ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 33, 2023, 1

UDK 5 Annales, Ser. hist. nat., 33, 2023, 1, pp. 1-142, Koper 2023 ISSN1408-533X

UDK 5

ISSN 1408-533X
e-ISSN 2591-1783

ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranei
Annals for Istrian and Mediterranean Studies

Series Historia Naturalis, 33, 2023, 1

KOPER 2023

ANNALES · Ser. hist. nat. · 33 · 2023 · 1

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

ISSN 1408-533X
e-ISSN 2591-1783

UDK 5

Letnik 33, leto 2023, številka 1

Tisk/*Stampa/Print:* Založništvo PADRE d.o.o.

Izdajatelja/*Editori/Published by:* Zgodovinsko društvo za južno Primorsko - Koper / *Società storica del Litorale - Capodistria*©
Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / *Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente*©

Sedež uredništva/*Sede della redazione/ Address of Editorial Board:* Nacionalni inštitut za biologijo, Morska biološka postaja Piran / *Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran*
SI-6330 Piran /*Pirano*, Fornače/*Fornace* 41, tel.: +386 5 671 2900, fax +386 5 671 2901;
e-mail: annales@mbss.org, ***internet:*** www.zdjp.si

Redakcija te številke je bila zaključena 23. 06. 2023.

Sofinancirajo/*Supporto finanziario/ Financially supported by:* Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS) in Mestna občina Koper

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).

Navodila avtorjem in vse znanstvene revije in članki so brezplačno dostopni na spletni strani https://zdjp.si/en/p/annalesshn/
The submission guidelines and all scientific journals and articles are available free of charge on the website https://zdjp.si/en/p/annalesshn/
Le norme redazionali e tutti le riviste scientifiche e gli articoli sono disponibili gratuitamente sul sito https://zdjp.si/en/p/annalesshn/

Anali za istrske in mediteranske študije - Annali di Studi istriani e mediterranei - Annals for Istrian and Mediterranean Studies

UDK 5 Letnik 33, Koper 2023, številka 1 ISSN 1408-53 3X
e-ISSN 2591-1783

VSEBINA / *INDICE GENERALE / CONTENTS 2023(1)*

BIOTSKA GLOBALIZACIJA

GLOBALIZZAZIONE BIOTICA

BIOTIC GLOBALIZATION

received: 2022-11-23 DOI 10.19233/ASHN.2023.01

A NEW MEDITERRANEAN RECORD OF THE SACOGLOSSAN *THURIDILLA MAZDA* (MOLLUSCA, GASTROPODA) WITH A REVIEW OF ITS DISTRIBUTION, BIOLOGY AND ECOLOGY

Andrea LOMBARDO
University of Catania, Department of Biological, Geological and Environmental Sciences, 95124 Catania, Italy
e-mail: andylombardo94@gmail.com

ABSTRACT

The present note reports the second Mediterranean record of the sacoglossan Thuridilla mazda *Ortea & Espinosa, 2000. This species, originally described from the Caribbean Sea (West Atlantic), has been, in the last 20 years, reported in two areas of Macaronesia (the Azores and the Canary Islands) and in the westernmost part of the Mediterranean basin. This second Mediterranean record, occurring in the central-eastern coast of Sicily (Ionian Sea), represents another important step in the knowledge of this species. In addition, the note summarizes available information on the distribution, biology and ecology of this species.*

Key words: Ionian Sea, marine Heterobranchia, Sacoglossa, Santa Maria La Scala, Sea slugs

NUOVA SEGNALAZIONE PER IL MEDITERRANEO DEL SACOGLOSSO *THURIDILLA MAZDA* (MOLLUSCA, GASTROPODA) CON REVISIONE DELLA SUA DISTRIBUZIONE, BIOLOGIA ED ECOLOGIA

SINTESI

La presente nota riporta la seconda segnalazione per il Mediterraneo del sacoglosso Thuridilla mazda *Ortea & Espinosa, 2000. Questa specie, originariamente descritta per il Mar dei Caraibi (Atlantico occidentale), negli ultimi 20 anni è stata segnalata in due aree della Macaronesia (Azzorre e Canarie) e nella parte più occidentale del bacino Mediterraneo. Questa seconda segnalazione mediterranea, avvenuta lungo la costa centro-orientale della Sicilia (mar Ionio), rappresenta un altro importante passo avanti nella conoscenza della specie. La nota inoltre riassume le informazioni disponibili sulla distribuzione, la biologia e l'ecologia di questa specie.*

Parole chiave: mar Ionio, Heterobranchia marini, Sacoglossa, Santa Maria La Scala, lumache di mare

INTRODUCTION

One of the most striking and particular groups featured among the sacoglossans of the family Plakobranchidae Gray, 1840 is, without any doubt, the genus *Thuridilla* Bergh, 1872. Its members, unlike the majority of the Sacoglossa, are mainly characterised by flamboyant body coloration and the habit of living in open environments rather than hiding in various substrates (Jensen, 1992; Gosliner, 1995). Generally, these molluscs display black, brown or violet base coloration along with bands, spots and dots of various colour (*e.g.*, orange, red, yellow, blue, purple or green) (Jensen, 1992; 1997) which, on the whole, correspond to the chromatic patterns shared by the different species of this genus (Martín-Hervás *et al*., 2021).

These sacoglossans have a relatively narrow head and foot, and their parapodia are never joined at the front (Schmekel & Portman, 1982). The rolled-shaped rhinophores are joined proximally on the middle-dorsal part of the head, which is smaller in size than the rhinophores (Jensen, 1992; 1997). There are 25 species of the genus Thuridilla (MolluscaBase eds., 2023), which are distributed in tropical and warm-temperate waters (Martín-Hervás *et al*., 2021). The large part of these species inhabits the tropical Indo-West Pacific, while a distinct minority is found in the Atlantic Ocean (Martín-Hervás *et al*., 2021). Until recently, the only species of the *Thuridilla* genus distributed in the Mediterranean basin was *T. hopei* (Vérany, 1853) (Schmekel & Portman, 1982; Trainito & Doneddu, 2014). However, in February 2021 another species of this genus, *T. mazda* Ortea & Espinosa, 2000 was found in the Alboran Sea (Orfanidis *et al*., 2021). Being the species initially reported in Cuba and Costa Rica (Ortea & Espinosa, 2000; Valdés *et al*., 2006), subsequently in the Bahamas (Redfern, 2002; 2013), Guadeloupe (Ortea *et al*., 2012), Mexico (Carmona *et al*., 2011), Florida (Martín-Hervás *et al*., 2021), and, finally, in the area of Macaronesia (the Azores and the Canary Islands) (Malaquias *et al*., 2012; Ortea *et al*., 2015) (Fig. 1A-B), it took over 20 years for it to extend its known distribution towards the east, beyond the Strait of Gibraltar and into the westernmost part of the Mediterranean Sea (Orfanidis *et al*., 2021) (Fig. 1B). The present note documents a further finding of *T. mazda* within the Mediterranean basin, reported in this case in the central-eastern coast of Sicily (Ionian Sea).

MATERIAL AND METHODS

The finding of *Thuridilla mazda* was made during a morning scuba dive taken on 8 November 2022 in Santa Maria La Scala (37°36′46.5″ N, 15°10′31.4″ E). This site is located in the homonymous hamlet of the municipality of Acireale in the central-eastern coast of Sicily. The area is near a harbour used mainly by fishing boats throughout the year. Moreover, there are several freshwater outlets (mostly of natural origin) nearby, which flow directly into the sea. The *T. mazda* specimen was not collected, but its presence was documented by photographs made using an Olympus TG-4 underwater camera. The animal was found at 12.9 m of depth on a vertical rocky wall (water temperature: 21 °C). The examination of the photographs through comparison with the relevant scientific literature (Ortea & Espinosa, 2000; Valdés *et al*., 2006; Malaquias *et al*., 2012; Orfanidis *et al*., 2021) allowed the species identification. At the same time, the depth and temperature of the water (at the time of the finding) were registered using a Suunto D6i dive computer. Based on the photographs it was also possible to determine the nature of the substrate on which the animal was found.

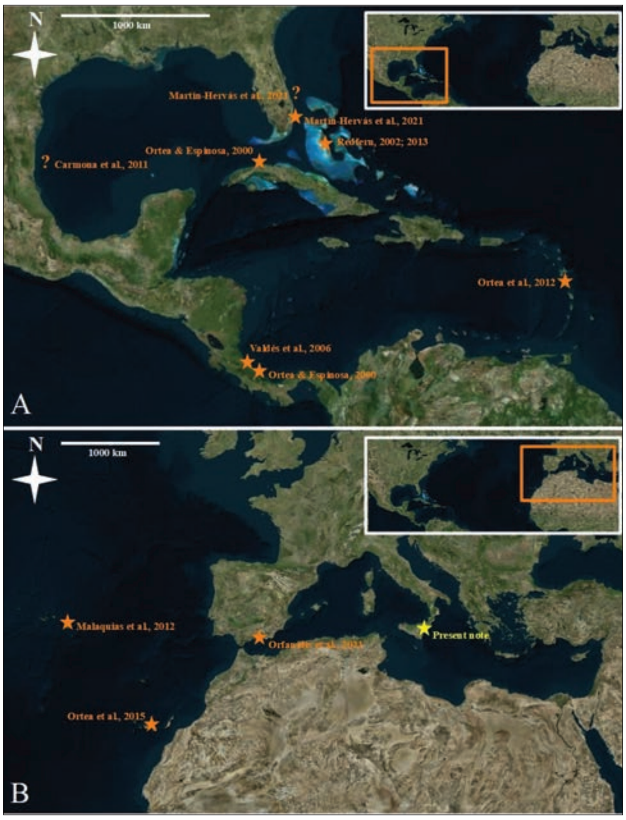

Fig. 1: Geographic distribution of *Thuridilla mazda****. A) Reports of this species in the Caribbean Sea (West Atlantic); B) Reports of*** *T. mazda* ***in Macaronesia (East Atlantic) and the Mediterranean Sea. The stars represent records with confirmed location, while the question marks indicate reports with unspecified location. Both symbols are followed by related manuscripts.***

Sl. 1: Geografska razširjenost vrste *Thuridilla mazda****. A) Zapisi o pojavljanju vrste*** *T. mazda* ***v Karibskem morju (zahodni Atlantik); B) Zapisi o pojavljanju vrste*** *T. mazda* ***v Makaroneziji (vzhodni Atlantik) in v Sredozemskem morju. Zvezdice predstavljajo zapise s potrjeno lokaliteto, vprašaji pa označujejo zapise z nedoločeno lokaliteto. Simbola se nanašata na objavljene prispevke.***

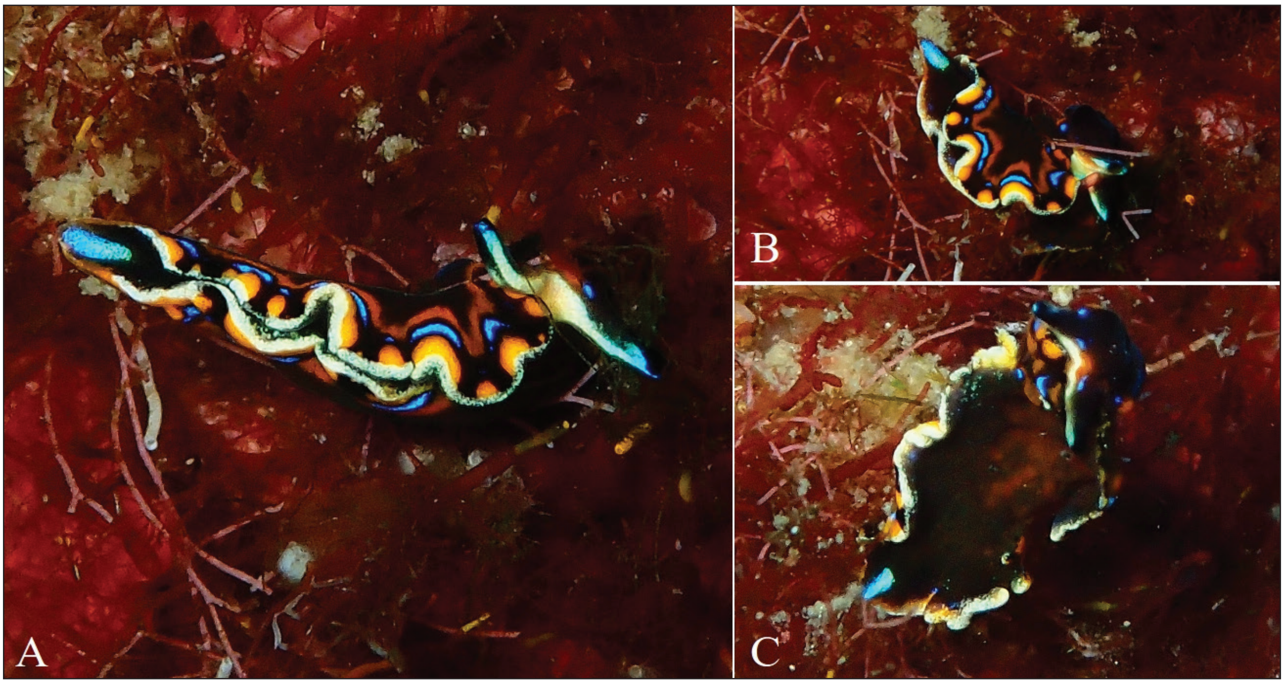

Fig. 2: The specimen of* Thuridilla mazda *found in Santa Maria La Scala; A) Dorsal view; B) Lateral view of the contracted animal; C) The specimen with the parapodia opened.
Sl. 2: Primerek vrste* Thuridilla mazda*, najden v Santa Maria La Scala; A) hrbtni pogled; B) pogled s strani na pokrčenem primerku; C) primerek z odprtimi parapodiji.

RESULTS

The animal (Fig. 2 A-C) had an elongated body with black base coloration. The parapodial margins were scattered with numerous white dots which, overall, tended to merge into a white stripe that faded slightly on the innermost side of each parapodial margin. Extending from the edge of these latter to the foot were 3 longitudinal "bands" of different colour, each continuing in an anteroposterior direction. The first band (closer to the white margin of each parapodium) had an overall black coloration alternating with striking semicircular/crescent light orange blotches. The band immediately below it was characterised by bright azure lines matching the course of the blotches of the first band. The third band was a continuous dark orange line also following the course of the two previous ones. Below this line, the flanks were black. The dorsal part of the body (normally covered by parapodia) had a uniform black-brown coloration, and on the inner side of each parapodium there were several scattered bright green dots. The dorsal surface of the tail displayed a conspicuous bright azure and longitudinally elongated blotch. The head featured a large white dorsal blotch that continued onto the surface of each rhinophore. These latter presented bright azure hues and, laterally, black colouration. The rest of the head was generally black with bright azure dots appearing in its anterior and lateral areas. The specimen was observed on a turf of filamentous Rhodophyta. Once touched by the author, the mollusc started to contract and, on further prodding, immediately unfurled the parapodia, showing the black-brown dorsum in a very evident manner.

DISCUSSION AND CONCLUSIONS

The present report of *Thuridilla mazda* is, at the moment of writing, the second for the Mediterranean basin and the first for the Ionian Sea. If we accept the hypothesis of Malaquias *et al.* (2012) that *T. mazda* is of Caribbean origin, then the present finding would represent a further important eastward progression of this sacoglossan, which would have crossed the entire Atlantic Ocean (West-East direction) over a period of about 20 years and infiltrated as far as the centre of the Mediterranean (Ortea & Espinosa, 2000; Malaquias *et al.*, 2012; Ortea *et al.*, 2015; Orfanidis *et al.*, 2021; present note). How this species would have managed to increase its presumed geographic range cannot be known with absolute certainty. *T. mazda* may have spread to new areas via both natural (e.g., currents and larval dispersal) and anthropogenic (e.g., ballast water or attached to ships' keels) pathways (Malaquias *et al.*, 2012).

Tab. 1: Known information on the distribution, biology and ecology of* T. mazda*. The question marks indicate a lack of data on the subject. In the case of Ortea et al. (2015), the asterisk suggests it was not possible to consult this publication during the writing of this note.

Tab. 1: Znani podatki o razširjenosti, biologiji in ekologiji vrste* T. mazda*. Vprašaj označuje pomanjkanje podatkov. V primeru vira Ortea et al. (2015) zvezdica označuje, da v času pisanja pričujočega prispevka ni bilo možno pregledati publikacije.

References	N° of specimen	Month and year	Location	Substrate	Depth
Ortea & Espinosa, 2000	1	September 1999	Naútico de La Habana (Cuba)	rocky reef poor in vegetation	20 m
Ortea & Espinosa, 2000	1	April 2000	Manzanillo (Costa Rica)	rocky substrate scratching	20 m
Redfern, 2002, 2013	1	June 1995	Cooperstown (Bahamas)	Algae-covered shoreline rocks	0.3 m
Valdés *et al.*, 2006	?	?	Puerto Viejo (Costa Rica)	Calcareous red algae	?
Carmona *et al.*, 2011	3	?	? [Mexico (ATL)]	?	?
Malaquias *et al.*, 2012	1	July 2011	Piscinas Naturais dos Mosteiros (Azores)	on algae	1 m
Ortea *et al.*, 2015*	*	*	* (Canary Islands)	*	*
Martín-Hervás *et al.*, 2021	1	?	Lauderdale-by-the-Sea (Florida)	?	?
Martín-Hervás *et al.*, 2021	2	?	? (Florida)	?	?
Orfanidis *et al.*, 2021	1	February 2021	Almuñécar (Spain)	turf of filamentous algae and calcareous red algae	12 m
Present note	1	November 2022	Santa Maria La Scala (Italy)	Turf of filamentous red algae	12.9 m

At the same time, it cannot be excluded that *T. mazda* may be a cryptogenic species. In fact, there are not enough data to date to support the Caribbean origin of this sacoglossan. This case is virtually identical to that recently highlighted by Trainito *et al.* (2022) in relation to the nudibranch *Okenia picoensis* Paz-Sedano, Ortigosa & Pola, 2017 in the Mediterranean basin, a species which, depending on the author, may be regarded as alien/allochthonous (Orfanidis *et al.*, 2021; Crocetta *et al.*, 2021; Lombardo & Marletta, 2021), autochthonous (Crocetta *et al.*, 2021; Trainito *et al.*, 2022) or cryptogenic (Crocetta *et al.*, 2021). *O. picoensis* is currently considered a species native to the entire Atlanto-Mediterranean region (Trainito *et al.*, 2022). It is not excluded that the same could be argued for *T. mazda*.

Furthermore, the actual distribution potential of this species is unknown, as is its colonisation potential. Indeed, apart from the scientifically documented reports of *T. mazda*, there is no information on any further occurrence or established populations of this species in the mentioned areas. Thus, there is not enough information to fully identify the area/s of origin of this sacoglossan. Even information on the ecology and biology of *T. mazda* is still very scarce (Tab. 1). The only biological and ecological data on this mollusc concern its bathymetric range (from just below the sea surface to 20 m of depth) and the substrates on which it lives (rocky environments covered by poor vegetation; turfs of filamentous algae and calcareous red algae) (Ortea & Espinosa, 2000; Redfern, 2002; 2013; Valdés *et al.*, 2006; Malaquias *et al.*, 2012; Orfanidis *et al.*, 2021; present note). The reports of this species were documented in the months of April, June and September in the Caribbean Sea (Ortea & Espinosa, 2000; Redfern, 2002; 2013); and in February, July and November in the areas of Macaronesia and the Mediterranean Sea (Malaquias *et al.*, 2012; Orfanidis *et al.*, 2021; present note). Considering all of the above, *T. mazda* could represent, in the Mediterranean basin, a species with an unknown biology and ecology suitable for further study by both specialists and enthusiasts to better understand the distribution and colonisation dynamics of marine heterobranchs and sacoglossans.

ACKNOWLEDGEMENTS

The author would like to thank two anonymous reviewers who, through their suggestions, improved the quality of the article.

NOV SREDOZEMSKI ZAPIS O POJAVLJANJU POLŽA ZAŠKRGARJA VRSTE *THURIDILLA MAZDA* (MOLLUSCA, GASTROPODA) S PREGLEDOM NJENE RAZŠIRJENOSTI, BIOLOGIJE IN EKOLOGIJE

Andrea LOMBARDO
University of Catania, Department of Biological, Geological and Environmental Sciences, 95124 Catania, Italy
e-mail: andylombardo94@gmail.com

POVZETEK

Pričujoči prispevek poroča o drugem sredozemskem zapisu o pojavljanju zaškrgarja vrste Thuridilla mazda *Ortea & Espinosa, 2000. O tej vrsti, izvorno opisani v Karibskem morju (zahodni Atlantik), so v zadnjih dvajsetih letih poročali v dveh predelih Makaronezije (Azori in Kanarsko otočje) in v skrajnem zahodnem delu Sredozemskega bazena. Drugi zapis o pojavljanju te vrste iz centralno-vzhodne obale Sicilije (Jonsko morje) predstavlja še en pomemben korak k poznavanju vrste. Poleg tega ta zapis opisuje razpoložljive podatke o razširjenosti, biologiji in ekologije obravnavane vrste.*

Ključne besede: Jonsko morje, morski Heterobranchia, Sacoglossa, Santa Maria La Scala, morski zaškrgarji

REFERENCES

Carmona, L., M.A.E. Malaquias, T.M. Gosliner, M. Pola & J.L. Cervera (2011): Amphi-Atlantic distributions and cryptic species in sacoglossan sea slugs. J. Molluscan Stud., 77, 401-412. https://doi.org/10.1093/mollus/eyr036

Crocetta F., S. Al Mabruk, E. Azzurro, R. Bakiu, M. Bariche, I. Batjakas, T. Bejaoui, J. Ben Souissi, J. Cauchi, M. Corsini-Foka, A. Deidun, J. Evans, J. Galdies, R. Ghanem, T. Kampouris, S. Katsanevakis, G. Kondylatos, L. Lipej, A. Lombardo, G. Marletta, E. Mejdani, S. Nikolidakis, P. Ovalis, L. Rabaoui, M. Ragkousis, M. Rogelja, J. Sakr, I. Savva, V. Tanduo, C. Turan, A. Uyan & A. Zenetos (2021): New Alien Mediterranean Biodiversity Records (November 2021). Mediterr. Mar. Sci., 22(3), 724-746. https://doi.org/10.12681/mms.26668.

Gosliner, T.M. (1995): The genus *Thuridilla* (Opisthobranchia: Elysiidae) from the Tropical Indo-Pacific, with a revision of the phylogeny and systematics of the Elysiidae. Proc. Calif. Acad. Sci., 49(1), 1-54.

Jensen, K.R. (1992): Anatomy of some Indo-Pacific Elysiidae (Opistobranchia: Sacoglossa (=Ascoglossa)), with a discussion of the generic division and phylogeny. J. Molluscan Stud., 58, 257-296. https://doi.org/10.1093/mollus/58.3.257

Jensen, K.R. (1997): Systematics, phylogeny and evolution of the Sacoglossa (Mollusca, Opisthobranchia). Vestjydsk Forlag, Denmark, 94 pp.

Lombardo, A. & G. Marletta (2021): New evidence of the ongoing expansion of *Okenia picoensis* Paz-Sedano, Ortigosa & Pola, 2017 (Gastropoda: Nudibranchia) in the central-eastern Mediterranean. Annales. Ser. Hist. Nat., 31(2), 173-178. https://doi.org/10.19233/ASHN.2021.21

Malaquias, M.A.E., G. Calado, J.F. Da Cruz & K.R. Jensen (2012): On the occurrence of the Caribbean sea slug *Thuridilla mazda* in the eastern Atlantic Ocean. Mar. Biodivers. Rec., 5, e50. https://doi.org/10.1017/S1755267211001023

Martín-Hervás, M., L. Carmona, M.A.E. Malaquias, P.J. Krug, T.M. Gosliner & J.L. Cervera (2021): A molecular phylogeny of *Thuridilla* Bergh, 1872 sea slugs (Gastropoda, Sacoglossa) reveals a case of flamboyant and cryptic radiation in the marine realm. Cladistics, 0, 1-30. https://doi.org/10.1111/cla.12465

MolluscaBase eds. (2023): MolluscaBase. *Thuridilla* Bergh, 1872. Accessed through: World Register of Marine Species. (https://www.marinespecies.org/aphia.php?p=taxdetails&id=137929))

Orfanidis, S., A. Alvito, E. Azzurro, A. Badreddine, J. Ben Souissi, C. Chamorro, F. Crocetta, C. Dalyan, A. Fortič, L. Galanti, K. Geyran, R. Ghanem, A. Goruppi, D. Grech, S. Katsanevakis, E. Madrenas, F. Mastrototaro, F. Montesanto, M. Pavičić, D. Pica, L. Pola, M. Pontes, M. Ragkousis, A. Rosso, L. Sánchez-Tocino, J.M. Tierno De Figueroa, F. Tiralongo, V. Tirelli, S. Tsioli, S. Tunçer, D. Vrdoljak, V. Vuletin, J. Zaouali & A. Zenetos (2021): New Alien Mediterranean Biodiversity Records (March 2021). Mediterr. Mar. Sci., 22(1), 180-198. https://doi.org/10.12681/mms.25294.

Ortea, J. & J. Espinosa (2000): Nueva especie del género *Thuridilla* Bergh, 1872 (Mollusca: Sacoglossa) de Cuba y Costa Rica. Avicenna, 12/13, 87-90.

Ortea, J., J. Espinosa, M. Caballer & Y. Buske (2012): Initial inventory of the sea slugs (Opisthobranchia and Sacoglossa) from the expedition Karubenthos, held in May 2012 in Guadeloupe (Lesser Antilles, Caribbean Sea). Rev. Acad. Canar. Cienc., 24(1), 153-182.

Ortea, J., L. Moro & J.J. Bacallado (2015): Babosas marinas canarias. Turquesa Ediciones, Santa Cruz de Tenerife, 138 pp.

Redfern, C. (2002): Sea Slug Forum. *Thuridilla mazda* from the Bahamas. (http://www.seaslugforum.net/find/7638)

Redfern, C. (2013): Bahamian Seashells. 1161 species from Abaco. Boca Ratón, Florida, 501 pp.

Schmekel, L. & A. Portmann (1982): Opisthobranchia des Mittelmeeres. Nudibranchia und Saccoglossa. Springer-Verlag, Berlin, 410 pp.

Trainito, E. & M. Doneddu (2014): Nudibranchi del Mediterraneo. Il Castello, Cornaredo, 192 pp.

Trainito, E., V. Migliore & M. Doneddu (2022): Now many seas must a nudibranch sail? *Okenia picoensis* (Mollusca: Nudibranchia: Goniodorididae) conquering the Mediterranean. Stud. Mar., 35(1), 15-25. https://doi.org/10.5281/zenodo.6676729

Valdés, Á., J. Hamann, D.W. Behrens & A. DuPont (2006): Caribbean Sea Slugs. A field guide to the opisthobranch mollusks from the tropical northwestern Atlantic. Sea Challengers Natural History Books, Washington, 289 pp.

received: 2023-01-05 DOI 10.19233/ASHN.2023.02

ON THE OCCURRENCE OF *LUTJANUS ARGENTIMACULATUS* (FORSSKÅL, 1775) IN THE SOUTH-EASTERN MEDITERRANEAN, TURKEY

Deniz ERGUDEN
Marine Science Department, Faculty of Marine Science and Technology, Iskenderun Technical University, 31220 Iskenderun, Hatay, Turkey
e-mail: derguden@gmail.com; deniz.erguden@iste.edu.tr

Sibel ALAGOZ ERGUDEN
Vocational School of Imamoglu, University of Cukurova, Imamoglu, Adana, Turkey
Department of Biomedical Engineering, Faculty of Engineering and Natural Science, University of Iskenderun Technical, Iskenderun, Hatay, Turkey

Deniz AYAS
Fisheries and Fish Processing Department, Faculty of Fisheries, University of Mersin, Mersin, Turkey

ABSTRACT

A single large specimen of mangrove red snapper Lutjanus argentimaculatus *(Forsskål, 1775) with a total length of 59.5 cm and weight of 3386 g was caught with a spear gun on 30 November 2022 in the coastal waters of the Iskenderun Bay (Konacik), Turkey at a depth of 12 m. The present paper is the first report of the occurrence of* L. argentimaculatus *in Turkey's south-eastern Mediterranean marine waters. The species is believed to be spreading rapidly in the Mediterranean waters of Turkey.*

Key words: Mangrove Red Snapper, Lutjanidae, Extension, Mediterranean Sea

PRESENZA DI *LUTJANUS ARGENTIMACULATUS* (FORSSKÅL, 1775) NEL MEDITERRANEO SUD-ORIENTALE, TURCHIA

SINTESI

Un unico grande esemplare di Lutjanus argentimaculatus *(Forsskål, 1775), con una lunghezza totale di 59,5 cm e un peso di 3386 g, è stato catturato con un fucile subacqueo il 30 novembre 2022 nelle acque costiere della baia di Iskenderun (Konacik), in Turchia, a una profondità di 12 m. Il presente lavoro rappresenta la prima segnalazione della presenza di* L. argentimaculatus *nelle acque marine del Mediterraneo sud-orientale della Turchia. Si ritiene che la specie si stia diffondendo rapidamente nelle acque mediterranee della Turchia.*

Parole chiave: Lutjanidae, estensione, mare Mediterraneo

INTRODUCTION

Since its opening in August 1869, the Suez Canal has enabled numerous marine organisms originating from the Indian Ocean and the Red Sea to enter the Mediterranean Sea. This phenomenon was designated as 'Lessepsian migration' by Por (1978).

The mangrove red snapper *Lutjanus argentimaculatus* (Forsskal, 1775) belongs to the Lutjanidae family, which consists of 112 species distributed worldwide (Nelson *et al*., 2016; Akyol *et al*., 2019; Froese & Pauly, 2022). *L. argentimaculatus* is a benthic fish species with a preference for sandy and rocky substrates, inhabiting depths between 1 and 120 m (Lieske & Myers, 1994).

The mangrove red snapper *L. argentimaculatus* is widespread in the Indo-Pacific region, from the Red Sea to eastern Africa, including Madagascar, to the Ryukyu Islands, northern Australia and Samoa (Golani *et al.,* 2021; Froese & Pauly, 2022). Adult specimens are often found in groups around coral reefs (Lieske & Myers, 1994), sometimes penetrating deeper reef areas exceeding 100 m (Froese & Pauly, 2022). Young specimens are found in shallow sandy shores, often entering estuaries. This species is mainly nocturnal and commonly feeds on fishes and crustaceans (Allen *et al.,* 2002; Golani *et al.,* 2021; Froese & Pauly, 2022).

While non-commercial in the Mediterranean Sea, *L. argentimaculatus* is an important commercial and recreational fish and one of the most appreciated food fish species in the Indo-Pacific region. It is caught mainly with handlines, bottom longlines, and bottom trawls, and is commonly sold in fish markets throughout the region (Anderson & Allen, 2001).

L. argentimaculatus is an oceanodromous, reef-associated species of large fish. The females are larger than the males of the same age group (Russell *et al.,* 2003) and can reach a maximum total length of 150 cm, the common size (TL) being 40-80 cm (Golani *et al.,* 2021; Froese & Pauly, 2022). This species differs from other Mediterranean Lutjanus species in having scale rows mostly parallel to lateral line with some ascending obliquely above the lateral line.

In the Mediterranean, the Lutjanidae family is represented by four species (Vella *et al.,* 2015; Zenetos *et al.,* 2016; Deidun & Piriano, 2017; Golani *et al*., 2021). These are *Lutjanus argentimaculatus* (Forsskål, 1775), *Lutjanus fulviflamma* (Forsskål, 1775), and *Lutjanus sebae* (Cuvier, 1816), which are all found in the Red Sea as well (Golani & Fricke, 2018), and *Lutjanus juco* (Bloch & Schneider, 1801), which has Atlantic origins (Golani *et al*., 2021) and occurs in the Mediterranean only rarely (Vachi *et al*., 2010).

The first record of mangrove red snapper *L. argentimaculatus* for the Mediterranean Sea was reported from Lebanon by Mouneimne (1979). Crocetta and Bariche (2016) collected the second sample from the Lebanese coast. Later, it was recorded in the Turkish waters (Akyol, 2019), Israel (Sonin *et al*., 2019) and Greece (Tiralongo *et al*., 2019). Recently this species has been reported from Maltese waters (Central Mediterranean) (Deidun *et al*., 2022).

L. argentimaculatus was first reported from the Turkish Aegean Sea in 2018 by Akyol (2019), the specimen reported in the present paper represents the second record of the mangrove red snapper in Turkish waters and the first from Turkey's south-eastern Mediterranean region (Iskenderun Bay).

MATERIAL AND METHODS

A specimen of *L. argentimaculatus* was caught with a spear gun at a depth of 12 m in Konacik, Iskenderun Bay (36º21'N, 35º48'E), on 30 November 2022 (Fig. 1). The distribution of *L. argentimaculatus* in the Mediterranean coast of Turkey is presented based on previous capture records and the present report from Iskenderun Bay (Fig. 1).

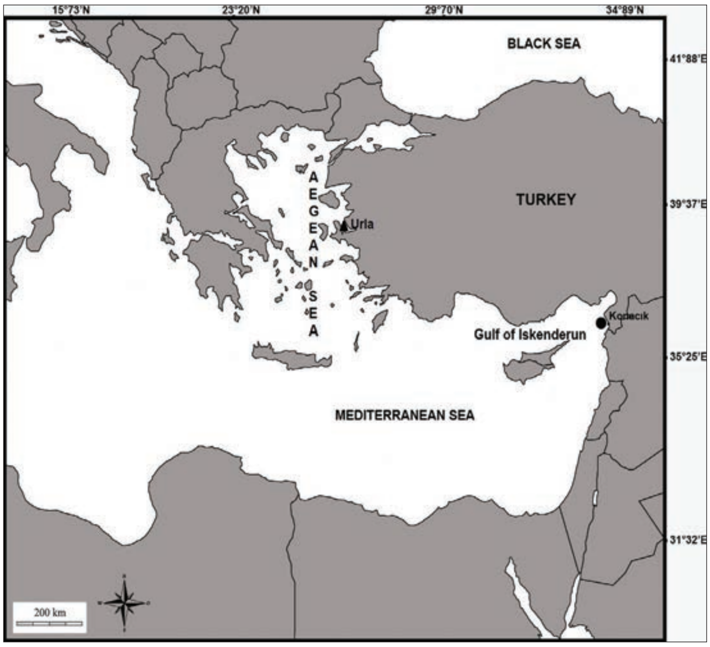

Fig. 1: Map showing the capture site (•) of *Lutjanus argentimaculatus* ***in Iskenderun Bay (north-eastern Mediterranean) and previous record (▲) from the Urla coast (Akyol, 2019).***
Sl. 1: Zemljevid obravnavanega območja z označeno lokaliteto ulova (•) primerka vrste *Lutjanus argentimaculatus* ***v zalivu Iskenderun (severovzhodno Sredozemsko morje) in lokaliteta (▲) ob obali Urla, kjer je bil primerek te vrste predhodno ujet (Akyol, 2019).***

Fig. 2: The specimen of *Lutjanus argentimaculatus* **(Forsskal, 1775), 59.5 cm TL, captured from Iskenderun Bay (Konacik), north-eastern Mediterranean, Turkey.**
Sl. 2: Primerek vrste *Lutjanus argentimaculatus* **(Forsskal, 1775) z 59,5 cm telesne dolžine, ki so ga ulovili v zalivu Iskenderun Bay (Konacik) v severovzhodnem Sredozemskem morju (Turčija).**

The fresh specimen was photographed and measured and later deposited at the Museum of Marine Life, Mersin University under catalogue number MEUFC-22-11-144. The morphometric measurements of the sample to the nearest 0.01 mm were taken using a digital caliper, and the total body was weighed to the nearest 0.1 g (Fig. 2). All measurements and counts, as well as the morphological description and colour agree with the descriptions of Allen (1985) and Golani *et al.* (2006).

RESULTS AND DISCUSSION

The captured specimen of *L. argentimaculatus* measured 59.5 cm in total length (48.0 cm in standard length), and 3386 g in total weight. Its main diagnostic characters and morphometric measurements are given in millimetres in Table 1. A comparison to previous Mediterranean reports from Turkey (Akyol, 2019) and Israel (Sonin *et al.,* 2019) is presented in Table 2.

The characteristics of this Mediterranean record are as follows: body moderately elongated, somewhat compressed, and covered with large ctenoid scales, longitudinal scale rows above the lateral line primarily horizontal, with some rows ascending obliquely below posterior dorsal fin spines; snout somewhat pointed, mouth large and terminal; dorsal fin continuous, with third to fifth spines the longest; posterior edge of dorsal fin round; pelvic fin origin slightly behind pectoral base, caudal fin truncated; maxilla slips under pre-orbital bone when mouth is closed, a few rows of sharp conical teeth with several distinct large canines, operculum edge serrated; dorsal fin with X, 14 rays, pectoral fin rays 16, anal fin rays III, 18. caudal fin rays 17. Colour (fresh specimen): body reddish-bronze, darker on the back, with a silvery-grey patch on scales.

Tab. 1: Measurements of *Lutjanus argentimaculatus* **compared to two previous records.**
Tab. 1: Meritve primerka vrste *Lutjanus argentimaculatus* **in primerjava s primerki iz predhodnih dveh zapisov o pojavljanju.**

Measurements (cm)	This Study	Akyol (2019)	Sonin *et al.* (2019)
Number(s)	(1)	(1)	(1)
Total length	59.5	30.5	66.0
Standard length	48.0	26.0	54.0
Body depth	15.0	-	-
Head length	16.3	9.0	16.8
Eye diameter	2.6	1.6	3.6
Preorbitary length	7.0	2.8	-
Interorbital length	4.7	1.6	5.1
Mouth	6.5	-	-
Snout length	5.6	-	8.3
Dorsal fin length	28.0	-	-
Pectoral fin length	14.0	-	-
Anal fin length	10.5	-	-
Pelvic fin length	10.0	-	-
Predorsal fin length	21.5	9.5	-
Prepectoral fin length	17.0	8.5	-
Prepelvic fin length	18.5	-	-
Preanal fin length	33.0	-	-

Tab. 2: Records of** Lutjanus argentimaculatus **from Mediterranean Sea during the period 1979-2022.
Tab. 2: Zapisi o pojavljanju vrste** Lutjanus argentimaculatus **v Sredozemskem morju v obdobju 1979-2022.

References	Number of samples	Record date	Location/ Country	Sampling gear	Depth (m)	Total Length (mm)	Weight (g)
Mouneimne (1979)	1	1979	Lebanon	-	-	-	-
Crocetta & Bariche (2016)	1	17.01.2014	Tripoli, Lebanon	Scuba observation	45	-	-
Akyol (2019)	1	4.10.2018	Off Urla, Gulf of İzmir, Turkey	Gill net	8	305	473
Sonin *et al.* (2019)	1 1	21.01.2019 17.11.2018	Tel Aviv, Israel	Hook and Line	50 35	660 450	4452 -
Trialongo *et al.* (2019)	2 1	21-28.07.2019 14.08.2019	Salamina Bay, Megara Gulf, Greece Salamina Bay, Greece	Spear gun Spear gun	6-8 5	Unknown-600 400	- 2800 1500
Deidun *et al.* (2022)	1	12.01.2021	Sliema, Malta	Spear gun	12	430	1630
Present study	1	30.11.2022	Konacık Iskenderun Bay, Turkey	Spear gun	12	595	3386

Proportions as % TL: body depth 25.21%; head length 27.39%; pre-dorsal length 36.13%; pre-pectoral length 28.57%; pre-pelvic length 31.09%; pre-anal length 55.46%. Eye diameter 15.95% of head length; interorbital length 28.83% of head length.

Although only one specimen of *L. argentimaculatus* is reported in the present study, previous records by many researchers (Crocetta & Bariche, 2016; Deidun, & Piriano, 2017; Akyol, 2019; Sonin *et al.,* 2019; Tiralongo *et al.,* 2019) confirm that *L. argentimaculatus* has been seen many times in the Mediterranean Sea. This study reports the second record of the species in Turkish seas, and the finding of a large specimen strongly suggests an established population of the species in the Mediterranean waters of Turkey. A comparison of previous and present records of capture *L. argentimaculatus* in the Mediterranean Sea is given in Table 2.

CONCLUSIONS

This paper is the first report of the species from Iskenderun Bay (Konacik) and the first evidence of its presence in the south-eastern Mediterranean coast of Turkey. The data presented herein are essential in terms of the species' current status, possible population establishment, and regional biodiversity. Further research is required to obtain details about the habitat requirements for establishing alien fish species in a new area.

ACKNOWLEDGEMENTS

We would like to thank İsa TURAN and Corc TURAN for providing the fish sample.

O POJAVLJANJU MANGROVSKEGA RDEČEGA HLASTAČA *LUTJANUS ARGENTIMACULATUS* (FORSSKÅL, 1775) V JUGOVZHODNEM SREDOZEMSKEM MORJU (TURČIJA)

Deniz ERGUDEN
Marine Science Department, Faculty of Marine Science and Technology, Iskenderun Technical University, 31220 Iskenderun, Hatay, Turkey
e-mail: derguden@gmail.com; deniz.erguden@iste.edu.tr

Sibel ALAGOZ ERGUDEN
Vocational School of Imamoglu, University of Cukurova, Imamoglu, Adana, Turkey
Department of Biomedical Engineering, Faculty of Engineering and Natural Science, University of Iskenderun Technical, Iskenderun, Hatay, Turkey

Deniz AYAS
Fisheries and Fish Processing Department, Faculty of Fisheries, University of Mersin, Mersin, Turkey

POVZETEK

Primerek mangrovskega rdečega hlastača Lutjanus argentimaculatus *(Forsskål, 1775), dolg 59,5 cm in težak 3386 g, je bil 30 novembra 2022 ujet s podvodno puško na 12 m globine v obrežnih vodah v zalivu Iskenderun (Konacik, Turčija). Gre za prvi primer o pojavljanju vrste* L. argentimaculatus *v turških vodah jugovzhodnega Sredozemskega morja. Domnevajo, da se bo vrsta hitro razširjala v sredozemskih vodah Turčije.*

Ključne besede: mangrovski rdeči hlastač, Lutjanidae, širjenje areala, Sredozemsko morje

REFERENCES

Akyol, O. (2019): The first record of a mangrove red snapper, *Lutjanus argentimaculatus* (Actinopterygii: Perciformes: Lutjanidae), from the Aegean Sea (Gulf of Izmir, Turkey). Acta Ichthyol. Piscat., 49(2), 209-211. https://doi.org/10.3750/AIEP/02572

Allen, G.R. (1985): FAO species catalogue Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date. Vol. 6, FAO Fish Synop. 125, 208 pp.

Allen, G.R., S.H. Midgley & M. Allen (2002): Field guide to the freshwater fishes of Australia. Western Australian Museum, Perth, Western Australia, 394 p.

Anderson, W.D. Jr. & G.R. Allen (2001): Lutjanidae. Jobfishes. In: Carpenter, K.E. & V. Niem (eds.): FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Vol. 5. Bony fishes part 3 (Menidae to Pomacentridae), FAO, Rome, pp. 2840-2918.

Crocetta, F. & M. Bariche (2016): Citizen scientist's contribution to better knowledge of the Mediterranean marine biota: records of five alien and native species from Lebanon. In: Dailiaanis, T., O. Akyol, M. Badali, *et al*. (eds.): New Mediterranean biodiversity records, pp.620-621. Medit. Mar. Sci., 17(2), 608-626. https://doi.org/10.12681/mms.1734

Deidun, A. & S. Piriano (2017): First record of an adult-sized red empereor snapper *Lutjanus sebae* (Cuvier, 1816) in the Mediterranean Sea. Medit. Mar. Sci., 18(2), 361-362. https://doi.org/10.19233/ASHN.2022.06

Deidun, A., B. Zava & M. Corsini-Foka (2022): Distribution extension of *Lutjanus argentimaculatus* (Lutjanidae) and *Psenes pellucidus* (Nomeidae) to the waters of Malta, Central Medıterranean Sea. Annales, Ser. Hist. Nat., 32(1), 49-58. https://doi.org/10.19233/ASHN.2022.06

Froese, R. & D. Pauly (Eds.) (2022): FishBase. World Wide Web electronic publication. www.fishbase.org. version (02/2022) (Last accession: 22 December 2022).

Golani, D., B. Öztürk & N. Başusta (2006): Fishes of the eastern Mediterranean. Publication. No. 24, Turkish Marine Research Foundation, Istanbul, Turkey, 260 pp.

Golani, D., E. Azurro, J. Dulčić, E. Massuti & L. Orsi-Relini (2021): Atlas of exotic fishes in the Mediterranean Sea. 2th Edition. (F. Briand ed.). CIESM Publishers, Paris, Monaco, 365 pp.

Golani, D. & R. Fricke (2018): Checklist of the Red Sea fishes with delineation of the Gulf of Suez, Gulf of Aqaba, endemism and Lessepsian migrants. Zootaxa, 4509(1), 1-215. https://doi.org/10.11646/zootaxa.4509.1.1

Lieske, E. & R. Myers (1994): Collins Pocket Guide. Coral reef fishes. Indo-Pacific & Caribbean including the Red Sea. Haper Collins Publishers, 400 pp.

Mouneimné, N. (1979): Poissons nouveaux pour les cotes Libanaises (Méditerranée orientale). Cybium, 6, 105-110.

Nelson, J.S., T.C. Grande & M.V.H. Wilson (2016): Fishes of the world. 5th ed. John Wiley & Sons, Hoboken, New Jersey, USA, 707 pp.

Por, F.D. (1978): Lessepsian migration: the influx of Red Sea biota into the Mediterranean by way of the Suez Canal. Ecological Studies, Vol. 23. Springer–Verlag, Berlin, Germany, 228 pp.

Russell, D.J., T.J. Ryan, A.J. McDougall, S.E. Kistle & G. Aland (2003): Species diversity and spatial variation in fish assemblage structure of streams in connected tropical catchments in northern Australia with reference to the occurrence of translocated and exotic species. Mar. Fresh. Res., 54, 813-824.

Sonin, O., D. Edelist & D. Golani (2019): The occurrence of the Lessepsian migrant *Lutjanus argentimaculatus* in the Mediterranean, (Actinopterygii: Perciformes: Lutjanidae) first record from the coast of Israel. Acta Adriat., 60(1), 99-102.

Tiralongo, F., I. Giovos, N. Doumpas, J. Langeneck, P. Kleitou & F. Crocetta (2019): Is the mangrove red snapper *Lutjanus argentimaculatus* (Forsskål, 1775) established in the eastern Mediterranean Sea? First records from Greece through a citizen science project. BioInvas. Rec., 8(4), 911-916. https://doi.org/10.3391/bir.2019.8.4.19

Vachi, M., P.N. Psodomakis, N. Repetto & M. Würtz (2010): First record of dog snapper *Lutjanus jocu* in the Mediterranean Sea. J. Fish Biol., 76, 723-728.

Vella, A., N. Vella & S.A. Darmanin (2015): First record of *Lutjanus fulviflamma* (Osteichthyes: Lutjanidae) in the Mediterranean Sea. J. Black Sea/Medit. Environ., 21(3), 307-315.

Zenetos, A., G. Apostolopoulos & F. Crocetta (2016): Aquaria kept marine fish species possibly released in the Mediterranean Sea: First confirmation of intentional release in the wild. Acta Ichth. Piscat., 46(3), 255-262. https://doi.org/10.3750/AIP2016.46.3.10

received: 2022-11-02 DOI 10.19233/ASHN.2023.03

THE FIRST SUBSTANTIATED RECORD OF AREOLATE GROUPER *EPINEPHELUS AREOLATUS* (SERRANIDAE) AND ADDITIONAL RECORDS OF PILOTFISH *NAUCRATES DUCTOR* (CARANGIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

Adib SAAD
Al Andalus University, Kadmus, Tartus, Syria (au.edu.sy)

Lana KHREMA & Amina ALNESSER
Tishreen University, Department of Basic Sciences, Faculty of Agriculture, Lattakia, Syria

Issa BARAKAT
Tishreen University, Department of Floristries and Ecology, Faculty of Agriculture, Lattakia, Syria

Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

ABSTRACT

A specimen of the non-indigenous species areolate grouper Epinephelus areolatus *(Forsskål, 1775) and two specimens of pilotfish* Naucrates ductor *(Linnaeus 1758) were fished from the coastal waters off Latakia, Syria. The finding of* E. areolatus *constitutes the first substantiated record of this species for Syrian marine waters and the third for the entire Mediterranean Sea. The areolate grouper is a Lessepsian migrant from the Red Sea which entered the Mediterranean through the Suez Canal.* N. ductor*, on the other hand, has been known to inhabit the Mediterranean Sea together with several other fish species. However, the semi-obligate commensal relationship that it develops with large sharks and rays could explain the species' occurrence in both the Mediterranean and Syrian marine waters. The capture of* N. ductor *reported herein is the second record for the Syrian coast.*

Key words: Levant Basin, Lessepsian migration, commensalisme, large sharks and rays, population

PRIMO RITROVAMENTO DOCUMENTATO DI *EPINEPHELUS AREOLATUS* (SERRANIDAE) E ULTERIORI SEGNALAZIONI DI *NAUCRATES DUCTOR* (CARANGIDAE) PER LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

Un esemplare della specie non indigena Epinephelus areolatus *(Forsskål, 1775) e due esemplari di pesce pilota* Naucrates ductor *(Linnaeus 1758) sono stati pescati nelle acque costiere al largo di Latakia, in Siria. Il ritrovamento di* E. areolatus *costituisce il primo record documentato di questa specie per le acque marine siriane e il terzo per l'intero Mediterraneo. Si tratta di un migrante lessepsiano proveniente dal Mar Rosso ed entrato nel Mediterraneo attraverso il Canale di Suez.* N. ductor*, invece, è noto per il Mediterraneo, dove convive assieme a diverse altre specie ittiche. Tuttavia, la relazione di commensalità semi-obbligatoria che sviluppa con grandi squali e razze potrebbe spiegare la presenza della specie sia nelle acque marine del Mediterraneo che in quelle siriane. La cattura di* N. ductor *qui riportata è il secondo record per la costa siriana.*

Parole chiave: Bacino del Levante, migrazione lessepsiana, commensalismi, grandi squali e razze, popolazione

INTRODUCTION

It has been known from Gruvel (1931) as well as more recent literature (Saad, 2005, 2010; Ali, 2018) that fisheries play an important economic role in Syria. Consequently, the local marine waters have been regularly and continuously investigated by researchers assessing the quality and quantities of fish species present in the region (Foulquié & Dupuy de la Grandrive, 2003); Saad *et al.*, 2005; Saad & Alkusairy, 2022). Ali (2018), for example, pointed out the occurrence of non-indigenous species migrating from other areas: from the Red Sea through the Suez Canal or from the eastern tropical Atlantic through the Strait of Gibraltar.

Tab. 1: Morphometric measurements in mm with percentages of total length (%TL), meristic counts and total body weight recorded in the specimen of *Epinephelus areolatus* ***(MSL 11/2022) caught off the Syrian coast.***
Tab. 1: Morfometrične meritve v mm in izražene kot delež celotne dolžine (%TL), meristična štetja in totalna telesna masa primerka vrste *Epinephelus areolatus* ***(MSL 11/2022), ujetega ob sirski obali.***

References	**MSL 11/2022**	
Morphometric measurements	**mm**	**%TL**
Total length	297	100
Standard length	242	81.4
Body depth	73	24.5
Head length	86	28.9
Eye diameter	14	4.7
Snout length	25	8.4
Length of dorsal fin base	133	44.7
Length of anal fin base	39	13.1
Pre-dorsal length	80	26.9
Pre-pectoral length	82	27.6
Pre-pelvic length	84	28.2
Pre-anal length	155	52.1
Meristic counts		
Dorsal fin spines	XI	
Dorsal fin soft rays	17	
Pectoral fin spines	-	
Pectoral fin soft rays	16	
Ventral fin spines	I	
Ventral fin soft rays	5	
Anal fin spines	III	
Anal fin soft rays	9	
Total body weight (gram)	285	

Surveys recently conducted in the area with assistance of local fishermen have allowed the collection of a specimen of areolate grouper *Epinephelus areolatus* Forsskål, 1775, and two specimens of pilotfish *Naucrates ductor* (Linnaeus, 1758). The aim of the present study is to report these captures and comment the distribution of both species in the region and the Mediterranean Sea.

MATERIAL AND METHODS

On 30 July 2022, a specimen of *Epinephelus areolatus* was caught by fish trap at a depth of 30 m, off the Ibn Hani region (Fig. 1), close to the city of Latakia (35°35'37.3"N, 35°45'05.6"E). On 3 October 2022, two specimens of *Naucrates ductor* were caught using a trawling net at a depth of 30 m, south of the city of Latakia (35°27'05.9"N, 35°43'11.3"E). Some morphometric measurements were recorded to the nearest millimetre and expressed as percentages of total length (TL), together with meristic counts and total body weight (TBW) in gram (Tables 1 and 2). The three specimens were preserved in 10% buffered formalin and deposited in the collection of the Marine Sciences Laboratory, Tishreen University, and assigned reference numbers MSL 11/2022 for *E. areolatus*, and MSL 15/2022 and MSL 16/2022 for *N. ductor*.

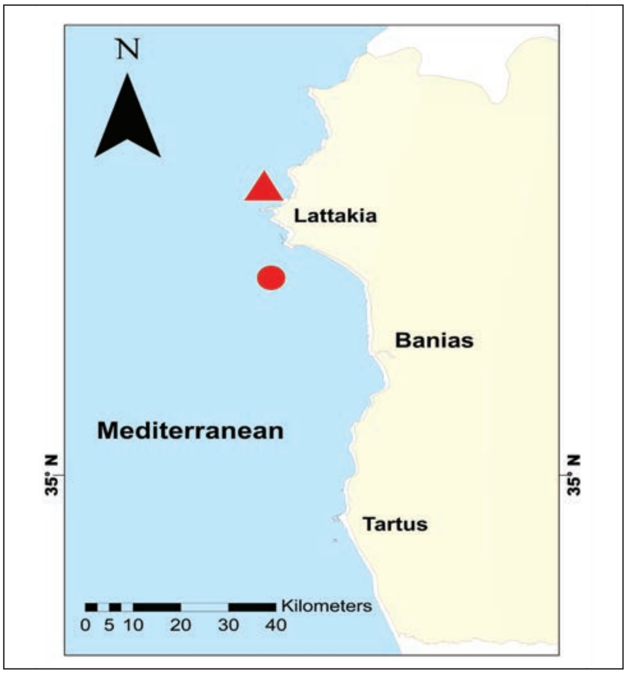

Fig. 1: Map of the Syrian coast indicating the captures sites of *Epinephelus areolatus* ***(red triangle) and*** *Naucrates ductor* ***(red circle).***
Sl. 1: Zemljevid sirske obale z označenimi lokalitetami ulova vrst *Epinephelus areolatus* ***(rdeči trikotnik) in*** *Naucrates ductor* ***(rdeči krogec).***

RESULTS AND DISCUSSION

Epinephelus areolatus (Forsskål, 1775)

The specimen of *E. areolatus* (MSL 11/2022) measured 297 mm total length (TL) and weighed 285 g (Fig. 2). It was identified based on the following: body depth less than head length and 3.3 times in standard length (SL), head length 2.8 times in SL; gill rakers of first gill arch 9 on the upper limb and 16 on lower limb; preopercle with 5 enlarged serrations at the angle; caudal fin truncate or slightly emarginated; head, body, and fins pale, all covered with numerous brownish yellow spots, posterior edge of caudal fin with a distinct white margin. *E. areolatus* can be confused with another alien serranid species recently occurring in the Mediterranean Sea, namely, the spotted grouper *E. geoffroyi* Klunziger, 1870. This latter species does not exhibit a whitish margin on the posterior edge of caudal fin, conversely, it displays more numerous and smaller dark brown spots covering the entire body.

The morphology, morphometric measurements, meristic counts and colour recorded in the present specimen of *E. areolatus* are in agreement with previous descriptions of this species by Heemstra & Randall (1993), Rothman *et al.* (2016) and Bariche & Edde (2020). Al Mabruk *et al.* (2021) reported the first occurrence of *E. areolatus* in Syrian marine waters based on a photograph of a specimen that was discovered on social media but was unavailable for confirmation in an ichthyological collection. The present specimen, on the other hand, was thoroughly described following Bello *et al.* (2014) and deposited in the Ichthyological Collection of the Marine Sciences Laboratory, Tishreen University, with reference number MSL 11/2022. It therefore constitutes the first substantiated record of *E. areolatus* from the Syrian coast.

E. areolatus is widely distributed in the Pacific Ocean region bounded by Fiji in the east, Japan in the north, and the Arafura Sea and northern Australia in the south. It is also widespread in the Indian Ocean, from southern Africa and KwaZulu-Natal to the Arabo-Persian Gulf

Tab. 2. Morphometric measurements in mm with percentages of total length (%TL), meristic counts and total body weight recorded in the two specimens of* Naucrates ductor *(MSL 15/2022 and MSL 16/2022) caught off the Syrian coast.
Tab. 2: Morfometrične meritve v mm in izražene kot delež celotne dolžine (%TL), meristična štetja in totalna telesna masa primerkov vrste* Naucrates ductor *(MSL 15/2022 in MSL 16/2022), ujetih ob sirski obali.

References	**MSL 15/2022**		**MSL 16/2022**	
Morphometric measurements	**mm**	**%TL**	**mm**	**%TL**
Total length (TL)	357	100	351	100
Standard length (SL)	290	81.23	290	82.6
Fork length (FL)	315	88.23	310	88.3
Body depth (BD)	63.2	17.7	77.7	22.13
Head length (HL)	73	20.4	75	21.3
Eye diameter	11	3.11	11	3.25
Pre-orbital length	23	6.4	22	6.26
Post-orbital length	37	10.3	37	10.5
Pre-dorsal length	103	28.8	107	30.4
Dorsal fin base	151	42.2	155	44.15
Pre-pelvic length	83	23.2	84	23.9
Pre-pectoral length	70	19.6	70	19.9
Pectoral fin base	14	3.92	14	3.9
Pre-pelvic length	83	23.2	84	23.9
Pre-anal length	184	51.5	180	51.2
Anal fin base	72	20.1	76	21.6
Peduncle depth	18	5.0	17	4.87
Caudal peduncle length	40	11.2	40	11.3
Meristic counts				
Dorsal fin	III+I+27		IV+I+27	
Anal fin	II+I+16		II+I+16	
Pelvic fin	I+5		I+5	
Total weight (gram)	580 g		540 g	

Fig. 2: Specimen of *Epinephelus areolatus* **(MSL 11/2022) caught off the Syrian coast, scale bar = 50 mm.**
Sl. 2: Primerek vrste *Epinephelus areolatus* **(MSL 11/2022), ujet ob sirski obali, merilo = 50 mm.**

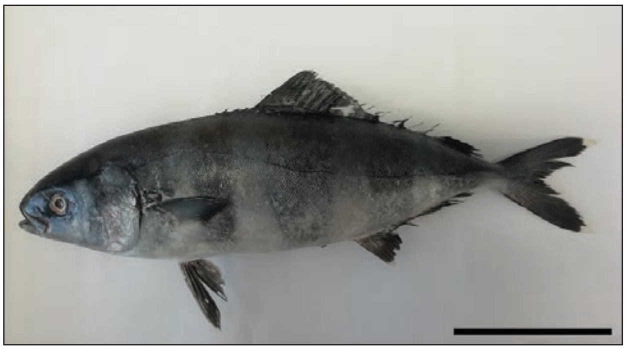

Fig. 3: Specimen of *Naucrates ductor* **(MSL 16/2022) caught off the Syrian coast, scale bar = 100 mm.**
Sl. 3: Primerek vrste *Naucrates ductor* **(MSL 16/2022), ujet ob sirski obali, merilo = 100 mm.**

and the Red Sea *E. areolatus* could be considered a Lessepsian migrant (*sensu* Por, 1978) coming into the Mediterranean Sea through the Suez Canal. The present record and other previous findings in the Levant Basin suggest that a viable population is probably being established in this area.

Naucrates ductor (Linnaeus, 1758)

The two specimens of *N. ductor* herein presented measured 357 mm and 351 mm TL, and weighed 580 g and 540 g, respectively. They were identified based on the following: body elongate, shallow, and barely compressed with nearly equal upper and lower profiles; head profile tapering sharply above anterior half of upper jaw producing a nearly blunt snout; upper jaw very narrow posteriorly and extending to about the anterior margin of eye; teeth in upper and lower jaws minute, arranged in a band; gill rakers on first arch 6 upper, 14 lower for a first specimen, and 8 upper, 15 lower for the second; dorsal fin with 4 spines (last spine in first specimen possibly reduced and skin-covered due to fork length over 20 cm), followed by 1 spine and 25 to 29 soft rays, anal fin with 2 spines separated from the rest of fin followed by 1 spine and 16 soft rays, second dorsal fin lobe short, 2.4 times the fork length; anal fin base short, 1.7 and 1.8 times the second dorsal fin base length, respectively; caudal peduncle with a well-developed lateral, fleshy keel on each side and dorsal and ventral peduncle grooves; body displaying 5 or 6 broad black bands, caudal fin banded with prominent white tips. This description is in total accordance with Smith-Vaniz (1986), Bauchot (1987) and Carpenter & De Angelis (2016). The present specimen (Fig. 3) thus constitutes the third occurrence of the species in Syrian marine waters, where a viable population appears to be fully established (Ali-Basha et *al*., 2021).

N. ductor is a circumtropical marine fish. In the eastern Atlantic, the species is known from the Strait of Gibraltar to southern Angola, including the Azores, Madeira, the Canaries, and the Cape Verde, Ascension and St Helena Islands (Bauchot, 1987). Conversely, it is considered a rare vagrant off the British Isles (Smith-Vaniz, 1986). The species is also found in the Mediterranean Sea and has been reported from the Adriatic Sea (Kovačić *et al*., 2020), Egypt (El Sayed *et al*., 2017), Libya (Elbaraasi *et al*., 2019), Turkey (Akyol, 2019) and the Levant Basin (Ben Tuvia, 1971, Ali-Basha et *al*., 2021). Quignard & Tomasini (2000) count *N. ductor* among the inhabitants of the Mediterranean Sea together with several other fish species. However, Smith-Vaniz (1986) note that *N. ductor* displays a semi-obligate commensal relationship with large sharks and rays, which could explain its occurrence in the Mediterranean and in Syrian marine waters, where these elasmobranch species are captured in relative abundance (Saad & Alkusairy, 2022). Similar patterns could also explain the occurrence of sea lamprey, *Petromyzon marinus* (Linnaeus, 1758) in the same area (Saad *et al*., 2021).

