

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/321229065>

First record of the Bath's goby, *Pomatoschistus bathi* (Miller 1982), from central-south Italy: a southern proof of fragmented distr....

Article in *Marine Biodiversity* · June 2017

DOI: 10.1007/s12526-017-0741-0

CITATIONS

0

READS

82

4 authors:



Salvatore Giacobbe

Università degli Studi di Messina

76 PUBLICATIONS 334 CITATIONS

SEE PROFILE



Andrea Spinelli

Università degli Studi di Messina

18 PUBLICATIONS 35 CITATIONS

SEE PROFILE



Sergio De Matteo

Università degli Studi di Messina

10 PUBLICATIONS 28 CITATIONS

SEE PROFILE



Marcelo Kovačić

Natural History Museum Rijeka

98 PUBLICATIONS 766 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Local ecological knowledge and fisheries research in Croatia: Changes in Fishing and Marine Biological diversity [View project](#)



Coastal nursery habitats: Patterns and processes of demographic variability in marine fish species along the eastern Adriatic coast [View project](#)

First record of the Bath's goby, *Pomatoschistus bathi* (Miller 1982), from central-south Italy: a southern proof of fragmented distribution restricted to the north?

Salvatore Giacobbe¹ · Andrea Spinelli¹  · Sergio De Matteo¹ · Marcelo Kovačić²

Received: 7 March 2017 / Revised: 16 May 2017 / Accepted: 24 May 2017
© Senckenberg Gesellschaft für Naturforschung and Springer-Verlag Berlin Heidelberg 2017

Abstract The ecology and distribution of *Pomatoschistus bathi* are discussed on the basis of the first record from central-south Italy. A comparison with the co-generic and apparently similar *P. tortonesei*, indicated the two species are ecologically distinct and their areal does not overlap. The present record, from an area whose surface waters are cooled by upwelling currents, agrees with the hypothesis of a fragmented distribution restricted to the north. The species, which has not been of conservation interest, might be thus emblematic of ongoing habitat regression and fragmentation in strictly cold-water Mediterranean species. The present record, from a deeply anthropized basin, also represents a profitable case-study on the conservation dynamics in human-mediated aquatic ecosystems.

Keywords Gobiids · Conservation · Habitat fragmentation · Transitional waters

Introduction

Bath's goby, *Pomatoschistus bathi* (Miller 1982), is a Mediterranean endemic species, initially known from south-western France to the Turkish Aegean coast (Miller 1986), and

recently reported from the Black Sea (Caucasus, Crimea, Bulgaria: summarized in Boltachev et al. 2016). Within such distribution, the populations of the Liguro-Provençal area, East Adriatic and East Aegean appear disjoined, due to the lack of records from both the Italian peninsula and Greece (Fig. 1). Furthermore, the scattered published records from the western Mediterranean (Miller 1986; Tunesi et al. 2005; Dufour et al. 2007; Piazzini et al. 2009), as well as the continuous Adriatic areal (Kovačić 2005), seem to be bounded northern of the 41st parallel, differently from the eastern Mediterranean distribution that extends southward from the 41st to the 36th parallel (Miller 1986; Engin et al. 2016) (Fig. 1).

Aims of the present paper are: (1) to report the occurrence of *P. bathi* in Lake Faro (north-eastern Sicily), as its most south-western record; (2) to provide further information on the habitat of this species; (3) to discuss this finding in biogeographical and ecological terms, in comparison with the related species *P. tortonesei* (Miller 1986); and (4) to provide a contribution to the topic of the threatened species in the ongoing Mediterranean climatic changes.

