



FEASIBILITYASSESSMENT

Fish Sanctuary Assessment for the Portland Bight Protected Area
Dr. Donovan Campbell | August 2018

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Acronyms

AGRRA	Atlantic and Gulf Rapid Reef Assessment
C-CAM	Caribbean Coastal Area Management (Foundation)
IUCN	The World Conservation Union (formally The International Union for Conservation of Nature)
CCCCC	Caribbean Community Climate Change Centre
KfW	Kreditanstalt für Wiederaufbau
MPA	Marine Protected Area
NEPA	National Environment and Planning Agency
PBPA	Portland Bight Protected Area
RHI	Reef Health Index
SFCA	Special Fishery Conservation Area

Introduction

Purpose of Study

The Purpose of this Consultancy is to support the Caribbean Coastal Area Management (C-CAM) Foundation in their larger project entitled “*Climate Change Adaptation in the Portland Bight Protected Area, Jamaica*”, a project funded by the Caribbean Community Climate Change Centre (CCCCC) with support from Kreditanstalt für Wiederaufbau (KfW) Bank. The Specific Objectives of this consultancy are to:

1. Evaluate the top three potential sites to determine the priority of for intervention
2. Conduct a socio-economic assessment in the highest priority site
3. Carry out a feasibility assessment of the site (using the results of the socio-economic and biophysical assessments)

This document presents the findings of Objective #3, the Feasibility Assessment, including summaries of the Socio-economic Assessment (Objective #2) and the Biophysical Assessment (conducted by Dr. Suzanne Palmer).

Site Selection Process

Three sites within the Portland Bight Protected Area (PBPA) were considered for additional protection status, namely the Portland Cays, Pigeon and Pelican Islands, and North-central West Harbour (Figure 1).



Figure 1: Site identified for protection status within the PBPA, namely (1) Pigeon and Pelican Cays (2) Portland Cays and (3) North-Central West Harbour.

In order to identify the site for the Feasibility Assessment a selection criteria list was developed through review of national guidelines, and with input from local expertise (see Table 1). The criteria list was then used by the Consultants and the Caribbean Coastal Area Management (C-CAM) Foundation as a guiding document to rank and determine which site would be best suited for additional protection status. Each criteria was examined and compared with respect to the proposed sites, and their relative scores for each category recorded, to provide an overall ranking. At the end of the exercise the Pigeon and Pelican Cay site was identified to be the best option (followed by Portland Cays and then West Harbour).

Table 1: Selection criteria list (grouped into 3 main categories) used to aid in site selection exercise

Ecological and Physical	Socio-Economic	Management
(1) Coral reef presence; (2) Reef fish and associated species presence; (3) Associated with adjoining mangrove growth; (4) Seagrass present; (5) Dominant habitat; (6) Relatively unpolluted (7) Depth; (8) Should be a minimum area of 10 km ² (estimate modifiable).	(9) Absence of substantial development in close proximity; (10) Should not cause massive of large numbers of fishers; (11) Should take into consideration fishing practices (time of fishing, species caught); (12) Should have significant support from adjoining community	(13) Should not have significant boating traffic through the area; (14) Associated & operated by a functioning NGO; (15) Should have minimum 5 years funding; (16) Should have relatively easy patrolling access; (17) Does it add to the variety of sanctuaries in the C-CAM area?

Site Information

The Pelican and Pigeon Cays lie south of Old Harbour at 17.800007°, -77.015277° and 17.796311°, -77.074060° respectively. The cays fall within the PBPA and have historically and currently, played an important role in fisheries (as layover points, and as fishing grounds through its associated reefs) and recreation.



Figure 2: Location of important cays included in study. Image also shows existing SFCAs.

Big Pelican Cay lies to the eastern side of the Portland Bight and is a sandy cay, wooded with beach rock on its lee side (Stoddart & Lofthouse, 1940). Stoddart & Lofthouse (1940) documented well-developed mangrove stands (*Avicennia*) to the northern end and evidence of *Rhizophora* seedlings to the southern windward side. The fore reef reefs lie to the southern windward side and extend eastwards.

Little Pelican Cay was originally described as a simple small island with beach-rock zones on the southern-western side and with a small reef (Stoddart & Lofthouse, 1940). Over recent decades the cay has eroded leaving very little visible cay above sea level. Today there are patches of coral colonies and extensive seagrass beds surrounding the cay.

Pigeon Island is different to other part of the cays and was described as a mangrove island with ridges of coarse coral shingle and mangroves around, and dense thickets of trees and brushwood to the western end (Stoddart & Lofthouse, 1940). There is an extensive central salt water lagoon to the island which has been previously been used for local salt industries. Recent projects on the island include extensive planting of coconut and other fruit trees. The island is used by recreational fishermen and yacht clubs, plus by local fishermen as a camping base whilst en route to the southern cays. Today the most extensive reefs

development is to the east of the island, and patchier reef development to the south, south-western, and northern parts of the island.

'Pigican' or Dry Shoal is a submerged ridge formed by shallow coral reef formations that extend eastward toward Big and Little Pelican Cays. It is separated from Pigeon Islands by a deeper channel. Pigican Shoal is sometimes frequented for recreational and fishing purposes.

Methodology

This Feasibility Assessment was conducted by reviewing data from a wide range of local and scientific sources. Below outlines the various methodologies employed:

Literature Review: A large amount of secondary data was reviewed and compiled from academic, reports and other grey sources to provide background and guidance for the assessment. This review can be sourced as a separate report.

Expert Knowledge: One (1) technical team meeting was held between the Consultants, representatives from the C-CAM Foundation, and expert scientists in the field of fisheries and good local knowledge of the PBPA. Two (2) Stakeholder Sessions were hosted by C-CAM with attendees from local communities, governmental representatives (National Environment and Planning Agency, NEPA) and scientists. In addition to these, multiple meetings were held between the Consultants to discuss approaches and findings.

Socio-Economic Surveys: A total of 219 fishers were interviewed from Mitchell Town (35), Old Harbour Bay (73), Salt River (41), Rocky Point (30), and Portland Cottage (40), capturing information on the social demographics of the area, attitudes and perceptions of the SFCAs, fisheries in the area and the need for new conservation zones.

Atlantic and Gulf Rapid Reef Assessment (AGRRA) Surveys: Five (5) survey sites (Figure 3) around and between Pigeon Island and Pelican Cay were assessed using AGRRA's Benthic (40 transects total) and Fish (45 transects total) Protocols. Results from the transects were reviewed and produced by AGRRA's online Data Analyst. Please see Appendices for more detailed information on Biophysical methodology and results.

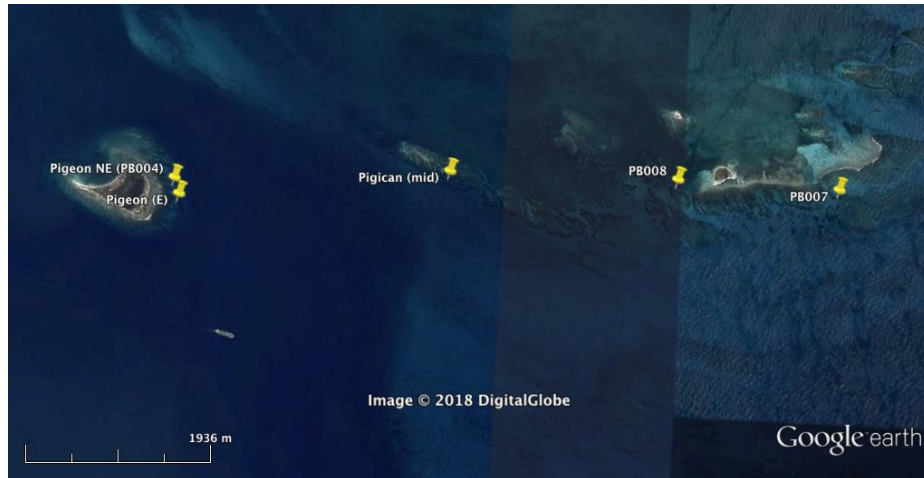


Figure 3 Location of AGRRA survey sites within the Selected Area For the Feasibility Study, Portland Bight Protected Area, Jamaica. Source: Google earth.

Note that for the Socio-Economic assessment, sites were broken down into (i) Pigeon Island, (ii) Big Pelican Cay and (iii) Little Pelican Cay, based on the social constructs or perceived separation of sites by fishers. Whereas for the Biophysical assessment, sites were broken down into (i) Pigeon Island, (ii) Big Pelican Cay and (iii) Pigican Shoal, based on the physical or ecological distinctions between sites.

Baseline Study Results

Socio-Economic

The below results are broken down either by:

- Overall results for the entire survey group, across all communities
- Community profiles: (Mitchell Town, Old Harbour, Portland Cottage, Rocky Point, and Salt River)
- Fishing method: (Fish Pot, Spear, Hook-and-Line, Net, Two Methods, Three Methods, Four Methods)

Socio-Demographic Characteristics

Most fishers (92%) considered themselves to be the heads of their household. The average number of dependents across all fisher communities and groups was three persons. Within the data set, ages ranged from 16 to 81 years old, with the average age being 46 years. Fishers with the highest average age of 56 used 'Fish Pots', while fishers with the lowest average age of 36 used a 'Spear' while fishing.

Table 2: Socio-demographic characteristics of surveyed fishers based on associated community

Community Profiles: Socio-Demographic Characteristics*					
	Mitchell Town	Old Harbour	Portland Cottage	Rocky Point	Salt River

Household Size (#)	4	4	4	4	5
Age (yrs)	48	44	50	50	43

* Characteristics listed are average

On average, most fishers had a secondary level education, and this group was dominated by ‘Spear’ or ‘Hook-and-Line’ fishers. Those fishers with no formal education (3%) mainly used fish pot and a combination of two methods; those who had post-secondary education (2%) used a spear, hook and line; those fishers who attended up to primary school level used all four methods.

Fishing Activities

Fishing Employment

Most fishers (76%) considered themselves to be working full time as fishers (with the remaining percent being considered as part-time). Some part-time fishers had indicated that they do engage in other activities, such as farming and shopkeeping.

Table 3: Fishing employment characteristics by community

Community Profiles: Fishing Activity Characteristics*					
	Mitchell Town	Old Harbour	Portland Cottage	Rocky Point	Salt River
Full-time fishers (%)	57	94	64	90	76
<5 years fishing (%)	3	8	15	3	15
5-10 years fishing (%)	29	8	13	7	13
>10 years fishing (%)	69	84	73	90	74

After reviewing each fishing group, all fishers who utilize all ‘Four Methods’ fish on a full-time basis (100%). This is followed by ‘Three Methods’ (93%), ‘Net’ (92%), ‘Two Methods’ (86%), ‘Fish Pot’ (79%), ‘Spear’ (65%), ‘Hook and Line’ (50%).

