Status of the coral reefs in Foul and Folly Bays, Morant Wetlands, south-eastern Jamaica, with emphasis on corals and macroalgae

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Abstract: Foul and Folly Bays are located within the Morant Wetlands near the eastern tip of Jamaica. They have never been investigated but were believed to be important for larval productivity because of the extent of benthic habitats, absence of major coastal developments and remote location. The study was aimed at providing baseline data on the spatial distribution and status of corals and associated benthos. We investigated coral reefs and associated areas with phototransects at eight stations analysed with the Coral Point Count software. Most areas were dominated by algae, evidence of a phase shift from coral to algal reefs. Coral cover varied significantly across the bays (ANOVA, $p = 0.0342$) with a maximum of 27.03% at the deepest station and a mean of 5.6% at all other stations combined. Mean cover of macroalgae was 39% and varied significantly across stations ($\alpha = 0.05$, $F = 7.472$, $p = 0.005$). The deepest station also had the highest percentage of calcareous algae and live coral while dead coral with algae (DCA) was a significant variable across all other stations (ANOVA, $p < 0.001$). Gorgonians (ANOVA, $p < 0.001$), sponges and urchins were also assessed. *Diadema antillarum* was not observed at any station. Overall the status of the reefs was poor, probably due to overfishing, absence of urchins and the resultant algal proliferation. Rev. Biol. Trop. 62 (Suppl. 3): 39-47. Epub 2014 September 01.

Key words: Coral Reefs, Spatial Variation, Foul Bay, Folly Bay, Jamaica.

Coral reefs are complex and diverse marine ecosystems (Woodley et al., 1981; Moberg & Folke, 1999). They offer many economic and environmental services including their natural beauty, recreation, food, jobs, chemicals, pharmaceuticals and shoreline protection (Moberg & Folke, 1999). Jamaica is the third largest island of the Caribbean and is said to be in the center of the coral diversity in the Atlantic Ocean (Hughes, 1994). In Jamaica, the effects of overfishing, hurricane damage, bleaching and disease have combined to destroy many reefs, evidenced by reduction in coral cover from 50% on reefs in the late 1970's to less than 5% today (Hughes, 1994; Goreau, 1992). Burgeoning populations, destructive fishing practices, coastal development, unsound agricultural practices, sedimentation from forests clearing, expanding tourism, and increasing pollution (Grimsditch & Salm, 2006) all exacerbate the rapid decline of coral reef systems.

There has been extensive research on coral reefs in Jamaica beginning in the 1950's with Thomas Goreau studying areas on the north and south coasts of Jamaica (Goreau, 1959; Goreau & Wells, 1967; Barnes, 1970; Liddell & Olhorst, 1981; Woodley et al., 1981; Hudson, 1985; Gates, 1990; Goreau, 1992; Aronson & Percht, 1995; Hughes, 1994; LaPointe, 1997; Mendes & Woodley, 2001; Crabbe, Mendes & Warner, 2002). However, the coral reef community of the Foul and Folly Bays, Morant Wetlands, St. Thomas, Jamaica has never been described or quantitatively assessed.

The study site was positioned on the south-eastern coast of Jamaica encompassing two bays (Foul Bay and Folly Bay). They are lined by an extensive mangrove forest which has been designated as a bird reserve since 1984. Beyond the mangrove forest the land use is primarily for sugar cane and a sugar cane factory is associated with the fields. Artisanal fishing is done within the bays and off-shore banks associated with the easternmost end of Jamaica, supports the fishing community (144 registered fishers and 21 registered vessels in 2010) of Rocky Point. Due to the prevailing east to west currents and the lack major developments, the two bays were thought to be pristine with healthy coral reef communities.

Since this coral community has never been studied, this research sought to achieve the objectives of determining the composition and relative abundance of all living and non-living substrate types associated with the reef and to describe the spatial variation of corals and associated benthic organisms across Foul and Folly Bays.

MATERIALS AND METHODS

Coral surveys were conducted between 8:00a.m. and 12:00p.m. Sampling was done on four occasions: December 5, 2007; January 31, 2008; April 11, 2008 and November 21, 2008. Eight stations were chosen using a stratified random process based on areas with live corals across the Morant Wetlands bays (17°52'8.77"N-76°15'2.18"W) using a bathymetry map and reconnaissance surveys (Fig. 1). Stations 1-7 were referred to as the shallow stations (<1-3m) and station 8 the deep station (~12m). A Garmin® GPSMAP® 76CSx was used (accuracy <10m 95% typically) to locate the station previously chosen and accessed by a fishing vessel. Once in the general area of the station, a reef was randomly chosen and 'marked' on the Global Positioning System (GPS) to indicate its exact location.

