Recreational boaters support the use of mooring buoys to reduce anchor damage to *Posidonia oceanica* (L.) Delile meadows

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Recreational boating is an important economic activity in the Mediterranean Sea that often leads to disturbance by anchoring of *Posidonia oceanica* meadows, an endemic seagrass that is a critical component of shallow coastal ecosystems. A self-administered survey of recreational boaters that anchor in a popular mooring site (Cala Blava) in the coast of Mallorca (Balearic Islands, Western Mediterranean) was carried out during the summer season of 2011 to assess their preferences regarding the number of boats anchoring at the cove and the distance between them, their willingness to pay for the use of mooring buoys and their perception of the negative effects that recreational boating may have on the marine environment. Four hundred and twenty five surveys were obtained over a period of 23 days (11 weekend days, 14 week days) with a response rate of 95 %. The number of boats anchored was higher during weekends (30 ± 13 boats) than during the rest of the week (15 ± 5 boats). Most of the respondents considered that both the number of anchored boats and distance between them were adequate, and they were satisfied with their visit to Cala Blava. Anchor damage was identified as the main impact caused in the marine environment by recreational boating. Support for the use of mooring buoys was high (72 %) and 58 % of boaters were willing to pay a fee for buoy use. The most widely accepted fee was 5 Euros per day of use. These results suggest that the public is well aware of the damage caused by anchoring on *P. oceanica* meadows and that environmental regulation that would reduce this harm through the use of mooring buoys would have wide support from the main users, who would be even willing to pay for the service. This is a bright prospect for the conservation of this valuable and fragile coastal ecosystem.

Keywords: *Posidonia oceanica, recreational boating, mooring buoys.*

RECOLZAMENT DELS USUARIS NÀUTICS RECREATIUS PER A L'ÚS DE BOIES DE FONDEIG PER A LA REDUCCIÓ DE L'IMPACTE DEL FONDEIG SOBRE LES PRADERES DE *Posidonia oceanica* (L.) DELILE. La nàutica recreativa és una activitat econòmica important a la Mar Mediterrània que sovint es responsabilitzada de l'alteració, mitjançant el fondeig, de les praderies de *Posidonia oceanica*, una fanerògama marina endèmica i que constitueix un component essencial dels ecosistemes costaners d'aigües somes. S'ha realitzat una enquesta als usuaris de la nàutica recreativa a una àrea de fondeig popular (Cala Blava) localitzada a la costa de Mallorca (Illes Balears, Mediterrània Occidental) durant la temporada d'estiu de 2011 per a avaluar les seves preferències respecte el nombre d'embarcacions fondejades a la cala i la distància entre elles, la seva voluntat de pagar per a l'ús de les boies de fondeig i la seva percepció dels efectes negatius que la nàutica recreativa pot tenir sobre el medi marí. S'han realitzat un total de 425

enquestes per a un període de 23 dies de mostreig (11 caps de setmana i 14 dies de dilluns a divendres) amb un percentatge de resposta del 95%. El número d'embarcacions fondejades va esser major durant els caps de setmana (30 ± 13 embarcacions) que durant la resta de la setmana (15 ± 5 embarcacions). La major part dels enquestats consideraren que tant el número d'embarcacions fondejades i la distància entre elles era l'adequada, així com també estaven satisfets amb la visita a Cala Blava. El perjudici causat pel fondeig d'embarcacions sobre el medi marí va esser identificat com el major impacte causat per la nàutica recreativa. El suport per a l'ús de les boies de fondeig va ésser elevat (72%) i el 58% dels usuaris estaven disposats a pagar una taxa de 5 euros/dia per al seu ús. Aquests resultats suggereixen que el públic està ben conscienciat de l'impacte causat pel fondeig sobre les praderies de *P. oceanica* i que la seva regulació ambiental podria reduir aquesta amenaça amb la instal·lació de boies de fondeig. La major part dels usuaris nàutics recreatius recolzen l'ús de les boies i inclús estarien disposats a pagar pel servei. Aquests resultats milloren les expectatives per a la conservació d'aquest valuós i fràgil ecosistema costaner.

