 2020), and ontogenetic shifts in diet toward piscivory at higher trophic levels (Jeong *et al*., 2016; Wei *et al*., 2025). Adult individuals are highly mobile and perform large-scale seasonal migrations driven primarily by sea surface temperature and oceanographic currents, such as the Kuroshio and Tsushima currents (Tian *et al*., 2012; Park *et al*., 2024). These ecological characteristics, combined with the species' importance in intensive aquaculture systems, make *S. quinqueradiata* a species with significant potential for human-mediated translocation (Ikegami *et al*., 2025).

To date, *S. quinqueradiata* has not been reported from the Mediterranean Sea, and its occurrence in this basin would represent a remarkable biogeographical novelty. The detection of a specimen outside its native range raises questions regarding possible introduction pathways, including transport *via* ballast waters/sea-chests, escape from undeclared aquaculture facilities, or, less likely, natural dispersal. Here, we report the first record of *S. quinqueradiata* in the Mediterranean Sea, based on the analysis of a specimen caught by a recreational fisherman on 13 February 2026 along the coast of Nardò (Ionian Sea, Italy), within or near Zone C of the Porto Cesareo Marine Protected Area. A second specimen, likely belonging to the same species, was captured shortly thereafter in the same area. It exhibited the same general diagnostic morphological characteristics as the first specimen; however, it was not possible to perform molecular analyses in this latter case. The record of *S. quinqueradiata* in the Mediterranean Sea provides new insights into the potential arrival of Pacific taxa in the Mediterranean and highlights the need for enhanced monitoring of pelagic species with high dispersal capacity.

MATERIAL AND METHODS

Study area and data collection

A specimen of *Seriola quinqueradiata* was caught on 13 February 2026 from the Ionian coast of southern Italy, along the coast of Nardò (Apulia), around the Zone C of the Porto Cesareo Marine Protected Area (40° 14′ 4.67″ N, 17° 54′ 47.12″ E), in an area with an approximate bottom depth of 2 m. The individual was captured from the shore by a recreational fisher (angler at surface spinning technique with a fishing lure). Notably, the fisherman, who has several years of experience, recognized that the specimen differed from the commonly encountered *Seriola dumerili*, suspecting it to belong to a different amberjack species and contacting us for further clarifications. The specimen was subjected to detailed morphological and meristic examination, integrated by molecular analysis performed on a muscle sample preserved in alcohol 96%. Diagnostic characters were assessed following standard taxonomic criteria for the genus *Seriola*, including body proportions, coloration patterns, fin morphology, and supramaxilla morphology, particularly its posterior extent relative to the eye, a key feature for distinguishing *S. quinqueradiata* from congeneric species occurring in the Mediterranean Sea (Balanov, 2008; Valls *et al*., 2011; Carpenter and De Angelis, 2016; Galbraith *et al*., 2022).

A second specimen, likely belonging to the same species, was captured shortly thereafter by the same fisherman in the same area using the same surface spinning technique. The second specimen was not available for direct examination; therefore, morphological identification was based on photographs provided by the fisherman, with particular attention given to key external diagnostic features, including body shape, supramaxilla shape, and colour pattern, all of which were consistent with those observed in the first specimen and with the diagnostic characteristics of *S. quinqueradiata*.