A camera framer with base dimensions of 0.75m x 0.5m was used to maintain the dimensions of each photo. The camera framer was constructed from 2cm cold water PVC (White & Porter, 1985). A Canon Power Shot G5 Digital camera housed in a waterproof casing was used to capture the contents of the frame. Pictures were taken along the entire length of the reef in the direction parallel to the shoreline. Transects were done in replicate per station.

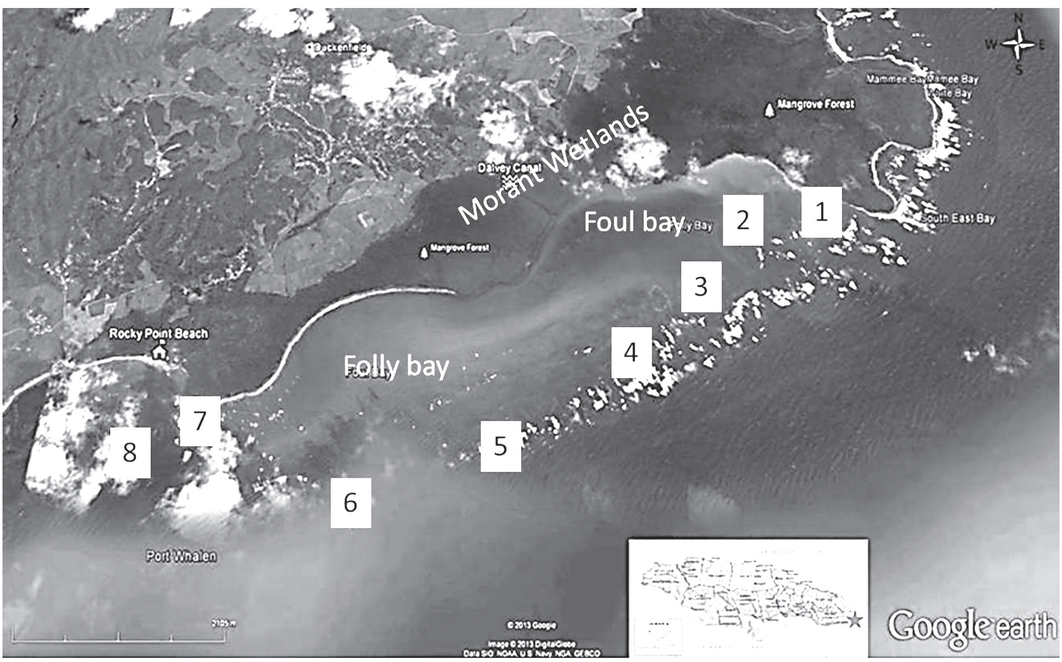

Fig. 1. Sampling areas showing the eight stations numbered from east to west. Plate Inset courtesy of Maptown Ltd.

Coral Point Count with Excel extensions (CPCe) version 3.5 software (Kohler & Gill, 2006) was used to analyze the photographs. Twenty randomly positioned dots were generated on each photograph. The substrate type overlain by each dot was identified using the categories listed in the software. Excel data sheets were produced using CPCe version 3.5 for statistical analysis. Percentage coral cover was assessed.

Cumulative species richness curves were done for each transect at each station to ensure adequate sampling intensity. The percentage cover of all species and substrates associated with the reef were log transformed (Sokal & Rohlf, 1981) and normality confirmed using Shapiro-Wilks W- test. One-way analysis of variance (ANOVA, p= 0.05), tests were done to indicate whether significant spatial variability existed using Statistica V.7. Coral species diversity was calculated using the Shannon-Weaver Index (H´).

RESULTS

The spatially dominant substrates found in the reefal areas of the Morant Wetlands bays (Foul and Folly Bays) were coral, macroalgae, dead coral with algae (DCA), gorgonian, *Porites asteroides, Porites porites, Dictyota* sp., *Sargassum* sp., *Turbinaria* sp., and *Halimeda* spp. These were all found to vary significantly (ANOVA, p≤0.01) across stations.