Paraules clau: *Posidonia oceanica, nàutica recreativa, boies de fondeig.*

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Introduction

Posidonia oceanica is a seagrass endemic to the Mediterranean Sea where it forms extensive meadows to a depth of 40 m (Procaccini *et al.*, 2003). Similar to other seagrasses, *P. oceanica* is a critical component of shallow coastal ecosystems due to its contribution to biodiversity maintenance, biological productivity, nutrient cycling, carbon burial, and sediment stabilization (Hemminga and Duarte, 2000). *P. oceanica* meadows harbor a species-rich community of algae, invertebrates and fishes (Templado *et al.*, 2004). *P. oceanica* meadows trap suspended particulate matter, carbon and nutrients (Gacia *et al.*, 2002; Hendricks *et al.*, 2008), reduce sediment resuspension (Terrados and Duarte, 2000; Gacia and Duarte, 2001) and absorb nutrients (Lepoint *et al.*, 2004) becoming a filter for coastal water. Moreover, they contribute to coastal protection through wave attenuation (Infantes *et al.*, 2012). Additionally, *P. oceanica* meadows bury about 25 % of the annual primary production in the sediment, where it takes several years to decompose, building a long-term carbon sink (Mateo and Romero, 1997). Seagrasses are under global threat (Waycott *et al.*, 2009) and *P. oceanica* is no exception: a 5 – 20 % reduction of its extent has been reported for the last century (Boudouresque *et al.*, 2009). The destruction of *P. oceanica* meadows will result in the reduction or loss of the resources and ecological services they provide.

Nautical activities are an important sector of coastal economies in the Mediterranean and mooring demand by recreational boaters surpasses supply in

most coastal areas during the high touristic season (summer). This often leads to disturbance of *P. oceanica* meadows by anchoring, since many boaters will anchor indiscriminately in areas adjacent to mooring grounds, whether *P. oceanica* is present or not. Hence, disturbance of *P. oceanica* meadows by anchoring of recreational boats in coves that are popular mooring sites is bound to happen. A census of recreational boats anchored inside the Cape of Creus (NE Spain) marine protected area (MPA) showed that 50 % of them were anchored in *P. oceanica*, and this pressure increased up to 70 % in some coves (Lloret *et al.*, 2008). More than 6000 recreational boats are estimated to sail during the busiest day of the summer season along the Mallorca coast (Balaguer *et al.*, 2011). These boats would be able to anchor on sandy bottom and, therefore, avoid damaging of *P. oceanica* meadows, only if they anchored at distances of 25 m or less (Balaguer *et al.*, 2011), a condition that frequently is not met (Diedrich *et al.*, 2011). Indeed, boat anchoring has been identified as one of the major causes of destruction of *P. oceanica* meadows (Boudouresque *et al.*, 2009). Light weight anchors (4-12 kg) used by small recreational boats (length < 9 m) destroy from 5 to 34 shoots during one anchoring event (Francour *et al.*, 1999; Milazzo *et al.*, 2004). Heavier anchors, as those used by larger boats, together with a low compactness of the bottom and a high baring (un-burial) of *P. oceanica* rhizomes will promote an increase of anchor damage (Francour *et al.*, 1999; Ceccherelli *et al.*, 2007). The cumulative effect of anchoring in *P. oceanica* meadows has not been quantified but an anchoring density of 3 boats day^{-1} and 2500 m^{-2} is associated with *P. oceanica* regression in Port Cros MPA (France) while meadow cover seems to be stable around to an anchoring density of 1 boat day^{-1} and 2500 m^{-2} (Francour *et al.*, 1999). Chronic damage by boat anchoring may lead to complete *P. oceanica* loss because recovery of this seagrass species is very slow (from > 5 years to hundreds of years, Francour *et al.*, 1999; Kendrick *et al.*, 2005). Restriction to anchoring and the installation of mooring buoys that do not damage *P. oceanica* (Francour *et al.*, 1999; Marbà *et al.*, 2002; Francour *et al.*, 2006) have been shown to improve the status of meadows.

Mooring buoys are being installed increasingly to manage the anchoring demand of recreational boaters, particularly in MPAs (Francour *et al.*, 1999; Marbà *et al.*, 2002; Milazzo *et al.*, 2002). Stake-holder acceptance of environmental regulations is critical for the success of environmental management, and it is likely to be higher if environmental regulations consider in their design and implementation elements such as the perceptions and attitudes of the various sectors involved in decision making (Bradshaw and Bekoff, 2000; Clark, 2007; Ehler and Douvere, 2009). Diedrich *et al.* (2011) have shown how the assessment of preferences of recreational boaters regarding the number of boats present in a cove and the distance between them can be used to identify the levels of crowding that would be accepted by the majority of users. Other elements that likely influence the acceptance and support by recreational boaters of anchoring regulations are their perception of the negative effects that recreational boating might have on the marine environment or their willingness to pay (WTP) a fee for the use of a mooring buoy (Mitchell and Carson, 1989). The objectives of this study were to assess the preferences of recreational boaters regarding the number of boats anchoring at

