

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

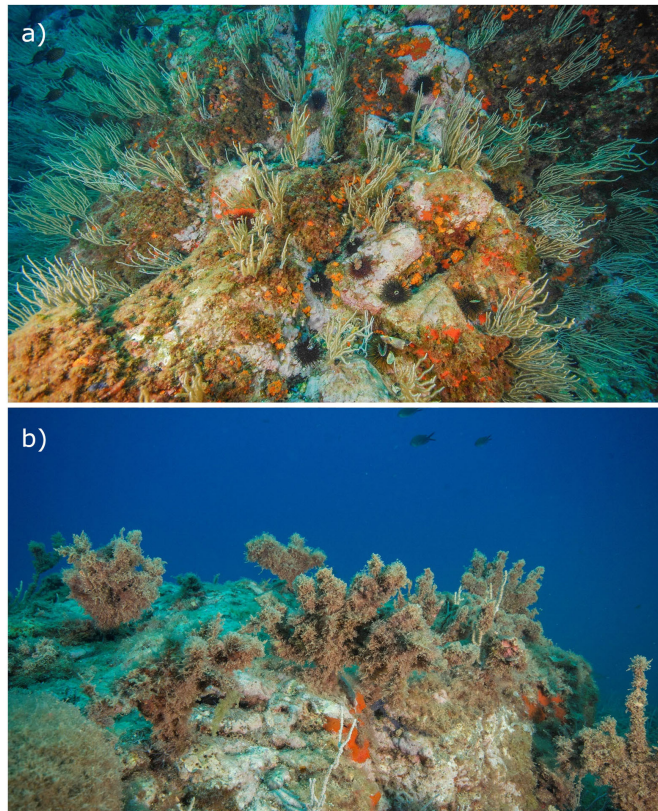
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## INTRODUCTION

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

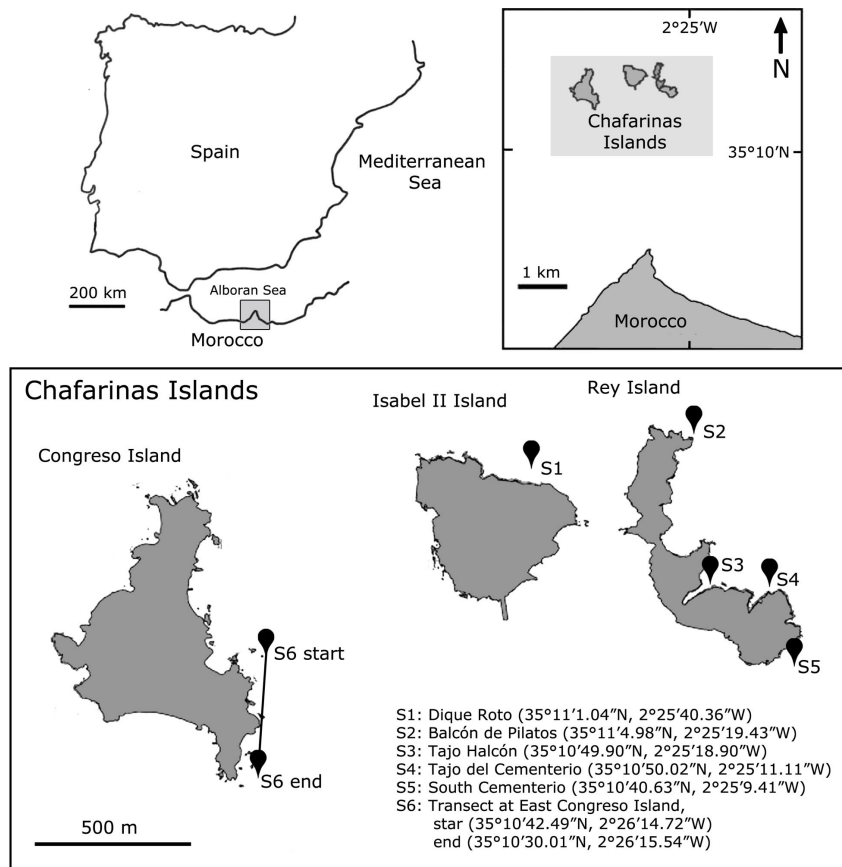
Six sites around the Chafarinas islands ( $35^{\circ}11'00''\text{N}$ ;  $2^{\circ}26'00''\text{W}$ ) were sampled through SCUBA diving in the summer of 2015 (stations 1, 2 and 6) and 2016 (stations 3, 4 and 5) (Fig. 2). The first 5 along a vertical transect and the sixth along an approximately horizontal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

