Perception of The Storm: Surveys

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Abstract

A group of 42 individuals including artisanal fishermen, spear fishermen, and SCUBA divers were surveyed on their perception about the impact of the storm. Around 70% reported moderate to severe effects in both the benthos and the fish populations. The high degree of detail and skill in their observations was remarkable, showing a good agreement with the results obtained by the research groups of this project. They detected a greater impact in the Costa Brava with respect to the coasts of Maresme or Barcelona; the extension of the impact down to 20 m of depth; the greater impact in rocky bottoms formed by big boulders; the changes in the algal cover, the burial of shoots of *Posidonia oceanica*, or changes in the number of individuals and the behaviour of some fish species. We conclude that these three groups have to be regarded as a valuable source of information of changes in the marine benthos both for monitoring purposes and for assess impacts after rare extreme events.

Images: Spear fishing by “Pitágoras”, pescasub.com; Artisanal fishermen and SCUBA diver, anonymous, Internet.

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Effects of the 2008 Sant Esteve´s storm in the Costa Brava as perceived by artisanal fishermen, spear fishermen, and SCUBA divers

By

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Resumen

Un total de 42 individuos entre pescadores artesanales, pescadores submarinos, y buceadores deportivos fueron encuestados sobre su percepción de los efectos del temporal. Entorno al 70% de ellos declararon efectos de moderados a severos sobre el bentos y las poblaciones de peces. El grado de detalle y acierto en sus observaciones fue sorprendentemente elevado, coincidiendo con los resultados obtenidos por los equipos de investigación reunidos en este proyecto. Informaron de un mayor efecto en la Costa Brava respecto a las costas del Maresme y de Barcelona; de la extensión del impacto hasta 20m de profundidad; de la mayor incidencia en fondos formados por bloques; de cambios en la cobertura algal, enterramiento de haces de *Posidonia oceanica*, o en el número de individuos y comportamiento de algunas especies de peces. Concluimos que estos tres colectivos deben considerarse una fuente de información valiosa de cambios en el bentos marino tanto a largo plazo como tras eventos puntuales.

Abstract

A group of 42 individuals including artisanal fishermen, spear fishermen, and SCUBA divers were surveyed on their perception about the impact of the storm. Around 70% reported moderate to severe effects in both the benthos and the fish populations. The high degree of detail and skill in their observations was remarkable, showing a good agreement with the results obtained by the research groups of this project. They detected a greater impact in the Costa Brava with respect to the coasts of Maresme or Barcelona; the extension of the impact down to 20 m of depth; the greater impact in rocky bottoms formed by big boulders; the changes in the algal cover, the burial of shoots of *Posidonia oceanica*, or changes in the number of individuals and the behaviour of some fish species. We conclude that these three groups have to be regarded as a valuable source of information of changes in the marine benthos both for monitoring purposes and for assessing impacts after rare extreme events.

Introduction

The adequate assessment of the effects of an extreme event on natural communities over a large area would require a detailed previous knowledge of the state of the ecosystems in that area. Such a knowledge is rarely available and hence any possible

source of information should be taken into account. Frequent 'users' of the ecosystems, for both leisure or professional purposes, often accumulate very detailed information at both specific populations or landscape levels. In order to assess the perception of the effects of the storm of Sant Esteve (2008) by people interested in the natural coastal communities of the Catalan coasts, we performed a series of surveys to three different groups: artisanal fishermen, spear fishermen, and SCUBA divers. The surveys were adapted to each group to capture perceptions of changes both in the sessile benthic populations and in fish populations.

Materials and Methods

Artisanal fishermen

Artisanal fishermen from Blanes (southern Costa Brava), Palamós (central Costa Brava) and Cadaquès (northern Costa Brava) were interviewed on their perceptions of the impacts of the storm. Not many fishermen were interviewed because it was extremely difficult to find them together in one place and with time enough to answer the questions. Two visits to the fishing ports of Blanes and Palamós only resulted in 6 successful interviews each. In Cadaquès. all fishermen based at Port Lligat were consulted thanks to the presence of an interviewer from the University of Girona who was evaluating the fishing activity in the area.

The questions included in the survey were grouped into three sections: the first two sections were aimed at determining the fishermen's level of experience and the fishing gear normally used. In the last section of the survey the fishermen were asked about their perception of the impact of the storm on the sites, depths and their usual target species. The general outline of the questionnaire was:

1) The experience of the fisherman in relation to their age and the years as a professional fisherman.
2) The fishing gears and the depth at which they usually fish (maximum and minimum).
3) Their perception of the effects of the storm:
    a. Differences before and after the storm
    b. Increases or decreases in catches and which species seemed affected by the variations.
    c. Perception of damages in fishing areas (nil, low, high, severe).

SCUBA divers

The questionnaires were distributed on the internet thanks to the collaboration of the Catalan Federation of Underwater Activities (FCDAS: *Federació Catalana d'Activitats Subaquàtiques*). They were also available as a printed form to be filled out *in situ* and were distributed at the headquarters of the Medes Islands Marine Protected Area (APIM, *Àrea Protegida de les Illes Medes*). Unlike the fishermen and spear fishermen, not all the respondents

were local divers, since most of the forms distributed by the APIM were answered by divers with little experience in the area. This has greatly conditioned the results because the foreign and local divers showed very different levels of familiarity with the area and enthusiasm for answering the questionnaire. The disparity between the two groups (locals and foreigners) made it necessary to treat the data separately. Like the artisanal fishermen and spear fishermen, few scuba divers responded to the questionnaires, and only 18 were completed.