Materials and methods

Specimens of *P. bathi* have been recorded in the framework of the program: "Settlement dynamics and colonization of allochthonous assemblages in the Capo Peloro Lagoon". The Lagoon is a protected transitional environment composed by two interconnected basins, Lake Faro and Lake Ganzirri, each of them receiving significant tidal inflows from the Strait of Messina (Ionian Sea). Despite the protection regime, it is affected by a high anthropogenic pressure, due to mollusk farming and urbanization. The Lake Faro (38°16'4.05" N, 15°38'9.72" E), although covering an area of just 263,600 m², is the deepest coastal basin in Italy, reaching 29 m maximum depth,

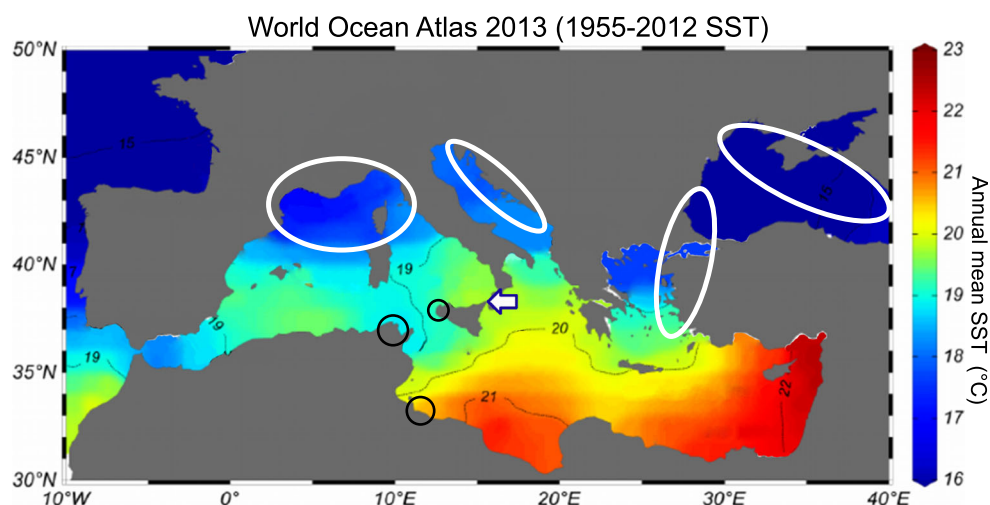
Communicated by R. Thiel

✉ Andrea Spinelli
andspinelli@unime.it

¹ Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, Viale Ferdinando Stagno d'Alcontres, 31, 98166 Messina, Italy

² Prirodoslovni muzej Rijeka, Lorenzov prolaz 1, HR-51000 Rijeka, Croatia

Fig. 1 Distribution of *Pomatoschistus bathi* (white ellipses) and *P. tortonesei* (black circles) compared with the annual mean sea surface temperatures in Mediterranean and Black Sea (modified from Jalali et al. 2016). The white arrow indicates the present record



with anoxic waters below 10 m depth, that may occasionally rise to the surface (Saccà et al. 2008).

During regular investigations, started in April 2012, the goby fauna was biweekly monitored by SCUBA divers along the whole shallower lake-floors (0–2.5 m depth). A 100 m² grid was employed to estimate specimen density. The observed specimens were photographed in situ using a Canon G12 camera in order to document live coloration and small-scale habitat characteristics. Contextually, the main physico-chemical parameters were measured in situ, using a multi-parameter probe. Periodically, a small number of specimens was captured by hand net (30 cm mouth opening, 0.5 mm mesh size). Part of the material was fixed in 96% ethanol and then preserved in 75% ethanol for morphological study and identification. Species determination was carried out at the Natural History Museum Rijeka on four specimens (PMR). Material examined: PMR VP3872 male, 31.6 + 7.0 mm; PMR VP3873, female, 31.0 + 6.5 mm; PMR VP3874, female, 30.1 + 6.2 mm; PMR VP3875, female, 29.9 + 6.5 mm (Fig. 2); Italy, Sicily, Lake Faro, 38°16'3.90" N, 15°38'6.58" E, 17 April 2016, collected by S. De Matteo. The diagnosis is a minimum combination of characters that positively identify the collected specimens among species of the family Gobiidae in the CLOFNAM area (Miller 1986, Ahnelt and Dorda 2004, references therein). The description represents the data of examined material. The meristic methods and terminology used followed Schlieffen and

Kovačić (2008). The terminology of the lateral-line system followed Miller (1986).

