Final Report submitted to the PR Infrastructure Financing Authority (PRIFA)

Biological characterization and mapping of marine habitats in Ponce Bay, Puerto de Las Americas

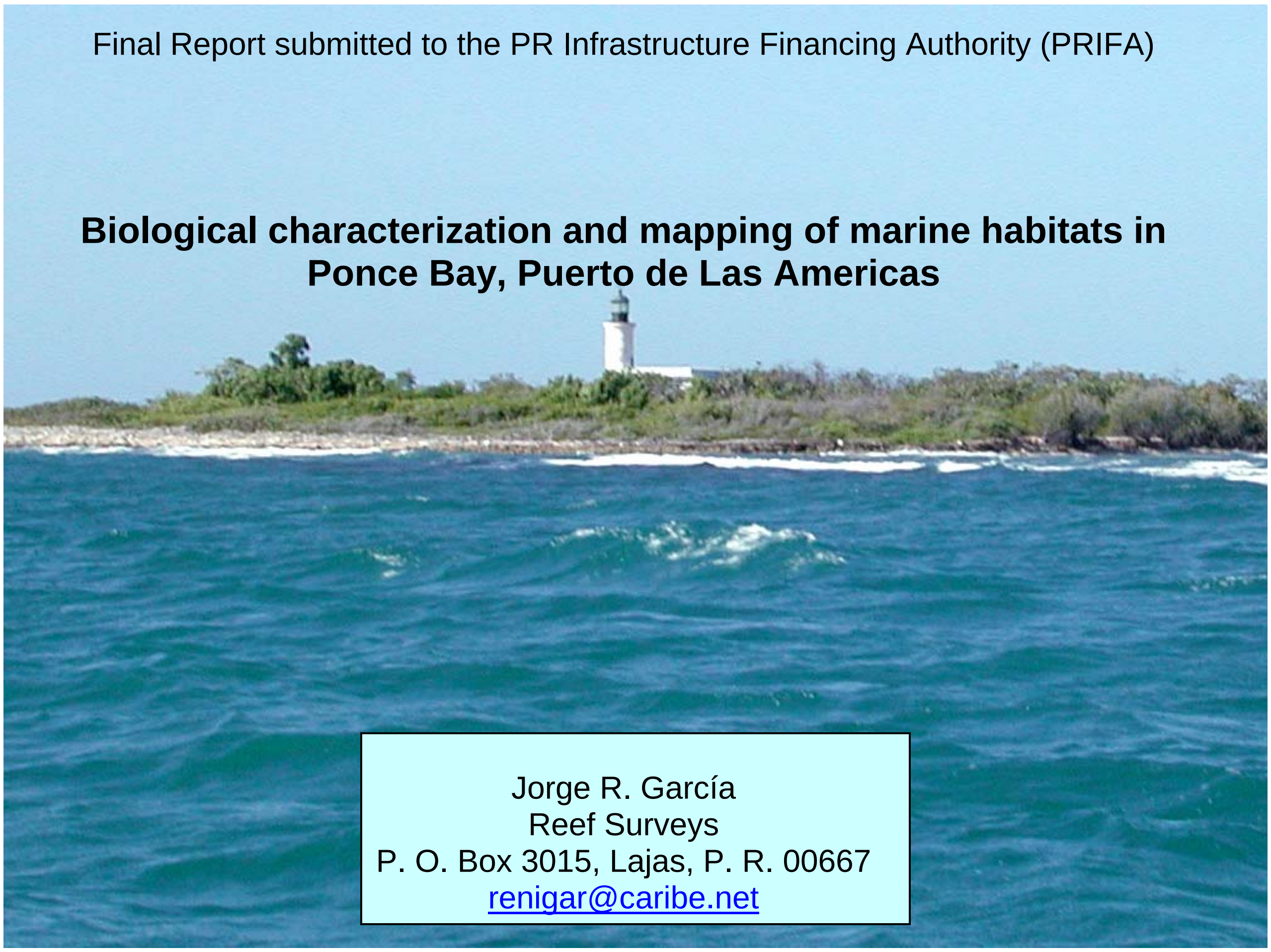

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Table of Contents

Page

Background

Ponce Bay is located on the south central coast of Puerto Rico, between Punta Cucharas to the west and Punta Carenero to the east. Two rivers discharge into the bay, Río Matilde near the center of the bay and Río Portugués to the east. Primary treated sewage and industrial effluents from a tuna factory were discharged into Ponce Bay for several decades before any quantitative studies of the marine communities were performed. Thus, baseline characterizations of the "pristine" conditions of marine communities in Ponce Bay are not available. During the late 1990's the tuna factory closed down operations and the domestic sewage submarine outfall discharging inshore was extended towards the shelf-edge and now discharges down the insular slope into deep oceanic waters. Previous studies of the marine communities in Ponce Bay include the qualitative descriptions of coral reefs by Goenaga and Cintrón (1979) as part of their general inventory of coral reefs around Puerto Rico. Quantitative characterizations of the reef and seagrass communities were later provided by García et al. (1985 a, b) in relation to the operations of the Puerto Rico Aqueducts and Sewers Authority (PRASA) Regional Waste Water Treatment Plant (RWWTP) submarine outfall in the bay. A preliminary characterization of marine communities at the navigation channel and inshore sections of Ponce Bay was prepared by García (2001).

There are six reef systems in Ponce Bay; these are: Cayo Arenas and Cayo Ratones located south off Punta Cucharas; Cayo Viejo and Las Hojitas in the center of the bay and Isla Cardona and Gatas Reefs at the bay's entrance. The initial study by Goenaga and Cintrón (1979) described the reef systems in Ponce Bay as poorly developed in terms of scleractinian (reef building) coral growth, except for the high density of Elkhorn Coral, *Acropora palmata* in the shallow fore reef sections of Cayo Ratones and Isla Cardona. García et al. (1985 a, b) noted that the "Palmata Zone" of Isla Cardona and Ratones reefs had virtually transformed into a zone of dead coral rubble overgrown by benthic algae and other encrusting biota. The abrupt decline of the Elkhorn Coral biotope was observed in other reefs along the south coast of Puerto Rico after the pass of hurricane David in 1979. This hurricane generated very high waves with severe impacts upon shallow reef communities. The highest live coral cover of reefs in Ponce Bay (18 %) was reported by García (1985 b) for the fore reef slope of Cayo Ratones at a depth of 17-19 meters. Cayo Las Hojitas and Cayo Viejo presented very low live coral cover (< 5 %), with hard substrates mostly colonized by turf algae and encrusting sponges and zoanthids (García et al., 1985 b). A marked pattern of decreasing live coral cover towards the shoreline has been reported for reefs in coastal embayments of Puerto Rico (Matos et al., 2000).

Seagrass communities of Ponce Bay were described by García et al. (1985 a, b) for the back reef zones of Cayo Arenas and Cayo Viejo. At Cayo Arenas, Turtle Grass, *Thalassia testudinum* was reported growing in association with green benthic fleshy macroalgae, *Ulva lactuca*, *Cladophora sp*. and *Enteromorpha sp*., which are known biological indicators of high nutrient availability for primary producers. Motile megabenthic invertebrate and fish populations associated with the seagrass habitat at Cayo Arenas were described as of low species diversity and low abundance of individuals (García et al.,1985 a, b). Midrib Seagrass, *Halophila decipiens* was reported as the prevailing seagrass stand at the backreef of Cayo Viejo, growing at depths between 5 – 8 meters in association with fleshy brown (*Dictyopteris sp*.), green calcareous (*Udotea sp., Caulerpa spp*.) and fleshy red (*Gracilaria* sp.) macroalgae (García et al.,1985 a, b).

