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Abundance, distribution and habitat preference of *Hippocampus guttulatus* and *Hippocampus hippocampus* in a semi-enclosed central Mediterranean marine area

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Abstract

Population abundance, distribution and habitat preference of the Mediterranean sympatric seahorses *Hippocampus guttulatus* and *Hippocampus hippocampus* were investigated in a semi-enclosed sea system (Apulian coast, Ionian Sea). A total of 242 individuals of seahorses were sighted in the 11 transects surveyed in summer 2011. *Hippocampus guttulatus* ($n = 225$) were 14 times more abundant than *H. hippocampus* (17). The mean abundance of *H. guttulatus* for all the pooled sites was 0.018 m^{-2} ($\text{SE} \pm 0.003$) ranging from a maximum of 0.035 ($\text{SE} \pm 0.007$) to a minimum of 0.008 ($\text{SE} \pm 0.002$). The size structure of long-snouted seahorse shows a population ranging from 7 to 14 cm (SL) with a peak at 10 cm (TL). Juveniles (96.0 ± 8.0 mm) represent a significant fraction of the population, accounting more than 21% of the sighted individuals. In Mar Piccolo, *H. guttulatus* is able to shelter both in monotonous habitats, including the algal beds, and diversified ones, such as the rich filter-feeder communities that colonize hard substrates. By contrast, *H. hippocampus* is mainly associated with habitats of low complexity. Today, the Mar Piccolo di Taranto is among the most heavily polluted water bodies in South Italy, with trace metals, hydrocarbons, pesticides and organic wastes affecting both biotic and abiotic matrices. However, despite the high level of degradation, the presence of a large mussel farm has avoided the impact of towed fishing gears, and eutrophication of water bodies has ensured a high trophic level that supports large crustacean populations, potential prey for seahorses.

Introduction

Worldwide, seahorse (*Hippocampus* Rafinesque 1810 spp.) populations and their relatives in the family Syngnathidae (pipefishes, seadragons and pipehorses) are threatened by (i) degradation of their estuarine, seagrass, mangrove and coral habitats (Olden *et al.* 2007), (ii) incidental capture in fishing gear (bycatch) (Vincent 1996), and (iii) over-exploitation for use in traditional medicines and in the aquarium trade (Salin *et al.* 2005). Moreover, seahorses

have life histories, behaviour and ecology that make them particularly vulnerable to population decline (Foster & Vincent 2004): they provide lengthy and vital parental care for small broods, exhibit low mobility and high site fidelity, have low natural rates of adult mortality, and (in many species) maintain faithful pairbonds (Lourie *et al.* 1999; Vincent *et al.* 2011). In addition, seahorses inhabit shallow, coastal areas worldwide, where anthropogenic disturbances tend to be the most frequent and severe, and represent the main threat to their integrity. The

decline of seahorse populations worldwide has therefore been brought to the attention of the international community, leading to their classification as threatened species, and their inclusion on the World Conservation Union Red List of Threatened Species (Vincent & Hall 1996; World Conservation Union 2002) and, in 2002, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2002).

In particular, *Hippocampus guttulatus* Cuvier, 1829 and *Hippocampus hippocampus* Linnaeus, 1758 – the two Mediterranean species of seahorses – are also listed under OSPAR, European CITES (Curd 2009), the Bern Convention and the Barcelona Convention (Abdul Malak *et al.* 2011) and protected by the UK Wildlife and Countryside Act of 2008 (DEFRA 2008). However, as few data are available across most of their geographic range, neither species can be reliably classified in terms of global level risk according to IUCN categories, and they are listed, at present, as data-deficient (DD).

Along the Italian coasts, the trend of *Hippocampus* populations (*H. guttulatus* and *H. hippocampus*) is very similar to that described for other seahorse species in coastal areas worldwide (Vincent *et al.* 2011). Until 1980, sightings of seahorses along Italian coasts were frequent, with individuals of both species often being accidentally taken as bycatch by trammel nets and trawlers. However, in the last few decades the degradation of sensitive habitats, the use of illegal fishing gear on coastal biocenoses, and the development of snorkelling and SCUBA diving have slowly but inexorably reduced seahorse population densities, structure and spatial distribution. As a result, in the last decade, seahorse sightings have been rare or scanty along most of the Italian coast and populations appear scattered, showing peaks of abundance in the Northern Tyrrhenian (Tuscany and Liguria) and Northern Adriatic Seas (Goffredo *et al.* 2004). Paradoxically, species which have been included on the World Conservation Union Red List of Threatened Species and are protected by several international conventions (CITES 2002) appear to have found suitable habitats in heavily anthropic areas. Indeed, *Hippocampus* spp. populations now appear to be mainly concentrated in harbours, mussel farms or artificial structures, which provide shelter from the direct impact of mechanical human activities (commercial fishing, dredging, dumping, SCUBA diving, snorkelling).

