Final Report

Project Title: **Sampling Survey Frame and Database Refinements for Disturbance Response Monitoring in the Florida Coral Reef Ecosystem**

Contractor: Dr. Jerald S. Ault, President, The Ault Group, Inc., (F.E.I.D. #65-0854041), 445 Grand Bay Drive #901, Key Biscayne, Florida 33149, (305)361-0900

TNC Program Manager: Dr. James Byrne

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Background.- The Nature Conservancy initiated a large-scale probability sampling survey in the southern Florida coral reef tract in 2005 to estimate the prevalence of stony coral bleaching during the peak 'bleaching season' in late summer. This diver visual survey, referred to as the Disturbance Response Monitoring (DRM) program, has continued through 2013 and involves a large number of government agencies (federal, state, local), universities, and non-profit organizations who contribute vessels, equipment, and personnel for the annual surveys.

The DRM employs a sophisticated two-stage stratified random survey design (Smith et al. 2011). The survey frame (i.e., spatial domain) encompasses all mapped live-coral habitats at depths <33 m stretching from Martin County south-southwest through the Florida Keys out to the Dry Tortugas. This survey frame was developed in 2005, building upon the sampling grid utilized in the Florida Keys-Dry Tortugas reef-fish visual census (RVC) conducted since 1979 by NOAA's Southeast Fisheries Science Center, the University of Miami, and other partner agencies. The RVC survey frame covered the region from Key Biscayne south-southwest through the Dry Tortugas, but did not include the northern region from Key Biscayne to Martin County. For the DRM, a sampling grid for this northern region was added to the existing reef-fish grid using the best available mapping data for bathymetry and benthic habitats, the key variables that define sampling strata; however, the quality of the benthic habitat data in this area was much lower compared to the Florida Keys-Dry Tortugas. In general, the accuracy and precision of survey estimates for bleaching prevalence of stony corals and other important population-community metrics go hand-in-hand with the quality of the survey frame sampling grid.

The quality and spatial resolution of mapping data for this northern region has significantly improved in recent years (Walker 2012). In 2012 the RVC program utilized these newer mapping data when it added this northern region to the reef-fish survey

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frame. This new reef-fish sampling grid for the Key Biscayne-Martin County region has higher spatial resolution (100 x 100 m grid cell size), more refined benthic habitat classification, and improved bathymetry compared to the existing DRM sampling grid. There was thus a need to update the DRM sampling grid using these improvements.

Objective and Tasks.- The objective of this project was to update the sampling grid GIS and database for the DRM using the most recent mapping and survey data, and fully consonant with the NOAA National Coral Reef Conservation Program. This objective was comprised of five project tasks. Descriptions of the work performed for each of these tasks is detailed below.

Task 1: Obtain the DRM database for the period 2005 to 2013.

The Access database for DRM sampling (file 'FRRP.mdb') for the years 2005-2013 was obtained from the database manager, Ken Marks.

Task 2: Replace the existing DRM sampling grid GIS with the new RVC program sampling grid GIS, in consultation with the DRM database manager.

The original sampling grid GIS for the southern Florida region extending from the Dry Tortugas to Martin County was divided into two parts: (1) a Florida Keys (FK) sampling grid extending from Key Biscayne (south of Government Cut) southwest to the Dry Tortugas; and (2) a Southeast Florida (SEF) sampling grid extending from north of Government Cut to through Martin County. The FK grid is the same as before, comprised of grid cells 200 x 200 m in area and containing all the relevant map grid variables for conducting and analyzing DRM surveys. The SEF grid is a complete update from the old sampling grid for this region, comprised of grid cells 100 x 100 m in area. Also, the mostly unclassified reef habitat types in the old grid have been replaced with new reef habitat classes.

The variables in the GIS shapefiles for the FK and SEF sampling grids are identical. Table 1 lists the variables and provides descriptions. The variable 'num_id', the grid cell identifier, has non-overlapping values for the two grids. Habitat classes are defined in Table 2, geographic subregions are defined in Table 3, cross-shelf reef zones are defined in Table 4, no-take marine protected areas implemented beginning in 1997 are defined in Table 5, and long-term marine life/aquaria species no-take areas are defined in Table 6.

Table 1.- Variables and descriptions for the GIS shapefiles for the Florida Keys and Southeast Florida sampling grids.

