



## The effects of SCUBA diving on the endemic Mediterranean coral *Astroides calycularis*



Alejandro Terrón-Sigler<sup>a, b, \*, 1</sup>, David León-Muez<sup>b, 1</sup>, Patricio Peñalver-Duque<sup>a, b, 1</sup>, Free Espinosa Torre<sup>a</sup>

<sup>a</sup> Departamento de Zoología, Facultad de Biología, Universidad de Sevilla, Avda. Reina Mercedes 6, 41012, Sevilla, Spain

<sup>b</sup> Asociación Hombre y Territorio, C/Betania n° 13, CP. 41007, Sevilla, Spain

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### ABSTRACT

Many papers have dealt with the impact of diving activities, although most have been focussed on divers' physical contact and their equipment. Nevertheless, there are more factors that may be affecting the benthic community, for example, environment, diver's behaviour, dive characteristics, or previous knowledge of the diver about the surrounding wildlife. In the present study, several factors have been studied that may affect the orange coral (*Astroides calycularis*) populations in the North Alborán Sea (Mediterranean Sea). It has been demonstrated that detached colonies are more common in an impacted station than in a controlled station. However, larger sized detached colonies were found in the controlled station, which is probably due to the species growing without impact factors until they reach a size that they become detached naturally. Dimensions studied such as characteristics of dives, diver experience, environmental perception, or previous knowledge of divers are affecting at the endangered orange coral, showing that the characteristics of dives is a more noteworthy dimension. But this, in synergy with other factors, may be the cause of losing colonies. The results of this study are helpful to the managers of marine environment and MPAs, especially where sensitive species are present during diving activities. Therefore, essential diver education programmes must teach the environmental value and the fragility of different species. Protecting these populations should be a high priority of the environment managers to preserve our natural heritage.

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### 1. Introduction

The increase in recreational diving is resulting in more frequent physical contact between diving tourists and habitats, causing habitat damage largely due to diver inexperience and ignorance (Davis and Tisdell, 1995). Many scientific manuscripts have dealt with the impact of diving activities (e.g. Hawkins and Roberts, 1997; Rouphael and Inglis, 1997, 2001). Nevertheless, most of the studies focus on tropical regions, while temperate ones such as in the case of the Mediterranean Sea, are poorly studied (Di Franco et al., 2009; Luna et al., 2009). SCUBA divers may affect organisms both intentionally and unintentionally through physical contact with their hands, body, equipment, and fins (Pulfrich et al., 2003; Tratalos and

Austin, 2001; Uyarra and Côté, 2007; Zakai and Chadwick-Furman, 2002). These contacts are more frequent, for example, when the intensity of dive users is high (Hawkins et al., 1999, 2005); the dive time is longer (Di Franco et al., 2009; Luna et al., 2009); diver experience is lower (Roberts and Harriot, 1994); and/or the behaviour of divers is poor (Barker and Roberts, 2004; Davis and Tisdell, 1995; Rouphael and Inglis, 2001). Nevertheless, the impact of recreational activities may be influenced more by experience and the behaviour of the divers than by their numbers (Barker and Roberts, 2004; Davis and Tisdell, 1995; Rouphael and Inglis, 2001). The diver's experience, the characteristics of the dive, and/or diver behaviour are factors that may determine the degree of impact that divers perform during their activity (Luna et al., 2009). However, the previous knowledge that divers have about the marine biota present around their dive has had less attention. Moreover, the effects of recreational activities on marine fauna may be bigger when this activity focuses on Marine Protected Areas (MPAs). Over the last decade, MPAs have been designated around the world (Agardy et al., 2003; Ballantine, 1995). These are

\* Corresponding author. Departamento de Zoología, Facultad de Biología, Universidad de Sevilla, Avda. Reina Mercedes 6, 41012, Sevilla, Spain.

E-mail address: [terrónsigler@hombreyterritorio.org](mailto:terrónsigler@hombreyterritorio.org) (A. Terrón-Sigler).

<sup>1</sup> [www.hombreyterritorio.org](http://www.hombreyterritorio.org).

contributing, among other attributes, to the promotion of tourism activities along the coastlines (Badalamenti et al., 2000; Milazzo et al., 2002). Additionally, MPAs are an important component of the socio-economy of the area (Parsons and Thur, 2008; Sorice et al., 2007). Recently, studies made in Mediterranean MPAs have highlighted this problem, and management programmes have been instigated (Luna et al., 2009).

