Occurrence and distribution of the coral *Dendrophyllia ramea* in Cyprus Insular shelf: Environmental setting and anthropogenic impacts

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Abstract

Occurrence and abundance of deep-water corals in the Levantine Mediterranean Sea is still largely unknown. This is the first attempt to quantitatively describe a *Dendrophyllia ramea* population discovered in June 2015 during the CYCLAMEN expedition on board the Research Vessel Aegaeo. This population is the deepest ever described until now in the Mediterranean and was found on the outer insular shelf off eastern Cyprus (Protaras, 35º02'N; 34º05'E). Video transects conducted by means of a remotely operated vehicle revealed a well-developed population of *D. ramea* located on a sandy seabed at 125–170 m depth. The highest density was 6 colonies m^{-2} and on average 1.6 ± 1.4 (SD) colonies m^{-2}. The population consists of isolated or piled up branches of various sizes and large colonies, some ~ 50 cm max width. The corals thrive on soft bottoms, representing a rather novel aspect of the research on *D. ramea,* since the species is still considered to be mostly associated with rocky substrates. The occurrence of the species in sedimentary grounds makes it especially vulnerable to bottom contact fishing gears as bottom trawling. Spatial distribution of the coral population, as well as a first attempt to characterize its habitat, are explored as an approach to describe the habitat's suitability and the vulnerability for the species in the area.

Key words: Deep-water corals, Levantine Mediterranean, ROV video transects, geomorphology, sedimentology, nutrients, water column, zooplankton, geomorphology, habitat suitability

1 Introduction

Quantitative studies on deep-sea benthic ecosystems using visual non-invasive methods are still scarce. However, they are of paramount importance to define species and community distribution, population structure and state of conservation. This information is fundamental to establish adequate management and conservation plans and to evaluate the Good Environmental Status (GES) of the deep sea, as required by the Marine Strategy Framework Directive (EC, 2008). The scarcity of quantitative studies on deep-sea benthic communities is mostly due to the technological challenges and high monetary costs associated to access their remote locations.

Deep-sea corals[1] (DSC) are among the most studied deep-sea organisms. They are ubiquitous and extend from sub-polar to tropical latitudes (Roberts et al., 2009). Several studies have focussed on deep-water coral reefs and coral gardens in the North Atlantic Ocean (e.g. Norwegian Reefs: Buhl-Mortensen et al., 2010; Buhl-Mortensen, 2017; Mingulay Reef in the Scottish shelf: Roberts et al., 2009; North West Atlantic: Lumsden et al., 2007). Communities of DSC have been also documented and described in the Mediterranean Sea (e.g. Freiwald et al., 2009; Pérès and Picard, 1964), especially in the western (e.g., Fabri et al., 2014; Gori et al., 2013; Grinyó et al., 2016; Lo Iacono et al., 2018; Lo Iacono et al., in press; Orejas et al., 2009) and central basin (e.g. Lo Iacono et al., in press; Savini et al., 2014; Taviani et al., 2005; Vertino et al., 2010). However, there is still a large gap of knowledge about DSC on the Levantine side of the Mediterranean Sea. Notwithstanding that there are records of numerous dead or fossil DSC in the Levantine Sea (Taviani et al., 2011), only *Dendrophyllia cornigera* (South of Crete, Salomidi et al., 2010) and *D. ramea* (Cyprus, Orejas et al., 2017; Orejas et al., in press) are known to occur alive in the area.

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[1] Although the most used name for the coral species living in deep areas is “cold-water corals”, in this specific case we prefer to use the term deep-sea corals (DSC) as the areas where *Dendrophyllia ramea* is found in Cyprus display temperatures around 16ºC, which cannot be considered “cold temperatures”.

Dendrophyllia ramea is considered rare in the Mediterranean Sea and with a patchy distribution. It inhabits continental shelf regions, attached to rocky substrates or substrates covered by calcareous algae and shells in areas with moderate currents and turbidity (Aguilar et al., 2006; Templado et al., 2009; Zibrowius, 1980). Along the southern Mediterranean coast, *D. ramea* has been found on rocky slopes and cliffs (Ocaña et al., 2000; Templado et al., 2009). Other known occurrences of *D. ramea* are in the Ionian Sea (Greece) on soft substrate (Salomidi et al., 2010) as well as in the Alboran Sea, where it is found on rocky shallow bottoms associated to the orange coral *Astroides calycularis* (Casado-Amezúa pers. comm.; Terrón-Singler pers. comm.). To the best of our knowledge, no study has previously assessed the density and distribution pattern of any DSCs in the Levantine Mediterranean Sea. In order to contribute to bridge the gap, this work aims to characterize the *D. ramea* population in Cyprus by investigating its distribution and density patterns as well as its surrounding environmental features (i.e. substrate, water column characteristics, and zooplankton abundance). Since *D. ramea* has been classified as an “endangered” species by the International Union for Conservation of Nature (IUCN), and it has been recently included (December 2017) in the Annex II of the Barcelona Convention (http://web.unep.org/unepmap/ and http://www.rac-spa.org/sites/default/files/annex/annex_2_en_20182.pdf), potential threats to the corals in the study area are also discussed.

2 Material and methods

The CYCLAMEN cruise (8–10 June 2015) on board the Research Vessel (RV) Aegaeo surveyed the area located off Protaras (eastern coast of Cyprus) (Fig. 1 a,b). During the multidisciplinary cruise diverse goals were achieved: a bathymetric survey of the coral area and surroundings, exploration of the benthic communities using a remotely operated vehicle (ROV), hydrographic characterization, and the description of the zooplankton community. Tables 1 and 2 provide the locations of all sampling stations of the CYCLAMEN cruise. The short duration of the cruise prevented the collection of sediment samples, which were gathered using a Van Veen Grab (Fig. 2, Table 2) during a second visit (11 April 2016) to the research area.

2.1 Bathymetric survey and sonar scanning

Bathymetric data were collected using a multibeam echosounder (MBES) SeaBeam 2120 system from L3 ELAC NAUTIK. The MBES operation frequency is 20 kHz and the maximum swath width is 148 degrees achieved through 149 beams arranged in a fix equiangular configuration. Daily CTD casts were used for sound velocity correction. A total area of 154.25 km^2 was surveyed with a 30 % overlap among survey lines. Swath bathymetry has been processed using CARIS 9.0. Fledermaus 7 and ArcGIS 10 were used for visualization and analysis of the resultant Digital Terrain Models (DTMs). In addition to bathymetric data, several side scan sonar (SSS) records were acquired where high densities of *D. ramea* colonies were spotted during previous ROV dives. The SSS was a dual frequency (110 - 410 kHz) SSS from Geoacoustics Ltd.

2.2 Sediment sampling

Twelve sediment samples were collected using a Van Veen grab (Table 2, Fig. 2). The twelve stations were distributed in two parallel sections (six samples each) arranged perpendicular to the isobaths from 50 to 250 m depth. Sections were 1.5 km apart, and stations were located every 0.5 km along each section (Fig. 2).

From each sediment sample, two subsamples were analysed to determine granulometry, and four to determine organic matter (OM) content. Granulometry analyses were conducted applying the sieving method using quarter phi intervals sieves. Sieve weights were processed using GRADISTAT v8.0 (Blott and Pye, 2001) in order to obtain grain size distribution and descriptive statics (mean, sorting, skewness and kurtosis) by method of moments and Folk and

Ward method (Blott and Pye, 2001). The OM content was obtained by “Loss on ignition” method and results are expressed in weight percentage of the dry sample.

2.3 ROV survey

Based on the MBES mapping and additional information on the coral distribution obtained from local fishermen that use bottom nets (Orejas et al., in press), a total of seven ROV (MAX ROVER) transects were performed (Fig. 1 c, d, Table 1). The ROV was equipped with three video cameras, a Tritech dual frequency scanning sonar, a compass, a narrow beam altimeter, depth sensors, and a robotic arm with five axes of movement for collection of specimens. Exact positioning of the ROV was acquired via a Trackpoint II USBL positioning system. Two laser beams 10 cm apart acted as scale for quantitative analyses of the video records (e.g. coral colonies density and size). The analysis of the video records was carried out with the video editing software Final Cut (Apple). Time and depth of occurrence of each *D. ramea* colony was recorded; time was converted into position along each transect by means of the ROV positioning data. Each coral colony was assigned to one of four size classes: small colonies with one or two polyps < 10 cm wide, medium size colonies 10–20 cm wide, large colonies 20–40 cm wide, and very large colonies wider than 40 cm. Dominant substrate type (> 50% of the transect width) was also identified (soft sediment, rocky boulders). Coral density (colonies m^{-2}) was calculated along each transect in adjacent 1 m length sections (1×1.5 m = 1.5 m^2). Occupancy was calculated as the percentage of sections with coral presence. Bathymetric distribution of coral colonies was assessed in 5 m depth intervals. Coral population size structure was assessed for the two transects comprising most of the observed coral colonies (Stations 9 and 29, see Table 1).

2.4 Hydrographical survey

Environmental features of the water column were recorded by means of a SBE-911plus CTD in 12 sampling stations (Table 2) located in the area where high density of corals was observed through the ROV images. The CTD was attached at the bottom of a Model 1015 Rosette sampler and equipped with sensors to measure temperature, conductivity, salinity, dissolved oxygen (DO) as well as fluorescence. Raw data measurements from the CTD deployments were filtered and processed, according to SBE software manual, in order to derive all measured parameters values as 1-m bin average.

Water samples were collected at various depths in 6 out of the 12 stations (1, 5 ,6 ,11 ,15 and 19, Table 2) to measure nutrients (N-NH_4, N-NO_2, N-NO_3, P-PO_4, and SiO_4), as well as chlorophyll-*a* (Chl-*a*), and particulate organic carbon (POC) concentration (Tables 3 and 4). The sampling strategy was designed to acquire a sample close to the seafloor, a second sample from the Chl-*a* maximum layer (determined by fluorescence measurements of the CTD downcast), and a third sample between these two layers in order to increase the detail of the description of nutrients and Chl-*a* distribution along the entire water column. Additional water samples were taken every 30 m at station 19 up to a maximum depth of 270 m.