In this paper, we describe the *Hippocampus* populations (*H. guttulatus* and *H. hippocampus*) in the semi-enclosed sea system around the city of Taranto (Apulian coast, Ionian Sea). The first scientific report of seahorses in the Mar Piccolo of Taranto dates back to Cerruti (1938). Later, Parenzan (1969) reported the occurrence of *Hippocampus* in association with photophilous algal beds

(mainly '*Caulerpa*, *Rhytiphloea*, *Gracilaria* spp., *Chaetomorpha* and *Cladophora prolifera*'). According to older local fishermen, in the last century, seahorses were frequently sighted and collected as bycatch during traditional fishing activities. Moreover, fishermen report a remarkable increase in seahorse sightings in the last 50 years, with the spread of mussel farming. According to this scenario, the increase in pools and hard structures utilized by farmers had strongly reduced the fishery, thus reducing sea horse captures. Purse seining, which up to the middle of the 20th century was the prevalent fishing activity within the Mar Piccolo, is now only very occasionally used, and is confined to a few tracts along the eastern coast of the inner inlet (Fig. 1).

Today, the Mar Piccolo di Taranto is among the most heavily polluted water bodies in Southern Italy. Surrounding urban developments are known and presumed to have affected the semi-enclosed sea ecosystem with trace metals, hydrocarbons, pesticides and organic wastes (Cardellicchio *et al.* 2007; Petronio *et al.* 2012). However, despite the high level of degradation, the presence of a large mussel farm avoids any impact from towed fishing gears and the eutrophication of the water bodies ensures a high trophic level that supports large crustacean populations, mainly amphipods, which are potential prey for seahorses (Prato & Biandolino 2003).

In the present paper, our main objectives were to (i) assess the abundance of the local population; (ii) evaluate differences in habitat preference; (iii) describe the spatial distribution of *Hippocampus* populations in the semi-enclosed sea system of the Mar Piccolo. To achieve these goals, a visual census survey (during summer 2011) was carried out at 11 stations representative of the main benthic habitats and distributed along a confinement gradient. Abundance of the two species was then compared across different stations and substrates, and habitat preference was established.

Methods

Study species

The long-snouted (*Hippocampus guttulatus*) and the short-snouted (*H. hippocampus*) seahorse are notable residents of European coastal waters. Both species inhabit shallow inshore waters, mainly in seagrass meadows and algal beds from the Eastern Atlantic to the Western Mediterranean (Lourie *et al.* 2004).

Hippocampus hippocampus occurs in shallow coastal waters from the North Sea, down the European coast and into the Mediterranean Sea. Its geographic range extends down the Atlantic African coast as far as Senegal, including the Atlantic islands of the Azores, Madeira and

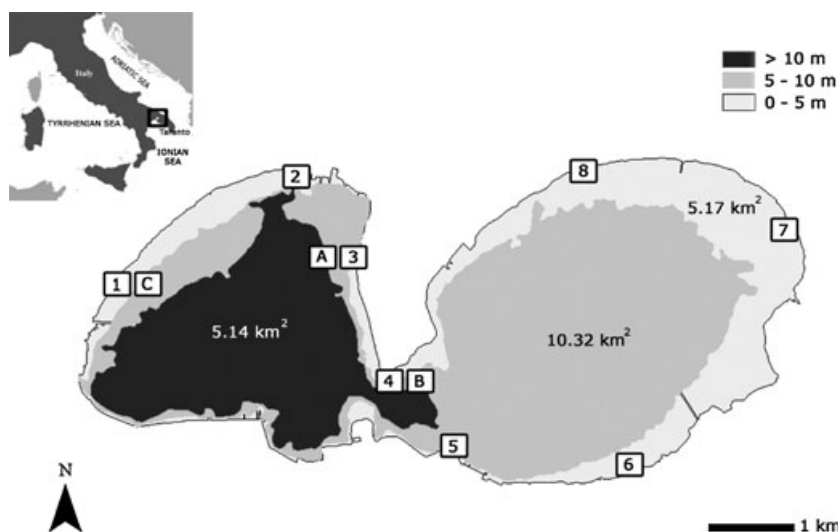


Fig. 1. Mar Piccolo di Taranto. Location of 11 underwater visual census sites: 1–8 subtidal sites 0.5–5 m depth; A–C deep sites (5.1–10 m depth). Surface area per stratum is also indicated.

