Biological Monitoring Program Plan Report for 2019-2021: EcoEléctrica

Peñuelas, Puerto Rico

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Hardbottom Habitat Benthic Communities

1 Introduction (Coral Reefs)

Coral reefs throughout Puerto Rico's archipelago have been subjected to a wide variety of human induced and natural impacts operating at local, regional and global scales. Vicente & Associates, Inc. prepared various marine community assessments of the benthic marine habitats located in Guayanilla Bay from 1999 to 2008. These studies generated data for a wide scale characterization of the benthic habitats of marine areas of Peñuelas and Tallaboa near the EcoEléctrica pier including coral reefs, seagrass beds and unconsolidated sediments. The current methodology designed by HJR Reefscaping and implemented in 2012 increased the spatial resolution of the survey areas to be able to detect changes in the coral reef community at the Intake and Discharge stations of the EcoEléctrica pier. Data collection was designed to measure changes over time for the main coral biota population (scleractinian corals, gorgonians, sponges, algae, tunicates and zoanthids) and in seagrass beds. Fishes associated with coral reefs and neighboring habitats are monitored to quantify changes in abundance, species composition and community structure at both stations.

Cora Reef Study

Coral reefs are natural resources of fundamental socioeconomic importance in Puerto Rico. Coral reefs protect the coastline from erosion, contribute to the formation of (coralline) sandy beaches, sustain (local) commercial and recreational fisheries, are the main attraction of a rapidly growing recreational diving businesses and represent, as in many other Caribbean islands, the key coastal feature that supports tourism. Coral reefs promote development and growth of seagrass beds and fringing mangroves, which then function as an interdependent system to maintain a highly productive and biodiverse marine community. Most importantly corals and associated habitats, such as seagrasses and mangroves constitute essential fish habitats (EFH) for fishery species and are of particular interest to federal (NMFS, 2002) and state (DNER) fisheries management.

Previous studies in the region of Guayanilla and Tallaboa include characterizations and quantifications of coral reef habitats conducted by various research efforts. Morelock et al. 1979, reported 2-3 % live coral cover in the western walls of the shelf break and less than five coral species, suggesting low coral diversity in the region (Figure1). According to Wells (1988) live coral cover was insignificant due to impact associated with industrial development, although isolated colonies of stony corals *Acropora palmata* and *Millepora complanata* survived on the seaward side of the bay. Wells stated that living coral cover declined from 10-20% to less than 1% in a four-year period. According to this study, the walls of Guayanilla Canyon had high coral cover and diversity, while the reefs off Punta Verraco had very few stony coral areas interspersed with seagrass beds composed of *Thalassia* and *Syringodium*, while deeper forereefs have a broad community of soft corals and gorgonians (Wells 1988).

Underwater observations by Raytheon Environmental Services (EcoEléctrica 1995) during surveys conducted in 1993 noted the absence of living coral colonies in the shallow waters off Punta Guayanilla, except for a few colonies at nearby islands. The EcoEléctrica biological monitoring program characterized the submerged benthic habitats (coral reef, hard bottoms, seagrass, and unconsolidated sediments) adjacent to the liquefied natural gas (LNG) terminal pier at the intake and discharge stations 50 meters from the pylons (Vicente 2008). This study concluded that there were no significant differences in the percentage of live coral cover over time, however live coral cover was considered low (2%).

The current monitoring study implemented by HJR Reefscaping modified the methodology in 2012 to generate more specific information on coral species composition, relative abundances and spatial distribution as a function of time and under different environmental conditions, such as those of the Discharge, Intake stations and a new reference station (Luis's reef). For this the sampling design focused specifically in areas with higher live coral cover. With this modification in survey methodology changes over time in live coral and associated benthic biota (algae, sponges, octocorals, tunicates and zooanthids) could be quantified.

Benthic Characterization

Benthic communities were characterized at 3 permanently established locations, one at the Intake station (approximately 2 meters depth), another at the Discharge station (approximately 4.5 meters depth) and at Luis's reef near one of the dolphin docks at the end of the pier. At each location six permanent 10-meter transects were established (Figure 2). Transect were placed in coral reef habitat areas with high coral cover. Three transects were located to the east of the pier and three were located towards the west (Figure 2). The line intercept method (Loya 1972) was used to collect data in situ to estimate the percent cover of corals, octocorals, sponges, macroalgae, anemones, tunicates, calcareous algae, hard ground, sand and rubble.

The NOAA coral demographic protocol was used to monitored coral at a small scale. The goal of the coral demographic surveys is to collect data and report details on species composition, density, size, abundance, and specific parameters of condition (% live vs. dead, bleaching, disease) of non-juvenile scleractinian corals (> 4 cm maximum diameter), and of overall species diversity (all corals) using 10m x 1m belt transects in coral reef habitats at the three study sites.

