Evaluation of current status of seagrasses and marine ecosystem health in St. Jean Bay, St. Barthelemy FWI

A Sustainable Ecosystems Institute, St Jean Bay Science Group Report

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August 2009

Acknowledgements

We thank the COM including President Bruno Magras, M. Michel Magras, and members of the COM and Technical Services Department, the Marine Reserve, Sustainable Ecosystems Institute and Mr. David Graham for support and assistance. We also thank the St Jean Bay community for their input and efforts to sustain and restore the ecosystem for the benefit of all.

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Executive Summary

The loss of seagrass within St. Jean Bay began several years prior to the beach nourishment project conducted in late 2007. The dominance of cyanobacteria and fleshy macroalgae on St. Jean reefs and seagrass beds is an indicator of elevated nutrient levels in the bay. These elevated nutrient levels are likely caused by a combination of point and non-point sources of pollution, including direct stormwater discharge, groundwater seepage, run-off from coastal development activities, and septic tank leakage and sewage input.

Seagrasses should not be transplanted in St. Jean Bay at this time. Attempts to restore seagrass should focus on the elimination of the direct sources of nutrient pollution into the bay. Two direct point sources of nutrients were identified during site visits conducted in April and June 2009. Stormwater discharges directly into Pelican Bay through a drainage pipe under the road adjacent to Nikki Beach and also directly over the seagrass-calcareous macroalgal beds adjacent to the north shorelineof St. Jean Beach. These two point sources of pollution must be eliminated by retrofitting the stormwater and discharge outfalls so that they no longer directly discharge into the bay.

In order to protect existing seagrass-calcareous macroalgal beds and coral reefs and to minimize adverse impacts related to sedimentation, turbidity and burial d the proposed beach nourishment project, biological and physical construction guidelines have been provided (See Attachment 1). These guidelines include establishment of a physical monitoring program and seagrass/coral reef monitoring program for the evaluation of long-term beach fill and dredging related impacts.

High water quality is extremely important for human health and the health of coral reefs and seagrasses. A detailed water quality monitoring program should be established and better coastal resource management is needed to protect these valuable resources. To address the long-term sustainability of valuable coral reef and seagrass resources adjacent to the St. Jean Bay shoreline, a Master Plan is needed to resolve the cumulative impacts resulting from sewage and septic leakage, groundwater contamination, storm-water runoff, and inappropriate coastal development activities which release nutrients into St. Jean Bay and other bays/lagoons on St Barthelemy.

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Introduction

An emergency beach nourishment project was conducted in late 2007 along the central and eastern portions of St. Jean Beach with sand placement between the properties of Eden Rock and Emeraude Plage. The sand borrow site was located within the bay system; dredging occurred in the sand deposits offshore of Eden Rock, the channel between the reef, and additional sites inside and outside the reef. The dredging project created deep "holes" within the bay system, and the deepening of the channel caused erosion on the western side of St. Jean Bay and sediment deposition/siltation on the coral reef.

A second nourishment of St. Jean Bay beach has been planned for 2009. Following the recommendations of Dr. Deborah Brosnan, Mr. Ralph Clark (FDEP-BBCS) and Dr. Joan Oltman-Shay, the sand will be mined from outside the reef to inject a new source of sand into the bay system. Brosnan has proposed a scientific adaptive approach to restore the beach, the coral reef, and the seagrass beds within the bay system. The author was requested to evaluate the status and health of seagrasses within St. Jean Bay and the potential for seagrass restoration in light of the proposed beach renourishment project. This report is based on the author's personal observations during two site visits to Greater St. Jean Bay conducted between April 23 and 25, 2009, and June 22 and 25, 2009.

Seagrasses

Seagrasses provide valuable ecological services to the marine environment (Orth et al. 2006, Costanza et al. 1997). These services include provision of physical habitat structure/shelter, alteration of water flow, nutrient cycling, and food web structure (Hemminga and Duarte 2000). Seagrasses are an important food source for endangered green sea turtles and provide critical habitat for many commercially and recreational important fishery species such as conch and lobster (Beck et al. 2001). Seagrasses are important physical stabilizers of the seabed; their root and rhizome systems bind unstable, silty sediments and trap organic matter. Trapping of fine sediments within seagrass beds aids in the prevention of siltation on adjacent coral reef habitats. Seagrass beds also provide storm protection and help prevent coastal erosion by dampening wave action (Erftemeijer and Lewis, 2006; Di Carlo et al., 2005; Czerny and Dunton, 1995).

Due to the global importance of seagrass habitats to key ecological services such as organic carbon production and export, sediment stabilization, enhancement of biodiversity, and trophic transfers to adjacent habitats, seagrasses can be considered "coastal canaries," global biological sentinels of increasing anthropogenic influences in coastal ecosystems (Orth et al. 2006). Large-scale losses of seagrasses are being reported worldwide due to the cumulative effects of multiple stressors, including sediment and nutrient runoff, physical disturbance, invasive species, disease, commercial fishing practices, aquaculture, overgrazing, algal blooms, and global warming, causing declines at scales of square meters to hundreds of square kilometers (Orth et al. 2006).

St. Jean Bay

Brosnan provides an overview of the Greater St Jean Bay system in her white paper entitled "From the beach to the reef: Designing the future of coasts and oceans, Focus: St Jean Bay, St Barthelemy, FWI." As described by Brosnan, St. Jean Bay is separated into two sections by a rock protrusion known locally as Eden Rock. The larger western section is known as St. Jean Bay, and the smaller eastern section is locally referred to as Pelican Bay. The fringing reef system protecting the bay is comprised of a central reef located approximately 0.16 km from the shore, and an east and west reef to either side of the central reef. Within St. Jean Bay, the west reef is separated from the central reef by a small channel.

