Field notes on impact assessment in Miami Harbor Phase III Federal Channel Expansion Permit # 0305721-001-BI

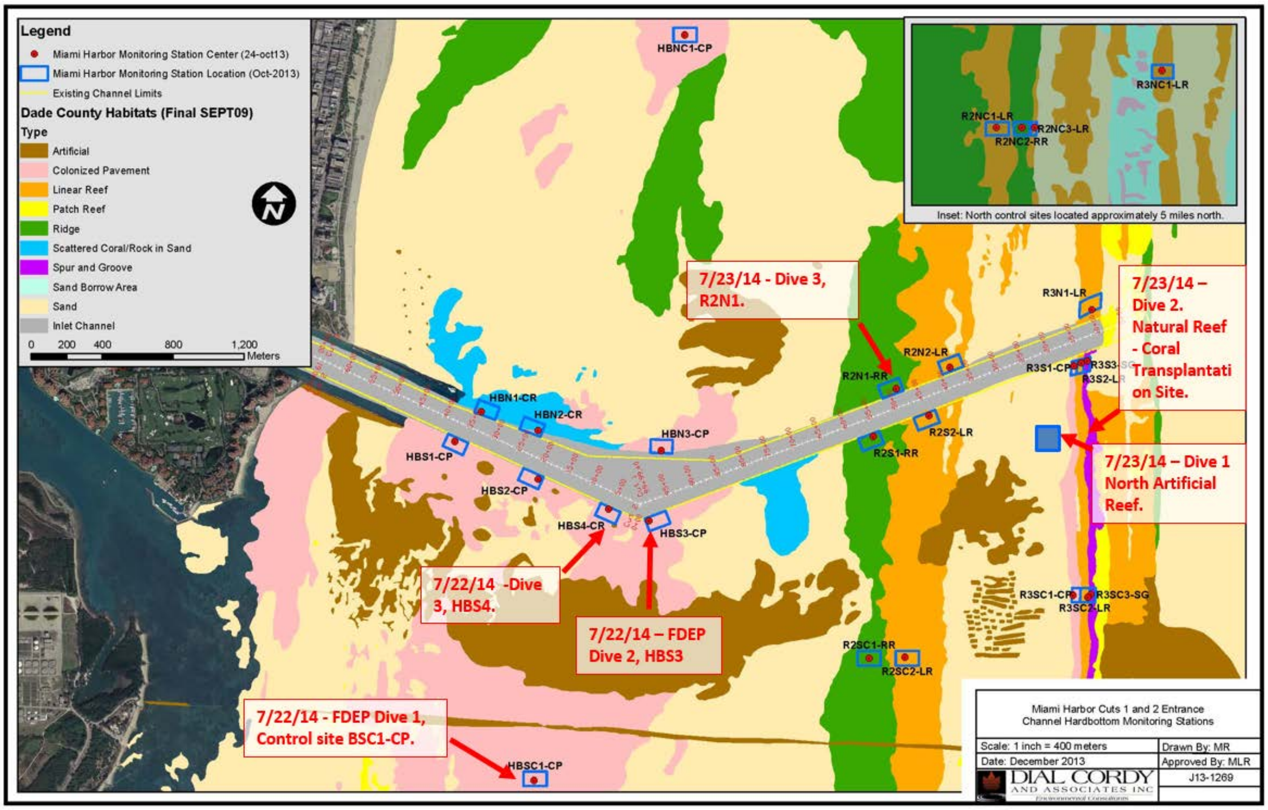

Figure 1. Dive sites for the impact assessment.

DEP BMES and BIP staff conducted site visits based on the review of the weekly monitoring reports, which included coral stress data that indicated continuous elevated stress on scleractinian corals. Corals were used as organisms-indicators in the during-construction monitoring (Figure 1). Stress was related to increased sedimentation according to observations of monitoring crews (DCA&A as the monitoring team for the project, and independent monitoring observations of Miami-Dade County DERM). The DEP team used visual qualitative observations along 200m transects plotted from the monitoring stations in a north-south direction away from the channel. In addition, sediment depth measurements were taken at 1 m intervals along four of the five transects surveyed by the DEP team (Table 1).

The monitoring protocol for the Miami Harbor project was not designed to document possible impacts beyond the monitoring stations, which are located adjacent to the channel (10 m off the channel) and extended 20 m (Figure 2). However, according DEP Permit No. 0305721-001-BI, Specific Condition 32.a.ii.d, provides that “stress expressed above normal by corals and/or octocorals within transects (stress scale used for Broward County Segment III project) will require an additional survey to outline the area(s) of impact. Impacted areas shall continue to be monitored monthly during the construction, one month post-construction, and two times during the next year in order to document the results of the impact. Final monitoring results shall document permanent impacts, if any, to be used for estimates of additional mitigation using UMAM."

Table 1. Interval sediment depth measurements at visited sites.

Date	**Dive**	**Site Name**	**Site Type**	**Sediment Depth**			
				Mean	**SD**	**Min**	**Max**
(mm/dd/yyyy)	#			(cm)	(cm)	(cm)	(cm)
7/22/2014	1	HBSC1 - CP	Control	0.5	1.01	0	4
7/22/2014	3	HBS4 - CR	Assessment	3.8	2.98	0.5	14
7/23/2014	2	3rd Reef	Coral Transplant	0.7	1.42	0	8
7/23/2014	3	R2N2 - LR	Assessment	1.5	1.08	0	6

During the DEP the site visit, sedimentation impacts to scleractinian corals were visually evaluated using the sedimentation level stress on corals with a 5-grade scale; this method was recommended by DEP staff for the rapid assessment of secondary impacts (i.e., sedimentation) on corals. This scale represents a range of sediment cover from no cover (0), dusting of sediment (1), light accumulation of sediment (2), moderate accumulation of sediment (3), severe accumulation of sediment (4), and complete burial (5).

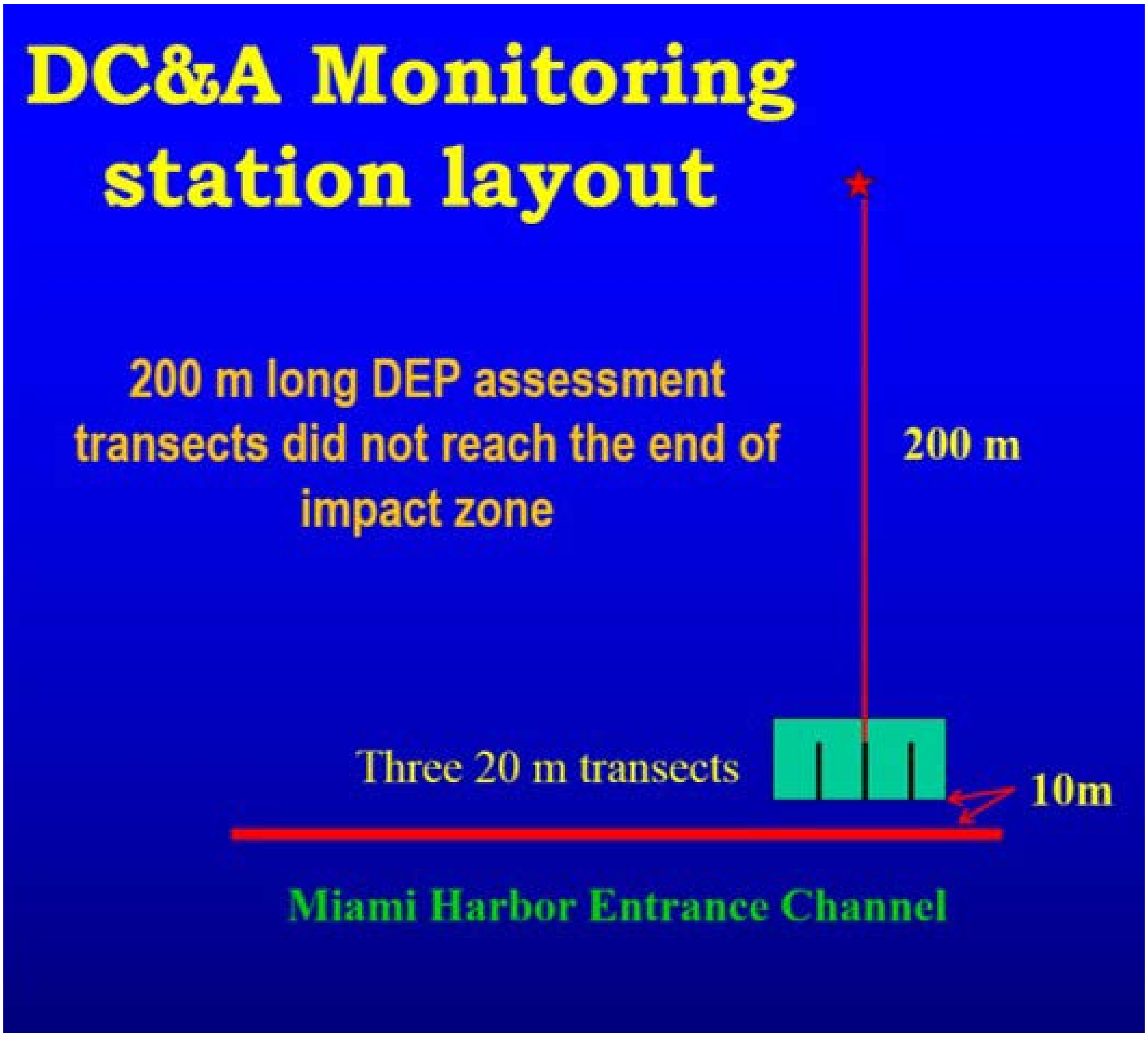

Figure 2. Monitoring station layout. DEP 200 m assessment transects initiated from one of 20 m monitoring transects.

07.22.14.

Dive 1, control site HBSC1-CP. According to the USACE/DC&A monitoring plan for the project, this control station was designated for the comparison to monitoring stations in the compliance area (in this case stations HBN1-3 and HBS1-4).