N. ductor is unknown in the Red Sea, and the Suez Canal does not offer sufficient space for migration of large fishes. Hence, entering through the Strait of Gibraltar would seem to be a more likely hypothesis, however, *N. ductor* cannot be considered a Herculean migrant (*sensu* Quignard & Tomasini, 2000). The successful establishment of *E. areolatus* and *N. ductor* in Syrian marine waters speaks to the fact that Syrian marine waters is an environment suitable for the development and production of local fisheries. Such favourable conditions have been confirmed by several papers published over the past decades which show that the number of species comprised in the Syrian ichthyofauna has been regularly increasing (Saad, 2005; Ali, 2018). The number of records of both *E. areolatus* and *N. ductor* to date is sufficient to regard these fish as resident species in Syrian marine waters.

PRVI POTRJEN ZAPIS O POJAVLJANJU RDEČEPIKASTE KIRNJE, *EPINEPHELUS AREOLATUS* (SERRANIDAE), IN DODATNI ZAPIS O POJAVLJANJU PILOTA, *NAUCRATES DUCTOR* (CARANGIDAE), IZ SIRSKE OBALE (VZHODNO SREDOZEMSKO MORJE)

Adib SAAD
Al Andalus University, Kadmus, Tartus, Syria (au.edu.sy)

Lana KHREMA & Amina ALNESSER
Tishreen University, Department of Basic Sciences, Faculty of Agriculture, Lattakia, Syria

Issa BARAKAT
Tishreen University, Department of Floristries and Ecology, Faculty of Agriculture, Lattakia, Syria

Christian CAPAPÉ
Laboratoire d'Ichtyologie, case 104, Université de Montpellier, 34 095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

POVZETEK

V obalnih vodah Latakije (Sirija) so bili ujeti primerek rdečepikaste kirnje Epinephelus areolatus *(Forsskål, 1775) in dva primerka pilota* Naucrates ductor *(Linnaeus 1758). Najdba vrste* E. areolatus *predstavlja prvi potrjen zapis o pojavljanju te vrste v sirskih morskih vodah in tretji za celotno Sredozemsko morje. Rdečepikasta kirnja je lesepska selivka, ki je prišla skozi sueški prekop iz Rdečega morja.* N. ductor *pa je domorodna vrsta, ki prebiva v Sredozemskem morju skupaj z drugimi vrstami. Kljub vsemu pa povezujemo pojavljanje te vrste v Sredozemskem morju in sirskih vodah s semiobligatnim odnosom z velikimi morskimi psi in skati. Ulov pilota* N. ductor*, o katerem avtorji poročajo, je drugi primer pojavljanja te vrste v sirskih vodah.*

Ključne besede: levantski bazen, lesepska selitev, komenzalizem, veliki morski psi in skati, populacija

REFERENCES

Akyol, O. (2019): Occurrence of pilotfish *Naucrates ductor* (Carangidae) in Izmir Bay(Aegean Sea). Turk. J. Marit. Mar. Sci., 5(1), 17-20.

Ali, M. (2018): An updated checklist of the marine fishes from Syria with emphasis on alien species. Medit. Mar. Sci., 19(2), 388-393.

Ali-Basha, N., A. Saad, A., N. Hamwi & A. Tufahha (2021): First record of pilotfish *Naucrates ductor* (Linnaeus 1758), Carangidae, in the Syrian marine waters (Levantine Basin). Mar. Biodiv. Rec., 14. 10.1186/s41200-021-00202-y.

Al Mabruk, S., I. Giovos & F. Tiralongo (2021): New record of *Epinephelus areolatus* in the Mediterranean Sea: first record from Syria. Annales, Ser. Hist. Nat., 31(1), 23-31.

Bariche, M. & D. Edde (2020): First records of exotic marine fish species (*Morone saxatilis*, *Himantura leoparda, Epinephelus areolatus, Diodon hystrix*) from Lebanon.. Medit. Mar. Sci., 21(1), 129-145.

Bauchot, M.L. (1987): Poissons osseux, in Fiches FAO d'Identification pour les Besoins de la Pêche (Rev. 1). Méditerranée et Mer Noire, Zone de Pêche 37 (Fischer, W., et al., Eds.), Rome: Comm. Communauté Européenne, FAO, vol. 2, pp. 891-1421.

Bello G., **R. Causse., L. Lipej & J. Dulčić (2014):** A proposal best practice approach to overcome unverified and unverifiable «first records» in ichthyology. Cybium, 38(1), 9-14.

Ben-Tuvia, A. (1971): Revised list of the Mediterranean fishes of Israel. Isr. J. Zool., 20, 1-39.

Carpenter, K.E. & N. De Angelis (2016): The living marine resources of the Eastern Central Atlantic. Volume 4: Bony fishes, part 2 (Perciformes to Tetradontiformes) and sea turtles. FAO Species Identification Guide for Fishery Purposes, Rome, FAO. pp. 2343-3124.

Elbaraasi, H, B. Elabar, S. Elaabidi, A. Bashir, O. Elsilini, E. Shakman & E. Azzurro (2019): Updated checklist of bony fishes along the Libyan coast (southern Mediterranean Sea). Medit. Mar. Sci., 20(1), 90-105.

El Sayed, H., K. Akel. & P.K. Karachle (2017): The marine ichthyofauna of Egypt. Egyptian J. Aquat. Biol. Fish., 21(3), 81-116.

Foulquié, M. & R. Dupuy de la Grandrive (2003): First assignment concerning the development of marine protected area on the Syrian coast, 8-15 November 2002, RAC/SPA, 33 pp.

Gruvel, A. (1931): Les états de Syrie, richesses marines et fluviales. Exploitation actuelle. Avenir. Société d'Éditions géographiques, maritimes et coloniales, Source gallica.bnf.fr / Bibliothèque nationale de France, 542 pp.

Heemstra, P.C. & J.E. Randall (1993): FAO Species Catalogue. Vol. 16. Groupers of the world (family Serranidae, subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. Rome: FAO. FAO Fish. Synopsis, 125, 382 pp.

Kovačić, M., L. Lipej & J. Dulčić (2020): Evidence approach to checklists: critical revision of the checklist of the Adriatic Sea fishes. Zootaxa, 4767(1), 1-55.

Por, F.D. (1978): Lessepsian migration. Ecological studies 23. Springer-Verlag: Berlin, New-York. 228 pp.

Quignard, J.-P. & J. -A. Tomasini (2000): Mediterranean fish biodiversity. Biol. Mar. Medit, 7, 1-66.

Rothman, S.B., N. Stern & M. Goren (2016): First record of the Indo-Pacific areolate grouper *Epinephelus areolatus* (Forsskål, 1775) (Perciformes: Epinephelidae) in the Mediterranean Sea. Zootaxa, 4067, 479-483.

Saad, A. (2005): Check-list of bony fish collected from the coast of Syria. Turk. J. Fish. Aquat. Sci., 5(2), 99-106.

Saad, A. (2010): Fisheries resources in Syria: its reality and prospects for its development. In: Syrian Economy Bulletin-Agricultural Section-Edition Economic Comittee. Chapitre 5, pp. 113-136. Presidence of the Council of Ministers. [In Arabic]

Saad, A., I. Barakat, M. Masri, W. Sabour & C. Capapé (2021): First substantiated record of sea lamprey *Petromyzon marinus* from the Syrian coast (Eastern Mediterranean Sea). Fish Taxa, 21, 21-24.

Saad, A. & H. Alkusairy (2022): Atlas of Sharks and Rays in the Syrian marine waters. Tishreen University and Syrian Society for Aquatic and Environment Protection (SSAEP), 94 pp. https://www.researchgate.net/publication/362858123_Atlas_of_Sharks_and_Rays_in_the_Syrian_marine_waters

Smith-Vaniz, R.L. (1986): Carangidae. In: P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau., J. Nielsen J.& E. Tortonese. (Eds.), pp. 815-844. Fishes of the North-eastern Atlantic and the Mediterranean, Vol II, UNESCO, Paris.

received: 2022-10-18 DOI 10.19233/ASHN.2023.04

ADDITIONAL RECORD OF *SILLAGO SUEZENSIS* (SILLAGINIDAE) FROM THE AEGEAN SEA, TURKEY

Okan AKYOL & Vahdet ÜNAL
Ege University Faculty of Fisheries, 35440 Urla, Izmir, Turkey
e-mail: okan.akyol@ege.edu.tr

ABSTRACT

Two specimens of the Lessepsian migrant S. suezensis *were captured by trammel net on 2 August 2022 off Akyaka, Gökova Bay, Turkey at a depth of 2 m over a sandy bottom. This finding documents the third occurrence of* S. suezensis *in the south-eastern Turkish Aegean Sea. It is also the second northernmost record of the taxon in the Mediterranean Sea.*

Key words: smelt-whiting, Lessepsian migration, occurrence, eastern Mediterranean

NUOVO RITROVAMENTO DI *SILLAGO SUEZENSIS* (SILLAGINIDAE) NEL MAR EGEO, TURCHIA

SINTESI

Due esemplari di S. suezensis*, migrante lessepsiano, sono stati catturati con un tramaglio il 2 agosto 2022 al largo di Akyaka, nella baia di Gökova, in Turchia, a una profondità di 2 m su un fondale sabbioso. Questo risultato documenta il terzo ritrovamento di* S. suezensis *nel mar Egeo turco sud-orientale. Si tratta inoltre del secondo ritrovamento più settentrionale della specie nel mare Mediterraneo.*

Parole chiave: *Sillago suezensis*, migrazione lessepsiana, presenza, Mediterraneo orientale

INTRODUCTION

The Sillaginidae family comprises 38 valid species (Fricke *et al.,* 2020) commonly known as smelt-whitings. Based on their elongated bodies, long snout, and long soft dorsal and anal fins as well as the horizontally positioned preopercles, the identification of the Sillaginidae at the level of family is easy (Golani *et al*., 2014).

The species *Sillago suezensis* Golani, Fricke & Tikochinski, 2013 is endemic to the Northern Red Sea (Gulf of Suez, Egypt) and to date it is the only sillaginid species to have entered the Mediterranean from the Red Sea via the Suez Canal, i.e., through Lessepsian migration (Golani *et al*., 2006, 2014; Golani & Fricke, 2018). In the Mediterranean, the species was initially misidentified as *S. sihama* (Golani *et al*., 2014).

In the Mediterranean, *S. suezensis* was recorded for the first time (as *S. sihama*) in 1976 in the Lebanese coast by Mouneimne (1977) and in 1977 off the coasts of Israel (Ben-Tuvia, 1978). Along the Mediterranean coasts of Turkey, *S. suezensis* has been recorded from Iskenderun and Mersin Bays in the 1983-1984 (Gücü *et al*., 1994) and 1997-1998 periods (Taskavak & Bilecenoğlu, 2001); from off Karataş (Başusta & Erdem, 2000; Torcu & Mater, 2000); from Antalya (Innal *et al*., 2015; Innal, 2020); and repeatedly from Iskenderun Bay (Erguden *et al*., 2009; Keskin *et al*., 2011; Yemişken *et al*., 2014; Mavruk *et al*., 2017; Erguden & Doğdu, 2020). In the Levantine Sea, the species has also occurred in Egyptian waters since 1992 (cf. Halim & Rizkalla, 2011; Akel & Rizkalla, 2015; Rizkalla & Heneish, 2021), spreading as far as the waters of Cyprus (Katsanevakis *et al*., 2009). Today, *S. suezensis* is common in Lebanese and Israeli waters (Bariche & Fricke, 2020; Galil *et al*., 2020) as well as in the northeastern Mediterranean waters of Turkey (Erguden & Doğdu, 2020). In the southeastern Aegean Sea, *S. suezensis* was recorded for the first time in the southern waters of the Datça Peninsula, Turkey, by Bilecenoğlu (2004). The species has been recently reported from Gökova Bay, situated in the same region of the southeastern Turkish Aegean Sea (Çelik *et al*., 2019), and from the Island of Rhodes, the latter being the first record for Greek waters (Tiralongo & Doumpas, 2019). Details of records of *S. suezensis* in Turkish waters are summarised in Table 1.

Tab. 1: Records of *Sillago suezensis* ***in the Mediterranean and Aegean waters of Turkey (N: number of specimens collected; BT: bottom trawl; TN: trammel net; GN: gill net; HL: handline).***
Tab. 1: Pojavljanje vrste *Sillago suezensis* ***v sredozemskih in egejskih vodah Turčije (N: število ujetih primerkov; BT: pridnena vlečna mreža; TN: trislojna mreža; GN: zabodna mreža; HL: ročna vrvica).***

Location	Coordinates Lat.N/Lon. E	Depth (m)	Record Date	N	Size (mm)	FG	References
Mediterranean Sea, Turkey							
Iskenderun and Mersin Bays	?	?	1983-1984	5	129-203 TL	BT	Gücü *et al.* (1994)
Off Karataş	?	?	1991-1994	2	149-173 TL	?	Torcu & Mater (2000)
Off Karataş	?	20-30	1994-1996	7	65-166 TL	BT	Başusta & Erdem (2000)
Iskenderun and Mersin Bays	?	10-80	1997-1998	108	94-203 TL	BT	Taskavak & Bilecenoğlu (2001)
Iskenderun Bay	?	12-120	2007-2008	23	87-205 TL	BT	Erguden *et al.* (2009)
Iskenderun Bay	?	54-64	2007-2008	?	?	BT	Keskin *et al.* (2011)
Iskenderun Bay	?	31-110	2010-2011	4	170-181 TL	BT	Yemisken *et al.* (2014)
Antalya Bay	?	?	2011-2012	149	122-176 TL	TN	Innal *et al.* (2015)
Iskenderun Bay	?	40	2013-2014	872	115-242	BT	Erguden & Doğdu (2020)
Brackish waters in Antalya	?	?	2014-2017	?	?	?	Innal (2020)
Aegean Sea, Turkey							
Palamutbükü, Datça	36°40 - 27°28	12	7th July 2004	2	148-157 SL	GN	Bilecenoğlu (2004)
Gökova Bay	37°02 - 28°19	2	9th July 2018	1	174 TL	HL	Çelik *et al.* (2019)
Gökova Bay	37°02 - 28°18	2	2nd Aug. 2022	2	174-175 TL	TN	This study

Continuous monitoring of the occurrence in space and time of marine non-indigenous species is of fundamental importance for assessing the levels of biological invasions, especially in marine regions such as the Aegean Sea, a basin of the Mediterranean Sea under high impact of thermophilic Lessepsian species, in particular in its southeastern sector (Katsanevakis *et al.*, 2020).

The paper documents a new record of the Lessepsian migrant *S. suezensis* in the Aegean Sea (eastern Mediterranean).

MATERIAL AND METHODS

On 2 August 2022, two specimens of *Sillago suezensis* were captured by trammel net off Akyaka, Gökova Bay (37°02′56′′N, 28°18′47′′E, Fig. 1) at a depth of 2 m over a sandy bottom. The specimens were fixed in a 5% formaldehyde solution and then measured to the nearest mm with a caliper and weighed. The samples are deposited in the fish collection of the Faculty of Fisheries, Ege University (ESFM-PIS/2022-004).

RESULTS AND DISCUSSION

Short descriptive characteristics of the *S. suezensis* specimens from Gökova Bay (Fig. 2): body elongated; head conical with pointed snout; small and terminal mouth with villiform teeth, upper jaw slightly longer than the lower; two dorsal fins close to each other, the first set higher than the second; second dorsal fin opposite to anal fin; absence of scales on the preoperculum and operculum. Body colour of fresh specimen silvery yellow, growing paler along

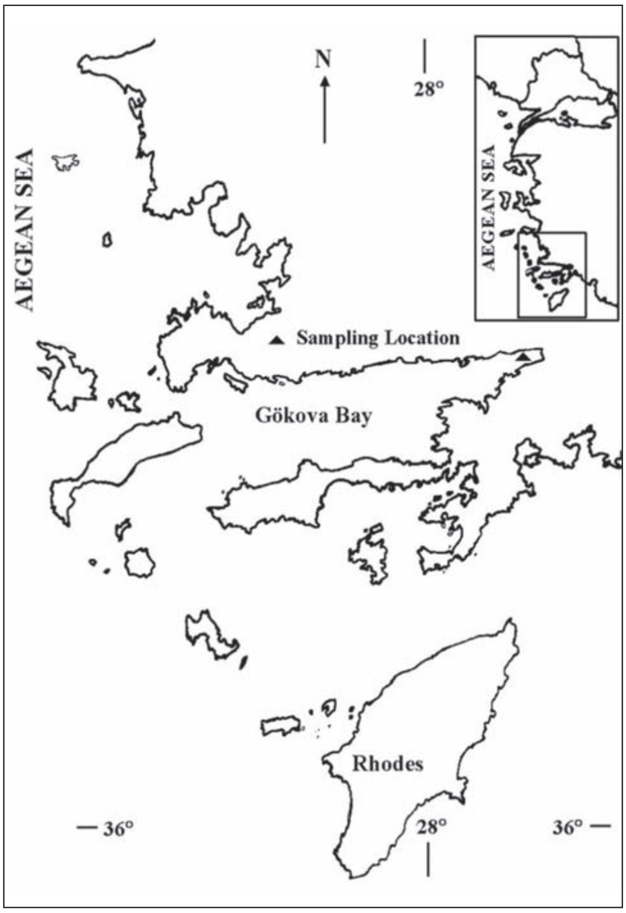

Fig. 1: Sampling location (black triangle) of *Sillago suezensis* ***in the Aegean Sea.***
Sl. 1: Lokaliteta ulova (črn trikotnik) vrste *Sillago suezensis* ***v Egejskem morju.***

Fig. 2: The largest specimen of *Sillago suezensis* ***captured from Gökova Bay, SE Aegean Sea (ref. ESFM-PIS/2022-004) (Photo: O. Akyol).***
Sl. 2: Večji primerek vrste *Sillago suezensis****, ujet v zalivu Gökova, JV Egejsko morje (ref. ESFM-PIS/2022-004) (Foto: O. Akyol).***

Tab. 2: Morphometric measurements in mm, also expressed as percentages of total length (%TL), and head length (%HL), meristic counts, and weights recorded in the two specimens of* Sillago suezensis *(ref. ESFM-PIS/2022-004) captured from Gökova Bay, SE Aegean Sea.

Tab. 2: Morfometrične meritve v mm in izražene kot delež telesne dolžine (%TL), in dolžine glave (HL%), meristična štetja in teža dveh primerkov vrste* Sillago suezensis *(ref. ESFM-PIS/2022-004), ujetih v zalivu Gökova, JV Egejsko morje.

Specimens	**Specimen 1**		**Specimen 2**	
Measurements	mm	Proportion %	mm	Proportion %
Total length (TL)	175		174	
Standard length (SL)	154	88.0 TL	153	87.9 TL
Predorsal fin length	51	29.1 TL	50	28.7 TL
Prepectoral fin length	44	25.1 TL	44	25.3 TL
Pre-anal fin length	88	50.3 TL	87	50.0 TL
Head length (HL)	42	24.0 TL	42	24.1 TL
Eye diameter	9	21.4 HL	9	21.4 HL
Preorbital length	17	40.5 HL	17	40.5 HL
Meristic counts				
1st Dorsal fin rays	X		X	
2nd Dorsal fin rays	I+21		I+21	
Anal fin rays	II+18		II+18	
Pelvic fin rays	I+5		I+5	
Pectoral fin rays	16		16	
Weight (g)	44.2		37.5	

the belly; a longitudinal silvery stripe present on the midlateral line; both dorsal fins and caudal fin dusky, other fins pale. All determined measurements, proportions, meristics (Tab. 2) and colour patterns are in accordance with those given for *S. suezensis* by Bilecenoğlu (2004), Golani *et al*. (2006, 2014), Innal *et al*. (2015) and Çelik *et al*. (2019).

While the *S. suezensis*, following the Lessepsian migration pattern along Anatolian coasts, has been spreading westwards as far as the Aegean Sea (Bilecenoğlu, 2004), a rising trend in the abundance of its populations in the Levant Sea has been observed (see also Table 1). This species has in fact acquired commercial value in Israel (Golani *et al*., 2014) and in the southeastern waters of Turkey (Yemisken *et al*., 2014; Innal, 2015). For example, in a trawl fishery survey carried out from 2004 to 2015, *S. suezensis* resulted the fifth most abundant Lessepsian fish (4.73% of total teleost biomass) in Iskenderun Bay (Mavruk *et al*., 2017).

This study presents the third record of *S. suezensis* from the southeastern Turkish Aegean Sea. For the time being, the occurrence of this species in the Aegean Sea appears sporadic, but the frequency of findings in the southeastern part of the basin reported in the last four years, both from Turkish and Greek waters, may be taken as indication of an ongoing establishment of this Lessepsian fish in the area. In addition, this is the second northernmost record of the species in the Mediterranean Sea.

ACKNOWLEDGEMENTS

The authors thank the anonymous referees for their kind contributions to the earlier version of the manuscript.

NOV ZAPIS O POJAVLJANJU RDEČEMORSKEGA MOLA *SILLAGO SUEZENSIS* (SILLAGINIDAE) V TURŠKEM EGEJSKEM MORJU

Okan AKYOL & Vahdet ÜNAL
Ege University Faculty of Fisheries, 35440 Urla, Izmir, Turkey
e-mail: okan.akyol@ege.edu.tr

POVZETEK

Dva primerka rdečemorskega mola Sillago suezensis *sta bila 2. avgusta 2022 ujeta v trislojno mrežo v vodah blizu Akyaka v zalivu Gökova (Turčija) na 2 m globine na peščenem dnu. To je tretji primer pojavljanja vrste* S. suezensis *v jugovzhodnem turškem delu Egejskega morja in hkrati drugi najsevernejši primer o pojavljanju tega taksona v Sredozemskem morju.*

Ključne besede: rdečemorski mol, lesepska selitev, pojavljanje, vzhodno Sredozemsko morje

REFERENCES

Akel, E.S.H.K. & S.I. Rizkalla (2015): A contribution to the fishery biology of an immigrant new species, *Sillago suezensis* (Golani, Fricke & Tikochinski, 2014) (Family Sillaginidae), in the Egyptian Mediterranean waters "Off Port Said". Int. J. Innov. Stud. Aquat. Biol. Fish. (IJISABF), 1(1), 38-45.

Bariche, M. & R. Fricke (2020): The marine ichthyofauna of Lebanon: an annotated checklist, history, biogeography, and conservation status. Zootaxa, 4775(1), 1-157.

Başusta, N. & Ü. Erdem (2000): A Study on the Pelagic and Demersal Fishes of İskenderun Bay. Turk J. Zool., 24, 1-19.

Ben-Tuvia, A. (1978): Immigration of fishes through the Suez Canal. Fish. Bull., 76, 249-255.

Bilecenoğlu, M. (2004): Occurrence of the Lessepsian migrant fish, *Sillago sihama* (Forsskål, 1775) (Osteichthyes: Sillaginidae), from the Aegean Sea. Isr. J. Zool., 50, 420-421.

Çelik, M., I. Giovos, A. Deidun, & C. Ateş (2019): A new occurrence of *Sillago suezensis* (Fosskla, 1775) from the Aegean Sea coastal waters of Turkey. Int. J. Fish. Aquat., 7(2), 213-215.

Erguden, D., C. Turan, & M. Gurlek (2009): Weight-length relationships for 20 lessepsian fish species caught by bottom trawl on the coast of Iskenderun Bay (NE Mediterranean Sea, Turkey). J. Appl. Ichthyol., 25, 133-135.

Erguden, D. & S.A. Doğdu (2020): Age, growth and mortality estimates of Sillago suezensis from Iskenderun Bay, northeastern Mediterranean Sea. Cah. Biol. Mar., 61, 81-90.

Fricke, R., W. Eschmeyer & J. Fong (2020): CAS - Eschmeyer's Catalog of Fishes - Genera/Species by Family/Subfamily. Retrieved from http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp (Accessed 11 Oct. 2022).

Galil, B.S., H.K. Mienis, R. Hoffman & M. Goren M (2020): Non-indigenous species along the Israeli Mediterranean coast: tally, policy, outlook. Hydrobiologia, 848, 2011-2029.

Golani, D., B. Öztürk & N. Başusta (2006): Fishes of the eastern Mediterranean. Turkish Marine Research Foundation (Publication No. 24), Istanbul, 260 pp.

Golani, D. & R. Fricke (2018): Checklist of the Red Sea fishes with delineation of the Gulf of Suez, Gulf of Aqaba, endemism and Lessepsian migrants. Zootaxa, 4509(1), 1-215.

Golani, D., R. Fricke& Y. Tikochinski (2014): *Sillago suezensis*, a new whiting from the northern Red Sea, and status of *Sillago erythraea* Cuvier (Teleostei: Sillaginidae). J. Nat. Hist., 48(7-8), 413-428.

Gücü, A.C., F. Bingel, D. Avsar, & N. Uysal (1994): Distribution and occurrence of Red Sea fish at the Turkish Mediterranean coast – northern Cilician basin. Acta Adriat., 34(1/2), 103-113.

Halim, Y., & S. Rizkalla (2011): Aliens in Egyptian Mediterranean waters. A check-list of Erythrean fish with new records. Medit. Mar. Sci., 12(2), 479-490.

Innal, D., B. Kisin & D. Akdoganbulut (2015): Length-weight relationships and morphometry of *Sillago suezensis* from Antalya Gulf-Turkey. Int. J. Fish. Aquat., 2(4), 107-112.

Innal, D. (2020): Distribution of Lessepsian migrant and non-native freshwater fish species in Mediterranean brackish waters of Turkey. Acta Aquatica Turcica, 16(4), 545-557.

Katsanevakis, S., K. Tsiamis, G. Ioannou, N. Michailidis & A. Zenetos (2009): Inventory of alien species of Cyprus (2009). Med. Mar. Sci., 10(2), 109-133.

Katsanevakis, S., A. Zenetos, M. Corsini-Foka & K. Tsiamis (2020): Biological invasions in the Aegean Sea: temporal trends, pathways, and impacts. *In*: The Handbook of Environmental Chemistry. Springer, Berlin, Heidelberg, 24.

Keskin, Ç., C. Turan & D. Ergüden (2011): Distribution of the demersal fishes on the continental shelves of the Levantine and North Aegean seas (Eastern Mediterranean). Turk. J. Fish. Aquat. Sci., 11, 413-423.

Mavruk, S., F. Bengil, H. Yeldan, M. Manasirli & D. Avsar (2017): The trend of lessepsian fish populations with an emphasis on temperature variations in Iskenderun Bay, the Northeastern Mediterranean. Fish Oceanogr., 26, 542-554.

Mouneimne, N. (1977): Liste des poissons de la cote du Liban (Méditerranée orientale). Cybium, 1, 37-66.

Rizkalla, S.I. & R.A. Heneish (2021): The update of immigrant Red Sea fish of Egyptian Mediterranean waters during (2013-2021). Egypt. J. Aquat. Biol. Fish., 25(5), 739-753.

Taskavak, E. & M. Bilecenoğlu (2001): Length-weight relationships for 18 Lessepsian (Red Sea) immigrant fish species from the eastern Mediterranean coast of Turkey. J. Mar. Biol. Ass. U.K., 81, 895-896.

Tiralongo, F. & N. Doumpas (2019): First record of *Sillago suezensis* Golani, Fricke & Tikochinski, 2013 from Greece. In: Kousteni, V., Bakiu, R., Benhmida, A., Crocetta, F., Di Martino, V., Dogrammatzi, A., 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 (April 2019). Medit. Mar. Sci., 20(1), 230-247.

Torcu, H. & S. Mater (2000): Lessepsian Fishes Spreading Along the Coasts of the Mediterranean and the Southern Aegean Sea of Turkey. Turk J Zool, 24, 139-148.

Yemisken, E., C. Dalyan & L. Eryılmaz (2014): Catch and discard fish species of trawl fisheries in the Iskenderun Bay (North-eastern Mediterranean) with emphasis on lessepsian and chondrichtyan species. Med. Mar. Sci., 15(2), 380-389.

SREDOZEMSKI MORSKI PSI

SQUALI MEDITERRANEI

MEDITERRANEAN SHARKS

received: 2023-02-22 DOI 10.19233/ASHN.2023.05

OCCURRENCE OF DEEP-SEA SQUALIFORM SHARKS, *ECHINORHINUS BRUCUS* (ECHINORHINIDAE) AND *CENTROPHORUS UYATO* (CENTROPHORIDAE), IN MARMARA SHELF WATERS

Hakan KABASAKAL
İstanbul University, Institute of Science, Fisheries Technologies and Management Program, Süleymaniye, Esnaf Hastanesi 4. Kat, 34116 Fatih, İstanbul, Türkiye
e-mail: kabasakal.hakan@gmail.com

Uğur UZER & F. Saadet KARAKULAK
İstanbul University, Faculty of Aquatic Sciences, Department of Fisheries Technologies and Management, Kalenderhane Mahallesi Onaltı Mart Şehitleri Caddesi, No: 2, Vezneciler, 34134 Fatih, İstanbul, Türkiye

ABSTRACT

On 2 October 2019, a female little gulper shark, Centrophorus uyato*, was captured at a depth of 150 m in the central Sea of Marmara. The species had been last documented in the region in 1991 and the capture of the present specimen occurred more than 30 years after the species' first occurrence in this area. On 21 August 2021, a shoal of bramble sharks (n=17),* Echinorhinus brucus*, were captured in the same station at a depth of 150 m. Large deep-sea sharks, such as* E. brucus*, should not be exclusively considered as solitary sharks, since the species has also been sighted in shoals; however, the aggregation recorded in the area requires further investigation to assist with future management plans for this species. The occurrence of these rare deep-sea sharks in the Sea of Marmara should be monitored carefully to ensure their existence in this marine environment.*

Key words: sharks, deep-sea, occurrence, continental shelf, anoxic conditions

PRESENZA DI SQUALI SQUALIFORMI, *ECHINORHINUS BRUCUS* (ECHINORHINIDAE) E *CENTROPHORUS UYATO* (CENTROPHORIDAE), NELLE ACQUE DELLA PIATTAFORMA DI MARMARA

SINTESI

Il 2 ottobre 2019 è stata catturata una femmina di centroforo boccanera, Centrophorus uyato*, a 150 m di profondità nel Mar di Marmara centrale. La specie era stata documentata per l'ultima volta nella regione nel 1991 e la cattura di questo esemplare è avvenuta più di 30 anni dopo la prima segnalazione della specie in quest'area. Il 21 agosto 2021, un banco di ronchi (n=17),* Echinorhinus brucus*, è stato catturato nella stessa stazione a una profondità di 150 m. I grandi squali di profondità, come* E. brucus*, non dovrebbero essere considerati esclusivamente come squali solitari, dal momento che la specie è stata avvistata anche in banchi; tuttavia, l'aggregazione registrata nell'area richiede ulteriori indagini per contribuire ai futuri piani di gestione di questa specie. La presenza di questi rari squali di profondità nel Mar di Marmara dovrebbe essere monitorata con attenzione per garantire la loro esistenza in questo ambiente marino.*

Parole chiave: squali, acque profonde, presenza, piattaforma continentale, condizioni anossiche

INTRODUCTION

Deep-sea chondrichthyans have been defined as sharks, rays and chimaeras whose predominant distribution or most of their lifecycle is restricted to depths from about 200 m to over 2000 m (Ebert, 2013; Cotton & Grubbs, 2015). Of the global chondrichthyan fauna (1,207 species), 575 species are considered to be deep-sea (47.6% of global total; Cotton & Grubbs, 2015), with the order of Squaliformes being the most species-rich group among these (Ebert, 2013, 2015). To date, a total of 88 chondrichthyan species have been recorded in the Mediterranean Sea, including 48 shark species, 38 batoid species, and 2 chimaeras (Serena *et al*., 2020). According to a recent overview of the deep-sea fauna of the eastern Mediterranean Sea (Damalas *et al*., 2022), the number of chondrichthyan species occurring at >200 m depth is 22 in the eastern Ionian Sea, 12 in the southern Aegean Sea, 11 in the Libyan Sea and 7 in the northern Aegean Sea. From a chronological perspective, Sion *et al*. (2004) identified 7 species occurring between 600 and 4,000 m during a DESEAS survey carried out in three areas of the Mediterranean Sea (the Balearic Sea - GSA 5, and western and eastern Ionian Sea - GSAs 19 and 20, respectively). During a MEDITS survey covering an extensive marine area (GSAs 1, 5, 6, 7, 8, 9, 10, 11, 16, 17, 18, 19, 20, 22, 23 and 25), Follesa *et al*. (2019) recorded 14 species of deep-sea sharks occurring in the area, with 2 of them occupying depths between 10 and 800 m, and the remaining 12, including *Centrophorus* cf. *granulosus* (Bloch and Schneider, 1801) (which is no longer a valid species) and *C. uyato*, occupying depths between 200 and 800 m. In a recent study, Carluccio *et al*. (2021) observed 6 shark species by means of a MEMO baited lander in central Mediterranean between 300 and 1,110 m in depth.

One of the primary obstacles in deep-sea chondrichthyan research is the difficulty of observing, sampling, or collecting data (Cotton & Grubbs, 2015). Since deep-sea research requires a significant amount of logistic support and funding, the deep-sea condrichthyans in the Sea of Marmara were, in the past, neglected in systematic research in favour of commercially valuable teleosteans. For many years, the main source of knowledge on the deep-sea chondrichthyans of the region has been opportunistic sampling, carried out during general ichthyological demersal surveys or deep-sea imaging surveys for geological purposes (Benli *et al*., 1993; Meriç, 1995; Kabasakal *et al*., 2005; Kabasakal & Dalyan, 2011; Kabasakal & Bilecenoğlu, 2014; Kabasakal, 2009a, 2009b, 2017). In a recent review of the deep-sea shark populations of the Sea of Marmara, Kabasakal (2022) stated that bathydemersal species accounted for approximately 43% (6 species) of the sharks in the region. Since every piece of data can provide a valuable contribution to describing the life history of the deep-sea shark species of the Sea of Marmara, researchers are now more involved in sampling and examining rare and previously neglected species. In the present article, we provide new evidence of the presence of *Echinorhinus brucus* (Bonnaterre, 1788) in Marmara shelf waters based on a recent incidental capture of a shoal of bramble sharks in research surveys. We also discuss the reasons that may have led to the capture of a shoal of *E. brucus,* which normally occurs as a sporadic species. Furthermore, we report the occurrence of *Centrophorus uyato* (Rafinesque, 1810) more than 30 years after its first appearance in the Sea of Marmara.

MATERIAL AND METHODS

Study area

Beşiktepe *et al*. (1994) define the Sea of Marmara (Fig. 1) as a small basin between the continents of Europe and Asia, with a surface area of 11,500 km^2 and a maximum depth of 1,390 m. The Sea of Marmara is connected to the Mediterranean Sea and the Black Sea through the Dardanelles and the Bosphorus Strait, respectively. A distinguishing feature of the Sea of Marmara is the constant oxygen deficiency below the halocline, which is more pronounced in the eastern Marmara basin (Ünlüata & Özsoy, 1988; Beşiktepe *et al*., 1994). Recent surveys have demonstrated that in deep trenches anoxic conditions may soon occur (Mantıkçı *et al*., 2022; Salihoğlu *et al*., 2022).

Sampling methodology

Specimens of *E. brucus* and *C. uyato* were collected during two demersal fishery surveys in autumn 2019 and summer 2021, performed as substudies of an extensive governmental project entitled "Integrated Marine Pollution Monitoring 2017-2019 and 2020-2022 Programme in Turkish Seas". Demersal sampling was carried out by means of a MEDITS-designed otter-trawl, which has a 24 m width at the front opening and a cod-end mesh size of 14 mm (knot-to-knot). Hauling was performed over suitable bottoms at a towing speed of 3 miles/hour for 30 minutes. Field surveys were carried out on board of a stern-trawling research vessel *R/V Yunus-S* of Istanbul University.

The water parameters (salinity, temperature, pH, conductivity and oxygen) were recorded by a CTD (SeaBird SBE 19+). Environmental parameters at station MD18, where the examined specimens of

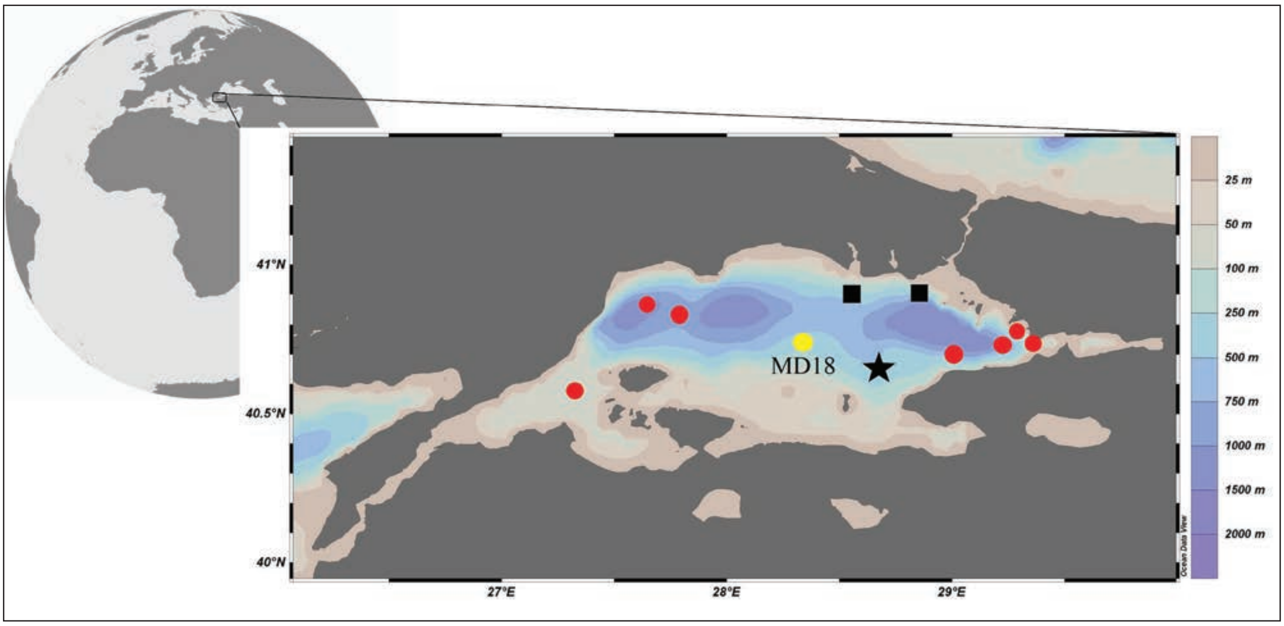

Fig. 1: Sampling localities of earlier and more recent specimens of *Centrophorus uyato* ***and*** *Echinorhinus brucus* ***captured in the Sea of Marmara. (■) indicates earlier capture sites for*** *C. uyato****, one specimen per site (Meriç, 1995); (★) indicates the capture sites for the*** *C. granulosus* ***reported in Benli*** *et al.* ***(1993); the red circles present capture sites for the*** *E. brucus* ***reported in Kabasakal*** *et al.* ***(2005), Kabasakal & Dalyan (2011), Kabasakal & Bilecenoğlu (2014), Kabasakal (2017), Kabasakal*** *et al.* ***(2023), one specimen per site; the yellow circle indicates the capture sites for specimens of*** *C. uyato* ***and*** *E. brucus* ***collected in the present study.***

Sl. 1: Lokalitete, na katerih so bili ugotovljeni predhodni in recentni primeri pojavljanja primerkov vrst *Centrophorus uyato* ***in*** *Echinorhinus brucus****, ujetih v Marmarskem morju. Črn pravokotnik (■) prikazuje prejšnje podatke o ulovu primerkov vrste*** *C. uyato****, en primerek na lokaliteto (Meriç, 1995); zvezdica (★) označuje lokalitete ulova primerkov vrste*** *C. granulosus****, nanašajoč se na vir Benli*** *et al.* ***(1993); rdeči krogci označujejo lokaliteto ulova primerkov vrste*** *E. brucus****, nanašajoč se na vire Kabasakal*** *et al.* ***(2005), Kabasakal & Dalyan (2011), Kabasakal & Bilecenoğlu (2014), Kabasakal (2017), Kabasakal*** *et al.* ***(2023), en primerek na lokaliteto; rumeni krogec kaže lokaliteto ulova primerkov vrst*** *C. uyato* ***in*** *E. brucus****, obravnavnih v pričujoči raziskavi***

E. brucus and *C. uyato* were collected, are presented in Fig. 2. The starting and ending coordinates of bottom-trawl hauling at MD18 station were as follows: starting plot, 40º42′18′′ N-28º20′20′′ E; ending plot, 40º42′78′′ N-28º18′44′′ E. Following the capture of *E. brucus* specimens, only their total weight was recorded for biomass estimations. Due to the absence of a suitably sized water tank on board for keeping the sharks in good conditions during morphometric measurements etc., the shoal of bramble sharks were immediately returned to the sea alive. Nevertheless, the total length (TL) of the single specimen of *C. uyato* was measured. Total length (TL) is the distance between the tip of the snout and tip of the upper caudal lobe, where the upper caudal lobe is in depressed position (Compagno, 1984). All of the specimens were photographed fresh. Species identification followed Veríssimo *et al*. (2014), Barone *et al*. (2022) and White *et al*. (2022), while taxonomic nomenclature and the IUCN Red List status followed Serena *et al*. (2020). The specimen of *C. uyato* was stored at the Faculty of Aquatic Sciences, Istanbul University, without a registration number.

RESULTS AND DISCUSSION

On 2 October 2019, a female little gulper shark (Fig. 3), *Centrophorus uyato*, was captured at a depth of 150 m at bottom-trawl station MD18 located in the central Sea of Marmara. The examined gulper shark measured 82 cm in total length (TL), the remaining descriptive characteristic were as follows: a typical squaliform species, with spines in front of two dorsal fins and a moderately long pectoral-fin free rear tip; anal fin absent; first dorsal fin slightly greater in height than second dorsal fin; caudal fin with a strongly notched posterior margin; coloration brownish-grey dorsally and lighter in the same colour ventrally; wide blackish-dark bands on posterior margins of dorsal fins; pectoral, pelvic and caudal fins with conspicuous white margins.

The described specimen coincided with the descriptions of *C. uyato* in Veríssimo *et al*. (2014), Barone *et al*. (2022) and White *et al*. (2022).

On 21 August 2021, a shoal of bramble sharks (n = 17; Fig. 3, 4), *E. brucus*, were captured at the same station (MD18) at a depth of 150 m. The total mass of the bramble sharks was 445 kg. The descriptive characteristics of the examined bramble sharks were as follows: a large, short nosed and flat-headed squaliform species, with two spineless dorsal fins, first dorsal fin originating behind pelvic fin origin; enlarged, tack-like, conspicuous denticles scattered over body and fins; dorsal surface light to medium grey, with fin edges blackish. The described specimens coincided with the descriptions of *E. brucus* in Ebert and Stehmann (2013) and Barrone *et al*. (2022). Environmental parameters at station MD18 (the depth of measurement was 122 m) were as follows: salinity 38.80‰; temperature 15.31ºC; and dissolved oxygen 1.39 mg/L (Fig. 2).

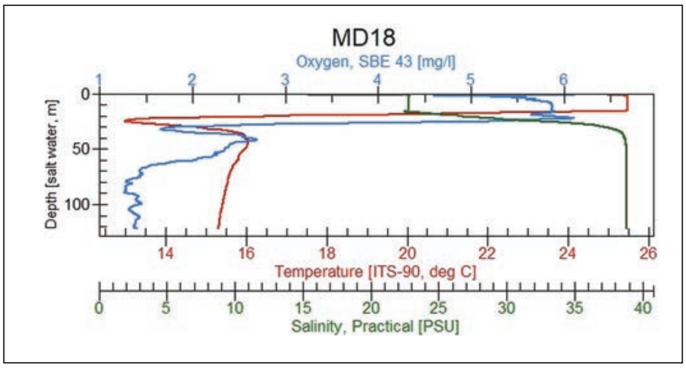

Fig. 2. Oceanographic parameters at station MD18, measured at the beginning of bottom trawling.
Sl. 2: Oceanografski parametri na postaji MD18, merjeni na začetku vleke s pridneno vlečno mrežo.

The first accounts of the occurrence of *E. brucus* were provided by Ninni (1923) and Deveciyan (1926), both referring to the species as *Echinorhinus spinosus*. Moreover, in a recent checklist of Turkish Marine Fishes, Bilecenoğlu *et al*. (2014) mentioned an occurrence of *E. brucus* in the Sea of Marmara based on Ninni (1923). The main doubt about the reliability of information given by Ninni (1923) and Deveciyan (1926) arises from the fact that neither author gave any information on the locality of capture of the bramble sharks they examined. Since both authors' observations on *E. brucus* were based on specimens landed at the Istanbul wholesale fish market during early 1920s, it is uncertain whether these were indeed captured in the Sea of Marmara or elsewhere in Turkish waters. Furthermore, the species was not mentioned in the noteworthy ichthyological inventory of the Sea of Marmara issued in the 1940s (Rhasis Erazi, 1942). Therefore, the information on the early Marmara records of *E. brucus* appear to be contradictory.

In the early 2000s, *E. brucus* was considered extinct in eastern Mediterranean waters (Hemida & Capapé, 2002); however, during an underwater imaging survey of the North Anatolian Fault Zone, in October 2002, a bramble shark was imaged by means of a remotely operated vehicle deployed in Tekirdağ Trench (northwestern Sea of Marmara), at a depth of 1214 m (Kabasakal *et al*., 2005). Following that record, other bramble sharks were incidentally captured in several regions of the Sea of Marmara. Kabasakal and Dalyan (2011) reported the capture of 3 specimens. Kabasakal and Bilecenoğlu (2014) reported the capture of a single specimen and that record was followed by a relatively recent capture of a female bramble shark in the shelf waters of southwestern Sea of Marmara (Kabasakal, 2017). Basic data of the bramble sharks captured in the Sea of Marmara are summarized in Table 1.

Records of *Centrophorus* sp. in the Sea of Marmara are sparser and dating back to 1989 (Table 1). In autumn 1992, during a cruise of *R/V K. Piri Reis* in the region, 5 specimens of *C. granulosus* were collected (total weight 11 kg) at a depth of 400 m (capture site 40º36'5" N - 28º36'3" E) (Benli *et al*., 1993). Later, *C. granulosus* was also captured in trammel nets deployed in depths between 120 and 350 m on the northern continental slope of the Sea of Marmara (Meriç, 1995). However, recent studies by Veríssimo *et al*. (2014), Bellodi *et al*. (2022) and White *et al*. (2022) demonstrate that only one species (*C. uyato*) is currently present in the Mediterranean Sea. The occurrence of *C. uyato* in the northern slope of the Sea of Marmara was also reported by Meriç (1995), following the captures of a female (44.2 cm TL) on 19 May 1989, at a depth of 150 m, and a male (45.3 cm TL) on 11 August 1991, at a depth of 270 m.

As seen in Table 1, there are several previous reports of both *C. granulosus* and *C. uyato* from the Sea of Marmara. Furthermore, in the ichthyological checklist of Turkish Marine Fishes, Bilecenoğlu *et al*. (2014) included *C. granulosus* and *C. uyato* among the fishes of the Sea of Marmara; however, the mentioned records in the checklist refer to Benli *et al*. (1993; for *C. granulosus*) and Meriç (1995; for *C. uyato*). Since *C. granulosus* is no longer a valid species, the recent revisions (Veríssimo *et al*. 2014; Bellodi *et al*., 2022; White *et al*., 2022) cite only one species of the *Centrophorus* genus to be currently present in the Mediterranean Sea, namely, *C. uyato*. Following the example of Kousteni *et al*.

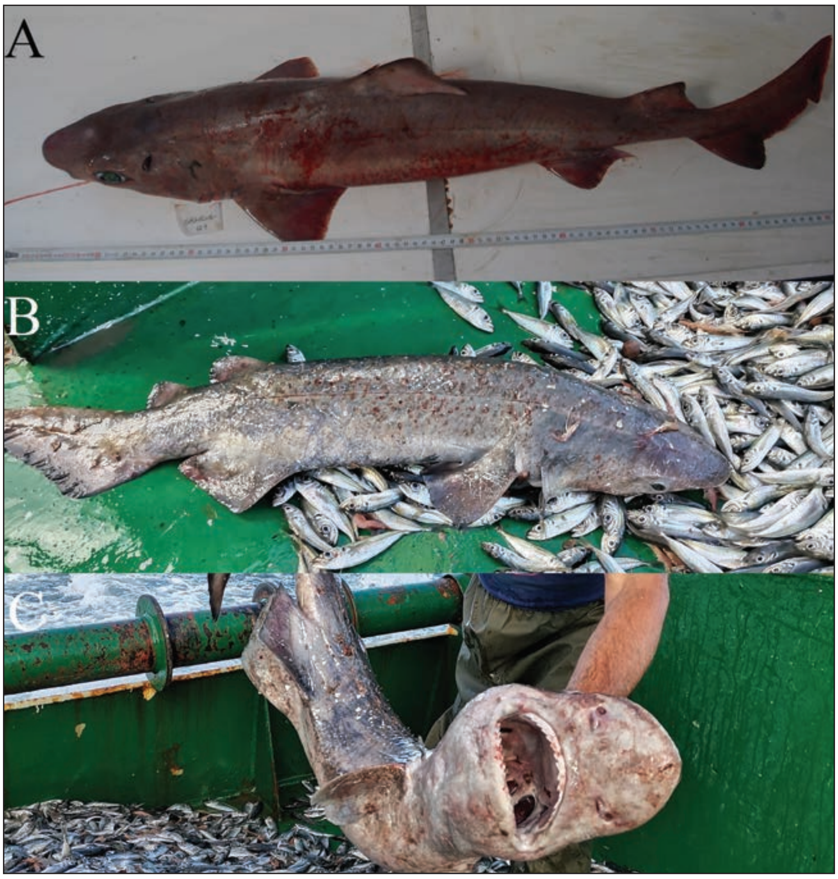

Fig. 3. Specimens of** Centrophorus uyato **(A) and** Echinorhinus brucus **(B and C) captured at station MD18 among a shoal of horse mackerel,** Trachurus trachurus**.
Sl. 3: Primerki vrst** Centrophorus uyato **(A) in** Echinorhinus brucus **(B in C), ujeti skupaj z jato šnjurov** Trachurus trachurus **na postaji MD18.

(2021), who genetically confirmed the presence of the little gulper shark in Cypriot waters, it would be necesary to conduct a further investigation based on the morphological measurements of the deposited specimens that are believed to have been captured in the Sea of Marmara and were identified as *C. granulosus* by Benli *et al*. (1993) and Meriç (1995), to confirm the presence of *C. uyato* in the region. *C. uyato* was last documented in the Sea of Marmara in 1991 and the present specimen was captured more than 30 years after the first occurrence of the species in this area.

The most recent identification of the demersal fish fauna of the Sea of Marmara was made in monthly sampling campaigns during bottom-trawl surveys conducted between March 2017 and December 2018 at 34 stations, during which Daban *et al*. (2021) collected 12 species of cartilaginous fishes, but no specimen of either *C. uyato* or *E. brucus*. Although the numerosity of the cartilaginous fish species increased with depth, only *Hexanchus griseus* and *Oxynotus centrina* were obtained of the bathidemersal shark species (Daban *et al*., 2021). According to Serena (2005), *C. uyato* is an occasional species in the Mediterranean Sea, captured as bycatch in deep bottom trawling and longlining. The occurrence of *Centrophorus* sp. in bottom longline fishery was also reported by Megalofonou and Chatzispyrou (2006), based on specimens caught off the island of Crete in depths between 350-480 m and identified as *C. granulosus* in the published article. Lteif *et al*. (2017) reported the capture of 38 specimens of *C. uyato* at depths ranging from 115 to 600 m between May 2013 and February 2014 (3.8 specimens per month) in Lebanese waters. Based on the data gathered in the 25 years of MEDITS surveys, Follesa *et al*. (2019) reported the occurrence of *C.* cf. *granulosus* in several GSAs (1, 8, 9, 11, 16, 18, 19, 20 and 22) of the Mediterranean, while *C. uyato* was only reported from GSA 1. Recently, the morphometrics of a little gulper

Tab. 1: Fishing data of** Centrophorus granulosus**,** C. uyato **and** Echinorhinus brucus **sighted or captured in the Sea of Marmara since 1989. *Benli** et al. **(1993) reported the TL of only one specimen.

Tab. 1: Podatki o primerkih vrst** Centrophorus granulosus, C. uyato **in** Echinorhinus brucus **opaženih ali ujetih v Marmarskem morju od leta 1989. *Benli** et al. **(1993) omenja telesno dolžino (TL) le enega primerka.

No	TL (cm)	W (kg)	Sex	Date of capture or sighting	Depth of capture or sighting (m)	Type of gear	Reference
Centrophorus granulosus							
1-5	62.6*	1.4	?	Autumn 1992	400	Bottom-trawl	Benli *et al.* (1993)
6	?	?	?	Before 1991	120-350	Trammel-net	Meriç (1995)
Centrophorus uyato							
1	44.2	?	♀	19 May 1989	150	Trammel-net	Meriç (1995)
2	45.3	?	♂	11 August 1991	270	Trammel-net	Meriç (1995)
3	82	?	♀	2 October 2019	150	Bottom-trawl	Present study
Echinorhinus brucus							
1	?	?	?	October 2002	1214	ROV	Kabasakal *et al.* (2005)
2	170	45	♀	9 December 2005	600-700	Bottom-trawl	Kabasakal & Dalyan (2011)
3	225	140	♀	20 November 2008	100	Gill-net	Kabasakal & Dalyan (2011)
4	250	175	♀	28 December 2009	150	Gill-net	Kabasakal & Dalyan (2011)
5	220	300	♀	19 May 2010	300	Gill-net	Kabasakal & Bilecenoğlu (2014)
6	160	100	♀	24 January 2017	45	Gill-net	Kabasakal (2017)
7	ca. 200	?	?	18 March 2022	<100	Beam-trawl	Kabasakal *et al.* (2023)
8-24	?	?	?	21 August 2021	150	Bottom-trawl	Present study

shark incidentally hooked in commercial longlines at a depth of 140 m in the Gulf of Antalya (northeastern Mediterranean Sea) has been reported (Kabasakal *et al.*, 2022). Compared to other parts of the Mediterranean (Megalofonou & Chatzispyrou, 2006; Lteif *et al.*, 2017; Follesa *et al.*, 2019), in Turkey, *C. uyato* has apparently been caught in shallower waters in recent years. It can be suggested that the increasing deoxygenation of the deep waters of the region has been driving *C. uyato* to shallower regions, where it becomes bycatch. Moreover, the fact that before the end of the 1990s, when aerobic conditions prevailed in deep waters (Kocataş *et al.*, 1993), captures of *Centrophorus* species in the Sea of Marmara had always been reported from waters deeper than 200 m (Benli *et al.*, 1993; Meriç, 1995), also supports this suggestion. Previous records of bramble sharks from the Sea of Marmara were either of incidental captures or sightings of solitary specimens (Kabasakal *et al.*, 2005; Kabasakal & Dalyan, 2011; Kabasakal & Bilecenoğlu, 2014; Kabasakal, 2017), while the individuals of *E. brucus* examined herein were for the first time captured as a shoal. According to Ebert and Stehmann (2013), *E. brucus* is an uncommon to rare shark in most of its distributional range and generally occurs as sporadic bycatch of other fisheries. Deep-sea sharks are known to aggregate in small to large schools, and it has been hypothesised that these sharks (e.g., *Squalus* spp., *Etmopterus* spp., *Proscymnodon* spp.) may hunt in packs to subdue larger prey (Ebert, 2013). However, De Maddalena and Zuffa (2003) as well as Javadzadeh *et al*. (2011) stated that the bramble shark is a rare deep-water shark that has only been recorded sporadically and as a rule solitarily at widely dispersed locations throughout the world.

In the same bottom-trawl hauling more than 700 kg of horse mackerel, *Trachurus trachurus*, was captured together with the shoal of *E. brucus*, suggesting the bramble sharks may have been captured while pursuing easy prey. Another assumption about this unusual capture of a shoal of *E. brucus* is that it occurred in consequence to the deoxygenation of the bathyal bottom of the Sea of Marmara (Mantıkçı *et al.*, 2022). At station MD18, where the shoal of bramble sharks was captured, the dissolved oxygen of the bottom water was 1.39 mg/L, which is already lower than the hypoxia limit (<2 mg/L; Fig. 2). The MD18 station is in the vicinity of Çınarcık Trench, the deepest point (1390 m) of the Sea of Marmara, where anoxia is about to develop (Mantıkçı *et al.*, 2022). In recent years, no captures of *E. brucus* have occurred in deep bathyal zones and deep-sea trenches, and most bramble sharks (n=21; 87.5%) have been captured in shelf waters (<200 m depth). The prevailing deoxygenation in the deep waters of the region (Mantıkçı *et al.*, 2022; Kabasakal *et al.*, 2023) may have also led to the capture of the present shoal. Generally, deep-sea sharks are not highly migratory, except for the vertical migrations of gravid females at the end of gestation when they approach the shore to give birth (Hemida & Capapé, 2002). Although aggregation of large deep-sea sharks, such as bluntnose sixgill shark, *Hexanchus griseus*, is an unusual phenomenon (Ben Amor *et al.*, 2019), there are some large deep-sea shark species, such as *E. brucus*, that cannot be considered as exclusively solitary; this should be taken into consideration, in addition to the shark's seasonality, when developing and implementing management plans in the future. During extensive MEDITS surveys in the last 25 years, *E. brucus* has not been captured in any of the GSAs. Due to the alarming paucity of Mediterranean records and the restricted distribution of this species (Hemida & Capape, 2002; De Maddalena & Zuffa, 2003; Sion *et al.*, 2004; Kabasakal & Bilecenoğlu, 2014; Follesa *et al.*, 2019; Damalas *et al.*, 2022) is the population inhabiting the Sea of Marmara all the more important for the survival of the species in the entire Mediterranean Sea. The 2020 IUCN Red List of Threatened Species assessed *C. uyato* and *E. brucus* as endangered (Finucci *et al.*, 2020a, b), and to date neither of these two sharks has been included in the list of protected species in Turkish seas. Finally, the paucity of information about *E. brucus* in the Mediterranean Sea is making these species even more vulnerable and threatened, which is why the population of bramble shark inhabiting the Sea of Marmara requires even more attention than other sharks.

Fig. 4. A bramble shark, *Echinorhinus brucus****, being released by the fisherman. The arrows indicate bramble sharks swimming among a shoal of horse mackerel,*** *Trachurus trachurus****.***

Sl. 4: Bodičastega morskega psa (*Echinorhinus brucus****) je ribič izpustil na svobodo. Puščica označuje bodičaste morske pse, ki plavajo okoli jate navadnih šnjurov (****Trachurus trachurus****).***

ACKNOWLEDGMENTS

This work has been supported by "Integrated Marine Pollution Monitoring 2017-2019 and 2020-2022 Programme" carried out by the Ministry of Environment and Urbanization/ General Directorate of EIA, Permit and Inspection/ Department of Laboratory, Measurement and coordinated by TUBITAK- MRC ECPI. Authors would like to thank the crew of *R/V Yunus-S* for their participation in the field surveys, and the two anonymous reviewers for their comments which improved the content and quality of the article.

POJAVLJANJE DVEH GLOBOKOMORSKIH MORSKIH PSOV *ECHINORHINUS BRUCUS* (ECHINORHINIDAE) IN *CENTROPHORUS UYATO* (CENTROPHORIDAE), V VODAH MARMARSKEGA ŠELFA

Hakan KABASAKAL
İstanbul University, Institute of Science, Fisheries Technologies and Management Program, Süleymaniye, Esnaf Hastanesi 4. Kat, 34116 Fatih, İstanbul, Türkiye
e-mail: kabasakal.hakan@gmail.com

Uğur UZER & F. Saadet KARAKULAK
İstanbul University, Faculty of Aquatic Sciences, Department of Fisheries Technologies and Management, Kalenderhane Mahallesi Onaltı Mart Şehitleri Caddesi, No: 2, Vezneciler, 34134 Fatih, İstanbul, Türkiye

POVZETEK

*Drugega oktobra 2019 so na globini 150 m v osrednjem delu Marmarskega morja ujeli manjši primerek globokomorskega trneža (*Centrophorus uyato*). Zadnji dokumentiran pojav te vrste v regiji izvira iz leta 1991, ulov pričujočega primerka se je torej pojavil trideset let po prvem zapisu o pojavljanju te vrste v regiji. Enaindvajsetega avgusta 2021 so na isti vzorčevalni postaji na globini 150 m ujeli jato 17 primerkov bodičastih morskih psov (*Echinorhinus brucus*). Kaže, da se veliki globokomorski psi kot npr.* E. brucus*, ne pojavljajo posamič, ampak tudi v jatah. Da bi prispevali k prihodnjim načrtom upravljanja za to vrsto, bo potrebno še naprej spremljati njeno populacijo, da bi preverili združevanje primerkov v jate v raziskani regiji. Potreben je natančen monitoring primerkov tega redkega globokomorskega psa v Marmarskem morju, da bi zagotovili njegov obstoj v morskem okolju.*

Ključne besede: morski psi, globokomorsko okolje, pojavljanje, kontinentalni šelf, anoksične razmere

REFERENCES

Barone, M., C. Mazzoldi & F. Serena (2022): Sharks, rays and chimaeras in Mediterranean and Black Seas - Key to identification. Rome, FAO. https://doi.org/10.4060/cc0830en.

Bellodi, A., A. Benvenuto, R. Melis, A. Mulas, M. Barone, C. Barría, A. Cariani, L. Carugati, A. Chatzispyrou, M. Desrochers, A. Ferrari, A.J. Guallart, F. Hemida, C. Mancusi, D. Scannella, F. Serena, R. Tinti, A. Vella, M.C. Follesa & R. Cannas (2022): Call me by my name: unravelling the taxonomy of the gulper shark genus *Centrophorus* in the Mediterranean Sea through an integrated taxonomic approach. Zoological Journal of the Linnean Society, 20, 1-26.