Coral distribution: 17 species of corals were identified including *Millepora complanata* and *Millepora alcicornis, M. complanata* and *M. alcicornis*, though not true corals, were grouped with the true corals as they are important cnidarians on the reef. Corals were identified from all stations except for station five (17°52'27.07"N-76°14'9.78"W). The 17 coral species identified were not equally distributed across all stations as stations 1-7 had means not exceeding seven species while station eight had 16 coral species. The mean coral cover was 5.6% across stations (Fig. 2). The highest mean percentage cover was noted at station eight (17°52'25.43"N-76°16'23.45"W) with 27.03%. Station five had the lowest mean percentage cover (0%) of coral. Stations one to four located within Folly Bay had a coral percentage cover values of <7%. In Foul Bay (stations five to eight) there was a dramatic

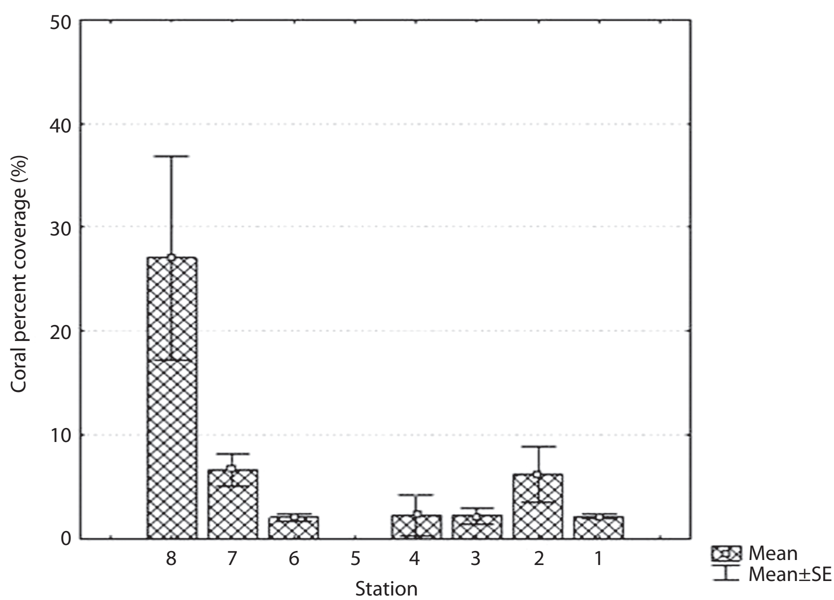

Fig. 2. Mean coral percentage cover across stations. Station 5 is not represented by a bar as it had a percentage cover of zero. Y-axis has been reduced to a maximum of 50%.

increase in coral cover with progression from station five to station eight. The total coral percentage cover was significantly different across stations (ANOVA, p= 0.0342). It should be noted that for good visual effect, graphical presentation of the data has stations numbered in the reverse order (i.e. stations eight à one) which is indicative of the actual position of the stations in the area; station eight being westernmost.

Foul Bay had the higher coverage of *P. asteroides* with station eight having the highest percentage cover. The overall coverage of *P. porites* was very low with the highest mean percentage cover being 3.17% at station two and the lowest at stations five (0%) and six (0%). *A. agaricites* was found only at stations one, three, four, seven and eight. Station eight had the highest mean percentage cover of 23.2%.

Algal cover: Macro-algae was the dominant benthic substrate across all stations and showed significant spatial variation (ANOVA, p= 0.005). The highest mean percentage cover was seen at station six (75.4%) and lowest (8.52%) at station four (Fig. 3). However, in Folly Bay (stations one to four), macroalgae gradually decreased with progression from station one to four. Between the two bays, Foul Bay had the higher percentage cover of macroalgae. There was no gradual decrease in Foul Bay (stations five to eight), as was seen in Folly Bay.

The algal groups examined (*Dictyota* sp., *Sargassum* sp., *Turbinaria* sp. *a*nd *Halimeda* spp.) varied significantly (ANOVA, p≤0.01) across the stations. The more fleshy algae dominated in the shallow areas of Foul and Folly Bays while the calcareous algae (*Halimeda* spp.) tended to be high at station 8. It should be noted that no *Diadema antillarum* were observed along the transects.