Molecular analysis

Total genomic DNA was extracted from muscle tissue using the DNeasy Tissue Kit (Qiagen, Hilden, Germany), following the manufacturer's instructions. The DNA sample was analyzed using the Nanodrop ND-1000 spectrophotometer (Thermo Fisher Scientific, Waltham, MA, USA): absorbance ratios at 260/280 nm and 260/230 nm were used to estimate purity levels and concentration of the sample. The extracted DNA was stored at -20 °C until further use for PCR amplification. A fragment of approximately 650 bp of the mitochondrial cytochrome c oxidase subunit I (COI) gene was amplified through the Polymerase Chain Reaction (PCR) using the primer combination of universal primers VF2_t1 and FishR2_t1 (Ivanova *et al.,* 2007) with M13 tails in order to enhance sequencing performance (Messing, 1983). PCR amplification was performed in a 50 µL total reaction volume, using the thermal profile reported in Pappalardo *et al*. (2025). Amplicons were verified by electrophoresis on a 1% agarose gel and visualized through a Safe Imager TM 2.0 Blue Light Transilluminator (Thermo Fisher, Waltham, MA, USA) using the SYBR® Safe staining (Thermo Fisher, Waltham, MA, USA). Subsequently, the amplicons were bidirectionally sequenced by Macrogen Europe service (Milan Genome Centre, IT) and the resulting chromatograms were checked for the quality of peaks and assembled using ChromasPro 2.6.6 software (https://technelysium.com.au/wp/chromaspro). Sequences were trimmed near the beginning and at the end of both sequences and checked for insertions, deletions, premature stop codons or nuclear mitochondrial DNA segments (NUMTs).

To confirm the identity of the amplified sequences, we conducted Basic Local Alignment Searches (BLAST) (https://blast.ncbi.nlm.nih.gov) against GenBank with Megablast and default parameters (https://www.ncbi.nlm.nih.gov/genbank/). Species identification was based on the highest values of percentage identity between the query sequences and the corresponding matches retrieved from BLAST. In addition, multiple sequence alignments were performed using MAFFT v.7 (Katoh *et al*., 2019) and a Maximum Likelihood (ML) tree was generated in MEGA X software (Stecher *et al*., 2020) using the HKY + G model and including 16 COI barcode sequences of congeneric species, retrieved from GenBank (Table 1). A *p-distance* matrix was generated between *Seriola* species in MEGA X (Table 2). The assessment of statistical confidence of nodes was based on 1000 non-parametric bootstrap replicates (Felsenstein, 1985).

RESULTS AND DISCUSSION

The first specimen, caught on 13 February 2026, exhibited the following meristic counts for the dorsal (D) and anal (A) fins: D = V + 35; A = III + 22. It showed an elongate and moderately compressed body and a deeply forked caudal fin. The typical yellow longitudinal stripe extending from the snout through the eye to the caudal peduncle was not visible in the examined dead specimen. The supramaxilla was broad, with a posterodorsal angle close to a right angle and extending approximately to the midorbit, representing one of the main diagnostic characters distinguishing the species from Mediterranean congeners (Balanov, 2008; Galbraith *et al*., 2022). The specimen also exhibited long and flattened gill rakers. Overall, the observed meristic counts and morphological features are consistent with those reported for *Seriola quinqueradiata* and distinguish the species from other congeners occurring in the Mediterranean Sea and adjacent Atlantic Ocean (Pizzicori *et al*., 2000; Galbraith *et al*., 2022). The specimen had an eviscerated weight of 587 g and a fork length (FL) of 35.5 cm, as the caudal fin tips had been cut by the fisherman, making it impossible to measure the total length (TL) (Fig. 1).

A 644 bp-long region of the mitochondrial COI gene was sequenced (GenBank Accession Number: PZ405529) using genomic DNA from the specimen identified based on morphological characters. The BLAST search against the GenBank database revealed an identity percentage of 99.84% with a 100% query coverage corresponding to a COI sequence of *S. quinqueradiata* (GenBank Accession Number PV541576). This result was confirmed by the ML tree, where our sequences cluster together with those of *S. quinqueradiata* (Fig. 2).

Table 1. COI sequences retrieved from GenBank and included in the dataset.