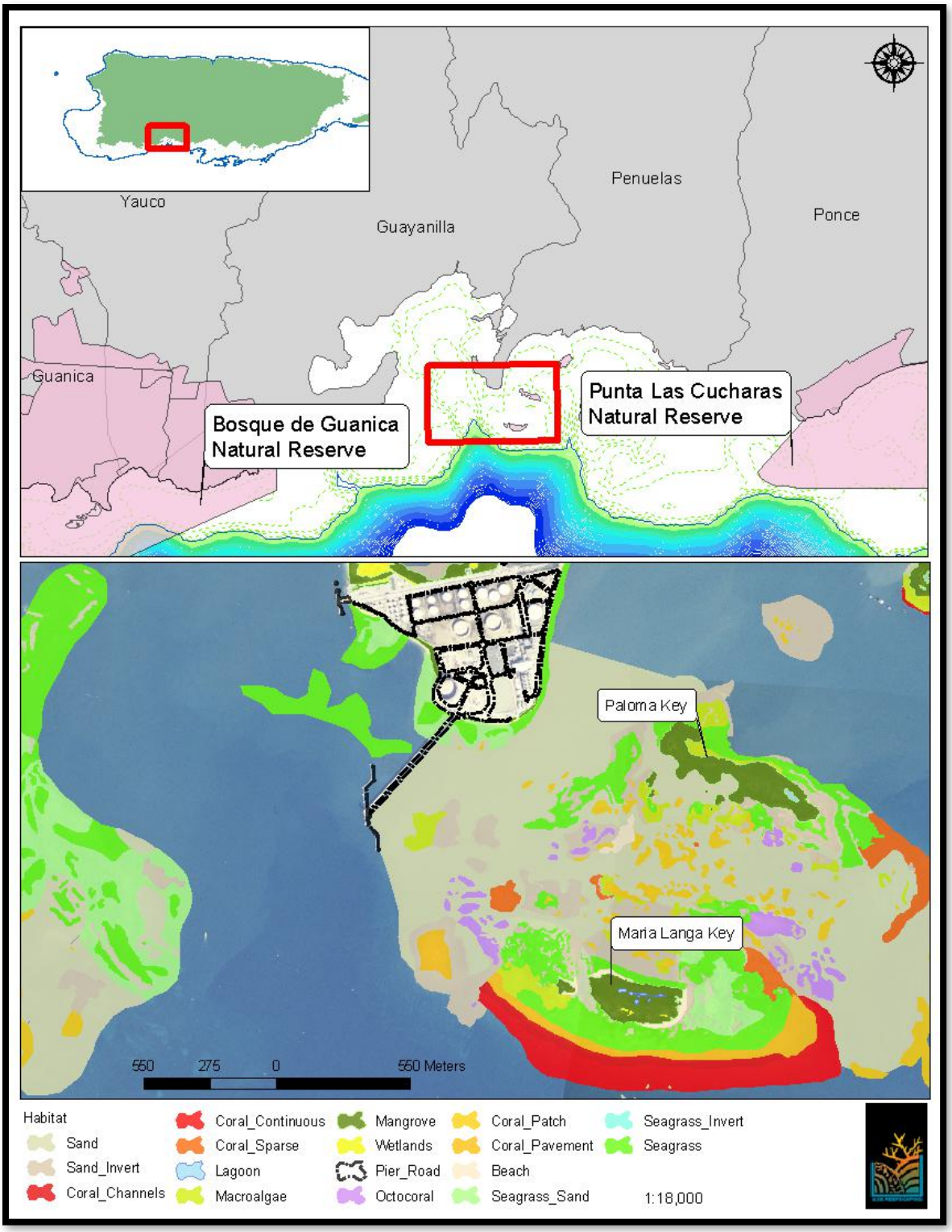

Figure 1. Study area at Peñuelas southern Puerto Rico.