Prior to the development of the St. Jean Bay shoreline, aerial photographs indicate large areas of seagrass existed in the central portion of the bay. Based on an analysis of photographic data, Brosnan reported that over 99% of the seagrass in the central part of St. Jean Bay was lost between 1995 and 2003. The remaining seagrass beds in St. Jean Bay are currently located in the shallow waters on the west side of St. Jean Bay along the north shoreline and in the eastern half of Pelican Bay.

April 2009 site visit

The April 2009 site visit was the author's first visit to St. Jean Bay. Several transects were swum from the shoreline through seagrass beds to the western fringing reef. These transects revealed a transition from calcareous macroalgal beds dominated by *Halimeda* spp. to sparse seagrass intermixed with calcareous macroalgae such as *Halimeda*, *Penicillus, Udotea, Avrainvillea* and *Caulerpa*, and scattered dense patches of seagrass dominated by shoal grass (*Halodule wrightii*) and manatee grass (*Syringodium filiforme*). *Halimeda* beds are very important for the St. Jean Bay system because these calcareous green algae are sediment producers; upon death, the algae are contributors to the beach sand supply. The macroalgae beds also serve to stabilize the sediment, helping to trap beach sand within the bay.

A small, dense mixed bed of turtle grass (*Thalassia testudinum*) and manatee grass with lesser amounts of shoal grass exists at the north end of the bay adjacent to the shoreline. The interior of this mixed bed appeared visually healthy with low epiphytic cover (Photos 4 and 6). However, the bed edges were extremely eroded, and a strong current was encountered in April 2009. The current had exposed the turtle grass rhizome mat, and the majority of the exposed rhizomes were dead (Photos 1 and 2). In mature turtle grass beds, rhizomes typically form a tightly woven map approaching a half meter thick, and the rhizomes are generally buried approximately 8 to 25 cm below the sediment surface. Because *Thalassia* rhizomes are extremely strong binders of sediment, exposure of the rhizome mat has reduced the sediment trapping capability of the seagrass bed and has destabilized the remainder of the bed. Erosion of the bed edge was attributed to the high current velocity. No physical measurements of current velocity were performed during the site visit.

Although the interior of the small seagrass bed along the north shoreline appeared healthy with low epiphytic cover, this bed was not characteristic of the remaining mixed seagrass/calcareous macroalgal beds in the bay. Excessive growth of cyanobacteria and fleshy macroalgae on the corals reefs, seagrasses and macroalgal beds within the St. Jean Bay system suggests that bay is receiving elevated levels of land-based sources of nutrient pollution. The *Halimeda* beds and reefs were covered in dense overgrowth of filamentous cyanobacteria such as *Lyngbya* spp. (Photos 5 and 6), and the exposed *Thalassia* rhizome mats were also overgrown with *Lyngbya* and other filamentous cyanobacteria (Photos 1-3). Heavy cyanobacterial overgrowth was observed on the branching stony corals such as *Porites porites* on the western reef (Photo 5). The proliferation of this epiphytic cyanobacteria suggests significant nutrient pollution into St. Jean Bay. Proliferation of filamentous cyanobacterial mats is a typical indicator of high sewage inputs and/or elevated phosphorus to nitrogen ratios.

The landward portion of central St. Jean reef was heavily silted and overgrown with algae in April 2009. The dominant species were the brown macroalgae *Sargassum polyceratium* and *Dictyota mertensii*. Dead corals were overgrown with turf algae, cyanobacteria and fleshy macroalgae, and the turf-algal matrix had bound large amounts of silt and fine sediment to the reef surface. In addition to the effects of sedimentation/siltation from the 2007 dredging project, algal overgrowth inhibits settlement of coral recruits and reduces survivorship of existing corals due to tissue loss from smothering and/or abrasion and competition for space and light. The fast growth/turnover rates of the algae allow these species to serve as indicators of reef degradation, particularly in areas subjected to anthropogenic activities.

Eden Rock also showed high overgrowth by fleshy macroalgae in April 2009. The dense algal canopy was dominated by *Dictyopteris justii*, *Sargassum polyceratium*, and *Dictyota* spp (Photo 18). These species were also dominant in Discovery Bay, Jamaica, during the transition from coral to macroalgal dominance in the late 1980s (Lapointe et al. 1997). The overgrowth of frondose macroalgae on Eden Rock in April 2009 suggests elevated nutrient levels and reduced herbivory pressure. Few urchins or herbivorous fishes were observed on Eden Rock and St. Jean reef in April 2009.

Several east-west transects were swum in Pelican Bay from the fringing reef on the east side of Pelican Bay to Eden Rock. The east side of Pelican Bay was colonized by calcareous macroalgal beds dominated by *Halimeda* spp., *Caulerpa prolifera*, *Caulerpa cupressoides*, *Penicillus capitatus*, *Udotea*, and *Avrainvillea* (Photo 26). Mixed macroalgal-seagrass beds with sparse to moderate cover of manatee grass and turtle grass occur in the central and eastern portions of Pelican Bay, and new growth of shoal grass was observed in shallow areas of the fringing reef on the east side of Pelican Bay. The east reef in Pelican Bay was heavily overgrown with turf algae, filamentous and fleshy algae, mainly *Lyngbya* spp., *Dicytota pulchella* and *D. crispata*, *Turbinaria*, and *Lobophora* (Photos 24 and 25). Areas of dense *Caulerpa prolifera* mixed with sparse to moderate cover of manatee grass occur in the central portion of Pelican Bay. There was evidence of recent burial of calcareous macroalgal beds, and relatively minor erosion of turtle grass bed edges with exposure of rhizome mats. Six green sea turtles (*Chelonia mydas*, 4 adults, 2 subadults) were observed selectively feeding on turtle grass blades in Pelican Bay during both the April and June site visits.