Accession Number	Species	Locality	Reference
PQ347600	*Seriola dumerili*	USA	Unpublished
GU672710	*Seriola dumerili*	Mexico	Unpublished
HM390010	*Seriola dumerili*	Belize	Unpublished
MG837997	*Seriola dumerili*	Mexico	Sarmiento-Camacho and Valdez-Moreno, 2018
MG837996	*Seriola dumerili*	Mexico	
HM390173	*Seriola rivoliana*	Mexico	Unpublished
PQ347601	*Seriola rivoliana*	USA	Unpublished
OQ387111	*Seriola rivoliana*	Philippines	Bemis *et al*., 2023
OQ386991	*Seriola rivoliana*	Philippines	
HM422262	*Seriola rivoliana*	New Zealand	Unpublished
KX512706	*Seriola carpenteri*	Angola	Damerau *et al*., 2018
HM389923	*Seriola fasciata*	Mexico	Unpublished
MZ436493	*Seriola fasciata*	USA	Galbraith *et al*., 2022
KF930429	*Seriola fasciata*	USA	Unpublished
MT102236	*Seriola fasciata*	Türkiye	Unpublished
FLBAR1980-22	*Seriola fasciata*	Türkiye	Unpublished
MK560632	*Seriola quinqueradiata*	South Korea	Unpublished
KU168712	*Seriola quinqueradiata*	United Kingdom	Vandamme *et al*., 2016
KU168711	*Seriola quinqueradiata*	United Kingdom	
KU168705	*Seriola quinqueradiata*	United Kingdom	
KU168702	*Seriola quinqueradiata*	United Kingdom	

Table 2. *P-distance* (values in percentages) between *Seriola* species. Our sample is labelled as SER_COI.

	PQ347600_*S. dumerili*	GU672710_*S. dumerili*	HM390010_*S. dumerili*	MG837997_*S. dumerili*	MG837996_*S. dumerili*	OQ386991_*S. rivoliana*	HM422262_*S. rivoliana*	PQ347601_*S. rivoliana*	OQ387111_*S. rivoliana*	HM390173_*S. rivoliana*	KU168712_*S. quinqueradiata*	KU168702_*S. quinqueradiata*	KU168711_*S. quinqueradiata*	KU168705_*S. quinqueradiata*	SER_COI	MK560632_*S. quinqueradiata*	MZ436493_*S. fasciata*	KF930429_*S. fasciata*	MT102236_*S. fasciata*	FLBAR198022_*S. fasciata*	HM389923_*S. fasciata*	KX512706_*S. carpenteri*
PQ347600_*S. dumerili*																						
GU672710_*S. dumerili*	0																					
HM390010_*S. dumerili*	0.37	0.37																				
MG837997_*S. dumerili*	0.37	0.37	0																			
MG837996_*S. dumerili*	0.37	0.37	0	0																		
OQ386991_*S. rivoliana*	6.18	6.18	5.81	5.81	5.81																	
HM422262_*S. rivoliana*	6.18	6.18	5.81	5.81	5.81	0																
PQ347601_*S. rivoliana*	6.37	6.37	5.99	5.99	5.99	0.19	0.19															
OQ387111_*S. rivoliana*	6.37	6.37	5.99	5.99	5.99	0.19	0.19	0														
HM390173_*S. rivoliana*	6.37	6.37	5.99	5.99	5.99	0.94	0.94	0.75	0.75													
KU168712_*S. quinqueradiata*	10.3	10.3	9.93	9.93	9.93	9.74	9.74	9.93	9.93	9.55												
KU168702_*S. quinqueradiata*	10.49	10.49	10.11	10.11	10.11	9.93	9.93	10.11	10.11	9.74	0.19											
KU168711_*S. quinqueradiata*	10.3	10.3	9.93	9.93	9.93	9.74	9.74	9.93	9.93	9.55	0	0.19										
KU168705_*S. quinqueradiata*	10.3	10.3	9.93	9.93	9.93	9.74	9.74	9.93	9.93	9.55	0	0.19	0									
SER_COI	10.3	10.3	9.93	9.93	9.93	9.74	9.74	9.93	9.93	9.55	0	0.19	0	0								
MK560632_*S. quinqueradiata*	10.49	10.49	10.11	10.11	10.11	9.93	9.93	10.11	10.11	9.74	0.56	0.75	0.56	0.56	0.56							
MZ436493_*S. fasciata*	11.8	11.8	11.99	11.99	11.99	10.67	10.67	10.86	10.86	10.67	9.55	9.74	9.55	9.55	9.55	9.74						
KF930429_*S. fasciata*	11.8	11.8	11.99	11.99	11.99	10.67	10.67	10.86	10.86	10.67	9.55	9.74	9.55	9.55	9.55	9.74	0					
MT102236_*S. fasciata*	11.8	11.8	11.99	11.99	11.99	10.67	10.67	10.86	10.86	10.67	9.55	9.74	9.55	9.55	9.55	9.74	0	0				
FLBAR198022_*S. fasciata*	11.8	11.8	11.99	11.99	11.99	10.67	10.67	10.86	10.86	10.67	9.55	9.74	9.55	9.55	9.55	9.74	0	0	0			
HM389923_*S. fasciata*	11.61	11.61	11.8	11.8	11.8	10.49	10.49	10.67	10.67	10.49	9.74	9.93	9.74	9.74	9.74	9.93	0.19	0.19	0.19	0.19		
KX512706_*S. carpenteri*	11.99	11.99	11.99	11.99	11.99	11.24	11.24	11.42	11.42	11.42	10.11	10.3	10.11	10.11	10.11	10.49	8.43	8.43	8.43	8.43	8.61	