Results

Morphology

Diagnosis The specimens differ from all other gobiid species and fit to *P. bathi* by the following combination of characters: (1) sensory papillae row *a* present, (2) pelvic fin anterior membrane present with straight rear edge, (3) head with anterior and posterior oculoscapular, and preopercular canals without numerous extra pores, (4) suborbital transverse sensory papillae rows present; (5) head canals extends to snout, to paired pore σ , (6) scales in lateral series 30–38 (32–36 in studied specimens), (7) predorsal area back to at least middle of the first dorsal fin base naked, base of the second dorsal fin scaled; (8) pectoral fin rays 13–17 (14–15 in studied specimens); and (9) pore ω absent.

Description of material (Fig. 2) Eyes large, dorsolateral. Anterior nostril short, tubular, erect, without process from rim; posterior nostril pore-like, near orbit. Mouth oblique, posterior angle of jaws below pupil. Branchiostegal membrane attached to entire side of isthmus. Fins: D1 V–VI; D2 I/7–8 (7: 1, 8: 3); A I/7–8 (7: 2, 8: 2); C 14–15 segmented rays (14: 1; 15: 3), 11–12 branched rays (11: 3, 12: 1); P 14–15 (both sides: 14:4, 15:4), V I/5 + 5/I. D1 spines not reaching to D2. Interdorsal space broad. P uppermost rays within membrane. V complete, rounded, with anterior transverse membrane, rear edge of V anterior transverse membrane straight. C rounded. Body with ctenoid scales, LL 32–36, TR 6–8, CP 11–12. Head, predorsal area, breast and central belly naked. All first dorsal fin base and behind pectoral axilla naked, base of the second dorsal fin scaled. Head with anterior and posterior oculoscapular, and preopercular canals, with pores σ , λ , κ ,



Fig. 2 *Pomatoschistus bathi*, preserved specimen, PMR VP3875, female, 29.9 + 6.5 mm, Italy, Sicily, Lake Faro, photo M. Kovačić

α , ρ , ρ^1 , ρ^2 , and γ , δ , ε , respectively, (δ missing in one specimen). Rows of sensory papillae: (I) *preorbital*: snout with three rows in median preorbital series: internal longitudinal row r (2–5), outer longitudinal row s (3–5), anterior transverse row s^3 (1–2). Lateral series c in two parts: superior c^1 (4–6) close to nostrils; inferior c_1 (4–6) above lips. (II) *suborbital*: infraorbital row a extending forwards to below pupil midline, consisting of five longitudinally arranged papillae and a single transverse row atp (3). Longitudinal row b (6) anteriorly beginning behind vertical of rear border of eye. Five suborbital transverse rows c as single papilla or short rows (1–4) and row cp as longest (7–8), only cp transverse row placed below b , ending below level of row d . Longitudinal row d separated in supralabial (4–6) and posterior part (4–6) by gap below rows 2 or 3, row d not reaching posteriorly row cp . (III) *preoperculo-mandibular*: external row e and internal row i divided into anterior (e : 4–6, i : 11–15), and posterior sections (e : 13–19, i : 16–21); mental row f (2). (IV) *oculoscapular*: anterior transverse row tra divided in upper (2–3) and lower sections (1), above and behind pore α , anterior longitudinal row x^1 divided in frontal part (4–6) and rear part (2), with posterior transverse row trp (3–4) placed in between and behind pore ρ , row z (6–8) behind pore γ , posterior longitudinal row x^2 (3–4) over pore ρ^2 , row y (1) behind pore ρ^2 , row q (1) in front of pore ρ^1 . Axillary rows as^1 (7–9), as^2 (6–9), as^3 (8–9), la^1 (2–3) and la^2 (2–3) present. (V) *opercular*: transverse row ot (14–18); superior longitudinal row os (7–10); and inferior longitudinal row oi (7–8). (VI) *anterior dorsal*: transverse row n (5), row o absent; longitudinal rows g (6), m (3) and h (7) present. Color preserved: body yellowish, with dark pigmentation on the upper and lateral parts of the body. Underside of body without pigmentation. Upper part of body with reticulate pattern, formed by dark pigment along the scale margins and four more or less distinctive saddles: at D1 origin, interdorsally and origin of D2, rear of D2 base and on caudal peduncle. Ill defined marks or short stripes along lateral midline, about four primary marks and additional narrow stripes not extended on upper half in between these primary ones. On rear side of caudal peduncle and beginning of caudal fin base triangular mark visible in both sexes. Head similar to body: predorsal area pigmented, dark mark on anterior opercle, dark preorbital bar from eye to upper lip, and less evident from eye downwards the cheek; head underside and breast pigmented in males, female underside only with dark pigmented median band. D1 with three oblique bands. D2 with less pronounced 3–4 oblique bands, C pigmented, A and V pigmented in males, clear in females, P fin poorly pigmented, except for the dark mark in upper anterior fin corner.