Water depth at the beginning of transect was 6.6m. Landscape: low relief hardbottom (10 cm - 20 cm amplitude of relief), octocoral-sponge-macroalgal community with scattered scleractinian corals (Figure 3). Octocorals often form small groups and colonies can be up to 1m tall. The majority of the substrate was exposed hardbottom, a small percent of the substrate was small pits filled with 1-2 cm of sediments. Sediments within these pits are mostly sand, however some finer sediments were present. Fine sediments did not form a continuous cover, but these fine sediments had dusted over entire hardbottom and benthos. Fine sediments were mixed with sand only at the very surface of sand in small sediment patches, indicating that they were recently deposited. Measurements of sediment thickness were taken at 1 m intervals along the transect; these measurements demonstrated low sediment cover between a minimum of 0 cm on exposed hardbottom and a maximum of 4 cm in small pits filled with sand. Average (±sd) sediment depth is 0.5 ±1.01 cm (Table 1). A considerable part of the area was covered with cyanobacterial mats, which seemed to be associated with the above-mentioned dust of fine sediments (Figure 4). *Lyngbya* sp. was also present and had attached to octocorals (smothering them), but it was not abundant at the site. Scleractinian corals exhibit no or very low sedimentation stress: 0 to 1 according to the scale described above.

Sedimentation appeared to have no adverse effect on corals (Figures 5 and 6), octocorals, and sponges, except for the presence of the above-mentioned slight cover with fine sediments over substrate, which may have stimulated the development of cyanobacterial growth. The distance from this site to the channel (1400 m) is not necessarily long enough to completely discount the possibility that fine material can reach this area with the turbidity plume; see aerial photo in Fig. 7, where the length of the plume is over 1500 m to the west and 1000 m southwest from the source of turbidity.

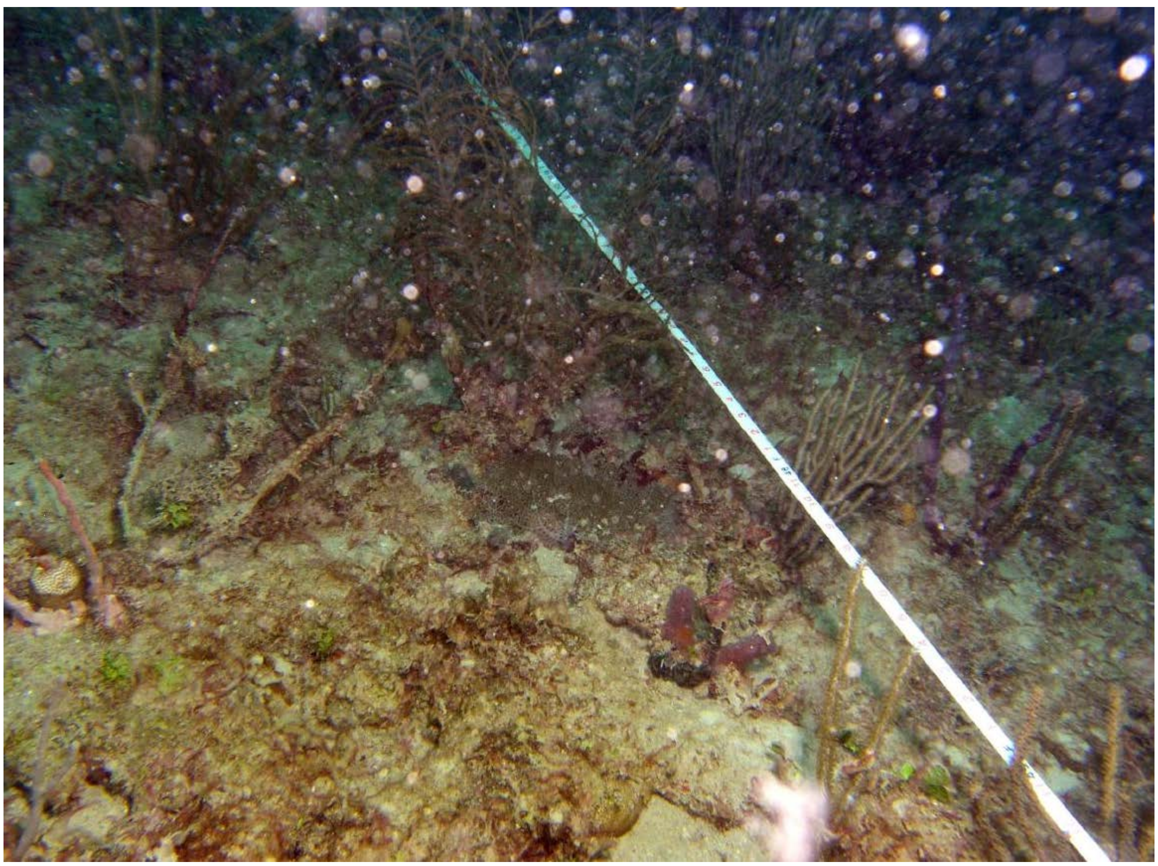

Figure 3. Landscape in Control Site HBSC1-CP. Low sediment cover, mostly accumulated in small pits. However, some cover of fine sediments exists; development of cyanobacterial mats seems to be related to this slight fine sediment cover.

Figure 4. Cyanobacterial growth over hardbottom at Control Site HBSC1 seems to be related to light sedimentation of fine material accumulated rather on benthos than on sand patches.

Figure 5. Small *Siderastrea siderea* at Control Site HBSC1 exhibit no sedimentation stress.

Figure 6. Small *Stephanocoenia intersepta* showing no sedimentation stress, although algae are smothering one side of the colony. Notice characteristically low sediment accumulation on the tag.

Figure 7. Aerial photo of current dredging (adopted from Google Maps in July of 2014). The length of turbidity plume is over 1500 m westward and 1000 m southwestward. There were no documented turbidity violations at this time according to project data.

Dive 2, compliance site HBS4.

Water depth was 7.6m at the beginning of the transect. The transect stretched along one of the monitoring transects and extended farther southward; observations and measurements along the transect continued over 100 m along the transect. Landscape: low relief hardbottom – relatively flat, with some scattered bumps and rocks (20-40 cm amplitude of relief), formed by previous coral growth; octocoral-sponge dominated community with scattered scleractinian corals. Microrelief of hardbottom was obscured by 1 - 5 cm thick layer of fine sediments, according to measurements around coral and octocoral colonies (Figure 8). Visually and by hand-test sediments are silt and clay. Within less than 1 cm from the surface, the sediments become anoxic (Figure 9). Most small (< 10 cm) scleractinian corals were influenced by sedimentation with stress levels ranging from 3 to 4. Larger colonies (> 10 cm) were able to shed sediments down to the base of colony, however, as a result, this material covered the base of the colony and often resulted in partial mortality, i.e., forms dead fringe up to 7-12 cm wide depending on the morphology of corals (Figures 10 and 11). Very few juvenile scleractinian corals were observed, located only on higher relief hardbottom, and no recruits < 3 cm size were observed due to the cover of substrate by sediments. Practically all octocorals, excluding very few growing on highest parts of hardbottom, have holdfasts covered by sediments; all juvenile octocorals were partially buried. Sea fans *Gorgonia ventalina* were often covered with sediments and cyanobacterial mats had developed on those sediments (Figure 12). *Gorgonia ventalina* normally prefer clear water, and the current situation of high sedimentation is obviously not common for this habitat. Sediment cover over hardbottom was documented up-to the 100 m transect mark; moreover, sediment cover continued at least within the distance of visibility beyond that point.

Figure 8. Landscape south of the site HBS4. A layer of fine sediments covers practically entire hardbottom. Holdfasts of octocorals are buried under 1-5 cm of sediments. Gray cones are borrows of benthic infauna; gray color is because the sediments are excavated from anoxic layer.

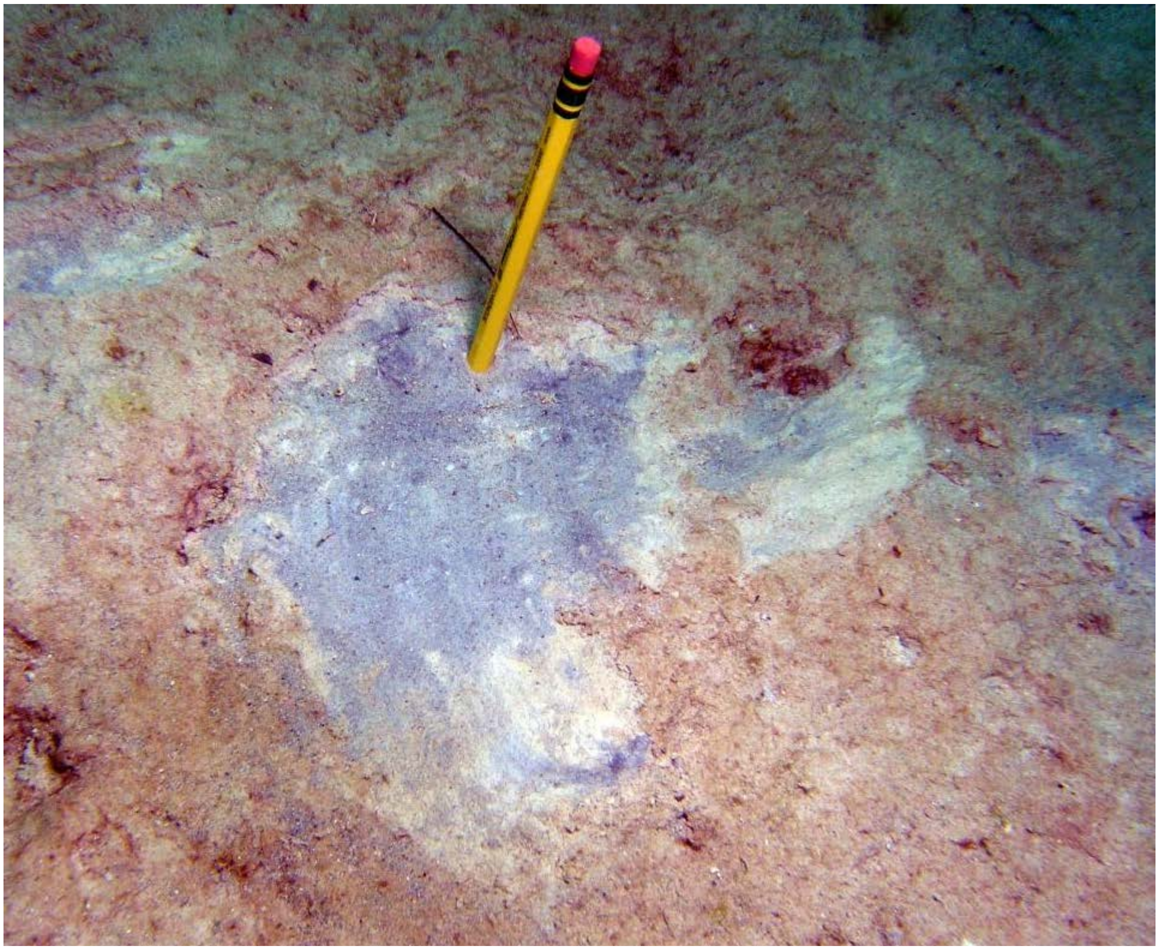

Figure 9. Sediments that covered practically entire area more than 100 m from the channel and southward from monitoring sites HBS3 and HBS4 become anoxic in less than 1 cm below the surface. Notice that almost all surface of recently accumulated fine sediments was covered with cyanobacterial mat.