Benli, H.A., B. Cihangir & K.C. Bizsel (1993): A new record for the Sea of Marmara; (Family: Squalidae) *Centrophorus granulosus* (Bloch & Schneider, 1801). Tr. J. of Zoology, 17, 133-135.

Ben Amor, M.M., K.O. Ben Amor & C. Capapé (2019): A shoal of bluntnose sixgill shark *Hexanchus griseus* (Chondrichthyes: Hexanchidae) from the Tunisian coast (central Mediterranean). Thalassia Sal., 41, 85-90. doi: 10.1285/i15910725v41p85.

Beşiktepe, Ş.T., H.İ. Sur, E. Özsoy, M.A. Latif, T. Oğuz & Ü. Ünlüata (1994): The circulation and hydrography of the Marmara Sea. Prog. Oceanogr., 34, 285-334.

Bilecenoğlu, M., M. Kaya, B. Cihangir & E. Çiçek (2014): An updated checklist of the marine fishes of Turkey. Tr. J. of Zoology, 38, 901-929.

Carluccio, A., F. Capezzuto, P. Maiorano, L. Sion & G. D'Onghia (2021): Deep-water cartilaginous fishes in the central Mediterranean Sea: comparison between geographical areas with two low impact tools for sampling. J. Mar. Sci. Eng., 9, 686. https://doi.org/10.3390/jmse9070686.

Compagno, L.J.V. (1984): FAO species catalogue: Sharks of the world. Vol. 4. An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. Rome: FAO Fisheries Synopsis.

Cotton, C.F. & R.D. Grubbs (2015): Biology of deep-water chondrichthyans: introduction. Deep Sea Res. Part II Top. Stud. Oceanogr., 115. https://doi.org/10.1016/j.dsr2.2015.02.030.

Daban, B., A. İşmen, M. Şirin, C.C. Yığın & M. Arslan İhsanoğlu (2021): Analysis of demersal fish fauna off the sea of Marmara, Turkey. COMU J. Mar. Sci. Fish, 4, 20-31.

Damalas, D., P. Peristeraki, C. Gubili, M. Lteif, M. Otero, I. Thasitis, M. Ali, S. Jemaa, Ch. Mytilineou, S. Kavadas & M.M.S. Farrag (2022): Vulnerable megafauna. Deep-sea cartilaginous fish. In Otero, M., Mytilineou, C. (Eds.), Deep-sea Atlas of the Eastern Mediterranean Sea (pp. 185-237). IUCN-HCMR DeepEastMed Project. Publisher, IUCN Gland, Malaga.

De Maddalena, A. & M. Zuffa (2003): A gravid female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), caught off Elba Island (Italy, northern Tyrrhenian Sea). Annales, Ser. Hist. Nat., 13, 167-172.

Deveciyan, K. (1926): Peĉhe et Pećheries en Turquie. İstanbul: Imprimerie de l'Administration de la Dette Publique Ottomane.

Ebert, D.A. (2013): Deep–sea Cartilaginous Fishes of the Indian Ocean. Volume 1. Sharks. FAO Species Catalogue for Fishery Purposes. No. 8, Vol. 1. Rome, FAO. 256 pp.

Ebert, D.A. (2015): Deep–sea cartilaginous fishes of the Southeastern Atlantic Ocean. FAO Species Catalogue for Fishery Purposes. No. 9. Rome, FAO. 251 pp.

Ebert, D.A., & M.F.W. Stehmann (2013): Sharks, batoids and chimaeras of the North Atlantic. Rome: FAO Species Catalogue for Fishery Purposes, No. 7.

Finucci, B., K.K. Bineesh, C.F. Cotton, D.W. Kulka, F.C. Neat, C. Pacoureau, C.L. Rigby, S. Tanaka & T.I. Walker (2020a): *Centrophorus uyato*. The IUCN Red List of Threatened Species 2020: e.T41745A124416090. https://dx.doi.org/10.2305/IUCN.UK.2020- 3.RLTS.T41745A124416090.en

Finucci, B., K.K. Bineesh, J. Cheok, C.F. Cotton, D.W. Kulka, F.C. Neat, N. Pacoureau, C.L. Rigby, S. Tanaka & T.I. Walker (2020b): *Echinorhinus brucus*. The IUCN Red List of Threatened Species 2020: e.T41801A2956075. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T41801A2956075.en

Follesa, M.C., M.F. Marongiu, W. Zupa, A. Bellodi, A. Cau, R. Cannas, F. Colloca, M. Djurovic, I. Isajlovic, A. Jadaud, C. Manfredi, A. Mulas, P. Peristeraki, C. Porcu, S. Ramirez-Amaro, F.S. Jiménez, F. Serena, L. Sion, I. Thasitis, A. Cau & P. Carbonara (2019): Spatial variability of Chondrichthyes in the northern Mediterranean. In: Mediterranean demersal resources and ecosystems: 25 years of MEDITS trawl surveys (M.T. Spedicato, G. Tserpes, B. Mérigot & E. Massutí, eds.) Sci. Mar., 83S1, 81-100. https://doi.org/10.3989/scimar.04998.23A.

Hemida, F. & C. Capapé (2002): Observations on a female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Chondrichthyes: Echinorhinidae), caught off the Algerian coast (southern Mediterranean). Acta Adriat., 43, 103-108.

Javadzadeh, N., G. Vosoughi, M.R. Fatemi, A. Abdoli & T. Valinassab (2011): The first record of mesopelagic shark, *Echinorhinus brucus* (Bonnaterre, 1788; Squaliformes; Echinorhinidae), from the Oman Sea, Iran. J. Appl. Ichthyol., 27, 1119. doi: 10.1111/j.1439-0426.2010.01615.x.

Kabasakal, H. (2009a): Observations on a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), in the Sea of Marmara (north-western Turkey). PANAMJAS, 4, 609-612.

Kabasakal, H. (2009b): On the occurrence of the bluntnose sixgill shark, *Hexanchus griseus* (Chondrichthyes: Hexanchidae), in the Sea of Marmara. Mar. Biodivers. Rec., 2, e110: 1-5; doi:10.1017/S1755267209001018.

Kabasakal, H. (2017): Remarks on incidental captures of deep-sea sharks in Marmaric shelf waters. Annales, Ser. Hist. Nat., 27, 37-144.

Kabasakal, H. (2022): Sharks of the Sea of Marmara: an overview on the sharks of a small inland sea. In: Öztürk, B., H. A. Ergül, A. C. Yalçıner & B. Salihoğlu (eds.), Proceedings of the Symposium "The Sea of Marmara 2022", Turkish Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 337-343.

Kabasakal, H. & M. Bilecenoğlu (2014): Not disappeared, just rare! Status of the bramble shark, *Echinorhinus brucus* (Elasmobranchii: Echinorhinidae) in the seas of Turkey. Annales, Ser. Hist. Nat., 24, 93-98.

Kabasakal, H. & C. Dalyan (2011): Recent records of the bramble shark, *Echinorhinus brucus* (Chondrichthyes: Echinorhinidae), from the Sea of Marmara. Mar. Biodiv. Rec., 4 (e12), 1-4.

Kabasakal, H., M.İ. Öz, S.Ü. Karhan, Z. Çaylarbaşı & U. Tural (2005): Photographic evidence of the occurrence of bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Squaliformes: Echinorhinidae) from the Sea of Marmara. Annales, Ser. Hist. Nat., 15, 51-56.

Kabasakal, H., A. Oruç, C. İlkılınç, E. Sevim, E. Kalecik & N. Araç (2022): Morphometrics of an incidentally captured little gulper shark, *Centrophorus uyato* (Squaliformes: Centrophoridae), from the Gulf of Antalya, with notes on its biology. Annales, Ser. Hist. Nat., 32, 351-358.

Kabasakal, H., S. Sakınan, L. Lipej & D. Ivajnšič (2023): A preliminary life history traits analysis of sharks in the Sea of Marmara (Türkiye), where deoxygenation and habitat deterioration are raising concerns. Aquat. Res., 6, 72-82. https://doi.org/10.3153/AR23008.

Kocataş, A., T. Koray, M. Kaya & Ö. F. Kara (1993): Review of the fishery resources and their environment in the Sea of Marmara. General Fisheries Council for the Mediterranean, Studies and Reviews No. 64, 87-143.

Kousteni, V., M. Papageorgiou, M. Rovatsos, I. Thasitis & L. Hadjioannou (2021): First genetically confirmed results of the little gulper shark *Centrophorus uyato* (Squaliformes: Centrophoridae) from Cypriot waters. Biodiversity Data Journal, 9, e71837. doi: 10.3897/BDJ.9.e71837.

Lteif, M., R. Mouwad, G. Khalaf, P. Lenfant, B. Seret & M. Verdoit-Jarraya (2017): Population biology of the little gulper shark *Centrophorus uyato* in Lebanese waters. J. Fish Biol., 91, 1491-1509. https://doi.org/10.1111/jfb.13484.

Mantıkçı, M., H. Örek, M. Yücel, Z. Uysal, S. Arkın & B. Salihoğlu (2022): Current oxygen status of the Sea of Marmara and the effect of mucilage. In: Öztürk, B., H. A. Ergül, A. C. Yalçıner & B. Salihoğlu (eds.), Proceedings of the Symposium "The Sea of Marmara 2022", Turkısh Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 18-24.

Megalofonou, P. & A. Chatzispyrou (2006): Sexual maturity and feeding of the gulper shark, *Centrophorus granulosus*, from the eastern Mediterranean Sea. Cybium, 30(4) suppl., 67-74.

Meriç, N. (1995): A study on existence of some fishes on the continental slope of the Sea of Marmara. Tr. J. of Zoology, 19, 191-198.

Ninni, E. (1923): Primo contributo allo studio dei pesci e della pesca nelle acque dell'Impero Ottomano. Venezia: Premiate Officine Grafiche Carlo Ferrari.

Rhasis Erazi, R.A. (1942): Marine fishes found in the Sea of Marmara and in the Bosphorus. İstanbul Üniversitesi Fen Fakültesi Mecmuası, Seri B, 7, 103-115.

Salihoğlu, B., B.F. Salihoğlu, D. Tezcan, S. Tuğrul, E. Akoğlu, K. Özkan & S. Arkın (2022): Sea of Marmara ecosystem under multiple stressors and rehabilitation plans. In: Öztürk, B., H. A. Ergül, A. C. Yalçıner & B. Salihoğlu (eds.), Proceedings of the Symposium "The Sea of Marmara 2022", Turkish Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 49-53.

Serena, F. (2005): Field Identification Guide to the Sharks and Rays of the Mediterranean and Black Seas. FAO Species Identification Guide for Fishery Purposes. Rome: FAO.

Serena, F., A.J. Abella, F. Bargnesi, M. Barone, F. Colloca, F. Ferretti, F. Fiorentino, J. Jenrette & S. Moro (2020): Species diversity, taxonomy and distribution of Chondrichthyes in the Mediterranean and Black Sea. The European Zoological Journal, 87, 497-536.

Sion, L., A. Bozzano, G. D'Onghia, F. Capezzuto & M. Panza (2004): Chondrichthyes species in deep waters of the Mediterranean Sea. Sci Mar., 68 (Suppl. 3), 153-162.

Ünlüata, Ü. & E. Özsoy (1988): Deep water renewals and oxygen deficiency in the Sea of Marmara. Rapp. Comm. int. Mer Médit., 32, 193.

Veríssimo, A., C.F. Cotton, R.H. Buch, J. Guallart & G.H. Burgess (2014): Species diversity of deep-water gulper sharks (Squaliformes: Centrophoridae: *Centrophorus*) in North Atlantic waters – current status and taxonomic issues. Zoological Journal of the Linnean Society, 172, 803-830.

White, W.T., J. Guallart, D.A. Ebert, G.J.P. Naylor, A. Veríssimo, C.E. Cotton, M. Harris, F. Serena & S.P. Iglésias (2022): Revision of the genus *Centrophorus* (Squaliformes: Centrophoridae): Part 3—Redescription of *Centrophorus uyato* (Rafinesque). with a discussion of its complicated nomenclatural history. Zootaxa, 5155, 001-051. https://doi.org/10.11646/zootaxa.5155.1.1

received: 2023-03-29 DOI 10.19233/ASHN.2023.06

ADDITIONAL CAPTURES OF SMOOTHBACK ANGEL SHARK *SQUATINA OCULATA* (SQUATINIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN SEA)

Khadija OUNIFI-BEN AMOR, Mohamed Mourad BEN AMOR & Marouène BDIOUI
Institut National des Sciences et Technologies de la Mer, port de pêche, 2025 La Goulette, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

ABSTRACT

The present paper reports the captures of two specimens of smoothback angelshark Squatina oculata *Bonaparte, 1840 from the northern Tunisian coast. The specimens were two large females measuring 1.70 m and 1.60 m in total length and weighed 30 kg and 25 kg in total body weight, respectively. The smaller female carried yellow yolked oocytes and was probably at the beginning of its pregnancy. A total of eight smoothback angelsharks were caught between 2005 and 2021, which indicates a decline of captures in the area. However, the species is not extinct, but as in all Mediterranean regions it needs a management plan to preserve viable populations.*

Key words: *Squatina oculata*, distribution, viable populations, management plan, large specimens

NUOVE CATTURE DI SQUADRO PELLE ROSSA *SQUATINA OCULATA* (SQUATINIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Il presente lavoro riporta la cattura di due esemplari di squadro pelle rossa Squatina oculata *Bonaparte, 1840 lungo la costa tunisina settentrionale. Gli esemplari erano due femmine di grandi dimensioni che misuravano 1,70 m e 1,60 m di lunghezza totale e pesavano rispettivamente 30 kg e 25 kg di peso corporeo totale. La femmina più piccola portava ovociti gialli e probabilmente era all'inizio della gravidanza. Tra il 2005 e il 2021 sono stati catturati in totale otto esemplari di squadro pelle rossa, il che indica un calo delle catture nell'area. Tuttavia, la specie non è estinta, ma come in tutte le regioni mediterranee necessita di un piano di gestione per preservare popolazioni vitali.*

Parole chiave: *Squatina oculata,* distribuzione, popolazioni vitali, piano di gestione, grandi esemplari

INTRODUCTION

The smoothback angelshark *Squatina oculata* Bonaparte, 1840 is known in the eastern tropical Atlantic waters extending from Morocco (Lloris & Rucabado, 1998) to probably Angola (Roux, 1984). From off the coasts of Senegal downwards it is abundant enough to allow the study of some traits of the reproductive biology of the species (Capapé *et al*., 2002). *S. oculata* is of important economic interest in the area, targeted by craft fisheries and landed in relative abundance at local fishing sites (Diatta, *pers. comm*., 2023).

In the Mediterranean Sea, *Squatina oculata* occurs together with two congeneric species, the sawback angelshark *S. aculeata* Cuvier, 1829 and the common angelshark *S. squatina* (Linnaeus, 1758). (Roux, 1984). *S. oculata* appears to be unknown off the Mediterranean coast of France (Capapé *et al*., 2000), conversely, Tortonese (1956) noted its occurrence in Italian waters, and Zava *et al*. (2016) collected 4 juvenile specimens from the Strait of Sicily. Additionally, Zava *et al*. (2022) observed 21 specimens off the Malta Islands.

S. oculata is reported from the eastern Mediterranean, where its occurrence was first confirmed in the Levant Basin (Golani, 2005) and furtherly reported from the Syrian coast (Ali, 2018) and the Lebanese coast (Bariche & Fricke, 2020). Ergüden *et al*. (2019) listed the records of *S. oculata* throughout the Turkish waters, but the species is considered rather rare in the region and caught only sporadically.

S. oculata used to be reported as relatively abundant off the Tunisian coast, especially in the northern areas, and information on its reproductive biology was provided (Capapé *et al*., 1990). Southwards, Bradaï *et al*. (2002) reported captures of specimens in the Gulf of Gabès. Six specimens were detected between 2005 and 2021 in Tunisian marine waters according to Zava *et al*. (2022). The present paper reports two more captures of *S. oculata* specimens that occurred during 2021 in the same area.

MATERIAL AND METHODS

The first specimen of *S. oculata* was caught on 25 April 2021, by trammel net at a depth of 61-62 m, over a sandy-muddy bottom, together with specimens of common cuttlefish *Sepia officinalis* Linnaeus, 1758 and starry weever *Trachinus radiatus* Cuvier, 1829. The capture occurred off the fishing site of Sidi Daoud (37°3′51′′ N and 10°57′39′′ E), where it was landed (Fig. 1).

The second specimen was caught on 27 April 2021, by trammel net at a depth of 30-35 m, over a sandy-muddy bottom, together with specimens of

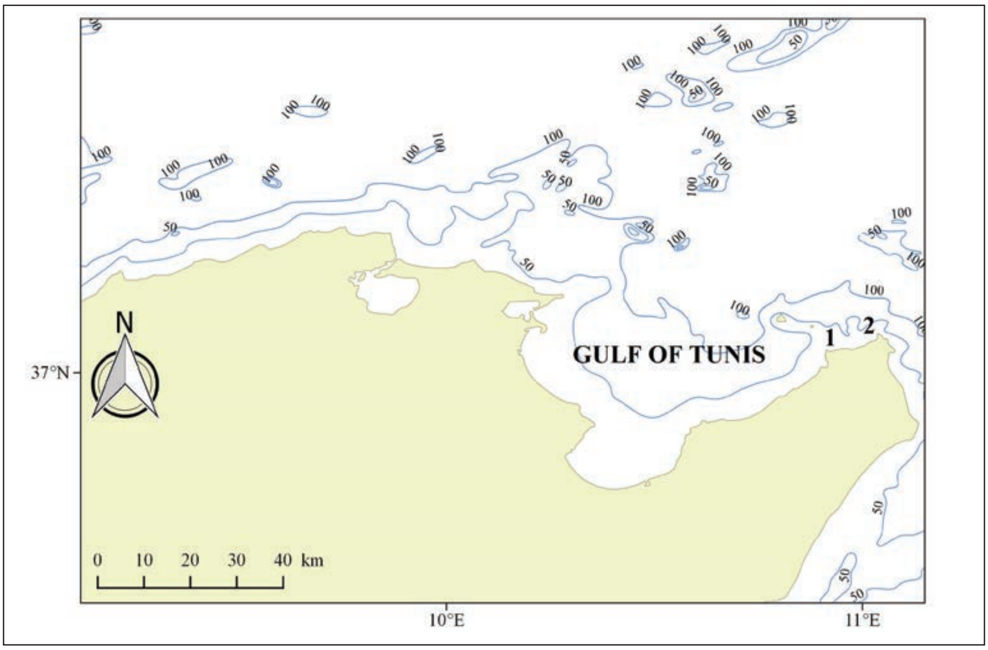

Fig. 1: Map of the northern Tunisian coast indicating: 1. Capture site of the first *Squatina oculata* ***off Sidi Daoud. 2. Capture site of the second*** *S. oculata* ***off El Haouaria.***
Sl. 1: Zemljevid severne tunizijske obale z označenimi: 1. Lokaliteta ulova prvega primerka vrste *Squatina oculata* ***v vodah blizu Sidi Daoud. 2. Lokaliteta ulova drugega primerka vrste*** *Squatina oculata* ***v vodah blizu El Haouaria.***

Fig. 2. First *Squatina oculata* ***captured off Sidi Daoud, with front of head showing: 1. barbels bordering a fringed median lobe, 2. dermal folds on sides of head slightly undulated, scale bar = 500 mm.***
Sl. 2: Prvi primerek vrste *Squatina oculata****, ujet v vodah blizu Sidi Daoud; sprednji del glave kaže: 1. Izrastke, ki mejijo na resasti srednji reženj, 2. Rahlo nagubane kožne gube na straneh glave, merilo = 500 mm.***

Fig. 3: Second *Squatina oculata* ***captured off El Haouaria, scale bar = 500 mm.***
Sl. 3: Drugi primerek vrste *Squatina oculata* ***ujet v vodah blizu El Haouaria.***

smoothhound *Mustelus mustelus* (Linnaeus, 1758), John Dory *Zeus faber* Linnaeus, 1758, and *T. radiatus*. The capture occurred off the fishing site of El Haouaria (37°3′51′′ N and 11°1′10′′ E), where it was landed (Fig. 1). Both specimens were measured for total length (TL) and total body weight (TBW), the information was provided by the fishermen. The specimens were cut into slices and rapidly sold, and no morphometric measurements could be carried out at the fishing sites.

RESULTS AND DISCUSSION

The first specimen was a female measuring 1.70 m TL and weighing 30 kg TBW (Fig. 2). The second specimen, also a female, measured 1.60 m TL, weighed 25 kg and carried yellow yolked oocytes (Fig. 3). Both specimens were identified as *S. oculata* based on the combination of the following main morphological characters: trunk very broad; eye diameter equal or larger than spiracle length; external nasal flap with two barbels bordering a fringed median lobe (Fig. 2.1); dermal folds on sides of head slightly undulated (Fig. 2.2); pectoral fins very high and broad with rounded rear tips; hind tips of pelvic fins not reaching the level of first dorsal fin origin, dorsal surface rough with a median line of small spines, lower surface with small denticles only on front margin of pectoral and pelvic fins and down the centre of tail; teeth pointed, slightly curved at the distal end and with triangular base; greyish-brown back with some white spots, belly beige. The description and colour of both specimens are in complete accordance with Roux (1986), Capapé & Roux (1980), Compagno (1984), Kabasakal and Kabasakal (2014), Ergüden *et al.* (2019), Rafrafi-Nouira *et al.* (2022), and Akyol *et al.* (2023).

Roux (1984) state the maximum TL for *S. oculata* to be 1.50 m and TWB 35 kg. Later, Ergüden *et al.* (2019) suggested that the species could reach up to 160 cm TL, with a common TL of 120 cm. Rafrafi-Nouira *et al.* (2022) reported the captures of two large specimens from the northern Tunisian coast measuring 1350 mm and 1400 mm, respectively, while the present specimens are the largest known to date in this area and probably outside it as well. It appears that between 2002 and 2022 a total of eight specimens were captured in the entire Tunisian coast, which could suggest a drastic decline of the species' population. However, according to the data provided by Zava *et al*. (2022), a total of 32 specimens were captured in the central Mediterranean Sea, among them five neonate specimens and one female at the beginning of its pregnancy like in the present study. This would seem to indicate that a viable population still exists in the region, and possibly one or more nursery grounds. Akyol *et al.* (2023) listed the captures of specimens from the eastern Mediterranean between 1996 and the present and noted a permanent presence of the species in the region despite scarce captures. Therefore, based on the data provided by Ergüden *et al*. (2019), Rafrafi-Nouira *et al.* (2022), Zava *et al*. (2022) and Akyol *et al*. (2023), we can conclude that the species is not extinct in the Mediterranean Sea despite facing significant fishing pressure as a result of its *k*-selected reproductive characteristics.

Therefore, following Ergüden *et al*. (2019), Kabasakal (2021), Zava *et al.* (2022) and Akyol *et al.* (2023), a management plan should be developed that involves local fisheries and encourages the active participation of fishermen. They are aware of the crucial role they can play in preserving *S. oculata* and preventing its extinction in areas where it is typically found.

ACKNOWLEDGEMENTS

The authors are grateful to the professional fishermen from the Cape Bon area (northeastern Tunisia) for their kind and helpful assistance.

NOVA ULOVA PEGASTEGA SKLATA *SQUATINA OCULATA* (SQUATINIDAE) IZ TUINIZIJSKE OBALE (OSREDNJE SREDOZEMSKO MORJE)

Khadija OUNIFI-BEN AMOR, Mohamed Mourad BEN AMOR & Marouène BDIOUI
Institut National des Sciences et Technologies de la Mer, port de pêche, 2025 La Goulette, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

POVZETEK

V prispevku avtorji poročajo o ulovu dveh primerkov pegastega sklata Squatina oculata *Bonaparte, 1840 iz severne tunizijske obale. Bili sta veliki samici, od katerih je prva merila 1,70 m v dolžino in tehtala 30 kg, druga pa je merila 1,60 m in tehtala 25 kg. Manjša samica je imela rumene oocite z rumenjakom in je bila verjetno na začetku obdobja brejosti. Med leti 2005 in 2021 je bilo ujetih osem pegastih sklatov, kar kaže na upad števila ulovov v obravnavanem predelu. Kakorkoli že, vrsta še ni izumrla, je pa potrebno poskrbeti za načrt upravljanja, da bi uspeli zagotoviti vijabilne populacije.*

Ključne besede: *Squatina oculata*, razširjenost, vijabilne populacije, načrt upravljanja, veliki primerki

REFERENCES

Akyol, A., T. Çoker, H. Bernil Toprak & C. Capapé. (2023): Capture of a rare smoothback angelshark *Squatina oculata* (Squatinidae) in Turkish waters, with updated records from the eastern Mediterranean Sea. Nat. Engin. Sci., 8(1), 38-45.

Ali, M. (2018): An updated checklist of marine fishes from Syria with an emphasis on alien species. Medit. Mar. Sci., 19(2), 388-393.

Bariche, M. & R. Fricke (2020): The marine ichthyofauna of Lebanon: an annotated checklist, history, biogeograpphy, and conservation status. Zootaxa, 4775(1), 1-157.

Bradaï M.N., B. Saïdi, M. Ghorbel, A. Bouaïn, O. GuÉlorget & C. Capapé (2002): Observations sur les requins du golfe de Gabès (Tunisie méridionale, Méditerranée centrale). Mésogée, 60, 61-77.

Capapé, C. & C. Roux (1980): Etude anatomique des ptérygiopodes des Squatinidæ (Pisces, Pleurotremata) des côtes tunisiennes. Bull. Mus. Natn Hist. Nat., Paris, 4 ème série, 2ème section A, 4, 1161-1180.

Capapé, C., J.-P. Quignard & J. Mellinger (1990): Reproduction and development of two angel sharks, *Squatina squatina* and *S. oculata* (Pisces: Squatinidæ), off Tunisian coasts: semi-delayed vitellogenesis, lack of egg-capsules and lecithotrophy. J. Fish Biol., 37(3), 347-356.

Capapé, C., J.A Tomasini. & J.-P. Quignard (2000): Les Elasmobranches Pleurotrêmes de la côte du Languedoc (France méridionale, Méditerranée septentrionale). Observations biologiques et démographiques. Vie Milieu, 50(2), 123-133.

Capapé, C., A.A. Seck., A. Gueye-Ndiaye, Y. Diatta & M. Diop (2002): Reproductive biology of the smoothback angelshark, *Squatina oculata* (Elasmobranchii: Squatinidae), from the coast of Senegal (eastern tropical Atlantic). J. Mar. Biol. Assoc. U. K., 82(4), 635-640.

Compagno, L.J.V. (1984): FAO Species Catalogue, vol. 4, Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species known to Date. FAO Fisheries Synopsis, 125, vol. 4, part 1 (non carcharhinoids): viii+1–250 pp.

Ergüden, D., D. Ayas, M. Gürlek, S. Karan & C. Turan (2019): First documented smooth angelshark, *Squatina oculata* Bonaparte, 1840. Cah. Biol. Mar., 60(2), 189-194.

Golani, D. (2005): Check-list of the Mediterranean Fishes of Israel. Zootaxa, 2005 (947), 1-200.

Kabasakal, H. (2021): Chapters from life history of common angel shark *Squatina squatina,* from Turkish waters:a historical, ethnoichthoylogical and contemporary approach to a litle-known shark species. J. Black Sea/ Medit. Environ, 27(3), 317-341.

Kabasakal, H. & E. Kabasakal (2004): Sharks captured by commercial fishing vessels off the coasts of Turkey in the Northern Aegean Sea. Annales, Ser. Hist. Nat., 14(2), 171-180.

Lloris, D. & J. Rucabado (1998): Guide FAO d'identification des espèces pour les besoins de la pêche. Guide d'identification des ressources marines vivantes pour le Maroc. FAO, Rome, 263 pp.

Rafrafi-Nouira, S., M. Chérif, C. Reynayd & C. Capapé (2022): Captures of the rare smoothback angelshark *Squatina oculata* (Squatinidaer) from the Tunisian coast (Central Mediterranean Sea). Thalassia salentina, 44, 3-8.

Roux, C. (1984): Squatinidae. In: Whitehead, P.J.P., M.L. Bauchot, J.-C. Hureau., J. Nielsen J. & Tortonese. E. (eds.), pp. 83-88. Fishes of the North-eastern Atlantic and the Mediterranean, Vol 1, Unesco, Paris.

Tortonese, E. (1956): Fauna d'Italia, Vol. II. Leptocardia, Ciclostomata, Selachii., Calderini, Bologna, Italy. [In Italian.], 332 pp.

Zava, R., F. Fiorentino & F. Serena (2016): Occurrence of juveniles *Squatina oculata* Bonaparte, 1840 (Elasmobranchii: Squatinidae) in the Strait of Sicily (Central Mediterranean). Cybium, 40(4), 341-343.

Zava, B., G. Insacco, A. Deidun, A. Said, J. Ben Suissi, O.M. Nour, G. Kondylatos, D. Scannella & M. Corsini-Foka (2022): Records of the critically endangered *Squatina aculeata* and *Squatina oculata* (Elasmobranchii: Squatiniformes: Squatinidae) from the Mediterranean Sea. Acta Ichthyol. Piscat., 52(4), 285–297.

received: 2022-10-21 DOI 10.19233/ASHN.2023.07

ON A LARGE SHORTFIN MAKO SHARK *ISURUS OXYRINCHUS* (LAMNIDAE) OBSERVED AT PANTELLERIA (CENTRAL MEDITERRANEAN SEA)

Alessandro DE MADDALENA
Shark Museum, 26 Forest Hill Road, Simon's Town, 7975 Cape Town, South Africa
e-mail: alessandrodemaddalena@gmail.com

Marco Giovanni BONOMO
Dive-y Cala Levante, Strada dell'arco dell'elefante, 91017 Pantelleria (TP), Italy
e-mail: marco-bonomo@hotmail.it

Andrea CALASCIBETTA
Avvistiamo, Via marchese di villabianca 24, 90143 Palermo, Italy
e-mail: avvistiamo@gmail.com

Lorenzo GORDIGIANI
Avvistiamo, Via marchese di villabianca 24, 90143 Palermo, Italy
e-mail: avvistiamo@gmail.com

ABSTRACT

A large female shortfin mako shark, Isurus oxyrinchus *Rafinesque, 1810, was observed on 7 October 2022 near Pantelleria, in the Strait of Sicily, Italy. The total length was carefully estimated at 350-370 cm based on a comparison with a 690 cm boat. This specimen is one of the largest* I. oxyrinchus *photographed and filmed alive in the Mediterranean waters.*

Key words: shortfin mako shark, *Isurus oxyrinchus*, Pantelleria, Italy, Mediterranean Sea

IN MERITO A UN GRANDE SQUALO MAKO DALLE PINNE CORTE *ISURUS OXYRINCHUS* (CHONDRICHTHYES: LAMNIDAE) OSSERVATO A PANTELLERIA, ITALIA

SINTESI

Un'enorme femmina di squalo mako dalle pinne corte Isurus oxyrinchus *Rafinesque, 1810, è stato osservato nei pressi di Pantelleria, nel Canale di Sicilia, in Italia, il 7 ottobre 2022. La lunghezza totale dell'esemplare è stata stimata con accuratezza tra 350 e 370 cm sulla base delle dimensioni dell'imbarcazione di 690 cm. Tale esemplare è uno dei più grandi della sua specie fotografati e filmati vivi in acque mediterranee.*

Parole chiave: squalo mako dalle pinne corte, *Isurus oxyrinchus*, Pantelleria, Italia, mare Mediterraneo

INTRODUCTION

The shortfin mako *Isurus oxyrinchus*, Rafinesque, 1810, inhabits temperate and tropical waters of the Atlantic, Pacific and Indian Oceans. It is pelagic, coastal and oceanic, occurring at a depth range from 0 to 500 m (Compagno, 2001). The shortfin mako is present in the entire Mediterranean (De Maddalena & Baensch, 2005), where it is caught mainly by tuna longline fisheries and occasionally by swordfish fisheries using longlines and driftnets (Celona *et al*., 2004; Megalofonou *et al*., 2005). Although the majority of shortfin mako catches are recorded in pelagic fisheries, in a recent report, Kabasakal (2015) emphasized that new-born and juvenile specimens of *I. oxyrinchus* can be incidentally caught by coastal stationary netting and bottom longline fishing, as well. Data on the presence of the species in the Strait of Sicily has also been reported in recent years by Rafrafi-Nouira *et al.* (2019).

In the present article we report a record of a large shortfin mako spotted in October 2022 by sport fishermen at Pantelleria, in Italian Mediterranean waters.

MATERIAL AND METHODS

On the morning of 7 October 2022, five sport fishermen, the second author (M.G. Bonomo), Enio Koshi, Emanuele Rizzo, Antonio Rizzo, and Peppino Bencivenga, were aboard a 6.9 m long boat in the waters of Pantelleria, Italy, in the central Mediterranean Sea. The anglers were trolling for little tunny, *Euthynnus alletteratus* (Rafinesque, 1810), without chum. The little tunny were intended to be used later as bait for greater amberjacks, *Seriola dumerili* (Risso, 1810).

RESULTS AND DISCUSSION

During the morning, the anglers caught two little tunny measuring about 40 cm in total length. At 12:00 p.m., with an almost completely calm sea and sunny weather, the dorsal fin of a shark was observed in 40 m deep blue waters, at 36.82895° N and 11.91366° E, 0.7 nautical miles north of Pantelleria. The large shark was observed by the anglers for 30 minutes (Fig. 1). They were the only boat in the area at that moment, but other boats could be seen far in the distance. The shark was accompanied by many pilotfish, *Naucrates ductor* (Linnaeus, 1758), swimming close to the shark's pectoral area (Fig. 2). Several copepods were attached to the skin of the shark, more numerous on the lower jaw and on the gills. The shark showed no interest in the boat and let it approach repeatedly. At one point, the second author briefly touched the dorsal fin of the shark with his hand without the animal showing any reaction. Later, the shark dived under the boat a few times, incurring some light whitish abrasions on the skin of the head and the apex of the first dorsal fin. At 12:30 p.m. the shark suddenly dived and apparently left the area.

After the encounter the sport fishermen didn't resume fishing, rather returned to the harbour. Many pictures and short videos of the shark were shot by the second author with an iPhone 13 pro and an iPhone 11 for subsequent analysis. The images show the shark as seen from the boat and underwater. Some of these images were uploaded to social media, raising increased public attention to this case.

Some evident morphological features, including the markedly spindle-shaped body, pointed conical snout, presence of wide caudal keel, lunate caudal fin, long gill slits, high and erect first dorsal fin, and greyish blue colouration with strong metallic reflection on the flanks, allowed the authors to make an immediate identification of the animal as an unusually large shortfin mako shark. Additionally, the underwater images clearly showing the shape of the teeth – long, curved and pointed, with cutting edges, and protruding from the mouth in the lower jaw–left no doubt as to the identification of the species. The length of pectoral fins, markedly longer than in an average shortfin mako, is in accordance with the observation reported in Lopez-Mirones *et al.* (2020), that while newborns of *I. oxyrinchus* have very short pectoral fins, these get conspicuously longer as the individual grows.

The coloration of the underside of the snout and the lower jaw is dusky (Fig. 3), similar to the *marrajo criollo* form that was postulated by Moreno & Moron (1992) to be endemic to the Azores.

Fig. 1: The female shortfin mako shark *Isurus oxyrinchus* ***Rafinesque, 1810, estimated 350-370 cm TL, observed near Pantelleria, Italy, on 7 October 2022 (photo by Marco Giovanni Bonomo).***
Sl. 1: Samica atlantskega maka, *Isurus oxyrinchus* ***Rafinesque, 1810, ocenjena na 350 do 370 cm telesne dolžine, opažena sedmega oktobra 2022 blizu Pantellerie (Italija) (foto: Marco Giovanni Bonomo).***

Fig. 2: The shark was accompanied by at least 27 pilotfish, *Naucrates ductor* ***(Linnaeus, 1758), swimming close to its pectoral area (photo by Marco Giovanni Bonomo).***
Sl. 2: Morskega psa je spremljalo vsaj 27 pilotov *Naucrates ductor* ***(Linnaeus, 1758), ki so plavali blizu prsnih plavuti (foto: Marco Giovanni Bonomo).***

On the dorsal and lateral surfaces of the trunk there were several bite scars that are likely the result of love bites by another mako (Fig. 4).

The pictures and a video allowed the observation of the pelvic area, including a glimpse of the pelvic fin's free rear tip, which revealed the absence of claspers. We could therefore conclude that the observed shark was a female.

The size of the shark was carefully estimated by the second author at 350-370 cm total length (TL), based on the size of the boat, which was 690 cm.

The estimated size of the mako observed at Pantelleria is unusual for *I. oxyrinchus*. A study of 199 shortfin mako sharks showed an average total length of 171 cm (Kohler *et al*., 1996). However, this species can sometimes attain much larger sizes. Several huge specimens have been recorded in the Mediterranean area. The largest shortfin mako reported to date worldwide was a female caught in the late 1950s in the Aegean Sea off Marmaris, Turkey, which was estimated at 585 cm TL with a 577-619 cm range (Kabasakal & De Maddalena, 2011). An estimated 500 cm long female was observed on 28 June 2018 near Cabrera Grande, in the Balearic Islands, Spain (Lopez-Mirones *et al*., 2020). A 445 cm long specimen was caught off Six-Fours-les-Plages, France, in September 1973 (Capapé, 1977). A 425 cm long shortfin mako was caught off La Galite Island, Tunisia, on 24 September 1876, and its jaws are preserved in the Natural History Museum of Genoa, Italy (Doria & Gestro, 1877). An estimated 400-430 cm long female was observed on 21 June 2011 near Capraia, in the Tuscan Archipelago, Italy (De Maddalena & Heim, 2012). Lawley (1881) reported a 4-metre-long specimen that weighed 1000 kg, which was observed in a fishmonger's warehouse in Livorno and had been caught off Piombino, Italy. A 400 cm long shortfin mako captured off Caska, Novalja, Croatia, on 13 May 1882 was reported by Brusina (1888). A 390 cm long shortfin mako was caught on 30 November 1991 off Bagnara Calabra, Italy (Storai *et al*., 2001). Another 390 cm long specimen, weighing 513 kg, was caught on 20 September 2000 off Punta Alice, Italy (Storai *et al*., 2001). A 390 cm long female was caught on 26 July 2003 off

Fig. 3: The coloration of the underside of the snout and the lower jaw is dusky, similar to the* marrajo criollo *form that was postulated by Moreno & Moron (1992) to be endemic to the Azores (photo by Marco Giovanni Bonomo).
Sl. 3: Obarvanost spodnjega dela gobca in spodnje čeljusti je temna, podobno kot sta to opisala Moreno & Moron (1992) (*marrajo criollo*) (foto: Marco Giovanni Bonomo).

Scaletta Zanclea, Italy. A 380 cm long female was caught in summer 2012, by a commercial purse-seiner operating in İskenderun Bay, eastern Levantine Sea (Kabasakal, 2015). Another female, measuring 370 cm TL, was caught between Portopalo di Capo Passero and Marzamemi, Italy, on 22 June 2004 (Celona *et al*., 2004).

The estimated 350-370 cm TL female shortfin mako shark observed near Pantelleria is one of the largest of its species to be photographed and filmed alive in Mediterranean waters.

It is also of interest to note that the number of pilotfish accompanying the shark – at least 27 could be counted – was unusually large for a mako, more similar to that normally found in the oceanic whitetip shark, *Carcharhinus longimanus* (Poey, 1861).

ACKNOWLEDGEMENTS

The authors wish to thank Eric Glenn Haenni for taking the time to edit the manuscript. Marco Giovanni Bonomo thanks Enio Koshi, Emanuele Rizzo, Antonio Rizzo, Peppino Bencivenga, that were on board with him at the time of the observation reported in this article. Alessandro De Maddalena thanks Alessandra, Antonio and Phoebe for their support and love. Lorenzo Gordigiani thanks Sofia for her continuous support.

Fig. 4: On the dorsal and lateral surfaces of the trunk there are several bite scars that are likely the result of love bites by another mako (photo by Marco Giovanni Bonomo).
Sl. 4: Na hrbtnih in bočnih površinah trupa so vidne številne brazgotine, ki jih je najverjetneje povzročil drugi primerek maka (foto: Marco Giovanni Bonomo).

O VELIKEM PRIMERKU ATLANTSKEGA MAKA, *ISURUS OXYRINCHUS* (LAMNIDAE), OPAŽENEGA BLIZU PANTELLERIE (OSREDNJE SREDOZEMSKO MORJE)

Alessandro DE MADDALENA
Shark Museum, 26 Forest Hill Road, Simon's Town, 7975 Cape Town, South Africa
e-mail: alessandrodemaddalena@gmail.com

Marco Giovanni BONOMO
Dive-y Cala Levante, Strada dell'arco dell'elefante, 91017 Pantelleria (TP), Italy
e-mail: marco-bonomo@hotmail.it

Andrea CALASCIBETTA
Avvistiamo, Via marchese di villabianca 24, 90143 Palermo, Italy
e-mail: avvistiamo@gmail.com

Lorenzo GORDIGIANI
Avvistiamo, Via marchese di villabianca 24, 90143 Palermo, Italy
e-mail: avvistiamo@gmail.com

POVZETEK

Sedmega oktobra 2022 so avtorji blizu Pantellerie v sicilskem prelivu (Italija) opazovali večji primerek samice atlantskega maka, Isurus oxyrinchus *Rafinesque, 1810. Celotno dolžino so glede na dolžino plovila, ki je bila 690 cm, ocenili na 350 do 370 cm. Opazovani primerek je eden izmed največjih primerkov vrste* I. oxyrinchus*, ki so bili doslej fotografirani ali posneti v sredozemskih vodah.*

Ključne besede: atlantski mako, *Isurus oxyrinchus*, Pantelleria, Italija, Sredozemsko morje

REFERENCES

Brusina, S. (1888): Morski psi Sredozemnoga i Crljenog mora (Sharks of the Adriatic and the Black Sea). Glasnik hrvatskoga naravoslovnoga družtva, III, 167-230, Zagreb.

Capapé, C. (1977): Liste commentée des sélachiens de la région de Toulon (de La Ciotat à Saint-Tropez). Bull. Mus. Hist. Nat. Marseille, 37, 5-9.

Celona, A., L. Piscitelli & A. De Maddalena (2004): Two large shortfin makos, *Isurus oxyrinchus*, Rafinesque, 1809, caught off Sicily, western Ionian Sea. Annales, Ser. Hist. Nat., 14, 35-42.

Cliff, G., S.F.J. Dudley & B. Davis (1989): Sharks caught in the protective gill nets off Natal, South Africa. 3. The shortfin mako shark *Isurus oxyrinchus* (Linnaeus). S. Afr. J. Mar. Sci., 9, 115-126.

Compagno, L.J.V. (2001): Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Volume 2. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO Species Catalogue for Fishery Purposes. No. 1, Vol. 2. FAO, Rome, 269 pp.

De Maddalena, A. & H. Baensch (2005): Haie im Mittelmeer. Franckh-Kosmos Verlags-GmbH & Co., Stuttgart, 240 pp.

De Maddalena, A. & W. Heim (2012): Mediterranean Great White Sharks. A Comprehensive Study Including All Recorded Sightings. McFarland, Jefferson, 254 pp.

De Maddalena, A., A. Preti & R. Smith (2005): Mako sharks. Krieger Publishing, Malabar, 72 pp.

De Maddalena, A., M. Zuffa, L. Lipej & A. Celona (2001): An analysis of the photographic evidences of the largest great white sharks, *Carcharodon carcharias* (Linnaeus, 1758), captured in the Mediterranean Sea with considerations about the maximum size of the species. Annales, Ser. Hist. Nat., 11, 193-206.

Doria, G. & R. Gestro (1877): Crociera del "Violante" comandato dal capitano armatore Enrico D'Albertis durante l'anno 1876. Ann. Mus. Civ. Sto. Nat. "G. Doria", Genova, 11, 302-304.

Kabasakal, H. (2015): Occurrence of shortfin mako shark, *Isurus oxyrinchus* Rafinesque, 1810, off Turkey's coast. Marine Biodiversity Records. doi:10.1017/S1755267215001104, Vol. 8, e134.

Kabasakal, H. & A. De Maddalena (2011): A huge shortfin mako shark *Isurus oxyrinchus* Rafinesque, 1810 (Chondrichthyes: Lamnidae) from the waters of Marmaris, Turkey. Annales, Ser. Hist. Nat., 21(1), 21-24.

Kohler, N.E., J.G. Casey & P.A. Turner (1996): Length-length and length-weight relationships for 13 shark species from the Western North Atlantic. NOAA Tech. Memo. NMFS-NE-110, 1-22.

Lawley, R. (1881): Studi comparativi sui pesci fossili coi viventi dei generi *Carcharodon, Oxyrhina* e *Galeocerdo*. Nistri, Pisa, 151 pp.

Lopez-Mirones, F., A. De Maddalena & R. Sagarminaga Van Buiten (2020): On a huge shortfin mako shark *Isurus oxyrinchus* Rafinesque, 1810 (Chondrichthyes: Lamnidae) observed at Cabrera Grande, Balearic Islands, Spain. Annales, Ser. Hist. Nat., 30(1), 25-30.

Megalofonou, P., C. Yannopoulos, D. Damalas, G. De Metrio, M. Deflorio, J.M. De La Serna & D. Macias (2005): Incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea. Fish. Bull., 103, 620-634.

Moreno, J.A. & J. Moron (1992): Comparative study of the genus *Isurus* (Rafinesque, 1810) and description of a form ('*marrajo criollo*') apparently endemic to the Azores. Australian Journals of Scientific Research, 43(1), 109–122.

Rafrafi-Nouira, S., Y. Diatta, A. Diaby & C. Capapé (2019): Additional records of rare sharks from Northern Tunisia (Central Mediterranean Sea). Annales, Ser. Hist. Nat., 29(1), 25-34.

Storai, T., M. Zuffa & R. Gioia (2001): Evidenze di predazione su odontoceti da parte di *Isurus oxyrinchus* (Rafinesque, 1810) nel Tirreno Meridionale e Mar Ionio (Mediterraneo). Atti Soc. tosc. Sci. nat., Mem., Serie B, 108, 71-75.

IHTIOFAVNA

ITTIOFAUNA

ICHTHYOFAUNA

received: 2022-12-11 DOI 10.19233/ASHN.2023.08

THE FIRST WELL-DOCUMENTED RECORD OF MALTESE SKATE *LEUCORAJA MELITENSIS* (RAJIDAE) FROM THE ALGERIAN COAST (SOUTHWESTERN MEDITERRANEAN SEA)

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

Christian REYNAUD
Laboratoire Interdisciplinaire en Didactique, Education et Formation, Université de Montpellier, 2, place Marcel Godechot, B.P. 4152, 34092 Montpellier cedex 5, France

Farid HEMIDA
École Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral (ENSSMAL), BP 19, Bois des Cars, 16320 Dely Ibrahim, Algiers, Algeria

ABSTRACT

The authors present a well-documented record of the first specimen of Maltese skate Leucoraja melitensis *(Clark, 1926) ever to be reported from the coast of Algeria. According to data provided by the fishermen, it was an adult male measuring 253 mm in disc width, 232 mm in disc length and 455 mm in total length, and weighing 300 g approximately. Although the occurrence of this specimen is more likely attributable to migrations from other eastern Mediterranean areas such as the Tunisian coast, the possibility that it may indicate the presence of a viable population of* L. melitensis *in Algerian waters cannot be excluded.*

Key words: Rajidae, first record, migration, extension range, distribution, Algerian coast

PRIMO RITROVAMENTO DOCUMENTATO DI RAZZA MALTESE *LEUCORAJA MELITENSIS* (RAJIDAE) LUNGO LA COSTA ALGERINA (MEDITERRANEO SUD-OCCIDENTALE)

SINTESI

Gli autori presentano un ritrovamento ben documentato del primo esemplare di razza maltese Leucoraja melitensis *(Clark, 1926) mai segnalato lungo le coste dell'Algeria. Secondo i dati forniti dai pescatori, si trattava di un maschio adulto che misurava 253 mm di larghezza del disco, 232 mm di lunghezza del disco e 455 mm di lunghezza totale, con un peso di circa 300 g. Sebbene la presenza di questo esemplare sia più probabilmente attribuibile a migrazioni da altre aree del Mediterraneo orientale, come la costa tunisina, non si può escludere che possa indicare la presenza di una popolazione vitale di* L. melitensis *nelle acque algerine.*

Parole chiave: Rajidae, primo ritrovamento, migrazione, estensione dell'areale, distribuzione, costa algerina

INTRODUCTION

The Maltese skate *Leucoraja melitensis* (Clark, 1926) is a species endemic to the Mediterranean Sea and its distribution seems to be restricted to the Sicilian Channel (Relini *et al.*, 2010; Dulvy & Walls, 2015). However, investigations carried out in the Aegean Sea allowed to collect some specimens (Damalas & Vassilopoulou, 2011), and Ferretti *et al.* (2013) noted that a single specimen had been recorded during a bottom trawl survey in this area in 2005.

The species used to be caught in relative abundance in Tunisian waters and the 674 specimens captured in this area between 1970 and 1975 provided the opportunity for a study of the reproductive biology of the species (Capapé, 1977). Investigations conducted by Mnasri (2008) in northern Tunisian area allowed for a collection of 7 specimens only. Captures of *L. melitensis* are extremely rare in southern Tunisian areas such as the Gulf of Gabès, probably due to the fact that the local fishing fleets operate outside its area of occurrence (Ennajar, 2002). More recently, Ben Amor (2018) recorded a juvenile specimen in northern Tunisia and noted a drastic decline of the species in this area, where it is already considered to be critically endangered.

Along the Algerian coast, *L. melitensis* is considered a rare species. Surveys regularly monitoring waters off the Algerian coast have allowed the collection of the *L. melitensis* specimen described in the present paper, which also provides comments on the distribution of the species in the area.

MATERIAL AND METHODS

The present specimen of *L. melitensis* was caught by commercial trawl on 14 November 2016 off Annaba, a city located in the eastern Algerian coast, 37°06′10″ N and 7°51′02″ E (Fig. 1). It was captured at a depth of 337 m, on sandy/muddy bottom, together with scorpaenid, lophiid and rajid species, including several thornback skates *Raja clavata* Linnaeus, 1758 and a brown ray *R. miraletus* Linnaeus, 1758. After being measured and photographed, the specimen of rare Maltese skate was carefully examined and identified using the relevant literature (Serena *et al.*, 2020; Barone *et al.*, 2022). It was generally difficult to get morphometric measurements as the specimen was rapidly sold for local consumption together with other fish species.

RESULTS AND DISCUSSION

The studied specimen of *L. melitensis* measured 253 mm in disc width, 232 mm in disc length and 455 mm in total length, and weighed 300 g approximately according to interviews with the fishermen. It was a very large specimen displaying well-developed, calcified, and rigid claspers, characteristic of adult males (Capapé, 1977). Tortonese (1956) found in the Italian waters a specimen measuring 383.9 mm TL, while the largest male and the largest female measured 222 and 228 mm DW, and 400 and 420 mm TL, respectively (Capapé, 1975). The present Algerian specimen was identified *as L. melitensis* via a combination of main morphological characters: dorsal surface almost rugose except in the centre of the disc, pelvic fins rather smooth, snout and tail with dense prickles; ventral surface smooth except for snout, disc margins and tail; two thorns in front and four around the inner margin of each eye, one on each shoulder, eight along the nape, a median series discontinuous from the central area of body

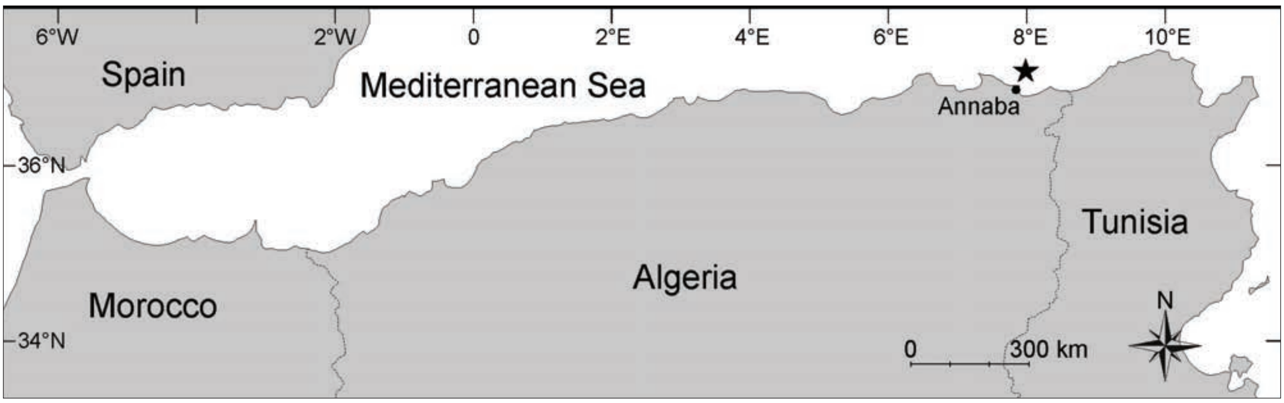

Fig. 1: Map of the Algerian coast indicating the capture site of** Leucoraja melitensis **off Annaba (black star).
Sl. 1: Zemljevid alžirske obale z označeno lokaliteto ulova primerka vrste** Leucoraja melitensis **v vodah okoli Annabe (črna zvezdica).

to tail base; tail slender with a median groove in the anterior part, flanked by a parallel row of thorns on either side, no groove on the hind part of tail with three rows of thorns – a median and two lateral rows –, no thorns between the two dorsal fins; dorsal surface ochre to greyish-brown, with one large, darkish and vermiculated eye spot and three fainter dusky blotches on each pectoral fin (Fig. 2).

The general shape, morphometric measurements, meristic counts and coloration recorded in the present specimen are in total agreement with Clark (1926), Capapé (1975), Stehmann & Bürkel (1984), Serena (2005), Serena *et al.* (2010) and Last *et al.* (2016).

Previously, *L. melitensis* was reported from the Algerian coast in the historical book by Dieuzeide *et al.* (1953) concerning the local ichthyofauna. However, it appears that the two specimens reported by Dieuzeide *et al.* (1953, see page 105) were captured in the Skerki Bank and in the Gulf of Gabès, *i.e.*, in Tunisian and not Algerian waters. Even though the species was frequently cited in the latter region, no specimen was available for confirmation, and such occurrences can be considered as doubtful or even wrong.

Therefore, the finding of *L. melitentis* presented herein constitutes the first well-documented record of the species from the Algerian coast, which could be taken as indication of the species' presence in this area and consequently support its inclusion in the list of local ichthyofauna. On the other hand, the specimen could have migrated from Tunisian waters, where the species used to be caught in relative abundance, but is nowadays considered endangered. Recruitment from close eastern areas remains questionable, as does the presence of a viable population in Algerian waters, even if such a hypothesis cannot be totally ruled out. In the coast of Algeria, *L. melitensis* is probably just an occasional species.

Fig. 2. The** Leucoraja melitensis **captured off the Algerian coast, scale bar = 50 mm.
Sl. 2: Primerek vrste** Leucoraja melitensis**, ujet ob alžirski obali, merilo = 50 mm.

PRVI POTRJENI PRIMER O POJAVLJANJU SKATA VRSTE *LEUCORAJA MELITENSIS* (RAJIDAE) IZ ALŽIRSKE OBALE (JUGOZAHODNO SREDOZEMSKO MORJE)

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier cedex 5, France
e-mail: christian.capape@umontpellier.fr

Christian REYNAUD
Laboratoire Interdisciplinaire en Didactique, Education et Formation, Université de Montpellier, 2, place Marcel Godechot, B.P. 4152, 34092 Montpellier cedex 5, France

Farid HEMIDA
École Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral (ENSSMAL), BP 19, Bois des Cars, 16320 Dely Ibrahim, Algiers, Algeria

POVZETEK

Avtorji poročajo o potrjenem primeru pojavljanja vrste Leucoraja melitensis *(Clark, 1926) ob obali Alžirije. Na podlagi podatkov ribičev je šlo za odraslega samca, ki je meril 253 mm v premeru diska, 232 mm v dolžini diska in 455 mm v telesno dolžino ter tehtal približno 300 g. Čeprav avtorji pripisujejo pojav obravnavane vrste migraciji iz drugih vzhodnih sredozemskih predelov kot npr. tunizijske obale, dopuščajo možnost, da obstaja viabilna populacija v alžirskih vodah.*

Ključne besede: Rajidae, prvi zapis, selitev**,** širjenje areala, razširjenost, alžirska obala

REFERENCES

Barone, M., C. Mazzoldi & F. Serena (2022): Sharks, rays and chimaeras in Mediterranean and Black Seas – Key to identification. Rome, FAO. https://doi.org/10.4060/cc0830en

Ben Amor, M.M., K. Ounifi-Ben Amor & C. Capapé (2018): Record of a critically endangered skate, *Leucoraja melitensis* (Chondrichthyes: Rajidae) from Tunisian coast (central Mediterranean). Thalassia sal., 40, 9-16.

Capapé, C. (1975): Note sur la présence en Tunisie de *Raja nævus* Müller et Henlé, 1841 et *R. melitensis* Clark, 1926: description, premières observations biologiques. Bull. Inst. nat. scient. Tech. Océanogr. Pêche, Salammbô, 4(1), 75-96.

Capapé, C. (1977): Contribution à la biologie des Rajidæ des côtes tunisiennes. VII. *Raja melitensis* Clark, 1926: sexualité, reproduction, fécondité. Cah. Biol. Mar., 18(2), 177-190.

Clark, R. S. (1926): Rays and skates. A revision of the European species. Fish., Scotland, Scient. Invest., 1, 1-66.

Damalas, D. & V. Vassilopoulou (2011): Chondrichthyan by-catch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). Fish. Res., 108(1), 142-152.

Dieuzeide, R., M. Novella & J. Roland (1953): Catalogue des poissons des côtes algériennes, Volume I. Squales – Raies – Chimères. Bull. Sta. Aquic. Pêche, Castiglione, n. s. 6, I, 1-274.

Dulvy, N. & R. Walls (2015): *Leucoraja melitensis*. The IUCN Rest list of Threatened Species 2015: e. T61405A48954483.- Downloaded on 11 March 2022.

Ennajar, S. (2002): Contribution à l'étude écobiologique des élasmobranches hypotrêmes de la région du golfe de Gabès. Dissertation, University of Sfax, Tunisia, 201 pp.

Ferretti, F., G.C. Osio Jenkins, A.A. Rosenberg & H.K. Lotze (2013): Long-term change in a meso-predator community in response to prolonged and heterogeneous human impact. Sci.. Rep., 3, 1057.

Last, P., G. Naylor, B. Séret, W. White, M. Stehmann & M. de Carvalho (2016): Rays of the world. CSIRO Publishing, 800 pp.

Mnasri, N. (2008): Les élasmobranches de la Tunisie septentrionale: biodiversité et méthode d'approche de la production débarquée. Dissertation, University of Carthage, Tunisia, 125 pp.

Relini, G., A. Mannini, S. De Ranieri, I. Bitetto, M.C Follesa., V. Gancitano, C. Manfredi., I. Casciaro & I. Sion (2010): Chondrichthyes caught during the Mdits survey in Italian waters. Biol. Mar. Medit., 17(1), 186-204.

Serena, F. (2005): Field Identification Guide to the sharks and rays of the Mediterranean and Black Sea. FAO species Identification Guide for Fisheries Purposes. FAO: Rome, 97 pp.

Serena, F., C. Mancusi & M. Barone (2010): Field identification guide to the skates (Rajidae) of the Mediterranean Sea. Guidelines for data collection and analysis. Biol. Mar. Medit., 17 (Suppl. 2), 204 pp.

Serena, F., A.J. Abella, F. Bargnesi, M. Barone, F. Colloca, F. Ferretti, F. Fiorentino, J. Jenrette & S. Moro (2020): Species diversity, taxonomy and distribution of chondrichthyes in the Mediterranean and Black Sea. Eur. J. Zool., 87(1), 497-536.

Stehmann, M. & D.L. Bürkel (1984): Rajidae. pp. 163-196. In: Whitehead P.J.P., Bauchot, M.L., Hureau J.C., Nielsen J. & Tortonese. E. (eds), Fishes of the North-western Atlantic and the Mediterranean. Vol I. UNESCO, Paris.

Tortonese, E. (1956): Fauna d'Italia vol.II. Leptocardia, Ciclostomata, Selachii., Calderini, Bologna, Italy. [In Italian.], 332 pp.

received: 2023-03-18 DOI 10.19233/ASHN.2023.09

FIRST RECORD OF *CARANX CRYSOS* (MITCHILL, 1815) IN THE LIGURIAN SEA (NORTHWESTERN MEDITERRANEAN SEA) SUGGESTS NORTHWARD EXPANSION OF THE SPECIES

Alessandro NOTA
Deptartment of Biology and Biotechnology, University of Pavia, 27100 Pavia, Italy
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
e-mail: alessandro.nota01@universitadipavia.it

Sara IGNOTO
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy

Sandro BERTOLINO
Department of Life Sciences and Systems Biology, University of Turin, 10123 Turin, Italy

Francesco TIRALONGO
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy
National Research Council, Institute of Biological Resources and Marine Biotechnologies, 60125 Ancona, Italy

ABSTRACT

Four specimens of Caranx crysos *(blue runner) were spotted on 15th October 2022 in the waters of Ospedaletti (province of Imperia, Italy). This record is the first documented sighting of the species in the Ligurian Sea, and the northernmost in the western Mediterranean. Therefore, it could indicate a further expansion northwards of the species, with subsequent possible impacts on ecosystems, fishing and related commercial activities.*

Key words: *Caranx crysos*, Mediterranean, thermophilic species, Ligurian Sea, global warming

LA PRIMA SEGNALAZIONE DI *CARANX CRYSOS* (MITCHILL, 1815) NEL MAR LIGURE (MEDITERRANEO NORD-OCCIDENTALE) SUGGERISCE UN'ESPANSIONE VERSO NORD DELLA SPECIE

SINTESI

Quattro esemplari di Caranx crysos *(carango mediterraneo) sono stati avvistati il 15 ottobre 2022 nelle acque di Ospedaletti (provincia di Imperia, Italia). Questo ritrovamento è il primo avvistamento documentato della specie nel mar Ligure e il più settentrionale nel Mediterraneo occidentale. Potrebbe quindi indicare un'ulteriore espansione della specie verso nord, con conseguenti possibili impatti sugli ecosistemi, sulla pesca e sulle relative attività commerciali.*

Parole chiave: *Caranx crysos*, Mediterraneo, specie termofila, mar Ligure, riscaldamento globale

INTRODUCTION

Caranx crysos (Mitchill 1815), commonly called blue runner, is an Atlanto-Mediterranean fish belonging to the Carangidae family, which includes nearly 150 recognized species (Froese & Pauly 2022). In the western Atlantic, this species is reported from Argentine to Canada (Delpiani *et al.*, 2011; Devine & Fisher 2014), while in the eastern Atlantic, it is distributed from Angolan to British waters (Swaby *et al.*, 1996). However, in the last decades, this species has expanded its distribution along both the western and eastern Atlantic coasts (MacKay & Gethin 1969; Swaby *et al.*, 1996; Delpiani *et al.*, 2011; Devine & Fisher 2014). Similarly, this expansion process has been reported in Mediterranean waters (Psomadakis *et al.*, 2011; Raya & Sabatés, 2015; Tiralongo *et al.*, 2020). In particular, like other carangid species (*e.g.* Coco *et al.*, 2022), the blue runner is a perfect indicator of the so-called "meridionalization" of the Mediterranean Sea. This process involves the expansion, specifically a northward migration, of thermophilic native species whose original ranges were once confined to Atlantic waters or to the southern parts of the Mediterranean basin (Templado, 2014).