This work forms part of the environmental studies associated with the establishment of the Port of the Americas in Ponce Bay.

The main objectives of the study were the following:

1) Construct a geo-referenced map of benthic habitats present within the navigation channel and the interior sections of Ponce Bay.

2) Provide a biological characterization of the fish and benthic communities associated with the main habitats present within the navigation channel and interior sections of Ponce Bay.

3) Provide a general description of oceanographic conditions in Ponce Bay based on a series of water column profiles of temperature, salinity, density and chlorophyll-a.

Methods

Water temperature, salinity, density and chlorophyll-a profiles were obtained from the surface to the bottom using a CTD instrument with an integrated fluorometer. Profiles were taken from a series of 36 sampling stations in Ponce Bay (Figure 1). Geographic coordinates and depths of CTD stations are presented in Table 1. Sampling stations were geo-referenced using a 12 channel DGPS unit interfaced with an on-deck computer. Distance from the center of station was kept within a 20 meter radius. Dynamic position at station was maintained using Hypack Software. Horizontal surface contours of density (Sigma-t), temperature (°C), salinity (ssu) and chlorophyll-a (ug/l) were constructed from readings at a depth of 1.0 meter using Surfer Software.

Mapping of benthic habitats was prepared from data generated by direct observations of the bottom by divers. A grid of 120 equidistant points within an area of 3.88 Km^2 was prepared on Hypack Software and loaded onto a nautical chart of Ponce Bay (Map Tech Pilot Software) (Figure 2). Bounce dives were performed at each point and habitat observations were recorded on the computer. Additional bounce dives were performed to identify habitat transitions where required. Navigation between stations and geo-references of bounce dive positions was aided by Map-tech Pilot and Hypack Software. Geographic coordinates, depths and dominant habitat types present at each station are listed in Table 2. Separate polygons of each benthic habitat were constructed and the surface area covered by each habitat category computed in Arc View Software.

Quantitative and qualitative characterizations of the main benthic habitats in Ponce Bay (deep mud, reefs and seagrass) were approached by video-transects and random swim surveys. Quantitative video data were collected along each transect to determine percent cover by substrate categories at each habitat. Triplicate 10-meter long video-transects were recorded at the three reef habitats present within the study area (e.g. Isla Cardona, Las Hojitas and Gatas Reefs). Triplicate transects were also recorded from one seagrass station and from the deep mud station. A stainless steel rod that extended

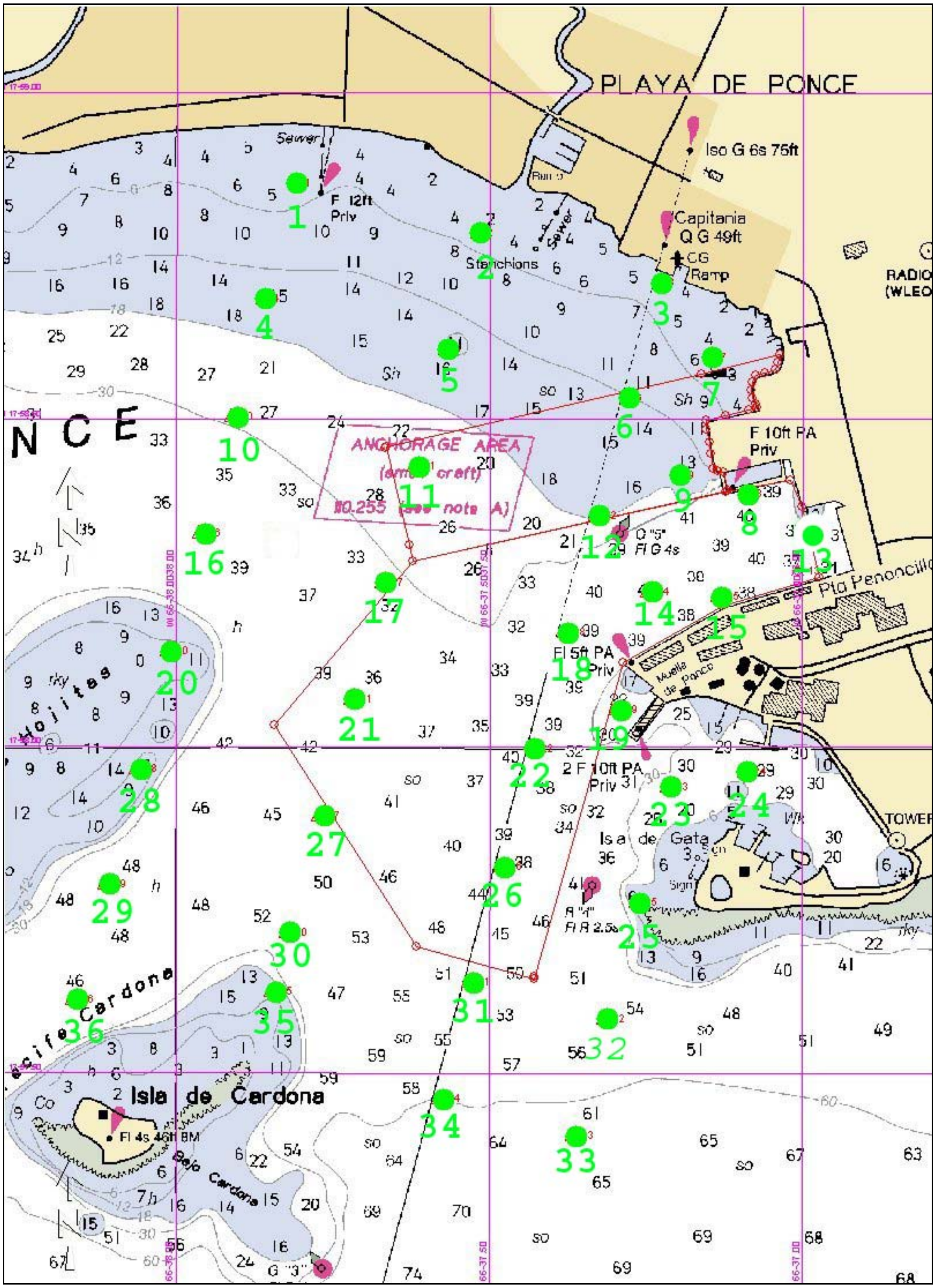

Figure 1. Location of CTD, chlorophyll-a sampling stations in Ponce Bay.

