June 2016

Recommendations by DEP and NMFS for monitoring impacts of the Miami Harbor Phase III Federal Channel Expansion (File No. 0305721-001-BI)

A. BACKGROUND

Impacts due to sedimentation generated by the Miami Harbor Expansion project were documented in weekly during-construction monitoring reports and have been verified in the field by regulatory agencies. The FDEP permit[1] requires delineation of the potential project-related impact areas and impact assessment surveys within the delineated areas to be completed twice within one year post-construction[2]. The permit[3] also requires that permanent monitoring stations, where impacts were documented, be monitored two times[4] within one year post-construction. An impact assessment is also needed for Essential Fish Habitat (EFH) consultation and may or may not also be needed for Endangered Species Act (ESA) consultations with NMFS.

The USACE has delineated the impacted areas (Figure 1 and 2) and has provided FDEP and NMFS staff with a draft monitoring protocol for assessing the project-related, permanent impacts within these previously delineated areas[5]. The monitoring protocol proposed by USACE mirrors the methods used for the 2010 baseline survey for the project. FDEP, NMFS, and USACE staff have met several times, most recently on March 18, 2016, to review the merits of using methods similar to those used during the 2010 baseline survey versus the merits of new approaches. The monitoring protocol outlined below reflects those discussions, is the joint recommendation of the FDEP and NMFS, and will satisfy FDEP permit requirements and the NMFS requirements for EFH consultation. Additional justification for the new protocol and details regarding the specific monitoring tasks, supplementing that already provided during the meetings between FDEP, NMFS, and USACE staff, can be provided if needed.

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[1] Condition 32 a.ii.d states that "…Impacted areas shall continue to be monitored monthly during the construction, one month post-construction, and two times during next year in order to document results of the impact. Final monitoring results shall document permanent impacts, if any, to be used for estimates of additional mitigation using UMAM."

[2] According to the "Quantitative Post-Construction Analysis for Middle and Outer Reef Benthic Communities" (November 19, 2015): "All Cut 1 and Cut 2 dredging (offshore) was accepted and therefore deemed complete, by the USACE on April 8, 2015. Dredging inshore continued until September 16, 2015. The USACE accepted the project as complete on September 17, 2015."

[3] Permit Modification 0305721-008-BN states that "…If any impact from the project is documented, the permanent station monitoring shall be conducted two times within one year, in the stations where the impact was documented as well as in the control station. Monitoring of permanent stations shall be done concurrently with monitoring of delineated impact areas (areas where sedimentation impacts have been documented and delineated). Data from all monitoring events for permanent stations and impacted areas shall be submitted to the Department as soon as it becomes available, but no more than 30 days after each monitoring event at the permanent station or the impacted areas.

[4] One survey (i.e., the immediate post-construction survey) of the permanent stations was completed in June – July 2015.

[5] The spatial boundaries for the EFH and, if necessary ESA consultations have been informed by fieldwork NMFS completed in April 2016 and are reflected in Table 2. For this reason, "NMFS areas of concern" have been identified outside of the FDEP/USACE delineated area and are included in this joint monitoring protocol. NMFS recommends the full survey effort at sites where sedimentation was documented in April 2016. Note some sites of concern were eliminated from Table 2 due to overlay with the commercial anchorage and diver safety within those sites

Figure 1: Delineation of potential sedimentation effect area within nearshore hardbottom (September 2014). Impacted areas are shown as hashed.

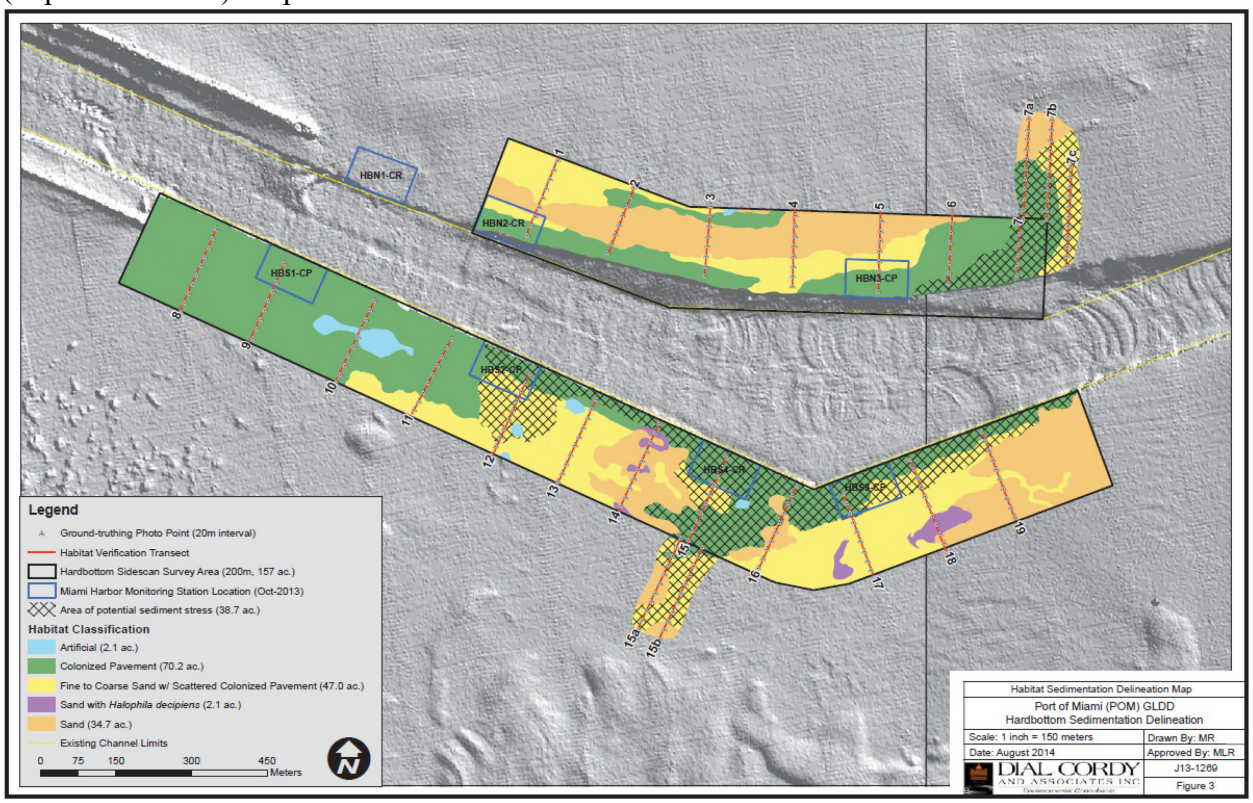
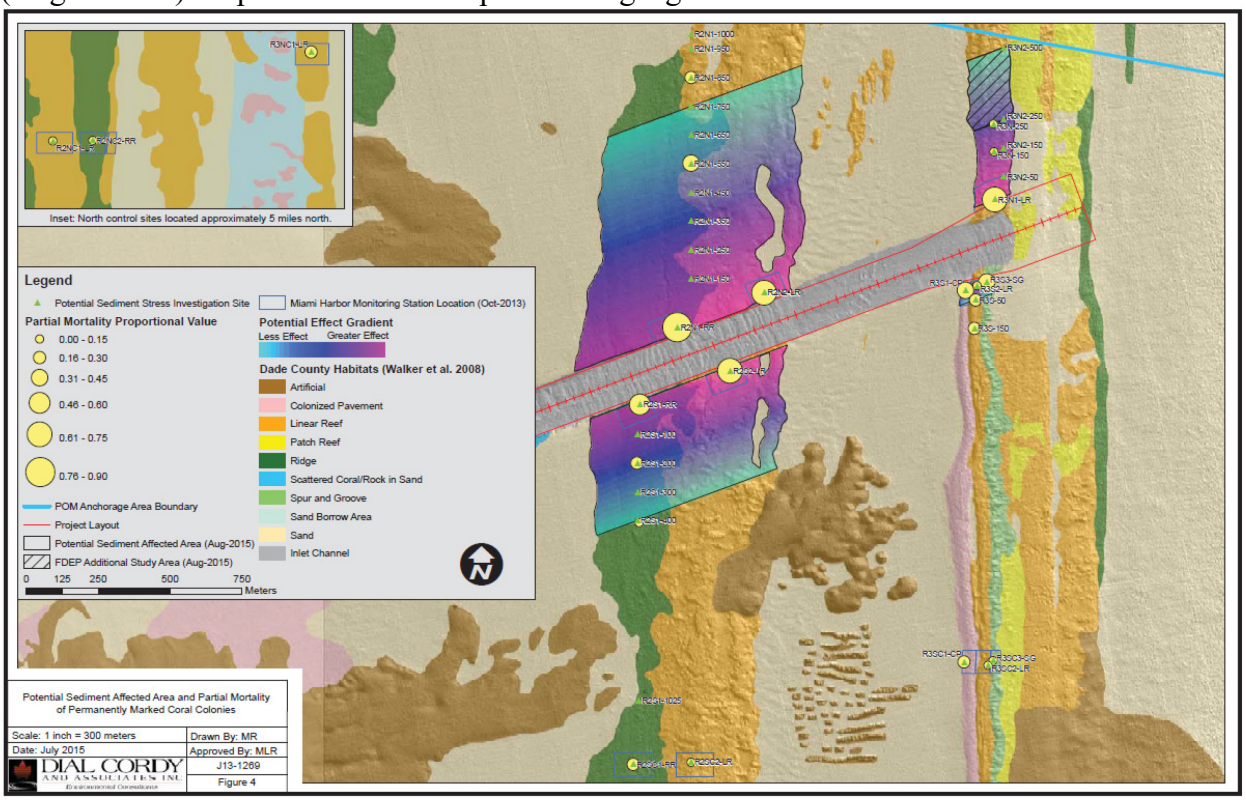


