Table 15. Estimated permanent cable footprint over non-cemented EFH, hardbottom EFH and coral Critical Habitat (EFH/CH) out to 98 ft (30 m) depth.

Cable Type (m)	Cable Length (m)			Cable Footprint (m^2)				
	Non cemented*	Hardbottom (non-CH)	CH	Non cemented*	Hardbottom (non-CH)	CH	Total cemented	Totals
Double Armor (0.035 m)	709	291	368	24.8	10.2	12.9	23.1	47.9
Articulated Pipe (0.130 m)	0	210	0	0	27.3	0	27.3	27.3
Total	709	501	368	24.8	37.5	12.9	50.4	**75.2**

*algal grounds and seagrass combined

Figure 3. Overlay of the route, survey stations, temporary anchor and cable hold back points on the aerial photo of the project site.

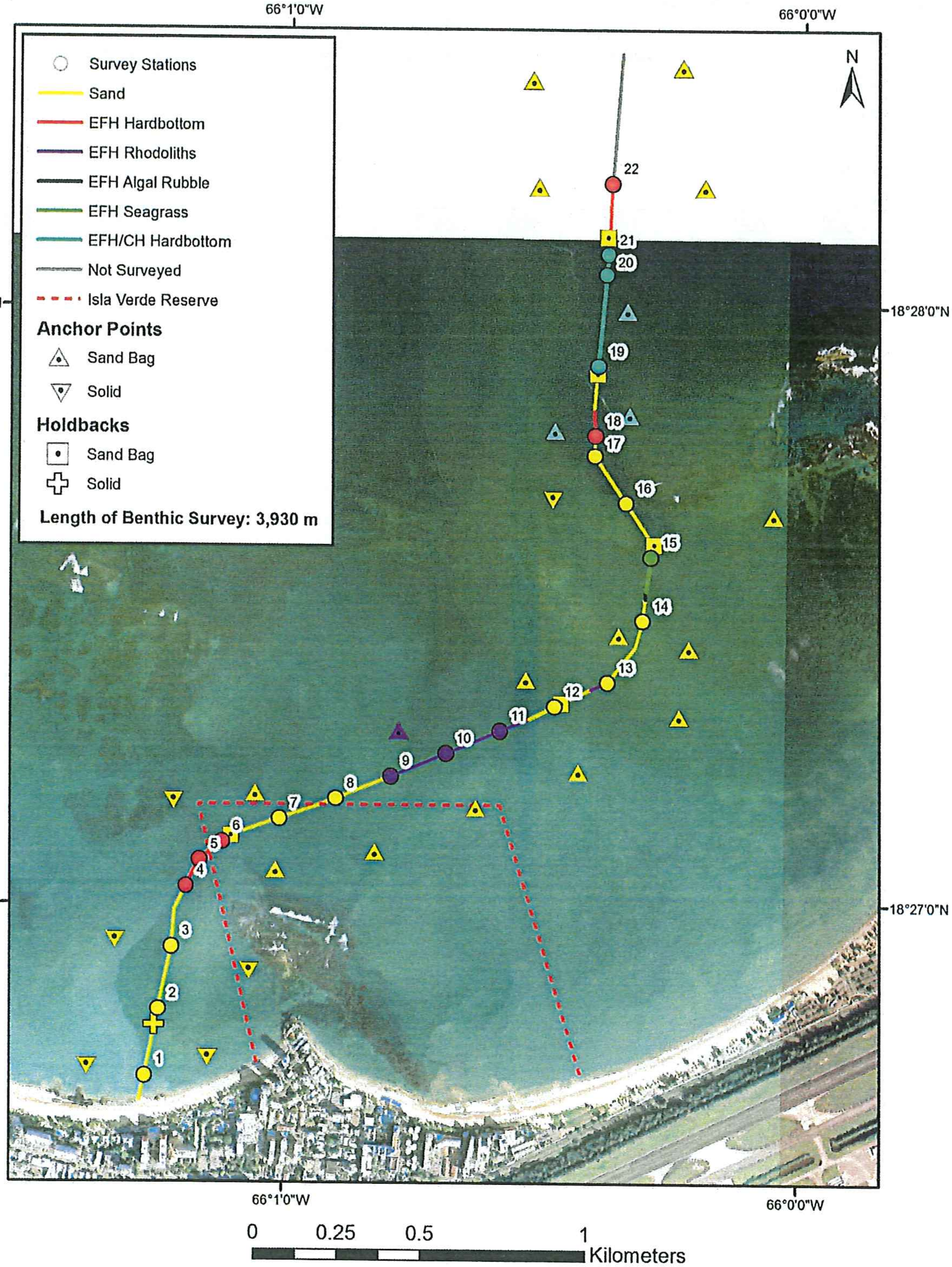


Figure 4. Overlay of the route, survey stations, temporary anchor and cable hold back points on the NOAA nautical chart no. 25668. (Soundings in fathoms).

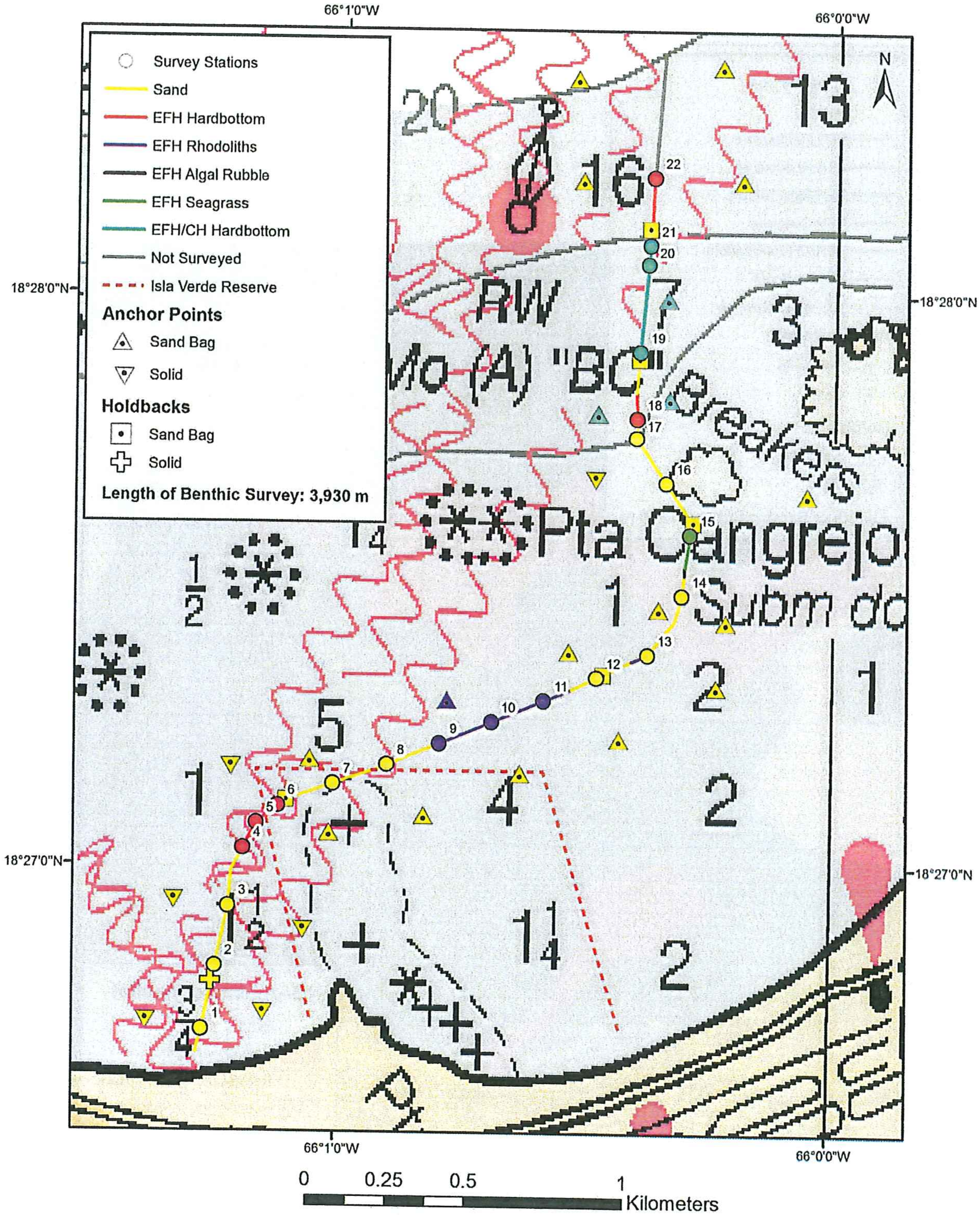


Figure 5. Adaptation of categories from the NOAA Benthic Habitat Map to show habitats at the project site and those intercepted by the route, survey stations, temporary anchor and cable hold back points.

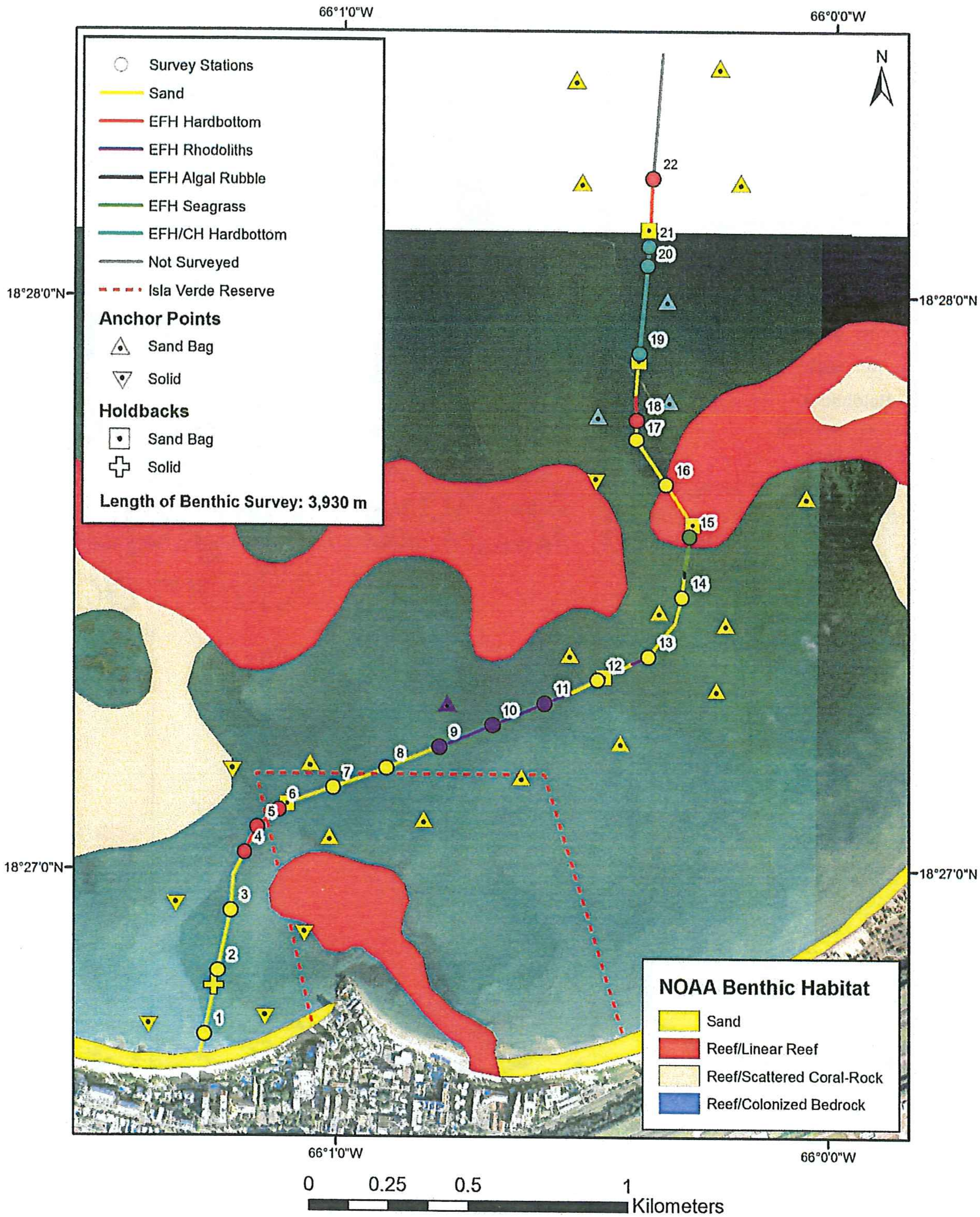
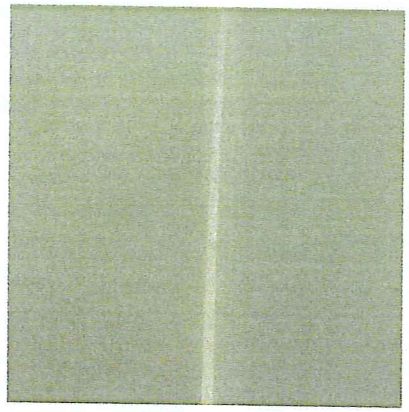
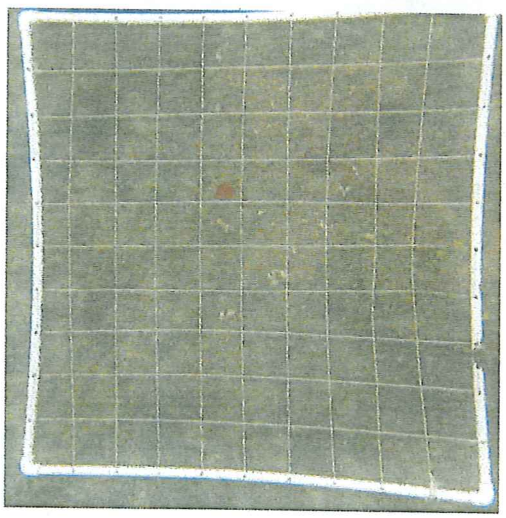


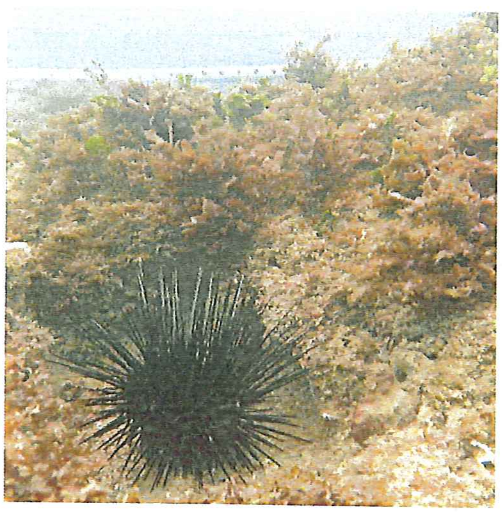
Figure 6. Backreef (stations 1-15).

Station 3

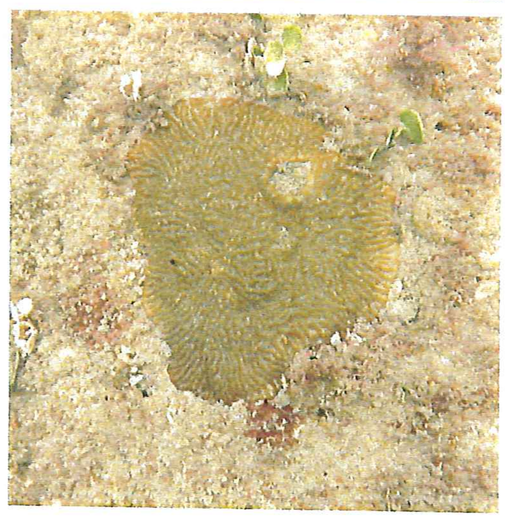


Station 4



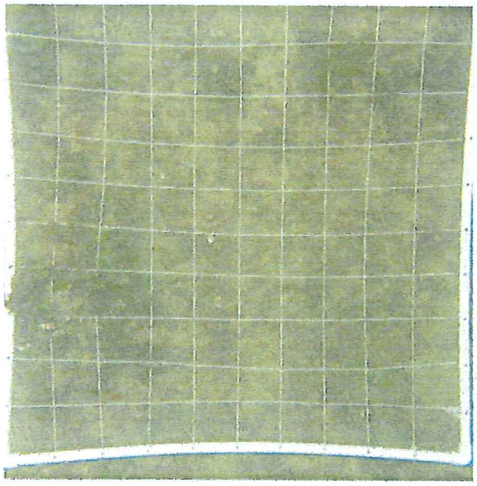


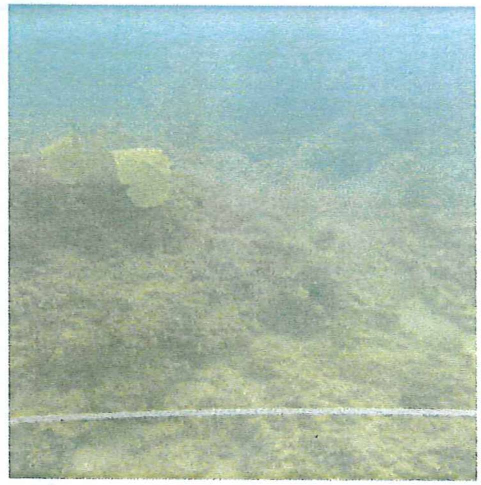
Diadema antillarum



Pseudodiploria clivosa

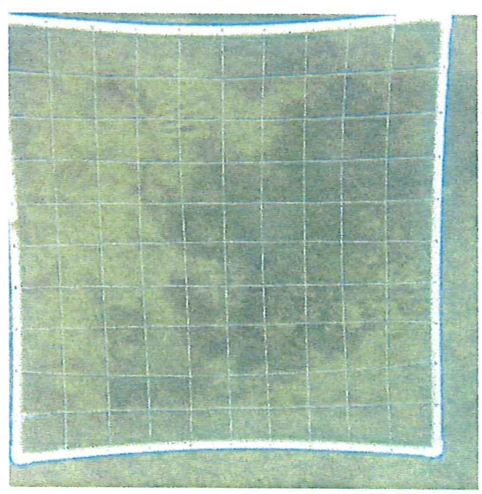
Station 5





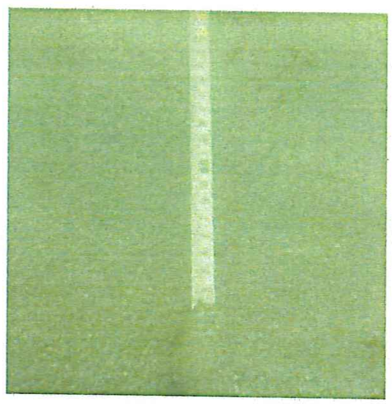
Pseudodiploria clivosa

Station 6

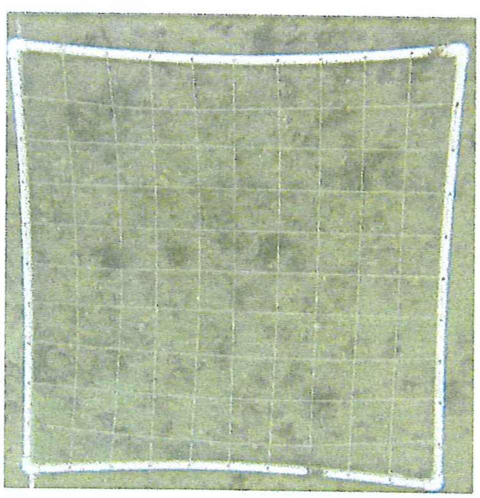


Montastraea cavernosa

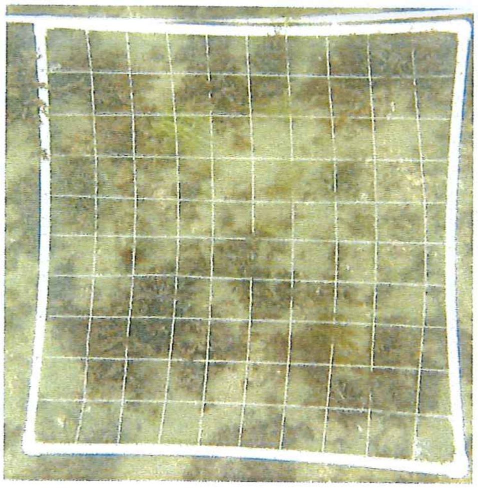
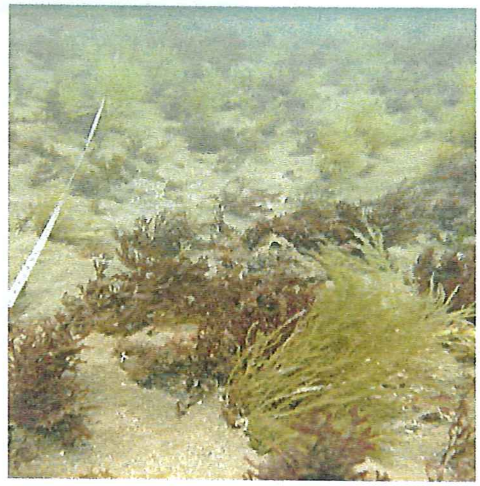
Station 7



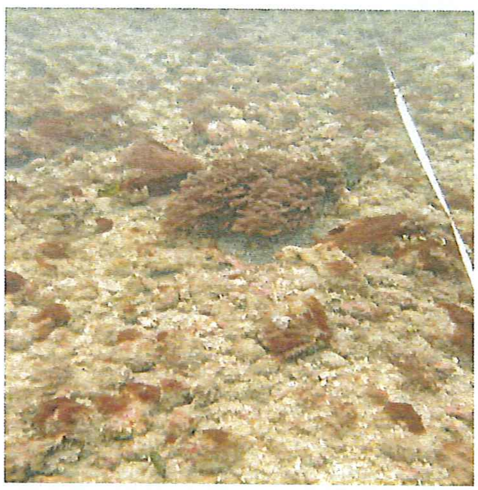
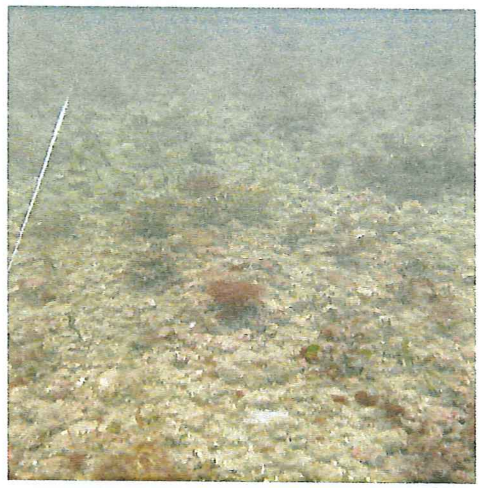
Station 9

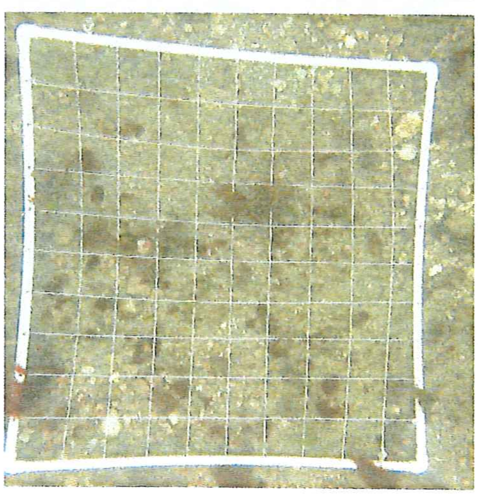
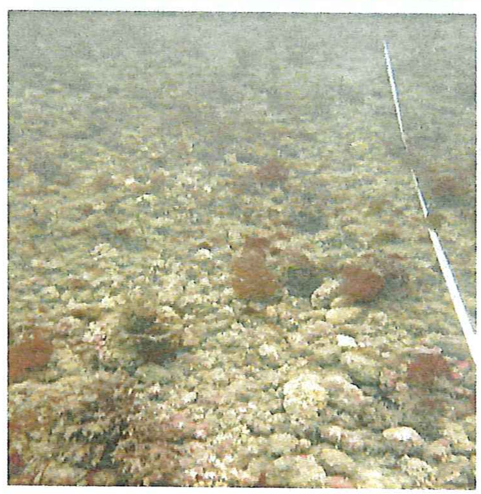


Station 10

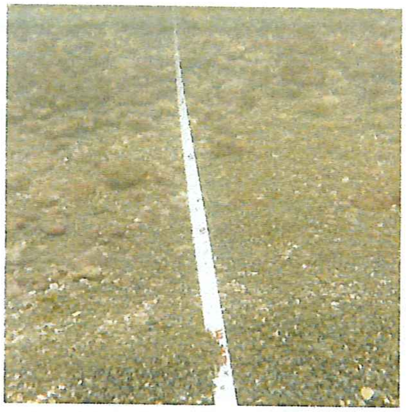
 

Station 11

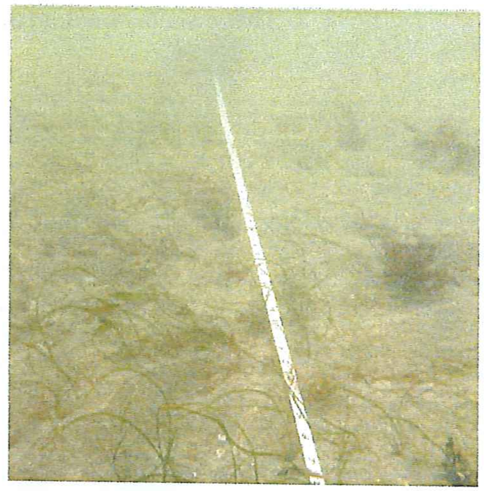
 

Station 12

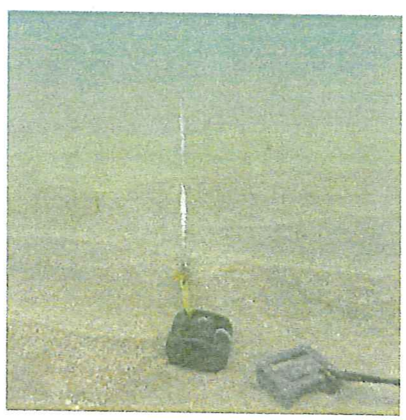
 

Station 13

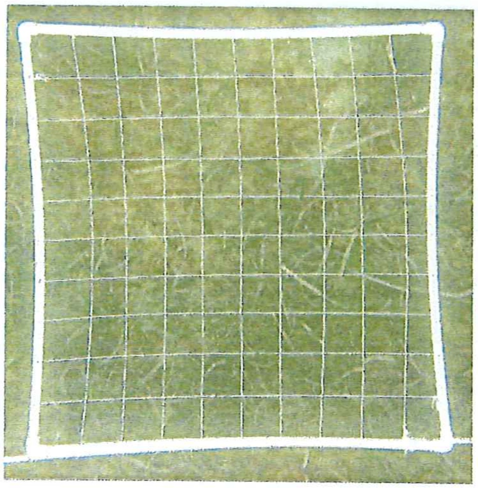
 

Halodule wrightii (L) and *Syringodium filiforme* (R) shoots

Station 14



Station 15

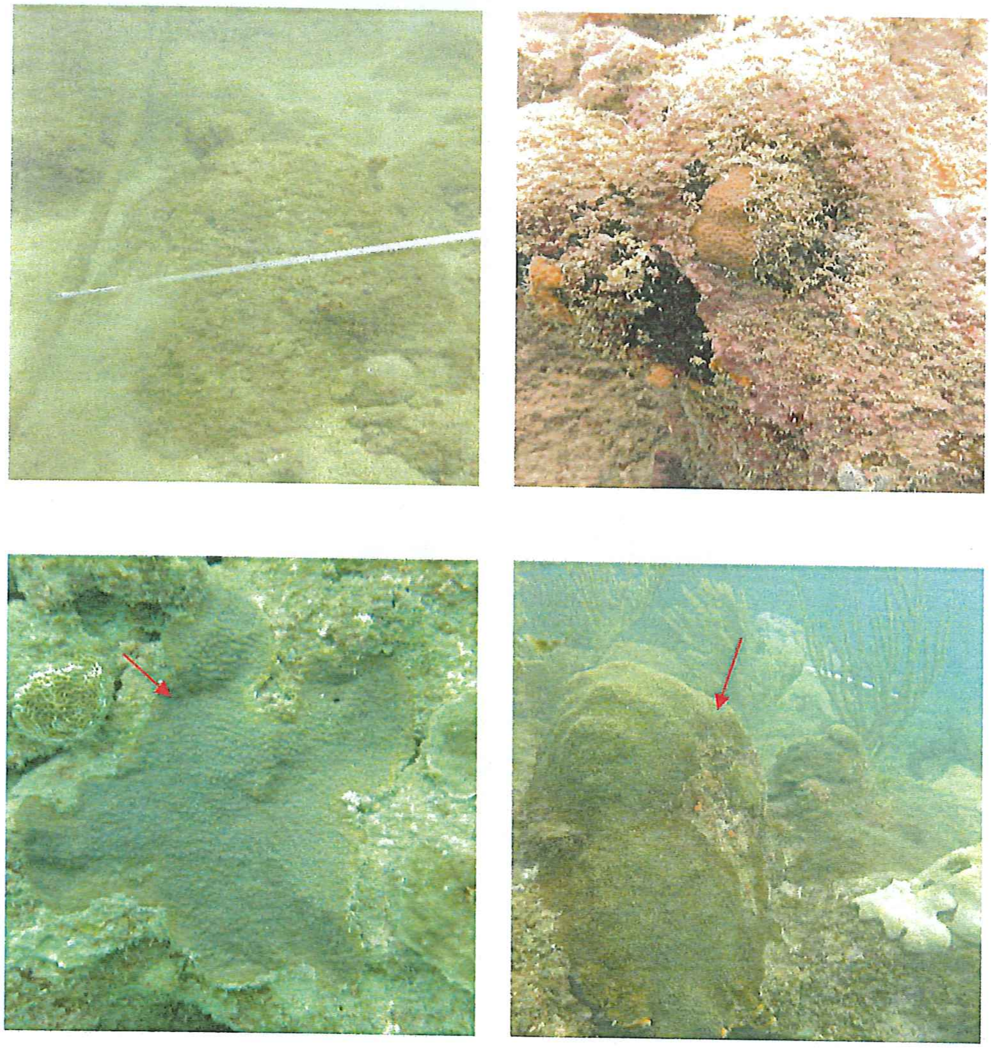



Thalassia testudinum and *Syringodium filiforme*

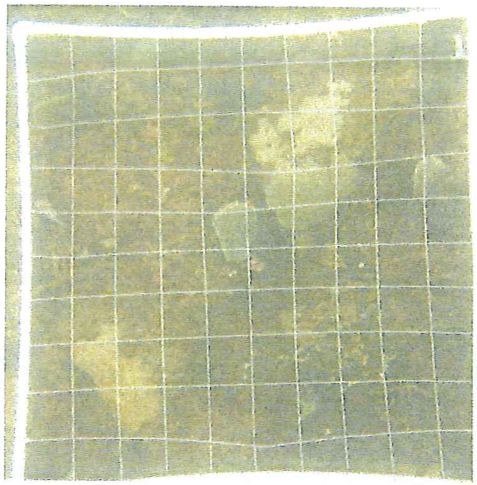
Detail of interspersed *T. testudinum*, *S. filiforme* and *H. decipiens*

Figure 7. Reef (stations 16-17).

Station 16

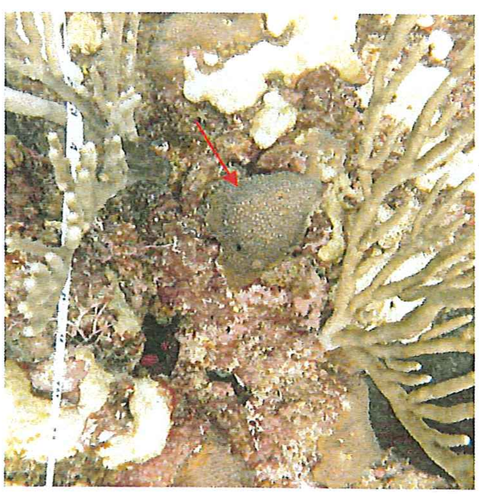


Orbicella faveolata (pointed by red arrows)



Station 17

channel eastern section

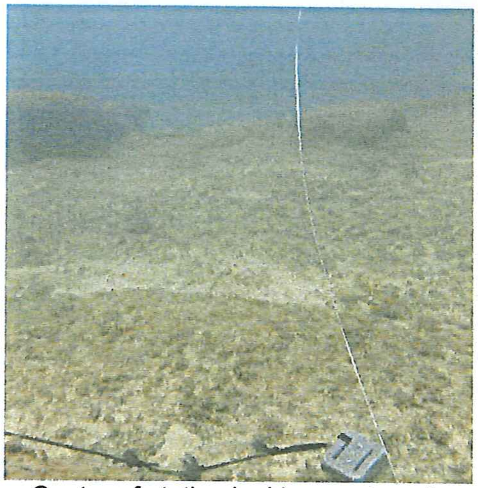


Orbicella faveolata (pointed by red arrows)

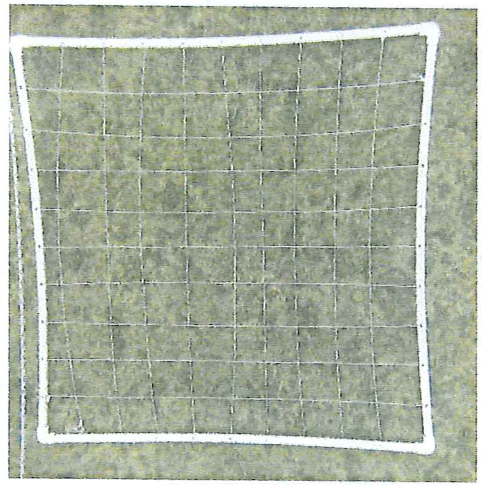
Upper reef sections away from center of reef gap

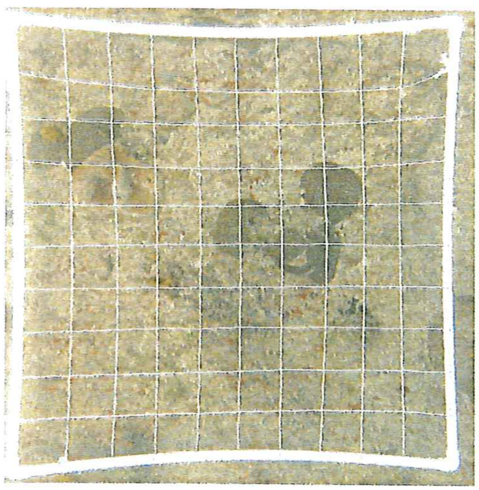
Figure 8. Forereef (stations 18-20).

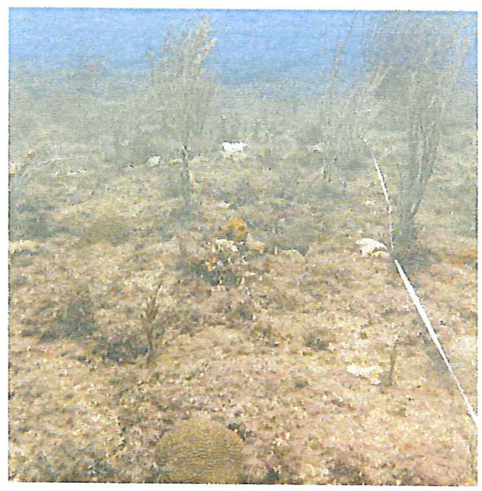
Station 18



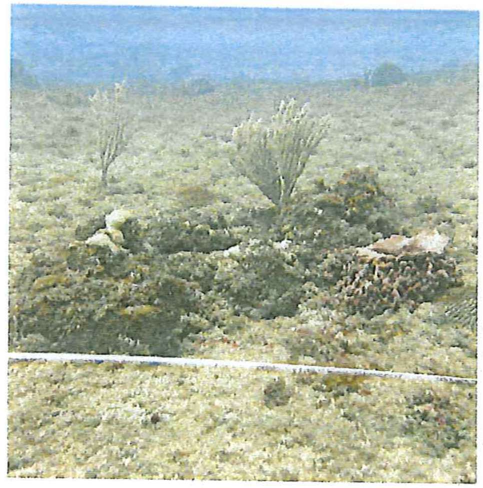
Center of station looking westward

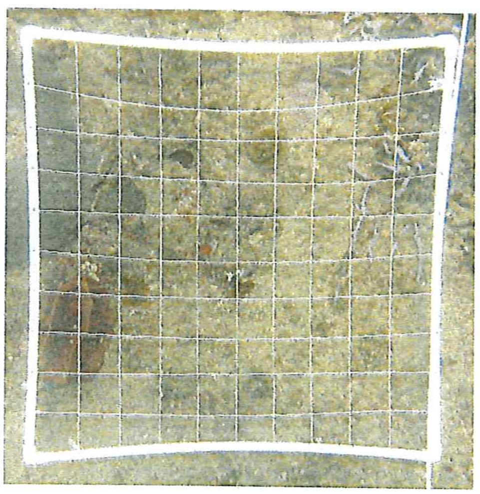




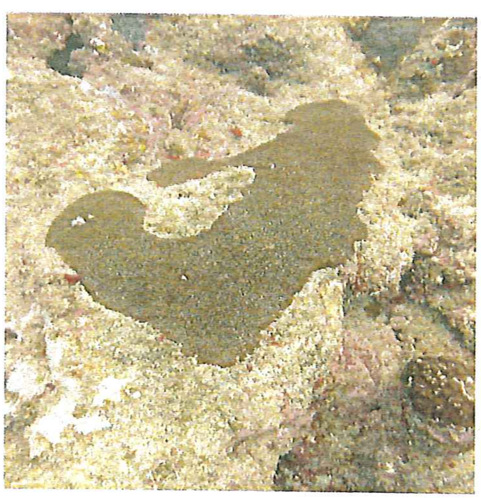


Station 19





Station 20



Orbicella faveolata

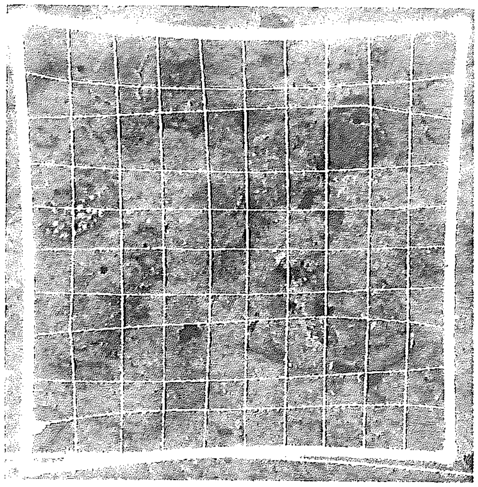
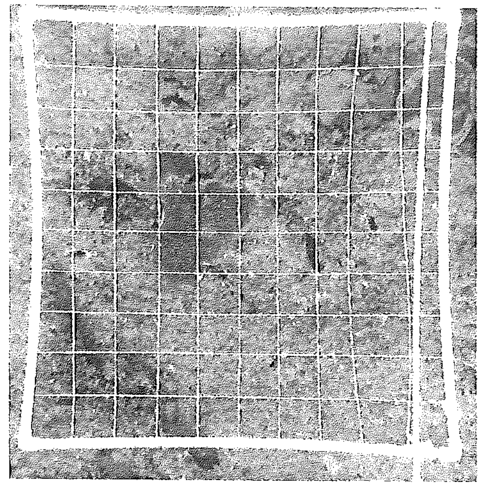
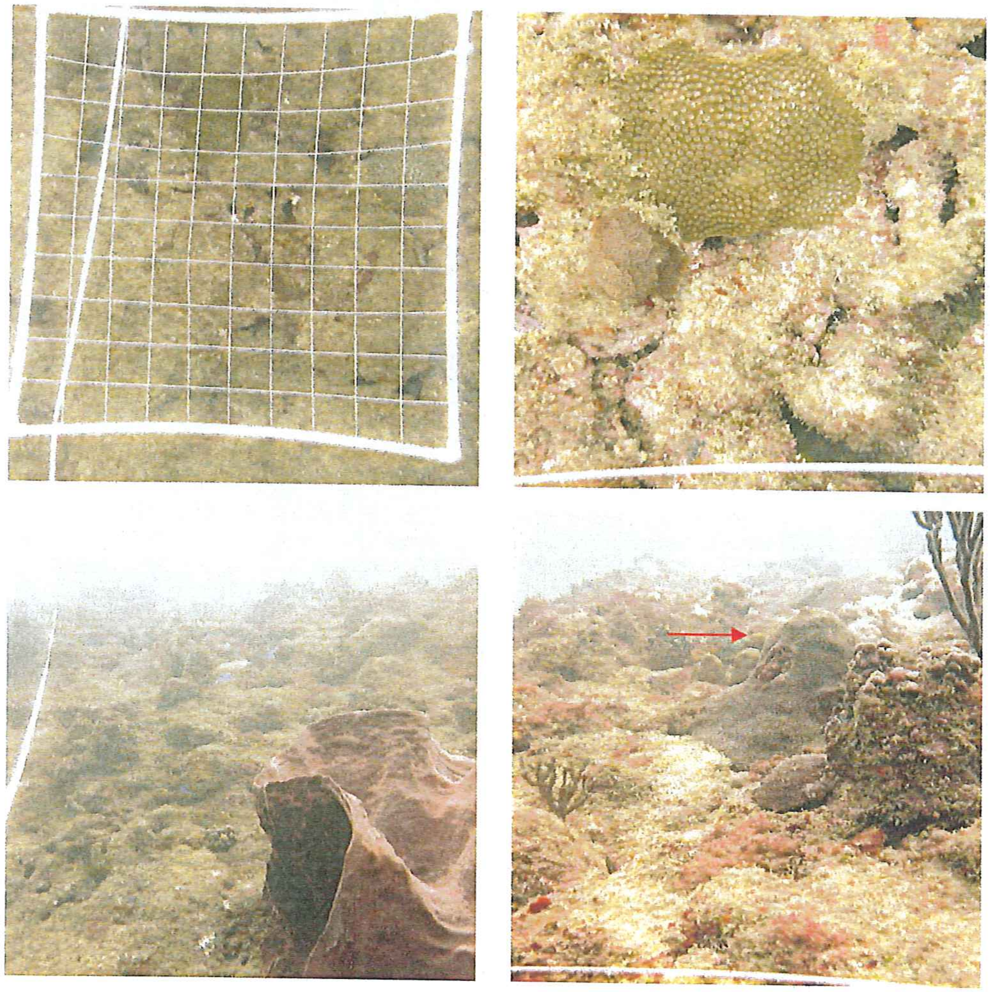



Figure 9. Deep reef (stations 21-22).

Station 21



Orbicella faveolata

Station 22

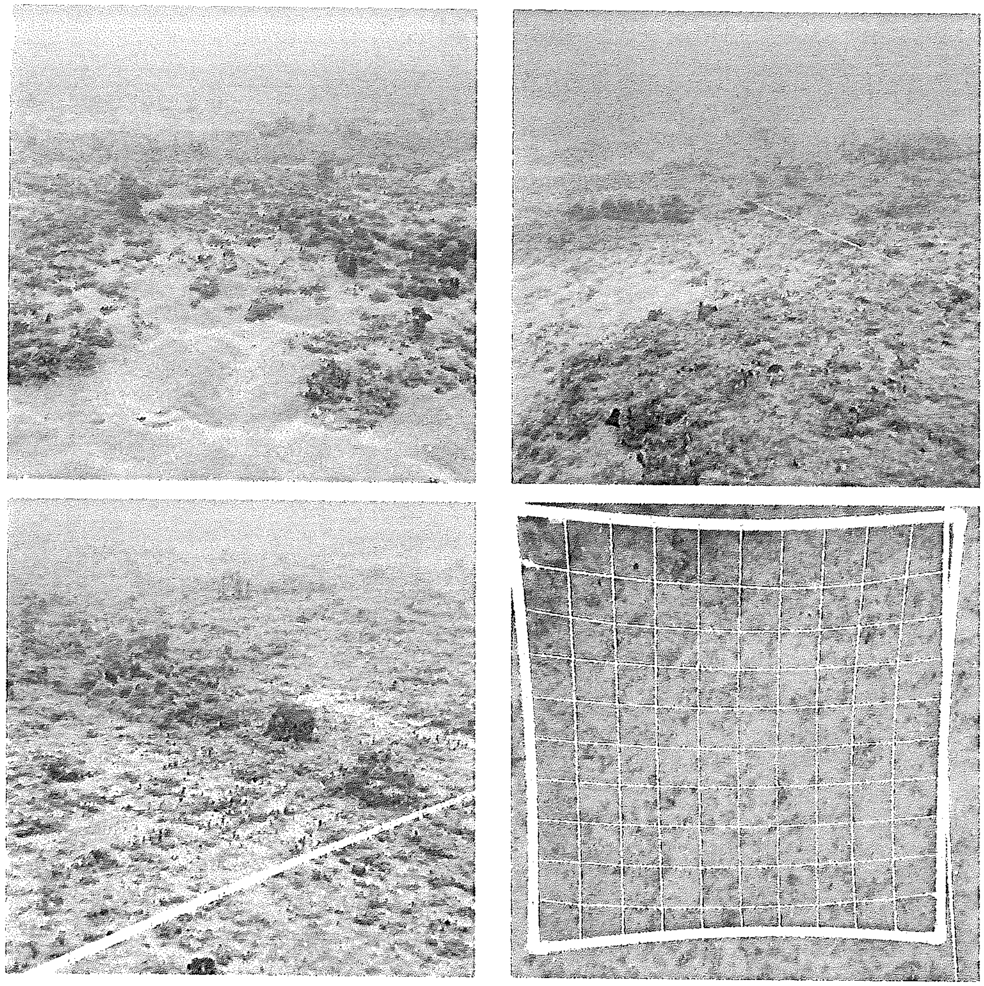
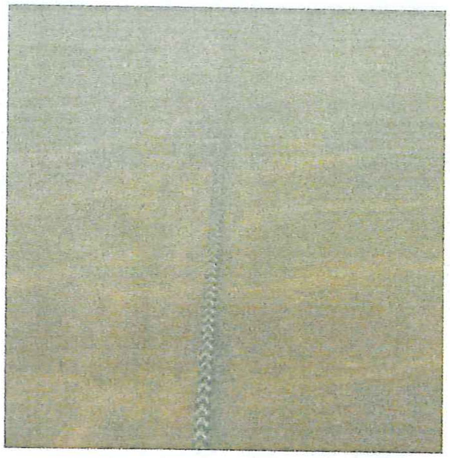
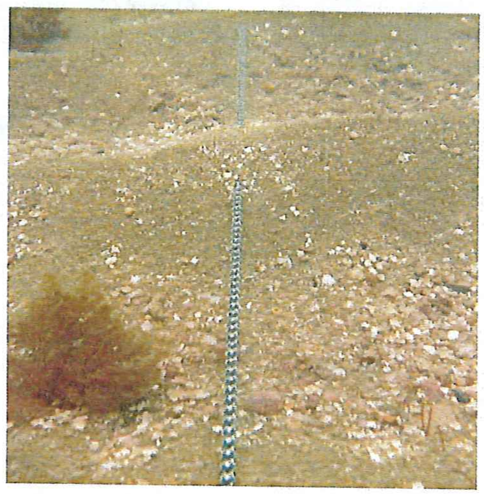


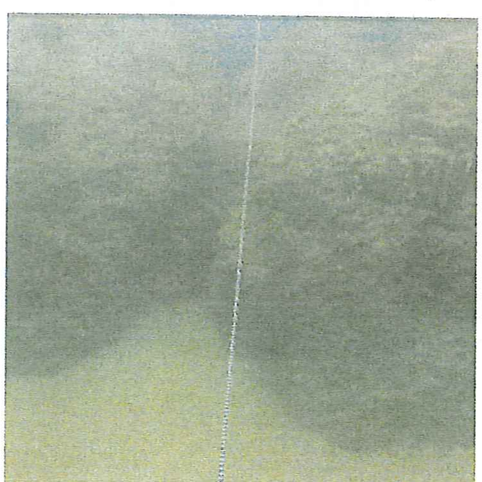
Figure 10. Along route.

Sand, KP 0.116-0.778

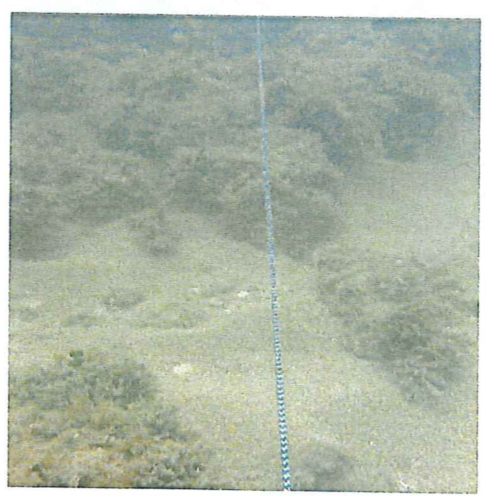


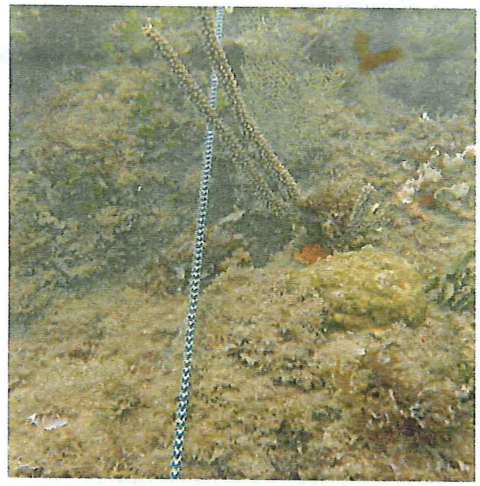
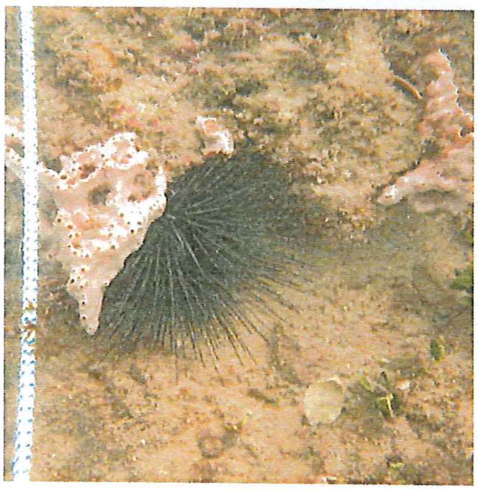


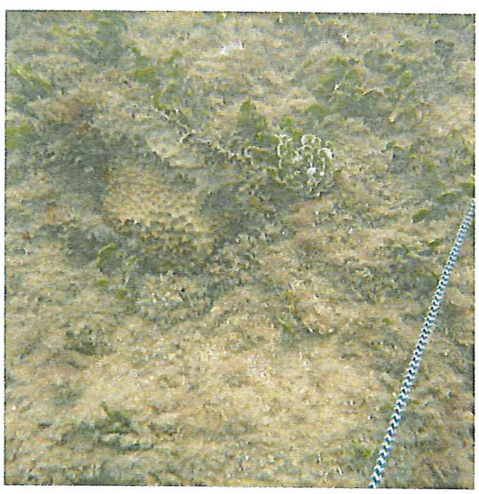
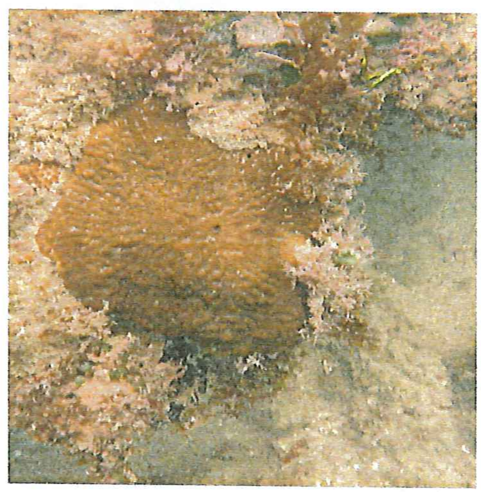
IVRMR, KP 0.778-0.988

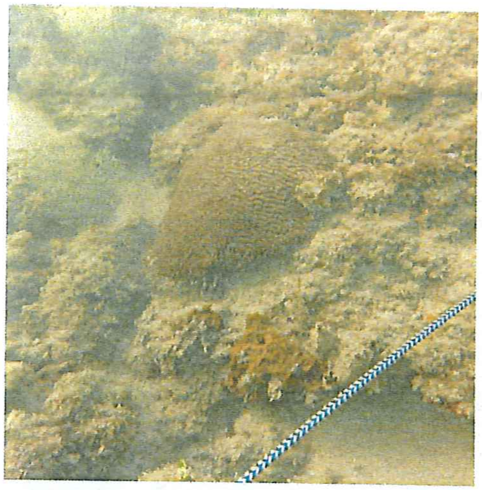


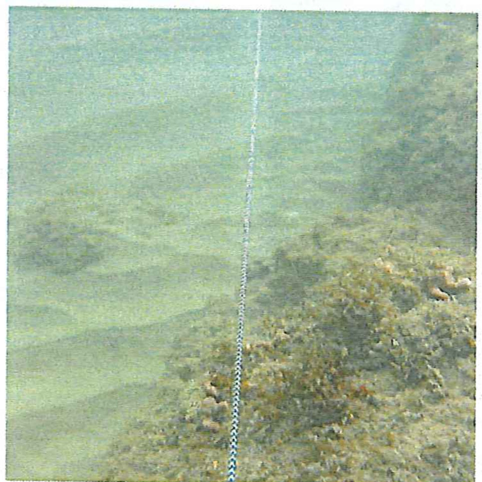
Start of the hardbottom in the IVRMR



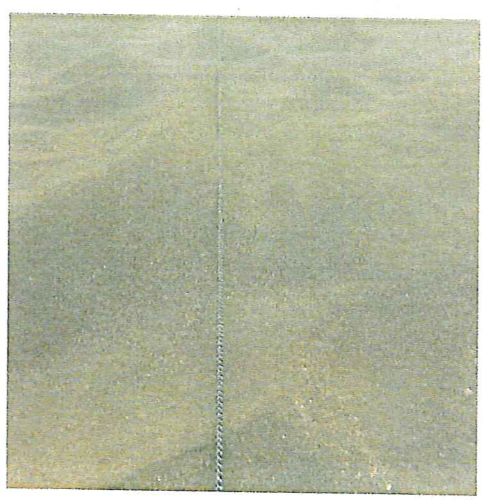





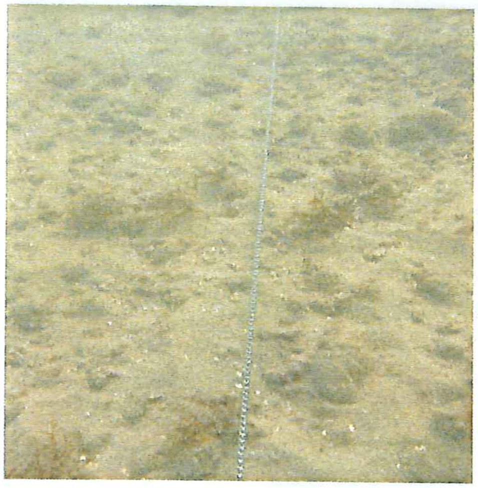


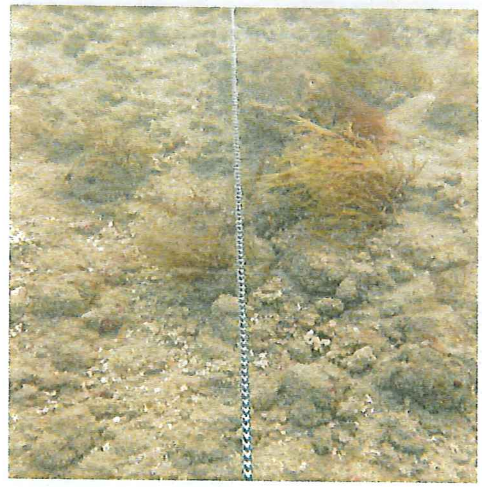
End of hardbottom at the IVRMR

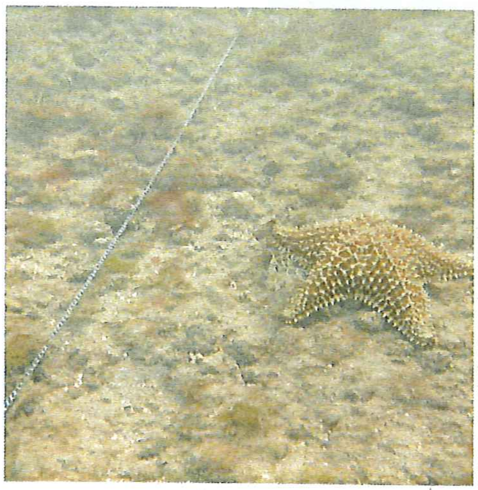
Sand, KP 0.989-1.599

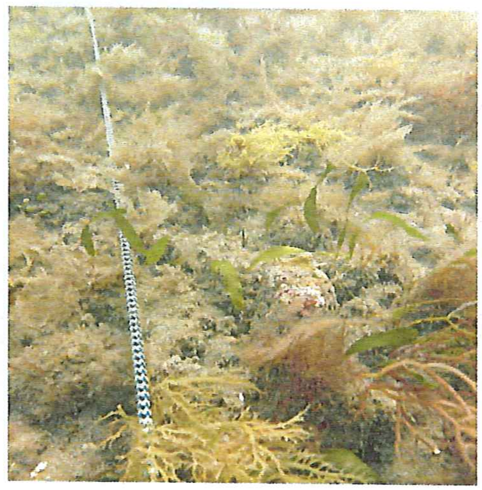


Algal Rhodolith, KP1.599-2.113

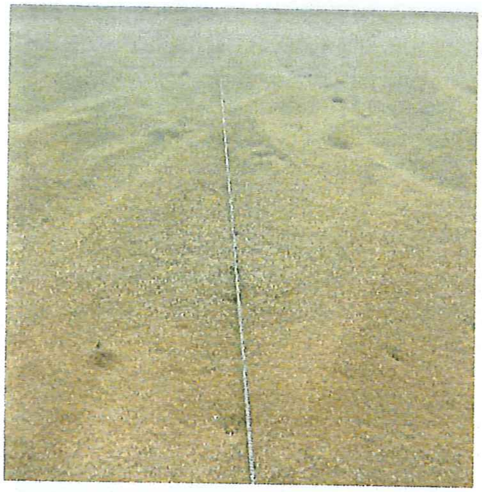
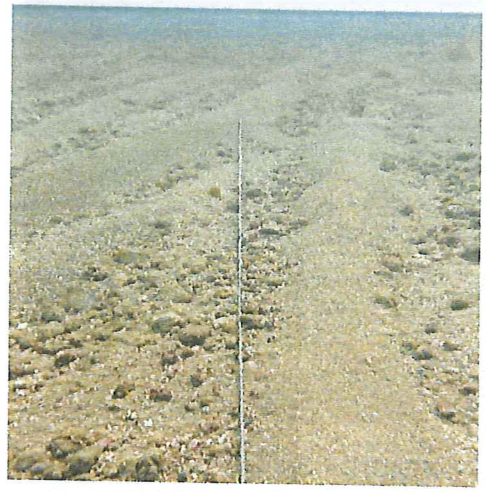
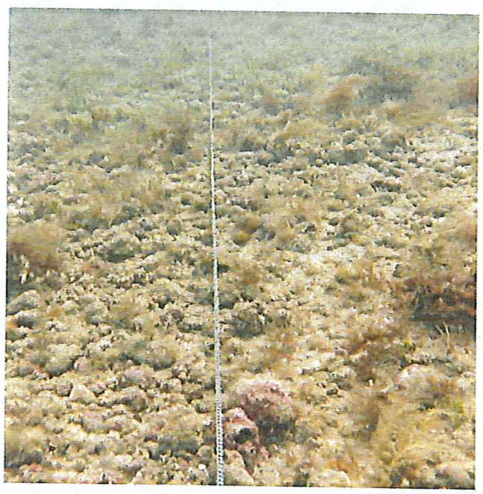


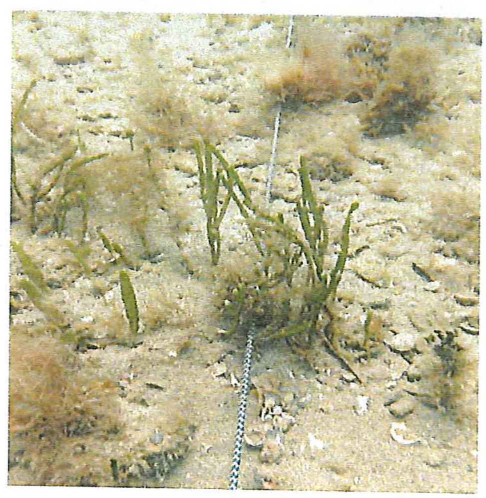


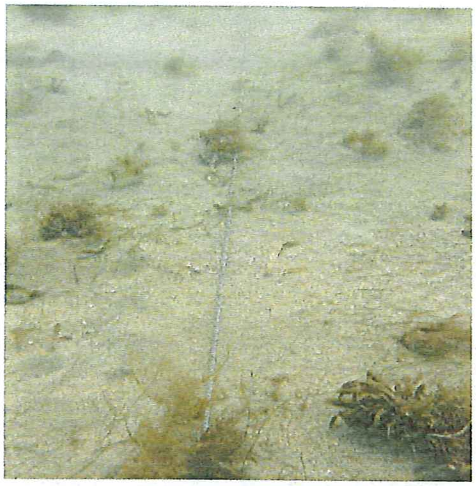
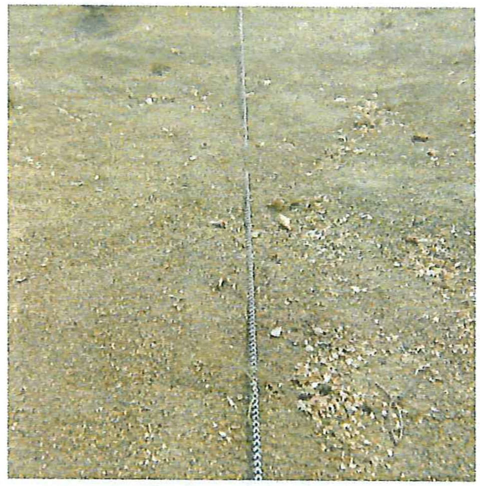