Table 1. Location and depths of CTD, chlorophyll-a sampling stations in Ponce Bay

CTD Station	X	Y	Latitude	Longitude	Time	Date	Station Depth (ft.)	Station Depth (m)
1	587746.6	709834.0	17.98103	66.63023	17:13	Dic. 7/ 02	4	1.2
2	589429.3	709367.3	17.97975	66.62538	17:08	Dic. 7/ 02	4	1.2
3	591119.0	708907.8	17.97848	66.62052	17:32	Dic. 6/ 02	5	1.5
4	587449.7	708752.3	17.97805	66.63108	17:19	Dic. 7/ 02	16	4.8
5	589139.4	708285.6	17.97677	66.62622	17:04	Dic. 7/ 02	16	4.8
6	590822.1	707833.1	17.97552	66.62137	17:38	Dic. 6/ 02	13	3.9
7	591599.8	708207.9	17.97656	66.61914	17:28	Dic. 6/ 02	5	1.5
8	591932.1	706956.5	17.97311	66.61818	17:47	Dic. 6/ 02	40	12.1
9	591302.9	707119.1	17.97356	66.61999	17:42	Dic. 6/ 02	14	4.2
10	587159.8	707670.5	17.97507	66.63191	17:23	Dic. 7/ 02	29	8.8
11	588842.5	707211.0	17.97381	66.62707	17:30	Dic. 7/ 02	26	7.9
12	590532.2	706751.4	17.97254	66.6222	18:05	Dic. 6/ 02	20	6.1
13	592405.8	706242.4	17.97115	66.61681	17:53	Dic. 6/ 02	38	11.5
14	591013.0	706044.4	17.97060	66.62082	18:01	Dic. 6/ 02	40	12.1
15	591663.4	706002.0	17.97048	66.61895	17:57	Dic. 6/ 02	38	11.5
16	586862.9	706588.8	17.97209	66.63276	17:40	Dic. 7/ 02	39	11.8
17	588545.5	706129.3	17.97083	66.62792	17:33	Dic. 7/ 02	33	10.0
18	590235.3	705669.7	17.96956	66.62305	18:11	Dic. 6/ 02	39	11.8
19	590723.1	704962.7	17.96762	66.62165	18:15	Dic. 6/ 02	22	6.7
20	586565.9	705507.1	17.96911	66.63361	17:51	Dic. 7/ 02	11	3.3
21	588255.7	705054.6	17.96787	66.62875	17:46	Dic. 7/ 02	37	11.2
22	589938.3	704595.1	17.96660	66.62391	18:19	Dic. 6/ 02	40	12.1
23	591196.8	704248.6	17.96565	66.62028	18:27	Dic. 6/02	26	7.9
24	591910.9	704383.0	17.96603	66.61823	18:32	Dic. 6/ 02	29	8.8
25	590899.9	703174.0	17.96269	66.62113	10:54	Dic. 8/ 02	6	1.8
26	589648.5	703506.3	17.96361	66.62474	11:02	Dic. 8/02	40	12.1
27	587958.7	703972.9	17.96489	66.6296	17:58	Dic. 7/ 02	45	13.6
28	586276.1	704418.3	17.96611	66.63444	18:05	Dic. 7/ 02	9	2.7
29	585986.2	703350.7	17.96317	66.63527	18:11	Dic. 7/ 02	48	14.5
30	587668.9	702891.2	17.96191	66.63043	9:56	Dic. 8/ 02	52	15.8
31	589351.5	702431.6	17.96064	66.62559	10:41	Dic. 8/ 02	52	15.8
32	590610.0	702085.2	17.95969	66.62197	10:48	Dic. 8/ 02	55	16.7
33	590320.1	701010.6	17.95673	66.6228	8:49	Dic. 8/ 02	64	19.4
34	589068.7	701349.9	17.95767	66.6264	9:38	Dic. 8/ 02	60	18.2
35	587520.4	702346.8	17.96041	66.63086	9:41	Dic. 8/ 02	13	3.9
36	585689.3	702276.1	17.96021	66.63612	18:15	Dic. 7/ 02	46	13.9

approximately 45 cm (18 inches) beyond the camera housing lens plate was attached to the housing to maintain a constant camera-subject distance during filming. Quantitative video data collected from each permanent transect were analyzed to determine dominance, based on percent coverage, of the following substrate types and epibiota:

- **Live stony corals** – reported by species and total live corals, also includes stony hydrocorals (e.g. *Porites astreoides*, *Millepora sp*.)
- **Sponges** – reported as total sponges, or lowest possible taxon
- **Zoanthids** – mostly the colonial *Palythoa* sp.
- **Algal Turf** – consisting of a mixed assemblage of short articulate coralline algae, intermixed with red, brown macroalgae and other small epibenthic biota forming a mat or carpet over hard substrate
- **Calcareous Algae** – reported as total calcareous algae, or lowest possible taxon
- **Fleshy Algae** – vertically projected, mostly brown and green macroalgae
- **Abiotic Substrate** – includes unconsolidated sediments (e.g. mud, sand, silt), bare rock, deep holes and gaps.

Soft coral colonies (gorgonians) have a very small basal area in relation to their size and thus, are not properly characterized by their percent cover of the substrate. A relative measure of soft coral abundance was obtained by enumerating the amount of colonies in contact with the 10-meter transect line.

Ten randomly selected, non-overlapping video frames were selected from each video transect. Video frames were reviewed using a digital camera interfaced with a color video monitor. Individual video frames were "frozen" and saved as picture files in a computer. Two sets of 25 electronic point overlays were constructed from x, y plots of random numbers generated in Excel Software and saved as templates. These templates were overlaid on each frozen video frame, resulting in 50 random points within each frame. The number of points over each of the substrate categories was recorded and the total points divided by 500 (50 points x 10 frames) and multiplied by 100 to obtain the percent cover by substrate category per transect. The reported value for each substrate category per habitat is the mean from the three transects. Qualitative descriptions of each benthic habitat included taxonomic identifications of dominant sessile-benthic biota during 10-minute random swim surveys at each habitat type. Underwater digital photography was used to support habitat descriptions where possible.

Fish and epibenthic invertebrate communities were quantitatively and qualitatively described by fish trap collections, hook and line collections, 10-meter long by 3 meters wide belt-transects (transect area: $30m^2$) and 10-minute random swim surveys at each habitat type. Location of fish and epibenthic invertebrate sampling stations in Ponce Bay are shown in Figure 3. Triplicate belt- transects and random swim surveys were obtained from the three reef habitats occurring within the study area (e.g. Isla Cardona, Las Hojitas, Gatas Reefs). Belt transects were centered over the video-transect lines. Non-criptic fishes and motile megabenthic (>1 cm) invertebrates present within and five (5) meters above the 10 x 3 m belt-transect area were identified and enumerated

