ORIGINAL ARTICLE

Looking for long-term changes in hydroid assemblages (Cnidaria, Hydrozoa) in Alboran Sea (South-Western Mediterranean): a proposal of a monitoring point for the global warming

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Abstract In the last 20–30 years, the temperature of the Mediterranean Sea has increased and global warming is allowing the establishment of tropical-affinity species into more temperate zones. Sessile communities are particularly useful as a baseline for ecological monitoring; however, a lack of historical data series exists for sessile marine organisms without commercial interest. Hydroids are ubiquitous components of the benthic sessile fauna on rocky shores and have been used as bio-indicators of environmental conditions. In this study on the benthic hydroid assemblages of the Chafarinas Islands (Alboran Sea, South-Western Mediterranean), we characterized the hydroid assemblages, identified the bathymetric gradients, and compared them with a previous study carried out in 1991. Hydroid assemblages showed a significant difference both between year and among depths. Furthermore, eight species not present in 1991 were found, including two possible new species and the tropical and subtropical species *Sertularia marginata*. Due to its strategic position at the entrance of the Mediterranean and the existence of previous data on hydroid assemblages, the Chafarinas Islands are proposed as a possible monitoring point for entrance of Atlantic tropical species into the Mediterranean Sea.

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Introduction

Reliable evidence demonstrates that the climate is changing, and the average surface temperature of the sea is increasing (Brierley and Kingsford 2009). In the last decades, the mean surface temperature has increased in the Mediterranean (Nykjaer 2009; Skliris et al. 2012) and, for example, the Alboran Sea (Western Mediterranean) has shown a rise of the superficial average temperature of 0.5 °C since the early 1990s–2005 (Vargas Yáñez et al. 2007). The clime is an important determinant in the range of distribution of species (Thomas 2010), and rapid climatic changes are associated with changes in the distributional range of the species (Hughes 2000; Harley et al. 2006). This together with other anthropogenic impacts of global effects, such as worldwide translocation of species and the associated biological invasions and ocean acidification, is changing the composition of the communities (Walther et al. 2002; Occhipinti-Ambrogi 2007; Brierley and Kingsford 2009). Global warming, the increase of the warm season and human-mediated species translocation are allowing the species of tropical affinity to move into more temperate zones (Hughes 2000).

The climate variations modify the distribution patterns of the marine species in the Mediterranean Sea and nearby waters resulting in a process known as "tropicalization" (Bianchi 2007). This phenomenon is favoured by three

main elements: (1) the continuous entrance of Atlantic species into the Mediterranean since the opening of the Strait of Gibraltar in the basal Pliocene (Boero et al. 2003); (2) the opening of the Suez Canal in 1869 permitted the entrance of species from the Red Sea, generally confined to the Eastern Mediterranean (Bianchi and Morri 2000; Morri et al. 2009); and (3) the direct introduction of exotic species, most of them of warm-water affinity, by activities such as maritime traffic or aquaculture that constitutes an additional source of species to Mediterranean Fauna (Zaitsev and Öztürk 2001).

The study of the diversity and composition of marine communities is the first step in understanding the development of marine ecosystems (Elahi et al. 2013). Furthermore, the changes in the abundance and composition of species are the main factors to obtain information about the dynamic of communities (Micheli et al. 1999). However, the lack of historical data is the main problem for relating changes in marine communities with climatic changes (Southward 1995; Hawkins et al. 2003; Vandepitte et al. 2010). Sessile communities are particularly useful as a reference for ecological monitoring (Carballo et al. 1996; Naranjo et al. 1996; Guerra-García et al. 2006; González-Duarte et al. 2013a). Although conspicuous groups are not sufficient to appreciate marine biodiversity and to understand its functioning (Boero et al. 2003), most studies about long-term changes in marine communities are focused on plankton (Degobbis et al. 1995; Beaugrand and Ibanez 2004; Molinero et al. 2007) or commercial species: fisheries (Golani et al. 2002), crustacea (Galil et al. 2002) or mollusks (Zenetos et al. 2004). Indeed, Burrows et al. (2011) cited the study of Puce et al. (2009) on the hydroid assemblages in the Ligurian Sea (Central Mediterranean) as the only report of the effects of global warming on marine benthic organisms.

Most of the historical data are difficult to compare because they were not usually collected with the purpose of a standardized comparison with future studies. However, due to the critical importance of ascertaining changes in marine communities associated with global warming, some researchers are at present facing the challenge of analysis of disparate datasets coming from previous studies (Elahi et al. 2013). In the absence of adequate replicated historical data, the available data are often the only possible chance to study long-term changes (Bradshaw et al. 2002). Indeed, one common practice in the studies about global warming is the comparison of different works, especially if the sampling designs are similar, but not identical (Elahi et al. 2013) (e.g. Puce et al. 2009). We tested our results by performing a comparison with similar studies in the Mediterranean Sea.