a given cove/bay and the distance between them, their WTP for the use of mooring buoys and their perception of the negative effects that recreational boating may have on the marine environment. Our aim was to contribute to the design of environmental regulations that would be more successful at preventing anchoring disturbance by the provision of elements that might increase acceptance and support by recreational boaters. To this end, a survey of recreational boaters that use a popular mooring site in the coast of Mallorca (Balearic Islands, Western Mediterranean) was carried out during the summer season.

Methods

A self-administered survey was implemented in Cala Blava, a popular recreational boating site located in the Bay of Palma (Mallorca), the main port and urban center in the Balearic Islands (Fig. 1) and where more than 5000 berths are offered (Balaguer *et al.*, 2011). Cala Blava is part of a MPA designated by overlapping regional and European legislations. The dominant benthic communities in the cove are *Posidonia oceanica* meadows and unvegetated sands. Cala Blava is the only anchoring site in the bay of Palma where mooring buoys have been installed in previous years to protect *P. oceanica* from anchoring impacts: 49 buoys have been installed during summer since 2006. There were no fees charged for the use of these buoys and boaters were also allowed to anchor in sandy zones. Mooring buoys were not installed during summer 2011, when this study was done.

The survey (see the Appendix) was designed to collect data related to the perceptions of recreational boaters of the number of boats present in Cala Blava and the distance between them, their WTP for the use of buoys and their perception of the negative effects that recreational boating may have on the marine environment. We also registered data related to boat characteristics and port of origin, prior knowledge of the site, residence status and other demographic data of the recreational boaters. The survey, printed in five languages (Catalan, Spanish, English, French, and German) was distributed to recreational boaters anchored at the study site over a period of seven weeks in the high season for tourism of 2011 (from 24th July to 11th September). Pilot tests of the survey were carried out with native speakers of each language. It took an average of seven minutes to complete.

The study aimed to sample two week days and both weekend days every week although this varied somewhat since sample days were influenced by weather conditions. A team of two surveyors zigzagged through the site in a small inflatable distributing one survey per boat. The sampling approach was a combination of opportunistic and quota. The sample ranged from 50 – 100% of the maximum number of boats observed each day. Repeat visits of individuals who had already completed the survey, refusals, and boats leaving before the team was able to administer a survey were limiting factors to the sample. The team arrived at 10 am when boaters started to arrive at the cove and left between 4 – 6 pm once peak hour for boats had passed. The total number of boats could be counted visually from any location within the cove so the surveyors were able to obtain periodic counts of boat fluctuations throughout the day.

The number of anchored boats and the distance between them considered acceptable by the majority (> 50%) of recreational boaters present in Cala Blava,

