Mona Passage 280 m – SeaBed AUV photo 2015

Puertorrican Coral Reefs:

far more than meets the eye

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DNER, 2015

Presentation Overview

- Review of historic and recent exploration and characterization of deep, cold, aphotic coral reefs
- Research synthesis on mesophotic coral reefs ecosystems and communities
- Status of shallow (neritic) coral reefs from natural reserves in PR – inferences from the monitoring program (1999 – 2014)

Research Background

Mona Passage 260 m – SeaBed AUV photo 2015

1873 H. M. S. Challenger Expedition (St. Thomas, USVI)

1877R/V Blake Expedition to the Caribbean Sea (dredging surveys)

1880's R/V Albatross Expedition to the Caribbean Sea

1879 R/V Fish Hawk (USFC) Expedition to the Caribbean Sea

1920-1930's R/V Dana, R/V Pawnee and the R/V Atlantis

1933Johnson- Smithsonian (Caroline) Expedition to the Puertorrican Trench

1950's - 60's R/V Oregon, R/V Silver Bay

1960's – 2000's Deep sea sampling expeditions to the Caribbean Sea by the U. Miami (RSMAS)

1972-1986 Exploratory surveys of deep sea snapper/grouper fisheries (NMFS/NOAA, DNER, CFMC)

1985 Seward Johnson Sea-Link submersible survey

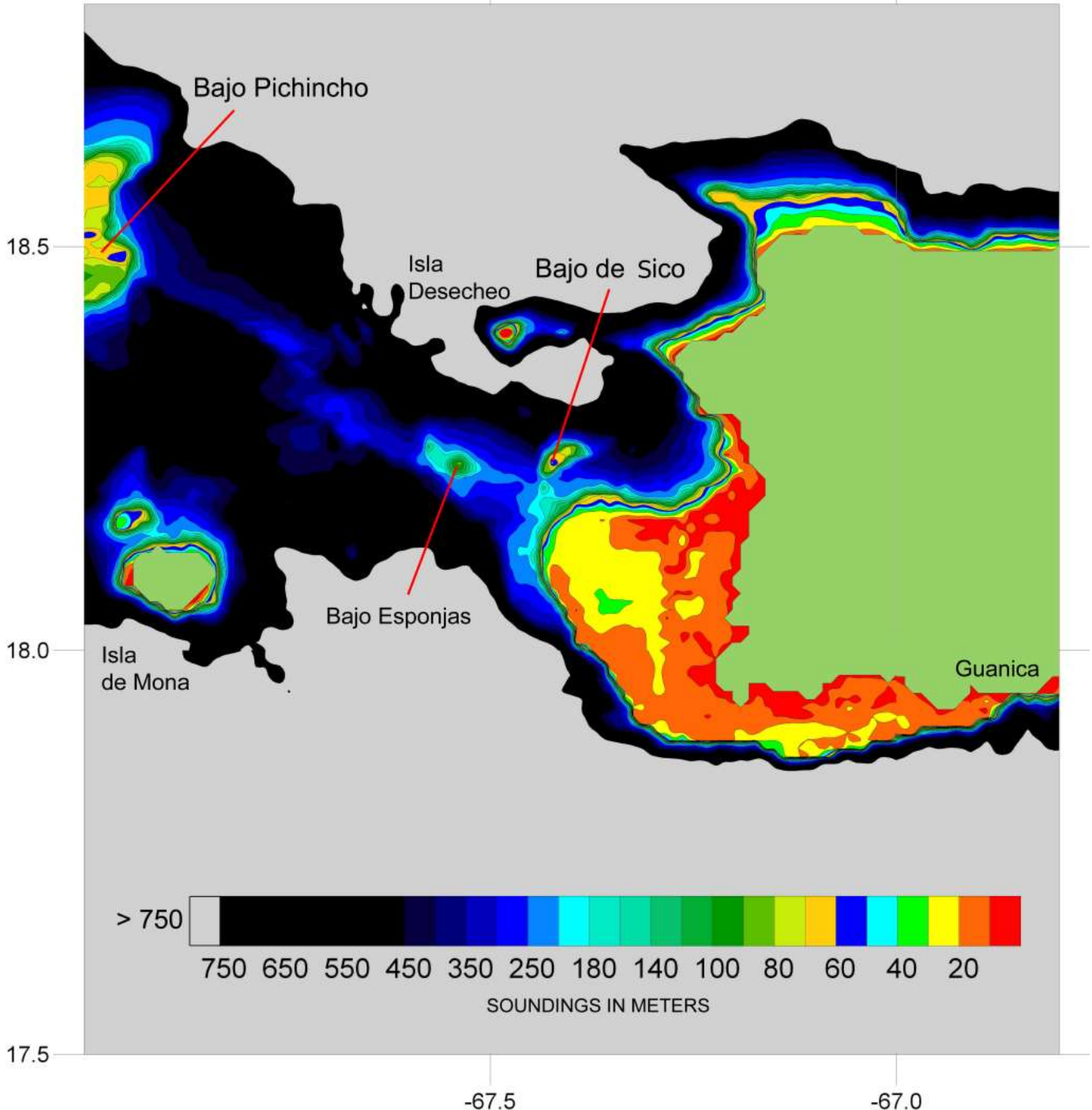
2015 R/V Okeanus Geological/biological deep seafloor characterization (mostly PR Trench, basin)

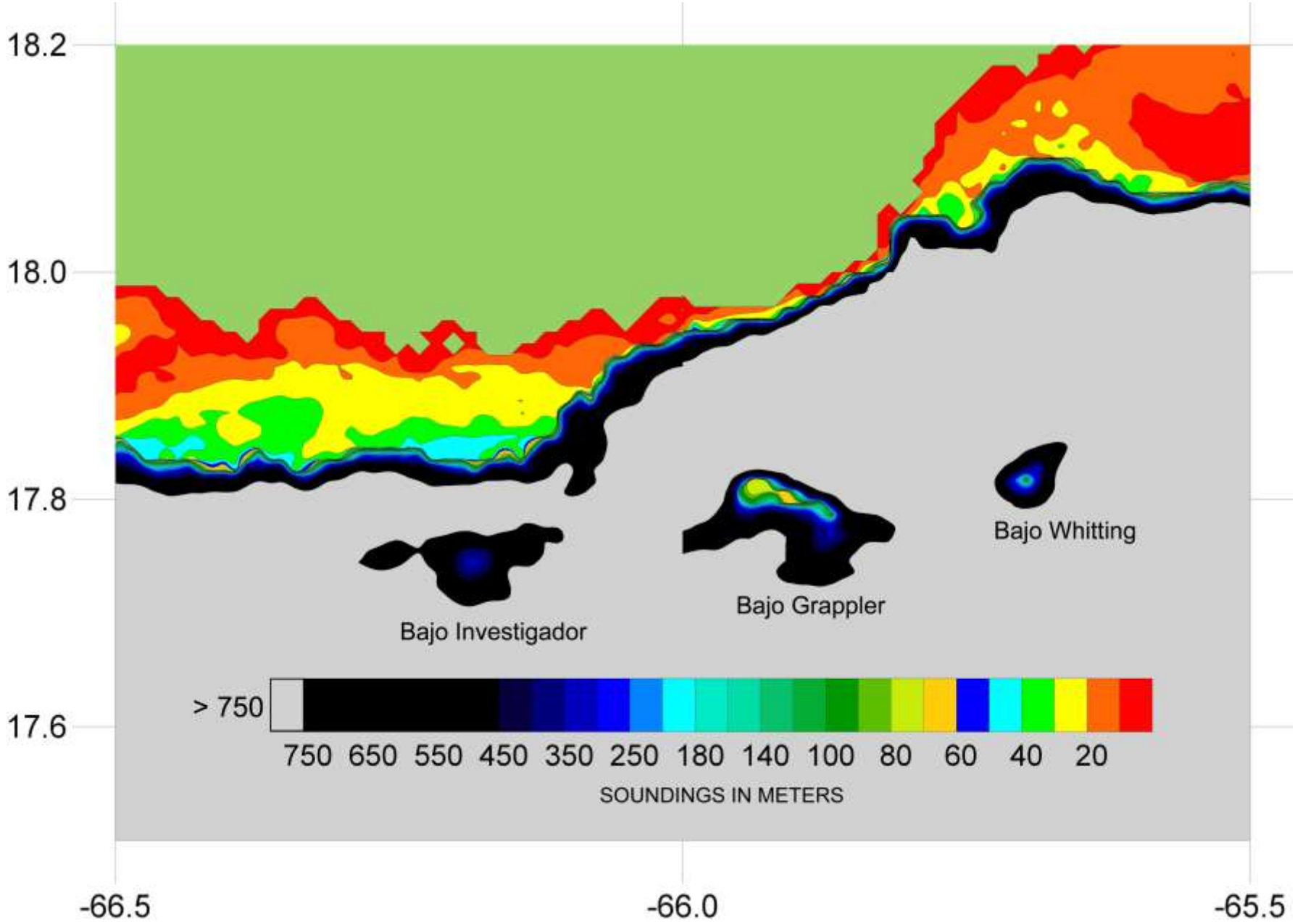
2015 R/V Sultana qualitative/quantitative assessments of substrate cover, density of demersal biota and benthic habitat characterizations (CFMC-NOAA)

