



Paramuricea clavata

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Abstract

The damage caused by the Sant Esteve's storm (2008) on the populations of *Paramuricea clavata* in the Marine Reserve of the Medes Islands and Montgrí coasts (NW Mediterranean) was assessed in permanent plots. As a consequence of the storm the decrease in density of colonies at the six locations studied varied between 6.1 and 20.6 % with a mean value of 13.4 ± 2.7 % (mean \pm SE). This mortality is eight times greater than the natural mortality rate due to detachment (1.5 % y^{-1}).

Coma, R., Serrano, E., Linares, C., Zabala, M., and Ribes, M. (2012) Effect of a severe storm event on the mortality rate of the gorgonian *Paramuricea clavata* on the Medes Islands marine Reserve and the nearby Montgrí coast. In: Mateo, M.A. and Garcia-Rubies, T. (Eds.), Assessment of the ecological impact of the extreme storm of Sant Esteve's Day (26 December 2008) on the littoral ecosystems of the north Mediterranean Spanish coasts. Final Report (PIEC 200430E599). Centro de Estudios Avanzados de Blanes, Consejo Superior de Investigaciones Científicas, Blanes, pp. 67 – 78.

**Effect of a severe storm event on the mortality rate of the
gorgonian *Paramuricea clavata* on the Medes Islands Marine
Reserve and the nearby Montgrí coast.**

By

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Resumen

El daño ocasionado por el temporal de Sant Esteve (2008) en la poblaciones de la gorgonia *Paramuricea clavata* en la Reserva Marina de las Illes Medes y costas del Montgrí (Mediterráneo NO), fue examinado en parcelas permanentes. El temporal produjo una disminución de la densidad de colonias en las 6 estaciones estudiadas entre 6.1 y 20.6 %, con un valor medio de 13.4 ± 2.7 % (media \pm EE). Esta mortalidad es 8 veces superior a la tasa natural de mortalidad por arrancamiento (1.5 % y⁻¹).

Abstract

The damage caused by the Sant Esteve's storm (2008) on the populations of *Paramuricea clavata* in the Marine Reserve of the Medes Islands and Montgrí coasts (NW Mediterranean) was assessed in permanent plots. As a consequence of the storm, the decrease in density of colonies at the six locations studied varied between 6.1 and 20.6 % with a mean value of 13.4 ± 2.7 % (mean \pm SE). This mortality is eight times greater than the natural mortality rate due to detachment (1.5 % y⁻¹).

Introduction

The coralligenous community is one of the most characteristic Mediterranean communities. It is a low turnover hard

bottom community of biogenic origin mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions (Ballesteros 2006). The ecological importance of the community is due to

the vast diversity of species that it contains (up to 1666, Ballesteros 2006). This diversity is a consequence of the great structural complexity provided by engineering species among which the gorgonian *Paramuricea clavata* (Cnidaria:

specimens usually reach 50 years of age (Weinberg 1991, Coma et al. 1998). The species, which mainly reproduces sexually (Coma et al. 1995), has low recruitment rates (Coma et al. 2001) and long turnover time (8-9 years, Mistri and Ceccherelli



Figure 1. Map of the locations on the Medes Islands Marine Reserve (Medallot, Carall Bernat and Tascó Petit) and the nearby Montgrí coast (Puig de la Sardina, Cap d'Ultrera y Punta Salines) where the population of the gorgonian *P. clavata* has been studied.

Octocorallia) is one of the most representative and emblematic members. The species inhabits mostly vertical walls in the circalittoral zone (10-80 m) and forms erect arborescent colonies up to about 130 cm in height (Harmelin and Marinopoulos 1994). This is a long-lived species, in which older

1994, Coma et al. 1998). In agreement with the life history traits suggested by high longevity and low recruitment rates, extremely low rates of adult natural mortality should be expected.