The orange coral *Astroides calycularis* is an endemic Mediterranean azooxanthellate scleractinian colony coral that inhabits the rocky shores from the surface to a 50-m depth (Zibrowius, 1980, 1983; Ocaña et al., 2000; Rossi, 1971) but is typically found in the shallow infralittoral region (0–15 m), on vertical walls or inside caves (Rossi, 1971; Cinelli et al., 1977; Zibrowius, 1978; Kružić et al., 2002). It occupies both light and dark habitats and appears to prefer a highly hydrodynamic environment (Cinelli et al., 1977; Zibrowius, 1978, 1995; Kružić et al., 2002). The population density can be high locally, with colonies covering up to 90% of the sea bed (Goffredo et al., 2011).

*A. calycularis* has a narrow distribution limited to the western Mediterranean due to its temperature tolerance (Zibrowius, 1995) and its preference to unpolluted environments (Terrón-Sigler et al., 2015). It is affected by siltation caused by high coastal urbanisation (Ocaña et al., 2009) because it is a suspension feeder (Cebrián and Ballesteros, 2004). Moreover, orange coral is affected by human activities on the littoral, such as the constructions of recreational ports or beach regenerations that increase marine pollution and/or habitat destruction (Moreno et al., 2007). It has also been demonstrated that recreational activities like SCUBA diving have a negative effect on their populations because colonies can be damaged or removed by fins, hands, and other diving equipment parts (Di Franco et al., 2009; Moreno et al., 2007; Terrón-Sigler and León-Muez, 2009). As a result, *A. calycularis* is presently protected by national and international organisations as an endangered species (i.e. the Bern and Barcelona Conventions and the Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES]).

Knowledge about the level of interaction between recreational activities and benthic communities and/or species is needed. This may be vital to apply the appropriate assessment measure for the conservation of marine benthic fauna. The aim of this study was to increase the knowledge about the impact of recreational activities on marine benthic species. Thus, the populations of the Mediterranean *A. calycularis* in the southern Iberian Peninsula were studied, taking two populations as reference: one from a protected area and another one from a more highly impacted area where recreational activities occur.

## 2. Materials and methods

### 2.1. Study area

The study was conducted at the coast of Granada (southern Iberian Peninsula, northern Alborán Sea, western Mediterranean Basin), between April and October 2008. This area is a biodiversity hotspot in the region (Templado et al., 2006), and *A. calycularis* is the dominant coral between 0 and 12 m depth (Terrón-Sigler et al., 2015). In order to assess the impact of recreational activities on the orange coral, two stations were established: one control area and one impacted station. The control station was placed in the MPA of the Acantilados de Maro-Cerro Gordo Natural Park (Fig. 1). This MPA has marine recreational uses restrictions including anchoring, recreational fishing, spear fishing, SCUBA diving, and vehicle access by land. SCUBA diving is regulated by special permits to divers, which only allow a specific numbers of daily dives. The impacted station was placed at Marina del Este beach, a well-known dive site

in the Andalusia coast, which is frequently used by recreational SCUBA divers (Terrón-Sigler and León-Muez, 2009), due to the easy accessibility by land (the vehicles may park very close to the beach). It is close to the recreational harbour (Marina del Este harbour, where the dive boats anchor) and high diversity of fauna is present, with excellent water transparency, and lastly, it is a sheltered beach. Moreover, it has been estimated that no more than 1000 divers per year occur in the MPA and between 7000 and 8000 divers per year are made in Marina del Este beach (Terrón-Sigler et al., 2008). Therefore, for these reasons Marina del Este beach station was considered impacted relative to the MPA station.

Both stations are situated in an easterly direction and sheltered from the western windstorms. However, following Howes et al. (1994), a fetch model index was developed for each station. This model provides good quantitative approximations of wave exposure in order to predict marine community patterns (e.g. Hill et al., 2010). This model relies on two indices of fetch: the modified effective fetch and a maximum fetch. A combination of the two indices allows for the determination of the wave exposure class of each area (Table 1) and is calculated using the following equation:

$$Fe = \left[ \sum (\cos\theta_i) \times Fi \right] / \sum \cos\theta_i$$

where  $Fe$  is the effective fetch in km,  $\theta_i$  is the angle between the shore and the direction ( $0^\circ$ ,  $45^\circ$  to the left and  $45^\circ$  to the right), and  $Fi$  is the fetch distance in km along the relevant vector. Maximum fetch is defined as the maximum fetch distance in km measured from the point of interest. A value of 1000 km is conventionally used when open-ocean fetches occur. The mean values in km of the modified/effective fetch combined with the maximum fetch (hereafter termed the average fetch) for each station were used as continuous variables in subsequent analysis.