Mona Passage 280 m – SeaBed AUV photo 2015

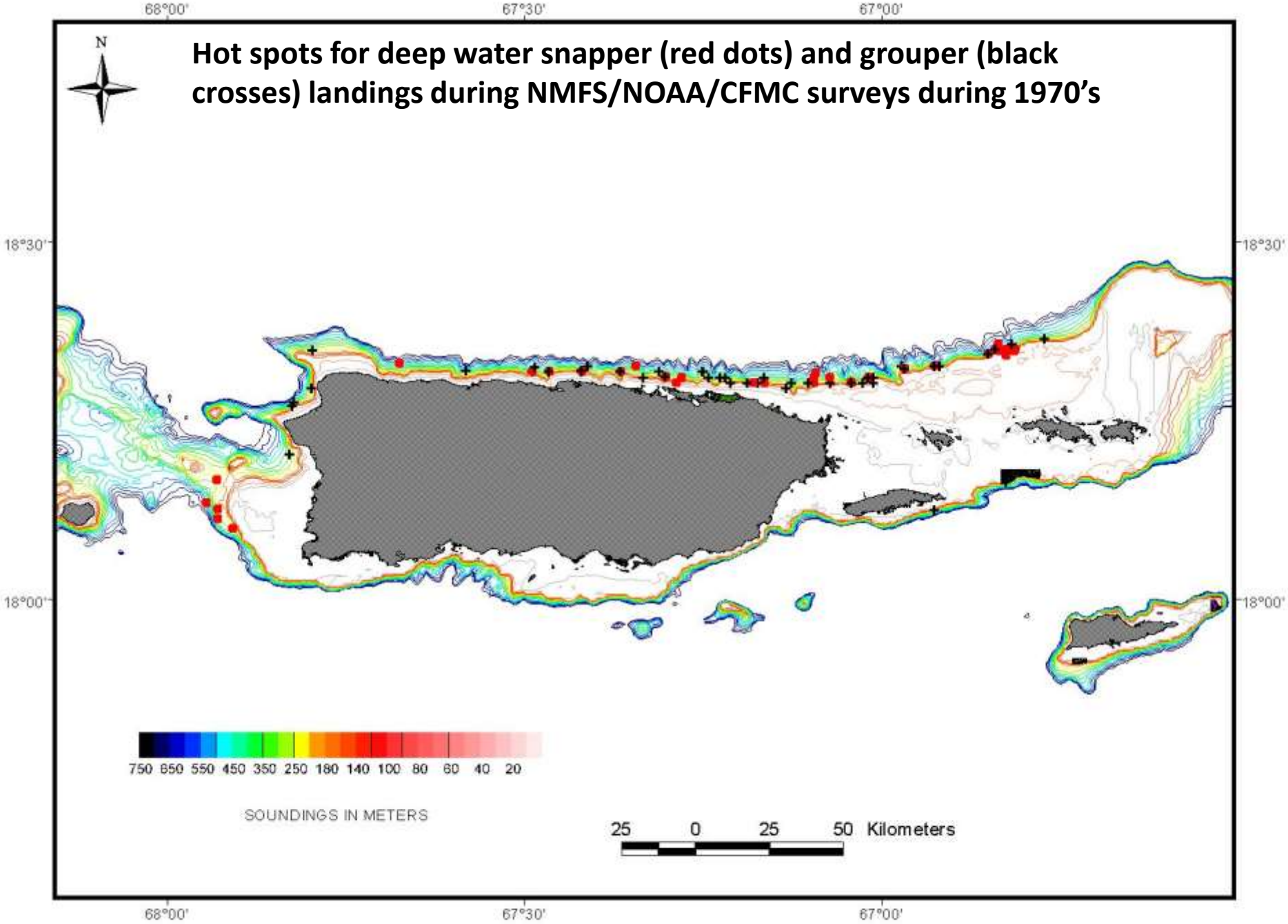
Deep cold aphotic reefs

- Deeper than 150 m, < 20 ^{0}C, no light, w/i SUW and NACW
- Associated with the insular slope, volcanic seamounts and ridges along the southern Puertorrican fault
- Habitats of the deep water snapper/grouper assemblage of primary relevance for Puertorrican fisheries
- Prime fishing grounds for migratory pelagic fisheries (marlin, mahi-mahi, tunas, mackerel, etc).
- high biodiversity
  - azooxanthellate coral species 129 spp in western tropical Atlantic, incl. 85 for PR and the USVI


Bajo Pichincho
Isla
Desecheo
Bajo de Sico
Bajo Esponjas
Isla
de Mona
Guanica
18.5
18.0
17.5
-67.5
-67.0
> 750
750 650 550 450 350 250 180 140 100 80 60 40 20
SOUNDINGS IN METERS


18.2
18.0
17.8
17.6
-66.5
-66.0
-65.5
Bajo Investigador
Bajo Grappler
Bajo Whitting
> 750
750 650 550 450 350 250 180 140 100 80 60 40 20
SOUNDINGS IN METERS

Hot spots for deep water snapper (red dots) and grouper (black crosses) landings during NMFS/NOAA/CFMC surveys during 1970's



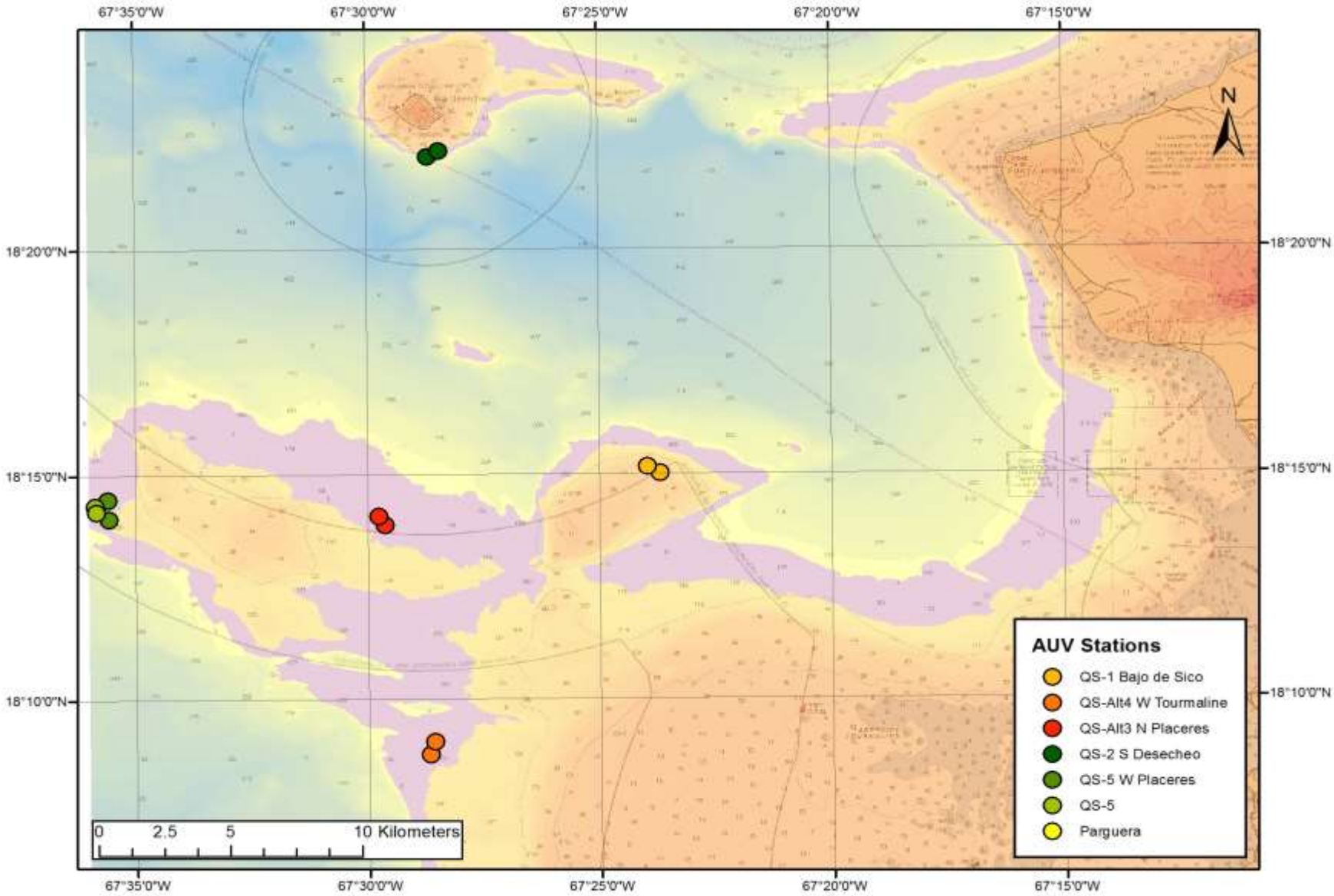

67°35'0"W
67°30'0"W
67°25'0"W
67°20'0"W
67°15'0"W
18°20'0"N
18°15'0"N
18°10'0"N
N
AUV Stations
QS-1 Bajo de Sico
QS-Alt4 W Tourmaline
QS-Alt3 N Placeres
QS-2 S Desecheo
QS-5 W Placeres
QS-5
Parguera
0 2.5 5 10 Kilometers

Table 7. QS – 5 (N – S). Placeres W. Percent cover by substrate categories and densities of predominant biota within the transect area photographed by the SeaBed AUV at Bajo Placeres W during Feb 2015. Depth range: 260 – 280 m.

Total photos analyzed: 91		**Total Area: 647.9 m^2**
SUBSTRATE CATEGORY	**% Substrate Cover Mean**	**Density** (# col/100m^2)
Total Abiotic	**64.02**	
Total Sponges	**5.75**	**40.4**
Ahermatypic Coral		
Unknown	4.74	33.29
Lophelia or *Oculina*	2.95	20.72
White polyps	1.81	12.71
Enallopsamma profunda	1.53	10.74
Madrepora oculata	0.34	2.39
Bamboo coral	0.1	0.70
Total Ahermatypic Coral	**11.47**	**80.6**
Antipatharians		
Bathypathes sp.	2.66	18.68
Unknown	0.62	4.35
Planular black coral	0.05	0.35
Short bushy black coral	0.03	0.21
Tall bushy coral	0.03	0.21
Total Antipatharians	**3.38**	**23.7**
Hydrocorals an Octocorals	**0.41**	**2.8**

TOTAL CORALS **15.3 % of total area, 42.5 % of hard bottom**

(modified from Garcia-Sais et al., 2015)

Mesophotic Coral Reefs

Distributed in the 30 – 150 m depth range at the edge of the SML and the SUW
Shelf-edge and upper insular slopes, deep outer shelf and oceanic island basins, upper seamount ranges

Spawning aggregation sites for many commercially important reef fishes

Foraging habitats of many highly migratory fishes that are commercial and recreational targets

Residential habitats and perhaps, the last refugee for many overfished large demersal fishes

Foraging habitats for Hawksbill turtles

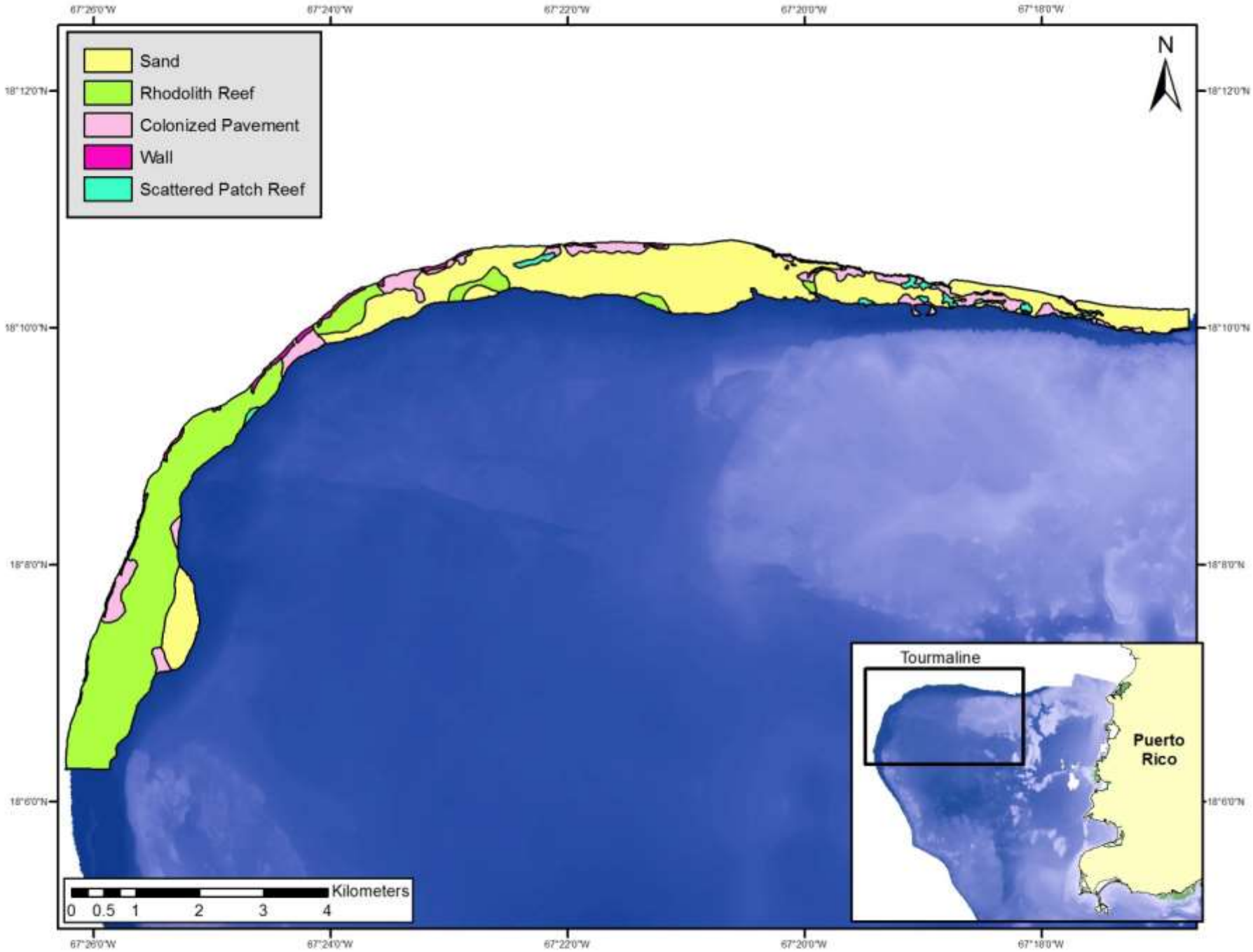
Most important habitat for Boulder Star Coral, *Orbicella franksi*, black corals (Antipatharia)

