Endangered Species Act
Listed Coral Species
Survey and Results

Port Everglades
Navigation Improvements Project

FINAL REPORT

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1.0 INTRODUCTION

Some imperiled coral species in the United States are protected under the *Endangered Species Act of 1973* (ESA), 16 United States Code (USC) 1538(a)(1). Seven Atlantic coral species are listed as threatened under the ESA, under the jurisdiction of the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), 50 Code of Federal Regulations (CFR)Part 17: *Acropora palmata* (elkhorn coral), *Acropora cervicornis* (staghorn coral), *Dendrogyra cylindrus* (pillar coral), *Mycetophyllia ferox* (rough cactus coral), *Orbicella annularis* (lobed star coral), *Orbicella faveolata* (mountainous star coral), *Orbicella franksi* (boulder star coral) (see Figure 1).

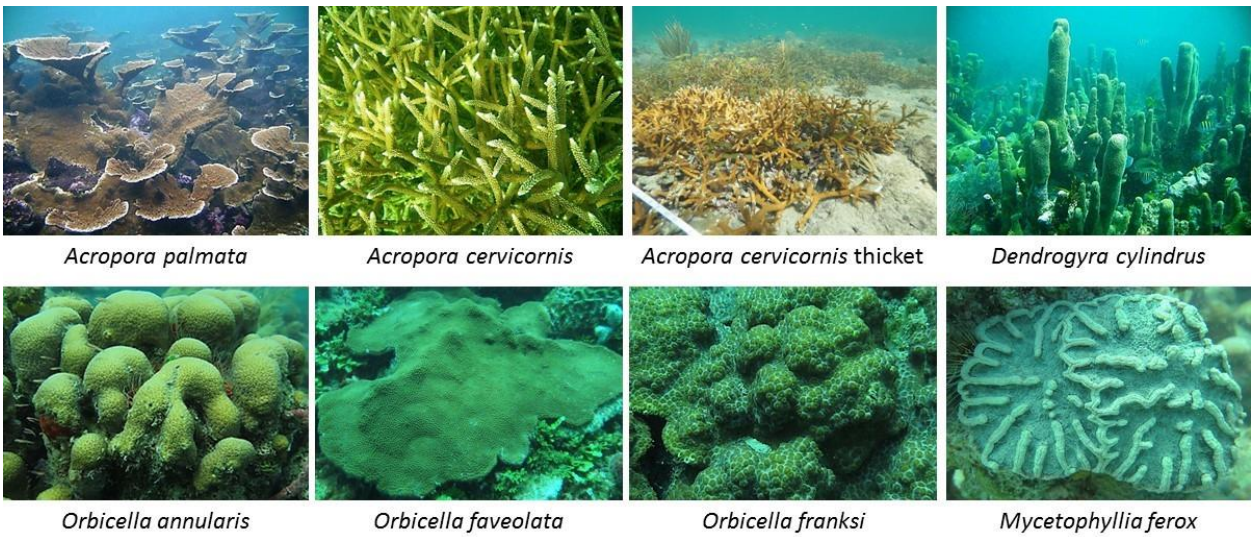

Figure 1. Photographs of Western Atlantic ESA listed Corals. Photos from W.F. Precht, except *A. cervicornis* thicket, taken by Dial Cordy and Associates (DCA).

1.1 ESA Listed Coral Species

Acropora cervicornis is listed as critically endangered by the International Union for Conservation of Nature (IUCN) due to a population reduction exceeding 80% over the last 30 years due to disease, climate change, bleaching, and several other factors (Aronson et al 2008a). *A. cervicornis* has a patchy distribution but can be locally abundant in Miami-Dade, Broward and Palm Beach counties where it has been documented by several authors (D'Antonio 2016, NSU 2011). Previous surveys within the study area documented abundant *A. cervicornis* in the shallow (<7.6 meter (<25 feet (ft)) northwestern portion of the study area on the inner reef (D'Antonio 2016). The nearest sighting of *A. cervicornis* north of the channel (~365 m (1,198 ft)) was documented by Nova Southeastern University (NSU) in 2014 and 2017, when divers documented *A. cervicornis* within the sand bypass study area (SBA) (NSU 2015 and 2017) (Figure 2). The nearest sighting south of the channel (~170 m (558 ft)) was documented by NSU in 2011 (NSU 2011). In 2009 DCA performed an *A. cervicornis* survey of the proposed direct and indirect impact areas of the Port Everglades Navigation Improvements Project (PENIP) using towed video and diver surveys in a survey protocol developed in partnership with the USACE and NMFS (DCA 2010). No *A. cervicornis* colonies were documented within 150 m (492 ft) of the channel of the PENIP (DCA 2010).

Acropora palmata is also listed as critically endangered by the IUCN (Aronson et al. 2008b) but colonies are rare within Southeast Florida reefs, with few colonies documented in Miami-Dade, Broward, and Palm Beach Counties (Vargas-Angel et al. 2003; Precht and Aronson 2004, ABRT 2005). No recent surveys have documented *A. palmata* within the PENIP.

Orbicella faveolata and *Orbicella* annularis, and *Orbicella franksi* are listed as endangered by the IUCN due to a population reduction exceeding 50% over the last 30 years due to disease, climate change, bleaching, and several other factors (Aronson et al 2008c, Aronson et al. 2008d, Aronson et al. 2008e). Previous surveys have identified *O. annuarlis* and *O. faveolata* in the southern portion of the study area (NSU 2011) and all three sibling species of the *O. annularis* species complex (*O. annularis, faveolata*, and *franks*i) were reported from surveys within the PENIP (DCA 2009).

Mycetophyllia ferox is listed as threatened by the IUCN due to dramatic population declines linked to the species' susceptibility to bleaching and disease (Aronson et al. 2008f). *M. ferox* has experienced localized mass mortalities at other locations in the Caribbean as a result of white plague disease (Aronson et al. 2008f). *M. ferox* was documented within the PENIP in 2006 (DCA 2009) and in 2011 (NSU 2011).

Dendrogyra cylindrus is considered a vulnerable species by the IUCN and was noted as being uncommon throughout its range (Aronson et al. 2008g). *D. cylindrus* has suffered approximately 98% regional loss in Southeast Florida associated with the ongoing regional white plague disease event that began in 2014 (Kabay et al. 2017). No *D. cylindrus* have previously been documented in the PENIP although one colony of *D. cylindrus* was noted at Barracuda Reef, which is outside the PENIP, in the summer of 2016 (Milman 2016).

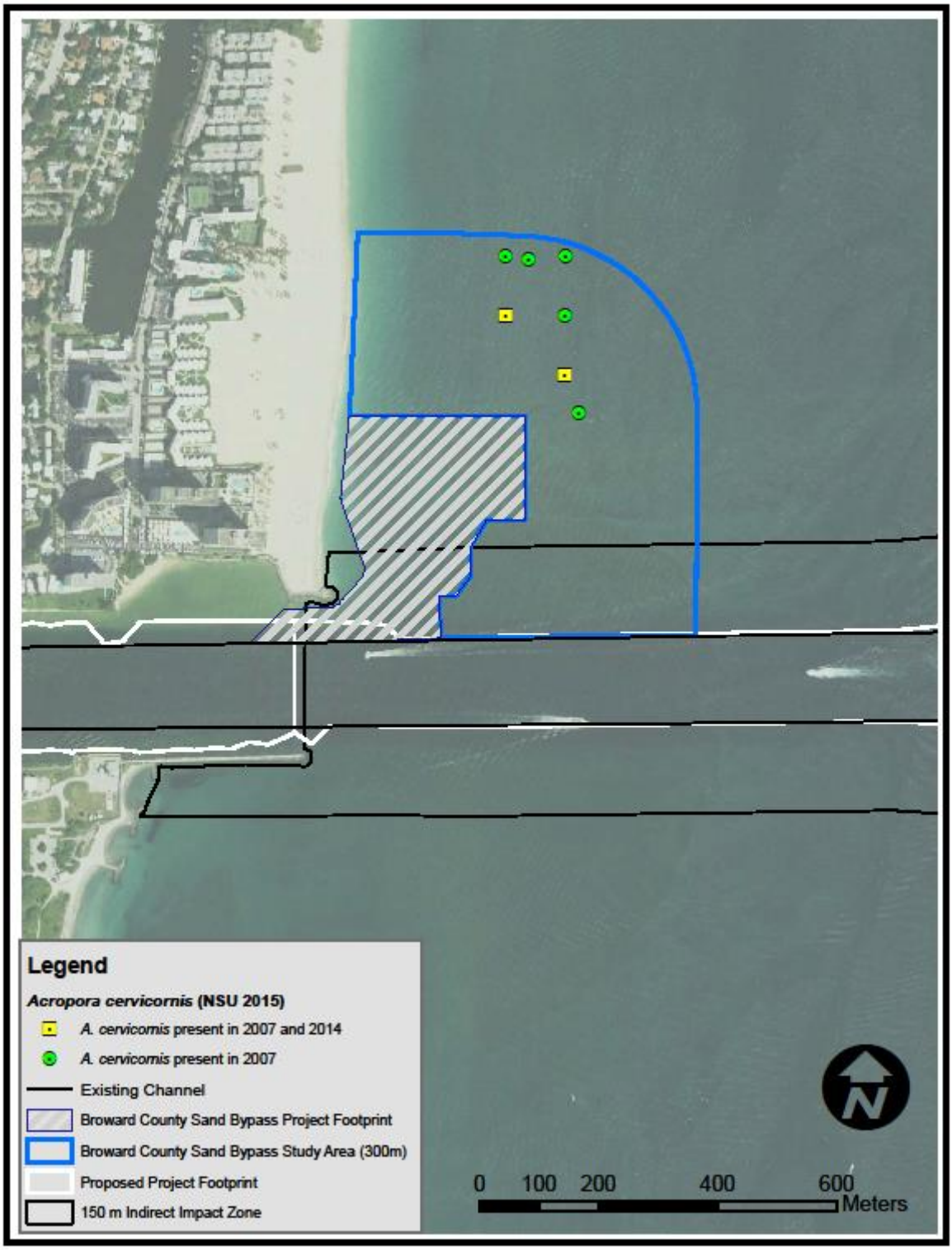

Figure 2. Sand Bypass Project Study Area and Locations of *A. cervicornis*.

The Southeast Florida Coral Reef Tract (SFCRT), where the PENIP is located, contains designated “Critical Habitat for Threatened Elkhorn and Staghorn Corals” which extends from Palm Beach County to Key West (50 CFR Parts 223 and 226). However, the U.S. Naval Surface Warfare Center (NSWC) South Florida Testing Facility “Dania Restricted Access Area (RAA)” (33 CFR 333.550), shown below in Figure 3, is excluded from the designated Critical Habitat. NMFS has not, as of this writing, proposed critical habitat for the remaining five threatened coral species. The SFCRT is also protected under the *Florida Coral Reef Protection Act* (Florida Statute 403.93345).

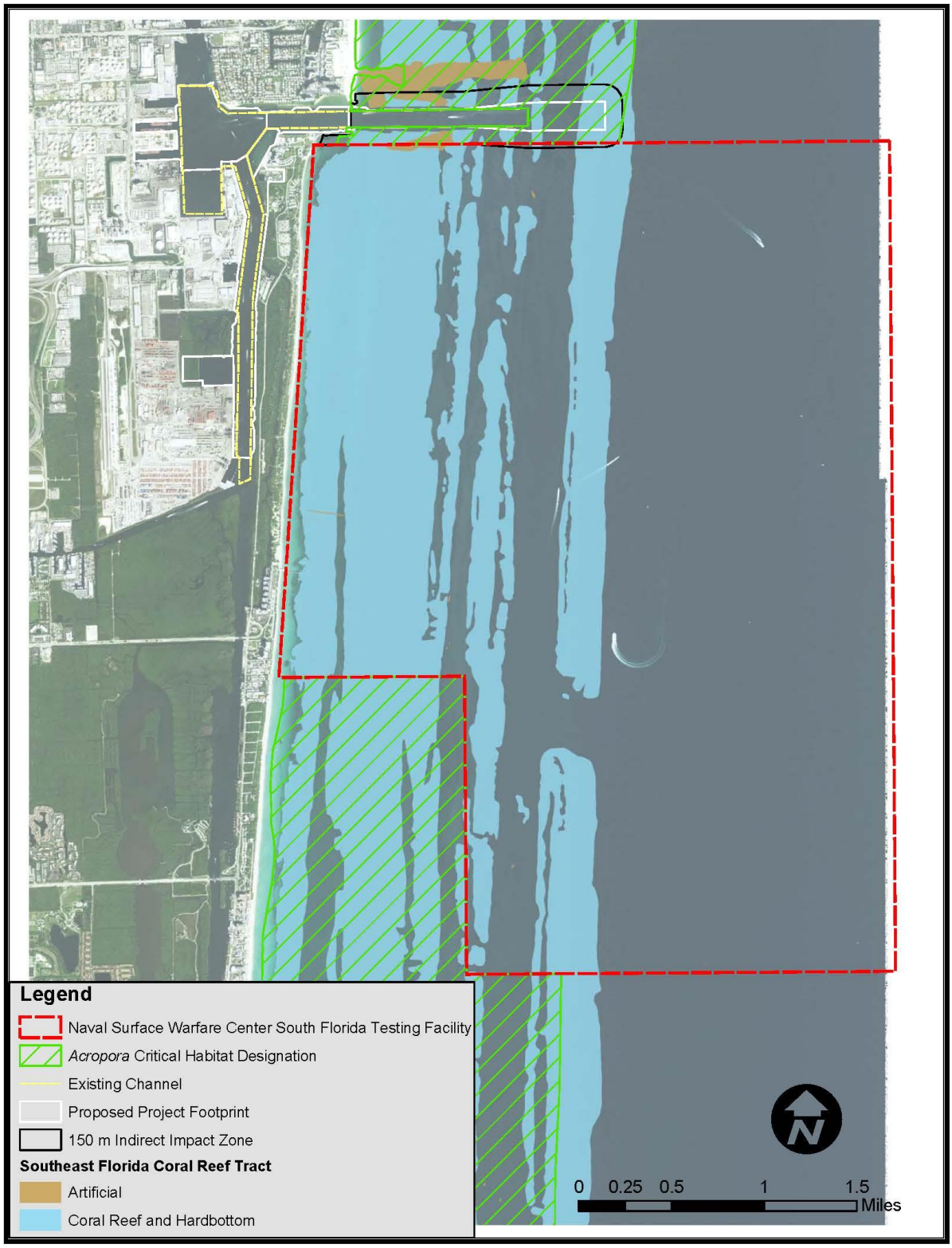

Figure 3. Naval Surface Warfare Center South Florida Testing Facility Area.

1.2 Regional Influences on ESA Listed Coral Species

Following a severe mass bleaching event in 2014 and 2015, a white-plague disease event affected coral populations in Southeast Florida including the PENIP. The white-plague disease affected as many as 15 susceptible coral species with nearly 100% mortality of infected coral colonies, killing as much as 98% of certain species regionally (Precht et al. 2016, 2018, FWC 2016, Bohnsack 2017, FDEP 2017, 2018, Hayes et al. 2017, Kabay et al. 2017, Lunz et al. 2017, USCRTF 2017, Ruzicka 2018). Of the ESA listed species, *O. faveolata, O. annularis,* and *D. cylindrus,* suffered mortality from the coral disease (Walker and Klug 2015, Precht et al. 2016, Kabay et al. 2017). As a result of both bleaching and disease during 2014-2016, estimates of ESA listed corals from the NSU (2011) survey results, are likely an over-estimation of present-day abundance, as the NSU (2011) survey was performed prior to the onset of the regional disease-event.

In addition, Hurricane Irma, crossed the region as a Category 3 hurricane on September 10th, 2017 causing significant injury to benthic habitats and species. The passage of the storm occurred shortly after the completion of all ESA listed coral species surveys, and the full extent of impacts on ESA listed species is unknown. However, a single ESA survey site was revisited after Irma for qualitative comparisons of resources prior to the storm (see Results).

1.3 ESA Listed Coral Species Survey Study Plan

On July 26th, 2016 an Interagency Working Group (IWG) was created to evaluate and minimize potential environmental impacts from the PENIP. The IWG includes representatives from the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), NMFS, Florida Department of Environmental Protection (FDEP), Florida Fish and Wildlife Conservation Commission (FWC), Broward County Environmental Protection and Growth Management Department (EPGMD), and Broward County Port Everglades Department. On March 27th, 2017, the IWG approved the *ESA Listed Coral Species Survey Study Plan* (Appendix A). This plan provided the agreed upon study objectives and survey methods.