Caranx crysos has been reported almost all over the Mediterranean: the species is well established in the southeastern sector of the basin; it is also reported in Aegean and Peloponnese waters, at least in some areas (Psomadakis *et al.*, 2011). In the northern and western basin, *C. crysos* reached the Catalan coast (Raya & Sabatés, 2015), and the coasts of most southern Italian regions (Tiralongo *et al.*, 2020). Finally, even in the Adriatic Sea its distribution has been expanding in the last years (Pavičić *et al.*, 2014; Nerlović *et al.*, 2015; Iveša *et al.*, 2021).

The blue runner is an opportunistic predator which primarily feeds on pelagic preys; its diet mainly includes other teleosts and crustaceans (Sley *et al.*, 2009). Besides the ecological impacts that the expansion of this species may imply, the remarkable size it can reach (up to 70 cm, Froese & Pauly 2022) makes *C. crysos* a targeted species by both professional fishermen and amateurs (Tiralongo *et al.*, 2020; Escamilla-Pérez *et al.*, 2021). Moreover, this fish has a good growth performance which makes him even a considerable resource for aquaculture activities (Rombenso *et al.*, 2014). Therefore, predicting how its distribution may change in the next future may allow us to understand how fishing habits and trade of fish products will change as well.

Here we report the first documented record of the species in the Ligurian Sea, in Ospedaletti (Imperia). In fact, previous records of the species from Nice and Genoa were considered unreliable, as based only on questionable museological material that lacked information (Psomadakis *et al.*, 2011). Our record is thus the northernmost in the western Mediterranean, as reports further north in the basin only come from the high Adriatic (Dulčić *et al.*, 2009).

MATERIAL AND METHODS

This observation was collected during the AlienFish project campaign (Tiralongo *et al.*, 2019). On 15th October 2022, four specimens of *C. crysos* were spotted swimming together at a depth of 4 m (fish were 1 meter below the surface) by an AlienFish collaborator (PC) in the waters of Ospedaletti (43.79732 N, 7.72672 E; province of Imperia, Ligurian Sea, Fig. 1), during a spearfishing hunt. The spearfisherman didn't immediately recognize the species, as he had never encountered it before; in fact, he initially misidentified them as 4 specimens of the common dolphinfish (*Coryphaena hippurus*). After shooting one of them, he recognized the exact species; in fact, he stated that he had previously watched online spearfishing videos with this fish being caught.

RESULTS

The specimen caught (Fig. 2) was weighed once eviscerated, and had a weight of 800 g. The fisher reported that the four specimens observed appeared to be the same size. After showing the specimen to all his local spearfishermen acquaintances, he reports that none of them had ever encountered the species before.

Fig. 1: The red spot indicates the location of the record of *Caranx crysos* ***in the Ligurian Sea.***
Sl. 1: Rdeča pika kaže lokaliteto, kjer so bili opaženi primerki vrste *Caranx crysos* ***v Ligurskem morju.***

Fig. 2: The captured specimen of* C. crysos *indicated by a red arrow.
Sl. 2: Ujeti primerek vrste* C. crysos*, označen z rdečo puščico.

DISCUSSION

The recent expansion of *C. crysos* and other thermophilic Carangidae species along the Mediterranean coasts is well documented (Psomadakis *et al.*, 2011; Raya & Sabatés, 2015; Tiralongo *et al.*, 2018, 2020). The blue runner presence has now been reported in almost all the basin's waters (Psomadakis *et al.*, 2011; Pavičić *et al.*, 2014; Nerlović *et al.*, 2015; Raya & Sabatés, 2015; Iveša *et al.*, 2021), and a further range expansion and population increase in the near future are very likely. In fact, Mediterranean seawater temperatures are constantly rising, and the Ligurian Sea is one of the most sensitive areas to the increase in sea surface temperature (Pastor *et al.*, 2020). In this context, *C. crysos* spawns in the warmer months of the year, and its distribution is strictly related to water temperature (Raya & Sabatés, 2015). Therefore, future climatic conditions will be in favour of *C. crysos*, and the 4 specimens we are hereby reporting could be the first of a long list for this species, even in Ligurian waters.

Unfortunately, it was not possible to obtain the captured specimen, and it was therefore impossible to conduct morphological or genetic analyses to trace its geographical provenance. It is thus difficult to venture whether the origin of these 4 specimens should be Tyrrhenian (*i.e.* coming from central/southern Italy) or western (coming from France). In fact, the northernmost Tyrrhenian record of the species is from Civitavecchia and dates back to 2007 (Psomadakis *et al.*, 2011); on the other side, this fish's larvae were recorded along the Catalan coast

Fig. 3: Specimens of* C. crysos *and* C. rhonchus *sold in Sicily (Avola, Ionian Sea) on 4th March 2019. Photo credit: Francesco Tiralongo.
Sl. 3: Primerki modrega* C. crysos *in rumenega trnoboka* C. rhonchus*, ki so bili 4. marca 2019 naprodaj v Siciliji (Avola, Jonsko morje). Foto: Francesco Tiralongo.

in 2003 and 2004 (Raya & Sabatés, 2015). The recent expansion of the blue runner in Mediterranean and Atlantic waters suggests that the species may have already colonized both the north Tyrrhenian and French Mediterranean coasts in the last years. However, a general dearth of data may have prevented us from tracing its progressive expansion in these areas.

However, it must be underlined that nearly all the data on this species we collected in the AlienFish campaign are referred to the southern Italian regions, and our other northernmost record comes from San Felice Circeo, in Latina province.

The expansion of alien and thermophilic species in the Mediterranean Sea has often been considered an opportunity to increase the provision of food for human consumption (Tsirintanis *et al.*, 2022; Coco *et al.*, 2022). For example, Coco *et al.* (2022) proposed that the recent expansion of the congener *C. rhonchus* in the Mediterranean Sea could represent a commercially valuable resource, with subsequent benefits for humans and the environment, as it could both increase food provision and reduce fishing pressures on other species. Similarly, in Mediterranean, *C. crysos* will probably achieve further fishing and economic attention as well, even in areas where the species is currently still considered absent or rare. In fact, in Sicily, both species (*C. crysos* and C. rhonchus) now appear frequently in fish markets (Fig. 3). On the other hand, competition for food resources with some ecologically similar species (*e.g. Seriola* spp., *Caranx* spp.) could reshape the structure of fish community and ecosystems in general.

Finally, we also underline the importance of citizen science-based monitoring for the early detection of species of interest in new areas. The project AlienFish was launched in 2012 by Ente Fauna Marina Mediterranea, with the aim to monitor rare, thermophilic, and non-indigenous fish species along Italian coasts. Today, this initiative involves more than thirty researchers from all over Italy. The approach adopted to collect data is mainly citizen-science based, as it implies the involvement of both Social Networks and direct surveys in strategic areas such as fishing ports and landing points. The new record provided here was obtained thanks to a survey conducted within this project by one of the authors (AN).

ACKNOWLEDGEMENTS

We would like to thank our collaborator, Pino C., for his time and help. We would also like to thank Antonio Oscar Lillo for his help with the map design.

PRVI ZAPIS O POJAVLJANJU MODREGA TRNOBOKA *CARANX CRYSOS* (MITCHILL, 1815) V LIGURSKEM MORJU (SEVEROZAHODNO SREDOZEMSKO MORJE) DOKAZUJE ŠIRJENJE VRSTE PROTI SEVERU

Alessandro NOTA
Deptartment of Biology and Biotechnology, University of Pavia, 27100 Pavia, Italy
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
e-mail: alessandro.nota01@universitadipavia.it

Sara IGNOTO
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy

Sandro BERTOLINO
Department of Life Sciences and Systems Biology, University of Turin, 10123 Turin, Italy

Francesco TIRALONGO
Ente Fauna Marina Mediterranea, Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy
Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy
National Research Council, Institute of Biological Resources and Marine Biotechnologies, 60125 Ancona, Italy

POVZETEK

Petnajstega oktobra 2022 so v vodah blizu lokalitete Ospedaletti (provinca Imperia, Italija) opazili štiri primerke modrega trnoboka Caranx crysos. *Ta zapis je prvo dokumentirano opazovanje vrste v Ligurskem morju in v najsevernejšem delu zahodnega Sredozemskega morja. Obenem nakazuje, da gre za nadaljnje širjenje areala te vrste proti severu, ki bi lahko imelo možen vpliv na ekosistem, ribištvo in sorodne gospodarske aktivnosti.*

Ključne besede: *Caranx crysos*, Sredozemsko morje, termofilne vrste, Ligursko morje, globalno segrevanje

REFERENCES

Coco, S., A. Roncarati, F. Tiralongo & A. Felici (2022): Meridionalization as a Possible Resource for Fisheries: The Case Study of *Caranx rhonchus* Geoffroy Saint-Hilaire, 1817, in Southern Italian Waters. J. Mar. Sci. Eng., 10, 274.

Delpiani, S.M., P.H. Lertora, E. Mabraga & J.M.D. de Astarloa (2011): Second record of the blue runner *Caranx crysos* (Perciformes: Carangidae) in Argentine waters. Mar. Biodivers. Rec., 4, e31.

Devine, B.M. & J.A.D. Fisher (2014): First records of the blue runner *Caranx crysos* (Perciformes: Carangidae) in Newfoundland waters. J. Fish Biol., 85, 540-545.

Dulčić, J., A. Pallaoro & B. Dragičević (2009): First record of the blue runner, *Caranx crysos* (Mitchill, 1815), in the Adriatic Sea. J. Appl. Ichthyol., 25, 481-482.

Escamilla-Pérez, B.E., L. Ortiz-Lozano, D.O. Molina-Rosales & A. Espinoza-Tenorio (2021): Cultural importance of marine resources subject to fishing exploitation in coastal communities of Southwest Gulf of Mexico. Ocean Coast. Manag., 208, 105605.

Froese, R. & D. Pauly. Editors (2022): FishBase. World Wide Web electronic publication. www.fishbase.org, version (08/2022).

Iveša, N., M. Piria, M. Gelli, T. Trnski, I. Špelić, T. Radočaj, K. Kljak, J. Jug-Dujaković & A. Gavrilović (2021): Feeding Habits of Predatory Thermophilic Fish Species and Species with Subtropical Affinity from Recently Extended Distributional Range in Northeast Adriatic Sea, Croatia. Diversity, 13, 357.

MacKay, K.T. & T. Gethin (1969): First Records of *Ariomma bondi*, *Caranx crysos*, and *Selar crumenopthalmus* (Pisces) in the Gulf of St. Lawrence. J. Fish. Res. Board Can., 26, 2769-2771.

Nerlović, V., B. Mravinac & M. Devescovi (2015): Additional information on the blue runner, *Caranx crysos* (Mitchill, 1815), from the northern Adriatic Sea: meristic and molecular characterizations. Acta Adriat., 56, 309-318.

Pastor, F., J.A. Valiente & S. Khodayar (2020): A Warming Mediterranean: 38 Years of Increasing Sea Surface Temperature. Remote Sens., 12, 2687.

Pavičić, M., J. Šiljić, P. Duganđžić & B. Skaramuca (2014): New record of blue runner, *Caranx crysos* (Mitchill, 1815), in the Adriatic Sea. Ribar. Croat. J. Fish., 72, 125-127.

Psomadakis, P.N., F. Bentivegna, S. Giustino, A. Travaglini & M. Vacchi (2011): Northward spread of tropical affinity fishes: *Caranx crysos* (Teleostea: Carangidae), a case study from the Mediterranean Sea. Ital. J. Zool., 78, 113–123.

Raya, V. & A. Sabatés (2015): Diversity and distribution of early life stages of carangid fishes in the northwestern Mediterranean: responses to environmental drivers. Fish. Oceanogr., 24, 118-134.

Rombenso, A.N., J.C. Bowzer, C.B. Moreira & L.A. Sampaio (2014): Culture of *Caranx* species [Horse-eye Jack *Caranx latus* (Agassiz), Blue Runner *Caranx crysos* (Mitchill), and Crevalle Jack *Caranx hippos* (Linnaeus)] in near-shore cages off the Brazilian coast during colder months. Aquac. Res., 47, 1687-1690.

Swaby, S.E., G.W. Potts & J. Lees (1996): The First Records of the Blue Runner *Caranx Crysos* (Pisces: Carangidae) in British Waters. J. Mar. Biolog. Assoc. U.K., 76, 543-544.

Templado, J. (2014): Future Trends of Mediterranean Biodiversity. In: Goffredo, S. & Z. Dubinsky (eds): The Mediterranean Sea, Springer, Dordrecht, pp. 479-498.

Tiralongo, F., D. Tibullo, G. Messina & B.M. Lombardo (2018): New records of two carangid species from the south-east coast of Sicily (Ionian Sea) and considerations about their presence and abundance. Acta Adriat., 59, 225-230.

Tiralongo, F., A.O. Lillo, D. Tibullo, E. Tondo, C. Lo Martire, R. D'Agnese, A. Macali, E. Mancini, I. Giovos, S. Coco & E. Azzurro (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., F. Crocetta, E. Riginella, A.O. Lillo, E. Tondo, A. Macali, E. Mancini, F. Russo, S. Coco, G. Paolillo & E. Azzurro (2020): Snapshot of rare, exotic and overlooked fish species in the Italian seas: A citizen science survey. J. Sea Res., 164, 101930.

received: 2022-09-30 DOI 10.19233/ASHN.2023.10

THE FIRST MARINE RECORD OF NORTHERN PIKE *ESOX LUCIUS* LINNAEUS, 1758 IN THE MEDITERRANEAN SEA

Alen SOLDO
University of Split, Department of Marine Studies, Ulica Ruđera Boškovića 37, 21000 Split, Croatia
e-mail: soldo@unist.hr

ABSTRACT

Near the coast of Stobreč, Central Adriatic Sea, a recreational fisher caught a strange fish specimen at a depth of 5 m, using a fishing trident. Upon the arrival of the fisher in the harbor the specimen was taken away for analysis. This revealed that the specimen's morphological characteristics matched those of the northern pike Esox lucius *Linnaeus, 1758. As the northern pike is a stenohaline freshwater fish, it had never been recorded before in the high salinity marine conditions of the Adriatic Sea or anywhere else in the Mediterranean. The collected specimen most likely originated from the nearby short river Žrnovnica. This paper discusses the possibility that the northern pike introduced to some rivers emptying into the Adriatic Sea may possess the local ability to withstand short trips to high salinity waters.*

Key words: *Esox lucius***,** northern pike, salinity tolerance, hypo-osmoregulatory process, Adriatic Sea, area expansion

PRIMO RITROVAMENTO MARINO DEL LUCCIO *ESOX LUCIUS* LINNAEUS, 1758 NEL MARE MEDITERRANEO

SINTESI

Lungo la costa di Stobreč, nell'Adriatico centrale, un pescatore sportivo ha catturato uno strano esemplare di pesce a 5 m di profondità, utilizzando un tridente da pesca. All'arrivo del pescatore in porto, l'esemplare è stato portato via per essere analizzato. Le caratteristiche morfologiche dell'esemplare corrispondevano a quelle del luccio Esox lucius *Linnaeus, 1758. Essendo un pesce d'acqua dolce stenoalina, il luccio non era mai stato trovato prima d'ora in condizioni marine ad alta salinità dell'Adriatico o in qualsiasi altra parte del Mediterraneo. L'esemplare raccolto proveniva molto probabilmente dal vicino fiume Žrnovnica. Il presente lavoro esamina la possibilità che il luccio introdotto in alcuni fiumi che sfociano nel mare Adriatico possa resistere a brevi spostamenti in acque ad alta salinità.*

Parole chiave: *Esox lucius*, luccio, tolleranza alla salinità, processo ipo-osmoregolatore, mare Adriatico, espansione dell'area

INTRODUCTION

The northern pike *Esox lucius* Linnaeus, 1758 is spread in the temperate and subtropical areas of the northern hemisphere (Raat, 1988). It is found in all kinds of freshwater habitats (Raat, 1988) and in some brackish areas such as the Baltic Sea, where salinities vary from 4 to 7 (Jakobsen *et al*., 2007). The distribution range of the northern pike extends to the western part of the Baltic Proper in the south-eastern part of Denmark, where the salinity gradient rises steeply and varies between 8 and 12, with peaks of up to 20 during periods of Major Baltic Inflows of North Sea water. According to Karås & Lethonen (1993) adult pike individuals can momentarily survive short term fluctuations of up to 12 to 15. Nevertheless, sudden exposures to salinities higher than 11 have shown that an increase in excretion of salt and salinities from 11.3 to 12.4 cause immobilisation and inclination of the body (Raat, 1988). Similar results were obtained during the study of a northern pike fry that was hatched and raised in fresh water and could tolerate salinities up to 11, whereas salinities more than 12 proved lethal for it (Jakobsen *et al*., 2007).

Freshwater fish are occasionally found in brackish waters, either as a result of migration between fresh and saltwater or as more obligate brackish water populations. The fish have to adjust their body salinity to the salinity of the surrounding environment, but non-anadromous freshwater fish are not able to adjust their body salinity to the degree that marine fish species can. The northern pike is a stenohaline freshwater fish, and these are supposedly unable to cope with highly saline water through hypo-osmoregulatory processes (Jakobsen *et al*., 2007). As such, the northern pike had never before been recorded in the high salinity environment of the Adriatic Sea or anywhere else in the Mediterranean.

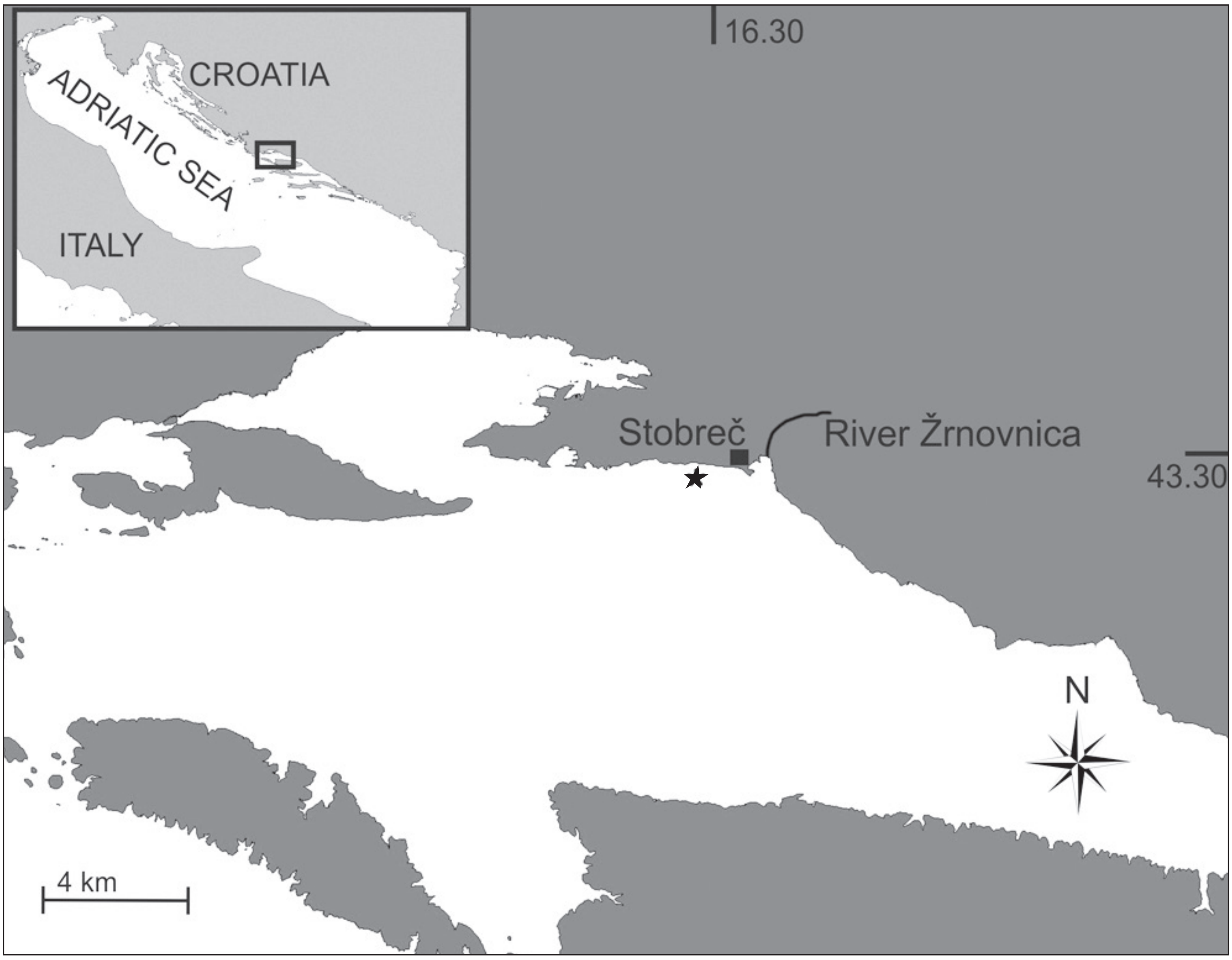

Fig. 1: Map of the capture (★ indicates the exact location).
Sl. 1: Zemljevid ulova ščuke (★ označuje natančno lokaliteto ulova).

MATERIAL AND METHODS

The author was contacted by a recreational fisher at sea about the catch of a strange fish specimen near the coast of Stobreč, Central Adriatic Sea, at a depth of 5 m, using a fishing trident (Fig. 1). Upon the arrival of the fishermen in the harbour the specimen was taken away and deposited in the ichthyological collection of the Department of Marine Studies, University of Split, where it was measured to the nearest mm using a measuring board ichthyometer and weighed to the nearest gram. The fish was dissected, its stomach content removed and immediately analysed.

The identification of the specimen was made according to Fickling (1982), Habeković and Pažur (1998) and Lucentini *et al*. (2011).

RESULTS AND DISCUSSION

The northern pike is the only species of the Esocidae family living in rivers and lakes of the Adriatic drainage area and has been introduced into some lakes close to the coast as well as into some freshwater lakes on the Adriatic islands (Ćaleta *et al*., 2019). An analysis of the collected specimen (Fig. 2) revealed that its morphological and coloration characters, including the skin coloration pattern, which are qualitative characters useful for discriminating the Esocidae species, matched the diagnostic features of *Esox lucius* (Fickling, 1982; Habeković & Pažur, 1998; Lucentini *et al*., 2011). The total length of the specimen was 635 mm, the weight 2,074 g. The stomach content was analyzed to determine the feeding habit of the caught northern pike but the content was nearly digested, so the prey was identified only as a fish, without genus or family level. Although this record represents the first confirmed report of the northern pike in the Mediterranean Sea, it has to be noted that Šoljan (1948) also reported *E. lucius* as an Adriatic Sea species. His listing was based on an old record by Canestrini (1874), who reported the presence of this species in Venice lagoons. Still, although Šoljan (1948) allowed for such a report to have been based on an exceptional occurrence during a big flood, he nevertheless considered it doubtful and, consequently, omitted the northern pike from all further listings of the Adriatic ichthyofauna.

Lucentini *et al*. (2011) suggested the existence of a new species *Esox flaviae (*synonym for *Esox cisalpinus* Bianco & Delmastro, 2011), the southern pike, occupying central and northern Italy and, potentially, other European water bodies in the Mediterranean area, including the north-eastern shores of the Adriatic and Mediterranean France. They reported that the southern pike is very varied and displays four different colour patterns (a stellate spot, diagonal bars, longitudinal bars and vertical bars), but never the colour pattern with a round spot, which is typical of *E. lucius* (Lucentini *et al*., 2011) and was visible in the specimen described herein.

The current distribution of the northern pike along the eastern Adriatic drainage area ranges from northern Adriatic rivers and lakes to the Neretva River in the south (Habeković & Pažur, 1998; Ćaleta *et al*., 2019). Of the rivers with a published record of *E. Lucius*, the one situated closest to the present locality of collecting in the coastal area of central Adriatic is the Cetina (Ćaleta *et al*., 2019).

The particular location where the specimen was collected has an average salinity of 36 to 38 (Barić *et al*., 1998). The northern pike is a freshwater fish

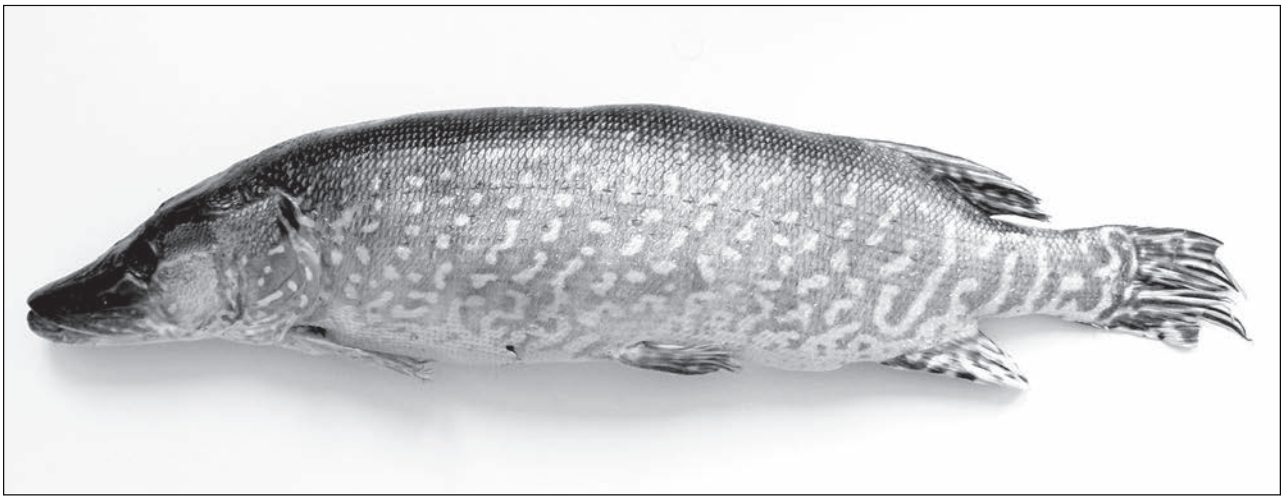

Fig. 2: The captured specimen of the northern pike *Esox lucius* ***with typical colour pattern.***
Sl. 2: Ujeti primerek ščuke *Esox lucius* ***z značilnim barvnim vzorcem.***

able to withstand moderately brackish water, most notably in the Baltic Sea, which is one of the largest brackish water (estuarine) areas on Earth (Raat, 1988; Jakobsen *et al*., 2007), but, so far, it has never been observed to tolerate salinities as high as in the present location of collecting. In the vicinity of the location where the specimen was caught (2 NM northeast) lies the mouth of a short river named Žrnovnica. While the northern pike has never been officially recorded in that river, from an interview of the local population it has transpired that the northern pike had probably been introduced to the Žrnovnica and is still present in it. Therefore, the collected specimen most likely originated from this nearby river of Žrnovnica.

Due to the seasonal inflow of high salinity marine water, a large part of the river is brackish and even saline. Previous studies have revealed that the pike fry of brackish water origin exhibit a higher salinity tolerance and that certain populations, e.g., those living in the Danish part of the Baltic Sea, have a unique ability to adapt to external changes in salinity that other populations lack (Jakobsen *et al*., 2007). Moreover, the acclimatisation period is likely to increase the salinity tolerance of the fish (Brown *et al*., 2001), while it is known that some freshwater fish, when exposed to saline water, developed an apical crypt with of a denser network of anastomosed tubules containing chloride cells with a high level of mitochondria that was denser in specimens feeding on a saline diet than in those feeding on a neutral diet (Jørgensen, 2009). This could indicate that the northern pike living in brackish water can adapt to increases in salinity faster than the pike originating from freshwater. Therefore, it can be hypothesised that a northern pike that spent its entire life in the brackish water of the Žrnovnica and fed on a saline diet exited the river and after swimming through the surface layers of brackish and saline water arrived at the place where it was caught. It has to be noted that this record of the northern pike in a high salinity marine environment is not an exception for the region of the Adriatic Sea, as similar cases were also observed with some other species that are generally considered freshwater (Soldo, 2013). Hence, this record coincides with the results of Sunde *et al*. (2018), who concluded that some subpopulations of the northern pike exhibit large genetic variations in salinity tolerance and appear to be preadapted to future changes in salinity regimes. It is presumed that high functional genetic diversity increases establishment success in novel areas and the capacity by which some populations adapt to new conditions using evolutionary modifications, ultimately resulting in range expansions (Sunde *et al*., 2018).

In addition, the author of this paper has recently received information that another northern pike was caught in the northern Adriatic Sea area close to the mouth of the Dragonja River. Therefore, it can be concluded that the northern pike introduced into some rivers that empty into the Adriatic Sea has a local ability to withstand short trips to high salinity waters and that the brackish waters of the Adriatic Sea can be considered an area of potential further northern pike presence.

PRVI MORSKI ZAPIS O POJAVLJANJU ŠČUKE *ESOX LUCIUS* LINNAEUS, 1758 V SREDOZEMSKEM MORJU

Alen SOLDO
University of Split, Department of Marine Studies, Ulica Ruđera Boškovića 37, 21000 Split, Croatia
e-mail: soldo@unist.hr

POVZETEK

Blizu obale Stobreča v srednjem Jadranu je rekreacijski ribič na 5 metrih globine s trizobom ujel nenavadno ribo. Po prihodu v pristanišče so ribo poslali na analizo. Izkazalo se je, da gre za ščuko Esox lucius *Linnaeus, 1758. Ščuka je stenohalina vrsta, ki je doslej še niso ujeli v slanovodnih razmerah v Jadranu ali kjerkoli v Sredozemskem morju. Ujeti primerek je verjetno izviral iz bližnje reke Žrnovnice. Avtor razpravlja o možnosti, da je ščuka, ki so jo naselili v reke jadranskega povodja, sposobna preživeti krajše izlete v slanovodna okolja.*

Ključne besede: *Esox lucius***,** ščuka, toleranca na slanost, hipo-osmoregulatorni procesi, Jadransko morje, širjenje

REFERENCES

Barić, A., M. Carić, V. Dadić, B. Grbec, F. Kršinić, D. Lučić, N. Krstulović, G. Kušpilić, Ž. Ninčević, I. Marasović & M. Šolić (1998): Results of marine research for the purpose of designing submarine outfalls Split- Stobreč. Study of the Institute of Oceanography and Fisheries, Split.

Brown, J.A., W.M. Moore & E.S. Quabius (2001): Physiological effects of saline waters on zander. J. Fish. Biol., 59, 1544-1555.

Canestrini, G. (1874): Fauna d'Italia. Parte terza. Pesci. Milano: Vallardi, Milano, 208 pp.

Ćaleta, M., Z. Marčić, I. Buj, D. Zanella, P. Mustafić, A. Duplić & S. Horvatić (2019): A review of extant Croatian freshwater fish and lampreys. Annotated list and distribution. Ribarstvo, 77, 137-234.

Fickling, N.J. (1982): The identification of pike by means of characteristic marks. Aquac. Res., 13, 79-82.

Habeković, D. & K. Pažur (1998): Pike (*Esox Lucius* L.), its characteristics and importance. Ribarstvo, 56(2), 55-60.

Jakobsen, L., C. Skov, A. Koed & S. Berg (2007): Short term salinity tolerance of northern Pike, *Esox lucius*, fry, related to temperature and size. Fish. Manag. Ecol., 14, 1-6.

Jørgensen, A.T. (2009): Salinity tolerance of fertilized eggs and fry of the brackish water northern pike, *Esox lucius* L. MSc thesis. The Department of Environmental, Social and Spatial Change. Roskilde University, 40 pp.

Karås, P. & H. Lethonen (1993): Patterns of movement and migration of Pike (*Esox lucius* L.) in the Baltic Sea. Nord. J. Freshw. Res., 68, 72-79.

Lucentini, L., M.E. Puletti, C. Ricciolini, L. Gigliarelli, D. Fontaneto, L. Lanfaloni, F. Bilò, M. Natali & F. Panara (2011): Molecular and Phenotypic Evidence of a New Species of Genus *Esox* (Esocidae, Esociformes, Actinopterygii): The Southern Pike, *Esox flaviae*. PLoS ONE, 6(12), e25218.

Raat, A.J. (1988): Synopsis of the biological data on the Northern Pike *Esox lucius* Linnaeus, 1758. FAO Fisheries Synopsis (30) Review 2: Food and Agriculture Organization of the United Nations, FAO, Rome, 178 pp.

Soldo, A. (2013): First marine record of marble trout *Salmo marmoratus*. J. Fish. Biol., 82(2), 700-702.

Sunde, J., C. Tamario, P. Tibblin, P. Larsson & A. Forsman (2018): Variation in salinity tolerance between and within anadromous subpopulations of pike (*Esox lucius*). Sci. Rep., 8, 22.

received: 2022-03-22 DOI 10.19233/ASHN.2023.11

DIET AND FEEDING HABITS OF THE GREATER WEEVER *TRACHINUS DRACO* (TRACHINIDAE) FROM THE GULF OF TUNIS (CENTRAL MEDITERRANEAN SEA)

Mourad CHÉRIF
Institut National des Sciences et Technologies de la Mer, port de pêche, 2060 La Goulette, Tunisia

Rimel BENMESSAOUD
Institut National Agronomique de Tunis, 43 Avenue Charles Nicolle 1082, Tunis- Mahrajène, Tunisia

Sihem RAFRAFI-NOUIRA
Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier, France
e-mail: christian.capape@umontpellier.fr

ABSTRACT

The dietary patterns and the feeding habits of greater weever Trachinus draco *(Linnaeus, 1758) are described based on an analysis of 280 stomach contents collected between May 2018 and March 2019 in the Gulf of Tunis. The vacuity index (%VI) was relatively low (23.92%). The proportion of empty stomachs varied significantly by season but not by sex. The most important preys were crustaceans (IRI = 54.55%), followed by teleosts (IRI = 32.93%), molluscs (IRI = 3.3%), and annelids (IRI = 0.05%), which were found occasionally. The specimen body size appeared to be the main factor influencing the diet composition of* T. draco*, as small specimens fed on crustaceans (IRI = 83.5%) and molluscs (IRI = 8.6%), and larger specimens consumed teleosts. The* T. draco *from the Gulf of Tunis is a carnivore species displaying a high trophic level (3.7 < TROPH < 4.5) and a positive allometry in the length-weight relationship. The species finds in the area sufficient resources to develop and reproduce.*

Key words: *Trachinus draco,* northern Tunisia, diet composition, feeding behavior, trophic level

DIETA E ABITUDINI ALIMENTARI DI *TRACHINUS DRACO* (TRACHINIDAE) NEL GOLFO DI TUNISI (MEDITERRANEO CENTRALE)

SINTESI

L'articolo riporta i modelli e le abitudini alimentari della tracina draco Trachinus draco *(Linnaeus, 1758) sulla base di un'analisi di 280 contenuti stomacali, raccolti tra maggio 2018 e marzo 2019 nel Golfo di Tunisi. L'indice di vacuità (%VI) era relativamente basso (23,92%). La percentuale di stomaci vuoti variava significativamente in base alla stagione ma non al sesso. Le prede più importanti erano crostacei (IRI = 54,55%), seguiti da teleostei (IRI = 32,93%), molluschi (IRI = 3,3%) e anellidi (IRI = 0,05%), trovati occasionalmente. Le dimensioni degli esemplari sembrano essere il fattore principale che influenza la composizione della dieta di* T. draco*, poiché gli esemplari piccoli si nutrivano di crostacei (IRI = 83,5%) e molluschi (IRI = 8,6%), mentre gli esemplari più grandi consumavano teleostei. Nel Golfo di Tunisi* T. draco *è una specie carnivora che presenta un livello trofico elevato (3,7 < TROPH < 4,5) e un'allometria positiva nel rapporto lunghezza-peso. La specie trova nell'area risorse sufficienti per svilupparsi e riprodursi.*

Parole chiave: *Trachinus draco*, Tunisia settentrionale, composizione della dieta, comportamento alimentare, livello trofico

INTRODUCTION

Four trachinid species have been present to date in Tunisian marine waters: the lesser weever *Echiichthys vipera* (Cuvier, 1829); the spotted weever *Trachinus araneus* (Cuvier, 1829); the greater weever *T. draco* (Linnaeus, 1758); and the streaked weever *T. radiatus* (Cuvier, 1829) following (Hamed & Chakroun-Marzouk, 2016). Among these species, *T. draco* is the most frequently caught throughout the year by trawlers and artisanal fleets where it was previously often considered by-catch (Hamed & Chakroun-Marzouk, 2016). In fact, due to the drastic decline of fish resources, the high demand of fishery products enhanced the value of some fish species, including *T. draco*. Currently, this species is of high commercial value because it is frequently used for local consumption (Hamed *et al.*, 2017).

Despite the abundance of the greater weever in Tunisian waters, little is known about certain aspects of its biology, especially food and feeding. Therefore, the purpose of the present work is to provide information about the diet composition of the *T. draco* from the Gulf of Tunis, especially its feeding patterns according to season, size, and sex. Studying the food and feeding habits of the species remains a valuable method for investigating and delineating its impact in the wild.

MATERIAL AND METHODS

The greater weevers, *Trachinus draco* were sampled from different landing sites located in the Gulf of Tunis. The specimens were caught by different fishing gears, mainly gill nets, trammel nets, and bottom trawlers at depths between 30 and 150 m (Fig. 1). Samplings were carried out from May 2018 to March 2019. A total of 280 specimens were examined. Immediately after landing, all specimens were dissected and the preys removed, sorted, and identified to the lowest possible taxonomic level using keys and field guides (Riedl, 1963; Perrier, 1964, 1975; Fischer *et al*., 1987).

The food composition and feeding habits of *T. draco* were analysed using the following indices suggested by Hureau (1970), Hyslop (1980), and Rosecchi and Nouaze (1987):

Vacuity Index, VI = (number of empty stomachs/total number of stomachs) x 100

Mean number of prey items per stomachs: Nm = total number of prey ingested / total number of full stomachs

Percentage of numerical abundance: %N = (number of prey item i/ total number of preys) x100

Percentage in weight: %W = (weight of prey i / total weight of all preys items) x 100

Percentage frequency of occurrence: %F = (number of stomachs containing prey item *i* / total number of full stomachs) x 100.

The main food items were identified using the index of relative importance (IRI) defined by Pinkas *et al*. (1971) and modified by Hacunda (1981): IRI = %F x (%N + %P). This index is expressed as: %IRI = (IRI/∑ IRI) x 100. The IRI values were converted to percentages to facilitate comparisons between prey items (Cortés, 1999). All indices listed above contribute to a better understanding of the importance of specific prey items in the feeding behaviour of the investigated fish species.

The diet composition data were also used to establish the trophic level of the greater weever. The trophic level for any consumer species (*i*) is:

$$TROPH_i = 1 + \sum_{i=1}^{G} DC_{ij} * TROPH_j$$

where *TROPHj* is the fractional trophic level of prey (*j*), *DCij* represents the fraction of (*j*) in the diet of (*i*), and (*G*) is the total number of prey species (Pauly *et al.,* 1998; Pauly & Christensen, 2000; Pauly & Palomares, 2000; Stergiou & Karpouzi, 2002).

The *TROPH* and standard errors (*SE*) of the *T. draco* specimens in the study area were calculated using

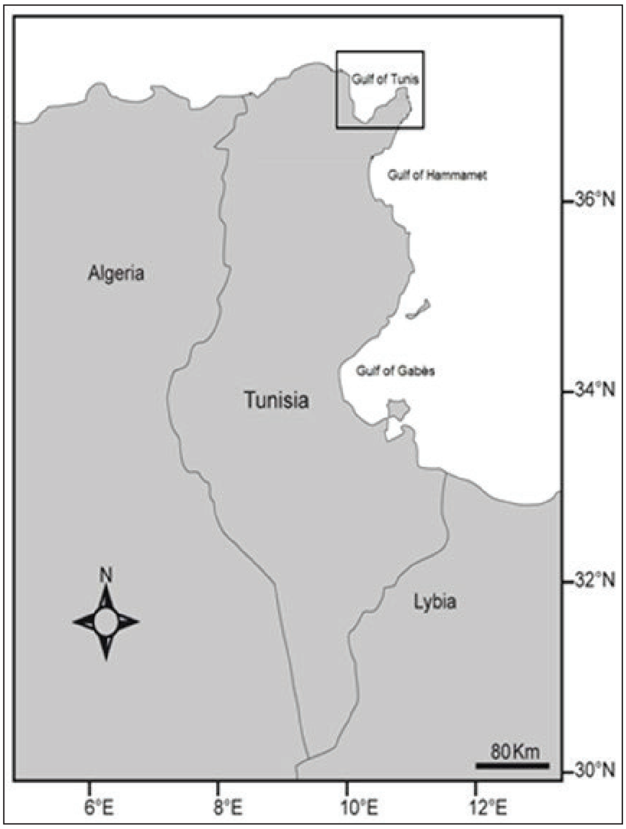

Fig. 1: Map of the Tunisian coast with a rectangle indicating the sampling area of *Trachinus draco.*
Sl. 1: Zemljevid tunizijske obale z označeno lokaliteto, kjer so ulovili primerke vrste *Trachinus draco.*

TrophLab (Pauly *et al.,* 2000). The relationship between TROPH and the midpoint of each length class considered here was quantified using the following equation:

$$\mathrm{TROPH_{Li}} = \mathrm{TROPH}_{L\infty}\,(1 - e^{-KL}i)$$

where *TROPHL∞* is the asymptotic *TROPH* and (*K*) is the rate at which (*TROPHL∞*) is approached (Cortès, 1999).

Statistical analyses were carried out considering the main prey categories: crustaceans, teleosts, molluscs, and annelids. Indeed, a Chi-square test (Sokhal & Rohlf, 1987) was performed to identify the main prey groups responsible for the differences among the factors of sex, season, and size class. The significance level adopted was 5%.

The length-weight relationship of total length (TL) *versus* total body weight was used as a complement for feeding studies following Froese *et al.* (2011). It was estimated from the allometric formula $W = a\ L^b$, where (*W*) is total body weight (g), (*L*) the total length (cm), and (*a*) and (*b*) are the coefficients of the functional regression between (*W*) and (*L*) (Ricker, 1973). In order to confirm whether the b values obtained in the linear regressions were significantly different from the isometric value (b=3), t-tests with appropriate degrees of freedom were used (Zar, 1999).

RESULTS

Vacuity index

A total of 280 specimens of *T. draco* were examined, 115 males and 165 females. They ranged from 11.3 to 28.6 cm in total length (TL), and 23.3 to 202.8 g in total body weight (Fig. 2). The vacuity index (VI) of *Trachinus draco* was 23.92% (Tab. 1). The VI of males (20.87%) and females (26.6%) were significantly different (χ^2 = 5.21; P < 0.05; df = 1). The proportion of empty stomachs also significantly varied by season (χ^2 = 11.34; P < 0.05; df = 3), with a maximum of 33.03% during the spring and 21.31% in summer, while the minimum was observed in winter (15.91%).

Tab. 1: Variations of the vacuity index (%VI) of** Trachinus draco* ***depending on the season and sex.
Tab. 1: Spremenljivost indeksa praznosti (%VI) za vrsto** Trachinus draco* ***glede na sezono in spol.

Seasons				Sex	
Summer	Autumn	Winter	Spring	Males	Females
21.31	16.67	15.91	33.03	20.87	26.06
χ^2 = 11.34; P < 0.05; df = 3				χ^2 = 5.21; P < 0.05; df = 1	

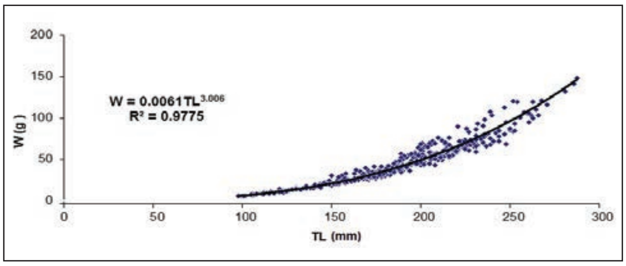

Fig. 2: Length-weight relationships of** Trachinus draco* ***from the Gulf of Tunis.
Sl. 2: Dolžinsko-masni odnos za vrsto** Trachinus draco* ***v Tuniškem zalivu.

Diet composition

The diet of *T. draco* consisted of a large variety of invertebrates and teleosts from four different zoological groups (Tab. 2). Based on the index of relative importance (%IRI), crustaceans were the most frequently ingested prey (IRI = 54.55%), followed by teleosts (IRI = 32.93%). Conversely, molluscs (IRI = 3.3%) and annelids (IRI = 0.05%) were only occasionally found in stomach contents. The index of relative importance of unidentified species was less significant (IRI = 1.54%).

Seasonal variation in diet composition

The analysis of the diet composition of *T. draco* revealed significant variance in the IRI index depending on the season (Tab. 3). The mean IRI indicated crustaceans and teleosts as the main prey groups throughout the year, with crustaceans generally displaying a higher %IRI in summer and autumn (reaching 64.9% and 66.6%, respectively) and lower during winter and spring (51.8% and 54.8%, respectively). Teleosts were generally less abundant in summer (28.9%) and autumn (26.7%), their number gradually increasing from winter (34.2%) to spring (36.3%). Annelids were only found during winter (0.1%), while molluscs varied seasonally, between 2.2% in spring and 6.6% in winter. A Chi-square test revealed significant differences in diet between the season and prey categories (χ^2 = 14.51; P < 0.05; df = 3) (Tab. 3).

Feeding variation and trophic level according to fish size

To assess changes in diet with size (Tab. 3), three size classes were considered: TL < 15 cm, 15 < TL < 20 cm, and TL > 20 cm. The diet of small specimens

Tab. 2: Diet composition of* Trachinus draco *(% Cn percentage in number; % Cw percentage in mass; % F frequency of occurrence; IRI index of relative importance; % IRI percentage index of relative importance of prey items).
Tab. 2: Sestava prehrane vrste* Trachinus draco *(% Cn - delež primerkov plena; % Cw - delež biomase plena; % F - frekvenca pojavljanja plena; IRI - indeks relativne pomembnosti plena; % IRI – delež indeksa relativne pomembnosti plena).

Prey item/index			% Cn	% Cw	% F	IRI	%IRI
Mollusca	Gasteropoda	*Turitella* sp.	0.56	0.13	0.94	0.65	0.01
	Cephalopoda	*Illex* sp.	0.38	0.57	0.47	0.44	0.01
		Sepia elegans	1.31	1.33	0.94	2.49	0.03
		Sepia officinalis	0.94	1.09	0.47	0.95	0.01
		Loligo vulgaris	0.56	0.83	1.41	1.96	0.03
	Non-identified Cephalopoda		2.25	4.89	2.35	16.75	0.23
Total Mollusca			6.00	8.83	15.96	236.84	3.30
Teleostei	Carangidae	*Trachurus* sp.	0.56	1.01	1.41	2.21	0.03
	Congridae	*Conger conger*	0.56	1.37	0.94	1.81	0.03
	Caproidae	*Capros aper*	0.94	1.64	1.88	4.85	0.07
	Clupeidae	*Sardina pilchardus*	1.31	1.87	1.41	4.48	0.06
	Engraulidae	*Engraulis encrasicolus*	0.94	1.06	2.35	4.69	0.07
	Bothidae	*Arnoglossus laterna*	1.31	1.52	1.41	3.99	0.06
	Citharidae	*Citharus linguatula*	0.75	0.62	1.88	2.57	0.04
	Callionymidae	*Callionymus maculatus*	2.25	2.88	0.94	4.82	0.07
	Aulopodidae	*Aulopus filamentosus*	0.56	0.87	0.47	0.67	0.01
	Clinidae	*Clinitrachus argentatus*	0.94	1.07	1.41	2.82	0.04
	Gobiidae	*Gobius cobitis*	3.00	4.32	2.35	17.18	0.24
		Gobius paganellus	3.56	4.09	1.88	14.38	0.20
		Zebrus zebrus	2.44	2.49	1.88	9.25	0.13
		Lesueurigobius friesii	3.94	5.20	2.35	21.46	0.30
	Cepolidae	*Cepola rubescens*	2.25	2.12	1.88	8.20	0.11
		Cepola macrophthalma	2.81	4.36	1.88	13.47	0.19
	Ophichthidae	*Ophichthus rufus*	1.88	2.50	1.88	8.22	0.11
		Echelus myrus	1.69	1.60	1.41	4.63	0.06
	Non-identified Teleostei		6.19	6.78	3.29	42.62	0.59
Total Teleostei			37.90	47.36	27.70	2361.61	32.93
Crustacea	Mysida	*Gastrosaccus sanctus*	3.94	2.79	2.82	18.95	0.26
		Siriella crassipes	3.38	2.42	2.35	13.60	0.19
		Siriella clausii	4.50	3.34	3.76	29.45	0.41
		Paramysis sp.	3.94	2.86	2.82	19.17	0.27
		Gastrosaccus normani	3.56	3.17	3.76	25.28	0.35
		Leptomysis mediterranea	2.25	2.24	4.23	19.00	0.26
		Gastrosaccus normani	3.38	2.62	5.63	33.81	0.47
	Decapoda	*Phyllodoce* sp.	3.38	1.77	2.82	14.50	0.20
		Liocarcinus sp.	2.06	1.71	2.35	8.86	0.12
	Amphipoda	*Gammarus* sp.	1.50	1.52	1.41	4.26	0.06
		Ampelisca sp.	2.63	1.21	2.82	10.82	0.15
	Isopoda	*Anthura gracilis*	3.19	2.56	3.76	21.61	0.30
	Non-identified Crustacea		9.01	7.58	7.98	132.36	1.85
Total Crustacea			46.72	35.80	47.42	3912.72	54.55
Annelids	Polychaeta	*Nereis* sp.	1.31	1.41	1.41	3.84	0.05
Non-identified items			8.07	6.60	7.51	110.16	1.54

Tab. 3: *Trachinus draco*. ***Variations in the index of relative importance (%IRI) of major prey groups depending on the season, fish size, and sex.***
Tab. 3: *Trachinus draco*. ***Spremenljivost indeksa relativne pomembnosti plena (%IRI) glavnih skupin plena v odvisnosti od sezone, velikosti ribe in spola.***

	Seasons				Fish size TL (cm)			Sex	
Prey Groups	**Winter**	**Spring**	**Summer**	**Autumn**	**TL<15**	**15<TL<20**	**TL>20**	**Males**	**Females**
Mollusca	6.6	2.2	3.5	3.3	6.4	8.6	11.4	2.7	2.4
Teleosts	34.2	36.3	28.9	26.7	1.3	8.7	21.9	33.8	31.3
Crustaceans	51.8	54.8	64.9	66.6	83.5	76.2	60.6	58.4	61.6
Annelids	0.1	0	0	0	0.1	0	0	0	0.1
Unidentified	7.3	6.7	2.7	3.4	9.7	6.5	6.1	5.1	4.6
	$\chi^2 = 14.51$; $P > 0.05$; df = 3				$\chi^2 = 20.11$; $P > 0.05$; df = 2			$\chi^2 = 2.78$; $P < 0.05$; df = 1	

(TL < 15cm) mainly included crustaceans (IRI = 83.5%) and molluscs (IRI = 8.6%), while teleosts and annelids accounted for only 1.3% and 0.1% of consumed prey, respectively. In contrast, the diet composition of larger specimens of the greater weever shifted progressively towards small fishes (21.9%), and annelids disappeared completely from stomach contents. The Chi-square test indicated differences in diet composition among fish size classes ($\chi^2 = 20.11$; $P < 0.05$; df = 2).

Food items in relation to sex

The index of relative importance (IRI) showed that crustaceans and teleosts were the main prey items for both sexes all year round (Tab. 3). In contrast, molluscs were always a minor component of the diet of the species. The remaining prey items, i.e., the annelids, represented a low contribution to the diet and were only consumed by males (IRI = 0.1%). A Chi-square test revealed no significant differences between females and males in any of the prey categories ($\chi^2 = 2.78$; $P > 0.05$; df = 1).

The TROPH values for the greater weever in the study area were calculated using the quantitative routine of TrophLab (Pauly *et al.,* 2000). The relationship between TROPH and the midpoint of each length class revealed that *T. draco* is a carnivorous species that mainly consumes large crustaceans, cephalopods and fishes (3.7 < TROPH < 4.5) (Fig. 3).

$$\mathrm{TROPH_{Li}} = 3.94 * (1 - e^{-0.31 * L}i)$$

Length-weight relationship

The values of the exponent b for the combined sexes were significantly higher than 3 (b = 3.006; $R^2 = 0.97$), indicating a positive allometry for the greater weever from the Gulf of Tunis (t-test = 5.17; $P < 0.05$).

DISCUSSION

The feeding behaviour of the greater weever has been studied in the Danish coast (Bagge, 2004) and various areas of the Mediterranean Sea (Vivo & Sanz 1989; Morte *et al.,* 1999; Karachle & Stergiou, 2010; Karachle & Stergiou, 2011; Šantić *et al.,* 2016), but not the central Mediterranean Sea. Our study showed that the *T. draco* from Tunisian waters feeds on a wide range of prey, largely crustaceans and small teleost species and, to a lesser extent, molluscs and annelids. These observations corroborate *pro parte* Morte *et al.,* (1999) and Šantić *et al.,* (2016), who reported decapods as an important prey group, and fishes as secondary prey items.

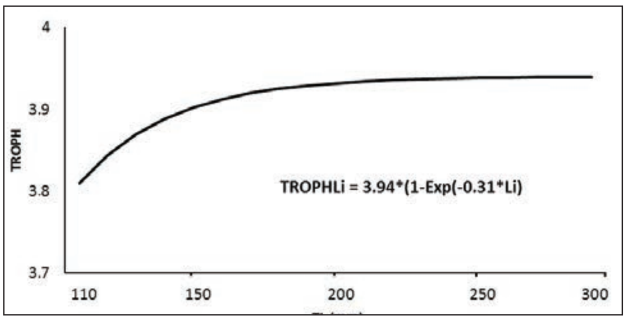

Fig. 3: Relationship between trophic level (TROPH) and total length (TL).
Sl. 3: Odnos med trofičnim nivojem (TROPH) in totalno dolžino (TL).

However, the diet variation and prey composition may be related to the occurrence and availability of different benthic assemblages in different areas (Ferrari & Chieregato, 1981).

Of the 280 *T. draco* stomachs examined, 67 were found empty (VI = 23.9%). The percentage of empty stomachs in specimens of this species from the Gulf of Tunis was relatively low compared to those recorded in previous studies. Morte *et al.* (1999) reported a VI of 42.12% in the Gulf of Valencia (Spain). The percentage of empty stomachs observed in the Danish coast was also very high, close to 100% during certain months (Bagge, 2004). Several studies have noted variations in the vacuity index, which is probably due to the availability of preys for the predators (Andaloro, 1982; Giarrita, 1985). Additionally, variations in temperature have been shown to influence feeding intensity (Jukić & Županović, 1965; Tyler, 1971; Zore-Armanda *et al.,* 1991).

Ontogenetic changes in food composition are well known among fishes (Karachle & Stergiou, 2010; Rafrafi-Nouira *et al.,* 2016). The present study confirms the relationship between prey items and body size for *T. draco* in Tunisian waters, with consumption of crustaceans decreasing and consumption of cephalopods and teleosts increasing with the fish's body size. Similar patterns were reported by Morte *et al.* (1999) from the Gulf of Valencia and by Šantić *et al.* (2016) in the Adriatic Sea. The seasonal changes in the diet of *T. draco* observed herein are also in agreement with the data reported by Morte *et al,* (1999) and Šantić *et al.* (2016) for the Adriatic Sea. The food spectrum was also influenced by prey availability, which likely varied with the seasons, as well as by the adaptability of predators and ability to locate prey (Zander, 1996). In the present study, no significant difference was observed in prey composition between males and females of *T. draco*. Since neither Morte *et al.* (1999) nor Šantić *et al.* (2016) examined sex differences in dietary patterns, a comparison between the studied areas in this respect is not possible.

Stergiou & Karpouzi (2002) and Karachle & Stergiou (2017) classified fishes in five distinct functional trophic groups. Following their classifications, *T. draco* could be considered a carnivorous species with a preference for large decapods, cephalopods, and teleosts (TROPHL∞ = 3.94, S.E = 0.22). This is the first paper to study the trophic level for *T. draco*.

The abundance of *T. draco* in northern Tunisian waters and the positive allometry observed in the length-weight relationship indicates that the species has found here sufficient resources to thrive. This suggests a wealth of other fish in the area that may have a favourable impact on the local economy. It is worth noting that *T. draco* is now actively targeted by fishermen and no longer considered a by-catch species (Hamed *et al*., 2017).

However, *T. draco* is a venomous and thereby dangerous fish, which can cause injury to humans (Mebs, 2006). The species has venomous spines on the first dorsal fin and one on the opercular bone, which are effective against predation by other species, but can pose a risk to humans. The species' presence in the area is therefore a potential public health problem (Capapé *et al*., 1976). Information provided by fishermen indicates that they have sustained injuries while handling the species. Furthermore, tourism, which plays an important role in the Tunisian economy, especially health tourism on the sandy beaches along the coast (El Bekri, 2013), could also be impacted by the presence of *T. draco*. Bathers and recreational fishermen, who are particularly abundant in spring and summer, are at risk for injury by this and/or other venomous species (Capapé *et al*., 1975, 1976).

The dietary patterns and the feeding habits of *T. draco* allow us to understand the biodiversity of the study area, and the trophic level clearly indicates the role of the species as a top predator regulating local biotopes. It appears that a viable population of *T. draco* is successfully established in the area where the species is appreciated by local consumers, and therefore plays an interesting economic role despite the fact that it can cause serious injuries and envenomation. This study could serve as a reference point for designing appropriate measures to regulate the capture of the species and thus safeguard its presence in the area (La Mesa *et al.,* 2007; Kitsos *et al.,* 2008).

ACKNOWLEDGEMENTS

The authors wish to thank and acknowledge the assistance of professional fishermen in collecting material for this study.

PREHRANJEVALNE NAVADE MORSKEGA ZMAJA *TRACHINUS DRACO* (TRACHINIDAE) IZ TUNIŠKEGA ZALIVA (OSREDNJE SREDOZEMSKO MORJE)

Mourad CHÉRIF
Institut National des Sciences et Technologies de la Mer, port de pêche, 2060 La Goulette, Tunisia

Rimel BENMESSAOUD
Institut National Agronomique de Tunis, 43 Avenue Charles Nicolle 1082, Tunis- Mahrajène, Tunisia

Sihem RAFRAFI-NOUIRA
Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ
Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier, France
e-mail: christian.capape@umontpellier.fr

POVZETEK

Avtorji opisujejo prehranjevalne vzorce morskega zmaja Trachinus draco *(Linnaeus, 1758), pridobljene na podlagi preiskave iz želodcev 280 primerkov, ujetih med majem 2018 in marcem 2019 v Tuniškem zalivu. Indeks praznosti (%VI) je bil relativno nizek (23,92%). Delež praznih želodcev se je glede na sezono spreminjal, ne pa tudi glede na spol. Najpomembnejše vrste plena so bili raki (IRI = 54,55%), sledile so jim kostnice (IRI = 32,93%), mehkužci (IRI = 3,3%) in kolobarniki (IRI = 0,05%), ki so bili najdeni občasno. Kaže, da je telesna velikost ključni dejavnik, ki vpliva na prehrano vrste* T. draco*, saj so manjši primerki plenili rake (IRI = 83.5%) in mehkužce (IRI = 8.6%), večji pa kostnice. Morski zmaj iz Tuniškega zaliva je mesojeda vrsta z visokim trofičnim nivojem (3.7 < TROPH < 4.5) in pozitivno alometrijo glede na masno-dolžinski odnos. Na obravnavanem območju ima zadovoljive razmere za rast in razmnoževanje.*

Ključne besede: *Trachinus draco,* severna Tunizija, sestava prehrane, prehranjevalno vedenje, trofični nivo

REFERENCES

Andaloro, F. (1982): Résumé des paramètres biologiques sur *Pagellus acarne* de la mer Ionienne septentrionale. FAO, Fish/FAO Rapp. Pech., 266, 89-92.

Bagge, O. (2004): The biology of the greater weever (*Trachinus draco*) in the commercial fishery of the Kattegat. ICES J. Mar. Sci., 61, 933-943.

Capapé, C., R. Prieto & A. Chadli (1975): Les sélaciens dangereux des côtes tunisiennes. Arch. Inst. Pasteur, Tunis, 52(1-2), 61-108.

Capapé, C., R. Prieto & A. Chadli (1976): Les téléostéens dangereux des côtes tunisiennes. I. Les espèces venimeuses. Arch. Inst. Pasteur, Tunis, 53(3), 293-315.

Cortés, E. (1999): Standardized diet compositions and trophic levels of sharks. ICES Journal of Marine Science, 56(5), 707-717.

El Bekri, F. (2013): Le tourisme en Tunisie et son impact environnemental. Maghreb-Machrek, 2019(2), 73-93.

Ferrari, I., & A.R. Chieregato (1981): Feeding habits of juvenile stages of *Sparus auratus* L., *Dicentrarchus labrax* L. and Mugilidae in a brachish embayment of the Po River Delta. Aquaculture, 25, 243-257.