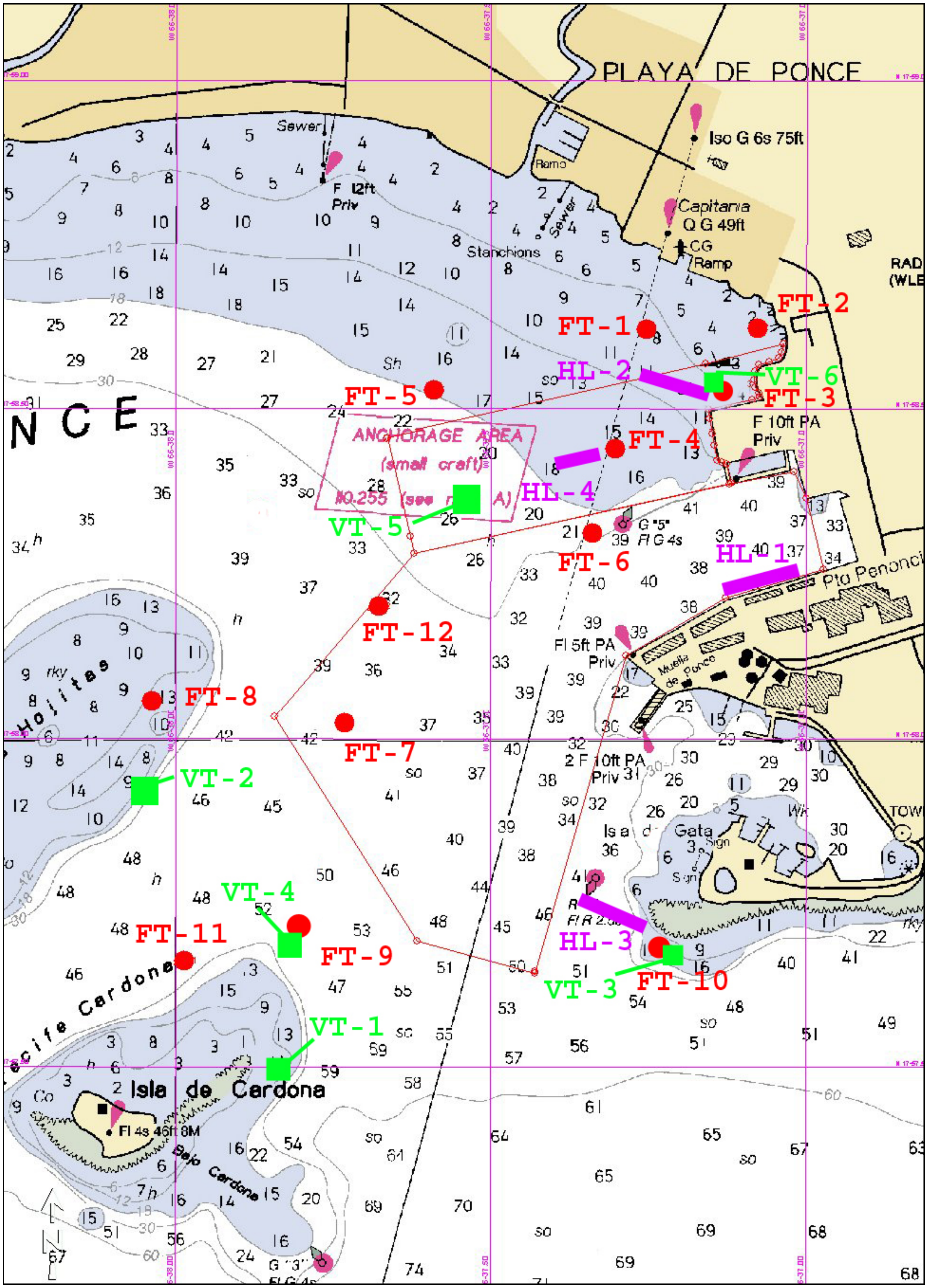

Figure 2. Location of fish sampling stations in Ponce Bay. Fish Traps (FT); Hook & Line (HL); Visual Surveys/Video Transects (VT).

underwater on plastic paper. All fishes and epibenthic invertebrates identified from 10-minute random swim surveys were recorded and included in a taxonomic list for each habitat type. Four baited fish traps were set at each of the three main habitats in Ponce Bay. Soaking time for fish trap samplings was 24 hours. Hook and line fishing was practiced for 30 minutes at each habitat type (deep mud, shallow mud, seagrass, reef). Four hand lines baited with squid were used for the hook and line fishing effort.

Results and Discussion

Oceanographic Conditions

Water temperature, salinity and density profiles were mostly homogeneous from the surface to the bottom, indicative of a well mixed water column and absence of any significant processes influencing vertical stratification (Appendix 1.1 – 1.36). Minor departures from this generalized pattern were observed at stations 25 - 26, where slightly higher water temperatures (delta ~ 0.2 °C) near the surface were measured. The maximum depth of CTD stations sampled within Ponce Bay was 20 meters (66'), well above the minimum seasonal pycnocline that forms at depths of approximately 45 meters during the summer along the south coast of Puerto Rico. Thus, the isothermal and isohaline profiles measured in Ponce Bay reflect the conditions that characterize the superficial water mass in the northern Caribbean (e.g. Caribbean Surface Mixed Layer). Daytime solar heating and surface films of freshwater may cause vertical micro-stratification in semi-enclosed embayments and coastal lagoons. The strong wind that prevailed from the east-southeast (15 – 20 knots) was probably a factor influencing the effective vertical mixing of the water column during our sampling.

Surface temperatures (1.0 meters) ranged between 27.72 °C and 28.04 °C. A marked horizontal gradient of increasing surface temperature toward the shoreline was observed (Figure 3). This pattern probably resulted from limited circulation within the inner bay, resulting in accumulation of warmer (solar heated) water near the eastern shoreline, which is shallow and protected from the wind. On the other hand, the effective mixing of a deeper water mass maintains cooler surface waters at the entrance of the bay. The surface temperature gradient was the main physical factor regulating the surface density structure within the study area in Ponce Bay (Figure 4). Both temperature and salinity have a direct influence upon seawater density. During our sampling event in late December, however, surface salinity was uniformly distributed throughout the bay, except for low scale dilutions near the pier facilities (Figure 5). Rather than influenced by rainfall runoff, these films appear to be associated with drainage from domestic activities near the port. Conditions of dry weather prevailed during our water quality sampling of Ponce Bay and river plumes were not observed within the study area.

Surface chlorophyll-a concentrations ranged between 1.5 and 2.0 ug/l throughout most of the inshore stations in Ponce Bay. Maximum concentrations of chlorophyll-a (2.6 ug/l) were measured near the surface at station 30, close to Isla Cardona. This may be

