The Jamaican CARICOMP Site: using a temporal data set to assist in managing coastal resources

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Abstract: Discovery Bay is one of nine sites around Jamaica's coastline, soon to gain the legislative protection of Fish Sanctuary (and Scientific Reserve) status. Cumulative natural and anthropogenic impacts drove the 1980's coral to algae phase shift. Discovery Bay CARICOMP data (1994 to 2007) showed an increase in coral cover from less than 5% reported in the mid 1980's to 11.7±0.31% (mean±SE) despite chronically high algal cover (61.4±2.2%) at 9m. Coral cover has been sustained despite low urchin densities (0.99±0.91 urchins m^{-2}), low juvenile coral abundance (2.15±0.19 corals m^{-2}) and coral mortality from repeated bleaching events. Community metrics from the CARICOMP site were compared to an adjacent reef habitat which was found to have higher coral cover (16.36±3.1%), as well as higher urchin (13.7±0.84m^{-2}) and juvenile coral (9.7±1.7m^{-2}) densities. Large branching coral species were absent along the CARICOMP transects and sparse at the nearby shallow reef. Both sites continue to be heavily overfished. Local history records the use of spatially and temporally isolated management strategies which have attempt to rehabilitate various aspects of this area. This unique temporal data set (based on the CARICOMP Methods Manual 2000) provides a baseline for evaluating Government (in)action and is used to justify proposals for ecosystem management which could facilitate phase shift reversal in a coral dominated system. An ecosystem approach that implements several concurrent strategies within and adjacent to the Reserve could accelerate the recovery process. The long term viability and benefit of both old and new marine protected or reserve areas could be enhanced through coral gardening on artificial reef structures with a view to restoring the reefs' three-dimensional complexity. Such actions could theoretically accelerate phase reversal to coral dominated reefs common in the area prior to the devastating impacts of the 1980s. Rev. Biol. Trop. 58 (Suppl. 3): 63-69. Epub 2010 October 01.

Keywords: CARICOMP, Discovery Bay, fisheries reserve, coral gardening, artificial reefs, ecosystem, phase shift reversal.

The stated goals of the Caribbean Coastal Marine Productivity (CARICOMP) Program at its inception were to implement and sustain a regional monitoring program and Data Management Centre (DMC) directed at the long-term assessment of various country trends for key variables in the major Caribbean coastal ecosystems: coral reefs, seagrasses and mangroves. It was anticipated that the network would evolve to become more responsive to local needs, with particular emphasis on informing upper echelon decisions regarding the management of coastal zones and their resources.

The Discovery Bay, Jamaica-CARICOMP site is part of a reef system that has been shaped by several natural and anthropogenic stressors including chronic overfishing (Munro 1983, Jackson 1997), the loss of reef structure and complexity from hurricane wave energies (Woodley *et al*. 1981), mass invertebrate mortalities (Hughes *et al*. 1985, Liddell & Ohlhorst

1987), coral diseases (Aronson & Precht 2001), snail predation (Knowlton *et al*. 1981), repeated bleaching episodes (Woodley 1988).

The recent Government decision (Parliamentary Budget Debate speech by Hon. Minister of Agriculture and Fisheries, 2009) to declare Discovery Bay one of nine Fish Sanctuaries around the island of Jamaica and a Scientific Reserve provides an ideal opportunity for research on coral reef communities, with a focus on fisheries interventions in the area. In the past, single interventions such as the Discovery Bay Marine Lab's Fisheries Improvement Program "2 for 1" mesh exchange initiative (Sary *et al*. 1991) were designed and implemented based on limited area studies and to a great extent, on anecdotal knowledge of the area and local fishing practices. The presence of a CARICOMP site in Discovery Bay has resulted in the generation of a temporal data set for three main ecosystems and presents a unique opportunity to monitor changes and ultimately the success of the newly declared fishing sanctuary in the area. The temporal CARICOMP data set provides a baseline against which the efficacy of proposed management actions can be evaluated. The proximity of the CARICOMP site to the Fish Sanctuary/Reserve also sets the stage for investigating the underlying mechanisms which perpetuate coral assemblages in impacted systems. Primary considerations relate to the extent of coupling between impacts such as habitat loss, overfishing, regional mass mortality of key herbivores and their consequent effects on ecosystem resilience and stability (Grimsditch & Salm 2006). The objective of this study was to: a) compare the current status of the Jamaican CARICOMP site to a nearby shallow reef habitat, and b) to analyze elements of the temporal CARICOMP data and use the results as the basis for identifying area-specific management interventions aimed at restoring a disturbed reef system.

