Marine Pollution Bulletin 76 (2013) 194–202

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Drawing lines at the sand: Evidence for functional vs. visual reef boundaries in temperate Marine Protected Areas

E.V. Sheehan [a,*], S.L. Cousens [a], S.J. Nancollas [a], C. Stauss [b], J. Royle [b], M.J. Attrill [a]

[a] Marine Institute, Plymouth University, Drake Circus, Plymouth PL4 8AA, United Kingdom
[b] Common Seas, White Hill, Finchdean, Waterlooville PO8 OAU, United Kingdom

ARTICLE INFO

Keywords:
Marine Protected Area
Management
Benthos
Ecosystem
Recovery
Fisheries

ABSTRACT

Marine Protected Areas (MPAs) can either protect all seabed habitats within them or discrete features. If discrete features within the MPA are to be protected humans have to know where the boundaries are. In Lyme Bay, SW England a MPA excluded towed demersal fishing gear from 206 km^2 to protect rocky reef habitats and the associated species. The site comprised a mosaic of sedimentary and reef habitats and so 'non reef' habitat also benefited from the MPA. Following 3 years protection, video data showed that sessile Reef Associated Species (RAS) had colonised sedimentary habitat indicating that 'reef' was present. This suggested that the functional extent of the reef was potentially greater than its visual boundary. Feature based MPA management may not adequately protect targeted features, whereas site based management allows for shifting baselines and will be more effective at delivering ecosystem goods and services.

1. Introduction

Healthy biodiverse seas are vital for future proofing marine ecosystem services such as global food security (Ehrlich et al., 1993; Toledo and Burlingame, 2006; Worm et al., 2006) and climate regulation (Danovaro et al., 2008; Mooney et al., 2009). Natural biodiverse communities have greater functional redundancy than disturbed communities, which increases ecosystem resilience to future climatic changes, such as rising temperatures and ocean acidification (Costanza et al., 1997; Naeem, 1998; Naeem and Li, 1997; Yachi and Loreau, 1999).

Benthic ecosystems play a key role in maintaining prosperous fisheries (Hovey et al., 2012; Walters and Juanes, 1993). Benthic communities include commercial target species, such as flat fishes and shellfish (lobsters and scallops) and non-target, sessile, colonial fauna, such as corals, sponges and bryozoans (Garthe et al., 1996; Hiddink et al., 2008; Saila et al., 2002). The targeted fishes, crustaceans and molluscs live amongst the non-target fauna that give structural complexity to the seabed (Bradshaw et al., 2003). Biogenic structural complexity provides nursery areas for larvae, substrate for spat settlement and cover to hide from predation (Eggleston et al., 1990; Lima and Dill, 1990; Mittelbach, 1984; Pirtle et al., 2012). Sessile species capture and recycle water column nutrients through filter feeding (Beaumont, 2009), and produce planktonic larvae that support higher trophic levels. This bentho-pelagic coupling, through a range of trophic links, provides prey for birds (Grecian et al., 2010), commercially important fishes such as cod (*Gadus morhua*, Heath and Lough, 2007; Lomond et al., 1998) and plaice (*Pleuronectes platessa*, Hiddink et al., 2011) and pelagic species of conservation value such as basking sharks (*Cetorhinus maximus*, Musick et al., 2004).

Globally, fishing fleets harvest benthic target species using towed demersal gear, often digging into sediments and so removing slow growing, long lived, structure forming fauna (Thrush and Dayton, 2002). Recovery of some impacted species from just one passage of fishing gear can take decades (Babcock et al., 1999; Foden et al., 2010; Watling and Norse, 1998).

Marine managers' best tool to protect discrete patches of the seabed from fishing, therefore allowing benthic species to contribute to ecosystem function, is the application of Marine Protected Areas (MPAs) (Agardy, 1994; Auster and Shackell, 2000; Babcock et al., 1999; Gell and Roberts, 2003; Halpern, 2003; Murawski et al., 2000; Roberts et al., 2005). MPAs come in a variety of sizes, shapes and forms (Agardy et al., 2003; Agardy, 1994; Rabaut et al., 2009) depending on the 'features' that they are designated to protect, a feature being a species or specific habitat that has received formal protection from a type of human activity. The size and level of protection from human activity in MPAs ranges from 1 to 1000s km^2; and from 'No-take' to seasonal fishing closures (Lester and Halpern, 2008). Protection of the features can be limited to the features' periphery such as Special Areas of Conservation in Europe

* Corresponding author. Tel.: +44 1752 584699.
E-mail address: emma.sheehan@plymouth.ac.uk (E.V. Sheehan).

0025-326X
http://dx.doi.org/10.1016/j.marpolbul.2013.09.004

(European Commission, 2000) or protection can surround features and therefore protect the whole 'site' such as Tortugas Ecological Reserve, Buck Island National Reef Monument and Chagos (Jeffrey et al., 2012; Kendall et al., 2004; Koldewey et al., 2010). The former relies on human ability to adequately draw lines around the features' functional extent, which is generally considered to be the visible, physical extent of the feature (e.g. reef) used as an analogue of the associated species that require protection. Some European and international MPAs, such as La Restinga Marine Reserve (Spain) and the Great Barrier Reef Marine Park (Australia) (Claudet et al., 2008; Day, 2002), have surrounding areas called Buffer Zones to prevent direct and indirect physical interaction and disturbance of fishing gear on the feature(s) of interest.

