PRELIMINARY REPORT

Coral-seaweed interactions and the implications for resilience of coral reefs

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Introduction

On coral reefs, coral-seaweed competition is one of the main determinants of the benthic community, as it impacts food web dynamics, topographic complexity and, as a consequence, biodiversity and ecosystem function (Edmunds & Carpenter 2001; Lessios *et al.* 2001; Bellwood *et al.* 2004). On reefs where herbivores have been overharvested, competition between corals and seaweeds becomes increasingly important, with seaweeds implicated in coral loss and ecosystem degradation (Hughes 1994; Bellwood *et al.* 2004; Hughes *et al.* 2007). Seaweeds compete with corals via multiple mechanisms (e.g. Tanner 1995; Jompa & McCook 2003; Kuffner *et al.* 2006; Birrel *et al.* 2008), but some are allelopathic to corals on contact, causing bleaching and mortality (Rasher & Hay 2010; Rasher *et al.* 2011).

On healthy reefs, establishment and survival of corals is facilitated by high rates of herbivory that suppress rapidly growing seaweeds that compete with corals (Lewis 1986, Hughes 1994; Bellwood *et al.* 2004). Recently, however, tropical reefs have suffered massive loss of herbivorous fishes, corals, topographic complexity, and biodiversity (Gardner *et al.* 2003; Bellwood *et al.* 2004). The relative roles of global change, loss in herbivores, outbreaks of diseases, etc. in generating coral loss are debated (Jackson *et al.* 2001; McCook et al. 2001; Mumby & Steneck 2008), but irrespective of the cause of reef degradation, disturbed reefs commonly convert from species-rich and topographically complex communities dominated by corals to species-poor and structurally simplified communities dominated by seaweeds (Gardner *et al.* 2003; Hughes *et al.* 2003).

The loss of species, functional groups, and critical biotic processes highlights the need to better understand key factors, mechanisms, and processes shaping coral-seaweed interactions and how these help maintain or degrade the resilience of coral reef ecosystems (e.g. Hughes 1994; Gardner *et al.* 2003; Bellwood *et al.* 2004;

Bonaldo *et al.* 2009). Several studies have addressed the physical effects (shading, abrasion) of seaweeds on corals and the consequences of coral to seaweed phase-shifts that reduce reef biodiversity and structural complexity (e.g. McCook *et al.* 2001; Titlyanov *et al.* 2007), but few studies have investigated the potential of seaweeds to chemically compete against corals and the dynamics and extent of these interactions in nature. Recent studies demonstrate that some seaweeds contain allelopathic metabolites on their surfaces that cause bleaching, and sometimes death, of corals when coral are contacted by these seaweeds (Rasher & Hay 2010; Rasher *et al.* 2011).

This study aimed to examine the frequency coral-seaweed contacts in protected and unprotected coral reefs in Moorea, French Polynesia, the effects of seaweed contact on different corals, the species specificity of these interactions, and the herbivorous fishes responsible for consumption of harmful seaweed species. More specifically, this study will respond the following questions: (1) What is the frequency of coral-seaweed contacts in the field? (2) Does this frequency differ inside and outside of Marine Protected Areas? (3) Do common corals differ in the extent of damage done by contact with different seaweeds? (4) Do rates of seaweed removal differ between fished and protected areas? (5) What herbivorous species are responsible for the removal of harmful seaweed species?

Data collection methodology

Study sites – The present study was conducted during December 2012 and January 2013 at coral reefs on the Northern coast of Moorea, French Polynesia. More precisely, four study sites were used: two inside Marine Protected Areas (MPAs), (Tiahura and Pihaena), and two in areas where fisheries are allowed (Zone de Peche de Papetoai and Zone de Peche de Maharepa). The entire study was conducted on reefs inside the lagoon, and depth on all study sites was always less than 3 m.

Coral-seaweed contact surveys, fish census and sampling design - Benthic composition, fish census, and density and identity of coral-seaweed contacts were surveyed with four haphazardly placed 30m x 4m (=120m^2) transects in each study

site (16 transects total). A first snorkeler deployed the transect tape, while counting all herbivorous fishes found and classifying them into species and size (total length). A second snorkeler followed the first one, photographing the bottom of the reef every 2m from a distance of 0.5 m above the benthos. Once this procedure was completed, the first snorkeler swam along back the transect tape, recording all coral-macroalgal contacts found, and examining coral colonies for bleaching or tissue death in the area of contact with the macroalgae. The percentage of each coral colony in contact with macroalgae was also visually estimated. This procedure was performed to all transects conducted in the present study.