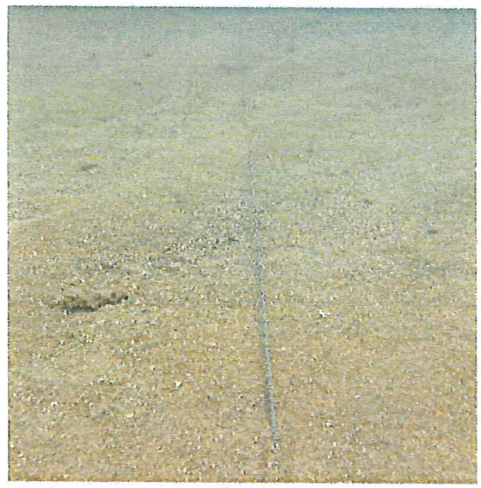


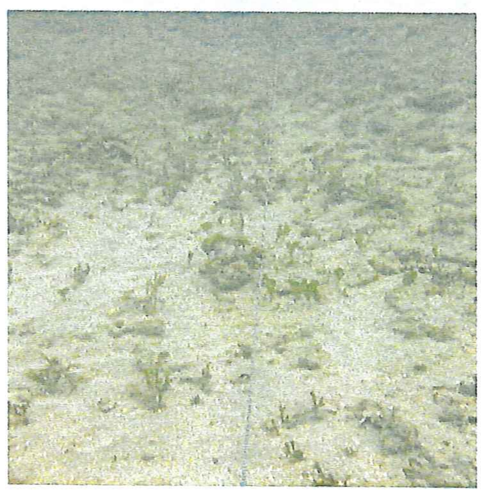
Mixed, KP 2.113-2.715

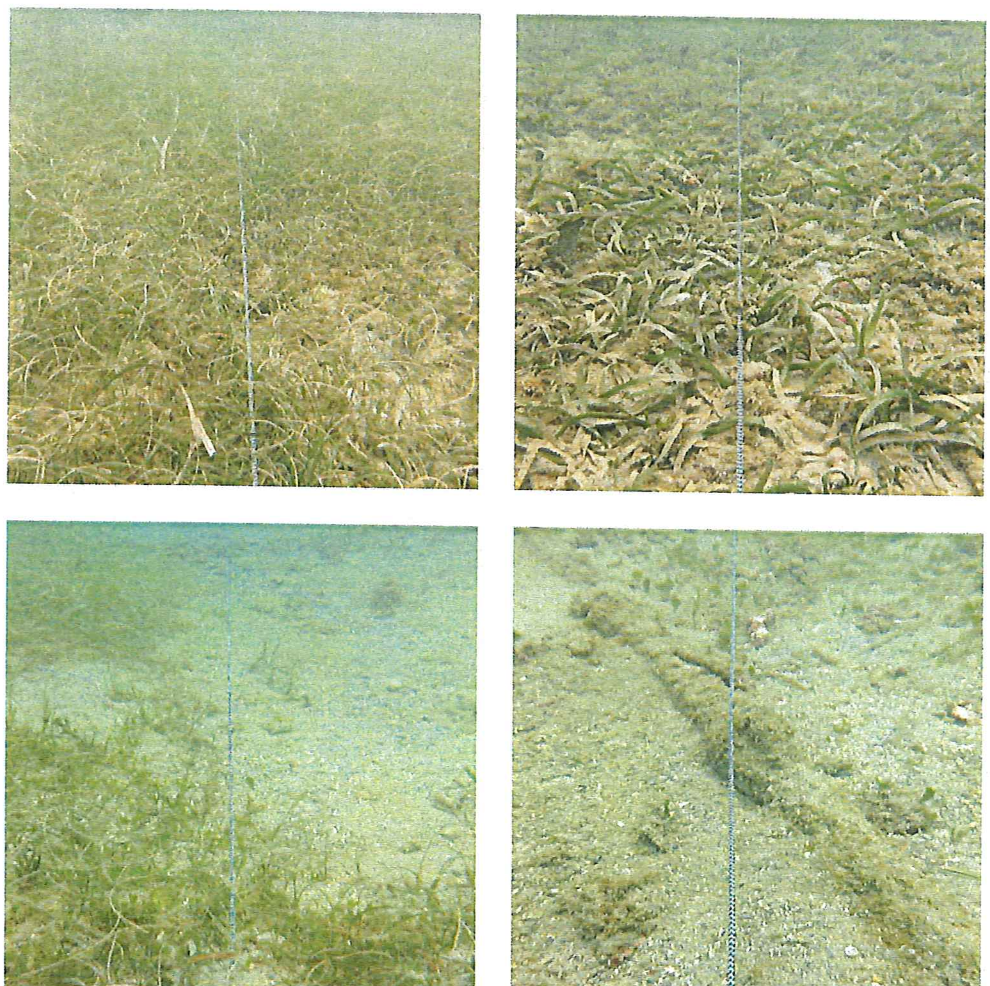



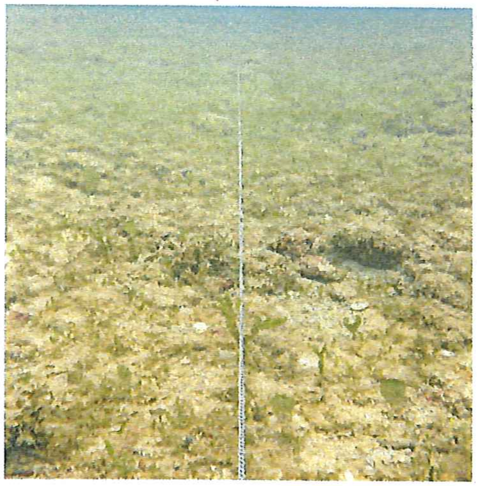


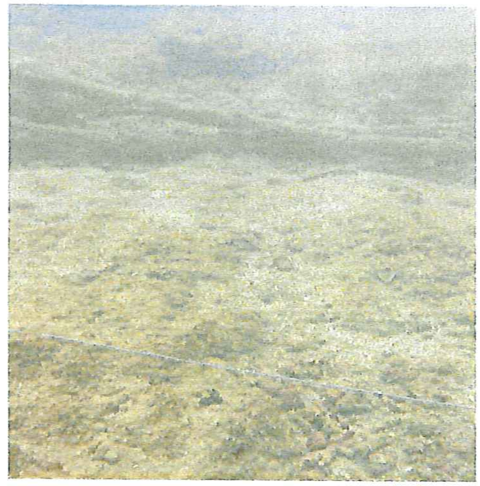


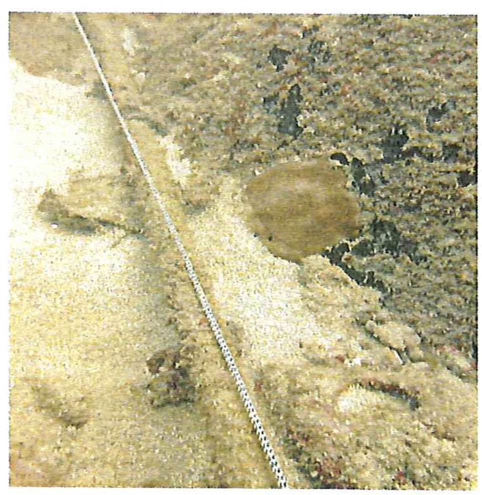
Seagrass, KP 2.715-2.824

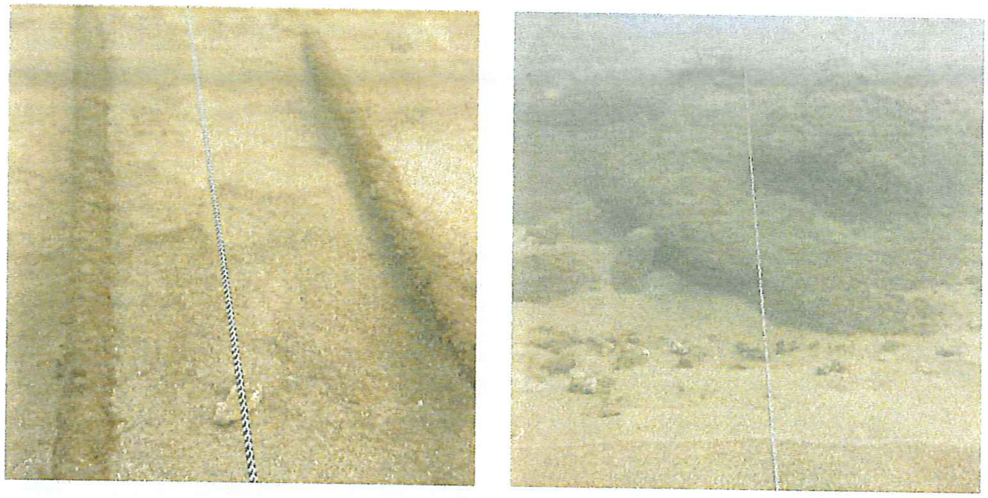


Reef Gap, KP 2.824-3.264

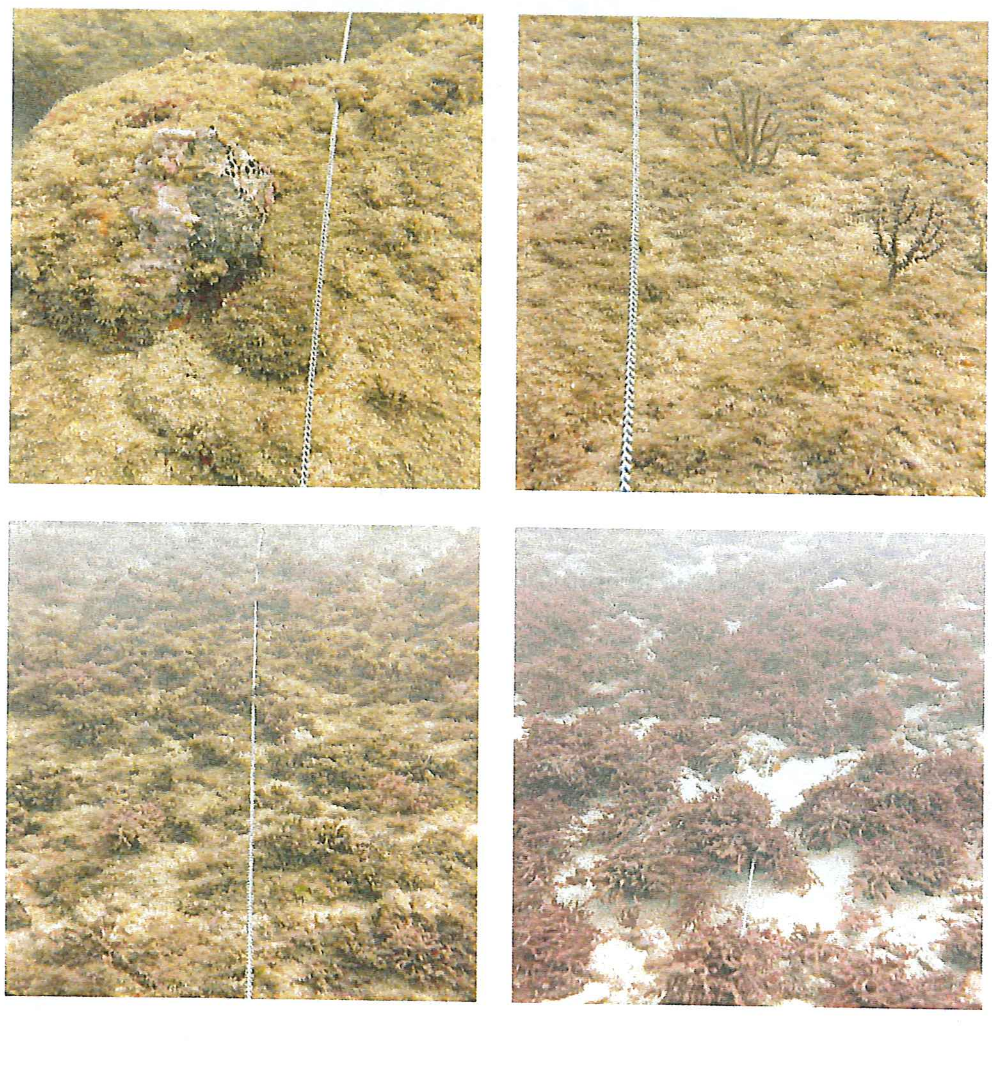




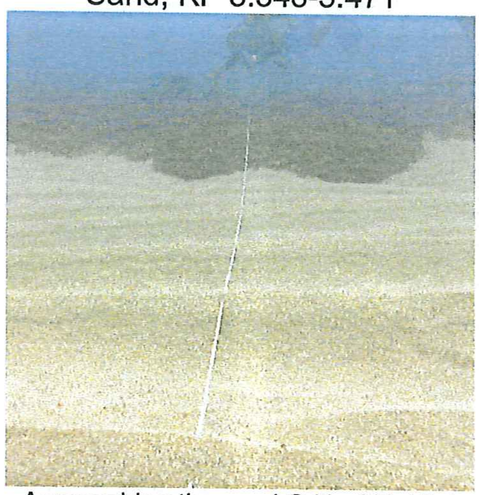




North of Reef Gap, KP 3.264-3.348

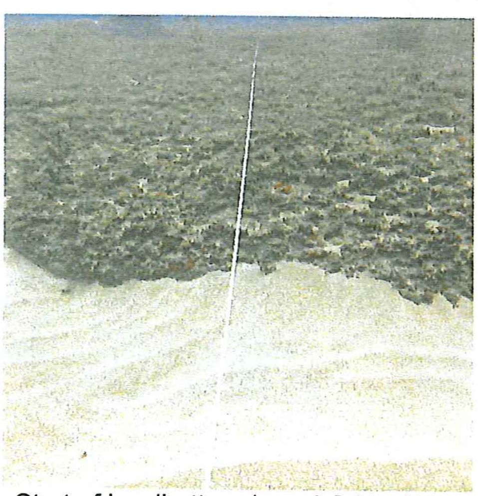


Sand, KP 3.348-3.471

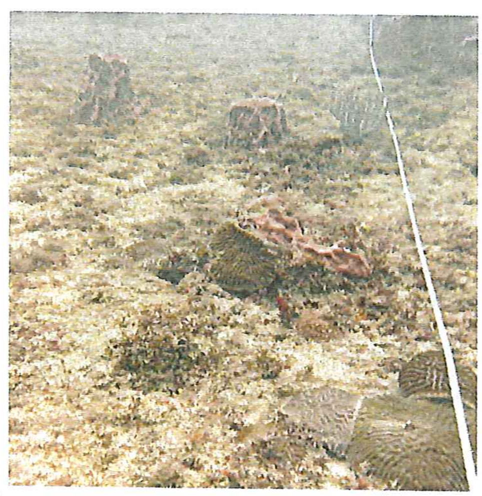


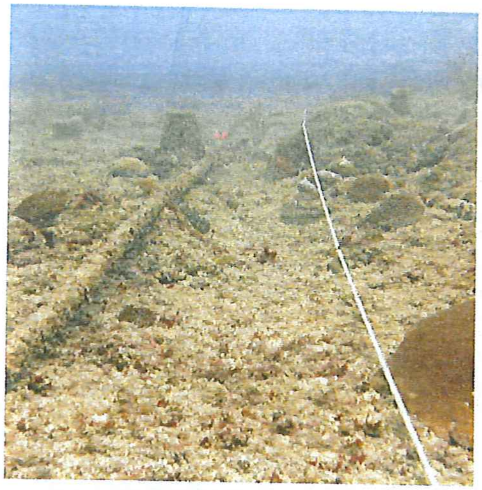
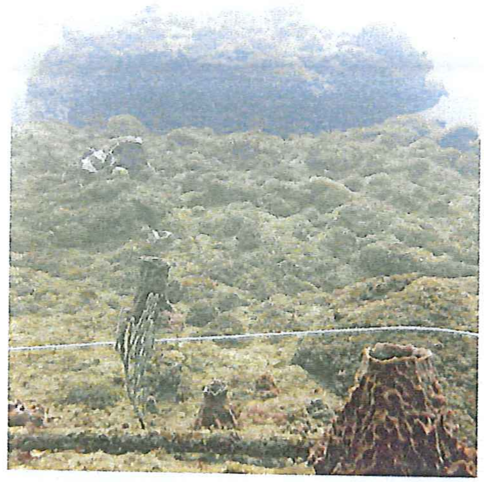
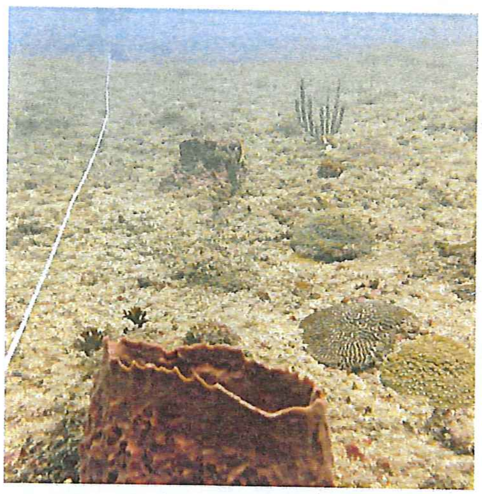
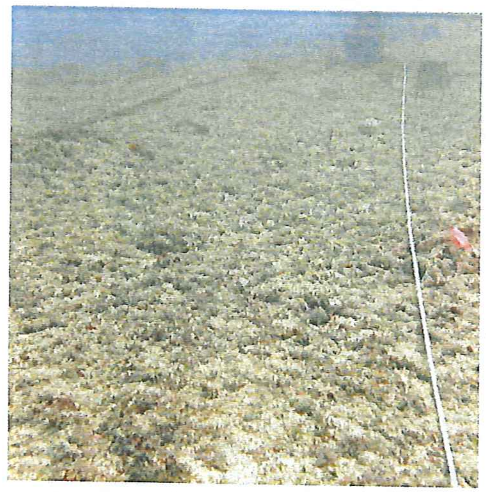
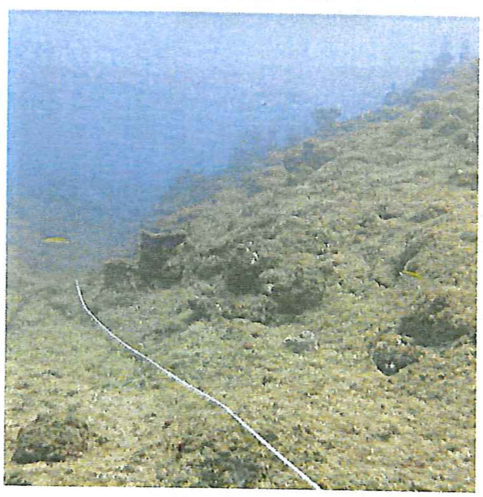
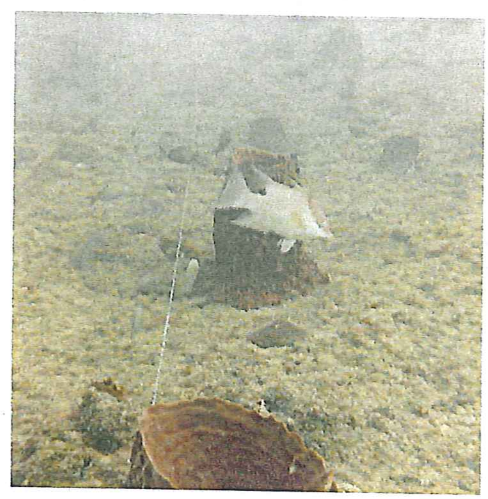
Approaching the coral Critical Habitat

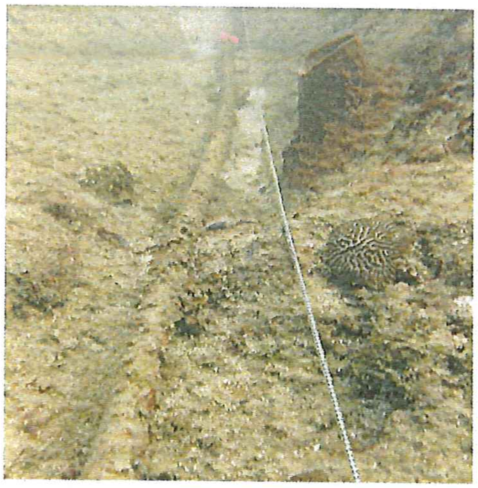
Critical Habitat, KP 3.471-3.839

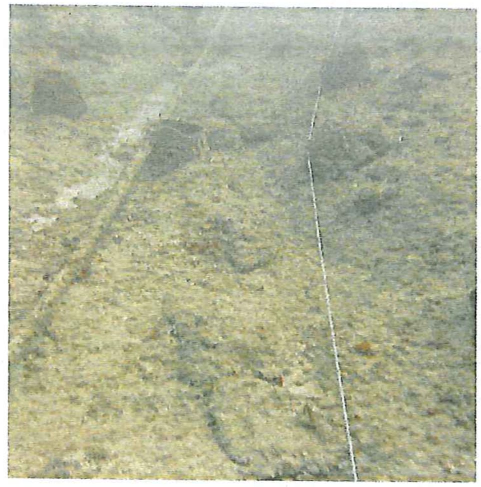


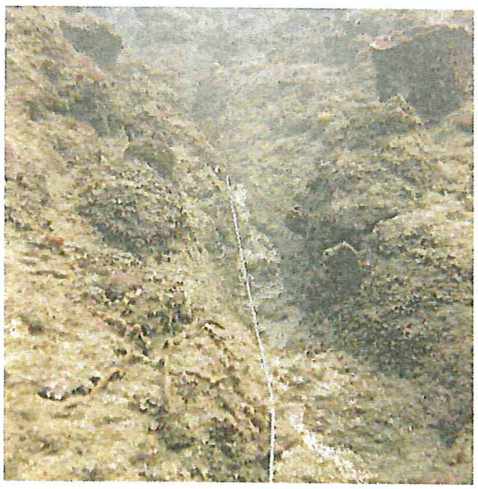
Start of hardbottom / coral Critical Habitat

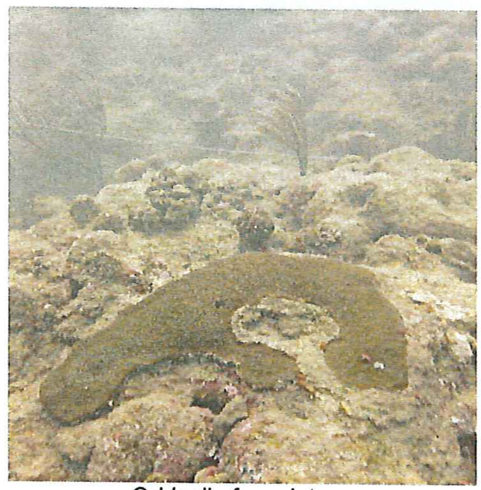










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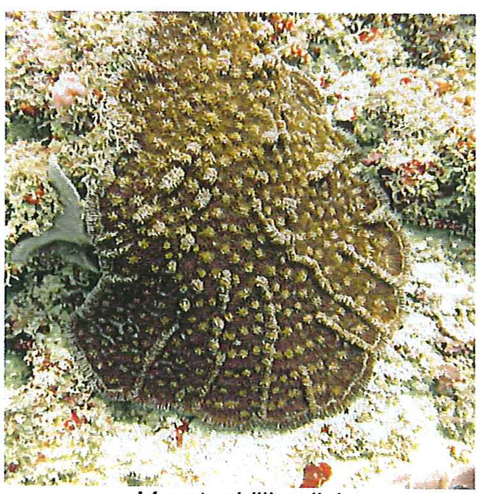
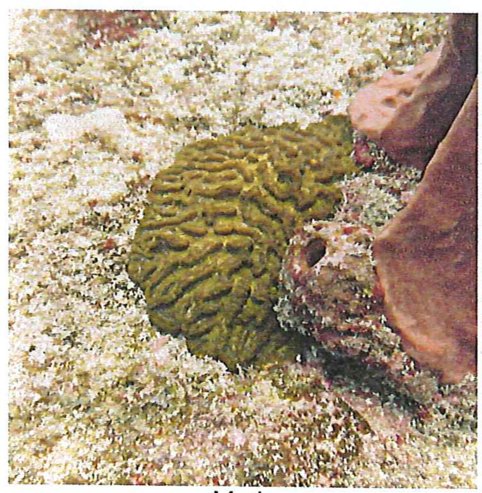
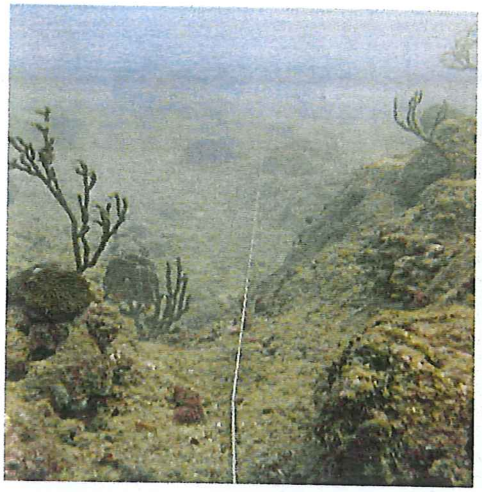
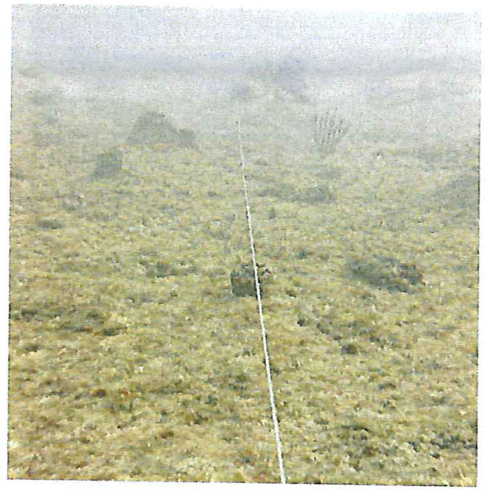


Mycetophillia aliciae



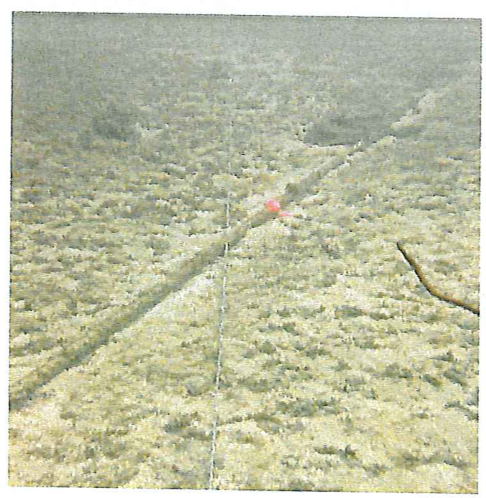
M. danaana

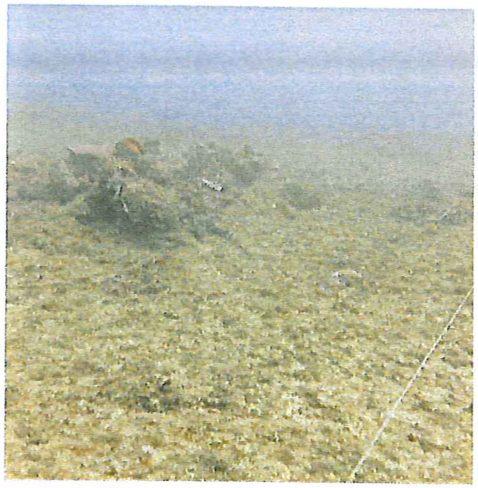
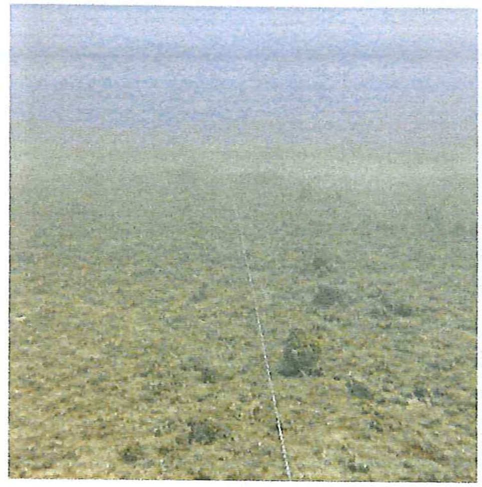
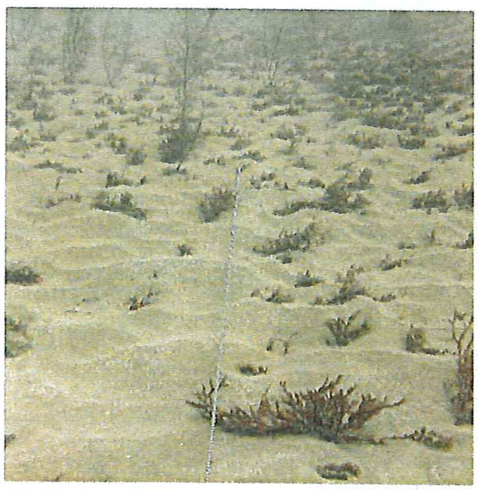


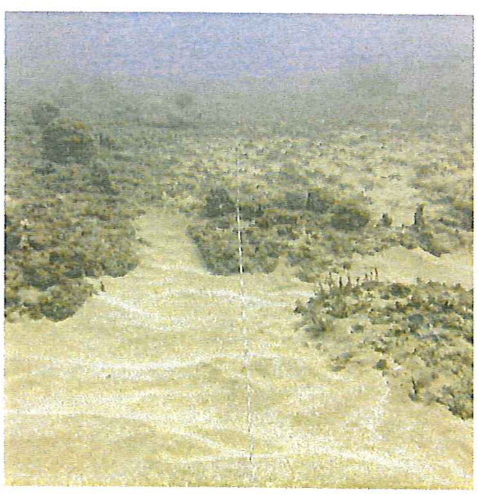
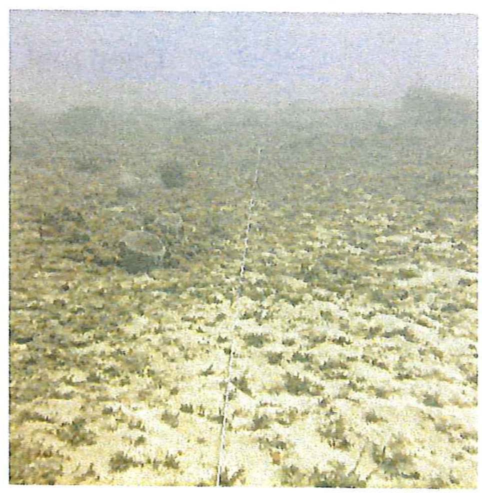


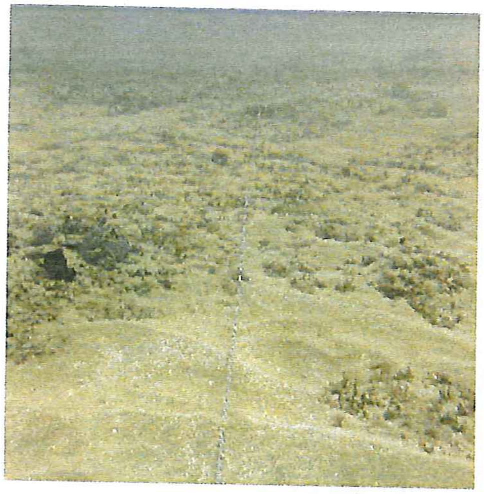
Edge of coral Critical Habitat

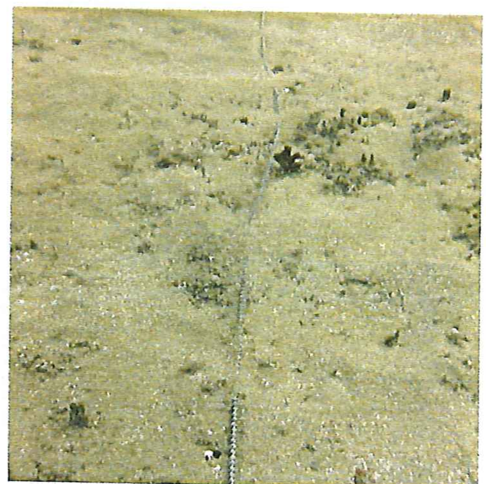
Deep reef, 3.839-4.046





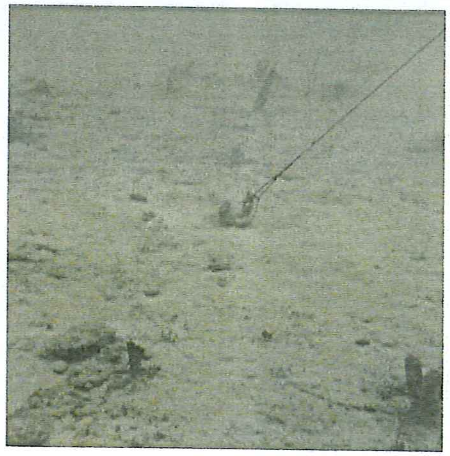



End of survey

Figure 11. Drift dive over Station 22.

Figure 12. Sites for placement of temporary SWIV anchors.

Site # 2



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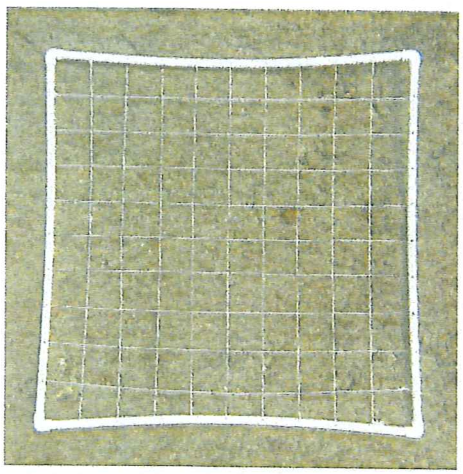

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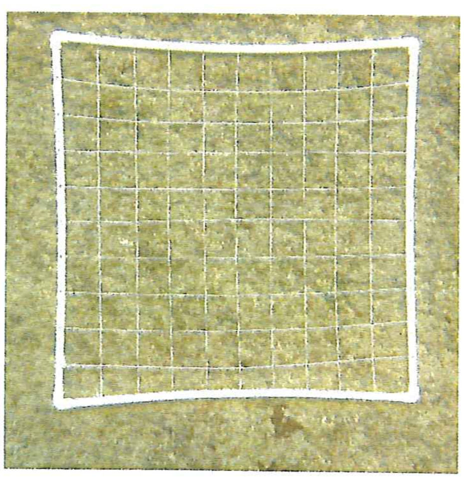

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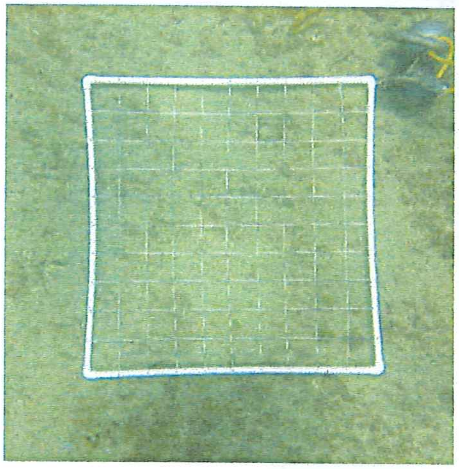

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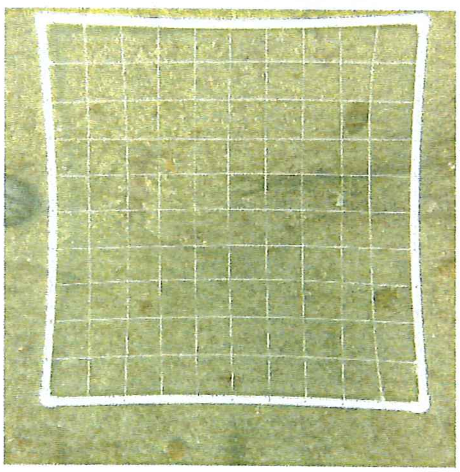

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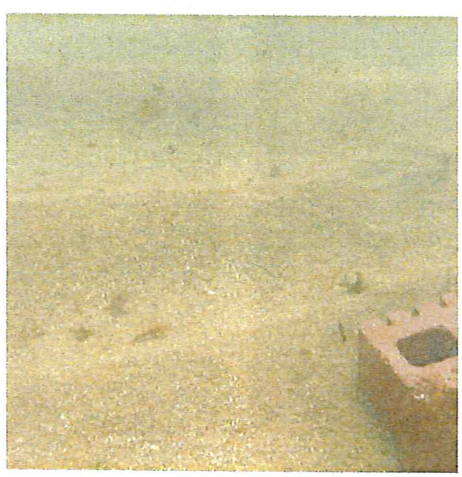

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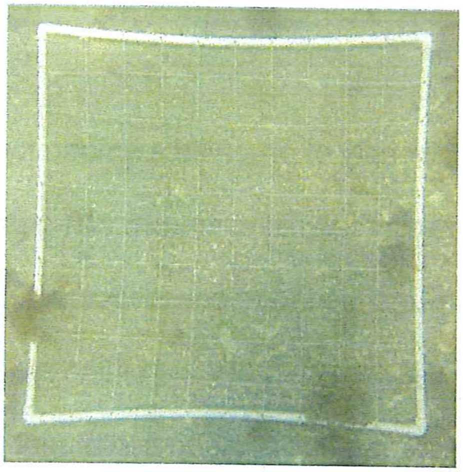

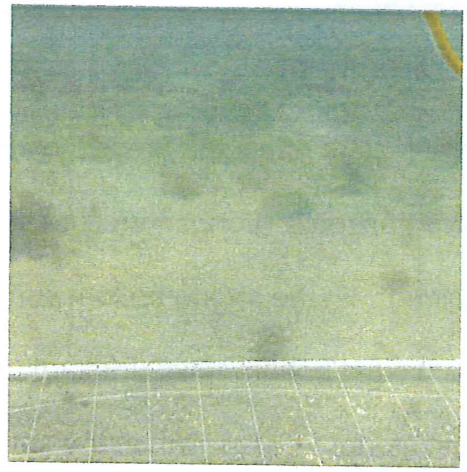

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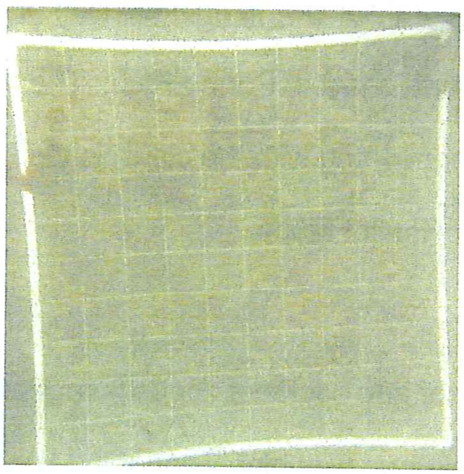

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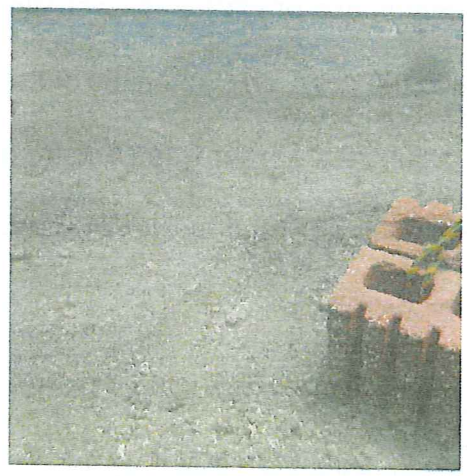

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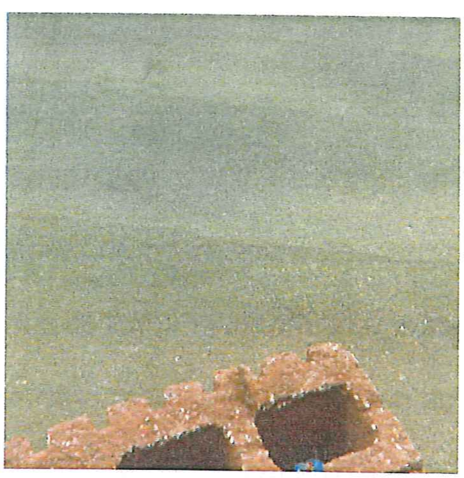

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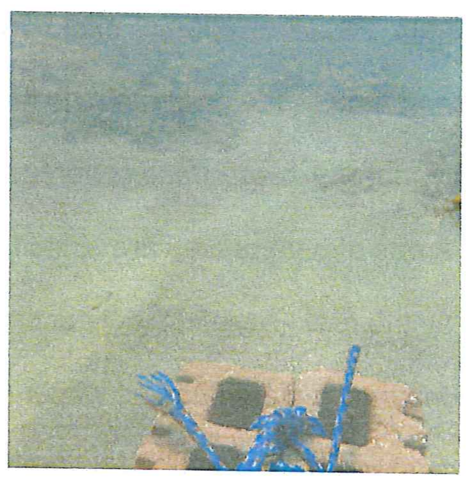

DISCUSSION

Physical environment

Several factors affect the presence and diversity of organisms among the representative transects. Longshore currents move material westward along the coast, which, combined with the strong bottom surge, removes the unconsolidated sediments and exposes the flat bottom relief (Pickard and Emery 1990). Wave action removes suitable substrate for algal growth in the sandy areas and limits the settlement of seagrasses and coral species.

The dominance of plate and encrusting coral species is an indication of the high energy level in the area, characteristic of the north coast of Puerto Rico. The continuity of the hard ground linear reef was confirmed, concurring with the classification of the habitats and zones provided by NOAA Benthic Habitat Maps.

Marine communities

The macroalgal community of the forereef and backreef zones is resilient to physical impact. Substrate cover by this biotic group was highly variable. High energy arriving from the Atlantic Ocean is known to scour the seafloor leaving hardbottom devoid of algae. Recolonization of those areas by green, red and brown algal species occur in a short time frame given its high growth rate.

High variability in seagrass coverage is an indication of two major conditions. High cover areas of seagrasses are limited, permanent, well defined and protected from high surge by the reef. Areas of low density, emergent shoots or small size may be subject to seasonal factors such as winter surge produced by northern cold fronts arriving during November-March and storms generated during the hurricane season (i.e., July-November). *Halophila decipiens* is highly affected by the latter factors while *S. filiforme* and *T. testudinum* are more resistant.

Coral community covering the hardbottom of the forereef and the deep reef produced the highest relative abundances and diversity of soft and hard corals. Low cover percentage of both coral groups corresponds with data from other similar surveys in Puerto Rico for submarine cable projects (Rivera 2011, 2013) and the general status of coral communities in the Caribbean (Cortés 2003, Wilkinson and Souter 2008).

Commercially important, ornamental and other reef and reef-associated fish species were observed mainly in the reef and forereef zones showing different life history phases. Higher fish abundance in these two zones is explained by the behavior and habitat preference of fishes to areas where food and refuge is present. These fishes are intrinsically attached to the hardbottom community for the major part of their life span.

The project could impact vegetation and sessile organisms in the above-mentioned communities, such as sponges, soft and hard corals, and other macroinvertebrates. However, the impact would be limited and/or minimize due to the quick recovery of algae and seagrass, flexibility and low cover of the gorgonians, the size and growth morphology in most of the hard corals and the use of cable stabilization hardware. Also, because of the low coverage and scattered distribution of hard corals, they can be avoided by the cable routing and during installation.

Linear communication and power cable utilities pose an initial direct impact over a very limited area due to the narrow footprint. In some instances cable repair is necessary, which may lead to additional impacts (USFWS 2004). Secondary indirect and cumulative impact can be avoided by stabilizing the cable to the seafloor.

ESA coral species

Coral species *Acropora palmata* and *A. cervicornis* were not observed on the survey stations or along the proposed route. Typical *A. palmata* habitat (i.e., reef crest) was not crossed by the cable alignment.

Orbicella faveolata is found in the Wider Caribbean region (i.e., Caribbean, Florida and Bermuda) inhabiting most reef environments. The depth range of *O. faveolata* is 20-130 ft, predominantly 20-75 ft, but it was mostly found in the shallow waters at both sides of the Reef Gap.

None of the recorded ESA corals in the critical habitat were found either at the center of any of the route stations (i.e., zero point) or in contact with the leaded line along the cable routes thus those colonies will be protected by keeping a significant separation from the cable and by installing suggested cable clamps. The planned cable route avoids the observed species in stations 17-18. Those colonies were located in the reef, east and west, of the navigation channel (i.e., reef gap).

Essential Fish Habitat and coral Critical Habitat

Estimated direct unavoidable impact by the cable footprint within surveyed EFH and CH will be low in said areas. Indirect impact can be minimized if cable is stabilized by installing cable clamps directly to the cable or by encasing it in protective articulated (i.e., armored) pipe. This measure represents two benefits. First, preventing lateral movement, principally under extreme marine conditions (e.g., hurricanes, winter storm surge) avoids impacts to neighboring benthic organisms. Secondly, protection extends the service life of the cable and significantly lowers the probability of a cable break and further replacement.

Route alternatives

Linear communication and power cable projects usually have a small impact footprint, especially as proposed for BRUSA, which does not propose burial or dredging. Impact avoidance and minimization is usually achieved by designating a lower coral density corridor, and requiring either diver directed deployment or cable adjustment around corals immediately following deployment (USFWS 2004). The first alternative was successfully implemented during the RPL swim survey and the latter has been demonstrated in recent cable installations (e.g., AMX, PCCS). Both alternatives revealed feasible and environmentally positive ways to avoid impact to the coral community of the deep reef.

The drift dive over station 22 allowed to confirm that the proposed route minimize the impact to deep habitat. This action does not eliminate the permanent direct impact on EFH but avoids impacting organisms in rocky outcrops. Cable movement over the deep hard substrate is not expected. Monitoring of other cable systems revealed no cable movement at depths over 85 ft (Rivera 2007a, 2007b).

Use of temporary anchors

Lack of substrate relief and absence or very low or low cover by benthic organisms at selected sandy and colonized locations provide a favorable setting for the use of temporary anchors for the SWIV and hold back for the cable. The algal community in the backreef and the forereef is directly exposed and subject to the seasonal natural impact caused by high energy wave action during the hurricane season and winter storm surge resulting in a significant reduction of cover by algae (Rivera 2007a, 2007c, 2008, 2009a, 2009b). However a complete recovery of the species shall occur in a short time frame.

The availability of very low cover or free substrate by sponges and corals within the areas of the surveyed hardbottom locations in the reef and forereef shall facilitate the installation of temporary anchors. Low cover percentage by sponges and both coral groups simplified the installation of temporary anchors during a cable repair project (Rivera 2008). The use of a bolted steel plate at Site 7 will avoid potential impacts by towing a sand bag over a long stretch of shallow sensitive habitat.

Use of the proposed offshore sand borrow filling area avoids or minimize the distance to transit in the Reef Gap thus avoiding and potentially minimizing impacts to by shallow water habitat bordering the channel where ESA corals were documented.

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Attachment B
2013 Final Report: Benthic Habitat Mapping and Mesophotic Coral Survey – PCCS Route Segments 2 and 2a

Final Report
Benthic Habitat Mapping and Mesophotic Coral Survey

Pacific Caribbean Cable System
Cable Route Segments 2 and 2A

PCCS
Pacific Caribbean Cable System

Prepared for:

Alcatel·Lucent

ALCATEL-LUCENT SUBMARINE NETWORKS
Marine Operations
Christchurch Way
Greenwich
London, SE10 0AG England
United Kingdom

Prepared by:

TETRA TECH

19803 North Creek Parkway
Bothell, WA 98011

November 2013

Final Report
Benthic Habitat Mapping and Mesophotic Coral Survey

Pacific Caribbean Cable System

PCCS
Pacific Caribbean Cable System

Cable Route Segments 2 and 2A

Prepared for:

Alcatel·Lucent

ALCATEL-LUCENT SUBMARINE NETWORKS
Marine Operations
Christchurch Way
Greenwich
London, SE10 0AG England
United Kingdom

Prepared by:

TETRA TECH

19803 North Creek Parkway
Bothell, WA 98011

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Rev	Date	Description	Prepared by	Checked by	Approved by
0	4 /11/ 2013	Preliminary	Jorge R. García Sais, Ph. D. Stacey M. Williams, Ph. D. David B. Hericks	D. Hericks	
1	27/11/2013	Final	Jorge R. García Sais, Ph. D. Stacey M. Williams, Ph. D. David B. Hericks	D. Hericks	Jorge R. García Sais, Ph. D.

Executive Summary

Tetra Tech conducted a video and photographic benthic habitat survey on two segments of the planned Pacific Caribbean Cable System (PCCS) cable route in Puerto Rico and the U.S. Virgin Islands (USVI) between 28 August and 21 September, 2013. PCCS segment 2A (PCCS 2A), located off Boca de Cangrejos on the northeast coast of Puerto Rico, was surveyed in water depths ranging from 102 to 24 meters from kilometer point (KP) 151.456 to KP 155.113 respectively. Segment 2 (PCCS 2), located off the southern coast of St. John, USVI, was surveyed in water depths ranging from 36 to 72 meters from KP 19.901 to KP 36.942.

The primary survey objective was to characterize the benthic habitat along the planned route in water depths ranging from 25 to 100 meters, utilizing underwater video and still photography collected with a towed camera system and remotely operated vehicle. The survey work was conducted as proposed by Alcatel-Lucent Submarine Networks (ASN) in the Proposed Mesophotic Habitat Mapping Scope submitted to National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) and the U.S. Army Corps of Engineers (USACE) on 3 September, 2013. (Bioimpact, Inc., 2013)

Data on benthic habitats and associated mesophotic communities were produced from the analyses of continuous geo-referenced videos and digital photos of the seafloor along the planned cable route. In addition to the habitat mapping, a general taxonomic inventory of benthic species composition has been compiled and a quantitative assessment of the percent cover by substrate categories on hard ground habitats has been performed. The quantitative assessment has been undertaken with particular attention to the occurrence of listed and/or proposed Endangered Species Act (ESA) coral species: *Acropora palmata, A. cervicornis, Montastraea annularis, M. faveolata, M. franksi, Agaricia lamarcki, Mycetophyllia ferox, Dendrogyra cylindrus,* and black corals *(Antipatharia)*.

Thirty-one to ninety-three still photos were analyzed from the various habitat types along the entire route using Coral Point Count software. Tabular data are presented as:

1) Mean percent cover by transition/linear habitat segment. CPCe results of species within each contiguous habitat type segment/transition, along the route.

2) Mean percent cover by habitat type/substrate category. Combined mean of CPCe percent cover for all species identified within all segments of the same habitat/substrate type along each route.

3) A comprehensive list of all invertebrate species identified in each habitat type on each route (observed in any video/photographs viewed, but not necessarily found or selected by randomization in a CPCe analyzed photo).

Benthic habitats along the PCCS 2A route included patch reefs (PRF), colonized pavement (CPV), sand (SND), and sand with scattered rocks (SWS). A flat, discontinuous hard ground platform, or colonized pavement (CPV) habitat transitioned from the sandy substrate at a depth of 21.63 m (KP 155.113). Benthic algae were the most prominent component of the CPV habitat with a mean cover of 64.5percent. Sand pockets within the CPV comprised the other main substrate category, representing 25.8percent of the total CPV cover. Scleractinian corals were not observed at densities that approached 10 percent anywhere within the CPV habitat. Four species were present, including small, isolated colonies of *M. franksi*. Of particular relevance was the occurrence of feather black coral, *Antipathes pennacea* at a depth of 34.3 m (KP 154.28 – KP 154.22) within the CPV habitat, presenting a maximum substrate cover of 1.2 percent. Sand (SND) and sand with scattered rocks (SWS) represented the most extensive benthic habitats along route PCCS 2A. SND was more than 99% abiotic, whereas benthic algae and sponges comprised minor components of the available hard ground at the SWS habitat.

Patch reefs were observed from KP 154.661 at a depth of 28.79 meters to KP 154.513 at a depth of 29.78 meters as a discontinuous set of rock promontories rising from a sandy bottom. Benthic algae were the main biological agent colonizing the PRF habitat with a mean cover of 29.3 percent. Sandy sediments comprised the other main substrate category of the PRF habitat with a mean cover of 70.1 percent. Scleractinian corals were represented by seven species, typically growing as isolated encrusting colonies of relatively small size and providing minor contributions to the reef topographic relief.

The PCCS 2 segment South of St. John featured three main benthic habitat types that occurred as single segments/transitions along the route: bank coral reef (BCR), colonized rhodolith reef (CRR), and PRF. A bank coral reef system was present at the shallower eastern end of the survey area at a depth of 35.8 meters (KP 19.901). This reef extended to the west- southwest along the St. John outer shelf down to a depth of 44.9 meters atKP 20.69. Live coral was the dominant benthic invertebrate in terms of reef substrate cover with a mean of 36.8 percent in the BCR, largely driven by *Montastraea franksi*, which represented 96.7 percent of the total scleractinian coral cover. Seven other coral species were identified from the BCR, including *Agaricia lamarki*. Reef hard ground spaces not colonized by live corals were mostly covered by benthic macroalgae (mean: 54.7 percent). Below 48.0 meters depth (KP 20.832) the bank reef transitioned into a sandy bottom with crustose algal nodules, or rhodoliths. As rhodoliths become motionless, they are colonized by turf, fleshy and coralline macroalgae, sponges, corals and other encrusting biota forming a low relief reef habitat, or CRR.

At least 29 sponges and 15 coral species were recognized from photos taken at the CRR. Scleractinian corals were observed throughout the CRR habitat, including proposed ESA species *M. franksi* and *A. lamarki*. Colonies were typically observed as isolated colonies of variable sizes. Some colonies of *A. lamarki* and other lettuce corals (*Agaricia* spp.) were observed to reach substantial horizontal (1 meter) and vertical dimensions (0.5 meter), contributing markedly to the reef topographic relief. Still, reef substrate cover was below 1 percent for all each coral species, including *M. franksi* and *A. lamarki*. The combined mean substrate cover by scleractinian corals at the CRR was 2.2 percent. Live coral colonies were observed at the CRR down to 58.4 meters. Sponges were observed as small encrusting types, but several branching forms of *Agelas* spp. and *Aplysina* spp. and erect forms of giant barrel sponge, *Xestospongia muta*, were present. Overall, sponges constituted a minor component of the CRR benthos with a combined mean substrate cover of 0.5 percent.

At KP 36.79, the CRR transitioned into a sandy area with interspersed rock outcrops, or PRF. These were small mound shaped structures colonized by macroalgae and some corals. Macroalgae (53.8 percent) and abiotic/sand (40.7 percent) composed the main benthic categories at the PRF habitat. Scleractinian corals were represented by three species, including *M. franksi* with a combined mean substrate cover of 1.8 percent. A narrow, sandy ridge with some rock outcrops was observed at the shelf-edge. The survey ended at the shelf-edge, where it breaks abruptly into a steep wall at a depth of 71.5 meters (KP 36.959).

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Acronyms and Abbreviations

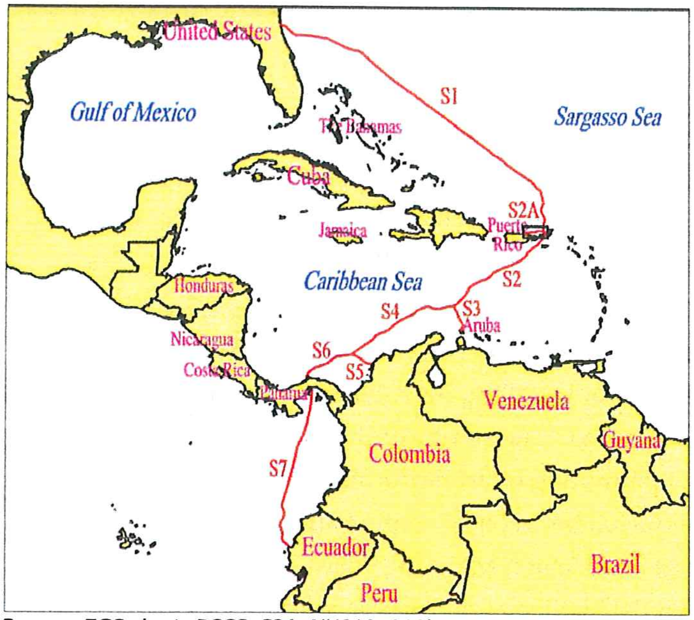
ASCII	American Standard Code for Information Interchange
ASN	Alcatel-Lucent Submarine Networks
BA	Biological Assessment
BVI	British Virgin Islands
CPCe	Coral Point Count
CRR	colonized rhodolith reef
DGPS	Differential Global Positioning System
ESA	Endangered Species Act
GAPS	Global Acoustic Positioning System
GIS	geographic information system
GNSS	Global Navigation Satellite System
HD	high definition
INS	inertial navigation system
km	kilometer
MACx	Mid-Atlantic Crossing Extension
MB	megabyte
MCD	Marine Conservation District Reef
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries Service
PCCS	Pacific Caribbean Cable System
PRF	patch reefs
R/V	Research Vessel
ROV	remotely operated vehicle
RPL	Route Position List
RTK	Real-Time Kinematic
SND	sandy bottom
SWR	sand with scattered rocks
TCS	towed camera system
USBL	ultra-short baseline
USVI	U.S. Virgin Islands
UTC	Universal Coordinated Time

1. Introduction

Tetra Tech, Inc. (Tetra Tech) was contracted by Alcatel-Lucent Submarine Networks (ASN) to conduct benthic habitat mapping with an emphasis on identifying specific mesophotic coral species along the planned Pacific Caribbean Cable System (PCCS) route. Two of the PCCS cable route segments will pass through the U.S. territorial sea and are likely to have mesophotic corals in the 25- to 100-meter depth range. Segment 2A will run from Tortola, British Virgin Islands (BVI) to San Juan, Puerto Rico and Segment 2 will run from Tortola, BVI, to Aruba (Figure 1-1). To obtain the necessary permits for installing the cable, the preparation of a Biological Assessment (BA) document is required. The results or this survey are to be used in support of the BA and the environmental permitting effort performed by other ASN consultants on behalf of PCCS. This survey was conducted between 30 August and 21 September, 2013 as proposed by ASN in the Proposed Mesophotic Habitat Mapping Scope submitted to National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) and the U.S. Army Corps of Engineers (USACE) on 3 September, 2013. (Bioimpact, Inc., 2013)

1.1 Project Overview

ASN is proposing to install the PCCS, a fiber optic submarine telecommunications cable system linking Jacksonville, Florida, to Manta, Ecuador. The 6,000-kilometer submarine cable system will strengthen digital links as demand grows rapidly throughout the Caribbean and Central and South America. In addition to Florida and Ecuador, the system will connect the islands of Tortola, Puerto Rico, Aruba, and Curacao, as well as Cartagena in Colombia and Maria Chiquita and Balboa in Panama (Alcatel 2012).



Source: EGS chart: PCCS_S2A_NU019_010k

Figure 1-1. PCCS Cable Route Overview

On December, 7, 2012, the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) proposed Endangered Species Act (ESA) listings for 66 coral species: 59 in the Pacific and 7 in the Caribbean. In the Pacific, 7 species would be listed as endangered and 52 as threatened. In the Caribbean, 5 would be listed as endangered and 2 as threatened. In addition, NOAA Fisheries proposed that two Caribbean species, elkhorn (*Acropora palmata)* and staghorn corals (*Acropora cervicornis)*, already listed under the ESA be reclassified from threatened to endangered. Because of these proposed listings, the permitting agencies have requested ASN to perform assessment of the portions of these cable route segments that are in United States territorial waters to specifically address the potential impact on the proposed species. The decision on the listing was initially supposed to be made in December 2013 but, due to extensive public comment, the schedule for the ruling has been postponed until June 2014.

1.2 Project Objectives and Constraints

The primary objectives of this survey were to:

- Perform benthic habitat mapping of the cable route corridors,
- Prepare a general taxonomic inventory of benthic species composition, and
- Conduct a quantitative assessment of the percent cover by substrate categories on hard ground habitats, with particular attention to the occurrence of listed and/or proposed ESA coral species: *Acropora palmata, A. cervicornis, Montastraea annularis, M. faveolata, M.*

franksi, Agaricia lamarcki, Mycetophyllia ferox, Dendrogyra cylindrus and other benthos of interest including black corals (*Antipatharia*).

While benthic habitat surveys are routinely performed by divers in shallow water along cable landing routes, this is the first known survey of mesophotic habitats and associated benthic communities performed for the installation of a submarine cable in Puerto Rico or the U.S. Virgin Islands (USVI). An effort has been made to provide the most comprehensive taxonomic inventory and quantitative assessment of benthic communities found along the routes. This survey has recorded features of the habitat along these routes at a level of detail previously not available in this area. Yet, it is important to consider that these data were produced from the analyses of video and photographic images taken from mesophotic depths (> 30 meters) by a remotely operated vehicle (ROV) and a towed camera system. Compared with the methods employed by divers using tape measures, quadrat frames, and posed still photographs, the methods employed for this survey are quite different.

A state-of-the-art navigation system and remotely operated cameras have been utilized during this work to obtain substantial quantities of geo-referenced video and high definition photography with very accurate positioning while trying to cover long distances in a cost-effective manner. In comparison with a diving survey, this approach is superior in data quantity and positioning, but cannot overcome some of the inherent difficulties posed by scale and the lack of human presence. The positive identification of many organisms using a remote camera is limited by the organism's small size (including corals), and the inability of the observers to have direct contact with the organism.

The video and photo quality are significantly influenced by sea-state and vessel speed. The vessel is required to maintain speed at less than 1 knot while maintaining course on the route within 10-meters; This is extremely difficult to do when wind speeds are in excess of 10 knots. When significant wave height exceeds 0.8 meters, the vertical acceleration of the camera system causes blurring of the still images, shock loading of the umbilical, and a significant risk of impact with the bottom. Additionally, the steep terrain and currents encountered at the shelf-edge habitats make it particularly difficult to make observations in close proximity to rock walls without causing significant risk to the equipment. Despite these challenges, this survey has produced qualitative and quantitative data, based on the proposed methods, within the constraints of operational conditions.

1.3 Survey Areas

Table 1-1 presents the details of the areas surveyed.

Table 1-1. Location and Dates of PCCS Mesophotic Coral Surveys

	PCCS2A	PCCS2
Start Survey Date	30 August, 2013	20 September, 2013
End Survey Date	7 September, 2013	21 September 2013
Start KP	151.456m	19.901m
End KP	155.113m	36.959m
Start Depth	101.7m	35.8m
End Depth	23.8m	71.5m
Start Latitude	18° 29.20793′	18° 14.99919′
Start Longitude	065° 58.69067′	064° 39.41770′
End Latitude	18° 28.11247′	18° 11.22493′
End Longitude	066° 00.20922′	064° 48.08166′
RPLs used	PCCS_SEG 2A_BMH TORT-BMH SANJ_PSR05_14-Jun-13.xls PCCS_SEG 2_BMH TORT-BU ARUB_PSR06_14-Jun-13.xls (App. A)	

1.3.1 PCCS Segment 2A – Puerto Rico

1.3.1.1 Route Description PCCS 2A

PCCS segment 2A (PCCS 2A), located off Boca de Cangrejos on the northeast coast of Puerto Rico, was surveyed in water depths ranging from 101.7 to 23.8 meters from kilometer point (KP) 151.456 to KP 155.113 respectively. (Figure 1-2). The Survey Report for Cable Route Design and Engineering, EGS 2013b, describes the physical characteristics of the portion of the PCCS 2A route surveyed from east to west: From 18° 29.939' N, 65° 57.959' W (KP149.5) onwards, the route begins to climbs up the south-western flank of this broad valley with some very steep slope gradients in excess of 60° locally. Beyond the broad valley at 18° 29.154' N, 65° 58.820' W (KP151.7), the proposed route continues the southward deviation within the survey corridor to avoid an area of fan-shape erosional gullies. The gullies have a general dimension of 150m long and less than 2m deep. The engineered route then crosses 3 areas of low to high relief rock/ coral from 18° 28.525' N, 65° 59.740' W (KP153.9) to 18° 28.494' N, 65° 59.766' W (KP154.0), from 18° 28.386' N, 65° 59.841' W (KP154.2) to 18° 28.358' N, 65° 59.859' W (KP154.3) and from 18° 28.253' N, 65° 59.924' W (KP154.5) to 18° 28.201' N, 65° 59.995' W (KP154.7) before reaching to the end of the offshore geophysical survey at 18° 28.233' N, 66° 0.128' W (near KP154.9). The Route Position List (RPL) PCCS_SEG 2A_BMH TORT-BMH SANJ_PSR05_14-Jun-13.xls for Segment 2A is included in Appendix A.

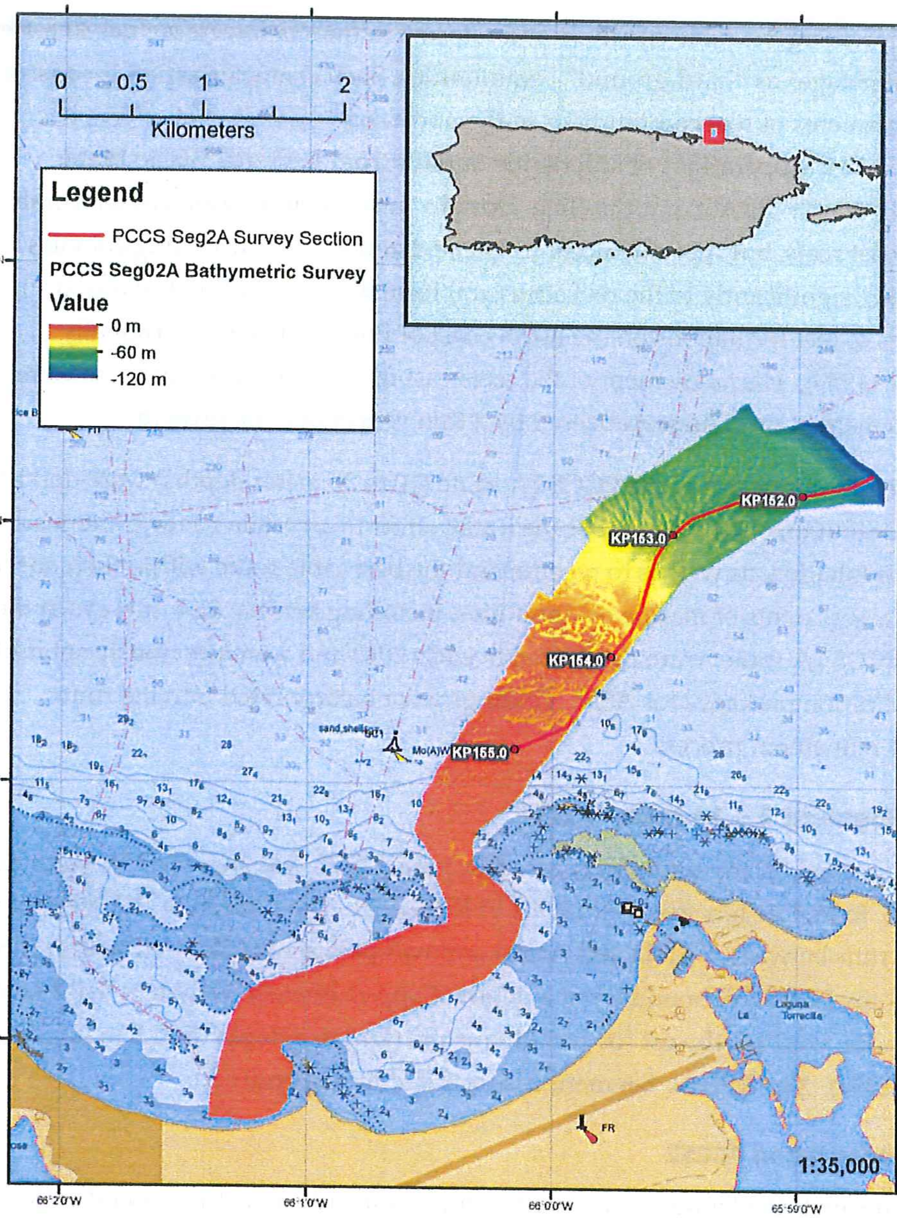


Figure 1-2. Location Map PCCS Segment 2A, Boca de Cangrejos, Puerto Rico

1.3.1.2 Biological Background PCCS 2A

Previous surveys of benthic communities off Boca de Cangrejos were prepared by Vicente and Associates (2000) in relation to the fiber optics cable landing of the ARCOS-1 project and by Garcia-Sais (2001) in relation to the Mid-Atlantic Crossing Extension (MACx). Vicente (2000) provided a general taxonomic survey of marine communities present along the ARCOS-1 cable landing routes and included quantitative estimates of stony corals and gorgonians (soft corals) intercepted by transect lines. From that field survey, Vicente (2000) concluded that there were no coral reef systems along the cable corridors and referred to the shallow (less than 30 meter) reef biological assemblages as "hard-ground" communities. Such characterization is consistent with previous assessments of reef communities in the north coast (García et al. 1985a, b, c) prepared in relation to the operations of submarine outfalls from Regional Waste Water Treatment Plants (RWWTP-PRASA) in Carolina, Dorado, and Arecibo. Scleractinian corals are present in north coast reefs, but typically occur as isolated and mostly encrusting colonies without contributing significantly to the reef structural formation (García et al. 1985a, b, c). Geological features of reef formations on the north coast of Puerto Rico were originally examined by Kaye (1959). His assessment of the reefs east of San Juan was that these were eolianite ridges (cemented sand dunes) covered by a thin veneer of coral growth.

Seafloor features of the shore end of the PCCS 2A route (10 to 30 meter depths) were described by Kraken Marine Solutions (2013) as part of the initial effort to ascertain routing and feasibility for system cable installation, as well as to recommend the best cable route within their survey swath. Biological assessments of marine communities, including benthic dive surveys at the shore end of the PCCS 2A route, were conducted in early 2013 and were previously submitted in the permit application packages for ASN. Findings were incorporated into the route development and refinement process. .

1.3.2 PCCS Segment 2 – St John, USVI

PCCS Segment 2, located off the southern coast of St. John, USVI, was surveyed in water depths ranging from 35.8 to 71.5 meters from KP 19.901 to KP 36.959. The portion of PCCS Segment 2 South of St. John runs between Tortola and Aruba and will pass across the shelf within U.S. waters starting at the USVI/BVI boundary at a depth of approximately 40 meters (KP 19.968) and continuing to the west southwest for 16.9 kilometers (km) to a depth of 71.5 meters at the shelf edge (KP 36.959). The RPL for Segment 2 is included in Appendix A.

1.3.2.1 Route Description PCCS2

The proposed route exits the United Kingdom territorial sea and enters the United States territorial sea (Figure 1-3) at 18° 14.969'N, 64° 39.440'W (KP20.0). The proposed route does not enter US Virgin Islands 3-nautical mile coastal zone at any point.

The proposed route proceeds to the west southwest and enters an area of loose sandy gravel over coral/ rock at 18° 14.622'N, 64° 40.197'W (KP21.5). Southward route deviation is performed to avoid several areas of low to high relief coral/ rock in the northern side of the survey corridor. The route crosses the out of service cable St. Thomas-St. Maarten-Curacao at 18° 13.367'N, 64° 44.613'W (KP29.6) with an angle of 89° in 53 meter water depth.