For nutrient determination, a total volume of 500 ml for each sample was filtered through 0.45 µm pore cellulose filters onboard, by means of an electrical vacuum pump. The samples were divided into five aliquots of 100 ml, and each subsample designated for the determination of one nutrient. All subsamples were kept frozen (-20 ^{o}C) and subsequently analyzed in the home laboratory. For N-NH_4, N-NO_2, N-NO_3, and P-PO_4 determination the photometric method by Strickland and Parsons (1972) was followed. SiO_4 concentrations were determined following APHA 3120B (1992) protocol, with the use of an ICP-OES. For Chl-*a*, approximately 1000 ml of each water sample was filtrated through GF/F filters, and chlorophyll concentrations were determined using the trichromatic methodology described by APHA (1988). Each filter was grinded in a 15 ml test tube filled with 10 ml dilution of 90 % acetone and 10 % $MgCO_3$ and left overnight in a fridge. In order to separate the liquid from the solid phase, the tubes were centrifuged at 3000 rounds/min at 9 °C for 30 min. After that, the light absorption of the supernatant was measured at four wavelengths (630, 647, 664 and 750 nm), using a Hitachi U-2001 spectrophotometer. For POC determination, water samples were collected and transferred immediately to dark polyethylene bottles in order to reduce biological activity. A volume of 2 L of each sample was filtrated through GF/F filters onboard. The filters were kept frozen (-20 °C) until analysis. Concentrations of POC were determined following the "wet oxidation" method (Parsons et al., 1984).

2.5 Zooplankton collection

Five vertical plankton samples were collected during the cruise, using a conical plankton net (WP2, mesh size: 200 μm) cast vertically at strategic stations (Table 2) where high density of coral colonies was observed through the ROV images. The net was lowered until it reached 10 m above the sea-bottom as to avoid the disruption of the benthos and the clogging of the net by sediment. The net was raised slowly and washed from the outside once it surfaced, to concentrate zooplankton in the cod-end, a bucket-like tube lined with mesh. Zooplankton was then collected in a container and fixed with a 90% ethanol solution. In the home laboratory, subsamples (of at least 1500 specimens) were analyzed. The number of specimens per cubic meter was calculated using the total volume filtered at each net tow. Statistical analysis (calculations of mean and standard deviation of abundance of each group/station and Kruskal-Wallis analysis of variance) were performed using Microsoft Excel and PAST (Hammer et al., 2001).

3 Results

3.1 Geomorphology and sedimentary facies

Gathered bathymetric data show the Cyprus southeast insular margin from 50 to 800 m depth (Fig. 1 b, c). The insular shelf is narrow, up to 3 km wide, with the shelf break being hard to discriminate on the DTM, due to the presence of numerous canyons, several sub-horizontal terraces and changes in slope gradient affecting the local geomorphology. Contrastingly, in the northern sector of the DTM, a 12 km^2 wide region is characterized by a gentle slope, facing east-north-east, where no remarkable geomorphological features have been observed. This sector is delimited by east - west escarpments to the north, the coast to the west, the abyssal plain to the east (then including the adjacent slope without displaying any drastic break in the gradient between shelf and slope), and a well-developed canyon to the south. An in depth examination of the slope gradient in this particular area shows that its value gradually varies as follows: from 50 m to 120 m depth the average slope gradient is 2.3º. From 120 m to 400 m it increases to 5.6º on average, increasing up to an average value of 7.9º from 400 m to 550 m depth. The highest average slope gradient (12.2º) is observed in the distal part, between 550 m and the foot of the slope at 750 m depth. This slope gradient variation draws a convex bathymetric profile where slope gradient increases with depth eastwards (Fig. 3).

Bathymetric profiles along both sediment sampling sections show a similar geomorphologic configuration of the terrain (Fig. 2 and 3). The southern section crosses an area where a high density of *D. ramea* has been detected (see section 3.2), whereas the northern section crosses a sector without corals. Plots of depth *vs* slope along these two parallel sections show slight differences between them (Fig. 3). Whereas the slope value of both profiles is almost coincident in the sallower part (up to 130 m depth), a difference of 2º exists in the depth range where the colonies of *D. ramea* are present in the southern section (130–160 m). The average slope value along that depth interval is 9º for the northern section *vs* 7º on average for the southern one, where corals are present. For greater depths, larger slope differences are evident, although both profiles show the same slope increasing trend up to a sudden decrease when reaching the foot of the slope at 750 m depth. Acoustic facies from the SSS backscatter do not present relevant differences between areas where *D. ramea* is abundant and areas where it is absent (Appendix A).

Sediment analysis shows similar results for both sampling transects. Granulometric analysis revealed the dominance of “Sand” to “Slightly Gravelly Muddy Sand” in the shallower sector decreasing in size with depth, up to “Muddy Sand” in the deepest station. Although the mean grain size is nearly similar in the deeper portions of both sections (around 100 µm), sediment size of the sallower and intermediate segment (50–200 m depth), is different (around 150 µm difference) evidencing coarser sediments for shallower and intermediate parts of the southern section (245 µm at south *vs* 98 µm at north) (Fig. 2). Sorting ranges from “Poorly Sorted” to “Very Poorly Sorted” for all sampling stations independently of depth ranges and geographical location. The same is equally applied to Kurtosis. Only Skewness show some difference between sections, as the sediments collected along the southern section are slightly finer skewed than the one of the northern section from 50 to 120 m depth. On the contrary, from 120 to 250 m depth, sediments of the northern section are slightly finer skewed than the ones collected along the southern section.

Organic matter (OM) content increases with depth from about 5 % in the shallow part to a maximum value of 12.8 % in the deepest station (245 m) (Fig. 2).

3.2 Coral occurrence, density and population size structure

A total of 522 colonies of *Dendrophyllia ramea* were observed in 5 of the 7 transects (Fig. 1c, d, and 4), with a maximum density of 6.7 colonies m^{-2} and an average density of 1.6 ± 1.4 (mean ± SD) colonies m^{-2} (Table 1). Regarding the bathymetric distribution of the coral colonies, they were present between 125 and 155 m depth (a single colony was observed deeper at 165–170 m depth), with most of the colonies (more than 240) occurring at 145–150 m depth (Fig. 5). Two of the analysed transects (Transect 3, Station 9 and Transect 7, Station 29) display a large number of coral colonies (236 in Transect 3 and 224 in Transect 7) with maximal densities of

6.7 and 4.0 col m^{-2}, respectively, and average densities of 1.4 ± 1.2 col m^{-2} and 1.3 ± 0.9 col m^{-2}, respectively (Table 1). Transect 6 (Station 29) displays a medium number of colonies (54) with maximal density values of 6.0 col m^{-2} and an average value of 1.6 ± 1.4 col m^{-2}.

The size structure of the *D. ramea* population has been analysed in the two transects that displayed the largest number of colonies (Transects 3 and 7) (Fig. 4, 6). Transect 3 shows a dominance of medium-sized colonies, followed by small colonies and large colonies, whereas very large colonies were the less abundant (Fig. 6). In Transect 7, small colonies largely dominated, followed by medium sized, large and very large colonies (Fig. 6). The distribution of the colonies across these two transects are displayed in Figure 7, with medium to very large colonies represented separately from small colonies in each transect. All along Transect 3 (the longest one) it can be appreciated a general trend of positive association between small colonies and larger ones, with most of the small colonies occurring in correspondence of patched of large colonies (Fig. 7). Such clear pattern was not detected in Transect 7 that displays lower densities of coral colonies but with a more homogeneous distribution of colonies through the transect.

3.3 Hydrography

The Temperature – Salinity (T-S) diagram revealed the presence of three different water bodies: (a) the high saline (S= 39.05–39.2) and warm (T= 17–24.1 ºC) Levantine Surface Water (LSW) which occupies the first 150 m of the water column, (b) the lesser saline (S= 38.8–39.1) and colder (T= 13.9–17.3 ºC) Levantine Intermediate Water (LIW) located at 130–400 m depth, and (c) the less saline (S= 38.8–38.9) and cold (T= 13.7–14.3 ºC) East Mediterranean Deep Water (EMDW) detected from 400 m to the maximum investigated depth (750 m) (Fig. 8a,b). The salinity decrease (~39.00–39.05) detected between 30 and 70 m depth (Fig. 8b) indicates the presence of the Modified Atlantic Water (MAW) mixed with LSW. The mixing between LSW and LIW occurred at 130–150 m depth. The mixing zone of MAW with LSW is clearly showed in figure 8, characterized by salinity lower than 39.05.

High water temperatures (> 22ºC), which in this area typically occur in the summer season, were measured in the first 15 m depth, and thermal stratification was detected between 12 and 22 m depth. Below 22 m depth temperature decreased at slower rates, ranging between 16.2 and 16.9 °C at the depth where the corals were found (130–155 m) (Fig. 9a). At the bottom layer the values of salinity and density were found stable in all sampled stations at 39.1 and 28.7 kg m^{-3}, respectively (Fig. 9b). Profiles of Dissolved Oxygen (DO) showed a subsurface maximum between 20 and 100 m depth (> 7 mg L^{-1}; Fig. 9c); this zone extended to 125 m at the northeastern part of the sampling area. Deeper in the water column (144–177 m) detected DO concentrations ranged from 6.2 to 6.8 mg L^{-1}. Low Chl-*a* concentrations were detected down to a depth of 90 m (0.04–0.08 µg L^{-1}), while the deep chlorophyll maxima (DCM) layer was observed between 95 and 120 m depth (0.09–0.13 µg L^{-1}; Fig 9d, Table 4); a second peak of Chl-*a* was detected at 270 m depth. At depths where the corals were found, Chl-*a* ranged from 0.08 µg L^{-1} (114–140 m depth) to 0.04 µg L^{-1} (170 m depth) (Fig. 9d).

Nutrients displayed low concentrations throughout the entire water column at all sampling stations due to the oligotrophic nature of the area (descriptive statistics for a number of physicochemical parameters per station are summarised in Tables 3 and 4). Concentrations of N-NO_3 together with P-PO_4 showed their highest values below 200 m depth; lower values were measured at LSW-LSW+MAW influence zone (0–150 m depth). The NH_4^+ was distributed almost uniformly in the entire water column, N-NO_2 presented highest values at the same depth as DCM layer (~ 100–110 m), while SiO_4 showed higher values at DCM and below 200 m depth. The dominant nitrogen compound was NO_3, followed by NH_4^+. For POC, higher concentrations were found at Chl-*a* maxima layer, and lower concentrations at 120–170 m and 200–400 m depth.