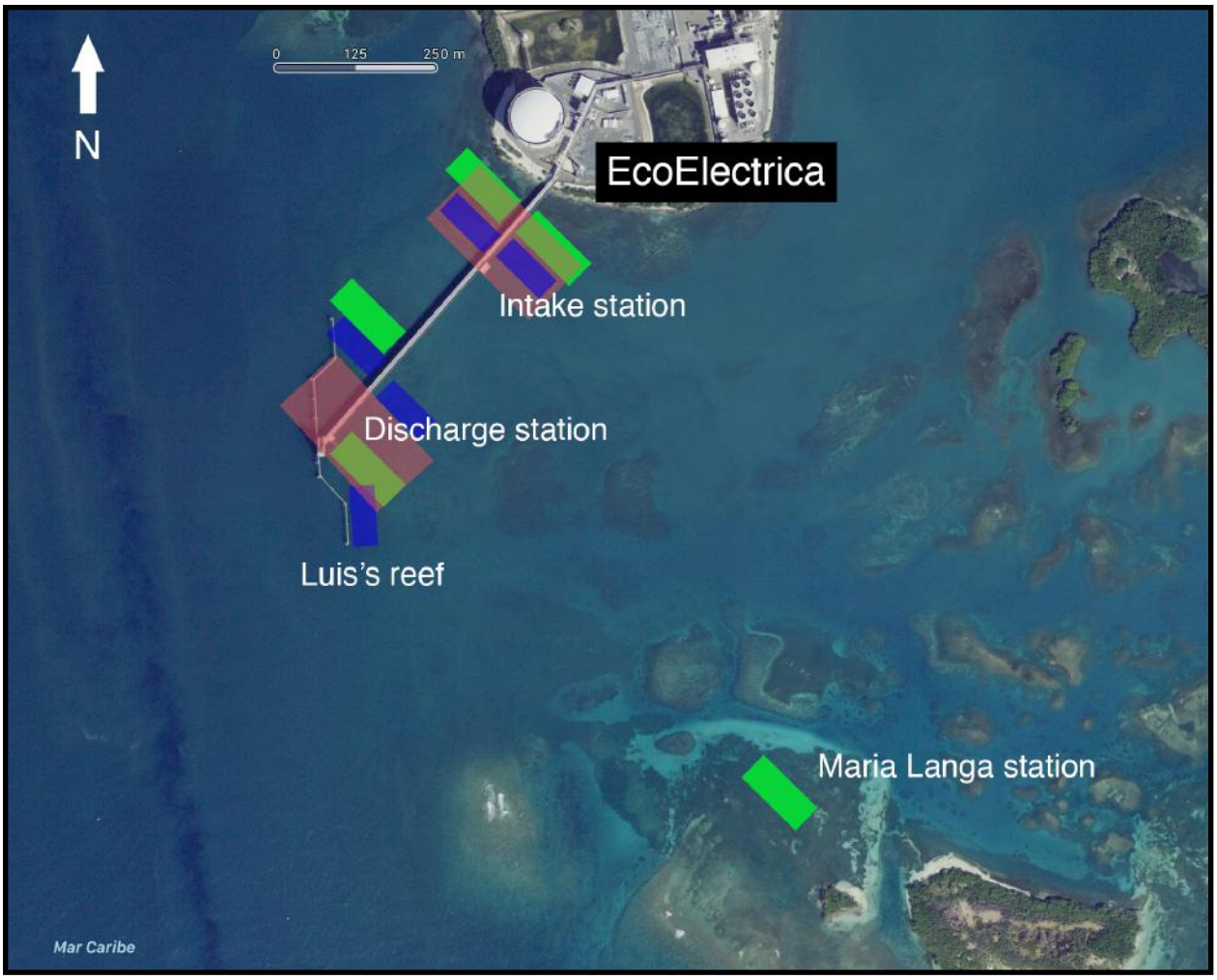

Figure 2. Location of the different studies areas around the LNG terminal pier. Blue areas marked the location of coral transects, green areas marked seagrass transects and finally red areas marked the fish study zones.

Results

Intake station 2021

At the Intake station macroalgae was the dominant biological component of the sessile benthos in terms of cover with a mean of 56.91% (Figure 3). Live scleractinian (stony) corals ranked second in live cover with a mean of 14.65%. Sponges ranked third with a mean live cover of 6.59%. Gorgonians, tunicates, anemones and calcareous algae were also present at this station, but only represent a minor component of the reef community structure (6.5% cover). Abiotic categories, particularly sand, rubble and hard ground accounted most of the cover of 15.3%. At the Intake station there were no significant differences in the live cover of corals over the years from 2015 to 2021 (Figure 3).

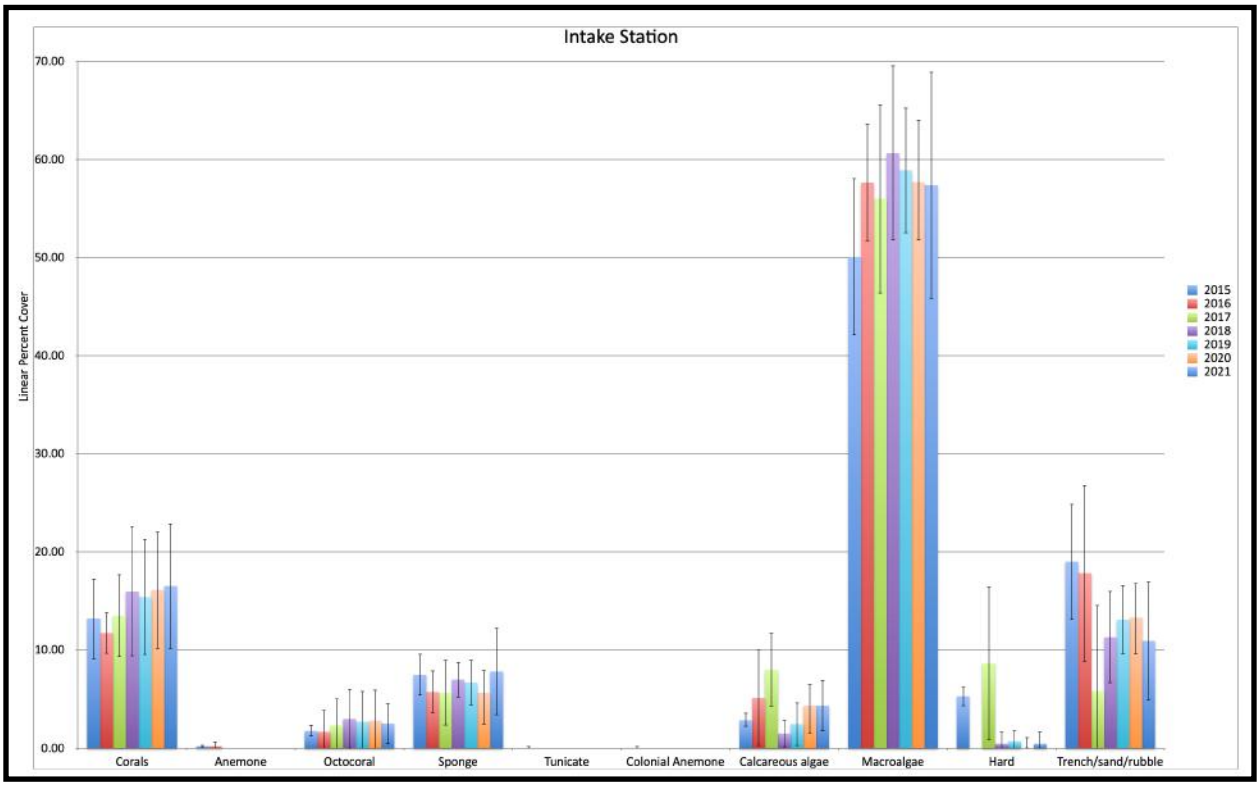

Figure 3. Mean percent cover and standard deviation of benthic categories at the Intake station (N=6) per year.

The demographic monitoring transects recorded 192 coral colonies with an average of 3.2 col/m^2 (Table 1). within these transects, 8 different coral species were identified, with *Porites astreoides* (35%), *Siderastrea siderea* (49%), and *Pseudodiploria strigosa* (6%) dominating the surveyed area among other coral species (Table 1). Thirteen coral colonies were observed bleached (6.77%) at this station.