Canaries (Lourie *et al.* 2004). Exact locations for the populations are unknown, but it is expected that seahorses usually occur at low densities along the coastline (L. Woodall personal observations).

Hippocampus guttulatus is present along the Atlantic coast from the UK, Ireland and Netherlands to the Mediterranean Sea. Distribution continues into the Mediterranean Sea and the Black Sea (Lourie *et al.* 2004). Although the two species are commonly distinguished by the presence or absence of skin filament, having a smooth or a filamentous appearance has proved to be an unreliable distinction. Otherwise, *H. guttulatus* and *H. hippocampus* can be identified (also *in situ*) by differences in head, snout and trunk shape (Lourie *et al.* 1999).

Study area description

The Mar Piccolo of Taranto (40°28'N, 17°16'W) is located at the northern end of the Gulf of Taranto (Ionian Sea). It has a total surface area of about 20.63 km² and consists of a system of two distinct inlets, called 'Primo' and 'Secondo Seno' (first and second inlet), the innermost of which receives an inflow from some small streams (Fig. 1). The Mar Piccolo is characterized by low water turnover and water movement. Water circulation is mainly due to water flowing through the main channel, supplied by tidal currents and by a powerful pump utilized for industrial purposes. Currents are moderate, anticyclonic, and more intense in the first inlet than in the second one, where they are more appreciable near the narrows which connect the two inlets (Capasso *et al.* 1989). Water temperature varies from 8.4 °C (December) to 26.8 °C (August). Salinity values are around 36‰ (Caroppo & Cardellicchio 1995).

Locally, however, continental inflows may determine a marked drop in salinity (25–20‰) (Corriero G. & Cardone F., unpublished data). Dissolved oxygen shows wide seasonal variability: from May to October, the oxygen deficit in the deep layers of the Mar Piccolo (from about 7 to 10 m in depth) can reach marked levels which are responsible for dystrophic events (Alabiso *et al.* 1997; Gaino *et al.* 2010). Soft bottoms are dominant, varying from muds to mixed sands. They are sparsely covered by patches of *Cymodocea nodosa*, currently reported to be in regression, and by large beds of unattached macroalgae (Cecere & Petrocelli 2009). Where plants are missing, large numbers of sabellids, molluscs and ceriantharia have colonized the soft bottoms. Hard substrates are very abundant and diversified, consisting mainly of stones and debris of human origin, ropes and material abandoned by mussel farmers and fishermen. In addition, there are several kilometres of stone walls along the coastline. The macrozoobenthic community is rather unique, characterized by very rich assemblages of filter feeders (mainly poriferans, hydrozoans, polychaetes, bryozoans, bivalves, crinoids and ascidians) that colonize all of the various types of hard substrate, forming pluristratified assemblages. Among the vagile fauna, amphipods – in particular *Gammarus aequicauda* – are dominant, with remarkable seasonal peaks. According to the literature (Kevrekidis & Koukouras 1989), this species – which in summer in the Mar Piccolo reaches densities of up to 7200 individuals per m² (Prato & Biandolino 2003) – plays a key role in the structure of benthic communities and is an important component in marine benthic food webs. The zooplanktonic community is rich, diversified and subject to seasonal changes in biomass, with autumn peaks (Belmonte *et al.* 2001).

Zooplankton composition and distribution shows a confinement gradient from the outer to the inner area (Belmonte *et al.* 2001) according to the model of paralic systems (Guelorget & Perthuisot 1992). A total of 119 taxa belonging to 15 phyla were surveyed in the Mar Piccolo; the abundance of zooplankton ranged from 53,917 ind. \cdot m⁻³ in the first inlet to 2720 ind. \cdot m⁻³ in the second inlet (Belmonte *et al.* 2001).