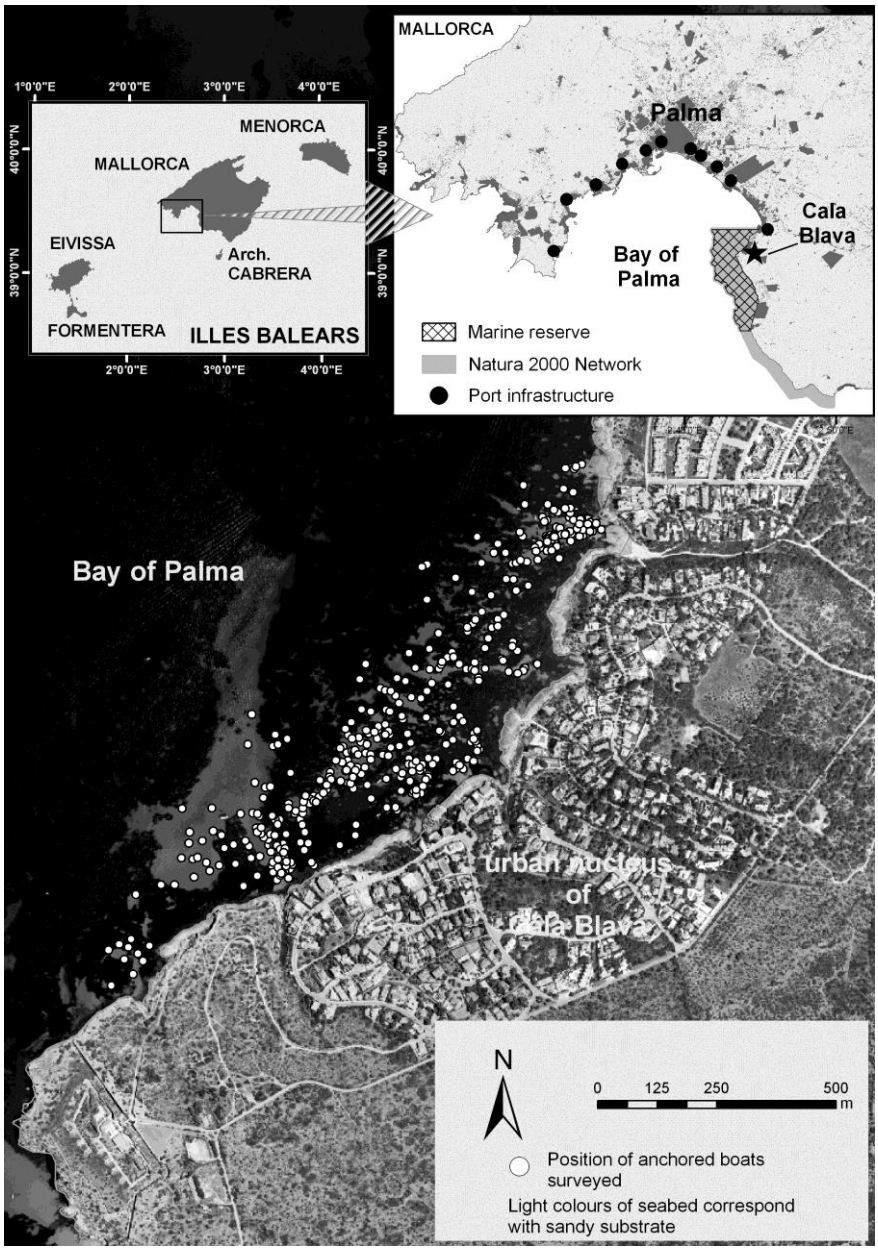

Fig. 1. Cala Blava mooring site (Mallorca, Balearic Islands).
Fig. 1. *Àrea de fondeig de Cala Blava (Mallorca, Illes Balears).*

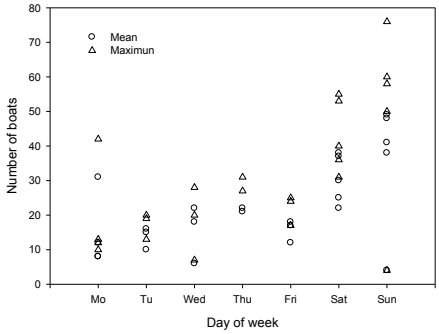

Fig. 2. Mean and maximum number of boats anchoring in Cala Blava from Monday to Sunday. Each symbol represents the value (mean or maximum) corresponding to each of the survey days.
Fig. 2. *Nombre mitjà i màxim d'embarcacions fondejades a Cala Blava de dilluns diumenge. Cada símbol representa el valor (mitjà o màxim) corresponent a cada dia de mostreig.*

and how their satisfaction from visiting the site would change if the number of anchored boats increased or the distance between them decreased were assessed using the methodology proposed by Diedrich *et al.* (2011) which is based on the Limits of Acceptable Change (LAC) process. In brief, as opposed to focusing directly on visitor numbers, the LAC process requires the definition of acceptable social and environmental conditions in the management area and the prescription of measures to monitor and protect these conditions (Stankey *et al*., 1985).

Differences between week days and weekend days in the number of boats anchoring in Cala Blava were evaluated using a t-test. The association between crowding (number of boats anchored in the site) and the perceptions of recreational boaters about the number and distance between boats anchoring was evaluated using Spearman rank correlation (r_s). Frequency distribution of the amount in euros that recreational boaters would be willing to pay for one day of use of a mooring buoy (see question 11 in Appendix) was built to identify WTP.

Results

Four hundred and twenty five surveys were obtained over a period of 23 days (11 weekend days, 14 week days) with a response rate of 95 %. The proportion of repeat visitors increased during the study and reached a maximum of 32 % at the end of the sampling period.