Dead coral with algae (DCA): The category DCA was found at all stations with a

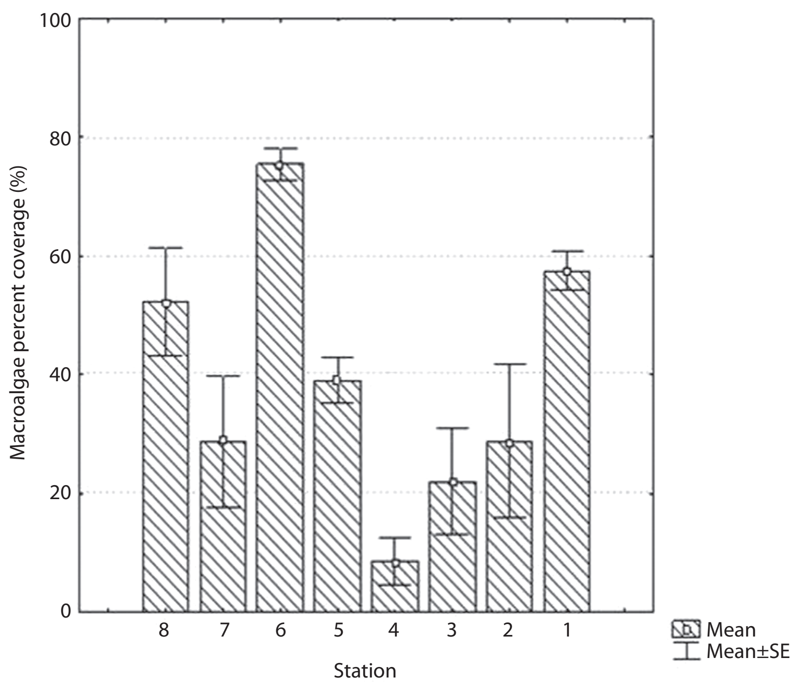

Fig. 3. Mean macroalgae percentage cover across stations. A- Total, -. *Dictyota* sp., B- *Sargassum* sp., C- *Turbinaria* sp., D- *Halimeda* spp.

percent coverage ranging from 15.19-83.86% (Fig. 4). DCA showed a gradual increase in percent coverage in Folly Bay from station one to four. There was no pattern observed for Foul Bay. The highest coverage of DCA was seen at station four (83.86%) and the lowest at station eight (15.19%).DCA was significantly different across stations (ANOVA, $p < 0.001$).

Gorgonians (soft corals): All stations except for stations five and six had gorgonians present. Station two (11.46%) had the highest percentage of gorgonians while stations five and six had the lowest (0%). Folly Bay had a higher percentage of gorgonians than Foul Bay. Gorgonians were significantly different across stations (ANOVA, $p<0.01$).

Diversity: Shannon-Weaver Index (H') diversity across the stations (Fig. 5) ranged from zero at station five (no coral species were found) to 0.34 at station eight. There was no clear trend for stations one to four (Folly Bay). Foul Bay (stations five to eight) however, demonstrated a trend of increasing coral species diversity from station six to eight.

DISCUSSION

Location and extent of the coral reef system: The coral reef system studied across the Morant Wetlands bays was situated at the southeastern tip of Jamaica and as such, the area is exposed to the open waters of the Caribbean Sea. The coral reef area, which runs parallel to the shoreline, spanned approximately 7km that was 80% of the length of the shoreline. Previous representations of the reef in older bathymetric charts show a continuous barrier reef system but this has been severely degraded without the charts being updated. The reasons for the degradation would appear to be a combination of natural and anthropogenic causes.

This study suggests that the reef system was of a patchy barrier reef type with channels along the shallower stations, found mostly in Folly Bay and a section of Foul Bay. The edge of the system has a reef oriented perpendicular to the shoreline (station eight) which is located on the edge of a channel between Foul Bay and Rock Point Bay. This was observed to be a part of a buttress system (I. Wilmot pers. comm.). Buttresses were generally reported to be found only on the north coast of Jamaica (Goreau, 1959), but this area has never received a detailed survey and so the feature may have never been described. Further assessment would be needed in areas outside of the immediate sample location to confirm whether station eight was an anomaly. Surveys of deeper areas south and west of Foul and Folly bays may reveal a similar reef as

