INTRODUCTION

Plankton and benthos are traditionally considered as distinct communities: the first living suspended in the water column, the second in strict association with the sea-bottom. However, despite the formal distinction, plankton and benthos are strongly interconnected in coastal marine ecosystems (Boero et al., 1996; Griffiths et al., 2017), in virtue of: i) continuous downward fluxes of organic detritus produced by plankton and consumed at the sea bottom; ii) intermittent upward fluxes of inorganic nutrients released by benthic bacteria; and iii) periodic formation of benthic resting stages in planktonic protists and metazoans and release of planktonic larval stages by benthic animals.

A further, but less investigated route for plankton-benthos coupling is represented by trophic interactions. These are based on fluxes of living matter among organisms set at different trophic levels and can be roughly categorized as either nonselective or selective feeding. Nonselective feeding, involving plankton unicellular producers as food source and benthic organisms as consumers, is the most renowned of such interrelationships – e.g., the remarkably strong suspension-feeding carried out by benthic organisms in shallow coastal regions (Gili and Coma, 1998; Lucas et al., 2016). Yet, selective feeding (i.e., the active catching of living preys) is seldom reported among trophic interactions involving plankton and benthos (Hoeksema and Waheed, 2012).

In this paper, we report direct, de visu evidence that the benthic Mediterranean rainbow wrasse Coris julis (Linnaeus, 1758, Labridae) selectively feeds on the colonial salp Pegea confederata (Forskål, 1775, Thaliacea). This trophic relationship was documented in the Gulf of Naples (Italy) in the course of a citizen science investigation employing recreational SCUBA-diving and carried out at the top side of Banco di Santa Croce, an underwater rocky outcrop whose higher pinnacles set at the boundary between the benthic and pelagic realms. We present and describe photographic frames documenting the above-mentioned trophic relation, discuss plankton-benthos coupling in light of the existence of trophic routes connecting pelagic tunicates and benthic fish and we eventually analyse conceptually some possible perturbations to this route induced by global change.

METHODS

The Banco di Santa Croce (BSC) is a submerged rocky outcrop located 700 m off the coast of Vico...
Equense, on the eastern side of the GoN (40° 40.68’N, 14° 26.00’E, Fig. 1). BSC includes a number of pinnacles elevating towards the sea surface while its base sets at 65 m below the sea level. The observations herein presented have been gathered during a recreational SCUBA-diving session carried out on top of the pinnacle named Secca Principale (SP), at -12 m. During February 2017, ten of such diving sessions were carried out. This period of observation was chosen based on the fact that the yearly maximum abundance of salps in the GoN was recorded in winter and summer (Mazzocchi et al., 2011). Pictures presented herein have been taken underwater using a Nikon D7100 camera hold into a Nauticam housing with two Sea & Sea YS-110 α strobes.

In addition to visual census, reference salp abundances at basin level were gathered at the Long Term Ecological Research station MareChiara (LTER-MC, 40°48.5’N, 14°15’E, Fig. 1) (Ribera d’Alcalà et al., 2004; Mazzocchi et al., 2011). Meso-zooplankton (0.2-20 mm) were collected with a WP2 net (mouth area = 0.25 m², mesh = 200 μm) towed vertically from -50 m to sea surface. Samples were fixed immediately after collection and preserved in a 4% buffered formaldehyde-seawater solution. Once in the laboratory, samples were concentrated via filtering through a smaller mesh (<200 μm) and concentrated zooplankton samples were diluted with filtered seawater in a graduated cup up to a volume of 100-200 ml depending on sample richness. Aliquots of 5 ml were then sub-sampled by Stempel pipettes and analysed in a Mini-Bogorov Chamber under the stereomicroscope at different magnifications.

RESULTS

During February 2017, the SP section of BSC appeared to be colonized by different species of algae, anthozoans, crustaceans and benthic fish, among which the two labrid species *Corius julis* and *Thalassoma pavo* (Linnaeus, 1758). Colonies of salps were also regularly detected and *Pegea confoederata* (Fig. 2) was one of the most recorded species. All along the same period, the average salp abundance at LTER-MC, which is almost 11
nautical miles far from BSC, accounted for 5.6±1.4 individuals per m$^{-3}$. Nonetheless, *P. confaederata* was not detected in plankton samples collected at LTER-MC.

A colony of *P. confaederata* was floating in the open water in the immediacy of the BSC on 18 February 2017. This colony was transported by currents nearby the SP substrate and the following trophic interaction quickly established (Fig. 3 A-H): i) a solitary rainbow wrasse moved towards the salp colony and attacked the exterior blastozoids; ii) the fish initially bit salp’s stomach, while detaching its prey from the colony; iii) in few minutes, the fish ate the interior part of the blastozoid and left the gelatinous body of the salp torn and empty; iv) the fish attacked the colony again, biting the stomach of a second blastozoid and making the latter detaching from the colony; v) the fish ate specifically the internal part of the salp at the second attack too. As soon as water-current slowly brought *P. confaederata* colony away from the proximity of the substrate and towards the open waters, the wrasse stopped eating and did not follow the chain of blastozoids. Remarkably, the wrasse did not bite pelagic crustaceans setting in the interior side of the salp body, i.e., the ovigerous females of copepod *Sapphirina* spp. (Thompson, 1830) (Fig. 2 B-C) and some specimens of amphipod *Hyperiidea* (Milne-Edwards, 1830) (Fig. 2 A-B).