Figure 2: Delineation of potential sedimentation effect area within middle and outer reef habitats (August 2015). Impacted areas are depicted using a gradient of colors.



B. SURVEY OBJECTIVES

The objective of this proposed protocol is to outline the methods that shall be used to survey the six hardbottom and coral reef assessment areas within the project area and their respective control areas (see Table 1) to determine the permanence (persistence), extent (acreage), and level of severity (functional degradation / loss) of project-related sedimentation impacts.

This protocol was developed to ensure that monitoring will provide information that is: 1) required by the FDEP to conduct a Uniform Mitigation Assessment Method[6] (UMAM) analysis in order to determine the amount of compensatory mitigation that will be required to offset impacts; and 2) needed for the EFH consultation (specifically the consultation's Habitat Equivalency Analysis) and may also be needed for Endangered Species Act consultation with NMFS.

Table 1. Six hardbottom / coral reef assessment areas, subareas, and corresponding control areas.

Assessment Area	Control Area	USACE Delineated impact area (acres)
1. Nearshore Hardbottom North	HBNC	9.9
2. Nearshore Hardbottom South	HBSC	28.8
3. Middle (2nd) Reef North		130.3
3a. Ridge Reef	R2NC2-RR	
3b. Linear Reef	R2NC3-LR	
4. Middle (2nd) Reef South		64.4
4a. Ridge Reef	R2SC1-RR	
4b. Linear Reef	R2SC2-LR	
5. Outer (3rd) Reef North	R3NC	17.4
6. Outer (3rd) Reef South		1.6
6a. Linear Reef	R3SC2-LR	
6b. Spur and Groove[7]	R3SC3-SG	

C. SITE SELECTION

Previously established (channel-side and control) permanent monitoring stations are included in this survey protocol. Additional stations will be established in order to assess the entire area (approximately 250 acres, Table 1) potentially impacted by the project. Details for the 57 survey sites[8] recommended by both FDEP and NMFS are provided in Table 2 below. Note: Table 2 and Figure 3 are included for illustrative purposes only; the exact locations of monitoring stations should be coordinated with NMFS and FDEP.

An additional 11 sites located outside of the previously delineated impact area are included in this recommended protocol; these sites are referred to as "NMFS areas of concern" and are denoted in red (Table 2 and Figure 3). The exact locations of the "NMFS areas of concern" will

[6] Mitigation will be assessed by the Department in accordance with 62-345 F.A.C.

[7] The spur and groove habitat in the Outer Reef was not examined in delineation surveys and is added to the assessment based on recommendations from the NMFS.

[8] Note regarding survey site naming convention: site names refer to habitat types (e.g., LR – linear reef) and follow similar naming convention to past surveys of the project area and Walker (2009) coral reef maps. Naming convention may differ from that used by NMFS in report of December field-surveys. Full citation for Walker (2009): Walker, B.K. 2009. Benthic Habitat Mapping of Miami-Dade County: Visual Interpretation of LADS Bathymetry and Aerial Photography. Florida DEP report #RM069. Miami Beach, FL. 47pp.

be provided to the Port by NMFS prior to the commencement of monitoring and may include shifting the site location up to 200 meters, but will not include moving the dive sites into deeper waters. These additional 11 stations are not required to be monitored pursuant to the DEP permit, but information on these sites is needed for the NMFS Essential Fish Habitat (EFH) consultation.

Table 2. Information on all survey sites and transects.