Figure 10. Sediment cover over *Colpophyllia natans* and *Stephanocoenia intersepta*. *Colpophyllia natans* was able to remove considerable amount of sediments from top of colony down to its base, forming thick rim of sediments at the base of coral, which buries lower part of the colony. See next picture in Figure 11.

Figure 11. The same colony of *Colpophyllia natans* after sediments were removed from the base of the colony. Considerable part of the colony is dead due to the accumulation of sediments at its base.

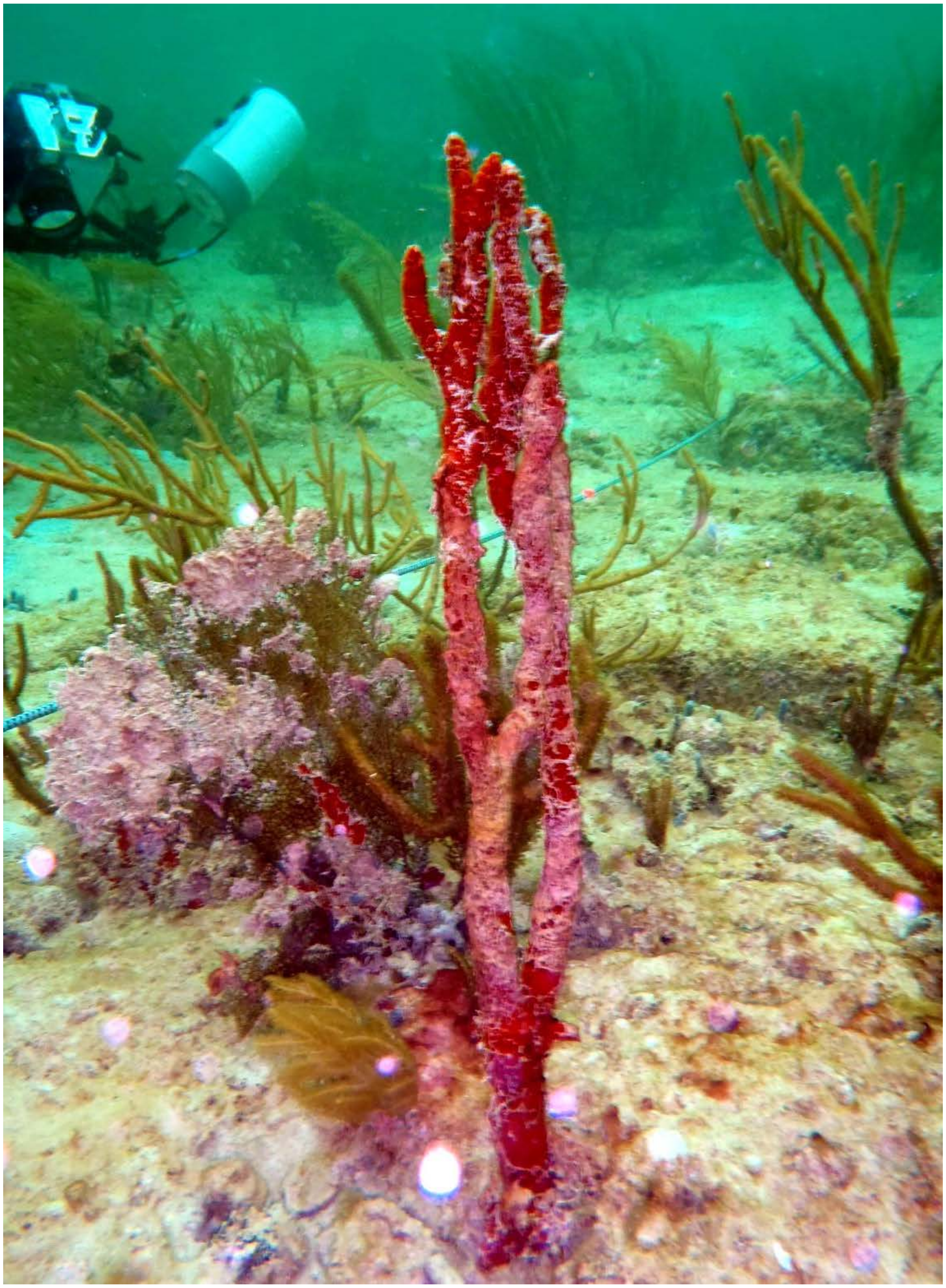

Figure 12. Over 50% of this *Gorgonia ventalina* colony (background) was dead due to sediment accumulation. The sponge *Ptilocaulis walpersii* (front) was also impacted.

Dive 3, compliance site HBS3.

Water depth was 7.5 m at the beginning of the transect. A transect was established along one of the monitoring transects and extended farther southward; observations and measurements along the transect continued for 105 m along the transect. The landscape was very similar to the site assessed southward of HBS3 and was uniform through the entire length of the transect (Figure 12). The hardbottom was low relief, seldom more than 10-15 cm in amplitude, excluding very few larger rocks with relief of 30-40 cm noticed closer to the end of the transect. Around 100 m a rubble field was observed on the western side of the transect (Figure 13). Tall octocorals dominated the community (octocoral-sponge-scleractinian community). Macroalgae were only observed in sparse higher relief areas; macroalgae in lower-relief areas had been buried. Cyanobacterial mats were widespread on sediment layer over substrate and benthic organisms. Thickness of fine sediments, according to measurements around coral and octocoral colonies is 1 cm to 5 cm (Figures 14 and 15). Sediments were silt and clay, with possible small part of very fine sand closer to the channel. Measurements of sediment thickness along the transect (1 m interval sediment depth measurements) demonstrated variable cover between 0.5 cm and 14 cm, with average (±sd) of 3.8±2.98 cm (Table 1). Most of small (< 10 cm) scleractinian corals (of survived) had elevated levels of sedimentation stress, at the level of 3-4. Even large colonies, which were able to shed sediments down to the base of colony, often have dead fringe around them up to 7-12 cm depending on the morphology of corals (Figures and). Very few juvenile scleractinian corals were observed, located only on higher relief hardbottom, and no recruits were observed due to sediment cover over hardbottom. Practically all octocorals, excluding very few growing on highest parts of hardbottom, have holdfasts covered by sediments; all juvenile octocorals are partially buried (Figure 14). Sea fans *Gorgonia ventalina* were affected by sediments and by cyanobacterial mats that developed on these sediments. Sediment cover over hardbottom was traced to the transect mark 105 m and at that point it was continued at least within the distance of visibility beyond that point.

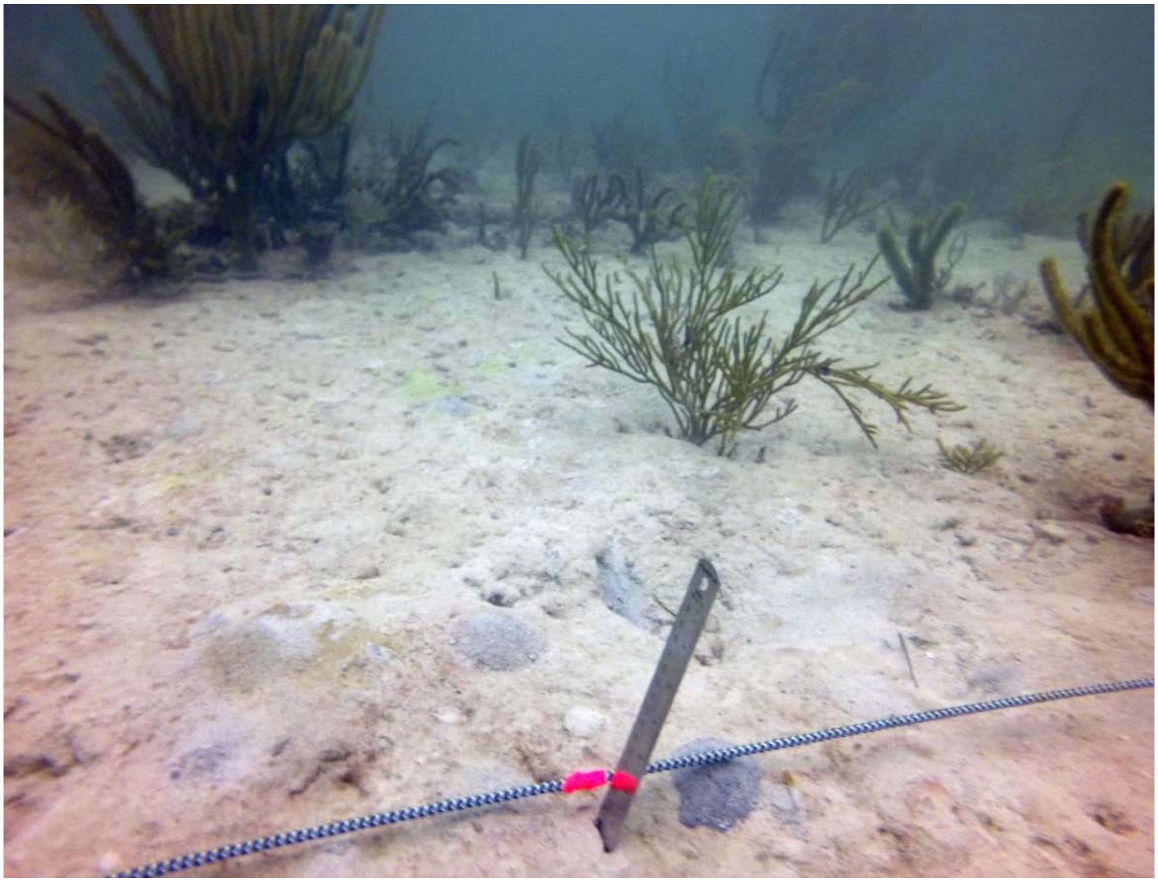
Figure 12. Landscape along the transect south of compliance station HBS3. Sediment accumulation was continuous along transect and was measured every meter.