On June 13th, 2017, Dial Cordy and Associates (DCA) was contracted by David Miller and Associates (DMA), under contract with the Broward County Port Everglades Department, to implement the *ESA Listed Coral Species Survey Study Plan* (Appendix A) and prepare this report. As noted in the study plan objectives and survey methods, the study area includes hardbottom habitats both adjacent to and within 1050 m (3,445 ft) north and 1020 m (3,346 ft) south of the Port Everglades entrance channel, which includes the proposed direct and indirect impact areas of the PENIP (Appendix A). The majority of the area to the south of the Port Everglades entrance channel was previously surveyed by NSU in 2011. This area was not re-surveyed in the current effort but information from the NSU (2011) report were used to estimate ESA listed coral abundance in the southern portion of the survey area.

As noted in the study objectives, the purpose of the quantitative estimates of ESA listed coral abundance is to provide the necessary information required for the USACE to complete their consultation requirements for the PENIP, under Section 7 of the ESA, by preparing a Biological Assessment for submittal to the NMFS.

2.0 SURVEY METHODS

This survey implemented the project-specific methodology approved by the IWG in the *ESA Listed Coral Species Survey Study Plan* (Appendix A) at 163 sites between June 26th and September 1st, 2017. Figure 4 shows the locations of the 163 sites surveyed. All 163 surveyed sites are denoted by red crosses within a 100 m (328 ft) x 100 m (328 ft) box. Sites that were previously surveyed by NSU in 2011 were denoted by a small numbered cross. The area surveyed within the 163 sites is approximately 12.26 hectares (30.3 ac) of *A. cervicornis* and *A. palmata* critical habitat, covering 7.9% of the total habitat covered by the 163 surveyed sites.

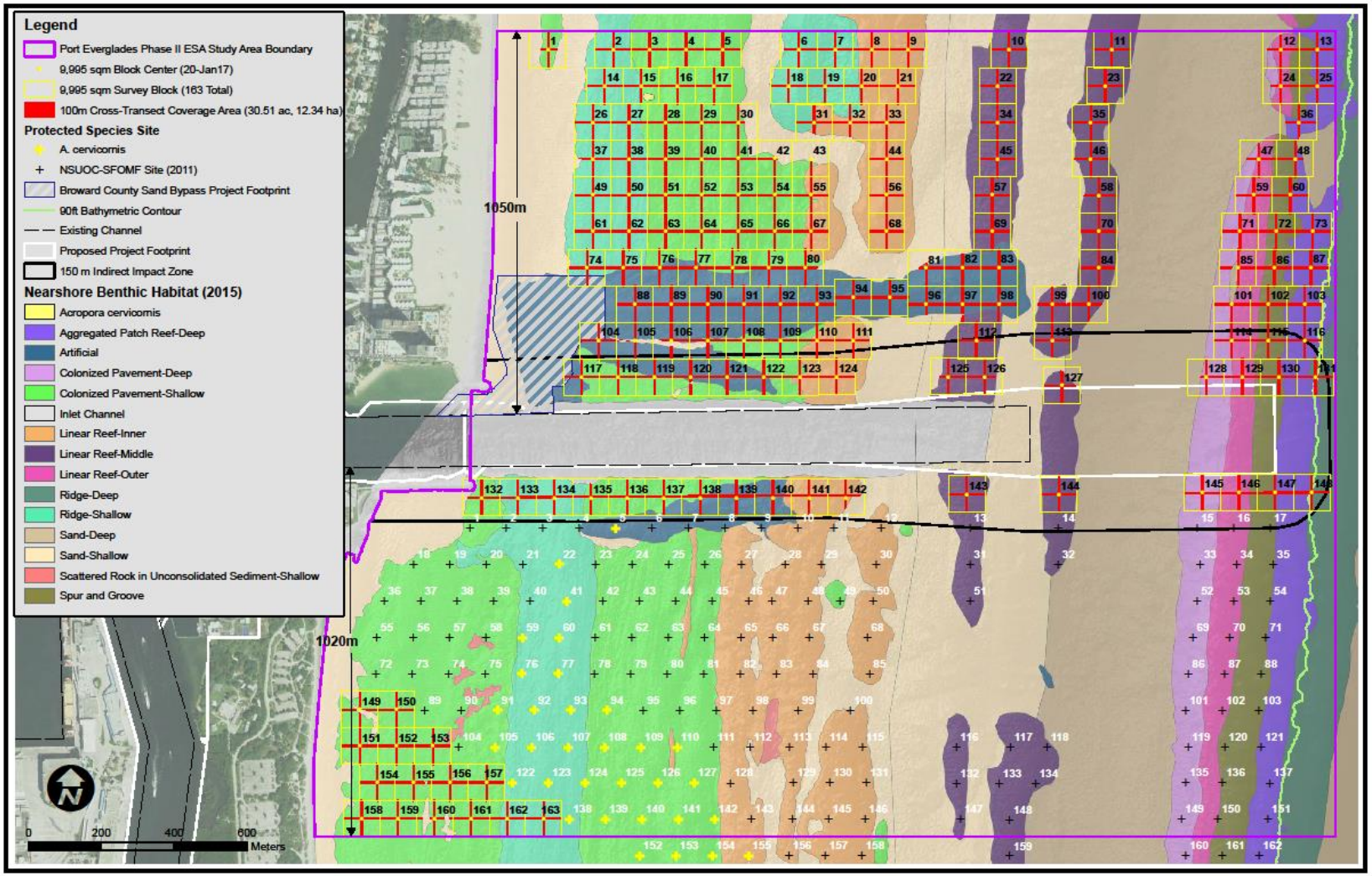

Figure 4. Locations of the 2017 ESA Listed Coral Species Survey Transects

Each of the 163 sites were surveyed using a cross-transect survey design (Figure 5). Each cross site transect was 50 m (164 ft) x 4 m (13 ft) wide and all transects began at the same center point. Within each transect, the position and size of all ESA listed coral species were identified during the surveys. Since each transect had the same origin, the corals within the first 2 m (6.6 ft) near the center of the cross in each direction would potentially be counted twice (Figure 5). Scientific divers coordinated underwater to designate which diver team would survey these areas of overlap so that ESA listed coral colonies were only counted and measured once per site. As a result, the adjusted survey area was 784 m^2 (8,439 sf), (800 m^2 (8,611 sf) – 16 m^2 (172 sf) of overlapping transects) for calculating the number of ESA listed corals per acre (Figure 5).

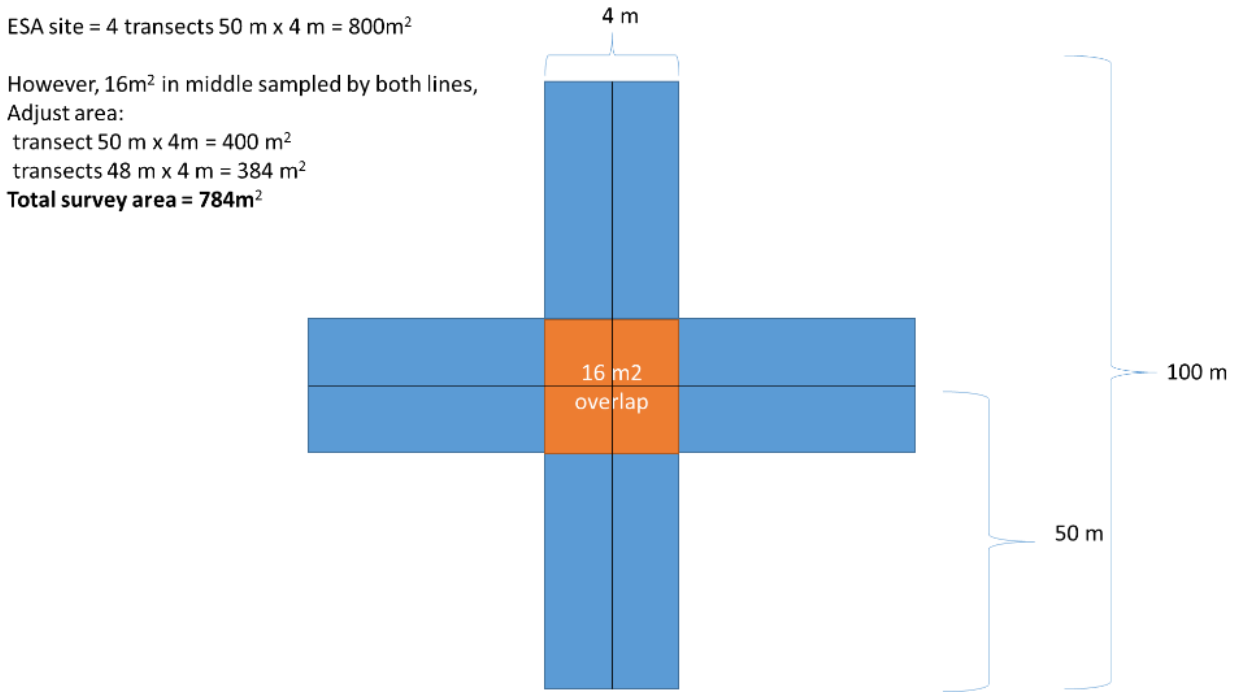

Figure 5. Diagram of 50 m (164 ft) x 50 m (164 ft) Cross Survey Area

Within each cross-survey location, all ESA listed coral species were documented with reference to their:

1. Species;
2. Dimensions of the colony length, height, and width (units = mm) ;
3. Percentage live tissue (recorded in 10% increments);
4. Location of the colony (distance along the transect line, direction of colony off the transect line and perpendicular distance from the transect line).
5. Site map with locations of each colony. The approximate location, based on direction and distance from center point, was mapped. GPS coordinates for each colony were created based on direction and distance from center points.

For the purposes of this report the maximum dimension of the ESA listed coral is the maximum of either the length, height, or width measurements. For *A. cervicornis*, that can exist as isolated individuals, or as part of dense thickets, the coral colony was defined in this study as the skeletal branches of *A. cervicornis* that extend from a common basal attachment to the substrate (Huntington and Miller 2014). Unattached fragments were also counted as individual colonies.

2.1 Extrapolating ESA Listed Species Abundance

2.1.1 2017 ESA Survey

The amount of coral habitat encountered at each survey site was estimated using the Walker and Klug (2014) benthic habitat map, which covers 68.5 kilometer (km) (42.6 mile (mi)) from Key Biscayne to Hillsboro Inlet. The survey was planned to avoid mapped sand and therefore no site boxes were planned in areas of mapped sand habitat (Figure 4).

All site boxes were plotted in NAD 83 Florida State Plane (ft) and were plotted as 100 m (328 ft) side blocks. The conversion of the proposed 100 m side to 328 ft is a rounded estimate; the actual conversion of a 100 m side to feet is 328.084 ft per side. As a result of using the rounded dimension, when converted to m^2, the total maximum area of each site block is 9,995 m^2 (107,585 sf).

Survey-level ESA species density

The amount of coral habitat within each cross-site transect was estimated using the Walker and Klug (2014) benthic habitat map, and any areas of mapped sand habitat were removed from the total m^2 (sf) of habitat (calculation 1).Survey-level estimates of ESA listed species density were calculated by dividing the abundance of ESA listed species surveyed at each cross survey location, by the amount of coral habitat within each cross transect (maximum of 784 m^2 (8,439 sf)) (calculation 2).

1) Coral Habitat per Survey (m^2) = 784 m^2 (total cross transect area) – (X m^2 of mapped sand habitat)

2) Survey-Level Coral Density = Survey Abundance (Number of corals) / (m^2 of Coral Habitat)

Estimation of Site-level ESA species Abundance

Estimates of coral habitat within the site box were based on the Walker and Klug (2014) habitat map and any areas of mapped sand habitat were removed from the total m^2 (sf) of the site (calculation 3). To estimate the total number of corals within the site box, the survey-level species densities were multiplied by the estimated m^2 (sf) of coral habitat within the site box (calculation 4).

3) Coral Habitat per Site (m^2) = 9,995 m^2 (total site area) – X m^2 (mapped sand habitat)

4) Site-Level Coral Abundance = Survey Density (number of corals/m^2) * X m^2 Coral Habitat per Site

The result of the above calculations is an estimate of the number of ESA listed corals within each Site box.

Existing Channel and Unsurveyed Channel Extension Area

Since ESA data were not collected within the existing channel (Figure 4, black line) or within the proposed channel extension (Figure 4, white line) data from nearby surveyed site locations were used as a proxy. For unsurveyed areas within the existing channel, data from the nearest diver-

surveyed cross site were used to estimate species densities. For the unsurveyed area within the proposed channel extension, coral densities from the nearest diver-surveyed cross station located to the north of the channel were used to estimate ESA abundance. This was done in accordance with IWG meeting discussion on October 4, 2016 (Appendix A).

2.1.2 NSU 2011 ESA Survey

Most of the habitat south of the Port Everglades entrance channel was previously surveyed in 2011 for ESA-species abundance (NSU 2011, also Appendix B). A total of 151 sites were sampled during the NSU (2011) survey. The locations of the 151 sites are shown in Figure 4 as small numbered crosses. All members of the IWG agreed to utilize the data from this survey in lieu of conducting a new survey of the area.

The NSU (2011) survey implemented the "Recommended Survey Protocol for *Acropora* spp. In Support of Section 7 Consultation (Revised October 2007) (NMFS 2007)." The survey was a tiered approach, a first pass "Tier 1" survey was performed at each site. During the Tier 1 survey, diver pairs performed a 20 minute timed-swim survey in which all ESA listed species were counted within a 60 m (197 ft) x 60 m (197 ft) area (3,600 m^2 (38,750 sf) surveyed) within the site. If more than five colonies of *A. cervicornis* were documented during a Tier 1 survey, a second pass "Tier 2" survey was performed in which three 50 m (164 ft) x 4 m (13 ft) (600 square meter (m^2) (6455 square feet (sf)) random heading transects were surveyed in which all *A. cervicornis* colonies were counted and measured. The number of *A. cervicornis* colonies counted in the 3,600 m^2 (38,730 sf) Tier 1 survey and *A. cervicornis* densities from the Tier 2 survey were provided in Appendix 2 of the NSU (2011) report (Appendix B).

Tier 2 *A. cervicornis* densities were only determined at a subset of sites; therefore, the Tier 1 abundance information is used in this report in conjunction with the 2017 survey results. Specific counts of ESA listed coral species are only provided for *A. cervicornis* in the NSU (2011) report. Abundance of all other ESA listed coral species was documented as binned abundance information at each Tier 1 site. The bins used were: 1-5 colonies, 6-10 colonies, 11-50 colonies, 51-100 and >100 corals per site (NSU 2011). Site-specific densities were calculated for *A. cervicornis* using the colony counts at each site divided by the estimated survey area. The estimated survey area was calculated by estimating the m^2 (sf) of coral habitat within the 60 m (197 ft) x 60 m (197 ft) box at the center of each survey site where the Tier 1 2011 survey was performed using the Walker and Klug (2014) benthic habitat map. Any sand habitat within the 60 m (197 ft) x 60 m (197 ft) box was subtracted from the 3,600 m^2 (38,750 sf) potential survey area. Sand habitat was excluded using the Walker and Klug (2014) map so calculations of abundance were as consistent as possible between DCA (2017) and NSU (2011) survey data.

Estimates of the amount of coral habitat within the 2011 survey locations and within the 2011 site boxes were made in the same manner as the 2017 surveys, and all sand habitat within these locations as mapped by Walker and Klug (2014) was subtracted from the total survey/site areas. See section 2.1.1 for methods. To estimate the number of *A. cervicornis* within a site box, the species-specific density of *A. cervicornis* documented by NSU (2011) is multiplied by the estimated m^2 (sf) of coral habitat within the site box.

Only binned data were provided for all other ESA listed coral species surveyed by NSU (2011), so to prevent any potential under-estimation of ESA abundance within the PENIP, the maximum bin value of each ESA listed species observed at a given site was used as an estimate of the abundance recorded during the 2011 survey. Site-specific densities were calculated for non- *A.*

cervicornis colonies using the maximum bin value and dividing it by the estimated amount of coral habitat within the survey area. The potential number of non-*A. cervicornis* ESA listed corals within each site was then extrapolated by multiplying the species-specific density by the total amount of coral habitat within the site box (maximum area of 9,995 m^2 (107,585 sf) per site).