Fishing Methods

Fishers in the study predominantly (64%) employ a single fishing method. Of these fishers 18% are ‘Spear’ fishers, 21% are ‘Net’ fishers, 13% are ‘Fish Pot’ fishers and 13% are ‘Hook-and-Line’ fishers. The remaining 36% combine up to ‘Four Methods’; 27% combine ‘Two Methods’, 7% combine ‘Three Methods’ and 2% employ all ‘Four Methods’.

The majority of fishers (71%) tend to fish 3-6 days/week. Only 11% fish 7 days/ week and 18% 1-2 days per week. ‘Pot’ fishers were more likely to report that they fish 1-2 days per week spending on average

between 0-10 hours per trip. 'Spear' fishers tend to fish more often than other groups of fishers with 65% of spear fishers reporting that they go to 5-7 days/week. Most 'Spear' fishers spend 0-10 hours at sea per trip. The number of fishing methods employed is not associated with changes in number of fishing days or the length of time spent fishing ($p=0.540$ and $p=0.728$ respectively).

More than half of the fishers (54%), complete their fishing trips during the day. Older more experienced fishers tend to fish at nights while younger less experienced fishers fish during the day and night. Only 11% of 'Pot' and 33% of 'Spear' fishers fish at night. 'Net' fishers are more likely to fish at nights with 58% of these fishers fishing only at night or fish during the day and night. Fishers who combine multiple fishing methods were more likely to fish during the day and nights.

Most fishers (58%), do not own their own boat, and more than half of these hire a boat for their fishing. 'Pot' fishers and fishers who use multiple fishing methods generally own boats, while 78% of 'Spear' fishers, 70% of 'Hook-and-line' fishers and 67% of 'Net' fishers do not own their boat. The majority of boats being used are fibre glass and engine boats, however 13% of the fishers utilize traditional wooden canoes to fish. Of these fishers, 26% are 'Hook-and-line' fishers, 22% are 'Pot' fishers and 18% are 'Spear' fishers.

Targeted Species

Snapper and Parrotfish were the two main species being targeted, however Grunts, Jacks, Doctorfish, Lobster, Mullet, Wenchman, Shad and Mackaback were all species that were targeted to some degree.

Table 4: Primary species targeted by different fishing method groups

Fishing Group Profiles: Primary Targeted Species Characteristics*						
	Fish Pot	Hook-and-Line	Net	Spear	2 methods	3 methods
Snapper (%)	51	83	58	40	56	40
Parrotfish (%)	17	-	-	46	15	27
Lobster (%)	-	-	-	-	-	13

Table 5: Overall species targeted by different fishing method groups

Fishing Group Profiles: Targeted Species Characteristics*				
	Fish Pot	Hook-and-Line	Net	Spear
Snapper (%)	58	83	58	40
Grunt (%)	21	30	23	28
Parrotfish (%)	28	-	-	46
Jack (%)	21	33	-	-
Doctorfish (%)	21	-	-	25
Mullet (%)	-	16	-	-

Welchman (%)	21	-	-	-
Shad (%)	-	-	15	-
'Mackaback' (%)	-	-	17	-

Table 6: Primary species targeted by different communities

Community Profiles: Primary Targeted Species Characteristics*					
	Mitchell Town	Old Harbour	Portland Cottage	Rocky Point	Salt River
Snapper (%)	66	61	32	43	55
Parrotfish (%)	31	12	20	13	26
Lobster (%)	-	-	-	17	-
Grunt (%)	-	-	12	-	-

Fishing Expenditures

Fishers from the survey spend between JMD \$6,439 to \$14,934 per trip. On average they spend JMD \$11,382 per trip, with 'Spear' fishers spending the least average per trip and 'Pot' fishers spending the most.

Fishing Activities at Pigeon Island & Pelican Cays

The origin of fishers who use Pigeon Island, Big Pelican Cay and Little Pelican Cay vary. As fishing grounds they are most important to fishers from Salt River and Old Harbour Bay, and least important to Mitchell Town. The profiles of the fishing practices at each location are similar, with only small variances.

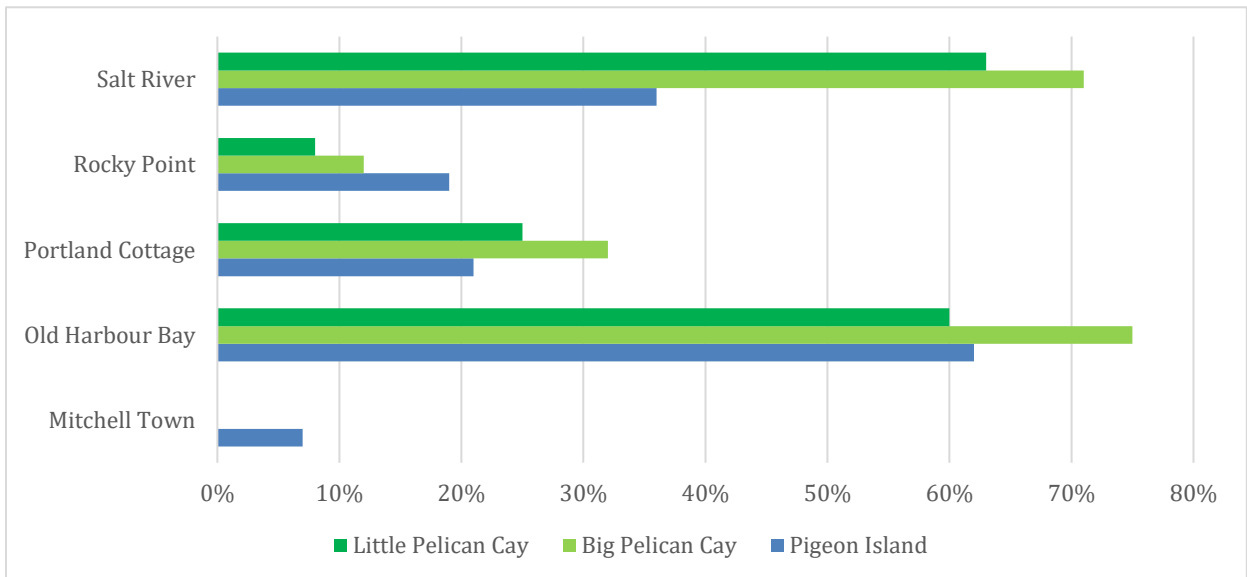


Figure 4: Fishing activity (pressure) at selected sites, based on associated community

Table 7: Fishing activity profiles for Pigeon Island, Big and Little Pelican Cay

	Pigeon Island	Big Pelican Cay	Little Pelican Cay
Fishing method	'Spear' and 'Net'	'Spear' and 'Net'	'Net' and '2 or more'
Average no. of years fishing in the area	18 yrs	17 years	17 years
Duration of average fishing trip	0-10 hours	0-10 hours	0-10 hours
Average frequency of fishing trips	3-6 dys / week	3-6 dys / week	3-6 dys / week
Prevalence of night fishing	47%	47%	46%
Primary targeted species	Snapper (73%)	Snapper (78%)	Snapper (65%)
Other targeted species	Parrotfish, Grunt, Doctorfish, Jack	Parrotfish, Grunt, Doctorfish, Jack	Parrotfish, Grunt,

Perceptions & Attitudes

Changes in fishing

Most fishers (73%) report a decline in the amount of fish catches in the area since they started fishing. Fishers from Portland Cottage were most likely to report declines in catches, while some fishers (43%) from Mitchell Town reported no change in the amount of fish being caught.

Special Fishery Conservation Areas

Only 19% of fishers were unaware of the existing Special Fishery Conservation Areas (SFCAs). The majority of these came from the group of 'Hook-and-line' fishers (40% of this group were unaware of the SFCAs), and from fishers from Mitchell Town, Rocky Point and Portland Cottage. Over half the fishers from Rocky Point, 26% from Mitchell Town and 28% from Rocky Point indicated that they are unaware of the sanctuaries in the Portland Bight protected area.

Most fishers believed that the existing SFCAs are working. Only 9% of fishers, most of which are 'Hook-and-line' fishers, do not believe the SFCAs are working. Of note is that 23% of fishers who are unsure as to whether the SFCAs are working. Only 10% of fishers are unaware of the rules and regulations of the SFCAs, mostly coming from Portland Cottage and Rocky Point.

Most fishers (61%) are satisfied with the enforcement of the SFCAs. Rocky Point and Old Harbour Bay fishers had the highest percentages of fishers who did not believe that the enforcement was adequate. Less than half of respondents (49%), believe that fishers adhere to the rules and regulation of the sanctuaries. 'Pot' fishers are more likely to believe that the rules are not being followed by other fishers (41% of 'Pot' fishers do not believe the rules are being followed).

Table 8: Perception of SFCA functioning based on community

Community Profiles: SFCA Perceptions*						
		Mitchell Town	Old Harbour	Portland Cottage	Rocky Point	Salt River
Enforcement is adequate	No (%)	27	32	41	39	21
	Yes (%)	62	53	41	39	42
	Not Sure (%)	12	16	18	23	37
More community management	No (%)	0	4	2	0	0
	Yes (%)	80	67	78	86	91
	Not Sure (%)	20	29	20	14	9
Support for new SFCA in PBPA	No (%)	37	38	20	10	63
	Yes (%)	63	36	65	76	7
	Not Sure (%)	0	26	15	14	30

The majority of fishers interviewed believe that:

- The SFCAs are important for conserving and protecting fish and other marine species (98%)
- Penalties for fishing in the SFCAs should be increased (62%)
- The community should be more involved in the management of the SFCAs (78%)
- Ecotourism (33%) and boat tours (34%) are the best types of tourism for the PBPA
- Are interested in participating in tourism (69%)
- Would support the introduction of a new SFCA (46%)

Fishers are aware of the ecological benefits of the sanctuaries, and most are open to the designation of a new sanctuary in the Portland Bight area. They are however concerned about the negative implications of another protected area on their livelihoods. Getting the community involved in the management of the sanctuaries could increase acceptance of the new sanctuary, educate fishers on the successes of the established sanctuaries, and increase compliance. Introducing tourism, specifically ecotourism should be encouraged to negate possible loss of income from fishing and increase compliance and acceptance of sanctuaries.

Support for Identified Areas

Overall, there was no clear majority on whether or not respondents thought that the identified locations should be protected. In general however, more respondents felt that 'No', the areas did not need to be protected, rather than either 'Yes' or 'Not Sure'.