3.4 Zooplankton community

Total zooplankton abundances ranged from 241 to 535 ind m^{-3}. Station 18 had the highest zooplankton abundance while station 8 had the lowest. Although there were no significant differences among sampling sites (Kruskal-Wallis, $p > 0.05$), there was an observed heterogeneity in zooplankton diversity in the water column above *D. ramea* assemblages. High abundance of copepods was the only constant feature among samples, varying between 45 and 83 % among different stations (Fig. 10). Other groups of small crustaceans, namely Cladocera and Ostracoda, were also present, displaying higher abundance in the station with low Chl-*a* concentration (Station 17, 0.12 µg L^{-1} at 107–135 m depth (n= 2), Table 4) close to high coral abundance. More than 50 % of the ichthyoplankton and 33% of fish eggs collected in the study, has been recorded in Station 20. The planktonic assemblage at Station 8, which is located directly above a dense patch of corals, is of particular interest. Although, concentration of Chl-*a* is comparable to Station 20 described above (0.17 µg L^{-1} between 107–135m depth (n= 2) for Station 20 and 0.17 µg L^{-1} between 112–130 m depth (n= 2) for Station 8), total abundance of zooplankters was 53 % less at Station 8. The assemblage also had the highest abundance of soft-bodied zooplankton (Chaetognatha, Cnidaria and Larvacea).

4 Discussion

4.1 *Dendrophyllia ramea* occurrence, distribution, and demography

To the best of our knowledge, this is the first quantitative study of a *Dendrophyllia ramea* population in Cyprus and in the Mediterranean in general. The recently discovered population off Cyprus (Orejas et al., 2017) thrives on a soft substrate, this observation being in discordance with previous reports for this species, described as a typical inhabitant of hard substrate in the Atlantic as well as in the Mediterranean (e.g. Aguilar et al., 2006; Brito and Ocaña, 2004; Salvati et al., 2004; Templado et al., 2009; Zibrowius, 1980). Only Salomidi et al. (2010) refer to an isolated *D. ramea* colony in the Ionian Sea found on a shallow sedimentary slope; however, the coral most probably was attached to the hard-substrate underneath the sediment cover. This could be also the case of the population we studied. However, a close examination of five small colonies collected for biodiversity studies did not allow to distinguish clearly enough the attachment point where the colony originated. It could be that the colonies were branches fragmented from larger colonies or that the "anchorage" material is too small and was overgrown by the basal calcareous portion of the skeleton, or a combination of both. In the study site coral colonies are, in several cases, quite embedded in the sediment (Fig. 4b); the ROV manipulator was able to penetrate the sandy substrates in several locations close to the coral colonies, confirming the occurrence of soft sediments at least within the first 20 cm of the sub-seafloor. Observed colonies displayed a bizarre polyp growth orientation in which only the apical part of the polyp, where the tentacle crone is located, changes the growth direction upwards, away from the sedimentary bottom, probably to avoid the sediment arrow that can affect the feeding activity of the corals (see polyps in panel f Fig. 11). This orientated growth could be a response to periodic disturbances (as fishing activity) that cause overturning of entire colonies and possibly fragmentation (see section 4.3).

The studied *D. ramea* population, presented a patchy distribution, with maximum densities up to ~ 6 col m^{-2}, and an average density of 1.6 ± 1.4 col m^{-2} (Fig. 7, Table 1). The lack of previous information on the density of this species from elsewhere, prevents any comparison with data from other areas. However, density data for other deep-water coral species are available for Mediterranean waters, namely *Dendrophyllia cornigera, Lophelia pertusa* and *Madrepora oculata*. Density values for these three coral species have been documented for hard substrate areas in the Cap de Creus and Lacaze Duthiers submarine canyons in the Gulf of Lions, North-western Mediterranean (Gori et al., 2013; Orejas et al., 2009). The yellow coral *D. cornigera* develops on rocky boulders and hardrock outcrops, displaying density average values of 0.02 ± 0.01 col m^{-2} and 0.005 ± 0.01 col m^{-2}, respectively; maximal values detected were of 1.33 colonies m^{-2} (Orejas et al., 2009) These densities are much lower than the ones registered in the *D. ramea* Levantine population. However, as mentioned before, this comparison should be taken with caution as the species, though it belongs to the same genus, is associated to different substrates. Regarding *L. pertusa* and *M. oculata*, these species display maximal average densities of 0.01 ± 0.08 col m^{-2} and 0.30 ± 1.14 col m^{-2} and maximal densities of 1.33 and 10.67 col m^{-2} respectively (Orejas et al., 2009). Density values are available for other cnidarian species inhabiting Central Mediterranean soft substrates. The sea pen *Pteroides spinosum* displays maximal densities of less than 10 ind m^{-2} (Porporato et al., 2014) and the bamboo coral *Isidella elongata* show maximal densities of 2.7 col m^{-2} (Bo et al., 2015).

The size structure of the *D. ramea* population is dominated by small and medium-sized colonies suggesting that there is an active recruitment. There are also “large” and “very large” colonies, which are probably older (Fig. 6). The presence in some locations of very high densities of small colonies together with large colonies (Fig. 7) points out to low dispersion of larvae originated from sexual reproduction, or alternatively suggests a possible origin of small colonies from fragmentation of large ones (Bruckner and Bruckner, 2001; Okubo et al., 2007).

4.2 *Dendrophyllia ramea* and the environmental framework

All coral colonies were found on soft sediment areas (Fig. 1 b,c). Most of the coral colonies (> 240) occur at 145–150 m depth. Results from sediment analyses show slight differences in grain sizes at the depth range of 125–155 m between the southern and the northern sediment sampling sections. Along the southern section, sediments are 150 µm coarser along this bathymetric range, where corals occur at their highest densities. This small difference could be due to a slightly stronger local hydrodynamic regime as well as to an increase of large coral fragments and the production of other bioclastic material.

The interaction between gentle slopes and internal waves can result in the formation of bores and internal wave breaking (Cacchione and Wunsch, 1974). Numerical models determine that convex slopes, as the one where coral colonies are present, boost internal waves, which can break on the seafloor and cause sediment resuspension (Legg and Adcroft, 2003). Mid-depth water column stratification, as the one observed between LSW and LIW, may increase the intensities of bottom currents due to internal waves break (Hall et al., 2013). The same models also predict that differences of few degrees in the slope value are enough to determine if the internal wave will be reflected, transmitted to shallower depths or will break. The gap in available data from the area limits us from extracting clear conclusions. Albeit, several studies on different settings relate the occurrence of coral colonies on gentle slopes with the action of internal waves (Leichter et al., 1998; Mienis et al., 2007; Rivera et al., 2016; Wall et al., 2015) even in the sedimentary record (Pomar et al., 2012). Although the relationship between internal waves and coral occurrence still needs to be demonstrated in the Mediterranean Sea, where tidal forces are constrained, it is also true that evidence is increasing on the presence of internal waves in the Mediterranean Sea (Brandt et al., 1996; Puig et al., 2001, 2004).

Corals grow at depths characterized by the LIW and LSW-LIW mixing zone (salinity 38.8–39.1, temperature 13.9–17.3 ºC), which occur in the study area at 130–150 m depth (Fig. 8). The LIW is the largest water mass flowing across the whole Mediterranean basin (Millot and Taupier-Letage, 2005; Robinson et al., 2001). Numerous communities of DSC thrive along the path of the LIW, probably because it supplies food, facilitates removal of sediments preventing thus smothering, and facilitates larval dispersion (Chimienti et al., in press; Taviani et al., 2016).

Water density where the corals occur (28.71–28.79 kg m^{-3}) differs from the density envelope that seems to characterize the presence of *L. pertusa* in most North East Atlantic waters (sigma-theta (σ_{Θ}) = 27.35–27.65 kg m^{-3}, Dullo et al., 2008). *Lophelia pertusa* has also been documented to occur in denser sigma-theta envelope (27.74–27.84 kg m^{-3}) possibly due to high food availability under low temperatures (~5–7º C), however this is still speculative and the authors of this work highlight the need of more quantitative studies to better understand the relationship between coral occurrence and physical oceanography (Huvenne et al., 2011).

In the case of *D. ramea* off Protaras, temperature ranged between 16.2 and 16.9 °C (Fig. 8a), which fall in the temperature range recorded in the Canary Islands (13–21 ºC, Brito, pers. comm.) at depths where *D. ramea* is present with dense populations (Brito and Ocaña, 2004). These temperature values are within the warmest range for DSC in the Mediterranean, where the highest temperature recorded for DSC is around 14 ºC (Freiwald et al., 2009; Gori et al., 2014; Orejas et al., 2009). Moreover, the high thermal tolerance of Mediterranean DSC has also been recently confirmed in aquaria experiments (Gori et al., 2014; Naumann et al., 2013), where ten times higher growth rates were measured for *D. ramea* at 24 ºC than at 17º C, the latter being the temperature recorded off Cyprus (Reynaud and Ferrier Pagès, in press). Concentrations of DO within the area with corals (6.2–6.8 mg L^{-1}) agree with DO values recorded for deep coral reefs dominated by *L. pertusa* (e.g. 6.38–9.9 mg L^{-1} for the Swedish Kosterfjord, Wishak et al. 2005; 3.99–6.65 mg L^{-1} for the NE Atlantic, Freiwald, 2002; Freiwald et al., 2004; 4.92–5.99 mg L^{-1} for the Mediterranean Sea under temperatures of 12.5 to 14 ºC, Freiwald et al., 2009; Tursi et al., 2004).

The distribution of DSC has been directly related, among other factors, to the presence of enhanced currents that are strong enough to prevent high sedimentation rates on the top of the corals, and to provide rapid transport of fresh and labile food particles to the coral polyps (Kiriakoulakis et al., 2005; Thiem et al., 2006). The Chl-*a* values where the coral colonies are found in the study area ranged from 0.08 µg L^{-1} (114–140 m depth) to 0.04 µg L^{-1} (170 m depth), which are typical values for the East Mediterranean Sea (Robarts et al., 1996; Tanaka et al., 2007). The fact that vertical mixing with the upper column (0–50 m) fails to happen during the summer period due to the thermocline development (Tselepides et al., 2000), supports the hypothesis that some material from the DCM layer arrive to the underlying coral population. On the other hand, the column stratification breakdown during winter favours the vertical mixing resulting in surface Chl-*a* concentration two-fold higher than in summer, and the arrival of fresher organic matter to the sea bottom (Hannides et al., 2015).

Distribution in deep waters generally results in low Chl-*a* concentration around DSC (e.g. 0.4–0.6 µg Chl-a L^{-1} at 200–300 m depth in February in the Cap de Creus Canyon, Western Mediterranean, Gili et al., 2011; 0.1 µg L^{-1} at 140–180 m depth in Mingulay Reef, North East Atlantic, Davies et al., 2009). Nevertheless low values for Chl-*a* in areas populated by DSC is not necessarily the rule. The continental shelf (~ 180 m depth) of the Porcupine Bank, located in the productive North East Atlantic, is characterized by winter values lower than 0.3 mg L^{-1} and higher in spring reaching up to 2 mg L^{-1} (White et al., 2005). According to the literature, the water in Eastern Mediterranean at the same depth is by far more oligotrophic under summer stratified regime, preserving the low chlorophyll concentrations under winter mixing conditions (Tselepides et al., 2000). As for nitrates, LIW demonstrates seasonal variability in their concentrations with elevated values measured during spring (average: 1.99± 1.02 µM/L), while phosphates and silicates preserved almost uniform concentrations throughout the entire year (Kress and Herut, 2001).