2.1.3 Supplemental Non-Surveyed Habitat within the Project Area

The 2017 survey site locations covered approximately 154 hectares (ha) (380 acres (ac)) of habitat and make up approximately 47% of the proposed project habitat area. The NSU (2011) surveys site locations covered approximately 39 hectares (339 ac) of habitat and made up approximately 41% of the proposed project area. However, approximately 39 hectares (97 ac) of habitat (approximately 12% of the total project area) extended beyond the boundaries of the 2017 and NSU (2011) survey site locations. The abundance of ESA listed species associated with the remaining 12% of project habitat were estimated by applying the density of ESA listed species in adjoining surveyed sites to any additional pieces of un-surveyed habitat based on Walker and Klug (2014) maps. Figure 6 shows the small portions of un-surveyed habitat in the supplemental habitat boxes. Coral densities within the direct and indirect impact areas that were not surveyed by divers, were estimated by applying the adjacent northern-site abundance values to the un-surveyed area. This was conducted in accordance with direction provided at the IWG October 4, 2016 meeting.

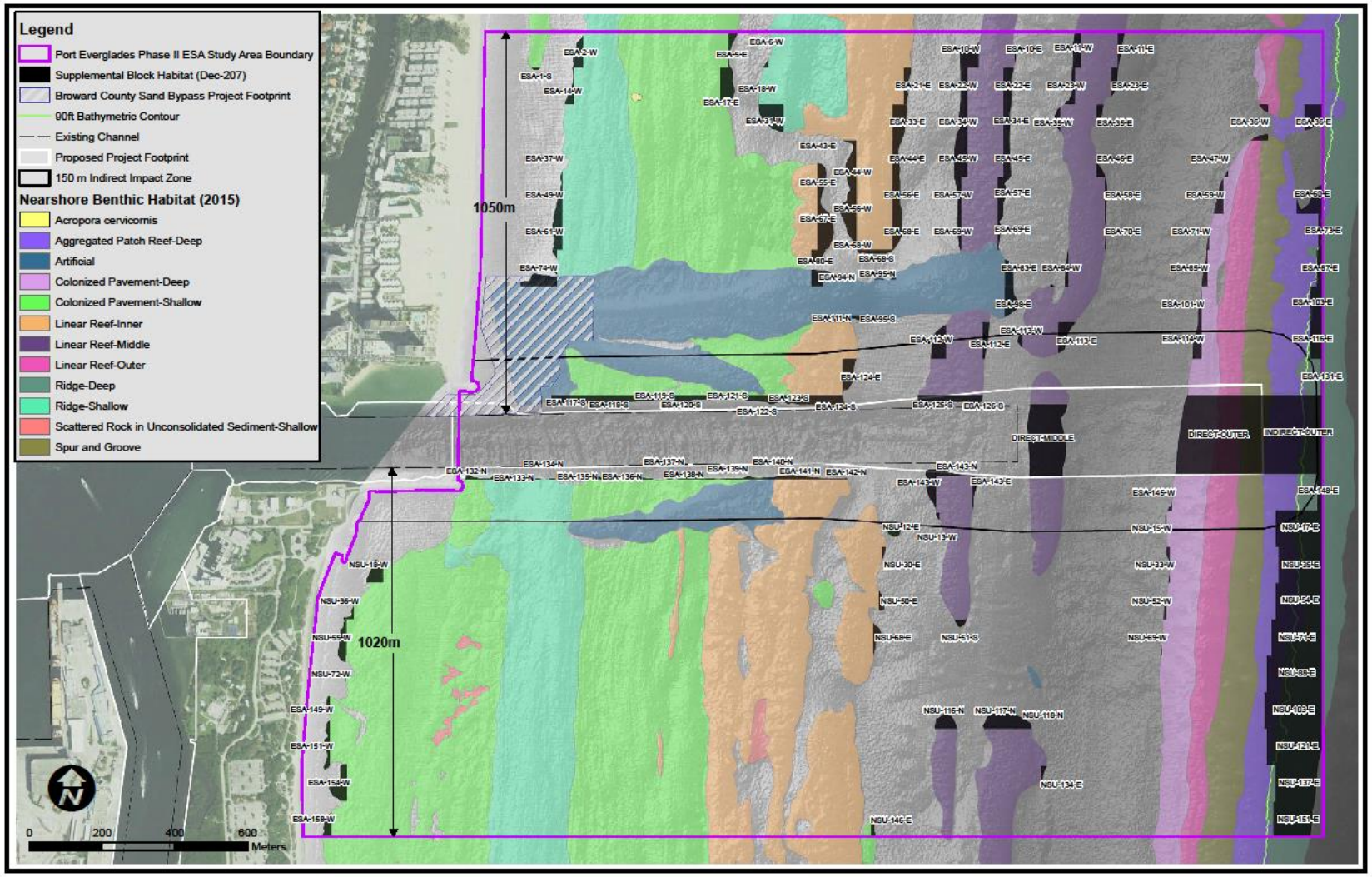

Figure 6. Supplemental Habitat not Surveyed in 2017 and 2011 Surveys.

2.2 Estimating ESA Coral Abundance within the Direct and Indirect Project Areas

To determine the estimated number of ESA listed corals found in either the direct or indirect project areas, the number of corals estimated within each DCA (2017), NSU (2011), or supplemental site areas that were completely within the direct or indirect area boundary were added together. Estimated abundance from DCA (2017), NSU (2011) or supplemental sites that were only partially within either the direct or indirect areas were calculated as the percentage of the site that lies within that area boundary. For example, ESA-129 on the outer reef has an extrapolated value of 51 *O. faveolata* colonies with 27% and 73% within the direct and indirect footprints respectively. As a result, 14 (27%) coral colonies were estimated to lie within the direct impact area and 37 (73%) were estimated within the indirect impact area.

2.3 Measurements of Distance to Channel

The distance of the nearest ESA listed coral colonies are based on a direct line north or south of the existing Port Everglades federal channel toe-of-slope, which marks the navigable channel as opposed to the upper edge of the cut. These distances are reported in Section 3 Results.

2.4 Data Management and Quality Assurance/Quality Control Plan

Training on organism identification was conducted prior to data collection to ensure all scientific divers were collecting data using the same criteria. After *in situ* data collection was completed, scientific divers reviewed their results and discussed issues with other on-site scientific divers. Any questions or concerns with identification or survey issues were forwarded onto the Data Manager for finalization. Underwater data sheets were washed, dried and quality controlled by trained staff, and then data were entered into a Microsoft Excel spreadsheet. Quality Assurance/Quality Control (QA/QC) of data input was conducted by another scientist to ensure accurate data entry for analysis. QA/QC review of coral species identification was performed by the Data Manager to confirm field identifications. Due to the similarity of appearance of *Mycetophllia sp.* all encountered colonies of *Mycetophyllia sp.* were identified and surveyed underwater according to the ESA protocol so that the Data Manager/Coral Biologist could verify the species identification from photographs during the QA/QC process (Figure 7). Since colonies of *Mycetophyllia sp.* are often visually similar, training images and characteristics developed by Atlantic and Gulf Rapid Reef Assessment (AGRRA) were used to help differentiate similar species (AGRRA 2013). In particular, the fact that *M. ferox* septa often intercept each other and cover the entire surface of the colony were useful for species identification. *M. aliciae* tends to have less pronounced septa that do not intersect each other. In addition, the center of the colony is often devoid of septa in *M. aliciae* (Figure 7). If photographs were insufficient to delineate species verification of *Mycetophyllia sp.* in the office, the in-water identification by the diver was used. Only verified colonies of *M. ferox* were entered into excel files for data analysis. Raw data and photos were provided to Broward County Port Everglades Department on October 17th, 2017 for all ESA surveyed sites. All raw data were made available to members of the IWG via mailed external hard drives in November 2017.

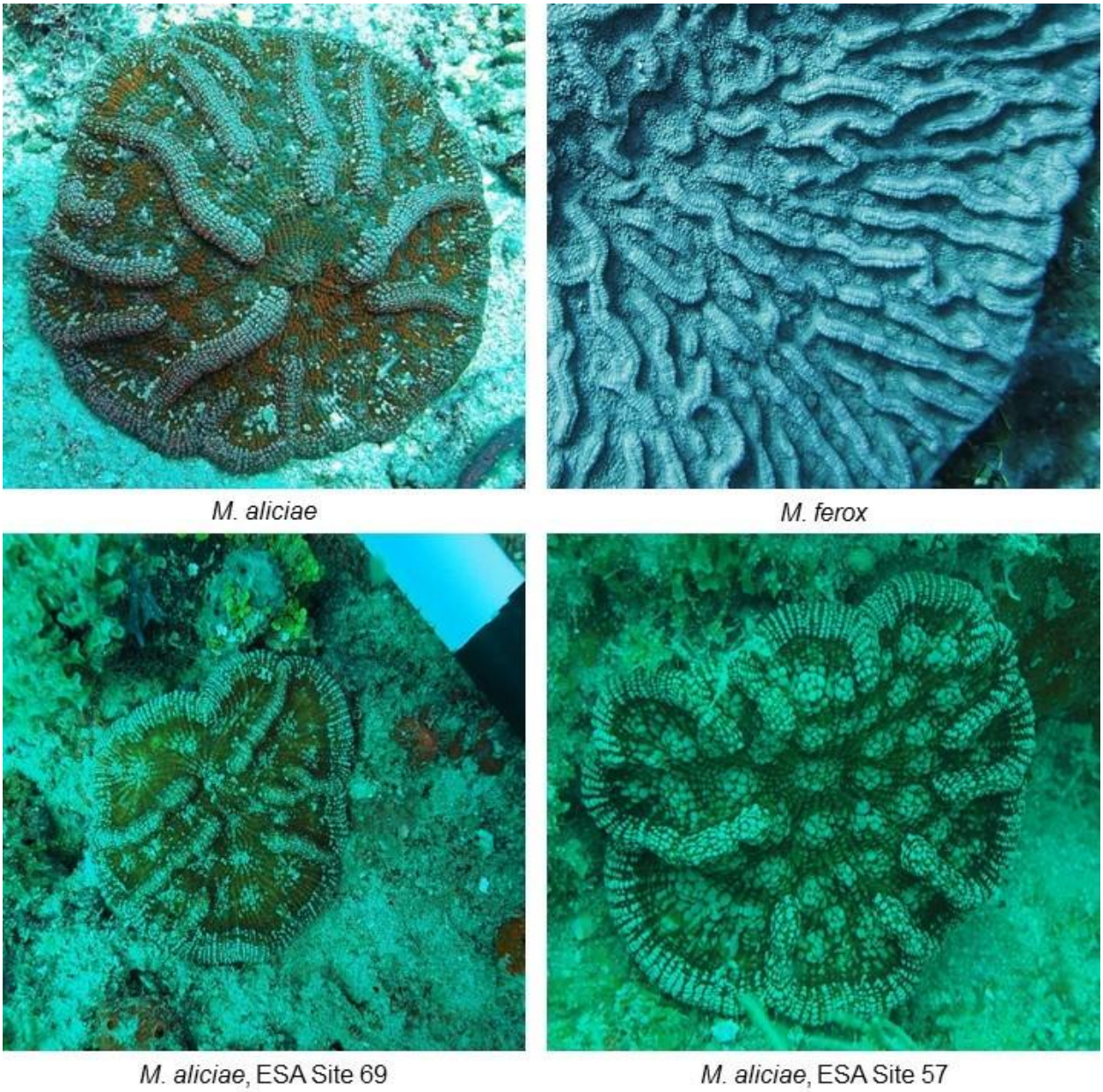

Figure 7. Examples of *M. aliciae* and *M. ferox.* Top images taken by W. F. Precht, bottom images by DCA.

2.6 Post-Hurricane Irma Visit

Site 26 was chosen as a potentially informative site to visit after Hurricane Irma, since it was one of the sites with greatest abundance of *A. cervicornis*. The ESA survey protocol was not followed at this location as this site was re-visited to provide a qualitative comparison of resources following the passage of Hurricane Irma. Data collected included colony location, size (L x H x W), and percent live tissue for select corals. Photographs were used to match colonies between time periods. Comparisons were made and reported in Section 3.4.

3.0 RESULTS

3.1 2017 Survey Results

A total of 3,624 colonies of ESA listed coral species were surveyed within the 163 sites. Of the colonies surveyed, 3,597 (99%) were *A. cervicornis* colonies and 45 (1%) were *O. faveolata* (Appendix C). No other ESA listed coral species were identified within the 163 sites surveyed. A table of the sites surveyed and the numbers of corals of each ESA listed species that were surveyed at each site are provided in Appendix C. Out of 163 surveyed sites, ESA listed species were documented at 57 sites (35%), 35 of the 57 sites (21%) contained *A. cervicornis* colonies, 24 sites (15%) contained *O. faveolata* colonies, and 2 sites (1%) contained both *A. cervicornis* and *O. faveolata* (Table 1 and 2). The mean maximum dimension, and mean percent live tissue, are also provided for each survey site (Appendix C).

The precise location of all ESA listed coral colonies were mapped within each of the 163 survey sites. Mapped locations of all surveyed colonies are provided in Appendix D. An example map of colony locations within a study site is provided below (Figure 8). Maps of all 57 sites in which ESA listed species found are provided in Appendix E.

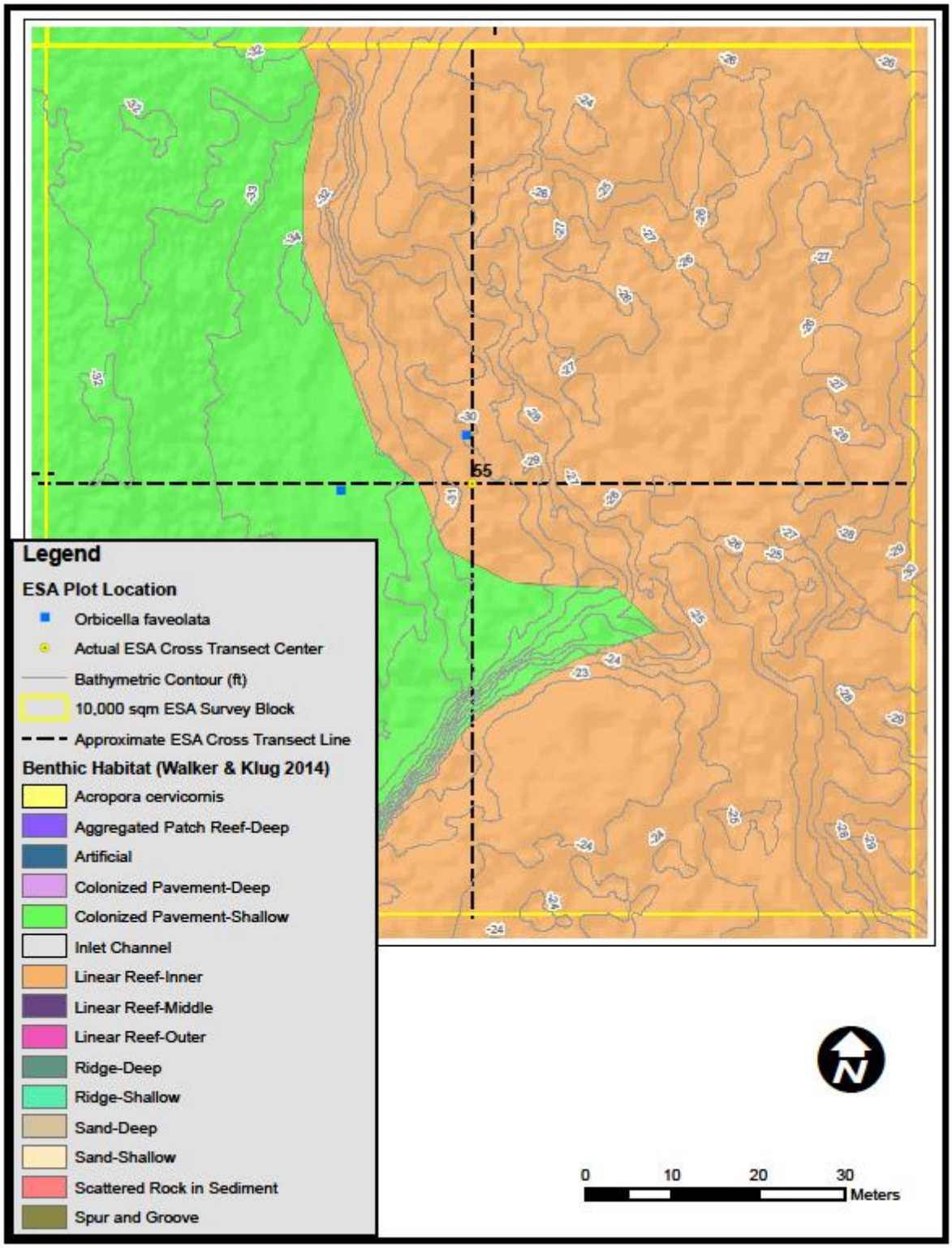

Figure 8. Locations of Two *O. faveolata* Colonies at Site 55.