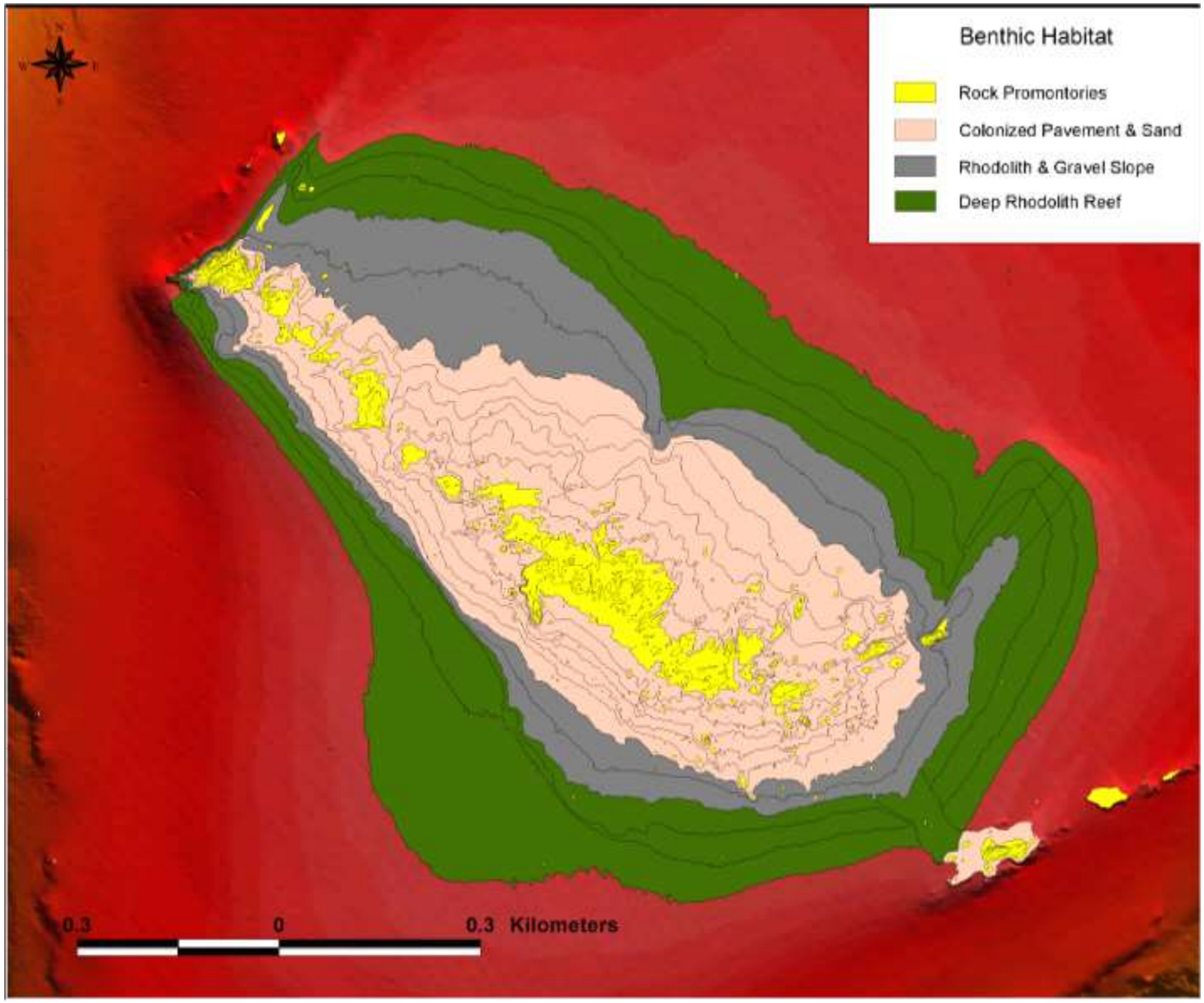
Genetic reservoir of many shallow water corals and commercially exploited fish and shellfish (Queen conch)

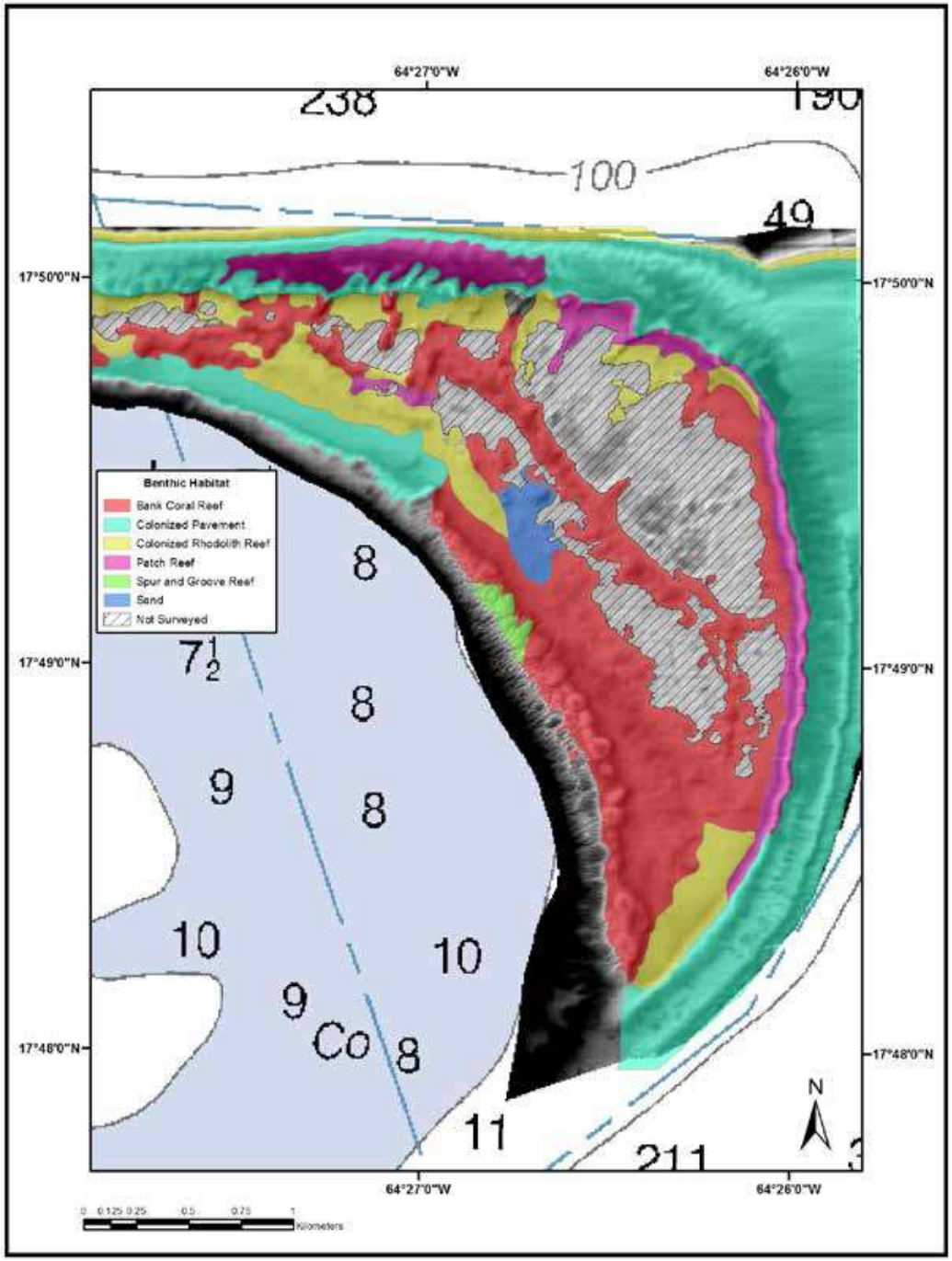
Includes some of the most extensive coral reef systems, El Seco – Vieques, Lang Bank and MCD, USVI

Largely unaffected by bleaching events

Poorly studied. Baseline characterization surveys and benthic habitat mapping at BDS, ALS, Tour, El Seco – Vieques, Lang Bank and MCD, USVI


Sand
Rhodolith Reef
Colonized Pavement
Wall
Scattered Patch Reef
N
Tourmaline
Puerto Rico
Kilometers
0 0.5 1 2 3 4
67°26'0"W
67°24'0"W
67°22'0"W
67°20'0"W
67°18'0"W
18°12'0"N
18°10'0"N
18°8'0"N
18°6'0"N


Benthic Habitat
Rock Promontories
Colonized Pavement & Sand
Rhodolith & Gravel Slope
Deep Rhodolith Reef
0.3
0
0.3 Kilometers


64°27'0"W
64°26'0"W
17°50'0"N
17°49'0"N
17°48'0"N
100
49
Benthic Habitat
Bank Coral Reef
Colonized Pavement
Colonized Rhodolith Reef
Patch Reef
Spur and Groove Reef
Sand
Not Surveyed
8
8
8
9
10
10
9
Co
8
11
N
0 0.125 0.25 0.5 0.75 1
Kilometers

