CORAL REEFS OF JAMAICA

An Evaluation of Ecosystem Health: 2013

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A REPORT CARD FOR REEFS

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SUMMARY FOR DECISION MAKERS

The 2014 Coral Reef Health Index (CRHI) report card is a follow-up to the first comprehensive health assessment of the Jamaican Reef Ecosystem conducted in 2012. This second biennial CRHI report was produced based on assessments conducted in 2013 on twenty-three reef sites located across nine areas.

The index produced is useful to track management progress both for maintaining and rebuilding reef health. For this report card the indices assessed were coral percentage cover, coral recruitment, macro-algal percentage cover, herbivorous fish abundance, commercially important fish abundance and *Diadema* sp. abundance.

Preliminary assessments indicate that like the 2012 CRHI report, the overall index continues to be poor (2.1). The current index indicates that there has been little improvement in the management for increased reef health and resilience. Of the 23 sites assessed 16 sites were ranked as poor, 6 sites as critical and 1 site as fair; none of the sites assessed achieved a ranking of good or very good.

Overall the sites are still being heavily impacted by high fishing pressure as the recorded abundances for herbivorous fish and commercially important fish continues to be low. Compared to the 2011 assessments, areas such as the Montego Bay Marine Park, Falmouth, Oracabessa Bay Special Fishery Conservation Area and the Negril Marine Park have recorded increases in the abundances of herbivorous fish and commercially important fish. These increased abundances do not mean a job well done; they are still not enough to produce a marked and sustained increase in the overall index as the levels are still considered to be in the range of critical to poor.

While other indices were assessed there is no direct activity which can be employed to influence or increase indices such as coral recruitment or *Diadema* sp. abundance as these activities are heavily dependent on circulation patterns, currents and suitable spaces to settle. Fishing pressure can however be influenced by management decisions and needs to be addressed before any marked positive change will be reflected in the calculated index.

EVALUATING REEF HEALTH

The reporting on reef health and resilience via a health index was first conducted in 2012 based on data collected during the 2011 surveys. The tool used was a Coral Reef Health Index (CRHI) which was calculated from a suite of indicators. This tool is an overall measure of reef health which is used on the Mesoamerican Reef (MAR) ecosystem to track management progress, both for maintaining and for rebuilding reef health.

Indicators of Reef Health

Six indicators were chosen to inform the Coral Index and the Reef Biota Index; these two sub-indices were then averaged to attain the overall CRHI. For this report coral recruitment has replaced the indicator "rugosity" (measure of the three-dimensional nature of the reef) which was used for the 2012 report; *Diadema* sp. abundance has also been included. The decision to change the indicators was based on the 2011 surveys where it was determined that there was little variability in the rugosity of reef sites assessed. The reefs were relatively low to medium relief and displayed no clear trend for the number of fish species identified[1].

CORAL INDEX

- Coral cover - indicates a measure of the proportion of reef surface covered by live stony corals which form the three-dimensional network of the reef.
- Coral recruitment - measures the density of coral recruits per square meter on the reef, and is critical to recovery after disturbances.

REEF BIOTA INDEX

- Macro-algal cover - indicates the amount of fleshy algae on a reef
- Herbivorous fish abundance - measures the biomass of surgeonfish and parrotfish; the most important grazers on plants that could overgrow the reef.
- Commercial fish abundance - measures the biomass of commercially significant fish; grunts, groupers and snappers.
- *Diadema* sp. abundance - measures the density of the long-spined sea urchin, a key grazer of algae that otherwise compete with corals for precious reef space.

[1] NEPA, 2012. Coral Reefs of Jamaica, An Evaluation of Ecosystem Health: 2011. NEPA. 16pp

Index Calculations

The grades are calculated by converting the mean data-value of each indicator into a condition ranked from one ("critical") to five ("very good"), based on the data ranges given in Table 1. The indicators were grouped into two sub-indices; a Coral Index and a Reef Biota Index. The ranked scores for each of the coral indicators (coral cover and coral recruitment) were then averaged for the Coral Index, while the other four indicators (macro-algae cover, herbivorous fish abundance, commercial fish abundance and Diadema abundance) were averaged into the Reef Biota Index. These two sub-indices (coral index and reef biota index) were then averaged to calculate the overall Coral Reef Health Index[2] (Figure 1).