3.1.1 *Acropora cervicornis*

A total of 12.3 hectares (30.3 ac) of designated "Critical Habitat for Threatened Elkhorn and Staghorn Corals" were surveyed in the DCA (2017) survey of 163 site locations. As noted above, *A. cervicornis* was the most abundant ESA listed coral species. Very little of the direct impact area of the PENIP was surveyed by divers due to safety concerns, however, no *A. cervicornis* were found within the 2017 survey locations within the indirect impact area (Figure 9). The closest *A. cervicornis* to the Port Everglades entrance channel documented in the 2017 survey was located approximately 460 m (1,509 ft) north of the channel at Site 61 (Figure 9). The nearest *A. cervicornis* documented south of the channel in the 2017 survey was located approximately 820 m (2,690 ft) south at Site 151.

Smallest and largest colonies per site are reported below in Table 1, in centimeters (cm) as well as inches (in). *A. cervicornis* colonies ranged in size across sites. The smallest colony of *A. cervicornis* was documented at ESA Site 18 and the largest colony documented was 900 centimeter (cm) (354 inch (in)) at Site 26 (site with highest *A. cervicornis* abundance) (Table 1). Mean percent live tissue ranged from 26% at Site 5 to 100% at Site 29 (Site 29 had only 1 *A. cervicornis* colony) (Table 1). Average colony size ranged from 12.1 cm at Site 158 to 57.1 cm at Site 15.

The distribution of *A. cervicornis* was highly clumped with all 3,579 colonies located within 35 survey sites (21.5% of all surveyed sites). In addition, colony abundance within those sites was greater than 1, at all but 4 surveyed site locations (Table 1). Abundance was highest at Site 26, where 753 corals were documented during the ESA survey (Figure 9).

Table 1. 2017 Survey *A. cervicornis* Colony Counts and Sizes. Average measurements are presented with +/- one standard error (SE).

ESA Site	*A. cervicornis* (N)	Area surveyed (m^2)	Smallest Colony (cm)	Smallest Colony (in)	Largest Colony (cm)	Largest Colony (in)	Avg. Colony Size (cm)	SE	Avg. Colony Size (in)	SE	Average % Live Tissue	SE
2	55	784	5	2.0	110.0	43.3	27.9	2.9	11.0	1.1	62	4.2
3	50	784	4.8	1.9	90.2	35.5	29.4	2.5	11.6	1.0	79.8	3.1
4	58	784	10	3.9	122.0	48.0	36.9	2.6	14.5	1.0	54	4.1
5	5	784	5.8	2.3	90.6	35.7	55.2	15.0	21.7	5.9	26	10.3
6	37	742	8	3.1	125.0	49.2	35.2	3.8	13.9	1.5	85.4	2.6
7	4	784	12	4.7	28.0	11.0	21.5	3.5	8.5	1.4	100	0
14	156	784	3	1.2	196.0	77.2	34.0	2.1	13.4	0.8	70.2	2
15	236	784	4.8	1.9	480.0	189.0	57.1	3.4	22.5	1.3	48.6	1.7
16	541	784	4	1.6	147.0	57.9	32.3	0.9	12.7	0.4	63.8	1.2
17	38	784	7.5	3.0	157.0	61.8	39.5	5.0	15.6	2.0	60.5	4.6
18	191	784	2	0.8	270.0	106.3	35.5	2.0	14.0	0.8	66	1.9
19	49	784	8	3.1	134.0	52.8	39.3	4.0	15.5	1.6	82.2	3.1
20	4	784	28	11.0	37.0	14.6	31.8	2.3	12.5	0.9	55	21
26	753	767	4	1.6	900.0	354.3	49.2	2.6	19.4	1.0	60.8	1
27	621	784	2.4	0.9	300.0	118.1	28.8	1.0	11.3	0.4	67.1	1.1
28	79	784	9	3.5	96.0	37.8	28.3	1.8	11.1	0.7	74.1	3
29	1	784	18	7.1	18.0	7.1	18.0	0.0	7.1	0.0	100	0
37	35	714	5	2.0	56.0	22.0	21.2	2.2	8.3	0.9	76.5	4.4
38	10	784	7	2.8	49.5	19.5	21.2	4.0	8.3	1.6	76	7.3
41	1	784	38.7	15.2	38.7	15.2	38.7	0.0	15.2	0.0	40	0
49	175	784	4	1.6	150.0	59.1	33.9	2.0	13.3	0.8	73	2
50	32	784	10	3.9	97.0	38.2	32.6	2.9	12.8	1.1	65.9	5.1
51	39	784	10	3.9	72.0	28.3	29.1	2.2	11.5	0.9	63.8	4.1
61	99	784	3	1.2	170.0	66.9	34.4	2.9	13.5	1.1	70.3	2.2
62	37	784	6.6	2.6	74.0	29.1	24.2	2.4	9.5	0.9	61.4	5.1
151	1	784	14.4	5.7	14.4	5.7	14.4	0.0	5.7	0.0	90	0
155	3	727	13	5.1	25.6	10.1	18.5	3.7	7.3	1.5	56.7	13.3
156	10	784	4	1.6	51.0	20.1	21.0	5.2	8.3	2.0	78	10.2
157	2	784	21.2	8.3	25.6	10.1	23.4	2.2	9.2	0.9	80	10
158	1	784	12.1	4.8	12.1	4.8	12.1	0.0	4.8	0.0	80	0
159	11	784	5	2.0	32.4	12.8	15.4	2.6	6.1	1.0	78.2	8.7
160	15	626	11.8	4.6	42.8	16.9	23.1	2.2	9.1	0.9	69.3	6.9
161	14	784	9.4	3.7	46.6	18.3	23.3	3.2	9.2	1.3	57.1	9.5
162	106	784	3	1.2	63.4	25.0	24.4	1.1	9.6	0.4	58.9	2.8
163	110	784	3	1.2	60.0	23.6	24.5	1.3	9.6	0.5	62.7	2.8
Totals	**3579**	**27096**										

Table 2. 2017 Survey *O. faveolata* Colony Counts and Sizes. Average measurements are presented with +/- one standard error (SE).

ESA Site	*O. faveolata* (N)	Area surveyed (m^2)	Smallest Colony (cm)	Smallest Colony (in)	Largest Colony (cm)	Largest Colony (in)	Avg. Colony Size (cm)	SE	Avg. Colony Size (in)	SE	Avg. % Live Tissue	SE
7	2	784	96	37.8	104.0	40.9	100.0	4.0	39.4	1.6	50	40
9	3	742	19	7.5	35.0	13.8	27.7	4.7	10.9	1.9	80	20
12	2	677	40.5	15.9	47.0	18.5	43.8	3.3	17.2	1.3	50	10
17	4	784	22.5	8.9	66.8	26.3	42.2	9.5	16.6	3.7	82.3	14
31	3	700	17.1	6.7	39.5	15.6	27.6	6.5	10.9	2.6	93.3	3.3
32	2	734	59.5	23.4	110.5	43.5	85.0	25.5	33.5	10.0	70	0
36	1	688	16.5	6.5	16.5	6.5	16.5	0.0	6.5	0.0	100	0
48	1	660	31	12.2	31.0	12.2	31.0	0.0	12.2	0.0	100	0
55	2	784	6	2.4	42.3	16.7	24.2	18.2	9.5	7.2	85	15
59	3	784	27.2	10.7	39.5	15.6	31.6	4.0	12.4	1.6	93.3	3.3
71	1	784	23	9.1	23.0	9.1	23.0	0.0	9.1	0.0	90	0
72	1	784	40.2	15.8	40.2	15.8	40.2	0.0	15.8	0.0	100	0
85	2	625	25	9.8	62.0	24.4	43.5	18.5	17.1	7.3	85	15
86	1	784	49.8	19.6	49.8	19.6	49.8	0.0	19.6	0.0	99	0
87	2	784	30.1	11.9	55.0	21.7	42.6	12.5	16.8	4.9	60	0
101	2	557	32	12.6	155.0	61.0	93.5	61.5	36.8	24.2	55	45
114	2	784	15	5.9	29.0	11.4	22.0	7.0	8.7	2.8	75	25
115	2	784	35	13.8	45.0	17.7	40.0	5.0	15.7	2.0	25	15
128	1	636	85.4	33.6	85.4	33.6	85.4	0.0	33.6	0.0	10	0
129	4	784	24	9.4	43.0	16.9	36.3	4.5	14.3	1.8	85	9.6
140	1	784	42	16.5	42.0	16.5	42.0	0.0	16.5	0.0	10	0
141	1	784	61	24.0	61.0	24.0	61.0	0.0	24.0	0.0	70	0
142	1	640	12.4	4.9	12.4	4.9	12.4	0.0	4.9	0.0	100	0
144	1	750	14.2	5.6	14.2	5.6	14.2	0.0	5.6	0.0	99	0
Totals	**45**	**17601**										

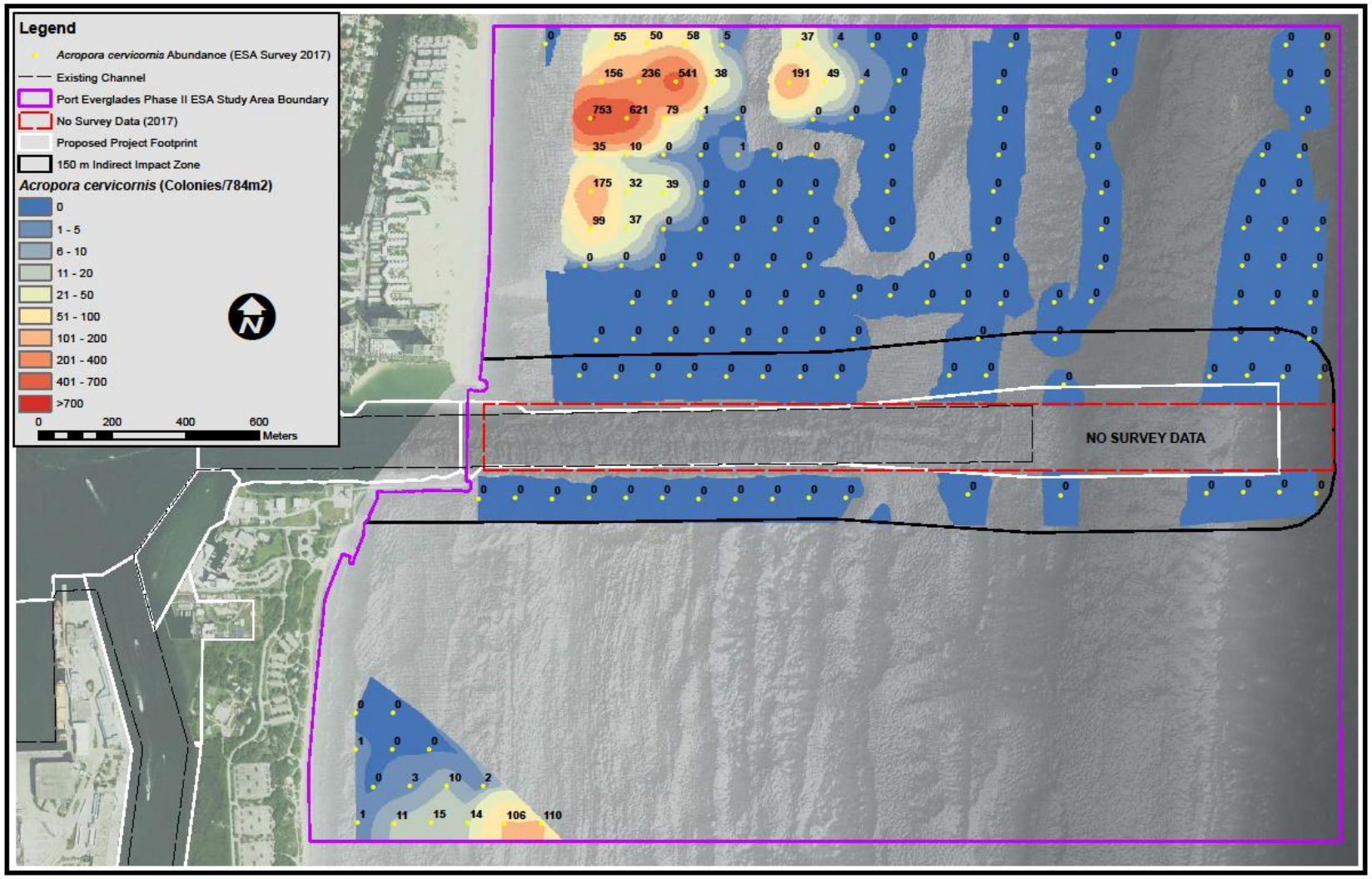

Figure 9. Map of *A. cervicornis* Colonies Documented in 2017.

3.1.2 *Orbicella faveolata*

A total of 45 colonies of *O. faveolata* were identified within 26 survey sites (16%; Table 2). The distribution of *O. faveolata* was greatest on the outer reef habitat, although colonies were found within most surveyed habitats. None of the survey sites had greater than 4 colonies per 784 m^2 (8,439 sf; Table 2). No *O. faveolata* were located within the surveyed portions of the direct impact area, but 13 were found within the indirect area on the middle and outer reef (Figure 10).

Within the 163 sites surveyed in 2017, the maximum dimension of *O.faveolata* at each survey site ranged from 12.4 cm (4.88 in) at Site 142, to 155 cm (61 in) at Site 101. Mean percent live tissue ranged from 10% at Sites 128 and 140 to 100% at Sites 36, 48, 72, and 148 (Table 2).

3.2 Estimated Abundance of ESA Listed Species within the Project Area

The species-specific survey counts (DCA 2017) and survey estimates based on binned data (NSU 2011) for each of the sites within the project area are provided in Appendix F. In addition, the m^2 (sf) of habitat surveyed, and estimated m^2 (sf) of habitat within each site are also provided in Appendix F. Site-specific ESA listed coral densities used to estimate ESA coral abundance are provided in Appendix F in corals per hectare (acre). The amount of habitat found in supplemental sites not covered by the DCA (2017) or the NSU (2011) surveys are provided in Appendix G along with information about which adjacent site was used for abundance estimation purposes. Estimates of species-specific abundance of ESA listed coral species within the project area are discussed below and include estimates of the DCA (2017), NSU (2011) and all supplemental survey areas within the proposed project area.

3.2.1 *Acropora cervicornis*

The NSU (2011) survey of 151 sites recorded 1,675 *A. cervicornis*. Surveyed densities of *A. cervicornis* were extrapolated to each site for both the DCA (2017) and NSU (2011) surveys and the estimated *A. cervicornis* abundance for the entire project area is shown in Figure 11. The abundance of *A. cervicornis* within sites surveyed by DCA in 2017 was estimated to be 45,258 colonies, and the abundance within the sites surveyed by NSU in 2011 was estimated to be 4,653 corals (Figure 11). When the supplemental areas beyond the DCA and NSU surveys are included in the calculation of *A. cervicornis* abundance, the total estimate is 51,002 colonies within the proposed project area (49,912 colonies are estimated within the habitat surveyed by DCA (2017) and NSU (2011) and 1,090 are estimated in supplemental survey areas). The large variability in estimates of *A. cervicornis* between surveys is likely a result of the patchy distribution of the species (D'Antonio, 2016), differing sampling methods used in the surveys (see also Miller et al. 2013), and the dynamic nature of *A. cervicornis* colonies in time and space (Walker et al. 2012, Walker 2017).

