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Research Note

Mass mortality of *Eunicella singularis* (Anthozoa: Octocorallia) in the Chafarinas Islands (North Africa, Western Mediterranean Sea)

Mortalidad masiva de *Eunicella singularis* (Anthozoa: Octocorallia) en las Islas Chafarinas (Norte de África, Mar Mediterráneo occidental)

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Abstract.- Records of mortality after a high temperature event in 2014 in the white gorgonian *Eunicella singularis* were compiled in six different locations around the Chafarinas Islands. Quadrats were used to quantify dead colonies, colonies affected by epibionts and healthy colonies at different depths. No relationship was found between depth and percentage of affected colonies; however, differences in the mortality among sites were detected. On average, 43% of the colonies of *E. singularis* were found dead, 21% damaged and 36% healthy. These results highlight the need of further researches for monitoring the colonies of this species considering future scenarios of rising temperature.

Key words: Conservation status, damaged colonies, high water temperature, white gorgonian

Introduction

In the last 20 years, several mass mortality events of marine benthic organisms related to high summer water temperatures have been reported in the Western Mediterranean European coasts: years 1999 and 2003 (Cerrano *et al*. 2000, Pérez *et al*. 2000, Garrabou *et al*. 2001, 2009; Linares *et al*. 2005, Coma *et al*. 2006, 2009; Lejeusne *et al*. 2010, Crisci *et al*. 2011), 2008 and 2009 (Maldonado *et al.* 2010, Cebrian *et al*. 2011), 2015 (Rubio-Portillo *et al*. 2016) and 2016 (Sánchez-Tocino & Tierno de Figueroa 2016). Similar events in the vicinity of the North African coasts have been less frequently reported (*e.g.,* Maldonado *et al*. 2010). All those mass mortality episodes have particularly affected sessile invertebrate taxa, such as cnidarians and poriferans. Increased pathogenic organisms, thermal stress or decrease oxygen concentrations are some of the causes that contribute to mortality due to abnormally high temperatures (Cerrano *et al.* 2000, Cerrano & Bavestrello 2008, Coma *et al*. 2009, Maldonado *et al*. 2010). Other disturbances with direct anthropogenic origin, such as habitat modification and degradation, professional and recreational fishing, diving and pollution, also interact synergistically impacting invertebrate communities and contributing to the impoverishment of their populations (Linares *et al*. 2008a, Rossi 2013, Templado 2014).

During a sampling campaign in the summer 2015, a high mortality of the white gorgonian *Eunicella singularis* (Esper, 1791) was detected (Fig. 1). The aim of this research note was to evaluate the health status of the colonies of *E. singularis* in Chafarinas islands after this high mortality event.

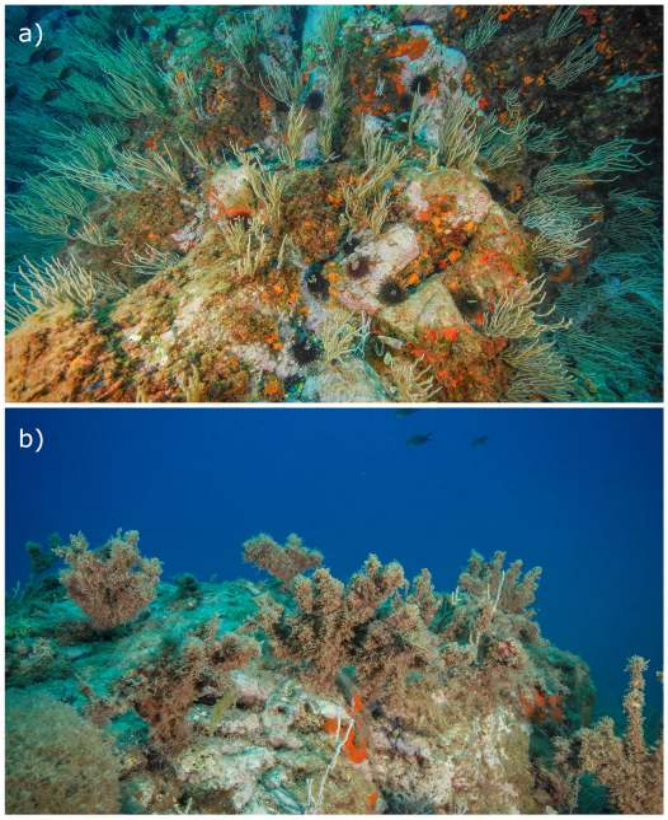

Figure 1. Photographs of *Eunicella singularis* populations in the Chafarinas Islands. a) 2014 and b) 2015. Photo Credits: Luis Sánchez-Tocino / Fotografías de poblaciones de *Eunicella singularis* en las Islas Chafarinas. a) 2014 y b) 2015

Materials and methods

Six sites around the Chafarinas islands (35°11'00″N; 2°26'00″W) were sampled through SCUBA diving in the summer of 2015 (stations 1, 2 and 6) and 2016 (stations 3, 4 and 5) (Fig. 2). The first 5 along a vertical transect and the sixth along an approximately horizontal transect.