### 2.2. Recreational activities

At each station, the number of users of each activity such as SCUBA diving, snorkelling, spear fishing, recreational fishing, kayaking, and anchoring, that have been seen as a potential to affect the marine benthic invertebrates were counted on two days per month during the study period.

### 2.3. Biometric and statistical analyses of detached colonies

Two days per month at each study station, all detached coral colonies from the rocky wall at an area of  $5 \times 2$  m ( $10 \text{ m}^2$ ) were collected. The collected colonies were counted, weighed, measured, and returned to the environment.

Each colony area was calculated using the formula of the ellipse, according to Goffredo et al. (2011):

$$A_c = \pi(L_c * W_c) / 4$$

where  $A_c$  is the area of the colony;  $L_c$  is the colony length (major axis); and  $W_c$  is the colony width (minor axis).

In addition, the weight was measured to obtain data on the length–weight relationship of populations in areas with high and low pressure activities. The number of detached colonies between stations (impact vs. control) was analysed by one-way ANOVA test. Prior to ANOVA, the heterogeneity of variance was tested with the Levene test. Weight data and the detached colonies' area were analysed using a two-way ANOVA test where the factors were time (fixed) and area (fixed and orthogonal with time). Prior to ANOVA, the heterogeneity of variance was tested with Cochran's C-test. Data from four months (June, July, August and September) and two areas (impact vs. control) in which there were a significant