Table 1. Coral species at the Intake station, Guayanilla Puerto Rico

Species	**Number of colonies**	**Percent Occurrence**
Porites astreoides	67	35
Siderastrea siderea	94	49
Favia fragum	1	1
Stephanocoenia intercepta	6	3
Agaricia agaricites	5	3
Pseudodiploria strigosa	12	6
Colpophyllia natans	5	3
Pseudodiploria clivosa	2	1
Total	**192**	**100**

Discharge Station 2021

At the Discharge station macroalgae was the dominant biological component of the sessile benthos in terms of cover with a mean of 34.82% (Figure 4). Sponges ranked second with a mean live cover of 20.59%. Live scleractinian (stony) corals ranked third in live cover with a mean of 8.63%. Gorgonians, tunicates, anemones and calcareous algae were also present, but only represented a minor component of the reef community structure (5.22% cover). Abiotic categories, particularly sand, rubble and hard ground accounted for most of the cover at 30.6%. At the Discharge station there were no significant differences in the proportion of live cover of corals over the years from 2015 to 2021 (Figure 4).

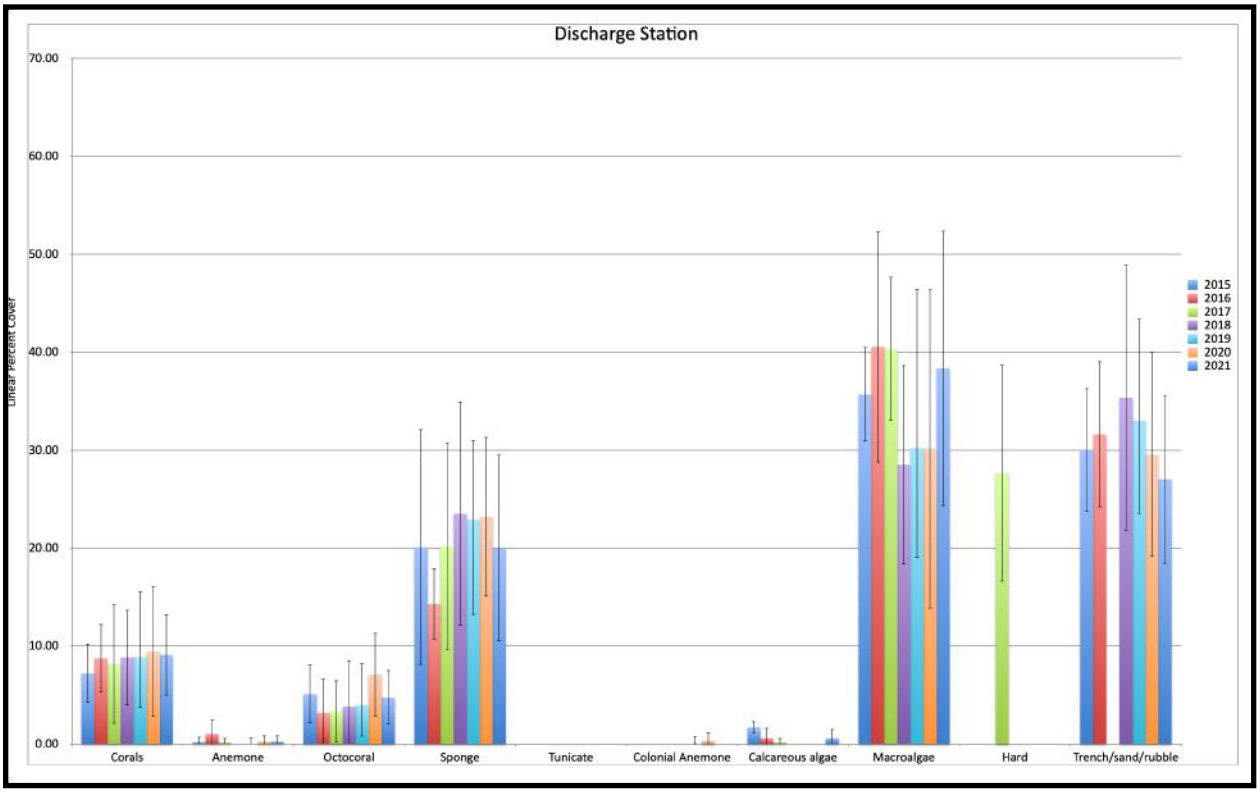

Figure 4. Mean percent cover and standard deviation of major benthic components at the Discharge station (N=6) per year.

The demographic monitoring recorded 191 coral colonies with an average of 3.18 col/m^2 (Table 2). At least 10 coral species were identified, with *Porites astreoides* (14%), *Siderastrea siderea* (41%), *Montastraea cavernosa* (17%), and *Pseudodiploria strigosa* (18%) colonies dominating the surveyed area (see table 2 for a list of coral species). Six coral colonies were observed in bleached condition (3.14%) at this station.

Table 2. Coral species at the discharge station, Guayanilla Puerto Rico

Species	Number of colonies	Percent occurrence
Porites astreoides	27	14
Siderastrea siderea	78	41
Montastraea cavernosa	33	17
Orbicella faveolata	1	1
Dichocoenia stokessii	2	1
Stephanocoenia intercepta	11	6
Pseudodiploria strigosa	34	18
Colpophillia natans	1	1
Pseudodiploria clivosa	3	2
Meandrina meandrites	1	1
Total	**191**	**100**

Reference Station (Luis's reef) 2020

At the reference station macroalgae was the dominant biological component of the sessile benthos in terms of live cover with a mean of 33% (Figure 5). Live scleractinian (stony) corals ranked second in cover with a mean of 23.33%. Octocorals ranked third with a mean live cover of 19.67%. Sponges, tunicates, anemones and calcareous algae were also present at this station, but only represent a minor component of the reef community structure (12.33% cover). Abiotic categories, particularly sand, rubble and hard ground accounted most of the cover of 11.67%.