Between S1 and S5, 10 quadrats of 0.25 m^2 were delimited and observed at 5 m depth intervals (5-10, 10-15 and 15-20 m depth), according to the species occurrence range. Ten quadrats of 0.25 m^2 were also delimited in S6, in which an approximately horizontal transect from 9 to 17 m depth was conducted. The number of healthy colonies, colonies with more and less than 50% of damaged parts (covered by epibionts), and dead colonies were estimated by observation and counting of *Eunicella singularis* colonies in each quadrant. A Spearman correlation was used to evaluate the existence of a possible relation between depth and the percentage of colonies damaged. This analysis was performed using the vegan package within R software (Oksanen *et al*. 2018, R Core Team 2018) for every sampling site with the only exception of the horizontal transect (S6), where a significant depth gradient does not exist.

Records of seawater temperature at 15 m depth from the buoy of Melilla (the closest area from where there are available data) were downloaded from the Spanish Government (*Puertos del Estado* webpage)[1]. The maximum temperatures in summer 2014 reached 26.8 ºC in July and 26.5 ºC in August. The mean temperature remained above 24 ºC during three summer months (July, August and September).

[1]<http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx>

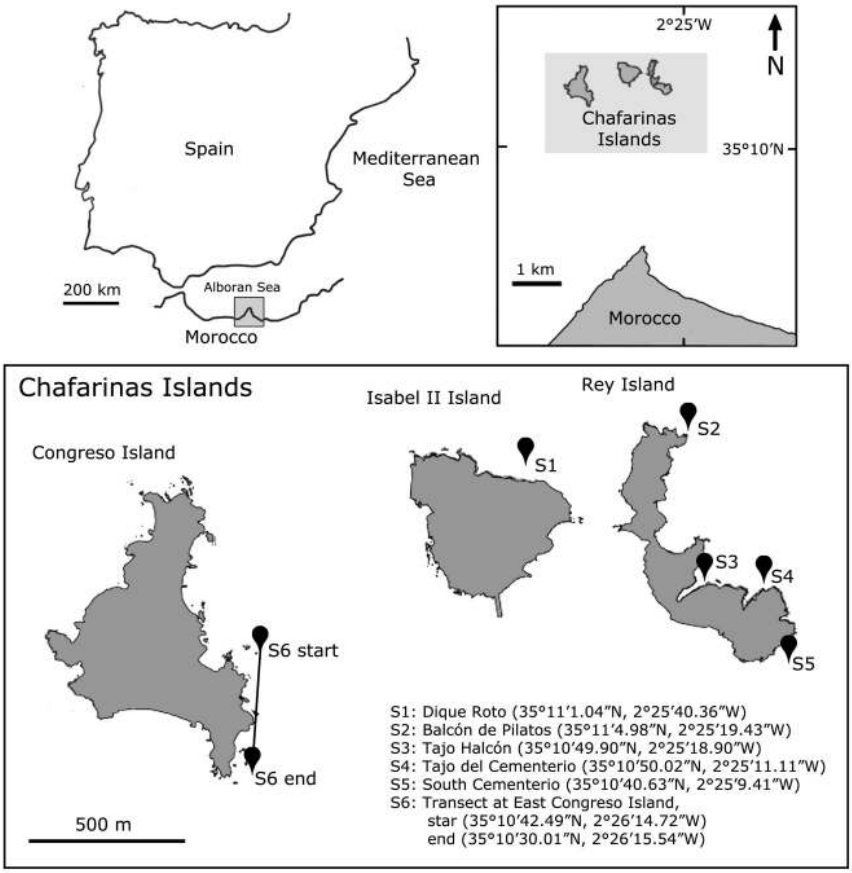

Figure 2. Map of the Chafarinas Islands showing the sampling sites (S1-S6) / Mapa de las Islas Chafarinas mostrando los lugares de muestreo (S1-S6)