Although nutrients displayed low concentrations throughout the entire water column at all sampling stations, N-NO_3 and N-NO_2, together with P-PO_4 showed the highest concentrations below 200 m depth (N-NO_3: 3.4–5.4 µmol L^{-1}, P-PO_4: 0.3–0.4 µmol L^{-1}, respectively). These values are similar to those reported from other studies (Kovačević et al., 2012; Techtmann et al., 2015; Tselepides et al., 2000), and were attributed to the existence of a nitracline layer (Kress et al., 2014; Tselepides et al., 2000). According to Herbland and Voituriez (1979) and Estrada et al. (1993), the DCM layer coincides with the nitracline rather than isopycnal distribution (stratification). Lower nitrate and phosphate values (N-NO_3: 0.74–1.18 µmol L^{-1}, P-PO_4: 0.15–0.2 µmol L^{-1}), were measured at LSW-LSW+MAW influence zone (0–150 m depth) and at LSW-LIW mixing zone where the coral population has been documented (130–150 m depth). Nitrite highest concentrations found at DCM layer (N-NO_2: 0.30–0.65 µmol L^{-1}) can be attributed to the incomplete nitrate assimilation for cellular requirements due to low light intensities (Blasco, 1971; Olson, 1981). Silicates concentration was higher than values reported from previous studies for LIW in the Levantine Mediterranean (e.g. Techtmann et al., 2015; Tselepides et al., 2000) and presented similarities with concentrations found at the deeper layer (EMDW; Kovačević et al., 2012). The high Si concentrations at the coral depth and in the rest of the water column (SiO_4: 6.4–20.6 µmol L^{-1}) can be explained by the proximity of the coastline of Protaras. Silicate maxima at DCM (9.8–38.3 µmol L^{-1}) is a result of biological processes. At this layer, low N and P availability suggests that there is an intake from autochthonous organisms resulting in depletion from the water column, while Si preserved its normally high concentration in the water.

Regarding POC, very high values (217–361 µg L^{-1}) were recorded at the Chl-*a* maxima layer (217–361 µg L^{-1}) due to the direct relation between POC and Chl-*a* values in the euphotic zone (Legendre and Michaud, 1999), and depths between 120–170 m (277–296 µg L^{-1}). These concentrations are considered to be elevated compared to other areas in the Eastern Mediterranean (Tanaka et al., 2007; Tselepides et al., 2000) and can be attributed to the proximity to the coastline. Also very high values of POC from DSC areas in the NE Atlantic are known to range from 9.61 to 48.04 µg L^{-1} (Huvenne et al., 2011; Lavaleye et al., 2009).

The results regarding the composition and abundance of the zooplankton community of this study are in general agreement with historical information from the Eastern Mediterranean (e.g. Siokou-Frangou et al., 1997). The analysed zooplankton community in the water column above coral assemblage displays an observed heterogeneity among the different sampled stations. Total abundance of mesozooplankton during the CYCLAMEN expedition was 384±130 ind m^{-3}, which is in agreement with results from a 2010 study of the area during the same season (497±106 ind m^{-3}; Hannides et al., 2015). Contradicting this, total abundance of zooplankton observed in this study is lower than that observed in other coastal areas in the Levantine Sea (El Maghraby and Dowidar, 1973; Lakkis and Kouyoumijan, 1974). In studies where mainland coastal and offshore areas were considered, total abundance of zooplankton of the northern rim was 237–1,543 and 1,848–13,652 ind m^{-3} (Yilmaz and Besiktepe, 2010);

and 370 and 2,003 ind m^{-3} in the southern rim (Zakaria, 2006). This reflects the oligotrophic nature of coastal waters around Cyprus, which has been linked to strong offshore water influence of the Mid-Mediterranean Jet and the absence of alluvial import due to heavy damming (Abousamra, 2003; Hannides et al*.,* 2015).

Regarding the taxa/group composition (Fig. 10), copepods are the dominant group in zooplankton: 45–83 % in the present study, 41–82 % in Mersin Bay (Yilmaz and Besiktepe, 2010), > 80 % in the coast of Lebanon (Ouba et al., 2016), and 87 % in the coast of Egypt (Zakaria, 2006). Soft-bodied plankton (Chaetognatha, Cnidaria, Larvacea) was the second contributor reaching collectively 9–47 %, which is in agreement with results from Cypriot and other Levantine coasts (Hannides et al., 2015; Ouba et al., 2016; Zakaria, 2006). Small crustaceans were an important group in the sampled stations, mostly represented by Cladocera and Ostracoda that are thought to be good competitors to larger crustaceans and other planktonic species, especially in oligotrophic warm conditions, and found to be abundant in the coast of Cyprus by previous studies (Hannides et al., 2015). It has been stipulated that the contribution of smaller groups of plankton are important in oligotrophic systems (Pasternak et al., 2005; Zervoudaki et al., 2007). A dominance of smaller *vs* large zooplankters does not prevent the development of vigorous DSC assemblages as they are known to be opportunistic feeders, able to take profit of prey and items of different nature (Carlier et al., 2009; Orejas et al., 2016), as well as of different sizes and under different current velocities (Gori et al., 2015; Orejas et al., 2016; Purser et al., 2009; Tsounis et al., 2010). Mediterranean zooplankton seasonal variability at this depth is highly influenced by temperature and stratification favouring the different species during the progression of a year (Cartes et al., 2010). Winter/ spring biomass appears to be high, favouring chaetognaths, medusae and *Calanus* spp. Summer/ fall samples are lower in biomass albeit maintaining a high abundance level, due to the plethora of smaller individuals such as Cyclopoids, cladocerans, *Temora* spp. and *Acartia* spp. (Hannides et al., 2015; Ouba et al., 2016). Previous studies have also observed differences between the studied area and other sites in Cyprus (Hannides et al., 2015). An in-depth investigation of the planktonic communities and its comparison to other sites may provide insight as to the ecological drivers for the growth of DSC assemblages in the coastal area of Protaras.

4.3 Conservation status of the off Protaras *Dendrophyllia ramea* population and threats

The remarkable *D. ramea* population described is far from being in a pristine state. Overturned colonies, abundant fragments, ranging from small branches to half broken colonies, but also abundant presence of litter of different nature (Fig. 11), all suggest that disturbance to the coral population is frequent in the area. For generations, local fishermen knew about the *Dendrophyllia* area off Protaras. The "coral bank" was known due to the simple fact that is a predilect fishing ground; however, it is also the site where inexperienced fishermen frequently damage bottom nets if entangled to the corals. When deployed too close to the coral population, nets and longlines bring up entire *D. ramea* colonies or loose branches. It was due to this accidental bycatch that we got aware of the coral area in the first instance (Orejas et al., 2017). Derelict fishing lines and nets were observed in almost all ROV dives. Bottom trawling is another fishing activity that needs attention; it hasn't been quantified or properly characterized yet but it occurs in the area off Protaras. Sediment loads and turbidity can increase if trawling occurs nearby or upstream from the area and mechanical damage is common. The latter produces colony fragmentation and piling of material.

The seafloor in the area of the coral population is also populated by a high diversity of detrital material, which is nothing else than anthropogenic. Plastic of various types is the most pervasive waste and could have been transported by superficial and bottom currents. Metal (e.g. cans), glass and textiles most probably are from vessels transiting and visiting the area (Fig. 11). During summer months and particularly during the period of July-September, there is heavy traffic by touristic vessels although they tend to stay closer to shore. In general, the fishing opportunities that the coral area offers attract both recreational and commercial fishers year-round.

Plastic and fishing waste in contact with corals (e.g. friction) increase the prevalence of tissue partial mortality, microbial infections and eventual outbreaks (Bo et al., 2014; Lamb et al., 2018) as well as infestation by opportunistic epibionts (Ferrigno et al., 2018). In a preliminary study of the epibiotic community on the *D. ramea* (Jiménez et al., 2016), a number of opportunistic species were found on the living portions of the colonies including the parasitic octocoral *Alcyonium coralloides*. The tissue in these areas of the coral most probably was killed by unidentified agents allowing the settlement of epibionts.

The abundance of dead *D. ramea* colonies in the study area as loose or partially buried rubble cannot be attributed to an episodic widespread mortality, but beyond any reasonable doubt, historical and episodic events have been shaping this coral population. Deep-water mortalities of corals in areas far from coastal pollution have been documented in the Mediterranean (e.g. Bavestrello et al., 2014). It is now clear that invasive non-indigenous species are a real threat to DSC habitats in the Mediterranean (Galil et al., 2018; Galil, in press). There is scant, anecdotal evidence that the *D. ramea* population is already experiencing a sort of bioinvasion. For example, the invasive alien lionfish *Pterois miles* is present in the *D. ramea* population as well as in the rest of the coastal areas of Cyprus (Jimenez et al., 2019; Orejas et al., in press). The effects of this invasive fish species on the fauna associated to the corals are to be identified, but given the body of information on the ecological and biological traits that confer *P. miles* the potentiality to affect ecological communities in the invaded areas (Côté and Smith., 2018), changes in the habitat are expected.

In general, pollution from coastal development in Protaras but also in upstream areas (e.g. Famagusta Bay) might reach the coral population but it needs to be systematically studied. This is important since multiple stressor interactions (e.g. irradiance and temperature effects) could be affecting the corals.

Conclusions

This is the first quantitative study of a *Dendrophyllia ramea* population in the Mediterranean. This is also the first time that a population of this species have been described at large depths in a soft substrate in the Levantine Sea, which makes the species vulnerable to the impact of fisheries activities. *D. ramea* display a patched distribution, exhibiting maximum densities up to around 6 col m^{-2}, and an average density of 1.6 ± 1.4 col m^{-2}. The population is dominated by small and medium-sized colonies suggesting active recruitment. Corals grow at depths characterized by the LIW and LSW-LIW mixing zone and under temperature ranging between 16.2 and 16.9 °C. The soft substrate where the species develop display small differences respect to nearby areas where the corals are absent, this might suggest slightly stronger local hydrodynamic regime.

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References

Abousamra, F., 2003. Riverine transport of water, sediments and pollutants to the Mediterranean Sea, No. 141. MAP Technical Reports Series. UNEP/MAP, Athens, Greece.