The survey consisted of two distinct parts. The first part aimed at evaluating the diver's experience in the area, and the second part assessed their perception of the effects of the storm. The specific questions were:

1) Experience
    a. Years of experience in sport diving.
    b. Usual diving area.
    c. How often the diver goes diving (days year^{-1}).
    d. Preferred season of the year for diving.
2) Perception of the impact of the storm.
    a. Observation of evident changes on the bottoms (yes / no)
    b. Estimated degree of damage, if any (nil, low, high, severe).
    c. Types of bottom and/or benthic communities most affected by the storm.
    d. Most affected species.
    e. Other supplementary observations.

Spear fishermen

Only 12 surveys were completed even though they were sent out by e-mail and supported by the Catalan Federation of Underwater Activities. However, the small amount was compensated by some very skilled respondents, as could be expected from people with extensive experience in underwater observation.

The questionnaire comprised two distinct parts. The first part evaluated the diving experience of the respondent and the second part assessed the spear fishermen's perception of the impact of the storm on target species and the benthic communities. The questions were:

1) Experience:
    a. Age, years of experience in spear fishing and customary fishing area along the Catalan coast.
    b. Depth at which they usually dive while fishing.
    c. Which spear fishing technique did they usually use (bottom hunt or water hunt).
    d. How often did they go spear fishing during the year (days year^{-1}).
2) Perception of the storm effects:
    a. Evidence of changes on the sea bottom (yes/no).

b. Damage level (nil, low, high, severe).
c. Changes in catch (none, less, more).
d. Which species among their usual catch have been most affected.
e. Which kinds of bottoms or benthic communities have been most affected by the storm.
f. Supplementary observations.

Results and Discussion

Artisanal fishermen

The fishermen interviewed had quite a high level of experience, with an average over 16 years in the activity, and ranging from 2 to 40 years. The fishermen from Cadaquès and Palamós, had on average over 18 years of fishing experience, whereas the fishermen from Blanes had barely more than 12 years of fishing experience.

The most used gear was the long-line (*palangre*), which was used by 16 fishermen, followed by trammel nets (*tresmall*), which were employed by 8 fishermen (Figure 1). Less frequently used gears were: traps (*nanses*), mainly for octopus and occasionally for certain large decapods; the so-called '*sonsera*' a small purse seine used specifically to catch Mediterranean sand eels (*Gymnammodytes cicerelus*), known as *sonsos* in Catalan; and gillnets (*soltes*).

Artisanal fishermen normally alternate between different gears during the year so the same boat can operate with two or even more fishing gears. This seems to be the norm in Blanes and Palamós and possibly also in Cadaquès, although the fishermen interviewed here reported that the long-line was the only gear employed. In Blanes only one fisherman reported using a single gear (the small purse seine or *sonsera*); however, it is likely that, even in this case, he alternated with other fishing gears because the Mediterranean sand eel can only be legally fished in Catalonia from 15 December to 1 March.

Most of fishermen considered that the damage to the seabed was severe (40%) or high (27%), while 13% judged the effects as low, and 20% as nil (Figure 2). More than direct evidence in catches, these judgments were mainly based on observations of the environment, such as the presence of the remains of benthic organisms entangled in the gears (especially *P. oceanica* and to a lesser extent algae and sponges) or drastic changes in the bottoms where they traditionally fish (especially shallow rocky bottoms and *Posidonia oceanica* meadows at less than 20m deep). The fishermen that stated that the storm had had no effect either fished quite deep or exclusively on sandy bottoms (i.e. *sonsera*).

The general opinion of most fishermen was that the catch of some species decreased after the storm. Only three felt that the overall catch was similar to that before the storm and just one asserted that the overall catch had increased. Five Cadaquès fishermen considered spiny lobster

(*Palinurus vulgaris*) to be the most affected species. Two fishermen observed a reduction in the catches of common pandora (*Pagellus erythrinus*), octopus (*Octopus vulgaris*), gilthead sea bream (*Sparus aurata*) and hake (*Merluccius merluccius*). Only one fisherman reported decreases in other species such as the conger eel (*Conger conger*), common dentex (*Dentex dentex*), sea bass (*Dicentrachus labrax*), lobster (*Homarus gammarus*), scorpion fish (*Scorpaena scrofa*), red mullet (*Mullus surmuletus*), white sea bream (*Diplodus sargus*) and common cuttlefish (*Sepia officinalis*) (Figure 3).

In contrast, there was a slight increase in the catch of the Mediterranean sand eel (*Gymnammodytes cicerelus*), triggerfish (*Balistes carolinensis*), pearly razor fish (*Xyrichthys novacula*), mackerel (*Scomber scombrus*) and, contrary to the observations of two other fishermen, one fisherman stated that the hake (*M. merluccius*) catch had also increased after the storm. These increases were observed by only one fisherman for each species. Given the fishing gear used by the artisanal fleet, apart from sand eels and hake, catches of the rest of the species must be considered as merely sporadic.

SCUBA divers

The divers interviewed had considerable experience in diving (around 20 years on average), they usually went diving more than 50 days a year and reached an average depth of around 30m deep (Table 2). In terms of years of experience there was little difference between the local and foreign divers, although the frequency in diving was much higher among the locals (more than 70 dives year^{-1} on average) than the foreigners (around 54 dives year^{-1}) (Table 2). There were two fundamental differences between the two groups: the area where they usually went diving, which was totally focused on the Catalan coast among locals, but on exotic seas (Atlantic, Red Sea, Indian Ocean) among foreign divers (Figure 4); and the seasonality, as local divers tended to practice diving all year long, while the foreigners mainly dived in summer (on holidays at exotic seas). These differences show that there were fundamental differences between the two groups in terms of the familiarity and knowledge of the environment presumably affected by the storm.

Overall, 10 out of the 18 divers observed obvious changes on the bottom after the storm. As expected, the perception was very different between local divers and outsiders: while all locals (7) detected clear changes after the storm, only 3 of the 11 foreigners reported being aware that something had changed on the seabed (Figure 5a). This also occurred with the assessment of the damage; while local divers perceived the damage caused by the storm as high (6) or even severe (1), most of the foreign divers saw no (6) or low (4) damage (Figure 2b). Only one of the foreigners stated that the storm damage was high.