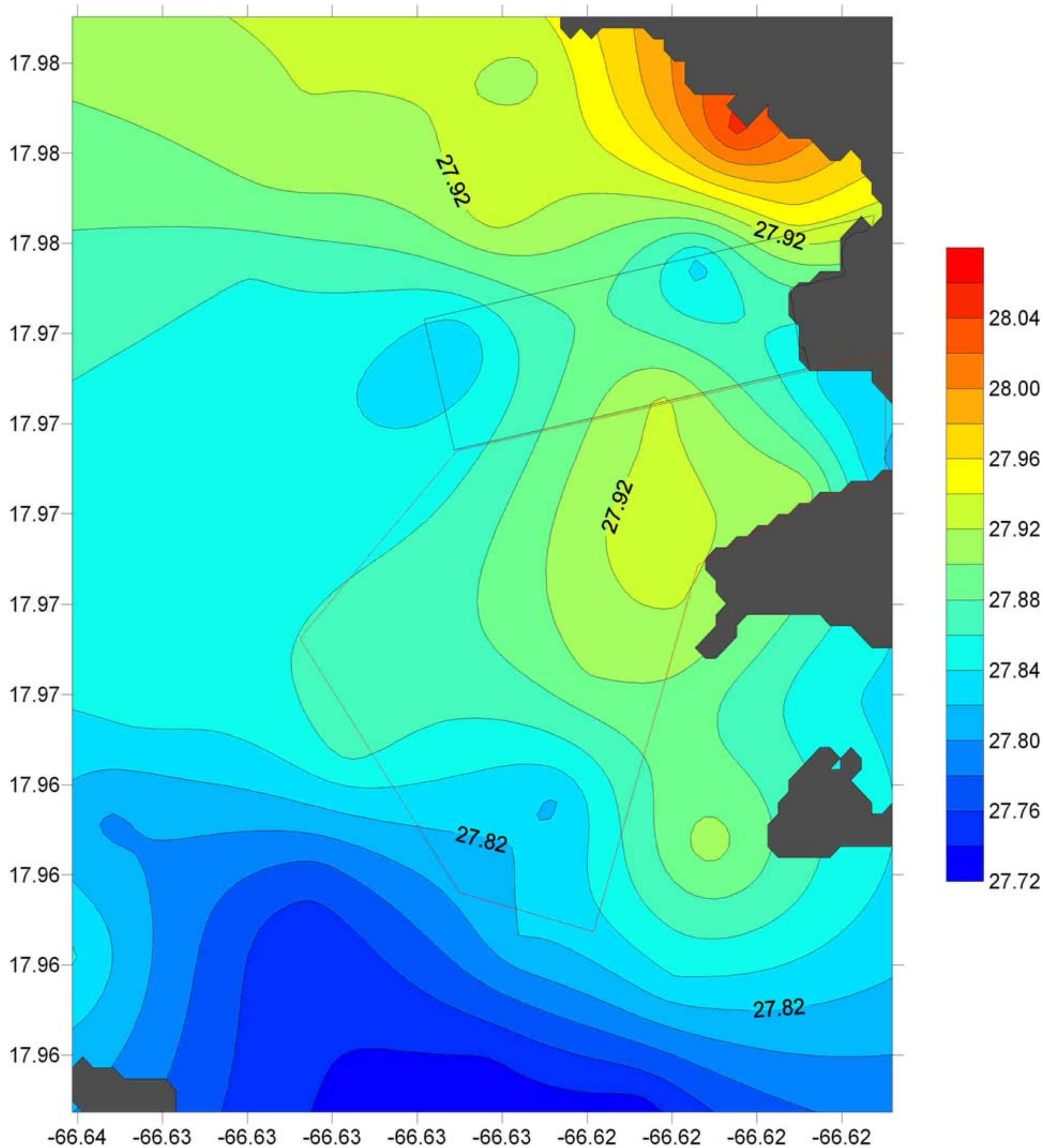

Figure 3. Contours of water temperature (° C) at 1.0 meter in Ponce Bay during December 2002.

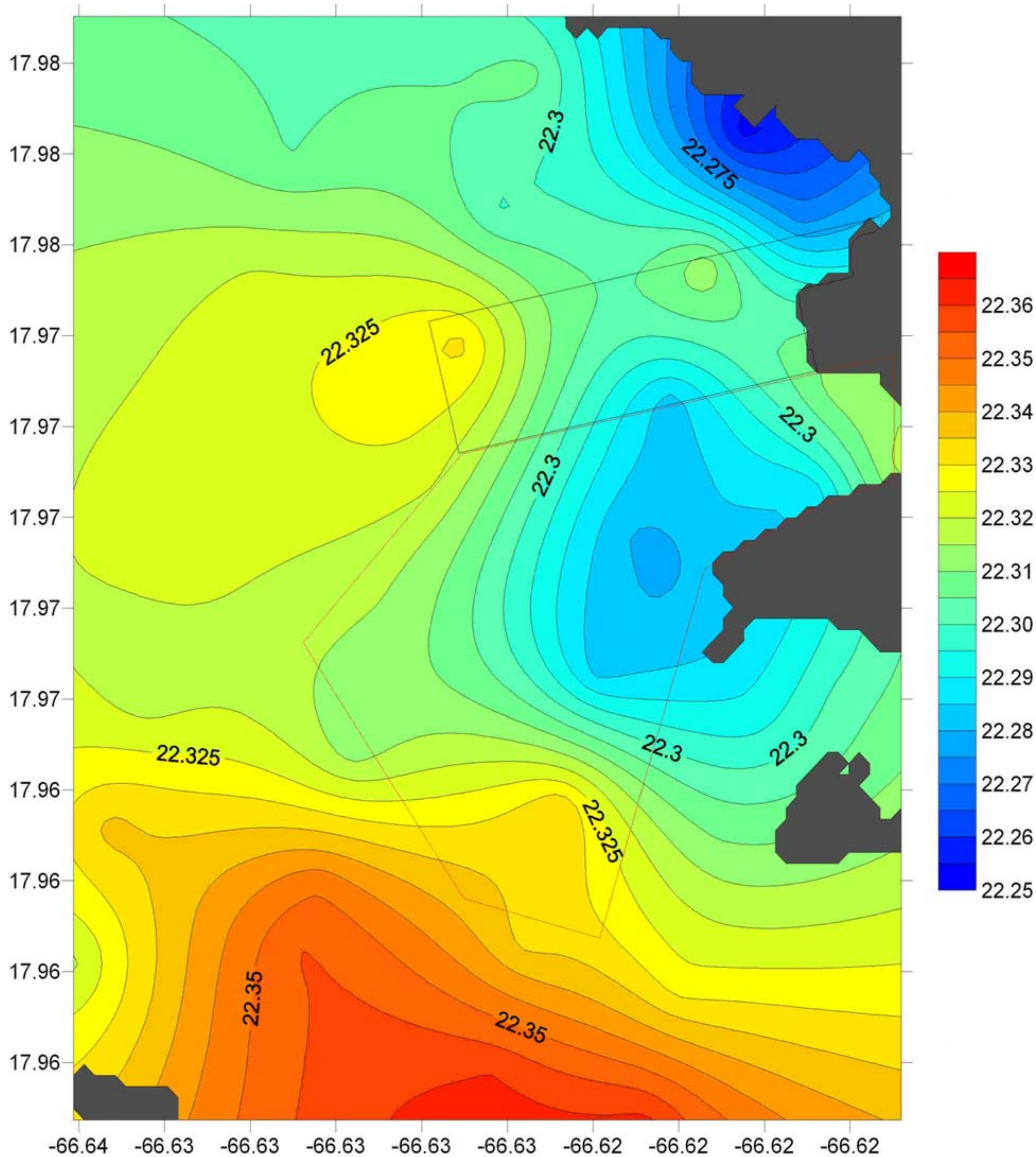

Figure 4. Contours of water density (Sigma-t) at 1.0 meter in Ponce Bay during December 2002.