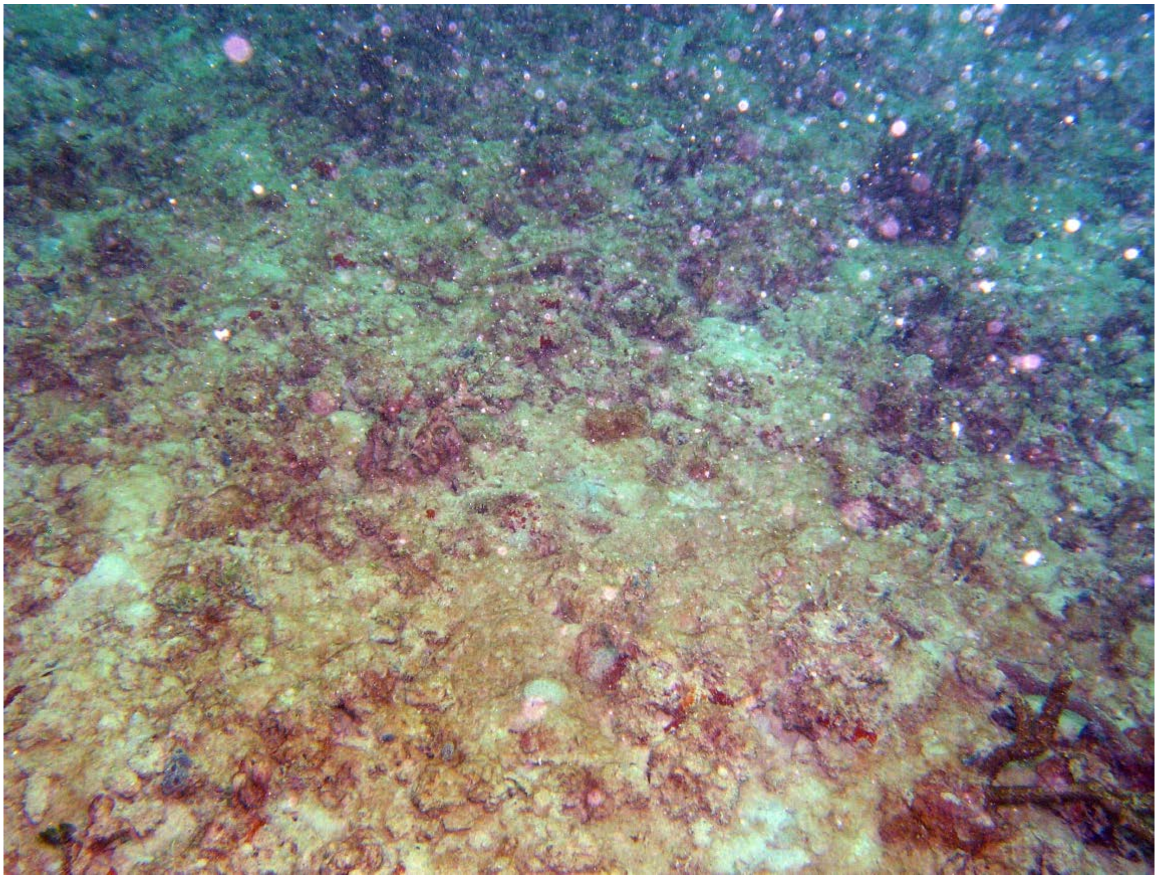

Figure 13. Sediment cover and cyanobacterial mats over rubble field at the 100 m mark of the transect south of compliance station HBS3.

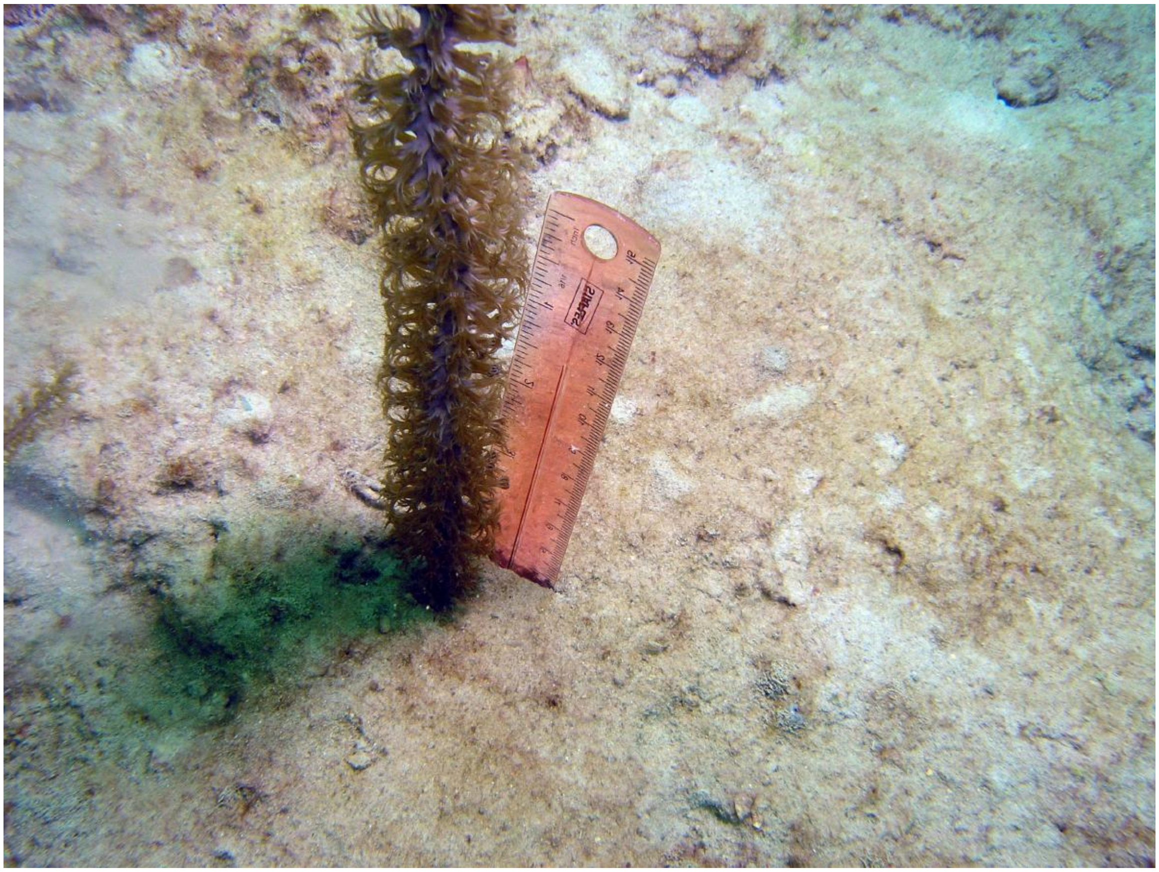

Figure 14. The holdfast and lower part of small octocoral colony is buried in about 4.5 cm of sediments.

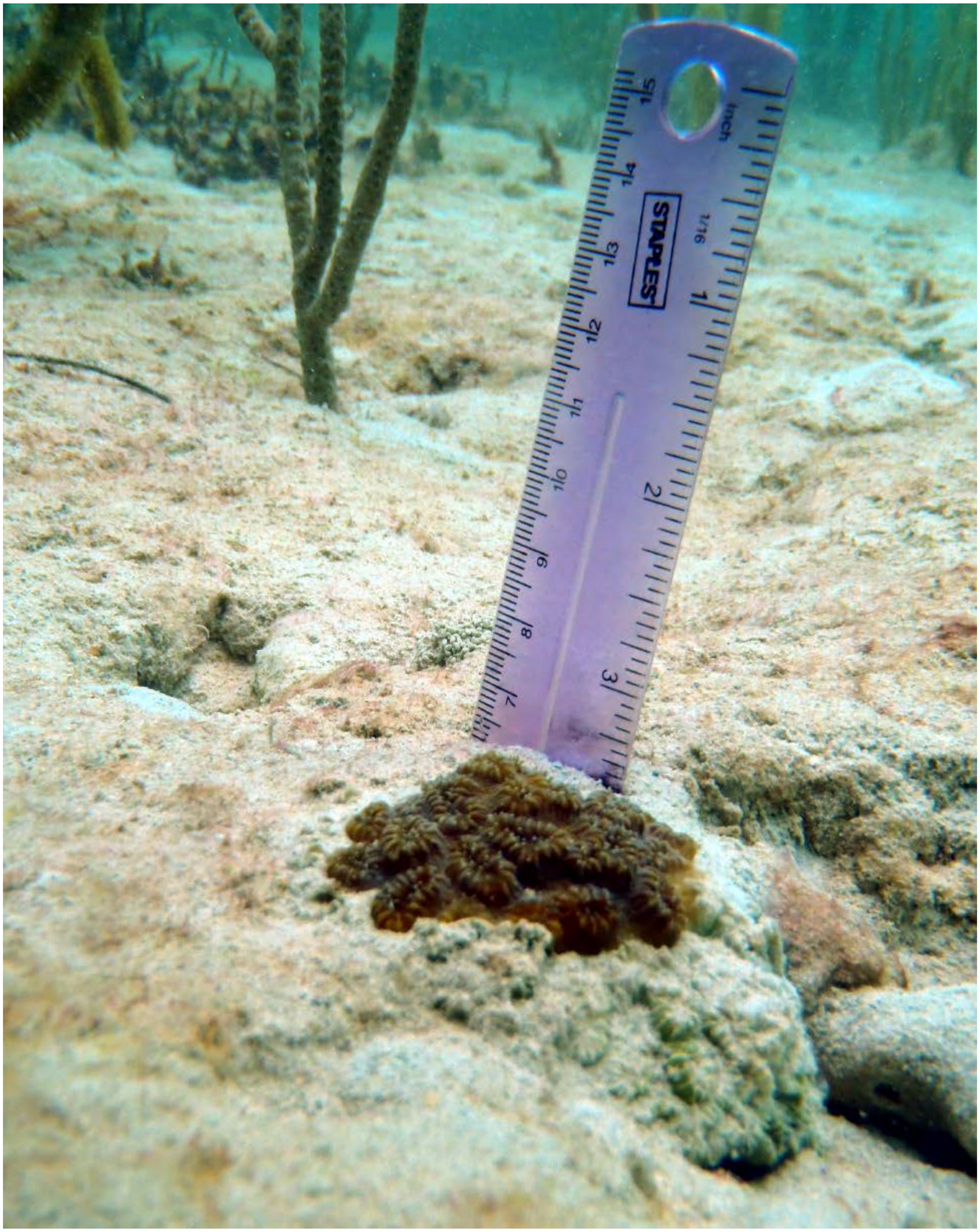

Figure 15. Small *Dichocoenia stokesi* is partially buried and dead (about 60% of colony). Sediment depth at the colony is about 6.5 cm.