The number of boats anchored in Cala Blava was significantly higher during weekends than during the rest of the week (Fig. 2): the mean (of daily averages) number of boats increased from 15 ± 5 (1 SD) to 30 ± 13 ($t = 4.8$, d.f. = 23, $P < 0.01$) while the average of the daily maximum number of boats increased from 19 ± 7 to 46 ± 19 ($t = 4.9$, d.f. = 23, $P < 0.01$).

Sixty two percent of the boats had engine as the only propulsion system while 38 % had also sails. Eighty three percent of the boats had lengths smaller than 13 m (Fig. 3a). The majority of the boats (95 %) departed from ports located in Palma Bay and only 1 % of the boats arrived from other islands of the Balearic Archipelago or other ports outside it (Fig. 3b).

The boats were mainly privately owned (90 %) and skipped by residents in Mallorca (83 %). Three to five was the most frequent number of persons present in the boats (Fig. 3c). Cala Blava was known by many of the respondents because 62 % of them had visited it more than 40 times while 21 % had visited it between 2 and 10 times (Fig. 3d). The knowledge of Cala Blava extends quite far in the past because

59 % of the respondents had first visited it between 1945 and 1975 and only 16 % of respondents had first visited it after 2006 (Fig. 3e). Most of the respondents were Spaniards (81 %), followed by Germans (10 %), British (2.5 %) and French (1.8 %). Non-European respondents were only 0.8 % (Fig. 3f). Proximity to port of origin, weather conditions and habit were the most frequent reasons given by respondents for choosing Cala Blava as the visit site (Fig. 4).

The percentage of respondents that considered that the number of boats anchored was adequate decreased (r_s =0.86, $P < 0.05$) as crowding increased: from 89%

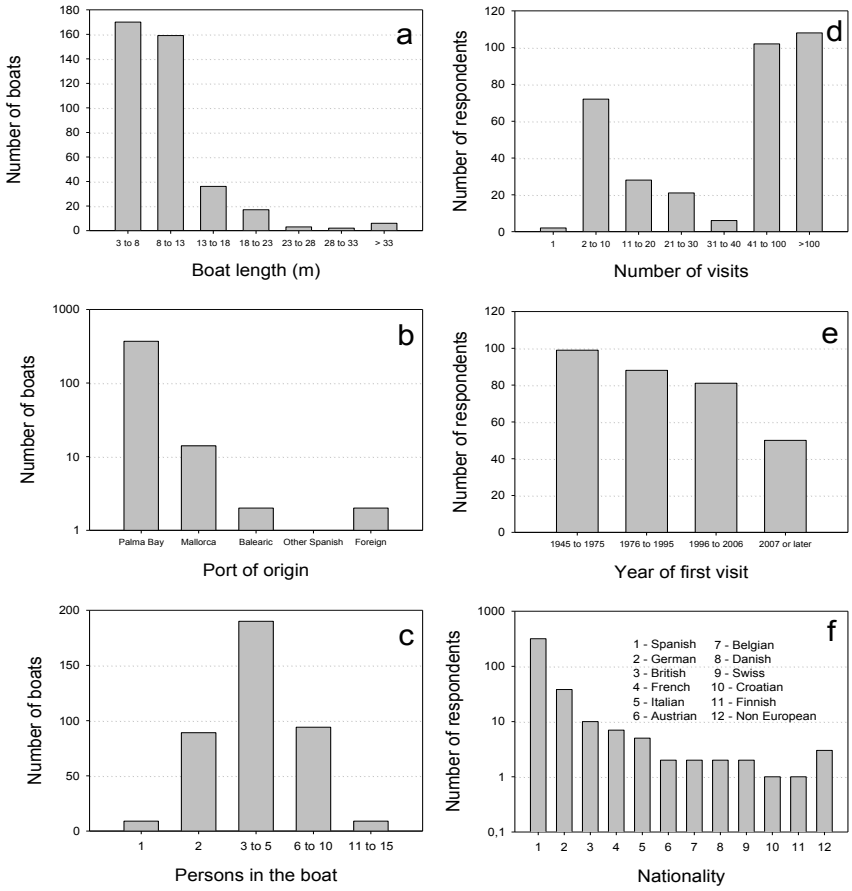

Fig. 3. Frequency distributions of a) boat lengths, b) port of origin, c) number of persons in boat, d) number of visits to Cala Blava, e) year of first visit to Cala Blava, and f) respondent nationality of the boats anchoring in Cala Blava.