Table 1: Threshold values used to determine ranking for each indicator

INDEX/INDICATOR	VERY GOOD (5)	GOOD (4)	FAIR (3)	POOR (2)	CRITICAL (1)
CORAL INDEX					
Coral Cover (%)	≥40	20.0-39.9	10.0-19.9	5.0-9.9	<5
Coral Recruitment (#/m^2)	≥10	5.0-9.9	3.0-4.9	2.0-2.9	<2.0
REEF BIOTA INDEX					
Macro-algae Cover (%)	<10	10.0-19.9	20.0-39.9	40.0-59.9	≥60
Herbivorous Fish Abundance (g/$100m^2$)	≥4800	3600-4799	2400-3599	1200-2399	<1200
Commercial Fish Abundance (g/$100m^2$)	≥2800	2100-2799	1400-2099	700-1399	<700
Diadema abundance (#/m^2)	>2.5 (and <~7)	1.1-2.5	0.5-1.0	0.25-0.49	<0.25

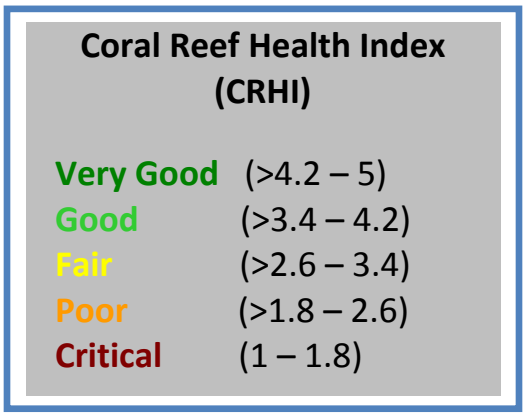

Figure 1: Coral Reef Health Index[3]

[2] Healthy Reefs Initiative (2008) Eco-health Report Card for the Mesoamerican Reef: An Evaluation of Ecosystem Health. www.healthyreefs.org.

[3] ibid

TRACKING REEF HEALTH

During 2013 a total of 23 sites were surveyed. The locations assessed were the Montego Bay Marine Park, the Negril Marine Park, the Ocho Rios Marine Park, the Oracabessa Bay Special Fishery Conservation Area, Sandals Boscobel Special Fishery Conservation Area, Palisadoes-Port Royal Protected Area, Falmouth, Discovery Bay and Belmont, Westmoreland.

The data was collected using a combination of the point intercept method to assess substrate type and belt transects to assess for fish and invertebrates. The point intercept assessment was conducted every 0.5m along four 20m long transects and the substrate type at each point recorded. This information was then used to determine the mean percentage substrate cover on the reefs assessed. An assessment of coral recruits was conducted along the same 20m transects laid for the substrate surveys. A sampling quadrat measuring $0.25m^2$ was placed at intervals of 0, 5, 10, 15 and 20m; in this area the numbers and species of all coral colonies measuring 3cm or less were recorded. The density of recruits was then calculated for each site and became the final recruitment measure; sum total of recruits across all quadrats divided by 4 (for meters) to obtain recruit density per square meter[4].

Fish assessments conducted yielded information on the biomass of herbivorous fish and commercially important fish. This was obtained by sampling four 5m wide by 20m long segments for the targeted species. *Diadema* sp. density assessments were also conducted along the same belt transects used for the fish assessments.

SCORE CARD RESULTS and INTERPRETATIONS

From the data collected both site specific and location specific indices were calculated. The data showed that of the 23 sites assessed 70% were ranked as poor, 26% as critical and 4% as fair; no sites fell in the other classifications of good or very good (Appendix I). Of the nine locations assessed only one (Oracabessa Bay Special Fishery Conservation Area) with a grade of 1.6 was listed as critical. The Palisadoes-Port Royal Protected Area was determined to be the healthiest location with a grade of 2.6 based on the assessment conducted on two reef sites (Table 2). The CRHI calculated for the 23 sites indicates that overall the reefs are in a poor state.