Fischer, W., M.L. Bauchot & M. Schneider (1987): Fiches FAO d'Identification des Espèces pour les Besoins de la Pêche "Révision" Méditerranée et Mer Noire. Zone de Pêche 37. Vol. II. Vertébrés. Rome, FAO, 2, 761-1530.

Froese, R., A.C. Tsikliras & K.I. Stergiou (2011): Editorial note on weight-length relations of fishes. Acta Ichthyol. Piscat., 41(4), 261-263.

Giarrita, P.S. (1985): Contribution to the knowledge of the age, growth and feeding of Pandora, *Pagellus erythrinus* (L. 1758) in the Sicilian Channel. FAO Rapp., Pech/FAO Fish Rep., 336, 85-87.

Hacunda, J.S. (1981): Trophic relationships among demersal fishes in coastal area of the Gulf of Main. Fish. Bull., 79, 775-788.

Hamed, O. & N. Chakroun (2016): Caractérisation des Trachinidae du golfe de Tunis: Caractéristiques morphométriques, structure démographique et croissance. Editions universitaires européennes, 120 pp.

Hamed, O., K. Mahé & N. Chakroun-Marzouk (2017): Somatic growth, condition and form factor of Trachinus draco Linnaeus, 1758 in the Gulf of Tunis. Bull. Inst. Sci. Technol. Mer, Salammbô, 44, 1-11.

Hureau, J.C. (1970): Biologie comparée de quelques poissons antarctiques (Notothenidae). Bull. Inst. océanogr. Monaco, 68, 1-244.

Hyslop, E.J. (1980): Stomach content analysis-a review of methods and their application. J. Fish Biol., 17(4), 411-429.

Jukić, S. & Š. Županović (1965): Relation between temperature and feeding intensity for *Mullus barbatus* (L.) and *Pagellus erythrinus* (L.) in the Bay of Kaštela. Proc. Gen. Fish. Coun. Medit., 8(17), 173-177.

Karachle, P.K. & K.I. Stergiou (2010): Gut length for several marine fish: relationships with body length and trophic implications. Mar. Biodiv. Rec., 3, 1-10.

Karachle, P.K. & K.I. Stergiou (2011): Mouth allometry and feeding habits in fishes. Acta Ichthyol. Piscat., 41(4), 265-275.

Karachle P.K., & K.I. Stergiou (2017): An update on the feeding habits of fish in the Mediterranean Sea (2002-2015). Medit. Mar. Sci., 18(1), 43-52.

Kitsos, M.S., T. Tzomos, L. Anagnostopoulou, & A. Koukouras (2008): Diet composition of the sea horses, *Hippocampus guttulatus* Cuvier,1829 and *Hippocampus hippocampus* (L.,1758) (Teleostei, Syngathidae) in the Aegean Sea. J. Fish Biol., 72(6), 1259–1267.

La Mesa, G., M. La Mesa, & P. Tomassetti (2007): Feeding habits of the Madeira rockfish, Scorpaena maderensis, from central Mediterranean Sea. Mar. Biol., 150(6), 1313-1320.

Lassalle, G., T. Chouvelon, P. Bustamante, & N. Niquil (2014): An assessment of the trophic structure of the Bay of Biscay continental shelf food web: Comparing estimates derived from an ecosystem model and isotopic data. Prog. Oceanog., 120, 205-215.

Mebs, S. (2006): Animaux venimeux et vénéneux. Édition française Max Goyffon, Éditions Tect & Doc, Paris, 346 pp.

Morte, S., M.J. Redon, & A. Sanz-Brau (1999): Feeding habits of *Trachinus draco* on the eastern coast of Spain (Western Mediterranean). Vie Milieu, 49(4), 287-291.

Pauly, D., A.W. Trites, E. Capuli, & V. Christensen (1998): Diet composition and trophic levels of marine mammals. ICES J. Mar. Sci., 55, 467-481.

Pauly, D. & V. Christensen (2000): Trophic levels of fishes. In: Froese R., Pauly D. (eds.) Fishbase 2000: Concepts, design and data sources. ICLARM, Manila, Philippines.

Pauly, D., R. Froese, P. Sa-a, M.L. Palomares, V. Christensen, & J. Rius (2000): TrophLab Manual. ICLARM, Manila, Philippines.

Pauly, D., & M.L Palomares (2000): Approaches for dealing with three sources of bias when studying the fishing down marine food web phenomenon. Pp. 61-66. In: Briand F. (ed.) Fishing down the Mediterranean food webs, CIESM Workshop Series 12.

Perrier, R. (1964): La faune de la France illustrée. 1B. Vers et némathelminthes. Delagrave, Paris, 179 pp.

Perrier, R. (1975): La faune de la France illustrée. II. Arachnides et crustacés. Delagrave, Paris, 220 pp.

Pinkas, L., M.S. Oliphant, & I.L.K Iverson (1971): Food habits of albacore, blue-fin tuna, and bonito in California waters. Calif. Fish Game, 152, 1-105.

Rafrafi-Nouira, S., M. El Kamel-Moutalbi, M. Boumaiza, C. Reynaud, & C. Capapé (2016): Food and feeding habits of black scorpionfish, *Scorpaena porcus* (Osteichthyes: Scorpaenidae) from the northern coast of Tunisia (central Mediterranen). J. Ichthyol., 56(1), 107-123.

Ricker, W.E. (1973): Linear regressions in fishery research. J. Fish. Res. Board Canada, 30, 409-434.

Riedl, R. (1963): Fauna and flora der Adria. Paul Parey, Hamburg, 702 pp.

Rosecchi, E. & Y. Nouazé (1987): Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux. Rev. Inst. Pêch. marit., 49(3-4), 111-123.

Šantić, M., A. Pallaoro, B. Rada, & I. Jardas (2016): Diet composition of greater weever, (Linnaeus, 1758)

received: 2022-11-22 DOI 10.19233/ASHN.2023.12

SKELETAL ABNORMALITIES IN A *SPHYRAENA SPHYRAENA* (LINNAEUS, 1758) AND A *TRACHINUS RADIATUS* CUVIER, 1829 COLLECTED FROM THE NORTH-EASTERN AEGEAN SEA, IZMIR, TURKEY

Laith A. JAWAD
School of Environmental and Animal Sciences, Unitec Institute of Technology, 139 Carrington Road, Mt Albert, Auckland 1025, New Zealand
email: laith_jawad@hotmail.com

Okan AKYOL
Ege University, Faculty of Fisheries, 35440 Urla, Izmir, Turkey

ABSTRACT

This study targeted the skeletal anomalies in a European barracuda, Sphyraena sphyraena*, and a starry weever,* Trachinus radiatus *obtained from the wild population of the north-eastern Aegean Sea, Izmir, Turkey. A severe case of consecutive repetition of lordosis-kyphosis was observed in the* S. sphyraena*, and a mild case of cranial lordosis, ankylosis, and hyperostosis in the* T. radiatus*. These records are equally important for fisheries biologists and aquaculturists as this is the first such report for the European barracuda and the starry weever, which supplements the abnormality incidences already recorded from Turkish waters. The evaluation of the anomalies in the investigated specimens was carried out based on morphological identification and using radiography. Possible reasons for such abnormalities are discussed. Additional investigation would be necessary to link specific contaminants with the examined types of anomaly.*

Key words: deformities, pollution, vertebral column, lordosis, kyphosis, hyperostosis

ANOMALIE SCHELETRICHE IN *SPHYRAENA SPHYRAENA* (LINNAEUS, 1758) E *TRACHINUS RADIATUS* CUVIER, 1829 PROVENIENTI DALL'EGEO NORD-ORIENTALE, IZMIR, TURCHIA

SINTESI

Lo studio prende in esame le anomalie scheletriche del luccio di mare, Sphyraena sphyraena*, e della tracina raggiata,* Trachinus radiatus*, appartenenti alla popolazione selvatica dell'Egeo nord-orientale, vicino a Izmir, in Turchia. È stato osservato un caso grave di ripetizione consecutiva di lordosi-cifosi in* S. sphyraena *e un caso lieve di lordosi cranica, anchilosi e iperostosi in* T. radiatus*. Questi dati sono importanti sia per i biologi della pesca che per gli acquacoltori, poiché si tratta della prima segnalazione di tali malformazioni per queste due specie, che va a integrare le incidenze di anomalie già registrate nelle acque turche. La valutazione delle anomalie negli esemplari esaminati è stata effettuata in base dell'identificazione morfologica e utilizzando la radiografia. Vengono discusse le possibili ragioni di tali anomalie. Sarebbero necessarie ulteriori indagini per collegare specifici contaminanti con i tipi di anomalia esaminati.*

Parole chiave: deformità, inquinamento, colonna vertebrale, lordosi, cifosi, iperostosi

INTRODUCTION

The European barracuda, *Sphyraena sphyraena,* is a marine species living in the pelagic-neritic region in the depth range of 0–100 m (Reiner, 1996). It reaches a maximum total length of 1650 mm (Bauchot, 1987) and a maximum reported weight of 3.6 kg (IGFA, 2001). Individuals of this species are distributed in the eastern Atlantic Ocean from the Bay of Biscay to Mossamedes, Angola, including the Mediterranean and the Black Sea, the Canary Islands, and the Azores. They are also reported from the western Atlantic Ocean in Bermuda and Brazil. Torcu *et al.* (2001) suggests that the European barracuda should be listed among the highly commercial fish species in the Mediterranean Sea and the seas around Turkey.

The starry weever, *Trachinus radiatus*, is a marine species inhabiting demersal environments in the depth range of 1–150 m (Roux, 1990). It attains a maximum total length of 500 mm (Bauchot, 1987). Individuals of this species prefer areas with sand and mud bottoms on the continental shelf, from the shoreline to a depth of about 150 m (Roux, 1990). The females are oviparous (Tortonese, 1986). This species is distributed in the eastern Atlantic Ocean region from Gibraltar to the Gulf of Guinea, possibly more to the south. It is also reported from the Mediterranean Sea (Fischer *et al*., 1987). Akyol (2003) included *T. radiatus* in the list of commercial and genuine trash catches from beach-seining. Conversely, Aytaç *et al*. (2020) suggested that this species is not among the important commercial fish species in Turkey.

Like all wild marine and freshwater fishes, *S. sphyraena* and *T. radiatus* face the possibility of a wide range of skeletal abnormalities due to several factors. In general, skeletal anomalies in fish is a critical issue for fisheries as well as the aquaculture sectors (Kužir *et al*., 2015). Numerous incidents of various anomalies have been reported in wild and reared fishes (Afonso *et al*., 2000; Sato, 2006; Jawad *et al*., 2017b; Jawad & Ibrahim, 2018). It has been known that these anomalies can impact several areas of the fish body (De La Cruz-Aguero & Perezgomez-Alvarez, 2001). These deformities have been revealed to negatively influence the life of fish and curtail the market value of certain fish species (Raja *et al*., 2016; Majeed *et al*., 2018). In the fish that live in the wild, skeletal deformities, which may occur during the phase of development, may produce problems, for instance, in their abilities to defend the habitat (Sato, 2006; Majeed *et al*., 2018) or contend for a mate (Sato, 2006), and lessen fisheries production (Noble *et al*., 2012). In aquaculture facilities, these anomalies could disturb the fish by stalling their development (Hansen *et al*. 2010), impairing their feeding capability (López-Olmeda *et al*., 2012; Okamura *et al*., 2018), increasing the risk of contamination (Janakiram *et al*., 2018) and escalating mortality rates (Jara *et al*., 2017). Additionally, these unwanted impacts of skeletal abnormalities will indirectly affect the economy of fish farms (Boglione, 2013; Yıldırım *et al*., 2014).

Deformities in the fish skeleton are often perceived and defined in numerous fish taxa, and these can be vertebral centra deformities (including kyphosis and lordosis). These can be severe or mild both in aquaculture and wild individuals (Jawad & Ibrahim, 2018; Näslund & Jawad, 2021). In case of severe deformity of the vertebral centra (compression or a combination of compression and fusion of the vertebrae) the fish will have trouble swimming (Witten *et al*., 2006). Lordosis is another often designated axis anomaly in fish. It can be present in any part of the vertebral column, including pre-haemal and haemal locations (Boglione *et al*., 1995). When occurring in the pre-hemal region it is associated with swim bladder inflation failure (Chatain, 1994). Other types of lordosis comprise haemal lordosis, which is a common fish abnormality (Jawad *et al*., 2014; Fjelldal *et al*., 2009), cranial lordosis (affecting the most anterior vertebrae), and caudal lordosis (affecting the centra of the caudal peduncle). Kyphosis is considered less common than lordosis (Boglione *et al*., 2013).

Commonly, hyperostosis was thought to be an osteoma, a non-carcinogenic bone neoplasm. In English, these formations are called hyperostotic bones, swollen bones, or even "Tilly bones" (named after the late Tilly Edinger, an enthusiastic student of these structures, see Konnerth, 1966; Smith Vaniz *et al*., 1995). They are almost exclusively limited to marine teleosts and frequently affect members of the Carangidae family in response to hormonal changes that generally occur (Smith-Vaniz *et al*., 1995). While these structures have been observed in at least 92 marine teleost fishes belonging to 22 families (Smith-Vaniz *et al*., 1995), they are also typical of specific fish species such as trichiurids, carangids, and sciaenids, where hormonal imbalance occurs (Giarratana *et al*., 2012; Meunier *et al*., 2008; Smith-Vaniz *et al*., 1995). Further, in the over 28 years since Smith-Vaniz *et al*. (1995), 21 fish species with hyperostosis appearance belonging to 14 families have been recognised (Fjelldal *et al*., 2012; Jawad, 2013; Jawad & Bannai, 2014; Jawad & Ibrahim, 2017; Mahmoud & Ibrahim, 2021; Matić-Skoko & Ferri, 2009; Meunier *et al*., 1999; Meunier *et al*., 2010; Paig-Tran *et al*., 2016; Smith-Vaniz & Carpenter, 2007; Tuna *et al*., 2021).

For marine fish species collected from Turkish waters, cases of lordosis-kyphosis have been recorded in *Atherina boyeri* (Jawad *et al.*, 2017a) and *Mullus barbatus* (Jawad *et al.*, 2018). Recently, Jawad *et al.* (2022) described cases of lordosis-kyphosis in speciments of *Merluccius merluccius*, *Trachurus trachurus*, and *Mullus surmuletus* from the Sea of Marmara.

The present study discusses a severe case of consecutive repetition of lordosis-kyphosis in a *S. sphyraena* and a mild case of cranial lordosis, ankylosis, and hyperostosis in a *T. radiatus*. These fish specimens were captured in the Bay of Çandarlı and off the coasts of Çeşme, Izmir, respectively, in the north-eastern Aegean Sea, Turkey. The two records are considered essential for both fisheries biologists and aquaculturists as they are the first such cases to be reported for the European barracuda and the starry weever and will importantly complement the records of abnormality incidences collected from Turkish waters so far.

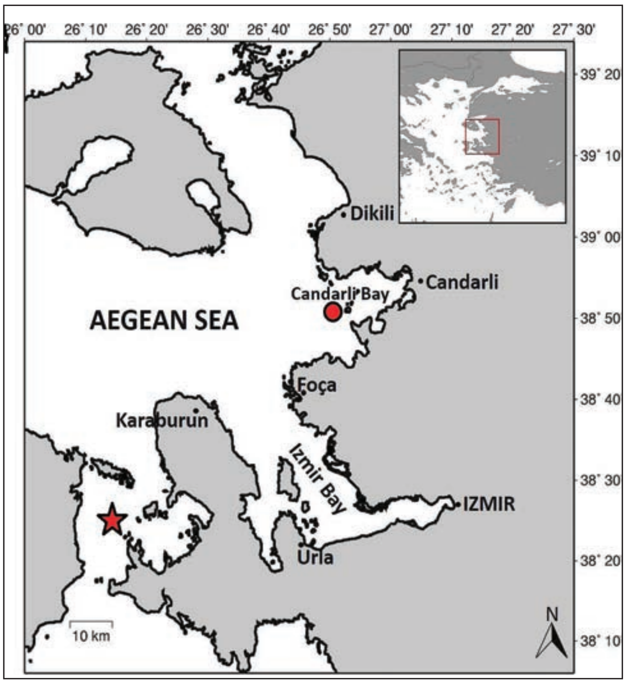

Fig. 1: Map showing sampling localities of *Sphyraena sphyraena* **(red dot) and** *Trachinus radiatus* **(red star).**
Sl. 1: Zemljevid z označenimi vzorčevalnimi postajami ulova primerkov vrst *Sphyraena sphyraena* **(rdeča pika) in** *Trachinus radiatus* **(rdeča zvezdica).**

Tab. 1: Morphometric (mm) and meristic characteristics of the two *Sphyraena sphyraena* ***captured in the Bay of Çandarlı, Izmir, NE Aegean Sea.***
Tab. 1: Morfometrične (mm) in meristične značilnosti dveh primerkov vrste *Sphyraena sphyraena****, ujetih v zalivu Çandarlı, Izmir, SV Egejsko morje.***
ža; GN: zabodna mreža; HL: ročna vrvica).

Characteristics	Normal specimen	Abnormal specimen
Total length	329	256
Standard length	295	223
Fork length	310	232
Head length	89	75
Preorbital length	40	35
Eye diameter	15	14
Interorbital length	13	13
Pre-first dorsal fin length	126	103
Prepectotal fin length	88	73
Preanal fin length	215	167
Number of spines of the first dorsal fin	V	V
Number of spines of the second dorsal fin	9	9
Number of rays in the anal fin	I+9	I+9
Number of rays in the pectoral fin	13	13
Number of spines and rays in the pelvic fin	I+5	I+5

MATERIAL AND METHODS

One abnormal specimen of *S. sphyraena* (256 mm TL) and one of *T. radiatus* (239 mm TL) were captured, respectively, off the coast of Çandarlı Bay, NE Aegean Sea (38°52′ N - 26°51′ E) (Fig. 1) on 19 August 2016, and off the coast of Çesme, NE Aegean Sea (38°25′ N - 26°16′ E) (Fig. 1) on 30 March 2018. No such abnormalities were observed in these two fish species after the date of March 2018. Both specimens were caught by bottom trawl, the *S. sphyraena* at 50 m and the *T. radiatus* at 80 m of depth. They were fixed in a 10% formaldehyde solution and deposited in the fish collection at the Museum of the Faculty of Fisheries at Ege University, Faculty of Fisheries under museum numbers ESFM-PIS/2016-04 for *S. sphyraena* and ESFM-PIS/2018-05 for *T. radiatus*. For the purpose of comparison, two normal specimens of *S. sphyraena* (329 mm TL) and *T. radiatus* (314 mm TL) were obtained from the same localities. In defining the anomalies of the vertebral column of the fishes, all the vertebrae missing haemal spines were labelled "abdominal vertebrae" and those exhibiting haemal spines were termed "caudal vertebrae".

Tab. 2: Morphometric (mm) and meristic characteristics of the two* Trachinus radiatus *captured off Çeşme, Izmir, NE Aegean Sea.
Tab. 2: Morfometrične (mm) in meristične značilnosti dveh primerkov vrste* Trachinus radiatus*, ujetih blizu Çeşme, Izmir, SV Egejsko morje.

Characteristics	**Normal specimen**	**Abnormal specimen**
Total length	314	239
Standard length	281	205
Head length	79	66
Preorbital length	11	11
Eye diameter	13	13
Interorbital length	11	10
Pre-first dorsal fin length	65	48
Prepectotal fin length	76	63
Preanal fin length	84	68
Number of spines of the first dorsal fin	VI	VI
Number of spines of the second dorsal fin	25	24
Number of rays in the anal fin	I+26	I+26
Number of rays in the pectoral fin	16	16
Number of spines and rays in the pelvic fin	I+5	I+5

The specimen of *S. sphyraena* displayed a severe case of consecutive repetition of lordosis-kyphosis, and the *T. radiatus* a mild case of dorsal lordosis. Both specimens showed additional malformations, deletions, and morphological deformities.

To examine the vertebral columns of the two deformed fish specimens the Amadeo V mini II x-ray machine was used. The angle of the vertebral anomaly was recorded from the centre of the abnormality (located in the caudal region for *S. sphyraena* and in the thoracic region for *T. radiatus*) by using a digital protractor. To measure the degree of aberration in the anomalous individuals, the height of the curvature of the spinal column (HC) was measured. This paralleled with the distance between the tangent to the apical vertebra and a straight line passing through the bases of the two vertebrae limiting the curvature. The morphometric measures for both species were taken using a digital caliper and recorded to the nearest 0.01 mm following De Sylva (1990) for *S. sphyraena* and Roux (1990) for *T. radiatus* (Tables 1 and 2). The depth of the curvature (DC) was recorded using the following relationship given by Louiz *et al*. (2007):

$$DC = (HC / SL) \times 100 \text{ (SL = standard length of fish)}$$

RESULTS

Described below are the case of consecutive repetition of lordosis-kyphosis in the specimen of *S. sphyraena* below, and three types of deformity – i.e., mild cranial lordosis, ankylosis, and hyperostosis – observed in the abnormal specimen of *T. radiatus*.

Family: Sphyraenidae
Sphyraena sphyraena (Figs. 2 & 3)
A severe case of consecutive repetition of lordosis-kyphosis

The structures of the vertebral columns of the normal and abnormal specimens of *S. sphyraena* are shown in Figs. 2a and 2b. In this radiograph, the anomalous specimen of *S. sphyraena* exhibits three lordotic and two kyphotic areas spreading along all vertebrae from V2 to V23. Every part of these anomalies affects several vertebrae. The vertebrae composing the first lordotic arch are V1–V4, the first kyphotic arch is confined to vertebrae 5–11, the second lordotic arch includes vertebrae 12–15, the second kyphotic arch vertebrae 16–20, and the third lordotic arch encompasses vertebrae 21–23 (Fig. 2a). The value of the first lordotic angle “A” is 160°, of the first kyphotic angle “B” 150°, of the second lordotic angle “C” 137°, of

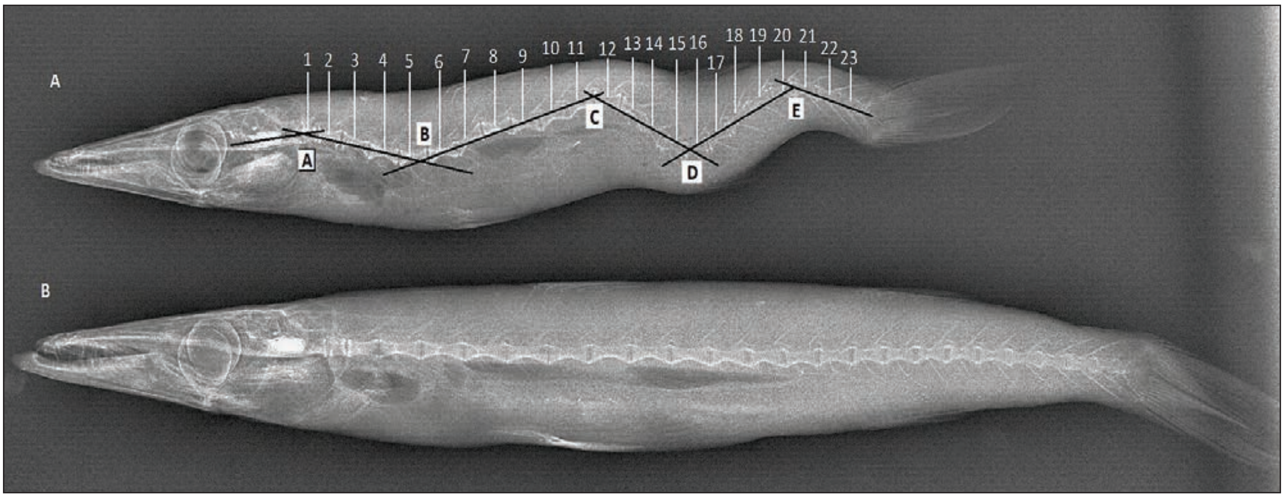

Fig. 2: Radiograph of** Sphyraena sphyraena **– a) abnormal specimen, 256 mm TL, exhibiting consecutive repetition of lordosis-kyphosis; b) normal specimen, 329 mm TL.
Sl. 2: Radiografija primerkov vrste** Sphyraena sphyraena **– a) abnormalen primerek, 256 mm TL, z zaporednim pojavljanjem lordoze-kifoze; b) normal primerek, 329 mm TL.

Fig. 3:** Sphyraena sphyraena **– a) normal specimen, 329 mm TL; b) abnormal specimen, 256 mm TL.
Sl. 3:** Sphyraena sphyraena **– a) normalen primerek, 329 mm TL; b) abnormalen primerek, 256 mm TL.

the second kyphotic angle "D" 130°, and of the third lordotic angle "E" 138°. Generally, the sizes of the vertebrae involved in lordosis-kyphosis repetition are not disturbed. The depths of the curvature (DC) of angles A, B, C, D, and E are 5.1, 5.7, 10.2, 10.9, and 10.4 mm, respectively. Compared to the normal specimen of *S. sphyraena* (Fig. 3a), the external morphology of the abnormal specimen showed two lordotic arches and one kyphotic arch (Fig. 3b).

Family: Trachinidae
Trachinus radiatus (Figs. 4 & 5)
Mild cranial lordosis

The images of abnormal and normal specimens of *T. radiatus* are shown in Fig. 4a and 4b. In comparison with the normal specimen, the abnormal specimen exhibits one cranial lordotic arch located just under the dorsal fin. The radiographs of the abnormal and normal specimens (Figs. 5a and 5b) show that the abnormal specimen has

Fig. 4: *Trachinus radiatus* ***– a) abnormal specimen, 239 mm TL; b) normal specimen, 314 mm TL.***
Sl. 4: *Trachinus radiatus* ***– a) abnormalen primerek, 239 mm TL; b) normalen primerek, 314 mm TL.***

one cranial lordotic arch involving thoracic vertebrae 1–5, and one thoracic kyphotic arch including thoracic vertebrae 6–10. The value of the first lordotic angle "A" is 150°, the value of the kyphotic angle "B" 155°. The depths of the curvature (DC) of angles A and B were 4.2 and 3.3 mm, respectively (Fig. 4b).

Ankylosis

Viewed externally, the distance between the posterior edge of the operculum and the anterior end of the dorsal fin is shorter in the abnormal specimen than in the normal specimen (Figs. 4a & 4b). The radiograph reveals that thoracic vertebrae 2–4 and 5–7 are compressed, deformed, and ankylosed together. In addition, vertebrae 8–14 are compressed. Finally, vertebrae number 15 is evidently compressed and deformed.

Hyperostosis

The abnormal specimen does not show any sign of abnormality related to the hyperostosis case it has (Fig. 4a). The radiograph of the abnormal specimen (Fig. 5a) shows hyperostotic deformities in two regions of the vertebral column: in the neural spine of the 16th and in the haemal spines of the 15th–17th caudal vertebrae. The diameter of the hyperostotic part of the neural spine of the 16th caudal vertebra is 2.9 mm, the sizes of the hyperostotic parts of the haemal spines of the 15th–16th caudal vertebrae are 4.3 x 1.4 and 5.7 x 1.4 mm, respectively. The diameter of the hyperostotic part of the 17th caudal vertebrae is 2.1 mm. The shapes of the hyperostotic parts of the neural spine of the 16th and of the haemal spine of the 17th caudal vertebrae are spherical, while the shapes of the hyperostotic parts of the haemal spine of the 15th and the 16th caudal vertebrae are elongated.

DISCUSSION

This is the first report investigating the incidence and types of vertebral deformity in adult wild teleost fish species from the Aegean Sea, Izmir, Turkey. The objective was to identify skeletal deformities and define a potential link between these anomalies and environmental impacts.

There is an extensive number of publications on wild fish deformities (Divanach *et al.*, 1996; Jawad *et al.*, 2013; Jawad & Liu, 2015) that investigate both genetic (Ishikawa, 1990) and epigenetic issues as plausible reasons for such abnormalities (Boglione *et al.*, 1995), as well as environmental issues such as temperature, light, salinity, pH, low oxygen concentrations, and inadequate hydrodynamic conditions.

The morphological anomalies in the vertebral column in the form of lordosis and kyphosis observed in the specimens of *S. sphyraena* and *T. radiatus* were associated with anterior-posterior (i.e., cranial-caudal) compression along the spine. Radiographs of the deformed specimens showed structural anomalies; the normal amphicoelous (hourglass) shape of the vertebrae was imprecise, with vertebral height reduced on the convex and increased on the concave side of the vertebral column. In addition, vertebrae at the approximate bottom centre of the curvature (in the case of lordotic arch) were wedged, with the length on the concave side of the vertebral column reduced compared to the convex length of the vertebral column. Comparable differences were perceived in *Poecilia reticulata* by Gorman *et al*. (2010). They suggested that the observed deviancies in vertebral bone structure might be due to either (1) distortion of normal vertebral shape or (2) active remodelling of vertebral osteoid bone as an outcome of exterior influences. They also commented that vertebral development in fish is unlike that of other animal models. The *Poecilia reticulata* which they examined had vertebrae containing an acellular bone (i.e., without entrenched osteocytes and formed by intramembranous ossification) (reviewed in Witten & Huysseune, 2009). Accordingly, in the future, additional examinations of vertebral wedging in the two teleost fish species studied herein as well as in other fish species displaying lordosis and kyphosis should be conducted to test the cellular activity at the intervertebral region, *i.e.*, the alleged growth zone of guppy vertebrae (Inohaya *et al*., 2007), and determine any variation of growth in curved individuals.

The cases of lordosis, kyphosis and consecutive recurrence of lordosis-kyphosis examined herein are related to similar cases observed in other fish species collected from Turkish waters. Jawad & Öktener (2007) studied these abnormalities in *Liza* (= *Planiliza*) *abu* from Ataturk Dam Lake. Jawad *et al*. (2017a,b) and Jawad *et al*. (2018) described cases of lordosis, kyphosis, and consecutive repetition of lordosis-kyphosis in the *Atherina boyeri* collected from the Homa Lagoon, Izmir, and in the *Mullus barbatus* and *Mugil cephalus* obtained from the northern Aegean Sea, respectively. The lordosis and kyphosis in the specimens of *Liza* (= *Planiliza*) *abu* and *M. cephalus* were similar in intensity to those of the *S. sphyraena* specimen in the current study. Also, the severity of the consecutive repetition of lordosis-kyphosis described for *A. boyeri* (Jawad *et al*., 2017a) and *Mullus barbatus* (Jawad *et al*., 2018) was similar to that observed in the *S. sphyraena* specimen from the study at hand. Moreover, Jawad *et al*. (2022) reported similar cases of lordosis-kyphosis repetition in *Trachurus trachurus* and *Mullus surmuletus* collected from the Sea of Marmara. These cases are similar in severity to the case of *S. sphyraena* investigated in the current study.

Several authors have shown that bone-forming may be disturbed in waters with decreased oxygen levels through its impact on bone mineral configuration (Martens *et al*., 2006). In the waters of the Aegean Sea in general, the annual variations of temperature would seem to suggest similar discrepancies in oxygen levels, with tremendously low levels in summer, when the temperature and salinity are at their highest (Eronat & Sayin, 2014; Tukenmez & Altiok, 2022). Hypoxia or oxygen shortage is a recognised cause of teratogenic malformations in the musculoskeletal system throughout the embryonic growth and first larval stage. Hypoxia can also initiate cell apoptosis, a key procedure in these stages (Shin *et al*., 2004). Sub-lethal hypoxia during growth can escalate the occurrence of malformations in fish (Eva *et al*., 2004). Instances of hypoxia have been reported from different regions of the Aegean Sea (Kalemci *et al*., 2015; Yalçın *et al*., 2017). Any anomaly in the morphology of the vertebrae will have a direct impact on the swimming ability of a fish and its existence (Koumoundouros *et al*., 1997); in fact, a significant link between the severity of lordosis and swimming function has already been established in sea bass (*Dicentrarchus labrax*), at least in juveniles (Peruzzi *et al*., 2007).

Ytteborg *et al*. (2012) proposed four characterising phases of vertebral fusion that may produce spinal fusion (as in *T. radiatus*): (i) the early phases in the merging procedure are characterised by disorderly and multiplying osteoblasts and chondroblasts; (ii) subsequently, the proliferating cells undergo a metaplastic shift: the proliferating osteoblasts co-express a mixed signal of both chondrogenic and osteogenic markers, and the proliferating chondroblasts alter transcription to a more osteogenic profile; (iii) as the pathology progresses, the elastic membrane contiguous to the notochord becomes disjointed and the notochordal sheath loses its integrity; (iv) finally, the mineralisation of intervertebral regions and arch centra becomes visible.

Indications from numerous mammalian investigations suggest that deviances in the balance between cell death and cell propagation might lead to defects (Kanda & Miur, 2004). The results of the examinations conducted by Ytteborg *et al*. (2012) propose that a boosted growth of osteoblasts in progress zones can partially be fixed by increased cell death; subsequently, the phase of metaplastic shift to vertebral fusion takes place, followed by a period of notochordal sheath vitiation, where this sheath presents itself in a reinstated shape after brief

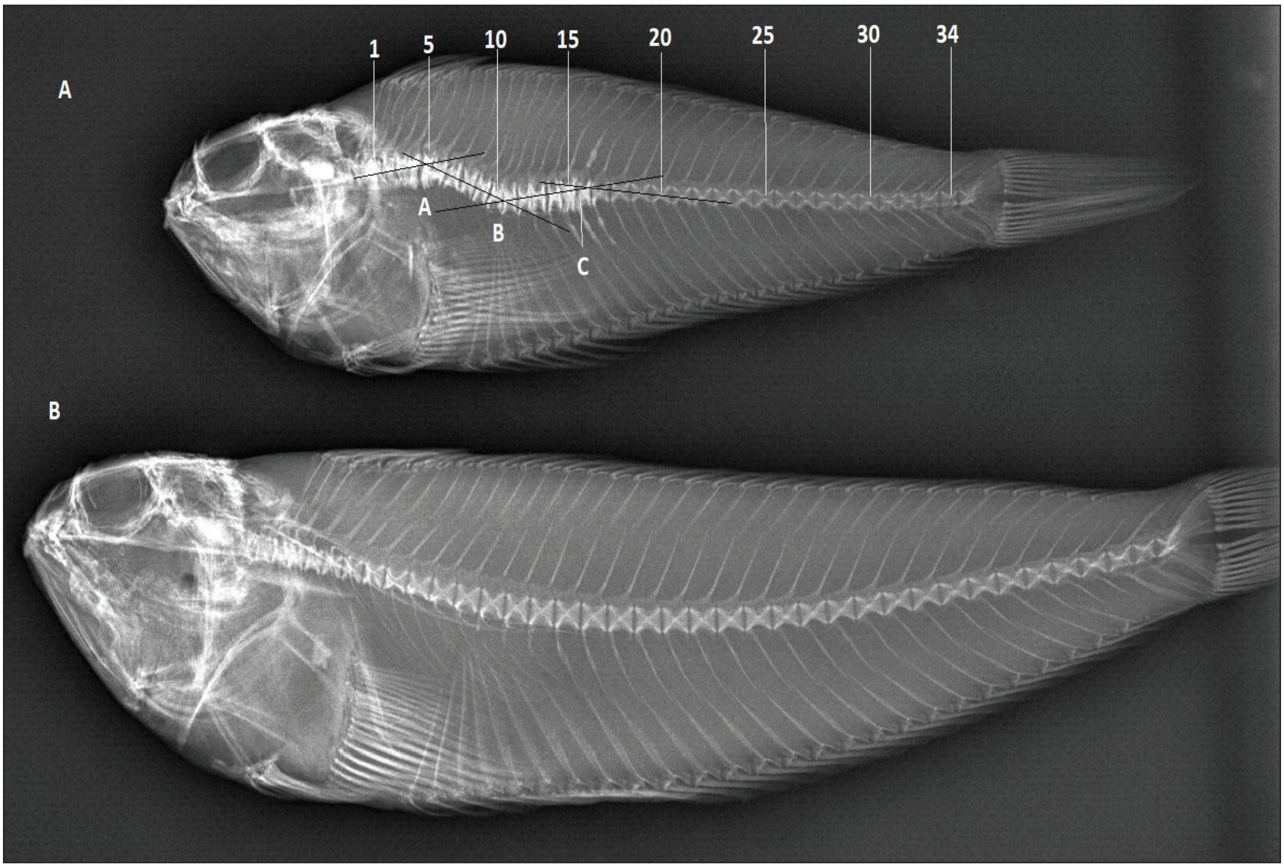

Fig. 5: Radiograph of** Trachinus radiatus**: a) abnormal specimen, 239 mm TL; b) normal specimen, 314 mm TL.
Sl. 5: Radiografija primerka vrste** Trachinus radiatus**: a) abnormalen primerek, 239 mm TL; b) normalen primerek, 314 mm TL.

deformation (Yu *et al*., 2005); accordingly, a tear in this sheath might lead to a spinal abnormality.

It is likely that the deformed specimens of *S. sphyraena* and *T. radiatus* were exposed to unfavourable environmental impacts that might have led to such type of vertebral anomaly. Since the specimens reached a sub-adult stage, the deformity, clearly, was not fatal; nevertheless, it would have certainly impaired their swimming ability in some way when the fish attained adulthood.

Papers on hyperostosis are frequently published in relation to teleosts fishes (see Meunier *et al*. 1999 for review). A number of specimens from the following taxa have already been discussed: Clupeidae (Gaudant & Meunier, 1996), Cyprinidae (Chang *et al*., 2008), Cyprinodontidae (Meunier & Gaudant, 1987), Carangidae (Fierstine, 1968), Cichlidae (Schlüter *et al*., 1992), and Tetraodontidae (Tyler *et al*., 1992).

Hyperostosis has been used by taxonomists as a taxonomic tool (Johnson, 1973; Weiler, 1973; Gauldie & Czochanska, 1990; Smith-Vaniz *et al*., 1995; Smith Vaniz & Carpenter, 2007) and by archeoichtyologists (Béarez, 1997; Olsen, 1969; von den Driesch, 1994) as an accurate diagnostic criterion.

Smith-Vaniz *et al*. (1995) give an account of the occurrence and dispersal of hyperostosis in fishes. The features of the hyperostotic bones shown in the starry weever *T. radiatus* investigated herein are comparable to those given by Smith-Vaniz *et al*. (1995), and to those given by other authors (Murty, 1967; Jawad, 2013; Jawad & Bannai, 2014; Jawad *et al*., 2015; Jawad & Ibrahim, 2017).

Since only one specimen was obtained for *T. radiatus*, it would not have been plausible to verify the suggestion of Capasso (2005) that the number of hyperostotic bones in a specimen could be associated with increased body weight that would enable bottom browsing.

There are no clear data on the possible advantages or confirmed cause of any hyperostotic incidence reported so far, but some suggestions have been put forward: the affected bones may provide assistance in fin erection or in neutral buoyancy, and may be the result of ageing, high temperatures, metabolic abnormality, ionic poisoning, fungal infestation, tumours, genetic factors etc. (see review in Meunier

& Desse 1986). Schlüter & Kohring (2002) speculated that hyperostosis could be linked to the high content of fluorine in specific habitats. Previously, Greenwood (1992) also suggested that the formation of hyperostosis could be owed to high calcium carbonate content in the water, as seen in *Tilapia guinasana* from Lake Guinas.

Apart from Bhati and Murti (1960) and Selvaraj *et al*. (1973), researchers agree that hyperostoses are not clinical occurrences (Desse *et al*., 1981; Gauldie & Czochanska, 1990; Olsen, 1971). It also seems that fishes with swollen bones exhibit normal activity (Johnson, 1973). For instance, hyperostotic developments seem predictable in the jack mackerel, *Trachurus trachurus* (Carangidae), since a high number of individuals demonstrate swollen bones at the end of their lives (Desse *et al*., 1981). As these fish do not display anomalous behaviour, we can assume that the phenomenon is not pathologic (Smith-Vaniz *et al*., 1995; Smith-Vaniz & Carpenter, 2007).

The occurrence of a large number of deformed fish in commercial catch regions can significantly affect the local fisheries economy. Such deformities have the potential to reduce the weight of the fish and their value per kg. Therefore, more effort should be put into improving the management of the fisheries industry and discovering the etiological reasons behind the anomalies. Also, in order to assess the economic factors, we should ascertain the prevailing types of anomalies in the wild.

CONCLUSIONS

In this study, four types of skeletal abnormalities – ankylosis, lordosis, hyperostosis and kyphosis – were observed in two marine fish species collected from the north-eastern Aegean Sea, Izmir, Turkey. These deformities were observed in both the abdominal and caudal regions of the vertebral column and occurred in mild and severe forms. The *S. sphyraena* species showed higher vulnerability to the factors causing such abnormalities than the *T. radiatus* that we examined. The results of the present study can be considered as preliminary health status markers for the Aegean Sea and suggest that this sea environment should be investigated further in terms of pollution in order to suitably and precisely regulate its condition.

SKELETNE ANOMALIJE NA PRIMERKIH VRST *SPHYRAENA SPHYRAENA* (LINNAEUS, 1758) IN *TRACHINUS RADIATUS* CUVIER, 1829, UJETIH V SEVEROVZHODEN EGEJSKEM MORJU (IZMIR, TURČIJA)

Laith A. JAWAD
School of Environmental and Animal Sciences, Unitec Institute of Technology, 139 Carrington Road, Mt Albert, Auckland 1025, New Zealand
email: laith_jawad@hotmail.com

Okan AKYOL
Ege University, Faculty of Fisheries, 35440 Urla, Izmir, Turkey

POVZETEK

*Raziskava obravnava skeletne anomalije na morski ščuki (*Sphyraena sphyraena*), in črnoglavem morskem zmaju (*Trachinus radiatus*), ujetih v severovzhodnem Egejskem morju (Izmir, Turčija). Pri vrsti* S. sphyraena *je bil ugotovljen hud primer zaporednega pojavljanja lordoze-kifoze, pri vrsti* T. radiatus *pa blag primer kranialne lordoze, ankiloze in hiperostoze. Tovrstni primeri so pomembni tako za ribiške biologe kot tudi za gojitelje rib, saj gre za prvo poročilo o takšnih deformacijah za ti dve vrsti, ki dopolnjuje pojavnost anomalij, ki so že zabeležene v turških morjih. Vrednotenje anomalij na pregledanih primerkih so opravili na podlagi morfološke identifikacije in z radiografijo. Avtorji nadalje razpravljajo o možnih vzrokih za takšne anomalije. Potrebne bi bile nadaljnje preiskave za povezavo raziskanih anomalij s specifičnimi onesnaževali.*

Ključne besede: deformacije, onesnaževanje, hrbtenica, lordoza, kifoza, hiperostoza

REFERENCES

Afonso, C.L., E.R. Tulman, Z. Lu, L. Zsak, G.F. Kutish & D. Rock (2000): The genome of fowl pox virus. Journal of Virology, 74, 3815-3831. https:// doi.org/10.1128/ JVI. 74.8.3815- 3831.2000 PMID:10729156.

Akyol, O. (2003): Retained and trash fish catches of beach-seining in the Aegean coast of Turkey. Turkish Journal of Veterinary & Animal Sciences, 27, 1111-1117.

Altın, A., H. Ayyıldız & S. Kale (2020): Fish biodiversity in the shallow waters around the Gökçeada Island, Turkey. Research in Marine Sciences, 5, 733-764.

Bauchot, M.–L. (1987): Poissons osseux. pp. 891-1421. In W. Fischer, M.L. Bauchot and M. Schneider (eds.) Fiches FAO d'identification pour les besoins de la pêche. (rev. 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Commission des Communautés Européennes and FAO, Rome.

Béarez, P. (1997): Las piezas esqueléticas diagnosticas en arqueoic- tiología del litoral ecuatoriano. Bull l'Instit français d'Etudes andines, 26, 11-20.

Bhati, Y.M. & N.N. Murti (1960): Hyperostosis in *Trichiurus houmela* (Forskål). Journal of the University of Bombay, 28, 84-89

Boglione, C., P. Gavaia & G. Koumoundouros (2013): A review on skeletal anomalies in reared European fish larvae and juveniles. 1: normal and anomalous skeletogenic processes. Review in Aquaculture, 5, 99-120.

Boglione, C., G. Marino, A. Fusari, F. Ferreri, M.G. Finoia & S. Cataudella (1995): Skeletal anomalies in *Dicentrarchus labrax* juveniles selected for functional swimbladder. ICES Marine Science Symposium, 201, 163-169.

Capasso, L.L. (2005): Antiquity of cancer. International Journal of Cancer, 113, 2-13.

Chang, M., X. Wang, H. Liu, D. Miao, Q. Zhao, G. Wu, J. Liu, Q. Li, Z. Sun & N Wang (2008): Extraordinarily thick-boned fish linked to the aridification of the Qaidam Basin (northern Tibetan Plateau). Proceedings of the National Academy of Science, 105, 13246-13251.

Chatain, B. (1994): Abnormal swimbladder development and lordosis in sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus auratus*). Aquaculture, 119, 371-379. https://doi.org/10.1016/0044- 8486(94)90301-8

De La Cruz-Aguero, J. & L. Perezgomez-Alvarez (2001): Lordosis in topsmelt *Atherinops affinis* (Ayers, 1860) (Teleostei: Atherinopsidae). Revista de biología marina y oceanografía, 36, 109-110. https://doi.org/10.4067/ S0718-19572001000100010.

De Sylva, D.P. (1990): Sphyraenidae. pp. 860-864. In J.C. Quero, J.C. Hureau, C. Karrer, A. Post and L. Saldanha (eds.), Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2.

Desse, G., F.J. Meunier, M. Peron & J. Laroche (1981): Hyperostose vertebrale chez l'animal. Rhumatologie, 33, 105-119.

Divanach, P., C. Boglione, B. Menu, G. Koumoudouros, M. Kentouri & S. Cataudella (1996): Abnormalities in finfish mariculture: an overview of the problem, causes and solutions, In: Chantain B., Saroglia M., Sweetman J., Lavens P. (eds.), Seabass and seabream culture: Problem and prospects, International Workshop, Verona, Italy, October 16-18, 1996, European Aquacultural Society, Oostende, Belgium.

Eronat, C. & E. Sayin (2014): Temporal evolution of the water characteristics in the bays along the eastern coast of the Aegean Sea: Saros, İzmir, and Gökova bays. Turkish Journal of Earth Science, 23, 53-66.

Eva, H., H. Shang & S. Rudolf (2004): Aquatic hypoxia is a teratogen and affects fish embryonic development. Environmental Science and Technology, 38, 4763-4767.

Fierstine, H.L. (1968): Swollen dorsal fin elements in living and fossil Caram (Teleostei: Carangidae). Contribution to Sci, Los Angeles Natural History Museum, 137, 1-10.

Fischer, W., M.–L. Bauchot & M. Schneider (eds.) (1987): Fiches FAO d'identification des espèces pour les besoins de la pêche. (Révision 1). Méditerranée et mer Noire. Zone de Pêche 37. FAO, Rome. 1529 pp.

Fjelldal, P.G., T. Hansen, O. Breck, R. Ørnsrud, E.J. Lock, R. Waagbø, A. Wargelius & P. Eckhard Witten (2012): Vertebral deformities in farmed Atlantic salmon (Salmo salar L.)–etiology and pathology. Journal of Applied Ichthyology, 28, 433-440.

Fjelldal, P.G., T. Hansen, O. Breck, R. Sandvik, R. Waagbø, A. Berg & R. Ørnsrud (2009): Supplementation of dietary minerals during the early seawater phase increases vertebral strength and reduces the prevalence of vertebral deformities in fast-growing under-yearling Atlantic salmon (*Salmo salar* L.) smolt. Aquaculture Nutrition, 15, 366-378. https://doi.org/10.1111/j. 1365-2095.2008.00601.x

Gaudant, J. & F.J. Meunier (1996): Observation d'un cas de pachyostose chez un Clupeidae fossile du miocene terminal de l'oueSI Algérien, Sordirw. erassa (Sauvage, 1873). Cybium, 20, 169-183.

Gauldie, R.W. & Z. Czochanska (1990): Hyperostotic bones from the New Zealand snapper Chrysophys auratus (Sparidae). Fishery Bulletin, 88, 201-206.

Giarratana, F., A. Ruolo, D. Muscolino, F. Marino, M. Gallo, A. Panebianco (2012): Occurrence of hyperostotic pterygiophores in the silver scabbardfish, *Lepidopus caudatus* (Actinopterygii: Perciformes, Trichiuridae). Acta Ichthyologia et Piscatoria, 42, 233-237.

Gorman, K.F., G.R. Handrigan, G. Jin, R. Wallis & F. Breden (2010): Structural and microanatomical changes in vertebrae associated with idiopathic-type spinal curvature in the curve back guppy model. Scoliosis, 5, 10.

Greenwood, P.H. (1992): A redescription of the uniquely polychromatic African cichlid fish Tilapia guinasana Trewavas, 1936. Bulletin of the British Museum (Natural History). Zoology, 58, 21-36.

Hansen, T., P. Fjelldal, A. Yurtseva & A. Berg (2010): Possible relation between growth and number of deformed vertebrae in Atlantic salmon (*Salmo salar* L.). Journal of Applied Ichthyology, 26, 355-359. https://doi.org/10.1111/ j.1439-0426.2010.01434.x

IGFA (2001): Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA.

Inohaya, K., Y. Takano & A. Kudo (2007): The teleost intervertebral region acts as a growth centre of the centrum: in vivo visualization of osteoblasts and their progenitors in transgenic fish. Developmental Dynamics, 236, 3031-3046.

Ishikawa, Y. (1990): Development of caudal structures of a morphogenetic mutant (Da) in the teleost fish, medaka (*Oryzias latipes*). Journal of Morphology, 205, 219-232.

Janakiram, P., G.K. Geetha, D. Sunil Kumar & L. Jayasree (2018): Aetiological studies on mixed infection of Abdominal segment deformity disease (ASDD) and *Enterocytozoon hepatopenaei* (EHP) in cultured *Litopenaeus vannamei*. International Journal of Fisheries and Aquatic Studies, 6, 19-26.

Jara, B., M. Abarca, R. Wilson, S. Krapivka, A. Mercado, R. Guiñez & L. Marchant (2017): Qualitative analysis of cartilaginous jaw element malformation in cultured yellowtail kingfish (*Seriola lalandi*) larvae. Aquaculture Research, 48, 4420-4428. https://doi.org/10.1111/ are.13267.

Jawad, L.A. & A. Öktener (2007): Incidence of lordosis in the freshwater mullet, *Liza abu* (Heckel, 1843) collected from Atatürk Dam Lake, Turkey. Anales de Biologia, 29, 105-108.

Jawad, L.A. (2013): Hyperostosis in three fish species collected from the Sea of Oman. Anatomical Record, 296, 1145-1147.

Jawad, L.A., Z. Sadighzadeh, A. Salarpouri & S. Aghouzbeni (2013): Anal Fin Deformity in the Longfin Trevally, *Carangoides armatus* collected from Nayband, Persian Gulf. Korean Journal of Ichthyology, 25, 169-172.

Jawad, L.A. & M. Bannai (2014): Characterization of hyperostosis in *Platax teira* (Forsskål, 1775) collected from marine water of Iraq, North West Arabian Gulf. Sky Journal of Agricultural Research, 3, 109-111.

Jawad, L.A., A.J. Al-Faisal & F.M. Al-Mutlak (2014): Incidence of lordosis in the cyprinid fish, *Carasobarbus luteus*, and the Shad, *Tenualosa ilisha* collected from Barash waters, Iraq. International Journal of Marine Science, 4, 1-5.

Jawad, L.A. & J. Liu (2015): First record of vertebral anomalies in some members of the genus Pampus (family: Stromateidae) collected from Guangdong, China, and from the Kii Peninsula, Honshu Island, Japan. Marine Biodiversity Record, 8, e110.

Jawad, L.A., A. Wallace & W. Dyck (2015): Documentation of the case of hyperostosis in the silver bream, *Pagrus auratus* (Forster, 1801) sampled from waters around New Zealand. Boletim do Instituto de Pesca, São Paulo, 41, 1043-1047.

Jawad, L.A. & M. Ibrahim (2017): On some cases of fish anomalies in fishes from the Port of Jubail, Saudi Arabia, Arabian Gulf. International Journal of Marine Science, 7, 188-199.

Jawad, L.A., O. Akyol & C. Saglam (2017a): Consecutive repetition of lordosis-kyphosis in silverside *Atherina boyeri* Risso, 1810 collected from a wild population in Homa Lagoon, Izmir, Turkey. Fish Aquatic Life, 25, 117-122.

Jawad, L.A., M. Çelik & C. Ateş (2017b): Occurrence of scoliosis, pugheadness and disappearance of pelvic fin in three marine fish species from Turkey. International Journal of Marine Science, 7, 275-283.

Jawad, L.A. & M. Ibrahim (2018): Environmental oil pollution: a possible cause for the incidence of ankylosis, kyphosis, lordosis, and scoliosis in five fish species collected from the vicinity of Jubail City, Saudi Arabia, Arabian Gulf. International Journal of Environmental Studies, 75, 425-442.

Jawad, L.A., O. Akyol & I. Aydin (2018): Severe Case of Lordosis-Kyphosis-Ankylosis in *Mullus barbatus* Linnaeus, 1758 (Teleostei: Mullidae) Collected from the Northern Aegean Sea, Turkey. International Journal of Marine Science, 8, 101–105.

Jawad, L.A., M. Şirin, M. Petrtýl, A. Öktener, M. Çelik & A. Qasim (2022): Skeletal abnormalities in four fish species collected from the Sea of Marmara, Turkey. Annales, Ser. Hist. Nat., 32, 119-134.

Johnson, C.R. (1973): Hyperostosis in fishes of the genus Platycephalus (Platycephalidae). Japanese Journal of Ichthyology, 20, 178.

Kalemci, V., A. Demirak & F. Keskin (2015): Water quality seasonal investigation in the coastal areas of güllük bay (southeast of Aegean Sea-Turkey). ЭКОЛОГИЧЕСКИЙ ВЕСТНИК, 1, 14-19.

Kanda, H. & M. Miura (2004): Regulatory roles of JNK in programmed cell death. Journal of Biochemistry, 136, 1-6.

Konnerth, A. (1966): Tilly bones. Oceanus, 12, 6-9

Koumoundouros, G., G. Oran, P. Divanach, S. Stefanakis & M. Kentouri (1997): The opercular complex deformity in intensive gilthead sea bream (*Sparus aurata* L.) larviculture. Moment of apparition and description. Aquaculture, 156, 165-177.

Kužir, S., L. Maleničić, D. Stanin, T.T. Trbojević, I. Alić & E. Gjurčević (2015): Description of head deformities in cultured common carp (*Cyprinus carpio* Linnaeus, 1758). Veterinarski Arhiv, 85, 437-449.

López-Olmeda, J.F., C. Noble & F.J. Sánchez-Vázquez (2012): Does feeding time affect fish welfare? Fish Physiology and Biochemistry, 38, 143-152. https://doi.org/10.1007/ s10695-011-9523-y PMID:21671025.

Louiz, I., D. Menif, M. Ben Attia & O. K. Ben Hassine (2007): Incidence des déformations squelettiques chez trois espèces de Gobiidae de la lagune de Bizerte (Tunisie). Cybium, 31, 199-206.

Mahmoud, M.A. & M. Ibrahim (2021): Overview on pathogenesis and histopathological observations of hyperostosis in two fish species; *Scomberoides lysan* (Forsskal, 1775) and *Pomacanthus sextriatus* (Cuvier, 1831) collected from El-Jubail province, Saudi Arabia. Bulletin of the European Association of Fish Pathologists, 41, 111-117.

Majeed, Z., Z. Ajab, A. Zuberi, S. Akther & A. Muhammad (2018): Meristic variations and skeletal deformities in a natural population of mahseer fish, *Tor putitora* (Hamilton, 1822). Iranian Journal of Fisheries Science, 17, 208-216.

Martens, L.G., P.E. Witten, S. Fivelstad, A. Huysseune, B. Sævareid, V. Vikeså & A. Obach (2006): Impact of high water carbon dioxide levels on Atlantic salmon smolts (*Salmo salar* L.): effects on fish performance, vertebrae composition, and structure. Aquaculture, 261, 80-88.

Matić-Skoko, S. & J. Ferri (2009): First record of hyperostotic bones in a common dentex, *Dentex dentex* (Sparidae) from Adriatic. Cybium, 33, 341-342.

Meunier, F.J. & G. Desse (1986): Les hyperostoses chez les Téléosléens: description, hislologie et probIemes étiologiqucs/ehlhyophysio/. Acro 10, 130-141.

Meunier, F.J. & J. Gaudant (1987): Sur un cas de pachyostose chez un poisson du Miocène terminal du bassin méditerranéen, *Aphanius crassicaudus* (Agassiz), (Teleostei, Cyprinodontidae). Comptes rendus de l'Académie des sciences. Série 2. Mécanique, Physique, Chimie, Sciences de l'univers, Sciences de la Terre, 305, 925-928.

Meunier, F.J., M.H. Deschamps, F. Lecomte & A. Kacem (2008): Le squelette des poissons téléostéens: structure, développement, physiologie, pathologie. Bulletin de la Société zoologique de France, 133, 9.

Meunier, F.J., J. Gaudant & E. Bonelli (2010): Morphological and histological study of the hyperostoses of *Lepidopus albyi* (Sauvage, 1870), a fossil Trichiurideae from the Tortonian (Upper Miocene) of Piedmont (Italy). Cybium, 34, 293-301.

Meunier, F.J., P. Béarez & H. Francillon-vieillot (1999): Some morphological and histological aspects of hyperostosis in the eastern pacific marine fish *Prionotus stephanophrys* Lockington, 1880 (Triglidae). In: B. Séret & J.-Y. Sire (eds.), 5th Indo-Pacific Fish Conference, Nouméa, 1997. Proceedings (pp. 125-133). Institut de recherche pour I.

Murty, V.S. (1967): Notes on hyperostosis in the fish *Drepane punctata* (Linnaeus). Journal of the Marine Biological Association of India, 9, 323-326.

Näslund, J. & L.A. Jawad (2021): Pugheadedness in Fishes. Reviews in Fisheries Science and Aquaculture, 1-24. https:// doi.org/10.1080/23308249.2021.1957772

Noble, C., H.A. Canon Jones, B. Damsgård, M.J. Flood, K.Ø. Midling, A. Roque, B.S. Sæther & S. Yue Cottee (2012): Injuries and deformities in fish: Their potential impacts upon aquacultural production and welfare. Fish Physiology and Biochemistry, 38, 61-83. https:// doi.org/10.1007/ s10695-011-9557-1 PMID:21918861

Okamura, A., N. Horie, N. Mikawa, Y. Yamada & K. Tsukamoto (2018): Influence of temperature and feeding regimes on growth and notochord deformity in reared *Anguilla japonica* leptocephali. Fisheries Science, 84, 505-512.

Olsen, S.J. (1969): Hyperostosic fish bones from archaeological sites. Bulletin of the Archaeological Society of New Jersey, 24, 17-20.

Olsen, S.J. (1971): Swollen bones in the Atlantic cutlassfish, *Trichiurus lepturus* Linnaeus. Copeia, 1, 174-175.

Paig-Tran, E.M., A.S. Barrios & L.A. Ferry (2016): Presence of repeating hyperostotic bones in dorsal pterygiophores of the oarfish, *Regalecus russellii*. Journal of Anatomy, 229, 560-567.

Peruzzi, S., J.I. Westgaard & B. Chatain (2007): Genetic investigation of swimbladder inflation anomalies in the European sea bass, *Dicentrarchus labrax* L. Aquaculture, 265, 102-108.

Raja, M., R.K. Raja, R. Ramkumar, M. Kavitha, D. Aiswarya, P. Deepak & P. Perumal (2016): First report on the occurrence of abnormal vertebrae-containing giant danio fish, *Devario aequipinnatus* (McClelland, 1839) in Stanley Reservoir of Cauvery River Tamil Nadu (India). International Journal of Fisheries and Aquaculture Studies, 4, 528-531.

Reiner, F. (1996): Catálogo dos peixes do arquipélago de Cabo Verde. Publicações avulsas do IPIMAR, 2, 339 pp.

Roux, C. (1990): Trachinidae. pp. 893-895. In J.C. Quero, J.C. Hureau, C. Karrer, A. Post and L. Saldanha (eds.) Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2.

Sato, T. (2006): Occurrence of deformed fish and their fitness-related traits in Kirikuchi charr, *Salvelinus leucomaenis japonicus*, the southernmost population of the genus *Salvelinus*. Zoological Science, 23, 593-599. https://doi. org/10.2108/zsj.23.593 PMID:16908958

Schlüter, T. & R. Kohring (2002): Palaeopathological fish bones from phosphorites of the Lake Manyara area, Norther Tanzania—Fossil evidence of a physiological response to survival in an extreme biocenosis. Environmental Geochemistry and Health, 24, 131-140.

Schlüter, T., R. Kohring & J. Mehl (1992): Hyperostotic fish bones ("Tilly bones") from presumably Pliocene phosphorites of the Lake Manyara area, northern Tanzania. Paläontologische Zeitschrift, 66, 129-136.

Selvaraj, G.S.D., K. Gopakumar & M. Rajagopalan (1973): On the occurrence of osteochondroma and osteoma in the marine catfish *Tachysurus jella* (Day). Journal of Marine Biological Association of India, 15, 571-576.

Shin, D.H., E. Lee, J.W. Kim, B.S. Kwon, M.K. Jung, Y.H. Jee, J. Kim, S.R. Bae & Y.P. Chang (2004): Protective effect of growth hormone on neuronal apoptosis after hypoxia–ischemia in the neonatal rat brain. Neurosci Letters, 354, 64-68.

Smith-Vaniz, W.F. & K.E. Carpenter (2007): Review of the crevalle jacks, *Caranx hippos* complex (Teleostei: Carangidae), with a description of a new species from West Africa. Fishery Bulletin, 105, 207-233.

Smith-Vaniz, W.F., L.S. Kaufman & J. Glowacki (1995): Species-specific patterns of hyperostosis in marine teleost fishes. Marine Biology, 121, 573-580.

Torcu, H., Z. Aka & A. İşbilir (2001): An investigation on fishes of the Turkish Republic of Northern Cyprus. Turkish Journal of Veterinary & Animal Sciences, 25, 155-159.

Tortonese, E. (1986): Trachinidae. pp. 951-954. In: J.C. Hureau and Th. Monod (eds.) Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean (CLOFNAM). UNESCO, Paris. Vol. 2.