Underwater visual census

A preliminary survey was carried out in summer 2011 (June–September) to obtain a general overview of the Mar Piccolo's habitat features and spatial distribution of the *Hippocampus* spp. As a consequence, in summer 2012 (from June to September) a total of eight sites were surveyed by SCUBA diving (Fig. 1). Surveys were carried out using standard underwater visual census (UVC) techniques (Samoilys 1997). For each site, two stations were set up, and for each station two randomly selected 2 × 150 m linear transects were monitored. The transects were located perpendicular to the coastal line at a depth of between 0.5 and 5 m, and were >50 m apart. Although during the preliminary survey the bulk of seahorse individuals was concentrated in the subtidal area (0.5–5 m depth), to experimentally verify the bathymetric range occupied by *Hippocampus* spp. populations, three additional sites (A–C) were chosen at depths of between 5.0 and 10.0 m. This sampling design enabled a total area of about 26,400 m² to be surveyed.

For each seahorse sighted on the transects, sex, total length and life stage (juvenile or adult) were recorded *in situ*; to obtain further biometric information, all specimens encountered were photographed with a ruler placed as close to them as possible (Curtis *et al.* 2004). *Hippocampus guttulatus* specimens were considered juveniles if they were <50% size at maturity, corresponding to 96.0 ± 8.0 mm (TL) (Curtis 2004). Moreover, for each sighting, information on depth and habitat was recorded. Data on population density used in the subsequent analysis were averaged among transects within sites. Finally, the abundance of homogeneous habitat structures was estimated as percent cover of the surveyed area for each transect. Using sedimentological and biological features of the sea bottom, SCUBA divers described and mapped (along each transect) the following different habitats:

- Pools with soft bottom (PWSB) – Wood pools are colonized by a rich sessile filter feeder fauna, with more than 100 species of zoobenthic invertebrates reported in the literature (Scalera-Liaci & Corriero 1993; Longo *et al.* 2004; Panetta *et al.* 2004; Mastrototaro *et al.* 2008; Pierri *et al.* 2010). This benthic assemblage is distributed in a pluristratified pattern. The basal layer is

mainly colonized by bivalves (*Mytilus galloprovincialis* and *Ostrea edulis*), demosponges (*Cliona* spp., *Hymeniacidon perlevis*, *Oceanapia isodyctiformis*, *Suberites carnosus*) and ascidians (*Styela* spp.). The epibenthic layer is characterized by various benthic facies, varying with depth. From the surface to about 1 m depth, macroalgae and sea anemones (*Anemonia sulcata*) largely prevail. From 1 m to about 3 m depth, the sabellids *Sabella spallanzani* and *Branchiomma luctuosum*, together with a dense community of soft hydrozoans and a few large encrusting colonial didemniidae, are dominant. At greater depths, the epibenthic layer species mainly consist of large specimens of the calcareous sponge *Paraleucilla magna*, serpulids (*Hydroides* spp.), large bioconstructions of the bryozoan *Schizoporella sanguinea* and large ascidians (*Microcosmus* spp., *Phallusia mammillata*). Due to the usual occurrence of large amounts of hard artificial substrates (ropes, chains, bricks) and benthic organisms (mussel shells, bryozoa), the soft bottom displaced around each pool was also sampled.

- Artificial hard substrates (AHS) – These substrates are colonized by macroalgal assemblages down to a depth of about 1 m; at the greatest depth they are heavily colonized by bivalves, gastropods (*Murex* sp.), large sabellids, both colonial and solitary ascidians, demosponges, bryozoans and hydrozoans.
- Vegetal beds *Cymodocea nodosa* (CYNOD), *Ulva* spp. (ULVA), *Chaetomorpha linum* (CLIN), *Cladophora prolifera* (CPRO). *Cymodocea nodosa* is the only phanerogam reported for the Mar Piccolo (Pierpaoli 1923; Cecere & Petrocelli 2009), with several scattered patches, varying greatly in size and density, occurring in both the inlets (Cecere & Petrocelli 2009). Seaweed beds consist of very monotonous habitats, with a few associated zoobenthic species (some gastropods, large opisthobranchs, the sea anemone *Aiptasia* sp.), mainly distributed in the upper layer of the phytocoenosis. A very rich vagile fauna, with a few species of amphipods and isopods, is usually associated with such algal beds.
- Soft bottom with scattered concretions (SBSB) – Near the coastline, soft bottoms are mixed with a large amount of organogenous concretions (bivalve and gastropods shells), small stones and artificial hard substrates, which are mainly colonized by sabellids and solitary ascidians.