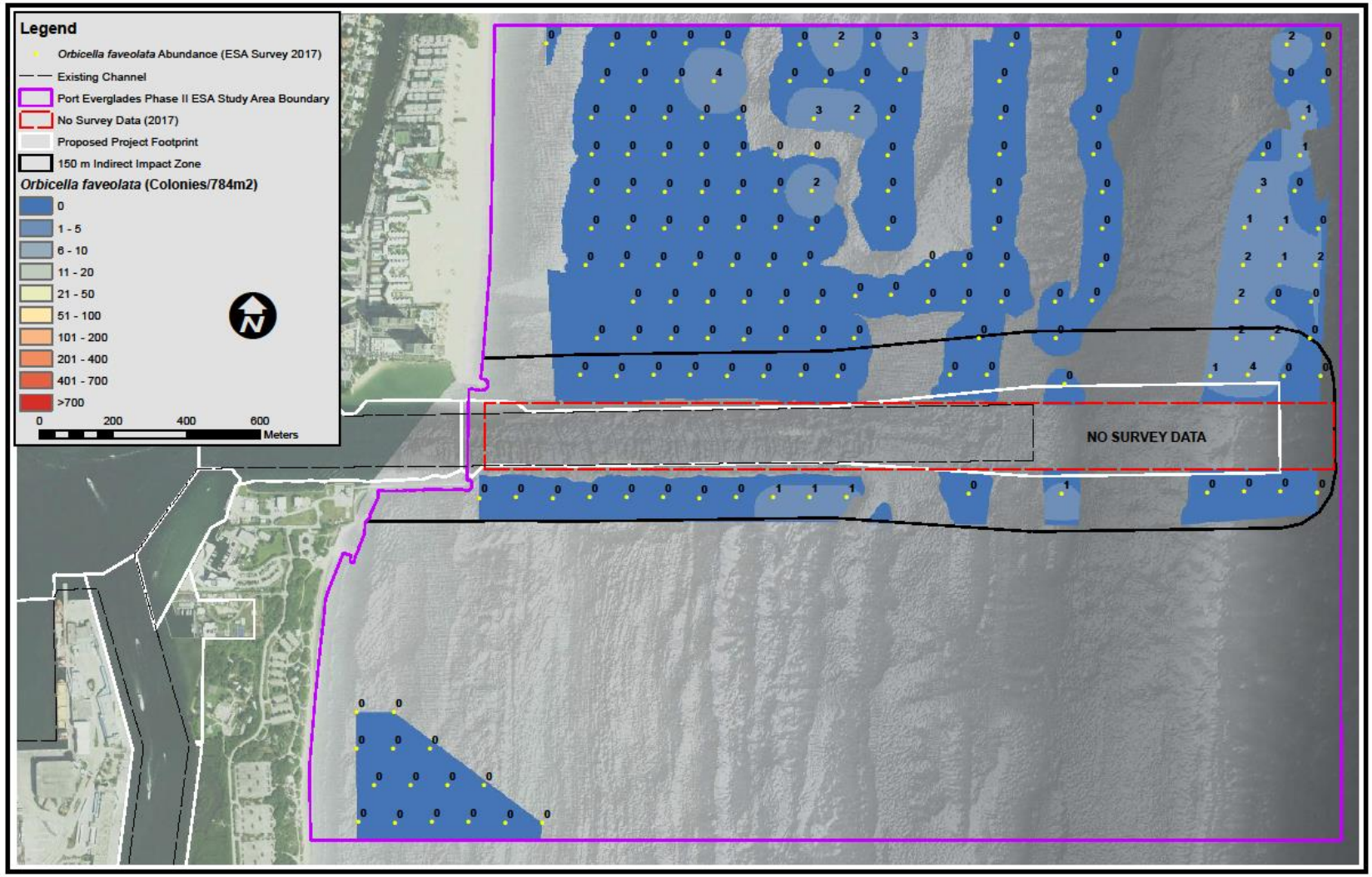

Figure 10. Map of *O. faveolata* Colonies Documented in 2017.

Despite a large population of *A. cervicornis* within the proposed project area, no colonies of *A. cervicornis* were observed in either the DCA 2017 or NSU 2011 surveys within the indirect project areas, and the number of colonies estimated within this area was zero (Figure 11). The documentation of the local population of *A. cervicornis* outside the direct and indirect project areas is consistent with other published reports of *A. cervicornis* within the proposed project area. NSU, in a 2012 mapping effort, documented a large area of *A. cervicornis* approximately 850 m (2,789 ft) north of the channel that were also documented as part of the current survey (NSU 2012). DCA 2017 surveys also documented *A. cervicornis* closer at approximately 460 m (1,509 ft) to the north of the channel.

In 2011, NSU documented a single *A. cervicornis* colony south of the Port Everglades entrance channel. The colony was 170 m (558 ft) from the channel, just outside of the indirect impact area. This is the closest documented location of an *A. cervicornis* colony with regards to the Port Everglades entrance channel to date. DCA (2017) and NSU (2011) both documented thickets of *A. cervicornis* approximately 820 m (2,690 ft) south of the channel and other mapping efforts of ESA species have mapped large thickets of *A. cervicornis a*pproximately 2040 m (6,693 ft) south of the Port Everglades entrance channel (NSU 2011).

The distribution of *A. cervicornis* was highly clumped both north and south of the Port Everglades entrance channel. Sites of solitary *A. cervicornis* were rare and dense thickets of *A. cervicornis* were noted at several sites both to the north and to the south. The spatial clustering of *A. cervicornis* was previously documented by D'Antonio et al. (2016); see also Walker et al. (2012) in which significant spatial clustering of the species was noted along ridge crests within the reef habitat. In the current project area, abundance of *A. cervicornis* has also been constrained to the first (inner) reef habitat because no *A. cervicornis* were documented in the middle or outer reef habitat in either this survey, the NSU 2011 survey, or the DCA 2010 survey (see Figure 4 for habitat location information). Note, similar results were observed during Reconnaissance Surveys (DCA 2018).

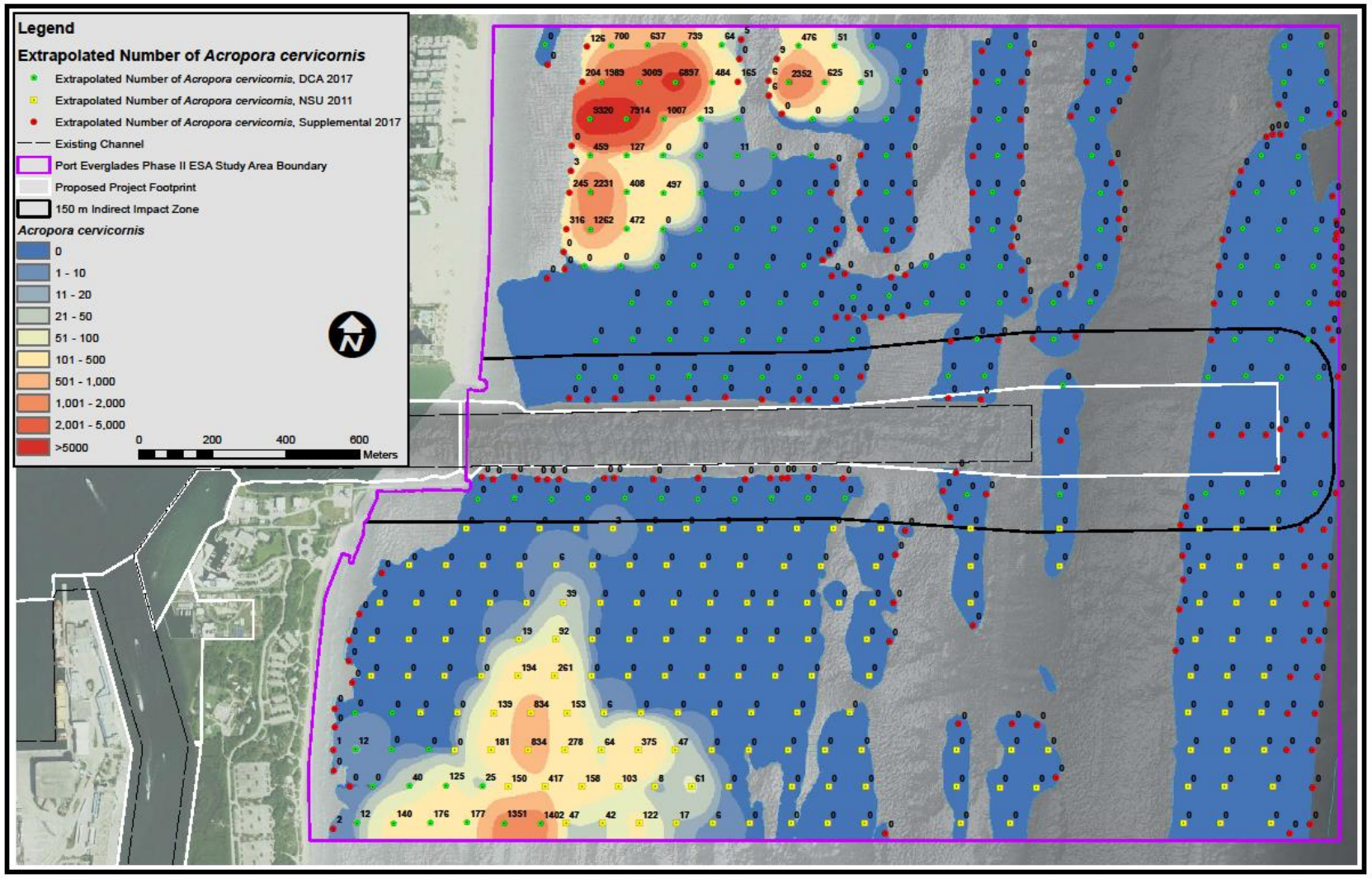

Figure 11. Map of Extrapolated *Acropora cervicornis* Abundance within the Proposed Project Area.

3.2.2 *Orbicella faveolata*

O. faveolata was the only other ESA listed species documented in the 163 sites surveyed by DCA (2017). A total of 45 colonies of *O. faveolata* were found within 26 survey site locations (28% of all surveyed sites, Figure 12, Table 2). Only binned abundance data were reported in the NSU (2011) report and as a result only the maximum bin data were used as estimates for site-specific abundance at the 151 southern sites surveyed in 2011. Eighty three (83) survey sites (55% of sites surveyed) were documented in the NSU (2011) survey with at least one *O. faveolata* colony. Sixty seven sites had between one and five coral colonies, ten sites had between six and ten colonies, and six sites had between eleven and fifty colonies within the NSU (2011) surveyed sites (Appendix B). *O. faveolata* was documented during Reconnaissance Surveys as well (DCA 2018).

Surveyed densities of *O. faveolata* were extrapolated to each site for both the DCA (2017) and NSU (2011) surveys and the estimated *O. faveolata* abundance is shown in Figure 12. *O. faveolata* abundance within the 163 sites surveyed by DCA in 2017 was estimated to be 567 colonies. *O. faveolata* abundance within the 151 sites surveyed by NSU in 2011 was estimated to be 1,893 colonies (Figure 10). When the supplemental areas beyond the DCA and NSU surveys are included in the calculation, the total estimated *O. faveolata* abundance is 2,743 colonies (2,460 colonies are estimated within the habitat surveyed by DCA (2017) and NSU (2011) and 286 are estimated in supplemental survey areas).

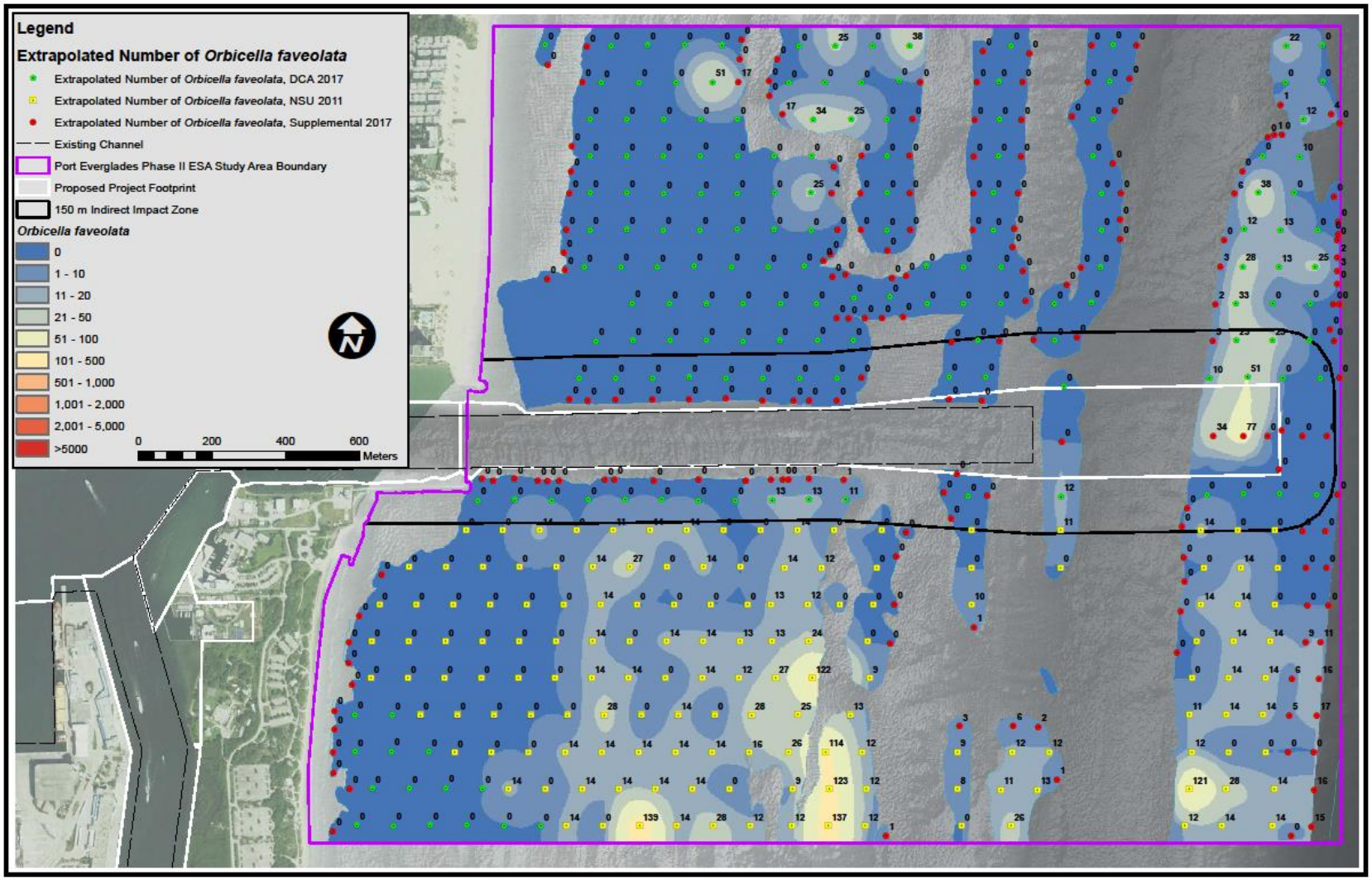

Figure 12. Map of Extrapolated *O. faveolata* Abundance within the Proposed Project Area.

3.2.3 *Orbicella annularis*

No *O. annularis* were documented in 2017. In addition, no *O. annularis* colonies were documented within sites located in the direct or indirect project areas from the NSU (2011) survey. Ten survey sites (6.6% of NSU sites surveyed) were documented with at least one *O. annularis* colony in the NSU (2011) survey. All ten sites had between one and five colonies within the 3,600 m^2 (38,750 sf) surveyed. The Reconnaissance Survey documented only a single colony of *O. annularis* in 2017 (DCA 2018).

Surveyed densities of *O. annularis* were extrapolated to each site (Figure 13). When the supplemental areas beyond the DCA and NSU surveys were included in the calculation, the total estimated *O. annularis* abundance was 149 colonies (132 colonies are estimated within the habitat surveyed by NSU (2011) and 17 were estimated in supplemental survey areas) (Figure 13).

3.2.4 *Orbicella franksi*

No *O. franksi* were documented in 2017. Six survey sites (4% of NSU sites surveyed) were documented in the NSU (2011) survey with at least one *O. franksi* colony. All six sites had between one and five coral colonies within the surveyed sites. Also see Reconnaissance Survey results (DCA 2018).

Surveyed densities of *O. fransksi* were extrapolated to each site (Figure 14). When the supplemental areas beyond the NSU surveys are included in the calculation, the total estimated *O. franksi* abundance was 98 colonies (81 colonies are estimated within the habitat surveyed by NSU (2011) and 17 are estimated in supplemental survey areas) (Figure 14).