With regard to hydroids, they are among the most important components of benthic communities on rocky shores (Boero 1984; Gili and Hughes 1995; Bouillon et al. 2006), being usually present with a large number of colonies and species (Boero and Fresi 1986; Gili and Hughes 1995; Piraino et al. 2002). They are among the first to colonize virgin substrates, but they are also present in later stages of community development (Boero 1984; Morri and Boero 1986; Gili and Hughes 1995). They also serve as a trophic source and provide secondary substrates for many invertebrates (Di Camilo et al. 2013). Their benthic assemblages have some properties that make them a very informative model for environmental and ecological studies (Gili and Hughes 1995; González-Duarte et al. 2013a; Megina et al. 2013). Thus, the temperature is a critical factor for the benthic hydroid communities, affecting crucial aspects of their life cycle and biology: their seasonality, the rate of oxygen consumption, stolon regeneration, etc. (Boero 1984; Boero and Fresi 1986; Gili and Hughes 1995; Bavestrello et al. 2006). Furthermore, they are common components of fouling communities being frequently involved in introduction and invasion phenomena since the globalization of maritime routes (Boero 1984; Boero et al. 2003; Gravili et al. 2008); some of them are considered as perfect invaders because their life cycles include encystment phases or ability for reverse development (Boero 2002; Megina et al. 2013).

The hydroid assemblages of the Portofino Promontory (Ligurian Sea) were extensively studied between 1976 and 1983 (Boero 1984; Boero and Fresi 1986; Boero et al. 1986; Morri and Boero 1986). This pool of data allowed Puce et al. (2009) to investigate the changes in hydroid assemblages and to evaluate the influence of global warming on the benthic marine ecosystem.

Similarly, in 1991, Peña Cantero and García Carrascosa (2002) conducted extensive faunistic research about hydroid assemblages of the Chafarinas Islands (Alboran Sea, Western Mediterranean). They identified the species present, their substrates and zonation pattern in depth.

As a first step, we studied the benthic hydroid assemblages on hard bottom of the Chafarinas Islands in the summer of 2007. We used a standardized sampling design to explore the horizontal variability in these assemblages, identifying the bathymetric gradients and the species composition. Later, we compared these data with the previous census, 16 years previously, to reveal possible changes in the hydroid assemblages on hard bottom. Finally, we compared our results with similar works carried out in the Mediterranean Sea (i.e. Puce et al. 2009), which established a relationship between global warming and changes in hydroid assemblages. We provide information about hydroid assemblages of the Chafarinas as a baseline study, and we propose this archipelago as a point for monitoring the long-term changes in the benthic communities of the Alboran Sea and Western Mediterranean.

Materials and methods

Sampling and sorting

Hydroid sampling was carried out in the archipelago of Chafarinas in summer (August 2007), as well as previous study (Peña Cantero and García Carrascosa 2002). Chafarinas islands are a protected area with restricted access due to military surveillance, where only scientific activities are allowed in both the terrestrial and marine environment, so that direct anthropogenic influence is minimal. It is situated in the Alboran Sea (Western Mediterranean), near the North African coast (35°10′45.33″N; 2°25′49.49″W). Three volcanic islands form the Chafarinas archipelago ("Congreso", "Isabel II" and "Rey Francisco") close to the mouth of the Ouad-Moulouya River. Two sampling points were selected at the easternmost and westernmost ends of the archipelago to consider the internal geographical variability, and two replicate random transects at each point, from some metres to tens of metres apart (Fig. 1). Each transect was subdivided into four depth bands (0/−5 m, −5/−10 m, −10/−15 m and −15/−20 m) following the methodology of Boero and Fresi (1986).