The most affected bottoms, according to 7 divers were those of large rocky boulders. followed by rocky walls (4 divers), *Posidonia oceanica* meadows (2 divers) and underwater caves (1 diver). Most damage was concentrated in the first 20 metres of depth, although some effects were also detected down to 28 m deep.

According to 6 divers, the most affected organisms were the gorgonians (possibly *Paramuricea clavata* and *Eunicella stricta*), benthic algae on rocky bottoms (5 divers), sponges (2 divers) and all benthic coverage on rocky substrates in general (2 divers) (Fig. 6). The seagrass *Posidonia oceanica*, fan mussel (*Pinna nobilis*), and octopus (*Octopus vulgaris*) were considered among the most affected organisms in the opinion of one diver each.

The perception of damage was sometimes complemented by very detailed observations of the consequences of the storm. Especially interesting was the considerable movement of sand, which had two opposite effects: while in certain areas *P. oceanica* and the fan mussel (*Pinna nobilis*) were uprooted, in other areas they were buried (see also Chapters 11 and 12). The depth was also important for explaining the disappearance of 77% of the fan mussels (*P. nobilis*) at less than 20m deep in an area near Sant Feliu de Guixols (central Costa Brava), while no fan mussels disappeared at 22-23m deep in the same area. The differences which were observed among nearby areas were explained by the different degrees of exposure to wave action, and only 1 specimen of a population of 35 fan mussels was lost between 6 and 14m depth in a sheltered place near Sant Feliu de Guixols. The movement of large boulders was also observed and even the detachment of massive blocks of coralligenous formations. One of the divers described the recovery of algal cover on rocky bottoms as an "uncontrolled growth of algae".

Spear fishermen

The spear fishermen interviewed here were quite experienced: 39.7 years old on average with more than 20 years of experience in spear fishing, which they did more than 70 days during the year (Table 3). Most of them generally fished in El Maresme area (central Catalan coast, slightly north of Barcelona) and the Costa Brava (northern Catalan coast) or in both areas, and only three of the fishermen regularly practiced spear fishing along the entire Catalan coast (Fig. 7a). They were capable skin divers and fished at considerable depths (ranging from a minimum of 4m down to a maximum of 35m depth). Four of them practiced ‘water hunting’ almost exclusively (Fi. 7b), looking for highly mobile species such as sea bass (*Dicentrachus labrax*), common dentex (*Dentex dentex*) and gilthead sea bream (*Sparus aurata*), along with other more pelagic fish such as *Seriola dumerilli* and *Lichia amia*. ‘Bottom hunting’ of benthic or necto-benthic species, such as groupers (*Epinephelus marginatus*), brown meagres (*Sciaena umbra*),

conger eels (*Conger conger*) and scorpion fish (*Scorpaena scrofa*), among many other species, was only performed exclusively by 2 spear fishermen. Most of them (6) alternated between the two techniques. The effects of the storm on the sea bottom were evident for 10 out of the 12 respondents (Fig. 8a); only 2 fishermen found no obvious changes in the Maresme area, which was less affected than the Costa Brava, where the storm was much more violent. The perceptions of the severity of the damage caused by the storm were perfectly balanced (Fig. 8b): while 4 fishermen rated it as low, the other 4 considered it high and the 4 remaining considered it severe.

Most (9) of the respondents considered that the catch had decreased after the storm (Fig. 9), while 2 (who fished only or mostly in the Maresme) felt that the catch had not changed. One fisherman did not answer this question. The most affected species among those that were regularly caught were groupers (*Epinephelus marginatus*), seabass (*Dicentrarchus labrax*), white sea bream (*Diplodus sargus*) and conger eels (*Conger conger*). One of the fishermen found a decline in fish in general, while others considered that octopuses and sea urchins had significantly decreased. Three spear fisherman observed a drastic reduction in benthic algae, and one of them generalised the loss to all benthic coverage on large blocks. Serious havoc on *P. oceanica* meadows, along with a marked decline in sea urchin densities was also observed by two fishermen.

It is worth noting that 2 spear fishermen asserted that the storm caused greater destruction in the north of the Costa Brava and that damage was especially noticeable on large rocky blocks down to about 20m depth. In addition to the effects on the catch and benthic communities, 2 spear fishermen also observed significant changes in fish behaviour: one fisherman said that some benthic fish seemed 'lost' and disoriented and the other pointed out that groupers were more frequent at shallower depths than before the storm.

Conclusions

Artisanal fishermen

From the surveys we can deduce that most artisanal fishermen (80%) in the area clearly perceived the effects of the storm, regardless of the gear they used, although not always regardless of the depths at which they usually fish. A perceived decrease in catches was the norm although this did not always coincide with the landings data obtained at the Palamós port (see Chapter 17). It is interesting to note that the spiny lobster (*P. vulgaris*), which according to the Cadaquès fishermen decreased significantly after the storm, showed a marked increase in the landings reported at the Palamós port after the storm. What appears to be a clear contradiction may actually be due to increased mobility, which has been reported previously for lobsters after hurricanes. It is therefore possible that

due to this phenomenon lobsters increaseed in certain areas and/or depths and decreased in other areas and depths after strong weather events.

Among the increases in catches, the increase in sand eels (*Gymnammodytes cicerelus*) is fully confirmed by the landings data from Blanes and Palamós. Palamós fisherman even stopped targeting this species due to the difficulty of marketing such large catches. It also seems significant that none of the species that were presumably favoured by the storm were characteristic of rocky bottoms, which seems to confirm that the rocky bottoms were the hardest hit by the storm.