Between S1 and S5, 10 quadrats of  $0.25\text{ m}^2$  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  $0.25\text{ m}^2$  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)<sup>1</sup>. The maximum temperatures in summer 2014 reached  $26.8^{\circ}\text{C}$  in July and  $26.5^{\circ}\text{C}$  in August. The mean temperature remained above  $24^{\circ}\text{C}$  during three summer months (July, August and September).

<sup>1</sup><<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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## LITERATURE CITED

- Cebrian E, MJ Uriz, J Garrabou & E Ballesteros. 2011.** Sponge mass mortalities in a warming Mediterranean Sea: Are Cyanobacteria-harboring species worse off? *PLoS ONE* 6: e20211. <<https://doi.org/10.1371/journal.pone.0020211>>
- Cerrano C & G Bavestrello. 2008.** Medium-term effects of die-off rocky benthos in the Ligurian Sea. What can we learn from gorgonians? *Chemistry and Ecology* 24: 73-82.
- Cerrano C, G Bavestrello, N Bianchi, R Cattaneo-Vietti, S Bava, C Morganti, C Morri, P Picco, G Sara, S Schiaparelli, A Siccardi & F Sponga. 2000.** A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. *Ecology Letters* 3: 284-293.
- Coma R, C Linares, M Ribes, J Garrabou & F Ballesteros. 2006.** Consequences of a mass mortality in populations of *Eunicella singularis* (Cnidaria: Octocorallia) in Menorca (NW Mediterranean). *Marine Ecology Progress Series* 327: 51-60.
- Coma R, M Ribes, E Serrano, E Jiménez, J Salat & J Pascual. 2009.** Global warming-enhanced stratification and mass mortality events in the Mediterranean. *Proceedings of the National Academy of Sciences of the United States of America* 106: 6176-6181.
- Crisci C, N Bensoussan, JC Romano & J Garrabou. 2011.** Temperature anomalies and mortality events in marine communities: insights on factors behind differential mortality impacts in the NW Mediterranean. *PLoS ONE* 6: e23814. <<https://doi.org/10.1371/journal.pone.0023814>>
- Garrabou J, T Perez, S Sartoretto & JG Harmelin. 2001.** Mass mortality event in red coral *Corallium rubrum* populations in the Provence region (France, NW Mediterranean). *Marine Ecology Progress Series* 217: 263-272.
- Garrabou J, R Coma, N Bensoussan, M Bally, P Chevaldonné, M Cicliano, D Díaz, JG Harmelin, MC Gambi, DK Kersting, JB Ledoux, C Lejeusne, C Linares, C Marschal, T Pérez, M Ribes, JC Romano, E Serrano, N Teixido, O Torrents, M Zabala, Z Zuberer & C Cerrano. 2009.** Mass mortality event in northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave. *Global Change Biology* 15: 1090-1103.
- Garzón-Ferreira JG & S Zea. 1992.** A mass mortality of *Gorgonia ventalina* (Cnidaria: Gorgoniidae) in the Santa Marta area, Caribbean Coast of Colombia. *Bulletin of Marine Science* 50: 522-526.
- Lejeusne C, P Chevaldonné, C Pergent-Martini, CF Boudouresque & T Pérez. 2010.** Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. *Trends in Ecology and Evolution* 25: 250-260.
- Linares C, R Coma, D Diaz, M Zabala, B Hereu & L Dantart. 2005.** Immediate and delayed effects of a mass mortality event on gorgonian population dynamics and benthic community structure in the NW Mediterranean Sea. *Marine Ecology Progress Series* 305: 127-137.
