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Effects of sympatric predatory crabs *Romaleon polyodon* and *Cancer plebejus* (Decapoda, Brachyura, Cancridae) on sublittoral macrobenthic communities

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ABSTRACT

Although large crabs are recognized as important sediment disturbers influencing the structure of benthic communities, the role of dominant predatory crabs in soft-bottom habitats along the Humboldt Current Ecosystem, remains largely unknown. A field study was conducted, hypothesizing that the digging activity of these predators disturbs the habitat thereby leading to a reduction in individual abundance, biomass and species richness; these changes result in a modified structure of macrobenthic communities. A directed sampling (crab pits vs. reference areas) showed significant reductions in total abundances in pits compared to reference areas, but no differences were observed in taxonomic richness or benthic biomass. Short-term cage experiment showed significant decreases in total abundance and biomass of macroinvertebrates in predator inclusion treatments compared to exclusions and controls. In consequence, our results confirmed that burrowing activities and the generation of small disturbed sediment patches influence the community structure. These results highlight the importance of large cancrid crabs in soft-bottom habitats, where their modification of the physical configuration of the sediment affects community structure over small spatial scales. Crabs are thus an important source of spatial heterogeneity of the sea-floor landscape. This ecological role must be considered in management strategies of the extensive artisanal fishery for these crabs, as current evidence is showing increasing populations of intermediate predators (like cancrid crabs) in many benthic habitats in response to the depletion of top predators.
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1. Introduction

Benthic predators, such as large crustacean species, are very important creators of small patches of disturbed sediment as they stir up the bottom during feeding and burrowing activities (Hall et al., 1991, 1993; Thrush, 1986). A single predator can create small patches which are recolonized via immigration of post-larval and adult colonizers (Pacheco et al., 2012; VanBlaricom, 1982), while large-scale disturbances (e.g., hypoxia, ice scour, storms) generate large disturbed areas where biota recovery is mediated primarily via larval settlement (Lenihan and Micheli, 2001). Therefore, disturbed patches are predicted to differ in terms of macrobenthic community structure depending on predator abundance and the intensity and frequency of their disturbing activities. Predators may influence the structure of their habitat community by (1) physically modifying the habitat (bioturbation), (2) consuming either a selected prey or a wide spectrum of them, (3) triggering escape responses of their prey, and (4) provoking immigration into the disturbed patch by opportunistic species. Even though these effects may be intuitively recognized, reviews documenting disturbance and recolonization processes suggest that these different types of biological effects are not always easy to detect (Ólafsson et al., 1994; Thrush, 1999). Studies about the role of predators influencing benthic community structure, particularly those using exclusion/inclusion cage experiments have also suggested that (1) predation is not generally an important process directly structuring soft-sediment communities, and/or (2) complex interactions are common in these systems (e.g., confounding natural seasonal variations of predator densities and their disturbing activities), which may preclude the detection of significant predator effects (Ólafsson et al., 1994; Thrush, 1999). This type of variability found in predation studies makes the role of predators in structuring benthic communities an important topic of research.

Predators such as large crabs of the Cancridae family are important megafaunal components of sedimentary ecosystems. Crabs influence the structure of macrobenthic communities by digging pits when foraging for food, or when burying for resting in the sediment (Hall et al., 1991; Thrush, 1986). Macrobenthic communities in pits created by crabs usually have low species richness but variable species abundances, with some taxa showing drastic reductions and others no changes or even higher densities in pits compared to undisturbed sediments (Hall et al., 1991, 1993). As crabs are constantly digging the sea

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floor they are important sources of habitat heterogeneity thereby influencing the patchy distribution of soft-bottom communities.

There is an increasing interest in understanding the effects of large predatory crabs in benthic ecosystems because fisheries are intensively removing predators from upper (e.g., Baum and Worm, 2009; Boudreau and Worm, 2012; Heithaus et al., 2008; Smith et al., 2011) and intermediate (Eriksson et al., 2011) trophic levels. The effects of the removals are reflected in drastic cascade changes in the trophic structure and unpredictable fluctuations in community structure (Eriksson et al., 2011). In some ecosystems the reduction of top predators have promoted the release of intermediate predators (e.g., crabs) that have led to the development of fisheries on them (Quijón and Snelgrove, 2005a,b), while in other ecosystems such as in the Humboldt Current Ecosystem (HCE), where fishery pressures occurs at nearly all trophic levels, the consequences of removal of predators have been poorly documented (e.g., Moreno, 2001; Ory et al., 2012).