23 sites assessed

6 sites ranked as critical

16 sites ranked as poor

1 site ranked as fair

[4] Maynard J., S. McKagan, S. Johnson, P. Houk, G. Ahmadia, R. van Hooidonk, L. Harriman and E. Mcleod (2012) Coral reef resilience to climate change in Saipan, CNMI; field-based assessments and implications for vulnerability and future management

Table 2: Location CRHI from averaged indices

LOCATION	Location CRHI	
	# of sites	CRHI
Montego Bay Marine Park	4	2.0
Falmouth	3	2.0
Discovery Bay	2	1.9
Ocho Rios Marine Park	4	2.0
Sandals Boscobel Special Fishery Conservation Area	1	2.3
Oracabessa Bay Special Fishery Conservation Area	3	1.6
Palisadoes Port Royal Protected Area	2	2.6
Belmont, Westmoreland	1	2.5
Negril Marine Park	3	2.1
OVERALL CRHI		2.1

CORAL, ALGAE and HERBIVORES

A breakdown of the data by the individual indices produced varying site statistics. The analyses revealed that the lowest percentage coral coverage recorded was 5.6% and was noted at both Golden Eye Beach Bar (Oracabessa Bay Special Fishery Conservation Area) and RIU Nursery (Ocho Rios Marine Park). The highest recorded coral coverage was 36.9% at Channel Edge located in the Sandals Boscobel Special Fishery Conservation Area. Sewage End located in the Ocho Rios Marine Park and Rock Edge located in the Oracabessa Bay Special Fishery Conservation Area recorded the lowest and highest macro-algal cover of 1.9% and 48.8% respectively (Appendix II). Further analysis of the data revealed an overall hard coral average of 20.3%

14.0% - lowest coral cover
(Oracabessa Bay Special Fishery Conservation Area)

36.9% - highest coral cover
(Sandals Boscobel Special Fishery Conservation Area)

8.1% - lowest algal cover
(Sandals Boscobel Special Fishery Conservation Area)

40.3% - highest algal cover
(Discovery Bay, St. Ann)

and a macro-algal average of 28.3%. Of the 23 sites, 62% or 14 sites recorded coral cover greater than or equal to 20% while 17% or 4 sites recorded less than 10%.

At the time monitoring was conducted, there was no sustained management or enforcement at the Sandals Boscobel Special Fishery Conservation Area and as a result there was reported high levels of poaching. This activity was reflected in the biomass recorded on the Channel Edge reef site located within the boundaries of the conservation area. While the site received high grades for coral and algal cover the lowest biomass for both herbivorous and commercially important fish was also recorded. Increased abundances of herbivorous fish were recorded at the Oracabessa Bay Special Fishery Conservation Area; 578.6g/100m^2 in 2012 compared to 918.0g/100m^2 in 2013.

The presence of herbivores such as *Diadema* sp., parrotfish and surgeonfish on reefs play important roles in maintaining reef health and ecosystem resilience as they are known to exert control on macro-algal cover. The calculations revealed that 96% of the sites were rated as poor to critical for the indices herbivorous fish biomass and commercially important fish; the Bloody Bay reef site recorded the highest abundances for both parameters. It should be noted that herbivorous fish continues to be the most abundant trophic guild on the reefs with an average of 207 herbivores to 5 carnivores per site.

Parrotfish is the most abundant fish on the reefs

Negril Marine Park registered the highest herbivorous fish abundance

A direct relationship between Diadema density and percentage of bare substrate exists

Bare substrate is available but coral recruitment is low

Parrotfish remains the most abundant fish on the reefs assessed with an average biomass of 939.6 g/100m^2 and average densities of 37.9 fish/100m^2. Surgeonfish follows with averages of 245.7 g/100m^2 and 9.3 fish/100m^2 for biomass and density respectively. Densities of the other key herbivore (*Diadema* sp.) peaked at 4.4 urchins/m^2 on the Sewage End reef site; two sites displayed no evidence of the species along the transect that was surveyed.