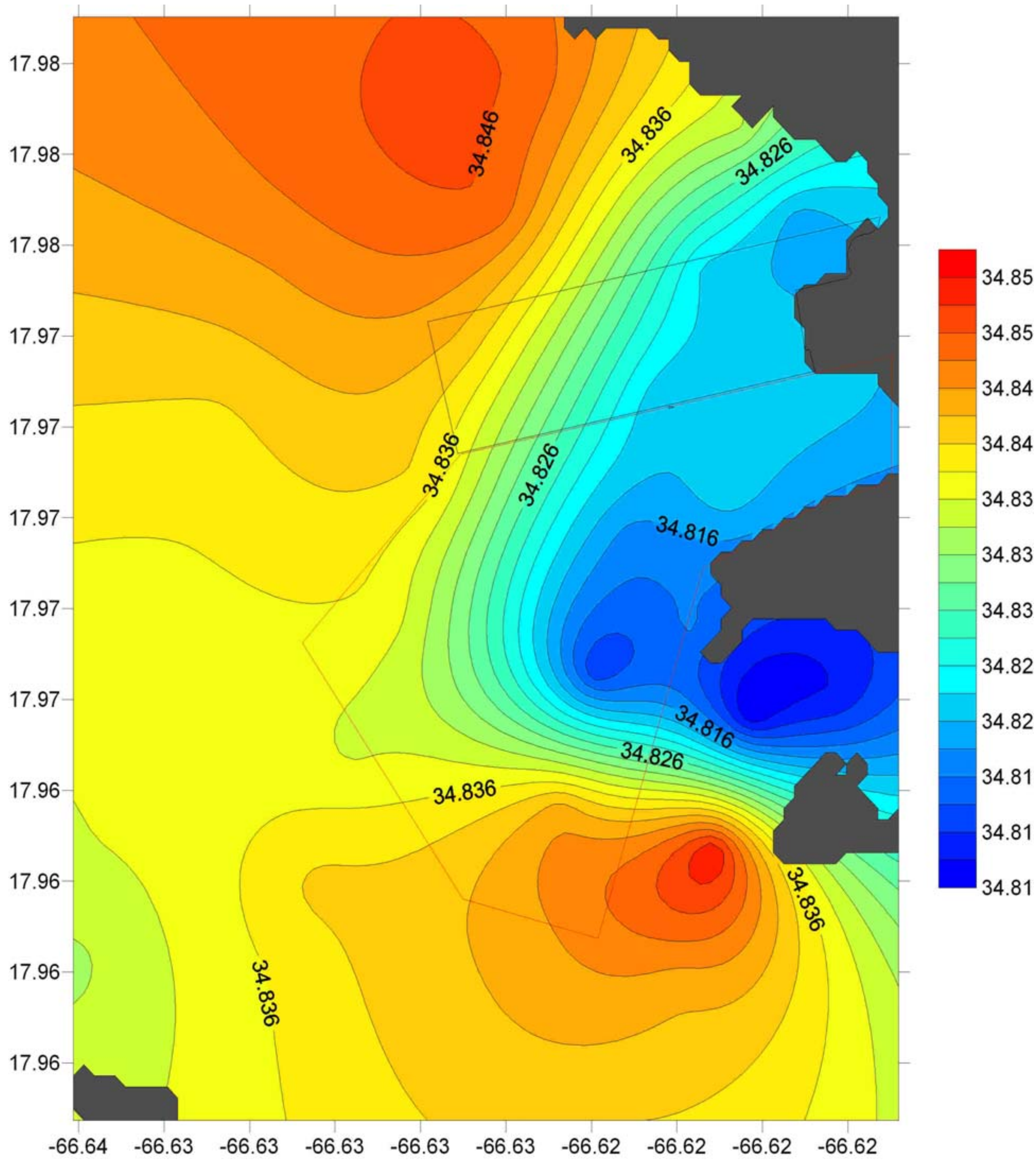

Figure 5. Contours of water salinity (ssu) at 1.0 meter in Ponce Bay during December 2002.

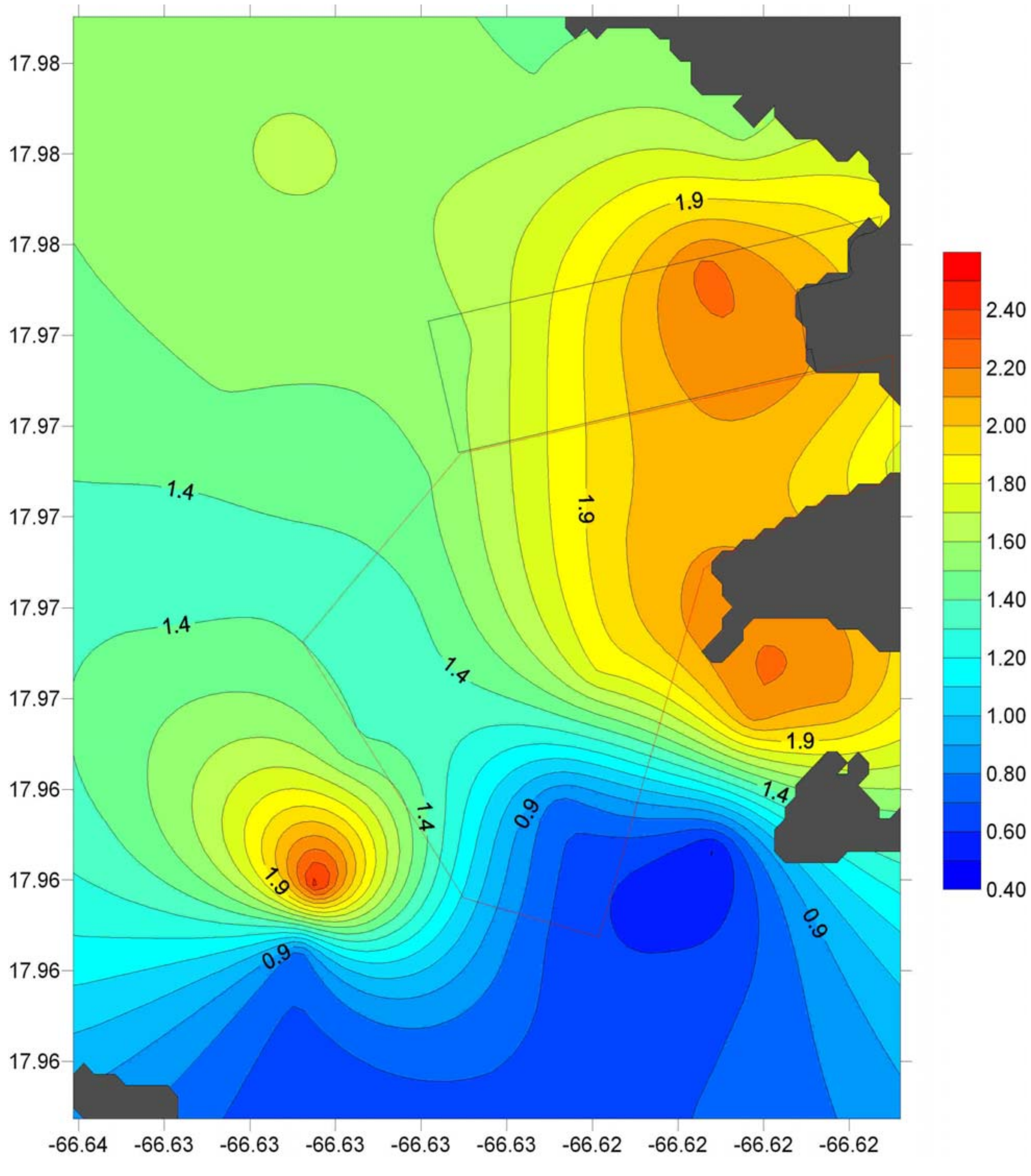

Figure 6. Contours of chlorophyll-a concentrations (ug/l) at 1.0 meter in Ponce Bay during December, 2002.

associated with a phytoplankton patch from the eastern shoreline, which appears to be a source of higher phytoplankton productivity in the bay (Figure 6). The higher productivity may be associated with resuspension of sediments from the bottom due to maritime activities near ports. Organic materials decompose in sediments and may represent an important source of inorganic nutrients influencing primary production upon resuspension. A mild pattern of increasing chlorophyll-a concentrations with depth was observed at stations 24 - 26 and 32 - 35. Water column profiles of chlorophyll-a are shown in Appendices 1.1 –1.36. This may be associated with nutrient release during sediment resuspension and/or the accumulation of dying, but still viable phytoplankton cells near the bottom. A marked gradient of decreasing chlorophyll-a concentrations towards the entrance of the bay was detected (Figure 6), indicative of the higher phytoplankton productivity inside the bay as compared to the oligotrophic character of oceanic waters. In general, chlorophyll-a concentrations were typical of estuarine coastal environments during the dry season in Puerto Rico.

The influence of river discharge upon oceanographic conditions in Ponce Bay was not evident during this survey, perhaps due to the dry weather. Streamflow from Río Portugués was minimal and appeared to move westerly along a long-shore current fringing the coastline. The southeasterly winds act to accumulate water onto the shoreline, creating this long-shore movement. During conditions of significant river discharge, the oceanographic conditions of Ponce Bay would be expected to display the typical gradients of lower water salinity and temperature associated with river plumes and the high sediment and nutrient loads affecting inshore communities.