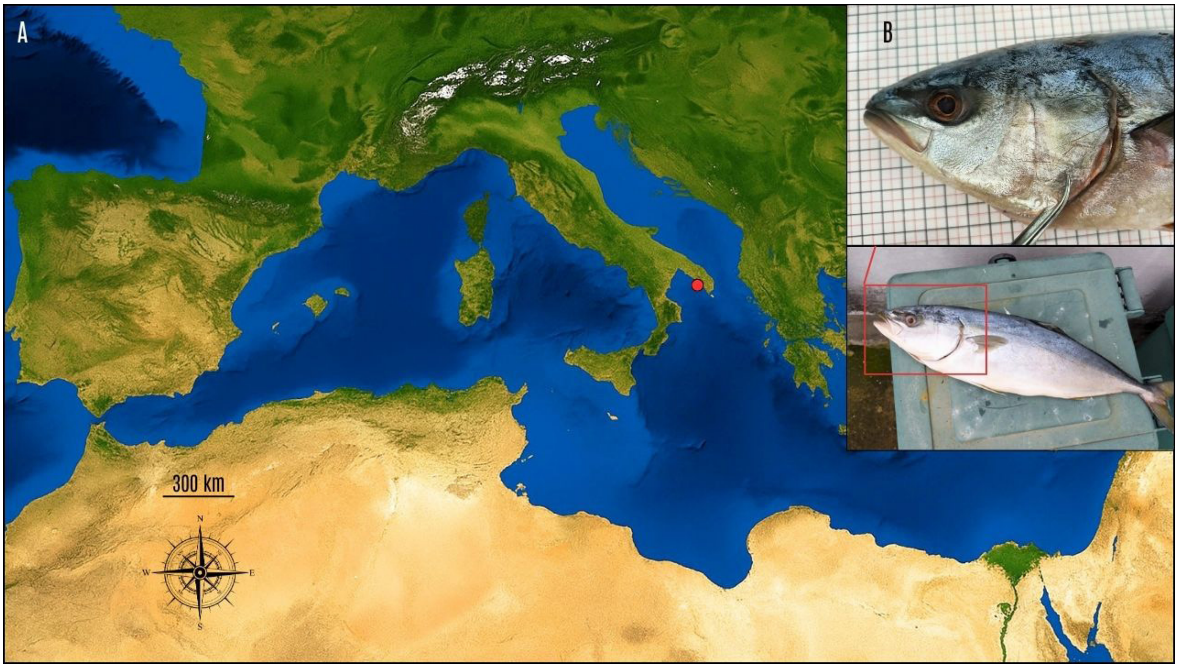

Fig. 1. Location of the capture site of *Seriola quinqueradiata* in the Mediterranean Sea, indicated by the red circle **(A)**; and the specimen caught on 13 February 2026 with zoom on the head region **(B)**.

