

Cold-water coral habitats and canyons as Essential Fish Habitats in the southern Adriatic and northern Ionian Sea (central Mediterranean)

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Abstract: The objective of this study is to provide additional evidence of the utilization of Cold-Water Corals (CWC) and Submarine Canyons (SC) by fishes as areas for growing to maturity and to reproduce and thus for the classification of CWC as Essential Fish habitats (EFH). Data were collected with longline experimental surveys carried out during spring-summer and autumn-winter from 2010 to 2014, in different CWC sites distributed along the Apulian margin: Gondola Slide (GS), Bari Canyon (BC), Monopoli (Mn) and Santa Maria di Leuca (SML). In the present study the reproductive phase of *Galeus melastomus*, *Conger conger*, *Helicolenus dactylopterus*, *Merluccius merluccius*, *Pagellus bogaraveo* and *Phycis blennoides* collected in the abovementioned CWC communities has been analysed with respect to fish size. Maturing and mature individuals as well as post-reproductive specimens of *G. melastomus*, *H. dactylopterus* and *M. merluccius* were observed in all the investigated CWC sites. Mature gonads were also found in the other three species, although the investigated period was outside their reproductive peak, indicating that these CWC sites act as spawning areas and therefore as a potential ‘renewal network’ for fish species exploited in the neighbouring fishing grounds. This provides a strong argument for the categorization of CWC as EFH in the design of management programs.

Keywords: cold-water coral, canyon, essential fish habitat, Mediterranean

Introduction

Essential Fish Habitats (EFH) are bodies of waters and substrate required for fish spawning, breeding and feeding as well as a place they can grow to maturity (Rosenberg et al. 2000). According to the General Fisheries Commission for the Mediterranean (GFCM), EFH are defined as habitats identified as essential to the ecological and biological requirements for critical life history stages of exploited fish species, and which may require special protection to improve the conservation status of the stocks and their long-term sustainable exploitation (GFCM 2008).

Many studies have demonstrated that the structural complexity of the habitat plays a very important role in the life history of marine species both in shallow and deep waters (e.g. Pearcy et al. 1989; Sale 2002; Auster 2005; Caddy 2007 and references therein; Juanes 2007 and references therein; Buhl-Mortensen et al. 2010 and references therein; Miller et al. 2012; Ross et al. 2015; D’Onghia 2018).

In particular, heterogeneous and complex habitats, such as submarine canyons and cold-water coral reefs, host a high concentration of life forms to be identified as hot-spots of biodiversity (Freiwald et al. 2004; Roberts et al. 2009; De Leo et al. 2010; Fernandez-Arcaya et al. 2017;

Henry & Roberts 2017). These types of habitats, due their structural, hydrological and biological complexity as well as their enhanced trophic resources, may represent suitable sites for many species which spend critical phases of their life cycles there feeding, growing to maturity, spawning, and as a nursery as well as sheltering from predators and adverse physical conditions (e.g. Brodeur 2001; Fosså et al. 2002; Reed 2002; Costello et al. 2005; Busby et al. 2006; Stone 2006; Etnoyer & Warrenchuk 2007; Sulak et al. 2007; Quattrini et al. 2009; Baillon et al. 2012; Miller et al. 2012; Henry et al. 2013; Ross et al. 2015; D'Onghia 2018).

In the Mediterranean several Cold-Water Coral communities (CWC) (Freiwald et al. 2009) and more than 500 submarine canyons (SC) (Harris & Whiteway, 2011) have been identified. Although in the last two decades there has been a growing number of studies on both CWC and SC throughout this basin (e.g. Cartes et al. 2004 and references therein; Freiwald et al. 2009; Würtz 2012 and references therein; Fernandez-Arcaya et al. 2017 and references therein; Grehan et al. 2017 and references therein), only recently research efforts, carried out by means of video systems and gears at low impact, provided new insights into the role of CWC and SC as fish habitats (Hebbeln et al. 2009; D'Onghia et al. 2010, 2011, 2012, 2015a, 2015b, 2016; Farrugio 2012; Bo et al. 2011, 2012, 2014, 2015; Fabri et al. 2014; Cau et al. 2017; Mastrototaro et al. 2017). However, only a few of these studies reveal a clear relationship between fishes and CWC and SC (e.g. D'Onghia et al. 2010, 2016; Bo et al. 2015; Cau et al. 2017; Mastrototaro et al. 2017).

Considering that CWC and SC are impacted by commercial fishing (e.g. Roberts et al. 2000; Fosså et al. 2002; Hall-Spencer et al. 2002; Reed 2002; Grehan et al. 2005; Wheeler et al. 2005; Orejas et al. 2009; Buhl-Mortensen et al. 2010; Fabri et al. 2014; Savini et al. 2014; D'Onghia et al. 2017), the associations between fish and habitats for feeding, spawning and as a nursery are of utmost importance for the development of effective management and conservation measures (Rosenberg et al. 2000; Grehan et al. 2009, 2017). Unfortunately, the evidence of a functional role that would qualify CWC and SC as EFHs in support of their protection (Foley et al. 2010) is still lacking (Baillon et al. 2012).

The objective of this study is to provide additional evidence of the utilization of CWC and SC by fishes as areas for growing to maturity and to reproduce.