Natural causes of total mortality include overgrowth by other organisms and detachment by storms (Weinberg and Weinberg 1979, Whale

1985, Yoshioka and Yoshioka 1991, Yoshioka 1994). Detachment and pollution are the two main causes of man-induced mortality. Man-induced sources of detachment comprise anchors, fishing apparatus, predation and divers (Harmelin and Marinopoulus 1994). In some areas of the Mediterranean, an extraordinary increase in overgrowth of this species by epibiotic organisms has been reported (Arnoux et al. 1992). It has

to understand its population dynamics and to distinguish and estimate natural and man-induced sources of mortality. As mentioned above detachment by storms is one of the main causes of mortality (Weinberg and Weinberg 1979, Whale 1985, Yoshioka and Yoshioka 1991, Yoshioka 1994). However, during this time period no storms with the duration and intensity of that occurred on late December 2008 has

Table 1. Positioning and characteristics of the three locations examined within the Medes Islands Marine Reserve (Medallot, Carall Bernat and Tascó Petit), and of the three locations examined at the nearby Montgrí coast (Puig de la Sardina, Cap d'Utrera y Punta Salines). Slope categories: 0-30°: 1, >30-60°: 2, >60-90°: 3 and >90°: 4.

Location	X	Y	Depth	Bearing	Slope	Substrate
Medallot	518317,71	4655523,35	16-17 m	O	3	Rocky wall
Carall Bernat	518904,70	4655410,83	17-19 m	NE	3	Rocky wall
Tascó Petit	518786,04	4654478,96	17-19 m	O	3	Rocky wall
Puig de la Sardina	517333,76	4657834,34	20 m	SE	3	Rocky wall
Cap d'Utrera	517680,72	4657497,00	18-19 m	N	3	Rocky wall
Pta. Salines	517791,40	4656580,02	20 m	N	3	Rocky wall

been suggested that pollution may be either killing gorgonians or increasing overgrowth by decreasing regeneration rate and competitive ability of the colonies with respect to the epibiotic community (Arnoux et al. 1992). In addition, mass mortality events have been reported and appear to be related to climate change (Perez et al. 2000, Coma and Ribes 2003, Coma et al. 2009, Garrabou et al. 2009).

During the last 15 years, population of *Paramuricea clavata* have been monitored at the Medes Island marine protected area and at the nearby coast

occurred. Therefore, the long term monitoring of the population provides the reference baseline against which to evaluate the effect of severe storms events on mortality rate of the species.

Material and Methods

In a long term monitoring program carried out on *P. clavata* populations since 2001, a permanent plot were set up in each of three different locations (Medallot, Carall Bernat, Tascó Petit) within the Medes Islands Marine Reserve and another three were installed in different locations (Punta Salinas, Cap d'Utrera, Puig de la

Sardina; Fig. 1) outside the Marine Reserve in the nearby Montgrí coast in 2005 (Table 1).

The distance between all these

short distances between them (20-200 m) were also examined.