Data analysis

To assess patterns of seahorse habitat preference in the Mar Piccolo subtidal area, a two-way design was used, including the following factors: 'Habitat' as a fixed factor with seven levels – *i.e.* soft bottoms with scattered

bioconcretions (SBSB), *Cymodocea nodosa* beds (CYNOD), *Chaetomorpha linum* beds (CLIN), *Ulva* beds (ULVA), pools with soft bottom (PWSB), Artificial hard substrates (AHS) and Muds (MUDS) – and ‘Sites’ as a fixed orthogonal factor with eight levels (Sites 1–8). Four random density replicates (number of individuals · 1 m⁻²) were considered for each combination of the above factors (n = 224). When ANOVA gave significant results, a *post hoc* comparison was performed using the Student–Newman–Keul (SNK) test. All the analyses were performed using GMAV_{INC}. Software (Underwood 1997).

On the basis of a bathymetric map (1: 20,000) provided by the Italian Military Geographic Institute and available from the Cartographic Service of the Apulia Region (http://sit.puglia.it/portal/sit_cittadino/Download/CTR-Uso+suolo-DTM-Ortofoto), the surface per stratum of the Mar Piccolo was calculated in both the inlets. In particular, using an ARCVIEW GIS ESRI 3.2 platform, the surfaces of the subtidal (0–5 m), intermediate (5.1–10 m) and deeper layers (>10 m) were estimated. Population sizes were estimated by extrapolating the mean densities of the subtidal and intermediate layer surfaces.

Results

A total of 242 individuals of seahorses were sighted along the 11 transects surveyed. *Hippocampus guttulatus* (n = 225) was 14 times more abundant than *H. hippocampus* (n = 17) (Table 1). *Hippocampus guttulatus* specimens were distributed at all sites surveyed, whereas *H. hippocampus* individuals were located only at sites 3, 4 and 6 (see Fig. 1). The mean abundance of *H. guttulatus* for all pooled sites was 0.018 per m² (SE ± 0.003), ranging from a maximum of 0.035 (SE ± 0.007) at site 3 to a minimum of 0.008 (SE ± 0.002) at site 1.

In particular, *H. guttulatus* density was higher at sites in the central area of the Mar Piccolo (sites 2, 3, 4, 5) (Fig. 1, Table 1), and less abundant in the outer and inner parts of

the semi-enclosed sea. The *H. hippocampus* mean density for all the pooled sites was, obviously, very low (0.0005 ± 0.0002 SE) with a peak at site 6 (0.003 ± 0.001 SE) located in the inner part of the Mar Piccolo (Fig. 1). The *H. guttulatus* sex ratio (females/total) was slightly female-biased (53.7%); sightings of *H. hippocampus* were too limited to calculate a proportion by sex.

The size (sexes combined) of long-snouted seahorse shows a population ranging from 7 to 14 cm (TL) with a peak at 10 cm (TL). Juveniles (with a size <96.0 ± 8.0 mm) represent a significant fraction of the population, accounting for more than 21% of the sighted individuals (Fig. 2). Unfortunately, there were too few sightings of *H. hippocampus* for a proper analysis of the population structure.

Hippocampus guttulatus density (data pooled across all sites) was broadly related to habitat characteristics. *Ulva* beds shelter the maximum density of long-snouted seahorse (0.058 ind.m⁻²), whereas no sightings were recorded on Muds. The two-way ANOVA analysis performed on *H. guttulatus* density revealed significant differences between ‘Sites’ and ‘Habitats’ (Table 2). The SNK test performed on the ‘Habitat × Sites’ combination shows no differences in habitat preference in sites 1 and 7 (Table 2, Fig. 1). ULVA was the favourite habitat at sites 2 and 5, whereas artificial structures (AHS and PWSB) were the preferred habitats at sites 3, 4 and 8 (Table 2, Fig. 3).

As reported in Fig. 1, the first inlet covers a total area of 8.01 km², with 1.19 km² within the bathymetric range 0–5 m, 1.93 km² within the bathymetric range 5.1–10 m and 4.89 km² deeper than 10 m. The second inlet covers a total area of 12.60 km², with 3.98 km² within the bathymetric range 0–5 m, 8.39 km² within the bathymetric range 5.1–10 m and 0.25 km² deeper than 10 m. Thus, considering the whole Mar Piccolo, the subtidal layer (0–5 m) covers a total of 5.17 km², whereas the 5–10 m layer measures about 10.32 km².