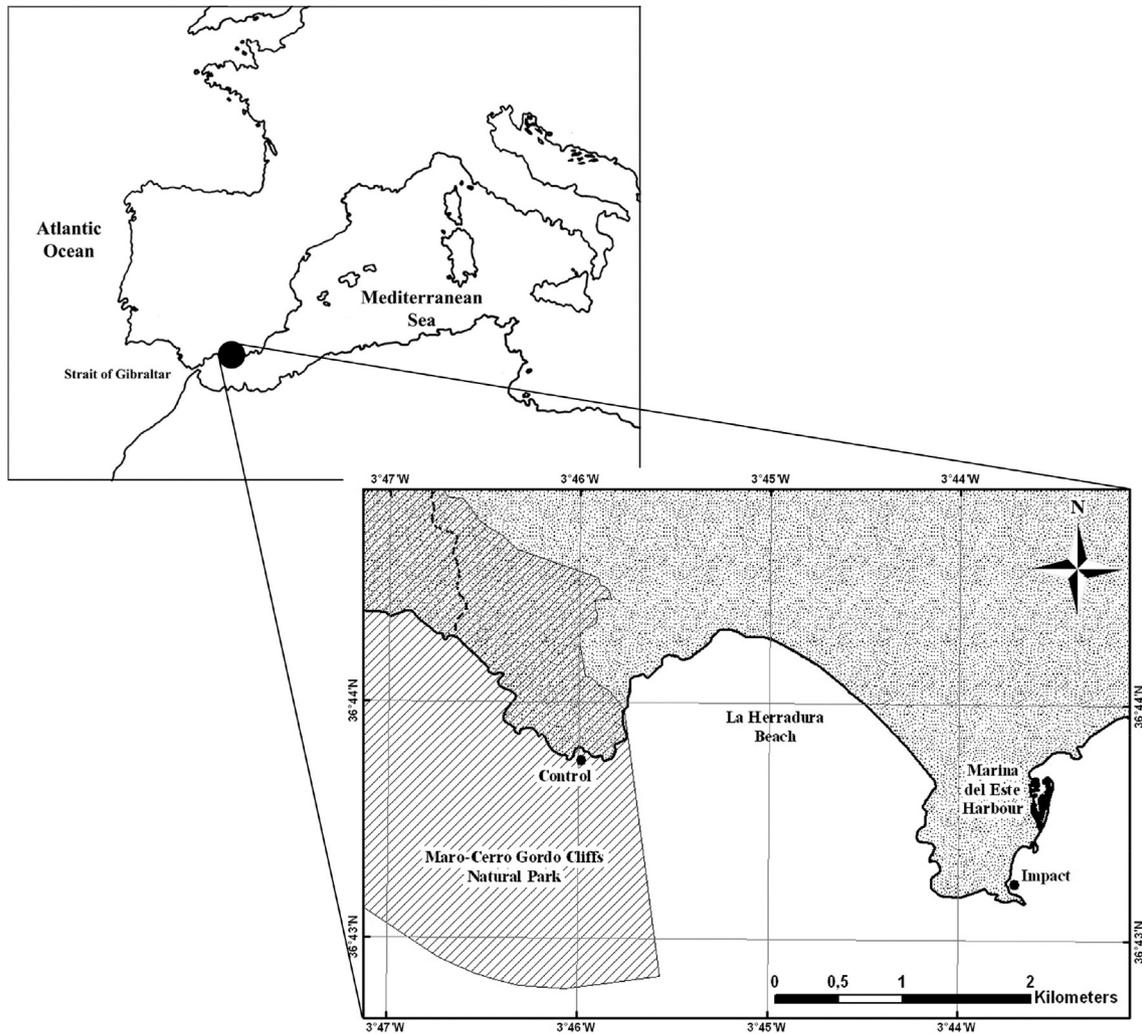


Fig. 1. Study site showing impact and control areas on the Granada coast (Andalusia, south of Spain).

Table 1

Wave exposure classes based on the modified-effective fetch and maximum fetch matrix (after Howes et al., 1994). VP: very protected; P: protected; SP: semi-protected; SE: semi-exposed; E: exposed; n/a: no assessment.

Max fetch (km)	Modified-effective fetch (km)				
	<1	1–10	10–50	50–500	>500
< 10	VP	P	n/a	n/a	n/a
10–50	n/a	SP	SP	n/a	n/a
50–500	n/a	SE	SE	SE	n/a
> 500	n/a	n/a	SE	E	E

minimum number of replicates for each factor level ( $n = 9$ ) were analysed. In those months in which there were less than nine data points collected, they were eliminated from the analysis to balance all levels of each factor. Statistical analyses were performed using SPSS<sup>®</sup> 15.0 and GMAV5<sup>®</sup>.

#### 2.4. Divers questionnaire

After the sampling described in Section 2.2, divers were randomly selected and surveyed. Following Ramos et al. (2007), four dimensions were established as potential impacts of the SCUBA divers' activities on the orange coral in the study area: diver

experience, the characteristic of the dive, environmental perception, and orange coral knowledge. For each dimension, factors likely to be affected by divers were identified, and a questionnaire was performed and addressed to target people with different perceptions and qualification levels (Table 2). For each factor, a question to ascertain the incidence on the target species was asked. This incidence may be positive, negative or neutral, depending on the diver's answer to each question. The questionnaire was pre-tested and adjusted and was given directly to each diver after the activity. The questionnaire was applied to all divers, starting from boats or from the shore.

Four hundred and sixty one questionnaires were given to the SCUBA divers 10 min after their dives. During questionnaire analysis, answers were weighted with values: 5 if positive, 3 if neutral, and 1 if negative. However, after analysis, positive values were considered to be between 5 and 3.6; neutrals between  $>3.6$  and 2.3; and negative  $>2.3$  due to the mean of the weighted answers (following Ramos et al., 2007; Ten Brink et al., 1991). For each factor, the mean of all answers was taken and the sum of all answers of each factor was used to calculate the mean for each dimension.

To show the interactions of each factor and dimension, an AMOEBA plot was used, which is a graphical device that uses a 'radar' diagram. Although the approach is simplistic, it has the advantage of representing the intervention's impact on

**Table 2**  
Brief description of each factor from the dimensions selected.

Dimension	Factors	Brief description
Divers' experience	A.- Age	The age range of users influences the type of diving. For example, younger divers are more impulsive and impatient, and can have a negative effect on the environment. The older the diver is, the more considerate he/she is on the environment.
	B.- Number of dives	Higher number of dives improves buoyancy control and dexterity underwater.
Characteristics of dive	C.- Depth/time	Between 0 and 15 m is where the most abundant populations of orange coral are present.
	D.- Area frequency	Continued use of the dive area increases pressure on the environment.
Environmental perception	E.- Environmental health	Perception of the divers on environmental quality. To find out the user perception about the environmental health; the questionnaire will give options regarding the state of the environment.
	F.- Control	Assessment of any access control or activity limitation.
Orange coral knowledge	G.- Orange coral	Knowledge about the endemic orange coral characteristics.
	H.- Protection	Diver awareness about the orange coral's level of endangerment.

respondents in a clear and easily understandable manner (Ten Brink et al., 1991).