SCUBA divers

The local divers perceived the effects of the storm of 28 December 2008 accurately. They detected the most obvious impacts, which have been confirmed in more detail in this study based on biological data collected before and after the storm. There were large differences between local and foreign divers' perceptions of the effects of the storm. The reasons were obvious: the local divers know the environment better as they visit it frequently and observe it closely. Local divers were also more motivated, as they bothered to find and complete the survey voluntarily. In spite of being experienced divers, most of the foreign divers could be compared to tourists visiting a new country. Most of foreigners had no previous or very limited references with which to compare their current observations. Moreover, the lack of enthusiasm for filling in the form could be perceived in the answers of many of the questionnaires answered by foreign divers, who seemed to treat it as another bureaucratic formality before the dive.

Despite the low number of questionnaires filled in, the majority of the comments were in line with what actually happened on the sea bottoms of the Costa Brava after the storm, as demonstrated by studies in this work: briefly, a massive loss of benthic cover (mainly benthic macroalgae) on rocky substrata (blocks and walls) and large destruction in other communities (*P. oceanica* meadows) and on single populations (gorgonians, sponges, *Pinna nobilis*) to a depth of about 20m. Other observations, such as the decrease in abundance of *O. vulgaris*, had gone unnoticed until now as there had been no previous data.

Spear fishermen

In general there was strong agreement between the observations made by the spear fishermen and the results obtained in the field. As it turned out, they noticed that the storm did affect the northern Catalan coast more than the central or southern Catalan coast. Benthic cover (algae and other sessile organisms) on large rocky boulders at less than 20m deep and *P. oceanica* meadows were the most severely affected benthic communities. The severe decrease in sea urchin density observed by the spear fishermen was proved in the field. Some fish were also particularly

affected by the storm (see Chapters 14 to 17) in the way the fishermen observed (i.e., groupers seemed more abundant in the partially protected coast near Medes Is. marine reserve, and several species showed declines in abundance after the storm).

Overall conclusions

Despite of the fact that the total number of individuals that reacted or that could be interviewed was lower than the initially expected, the 42 perceptions analysed showed a remarkable agreement with observations from scientific studies. The great majority agreed in the perception of a decrease in the number of fish and benthic organisms in the Costa Brava. The 3 groups of users surveyed provided complementary information on the impact of the storm. While artisanal fishermen had an opinion on the effect on highly targeted fish species, spear fishermen and SCUBA divers gave details on species behavior, changes in bathimetric distribution and abundance, and on landscape-related features (cover of algae, and sessile and vagile animals). We conclude that broader surveys using the methodology presented here can be very powerful tools to assess changes and trends in natural coastal populations.

Acknowledgements

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Table 1. Basic statistics of the fishermen interviewed at each one of the ports included in the study ('skill' in years of practice; 'depth' in meters).

Port		Mean	sd	Min.	Max.	n
Blanes	**Skill**	18.8	13.3	5.0	40.0	6
	Min. depth	22.5	25.5	5.0	60.0	6
	Max. depth	119.0	118.0	10.0	300.0	6
	Mean depth	70.8	71.5	9.0	180.0	6
Palamós	**Skill**	12.3	7.1	2.0	21.0	6
	Min. depth	72.0	50.9	8.4	150.0	6
	Max. depth	116.0	46.1	58.5	167.2	6
	Mean depth	94.0	41.7	33.4	150.0	6
Cadaquès	**Skill**	18.7	10.9	4.0	30.0	6
	Min. depth	94.5	63.8	26.8	170.0	6
	Max. depth	251.1	170.6	70.0	501.6	6
	Mean depth	172.8	88.9	50.0	264.2	6
TOTAL						
	Skill	16.6	10.6	2.0	40.0	18
	Min. depth	63.0	55.7	5.0	170.0	18
	Max. depth	162.0	132.2	10.0	501.6	18
	Mean depth	112.5	79.7	9.0	264.2	18

Table 2. Statistics of the respondent SCUBA divers

	Mean	sd	Min.	Max.	n
Age (years)	39.7	8.72	25	56	12
Experience (years)	20.2	10.05	4	36	11
Max. Depth (m)	21.4	7.66	7	35	12
Frequency (days.year^{-1})	70.4	48.26	30	167	7

Table 3. Statistics of the spear fishermen interviewed in this study.

Local divers	**Mean**	**sd**	**Min.**	**Max.**	**n**
Experience (years)	22.4	13.8	8.0	44.0	7
Depth (m deep)	29.6	9.9	10.0	45.0	7
Frequency (dives year^{-1})	70.5	50.2	15.0	165.0	6
Foreign divers					
Experience (years)	17.0	13.8	1.0	40.0	11
Depth (m deep)	30.0	4.5	20.0	40.0	11
Frequency (dives year^{-1})	45.6	41.9	12.0	125.0	11
All divers					
Experience (years)	19.1	13.6	1.0	44.0	18
Depth (m deep)	29.9	7.0	10.0	45.0	18
Frequency (dives year^{-1})	54.4	45.1	12.0	165.0	17