DIADEMA, BARE SUBSTRATE and RECRUITS

The presence and abundance of herbivorous organisms such as fish and invertebrate grazers can influence coral recruitment by ensuring that bare substrate is available for settlement by coral polyps[5]. In areas where the numbers of herbivores and grazers have been reduced

[5] Edmunds, P.J. and R.C. Carpenter (2001) Recovery of Diadema antillarum reduces macroalgal cover and increases abundance of juvenile corals on a Caribbean reef. Proceedings of the National Academy of Science USA. 98(9): 5067-5071

recovery of coral communities have been compromised[6]. The data has indicated that the average abundance of herbivorous fish was 1,185.2g/100m^2; this average is unlikely to have exerted significant grazing pressure on algae.

When assessed according to location, the data exhibited a relationship between the urchin density and total percentage cover of bare substrate (Figure 2). The classification of bare substrate included rock, rubble and recently killed coral which had little or no algal growth and would therefore facilitate the settlement of coral polyps. The Sewage End reef site exhibited the highest urchin density of 4.4 urchins/m^2 and the highest percentage bare substrate of 57.5%. This direct relationship was only noted on two other sites; Channel Edge reef site and Dickies Reef.

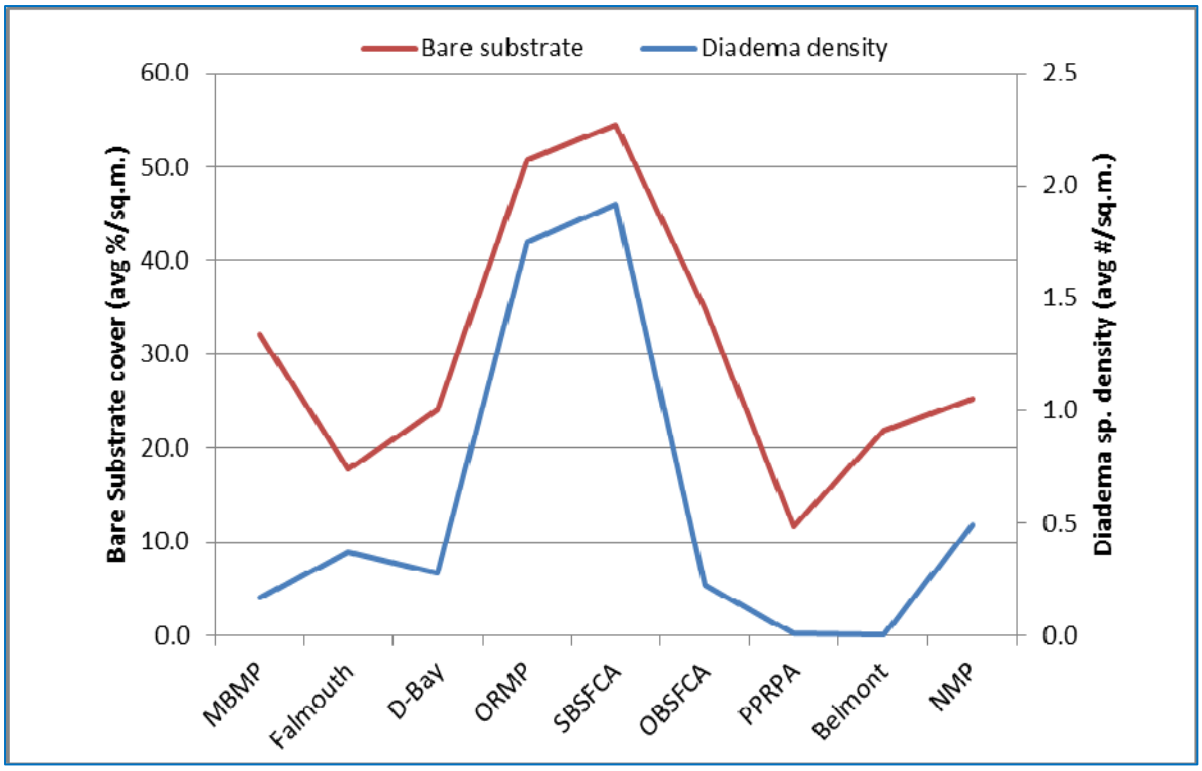

Figure 2: Relationship between percentage bare substrate and *Diadema* sp. density