MATERIALS AND METHODS

Site Description

The West Fore-reef of Discovery Bay is situated on the north central coast of Jamaica. The reef lobe under investigation in this study is known as Monitor Reef and is located on the West Fore Reef 0.6 km west of the ship channel at 18°28'22.35"N and 077°24'49.76"W.

Sampling Technique

Shallow reef (4.5m depth) coral cover data were extracted from Gayle (2009). Surveys for CARICOMP reef (9m depth) coral cover were carried out according to the methodology outlined in the CARICOMP (2000) methods manual. Chain link coverage along ten permanent (10m) transects established at the CARICOMP site (Monitor Reef) on the Discovery Bay West Fore-reef were used to establish percent substrate composition. Half meter wide swathes on either side of the main 10m long transect lines were used to assess urchin and juvenile coral (<4cm diameter) densities at the CARICOMP site and also along randomly placed shallow reef transects.

Algal biomass was determined as per CARICOMP (2000). Coral mortality data were derived from the 2005/6 (November 2005, March and August 2006) bleaching time-series photo-transects of CARICOMP transects and other depth contours on Monitor Reef (Gayle 2009).

RESULTS

Survey results for the Shallow Reef and the CARICOMP sites are summarised in Table 1. Between 1994 and 2007, mean coral cover along the ten permanent 10m long CARICOMP transects remained relatively constanta at 11.73±0.31% (mean±SE) despite high and

TABLE 1
Summary results of surveys carried out at the CARICOMP and the comparison shallow site on the West Fore-reef of Discovery Bay, Jamaica

	Shallow Reef Station (4.5m depth)	CARICOMP Station (9m depth)
% Coral cover (mean±SE)	16.36±3.1	11.73±0.31
% Algal cover (mean±SE)	72.5±3.63	61.41±2.16
Algal biomass (dry weight) g m^{-2} (mean±SE)	101.11±34.2	770.8 ±185.7
Urchin (*D. antillarum*) density (mean±SE)	13.67±0.84	0.99±0.19
Juvenile coral density (mean±SE)	9.7±1.74	2.15±0.19

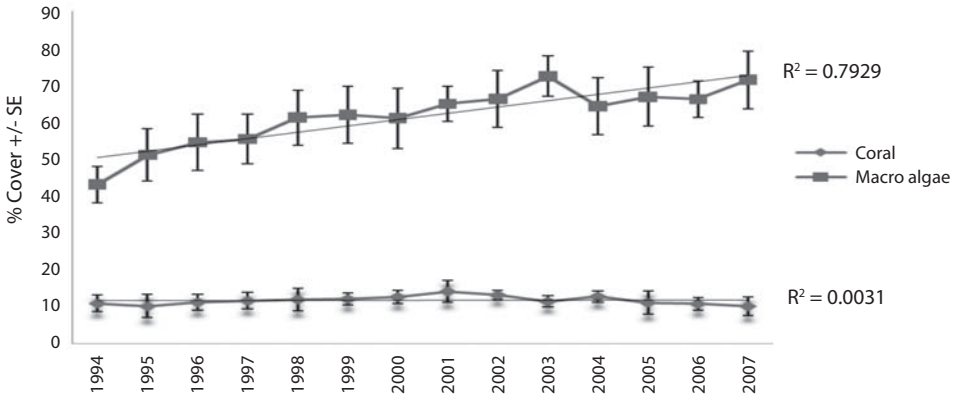

Fig. 1. Change in coral and macroalgal cover at the Discovery Bay, Jamaica, CARICOMP site between 1994 and 2007.

steadily increasing algal cover (61.41±2.16%) (Fig. 1, 2). Algal biomass was significantly higher at this depth than at the shallow site ($F=60.1$; $df=39$; $P<0.001$). The algal cover was comprised primarily of fleshy algae (Fig. 3) particularly *Sargassum, Lobophora* and *Dictyota* spp. The density of *Diadema antillarum*, the most important remaining herbivore on the West Fore Reef of Discovery Bay, was consistently low with a mean density of 0.99±0.19 urchins m^{-2} (Fig. 4). The number of juvenile corals (<4cm) was also low at 2.15±0.19 corals m^{-2} (Fig. 5). The density of juvenile corals (9.7±1.74m^{-2}) at the Shallow water site was also significantly higher ($F=75.8$; $df=19$; $P<0.001$) than the density of juvenile corals found at the CARICOMP site.