Tukenmez, E. & H. Altiok (2022): Long-term variations of air temperature, SST, surface atmospheric pressure, surface salinity and wind speed in the Aegean Sea. Mediterranean Marine Science, 23, 668-684.

Tuna, F.A.P., F.A.A. Calixto, M.C. Salomao, C.E.R. Coutinho, K.R. Estanek & E.F.M. Mesquita (2021): The presence of hyperostosis in Atlantic moonfish, *Selene setapinnis* (Mitchill, 1815) in the Brazilian Coast- case report. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 73, 179-183.

Tyler, J.C., R.W. Purdy & K.H. Oliver (1992): A new species of Sphoeroides pufferfish (Teleostei: Tetraodontidae) with extensive hyperostosis from the Pliocene of North Carolina. Proceedings of the Biological Society of Washington, 105, 462-482.

von den Driesch, A. (1994): Hyperostoses in fish. In: W. van Neer (Ed.), Fish Exploiuuion in the Pas. Proceedings of 7th Meeting. Annals of the Royal Museum of Central Africa (vol. 274, pp. 47-53). CAZ Fish Remains Working Group.

Weiler, W. (1973): Durch Hyperostose verdickte Fischknochen aus dem oberen Sarmat von Nord-Carolina, USA. Senckenbergiana Lethaea, 53, 469-477.

Witten, P.E. & A. Huysseune (2009): A comparative view on mechanisms and functions of skeletal remodeling in teleost fish, with special emphasis on osteoclasts and their function. Biological Reviews of the Cambridge Philosophical Society, 84, 315-346. https://doi.org/10.1111/j.1469- 185X.2009.00077.x PMID:19382934.

Witten, P.E., A. Obach, A. Huysseune & G. Baeverfjord (2006): Vertebrae fusion in Atlantic salmon (*Salmo salar*): development, aggravation, and pathways of containment. Aquaculture, 258, 164-172.

Yalçın, B., M.L. Artüz, A. Pavlidou, S. Çubu & M. Dassenakis (2017): Nutrient dynamics and eutrophication in the Sea of Marmara: Data from recent oceanographic research. Science of the Total Environment, 601, 405-424.

Yıldırım, Ş., D. Çoban, C. Süzer, K. Fırat & Ş Saka (2014): Skeletal deformities of cultured sharpsnout seabream (*Diplodus puntazzo*) larvae during early life development. Veterinary Journal of Ankara University, 61, 267-273.

Ytteborg, E., J. Torgersen & G. Baeverfjord (2012): Four stages characterizing vertebral fusions in Atlantic salmon. Journal of Applied Ichthyology, 28, 453-459.

Yu, J., J.C. Fairbank, S. Roberts & J.P. Urban (2005): The elastic fibre network of the anulus fibrosus of the normal and scoliotic human intervertebral disc. Spine, 30, 1815-1820.

received: 2023-04-05 DOI 10.19233/ASHN.2023.13

A RARE OCCURRENCE AND CONFIRMED RECORD OF SCALLOPED RIBBONFISH *ZU CRISTATUS* (OSTEICHTHYES: TRACHIPTERIDAE) IN THE GULF OF ANTALYA (EASTERN MEDITERRANEAN), TURKEY

Deniz ERGUDEN
Marine Science Department, Faculty of Marine Science and Technology, Iskenderun Technical University, 31220 Iskenderun, Hatay, Turkey
e-mail: derguden@gmail.com; deniz.erguden@iste.edu.tr

Sibel ALAGOZ ERGUDEN
Vocational School of Imamoglu, University of Cukurova, Imamoglu, Adana, Turkey,
Department of Biomedical Engineering, Faculty of Engineering and Natural Science, University of Iskenderun Technical, Iskenderun, Hatay, Turkey

Deniz AYAS
Fisheries and Fish Processing Department, Faculty of Fisheries, University of Mersin, Mersin, Hatay, Turkey

ABSTRACT

On 25 October 2022, a juvenile specimen of scalloped ribbonfish Zu cristatus *was captured in the Finike coast, Gulf of Antalya (Eastern Mediterranean, Turkey) by a commercial trawler at a depth of 50 m. The paper reports the first occurrence and confirms the presence of* Z. cristatus *in the Antalya Bay. The morphological and colour descriptions of the captured* Z. cristatus *specimen agree with previous descriptions of the species. This record is the first evidence of a juvenile specimen of* Z. cristatus *in the Mediterranean coast of Turkey. Additionally, the study documents the historical records of the species in the Mediterranean Sea and can contribute to the field of fisheries science and aid in fisheries management.*

Key words: Trachipteridae, ribbonfish, record, Antalya Gulf, Mediterranean Sea

CASO RARO E RITROVAMENTO CONFERMATO DI PESCE FALCE *ZU CRISTATUS* (OSTEICHTHYES: TRACHIPTERIDAE) NEL GOLFO DI ANTALYA (MEDITERRANEO ORIENTALE), TURCHIA

SINTESI

Il 25 ottobre 2022, un esemplare giovane di pesce falce Zu cristatus *è stato catturato lungo la costa di Finike, nel Golfo di Antalya (Mediterraneo orientale, Turchia) da un peschereccio a strascico commerciale a una profondità di 50 m. Il lavoro riporta il primo ritrovamento e conferma la presenza di* Z. cristatus *nella baia di Antalya. Le descrizioni morfologiche e cromatiche dell'esemplare di* Z. cristatus *catturato concordano con le precedenti descrizioni della specie. Questo ritrovamento è la prima prova di un esemplare giovanile di* Z. cristatus *lungo la costa mediterranea della Turchia. Inoltre, lo studio documenta i ritrovamenti storici della specie nel Mediterraneo e può contribuire al campo della scienza della pesca e alla gestione della pesca.*

Parole chiave: Trachipteridae, pesce falce, ritrovamento, Golfo di Antalya, Mediterraneo

INTRODUCTION

The family Trachipteridae is composed of two main genera, *Trachipterus* (Goüan, 1770) and *Zu* (Walters & Fitch, 1960). The *Zu* genus is represented in the Mediterranean Sea only by the native species, the scalloped ribbonfish *Z. cristatus* (Bonelli, 1819) (Nelson, 2006). This species occurs in the Mediterranean Sea (Fischer *et al*., 1987; Quignard & Tomasini, 2000; Bianco et al., 2006, Bradai & El Ouaer, 2012), as well as in the Atlantic, Indian and Pacific Oceans (Mundy, 2005; Froese & Pauly, 2023).

In the Mediterranean, *Z. cristatus* is distributed throughout the basin (Bonelli, 1820, Oliver, 1955; Tortonese, 1958; Gavagnin, 1976; Fischer *et al.,* 1987; Papakonstantinou, 1988; Golani *et al.,* 2006), as supported by several records, including a few from the Adriatic waters (Dieuzeide *et al.,* 1953; Tortonese, 1958; Palmer, 1961, Ibanez & Gallego, 1974; Gavagnin, 1976; Cau, 1980; Jardas, 1980; 1996; Roig & Demestre, 1982; Dulcic, 2002; Bianco *et al.,* 2006; Psomadakis *et al.,* 2006; Psomadakis *et al.,* 2007; Dhora, 2010; Bradai & El Ouaer, 2012; Mytilineou *et al.,* 2013; Dulcic *et al.,* 2014; Quigley and Henderson, 2014; Garibaldi, 2015; Sperone and Giglio, 2015; Garcia-Barcelona *et al.,* 2016; Falsone *et al.,* 2017; Trialongo *et al.,* 2019; Albano *et al.,* 2022a). Most recently, *Z. cristatus* was caught in July 2020 by a bottom trawler targeting deep water off the Gulf of Patti, the Tyrrhenian Sea, and western Mediterranean (Stipa *et al.,* 2022), while the last confirmed report in the Mediterranean Sea is of two specimens captured in the Israeli coast in June 2022 and in the Levantine coast by Golani *et al.* (2023). The historical records of this species in the Mediterranean basin are documented in Table 1.

Although *Z. cristatus* has been found throughout the Mediterranean Sea and is mentioned in the checklists of species found in Turkish marine waters (Bilecenoglu *et al.,* 2002), including the Turkish Mediterranean coast (Akyuz, 1957), it is only rarely seen in the eastern Mediterranean. In fact, until now, no specimens of this species were reported from the Gulf of Antalya (Eastern Mediterranean, Turkey). In the present study, we thus report the first record of *Z. cristatus* from the western Mediterranean coast of Turkey (Finike coast, Antalya).

MATERIAL AND METHODS

A single juvenile specimen of *Z. cristatus* was caught by a commercial trawler at a depth of 50 m in the Finike coast, Antalya Bay (36º25′ N, 30º21′ E) on 25 October 2022 (Fig. 1). After being photographed and recorded by a video camera on deck, it was measured for total length and weight by the fishermen, and released back into the sea alive. The specimen was identified from a photograph supplied by the vessel's captain. The morphological descriptions and colour of the captured *Z. cristatus* are in agreement with those by Palmer (1986) and Olney (1999) (Fig. 2).

RESULTS AND DISCUSSION

The juvenile specimen of scalloped ribbonfish measured 786 mm in total length (TL) and weighed 940 g. Its body was naked and compressed, eyes large, dorsal fin formed by elongated rays and continuing along the entire length of the body to the tail and the two lobes constituting the caudal fin. The caudal part of the body was scalloped, anal and pelvic fins absent. The body was silvery with approximately six vertical bars on the dorsal part and four on the ventral, and about six complete black bars in the tail. The caudal fin was blackish, the fin base pale.

Zu cristatus is a mesopelagic fish species that has a wide depth distribution of 0 to 950 m, but is usually found at 90 m (Fricke et al., 2011; Froese & Pauly, 2023). Juvenile specimens have occasionally been observed swimming freely in the upper water layers with a trailing elongated dorsal fin and pelvic fin rays that give them a jellyfish-like appearance (Heemstra & Kannemeyer, 1984; Bianco *et al.,* 2006). While adult specimens may prefer deeper waters – Tiralongo *et al.* (2019) reported the maximum depth recorded for *Z. cristatus* in Mediterranean waters to be about 2000 m – Albano *et al.* (2020b) observe that juvenile specimens are frequently encountered in shallow waters. The recorded depth range (50 m) of the observed juvenile specimen is in accordance with the literature (Froese & Pauly, 2023).

Heemstra & Kannemeyer (1984) stated that *Z. cristatus* undergoes various body changes during its life cycle. Significant differences can occur in the 600–800 mm TL size range, which coincides with the transition from pre-juvenile to juvenile stages. These changes include the loss of long anterior dorsal fin rays and pelvic fins. Also, juvenile specimens are characterized by a ribbon-shaped body (Bini, 1970; Tortonese, 1970; Olney *et al.,* 1993), have a short head and a narrow mouth, with a distinctly protruding upper jaw (Heemstra & Kannemeyer, 1986; Olney *et al*., 1993). Our present specimen measured 786 mm (SL), which qualifies it as juvenile and makes this first record of occurrence of a juvenile specimen of *Z. cristatus* on the Mediterranean coast of Turkey.

Tab. 1: Historical records of** Zu cristatus **from the Mediterranean Sea during the period 1820–2022.
Tab. 1: Historični zapisi o pojavljanju vrste** Zu cristatus **v Sredozemskem morju v obdobju med 1820 in 2022.

References	Number of samples	Year(s)	Location/Country	Depth (m)	Gear	Length, TL (mm)	Weight (g)
Bonelli (1820)	1	1818	off the coast of Lerici, Gulf of La Spezia, Italy	-	-	700	-
Ben-Tuvia (1953)	1	1953	Eastern Mediterranean shores, Isreal	-	-	190	-
Oliver (1955)	1	1955	Palma de Mallorca (Spain)	-	-	1000	-
Postel (1955)	1	December 1954	Gulf of Tunis, (southern Mediterranean Sea), Tunisia	-	Trammel net	285	-
Tortonese (1958)	1	August 1958	off Genova (Ligurian Sea), Italy	700-800	Bottom long-line	1105	2800
Ibanez, & Gallego (1974)	1	1969	off the coast of Blane, Iberian Sea, Spain	600	Bottom Trawl	875	-
Gavagnin (1976)	1	1976	Ligurian Sea, Italy	20	-	-	-
Roig & Demestre (1982)	1	June 1980	Arenys de Mar, Spain	-	Bottom Trawl	700	500
	1	1981	Malgrat de Mar, Spain	380	Bottom Trawl	1115	2160
Bianco *et al.* (2006)	2	June 1998	Gulf of Castellamare (central Tyrrhenian Sea), Italy	2	Hand net	180-150 (SL)	-
Psomadakis *et al.* (2006)	1	2001-2022	off the coast of Anzio, (central Tyrrhenian Sea), Italy	500-600	Bottom Trawl	800	-
Psomadakis *et al.* (2007)	2	May-August 2003	Gulf of Genova (Ligurian Sea), (NW Mediterranean Sea), Italy	150-400	Bottom Trawl	1219 1031	4400 2292
Sperone & Giglio (2015)	1	July 2014	Calabria (Southern Tyrrhenian Sea), Italy	Surface	Rod fishing	980	2000
Garcia-Barcelona *et al.* (2016)	2	May 2013-July 2014	Balearic Sea, Spain	-	Longline	1030 878	2400 1300
Falsone *et al.* (2017)	1	2016	Southwestern Tyrrhenian Sea, Italy	-	Longline	876	1301
Bradai & El Quaer (2012)	1	October 2009	Tunisian waters, (central Tunisia) Tunisia	50-80 (cm)	Casting Net	170	-
Albano *et al.* (2022a)	1	2022	off the coast of Noto, Ionian Sea (Sicily, Italy)	720	Longline	1210	4000
Stipa et al. (2022)	1	July 2020	Gulf of Patti, Tyrrhenian Sea (western Mediterranean Sea), Italy	600	Bottom Trawl	998.7	1548
Golani *et al.* (2023)	1	1978	Mediterranean coast, Israel	surface	-	234	-
Golani *et al.* (2023)	1	June 2022	Mediterranean coast, Israel	250-400	Longline	1275	-
This study	1	October 2022	eastern Mediterranean, Gulf of Antalya, Turkey	50	Bottom Trawl	786	940

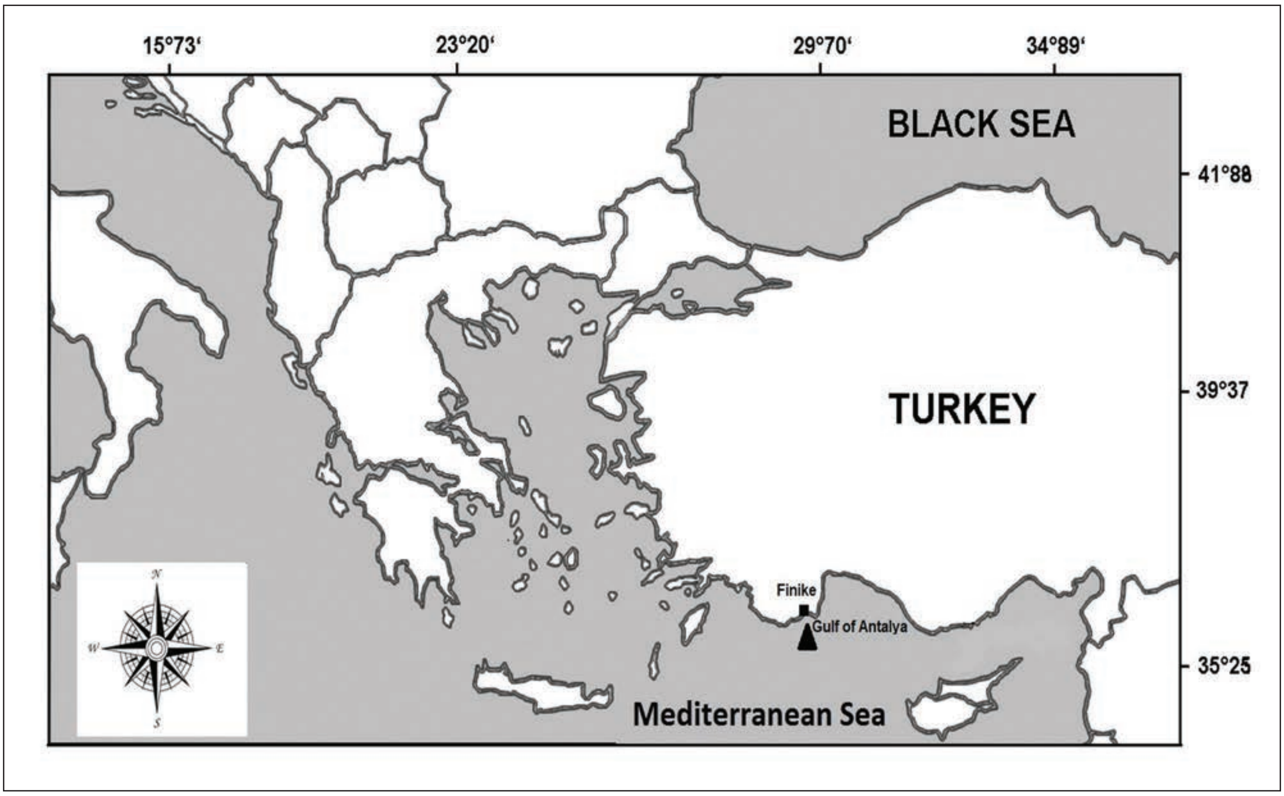

Fig. 1: Map of the study area indicating the capture sites (•) of *Zu cristatus* ***in the Gulf of Antalya (western Mediterranean coast of Turkey).***
Sl. 1: Zemljevid obravnavanega območja z označeno lokaliteto (•) ulova vrste *Zu cristatus* ***v Antalijskem zalivu (zahodna sredozemska obala Turčije).***

While Heemstra & Kannemeyer (1984) found that specimens of *Z. cristatus* longer than 800 mm SL were rarely reported in the Mediterranean Sea, several studies report captions of large specimens measuring over 800 mm TL (Tortonese, 1958; Roig & Demestre, 1982; Psomadakis *et al.,* 2006; Bradai & El Quaer, 2012), with Psomadakis *et al*. (2007) documenting two specimens measuring over 1000 mm in TL (1219 and 1031 mm, respectively) from NW Mediterranean (Gulf of Genoa, Italy).

Information on the occurrence of *Z. cristatus* in the Turkish coast is scarce, as is the general knowledge of this species in the Mediterranean Sea (Stipa *et al.,* 2022), especially with regard to the biology of the adult stage, the species' reproduction and environmental habits. According to the fairly limited data on *Zu cristatus,* both eggs and larvae are planktonic, large, and red (Charter & Moser, 1996). Adult specimens feed on small cephalopods, fishes, and large invertebrates (Palmer, 1986; Albano *et al.,* 2022b).

Finally, species from the Trachipteridae family are in general considered by-catch species and thus often discarded. While *Z. cristatus* is sometimes incidentally caught in longline fishing, such fishing

Fig. 2: Specimen of *Zu cristatus****, 786 mm TL, captured in the Gulf of Antalya, Turkey.***
Sl. 2: Primerek vrste *Zu cristatus****, dolg 786 mm, ujet v Antalijskem zalivu (Turčija).***

gear does not pose a significant threat to this species' population. Consequently, it has been categorized as Least Concern (LC) on the IUCN Red List (Arnold, 2015; IUCN, 2023).

CONCLUSIONS

In this study, we confirm the presence of *Z. cristatus* in the Mediterranean waters of Turkey, and our finding in Antalya Bay is the first evidence of a juvenile specimen of this species in the western Mediterranean coast of Turkey. The present study has the potential to be a valuable contribution to the field of fisheries science by offering insights that may inform and improve fisheries management practices.

ACKNOWLEDGEMENTS

The authors thank the captain and staff of the commercial fishing vessel for their kind collaboration.

O REDKEM POJAVLJANJU IN POTRJENI NAJDBI ČOPASTE KOSICE *ZU CRISTATUS* (OSTEICHTHYES: TRACHIPTERIDAE) V ANTALIJSKEM ZALIVU (VZHODNO SREDOZEMSKO MORJE), TURČIJA

Deniz ERGUDEN
Marine Science Department, Faculty of Marine Science and Technology, Iskenderun Technical University, 31220 Iskenderun, Hatay, Turkey
e-mail: derguden@gmail.com; deniz.erguden@iste.edu.tr

Sibel ALAGOZ ERGUDEN
Vocational School of Imamoglu, University of Cukurova, Imamoglu, Adana, Turkey,
Department of Biomedical Engineering, Faculty of Engineering and Natural Science, University of Iskenderun Technical, Iskenderun, Hatay, Turkey

Deniz AYAS
Fisheries and Fish Processing Department, Faculty of Fisheries, University of Mersin, Mersin, Hatay, Turkey

POVZETEK

Petindvajsetega oktobra 2022 so ob obali Finike v Antalijskem zalivu (vzhodno Sredozemsko morje, Turčija) na globini 50 m s povlečno mrežo ujeli mladostni primerek čopaste kosice Zu cristatus. *Avtorji poročajo, da gre za prvi potrjeni zapis o pojavljanju te vrste v Antalijskem zalivu. Morfološki opisi in barva ujetega primerka* Z. cristatus *se ujema z znanimi opisi vrste. Ta zapis je prva najdba mladostnega primerka vrste* Z. cristatus *ob sredozemski turški obali. Poleg tega raziskava navaja zgodovinske zapise o tej vrsti v Sredozemskem morju, je pomemben prispevek s področja ribiške znanosti in pomaga pri upravljanju ribištva.*

Ključne besede: Trachipteridae, čopasta kosica, zapis o pojavljanju, Antalijski zaliv, Sredozemsko morje

REFERENCES

Akyuz, E. (1957): Observations on the Iskenderun red mullet (*Mullus barbatus*) and its environment. GFCM Proceed. Tech. Pap., 4(38), 305-326.

Albano, M., C. D'Iglio, N. Spanò, D. Di Paola, A. Alesci, S. Savoca & G. Capillo (2022a): New report of *Zu cristatus* (Bonelli, 1819) in the Ionian Sea with an in-depth morphometrical comparison with all Mediterranean records. Fishes, 7, 305.

Albano, M., C. D'Iglio, N. Spanò, J.M.O. Fernandes, S. Savoca & G. Capillo (2022b): Distribution of the order Lampriformes in the Mediterranean Sea with notes on their biology, morphology, and taxonomy. Biology, 11, 1534.

Arnold, R. (2015): *Zu cristatus*. *The IUCN Red List of Threatened Species* 2015: e.T190346A21911500. https://dx.doi.org/10.2305/IUCN.UK.2015.4.RLTS.T190346A21911500.en. (Last accession: 30 March 2023).

Ben-Tuvia, A. (1953): Mediterranean fishes of Israel. Bull. Sea Fish. Res. Stat. Haifa, 8, 1-40.

Bianco, P.G., V. Zupo & V. Ketmaier (2006): Occurrence of the scalloped ribbonfish *Zu cristatus* (Lampiridiformes) in coastal waters of the central Tyrrhenian Sea, Italy. J. Fish Biol., 68, 150-155.

Bilecenoğlu, M., E. Taskavak, S. Mater & M. Kaya (2002): Checklist of the Marine Fishes of Turkey. Zootaxa, 113, 1-194.

Bini, G. (1970): Atlante dei pesci delle coste Italiane. Mondo Sommerso edition. Vol. 3. Osteitti, pp. 183-186.

Bonelli, F.A. (1820): Description d'une nouvelle espèce de poisson de la Méditerranée appartenant au genre Trachyptère avec des observations sur les caractères de ce même genre. Mem. Reale. Accad.. Sci. Torino, 24, 485-494.

Bradai, M.N. & A. El Ouaer (2012): New record of the scalloped ribbonfish, *Zu cristatus* (Osteichthyes: Trachipteridae) in Tunisian waters (central Mediterranean). Mar. Biodiv. Rec., 5: e59.

Cau, A. (1980): Second note on the bathyal ichthyofauna of the seas around southern Sardinia. Quaderni della Civica Stazione Idrobiologia di Milano, 8, 39-44.

Charter, S.R. & H.G. Moser (1996): Trachipteridae: ribbonfishes. In: H.G. Moser (eds.): The early stages of fishes in the California Current region, Atlas No. 33, California Cooperative Oceanic Fisheries Investigations (CalCOFI). pp. 669-677.

Dhora, D. (2010): Register of species of the fauna of Albania 2010. Camaj-Pipa, Shkoder, 208 pp.

Dieuzeide, R., M. Novella & J. Roland (1953): Catalogue des poissons des cotes algeriennes. II. Osteopterygiens. Bull. Stat. Aqu. Pec. Castiglione (new series), 4, 1-384.

Dulčić, J. (2002): First record of scalloped ribbon fish, *Zu cristatus* (Pisces: Trachipteridae), eggs in the Adriatic Sea. J. Plankton Res., 24(11), 1245-1246.

Dulčić, J., B. Dragičević, M. Pavičić, Z. Ikica, A. Joksimović & O. Markoić (2014): Additional records of non-indigenous, rare and less known fishes in the eastern Adriatic. Annales, Ser. Hist. Nat., 24(1), 17-22.

Falsone, F., M.L. Geraci, D. Scanella, C.O.R. Okpala, G.B. Giusto, M. Bosch-Belmar, S. Gancitano & G. Bono (2017): Occurrence of two rare species from order. Lampriformes: Crestfish *Lophotus lacepede* (Giorna, 1809) and scalloped ribbonfish *Zu cristatus* (Bonellli, 1819) in the northern coast of Sicily, Italy. Acta Adriat., 58(1), 137-144.

Fischer, W., M.L. Bauchot & M.S. Schneider (1987): Fiches FAO d'Identification des Espe`ces pour les Besoins de la Peˆche. Me´diterrane´e et Mer Noire, Volume II (Verte´bre´s). FAO, Rome, 1529 pp.

Fricke, R., M. Kulbicki & L. Wantiez (2011): Checklist of the fishes of New Caledonia, and their distribution in the Southwest Pacific Ocean (Pisces). Stuttgart. Beitr. Naturkund., Serie A (Biologie), 4, 341-463.

Froese, R. & D. Pauly (Eds.) (2023): FishBase. World Wide Web electronic publication. www.fishbase.org. version (02/2022) (Last accession: 25 March 2023).

Garcia-Barcelona, S., R. Garcia-Cancela, M.J. Cayuela, A. De Carlos, R. Bañon, D. Macias & J.C. Baez (2016): Descripción de dos ejemplares de *Zu cristatus* (Bonelli, 1820) capturados accidentalmente con unpalangre semipelágico en el Mediterráneo occidental. Arx. Misc. Zool., 14, 91-98.

Garibaldi, F. (2015): By-catch in the mesopelagic swordfish longline fishery in the Ligurian Sea (Western Mediterranean). Collect. Vol. Sci. Pap. ICCAT, 71(3), 1495-1498.

Gavagnin, E.P. (1976): Considerazioni sulla cattura di uno *Zu cristatus* (Bonelli) a San Remo (Osteichthyes Trachipteridae). Natura, 67(3-4), 258-261.

Golani, D., B. Ozturk & N. Basusta (2006): The Fishes of the Eastern Mediterranean. Turkish Marine Research Foundation, Istanbul, Turkey, 259 pp.

Golani, D., D. Edelist, A.R. Morov & N. Stern (2023): First confirmed record of *Zu cristatus* in the Mediterranean coast of Israel and the eastern shores of the Levant. Medit. Mar. Sci., 24(1), 87-89.

Heemstra, P.C. & S.X. Kannemeyer (1984): The families Trachipteridae and Radiicephalidae (Pisces, Lampriformes) and a new species of *Zu* from South Africa. Ann. S. Afr. Mus., 94(2), 13-39.

Heemstra, P.C. & S.X. Kannemeyer (1986): Trachipteridae. In: M.M. Smith & P.C. Heemstra (eds.): Smiths' sea fishes, Springer-Verlag, Berlin, pp. 399-402.

Jardas, I. (1980): Contribution a` la connaissance des Trachipteres dans la mer Adriatique. 1. *Trachipterus trachypterus* (Gmelin, 1789). Acta Adriat., 21, 3 -17.

Jardas I. (1996): Adriatic ichthyofauna. School Book, Zagreb, 533 pp.

Ibanez, M. & L. Gallego (1974): A new record of a *Zu cristatus* (Trachipteridae, Pisces) off the coast of Blanes (Spain). Vie et Milieu, 26, 523-526.

IUCN (2023): The IUCN Red List of Threatened Species. Version 2022-2. Available at: www.iucnredlist.org. (Accessed: 29 March 2023).

Mytilineou, C., A. Anastasopoulou, G. Chris-Tides, P. Bekas, C.J. Smith, K.N. Papado-Poulou, E. Lefkaditou & S. Kavadas (2013): New records of rare deep-water fish species in the Eastern Ionian Sea (Mediterranean Sea). J. Nat. Hist., 47(25-28), 1645-1662.

Mundy, B.C. (2005): Checklist of the fishes of the Hawaiian Archipelago. Bishop Mus. Bull. Zool., 1-703.

Nelson, J.S. (2006): Fishes of the World, 4 Edition. John Wiley & Sons, New Jersey, USA, 601 pp.

Oliver, M. (1955): Cita de peces no frecuentes pescados en aguas de Mallorca. *Trachiptenes cristatus* (Bonelli) y *T. iris* (Walbaum). Bol. Soc. Hist. Nat. Baleares, 1955(1), 45.

Olney, J.E., G.D. Johnson & C.C. Baldwin (1993): Phylogeny of lampridiform fishes. Bull. Mar. Sci., 52, 137-169.

Olney, J.E. (1999): Order Lampriformes. In: K.E. Carpenter & V.H. Niem, (Eds.): FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific. Volume 3: Batoid Fishes, Chimaeras and Bony Fishes Part 1 (Elopidae to Linophrynidae); FAO, Rome, Italy, pp. 952-959.

Palmer, G. (1961): The dealfishes (Trachipteridae) of the Mediterranean and North-East Atlantic. Bull. Br. Mus. Nat. Hist, D., 7(7), 335-352.

Palmer, G. (1986): Trachipteridae. In: P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen & E. Tortonese (eds.): Fishes of the north-eastern Atlantic and the Mediterranean. Vol. 2, UNESCO, Paris, pp. 729-732.

Papakonstantinou, C. (1988): Checklist of marine fishes of Greece. Fauna Graeciale IV Pisces. Hellenic Zoological Society, Athens, 257 pp.

Postel, E. (1955): Capture d'un trachyptere *Trachypterus cristatus* Bonelli en baie de Tunis. Bull. Stat. Oceanogr., Salammbo, 51, 69-70.

Psomadakis, P.N., U. Scacco & M. Vacchi (2006): Recent findings of some uncommon fishes from the central Tyrrhenian Sea. Cybium, 30(4), 297-304.

Psomadakis P.N., M. Bottaro & M. Vacchi (2007): On two large specimens of *Zu cristatus* (Trachipteridae) from the Gulf of Genoa (NW Mediterranean). Cybium, 31(4), 480-482.

Quigley, D.T.G. & G. Henderson (2014): First record of the scalloped ribbonfish *Zu cristatus* (Bonelli, 1819) (Lampriformes: Trachipteridae) from N.W. European waters. The Glasgow Natur., 26(1), 103-104.

Quignard, J.P. & J.A. Tomasini (2000): Mediterranean fish biodiversity. Biol. Mar. Medit., 7, 1-66.

Roig, A. & M. Demestre (1982): Sobre la captura de dos *Zu cristatus* (Bonelli, 1820) en aguas del litoral catalán (Pisces, Trachipteridae). Misc. Zool., 6, 152-154.

Sperone, E. & G. Giglio (2015): On the occurrence of *Ranzania laevis* and *Zu cristatus* in Calabria (Southern Tyrrhenian Sea). In: A. Zenetos, E.H.Kh. Akel, C. Apostolidis M. Bilecenoglu, G, Bitar, V. Buchet, N. Chalari, M. Corsini-Foka, F. Crocetta, A. Dogrammatzi, M. Drakulić, G. Fanelli, G. Giglio, A. Imsiridou, K. Kapiris, P.K. Pkarachle, S. Kavadas, G. Kondylatos, E. Lefkaditou, L. Lipej, B. Mavrič, G. Minos, R. Moussa, M.A. Pancucci-Papadopoulou, E. Prato, W. Renda, N. Ríos, S.I. Rizkalla, F. Russo, M. Servonnat, A. Siapatis, E. Sperone, J.A. Theodorou, F. Tiralongo & Tzovenis, I. New Mediterranean Biodiversity Records. Med. Mar. Sci., 16(1), 266-284.

Stipa, M.G., F. Longo, G. Ammendolia, T. Romeo & P. Battaglia (2022): New data on *Trachipterus trachypterus* Gmelin, 1789 and *Zu cristatus* (Bonelli, 1820) (Pisces: Trachipteridae) from the Mediterranean Sea. Acta Adriat., 63(1), 65-74.

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

Tortonese, E. (1958): Cattura di *Trachypterus cristatus* Bonell. Note sui Trachypteridae del Mar Ligure. Doriana, 2(89), 1-5.

Tortonese, E. (1970): Osteichthyes (pesci ossei). Parte prima. Calderini (Editors), Bologna, Italy, 595 pp.

FAVNA

FAVNA

FAVNA

received: 2023-04-03 DOI 10.19233/ASHN.2023.14

EPIBENTHIC MACROFAUNA ON AN ARTIFICIAL REEF OF THE NORTHERN ADRIATIC SEA: A FIVE-YEARS PHOTOGRAPHIC MONITORING

Nicola BETTOSO, Lisa FARESI & Ida Floriana ALEFFI
Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia (ARPA FVG), via Cairoli 14 – 33053 Palmanova (UD), Italy
e-mail: nicola.bettoso@arpa.fvg.it

Valentina PITACCO
Marine Biology Station Piran, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia

ABSTRACT

Artificial reefs (ARs) are man-made structures used with the aim of improving fisheries and increasing natural production of biological resources. In 2006 an AR made of three types of modules was sunk near an underwater sewage outfall. The objectives of the project were: (a) to use the AR to restock some target species of commercial interest and (b) to promote biodiversity in selected areas. The epibenthic macrofauna that had settled on this AR was annually monitored for five years (2007- 2011) using non-destructive photographic methods. A total of 88 taxa from 8 phyla were identified, with a predominance of Porifera, Mollusca and Ascidiacea. Among the types of modules used to construct the AR, polyethylene panel nets were functional for bivalve settlement in the first year, whereas concrete structures seemed to perform best in promoting biodiversity in terms of species richness in the long term. Nevertheless, the 5-year monitoring period was too short to speculate on the stability or homeostasis of communities settled on the AR in terms of ecological succession.

Key words: artificial reefs, macrozoobenthos, Adriatic Sea, photographic monitoring

LA MACROFAUNA EPIBENTONICA DI UNA BARRIERA ARTIFICIALE SOMMERSA DELL'ALTO ADRIATICO: RISULTATI DI UN MONITORAGGIO FOTOGRAFICO QUINQUENNALE

SINTESI

Le barriere artificiali (BA) sono strutture solitamente utilizzate per incrementare le rese di pesca. Nel 2006 è stata realizzata una BA, costruita con tre diverse tipologie di moduli e situata in prossimità di un dotto fognario sottomarino. Gli obiettivi del progetto erano: (a) sperimentare la BA per il ripopolamento di alcune specie di interesse commerciale e (b) promuovere la biodiversità. La macrofauna epibentonica insediata su questa BA è stata monitorata a cadenza annuale durante 5 anni (2007-2011) per mezzo di rilievi fotografici. Complessivamente sono stati identificati 88 taxa appartenenti ad 8 phyla, in cui i Porifera, Mollusca ed Ascidiacea sono stati prevalenti. I pannelli in rete di polietilene sono stati efficaci durante il primo anno per l'insediamento dei molluschi bivalvi, mentre nel lungo periodo il cemento si è dimostrato il più efficace per promuovere la biodiversità in termini di ricchezza specifica. Il monitoraggio di 5 anni comunque non è stato del tutto soddisfacente per trarre conclusioni sulla successione ecologica della comunità insediata sulla BA.

Parole chiave: Barriere artificiali, macrozoobenthos, mare Adriatico, monitoraggio fotografico

INTRODUCTION

Artificial reefs (ARs) are man-made structures that have long been used with the aim of improving fisheries by concentrating fish and increasing the natural production of biological resources (Bohnsack & Sutherland, 1985). Parenzan (1957) was one of the first scientists to suggest the use of artificial structures as a tool to increase fishery production in oligotrophic environments by sinking wrecks and testing ad hoc experimental areas (Parenzan, 1986). In Italy the first AR was made in December 1970, when a team of recreational fishermen, without any scientific support, obtained the permission to sink 1,300 cars at depth between 35 and 50 m in order to discourage trawling and to improve recreational fishing (Relini & Orsi Relini, 1989). The first scientifically oriented AR was built in 1974 in the Adriatic Sea, with stones and concrete blocks (Bombace, 1989). After about 40 years, Fabi *et al*. (2011) reported more than 70 ARs along the Italian coast, most of them built thanks to the financial support of the European Community.

In the oligotrophic waters of the Mediterranean, ARs have been used mainly to protect *Posidonia oceanica* meadows from illegal trawling and to increase habitat complexity and species diversity (Relini *et al*., 1994; Gonzalez-Correa *et al*., 2005; Ponti *et al*., 2015). In contrast, in the eutrophic waters of the central and northern Adriatic, ARs have been used to increase fishery yields (Bombace *et al*., 1994; Bombace *et al*., 1997). Concrete, pebbles, limestone rocks, and PVC are the most common materials used to build ARs (Toledo *et al*., 2020 and references therein). The concrete is frequently used because it is cheap and allows the realization of different structures in terms of shape and size. In addition, concrete is resistant to chemical and physical marine actions, thus ensuring long duration (Fabi *et al*., 2011; Ponti *et al*., 2015).

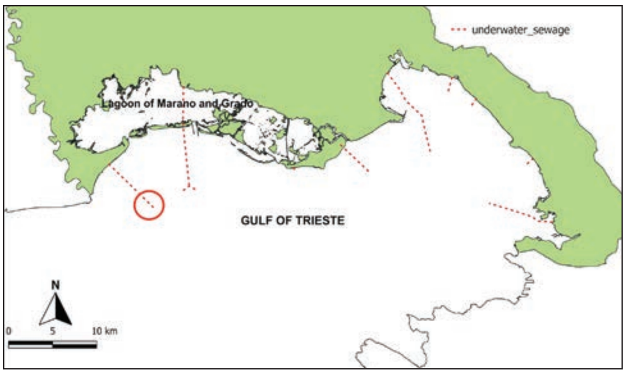

Fig. 1: Map of the study area, the circle indicates the terminal tract of Lignano Sabbiadoro sewage outfall.
Sl. 1: Zemljevid obravnavanega območja z označenim delom terminala kanalizacije mesta Lignano Sabbiadoro (krogec).

ARs are intentionally placed on the seafloor with the goal of imitating the function of a natural reef, therefore most studies after the installation of an AR are focused on the ecological succession of benthic organisms on these manmade substrates (Toledo *et al*., 2020 and references therein). The colonization process can be broadly divided in early and late succession: the former is associated with the first organisms that settle on the ARs, including organized microorganisms creating microbial mats or biofilms; the latter is characterized by the arrival of more complex organisms, which in turn attract predator species from further up the trophic chain (Herbert *et al*., 2017; Toledo *et al*., 2020 and references therein).

The AR analyzed in the present study was based on guidelines developed as part of the project ADRI. BLU (2006). This project addressed the sustainable management of fisheries activities and resources in the northern Adriatic Sea. More information on the project is available on internet in Italian. The specific objectives of the project were: (a) to use the AR in

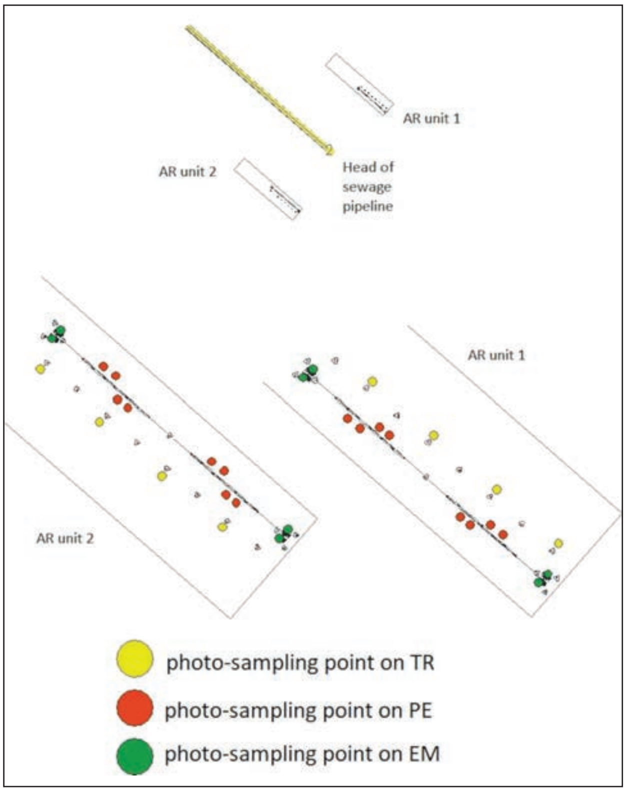

Fig. 2: Particular of the terminal tract of the sewage outfall, location of the AR units and photo sampling points.
Sl. 2: Del terminala kanalizacije, lega UPG in vzorčevalne postaje fotografskega monitoringa.

Fig. 3: a) Tecnoreef® pyramid (TR); b) Ecomare pyramids (EM); c) Polyethylene net for scallops settlement (PE) (photos: Arpa FVG).
Sl. 3: a) Tecnoreef® piramida (TR); b) Ecomare piramide (EM); c) Polietilenska mreža za naseljevanje pokrovač (PE) (fotografije: Arpa FVG).

order to restock some target species of commercial interest, such as pectinid bivalves, and (b) to promote biodiversity in some selected areas, such the Gulf of Trieste for the Region Friuli-Venezia Giulia. In this context, in 2006, an AR was sunk three miles off Lignano Sabbiadoro, near an underwater sewage outfall (Solis-Weiss et al., 2007, and references therein), and the settled macrofauna was monitored annually for the following five years (2007- 2011) using photographic methods based on a guide specifically developed within this project (Arpa FVG, 2007; Bettoso *et al*., 2023). The photographic method is less accurate than other sampling techniques, but has the advantage of being non-destructive, fast, and efficient enough to monitor the evolution of epibenthic communities on the AR with a good benefit-cost ratio. In the present work the results of this photographic monitoring are presented.

MATERIAL AND METHODS

Study area

The AR was located in the Gulf of Trieste, the northernmost part of the Adriatic Sea (Fig. 1). It is a shallow semi-enclosed basin (max depth 25 m), characterized by the largest tidal amplitudes and the lowest winter temperatures in the Mediterranean Sea (Boicourt *et al*., 1999), high temperature and salinity variations, and important stratification of the water column (Stravisi, 1983). The hydrodynamism is related mainly to the ascending eastern current coming from the Istrian coast. The general circulation pattern is predominantly counterclockwise in the lower layer and clockwise in the surface layer. This circulation, especially in the surface layer can be modulated by prevailing winds from

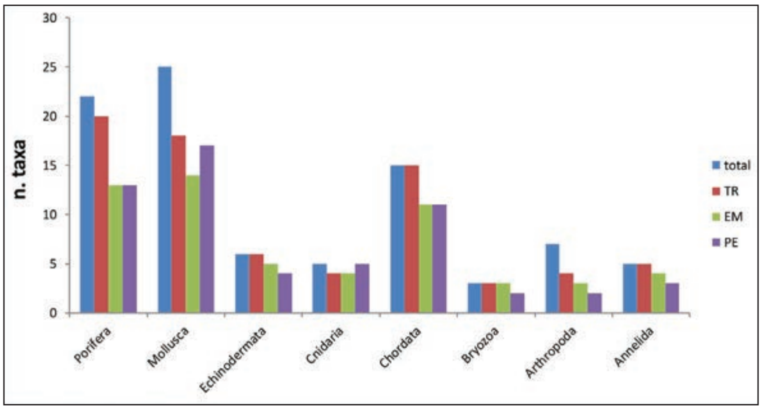

Fig. 4: Taxa richness (TR, Tecnoreef; EM, ecomare; PE, polyethylene).
Sl. 4: Pestrost taksonov (TR, Tecnoreef; EM, ecomare; PE, polietilenska mreža).

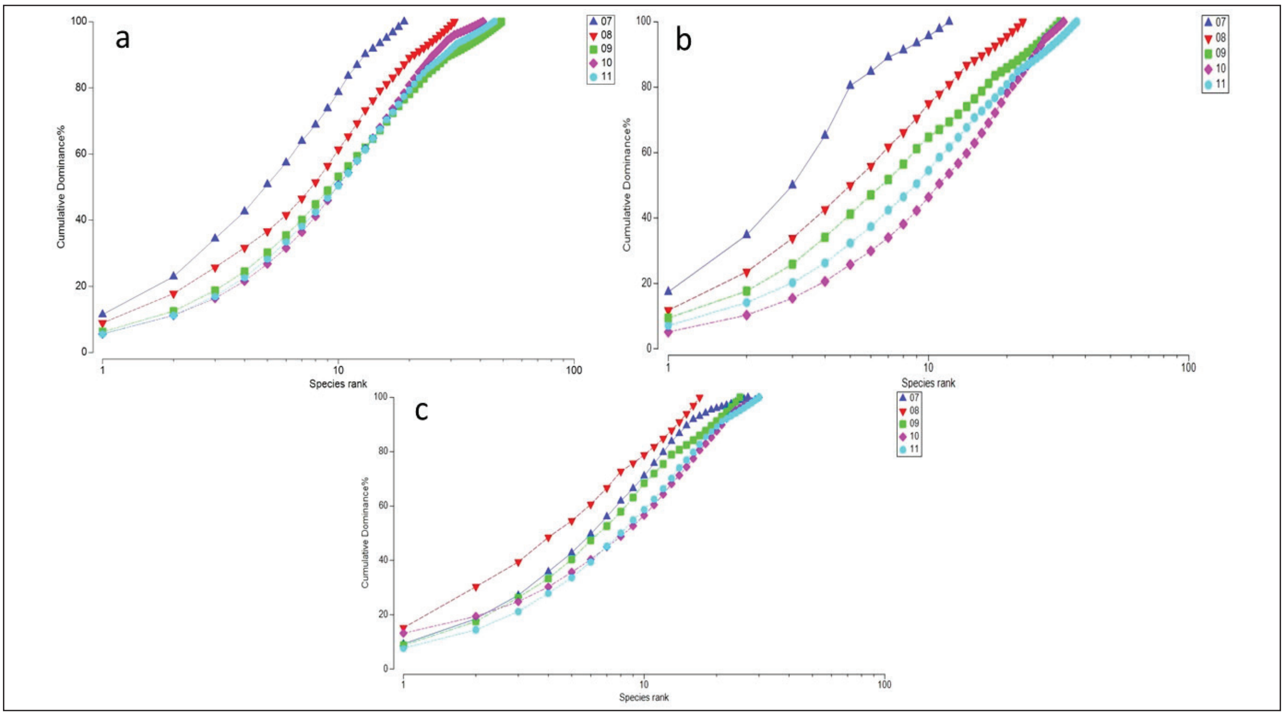

Fig. 5: a) K-dominance curves for Tecnoreef (TR), b) K-dominance curves for ecomare (EM); c) K-dominance curves for polyethylene net (PE).
Sl. 5: Krivulje K-dominance za Tecnoreef (TR), b) krivulje K-dominance za ecomare (EM); c) krivulje K-dominance za polietilensko mrežo (PE).

eastern quadrants such as Bora (Stravisi, 1983). The sediments are quite varied, from sands with beachrocks to muds, predominantly detritical, and the associated biocoenoses of the Gulf belong mainly to the DC (Détritique Côtier), DE (Détritique Envasé) and VTC (Vases Terrigènes Côtières) biocoenoses, as defined by Pérès & Picard (1964) (Solis-Weiss *et al.*, 2001).

The AR was deployed in August/September 2006 about 3 nautical miles off Lignano Sabbiadoro near the underwater sewage outfall (Fig. 1), where anchoring and fishery are forbidden. The site is located at 16 m depth, where the sediment consists of pelitic sand and very sandy pelite, and benthic community of the soft bottom is mainly represented by the biocoenosis of Coastal Detritic (DC) (Solis-Weiss *et al.*, 2007). The AR consisted of

Tab. 1: Taxa richness year by year on every AR module (TR – Tecnoreef, EM – ecomare, PE – polyethylene net) and Mann-Kendall test (ns – not significant, in bold – upward trend).
Tab. 1: Pestrost taksonov v posameznih letih na vsakem UPG modulu (TR – Tecnoreef, EM – ecomare, PE – polietilenska mreža) in Mann-Kendallov test (ns – ni statistično značilen, mastni tisk – trend naraščanja).

TR	**2007**	**2008**	**2009**	**2010**	**2011**	**Mann-Kendall**
tot	19	31	49	41	46	ns
Porifera	1	6	13	11	16	**0.042**
Mollusca	8	8	10	7	9	ns
Echinodermata	5	2	3	5	2	ns
Cnidaria	0	2	3	2	3	ns
Chordata	3	9	12	12	9	ns
Bryozoa	0	1	2	2	3	**0.0083**
Arthropoda	0	1	3	0	1	ns
Annelida	2	2	3	2	3	ns
EM	**2007**	**2008**	**2009**	**2010**	**2011**	
tot	12	23	32	33	37	**0.0083**
Porifera	2	4	8	7	8	**0.042**
Mollusca	7	5	8	7	10	ns
Echinodermata	0	2	3	3	2	ns
Cnidaria	0	1	2	2	3	**0.0083**
Chordata	2	8	7	9	5	ns
Bryozoa	0	1	2	2	3	**0.0083**
Arthropoda	0	1	0	1	2	ns
Annelida	1	1	2	2	4	**0.042**
PE	**2007**	**2008**	**2009**	**2010**	**2011**	
tot	27	17	25	30	30	ns
Porifera	1	1	7	7	11	**0.042**
Mollusca	12	3	6	8	5	ns
Echinodermata	3	0	1	2	2	ns
Cnidaria	2	3	3	2	3	ns
Chordata	6	6	5	6	4	ns
Bryozoa	0	1	1	2	2	**0.042**
Arthropoda	1	0	0	1	0	ns
Annelida	2	3	2	2	3	ns

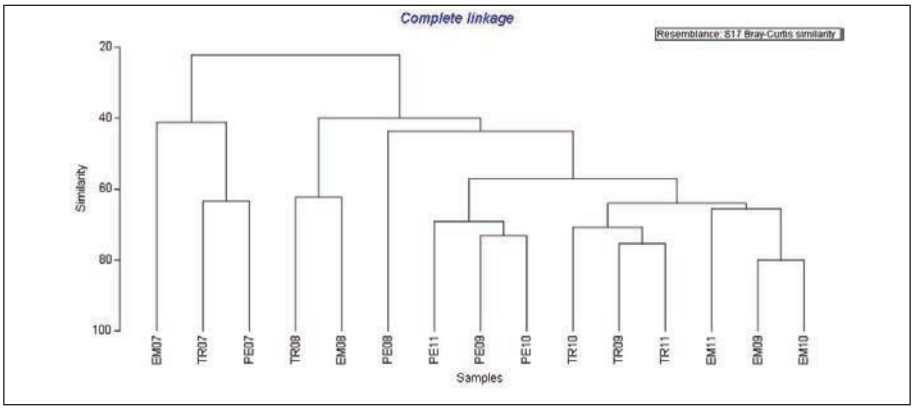

Fig. 6: Dendrogram on the basis of years (07-11) and AR module (TR, EM, PE).
Sl. 6: Dendrogram na podlagi različnih let (07-11) in modula AR (TR, EM, PE).

two different units (hereafter AR units) placed on both sides of the sewage duct, at a distance of 500 m from the end section of the sewer (Fig. 2). These AR units were made of three different types of artificial modules (hereafter AR modules) placed in a symmentrical and specular way with respect to the sewer (Fig. 2). These modules were: 30 pyramids made of concrete slabs (TR – declared "sea-friendly" by the producer Tecnoreef®, manifactured using only natural components, without synthetic additives; pH – 9; 180 cm height) (Fig. 3a); 4 pyramids made of PVC tubes (EM – Ecomare, diameter of tubes is 100 cm and pyramid high is 273 cm) (Fig. 3b); 4 sets of polyethylene panel nets (PE) (mesh size 40 mm, length 100 m, height 300 cm, width 100 cm) used for the settlement of scallop larvae (Fig. 3c).

Sampling and analysis

Epibenthic faunal communities on the AR were surveyed once a year using SCUBA photo-sampling (Fujifilm Finepix F30 model). Pictures of a 50x50 cm (2,500 cm^2) quadrat (divided in 4 subquadrats) were taken at 16 points for each unit (4 for TR, 4 for EM, and 8 for PE) for a total of 32 sampling points (displayed in Fig. 2). Animals that were readily identifiable in the photographs were determined to the lowest possible taxonomic level, whereas those not easily recognizable at the species level were collected and stored for determination at the laboratory (Bettoso *et al.*, 2023). The first survey took place in June 2007, nine months after the sinking of the AR, and was repeated each spring/summer until 2011, for a total of 132 quadrats analysed. Cluster, K-dominance curves and SIMPER analysis (Clarke and Warwick, 2001) were performed on presence/absence data subdivided for type of AR module and year of sampling. Mann Kendall test was applied to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time.

RESULTS

A total of 88 taxa of epibenthic invertebrates, belonging to 8 phyla, were detected by photo sampling, of which 75 were recorded on concrete pyramids (TR), 57 in both PVC pyramids (EM) and polyethylene panel nets (PE). The most abundant phyla in terms of taxa richness were Mollusca followed by Porifera and Chordata, the latter represented by class Ascidiacea. The same pattern was observed considering the three types of AR modules separately, except for TR, where Porifera slightly outweigh Mollusca (Fig. 4). The highest taxa richness was observed on TR modules for all phyla except for Cnidaria, showing the highest richness on PE modules (Fig. 4). Considering the total number of taxa, an increase with time was observed only for EM (Mann-Kendall test, Tab. 1). Considering the different phyla separately, Porifera and Bryozoa were the only groups to show an increasing trend in richness values in all types of AR modules (Tab. 1).

The K-dominance curves generated for TR showed decreasing dominance from 2007 to 2008, whereas curves for 2009, 2010 and 2011 showed a comparable shape (Fig. 5a). Similar pattern was observed for EM, although the curves from 2009 to 2011 intersect at one point (Fig. 5b). For PE, the shape of the curve for 2007 was more similar to the curves for 2009-2011, whereas the curve for 2008 was the steepest and showed the highest dominance (Fig. 5c).

The dendrogram clearly separated the first survey of 2007 (Group A: EM07, TR07, PE07) at a similarity level of about 20%, whereas the Group B included TR08 and EM08 surveyed in 2008. The remaining clusters (2009-2011) were grouped at a similarity level of about 60%, except PE08 which was grouped apart (Group C). The cluster 2009-2011 was subdivided on the basis of the type of

Tab. 2: SIMPER analysis performed on clusters of the dendrogram (cut off 50%).
Tab. 2: SIMPERjeva analiza posameznih gruč na dendrogramu (rez na nivoju 50%).

	Group A 2007 (TR, EM, PE)		**Group B 2008 (TR, EM)**		**Group C 2008 (PE)**
POR	*Crambe crambe*	POR	*Crambe crambe*	CNI	*Cereus pedunculatus*
MOL	*Hexaplex trunculus*	POR	*Ulosa digitata*	ANN	Serpulidae indet.
MOL	*Ostrea edulis*	MOL	*Hexaplex trunculus*	CHO	*Phallusia mammillata*
MOL	*Mimachlamys varia*	MOL	*Ostrea edulis*	CHO	*Styela plicata*
MOL	*Pinna nobilis*	ANN	Serpulidae indet.	CHO	*Didemnum lahillei*
MOL	*Mytilus galloprovincialis*	CHO	*Didemnum lahillei*		
MOL	*Flexopecten glaber*	CHO	*Phallusia mammillata*		
ANN	Serpulidae indet.	CHO	*Phallusia fumigata*		
CHO	*Phallusia mammillata*	CHO	*Diplosoma listerianum*		
CHO	*Botryllus schlosseri*				
	Group D 2009-2011 (TR)		**Group E 2009-2011 (EM)**		**Group F 2009-2011 (PE)**
POR	*Crambe crambe*	POR	*Crambe crambe*	POR	*Crambe crambe*
POR	*Dysidea fragilis*	POR	*Dysidea fragilis*	POR	*Ulosa digitata*
POR	*Haliclona (Reniera) mediterranea*	POR	*Haliclona (Reniera) mediterranea*	POR	*Dysidea fragilis*
POR	*Phorbas fictitius*	POR	*Ulosa digitata*	POR	*Haliclona (Reniera) mediterranea*
POR	*Dictyonella incisa*	CNI	*Cereus pedunculatus*	CNI	*Epizoanthus* sp.
POR	*Ulosa digitata*	MOL	*Hexaplex trunculus*	CNI	*Cereus pedunculatus*
CNI	*Cereus pedunculatus*	MOL	*Ostrea edulis*	MOL	*Hexaplex trunculus*
MOL	*Hexaplex trunculus*	MOL	*Anomia ephippium*	MOL	*Ostrea edulis*
MOL	*Ostrea edulis*	MOL	*Mimachlamys varia*	MOL	*Anomia ephippium*
MOL	*Mimachlamys varia*	ANN	Serpulidae indet.	MOL	*Mytilus galloprovincialis*
ANN	Serpulidae indet.	BRY	Bryozoa indet.	ANN	Serpulidae indet.
BRY	Bryozoa indet.	BRY	*Schizobrachiella sanguinea*	BRY	Bryozoa indet.
BRY	*Schizobrachiella sanguinea*	ECH	*Ocnus planci*	ECH	*Ophiothrix fragilis*
ECH	*Ocnus planci*	CHO	*Phallusia mammillata*	CHO	*Didemnum lahillei*
CHO	*Microcosmus* sp.	CHO	*Phallusia fumigata*	CHO	*Diplosoma listerianum*
CHO	*Didemnum lahillei*	CHO	*Didemnum lahillei*		
CHO	*Diplosoma listerianum*	CHO	*Microcosmus* sp.		

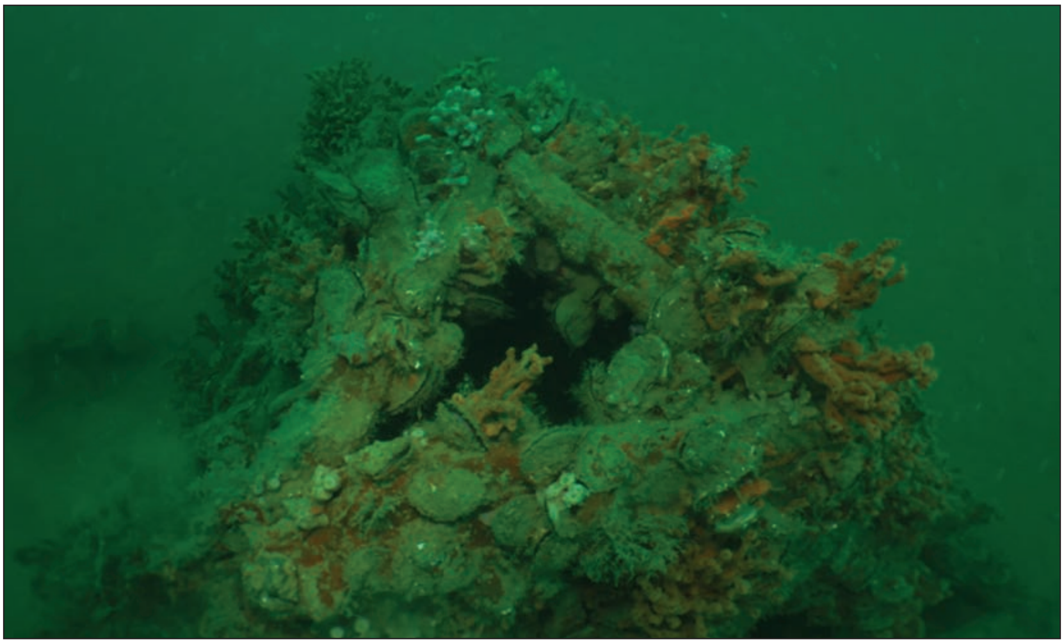

Fig. 7: Tecnoreef pyramid (TR) in 2015 (photo: G. Pessa).
Sl. 7: Tecnoreef piramida (TR) leta 2015 (foto: G. Pessa).

AR modules rather than years (Group D: TR09, TR10, TR11; Group E: EM09, EM10, EM11; Group F: PE09, PE10, PE11) (Fig. 6).

SIMPER analysis was used to identify the most representative species for each cluster of the dendrogram (Tab. 2). *Crambe crambe* was the first Porifera species recorded on the AR and was found every year and on all types of AR modules, except PE in 2008. In the second year, *Ulosa digitata* was detected on TR and EM and was observed on all types of AR modules in all subsequent years. *Dysidea fragilis* and *Haliclona (Reniera) mediterranea* were among characteristic species from 2009 onwards. SIMPER identified two more species of Porifera only on TR (group D) (Tab. 2). Considering phylum Annelida, the taxon Serpulidae was constantly found in every year and all types of AR modules. The phylum Mollusca was mainly represented by bivalves and had the highest number of characteristic species in 2007. *Flexopecten glaber* and *Pinna nobilis* were recorded only during the first year, whereas the gastropod *Hexaplex trunculus* and the oyster *Ostrea edulis* characterized all groups of dendrogram, except the group C (PE in 2008) where no molluscs were identified by SIMPER analysis. *Mytilus galloprovincialis* was included in the group F (PE 2009-11) and *Mimachlamys varia* in those D and E (TR and EM 2009-11). The phylum Cnidaria was represented mainly by *Cereus pedunculatus*, being characteristic of group C on PE in 2008 and in all types of AR modules from 2009 to 2011. The Chordata Ascidiacea were characteristic in all cluster groups. It is interesting to note the exclusive presence of *Botryllus schlosseri* in 2007 and the particular abundance of *Phallusia mammillata* in 2007 and 2008 on all types of AR. *Didemnum lahillei* was among characteristic species from 2008 onwards (Tab. 2).