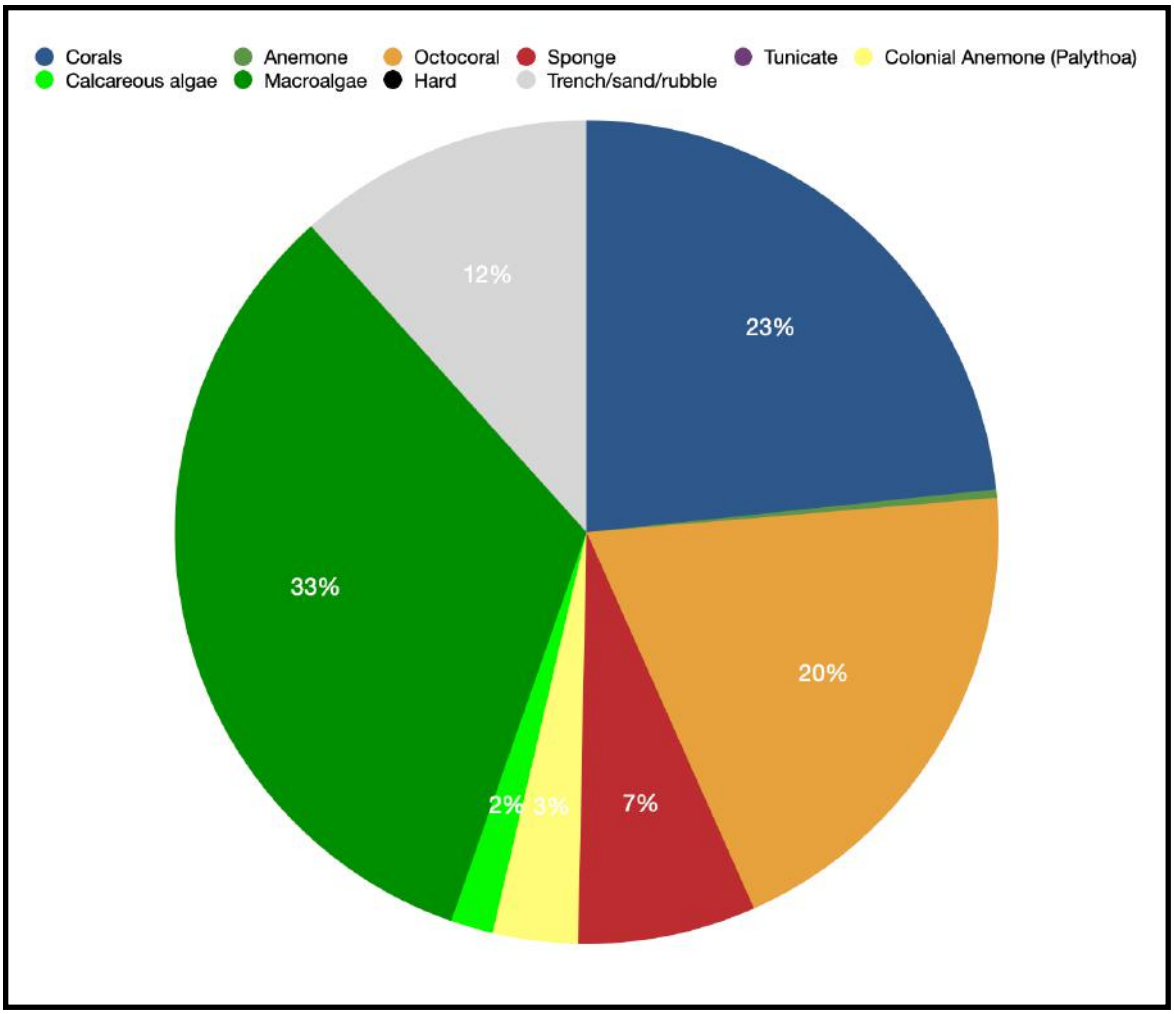

Figure 5. Mean percent cover of major benthic components at the Reference station (N=3) in 2020.

The demographic monitoring recorded 132 coral colonies with an average of 4.4 col/m^2. In the transects, 13 different coral species were quantified, with *Porites astreoides* (30%), *Siderastrea siderea* (27%), *Montastraea cavernosa* (22%), and *Orbicella faveolata* (5%) colonies dominating this taxonomic group (Table 3). Five coral colonies were bleached (3.79%) at this station.Table 3. Coral species present at transects in the reference station, Guayanilla Puerto

Table 3. Coral species at the reference station, Guayanilla Puerto Rico

Species	Number of colonies	Percent occurrence
Porites astreoides	40	30
Siderastrea siderea	35	27
Montastraea cavernosa	29	22
Orbicella faveolata	6	5
Siderastrea radians	1	1
Pseudodiploria labyrinthiformis	1	1
Stephanocoenia intercepta	3	2
Madracis decactis	1	1
Agaricia agaricites	4	3
Pseudodiploria strigosa	9	7
Colpophillia natans	1	1
Pseudodiploria clivosa	1	1
Meandrina meandrites	1	1
Total	**132**	**100**

In conclusion the benthic community dominating the substratum at the coral reef stations have not shown any significant changes over time. There have been no major differences in the proportion of live cover of benthic organisms that could be attributed to localized impacts to water quality such as those resulting from the operations of EcoEléctrica. No coral disease signs have been observed at any of the stations during the monitoring from 2015 to 2021. Coral bleaching observed at the stations occurred along with the island wide bleaching event that happened from September to November in 2020 & 2021, when temperatures were highest than the rest of the year. All coral colonies were tracked and have since recovered from these bleaching events.

Seagrass

The purpose of the seagrass surveys is to provide a continuous monitoring of these key benthic communities in and around the EcoEléctrica pier as well as the reference site at Maria Langa Key over time. Seagrass abundance (i.e. area of cover), distribution, growth and productivity are some of the parameters estimated to measure the condition of this ecosystem. The seagrass communities around the LNG terminal pier are dominated by one specie *Thalassia testudinum* and the distribution of the seagrasses is spatially variable.