### 3. Results

#### 3.1. Wave exposure analysis

For the control station, the maximum fetch was 368.05 km, and the calculated modified effective fetch was 179.48 km. Meanwhile, for the impacted station, the maximum fetch obtained was 343.14 km, and the modified effective fetch was 167.33 km. Thus, following Howes et al. (1994) fetch model index (Table 1), both stations are considered as semi-exposed (SE), and both present the same hydrodynamic conditions.

#### 3.2. Recreational activities

Six different recreational activities with a potential to affect the orange corals in the study area have been surveyed: SCUBA diving, snorkelling, spear fishing, recreational fishing (from the shore), kayaking, and anchoring (of recreational boats). In general, the activity with the highest user numbers was SCUBA diving (69.8%), followed by anchoring boats (14.8%), snorkelling (6.9%), spear fishing (3.8%), kayaking (2.5%), and recreational fishing (2.2%). According to the monthly studies, SCUBA diving activity is the most common and has the highest user numbers every month. Nevertheless, anchoring is mainly present in summertime (June to August), and snorkelling had the same low frequency every month, as did the other activities.

#### 3.3. Detached colonies analysis

The number of colonies (or of fragments) was higher in the impact station (see Table 3), but there was no significant difference

between the control area and impact station ( $F_{1,12} = 2.33$ ;  $p = 0.15$ ). The higher number of detached colonies occurs from April to September. Additionally, there was an even higher number of detached colonies between June and August (summertime), in either the control or the impacted station when SCUBA divers and other users are more frequent. Therefore, recreational activities (SCUBA divers principally) have the most influence on the colonies of this coral. At the end of the summer season the numbers of detached colonies decreased.

Regarding the area and weight of the detached colonies, the results were higher in size and weight in the control than the impacted station (see Table 4). However, there was no significant difference during the study months. No interaction was observed between factors for both variables (see Table 4).

#### 3.4. Diver questionnaire

SCUBA divers from 17 different countries were interviewed. Among those, more than 70% were divers from the different localities of the Andalusia region, 14.3% from the rest of Spain, and fewer than 15% from other countries (for example, UK 6.57%, Ireland 2.41% or USA 1.53%). This data can be used in conjunction with previous knowledge on orange coral and the local marine environment.

##### 3.4.1. Diver experience

Taking into account the age and previous dive numbers as an experience index, more than 60% of the divers were between 15 and 35 years old, while 30.4% were between 35 and 45, and 8.1% were older than 46 years old. As a first assessment in this area, the majority of divers were below 35 years old.

On the other hand, this area is frequented by three diver categories. Firstly, 42.7% of divers were inexperienced (who were doing their certificate course) or with a little experience (fewer than five

**Table 3**  
Number of colonies detached (N); average and standard deviation (SD) of the area (cm<sup>2</sup>) and weigh (gr) per month and points samples.

	Control					Impacted				
	N	Area		Weigh		N	Area		Weigh	
		Average	SD	Average	SD		Average	SD	Average	SD
April	2	37.6	43.92	150	183.84	9	17.26	11.85	33.33	25.77
May	6	7.9	3.07	21.83	8.68	8	5.85	5.38	16.87	14.14
June	9	30.57	11.83	94.4	35.99	17	7.23	4.24	17.82	16.41
July	11	25.77	24.41	91.54	96.03	18	8.85	7.74	13.11	17.39
August	12	26.2	13.32	81.41	59.28	14	4.44	4.28	8.42	15.65
September	9	26.21	14.76	74.55	54.06	15	13.12	14.24	28.33	39.84
October	No data					7	5.48	6.85	9.57	13.83
November	No data					6	7.13	5.03	24.33	22.71

**Table 4**Analysis of the *Astroides calycularis* colony area and weight in impacted and control zones through four months (June, July, August, and September).