- Linares C, R Coma, J Garrabou, D Diaz & M Zabala. 2008a.** Size distribution, density and disturbance in two Mediterranean gorgonians: *Paramuricea clavata* and *Eunicella singularis*. *Journal of Applied Ecology* 45: 688-699.
- Linares C, R Coma & M Zabala. 2008b.** Restoration of threatened red gorgonian populations: an experimental and modelling approach. *Biological Conservation* 141: 427-437.
- Linares C, E Cebrian & R Coma. 2012.** Effects on turf algae on recruitment and juvenile survival of gorgonian corals. *Marine Ecology Progress Series* 452: 81-88.
- Maldonado M, L Sánchez-Tocino & C Navarro. 2010.** Recurrent disease outbreaks in corneous demosponges of the genus *Ircinia*: epidemic incidence and defence mechanisms. *Marine Biology* 157: 1577-1590.
- Oksanen J, F Guillaume Blanchet, M Friendly, R Kindt, P Legendre, D McGlenn, PR Minchin, RB O'Hara, GL Simpson, P Solymos, MHH Stevens, E Szoecs & H Wagner. 2018.** *vegan*: Community Ecology Package. R package version 2.5-2. <<https://CRAN.R-project.org/package=vegan>>
- Pérez T, J Garrabou, S Sartoretto, JG Harmelin, P Francour & J Vacelet. 2000.** Mortalité massive d'invertébrés marins: un événement sans précédent en Méditerranée nord-occidentale. *Comptes Rendus de l'Académie des Sciences Paris, Science de la Vie/Life Sciences* 323: 853-865.
- R Core Team. 2018.** R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <<https://www.R-project.org/>>
- Ribes M, R Coma, S Rossi & M Micheli. 2007.** Cycle of gonadal development in *Eunicella singularis* (Cnidaria: Octocorallia): trends in sexual reproduction in gorgonians. *Invertebrate Biology* 126: 307-317.
- Rossi S. 2013.** The destruction of the 'animal forests' in the oceans: Towards an over-simplification of the benthic ecosystems. *Ocean & Coastal Management* 84: 77-85.
- Rubio-Portillo E, A Izquierdo-Muñoz, JF Gago, R Roselló-Mora, J Antón & AA Ramos-Esplá. 2016.** Effects of the 2015 heat wave on benthic invertebrates in the Tabarca Marine Protected Area (southeast Spain). *Marine Environmental Research* 122: 135-142.
- Sánchez-Tocino L & JM Tierno de Figueroa. 2016.** Mass mortality event of the sponges *Ircinia variabilis* (Schmidt, 1862) and *Sarcotragus fasciculatus* (Pallas, 1766) (Porifera, Demospongia) in the southern Spain. *Zoologica Baetica* 27: 39-46.

**Sánchez-Tocino L, A de la Linde-Rubio, MS Lizana-Rosas, T Pérez-Guerra & JM Tierno de Figueroa. 2017.** Pruning treatment: A possible method for improving the conservation status of a *Ellisella paraplexauroides* Stiasny, 1936 (Anthozoa, Alcyonacea) population in the Chafarinas Islands? *Mediterranean Marine Science* 18: 479-485.

**Templado J. 2014.** Future trends of Mediterranean biodiversity. In: Goffredo S & Z Dubinsky (eds). *The Mediterranean Sea. Its history and present challenges*, pp. 479-498. Springer, Dordrecht.

**Weinberg S & F Weinberg. 1979.** The life cycle of a gorgonian: *Eunicella singularis* (Esper, 1794). *Bijdragen tot de Dierkunde* 48: 127-137.

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