Ecology

P. bathi suddenly appeared in early April 2016, when a dozen specimens were observed in the central, shallower area of the

Lake. In late April, more numerous specimens had been observed, after which the population apparently disappeared. New records occurred just one year later, concentrated between late March to early May 2017. During the sampling period, the surface water temperature ranged from 16 °C in April to 25 °C in August, salinity respectively from 36.8 psu to 37.65 psu, dissolved oxygen from 142% to 120%, whilst low pH variations were recorded (from 8.0 to 8.2 units).

Distribution, in both years covered a limited, shallower area (0.5–1.5 m depth), characterized by a dense network of mounds and canals. The mounds consist in artificial sand deposit employed for traditional clam culture, hosting a mixture of edible species, namely *Cerastoderma glaucum* (Bruguière 1789), *Polittapes aureus* (Gmelin 1791), *Ruditapes decussates* (Linnaeus 1758) and the introduced *Ruditapes philippinarum* (Adams and Reeve 1850). The local population appeared divided among four sites (Fig. 3a), each of them corresponding to the top of a mound, from 50 to 100 m² wide. Three of such mounds (stations 2S, 3S, 4S) were composed by well-sorted coarse sands with sparse shell remains, whereas the last one (station 1C), since abandoned, was partially covered by the sea grass, *Cymodocea nodosa* (Ucria) Ascherson 1870. In this latter habitat, *P. bathi* is less frequent, accounting for a maximum of 4/100 specimens/m² in the period of peak abundance, in respect to a maximum of 15/100 specimens/m² on bare sands. All the specimens in fact were observed lying on the sand, perfectly mimetic with the substrate (Fig. 3b); when disturbed, they fled laterally with quick shots rather than hiding in the sand. Both solitary specimens and small groups of three to four individuals have been observed.

Discussion

Data about the geographic and ecological distribution of *Pomatoschistus bathi*, are rare and sporadic, despite the remarkable contribution of gobiids to fish biodiversity (Miller 1986), due to the very small size, peculiar habit and habitat, and lack of commercial interest. The present record of *P. bathi* is the first documented record from the Italian peninsula south of Livorno (Piazzi et al. 2009) and the southernmost in the central-western Mediterranean. With this finding Sicily becomes the closest point between geographic distributions of southern *P. tortonesei* and northern *P. bathi*, however, that still remain distinct and not overlapping (Fig. 1).

The characteristics of locality of the new record, despite being intermediate between the western and eastern *P. bathi* populations, indicates that species distribution could be really fragmented, contrary to expectation that each new record contributes to the knowledge on possible continuous distribution of the species within its range. The fragmented distribution of *P. bathi* could be an effect of postglacial regression led by local climatic factors, as already suggested

Fig. 3 **a)** Lake Faro. The squares indicate the sampling stations where specimens of *Pomatoschistus bathi* have been recorded. **b)** *P. bathi* photographed at Lake Faro in May 2017, photo A. Spinelli. Arrow indicates the specimen



by Miller (1982) about the presence of *P. bathi* in the Sea of Marmora (*locus typicus*). In fact, the known Mediterranean areal of *P. bathi* perfectly overlaps those areas that are characterized by the coldest surface waters (Jalali et al. 2016), mostly due to the coaction of northerly dry winds and related upwelling, or with other processes as the issue of coolest water from the Dardanelles towards the East Aegean (Fig. 1). In such a context, the Strait of Messina is a singular point of coldest and nutrient enriched waters due to tidal-induced upwelling (Norton 1978) that has proven ingression in the Lake Faro (Saccà et al. 2008) and agrees with a prevalent North Atlantic-Mediterranean biogeographic pattern (Marra et al. 2016) and with recorded lake surface temperatures in this research (see Results).

