Benthic Survey Addendum to

Preliminary Engineering Report for Grand Palladium Beach Development Lucea, Jamaica

submitted to

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representing

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by

SMITH WARNER INTERNATIONAL
COASTAL ENVIRONMENT

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1.0 Introduction

A benthic survey was conducted in June 2011 so as to inform the design of coastal structures and coastal works planned for the proposed construction site. That benthic survey identified sensitive marine resources in the footprint and in the vicinity of the footprint of the proposed construction site that would be impacted by any works and therefore the report also included mitigation measures so as to minimise the extent of any potential impact to these resources.[1]

Subsequent to the June 2011 benthic survey the proposed design of the works evolved and the number, position, and extent of the coastal structures and coastal works changed. Given these changes a follow up benthic survey was conducted in April 2012 so as to;

- identify precisely what resources were in the footprint of the coastal structures and coastal works,
- collect photographs and GPS waypoints of significant marine resources that would be impacted, and
- further evaluate the proposed mitigation measures including the seagrass relocation sites identified in the C.L. Report[2].

2.0 Methodology

The plan of the site showing the proposed coastal works was examined and GPS coordinates extracted for the three groynes (the northern groyne, the T-groyne, and the southern groyne), the two breakwaters (the northern breakwater and the southern breakwater), and the two swim areas (beach areas 1 and 2) and these were uploaded to a GPS instrument.

A field trip was conducted to the site on the 14-15 of April 2012 and the GPS instrument was used to identify the approximate location and extent of each of the proposed coastal structures and the areas of coastal works on the ground. The footprint of each proposed structure and area of coastal work was then marked out using anchored floats so that a detailed examination of the resources within the

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[1] Preliminary Engineering Report for Grand Palladium Beach Development, Lucea, Jamaica submitted to Mr. Dimitris Kosvogiannis representing Fiesta Jamaica Limited by Smith Warner International March 2012.

[2] Proposed Seagrass Relocation and Replanting and Coral Relocation Methodology (2006) by CL Environmental and CEAC.

footprint (and within a band around the footprint) could be facilitated. Figure 1 hereunder gives the overall extent of the benthic survey.

The footprint and an area around it were examined by snorkelling and photographs along with video were collected while general observations made were recorded on a slate. Along with these observations a 0.5m quadrat was used to guide the collection of information on seagrass and the density of urchins. Where 'monument' coral colonies (i.e. those colonies with a diameter >0.1m) were observed in the footprint (or in the vicinity of the footprint) a photograph and a GPS coordinate were collected. The depth of the water column was also measured.

GPS coordinates were also extracted from the C.L. Report for the spaces[3] that were found in the zone suitable for seagrass replanting, and these coordinates were uploaded into the GPS instrument. Each of the four areas identified as spaces were snorkelled along with the surrounding seagrass meadow and general observations were recorded.

3.0 Findings

3.1 Beach Area 1

The proposed footprint of Beach Area 1 similar to the footprint that was investigated in the June 2011 and the findings of the benthic survey at that time remain current and relevant. In relation to the June 2011 benthic survey the following was reported;

> "The foreshore of beach area 1 is comprised primarily of white sand. The floor of the sea at beach area 1 is part of a shallow embayment consisting of a seagrass meadow dominated by *Thalassia testudinum* (no *Syringodium filiforme* or *Halodule wrightii* were seen). The seagrass provides a habitat to a variety of invertebrates (such as urchins) and fish (rays and schools of juvenile stages of finfish).
>
> There are frequent occurrences of small corals (less than 10cm in diameter) that lie loosely attached to sand within the seagrass bed. The benthos is a mix of sand, sand overlaying rock, and rocky seafloor. Where there are rocky areas, these are often colonized by small corals (such as *Siderastrea* species) that are affixed to the rock. Within the seagrass beds, *Lytechenus* species of sea urchins were common and there were species of algae such as *Dictyota*, *Penicillus*, and *Halemeda* present.

[3] Ibid p36 at Figure 18

> The area to be dredged is roughly 2,100m^2 and, of this area, approximately 60% is covered by seagrass. The seagrass bed in this area is growing over relatively shallow sandy sediment and is more or less continuous with moderate density and short blade lengths. There is evidence of grazing on the blades of the seagrass.
>
> There were some areas of the floor of the sea close to the foreshore that had loose rolling mats of debris consisting of dead algae, seagrass blades and other detritus from terrestrial vegetation.
>
> This embayment is part of the larger nearshore ecosystem and is comprised of seagrass beds behind a back reef that, with the associated invertebrate and fish community, comprise relatively healthy, well-developed and ecologically significant marine resources."

The size of the proposed beach area has increased slightly in the latest design and it is now approximately 2,849.4m^2 and of this area it is estimated that approximately 40% (or 1,709.6m^2) is covered with seagrass. The April 2012 benthic survey confirmed that there were no 'monument' corals present in the footprint of beach area 1; i.e. no coral colonies >0.1m observed in this area.

3.2 Beach area 2

The proposed footprint of Beach Area 2 is similar to the footprint that was investigated in June 2011 and the findings of the benthic survey at that time remain current and relevant. In relation to the June 2011 benthic survey the following was reported;

> "Of the two beach areas to be enhanced this beach area is closest to the molasses pier. As with beach area 1, the foreshore of beach area 2 is comprised primarily of white sand. The floor of the sea in this shallow embayment consists of a seagrass meadow that is dominated by *Thalassia testudinum* (no *Syringodium filiforme* or *Halodule wrightii* were seen). The sea grasses provide a habitat to a variety of invertebrates (such as *Diadema* species) and fish (rays and schools of juvenile stages of finfish). There are frequent occurrences of small corals (less than 10cm in diameter), which lie loosely attached to sand within the seagrass bed. The benthos is a mix of sand, sand overlaying rock, and pavement. Where there are rocky areas of the seafloor these are often colonized by small corals (such as *Siderastrea* species) which are affixed to the rock. Within the seagrass bed there are algae such as *Dictyota*, *Penicillus* and *Halemeda* species present.

The foreshore of beach area 2 is predominantly sandy, and the floor of the sea from the shore to 20m seaward is sandy, followed by a coral rubble zone (at 21-26m), then a sparse Thallasia species seagrass bed (at 27-40m), followed by a dense Thallasia species seagrass bed (at 41-55m), and thereafter (from 56m onward) it is a predominantly hard bottom with algal communities.

The footprint of the area to be dredged in beach area 2 is roughly 2,100 m^2, and of this area, approximately 40% is covered by seagrass.

There were *Diadema* sp. sea eggs present on these pavement areas and also small coral colonies including Porities species and Siderastrea species affixed to the sea bottom.

There were a few large monument/massive coral colonies growing in the shallows of the embayment amongst the seagrass.

As with beach area 1, this embayment is part of the larger nearshore ecosystem of seagrass beds and back reef which, along with the associated invertebrate and fish community comprise relatively healthy, well-developed and ecologically significant marine resources."

The size of the proposed beach area has increased slightly in the latest design and it is now approximately 3,367m^2 and of this area it is estimated that approximately 40% (or 1,346.8m^2) is covered with seagrass. The April 2012 survey revealed that there were four 'monument' corals present in the footprint of beach area 2 and these are reported below in the section on monument corals. It was also noted that the seagrass in beach area 2 appeared to be flowering.

3.3 The northern groyne

To the north-east of the shallow embayment where beach area 1 is proposed to be developed there is small rocky headland on the coast where a finger groyne is proposed to be constructed.

The foreshore in this area is rocky, and the floor of the sea of the footprint of the groyne (and the area surrounding it) from the shore to the distal end of the proposed structure is rocky/pavement with sparse patchy *Thallasia* species seagrass from 0m to approximately 15m where after it is comprised of a fairly continuous *Thallasia* sp. seagrass bed growing over a thin sandy substrate.

Average length of the seagrass blades ranged from 0.05m – 0.15m.

Along with *Thallasia* sp. seagrass, urchins such as *Lytechinus sp.*, juvenile fish (slippery dick), algae such as *Halimeda spp.*, and a few small coral colonies such as *Siderastrea sp.* (all with diameters of <5cm), and mulloscs such as *Pinna carnea* (amber pen) were observed. A species list indicating the general observations made is included in the Appendix A to this report.

At the time of the site visit it was low tide and the depth of water was approximately 0.65m at the deepest point and 0.43m at the shallowest point of the footprint.

The footprint of the groyne is approximately 281m^2 and of this approximately 60% (or 169m^2) is covered by seagrass.

3.4 The T-groyne

Between the shallow embayments where beach area 1 and 2 are proposed to be developed there is a rocky headland where a T-groyne is proposed to be constructed.

The foreshore in this area is rocky, and the floor of the sea of the footprint of the T-groyne (and the area surrounding it) from the low-water mark to the shore parallel part of the T-groyne is rocky/rubble with an algal bed from 0m to approximately 15m where after it is comprised of a sparse and patchy *Thallasia* sp. seagrass bed growing over a thin sandy layer with rubble inclusions. Average lengths of the seagrass blades ranged from 0.05m – 0.1m.

Along with occasional tufts of *Thallasia* sp. seagrass, urchins such as *Lytechinus, Diadema*, and *Tripnustes sp.*, algae such as *Dictyota sp., Halimeda spp.* and *Penicillus* sp., a few small coral colonies such as *Siderastrea sp.* (all with diameters of <0.05m) were observed. Hydroids, encrusting sponge, and anemones were also observed growing on the hard bottom. Individuals and small schools of fish (often juvenile phases) such as slippery dick, red band parrot, blue head wrasse, Beaugregory, striped parrot, squirrel fish, scorpion fish, spotted goat fish, yellow tail snapper, and doctor fish were seen. A species list indicating the general observations made is included in the Appendix A to this report.

The footprint of the shore parallel part of the T-groyne was comprised of a fairly continuous *Thallasia* sp. seagrass bed growing over a thin sandy layer with rubble inclusions. Average lengths of the seagrass blades ranged from 0.05m – 0.15m. It was noted that the seagrass bed itself was eroding, and just seaward of the footprint of the shore parallel part of the T-groyne the bed edge was exposed and there was a large depression in the floor of the sea.

Along with *Thallasia* sp. seagrass, urchins such as *Lytechinus,* algae such as *Halimeda spp.* and *Penicillus* sp., and few small coral colonies such as *Siderastrea sp.* (all with

diameters of <0.05m) were observed. A species list indicating the general observations made is included in the Appendix A of this report.

At the time of the site visit it was low tide and the depth of water was approximately 0.9m at the deepest point and 0.3m at the shallowest point of the footprint.

The footprint of the groyne is approximately 720m^2 and, of this area, approximately 80% (or 576m^2) is covered by seagrass.

3.5 The southern groyne

To the west of the shallow embayment where beach area 2 is proposed to be developed there is a rocky shoreline on the coast where a finger groyne is proposed to be constructed.

The foreshore in this area is rocky, and the floor of the sea of the footprint of the groyne (and the area surrounding it) from the shore to the distal end of the proposed structure is rocky/rubble with very sparse *Thallasia* sp. seagrass from 0m to approximately 25m where after it is comprised of a fairly continuous *Thallasia* sp. seagrass bed growing over a thin sandy layer with rubble inclusions.

Average lengths of the seagrass blades ranged from 0.05m – 0.15m.

Along with *Thallasia* sp. seagrass, urchins such as *Lytechinus, Diadema*, and *Echinometra luncunter*, algae such as *Halimeda spp.* and *Penicillus* sp., and few small coral colonies such as *Siderastrea sp.* (all with diameters of <0.05m) were observed. A species list indicating the general observations made is included in Appendix A of this report. At the time of the site visit it was low tide and the depth of water was approximately 0.83m at the deepest point and 0.69m at the shallowest point of the footprint.