The unconsolidated sediment benthic composition and their mean percent cover area in the Intake station, the Discharge station and the Maria Langa reference station during 2020 assessment are presented in Figure 6. As observed previously (surveys 2015-2019), the Maria Langa station still has the highest percentage of live seagrass cover while the Intake and Discharge stations showed a lower cover percentage that was similar in average. In term of the composition of seagrass species, *Thalassia testudinum* is the most common specie (Figure 7), but with a much higher percent cover at Maria Langa Key.

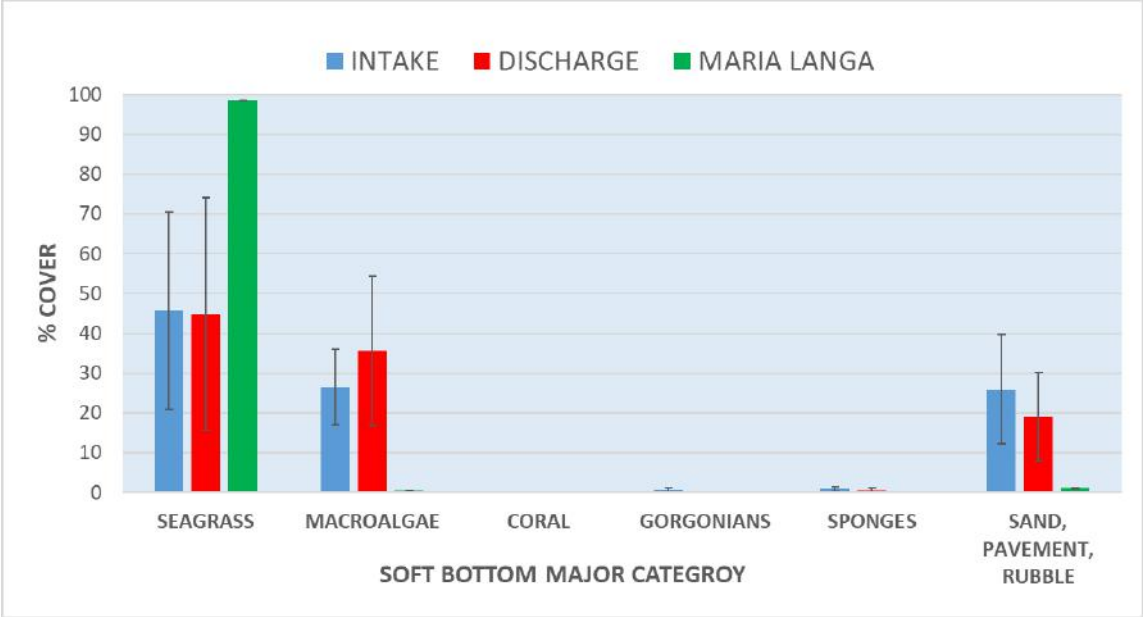

Figure 6. Mean percentage distribution of major soft bottom category at three study stations (Intake, Discharge and Maria Langa stations) during 2020 survey. Line above the column represent one standard error.

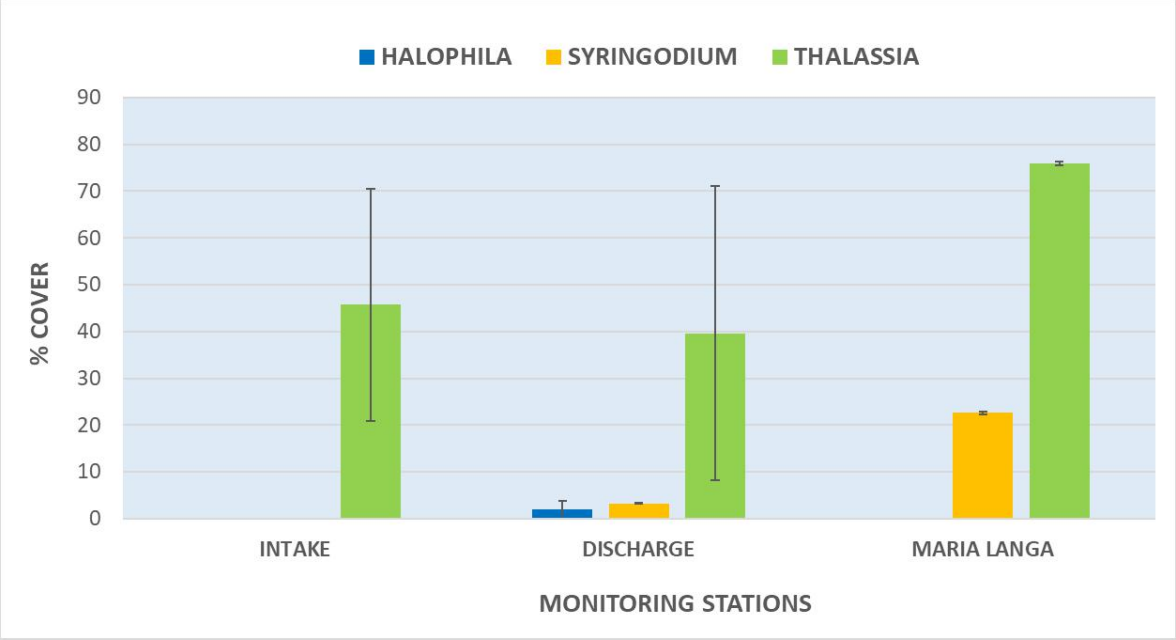

Figure 7. Mean percentage cover area of seagrass species among three study sites (Maria Langa, Intake and Discharge stations) during 2020 survey. Line above the column represent one standard error.