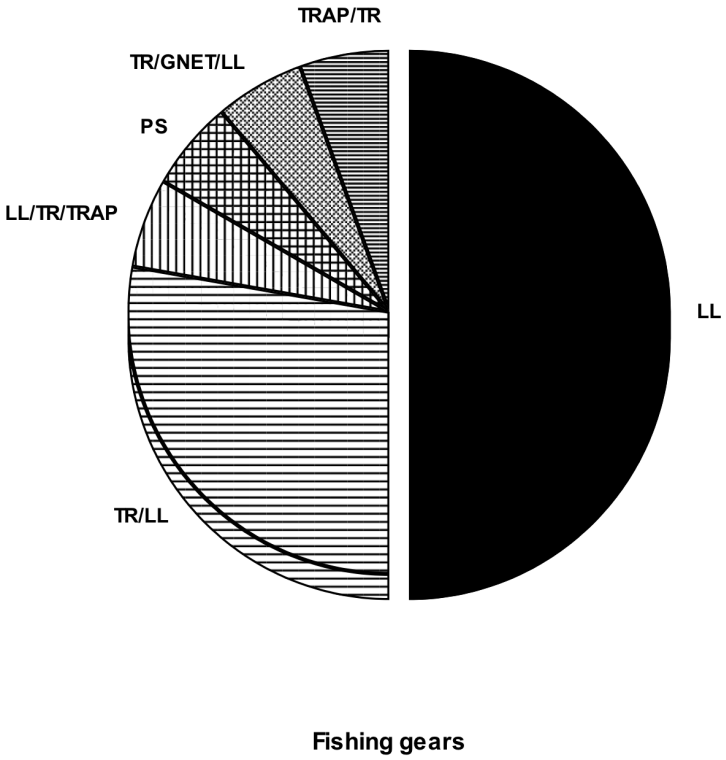

Figure 1. Fishing gears, and combinations of them, used by the fishermen interviewed in the study (LL: Long Line or *palangre*; TR: trammel net or *tresmall*; PS: small purse seine or *sonsera*; TRAP: trap or *nansa*; GNE: gillnet or *solta*).

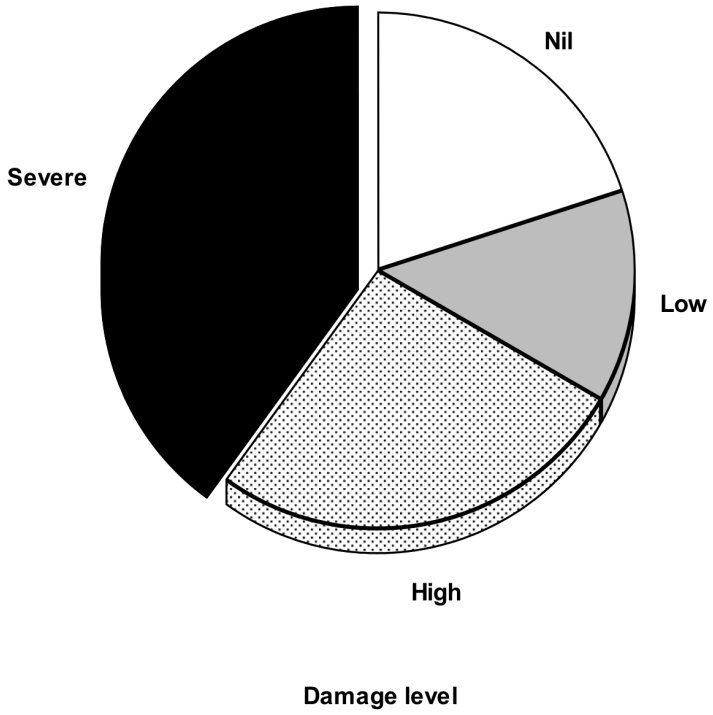

Figure 2. Most fishermen felt that damage caused by the storm on marine environment had been severe or high.