PROJECT AREA	SITE NAME		Distance from channel (m)	Number of transects per site by transect type (N)			Length of each transect by transect type (m)	
				Control	Assess.	Permanent	Contr./Asses.	Permanent
NSHB North	HBNC-1		~ 2,175	1		3	100	20
(N=4 Sites)	HBN3		~ 30		1	3	100	20
	7a-75		75		1		100	
	7a-150		150		1		100	
NSHB South	HBSC-1		~ 1,600	1		3	100	20
(N=5 Sites)	HBS4		~ 30		1	3	100	20
	15b-150		150		1		100	
	15b-250		250		1		100	
	HBS3		~ 30		1	3	100	20
Reef 2, North	R2NC2-RR	R2NC3-LR	~ 8,050	1		3	100	20
(N=22 Sites)		R2NC1-LR		1		3	100	20
*4 additional NMFS sites	R2N1-RR	R2N1-LR	~ 30		1	3	100	20
	R2N-50-RR	R2N-50-LR	50		1		100	
	R2N-100-RR	R2N-100-LR	100		1		100	
	R2N-150-RR	R2N-150-LR	150		1		100	
	R2N-250-RR	R2N-250-LR	250		1		100	
	R2N-350-RR	R2N-350-LR	350		1		100	
	R2N-450-RR	R2N-450-LR	450		1		100	
	R2N-550-RR	R2N-550-LR	550		1		100	
	R2N-650-RR	R2N-650-LR	650		1		100	
	R2N-750-RR	R2N-750-LR	750		1		100	
	R2N-850-RR	R2N-875-LR	850/875		1		100	
		R2N-1050-LR	1050		1		100	
Reef 2, South	R2SC-1-RR	R2SC-2-LR	~ 1,320	1		3	100	20
(N=14 Sites)	R2S1-RR	R2S1-LR	~ 30		1	3	100	20
*6 additional NMFS sites	R2S-50-RR	R2S-50-LR	50		1		100	
	R2S-100-RR	R2S-100-LR	100		1		100	
	R2S-200-RR	R2S-200-LR	200		1		100	
	R2S-300-RR	R2S-300-LR	300		1		100	
	R2S-400-RR	R2S-400-LR	400		1		100	
	R2S-500-RR	R2S-500-LR	500		1		100	
	R2S-600-RR	R2S-600-LR	600		1		100	
	R2S-2200-RR	R2S-2200-LR	2200		1		100	
Reef 3, North	R3NC-1-LR		~ 8,050	1		3	100	20
(N=9 Sites)	R3N1-LR		~ 30		1	3	100	20
	R3N-50-LR		50		1		100	
	R3N-100-LR		100		1		100	
	R3N-150-LR		150		1		100	
	R3N-200-LR		200		1		100	
	R3N-300-LR		300		1		100	
	R3N-400-LR		400		1		100	
	R3N-500-LR		500		1		100	
Reef 3, South	R3SC-2-LR		~ 1,285	1		3	100	20
(N=3 Sites)	R3S2-LR		~ 30		1	3	100	20
*1 additional NMFS site	R3S-50-LR		50		1		100	
	R3S-350-LR		350		1		100	

Replicate sites will be surveyed in each of the six hardbottom / coral reef assessment areas, and sites within each of these six areas (and their subareas, as defined in Table 1) are matched with control sites for comparative purposes (Tables 1 and 2). Approximate locations for the survey sites (Table 2) are based on the distance from the channel. While the number of recommended assessment areas will not change, FDEP, NMFS, USACE, and the Port of Miami should further coordinate on exact locations to ensure priority areas are assessed and natural sand channels[9] and natural habitat transition areas are avoided.

For the middle (2nd) reef, Ridge Reef (RR) sites are paired with Linear Reef (LR) sites at all locations (distances from the channel) in order to account for the spatial scale of the potentially impacted area and to account for potential differences in habitat type (Table 2 and Figure 3). Each site, in each habitat, at each distance should be surveyed.

The impact delineation of hardbottom sites was generally confined to areas located within 200 m of the channel (Figure 1). However, in some hardbottom areas, impacts extended greater than 200 m from the channel, including 1) an area north of the channel west of HBN3, where transects 7a and 7b are located and 2) an area south of the channel near HBS4, where transects 15a and 15b are located. Channel-side sites and sites farther away from the channel, in the hardbottom areas near transects 7 and 15, should be surveyed (Table 2, Figures 1 and 3).

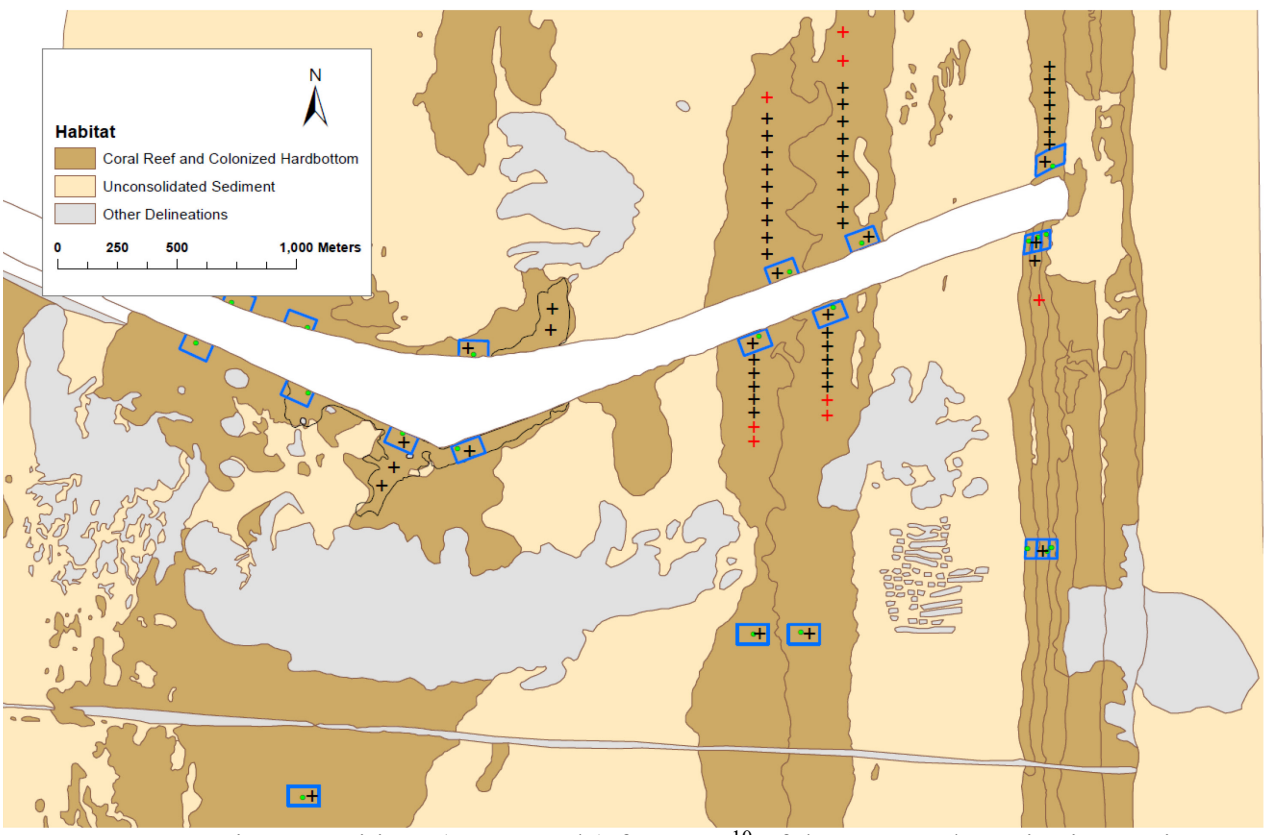


Figure 3: Approximate positions (not-to-scale) for some[10] of the proposed monitoring stations.