Each plot was partitioned in 40x40 cm quadrats to facilitate mapping and

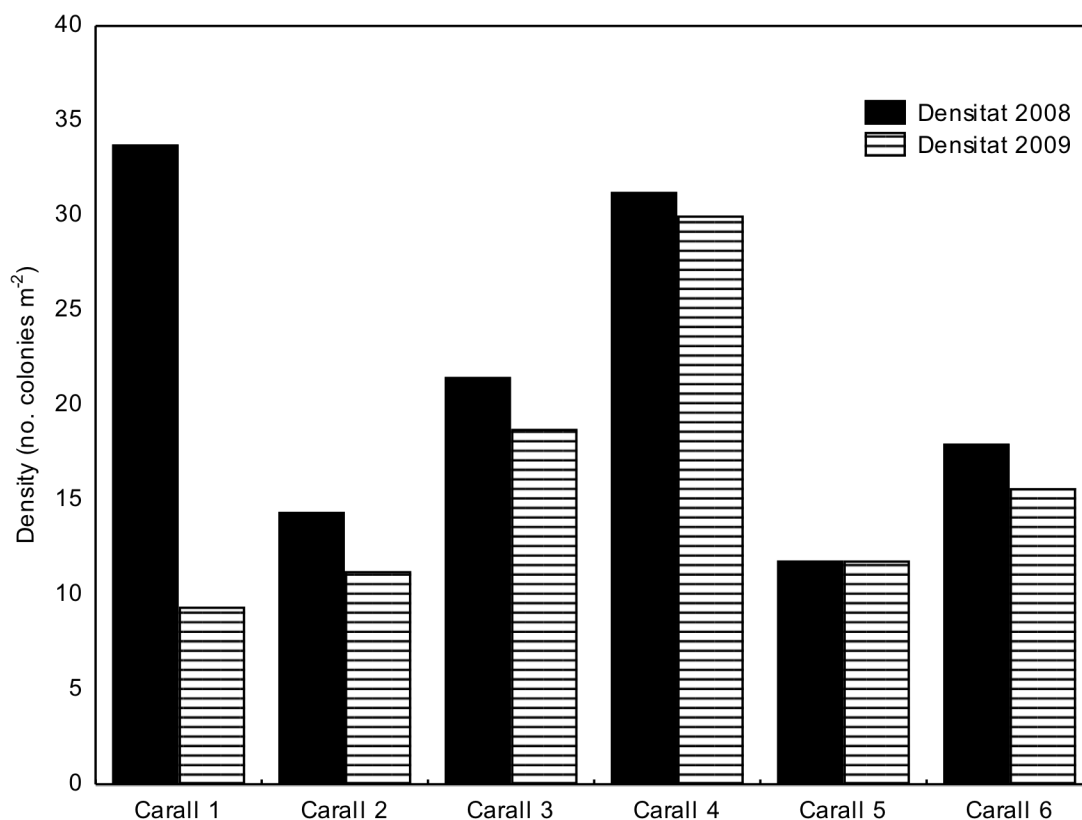


Figure 2. Variation in density (colonies/m²) between August 2008 and February 2009 of the population of the gorgonian *P. clavata* at the six permanent plots situated at short distances between them (20-200 m) and placed at the Carall Bernat location (Medes Islands Marine Reserve).

locations ranged between 500 and 4000 m (Fig. 1). The plots were randomly selected within the same depth (16-20 m) to reduce the effect of depth on density and population structure of the species. Each plot was 4 m long and 0.8 m wide (3.2 m² in surface). At the Carall Bernat location, five additional permanent plots labeled in 1997 with a surface area between 1.3 and 2.6 m² located at

individual colony identification. To this end, the corners of each plot, as well as those of each quadrat, were marked with PVC screws fixed to hole in the rocky substratum with a two-component putty. In each survey, elastic bands were placed around the corners of each quadrat to draw its limits and to facilitate individual colony recognition.

During the first survey, all gorgonian colonies in each 40x40 cm

quadrat were mapped on a polyvinyl sheet by scuba divers. On subsequent surveys, maps from the former surveys were used to facilitate colony recognition. Colony height was recorded for each gorgonian colony. Colony height was measured with a ruler as the distance between the colony base and the end of the farthest tip.

Gorgonian colonies within the plots have been monitored once per year in summer since they were set up. To distinguish the effect of the severe storm of late December 2008, the results of the survey conducted before the storm (August 2008) were contrasted to those of the survey conducted after the storm (February 2009).