As observed previously (2015-2019), the relative cover of the major components varied among zones within the Intake station (Figure 8). The western Intake station still has a significantly higher cover of seagrass compared with the eastern Intake station. Similarly, the western Discharge station also has a significant difference in major benthic components compared with the eastern Discharge station (Figure 9). The western Discharge station had a significantly higher cover of seagrass compared with the eastern Discharge station, principally due to the cover of one specie, *Thalassia testudinum* (Figure 10). These seagrass communities haven't not shown any significant changes over time due to localized impacts to water quality associated that could be attributed with the operations of EcoEléctrica.

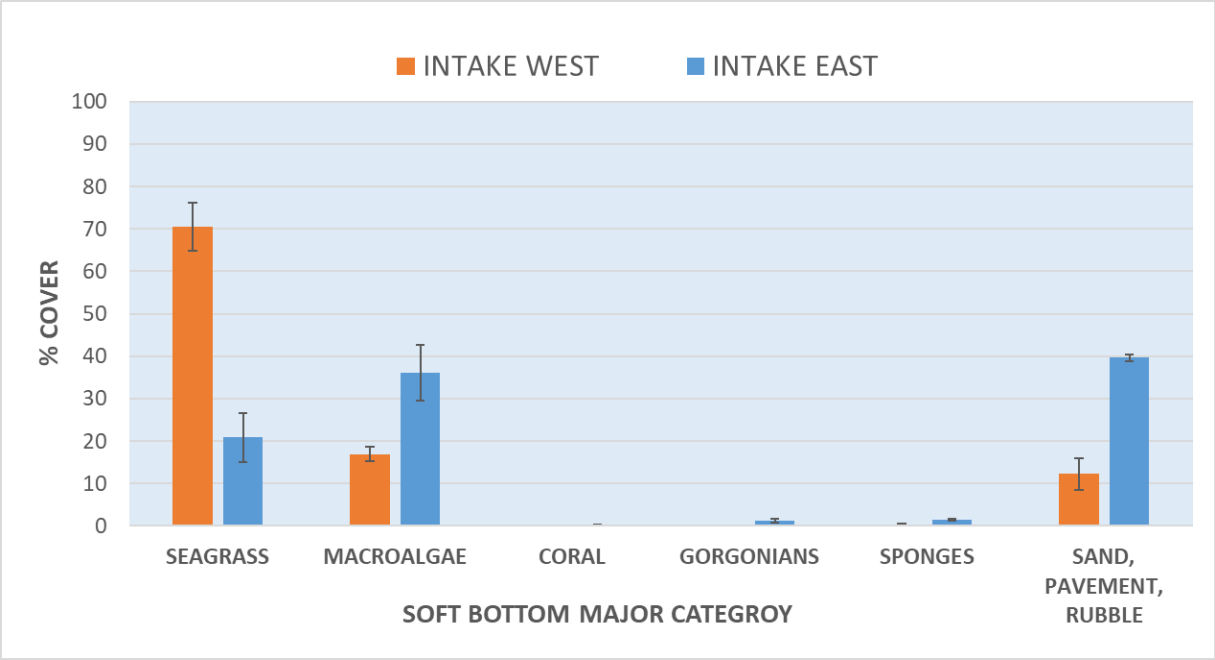

Figure 8. Mean percentage distribution of each major soft bottom category in each zone of the Intake station (West and East stations) during the 2020 survey. Line above the bar represent one standard error. .

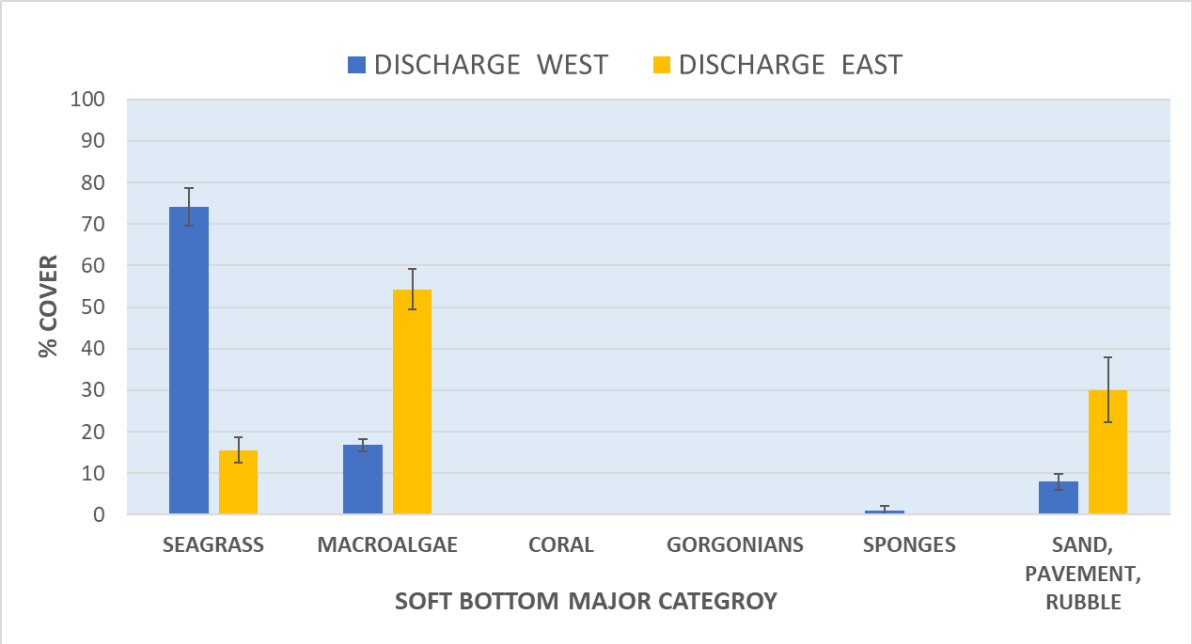

Figure 9. Mean percentage cover of each major soft bottom category at the western Discharge station and at the eastern Discharge stations during the 2020 survey. Line above the bar represent one standard error.

