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Harvesting effects on tropical invertebrate assemblages in New Caledonia

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ABSTRACT

Despite the importance of invertebrate resources for Pacific coral reef islands, few studies have specifically addressed the effects of harvesting on invertebrate assemblages including targeted and non-targeted species. The impacts of recreational harvesting on reef and seagrass invertebrate assemblages in New Caledonia (South Pacific) are investigated by comparing communities in non-MPA and MPA areas. Sampling was done using a standard core method on seagrasses and by visual survey along belt transects on reefs. A total of 371 species were recorded, 174 on seagrasses and 254 on reefs, with 57 common species. Reef and seagrass invertebrate communities were very different in MPA and non-MPA areas. On both habitats, MPAs were identified as undisturbed areas while non-MPAs were defined as moderately disturbed with a predominance of small-sized and opportunistic species. Fishing not only affects target species but also non-target species through secondary effects. These results highlight the necessity of a community based approach for the conservation of resources in tropical poorly known environments.

1. Introduction

Marine ecosystems are subjected to increasing anthropogenic activities which disrupt their functioning, particularly in coastal areas (Suchanek, 1994; Fraschetti et al., 2001; Jackson et al., 2001). Among these activities, invertebrate harvesting during low tides is considered as an important cause of disturbance to intertidal communities (Moreno et al., 1984; Castilla and Duran, 1985; Duran and Castilla, 1989; Keough et al., 1993; Rius et al., 2006). This activity has been practiced by coastal inhabitants for centuries (e.g., Swadling, 1976; Hockey, 1988; Siegfried et al., 1994; Griffiths and Branch, 1997; Castilla, 1999) and still remain common today. In most Pacific islands for example, invertebrate resources represent a large part of local consumption and/or cash income (e.g., Dalzell et al., 1996; Kinch, 2003).

The effects of collecting intertidal resources have been described in several studies, from South America (e.g., Moreno et al., 1984; Castilla and Duran, 1985; Ortega, 1987; Defeo and Alava, 1995; Pombo and Escofet, 1996; Brazeiro and Defeo, 1999), to South Africa (e.g., Hockey and Bosman, 1986; Lasiak and Field, 1995; Griffiths and Branch, 1997), and Australia (e.g., Catterall and Poiner, 1987; Underwood and Kennelly, 1990; Kingsford et al., 1991; Sharpe et al., 1998). Generally reported effects include a decrease in targeted species density, generally up to 90% (e.g., Castilla and Duran, 1985; Siegfried et al., 1994; Roy et al., 2003), a decrease in total density and biomass (e.g., Wynberg and Branch, 1994; Lasiak and Field, 1995; Griffiths and Branch, 1997; deBoer and Prins, 2002), and a 10–20% decrease in mean size (e.g., Moreno et al., 1984; Hockey and Bosman, 1986; Ortega, 1987) due to the preference for collecting larger individuals. In terms of community composition, studies have reported a predominance of rapidly growing, low biomass, opportunistic species in exploited areas compared to non-exploited areas (e.g., Marine Protected Areas, MPAs thereafter), which are preferentially dominated by slow-growing, large-biomass, 'conservative' species present in low density (Lasiak and Field, 1995; deBoer and Prins, 2002). Harvesting can also alter the variability of invertebrate assemblages, through changes in the population structure of individual species or changes in the succession of species (Chapman et al., 1995). This consequently increases the dissimilarity among samples in exploited areas (Warwick and Clarke, 1993).

Coral reefs are highly diversified environments where few studies have addressed harvesting activity effects (Newton et al., 1993; deBoer and Prins, 2002; Rius et al., 2006). However, the poor

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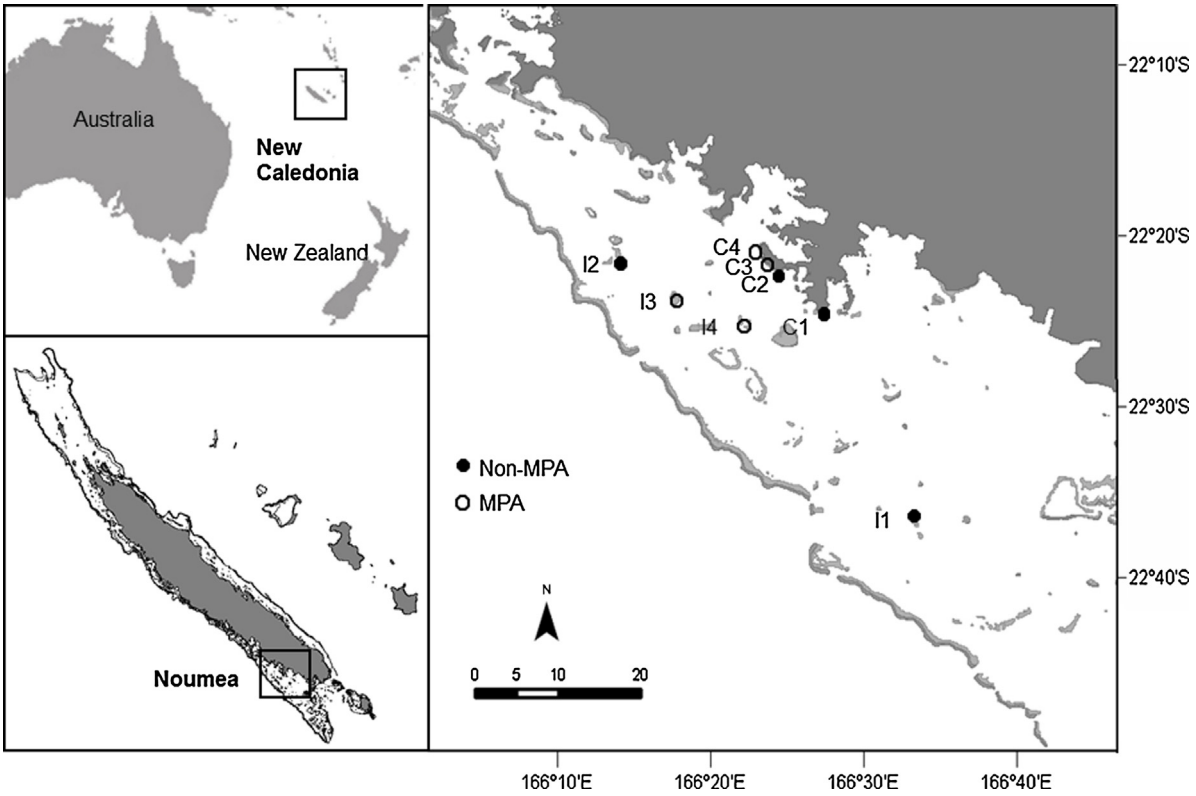