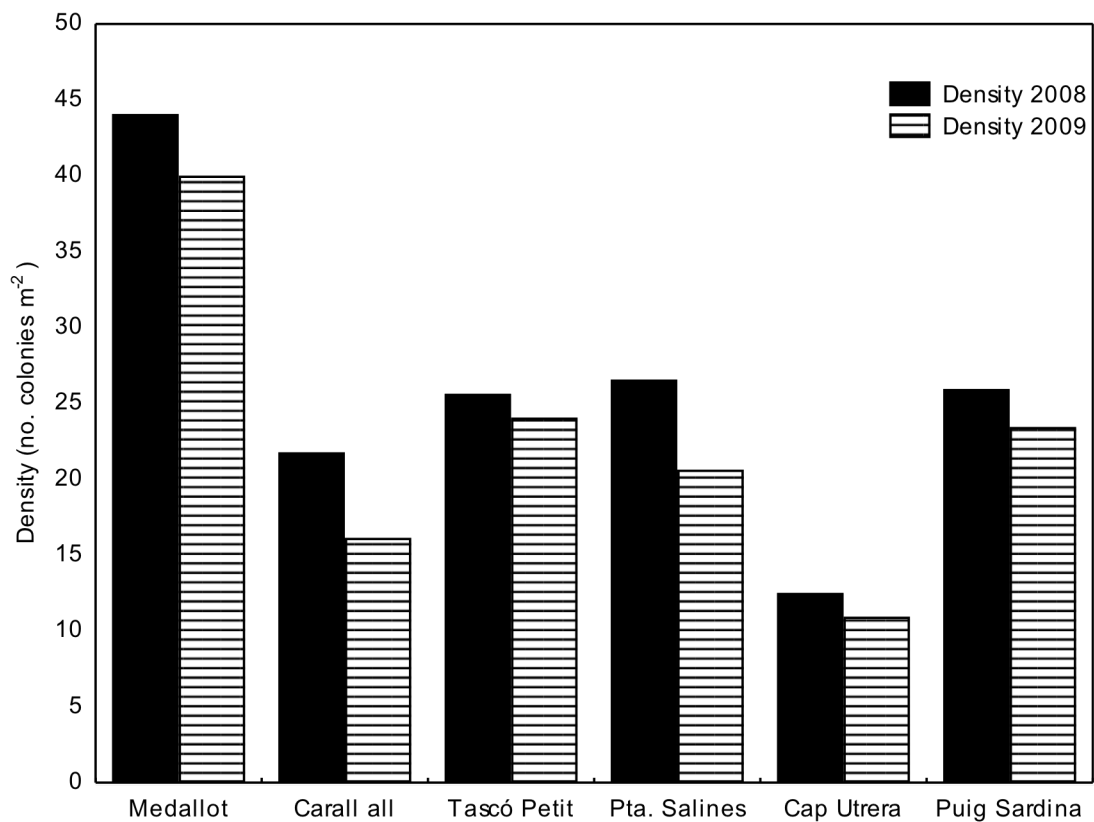


Figure 3. Variation in density (colonies/m²) between August 2008 and February 2009 of the population of the gorgonian *P. clavata* at the six permanent plots situated at distances of 500 to 4000 m between them and placed at the Medes Islands Marine Reserve and the nearby Montgrí coast.

A number was assigned to each colony for purposes of recognition for the data-base and for use in the following surveys. This procedure allowed us to monitor a mean value of 90 colonies within each 3.2 m² permanent plots and survey.

Results

The contrast of the surveys conducted before and after the storm of late December 2008 on the basis of the recognition of each individual colony allowed us to determine the

amount of *P. clavata* colonies that were lost because of detachment from the substrata.

The six plots available within the Carall Bernat site allowed us to examine the small scale variability in the effect of the storm. Density of the population at this location significantly varied before and after the storm (Chi-Square= 18,9872, df=5, $P>0,0019$). Density decreased from $21,8 \pm 3,7$ col/m² (mean \pm SE) before the storm to $16,1 \pm 3,1$ col/m² (mean \pm SE) after it (Fig. 2). Decrease in density at the six permanent plots of the Carall Bernat location placed at distances between 20 and 200 m among them varied between 0 and 72% with a mean value of $20,6 \pm 10,8$ % (mean \pm SE). This average value will be used for this site in the examination of the effect of the storm at a larger scale (see below). Density of the species at the six locations placed at a distance ranging between 500 and 4000 m between them showed a decrease in density before and after the storm (Fig. 3). Decrease in density at the six locations varied between 6,1 and 20,6 % with a mean value of $13,4 \pm 2,7$ % (mean \pm SE). The six examined locations, three within the Marine Reserve and three outside, allowed us to examine whether the effect of the storm on *P. clavata* within the Marine Reserve differed from that outside. The percentage of colonies lost within the Reserve did not differ from that outside the Reserve (ANOVA, $F_{1,4}=0,2368$, $p=0,6520$). Mean density for all locations decreased from $26,1 \pm 4,2$ col/m² (mean \pm SE) before the

storm to $22,5 \pm 4,0$ col/m² (mean \pm SE) after it.