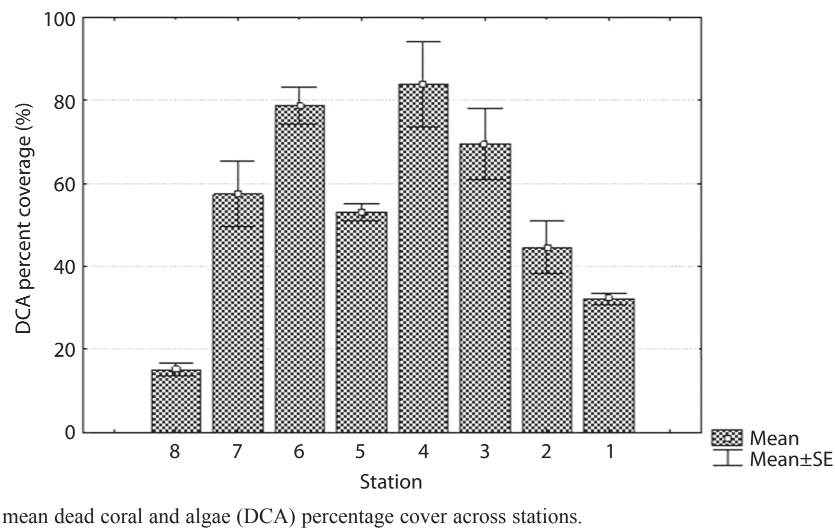

Fig. 4. The mean dead coral and algae (DCA) percentage cover across stations.

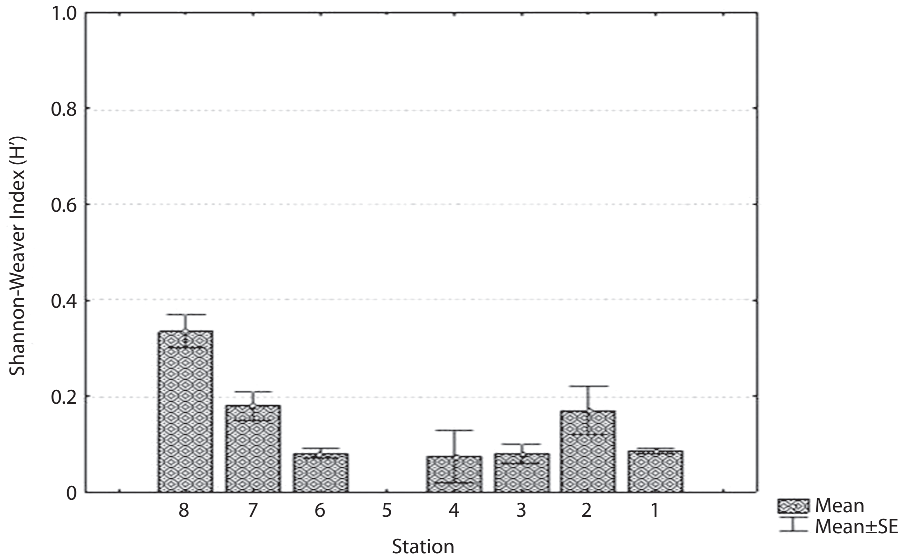

Fig. 5. Shannon-Weaver Index (H') across stations. Station 5 had no corals within sample area.

was observed at station eight. This would be expected as there is a positive correlation of depth and diversity (Bonem & Stanley, 1977; Huston, 1985) in corals.

Composition and relative abundance of coral species: The seventeen hermatypic coral species found in the Morant Wetlands bays included species previously reported from the north coast (Goreau, 1959; Wells & Lang, 1973) as well as the south coast (Goreau, 1959; Mendes, 1992). This represents approximately 1/3 of the species previously reported to be occurring in Jamaica (Goreau & Wells, 1967).

Circulation patterns with very high current speeds (Wilmot, 2010) found within Foul and Folly Bays appear to be unfavorable for coral recruitment (Lugo-Fernandez, 2001; Blanco-Martin, 2006) especially in the shallow algal dominated areas. Station eight situated on the edge of Foul Bay seemed to be most suitable for coral growth as it had the highest diversity and percentage cover of corals. This is further supported by the fact that this station had the highest abundance of massive reef-building corals (Loya, 1976; Goreau, 1959) corals such as *M. annularis, M. cavernosa* and *Diploria strigosa*.