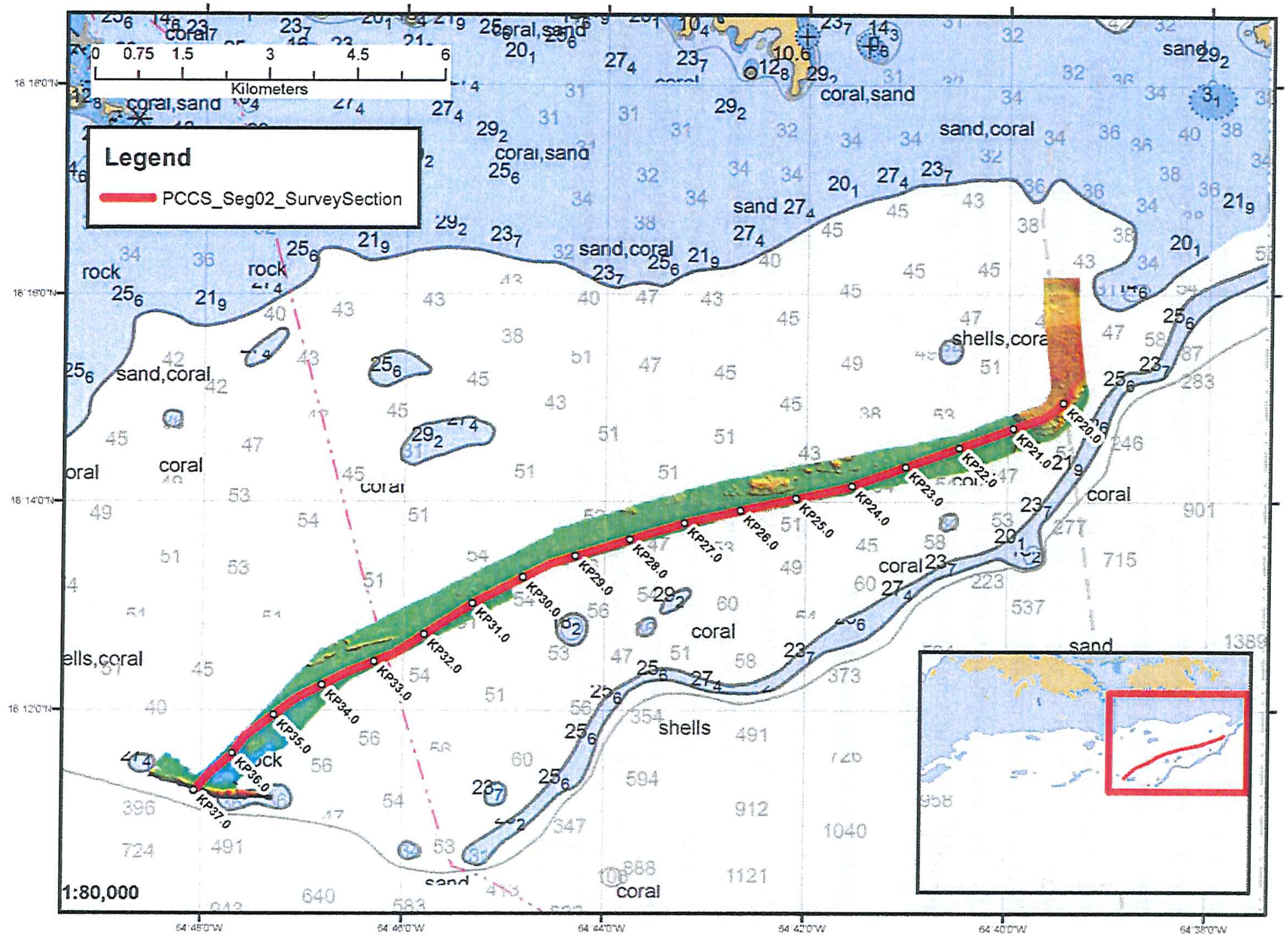


Figure 1-3. Location Map PCCS Segment 2 St John USVI

The seafloor along the route undulates with very gentle to gentle slopes from 18° 14.674'N, 64° 40.046'W (KP21.2) to 18° 11.385'N, 64° 47.922'W (KP36.6) with water depths in between 52 meters and 58 meters. The engineered route alters course at 18° 11.753'N, 64° 47.559'W (KP35.6) to descend the shelf break in a more perpendicular manner. The route crosses a narrow ridge at 18° 11.325'N, 64° 47.977'W (KP36.7) with a slope gradient of 11° at the flank and the ridge peaked at 18° 11.269'N, 64° 48.029'W (KP36.8) with a height of about 11 meters to the ambient seabed before descending to the irregular continental slope.

The proposed route descends the irregular continental slope with predominately very steep slopes in excess of 30° at 18° 11.250'N, 64° 48.047' W (KP36.9). The seafloors drops from 48 meters WD at 18° 11.269'N, 64° 48.029'W (KP36.8) to 187-meter WD at 18° 11.209'N, 64° 48.084'W (KP37.0) in a horizontal distance of 144 meters. The proposed route enters the area of low to high relief rock with intermittent veneer of sandy silt/ silty sand at 18° 11.229'N, 64° 48.065'W (KP36.9) (EGS 2013a).

1.3.2.2 Biological Background PCCS2

An extensive mesophotic bank coral reef system has been described for the south coast of St Thomas, USVI (Nemeth et al. 2008; Smith et al. 2010). The Marine Conservation District Reef (MCD), as it is regionally known, is fully submerged at depths between 25 to 45 meters and is largely a biogenic coral formation dominated by one of the sibling species of boulder star coral, *Montastraea franksi*, which is the prevailing species within the previously regarded "*Montastraea annularis* coral complex" at mesophotic depths. The reef is known to be the residential habitat of many fish species of commercial value, including the red hind (*Epinephelus guttatus*), and is permanently closed to fishing.

2. Methods

2.1 Project Coordinate System

In accordance with the PCCS project survey specifications, all charts and reports are presented in Mercator projection, with the parameters as listed in Table 2-1.

Table 2-1. Geodetic Parameters for Survey and Charting for PCCS

Datum Parameters	
Datum	WGS-84
Spheroid	WGS-84
Semi-Major Axis (a)	6378137.000m
Inverse Flattening (1/f)	298.257223563
Projection Parameters	
Grid Projection	Mercator
Latitude of Origin of Projection	0° (Equator)
Longitude of Origin of Projection	82° W
False Easting (meters)	5 000 000
False Northing (meters)	1 100 000
Standard Parallel	22° N
Scale Factor along Standard Parallel	1.0

2.2 Survey Equipment

The video and photographic data were acquired with a suite of instruments that were integrated on either a towed camera system (TCS) or ROV and deployed from the *Research Vessel (R/V) Streak.* The installation of equipment and site-calibrations of the GPS are described in the Mobilization Report in Appendix B. Instrumentation used is summarized in Table 2-2.

Table 2-2. Survey Equipment

Equipment	Manufacturer and Model
ROV	Seabotix vLBV950 with high resolution digital video camera
USBL underwater positioning, vessel heading and attitude	iXBlue GAPS with M900-series transponders
Primary vessel positioning	Trimble AG332/ SPS-5XX L1/L2 GNSS with MarineStar high precision corrections
Backup vessel positioning	Trimble AG132 DGPS with US Coast Guard beacon corrections
Analog video camera (TCS)	DeepSea Power & Light Super Wide-i SeaCam
Digital video/still camera (TCS)	Imenco TigerShark 14MP digital still underwater camera with Lantern Shark high-power strobe and video light

Table 2-2. Survey Equipment (continued)

Equipment	Manufacturer and Model
Digital still camera (ROV &TCS)	GoPro HERO3 Black Edition 12MP still or 1080P video in Cam-Do deep water housing
Real-time video enhancer	LYYN Hawk Portable™
Surface powered underwater video lights	DeepSea SeaLite Sphere high intensity (3000 lumen) LED lights
Rechargable underwater video lights	Intova Galaxy 2500 lumen battery powered video lights
Scaling lasers (TCS)	Deep Sea Power and Light dual SeaLaser with a 10 cm separation. Mounted with 2 scaling points in the field of view of GoPro, TigerShark and Video cameras.
Sound Velocity Profiler (SVP)	YSI CastAway CTD (for USBL sound velocity corrections)
Umbilical Winch	AGO PID-05 Oceanographic Elec. winch w/12-position slip ring 160m umbilical
Utility winch (for ROV clump weight)	Pullmaster PL2 hydraulic with 125m of 5/32 spectra

2.2.1 Survey Vessel Streak

The 9-meter (29.5-foot) *R/V Streak* was located in Puerto Rico at the time Tetra Tech was notified to conduct this survey. The critical PCCS project timeline and short (2-3 week) mobilization schedule dictated the use of the only available vessel, which was already outfitted to conduct the work. The *R/V Streak* had an installed A-frame, hydraulic winch, umbilical winch, and multi-conductor umbilical suitable for performing the camera operations and a retractable side-mount pole for the ultra-short baseline (USBL) navigation system deployment.

Figure 2-1. Survey Vessel *R/V Streak*

Vessel Specifications

Hull Construction: Welded Aluminum
Overall Length: 29.5 feet. **Beam:** 9 feet.
Draft: ~2.5 feet. **Gross Tons:** ~5
Propulsion: VolvoPenta KAD44 Turbo charged Diesel with duo prop outdrive
Electrical Generation: Honda 1500/3000 Watt
Safety Equipment: All required U.S. Coast Guard equipment
Bridge Equipment: Differential Global Positioning System (DGPS), POS MV, Real-time Kinematic (RTK) GPS, Ross Hypack Control, Radar, VHF
Survey Facilities: Equipment rack with operator stations and 2-6 LCD
Transducer Mounts: RESON 8101/8125/7125/7101/NS 420/Benthos C3D/R2 Sonics 2024/Ross 825B/Innerspace 448, iXBlue Global Acoustic Positioning System (GAPS) USBL, customized as needed
Hull Mounted Transducers: As required
A-Frame and Winches: Pullmaster PL-2 support by hydraulic A-frame
Umbilical Winch: AGO Electric Oceanographic Elec. winch w/12-position slip-ring & 160m umbilical

2.2.2 Navigation Instrumentation

The survey vessel positioning was provided by primary and backup DGPS receivers. A Trimble SPS-561 L1/L2 GNSS RTK GPS receiver with MarineStar XP (10 centimeter) high precision corrections was integrated with was HYPACK® data collection and navigation software. Secondary GPS receivers used during the survey were a Trimble AG332 with MarineStar XP corrections and a Trimble AG132 with USCG Beacon corrections.

Precise location of the TCS/ROV was provided by an iXBlue GAPS USBL acoustic positioning system integrated with the navigation computer/software. The GAPS is a USBL acoustic range-bearing system with a built in inertial navigation system (INS). The INS provides a tightly-coupled, integrated attitude (pitch and roll) and motion (heave) system so it requires no offset measurements or heading, pitch and roll calibrations. The positioning accuracy of the GAPS is among the best commercially available at 0.2 percent of slant range. Coupling with a sub-meter accurate GPS receiver, at the ranges experienced during these surveys, results in actual TCS/ROV location accuracies of 1 meter. The iXBlue GAPS is shown in Figure 2-2 mounted on the pole that has been retracted out of the water for vessel transit. The Global Navigation Satellite System (GNSS)/GPS antenna was also mounted on the pole so that when the pole was deployed, it and the GAPS hydrophone were at the same position with no horizontal offset. The XY of the pole, at the waterline, was used as the reference point for the vessel.

Figure 2-2. GPS Antenna and GAPS Hydrophone USBL on Side-mount Pole (Retracted)

2.2.3 Towed Camera System

The TCS (Figure 2-3) is a custom configurable platform for collecting underwater video and high resolution still photographs. For this survey, the TCS was configured with a Super wide-I composite video camera with extreme wide angle, low-distortion dome port, providing a 150 degree (h) x 120 degree (v) underwater view. This camera enabled an in-focus view of the bottom within a meter of the TCS while simultaneously enabling a wide panoramic forward view to the limit of visibility. The video camera was connected to the surface with a coaxial conductor inside the umbilical. Aboard the vessel, the video signal was processed through the LYNN video enhancer, was overlaid with navigation data, displayed on several monitors, and then converted from analog to digital video and automatically stored in 10-minute segments on the video acquisition computer.

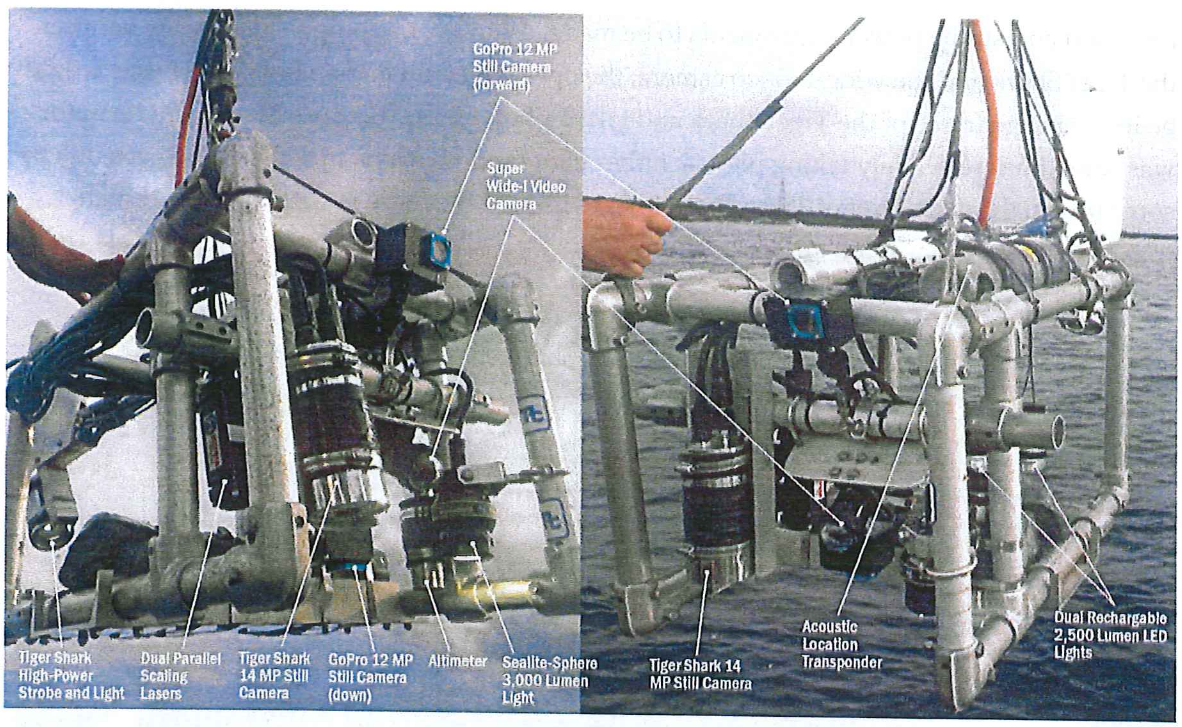


Figure 2-3. Towed Camera System Configuration

On each dive of the TCS or ROV, one to three internally-recording digital still cameras were mounted on the platform. A single down-looking GoPro Hero3 camera configured to take one 12-megapixel photograph every 2 seconds was the primary instrument for recording high-quality random imagery. On some survey segments, a second GoPro camera was also configured in a forward-looking orientation to capture more detailed imagery than possible with the video camera.

A Tiger Shark 14-megapixel digital still camera coupled with a Lantern Shark strobe was employed to take high resolution photos for use in identifying benthic organisms to the lowest taxonomic level. The high-powered strobe provided illumination and near-stop-action photos up to 4 meters above the seabed. The strobe and the camera were separated 1.2 meters horizontally, which provided optimal lighting at distances of 1 to 2 meters above the seabed and minimized the appearance of backscatter from floating particulate in the images. The Tiger Shark camera was manually triggered using a hand-held wired remote control on the survey vessel. The video signal from the Tiger Shark thru-the-lens display was displayed on a video monitor, allowing the camera operator to view and adjust the camera settings and to review each photo after it was taken. (Figure 2-4). Tiger Shark images were typically taken randomly at 5-15 second intervals, with time in between shots for the flash to recharge, the last photo to be reviewed and strobe power adjustments to be made. With overlapping fields of view between the Tiger Shark and the wide-I video camera, the operator could anticipate when objects would be in the image frame of the Tiger Shark and take a photograph. Because the camera operator was sometimes selectively taking photos, rather than random exposures, there is expected to be some bias in the overall set of Tiger Shark images toward the more interesting subject matter.

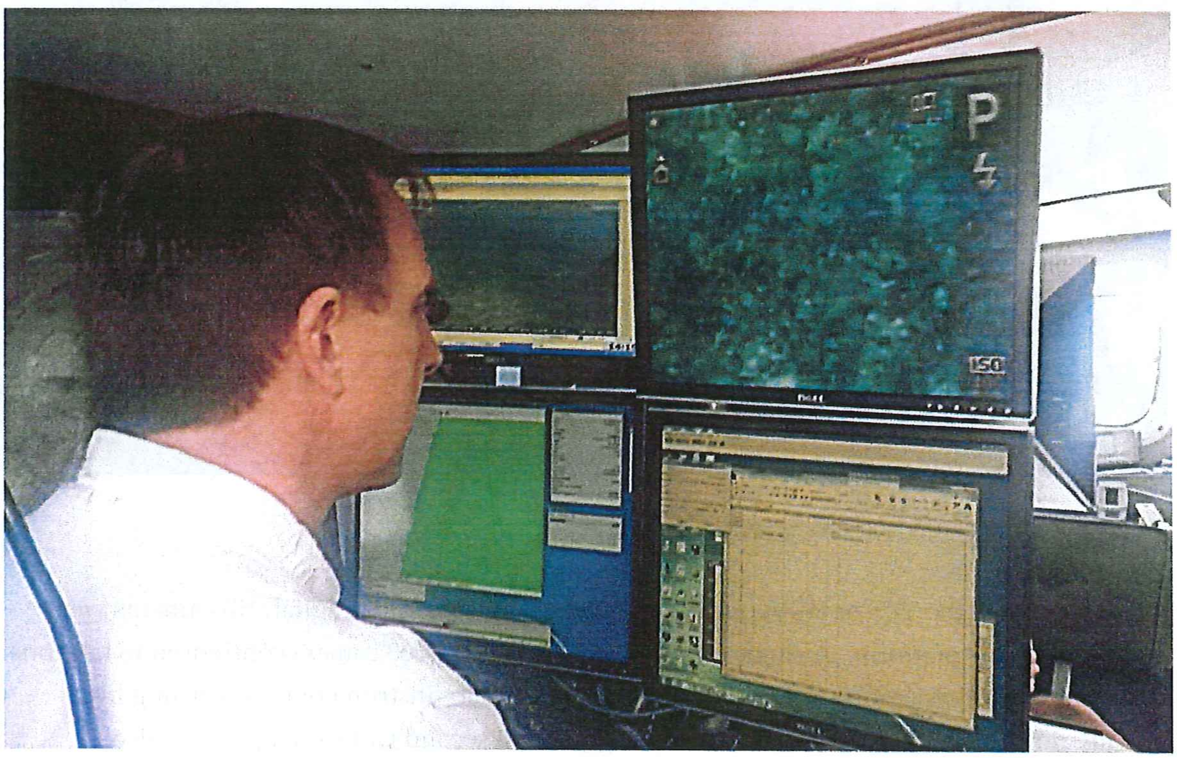


Figure 2-4. Camera and Navigation Control Station

TCS and ROV lighting were provided by both surface-powered and rechargeable LED video lights. Two to four 2500-3000 lumen lights were used at various times to provide the primary lighting for the down-looking GoPro camera and to light the area immediately in front of the TCS for both the video and Tiger Shark cameras. A pair of lasers, projecting two green parallel beams separated at 10 centimeter distance, was mounted coaxially with the Tiger Shark camera. The video and down-looking GoPro cameras were mounted and aimed such that all three cameras would have the scaling lasers within their field of view.

TCS navigation sensors include an on-board altimeter for measuring real-time height above the seabed and an acoustic transponder, allowing sub-meter location by the USBL system.

2.2.4 Remote Operated Vehicle (ROV)

In addition to the TCS, a SeaBotix VLBV 950 ROV was mobilized for the survey (Figure 2-5).

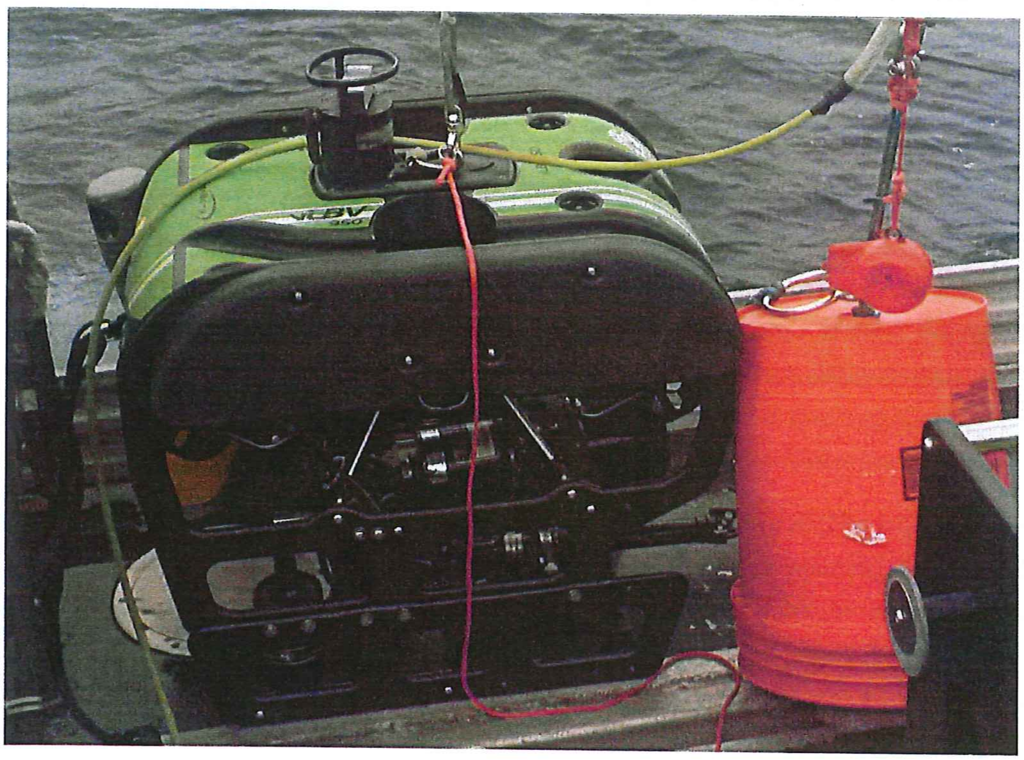


Figure 2-5. Seabotix VLBV 950 Inspection ROV and Clump Weight

This inspection-class ROV was configured with additional lights and a down-looking GoPro digital camera mounted on the skids for capturing still images. A custom wiring harness was fabricated and tested at the ROV manufacturer for integrating the Tiger Shark camera with the ROV. Despite days of effort the Tiger Shark controller was never able to communicate with the camera through the ROV serial/Ethernet to fiber-optic converters. The high-definition (HD) video camera on the ROV provided high quality video at shallow depths where the ambient light was sufficient. With the addition of more lighting and the ability to capture HD frame-grabs, the lack of having the Tiger Shark still camera on the ROV was not a significant liability. In addition, the ROV was equipped with a forward-looking sonar and bathymetric profiler, which both could have been used for investigations in limited visibility.

The ROV was deployed with a clump-weight system to lower the ROV to the seabed, once on bottom, the ROV grabber, would release the clump weight and had approximately 10 meters of free-floating umbilical for maneuvering. In practice, the ability to simultaneously maintain course along the cable route with both the vessel and the ROV proved difficult. In good weather conditions, when the surface vessel was less influenced by wind and current, the ROV did provide the ability to obtain high-quality near bottom photos and video while near stationary. The ROV is a very capable tool and was useful for more detailed investigations. It was more time consuming to deploy and operate than the TCS and was less productive in covering the long linear route; its use on this project was therefore limited to the investigations of specific habitat areas on PCCS 2A.

2.2.5 Video Recording System

A sophisticated video database recording system was used to digitally record video, overlay navigational data on the video in real-time, and store synchronized American Standard Code for Information Interchange (ASCII) navigational data along with the video in a database structure. VisualSoft Suite is a modular collection of software applications designed to acquire, edit, and review subsea video and data using a common user interface. It is suitable for any type of subsea video inspection where large volumes of video must be recorded from one or more cameras and synchronized along with other data sources.

For this survey, the VisualDVR and VisualOverlay modules were employed to apply video data overlay and record the primary video on one DVR channel. A second video channel was employed later in the survey to also record the low-resolution video monitor from the Tiger Shark still camera. In addition to the overlay and recording the software allows the synchronized integration of digital survey data along with the video and also provides a means to manage storage and backup of recorded files. To review the recorded video, along with associated digital data, VisualSoft provides free VisualReview software for playback and searching of pre-recorded video.

2.3 Survey Methods

2.3.1 Primary Route Survey

A survey down the route corridor was first undertaken to obtain an overview of the substrate, cover and coral abundance, if any. During the primary survey, video of the entire route was taken to provide a panoramic record of the benthic habitats and associated communities. The biologist on board made real-time observations of the video, provided commentary for the data log, and made a preliminary classifications of benthic habitat types and transition locations along the route. Once the primary route survey was complete, the biologist would identify areas with high densities of coral (>10 percent cover) or areas of interest and these areas would be revisited for further investigation.

The along-route survey was generally conducted at the slowest speed possible to obtain the best quality video and still images. Operationally, to maintain steerage and keep the vessel and camera system along the cable route, this resulted in survey speeds ranging from 0.5 to 1.2 knots. At times, when pushed by winds or current, a storm drogue was deployed from the stern of the vessel to slow the over-the-ground speed. Each "dive" of the primary route survey lasted approximately 2 hours and would cover a distance of 2-4 km depending upon sea/weather conditions.

A daily dive log was initiated each day and a timeline of events and observations during the day were recorded, including times for the beginning and end of each dive, biologist observations, and data file names. The navigation system was also used to mark and annotate targets of interest during the survey. The dive logs, navigation target data and post-processed navigation and photo data have been compiled into Daily Survey Logs, which are included in Appendix C.

The optimal camera height above the seabed for lighting and still photo resolution was 1 to 1.5 meters, which required the constant attention of the winch operator using a joystick winch controller while monitoring video from the TCS, altimeter and vessel heave. The camera height-above-bed was a balance between obtaining high-quality imagery and keeping the TCS from coming in contact with the seabed. The video/photo quality was significantly influenced by sea-state. In conditions when significant wave height exceeded approximately 0.8 meter, with typical wave periods of 4-6 seconds, the vertical acceleration of the TCS caused blurring of the still images, shock loading of the umbilical, and a significant risk of impact with the bottom.

2.3.2 Cross Transect Survey

In accordance with the survey protocols, at locations where proposed ESA coral species were observed from the video in densities visually approaching or higher than 10 percent, slow speed 100-300 meter long drift transects, running roughly perpendicular to the route, were performed. In the case of route PCCS 2A, ESA corals (listed or proposed) were not observed in densities higher than 10 percent anywhere along the route. ROV transect investigations were conducted on PCCS 2A relative to initial siting of black coral and to obtain enough photos on the patch reef substrate to conduct the necessary analysis. Proposed ESA corals were observed along the entire PCCS 2 route south off St. John, USVI. Densities higher than 10 percent were inferred during the initial route survey for boulder star coral, *Montastraea franksi* from a bank coral reef that prevailed as the dominant benthic habitat from KP 19.9 to KP 20.7 along the route. Five cross route transects were surveyed on PCCS2, even in some areas where there was no cover approaching 10 percent. Two 200-meter-long drift transects were run across the route within the bank reef habitat, and a total of 60 randomly selected photos (1/10) from a batch of approximately 600 taken were used for percent substrate cover determinations. These analyses were used as supplementary data for quantitative assessments of the with primary-route analyses.

2.4 Data Processing and Analysis

The onboard biologist viewed the data on video as it is was being collected, but a much more definitive view of the habitat and biological structure was derived by viewing a gallery of thousands of still photographs after being downloaded from the internally-recording still cameras. During the review of the photos, a log was kept to annotate species identified on individual photos, identify substrate/community transitions and identify usable and unusable photographs. With the GoPro taking photographs at 1 every 2 seconds and the Tiger Shark once every 8-12 seconds, in a 2-hour dive approximately 4,300 photographs were taken.

2.4.1 Photo Geo-referencing

Tetra Tech developed custom software to perform geo-referencing, geographic information system (GIS) output and annotation for all still-camera images. The software merges the navigation data, available bathymetric survey data, current RPL, and EXIF data imbedded within each digital photograph. Time synchronization photographs were taken with each camera at the beginning and end of each dive. Photos of the GPS time displayed on the navigation monitor or a digital laboratory clock were taken for use in post-processing. At the beginning of the processing procedure, camera clock errors were determined by comparing the time of the clock (computer monitor) in the image with the (EXIF) camera time recorded in the image file. During processing, the embedded time is read from each photo, the photo time is corrected for camera clock error, and then the corrected photo time is matched with the correct positioning information (typically to ±1 second).

Using the geographic coordinates of each photo and a file containing the RPL, the KP and offline distance are calculated. Depth data are optionally read from the navigation data or existing bathymetric files. Each photo is then annotated with route name, dive number, latitude, longitude, KP, offline distance, depth, and Universal Coordinated Time (UTC) time and saved to a separate directory. The photos are saved with additional JPG compression to reduce the file size from approximately 4 megabytes (MB) to 1.5–2 MB. ASCII *.csv files with photo locations and metadata are produced for GIS input and photo mapping.

2.4.2 Coral Point Count (CPCe) Analysis

After an initial screening for unusable shots, a random array of up to 50 photos per benthic habitat type were processed for quantitative analyses of percent substrate cover using Coral Point Count (CPCe) software. A random overlay of 25 points was assigned to each image and the major benthic categories identified from each photo. All scleractinian corals, sponges, and octocorals were identified to species whenever possible, and a comprehensive species list of benthic taxa was constructed during the CPCe analytical procedure. Summarized structure, substrate, and biological cover information derived from each photo were used to develop a general characterization of each benthic habitat type and present average substrate cover by benthic categories along the PCCS routes.

A list of all analyzed photos and maps with position references are included in Appendix D.

3. Results and Discussion

3.1 PCCS Segment 2A

The survey of benthic habitat along the PCCS 2A started at a depth of 21.6 meters (KP 155.113). At this initial survey point, the main feature of the seafloor was a flat, hard ground platform colonized by benthic algae, or colonized pavement (CPV) emerged from the sandy substrate. A benthic habitat classification map of the PCCS 2A route corridor, overlaid on the multibeam bathymetry image is shown in Figure 3-1. CPV was found as a discontinuous hard ground transitioning to sand with scattered rocks (SWS) bottom (Table 3-1). Representative photos of colonized pavement (CPV) habitat on PCCS 2A are presented in Figure 3-2. Benthic algae, including both turf and fleshy macroalgae were the most prominent component of the CPV benthos with a mean of 64.5 percent cover (Table 3-2). Sand pockets within the CPV comprised the other main substrate category, representing 25.8 percent of the total CPV cover. Due to the vast surrounding sand deposits, it is likely that the abiotic component within this habitat fluctuates markedly depending on sand transport over the hard ground habitat. Sponges were also the main invertebrate category in terms of substrate cover with a mean of 3.26percent. Large erect giant barrel sponges, with a mean cover of 2.32percent were the main species (in terms of substrate cover) of the sponge assemblage. At least 15 sponge species were present from the entire set of photos examined (Table 3-3). A reddish cyanobacteria film overlying sand was prominent at KP 154.29, covering an average 27.2 percent of the seafloor on the 12th benthic habitat transition of the route at a depth of 34.30 m (Table 3-1).

Scleractinian corals were not observed at densities that approached 10 percent anywhere within the CPV habitat. Four species were present, including *M. franksi* and *A. lamarki* (Table 3-3), none of which were included amongst the random set of photos analyzed for quantitative determinations of substrate cover at the CPV habitat. Sand abrasion and scouring likely associated with surge processes act to constrain development of scleractinian corals and other colonizing agents other than barrel (and few other) sponges within this habitat. Of particular relevance was the observation of feather black coral, *Antipathes pennacea* at a depth of 34.3 m (KP 154.28 – KP 154.22) within the CPV habitat. Several colonies, typically of small size (< 30 cm) were observed attached to the hard bottom, presenting a mean substrate cover of 2.4 percent within transition 12 (Table 3-1). The survey of the PCCS 2A route ended at KP 151.456.

An irregular and discontinuous group of rock promontories, here classified as patch reefs (PRF) of variable sizes and shapes surrounded by sand was observed at the start of transition three. PRF and sand shared the two to eleven benthic habitat transitions along the route (Table 3-1). Benthic algae were the main biological agent colonizing the PRF habitat with a mean cover of 29.3 percent (Table 3-2). It was mostly observed as algal turf, a combined assemblage of short filamentous brown and fleshy macroalgae growing as a carpet over hard ground substrates. Sandy sediments comprised the other main substrate category on PRF with a mean of 70.1 percent. Scleractinian corals were represented by seven species at the PRF habitat (Table 3-3), all present as isolated encrusting colonies of relatively small size providing minor contributions to the reef topographic relief.

Sponges, mostly the giant barrel sponge, *Xestospongia muta*, were the main invertebrate taxon in terms of combined mean substrate cover with 0.04 percent. A total of 28 sponge species were recognized from the photo gallery of the PRF habitat, three of which were identified within photos analyzed for quantitative determinations of substrate cover (Table 3-2). Because of their size and erect growth, giant barrel sponges were the most prominent biological component contributing topographic relief in the PRF habitat along route PCCS 2A. Patch reefs within this route section were observed to a maximum depth of 31.78 m, producing a total of 11 benthic habitat transitions to sandy bottom (SND) or sand with scattered rocks (SWR) along the route up to KP 154.289 (Figure 3-1). Representative photos of the PRF habitat off Boca de Cangrejos are shown as (Figure 3-3)

A previous assessment of the Boca de Cangrejos outer shelf PRF habitat was prepared by Garcia-Sais (2001) as part of the baseline environmental studies in support of the MACx cable landing project. At depths between 30 and 40 meters, PRF structures, described as relict cemented sand dunes, or eolianites, exhibited similar heavy colonization by turf algae and sponges, with scleractinian coral representing very minor components of the colonizing biota (less than 1 percent). The transitional sandy substrate was reported to be mostly abiotic with minor patches of cyanobacteria films overlying the unconsolidated seafloor.

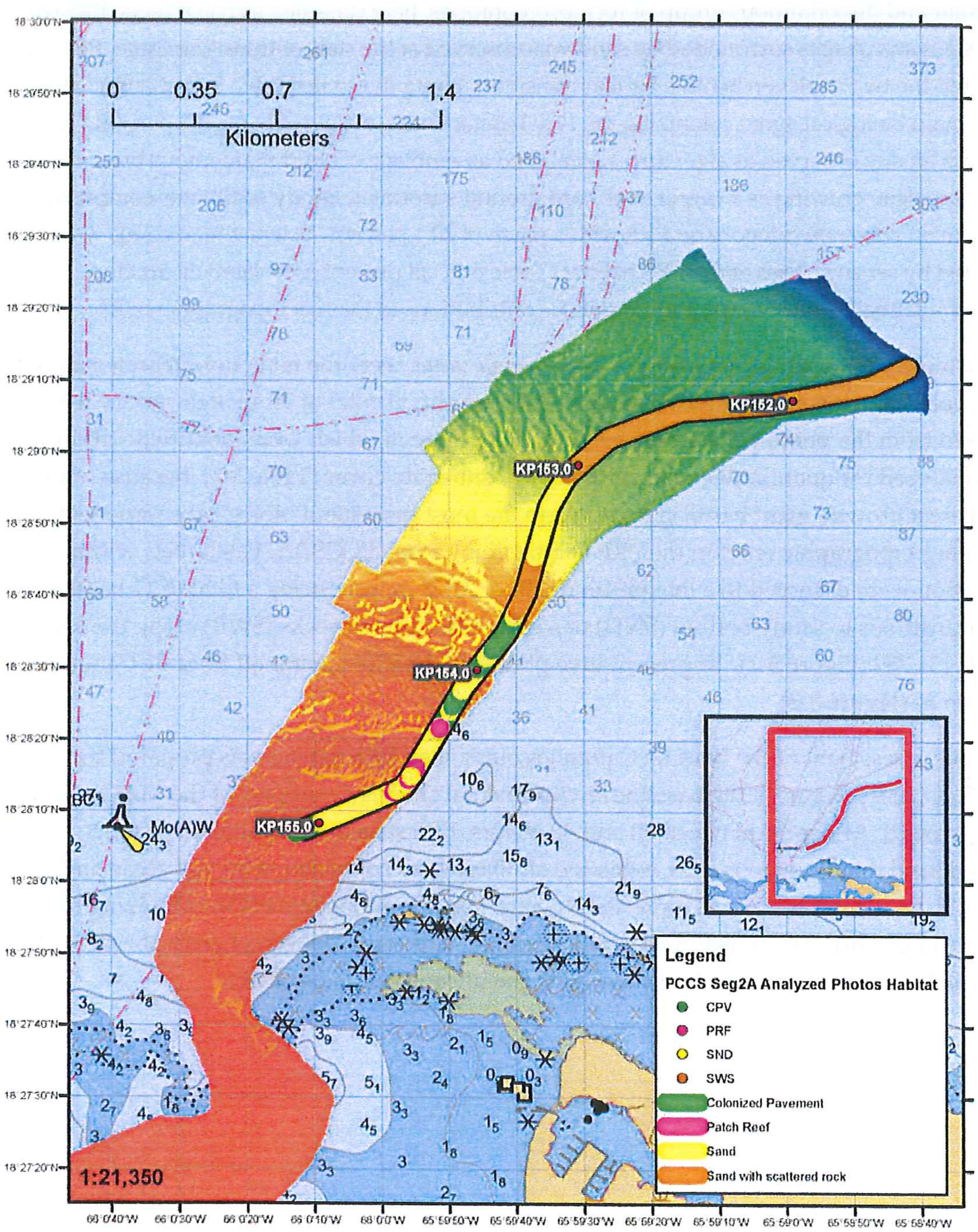


Figure 3-1. Benthic Habitat Map of Segment PCCS 2A North of Boca de Cangrejos, Puerto Rico

Table 3-1. Percent Cover by Benthic Habitat Transitions/ Substrate Category along PCCS 2A

Route Transition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Start KP	155.113	155.009	154.661	154.633	154.624	154.584	154.563	154.552	154.503	154.489	154.400	154.289	154.219	154.189	154.120	153.993	153.934	153.897	153.721	153.689	153.442	153.071
End KP	155.009	154.661	154.633	154.624	154.584	154.563	154.552	154.503	154.489	154.400	154.289	154.219	154.189	154.120	153.993	153.934	153.897	153.721	153.689	153.442	153.071	151.456
Habitat Segment Length (m)	104	348	28	9	40	21	11	49	14	89	111	70	30	69	127	59	37	176	32	247	371	1615
Photos Analyzed CPCe	10	16	9	8	9	8	9	9	9	9	7	19	9	9	9	12	8	9	9	9	18	21
Benthic Habitat	**CPV**	**SND**	**PRF**	**SND**	**PRF**	**SND**	**PRF**	**SND**	**PRF**	**SND**	**PRF**	**CPV**	**SND**	**CPV**	**SND**	**CPV**	**SND**	**CPV**	**SND**	**SWS**	**SND**	**SWS**
Substrate Categories																						
Abiotic	1.50	99.29	61.70	99.11	78.80	100.00	61.20	99.60	57.60	100.00	91.00	23.60	100.00	38.00	99.60	30.70	100.00	35.20	100.00	88.80	100.00	96.18
Benthic algae	88.50	0.71	37.60	0.44	20.40		38.40	0.40	41.60		8.50	46.80		58.00		70.00		59.20		7.60		0.73
Cyanobacteria/algal mix												27.20										
Coral																						
Agaricia grahamae	0.50																					
Montastraea cavernosa	0.50																					
Montastraea franksi	2.50																					
Porites astreoides	1.00																					
Total Scleractinian Coral	4.50																					
Sponges																						
Agelas sp.												0.20						1.20				
Aplysina cauliformis																						0.36
Cliona sp.	0.50																					
Unknown sponge			0.80	0.44	0.40		0.40		0.40		0.50	0.40		1.20				1.20		0.80		2.00
Xestospongia muta	5.00				0.40				0.40			0.60		2.80	0.40			3.20		2.80		0.73
Total Sponge	5.50		0.80	0.44	0.80		0.40		0.80		0.50	1.20		4.00	0.40			5.60		3.60		3.09
Octocoral																						
Unknown octocoral																						
Total Octocoral																						
Black coral																						
Antipathes pennacea												1.20										
Total Black Coral												1.20										
Unknown/other																						

Note: Data are means from a series of randomly selected photos for each habitat transition analyzed on Coral Point Count (CPCe) software. Codes for habitat: SND (Sand), PRF (Patch reef), CPV (Colonized pavement), SWS (Sand with scattered rocks or rhodoliths).

Table 3-2. Mean Percent Cover by Habitat Type/Substrate Category on PCCS 2A

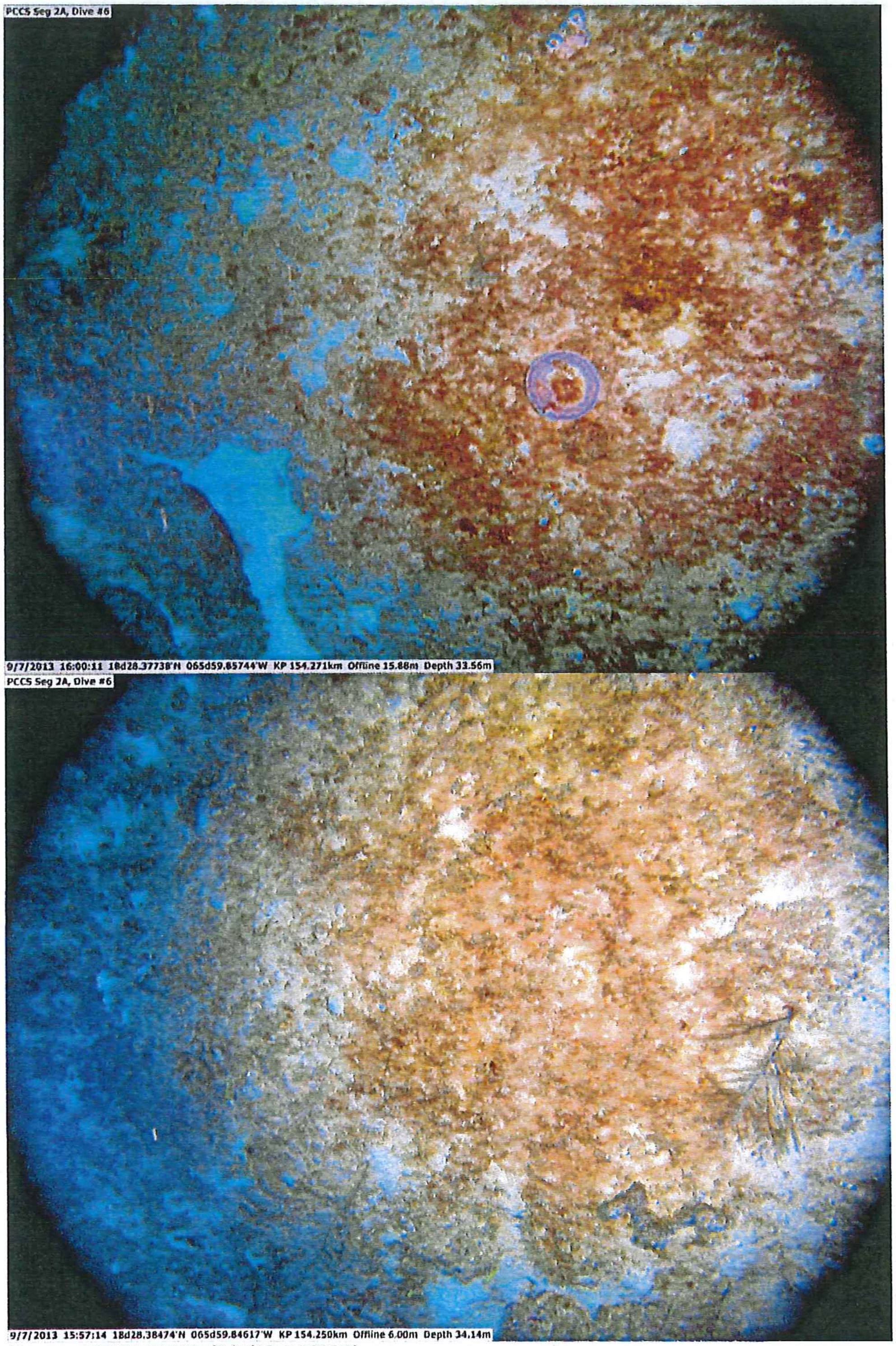
Habitat Segment Length (m)	398	1113	578	1475
Photos Analyzed CPCe	59	93	47	31
Benthic Habitat Type	**CPV**	**SND**	**PRF**	**SWS**
Substrate/Cover Categories				
Abiotic	25.80	99.76	70.06	92.49
Benthic algae	64.50	0.16	29.30	4.17
Cyanobacteria/algal mix	5.44			
Coral				
Agaricia grahamae	0.10			
Montastraea cavernosa	0.10			
Montastraea franksi	0.50			
Porites astreoides	0.20			
Total Scleractinian Coral	0.90			
Sponges				
Agelas sp.	0.28			
Aplysina cauliformis				0.18
Cliona sp.	0.10			
Unknown sponge	0.56	0.04	0.50	1.40
Xestospongia muta	2.32	0.04	0.16	1.77
Total Sponge	3.26	0.08	0.66	3.35
Octocoral				
Unknown octocoral				
Total Octocoral				
Black coral				
Antipathes pennacea	0.24			
Total Black Coral	0.24			
Unknown/Other				

Note: Data for each benthic habitat type are the means from all habitat segments with the same habitat type found along the surveyed route. Codes for habitats:SND (Sand), PRF (Patch reef), CPV (Colonized pavement), and SWS (Sand with scattered 'rocks or rhodoliths)

Table 3-3. List of Invertebrate Species Observed on PCCS 2A Boca de Cangrejos, PR

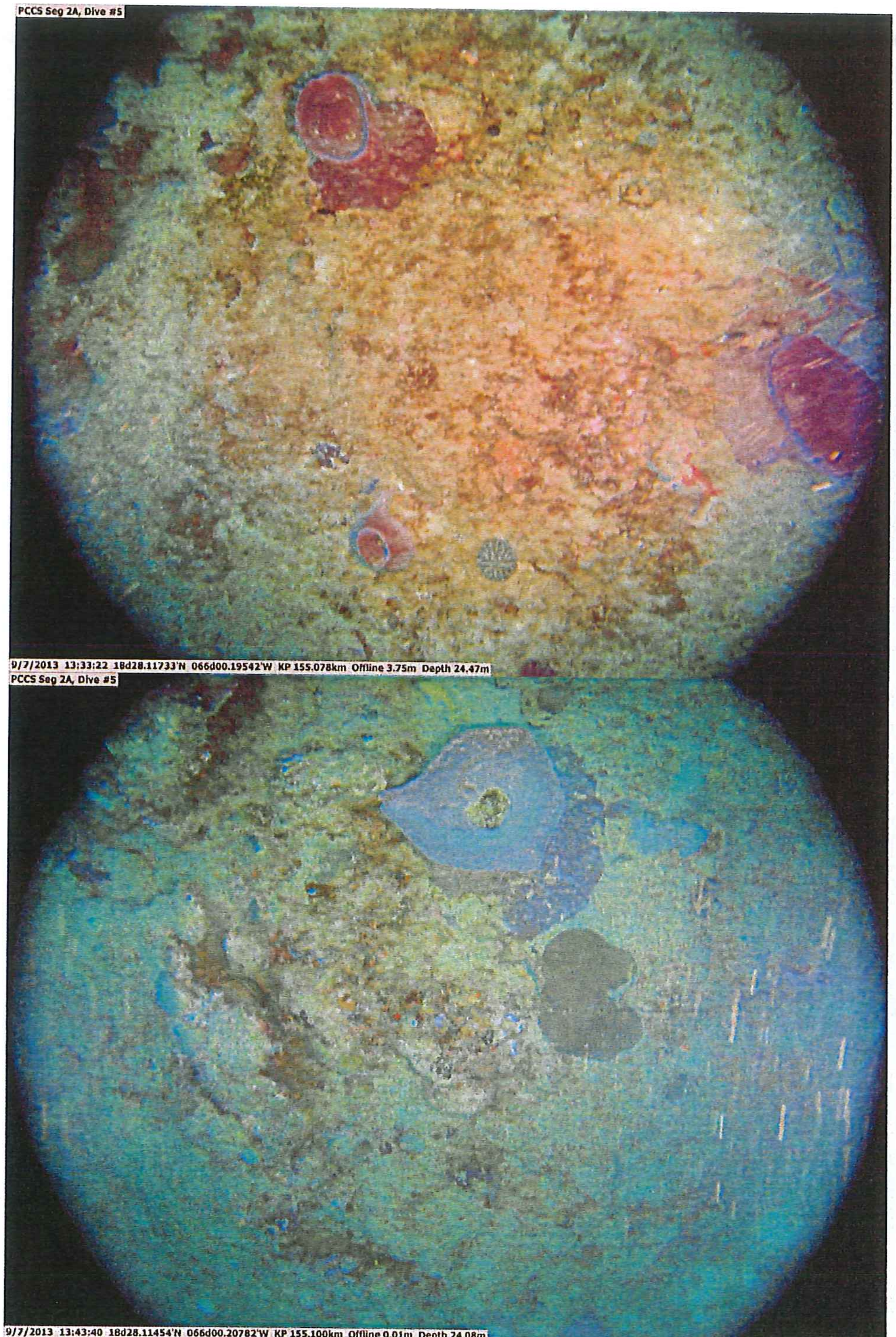
Species		CPV	PRF	SWS
Antipatharian	*Antipathes pennacea*	x		
Scleractinian Corals				
	Agaricia lamarcki	x		
	Colpophyllia natans		x	
	Madracis decactis		x	
	Meandrina meandrites	x	x	
	Montastraea cavernosa	x	x	
	Montastraea franksi	x	x	
	Porites astreoides		x	
	Siderastrea siderea		x	
	Octocoral			
	Briareum		x	
	Ellisela sp.		x	
	Unknown octocoral	x	x	
	Sponges			
	Agelas clathrodes	x		
	Agelas sp.	x		
	Agelas tubulata	x		
	Agelas conifera	x		
	Aka xamaycaensis		x	x
	Aplysina archeri	x	x	
	Aplysina cauliformis	x	x	
	Aplysina fistularis		x	x
	Aplysina sp.		x	x
	Callyspongia plicifera		x	
	Cliona sp.		x	
	Ectyoplasia ferox		x	
	Geoidia neptuni		x	
	Ircinia campana		x	
	Ircinia sp.	x	x	
	Ircinia strobilina	x	x	
	Niphates erecta		x	
	Niphates sp.	x	x	
	Petrosia pellasarca		x	
	Sclerosponge			x
	Spirastrella coccinea		x	
	Svenzea zeai	x		x
	Unknown lobate sponge	x	x	
	Unknown massive sponge		x	x
	Unknown orange encrusting sponge	x	x	x
	Unknown orange lobate sponge	x	x	
	Unknown pink lobate sponge		x	x
	Unknown purple rope sponge			
	Unknown small orange sponges		x	
	Unknown small pink sponges		x	
	Unknown white encrusting sponge	x		
	Unknown white rope sponge		x	
	Unknown yellow encrusting sponge		x	
	Unknown yellow lobate sponge		x	x
	Unknown yellow rope sponge			x
	Unknown yellow sponge			x
	Xestospongia muta	x	x	x

Note: Habitat Type: CPV (Colonized pavement), PRF (Patch reef), and SWS (Sand with scattered rocks or rhodoliths)



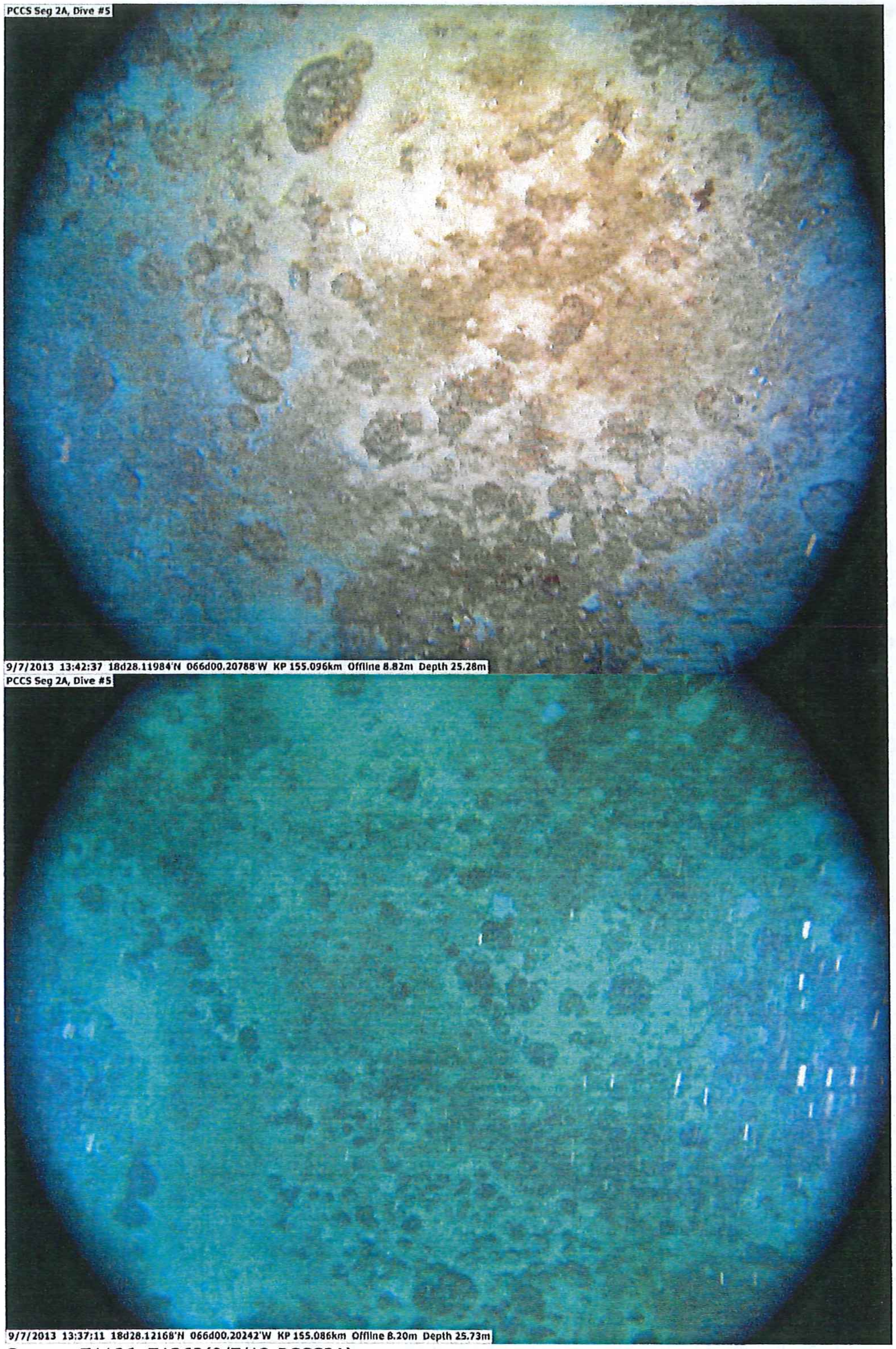
Source: 30681,30585 (9/7/13-PCCS2A)

Figure 3-2. Representative photos of colonized pavement (CPV) habitat PCCS 2A.



Source: 71060, 71395(9/7/13-PCCS2A)

Figure 3-3. Representative Photos of Patch Reef Habitat (PRF) PCCS 2A.



Source: 71186, 71362(9/7/13-PCCS2A)

Figure 3-4. Representative Photos of Sand with Scattered Rock or Rhodolith Habitat PCCS 2A

3.2 PCCS Segment 2

The PCCS segment 2 cable route featured three main benthic habitat types that occurred as single transitions along the route (Figure 3-5). A bank coral reef system was present at the shallower eastern end of the survey area, at a depth of 35.8 meters (KP 19.901). This reef extended to the west-southwest along the St. John outer shelf down to a depth of 44.9 meters at KP 20.69. The reef is evidently of biogenic origin and very similar to the MCD reef previously described by Nemeth et al. (2008) and Smith et al. (2010) for the south coast of St. Thomas. Representative photos of the bank reef habitat are presented in Figure 3-6 . Live coral was the dominant benthic invertebrate category in terms of reef substrate cover in the BCR with a mean of 36.8 percent (Table 3-4), largely driven by *Montastraea franksi*, which represented 96.7 percent of the total scleractinian coral cover. Five additional coral species were represented in the photos used for quantitative determinations of reef substrate cover (Table 3-4). These included *Agaricia lamarki, A. undata, Montastraea cavernosa, Mycetophyllia lamarckiana,* and *Porites astreoides. Madracis decactis* and *Scolymia* spp. were also identified from qualitative analyses of the photo gallery (Table 3-5). Boulder star coral, *M. franksi*, was observed growing as thick laminar colonies of variable sizes, including very large round colonies one meter or more in diameter, creating overlaps with adjacent colonies in many reef areas. Corals typically grew separated from the reef base by a pedestal leaving substantial spaces between colonies and forming a highly complex physical structure with high topographic relief. Cross-route transects were conducted at two locations over the BCR extending approximately 100 meters to either side of the planned route; the cover and structure of the BCR was to be similar throughout the area surveyed.

Reef hard ground spaces not colonized by live corals were mostly covered by benthic macroalgae (mean: 54.7 percent). The dominant benthic algal component was the turf (29.8 percent), a mixed assemblage of brown and red macroalgae growing encrusted over the substrate. Crustose coralline algae were also prominent, with a mean reef substrate cover of 21.0 percent (Table 3-4). Sponges, with a mean cover of 1.4 percent, represented only a minor component of the bank reef biota. Likewise, gorgonians were present but in relatively low densities.

Below 48.0 meters depth (KP 20.832), the bank reef transitioned into a sandy bottom with crustose algal nodules, or rhodoliths. Rhodoliths appeared to increase in numbers with increasing depth until a large deposit of rhodoliths was evident within the 50 to 58 meters depth range. Benthic algae, comprising a diverse assemblage of crustose coralline (26.0 percent), brown (10.5 percent), turf (4.0 percent), and calcareous (*Halimeda* sp.) macroalgae, were the most prominent taxon at the colonized rhodolith reef habitat (CRR) with a combined mean substrate cover of 45.5 percent (Table 3-4). Crustose coralline algae, particularly

Peyssonnelia flavescens, seem to play an important role of stabilizing the rhodolith deposit as they grow in laminar forms, fusing rhodoliths together and creating a quasi-stable substrate. As rhodoliths become motionless, they are colonized by corals and sponges (Figure 3-7). At least 29 sponges and 15 coral species were recognized from photos taken at the CRR (Table 3-5).

Scleractinian corals were observed throughout the CRR habitat, including proposed ESA species *Montastraea franksi* and *Agaricia lamarki*. Colonies were typically observed as isolated colonies of variable sizes. Some colonies of *A. lamarki* and other lettuce corals (*Agaricia* spp) were observed to reach substantial horizontal (approximately 1 meter) and vertical dimensions (approx. 0.5 m), contributing markedly to the reef topographic relief. Still, reef substrate cover was below 1 percent for all corals, including *M. franksi* and *A. lamarki*. The combined mean substrate cover by scleractinian corals at the CRR was 2.25 percent (Table 3-4). Live coral colonies were observed at the CRR down to 58.4 meters .

Sponges were typically observed as small encrusting types, but several branching forms of *Agelas* spp. and *Aplysina* spp. and erect forms of giant barrel sponge, *Xestospongia muta*, were present (Table 3-5). Overall, sponges comprised a minor component of the benthos with a combined mean substrate cover of 0.5 percent (Table 3-4). Abiotic substrates, mostly interspersed sand pockets within the CRR habitat, were prominent in terms of substrate cover with a mean of 51.7 percent.

At KP 36.79, the CRR transitioned into a sandy area with interspersed rock outcrops, or PRF. These were small mound shaped structures colonized by macroalgae and some corals (Figure 3-8). Macroalgae (53.8 percent) and abiotic/sand (40.7 percent) constituted the main benthic categories at the PRF habitat. Scleractinian corals were represented by three species, including *Montastraea franksi*, with a combined mean substrate cover of 1.8 percent (Table 3-4). A narrow sandy ridge with some rock outcrops was observed at the shelf-edge. The survey ended at the shelf-edge, where it breaks abruptly into a steep wall at a depth of 71.5 meters (KP 36.959).

(Figure 3-5).

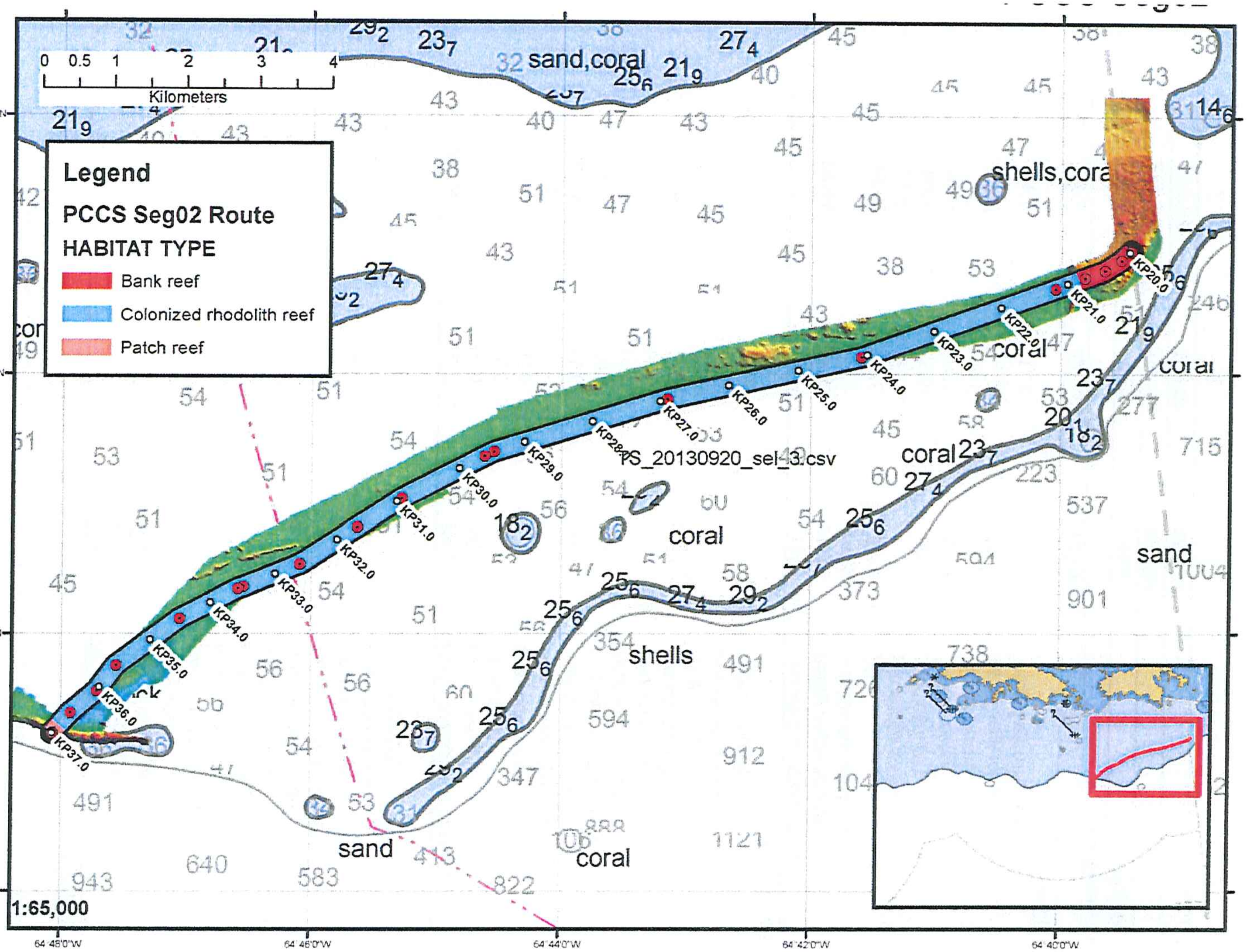


Figure 3-5. Benthic Habitat Map of Segment PCCS 2 South of St. John, USVI

Table 3-4. Percent Cover by Benthic Habitat Transition and Substrate Category along PCCS 2

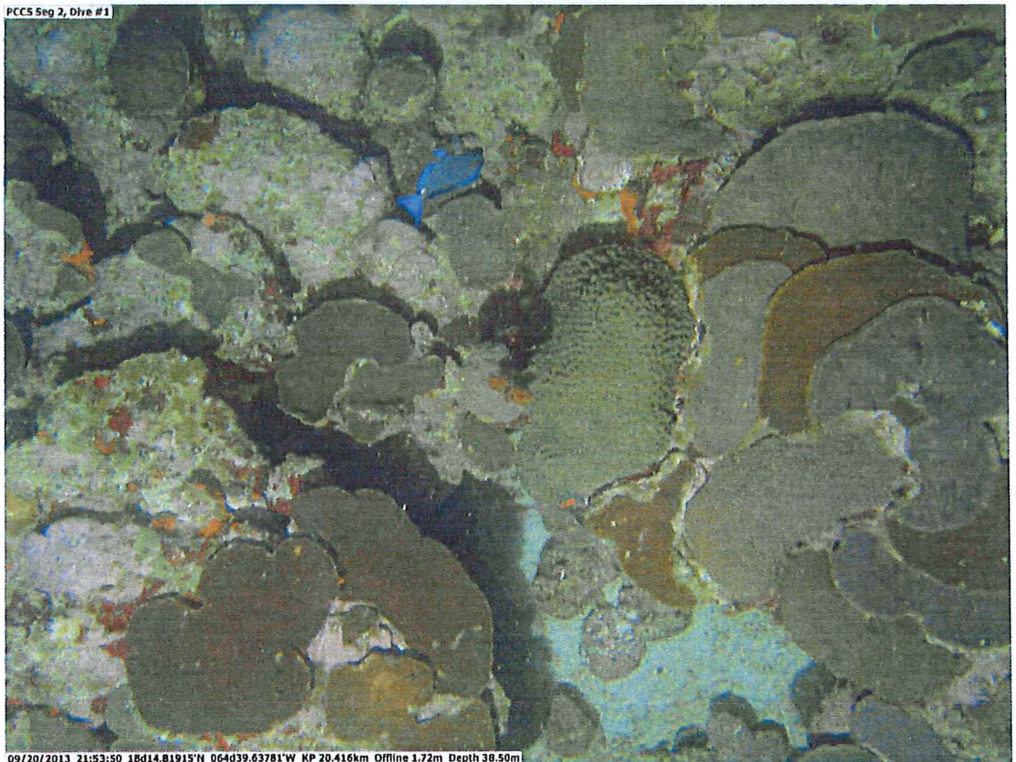
	Route Transition		
	1	**2**	**3**
Start KP	**36.790**	**20.832**	**19.901**
End KP	**36.959**	**36.790**	**20.832**
Benthic Habitat	**PRF**	**CRR**	**BCR**
Substrate Categories			
Abiotic	*40.73*	*51.72*	*7.50*
Benthic algae			
Brown encrusting algae		0.31	0.44
Crustose coralline algae	5.09	23.11	21.04
Galaxaura sp.		0.06	
Halimeda sp.	0.36	1.91	0.16
Lobophora sp.	8.00	10.52	2.88
Peyssonnelia flavescens		2.89	0.32
Turf	1.45	3.96	29.84
Unknown macroalgae	38.91	2.71	
Total Benthic Algae	***53.81***	***45.47***	***54.68***
Cyanobacteria/algal mix	2.91		
Scleractinian coral			
Agaricia fragilis		0.06	
Agaricia grahamae		0.89	
Agaricia lamarcki		0.39	0.16
Agaricia undata	0.36	0.23	0.08
Colpophyllia natans		0.04	
Leptoseris cucullata		0.04	
Montastraea cavernosa		0.02	0.40
Montastraea franksi	0.36	0.44	35.60
Mycetophyllia lamarckiana			0.16
Porites astreoides		0.06	0.40
Scolymia sp.		0.04	
Unknown coral	1.09	0.04	
Total Scleractinian Coral	***1.82***	***2.25***	***36.80***
Sponge			
Agelas conifera		0.04	
Agelas clathrodes			0.08
Agelas tubulata		0.02	
Amphimedon compressa		0.02	
Aplysina cauliformis		0.02	
Geoidia neptuni			0.32
Petrosia pellasarca		0.02	
Plaktoris sp.			0.16
Spirastrella coccinea		0.02	
Svenzea zeai			0.80
Unknown sponge	0.36	0.36	
Xestospongia muta	0.37	0.04	
Total Sponge	***0.73***	***0.54***	***1.36***
Unknown/other		***0.13***	

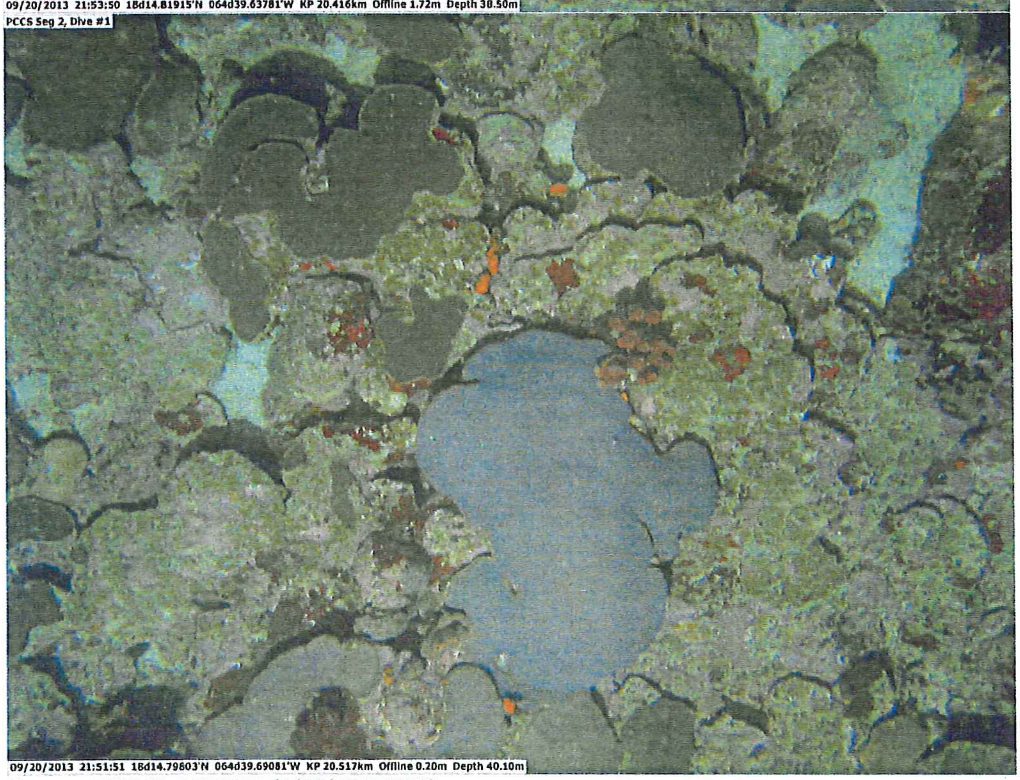
Note:
Habitat codes: BCR (Bank coral reef), CRR (Colonized rhodolith reef), and PRF (Patch reef).