The footprint of the groyne is approximately 365m^2 and, of this area, approximately 20% (or 73m^2) is covered by seagrass.

3.6 Northern breakwater

A shore parallel breakwater is proposed to be constructed seaward of beach area 1.

The floor of the sea of the footprint of the breakwater (and the area surrounding it) is comprised of a fairly continuous *Thallasia* sp. seagrass bed growing over a sandy layer with rubble inclusions.

Average lengths of the seagrass blades ranged from 0.05m – 0.15m.

Along with *Thallasia* sp. seagrass, urchins such as *Lytechinus, Diadema*, and *Echinometra luncunter*, algae such as *Halimeda spp.* and *Penicillus* sp., and few small coral colonies such as *Siderastrea sp.* and *Porities divaricata* all with diameters of <0.05m were observed. Individuals and small schools of fish (often juvenile phases) such as slippery dick, red band parrot, blue head wrasse, cocoa damselfish, banded butterfly fish, spotted goat fish, flat needle fish, and doctor fish were seen. A species list indicating the general observations made is included in the Appendix A of this report.

At the time of the site visit it was low tide and the depth of water was approximately 0.68m at the deepest point and 0.6m at the shallowest point of the footprint.

The footprint of the breakwater is approximately 605m^2 and, of this area, approximately 95% (or 575m^2) is covered by seagrass.

3.7 Southern breakwater

A shore parallel breakwater is proposed to be constructed seaward of beach area 2.

The floor of the sea of the footprint of the breakwater (and area surrounding it) from the north-eastern most extent of the footprint of the breakwater to around the midpoint of the structure, i.e. approximately 40m along the length of the breakwater (in a south-western direction), is comprised of a fairly continuous *Thallasia* sp. seagrass bed. Average lengths of the seagrass blades ranged from 0.05m – 0.15m.

From the midpoint to the south-west end of the breakwater the floor of the sea is comprised of an old/relic patch reef on a hard bottom with rubble. There was very little live coral cover and the reef was severely degraded although the three dimensional structure was visible. There were three 'monument' corals present in the actual footprint of the breakwater and three 'monument' corals within 10m of the footprint; these are reported on below in the section on monument corals.

Along with *Thallasia* sp. seagrass, urchins such as *Lytechinus* and *Diadema*, algae such as *Halimeda spp.* and *Dictyota* sp., and individuals and small schools of fish (often juvenile phases) such as slippery dick, red band parrot, four-eye butterfly fish, and yellow tail snapper were seen. A species list indicating the general observations made is included in the Appendix A of this report.

At the time of the site visit it was low tide and the depth of water was approximately 2.5m at the deepest point and 1.4m at the shallowest point of the footprint.

The footprint of the breakwater is approximately 699m^2 and, of this area, approximately 50% (or 350m^2) is covered by seagrass.

3.8 Urchin density

The following species of urchin were observed in the proposed construction site; *Diamdema antillarum, Eucidaris tirbuloides, Lytechinus variegatus, Tripneustes ventricosus* and *Echinometra lucunter.*

A total of 68 individuals were observed from 30 quadrats giving a density of 4.53 urchins per square meter. With the total area to be impacted from the construction being approximately 4,799.4m^2 it can be estimated that approximately 21,741 urchins will need to be moved to the adjacent undisturbed areas of the seagrass bed.

3.9 'Monument' Corals

A number of 'monument' coral colonies were identified; i.e. those with a diameter of >0.1m. A photograph of each of these was taken along with the GPS coordinates. The photographs of the corals can be found in the Appendix B – Benthic Photos of Monument Corals. The GPS coordinates were plotted over the plan for the coastal works so as to be able to determine if these monument corals fell within the construction areas. Figure 1 below gives the spatial representation of these findings.

A total of 17 monument coral colonies were identified as being likely to be impacted by the construction works and the following table and satellite image with waypoints overlaid provides a summary of the observations made.

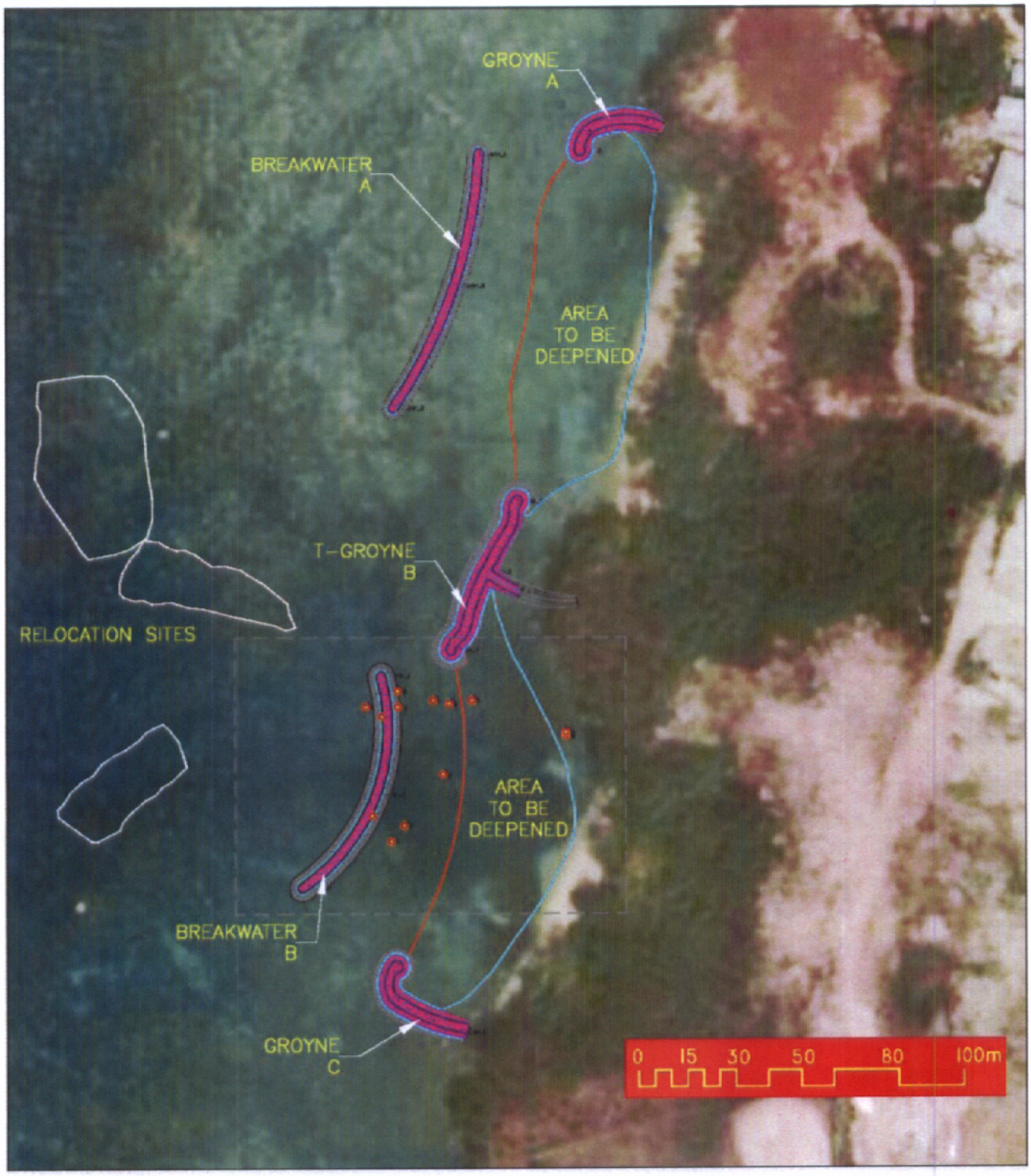

Figure 1 – Extent of Benthic Survey and Location of Monument Corals

Way point	Photo number	Species	Approx. diameter in m	Number of colonies
001	0696	*Siderastrea sp.*	0.35	1
002	0722	*Diploria sp.*	0.1	1
004	0725	*Montastraea sp.*	0.1	1
005	0727 - 0728	*Siderastrea sp.*	>0.5 and 0.3	2
006	0729	*Siderastrea sp.*	0.45	1
007	0730	*Siderastrea sp.*	>0.5	*1 (not in footprint)*
009	0737 - 0739	*Siderastrea sp.*	0.1 each	3 (in poor health)
010	0740	*Siderastrea sp.*	0.4	1
011	0741	*Siderastrea sp.*	0.4	*1 (not in footprint)*
014	0749	*Siderastrea sp.*	0.25	*1 (not in footprint)*
014	0750	*Diploria sp.* and *Porities asteroides*	0.1 each	2
014	0751	*Siderastrea sp.*	0.1 each	2
014	0752	*Siderastrea sp.*	0.1	1
014	0753	*Siderastrea sp.*	0.2 and 0.1	2
				17 in footprint

Table 1 - Monument Corals

3.10 Seagrass relocation sites

A seagrass meadow to the east of the proposed construction site had been evaluated in 2006 for its suitability as a replanting site for the seagrasses that were likely to be impacted by the construction of coastal structures forming part of the phase 1 of the hotel development. The seagrass meadow is found within a shallow and relatively sheltered embayment and it is comprised primarily of *Thallasia* sp. seagrass and the typical associated invertebrate community and coral reef.

As part of the evaluation the C.L. Report analysed parameters such as temperature, dissolved oxygen, salinity, pH, total suspended solids, light extinction, nitrates, ortho-phosphates, nitrates, depth, sediment type, and current regime so as to identify a suitable zone for replanting of seagrasses. Within this zone there were 4 bare patches identified within the seagrass meadow. These bare areas had a total area of approximately 4,000m^2. The proposed relocation site is located close to the construction site and it is similar in nature to the harvest site. Figure 18 has been extracted from the C.L. Report and it appears below.

Figure 18 **Ideal replanting areas and areas that are currently bare**

The patches were approved by NEPA as an appropriate seagrass relocation site for the mitigation works that formed part of Phase 1 of the development. It should be noted however, that the replanting sites were not utilized as none of the coastal structures proposed at that time for the southern main bay were constructed. They are therefore now available for that purpose.

So as to verify the continued existence of these replanting sites the areas were snorkelled in the April 2012 survey and the observations made were recorded. The April 2012 survey confirmed that the findings of the C.L. Report and each of the 4 replanting sites subsisted at that time.

Each patch had a sandy substrate with seagrass around the margin of the patches. Maximum water depth over the patches was greater (approximately 2m) than at the harvesting sites. At the time of the snorkel the sea was rough just offshore and the water column was partially occluded making photography difficult on the day. However, it was noted from the previous day when the seas were calmer that light penetration and water clarity appeared to be adequate as the sand patches could be seen as distinct areas amongst the seagrass meadow even when viewed from the land. During the snorkel several large (>0.25m diameter) and healthy *Siderastrea* sp. coral colonies were observed in the seagrass meadow.

The seagrass in the areas surrounding the patches had blade lengths of 0.1 – 0.2m.

4.0 Potential Impacts to Benthic Resources

The potential impacts to benthic resources and mitigation measures were described in the Preliminary Engineering Report (at pages 74-78); but given the new findings arising from the April 2012 benthic survey the impact and mitigation section has been reproduced here with relevant modifications.

The potential negative impacts to benthic resources were examined in relation to the construction phase and the operational phase of the development and are described in the following sections.

4.1 Construction

Smothering: The area of sea floor to be dredged and then nourished in beach area 1 and 2, the 3 groynes, and the 2 breakwaters are all to be constructed using land-based heavy machinery. There will be the need to deploy construction pads on the sea floor to facilitate heavy machinery accessing the construction area for each breakwater.