[9] Natural sand channels should be identified based on in-water observations (i.e., ground-truthing of sites); care should be taken to avoid mischaracterizing areas impacted by sediments as sand channels. Side-scan data may misrepresent areas that have been heavily impacted by project-related sedimentation as "sand". Ground-truthing to verify areas of consolidated vs. unconsolidated substrate will take considerable effort. If the Corps undertakes this task it should be considered separate from the permit-required monitoring that is needed to assess project-related impacts.

[10] The three reference sites at Reef 2 north and one reference site at Reef 3 north are not shown because they are located over 5 miles north of the channel. In addition, the NMFS located ~ 2,200 meters south of the channel on Reef 2 are also not depicted.

D. MONITORING

Best practices should be used to provide consistent and repeatable data collection across all sites to be surveyed. The aim of the surveys is to document any unpermitted permanent impacts to hardbottom / coral reef resources that resulted from the project.

Monitoring will consist of two discrete surveys: **Survey 1**) *in situ* surveys of assessment area sites and their corresponding control sites (within previously delineated impact areas and in the additional NMFS areas of concern) using a transect cross design (see section E below); and **Survey 2**) *in situ* surveys of previously established channel-side sites and their corresponding control sites using permanent 20 m long transects (N=3 parallel transects at each of 17 sites, see section F below).

For **Survey 1**, each of the assessment areas and control sites (N=68 survey sites, including 57 sites within the previously delineated impact area and 11 additional NMFS areas of concern) will be surveyed, including: collection of digital video, interval sediment depth measurements[11], substrate characterization, and 1 m belt surveys of benthic organisms along each axis of the 50 m x 50 m transect cross. For **Survey 2**, permanent transects at channel-side and control sites[12] (N=17 sites) will be surveyed using a slightly expanded protocol based on methods previously used at these sites, which are described in the pre- and post-construction monitoring reports for the project.

E. SURVEY 1: TRANSECT CROSS IN ASSESSMENT AREAS AND CONTROL SITES

Monitoring tasks for each assessment and control site to be surveyed should include the following: 1) establishment of 2 perpendicular 50 m long transects to form a transect cross; 2) digital video collection; 3) interval sediment depth measurements; 4) substratum characterization; and 5) belt transect survey of benthic organisms.

E1. Transect configuration and setup

A transect cross should be used to survey the benthic environment and community at each control area and assessment area site (N=68 survey sites, including 57 sites within the previously delineated impact area and 11 additional NMFS areas of concern). The sampling station should be formed by two 50 m long transects deployed such that each transect intersects the other at roughly the 25 m mark to form a cross (transects are perpendicular to one another) (Figure 4). The cross configuration (Figure 4) provides considerable spatial coverage for assessment while limiting the total number of transects needed at each site. The length[13] of each transect line (50 m) ensures that an adequate area is sampled to account for potential heterogeneity of the benthic habitat and spatial variation in impacts.

[11] Direct measurements of sediment will be required by the Department to evaluate project-related sedimentation.

[12] Previously established control and channel-side sites will be monitored in Survey 1 and Survey 2, using both transect crosses and the permanent transects. See Table 2 and Figure 3.

[13] If shorter (e.g., 10 m long) transects were used many more transects would be needed to ensure that the area was thoroughly sampled such that data are representative of the area and capture spatial variation in the benthic habitat and impacts.

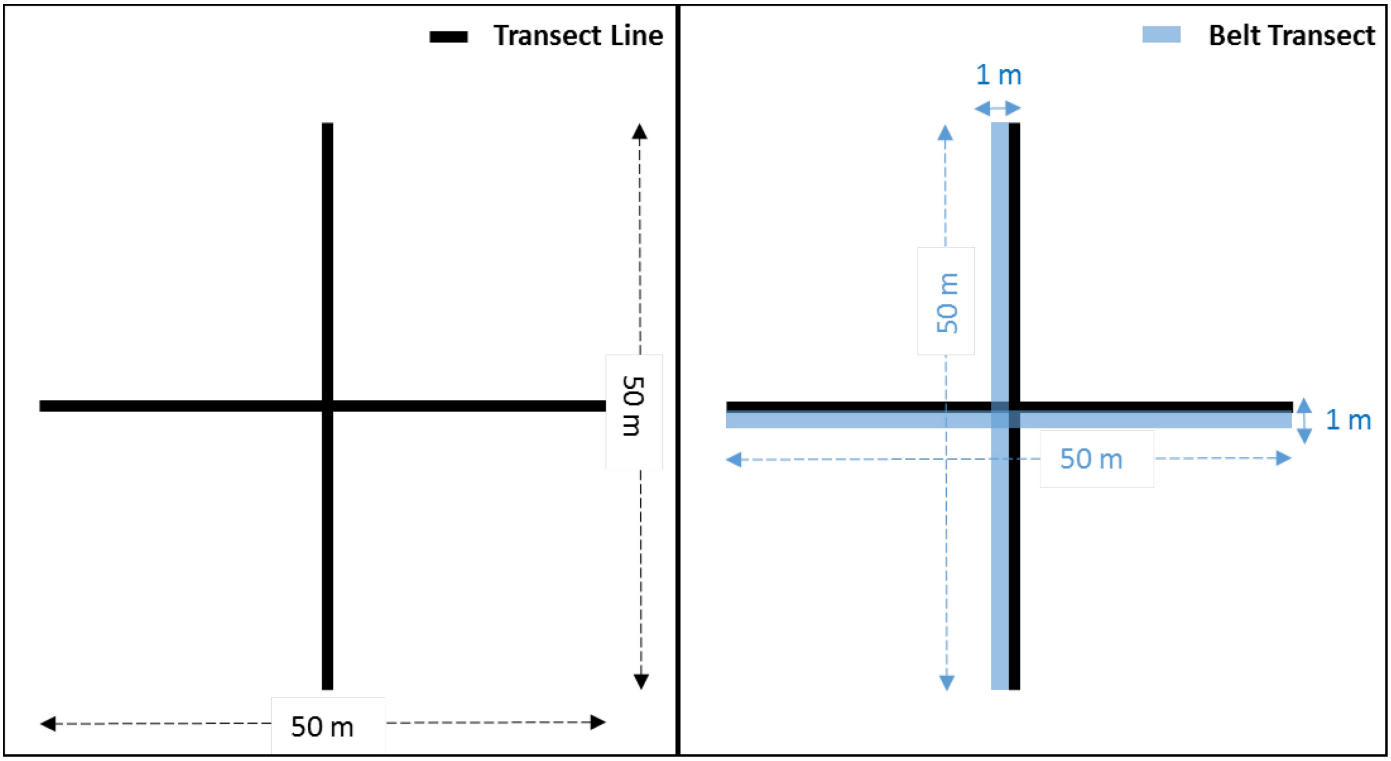


Figure 4. Transect configuration. **Left.** Cross configuration formed by the two intersecting 50 m transect lines. **Right.** 1 m belt transects on the side of each 50 m transect line.