DISCUSSION AND CONCLUSIONS

The Gulf of Trieste is characterized by various environmental and anthropogenic pressures that affect benthic communities, such as periodic "mare sporco" phenomena (mucilage aggregations), episodes of hypoxia and anoxia, significant riverine inflow, intense maritime traffic, intensive fishery, mariculture and others (Stachowitsch & Fuchs, 1995; Solis-Weiss *et al.*, 2004). These pressures could lead to changes in the soft- and hard-bottom benthic communities, at least in terms of succession (Mavrič *et al.*, 2010).

A recent census of ARs in the Adriatic Sea recorded a total of 47 sites along the Italian coast, 8 of which are located in the Gulf of Trieste (Minelli *et al.*, 2021). The oldest AR of the gulf was built in 1978 inside the Miramare Marine Protected Area in Trieste, while the last one was established near mussel farms on the maritime border Italy-Slovenia (Project EcoSea, 2016). The site for the present work, near the sewage outfall off Lignano Sabbiadoro was selected to avoid damage to the AR and sewage pipeline from anchoring and fishing, and because this area is characterized by the presence of pelitic sand or very sandy pelite. In fact, this sediment texture is suitable to prevent the sinking

Fig. 8: Smooth scallops (*Flexopecten glaber*) and* Spirobranchus triqueter *settled on polyethylene nets (PE) (photo: Arpa FVG).
Sl. 8: Gladka pokrovača (*Flexopecten glaber*) in* Spirobranchus triqueter *sta se naselila na polietilensko mrežo (PE) (foto: Arpa FVG).

Fig. 9: Smooth scallops (*F. glaber*) on sea floor nearby polyethylene nets (photo: Arpa FVG).
Sl. 9: Gladka pokrovača (*F. glaber*) na morskem dnu v bližini polietilenskih mrež (foto: Arpa FVG).

of AR modules into the seafloor and the accumulation of muddy sediment on the AR, which could inhibit the development and diversification of epibenthic organisms. In addition, the proximity of natural rocky outcrops (locally knows as Trezze) very rich in term of epibenthic fauna (Lipej *et al*., 2016; Bettoso *et al*., 2023), could represent a good larval source for the settlement of species common in coralligenous biotopes. According to Ponti *et al*. (2015) the environmental conditions are the main drivers of the recruitment processes on ARs. In particular, the sedimentation rate seemed the most important in the establishment of different benthic assemblages and therefore in the ecological effectiveness of the ARs (Ponti *et al*., 2015). In the present study the area off Lignano Sabbiadoro shows a heterogeneous sediment texture: AR modules are located on prevailing sandy sediment close to the rocky outcrops, but just 1 Nm toward the coast the sediment becomes muddy due to the pelitic belt originated by the Tagliamento river mouth. Thus, this zone can be considered a transitional habitat between areas with high sedimentation rate and coralligenous biotopes.

A total of 88 taxa belonging to 8 phyla, identified for the present work on the AR by photographic monitoring only, is a high number when compared to the 196 taxa of epibenthic invertebrates recorded by Bettoso *et al*. (2023) using the same method on 45 natural rocky outcrops not far from the study area. Porifera, Mollusca and Ascidiacea predominated on the AR, as well as on those natural rocky outcrops (Bettoso *et al*., 2023). The faunal component on the AR dominated over macroflora, because the site was at 16 m depth with recurring events of water turbidity. The same was observed for the natural rocky outcrops (Bettoso *et al*., 2023). So, the proximity of the sewage pipeline did not seem to have a negative impact on the epibenthic fauna settled on the AR. Consistently, no negative impact had been observed on the soft bottom macrofauna near the same sewage outfall by Solis-Weiss *et al*. (2007).

According to Ponti *et al*. (2015) the shape and materials of ARs were of little importance in determining the structure of the benthic assemblage. Conversely, in the present work, some differences between the types of AR modules deployed were observed. In particular, TR showed overall higher richness values compared to EM and PE (Fig. 4).

The cluster showed that those differences are not evident immediately after the deployment of the AR (in 2007 all AR modules are clustered together), but from 2009 on, when benthic communities are clustered by type of modules rather than by years. On TR and EM total taxa richness increased from 2007 to 2008, mainly due to Porifera and Ascidiacea. From the third year (2009) the number of taxa did not increase on any AR module (Tab. 1). Dominance decreased for 2007 to 2009, and did not changed in the subsequent years on both TR and EM. Unfortunately the photographic monitoring on epibenthic fauna lasted only 5 years and further observations on the variability and/or stability on this community was not possible. Nevertheless, some pictures taken in 2015 on TR modules showed an assemblage with oysters, sponges and tunicates clearly observable (Fig. 7).

In the first year of monitoring the richness of bivalves was much higher on polyethylene panel nets (PE) than on concrete pyramids (TR) and PVC pyramids (EM). However, the permanent immersion of PE did not allow similar settlement of scallops and other bivalve

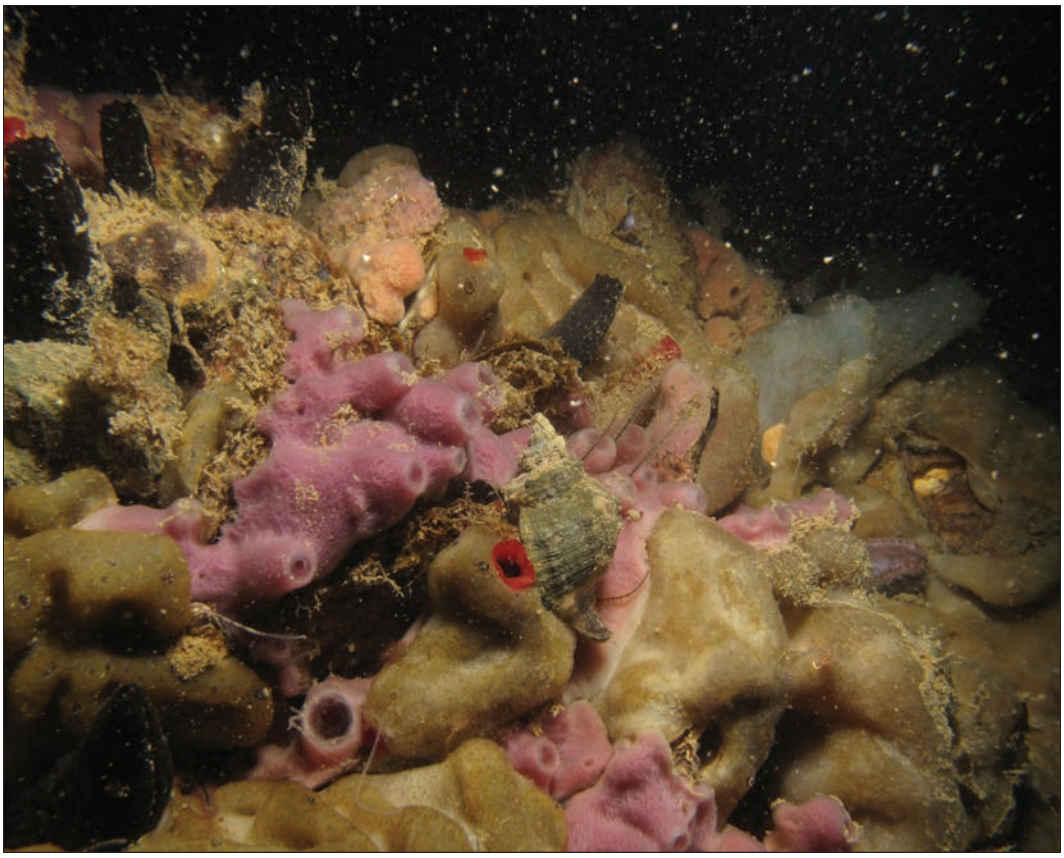

Fig. 10: Macrofauna assemblage on concrete plates (TR) in 2009 with the presence of the sponge *Haliclona (Reniera) mediterranea* ***(photo: Arpa FVG).***
Sl. 10: Združba makrofavne na betonskih ploščah (TR) v letu 2009 s spužvo *Haliclona (Reniera) mediterranea* ***(foto: Arpa FVG).***

in subsequent years as in 2007. On PE a decrease in richness was observed from 2007 to 2008 (Tab. 1), and at the same time dominance increased (Fig. 5c).

Polyethylene panel nets (PE) were specifically deployed to test the settlement of scallops, particularly for the smooth scallop *Flexopecten glaber*. This species is a very appreciated fisheries resource in the northern Adriatic Sea. It is usually caught together with *Pecten jacobaeus* by *rapido*, a type of beam trawl, used only in Adriatic Sea, with a very severe impact on benthic communities and whose use should be better regulated (Giovanardi *et al.*, 1998). The effectiveness of panel nets or collector bags as substratum for the settlement of *F. glaber* pediveligers has been successfully tested in other areas of the Gulf of Trieste (Orel & Zamboni, 2003). A massive production of this resource was found on PE also in the present study (Fig. 8). After 10 months from the immersion of 400 m of these panel nets, the smooth scallops reached a commercial size with an average density on the seafloor of 17 ind. m^{-2} and an estimated total biomass of 6,597 kg (Fig. 9) (Arpa FVG, 2007). Nevertheless, the effectiveness of panel nets for larval settlement of the smooth scallops, the queen scallop *Aequipecten opercularis* and other bivalves requires a clean substrate and a correct period of immersion for each species in order to detect the massive swarming of larvae (Orel & Zamboni, 2003). For instance, the period between June and September was considered the best for the captation of the variegated scallop *Mimachlamys varia* in the central Adriatic (Marguš *et al.*, 1993).

PE proved to be efficient also for the settlement of the critically endangered species *Pinna nobilis*, but almost all individuals were observed in 2007. So even if the species settles successfully, it probably does not survive in such types of structures. ARs made of plastic nets are recommented as larval captators by IUCN (Kersting & Hendriks, 2019) and have been extensively studied and used in different areas of the Mediterranean since the first mass mortality event of *P. nobilis* in 2016 (Kersting *et al.*, 2020). According to IUCN guidelines the main reproduction period of *P. nobilis* is from May to August and the main settlement period is between July and September (in the western Mediterranean), so collectors are usually deployed in June and removed in October-November (Kersting & Hendriks, 2019). These periods could change depending on environmental conditions (e.g., water temperature) in different years and Mediterranean regions (Kersting & García-March, 2017).

Based on the present work it is not possible to define a clear species succession, although, as the results show, some taxa such as Serpulidae, *Ostrea edulis* and *Crambe crambe* characterized the community every year; other like *Botryllus schlosseri* and *F. glaber* characterized only the first year, while some Porifera species (*e. g. Dysidea fragilis* and *Haliclona (Reniera) mediterranea*) characterized the community from 2009 onward (Fig. 10; SIMPER analysis). Serpulids, like *Spirobranchus triqueter*, are considered among pioneer species (Maggiore & Keppel, 2006; Nicoletti *et al*., 2007) able to drive the early stages of settlement, because of encroaching on clear surfaces (D'Anna *et al*., 2000; Moura *et al*., 2004) such ARs or molluscan shells (Fig. 8). Their dominance at the early stage of succession seems dependent on the timing of immersion of the AR. In fact, according to a recent research serpulids were dominant on plates placed in summer and autumn, while they were overweighed by bryozoans on plates placed in winter and spring (Fortič *et al*., 2021). About bivalves the settlement of *F. glaber* was above discussed, whereas the employment of artificial substrates can drive the production of the oyster *O. edulis* and the blue mussel *Mytilus galloprovincialis* (Fabi *et al*., 1989; Ardizzone *at al*., 1989). Oysters resulted very abundant on the Lignano AR and reached a commercial size (>70 gr) after 14 months from the deployment of structures (Arpa FVG, 2007), a shorter time compared to other areas in the Gulf of Trieste where about 23 months are needed (Orel & Zamboni, 2003). The following project Ecosea used the same sets of AR modules for further experiment on oyster culture. The blue mussel did not show any dominance stage on modules as observed by Nicoletti *et al*. (2007) on the Fregene AR (Tyrrhenian Sea), although it was among characterizing species in 2007 and on PE nets in 2009-2011. *Mytilus* pediveligers are more abundant in the surface layer (Dobretsov & Miron, 2001) and the settlement on the AR could be induced by mussels attached on the ropes, used to link the signal buoys floating on the sea surface. Considering the sponge *C. crambe*, this species is normally settled on shells of bivalves, e.g. *Arca noae, A. opercularis, M. varia*, and gastropods such *Hexaplex trunculus* (Corriero *et al.*, 1991) and it seems possible to farm this species for sponge culture purposes by means of artificial substrates (Padiglia *et al.*, 2018).

The colonial ascidian *B. schlosseri* can be an important driver of benthic community composition, but it strictly depends on local environmental conditions (Sams & Keough, 2012). In the present study it was very frequent in 2007 on all AR modules, whereas it was almost absent in the following years. The sponges *D. fragilis* and *H. mediterranea*, which were constantly recorded since 2009, are considered respectively as common and characteristic in coralligenous habitat (*sensu* Ballesteros, 2006) and were constantly found in assemblages on the rocky outcrops in the Gulf of Trieste (Bettoso *et al.*, 2023).

Based on this 5-year non-destructive monitoring on the AR realized thank to Project ADRI.BLU (2006) it is possible to conclude that the selected site was suitable for epibenthic settlement and in particular for bivalves captation. Nevertheless, according to Taormina *et al.* (2020) a 5-year monitoring is too short to speculate about stability or homeostasis of the AR in term of ecological succession. On regard the modules, polyethylene panel nets (PE) were functional only if employed during bivalve settlement, after this period they should be removed and cleaned for future employment. Considering long term settlement and evolution of epibenthic assemblage, TR seemed to give the best performance in term of species richness if compared to PE and EM, but a longer survey is needed to discriminate between long-term ecological successions and shorter-term variability. Anyway, on our opinion the use of EM and PE should be limited, being made by plastic material.

ACKNOWLEDGEMENTS

The Artificial Reef in Lignano Sabbiadoro was realized thank to the Project ADRI.BLU Interreg IIIA North Adriatic and the monitoring was funded by Regione Autonoma Friuli Venezia Giulia – Direzione centrale risorse agricole, naturali, forestali e montagna. Particular thanks are due to Giorgio Mattassi, Pietro Rossin and Walter de Walderstein. The present work was possible also thanks to the financial support from the Slovenian Research Agency (research core funding No. P1-0237).

EPIBENTOŠKA MAKROFAVNA NA UMETNEM PODVODNEM GREBENU V SEVERNEM JADRANU: PET LETNI FOTOGRAFSKI MONITORING

Nicola BETTOSO, Lisa FARESI & Ida Floriana ALEFFI
Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia (ARPA FVG), via Cairoli 14 – 33053 Palmanova (UD), Italy
e-mail: nicola.bettoso@arpa.fvg.it

Valentina PITACCO
Marine Biology Station Piran, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia

POVZETEK

Umetni podvodni grebeni (UPG) so umetne strukture, ki jih uporabljajo z namenom izboljšanja ribištva in povečanje naravne produkcije bioloških virov. Leta 2006 so potopili tri tipe UPG blizu podvodnega iztoka kanalizacije. Cilji projekta so bili: (a) uporaba UPG za repopulacijo nekaterih komercialnih tarčnih vrst in (b) za promocijo biodiverzitete na izbranem območju. V petletnem obdobju (2007-2011) so z nedestruktivnimi fotografskimi metodami letno spremljali epibentoško makrofavno. Določili so 88 taksonov iz 8 debel, med katerimi so prevladovale spužve, mehkužci in kozolnjaki. Med različnimi tipi UPG so bile polietilenske panelne mreže funkcionalne za naseljevanje školjk v prvem letu, medtem ko so se betonske strukture izkazale za najboljše v smislu vrstne pestrosti biodiverzitete v dolgoročnem obdobju. Kakorkoli že, petletno obdobje je bilo prekratko za razumevanje stabilnosti oziroma homeostaze združb, ki so se v smislu ekološke sukcesije naselile na UPG.

Ključne besede: umetni podvodni grebeni, makrozoobentos, Jadransko morje, fotografski monitoring

REFERENCES

Ardizzone, G.D., M.F. Gravina & A. Belluscio (1989): Temporal development of epibenthic communities on artificial reefs in the Central Mediterranean Sea. Bull. Mar. Sci., 44(2), 592-608.

Arpa FVG (2007): Supporto tecnico-scientifico in materia di gestione sostenibile delle risorse marine e lagunari, con particolare riferimento all'aggiornamento, implementazione, mantenimento del sistema georeferenziato di gestione delle attività economiche del settore ittico Alto Adriatico e di monitoraggio delle barriere artificiali sommerse, realizzati nell'ambito del Progetto "ADRI.BLU" (PIC INTERREG IIIA Transfrontaliero Adriatico) Rapporto 2007, 44 pp.

Ballesteros, E. (2006): Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanogr. Mar. Biol. Ann. Rev., 44, 123-195.

Bettoso, N., L. Faresi, V. Pitacco, M. Orlando-Bonaca, I.F. Aleffi & L. Lipej (2023): Species Richness of Benthic Macrofauna on Rocky Outcrops in the Adriatic Sea by Using Species-Area Relationship (SAR) Tools. Water, 15(2), 318.

Bohnsack, J.A. & D.L. Sutherland (1985): Artificial reef research: a review with recommendations for future priorities. Bull. Mar. Sci., 37(1), 11-39.

Boicourt, W.C., M. Kuzmić & T.S. Hopkins (1999): The Inland Sea: circulation of Chesapeake Bay and the Northern Adriatic. In: T.C. Malone *et al.* (eds.): Ecosystems at the Land-Sea Margin: Drainage Basin to Coastal Sea. Am. Geophysical Union, pp. 81-129.

Bombace, G. (1989): Artificial reefs in the Mediterranean Sea. Bull. Mar. Sci., 44(2), 1023-1042.

Bombace, G., G. Fabi, L. Fiorentini & S. Speranza (1994): Analysis of the efficacy of artificial reefs located in five different areas of the Adriatic Sea. Bull. Mar. Sci., 55, 559-580.

Bombace, G., L. Castriota & A. Spagnolo (1997): Benthic communities on concrete and coal-ash blocks submerged in an artificial reef in the central Adriatic Sea. In: Proceedings of the 30th European Marine Biological Symposium, Southampton, UK, September 1995, pp. 281-290.

Clarke, K. & R. Warwick (2001): Change in marine communities: an approach to statistical analysis and interpretation, PRIMER-E Ltd: Plymouth, United Kingdom, 256 pp.

Corriero, G., R. Pronzato & M. Sarà (1991): The sponge fauna associated with *Arca noae* L (Mollusca, Bivalvia). In: Reitner J. & H. Keupp (eds): Fossil and recent sponges. Berlin, Springer, pp. 395-403.

D'Anna, G., F. Badalamenti & S. Riggio (2000): Artificial reefs in North-West Sicily: comparisons and conclusions. In: Jensen, A.C., K.J. Collins & A.P.M. Lockwood (eds.): Artificial reefs in European seas. Kluwer Academics Publishers, London, pp. 97-112.

Dobretsov, S.V. & G. Miron (2001): Larval and post-larval vertical distribution of the mussel *Mytilus edulis* in the White Sea. Mar. Ecol. Prog. Ser., 218, 179-187.

Fabi, G., L. Fiorentini & S. Giannini (1989): Experimental shellfish culture on an artificial reef in the Adriatic Sea. Bull. Mar. Sci., 44(2), 923-933.

Fabi, G., A. Spagnolo, D. Bellan-Santini, E. Charbonnel, B. Ali Çiçek, J.J. Goutayer García, A.C. Jensen, A. Kallianiotis & M. Neves dos Santos (2011): Overview on artificial reefs in Europe. Braz. J. Oceanogr., 59, 155-166.

Fortič, A., B. Mavrič, V. Pitacco & L. Lipej (2021): Temporal changes of a fouling community: Colonization patterns of the benthic epifauna in the shallow northern Adriatic Sea. Reg. Stud. Mar. Sci., 45101818.

Giovanardi, O., F. Pranovi & G. Franceschini (1998): "Rapido" trawl fishing in the northern Adriatic: preliminary observations of the effects on macrobenthic communities. Acta Adriat., 39(1), 37-52.

Gonzalez-Correa, J.M., J.T. Bayle, J.L. Sanchez-Lizasa, C. Valle, P. Sanchez-Jerez & J.M. Ruiz (2005): Recovery of deep *Posidonia oceanica* meadows degraded by trawling. J. Exp. Mar. Biol. Ecol., 320, 65-76.

Herbert, R.J.H., K. Collins, J. Mallinson, A.E. Hall, J. Pegg, K. Ross, L. Clarke & T. Clements (2017): Epibenthic and mobile species colonization of a geotextile artificial surf reef on the South coast of England. PLoS One, 12(9), 1-28.

Kersting, D.K. & J.R. García-March (2017): Long-term assessment of recruitment, early stages and population dynamics of the endangered Mediterranean fan mussel *Pinna nobilis* in the Columbretes Islands (NW Mediterranean). Mar. Environ. Res., 130, 282-292

Kersting, D.K. & I.E. Hendriks (2019): Short guidance for the construction, installation and removal of *Pinna nobilis* larval collectors. IUCN, 6 pp.

Kersting, D.K., M. Vázquez-Luis, B. Mourre, F.Z. Belkhamssa, E. Álvarez, T. Bakran-Petricioli, C. Barberá, A. Barrajón, E. Cortés, S. Deudero, J. García-March, S. Giacobbe, F. Giménez-Casalduero, L. González, S. Jiménez-Gutiérrez, S. Kipson, J. Llorente, D. Moreno, P. Prado, J. Pujol, J. Sánchez, A. Spinelli, J. Valencia, N. Vicente & I. Hendriks (2020): Recruitment disruption and the role of unaffected populations for potential recovery after the *Pinna nobilis* mass mortality event. Front. Mar. Sci., 7, 594378. doi: 10.3389/fmars.2020.594378.

Lipej, L., M. Orlando-Bonaca & B. Mavrič (2016): Biogenic formations in the Slovenian Sea. National Institute of Biology, Marine Biology Station Piran, UNEP, RAC/SPA Tunis, 206 pp.

Maggiore, F. & E. Keppel E (2006): Colonizzazione su substrato duro nell'area a barriere artificiali del campo sperimentale: un anno di studio. In: Campo sperimentale in mare: prime esperienze nel Veneto relative a elevazioni del fondale con materiale inerte. Regione Veneto, ARPAV, 109-122.

Marguš, D., E. Teskeredžić, Z. Teskeredžić & M. Tomec (1993): Reproduktivni ciklus male kapice (*Chlamys varia* L.) i monitoring ličinki češljaša (Pectinidae) u planktonu ušća rijeke Krke. Ribarstvo, 48(4), 115-124.

Mavrič, B., M. Orlando-Bonaca, N. Bettoso & L. Lipej (2010): Soft-bottom macrozoobenthos of the southern part of the Gulf of Trieste: faunistic, biocoenotic and ecological survey. Acta Adriat., 51(2), 203-216.

Minelli, A., C. Ferrà, A. Spagnolo, M. Scanu, A.N. Tassetti, C.R. Ferrari, C. Mazziotti, S., Pigozzi, Z. Jakl, T. Šarčević, M. Šimac, C. Kruschel, D. Pejdo, E. Barbone, M. De Gioia, D. Borme, E. Gordini, R. Auriemma, I. Benzon, Đ. Vuković-Stanišić, S. Orlić, V. Frančić, D. Zec, I. Orlić Kapović, M. Soldati, S. Ulazzi & G. Fabi (2021): The ADRIREEF database: a comprehensive collection of natural/artificial reefs and wrecks in the Adriatic Sea. Earth Syst. Sci. Data, 13, 1905-1923.

Moura, A., D. Boaventura, J. Cúrdia, S. Carvalho, P. Pereira, L. Cancela da Fonseca, F.M. Leitão, M.N. Santos & C.C. Montero (2004): Benthic succession on an artificial reef in the South of Portugal – preliminary results. Revista. Biol. (Lisboa), 22, 169-181.

Nicoletti, L., S. Marzialetti, D. Paganelli & G.D. Ardizzone (2007): Long-term changes in a benthic assemblage associated with artificial reefs. Hydrobiologia, 580, 233-240.

Orel, G. & R. Zamboni (2003): Proposte per un piano pluriennale di gestione della fascia costiera del golfo di Trieste, II ed., Azienda Speciale ARIES, Camera di Commercio I.A.A. di Trieste, Progetto pilota sulla gestione delle zone di pesca, Iniziativa Comunitaria PESCA L. R. 11/98, Progetto ARIES-PESCA 2000/2003 SFOP 2000-2006, 272 pp.

Padiglia, A., F.D. Ledda, B.M. Padedda, R. Pronzato & R. Manconi (2018): Long-term experimental in situ farming of *Crambe crambe* (Demospongiae: Poecilosclerida). PeerJ, 6, e4964. DOI 10.7717/peerj.4964

Parenzan, P. (1957): Conseguenze biocenotiche dei relitti sottomarini. Banchi sperimentali e pescosi artificiali. Boll. Soc. Nat. Napoli, 56, 91-96.

Parenzan, P. (1986): Vita agitata. Congedo Editore, 160 pp.

Pérès, J.M. & J. Picard (1964): Noveau manuel de bionomie bentique de la Mer Méditerranée (New manual on benthic bionomy of the Mediterranean Sea). Réc. Trav. Stat. Mar. Endoume, 31, 5-137.

Ponti, M., F. Fava, R.A. Perlini, O. Giovanardi & M. Abbiati (2015): Benthic assemblages on artificial reefs in the northwestern Adriatic Sea: does structure type and age matter? Mar. Environ. Res., 104, 10-19.

Project ADRI.BLU (2006): Activity report of the project available online in the following website: https://www.regione.fvg.it/rafvg/export/sites/default/RAFVG/economia-imprese/pesca-acquacoltura/FOGLIA24/FOGLIA5/allegati/ADRI.BLU_rid.pdf

Project EcoSea (2016): Activity report of the project available online in the following website: https://www.regione.fvg.it/rafvg/export/sites/default/RAFVG/economia-imprese/pesca-acquacoltura/FOGLIA24/FOGLIA9/allegati/04102016_503_brochure_LGG_.pdf

Relini, G. & L. Orsi Relini (1989): Artificial reefs in the Ligurian Sea (Northwestern Mediterranean Sea): aims and results. Bull. Mar. Sci., 44(2), 743-751.

Relini, G., N. Zamboni, F. Tixi & G. Torchia (1994): Patterns of sessile macrobenthos community development on an artificial reef in the Gulf of Genoa (North-western Mediterranean). Bull., Mar. Sci., 55, 745-771.

Sams, M.A. & M.J. Keough (2012): Contrasting effects of variable species recruitment on marine sessile communities. Ecology, 93(5), 1153-1163.

Solis-Weiss, V., P. Rossin, F. Aleffi, N. Bettoso, G. Orel & B. Vrišer (2001): Gulf of Trieste sensitivity areas using Benthos and GIS techniques. Proc. 5th International Conference on the Mediterranean coastal Environment Medcoast 2001, Hammamet Tunisia, 3, 1567-1578.

Solis-Weiss, V., P. Rossin, F. Aleffi, N. Bettoso & S. Fonda Umani (2004): A regional GIS for benthic diversity and environmental impact studies in the Gulf of Trieste, Italy. In: E. Vanden Berghe *et al*. (Editors). Proceedings of "The Colour of Ocean Data" Symposium, Brussels, 25-27 November, 2002. IOC Workshop Report 188 (UNESCO, Paris), pp. 245-255.

Solis-Weiss, V., I.F. Aleffi, N. Bettoso, P. Rossin & G. Orel (2007): The benthic macrofauna at the outfalls of the underwater sewage discharges in the Gulf of Trieste (northern Adriatic Sea). Annales, Ser. Hist. Nat., 17(1), 1-16.

Stachowitsch, M. & A. Fuchs (1995): Long-term changes in the benthos of the northern Adriatic Sea. Annales, Ser. Hist. Nat., 7, 7-16.

Stravisi, F. (1983): The vertical structure annual cycle of the mass field parameters in the Gulf of Trieste. Boll. Oceanol. Teor. Applic., 1(3), 239-250.

Taormina, B., A. Percheron, M.P. Marzloff, X. Caisey, N. Quillien, M. Lejart, N. Desroy, O. Dugornay, A. Tancray & A. Carlier (2020): Succession in epibenthic communities on artificial reefs associated with marine renewable energy facilities within a tide-swept environment. ICES J. Mar. Sci., 77(7-8), 2656-2668.

Toledo, M.I., P. Torres, C. Díaz, V. Zamora, J. López & G. Olivares (2020): Ecological succession of benthic organisms on niche-type artificial reefs. Ecol. Process., 9, 38.

received: 2022-11-14 DOI 10.19233/ASHN.2023.15

FIRST RECORD OF THE GOLDEN CORAL SHRIMP, *STENOPUS SPINOSUS* RISSO, 1827, IN THE GULF OF VENICE

Roland R. MELZER
Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany
Biozentrum der Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany
e-mail: melzer@snsb.de

Martin PFANNKUCHEN
Center for Marine Research, Ruđer Bošković Institute, G. Paliaga 5, 52210 Rovinj, Croatia

Sandro DUJMOVIČ
Nacionalni Park Brijuni, Brionska 10, 52212 Fažana, Croatia

Borut MAVRIČ
Marine Biology Station Piran, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia

Martin HEß
Biozentrum der Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany

ABSTRACT

We present the first record of Stenopus spinosus *Risso, 1827 for the Gulf of Venice based on several specimens we found during our inventories of Banjole Island off Rovinj and the marine protected area of the Brijuni National Park, Croatia.*

Key words: *Stenopus spinosus*, cave, crevice, upper infralittoral, Banjole, Brijuni National Park

PRIMA SEGNALAZIONE DEL GAMBERO MECCANICO, *STENOPUS SPINOSUS* RISSO, 1827, NEL GOLFO DI VENEZIA

SINTESI

Gli autori presentano il primo ritrovamento di Stenopus spinosus *Risso, 1827 per il Golfo di Venezia, basata su alcuni esemplari trovati durante gli inventari nelle acque dell'isola di Banjole al largo di Rovigno, e dell'area marina protetta del Parco Nazionale di Brioni, in Croazia.*

Parole chiave: *Stenopus spinosus*, grotta, crepaccio, infralitorale superiore, Banjole, Parco Nazionale di Brioni

INTRODUCTION

It is certainly a special pleasure to find *Stenopus spinosus* Risso, 1827, an impressive (up to 8 cm body length) and beautifully coloured Mediterranean ornamental shrimp for the first time in a sector of the Mediterranean, especially if this sector has been well-studied in the past. Correspondingly, we report here the first records of this species in the Gulf of Venice.

Antoine Risso used specimens found off Nice, France, collected from „régions coralligènes" for his description of *S. spinosus*. Later on, this species was recorded in many regions in the Mediterranean Sea including the Adriatic (first record in Karlovac (1953), near Šibenik, and later Števčić (1990), and Froglia (2010)) except for one sector, the Gulf of Venice (Northern Adriatic or sector 9 *sensu* Bianchi (2004) and Relini (2010), *i.e.* north of the line Conero (near Ancona) – Kap Kamenjak (southernmost cape of Istria).

MATERIAL AND METHODS

While scuba diving off the coast of the Brijuni archipelago at Javorika West and in the marine caves at Banjole island off Rovinj, we observed *Stenopus spinosus* in or in front of their shelters, i. e., small crevices. Using underwater macrophotography, we documented the specimens, their specific colouration, and other features, *e.g.*, basal dentation and form of cutting edge of chela fingers of third pereiopod. For identification, we used Noël (1992) and Goy (2010).

RESULTS

During our works on bioinventories of the marine protected area at Brijuni National Park, and at Banjole Isl. off Rovinj, we recorded specimens of *S. spinosus* at two localities:

1: Banjole Island, 45° 4′26.40″N, 13°36′39.71″E, depth: c. 12 m, deep end of cave; dive Ba21_10, 1 October 2021, afternoon (15:15), one specimen (underwater photo: Martin Heß; Fig. 1A); dives Ba22_1-7, 4 October 2022 - 7 October 2022, 11:00-21:00, two to five specimens of different size observed simultaneously (underwater photo: Martin Pfannkuchen; Fig. 1B). Also, we documented the species-specific shape of the right cheliped (Fig. 1B).

2: Veliki Brijuni Island, Uvala Javorika West, 44°54′6.32″N, 13°45′33.36″E, dive B22_2, 6 June 2022, short after midnight (0:10), depth: c. 3 m; crevice with *Conger conger* in mixed rock and sediment ground (underwater photo: Roland Melzer; Fig. 1C).

DISCUSSION

S. spinosus has often been observed during its nocturnal activity peak, and its common association with the Conger eel suggests that it is a facultative cleaner shrimp like, *e.g.*, *Lysmata seticaudata* (Risso, 1816), albeit other feeding techniques are probable. In addition to rocky slopes and small crevices that provide shelter during the day, it is also a characteristic inhabitant of Mediterranean caves (Goy, 2010; Bianchi *et al.*, 2022).

To decide whether *S. spinosus* had been overlooked for decades in the northernmost part of the Adriatic due to rarity and/or clandestine nocturnal activity or whether this species is currently extending its distribution range northwards is a rather intricate affair. Various expert carcinologists have studied the Western Istrian coast and the Gulf of Venice, for decades, but in none of their publications, be it original data or reviews, *S. spinosus* is listed for this area, though it is a large and well-known species (*e.g.*, Pesta, 1918; Manning & Števčić, 1982; Števčić, 1990, 1995, 2002; Müller & Schubarth, 2007; Froglia, 2010). Thus, the idea that this species has recently colonized the northernmost sector of the Mediterranean has some credibility. However, due to its hidden lifestyle during the day and exclusively nocturnal activities in open space, some authors have rated *S. spinosus* as a „fake" rare species (d'Udekem d'Acoz, 1997), since it turns out to be seen often during night dives, but not during the day. On the other hand, several authors of this paper have visited the Banjole caves since the early 1990s and did nightdives at the Brijuni Marine Protected Area since 2015, but had never seen *S. spinosus* at these localities before 2021 and 2022, respectively.

Our observations add to the list of previous new decapod records for the area (*Bathynectes longipes* (Meyer *et al.*, 2015), *Automate branchialis* (Ceseña *et al.*, 2017) and *Hippolyte prideauxiana* (Melzer *et al.*, 2019). These new records might indicate that by virtue of the northward directed surface currents along the eastern Adriatic sector (Orlić *et al.*, 1992) and increased temperature especially during winter (Raicich & Colucci, 2019), with Brijuni MPA as a putative stepping stone (Melzer *et al.*, 2016), rare species can arrive in and/or repopulate the Northern Adriatic at any time.

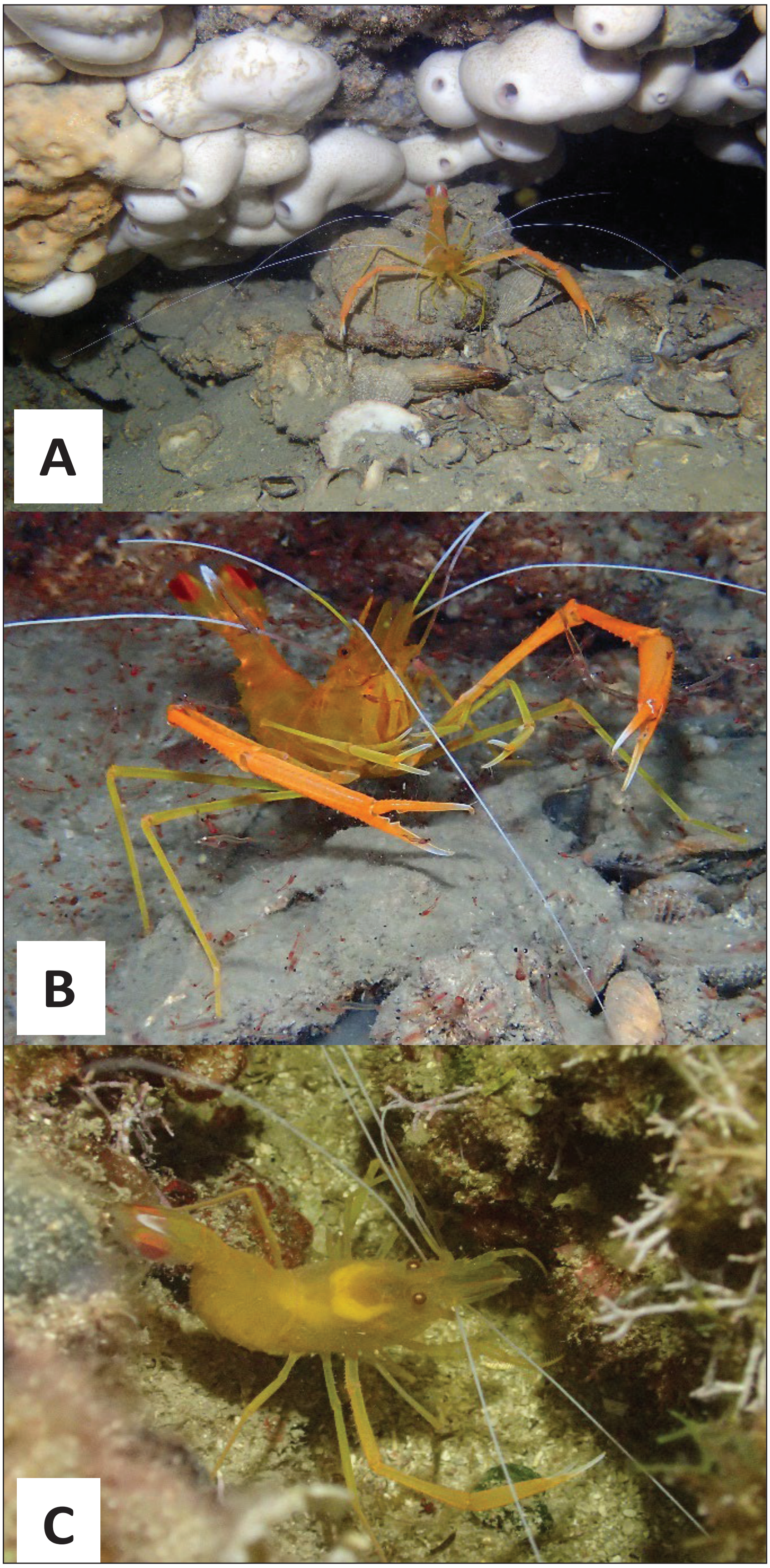

Fig. 1: *Stenopus spinosus* ***in the Gulf of Venice. A, B Banjole cave, C Uvala Javorika West. Note specific spinulation of fingers of third pereiopod (B) and length of antennae exceeding three times the body length (not fully visible here). All specimens showed the specific colour features of this species, namely the „golden" colour of the body, the specific brown, red and white marks on uropods and telson, and white antennal flagella.***

Sl. 1: *Stenopus spinosus* ***v Beneškem zalivu. A, B Jama Banjole, C Uvala zahodna Javorika. Vidna je posebna trnavost izrastkov na tretjem pereiopodu (B) in dolžina tipalke, ki je daljša od trikratne dolžine telesa (tu ni v celoti vidna). Vsi primerki kažejo značilen "zlati" barvni vzorec telesa, rdeče in bele pege na uropodih in telzonu***

ACKNOWLEDGEMENTS

Our inventories are conducted with the permission of the Croatian Ministry of Environment and Energy as well as the Croatian Ministery of the Sea, Transport and Infrastructure. This study was funded by a grant from Sea Life Center Munich given to R. R. Melzer (project "Biodiversity of the Brijuni marine protected area and adjacent sectors of the Adriatic Sea").

PRVI ZAPIS O POJAVLJANJU KORALNE KOZICE, *STENOPUS SPINOSUS* RISSO, 1827, V BENEŠKEM ZALIVU

Roland R. MELZER
Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany
Biozentrum der Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany
e-mail: melzer@snsb.de

Martin PFANNKUCHEN
Center for Marine Research, Ruđer Bošković Institute, G. Paliaga 5, 52210 Rovinj, Croatia

Sandro DUJMOVIČ
Nacionalni Park Brijuni, Brionska 10, 52212 Fažana, Croatia

Borut MAVRIČ
Marine Biology Station Piran, National Institute of Biology, Fornače 41, 6330 Piran, Slovenia

Martin HEß
Biozentrum der Ludwig-Maximilians-Universität München, Großhaderner Straße 2, 82152 Planegg-Martinsried, Germany

POVZETEK

Avtorji poročajo o prvem zapisu o pojavljanju vrste Stenopus spinosus *Risso, 1827 v Beneškem zalivu, ki temelji na več primerkih, ulovljenih v okviru inventarizacije otoka Banjole pri Rovinju in morskega zavarovanega območja Nacionalni park Brijuni (Hrvaška).*

Ključne Besede: *Stenopus spinosus*, jama, špranje, zgornji infralitoral, Banjole, Nacionalni Park Brijuni

REFERENCES

Bianchi, C.N. (2004): Proposta di suddivisione dei mari italiani in settori biogeografici. Notiziario della Società Italiana di Biologia Marina, 46, 57-59.

Bianchi, C.N., V. Gerovasileiou, C. Morri & C. Froglia (2022): Distribution and Ecology of Decapod Crustaceans in Mediterranean Marine Caves: A Review, Diversity, 14(3), 176.

Ceseña F., H. Geiselbrecht, M. Heß, S. Landmann, T. Lehmann, B. Mavrič, R.R. Melzer, R. Meyer, M. Pfannkuchen & M. Bursić (2017): First record of the snapping shrimp, *Automate branchialis* Holthuis & Gottlieb, 1958 for Croatian waters (Decapoda, Alpheidae). *Spixiana*, 40, 36.

D'Udekem D'Acoz, C. (1997): Contribution à la connaissance des crustacés décapodes helléniques II: Penaeidea, Stenopodidea, Palinuridea, Homaridea, Thalassinidea, Anomura, et note sur les stomatopodes. Bios (Macedonia, Greece), 3, 51-77.

Froglia, C. (2010): Crustacea, Malacostraca, Decapoda. Biologia Marina Mediterranea, 17(Suppl. 1), 519-534.

Goy, J.W. (2010): Infraorder Stenopodidea Claus, 1872. In: Treatise on Zoology-Anatomy, Taxonomy, Biology. The Crustacea, Volume 9 Part A, pp. 215-265. Brill.

Karlovac, O. (1953): Présence du *Stenopus spinosus* Risso dans l'Adriatique. Bil. Inst. Oceanogr. Ribar. Split, 5, 1-3.

Manning, R.B. & Z. Števčić (1982): Decapod fauna of the Piran Gulf. Quaderni del Laboratorio di Tecnologia della Pesca, 3, 285-304.

Melzer, R.R., M. Heß, T. Makovec, M.A. Staggl & B. Mavrič (2019): *Hippolyte prideauxiana* Leach, 1817: First record for the Northern Adriatic and observations on mimetic colouration. Annales, Ser. Hist. Nat., 29, 231-234.

Melzer, R.R., M. Bursic, F. Ceseña, J.S. Dömel, M. Heß, S. Landmann, M. Metz, M. Pfannkuchen, I. Reed & R. Meyer (2016): High decapod diversity revealed by minimal-invasive, short-term survey of Brijuni marine protected area. Biodiversity and Conservation, 25, 1559-1567. DOI 10.1007/s10531-016-1138-2.

Meyer, R., M. Türkay & R.R. Melzer (2015): First record of the swimming crab, *Bathynectes longipes* (Risso, 1816) (Portunidae) in the Northern Adriatic biogeographic sector. Spixiana, 38, 203-204.

Müller, C.H. & C.D. Schubart (2007): Insights into the Crustacea Decapoda of the Adriatic Sea. Observations from four sampling locations along the Croatian coast. Rostocker Meeresbiologische Beiträge, 18, 112-130.

Noël, P.Y. (1992): Clé préliminaire d'identification des Crustacea Decapoda de France et des principales autres espèces d'Europe, Collection patrimoines naturels, Secrétariat de la Faune et de la Flore, Muséum National d'Histoire Naturelle, Paris, 9, 145 pp.

Orlić, M., M. Gačić & P.E. Laviolette (1992): The currents and circulation of the Adriatic Sea. Oceanologica Acta, 15(2), 109-124.

Pesta, O. (1918): Die Decapodenfauna der Adria: Versuch einer Monographie. Verlag Franz Deuticke, Leipzig Wien.

Raicich, F. & R.R. Colucci (2019): A near-surface sea temperature time series from Trieste, northern Adriatic Sea (1899–2015). Earth Syst. Sci. Data, 11, 761-768. https://doi.org/10.5194/essd-11-761-2019.

Relini, G. (2010): Introduzione / Introduction. Biologia Marina Mediterranea 17 (Suppl. 1), V-X.

Risso, A. (1826-1827): Histoire naturelle des principales productions de l'Europe Méridionale et particulièrement de celles des environs de Nice et des Alpes Maritimes. Paris, F.G. Levrault., 3(XVI), 1-480. Available online at http://www.biodiversitylibrary.org/bibliography/58984

Števčić, Z. (1990): Check-list of the Adriatic decapod Crustacea. Acta Adriatica, 31, 183-274.

Števčić, Z. (1995): Contribution to the faunistic list of Adriatic decapod Crustacea. Natura Croatica, 4, 113-115.

Števčić, Z. (2002): New observations on the Adriatic decapod fauna (years 1990-2000). Crustaceana, 75, 643-647.

received: 2023-03-17 DOI 10.19233/ASHN.2023.16

AGE, GROWTH AND MORTALITY OF SURF CLAM *MACTRA STULTORUM* IN THE GULF OF GABES, TUNISIA

Abdelkarim DERBALI
National Institute of Marine Sciences and Technologies of the Sea (INSTM). BP 1035 Sfax 3018, Tunisia
e-mail: derbali10@gmail.com; abdelkarim.derbali@instm.rnrt.tn

Nour BEN MOHAMED
National Institute of Marine Sciences and Technologies of the Sea (INSTM). BP 1035 Sfax 3018, Tunisia

Ines HAOUAS-GHARSALLAH
National Institute of Marine Sciences and Technologies of the Sea (INSTM), La Goulette 2060, Tunisia

ABSTRACT

The population dynamics of surf clam Mactra stultorum *from the Gulf of Gabes was investigated monthly for the first time during a one-year period (2017), including population age, growth, and mortality rate. The allometric relationships between body sizes and length were determined; the shell length/total weight indicated a negative allometric growth relationship that is expressed as TW = 0.002 $SL^{2.314}$. The length frequency data were analyzed for estimation of population parameters. The asymptotic length (L_∞) was found to be 46.80 mm, the growth co-efficient (K) 0.71 yr^{-1}. The longevity (T_{max}) and the growth performance indices (φ′) were 5.42 yr^{-1} and 3.19, respectively. Total mortality (Z) and natural mortality (M) were estimated by length-converted catch curve at 0.63 yr^{-1}. The findings of the current study suggest that the most intensive growth occurred during the first two years. The data presented herein are essential for an appropriate fisheries management and conservation of surf clams.*

Key words: *Mactra stultorum*, population dynamic, growth, mortality rate, age, south Tunisia

ETÀ, CRESCITA E MORTALITÀ DI *MACTRA STULTORUM* NEL GOLFO DI GABES, TUNISIA

SINTESI

La dinamica di popolazione della madia bianca Mactra stultorum *del Golfo di Gabes è stata studiata mensilmente per la prima volta durante un periodo di un anno (2017), includendo l'età della popolazione, la crescita e il tasso di mortalità. Sono state determinate le relazioni allometriche tra le dimensioni corporee e la lunghezza; il rapporto lunghezza della conchiglia/peso totale ha indicato una relazione di crescita allometrica negativa, espressa come TW = 0,002 $SL^{2,314}$. I dati sulla frequenza delle lunghezze sono stati analizzati per stimare i parametri della popolazione. La lunghezza asintotica (L∞) è risultata essere di 46,80 mm, il coefficiente di crescita (K) di 0,71 annui. La longevità (Tmax) e gli indici di performance di crescita (φ′) sono risultati rispettivamente 5,42 e 3,19 anni. La mortalità totale (Z) e la mortalità naturale (M) sono state stimate dalla curva di cattura convertita in base alla lunghezza a 0,63 per anno. I risultati dello studio suggeriscono che la crescita più intensa si verifica durante i primi due anni. I dati qui presentati sono essenziali per un'appropriata gestione della pesca e per la conservazione della specie.*

Parole chiave: *Mactra stultorum*, dinamica di popolazione, crescita, tasso di mortalità, età, Tunisia meridionale

INTRODUCTION

The surf clam *Mactra stultorum* (Linnaeus, 1758) is a dominant species of the sandy beach macrofauna in the lower infra-littoral zone. It is widely distributed from Norway in the north of Europe to Senegal in West Africa, as well as in the Mediterranean and Black Seas (Conroy *et al*., 1993). *M. stultorum* is also extensively utilized as seafood and raw material for animal feed production at various aquaculture farms (Hou *et al*., 2006). Although an important commercial bivalve in many countries, this clam is still unexploited in Tunisia and has yet to be commercialized for the Mediterranean market.

Even with the socio-economic and ecological importance of invertebrate fisheries increasing, the scientific knowledge of the biology of commercial species is frequently insufficient (Anderson *et al*., 2011). In addition, invertebrate fisheries often operate without regulation, monitoring, and assessment (FAO, 2009). In Tunisia, commercial bivalve fisheries constitute a cultural, social and economic resource for numerous coastal communities. Therefore, further research on the cultivation of commercial species is required before adequate management measures promoting a sustainable exploitation of shellfish resources can be implemented.

In Tunisia, the surf clam *M. stultorum* is particularly abundant in the southern coast; however, the Tunisian clam fisheries seem to focus exclusively on the clam *Ruditapes decussatus* (Linnaeus, 1758) and regard *M. stultorum* as a discard, while in many countries this and other similar species are considered target species and are economically important in terms of employment and exportation. New initiatives in the shellfish fisheries sector include diversification into other exploitable species. Therefore, new projects dealing with the biology of potential shellfish species have been conducted in most production areas. One such species is also the surf clam *M. stultorum*.

The surf clam *M. stultorum* has often attracted considerable research attention because of its economic potential. Previous studies on *M. stultorum* in Tunisia has primarily focused on various aspects of the clam found in the north, including its occurrence (Zamouri *et al*., 2001; Charef *et al*., 2011), biology and biochemistry (Chetoui *et al*., 2018, 2019), and genetics (Chetoui *et al*., 2012; Chetoui, 2016). However, no data are currently available on the growth and age parameters of the *M. stultorum* from the south of Tunisia. The existing knowledge on this species is limited to the contribution of Derbali *et al*. (2021), which focuses on the species' stocks.

Given the frequent occurrence of *M. stultorum* in this region, it is essential to gather appropriate information about its growth to manage its exploitation more efficiently and propose regulatory measures to the fisheries authorities (*e.g*., establishing closed seasons for fishing). Understanding the species' population dynamics is crucial to determining its present status in the southern coastal areas. Therefore, the overall goal of the present study is to provide new data on several population parameters of *M. stultorum* in the coastal zone of the Gulf of Gabes, such as estimates of the species' age, growth, mortality, and performance index. With such data on the surf clam species it might be possible to commercially exploit it and generate economic activity in southern Tunisian waters.

MATERIAL AND METHODS

Sampling and laboratory procedure

Monthly samples of the surf clam *M. stultorum* (≈ 90 specimens) were collected from the primary shellfish production area of Sfax, southern Tunisia (Fig. 1), from January to December 2017. During each collection, seawater temperature and salinity were recorded. Initially, the *M. stultorum* individuals were measured for shell length (SL, mm) and shell height (SH, mm) using a digital caliper (with a precision of 0.01 mm), and weighed for total weight (TW, g) on a top-loading digital balance (with a precision of 0.001 g).

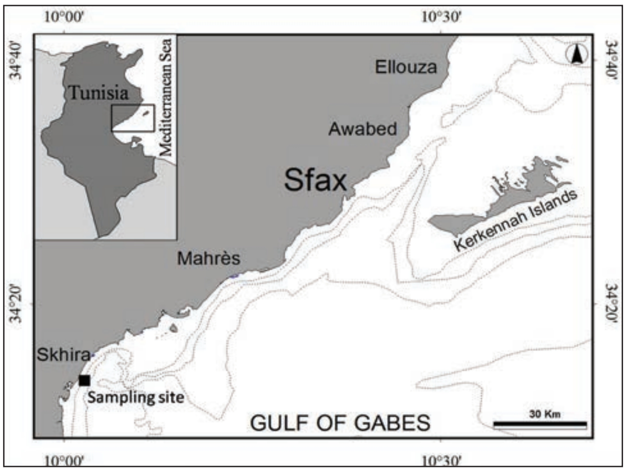

Fig. 1: Map of the study area indicating the sampling location in the south of Tunisia.
Sl. 1: Zemljevid obravnavanega območja z vzorčevalno lokaliteto v južni Tuniziji.

Data analysis

Relative growth

The relationship between total weight (TW, g) and anterior-posterior shell length (SL, mm) was described by the following allometric equation: logTW = log a + b log SL, where log a and b are intercept (initial growth coefficient) and slope (relative growth rate of variables) of the linear regression line, respectively. The deviation of the b value of the regression function from the isometric hypothetical value (b = 3) was analyzed by means of a Student's t-test. Significant deviation indicated a negative (b < 3) or positive (b > 3) allometric relationship.

Tab. 1: Allometric relationships between body sizes and shell length of the* Mactra stultorum *collected from the littoral zone of Sfax (south Tunisia) (NS = not significant, S = significant for p < 0.05).
Tab. 1: Alometrična razmerja med telesnimi velikostmi in dolžino lupine pri vrsti* Mactra stultorum, *nabranih v obrežnem pasu v Sfaxu (južna Tunizija) ((NS = ni statistično značilno, S = statistično značilno na nivoju p < 0,05).

Allometric relation	a	b	Determination coefficient (R^2)	Significance	Relationship (t-test)
SH/SL	0.895	0.970	0.970	S	negative allometry
SW/SL	0.468	1.011	0.944	NS	isometric
TW/SL	0.002	2.314	0.953	S	negative allometry

Age and absolute growth

The age growth parameters were determined using FiSAT II software (Gayanilo *et al.*, 2005). The asymptotic shell length (L∞, mm) and the growth coefficient (K, yr^{-1}) of the von Bertalanffy Growth Function (VBGF) were estimated from these data by means of ELEFAN-I (Electronic Length Frequency Analysis; Pauly & David, 1981). The VBGF is defined by the equation:

$$L_t = L_\infty [1 - e^{-K(t-t_0)}]$$

where L_t = means length at age t, L_∞ = asymptotic shell length, K = growth coefficient, t = age, and t_0, the hypothetical age at which the length is zero (Pauly & David, 1981), here $t_0 = 0$.

L∞ and K were used to calculate the growth performance index Φ′ (Pauly & Munro 1984) using the equation:

$$\Phi' = \log(K) + 2\log(L_\infty)$$

Growth performance is a relevant parameter that is closely related to population dynamics of benthic macro-invertebrates (Brey, 1999). This index makes it possible to compare the growth of populations and species allowing for species-specific features to be identified. In this study, growth performance index (ϕ′) was used to compare the growth parameters obtained in this work with data from the literature on surf clam populations. The theoretical maximum age (T_{max}) was calculated for each population by solving for t in the von Bertalanffy equation, then setting $SL_t = L_\infty$ and using the equation constructed by Michaelson & Neves (1995):

$$T_{max} = \frac{h\ L_\infty + K_o}{K}$$

Mortality rate

Mortality is an important aspect of the population dynamics of bivalve species. The total mortality (Z, yr^{-1}) was estimated from the slope of the right descending arm of a length-converted catch curve according to the method by Pauly (1990) using FiSAT II, which calculates Z $year^{-1}$ as well as the 95% confidence intervals surrounding the Z based on the goodness of fit of the regression. The natural mortality rate (M, yr^{-1}) was estimated using the empirical relationship developed by Pauly (1980):

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$

where T = mean annual temperature (°C). Once the Z and M were obtained, the fishing mortality (F, yr^{-1}) was estimated using the relationship: F = Z – M. The exploitation rate (E), which represents the portion of total mortality due to fisheries, was obtained with the formula proposed by Gulland (1971):

$$E = F/Z = F/(M+F)$$

RESULTS

Relative growth

The biometric data of the surf clam *M. stultorum* from the littoral zone of Sfax (Tab. 1) showed a strong significant correlation between shell length (SL, mm)/total weight (TW,

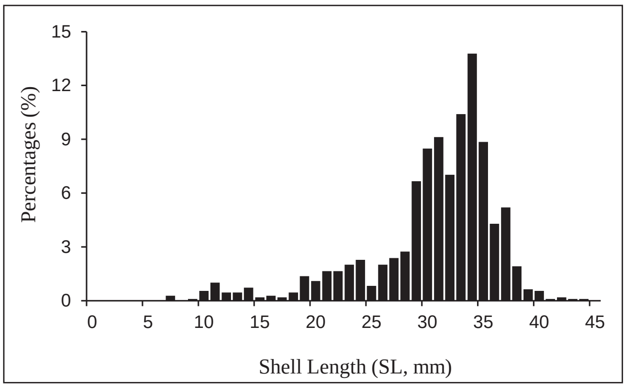

Fig. 2: Shell length frequency distributions of* Mactra stultorum *in the south of Tunisia.
Sl. 2: Velikostna porazdelitev lupin školjke* Mactra stultorum *na jugu Tunizije.

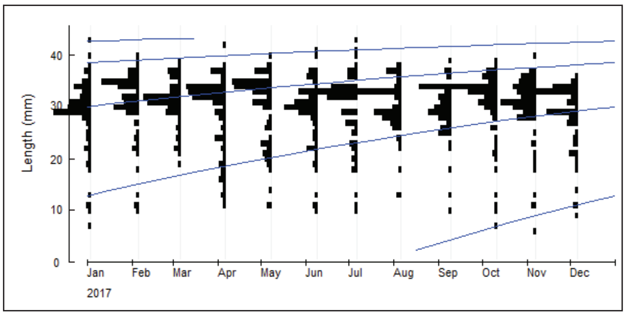

Fig. 3: Length frequency plot of** Mactra stultorum **with superimposed growth curves estimated by ELEFAN 1 (L∞ = 46.80 mm, K= 0.71 yr^{-1}).
Sl. 3: Velikostna porazdelitev vrste** Mactra stultorum **s superponiranimi krivuljami rasti, ocenjenimi z ELEFAN 1 (L∞ = 46,80 mm, K= 0,71 leto^{-1}).

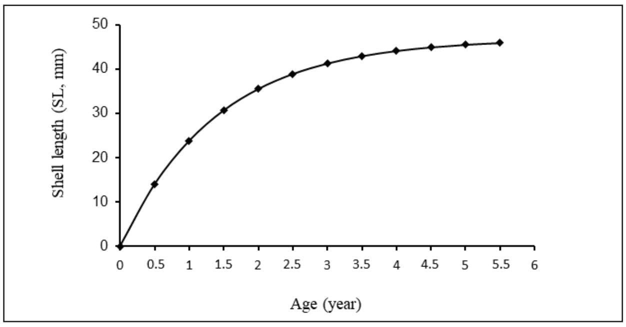

Fig. 4: The von Bertalanffy growth curves in terms of size at determinate age for** Mactra stultorum **based on growth parameters estimated by ELEFAN-I.
Sl. 4: Von Bertalanffyijeve rastne krivulje glede na velikost pri določeni starosti primerkov vrste** Mactra stultorum **na podlagi rastnih parametrov, ocenjenih z ELEFAN-I.

g) and shell length (SL, mm)/shell height (SH, mm) (R^2 > 0.95; p < 0.001) indicating negative allometric growth patterns; however, an isometric pattern was also recorded in the relation: shell length/shell width (SW, mm) (p > 0.05).

Population structure

During the study period, a total of 1096 individuals of *M. stultorum* were studied, with a size range from 6.82 to 43.60 mm. A peak was observed in the population corresponding to individuals with a shell length of 34 mm. The majority of the clam population (73.81%) belonged to the size classes between 29 and 37 mm (Fig. 2). Conversely, the smallest (6.82–28 mm) and the largest (38–43.60 mm) size classes were less represented, accounting for only 22.63% and 3.56% of the total sample, respectively.

Absolute growth and age

Based on the von Bertalanffy Growth Function (VBGF) estimated by ELEFAN-I, the asymptotic length (L_∞) and growth coefficient (K) stood at 46.80 mm and 0.71 yr^{-1} for the surf clam population collected from the littoral zone of Sfax in southern Tunisia. The length frequency distribution and the superimposed growth curves for *M. stultorum* are shown in Figure 3. The growth performance index (Φ′) and the theoretical maximum age (T_{max}) were 3.19 and 5.42 yr^{-1}, respectively. The *M. stultorum* population attained sizes of 23, 35, 41, 44, and 45 mm at the end of 1st, 2nd, 3rd, 4th and 5th years of age (Fig. 4).

Mortality rate

The length-converted catch curve analysis using L_∞ = 46.80 mm and K= 0.71 yr^{-1} showed a low rate mortality (Z = 0.63 yr^{-1}). The darkened circles shown in Figure 5 represent the points used in calculating Z via linear regression analysis. The estimated value of natural mortality (M) as per Pauly's empirical formula was 0.63 yr^{-1}, and the fishing mortality was estimated to be zero.

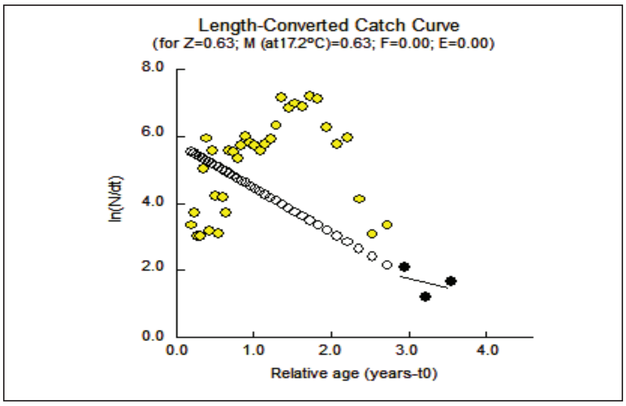

Fig. 5: Length-converted catch curve of** Mactra stultorum **in the south of Tunisia.
Sl. 5: Krivulja ulova za vrsto** Mactra stultorum **na jugu Tunizije, pretvorjena po dolžini.

During the sampling period, the salinity remained almost stable throughout the year (29–45.5). The temperature of the seawater ranged between 12.2°C (winter) and 25.6°C (summer).