Opposite to the habitats of *P. bathi*, the *locus typicus* of *P. tortonesei*, namely the “Stagnone di Marsala”, is a wide brackish area, which can be ascribed to the xero-Mediterranean lagoon complex, together with the facing North African lagoons that host *P. tortonesei* (Mejri et al. 2009a). The Miller’s (1982) prediction that *P. tortonesei* might occur in northern Mediterranean, maybe misidentified as *P. quagga* (Heckel 1840), overlooked habitat preferences of the species. The areal of the two related species are thus confirmed as climatically separated, although other discriminants should be also considered. *P. tortonesei*, in fact, is a strictly brackish species tolerating hyperhaline conditions (Mejri et al. 2009a), whilst *P. bathi* is a marine euryhaline species that prefers biotopes with low to moderately high salinity (Matić-Skoko et al. 2005). Both climatic and edaphic constraints, however, do not explain the absence of *P. tortonesei* in the suitable habitats of the south eastern Mediterranean (Miller 1982), for which causes might be found in the post-Messinian and post-glacial Mediterranean evolution (Mejri et al. 2009b). The same “historical” causes together with the small size of such gobiids and low dispersal capacity, might be responsible of a restricted gene flow recorded between the Sicilian and north-African populations of *P. tortonesei* (Mejri et al. 2009b) and, inside the latter, westwards and eastwards of the Strait of Sicily biogeographic breakpoint (Mejri

et al. 2012). It is possible that such different success of the two superficially similar species in terms of areal expansion was primary due to the intrinsic discontinuity of the brackish environments inhabited by *P. tortonesei*. In fact, although both species may be considered poor swimmers, *P. tortonesei* is a non-migratory, euryhaline species which spends its entire life in lagoons (Miller 1986), whilst *P. bathi* could be found in pure marine conditions, approaching shallow waters seasonally (Boltachev et al. 2016). Such different behavior agrees with the regular presence of *P. tortonesei* (Mejri et al. 2009a) in contrast with the seasonal fluctuation of occurrence of *P. bathi* (Matić-Skoko et al. 2005), with spawning groups in spring and summer (Boltachev et al. 2016), as also observed in Lake Faro. The lack of regular investigations before the present research program could explain the overlook of earlier irregular occurrences of *P. bathi* in Lake Faro.

P. tortonesei is an endangered species, strictly protected both at regional and global level, whose supposed decline has been attributed to habitat loss and coastal pollution (Abdul Malak et al. 2011). In contrast, no conservation measures are in place for *P. bathi*, since it was assessed “Least Concern” (Herler et al. 2014), in accordance with the wide geographic distribution and increasing frequency of records. On the other hand, the apparent expanding of *P. bathi* might be due to new techniques of investigation as in the Black Sea, where *P. bathi* might be native but not found earlier due to its small size (Vasil’eva and Bogorodskii 2004). There are no known threats to this species, although locally it may be a minor component of the shrimp trawl bycatch (Zengin and Akyol 2009). This reassuring state of *P. bathi*, however, does not take into account the potential effect of ongoing climatic changes on Mediterranean ecosystems and related biodiversity. Projected climate change in the Mediterranean Sea, in fact, involves a significant loss of climatically suitable habitat for endemic fish species and loss of small and low trophic-level fishes (Albouy et al. 2013). In this regard, Coll et al. (2010), showed that in the Western Mediterranean the northward shift of the “14 °C divide” allowed native but “meridional” warm-water species to colonize the northern sectors. In agreement

with a postulated scenario in which the Gulf of Lions and the northern Adriatic will represent the last Mediterranean cool enclaves (Somot et al. 2006), a generalized areal regression and fragmentation of strictly cold-water species, as *P. bathi*, is predictable. The Strait of Messina, as ultimate refuge of cold-water species at lower latitudes, includes relict brackish environments, which have proved to be hot spots of biodiversity (Marra et al. 2016). In such environments, whilst a census of the resident species is still far from being defined, decline of native and endemic taxa versus increasing introduction of not indigenous species has been recorded (Marra et al. 2016). As far as concerns the goby fauna, the present record closely follows the first one from Italy of the probably native *Millerigobius macrocephalus* (Giacobbe et al. 2016) and the first one from Sicily of the invasive *Knipowitschia panizzae* (Spinelli et al. 2016). The recent records of “rare” goby fishes from transitional waters in the Strait of Messina, a recognized refuge area for cold-temperate species (Norton 1978), testify that a disregarded and apparently marginal basin may be significant in terms of biodiversity conservation and, although driven by a pluri-millenary interaction with local human cultures, represents a profitable case-study on the conservation dynamics in human-mediated marine ecosystems.