June 2009 site visit

During the site visit conducted on June 22 & 23, 2009, the strong current which had been observed along the seagrass bed in the west side of St. Jean Bay seemed weaker in comparison to April, and erosion of the main seagrass bed was less obvious. No new areas of rhizome exposure were observed. A shallow layer of fine sediment had been deposited on top of the exposed turtle grass rhizome mat since April, and new growth of shoal grass and turtle grass was observed in these areas (Photos 9 and 10). A recent bathymetry survey provided by Mr. Xavier David suggested that the dredged channel and holes created during the 2007 beach fill project had been filled with sand, possibly reducing the erosion rate on the western side of the bay. Additionally, redistribution of sand from the beach fill project may be serving as a source of fine sediments to this area. Although the rhizome mat is dead on the sediment surface, it is functioning at a reduced level to slowly trap fine sediments. However, any strong storm or wave action could disrupt this process and destroy the network of dead surface rhizomes.

An increase in urchin abundance was observed on the western fringing reef in St. Jean Bay and on Eden Rock in June 2009. Areas of the reef had been cleared of cyanobacteria and fleshy macroalgae by urchin scraping activity, and several colonies of the stony coral *Porites astreoides*, and small colonies of *P. porites* were observed in the cleared areas on the western reef (Photos 15, 16, 21 and 22). *Porites astreoides* is a dominant species recruiting to newly exposed substrate due to the release of brooded planulae which settle rapidly. However, heavy overgrowth of *Lyngbya* and other filamentous cyanobacteria persisted on the western reef and macroalgal-seagrass beds in the west end of St. Jean Bay in June 2009, indicating that top-down control by grazers is not adequate to maintain low levels of fleshy macroalgae in the bay's current nutrient regime (Photos 8, 11, and 17). The landward portion of the central reef and isolated reef patches landward of the central reef remained heavily sedimented with up to 10 cm of fine sand/silt (Photos 13 and 14). Two green sea turtles were observed resting on these patch reefs.

The large increase in the urchin population (*Echinometra lucunter* and *Diadema antillarum*) on Eden Rock in June 2009 appeared to have contributed to the reduction in the fleshy macroalgal canopy (Photos 21 and 22). In June 2009, the inshore portion of the canopy had been largely removed and replaced with a short, wiry turf algal matrix (Photo 23). However, dense algal canopy overgrowth remained in the deeper portions of the rock formation, causing abrasion impacts and tissue loss in the few remaining massive corals at Eden Rock (Photos 19 and 20).

Large changes in cyanobacterial cover were observed between April and June 2009 in Pelican Bay. Significant overgrowth of *Lyngbya* spp was observed on the macroalgal-seagrass beds offshore of Nikki Beach in June 2009 (Photos 28 and 29), and the unvegetated sand bottom was covered with mat cyanobacteria, suggesting potential groundwater nutrient input. This proliferation is of particular concern due to the importance of these seagrass beds as foraging habitat for resident green sea turtles (Photo 30). *Lyngbya* and other cyanobacterial species produce nitrogenous secondary metabolites that serve as chemical defenses against herbivores (Paul et al. 2001).

Proliferation of cyanobacteria may also have important implications for human health. *Lyngbya* spp. have been associated with reports of dermatitis among recreational water users and fishermen since the 1950s, and aplysiatoxins, which are metabolites of *L. majuscula*, were found to be the causative agents of the acute dermal lesions following contact. The marine species, *Lyngbya majuscula*, is known to produce debromoaplysiatoxin and lyngbyatoxin A in Florida waters (Codd et al. 1999). These toxins have been shown to be potent tumor promoters, are highly inflammatory, and have been shown to cause severe dermatitis with skin contact, in addition to respiratory irritation and gastrointestinal inflammation with oral exposure (Chorus 1999).

Recommendations

Sedimentation, turbidity, and increased erosion associated with the dredging project are not the only factors which have negatively impacted seagrass distribution within St. Jean Bay. The dominance of cyanobacteria and fleshy macroalgae on St. Jean reefs and seagrass beds is an indicator of elevated nutrient levels in the bay which are higher than the levels supportive of coral resilience and recovery. These elevated nutrient levels are caused by a combination of point and non-point sources of pollution, including direct stormwater discharge, groundwater seepage, run-off from coastal development activities, septic tank leakage and sewage input.

Seagrasses should not be transplanted in St. Jean Bay at this time. Attempts to restore seagrass should focus on the elimination of the direct sources of nutrient pollution into the bay. Two direct point sources of nutrients were identified during the site visits. Stormwater discharges directly into Pelican Bay through a drainage pipe under the road adjacent to Nikki Beach and directly over the seagrass-calcareous macroalgal beds adjacent to the north shoreline of St. Jean Beach (Photos 31 through 34). These two point sources of pollution must be eliminated by retrofitting the stormwater and discharge outfalls so that they no longer directly discharge into the bay.

In order to protect the existing seagrass-macroalgal beds and coral reefs and minimize adverse impacts related to sedimentation, turbidity and burial during and following the proposed beach nourishment project, the biological and physical construction guidelines outlined in Attachment 1 must be followed. These guidelines include establishment of a physical monitoring program and seagrass/coral reef monitoring program for the evaluation of beach fill and dredging impacts.

High water quality is central to human health and the health of coral reefs and seagrasses. A monitoring program should be established for the coastal waters of St. Barts and better coastal resource management is needed to protect these valuable resources. To address the long-term sustainability of valuable coral reef and seagrass resources adjacent to the shoreline, a Master Plan is needed to resolve the cumulative impacts resulting from sewage and septic leakage, groundwater contamination, storm-water runoff, and inappropriate coastal development activities which release nutrients into St. Jean Bay.

Sewage enters coastal waters when it is released directly or seeps into groundwater from septic tanks. Sewage effluents carry fecal bacteria which can cause human illness. Fecal coliform bacteria are short-lived once they enter the marine environment, therefore, monitoring for fecal coliform levels should be accompanied by coral reef health assessment, water quality monitoring and algal tissue analysis. Reef health assessment should include monitoring the distribution, abundance and composition of algal communities and detailed, year-round water quality nutrient monitoring is necessary to identify and eliminate the sources of nutrient pollution. Assessment of fecal coliform bacteria should be conducted in heavily utilized recreational areas such as St. Jean Bay.