DISCUSSION

The present study provides, for the first time, data about the population structure, growth, age, and mortality of the surf clam *M. stultorum* from the south of Tunisia. These findings can serve as a baseline for sustainable stock management prior to exploitation. The population parameters are useful bases for evaluating the status of exploited resources as they provide valuable information on how exploitation affects the population (Pauly, 1984).

The von Bertalanffy growth model has been found to be a good description of bivalve growth (Vakily, 1992), and this is confirmed in the present study of *M. stultorum* from the Gulf of Gabes. The strong correlation between the shell length and total weight observed in the studied surf clam population is similar to that reported for other bivalves (Derbali *et al.*, 2020, 2022; Gaspar *et al.*, 2001).

The biometric characteristics of the shell form showed a negative allometric relationship between shell length and total weight and between shell length and shell height, indicating that the shell was elongated in shape. Similar events were observed for some bivalve species in Algeria (Bensaad-Bendjedid, 2017), Egypt (Mohammad *et al.*, 2014), and Italy (Costa *et al.*, 2008). The authors suggested that this form was the result of an improved burrowing efficiency, which reduced the surf clam's risk of dislodgement by hydrodynamics and predation. In general, variations in the allometry of bivalves have been associated with latitude, species, physiological traits, and local environmental conditions (Caill-Milly *et al.*, 2012; Bensaad-Bendjedid *et al.*, 2017; Derbali, 2011; Derbali *et al.*, 2020, 2022). An isometric relationship was observed between shell length (SL) and shell width (SW), indicating a proportional growth of size and width. The same sequence of events has been reported for *Mactra stultorum* and *Donax semistriatus* from other investigated area in the southern part of Tunisia (Derbali *et al.*, 2018).

The VBGF parameters L_∞ and K obtained from the length-frequency distribution data were 46.80 mm and 0.71 y^{-1}, respectively. The negative correlation between the asymptotic shell length (L_∞) and growth coefficient (K) invalidated a comparison based on individual parameters (Pauly & Munro, 1984). As a result, the comparison of the growth performance of bivalve populations was better fitted by the growth index phi prime (Φ′). This criterion was used to characterize not only similar species (Pauly & Munro, 1984), but also related ones, as was the case of scallops (Del Norte, 1988). When our results were compared with those recorded for *M. stultorum* in previous studies from other Mediterranean regions, the asymptotic shell length (L_∞ = 46.80), for example, appeared lower than that from the eastern Catalan coast (64.76 mm), the value of the growth performance index (Φ′) was higher (3.19) than that from the Catalan coast (3.51) (Solis *et al.*, 2021) – most likely a result of favorable environmental conditions (mainly temperature and food availability) in the Gulf of Gabes – but consistent with those obtained for the clam *Ruditapes decussatus* from the eastern Adriatic Sea (Jurić, 2012) and the cockle *Cerastoderma glaucum* in the south of Tunisia (Derbali *et al.*, 2022), while the theoretical maximum age (T_{max} = 5.42 yr^{-1}) was much higher than that reported for the same species (4 yr^{-1}) along the Catalan coast (Solis *et al.*, 2021). In addition, the specific growth rate of the *M. stultorum* population in the present study was fast in the organisms' first year of life but became progressively slower with their age. All these differences can be explained by the different methods used to determine age, as well as different survival strategies, and ecological factors present at different latitudes.

The low mortality rate (Z = 0.63 y^{-1}) found in the present study can be only attributed to natural causes, such as predation, pathogens, or other environmental factors, as there is currently no fishing activity for the surf clam *M. stultorum* in the study area. However, research by Park & Zhang (2008) suggests that mortality rates in *Mactra chinensis*, especially in natural beds, may be influenced by a complex interaction of biotic and abiotic factors. In fact, the relatively low natural mortality for *M. stultorum* in the south of Tunisia could be attributed to habitat degradation resulting from runoff and pollution from drainage water. Robinson & Richardson (1998) discovered that the small-sized individuals of *Ensis magnus* (Schumacher, 1817) (= *Ensis arcuatus*) that were returned to the seabed were slow to re-bury and became highly vulnerable to predation by crabs.

The population dynamics of bivalves is also influenced by abiotic factors such as salinity, temperature, immersion time, water velocity, and sediment dynamics (Derbali *et al.* 2020, 2022). Salinity may be the main factor affecting macrobenthos abundance. Solis *et al.* (2021) reported that food availability can affect growth and aspects of population dynamics such as production, reproduction, recruitment, and mortality. Seawater temperature and salinity may be the primary factors governing *R. decussatus* densities in the intertidal area (Derbali *et al.*, 2021). The same authors also indicated that densities varied substantially according to strata. It appears that clam populations can be influenced by various strong impacts (e.g., physicochemical, edaphic, and hydrological factors). Previous surveys highlighted the role of seawater temperature and food potential as important factors contributing to phenotypic differences in growth patterns and maximum sizes in a variety of marine organisms.

In conclusion, the present work provides valuable insights into the population dynamics of the surf clam *M. stultorum* in Tunisia, which can be used as a baseline for sustainable and profitable exploitation in the future. It is essential to adopt and implement rules that limit the size of surf clams or catch levels in order to regulate surf clam ranching and thus ensure the protection of this new exploitable fishery resource.

ACKNOWLEDGEMENTS

The authors are grateful to the technical staff for their assistance in sample collection. Special thanks to the anonymous reviewers for their suggestions and constructive comments.

STAROST, RAST IN SMRTNOST KORITNICE *MACTRA STULTORUM* V GABEŠKEM ZALIVU (TUNIZIJA)

Abdelkarim DERBALI
National Institute of Marine Sciences and Technologies of the Sea (INSTM). BP 1035 Sfax 3018, Tunisia
e-mail: derbali10@gmail.com; abdelkarim.derbali@instm.rnrt.tn

Nour BEN MOHAMED
National Institute of Marine Sciences and Technologies of the Sea (INSTM). BP 1035 Sfax 3018, Tunisia

Ines HAOUAS-GHARSALLAH
National Institute of Marine Sciences and Technologies of the Sea (INSTM), La Goulette 2060, Tunisia

POVZETEK

Avtorji poročajo o prvi raziskavi populacijske dinamike koritnice vrste Mactra stultorum *v Gabeškem zalivu, v kateri so v mesečnih presledkih v enoletnem obdobju (2017) raziskovali še starost, rast in delež smrtnosti. Določili so alometrični odnos med telesnimi dimenzijami in dolžino. Odnos med dolžino lupine in celokupno težo je pokazal negativno alometrično rast, ki je izražena z enačbo $TW = 0.002\ SL^{2.314}$. Analizirali so tudi podatke velikostne porazdelitve za oceno populacijskih parametrov. Asimptotična dolžina (L_∞) je bila 46,80 mm, rastni koeficient (K) pa 0,71 na leto. Dolgoživost (T_{max}) je bila 5,42 na leto, rastni indeksi (φ') pa 3,19. Celokupno smrtnost (Z) in naravno smrtnost (M) so ocenili iz krivulje ulova, pretvorjene iz dolžine in je bila 0,63 na leto. Izsledki pričujoče raziskave kažejo, da je najbolj intenzivna rast značilna za prvi dve leti. Predstavljeni podatki so ključni za pripravo primernega ribiškega menedžmenta in ohranjanje koritnice.*

Ključne besede: *Mactra stultorum*, populacijska dinamika, rast, smrtnost, starost, južna Tunizija

REFERENCES

Anderson, S.C., J. Mills Flemming, R. Watson & H.K. Lotze (2011): Rapid global expansion of invertebrate fisheries: trends, drivers, and ecosystem effects. PLoS ONE, 6, e14735.

Bensaad-Bendjedid, L., S. Belhaouas, A. Kerdoussi, N. Djebbari, M. Tahri & M. Bensouillah (2017): Age, growth, mortality and condition index of an unexploited *Ruditapes decussatus* population from El Mellah lagoon Algeria. Int. J. Biol. Sci., 11(1), 436-442. DOI: 10.12692/ijb/11.1.436-442.

Brey T. (1999): Growth performance and mortality in aquatic macrobenthic invertebrates. Adv. Mar. Biol., 35, 153-223.

Caill-Milly, N., B. Bru, K. Mahé, C. Borie & F. D'Amico (2012): Shell Shape Analysis and Spatial Allometry Patterns of Manila Clam (*Ruditapes philippinarum*) in a Mesotidal Coastal Lagoon. J. Mar. Sciences, 2012, 1-11. https://doi.org/10.1155/2012/281206.

Charef, A., N. Zamouri Langar & I. Houas Gharsallah (2011): Stock size assessment and spatial distribution of bivalve species in the Gulf of Tunis. J. Mar. Biol. Ass. U.K., 92, 179-186.

Chetoui, I. (2016): Variabilité morphologique, biochimique et diversité génétique des populations *de Mactra corallina* (Bivalve, Mactridae) des cotes tunisiennes : implication dans la valorisation et la conservation de l'espèce. Ph.D. Thesis, University Tunis El Manar, Tunisia, 279 pp.

Chetoui, I., M. El Cafsi & M. Boussaid (2012): Allozymic and morphological variation in three populations of surf clam *Mactra coralline* (Bivalvia: mactridae) from Tunisian sandy beaches. Cah. Biol. Mar., 53, 409-417.

Chetoui, I., K. Telahigue, S. Bejaoui, I. Rabeh, F. Ghribi, F. Denis & M. El Cafsi (2018): Annual reproductive cycle and condition index of *Mactra corallina* (Mollusca: Bivalvia) from the north coast of Tunisia. Invertebr. Reprod. Dev., 63(1), 40-50.

Chetoui, I., I. Rabeh, S. Bejaoui, K. Telahigue, F. Ghribi & M. El Cafsi (2019): Seasonal first investigation in the fatty acid composition in three organs of the Tunisian bivalve *Mactra stultorum*. Grasas y Aceites, 70(1), https://doi.org/10.3989/gya.0571181.

Conroy, A.M., P.J. Smith, K.P. Michael & D.R. Stotter (1993): Identification and recruitment patterns of juvenile surf clams, *Mactra discors* and *M. murchisoni* from central New Zealand. N. Z. J. Mar. Freshw. Res., 27, 279-285.

Costa, C., J. Aguzzi, P. Menesatti, F. Antonucci, V. Rimatori & M. Mattoccia (2008): Shape analysis of different populations of clams in relation to their geographical structure. J. Zool., 276, 71-80.

Del Norte, A.G.C. (1988): Aspects of the growth, recruitment, mortality and reproduction of the Asian Moon Scallop, *Amusium pleuronectes* (Linné) in the Lingayen Gulf, Philippines. Ophelia, 29, 153-168.

Derbali, A. (2011): Biology, abundance and cartography of two bivalves species: the pearl-oyster *Pinctada radiata* and the cockle *Cerastoderma glaucum* in the Gulf of Gabes. Ph.D. Thesis, University of Sfax, Tunisia, 169 pp.

Derbali, A., A. Hadj Taieb, W. Kammoun, O. Jarboui & M. Ghorbel (2018): Shell morphometric relationships of the most common bivalve species (Mollusca: Bivalvia) in southern Tunisian waters. Cah. Biol. Mar., 59, 481-487. https://doi.org/10.21411/CBM.A.6C9B5600.

Derbali, A., A. Hadj Taieb & O. Jarboui (2021): Stock Size Assessment, Distribution and Biology of the Surf Clam *Mactra stultorum* (Mollusca: Bivalvia) Along the Sfax Coasts (Tunisia, Mediterranean Sea). Thalassas, 37, 781-789.

Derbali, A., E.K. Kandeel, A. Hadj Taieb & O. Jarboui (2022): Population dynamics of the cockle *Cerastoderma glaucum* (Mollusca: Bivalvia) in the Gulf of Gabes (Tunisia). Annales, Ser. Hist. Nat., 32(2), 431-442. https://doi.org/10.19233/ASHN.2022.43.

Derbali, A., E.K. Kandeel, & O. Jarboui (2020): Comparison of the dynamics between intertidal and offshore populations of *Pinctada radiata* (Mollusca: Bivalvia) from the Gulf of Gabes, Tunisia. Turkish J. Fish. Aquat. Sci., 20, 301-310. https://doi.org/10.4194/1303-2712-v20_4_06.

F.A.O. (Food and Agriculture Organization) (2009): The State of Food and Agriculture. Technical report. Rome: FAO Fisheries Department, 166 pp.

Gaspar M.B., M.N. Santos & P. Vasconcelos (2001): Weight-length relationships of 25 bivalve species (Mollusca: Bivalvia) from the Algarve coast (southern Portugal). J. Mar. Biol. Ass. U.K., 81, 805-807.

Gayanilo, F.C.Jr, P. Sparre & D. Pauly (2005): FAO-ICLARM stock assessment tools II (FiSAT)-revised version, User's guide, FAO, Rome.

Gulland, J.A. (1971): Fish Resources of the Ocean. Fishing New Books, London. 255 pp.

Hou L., H. Lu, X. Zou, X. Bi, D. Yan & C. He (2006): Genetic characterizations of *Mactra veneriformis* (Bivalve) along the Chinese coast using ISSR-PCR markers. Aquaculture, 26, 865-871.

Jurić, V., I. Bušelić, D. Ezgeta-Balić, N. Vrgoč & M. Melita Peharda (2012): Age, Growth and Condition Index of *Venerupis decussata* (Linnaeus, 1758) in the Eastern Adriatic Sea. Turkish J. Fish. Aquat. Sci., 12, 613-618. https://doi.org/10.4194/1303-2712-v12_3_08.

Michaelson, D.L. & R.J. Neves (1995): Life history and habitat of the endangered dwarf wedgemussel *Alasmidonta heterodon* (Bivalvia: Unionidae. J. North American Benthological Soc., 14, 324-340.

Mohammad, S.H., A.A.M. Belal & S.S.Z. Hassan (2014): Growth, age and reproduction of commercially clams *Venerupis aurea* and *Ruditapes decussatus* in Timsah Lake, Suez Canal, Egypt. Indian J. Mar. Sci., 43(4), 589-600.

Park, H.W. & C.I. Chang Ik Zhang (2008): A Population ecological study of the hen clam (*Mactra chinensis*) in the Dong-li self-regulatory community of Busan. J. Kor. Soc. Fish. Tech., 44(2), 129-140. https://doi.org/10.3796/KSFT.2008.44.2.129.

Pauly, D. (1980): On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer, 39, 175-192.

Pauly, D. (1984): Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies and Reviews, 8, 325 pp.

Pauly, D. (1990): Length-converted catch curves and the seasonal growth of fishes. ICLARM Fishbyte, 8, 33-38.

Pauly, D. & N. David (1981): ELEFAN-1, a BASIC program for the objective extraction of growth parameters from length frequency data. Meeresforsch, 28, 205-211.

Pauly, D. & J.L. Munro (1984): Once more on the comparison of growth in fish and invertebrate. Fishbyte, 2, 21 pp.

Robinson, R.F. & C.A. Richardson (1998): The direct and indirect effects of suction dredging on a razor clam (*Ensis arcuatus*) population. ICES J. Mar. Sc., 55, 970-977.

Solis, M.A., M. Baeta & M. Ballesteros (2021): Population structure, growth and recruitment of the clam *Mactra stultorum* (Bivalvia: Mactridae) from a high energy, temperate beach in the Ebro Delta – NW Mediterranean Sea. Poster, https://doi.org/10.13140/RG.2.2.34433.58727

Valiky, J.M. (1990): Determination and comparison of growth in bivalves, with emphasis on the tropics and Thailand. Ph.D., Christian-Albrechts-Universitat, Kiel, Germany.

Zamouri, N., L. Chouba & A. Abed (2001): Benthic macrofauna in the three ports of Tunis, impacts of pollution. In: Ozhan E (eds.), Proceedings of the Fifth International Conference on the Mediterranean Coastal Environment Med Coast01, 23-27 October 2001. Hammamet (Tunisia), pp 641-650.

received: 2023-01-06 DOI 10.19233/ASHN.2023.17

MAPPING STRANDED WHALES IN TURKISH MARINE WATERS

Cemal TURAN
Iskenderun Technical University, Marine Sciences and Technology Faculty Marine Science Department, Molecular Ecology and Fisheries Laboratory 31200 Iskenderun, Turkey
Nature and Science Society, Modernevler Mah. 303. Sk. No:9 D:1, Iskenderun, Turkey
e-mail: cemal.turan@iste.edu.tr

Servet Ahmet DOĞDU
Nature and Science Society, Modernevler Mah. 303. Sk. No:9 D:1, Iskenderun, Turkey
Iskenderun Technical University, Maritime Vocational School of Higher Education, Underwater Technologies, Iskenderun, Hatay, Turkey

İrfan UYSAL
[4]The General Directorate of Nature Conservation & National Parks, Republic of Turkey the Ministry of Agriculture and Forestry, 06560 Ankara, Turkey

ABSTRACT

The distribution of whales in the Mediterranean is primarily known through stranding records. The present study maps the stranding records of whales in Turkish marine waters to highlight the number of whale species that strand and to determine the general distribution pattern of such strandings in Turkey. This is an important step in generating conservation measures. The primary data were obtained from the published literature, grey literature, and fieldwork. A total of 29 stranding records of whale species were found between 1964 and 2023, which were varied along coasts and mainly located in Iskenderun Bay in the Mediterranean and Muğla Bay in the Aegean coasts of Turkey. A total of five species and one genus were documented: the Cuvier's beaked whale Ziphius cavirostris*, the fin whale* Balaenoptera physalus*, the sperm whale* Physeter macrocephalus*, the minke whale* Balaenoptera acutorostrata*, and True's beaked whale* Mesoplodon mirus *and* Mesoplodon *sp*.

Key words: whale species, Cetacea, strandings, distributional mapping, Mediterranean, Turkey

MAPPATURA DELLE BALENE ARENATE IN ACQUE TURCHE

SINTESI

La distribuzione delle balene nel Mediterraneo è conosciuta principalmente attraverso i dati degli arenamenti. Il presente studio mappa i ritrovamenti di balene spiaggiate nelle acque marine turche per evidenziare il numero di specie arenate e per determinare il modello generale di distribuzione di tali spiaggiamenti in Turchia. Si tratta di un passo importante per la definizione di misure di conservazione. I dati primari sono stati ottenuti dalla letteratura pubblicata, dalla letteratura grigia e dal lavoro sul campo. Per il periodo tra il 1964 e il 2023 sono state trovate 29 segnalazioni di arenamento di specie di balene, diverse lungo le coste e localizzate principalmente nella baia di Iskenderun nel Mediterraneo e nella baia di Muğla lungo le coste egee della Turchia. In totale sono state documentate cinque specie e un genere: lo zifio Ziphius cavirostris*, la balenottera comune* Balaenoptera physalus*, il capodoglio* Physeter macrocephalus, *la balenottera rostrata* Balaenoptera acutorostrata *e i mesoplodonti di True* Mesoplodon mirus e Mesoplodon *sp*.

Parole chiave: specie di balene, Cetacea, arenamenti, mappatura della distribuzione, Mediterraneo, Turchia

INTRODUCTION

Turkey has a coastline of more than 7,200 km, comprising the Mediterranean, Aegean, and Black Seas (Genç *et al.,* 2021). Ten whale species (Cetacea) are known to occur in Turkish marine waters, and they have all been protected since 1983 (Öztürk *et al.,* 2011). However, only a few efforts have been made to understand the whale fauna in the country's coastal waters. Strandings can be good indicators of the whale fauna of an area, although they may not represent the true composition of local populations. Nevertheless, as there are few sighting efforts and relatively rare species occurring, information obtained from strandings should not be ignored.

The whale species in Turkish marine waters are primarily known through stranding records, which have so far documented five whale species and one genus. The life history of Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823), for example, is poorly known (Heyning & Mead, 2009). This cosmopolitan, deep-diving pelagic cetacean inhabits nearshore waters of all oceans (Reeves *et al.,* 2002). *Z. cavirostris* has the largest distribution range of all beaked whale species (Heyning *et al.,* 2002). They are sucker feeders, often feeding on deep-sea cephalopods, and occasionally on fish and crustaceans (MacLeod *et al.,* 2003).

The fin whale, *Balaenoptera physalus* (Linnaeus, 1758), is a cosmopolitan species that primarily inhabits oceanic waters in both hemispheres and, less commonly, tropical waters. It only occasionally surfaces along coasts when the water is deep enough (Jefferson *et al*,. 2011). This is the only mysticete with a stable population in the Mediterranean Sea, which differs genetically from Atlantic populations (Giménez *et al.,* 2013). Fin whales are regularly observed throughout the western and central Mediterranean Sea, but are rarely seen in the Adriatic Sea and eastern parts of the Mediterranean Sea (Tonay *et al.,* 2020).

The sperm whale *Physeter macrocephalus* Linnaeus, 1758, has a wide geographic range (Rice 1989), encompassing almost all marine regions from the equator to high latitudes but displaying a preference for the continental slope and deeper water. Its range extends to many enclosed or partially enclosed seas, such as the Mediterranean Sea, the

Fig. 1: Fieldwork on protecting stranding *Balaenoptera physalus* ***(above) and*** *Physeter macrocephalus* ***(below left) and*** *Balaenoptera physalus* ***(below right) in Iskenderun Bay in north-eastern Mediterranean conducted by the Nature and Science Society and Iskenderun Technical University.***

Sl. 1: Terensko delo sodelavcev iz organizacije Nature and Science Society in tehnične univerze iz Iskenderuna na nasedlih primerkih vrst *Balaenoptera physalus* ***(zgoraj) in*** *Physeter macrocephalus* ***(spodaj levo) ter*** *Balaenoptera physalus* ***(spodaj desno) v zalivu Iskenderun v severovzhodnem Sredozemskem morju.***

Tab. 1: List of whale stranding reports on the coasts of Turkey (GL: grey literature, PO: personal observation by authors).
Tab. 1: Popis o nasedlih kitih ob obalah Turčije (GL: siva literatura, PO: lastna opažanja avtorjev).

Species	Body Length (m)	IUCN Status Mediterranean	Location	Date	References
Ziphius cavirostris	5.8	DD	Çanakkale, Gökçeada	8.03.1964	Marchessaux, 1980
Balaenoptera physalus	-	VU	Antalya	1.01.1977	Tonay *et al.*, 2020
Ziphius cavirostris	-	DD	Adana, Karataş	13.09.1982	Kinzelbach, 1985
Ziphius cavirostris	8	DD	Antalya, Serik	1.07.1994	Öztürk & Öztürk, 1998
Ziphius cavirostris	3.5	DD	Muğla, Ören	19.03.1995	Öztürk & Öztürk, 1998
Ziphius cavirostris	-	DD	Muğla, Dalyan	1.04.1997	Öztürk & Öztürk, 1998
Balaenoptera physalus	14.5	VU	Aydın, Kuşadası	1.01.1998	Tonay *et al.*, 2020
Balaenoptera physalus	10.5	VU	Adana, Yumurtalık	2000	Tonay *et al.*, 2020
Ziphius cavirostris	-	DD	Mersin, Bozyazı	19.04.2001	Podestà *et al.*, 2005
Ziphius cavirostris	7.55	DD	Muğla, Fethiye	27.01.2002	Öztürk, 2002
Physeter macrocephalus	-	EN	Muğla, Fethiye	21.06.2002	GL
Balaenoptera acutorostrata	4	LC	Mersin, Erdemli	15.08.2005	Öztürk *et al.*, 2015
Mesoplodon sp.	5	-	Muğla, Fethiye	9.01.2009	Notarbartolo di Sciara, 2009
Ziphius cavirostris	5	DD	Muğla, Sarıgerme	7.02.2009	Öztürk *et al.*, 2011
Ziphius cavirostris		DD	Not given	12.04.2012	Bachara & Norman, 2013
Balaenoptera acutorostrata	3.55	LC	Adana, Yumurtalık	10.04.2015	Öztürk *et al.*, 2015
Balaenoptera physalus	10.72	VU	Hatay, Iskenderun	8.01.2016	PO
Ziphius cavirostris	5.26	DD	Muğla, Gökova	3.06.2016	Öztürk *et al.*, 2016
Ziphius cavirostris	5.10	DD	İzmir, Seferihisar	5.06.2016	Öztürk *et al.*, 2016
Ziphius cavirostris	4.72	DD	Antalya, Gazipaşa	20.07.2016	Öztürk *et al.*, 2016
Physeter macrocephalus	18	EN	Hatay, Arsuz	21.06.2017	PO
Ziphius cavirostris	5	DD	Antalya, Kemer	14.11.2017	GL
Ziphius cavirostris	-	DD	Antalya, Serik	29.05.2018	GL
Physeter macrocephalus	3	EN	Muğla, Fethiye	10.07.2019	Tonay *et al.*, 2021
Balaenoptera physalus	13.5	VU	Edirne, Keşan	10.07.2019	Tonay *et al.*, 2020
Mesoplodon mirus	-	DD	Antalya, Finike	16.11.2019	GL
Physeter macrocephalus	1.5	EN	Adana, Karataş	10.08.2020	Tonay *et al.*, 2021
Physeter macrocephalus	5	EN	Antalya, Finike	14.08.2020	Tonay *et al.*, 2021
Balaenoptera physalus	12	VU	Hatay, Iskenderun	02.03.2021	This study

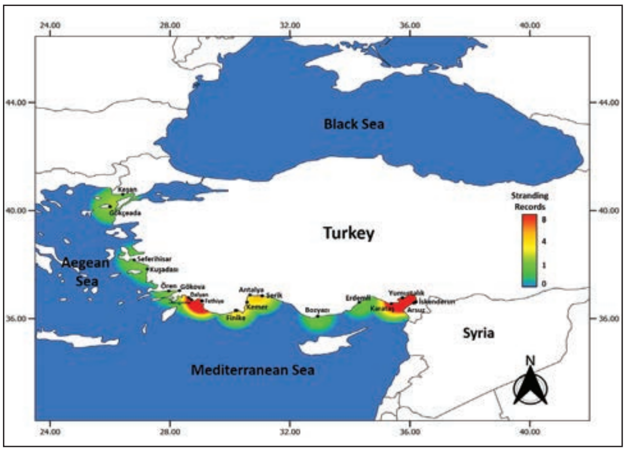

Fig. 2: Heat map of reports of all whale species stranded between 1964 and 2023 on the coasts of Turkey. The bar graph bar graph shows records in number.
Sl. 2: Zemljevid o pojavu nasedlih kitov v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.

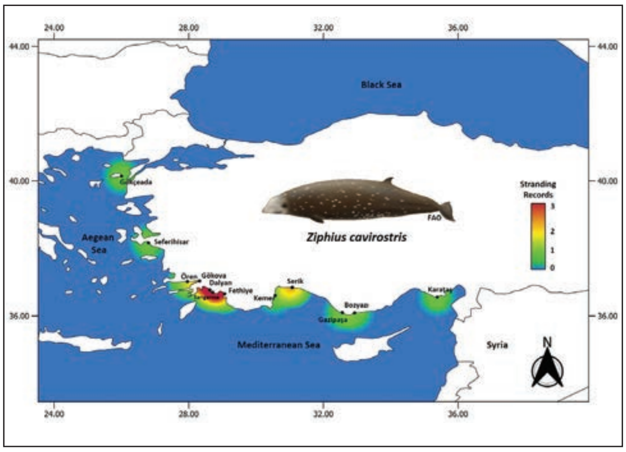

Fig. 3: Heat map of** Z. cavirostris **stranding reports on the coasts of Turkey. The bar graph legend shows records in number.
Sl. 3: Zemljevid o pojavu nasedlih kitov vrste** Z. cavirostris **v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.

Sea of Okhotsk, the Gulf of California, and the Gulf of Mexico (Barlow & Taylor, 2005).

The minke whale, *Balaenoptera acutorostrata* (Lacepède, 1804), is the smallest species of the family Balaenopteridae. It occurs regularly in both coastal and offshore waters worldwide and mainly feeds on krill, copepods, and schools of small fish (Pierce *et al.,* 2004). According to the IUCN red list, the minke whale is classified as Least Concern (LC) (Ibrahim *et al.,* 2020). Very little is known about its distribution in the Mediterranean, other than it is merely a visitor in the region (Fraija-Fernández *et al.,* 2015), and in the eastern Mediterranean a quite rare one, too (Kerem *et al.,* 2012; Öztürk *et al.,* 2015; Ibrahim *et al.,* 2020).

True's beaked whale, *Mesoplodon mirus* (True, 1913), is known only from strandings in Great Britain, from Florida to Nova Scotia in the western Atlantic, and from southeast Africa and southern Australia in the Indo-Pacific Ocean. It is one of the smallest members of the beaked whale family (Ziphiidae). *M. mirus* is the only beaked whale known to have an anti-tropical distribution, with one population in the warm- and cold-temperate North Atlantic and the other in the warm and cold-temperate Southern Hemisphere. In the Mediterranean it is considered merely a rare visitor.

Stranding data can offer insight into spatial distribution and seasonal movements of whale species in the Mediterranean and inform protection measures. Therefore, the collection of stranding records is crucial. The knowledge on the stranding of whale species in Turkish marine waters is based on published literature, newspapers, and other sources. In the present study, the stranding records of whales in Turkey were collected and mapped to visualize their general distribution pattern in Turkish marine waters.

MATERIAL AND METHODS

The primary data used in this study included occurrence points of whale species' strandings in Turkish marine waters, obtained from fieldwork, published literature, and grey literature. The geographic coordinates represent the location of stranding sites. In cases where only locality information was available, Google Earth was used to determine the coordinates. QGIS was used to map all occurrence records and produce a heat map of stranding records. The stranded whales found during fieldwork were transported to the safest location and buried upon necroscopic examination (Fig. 1). A tissue sample was also taken for further analysis.

RESULTS AND DISCUSSION

To date, 29 stranding records of five whale species and one genus have been reported from the coasts of Turkey. The species and number of strandings, listed in Table 1 together with additional information, are as follows: *Ziphius cavirostris* (14), *Balaenoptera physalus* (6), *Physeter macrocephalus* (5), *Balaenoptera acutorostrata* (2), *Mesoplodon mirus* (1) and *Mesoplodon* sp. (1). All the stranded whales were found dead. The first stranding was reported for *Z. cavirostris* from Gökçeada in 1964 (Marchessaux, 1980), whereas the most recent reported was *B. physalus* from Hatay-Iskenderun on 2 March 2021.

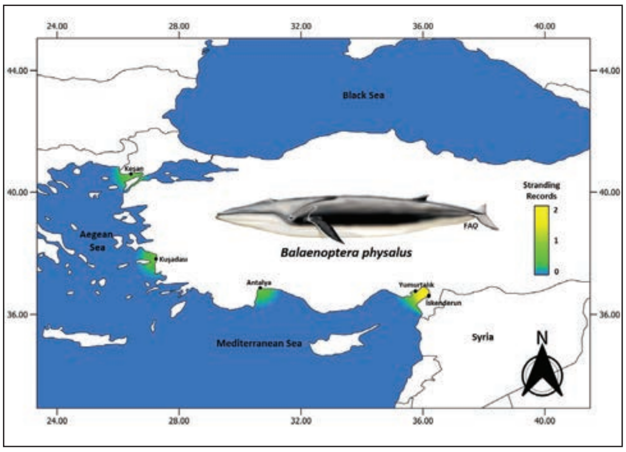

Fig. 4: Heat map of *B. physalus* ***stranding reports on the coasts of Turkey. The bar graph legend shows records in number.***
Sl. 4: Zemljevid o pojavu nasedlih kitov vrste *B. physalus* ***v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.***

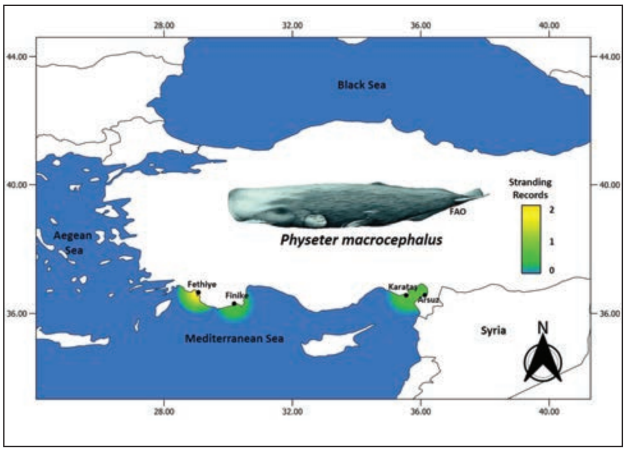

Fig. 5: Heat map of *P. macrocephalus* ***stranding reports on the coasts of Turkey. The bar graph legend shows records in number.***
Sl. 5: Zemljevid o pojavu nasedlih kitov vrste *P. macrocephalus* ***v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.***

Most of the strandings were reported from the Mediterranean coasts (Marchessaux, 1980; Kinzelbach, 1985; Öztürk & Öztürk, 1998; Podestà *et al.,* 2006; Öztürk, 2002; Notarbartolo di Sciara, 2009; Öztürk *et al.,* 2011; Bachara & Norman, 2013; Tonay *et al*., 2020). The majority of the strandings occurred in Fethiye (8), Iskenderun (7), and Antalya Bays (6) (Fig. 2). No stranded whales have been recorded in the Turkish Black Sea (Baş *et al.,* 2016).

Cuvier's beaked whales, *Z. cavirostris*, have stranded fourteen times, both in the Mediterranean and the Aegean Sea part of Turkey, with most of the strandings occurring in the Fethiye Bay in the Aegean Sea (Fig. 3). Species distribution is characterised by areas of high density, where individuals seem to be relatively abundant, such as the Alboran Sea, Ligurian Sea, central Tyrrhenian Sea, southern Adriatic Sea, and the Hellenic Trench (Canadas *et al*., 2013; Podesta *et al*., 2016). Occurrences of *Z. cavirostris* are rare in the Levantine Sea off Israel. A single population of *Z. cavirostris* in the low thousands is believed to exist in the Mediterranean, genetically isolated from the Atlantic population of the same species (Podestà *et al*., 2016). *Z. cavirostris* is subject to several threats, including the anthropogenic noise produced by military and industrial activities throughout the Mediterranean, as well as bycatch, and ingestion of plastics (Podestà *et al*., 2016).

Fin whales, *B. physalus*, have stranded six times along the Turkish coast. Three fin whale strandings were reported from Iskenderun Bay in the northeastern Mediterranean, the rest were recorded in Aydın, Antalya, and Çanakkale (Fig. 4). The Mediterranean subpopulation of the fin whale is currently assessed as vulnerable (VU) in the IUCN Red List, with the population trend decreasing (Panigada *et al.,* 2021). *B. physalus* occurs throughout the Mediterranean Sea, but predominantly in the western basin. Of the two populations occurring in the region, one is resident, observed mostly in the area extending from the waters north and east of the Balearic Islands to the Ionian and southern Adriatic seas. Populations of *B. physalus* also enter the Mediterranean from the northeastern North Atlantic Ocean seasonally through the Strait of Gibraltar. The population size of the resident *B. physalus* is presumed to be in the low thousands at most (predicted to decline), and is exposed to several threats, including ship strikes, disturbance, noise, and chemical contaminants (Castellote *et al*., 2012).

Sperm whales, *P. macrocephalus*, have been reported as stranded five times on the Turkish coast: two specimens in Fethiye Bay in the Aegean Sea, two specimens in Iskenderun Bay, and one specimen in Antalya Bay in the Mediterranean Sea (Fig. 5). The *P. macrocephalus* species is distributed over slope and deep waters throughout the Mediterranean Sea. A single panmictic population in the mid-hundreds is believed to exist in the Mediterranean Sea, genetically isolated from the Atlantic population of the same species (Rendell & Frantzis, 2016). This assumption supports the population's IUCN Red List status of endangered (Notarbartolo di Sciara *et al*., 2012). Ship strikes, entanglement in driftnets, ingestion of plastic debris, anthropogenic noise, and chemical contaminants are exerting major impact on and threatening Mediterranean sperm whale populations (Notarbartolo di Sciara, 2014).

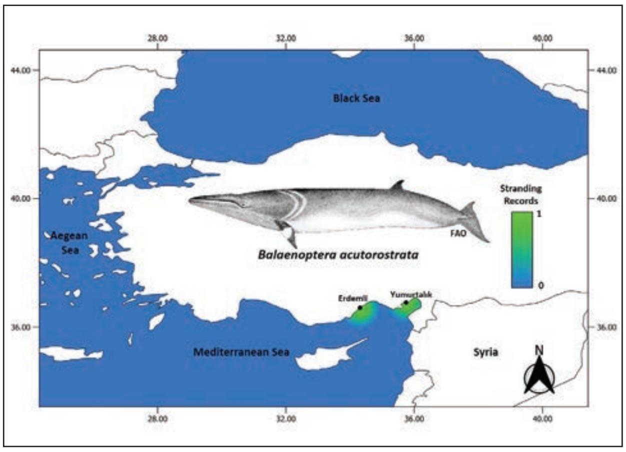

Fig. 6: Heat map of *B. acutorostrata* **stranding reports on the coasts of Turkey. The bar graph legend shows records in number.**
Sl. 6: Zemljevid o pojavu nasedlih kitov vrste *B. acutorostrata* ***v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.***

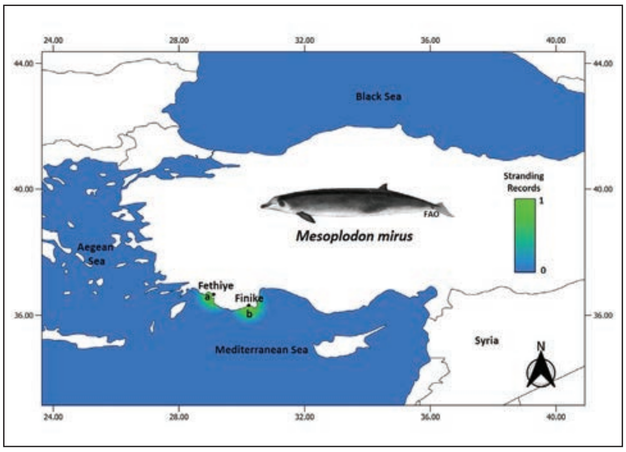

Fig. 7: Heat map of *Mesoplodon* ***species stranding reports on the coasts of Turkey (a:*** *Mesoplodon* ***sp.; b:*** *Mesoplodon mirus****). The bar graph legend shows records in number.***
Sl. 7: Zemljevid o pojavu nasedlih kitov iz rodu *Mesoplodon* ***v obdobju med 1964 in 2023 ob obalah Turčije. Stolpiči se nanašajo na število primerov.***

Minke whales, *B. acutorostrata*, have stranded twice: once in the Iskenderun Bay, and once in the Mersin Bay in the northeastern Mediterranean Sea (Fig. 6). *B. acutorostrata* is a visitor from the North Atlantic Ocean, occasionally entering the Mediterranean Sea through the Strait of Gibraltar. Most of these occasional sightings and strandings have occurred in the Algero-Provencal and Tyrrhenian subregions.

True's beaked whales, *M. mirus*, have stranded in Antalya Bay on the Mediterranean coast of Turkey. The *Mesoplodon sp.* was recorded as stranding in Fethiye Bay on the Mediterranean coast by Notarbartolo di Sciara (2009) on 9 January 2009 (Fig. 7).

The main threats to whales in the Mediterranean are ship strikes, which may even result in mortality, and noise pollution caused by ships, particularly in heavy vessel traffic areas. Seismic air guns can also have detrimental effects on fin whale populations by deterring them from feeding or breeding grounds (Castellote & Clark 2009). Other identified anthropogenic impacts on marine mammals in the Mediterranean Sea include fishing mortality, prey removal, xenobiotic contamination, climate change, and live capture (Bearzi *et al.,* 2012). Öztürk *et al.,* (2015) reported a *Balaenoptera acutorostrata* stranding in Yumurtalık, Adana, where the cause of stranding and death was not evident due to the advanced stage of decomposition. Öztürk *et al.* (2016) reported *Ziphius cavirostris* stranding in three different locations; while the cause of death of two specimens could not be established, it was determined that the death of the third specimen was caused by a severe infestation with subdermal endoparasites *Pennella sp*. and plastic waste in the stomach. It has also been reported that seismic surveys and military mid-frequency sonar studies should be considered as a possible cause of mortality in specimens whose cause of death cannot be determined. In the case of *P. macrocephalus* stranding in Finike in Antalya reported by Tonay *et al.* (2021) the results of necroscopy point to plastics found in the stomach of the whale as a possible reason for the stranding. Such a wide range of significant threats is worrisome because they affect cetacean populations that are already in decline, and the lack of field surveys further compromises the reliability of information about the population status of the respective species in the Mediterranean Sea.

The western and central Mediterranean Sea have been extensively studied with regard to cetacean abundance and distribution. However, studies on cetacean species in the eastern basin are scarce, and comparably fewer studies have been carried out in the northeastern Mediterranean (Frantzis *et al.*, 2003; Kerem *et al.*, 2012). The majority of cetacean studies in the eastern Mediterranean Basin have been conducted in Greek waters, in the Ionian Sea, the Hellenic Trench, and the Aegean Sea (Frantzis *et al.*, 2003). Additionally, Kerem *et al.* (2012) reported that the mean stranding frequency of whales per 100 km of coastline in Israel is twice as high as that of the well-monitored Spanish Mediterranean coastline (Cañadas, 2012). Therefore, more attention should be dedicated to the conservation of whales in the northeastern Mediterranean Sea.

Information about strandings of rare and endangered whale species significantly contributes to the understanding of their regional distribution. While an active whale stranding network covering the nearshore waters and shoreline of Turkey would facilitate the collection of data from fresh carcasses, crowdsourcing activities as part of citizen science, as well as regular monitoring of social and local media (grey literature) could help obtain valuable information that would further improve our basic knowledge of the biology and ecology of cetaceans in Turkish waters. This would ultimately enable the adoption of better targeted conservation measures.

ACKNOWLEDGMENTS

This study was supported by the Nature and Science Society (www.dogavebilim.com) with the project "Threatening Factors and Mitigation Measurements for the Marine Mammals in the Turkish Marine Waters". Some part of this study was presented at the 5th Conference on the Conservation of Cetaceans in the South Mediterranean Countries (CSMC5) 2021.

POPISOVANJE NASEDLIH KITOV V TURŠKIH MORSKIH VODAH

Cemal TURAN
Iskenderun Technical University, Marine Sciences and Technology Faculty Marine Science Department, Molecular Ecology and Fisheries Laboratory 31200 Iskenderun, Turkey
Nature and Science Society, Modernevler Mah. 303. Sk. No:9 D:1, Iskenderun, Turkey
e-mail: cemal.turan@iste.edu.tr

Servet Ahmet DOĞDU
Nature and Science Society, Modernevler Mah. 303. Sk. No:9 D:1, Iskenderun, Turkey
Iskenderun Technical University, Maritime Vocational School of Higher Education, Underwater Technologies, Iskenderun, Hatay, Turkey

İrfan UYSAL
[4]The General Directorate of Nature Conservation & National Parks, Republic of Turkey the Ministry of Agriculture and Forestry, 06560 Ankara, Turkey

POVZETEK

Razširjenost kitov v Sredozemskem morju temelji predvsem na podlagi zapisov o nasedlih kitih. Avtorji predstavljajo zemljevide o nasedlih kitih različnih vrst in o vzorcu razširjenosti v Turčiji. Gre za pomemben korak v načrtovanju ohranitvenih ukrepov. Primarne podatke so pridobili v objavljenih delih, sivi literaturi in na podlagi terenskega dela. Skupno je bilo med leti 1964 in 2023 zabeleženih 29 primerov nasedlih kitov. Ti so se pojavljali na različnih obalah, največ v zalivu Iskenderun in v zalivu Muğla ob egejski obali. Popisali so kite petih vrst in enega rodu: Cuvierjev kljunati kit Ziphius cavirostris*, brazdasti kit* Balaenoptera physalus*, kit glavač* Physeter macrocephalus*, ščukasti kit* Balaenoptera acutorostrata*, in severni dvozob* Mesoplodon mirus *in vrsta iz rodu* Mesoplodon.

Ključne besede: vrste kitov, Cetacea, nasedli primerki, zemljevidi o razširjenosti, Sredozemsko morje, Turčija

REFERENCES

Bachara, W. & S.A. Norman (2013): Ziphius cavirostris strandings-a short review. Reports of the International Whaling Commission SC65/SM1.

Barlow, J. & B.L. Taylor (2005): Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Mar. Mamm. Sci., 21(3), 429-445.

Bearzi, G., R.R. Reeves, E. Remonato, N. Pierantonio & S. Airoldi (2011): Risso's dolphin *Grampus griseus* in the Mediterranean Sea. Mamm. Biol., 76(4), 385-400.

Cañadas, A (2012): *Ziphius cavirostris* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2012: e. T16381144A16382769.

Cañadas, A., C. Fortuna, M. Pulcini, G. Lauriano, B. Bearzi, C. Cotte & L. Rendell (2011): Accobams collaborative effort to map high-use areas by beaked whales in the Mediterranean. In 63 Scientific Committee Meeting of the International Whaling Commission.

Castellote, M., C.W. Clark, F. Colmenares & J.A. Esteban (2009): Mediterranean fin whale migration movements altered by seismic exploration noise. J. Acoust. Soc. Am., 125(4), 2519-2519.

Castellote, M., C.W. Clark & M.O. Lammers (2012): Fin whale (*Balaenoptera physalus*) population identity in the western Mediterranean Sea. Marine Mammal Science, 28(2), 325-344.

Fraija-Fernández, N., P.D. Olson, E.A. Crespo, J.A. Raga, F.J. Aznar & M. Fernández (2015): Independent host switching events by digenean parasites of cetaceans inferred from ribosomal DNA. Int. J. Parasitol., 45(2-3), 167-173.

Frantzis, A., P. Alexiadou, G. Paximadis, E. Politi, A. Gannier & M. Corsini-Foka (2003): Current knowledge of the cetacean fauna of the Greek Seas. J. Cetacean Res. Manage., 5(3), 219-232.

Genç, M.S., F. Karipoğlu, K. Koca & Ş.T. Azgın (2021): Suitable site selection for offshore wind farms in Turkey's seas: GIS-MCDM based approach. Earth Sci. Inf., 14(3), 1213-1225.

Giménez, J., E. Gómez-Campos, A. Borrell, L. Cardona & A. Aguilar (2013): Isotopic evidence of limited exchange between Mediterranean and eastern North Atlantic fin whales. Rapid Commun. Mass Spectrom., 27(15), 1801-1806.

Heyning, J.E., G.M. Lento & A.R. Hoelzel (2002): The evolution of marine mammals. In: Marine Mammal Biology: An Evolutionary Approach, Wiley, 38-72.

Heyning, J.E. & J.G. Mead (2009): Cuvier's Beaked Whale: *Ziphius cavirostris*. In: Encyclopedia of Marine Mammals (pp. 294-295). Academic Press.

Ibrahim, A., C. Hussein, N. Ibrahim, M. Badran, F. Alshawy & A.A. Ahmad (2020): First stranding event of a Minke Whale Calf, *Balaenoptera acutorostrata* Lacépède, 1804, in the Syrian Coast, Eastern Mediterranean. Int. J. Aquat. Biol., 8(4), 296-299.

Jefferson, T.A., M.A. Webber & R.L. Pitman (2011): Marine mammals of the world: a comprehensive guide to their identification. Elsevier.

Kerem, D., N. Hadar, O. Goffman, A. Scheinin, R. Kent, O. Boisseau & U. Schattner (2012): Update on the cetacean fauna of the Mediterranean Levantine basin. Open Mar Biol J., 6(1), 6-27.

Kinzelbach, R (1985): The goosebeak whale (*Ziphius cavirostris*) in the eastern Mediterranean Sea. Mamm. Biol. Z. Saugetierkd., 50(5), 314-316.

MacLeod, C.D., M.B. Santos & G.J. Pierce (2003): Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. J. Mar. Biol. Assoc. U. K., 83(3), 651.

Marchessaux, D (1980): A review of the current knowledge of the cetaceans in the Eastern Mediterranean Sea. Vie Mar., (Six-Fours-les-Plages).

Notarbartolo di Sciara, G (2009): Stranding of a rare beaked whale in Turkey. ACCOBAMS FINS Newsletter, 4(2), 15.

Öztürk, A.A., A. Dede & A.M. Tonay (2016): Cetaceans in the Turkish Waters of the Mediterranean Sea. In: The Turkish Part of The Mediterranean Sea, 566.

Öztürk, A.A., A. Dede, A.M. Tonay, E. Danyer & I. Aytemiz (2015): Stranding of a minke whale on the eastern Mediterranean coast of Turkey. J. Black Sea/Mediterr. Environ., 2, 232-237.

Öztürk, A.A., A. M. Tonay & A. Dede (2011): Strandings of the beaked whales, Risso's dolphins, and a minke whale on the Turkish coast of the Eastern Mediterranean Sea. J. Black Sea/Mediterr. Environ, 17, 269-274.

Öztürk, B. & A.A. Öztürk (1998): Cetacean strandings in the Aegean and Mediterranean coasts of Turkey. Rapport Commissione Internationale Mer Méditerranée, 35, 476-477.

Öztürk, E (2002): Happiness of coming across a whale. Sualtı Dünyası, 68, 70-72.

Panigada, S., P. Gauffier & G. Notarbartolo di Sciara (2021): *Balaenoptera physalus* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2021: e.T16208224A50387979. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T16208224A50387979.en. Accessed on 12 March 2023.

Pierce, G.J., M.B. Santos, R.J. Reid, I.A.P. Patterson & H.M. Ross (2004): Diet of minke whales *Balaenoptera acutorostrata* in Scottish (UK) waters with notes on strandings of this species in Scotland 1992-2002. J. Mar. Biol. Assoc. U. K., 84(6), 1241-1244.

Podesta, M., A.D. Amico, G. Pavan, A. Drougas, A. Komnenou & N. Portunato (2005): A review of Cuvier's beaked whale strandings in the Mediterranean Sea. J. Cetacean Res. Manage., 7(3), 251.

Podestà, M., A. Azzellino, A. Cañadas, A. Frantzis, A. Moulins, M. Rosso & C. Lanfredi, (2016): Cuvier's beaked whale, *Ziphius cavirostris*, distribution and occurrence in the Mediterranean Sea: high-use areas and conservation threats. In: Advances in Marine Biology (Vol. 75, pp. 103-140). Elsevier.

Reeves, R., B. Stewart, P. Clapham & J. Powell (2002): Beaked whales. In: Scott G, Bredeson M, Nelson P, Hughes AK, O'Connor A, Fogarty P, editors. Guide to Marine Mammals of the World. 1st ed. New York, NY, USA: National Audubon Society, pp. 248-298.

Tonay, A.M., A. Dede, B. Gül & A.A. Öztürk **(2020):** First record of a fin whale (*Balaenoptera physalus*) stranding on the northern Aegean Sea coast of Turkey. J. Black Sea/Mediterr. Environ., 26(2), 223-230.

Tonay, A.M., A.A. Öztürk, A. Salman, A. Dede, I.A. Danyer, E. Danyer & B. Öztürk (2021): Stranding records of sperm whale (*Physeter macrocephalus*) on the Turkish coast in 2019-2020 with a note on the opportunistic sampling of stomach content. J. Black Sea/Mediterr. Environ., 27(3), 281-293.

OBLETNICE

ANNIVERSARI

ANNIVERSARIES

ŠESTDESET LET MORSKEGA BIOLOGA LOVRENCA LIPEJA

Prof. dr. Lovrenc Lipej, vodilni slovenski morski biolog in ekolog, praznuje letos šestdeset let. Že v zgodnjih najstniških letih ga je navduševala zoologija, predvsem ornitologija, zato je svojo pot iz rodne Izole in po zaključeni koprski gimnaziji nadaljeval na Biotehniški fakulteti Univerze v Ljubljani, kjer je leta 1988 diplomiral. Leta 1989 se je kot mladi raziskovalec zaposlil na Nacionalnem inštitutu za biologijo, v enoti Morske biološke postaje Piran in svojo študijsko pot nadaljeval na podiplomskem študiju oceanografije na Vseučilišču v Zagrebu. Leta 1992 je po zagovoru magistrskega dela o mikrozooplanktonu Tržaškega zaliva postal magister oceanografskih znanosti. Znanje o zooplanktonu je izpopolnjeval pri strokovnjakinji za ekologijo zooplanktona dr. Adrianni Ianori na Zoološki postaji Anton Dohrn v Neaplju. Leta 1996 je doktoriral na Univerzi v Ljubljani s področja prehranjevalne vloge rastlinojedega zooplanktona v obalnem morju, pri čemer ga je, tako kot pri magisteriju, tudi tekom doktorata vodila mentorica prof. dr. Alenka Malej. Po zaključenem doktoratu se je začel vedno bolj posvečati morski biotski raznolikosti in pridobil ARRS projekt Evidentiranje flore, favne in habitatnih tipov slovenskega morja (1998-2003). Od takrat je sodeloval še pri devetih drugih ARRS projektih, s kolegi iz jadranskih inštitutov je prijavil tudi številne bilateralne projekte.

V zadnjih petindvajsetih letih je vodil mnoge projekte za različne naročnike, kot so nekdanje Ministrstvo za okolje in prostor, Ministrstvo za kmetijstvo, gozdarstvo in prehrano, Zavod za Varstvo Narave, UNEP-MAP, Javni zavod Krajinski park Strunjan, Društvo za opazovanje in preučevanje ptic Slovenje, Luka Koper d.o.o., obalne občine, itd. Organiziral je več znanstvenih in strokovnih srečanj. Je član uredniških odborov znanstvenih revij Acrocephalus, Natura Sloveniae, Acta Adriatica, Studia marina, Natural and Engineering Sciences (NESciences) in že več kot 30 let odgovorni urednik znanstvene revije *Annales Series Historia Naturalis*, ki jo ureja še danes in se je v teh letih tudi po njegovi zaslugi dobro zasidrala v sredozemskem, predvsem pa jadranskem prostoru.

Glavna raziskovalna področja prof. dr. Lovrenca Lipeja pokrivajo predvsem ekološke raziskave morske biodiverzitete. Raziskovalna skupina na Morski biološki postaji Piran, katere je idejni vodja, se ukvarja s proučevanjem bentoških habitatnih tipov, biogradnikov, ribje združbe, ogroženih in tujerodnih vrst. Razvil je nedestruktivno metodo podvodnega kartiranja bentoških makro- in mikrohabitatnih tipov ter popisa bentoških organizmov in obrežne ribje združbe, ki je bila objavljena v znanstveni literaturi. Veliko pozornost namenja tudi raziskavam recentnih sprememb v jadranski biodiverziteti, kot posledic bioinvazije in podnebnih sprememb, v sodelovanju z italijanskimi in hrvaškimi kolegi. V zadnjem desetletju je bil vodja več mednarodnih odprav na otok Mljet, ki so pod okriljem Nacionalnega parka Mljet popisovale habitatne tipe in biodiverziteto na koralnem grebenu sredozemske

Sl. 1: Lovrenc Lipej med terenskim delom, z dolgoletnim sodelavcem Borutom Mavričem.

Sl. 2: Lovrenc Lipej kot panelist na Mednarodni Konferenci "Adriatic Biodiversity Protection - AdriBioPro 2019", aprila 2019 v Kotorju (Črna gora).

kamene korale. Med drugim je eden od ustanoviteljev sredozemske delovne skupine za proučevanje morskih psov (Mediterranean Shark Research Group), v kateri aktivno sodeluje. Prof. Lovrenc Lipej je objavil 151 recenziranih izvirnih in 7 preglednih člankov. Je soavtor 14 znanstvenih monografij in 12 poglavij v znanstvenih monografskih publikacijah.

Leta 2011 je bil izvoljen v rednega profesorja za področje ekologije na Univerzi v Mariboru, že pred tem pa je sodeloval v različnih študijskih programih na vseh slovenskih univerzah – v Ljubljani, Mariboru, Novi Gorici in Univerzi na Primorskem, med leti 2010 in 2013 pa tudi na Univerzi v Trstu. Kot uspešen raziskovalec prenaša svoje znanje iz morskih ved na številne študente. Bil je mentor ali somentor 22 diplomantom, 19 magistrantom in 6 doktorandom.

Poleg znanstvene dejavnosti je zelo pomembna publicistična dejavnost, ki jo prof. Lipej izkazuje z znanstvenimi in strokovnimi monografijami v slovenskem in angleškem jeziku. Že več kot 20 let redno objavlja v Primorskih novicah prispevke o biodiverziteti v morju in na kopnem ter naravovarstvenih ukrepih pri ogroženih vrstah. Z vsem tem in s številnimi objavami v medijih, ki jih je nemogoče prešteti, prof. Lipej veliko prispeva k popularizaciji znanosti in osveščanju javnosti o perečih in zanimivih okoljskih temah.

Za to svojo pomembno dejavnost, s katero že desetletja pripomore k dviganju zavesti o pomenu biodiverzitete, varovanju narave in okolja ter raziskavah morja, je prejel številne nagrade. Tako je bil že leta 1999 nagrajen s priznanjem Zlati legat, ki ga podeljuje Društvo za opazovanje in preučevanje ptic Slovenje, za najboljše izvirno znanstveno delo na področju ornitologije. Leta 2013 si je prislužil Bronasto plaketo Slovenske potapljaške zveze (SPZ), leta 2022 pa še Srebrno plaketo za izjemni prispevek pri delu SPZ, še posebej na področju podvodne biologije. Skupaj z najožjimi sodelavci je leta 2016 prejel priznanje Prometej znanosti za odličnost v komuniciranju, kasneje, leta 2020, pa še Nagrado Miroslava Zeia za izjemne dosežke na področju dejavnosti Nacionalnega inštituta za biologijo. Najnovejše v tej izjemni zbirki je Priznanje Finalist nacionalnega izbora Komunikator znanosti leta 2022 za knjigo esejev s področja znanosti o morju z naslovom Podobe iz modrine.

Kot dolgoletni sodelavki mu želiva še mnogo znanstvenih in osebnih uspehov ter veliko nepozabnih trenutkov s kolektivom Morske biološke postaje Piran.

Martina Orlando-Bonaca in Patricija Mozetič
Morska biološka postaja Piran
Nacionalni inštitut za biologijo

KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: Bogato zaraslo kamnito dno s pridneno makrofavno že od nekdaj privlači podvodne fotografe. Tako zarasla skupnost živali nudi pomembne ekosistemske storitve, saj številni filtratorski organizmi v njej precejajo različne delce iz vode, obenem pa privablja razne plenilce. (Foto: B. Furlan)

Sl. 1: *Stenopus spinosus* Risso, 1827 je velika (do 8 cm telesne dolžine) in barvita vrsta sredozemskih kozic. Na severni Jadran so jo najverjetneje zanesli proti severu gibajoči se površinski tokovi, ki potekajo vzdolž vzhodnega dela Jadrana, ustalila pa se je zaradi visokih temperatur, še posebej pozimi. (Foto: R. Melzer)

Sl. 2: Mangrovski rdeči hlastač (*Lutjanus argentimaculatus*) je lesepska selivka, ki so jo doslej potrdili na več lokalitetah v vzhodnem Sredozemskem morju in v malteških vodah. Pričakujemo lahko, da se bo razširila tudi v druge predele Sredozemskega morja. (Foto: B. Furlan)

Sl. 3: V zadnjih desetletjih je modri trnobok (*Caranx crysos*) razširil svoj areal ob vzhodni in zahodni atlantski obali in tudi v Sredozemskem morju. Zaradi velikosti je modri trnobok tarčna vrsta tako poklicnih kot amaterskih ribičev. (Foto: B. Furlan)

Sl. 4: Morska ščuka (*Sphyraena sphyraena*) je epipelagična morska vrsta, ki lahko zraste do 1650 mm v dolžino, njena maksimalna doslej izmerjena masa pa znaša 3,6 kg. Pred kratkim so v turških vodah pri tej vrsti odkrili resne skeletne anomalije. (Foto: B. Furlan)

Sl. 5: Istrska Madona je miniaturen umetni podvodni greben, ki so ga leta 2015 potopili na globino 9 m blizu Naravnega spomenika Rt Madona (Piran). Gre za tri metre visoko umetnino, ki jo sestavljajo pokončna Marija, krilati angel z mečem in Istran. (Foto: T. Makovec)

Sl. 6: Istrsko Madono so hitro poselile razne planktonske ličinke, ki so se preobrazile v pridnene živali. Bogato zarasla filtratorska skupnost po eni strani opravlja vlogo miniaturne čistilne naprave, po drugi pa privablja različne nevretenčarje in ribe, ki na taki umetni strukturi iščejo plen. (Foto: T. Makovec)

INDEX TO PICTURES ON THE COVER

FRONT COVER: A rocky bottom richly overgrown with benthic macrofauna has always attracted underwater photographers. Such an overgrown community of animals provides important ecosystem services, as it consists of many filtering organisms and at the same time attracts various predators. (Photo: B. Furlan)

Fig. 1: *Stenopus spinosus* Risso, 1827 is an impressively large (up to 8 cm body length) and beautifully coloured Mediterranean ornamental shrimp. The species may have been carried into northern Adriatic areas by northward surface currents that run along the eastern Adriatic sector, and eventually settled here due to higher temperatures especially during winter. (Photo: R. Melzer)

Fig. 2: The mangrove red snapper (*Lutjanus argentimaculatus*) is a Lessepsian migrant the occurrence of which has so far been confirmed in several localities of the eastern Mediterranean Sea and in Maltese waters. It is reasonable to expect that it will also spread to other parts of the Mediterranean Sea. (Photo: B. Furlan)

Fig. 3: In the recent decades, the blue runner (*Caranx crysos*) has expanded its distribution along both western and eastern Atlantic coasts, and in Mediterranean waters. Its remarkable size makes *C. crysos* a targeted species by both professional and amateur fishermen. (Photo: B. Furlan)

Fig. 4: The European barracuda, *Sphyraena sphyraena*, is an epipelagic marine species that may attain a maximum total length of 1,650 mm and has a maximum reported weight of 3.6 kg. Recently, severe skeletal deformities have been discovered in this species in the Turkish Seas. (Photo: B. Furlan)

Fig. 5: The Istrian Madonna is a miniature artificial underwater reef that was sunk in 2015 to a depth of 9 m near the Cape Madona Natural Monument. It is a 3 m tall work of art consisting of a standing Mary, a winged angel holding a sword, and an Istrian. (Photo: T. Makovec)

Fig. 6: The Istrian Madonna has quickly been populated by various planktonic larvae, which transformed into benthic animals. The richly overgrown filtrator community acts as a miniature sewage treatment plant while also attracting to this artificial structure various invertebrates and fish in search of prey. (Photo: T. Makovec)

Inštitut
IRRIS