Study area

This study regards a belt of heterogeneous and topographically complex habitats distributed between the south-western Adriatic and north-western Ionian on the Apulian

continental margin (southern Italy, central Mediterranean) (Fig. 1). The north-westernmost geomorphic structures, that indent the outer shelf and slope, are represented by the Gondola Slide (GS), Bari Canyon (BC) and Dauno Seamount (off BC) (Minisini et al. 2006; Verdicchio & Trincardi 2006; Ridente et al. 2007). Among these structures, the BC is a complex morphological structure that cuts through the south-western Adriatic shelf from east to west. It is 10 km wide, 30 km long and ranges between 200 and 1700 m in depth. The BC is characterized by two main branches separated by a mounded relief, a slope-confined trough between 500 and 700 m in depth (Ridente et al. 2007; Trincardi et al. 2007). The BC hosts a diversified CWC community with sponges, serpulids, bryozoans and fishes (Freiwald et al. 2009; Bo et al. 2012; Sanfilippo et al. 2013; Angeletti et al. 2014; D'Onghia et al. 2015a,b). Southward the BC, there is a CWC site off Monopoli (Mn), between 300 and 600 m in depth, characterized by the occurrence of *Madrepora oculata* (D'Onghia et al. 2016). Beyond the Otranto Channel, in the north-western Ionian, the slope at depths between 400 and 1100 m is characterized by coral-hardground and living coral mounds, which constitute the Santa Maria di Leuca (SML) CWC province (Savini and Corselli, 2010). This CWC province is the widest and deepest known deep-sea coral community in the Mediterranean (Freiwald et al. 2009; Corselli 2010; Savini et al. 2014; Bargain et al. 2017). Dead and living colonies of *Madrepora oculata* and *Lophelia pertusa*, together with other colonial and solitary CWC species, massive sponges and a high number of invertebrate and vertebrate species have been recorded between 350 and 1100 m in depth (Tursi et al. 2004; Longo et al. 2005; Taviani et al. 2005; Carlier et al. 2009; Bongiorno et al. 2010; D'Onghia et al. 2010, 2011; Mastrototaro et al. 2010).

Material and methods

Sampling

In order to investigate on the utilization of CWC and SC by fishes as areas for growing to maturity and to reproduce, a number of longline experimental surveys were carried out during spring-summer and autumn-winter from 2010 to 2014, according to the different abovementioned sites (GS, BC, Mn and SML) distributed along the Apulian margin. In both investigated periods, the same number of stations (8) was randomly allocated in depth ranges where corals had been recorded (D'Onghia et al. 2016). The hauls were repeated in approximately the same locations in both spring-summer and autumn-winter. A commercial fishing vessel was used. It was equipped with a 3 km monofilament longline with 500 hooks and snoods of 2.5 m in length. *Sardina pilchardus* was used as bait in all the study areas.

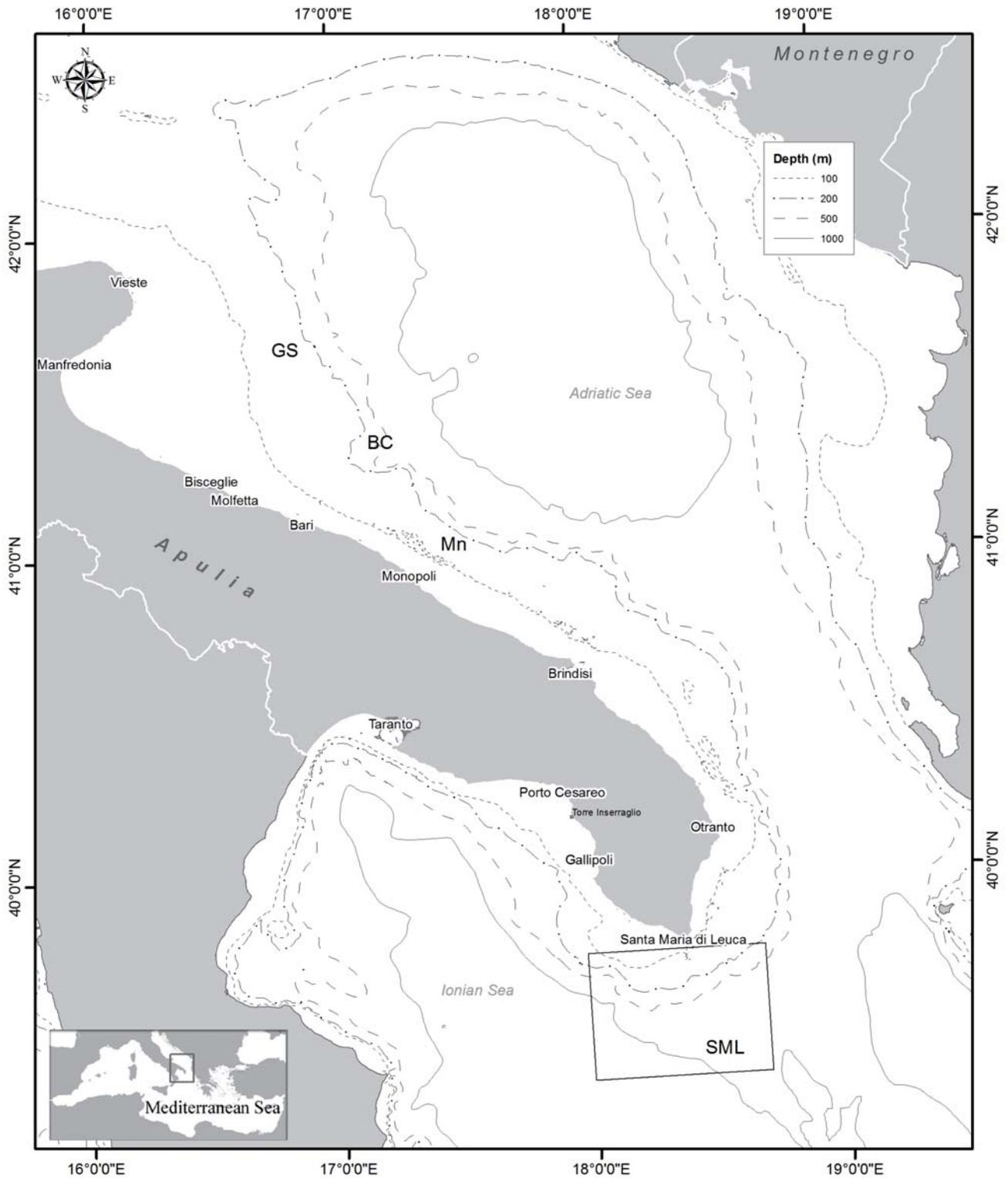


Figure 1. Cold-water coral communities investigated along the Apulian continental margin between the Southwestern Adriatic Sea and Northwestern Ionian Sea (Central Mediterranean). GS=Gondola Slide; BC=Bari Canyon; Mn=off Monopoli; SML=Santa Maria di Leuca cold-water coral (CWC) province

The fishing hauls were carried out from dawn to dusk and the set time had a duration of approximately 3–4 hours for each haul. Data on the sampling for each season and depth range are reported in Table 1.