Results and discussion

The present survey found a high percentage of dead colonies, with mean values ranging from 12.64 to 81.42% (Table 1). Damaged colonies ranged from 4.17 to 62.88%, while mean values for healthy colonies ranged from 4.17 to 51.17%. A higher percentage of dead colonies were detected in the sites sampled in 2015 (S1 and S2). The lower percentage of dead colonies in S3 and S4, and especially in shallow waters, could be due to the removal of dead colonies generated by the strong water currents at these sites. This lower percentage of dead colonies could also be consequence of the regeneration of some colonies two years after the high temperature event in 2014. On the other hand, a negative correlation between depth and the percentage of colonies damaged was only found in S1 (Spearman R= -0.50, $P < 0.05$). As reported in other studies (*e.g.*, Garzón-Ferreira & Zea 1992), this could be due to the particular characteristics of S1, which is located in the Northern part of the islands where the waves beat hardest. In all other sites no significant correlation was detected. Considering the depth range sampled in this research, the obtained results do not differ from those found by Linares *et al*. (2005) in the species *Paramuricea clavata* (Risso, 1826), at the same depth. Nevertheless, they detected a strong decrease in the extent of injury at higher depth.

In 2016, the percentage of young colonies was quantified in three of those sites. We considered as young colonies those with only one axis and, according to Linares *et al*. (2008a) categorization, those with less than 10 cm. Studies carried out in the Western Mediterranean point out that the release of planula larvae of this species occurs between late May and July (Ribes *et al*. 2007).

Table 1. Mean number and percentages of healthy, damaged and dead *Eunicella singularis* colonies in Chafarinas Islands. S1-S6= sampling sites (see Fig. 2); N= number of sampling quadrats; SD= standard deviation / Número medio y porcentaje de colonias de *Eunicella singularis* sanas, dañadas y muertas en las Islas Chafarinas. S1-S6= estaciones de muestreo (ver Fig. 2); N= número de cuadrantes de muestreo; SD= desviación estándar

Sites	N	Dead		>50% Damaged		<50% Damaged		Healthy		% Dead		% >50% Damaged		% <50% Damaged		% Healthy	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
S1	30	6	3	2	1	3	3	3	4	48	26	14	12	20	15	19	16
S2	30	8	3	0	1	1	1	1	2	81	18	3	6	5	7	11	13
S3	30	1	2	1	1	1	1	5	4	13	19	6	11	19	24	63	25
S4	30	4	3	1	1	2	1	7	4	24	17	6	8	19	24	51	24
S5	30	8	4	1	1	2	1	7	4	39	16	6	7	11	9	36	11
S6	10	2	2	0	0	1	1	0	0	63	45	10	32	23	42	4	9

The planulae have a mobile phase lasting from several hours to several days and, after the settlement, they metamorphose into a complete primary polyp in approximately 4 days (Weinberg & Weinberg 1979). So, the surveys carried out in August do not allow detecting new colonies because of the small size of the newly set ones, which implies a certain underestimation.

The percentage of young colonies in relation to the total number of colonies was 17.37% in S5, 35.45% in S1 and 40% in S2. The effects of this type of mortality events on *Eunicella singularis* populations can be observed even four years after they have occurred (Coma *et al*. 2006). Furthermore, the turf algae that settle on the substrate previously occupied by the gorgonians can hinder future recruitments (Linares *et al*. 2012). In fact, in an experimental study, Linares *et al*. (2012) observed that the exposure to the turf algae caused up to a five-fold reduction in the recruitment of *E. singularis*. Although our observations show a percentage of young colonies variables between sites, the values are within the percentage of recruitments reported by Linares *et al*. (2008a) for this species in the NW Mediterranean Sea. Further studies would help to assess whether the recruitment rate detected is enough to recover the population after this mortality event.

The red gorgonian *Paramuricea clavata* was also affected by the high temperature event in the Chafarinas Islands. A sampling conducted between 20 and 30 m depth in S4 in summer 2015 showed that from 128 colonies of *P. clavata*, none of them were dead but only half of them were completely healthy; 53.12% were partially covered by epibionts, almost all in less than 50% (66 colonies) compared with those with more than 50% (only two colonies). Unlike other mass mortality events in the Mediterranean (Crisci *et al*. 2011), *P. clavata* was apparently not so affected on the Chafarinas Islands.

Future sampling campaigns are needed in order to monitoring *E. singularis* populations in the Chafarinas Islands, as well as on other species that can be affected by those mortality events related to climatic change. An example of sampling protocol could include annual monitoring of the colonies and an intensification of the sampling frequency after high temperature events, and this information could be obtained from records from the nearby buoys. Also, the application of restoration measures should be carried out. In this sense, researches as those of Linares *et al*. (2008b) or Sánchez-Tocino *et al*. (2017) should be considered to recover the health status of the colonies.

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