Acknowledgements This research has been sponsored by the “Città Metropolitana di Messina”, the official management body of the reserve. Facilities have been provided by the mussel farm FARAU s.r.l.

References

- Abdul Malak D, Livingstone SR, Pollard D, Polidoro BA, Cuttelod A, Bariche M, Bilecenoglu M, Carpenter KE, Collette BB, Francour P, Goren M, Kara MH, Massuti E, Papaconstantinou C, Tunesi L (2011) Overview of the conservation status of the marine fishes of the Mediterranean Sea. IUCN, Gland, pp 1–6
- Adams A, Reeve L (1850) The zoology of the voyage of H.M.S. Samarang; under the command of Captain Sir Edward Belcher C.B., F.R.A.S., F.G.S., during the years 1843–1846. Reeve, Benham & Reeve: London. Parts I–III, pp. 1–79
- Ahnelt H, Dorda J (2004) Gobioid fishes from the north eastern Atlantic and the Mediterranean: new records and rarely found species. *Annalen des Naturhistorischen Museums in Wien* 105(1):5–19
- Albouy C, Guilhaumon F, Leprieur F, Ben Rais Lasram F, Somot S, Aznar R, Velez L, Le Loc'h F, Mouillot D (2013) Projected climate change and the changing biogeography of coastal Mediterranean fishes. *J Biogeogr* 40:534–547
- Ascherson P (1870) Meeting Report Society of Friends of Nature Researching in Berlin on February 16, 1869. [Sitzungs-Bericht Gesellschaft naturforschender Freunde zu Berlin am 16 Februar 1869]. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1869:4
- Boltachev A, Karpova E, Vdodovich I (2016) Distribution, Biological and ecological characteristics of alien species *Pomatoschistus bathi* Miller, 1982 (Gobiidae) in the Black Sea. *Turk J Fish Aquat Sci* 16: 113–122
- Bruguère JG (1789) Encyclopedie methodique ou par ordre de matières. Histoire naturelle des vers, Vol. 1, part 1. Pancoucke, Paris, pp 1–344
- Coll M, Piroddi C, Steenbeek J et al (2010) The biodiversity of the Mediterranean Sea: estimates, patterns and threats. *PLoS One* 5(8): e11842
- Dufour F, Guidetti P, Francour P (2007) Comparison of fish inventory in Mediterranean marine protected areas: influence of surface area and age. *Cybio* 31(1):19–31
- Engin S, Irmak E, Seyhan D et al (2016) Gobiid fishes of the coastal zone of the northeastern Aegean Sea. *Mar Biodivers* 2016. doi:10.1007/s12526-016-0550-x
- Gmelin JF (1791) Caroli a Linné, systema naturae. Tom. I. Pars VI. Lipsiae, Beer, pp 3021–3910
- Giacobbe S, Spinelli A, De Matteo S, Kovačić M (2016) First record of the large-headed goby, *Millerigobius macrocephalus* (Actinopterygii: Perciformes: Gobiidae), from Italy. *Acta Ichthyol Piscat* 46(1):49–52
- Heckel JJ (1840) Ichthyologische Beiträge zu den Familien der Cottoiden, Scorpaenoiden, Gobioiden und Cyprinoiden. *Annl n naturh Mus Wien* 2:145–164
- Herler J, Williams JT, Kovačić M (2014) *Pomatoschistus bathi*. The IUCN Red List of Threatened Species 2014: e. T194882A49082738. doi: 10.2305/IUCN.UK.2014-3.RLTS.T194882A49082738.en
- Jalali B, Sicre MA, Bassetti MA, Kallel N (2016) Holocene climate variability in the north-western Mediterranean Sea (gulf of lions). *Clim Past* 12:91–101
- Kovačić M (2005) An annotated checklist of the family Gobiidae in the Adriatic Sea. *Annales, Series Historia Naturalis* 15(1):21–44
- Linnaeus C (1758) Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima, reformata. Holmiae, Salvius, pp 1–4, 1–824
- Marra MV, Bertolino M, Pansini M, Giacobbe S, Manconi R, Pronzato R (2016) Long-term turnover of the sponge fauna in Faro Lake (north-East Sicily, Mediterranean Sea). *Italian Journal of Zoology* 83(4): 579–588
- Matić-Skoko S, Peharda M, Pallaoro A, Franičević M (2005) Species composition, seasonal fluctuations, and residency of inshore fish assemblages in the Pantan estuary of the eastern middle Adriatic. *Acta Adriat* 46(2):201–212
- Mejri R, Menif D, Louiz I, Ben Hassine OK (2009a) First record of Tortonese’s goby, *Pomatoschistus tortonesei*, from Tunisia. *Cybio* 33(1):85–87
- Mejri R, Lo Brutto S, Kalthoum Ben Hassine O, Arculeo M (2009b) A study on *Pomatoschistus tortonesei* Miller 1968 (Perciformes, Gobiidae) reveals the Siculo-Tunisian Strait (STS) as a breakpoint to gene flow in the Mediterranean basin. *Mol Phylogenet Evol* 53: 596–601
- Mejri R, Lo Brutto S, Hassine N, Arculeo M, Kalthoum Ben Hassine O (2012) Overlapping patterns of morphometric and genetic differentiation in the Mediterranean goby *Pomatoschistus tortonesei* Miller, 1968 (Perciformes, Gobiidae) in Tunisian lagoons. *Zoology* 115: 239–244
- Miller PJ (1982) A new *Pomatoschistus* from the Mediterranean, and redescription of *P. tortonesei* Miller 1968. *Senckenbergiana Biology* 62:5–19
- Miller PJ (1986) Gobiidae. In: Whitehead PJP, Bauchot M-L, Hureau J-C, Nielsen J, Tortonese E (eds) *Fishes of the North-eastern Atlantic and the Mediterranean*. UNESCO, Paris, pp 1019–1085
- Norton TA (1978) Mapping species distribution as a tool in marine ecology. *Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences* 76B:201–213
- Piazzi L, Cecchi E, Guerrieri S, Serena F (2009) Il popolamento ittico di Calafuria (livorno). *Atti Soc Tosc Sci Nat mem* 116B:73–79