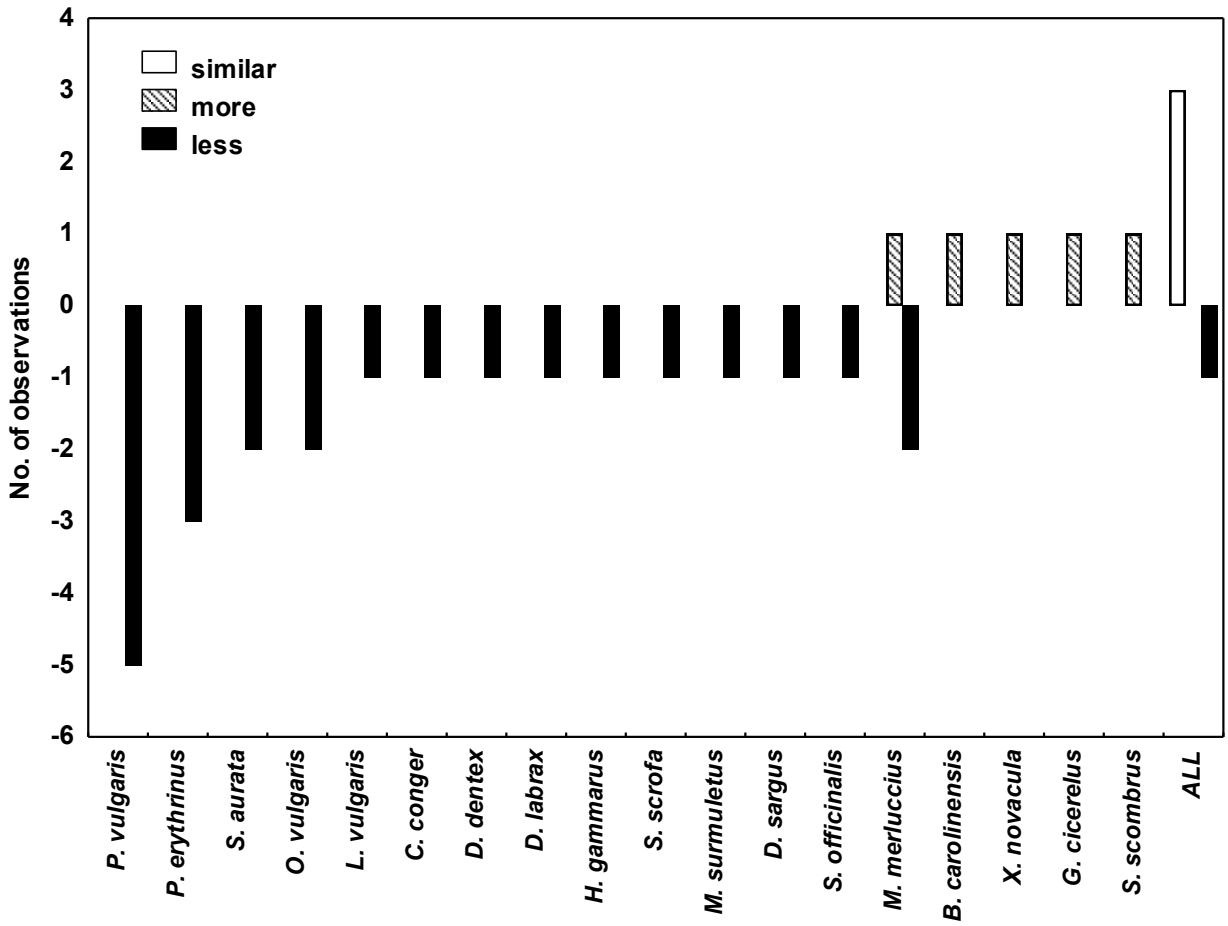

Figure 3. Species showing different catches after the storm, in opinion of fishermen. The number of observations refers to the number of times that the fishermen have mentioned the variation of each species.

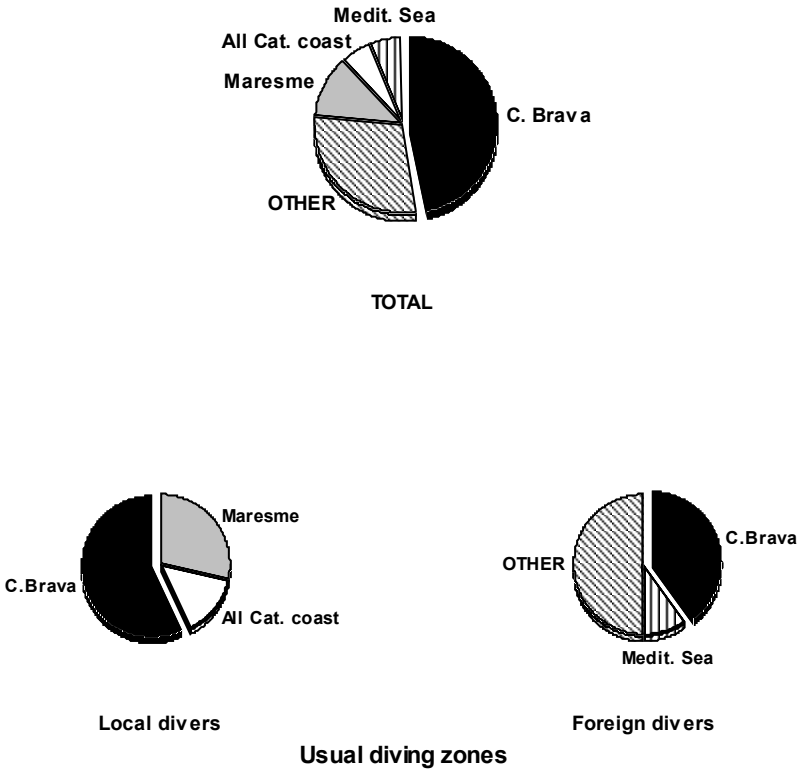

Figure 4. The zones which were habitually visited by local and foreign divers were radically distinct. This fact explained most of the differences in their answers.

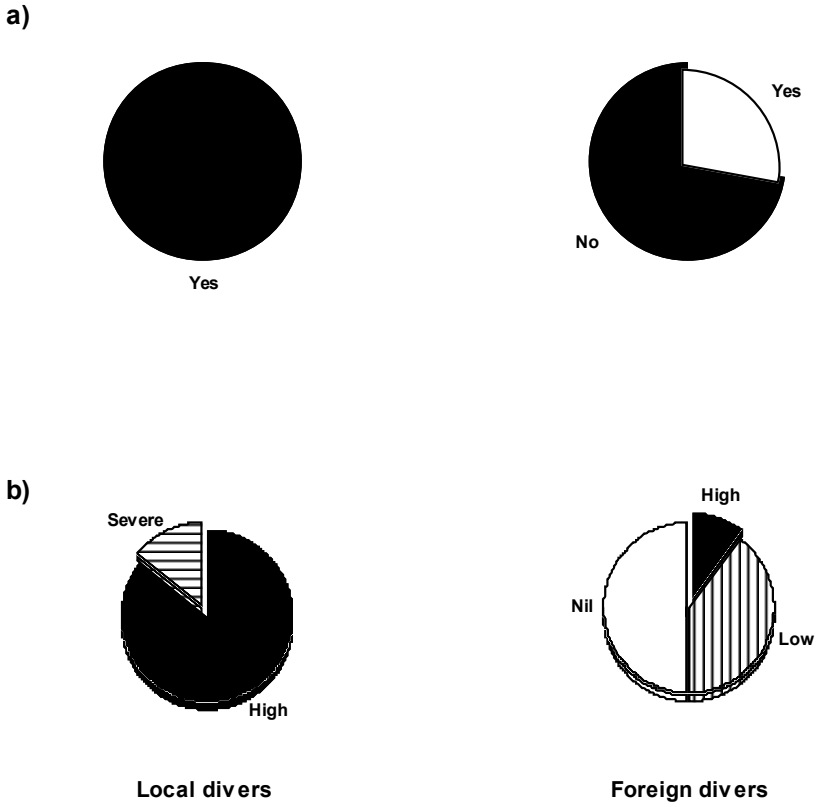

Figure 5. Differeneces in perceiving apparent changes (a) and damage level (b) on seabed were evident between local and foreign divers