Table 1. Indices of abundance for *Hippocampus guttulatus* and *Hippocampus hippocampus*.

	Mar Piccolo subtidal sites								Mar Piccolo deep sites			pooled sites
	1	2	3	4	5	6	7	8	A	B	C	
<i>Hippocampus guttulatus</i>												
Total no.	8	31	28	25	34	22	9	10	4	4	1	176
Juveniles	2	8	14	12	5	5	1	2	0	0	0	49
Mean density (m ⁻²)	0.008	0.033	0.035	0.031	0.033	0.023	0.008	0.010	0.006	0.011	0.006	0.018
SE	0.002	0.003	0.007	0.004	0.006	0.003	0.002	0.003	0.000	0.000	0.002	
<i>Hippocampus hippocampus</i>												
Total no.	0	0	1	3	0	12	0	0	0	0	0	16
Juveniles	0	0	0	0	0	1	0	0	0	0	0	1
Mean density (m ⁻²)	0.000	0.000	0.001	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.0005
SE	0.000	0.000	0.0001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	

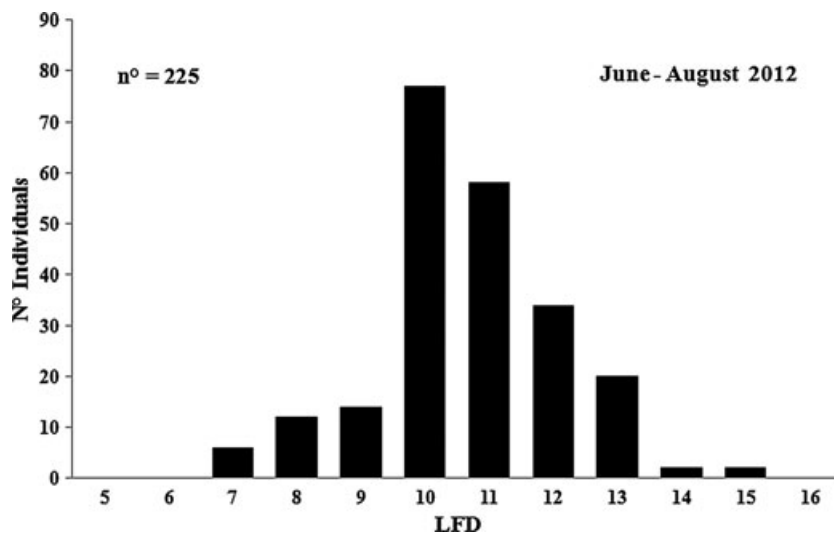


Fig. 2. Standard length-frequency distribution (sex combined) of individuals of *H. guttulatus* sighted from June to August 2012 (10 mm size classes).

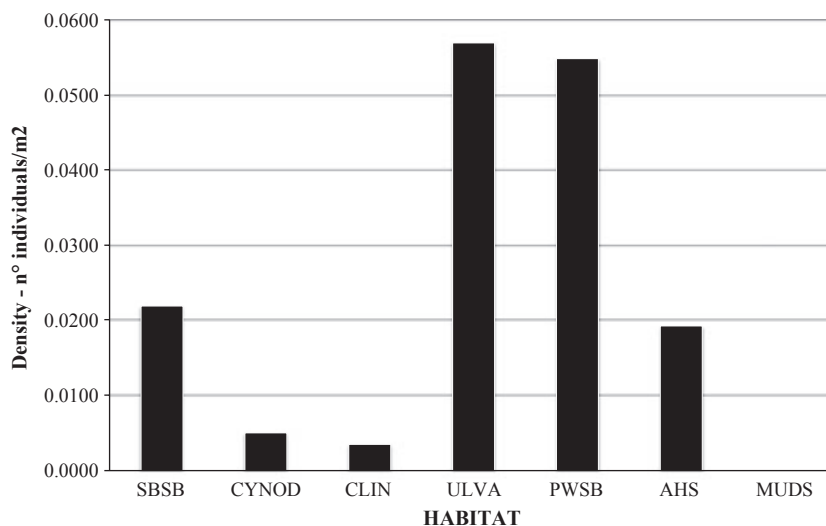


Fig. 3. Density of *Hippocampus guttulatus* in the surveyed habitats.