Source of variation	Colony area					Colony weight				
	SS	df	MS	F	P	SS	df	MS	F	P
Time (Ti)	113.7252	3	37.9084	0.2	n. s.	1980.0556	3	660.0185	0.26	n. s.
Zone (Zo)	5921.6217	1	5921.6217	30.63	***	89605.5556	1	89605.5556	35.09	***
Ti x Zo	428.963	3	142.9877	0.74	n. s.	4398.1111	3	1466.0370	0.57	n. s.
Residual	12373.8635	64	193.3416			259415.50000	64	2553.6215		
Cochran test ( $C = 0.4451$ , $p < 0.01$ )						Cochran test ( $C = 0.4950$ , $p < 0.01$ )				
n. s. = not significant, *** $p < 0.01$						n. s. = not significant, *** $p < 0.01$				

dives per year). Secondly, 37.3% of the SCUBA divers studied were experienced, with more than 20 dives per year since starting to dive. Finally, the rest of the divers surveyed were an intermediate level, with more than five dives per year.

#### 3.4.2. Dive characteristics

Most divers' activities were performed between 0 and 15 m depth (53.4%), and duration of dives were  $44 \pm 22.38$  min. The divers whose mean depth was between 15 and 20 m depth were diving approximately  $48 \pm 13.65$  min (38.4%). Lastly, only 7.8% of the divers surveyed were diving deeper than 20 m depth, and the activity lasted  $47 \pm 11.85$  min.

For 32.8% of interviewed divers, it was their first time in this area. Due to the 67.2% who were habitual divers in this area, a high percentage of divers were in a position to assess whether this area had been environmentally damaged.

#### 3.4.3. Environmental perception

From divers who were regulars in this area, only 12.4% considered that there was not any damage, while 31.6% thought that this underwater landscape had been damaged. Finally, 56% of the regular divers asserted that the area was being damaged by SCUBA divers and other recreational marine activities.

Interestingly, 60% of the divers who thought that the area was damaged recommended that some control of access is necessary due to the number of divers being so high, especially during summertime. Nevertheless, 32% said that it was not necessary; this is probably due to the fact that they are afraid the dive site could be closed. Only 8% of users had no opinion about this question.

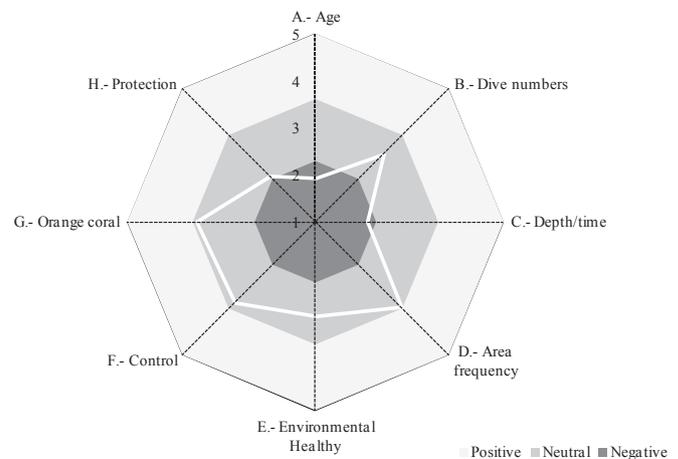
#### 3.4.4. Orange coral knowledge

From all divers surveyed, 63% confirmed that they have some knowledge about the orange coral *A. calycularis*. Nevertheless, when asked for a brief animal description, it was observed that some divers were confusing other marine life with the same colour, for example the sponge *Crambe crambe* or the false red coral *Myriapora truncata* (a bryozoan). The remainder (27%) confirmed that did not know the species. In fact, most of them did not even know that there were corals in the Mediterranean.

The divers who thought they knew the orange coral were asked if they knew that this species was endangered and protected by national and international conventions and/or laws. Only 27% of the divers answered affirmatively. Therefore, it is clearly shown that the regular divers in the area had no information about the species present in the underwater landscape.

#### 3.4.5. AMOEBA plots

The desegregation of the dimensions by factor shows that each one of them has potential impact (Fig. 2). After looking at all the SCUBA diver results by factor, it appears that age and depth/time had the most negative impacts. Although the rest are not present in a positive range, greater values are found inside the neutral range in relation to dive numbers, area frequency, environmental health,

**Fig. 2.** AMOEBA analyses of the different factors studied in the surveys.

control, species, and protection was the closest to the negative range.