The first transect at each site should be deployed in a north-south orientation, and the second in an east-west orientation. For all east-west transects, meter 0 should be at the eastern end of the transect line (i.e., these transects should run from east [0 m] to west [50 m] at every site). However, north-south transect should be oriented with respect to the channel. North of the channel, meter 0 should be at the southern end of the transect line (i.e., the transect should run from south [0 m] to north [50 m]). South of the channel, meter 0 should be at the northern end of the transect line (i.e., the transect should run from north [0 m] to south [50 m]). Orienting transects as described above ensures consistent and uniform meter mark positions across sites and allows for potential impact gradients to be assessed.

Divers should use their compasses to run transect lines as straight as possible and to ensure that the two transects are roughly perpendicular to one another (Figure 4). Transects should be laid as close as possible to the substrate and wherever possible, the transect should not be suspended on erect benthic organisms, such as octocorals. Divers should take care while running the transect lines in order to avoid suspending sediments and to minimize disturbance to benthic organisms. Both ends of each transect line and the intersection of the two lines should be secured with weights prior to conducting the survey. While different methods of deploying the two transects are possible[14], one method should be decided upon and used consistently across all sites.

[14] One way to deploy these transects would be to have one diver holding the transect reel at the intersection point, while another diver swam out the end of the transect tape in the pre-determined direction; the diver holding the reel could then stop the tape (keep it from dispensing further) to signal their dive partner when they have gone 25 m. The diver could secure the transect end with a weight. The diver could return to the interception point and secure the transect tape with a weight at the 25 m mark. The diver could swim the transect reel out in the opposite direction, until the tape extends to 50 m. The process could be repeated for the second transect; alternatively, a third diver could be used to swim the second tape, while one diver holds both reels at the interception point.

Prior to initiating field-work, a georeferenced map should be produced showing all locations to be sampled. A table with the GPS coordinates of all sampling locations should also be generated. During sampling, when transects are established in the field, the exact GPS coordinates of each transect (i.e., start and end positions, and the point of transect interception) should be recorded.

E2. Digital video survey

The aim of this task is to collect digital video at all assessment and control sites (Table 1 and 2). These videos will provide valuable information on benthic communities, e.g., the relative abundance of benthic organisms such as algae, tunicates, and zoanthids that are not monitored in other portions of this protocol. Videos will also serve as a visual record of each site and can be used to verify diver observations (e.g., belt transect data below).

The entire length of each 50 m transect at each site should be surveyed using a digital video camera in a waterproof housing. Quantitative analysis of digital video will not be required for the transect cross monitoring stations (see data analysis section below), but video collected at these stations should be of a quality that can be analyzed using point count procedures (e.g., CPCe); video should not be distorted (i.e., not taken with fisheye lens). Video of the seafloor along each transect should progress no faster than 5 meters per minute (10 min / transect) at a height of 40 cm above the seafloor. A convergent laser guidance system should be used to indicate the precise height of the camera at 40 cm from the bottom. The transect line should be clearly visible in all video so that locations may be accurately referenced. Additionally, a 360° panoramic view should be recorded both at the beginning and at the end of each transect as well as at their intersection, at an elevation of roughly 1 m above the seafloor and at an angle of roughly 30° to the horizon. At the beginning of each 50 m transect at each site, a standard underwater display should be videotaped and integrated directly onto the digital video record. The standard display should report: 1) the name of the site (see Table 2); 2) the orientation of the transect (N-S or E-W); 3) the survey date (e.g., 06/25/2016); and 4) any pertinent notes (e.g., poor visibility, large swell, lots of mud like sediment, etc.).

Video collection should be the first monitoring task conducted following transect setup. These data are to be collected first to ensure that the condition of the monitoring station is not inadvertently altered by diver activities / monitoring tasks. Divers should take care while swimming along the transect lines in order to avoid suspending sediments and to minimize disturbance to benthic organisms.

E3. Sediment measurements and substrate characterization

Sediment depth data (section E3a) provide information on the spatial distribution and abundance of sediments at each survey site. Substratum characterizations (section E3b) provide complementary information on the type of sediments at each survey site. Together these data enable an assessment of the presence and severity of project-related sedimentation at each site, which can be used in conjunction with information on benthic communities (condition of organisms and indicators of sediment stress provided by belt transects and videos) to determine adverse impacts of the project on hardbottom and coral reef resources. During this task, if the surveyor observes a visually conspicuous change in the substratum, then a description (e.g. area of higher relief) and the position (transect, meter mark) of this observation should be noted.

<u>E3a. Interval sediment depth measurements</u>

Interval sediment depth measurements should be made following the collection of video (described above). During the survey, sediment depth should be measured at 1-m

intervals along the entire length of each 50 m transect (N=2) at each site. Measurements should start at the 0 m mark and end at the 50 m meter mark on each transect, for a total of 51 measurements per transect and 102 measurements per site. Measurements should be taken immediately to the right of the transect line (offset by less than a cm from the tape). As the purpose of the task is to assess sediment depth, sampling should exclude organisms blocking the substratum. If an organism is encountered, such that the substratum cannot be accessed, then the depth of sediment should be measured at the closest point along the transect line in the direction of movement (i.e., 0-50 m). The data sheet should be updated to indicate the actual point (to the nearest single decimal place) at which the depth was measured (e.g., 10.2 m). For each measurement[15], a stainless-steel ruler, graduated in centimeters (0 to 30 cm), should be pressed through the sediment until the ruler reaches the surface of hard substrata or is totally immersed in sediment. Depth measurements should be recorded in cm to the nearest single decimal place (e.g., 3.2 cm). Sediment depths greater than 30 cm should be reported as > 30 cm.

E3b. Substratum characterizations survey

Characterization of the substratum should be done concurrently with interval sediment depth measurements (i.e., a single diver should collect these data as they move from meter 0 to meter 50 along each transect). Unlike sediment depth measurements that will be taken every meter, information on the type and character of the substratum should be recorded every 5 m along each transect line at each site (N=22 points per site). As with sediment depth measurements, sampling should exclude points containing organisms. If a sampling position (at 5 m interval) falls on an organism (e.g., coral), then the nearest point along the transect line (in the direction of travel) with unimpeded access to the substratum should be assessed and characterized instead. The data sheet should be updated to indicate the actual point (to the nearest single decimal place) at which the substratum was characterized (e.g., 10.2 m).