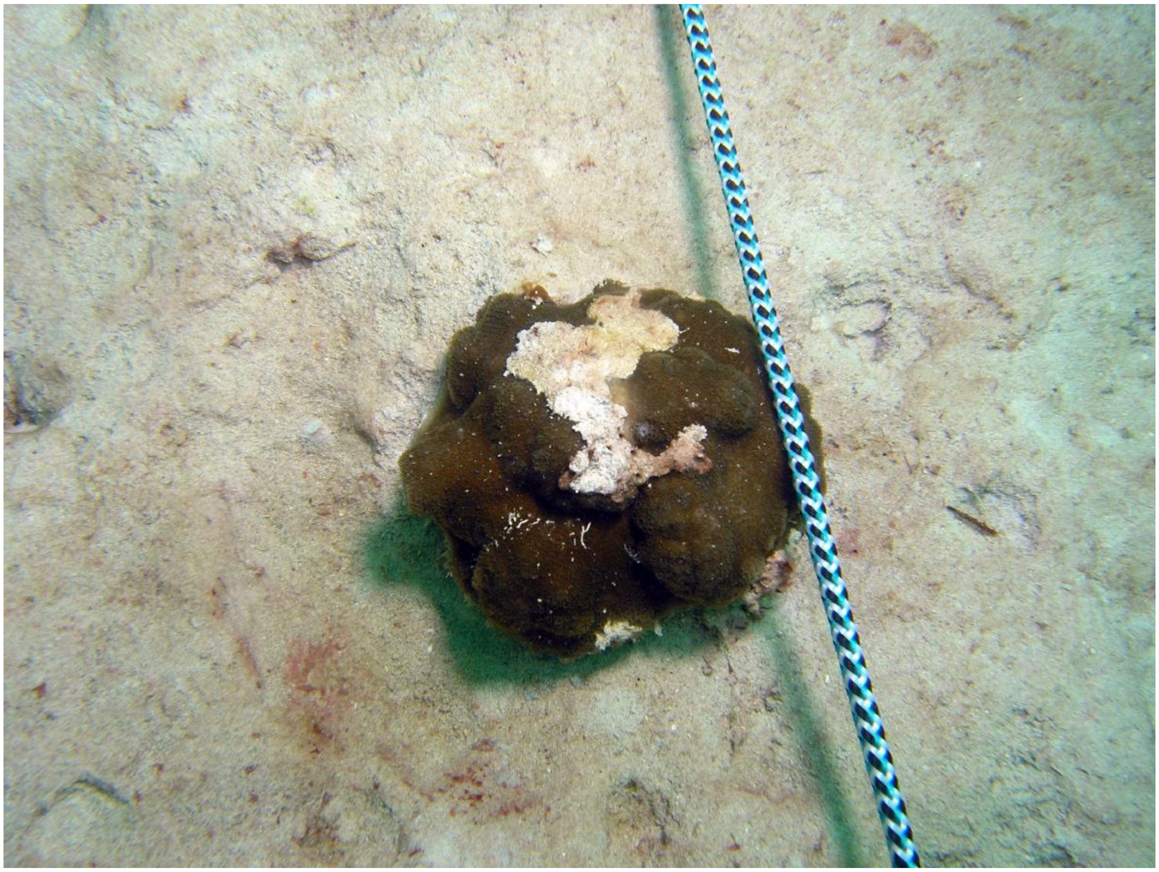

Figure 16. Small colony of *Porites astreoides* has about 15% partial mortality due to sediment accumulation. This species of corals is capable to produce considerable amount of mucus, which aids in sediment removal from the surface of coral, however sedimentation was more than coral can remove. See also Figures 25, 33, and 34 for the effect on the same species.

07.23.14.

Dive 1, North Mitigation Reef. The inspection of the Northern Mitigation Reef was done in order to compare this site with a nearby transplantation site on the natural Outer Reef, where sedimentation was previously observed by DERM. This dive was very brief and only a small portion of the artificial reef was observed; yet, several patches of natural hardbottom were observed. Patches of hardbottom contained well-developed communities with scleractinian corals, octocorals, sponges, algae, etc. These natural hardbottom areas had been impacted by the placement of boulders; the types of impacts varied from direct impacts by boulders to hardbottom substratum and benthos, to burial of benthic fauna and flora by displaced sediments or sedimentation over them in the areas where boulders were dropped adjacent to hardbottom patches. Fragmented corals, damaged sponges and octocorals were seen in several patches (Figures 17-22).

Figure 17. Diver is checking on hardbottom with boulder placed on it and broken large colony of *Montastraea cavernosa*.

Figure 18. Fragments of broken *Montastraea cavernosa* in the area of artificial reef. Coral was broken during the construction of artificial reef by boulder dropped on natural hardbottom.

Figure 19. A fragment of broken colony of *Montastraea cavernosa.*

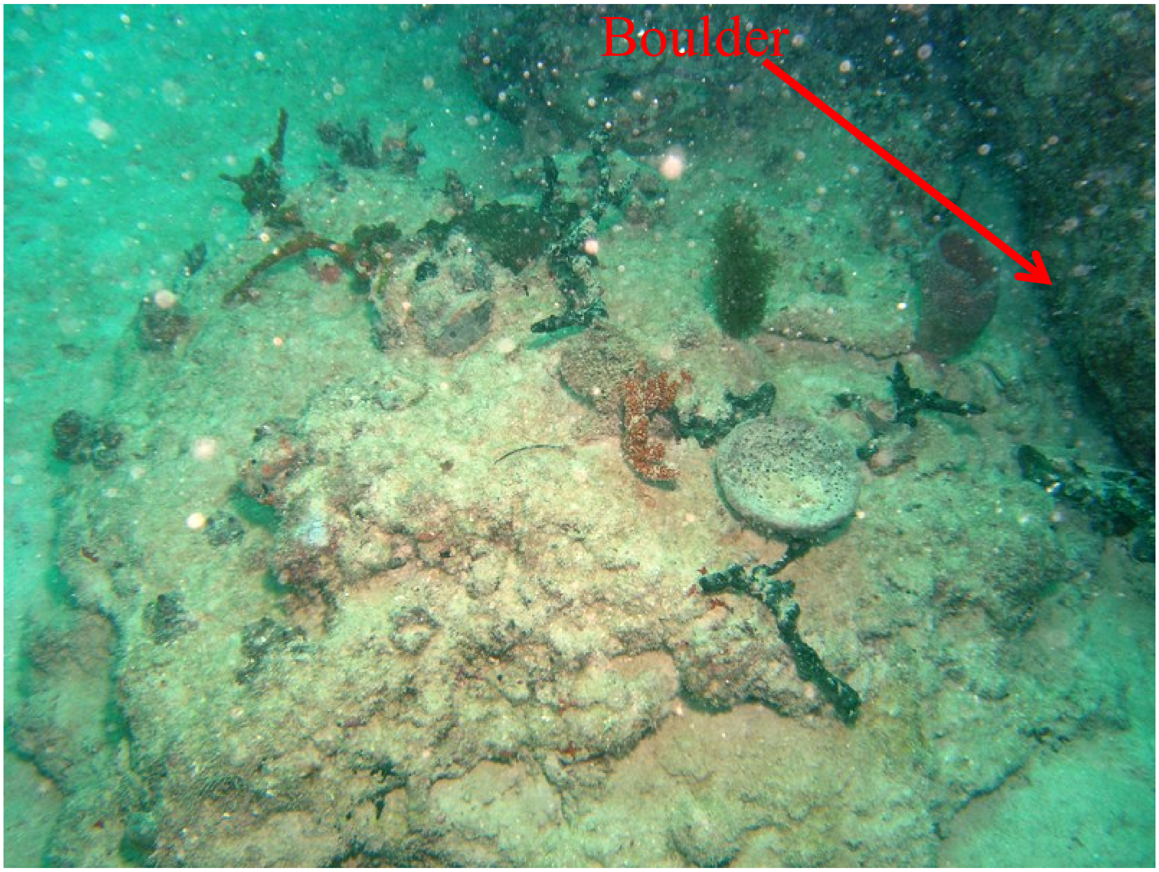

Figure 20. Patch of hardbottom with boulder placed over it.

Figure 21. Octocoral *Pterogorgia anceps* knocked down and partially buried in sediments displaced by adjacently dropped boulder.

Figure 22. Sponge *Ptilocaulis walpersii* is partially buried by sediments displaced by adjacent boulder.

Dive 2, coral transplantation site on Outer Reef

This dive was conducted on the leeward side of the Outer Reef close to its crest, at a location where corals were transplanted from the project area in order to minimize dredging impacts. The distance from the channel is about 450 m; however, Miami-Dade DERM reported considerable sedimentation in the area. A 200 m long transect was plotted from the transplantation site north toward the channel. Water depth at the transplantation site is about 11m and along the transect slightly varied from 11 to 12 m. The landscape is more complex than in previous sites. The Outer Reef visibly slopes toward the west at the site. The site contains scattered or grouped rubble and boulders up to 0.5m in diameter, low (10-30 cm) scarps, 20-30 cm in diameter and 10-20 cm high bumps formed by coral growth (dead colonies), small (few cm wide) channels and pits filled with coarse sediments (mostly sand). The community is dominated by octocorals (most frequent is *Antillogorgia americana*), scleractinian corals, and sponges (large *Xestospongia muta* and frequent smaller sponges); macroalgae are scattered as small clumps (most often *Halimeda* spp), while turf algae are widespread as well as incrusting coralline algae (including rhodoliths). Scleractinian corals of larger size (classes 25cm - 50 cm and > 50 cm) were common, represented most often by *Montastraea cavernosa*, *Solenastrea bournoni, Meandrina meandrites*; in smaller size classes most frequent were *Siderastrea siderea* and *Porites astreoides*. The hardbottom and benthos was visibly covered with fine sediments (Figures 23 and 24); however, the cover was not continuous or sheet-like as was observed in stations HBS3 and HBS4. Fine sediments covered the substrate and benthos; however, sandy sediments were found in pits and channels, where fine sediments had formed a thin top layer; this observation suggests that fine sediments have accumulated recently and are not as common for this area as sandy sediments. The effect of sedimentation on corals was variable, ranging from a level of 1 to 3, depending on the microhabitat (i.e., relief) where coral is growing. Some colonies were considerably affected by sedimentation (Figure 25), while others had a relatively small effect (Figure 24). Fine sediments had accumulated along the entire transect, and sediments visually increased toward the channel. Overall the effect of sedimentation was considerably lower than at the compliance stations HBS3 and HBS4.