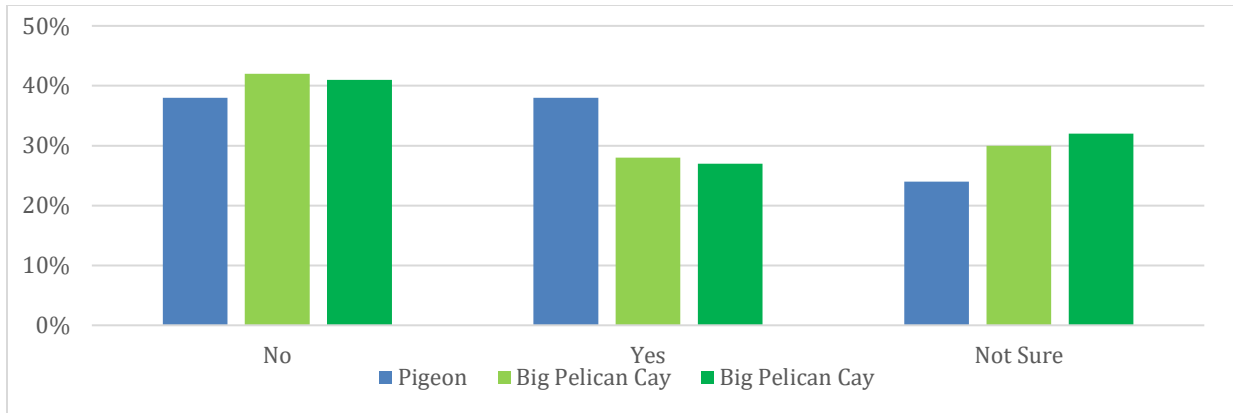


Figure 5: Results from socio-economic survey to determine if participants were interested in protecting areas of interest. N.B. the significant amount of respondents who were 'Not Sure'

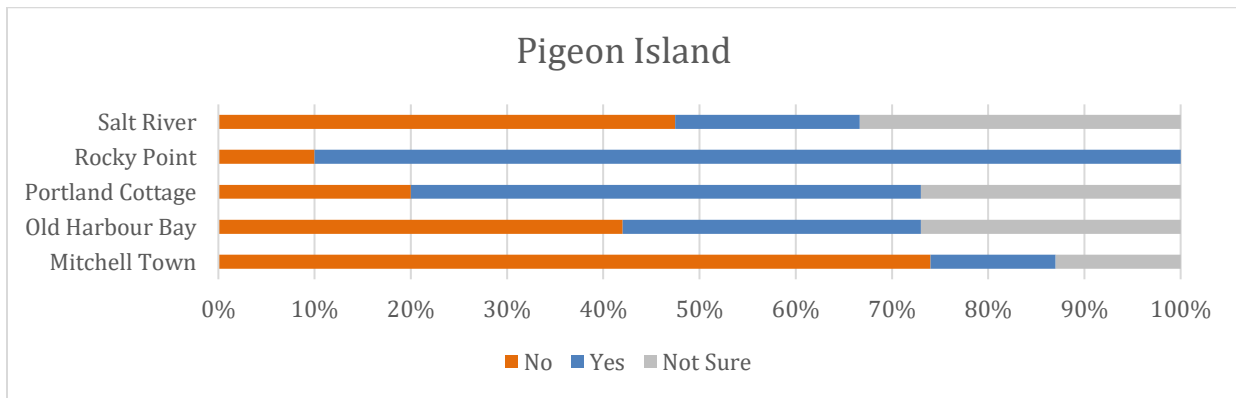


Figure 6: Support for the protection of fishing grounds around Pigeon Island based on respondents' associated community.

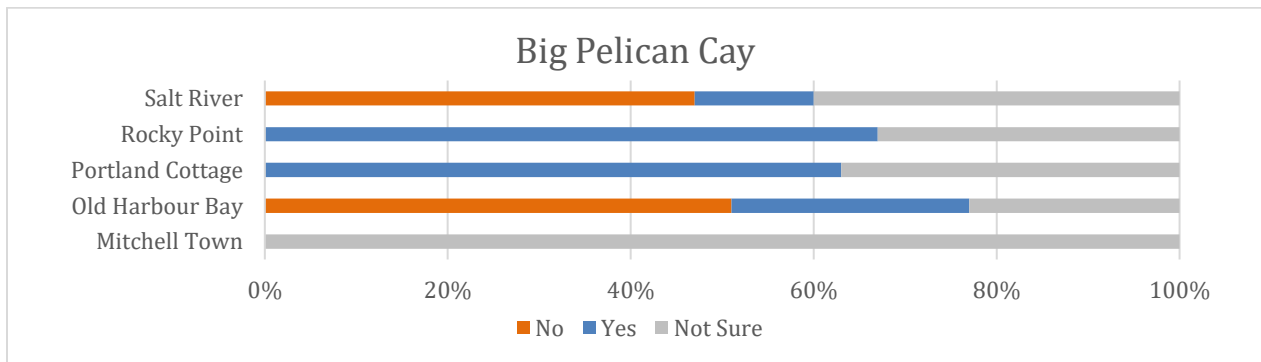


Figure 7: Support for the protection of fishing grounds around Big Pelican Cay based on respondents' associated community.

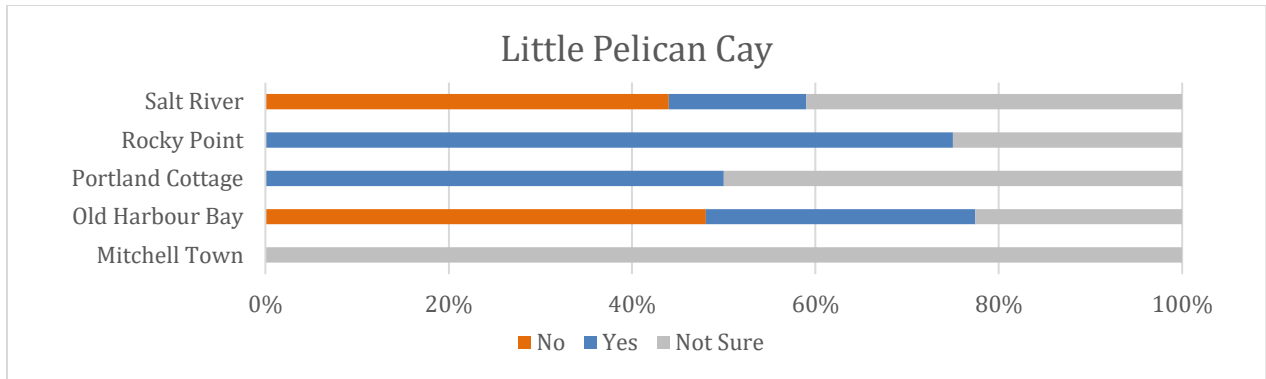


Figure 8: Support for the protection of fishing grounds around Little Pelican Cay based on respondents' associated community.

When looking at protection need based on fishing method groups, it is interesting to note that majority of 'Spear' and 'Net' fishers – those groups who utilize the area the most – indicate that they do not want the area protected. This is even more evident in those fishers who utilize 4 methods or more for fishing.

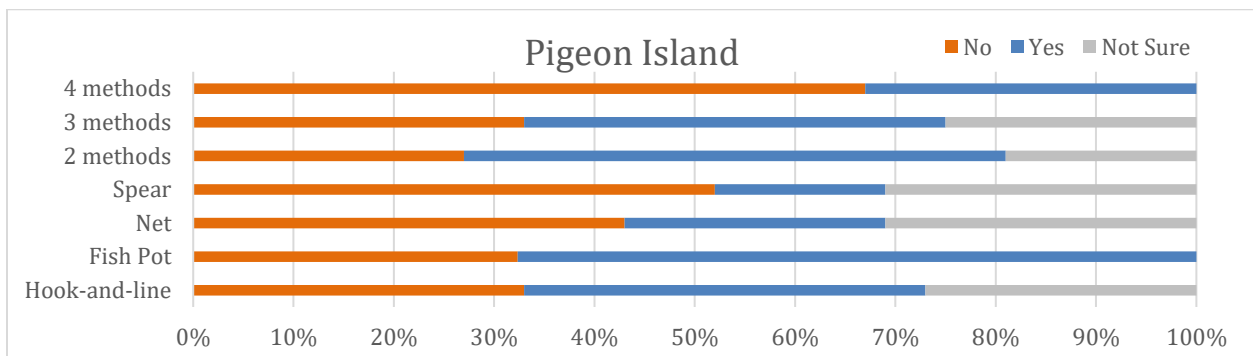


Figure 9: Support for the protection of fishing grounds around Pigeon Island based on respondents' fishing methods.

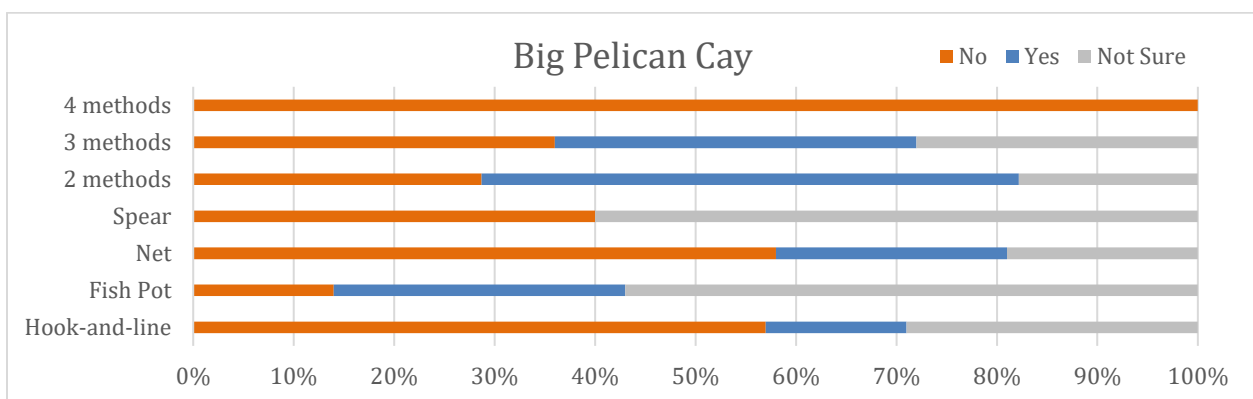


Figure 10: Support for the protection of fishing grounds around Big Pelican Cay based on respondents' fishing methods.