The most positive values were regular divers, species knowledge, and that there should be some control in the area. Noteworthy is that previous knowledge of the divers on orange coral is not totally true, due to the divers confusing the species with other organisms having the same colour. Therefore, this factor should be considered very carefully. On the other hand, during the first assessment, regular divers could be considered as a negative impact because these divers have a high probability of interacting with the coral colonies. Nevertheless, *a priori*, these divers have performed more dives, and their buoyancy and diving skills are better; finally this has been assessed as a positive factor. Indeed, the assessment that there should be an access control in the area by the regular divers is very relevant.

To have a global point of view of which could be the principal cause of coral perturbation in the area by SCUBA divers, a dimension analysis has been conducted. This showed that diver experience has the most negative impact, although this does not reach negative values. This dimension is followed by dive characteristics, orange coral knowledge, and environmental perception (Fig. 3).

## 4. Discussion

All activities surveyed in the study area have shown an impact on sessile organisms (Coelho and Manfrino, 2007; Dixon et al., 1993; Hawkins et al., 1999; Lloret et al., 2006), with SCUBA diving interaction being the most studied. Nevertheless, Di Franco et al. (2009) observed that one of the species most frequently damaged by diver contact was the colonies, and all contacts made on *A. calycularis* caused evident injuries to the colonies in the form of detaching one or more corallites.

In the Mediterranean Sea, Luna et al. (2009) demonstrated that

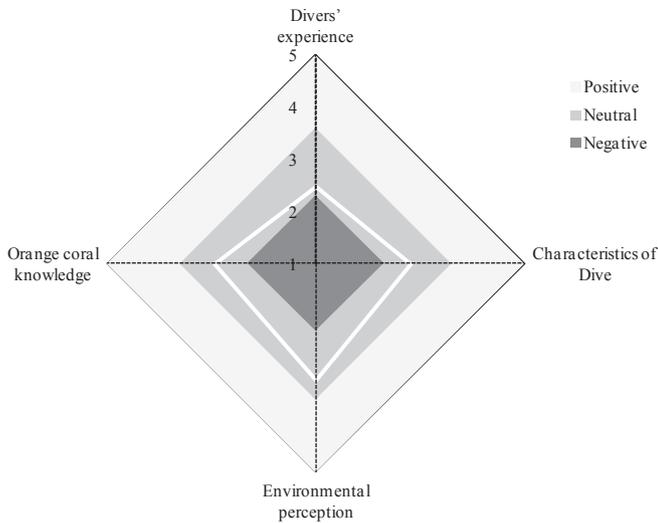


Fig. 3. AMOEBAs analyses of the different dimensions studied in the surveys.

divers' contact was caused by flapping and by contact with fins principally, as already shown in other seas around the world (e.g., Barker and Roberts, 2004; Harriot et al., 1997; Rouphael and Inglis, 2001). Moreover, with regard to any part of the body, the most frequent was contact with the hands (Luna et al., 2009). Additionally, divers make contact with the environment on average 2.52 times every 7 min, and this contact is unintentional in 76% of all cases (Di Franco et al., 2009). Therefore, in places in which SCUBA diving is the principal recreational activity, interactions with the benthic macro-fauna are potentially greater than those where this activity is secondary or lower. This assumption is corroborated in our data because the number of detached colonies was always higher in the impacted station.

Garrabou et al. (1998) demonstrated that *Pentapora fasciatis* colonies (Bryozoa) were detached as a consequence of intensive SCUBA diving at Medas Island (western Mediterranean Sea). These authors observed that there were no differences between colony size and time.

The data in the present study supports the fact that there are fewer detached colonies in the control station, but these have a larger size. Some publications have shown that coral reefs may present similar damage in areas with high diver presence as well as those of low diver presence, and the conclusion was that external factors damaging the corals should exist (Hawkins and Roberts, 1992; Hawkins et al., 1999; Riegl and Velimirov, 1991).

In the control station, the colonies loss may be explained because colonies grow without diver interference, and these colonies, when they are large in size, are more susceptible to being detached by environmental conditions as, for example, hydrodynamics or wind storms (pers. obs.). This factor may explain that in the control station, detached orange coral colonies are bigger and heavier than in the impact area, where the colonies are smaller, which may be caused by unintentional interactions between divers and colonies.