All the benthic resources in the footprint of the coastal structures (groynes, breakwaters), beach areas 1 and 2, and the construction pads will be impacted

negatively by the physical disturbance resulting from the dredging and from the deployment of boulders that make up the breakwaters and the groynes. It is estimated that approximately 4,799.4m^2 of seagrass bed and all invertebrates will be lost from these physical disturbances. The numerous small (<0.1m diameter) coral colonies and the 17 'monument' coral colonies, located within the seagrass bed and at the southern breakwater, will be impacted negatively.

Turbidity: The dominant component of the sediment in the project area is sand, however there is also some amount of fines present in the sediment. The deployment of boulders for the breakwaters and the groynes, the dredging of each beach area, the deployment and removal of construction pads, and the nourishment of the beach will all generate turbidity.

This turbidity can affect sensitive resources directly by smothering, or indirectly by occluding the water column in the vicinity of the construction. The limited circulation in these embayments makes it unlikely that the turbidity generated will lead to the formation of plumes affecting resources further alongshore.

4.2 Post-Construction

Debris: Any debris left on the seabed from the construction activity can become projectiles during severe wave activity, and this may cause damage to sensitive benthic resources.

5.0 Mitigation and Environmental Management Plan

An impact is defined as any change to the existing condition of the environment arising from project implementation. Impacts may arise during two phases of project implementation: (1) construction and (2) post-construction (operation). Understanding the nature of the impact can be assisted by categorizing the effect of the potential impact as being either:

- Positive or negative,
- Reversible or irreversible,
- Of short or long duration,
- Of small or large magnitude, and
- Being local or wide in extent.

Where the effect of an impact is negative, consideration should be given to implementing mitigation measures. It is important to design mitigation measures carefully so that potential negative impacts are minimized as much as possible, so that any damage to the environment is reduced. Mitigation measures are especially important when the nature of the impact has been identified as being irreversible, or being of long duration, or being of large magnitude, or where the expression is likely to be wide in extent.

A summary of the potential negative impacts and the proposed mitigation measures is presented in Table 2 following. All of the impacts identified are of small magnitude and are likely to be expressed in the vicinity of the proposed coastal works, however, some of the impacts identified were found to be irreversible and of long-lasting duration.

Table 2 Summary of potential impacts and proposed mitigation

Phase	Potential Impact	Impact reversible?	Duration		Magnitude		Extent		Proposed Mitigation
			Long	Short	Large	Small	Wide	Local	
Construction	Smothering of benthic resources in footprint of the groynes, breakwaters, and beach areas	No	X			X		X	Relocation of resources within footprint of structures and dredging to adjacent sand patches or coral reef, and restoration of disturbed areas of adjacent seagrass bed.
	Turbidity of water column	Yes		X		X		X	Deployment and maintenance of silt screens, carrying out of work only when sea conditions are suitable.
Post-construction	Damage to benthic resources by debris on the seabed after storm damage	Yes	X			X		X	Post-storm survey of seabed and removal of debris

For all of the impacts identified, regardless of their nature, appropriate mitigation measures have been proposed. These mitigation measures involve known techniques related to relocating resources, the use of silt screens, and visual inspections. These mitigation measures are outlined below.

5.1 Relocation of Ecosystem Resources

The area of benthic resources that will be impacted during construction and operation are easily identified. Based on the existing environmental conditions it would be appropriate to relocate these resources (comprised mainly of *Thallasia* species seagrass, urchins, and corals).

The general approach to the transplanting of marine resources will rely on the replanting methodology described in the C.L. Report (at sections 6 and 9). Where the sediment type allows, harvesting of seagrass as mats/planting units can be done for the material to be relocated and used in re-turfing. Additionally and where the sediment characteristics are such that harvesting seagrass as mats/planting units is not practical (due to depth of sediment, presence of rubble, etc.), the apical meristems may be harvested allowing for the restoration of the seagrass bed in other areas. The combination of relocation and restoration will minimize the impact of this development proposal on the seagrass bed.

It is proposed that an area to be replanted and/or restored should be approximately 4,800m^2, which is an area of seagrass equivalent to the area that will likely be disturbed by the coastal works.

As discussed in the findings (above), the seagrass relocation sites identified in the C.L. Report and approved as relocation sites for Phase 1 of the hotel development, continue to be suitable options for replanting of seagrass and should therefore be utilized as the primary relocation site.

Where the seagrass beds have been relocated, both the donor sites and the recipient sites may need to have appropriate stabilization treatments to the edge of the beds to prevent any erosion of the bed edges. This stabilization may be carried out using mesh and pins. It is expected that at the harvest site the newly exposed bed edge will be stabilized to a great extent by the re-nourishment fill to be placed in the newly created beach area.

All invertebrates (such as urchins) and all small corals in the seagrass bed can be collected by hand and transported underwater where they will be relocated to adjacent areas of the seagrass bed within the vicinity of the construction site.

The 17 'monument' coral colonies present in the footprint or the vicinity of the proposed works should be mechanically removed and relocated to adjacent areas of the reef in the vicinity of the construction site and properly anchored to the substrate using marine cement and pins as necessary. Suitable relocation areas are identified in the layout of the recommended options.

A specialized and experienced team/firm will be contracted to conduct the removal/relocation/replanting of the seagrasses, corals, and invertebrates. The specific names and qualifications, along with their experience conducting similar jobs, will be provided prior to the work commencing.

It is expected that the estimated survival success rate that will be achieved at the end of a 5 year monitoring period will be 75% for the corals relocated and 100% for the seagrasses against background levels.

5.2 Turbidity Screens

Areas of coastal construction should be surrounded by silt curtains where the depth of water is sufficient to allow deployment. Properly deployed and maintained turbidity screens can significantly reduce the transportation of sediment-loaded waters along the coast and offshore.

5.3 Debris Surveys

During the construction phase and immediately after construction is completed, the seabed around the proposed coastal works should be examined for any debris, which could have the potential to become a projectile in severe weather. This debris should be removed and appropriately disposed of.

5.4 Monitoring

During the replanting activity a detailed daily log will be kept by the contractor and the log will be submitted to NEPA every 2 weeks. The information logged will include the total area of seagrass and the total number of corals relocated for the period. GPS coordinates of the harvest site and relocation site for the seagrass will be recorded. The actual coral colonies harvested will be noted along with the GPS coordinates of the replanting location on the coral reef. A dated photographic record will be kept of the work done in the relocation exercise.

In order to monitor the success of the relocation exercise there should be appropriate long-term monitoring of the relocated resources and the ecosystem generally. The long term monitoring of the relocation exercise will be contracted to a team/firm of professionals who are independent from those persons who are carrying out the removal/relocation/replanting exercise.

Monitoring, although specified to be carried out over a period of five (5) years, will be assessed and the results evaluated at the end of the third year of monitoring. Based on observed changes from a year-to-year basis, the decision would be taken to extend, or not, the monitoring beyond the three year period. It may be that if the ecosystems have been found to stabilise, then the monitoring could be stopped, in agreement with NEPA. A minimum of 9 monitoring reports will be submitted in relation to the mitigation exercise. The first report will be made thirty days following the completion of the replanting exercise, thereafter every 3 months for the first year, and then every 6 months for the second to the third year.

Reports will include the names of the persons who carried out the monitoring, provide GPS coordinates of the harvest and replanting sites monitored, state the time/date of the monitoring period, and provide a description of any methods employed.

In relation to the relocated resources the reports will also include data on the percentage cover of relocated seagrass, replanted unit survival, shoot density and leaf length and the status of transplanted corals over time. Populations of special interest, such as urchins, will be monitored to provide estimates of their density within and outside of the transplanted seagrasses.

Any bleaching, disease, or other damage observed to the corals will be reported whether this occurs in the transplanted coral colonies or not.

Observations made in the field will be supplemented by photography to show the progression of replanted resources over time.

Water quality and physiochemical parameters will be monitored over time at the replanted sites.

6.0 Conclusion

The site proposed for the construction of the coastal works is located within a seagrass meadow and a shallow back reef. The coral reef is extremely degraded, however there are 17 monument coral colonies within the footprint of the proposed works, and the seagrass beds and the associated invertebrate and fish community comprise relatively healthy and ecologically significant marine resources.

The potential negative impacts identified from the construction of the breakwaters and groynes and the dredging and nourishment of the beach areas will have a significant negative impact on the seagrass habitat of the area. The associated impacts were identified to be of long lasting duration.

However, for all of the impacts there are appropriate mitigation measures available to reduce the damage to the environment. If the proposed mitigation measures are carried out in a sensitive manner, the benthic resources in the vicinity of the construction and those resources of the wider seagrass meadow can be minimised.

APPENDIX A – Species List

Species List For footprint of Coastal Structures (April 2012)

Northern Groyne	Northern Breakwater	'T' Groyne	Southern Groyne	Southern Breakwater
Turtle Grass	Turtle Grass	Turtle Grass	Turtle Grass	Turtle Grass
Variegated Urchin	Variegated Urchin	Variegated Urchin	Variegated Urchin	Lesser starlet coral
Slippery Dick	Long-spined Urchin	Long-spined Urchin	Long-spined Urchin	Yellow tail snapper
Halimeda sp	Boring Rock Urchin	Sea Egg	Boring Rock Urchin	Foureye butterfly fish
Lesser starlet coral	Lesser starlet coral	*Dictyota sp*	*Halimeda sp*	Spiny Lobster
Amber Pen shell	Thin finger coral	*Halimeda sp*	*Penicillus sp*	*Halimeda sp*
	Slippery Dick	Hydroids	Lesser starlet coral	*Dictyota sp*
	Blue head wrasse	Lesser starlet coral	Mustard Hill Coral	Slippery dick
	Red band parrot	Thin finger coral	Lettuce Sea Slug	Red band parrot (IP)
	Cocoa Damselfish	Slippery Dick (juv.)	Beaugregory	
	Starfish	Red band parrot (IP)	Doctor fish	
	Banded butterfly fish	Blue head wrasse	Grunts (juv.)	
	Doctor fish	Beaugregory (juv.)	Sergeant Major	
	Spotted goat fish	Blue head wrasse	Dusky damsels	
	Needle fish	Striped Parrot (juv.)		
	Queen Conch	Squirrel fish		
		Scorpion fish		
		Spotted goat fish		
		Yellow tail snapper		
		Doctor fish		
		Encrusting sponge		
		Anemone		
		Rose coral		
		Parallel Arm of		

		'T'		
		Turtle Grass		
		Variegated Urchin		
		Halimeda sp		
		Hydroids		
		Lesser starlet coral		
		Slippery Dick		
		Beaugregory (juv.)		
		Doctor fish		
		Coral rubble		

Species List – Outside of Footprints (April 2012)

Common Name	Scientific Name	Economic/ Ecological Value	Occurrence/ Frequency
Triton's Trumpet	*Charonia variegata*	Reef Check® bio-indicator species	R
Amber Pen Shell	*Pinna carnea*		R
Milk Conch	*Strombus costatus*	Potential Fishery	R
Spiny Lobster	*Panulirus argus*	Very Important Jamaican Fishery	R
Ivory Bush Coral	*Oculina sp*		R
Fire Coral	*Millepora complanata*		O
Scorpion Fish	*Scorpaena plumieri*		R
Red band parrot	*Sparisoma aurofrenatum*	Important Jamaican Fishery	F
Striped parrot	*Scarus iseri*	Important Jamaican Fishery	O
Cocoa Damselfish	*Stegastes variabilis*		R