Table 3-5. List of Invertebrate Species Identified on PCCS Segment 2, St. John, USVI

	Species	BCR	PRF	CRR
Coral	*Agaricia fragilis*			x
	Agaricia grahamae	x		x
	Agaricia lamarcki	x		x
	Agaricia sp.		x	x
	Agaricia undata			x
	Colpophyllia natans			x
	Leptoseris cucullata			x
	Madracis decactis	x		
	Montastraea cavernosa	x		x
	Montastraea franksi	x	x	x
	Mycetophyllia lamarckiana	x		x
	Porites astreoides	x		x
	Scolymia sp.1	x		x
	Scolymia sp.2			x
	Unknown encrusting coral			x
	Unknown coral			x
Anemone	*Condylactus gigantea*			x
Octocorals	*Erythropodium caribeorum*	x		
	Ellisela sp.	x		
Sponges	*Agelas citrina*			x
	Agelas clathrodes	x		x
	Agelas sp.			x
	Agelas tubulata		x	x
	Aka sp.			x
	Amphimedon compressa	x	x	x
	Aplysina archeri	x		
	Aplysina cauliformis	x		x
	Aplysina fistularis			x
	Aplysina fulva	x		
	Aplysina sp.			x
	Cinachyrella kuekenthali			x
	Cliona sp.			x
	Ectyoplasia ferox			x
	Geoidia neptuni	x		x
	Ircinia sp.			x
	Petrosia pellasarca			x
	Petrosia sp.			x
	Plakortis halichondriodes		x	
	Plakortis sp.			x
	Prosuberites laughlini			x
	Spirastrella coccinea		x	x
	Suberea sp.			x
	Svenzea zeai	x		
	Unknown black encrusting sponge			x
	Unknown lobate sponge			x
	Unknown orange encrusting sponge	x		x
	Unknown orange lobate sponge	x		x
	Unknown orange rope sponge			x
	Unknown pink encrusting sponge			x
	Unknown red rope sponge		x	x
	Unknown small tube sponge			x
	Xestospongia muta			x

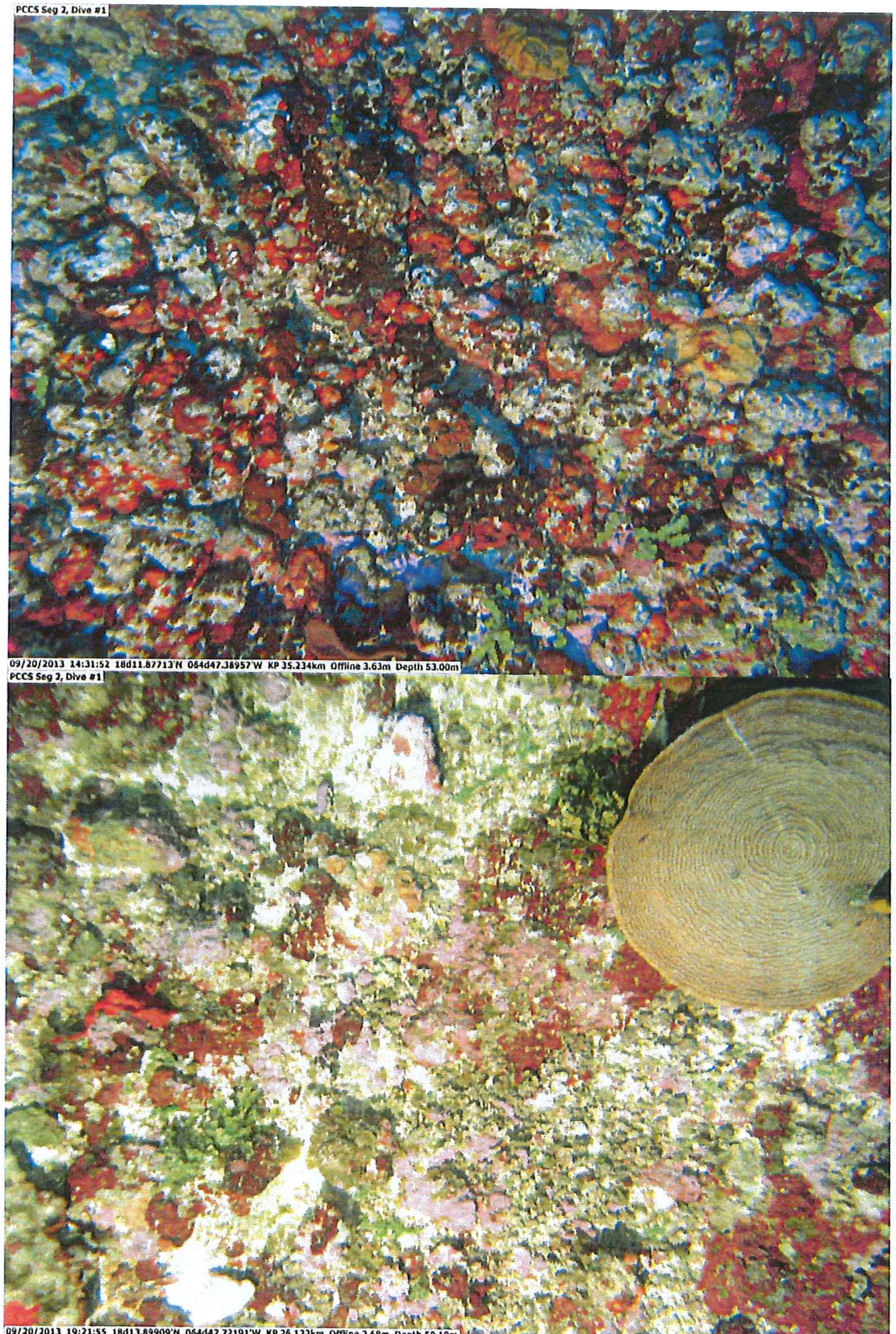
Habitat codes: BCR (Bank coral reef), PRF (Patch reef), and CRR (Colonized rhodolith reef)





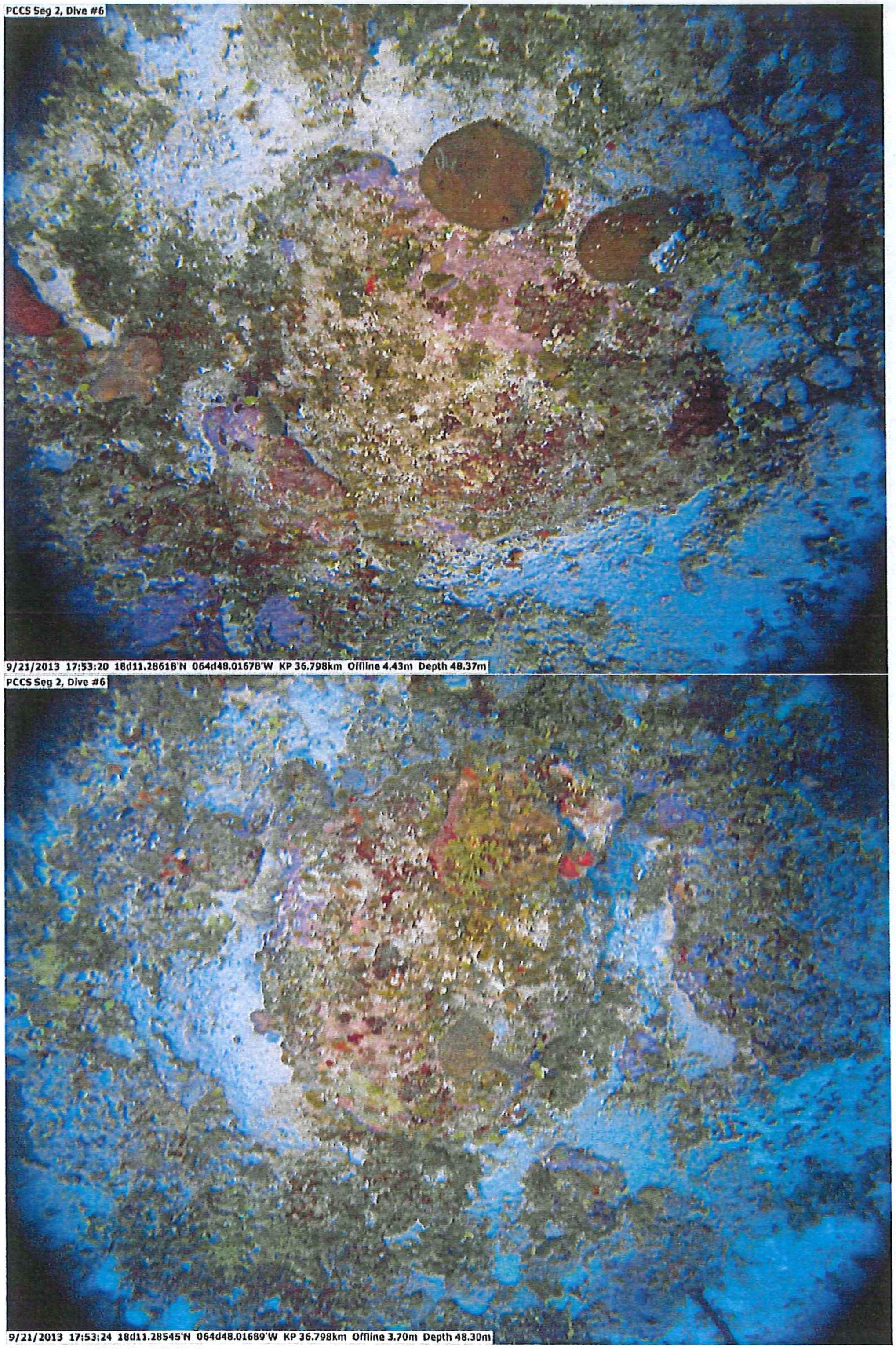
Source: TS2966, TS2950 (9/20/12 PCCS2)

Figure 3-6. Representative Photos of Bank Coral Reef (BCR) Habitat PCCS 2.



Source: 1703, 2492 (9/20/12 PCCS2)

Figure 3-7. Representative Photos of Colonized Rhodolith Reef (CRR) Habitat PCCS 2.



Source: 16724, 16726

Figure 3-8. Representative Photos of Patch Reef (PRF) PCCS–2.

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Bioimpact Inc. 2013. Email From: Amy Claire Dempsey Sent: Tuesday, September 03, 2013 11:03 AM To: Garcia, Edgar W SAJ; Castillo, Sindulfo SAJ; : Lisamarie Carrubba - NOAA Federal; Lia Ortiz; Jocelyn Karazsia - NOAA Federal; Subject: PCCS and viNGN Mesophotic Coral Surveys

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APPENDIX A

ROUTE POSITION LISTS

APPENDIX B

MOBILIZATION REPORT

APPENDIX C

DAILY SURVEY LOGS

APPENDIX D

TABLE AND MAPS OF ANALYZED PHOTOS

APPENDIX E

DAILY PROGRESS REPORTS

Attachment C
2014 National Marine Fisheries Service Biological Opinion for PCCS

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
http://sero.nmfs.noaa.gov

F/SER31:LC
SER-2013-00552
SER-2013-12257

11/10/2014

Chief, Antilles Regulatory Section
Antilles Office, Jacksonville District Corps of Engineers
Department of the Army
400 Fernández Juncos Avenue
San Juan, Puerto Rico 00901-3299

Ref.: SAJ-2013-00294, viNGN, Inc., Virgin Islands Next Generation Network (viNGN) Cable System between St. Thomas, St. Croix, and Water Island, U.S. Virgin Islands
SAJ-2013-01633, Telefónica International Wholesale Services, Pacific Caribbean Cable System with Segments in Puerto Rico and between U.S. Virgin Islands and British Virgin Islands

Dear Sir or Madam:

The enclosed Biological Opinion ("Opinion") was prepared by the National Marine Fisheries Service (NMFS) pursuant to Section 7(a)(2) of the Endangered Species Act (ESA). The Opinion considers the effects of the proposed actions related to the installation of the Virgin Islands Next Generation Network (viNGN) and Pacific Caribbean Cable System (PCCS) submarine cable systems on the following listed species and/or critical habitat:

Species or Critical Habitat	**NMFS's Determination viNGN**	**NMFS's Determination PCCS**
Hawksbill sea turtle, *Eretmochelys imbricata*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Green sea turtle, *Chelonia mydas*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Loggerhead sea turtle, *Caretta caretta*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Leatherback sea turtle, *Dermochelys coriacea*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Blue whale, *Balaenoptera musculus*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Finback whale, *Balaenoptera physalus*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Sei whale, *Balaenoptera borealis*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Sperm whale, *Physeter macrocephalus*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Humpback whale, *Megaptera*	May affect, but is not likely to	May affect, but is not likely to

Species or Critical Habitat	NMFS's Determination viNGN	NMFS's Determination PCCS
novaeangliae	adversely affect	adversely affect
Elkhorn coral, *Acropora palmata*	May affect, but is not likely to adversely affect	No effect
Staghorn coral, *Acropora cervicornis*	May affect, but is not likely to adversely affect	No effect
Pillar coral, *Dendrogyra cylindrus*	May affect, but is not likely to adversely affect	No effect
Lobed star coral, *Orbicella* (formerly *Montastraea*) *annularis*	May affect, but is not likely to adversely affect	No effect
Mountainous star coral, *Orbicella faveolata*	May affect, but is not likely to adversely affect	May affect, but is not likely to adversely affect
Boulder star coral, *Orbicella franksi*	May affect, but is not likely to jeopardize the continued existence	May affect, but is not likely to jeopardize the continued existence
Rough cactus coral, *Mycetophyllia ferox*	No effect	May affect, but is not likely to adversely affect
Elkhorn and staghorn coral critical habitat	No destruction or adverse modification	No destruction or adverse modification

The Opinion includes discretionary conservation recommendations to further the conservation of ESA-listed species and designated critical habitat. Please direct questions regarding this Opinion to Dr. Lisamarie Carrubba, Consultation Biologist, at (787) 851-3700, or by email at Lisamarie.Carrubba@noaa.gov.

Sincerely,

Miles M Croom

for Roy E. Crabtree, Ph.D.
Regional Administrator

Enc.: 1. *Sea Turtle and Small Tooth Sawfish Construction Conditions* (Revised March 23, 2006)
2. *Vessel Strike Avoidance Measures and Reporting for Mariners* (Revised February 7, 2008)
3. *PCTS Access and Additional Considerations for ESA Section 7 Consultations* (Revised June 11, 2013)

cc: F/SER4 –Pace Wilber, Lia Ortiz, Jocelyn Karazsia, José Rivera
USACE – Edgar Garcia, Sindulfo Castillo, Gisela Román, Johann Sasso

File: 1514.22.F.9 and 10

Endangered Species Act - Section 7 Consultation
Biological Opinion

Activity: Installation of Virgin Islands Next Generation Network (viNGN) Submarine Cable, Various Landing Sites in St. Thomas, Water Island, and St. Croix, U.S. Virgin Islands (USVI), and Installation of the Pacific-Caribbean Cable System (PCCS) by Alcatel-Lucent with Landing Site in Carolina, Puerto Rico, and Route between USVI and British Virgin Islands (BVI)

Consultation Number: SER-2013-10552 and SER-2013-12257

Federal Action Agency: U.S. Army Corps of Engineers

Species and Critical Habitat Affected, and ESA Conclusions:

ESA-Listed Species and Critical Habitat	ESA Listing Status of the Species (E=endangered, T=threatened)	Are the actions likely to adversely affect this species or its critical habitat?	Are the actions likely to jeopardize this species?	Will the actions destroy or adversely modify critical habitat for this species?
Hawksbill sea turtle, *Eretmochelys imbricata*	E	No	No	N/A
Green sea turtle, *Chelonia mydas*	T	No	No	N/A
Loggerhead sea turtle, *Caretta caretta*	T	No	No	N/A
Leatherback sea turtle, *Dermochelys coriacea*	T	No	No	N/A
Blue whale, *Balaenoptera musculus*	E	No	No	N/A
Finback whale, *Balaenoptera physalus*	E	No	No	N/A
Sei whale, *Balaenoptera borealis*	E	No	No	N/A
Sperm whale, *Physeter macrocephalus*	E	No	No	N/A
Humpback whale, *Megaptera novaeangliae*	E	No	No	N/A
Elkhorn coral, *Acropora palmata*	T	No for species (present viNGN	No	No

		only) Yes for critical habitat (PCCS only)		
Staghorn coral, *Acropora cervicornis*	T	No for species (present in viNGN only) Yes for critical habitat (PCCS only)	No	No
Pillar coral, *Dendrogyra cylindrus*	T	No (present viNGN only)	No	N/A
Lobed star coral, *Orbicella* (formerly *Montastraea*) *annularis*	T	No (present in viNGN only)	No	N/A
Mountainous star coral, *Orbicella faveolata*	T	No (present in PCCS only)	No	N/A
Boulder star coral, *Orbicella franksi*	T	Yes (both viNGN and PCCS)	No	N/A
Rough cactus coral, *Mycetophyllia ferox*	T	No (present PCCS only)	No	N/A

Consultation Conducted By: National Marine Fisheries Service (NMFS) Southeast Region

Issued By: Miles M Croom for Roy E. Crabtree, Ph.D. Regional Administrator

Date: 11/10/2014

LIST OF FIGURES

LIST OF TABLES

List of Acronyms

BMH – Beach manhole
BVI – British Virgin Islands
CCA – Crustose Coralline Algae
CFMC – Caribbean Fishery Management Council
CFR – Code of Federal Regulations
CRCP – Coral Reef Conservation Program
DEP – Division of Environmental Protection
DNER – Department of Natural and Environmental Resources (Puerto Rico)
DPNR – Department of Planning and Natural Resources (USVI)
DPS – Distinct Population Segment
EAR – Environmental Assessment Report
EEZ – Exclusive Economic Zone
EPA – U.S. Environmental Protection Agency
ESA – Endangered Species Act
FMP – Fishery Management Plan
FR – Federal Register
IPCC – Intergovernmental Panel on Climate Change
ITS – Incidental Take Statement
IUCN – International Union for the Conservation of Nature
MCD – Marine Conservation District
MMPA – Marine Mammal Protection Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NOS – National Ocean Service
NPS – National Park Service
PCCS - Pacific-Caribbean Cable System
RPA – Reasonable and Prudent Alternative
RPM – Reasonable and Prudent Measures
USACE – U.S. Army Corps of Engineers
USCG – U.S. Coast Guard
USFWS – U.S. Fish and Wildlife Service
USVI – U.S. Virgin Islands
viNGN – Virgin Islands Next Generation Network
VINP – Virgin Islands National Park
VIWAPA – Virgin Islands Water and Power Authority

INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §1531 et seq.), requires that each federal agency ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of those species. To fulfill this obligation, Section 7(a)(2) requires federal agencies to consult with the appropriate Secretary on any action that "may affect" listed species or designated critical habitat. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share responsibilities for administering the ESA.

Consultation is concluded after we (NMFS) determine that the action is not likely to adversely affect ESA-listed species or critical habitat, or issue a Biological Opinion ("Opinion") that identifies whether a proposed action is likely to jeopardize the continued existence of a listed species, or destroy or adversely modify critical habitat. If either of those circumstances is expected, we identify reasonable and prudent alternatives (RPAs) to the action as proposed that can avoid jeopardizing listed species or resulting in the destruction/adverse modification of critical habitat. In the Opinion we state the amount or extent of incidental take of the listed species that may occur, develop reasonable and prudent measures (RPMs) to reduce the effect of take, and monitoring to validate the expected effects of the action, and recommends conservation measures to further conserve the species.

This constitutes NMFS's Biological Opinion ("Opinion") based on our review of impacts associated with the issuance of a Department of the Army permit pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 for the Virgin Islands Next Generation Network (viNGN) and Pacific-Caribbean Cable System (PCCS) telecommunications cable installations. This Opinion analyzes project effects on elkhorn (*Acropora palmata*) and staghorn corals (*A. cervicornis*) and their designated critical habitat; pillar (*Dendrogyra cylindrus*), lobed star (*Orbicella annularis*), mountainous star (*O. faveolata*), boulder star (*O. franksi*), and rough cactus coral (*Mycetophyllia ferox*); hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles; and blue (*Balaenoptera musculus*), finback (*B. physalus*), sei (*B. borealis*), humpback (*Megaptera novaeangliae*), and sperm (*Physeter macrocephalus*) whales, that would result from the installation of the viNGN submarine telecommunications cable with landing sites around St. Thomas, Water Island, and St. Croix, U.S. Virgin Islands (USVI) and the installation of the PCCS submarine telecommunications cable with a landing site in Carolina, Puerto Rico, and a route between St. Thomas, USVI, and the British Virgin Islands (BVI).

NMFS has analyzed the effects of the submarine cable installation activities on ESA-listed species and designated critical habitat under our purview in accordance with Section 7 of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.). This Opinion is based on project information provided by the applicants, 2 site inspections by a NMFS biologist, published literature, and the best available scientific and commercial information.

It is NMFS's Biological Opinion that the viNGN project, as proposed, will have no effect on rough cactus corals; may affect, but is not likely to adversely affect, blue, finback, sei, humpback, and sperm whales; loggerhead, green, leatherback, and hawksbill sea turtles; elkhorn, staghorn, mountainous star, lobed star, and pillar corals; is not likely to jeopardize the continued existence of boulder star corals; and is not likely to destroy or adversely modify *Acropora* coral critical habitat.

It is NMFS's Biological Opinion that the PCCS project, as proposed, will have no effect on elkhorn, staghorn, pillar, and lobed star corals; may affect, but is not likely to adversely affect, blue, finback, sei, humpback, and sperm whales; loggerhead, green, leatherback, and hawksbill sea turtles, and mountainous star and rough cactus corals; is not likely to jeopardize the continued existence of boulder star corals; and is not likely to destroy or adversely modify *Acropora* coral critical habitat.

BIOLOGICAL OPINION

1 Consultation History

The consultation history for the viNGN project is as follows:

- Prior to receipt of the consultation request, we participated in a meeting with USACE, the project applicant and consultants, and the PCCS project applicant, on July 18, 2013, to discuss the deepwater survey methods and requirements for the 2 submarine cable projects. We met with viNGN and PCCS representatives on January 16, 2014, to receive and discuss the results of the mesophotic reef surveys. We received additional photos from the mesophotic surveys from the applicant on February 18, 2014.
- We received a request for consultation from the USACE on March 14, 2014.
- We requested additional information from the project applicant regarding the educational program via email on April 1, 2014. We received a response via email on April 1, 2014, as well as follow-up responses for the ESA and essential fish habitat consultations via emails dated June 13 and 21, 2014.

The consultation history for the PCCS project is as follows:

- Prior to receipt of the consultation request, we participated in a meeting with USACE, the project applicant and consultants, and the viNGN project applicant, on July 18, 2013, to discuss the deepwater survey methods and requirements for the 2 submarine cable projects. We met with viNGN and PCCS representatives on January 16, 2014, to receive and discuss the results of the mesophotic reef surveys. We received additional photos from the mesophotic surveys from the applicant on February 18, 2014.
- We received a request for consultation from the USACE on March 4, 2014. The consultation request only addressed the cable landing at Carolina, Puerto Rico.
- We informed the USACE via email dated March 12, 2014, that we were also going to consider the cable route between U.S. Virgin Islands (USVI) and the British Virgin Islands due to direct impacts of the cable route to corals that were proposed for ESA listing at the time the consultation was initiated. One of these coral species, *Orbicella franksi*, is now listed as threatened.
- We received additional information regarding sea turtles and potential impacts of the cable landing installation via email from the project consultant on March 19, 2014.

We decided to complete a batched consultation because the 2 projects are joint ventures, some of the cable segments will be installed in the same general location off the east end of St. Thomas, both projects are submarine telecommunications cables, and the cable segments will be installed simultaneously. The USACE also requested a Conference Opinion because of potential project impacts to 7 coral species that were proposed for listing under the ESA. Because the final listing decision was published on September 10, 2014, with an effective date of October 10, 2014, we revised this Opinion to reflect the change in status of these coral species to be our final Opinion for the cable projects.

2 Description of the Proposed Action

2.1 viNGN

The viNGN submarine fiber optic cable system will connect the islands of St. Thomas, Water Island, and St. Croix as part of an open-access fiber optic telecommunication network for the USVI. The system will have 8 cable landings at 7 landing points and will connect into a terrestrial fiber network that is also being constructed on each of the islands that will be serviced by the network. The project is comprised of 4 submarine segments (see Figure 1):

- Segment 1 from Brewers Bay, St. Thomas to Frederiksted, St. Croix
  - Landings are Brewers Bay, St. Thomas, and south of Frederiksted, St. Croix
- Segment 2 from Great Bay, St. Thomas to Christiansted, St. Croix
  - Landings are Great Bay, St. Thomas (where the existing landings for Little St. James and 1 of the Virgin Islands Water and Power Authority (VIWAPA) cables to St. John are located) and within the Altona Lagoon Park east of Christiansted, St. Croix
- Segment 3 from Brewers Bay, St. Thomas to Flamingo Bay, Water Island
  - Landings are Brewers Bay, St. Thomas (at the same location as for Segment 1) and Flamingo Bay, Water Island
- Segment 4 from Villa Olga (Careen Point), St. Thomas to Banana Bay, Water Island
  - Landings are Villa Olga at the site of VIWAPA's electrical cable to Hassel Island, St. Thomas and Banana Bay, Water Island

Connectivity to St. John will be via 2 fiber optic cables that are already in place and are, therefore, not considered as part of this consultation.

Two cables will connect to each island to provide redundancy and ensure that continuity of service will not be lost in the event that 1 of the cables becomes damaged. Two additional routes have been developed coming out of the Christiansted landing site to provide for future expansion. These 2 segments were included in the permit application and were included in the analysis in this Opinion. However, because we do not have information regarding the proposed routing of these segments other than at the landing site, reinitiation of ESA Section 7 consultation for these 2 routes will be needed if additional impacts to ESA-listed corals and acroporid coral critical habitat will occur outside the landing site (see Figure 2). The routes selected for each cable segment were chosen in order to avoid reefs and hard bottom to the greatest extent possible and also to avoid protected fishery spawning areas managed by the Caribbean Fishery Management Council (CFMC).

The cables will be between 14 millimeters (mm) (0.55 inches [in]) to 35 mm (1.378 in) in diameter, depending on the level of steel armoring considered necessary to protect the cables in shallow waters, where the risk of damage is greatest. Articulated pipe will also be installed to protect cables in shallow waters and also to reduce cable movement that could result in damage to benthic communities. The cables will be buried across beaches at landing sites where possible as well.

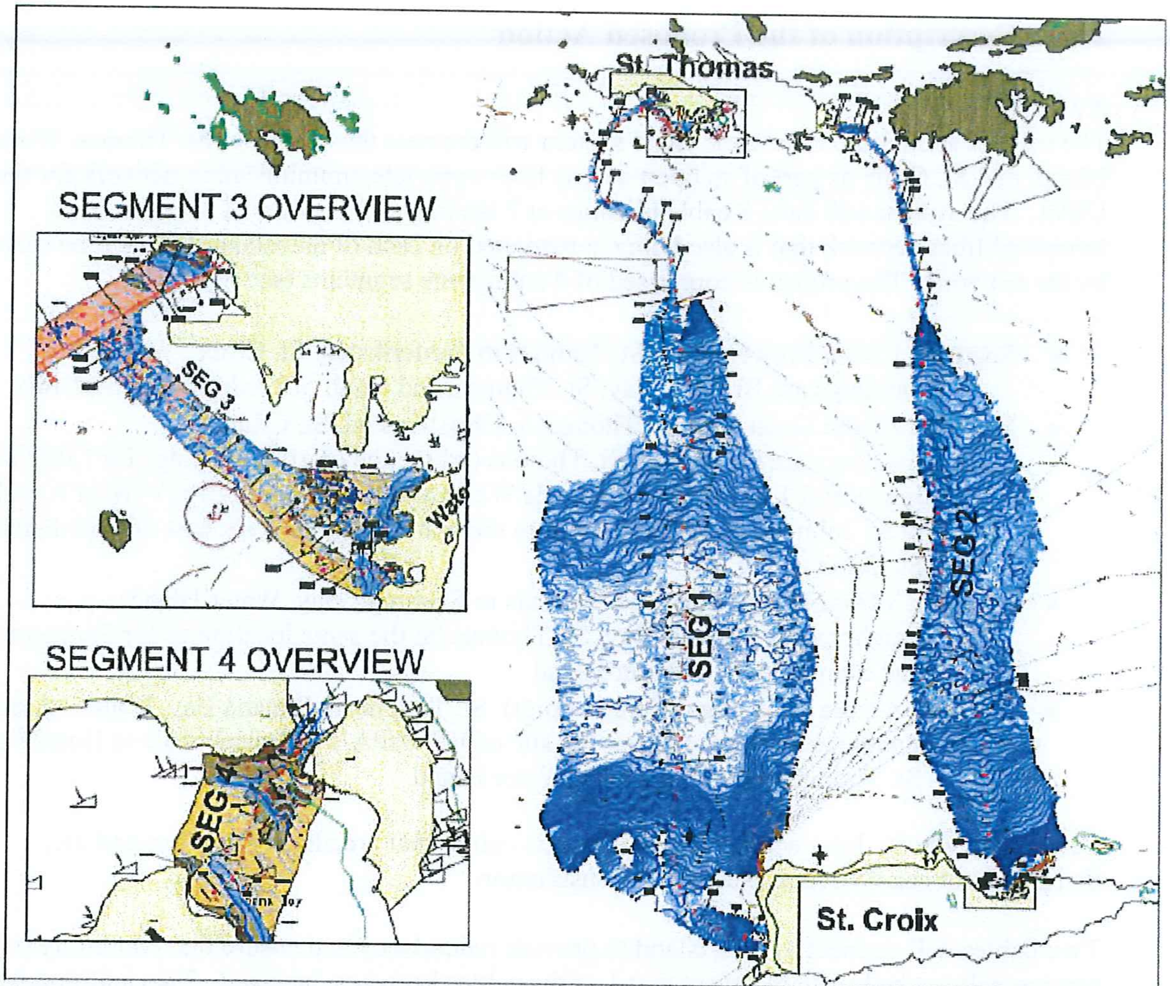

Figure 1. System-wide map showing viNGN segment locations and the results of the marine survey showing marine bottom types (from Environmental Assessment Report (EAR) prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

Details of each segment are as follows:

1. Segment 1: The Frederiksted landing is located on a large beach on the edge of Veteran's Shore Drive, St. Croix. The manhole for the landing will be built on the edge of the road subsurface conduits extending to the bottom of the hill. A concrete head-wall will be installed landward of the sand. Once the cable landing is complete, seagrape trees will be planted in front of the head-wall. The segment from the beach to water depths of approximately 16 feet (ft) will be protected with 328 ft of articulated pipe. This portion of the cable will cross sparse seagrass beds containing *Halophila beaudettei* and *Syringodium filiforme* and colonized pavement with scattered corals and sponges (see Figure 2). Off the beach, the cable will pass through a gap in the outer reef where a wide sand chute is present before descending the slope of the St. Croix shelf. The outer reef does contain some coral outcrops with *Orbicella annularis* being one of the most common stony corals on this reef. A survey of the deepwater area where the cable will pass through the gap in the reef found unconsolidated sand and sand with scattered rocks,

as well as an area with scattered rocky outcrops with limited colonization by organisms such as black corals and sponges (see Figure 3).

The route then crosses the Virgin Island Basin and climbs the shelf edge toward St. Thomas. The route crosses known in-service fiber optic cables and the applicant completed consultations with the owners of the cables to obtain approval for these crossings. On the St. Thomas shelf, Segment 1 was routed to avoid the Hind Bank Marine Conservation District (MCD) and Grammanik Bank before entering Brewers Bay where the cable landing is located on a beach. The route crosses colonized pavement, patch reef, sand with scattered rocks, bank coral reef, and colonized rhodolith reef off St. Thomas based on the mesophotic coral survey completed for the project (see Figure 4). Once at the top of the St. Thomas shelf and past the MCD, the cable routes around Saba Island and between known shipwreck locations, crosses an out-of-service telegraph cable and enters Brewers Bay.

Brewers Bay is composed of a sandy seabed with coral outcroppings and seagrass beds. The cable route was altered to avoid the coral areas, which have numerous *Orbicella annularis* colonies and some *O. faveolata*, *Dendrogyra cylindrus*, *Acropora palmata*, and *A. cervicornis* (see Figure 5). The cable will cross an area with seagrass before landing on the beach and entering a buried conduit to a manhole. The beach landing will be well-buried because the beach supports nesting by hawksbill sea turtles.

Segment 1 has a total length of approximately 86 kilometers (km) taking into account an average 2% bottom slack applied over the entire route to account for bottom contours.

2. Segment 2: The Great Bay landing is located at the Ritz-Carlton hotel beach in Great Bay, St. Thomas, within VIWAPA's utility easement where electrical cables already land. The cable route toward the center of the bay avoids coral habitats, which are present on the sides of the bay and include colonies of *Orbicella annularis*, *Dendrogyra cylindrus*, and *Acropora palmata*. Articulated pipe will be installed from the conduit onshore seaward 175 m or to the 5 meter (m) depth contour. The route will impact approximately 52 square meters (m^2) of dense seagrass near shore dominated by *Thalassia testudinum* and scattered seagrass dominated by *Syringodium filiforme* and *Halodule beaudettei* in the bay (Figure 6). The route then heads south over the shelf edge and descends to the floor of the Virgin Islands Basin (with a depth of approximately 12,139 ft) and then ascends the shelf of St. Croix to Christiansted. The route crosses the same in-service fiber optic cables as Segment 1.

   On the St. Thomas shelf, the mesophotic reef survey found that the cable route will cross an area dominated by colonized rhodolith reef with approximately 96% sand cover. Benthic algae dominated the colonizing organisms with very limited colonization (0.34%) by hard corals, including *Orbicella franksi*, and sponges (0.56%). An area of colonized pavement was found closer to the shelf edge, but this was again dominated by algal colonization with very limited colonization by hard corals, including *Orbicella franksi* (Figure 7).

The route crosses the St. Croix shelf in sand bottom with scattered coral outcroppings (Figure 8). The coral outcroppings along the shelf edge contain colonies of *Orbicella annularis*, *O. franksi*, and *Dendrogyra cylindrus*. The cable passes through an uncolonized grotto through the shelf edge reef and then over uncolonized sand bottom. The cables then follow (but do not enter, in case of future dredging) the Schooner Channel into Christiansted Harbor. The landing site in Christiansted is on a narrow sandy strip of land separating Christiansted Harbor from Altona Lagoon. Articulated pipe will be used to protect the cable from the shoreline to the 4-m depth contour, which equates to 350 m of articulated pipe. In shallow water near the landing site and along the eastern portion of the Schooner Channel, there are seagrass beds with a mixture of *Thalassia testudinum*, *Syringodium filiforme*, and *Halodule beaudettei*. There is also an area along the point near the proposed route with colonized hard bottom where *Orbicella annularis* and *Dendrogyra cylindrus* are present. The cable will affect some of the seagrass areas (approximately 195 m^2), but will not enter the colonized hard bottom areas (Figure 9). The landing site has space for 2 additional cables to be installed at a future time and 2 additional inshore routes have been charted to allow for this potential expansion. As noted previously, we have analyzed the potential effects of these 2 additional routes at the landing site. Reinitiation of ESA Section 7 consultation will be necessary if the final routes selected for the 2 segments will result in additional impacts to ESA-listed corals and acroporid coral critical habitat.

Segment 2 has a total length of approximately 72 km taking into account an average 2% bottom slack.

3. Segment 3: This route is entirely on the St. Thomas shelf in water depths less than 30 m. The Brewers Bay landing will be the same as for Segment 1. Articulated pipe will be placed seaward for 150 m or to the 5 m depth contour to protect the cable. The cable will lie over some seagrass areas. The Water Island landing will have a beach manhole in Flamingo Bay. The route will be trenched where possible onshore, but will encounter bedrock. The 300 m of articulated pipe that will be used to protect the cable will be hand-buried under the existing cobbles and gravel on the beach. It is possible that the cable will be exposed at times due to storms that move the gravel and cobble. The cable route is along the northern side of the bay to avoid anchorage areas for small boats and the barge that uses the bay as a landing point, as well as to avoid near shore hard bottom areas that have scattered coral colonization (see Figure 10). The cable will impact some areas of scattered seagrass.

   Segment 3 has a total length of approximately 6.4 km.

4. Segment 4: This route is also entirely on the St. Thomas shelf in shallow waters. This segment links Banana Bay, Water Island, to Villa Olga, St. Thomas. The Banana Bay landing site is at the bottom of an existing trail in a small clearing. Conduits will be installed from a beach manhole toward the water with a concrete head-wall constructed to secure the conduit ends. The remaining distance from the head-wall to the water will be hand-trenched and the cable will be protected with articulated pipe at this point, as well as 200 m seaward to the 5 m contour. Banana Bay is characterized by uncolonized sand,

but there are some hard bottom areas in the cut between Hassel Island and St. Thomas where the cable will be placed that are colonized, by corals including *Acropora palmata*. The cable placement will be monitored by divers to ensure that these areas are avoided (see Figure 11). There will be approximately 45.5 m^2 of impacts to seagrass beds as a result of the cable installation.

Segment 4 has a total length of approximately 1 km.

5. Additional Christiansted routes: Two additional inshore routes have been studied and charted to allow the Christiansted landing site to accept 2 additional cables (Figure 12). The additional conduits and cable routes are included in this Opinion for the landing site only because detailed information regarding the routes was not provided. Information in the EAR indicates that the eastern route will impact approximately 252 m^2 of seagrass and the middle route will impact approximately 236 m^2 as they enter the Christiansted landing site. The easternmost route will also cross approximately 37 m of reef and the middle route will cross approximately 35 m of hard bottom. Because details of these routes, other than the landing site in Christiansted, were not provided, the Opinion considers only the impacts of the 2 segments at the landing site. The use of these 2 routes in the future may require reinitiation of ESA Section 7 consultation if the final cable routes will result in impacts to ESA-listed corals or acroporid coral critical habitat.

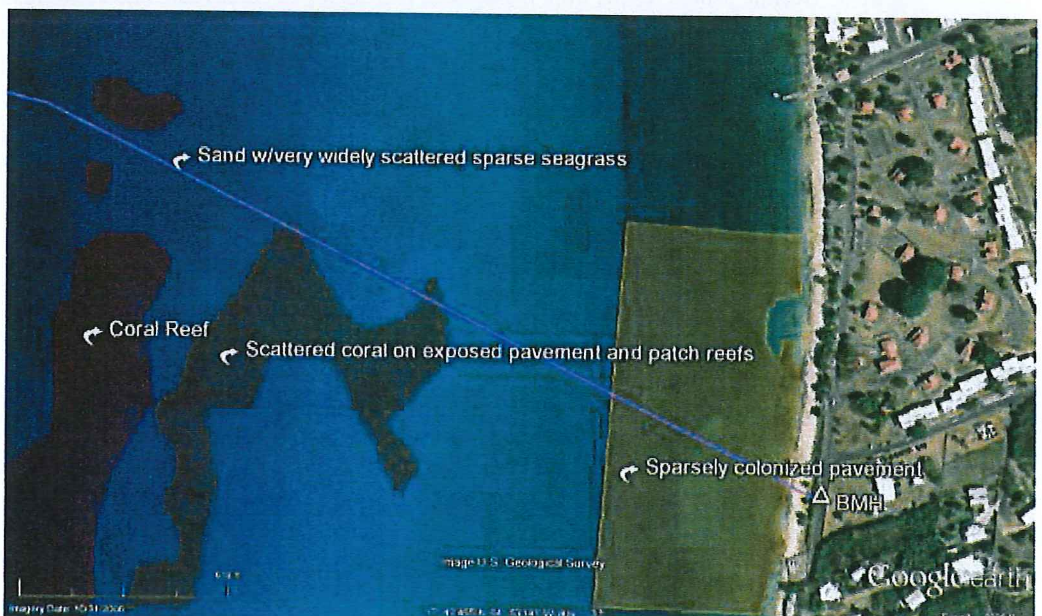

Figure 2. Benthic habitat map prepared for the Frederiksted landing and cable route (bluish line) where BMH stands for beach manhole (from EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

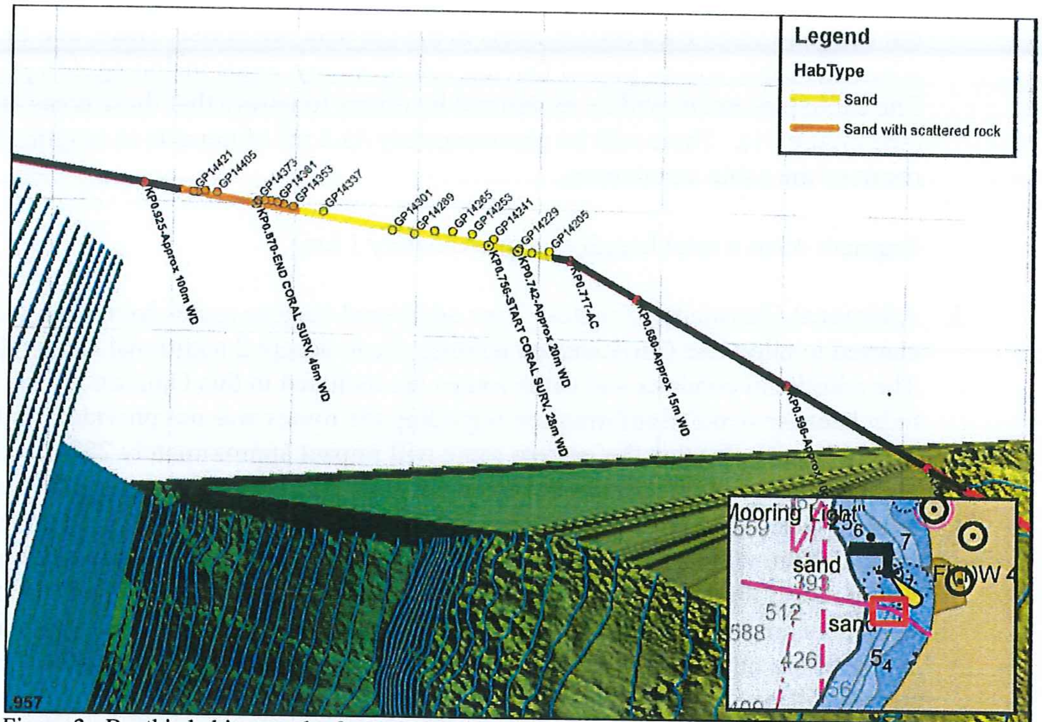

Figure 3. Benthic habitat results from mesophotic reef survey of cable route into Frekeriksted (from TetraTech 2013a)

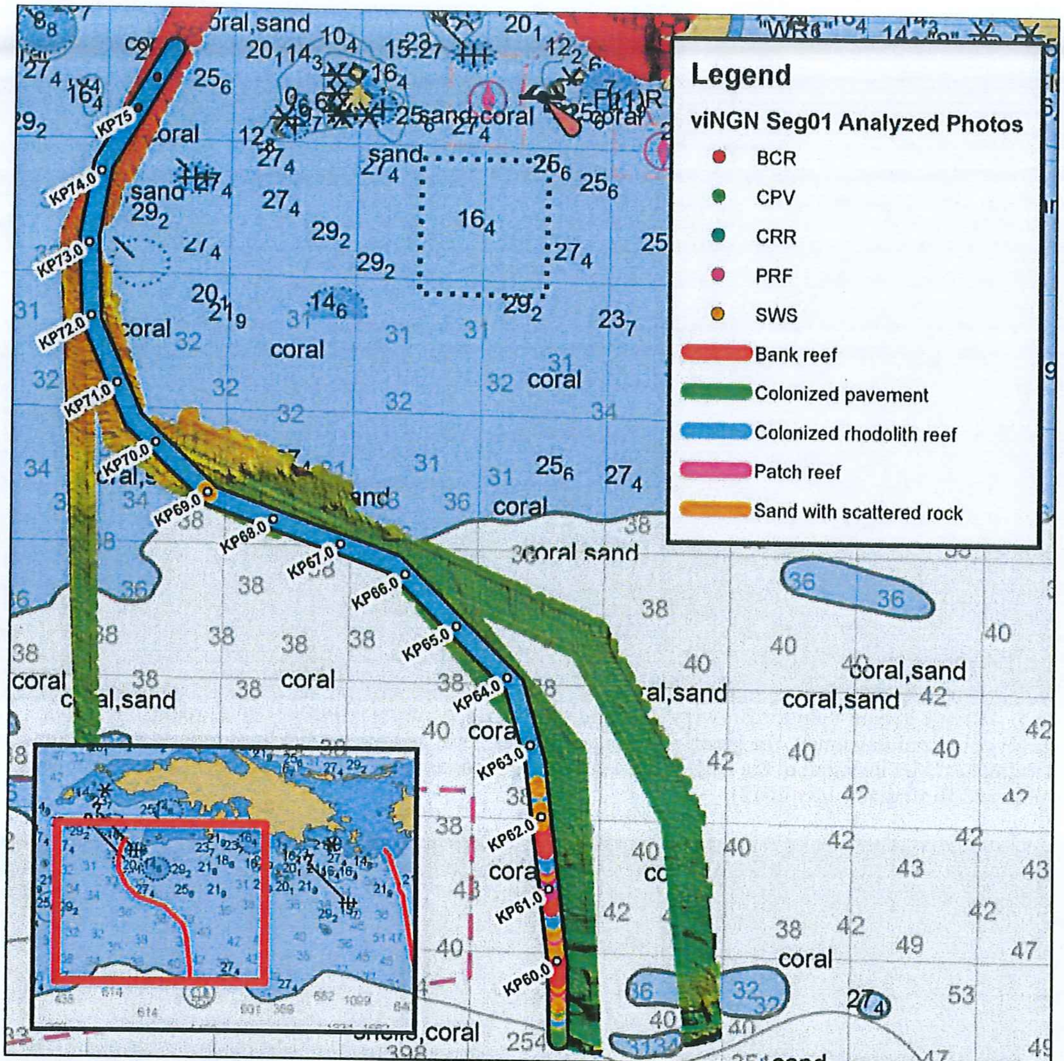

Figure 4. Benthic habitat results from mesophotic reef survey for route over St. Thomas shelf toward the Brewer Bay landing in Segment 1 (from TetraTech 2013b)

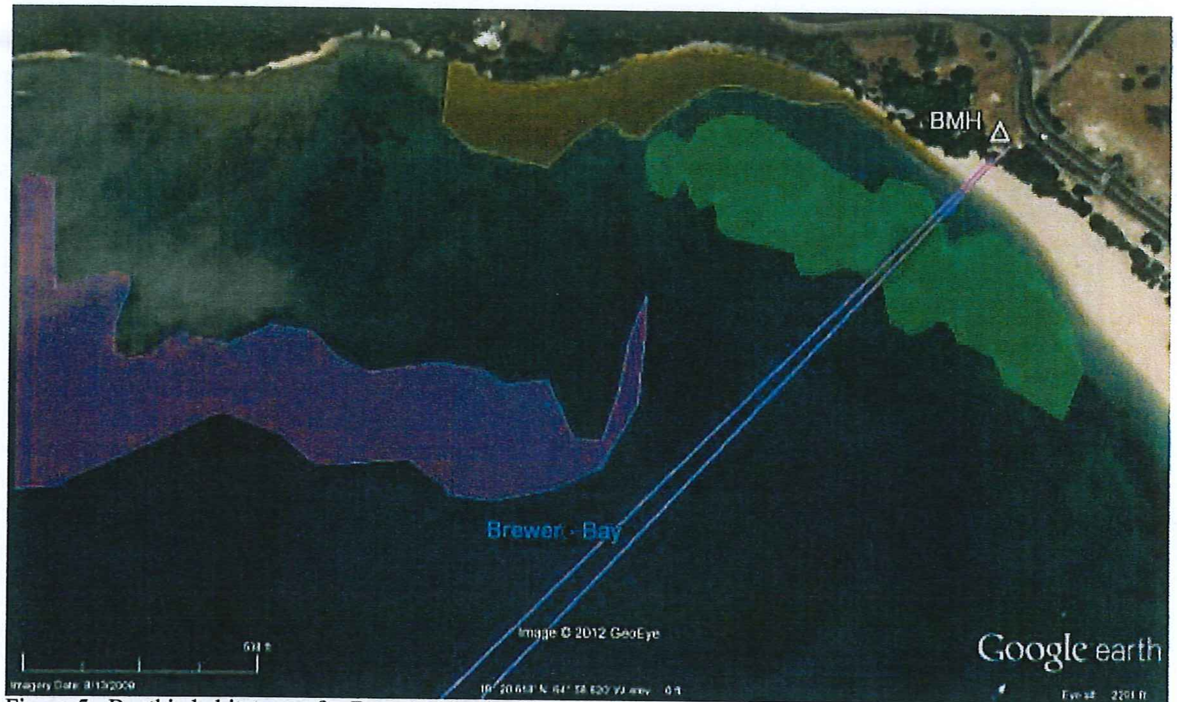

Figure 5. Benthic habitat map for Brewers Bay landing where the purple represents coral reefs, the brown represents colonized pavement, the green represents seagrass beds, and the double lines represent the redundant cable segments to be installed to the BMH (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

Figure 6. Benthic habitat map and cable route (light blue line) for Great Bay landing and BMH at the Ritz Carlton (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

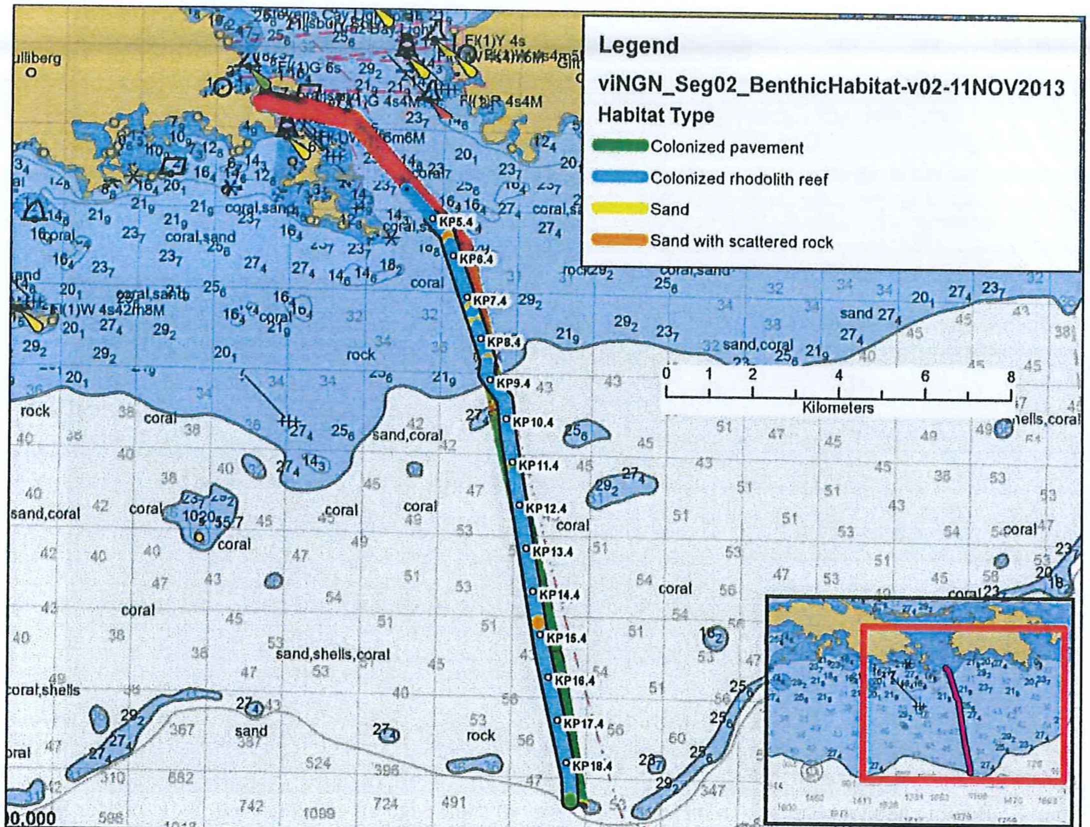

Figure 7. Benthic habitat results from mesophotic reef survey for segment from Great Bay over the St. Thomas shelf toward Christiansted, St. Croix for Segment 2 (from TetraTech 2013b)

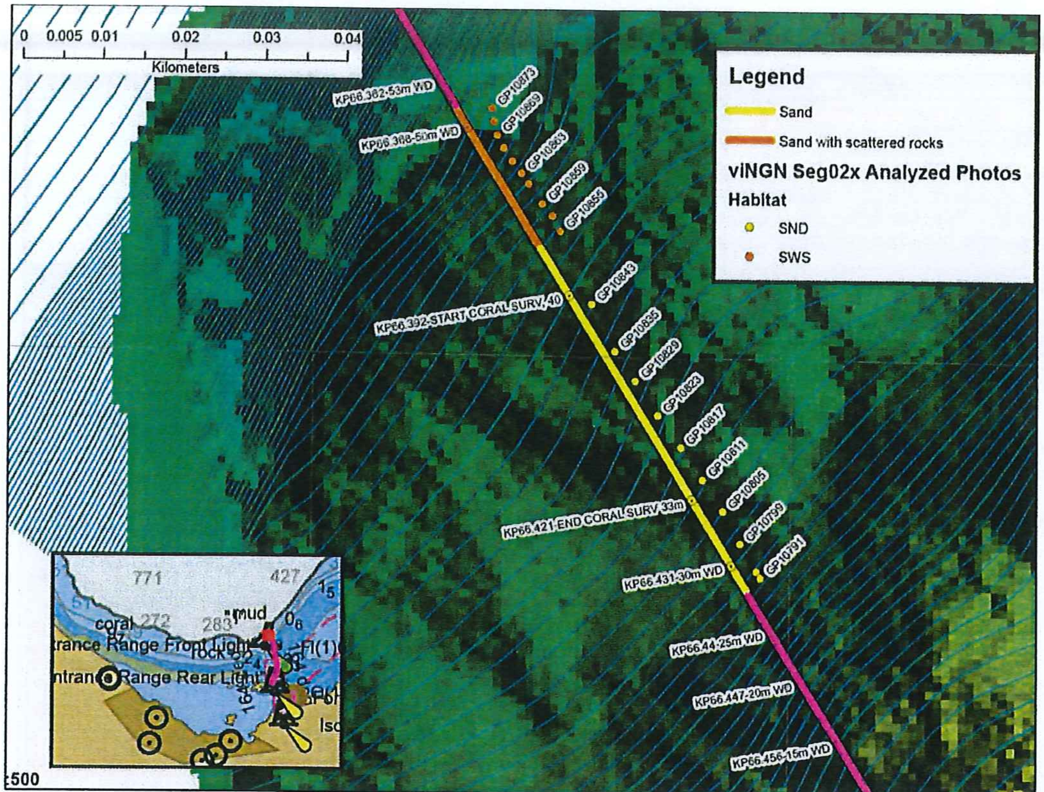

Figure 8. Benthic habitat results from mesophotic survey of shelf edge off Christiansted, St. Croix for Segment 2 (from TetraTech 2013b)

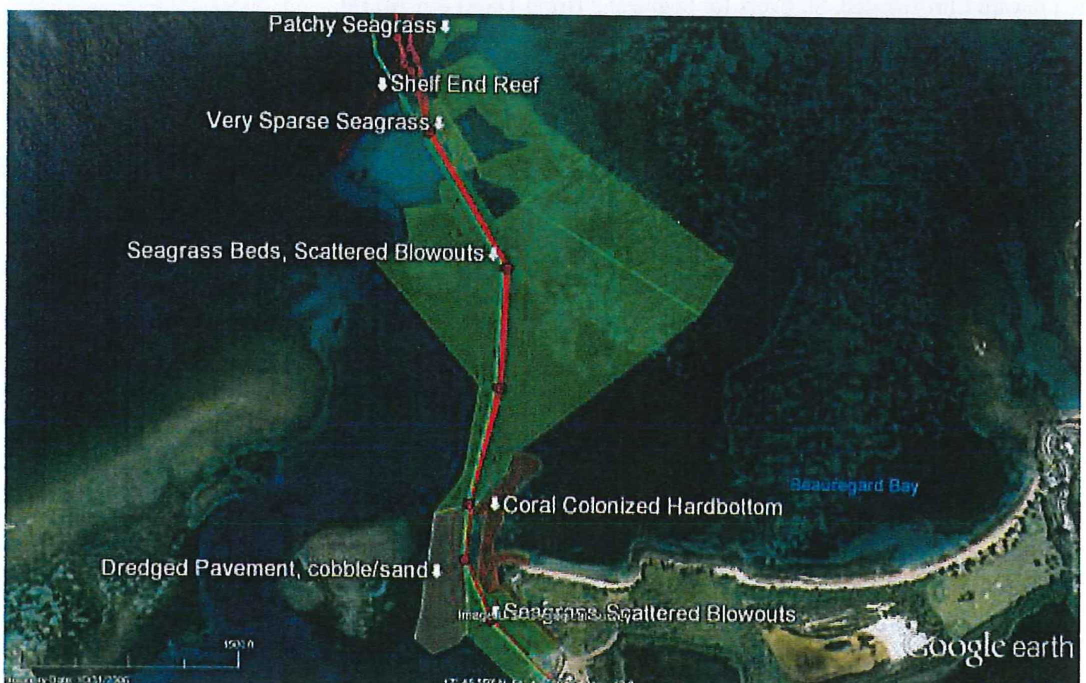

Figure 9. Benthic habitat map and cable route (red and yellow lines) for landing site to BMH in Christiansted Harbor, St. Croix (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

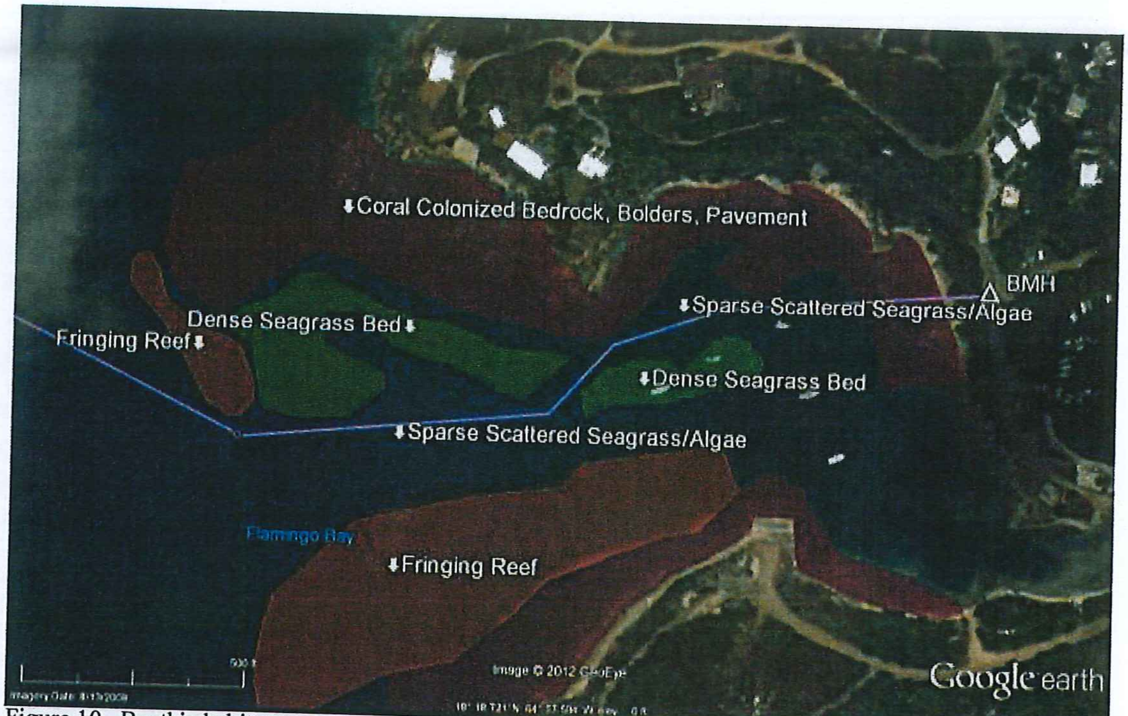

Figure 10. Benthic habitat map and cable route (purplish line) for cable landing to BMH in Flamingo Bay, Water Island (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

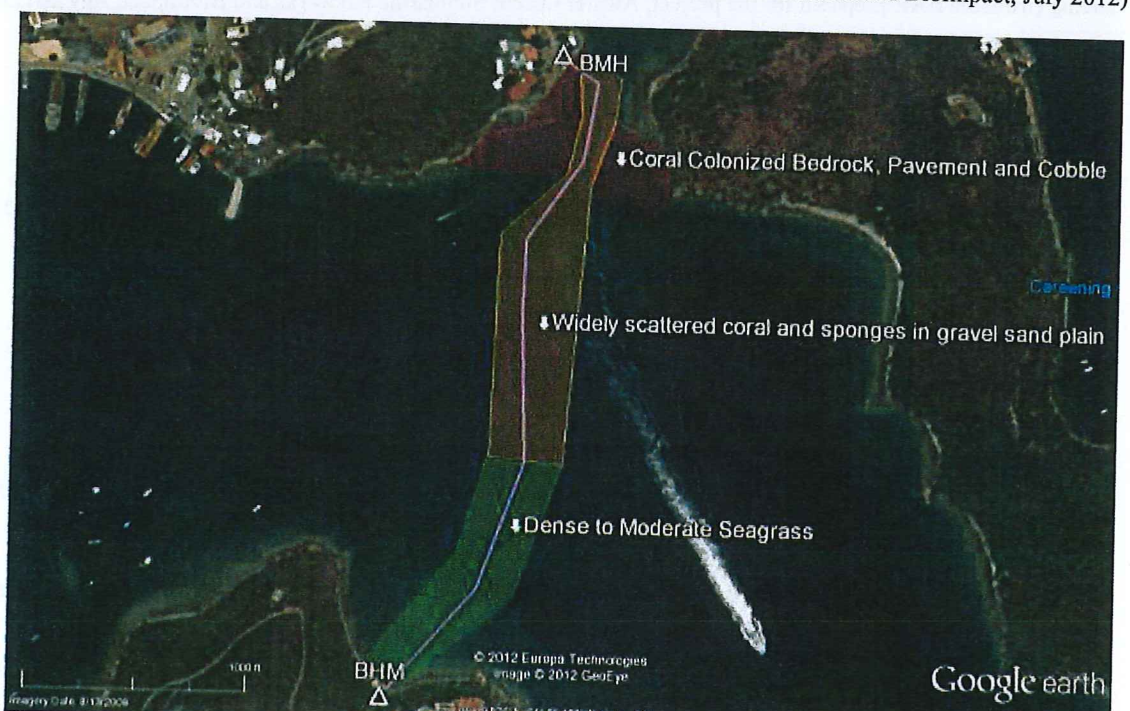

Figure 11. Benthic habitat map and cable route (bluish line) for cable landings to BMHs in Banana Bay, Water Island, and Villa Olga, St. Thomas (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

Figure 12. Image showing the 2 additional proposed routes in red and the portion of Segment 2 at its Christiansted landing (from the EAR prepared for the project, Alcatel Lucent Submarine Networks and BioImpact, July 2012)

The applicant has proposed the following construction methods and resource avoidance and minimization measures to protect ESA resources during cable installation:

1. For Segment 1, because the beach in Brewers Bay serves as sea turtle nesting habitat, cable conduits will be buried to a depth exceeding 1.3 m at the vegetation line and the beach corridor will be monitored for at least 60 days prior to any shoreline activity to ensure that no nests are disturbed. If nesting occurs, the excavation activity will be postponed or relocated to avoid the nest.