Samplings were carried out by SCUBA diving using visual collection techniques, which has been shown to efficiently represent the hydroid diversity in shallow coastal benthic habitats (Boero and Fresi 1986; Puce et al. 2009; González-Duarte et al. 2013a; Megina et al. 2013). Samples were preserved either in ethanol 90 % or in formalin 4 %. Specimens were sorted and identified to the maximum level of taxonomic resolution possible, in most cases to specific level. The abundance of every taxon was estimated by counting the number of polyp-bearing hydrocauli (stems) in the sample (see González-Duarte et al. 2013a; Megina et al. 2013).
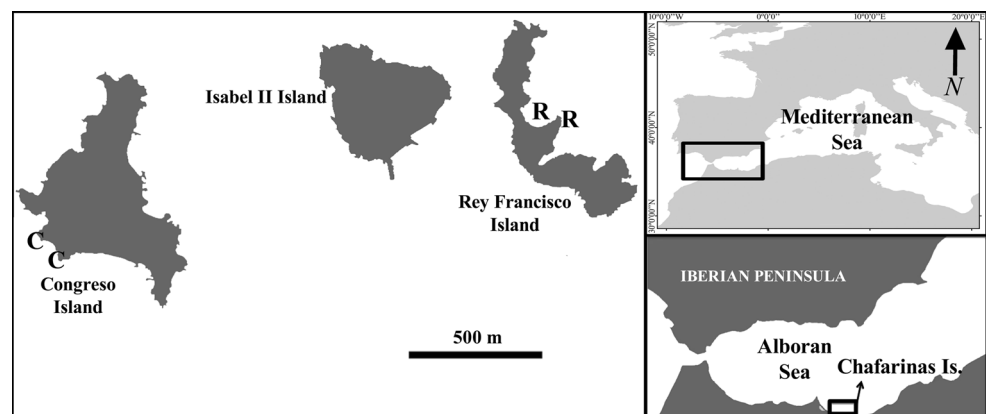
In the present study, we compared our results with the previous work carried out by Peña Cantero and García Carrascosa (2002) in the Chafarinas Islands. They did report information about transects, stations on every transect and species list, together with depth and substrate for each species. Hydroids are rather non-specific (with a few exceptions) and can be present in a high number of different substrates in a given area (Cornelius 1982; Calder 1991; Gili and Ballesteros 1991; Genzano and Rodriguez 1998). Thus, we counted the times that each species was present on a different substrate as an indication of their relative abundance. It allowed a more sensitive comparison of our data with those from the study of Peña Cantero and García Carrascosa (2002). The faunistic study carried out by Peña Cantero and García Carrascosa (2002) was also based on several transects in depth, but with a different quantity and distribution of them. For a more sensible comparison accounting for spatial variability within the archipelago and with depth gradient, we grouped the samples for each island and each depth band in the two sampling periods. The two sampling periods under comparison (1991 and 2007) were conducted in summer; therefore, the seasonal variations are not taken into account. Furthermore, to avoid artificial differences but trying to preserve the maximum information of similarities or differences between samples, all the specimens which could not be reliably separated as belonging to different species, due to the lack some diagnostic information (fertile material, a jellyfish stage or any other characters), were grouped together (sometimes by genus, sometimes by a group of species within a genus): *Scandia* spp.; *Lafoeina tenuis/Egmundella amirantensis*; *Filellum disaggregatum* and *Filellum* sp.1 sensu Peña Cantero and Garcia Carrascosa (2002) as *Filellum* sp.1 and *Filellum serpens* and *Filellum* sp.2 sensu Peña Cantero and Garcia Carrascosa (2002) as *Filellum* sp.2.

Data analysis

In the study of hydroid assemblages in 2007 considered two factors, "Depth" and "Island". In comparison between

Fig. 1 Chafarinas archipelago and its position in the Western Mediterranean showing the two transects sampled on each sampling point: "Congreso Island" (C) and "Rey Island" (R)

1991 and 2007, we considered two factors, "Depth" and "Year", considering the islands as replicates. The data were organized in species/sample abundance matrix. A Bray-Curtis similarity matrix was calculated as a distance measure among samples (Bray and Curtis 1957) on square root-transformed data in the analysis of the hydroid assemblages in 2007 and on standardized data to minimize the potential effect of different sampling efforts, in comparison with Peña Cantero and García Carrascosa (2002) data. We used a distance-based permutational multivariate analysis of variance (PERMANOVA) (Anderson 2001; McArdle and Anderson 2001) to partition variance in assemblage composition according to the above designs. When appropriate, significant terms in the full model were analysed individually using pair-wise comparison with the PERMANOVA test. The homogeneity of multivariate dispersion among the groups of each factor of interest was tested by PERMDISP (Anderson 2006).

The dissimilarities among samples were represented by non-metric multidimensional scaling ordinations (nMDS, (Clarke 1993)). SIMPER (Clarke 1993) was used to identify the percentage contribution that each taxon made to the measures of similarity within (or dissimilarity among) the different levels of the fixed factors for which significant differences were found. The ratio average similarity/standard deviation (SIM/SD) and average dissimilarity/standard deviation (DISS/SD) are useful measures of how consistently a component of the assemblage typifies a group or discriminates between groups (Clarke and Warwick 2001). We tabulated the taxa with these ratios larger than or equal to 1.4 (González-Duarte et al. 2013a; Megina et al. 2013). Multivariate analyses were performed using the software PRIMER v6.1.11 and PERMANOVA + v1.0.1 statistical package (Clarke and Gorley 2006).

Additionally, we examined the number of species in the explored assemblages in a two-way ANOVA, with a similar design to that explained above. This analysis was done using Statistica v6.0 package (Statsoft Inc 2001).

Results

Hydroid assemblages in 2007

The nMDS plots in Fig. 2 show the different distribution of the samples from the two islands based on hydroid assemblages, although this result was only marginally significant (Table 1). The samples also showed a vertical zonation in depth, with the samples between 0 and 10 m and samples between 15 and 20 m in depth as two different groups. These two groups were more evident in Rey Island than Congreso Island. The PERMANOVA showed significant differences in the multivariate structure of hydroid
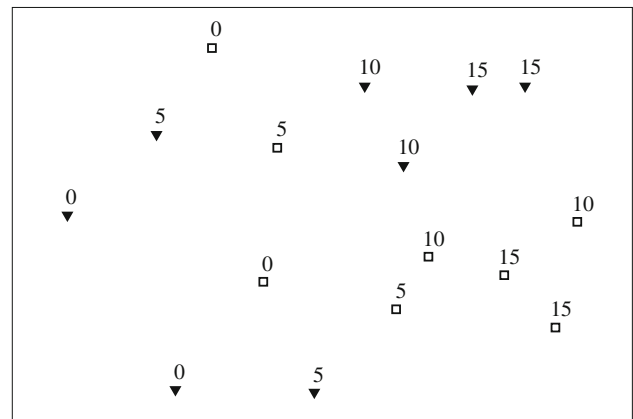