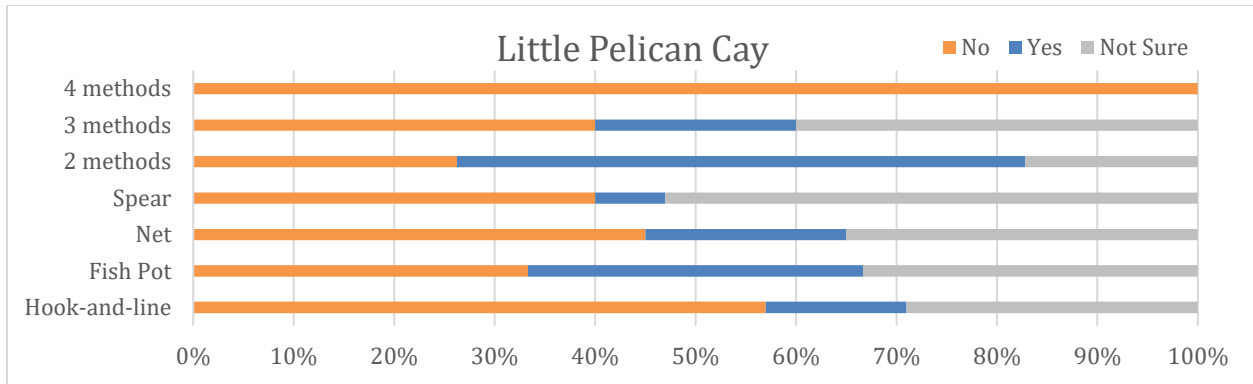


Figure 11: Support for the protection of fishing grounds around Little Pelican Cay based on respondents' fishing methods.

Summary of Socio-Economic Assessment

The specific methods and strategies fishers depend on to make a living are important considerations for establishment of SFCAs. While most fishers in the study area use a single method (spear, pot, net and hook & line) 36 percent use a combination of two or more of these methods. Most fishers (71%) fish 3-6 days per week and spend an average of 5-10 hours at sea per trip. Spear fishers tend to go to sea more often than other groups of fishers with 65% reporting a trip frequency of 5 -7 days/week. Fishers from Portland Cottage and Rocky Point account for the highest frequency of trips per week and are more likely to stay at sea longer; they tend to fish 1-4 days per week on average are more likely to fish for more than 23 hours during these trips. Older fishers (over 50 years) tend to fish at nights while younger fishers operate both day and night. Given these findings, it will be important to design livelihood programmes targeting spear fishers (especially from Portland Cottage and Rocky Point) when establishing the SFCA.

While household characteristics show some degree of similarities, the results demonstrate important differences across the five communities. For example, while fishers in Salt River on average have the largest household sizes (av. 5/household), Rocky Point fishers have the highest number of dependents. There are also important differences according to fishing methods. Analysis of the data revealed that older fishers (over 45 years old) were more likely to use hook & line only or a combination of the four main fishing methods. Unsurprisingly, this group has the lowest number of dependents. Understanding these nuances could help you to anticipate potential downstream impacts and direct trade-offs associated with the establishment of the SFCA.

Two-thirds of the fishers operate on a full-time basis. Fishers in Old Harbour Bay and Rocky Point are more dependent on fishing with 90% of the sample indicating that fishing is their only source of income. Mitchell Town and Salt River have the highest percentage of part-time fishers, with over 40% of the fishers indicating that fishing is not their only source of income. Spear fishers accounted for the highest

proportion (65%) of part-time fishers, while fishers who use more than three methods tend to operate on a full-time basis.

While the average age of the fishers is 46 years (min = 16, max = 81) there are important variations across fishing groups. With age averages of 56 and 51 years respectively, fish pot and hook & line fishers represent the older cohort while spear fishers (average age of 36 years) is the youngest fishing group. Fishers from Rocky Point have the longest history of fishing from their community (average of 31 years) while Salt River fishers averaged the shortest history (20 years). The other communities in the sample averaged 25 years fishing from their community. In terms of education, most of the fishers indicated that they have at least secondary level schooling. Salt River had the highest percentage (12%) of fishers with post-secondary level education and Rocky Point had the highest proportion (10%) with no formal education. There was not much variation in education level across communities. Understanding these basic demographic patterns can help to understand the value system of different groups of fishes and how they feel about the establishment of a new sanctuary.

BioPhysical

Benthic Communities

Coral Cover

The reefs between Pigeon Island and Big Pelican Cay had live coral cover of 16.5% - 20.3% with an overall average from all surveyed sites of 18.5% (1.6 std) (Figure 12). The lowest coral cover was found across Pigeon Island (W) and the highest across Pigeon Island (E). However, across individual reefs coral cover was variable in places. For example, NE sections of Pigeon Island ranged from 8-25% (average 17% std 6.7), and Pigican Shoal ranged from 11-32% (average 19.1% std 6.8).

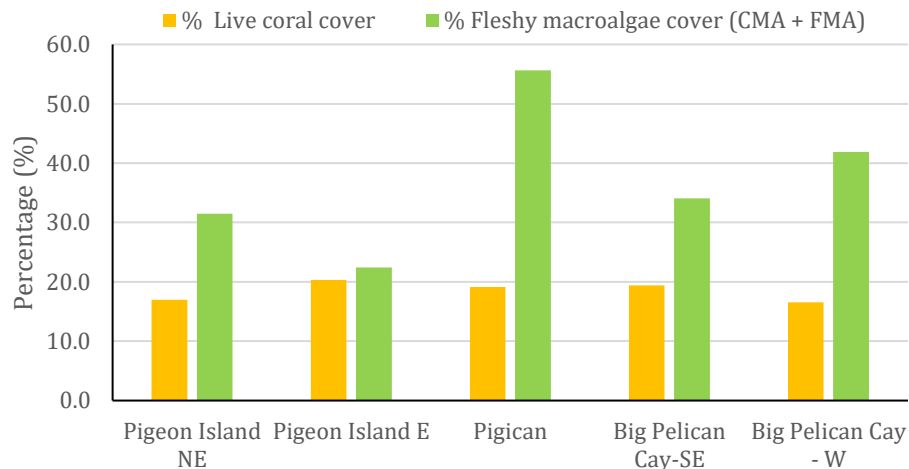


Figure 12 Graph showing the percentage of live coral cover, fleshy + calcareous macroalgae cover across the survey sites. Note that sites are arranged from West (left) to East (Right).

Coral Communities

The coral communities within the PBPA are dominated by *Porites astreoides* and *Agaricia agaricites*. Other notable species include *Orbicella annularis* and *Orbicella faveolata* at Pigeon Island, and *Siderastrea siderea* and *Porites porites* at Pigican Shoal.

Of note are the numerous elkhorn coral (*Acropora palmata*) colonies across Big Pelican Cay (W) (Figure 13). This species is listed by the IUCN Red List of Threatened Species as 'Critically Endangered' (<http://www.iucnredlist.org/details/133006/0>) and therefore their presence in numbers across Big Pelican Cay W is a positive indicator of reef health. It is recommended that these colonies are protected and monitored regularly. The colonies range in size from 20 cm diameter up to 1.5 m diameter growing atop a rubble-dominated spur. The colonies appear relatively healthy although some colonies have evidence of predation and paling.

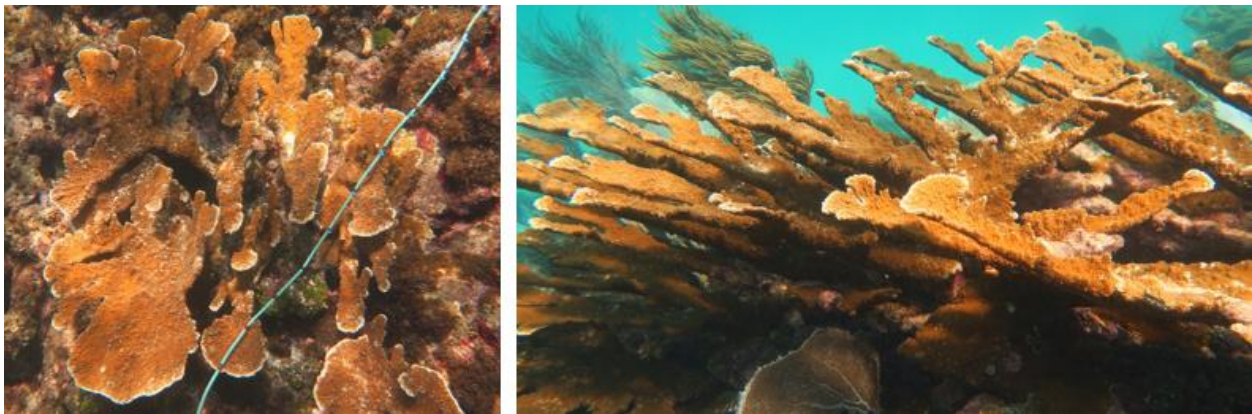


Figure 13: Elkhorn coral (*Acropora palmata*) at Big Pelican Cay West. (Photo:M.Burn, March 2018).

Overall there was no significant evidence of coral disease outbreaks across the surveyed coral colonies and only minor patches of coral bleaching indicating reasonably healthy coral communities.

Coral recruitment is measured as the number of new corals on a reef (Dahlgren, et al., 2016) and provide an insight into the next generation of corals growing on the reef. Specific to the AGRRRA protocol are small recruits (0-2 cm in diameter) and large recruits (2-4 cm in diameter). Between the different reefs the total number of recruits (small + large) was highest across Pigican Shoal (25.9/ m²) and Pigeon Island NE (19.2/ m²) (Figure 14 and Figure 15).

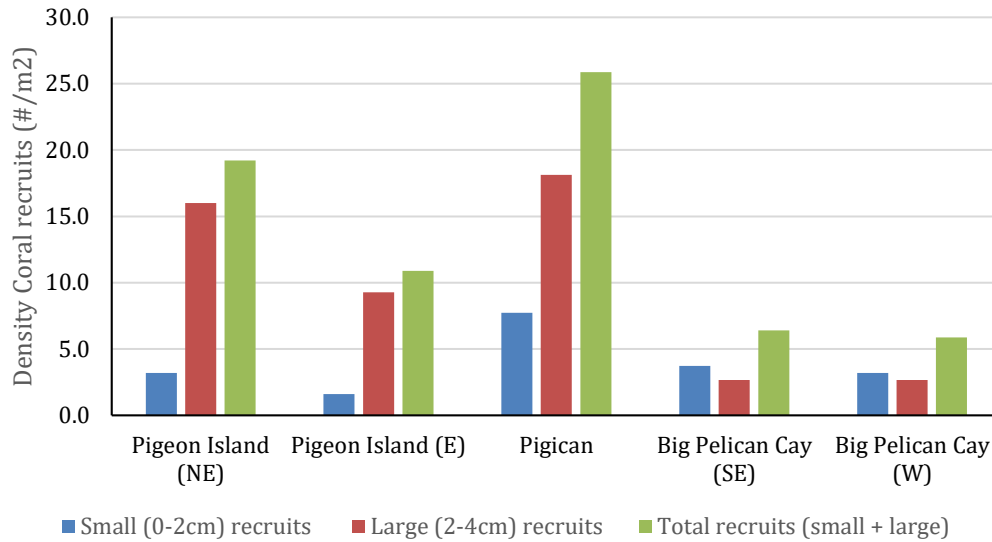


Figure 14 Graph showing the density of coral recruits across the survey sites. Note that sites are arranged from West (left) to East (Right).