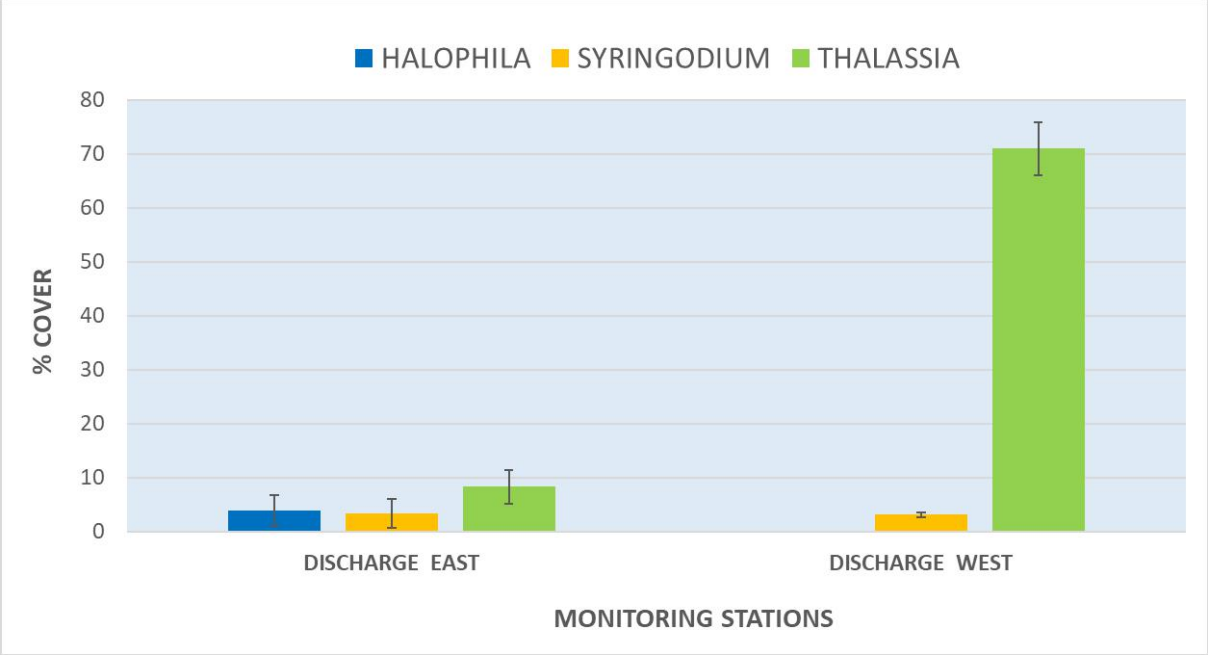

Figure 10 Mean percentage cover of seagrasses species at the eastern and western Discharge station during the 2020 survey. Line above the bar represent one standard error.

Fish Community

In 2019, a total of 20 visual censuses were conducted: 10 at the intake station in December 2019 and 10 at the discharge station in September 2020. These surveys were performed near the pier pilings, and off the pier in the adjacent patch reef habitat. The depth of the discharge station ranged from 3.0 to 6.0 meters and the intake station ranged from 1.5 to 2.0 meters.

The fish observed near the pier were representative of juvenile and adult life stages of coral reef associated species, as well as those commonly observed in mangroves and seagrass beds. There were 57 species in the Discharge station and 39 species in the Intake, with both stations sharing 28 species in common which remained consistent with previous years (i.e. 23 in 2018 and 25 in 2016). Species richness did not significantly differ from the 2016 and 2018 surveys at each station. The most common species at the intake was the dusky damselfish (*Stegastes adustus*; 0.532 fish/m2). The discharge station was dominated by the bluehead wrasse (*Thalassoma bifasciatum*; 0.126 fish/m2). These dominant species did differ from the previous years.

Lionfish were observed at the pier, which provides support that this invasive species is a permanent resident at this location. There was also the presence of commercially important species like the schoolmaster snapper (*Lutjanus apodus*), mahogany snapper (*Lutjanus mahogoni*) and gray snapper (*Lutjanus griseus*) as well as pelagic/reef transient species like the rainbow runner (*Elagatis bipinnulata*). The pier, an artificial substrate surrounded by seagrass and rocky reef, provides significant habitat for a variety of species in different life history stages. In particular, the seagrass habitat is well suited for juveniles, which later migrate to reef habitat as they grow. The proximity to the shelf edge and deeper water is also a factor that supports the observation of some pelagic species. The Intake station was dominated by fish less than 15 cm in length while the Discharge station was dominated by fish between 10-15 cm in size.

Fish species richness was compared between years. At the Discharge, there was no difference between species richness from the 2016-2020 sampling seasons (2016:

54 species, 2018: 52 species, 2019: 57 species). The same can be said for the Intake station (2016: 30 species, 2018: 32 species, 2020: 39 species). The difference in dominant species observed each year is likely a factor of the temporal sampling strategy because each location is surveyed only once per year. This means that recruitment pulses of some species, or random schooling of others, can strongly influence the survey estimate for that period. Generally, most surveys have been conducted in the winter months (September - December) which does not take into consideration seasonal variability in species richness.

This year, black spots were observed on a limited number of surgeonfish. This spotting (black spots on the body, referred to as Black Spot Syndrome) has been observed in other areas along the south coast of Puerto Rico that are not directly adjacent to any industrial activity (Harms-Tuohy, personal observation). This type of disease is caused by parasites and has been documented elsewhere in the Caribbean (Kohl et al. 2019). Overall, during fish community surveys from 2014 – 2020, fish species diversity and abundance has appears to have remained stable at the LNG Terminal.