Marine Pollution Bulletin xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Decadal increase in the number of recreational users is concentrated in no-take marine reserves

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ARTICLE INFO

Article history:
Received 4 September 2015
Received in revised form 1 April 2016
Accepted 8 April 2016
Available online xxxx

Keywords:
Recreational uses
MPA
Coral reef ecosystem
Spatio-temporal pattern
New Caledonia
Mooring practices

ABSTRACT

In coastal areas, demographic increase is likely to result in greater numbers of recreational users, with potential consequences on marine biodiversity. These effects may also occur within Marine Protected Areas (MPAs), which are popular with recreational users. Our analysis builds on data collected over a ten-year period during three year-round surveys to appraise changes in recreational boating activities in coral ecosystems. Results show that the number of boaters has greatly increased, particularly so within MPAs during weekends and the warm season, when peaks in boat numbers have become more frequent. We also observed that the number of anchored boats has increased over the period. These changes may be resulting in biophysical impacts that could be detrimental to conservation objectives in MPAs. This steady increase over time may cause changes in the spatial and temporal distribution of users and in their practices, thus highlighting the importance of monitoring recreational activities.

1. Introduction

In recent decades, coastal areas have been facing a substantial increase in both demography (Vallega, 2001; Duedall and Maul, 2005) and touristic development (Davenport and Davenport, 2006). As a consequence, recreational uses have increased and diversified (Chaboud et al., 2004; Widmer and Underwood, 2004; Monz et al., 2010). In particular, leisure transport has increased in a non-linear fashion with considerable impact on the coastal environment (Davenport and Davenport, 2006). Recreational uses are of importance in coastal areas (Kenchington, 1990), as has been shown for various regions of the world such as the Great Barrier Reef (Kenchington, 1993), Sydney harbor in Australia (Widmer and Underwood, 2004), Narragansett Bay in Rhode Island, USA (Dalton et al., 2010) and in Majorca, Spain (Balaguer et al., 2011).

Marine Protected Areas (MPAs) are now a central tool for ecosystem-based management of coastal and marine areas (Agardy, 2000; Browman and Stergiou, 2004). Their number and area are increasing worldwide (Wood et al., 2008; De Santo, 2013) in order to meet the international targets set by the World Summit on Sustainable Development (WSSD, http://www.un.org) and the United Nations Convention on Biological Diversity (CBD, https://www.cbd.int/web/default.shtml). MPAs may have a positive effect on visitor numbers, with subsequent benefits for the local economy (Alban et al., 2008). This increase may in turn support their existence or establishment despite their cost (Balmford et al., 2004). Recreational non-extractive users (i.e. excluding any kind of fishing) are generally authorized within MPA boundaries (Shivlani and Suman, 2000; Smallwood and Beckley, 2012). It may therefore be hypothesized that in coastal areas the proportion of such users will increase as more MPAs are established, which in turn may become a concern for the attainment of MPA management goals. Many studies have demonstrated that recreational non-extractive activities result in specific disturbances to and impacts on habitats and species, depending on user numbers and practices. For instance, anchoring has been shown to impact the composition and cover of marine biotic habitats (Walker et al., 1989; Glynn, 1994; Backhurst and Cole, 2000; Milazzo et al., 2002, 2004; Saphier and Hoffmann, 2005; Davenport and Davenport, 2006; Lloret et al., 2008; Maynard et al., 2010). Trampling by recreational users in very shallow water (Leujak and Ormond, 2008) has similar impacts on habitats (Kay and Liddle, 1989; Neil, 1990; Rodgers and Cox, 2003; Juhasz et al., 2010) and on macro-invertebrates (Brown and Taylor, 1999;

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http://dx.doi.org/10.1016/j.marpolbul.2016.04.007
0025-326X/

Casu et al., 2006). Boat traffic emerges as a source of disturbance for fish (Codarin et al., 2009; Slabbekoorn et al., 2010; Whitfield and Becker, 2014) and mammals (Bejder et al., 2006; Hodgson and Marsh, 2007; Rako et al., 2013; Merchant et al., 2014).

As well as conservation objectives, MPAs frequently seek to achieve socio-economic management goals (Claudet and Pelletier, 2004; Pomeroy et al., 2005; Pelletier, 2011), including the maintenance of sustainable uses. However, local density of boats has been shown to negatively affect boaters' satisfaction and their perception of safety levels (Ashton and Chubb, 1972). High local density of boats also increases the likelihood of conflicts between recreational boaters, especially near large metropolitan areas (Heatwole and West, 1982). Boat density, however, is not the only identified cause of such conflicts. Specific recreational crafts such as jet-skis are associated with disturbance and give rise to conflict among users, even though relatively few people use them (Widmer and Underwood, 2004).

The number of recreational users has been identified as the main information on uses required for protected area management (Griffin et al., 2010). However, although this overall number is informative, it reflects neither the spatial and temporal distribution of users nor the variety of activities practiced (Gray et al., 2010). Such information is necessary for design and site selection of MPAs (Parnell et al., 2010), for assessing human impacts on biodiversity (Chabanet et al., 2005) and MPA efficiency (Pelletier et al., 2005), and consequently for adapting management strategies to mitigate these impacts (Davenport and Davenport, 2006; Lloret et al., 2008). Because recreational uses' impacts are diversified and depend on user's spatial and temporal distribution, this information is wanted by environmental managers. It is also useful for pluridisciplinary research on integrated coastal management.