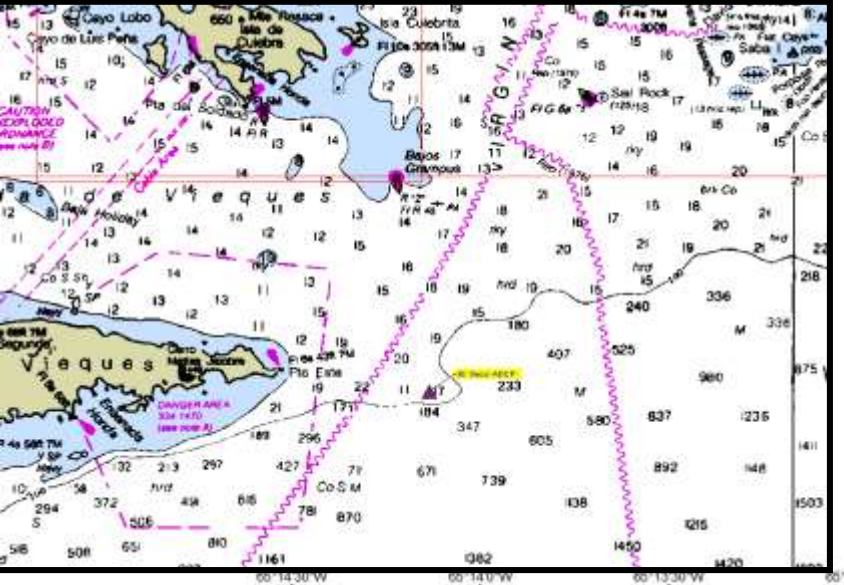
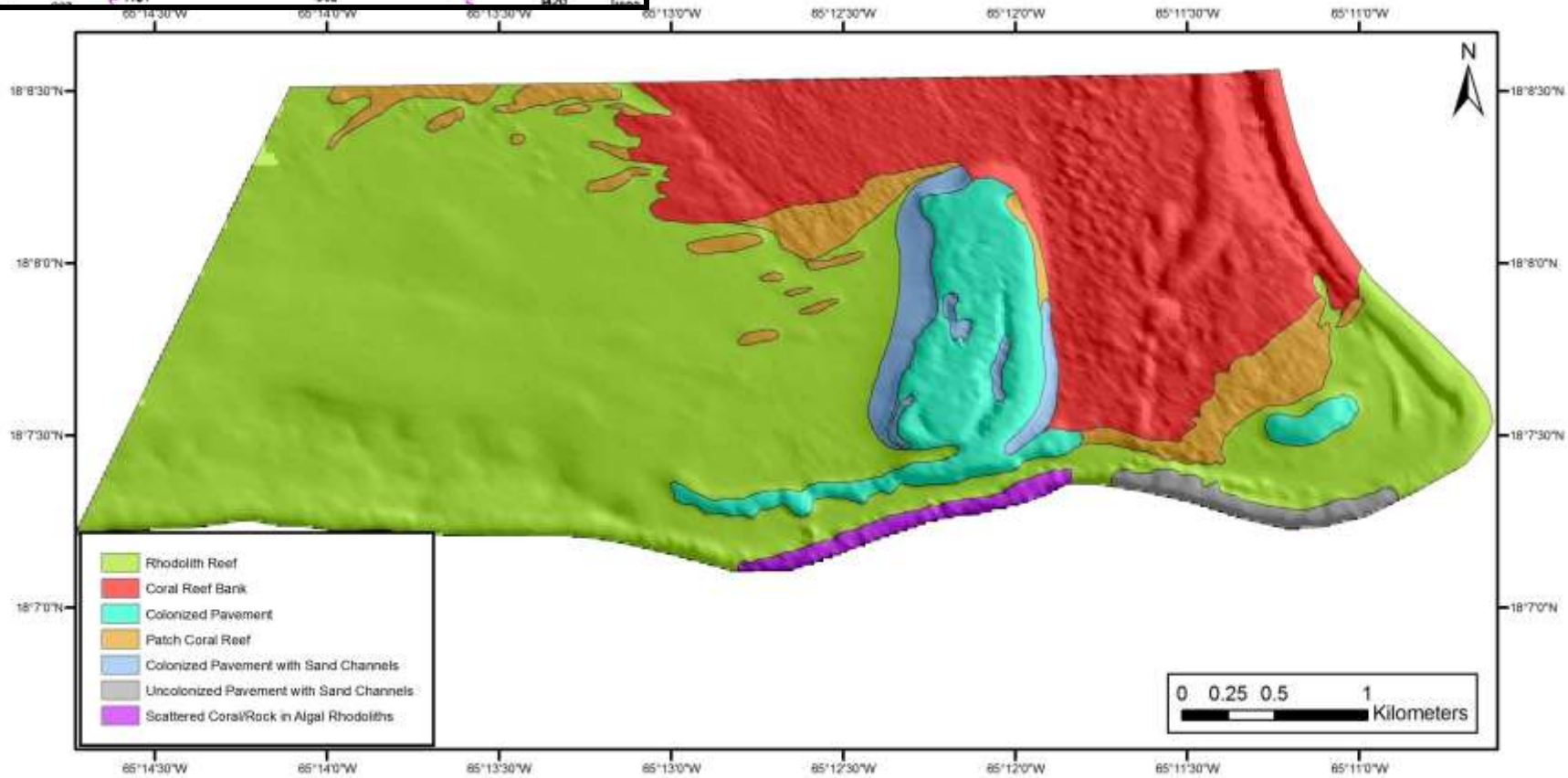
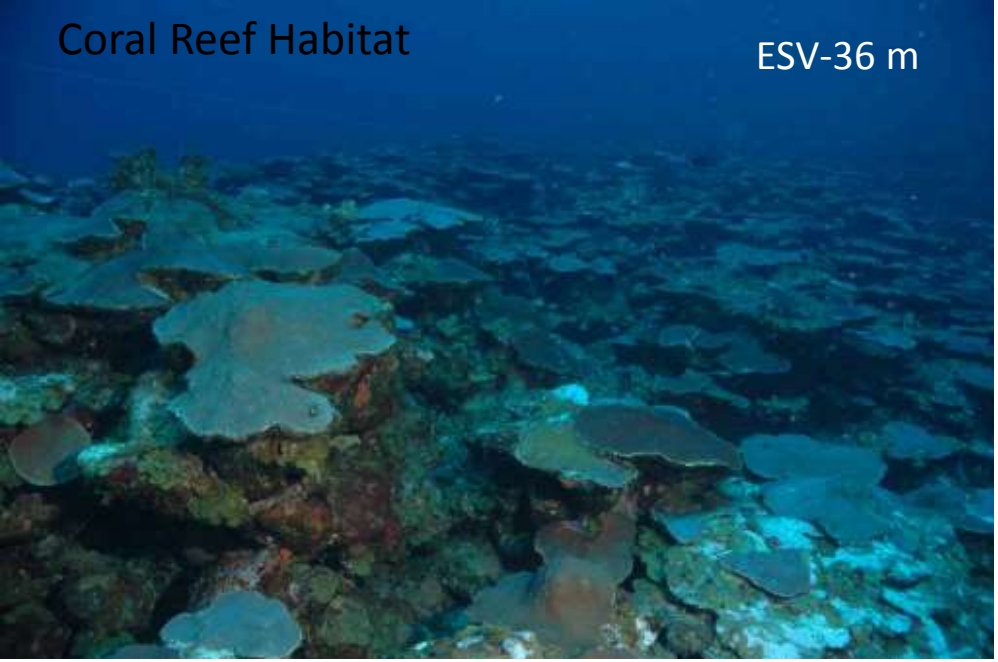


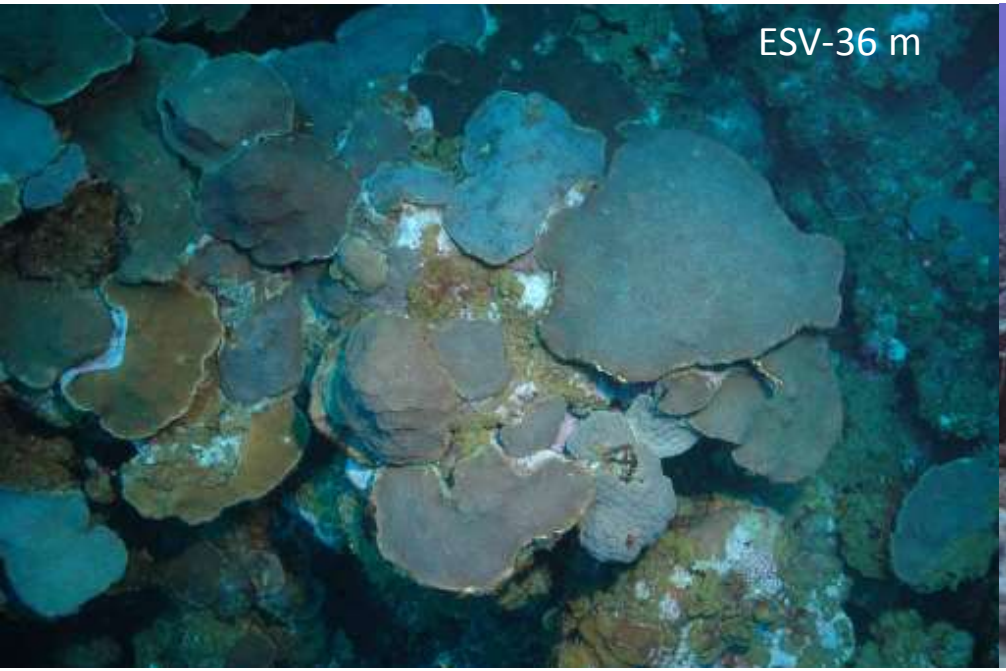
Table 5. Benthic habitat classifications and areal coverage at "El Seco", southeast Vieques

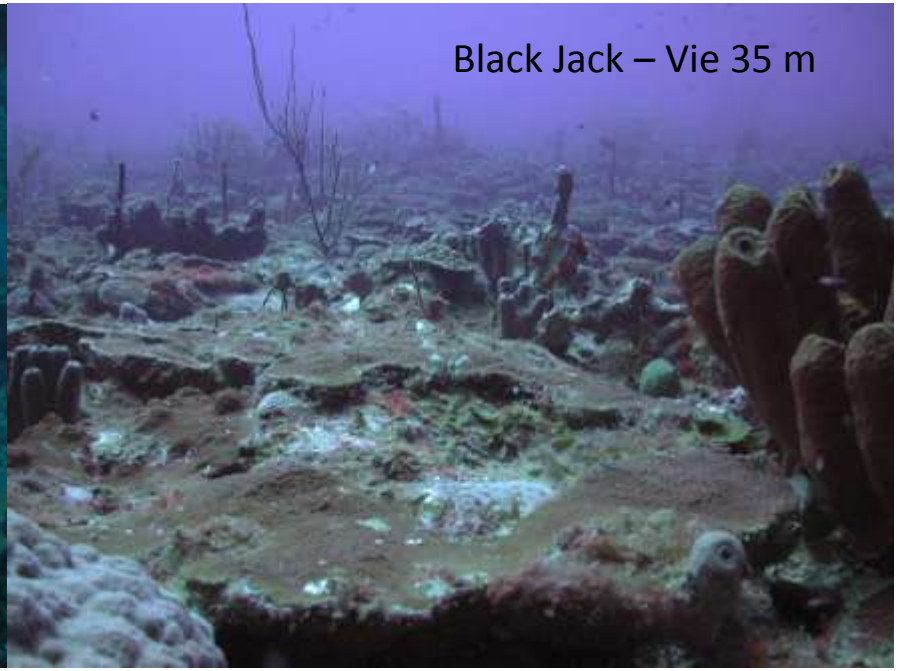
Habitat Type	Area (km2)	Area (Hectares)	%
Rhodolith Reef	8.56	856.2	57.9
Bank Coral Reef	3.68	368.2	24.9
Colonized Pavement	1.08	108.3	7.3
Patch Coral Reef	0.80	79.9	5.4
Colonized Pavement with Sand Channels	0.34	33.9	2.3
Uncolonized Pavement with Sand Channels	0.16	16.5	1.1
Scattered Coral/Rock in Algal Rhodoliths	0.15	15.4	1.0
	14.78	**1478.4**	**100**