Although coral cover was not significantly different between the two sites ($F=0.22$; $df=27$; $P>0.05$), both coral and algal cover at the shallow site were higher at 16.36±3.1% and 72.5±3.63% respectively. In contrast to the CARICOMP site, the algal assemblage on the

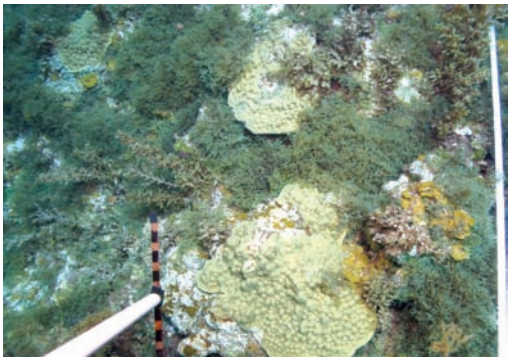

Fig. 2. Heavy algal cover in absence of urchins at the CARICOMP site.

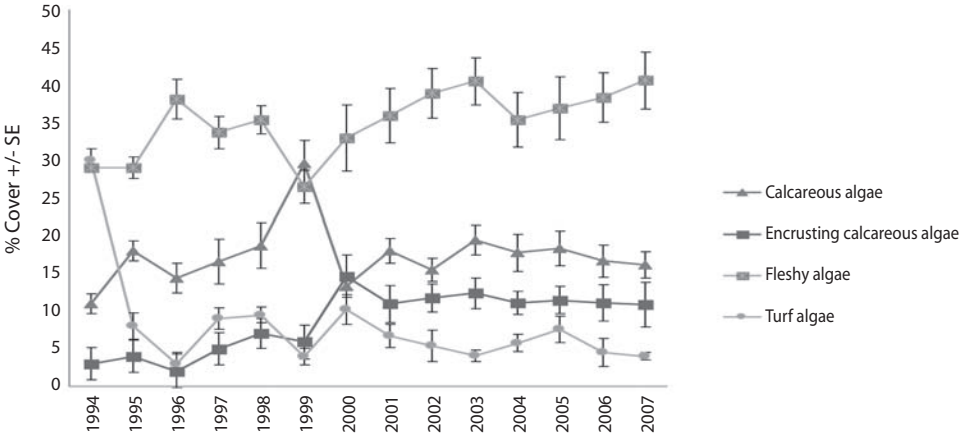

Fig. 3. Percent cover of main algal categories found at the CARICOMP (9m depth) site.

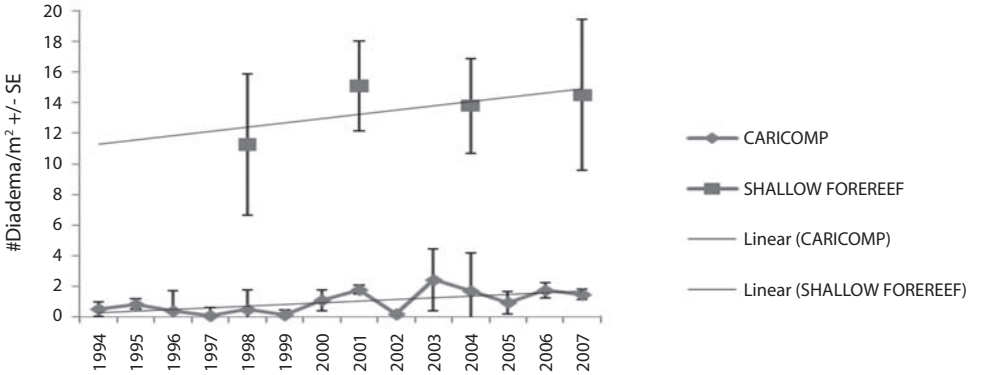

Fig. 4. Urchin densities at CARICOMP and Shallow Reef stations.