Fig. 3. *Distribució de freqüències de a) eslores (llargària) de les embarcacions, b) port d'origen, c) nombre de persones per embarcació, d) nombre de visites a Cala Blava, e) any que visità Cala Blava per primera vegada, i f) nacionalitat dels usuaris de les embarcacions que fondejen a Cala Blava.*

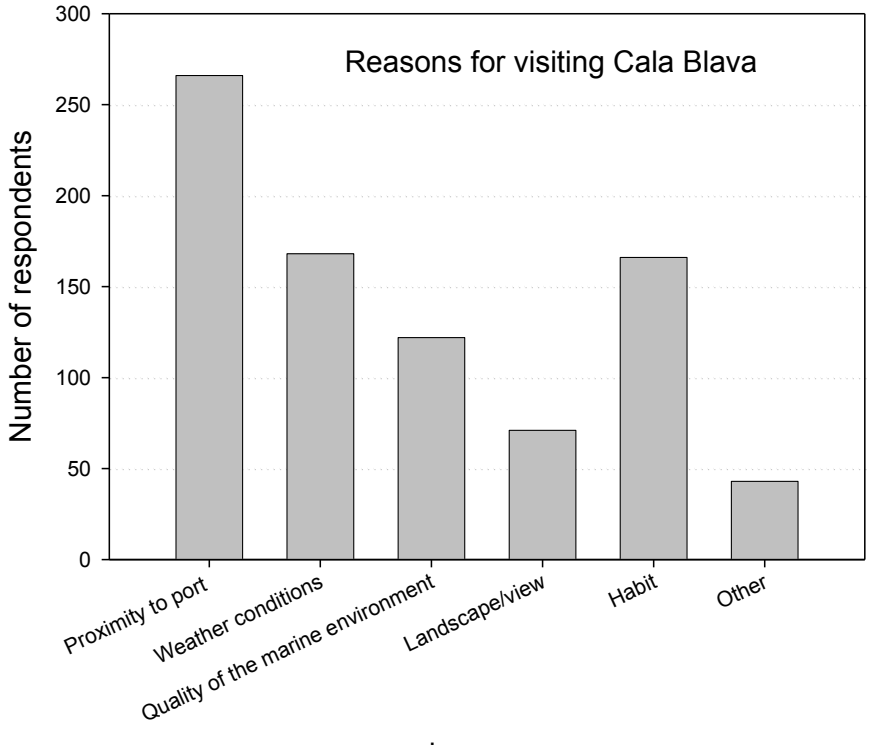

Fig. 4. Frequency distribution of the reasons provided by recreational boaters for anchoring in Cala Blava.
Fig. 4. *Distribució de freqüències de les raons per les quals els usuaris d'embarcacions recreatives elegeixen Cala Blava per al fondeig.*

when only 0 to 10 boats were anchored in Cala Blava to 63 % when there were 60 or more boats anchored (Fig. 5a). The percentage of respondents that preferred "many fewer" or "fewer" boats anchored also increased up to 10 % (r_s = 0.78, P < 0.05) and 21 % (r_s = 0.86, P < 0.05), respectively, as crowding increased.

More than 80 % of respondents considered that distance between the boats anchored in Cala Blava was adequate and this opinion was not influenced by crowding (Fig. 5b). Respondents that considered that the distance between ancho red boats was "much too close", "too close", "too far" and "much too far" were always below 20 % and were not associated to crowding. When respondents were asked about how the overall quality of their visit to Cala Blava would change if the number of anchored boats increased, 21 % considered that it would decrease a lot, 52 % considered that it would decrease a little and 25 % considered that it would not change. When asked about a reduction of distance between anchored boats, 37 % considered that the overall quality of their visit would decrease a lot, 49% considered that it would decrease