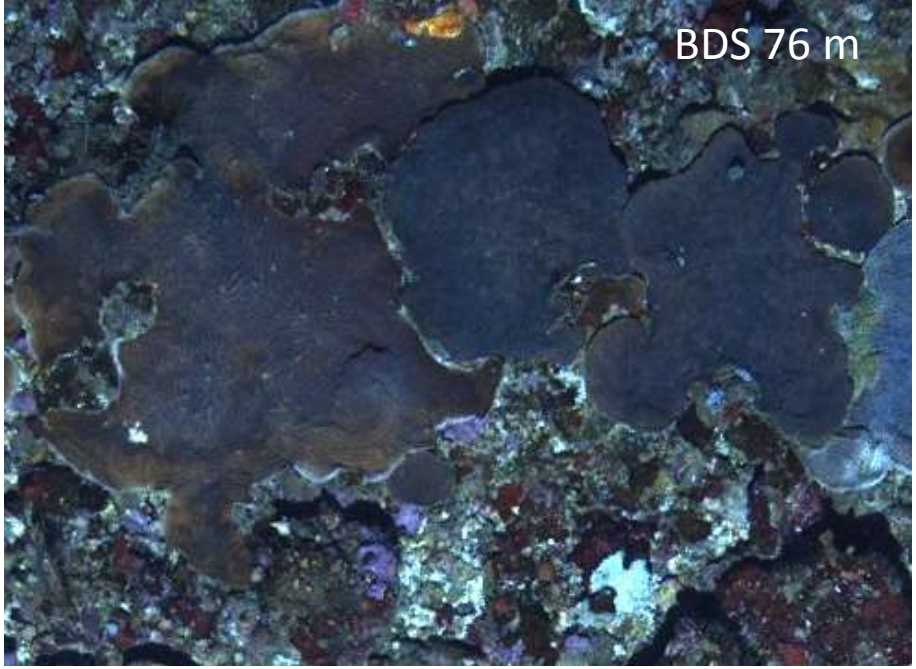
Coral Reef Habitat



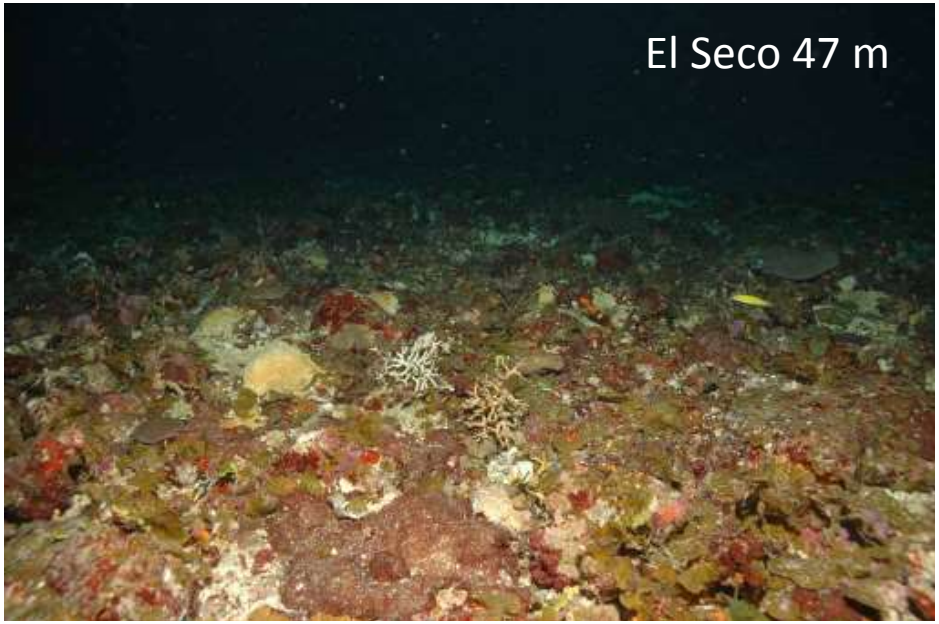




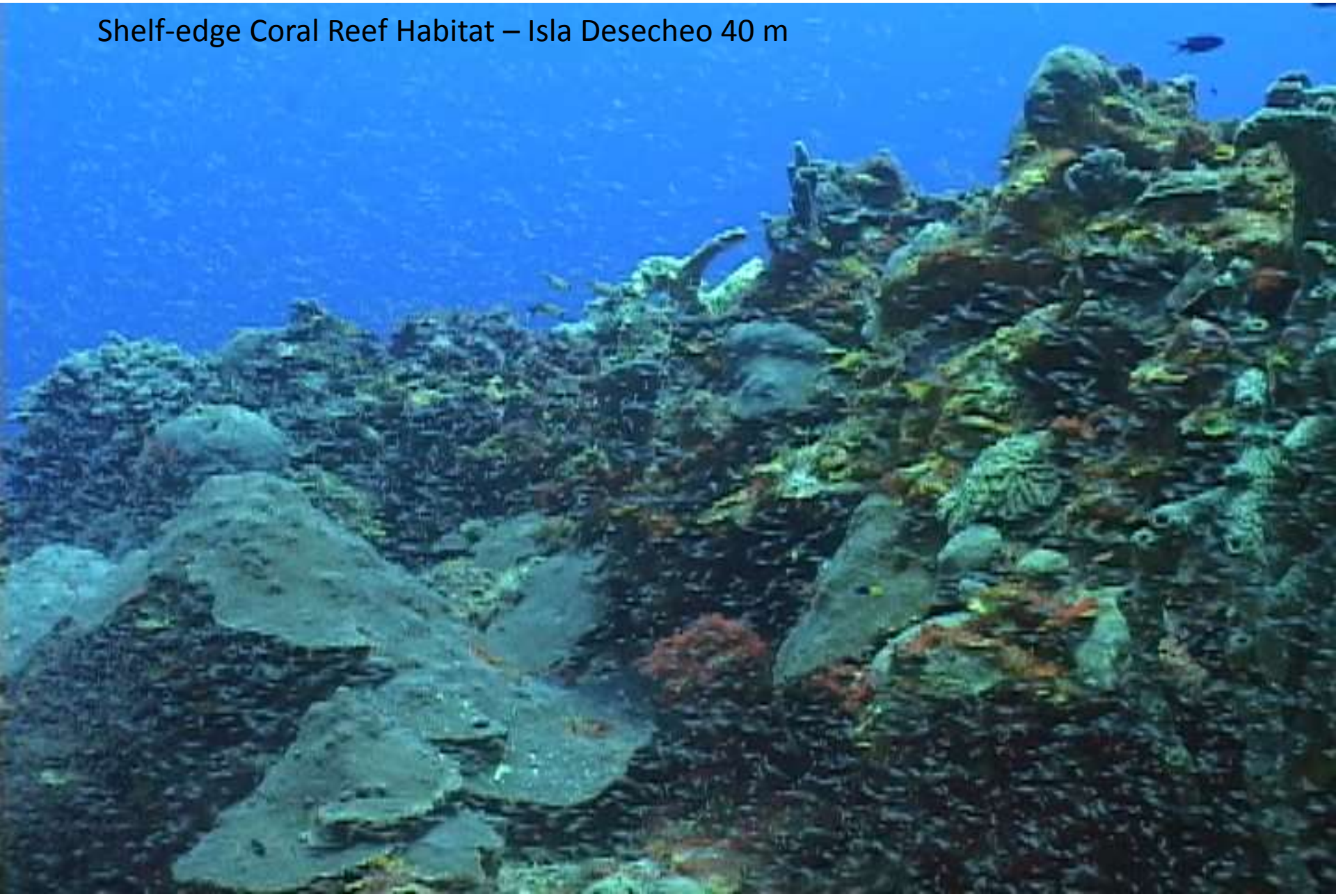
Rhodolith Reef Habitat
Des 50 m


BDS 76 m

El Seco 47 m

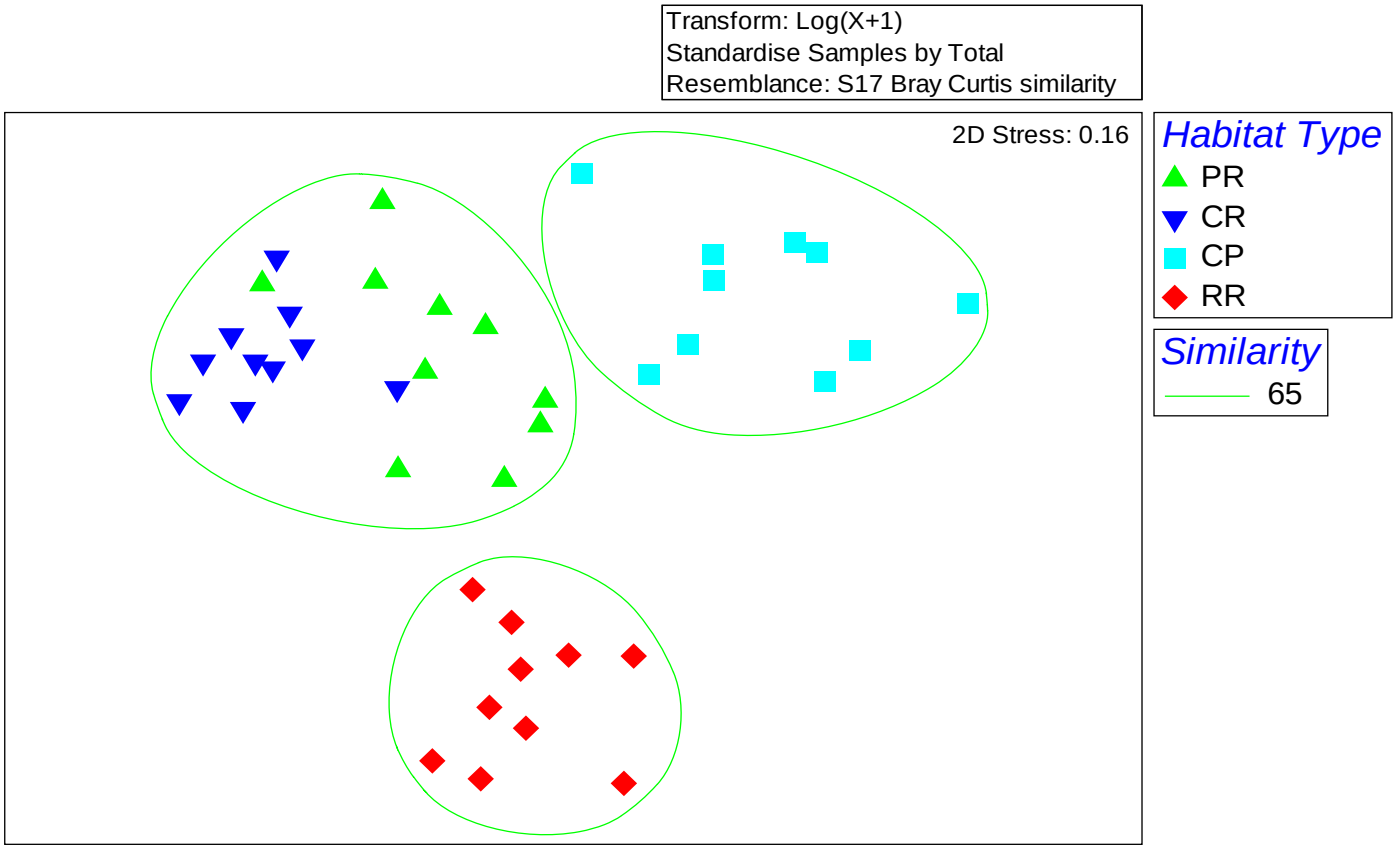

El Seco 47 m

Shelf-edge Coral Reef Habitat – Isla Desecheo 40 m



Reef tops – colonized pavement habitat – El Seco Vieques 35m

Figure 18. Multidimensional scaling plot of Bray-Curtis similarities between benthic habitats based on the data of percent substrate cover by sessile-benthic categories on photo-transects at El Seco, southeast Vieques. 2010-11



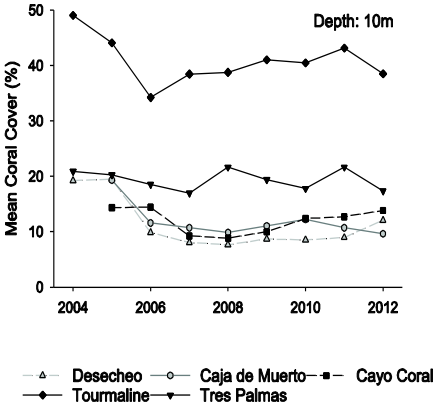
Shallow (neritic) Coral Reefs

- Coral reefs distributed on the insular shelf at depths 1 – 30 m.
- 42 reef stations from 14 DNER Natural Reserves included in the PR (State) Coral Reef Monitoring Program
- Baseline characterizations started in 1999-2001
- Sampling design follows a geographic, distance from shore and depth stratified non-random approach based on a set of 5 permanent 10 m long transects set up in reef zones of optimal coral growth.
- Annual/bi-annual monitoring of percent reef substrate cover by sessile-benthic categories and taxonomic composition and density of fishes and motile megabenthic invertebrates within 10 x 3 m belt-transects (visual surveys)
- Extension to 20 x 3 m belt-transects for density and size distribution surveys of fishes of commercial value, including parrotfishes
- Mean coefficient of variation for percent substrate cover by live corals at 28 %