The density of coral recruitment was generally low across all sites and further analysis of the data revealed no direct relationship between bare substrate coverage and the recorded densities for coral recruitment (Appendix III). The highest density recorded was 4 recruits/m^2 on the Lime Cay reef site; this was also the only site which recorded a grade of "fair" for this index.

[6] NEPA (2013) Coral Reefs of Jamaica: Reef Status and Trends 2012. Ecosystems Management Branch, National Environment and Planning Agency. 22 pp.

Coral recruitment is heavily dependent on circulation patterns and currents. The calculated recruitment densities indicate that regardless of the presence of suitable substrate for settlement, the sites were not resilient and did not display the ability to quickly rebound from large-scale disturbances.

CONCLUSIONS

The report card generated indicates that like the 2012 report, the reefs assessed are in poor condition. The data highlights that the harvesting of commercially important fish species and herbivorous fish continue to have a negative impact on the ability of reefs to remain healthy and resilient. Individual analyses of the values generated for each index shows that there have been mixed success at managing the marine environment (Table 3). We note that the average hard coral percentage cover was recorded at 20.3% and 28.3% for macro-algae. These percentages imply that one of every five data-point recorded during the point intercept assessment was either coral or algae. Together they accounted for approximately 50% of the data points recorded. While these figures are encouraging is should be tempered with the caution that these are snapshot values of discreet moments in time. An analysis of the trends over time will be useful to track progress, map areas and identify where greater efforts should be concentrated to improve management effectiveness.

Table 3: Country CRHI Report Card as calculated from overall indices

	INDICES					
	HC (%/100m^2)	**Recruits** (#/m^2)	**NIA** (%/100m^2)	**Herbivorous fish** (g/100m^2)	**Commercial fish** (g/100m^2)	**Diadema** (#/m^2)
VALUE (avg)	20.3	0.5	28.3	1,185.2	155.8	0.6
SCORE	4	1	3	1	1	3
CRHI (overall average)	**2.1 = POOR**					

Although the data collected offer time-specific snapshot values the calculated index provides a strong argument for prolonged management. The negligible positive changes noted on sites and more generally across locations are noteworthy. The positive changes highlighted are however not enough as they are not yet at the tipping point to effect an overall positive change.

RECOMMENDATIONS

Of the variables assessed, management initiatives such as enforcement and monitoring only have a direct impact on the abundance of fish. Positive changes in the other indices such as hard coral cover and macro-algal cover are influenced by several variables including land-based activities, natural disturbances, pollution and the abundance and diversity of key herbivore species.

Future Assessments

- ✓ Conduct trend analyses on coral and algae percentages.
- ✓ Identify refugia and investigate the connectivity of refugia across sites and locations.
- ✓ Identify specific indicators related to diversity and connectivity.

Climate change has the potential to disrupt societies and ecological communities however ecological resilience can play an important role in fisheries, water quality, coastal hazards mitigation, and other marine management goals[7]. There are approaches that can enhance the resilience of the communities and ecosystems. To effect tangible changes in ecosystem resilience requires the implementation of location specific management initiatives and actions. These approaches should account for the real impacts of climate change and provide the best possible outcomes for both the ecosystems and stakeholders/resource users[8]. Approaches to be considered include:

Coral reef fisheries management

1. Adaptive management (monitoring and enforcement) of all special fishery conservation areas to determine location specific trends and in due course include climate change adaptations in fisheries management such as diversification of livelihoods and the targeting of non-reef based fish.