Fig. 2 Non-metric multi-dimensional scaling ordination of the sampled hydroid assemblages on the basis of the Bray–Curtis dissimilarity. *Inverted triangle* Rey Is.; *square* Congreso Is.; 0 = 0/−5 m; 5 = −5/−10 m; 10 = −10/−15 m and 15 = −15/−20 m (stress = 0.15)

Table 1 Results of PERMANOVA partitioning spatial variation in hydroid assemblage composition in 2007

	df	SS	MS	Pseudo-F	P(perm)
Depth	3	5,541.3	1847.1	2.3988	0.003*
Island	1	1,602.7	1,602.7	2.0813	0.053
Depth × Island	3	2,820.8	940.26	1.2211	0.225
Residual	8	6,160.1	770.01		
Total	15	16,125			

* Significant differences at $P < 0.05$

Table 2 Results of pair-wise comparison for the fixed factor "depth" for the hydroid assemblages in 2007

Groups	t	P(perm)
0–5	0.969	0.555
0–10	1.732	0.026*
0–15	2.034	0.028*
5–10	1.380	0.099
5–15	1.749	0.044*
10–15	1.227	0.214

(0 = 0/–5 m; 5 = –5/–10 m; 10 = –10/–15 m; 15 = –15/–20 m).
* Significant differences at $P < 0.05$

assemblages among depths. Pair-wise comparison showed a clear gradient in depth (Table 2). This test did not show significant differences between contiguous depth bands and showed significant differences between more separated ones. The interactions between these two factors ("depth" and "islands") were not significant; thus, the differences with depth did not change significantly between sampling points.

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Table 3 SIMPER analysis

	Average of similarity			
	0–5 m (54.75 %)	5–10 m (56.56 %)	10–15 m (62.07 %)	15–20 m (60.98 %)
Aglaophenia kirchenpaueri	4.22	3.7	3.42	4.7
Aglaophenia tubiformis	1.91	4.88	3.55	–
Antennella ansini	4.44	4.54	5.39	4.41
Anthohebella parasitica	3.87	2.02	–	–
Campanularia hincksii	4.1	3.14	4.23	4.79
Clytia gracilis	3.93	5.31	–	–
Clytia hemisphaerica	2.01	–	–	–
Clytia linearis	5.28	2.67	4.03	4.5
Dynamena disticha	4.76	5.03	–	–
Filellum sp.1	2.94	3.14	5.54	4.67
Halecium beani	3.51	–	2.14	–
Halecium delicatulum	–	3.17	2.13	–
Halecium lankesteri	3.38	2	6.31	5.83
Halecium tenellum	–	–	–	4.39
Kirchenpaueria pinnata	–	3.02	2.13	–
Obelia dichotoma	–	2.7	–	2.87
Salacia desmoides	–	–	4	–
Scandia spp.	–	–	–	7.09
Sertularella ellisii	–	–	4.17	2.72
Sertularella polyzonias	–	–	–	2.41
Sertularia distans	–	–	2.14	–

Species significantly contributing to the similarity among depths in 2007 (average of similarity/SD ≥ 1.4). Data were transformed on square root

Table 3 shows the 21 most significant species (SIM/SD ≥ 1.4) to characterize the different depth bands according to SIMPER analysis. *Aglaophenia kirchenpaueri, Antennella ansini, Campanularia hincksii, Clytia linearis, Filellum* sp.1 and *Halecium lankesteri* characterized the assemblages at the four depth bands. *Anthohebella parasitica, Clytia gracilis, Clytia hemisphaerica* and *Dynamena disticha* characterized the superficial depths (0–10 m). On the other hand, *Halecium tenellum, Salacia*

desmoides, Scandia spp., *Sertularella ellisii, Sertularella polyzonias* and *Sertularia distans* characterized the deeper samples (10–20 m). Figure 3 visually represents the abundances across the different sampling depths of the most representative species identified by the SIMPER analysis.

The univariate analysis did not show significant differences between islands or among depths for the number of species (Depth: $F_3 = 0.154$, $p = 0.920$; Island: $F_1 = 2.727$, $p = 0.197$).

Two species belonging to the genus *Halecium* could not be assigned to any of the known species, and they are possible new species. Although beyond the scope of this paper, the description and discussion the identity of this material will be presented in future publications.

Long-term changes in the hydroid assemblages 1991 versus 2007

The nMDS showed a clear separation in the multivariate structure of hydroid assemblage between 1991 and 2007 (Fig. 4). Results of the multivariate analyses using PER-MANOVA are reported in Table 4 and revealed significant differences in the structure of the hydroid assemblages between 1991 and 2007 and among depths. The interactions between these two factors were not significantly different; thus, there were no significant changes in the variation of hydroid assemblages with depth gradient during these periods. Pair-wise comparison among depths also showed a vertical gradient of the hydroid assemblages (Table 5).