2. For Segment 1 at the Brewers Bay landing and other segments with landing sites containing seagrass, the cable will be monitored and, if it does not self-bury within 3 months of installation, it will be hand-buried out to a depth of approximately 12 m in Brewers Bay and to appropriate depths in other areas as determined to be necessary based on monitoring.

3. For Segment 2, the cable will be hand-buried in the shallows through the densest seagrass beds (approximately 51 m) to minimize permanent impacts to dense seagrass beds in Great Bay. In other areas where seagrass is very dense, the cable will be hand-buried in 3-m sections every 20 m.

4. For Segment 2, because the beach in Great Bay serves as sea turtle nesting habitat, the area will be monitored beginning at least 60 days prior to any shoreline activities. The conduits and/or cable will be buried to a minimum of 1.3 m. If nesting activity is

recorded within the footprint of the conduit or cable, the installation activity will be delayed or the cable slightly rerouted to avoid the nest.

5. The cable-installation vessel will be positioned offshore of a landing point at a depth sufficient to prevent disturbance of the marine bottom. The vessel will be held in place by dynamic positioning in order to avoid the need to anchor. Once the vessel is in place, a rope will be brought ashore by a small vessel that will then be used to pull the cable ashore. As the cable is pulled from the vessel, large floats will be placed on the cable to keep it at the water's surface. The cable will then be pulled ashore into the pre-excavated beach trench and conduits.

6. Divers will pre-mark the cable route using pin flags in sandy areas and concrete nails and flagging tape in rock and pavement areas in waters shallow enough for divers to assist with the installation. This pre-marking will be completed 4 weeks prior to the installation, along with videotaping of the areas. The videos will be provided to the resource agencies, including NMFS, for final review and approval.

7. Divers will position the floating cable over the marked route and remove the floats one at a time, allowing the cable to fall to the seabed with enough slack to allow for limited repositioning. Divers will ensure that the cable avoids corals and other sessile benthic organisms to the extent practicable. Once the cable is in place, divers will inspect the cable to a depth past all coral colonization or to 150 ft, whichever comes first. Divers will video the route and note any potential impacts to corals and other benthic organisms. Once the cable is secure, divers will remove the cable from on top of any corals or other benthic organisms. Divers will again video the areas where relocations are required.

8. The Christiansted, Flamingo Bay, and Villa Olga landings, which have restricted approaches, will use a small work barge with a lightship draft of 4 in for the cable installation.

9. NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* will be followed during cable placement/installation.

10. After the cable placement is complete, divers will place the articulated pipe in order to minimize damage to corals or seagrass in the vicinity of the pipe. The articulated pipe sections will be videoed following installation.

11. Turbidity monitoring will be done during installation of segments requiring articulated pipe and hand burial, as well as during beach excavations, to ensure that natural levels are not exceeded. Sediment and erosion control measures will also be implemented at the landing sites to minimize the transport of materials to near shore waters during trenching activities.

12. Where sensitive habitats lie near the cable routes, temporary buoys will be placed to ensure that vessels avoid those habitats.

13. A monitoring and mitigation plan will be implemented for the laying of all the cables. As part of this plan, water quality monitoring will take place, as well as monitoring before, during, and after the cable lay. Cables will be videoed monthly for the first 6 months following installation and then every 6 months for a period of 3 years. viNGN has also prepared a mitigation plan that includes the repair and reattachment of dislodged or fractured hard (no ESA-listed species) and soft corals, as well as the documenting of damages during post-installation monitoring to also document recovery of repaired colonies. viNGN also proposes a web-based education program to teach residents of the Virgin Islands about the importance of protecting the natural resources of the Territory. This will be done through a website feature in public computer centers in schools, libraries, and community centers throughout USVI. NMFS has already provided some educational materials and the applicant has prepared a mock-up of the website (see Figure 13).

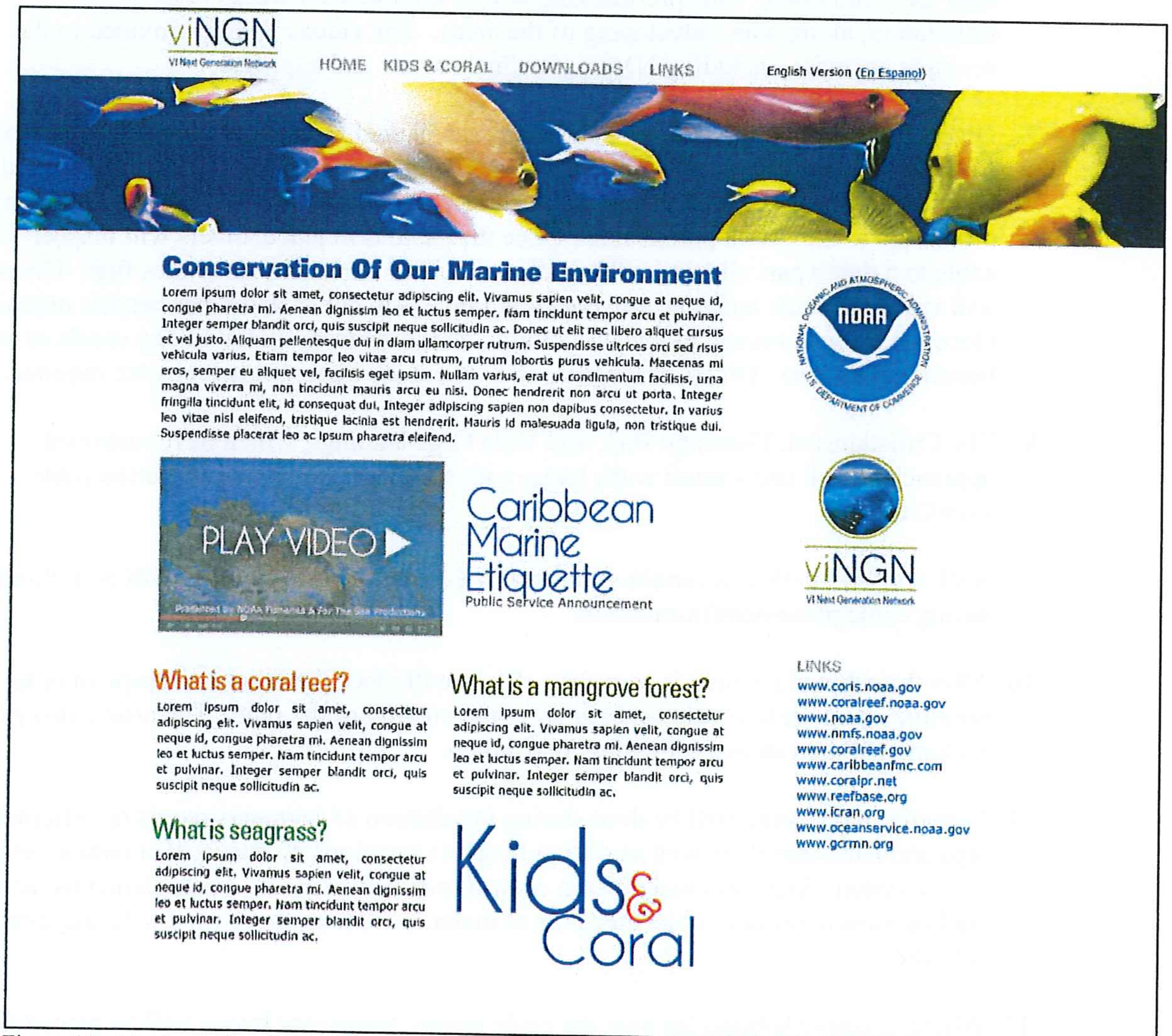

Figure 13. Mock-up of website proposed by viNGN as out-of-kind compensatory mitigation (from (BioImpact 2014)

The USACE will also require compliance with NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners*, (Revised February 2008), as part of the permit special conditions for any permit issued for the viNGN project.

2.2 PCCS

The PCCS submarine cable system will connect the continental United States, the British Virgin Islands (BVI), Puerto Rico, Aruba, Colombia, Panama, and Ecuador. Alcatel-Lucent Submarine Networks has been contracted by the PCCS Consortium to design, engineer, manufacture, and install the 6,000-kilometer (km) PCCS submarine cable system. The 6,000-km-long route will have 8 landing stations including 1 in Florida and 1 in Puerto Rico, 2 in Panama, and 1 each in BVI, Aruba, Colombia, and Ecuador (see Figure 4). The project is comprised of the following submarine segments (see Figure 14):

- Segment 1 from Jacksonville, Florida, to Tortola, BVI
- Segment 2 from Tortola, BVI, to Branching Unit near Aruba
- Segment 2A from Tortola, BVI, to San Juan, Puerto Rico
- Segment 3 Branching Unit near Aruba to Hudishibana, Aruba
- Segment 4 Branching Unit near Aruba to Branching Unit near Colombia
- Segment 5 Branching Unit near Colombia to Cartagena, Colombia
- Segment 6 Branching Unit near Colombia to Maria Chiquita, Panama
- Segment 6A Terrestrial segment between Maria Chiquita and Balboa, Panama
- Segment 7 from Balboa, Panama, to Manta, Ecuador

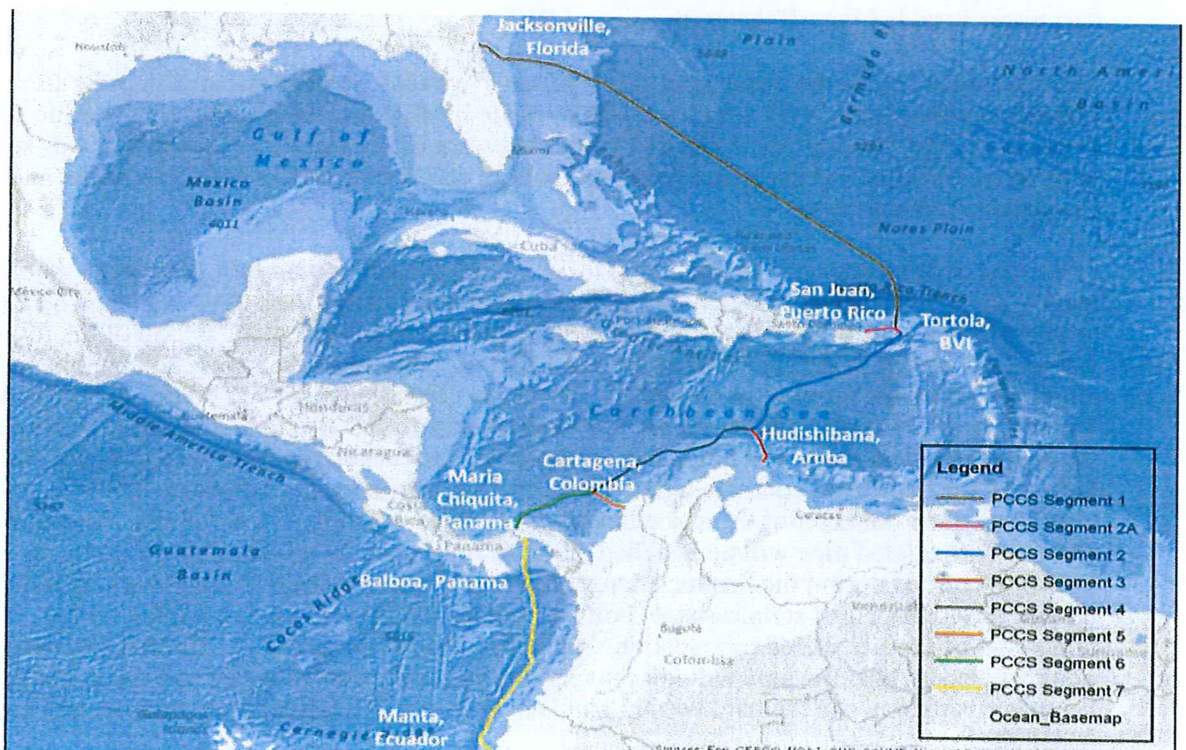

Figure 14. Map of the PCCS segments for the entire system (from the Joint Permit Application, Telefonica International Wholesale Services, 2013).

Although as described above the applicant's action involves various connections with and between U.S. territories and other Caribbean nations, this Opinion focuses on the cable segments connecting U.S. territories to each other and to BVI. The USACE is only issuing a permit for activities in U.S. territorial waters. However, consultations must consider the effects of all activities that are interrelated and interdependent to the federal action under consultation. We did not consider the effects of Segments 3-7 in this Opinion because these cable segments will function independently and are not interdependent activities relative to the USACE's proposed action. Many of these segments have already been installed because the system does not depend on a single segment in order to connect international locations together. We did verify that all of the international landing sites in the Caribbean (Tortola, BVI; Hudishibana, Aruba; Cartagena, Colombia; and Mar Chiquita, Panama) are existing landings and so there will be no additional effects from establishing landings in shallow waters. We also verified that the non-U.S. landings have separate environmental review and approval processes under the laws and permitting regulations of the relevant countries. It is normal practice for Alcatel-Lucent, who will be installing the cables, to plan and engineer cable routes to avoid impacts to corals as much as possible (D. Toombs, ERM, pers. comm. to L. Carrubba, NMFS, October 28, 2014).

For the segments within the scope of this consultation as explained above, namely Segment 2A and 2, we examined all the potential effects to ESA resources along the segments rather than focusing only on potential effects in U.S. territorial and federal waters. This is because the scope of the action, specifically the installation of Segment 2, will affect ESA-listed corals in deep waters between USVI and BVI. Segment 1 landing in Jacksonville, Florida, is not part of this Opinion because the landing site is outside the range of ESA-listed corals and acroporid coral critical habitat and the rest of the cable is in waters too deep for coral colonization. This cable ends at Segment 2A off Tortola, BVI. The deepwater survey for Segment 2A did not find deepwater coral habitat off the north coast of BVI.

The route selected for the cable entering San Juan (Segment 2A) was selected in order to minimize cable contact with corals and other sessile benthic resources based on a benthic survey of the area. The route for the cable that passes between USVI and BVI (Segment 2) was selected in order to minimize cable contact with hard bottom and reefs based on side scan sonar and mesophotic reef surveys.

The cables will be between 26 mm (1 in) to 35 mm (1.378 in) in diameter, depending on the level of steel armoring considered necessary to protect the cables in shallow waters, where the risk of damage is greatest. The smaller diameter cable will be used along 83 km of the route within U.S. waters in depths between 50 and 1,042 m. The larger diameter cable will be used along 5.4 km of the proposed route in U.S. waters in depths between 0 to 50 m. Articulated pipe will also be installed in shallow waters to protect the cable and also to reduce cable movement that could result in damage to benthic communities. Articulated pipe will be fitted over the cable buried on the beach and continue within the near shore surf zone for a distance of 164 m. The maximum outer diameter of the articulated pipe is 130 to 148 mm (5.1 to 5.8 in). An additional 636 m of articulated pipe will be installed along discrete sections of the cable by divers in locations defined during the benthic survey along with saddle clamps spaced every 25 m in hard bottom areas. A pair of stainless steel bolt sets will be installed at 10-m intervals on the remainder of the articulated pipe sections and at the ends of the sections. The saddle clamps and bolts will ensure that the pipe will not move to minimize impacts to corals and other sessile benthic invertebrates in the hard bottom habitats where the articulated pipe sections will be installed.

Details of Segments 2 and 2A, which are within the scope of this consultation as explained above, are as follows:

1. Segment 2: This segment connects Tortola, BVI, to a branching unit near Aruba and does not land in a U.S. territory, but does pass through U.S. territorial waters (between USVI and BVI) and through the U.S. Exclusive Economic Zone (EEZ) (see Figure 15).

   The mesophotic reef survey for the portion of this segment along the St. John outer shelf found a mix of bank coral reef, colonized rhodolith reef, and patch reefs with the majority of coral colonization in the bank coral reef area (36.8%), dominated by *Orbicella franksi*. *O. franksi* was also observed throughout the colonized rhodolith reef habitat, although cover was below 1% for this species and overall coral cover was a little more than 2% in total. *O. franksi* was also present in the patch reef habitat at the shelf edge, but at less than 1% cover (see Figure 16).

2. Segment 2A: This segment connects Puerto Rico to BVI with a landing site in San Juan at the existing Tartak Street cable landing that has been used for several past projects. The system will end at the beach manhole and then connect to an existing terrestrial network (see Figure 15). The cable will be installed through an existing conduit located approximately 2 m below the beach to connect with the existing network.

   The cable route from the beach to the near shore linear reef will extend over areas dominated by uncolonized sand, sand with scattered algal colonization, and hard bottom with limited colonization. No ESA-listed coral colonies are within these habitats. Once it reaches the near shore linear reef, the cable route was altered to take it through a rubble/sand channel through the linear reef. Prior to reaching this channel, the cable will cross approximately 140 m of seagrass. Once the cable goes through the reef, it will cross hardbottom and sand areas with scattered algal, hard and soft coral, and sponge colonization and then the deep reef offshore along the shelf edge. The benthic survey determined that the 116-m-long segment over the deep reef offshore of the San Juan landing site is coral critical habitat due to the lack of algal cover and the colonization of the area by hard corals. The route toward deeper water was re-configured to pass through natural channels in the deep reef in order to minimize impacts to colonized hard bottom in this area (see Figure 17). No elkhorn or staghorn corals were observed during the benthic surveys completed for this project. *Orbicella faveolata* and *Mycetophyllia ferox* were observed at different points near the proposed route. The distance from the proposed cable route to these coral colonies was estimated during the benthic survey as ranging from 10 to 42 m.

   Mooring points have also been selected for the cable laying vessel at 25 points along the cable route to the Tartak Street beach manhole. The benthic survey was used to select the location of these mooring points to ensure that they will avoid impacts to ESA-listed corals. Two of the stations are located in the flat forereef area in 27and 43 ft of water in an area identified as acroporid coral critical habitat during the benthic survey. Only 6 of these locations are new. The other 19 sites were used as part of the recent laying of another cable and will be reused for this project. Seventeen of the locations are in backreef in water depths ranging from 10 to 29 ft, but all are characterized by low cover by sessile benthic invertebrates, including hard corals (Glauco A. Rivera & Associates 2012). No ESA-listed corals are present at the proposed mooring locations.

The mesophotic reef survey for the deep portion of the cable segment off the Puerto Rico shelf found a discontinuous hard ground platform with benthic algae transitioning to sand with scattered rocks heading toward shore. Limited coral colonization was present on the colonized pavement habitat, including *Orbicella franksi*. Before reaching the sand with scattered rocks, a discontinuous group of rock promontories are present dominated by algae, mainly turf algae, with limited hard coral colonization (less than 1%), including by *O. franksi*.

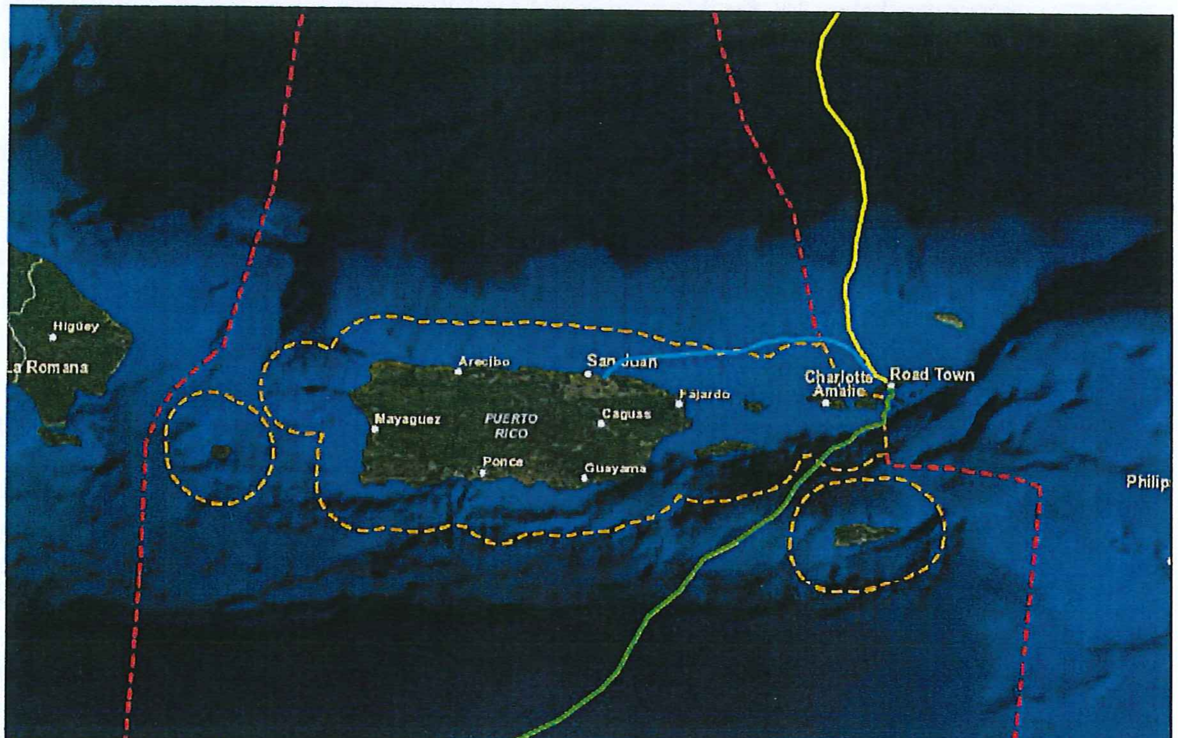

Figure 15. PCCS cable segments in U.S. waters are shown in light blue (Segment 2A landing in San Juan, Puerto Rico) and light green (Segment 2 passing between the USVI and BVI) along with the EEZ boundaries (dashed red line) (from Exhibit 4 of Joint Permit Application, Telefonica International Wholesale Services, 2013)

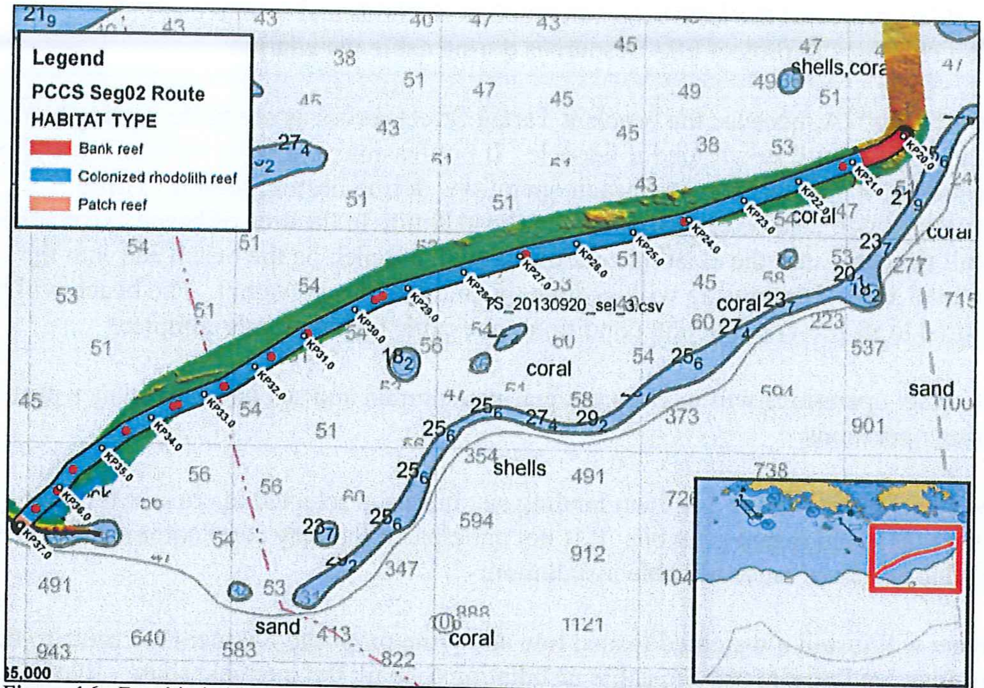

Figure 16. Benthic habitat results from mesophotic survey of shelf edge south of St. John for route to BVI for Segment 2 (from (TetraTech 2013a)

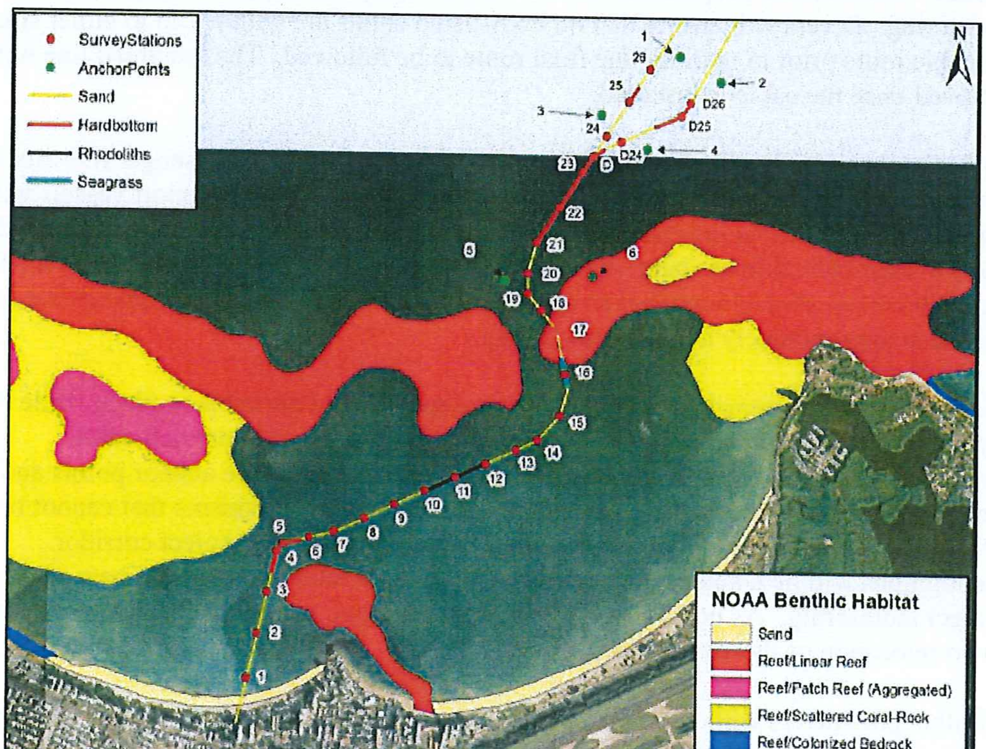

Figure 17. Benthic habitat map and cable route for landing in San Juan showing the alternative routes seaward to minimize impacts to hard bottom for Segment 2A (from (Associates 2012)

The applicant has proposed the following construction methods and resource avoidance and minimization measures to protect ESA resources during cable installation:

1. For Segment 2A, because the beach at Tartak Street serves as sea turtle nesting habitat, nesting season will be avoided if feasible. If not feasible, sea turtle monitoring will be conducted 70 days prior to any beach operations during nesting season. Turtle monitoring will also be carried out during installation in the area of beach excavation to install the cable into the existing conduit through a trench on the beach and into the intertidal zone. Monitoring will be done on land and from a vessel. The beach will be restored to its pre-construction condition once cable installation is complete.

2. All vessel operations will incorporate marine mammal and sea turtle avoidance protocols during operations.

3. The cable route into the San Juan landing site has been selected to cross soft bottom areas to the maximum extent possible. It is not anticipated that any coral colonies will need to be relocated in advance of cable installation.

4. Divers will install a weighted/leaded line along the proposed Segment 2A route to the San Juan landing site prior to cable installation to mark the intended route. Buoys will be placed temporarily along the weighted line to guide the installation route from the surface. The marked, proposed route will be photographed as part of the pre-installation monitoring. Divers will ensure that no ESA-listed corals are within 1 m to either side of the cable route prior to marking the final route to be followed. The weighted line will be removed once the cable is installed.

5. Immediately prior to cable landing, a small workboat will pull a messenger line attached to the cable from the cable laying vessel toward the beach. Small support vessels will guide the floating cable into position following the temporary marker buoys. Once the desired length of cable has been secured on the beach, divers will remove the floats from the cable one at a time to guide it to the seafloor. The diver-assisted portion of the lay will be to approximately a 25-m water depth.

6. Divers will use temporary anchors, mainly in sand, to hold the cable in place while the lay is completed, and permanent anchors in hard bottom areas to prevent cable movement. The benthic survey indicated that 20 permanent cable anchor points and 5 temporary anchor points will be necessary. Sessile benthic organisms that cannot be avoided by the cable route will be relocated to areas outside the project corridor. Photographs will be taken of the organisms before and after relocation as part of the project monitoring. As noted in #4 above, no ESA-listed corals will be within the route so no relocation of these corals is planned.

7. Weather parameters will determine whether or not cable installation proceeds. These parameters are a maximum wave height of 1 m, a maximum wind speed of 30 knots (kt) in a direction predominantly from shore and a maximum of 20 kt in a direction

predominantly from the sea. If any of these parameters will be exceeded, the installation operation will be delayed.

8. A separate shore end method will be used for the installation at Tartak Street (from seaward of the reef to the beach) due to the shallow water depths in the approach to the beach and the need to use a shallow draft vessel to position the cable carefully near corals. This vessel will be temporarily moored to the sea bed using sandbag anchors (see Figure 18). Benthic surveys were conducted to select mooring point locations in areas without coral colonization. A total of 25 temporary mooring points will be used, 19 of these have been used previously during other cable installations. Five of the mooring points will be used at any given time to anchor the vessel.

9. Sandbag anchors to moor the shallow draft cable laying vessel will be approximately 15 tons and will be composed of 10-15 bags that will be reused/rotated to the different mooring points as installation proceeds. Double bags will be used along with the installation of individual rope lines to distribute the pulling force on the bags and ensure that bags do not break. Filling, transportation, positioning, removal, and return of the sand will be diver assisted. The sand for the anchors will be collected from a sand area that has been identified and used in the past for a cable repair project. A low pressure pump with no moving parts that could produce suction will be used to fill the bags. The sandbags will be emptied into the location from which the sand will be taken after the cable installation operation is complete rather than remaining in place at the temporary mooring locations. Sand will be released slowly by placing the bag on the sea floor, making an incision at the bottom, and slowly lifting it using lift bags while pushing the bag for even distribution along the sea floor.

10. Prior to any operations, personnel will be given environmental training focusing on sensitive coral and other benthic communities and precautions to avoid impacting these communities during operations. Only personnel who have attended the training will be allowed to be involved in the cable installation operation.

11. Immediately following the installation of Segment 2A, the corridor and anchor points will be inspected by a biological monitoring team to assess the direct impact of the cable and the related laying activities in waters up to 25 m in depth. The cable will be relocated off of sessile benthic invertebrates if necessary. Any fragmented or dislodged corals will be reattached to the substrate. Any impacts to hard and soft corals will be documented.

12. A one-year post-deployment monitoring of Segment 2A will be completed and compensatory mitigation provided if determined to be necessary by the USACE based on impacts to hard and soft corals observed during the monitoring events.

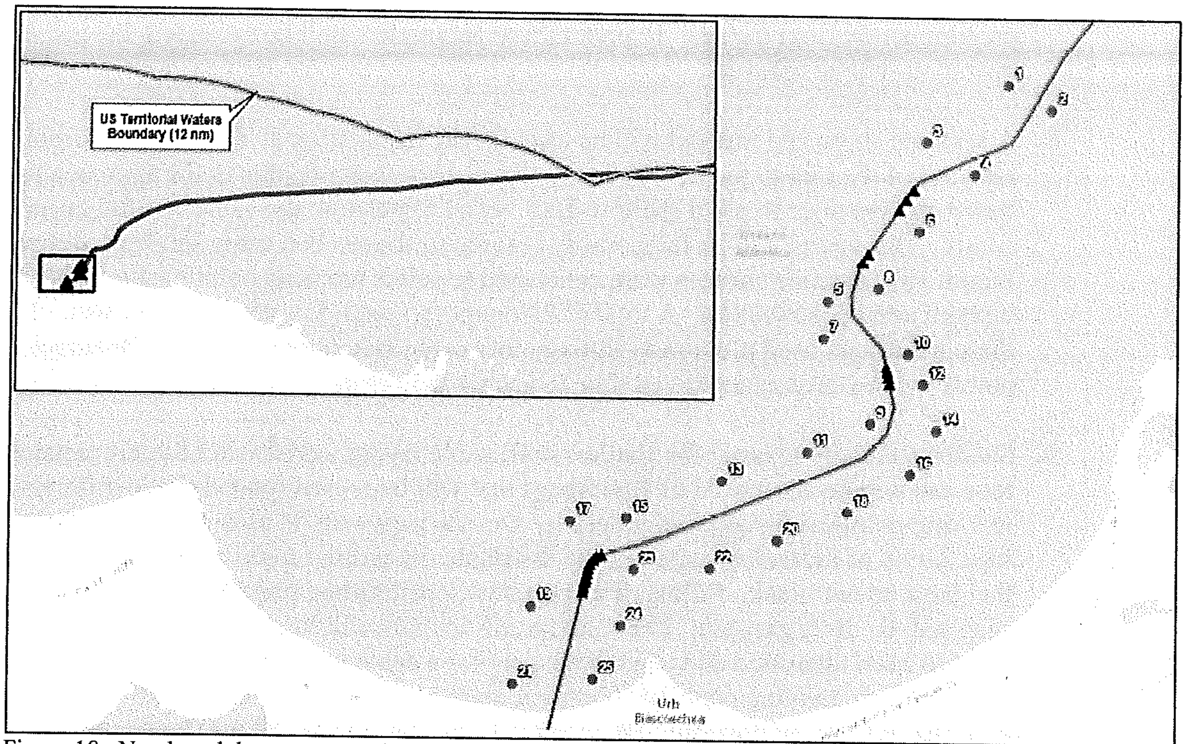

Figure 18. Numbered dots represent the location of temporary mooring points for the shallow draft cable installation vessel and black triangles represent the locations where articulated pipe will be installed to permanently anchor cable along Segment 2A into San Juan (from Revised Mitigation and Monitoring Plan, ERM 2014)

The USACE will also require the following as part of the permit special conditions for any permit issued for the PCCS project:

1. Compliance with NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners*

2. Compliance with NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions*.

3. Implementation of the Mitigation and Monitoring Plan (revised January 2014) developed by the applicant to avoid and minimize potential impacts to ESA resources during cable installation.

4. In-water monitoring before, during, and after the cable installation to assess the route and move the cable off any sessile benthic organisms as necessary.

5. The use of divers to guide the cables along the sea floor by hand to minimize impacts to corals and the installation of anchors on the cable to avoid scour of benthic habitats by preventing cable movement.

3 Action Area

The action area is defined by regulation as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR 402.02).

3.1 viNGN

The proposed action area for the viNGN project is the area along the proposed cable segment corridors (see Figure 1) where the cables will be installed and that are to be used by the cable laying vessel and all associated vessels, as well as all temporary anchor locations for vessels associated with the installation of the cable, and the shoreline landing areas for each cable segment. Figures 2 through 11 show details of the benthic habitats present along each of the cable segments.

3.2 PCCS

The proposed action area for the PCCS project is the area along the proposed cable corridors for Segments 2 and 2A (see Figure 5) where the cables will be installed in Puerto Rico and between the USVI and BVI and that are to be used by the cable laying vessel and all associated vessels, as well as the 25 temporary anchor locations for vessels during the installation of the cable, and the shoreline landing in San Juan (see Figures 16 and 17 for details of the benthic habitats present in shallow and deep waters for these routes).

4 Status of Listed Species and Critical Habitat

Table 1 lists the endangered (E) and threatened (T) species under the jurisdiction of NMFS that occur in or near the action area. Table 2 lists the designated critical habitat that occurs in or near the action area.

Table 1. Listed species likely to occur in or near the action area

Common Name	Scientific Name	Status
Marine Mammals		
blue whale	*Balaenoptera musculus*	E
finback whale	*Balaenoptera physalus*	E
sei whale	*Balaenoptera borealis*	E
humpback whale	*Megaptera novaeangliae*	E
sperm whale	*Physeter macrocephalus*	E
Turtles		
green sea turtle	*Chelonia mydas*	T[1]
loggerhead sea turtle	*Caretta caretta*	T[2]
hawksbill sea turtle	*Eretmochelys imbricata*	E
leatherback sea turtle	*Dermochelys coriacea*	E
Invertebrates		
elkhorn coral	*Acropora palmata*	T
staghorn coral	*Acropora cervicornis*	T
pillar coral	*Dendrogyra cylindrus*	T
lobed star coral	*Orbicella annularis*	T
mountainous star coral	*Orbicella faveolata*	T
boulder star coral	*Orbicella franksi*	T
rough cactus coral	*Mycetophyllia ferox*	T

Table 2. Designated critical habitat likely to occur in or near the action area

Species	Critical Habitat	Project
elkhorn coral	St. Thomas/St. John unit St. Croix unit Puerto Rico unit	viNGN and PCCS viNGN PCCS
staghorn coral	St. Thomas/St. John unit St. Croix unit Puerto Rico unit	viNGN and PCCS viNGN PCCS

[1] Green turtles are listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are listed as endangered.
[2] Northwest Atlantic Ocean DPS (Distinct Population Segment)

4.1 Analysis of Species and Critical Habitats Not Likely to be Adversely Affected

Whales

There are 5 species of whales (blue, finback, sei, humpback, and sperm) that can possibly be found in or near the action area for viNGN and PCCS. These species could be affected by vessel transit during the installation of the submarine cables, in particular for the segments between Puerto Rico, USVI, and BVI through deep, offshore waters. ESA-listed whale species are more common in the U.S. Caribbean during their winter migration to warmer waters from January to March of each year. Depending on when the cable installation takes place, there may be less likelihood of ESA-listed whales being in the project area.

The applicant did not report sightings of ESA-listed whale species during surveys conducted for the project, including mesophotic reef surveys in deepwater areas, although these were done in September through November 2013 for both the viNGN and PCCS cable segments. Anecdotal information from dive shop operators and boat captains in St. Croix indicates that humpback whales are the most common ESA-listed whale species observed in the area from January to March, but they are usually observed 2-3 miles offshore. Anecdotal information from dive shop operators in Puerto Rico, as well as information from NOAA's Office of Law Enforcement, also indicates that these animals are common in deeper waters off both the east and west coasts of Puerto Rico from January-March, with some humpbacks occasionally sighted off the east coast year-round. The cable installation will be done by an experienced operator who has worked in the action area in the past. There is no information from previous cable installation projects in the USVI within the same general area as PCCS Segment 2A in Puerto Rico that indicates that ESA-listed whales were sighted during cable installations or that there were any interactions between ESA-listed whales and work vessels. The USACE will also require the implementation of NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners* (enclosed) and NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* (enclosed). The applicant has also noted that the cable-laying vessels operate at controlled, slow speeds during cable installation in order to ensure that the cable is installed along the proposed route and to avoid any entanglement or other complications with the installation. Therefore, we believe that the potential project impacts to ESA-listed whale species from the viNGN and PCCS cable installations will be discountable.

Sea Turtles

Loggerhead sea turtles may be found in or near the action area. Loggerhead sea turtles are not common in the U.S. Caribbean. There are, however, reports of loggerhead sea turtles in waters around St. Croix (including unpublished stranding data from the Virgin Islands Department of Planning and Natural Resources [DPNR] showing 1 found dead from poaching in the Frederiksted area in 2003) and 2 females have now been documented nesting on Buck Island since 2003. Loggerheads could be present in the area of the Frederiksted or Christiansted landing sites where colonized hard grounds are present, although none were observed during the benthic surveys completed for the project or during site inspections of the landing sites by NMFS's biologists. Limited loggerhead nesting has also been reported on the east coast of Puerto Rico (Puerto Rico Department of Natural and Environmental Resources [DNER]) and unpublished stranding data from DNER also includes reports of dead loggerhead sea turtles from various points around Puerto Rico.

Green, hawksbill, and leatherback sea turtles are reported in the action area of the viNGN project. As noted previously, there is hawksbill sea turtle nesting in Brewer's Bay, which is the landing site for 2 of the viNGN cable sections. Leatherback sea turtles nest south of the viNGN Frederiksted landing site, although not on the beach segment where the cable landing is located, and infrequent nesting by green sea turtles is reported on some of the beaches along the west coast of St. Croix, although unpublished data from DPNR do not indicate that the Frederiksted cable landing site is one of the beaches used by green sea turtles). The viNGN Great Bay landing site also provides nesting habitat for sea turtles. Leatherback sea turtles nest at the San Juan landing site of PCCS Segment 2A. Depending on the time of year the PCCS cable installation takes place, these turtles may not be present because they are an offshore species that are only found near shore during nesting season, which peaks around April to May. If cable installation operations do take place during the nesting season of any of the sea turtle species for which nesting is reported at one or more of the landing sites, beach-monitoring plans have been developed to ensure installation operations do not affect nests or hatchlings. This will be done by monitoring for 60 days prior to any excavations and selecting excavation sites to avoid any nests if necessary or delaying excavation activities to avoid impacts to nests and hatchling sea turtles. Monitoring will also be done from a vessel in order to look for any hatchlings in the water to ensure cable installation activities will not impact these animals.

Effects to sea turtles include the risk of injury from in-water construction machinery (barges, anchors, etc.). We do not have reports of impacts to sea turtles from vessel operations during previous submarine cable installations at the Puerto Rico landing site or for projects that had landing sites in St. Thomas and St. Croix from Puerto Rico. Portions of the viNGN and PCCS segments will follow or cross other existing cable routes. The USACE will require compliance with NMFS's *Vessel Strike Avoidance Measures and Reporting for Mariners* (enclosed) and NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* (enclosed). This will also provide protection to sea turtles during the transit of work vessels and during construction operations by requiring monitoring for sea turtles and maintaining set distances for vessel transit and construction operations. Alcatel-Lucent, the entity responsible for the cable installation, has established requirements related to weather conditions to limit cable installation activities and vessel operation to periods when there are no heavy swells, strong winds, or storm conditions that would affect the security and accuracy of the lay. These conditions were specified in the permit application package for PCCS but, as the entity responsible for both the viNGN and PCCS cable installations, Alcatel-Lucent will apply these requirements to both projects. The large cable lay vessel will not be used in near shore areas where water depths could result in accidental groundings. Instead, smaller vessels will be employed. In Puerto Rico, because of the need to maintain the shallow-draft cable-laying vessel stable, temporary mooring points have been established to anchor the vessel using a 5-point mooring. All vessels will operate at low speeds and have sea turtle and marine mammal observers. Due to the ability of sea turtles to move away from the project site if disturbed and the fact that work vessels will operate at slow speeds or be anchored while the cable lay is occurring, the risk of injury from collision with work vessels during cable lay and transit of work vessels will be discountable for both viNGN and PCCS.

Sea turtles in the water, in particular greens, hawksbills, and loggerheads, may be affected by being temporarily unable to use the near shore cable landing sites due to construction activities and related noise that could cause them to abandon the area, and physical exclusion from areas where beach landings are being constructed. The installation operation at each landing site takes a week at most with the beach excavations to connect the cable to the terrestrial system completed the final 2 days of the installation operation. For nesting female sea turtles, there could be limited disruption of nesting activity during cable installation, including the installation of the beach manhole, should females try to nest during the 2 days of beach excavation. Beach monitoring will be done for 60 days prior to any excavations and in-water monitoring for hatchlings will be done if nests are observed, as noted previously. Therefore, we believe these effects are insignificant because of the species' ability to move to alternate habitat nearby, because measures specific to nesting season will be implemented to protect nests and hatchlings if applicable, and because there have been no reports of interactions with sea turtles as part of previous cable operations despite the fact that some of the landing points, such as those in San Juan, have been used on multiple occasions and are located at sea turtles nesting beaches.

Hawksbill, green, and loggerhead sea turtles could also be impacted by the temporary or permanent loss of use of potential foraging or refuge habitat associated with the installation of each of the cable segments. As shown in Table 3, approximately 253.06 m^2 (0.06 acre) of seagrass and 90 m^2 (0.02 acre) of hard bottom in waters with depths less than 30 m, and 4,416.55 m^2 (1.09 acres) of deep reef and hard bottom in waters with depths greater than 30 m will be affected by the installation of the viNGN cable segments. It is important to note that some of the seagrass impacts for the viNGN project include the hand burial of cable segments in areas of dense seagrass to accelerate natural recovery of the area after burial of the cable and recolonization by seagrass. Approximately 21 m^2 (0.005 acre) of seagrass and 93.16 m^2 (0.02 acre) of hard bottom in waters with depths less than 30 m, and 2,769.8 m^2 (0.7 acre) of deep reef and hard bottom in waters with depths greater than 30 m, will be affected by the installation of the PCCS cable segments that fall within U.S. waters (Table 3). The PCCS installation will also impact up to 2,221.3 m^2 (0.5 acre) of hard bottom during the installation of Segment 2A to the San Juan landing point, which includes impacts associated with the temporary mooring points. These calculations assume that the width of the cable corridor is 0.15 m, a measurement based on an estimate provided by the applicant.

The locations of the cable segments for viNGN and PCCS and the temporary mooring point locations for PCCS Segment 2A were selected to avoid direct impacts to sessile benthic invertebrates, including hard and soft corals and sponges, to the maximum extent practicable. Part of the permanent impacts in shallower waters is due to the installation of clamps and articulated pipe to hold the cable in place. These precautions will limit movement of the cable during storms or strong currents to prevent breakage and abrasion of benthic habitat that serves as refuge or foraging areas for hawksbill, green, and loggerhead sea turtles. The use of divers to install the cables in shallow waters and relocate portions of the cable that are laid over sessile benthic invertebrates will minimize impacts to habitat used by ESA-listed sea turtles. The greatest impact to benthic habitat is due to the length of the deepwater segments of the cables over the shelf edges around the islands. The mesophotic reef survey and side scan sonar surveys were used to relocate portions of the cable routes out of areas with very dense coral cover, although these areas cannot be completely avoided. Although estimated as a 0.15-m-wide corridor to account for movement during installation as the cable settles to the bottom or any slight changes in routing that need to be done during installation, the extent of impact will actually be 14-35 mm – the actual width of the cable to be used in both projects. Thus the calculation of permanent impacts is an overestimate to account for minor changes to the routes during installation. Therefore, we believe the impact of the loss of refuge or foraging habitat to green, hawksbill, and loggerhead sea turtles will be insignificant because: (1) the cable routes have been selected to minimize impacts to seagrass and hard bottom in shallower waters and avoid the areas with the highest coral cover in deepwater areas, and (2) in shallow water areas, the cables will be positioned by divers to minimize impacts to sensitive areas. We also believe that the likelihood of additional resource impacts is discountable because cables in shallow waters will be secured to the bottom to prevent movement. Leatherback sea turtles are pelagic feeders; as such, their foraging habitat will be unaffected by the project.

Table 3. Habitat Impacts from the viNGN and PCCS cable segments (given in m^2 where impacts are calculated as linear length of cable times 0.15 m, the width of cable corridor). Seagrass and hard bottom habitats are in water depths less than 30 m, while deep reef and hard bottom habitats are in water depths greater than 30 m.

Project	Segment	Temporary Impacts (m^2)	Permanent Impacts (m^2)	Habitat Type
viNGN	1 - Brewers Bay		18.58	seagrass
			0.5	hard bottom
	1 - Frederiksted		80	hard bottom
	1		2,368.45	deep reef and hard bottom
	2 - Great Bay		51.82	seagrass
	2 - Christiansted		137.16	seagrass
	2		2,048.1	deep reef and hard bottom
	3		9.5	hard bottom
	4		45.5	seagrass
	Additional Christiansted Routes		488	seagrass
	Additional Christiansted Routes		5.25	hard bottom
		Total: 0	Totals: 741.06 seagrass; 95.25 hard bottom (of which 9 are acroporid coral critical habitat); 4,416.55 deep reef and hard bottom	
PCCS	2A	2,221.3	93.16	hard bottom
			21	seagrass
			210.8	deep reef

				and hard bottom
	2		2,559	deep reef and hard bottom
		Total: 2,221.3 hard bottom (of which 928.7 are acroporid coral critical habitat)	Totals: 21 seagrass; 93.16 hard bottom (of which 25.54 are acroporid coral critical habitat); 2,769.8 deep reef and hard bottom	

<u>Corals</u>
Elkhorn, staghorn, pillar, and lobed star corals were observed during benthic surveys of the landing sites for the viNGN project. None of these corals were observed during benthic surveys for the San Juan landing site for the PCCS project. Mountainous star and rough cactus corals were observed during benthic surveys for the San Juan landing site for the PCCS project, but they were not observed in any of the benthic surveys conducted for the viNGN project. Therefore, we believe the viNGN project will have no effect on mountainous star and rough cactus corals, while the PCCS project will have no effect on elkhorn, staghorn, pillar, or lobed star corals.

Cable routes were selected to minimize potential impacts to benthic habitats, in particular those containing corals. Mesophotic reef surveys conducted using a remotely operated vehicle and side scan sonar surveys were used to relocate deepwater (depths greater than 30 m) portions of the cable routes out of areas with very dense coral cover. Still, these areas cannot be completely avoided in order to access the viNGN landing sites in St. Thomas from St. Croix and to pass between USVI and BVI to access the BVI landing site from Puerto Rico for the PCCS project. The selection of routes that pass through natural channels in the reefs for both the viNGN and PCCS projects will avoid any cable suspensions between high points such as large coral colonies to minimize the chance for the cables to swing and cause breakage and abrasion of corals. These routes will also be verified pre-installation by divers who will mark the cable route in the field for the installation vessels to follow. Planning of the cable-laying with slack in the cable will also allow divers to relocate the cable off of sessile benthic invertebrates if necessary. The cable will also be stabilized with articulated pipe in shallow waters to prevent lateral movement that can cause abrasion of substrate.

Although all shallow-water cable routes for both projects were selected to avoid ESA-listed corals, in deep water (greater than 30 m), this proved to be impossible. In particular, avoidance of listed corals off the shelf edge of St. Thomas for both the viNGN and PCCS projects proved to be challenging. Still, the routes were altered to minimize crossing of the deep reef and hard bottom areas with the densest coral cover (the discussion of impacts to an ESA-listed coral species, boulder star coral, is discussed in subsequent sections of this Opinion).

A monitoring plan has been prepared for the shallow-water portions of both projects for pre-, during, and post-installation surveys to determine whether any coral impacts occur as a result of the cable installation. The plan allows any restoration as necessary, such as reattaching of coral colonies or fragments, though the applicant anticipates that this will not be needed because the shallow water segments will be diver-assisted lays. Because the cable routes have been selected to avoid impacts to ESA-listed corals in shallow waters, the plan only applies to hard and soft corals that are not listed under the ESA. Thus, we believe that the risk of impacts of the proposed installation of the viNGN cable segments on elkhorn, staghorn, pillar, and lobed star corals and of the PCCS cable segments on mountainous star and rough cactus corals will be discountable.

4.2 Species and Critical Habitat Likely to be Adversely Affected

Boulder star corals may be adversely affected by the proposed installation of both the viNGN and the PCCS cable systems in U.S. waters, in particular in the deeper, mesophotic reef segments where colonies of these corals were found during a survey of the deep portions of the cable routes. The PCCS cable may also result in adverse effects to elkhorn and staghorn coral critical habitat.

The summaries that follow describe the status of the ESA-listed species and designated critical habitat that occur within the geographic area of these proposed actions and are considered in this Opinion. More detailed information on the status and trends of these listed resources and the biology and ecology of the species can be found in the listing regulations and critical habitat designations published in the Federal Register (FR), status reviews, recovery plans, and on these NMFS websites:

- http://sero.nmfs.noaa.gov/protected_resources/index.html
- http://www.nmfs.noaa.gov/pr/species/esa/index.htm

4.2.1 ESA-Listed Corals

In December 2012, NMFS proposed to list 7 coral species (lobed star, mountainous star, boulder star, pillar, rough cactus, Lamarck's sheet, and elliptical star coral) in the western Atlantic, Gulf of Mexico, and/or Caribbean basins under the ESA and change the listing status of elkhorn and staghorn corals to endangered. On September 10, 2014, NMFS published its Final Rule maintaining elkhorn coral (*Acropora palmata*) and staghorn coral (*A. cervicornis*) as threatened and listing the following corals as threatened under the ESA: pillar coral (*Dendrogyra cylindrus*), rough cactus coral (*Mycetophyllia ferox*), lobed star coral (*Orbicella annularis*), mountainous star coral (*O. faveolata*), and boulder star coral (*O. franksi*). The Final Rule became effective on October 10, 2014 (79 FR 53852; September 10, 2014). *Orbicella franksi* was found to occur, in some cases in densities greater than 35% cover, in deepwater areas that will be crossed by segments of both the viNGN and PCCS cables within U.S. waters. The following discussion summarizes those findings relevant to our evaluation of the 2 proposed actions.

Species Description – Boulder Star Corals

Corals are marine invertebrates in the phylum Cnidaria that occur as polyps, usually forming colonies of many clonal polyps on a calcium carbonate skeleton. Cnidaria includes true stony corals, the blue coral, and fire corals. All of the listed corals in the Southeast Region are stony corals. Most stony corals form complex colonies made up of a tissue layer of polyps (a column with mouth and tentacles on the upper side) growing on top of a calcium carbonate skeleton, which the polyps produce through the process of calcification. Stony corals are characterized by polyps with multiples of 6 tentacles around the mouth for feeding and capturing prey items in the water column (79 FR 53852).

Reef-building coral species are capable of rapid calcification rates because of their symbiotic relationship with single-celled dinoflagellate algae, zooxanthellae, which occur in great numbers within the host coral tissues. Zooxanthellae photosynthesize during the daytime, producing an abundant source of energy for the host coral that enables rapid growth. At night, polyps extend their tentacles to filter-feed on microscopic particles in the water column, such as zooplankton, which provides additional nutrients for the host coral. In this way, reef-building corals obtain nutrients autotrophically (i.e., via photosynthesis) during the day, and heterotrophically (i.e., via predation) at night (79 FR 53852).

Boulder star coral is 1 of 3 species in the *Orbicella annularis* complex. These 3 species were formerly in the genus *Montastraea*; however, recent work has reclassified the 3 species in the *annularis* complex to the genus *Orbicella* (Budd et al. 2012). The species complex was historically one of the primary reef framework builders throughout the wider Caribbean. The complex was considered a highly plastic, single species – *Montastraea annularis* – with growth forms ranging from columnar, to massive, to plate-like. In the early 1990s, Weil and Knowlton (1994) suggested the partitioning of these growth forms into separate species, resurrecting the previously described taxa, *Montastraea* (now *Orbicella*) *faveolata* and *Montastraea* (now *Orbicella*) *franksi*. These 3 sibling species were differentiated on the basis of morphology, depth range, ecology, and behavior (Weil and Knowton 1994). Subsequent reproductive and genetic studies have generally supported the partitioning of the *annularis* complex into 3 species. *Orbicella faveolata* is the most genetically distinct, while *Orbicella annularis* and *Orbicella franksi* are less so (Budd et al. 2012; Fukami et al. 2004; Lopez et al. 1999).

Boulder star corals are distinguished by large, unevenly arranged polyps that give the colony its characteristic irregular surface. Colony form is variable usually with irregular mounds and scattered lumps (Humann and DeLoach 2002). Colonies can reach up to 16 ft (5 m) in diameter with a height of up to 6.5 ft (2 m) and are green, grey, and brown in color (Szmant et al. 1997).

Distribution

In general, the corals in the Southeast Region are widely distributed throughout the western Atlantic, Caribbean, and Gulf of Mexico (exceptions noted below). Corals need hard substrate on which to settle and form; however, only a narrow range of suitable environmental conditions allows coral to grow and exceed loss from physical, chemical, and biological erosion. Reef-building corals do not thrive outside a typical temperature range of 25°-30°C, but they are able to tolerate temperatures outside this range for brief periods of time, depending on the how long and severe the exposure, as well as other biological and environmental factors. Two other important factors influencing suitability of habitat are light and water quality. Reef-building corals require light for photosynthesis, and poor water quality can negatively affect both coral growth and recruitment. Availability of light generally limits how deep corals are found. Hydrodynamic condition (e.g., high wave action) is another important habitat feature, as it influences the growth, mortality, and reproductive rate of each species adapted to a specific hydrodynamic zone.

Boulder star corals are distributed throughout the Caribbean, Bahamas, and Flower Garden Banks (IUCN 2010; Veron 2000). Along with the other 2 species in the *O. annularis* complex, this species commonly occurs throughout U.S. waters of the western Atlantic and Caribbean, including Florida (Martin though Monroe Counties) and the Gulf of Mexico. The species occupies most reef environments, occurring in both protected and wave-exposed habitats (Goreau and Wells 1967; Van Duyl 1985). It is often the most abundant coral between 33 and 66 ft in fore-reef environments. The depth range of boulder star coral has been reported as 1.5-130 ft, though the species complex has been reported to depths of 295 ft, indicating boulder star coral's depth distribution is likely deeper than 295 ft. *Orbicella* species are a common, often dominant component of Caribbean mesophotic reefs.

Life History Information

Corals use a number of diverse reproductive modes. Most coral species reproduce sexually and asexually. Corals reproduce sexually by developing eggs and sperm within the polyps. Some coral species have separate sexes (gonochoric), while others are both sexes at the same time (hermaphroditic). Strategies for fertilization are by "brooding" or "broadcast spawning" (i.e., internal or external fertilization, respectively). Asexual reproduction occurs through fragmentation when pieces of a colony break off and re-attach to hard substrate to form a new colony. Fragmentation results in multiple, genetically-identical colonies. In many species of branching corals, fragmentation is a common and sometimes dominant means of propagation.

Depending on the mode of fertilization, coral larvae (called planulae) undergo development either mostly within the mother colony (brooders) or outside in the ocean (broadcast spawners). In either mode of larval development, planulae larvae presumably experience considerable mortality (up to 90% or more) from predation or other factors prior to settlement and metamorphosis. Such mortality cannot be directly observed but is inferred from the large amount of eggs and sperm spawned versus the much smaller number of recruits observed later. Coral larvae are relatively poor swimmers; therefore, their dispersal distances largely depend on how long they remain in the water column and the speed and direction of water currents transporting the larvae. The documented maximum larval life span is 244 days (*Montastraea magnistellata* [Graham et al. 2008]), suggesting that the potential for long-term dispersal of coral larvae, at least for some species, may be substantially greater than previously thought and may partially explain the large geographic ranges of many species.

Biological and physical factors that have been shown to affect spatial and temporal patterns of coral recruitment include:

- substratum availability and community structure (Birkeland 1977)
- grazing pressure (Rogers et al. 1984; Sammarco 1985)
- fecundity, mode, and timing of reproduction (Harriott 1985; Richmond and Hunter 1990)
- behavior of larvae (Goreau et al. 1981; Lewis 1974)
- hurricane disturbance (Hughes and Jackson 1985)
- physical oceanography (Baggett and Bright 1985; Fisk and Harriott 1990)

- the structure of established coral assemblages (Harriott 1985; Lewis 1974)
- chemical cues (Morse et al. 1988)

In general, upon proper stimulation, coral larvae settle on appropriate substrates. Some evidence indicates that chemical cues from crustose coralline algae (CCA), microbial films, and/or other reef organisms (Gleason et al. 2009; Morse et al. 1996; Morse et al. 1994; Negri et al. 2001) or acoustic cues from reef environments (Vermeij et al. 2010) stimulate settlement behaviors. Once a settlement site is chosen, the larvae attach to the surface and lay down a calcium carbonate skeleton. Successful recruitment of larvae is the only way new genetic individuals enter a population, thereby maintaining or increasing genotypic diversity. The larval stage is also important as it is the only phase in the life cycle of corals where larval dispersion occurs over long distances. This helps genetically link populations and provides the potential to re-populate depleted areas. Because newly-settled corals barely protrude above the substrate, juveniles need to reach a certain size to limit damage or mortality from threats such as grazing, sediment burial, and algal overgrowth (Bak and Elgershuizen 1976; Birkeland 1977; Sammarco 1985). Once recruits reach about 1-2 years post-settlement, growth and mortality rates appear similar across species. In some species, it appears that there is virtually no limit to colony size beyond structural integrity of the colony skeleton, as polyps apparently can bud indefinitely.

Stony corals require consolidated substrate for settlement of their larvae, and presence of other benthic organisms can preclude settlement. Encrusting sponges and gorgonians, zoanthids, and macroalgae are major coral competitors because of their ability to blanket large areas of the sea floor. The presence of macroalgae inhibits coral settlement both by competing for space and by trapping sediment that can abrade and smother small recruits. Juvenile corals are the most susceptible to overgrowth and mortality from these competitors, and corals are generally better able to compete as they grow larger (Bak and Elgershuizen 1976; Birkeland 1977).

Boulder star corals are hermaphroditic broadcast spawners, with spawning concentrated on nights 6-8 following the new moon in late summer (Levitan et al. 2004). Fertilization success measured in the field was generally below 15%, but was highly linked to the number of colonies observed spawning at the same time (Levitan et al. 2004). Minimum size for reproduction was found to be 13 in^2 (83 cm^2) in Puerto Rico and was estimated to correspond to 4-5 years of age (Szmant-Froelich 1985). Corals in the *Orbicella annularis* complex typically exhibit a linear growth of ~0.4 in (1 cm) per year (Gladfelter et al. 1978), but increased appreciation for the slow rate of growth of post-settlement stages suggest this age for minimum reproductive size may be an underestimate (M. Miller, Southeast Fisheries Science Center, Miami, Floirda. pers. obs., October 2010). Growth rates are also negatively correlated with depth and water clarity (Hubbard and Scaturo 1985). Eggs (Szmant et al. 1997) and larvae are small, and post-settlement growth rates are very slow. Both of these factors may contribute to extremely low post-settlement survivorship, even lower than other Caribbean broadcasters, such as elkhorn coral (Szmant and Miller 2005). There may be a depth-related cost arising from morphological differences in polyp spacing (Villinski 2003), suggesting the spatial distribution of colonies may influence population fecundity on a reef.

Successful recruitment by *Orbicella* species has seemingly always been rare. (Hughes and Tanner 2000) reported the occurrence of only a single recruit for these species over 18 years of intensive observation of 129 ft^2 (12 m^2) of reef in Discovery Bay, Jamaica, while myriad of other recruitment studies throughout the Caribbean also report them to be negligible to absent (Bak and Engel 1979; Rogers et al. 1984). *Orbicella* juveniles also have higher mortality rates than larger colonies (Smith and Aronson 2006). Despite their generally boulder-like form, at least the lobbed star coral is capable of some degree of fragmentation/fission and clonal reproduction (Foster et al. 2007).

Population Dynamics

Documenting population dynamics for corals is confounded by several unique life history characteristics. Particularly, clonality and asexual reproduction makes it particularly difficult to census a species to determine population abundance estimates. This can only truly be done by tracking genotypically individual colonies within a set area over time to determine if a new colonies in the population are new sexual recruits or colonies formed by asexual reproduction or partial mortality (Williams et al. 2006). This is why coral abundance estimates are usually reported in percent cover rather than number of individuals.

Asexual reproduction can play a major role in maintaining local populations, but in the absence of sexual recruitment, it can also lead to decreased resilience to stressors due to decreased genetic diversity. Since corals cannot move and are dependent upon external fertilization to produce larvae, fertilization success declines greatly as adult density declines. In populations where fragmentation happens often, the number of genetically distinct adults is even lower than colony density. Likewise, when there are fewer adult colonies, there are also fewer sources of fragments to provide for asexual recruitment. These conditions imply that once a population declines to or below a certain level (i.e., the number of adults in an area is too low for sexual reproduction to be effective), the chances for recovery are low. Thus local (reef-scale) reductions in colony numbers and size may prevent recovery for decades.

As described previously, the 3 species in the *Orbicella annularis* complex were not suggested for formal separation until the mid-1990s, which was further supported by genetic studies through 2012 (Budd et al. 2012; Fukami et al. 2004; Lopez et al. 1999; Weil and Knowton 1994). The 3 species are potentially difficult to tell apart depending on their growth form (e.g., mounding versus plate-like) and survey method (e.g., video versus in situ). Therefore, many monitoring programs continue to lump the 3 species into the *O. annularis* complex. Future, focused studies may allow for more time to do field identification resulting in high confidence that the reported species is actually the one identified.

The *Orbicella annularis* complex has historically been dominant on Caribbean coral reefs, characterizing the so-called "buttress zone" and "annularis zone" in the classical descriptions of Caribbean reefs (Goreau 1959). There is ample evidence that it has declined dramatically throughout its range, but perhaps at a slower pace than staghorn corals. While the latter began its rapid declines in the early- to mid-1980s, declines in *Orbicella* species have been much more obvious in the 1990s and 2000s, most often associated with combined disease and bleaching events. In most cases where examined, additional demographic changes accompany these instances of declining abundance (e.g., size structure of colonies, partial mortality).