Seaweed assays – Although I still need to conduct the statistical analyses to have the precise frequency of coral-macrolagal contacts in the field, as well as the frequency of damage caused to live coral colonies by each macroalgal species, *Turbinaria* sp. was, by far, the dominant macroalgal species in all study locations. *Turbinaria* sp. was also the species most frequently contacting live coral colonies and most frequently associated to damage on live coral colonies, especially massive *Porites* spp. More than 90% of massive *Porites* colonies upon contact with *Turbinaria* presented bleaching and some of them had some evidence of partial mortality in the area contacting the macroalgae. For this reason, *Turbinaria* assays were conducted to quantify removal rates of this species by herbivores on the four studied reef. Samples of *Turbinaria* were collected in the field. For each bioassay, a total of five *Turbinaria* thalli were tied together by the base using rubber band and attached to the base of the reef with a piece of wire. A total of 4 bioassay days were conducted on each location (n = 16 bioassay days). In each sampled day, 5 bioassays were conducted: one of them placed inside exclusion a cage (manipulation control), one of them placed inside a fence (exclusion of herbivory by sea urchins), and three had no cages at all (exposed to herbivory by fishes and sea urchins). Each bioassay was left on the reef for 24 h. Each *Turbinaria* sample used in the assays was photographed before and after the assays, for a quantification of macroalgal loss during the experiment.

Coral-macroalgal damage recovery potential – As *Turbinaria* was frequently observed contacting live coral colonies in all the study sites and as most of massive *Porites* colonies upon contact with *Turbinaria* presented bleaching in the contact area, an experiment was performed to verify if bleaching would disappear when the *Turbinaria* contact was removed. Fifteen colonies of *Porites lobata* showing damage due to contact with *Turbinaria* were located, and were equally assigned to one of the following two treatments: (1) macroalgal removal or (2) macroalgal retention (control). Each coral was photographed periodically over 10 days to determine coral condition. Change in area damaged will be assessed using Image J.

Video Analysis - To identify of the herbivorous species removing the *Tubinaria* samples, stationary underwater digital video cameras were used to record feeding activity on the transplanted macroalgae within each site. Three cameras were used each day on each location, each of them placed approximately 1.5 m from of one of the three treatments exposed to herbivores at each study site. Filming commenced immediately after each *Turbinaria* sample was attached to the reef, with a small scale bar being placed adjacent to each thallus for approximately 10 s to allow calibration of fish sizes on the video footage. Video recording was continuous for 2 h.

Overall activities during my stay at CRIOBE

I have stayed in the CRIOBE during four weeks. During this time, most of my activities were focused on field work an data collection. However, during my stay in the centre I also have the opportunity to known other researchers and students working in the centre and exchange information about the dynamics and structure of the reefs in Moorea. Indeed, some researchers at the CRIOBE, especially Yannick Chancerelle, kindly provided me some data on fish community and benthic composition of the study sites I have worked on during my stay in Moorea. These data will be fundamentally important to the development of the scientific article I am going to write about the study I've conducted in Moorea.

In the last week of my stay at the CRIOBE, I have also presented a seminar entitled "Can herbivores save coral reefs? A case study from the Fiji Islands", in

which I presented general concepts about coral reef diversity and resilience and on the role of certain herbivorous species in intermediating coral-macroalgal interactions on coral reefs. During this presentation, I also showed a study in the subject I have conducted in the Fiji Islands on January 2012 and the aims and methodology of the project I have conducted in Moorea during my stay there.

Next steps

I am currently analysing the photographs of the benthic surveys, and well as the data collected for fish census in the study sites. Photographs from the benthic surveys are being analysed with the software Coral Point Count with Excel extension (Kohler & Gill 2006), in which 20 points haphazardly sorted by the program are placed in each of the photographs and identified. Once all the photographs are analysed, I will have an estimate of the percentage cover of different benthic components in each location.

Additionally, photographs of coral colonies in the 10-day experiment where *Turbinaria* contacts to *Porites lobata* were removed or not will be compared to verify if the removal of *Turbinaria* contact allows for the recovery of the coral colonies.

No *Turbinaria* removal was observed in all four study sites during the 16 bioassay days and, for these reason, video analyses are not required. A full report of this study will be written and sent to the EPHE until the 14th February 2014, with a complete presentation of the results and conclusions of the study. Additionally, the data obtained in the present study is going to be used to produce a scientific publication, which will probably be submitted to an international scientific journal in 2013 or 2014. A copy of this publication is going to be sent to IRCP as soon as I get the article accepted.

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