The SIMPER analysis identified 16 species as contributing most to the characterization of the assemblages in one or the other sampling period or to differentiate them (Table 6). Four species characterized the hydroid assemblage in the two periods: *Antennella ansini, Campanularia hincksii, Clytia linearis* and *Halecium lankesteri*. Only *Scandia* spp. characterized exclusively the hydroid assemblage in 1991 (SIM = 45.71 %). Eight taxa characterized the hydroid assemblage in 2007 (SIM = 57.35 %) and were not characteristics in 1991: *Aglaophenia kirchenpaueri, Aglaophenia tubiformis, Clytia gracilis, Filellum* sp.1, *Kirchenpaueria pinnata, Obelia dichotoma, Sertularella ellisii* and *Sertularia distans*. Eleven species contributed significantly to the dissimilarities between periods (DISS = 57.88 %): *A. kirchenpaueri, Anthohebella parasitica, C. gracilis, C. linearis, Filellum* sp.1, *Halecium delicatulum, H. lankesteri, O. dichotoma, Plumularia setacea, S. ellisii* and *S. distans*. Figure 5 visually represents the abundances of most representative species that contributed to the dissimilarity between years identified by the SIMPER analysis.
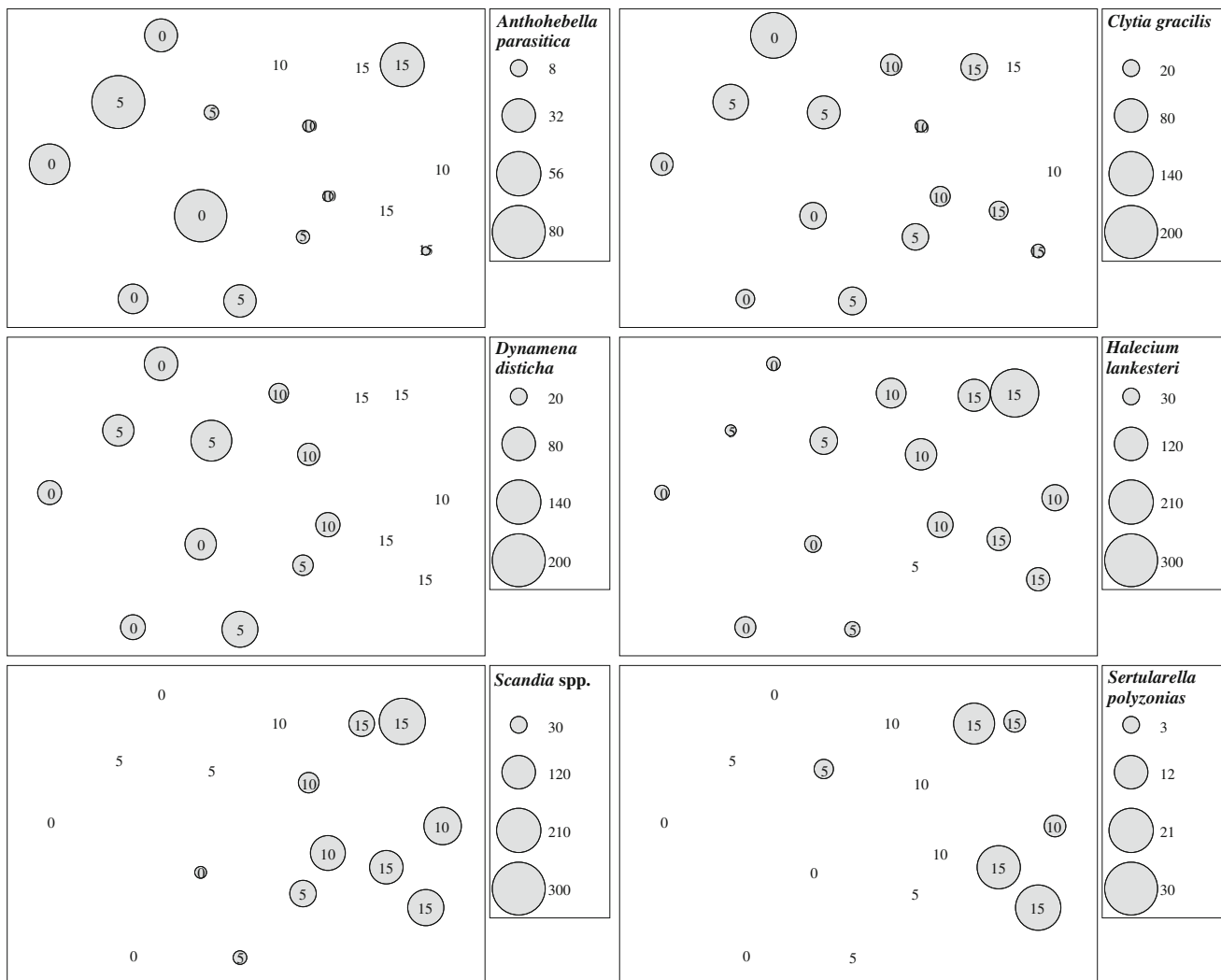
Fig. 3 Bubble plot of vertical zonation of some species sampled in 2007 identified by SIMPER analysis. Size of the bubbles is proportional to the abundance of the represented species. (0 = 0/–5 m; 5 = –5/–10 m; 10 = –10/–15 m; 15 = –15/–20 m) (stress = 0.15)

The univariate analysis of the number of species by the general linear model did not show significant differences between years ($F_1 = 1.809$; $p = 0.203$) or among depths ($F_3 = 0.183$; $p = 0.905$), with 60 being the total number of species collected in 2007 and 66 in 1991.