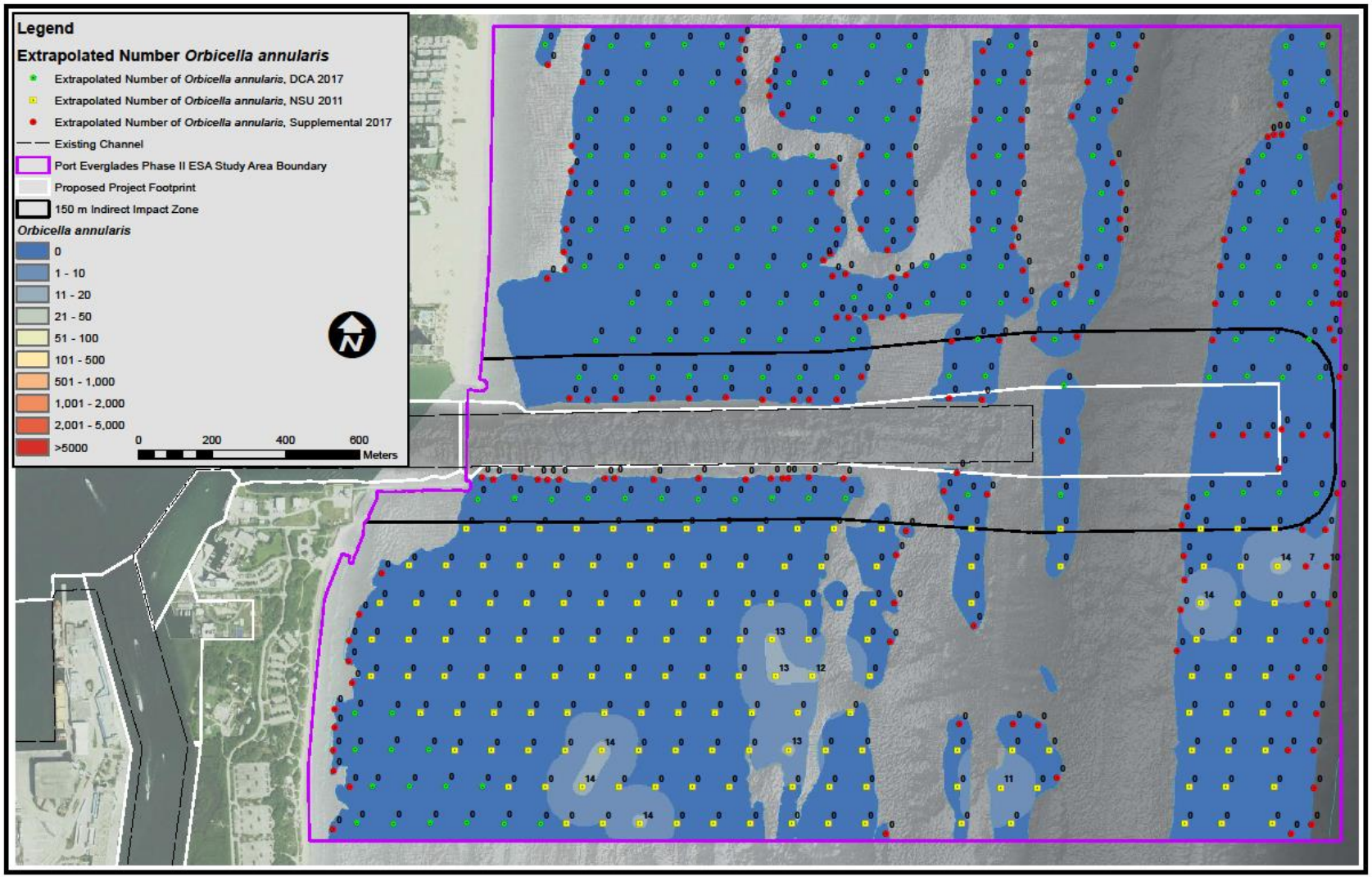

Figure 13. Map of Extrapolated *O. annularis* Abundance within the Proposed Project Area.

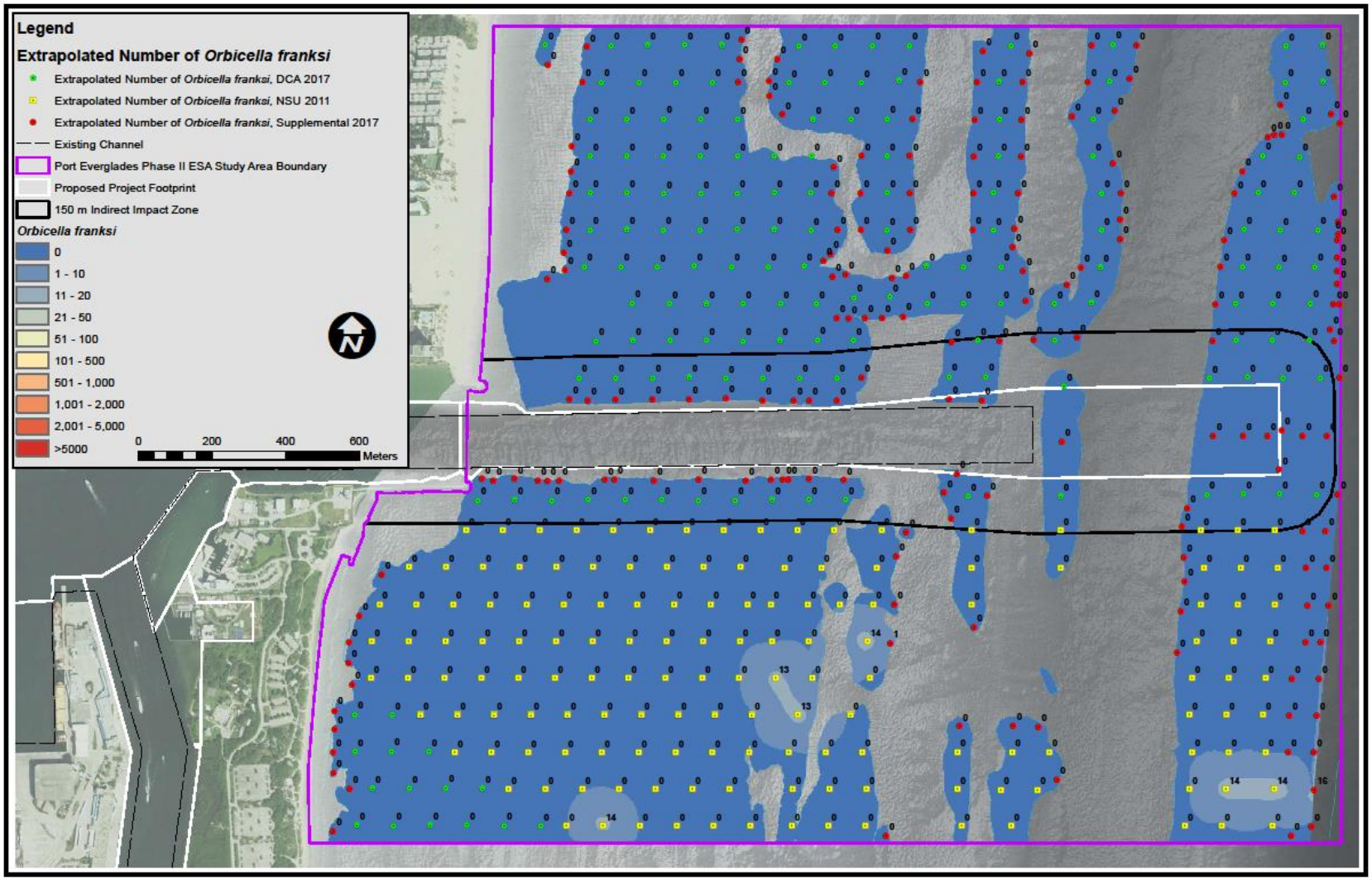

Figure 14. Map of Extrapolated *O. franksi* Abundance within the Proposed Project Area.

3.2.5 *Mycetophyllia ferox*

No *M. ferox* were documented in 2017. Binned abundance data were reported in the NSU (2011) report and maximum bin data were used as estimates for site-specific abundance of *M. ferox* at the 151 southern sites surveyed in 2011. Four survey sites (2.6% of NSU sites surveyed) were documented with at least one *M. ferox* colony (NSU 2011). All four sites had between one and five coral colonies per site (NSU 2011). In 2017, no *M. ferox* were observed during Reconnaissance Surveys (DCA 2018).

Surveyed densities of *M. ferox* were extrapolated to each site as shown in Figure 15. When the supplemental areas beyond the NSU surveys are included in the calculation, the total estimated *M. ferox* abundance was 48 colonies (45 colonies were estimated within the habitat surveyed by NSU (2011) and three were estimated in supplemental survey areas) (Figure 15).

3.2.6 *Dendrogyra cylindrus*

No colonies of *D. cylindrus* were documented in either the DCA (2017) or the NSU (2011) ESA surveys. However, the *Guardian* newspaper (Milman 2016) reported that a colony of *D. cylindrus* was sighted near the Port Everglades by “Project Baseline” at Barracuda Reef. This colony is one of the colonies being monitored by the State (Kabay et al. 2017).

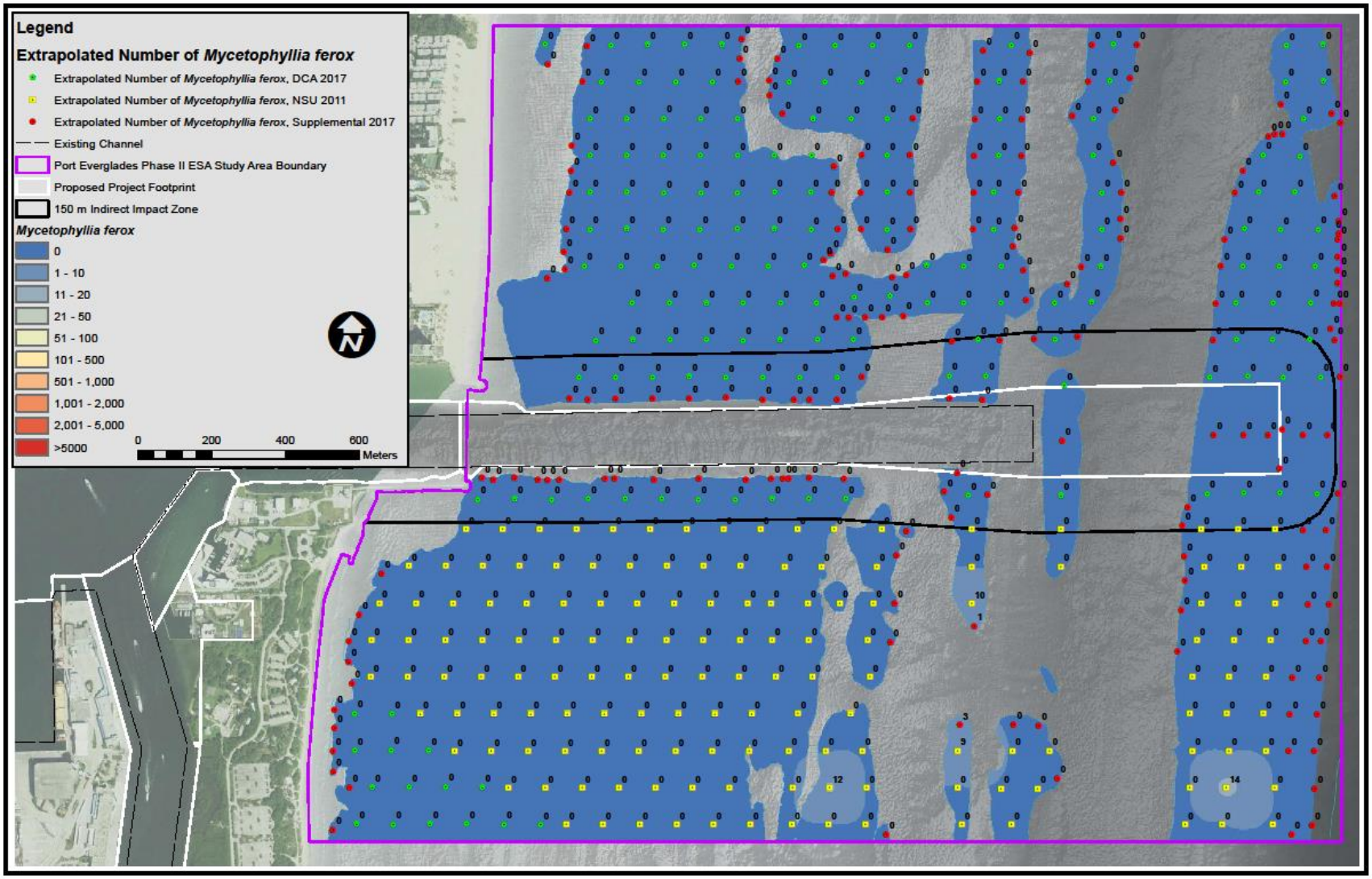

Figure 15. Map of Extrapolated *Mycetophyllia ferox* Abundance within the Proposed Project Area.

3.3 Estimated Abundance of ESA Listed Species within the Project Areas

The total estimated ESA listed species abundance within the proposed project area is shown in Figure 16. The only ESA listed species that were estimated to be located within the direct or indirect project areas (within 150m of the channel) were *O. faveolata* (Figure 17). All other ESA listed corals surveyed occurred outside the 150 m (492 ft) indirect area boundary (Figures 11-15). The estimated abundance within the direct and indirect areas are based on the DCA (2017) and NSU (2011) survey data. It is possible that additional ESA listed species are present beyond the areas surveyed by DCA (2017) and NSU (2011); however, these are likely rare occurrences or are spatially clustered in un-sampled areas.

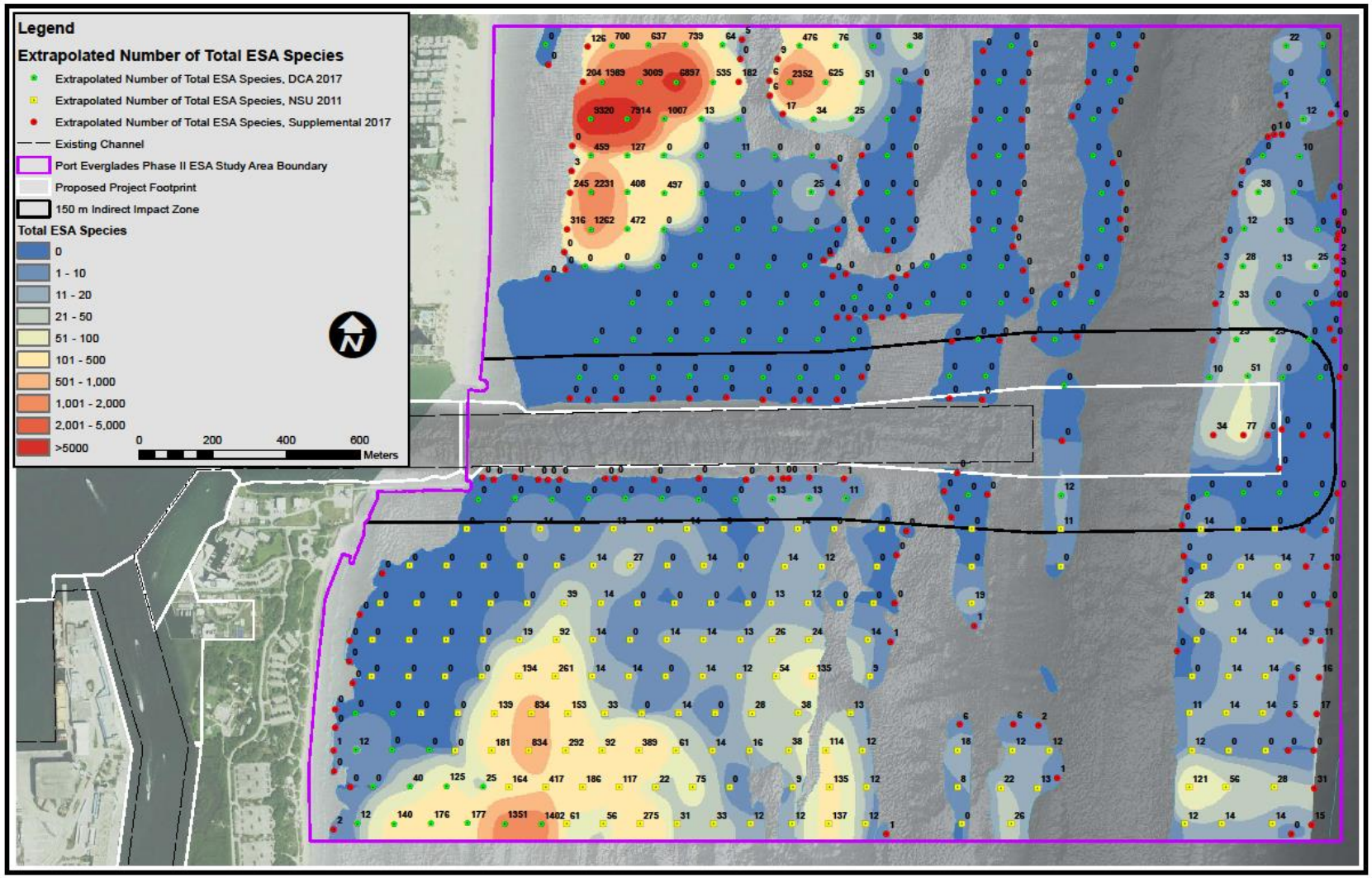

Figure 16. Map of Extrapolated Total ESA listed Species Abundance within the Proposed Project Area.