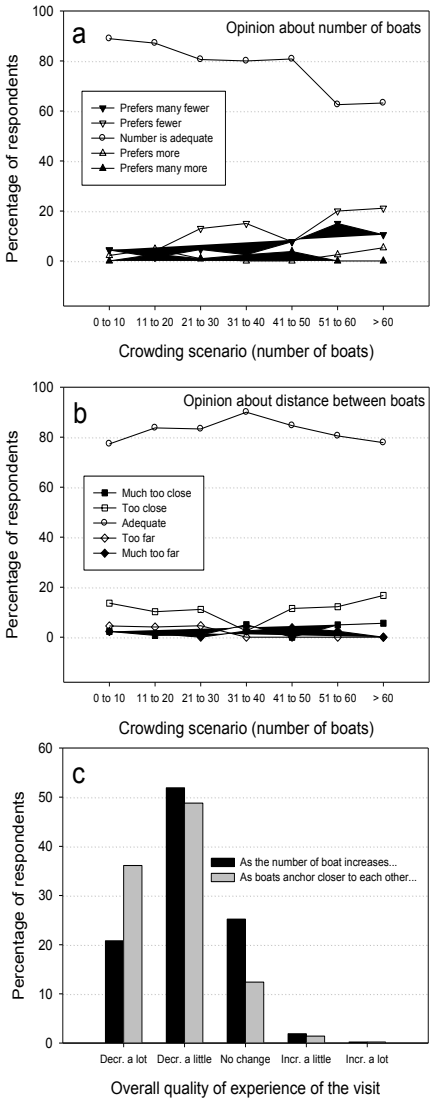

Fig. 5. Opinion of recreational boaters anchoring in Cala Blava about a) the number of boats anchored in the cove, b) distance between anchored boats, and c) overall quality of experience of their visit as the number of boats present in the cove increases.
Fig. 5. *Opinió dels usuaris de les embarcacions fondejades a Cala Blava sobre a) nombre d'embarcacions fondejades a la cala, b) distància entre les embarcacions fondejades, c) qualificació general de l'experiència de la visita a Cala Blava a mesura que el nombre d'embarcacions presents a la cala augmenta.*

a little and 12 % considered that it would not change (Fig. 5c).

Overall satisfaction of respondents was high because more than 90% were either satisfied or very satisfied with their experience of visiting Cala Blava.

The results of a the categorical response question about the perceived impacts of boating on the marine environment in Mallorca (see question 7 in Appendix) showed the highest response rate for anchor damage to *P. oceanica* followed by pollution from trash, oil and waste water (Fig. 6).

Although none were present at the time of the study, more than 80% of the respondents knew that mooring buoys had been installed in Cala Blava in the previous years, and 75. 2 % of them considered that they would be more likely to go to a site where mooring buoys were available than not. Almost 58 % of respondents were willing to pay a fee for the use of a mooring buoy. The modal fee was 5 Euros (Fig. 7).

Discussion

Recreational boaters mooring in Cala Blava did not feel that this cove zone was crowded because more than 60 % of them considered that the number of boats was adequate even at the highest level of crowding (number of anchored boats > 60) and also because the distance between anchored boats was always adequate for 80 % or more of them (Fig. 5). The level of use of Cala Blava at the time of the survey

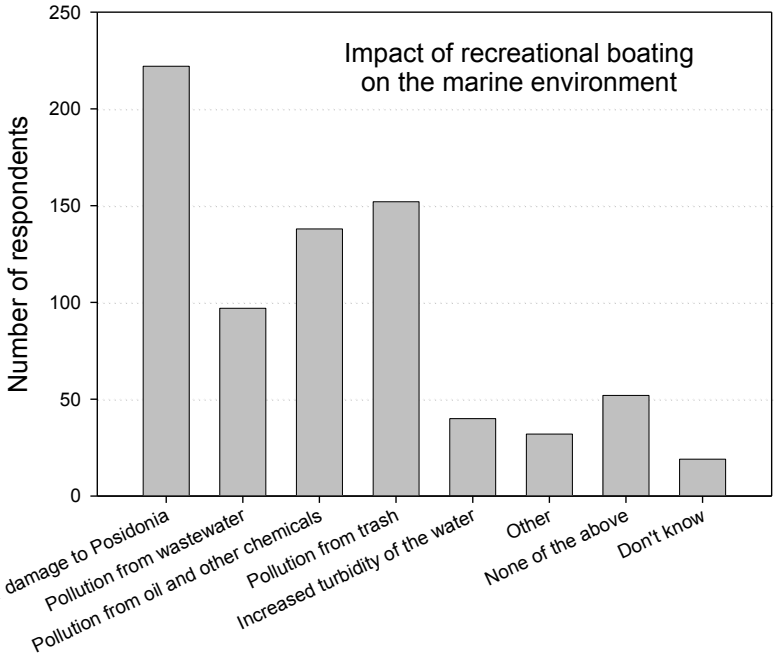

Fig. 6. Frequency distribution of the answers regarding the main impacts that recreational boating has on the marine environment as identified by visitors to Cala Blava.
Fig. 6. *Distribució de freqüències de les respostes referents als principals impactes que la nàutica recreativa te sobre el medi marí identificats pels visitants de Cala Blava.*

was considered adequate by recreational boaters even during weekends when the average maximum number of anchored boats was 49. This conclusion is further supported by the high level of satisfaction experienced by recreational boaters visiting Cala Blava. Hence, limits of acceptable change (Stankey *et al.*, 1985) were not reached by most recreational boaters using Cala Blava as mooring site during the survey.