Discussion

Marine Reserves (i.e. areas protected from all extractive and destructive activities) may represent a useful tool for the management of endangered gorgonian species because they may reduce two important sources of man-induced mortality by detachment (i.e. anchors and fishing gears, Harmelin and Marinopoulus 1994). Nevertheless, many Marine Reserve also became powerful attractors of recreational diving (Dixon et al. 1993, Vogt 1997, Fenton et al. 1998). Recreational diving may be responsible for an increase on total mortality of gorgonians because unintentionally detached colonies (i.e. by blows from fins and scraping) are commonly observed in sites exposed to high levels of recreational diving. On the early 1990, the effect of divers on *P. clavata* population was of great concern to the managers of the Medes Islands Marine Reserve because it is one of the most visited areas within the Mediterranean (several locations receiving on the order of 5500 dives per year, Coma et al. 2004). This effect was examined during a study conducted between 1992 and 2000. This study documented that mortality due to overgrowth at the Marine Reserve was similar to that at the controls and on the order of $1,2$ % y⁻¹. Mortality due to natural detachment ($1,5$ % y⁻¹) was similar to that of

natural overgrowth. The study documented that the mentioned levels of recreational diving activity was increasing mortality by detachment up to 6 % y⁻¹, therefore multiplying by four natural mortality due to detachment (Coma et al. 2004). This previous study provides the reference baseline on natural and man-induced rates of the gorgonian *P. clavata* at the study area to appropriately determine the effect of the severe storm of late December 2008.

Detachment due to diving activity has been documented to be important at the study area, however, its contribution to observed lost of colonies during the period September 2008-February 2009 could be considered small because diving activity is minimal during the winter period. Therefore, it can be concluded that the tangential forces of the severe storm of late December 2008 caused the overall lost of 13.4% of the *P. clavata* colonies from the study area. This value is eight times greater than the natural mortality rate due to detachment (1.5 % y⁻¹).

The relevance of this result needs to be evaluated within the demographic context of the species. Mortality rates about 8 % y⁻¹ have been observed to be relatively constant in many Caribbean gorgonian species (e.g., Yoshioka and Yoshioka 1991, Yoshioka 1994). In the Mediterranean, Weinbauer and Velimirov (1996) estimated an average mortality rate of 17.6 % y⁻¹ for

Eunicella cavolini, (ranging from 8.3 to 26.7 % y⁻¹). However, it must be pointed out that these are species with high recruitment rates. The rate of recruitment of *P. clavata* is low (Coma et al. 2001). The overall natural mortality rate of the species (2.7 % y⁻¹ due to both main causes, overgrowth and detachment) is among the lowest values reported for gorgonian colonies. Only *Corallium rubrum* has a reported mortality rate (1.8 % y⁻¹) lower than that of *P. clavata*.

The low mortality rate of *P. clavata* colonies is a fundamental descriptor of the demography of long lived species (Yoshioka 1994, Coma et al. 2004, Linares et al. In particular, the low mortality rate of large colonies plays a crucial role in attenuating the effects on the population of long episodes of low recruitment and against high mortality rates of small colonies. This is why even a small increase in mortality rate of large colonies may produce unsustainable long-term effects on the population. 2007).

Acknowledgements

Part of this study has been funded by the Consejo Superior de Investigaciones Científicas (PIEC 200430E599) and part by the "Direcció General de Pesca Marítima", the "Departament de Medi Natural", the "Generalitat de Catalunya", and by the "Ministerio de Ciencia e Innovación", projects CGL2007-66757-C02-01/BOS and CTM2006-01463. The authors wish to thank

CSIC for funding the general framework project "Assessment of the ecological impact of the extreme storm of Sant Esteve (26 December 2008) on the littoral ecosystems of the north Mediterranean Spanish coasts" (PIEC 200430E599).

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