In Florida, the percent cover data from 4 fixed sites have shown the *Orbicella annularis* complex declined in absolute cover from 5% to 2% in the Lower Keys between 1998 and 2003, and was accompanied by 5% to 40% colony shrinkage and virtually no recruitment (Smith et al. 2008). Earlier studies from the Florida Keys indicated a 31% decline of *Orbicella annularis* complex absolute cover between 1975 and 1982 at Carysfort Reef (Dustan and Halas 1987) and greater than 75% decline (from over 6% cover to less than 1%) across several sites in Biscayne National Park between the late 1970s and 2000 (Dupont et al. 2008). Further, Ruzicka et al. (2013) documented a Florida Keys-wide decline in all stony coral cover attributable to a decline in the *O. annularis* complex from 1999-2009. Most notably, they documented a 25% decline at the deep fore-reef sites, where declines are typically not as dramatic. Taken together, these data imply extreme declines in the Florida Keys (80–95%) between the late 1970s and 2003, and it is clear that further dramatic losses occurred in this region during the cold weather event in January 2010 (Colella et al. 2012).

Similar declines have also been documented for relatively remote Caribbean reefs. At Navassa Island National Wildlife Refuge, percent cover of *Orbicella annularis* complex on randomly sampled patch reefs declined from 26% in 2002 to 3% in 2009, following disease and bleaching events in this uninhabited oceanic island (Miller and Williams 2007). Additionally, 2 offshore islands west of Puerto Rico (Mona and Desecheo Islands) showed reductions in live colony counts of 24% and 32% between 1998-2000 and 2008, respectively (Bruckner and Hill 2009). At Desecheo, this demographic decline of one-third of the population corresponded to a decline in *Orbicella annularis* complex cover from over 35% to below 5% across 4 sites.

In the U.S. Virgin Islands, recent data from the U.S. National Park Service (NPS) Inventory and Monitoring Program across 6 sites at fixed stations show a decline of *Orbicella annularis* complex from just over 10% cover in 2003 to just over 3% cover in 2009 following mass bleaching and disease impacts in 2005 (Miller et al. 2009). This degree of recent decline was preceded by a decline from over 30% *Orbicella* coverage to approximately 10% between 1988 and 2003, as documented by Edmunds and Elahi (2007). Similarly, percent cover of *Orbicella annularis* complex in a marine protected area in Puerto Rico declined from 49% to 8% between 1997 and 2009 (Hernández-Pacheco et al. 2011). Taken together, these data suggest an 80-90% decline in *Orbicella annularis* complex over the past 2 decades in the main U.S. Caribbean territories.

While Bak and Luckhurst (1980) indicated stability in *Orbicella annularis* complex cover across depths in Curaçao during a 5-year study in the mid-1970s, this region has also manifested *Orbicella annularis* complex declines in recent years. Bruckner and Bruckner (2006) documented an 85% increase in the partial mortality of *Orbicella annularis* complex colonies across 3 reefs in western Curaçao between 1998 and 2005, approximately twice the level for all other stony corals combined. These authors noted that *Orbicella franksi* fared substantially better than the *Orbicella annularis* and *Orbicella faveolata* in this study. It is likely that *Orbicella annularis* complex populations in Curaçao have fared better than other Caribbean regions, but even those populations are not immune to losses.

Orbicella annularis complex declines in additional locations are noted. For example, at Glovers Reef, Belize, McClanahan and Muthiga (1998) documented a 38%-75% decline in relative cover of *Orbicella annularis* complex across different reef zones between 1975 and 1998, and a further 40% decline in relative cover has occurred since then (Huntington et al. 2011). In contrast, *Orbicella annularis* complex populations have shown stable status at sites in Columbia between 1998 and 2003 (Rodriguez-Ramirez et al. 2010), although demographic changes in *Orbicella annularis* complex at both degraded and less-degraded reefs imply some degree of population decline in this region (Alvarado-Chacon and Acosta 2009).

All information on boulder star coral's abundance and population trends can be summarized as follows: Boulder star coral is a common species throughout the greater Caribbean. Based on population estimates, there are at least tens of millions of colonies present in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands. Absolute abundance is higher than the estimate from these 3 locations given the presence of this species in many other locations throughout its range. Population decline has occurred over the past few decades with a 65% loss in boulder star coral cover across 5 countries. Losses of boulder star coral from Mona and Descheo Islands, Puerto Rico, include a 36%-48% reduction in abundance and a decrease of 42%-59% in its relative abundance (i.e., proportion relative to all coral colonies). High partial mortality of colonies has led to smaller colony sizes and a decrease of larger colonies in some locations such as The Bahamas, Bonaire, Puerto Rico, Cayman Islands, and St. Kitts and Nevis. Partial colony mortality is lower in some areas such as the Flower Garden Banks. We conclude that boulder star coral has declined, but it remains common and likely has at least tens of millions of colonies throughout its range. However, we also conclude that the buffering capacity of boulder star coral's life history strategy that has allowed it to remain abundant has been reduced by the recent population declines and amounts of partial mortality, particularly in large colonies.

Threats

Fishing, particularly overfishing, can have large scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs ("phase shifts"). Fishing pressure alters trophic interactions that are particularly important in structuring coral reef ecosystems. These trophic interactions include reducing the abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control. Thus an important aspect of maintaining resilience in coral reef ecosystems is to sustain populations of herbivores, especially species like parrotfish.

If herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (i.e., overgrowth, bleaching from toxic compounds), the ecosystem level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substratum by coral larvae by creating sediment traps that obstruct access to a hard substratum for attachment. Additionally, macroalgae can suppress the successful colonization of the substratum by corals through occupation of the available space, shading, abrasion, chemical poisoning, and infection with bacterial disease.

The trophic effects of fishing are likely to interact with many other threats. For example, when carnivorous fishes are overfished, corallivore populations may increase, resulting in greater predation on corals. Further, some corallivores are vectors of disease and can transmit disease from one coral colony to another as they transit and consume from each coral colony. Increasing corallivore abundance results in transmittal of disease to higher proportions of the corals within the population.

Predation on some coral genera, particularly *Acropora*, *Orbicella*, and *Porites*, is a chronic, though occasionally acute, energy drain (Cole et al. 2008; Rotjan and Lewis 2008). Predators of Caribbean corals include snails, polychaete worms, and several species of fishes. The effects of chronic and frequent predation on corals are usually inconsequential but can become significant once the coral population decreases below a threshold. If the living coral cover is substantially reduced by natural or anthropogenic disturbances, the effects of predation become larger even if the rate of predation does not change. The increased focus of predation on the fewer remaining colonies can energetically cost the coral in defensive reactions and could result in a reduced rate of healing and/or fecundity or reduced resistance to stressors and/or disease. Over-predation can lead to significant coral declines when the rate of coral predation is higher than the rate of healing or coral population replenishment.

Human activities in coastal watersheds introduce sediment into the ocean by a variety of mechanisms, including river discharge, surface run-off, groundwater seeps, and atmospheric deposition. Elevated sediment levels are generated by poor land use practices and coastal and near shore construction. Near shore sediment levels will also likely increase with sea level rise. Greater inundation of reef flats can erode soil at the shoreline and re-suspend lagoon deposits, producing greater sediment transport and potentially leading to leeward reefs' being flooded with turbid lagoon waters or buried by off-bank sediment transport.

The most common direct effect of sedimentation is deposition of sediment on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. In addition, corals can actively displace sediment by ciliary action or mucous production, both of which require energetic expenditures. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. Corals that are unsuccessful in removing sediment will be smothered and die. Sediment can also induce sublethal effects, such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. While some corals may be more tolerant of elevated short-term levels of sedimentation, sediment stress and turbidity can induce bleaching. Finally, sediment impedes fertilization of spawned gametes and reduces larval settlement, as well as the survival of recruits and juveniles.

Sedimentation is also likely to interact with many other threats. For example, when coral communities that are chronically affected by sedimentation experience a warming-induced bleaching event and associated disease outbreaks, the consequences for corals can be much more severe than in communities not affected by sedimentation.

Nutrients, toxins, and bioactive compounds (of plant or animal origin and having direct effects on living organisms) are added to coral reefs from both point sources (readily identifiable inputs from a single source such as a pipe or drain) and non-point sources (inputs that occur over a wide area and are associated with particular land uses). Anthropogenic sources of contaminants include sewage, agricultural run-off, river and inlet discharges, and groundwater. Development of coastlines and destruction of mangrove forests compound the problem of anthropogenic runoff, as mangroves are able to filter massive amounts of nutrients and sediment caused by development. The general effects of contaminants on coral communities are reductions in coral growth, coral cover, and coral species richness (Keller and Jackson 1991; Loya and Rinkevich 1980; Pait et al. 2007), and a shift in community composition to more tolerant species (Rachello-Dolmen and Cleary 2007). Contaminant effects are species specific and may have harmful effects in combination that would not be evident under experimental exposure to an individual substance.

Elevated nutrients affect corals through 2 main mechanisms: direct impacts on coral physiology and indirect effects through nutrient-stimulation of other community components (e.g., macroalgae and filter feeders) that compete with corals for space on the reef. Coral reefs are adapted to low nutrient levels, and overabundance of nutrients can cause an imbalance that affects the entire ecosystem. Nutrient-rich water can enhance benthic algae and phytoplankton growth rates in coastal areas, resulting in overgrowth, competition, and algal blooms. Excess nutrient loads affect coral physiology and the balance between corals and their zooxanthellae (Szmant 2002). Increased nutrients can decrease calcification and reduce skeletal density; however, nutrients may enhance linear growth. Either condition results in corals that are more prone to breakage or erosion. Increased levels of nutrients can also compromise coral health (Hodel and Vargas-Angel 2007). Notably, individual species have varying tolerance to increased nutrients. Additionally, experimental studies on diseased coral species indicate that nutrient augmentation adjacent to active disease lesions substantially increases disease severity (Bruno et al. 2003). Nutrient runoff from land also stimulates phytoplankton blooms, which provide food for the larvae of invertebrate corallivores and can cause outbreaks of these predators (Birkeland 1982; Fabricius et al. 2010).

Laboratory experiments have shown chemical contaminants are harmful to corals. However, linking coral decline to specific contaminants in the environment can be difficult. Low concentrations (parts per billion) of organic chemical contaminants including hydrocarbons (Negri and Heyward 2000), antifoulants (Knutson et al. 2012), pesticides (Negri and Heyward 2001), and metals such as copper, zinc, and iron (Bielmyer et al. 2010; Reichelt-Brushett and Harrison 2000; Reichelt-Brushett and Harrison 2005; Vijayavel et al. 2012) can impact photosynthesis (Jones and Kerswell 2003), growth, coral fertilization success, and larval settlement. Estrogen compounds at concentrations that occur in urban or sewage-affected coastal waters (i.e., 2 $\mu g\ L^{-1}$) can affect coral growth and fecundity (Tarrant et al. 2004). In laboratory experiments, various compounds found in common sunscreens caused coral bleaching (Danovaro et al. 2008). Both oil and chemical dispersants are toxic to coral larvae (Epstein et al. 2000; Negri and Heyward 2000; Goodbody-Gringley et al., unpublished data, K. Ritchie, Mote Marine Lab pers. comm. to A. Moulding, NMFS 2012). While toxic and biologically active substances impair corals, their effects are largely "silent," causing chronic and often sublethal stress or contributing to mortality of unapparent cause.

Coral reefs must endure physical damage from many different sources and threats acting over a range of spatial and temporal scales. Extreme wave events, such as those generated by severe tropical hurricanes, are naturally occurring processes that are typically viewed as acute disturbances. Direct physical effects from vessel groundings, anchor damage, and coastal construction activities, such as dredging, mining, and drilling, are somewhat analogous to storm damage in that they are relatively discrete events, although they generally occur over much smaller spatial scales than do storms. Other human-induced disturbances, such as those caused by tourism and recreational events, fishing gear, and marine debris, can have pervasive, chronic physical consequences. Chronic stresses reduce the ability of corals to recover from acute events (Connell et al. 1997). The relationships between injury interval and time required for reef recovery are the primary factors in evaluating equilibrium of the system (Connell 1978).

Because the 3 threatened species of star coral have traditionally been common and are among the main reef builders in the Caribbean, they have been the frequent subject of research, including responses to and impacts of environmental threats. Published reports of individual bleaching surveys have consistently indicated that *Orbicella* species are highly- to moderately-susceptible to bleaching (Brandt 2009; Bruckner and Hill 2009; Oxenford et al. 2008; Wagner et al. 2010). Bleaching can prevent gamete production in *Orbicella* colonies in the following reproductive season even after they recover normal pigmentation (Mendes and Woodley 2002; Szmant and Gassman 1990). Bleaching events leave permanent marks in coral growth records (Leder et al. 1991; Mendes and Woodley 2002). Particularly well-documented mortalities in these species following severe mass-bleaching in 2005 highlight the immense impact that thermal stress events and their aftermath can have on *Orbicella* populations (Miller et al. 2009). Using demographic data collected in Puerto Rico over 9 years straddling the 2005 bleaching event, Hernández-Pacheco et al. (2011) showed that population growth rates were stable in the pre-bleaching period (2001-2005), but declined in the 2 years following the bleaching event. Simulation modeling of different bleaching probabilities predicted extinction of a population with these dynamics within 100 years at a bleaching probability between 10% and 20%; in other words, once every 5-10 years (Hernández-Pacheco et al. 2011). Cervino et al. (2004) also showed that higher temperatures (over experimental treatments from 20°-31°C) resulted in faster rates of tissue loss and higher mortality in yellow-band affected *Orbicella* species. Recent work in the Mesoamerican reef system indicated that *Orbicella faveolata* had reduced thermal tolerances in many locations and over time (Carilli et al. 2010) with increasing human populations, implying increasing local threats (Carilli et al. 2009).

The only study conducted regarding the impact of acidification on this genus is a field study that did not find any change in *Orbicella faveolata* calcification in sampled colonies from the Florida Keys up through 1996 (Helmle et al. 2011). Preliminary experiments testing effects of acidification on fertilization and settlement success of *Orbicella* species (Albright et al., unpublished data) show results that are consistent with the significant impairments demonstrated for *Acropora palmata* (Albright et al. 2010).

Both Bruckner and Hill (2009) and Miller et al. (2009) demonstrated profound declines for *Orbicella annularis, O. faveolata,* and *O. franksi* from disease impacts, both with and without prior bleaching. Both white plague and yellow-band diseases can invoke this type of population level decline. Disease outbreaks can persist for years in a population; *Orbicella annularis* colonies suffering from yellow-band in Puerto Rico in 1999 still manifested similar disease signs 4 years later, with a mean tissue loss of 60% (Bruckner and Bruckner 2006).

Orbicella species do not suffer from catastrophic outbreaks of predators. While *Orbicella* can host large populations of corallivorous snails, they rarely display large feeding scars that are apparent on other coral prey, possibly related to differences in tissue characteristics or nutritional value (Baums et al. 2003). Low-level predation, however, can have interactive effects with other stressors. For example, predation by butterflyfish can serve as a vector to facilitate infection of *Orbicella faveolata* with black-band disease (Aeby and Santavy 2006). Parrotfishes are also known to preferentially target *Orbicella* in so-called "spot-biting," which can leave dramatic signs in some local areas (Bruckner et al. 2000; Rotjan and Lewis 2006). Chronic parrotfish biting can impede colony recovery from bleaching (Rotjan et al. 2006). Although it is not predation per se, *Orbicella* colonies have often been infested by other pest organisms. Bio-eroding sponges (Ward and Risk 1977) and territorial damselfishes, *Stegastes planifrons*, can cause tissue loss and skeletal damage. Damselfish infestation of *Orbicella* colonies appears to have increased in areas where their preferred, branching coral habitat has declined because of loss of Caribbean acroporids (Precht et al. 2010).

Large, massive, long-lived colonies of *Orbicella* lend themselves to retrospective studies of coral growth in different environments, so there is a relatively large amount known or inferred regarding relationships between water quality and *Orbicella* growth and status. For example, Tomascik (1990) found an increasing average growth (linear extension) rate of *Orbicella annularis* with improving environmental conditions on fringing reefs in Barbados. Within the same study, Tomascik also found a general pattern of decreasing growth rates within the past 30 years at each of the 7 fringing reefs and contributed this decrease to the deterioration of water quality along the west coast of Barbados. Torres and Morelock (2002) noted a similar decline in *Orbicella annularis* growth at sediment-impacted reefs in Puerto Rico. Density and calcification rate increased from high to low turbidity and sediment load, while extension rate followed an inverse trend (Carricart-Ganivet and Merino 2001). Eakin et al. (1994) demonstrated declines in *Orbicella annularis* linear extension during periods of construction in Aruba. Downs et al. (2005) suggested that localized toxicant exposure may account for a localized mortality event of *Orbicella* in Biscayne National Park. *Orbicella* species had somewhat lesser sensitivity to copper exposure in laboratory assays than *Acropora cervicornis* and *Pocillopora damicornis* (Bielmyer et al. 2010). Nutrient-related runoff has also been deleterious to *Orbicella annularis* complex. Elevated nitrogen reduced respiration and calcification in *Orbicella annularis* and stimulated zooxanthellae populations (Marubini and Davies 1996). Elevated nutrients increased the rate of tissue loss in *Orbicella franksi* and *Orbicella faveolata* affected by yellow-band disease (Bruno et al. 2003). Chronic nutrient elevation can produce bleaching and partial mortality in *Orbicella annularis*, whereas anthropogenic dissolved organic carbon kills corals directly (Kuntz et al. 2005).

In summary, the following describes the status of boulder star coral. The species has undergone major declines mostly due to warming-induced bleaching and disease. There is evidence of synergistic effects of threats for this species including disease outbreaks following bleaching events and reduced thermal tolerance due to chronic local stressors stemming from land-based sources of pollution. Boulder star coral is highly susceptible to a number of threats, and cumulative effects of multiple threats have likely contributed to its decline and exacerbate vulnerability to extinction. Despite high declines, the species is still common and remains one of the most abundant species on Caribbean reefs. Its life history characteristics of large colony size and long life span have enabled it to remain relatively persistent despite slow growth and low recruitment rates, thus moderating vulnerability to extinction. The buffering capacity of these life history characteristics, though, is expected to decrease as colonies shift to smaller size classes as has been observed in locations in its range. Its absolute population abundance has been estimated as at least tens of millions of colonies in each of several locations including the Florida Keys, Dry Tortugas, and the U.S. Virgin Islands and is higher than the estimate from these 3 locations due to its occurrence in many other areas throughout its range. Despite the large number of islands and environments that are included in the species' range, geographic distribution in the highly disturbed Caribbean exacerbates vulnerability to extinction over the foreseeable future because boulder star coral is limited to an area with high, localized human impacts and predicted increasing threats. Its depth range of 1.5 to at least 130 ft, possibly up to 295 ft, moderates vulnerability to extinction over the conceivable future because deeper areas of its range will usually have lower temperatures than surface waters, and acidification is generally predicted to accelerate most in waters that are deeper and cooler than those in which the species occurs. Boulder star coral occurs in most reef habitats, including both shallow and mesophotic reefs, which moderates vulnerability to extinction over the foreseeable future because the species occurs in numerous types of reef environments that are predicted, on local and regional scales, to experience wide shifts in temperature and ocean chemistry at any given point in time. Its abundance, life history characteristics, and depth distribution, combined with spatial variability in ocean warming and acidification across the species' range, moderate vulnerability to extinction because the threats are non-uniform. There will likely be a large number of colonies that are either not exposed to or do not negatively respond to a threat at any given point in time.

4.2.2 Designated Critical Habitat for Elkhorn and Staghorn Corals

On November 26, 2008, a Final Rule designating *Acropora* critical habitat was published in the Final Register. Within the geographical area occupied by a listed species, critical habitat consists of specific areas on which are found those physical or biological features essential to the conservation of the species. The feature essential to the conservation of *Acropora* species (also known as essential feature) is substrate of suitable quality and availability in water depths from the mean high water line to 30 m in order to support successful larval settlement, recruitment, and reattachment of fragments. Substrate of suitable quality and availability means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover. Areas containing these features have been identified in 3 locations within the U.S. Caribbean: Puerto Rico, St. Thomas/St. John, and St. Croix (see Figure 18). The Puerto Rico marine unit which includes the action area for the proposed PCCS project comprises approximately 1,383 square miles (mi^2) (3,582 km^2) of ESA-designated acroporid coral critical habitat. Of this area, approximately 292 mi^2 (756 km^2) are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOAA's National Ocean Service (NOS) Biogeography Program in 2000 (Kendall et al. 2001). The St. Thomas/St. John marine unit, which includes the action area for both cable projects, comprises approximately 121 mi^2 (313 km^2) of ESA-designated critical habitat. Of this area, approximately 26 mi^2 (67 km^2)

are likely to contain the essential element of ESA-designated *Acropora* coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). The St. Croix marine unit, which includes the action area for the proposed viNGN project, comprises approximately 126 mi^2 (326 km^2) of ESA-designated acroporid coral critical habitat. Of this area, approximately 90 mi^2 (233 km^2) are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001).

The benthic survey completed for the viNGN project found areas of colonized hard bottom at several of the landing sites and the routes were planned to avoid these areas as much as possible. There will be some impact to elkhorn and staghorn coral critical habitat associated with the installation of Segment 3 at the Flamingo Bay landing. The deepwater hard bottom and reef areas that will be affected by the cable segments extending off the St. Thomas and St. Croix shelf are beyond the 30-m depth range of coral critical habitat. The benthic survey completed for the PCCS project found that there will be some impacts to coral critical habitat associated with the placement of the cable at the Puerto Rico landing site. These impacts include those associated with the installation of articulated pipe to prevent the cable from moving once it is installed as well as the use of temporary anchor locations.

Elkhorn corals require hard, consolidated substrate, including attached, dead coral skeleton, devoid of turf or fleshy macroalgae for their larvae to settle. Atlantic and Gulf of Mexico Rapid Reef Assessment Program data from 1997-2004 indicate that although the historic range of both species remains intact, the number and size of colonies and percent cover by both species has declined dramatically in comparison to historic levels (Lang et al. 2003).

While algae, including crustose coralline algae and fleshy macroalgae, are natural components of healthy reef ecosystems, increases in the dominance of algae since the 1980s impedes coral recruitment. The overexploitation of grazers through fishing has also enabled fleshy macroalgae to persist in reef and hard bottom areas formerly dominated by corals. Impacts to water quality (in particular nutrient inputs) associated with coastal development are also thought to enhance the growth of fleshy macroalgae by providing them with nutrient sources. Fleshy macroalgae are able to colonize dead coral skeleton and other hard substrate and some are able to overgrow living corals and crustose coralline algae. Because crustose coralline algae is thought to provide chemical cues to coral larvae indicating an area is appropriate for settlement, overgrowth by macroalgae may affect coral recruitment (Steneck 1986). Several studies show that coral recruitment tends to be greater when algal biomass is low (Birrell et al. 2005; Connell et al. 1997; Edmunds et al. 2004; Hughes and Jackson 1985; Rogers et al. 1984; Vermeij 2006). In addition to preempting space for coral larval settlement, many fleshy macroalgae produce secondary metabolites with generalized toxicity, which also may inhibit settlement of coral larvae (Kuffner and Paul 2004).

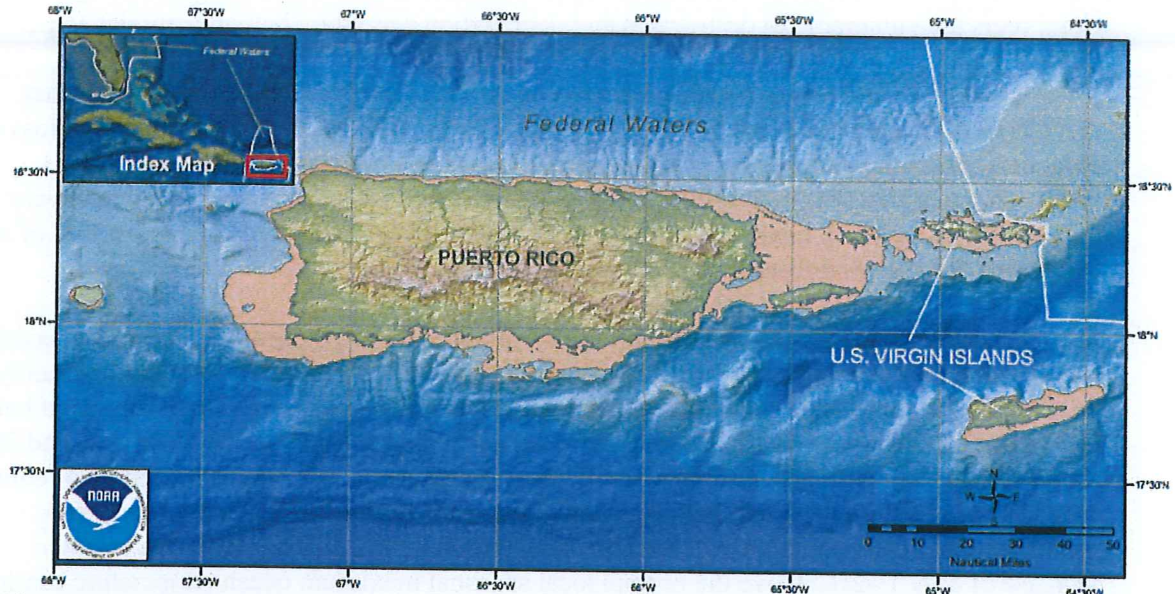

Figure 19. Coral critical habitat map for staghorn and elkhorn corals in the U.S. Caribbean (Acropora Critical Habitat map created by NMFS, 2008, see http://sero.nmfs.noaa.gov/maps_gis_data/protected_resources/critical_habitat/index.html)

Sediment from natural and anthropogenic sources can also affect reef distribution, structure, growth, and recruitment. Sediments can accumulate on dead and living corals and exposed hard bottom, thus reducing the available substrate for larval settlement and fragment attachment. In addition to the amount of sedimentation, the source of sediments can affect coral growth. In a study of 3 sites in Puerto Rico, (Torres 2001) found that low-density coral skeleton growth was correlated with increased re-suspended sediment rates and greater percentage composition of terrigenous sediment. In sites with higher carbonate percentages and corresponding low percentages of terrigenous sediments (sediments derived from terrestrial environments), growth rates were higher. This suggests that resuspension of sediments and sediment production within the reef environment does not necessarily have a negative impact on coral growth while sediments from terrestrial sources increase the probability that coral growth will decrease, possibly because terrigenous sediments do not contain minerals that corals need to grow (Torres 2001).

Overall, changes that have affected elkhorn and staghorn corals and led to significant decreases in the numbers and cover of these species have also affected the suitability and availability of habitat for these species.

4.2.3 Effects of Climate Change on Listed Corals and Coral Critical Habitat

There is a large and growing body of literature on past, present, and future impacts of global climate change exacerbated and accelerated by human activities. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. NOAA's climate information portal provides basic background information on these and other measured or anticipated effects (see http://www.climate.gov).

Coral reefs are vulnerable to destruction and degradation caused by human activities (e.g., nutrient pollution, sedimentation, contaminant spills, vessel groundings and anchoring, recreational uses) and are also highly sensitive to the effects of climate change (i.e., higher incidences of disease and coral bleaching) (Crabbe 2008; Wilkinson 2004). Continued loss of coral reef communities (especially in the greater Caribbean region) is expected to impact hawksbill and green sea turtle refuge and foraging and represents a major threat to recovery of the species, as well as a major threat to the recovery of ESA-listed corals due to the loss of areas containing the essential feature of coral critical habitat.

Mean seawater temperatures in reef-building coral have increased during the past few decades and are predicted to continue to rise between now and 2100 (IPCC 2007). More importantly, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past 2 decades and is also predicted to increase between now and 2100 (IPCC 2007). The primary observable coral response to ocean warming is bleaching of coral colonies, wherein corals expel their symbiotic algae (zooxanthellae) in response to stress. Bleaching can affect coral growth, maintenance, reproduction, and survival. An episodic increase of only 1°-2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, or prolonged bleaching can lead to colony death and mass mortality of many coral species.

In addition to coral bleaching, other effects of ocean warming detrimentally affect virtually every life-history stage in reef-building corals. For 1 Indo-Pacific *Acropora* species, abnormal embryonic development occurs at 32°C, and complete fertilization failure occurs at 34°C (Negri and Heyward 2000). In addition to abnormal embryonic development (Lundgren and Hillis-Starr 2008; Miller 2002; Polato et al. 2010; Randall and Szmant 2009a), symbiosis establishment, larval survivorship, and settlement success are impaired in some Caribbean brooding (Randall and Szmant 2009b) and broadcast spawning (Lundgren and Hillis-Starr 2008; Randall and Szmant 2009a; Voolstra et al. 2009) coral species at temperatures as low as 30°C-32°C. Further, warmer temperatures appreciably accelerate the rate of larval development in the water column for spawning species (Polato et al. 2010; Randall and Szmant 2009a), which suggests that total dispersal distances could also be reduced, potentially decreasing the likelihood of successful settlement and the potential for replenishment of depleted areas (Brainard et al. 2011).

Multiple threats stress corals simultaneously or sequentially, whether the effects are cumulative, synergistic, or antagonistic. Ocean warming is likely to interact with many other threats, especially considering the long-term consequences of repeated thermal stress, and ocean warming is expected to worsen over the foreseeable future. Increased seawater temperature interacts with coral diseases to reduce coral health and survivorship. Coral disease outbreaks often have accompanied or immediately followed bleaching events and also follow seasonal patterns of high seawater temperatures. The effects of greater ocean warming (i.e., increased bleaching, which kills or weakens colonies) are expected to interact with the effects of higher storm intensity (i.e., increased breakage of dead or weakened colonies) in the Caribbean, resulting in an increased rate of coral declines. Likewise, land-based runoff, pollution, or other local stressors may worsen bleaching impacts by increasing coral susceptibility to bleaching and/or increasing the duration of lowered growth after a bleaching event (Carilli et al. 2009; Wooldridge 2009).

Sea level rise may affect various coral life history events, including larval settlement, polyp development, and juvenile growth. It may also contribute to adult mortality and colony fragmentation, mostly due to increased sedimentation and decreased water quality (reduced light availability) caused by coastal inundation. The best available information suggests that sea level will continue to rise due to thermal expansion and the melting of land and sea ice. Theoretically, any rise in sea level could potentially provide additional habitat for corals living near the sea surface. Many corals that inhabit the relatively narrow zone near the ocean surface have rapid growth rates when healthy, which allowed them to keep up with sea-level rise during the past periods of rapid climate change associated with de-glaciation and warming. Depending on the rate and amount of sea level rise, rapid rises can lead to reef drowning. Rapid rises in sea level could affect many coral species by both submerging them below their common depth range and, more likely, by degrading water quality through coastal erosion and potentially severe sedimentation or enlargement of lagoons and shelf areas.

Rising sea level is likely to cause mixed responses in coral species depending on their depth preferences, sedimentation tolerances, and growth rates. Reductions in growth rate due to local stressors, bleaching, infectious disease, and ocean acidification may prevent the species from keeping up with sea level rise (e.g., from growing at a rate that will allow them to continue to occupy their preferred depth range despite sea-level rise). Additionally, lack of suitable new habitat, limited success in sexual recruitment, coastal runoff, and coastal hardening will compound some corals' ability to survive rapid sea level rise.

5 Environmental Baseline

This section identifies the effects of past and ongoing human and natural factors leading to the current status of the species, their habitat, and ecosystem, within the action area. The environmental baseline is a snapshot of the action area at a specified point in time and includes state, tribal, local, and private actions already affecting the species, or that will occur contemporaneously with the consultation in progress.

Unrelated federal actions affecting the same species or critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are federal and other actions within the action area that may benefit listed species or critical habitat.

The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of ESA-listed boulder star corals and the ability of designated critical habitat in the action area to support its intended conservation function for staghorn and elkhorn corals. This Opinion describes these activities' effects in the sections below.

5.1 Status of ESA-Listed Corals and Coral Critical Habitat within the Action Area

The action area for the viNGN project includes near shore and offshore habitats along the cable segments between St. Thomas and St. Croix in locations of the east and west coasts of both islands (Brewer's Bay, St. Thomas to Frederiksted, St. Croix, and Great Bay, St. Thomas, to Christiansted, St. Croix) and near shore habitats between Brewer's Bay, St. Thomas, and Flamingo Bay, Water Island, and Villa Olga, St. Thomas, and Banana Bay, Water Island. The near shore habitats include seagrass beds, sand, coral reefs, colonized hard bottom, and rubble. The offshore habitats include sand, patch reefs, colonized hard bottom, and colonized rhodolith reefs. The EAR for the project and information from site inspections by NMFS's biologists at the landing sites for this project show that elkhorn, staghorn, mountainous star, lobed star, and pillar corals are present in the area of the Brewer's Bay landing. Lobed star coral is present in the area of the Frederiksted landing. Lobed star, elkhorn, and pillar corals are present in the area of the Great Bay landing. Lobed star and pillar coral are present in the area of the Christiansted landing. Elkhorn coral is present in the cut between Hassel Island and St. Thomas through which Segment 4 will pass. The mesophotic reef surveys found boulder star coral in several areas on the eastern and western portions of the St. Thomas shelf where Segments 1 and 2 will cross from St. Thomas to St. Croix, as well as scattered on the St. Croix shelf off Frederiksted and Christiansted. As discussed above, only boulder star coral is expected to be adversely affected by the ViNGN project.

The action area for the PCCS project includes near shore and offshore habitats along Segment 2A into the San Juan, Puerto Rico, landing site and offshore habitats between USVI and BVI for Segments 2A and 2. The near shore habitats include seagrass beds, sand, coral reefs, and colonized hard bottom. The offshore habitats include sand, patch reefs, colonized hard bottom, and colonized rhodolith reefs. The benthic survey conducted for the PCCS project found mountainous star and rough cactus coral within 10-42 m of the proposed cable route into San Juan. The mesophotic reef surveys for areas off the Puerto Rico shelf and the area south of St. John between USVI and BVI found reef and hard bottom formations with boulder star coral. The densities of boulder star coral found south of St. John were the greatest found in any of the mesophotic reef surveys conducted for the 2 cable projects.

Within the Puerto Rico marine unit, approximately 292 mi^2 (756 km^2) are likely to contain the essential element of ESA-designated elkhorn and staghorn coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOAA's National Ocean Service (NOS) Biogeography Program in 2000 (Kendall et al. 2001). Within the St. Thomas/St. John marine unit, approximately 26 mi^2 (67 km^2) are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). Within the St. Croix marine unit, approximately 90 mi^2 (233 km^2) are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001).

5.1.1 Factors Affecting Boulder Star Corals and Elkhorn and Staghorn Critical Habitat within the Action Area for the viNGN and PCCS Projects

Activities funded, authorized, or carried out by federal agencies have been identified as threats and may affect colonies of boulder star corals and critical habitat for staghorn and elkhorn corals in the action area for each of the cable projects. The activities that shape the environmental baseline in the action area of this consultation are federal fisheries, effects of vessel operations, private vessel traffic, marine pollution, and natural disturbance.

Although many regulations exist to protect corals (see Section 5.1.2.1), including ESA-listed corals, many of the activities identified as threats still adversely affect the species and coral critical habitat. Poor boating and anchoring practices, poor snorkeling and diving techniques, and destructive fishing practices cause physical damage to habitat and coral colonies. Nutrients, contaminants, and sediment from point and non-point sources create an unfavorable environment for reproduction and growth of corals by promoting overgrowth of hard substrate by algae or the buildup of sediment layers that prohibit coral settlement.

5.1.1.1 Fisheries

Several types of fishing gears used within the action area may adversely affect coral critical habitat and coral colonies. Longline, other types of hook-and-line gear, and traps have all been documented as interacting with coral habitat and coral colonies in general, though no data specific to ESA-listed and proposed corals and their habitat is available. Available information suggests hooks and lines can become entangled in reefs, resulting in breakage and abrasion of corals. Net fishing can also affect coral habitat and coral colonies if this gear drags across the marine bottom either due to efforts targeting reef and hard bottom areas or due to derelict gear. Studies by Sheridan et al. (2003) and Schärer et al. (2004) showed that most trap fishers do not target high-relief bottoms to set their traps due to potential damage to the traps. Unfortunately, lost traps and illegal traps can affect corals and their habitat if they are moved onto reefs or colonized hard bottoms during storms or placed on coral habitat because the movement of the traps leads to breakage and abrasion of corals. For all fisheries for which there is a Fishery Management Plan (FMP) or for which any federal action is taken to manage that fishery, impacts are evaluated under Section 7 of the ESA. NMFS reinitiated Section 7 consultations for the Coral, Queen Conch, Reef Fish, and Spiny Lobster FMPs under the jurisdiction of the CFMC when elkhorn and staghorn corals were listed and critical habitat was designated for these corals. NMFS concluded that the implementation of the Coral FMP would have no effect on listed corals or coral-designated critical habitat. NMFS determined that the Queen Conch FMP is not likely to adversely affect listed corals or their designated critical habitat. NMFS has also completed Biological Opinions for the Reef Fish and Spiny Lobster FMPs as part of Section 7 consultations to consider the potential impacts of the fisheries on ESA-listed corals and their designated critical habitat. These same conclusions will likely apply to boulder star corals.

5.1.1.2 Vessel Operations

Potential sources of adverse effects from federal vessel operations in the action area include operations of the U.S. Coast Guard (USCG), U.S. Environmental Protection Agency (EPA), and NOAA. Through the Section 7 process, where applicable, NMFS will continue to establish conservation measures for agency vessel operations to avoid or minimize adverse effects to ESA-listed corals and coral critical habitat. At the present time, however, they present the potential for some level of interaction.

5.1.1.3 ESA Permits

Regulations developed under the ESA allow for the issuance of permits allowing take of certain ESA-listed species for the purposes of scientific research under Section 10(a)(1)(A) of the ESA. These regulations do not apply to designated critical habitat. In addition, Section 6 of the ESA allows NMFS to enter into cooperative agreements with states to assist in recovery actions of ESA-listed species. Prior to issuance of these permits, the proposal must be reviewed for compliance with Section 7 of the ESA, including the avoidance and minimization of potential impacts to elkhorn and staghorn coral critical habitat.

5.1.1.4 Vessel Traffic

Commercial and recreational vessel traffic can adversely affect coral colonies and elkhorn and staghorn coral critical habitat through propeller scarring, propeller wash, and accidental groundings. Based on information from the NOAA Restoration Center and NOAA's ResponseLink, reports of accidental groundings are becoming more common in USVI and Puerto Rico, but numerous vessel groundings are likely not reported. In the viNGN action area, there are DPNR reports regarding anchor damage to corals and coral habitat in the area of Frederiksted Pier (DPNR, unpublished data) and we have received notifications from the USCG of vessel groundings from different areas around St. Thomas, as well as in the Schooner Channel and other areas of the Christiansted Harbor and Gallows Bay. In the PCCS action area, there are anecdotal reports of vessel groundings on the reef that is now part of the Isla Verde Reserve from the community group that co-manages the reserve with DNER. Given the amount of vessel traffic, including jet skis, during the weekends in the area of the San Juan landing, it is likely that vessel groundings on the reefs in the area have occurred and not been reported. Through the Section 7 process for dock, port, and marine construction activities under the jurisdiction of the USACE, NMFS will continue to establish conservation measures to ensure that the construction and operation of these facilities avoids or minimizes adverse effects to ESA-listed species and critical habitat.

5.1.1.5 Coastal Development

Anthropogenic sources of marine pollution, while difficult to attribute to a specific federal, state, local or private action, may indirectly affect coral colonies and coral critical habitat in the action area. Nutrient loading from land-based sources, such as coastal communities, are known to stimulate plankton blooms in closed or semi-closed estuarine systems and algal blooms in these areas, as well as in near shore waters. Water quality monitoring studies by DPNR Division of Environmental Protection (DEP) in waters around USVI indicate that surface waters are affected by increasing point and non-point source pollution from failing septic systems, discharges from vessels, failure of best management practices on construction sites, and failure of on-site disposal methods (Rothenberger et al. 2008). These factors result in increased sedimentation and nutrient transport, bacterial contamination, and trash and other debris entering surface and near shore waters from developed areas. DEP reports that water quality around USVI continues to decline based on monitoring data. The 2010 impaired waters list included 86 sites, up from 50 in 2005, indicating that water quality continues to decline throughout USVI. Increases in pollutant levels and sediment loading result in habitat degradation leading to the loss of suitable habitat for coral settlement and growth due to increased algal growth and sedimentation as has been reported for sites around USVI. Beach monitoring studies by the Puerto Rico Environmental Quality Board from 2005-2008 found that only 32% of coastal waters complied with primary recreation standards, meaning direct contact with coastal waters (e.g., swimming); 34% complied with secondary recreation standards, meaning indirect contact with coastal waters (e.g., boating). In addition, of the beach miles monitored, only 26% of the areas designated for primary recreation (direct human contact with waters) complied with the water quality standards for this type of use (Junta de Calidad Ambiental, #123309). Monitoring data consist mainly of fecal coliform testing, meaning that there may be significant inputs of wastewater to some coastal areas. These inputs result in increased nutrient and bacterial contamination in near shore waters from developed areas.

5.1.1.6 Natural Disturbance

Hurricanes and large coastal storms can also harm coral colonies and coral critical habitat. Historically, large storms potentially resulted in asexual reproductive events, if the fragments encountered suitable substrate, attached, and grew into new colonies. Yet over the past 2 decades, the amount of suitable substrate has been significantly reduced; therefore, many fragments created by storms die. Hurricanes are also sometimes beneficial, if they do not result in heavy storm surge, during years with high sea surface temperatures, as they lower the temperatures providing fast relief to corals during periods of high thermal stress (Heron et al. 2008). Major hurricanes have caused significant losses in coral cover and changes in the physical structure of many reefs in Puerto Rico and the USVI. Based on data from the Caribbean Hurricane Network, there have been a total of 15 hurricanes and tropical storms that have affected Puerto Rico between 1975 and 2010 with 5 hurricanes occurring between 1995 and 1999. Hurricane David in 1979 caused violent sea conditions and flooding and was followed 5 days later by Tropical Storm Frederick which resulted in additional flooding. Tropical Storm Klaus in 1984 affected some parts of USVI. Hurricane Hugo in 1989 led to violent sea conditions and major flooding across USVI and Puerto Rico. Hurricanes Marilyn in 1995, Bertha in 1996, Georges in 1998, and Lenny in 1999 led to additional impacts to reefs already suffering damage from Hurricane Hugo. Tropical storms and hurricanes in 2004, 2008, and 2010 also resulted in severe flooding across USVI and in portions of Puerto Rico. Flooding from hurricane events leads to transport of land-based sources of pollutants to reefs, along with an influx of freshwater to near shore environments that affects water quality, in addition to physical damage caused by the storms themselves. In the action area, tropical storms frequently cause beach erosion, sometimes exposing bedrock along portions of the coast due to heavy surge.

5.1.2 Conservation and Recovery Actions Benefiting ESA-Listed Corals and Coral Critical Habitat

The CFMC has established regulations prohibiting the use of bottom-tending fishing gear in seasonally and permanently closed fishing areas containing coral reefs in federal waters of the EEZ. The Territory has similar fisheries regulations for both commercial and recreational fishers. In addition to regulations, education and outreach activities are ongoing as part of the NOAA Coral Reef Conservation Program (CRCP) as well as through NMFS's ESA program through the Southeast Regional Office. NOAA Restoration Center has also established a contract position in Puerto Rico to participate in grounding response in Puerto Rico and USVI and carry out restoration activities. The summaries below discuss these measures in more detail.

NMFS convened a recovery team comprised of fishers, scientists, managers, and agency personnel from Florida, Puerto Rico, and USVI, and federal representatives and has created a draft recovery plan based upon the latest and best available information for ESA-listed corals and their habitat. Once a final listing decision for the corals currently proposed for listing has been made, it is likely the draft recovery plan will be revised to include all ESA-listed coral species.

5.1.2.1 Regulations Reducing Threats to ESA-Listed Corals

Numerous management mechanisms exist to protect corals or coral reefs in general. Existing federal regulatory mechanisms and conservation initiatives most beneficial to branching corals have focused on addressing physical impacts, including damage from fishing gear, anchoring, and vessel groundings. The Coral Reef Conservation Act and the 2 Magnuson-Stevens Act Coral and Reef Fish FMPs (Caribbean) require the protection of corals and prohibit the collection of hard corals. Depending on the specifics of zoning plans and regulations, marine protected areas can help prevent damage from collection, fishing gear, groundings, and anchoring.

The Territorial Government regulates activities that occur in terrestrial and marine habitats of USVI. The Territory regulates activities that occur in terrestrial and marine habitats of USVI. The V.I. Code prohibits the taking, possession, injury, harassment, sale, offering for sale, etc., of any indigenous species, including live rock (V.I. Code Title 12 and the Indigenous and Endangered Species Act of 1990). Additionally, USVI has a comprehensive, state regulatory program that regulates most land, including upland and wetland, and surface water alterations throughout the Territory, including in partnership with NOAA under the Coastal Zone Management Act, and EPA under the Clean Water Act.

The Commonwealth Government regulates activities that occur in terrestrial and marine habitats of Puerto Rico. Puerto Rico Regulation 6766 (Law 241 of 1999, the New Wildlife Law) establishes protections for listed species. Permits can be issued by the Secretary of DNER for the collection and transport of species listed by the Commonwealth as vulnerable, threatened, endangered, or critically endangered species for rehabilitation, scientific use, or survival and species' benefit purposes. (Note that federally-listed species are also protected through this Commonwealth regulation, as is ESA-designated critical habitat). In addition, the regulation prohibits the modification of listed species' habitat without a mitigation plan approved by the Secretary of DNER, although the regulation also restricts the type of habitat that can be modified at all. Regulation 6768 under the same law also regulates the collection of all organisms, not just listed species. The DNER Secretary can issue a collection permit for the purposes of scientific investigation, or educational activities or exhibits. Puerto Rico Law 147 of 1999 for the protection, conservation, and management of coral reefs in Puerto Rico, prohibits the removal, extraction, mutilation, or destruction of coral reefs and associated systems. The Secretary of DNER can issue permits for scientific investigations that require extraction of corals, or those that will otherwise affect corals. Additionally, Puerto Rico has a state regulatory program that regulates most land, including upland and wetland, and surface water alterations, including in partnership with NOAA under the Coastal Zone Management Act, and EPA under the Clean Water Act. EPA has maintained regulatory authority for some activities regulated under the Clean Water Act, such as the non-point source discharge elimination system permits.

The Coral and Reef Associated Plants and Invertebrates FMP of the CFMC prohibits the extraction, possession, and transportation of any coral, alive or dead, from federal waters unless a permit is obtained from the Government of the USVI or NMFS. Similarly, the CFMC (50 CFR Part 622) prohibits the use of chemicals, plants, or plant-derived toxins and explosives to harvest coral. The CFMC also prohibits the use of pots/traps, gill/trammel nets, and bottom longlines on coral or hard bottom year-round in existing seasonally-closed areas in the EEZ (50 CFR Part 622).

On November 26, 2008, NMFS published a Final Rule designating critical habitat for ESA-listed elkhorn and staghorn corals. The critical habitat designation requires that all actions with a federal nexus ensure that the adverse modification of critical habitat will not occur as part of a Section 7 consultation with NMFS for the action.

5.1.2.2 Other ESA-Listed Coral and Elkhorn and Staghorn Critical Habitat Conservation Efforts

Restoration

The final Section 4(d) rule for elkhorn and staghorn corals allows certain restoration activities, defined in the rule as "the methods and processes used to provide aid to injured individuals," when they are conducted by certain federal, state, territorial, or local government agency personnel or their designees acting under existing legal authority, to be conducted promptly without the need for ESA permits. A 4(d) rule for boulder star corals has not been promulgated. There are ongoing restoration activities in the U.S. Caribbean led by the jurisdictions and by NOAA's Restoration Center in response to vessel groundings, large storms, and other natural and anthropogenic sources of damage to reefs that benefit boulder star corals. Restoration activities are also carried out to restore damaged critical habitat.

Outreach and Education

The NOAA CRCP, through its internal grants, external grants, and grants to the Territory, Commonwealth, and the CFMC, has providing funding for several activities with an education and outreach component for informing the public about the importance of the coral reef ecosystem of the USVI and Puerto Rico. The Southeast Regional Office of NMFS has also developed outreach materials regarding the listing of elkhorn and staghorn corals, the listing of 5 other coral species on September 10, 2014, the ESA Section 4(d) rule for elkhorn and staghorn corals, and the designation of elkhorn and staghorn coral critical habitat. These materials have been circulated to constituents during education and outreach activities and public meetings, and as part of other Section 7 consultations, and are readily available on the web at: http://sero.nmfs.noaa.gov/protected_resources/coral/index.html.

5.1.3 Summary and Synthesis of Environmental Baseline for ESA-Listed Corals and Elkhorn and Staghorn Designated Critical Habitat

In summary, several factors are presently adversely affecting ESA-listed corals and coral critical habitat in the action area. These factors are ongoing and are expected to occur contemporaneously with the proposed action. Marine pollution as a result of coastal development and vessel traffic that will continue to result in abrasion and damage to coral critical habitat due to accidental groundings and poor anchoring techniques are expected to be the activities that continue to have the greatest impact on coral colonies and the essential feature of coral critical habitat. Fishing activities, as well as marine operations and natural disturbance, are also expected to continue to result in impacts to coral colonies and elkhorn and staghorn coral critical habitat.

These activities are expected to combine to adversely affect the quality and suitability of elkhorn and staghorn coral critical habitat throughout the ranges of elkhorn and staghorn coral, and in the action area for the viNGN and PCCS projects. The factors' adverse effect on elkhorn and staghorn coral critical habitat in the viNGN and PCCS action area have led to a degraded baseline including sediment transport in stormwater runoff as evidenced by the water quality data from USVI and Puerto Rico.

6 Effects of the Action

As described below, NMFS believes that the proposed action will adversely affect threatened boulder star corals. As part of this Opinion and because the action will result in adverse effects to newly-listed boulder star corals, NMFS must evaluate whether the action is likely to jeopardize the continued existence of the species. If so, NMFS must develop reasonable and prudent alternatives to avoid the likelihood of jeopardy to the species. However, at the time of this opinion, NMFS has not promulgated a section 4(d) rule extending some or all of the Section 9 take prohibitions to this species. Thus, for this consultation for the 2 submarine cable projects, if NMFS determines the action is not likely to jeopardize the continued existence of ESA-listed corals but will result in some incidental take, NMFS would not provide an incidental take statement because the take is not prohibited. NMFS would, however, suggest voluntary conservation measures to minimize the effects of the incidental take.

As described below, NMFS believes the proposed action will adversely affect designated critical habitat for staghorn and elkhorn coral. As noted in Section 4.2.2, on November 26, 2008, NMFS finalized a rule designating critical habitat for elkhorn and staghorn corals (50 CFR 226.216). The Puerto Rico marine unit comprises approximately 1,383 mi^2 of ESA-designated acroporid coral critical habitat of which approximately 292 mi^2 are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). The St. Thomas/St. John marine unit comprises approximately 121 mi^2 of ESA-designated critical habitat of which approximately 26 mi^2 are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). The St. Croix marine unit comprises approximately 126 mi^2 of ESA-designated acroporid coral critical habitat of which approximately 90 mi^2 are likely to contain the essential element of ESA-designated acroporid coral critical habitat, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). As noted previously, the physical feature essential to the conservation of elkhorn and staghorn corals is defined as substrate of suitable quality and availability in water depths from mean high water to 30 m to support larval settlement and recruitment, and reattachment of asexual fragments. Substrate of suitable quality and availability is defined as natural consolidated hard bottom or dead coral skeleton that is free from turf or fleshy macroalgae cover and sediment cover. NMFS must evaluate whether a proposed action may result in the destruction or adverse modification of critical habitat.

6.1 Effects of the Actions on ESA-Listed Corals

viNGN

Based on the benthic and mesophotic surveys completed for the viNGN project, in shallow waters the cable segment routes were designed to avoid all impacts to ESA-listed coral colonies. Some impacts to coral habitat will occur due to the use of articulated pipe to anchor the cable and prevent movement in shallow, hard bottom areas. A total of 90 m^2 (0.02 acre) of hard bottom will be impacted by the installation of Segments 1 and 3 of the viNGN cable system due to the installation of the articulated pipe segments (see Table 3). Of this, only 9 m^2 contain the essential feature of acroporid coral critical habitat (see Section 6.2). No other hard bottom impacts are anticipated as a result of the installation of cable segments in the shallow water (less than 30 m) areas where the landing sites are located. This is due to the routing of the cable through natural sand channels and breaks in the reef in some areas or to the lack of reef and hard bottom habitat along the route into the bays in other areas.

In deep waters (greater than 30 m), impacts to boulder star corals, in particular for the segments around St. Thomas (Segments 1 and 2), will be unavoidable. The mesophotic survey for the viNGN cable segments (TetraTech 2013b) found that Segment 1 off the western shelf of St. Thomas will directly affect 37.82 m^2 of boulder star corals. In order to calculate the impacts in terms of the number of boulder star coral colonies, we used an average colony size of 3 m^2 (because colonies range from 0.09 to 6 m^2, in general) and divided the total area to be affected by the size estimate for a single colony. Thus, we estimate that 13 colonies of boulder star coral will be directly affected by the cable route. Segment 2 off the eastern shelf of St. Thomas will directly affect 0.016 m^2 of boulder star corals. We calculated that this equates to up to 1 colony. The cable will range from 14-35 mm in diameter, so the extent of the impact will depend on the linear length of the cable passing over each colony, as well as the amount of movement of the cable during installation. Alcatel-Lucent has stated that, once installed, due to the water depths and the weight of the cable because of its total length, there will be no cable movement in deep waters. They base this assertion on their post-lay surveys from other projects. Thus, we do not anticipate additional impacts to boulder star corals once the cable installation is complete.

In terms of deepwater habitat for boulder star corals, the cable corridor will lay over approximately 4,416.55 m^2 (1.09 acre) of deep reef and hard bottom based on the mesophotic survey and assuming a corridor width of 0.15 m. We believe that the placement of the cable over a 1.09-acre area will not have a measurable effect on the ability of boulder star corals to continue colonizing the areas of shelf edge off St. Thomas that will be affected by the viNGN cable installation. There are 2 factors that support our conclusion: (1) the observed extent of deep reef and hard bottom on the shelf edge of St. Thomas from the mesophotic survey, and (2) the fact that the corridor estimate (used by the applicant to calculate impacts of the cable to benthic habitat) is an overestimate based on the 14-35 mm actual size of the cable.

Vessel operations associated with the installation of the cable segments could affect boulder star corals due to sediment resuspension and transport by propellers, accidental groundings, and anchoring. We believe these impacts will be minimal because the large cable-laying vessel will be maintained in waters of sufficient depth for the draft of the vessel while small vessels serve as feeders to pull the cable through shallow areas to shore at the landing sites. The large vessel will stay in place using dynamic positioning rather than having to anchor. The small vessels will be in constant, slow speed movement between the cable-laying vessel and the landing sites and will not anchor either. The cable routes for each shallow water segment will be clearly marked prior to installation. The small vessels will follow this route, which will prevent accidental groundings because the vessels will be in the areas selected in part because there were fewer benthic resources such as coral reefs. Similarly, anchoring of the large cable-laying vessel will not be done in deepwater sections. In these areas, the vessel will be in constant slow-speed motion while the cable is laid out, sinking to the sea floor along the planned route. The vessel will follow the route using the on-board navigation system that will have the coordinates plotted in it.

PCCS

Based on the benthic and mesophotic surveys completed for the PCCS cable project, in shallow waters the cable routes were designed to avoid all impacts to ESA-listed coral colonies. Some impacts to coral habitat will occur due to the use of articulated pipe to anchor the cable and prevent movement in shallow, hard bottom areas. A total of 93.16 m^2 of hard bottom will be permanently impacted by the installation of Segment 2A of the PCCS cable system due to the installation of the articulated pipe segments (see Table 3). Of this only 25.52 m^2 contain the essential feature of acroporid coral critical habitat (see Section 6.2). Up to 2,221.3 m^2 of hard bottom could be impacted temporarily in the shallow water (less than 30 m) areas where the San Juan landing site is located (see Table 3). Of this only the temporary impact areas are estimated along the cable route as 1-m-wide corridors to either side. If, during installation, it is found that the cable has to be shifted because sessile benthic invertebrates have been trapped under it, the cable will stay within this designated space. The corridor space accounts for the temporary pinning of the cable to the sea floor while installation is underway, minimizes cable movement outside the planned route, and accounts for the temporary mooring points that are located in hard bottom (4 of them each with an impact area of 1 m^2). The temporary mooring points are the only temporary impacts that we know will occur because the 5-point mooring of the shallow-draft cable installation vessel is necessary in shallow waters. These mooring points will affect a total of 4 m^2 of hard bottom.

In deep waters (greater than 30 m), impacts to boulder star corals, in particular for Segment 2 south of St. John, will be unavoidable. The mesophotic survey for the viNGN cable segments (TetraTech 2013a) found that Segment 2A cable installation will directly affect 0.588 m^2 of boulder star corals. As stated above, we used this number and an average colony size for bounder star corals to estimate the number of colonies to which this equates. For Segment 2A, we estimate that up to 1 boulder star coral colony will be directly affected by the cable route. For Segment 2, the cable installation will directly affect 931.5 m^2 of boulder star corals or 311 colonies. The cable will range from 14-35 mm in diameter so the extent of the impact will depend on the linear length of the cable passing over each colony, as well as the amount of movement of the cable during installation. As noted above, Alcatel-Lucent stated that due to the water depths and the weight of the cable there will be no cable movement in deep waters once installation is complete. Thus, we do not anticipate additional impacts to boulder star corals once the cable installation is complete.

In terms of deepwater habitat for boulder star corals, the PCCS cable corridors in depths over 30 m in U.S. waters will be over approximately 2,769.8 m^2 (0.68 acre) of deep reef and hard bottom based on the mesophotic survey and assuming a corridor width of 0.15 m. We believe that the placement of the cable over a 0.68-acre area will not have a measurable effect on the ability of boulder star corals to continue colonizing the shelf edge south of St. John affected by the PCCS cable installation. There are 2 factors to support our conclusion: (1) the observed extent of deep reef and hard bottom on the shelf edge of St. John (the extent of habitat and level of colonization on the shelf edge of Puerto Rico in the area of the landing was low) from the mesophotic survey, and (2) the fact that the corridor estimate used by the applicant to calculate impacts of the cable to benthic habitat is an overestimate based on the 14-35 mm actual size of the cable.

Vessel operations associated with the installation of the cable segments could affect boulder star corals due to sediment resuspension and transport by propellers, accidental groundings, and anchoring. Still, we believe these impacts will be minimal because a shallow draft cable-laying vessel will be used for the installation of Segment 2A into San Juan and temporary mooring points will be used to hold the vessel in place as it is moved along the entire shallow water route (less than 30 m). This will also prevent accidental groundings because the vessel will be held in place in areas that were already selected for their low level of coral cover. The method to be used for installation of the PCCS cable will be the same as for previous cable landings in the same area. There were no accidental grounding or sediment resuspension incidents associated with previous cable installations. Anchoring of the large cable-laying vessel will not be done in deepwater sections. In these areas, the vessel will be in constant slow-speed motion while the cable is laid out, sinking to the sea floor along the planned route, which will be followed using the on-board navigation system.

6.2 Effects of the Actions on Elkhorn and Staghorn Critical Habitat

viNGN

Based on the benthic surveys and information provided by the applicant, the installation of Segment 3 will impact 9 m^2 (0.002 acre) of elkhorn and staghorn coral critical habitat. No other hard bottom areas that will be impacted by the cable installation were found to have the essential element of elkhorn and staghorn coral critical habitat. The impact will be from the installation of articulated pipe in shallow water areas to prevent movement of the cable following installation during storms. The use of articulated pipe will protect adjacent elkhorn and staghorn coral critical habitat from abrasion. Monitoring of past cable projects have also found that corals colonize articulated pipe segments.

PCCS

Based on the benthic survey for Segment 2A, which is the only segment of the PCCS cable system in shallow waters for the U.S. cable segments of the system, the installation will permanently impact 25.54 m^2 (0.006 acre) of elkhorn and staghorn coral critical habitat. The other hard bottom areas that will be impacted by the cable installation do not have the essential feature of elkhorn and staghorn coral critical habitat due to high sediment loading and/or algal cover. The impact will be due to the installation of articulated pipe segments and clamps to anchor the cable in place and prevent movement following installation, as well as from double-armored cable lying directly over the substrate in some areas where cable anchoring is not needed. The anchoring of the cable to hard substrate will ensure that adjacent elkhorn and staghorn critical habitat areas are protected from abrasion. Up to 928.7 m^2 (0.23 acre) of elkhorn and staghorn coral critical habitat could be temporarily affected by the installation of this cable segment. This is based on a 1-m corridor to either side of the cable and includes the impacts of the use of sandbag anchors to serve as temporary mooring points for the shallow draft cable-laying vessel. This is likely an overestimate of potential impacts but was calculated by the applicant in case there is a need to shift the cable route slightly during installation and to account for any relocation of sessile benthic invertebrates that may be necessary along the cable route because this will result in habitat disturbance. The hard bottom habitat where the cable route is proposed is a historic cable landing site with several other cable segments already present.

6.3 Summary of the Effects of the Actions on ESA-Listed Corals and ESA-Designated Acroporid Coral Critical Habitat

viNGN

The installation of the deepwater segments of the viNGN cable system will impact up to 14 boulder star coral colonies due to the installation of the cable directly over these colonies. We do not anticipate that this effect will be lethal as corals can continue to grow around the cable. Additionally, Alcatel-Lucent noted that the cable does not move in deepwater segments due to its weight.

The installation of the shallow portions of the viNGN cable system will affect 9 m^2 of elkhorn and staghorn coral critical habitat as the installation of articulated pipe will anchor the cable in place over a shallow hard bottom area for Segment 3 only.

NMFS anticipates the following incidental takes may occur as a result of the viNGN cable installation:

- nonlethal: 14 boulder star coral colonies due to placement of the deepwater (greater than 30 m) portions of Segments 1 and 2 off the east (up to 1 colony of the 14) and west (13 colonies of the 14) coasts of St. Thomas directly over these colonies

PCCS

The installation of the deepwater segments of the PCCS cable system will impact up to 312 boulder star coral colonies due to the installation of the cable directly over these colonies. We do not anticipate this effect will be lethal.

The installation of Segment 2A in shallow waters (less than 30 m) to the San Juan landing point will affect 25.54 m^2 of elkhorn and staghorn coral critical habitat permanently due to the installation of double-armored cable and articulated pipe segments along this route. The applicant also estimates that up to 928.7 m^2 of elkhorn and staghorn coral critical habitat could be affected temporarily during cable installation operation. The applicant calculated potential temporary impacts based on a 1-m corridor to either side of the cable in case there is a need to shift the cable route slightly during installation, to account for any relocation of sessile benthic invertebrates (of which none will be ESA-listed corals) along the cable route because this will result in habitat disturbance, and due to the placement of temporary sand bag anchors (2 of the 25 temporary mooring locations are in acroporid coral critical habitat).

NMFS anticipates the following incidental takes may occur as a result of the PCCS cable installation:

- nonlethal: 312 boulder star coral colonies due to placement of the deepwater (greater than 30 m) portions of Segment 2A (up to 1 colony) and Segment 2 (311 colonies) directly over these colonies

7 Cumulative Effects

Cumulative effects include the effects of future state, tribal, or local private actions that are reasonably certain to occur in the action area considered in this Opinion. We do not consider future federal actions that are unrelated to the proposed action in this section because they require separate consultation pursuant to Section 7 of the ESA.

Cumulative effects from unrelated, non-federal actions occurring within the action area for each project may affect boulder star corals and elkhorn and staghorn coral critical habitat. Activities affecting ESA-listed corals and coral critical habitat are highly regulated federally; therefore, any future activities within the action area will likely require ESA Section 7 consultation. Much of the development occurring around USVI and Puerto Rico that has been shown to affect water quality, in particular through increases in sedimentation rates, does not require federal authorization. Upland development often has no federal nexus if the project is located on uplands and is small in size. Depending on the number and location of these developments, sediment and nutrient loading to near shore waters could become a chronic stressor.

The fisheries occurring within the action area are expected to continue into the foreseeable future. NMFS is not aware of any proposed or anticipated changes in these fisheries that would substantially change the impacts each fishery has on the ESA-listed corals and coral critical habitat covered by this Opinion.

In addition to fisheries, NMFS is not aware of any proposed or anticipated changes in other human-related actions (e.g., collection, habitat degradation) or natural conditions (e.g., over-abundance of predators, changes in oceanic conditions) that would substantially change the impacts that each threat has on the ESA-listed corals and coral critical habitat covered by this Opinion. Therefore, NMFS expects that the levels of interactions with ESA-listed corals and coral critical habitat described for each of the fisheries and non-fisheries will continue at similar levels into the foreseeable future.

8 Jeopardy Analysis

This section considers the likelihood that the proposed action will jeopardize the continued existence of boulder star corals in the wild. To *jeopardize the continued existence of* is defined as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). The Effects of the Action section (Section 6.0) describes the effects resulting from the proposed action on boulder star corals and elkhorn and staghorn coral designated critical habitat. Sections

5.0 and 7.0 inform the context of these effects by considering the environmental baseline and cumulative effects relevant to the action area of the proposed project. The following jeopardy analysis first considers the effects of the action to determine if we would reasonably expect the action to result in reductions in reproduction, numbers, or distribution of ESA-listed corals. The analysis next considers whether any such reduction would in turn result in an appreciable reduction in the likelihood of survival and recovery of boulder star corals in the wild.

Boulder Star Corals

The proposed action will not affect the species' current geographic range. Although portions of the cable will lay over boulder star colonies in deep waters (greater than 30 m), the cable measures 14-35 mm in width and will affect up to 14 colonies in the case of the viNGN project and up to 312 colonies in the case of the PCCS project. The majority of these impacts (311 colonies) will be off the south coast of St. John where the density of coverage was found to be almost 40%. Other surveys sponsored by the CFMC for the MCD have also found dense colonization by this and other hard corals. Most of the viNGN Segments 1 and 2 areas surveyed during the mesophotic surveys found less than 10% coral cover on deep reefs and hard bottoms off St. Thomas and St. Croix. The area on the Puerto Rico shelf off San Juan was also found to have very low coral coverage in general, including of boulder star coral. We do not anticipate that the cable lying on corals will result in the mortality of these colonies, although some breakage and abrasion could occur that could also lead to tissue death or disease. Thus we do not anticipate changes in the populations of these coral species or effects to their distribution in the portions of Puerto Rico, USVI, and EEZ waters where the viNGN and PCCS cable segments will be located or in the wider Caribbean as a result of the proposed action.