- Saccà A, Guglielmo L, Bruni V (2008) Vertical and temporal microbial community patterns in a meromictic coastal lake influenced by the straits of Messina upwelling system. *Hydrobiologia* 600:89–104
- Schliewen UK, Kovačić M (2008) *Didogobius amicuscaridis* spec. Nov. and *D. wirtzi* (Perciformes, Gobiidae). *Spixiana* 31(2):247–261
- Somot S, Sevault F, Déqué M (2006) Transient climate change scenario simulation of the Mediterranean Sea for the twenty-first century using a high-resolution ocean circulation model. *Clim Dyn* 27: 851–879
- Spinelli A, Costagliola A, Giacobbe S, Kovačić M (2017) First record from Sicily of the Adriatic dwarf goby, *Knipowitschia panizzae* (Osteichthyes, Gobiidae), a threatened species or a threat for conservation? *Marine biodiversity* 47:237–242. doi: [10.1007/s12526-016-0455-8](https://doi.org/10.1007/s12526-016-0455-8)
- Tunesi L, Molinari A, Agnesi S, Di Nora T, Mo G (2005) Presence of fish juveniles in the Ligurian coastal waters: synthesis of available knowledge. *Biol mar Mediterr* 12(1):455–459
- Vasil'eva ED, Bogorodskii SV (2004) Two new species of gobies (Gobiidae) in the ichthyofauna of the Black Sea. *J Ichthyol* 44: 555–562
- Zengin M, Akyol O (2009) Description of by-catch species from the coastal shrimp beam trawl fishery in Turkey. *J Appl Ichthyol* 25(2):211–214