From a qualitative point of view, 15 species sampled in 1991 were not found in 2007, and eight species had not previously been recorded for the Chafarinas Islands (Table 7).

Discussion

Vertical zonation is the most obvious distribution pattern of hard-bottom communities, often explained in relation to environmental factors such as light, temperature and water movement (Terlizzi and Schiel 2009). A vertical zonation

in depth seems to be the rule for hydroids (Boero and Fresi 1986). Indeed, a gradual variability of the multivariate structure of the hydroid assemblages with depth was generally found in the study zone, despite the depth range surveyed was between 0 and 20 m in depth. Some species (Fig. 3) were particularly illustrative in this sense, showing a continuous decrease or increase with depth. For example, *Clytia gracilis* showed maximum abundances in the more superficial depth, and *Halecium lankesteri* showed an inverse trend.

Over this general trend, there exists slight evidence of a more abrupt discontinuity between the most superficial samples (0–10 m) and the deepest samples (10–20 m). Indeed, some species were almost exclusively present in these shallowest or deepest areas. *Anthohebella parasitica* or *Dynamena disticha* (0–10 m) and *Scandia* spp. or *Sertularella polyzonias* (10–20 m) indicated the separation
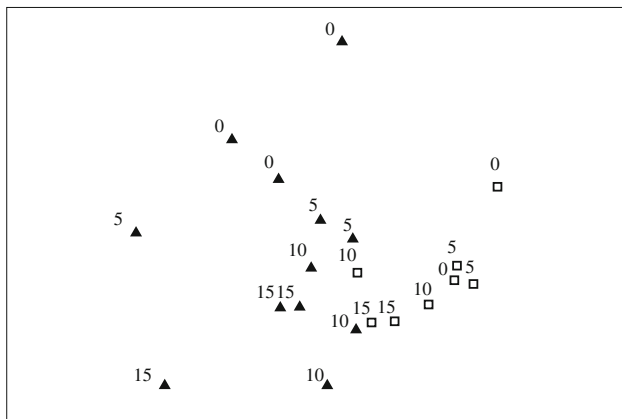
Fig. 4 Non-metric multi-dimensional scaling ordination of the sampled hydroid assemblages at Chafarinas Islands in 1991 (*triangle*) and 2007 (*square*). 0 = 0/−5 m; 5 = −5/−10 m; 10 = −10/−15 m and 15 = −15/−20 m (stress = 0.11)

Table 4 Results of PERMANOVA partitioning spatial variation in hydroid assemblage composition in comparison between years

	df	SS	MS	Pseudo-F	P(perm)
Year	1	5,914.3	5,914.3	5.262	0.001*
Depth	3	5,765.9	1,922	1.71	0.016*
Year × depth	3	3,670.4	1,223.5	1.0,885	0.332
Residual	12	13,488	1,124		
Total	19	29,600			

* Significant differences at $P < 0.05$

Table 5 Results of pair-wise comparison for the fixed factor "depth" in comparison between years

Groups	t	P(perm)
0–5	1.067	0.372
0–10	1.611	0.023*
0–15	1.793	0.015*
5–10	0.964	0.531
5–15	1.213	0.162
10–15	0.945	0.575

(0 = 0/–5 m; 5 = –5/–10 m; 10 = –10/–15 m; 15 = –15/–20 m).
* Significant differences at $P < 0.05$

between superficial and deeper samples. The distribution in depth of these species is in agreement with other studies carried out in the Mediterranean Sea (Gili and Castellò 1985; Boero and Fresi 1986; De Vito 2006; Puce et al. 2009). The exception was *Scandia* spp., because these authors described the species belonging to this genus as characteristics of a wider depth range of 0–30 m. This discontinuity was more evident in the samples from Rey Island, where transects were located in the easternmost part

Table 6 Species significantly contributing to characterizing each year and the dissimilarity between 1991 and 2007 (average of similarity/SD ≥ 1.4)

	SIM		DISS
	1991	2007	1991 versus 2007
Aglaophenia kirchenpaueri	–	5.53	3.15
Aglaophenia tubiformis	–	2.46	–
Antennella ansini	5.22	4.8	–
Anthohebella parasitica	–	–	0.57
Campanularia hincksii	3.27	3.64	–
Clytia gracilis	–	2.7	2.22
Clytia linearis	4.41	6.88	2.76
Filellum sp.1	–	3.34	1.84
Halecium delicatulum	–	–	1.81
Halecium lankesteri	4.97	2.53	2.01
Kirchenpaueria pinnata	–	2.55	–
Obelia dichotoma	–	2.01	1.77
Plumularia setacea	–	–	0.55
Scandia spp.	12.89	–	–
Sertularella ellisii	–	2.73	1.69
Sertularia distans	–	2.04	1.47

Data were standardized and square root-transformed data. SIM = Average of Similarity; DISS = Average of Dissimilarity

of the archipelago. In the deepest zones of these sampling points, the substrate and benthic organisms were more visibly covered with some muddy sediment than in Congreso Island, perhaps from the River Moulouya discharge (Guallart and Afan 2013), which could create some particular environmental conditions tending to increase the separation between deeper and superficial samples.