We cannot estimate the total numbers of colonies of boulder star corals in the action area for the viNGN and PCCS cable projects as there are very few mesophotic reef surveys for the area. Based on information from the mesophotic surveys, within the viNGN Segment 1 deepwater corridor, deep reef and colonized hard bottom habitats had levels of coral cover ranging from 0.53-24.31%, with boulder star coral contributing between 0.53% and 23.69%, respectively (TetraTech 2013b). Within the viNGN Segment 2 deepwater corridor, deep reef and colonized hard bottom habitats had levels of coral cover ranging from 0.18-2.4%, with boulder star coral contributing between 0.18% and 1.12%, respectively (TetraTech 2013b). In the deepwater portion of Segment 1, the cable will lay over 13 colonies and Segment 2 over up to 1 colony. Within the PCCS Segment 2A deepwater corridor off San Juan, only colonized hard bottom habitat had hard corals. Coral cover was 0.9% on this habitat with 0.5% being boulder star coral (TetraTech 2013a). This segment will affect up to 1 colony of boulder star coral due to cable installation over the colony. Within the PCCS Segment 2 deepwater corridor between USVI and BVI, deep reef and colonized hard bottom habitats had levels of coral cover ranging from 1.82%-36.8%, with boulder star coral contributing between 0.36% and 35.6%, respectively (TetraTech 2013a). This segment will affect 311 colonies of boulder star coral due to installation of the cable over the colonies. We do not anticipate that the cable's laying over colonies of boulder star coral will be lethal. Thus we believe that the viNGN and PCCS cable projects will not result in a reduction in numbers of boulder star coral because of the low number of colonies that will be affected by the cable installation and because we do not anticipate lethal effects.

We do not have exact population estimates for boulder star corals. Throughout the USVI, reefs dominated by *Orbicella* spp. suffered 70%-95% mortality following the 2005 mass bleaching (Woody et al. 2008). Similarly, between monitoring surveys of different sites around Puerto Rico in 2005 and 2006, live coral cover was found to have declined up to 56%, driven in almost all cases by the mortality of the *Orbicella* spp. complex (Garcia-Sais et al. 2008). As stated above, we do not believe there will be a population change in the action area of both projects for boulder star corals, so the survival of these corals in the wild will not be affected by the proposed action. Similarly, although we are not able to estimate the number of sexually mature individuals of boulder star corals from the information in the mesophotic surveys completed for the viNGN and PCCS cable projects and because we do not anticipate a reduction in numbers of these corals as a result of the proposed action, we reached an important conclusion. We do not believe the installation of the viNGN and PCCS cable systems will result in a decrease in the availability of reproductive individuals or will affect overall reproduction by these corals within the action area for the cable projects. Because we find that the projects will not result in a reduction in numbers, reproduction or distribution of boulder star corals, we conclude the projects will not result in an appreciable reduction of the likelihood of survival of the species in the wild.

Further, as discussed above and in Section 6.1, up to 14 boulder star coral colonies will be affected by the installation of Segments 1 and 2 of the viNGN cable and up to 312 boulder star coral colonies will be affected by the installation of Segments 2A and 2 of the PCCS cable. Impacts to the rest of the boulder star corals in the action area (for which an estimate is not available but, based on information from the mesophotic reef surveys done for this project as well as from CFMC surveys of the MCD and NOS surveys of areas in USVI, are numerous in deep waters on certain portions of the shelf edge of St. Thomas and St. John in particular) are not expected to occur as a result of the installation of the viNGN and PCCS cable systems. The proposed viNGN and PCCS cable installations are not expected to result in the permanent loss of whole colonies or of reproductive individuals or to affect ecosystem function. Therefore, we believe that the installation of the viNGN and PCCS cable systems will not appreciably reduce the likelihood of recovery of boulder star corals in the wild.

In conclusion, NMFS has determined that the anticipated level of nonlethal incidental take of boulder star corals, discussed above and in Section 6, Effects of the Action, is not likely to jeopardize their continued existence. Exceeding the estimated take will trigger the need for reinitiation of ESA consultation with NMFS: Reinitiation is not triggered because this anticipated level of nonlethal take is exceeded (there are as yet no Section 4(d) prohibitions in place for boulder star coral), but rather because "new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered."

9 Analysis of Destruction or Adverse Modification of Designated Critical Habitat for Elkhorn and Staghorn Corals

When determining the potential impacts to critical habitat, this Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR

402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

Ultimately, we seek to determine if, with the implementation of the proposed action, critical habitat would remain functional (or retain the current ability for the essential features to be functionally established) to serve the intended conservation role for the species. This analysis takes into account the geographic and temporal scope of the proposed action, recognizing that "functionality" of critical habitat necessarily means that it must now and must continue in the future to support the conservation of the species and progress toward recovery. Thus the analysis must take into account any changes in amount, distribution, or characteristics of the critical habitat that will be required over time to support a successfully recovering species.

Elkhorn and Staghorn Coral Critical Habitat
Critical habitat was designated for elkhorn and staghorn corals, in part, because further declines in the low population sizes of the species could lead to threshold levels that make the chances for recovery low. More specifically, low population sizes for these species could lead to an Allee effect[3] and lower effective density (of genetically distinct adults required for sexual reproduction), and a reduced source of fragments for asexual reproduction and recruitment. Therefore, the key conservation objective of designated critical habitat is to facilitate increased incidence of successful sexual and asexual reproduction, which in turn facilitates increases in the species' abundances, distributions, and genetic diversity. To this end, our analysis of whether the proposed action is likely to destroy or adversely modify designated critical habitat seeks to determine if the adverse effects of the proposed action on the essential feature of designated *Acropora* critical habitat will appreciably reduce the capability of the critical habitat to facilitate an increased incidence of successful sexual and asexual reproduction. This analysis takes into account the status of the species during the installation of the viNGN and PCCS cable systems. The level of increased incidence of successful reproduction needs to be facilitated by availability of the essential feature and may differ depending on the recovery status of elkhorn and staghorn corals in the action area for each cable project. This analysis also takes into account the geographic and temporal scope of the actions.

The only 2 areas of permanent impacts to elkhorn and staghorn coral critical habitat will be 9 m^2 for Segment 3 of the viNGN cable system (where articulated pipe will be installed to hold the cable in place), and 25.52 m^2 for Segment 2A of the PCCS cable system (where the double-armored cable will lay directly over hard bottom or articulated pipe will be installed over the cable to prevent it from moving). The PCCS cable installation may also affect up to 928.7 m^2 of elkhorn and staghorn coral critical habitat temporarily during the installation, but this is likely an overestimate on the part of the applicant as it assumes a 1-m-wide corridor to either side of the cable. The applicant calculated potential temporary impacts based on a 1-m corridor to either side of the cable in case there is a need to shift the cable route slightly during installation, to account for any relocation of sessile benthic invertebrates (of which none will be ESA-listed corals) along the cable route because this will result in habitat disturbance, and due to the placement of temporary sand bag anchors (2 of the 25 temporary mooring locations are in

[3] The Allee effect is the effect of population density on population growth by which reproductive rates fall at very low population densities and reproduction and survival of individuals increase as population density increases.

acroporid coral critical habitat). Benthic surveys and previous monitoring reports from other submarine cable projects indicate that hard and soft corals often colonize the cables and articulated pipe segments over time such that distinguishing the cable corridor becomes difficult. The hard bottom areas that will be affected by the PCCS Segment 2A installation are within a historic cable landing with several other cable segments already present. Portions of the viNGN cable system, including Segment 4 and the landing site in Great Bay are also located in areas where other cable segments and landings are present.

As noted in the critical habitat rule (73 FR 72210, November 26, 2008), the loss of suitable habitat is one of the greatest threats to the recovery of listed coral populations. The loss of suitable habitat affects the reproductive success of listed corals because substrate for sexual recruits to settle is lost. Nevertheless, NMFS does not believe the installation of the viNGN and PCCS cable systems will permanently alter the suitability or habitat quality of elkhorn and staghorn coral critical habitat in the action area. As noted above, the key objective for the conservation and recovery of listed coral species is the facilitation of an increase in the incidence of sexual and asexual reproduction. Recovery cannot occur without protecting the essential feature of critical habitat from destruction or adverse modification because the quality and quantity of suitable substrate for listed corals affects their reproductive success. Approximately 292 mi^2 are likely to contain the essential element of ESA-designated elkhorn and staghorn coral critical habitat within the Puerto Rico unit, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOAA's National Ocean Service (NOS) Biogeography Program in 2000 (Kendall et al. 2001). Approximately 26 mi^2 are likely to contain the essential element of ESA-designated elkhorn and staghorn coral critical habitat within the St. Thomas/St. John marine unit, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001). Approximately 90 mi^2 are likely to contain the essential element of ESA-designated elkhorn and staghorn coral critical habitat within the St. Croix marine unit, based on the amount of coral, rock reef, colonized hard bottom, and other coralline communities mapped by NOS in 2000 (Kendall et al. 2001).

Given the very small size of the impact corridor for each cable system compared to the area containing elkhorn and staghorn coral critical habitat within the action area for the viNGN and PCCS cable projects, NMFS does not anticipate that any of the action area containing the essential feature will cease to function as adequate substrate for settlement of listed coral larvae, reattachment of listed coral fragments, and growth of listed coral colonies. Therefore, NMFS does not believe the installation of the viNGN and PCCS cable systems will have an appreciable impact on the ability of elkhorn and staghorn coral critical habitat in the Puerto Rico, St. Thomas/St. John, and St. Croix units to provide for the conservation of these acroporid corals.

10 Conclusion

NMFS has analyzed the best available data, the current status of the species, environmental baseline, effects of the proposed action, and cumulative effects to determine whether the proposed action is likely to jeopardize the continued existence of boulder star corals or result in the destruction or adverse modification of critical habitat for elkhorn and staghorn corals. It is our Opinion that the installation of the viNGN and PCCS cable systems is not likely to jeopardize the continued existence of *Orbicella franksi*, and is not likely to result in the destruction or adverse modification of designated critical habitat for *Acropora palmata* and *A. cervicornis* corals.

11 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans, or to develop information.

We believe the following conservation recommendations further the conservation of ESA-listed sea turtles, corals, and staghorn and elkhorn coral designated critical habitat. We strongly recommend consideration and adoption of these measures. In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, we request notification of the implementation of any conservation recommendations.

1. We recommend that the USACE include the mesophotic survey protocol used for the viNGN and PCCS cable projects as an application requirement for all submarine cable projects with proposed routes within Territorial, Commonwealth, and EEZ waters. We also recommend that reporting requirements be established in coordination with NMFS to ensure that data collected by the surveys can be used to assess impacts on ESA-listed corals that occur in deep waters (greater than 30 m) and to ensure that the routes are developed to minimize potential impacts to ESA-listed corals.

2. We recommend that the USACE prepare a report of all permitted and proposed submarine cable and utility corridor projects in the range of ESA-corals to assess cumulative impacts of these projects on these coral species and to develop recommended corridors to concentrate impacts in the same areas for similar projects.

3. We recommend that the avoidance and minimization measures developed by Alcatel-Lucent for the viNGN (Section 2.1) and PCCS (Section 2.2) cable systems be included as special conditions of any permit to be issued by the USACE.

4. We recommend that NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* (2006) and NMFS's *Vessel Strike Avoidance Measures and Injured or Dead Protected Species Reporting* (2008) be included in the design of projects requiring the installation of in-water structures or other in-water or shoreline construction activities, as appropriate, in order to minimize the potential impacts to all ESA-listed sea turtle species during construction and operation of project components.

5. Provide NMFS Southeast Region PRD with copies of all monitoring reports completed for the viNGN and PCCS submarine cable projects.

12 Reinitiation of Consultation

As provided in 50 CFR Section 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the Biological Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

Because take of boulder star coral is not prohibited at this time due to its listing as threatened without the promulgation of a 4(d) rule establishing take prohibitions, in instances where the amount or extent of incidental take is exceeded, project activities may continue. If a 4(d) rule is promulgated prior to the installation of the cables or while installation is underway, if the amount or extent of incidental take is exceeded, project activities may only continue if the USACE establishes that such continuation will not violate Sections 7(a)(2) and 7(d) of the ESA.

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JOINT PERMIT APPLICATION
for the
BRUSA Cable System

Exhibit 7:

Marine Archaeological Baseline Conditions

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Attachment A
Memorandum: Underwater Archaeological Study Review and Recommendations for the BRUSA Submarine Cable System, 2016

Memorandum

Environmental
Resources
Management

1776 Street Northwest
Suite 200
Washington, DC 20...
(202) 466-9090
(202) 466-9191 (fax)

To:	Jamie Merrett, Alcatel-Lucent Submarine Networks
From:	Benjamin Siegel, M.A., R.P.A.
cc:	Denise Toombs, Kara Lagerloef
Date:	27 May 2016
Subject:	Underwater Archaeological Study Review and Recommendations for the BRUSA Submarine Cable System

Background

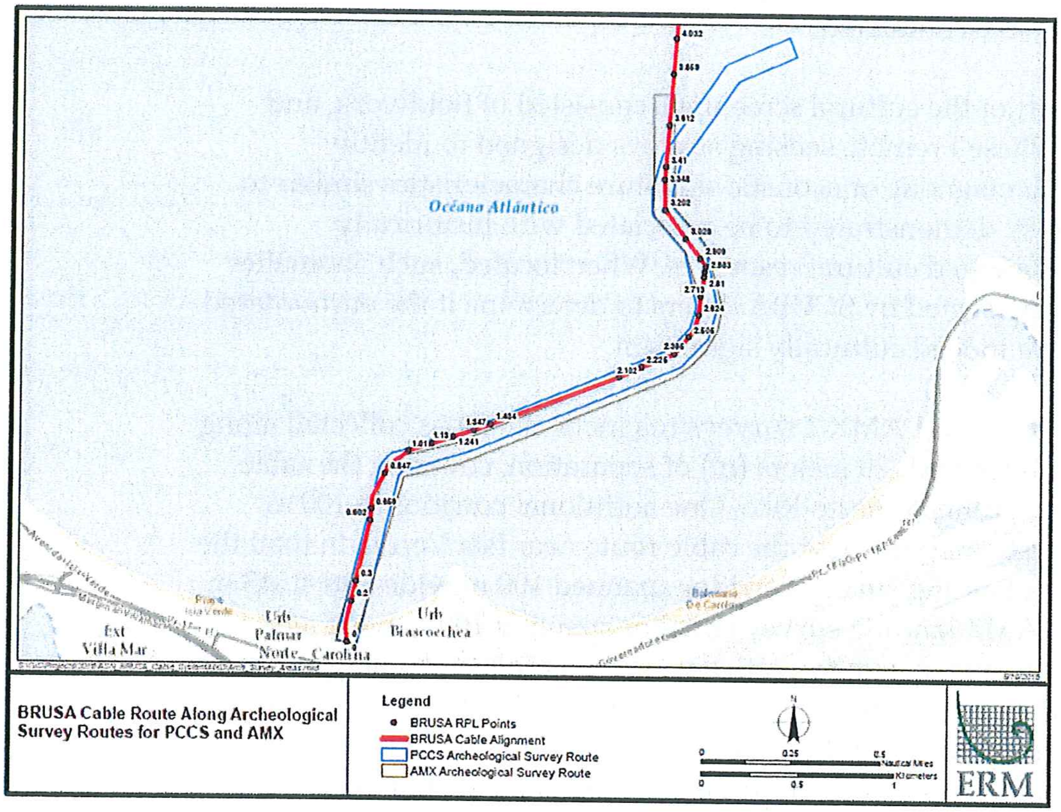
Alcatel-Lucent Submarine Networks (ASN) has been contracted by the BRUSA owners (Telefonica International Wholesale Services, TIWS) to design, engineer, manufacture, and install the 11,300 kilometer (km) BRUSA submarine cable system, which will land in Puerto Rico, as well as Virginia and Brazil. The segment of the BRUSA system connecting to Puerto Rico is proposed to land in the metropolitan area of San Juan at the site known as Tartak Street end beach area. The marine system will end at the beach manhole (BMH) located at 18°26.6075N and 66°01.2795W and connect to an existing terrestrial network.

In anticipation of the federal and local approvals required for the Puerto Rico segment of this project, ERM Marine Archaeologist, Benjamin Siegel, M.A., R.P.A., examined the BRUSA submarine cable system's nearshore route to determine what, if any, baseline studies would be required to comply with the regulatory guidelines set forth by Puerto Rico's State Historic Preservation Office (SHPO), the Instituto de Cultura de Puerto Rico, and the Consejo de Arquelogia Subacuática.

BRUSA Proximity to Recently-Installed Systems

The BRUSA cable route closely mirrors the nearshore routes of both the Pacific Caribbean Cable System (PCCS) submarine fiber optic cable system installed in April and May of 2015, and the American Movil Submarine Cable System-1 (AMX-1) submarine fiber optic cable system installed in 2013. Based on review of the PCCS and AMX-1 reports, the BRUSA route is in close proximity to both the PCCS and AMX-1 routes from the shoreline to 3.3 km (1.8 nautical miles) off the coast, and the baseline conditions would be essentially the same. See Figure 1.

Figure 1: Comparison of the Proposed BRUSA Nearshore Route and the Archaeological Survey Areas investigated for the PCCS and AMX-1 Fiber Optic Cables



Because the PCCS and AMX-1 routes are so close to the proposed BRUSA route, ERM reviewed the baseline archaeological surveys conducted for the previous systems to determine whether the findings would be applicable to the proposed BRUSA system.

Findings of Past Surveys and Installation Monitoring

Underwater archaeological investigations were conducted for both the PCCS and AMX-1 cable projects, and were accepted by the Instituto de Cultura Puertorriqueña and the Consejo de Arquelogia Subacuática. Both studies were conducted by Dr. Richard Fontánez Aldea. (Aldea 2014, 2015)

Both studies consisted of a two-part cultural screening. The first part of each study included an archival, cartographic, and technical report investigation to discern the location of previously documented submerged cultural resources in the vicinity of the proposed project. For both projects these desktop efforts identified three archaeological sites off the coast of Isla Verde. As a result of the number of archaeological sites and sensitive areas identified during these background research efforts, a second phase of the studies were conducted.

The second part of the cultural screenings consisted of fieldwork, and incorporated Phase I remote sensing surveys designed to identify anomalies with magnetic or acoustic signature characteristics similar to those previously demonstrated to be associated with historically significant submerged cultural resources. When located, such anomalies were visually inspected by SCUBA divers to determine if the encountered anomalies were indeed culturally significant.

For both the PCCS and AMX-1 surveys magnetic data was collected along five transects, each with 20 meters (m) of separation, covering the cable corridor near Carolina, Puerto Rico. One additional corridor of 100 m wide was investigated to cover the cable route near Isla Verde. In total the PCCS Carolina landing survey corridor spanned 100 m wide and 4,543 m long, and the AMX landing survey corridor spanned 100 m wide and 4,000 m long. Acoustic data for both surveys was collected using a range scale of 20 m to provide over 100% coverage and high target signature definition. During these studies, identified anomalies were analyzed based on anomaly intensity, duration, areal extent, and signature characteristics, and then classified as low, moderate, or high priority targets. Magnetometer targets and Side Scan Sonar targets of moderate or high priority were visually examined by divers who conducted 60 m circle searches around the location of the anomaly to search for cultural materials. Neither of the Phase I remote sensing surveys for the PCCS and AMX-1 revealed any cultural resources or culturally sensitive areas. However, Dr. Richard Fontánez Aldea concluded his cultural reports for both the PCCS and AMX-1 with recommendations that installation efforts for the two projects be monitored by a qualified underwater archaeologist to ensure that no previously undetected resources were encountered during construction.

The archaeological monitoring for the PCCS the AMX-1 systems took place between April 12 and June 18, 2015, and April and May 2014 respectively. Both monitoring efforts consisted of the visual inspection and documentation of any cultural resources in the cable route that could be impacted during the installation of the new cable segment from 100 ft water depth to the shore. Monitoring divers were directed to observe the cable laying, as well as any of the activities associated with the cable laying including: excavations required to place sand bag anchors, the deployment of sand bag anchors, the securing of the cable, and all required beach excavation efforts.

No sensitive archaeological resources were found along the cable routes during either the PCCS or AMX-1 installation processes. However, during the PCCS installation an isolated anchor classified as an admiralty type from the second half of the 19^{th} century to the first half of the 20th century was found by monitors at coordinates 18°27.945N and 66°00.321W , and a similar admiralty type anchor was found during the AMX-1 installation at coordinates 18°27.969N and 66°00.405W. Upon inspecting these two anchors, monitors found that neither anchor had associated debris, and that they were both isolated finds. Though both anchors laid outside of their respective cable corridors, four steel clamps were installed on segments of the PCCS and AMX-1 cables that ran closest to the anchors to ensure that no unexpected cable movements would jeopardize the safety of the newly discovered anchors.

Recommendations

Based on the review of prior surveys in the area, which included comprehensive investigation of the project area using magnetometer, side scan sonar, and SCUBA diving, and which found no archaeological resources, ERM concludes that the previous investigations provide adequate data to characterize baseline conditions in the project area. In addition, the two recent installations in the project area were conducted with archaeological monitoring teams and yielded no findings of archaeological resources that would be negatively impacted by the installation of cables. The combination of past baseline surveys and monitoring efforts provide sufficient information on the project area, which is heavily used for recreation and has been highly disturbed. Therefore, ERM recommends using the existing information to characterize the project area and does not believe additional field surveys are warranted for the BRUSA nearshore route.

Because there is a potential for archaeological resources to be present in the project area, ERM recommends having an archaeological monitor present during installation, consistent with prior installations.

Sincerely,

Benjamin D. Siegel, M.A., R.P.A.

Project Archaeologist & Cultural Heritage Consultant

References

Aldea, Dr. Richard Fontanez

2015 Underwater Archaeological Monitoring Report, for the PCCS Submarine Cable Carolina, Puerto Rico

2014 Underwater Archaeological Monitoring Report, for the AMX-1 Submarine Cable Project in San Juan and Carolina, Puerto Rico, REM Company

2013 Underwater Archaeological Phase 1-A, 1-B PCCS Submarine Fiber Optic Cable System, Isla Verde, Carolina, Puerto Rico, for the REM Company

2011 Underwater Archaeological Phase 1-A, 1-B San Juan Puerto Rico, for the REM Company

Attachment B
Underwater Archaeological Phase 1-A, 1-B PCCS Submarine Fiber Optic Cable System, Isla Verde, Carolina, Puerto Rico, for the REM Company, 2013

Underwater Archaeological Phase 1-A 1-B
PCCS Submarine Fiber Optic Cable System
Isla Verde, Carolina, Puerto Rico
REM Company

Executive Summary

This report records the archaeological research of Phase 1-A, 1-B under the standards of Site Historic Preservation Office, Instituto de Cultura Puertorriqueña and Consejo de Arqueología Subacuática, cultural Agencies of Puerto Rico's government. The work performed during May to June 2013 in connection with the planning of fiber optic cable PCCS landing in Puerto Rico north coast, Isla Verde beach in Carolina town.

Phase 1-A

Phase 1-A is a historical research with the intention to establish the archaeological potential on the vicinity of Isla Verde as well to perform a evaluation of the risk of impact over cultural resource in this location. The revision of archeological inventories and technical reports point to the high potential for underwater cultural resources in the reef of Isla Verde. Archives point to long history of seafearing with reference of over 100 wrecks in waters of San Juan. Previous underwater archaeological research discovered 4 archaeological sites and one ancient shore line in Condado and 3 archaeological sites in Isla Verde.

The proposed landing sites are located within a high potential area for submerged cultural resources of Isla Verde shore. Our Phase 1-A conclusion is supported by archive information as well for previous on site research. Activities related

to cable landing have high risk to impact archaeological material. After Phase 1-A findings archaeological Phase 1-B was granted.

Phase 1-B

Phase 1–B investigation was performed between May 26 to May 31, 2013. The work consisted of field research with remote sensing and visual inspection to cleared the occurrence of underwater archaeological resources within the landing sites in Isla Verde, Carolina. Test pits was planning close to Carolina's shore to ruled out impact over aboriginal site located by previous research in Punta del Medio but rocky bottom impeded the excavation. A visual inspection transect with hand fanning replace test pits.

Magnetometer produced 4 targets with archaeological potential. Sonar detected 2 acoustic target. None of the targets belong of submerged archaeological resources. Visual inspection by divers confirmed no submerged archaeological resource related with the magnetic or acoustic signature as well test pits transect close to Punta del Medio.

In conclusion the Phase 1-B showed that no archaeological resources were identified within the corridor in Carolina.

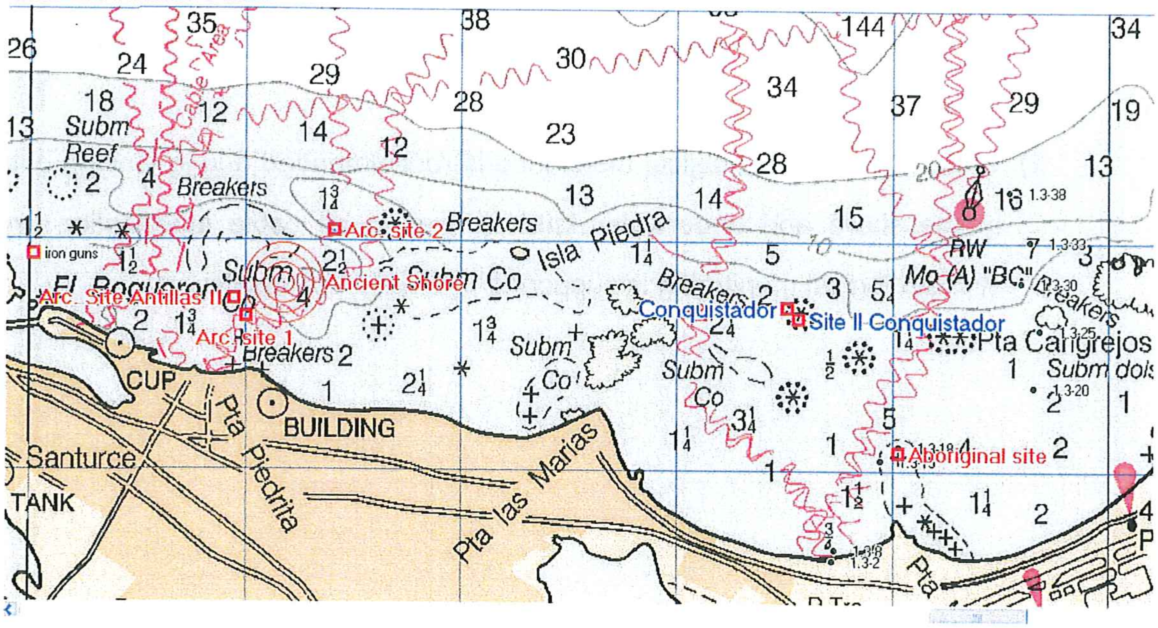
Dr. Richard Fontánez
Underwater Archeologist Maritime Historian
Haciendas El Molino 106, Calle Zaragoza
Vega Alta, PR. 00692-8709. Phone 787233 9447
e-mail fontanezr@me.com

Recommendations

1) Proceed with cable landing operation with condition to perform archaeological monitoring.
2) Underwater archaeological monitoring is recommended during landing operation in the shore and underwater land as well in all cable stabilization process. Archaeological monitoring is supported by Phase 1-A results

Description of Archaeological Sites discovered in previous researches in San Juan and Carolina Shore

Site Location Plan



-Archaeological site found by Jesús Vega during the Antillas II submarine cable installation in 1999. It consists of a submerged prehistoric midden dated from 3,000-4,000 B.P. The site was exposed by a prop-wash event by cable-ship during landing. The site is located close to the shore at 22 feet depth in the coordinates latitude N18°27.7407' longitud W66°04.0561' at 3 miles west of Isla Verde corridor.

-Archaeological site #1. It was found during the archaeological study for the GCN submarine cable in 2005 by Fontánez-Aldea. Probable fragment of a XIX century steamer located at coordinates latitude N18°27.6669' longitud W66°04.0013'. Distance to corridor 3 miles west.

-Archaeological site #2 It was found during the archaeological study for the GCN submarine cable in 2005 by Fontánez-Aldea. Boat davits and other pieces of a XIX ship. Coordinates latitude N18°28.0399' longitud W66°03.5883'. Distance to corridor 3 miles west.

-British cannons in Escambrón shore, Condado, San Juan. Describe in 2008 during underwater archaeological survey, Instituto de Investigaciones Costaneras and Texas A&M University by Castro and Fontánez-Aldea. Distance to corridor 4 miles west. Coordinates latitude N18°27.9351' longitud W66°04.9812'

-Ancient shore. Found during the GCN landing in 2005 by Fontánez-Aldea. Initially evaluated as probably wooden structure, further investigation verified the presence of compacted sediment with land wood's fragments. No archaeological material associated with this finding however the presence of an ancient coast point ahead the high potential for submerged cultural evidence of pre-agricultural groups. It is supported by the archaeological site found during the Antillas II installation. Coordinates latitude N18°27.8099' longitud W66°03.8223, Distance to corridor 3 miles west. Broad area.

-Historic wreck SS *Conquistador* sunk in 1892. Spanish steamer wreck in Isla Verde reef. Found in 2006 during an archeological evaluation for the artificial reef installation project, Carolina's municipal government by Fontánez-Aldea. Located at latitude N18°27.7070' longitud W66°01.4920'. Distance to corridor 400 meters or less to west. Site disperse in a broad area with debris zone of over 1000 meters to East South-East.

-Archaeological wreck from XIX century, part of the salvage cargo operation during *Conquistador* grounded. Found in 2006 by Fontánez-Aldea during an archeological evaluation for the artificial reef installation project, Carolina's municipal government. Distance to corridor 1181 north west. Site disperse in a broad area. Coordinates latitude N18°27.6580' longitud W66°01.4430'

-Archeological site Punta del Medio, Isla Verde reef. A pre-taíno aboriginal site number KA5 in the Site Historic Preservation Office inventory found by Vega in 1988. Distance to corridor 95 meters south. Coordinates latitud N18°26.8557' longitud W66°00.9372'

Methodology

Crew:

Two archaeologist, two divers, one skipper

Equipment

The equipment utilized in the Phase 1-B consisted of:

Diana, a 25 ft. boat with two 150 Hp engines

Diving tanks;

Magnetometer Shark Marine Technology SDM-4000;

Digital sidescan sonar model 330/800 kHz 881 Imagenex Sportscan;

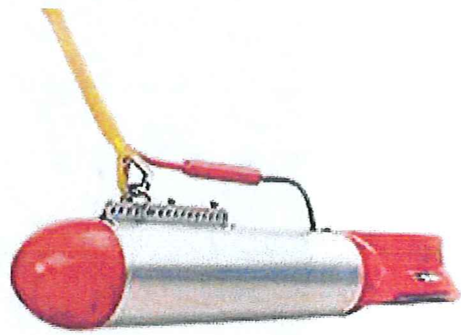
photographic cameras

Remote Sensing

Two main goals were established. "The first was to employ magnetic and acoustic remote sensing equipment to identify anomalies with signature characteristics similar to those previously demonstrated to be associated with historically significant submerged cultural resources. The second was to assess each target signature and identify those that require underwater investigation to confirm the nature and significance of the material generating the signature and those that could be dismissed as indicative of modern debris.

To accomplish those objectives, a SHARK MARINE TECHNOLOGY SDM-4000 magnetometer capable of plus or minus 1 gamma resolution was employed to collect magnetic data during the survey. Magnetic data was collected in five transect on each corridor with 20 meters of separation. One corridor of 100 meters wide were investigated in Isla Verde. Due to shoal water and reefs within the area, the magnetometer sensor was towed just below the water surface, approximately 15 meters aft of the GPS antenna at a speed of approximately 2.5 to 3.5 knots. Magnetic data were recorded as a text file with MAGPLOT data acquisition program and tied to positioning data by the computer navigation system.

Side Scan Sonar and Magnetometer



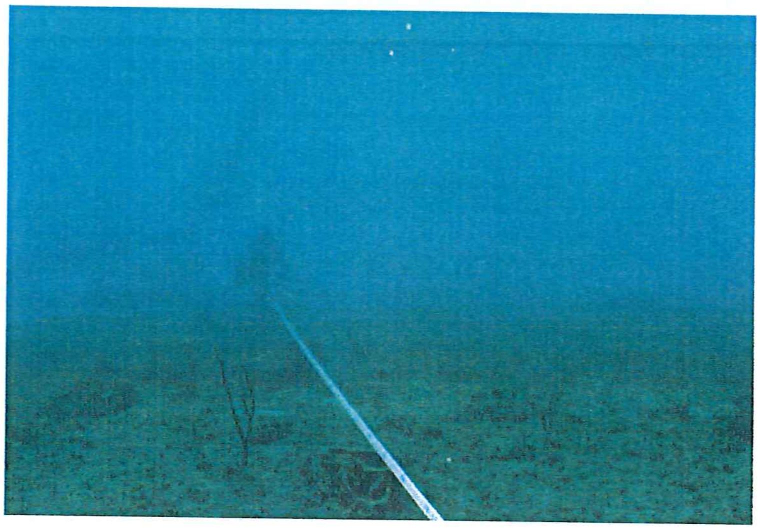
A 330/800 kHz 881 IMAGENEX Sportscan digital sidescan sonar was employed to collect acoustic data in the survey areas. Due to shoal water and reefs within San Juan and Carolina the sonar sensor was towed 1 to 1.5 meters below the water, approximately 3 meters aft of the GPS antenna at a speed of approximately 2.5 to 3.5 knots. Acoustic data were collected using a range scale of 20 meters to provide over a 100% coverage and high target signature definition. Acoustic data were recorded as a digital file with WIN881SS data acquisition program and tied to positioning data by the computer navigation system.

During the survey, positioning and lane spacing were maintained with a RAYMING Tripnav TN-204 differential system interfaced with a Toshiba Toughbook computer CF29. Navigation was controlled by Fungawi Global Navigator navigation software. This navigation system affords a positioning accuracy of plus/minus 1-5 meters. Remote sensing data were correlated to positioning by annotations recorded within the navigation program. All data were plotted to Latitude/Longitude, NAD 83"

Data was analyzed as it was generated, in order to provide information on the site assessment plan with enough anticipation to allow some dive planning. "Target signatures were isolated and assessed for characteristics that have previously been demonstrated to be indicative of submerged cultural resources. Analysis was based on factors such as anomaly intensity, duration, areal extent and signature characteristics. Each identified target was graded according to its potential association with shipwreck material and/or other submerged cultural resources. Those targets classified as moderate or high priority were selected for investigation by divers. All targets are listed and described and a map produced that shows their location within the project areas.

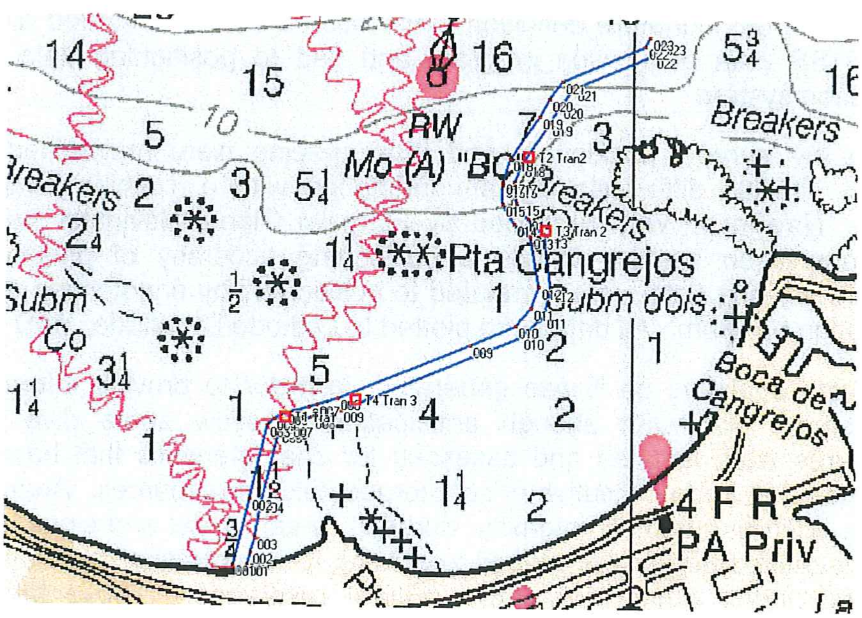
Targets confirmation was carried out with visual inspection. An area of 60 meters was investigate with diving circular pattern.

Diver performed a search in circular pattern. Magnetic target 2 area



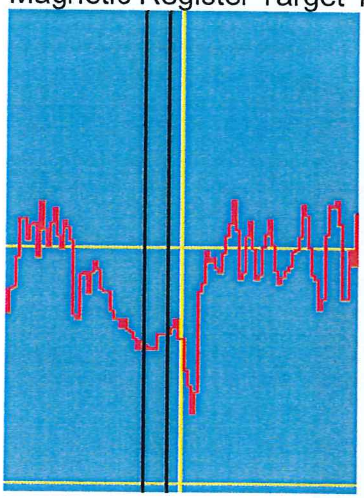
Remote Sensing and Data Analisis

Magnetic targets location, mark in red



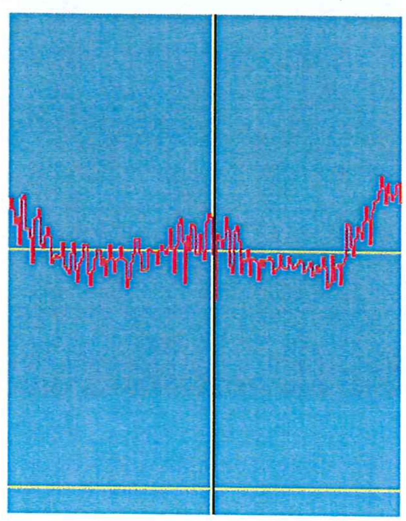
-Target 1. Located in coordinate latitude N18° 27.0942' longitude W66° 01.1328'. medium priority target with characteristic monopolar signal 5550 gamas for 70 seconds. Diving inspection revealed rocky bottom at 4.5 meters depth and a submarine metal cable crossing SW-NE. no archaeological materials found related with this target.

Magnetic Register Target 1 Photo of Metal Cable, Area of Target 1



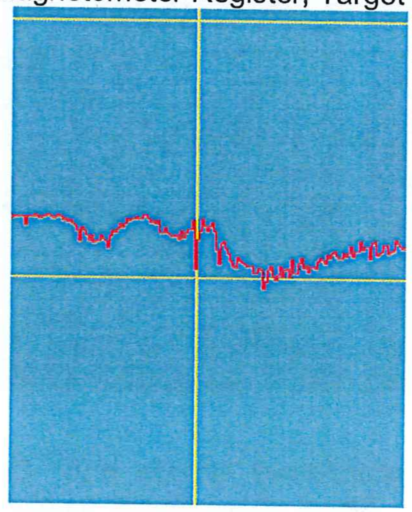
Target 2 Located in coordinates latitude N18° 27.8905' longitude W66° 00.3396'. Medium priority target. Signal characteristic bipolar, 5616 gamas with duration of 40 seconds. Diving investigation revealed rocky bottom and corals at 10.8 meters depth. No cultural evidence associated to target 2. No archaeological materials found related with this target.

Magnetometer Register, Target 2

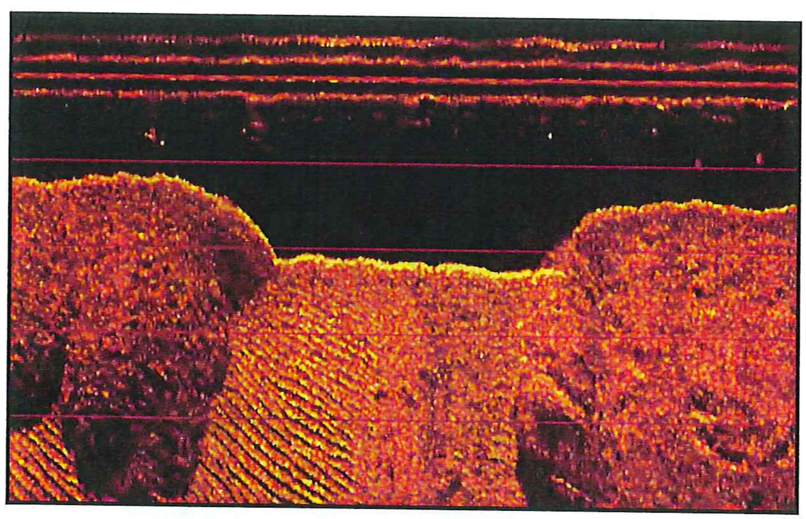


Target 3 Located in coordinates latitude N18° 26.6702' longitude W66° 00.2846'. Medium to high priority target. Signal characteristics monopolar, 5659 gammas with duration of 77 seconds. Several ferrous artifacts have been related with this magnetic signal. Diving investigation revealed a reef wall from 4.8 to 18.6 meters previously described by Fontánez-Aldea in 2006 as ancient river cannon from quaternary shore line. Modern iron-steel material could produce the magnetic signature of target 3, Outboard engine or metal cable observed during visual inspection. No archaeological materials related with target 3. Limited visibility for photos

Magnetometer Register, Target 3

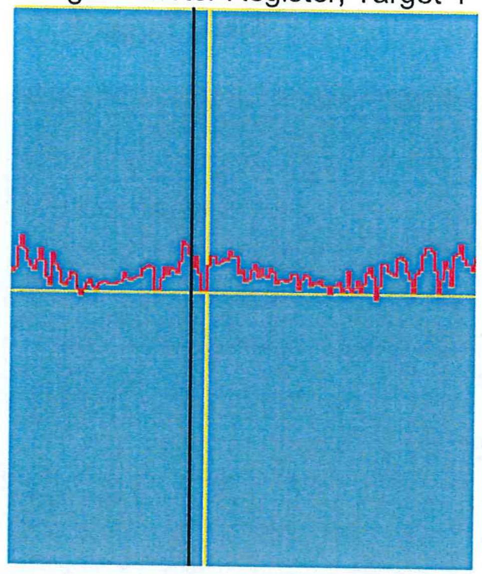


Sonar Signature Ancient River Channel, Quaternary Shore Line. (From Fontánez-Aldea 2006)

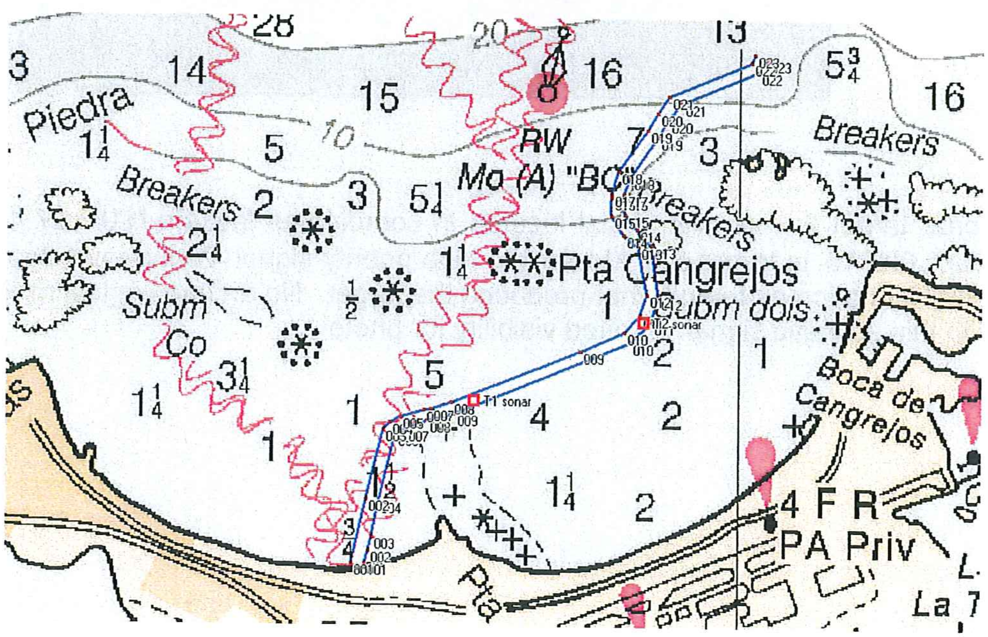


Target 4 Located in coordinates latitude N18° 27.1496' longitude W66° 00.9027'. Medium to low priority target. Signal characteristic bipolar, 5605 gamas with duration of 22 seconds. Diving investigation revealed sand and rocks bottom at 6.9 meters depth. No cultural evidence associated to target 2. No archaeological materials found related with this target.

Magnetometer Register, Target 4

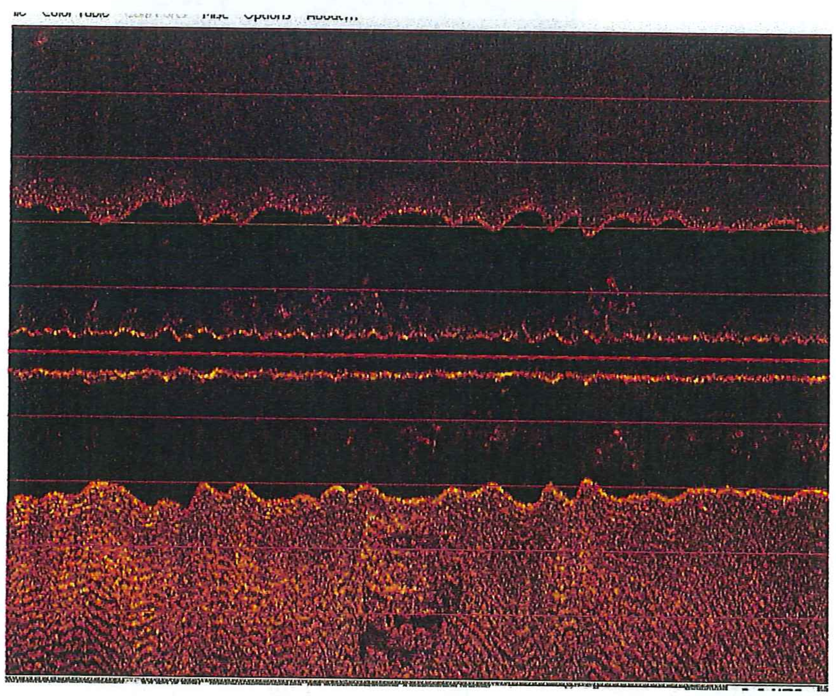


Sonar Targets Location, mark in red



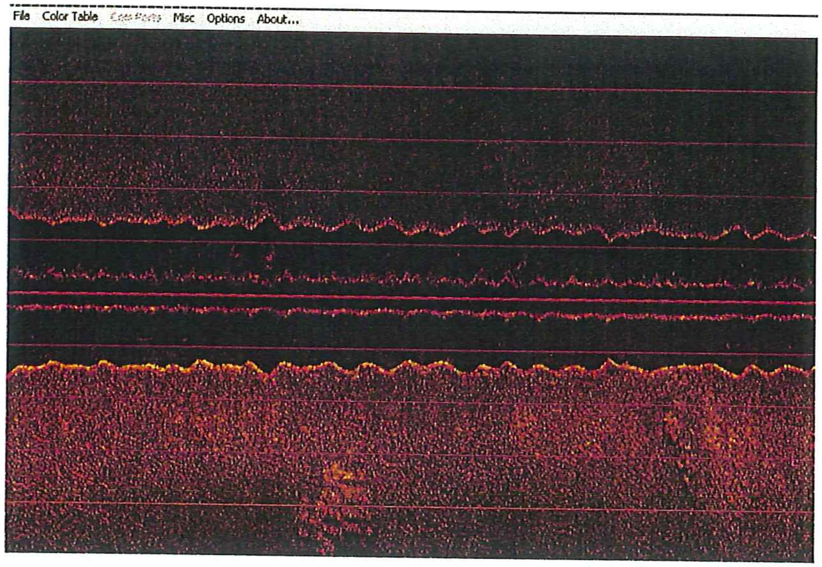
Sonar target 1. Acoustic signal located in coordinates latitude N18° 27.158' longitude W66° 00.886' in transect 2. Medium priority signal. Diving investigation revealed rocky formation as feature that produced the target. No archaeological materials related with this acoustic signal. Limited visibility for photo

Sonar Target 1



Sonar target 2. Acoustic signal located in coordinates latitude N18° 27.410' longitude W66° 00.316' in transect 5. Medium to high priority signal. Diving investigation revealed rocky formation as feature that produced the target. No archaeological materials related with this acoustic signal. Limited visibility for photo

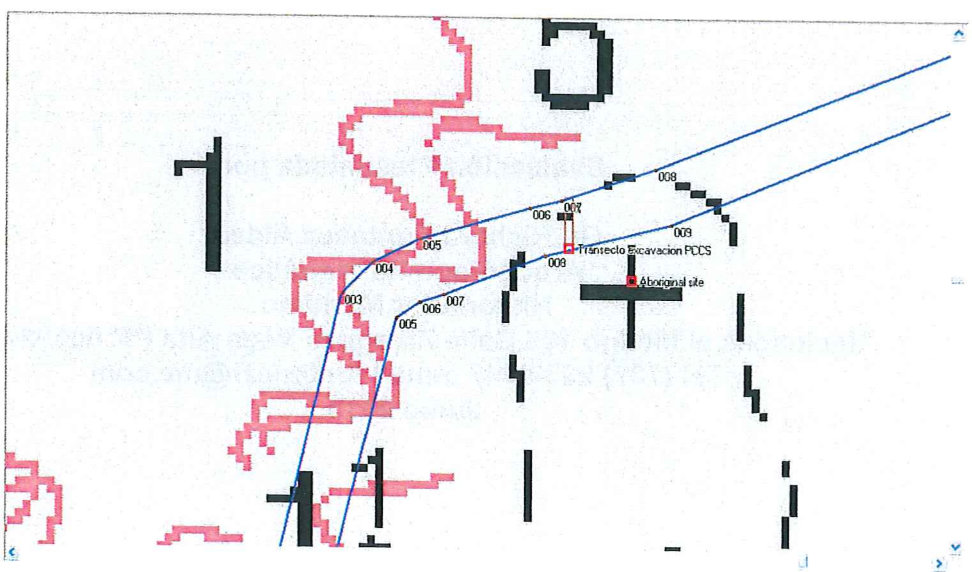
Sonar Target 2



Test Pit

A transect for test pit excavation designated in coordinates latitud N18° 27.0997' longitud W66° 01.0223' and latitudN18° 27.1322' longitud W66° 01.0223 100 meters long heading 0 degree north. As previously mentioned no test pit excavation performed due to rocky bottom. Excavation was replaced by visual inspection and hand fanning. No archaeological materials were observed in the transect. Depth 4-6 meters. Limited visibility for photos.

Location of Test Pits Transect, mark in red



Evaluación Arqueológica Subacuática de Fase 1-A y 1-B, Cable de Fibra Óptica

PCCS, Segmento Isla Verde, Carolina, Puerto Rico

Evaluación Presentada a:Emily Cooper
ERM
235 Park Avenue South, 4th floor
New York, NY 10003

Evaluación Presentada por:

Dr. Richard Fontánez Aldea
Arqueólogo Subacuático
Historiador Marítimo
Haciendas el Molino 106 Calle Zaragoza Vega Alta PR 00692-8709
Tel (787) 233-9447 e-mail fontanezr@me.com
Junio 2013

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RESUMEN

Este informe presenta una investigación documental y prospección arqueológica subacuática para la instalación del sistema de cable de fibra óptica PCCS que llegará a la costa norte de Puerto Rico, Isla verde Carolina. El estudio de Fase 1-A y 1-B tuvo el propósito de conocer la presencia o ausencia de recursos culturales sumergidos en el corredor propuesto así como la sensitividad arqueológica de la zona. El área revisada fue un corredor de 100 metros de ancho y 4543 metros de largo en la costa de Carolina.

La presencia humana y por consecuencia la navegación de esta porción de la costa puede remontarse a tiempos prehistóricos con el establecimiento de culturas precolombinas. Los registros indican que numerosos sitios históricos e indígenas se han localizado en el litoral de Isla Verde. La investigación documental arrojó información sobre la ocurrencia de más de 100 naufragios en las aguas adyacentes a San Juan-Carolina. Se conoce la localización específica de 3 sitios arqueológicos sumergidos en la costa cercana a Isla Verde. En Miramar se han identificados 4 sitios y evidencia de una costa antigua sumergida por cambios en el nivel del mar todos encontrados en pasados estudios arqueológicos subacuáticos para proyectos de cables de fibra óptica.

La investigación en las aguas de Carolina fue dividida en dos grandes actividades, la investigación histórica y la prospección de campo. La prospección fue dividida en tres tareas: Prospección con censor remoto realizada con un magnetómetro digital y un sonar de barrido lateral, inspecciones visuales y excavaciones de prueba. Con censor remoto se encontraron un total de 4 anomalías magnéticas y 2 acústicas.

Ninguna de las anomalías magnéticas correspondió a una anomalía acústica. Todas las anomalías se investigaron. Ninguna de las anomalías encontradas correspondía a materiales de procedencia arqueológica. Las excavaciones de prueba se sustituyeron por un transecto de inspección visual donde no se encontró evidencia arqueológica.

En resumen en el corredor de Carolina no se encontró evidencia cultural sumergida que indique un posible impacto a recursos arqueológicos durante la instalación del cable dentro de los límites del área de estudio. Se recomienda que se proceda con la instalación del cable de fibra óptica PCCS en Carolina con la condición de monitoreo arqueológico durante toda las actividades de deposición en la playa y terrenos subacuáticos así como en los procesos de estabilización submarina de los cables (steel pipe, anclajes y otros). La recomendación de monitoreo se justifica por los numerosos sitios arqueológicos identificados cerca de los corredores donde discurrirán los cables y pasadas experiencia donde se han impactado sitios arqueológicos durante los procesos de instalación.

Localización y Descripción del Área de Estudio

El proyecto arqueológico se realizó en el litoral norte, en la costa de Isla Verde, Carolina. Comenzó a 1 metro de profundidad en las coordenadas latitud N18°26.6868 longitud W66°01.2608y terminó en las coordenadas latitud N18°28.2520 longitud W65°59 alrededor de 30 metros de profundidad. El corredor tiene forma de letra S hasta salir por Boca de Cangrejos donde se dirige a aguas profundas muy similar al corredor estudiado por Fontánez en el 2011 para el cable submarino AMX.

Foto 1. Imagen Satélite de la Costa de Carolina (Google Maps 2013)

Figura 1, Área de Estudio

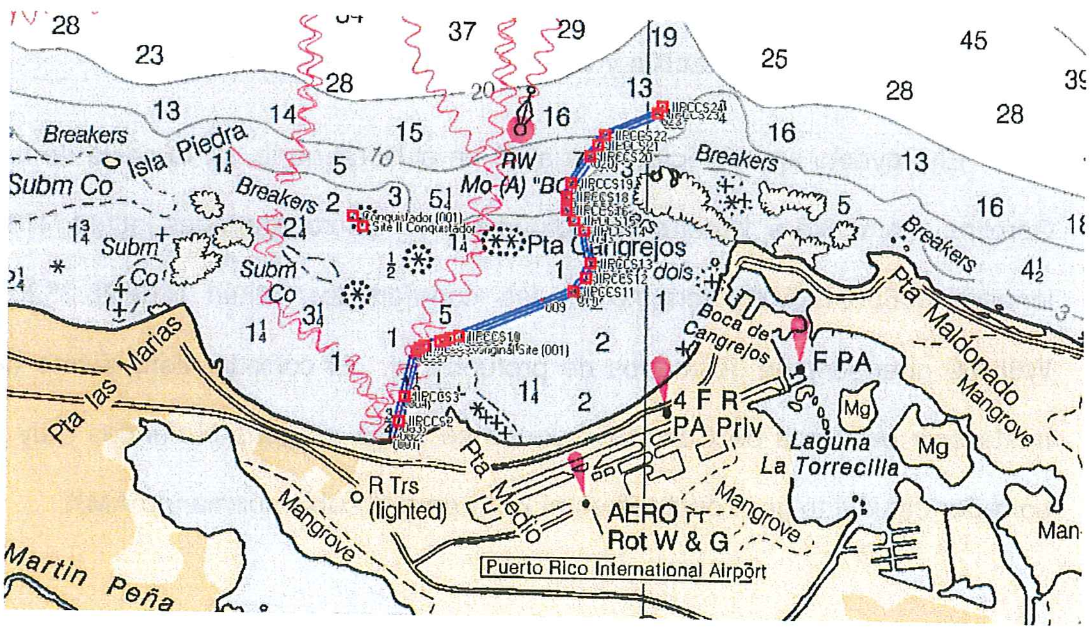


Foto 2, Isla Verde, Carolina, Hacia el Sur Este

Foto 3, Isla Verde, Carolina Hacia el Nor Este

De acuerdo a la carta náutica de esta parte de la costa norte (NOAA 25668) La profundidad del corredor propuesto ronda entre 1-10 metros hasta pasar la línea de arrecifes, luego el fondo llega hasta los 30 metros límite de nuestro estudio. En general las aguas llanas son turbias por toda la actividad humana y las descargas pluviales. Cerca de la salida de la laguna Torrecillas en Boca de Cangrejos la visibilidad es aún más reducida debido a los aportes sedimentarios del sistema lagunar que descarga al sur este del área de estudio. Alrededor de 600-1000 metros separados de la costa las aguas comienzan a aclarar llegando a tener más de 10 metros de visibilidad en algunos días. Este sector de las costa norte de la Isla está delimitada por una línea de arrecifes que se localiza de este a oeste a aproximadamente una milla de distancia formada por dunas cementadas. La formación corresponde a una antigua línea costera sumergida por cambios en el nivel del mar. Este arrecife protege el litoral del embate directo del oleaje Atlántico. El litoral es similar al resto de la costa norte con playas de alta energía y fuerte oleaje particularmente en los meses de invierno y durante las marejadas de huracanes. La línea de dunas cementadas ha permitido el establecimiento de una comunidad coralina de fondo duro. A lo largo de toda la costa norte de Puerto Rico el arrecife de dunas cementadas sumergidas representa un área sensitiva a la presencia de pecios. Las arenas entre este arrecife y el litoral son de grano mediano, en su mayoría de constitución calcárea intercaladas por fondo rocoso y arenas finas en la orilla. Cerca de Boca de Cangrejos en Carolina, el fondo se compone de cienos.

Estudios Arqueológicos Previos

El primer estudio para cable de fibra óptica sumergido entre la costa de San Juan a Carolina fue realizado en 1993 por Carmen Márquez para la instalación del *Taíno Caribe* en Isla Verde. Los resultados fueron negativos a la presencia de recursos culturales sumergidos. En 1999 el Dr. Vega realizó una monitoria del proceso de instalación del cable *Américas II* en Condado, San Juan. Este cable sale desde las instalaciones en la playa en las coordenadas latitud N18°26.630' longitud W066°01.284'. El estudio de Vega indica que se encontraron materiales arqueológicos bajo la roca de playa en el área cercana a Punta Piedrita, a 20 pies de profundidad. Estos materiales fueron expuestos durante la instalación del cable por la turbulencia de las hélices del barco instalador en un momento que este se acercó mucho a la costa. Según Vega los materiales encontrados pertenecen a culturas indígenas pre cerámicas que habitaron esta costa hace 3000-4000 años. En noviembre de 2000, Richard Fontánez Aldea llevó a cabo un estudio de Fase 1-A 1-B para la instalación de los segmentos de cable de fibra óptica *Arcos-1* en Isla Verde. La prospección electrónica con magnetómetro resultó en el hallazgo de 5 áreas con características magnéticas que podían indicar la presencia de materiales arqueológicos. Las inspecciones visuales no revelaron la existencia de evidencia cultural antigua en el corredor costanero de los cables *Arcos-1*. En el 2001 Fontánez realizó la Fase 1-A y 1-B para el proyecto *Mid-Atlantic Crossing Extension System* en Isla Verde. Se encontraron dos señales magnéticas y un área de señales en el arrecife que tenían las características de corresponder a posibles recursos culturales. La inspección de las señales tuvo resultados negativos a la presencia de material cultural. El estudio concluyó recomendando el endoso al proyecto y la realización de un monitoreo en la playa durante la instalación. En el 2001 también Fontánez-Aldea llevo a cabo una monitoria arqueológica durante las instalaciones del cable submarino *Arcos 1*. No se encontraron materiales arqueológicos en las excavaciones de la playa. En noviembre de 2003 Fontánez-Aldea realizó otro estudio de Fase 1-A y 1-B para la instalación del cable de fibra óptica sumergido *SMPR-1* en Isla Verde, Carolina, para la firma Caribe Environmental Services. En el estudio se encontró solo una señal magnética con las características de provenir de algún recurso arqueológico. Las inspecciones visuales evidenciaron que la señal no provenía de recursos culturales y se recomendó el endoso al proyecto y el monitoreo de la excavación en la playa durante la instalación del cable. El monitoreo de la instalación del cable lo realizó Fontánez-Aldea en 2005. No se encontraron materiales arqueológicos durante la instalación del cable o en la inspección subacuática. En el 2005 Fontánez-Aldea realizó una fase 1-A 1-B en Isla Verde, Carolina, para el proyecto de instalación del cable de fibra óptica *GCN1*. En la prospección se encontraron 3 señales magnéticas que podían provenir de materiales culturales. Durante la inspección visual se encontró una botella del siglo XX sin otros materiales relacionados. El estudio recomendó que se procediera con la instalación llevando a cabo un monitoreo arqueológico en el momento de desembarco del cable. En junio del 2005 la instalación del cable*GCN-1* fue movida a Condado, San Juan por razones logísticas de la empresa dueña del cable. Fontánez-Aldea realizó otro estudio de Fase 1-A 1-B para el *GCN-1*. En las coordenadas latitud 18°27.627 norte, longitud 66 °04.034 oeste, se encontró una agrupación de angulares y en las coordenadas latitud 18°28.001 norte, longitud 66 °03.621 oeste, se encontró un pescante para bote salvavidas y otro artefacto metálico con características de provenir de algún pecio de valor histórico del siglo XIX. Las recomendaciones arqueológicas fueron establecer una zona de amortiguamiento de 25 metros y monitoreo durante la instalación del cable. El monitoreo del *GCN-1* fue llevado a cabo en julio de 2006 por Fontánez-Aldea. El cable se instaló a más de 25 metros de los sitios encontrados. En la inspección visual post-instalación se encontró a 26 pies de profundidad un sedimento en el fondo que inicialmente se pensó eran los restos de madera de alguna embarcación. Un estudio más detallado de este sedimento reveló que existe en el lugar un fondo compuesto de una matriz vegetal con fragmentos de plantas vasculares que pueden ser los restos de una costa sumergida por cambios en el nivel del mar. Aunque este hallazgo no indicaba la presencia de recursos arqueológicos en la ruta del cable aumenta el potencial de encontrar asentamientos de los primeros habitantes de nuestro país.

Otro estudio fue realizado por Fontánez-Aldea en 2006. Este fue una prospección arqueológica de Fase 1-A y 1-B para la instalación del cable de fibra óptica *SAm-1 extensión* que parte desde frente a la calle Tartak en Isla Verde, Carolina. En el estudio no se encontró evidencia arqueológica en el corredor del cable.

En el 2007 Filipe Castro de la Universidad de Texas A&M junto a Fontánez-Aldea llevaron a cabo un reconocimiento arqueológico subacuático de las aguas entre Isla de Cabras, Cataño y Vacía Talega en Loíza. Se evaluaron numerosos sitios arqueológicos en la Bahía de San Juan y la costa cercana. Entre los materiales evaluados están dos cañones de hierro posiblemente de procedencia Inglesa de alrededor del siglo XVIII encontrados por pescadores en la ensenada del Escambrón. Estos cañones no están asociados a los restos de un pecio antiguo pero no deja de ser un recurso arqueológico importante. Estos cañones se localizan al oeste del corredor de estudio en el área del Condado, San Juan.

En el 2008 Fontánez-Aldea llevó a cabo un extenso monitoreo de las labores de reparación del cable de fibra óptica GCN en Condado, San Juan. Se encontraron algunos materiales aislados que pueden pertenecer al *debris* de algún barco naufragado que no ha sido localizado aún. Se encontró también evidencia de la costa sumergida mencionada anteriormente.

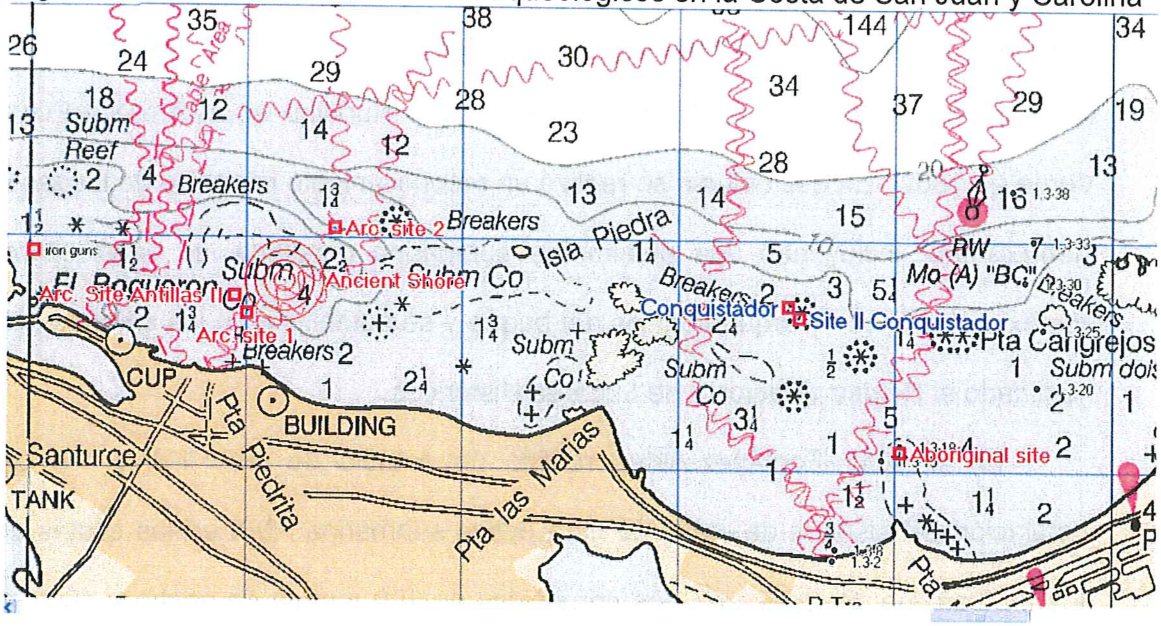
En 1997 como parte de la investigación histórica de tesis de maestría de Fontánez-Aldea con la ayuda de Amílcar García realizaron un estudio de los eventos del dragado español de la Bahía de San Juan en 1880. Parte de la información encontrada de 1892 relataba los esfuerzos del remolcador *Borinquén* de la Junta de Obras de Puerto, en el rescate de un vapor encallado en Isla Verde de nombre *Conquistador*. En el 2006 Fontánez-Aldea fue contratado por el municipio autónomo de Carolina para una evaluación arqueológica subacuática de las aguas entre Boca de Cangrejos y el Arrecife Isla Verde. El estudio fue una evaluación de Fase 1-A, 1-B previo a la instalación de arrecifes artificiales en el balneario y un inventario de recursos arqueológicos subacuáticos. Durante la investigación se encontraron los restos de dos embarcaciones, un barco de metal y una pila de lastre correspondiente a un pecio pequeño de madera. Ambos sitios arqueológicos tenían materiales cerámicos similares. Se identificaron preliminarmente los restos del barco de metal como el *Conquistador* coincidiendo con los relatos históricos que señalaban su encallamiento en el Arrecife Isla Verde en 1892. En el 2009 Fontánez-Aldea recibió fondos de la Oficina Estatal de Conservación Histórica y fondos federales provenientes del Servicio Nacional de Parques, Departamento de lo Interior de los EE.UU para el Estudio de Reconocimiento Intensivo Del Vapor *Conquistador* Hundido en el Arrecife Punta Isla Verde en 1882. En ese estudio se realizó un reconocimiento intensivo de los restos del *Conquistador* incluyendo una planimetría submarina detallada, se desarrollaron los contextos históricos y arqueológicos del buque y se establecieron los criterios para ser nominado al Registro Nacional de Lugares Históricos.