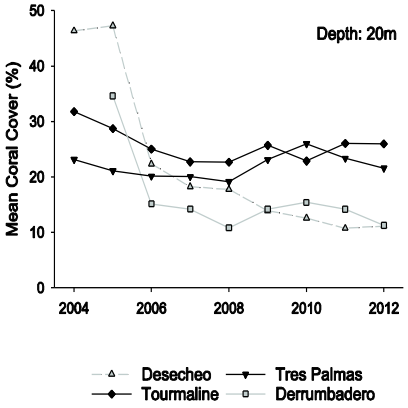
Status and Trends

- Coral reef systems located at the outer shelf (Derrumbadero, La Boya - LP, Media Luna and Turrumote – LP), oceanic islands (Desecheo, Mona) and east coast islands (Cordillera de Fajardo, Vieques) presented the highest percent of live coral cover during the baseline surveys.
- Live coral cover remained stable at most reefs during the monitoring program until 2006, when a variable decline of live coral was measured on the majority of the reef stations surveyed after a severe regional coral bleaching event affected reef systems of Puerto Rico and the U. S. Virgin Islands during late 2005.
- The decline of (total) live coral cover was largely driven by mortality of Boulder Star Coral, *Orbicella annularis*, a highly dominant species in terms of reef substrate cover and the principal reef building species.
- Live coral loss was highest amongst oceanic (Mona, Desecheo), shelf-edge (Derrumbadero) and east coast island reefs (Vieques), with maximum losses above 20 m depths. In general, coral mortality declined with increasing depth, towards the coast, and towards the west at similar depths. Reefs dominated by *Acropora palmata*, *Porites porites* and *Montastraea cavernosa* were the least affected.
- Mesophotic reef stations were not affected
- Phase shifts of coral species dominance (% cover) and recuperation of total live coral cover since 2006 to the present have been measured on coastal and estuarine influenced reefs, suggesting that water turbidity has played an important role in the degradation and recuperation of shallow water (neritic) reefs of PR

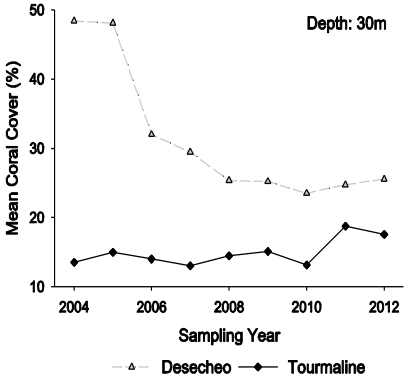
a.

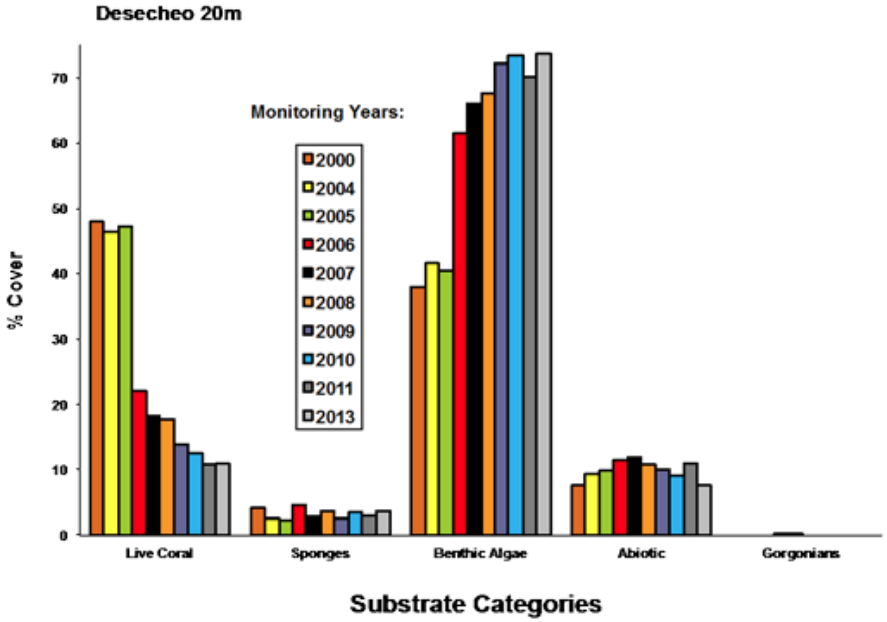

Depth: 10m
Mean Coral Cover (%)
0
10
20
30
40
50
2004
2006
2008
2010
2012
Desecheo
Caja de Muerto
Cayo Coral
Tourmaline
Tres Palmas

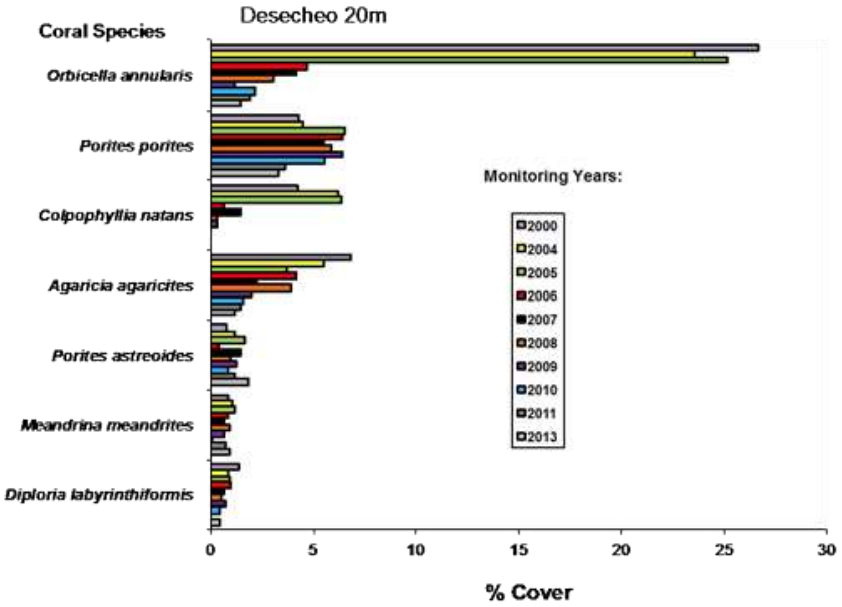
b.

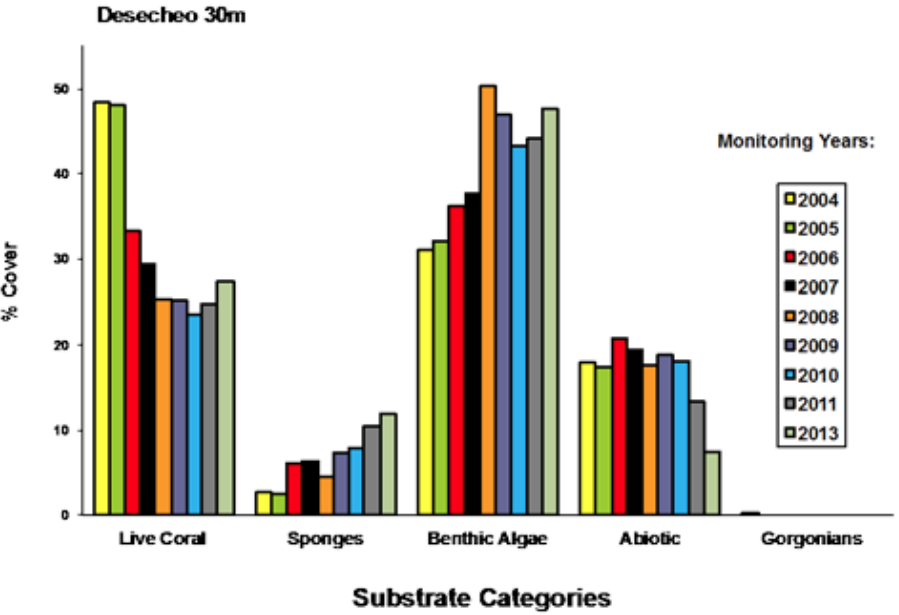

Depth: 20m
Mean Coral Cover (%)
0
10
20
30
40
50
2004
2006
2008
2010
2012
Desecheo
Tres Palmas
Tourmaline
Derrumbadero

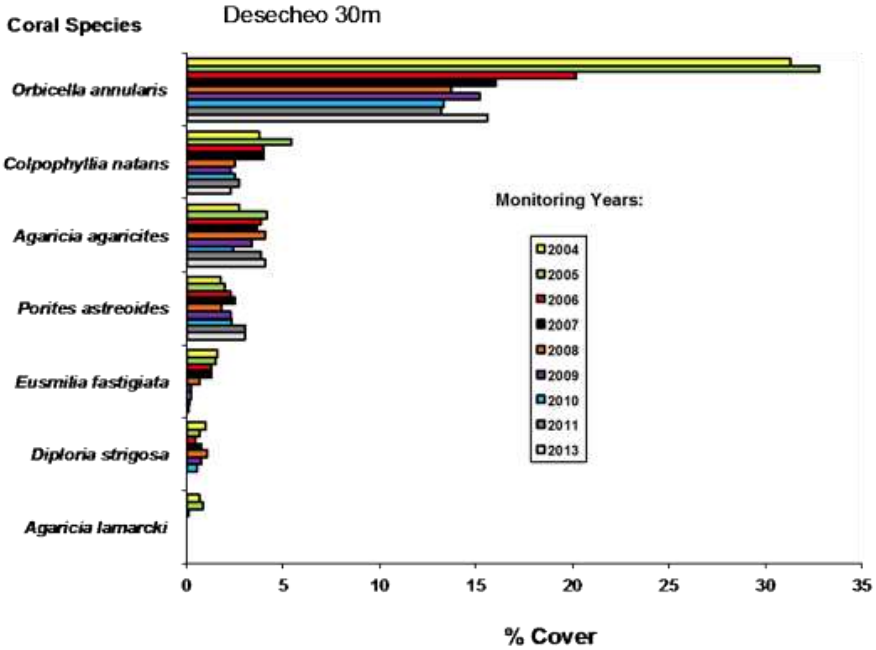
c.