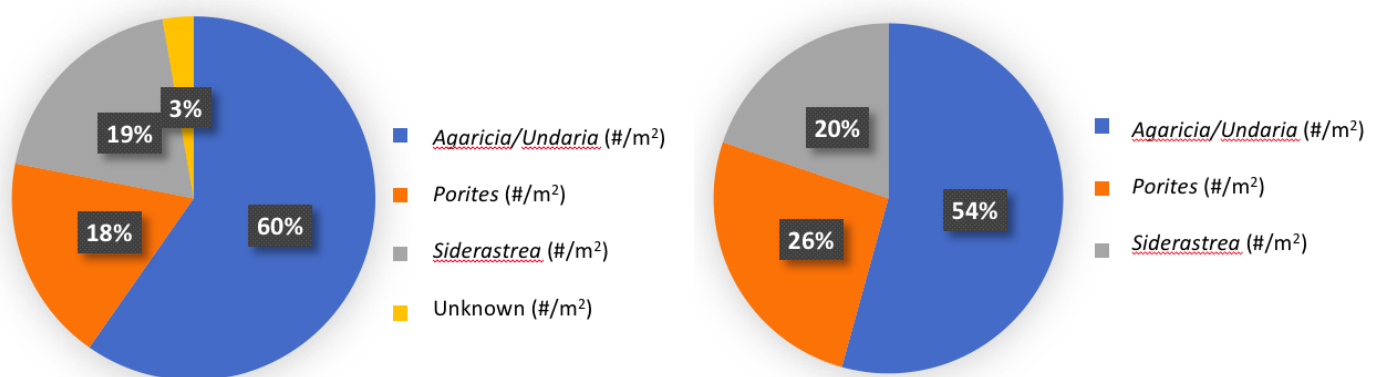


Figure 15 Pie Charts showing the dominant genus of (left) small (0-2CM) coral recruits across all survey sites and; (right) large (2-4CM) coral recruits across all survey sites.

Fleshy Macroalgal Cover

When considering the cover of both fleshy macroalgae (e.g. *Sargassum* sp., *Dictyota* sp.) and calcareous macroalgae (e.g. *Halimeda* sp.) it can be seen that the average cover is 37.1% (std 12.5%), with the highest values found at Pigican Shoal (55.6%) and lowest at Pigeon Island E (22.4%) (Figure 12). The lowest fleshy macroalgae was recorded at Pigeon Island E (2.3%) and lowest calcareous macroalgae at Big Pelican Cay (SW) (12.9%).

Key reef herbivores: *Diadema* and other urchins

Diadema antillarum urchins were recorded at all survey sites, however, in differing densities. The highest densities were recorded at Pigeon Island (E) (0.68/ m²) and lowest densities across Big Pelican Cay W)

(0.03/ m²) (Figure 16). Other urchins which contribute to grazing of algae, predominantly *Echinometra* sp., were recorded at all sites with densities ranging from 0.07-0.89/ m².

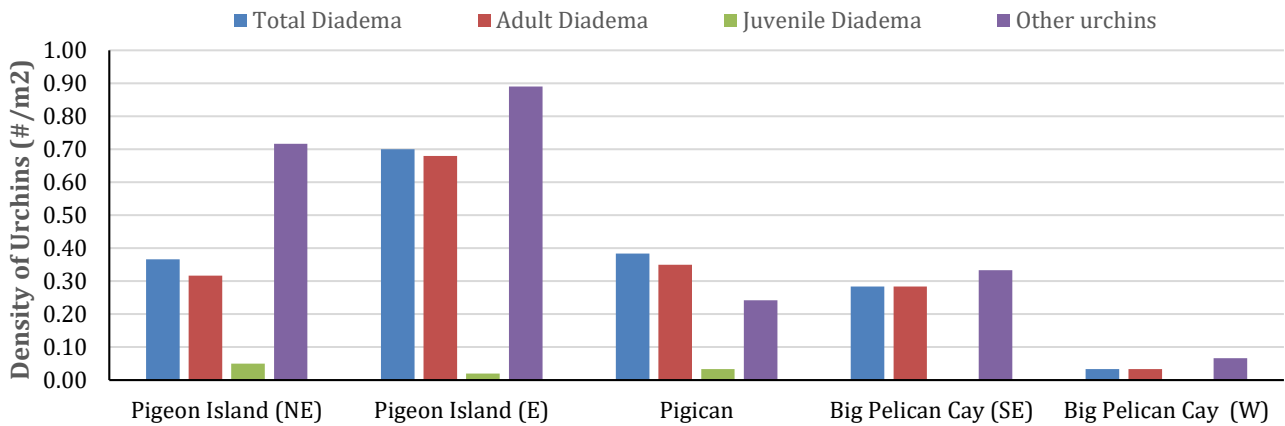


Figure 16 Bar chart showing the densities of urchins at each reef site.

When the 2014 and 2018 datasets are compared it can be seen that for *Diadema antillarum* urchins there has been an increase in the densities across Pigeon Island (0.14 to 0.70/ m²) and Pigican Shoal (0.01 to 0.3 /m²), whereas sites to the east around Big Pelican Cay have seen a decline (Big Pelican SE 0.55 – 0.28/ m² and Big Pelican W 0.14 – 0.03/ m²) (Figure 17). In comparison there have been no marked changes in other urchins (notably *Echinometra* sp.) across all surveyed sites (Figure 17).

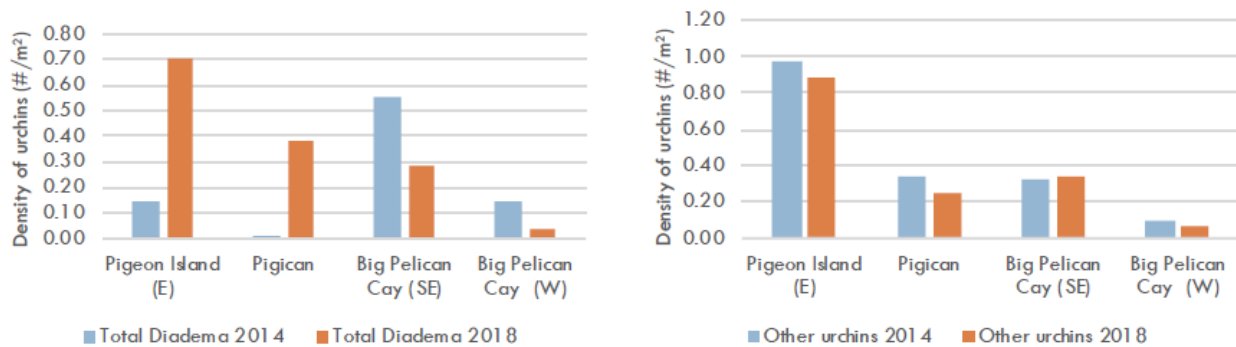


Figure 17: Graphs showing the total *Diadema* densities at each survey site for 2014 and 2018 (left); the other urchin densities at each survey site for 2014 and 2018 (right).

In comparison to other reefs around Jamaica the PBPA 2018 surveyed reefs had an average 0.35/ m² (std 0.28) which is higher than the densities recorded in 2013 in Montego Bay Marine Park (0.2/ m²), Discovery Bay (0.3/ m²), Oracebessa Bay Special Fishery Conservation Area (0.2/ m²), Palisadoes-Port Royal Protected Area (0.0/ m²) and Belmont, Westmoreland (0.0/ m²) (see data and full report: NEPA, 2014).

Other benthic invertebrates identified were lobster (0.04/ m²) and conch (0.04/ m²) at Big Pelican Cay (SE). No sea cucumbers were recorded throughout the surveys. Surveys of preferential habitats for sea

cucumbers including the surrounding soft bottoms, with muddy or sandy patches, and seagrass beds, would need to be carried out for an improved understanding of sea cucumber densities in the PBPA.

Fish Communities

Reef Fish Populations

The average total fish density was 48.6-167.3/100 m² with the highest densities recorded at Pigeon Island and Pigican Shoal (167.3 and 124.5/100 m² respectively) (Figure 18) With respect to average total fish biomass the highest biomass ranged from 1666-4736 g/100 m² though were extremely variable across reef sites (Figure 18). The lowest recorded fish biomass was across Pigican Shoal and NE Pigeon Island, and the highest fish biomass recorded was at Big Pelican Cay (W) and Pigeon Island (E). The fish biomass was dominated by parrotfish, particularly at Pigeon Island (E) and Big Pelican Cay (W) (Figure 19) in addition to grunts and to a lesser extent damselfish, snappers, and wrasses. One site, Big Pelican Cay (W) had a notably high biomass of chubs.

The most common fish species (i.e. recorded at all survey) were the surgeonfish (blue tang, *Acanthurus coeruleus*; Ocean Surgeonfish, *Acanthurus tractus*), parrotfish (Striped Parrotfish, *Scarus iseri*; Stoplight Parrotfish, *Sparisoma viride*; Redband Parrotfish, *Sparisoma aurofrenatum*), snapper (Yellowtail Snapper, *Ocyurus chrysurus*) and damselfish (Yellowtail Damselfish, *Microspathodon chrysurus*).