Fish Community Characterization

A total of 75 (non-criptic) juvenile and/or adult fishes were identified from benthic and pelagic habitats in Ponce Bay. The complete taxonomic list of fishes observed during this survey is presented in Table 2. The highest density of fishes (26.6 Ind/30 m^2) and mean number of species present within transect areas (11 spp/30 m^2) was observed from Isla Cardona Reef (Table 3). Gatas and Hojitas Reefs presented mean densities of 23.5 Ind/30 m^2 (4.3 spp/30 m^2) and 15.5 Ind/30 m^2 (6.3 spp/30 m^2). Deep and shallow mud habitats presented densities of 0.3 and 1.0 Ind/30 m^2, respectively, whereas the seagrass habitat presented a mean fish density of 5.7 Ind/ 30 m^2 (0.3 spp/30 m^2). Only two species (Hovering Goby, Blue runner) were observed within transects surveyed from mud habitats. A total of six fish species were present within belt-transects at the seagrass habitat (Table 3).

The fish community in the navigation channel and other sections of the bay with soft sediment substrates lacking reef structures was mostly comprised by pelagic populations. Small zooplanktivore species, such as sardines (*Jenkinsia lamprotaenia., Harengula spp., Opisthonema oglinum*), anchovies (*Anchoa spp*.) and silversides (Fam. Atherinidae) serve as forage for an assemblage of pelagic piscivorous predators. These include the Tarpoon, Cero mackerel, Little tunny, Great barracuda, Blue runners, Bar Jacks, Yellow Jacks and others (see Table 2). Also, a pair of adult dolphins (*Turciops* sp.) were sighted in the navigation channel. It is possible that dolphins enter the bay to feed upon jacks, small tunas and other schooling, mid-water fishes. The occurrence of dolphins in coastal embayments is common and has been previously reported for Guayanilla Bay (García and Castro, 1996). Several fish populations associated to the surface were present at the navigation channel, particularly the Half-beaks or Ballyhoo (Fam. Hemiramphidae) and Needlefishes (Fam. Strongyluridae). These fishes feed mostly on zooplankton and small invertebrates associated with floating seagrass and seaweeds (e.g. *Sargassum*). The navigation channel is also a pathway for pelagic fish and invertebrate larvae in transit between benthic habitats of Ponce Bay and offshore waters (García-Sais, 2001).

Soft mud habitats were depauperate with respect to demersal fish populations, presenting very low densities and species richness. Probably, the only species that lives permanently in the shallow and deep soft mud habitat of Ponce Bay is the Hovering goby (*Ioglossus helenae*), which was observed coming out of holes that are ubiquitous in the mud. The Lane snapper (*Lutjanus synagris*) and the Mutton snapper (*Lutjanus analis*) were collected by fish traps set on the shallow mud habitat (Plate 1). These are transitory species of commercial value which forage for epibenthic invertebrates and small fishes in soft bottom habitats. Blue crabs (*Callinectes sp*.) were also collected from the shallow mud habitat (Plate 2). The main existing pier structure in Ponce Bay, which comes out of a soft mud habitat, serves as an important nursery habitat for Lane snappers, as inferred from the relatively large collection of juveniles that were collected from hook and line samplings at that station (Table 4). The Bonefish (*Albula vulpes*) is also a transitory species previously reported from the navigation channel in Ponce Bay (García-Sais, 2001). Other transitory (demersal) populations of soft mud habitats in the bay include the Mojarras (Fam. Gerreidae), Drums and Croakers (Fam. Sciaenidae), Porgies (Fam. Sparidae), Mullets (Fam. Mugilidae) and Stingrays (Fam. Dasyatidae). Juvenile reef fishes (Doctorfishes, Butterflyfishes, Damselfishes and Jacks) associated with solid structures present in the soft mud (e.g. navigation buoys, chains and anchors) have been previously reported from the navigation channel in Ponce Bay (García-Sais, 2001).

Juvenile reef fishes and invertebrates were common in shallow sections of seagrass beds at Ponce Bay, where abundant debris and rocks provide protective habitat close to their feeding ground. Juvenile grunts (Fam. Haemulidae) and parrotfishes (Fam. Scaridae) were the numerically dominant taxonomic assemblage within belt-transects surveyed (Table 3). Yellowtail, Schoolmaster and Mutton snappers were also present as juveniles at shallow seagrass habitats. These juvenile snappers and other juvenile reef carnivores, such as barracudas and jacks, feed upon small planktivorous fishes (sardines, anchovies) that use the shallow seagrass as protective habitat from the larger predators present in the navigation channel and open reef areas. The fish community from the seagrass habitat is also comprised by resident adult species, such as the Bucktooth parrotfish (*Sparisoma radians*) and the Black-ear Wrasse (*Halichoeres poeyi*). A group of adult reef fishes, associated with the abundant debris and rocky shoreline were also observed within the shallow seagrass habitat. Several juvenile Spiny lobsters (*Panulirus argus*) and one Common octopus (*Octopus vulgaris*) were observed associated with hard substrate microhabitats within the shallow seagrass/macroalgal bed fringing the northeastern shoreline in Ponce Bay.

Fish densities and species richness from reef habitats in Ponce Bay are representative of the poorly developed and/or highly stressed shallow reefs located close to the shoreline along the south coast of Puerto Rico (Matos et al. 2000). These reefs show very high exposure to sedimentation and abrasion, with low live coral cover, standing

Table 2. Taxonomic list of fishes surveyed in Ponce Bay

		Reefs			Deep	Shallow	
Species	**Common name**	**Cardona**	**Hojitas**	**Gatas**	**Mud**	**Mud**	**Seagrass**
Abudefduf sexatilis	Sargeant major	X		X			X
Acanthurus bahianus	Ocean surgeon	X	X	X			X
Acanthurus chirurgus	Doctorfish	X	X				X
Acanthurus coeruleus	Blue tang	X		X			
Anchoa sp.	Anchovies				X	X	X
Anisotremus surinamensis	Black margate	X	X				
Anisotremus virginicus	Porkfish	X	X	X			X
Aulostomus maculatus	Trumpetfish	X		X			
Archosargus rhomboidalis	Sea bream						X
Bodianus rufus	Spanish hogfish		X				X
Canthigaster rostrata	Sharpnose puffer	X		X			X
Carangoides crysos	Blue runner		X				
Carangoides ruber	Bar jack		X				
Caranx bartholomaei	Yellow Jack	X				X	X
Cephalopholis cruentatus	Graysbe	X					
Cephalopholis fulva	Coney	X	X				
Chaetodipterus faber	Spadefish		X				
Chaetodon capistratus	Four-eye butterflyfish	X	X				X
Chaetodon striatus	Banded butterflyfish	X	X				
Chloroscombrus chrysurus	Atlantic bumper	X				X	
Chromis multilineata	Yellow-edge chromis	X					
Dasyatis americana	Southern stingray					X	
Diapterus argenteus	Mojarra						X
Diodon holocanthus	Balloonfish					X	X
Equetus acuminatus	Cubbyu		X				
Equetus lanceolatus	Jacknife fish						X
Euthynus alleteratus	Little Tunny			X	X		
Gobiosoma evelynae	Sharknose goby	X					
Haemulon aurolineatum	Tomtate	X	X	X		X	X
Haemulon flavolineatum	French grunt	X	X	X			
Haemulon macrostomum	Spanish grunt		X				
Haemulon sp.	Grunt		X				X
Halichoeres bivittatus	Slippery Dick			X			X
Halichoeres maculipinna	Clown wrasse	X	X	X			X
Halichoeres poeyi	Blackear wrasse						X
Harengula spp.	Sardines				X	X	
Hemiramphus brasiliensis	Ballyhoo				X	X	
Holocentrus rufus	Squirrelfish	X					
Labrisomus nuchipinnis	Hairy Blenny						X
Lutjanus apodus	Schoolmaster	X		X			
Lutjanus synagris	Lane snapper		X	X	X	X	X
Lutjanus analis	Mutton snapper					X	X
Lutjanus griseus	Mangrove snapper	X					