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Photo 1: Exposed rhizomes of turtle grass (*Thalassia testudinum*) along beds edges in the western section of St. Jean Bay, April 2009

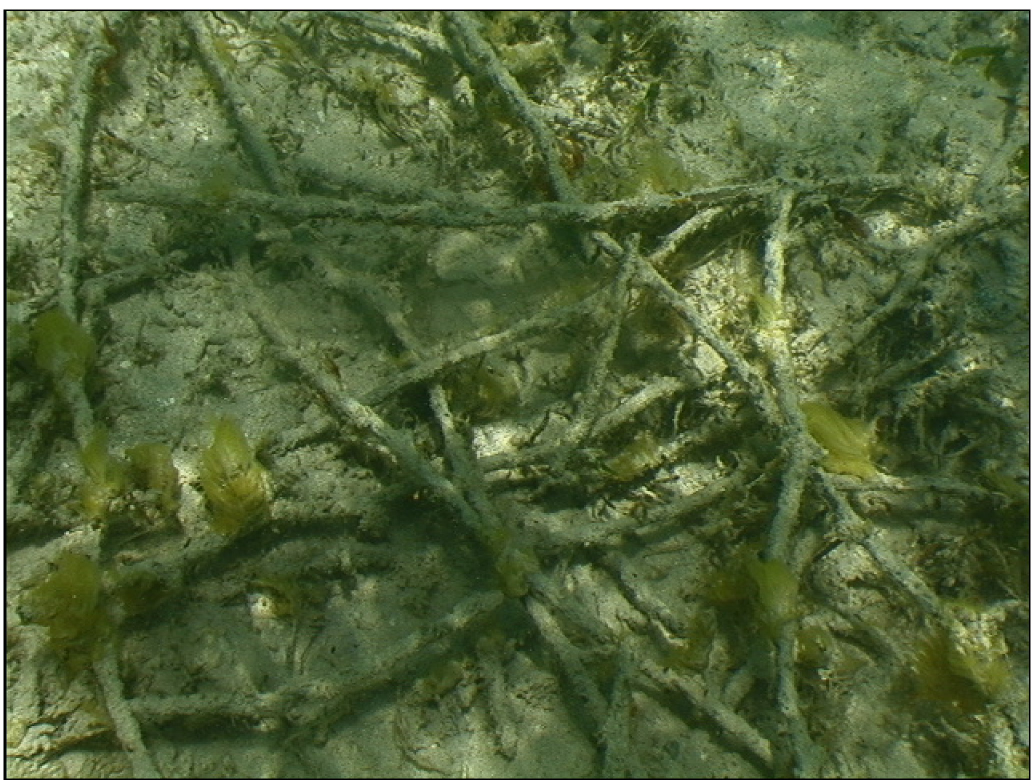


Photo 2: Exposed rhizome mat of turtle grass in western section of St. Jean Bay, April 2009

Photo 3: Overgrowth of filamentous cyanobacteria *Lyngbya* sp. on exposed rhizome mat of turtle grass, April 2009

Photo 4: Healthy, dense mixed bed of turtle grass and manatee grass with low epiphytic cover, west St. Jean Bay along north shoreline, April 2009

Photo 5: Heavy overgrowth of cyanobacteria on *Porites* on western section of reef in St. Jean Bay, April 2009

Photo 6: Overgrowth of *Lyngbya* on calcareous macroalgal beds in western section of St. Jean Bay, April 2009

Photo 7: Manatee grass and shoal grass with calcareous green macroalgae in western section of St. Jean Bay, April 2009

Photo 8: Heavy overgrowth of *Lyngyba* on western reef in St. Jean Bay reef, June 2009

Photo 9: Exposed rhizome mat of turtle grass in western section of St Jean Bay showing signs of sediment accumulation and *Lyngbya*, June 2009

Photo 10: New growth of turtle grass and shoal grass in area of exposed rhizome mat in western section of St Jean Bay, June 2009

Photo 11: Heavy *Lyngbya* cover remains on calcareous green macroalgae, June 2009

Photo 12: Healthy dense mixed bed of turtle grass and manatee grass along north shoreline of western section of St. Jean Bay, June 2009

Photos 13 and 14: Heavily silted patch reefs in central portion of St. Jean, June 2009