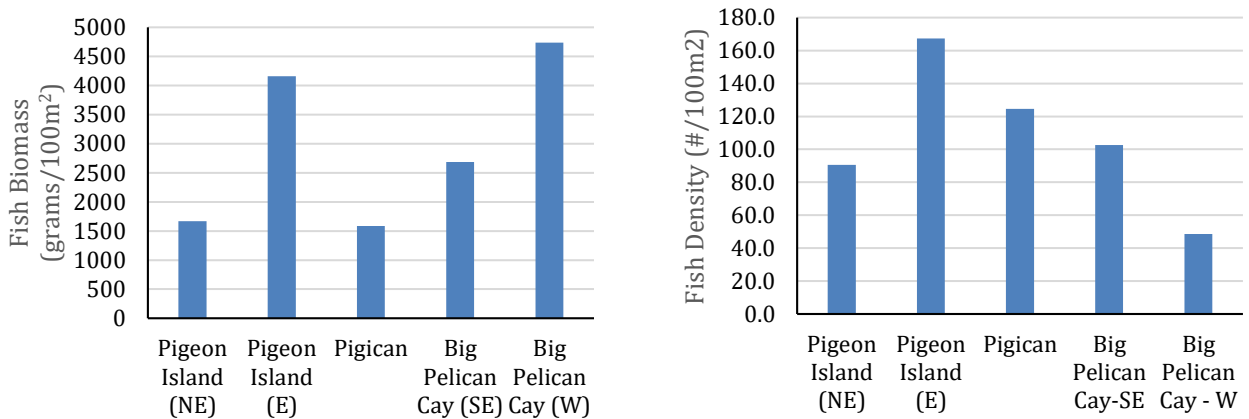


Figure 18 Graphs showing the Total fish Biomass (left) and total fish density (right) at each surveyed reef site

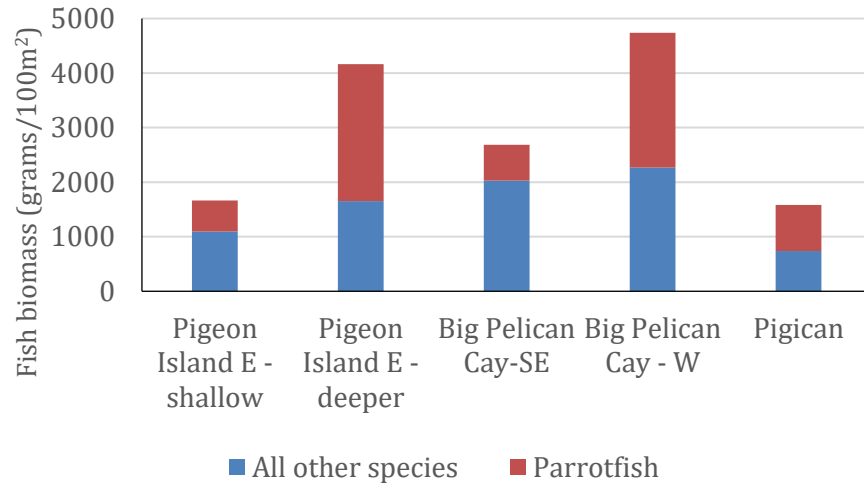


Figure 19: Chart showing the contribution of parrotfish to the overall fish biomass across each survey site. The percentage of parrotfish within the total fish biomass are indicated above each bar.

Key Herbivorous Fish (Biomass)

The total biomass of herbivorous fish (parrotfishes and surgeonfishes) varied significantly across the different reefs. Across all surveyed reefs the total average fish biomass for herbivorous fish averaged 2608 g/100 m² (912 std) (Figure 20). The highest herbivorous fish biomass was recorded at Pigeon Island (E) and Big Pelican (W), characterised by the highest biomass of parrotfishes for the surveys (2506 and 2467 g/100 m² respectively) and the lowest biomass of surgeonfishes recorded (96 and 141 g/100 m² respectively). Lower herbivorous biomass was recorded at all other sites (754 – 1105 g/100 m²) though they had relatively high proportion of surgeonfishes in comparison to Pigeon Island (E) and Big Pelican Cay (W).

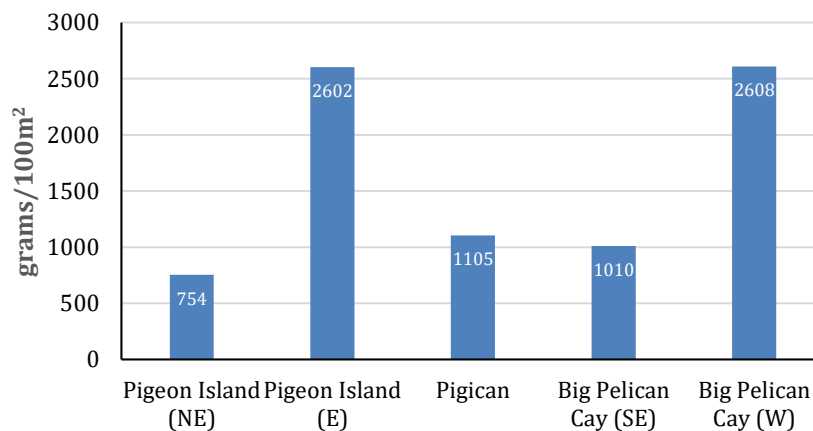


Figure 20 Chart showing the total biomass of herbivorous fish (parrotfish and surgeonfish only) across each survey site.

Smaller species of parrotfish, and juveniles of the large species, consume turf algae and can graze on macroalgae, but their smaller size limits their grazing ability of macroalgae (Dahlgren et al., 2016). Therefore, when considering indicators or coral reef health it is common to consider the number or percentage of the parrotfish species that grow greater than 30 cm at each reef, and importantly what their average length is at each reef (e.g. stoplight, queen, yellowtail, and rainbow parrotfishes).

Across the PBPA coral reef survey sites the average length of parrotfish was 10.5 cm with no parrotfish over 30 cm observed (Table 3). 65% of the parrotfish recorded were *Scarus iseri* (striped parrotfish) with an average length of 8.5 cm. 15% of the parrotfishes were *Sparisoma viride* (stoplight parrotfish) with an average length of 7.8 cm. The largest parrotfish were *Scarus guacamaia* (rainbow parrotfish) at 18 cm in length and *Sparisoma rubripinne* (yellowtail parrotfish) at 14.8 cm in length, however, they were found in very low numbers together accounting for <5% of all parrotfishes recorded.

Table 9 Data on the average length of parrotfishes within the PBPA during the 2018 surveys. Average length of fish (cm) using the midpoint of size classes.

Scientific Name	Common Name	Total number of fishes recorded (percentage of total parrotfishes recorded)	Average length of fish (cm)
<i>Scarus / Sparisoma</i>	Juvenile Parrotfish	81 (5%)	2.5
<i>Scarus guacamaia</i>	Rainbow Parrotfish	4	18.0
<i>Scarus iseri</i>	Striped Parrotfish	987 (65%)	8.5
<i>Scarus taeniopterus</i>	Princess Parrotfish	4	9.9
<i>Sparisoma atomarium</i>	Greenblotch Parrotfish	20	5.9
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	100 (7%)	7.6
<i>Sparisoma chrysopteron</i>	Redtail Parrotfish	34	11.2
<i>Sparisoma rubripinne</i>	Yellowtail Parrotfish	66 (4%)	14.8
<i>Sparisoma viride</i>	Stoplight Parrotfish	224 (15%)	7.8

Key Commercial Fish (Biomass)

The overall commercial fish biomass averaged 96 g/100 m² when only considering snapper and grouper. There was no grouper recorded.

There are issues and conflict with reporting only groupers and snappers as key commercial fish across the Caribbean given that grunts, parrotfish and surgeonfish commonly form a considerable percentage of the catch across the region. A comprehensive assessment of what the artisanal commercially important fishes specific to Jamaica is beyond the scope of this report. Therefore, whilst the 'key commercial fish biomass'

has been reported for comparative purposes it is important to note overall reef fish population metrics and variability of the surveyed reefs.

Considering the importance of grunts to Jamaica, for comparative purposes this has been included as 'commercially significant' in the below graph and shows that there is considerable difference between the reefs surveyed. The lowest 'commercial' fish biomass was recorded at Pigican Shoal (20 g/100 m² snapper only, 120 g/100 m² snappers + grunts) (Figure 21). The highest biomass of snapper was recorded at Big Pelican W and SE (178 and 155 g/100 m² respectively), whilst the highest biomass of grunts was recorded at Big Pelican Cay SE (1191 g/100 m² and Pigeon Island (E) (839 g/100 m²) (Figure 21).

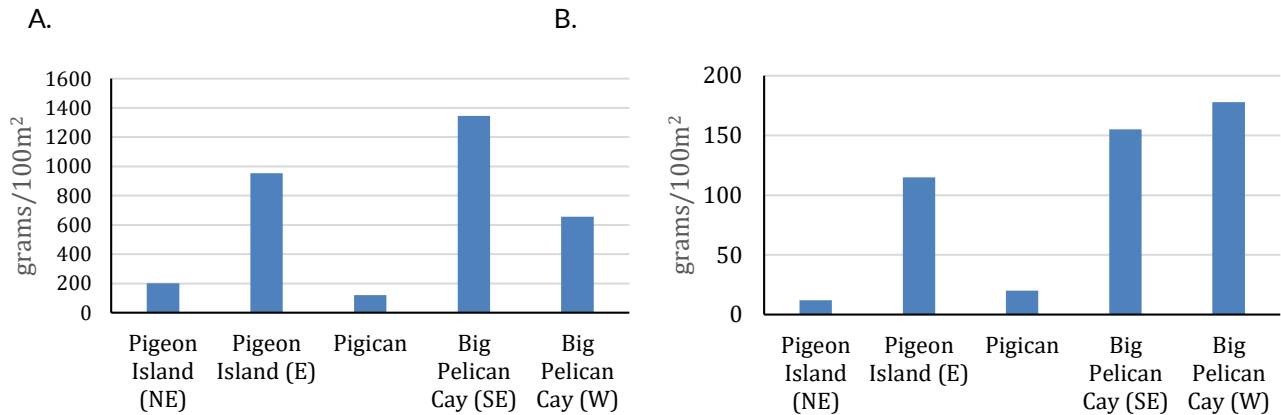


Figure 21 Graph showing (A) the Total commercial fish Biomass (grunt and snapper only), and (B) the Total Commercial fish biomass (snapper only) at each surveyed reef site.

Tracking Coral Reef Health

Reef Health Indicators for the PBPA (2018)

The Reef Health Index (RHI) integrates four indicators of coral reef health: live coral cover, fleshy macroalgae cover, herbivorous fish, and commercial fish. The RHI was developed by the Healthy Reefs Initiative (www.healthyreefs.org). The use of the RHI allows a complex ecosystem to be assessed and then tracked over using a ranked scaled metric. The mean value of each indicator is compared to thresholds and given a grade from one ('critical') to five ('very good'). The four grades are averaged to obtain the RHI for each reef sites. Note, a site which ranks a given RHI score (e.g. 'fair') may have some indicator(s) ranking in a different condition (e.g. 'good') (Table 10Table 10).

Table 10 The Reef Health Index (RHI) Reference Values (after www.healthyreefs.org).

Reef Health Index (RHI) Reference Values					
RHI Indicators	Very Good	Good	Fair	Poor	Critical
Coral Cover (%)	≥ 40	20.0-39.9	10.0-19.9	5.0-9.9	<5

Fleshy Macroalgal Cover (%)	0-0.9	1.0-5.0	5.1-12.0	12.1-25	>25.0
Key Herbivores Biomass (g/100 m ²)	≥3480	2880-3479	1920-2879	960-1919	<960
Key Commercial Biomass (g/100 m ²)	≥1680	1260-1679	840-1259	420-840	<420
RHI Grade	>4.2-5	>3.4-4.2	>2.6-3.4	>1.8-2.6	1-1.8

Note that herbivores include parrotfishes and surgeonfishes. Note that commercial fishes include snapper and groupers. However, due to the high reliance of grunts in Jamaica for commercial means they have been included in the key commercial biomass.