The final substratum categories, sediment types, and reporting protocols should be determined in consultation with NMFS and FDEP. However, it is recommended that the following abiotic benthic component categories (substratum categories) be used: exposed hardbottom (no sediment present), rubble, sediment over hardbottom, and sediment only. Whether or not sediment is covering hardbottom should be determined via excavation[16] (to at least 30 cm) and observation of hardbottom substratum and organisms or only sediment. Depth of sediment over hardbottom should be measured and recorded (as above, see section E3a). When encountered, sediment should be characterized using sediment comparator cards and as follows: fine sediment (mud-like), sandy sediment, or mixed sediment (fine and sand). If visually distinctive layers of sediments are observed (conspicuous, discrete layers), this should be noted and the sediment type, depth, and thickness of each layer should be briefly described. Digital still photos should be taken for each point for which observations are made (i.e., every 5 m along each transect), including additional photos for excavated areas.

[15] Sediment depth should be measured, regardless of the substratum type. Sediment may accumulate on areas dominated by rubble. Visual assessments of "no sediment" are not recommended. "No sediment present" needs to be determined by measuring the sediment depth; only areas with a measured sediment depth of 0.0 should be considered "no sediment".

[16] Excavation of small pits is only required for intercepts that fall on sediment (i.e., intervals that fall on exposed hardbottom or rubble would require no excavation). Pits need not be excavated deeper than ~ 30 cm, and in most areas pits will terminate in hardbottom before 30 cm is reached. Excavations are easily conducted using hands and by wafting away layers of sediment. As the pit is excavated, the characteristics of the sediment should be assessed and recorded. Fine particulate may appear as distinct layers or it may be mixed in with coarser material. During excavation, tactile properties and time for suspended sediments to settle can also be used to determine if fine materials are present.

E4. Belt transects for benthic organisms

This task should be completed last, after all other tasks (described above) have been completed. The goal of this task is to document the abundance, diversity (richness and evenness), size-class distribution and condition of several types of benthic organisms for the purpose of assessing potential adverse impacts (including but not limited to partial/complete mortality) due to project induced sedimentation. A one meter wide belt[17] along each 50 m transect (N=2) at each site should be surveyed (total area = 100 m^2 per site). Each 50 m^2 belt should be subdivided into 1 m^2 sections (N=50), and survey data should be recorded with reference to each section (i.e., 0-1 m, 1-2 m, 2-3 m, etc.). The following information should be recorded for scleractinian corals, octocorals, and sponges that fall with each belt transect:

E4a. Scleractinian corals:

Each individual should be identified to species, and the size (max dimension) and condition should be recorded for each colony. Scleractinian coral condition should be recorded as: healthy (no noticeable signs of stress), diseased, bleached, sediment stressed, partial mortality, or dead (100% mortality). Any dusting or accumulation of sediments and all signs of sediment stress should be reported, including the presence of a sediment halo (or partial mortality typically around the base of the colony), the presence of sediment or partial mortality in concave areas of encrusting and massive shaped colonies, and the presence of sediment or partial mortality on the upslope side of colonies growing on steep surfaces. These distinct patterns of sediment accumulation and/or partial mortality result from corals not being able to remove sediments rapidly enough from their surfaces.

Partial mortality should be visually estimated and recorded as the percentage of surface area lost. This will require the excavation of all portions of the coral skeleton that are buried beneath sediments. Guides for visually estimating percent cover (such as those provided in Appendix A) should be used and cross-training should be done to ensure consistency between surveyors.

Each colony should be documented by taking a photograph of the coral from above. The photo should be taken from a distance that allows the entire colony to be in the frame; a ruler should be included in the photo for scale. For corals exhibiting signs of sediment stress, close up photos should be taken to document stress.

E4b. Octocorals:

Each individual should be identified to genus; the size (max diameter for incrusting forms or height for erect forms), and condition should be recorded for each colony. Octocoral condition should be recorded as: healthy (no noticeable signs of stress), diseased, sediment stressed, or dead (100% mortality). Buried holdfasts and/or the presence of eroded axis material should be considered signs of sediment stress for octocorals and should be recorded if observed. Each colony should be documented by taking a photograph of the octocoral; additional close up photos should be taken to document signs of stress. In general, photographs should be taken from above for encrusting forms

[17] The side of the transect to be surveyed should be determined prior to initiating in-water work to reduce the potential for observer bias. The side to be surveyed could be chosen randomly, but it may be logistically simpler to consistently survey the same side of all transects, i.e., always to the left or right of the line.

and from the side for erect forms. A ruler should be included in each photograph for scale.

E4c. Sponges:
The sponge morphotype (encrusting, erect branching, tube/vase, spherical, and massive/amorphous) should be recorded for each individual. The size of each individual should also be measured (max diameter or height, depending on growth form). Sponge condition should be recorded as: healthy (no noticeable signs of stress), diseased, or sediment stressed. It is unlikely that any dead sponges (100% mortality) will be observed, since their skeletons disintegrate rapidly following death; still, any dead sponges observed should be recorded. Buried basal attachments and sediment accumulation on external layers (e.g., on the surface of encrusting forms, within the atrial cavities of tube/vase shaped sponges, on the branches of erect branching sponges) should be considered signs of sediment stress for sponges. Each individual should be documented by taking a photograph; additional close up photos should be taken to document signs of stress. In general, photographs should be taken from above for encrusting and spherical forms and from the side for erect forms. A ruler should be included in each photograph for scale.

F. SURVEY 2. PERMANENT CHANNEL-SIDE AND CONTROL TRANSECTS

All 17 control and channel-side sites identified in Table 2 (those with permanent transects that have been monitored over time) should be surveyed using previously established methods[18] (as outlined below and described in pre- and post-construction monitoring reports for the project). Some addition information shall also be recorded and reported, as described below.

F1. Evaluation of permanently marked corals

Each coral should be identified to species, and the size (max diameter) should be reported for each colony. Still photos of each coral should be taken; at least one photograph should be taken from a vertical position; additional photos should be taken from other angles, if needed, to capture the condition of each coral. A ruler should be included in each photo for scale. The condition of each permanently marked (tagged) coral should be visually evaluated and recorded. Assessment of stress[19] and coral health should be made as in previous surveys. If a coral is recorded as "stressed", then the observer should note the type(s) of stress.

Stress due to sedimentation should be recorded separately from other causes of stress, such as fish bites or disease. Any dusting or accumulation of sediments and all signs of sediment stress should be reported, including the presence of a sediment halo (or partial mortality typically around the base of the colony), the presence of sediment or partial mortality in concave areas of encrusting and massive shaped colonies, and the presence of sediment or partial mortality on the upslope side of colonies growing on steep surfaces. These distinct patterns of sediment accumulation and/or partial mortality result from corals not being able to remove sediments rapidly enough from their surfaces. Note: In addition to coral condition information (that was recorded during prior monitoring events), the partial (or complete) mortality of colonies should be recorded as the percentage of surface area lost for each colony. This will require the excavation of all portions of the coral skeleton that are buried beneath sediments. Guides for

[18] Note: While methods used during prior surveys should be repeated (for the purpose of temporal comparisons), additional information should be collected, as described herein, in order to more thoroughly characterize impacts.
[19] Table 4 located on page 12 -14 of the "Quantitative Post-Construction Analysis for Middle and Outer Reef Benthic Communities" (November 19, 2015)" outlines categories of coral stress.

visually estimating percent cover (such as those provided in Appendix A) should be used and cross-training should be done to ensure consistency between surveyors.