As expected, diversity and coral cover showed a positive correlation with progression from shallow stations to the deeper station eight (Porter, 1974). While the coral cover at station eight was much higher than average, by comparison the average coral cover of the Morant Wetlands was found to be 20% of the average coral cover found at Lime Cay, another south coast area (McNaught, 2007) .

Composition of other living and non-living substrate types: The rock-like pavement which would represent the fore-reef area seen across stations one to seven was thought to have been a part of what was a healthy, continuous barrier reef system as seen in older maps. The presence of this rock-like pavement was one of the reasons for sampling parallel to the shoreline.

The Morant Wetlands, now dominated by algae, seemed to have undergone a coral-algae phase-shift when compared to many reefs across Jamaica and the Caribbean (LaPointe, 1997; Hughes, 1994; Wilkinson, 2008; Bruno, Sweatman, Precht, Selig & Schutte, 2009).

Macroalgae showed a general trend increasing from station one to eight with the more fleshy algae (e.g. *Sargassum, Dictyota* and *Turbinaria*) in the shallow areas (Hudson, 1985) and the calcareous algae *Halimeda* being most abundant at station eight (deep station) was similar to observations by McNaught (2007), working near Lime Cay.

The absence of *Diadema antillarum* and *Echinometra lucunter* would further support the high abundance of algae (Sammarco, 1982). This observation was somewhat similar to Byrd's (2008) study also done within the Morant Wetlands. Although sampling was done only in the day, the strong wave action throughout this area is thought to be unfavorable for *D. antillarum* (Clemente & Hernandez, 2008; Alves, et al., 2001). Sponges had a positive correlation with coral cover; this trend was observed on other reefs such as Curacao, Santa Maria and N.E. Colombia with mean sponge cover below 25% (Aerts, 1998).

This study provides a baseline of the coral community within the Morant wetlands bays. The coral reef studied in the Morant Wetlands should be described as a patchy barrier reef. Seventeen coral species were identified within this area, the mean coral cover was low (5.4%) and macroalgae high (39%). While the coral reef system studied in the Morant Wetlands is situated at the eastern tip of Jamaica, and so is exposed to the pristine waters of the Caribbean Sea. The coral reef is very degraded and is not a continuous barrier reef system as was represented on older bathymetric charts. The degraded state of reefs in the Morant wetlands area is probably attributed to a combination of overfishing, absence of urchins and the resultant algal proliferation, as well as strong waves and currents (Wilmot, 2010) reducing coral recruitment. The anomalous high % coral cover at station eight was attributed to the depth in that area.

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RESUMEN

Las bahías Foul y Folly se encuentran dentro de los Humedales Morant cerca de la punta oriental de la isla de Jamaica. Estos dos bahías nunca han sido investigadas pero se cree que son áreas importantes para la productividad larvaria debido a la extensión de los hábitats bentónicos, ausencia de desarrollos importantes a lo largo de la costa y la ubicación remota de la zona. El estudio tuvo como objetivo proporcionar datos de referencia sobre la distribución espacial y el estado de los corales y del bentos asociado. Investigamos los arrecifes coralinos y áreas asociadas utilizando fototransectos en ocho estaciones analizadas con el programa Coral Point Count. La mayoría de las áreas tuvieron predominio algal, mostrando evidencia del desplazamiento de fase de coral a algas. La cobertura de coral varió significativamente a través de las bahías (ANOVA , $p= 0.0342$), con un máximo de 27.03% en la estación estación más profunda y una media de 5.6% en todas las demás estaciones combinadas. La media de porcentaje de cobertura de macroalgas fue de 39% y varió significativamente entre las estaciones ($\alpha= 0.05$, $F= 7.472$, $p= 0.005$). La estación mas profunda presentaba el mayor porcentaje de algas calcáreas y coral vivo, mientras que el coral muerto con algas (DCA) fue una variable significativa en todas las demás estaciones (ANOVA , $p<0.001$). También se evaluaron las gorgonias (ANOVA , $p<0.001$), esponjas y erizos de mar. No se observó *Diadema antillarum* en todas las estaciones dentro de los transectos. En general, el estado de los arrecifes era pobre, probablemente debido a la pesca excesiva, la ausencia de erizos y la proliferación de algas resultante.

Palabras claves: arrecifes coralinos, variación espacial, Bahía Foul, Bahía Folly, Jamaica.

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