Our comparison of previous and present studies in Chafarinas suggested that the hydroid assemblage has changed. Although the comparison between studies with different methodologies and sampling efforts must be considered with caution, some additional evidence and the comparison with similar studies make our results more reliable. In agreement with Puce et al. (2009), the family Aglaopheniidae and Corynidae showed a reduction in their abundance and in the number of species; *Clytia gracilis* and *Sertularella polyzonias* were also reported as being more abundant. In particular, eight species of the genus *Aglaophenia* were collected in 1991, and this was reduced to four in 2007. *Kirchenpaueria halecioides* or *Clytia* sp. were very abundant species in 1991 (they were present in a high number of different substrates), and they were not found in 2007.

The variation of the hydroid assemblages with the depth gradient, however, seems to have remained unchanged in Chafarinas since 1991. Also, the total number of species did not show significant changes between the compared
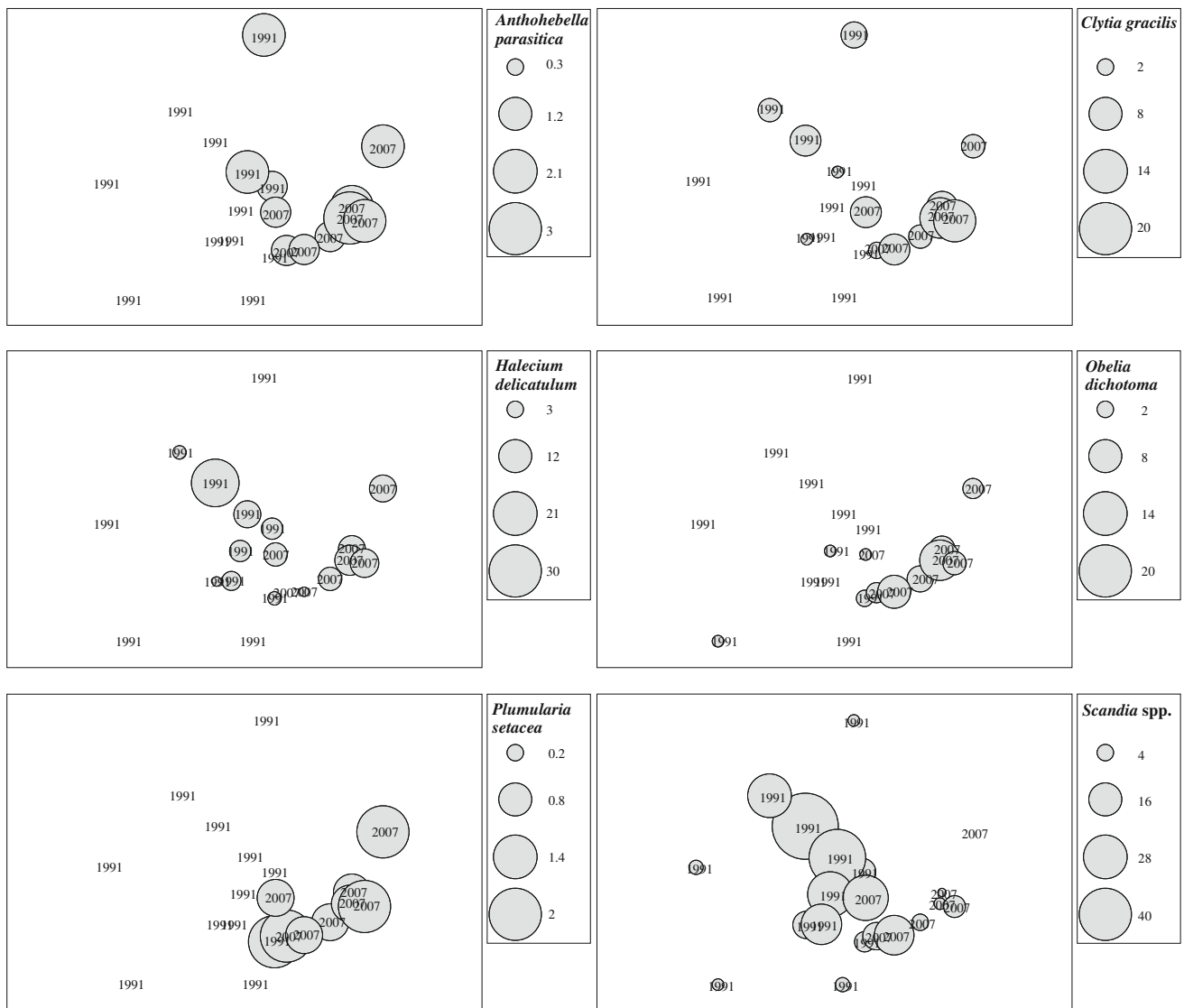
Fig. 5 Bubble plot of some species identified by the SIMPER analysis contributed to the dissimilarity between 1991 and 2007. Size of the bubbles is proportional to the abundance of the represented species (stress = 0.11)

periods. This is in agreement with other studies dealing with long-term changes in hydroid assemblages with global warming that suggest that the number of species tends to remain stable, but the structure and composition of the assemblages change (Puce et al. 2009; Gravili et al. 2013).