Table 1. Sampling data for each area and season, with indication of the depth range explored

sea	area	season	depth range (m)
Southwestern Adriatic	Gondola Slide (GS)	spring–summer 2014	183–432
		autumn–winter 2013	338–612
	Bari Canyon (BC)	spring–summer 2014	314–583
		autumn–winter 2013	350–595
Northwestern Ionian	Monopoli (Mn)	spring–summer 2014	382–603
		spring–summer 2010	449–635
	Santa Maria di Leuca (SML)	autumn–winter 2010	455–599

Data analysis

For the most abundant fish species, those for which the number of individuals captured was greater than 10/1000 hooks in both sampling seasons and investigated areas as in D'Onghia et al. (2016) (*Galeus melastomus*, *Conger conger*, *Helicolenus dactylopterus*, *Merluccius merluccius*, *Phycis blennoides*, *Pagellus bogaraveo*), total length (TL, mm) weight (g), sex and maturity stages were recorded for each specimen collected, following the modified Nikolsky's (1963) and Stehmann's (2002) macroscopic scales for Osteichthyes and Chondrichthyes, respectively. The features of the gonad in terms of size, shape, thickness and color were used to classify four main maturity stages: immature, maturing, mature and spent. For teleost fish the stages were: (i) immature (very small size, thin and ribbon-like translucent ovary and thin and whitish testis shorter than 1/3 of the body cavity); (ii) maturing (thicker, whitish-pink in color ovary with small visible oocytes; whitish to creamy testis long about 2/3 of the body cavity); (iii) mature (ovary with maximum thickness and weight full of oocytes of different sizes, many of which are hydrated; whitish-creamy soft testis long from 2/3 to full length of the body cavity. Under light pressure, sperm could be expelled); (iv) spent (opaque and flaccid ovary, no oocyte clusters are visible with the naked eye; bloodshot and flab-

by testis shrunken to about half length of the body cavity). For cartilaginous fish the stages were: (i) immature (ovary with small isodiametric eggs, thick oviducts, nidamental glands less evident; small and flaccid claspers not reaching the posterior edge of the pelvic fins, sperm ducts not differentiated and testis small and narrow); (ii) maturing (visible whitish and/or few yellow maturing eggs in the ovary, uteri well developed but empty, small nidamental glands; larger claspers with skeleton still flexible and extended to the posterior edge of the pelvic fins, sperm ducts well developed beginning to meander); (iii) mature (ovary with large yolk eggs, enlarged nidamental glands and presence/absence of egg-cases in the oviducts; claspers longer than the tips of the posterior pelvic fin with ossified skeleton, testis greatly enlarged and sperm ducts greatly meandering, sperm flowing on pressure from cloaca); (iv) spent (oviducts appear much enlarged, collapsed and empty, nidamental glands reduced; claspers longer than the tips of the posterior pelvic fin, skeleton hardened, sperm ducts empty and flaccid).

A table for each species, each area and season with the percentage of two functional phases observed in the sampled population, a reproductive phase and a non-reproductive one, has also been provided, considering as "reproductive" all individuals with gonad stage maturing, mature and spent together. The length-frequency distributions by maturity stage were obtained for each species in the investigated areas, combining the two seasons. Images of maturing and/or mature stages were recorded.

Results

Relative percentages of reproductive and non-reproductive individuals for each species, area and season are reported in Table 2. The length-frequency distributions by maturity stage of the blackmouth catshark (*Galeus melastomus*), the European conger (*Conger conger*), the blackbelly rosefish (*Helicolenus dactylopterus*), the European hake (*Merluccius merluccius*), the blackspot seabream (*Pagellus bogaraveo*) and the greater forkbeard (*Phycis blennoides*) for each investigated area are reported in Fig. 2-3-4-5-6-7, respectively.

Most of the *G. melastomus* specimens sampled in the SML and BC were reproductive in both investigated seasons, due to its fairly continuous reproduction throughout the year (Tursi et al. 1993). Noteworthy percentages were also reported for Mn area, especially during spring-summer (Table 2). Considering length-frequency distributions in all areas, the observed range of sizes was between 225 and 684 mm TL. Immature individuals had sizes between 225 and 464 mm TL. Maturing and mature specimens measured from 295 to 525 mm and from 305 to 684 mm, respectively. The smallest immature (305 mm TL) was re-

corded in SML, the largest mature (676 mm TL) was collected in the BC (Fig. 2).

In the area of greatest abundance of *C. Conger* (SML), the highest percentages were observed for non-reproductive individuals, in both seasons (Table 2). The length-frequency distribution of the European conger was reported only for the BC and SML, due to the very low number of individuals collected in the other areas (Fig. 3). Even if in both investigated areas most of the captured specimens were immature, with sizes from 470 to 1219 mm TL, some gonads in the reproductive phase were observed, especially in SML. Maturing individuals measured between 710 and 1519 mm TL. The smallest mature individual was 677 mm in TL, while the largest was 1580 mm in TL, both recorded in SML. Both small and large individuals were also found for this species.

The highest percentages of reproductive individuals of *H. dactylopterus* were observed in the BC, Mn and SML areas during autumn-winter, coinciding with its main reproductive period (Muñoz et al. 2010). The highest value (95.9 %) was observed during this season in the BC. In the GS area, where the experimental survey was only conducted during spring-summer, noteworthy percentages

of reproductive individuals were also observed, equal to 51.5 % (Table 2). The length-frequency distribution of *H. dactylopterus* showed the smallest and the largest mature individual respectively equal to 176 and 380 mm TL, both collected in SML. Maturing specimens had sizes from 160 to 299 mm TL. Except for the Mn area, spent specimens were found in all the other investigated sites. The smallest individuals were collected in GS (Fig. 4) in relation to the ontogenetic migration of this species, with juveniles distributed in the shallower waters on muddy bottoms and adults at the greatest depths (D'Onghia et al. 1992).