Fig. 1. Map showing the position of eight sampling stations located around Nouméa, New Caledonia, South Pacific. Coastal (C1, C2, C3, C4) and islet (I1, I2, I3, I4) flats are shown with MPAs (●) and non-MPAs (○) indicated.

knowledge of these activities (Dalzell et al., 1996), and the lack of invertebrate assemblage descriptions in tropical areas (e.g. Stella et al., 2011), represent a challenge, particularly when the effects of fishing are studied for the whole community, including both targeted and non-targeted species. Like most Pacific islands, New Caledonia is facing rising fishing pressure; intertidal shores close to the urban areas are increasingly subjected to recreational and subsistence harvesting (Jimenez et al., 2010, 2011).

This study aims to understand how harvesting activities affect reef and seagrass assemblages in New Caledonia by comparing community composition between MPA and non-MPA areas.

2. Materials and methods

2.1. Study site and sampling design

This study was carried out in New Caledonia, a large island located in the southwest Pacific (166° E, 22° S). New Caledonia is characterized by a large lagoon covering an area of 19 000 km^2, with numerous patches, islets and fringing reefs. Climate is defined as subtropical to temperate with a warm and wet season from mid-November to mid-April (called "summer"), and a cool and dry season from mid-May to mid-September (called "winter") (Météo France, 2007). Coastal and islet reef flats have been subjected to human exploitation for centuries and fishing pressure increased in the recent decades due to the growing urbanization around Nouméa city (Fig. 1). In 2009, human frequentation on reef flats was estimated to about 10 000 visitors, with an annual harvesting pressure of 8.4 ± 0.7 tons of invertebrates for an area of 324 Ha (see Jimenez et al., 2011). Collecting activity is essentially recreational and non-commercial (Baron and Clavier, 1992). Several protected areas (hereafter MPAs) were implemented in the 1990s to conserve local biodiversity and to sustainably manage marine resources. All fishing or harvesting activity is prohibited in these areas. The MPAs are mainly located in the southwest lagoon around Nouméa (cf. Fig. 1). These protected areas were initially chosen without a priori high diversity criteria. Collecting activities are strictly prohibited, regulated by local authorities and stakeholders.

Eight coastal (C_1, C_2, C_3, C_4) and islet (I_1, I_2, I_3, I_4) intertidal stations were selected in the southwest lagoon around Nouméa (Fig. 1, Table 1). Four stations were areas visited by invertebrate harvesters (non-MPAs) while the other four stations were closed to fishing (MPAs). For non-MPAs, the annual harvesting pressure was estimated by visual censuses of harvesters and interviews (see Jimenez et al., 2011) (Table 1). All stations are subject to semi-diurnal tides with a maximum amplitude of 1.8 m and oriented in front of a general hydrodynamic flow (from southwest to northeast). Two habitats were considered i.e., soft (sand/seagrass dominated) and hard (reef) bottom. Harvested species differed among habitats (see Jimenez et al., 2011). Both habitats were characterized using a photographic-based method to estimate benthic category percentage coverage (see Dumas et al., 2009). Soft-bottom habitat was dominated by seagrasses species *Cymodocea serrulata* and *Halodule uninervis* (~62%), green algae (*Halimeda spp.*, *Ulva spp.*, *Codium spp.*) and brown algae (*Padina sp.*, *Sargassum spp.*, *Turbinaria ornata*). Algae represented ~22% of community composition and sand ~16%. Hard-bottom habitat was mainly composed of dead corals, boulders or rubbles (~82%) (due to the high exposition of crests) with encrusting algae (~13%), living corals (~4%) and sponges (~1%) (from Jimenez et al., 2010). Seagrass habitats were found only on coastal stations while reef habitats were present on both (coastal and islets) stations (Table 1).

2.2. Invertebrate sampling

Field studies were conducted over two years (2008–2010) and two seasons (winter and summer), accounting for a total of four field surveys of 12 consecutive days. Intertidal macrofauna and