Aguilar, R., Pastor, X., de Pablo, M.J., 2006. Hábitats en peligro. Propuesta de protección de OCEANA. Oceana, Fundación Biodiersidad, 81 p.

American Public Health Association, 1988. Standard methods for the examination of water and wastewater. In: Greenberg A.E., Trussell R.R., Clesceri L.S. (eds.). 16th Edition, Eigenferlang, Washington DC

American Public Health Association, 1992. Standard methods for the examination of water and wastewater. Greenburg AE, Clesceri LS & Eaton AD (Eds.) 18th Edition, Washington DC.

Bavestrello, G., Bo, M., Canese, S., Sandulli, R., Cattaneo-Vietti, R., 2014. The red coral populations of the gulfs of Naples and Salerno: human impact and deep mass mortalities. Italian Journal of Zoology, DOI: 10.1080/11250003.2014.950349.

Blasco, D., 1971. Acumulación de nitritos en determinados niveles marinos por acción del fitoplancton. Ph.D. Thesis, Univ. Barcelona.

Blott, S.J., Pye, K., 2001. GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth surface processes and Landforms 26 (11), 1237-1248.

Bo, M., Bava, S., Canese, S., Angiolillo, M., Cattaneo-Vietti, R., Bavestrello, G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. Biological Conservation 171, 167–176. http://dx.doi.org/10.1016/j.biocon.2014.01.011.

Bo, M., Bavestrello, G., Angiolillo, M., Calcagnile, L., Canese, S., Cannas, R., Cau, A., D'Elia, M., D'Oriano, F., Follesa, M.C., Quarta G., Cau, A., 2015. Persistence of Pristine Deep-Sea Coral Gardens in the Mediterranean Sea (SW Sardinia). PLoS ONE 10, 21.

Brandt, P., Alpers, W., Backhaus, J.O., 1996. Study of the generation and propagation of internal waves in the Strait of Gibraltar using a numerical model and synthetic aperture radar images of the European ERS 1 satellite. J. Geophys. Res.: Oceans, 101(C6), 14237-14252.

Brito, A., Ocaña, O., 2004. Corales de las Islas Canarias. Francisco Lemus (ed), Tenerife.

Bruckner, A.W., Bruckner R.J., 2001. Condition of restored *Acropora palmata* fragments off Mona Island, Puerto Rico, 2 years after the Fortuna Reefer ship grounding. Coral Reefs 20, 235-243

Buhl-Mortensen, L., Vanreusel, A., Gooday, A.J., Levin, L.A., Priede, I.G., Buhl-Mortensen, P., Gheerardyn, H., King, N.J., Raes, M., 2010. Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins. Mar. Ecol. 31, 21-50

Buhl-Mortensen, P., 2017. Coral reefs in the Southern Barents Sea: habitat description and the effects of bottom fishing. Mar. Biol. Res. 13, 1027-1040.

Cacchione, D., Wunsch, C., 1974. Experimental study of internal waves over a slope. J. Fluid Mech. 66(2), 223-239.

Carlier, A., Le Guilloux, E., Olu, K., Sarrazin, J., Mastrototaro, F., Taviani, M., Clavier, J., 2009. Trophic relationships in a deep Mediterranean cold-water coral bank (Santa Maria di Leuca, Ionian Sea). Mar. Ecol. Progr. Ser. 397, 125−137.

Chimienti, G., Bo, M., Taviani, M., Mastrototaro, F., Occurrence and Biogeography of Mediterranean Cold-Water Corals. In: Orejas C, Jiménez C (eds). Mediterranean Cold-Water Corals: Past, Present and Future. Springer. https://doi.org/10.1007/978-3-319-91608-8_19.

Côté I.M., Smith N., 2018. The lionfish *Pterois* sp. invasion: Has the worst-case scenario come to pass? Re-evaluating the lionfish invasion. J. Fish Biol. 92:660-689. 10.1111/JFB.13544.

Davies, A., Duineveld, G., Lavaleye, M., Bergman, M., van Haren, H., Roberts, J., 2009. Downwelling and deep-water bottom currents as food supply mechanisms to the cold-water coral *Lophelia pertusa* (Scleractinia) at the Mingulay Reef complex. Limnol. Oceanogr. 54, 620−629.

Dullo, W.C., Flögel, S., Rüggeberg, A., 2008. Cold-water coral growth in relation to the hydrography of the Celtic and Nordic European continental margin. Mar. Ecol. Progr. Ser. 371, 165-176.

EC, 2008. Directive2008/56/EC of the European Parliament and the Council of June 17th 2008 establishing a framework for community action in the field of marine environmental policy.

El Maghraby, A.M., Dowidar, N.M., 1973. Observations on the zooplankton community in the Egyptian Mediterranean Waters. Rapp. Comm. int. Mer Médit., 21, 8, 527-530.

Estrada, M., Marrase, C., Latasa, M., Berdalet, E., Delgado, M., Riera, T., 1993. Variability of deep chlorophyll maximum characteristics in the Northwestern Mediterranean. Mar. Ecol. Progr. Ser. 92, 289–300.

Fabri, M.C., Pedel, L., Beuck, L., Galgani, F., Hebbeln, D., Freiwald, A., 2014. Megafauna of vulnerable marine ecosystems in French mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. Deep-sea Res. Part II: Top. Stud. Oceanogr. 104, 184-207.

Ferrigno, F., Appolloni, L., Russo, G., Sandulli, R., 2018. Impact of fishing activities on different coralligenous assemblages of Gulf of Naples (Italy). J. Mar. Biol. Ass. U.K. 98(1), 41-50. doi:10.1017/S0025315417001096.

Freiwald, A., 2002. Reef-Forming Cold-Water Corals. In: Wefer, G, Billet, D., Hebbeln, D., Jorgensen, B.B., Schluter, M., Van Weering, T. (eds.) Ocean Margin Systems. Springer-Verlag, Berlin, Heidelberg.

Freiwald, A., Fosså, J.H., Grehan, A., Koslow, T., Roberts, J.M., 2004. Cold-water coral reefs, Vol. UNEP-WCMC, Cambridge, UK.

Freiwald, A., Beuck, L., Rüggeberg, A., Taviani, M., Hebbeln, D., 2009. The white coral community in the Central Mediterranean Sea Revealed by ROV Surveys. Oceanography 22, 58-74.

Galil, B.S., Danovaro, R., Rothman, S.B.S., Gevili, R., Gorem, N., 2018. Invasive biota in the deep-sea Mediterranean: an emerging issue in marine conservation and management. Biol. Inv. https://doi.org/10.1007/s10530-018-1826-9.

Galil, B.S., The spread of non-indigenous species in the Mediterranean – a threat to cold-water corals? In: Orejas, C., Jiménez, C. (eds). Mediterranean Cold-Water Corals: Past, Present and Future. Springer. https://doi.org/10.1007/978-3-319-91608-8_43.

Gili, J.M., Madurell, T., Requena, S., Orejas, C., Gori, A., Purroy, A., Domínguez, C., Lo Iacono, C., Isla, E., Lozoya, J.P., Carboneras, C., Grinyó, J., 2011. Caracterización física y ecológica del área marina del Cap de Creus. Informe final área LIFE+ INDEMARES (LIFE07/NAT/E/000732). Instituto de Ciencias del Mar/CSIC (Barcelona). Coordinación: Fundación Biodiversidad, Madrid.

Gori, A., Orejas, C., Madurell, T., Bramanti, L., Martins, M., Quintanilla, E., Marti-Puig, P., Lo Iacono, C., Puig, P., Requena, S., Greenacre, M., Gili, J.M., 2013. Bathymetrical distribution and size structure of cold-water coral populations in the Cap de Creus and Lacaze-Duthiers canyons (northwestern Mediterranean). Biogeosciences 10,2049-2060.

Gori, A., Reynaud, S., Orejas, C., Gili, J.M., Ferrier-Pagès, C., 2014. Physiological performance of the cold-water coral *Dendrophyllia cornigera* reveals its preference for temperate environments. Coral Reefs 33,665-674.

Gori, A., Reynaud, S., Orejas, C., Ferrier-Pagès, C.,2015. The influence of flow velocity and temperature on zooplankton capture rates by the cold-water coral *Dendrophyllia cornigera* J. Exp. Mar. Biol. Ecol. 466, 92–97.

Grinyó, J., Gori, A., Ambroso, S., Purroy, A., Calatayud, C., Dominguez-Carrió, C., Coppari, M., Lo Iacono, C., López-González, P.J., Gili, J.M., 2016. Diversity, distribution and population size structure of deep Mediterranean gorgonian assemblages (Menorca Channel, Western Mediterranean Sea). Progr. Oceanogr. 145, 42-56.

Hall, R.A., Huthnance, J.M., Williams, R.G., 2013. Internal wave reflection on shelf slopes with depth-varying stratification. J. Phys. Oceanogr. 43(2), 248-258.

Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

Hannides, C.C.S., Zervoudaki, S., Frangoulis, C., Lange, M.A., 2015. Mesozooplankton stable isotope composition in Cyprus coastal waters and comparison with the Aegean Sea (eastern Mediterranean). Est. Coast. Shelf Sci. 154, 12-18.

Herbland, A., Voituriez, B., 1979. Hydrological structure analysis for estimating the primary production in the tropical Atlantic Ocean. J. Mar. Res. 37, 87–101.

Huvenne, V.A.I., Tyler, P.A., Masson, D.G., Fisher, E.H., Hauton, C., Huhnerbach, V., Le Bas, T.P., Wolff, G.A., 2011. A Picture on the Wall: Innovative Mapping Reveals Cold-Water Coral Refuge in Submarine Canyon. PLoS ONE 6 (12): e28755.

Jiménez, C., Achilleos, K., Abu Alhaija, R., Gili, J.M., Orejas, C., 2016. Living in close quarters: epibionts on *Dendrophyllia ramea* deep-water coral (Cyprus and Menorca channel). Rapp. Comm. Int. Mer. Médit. 41, 466.

Jiménez, C., Patsalou, P., Andreou, V., Huseyinoglu, M.F., Çiçek, B.A., Hadjioannou, L., Petrou, A., 2019. Out of sight, out of reach, out of mind: Invasive lionfish *Pterois miles* in Cyprus at depths beyond recreational diving limits. 1st Mediterranean Symp. Non-Indigenous Species, Antalya, Turkey, 17-18 January 2019. pp 59-64

Kiriakoulakis, K., Fisher, E.H., Wolff, G.A., Freiwald, A. et al., 2005. Lipids and nitrogen isotopes of two deep-water corals from the North-East Atlantic: initial results and implications for their nutrition. In: Freiwald A, Roberts JM (eds) Cold-water corals and ecosystems. Springer, Berlin.