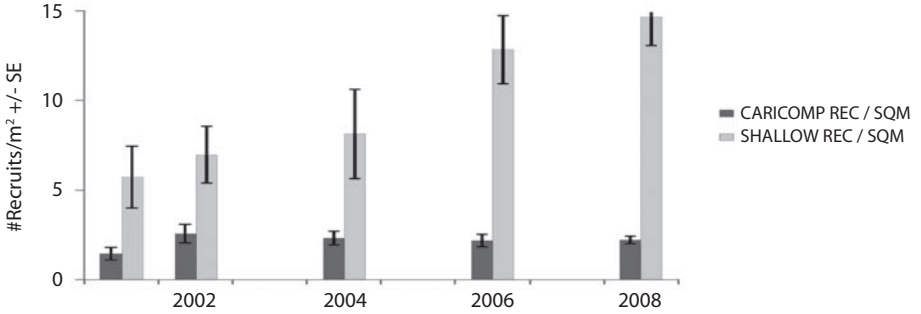

Fig. 5. Abundance of juvenile corals at CARICOMP site (9m) and on the adjacent shallow reef (4.5m depth).

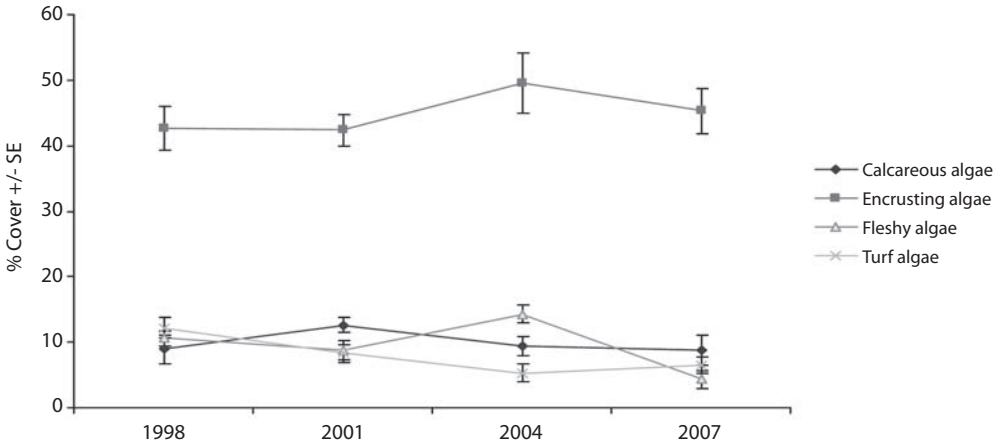

Fig. 6. Main algal categories found at the Shallow (4.5m depth) site.

shallow reef was dominated by crustose coralline (Fig. 6, 7), which can be attributed to the significantly higher density of *D. antillarum* (13.67±0.84 urchins m^{-2}) (ANOVA, $p<0.05$, $F=3.94$).

DISCUSSION

In a related study carried out on the shallow west fore reef of Discovery Bay, Edmunds and Carpenter (2001) showed that increased densities of *D. antillarum* contribute to reducing macroalgal cover, thereby increasing the availability of bare substrate for juvenile corals. Increasing herbivory in algal dominated systems had the potential to provide suitable conditions for increased coral recruitment in an area, paving the way for a gradual phase shift reversal to a coral dominated system (Murray 2003).

The analysis of the time series data spanning 13 years from the CARICOMP site suggested that:

- coral cover at 9 m has increased from 5% reported by Hughes (1994) to 11.7±0.31%,
- in the absence of fishing restrictions, the CARICOMP area remained overfished and herbivory depended mainly on existing *Diadema* populations which appeared better able to disperse laterally rather than into deeper water,
- despite the slow recovery of urchin populations, low coral recruitment rates and bleaching related coral mortality of 6% resulting from the 2005 bleaching event (Gayle 2009), the coral cover at this CARICOMP has remained relatively constant over the years.

Fig. 7. Minimal fleshy and calcareous algal cover in presence of urchins at the Shallow water (4.5m depth) site.