This circumstance imposes a limit on the applicability of the methodology proposed by Diedrich *et al*. (2011) because it was not possible to identify the number of moored boats and distance among them that could be used to establish a field of

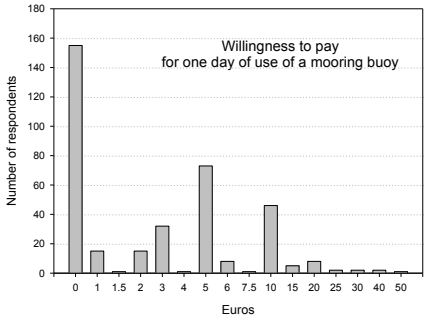

Fig. 7. Willingness to pay for use of mooring buoys of recreational boaters visiting Cala Blava.
Fig. 7. *Voluntat de pagament dels usuaris d'embarcacions recreatives que visiten Cala Blava per a l'ús de les boies de fondeig.*

mooring buoys that would have support from users.

The typical recreational boater visiting this Cala was a resident in Mallorca that owns an engine-powered boat of a length smaller than 12 m, having its port of origin in the Bay of Palma (Fig. 3). The boat would be carrying 3-5 persons who would be frequent visitors of the site. Indeed, proximity to port of origin, weather conditions and habit were the main reasons for choosing Cala Blava as the mooring site. Recreational boaters identified the damage caused to *P. oceanica* meadows by anchors as the main impact caused in the marine environment (Fig. 6). Pollution from trash, oil and waste water was identified as the second most important impact of recreational boating in the marine environment. This suggests that recreational boaters are aware of the negative effects that their activity might have on the environment.

Being long-term and frequent visitors of the site, recreational boaters anchoring in Cala Blava knew that mooring buoys were installed in the site in previous years (80 %) and indicated support for them (72 %). This support for the use of buoys translates into a WTP a fee for the use of a mooring buoy of 58 % of the users (Fig. 7). The most widely accepted fee would be 5 Euros. These results clearly show that social support for the use of mooring buoys as a way of reducing the negative effects that anchoring of recreational boats has on *P. oceanica* meadows is high.

Rationalist models of pro-environmental behaviour assumed that educating people about environmental issues would automatically result in more pro-environmental behaviour, but research over the years has proven these models wrong, since accumulating evidence proves that an increase in knowledge and awareness does not necessarily lead to pro-environmental behaviour (Kollmus and Agyeman, 2002). Our results however, show that in general recreational boaters were aware of the problems regarding *P. oceanica* and willing to protect it by using mooring buoys rather than anchoring on it. Hence, in this case cognitive barriers were surmounted, perhaps because the impact caused by anchors was a tangible reality experienced by them. Another element to consider in this regard is that mooring is a more or less gregarious activity that might exert a kind of "social pressure" on boaters to act pro-environmentally, since mooring neighbours would witness any damage caused to the *P. oceanica* meadows by their "irresponsible congeners".

Most studies about pro-environmental behavior stress the need to consolidate the stake-holder's locus of control, and that they will engage more in environmentally friendly attitudes if they feel responsible for the object of protection (e.g.: Stern, 2000). Considering that most recreational boaters mooring in Cala Blava are 1) long-term and frequent visitors residents in Mallorca, 2) with origin in one of the several ports present in the Bay of Palma (Fig. 1) and members of the nautical clubs installed in them, and 3) support the use of mooring buoys to protect *P. oceanica* meadows from anchoring damage, their participation in the installation and maintenance of fields of mooring buoys might increase social support for the implementation of anchoring regulations in the Bay of Palma and promote the protection of *P. oceanica* meadows.

In conclusion, our results suggest that the public is well aware of the damage caused by anchoring on *P. oceanica* meadows and that a mooring regulation that would reduce this harm through the use of mooring buoys would have wide support

from the main users, who would be even willing to pay for the service. This is a bright prospect for the conservation of this valuable and fragile coastal ecosystem.

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