En el 2011 Fontánez-Aldea realizó un estudio de fase 1-A y 1-B para la instalación del sistema de cable de fibra óptica submarina AMX en las costas de San Juan y Carolina. Se revisaron dos corredores de 100 metros de ancho y 4000 metros de largo en San Juan y 2800 metros de largo en Carolina.

En ninguno de los dos corredores se encontró evidencia cultural sumergida que indique un posible impacto a recursos arqueológicos durante la instalación del cable dentro de los límites del área de estudio. Se recomendó proceder con la instalación llevando a cabo monitoreo arqueológico durante toda las actividades de deposición en la playa y terrenos subacuáticos así como en los procesos de estabilización submarina de los cables.

Sitios Arqueológicos Identificados en la Costa de San Juan y Carolina

Figura 2, Localización de los Sitios Arqueológicos en la Costa de San Juan y Carolina



-Como se puede ver en la figura 1 en la costa de San Juan hay identificados un sitio arqueológico de procedencia aborigen arcaica encontrado por Vega en 1999. Su localización es latitud N18°27.7407' longitud W66°04.0561' Se localiza a mas de 3 millas al oeste de nuestra área de estudio.

-En las coordenadas latitud N18°27.9351' longitud W66°04.9812' se localizaron por Castro y Fontánez-Aldea 2007, unos cañones posiblemente del siglo XVIII. Se localizan a más de 4 millas al oeste del corredor de estudio.

- Al oeste del corredor en San Juan se encuentra un sitio arqueológico compuesto de angulares de metal descrito por Fontánez-Aldea en 2005. Sus coordenadas son latitud N18°27.6669' longitud W66°04.0013'. Se localiza alrededor de 3 millas al oeste del corredor para el cable PCCS.

-Otro sitio arqueológico compuesto por un pescante de bote salvavidas y otros materiales del siglo XIX fue descrito por Fontánez-Aldea 2005. Sus coordenadas son latitud N18°28.0399' longitud W66°03.5883'.Se localiza también alrededor de 3 millas al oeste de nuestro corredor.

-Alrededor de las coordenadas latitud N18°27.8099' longitud W66°03.8223'se encontró evidencia de una costa antigua sumergida descrita por Fontánez-Aldea en 2006. Esta zona se encuentra alrededor de 3 millas al oeste del corredor PCCS.

-En las coordenadas latitud N18°27.7070' longitud W66°01.4920'se encuentran los restos del vapor *Conquistador* descritos por Fontánez-Aldea en el 2006 y 2009. Estos se localizan a 1355 metros al noroeste del corredor de estudio. De acuerdo a los estudios de Fontánez-Aldea el rastro de *debris* asociado a este pecio se extiende por lo menos 1000 metros al este sureste lo que puede indicar que hayan materiales arqueológicos a menos de 400 metros o menos del corredor de estudio.

-Otro pecio asociado al vapor *Conquistador* estudiado por Fontánez-Aldea en el 2006 y 2009 se encuentra en las coordenadas latitud N18°27.6580' longitud W66°01.4430'. Este es una pila de lastre con materiales cerámicos. Su distancia al corredor es de 1181 metros al noroeste.

-En el cayo de Punta del Medio en las coordenadas latitudN18°26.8557' longitud W66°00.9372'se encuentran los restos del sitio indígena semisumergido descrito por Vega en 1988. Este se compone de cerámica, restos alimenticios y artefactos de piedra pertenecientes a la cultura subtaina que habitó entre el 600 al 1200 de nuestra era. Este sitio se localiza a 95 metros al sur del corredor.

Antecedentes Históricos del Área de Estudio

Fase Prehistórica

Según la prueba arqueológica las comunidades aborígenes más tempranas de Puerto Rico inmigraron a la isla entre el año 7000 y el año 4000 a.C. Los primeros moradores de la Isla fundaron sus asentamientos cerca de los cuerpos de agua, especialmente donde convergían en el litoral marino y la desembocadura de los ríos. Se cree también que los primeros habitantes de la isla se establecieron en partes de la costa que en la actualidad se encuentran sumergidas por cambios en el nivel del mar. Por la evidencia arqueológica se sabe que la costa de Puerto Rico estuvo habitada mucho antes de la llegada de los europeos al Nuevo Mundo. La teoría arqueológica más aceptada para explicar la habitación de las Antillas por grupos aborígenes es la de migraciones sucesivas que procedieron de norte y sur América en diferentes épocas anteriores al Descubrimiento. Los grupos más antiguos pudieron llegar hace unos 4,000-7,000 años a las Antillas por el arco de islas que conecta Cuba con Norte América o por las Antillas menores desde la región oriental de Sur América lo que ubica parte de estas migraciones entrando por el este de Puerto Rico. El primer componente cultural que llegó a la zona se conoce como arcaico. Estos se dedicaban a la caza y la pesca, desconocían la agricultura y la alfarería y se organizaban en forma comunal. Estos grupos se consideran nómadas o seminómadas. Se cree que al llegar ocuparon la costa moviéndose progresivamente al interior montañoso. En el Caribe este componente abarcó un lapso amplio de tiempo y se especula que todavía habitaban la isla al momento de la llegada de los grupos agro alfareros. El complejo cultural Aruaco fue la segunda oleada de emigrantes procedentes de la región del Delta del Orinoco.

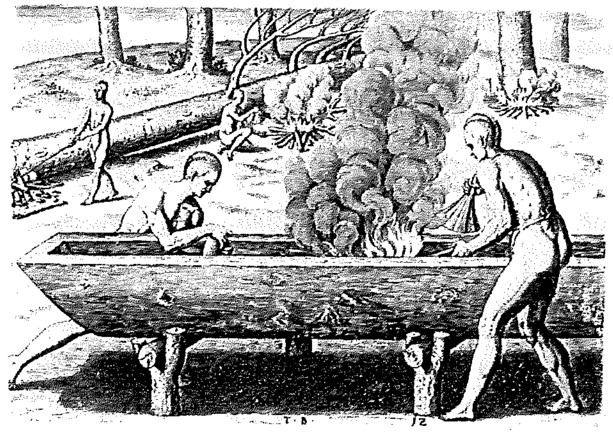


Figura 3, Construcción de una canoa. De Bry 1605 (en Justin Winsor 1886).

Su llegada a nuestra Isla se remonta a los 300 años antes de nuestra era. A diferencia de los anteriores habitantes los aruacos eran agricultores y ceramistas. Las migraciones agro-alfareras, como se les conoce, han sido divididas por los investigadores en tres fases mayores: Saladoide, Ostionoide y Chicoide o Taina. La fase Saladoide tenía como manifestación más sobresaliente la cerámica y la lapidaria. Materiales característicos de esta fase son las vasijas pintadas en diseños blancos sobre rojo, cerámicas con modelados en forma de animales, pequeños cemíes, y amuletos de piedra. La cultura ceramista Saladoide habito en la Isla entre el 300 a.C. hasta cerca del 600 d.C. y están asociados a esta cultura aborigen en su etapa tardía los sitios arqueológicos de Tecla en Guayanilla y Punta Borinquén en Aguadilla. El numero de yacimientos ceramistas o Saladoides se incrementa en las regiones centro-sur y suroeste de la Isla, lo que sugiere a los investigadores como Aguilú y Pantel (2001) un fortalecimiento y centralización sociopolítica de esta cultura aborigen en Puerto Rico a partir del 600 a.C. hasta el 800 d.C.

La fase subtaina, conocida también como Ostionoide, llegó al área de Puerto Rico en el siglo VI DC. A esta se le atribuye un mejoramiento en las técnicas del cultivo de la yuca y el desarrollo de los centros ceremoniales. Su cerámica era en general menos elaborada que en la Fase Saladoide. Ocuparon la Isla entre el 600 al 1200 de nuestra era.

Fase Histórica

En el siglo XVI luego de más de mil años de habitación aborigen el hombre occidental se sumaba al panorama de Borinquén. En el 1493 Puerto Rico fue descubierto durante el segundo viaje de Cristóbal Colón. Por doce años la presencia española en la isla se limito a viajes esporádicos de exploración con el propósito de recabar información de las fuentes de oro y otros viajes para introducir cabras y ganado.

Figura 4, Contacto de Españoles y Aborígenes, De Bry 1625(en Justin Winsor 1886)

La colonización de la isla comenzó formalmente en el 1509 bajo los esfuerzos de Juan Ponce de León con la fundación del poblado de Villa Caparra cercano a la bahía de San Juan. En la costa oeste se fundó el pueblo de San Germán. El establecimiento de ambos poblados respondía a la localización de ríos con potencial aurífero, que fue el gran motor de los primeros años de la empresa colonizadora. Menciona Escarano

(1994) que en los primeros años del siglo XVI la producción del oro de Borinquén aportó una cantidad significativa a las arcas españolas. La distancia al Puerto Rico como se conocía entonces a la bahía de San Juan y las malas condiciones de los accesos y cantidad de mosquitos que habían en Caparra motivaron que en el 1521 fuera trasladado el poblado a la isleta de San Juan Bautista al lado norte de la bahía. La ubicación del nuevo asentamiento respondió a las normas que España exigía para la fundación de pueblos: un lugar alto, sano y fértil con materiales para su desarrollo y cómoda bahía (Oficina Estatal de Preservación Histórica, O.E.P.H., 1989). La nueva ubicación de la capital también ofrecía a los pobladores magníficas cualidades defensivas por sus altos acantilados y anegados en su lado sudeste y sudoeste. Desde principio del siglo la posición estratégica de la Isla era comentada denominándosele la "vanguardia de la Indias Occidentales" (Morales-Carrión, 1995).Temprano en la habitación del Nuevo Mundo las nuevas tierras llamaron la atención de piratas y corsarios de otras naciones europeas. De las primeras naciones en atentar de forma decidida contra las colonias españolas se encontraba Francia que motivada por la guerra contra España lanzó una serie de ataques que afectaron los pueblos del oeste del país (Morales Carrión, 1995). Alrededor del 1540 la producción de oro había cesado casi por completo lo que trajo un cambio económico dirigido hacia la agricultura. Para ese tiempo la siembra de azúcar, jengibre y la producción de cueros reemplazó la búsqueda del mineral (Escarano, 1994). En el 1595 la isla experimentó la primera agresión inglesa a gran escala. Sir Francis Draque en compañía de John Hawkins alentados por la rivalidad política y religiosa del momento llegaron a la bahía con intenciones de tomar un cargamento de oro que se encontraba guardado en la Fortaleza. Dice Negroni (1992) que en la madrugada del 23 de noviembre la flota agresora se encontraba anclada en el área cercana a Punta Palo Seco en Isla de Cabras. Los ingleses fueron rechazados con grandes pérdidas humanas lo que según Negroni se debió a su ataque directo a las defensas de la Ciudad capital. Veremos que los próximos ataques ingleses a la isla evitarán la confrontación directa desembarcando al este de la bahía en el área de Boca de Cangrejos. El siglo XVI cierra con la ofensiva inglesa del Conde de Cumberland en el 1598.Cumberland exitosamente toma la plaza pero falla en poderla retener. Sus fuerzas habían preparado una estrategia efectiva para tomar San Juan. Con un nutrido ejército de 1,000 hombres la flota de Cumberland ancló cerca a la playa de Cangrejos y desembarcó dos regimientos de infantería. Estos marcharon hacia San Juan apoyados por los cañones de la flota que se componía de 20 barcos incluyendo al navío más poderoso de esa época *The Scourage Of Malice* de 800-900 toneladas (Negroni, 1992, p., 236). Los ingleses tomaron la capital pero un brote de disentería menguó sus fuerzas obligando la retirada del invasor.

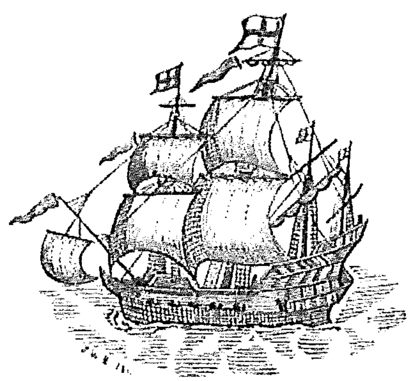
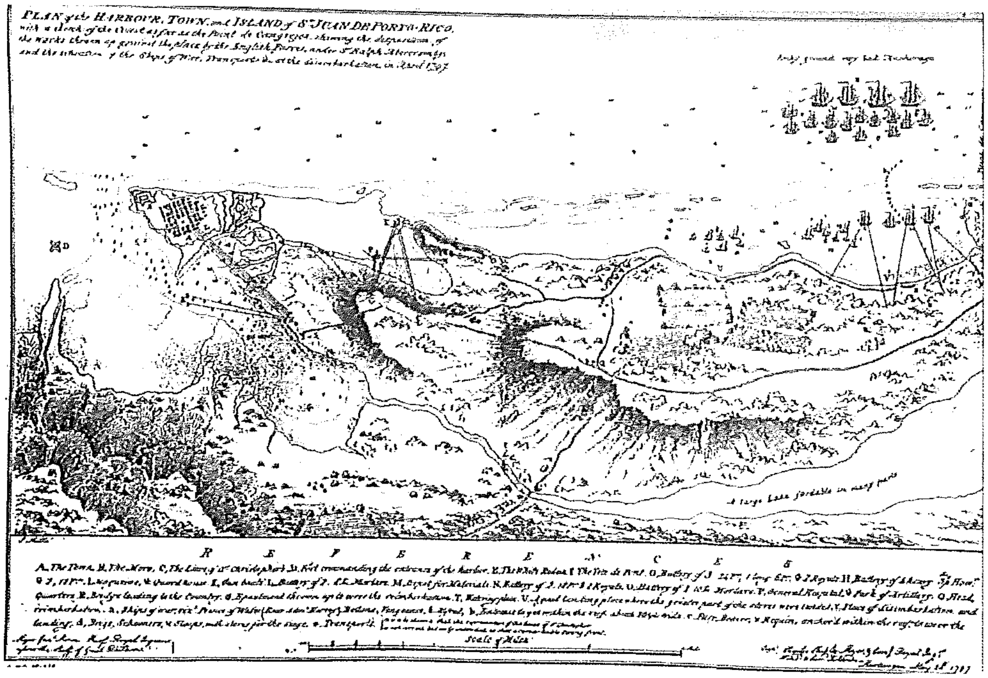


Figura 5, *The Scourage of Malice*, grabado de la época (Hakluyt Society, 2010)

Los constates ataques a San Juan expusieron áreas vulnerables en la defensa de la bahía. Luego de la segunda mitad del siglo XVI, España proyectó la formación de un sistema defensivo para su nuevo imperio. La primera fortificación de San Juan fue la Fortaleza de Santa Catalina en la rivera sur de San Juan. Su localización no fue la más adecuada para la defensa por mar y tierra por lo que se comenzó en el mismo siglo la construcción del castillo del Morro en la entrada de la bahía. Se cree que cercano a Boca de Cangrejos se construyó una fortificación para proteger la capital de los constantes ataques de indios Caribes que sucedieron en los primeros años de la conquista. Menciona Negroni (1992, p. 161) que se edificó una estructura entre el 1520 y 1530 conocida como Casa Fuerte de la Torrecilla. Su ubicación es incierta aunque se cree que estuvo en Punta Las Marías.

La isla no figuraba como punto importante en el establecimiento del sistema de flotas y las nuevas rutas de navegación, por lo que el monopolio comercial español empobreció la situación regional en el siglo XVII. Ya para el 1625 el intercambio comercial de Puerto Rico con la metrópolis era casi nulo (Morales-Carrión 1995). De acuerdo con Escarano (1994) en esta primera mitad del siglo muy pocos barcos arribaron a los puertos isleños. La pérdida de contactos con el exterior motivó el desarrollo de una economía de subsistencia que se mantuvo por siglos. En la segunda mitad del siglo XVII el contrabando entra a llenar el espacio que España había dejado en proveer los artículos de primera necesidad aunque ya desde el siglo XVI los portugueses contrabandeaban en las colonias españolas con la venta ilegal de esclavos (Parí et al, 1987). En el siglo XVII los holandeses se establecieron como amos de las aguas del Caribe. La creación de la Compañía de Indias Occidentales fue la culminación de un proceso de revelación de los Países Bajos contra España y sus aliados. Los holandeses no solo estaban interesados en el control de los mares también pretendían afianzar su dominio con posesiones permanentes en el Nuevo Mundo. En el 1625 el general Boudewijn Hendrikszoon aparece en las aguas de la bahía con una poderosa flota dispuesto a cumplir los planes expansionistas de los Países Bajos. Los residentes de la isleta y fuerzas militares se protegieron dentro de la fortificación del Morro. Luego de un mes de sitio y batalla contra las defensas del castillo, los holandeses salen derrotados de nuestras aguas no sin antes quemar la ciudad. En el siglo XVIII culminó gran parte de la obra de fortalecimiento de las defensas de la ciudad de San Juan. Las obras más importantes se realizaron durante la incumbencia del mariscal de campo Alejandro O'Railly y bajo la dirección de Tomás O'Dally y Francisco Mestre, jefes de ingeniería militar. Entre el 1765 al 1783 fue construido el castillo de San Cristóbal, se terminaron de edificar las tres líneas de defensa compuesta por las murallas que cerraban la isleta y una serie de edificaciones de costa a lo largo del litoral norte pasando Boca de Cangrejos. La economía del siglo XVIII giraba en torno a la agricultura de la caña de azúcar y frutos menores además del constante contrabando que nutria parte de las necesidades del país. La práctica del corzo cobró importancia para este tiempo destacándose el corsario puertorriqueño Miguel Enríquez. Fueron tan efectivos los corsarios con bandera española que las colonias inglesas del Caribe expresaron su malestar por la interferencia que esta actividad producía sobre su comercio. El malestar continuo en aumento y la gota que derramo la copa fue la alianza Franco-Española sumado a la envidiable posición estratégica de Puerto Rico. Finalmente los ingleses decidieron lanzar un ataque de grandes proporciones sobre San Juan. En el 1797 el general Sir Ralph Abercromby y el almirante Harvey pondrían a prueba el sistema defensivo de la capital. La ofensiva comenzó con un desembarco de tropas en el sector de Cangrejos las que marcharon hacia San Juan apoyadas por las 60 embarcaciones de la flota.

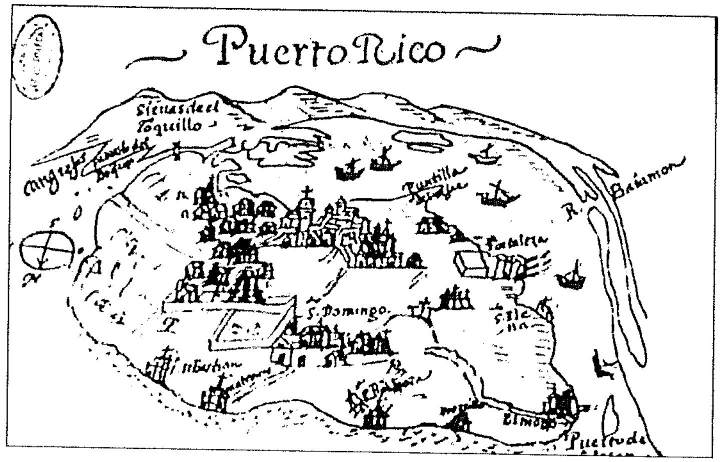
Figura 6, Plano del Ataque de Abercromby, 1797 (Tomado de Alonso y Flores, 1997)



En el siglo XIX la economía de la isla se fortaleció por la exportación de azúcar y café. Para este siglo Puerto Rico entró al mercado capitalista. La sociedad puertorriqueña ya había cristalizado una conciencia nacional dentro de su clase criolla y campesina. La presencia norteamericana era evidente desde la primera mitad del siglo en el comercio insular. Próximo a finalizar el siglo XIX la Guerra Hispanoamericana trajo cambios fundamentales en la sociedad puertorriqueña. En 1898 Puerto Rico es invadido por la armada de los Estados Unidos. La isla cambia de soberanía y el área de San Juan se convierte en los cuarteles generales del ejército norteamericano hasta mediados del siglo XX.

En la actualidad el área de estudio corresponde a la costa del municipio de Carolina. El sector formaba parte de partido de Cangrejos. Para el 1575 ya aparece el nombre de Cangrejos en el plano hecho presumiblemente por Juan Escalante de Mendoza.

Figura 7, Plano de Juan de Escalante de Mendoza



En las memorias sometidas al Rey por el capitán Melgarejo en 1582, Punta de Cangrejos se describe como sigue:

"Los cabos y puntas que hay en la costa del Norte desta isla, viniendo de la cabeza della para el Oeste, haze una punta la mar de tierra baxa de arena, que se llama la punta de Cangrejo, con bajos, y está de la cibdad cinco leguas..."

El desarrollo de Cangrejos ha estado relacionado a los cambios en la capital. La vía de acceso hacia el este de la isla conocida como Carretera Central atravesaba el territorio lo que permitió el establecimiento disperso de familias en el sector desde los primeros años de la conquista. Luego esta carretera se le nombró avenida Ponce de León. Como ya se mencionó la costa de Cangrejo fue utilizada en los ataques de 1598 y 1797 para el desembarco de tropas que luego marcharon a San Juan. En términos generales, no hubo una movilización masiva de residentes a la zona por lo menos en los primeros tres siglos de ocupación española. El ambiente anegado del área se menciona como uno de los grandes responsable de la lentitud del poblamiento de Cangrejos.

El área que en la actualidad se le conoce como Punta Piedrita se llamaba Punta del Condado. El Condado formaba parte del partido de Cangrejos el cual todavía en el siglo XVIII, se encontraba poco poblado. Extensas ciénagas y vegetación de mangle imperaban en los terrenos.

Figura 8, Plano de Thomás O'Daly de 1776, presenta el área de ciénagas (Tomado de Sepúlveda 1989)

Paulatinamente la región de Cangrejos fue poblándose en un principio de negros libres que provenía de otras Antillas. Salvador Brau (1983, p., 145-146) indica que en 1664 llegaron varios negros prófugos desde la colonia danesa de Santa Cruz. Las autoridades españolas no consideraron decoroso que se le impusiera la esclavitud a los que se acogieron al amparo de la Corona por lo que fueron dejados en libertad con la condición de que se cristianizaran y jurasen fidelidad a España. Para el 1714 habiendo 80 refugiados el gobernador dispone que se les asigne el usufructo de dos cuerdas a los habitantes varones en el terreno entre el Castillo de San Cristóbal y el Puente de San Antonio. Brau menciona que estas tierras no eran fértiles por lo que se le permitió establecerse al este de San Juan en el área de Cangrejos. La economía de Cangrejos estaba dirigida a abastecer la Capital. Esta se basaba principalmente en la agricultura de frutos menores, la pesca y la producción de carbón el que fabricaban con los abundantes árboles de mangle que tenían disponibles. De Hostos (1976, p., 216) indica que para el 1625 existía un ingenio azucarero en el Condado. Esto sugiere que la caña también fue cultivada en la zona de Cangrejos para el siglo XVII. En el 1769 el asentamiento de Cangrejos se separó de Río Piedras formándose el partido de San Mateo de Cangrejo (Tomás de Córdoba, 1968, en De Hostos, p 216, 1976).El nombre del poblado correspondía a una de las dos ermitas que había en el partido. El poblado estaba compuesto por 5 barrios entre los que figuraba Hato Rey. Fernando Millares González describe a Cangrejos para el 1775:

"Este partido se dividió del anterior por el actual gobernador y capitán general don Miguel de Muesas, sin embargo de hallarse a la orden del mismo teniente a guerra. Su principal vecindario es de negros que cultivan una tierra arenisca que produce varias raíces para la manutención y su mayor ingreso consiste de cazabe y no resultaría menos del arroz, si sus habitantes empleasen en este cultivo parte de las grandes ciénagas que comprende la jurisdicción"

Advierte el informe de Millares a las autoridades españolas que la población de Cangrejo estaba aumentando. Veintidós años más tardes el naturalista francés Andree Pierre Ledru hace mención de los habitantes de esta costa y sus cultivos. Indica que casi todos los habitantes de Cangrejos eran negros o mulatos libres. Ledru estima que el partido tenía ciento ochenta casas y más de setecientos habitantes.

El desarrollo económico y aumento poblacional experimentado en el siglo XIX modificó la distribución urbana de la ciudad capital. Menciona Sepúlveda (1989) que la cuidad se expandía hacia La Puntilla, Puerta de Tierras y Cangrejos. Hubo una especialización en el uso de estos terrenos como parte de las nuevas tendencias mercantilistas de este siglo. Añade Sepúlveda que en Cangrejos "se evidenció un crecimiento urbano alineado con la Carretera Central y el tranvía". Para el 1882 el partido de San Mateo de Cangrejos deja de ser pueblo. Su territorio pasó a formar parte de San Juan, Río Piedras y el Municipio de Carolina de reciente fundación. Para la década de 1880 surge una petición de los residentes de Cangrejo para cambiarle el nombre del territorio a Santurce en honor al Conde de Santurce, Pablo de Ubarri. La actividad económica de Cangrejos era dominada por Ubarri quien era dueño del tranvía de vapor que corría entre San Juan y Río Piedras. En la primera mitad del siglo XX hubo una gran emigración de personas pobres del interior montañoso hacia la capital. Como consecuencia la población aumentó para la zona de Santurce y Carolina.

Naufragios

Es difícil imaginar la historia del ser humano sin la existencia de barcos. Por miles de años el ser humano ha desarrollado la forma de surcar los cuerpos de agua de manera más rápida, segura y eficiente. Desde las primeras embarcaciones registradas en los anales de la historia se ha visto la evolución de estas como naves de comercio o invenciones indispensables en las acciones armadas decidiendo el balance de poder desde los tiempos de los pueblos egipcios hasta el presente.

La palabra isla que define los límites geográficos de Puerto Rico por necesidad implica que nuestros primeros pobladores requirieron de algún medio de transportación para cruzar los mares y cuerpos de agua menores. Ya desde ese momento y hasta nuestros días podemos contar con la pérdida de embarcaciones en las aguas que rodean a Puerto Rico.

Tabla 1, Listado de Pecios Mencionados en Documentos en Aguas de San Juan

Nombre	Año	Causa	Tipo	Fuente
Santa María	1524	encalló	Nao	Cardona Bonet
?	1529	asalto Caribe	Barca	" "
?	1530	huracán	Navío	" "
?	1530	huracán	Barco	" "
varios barcos	1545	huracán	?	" "
Concepción y Espíritu Santo	1550	?	Nao, negrero	" "
varios barcos	1550	huracán	?	" "
San Cristóbal	1551	entrando	Nao	" "
San Juan	1560	encalló	Galeote	" "
San Cristóbal	1573	entrando	Urca	" "
Nuestra Señora del Rosario	1588	encalló	Navío	" "
?	1589	encalló	Navío	" "
San Juan Garganta	1589	encalló	Navío	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Nao	" "
La Tejada	1595	batalla	Fragata	" "
?	1595	batalla	Navichuelo	" "
Nuestra Señora de la Magdalena	1595	batalla	Fragata	" "
Nuestra Señora de Begoña	1595	batalla	nave capitana	" "
Nombre	Año	Causa	Tipo	" "
?	1595	batalla	Esquife	" "
La Pandorga	1595	batalla	?	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Esquife	" "
?	1595	batalla	Esquife	" "
?	1601	encalló	Nao	

?	1615	huracán	Navío	" "
?	1615	huracán	Navío	" "
San Antonio	1622	entrando	Navío	" "
San Joseph	1623	tormenta	Navío	" "
Nuestra Señora del Rosario y San Antonio	1625	batalla	Navío	" "
Nuestra Señora de la Consolación	1625	batalla	Nao	" "
Jesús María?	1625-30	entrando	Navío	" "
?	1626	huracán	Navío	" "
?	1626	huracán	Chalupa	" "
San Juan Bautista	1626	huracán	Navío	" "
Nuestra Señora de Pena de Francia	1635	encalló	Nao	" "
?	1659	encalló	Patache	C.A.S
Nuestra Señora del Rosario	1659	entrando	Nao	C.A.S.
La Victoria	1738	?	?	C.A.S.
Amphitrite	1745	?	?	C.A.S.
Carmen	1853	huracán	Goleta	Coll y Tosté
Josefita	1853	huracán	Goleta	" "
?	1853	huracán	Maluca	" "
Rita	1853	huracán	Goleta	" "
Venus	1855-56	entrando	Fragata	C.A.S.
Vapor Alegría	1876	entrando	Vapor	C.A.S
Manila	1888	entrando	Vapor	C.A.S.
Gabarra de la C.I.A	1890	entrando	Barcaza	C.A.S.
Conquistador	1892	Bajo de Isla Verde	Vapor	A.G.P.R.
Manuela	1898	batalla	Vapor	C.A.S.
Cristóbal Colón	1898	batalla	Vapor	C.A.S.
Varios barcos	1915	huracán	?	Vega
Dos goletas y varios botes	1916	huracán	?	"
Gaviota	1932	huracán	Goleta	"
Hilda II	1961	Explosión	Yate	Hostos
Libertad	1962	?	Velero	Vega

Trans Caribbean	1963	entrando	Carguero contenedores	C.A.S.
Catalina	1964	?	?	Vega
Pocahontas	1965	Muelle 5	?	C.A.S

C.A.S.= Consejo de Arqueología Subacuática
A.G.P.R.=Archivo General de Puerto Rico

Figura 9, Plano del Pecio, Vapor *Conquistador* (Fontánez-Aldea 2009)

Sitios Prehistóricos Sumergidos

En nuestro litoral los cambios en el nivel del mar son los mayores responsables de la modificación de la línea costera. En muchas ocasiones a través de los años el mar ha inundado la tierra o se ha retirado. Menciona Bush et al (1995) que el mar a variado por lo menos unos 100 metros en los últimos dos millones de años mayormente como resultado de la formación y el derretimiento de glaciares en los polos. Otros factores que pueden variar el nivel del mar son la temperatura del agua, su salinidad, tectonismo y el patrón de los vientos (Rap y Hill, 1998). Hace unos 20,000 años atrás cerca del final de la edad de hielo, una capa glaciar cubría gran parte de Norteamérica. El nivel del mar era hasta 100 metros más bajo que el actual y por consiguiente el tamaño de Puerto Rico era mayor. Alrededor de dos mil años después, el hielo comenzó a derretirse al subir la temperatura de la tierra. Los efectos del aumento del nivel del mar son más severos en costas con pendientes suaves donde la agua pueden penetra más distancia tierra adentro. Hace unos 7000 años atrás el nivel del mar era 10m más bajo que al presente. En el caso particular de Puerto Rico alrededor de 5,000 años atrás el aumento del nivel del mar fue reduciéndose de 50cm a 10cm por siglo. Esto dejó un contorno costero muy similar al que persiste hoy en día. A esta dinámica ambiental se sumó el ser humano. Las modificaciones de la costa que nuestra sociedad ha realizado en especial durante los últimos 100 años han acelerado los procesos de la pérdida de litoral. Las construcciones en la orilla del mar, la modificación de las cuencas de los ríos, estuarios y otros han alterado los procesos litorales trayendo como consecuencia una erosión acelerada de la costa.

La elevación del mar está acompañada de periodos de interrupción en el proceso. Estos períodos pueden permitir la formación de "terrazas marinas" que pudieron ser utilizadas por culturas pasadas para la habitación permanente o semipermanente (Vega 1999, p21). La posibilidad de que haya sitios sumergidos ha sido explorada por arqueólogos desde hace muchos años. La primera excavación de un sitio sumergido en la Isla la hizo Jesús Vega en 1988 en la costa de Isla Verde. El estudio demostró la presencia de un yacimiento aborigen semisumergido con cerámica Ostionoide, herramientas de piedra y caracol y restos alimenticios entre los que se encontraban huesos de carey y manatí (Vega, 1981). En el 1999 Vega descubrió lo que él describe como un sitio arcaico en alrededor de 20 pies de profundidad en las cercanías del Condado en el área de Punta Piedrita asociado a una de las terrazas marinas antes mencionadas. A lo largo del tiempo los habitantes de Puerto Rico han ocupado la costa. La evidencia arqueológica demuestra que el litoral fue utilizado intensamente desde que llegaron los primeros grupos aborígenes entre los 5000 y 7000 años hasta el presente. Muchos de los sitios costeros que a principio del siglo XX estaban en la alta playa hoy se encuentran semisumergidos debido a los cambios del nivel del mar y la erosión.

La información recopilada en este estudio evidencia la alta sensitiva arqueológica a la presencia de recursos culturales sumergidos en la costa entre San Juan y Carolina. De acuerdo a la tabla presentada hay referencia a más de 100 naufragios en la zona. Existe también la posibilidad de encontrar recursos culturales pertenecientes a grupos aborígenes que hayan poblado el litoral en momentos cuando el nivel del mar era más bajo. Por la alta sensitividad arqueológica del área de estudio se procederá con la investigación de campo de Fase 1-B.

Metodología de la Investigación

El equipo de trabajo contó de 5 personas. El arqueólogo Raymond Tubby colaboró en la interpretación de las señales magnéticas y acústicas. El Sr. Gerardo Cabrera instructor de buceo fue el oficial de seguridad de operaciones marítimas, el Sr. Geraldo Rafael Cabrera Molina trabajó como buzo en la inspecciones visuales y las excavaciones de pozos de pruebas, Freddy Martínez González fue el capitán de la embarcación y el arqueólogo subacuático Dr. Richard Fontánez fue el jefe científico de la investigación. La prospección comenzó el 26 de mayo de 2013 y terminó el 31 de mayo de 2013. La primera semana del mes de junio se empleó para el análisis de los datos, depuración de la información magnética / acústica y redacción del informe. Se utilizó la embarcación *Diana* de 25 pies de eslora con dos con motores fuera de borda para buceo y prospección electrónica.

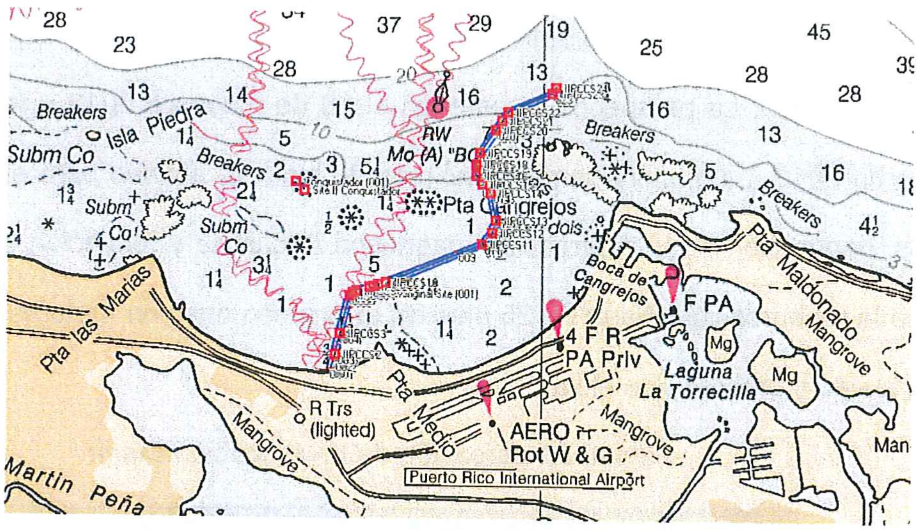
Foto 4, Embarcación de Investigación *Diana*

Prospección con Censor Remoto, Magnetómetro y Sonar de Barrido Lateral

El área de prospección comprendió un corredor de 100 metros de ancho, alrededor de 4543 metros de largo en Isla Verde.

Para asegurar data suficiente que permitiera localizar cualquier objetivo (*Target* o anomalía) potencialmente significativo en el estudio se hicieron transectos de 20 metros de separación.

Figura 10, Plano de los Corredores de Prospección



La investigación arqueológica de censores remoto fue diseñada para cumplir con dos metas principales. La primera fue el emplear equipos de prospección remota de detección magnética y acústica para identificar anomalías con características similares a las que previamente se ha demostrado que están asociadas a recursos culturales sumergidos de significancia histórica. La segunda fue la evaluación de cada objetivo (*target*) e identificar cuales requerían investigación subacuática para confirmar la naturaleza y la significancia de los materiales que generaron la anomalía y diferenciar las señales que pertenecían a materiales modernos.

Magnetómetro

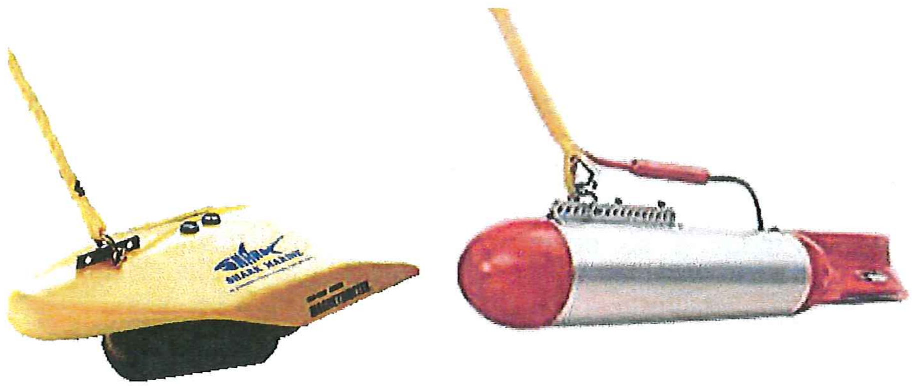
Para cumplir con estos objetivos un magnetómetro de la firma SHARK MARINETECHNOLOGY SDM-4000 capaz de una resolución de +-1 gamma fue empleado para coleccionar la data magnética en la prospección. Debido a las aguas llanas y arrecifes en ambos corredores el censor del magnetómetro fue arrastrado alrededor de 1 metro bajo la superficie del agua a una velocidad de aproximadamente 3-4 nudos. Fuera de la zona de arrecifes el censor era arrastrado de 6-9 metros bajo la superficie. Los datos magnéticos eran recolectados como un archivo digital por el programa MAGPLOT y referenciados a su posición geográfica por medio del sistema de navegación computarizado.

Sonar

Un sonar de barrido lateral digital IMAGENEX Sportscan de 330/800 kHz 881 fue empleado para coleccionar los datos acústicos en las áreas de prospección. Debido a las aguas llanas y los arrecifes en ambos corredores el censor del sonar fue arrastrado a 1-1.5 metros bajo la embarcación a una velocidad aproximada entre 3-4 nudos. La data acústica fue coleccionada usando una escala de 20 metros para proveer una cobertura mayor de 100% (*overlaping*) y una alta definición en la señal. La data acústica fue almacenada en archivos digitales del programa WIN881SS y referenciado a una posición geográfica por el sistema de navegación computarizado.

Durante la prospección la posición y la distancia entre las líneas de transectos fueron mantenidas con un *GPSRAYMING Tripnav TN-204differential system* en interface con una computadora portátil *Panasonic Toughbook CF29.* La navegación fue controlada por el programa *Fungawi Global Navigator.* Este sistema de navegación permitió una precisión que rondó entre 5 metros y menos de 1 metro de error. Todas las posiciones fueron almacenadas como latitud/longitud usando el datum NAD84.

Fotos 5 y 6, Magnetómetro Digital y Sonar de Barrido Lateral



Análisis de los Datos

Para asegurar una identificación confiable de los *targets* y su evaluación el análisis de la data se hizo a la par que esta iba generándose. La señal de los *targets* era aislada y evaluada en torno a las características que previamente se ha demostrado que son indicativo de recursos culturales sumergidos. El análisis se basó en factores tales como intensidad de la anomalía duración extensión del área que esta cubría y características de la señal. Cada *targets* fue seleccionado de acuerdo a su potencial como parte de materiales asociados a pecios o a otros recursos culturales sumergidos. Los *targets* clasificados como de moderado a alta prioridad fueron seleccionados para inspección subacuática. Todos los *targets* fueron tabulados, descritos y localizados en un plano que muestra su ubicación. Las anomalías se designaron de acuerdo al número del transecto.

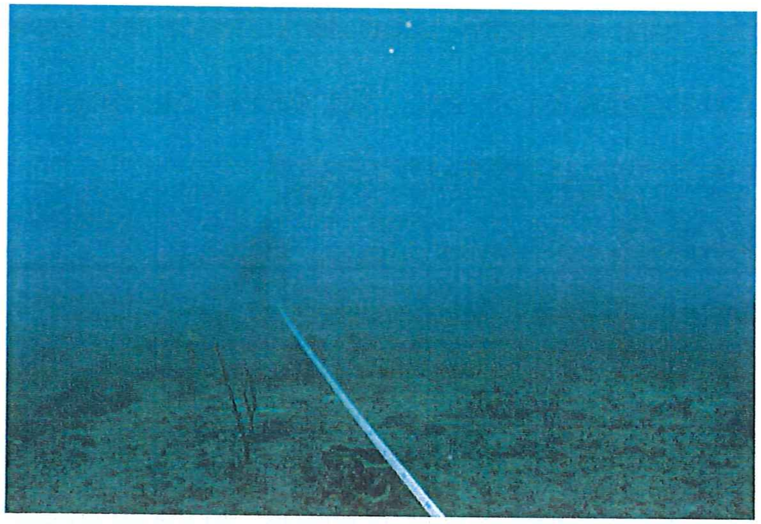
Prospección Visual

La prospección con métodos visuales fue la segunda actividad de búsqueda que se realizó. Se llevaron a cabo inspecciones visuales por medio de patrones de buceo en los lugares con anomalías magnéticas o acústicas con posibilidad de pertenecer a recursos arqueológicos así como en el arrecife. El buceo en patrones ha sido descrito ampliamente en publicaciones como *Nautical Archaeology* de Hill St. John Wilkes (David & Clark 1971) y *Archaeology Underwater* the N.A.S. Guide por Dean Martin et al (Archetype Publication Ltd, quinta edición, 2000). El patrón utilizado de buceo fue circular con tres buzos hasta cubrir un área de 60 metros de diámetro por inspección.

Documentación de los Hallazgos

Los materiales encontrados fueron documentados en términos de sus características mediante fotos y notas. Se empleo equipo SCUBA, cámaras submarinas, papel *maylar*, lápices mecánicos cintas métricas y compás.

Foto 7, Buceo en Patrones Circulares (Inspección visual anomalía magnética 2)



Excavaciones de Prueba

Se delimitó un transecto entre las coordenadas latitud N18° 27.0997' longitud W66° 01.0223'y N18° 27.1322' longitud W66° 01.0223'para pozos de prueba. El transecto fue del ancho del corredor, 100 metros, y se dirigía hacia el norte a 0 grados. Se localizó en esta zona porque es el lugar más cerca al sitio arqueológico de Punta del Medio. El objetivo de estas pruebas era conocer si existían materiales arqueológicos de procedencia aborigen dentro del corredor de estudio en el área de Punta del Medio. Los métodos convencionales de prospección arqueológica subacuática como el rastreo con magnetómetro, no perciben materiales de culturas prehistóricas porque estos carecen de masa ferrosa. Se desistió de las excavaciones porque el fondo era roca bajo una fina capa de arena. Se procedió solo a revisar el fondo abanicando el sedimento (hand fanning). No se hicieron fotos de esta actividad porque la visibilidad era menor de 30cm.

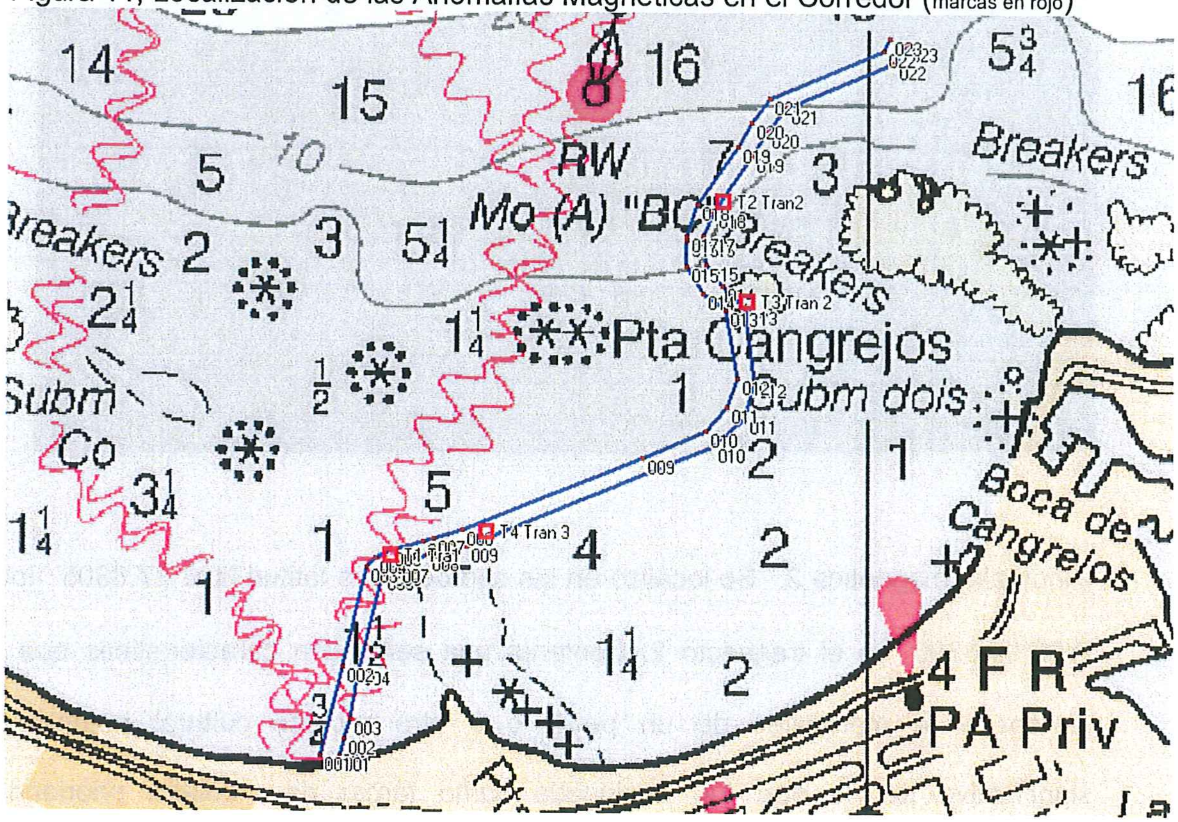
Resultados y Discusión

Prospección con Censor Remoto, Análisis de los *Targets*

El análisis de La data obtenida por los equipos de censor remoto en Carolina reveló un total de 4 anomalías magnéticas y 2 acústicas.

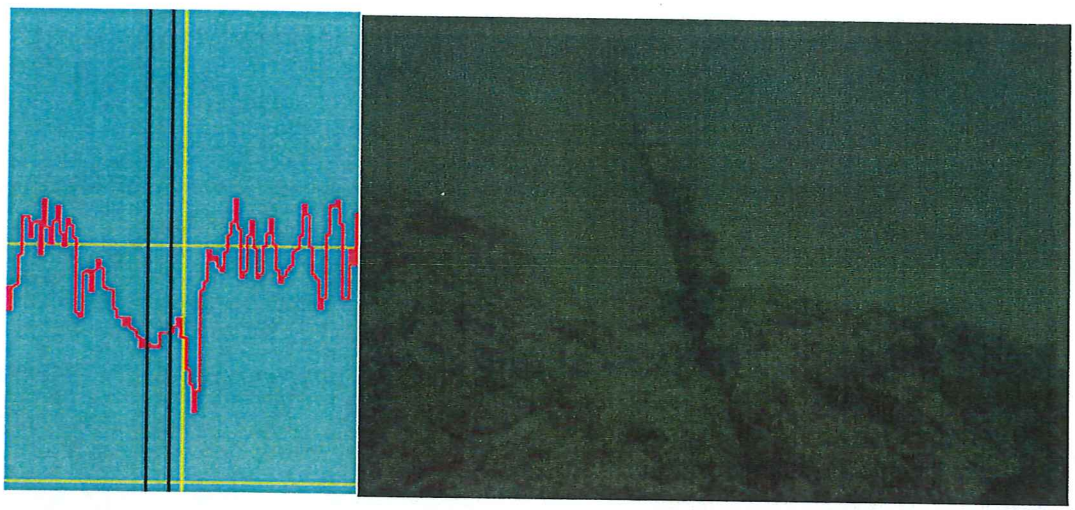
Anomalías magnéticas

Figura 11, Localización de las Anomalías Magnéticas en el Corredor (marcas en rojo)



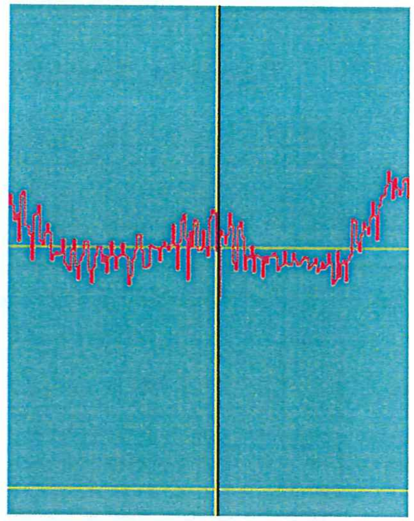
-Anomalía magnética 1. Encontrada en el transecto 1se localizó en las coordenadas latitudN18°27.0942' longitud W66°01.1328'. Contenía una señal con características que podía pertenecer a materiales de un pecio o a otro recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana prioridad para investigación adicional. La señal fue monopolar de 5550gamas con duración de 70 segundos. La investigación subacuática reveló un fondo de rocas a 4.5 metros de profundidad. Se encontró un cable de fibra óptica discurriendo de sur-oeste al nor-este. No se encontró evidencia de materiales pertenecientes a un pecio u otro recurso cultural antiguo asociados a esta anomalía

Figura 12, Anomalía 1Foto 8, Cable de Fibra Óptica, área de la anomalía 2



-Anomalía magnética 2. Se localizó en las coordenadas latitud N18°27.8905' longitud W66°00.3396' en el transecto 2. Contenía una señal con características que podía pertenecer a materiales de un pecio o a otro recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana prioridad para investigación adicional. La señal fue bipolar de 5616 gamas con duración de 40 segundos. La investigación subacuática reveló un fondo de rocas y corales a 10.8 metros de profundidad. No se encontraron materiales férricos que generaran la señal. No se encontró evidencia de recursos culturales antiguo asociados a esta anomalía

Figura 13, Anomalía 2



-La anomalía magnética 3 se localizó en las coordenadas latitud N18°26.6702' longitud W66°00.2846'. Contenía una señal con características que podía pertenecer a materiales de un pecio o a otro recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana a alta prioridad para investigación adicional. La señal fue monopolar negativa de 5659 gamas con duración de 77 segundos. La investigación subacuática reveló una depresión en el fondo de roca que comienza en los 4.8 metros de profundidad y llega hasta los18.6 metros de profundidad. Esta área fue descrita por el autor de este informe en la investigación para el municipio de Carolina de 2006 (Fontánez 2006) como un posible remanente de un canal de río de una antigua línea costera. Se encontraron numerosos materiales modernos correspondientes a naufragios de lanchas recientes y basura. Se identificó un cable de fibra óptica y un motor fuera de borda. Cualquiera de estos materiales pudo generar la señal. No se encontró evidencia de materiales pertenecientes a un pecio histórico u otro recurso cultural antiguo asociados a esta anomalía.

Figura 14, Anomalía 3

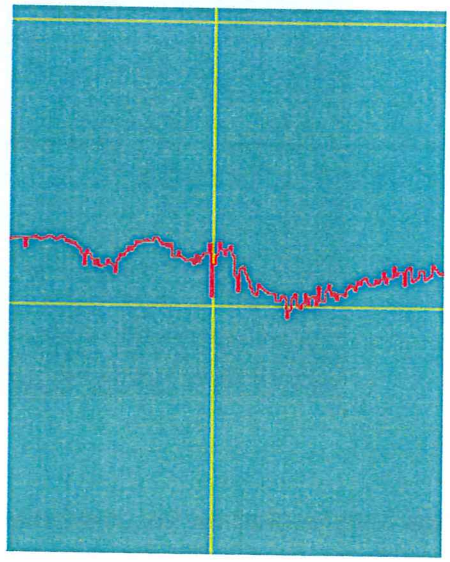
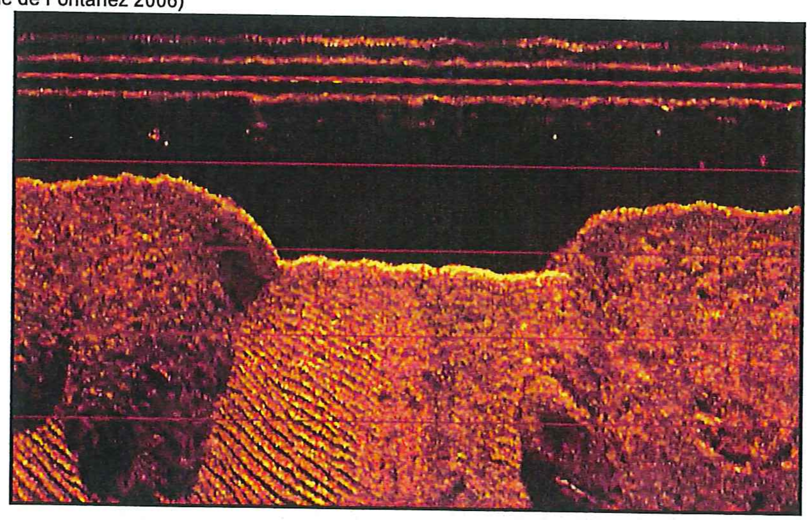
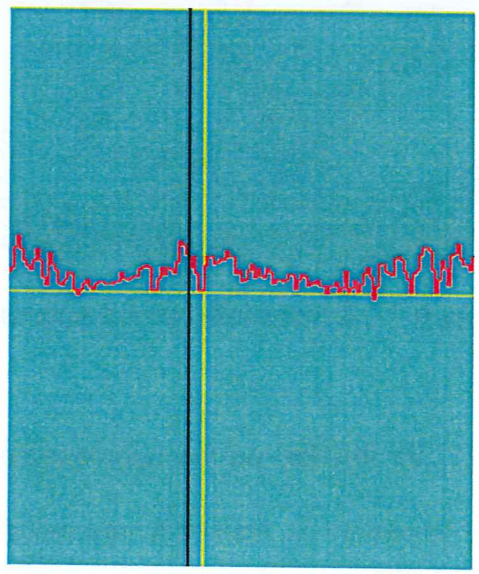


Figura 15, Imagen de Sonar de Antiguo Cauce de Río, área anomalía magnética 3
(Tomado del informe de Fontánez 2006)



-La anomalía magnética número 4 se localizó en las coordenadas latitud N18°27.1496' longitud W66°00.9027'. Contenía una señal que podía pertenecer a materiales de algún recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana a baja prioridad para investigación adicional. La señal fue bipolar de 5605 gamas con duración de 22 segundos. La investigación subacuática reveló un fondo de arena y algunas rocas a 6.9 metros de profundidad. No se observó materiales ferrosos que pudieran generar la señal. No se encontró evidencia de recursos culturales antiguo asociados a esta anomalía

Figura 16, Anomalía 4



Anomalías Acústicas.

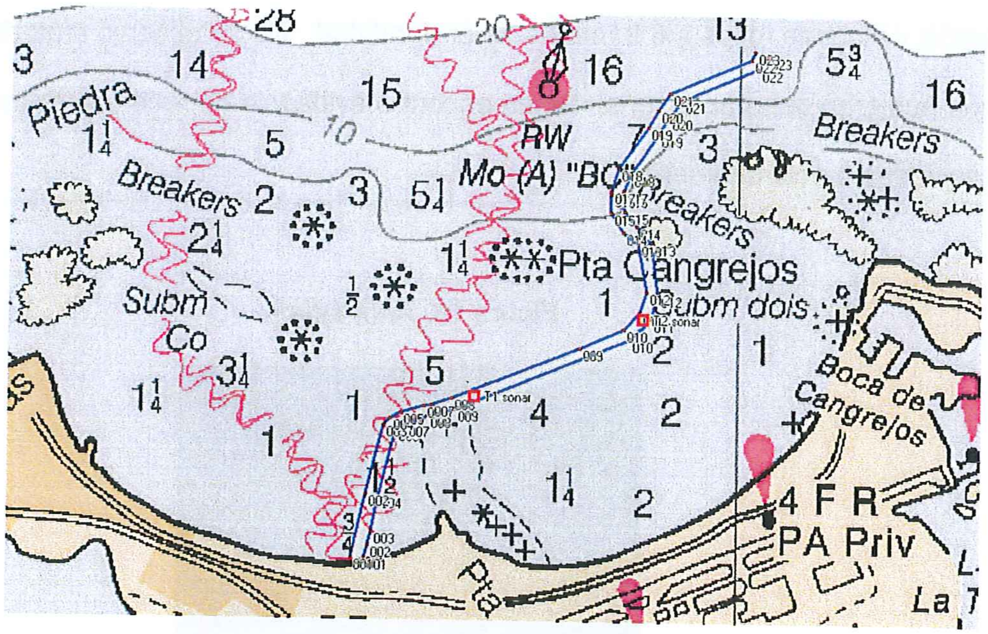
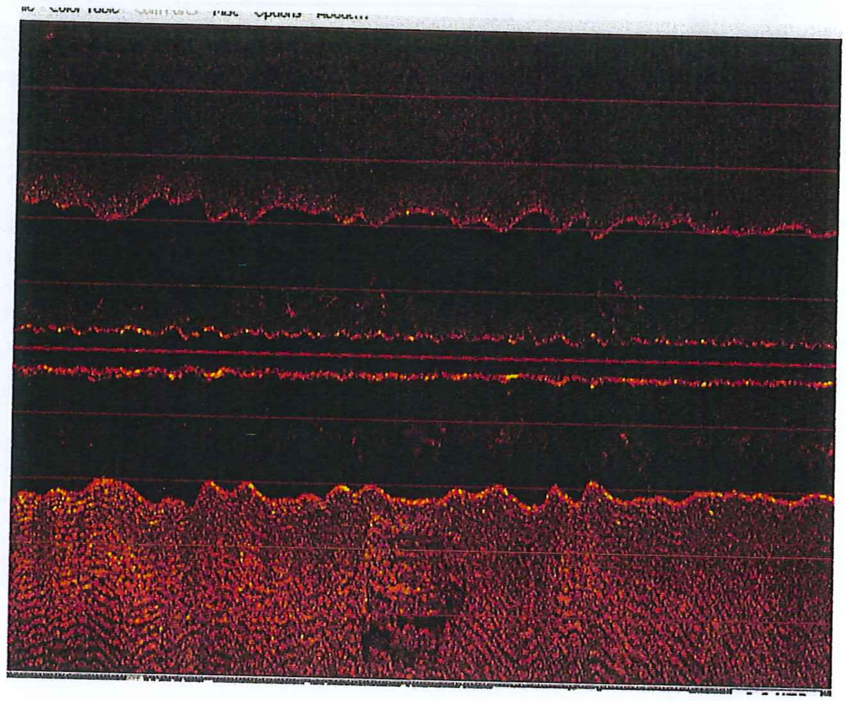


Figura 17, Localización de las Anomalías Acústicas

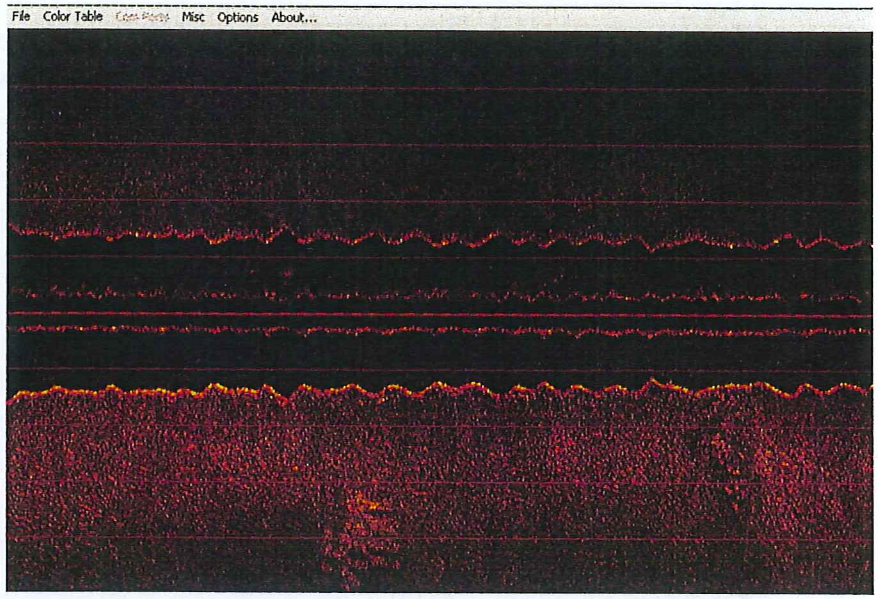
-Anomalía acústica 1. Se localizó en las coordenadas latitud N18° 27.158' longitud W66° 00.886' en el transecto 2. Contenía una señal con características que podía pertenecer a materiales de un pecio u otro recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana prioridad para investigación adicional. La investigación subacuática reveló que posiblemente la señal fue producida por rocas en un fondo de arena a 4.8 metros de profundidad. No había materiales arqueológicos asociados a esta señal. Visibilidad 30-60 centímetros.

Figura 18, Anomalía 1 sonar



-Anomalía acústica 2. Se localizó en las coordenadas latitud N18° 27.410' longitud W66° 00.316' en el transecto 5. Contenía una señal con características que podía pertenecer a materiales de un pecio u otro recurso cultural potencialmente significativo por lo que fue designada como *target* de mediana a alta prioridad para investigación adicional. La investigación subacuática reveló que posiblemente la señal fue producida por un promontorio rocoso en un fondo de arena a 6.6 metros de profundidad. No había materiales arqueológicos asociados a esta señal. Visibilidad de 0.3-1 metro.

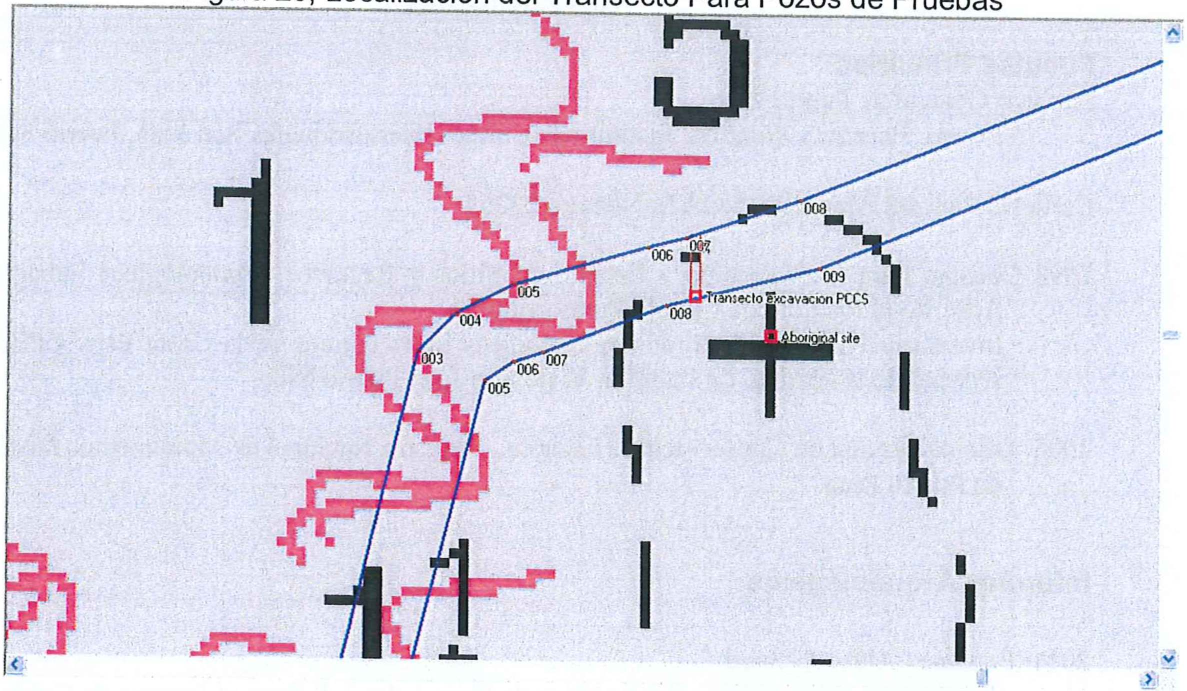
Figura 19, Anomalía 2 sonar



Pozos de Prueba

El transecto para pozos de prueba se localiza entre las coordenadas latitud N18° 27.0997' longitud W66° 01.0223' y latitudN18° 27.1322' longitud W66° 01.0223', fue de 100 metros de largo en dirección 0 grados norte. Como se mencionó no se realizaron pozos de prueba porque el fondo a lo largo del transecto era rocoso con una capa de arena de grano grueso de 3-5cm de espesor. Se abanicó el sedimento hasta llegar a la roca en múltiples ocasiones. No se encontraron materiales arqueológicos a lo largo de este transecto. La profundidad fue entre 4-6 metros, la visibilidad fue muy limitada para fotografías.

Figura 20, Localización del Transecto Para Pozos de Pruebas



Conclusión y Recomendaciones

En la prospección con sensor remoto, inspecciones visuales o inspección del transecto de excavación no se encontró evidencia cultural sumergida que indique un posible impacto a recursos arqueológicos durante la instalación del cable dentro de los límites del área de estudio. Se recomienda que se proceda con la instalación del cable de fibra óptica PCCS en Carolina con la condición de monitoreo arqueológico durante toda las actividades de deposición en la playa y terrenos subacuáticos así como en los procesos de estabilización submarina de los cables (*steel pipes*, anclajes y otros). La recomendación de monitoreo se justifican por los numerosos sitios arqueológicos identificados cerca del corredor donde discurrirá el cable y pasadas experiencia donde se han impactado sitios arqueológicos durante los procesos de instalación.

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JOINT PERMIT APPLICATION
for the
BRUSA Cable System

Exhibit 7:

Marine Archaeological Baseline Conditions

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