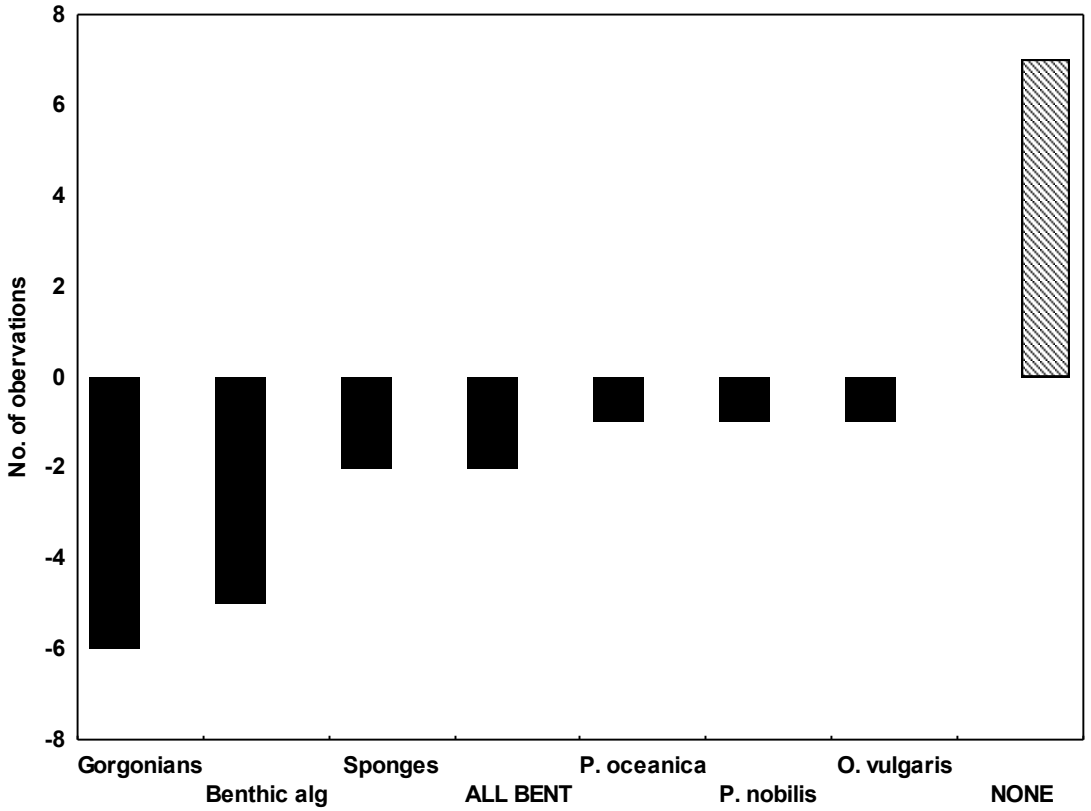

Figure 6. Number of divers that considered the species as most affected by the storm. Negative values represent losses (Benthic alg: benthic macroalgae; ALL BENT: all benthic organisms).

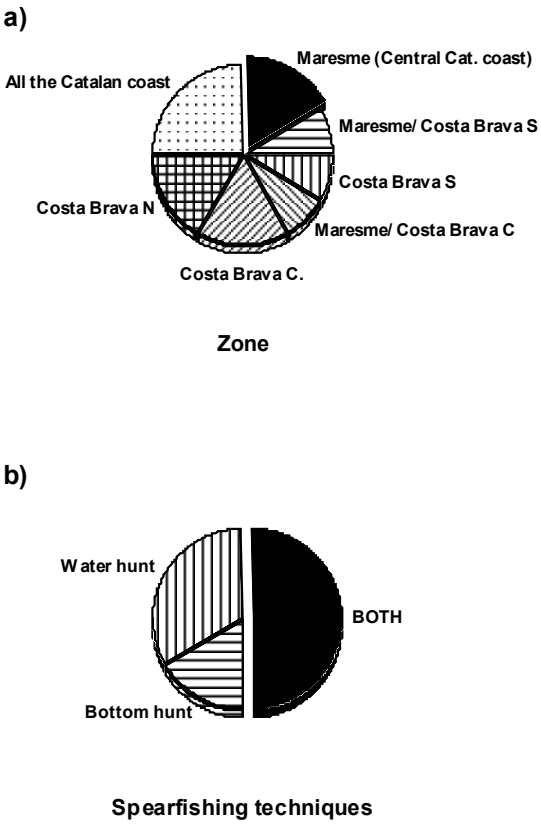

Figure 7. a) Detailed 'home range' along the Catalan coast of the 12 spear fishermen interviewed, and b) fishing techniques usually practised.

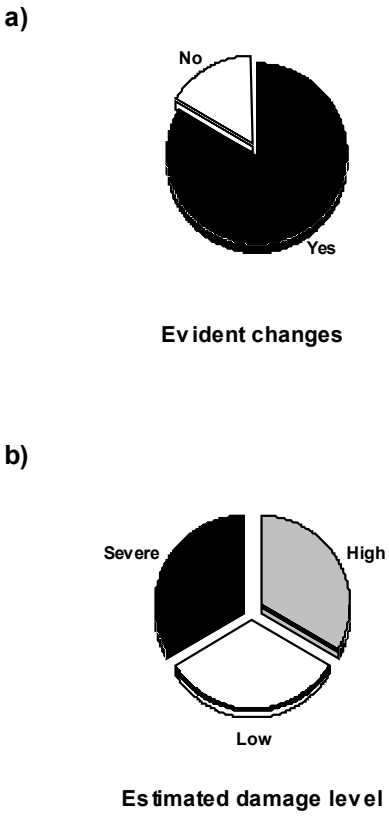

Figure 8. a) Perception of evident changes on the bottoms usually visited by spear fishermen and. b) damage degree observed on the bottom.