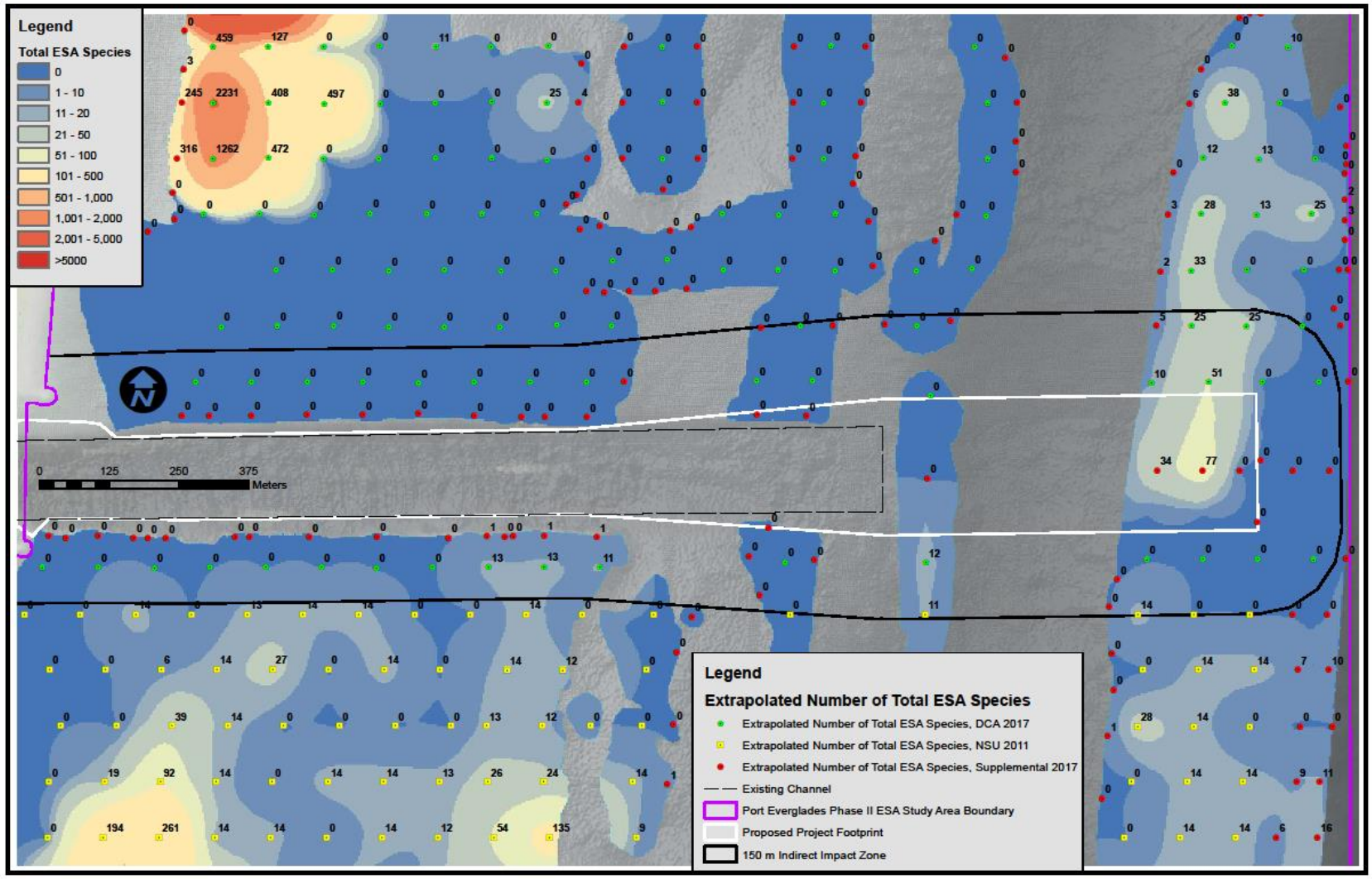

Figure 17. Close-up Map of ESA listed Species within the 150 m of the PENIP.

The total number of *O. faveolata* estimated within the direct and indirect project areas by habitat are shown in Table 3 and include abundance within habitat surveyed by DCA (2017), NSU (2011) and supplemental habitat. Within the direct project area the total abundance of *O. faveolata* is an estimated 128 colonies (Table 3). Within the indirect project area the total abundance of *O. faveolata* is an estimated 171 coral colonies. The total estimated abundance of *O. faveolata* within the direct and indirect project areas is 299 coral colonies.

Table 3. Estimates of *O. faveolata* within the Direct and Indirect Project Areas.

Project Area	Habitat	Estimated *O. faveolata* colonies
Direct	Outer Reef	128
Direct Project Area Total		**128**
Indirect	Inner Reef	59
Indirect	Middle Reef	19
Indirect	Outer Reef	93
Indirect Project Area Total		**171**
Estimated ESA corals in Direct or Indirect project areas		**299**

3.4 Potential Effects of Hurricane Irma on *Acropora cervicornis*

On September 10th, 2017 Hurricane Irma, a strong Category 3 storm, crossed the South Florida peninsula bringing strong onshore winds and waves to the Southeast Florida coast. Preliminary observations of reef habitats in Broward County showed damage to the reef, including corals, octocorals, sponges, and algae. In addition, large volumes of reef sediments were displaced. The "white" visual characteristics of the fine-grained carbonate sediments that were placed in suspension by the passage of the storm are clearly visible in the pre- and post-storm images (Figure 18). The reef landscape was altered by the redistributing of bottom sediments, macroalgae and other benthic organisms.

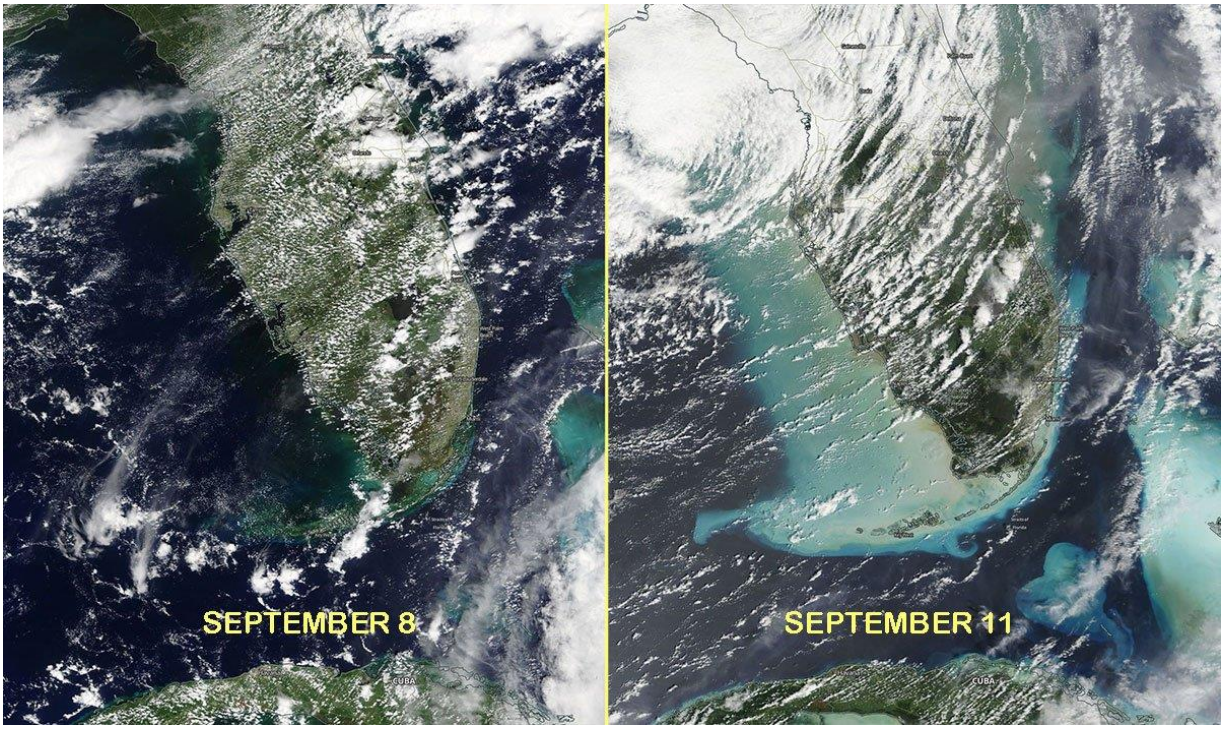

Figure 18. Satellite Images of Florida on September 8th and Post-Hurricane Irma on September 11th.

Maximum winds at Port Everglades were recorded as 84 mph on September 10, 2017 (NDBC 2017). Turbidity recorded by YSI sondes in the project vicinity was 99 Nephelometric Turbidity Unit (NTU) at the nearshore sonde, and 193 NTU at the offshore sonde, peaking on September 10 (nearshore) and September 11 (offshore) (Figure 19-21). Turbidity recorded in the pre-storm period at these locations ranged from 3-7 NTU in the nearshore and was usually between one and two NTU offshore, indicating a substantial storm effect on turbidity at the level of the reef.

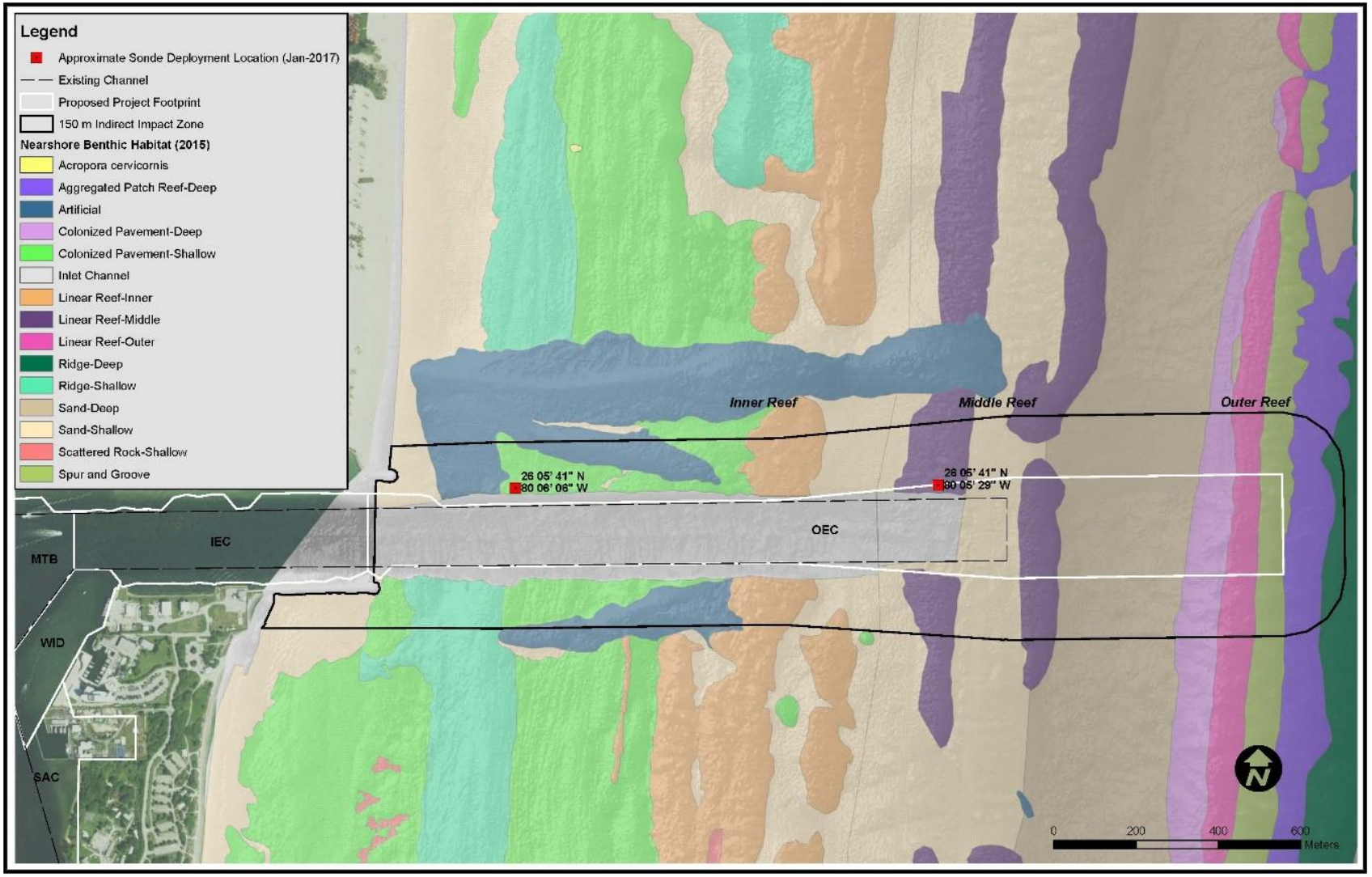

Figure 19. Turbidity Monitoring Stations.

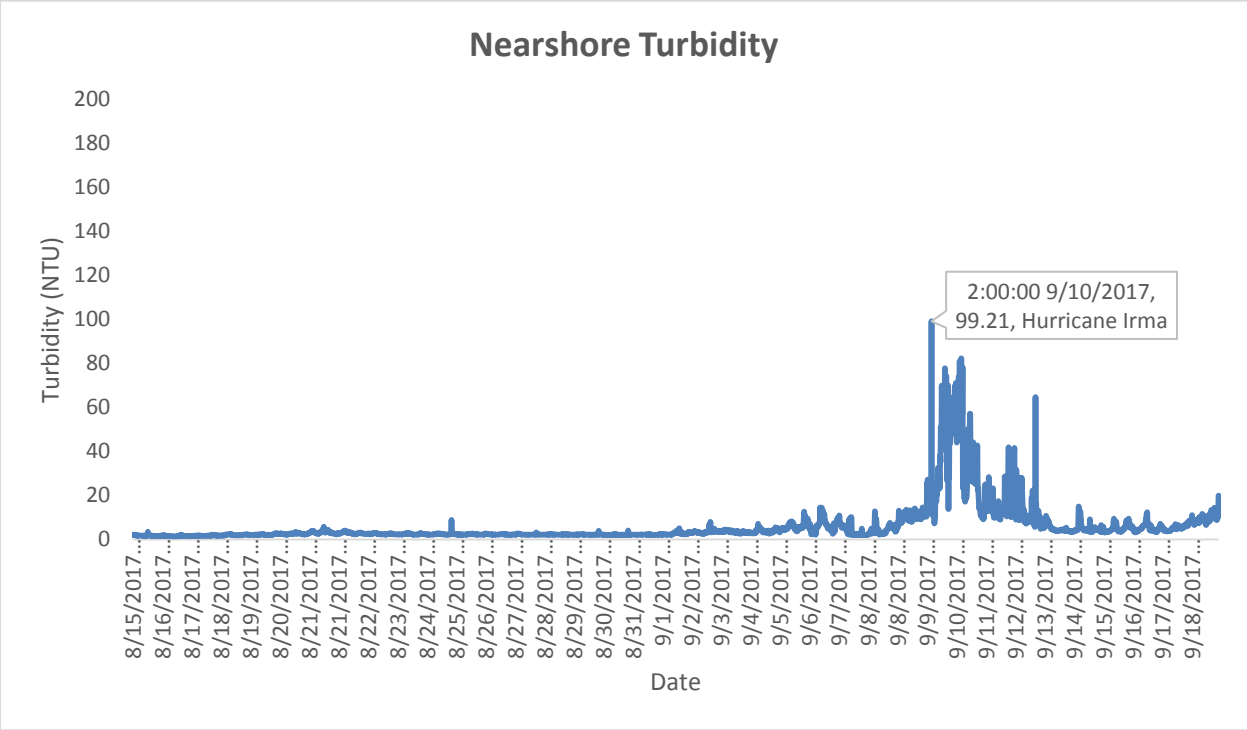

Figure 20. Nearshore Turbidity August-September, 2017.