Concerning *M. merluccius*, elevated percentages of reproductive individuals were found in all investigated areas and seasons, owing to the prolonged reproduction of this teleost fish (D'Onghia et al. 1995). The highest values were observed during spring in GS (88.9%) and autumn in BC (83.8%) (Table 2). Considering all the areas, the observed range of sizes was between 311 and 829 mm TL (Fig. 5). In all the investigated areas maturing individuals were the most abundant, with sizes between 335 and 794 mm TL, observed respectively in the BC and SML. Three specimens with spent gonads were collected both in the Mn and SML areas. The smallest and largest mature

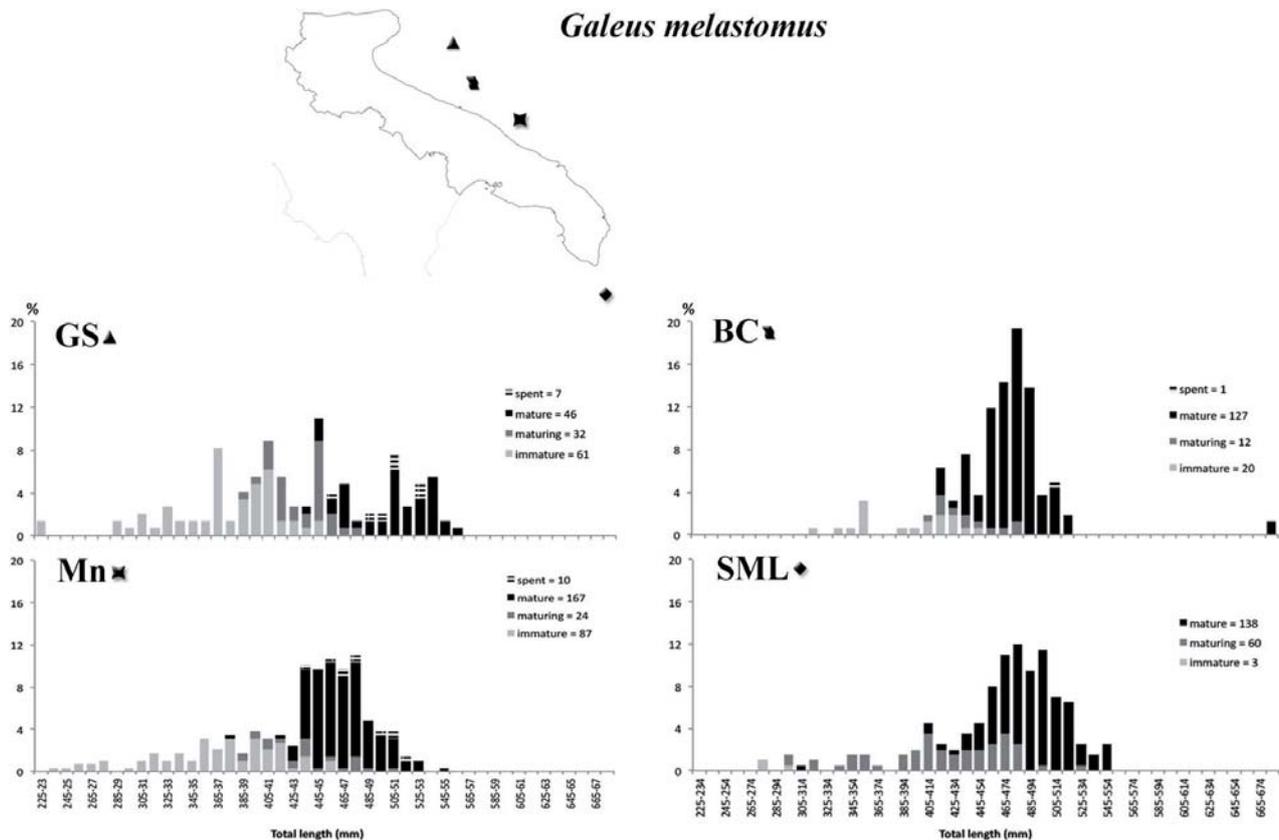


Figure 2. Length-frequency distributions by maturity stage of *Galeus melastomus* collected in the cold-water coral areas along the Apulian coast