The genus *Seriola* (family Carangidae) comprises nine species of pelagic and epi-benthic reef-associated fishes with a near-global distribution in tropical and warm-temperate oceans (Swart *et al*., 2015). In the Mediterranean Sea, four species have been reported to date: *Seriola carpenteri* Mather, 1971, *Seriola dumerili* (Risso, 1810), *Seriola fasciata* (Bloch, 1793), and *Seriola rivoliana* Valenciennes, 1833 (Balanov, 2008; Carpenter and De Angelis, 2016; Galbraith *et al*., 2022). Among these, *S. dumerili* is by far the most commonly observed and best-known species, whereas records of the other taxa are sporadic and likely underestimated due to their morphological similarity to *S. dumerili* (Pizzicori *et al*., 2000).

The present record represents the first documented occurrence of *S. quinqueradiata* in the Mediterranean Sea, significantly extending the known distribution of this species beyond its native northwestern Pacific range. Given the absence of previous records, the occurrence is unlikely to represent a natural, established population and instead suggests an isolated introduction event. Moreover, based on the maximum size reported for *S. quinqueradiata*, the fully examined specimen (587 g; 35.5 cm FL) can be considered a juvenile individual (Tian *et al*., 2012). However, the second specimen, captured within a short temporal interval in the same general area, may further support the hypothesis of a sporadic introduction event rather than an isolated accidental observation. This individual, captured on 23 March 2026, measured 60 cm in total length and had an eviscerated weight of 2,580 g. Unfortunately, this specimen was consumed by the fisher shortly after capture, preventing additional morphological or molecular anal-

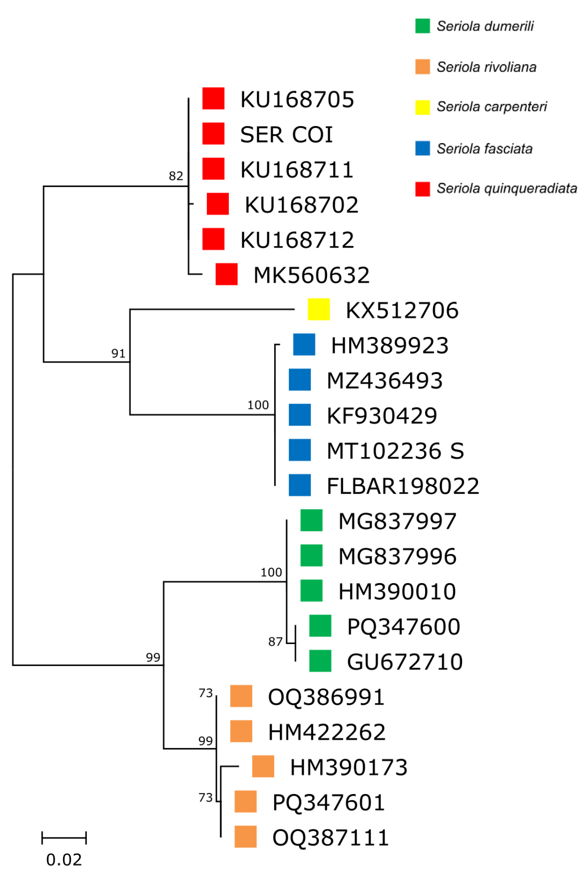

Fig. 2. A Maximum Likelihood (ML) unrooted tree was constructed using COI sequences from *Seriola* species retrieved from the GenBank database. Our sample is labelled as SER COI. Bootstrap support values at nodes are only shown when above 70.

yses. Although the available photographs were sufficient to assess the main external diagnostic features required for species identification, they were taken directly by the fisherman from non-ideal and insufficiently close angles, making them unsuitable for detailed morphological documentation.