Kovačević, V., Bruno Manca, B., Ursella, L., Shroeder, K., Cozzi, S., Burca, M., Mauri, E., Gerin, R., Notarstefano, G., Deponte, D., 2012. Water mass properties and dynamic conditions of the Eastern Mediterranean in June 2007. Progr. Oceanogr. 104, 59-79.

Kress, N., Gertman, I., Herut, B., 2014. Temporal evolution of physical and chemical characteristics of the water column in the Easternmost Levantine basin (Eastern Mediterranean Sea) from 2002 to 2010. J. Mar. Syst. 135, 6-13.

Kress, N., Herut, B., 2001. Spatial and seasonal evolution of dissolved oxygen and nutrients in the Southern Levantine Basin (Eastern Mediterranean Sea): chemical characterization of the water masses and inferences on the N: P ratios. Deep-Sea Res. Part I, 48, 2347–2372.

Lakkis, S., Kouyoumijan, H., 1974. Observations sur la composition et l'abondance du zooplankton aux embouchures d'effluents urbains des eaux de Beyrouth. Rapp. Comm. int. Mer Médit. 22 (9), 107-108.

Lamb, J.B., Willis, B.L., Fiorenza, E.A., Couch, C.S., Howard, R., Rader, D.N., True, J.D., Kelly, L.A., Ahmad, A., Jompa, J., Harvell, C.D., 2018. Plastic waste associated with disease on coral reefs. Science 359, 460–462. doi: 10.1126/science.aar3320.

Lavaleye, M., Duineveld, G., Lundalv, T., White, M., Guihen, D., et al., 2009. Cold water corals on the Tisler Reef. Oceanography 22(1), 76–84.

Legendre, J., Michaud, J., 1999. Chlorophyll a to estimate the particulate organic carbon available as food to large zooplankton in the euphotic zone of oceans. J. Plankt. Res. 21 (11), 2067–2083.

Legg, S., Adcroft, A., 2003. Internal wave breaking at concave and convex continental slopes. J. Phys. Oceanogr. 33(11), 2224-2246.

Leichter, J.J., Shellenbarger, G., Genovese, S.J., Wing, S.R., 1998. Breaking internal waves on a Florida (USA) coral reef: a plankton pump at work?. Mar. Ecol. Progr. Ser. 166, 83-97.

Lo Iacono, C., Robert, K., Gonzalez-Villanueva, R., Gori, A., Gili, J.M., Orejas, C., 2018a. Predicting cold-water coral distribution in the Cap de Creus Canyon (NW Mediterranean): Implications for marine conservation planning. Progr. Oceanogr. DOI: 10.1016/j.pocean.2018.02.012.

Lo Iacono, C., Savini A., Huvenne, V.A.I., Gràcia, E., Habitat Mapping of Cold-Water Corals in the Mediterranean Sea. In: Orejas C., Jiménez C. (eds.). Mediterranean Cold-Water Corals: Past, Present and Future, Coral Reefs of the World 9, Springer International Publishing. https://doi.org/10.1007/978-3-319-91608-8_15.

Lumsden, S.E., Hourigan, T.F., Bruckner, A.W., Dorr, G., 2007. The State of Deep Coral Ecosystems of the United States, Vol. NOAA Technical Memorandum CRCP-3. Silver Spring MD.

Mienis, F., De Stigter, H.C., White, M., Duineveld, G., De Haas, H., Van Weering, T.C.E., 2007. Hydrodynamic controls on cold-water coral growth and carbonate-mound development at the SW and SE Rockall Trough Margin, NE Atlantic Ocean. Deep Sea Res. Part I: Oceanogr. Res. Papers, 54(9), 1655-1674.

Millot, C., Taupier-Letage, I., 2005. Additional evidence of LIW entrainment across the Algerian subbasin by mesoscale eddies and not by a permanent westward flow. Progr. Oceanogr. 66, 231–250, doi.org/10.1016/j.pocean.2004.03.002.

Naumann, M., Orejas, C., Ferrier-Pagès, C., 2013. High thermal tolerance of two Mediterranean cold-water coral species maintained in aquaria. Coral Reefs 32 (3), 749–754.

Ocaña, A., Tocino, L.S., González, P.L., 2000. Consideraciones faunística y biogeográficas de los antozoos (" Cnidaria: Anthozoa") de la costa de Granada (Mar de Alborán). Zoologica Baetica 51-66.

Okubo, N., Motokawa, T., Omori, M. 2007. When fragmented coral spawn? Effect of size and timing on survivorship and fecundity of fragmentation in *Acropora Formosa*. Mar. Biol. 151, 353-363.

Olson, R.J., 1981. Differential photoinhibition of marine nitrifying bacteria - A possible mechanism for the formation of the primary nitrite maximum. J. Mar. Res. 39, 227-238.

Orejas, C., Gori, A., Lo Iacono, C., Puig, P., Gili, J.M., Dale, M.R.T., 2009. Cold-water corals in the Cap de Creus canyon, northwestern Mediterranean: spatial distribution, density and anthropogenic impact. Mar. Ecol. Progr. Ser. 397, 37-51.

Orejas, C., Gori, A., Rad-Menéndez, C., Last, K.S., Davies, A.J., Beveridge, C.M., Sadd, D., Kiriakoulakis, K., Witte, U., Roberts, J.M., 2016. The effect of flow speed and food size on the capture efficiency and feeding behaviour of the cold-water coral *Lophelia pertusa*. J. Exp. Mar. Biol. Ecol. 481, 34-40.

Orejas, C., Gori, A., Jiménez, C., Rivera, J., Lo Iacono, C., Hadjioannou, L., Andreou, V., Petrou, A., 2017. First in situ documentation of a population of the coral *Dendrophyllia ramea* off Cyprus (Levantine Sea) and evidence of human impacts. Galaxea 19, 15-16.

Orejas, C., Jiménez, C., Gori, A., Rivera, J., Lo Iacono, C., Aurelle, D., Hadjioannou, L., Petrou, A., Achilleos, K., Corals of Aphrodite: *Dendrophyllia ramea* populations of Cyprus. In: Orejas C, Jiménez C (eds). Mediterranean Cold-Water Corals: Past, Present and Future. Springer. https://doi.org/10.1007/978-3-319-91608-8_23

Ouba, A., Saab, M. A. A. and Stemmann, L., 2016. Temporal Variability of Zooplankton (2000-2013) in the Levantine Sea: Significant Changes Associated to the 2005-2010 EMTlike Event, PLoS ONE, 11(7), 1–18. doi: 10.1371/journal.pone.0158484.

Parsons, T.R., Maita, Y., Lalli, C.M., 1984. A manual of chemical and biological methods for seawater analysis. Oxford, Pergamon Press.

Pasternak, A., Wassmann, P., Wexels Riser, C., Shirshov, P.P., 2005. Does mesozooplankton respond to episodic P inputs in the Eastern Mediterranean? Deep-Sea Res. Part II, 52, 2975–2989. doi: 10.1016/j.dsr2.2005.09.002.

Pérès, J.M., Piccard, J., 1964. Nouveau manuel de bionomie benthique de la mer Mediterranée. Extrait du recueil des travaux de la station marine d'Endoume Bulletin 31, Fasc. 47, 1-137

Pomar, L., Morsilli, M., Hallock, P., Bádenas, B., 2012. Internal waves, an under-explored source of turbulence events in the sedimentary record. Earth-Science Reviews, 111(1-2), 56-81.

Porporato, E.M.D., Mangano, M.C., De Domenico, F., Giacobbe, S., Spanò, N., 2014. First observation of *Pteroeides spinosum* (Anthozoa: Octocorallia) fields in a Sicilian coastal zone (Central Mediterranean Sea). Mar. Biod. 44, 589-592.

Puig, P., Palanques, A., Guillén, J., 2001. Near-bottom suspended sediment variability caused by storms and near-inertial internal waves on the Ebro mid continental shelf (NW Mediterranean). Mar. Geol. 178, (1-4), 81-93.

Puig, P., Palanques, A., Guillén, J., El Khatab, M., 2004. Role of internal waves in the generation of nepheloid layers on the northwestern Alboran slope: implications for continental margin shaping. J. Geoph. Res. Oceans, 109(C9).

Purser, A., Bergmann, M., Lundalv, T., Ontrup, J., Nattkemper, T.W., 2009. Use of machine-learning algorithms for the automated detection of cold-water coral habitats: a pilot study. Mar. Ecol. Progr. Ser. 397, 241-251.

Reynaud, S., Ferrier Pagès, C., Biology and Ecophysiology of Mediterranean Cold–Water Corals. . In: Orejas C, Jiménez C (eds). Mediterranean Cold-Water Corals: Past, Present and Future. Springer. https://doi.org/10.1007/978-3-319-91608-8_35.

Rivera, J., Canals, M., Lastras, G., Hermida, N., Amblas, D., Arrese, B., Acosta, J., 2016. Morphometry of Concepcion Bank: evidence of geological and biological processes on a large volcanic seamount of the Canary Islands Seamount Province. PLoS ONE, 11(5), e0156337.

Robarts, R., Zohary, T., Waiser, M., & Yacobi, Y., 1996. Bacterial abundance, biomass, and production in relation to phytoplankton biomass in the Levantine Basin of the southeastern Mediterranean Sea. Mar. Ecol. Progr. Ser. 137, 273–281.

Roberts, J.M., Wheeler, A., Freiwald, A., 2009. Cold-water corals: the biology and geology of deep-sea coral habitats, Cambridge University Press.

Robinson, A.R., Leslie, W., Theocharis, A., Lascaratos, A., 2001. Mediterranean Sea circulation. Encyclopedia of ocean science 3. Academic, San Diego, pp 1689–1705.

Salomidi, M., Zibrowius, H., Issaris, Y., Milionis, K., 2010. *Dendrophyllia* in Greek waters, Mediterranean Sea, with the first record of *D. ramea* (Cnidaria, Scleractinia) from the area. Med. Mar. Sci. 11, 189–194.

Salvati, E., Tunesi, L., Molinari, A., 2004. Presence of the Scleractinian *Dendrophyllia ramea* in the shallow waters of Mediterranean Morocco (Al Hoceima, Alboran Sea). Rapp. Comm. Int. Mer. Médit. 37, 547.

Savini, A., Vertino, A., Marchese, F., Beuck, L., Freiwald, A., 2014. Mapping Cold-Water Coral Habitats at Different Scales within the Northern Ionian Sea (Central Mediterranean): An Assessment of Coral Coverage and Associated Vulnerability. PLoS ONE, 9:e87108

Siokou-Frangou, I., Christou, E.D., Fragopoulu, N., Mazzoc-chi, M.G., 1997. Mesozooplankton distribution from Sicily to Cyprus (Eastern Mediterranean): II. Copepod assemblages, Oceanol. Acta. 20, 537–548.