In soft-bottom sublittoral habitats along the coast of Peru and Chile (HCE) the hairy crab *Romaleon polyodon* (synonymous of *Cancer setosus* Molina, 1782 and *Cancer polyodon* Poeppig, 1836), and the queen crab *Cancer plebejus* (synonymous of *Cancer coronatus* Molina, 1782) (see Ng et al., 2008; Schram and Ng, 2012; Schweitzer and Feldmann, 2000, for an update on the systematics and nomenclature of the decapod family Cancridae) are conspicuous megafaunal components of the sea floor (Gutiérrez and Zúñiga, 1976; Muñoz et al., 2006; Wolff and Soto, 1992). Spatial overlap exists between large-sized adults of both species but different population dynamics likely allow the co-existence in sandy and muddy sediments in relatively high abundances (Jesse and Stotz, 2002). *R. polyodon* is a nocturnal predator (Wolff and Cerda, 1992) feeding on a wide variety of prey organisms (Cerda and Wolff, 1993), although selective consumption occurs depending on prey availability and habitat characteristics (León and Stotz, 2004). No information about the feeding ecology of *C. plebejus* is available. Although these species conspicuously disturb the sea floor (see Fig. 1), the impacts of these predatory species on the structure of soft-bottom communities are not well known (but see Ortiz, 2008 for effects on some megafaunal components). This is surprising, taking into account the vast literature about the role of large crustaceans (and other bottom predators) shaping the diversity and structure of communities through feeding, disturbance and bioturbation in sedimentary habitats elsewhere (e.g., Boudreau and Worm, 2012; Como et al., 2004; Gee et al., 1985; Hall et al., 1991, 1993; Quijón and Snelgrove, 2005a,b; Reise, 1977, 1978; Thrush, 1986, 1999). In addition, *R. polyodon* and *C. plebejus* together with other large Cancridae and Xanthidae are heavily exploited by artisanal fisheries. In Chile from 1991 to 2007 the landings of *R. polyodon* averaged more than 500 t with a maximum of 1320 t in 1994 and a minimum of less than 100 t in 2003, while an average of 120 t with a maximum of more than 400 t in 1995 and a minimum of less than 10 t in 2003 have been reported for *C. plebejus* (Aedo et al., 2009).

In this study, we conducted a field sampling and an exclusion/inclusion experiment aiming to determine the immediate effects of abundant crab predators (*R. polyodon* and *C. plebejus*) on the soft-bottom macrobenthic community structure. We predicted that patches disturbed by large crab predators will differ from areas not disturbed by these species, because the reduction in species abundance and species richness in disturbed patches leads to a changed community structure.

2. Materials and methods

2.1. Study area

This study was conducted from late July to early September 2011 (during austral winter) at a sublittoral site on the coast of Antofagasta in northern Chile. This region is characterized by strong upwelling, where cold waters with high nutrient and low oxygen contents rise to

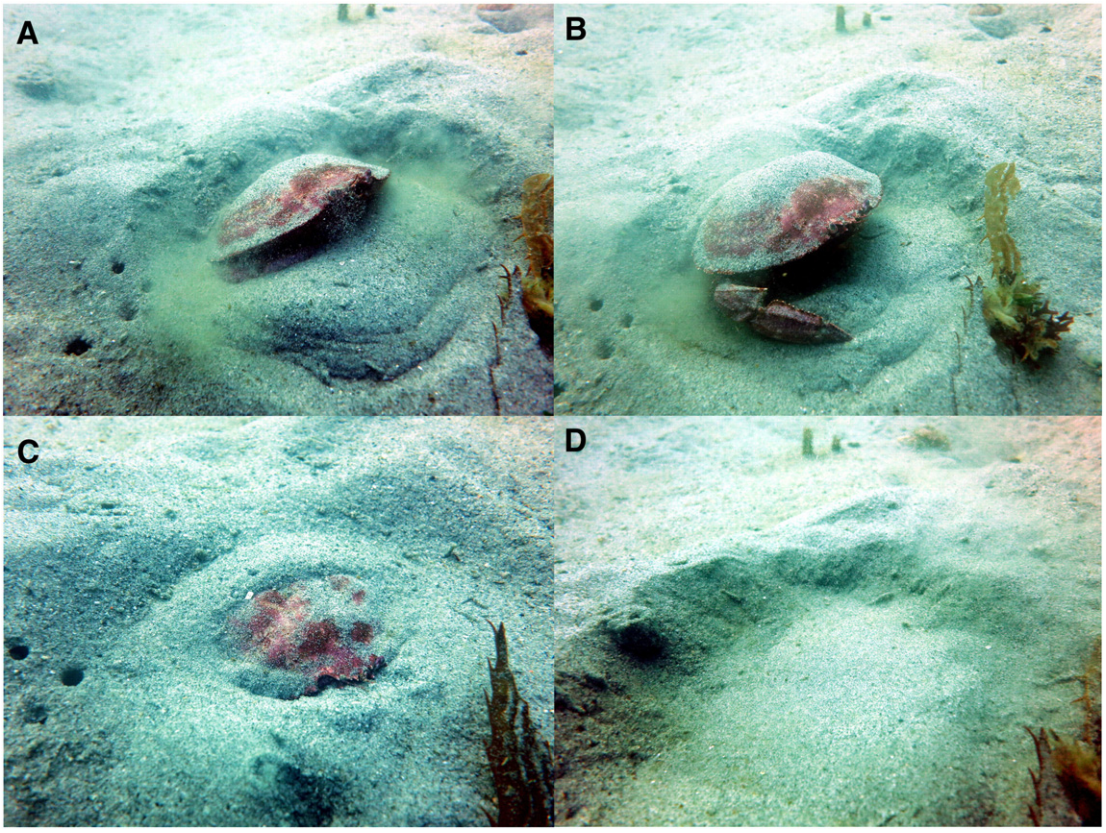

Fig. 1. *Cancer plebejus* disturbing sediment: A, crab lifting sediment; B, detail of the claw protruding into the sediment; C, buried crab; D, pit left by the crab.

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