In 2008, a statutory MPA in south west UK was designated to protect rocky reef habitat (Fig. 1). The management regime involved protecting all of the seabed at the 'site' level. This equated to a 206 km^2 exclusion zone from towed demersal fishing gear across a MPA that contained a mosaic of rocky reef (bedrock, boulders and cobbles), pebbly sand and soft muddy sediments.

To assess the success of the MPA, an annual monitoring program commenced soon after this MPA was instigated. The aim was to determine if and when recovery occurred for epibenthic assemblages on rocky reefs. A flying array with mounted High Definition video (Fig. 2) was flown over the seabed to sample benthic transects within the MPA and in Open Controls. While sites were located to survey hard substratum, pebbly sand habitats that occurred between the reefs were also recorded but not analysed as they were not considered a designated part of the reef feature. During analysis of rocky habitats, observations were made that sessile RAS were occurring on pebbly sand, which therefore must be overlying bedrock that the species could attach to (Keough and Downes, 1982). This observation became of critical importance as fishers were seeking permission to scallop dredge sediments between the reef features within the MPA.

By returning to the video archive we could formally enumerate pebbly sand Reef Associated Species (RAS) assemblages, which had previously been ignored for the reef species recovery analysis, and compare them over time from 2008, when the exclusion was enforced, to 3 years later in 2011. Here we test the hypothesis that, if protected from fishing, inter-reef pebbly sand habitats can support significantly more sessile RAS than similar habitats in areas that remain open to fishing. If pebbly sand habitats were found to support sessile RAS, this would provide evidence to broaden the definition of 'reef' as a feature, with consequences for how lines are drawn around such protected features in MPAs. We measured the following response variables for sessile RAS: Species Richness, Overall Abundance, Assemblage Composition, and a subset of sessile RAS indicator species that were preselected (ross coral *Pentapora fascialis*, sea squirt *Phallusia mammillata*, dead man's fingers *Alcyonium digitatum*, branching sponges, pink sea fans *Eunicella verrucosa* and hydroids (Jackson et al., 2008)).

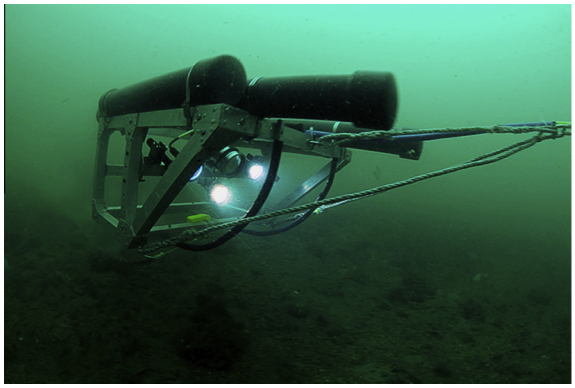

Fig. 2. The towed flying array mounted with high definition video.

2. Methods

The case study site is in Lyme Bay (Fig. 1), located on the south west coast of the UK. Lyme Bay comprises a mosaic of rocky reefs with boulders, cobbles and mixed sediments, known to support some fragile biogenic reef species of national importance (Hiscock and Breckels, 2007; Vanstaen and Eggleston, 2011). This study focused on pebbly sand habitats (particle size ⩽64 mm diameter (Irving, 2009)), which occurred between areas of rock, boulders and cobbles.

All identifiable species were enumerated; however, only the sessile Reef Associated Species (sessile RAS = structure forming species that are attached to the seabed and are associated with hard substratum) were analysed as it was considered that it was

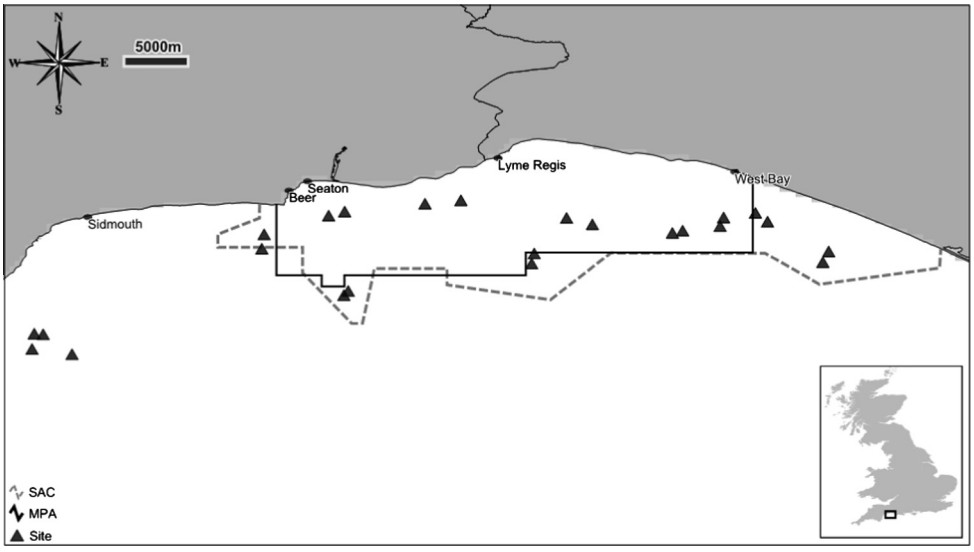

Fig. 1. Lyme Bay in SW UK. Triangles indicate site locations located in pairs (Areas), either inside or outside of the Marine Protected Area (solid line). Candidate Special Area of Conservation indicated by a dashed line.