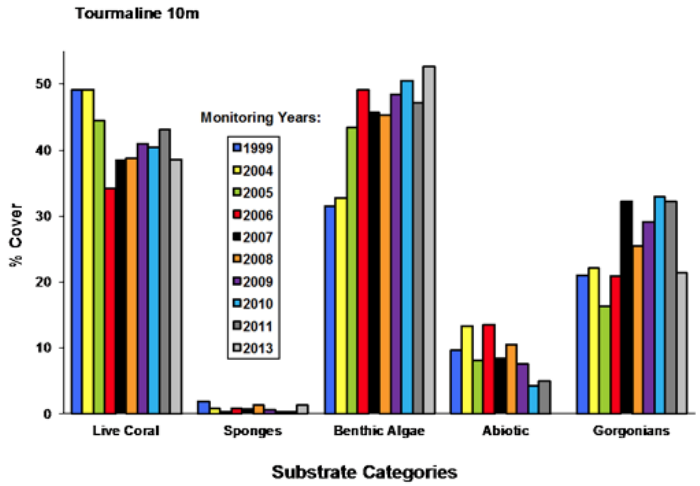

Depth: 30m
Mean Coral Cover (%)
10
20
30
40
50
2004
2006
2008
2010
2012
Sampling Year
Desecheo
Tourmaline

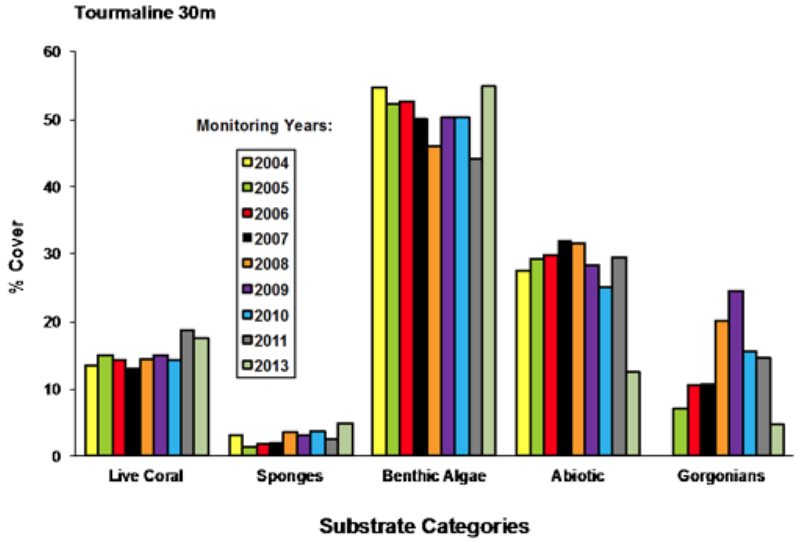

Desecheo 20m
Monitoring Years:
2000
2004
2005
2006
2007
2008
2009
2010
2011
2013
% Cover
0
10
20
30
40
50
60
70
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

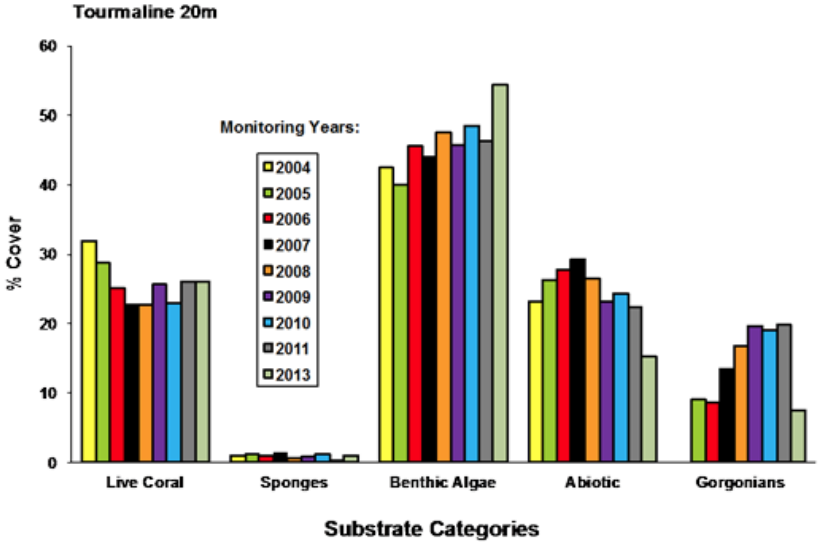

Desecheo 20m
Coral Species
Orbicella annularis
Porites porites
Colpophyllia natans
Agaricia agaricites
Porites astreoides
Meandrina meandrites
Diploria labyrinthiformis
Monitoring Years:
2000
2004
2005
2006
2007
2008
2009
2010
2011
2013
0
5
10
15
20
25
30
% Cover

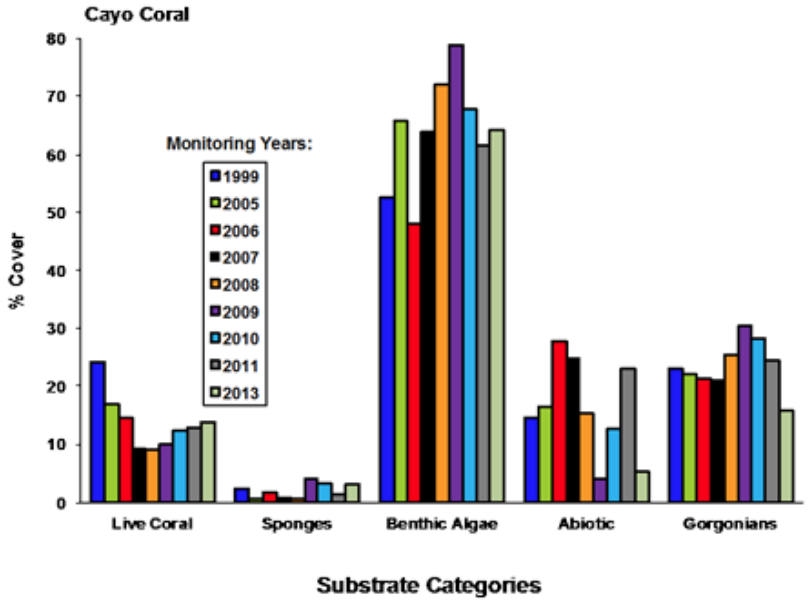

Desecheo 30m
Monitoring Years:
2004
2005
2006
2007
2008
2009
2010
2011
2013
% Cover
0
10
20
30
40
50
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

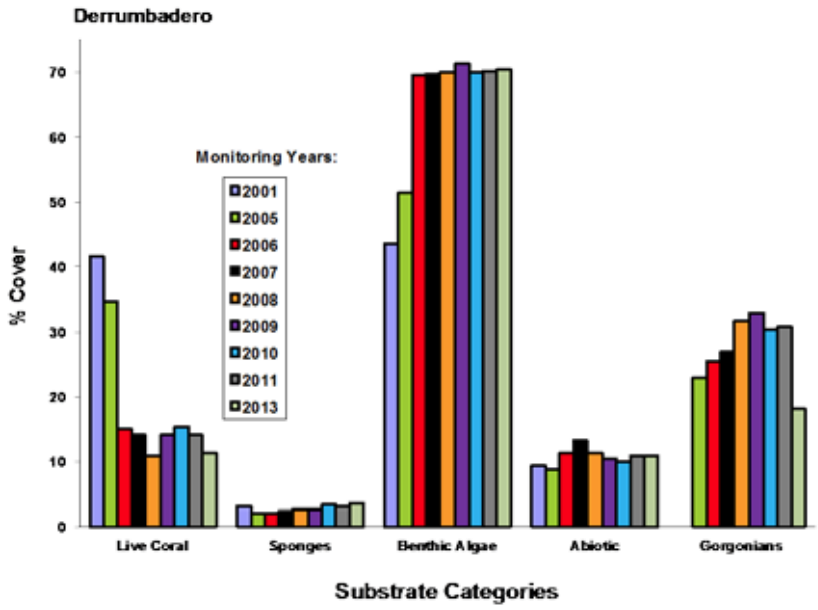

Desecheo 30m
Coral Species
Orbicella annularis
Colpophyllia natans
Agaricia agaricites
Porites astreoides
Eusmilia fastigiata
Diploria strigosa
Agaricia lamarcki
Monitoring Years:
2004
2005
2006
2007
2008
2009
2010
2011
2013
0
5
10
15
20
25
30
35
% Cover

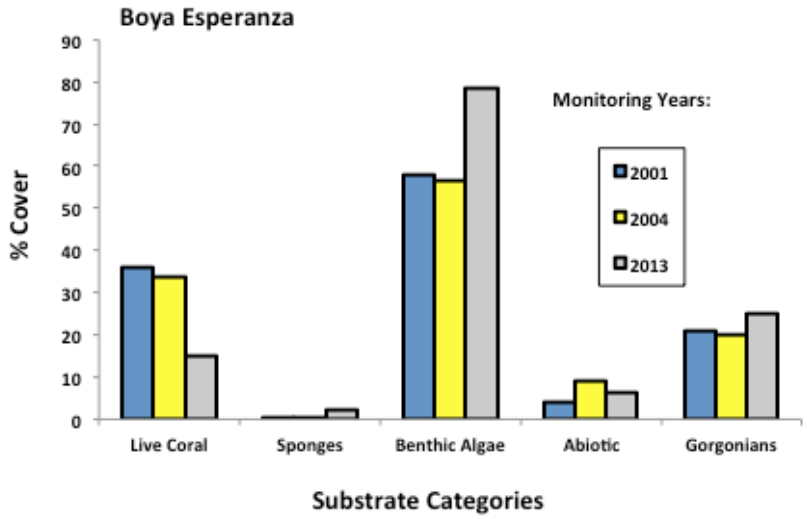

Tourmaline 10m
Monitoring Years:
1999
2004
2005
2006
2007
2008
2009
2010
2011
2013
% Cover
0
10
20
30
40
50
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

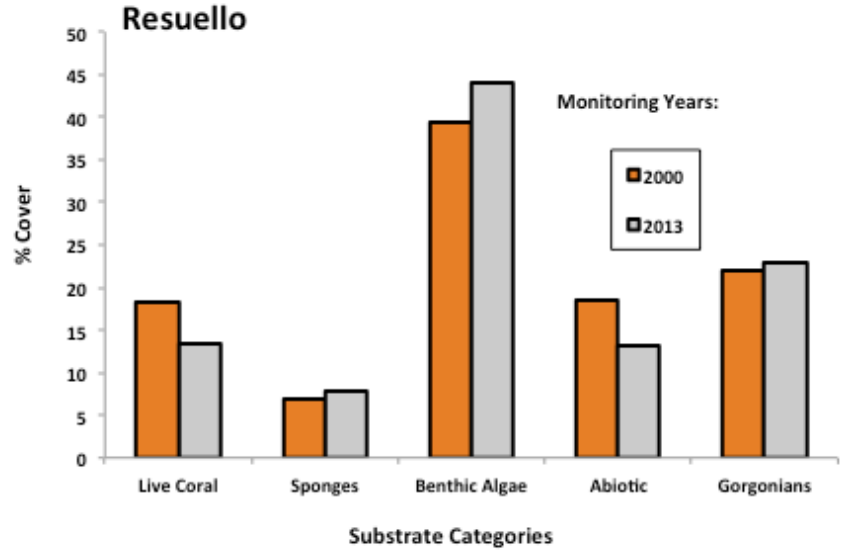

Tourmaline 30m
Monitoring Years:
2004
2005
2006
2007
2008
2009
2010
2011
2013
% Cover
0
10
20
30
40
50
60
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

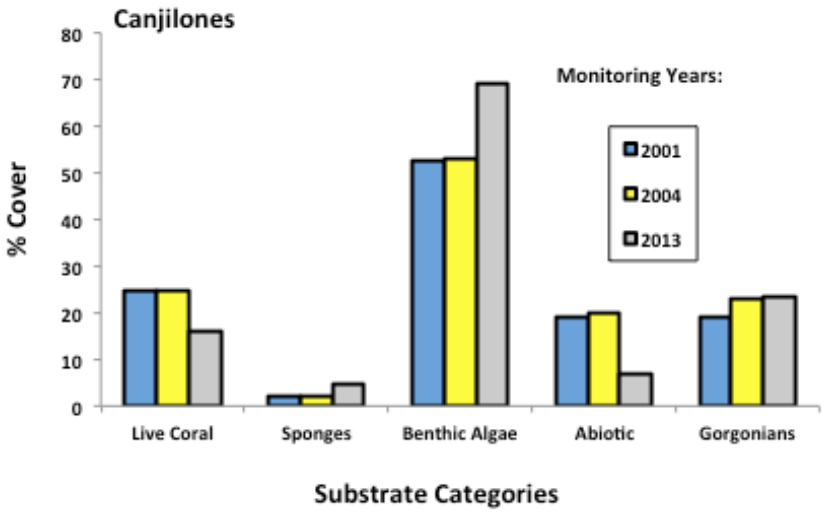

Tourmaline 20m
Monitoring Years:
2004
2005
2006
2007
2008
2009
2010
2011
2013
% Cover
0
10
20
30
40
50
60
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