2. Enforce designated no-take zones in marine protected areas.

3. Fishery stock assessment to inform on the status of the commercial fishing industry with a view to implement management and conservation strategies/models which reflect changing climate conditions. Attributes related to diversity (changes in species composition), connectivity (changes in primary productivity and larval dispersion), and adaptive capacity (ability to rebound from stress) should be investigated[9].

[7] Glazer, R. (2013) Alternative Futures under Climate Change for the Florida Key's Benthic and Coral Systems. Final Report - State Wildlife Grant FWC 6242

[8] Marine Ecosystems and Management. Vol.7, No.4, April - May 2014

[9] Bernhardt, J.R. and H.M. Leslie (2013) Resilience to Climate Change in Coastal Marine Ecosystems. Annual Review of Marine Science. 5: 371 - 392

4. Manage fishing effort by incorporating pertinent aspects of the International Coral Reef Initiative (ICRI) recommendation from General Meeting 28 known as the "*Recommendation on addressing the decline in coral reef health throughout the wider Caribbean: the taking of parrotfish and similar herbivores*".

> **Accordingly, the International Coral Reef Initiative urges Nations and multi-lateral groupings of the wider Caribbean to:**
>
> 1. ***Adopt*** conservation and fisheries management strategies that lead to the restoration of parrotfish populations and so restore the balance between algae and coral that characterises healthy coral reefs;
> 2. ***Maximise*** the effect of those management strategies by incorporating necessary resources for outreach, compliance, enforcement and the examination of alternative livelihoods for those that may be affected by restrictions on the take of parrotfish;
> 3. ***Consider*** listing the parrotfish in the Annexes of the SPAW Protocol (Annex II or III) in addition to highlighting the issue of reef herbivory in relevant Caribbean fisheries fora;
> 4. ***Engage*** with indigenous and local communities and other stakeholders to communicate the benefits of such strategies for coral reef ecosystems, the replenishment of fisheries stocks and communities' economy.
>
> Annex: *Executive Summary – Status and Trends of Caribbean Coral Reefs; 1970-2012, GCRMN Report*

Develop adaptation strategies and scenarios

5. Investigate how fishing effort will change in response to changing climatic conditions in an effort to predict how people will behave and the impacts on the commercial fishing industry.

6. Investigate the cumulative impacts of coastal development on coastal ecosystems and limit coastal development. This will ultimately allow for the inland migration of wetlands, thereby protecting key habitats that serve as nurseries.

APPENDICES

APPENDIX I – Site specific Coral Reef Health Index

LOCATION / SITE NAME		INDICES		CORAL REEF HEALTH INDEX
		CORAL INDEX	REEF BIOTA INDEX	
Montego Bay Marine Park	Airport Reef West	2.5	1.8	**2.2**
	Classroom Reef	2.5	1.5	**2.0**
	Sergeant Major	2.5	1.8	**2.2**
	Sunset Beach Mooring	2.0	1.5	**1.8**
Falmouth	Oyster Bay	2.5	1.8	**2.2**
	Relocation Site 1	2.5	1.5	**2.0**
	Relocation Site 3	2.5	1.3	**1.9**
Discovery Bay	Dairy Bull	2.5	1.8	**2.2**
	Pear Tree Bottom	2.0	1.3	**1.7**
Ocho Rios Marine Park	Dickies Reef	2.5	2.0	**2.3**
	Dunns River	2.0	1.5	**1.8**
	RIU Nursery	1.5	1.8	**1.7**
	Sewage End	2.5	2.3	**2.4**
Sandals Boscobel Special Fishery Conservation Area	Channel Edge	2.5	2.0	**2.3**
Oracabessa Bay Special Fishery Conservation Area	Golden Eye Beach Bar	1.5	1.3	**1.4**
	Outer Bank	2.5	1.5	**2.0**
	Rock Edge	1.5	1.3	**1.4**
Palisadoes-Port Royal Protected Area	Drunkenman's Cay	3.0	3.0	**3.0**
	Lime Cay	3.0	1.5	**2.3**
Belmont, Westmoreland	Peter Tosh Reef	2.5	2.5	**2.5**
Negril Marine Park	Bloody Bay	1.5	2.3	**1.9**
	El Punto Negrilo	2.5	2.0	**2.3**
	Little Bay	2.5	1.8	**2.2**