D – Dominant; A – Abundant; F – Frequent; O – Occasional; R – Rare

Species List (June 2011)

Fish and Rays (vertebrates) Data

Common Name	Scientific Name	Economic/ Ecological Value	Occurrence/ Frequency
School Master	*Lutjanus apodus*	Jamaican (reef) Fin Fishery	F
Stoplight Parrot	*Sparisoma viride*	Jamaican (reef) Fin Fishery,	D

		Herbivore	
Princess Parrot (juv)	*Scarus taeniopterus*	Jamaican (reef) Fin Fishery, Herbivore	O
Other Parrots	Scaridae	Jamaican (reef) Fin Fishery, Herbivore	F
Spanish Grunt	*Haemulon macrostomum*	Jamaican (reef) Fin Fishery	A
Spanish Hogfish	*Bodianus rufus*	Dive attraction/ Fin Fishery ?	R
Doctor Fish (juv)	*Acanthurus chirurgus*	Jamaican (reef) Fin Fishery	O
Blue Tang (Juvenile)	*Acanthurus coeruleus*	Ornamental/Dive attraction	F
Beaugregory (Juvenile)	*Stegastes leucostictus*	Ornamental/Dive attraction	F
Banded Butterfly Fish	*Chaetodon striatus*	Ornamental/Dive attraction	F
Foureye Butterfly Fish	*Chaetodon capistratus*	Ornamental/Dive attraction	F
Dusky Damsel	*Stegastes adustus*	Ornamental/Dive attraction	F
Cocoa Damsel	*Stegastes variabilis*	Ornamental/Dive attraction	F
Squirrel Fish	*Holocentrus adscensionis*	Jamaican (reef) Fin Fishery	A
Spotted Goat Fish	*Pseudupeneus maculatus*	Jamaican (reef) Fin Fishery	O
Needlefish (Juvenile)	*Ablennes hians*		R
Balloonfish	*Diodon holocanthus*	Dive attraction	O
Lionfish (adult)	*Pterois volitans*	Alien invasive species – threat	O
Unidentifiable Juveniles	Reef	Potential fishery,	O
Unidentifiable Juveniles	Pelagics	Potential fishery, bait	A
Yellow Sting Ray	*Urolophus jamaicensis*	Dive attraction	R

D – Dominant; A – Abundant; F – Frequent; O – Occasional; R – Rare

Coral Data

Common Name	Scientific Name	Economic/ Ecological Value	Occurrence/ Frequency
Finger Coral	*Porites porites*		O
Thin Finger coral	*Porites divaricata*		F
Lesser Starlet coral	*Siderastrea radians*	Potential Reef building corals; biodiversity; shoreline	F

Fire Coral	*Millepora alcicornis*	protection; habitat	R
Great Star coral	*Montastrea cavernosa*		R
Rose coral	*Manicina areolata*		O
Tube Coral	*Cladocora arbuscula*		R
Sea Fan	*Gorgonia ventalina*		R

D – Dominant; A – Abundant; F – Frequent; O – Occasional; R – Rare

Invertebrate Data

Common Name	Scientific Name	Economic/ Ecological Value	Occurrence/ Frequency
Sea Egg	*Tripnuestes ventricosus*	Potential fishery	F
Rock Urchin	*Echinometra viridis*	Herbivore	O
Pencil Urchin	*Eucidaris tribuloides*	Herbivore	O
Long-Spined Urchin	*Diadema antillarum*	Primary Herbivore	F
Green Urchin	*Lytechinus variegatus*	Herbivore	O
Rock Boring Urchin	*Echinometra lucunter*	Herbivore	F
Sand Dollar	*Clypeaster species*		O
Red Heart Urchin	*Meoma ventricosa*		O
Sea Cucumber	*Actinopygia sp*		O
Sea Star	*Oreaster reticulatus*		O
Hermit Crab	*Paguristes sp*		O
Blue Crab	*Callinectes sp*		O
Lettuce Sea Slug	*Elysia crispata*		O
Reef Squid	*Sepioteuthis sepioidea*		R
Conch	*Strombus gigas*	Very important Jamaican Fishery	R
Hydroid	*Thyroscyphus ramosus*		O
Chiton	*Acanthopleura granulata*		F
Sea Anemone	*Condylactis gigantea*		O
Tube Dwelling Anemone	Unidentified		R
Feather Duster	*Sabellastarte magnifica*		R
Mustard Sponge	*Pseudoceratina crassa*		R
Encrusting	*Plakortis*		O

sponge	*angulospiculatus*		
Fireworm	*Hermodice carunculata*		O

D – Dominant; A – Abundant; F – Frequent; O – Occasional; R – Rare

Algae and Plant Data

Scientific Name	Group	Economic/ Ecological Value	Occurrence/ Frequency
Caulerpa racemosa	Green Algae		O
Padina jamaicensis	Brown Algae		A
Udotea sp.	Green Algae	Pioneer species	R
Penicillus spp.	Green Algae	Pioneer species	A
Dictyota sp.	Brown Algae		A
Amphiroa rigida	Red Algae		R
Ventricaria ventricosa	Green Algae		O
Dictyosphaeria cavernosa	Green Algae		O
*Enteromorpha sp.**	Green Algae	Pioneer species	F
Halimeda tuna	Green Algae	Calcareous – forms part of sand	O
Halimeda incrassata	Green Algae		F
Acetabularia crenulata	Green Algae		R
Turbenaria sp.	Brown Algae		R
Codium sp.	Green Algae		R
Wrangelia penicillata	Red Algae		
Thalassia testudinum	Flowering Plant		D