Variable	Description
num_id	Grid cell ID number
lat	Latitude, decimal degrees
lon	Longitude, decimal degrees
x_coord	UTM x-coordinate, meters
y_coord	UTM y-coordinate, meters
depth	Depth, meters
habclass	Benthic habitat code (see Table 2 for code descriptions)
subreg_nr	Geographic subregion number (see Table 3 for descriptions)
subregion	Geographic subregion name (see Table 3 for descriptions)
zone_nr	Cross-shelf reef zone number (see Table 4 for descriptions)
zone_name	Cross-shelf reef zone name (see Table 4 for descriptions)
mpa_nr	No-take marine protected area number (1997-present; see Table 5 for descriptions)
mpa_name	No-take marine protected area name (1997-present; see Table 5 for descriptions)
mpa2_nr	Long-term marine-life/aquaria species no-take reserve number (see Table 6 for descriptions)
mpa2_name	Long-term marine-life/aquaria species no-take reserve name (see Table 6 for descriptions)
samp_reef	Live coral reef habitat identifier (0=non-reef habitat, 1=reef habitat)

Table 2.- Habitat class codes and descriptions for the FK and SEF sampling grids ('X' denotes occurrence in the respective regions).

Habclass	Description	FK	SEF
ARTF_NA	Artificial reef	X	
CONT_HR	Contiguous reef, high relief	X	
CONT_LR	Contiguous reef, low relief	X	
CONT_MR	Contiguous reef, moderate relief	X	
CPDP_HR	Colonized pavement, deep, high relief		X
CPDP_LR	Colonized pavement, deep, low relief		X
CPSH_HR	Colonized pavement, shallow, high relief		X
CPSH_LR	Colonized pavement, shallow, low relief		X
DPRC_HR	Deep ridge complex, high relief		X
DPRC_LR	Deep ridge complex, low relief		X
ISOL_HR	Isolated reef structures, high relief	X	
ISOL_LR	Isolated reef structures, low relief	X	
ISOL_MR	Isolated reef structures, moderate relief	X	
LIRI_HR	Linear reef, inner reef line, high relief		X
LIRI_LR	Linear reef, inner reef line, low relief		X
LIRM_HR	Linear reef, middle reef line, high relief		X
LIRM_LR	Linear reef, middle reef line, low relief		X
LIRO_HR	Linear reef, outer reef line, high relief		X
LIRO_LR	Linear reef, outer reef line, low relief		X
OTHR_NA	Other non-reef habitat		X
PTDP_HR	Patch reefs, deep, high relief		X
PTDP_LR	Patch reefs, deep, low relief		X
PTSH_HR	Patch reefs, shallow, high relief		X
PTSH_LR	Patch reefs, shallow, low relief		X
RGDP_HR	Reef ridge, deep, high relief		X
RGDP_LR	Reef ridge, deep, low relief		X
RGSH_HR	Reef ridge, shallow, high relief		X
RGSH_LR	Reef ridge, shallow, low relief		X
RUBB_LR	Reef rubble, low relief	X	
SAND_NA	Sand	X	X
SGRS_NA	Seagrass	X	
SPGR_HR	Spur-groove reef, high relief	X	X
SPGR_LR	Spur-groove reef, low relief	X	X
UCHB_LR	Unconsolidated hardbottom, low relief	X	
UNCR_UN	Unclassified reef	X	
UNDF_UN	Undefined, unknown	X	

Table 3.- Geographic sub-region codes and descriptions for the FK and SEF sampling grids ('X' denotes occurrence in the respective regions).

subreg_nr	subregion	FK	SEF
2	Tortugas--Rileys Hump	X	
3	Tortugas--Tortugas Bank	X	
4	Tortugas--Dry Tortugas NP	X	
5	Tortugas--Unmapped	X	
6	Marquesas-Tortugas Trans	X	
7	Marquesas	X	
8	Lower Keys	X	
9	Middle Keys	X	
10	Mid-Upper Keys Transition	X	
11	Upper Keys	X	
12	Biscayne	X	
13	Broward-Miami		X
14	Deerfield		X
15	South Palm Beach		X
16	North Palm Beach		X
17	Martin		X

Table 4.- Cross-shelf reef zone codes and descriptions for the FK and SEF sampling grids ('X' denotes occurrence in the respective regions).

zone_nr	zone_name	FK	SEF
0	Undetermined	X	X
1	Inshore	X	X
2	Mid Channel	X	
3	Offshore Patch Reef	X	
4	Forereef	X	
5	Deepwater	X	X
6	Lagoon	X	
7	Bank	X	
9	Intra Island	X	
10	Back Country Reef	X	
12	Inner Reef		X
13	Middle Reef		X
14	Outer Reef		X
15	Reef Ridge Complex		X
20	New Grounds	X	

Table 5.- No-take marine protected area (1997-present) codes and descriptions for the FK and SEF sampling grids ('X' denotes occurrence in the respective regions).