APPENDIX II – Summary data for coral and reef biota

LOCATION / SITE NAME		CORAL INDEX		REEF BIOTA INDEX			
		HC (%/100m^2)	Recruits (#/m^2)	NIA (%/100m^2)	Herbivorous fish (g/100m^2)	Commercial fish (g/100m^2)	Diadema (#/m^2)
Montego Bay Marine Park	Airport Reef West	28.8	0.5	18.1	958.6	306.9	0.5
	Classroom Reef	23.1	0.0	40.0	1,947.8	41.8	0.0
	Sergeant Major	27.5	0.0	25.6	1,342.3	36.5	0.1
	Sunset Beach Mooring	16.3	0.0	40.6	1,871.4	171.9	0.0
Falmouth	Oyster Bay	24.4	1.8	18.1	803.5	97.9	1.1
	Relocation Site 1	25.0	0.8	47.5	1,752.1	63.3	0.0
	Relocation Site 3	19.4	2.0	47.5	894.8	43.3	0.0
Discovery Bay	Dairy Bull	21.9	0.0	35.6	1,249.8	116.4	0.4
	Pear Tree Bottom	19.4	0.3	45.0	946.0	0.0	0.2
Ocho Rios Marine Park	Dickies Reef	26.9	0.0	3.8	602.4	23.0	1.7
	Dunns River	10.6	0.0	21.9	673.5	0.0	0.7
	RIU Nursery	5.6	0.0	39.4	1,510.1	54.2	0.1
	Sewage End	33.8	0.0	1.9	159.5	10.9	4.4
Sandals Boscobel Special Fishery Conservation Area	Channel Edge	36.9	0.0	8.1	147.8	3.8	1.9
Oracabessa Bay Special Fishery Conservation Area	Golden Eye Beach Bar	5.6	0.3	42.5	1,192.3	68.5	0.1
	Outer Bank	27.5	0.0	21.9	509.5	266.0	0.5
	Rock Edge	8.8	0.0	48.8	1,052.1	104.2	0.0
Palisadoes Port Royal Protected Area	Drunkenman's Cay	23.1	2.3	3.1	no data	no data	0.0
	Lime Cay	10.6	4.0	41.3	no data	no data	0.0
Belmont, Westmoreland	Peter Tosh Reef	22.5	0.0	15.0	no data	no data	0.0
Negril Marine Park	Bloody Bay	8.8	0.0	40.0	2,467.4	1,654.5	0.3
	El Punto Negrilo	20.6	0.8	18.8	1,982.8	30.2	1.1
	Little Bay	20.0	0.0	27.5	1,640.9	23.3	0.0

NB: Based on the index, deselected values indicate a classification of good to very good.

APPENDIX III – Location summary data highlighting the relationship across the variables average recruit abundance, average Diadema *sp. abundance and average bare substrate percentage cover.*

LOCATION	BARE SUBSTRATE (%/100m^2)	RECRUIT ABUNDANCE (#/m^2)	DIADEMA DENSITY (#/m^2)
Montego Bay Marine Park	32.0	0.1	0.2
Falmouth	17.7	1.5	0.4
Discovery Bay	24.1	0.1	0.3
Ocho Rios Marine Park	50.8	0.0	1.8
Sandals Boscobel Special Fishery Conservation Area	54.4	0.0	1.9
Oracabessa Bay Special Fishery Conservation Area	34.8	0.1	0.2
Palisadoes-Port Royal Protected Area	11.6	3.1	0.0
Belmont, Westmoreland	21.9	0.0	0.0
Negril Marine Park	25.2	0.3	0.5

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JCRMN volunteers:- Hugh Small (Port Royal Marine Laboratory), Camilo Trench (Discovery Bay Marine Laboratory).