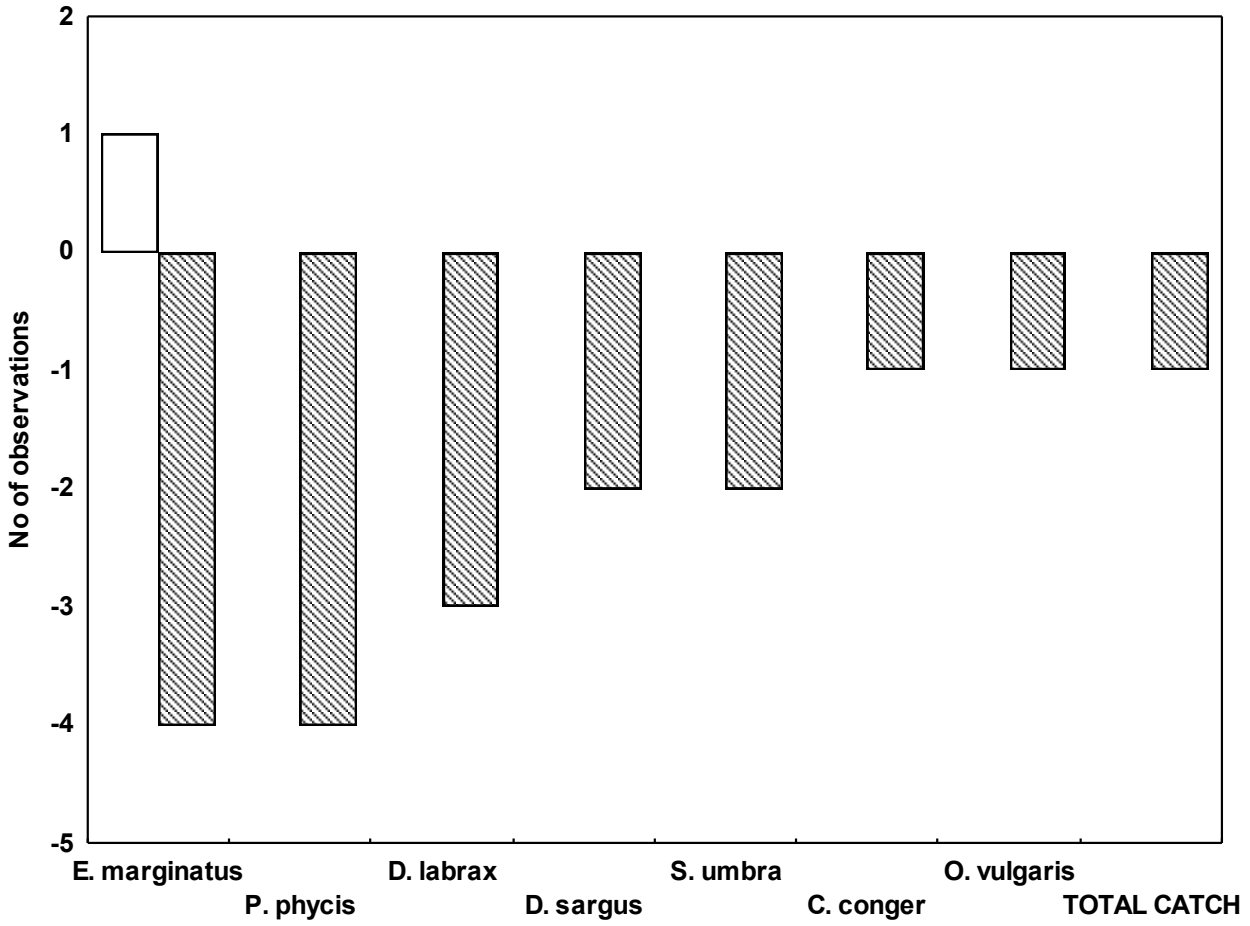

Figure 9. Number of spear fihermen's comments made about the species that showed negative or positive variations in catch after the storm.

GENERAL DISCUSSION

The contributions above constitute an unprecedented joint effort of the Centre of Advanced Studies of Blanes to answer a question of scientific and social concern: Which was the impact of the extreme storm of 26 December 2008 on the marine biota of the Catalan Coasts? Some of the studies were initially designed well enough to properly answer this question (quantitative monitoring programmes), some others lacked the ideal spatial-temporal sampling effort, and some others did not have information on the immediately 'before the storm condition' to allow for a rigorous assessment of the impact of the storm.

On spite of these limitations, this project represents the most accurate and broadest approach to the study of the impact of an extreme storm on Mediterranean coastal natural communities to date. It has provided a wealth of information about the mechanisms and factors that ultimately determine the damage caused by an extreme hydrodynamic effect on the coastal biota. Despite of the highly diverse response of the various populations and communities studied, in the overall the analysis has revealed a remarkable resistance, in some cases, and resilience, in some others, of the shallow water coastal biota to the extreme perturbation of Sant Esteve's Day 2008.

Wind, waves and shear stress

Using the integrated wave power during the storm duration (see Chapter 1), three different areas were identified: (i) the **northernmost part of the Catalan coast** (Costa Brava) – characterised by the Roses and Palamós buoys – where the greatest wave power, the largest wave heights, and the longest storm duration were recorded, and where the storm first began. Is in this area where the storm can be **classified as extreme** following the storm classification of Mendoza and Jiménez (2008). This storm was also the largest ever recorded by those two buoys. Maximum shear stress was above 70 Nm^{-2} at 5 m depth; (ii) **the central coast** – characterised by the Tordera and Llobregat buoys – where the wave power decreased down to about half of that in the northern area, with smaller wave heights (although still large), a slightly shorter duration and slightly later impact. Maximum shear stress was between ca. 50 and 70 Nm^{-2} at 5 m depth; and (iii) **the southernmost area** (the rest of the Catalan coast), where the wave power was only one third of that of the northern area, with relatively small wave heights. Maximum shear stress below ca. 50 Nm^{-2} at 5 m depth.

It seems that, in recent times, the previous comparable storm in the Catalan coast took place in 1947, i.e., **61 years before** the extreme event of