



The Northernmost Records of *Caranx crysos* (Osteichthyes: Carangidae) in the NW Mediterranean Sea

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Abstract

From October 2018 to November 2022 three individuals of blue runner (*Caranx crysos*) were caught in the coastal waters of the Ligurian Sea, NW Mediterranean basin, and three more ones were observed therein. On one specimen we carried out meristic counts and morphometric measurements, estimated the age by means of otoliths, observed gonadic development, investigated the stomach content, and calculated the hepato-somatic index. Being in the extreme north of the western Mediterranean, these new records represent the northernmost records of the distribution range of this species in the western Mediterranean Sea. Such new step indicates the completion of the expansion of the blue runner along the whole basin. All the observed individuals were adults, thus preventing us from assessing by now the actual establishment of the species in the Ligurian Sea, where, however, it is likely that the ongoing sea water warming could favour the spreading of this species in the future.

Keywords Blue runner · Ligurian Sea · Meridionalization · Range expansion · Thermophilic species · Water warming

Introduction

The blue runner *Caranx crysos* (Mitchill, 1815) is a coastal pelagic carangid, whose adult common size is around 400 mm (Sley et al. 2009). Length-at-maturity is reported to be around 210–250 mm when the individuals are 2.4–2.8 years old (Sley et al. 2012). Spawning season takes place from June to August in the Mediterranean Sea (Sley et al. 2009, 2012). Juveniles are commonly associated with floating objects (D’Anna et al. 1999), while adults associate

to rocky reef habitats (Azzurro 2008). It is an opportunistic predator, whose diet is mainly composed by pelagic bony fishes (chiefly belonging to families like Engraulidae, Clupeidae and Belonidae) and, to a lesser extent, by pelagic invertebrates (such as crustaceans and cephalopods), and benthic fishes (Sley et al. 2009; Iveša et al. 2021).

The blue runner has an amphi-Atlantic distribution with subtropical affinity, the core of its distribution range is in the western Atlantic, from Nova Scotia (Canada) to Brazil, and in the eastern Atlantic, from Senegal to Angola (Bañón Díaz and Casas Sánchez 1997). The species is present also in the Mediterranean Sea, where, until a few decades ago, was common only in the Levantine waters (Psomadakis et al. 2011).

Recently, the species has expanded towards higher latitudes both in the Atlantic Ocean and the Mediterranean Sea, likely favoured by the global raise of sea water temperatures (Azzurro 2008; Psomadakis et al. 2011; Iveša et al. 2021).

In the eastern Atlantic, it started spreading north from its main distribution area just before the 1990s, with scattered records occurring in the Bay of Biscay from 1988 to 2004 (Iglesias et al. 2020), in southern UK waters in 1993 (Swaby et al. 1996), off Galicia in 1996 (Bañón Díaz and Casas Sánchez 1997), in Madeira (Wirtz et al. 2008), and along the northern French coast in 2018 (Iglesias et al.

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2020). In the western Atlantic, across the last decades, the blue runner has shown a few hints of expansion towards higher latitudes both in the southern and northern hemisphere, reaching Argentinian coasts and the Newfoundland (Canada) in 2008 and 2013, respectively (Delpiani et al. 2011; Devine and Fisher 2014).

In the Mediterranean Sea, starting from the middle 1990s, the species has undertaken a westward and northward spread from the Levantine waters. It was first recorded in the Balearic Islands (Riera et al. 1995) and then along the Tunisian coasts, where it has quickly become fairly common (Sley et al. 2009). From the end of the 1990s it has been repeatedly censused in Sicily (D'Anna et al. 1999; Vacchi et al. 1999), and a few years later, in mid and late 2000s, it has been recorded also in other sectors of southern Italy, including the catch of two adult individuals off Civitavecchia (north to Rome) in 2007 as the northernmost record of the blue runner for the western Mediterranean Sea until now (Psomadakis et al. 2011). In the subsequent years, no other reports of the species came out concerning the western Mediterranean basin.