D – Dominant; A – Abundant; F – Frequent; O – Occasional; R – Rare

Appendix B – Benthic Photos at Structure Location

Photos Northern Groyne

Photos T-groyne

Photos Southern Groyne

Photos Northern Breakwater

Photos Southern Breakwater

Photos Monument Corals

Photo Appendix – Northern Groyne

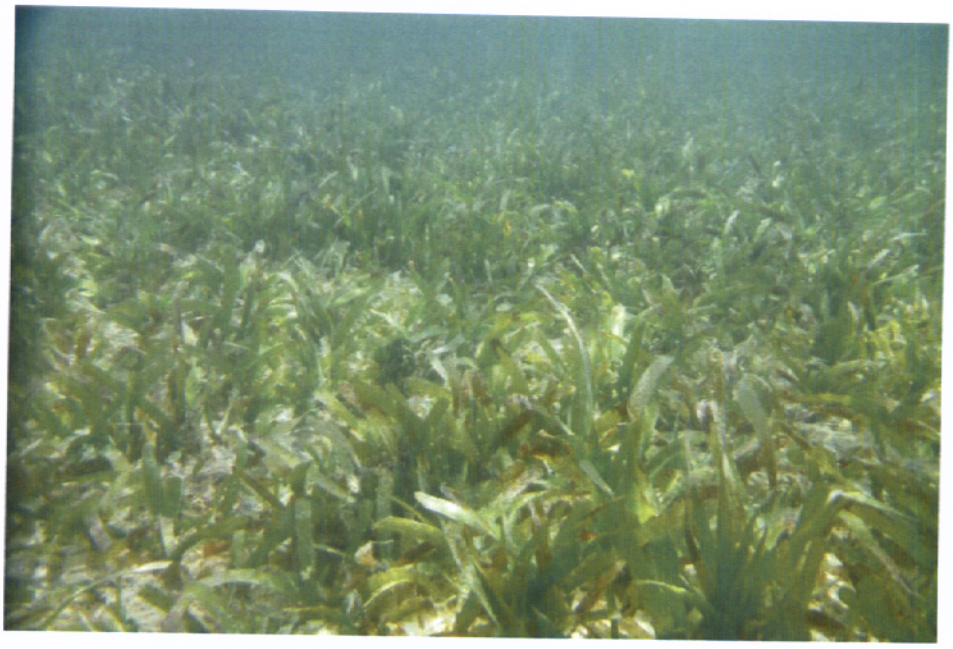

Photo: Seagrass bed

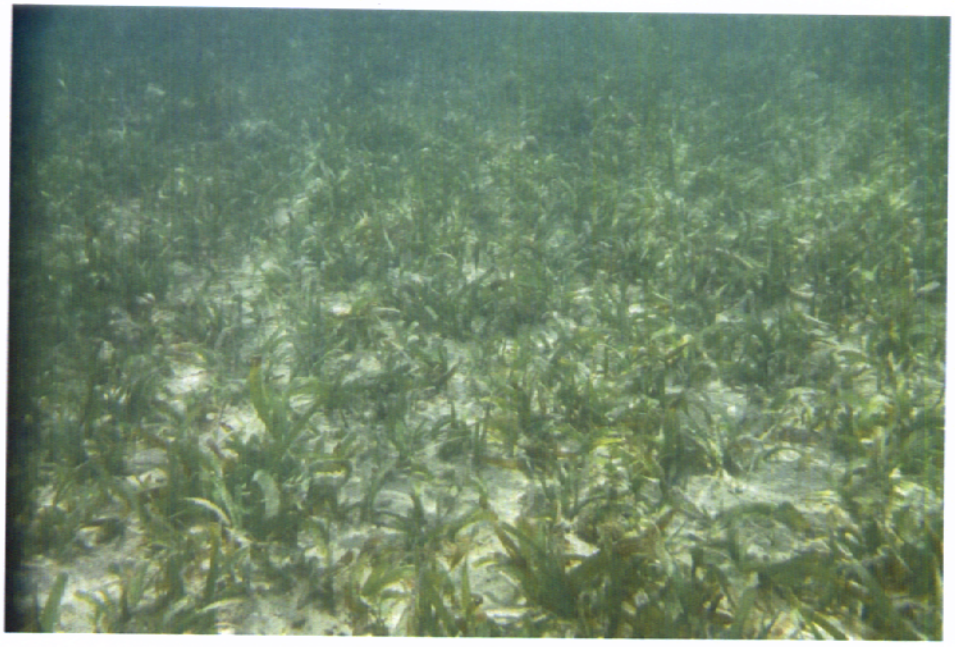

Photo: Seagrass bed

Photo: *Siderastrea* sp. colony in seagrass bed

Photo: *Siderastrea* sp. on hard bottom

Photo Appendix – T-Groyne

Photo: Seagrass bed

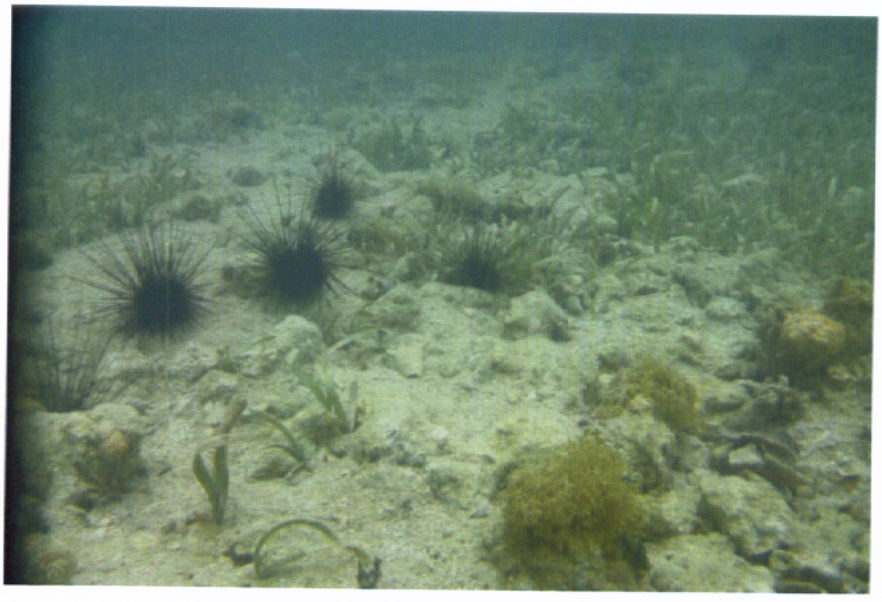

Photo: *Diadema* sp. in seagrass bed

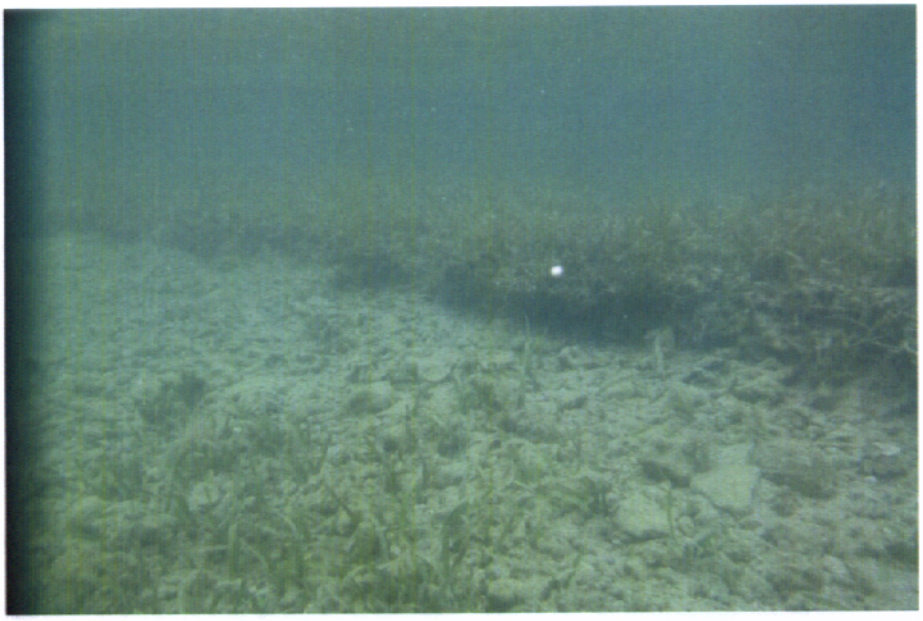

Photo: Eroding edge/ledge of seagrass bed

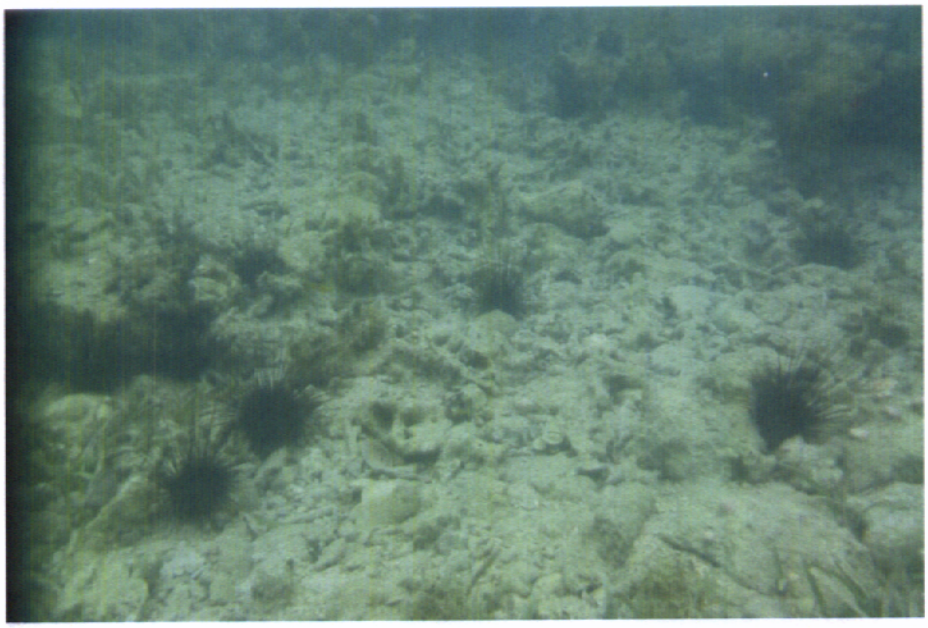

Photo: *Diadema* sp. on rubble bottom