Although Peña Cantero and García Carrascosa (2002) carried out a faunistic study with a higher sampling effort (time, depth range and number of samples) than our study in 2007, the samples in 2007 provided a good representation of the global diversity of hydroid assemblages. However, it is arguable that some rare species detected in 1991 could have passed unnoticed in 2007. Therefore, the species only sampled in 2007 and not found previously by Peña Cantero and García Carrascosa (2002) are particularly meaningful (Table 7). For example, Sertularia marginata

is a circumtropical and subtropical species introduced into the Mediterranean Sea (Bouillon et al. 2004; Morri et al. 2009). The specimens of S. marginata collected in Chafarinas constituted the first record for the western Mediterranean where this species may have recently expanded and naturalized in the Mediterranean (González-Duarte et al. 2013b).

The benthic species can react by varying its distribution and abundance to changes in the temperature in the order of 0.5 °C (Hiscock et al. 2004), such as the one observed in the superficial temperature in the Alboran Sea (Vargas Yáñez et al. 2007). Hydroids are extremely sensitive in their biology and community structure to climatic changes (Puce et al. 2009). Furthermore, global warming could facilitate the introduction and posterior spread of non-

Table 7 Species only found in 1991 or in 2007

Species only found in 1991 and not sampled in 2007	New records for Chafarinas Is. (2007)
Agalophenia acacia	*Clytia viridicans*
Aglaophenia picardi	*Eudendrium armatum*
Aglaophenia pluma	*Gonothyraea loveni*
Clytia sp.	*Halecium* sp.1
Coryne muscoides	*Halecium* sp.2
Ectopleura wrighti	*Halecium textum*
Eudendrium simplex	*Nemertesia antennina*
Eudendrium sp.	*Sertularia marginata*
Hydractinia inermis	
Hydranthea margarica	
Hydrodendron mirabile	
Kirchenpaueria halecioides	
Laomedea pseudodichotoma	
Nemertesia ramosa	
Sertularia perpusilla	

indigenous species in the Mediterranean Sea (Occhipinti-Ambrogi and Savini 2003), particularly those of warm-water origins. In general, warm-water species are expanding their distributional areas, while cold-water species are showing a reduction (CIESM 2002; Guidetti et al. 2002). Specifically, in our studied area, tropical Atlantic species are arriving at the Strait of Gibraltar and spreading into the Mediterranean Sea, where the southern part presents a higher abundance of subtropical species (Lejeusne et al. 2010). However, the North African coast is usually not well known (Peña Cantero and García Carrascosa 2002; Zenetos et al. 2005).

The Chafarinas archipelago is a marine-protected area isolated from human activities, located at the southern coast of the Alboran Sea, in the entrance of the Mediterranean. It is highly influenced by the asymmetric incoming surface Atlantic waters, directly driving towards its coast (Candela 1991; Skliris and Beckers 2009; González-Duarte et al. 2013a). It is therefore a very appropriate zone for early detection of new entrances of tropical Atlantic species that can potentially spread into the Mediterranean. González-Duarte et al. (2013a) described this asymmetrical influence of the Atlantic waters as extending to benthic communities. These authors defined an Atlantic Influence Zone (Atlantic coast of the Strait of Gibraltar and Southern Alboran Sea), where the benthic hydroid assemblages have a more Atlantic character. Iazza et al. (2013) also pointed out the strong relationship between the hydroid fauna in the entrance of the Mediterranean and the South Atlantic Moroccan fauna. Species arriving from the African Atlantic coast and coming into the Mediterranean could reach mainly the southern coast of the Alboran Sea. The

higher Atlantic affinity of the Alboran Sea Fauna (Bianchi and Morri 2000), the Atlantic Influence Zone described for the African coast of the Alboran Sea (González-Duarte et al. 2013a), the recent new records (González-Duarte et al. 2013b; Iazza et al. 2013 and present data) and the collection of new undescribed species in these coasts reinforce this idea.

These facts, together with the existence of previous data about the hydroid fauna, in 1991 (Peña Cantero and García Carrascosa 2002) and 2007 (present study), allow us to propose Chafarinas as a monitoring point for long-term changes in the western Mediterranean benthic communities and for the detection of novel tropical Atlantic species in the Mediterranean. Long-term monitoring may confirm whether the changes in the hydroid assemblages described here are consistent and stable with time. This will allow correlating the climatic changes and the changes in the benthic assemblages, excluding the influence of other factors such as the natural fluctuation of the marine benthic populations.

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