In the Adriatic Sea, the first individual was documented in 2008 near the coast of the Istria Peninsula (Croatia) (Dulčić et al. 2014), which represented until now the northernmost record of this species in the whole Mediterranean Sea. In 2013 and 2014 a few individuals were caught or photographed along the Montenegrin and Croatian coasts (Dulčić et al. 2014; Pavičić et al. 2014; Nerlović et al. 2015). One more individual was caught in 2018 off Istria (Iveša et al. 2021), and the species is reported as fairly frequent in

the commercial catches in the central Adriatic Sea during the last years (Tomanić et al. 2022).

Here we report the first records of the blue runner from the Ligurian Sea, representing the northernmost distribution area of the species in the western Mediterranean Sea.

Materials and Methods

From October 2018 to November 2022 three individuals of blue runner were caught and further three sighted underwater in the coastal waters of the Ligurian Sea (Fig. 1). The first occurrence dates back to October 16th, 2018, when a blue runner (Fig. 2a) was caught by means of a gillnet off Punta Chiappa (44°19'20"N, 9°08'40"E), inside the Marine Protected Area of Portofino (Genoa, Italy), on rocky reefs at about 35 m depth. A second individual was caught on November 6th, 2022 (Fig. 2b) by means of a gillnet set off Lavagna (44°17'40"N, 9°20'50"E, Genoa, Italy), close to offshore aquaculture structures, between 10 and 23 m depth, on a sandy bottom interspersed with boulders. A third blue runner was caught from a group of four individuals on November 19th, 2022 (Fig. 2c) by a spearfisher at Punta Crena, Varigotti (44°10'50"N, 8°24'30"E, Savona, Italy) on rocky reefs between 10 and 25 m depth.

On the specimen caught off Lavagna meristic counts and morphometric measurements were carried out. The otoliths were inspected for age estimation, immersed in 70% ethanol, after cleaning with 3% solution of hydrogen peroxide. We recorded stomach weight and content, and gonad's weight and stage of development. Liver was weighed to determine

Fig. 1 Map illustrating the locations where the blue runner records in the Ligurian Sea occurred. The icons indicate whether the individuals were caught by means of net or observed and/or spear-fished under water

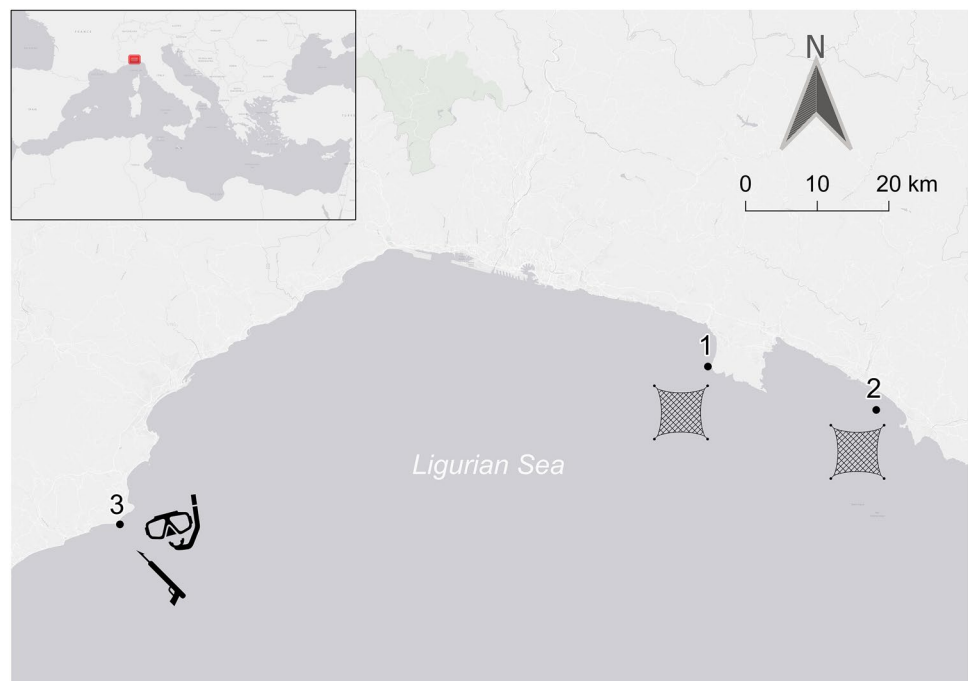
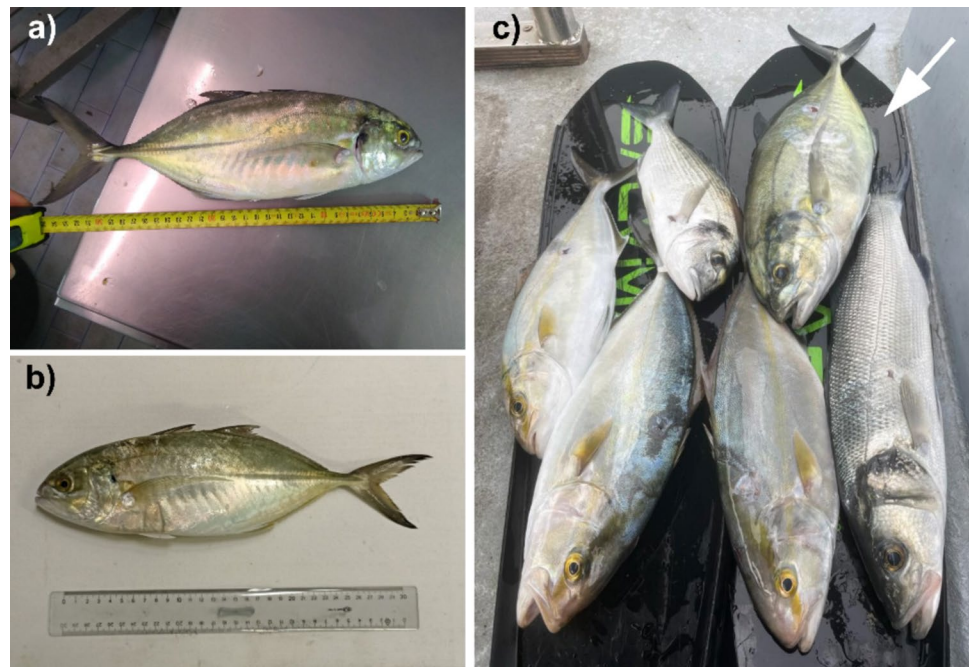