Strickland, J.D.H., Parsons, T.R., 1972. A practical handbook of seawater analysis.Fisheries Research Board of Canada, Ottawa.

Tanaka, T., Zohary, T., Krom, M.D., Law, C.S., Pitta, P., Psarra, S., Rassoulzadegan, F., Thingstad, F., Tselepides, A., Malcom, E., Woodward, S., Flaten, G.A.F., Skjoldal, E.F., Zodiatis, G., 2007. Microbial community structure and function in the Levantine basin of eastern Mediterranean. Deep Sea Res. Part I. 54, 1721-1743.

Taviani, M., Freiwald, A., Zibrowius, H., 2005. Deep coral growth in the Mediterranean Sea: an overview. In: Freiwald, A., Roberts J.M., Orejas C. (eds). Cold-water corals and ecosystems. Springer

Taviani, M., Vertino, A., López Correa, M., Savini, A., De Mol, B., Remia, A., Montagna, P., Angeletti, L., Zibrowius, H., Alves, T., Salomidi, M., Ritt, B., Henry, P., 2011. Pleistocene to recent deep-water corals and coral facies in the Eastern Mediterranean. Facies, 57 (4), 579-603

Taviani, M., Angeletti, L., Beuck, L., Campiani, E., Canese, S., Foglini, F., Freiwald, A., Montagna, P., Trincardi, F., 2016. On and off the beaten track: megafaunal sessile life and Adriatic cascading processes. Mar. Geol. 375, 146–160.

Techtmann SM, Fortney JL, Ayers KA, Joyner DC, Linley TD, Pfiffner SM, Hazen TC (2015) The Unique Chemistry of Eastern Mediterranean Water Masses Selects for Distinct Microbial Communities by Depth. PLoS ONE: DOI:10.1371/journal.pone.0120605.

Templado, J., Capa, M., Guallart, J., Luque, A., 2009. 1170 Arrecifes. In: VV.AA., Bases ecológicas preliminares para la conservación de los tipos de hábitat de interés comunitario en España. Madrid: Ministerio de Medio Ambiente, y Medio Rural y Marino. https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/rn_tip_hab_esp_bases_eco_preliminares.aspx.

Thiem, O., Ravagnan, E., Fossa, J.H., Berntsen, J., 2006. Food supply mechanisms for cold-water corals along a continental shelf edge. J. Mar. Syst. 60, 207-219.

Tselepides, A., Zervakis, V., Polychronaki, T., Danovaro, R., Chronis, G., 2000. Distribution of nutrients and particulate organic matter in relation to the prevailing hydrographic features of the Cretan Sea. Prog. Oceanogr. 46, 113-142.

Tsounis, G., Orejas, C., Reynaud, S., Gili, J.M., Allemand, D., Ferrier-Pagès, C., 2010. Prey-capture rates in four Mediterranean cold-water corals. Mar. Ecol. Progr. Ser. 398,149-155.

Tursi, A., Mastrototaro, F., Matarrese, A., Maiorano, P., D'onghia, G., 2004. Biodiversity of the white coral reefs in the Ionian Sea (Central Mediterranean). Chemi. Ecol. 20, 107-116.

Vertino, A., Savini, A., Rosso, A., Di Geronimo, I., Mastrototaro, F., Sanfilippo, R., Gay, G., Etiope, G., 2010. Benthic habitat characterization and distribution from two representative sites of the deep-water SML Coral Province (Mediterranean). Deep-Sea Res. Part II. 57, 380-396.

Wall, M., Putchim, L., Schmidt, G. M., Jantzen, C., Khokiattiwong, S., Richter, C., 2015. Large-amplitude internal waves benefit corals during thermal stress. Proc. Royal Soc. London Biol. Sci. 282(1799), 20140650.

Wisshak, M., Freiwald, A., Lundalv, T., Gektidis, M., 2005. The physical niche of the bathyal *Lophelia pertusa* in a non-bathyal setting: environmental controls and palaeoecological implications. In: Cold-water corals and ecosystems (Freiwald, A., Roberts, J. M., eds), Springer, Berlin, Heildeberg, pp 979-1001

White, M., Mohn, C., de Stigter, H., Mottram, G., 2005. Deep-water coral development as a function of hydrodynamics and surface productivity around the submarine banks of the Rockall Trough, NE Atlantic. In: Freiwald, A., Roberts J.M., Orejas C. (eds). Cold-water corals and ecosystems. Springer

Yilmaz, A.Z., Besiktepe, S., 2010. Annual variations in biochemical composition of size fractionated particulate matter and zooplankton abundance and biomass in Mersin Bay, NE Mediterranean Sea. J. Mar. Syst. 81(3), 260–271. doi: 10.1016/j.jmarsys.2010.01.002.

Zakaria, H.Y., 2006. The zooplankton community in Egyptian Mediterranean waters: A Review', Acta Adriatica, 47(2), 195–206.

Zervoudaki, S., Christou, E., Nielsen, T. G., Siokou-Frangou, I., Assimakopoulou, G., Giannakourou, A., Maar, M., Pagou, K., Krasakopoulou, E., Christaki, U., Moraitou-Apostolopoulou, M., 2007. 'The importance of small-sized copepods in a frontal area of the Aegean Se. J. Plankt. Res. 29(4), 317–338. doi: 10.1093/plankt/fbm018.

Zibrowius, H., 1980. Les Scléractiniaires de la Méditerranée et de l'Atlantique nord-oriental. Memoires de l'Institut Oceanographique Fondation Albert 1er, Prince de Monaco 11.

Table 1. ROV transects conducted during the CYCLAMEN survey. Station number is indicated as well as transect number (in brackets). Start and end position of each transects is depicted as well as depth range of the transects. Total number of colonies found in each transect is indicated as well as the occupancy (calculated as the percentage of 1 m length section with coral presence) and the density of colonies with the patches located in the transects (see also figure 1).

Date	Station	Transect length	Position		Depth	Number Colonies	Occupancy	Density colonies within the patch (m^{-2})
	(transect)	(m)	start	end	(m)		%	Avg±SD (max)
09/06/2015	3 (1)	787.4	35º 02.1523'N, 34º 05.7135'E	35º 01.8028'N, 34º 05.4467'E	245-144	6	0.5	1.0±0.7 (2)
09/06/2015	4 (2)	293.4	35º 01.6801'N, 34º 05.3941'E	35º 01.5442'N, 34º 05.3173'E	177-107	0		
09/06/2015	9 (3)	122.0	35º 01.9137'N, 34º 05.6842'E	35º 01.3183'N, 34º 05.3449'E	223-100	236	9.1	1.4±1.2 (7)
09/06/2015	10 (4)	520.3	35º 01.2784'N, 34º 05.4218'E	35º 01.3087'N, 34º 05.7367'E	109-157	2	0.4	0.7±0.0 (1)
10/06/2015	27 (5)	897	35º 02.6909'N, 34º 04.6298'E	35º 02.3678'N, 34º 05.0496'E	146-124	0		
11/06/2015	29 (6)	1398	35º 02.3521'N, 34º 05.0291'E	35º 01.7544'N, 34º 05.433'E	135-141	54	1.6	1.6±1.4 (6)
11/06/2015	29 (7)	1061.4	35º 01.7525'N, 34º 05.4631'E	35º 02.254'N, 34º 05.1496'E	143-142	224	10.6	1.3±0.9 (4)
						Total=522		

Table 2. Location of the CTD casts, zooplankton hauls (WP2 net 200 µm) and Van Veen Grab conducted during the CYCLAMEN survey.

Date	St. nr.	Gear	Position (Lat, Long)		Depth (m)
08/06/2015	1*	CTD	35º00.5492	34º06.0110	397.6
09/06/2015	5*	CTD	35º01.7661	34º05.4544	153.6
09/06/2015	6*	CTD	35º01.821	34º05.474	159
09/06/2015	11*	CTD	35º00.887	34º08.851	750
10/06/2015	15*	CTD	35º01.409	34º05.784	175
10/06/2015	19*	CTD	35º00.9586	34º05.8369	269
10/06/2015	21	CTD	35º01.599	34º05.7326	201
10/06/2015	22	CTD	35º01.7820	34º05.6440	178
10/06/2015	23	CTD	35º01.7050	34º05.5354	155
10/06/2015	24	CTD	35º01.6122	34º05.4251	135
10/06/2015	25	CTD	35º01.5453	34º05.334	113
10/06/2015	26	CTD	35º01.4413	34º05.2215	98
09/06/2015	7	WP2 (200 µm)	35º01.8145	34º05.4769	161
09/06/2015	8	WP2 (200 µm)	35º01.9141	34º05.5799	183.4
10/06/2015	16	WP2 (200 µm)	35º01.565	34º05.779	170
10/06/2015	17	WP2 (200 µm)	35º01.2845	34º05.8178	174.4
10/06/2015	18	WP2 (200 µm)	35º01.0179	34º05.0429	270
10/06/2015	20	WP2 (200 µm)	35º00.959	34º05.855	260
11/04/2016	1	Van Veen Grab	35º 01.461'	34º 04'15.289"	50
11/04/2016	2	Van Veen Grab	35º 01.572'	34º 04'38.346"	75
11/04/2016	3	Van Veen Grab	35º 01.700'	34º 05'5.176"	100
11/04/2016	4	Van Veen Grab	35º 01.794'	34º 05'24.880"	150
11/04/2016	5	Van Veen Grab	35º 01.869'	34º 05'40.602"	200
11/04/2016	6	Van Veen Grab	35º 01.932'	34º 05'53.495"	250
11/04/2016	7	Van Veen Grab	35º 02.011'	34º 06'9.326"	300
11/04/2016	8	Van Veen Grab	35º 02.099'	34º 06'27.998"	350
11/04/2016	9	Van Veen Grab	35º 02.099'	34º 03'42.423"	50
11/04/2016	10	Van Veen Grab	35º 02.305'	34º 04'4.331"	75
11/04/2016	11	Van Veen Grab	35º 02.553'	34º 04'36.515"	100
11/04/2016	12	Van Veen Grab	35º 02.553'	34º 04'55.277"	150
11/04/2016	13	Van Veen Grab	35º 02.648'	34º 05'14.818"	200
11/04/2016	14	Van Veen Grab	35º 02.778'	34º 05'41.657"	250
11/04/2016	15	Van Veen Grab	35º 02.908'	34º 06'8.434"	300

* Water samples have been collected in these stations.