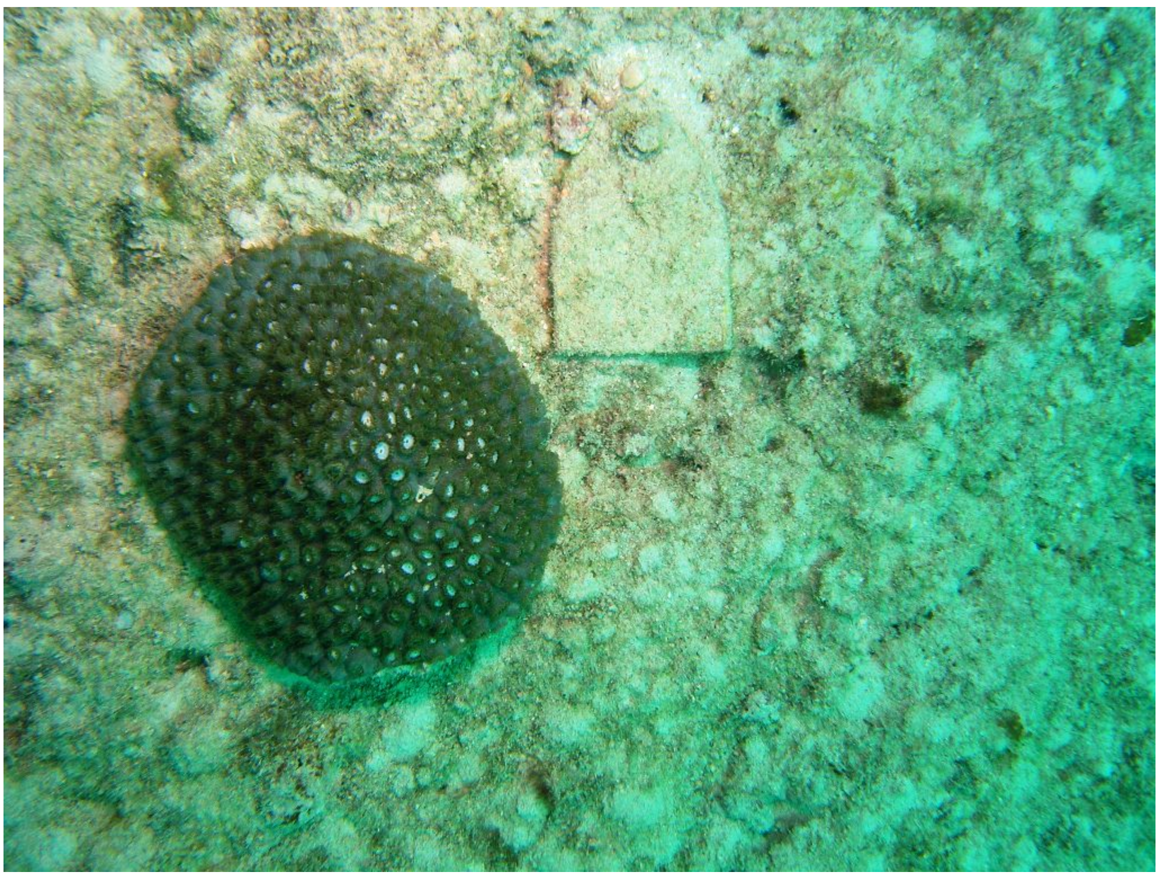

Figure 23. Small *Montastraea cavernosa* at the transplantation site on leeward (shoreward) side of the Outer Reef. Surrounding hardbottom is covered with sediments (note also that coral tag is completely covered with sediments, although tags are regularly cleaned during monitoring events), although sediments seems to have minimal effect on the coral.

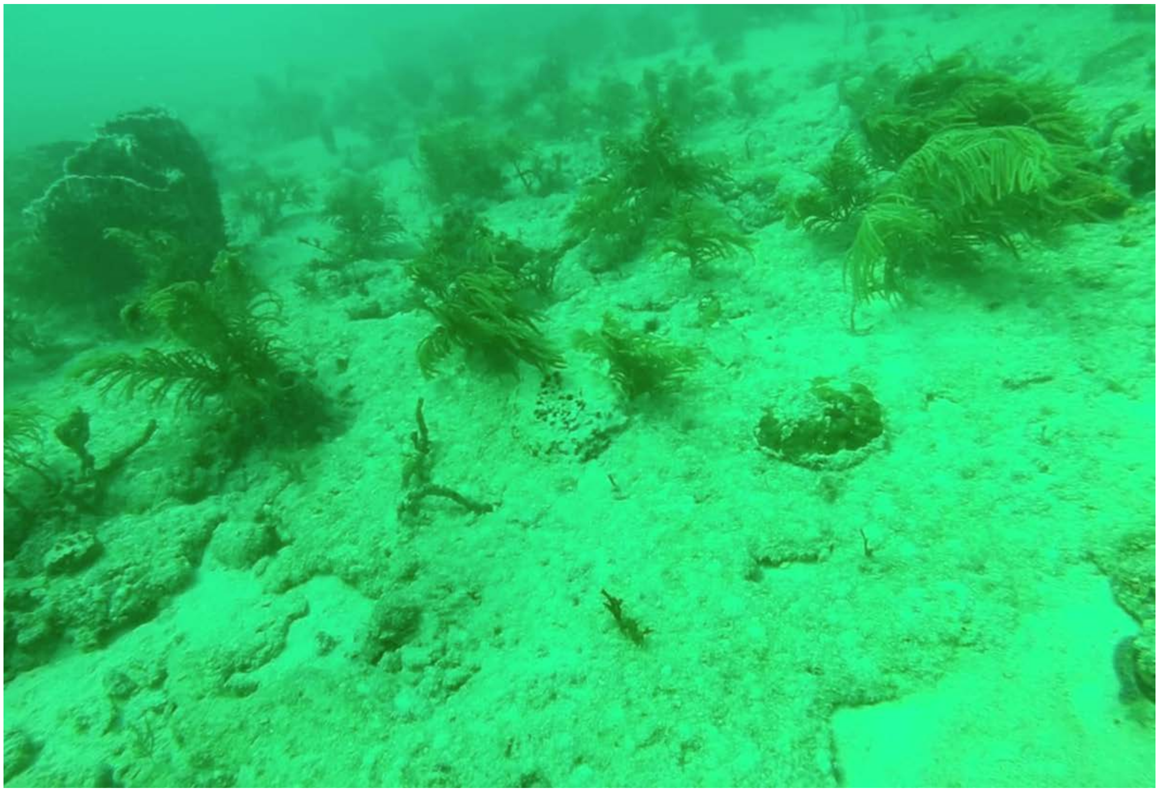

Figure 24. Landscape north of the transplantation site on leeward (shoreward) side of Outer Reef. Hardbottom and sand patches covered with thin layer of fine sediments.

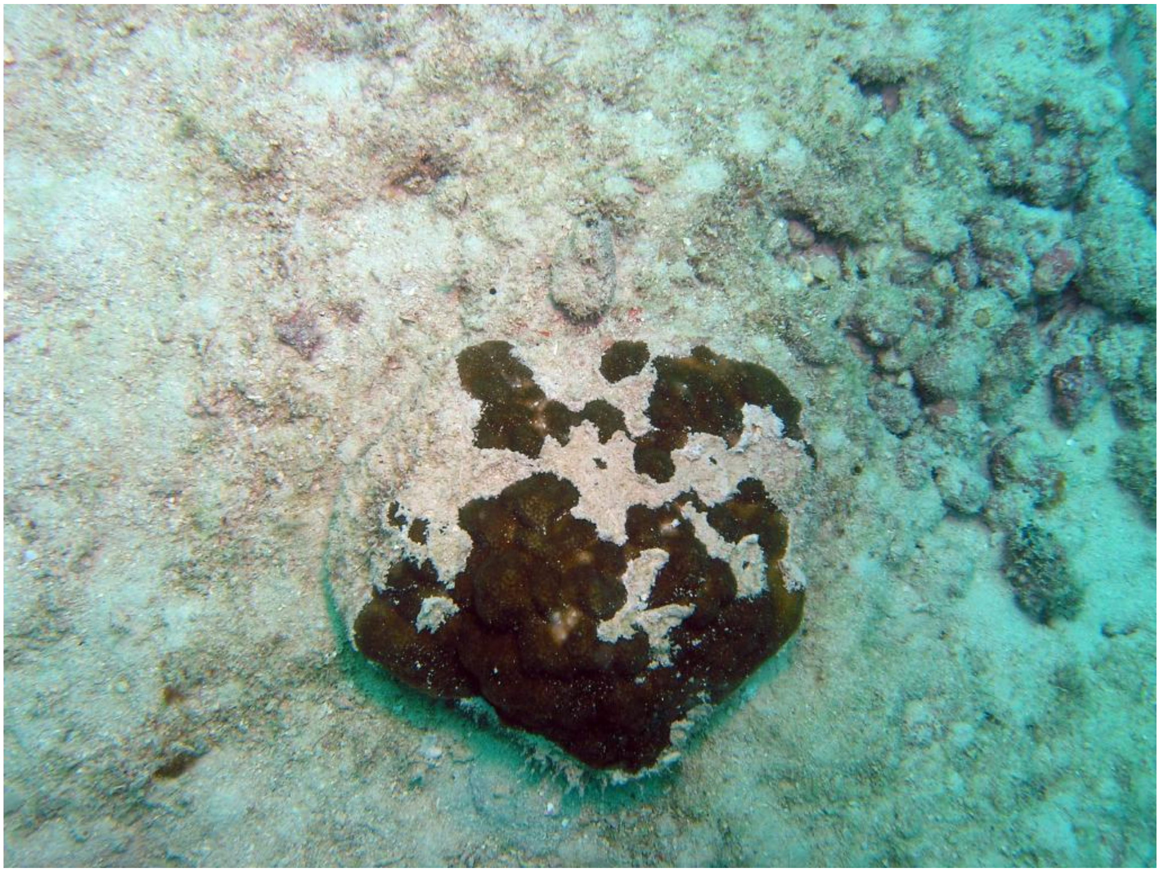

Figure 25. Colony of *Porites astreoides* was affected by accumulation of fine sediments, which caused about 50% mortality of the colony.