The lack of spatial data on recreational uses in the marine environment was previously reported (e.g. Martin and Hall-Arber, 2008) and accounted for by the logistics needed to survey dynamic and ephemeral activities in often extensive coastal and marine areas (Smallwood et al., 2011). However, in recent years several studies have assessed spatial patterns in recreational uses from field data (see references below). They show that the spatial distribution of boaters depends on factors such as habitat type, adjacent land tenure, MPA setting, boat type (Sidman and Fik, 2005; Dalton et al., 2010; Smallwood et al., 2011), and activity (Shivlani and Suman, 2000; Smallwood et al., 2012). To our knowledge, there is no study documenting the inter-annual evolution of such spatial patterns, although it might be expected that the increase and diversification of recreational activities are likely to affect the spatial distribution of users. Better understanding the causes of changes in user numbers would allow managers and decision makers to adapt conservation strategies, and in particular to find the appropriate levers for a trade-off between ecosystem protection and users' satisfaction.

Like spatial patterns, the short-term temporal distribution of recreational users depends on boat type and activity (Smallwood et al., 2011). A number of studies show that several factors significantly influence the number and spatial distribution of boats, including season, day type and weather conditions (Kuentzel and Heberlein, 1992; Smallwood and Beckley, 2012; Smallwood et al., 2012; Smallwood et al., 2011; Martin and Hall-Arber, 2008; Gray et al., 2010; Dalton et al., 2010; Widmer and Underwood, 2004; Balaguer et al., 2011; Navarro Jurado et al., 2013). These studies show that more boats are observed at weekends and on bank holidays (e.g. National Day), during summer months and when the weather is sunny (Widmer and Underwood, 2004; Smallwood and Beckley, 2008; Dalton et al., 2010; Smallwood et al., 2011). All together these factors were found to partly explain intra-annual variations of recreational use. But there is no study about possible changes in the relative importance of these factors over years. Such information would certainly help to anticipate expected user pressures and adapt management strategies accordingly, in order to i) mitigate the consequences of high use level on biodiversity and ii) maintain user satisfaction and safety (Davenport and Davenport, 2006). In particular, crowding – defined here as extreme values (peaks) in user numbers – is likely to cause the displacement of users and thus influence their distribution at several spatial scales. We could find no published study addressing the evolution either of peak event frequency or of their magnitude. This is more unfortunate as during peak's days, impacts on ecosystem and on user satisfaction are more likely to happen both in intensity and spatial extent.

This paper aims to assess spatial and temporal patterns of recreational users over a decade in a coastal area that has been subject to a marked demographic increase over the same period. This area is located in a coral reef ecosystem and encompasses several no-take reserves where boat access is permitted. We first studied changes in the distribution of users inside and outside these reserves, both overall and per boat type. In a second stage, we examined the influence of short-term temporal factors, such as season and day type (weekday versus weekend) on mean boat numbers and on the occurrence of peak numbers. Lastly, we investigated changes in mooring use as a consequence of increasing numbers of recreational boaters.

2. Materials and methods

2.1. Study site

New Caledonia is located in the South Pacific approximately 1500 km north-east of Australia. The New Caledonian lagoon has an exceptionally high diversity of habitat (Andrefouët and Torres-Pulliza, 2004), fish (Chabanet et al., 2010), and emblematic species such as turtles and dugongs. Eighty percent of the lagoon surface area was inscribed on the World Heritage list in 2008 (David et al., 2010). Most of the population lives in the Nouméa area, which encompasses the cities of Nouméa, Païta, Dumbéa and Mont-Dore (Fig. 1) with around 180,000 people in 2014, according to the latest demographic census taken in 2014 (ISEE, 2014) (Fig. 2). The population of Dumbéa and Païta increased at a rate of 5% per year between 2004 and 2014, twice the increase rate of Nouméa city and of New Caledonia as a whole. This study focuses on the islets and reefs in the lagoon facing the Nouméa area.

Boating is a highly popular recreational activity in New Caledonia: in 2014, 8% of Nouméa area inhabitants owned a boat, as against 6.4% in 2004 (Fisheries Office of the New Caledonian Government, unpublished data. Fig. 2). There are numerous boating amenities (mainly launch ramps) in the Nouméa area. In the last decade, the number of registered recreational boats in the Nouméa area increased to more than 14,100 in 2013, of which 38% were motorboats, 8% jet-skis, 8% sailboats and 46% other types of boat according to official data from the New Caledonian government. This sharp increase in boat numbers has become a concern for environmental management and especially for lagoon management.

Among the many reefs and islets in the study area (Fig. 1), we selected eleven sites (seven islets and three reefs), located within 10 nautical miles from the Nouméa area, all of which are popular destinations for recreational boaters. The selected sites include two no-take MPA islets and one no-take MPA reef, where all extractive activities (fishing and shell collection) are banned, but entry is not restricted. Inside these MPAs, thirty-eight permanent moorings were installed before 2012 and four more since then. The two protected islets have a number of amenities, such as shelters, barbecue sites, a pontoon, a botanic path, information signs and dry toilets (installed between 2010 and 2013). The three MPAs are among the closest sites to Nouméa city, where the majority of launch ramps and marinas are located.

2.2. Data collection

For this study, we used count data of recreational boats recorded over three year-round periods of time, in 2005/2006, 2008/2009 and 2013/2014. Field trip planning was temporally stratified per day type (weekday and weekend) and season (cold and warm season)

Please cite this article as: Gonson, C., et al., Decadal increase in the number of recreational users is concentrated in no-take marine reserves, Marine Pollution Bulletin (2016), http://dx.doi.org/10.1016/j.marpolbul.2016.04.007