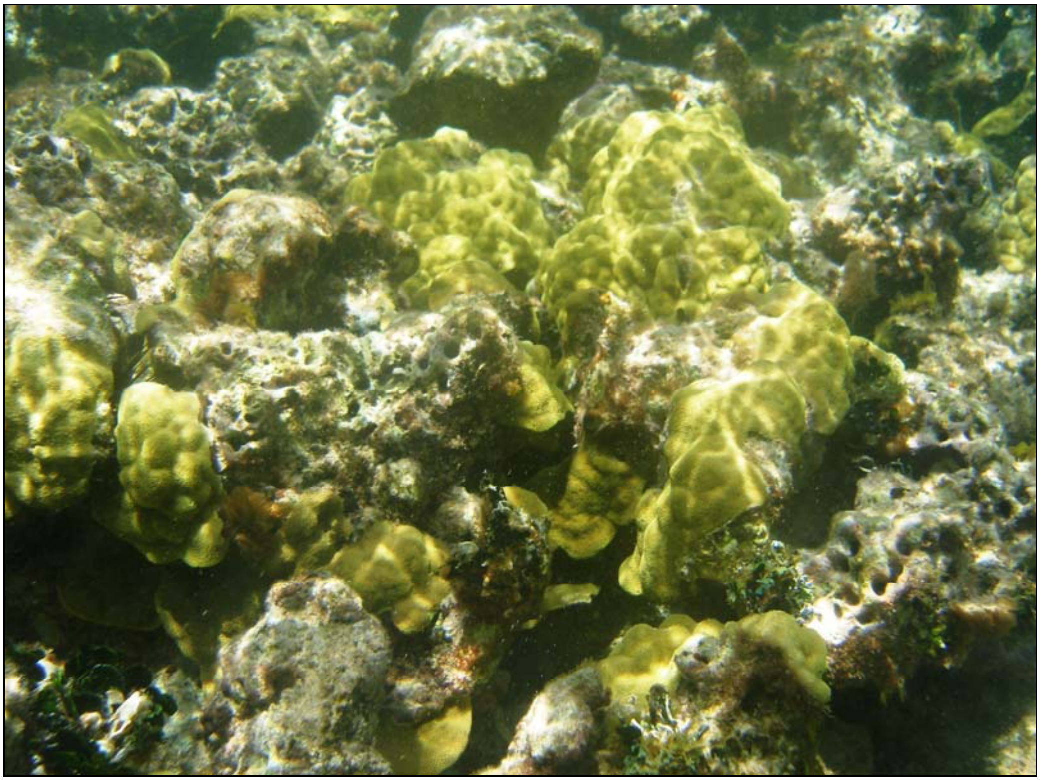
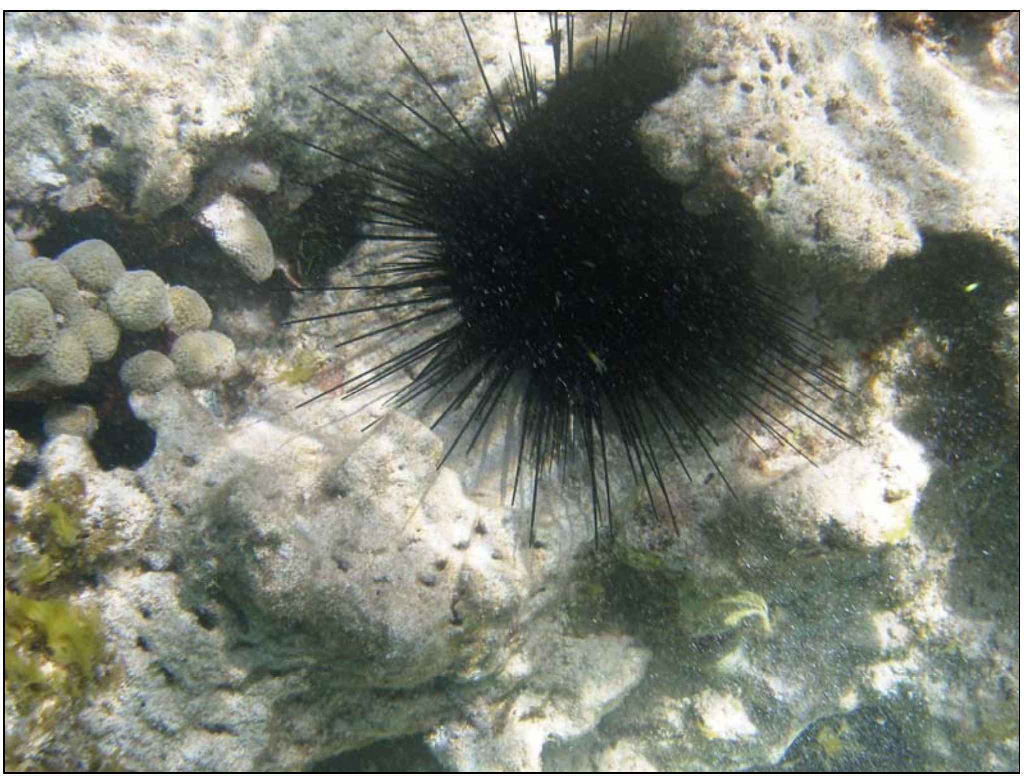


Photo 15 and 16: Urchin scraping has removed fleshy macroalgae, sediment and cyanobacteria , opening space for coral settlement and growth in areas on western reef in St. Jean Bay, June 20009