Photo Appendix – Southern Groyne

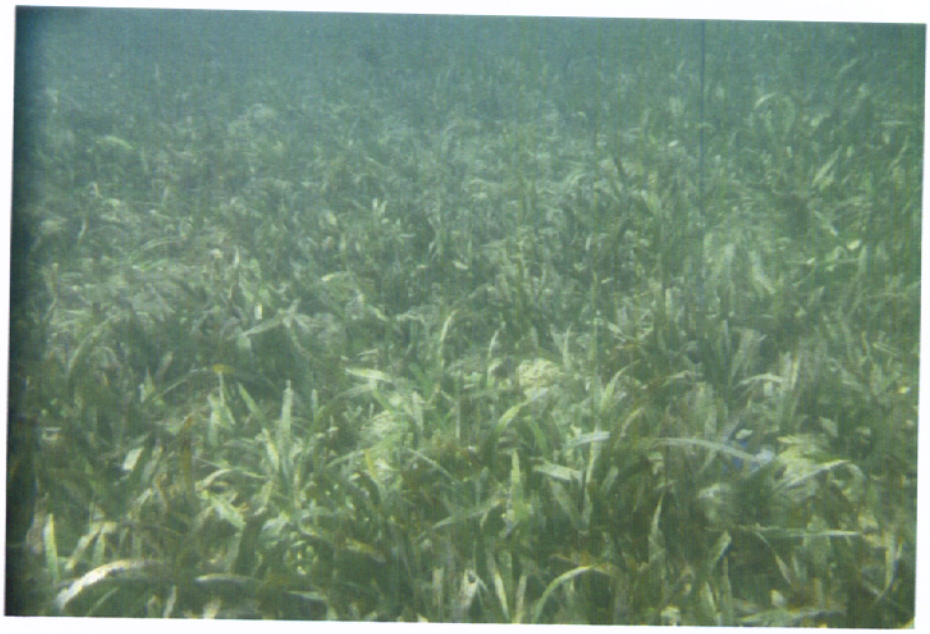

Photo: Seagrass bed

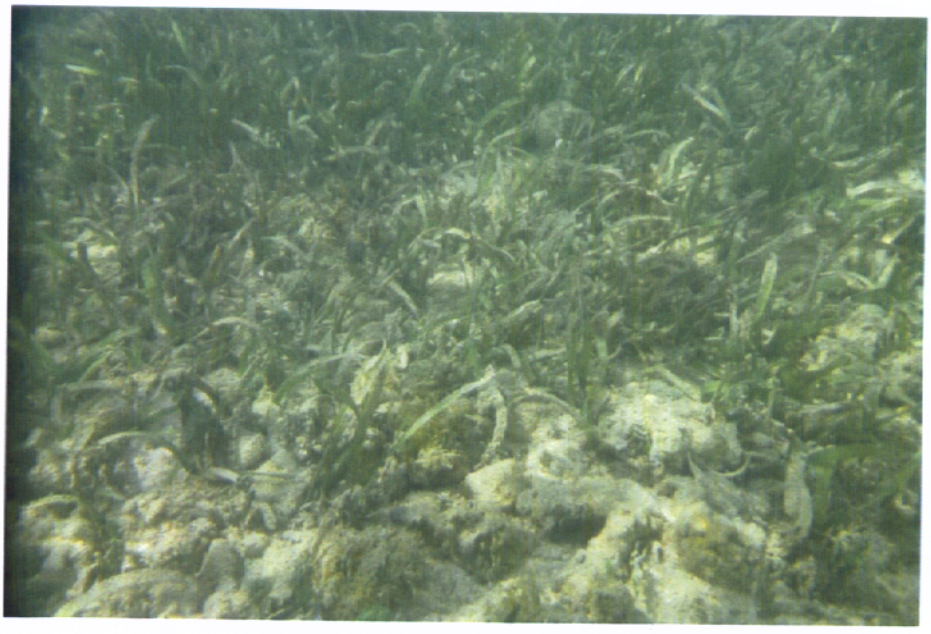

Photo: Seagrass bed

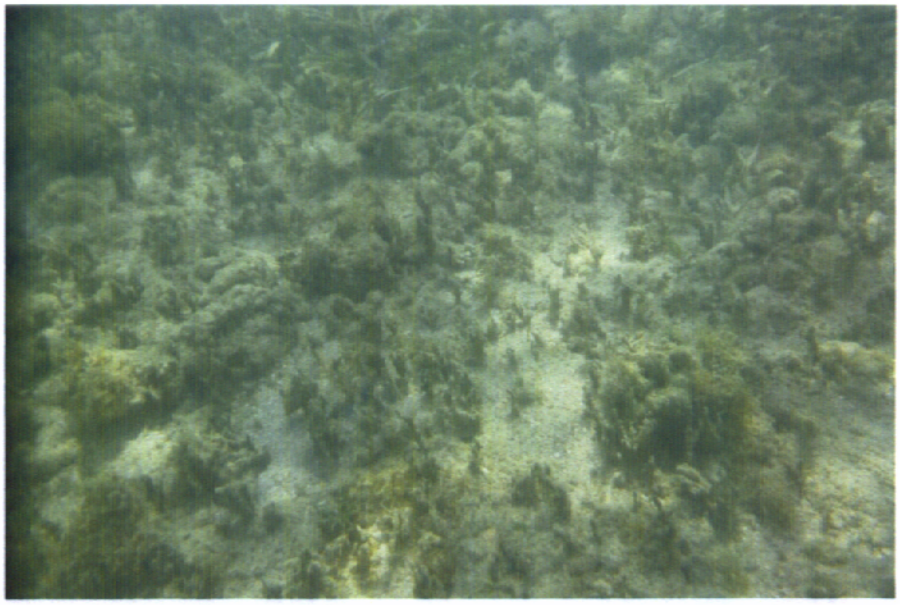

Photo: algae on floor of sea

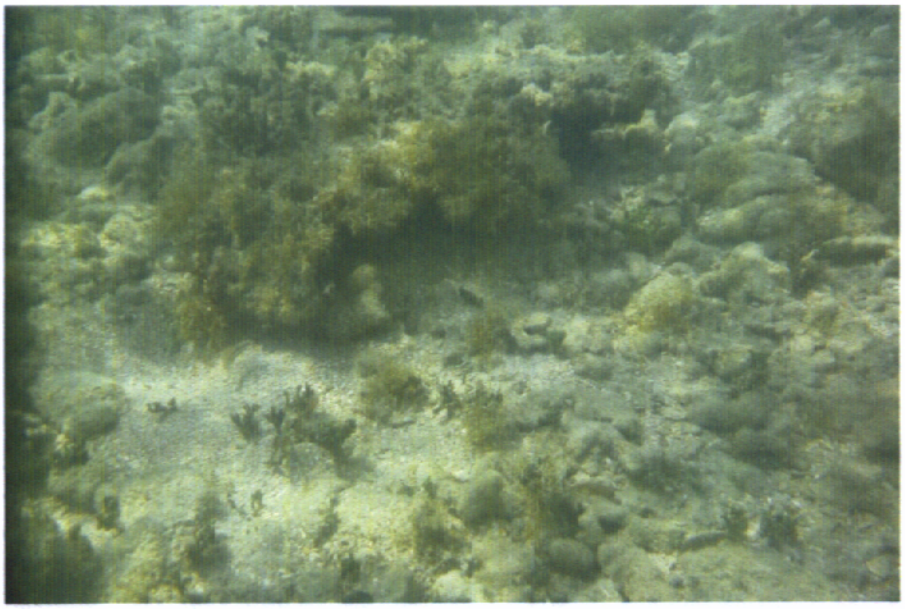

Photo: algae on floor of sea

Photo Appendix – Northern Breakwater

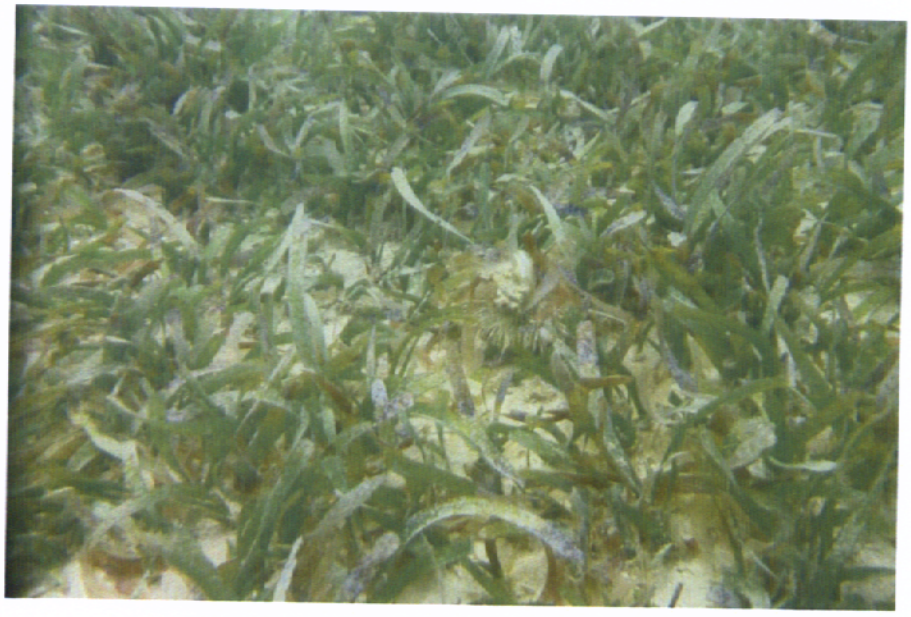

Photo: Seagrass bed

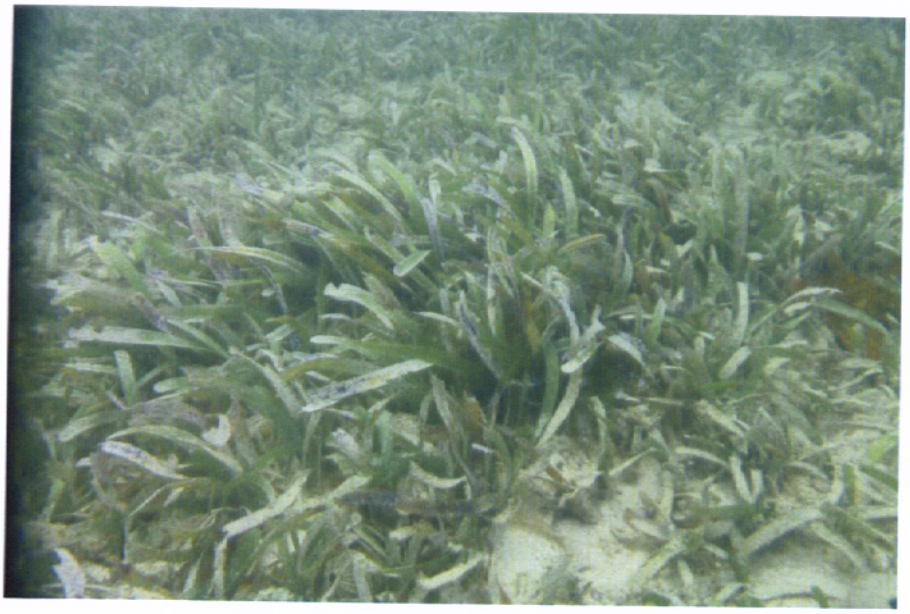

Photo: Seagrass bed

Photo: *Siderastrea* sp. colony in seagrass bed

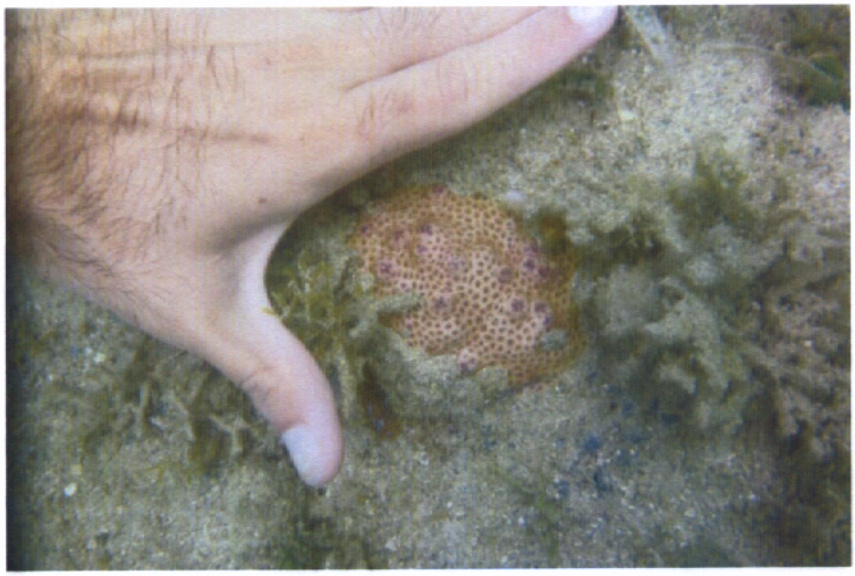

Photo: *Siderastrea* sp. colony in seagrass bed

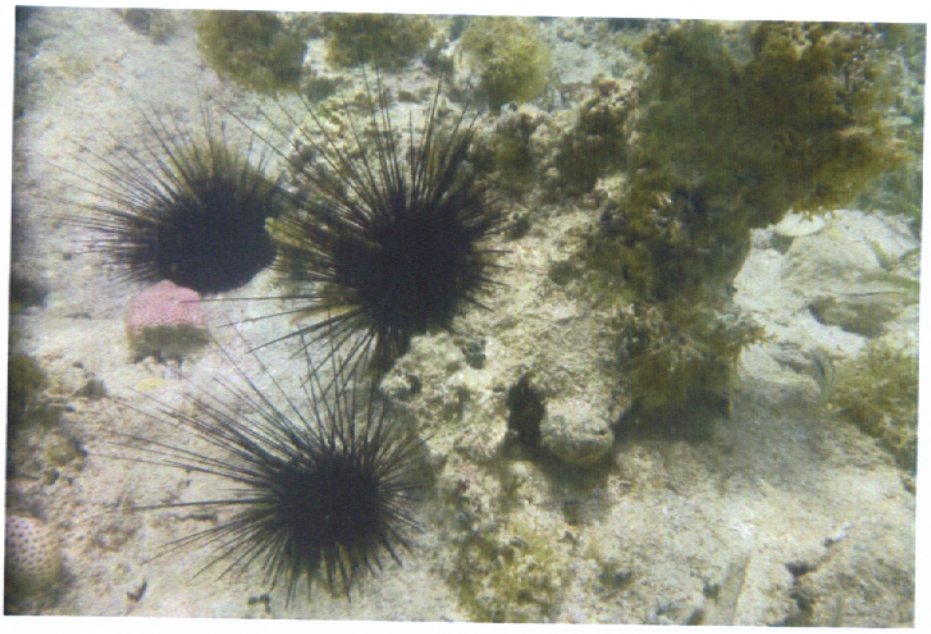

Photo: *Diadema* sp. urchins on hard bottom

Photo Appendix – Southern Breakwater

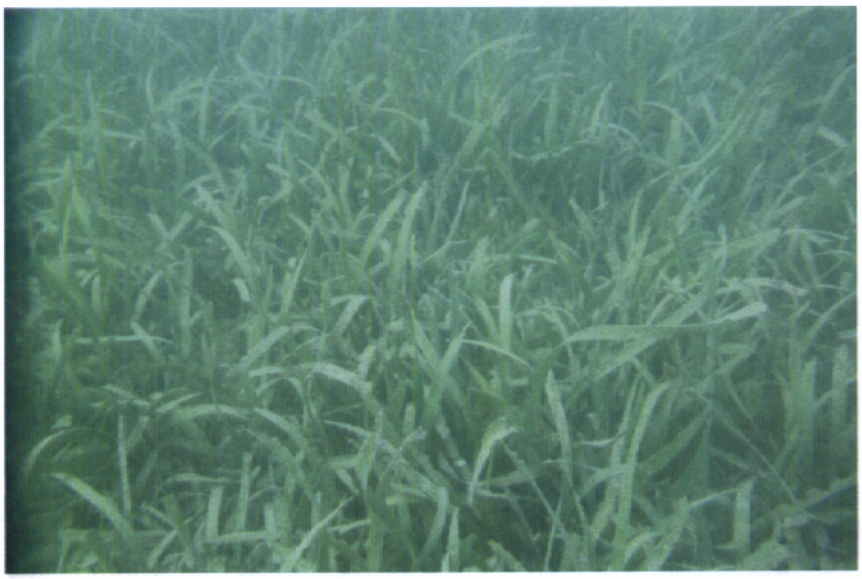

Photo: Seagrass bed