The Reef Health Index for the PBPA based on the selected sites was 2.5 (out of 5) (Figure 23). Despite key differences between each reef surveyed, coral cover which provides important habitats for fishes and other reef organisms, ranked fair to good (coral cover score = 3.2) (Figure 22). Fleshy macroalgal cover was variable between sites, however, typically abundant particularly where key fish herbivores are lower (score = 2.2, rank 'poor'). Note that whilst the Reef Health Index only include fleshy macroalgal cover in the score calculations that for the PBPA coral reefs consideration of the percentage calcareous macroalgal cover is also considered important. In Figure 18 note the percentages of fleshy macroalgal cover with the graph bars colour coded according to their Reef Health Index ranking, whereas the grey bars represent calcareous macroalgal cover. For the most part the calcareous macroalgal cover is mainly *Halimeda* sp. across the PBPA reefs and in places accounts for significant areal coverage on the reefs where it forms dense *Halimeda* mats that are capable of overgrowing and killing corals. Herbivorous fish biomass ranged from site to site ranking from 'critical' to 'fair'. (score = 2.2). Commercial fish biomass (score = 2.2) produced the lowest scores for the Reef Health Index due to the absence of groupers and low biomass of snappers. It was only the presence of grunts that avoided the PBPA commercial fish biomass from being scored at a critically low level.



Figure 22 The four reef health index criteria for each surveyed site: live coral cover, fleshy macroalgae cover, herbivorous fish biomass, and commercial fish biomass. N.B. The bars are colour coded to indicate corresponding RHI ranking. Above each graph is the average percentage and ranking when all surveyed sites are grouped together. The red dotted line indicates the Caribbean average based on AGRRA regional database 2011-2014 (www.agrra.org) (Kramer et al. 2016).

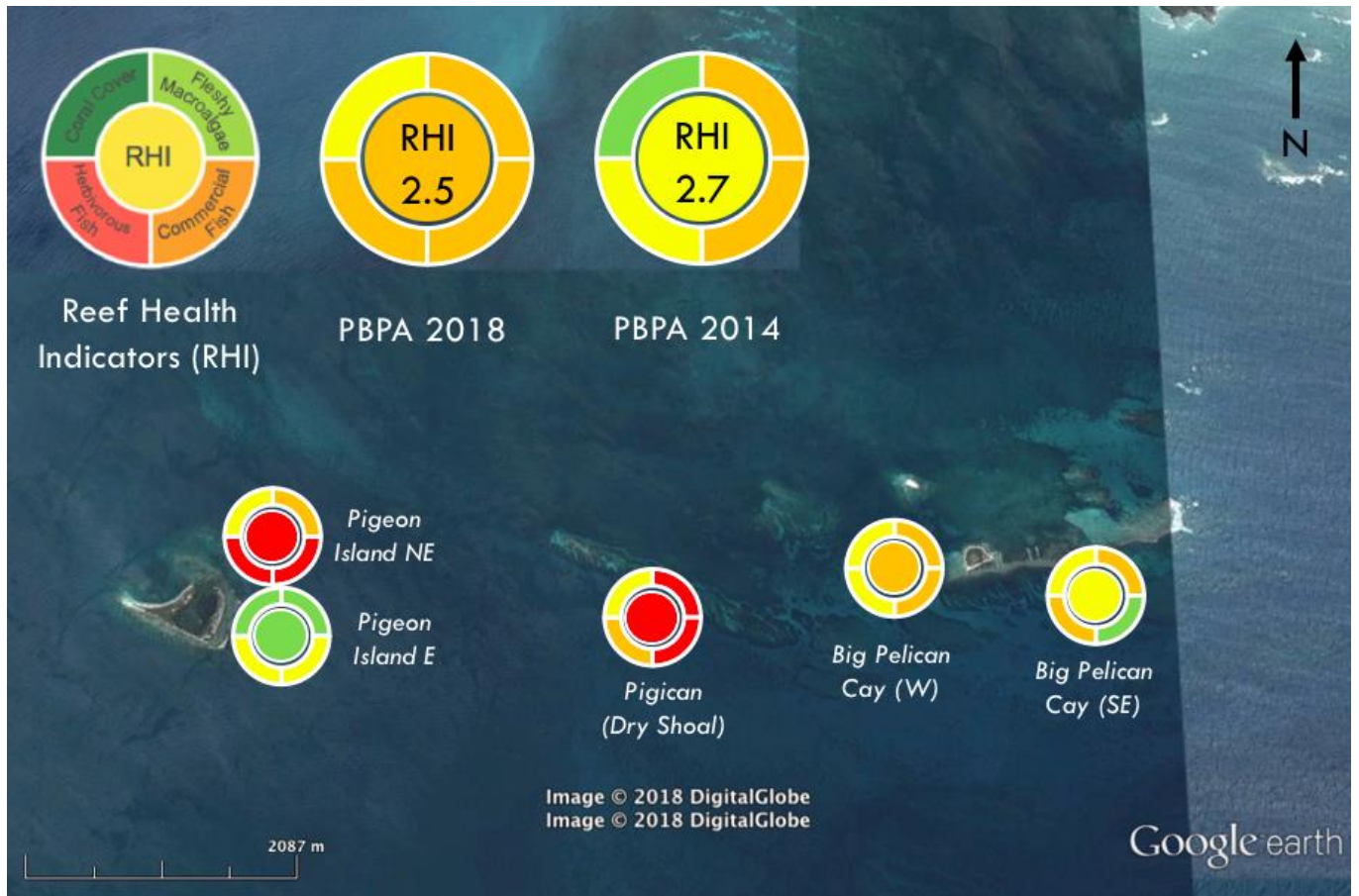


Figure 23 Map of the sites surveyed and the RHI scores for each survey site. N.B. The RHI and the overall reef health score for the PBPA reefs following the 2018 surveys (this study)(5 survey sites within selected area of the PBPA) and the 2014 surveys (Palmer and Lang, 2015)(12 sites across the PBPA). The pie charts display the overall RHI (middle) and each individual indicator to show how each indicator affects the score.

PBPA 2018 (AGRRA) vs. PBPA 2014 (AGRRA)

The most recent surveys using the same surveying protocol across the surveyed coral reefs were carried out in 2014. In comparing AGRRA data from key sites between 2014 and 2018 it can be seen that overall the live coral cover has shifted from 'good' to 'fair' though it must be noted that it is currently on the upper boundary of 'fair' (Figure 24). In terms of the fleshy macroalgal cover there has been an increase at some sites, but relatively lower values at others (Figure 24), with an overall shift from 'critical' to 'fair' on the Reef Health Index scale. The dramatic difference appears to be with the biomass of herbivorous fishes between the 2014 and 2018 surveys (Figure 24) with a shift from a 'good' to 'poor' ranking. Further surveys at different times of year and weather conditions are needed to verify the trajectory of any possible change. Whereas the 'commercial' fish biomass remains overall at the 'poor' level though with between site variation (Figure 24). Taking all the selected survey sites together the Reef Health Index

encompassing all criteria has shifted from 2.7 (fair) in 2014 to 2.5 (poor) in 2018 (note that 2.6 is the boundary between poor and fair).

Comparisons to earlier datasets (pre-2014) are limited due to the different methodologies employed, specifically as it relates to identifying and categorising fleshy macroalgae, and the metrics used to report fish population assessments. However, there can be a very basic comparison where there is both general overlap with survey location and comparable site data. This has been applied to the percentage live coral cover and the density of grunts and snappers which reveals possible spatial and temporal differences.

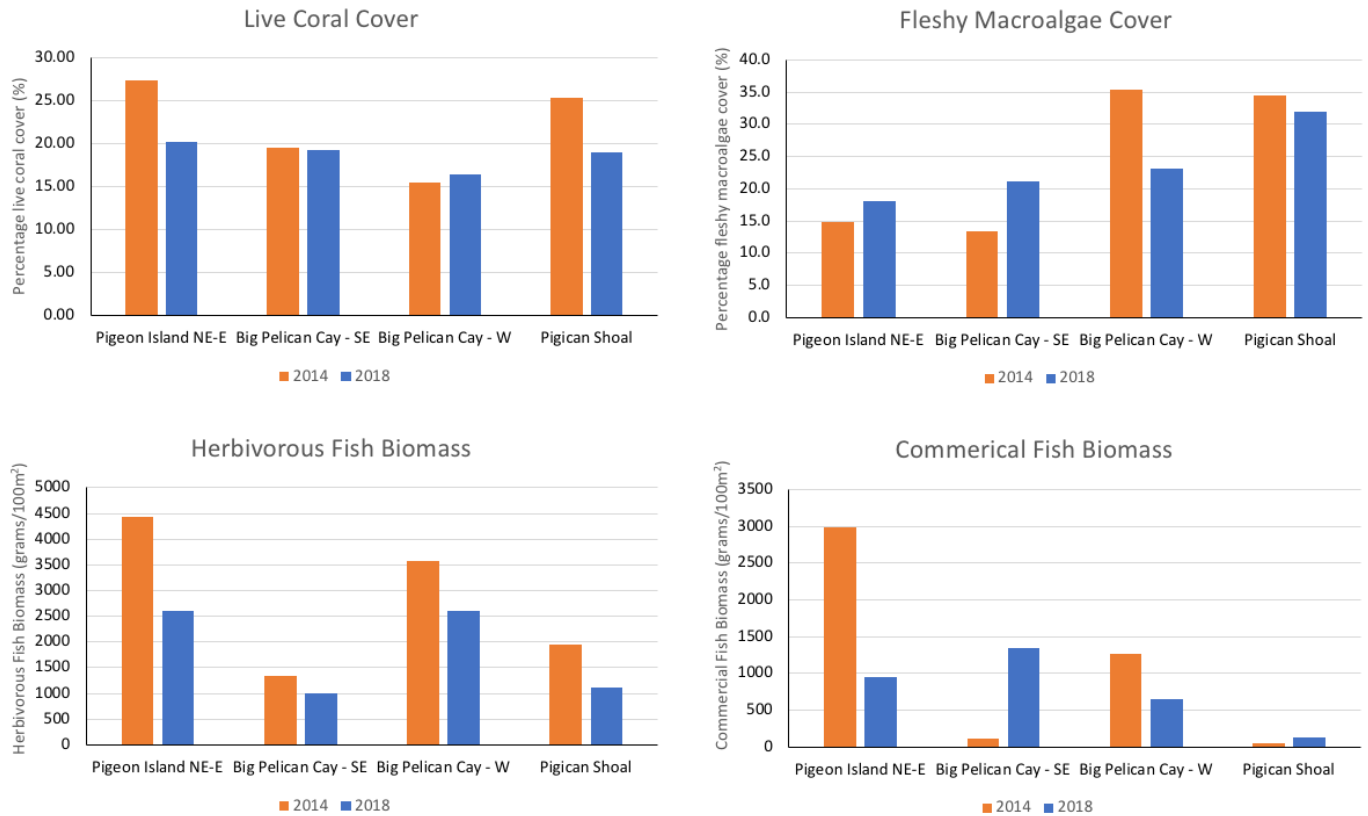


Figure 24 a comparison of the key reef health index criteria between 2014 and 2018 across the selected sites within the PBPA.