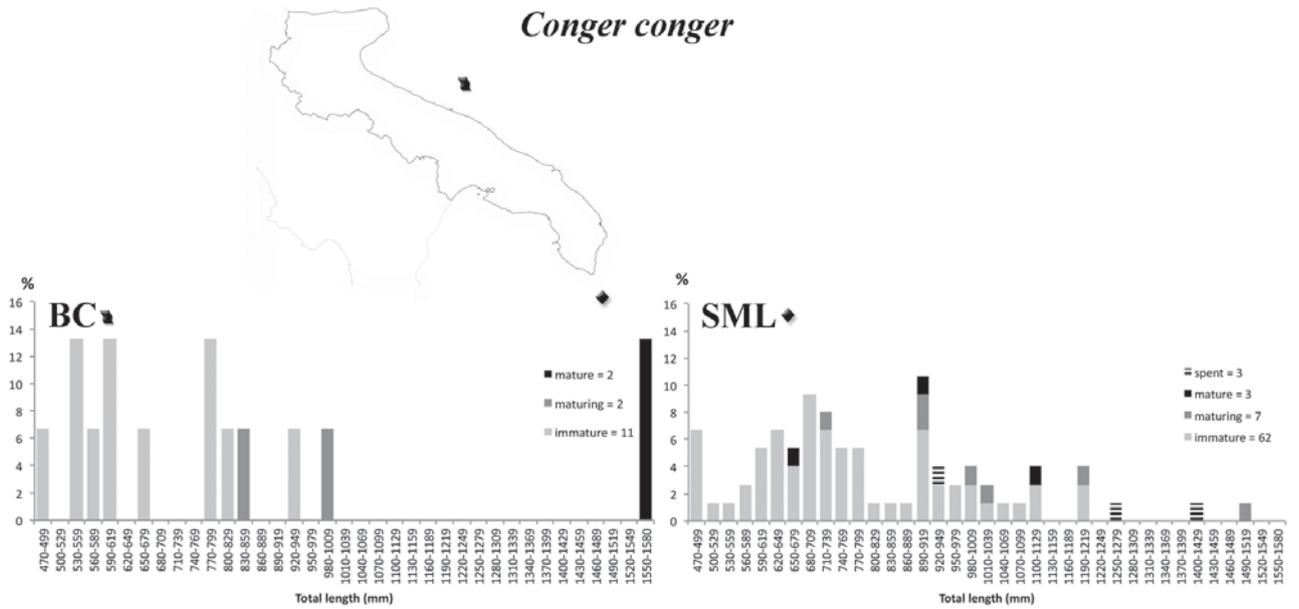


Figure 3. Length-frequency distributions by maturity stage of *Conger conger* collected in the cold-water coral areas along the Apulian coast

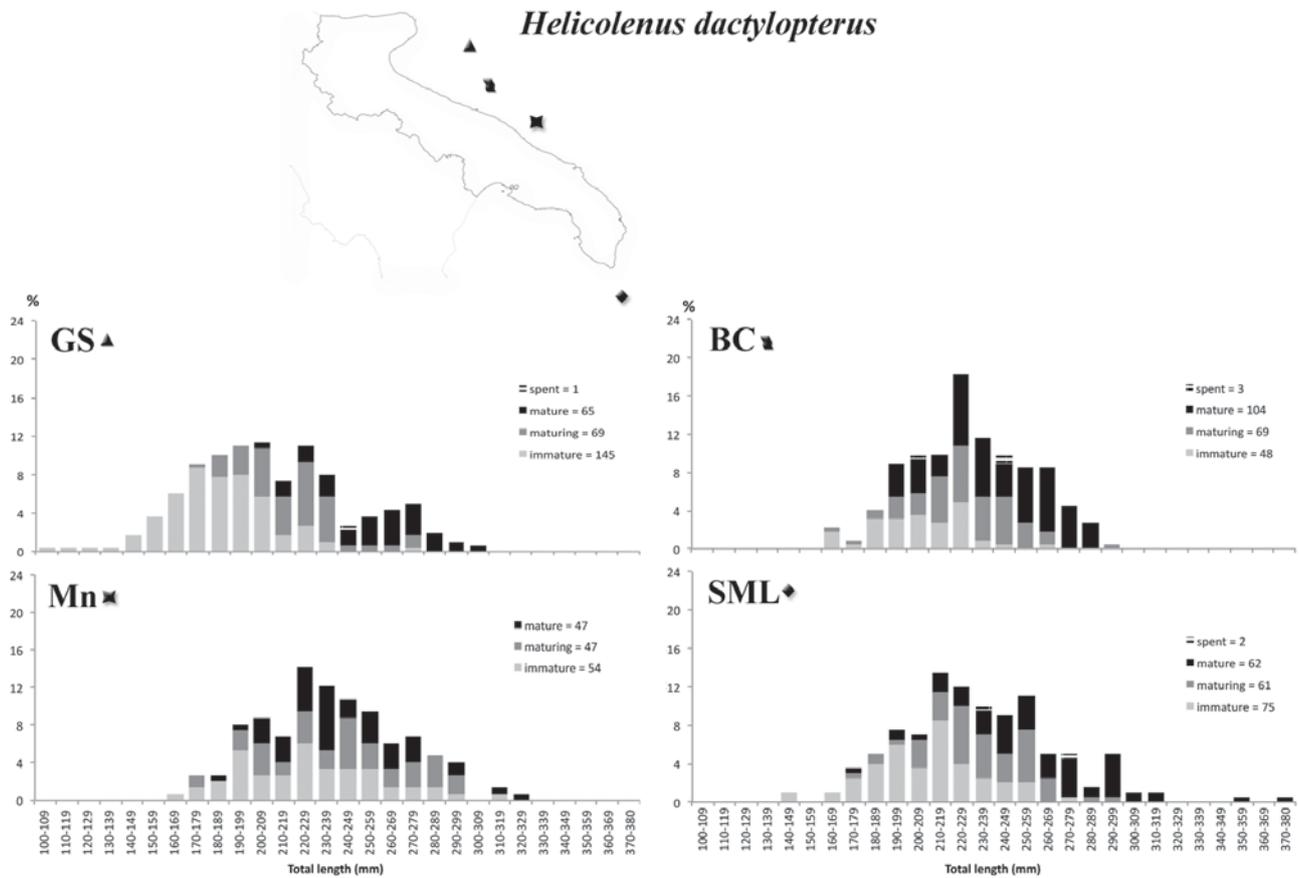


Figure 4. Length-frequency distributions by maturity stage of *Helicolenus dactylopterus* collected in the cold-water coral areas along the Apulian coast

Table 2. Relative percentages of reproductive (r) and non-reproductive (nr) individuals by species, area and season

		GS		BC		Mn		SML	
		spring-summer	spring-summer	autumn-winter	spring-summer	autumn-winter	spring-summer	autumn-winter	
<i>Galeus melastomus</i>	% r	58.2	85.3	88.1	77.5	62.7	98.3	98.8	
	% nr	41.8	14.7	11.9	22.5	37.3	1.7	1.2	
<i>Conger conger</i>	% r	-	100.0	10.0	0.0	-	32.4	4.9	
	% nr	-	0.0	90.0	100.0	-	67.6	95.1	
<i>Helicolenus dactylopterus</i>	% r	51.5	58.3	95.9	32.7	19.8	47.4	28.2	
	% nr	48.5	41.7	4.1	67.3	80.2	52.6	71.8	
<i>Merluccius merluccius</i>	% r	88.9	77.8	83.8	62.9	70.0	71.0	60.0	
	% nr	11.1	22.2	16.2	37.1	30.0	29.0	40.0	
<i>Pagellus bogaraveo</i>	% r	12.8	75.0	88.9	14.3	50.0	73.3	91.3	
	% nr	87.2	25.0	11.1	85.7	50.0	26.7	8.7	
<i>Phycis blennoides</i>	% r	0.0	16.1	36.4	24.4	13.6	16.2	36.0	
	% nr	100.0	83.9	63.6	75.6	86.4	83.8	64.0	

individuals of 349 and 810 mm TL respectively were collected in GS. Individuals of smaller sizes were found in all sites, except SML.