The estimate of population size shows a very high number of *H. guttulatus* individuals in the subtidal area [116,325 individuals, lower 95% confidence interval (CI) = 76,029; upper 95%CI = 156,621] and a less abundant fraction of the population in the intermediate stratum (5–10 m) (80,267 individuals, lower 95%CI = 47,316; upper 95%CI = 113,217). The *H. hippocampus* population is significantly small in the subtidal layer (3231 individuals, lower 95% CI = 1,878; upper 95%CI = 6,837) and completely absent in the intermediate layer.

Discussion

It is well documented that several seahorse species worldwide are targeted by fisheries in several countries (e.g. Vietnam, India), where they are dried for traditional

medicine markets (Zhang *et al.* 2003), for curiosities (Grey *et al.* 2005) or sold alive for the aquarium market (Martin-Smith & Vincent 2006). Moreover, several aspects of the seahorse's life strategies (*i.e.* small body size, paternal care, low mobility, sedentary adults and monogamous mating) (Foster & Vincent 2004) leave them particularly vulnerable to disturbance from human activities and sensitive to habitat degradation. European seahorse populations (*Hippocampus hippocampus* and *Hippocampus guttulatus*) in particular, which are not specifically targeted by fishing activities, are mainly threatened by accidental catch in towed fishing gears and by their sensitivity to habitat degradation (Woodall *et al.* 2011). According to the literature, *H. guttulatus* and *H. hippocampus* are considered to be organisms found in coastal habitats or ecosystems with good environmental

Table 2. Summary of the results of the Student–Newman–Keuls *post hoc* tests. Only significant interaction terms ($P < 0.01$) are reported.

Source	Df	SS	MS	F
Habitat	6	0.6639	0.1106	85.57***
Sites	7	0.2276	0.0325	25.14***
Habitat × Sites	42	0.9092	0.0216	16.74***
Residual	168	0.2172	0.0013	
Total	223	2.0179		
Habitat × sites SNK test				
SITES				
1	No differences			
2	ULVA > PWSB = AHS = SBSB > MUDES = CYNOD = CLIN			
3	AHS = PWSB > all			
4	AHS > PWSB = SBSB > all			
5	ULVA > PWSB > all			
6	PWSB > all			
7	No differences			
8	PWSB > all			

*** $P < 0.0001$.

status, very sensitive to environmental conditions and therefore a useful tool for analysing the environment health as a flagship species (Garrick-Maidment & Jones 2004). However, the present study describes seahorse populations (*H. guttulatus* and *H. hippocampus*) in a heavily polluted and human impacted semi-enclosed sea in Southern Italy. The estimated total abundance of seahorses in the two inlets of the Mar Piccolo di Taranto is really impressive, with values of 123,456–269,838 and 1878–6837 for *H. guttulatus* and *H. hippocampus*, respectively. Moreover, given the cryptic behaviour of seahorses and the poor water clarity in the study area, the mean density and population size of seahorses could be greatly underestimated. The long-snouted seahorse density recorded in the present study was comparable to that of similar sites in the Atlantic Sea (Curtis & Vincent 2005; Caldwell & Vincent 2012) and greater than that reported in the Mediterranean Sea (Goffredo *et al.* 2004), the latter being obtained by counting the number of seahorses per dive-hour. Length–frequency distribution (sex combined) of *H. guttulatus* shows a young population as whole, with a lack of large adults (more than 16 cm TL), and juveniles accounting for more than 21% of the population. Although a recruitment pattern is widely expected in the summer period, the juvenile fraction in the Mar Piccolo is abundant and, according to the literature (Woodall 2009), this would seem to reflect a good population status.

In the last three decades, the original landscape and ecology of the Mar Piccolo have been radically modified; soft bottoms have become dominant, varying from muds to mixed sands, whereas once-dominant sea grasses (*Cymodocea nodosa*) are now reported to be in regression, scattered in sparse patches and largely replaced by beds of