It has also been shown that the previous lack of knowledge about the orange coral as an endangered and endemic species by the SCUBA divers could be an impact factor. This could be the causes of the decreasing orange coral coverage in the study area (Terrón-Sigler and León-Múez, 2009), in synergy with other impact factors.

Impacts caused by recreational SCUBA diving may vary widely among different dive sites and individual divers (Rouphael and Inglis, 2001). *A priori*, experienced divers should cause fewer impacts by contact with the substratum than inexperienced divers

(Luna et al., 2009). Although this factor has been shown as a potential impact (Roberts and Harriott, 1994), some authors did not observe it (Harriott et al., 1997; Rouphael and Inglis, 2001). In the present study, the diver experience dimension has been the most negative impact, with age being the most important factor. Younger divers are more impatient and thus are more likely to inadvertently make contact with the coral colonies. According to Luna et al. (2009), diver experience may not be a good indicator as the only factor to determine whether a diver is qualified for diving at a site, and more factors must be studied and assessed.

In the present study, the frequency and the binomial depth-time as a dive characteristic and their potential impact on the orange coral have been studied. Generally, dives were conducted between 0 and 15 m depth, where *A. calycularis* is more abundant (Terrón-Sigler et al., 2015) and there is more probability of interacting with the colonies. Moreover, the means of the time dives were high and similar in all depth ranges (more than 40 min). In an MPA from the Mediterranean Sea, it has been demonstrated that in 45 min of immersion, recreational divers may make up to eight contacts with fragile organisms (Luna et al., 2009). These contacts may be unintentional in 76% of cases (Di Franco et al., 2009). During a 10-min immersion, SCUBA divers may cause serious damage to the environment (e.g., Uyarra and Côté, 2007); this may be worse when divers have little experience. This occurs in the present study area; normally, the divers which have low experience make their immersions at the depth precisely where *A. calycularis* predominantly occurs. Actually, the binomial factor depth/time was negative, and the dimension where it is nestled this factor obtained the second lowest values.

Diver experience, characteristics of the dive, and/or the behaviour of divers have been already studied as potential impact factors on the marine environment (Barker and Roberts, 2004; Luna et al., 2009; Medio et al., 1997). Nevertheless, the divers' perceptions about environment degradation and their knowledge of the species present in the dive site have been scarcely studied. These in conjunction with the above might be taken into account with futures species, habitats, ecosystems, and/or MPA conservation frameworks.

Here, it has been shown that divers perceive degradation of dive sites where the SCUBA activities are high. Moreover, habitual divers have not been afraid to affirm that some access control should be taken as a management measure, even when this might involve a restriction on their activity. On the other hand, there is little information addressed to divers about the singularity of the dive site with regards to the species, habitats, and/or ecosystems present. Therefore, one way of reducing damage is by providing environmental education programmes to promote awareness about endangered species within the diving community (Barker and Roberts, 2004). Actually, Medio et al. (1997) demonstrated that there were fewer interactions between divers and the underwater environment after a short briefing about the characteristics of the ecosystem and the problems caused by human contact. Recently, Krieger and Chadwick (2012) demonstrated that divers who received pre-dive ecological briefings in dive centres caused significantly less coral damage than those who did not. Although this measurement may be a good tool, high levels of damage may be unavoidable if the group is composed of large number of divers (Barker and Roberts, 2004; Luna et al., 2009). Therefore, the education must be combined with small diver groups, among other features.

## 5. Conclusions

The present study suggests that the divers' ignorance about *A. calycularis* is a potential impact factor combined with the diver

experience and characteristic of the dive on the Granada coast. Perhaps this is not the most negative impact, but whether the diver knows the special characteristics of this species, and additionally, do they take care of the environment and avoid touching the colonies. This topic needs to be considered when adopting management strategies in dive areas where these species are present, due to it having been demonstrated that *A. calycularis* may be one of the most frequently damaged species by divers (Di Franco et al., 2009).

To improve the management on MPAs which harbour endangered species and which permit recreational activities such as SCUBA diving, diver education programmes are essential to teach the environmental value and the fragility of different species, as well as to show the potential damage of diving activity and how to minimise the negative impact of scuba diving (Luna et al., 2009). The Andalusia region supports one of the most abundance populations of *A. calycularis*, and these are also present in MPAs (Terrón-Sigler et al., 2015). Protecting these populations should be a high priority for the environment managers to preserve the natural heritage of the region and of the country as a whole.

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