F2. Quantitative digital video survey

Video of a quality that can be analyzed using point count procedures (e.g., CPCe) should be collected; video should not be distorted (i.e., not taken with fisheye lens). This task should be completed first, immediately after transect tapes are secured, to ensure that the condition of the monitoring station is not inadvertently altered by diver activities / monitoring tasks.

The entire length of each of three 20 m transect at each channel-side and control site should be surveyed using a digital video camera in a waterproof housing. Video of the seafloor along each transect should progress no faster than 5 meters per minute (4 min / transect) at a height of 40 cm above the seafloor. A convergent laser guidance system should be used to indicate the precise height of the camera at 40 cm from the bottom. The transect line should be clearly visible so that locations may be accurately referenced. A 360° panoramic view should be recorded both at the beginning and at the end of each transect at an elevation of roughly 1 m above the seafloor and at an angle of roughly 30° to the horizon. At the beginning of each 20 m transect at each site, a standard underwater display should be videotaped and integrated directly onto the digital video record. The standard display should report: 1) the name of the site (see Table 2); 2) the number (identifier) of the transect; 3) the survey date (e.g., 06/25/2016); and 4) any pertinent notes (e.g., poor visibility, large swell, lots of mud like sediment, etc.). Such information should also be provided on datasheets for each survey site.

Post-collection quantitative analysis should be performed using point count procedures (PointCount '99 or a comparable software package) to estimate percent cover of functional groups from frame-grabbed digital images from underwater video. Each 20-meter quantitative video segment (transect) should result in approximately 40 non-overlapping frame grabbed images (N=120 frame grabbed images per site). A unique set of at least 10 random points per image should be generated at the time of frame-grabbing and stored with each set of images.

F3. Belt transects for benthic organisms

Benthic organisms (including scleractinian corals, octocorals, sponges) present within previously surveyed[20] 1 m belt transects at each of the permanent channel-side and control monitoring sites (n = 3 transects per site) should be surveyed during this impact assessment. Each individual (> 3 cm) within the belt transect shall be identified (i.e., scleractinian corals should be identified to species; octocorals to genus; sponges to morphotype), and the size and condition of each benthic organism shall be reported. Representative photographs of benthic organisms shall be provided for each transect.

G. DATA ANALYSES

The goal of data analyses outlined below is to use the field data collected (previously and during the impact assessment surveys outlined above) to identify whether there are differences (across sites or over time) in benthic communities that may indicate project-related impacts have occurred and may have persisted. Spatial comparisons of benthic communities (e.g., abundance, type and condition of benthic organisms) at sites sampled using transect crosses within (or beyond, in the case of NMFS areas of concern) the delineated impact area and their respective control sites (Survey 1) provides valuable information regarding potential impacts. Likewise, comparisons of benthic communities over time (i.e., temporal comparisons) using permanent

[20] Care should be taken to ensure the exact same areas are surveyed as before.

transect data collected at both channel-side sites and their respective control sites (Survey 2) provides information regarding potential impacts. Note: temporal comparisons are only appropriate when the same methods have been used over time and when the quality of data collected during surveys is comparable[21].

Summary statistics (including but not limited to the mean, standard deviation, and maximum value) should be presented for each type of data (each monitoring metric) collected in the field as described above. Data should be summarized by transect, by site and by assessment area.

H. DATA ANALYSIS FOR SURVEY 1: TRANSECT CROSS IN ASSESSMENT AREAS AND CONTROL SITES

Data collected from assessment area sites should be compared to data from their respective control sites (Table 2). Comparisons of data collected at assessment area sites to the 2010 baseline survey sites in the same area (location) may be possible for some metrics and some sites; still, the bulk of the analysis should focus on comparisons to controls (noting that no permanent transects sampled at a rigorous level capable for statistical analysis exist in the extended delineated areas beyond the channel-side sites). Sites within each area (e.g., Middle Reef north, linear reef) can be categorized by the degree to which they differ from the control for each metric. Categories should be informative with respect to severity of impacts from sedimentation. For example, an ANOVA test with user defined post-hoc contrasts (defined level = control) for each of the 6 areas could be done; alternatively, an ANCOVA test could examine the effect of site distance from channel.

H1. Sediment measurements and substrate characterization

Sediment depth data (section E3a) and substratum characterizations (section E3b) provide complementary information that should be evaluated together to assess the severity of project-related sedimentation at each site.

H1a. Interval sediment depth measurements

Mean sediment depth should be calculated for each site (average of 102 points) and for each transect (average of 51 points per transect) for each site. Figures or tables should present these data for each site with respect to the appropriate control site (e.g., for each Middle Reef north, linear reef area site and its control). The mean sediment depth at positions along transects that were determined to be "sediment over hardbottom" (using substrate characterization data) should also be reported for each site. The maximum sediment depth recorded at each site should also be reported in graphical and tabular format.

H1b. Substrate characterizations survey

The frequency of occurrence for each substratum category (sediment over hardbottom, bare / exposed hardbottom, rubble, and sediment only) should be reported and compared between sites, i.e., each of the assessment area sites should be presented with respect to its respective control site. Information should also be presented for each type of sediment

[21] NMFS and DEP have concerns regarding the quality of video collected in 2010 and determined it may have limited to no usability. Moreover, the 2010 survey did not include the entire area impacted by the project; in fact, the survey included only those areas within 450 to 500 m of the channel and very few stations were monitored far-from the channel. Therefore, at this time NMFS and DEP do not recommend that the2 2010 dataset be used for statistical analyses. The 2010 survey results may be used qualitatively in the assessment of impacts. The lack of baseline data for areas further than 500 m from the channel necessitates that spatial comparisons be made between impacted sites and control sites located further from the channel.

(fines, sand or mixed); e.g., the frequency of occurrence for fine sediments along transects should be reported for each site and compared to its respective control site.

H2. Belt transects for benthic organisms

Data for benthic organisms should be presented for each site and statistical comparisons should be made between assessment area sites and their respective control sites. The size-class distribution and, particularly, the presence of small individuals (recruits) should be analyzed to determine if impacted sites differ from controls.

H2a. Scleractinian corals:

Coral assemblage composition and structure should be compared between each channel-side site and its respective control site. Metrics for each site should include numbers of individuals per species, density per species (N/m^2), richness, diversity (Shannon-Weiner [H']), and evenness (Pielou [J']). Size classes should also be compared as stated above, using histograms (size-frequency distributions).