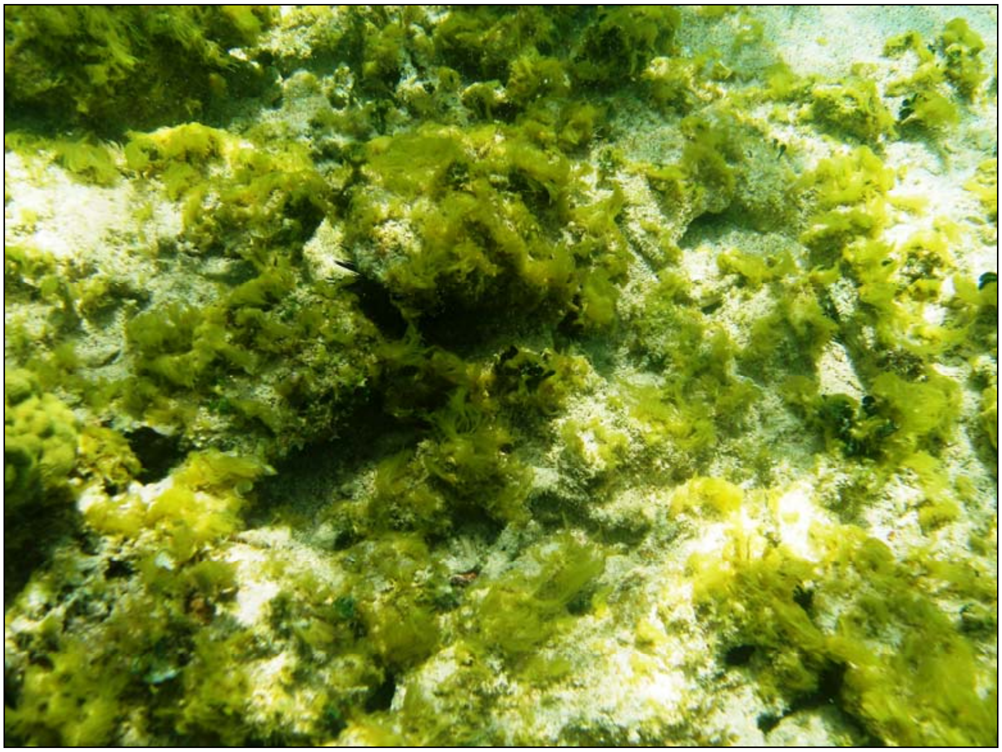
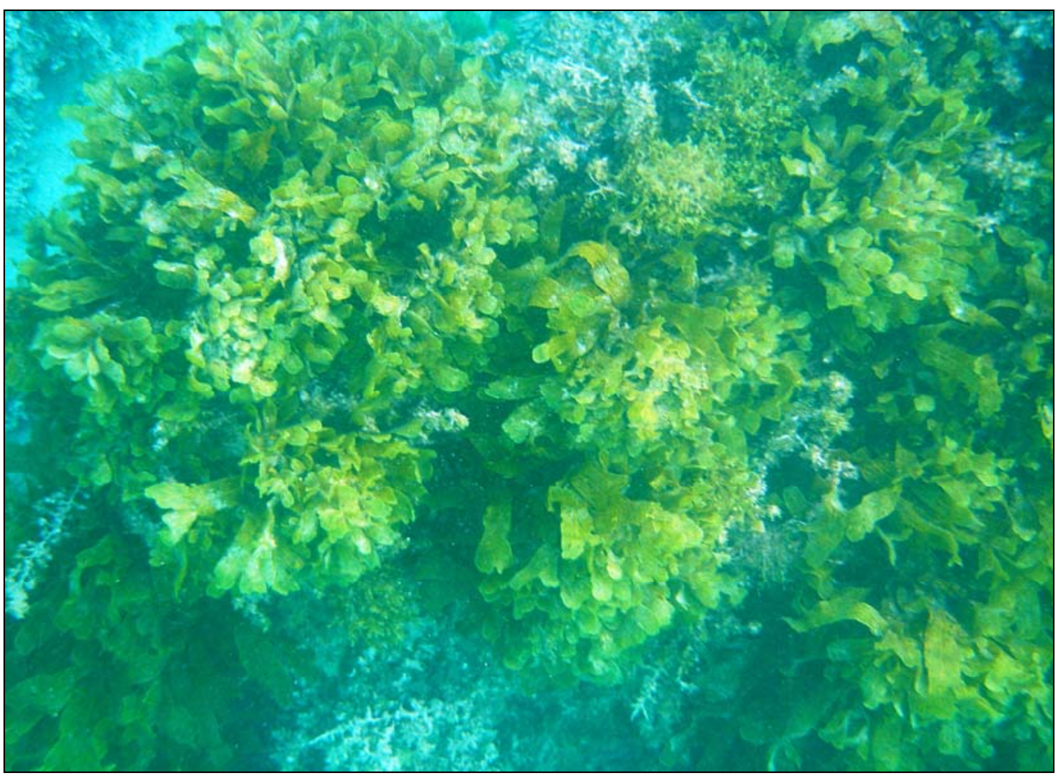


Photo 17: Heavy cover of filamentous cyanobacteria *Lyngbya* persists in seagrass beds and western reef in St. Jean Bay, June 2009

Photo 18: Eden Rock was almost completely covered in dense fleshy macroalgae in April 2009: *Sargassum, Dictyopteris*, *Dicyota* and *Spatoglossum* were dominant genera.

Photos 19 and 20: Large canopy of flesh brown macroalgae remains on the bottom half of the rock formation at Eden Rock in June 2009, causing abrasion impacts and tissue loss in large stony corals.



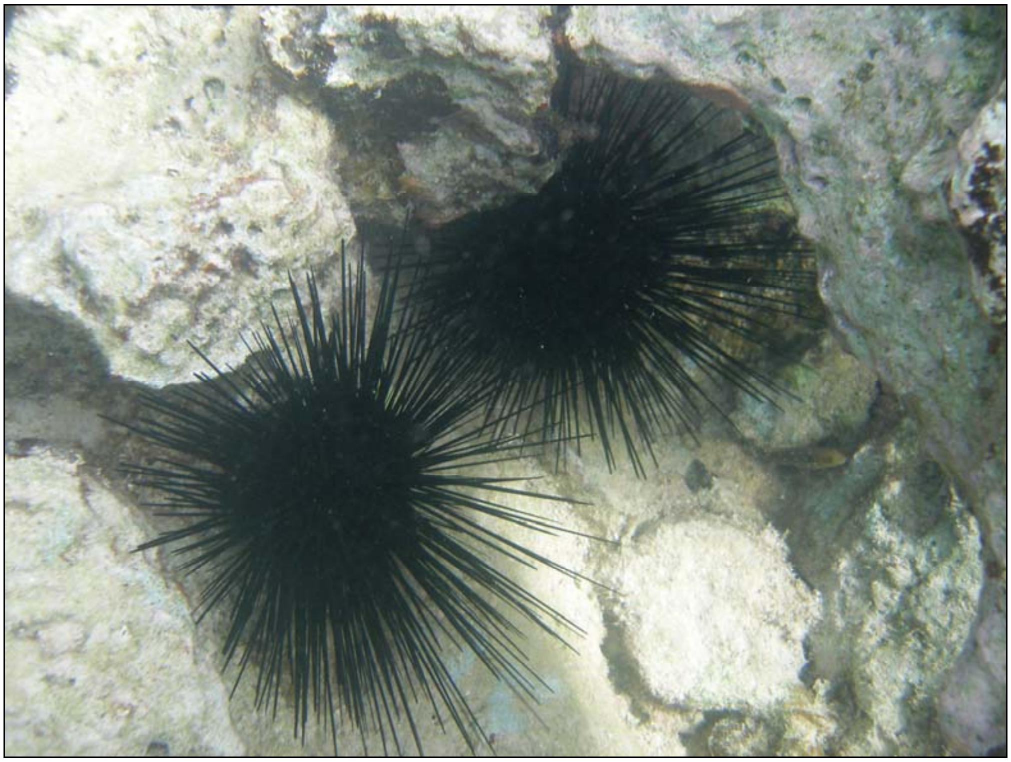


Photo 21: A significant increase in the urchin population (*Diadema* and *Echinometra*) was observed between April and June 2009 at Eden Rock.