The creation of marine protected areas (MPAs) and sanctuaries is a common government conservation tool for managing

coastal fisheries and protecting coral and marine resources (Reid-Grant & Bhat 2009). The Government of Jamaica stated goal in creating a Fisheries Sanctuary in Discovery Bay is to increase fisheries resources in the area with a view to creating a sustainable local fishery over time. More specifically, the reduction in fishing pressure within the Sanctuary is intended to protect the spawning stock biomass in order to establish a viable population age structure and diversity of fish assemblages. The proposed intervention constitutes a first level response to chronic overfishing with a secondary potential benefit of increasing herbivory on an algal dominated reef. Theoretically, the density and biomass of the fish stock within the reserve could recover fully and spill-over into adjoining areas, increasing the fish yield and herbivory at the CARICOMP and nearby reef sites. However, the recovery of fish stocks through reduced fishing pressure alone is a process that can take years if not decades (McClanahan & Graham 2005).

Preliminary results from the operation of an experimental Fisheries Reserve in the western quadrant of Discovery Bay (1995-1998) proved the feasibility of delaying recruitment of some species and in increasing the spawning stock biomass of others that took up residence in the Reserve (Munro 2001, Woodley *et al*. 2003). The delay in recruitment to the fishery reduced overfishing to some degree, allowing for an increase in the average size of fishes in the catch.

The current data set provides a baseline for a coral reef system in absence of any active management. The stability of the system or the slow rate of recovery observed at the CARICOMP site points to a need for additional measures required to tip the balance in favour of the desired phase shift reversal over a shorter time period. An ecosystem approach of implementing several concurrent strategies within and adjacent to the Reserve could enhance the recovery process. Additional interventions, including the placement of artificial reef structures would immediately increase the three dimensional complexity of the system, providing a favourable habitat to herbivores in terms of refuge and feeding.

The ecological functionality of newly established MPAs and reserves depends not only on decreased fishing pressure but also on a healthy, three-dimensional reef system which could be established in part through coral gardening. The seeding of bare substrate and artificial reef structures with suitable frame-building coral species has the potential to increase the chances of eventual success in restoring a disturbed system. Such actions could theoretically accelerate phase reversal to coral dominated reefs common in the area prior to the devastating impacts of the 1980s.

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RESUMEN

Discovery Bay es uno de los nueve sitios alrededor de Jamaica, pronta a obtener la protección legislativa como Santuario de Pesca (y Reserva Científica). Los impactos naturales y antropogénicos acumulativos de la década de 1980 condujo a cambio de fase de coral a algas. Los datos CARICOMP de Discovery Bay (1994 a 2007) mostraron un aumento en la cobertura de coral de menos del 5% informada a mediados de 1980 a 11.7±0.31% (media±ES) a pesar la alta cobertura crónica de algas (61.4±2,2%) a 9m de profundidad. La cobertura de coral se ha mantenido a pesar de las densidades bajas de erizo de mar (0.99±0.91 erizos m^{-2}), baja abundancia de juveniles de coral (2.15±0.19 m $corales^{-2}$) y mortalidad de corales debido a fenómenos de blanqueo repetitivos. Estadísticas de la comunidad del sitio CARICOMP contrasta con un hábitat de arrecife adyacente que tienen mayor cobertura de coral (16.36±3.1%), de erizos (13.7±0.84 m^{-2}) y de juveniles de coral (9.7±1.7 m^{-2}). Especies de coral de grandes ramas estaban ausentes de los transectos CARICOMP y eran pocos en los arrecifes poco profundos cercanos. Ambos sitios siguen siendo, en gran medida, objeto de sobrepesca. La historia local registra el uso de estrategias de gestión espacial y temporalmente aisladas que se implementaron en el pasado para intentar rehabilitar a diversos aspectos de esta área degradada. Los datos temporales de CARICOMP establecen una base única base para la evaluación "en"

acción del Gobierno y se utiliza para justificar las propuestas de gestión de los ecosistemas que podrían facilitar la reversión de fase a un sistema dominado por corales. Un enfoque de ecosistemas que implementa varias estrategias simultáneas dentro y adyacente a la Reserva podría acelerar el proceso de recuperación. La viabilidad a largo plazo y el beneficio de viejas y nuevas áreas marinas protegidas o reservas podría ser mejorada a través de cultivo de coral en arrecifes artificiales con el fin de restablecer la complejidad tridimensional de los arrecifes coralinos. Tales acciones podrían, teóricamente, acelerar la reversión de fase a coral como era común en el área antes de los impactos devastadores de la década de 1980.

Palabras clave: CARICOMP, Discovery Bay, Reserva pesquera, cultivo de coral, arrecifes artificiales, ecosistema, reversión de cambio de fase.

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