Fig. 2 The blue runners fished in the Ligurian Sea in 2018 and 2022 off **a** Portofino, **b** Lavagna and **c** Varigotti. In **c** the blue runner is indicated by a white arrow



the hepato-somatic index (HSI) as ratio between liver and gutted weight. Measurements were taken by means of a caliper with an accuracy of 0.1 mm and an ichthyometer with an accuracy of 0.1 cm, while weightings were done with a digital scale with an accuracy of 0.1 g. Standard length, fork length, total length and total weight were collected on the fresh sample, then the specimen was stored at $-20\text{ }^{\circ}\text{C}$ and other measurements and analyses were done after defrosting it at room temperature.

Results

The three caught blue runners for which we have pictures and/or sample had common morphological characteristics: laterally compressed body with oval profile, narrow caudal peduncle, sinuous lateral line with hard scutes in their posterior part, widening towards the peduncle. The livery was yellowish olive green coloured in the dorsal portion of the body, lighter to pearlescent along the flanks and ventrally, a dark spot was clearly visible on the edge of the operculum, and the eye showed a yellow sclera.

Being from 35 to 40 cm in terms of estimated or measured total length (TL), the individuals caught in the Ligurian Sea were adults, following Sley et al. (2012). Furthermore, the spearfisher reported that the individuals sighted at Varigotti were swimming along with the speared one and had a similar size around 35 to 40 cm (TL). Meristic features and morphometric measurements carried out on the analysed specimen (Table 1) were coherent with the general characteristics of the species (see *e.g.* Pavičić et al. 2014; Nerlović

et al. 2015). The age of the analysed specimen was estimated to be 4 years based on the otolith growth rings (Fig. 3). It was a female individual with spent gonads. The stomach was empty and weighed 6.9 g, while the liver, developed around

Table 1 Morphometric measurements, weights and meristic counts of the blue runner specimen fished off Lavagna (Genoa, Italy)