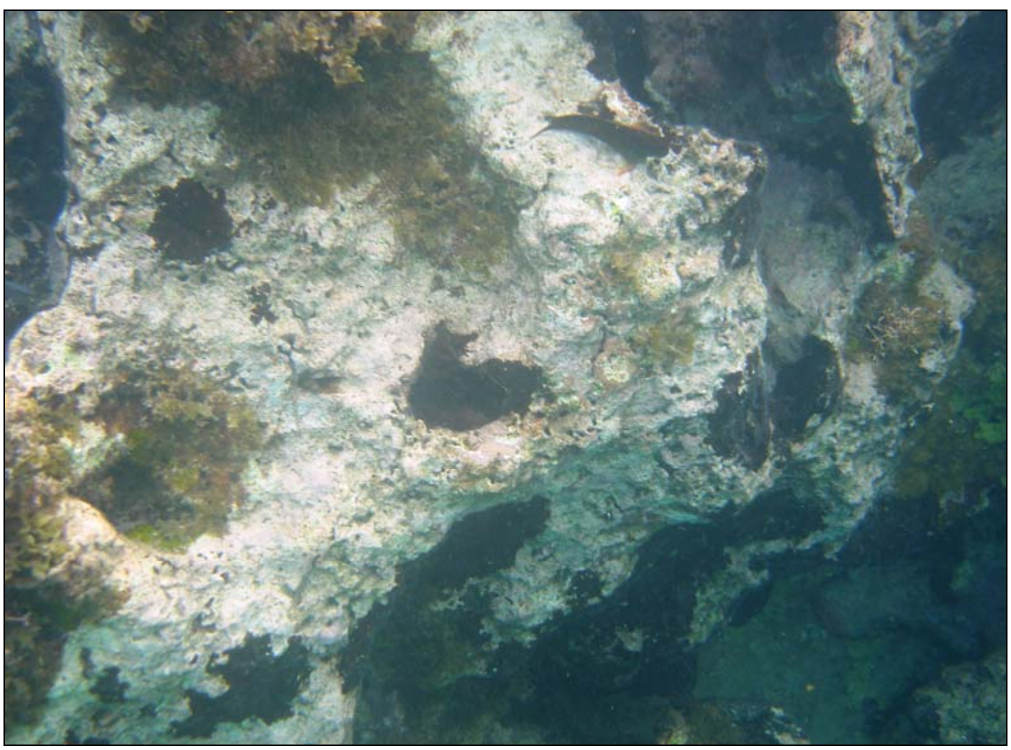


Photo 22: Urchins have removed large areas of fleshy macroalgae on Eden Rock, June 2009

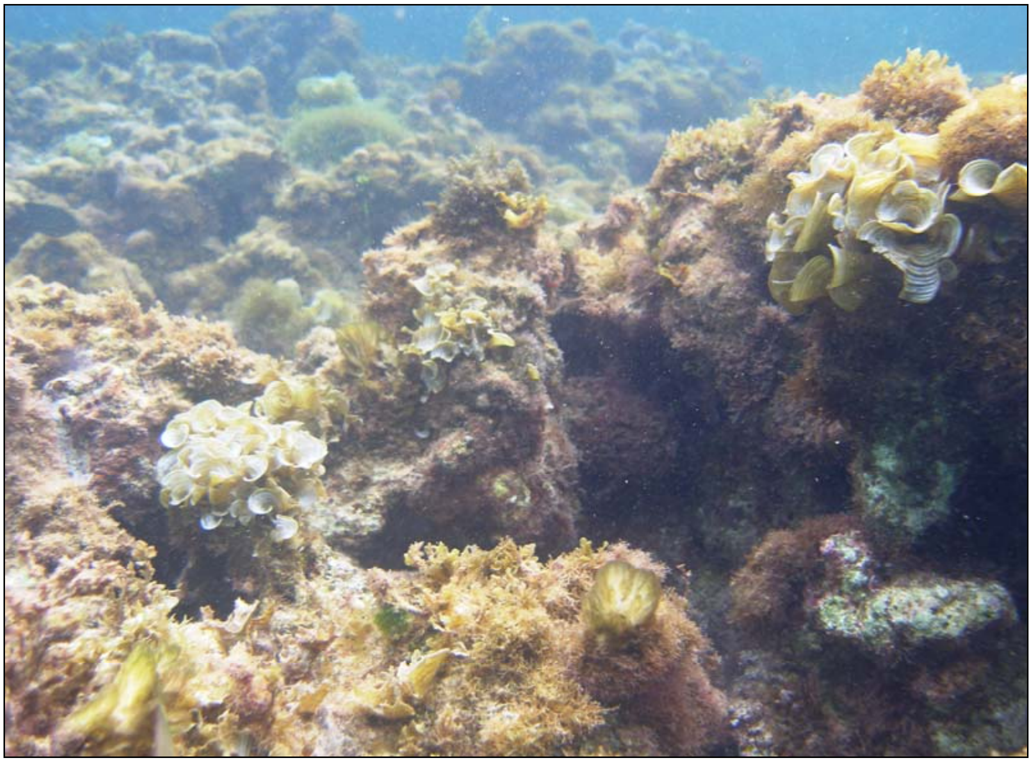


Photo 23: Wiry turf algae and the brown alga *Padina* dominant the upper zone of Eden Rock in June 2009, replacing the overgrowth of fleshy brown macroalgae observed in April 2009