Dive 3, compliance site R2N1.

A 200 m long transect was stretched north as an extension of the 20 m long transect #1 of the station R2N1 (2^{nd} or Middle Reef, North side of the channel). Depth at the station is 8.3 m and about the same through the length of the transect (e.g. at mark 100 m the depth is the same 8.3 m). Landscape of 2^{nd} Reef in its inner (western) side is relatively flat, with occasional small knolls 0.3-0.7m in diameter and 0.3-0.4 m high, appeared to be small build-ups consisting of single or a few coral colonies. Both octocorals (dominant group) and scleractinian corals demonstrate higher diversity and larger average size in comparison to octocorals and scleractinian corals in the visited sites of the Inner Reef on the south side of the channel (Figures 26-28). The effect of sedimentation visually is even higher on the northern side of the Middle (2^{nd}) Reef than on the south side in the area of the Inner Reefs, although the average depth (±sd) from direct measures is 1.5±1.08 cm, which is less than for example in HBS4 (Table 1). Sediment cover did not seem to be receding away from the channel along 200 m of investigated transect and farther. Some variability in sediment thickness was observed along the transect. Algae were only observed on tops of rocks/knolls, but even tops and algae on them were covered with sediments (Figure 32). Holdfasts of octocorals were buried in 1-7 cm of fine sediments (Figure 31). Scleractinian corals of several species in size class <10 cm were buried or almost buried; the mortality in larger scleractinians was observed at the edges of colonies, which are buried under sediments that have been shed down from the top of the colony (Figures 30, 33, 34). The zoanthid *Palythoa caribaeorum* is sediment tolerant, but colonies at this site were overloaded with sediments and may not survive (Figure 29). Sediments appeared to have been deposited recently, and cyanobacterial mats had not formed as an extensive cover as at sites on the southern side of the channel in the area of the Inner Reef. At the end of the transect, i.e. in a distance about 180-200m from the monitoring station, small groups of *Acropora cervicornis* were recorded growing west of the transect and at the end of transect (Figure 35).

Figure 26. Landscape along 200 m transect north of compliance site R2N1.

Figure 27. Landscape at the end of 200 m long transect north of compliance site R2N1.

Figure 28. Landscape along 200 m transect north of compliance site R2N1. Note continuous cover of hardbottom by sediments (in this picture, two landscape pictures above and one below).

Figure 29. *Palythoa caribaeorum*, which is normally quite tolerant to sedimentation, is in dire condition due to cover by layer of fine sediments.

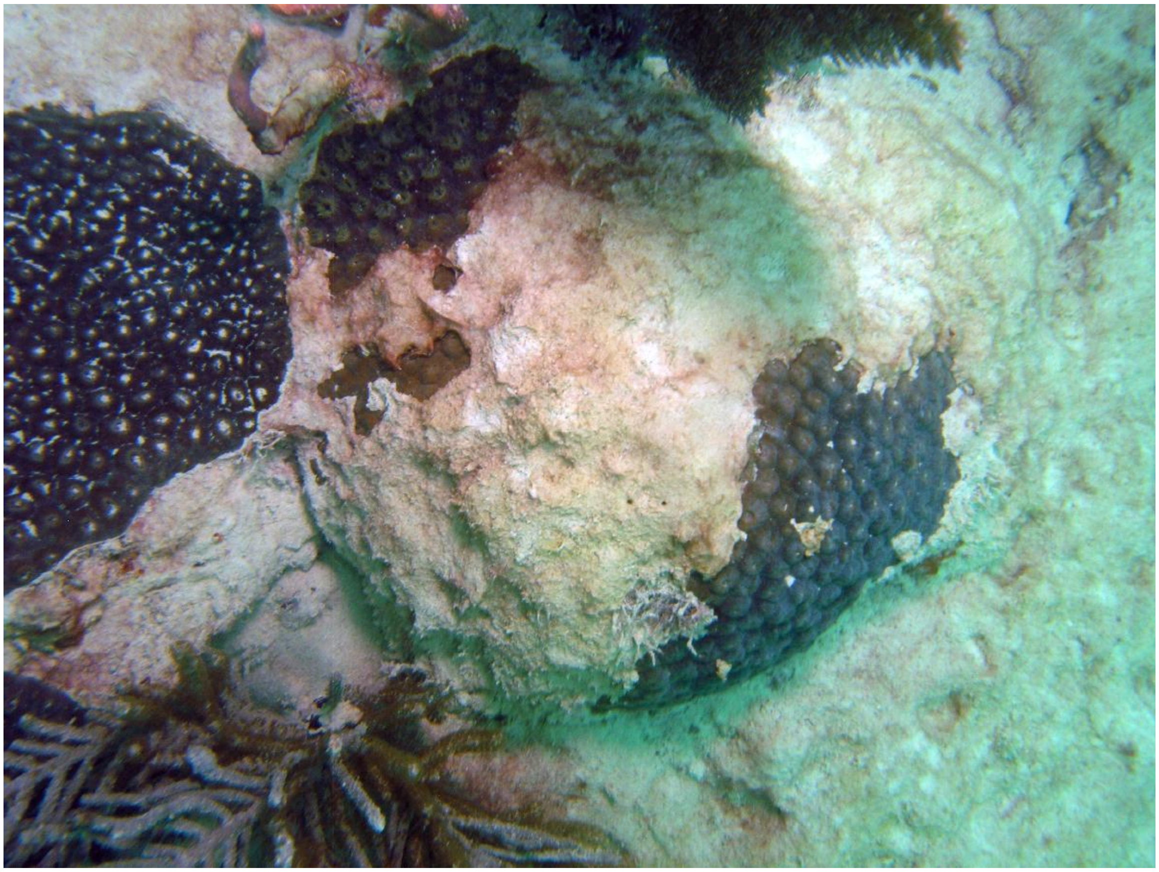

Figure 30. *Montastraea cavernosa* has over 50% of mortality due to sediment accumulation.

Figure 31. The holdfast of octocoral is buried; a small sponge nearby has been buried too. North of site R2N1.

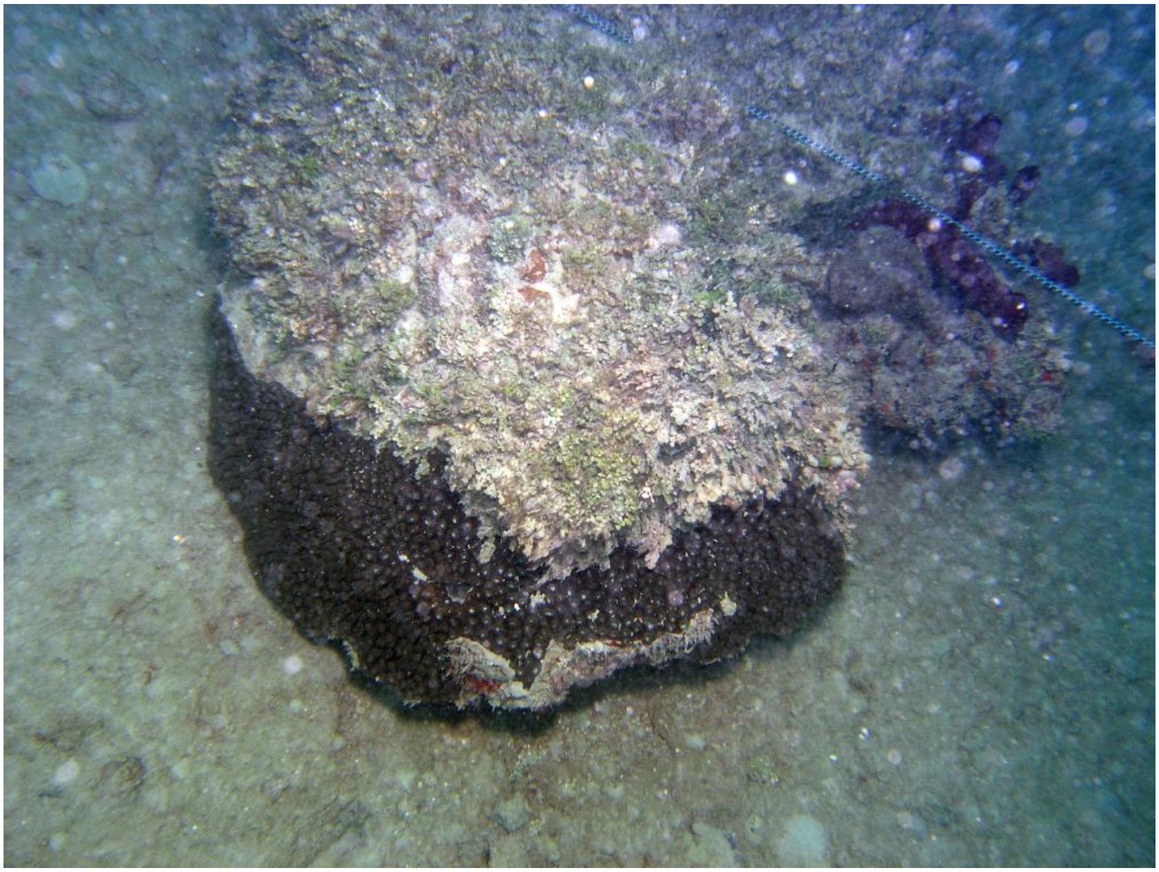

Figure 32. Small knoll formed by *Montastraea cavernosa*; the top of colony is dead and overgrown by *Halimeda* sp.