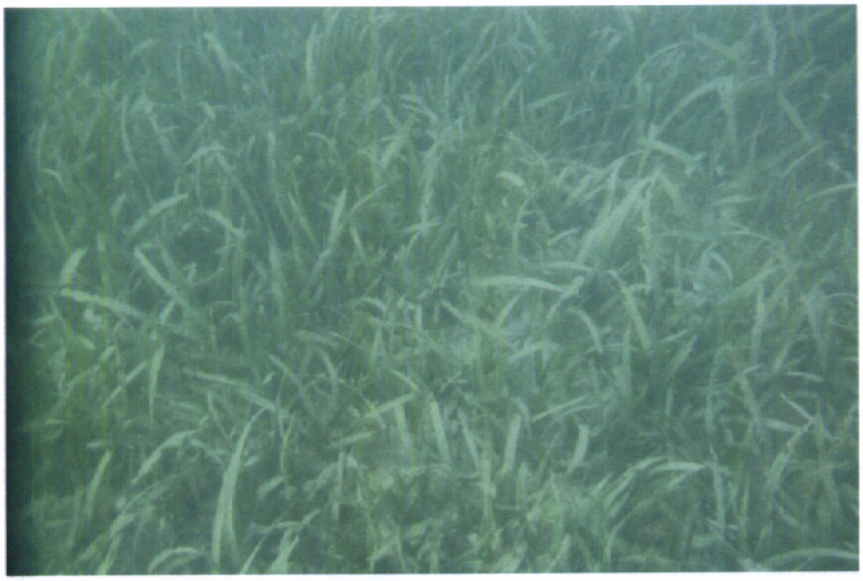

Photo: Seagrass bed

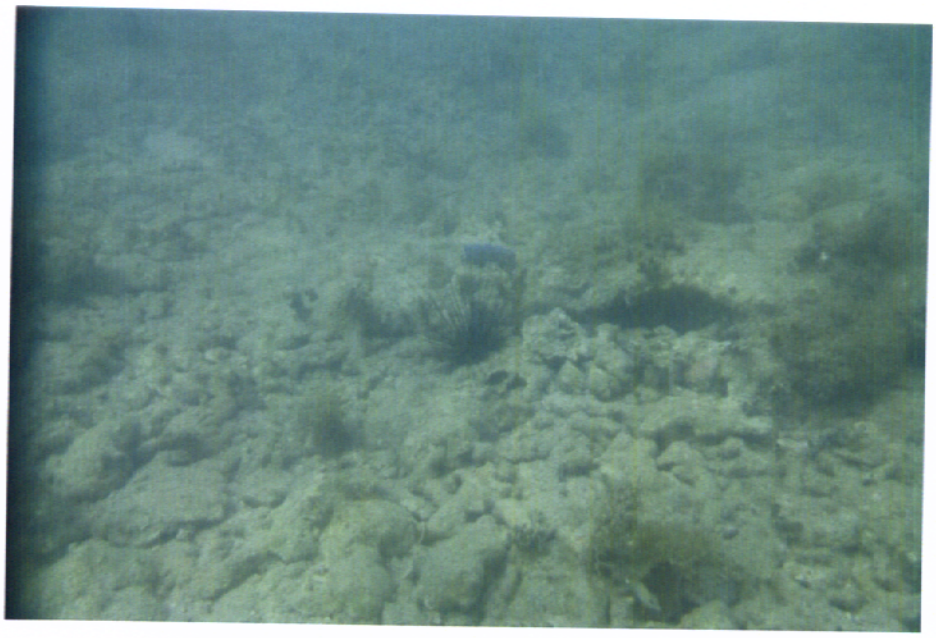

Photo: Rubble bottom

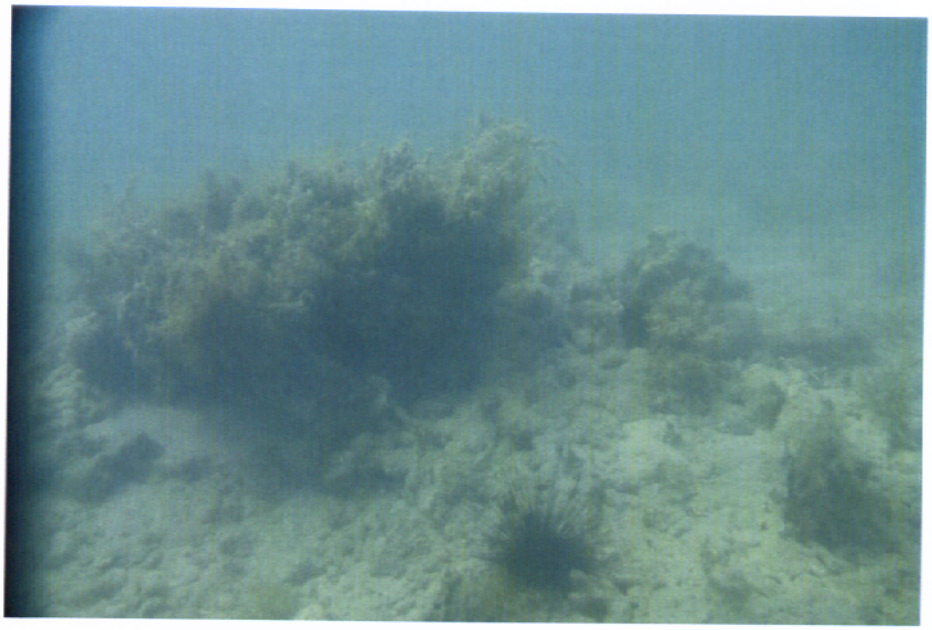

Photo: Relic coral reef

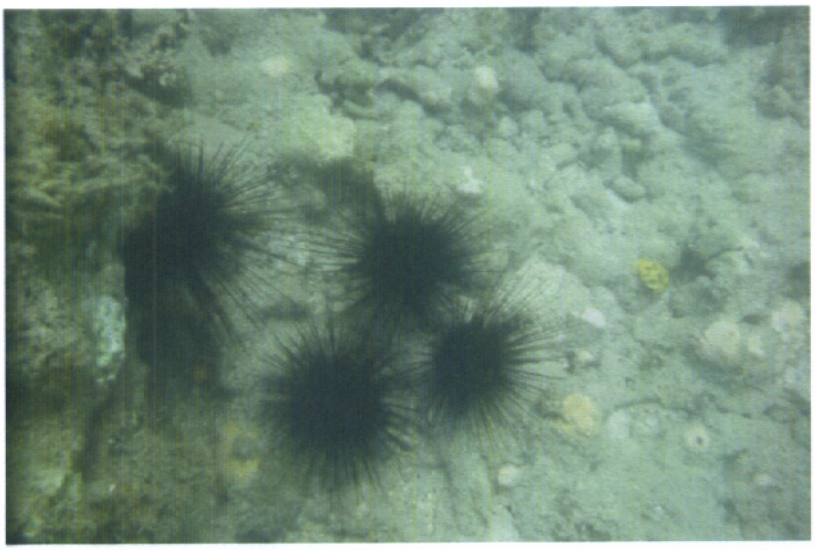

Photo: *Diadema* sp. urchins on rubble bottom

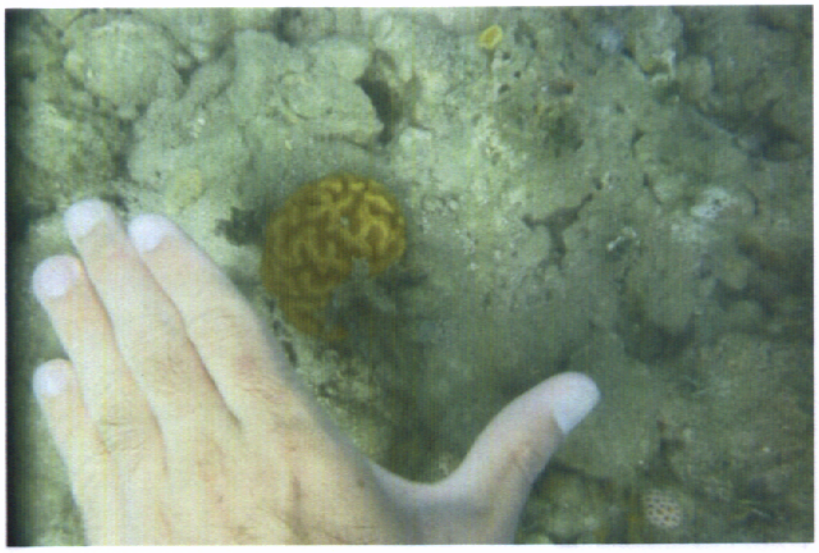

Photo: *Diplora* sp. colony on rubble bottom

Photo Appendix – Monument Corals

Photo: *Siderastrea* sp. colony at waypoint 001

Photo: *Diploria* sp. colony at waypoint 002

Photo: *Montastrea* sp. colony at waypoint 004

Photo: *Siderastrea* sp. colony at waypoint 005

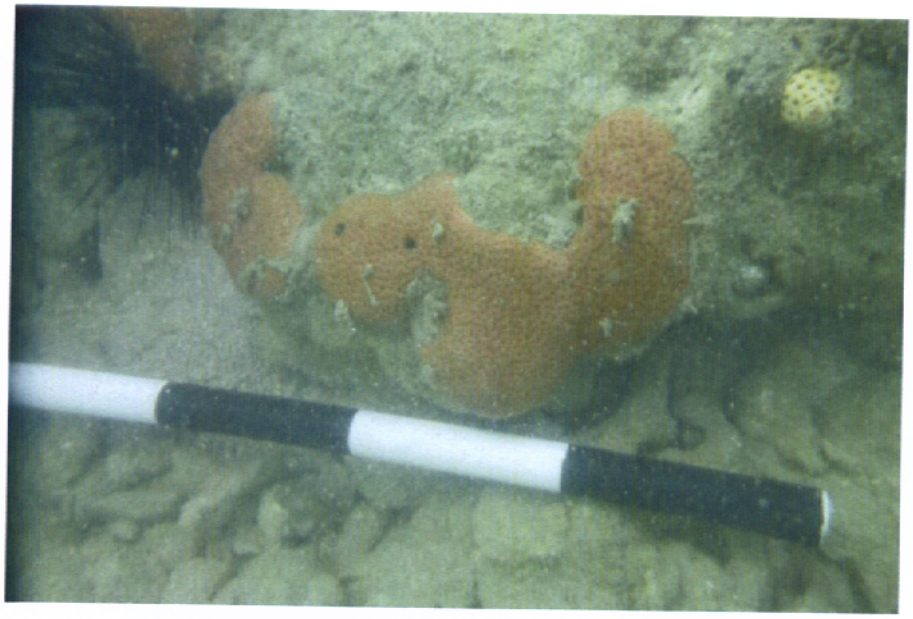

Photo: *Siderastrea* sp. colony at waypoint 005

Photo: *Siderastrea* sp. colony at waypoint 006

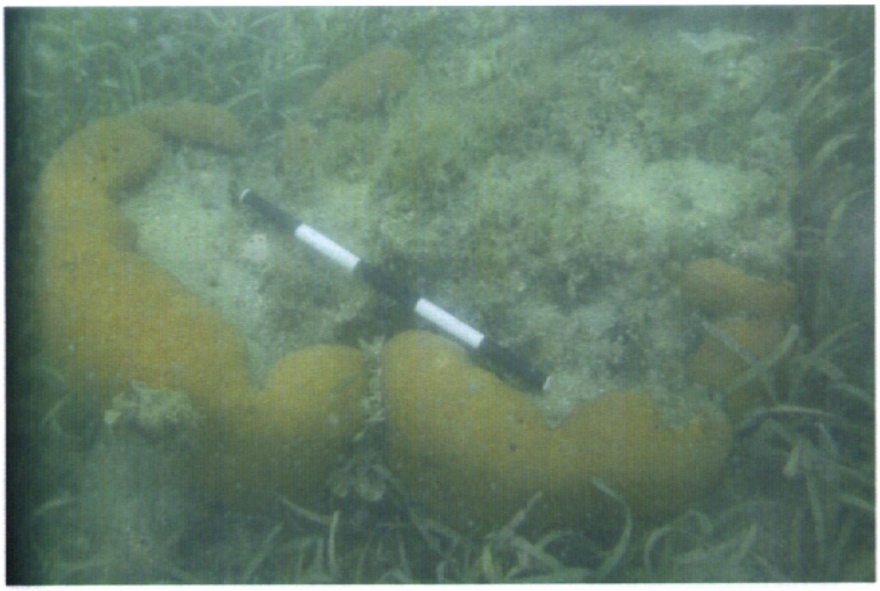