Table 3 Descriptive statistical values (mean ± SD) for the water column environmental parameters at all the examined stations. T: temperature, D.O. = dissolved oxygen.

Date	St. nr.	Position (Lat, Long)		Depth (m)	T (°C) mean±SD (range)	Salinity mean±SD (range)	σ_t-density(kg/m^3) mean±SD (range)	Fluorescence(μg/L) mean±SD (range)	D.O. (mg/L) mean±SD (range)
08/06/2015	1	35º00.5492	34º06.0110	397.6	16.42±2.1 (14.04-24.07)	39.02.4±0.09 (38.84-39.13)	2.73±0.49 (26.75-29.15)	0.04±0.02 (0.02-0.12)	6.45±0.75 (5.42-7.58)
09/06/2015	5	35º01.7661	34º05.4544	153.6	18.71±2.1 (16.8-23,9)	39.09±0.03 (39.04-39.17)	28.21±0.57 (26.83-28.72)	0.07±0.02 (0.04-0.12)	7.01±0.28 (6.55-7.38)
09/06/2015	6	35º01.821	34º05.474	159	18.62±2.1 (16.8-24.0)	39.09±0.03 (39.04-39.17)	28.23±0.57 (26.80-28.73)	0.07±0.02 (0.04-0.12)	7.01±0.29 (6.52-7.40)
09/06/2015	11	35º00.887	34º08.851	750	15.16±1.9 (13.76-23.81)	38.92±0.03 (38.77-39.14)	28.94±0.37 (26.84-29.16)	0.03±0.02 (0.02-0.13)	5.83±0.67 (5.31-7.39)
10/06/2015	15	35º01.409	34º05.784	175	18.16±2.0 (16.27-23.98)	39.10±0.13 (39.05-39.19)	28.36±0.52 (26.83-28.84)	0.06±0.02 (0.03-0.11)	6.90±0.35 (6.23-7.37)
10/06/2015	19	35º00.9586	34º05.8369	269	17.18±2.1 (14.81-23.98)	39.07±0.03 (38.97-39.19)	28.58±0.52 (26.82-29.08)	0.05±0.02 (0.02-0.12)	6.54±0.60 (5.56-7.41)
10/06/2015	21	35º01.599	34º05.7326	201	17.79±1.9 (15.78-23.8)	39.09±0.05 (39.04-39.17)	28.45±0.50 (26.86-28.94)	0.05±0.02 (0.03-0.11)	7.04±0.43 (6.30-7.62)
10/06/2015	22	35º01.7820	34º05.6440	178	18.06±1.9 (16.12-23.84	39.10±0.03 (39.05-39.18)	28.38±0.50 (26.86-28.87)	0.06±0.02 (0.03-0.12)	6.93±0.38 (6.17-7.42)
10/06/2015	23	35º01.7050	34º05.5354	155	18.32±1.9 (16.55-23.81)	39.10±0.03 (39.05-39.18)	28.31±0.52 (26.86-28.78)	0.07±0.02 (0.04-0.13)	6.99±0.32 (6.38-7.42)
10/06/2015	24	35º01.6122	34º05.4251	135	18.51±1.9 (16.88-23.78)	39.09±0.03 (39.04-39.17)	28.26±0.50 (26.87-28.71)	0.07±0.02 (0.04-0.11)	7.12±0.30 (6.53-7.45)
10/06/2015	25	35º01.5453	34º05.334	113	18.81±2.0 (17.06-23.75)	39.09±0.03 (39.05-39.17)	28.18±0.52 (26.88-28.67)	0.06±0.2 (0.03-0.10)	7.11±0.26 6.53-7.37)
10/06/2015	26	35º01.4413	34º05.2215	98	18.97±1.9 (17.24-23.75)	39.08±0.04 (39.04-39.17)	28.14±0.51 (26.88-28.61)	0.06±0.02 (0.04-0.11)	7.18±0.26 (6.53-7.42)

Table 4 Values of descriptive statistics (mean ± SD) for nutrients (NO_2, NO_3, NH_4, PO_4, SiO_4), Particulate Organic Carbon (POC) and Chlorophyll-a (Chl) concentrations measured at selected stations.

Date	St. nr.	Position (Lat, Long)		Depth (m)	NO_2(μM/L) mean±SD (range)	NO_3(μM/L) mean±SD (range)	NH_4(μM/L) mean±SD (range)	PO_4(μM/L) mean±SD (range)	SiO_4(μM/L) mean±SD (range)	POC(μg/L) mean±SD (range)	Chla(μg/L) mean±SD (range)
08/06/2015	1	35º00.5492	34º06.0110	397.6	0.43±0.2 (0.24-0.45)	3.65±1.0 (2.73-4.76)	1.15±0.1 (1.06-1.28)	0.28±0.08 (0.22-0.38)	17.7±4.4 (12.6-20.6)	258±67.2 (207-334)	0.12±0.1 (0.01-0.24)
09/06/2015	5	35º01.7661	34º05.4544	153.6	0.29±0.08 (0.20-0.35)	1.05±0.14 (0.90-1.18)	0.50±0.06 (0.44-0.56)	0.19±0.01 (0.18-0.2)	11.9±4.2 (8.04-16.4)	312±43.9 (277-361)	0.22±0.1 (0.10-0.34)
09/06/2015	6	35º01.821	34º05.474	159	0.28±0.06 (0.22-0.33)	0.97±0.20 (0.74-1.11)	0.50±0.1 (0.44-0.61)	0.18±0.03 (0.15-0.2)	11.5±3.6 (9.1-15.7)	260±39.1 (217-294)	0.12±0.1 (0.01-0.23)
09/06/2015	11	35º00.887	34º08.851	750							
10/06/2015	15	35º01.409	34º05.784	175	0.30±0.07 (0.22-0.35)	0.98±0.34 (0.66-1.34)	0.50±0.06 (0.44-0.56)	0.23±0.03 (0.19-0.25)	20.8±16.2 (6.4-38.3)	--	0.07±0.1 (0.01-0.22)
10/06/2015	19	35º00.9586	34º05.8369	269	0.23±0.06 (0.17-0.35)	2.34±1.56 (0.77-5.08)	0.54±0.06 (0.50-0.67)	0.23±0.08 (0.15-0.41)	8.12±2.6 (5.3-12.5)	281±27.9 (246-310)	0.04±0.07 (0.01-0.22)

Figure captions

Figure 1. Study area. (a) The white square shows the study area off the SW coast of Cyprus; (b) Digital Elevation Model of the surveyed area, POV indicates the point of view displayed in panel c; (c) The black lines display the ROV transects, the white spheres indicate the abundance of *Dendrophyllia ramea* in number of colonies per 50 m transect length; (d) details of the location with higher abundances of *D. ramea.* Panels b, c and d show depth in meters below sea level according to the depth color scale.

Figure 2. Granulometry and Organic matter (OM) content of the sediment samples. (a) Location map; (b) Histograms on the top of the panel display the weight percentage of each Folk and Ward textural fraction, different colours correspond to different grain size. Black circles display the samples location. Circle diameter is proportional to the OM content in weight percentage of dry sample according to legend at the right side of the figure. The white ellipse shows the area where high densities of *Dendrophyllia ramea* colonies were recorded (see Fig. 1). Depth range of the sampling area is indicated in the legend at the right side of the figure.

Figure 3. Depth *vs*. slope of the two parallel sections where sediment sampling was conducted. (a) The green line is the southern section profile where corals are present; the black line is the northern section profile where corals are absent (see Fig 2). The grey band represents the depth range where high abundance of *Dendrophyllia ramea* colonies has been detected in the southern transect. The lighter the band colour, the higher the number of coral colonies per surface area. Dashed line shows the trend of depth *vs* slope considering both profiles. (b) Blow up of the depth range of coral occurrence.

Figure 4. Video frames showing *Dendrophyllia ramea* colonies off Protaras. (a) high density patch of coral colonies, note the different colony sizes. (b) Close up of a large coral colony. The red dots are the laser pointers of the ROV, which are 10 cm apart.

Figure 5. Bathymetric distribution of *Dendrophyllia ramea* in the study area off Protaras. Vertical axes display the depth range. The grey histogram shows surveyed area for each depth interval. The black histograms indicate the number of *D. ramea* colonies recorded at each depth interval.

Figure 6. *Dendrophyllia ramea* population size structure for the video transects recorded in Stations 9 and 29. Bars indicate the percentage of colonies belonging to the determined size classes (colony width less than 10 cm, between 10 and 20 cm, between 20 and 40 cm and larger than 40 cm). n indicate the number of colonies measured for each transect.

Figure 7. Density (col m^{-2}) of *D. ramea* colonies across the length of the two transects conducted in Station 9 and 29 off Protaras. Panels (a) and (b) display the density plots for transect 3 and 7 respectively. The graphs above show the density for large colonies and graphs below for small colonies.

Figure 8. (a) Temperature-salinity diagram and (b) salinity profile displaying the different water masses identified in the sampling area. Levantine Surface Water (LSW, light brown), Levantine Surface Water and Modified Atlantic Water mixture (LSW+MAW, dark brown), Levantine Surface Water and Levantine Intermediate Water mixture (LSW+LIW, red), Levantine Intermediate Water (LIW, green), East Mediterranean Deep Water (EMDW, light purple). The blue ellipses indicate the presence of the *Dendrophyllia ramea* population.

Figure 9. Values for the environmental parameters: (a) temperature, (b) salinity, (c) oxygen, (d) fluorescence recorded in the sampling area during the CYCLAMEN cruise. Data belong to the Station 9, Transect 3, where the highest densities of *D. ramea* colonies have been recorded. *D. ramea* population is represented by a white line.

Figure 10. Proportion of the main zooplankton groups documented in the analysed stations of the study area. *Cladocera and Ostracoda, **Chaetognatha, Cnidaria and Larvacea

Figure 11. Evidences of the anthropogenic impact in the area where the *Dendrophyllia ramea* population has been documented and in its vicinity. (a) *Alcyonium* sp. growing in a glass bottle at 161 m depth; (b) *D. ramea* colonies entangled in remaining of a lost fishing gear at 141 m depth; (c) lost fishing gear at 162 m depth; (d) and (e) marks in the sediment of a bottom contact fishing gear at 149 m and 126 m depth, respectively; (f) alive *D. ramea* colony laying in the substrate, red arrows point to polyps displaying the growth pattern described in the text.

Appendix A. a) Side Scan Sonar mosaic of surveyed area. White line represents ROV track where the number of colonies is high (end of T1). Black line show where the colonies are scarce or are absent (T2). b) Enlargement of the area where colonies are abundant in. c) Enlargement of the area where colonies are absent.