Photo 24: Heavy cover of *Lyngbya* and *Dictyota* was observed on the east reef of Pelican Bay in April 2009

Photo 25: Heavy cover of *Lyngbya* and *Dictyota* on the east reef in Pelican Bay, April 2009

Photo 26: Mixed bed of calcareous green macroalgae dominated by *Caulerpa prolifera* with low to moderate cover of manatee grass (*Syringodium filiforme*) and turtle grass (*Thalassia testudinum*) and low epiphytic cover in Pelican Bay, April 2009

Photo 27: Several conch were observed within the mixed macroalgal-seagrass bed in Pelican Bay, June 2009

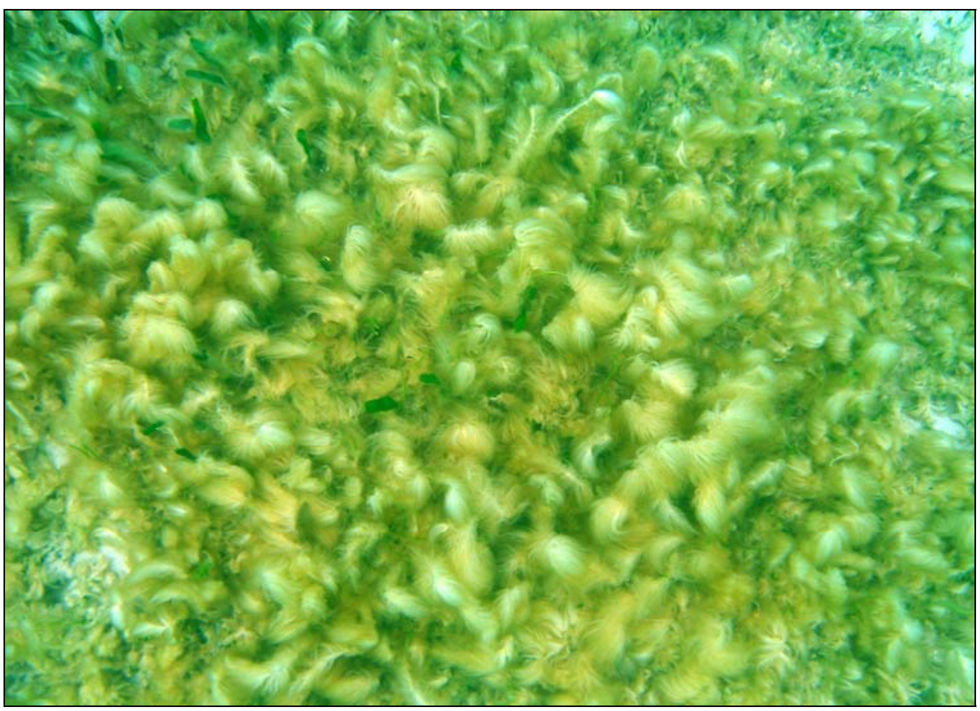


Photo 28: The mixed macroalgae-seagrass bed in Pelican Bay offshore of Nikki Beach was covered in dense *Lyngbya* and other filamentous cyanobacteria in June 2009. These mixed beds exhibited low epiphytic cover in April 2009.

Photo 29: Epiphytic *Lyngbya* on mixed macroalgae-seagrass bed in Pelican Bay in June 2009.

Photo 30: The health of the seagrass beds in Pelican Bay is important for the resident green sea turtles which utilize these beds as foraging habitat, June 2009

Photos 31 and 32: Stormwater drains directly into Pelican Bay under the road adjacent to Nikki Beach, a direct source of nutrient pollution into Pelican Bay

Photos 33 and 34: Stormwater drains directly into west St. Jean Bay in the area under the road adjacent to Nikki Beach, a direct source of nutrient pollution into St. Jean Bay

Attachment 1- Specific conditions for St. Jean beach nourishment

- Buffer distance from the sand borrow site to adjacent reef should be a minimum of 123 to 150 meters.

- Pipeline corridor must be located over sand bottom and should be diver-verified and marked with surface buoys prior to pipeline installation. Use of floating lines is recommended to avoid accidental damage to reef/hardbottom and submerged resources during dredging operations.

- Surface buoys should be installed to mark the sand borrow site boundaries. The dredge must remain within the identified boundaries at all times.

- The reef edge in closest proximity to the sand borrow site should be marked with surface buoys for visual reference for monitoring of turbidity plumes.

- Visual turbidity plume monitoring must be performed during all dredging operations. If the turbidity plume extends over reef or seagrass beds, dredging activities must cease until the plume has dissipated. If continued turbidity plumes occur over adjacent reef and seagrass habitats, dredging should be restricted to the outgoing tide. In situ monitoring by SCUBA divers should be performed during dredging operations to ensure no excessive sedimentation on reef communities.

- If sediment accumulation is observed on reef organisms (corals, sponges, and soft corals), dredging activities must cease to allow time for physical processes to remove sediment or for reef fauna to recover and clean their surfaces of sediment.

- Shore-parallel sand dikes should be constructed and maintained at the beach fill area during hydraulic discharge on the beach. The sand dike provides settling time for fine particles to be released from the water column prior to entering the open waters. Shore-parallel dikes must withstand incoming waves and maintain structural integrity during the discharging of sand onto the beach. Ultimately, the dike becomes the seaward edge of construction and is integrated into the final beach. No removal of a sand dike is necessary.

- Construction personnel must be educated regarding presence of green sea turtles in St. Jean Bay. Sea turtle observers should be present during all dredging operations to monitor for sea turtle surfacing in proximity to the dredge.

- Seagrass beds in close proximity to the beach fill placement area should be mapped with GPS prior to fill placement and during summer months for two years following fill placement to ensure that seagrass beds are not buried by beach fill spreading.

- Sand samples must be collected from the borrow site and beach site to visually inspect for compatibility. The borrow site should be characterized by a coarse mean grain size and contain less than 5% fines (silt and clay).