Data on sediment stress should be reported and spatial comparisons should be made between assessment and control sites. The percentage of organisms along each transect that are dusted by sediments, have sediment accumulation, or are partially or completely buried by sediments should be reported. The percentage of corals with any sign of sediment stress should also be reported. Information on the percentage of biomass lost for individual corals (in addition to the percentage of organisms with partial or complete mortality) should be reported, including the mean and standard deviation for each transect.

H2b. Octocorals:

Octocoral assemblage composition and structure should be compared between each channel-side site and its respective control site. Metrics for each site should include umbers of individuals per species, density per species (N/m^2), richness, diversity (Shannon-Weiner [H']), and evenness (Pielou [J']). Size classes should also be compared as stated above, using histograms (size-frequency distributions). Data on signs of sediment stress should also be compared, as stated above.

Data on sediment stress should be reported and spatial comparisons should be made between assessment and control sites. The percentage of octocorals that are dusted by sediments, have sediment accumulation, or are buried by sediments (including burial of holdfast) should be reported. The percentage of octocorals with any sign of sediment stress (including but not limited to eroded axis material) should also be reported.

H2c. Sponges:

Sponge assemblage composition and structure should be compared between each channel-side site and its respective control site. Metrics for each site should include umbers of individuals per species, density per species (N/m^2), richness, diversity (Shannon-Weiner [H']), and evenness (Pielou [J']). Size classes should also be compared as stated above, using histograms (size-frequency distributions). Data on signs of sediment stress should also be compared, as stated above.

I. DATA ANALYSIS FOR SURVEY 2: PERMANENT CHANNEL-SIDE AND CONTROL TRANSECTS

Data was repeatedly collected along transects at permanent monitoring stations; therefore, temporal patterns at channel-side and control sites can be assessed to determine if changes occurred over time (pre-, during, and post-construction). Spatial comparisons can also be made between channel-side sites and control sites. Changes observed at channel-side sites can be evaluated relative to changes at control-sites.

I1. Evaluation of permanently marked corals

For each colony within each site (channel-side and control), condition, partial mortality, and size for the current survey should be compared to baseline condition, partial mortality, and size. Temporal comparisons over the course of monitoring can also be made for each coral (condition/stress, partial mortality, size). Results should be presented on a site by site basis. Results from channel-side sites for the change in condition, partial mortality (surface area), and size for different species (numbers of individuals) should also be compared between each channel-side site and its respective control site.

I2. Quantitative digital videos

Post-collection quantitative analysis should be performed using point count procedures (PointCount '99 or a comparable software package) to estimate percent cover of functional groups from frame-grabbed digital images from underwater video. Each 20-meter quantitative video segment (transect) should result in approximately 40 non-overlapping frame grabbed images (N=120 frame grabbed images per site). A unique set of 10 random points per image should be generated at the time of frame-grabbing and stored with each set of images.

Percent cover of functional groups should be compared both temporally and spatially. Firstly, data from channel-side and control sites should be compared to baseline conditions for each site, respectively (i.e., results of the current survey should be compared to results from the baseline survey for each site independently). Additional temporal comparisons (i.e., over the course of the project) can also be made. Secondly, results for channel-side sites from the current survey should compared to their respective control site, independent for each channel-side site.

I3. Belt transects for benthic organisms

Data should be compared to previous survey data to examine potential changes over time in the benthic community and / or condition of organisms. Changes in community composition and structure should be reported for each transect. Changes in composition and structure should also be compared between each channel-side site and the respective control site. Metric for each site should include numbers of individuals per species, density per species (N/m^2), richness, diversity (Shannon-Weiner [H']), and evenness (Pielou [J']).

J. QUALITY CONTROL / ASSURANCE (QA/QC)

Quality assurance and control (QA/QC) procedures should be included in the final monitoring protocol; these QA/QC procedures should be developed in coordination with FDEP, NMFS, USACE, PortMiami and the monitoring firm. QA/QC during data collection in the field is critical. QA/QC protocols should be developed prior to monitoring and should be implemented before, during, and after data collection. Moreover, an independent third party review of data collection and data analysis is strongly recommended. An example of best practices that should be included in the QA/QC protocol are available in Appendix B. Additionally, representatives from each agency shall make every effort to be present for specific portions of the field collections efforts.

K. REPORTING AND LOGISTICS

It is necessary to develop templates for 1) field data sheets, 2) Excel workbooks for raw data, and 3) tables for presenting results in reports. NMFS and DEP have begun working on this task in order to set clear expectations for deliverables. It is important that deliverables be clearly identified, using a concise and consistent naming convention. Data deliverables should be named and organized in such a manner that the content is clearly understood (e.g., station and transect are included in file name for photos). Data and media files that are too large to be emailed or uploaded to an ftp site should be provided to NMFS and FDEP on an external hard drive supplied by USACE or PortMiami.

K1. Products

- Georeferenced map (ArcGIS files) and GPS coordinates for all sampling locations
- Raw data sheets in Excel (and scanned field sheets, upon request) [22]
- Report[23] summarizing field-data from impact assessment surveys[24]
- Output files from statistical analyses software programs used to analyze datasets
- All photos and digital videos

K2. Personnel

Resumes for all monitoring staff should be provided to the agencies for review; resumes should demonstrate experience with benthic surveys. Additionally, staff from NMFS (1 diver) and FDEP (1 diver) should be provided access to dive sites (and allowed on-board survey vessels) to enable collaboration and verification of surveys.

K3. Field Supplies

- Polyform buoy with line and anchor; dive gear (e.g., weights, tanks, safety equipment)
- Transect tapes (2 x 50m and 3 x 20m); meter sticks and stainless-steel rulers (metric)
- Digital cameras and video cameras (with laser guidance system)
- Dive slates, pencils, and datasheets
- Maps with dive site coordinates
- First aid (including AED and O2)
- Diver recall system
- Bottles for collecting representative sediment samples (if necessary)
- Sediment comparators (FDEP, NMFS and USACE should jointly-select a comparator), similar to the one below, Figure 5.

[22] Raw data should be submitted for NMFS and FDEP review within 30-days after field work, pursuant to 0305721-008-BN, and in a format approved by FDEP and NMFS.

[23] A report on the results of the field survey should be provided no later than 90 days after field work has been completed. There should be a 2-week review time for agency staff, and a final report should be submitted 2-weeks after the completion of that review.

[24] The report should provide a comprehensive summary of the results for each field survey task, including all information collected and all statistical analyses conducted, as prescribed above. A discussion of survey results (interpretation of data) should not be included in the report; regulatory agencies will evaluate survey results and draw conclusions regarding impacts.

Figure 5: Example of sediment comparator card that could be used to assist observers in distinguishing sediment types (silt vs. sand). Image from: http://www.virtual-geology.info/sediments-and-strata/grainsize.html