The biology and ecology of *S. quinqueradiata* provide important context for interpreting this finding. The species is a highly mobile pelagic predator capable of long-distance migrations driven primarily by thermal gradients and oceanographic currents (Tian *et al*., 2012; Park *et al*., 2024). However, its natural distribution is tightly linked to the Pacific basin, and there is currently no evidence supporting transoceanic natural dispersal into the Mediterranean. This hypothesis could involve previously undetected occurrences, potentially overlooked due to the high morphological similarity among congeners in the genus *Seriola*, which may have led to misidentifications in the past. Moreover, early life stages are associated with drifting seaweed, which can facilitate passive transport (Uehara *et al*., 2006), although such mechanisms are unlikely to account for inter-basin dispersal from the Pacific to the Mediterranean.

Among other potential introduction pathways, maritime transport *via* ballast water or sea-chests represents one of the most plausible explanations. Shipping is a well-established vector for the introduction of marine organisms, particularly in early life stages, including eggs and larvae. Given that *S. quinqueradiata* spawns pelagic eggs and larvae in coastal and shelf waters (Furukawa *et al*., 2020), their uptake and transport *via* ballast water cannot be excluded. Another plausible introduction pathway is associated with aquaculture activities. *Seriola quinqueradiata* is one of the most extensively farmed marine fish species in Japan and other parts of East Asia (Ikegami *et al*., 2025), and the globalization of aquaculture has increased the risk of species translocations and escape events. Although the species is not known to be cultured in the Mediterranean, experimental or small-scale introductions, including ornamental or private aquaculture, cannot be ruled out. A third, albeit less likely, hypothesis involves intentional or accidental human release (e.g., aquarium trade or live transport). However, given the size and commercial nature of the species, this pathway is considered less probable compared to shipping or aquaculture-related vectors.

From an ecological perspective, the establishment potential of *S. quinqueradiata* in the Mediterranean remains uncertain. The species is a top predator with a piscivorous diet (Wei *et al*., 2025) and could theoretically integrate into pelagic food webs. Furthermore, warming trends in Mediterranean waters may increase habitat suitability for thermophilic species, potentially facilitating the survival of introduced individuals (Chaikin *et al*., 2021). In its native range, the distribution and abundance of *S. quinqueradiata* are strongly influenced by sea temperature, with documented shifts linked to long-term warming trends (Tian *et al*., 2012). Nevertheless, the absence of confirmed additional records suggests that this observation may represent isolated, non-established individuals rather than a reproducing population. Continuous monitoring, particularly through citizen science and fisheries networks, will be essential to determine whether this species may reappear or establish itself in the basin.

This finding further supports the increasing role of human-mediated pathways and climate-driven processes in shaping the Mediterranean ichthyofauna and highlights the importance of continuous monitoring of marine biodiversity, particularly through the integration of citizen science and fisheries observations, which remain essential tools for the early detection of rare and potentially invasive species (Giovos *et al*., 2018; Tiralongo *et al*., 2020). Further investigations are needed to assess the recurrence, origin, and potential ecological implications of *S. quinqueradiata* in the Mediterranean Sea.

CONCLUSIONS

The present study reports the first occurrence of *Seriola quinqueradiata* in the Mediterranean Sea, supported by both morphological and molecular evidence. The record likely represents an isolated introduction event, with ballast water transport and aquaculture-related activities identified as the most plausible pathways. Although the establishment potential of the species remains uncertain, this finding highlights the ongoing reshaping of Mediterranean biodiversity driven by human-mediated processes and climate change. Continued monitoring, particularly through the integration of citizen science and fisheries observations, will be essential to detect future occurrences and assess potential ecological impacts.

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