P. bogaraveo showed the highest percentages of reproductive gonads in both seasons in the BC and SML areas, even if with higher values during autumn-winter, respectively equal to 88.9% and 91.3%. On the contrary, during spring-summer post-reproductive individuals were the most abundant in the GS and Mn areas. The length-frequency distributions of *P. bogaraveo* were only represented for GS, BC and SML, due to the low number of specimens sampled in the Mn area (Fig. 6). *P. bogaraveo* was collected with sizes between 185 and 404 mm TL. Immature and maturing specimens were between 185-405 and 225-404 mm TL, respectively. Mature specimens measured between 275 and 374 mm TL, both collected in the BC, even if the greatest size was also observed in SML.

Regarding *P. blennoides*, non-reproductive individuals were mostly recorded, especially during spring-summer (Table 2). This result was confirmed by the length-frequency distribution that showed, in the three areas where the species was found (BC, Mn, SML), the majority of the population consisted of immature individuals (Fig. 7). The observed size range was between 230 and 568 mm TL, respectively an immature and a maturing individual, with smaller specimens collected in all three areas. Maturing specimens had sizes between 320 and 569 mm TL. The four mature specimens collected measured between 440

and 539 mm TL. One post-reproductive specimen of 539 mm TL was observed in Mn.

Representative images of maturing and mature female and male gonads for each species and for the two areas of greatest abundance (BC, SML) are shown in Fig. 8.

Discussion

This study has provided additional evidence of the utilization of CWC and SC by fishes as areas for growing to maturity and reproduction. In the present study the reproductive phase of the most abundant species collected in a number of CWC communities have been analysed with respect to size. As reported in D'Onghia et al. (2016), these CWC sites are exposed to lower fishing pressure than neighbouring fishing grounds because of their complex topography. Thus, they can be considered refuge areas. The presence of maturing and mature individuals as well as post-reproductive specimens in all the CWC sites investigated, although with variable abundance in relation to the different spawning periods of the species and investigated depths, indicates that they also act as EFH.

Hebbeln et al. (2009), using a Remotely Operated Vehicle (ROV) in an area of the Alboran Sea (western Mediterranean), at about 320 m in depth, characterized by dead coral frameworks with live colonies of *Madrepora oculata* and *Lophelia pertusa*, and other CWC species, including

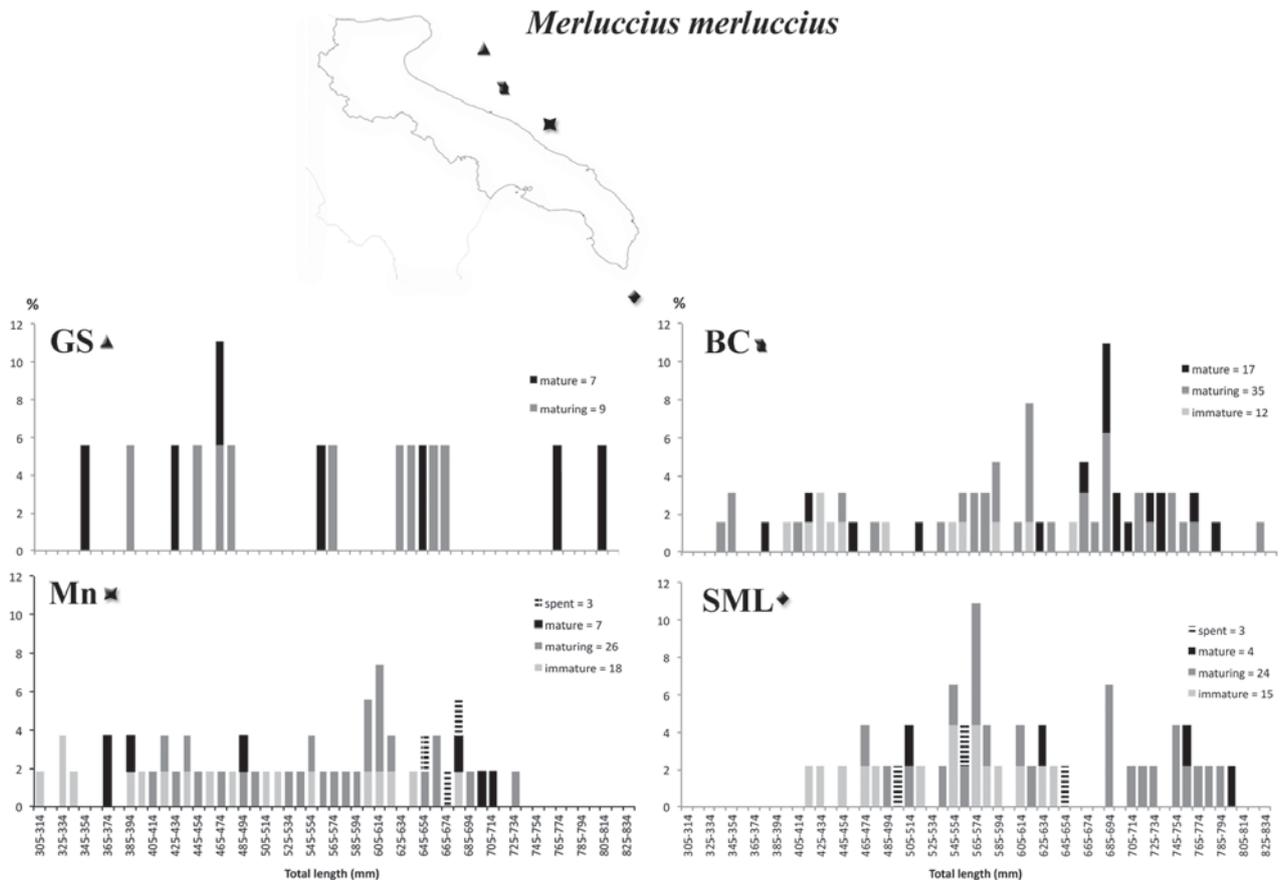


Figure 5. Length-frequency distributions by maturity stage of *Merluccius merluccius* collected in the cold-water coral areas along the Apulian coast