**DISCUSSION**

*Coris julis* is an omnivore fish with a preference for animal material (Karachle and Stergiou, 2017), it predated mainly benthic gastropods and crustaceans but even ectoparasites borne by fishes of same size (e.g., *Boops boops*) or even larger (e.g., *Mola mola*) than labrids (Bertoncini et al., 2009; Moosleitner, 1980; Narvaez et al., 2015; Vasco-Rodrigues and Cabrera, 2015). When

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**Fig. 2.** The salp *Pegea Confederata* at Banco di Santa Croce. A) Closer view of a colony of blastozoids, the sexual life-cycle stages. B) Closer view of salp’s stomach (i.e., the orange circular organ at the right side of the picture) and of female copepods of genus *Sapphirina* (whitish animals) and amphipods (brownish animals) adhering to salp’s body. C) Closer view of salp’s ‘tunic’ (i.e., the gelatinous and cellulose-based body envelop) and of parasitic *Sapphirina* spp.
Fig. 3. Labrid predation on salps at Banco di Santa Croce. A) Long colony of *Pegea confaeederata* blastozooids. B-H) Different phases of the predatory attack made by an individual of *Coris julis* on a colony of the salp; B) the fish removes a single blastozoid from the salp colony; C-D) the fish eats selectively the stomach of the salp individual; E-F) the fish attacks the prey following the same modality as above; H) the fish does not eat the gelatinous envelop of the salp.
behaving as a cleaner, *C. julis* is an opportunist feeder searching for preys attached to swimming hosts, which are inspected by means of high frequency bites (Narvaez et al., 2015). This consideration let us hypothesize that the trophic interaction reported herein arose from the visual attraction exerted by the slow moving and macroscopic salp-colony on the wrasse. This latter was plausibly attracted by the coloured (and nutritive) stomach placed at the lowest portion of the salp body. We cannot exclude that *C. julis* confused the salp stomach with an ectoparasite.

Salps are important components of the diet of 149 species of fishes (a review is presented in Henschke et al., 2016). Nonetheless, only one labrid species was reported to predate salps to date, *i.e.*, the tropical wrasse *Clepticus parrae*, whose stomach included mainly plankton, and salps accounted for 4.7% of total ingested food (Randall, 1967). There is no report of predation on salps by Mediterranean-wrasses to date, but salps are soft-bodied animals, they are digested rapidly and their identification by means of interior inspection of potential predators is weakly effective. Salps represent good targets to intermediate predators, including small fish, for a number of reasons: i) salps are macroscopic and easily detectable; ii) while feeding, they slowly move thanks to pulse movements of their gelatinous body and this may favour encounter with predators (Bone, 1998); iii) salps’ energetic value is relatively high (Henschke et al., 2013), since they concentrate a big amount of organic material *via* filter feeding, with preference on smaller and more nutritive plankton particles (Sutherland et al., 2010).

Salps are an apparently infrequent food for fish, probably because they have patchy geographic distributions and aperiodic population growths. The major demographic increases of these gelatinous organisms usually coincide with sudden and short-lived swarms of long colonies (up to 20 m in length) formed by specific life-cycle stages called blastozoids (Boero et al., 2013). The latter reproduce sexually and alternate with the solitary form called oozoid, which reproduces asexually *via* the release of colonial aggregates of blastozoids. Classical mesozooplankton sampling activity (*e.g.*, WP2 net with vertical haul operated from research vessels) are not suitable for detecting salp outbreaks since in many cases samplers destroy colonies. Lack of systematic observations of salp populations is probably at the base of the dispute about the actual increase of these organisms in the present warming oceans (see Condon et al., 2012). Nonetheless, salps may be favoured in the future oceans (see Condon et al., 2012).

In conclusion, underwater rocky crops are promising study-sites for plankton-benthos coupling: they are highly productive sites (Pitcher et al., 2008), represent ideal points of junction between planktonic and benthic communities, provide suitable conditions for the establishment of trophic interactions among organisms that are mainly associated to one of these sub-systems and, ultimately, they are relatively easily accessible to SCUBA-divers. To the latter respect, observational studies supported by citizen scientists are particularly promising.

CONCLUSIONS

In conclusion, underwater rocky crops are promising study-sites for plankton-benthos coupling: they are highly productive sites (Pitcher et al., 2008), represent ideal points of junction between planktonic and benthic communities, provide suitable conditions for the establishment of trophic interactions among organisms that are mainly associated to one of these sub-systems and, ultimately, they are relatively easily accessible to SCUBA-divers. To the latter respect, observational studies supported by citizen scientists are particularly promising.
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This work is dedicated to the memory of Ugo Di Capua, a pioneering scuba diver at Banco di Santa Croce.

Conflict of interest

The authors declare no competing interests.

Ethical statement

This article does not contain any studies with human participants or animals performed by any of the authors. Data included herein have been collected in nature as photographic material of living animals in their specific environment.

REFERENCES

Narvaez P, Furtado M, Neto AI, Moniz I, Azevedo JMN, Soares MC, 2015. Temperate facultative cleaner wrasses selectively...