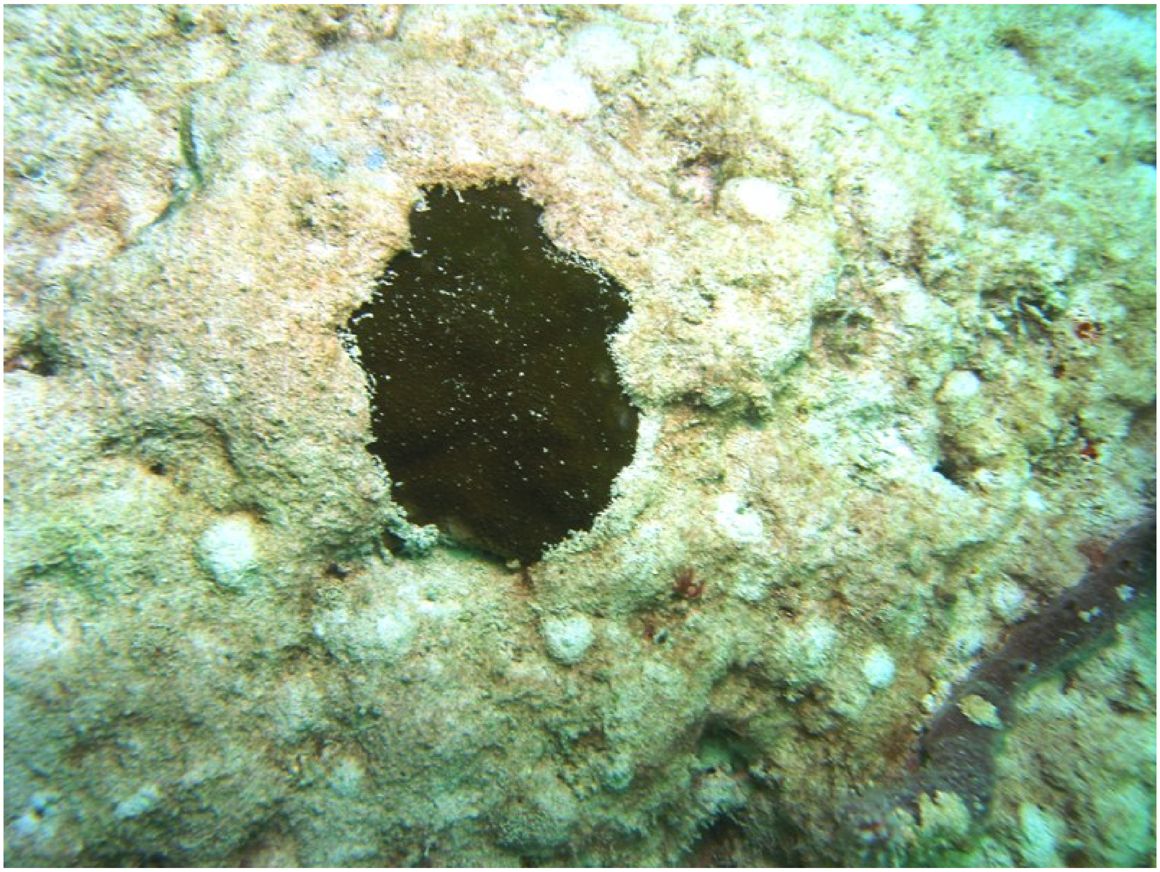

Figure 33. *Porites astreoides* colony experienced considerable burial and partial mortality (see also next picture).

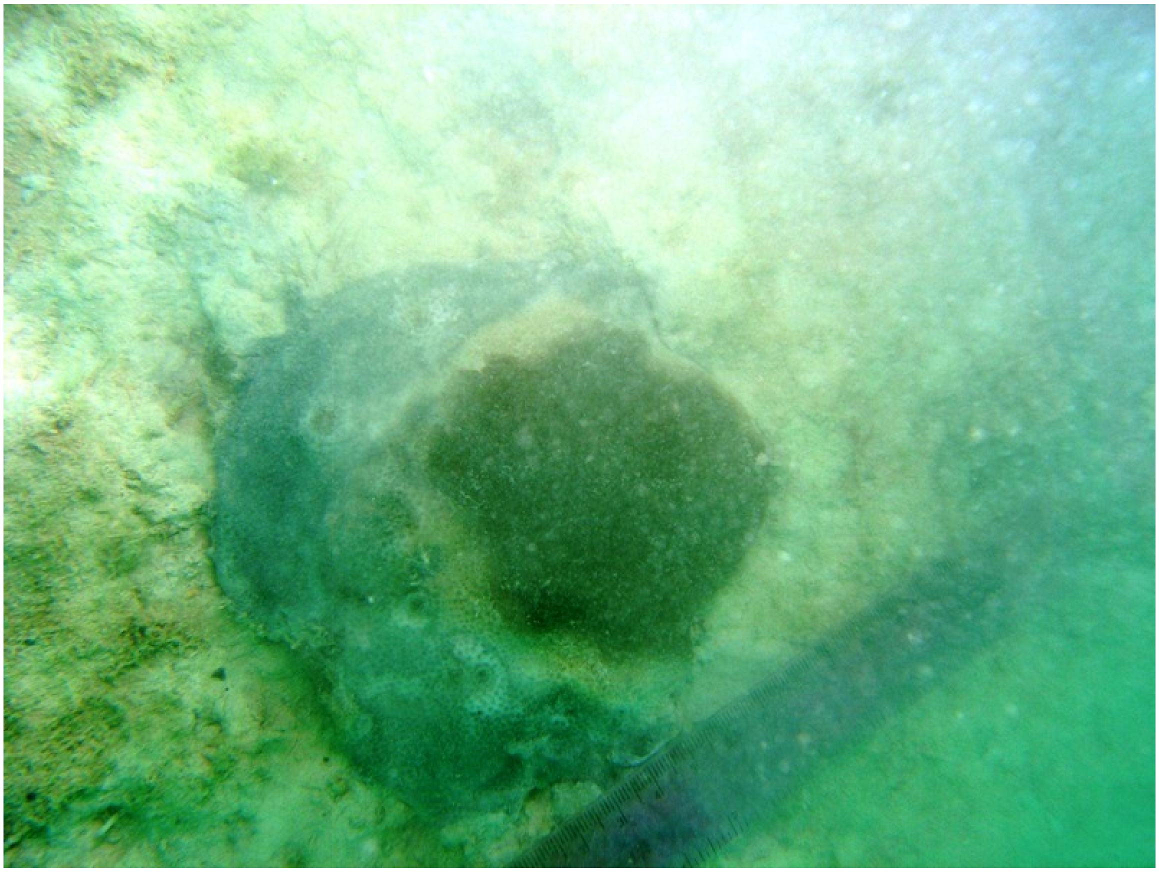

Figure 34. The same colony of *Porites astreoides* as in previous picture after excavation from sediments. 60% to 70% of colony is dead.

Figure 35. Colony of *Acropora cervicornis* close to the end of 200 m long transect to the north of compliance site R2N1.

Conclusions regarding impacts

DEP BMES and BIP staff inspected monitoring and mitigation sites for the Port of Miami Project in order to assess the severity and spatial extent of project-related impacts to hardbottom communities that had been documented in weekly reports (continuous elevated stress recorded on scleractinian corals). Methods included qualitative assessment and direct measurements of sediment thickness along assessment transects. The assessment team recorded impact to hardbottom communities at all visited compliance stations. The full spatial extent of the impact could not defined because 100 m to 200 m long assessments transects were not long enough to identify the end of impact areas.

The character of impact indicates that it was recent. Large areas of hardbottom were covered with 1 cm to 14 cm thick layer of fine sediments (visually silt and clay, with some mixture of fine sand at the monitoring stations). Such sediment cover is not characteristic for the hardbottom of this area (DEP staff pre-construction observations; pre-construction survey at monitoring stations). The sedimentation was observed during dredging activity (DERM reports). The baseline survey for the Middle and Outer Reefs happened when dredging started at the Inner Reefs and suspended sediments were already reaching sites in the Middle and Outer Reefs:

"*The second set of baseline assessments of the middle reef was conducted coincident with dredge activity in the nearshore hardbottom area (Cut 2), beginning in mid-November and concluding in mid-December. Sites surveyed during the second baseline assessment period were documented to have suspended sediment in the water column which reduced underwater visibility for the scientific dive team. In addition, sediment accumulation of fine sediment was noted on coral colonies (Table 20, Figure 22)*" (Quantitative Baseline for Middle and Outer Reef Communities. DC&A, April 2014, p.34).

The observed sediment cover has had a profound effect on the benthos. There were no scleractinian or octocoral recruits or juveniles less than 3 cm in maximum dimension observed along the assessment transects at the Inner and Middle Reefs; other small benthic organisms of the same size were also buried under the sediments. The survival of impacted scleractinian corals and octocorals in size class < 10 cm is highly unlikely; according to our observation, the sediment layer has resulted in anoxic conditions. Larger size classes of scleractinian corals, octocorals, and sponges were also adversely affected by project-related sedimentation, and impacts to these larger organisms is considerable. More than half of the larger scleractinian corals (> 10 cm in max dimension) observed had partial mortality caused by sediment accumulation, which can increase diseases in corals through infections in the affected areas. Erected sponges will lose their attachment because of the burial at the base and the death of tissue, and sponges of rope shape may have the same fate. The re-attachment and re-growth of these dislodged sponges will be impossible because of the standing sediment layer over the hardbottom. Holdfasts of octocorals were also buried under the sediments; this important functional part of an octocoral colony dies if buried, which can lead to the detachment of the octocoral; coral also can be infected in areas impacted by sediments. Incrusting forms of octocorals (*Erythropodium caribaeorum* and *Briareum asbestinum*) are especially affected by sediment accumulation. Macroalgae were either buried, or covered with a layer of sediments, which stimulates cyanobacterial growth over algae. Summer is the time of year during which recruitment occurs for the majority of benthic organisms; corals, octocorals, and sponges that have been impacted by sediment accumulation will have much less energy for reproduction. Additionally, the situation is worsened by the fact that the hardbottom substrate is now covered with a layer of sediment that will prohibit larval settlement and attachment. Lost reproductive output and recruitment resulting from this impact will have long-lasting effects on the impacted areas of reefs and hardbottom. The cohesive nature of fine sediments suggests that the sediment cover may persist for some time and have even more profound effects on the ecological function of the communities.

During the Department's site inspection, impacts were also documented at the mitigation reef site. Boulder placement at the site had damaged natural hardbottom resources and violated specific condition 33. A fast response to this issue may minimize long-lasting impacts.