Summary of BioPhysical

Coral

- 'Fair' to 'good' live coral coverage for most surveyed reefs.
- Typically, healthy coral colonies with no evidence of major coral disease outbreaks.
- High densities of coral recruits at Pigican (Dry Shoal) and Pelican Cay (NE).
- *Acropora palmata* stands at Big Pelican Cay (W).
- *Orbicella annularis* zone (plus other massive corals) around Pigeon Island (NE).

Benthic

- Highest fleshy macroalgal and calcareous macroalgal cover across Pigeon (Dry Shoal) and Big Pelican Cay (W).
- Extensive cover by encrusting peysonnelids across Pigeon Island (E). Some species of peysonellids encrust and overgrow corals and crustose coralline algae, therefore are not typically a positive sign of reef health.

Other Herbivores (urchins)

- Highest densities of *Diadema antillarum* were recorded at two sites around Pigeon Island, the highest being at Pigeon Island E (0.68/ m²).
- Other urchins that are important grazers, specifically *Echinometra* sp. were recorded at all sites, however, the highest densities were recorded at Pigeon Island E (0.89 /m²).

Herbivorous & Commercial Fish

- Herbivorous fish biomass ranges from fair (Pigeon Island E and Big Pelican Cay W) to poor (all other sites). Fish biomass is typically low whereas densities are reasonably high.
- Parrotfishes are consistently small across all sites irrespective of species.
- 'Commercially important' fish are at critically low levels. There were no groupers recorded.
- Grunts were included as 'commercially important' fish. Due to higher biomass of grunts at Pigeon Island E and Big Pelican Cay SE, these sites are ranked fair to good in terms of 'commercial fish', all other sites rank poor to critical. *Note:* surveys need to be repeated at different times of the year to account for annual variability and different weather conditions.


Habitat Connectivity

- Coral reef habitats were the focus of these surveys, however, rapid manta tows of surrounding habitats revealed extensive seagrass beds and mud bottoms adjoining the coral reef habitats over different depth and spatial scales. The main areas of mangrove development within the survey area were those associated with Pigeon Island.
- It is recommended that the connectivity between these important habitats is considered when determining boundaries and specific areas for a potential SFCA.

Feasibility Assessment

Table 11: Comparison and ranking of each site based on criteria mentioned previously. For ranking, 4-‘Feasible’; 3-‘Needs Improvement’; 2-‘Minimal’; 1-‘Not Feasible/Applicable’

Criteria	Comments	Ranking			Status at Site (justification)
		PI	PS	PC	
Biophysical					
Coral reef presence	Corals build the reef’s 3D structure, provide habitat, and protect coastlines and fleshy macroalgae, when too abundant, outcompete corals (Kramer et al., 2016). Coral reefs were assessed and their health ranked based on the Reef Health Indicators (RHI) from critical to very good.	4	4	4	All sites exhibit ‘fair’ coral cover
Reef fish and associated species presence	Herbivorous fish and Diadema urchins clean algae off reefs, and groupers and snappers are key predators that keep food chain in balance (Kramer et al., 2016). Where parrotfish populations thrive, there may be less macroalgae and more coral recruits (Dahlgren et al., 2016).	3	3	3	Pigeon Island – critical to good herbivorous fish biomass; critical to good commercial fish biomass Pigican Shoal – poor herbivorous fish biomass; critical commercial fish biomass Big Pelican Cay – poor to good herbivorous fish biomass; poor commercial fish biomass
Associated with adjoining mangrove growth		3	2	2	

Seagrass present	Manta tows carried out to reveal presence/absence of surrounding seagrass beds and mud flats.	3	4	4	Pigeon Island – mudflats and seagrass beds near island Pigican Shoal – seagrass beds and mudflats near shoals Big Pelican Cay – seagrass beds surround cays
Dominant habitat	Habitat maps are needed. Surveys focused on coral reef areas however manta tows identified surrounding habitats and substrate type.	4	4	4	Pigeon Island – reef (see above) Pigican Shoal – reef (see above) Big Pelican Cay – reef (see above)
Relatively unpolluted (sediment, nutrients, etc.)	Water quality monitoring is needed across this area, however notes were made on potential pollution indicators and water clarity during surveys.	-	-	-	Pigeon Island – exposed reefs well flushed to east, reefs to south show signs of pollution (cyanobacteria, aggressive invertebrates) possibly due to closer proximity to shipping channel? Pigican Shoal – frequently has turbid waters – maybe due to close proximity to mud bottoms rather than polluted waters. Big Pelican Cay – exposed south east fore reefs, reefs to west have high macroalgae cover, however this may be due to low herbivory rather than nutrients.
Depth	Interpreted to mean that the area encompasses different depth ranges in which there are different habitats, e.g. different depth ranges for seagrass beds, reefs, and mudflats	4	4	4	Pigeon Island: reef ~1.5-10m; surrounding bottoms ~11-20m Pigican Shoal: reef ~1.5-12m; to south ~12-15m, to north ~6-8m Big Pelican Cay: reef ~1.5-10m; to south ~10-14m; to north 1.5-8m
Should be a minimum area of 10 km ² (estimate modifiable).	Note that this minimum area does not need to be a square box and that this map is simply to demonstrate the spatial extent required for a fish sanctuary to be effective. Please note the connectivity between Pigican and Big Pelican Cay.	4	4	4	Each site has the ability to have a minimum area of 10km ² protected. red boxes indicate approximate 10km ² areas 

Socio-Economic					
Absence of substantial development in close proximity	'Substantial Development' is interpreted as no significant industrial or commercial activity or infrastructure. 'Close proximity' is interpreted as within 5km radius.	4	-	4	Despite the PBPA being a mixed use zone with industrial, fishing and recreational activities, there is no substantial development is occurring in close proximity of the sites.
Should not cause massive displacement of large numbers of fishers. Should take into consideration fishing practices (time of fishing, species caught)	This criteria focuses on usage of the sites. The higher the usage of the site, is the lower the feasibility ranking. The focus is on potential impact of protected the sites, rather than displacement of fishers.	2	-	3	Pigeon Island is utilized as fishing grounds by more (65%) fishers in the study that Pelican Cay(45%).
Should have significant support from adjoining community	'Adjoining Community' is defined as fishers who use the area (regardless of their landing site).	3	-	2	Fishers who fish at the Pelican Cays are less likely to be in support of the SFCA, however in Pigeon Island equal proportion of fishers are in support and not in support of the SFCA. At both sites the proportion of 'Not Sure' responses was significant (24 - 31%). Pigeon Island: No (38%) yes (38%) Pelican Cays: No (42%) yes (28%)
Should not have significant boating traffic through the area	'Boating traffic' is a reflection of usage - by fishers or other users.	-	-	-	All areas are utilized by fishers, however the routes of all fishing activity was not measured to determine boating traffic.
Management					

Associated & operated by a functioning NGO		4	4	4	The C-CAM Foundation has been in operation in the area for over 20 years, and has been responsible for the management of 3 other SFCAs in the area, among other projects in the wider PBPA.
Should have minimum 5 years funding		4	4	4	
Should have relatively easy patrolling access		4	4	4	
Does it add to the variety of sanctuaries in the C-CAM area?		4	4	4	All 3 sites equally add to the variety of existing SFCAs in the area, in that, currently all SFCAs are land-attached, small in area, and with little to no coral reef environments.

PI = Pigeon Island; PS = Pigican Shoal; PC = Pelican Cays. NB. Pigical Shoal was survey only for Biophysical criteria. Pelican Cays refers to Big Pelican Cay only for Biophysical and Big and Little Pelican Cay for Socio-Economic criteria.

Despite some minor differences depending on feasibility criteria, all 3 sites resulted in the same overall ranking score of 50 (out of a total 64).

Conclusions and Recommendations

Overall, the results of the assessment demonstrate that the areas being considered, i.e. Pelican Cays, Pigican Shoal and Pigeon Island are feasible options for the establishment of a new SFCA, but do require improvement or effort in certain areas to facilitate a smooth establishment or enhance the effectiveness of the new SFCA.

The results of the socioeconomic assessment show considerable variation in attitudes towards the establishment of a new sanctuary in the proposed region. Fishers who use specific areas are more likely to propose other locations for protection. This implies that the establishment of a new sanctuary would benefit from the engagement of fishers who use the proposed locations rather than community-wide engagement. There is a considerable number of fishers who are unsure about the establishment of a new sanctuary in the proposed locations. This provides a unique opportunity to engage these fishers and build awareness around the value of SFCAs in providing multiple livelihood and environmental co-benefits.

The biophysical surveys for this report focused on the health of the coral reefs and important reef fishes specifically around Pigeon Island, Pigican Shoal (Dry Shoal), and Big Pelican Cays. Surveys revealed ecologically and biologically important reef and fisheries habitats that require protection from existing fishing activities in order to sustain habitat functionality. It is therefore recommended that when identifying specific areas for protection that it is recognised that all the reefs surveyed showed both the potential for rehabilitation but also a strong need for protection from overfishing of small reef fishes.

Rapid manta tows across the surrounding habitats revealed extensive ecologically and biologically important seagrass beds and mud bottoms adjoining the coral reef habitats. Thus, whilst detailed connectivity data is lacking there is undoubtedly connectivity between these range of habitats (particularly Pigican and Big Pelican Cay) which exist over different depth and spatial scales. The main areas of mangrove development within the survey area were those associated with Pigeon Island. It is therefore recommended that when identifying specific areas for protection that one acknowledges the connectivity of these habitats rather than as isolated units.

Further, to inform the designation and management of these marine habitats it is strongly recommended that a water quality monitoring programme be established across the reefs, together with the development of a habitat map to accurately assess the areal coverage of coral reefs, seagrass, mud bottom, and mangroves. Opportunities for collaboration with the Department of Life Sciences, The University of the West Indies Mona would assist with facilitating this.

Developing an implementation plan for the establishment of the new SFCA including the above recommendation and findings of the Socio-Economic and Biophysical surveys would be a good first time toward successful establishment and operation of the new SFCA.

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[1] Varying terminologies exist to describe a zoned area designed for the enhancement of fisheries. For instance, Marine Protected Areas (MPAs) are often used even though technically fish sanctuaries are a type of MPA. Other terms used include

fishery replenishment zone, marine fishery reserves, etc. In this document, the term 'fish sanctuaries' is used in lieu of the legal designation in Jamaica of Special Fishery Conservation Areas (SFCAs).