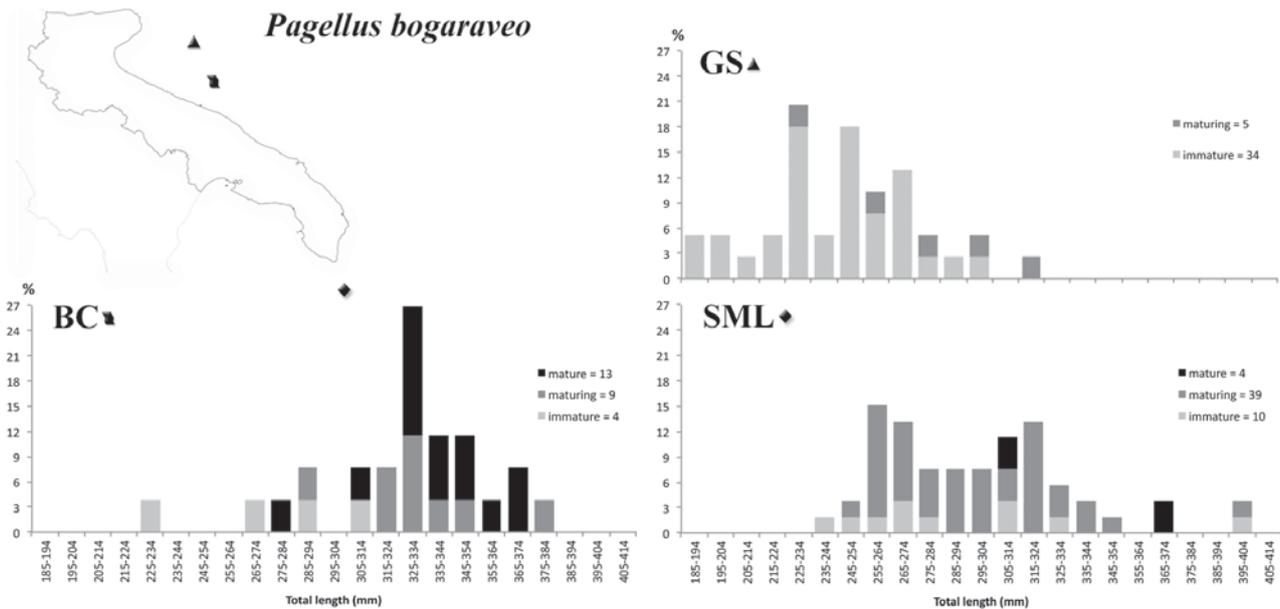


Figure 6. Length-frequency distributions by maturity stage of *Pagellus bogaraveo* collected in the cold-water coral areas along the Apulian coast

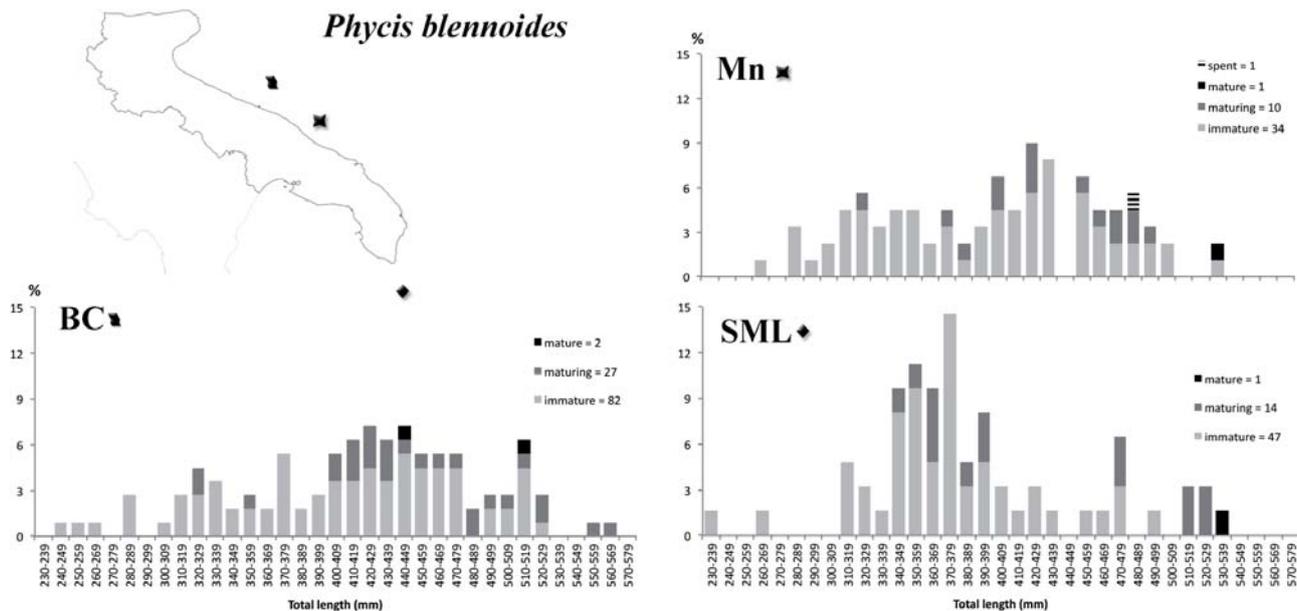


Figure 7. Length-frequency distributions by maturity stage of *Phycis blennoides* collected in the cold-water coral areas along the Apulian coast

gorgonians, black corals and sponges, observed several specimens of *H. dactylopterus* seek shelter close to and underneath coral colonies. Several other fish species, such as *P. blennoides*, *P. bogaraveo* and the lesser spotted dogfish (*Scyliorhinus canicula*), were also observed close to hardgrounds and coral frameworks with quite diverse epibenthic organisms (Hebbeln et al. 2009).