mpa_nr	mpa_name	FK	SEF
0	Unprotected	X	X
1	Carysfort	X	
2	Elbow	X	
3	Key_Largo_Dry_Rocks	X	
4	Grecian_Rocks	X	
5	French	X	
6	Molasses	X	
7	Conch_Reef	X	
8	Conch_RO	X	
9	Davis	X	
10	Hen_Chickens	X	
11	Cheeca_Rocks	X	
12	Alligator	X	
13	Tennessee	X	
14	Coffins_Patch	X	
15	Sombrero	X	
16	Looe_Key	X	
17	Looe_RO	X	
18	Newfound_Harbor	X	
19	East_Sambo	X	
20	West_Sambo	X	
21	East_Dry_Rocks	X	
22	Rock_Key	X	
23	Sand_Key	X	
24	Tortugas_NER	X	
25	Tortugas_SER	X	
26	DTNP_RNA	X	

Table 6. Long-term marine life/aquaria species protected area codes and descriptions for the FK and SEF sampling grids ('X' denotes occurrence in the respective regions).

mpa2_nr	mpa2_name	FK	SEF
0	None	X	X
1	Biscayne_Aq	X	
2	Pennekamp_Aq	X	
3	KeyLargo_Aq	X	
4	LooeKey_Aq	X	

Task 3: Use DRM historical survey data (2005-present) to update the revised sampling grid GIS.

The DRM survey transect data from the Access database that documented presence of stony coral colonies were used to ground-truth the habitat data in the sampling grid GIS shapefiles, updating grid cells not previously classified as reef to the relevant reef habitat class. The revised sampling grids for FK and SEF also include ground-truth updates from the fish surveys in both regions.

Task 4: Update the relevant data tables and variables of the DRM database with information from the new sampling grid, in consultation with the DRM database manager.

A revised grid table for the Access DB, named 'Grid_2014', was created to update the existing 'Grid_2008' database table. This new table contains all the variables in the GIS shapefiles (Table 1), and combines the map information for both the FK and SEF regions into one uniform table. The new table also includes the variable 'foredep' which is used in the Florida Keys region for stratification. Notable updates to the Grid_2014 table are the revisions of the habitat classes (Table 2) and subregions (Table 3) for the SEF region, and the addition of the long-term MPA variable 'mpa2' (Table 6). Also, several redundant variables have been removed from the Grid_2008 table in the updated Grid_2014 table; otherwise, the variables have remained unchanged.

To facilitate comparisons and analysis between old and new sampling grids for the SEF region, a file linking the DRM transect ID to both the Grid_2008 and Grid_2014 cell identifiers has been created. This will enable the historical DRM data for the SEF region to be linked to the updated map information (habitat class, etc.) in the new sampling grid.

Task 5: Update the stratification scheme in the new DRM sampling grid GIS, focusing on the northern region from Key Biscayne to Martin County, to facilitate creation of future randomized sampling plans.

Stratifying the upcoming 2014 DRM surveys in the Florida Keys region will use the same variables as before: subregion, cross-shelf zone (zone and foredep), and habitat class. For the Southeast Florida region, stratification for the 2014 DRM surveys can be based on just two variables from the new sampling grid, subregion (Table 3) and habitat class (Table 2). For the SEF grid, habitat class incorporates reef morphology and patchiness, complexity/rugosity, cross-shelf zone, and depth all in the same variable.

Deliverables.- The following deliverables are provided:

(1) folder 'DRM_FKGrid_1': folder with part 1 of the ArcGIS shapefiles for the updated Florida Keys DRM sampling grid GIS. Shapefile name: DRM_FKGrid_2013.

(2) folder 'DRM_FKGrid_2': folder with part 2 of the ArcGIS shapefiles for the updated Florida Keys DRM sampling grid GIS. Shapefile name: DRM_FKGrid_2013.

(3) folder 'DRM_SEFGrid': folder with ArcGIS shapefiles for the new Southeast Florida DRM sampling grid GIS. Shapefile name: DRM_SEFGrid_2014.

(4) folder 'Grid2014': folder with updated Access database table 'Grid_2014'. Filename: 'grid2014_table.csv'.

(5) file 'drm_sefcri_site_numid_table.csv'. File linking transect ID numbers (site) to the cell ID numbers for the old Grid_2008 table and new Grid_2014 table.

(6) This report provides documentation for the variables and codes for all files in deliverables (1) - (5).

References

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Walker, B.K. 2012. Spatial analyses of benthic habitats to define coral reef ecosystem regions and potential biogeographic boundaries along a latitudinal gradient. *PLoS ONE* 7(1): e30466. doi:10.1371/journal.pone.0030466