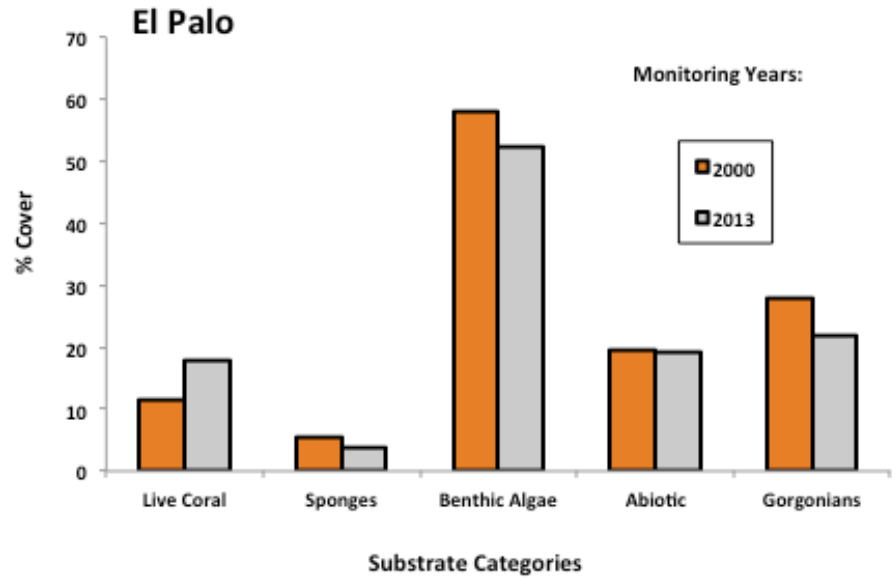

Cayo Coral
% Cover
Monitoring Years:
1999
2005
2006
2007
2008
2009
2010
2011
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories


Derrumbadero
% Cover
Monitoring Years:
2001
2005
2006
2007
2008
2009
2010
2011
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories


Boya Esperanza
% Cover
90
80
70
60
50
40
30
20
10
0
Monitoring Years:
2001
2004
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories


Resuello
% Cover
50
45
40
35
30
25
20
15
10
5
0
Monitoring Years:
2000
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

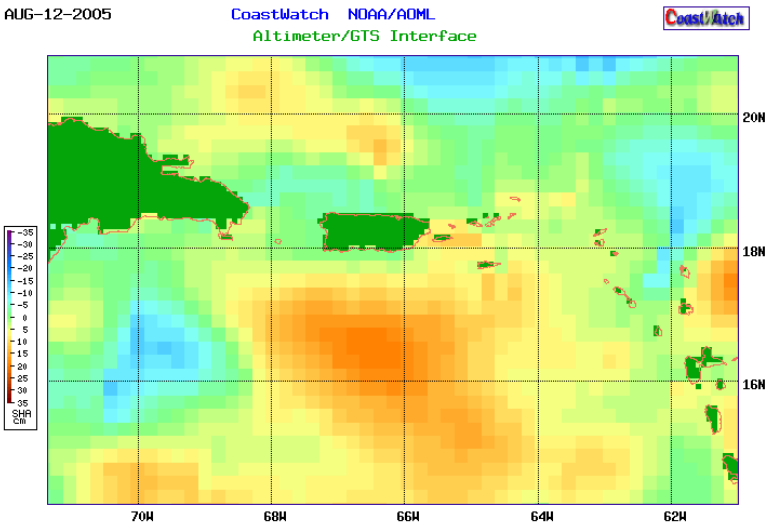

Canjilones
% Cover
80
70
60
50
40
30
20
10
0
Monitoring Years:
2001
2004
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

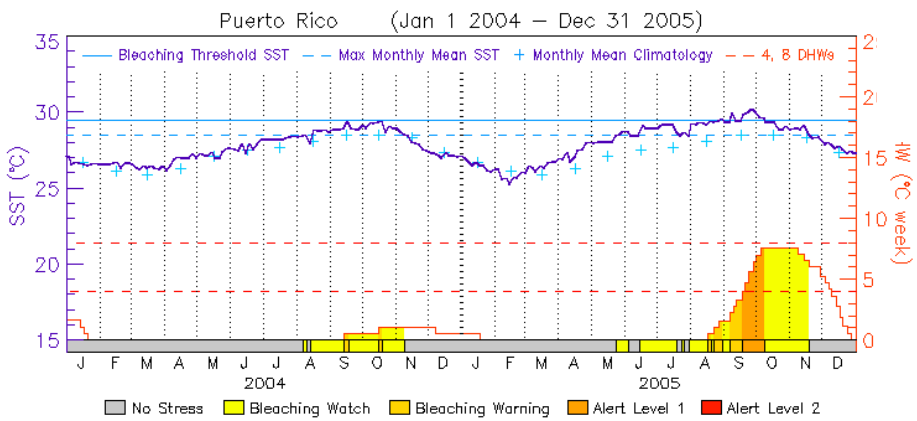

El Palo
% Cover
70
60
50
40
30
20
10
0
Monitoring Years:
2000
2013
Live Coral
Sponges
Benthic Algae
Abiotic
Gorgonians
Substrate Categories

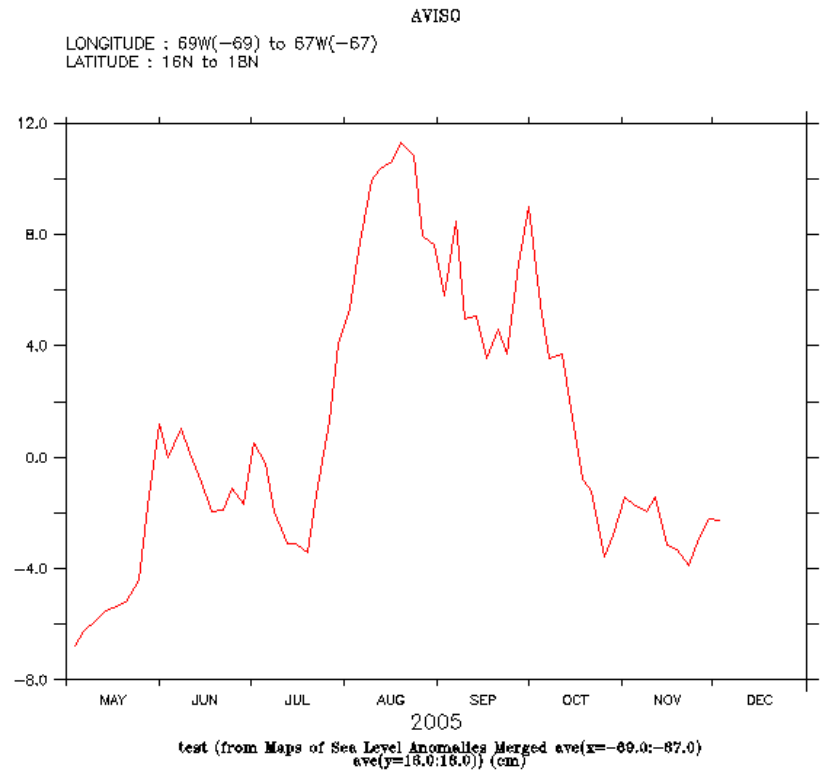
CORAL BLEACHING:

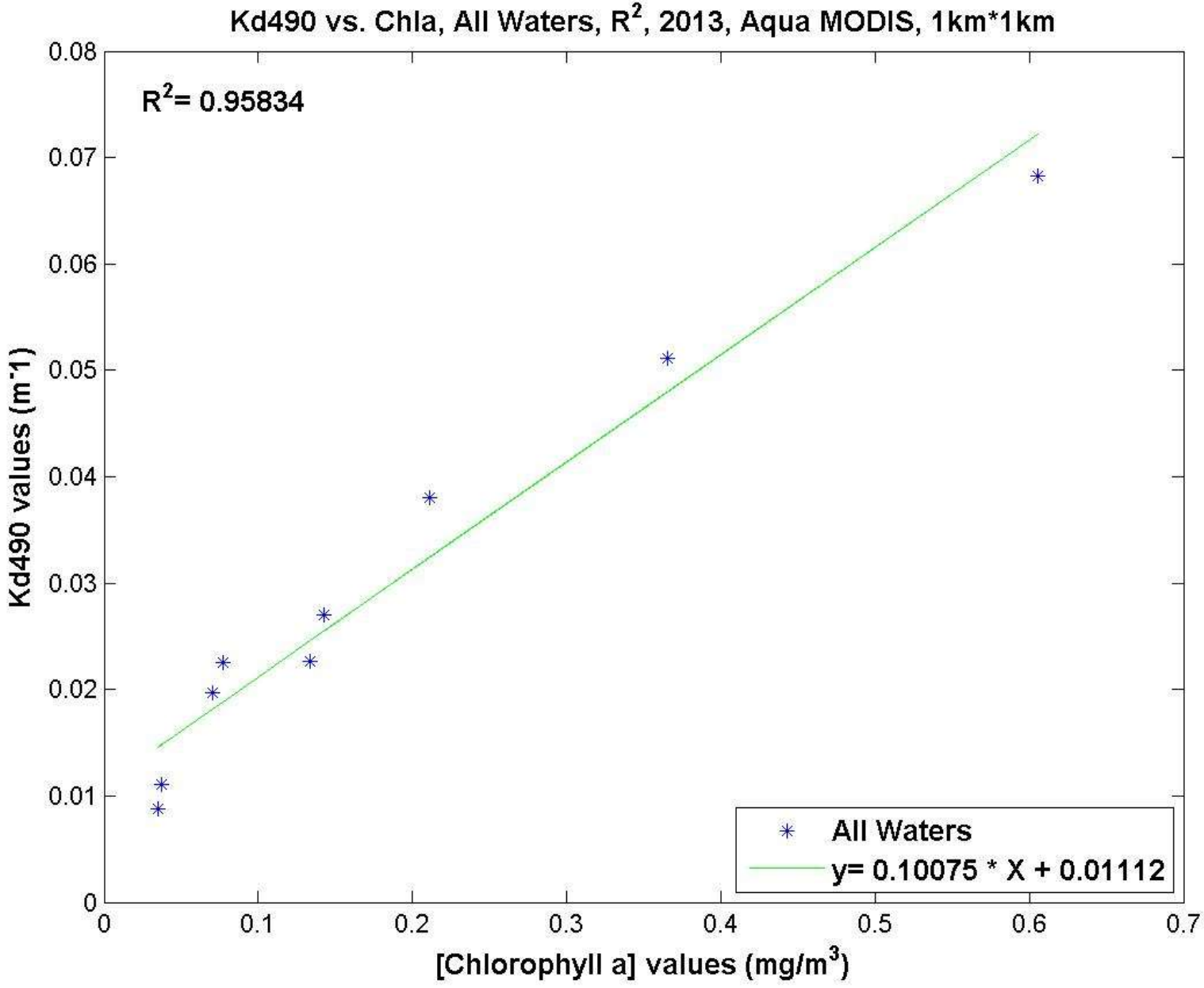
Passage of an anti-cyclonic eddy coincident with the 2005 coral bleaching event.

Increased heat content and UV radiation associated with anti-cyclonic eddies can exacerbate coral bleaching








Kd490 vs. Chla, All Waters, R2, 2013, Aqua MODIS, 1km*1km
R2= 0.95834
Kd490 values (m-1)
[Chlorophyll a] values (mg/m3)
All Waters
y= 0.10075 * X + 0.01112
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7