Large reproductive individuals of *G. melastomus* and *H. dactylopterus* and a noteworthy abundance of juveniles of *M. merluccius*, *P. blennoides* and *H. dactylopterus* had previously been collected in SML together with other species (D'Onghia et al. 2010). Further evidence of a tight relationship between *G. melastomus*, *C. conger*, *H. dactylopterus* and *P. bogaraveo* and CWC communities has been reported in other investigations with different gears and equipment (D'Onghia et al. 2011, 2012; Maiorano et al. 2013; Carluccio et al. 2014). Fernandez-Arcaya et al. (2013) report evidence of juveniles of some deep-sea fishes, like *P. blennoides*, in the Blanes canyon, which acts as a nursery area for these species. *H. dactylopterus*, *P. bogaraveo* and *P. blennoides* had been previously observed using a ROV in the Bari canyon (Angeletti et al. 2014). *G. melastomus*, *H. dactylopterus*, *P. bogaraveo*, *P. blennoides*, amongst other fish species, have been recorded in the Quirra and Nora canyons (Sardinian waters, western Mediterranean) (Sabatini et al. 2007; Taviani et al. 2017).

The species *G. melastomus* and *H. dactylopterus* were the most common fish species caught close to the black coral *Leiopathes glaberrima* and the gorgonian *Isidella elongata* in the eastern Ionian Sea (Mytilineou et al. 2014). *H. dactylopterus* was also found together with other fish

species in black coral habitats dominated by *L. glaberrima* at the Malta Escarpment (Angeletti et al. 2015).

G. melastomus, *H. dactylopterus*, *M. merluccius* and *P. blennoides* among other species have also been observed on the muddy bottoms with *Isidella elongata* forests between two seamounts east of Ibiza (Balearic Sea) (Mastro-totaro et al. 2017).

The same species reported in the present study were found sheltering, feeding and spawning in coral habitats and canyons in different Atlantic sites. For example, *H. dactylopterus* has been frequently recorded in different type of substrates both in canyons and in coral and transitional habitats (Uiblein et al. 2003; Costello et al. 2005; Ross & Quattrini, 2007; Sulak et al. 2007; Ross et al. 2015; Milligan et al. 2016; D'Onghia 2018). The residency of sub-adult and adult of *P. bogaraveo* at the Condor seamount (Azores, mid-North Atlantic) was ascertained using acoustic telemetry (Afonso et al. 2012). *G. melastomus* has been observed on *Lophelia* reefs (Roberts et al. 2008; Duran Muñoz et al. 2009; Kutti et al. 2014). Egg cases of *G. melastomus* have been found nested in live *L. pertusa* corals at depths between 165 and 172 m in the Mingulay Reef Complex (Henry et al. 2013). *C. conger* has been observed as a large opportunistic predator living and foraging close to rocky areas where it finds refuge during the day (Morato et al. 1999; Xavier et al. 2010). Apart from *G. melastomus*, which has non-pelagic development, the fishes studied here have pelagic eggs and larval dispersal in the water masses. Both the spill-over effect and larval seeding might contribute to the renewal of stocks in neighboring fishing grounds. The particular water mass circulation between



Figure 8. Representative images of maturing and mature female and male gonads for each species and for the two areas of greatest abundance, BC (a-f) and SML(g-l). a) *G. melastomus* mature female; b) *C. conger* maturing female; c) *H. dactylopterus* mature male; d) *M. merluccius* mature female; e) *P. bogaraveo* mature female; f) *P. blennoides* mature male; g) *G. melastomus* mature male; h) *C. conger* mature female; i) *H. dactylopterus* mature female; j) *M. merluccius* mature male; k) *P. bogaraveo* mature male; l) *P. blennoides* mature female

the southern Adriatic and northern Ionian (Freiwald et al. 2009; Taviani et al. 2017) seems to favour the transport of eggs and larvae from one CWC site to another including fished areas. Thus, CWC sites could act as marine reserves from which spill-over of individuals and larval seeding into adjacent fished areas has been documented (McClanahan & Kaunda-Arara 1996; Roberts & Hawkins 2000; Lowe et al. 2003; Hilborn et al. 2004).

Due to the complexity of their structure, CWC and SC are unsuitable for trawl fishing and only partly suitable for longline and other gears. Thus, many benthic and benthopelagic organisms can spend the critical phases of their life cycle, namely feeding, growing to maturity and spawning, there. In this way they reach greater biomass and size there than in exploited areas (e.g. Freiwald et al. 2004; Roberts et al. 2009; Buhl-Mortensen et al. 2010; D'Onghia et al. 2010; Baillon et al. 2012; Henry et al. 2013), becoming indirect providers of provisioning services in terms of food, for the commercial species. The importance of the role that CWC have in providing ecosystem services is even more important considering the overfishing condition of many demersal resources, such as *M. merluccius*, which is a spe-

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cies listed as Vulnerable on the Mediterranean IUCN Red List (Di Natale et al. 2011). Thus, a change in the environmental characteristics of these habitats, due to fishing, may have implications for service provision (Armstrong & Falk-Petersen 2008; Armstrong et al. 2009).

Since corals may provide Essential Fish Habitats (EFH) for commercial fish and invertebrates and provide provisioning services, their protection could combine biodiversity conservation and fisheries management objectives according to the Ecosystem Approach to Fisheries (EAF) (Garcia et al. 2003). To date, apart from a Fisheries Restricted Area (FRA) established for SML (GFCM-RAC/SPA 2007) and a proposal for a FRA recently made at the GFCM Sub-regional Committee for the Adriatic Sea held in Zagreb (GFCM 2018), no effective management measures have been established for other CWC sites along the Apulian margin. The present study highlights the role of these sites as EFH for several fish species and therefore the need for their protection and conservation, providing further data for the establishment of a representative network of Marine Protected Areas along the Apulian margin.

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