Morphometry/meristic	Measure (mm or g), or counts	% TL
Total length (TL)	365	100
Fork length	313	85.8
Standard length	302	82.7
Head length	78.5	21.5
Eye diameter	14.6	4.0
Preorbital length	23.8	6.5
Postorbital length	42.8	11.7
Predorsal length	100.1	27.4
Pectoral fin length	91.8	25.2
Maximum depth	90.7	24.8
Minimum depth	10.2	2.8
Total weight	590.7	
Gutted weight	537.7	
First dorsal fin	VII	
Second dorsal fin	I+21	
Anal fin	II+I+18	
Pectoral fin	I+20	
Ventral fin	I+5	
Caudal fin	V+28+V	
Lateral line scales	102 (50 scutes)	



Fig. 3 Otolith of the blue runner caught off Lavagna, slightly broken in the top right. The white dots indicate the growth rings

both sides of the stomach pouch, weighed 13.8 g, resulting in a HSI=0.03.

Discussion

The blue runner is among the thermophilic Mediterranean fish species that are reported to have undergone a northward expansion in relatively recent years, thus contributing to the ‘meridionalization’ of the northern sector of the basin (Azzurro 2008; Psomadakis et al. 2011).

The blue runner records reported here represent the first documented occurrences of the species in the Ligurian Sea, *i.e.* they are the northernmost records in the western Mediterranean. Considering the expansion of the species up to the northern Adriatic Sea (Dulčić et al. 2014) and the records up to Civitavecchia in the western sector (Psomadakis et al. 2011), the Ligurian Sea was the last

northern corner of the Mediterranean where this thermophilic species had never been seen before.

Most of the individuals here reported were caught or observed in correspondence with rocky reef habitats, which are reported as the preferential habitats of the blue runner (Rizzo et al. 2021). Our record in correspondence to the fish farming cages off Lavagna suggests that adults too can display a clear thigmotropism, which is usually observed during the juvenile stages (D’Anna et al. 1999; Devine and Fisher 2014).

On one hand, these new records represent the last pieces of the puzzle that complete the northern distribution shift of the species in the Mediterranean Sea described by Psomadakis et al. (2011). On the other hand, the fact that all the individuals were adults, prevents us from assessing the establishment of the blue runner in the Ligurian Sea. It is likely that these adult individuals were not resident but arrived by means of an active migration, as hypothesised for the records from the Adriatic Sea (Pešić et al. 2021). This is partly supported by the timing of these records, all occurring in Autumn, when the water is still warm.

Anyway, a future establishment of local populations, including reproduction and juvenile settlement, is not to be excluded. As a reference, along the southern Italian coasts, from Sicily to Campania, the species was absent until a few decades ago (Psomadakis et al. 2011), but after the first scattered records the species rapidly became quite common, along with the presence of juveniles (D’Anna et al. 1999; Rizzo et al. 2021).

Until now, the low winter temperature of the Ligurian Sea could have inhibited the presence of the thermophilic blue runner all year round (Devine and Fisher 2014), but the situation could change due to the ongoing sea water warming. If established, the blue runner could spread as it happened elsewhere (Sley et al. 2009; Rizzo et al. 2021), with potential overcompetition on species at similar trophic level and/or on prey. As its diet is mainly constituted by small pelagic fishes (Sley et al. 2009) representing important fishing resources in the Ligurian Sea, the spreading of the blue runner could also have negative socio-economic repercussions. For these reasons, we think it is important to keep monitoring the spread of the species in this sector of the Mediterranean basin through collaborative relationships with local fishers, citizen engagement, visual census activities and planktonic surveys of eggs and larvae.

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and shared data of the individuals sighted and caught at Varigotti. We like to thank Erica Carlig and Laura Ghigliotti (CNR-IAS) for the provision of the laboratory facilities.

Author Contributions All the authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Davide Di Blasi, Simone Bava, Elena Desiderà, Lorenzo Merotto and Federica Poli. The first draft of the manuscript was written by Davide Di Blasi and Paolo Guidetti and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials All the data for the work are present in the manuscript.

Declarations

Ethical Approval All the specimens were caught by professional and recreational fishermen, so there was not an extractive sampling design for this work. For this, ‘Ethical Approval’ is not applicable.

Competing Interests The authors declare no competing interests.

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