Photo: *Siderastrea* sp. colony at waypoint 007

Photo: *Siderastrea* sp. colony at waypoint 009

Photo: *Siderastrea* sp. colony at waypoint 009

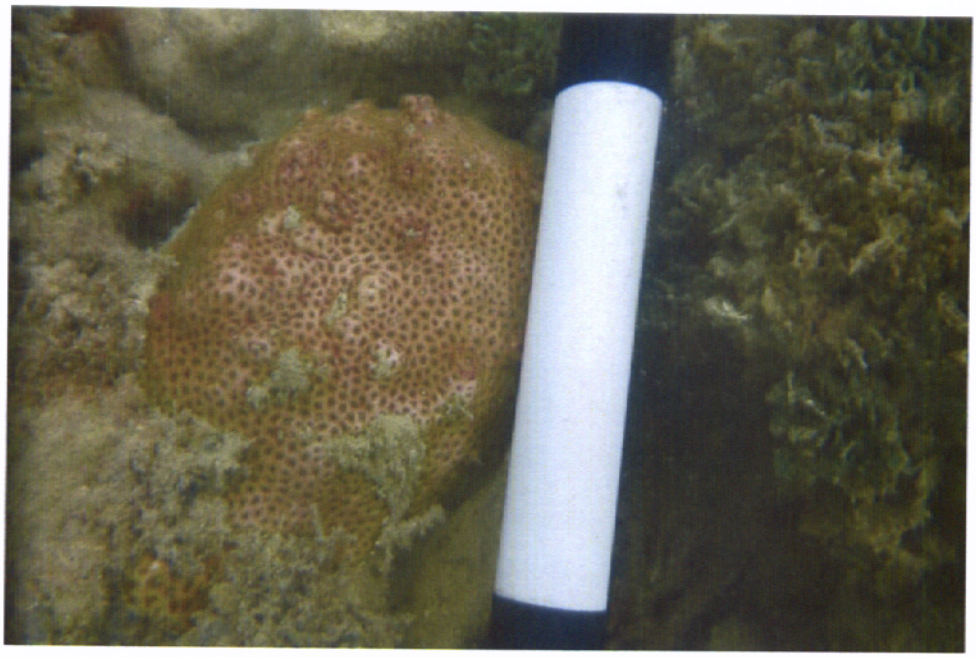

Photo: *Siderastrea* sp. colony at waypoint 009

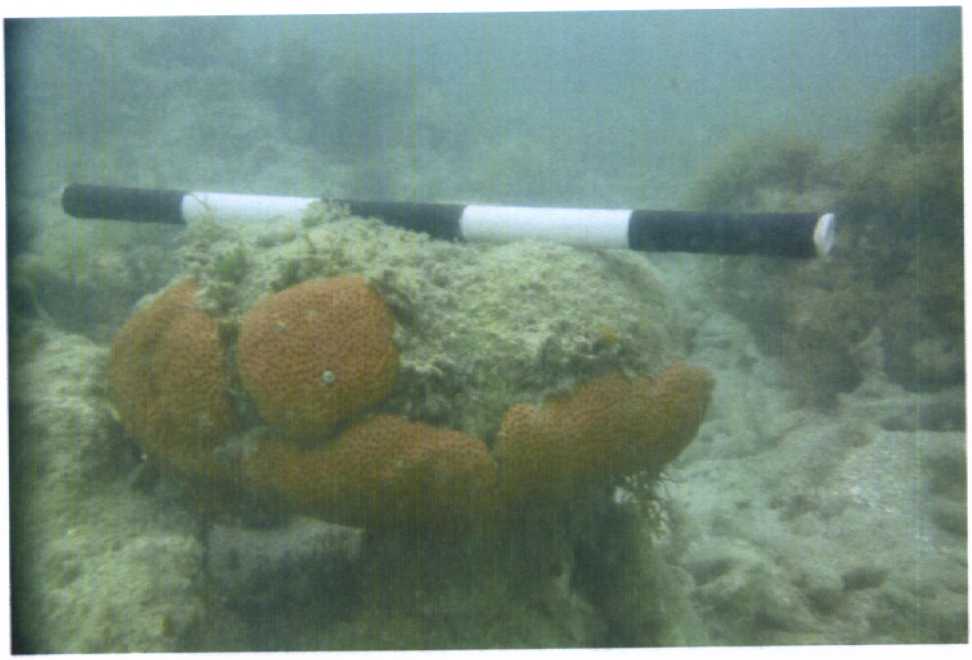

Photo: *Siderastrea* sp. colony at waypoint 010

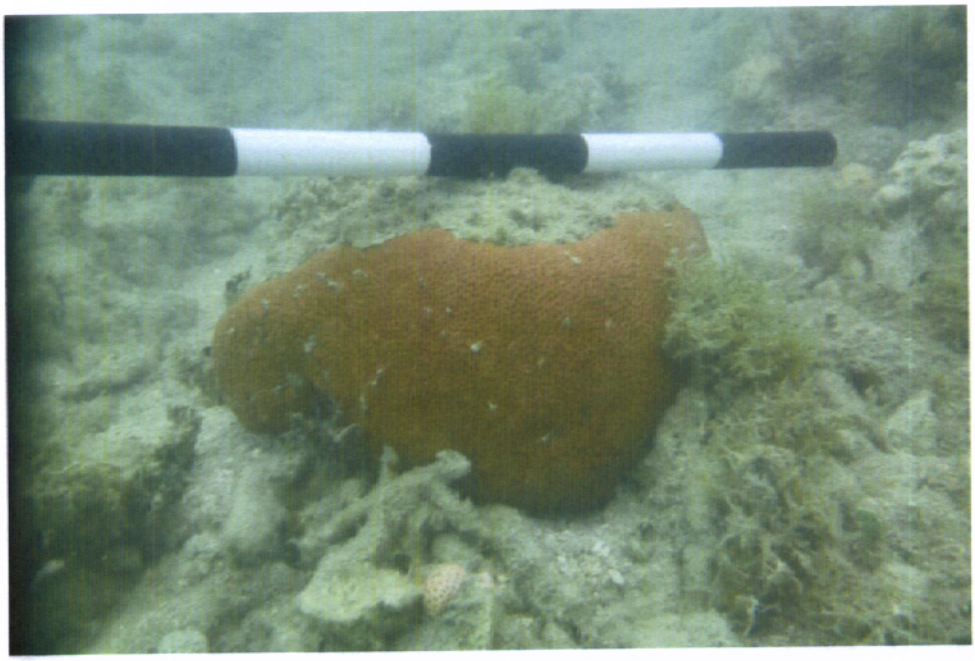

Photo: *Siderastrea* sp. colony at waypoint 011

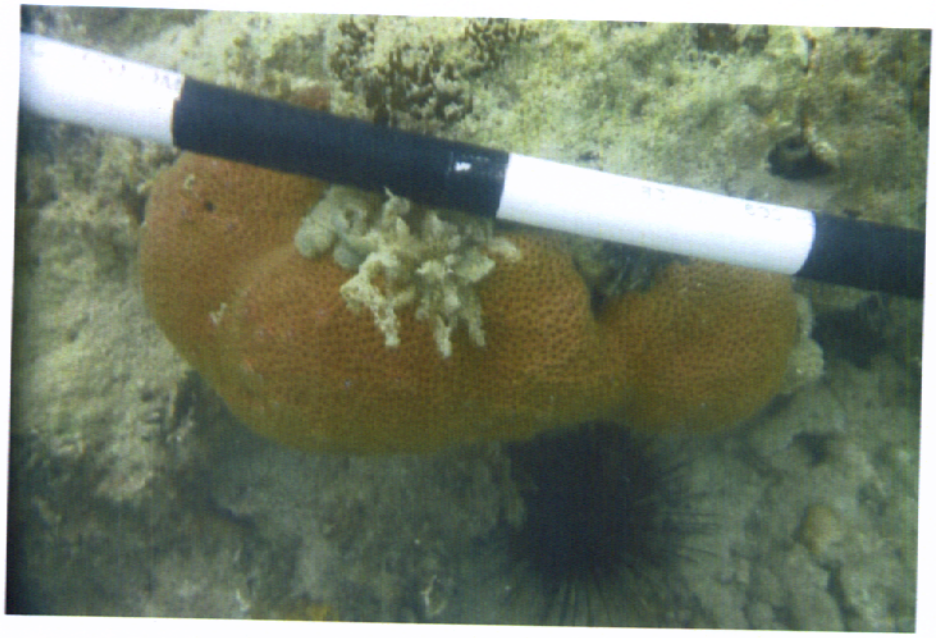

Photo: *Siderastrea* sp. colony at waypoint 014

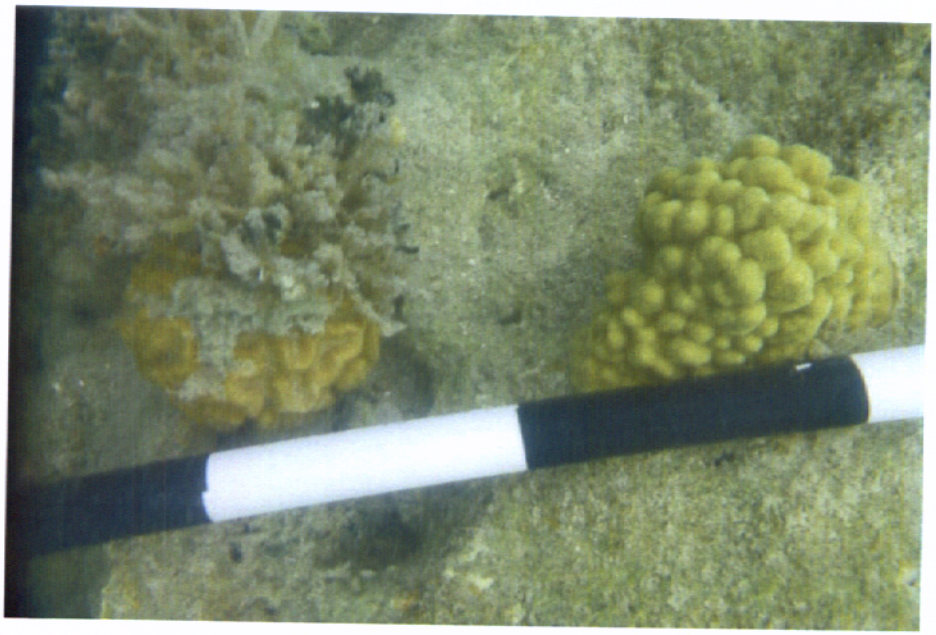

Photo: *Diploria sp.* and *Porities asteroides* colony at waypoint 014

Photo: *Siderastrea* sp. colonies at waypoint 014

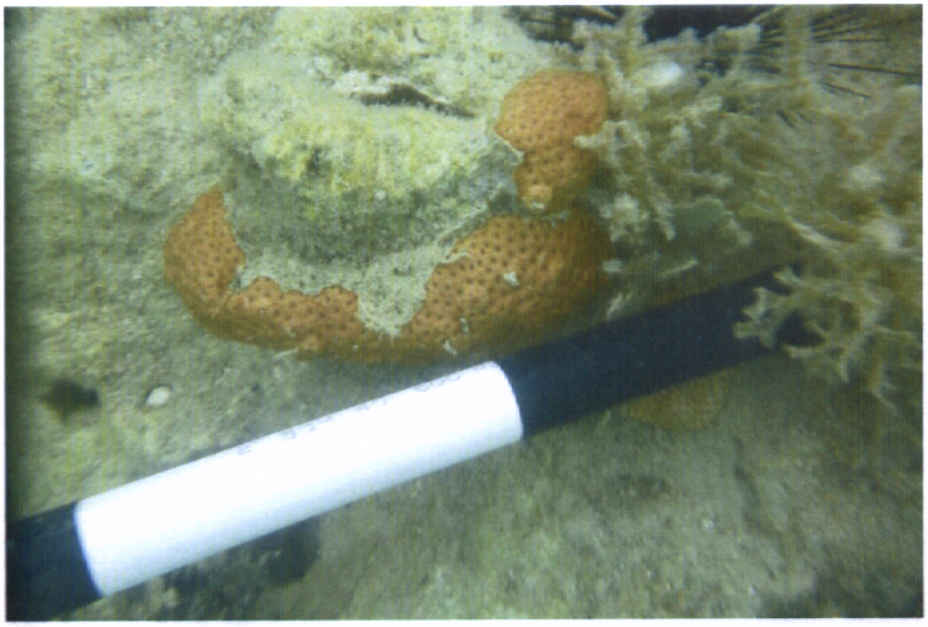

Photo: *Siderastrea* sp. colony at waypoint 014

Photo: *Siderastrea* sp. colony at waypoint 014