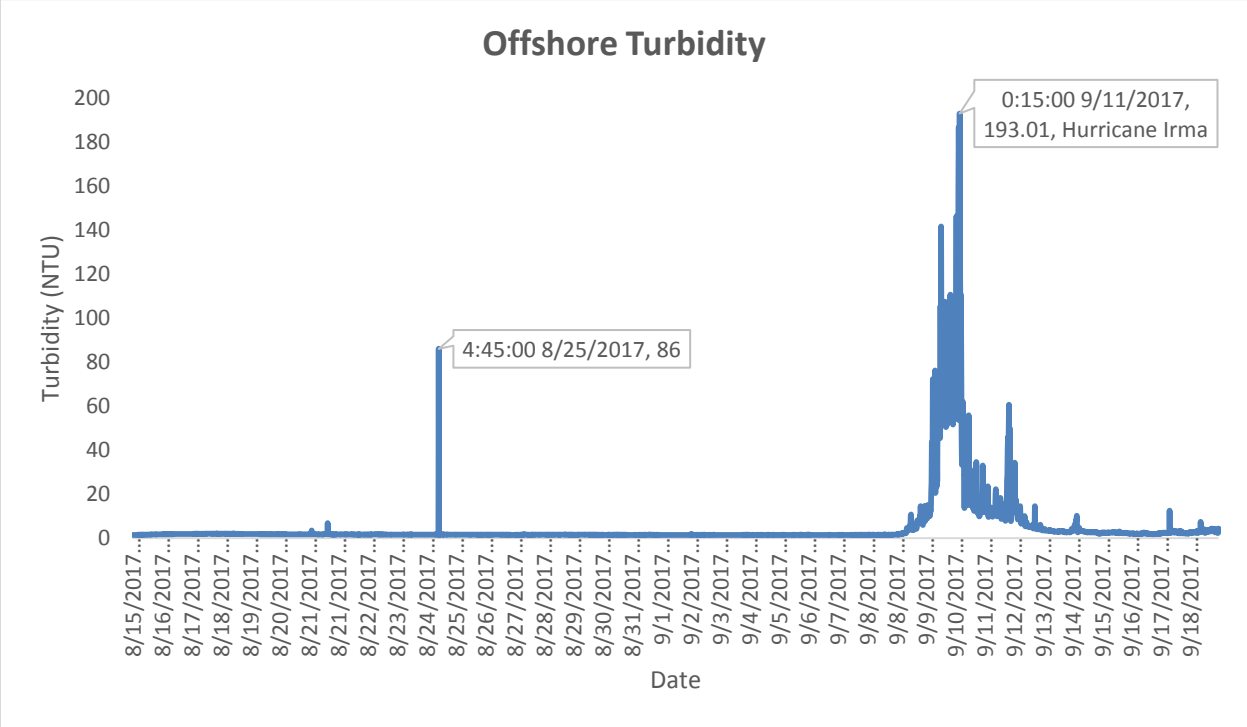

Figure 21. Offshore Turbidity August-September, 2017.

Post-hurricane in water surveys revealed removal of all macroalgae, physical damage to corals, octocorals, sponges, rubble in storm deposits and displacement of sand on the reefs near Port Everglades (Figure 22).

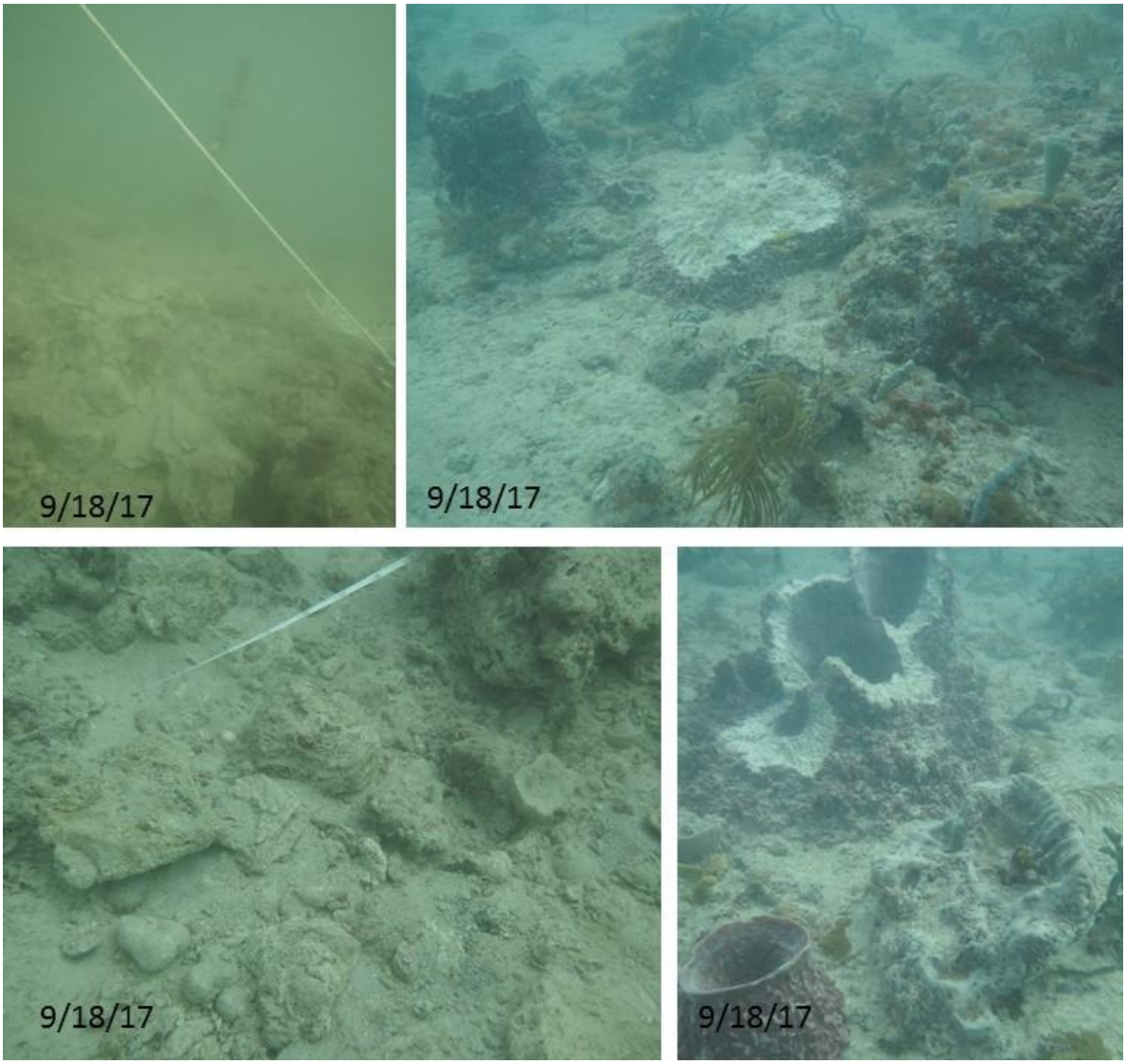

Figure 22. Post-Hurricane Irma Reconnaissance Photos, September 17, 2017.

A reconnaissance level assessment was conducted at ESA Site 26 on January 10th, 2018. Water clarity was reduced compared to summer time survey conditions, but many of the same colonies were identified and surveyed, documenting the persistence of *A. cervicornis* colonies through a significant hurricane event (Figure 23). While most colonies appeared to have persisted through the storm, there was a demonstrable difference in the size and live cover. A qualitative comparison of three large *A. cervicornis* colonies that were matched using pre-Irma photographs demonstrated as much as a 78% decline in total colony size (L x W x H) and a decrease in live cover. Although these data demonstrate the effects of a hurricane on a small sample size, *A. cervicornis* is known to be variable in space and time (Walker et al 2012).

Figure 23. Photos of *Acropora cervicornis* at Site 26 Before and After Hurricane Irma.

4.0 DISCUSSION

4.1 Synthesis of NSU (2011) and DCA (2017) Survey Results

In order to estimate ESA listed coral species for the PENIP, the IWG agreed to use existing data for the southern portion of the project area collected by NSU (2011) in combination with the DCA (2017) data, which was predominantly collected in the northern portion of the project area. Synthesis of the DCA (2017) and the NSU (2011) data sets were constrained in several ways. First, DCA survey areas were approximately 784 m^2 (8,439 sf) per survey site compared with 3,600 m^2 (38,750 sf) per site surveyed by NSU (2011). As a result, comparison of counts of ESA listed corals per survey are not directly comparable. Second, the NSU (2011) survey was designed as a rapid in-water methodology (20 minutes), where more detailed information that included colony size, and condition were completed only if the rapid assessment revealed the presence of more than 5 *Acropora* colonies (NMFS 2007). The tiered approach was predicated on the abundance of *Acropora* spp. and other ESA listed species (proposed at that time) were reported as binned abundance data (NSU 2011). Since DCA 2017 surveys were performed with no time limit they may have resulted in higher estimates of *A. cervicornis* abundance, because

more searching generally leads to higher counts of target species. In dense *A. cervicornis* habitat, it took a team of four DCA scientists up to four days (96 in-water survey hours) to completely count, measure, and assess each ESA listed coral colony within the survey area. Together, these methodological differences may have influenced estimates of abundance, particularly with regard to small unattached fragments.

4.2 The Impact of Regional Disturbances on Synthesized DCA (2017) and NSU (2011) Results

Several regional disturbances have affected coral communities of Southeast Florida in the time period between the NSU (2011) surveys and DCA (2017) surveys. Below is a timeline of regional disturbances that have occurred in this time period.

- **NSU (2011) ESA surveys in the southern part of the PENIP**
- Summer 2014 severe coral bleaching region-wide
- Summer 2014-present patchy mortality of *A. cervicornis* related to regional bleaching and localized outbreaks of white band disease (Gignoux-Wolfsuhn et al. under review, Drury et al. 2017)
- Fall/Winter 2014 are the first signs of white-plague disease epizootic in Southeast Florida
- Summer 2015 severe coral bleaching region-wide
- 2015-2018 continued coral mortality due to white-plague disease epizootic in Southeast Florida
- Summer 2016 mild/moderate coral bleaching in Southeast Florida
- Hurricane Matthew, October 2016
- **DCA (2017) ESA surveys in the northern part of the PENIP**
- Hurricane Irma, September 2017

Since the collection of the NSU (2011) survey data, severe bleaching stress of corals region-wide was noted in 2014 and 2015, and mild-moderate bleaching stress was documented in 2016 (FRRP 2016). A white-plague disease epidemic that caused high rates of coral mortality began in 2014 and has not yet abated at the time of this writing (Precht et al. 2016, Hayes et al. 2017, Kabay et al. 2017, Ruzicka 2018). In addition, Hurricane Matthew passed over the region in 2016. As a result, several regional coral disturbance events that may have affected ESA listed coral abundance have occurred since data were collected by NSU in 2011. The DCA (2017) estimates of coral abundance are inclusive of the multiple bleaching years, white-plague disease, and Hurricane Matthew, however, these more recent estimates do not include the potential loss of corals due to the passage of Hurricane Irma in September 2017. A discussion of how recent regional disturbance events may have impacted ESA listed corals is provided below.

The outbreak of white-plague disease that began in 2014 was not known to affect local *A. cervicornis* populations but white band disease, associated with high summer temperatures was documented in the summer of 2014, and may have caused significant mortality to local populations (Precht et al. under review). Changes to ESA species abundance due to the passage of Hurricane Matthew (October 2016) and subsequently Hurricane Irma (September 2017) may have also occurred. The effects of this latest major Category 3 storm on the coral populations of Southeast Florida is still being assessed along the SFCRT at the time of this writing, but *Acroporid* coral mortality and breakage were noted at the single ESA site that was revisited following the storm. The effects of Hurricane Irma on *A. cervicornis* populations have not been quantified within the proposed project area however it may be that estimates of *A. cervicornis* abundance from

both the DCA (2017) and NSU (2011) surveys are an over-estimate of the post-Hurricane Irma *A. cervicornis* populations. Conversely, fragmentation may also result in the spread and colonization of *Acropora* spp. over a greater area if fragments are able to reattach to the substrate (Lirman et al. 2000).

The 2014-2018 white-plague disease outbreak has been documented as a regional source of mortality for *O. faveolata* colonies. Precht et al. (2016) documented that *O. faveolata* was susceptible to white-plague disease and estimated that 13% of *O. faveolata* colonies region-wide were infected with or had recently died of white-plague disease. As a result, it is likely that the estimated abundance derived from the NSU (2011) survey data, taken prior to the disease epidemic, are an overestimate of the present population of *O. faveolata*. The estimated abundance of *O. faveolata* from the DCA (2017) surveys is likely an accurate estimate of the post white-plague-disease abundance of *O. faveolata,* however, the effects of the passage of Hurricane Irma have not been quantified. In either case, the current estimate is likely an overestimate of the present *O. faveolata* population due to the combined effects of the white-plague disease outbreak at sites surveyed by NSU (2011) and the passage of Hurricane Irma over the entire survey area.

The recent outbreak of white-plague disease was also a regional source of mortality for *O. annularis* colonies. Precht et al. (2016) documented that *O. annularis* was susceptible to white-plague disease and estimated that 77% of *O. annularis* colonies region-wide were infected with or had recently died of white-plague disease. The high rates of regional mortality in *O. annularis* since 2014 are likely the source of differences in surveyed abundance of this species between 2011 and 2017. *O. annularis* were rare in 2011 surveys and absent from surveys in 2017. As a result of regional mortality of *O. annularis* since the 2011 surveys, the species abundance derived from the NSU (2011) surveys are likely a significant overestimate of the present *O. annularis* population. The effects of white-plague disease on *O. franksi* have not been quantified but both related species *O. faveolata* and *O. annularis* were susceptible and suffered regional mortality as a result of the disease (Precht et al. 2016). It is unknown how Hurricane Irma may have affected local *Orbicella* spp. abundance, however, because it is less prone to storm breakage than *Acropora* spp.

Mycetophyllia ferox colonies were rare in the NSU (2011) surveys and absent from DCA (2017) surveys. The lack of *M. ferox* in the 2017 surveys may also be related to recent bleaching and disease mortality. The effects of the recent white-plague disease outbreak on *M. ferox* have not been quantified due to the scarcity of the species, but the more abundant and related species *M. aliciae* was susceptible to the disease and suffered minor regional-scale mortality since 2014 (Precht et al. 2016).

No *D. cylindrus colonies* were noted in either the NSU (2011) or DCA (2017) surveys of the PENIP. However, one colony was documented by “Project Baseline” just south of the PENIP at Barracuda Reef in 2016 (Milman 2016). It is unknown if this colony survived recent white-plague disease mortality that is estimated to have resulted in 98% regional loss of the species in Southeast Florida since 2014 (Kabay et al. 2017).

Despite several confounding factors that may have an impact on the species abundance estimates provided within this report, the only ESA listed coral species that was observed in either the NSU (2011) or DCA (2017) surveys within the direct or indirect impact areas (areas within 150 m of the channel) of the PENIP was *O. faveolata.* All other ESA listed corals were observed outside the 150 m (492.13 ft) potential indirect-effect area. In addition, since the majority of the

sites surveyed within the direct and indirect impact area were surveyed in 2017, any white-plague mortality associated with the ongoing disease event has likely already been realized in the current estimated abundance of *O. faveolata*. The only remaining uncertainty related to estimates of ESA listed species within the direct or indirect impact area is due to the unquantified effects of the passage of Hurricane Irma on *O. faveolata*. To date, no regional mass coral mortality has been noted following the passage of Hurricane Irma, but local dislodgement and toppling of colonies may have occurred.

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APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

APPENDIX F

APPENDIX G