unattached macroalgae such as *Ulva* spp. and *Chaetomorpha linum* (Cecere & Petrocelli 2009). Moreover, since the 1970s, mussel farms have colonized most of the sea bottom surface, increasing the availability of hard substrates and forming a mechanical obstacle to fishing activities with towed gears. Despite the critical environmental conditions, the Mar Piccolo di Taranto shelters a wide population of seahorses. In agreement with the data of Ria Formosa lagoon (Curtis & Vincent 2005), the population of *H. guttulatus* appears to be more numerous and distributed over a wider area, whereas sightings of *H. hippocampus* are scanty and concentrated in particular areas. According to Curtis & Vincent (2005), *H. hippocampus* in Mar Piccolo is mainly associated with habitats of low complexity (site 6; Fig. 1), whereas in other sites with the greatest habitat heterogeneity, its presence is rare and scanty. By contrast, *H. guttulatus* is able to shelter both in monotonous habitats, such as algal beds, and in diversified ones, such as the rich filter-feeder communities that colonize hard substrates. In addition, this seahorse can be found grasping both natural and artificial substrates, such as wooden poles, nets and ropes. The role of artificial substrates in sheltering seahorses has already been highlighted for both Mediterranean species (Curtis & Vincent 2005) and exotic species (Hellyer *et al.* 2011). Generally, seahorse density is patchy (Foster & Vincent 2004) and at most locations they are rare; however, they can be locally abundant (Curtis & Vincent 2005; Woodall 2009). Our data showed that seahorses are mainly concentrated in the central part of the Mar Piccolo (Sites 2, 3, 4, 5) (Fig. 1) where about 56% of the individuals were detected. The central part of the Mar Piccolo is served by tidal currents from the open sea (Capasso *et al.* 1989) and is unaffected by illegal activities of handling towed

fishing gears practised in the eastern side of the second inlet. No confinement gradient has been observed, as the number of sighted specimens decreases from the central portion of the Mar Piccolo towards the innermost and the outermost portions of the sea system. The depth range seems to be more contracted than that reported in the literature for European seahorses. In fact, most of the sightings occurred in the subtidal zone, with only a small fraction of the population sheltered in the intermediate sites (5–10 m), where muds are dominant. This finding can be partially explained by the frequent dystrophic and anoxic events occurring in the deep layers of the Mar Piccolo (from about 7–10 m of depth) in summer time (Alabiso *et al.* 1997; Gaino *et al.* 2010). Moreover, the anoxia phenomenon seems to prevent the seasonal migration into deeper water (>10 m) described by Boisseau (1967) in cooler waters for both *H. hippocampus* and *H. guttulatus* (Corriero pers. obs.). In addition, most of the suitable seashore habitats, such as phanerogams and algal beds, but also hard substrates, are mainly concentrated within the first 5 m of depth.

Seagrasses (*Posidonia oceanica*, *C. nodosa*) are widely thought to be a common habitat for European seahorse species (Foster & Vincent 2004; Garrick-Maidment 2007). However, in the current study, only a very small number of seahorses were surveyed on the residual *C. nodosa* beds. Notwithstanding, in the Mar Piccolo di Taranto the seagrass has declined dramatically, and seahorse populations seem to prefer to shelter and feed in artificial habitats where they can find resources and safe holdfasts.

Hard complex substrates of human origin (mussel farm pools, rocky artificial substrates) are the most favourable habitats for seahorse populations in the Mar Piccolo. The abundant colonization of epifauna on artificial hard substrates offers shelter and camouflage and supports very abundant potential prey populations while increasing protection against predators (Wennhage & Pihl 2007). Both mussel farm pools and rocky artificial substrates increased structural complexity, maintaining a very high abundance of mobile crustaceans (mainly amphipods and copepods), which are considered to be common prey items for *H. guttulatus* and *H. hippocampus* (Kitsos *et al.* 2008). Moreover, this finding agrees with a recent study carried out by Hellyer *et al.* (2011) in Sydney Harbour, where artificial habitats support much higher abundances of the mobile epifauna (amphipods, copepods) that are consumed by seahorses. Among the algae, *Ulva* beds are a habitat of low complexity, giving rise to a rich detritus food chain due to its rapid turnover, thus supporting an abundant population of crustacean detritivores. By contrast, the presence of seahorse individuals on *C. linum* is rare or scanty; as suggested by Sundin *et al.* (2011), fila-

mentous algae reduce visibility by obscuring objects in the water, thus decreasing the possibility of food intake.

Further study is required to determine whether habitat distribution changes on a seasonal basis or depending on the sex and life stages of seahorse individuals. In our opinion, in fact, whether prey item availability could be the main factor explaining the patchy distribution of seahorse habitat, ecological and behavioural aspects can affect the use and habitat preference during crucial and vulnerable stages of the seahorse life cycle (*e.g.* recruitment, courtship, coupling, male parental care).

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