Table 2. Continued

Species	Common name	Reefs Cardona	Reefs Hojitas	Reefs Gatas	Deep Mud	Shallow Mud	Seagrass
Malacoctenus triangulatus	Saddled blenny	X					
Megalops atlantica	Tarpoon					X	
Microspathodon chrysurus	Yellowtail damselfish		X				
Mugil curema	White mullet					X	X
Ocyurus chrysurus	Yellowtail snapper	X	X	X			
Odontoscion dentex	Reef croaker	X	X	X			
Oligoplites saurus	Leatherjacket				X		X
Ophioblennius atlanticus	Redlip blenny	X					
Opistognathus aurifrons	Yellowhead jawfish	X	X				
Holacanthus ciliaris	Queen angelfish		X				
Holacanthus tricolor	Rock beauty	X		X			X
Ioglossus helenae	Hovering goby				X	X	
Pomacanthus arcuatus	Gray angelfish	X		X			
Pomacanthus paru	French angelfish	X	X				
Priacanthus cruentatus	Glasseye		X				
Pseudupeneus maculatus	Spotted goatfish	X	X				
Scarus isertii	Stripped parrotfish	X		X			
Scarus taeniopterus	Princess parrotfish	X					
Scarus vetula	Queen parrotfish	X		X			
Scomberomorus regalis	Cero mackerel				X		
Serranus tigrinnus	Harlequin bass	X	X				
Sparisoma aurofrenatum	Red-band parrotfish	X	X	X			
Sparisoma spp.	Juvenile parrotfishes						X
Sparisoma rubripinne	Yellowtail parrotfish	X	X	X			
Sparisoma viride	Stoplight parrotfish	X	X	X			
Sphyraena barracuda	Barracuda		X				X
Stegastes dorsopunicans	Dusky damselfish	X	X	X			
Stegastes leucostictus	Beau gregory	X	X	X			
Stegastes partitus	Bicolor damselfish	X	X	X			
Strongylura timucu	Needlefish				X	X	X
Thalassoma bifasciatum	Bluehead wrasse	X	X	X			
Tylosurus crocodilus	Houdfish				X	X	
	Total Species	**42**	**35**	**26**	**10**	**15**	**27**

Table 3. Mean density of fishes surveyed in belt-transects from benthic habitats in Ponce Bay.

		Benthic Habitats Surveyed					
Scientific Name	**Common Name**	**Reef Cardona**	**Reef Hojitas**	**Reef Gatas**	**Mud Deep**	**Mud Shallow**	**Seagrass**
Acanthurus bahianus	Ocean surgeon	0.7					0.3
Acanthurus chirurgus	Doctorfish		1.3				
Anisotremus virginicus	Porkfish		0.3				
Aulostomus maculatus	Trumpetfish	0.3		0.3			
Canthigaster rostrata	Caribbean puffer	1.0		0.3			
Carangoides crysos	Blue runner		0.3		1.0		
Chaetodon capistratus	Four-eye butterflyfish	0.7	0.7				
Chromis multilineata	Brown chromis	2.0					
Equetus lanceolatus	Jacknife fish		0.3				
Gobiosoma evelynae	Sharknose goby	1.0					
Haemulon flavolineatum	French grunt	0.3					
Haemulon sp.	Grunts (juveniles)						2.0
Halichoeres poeyi	Black-ear wrasse						0.3
Holocentrus rufus	Squirrelfish	0.3					
Ioglossus helenae	Hovering goby					1.0	
Ocyurus chrysurus	Yellowtail snapper	0.3		0.7			0.7
Odontoscion dentex	Reef croaker	1.0					
Ophioblennius atlanticus	Redlip blenny	1.7	0.7				
Pomacanthus paru	French angelfish		0.3				
Sparisoma aurofrenatum	Redband parrotfish	0.3		0.3			
Sparisoma radians	Bucktooth parrotfish						1.7
Sparisoma rubripinne	Yellowtail parrotfish			0.3			
Sparisoma viride	Stop-light parrotfish		0.3				
Stegastes dorsopunicans	Dusky damselfish	9.0	8.0	8.0			0.7
Stegastes leucostictus	Beau gregory		1.0	0.3			
Stegastes partitus	Bicolor damselfish	2.0	1.0				
Thalassoma bifasciatum	Bluehead wrasse	6.0	1.3	13.3			
	Mean Density (Ind/30m2)	**26.6**	**15.5**	**23.5**	**0.3**	**1**	**5.7**
	Mean Number of Species/30m2	**11.0**	**6.3**	**4.3**	**0.3**	**0.3**	**1.3**
	Total Species (3 transects)	**15**	**12**	**8**	**1**	**1**	**6**

Table 4. Fishes and epibenthic invertebrates collected with fish traps and hook and line methods in Ponce Bay.

Station	Sampling Method	Depth (m)	Species	Common Name	Habitat	Comme nts
FT-1	Fish Trap	2.8	*n/a*		seagrass	empty
FT-2	Fish Trap	1.0	*n/a*		seagrass	empty
FT-3	Fish Trap	2.5	*n/a*		seagrass	empty
FT-4	Fish Trap	5.2	*n/a*		Shallow mud	empty
FT-5	Fish Trap	6.0	*Carangoides crysos*	Blue runner	Shallow mud	adult
FT-5	Fish Trap	6.0	*Carpilus coralinus*	Coral Crab	Shallow mud	adult
FT-6	Fish Trap	9.0	*Lutjanus analis*	Lane snapper	Shallow mud	adult
FT-7	Fish Trap	12.1	*n/a*		Deep mud	empty
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-8	Fish Trap	4.0	*Caranx bartholomaei*	Yellow jack	reef	adult
FT-9	Fish Trap	15.8	*n/a*		Deep mud	empty
FT-10	Fish Trap	3.9	*n/a*		reef	empty
FT-11	Fish Trap	13.7	*Lutjanus synagris*	Lane snapper	Deep mud	adult
FT-12	Fish Trap	9.7	*Callinectes sp.*	Blue crab	Deep mud	adult
FT-12	Fish Trap	9.7	*Callinectes sp.*	Blue crab	Deep mud	adult
FT-12	Fish Trap	9.7	*Callinectes sp.*	Blue crab	Deep mud	adult
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-1	Hook & Line	12.0	*Lutjanus synagris*	Lane snapper	Mud-pier	juvenile
HL-2	Hook & Line	3.0	*n/a*		Seagrass	empty
HL-3	Hook & Line	12.0	*n/a*		Reef	empty
HL-4	Hook & Line	5.0	*n/a*		Shallow mud	empty

dead coral colonies and high substrate cover by algae and other encrusting biota. Nevertheless, the reef structure serves as protective habitat to a biologically complex community of fishes and invertebrates that are highly resilient and appear to be adapted to the prevailing conditions of high sedimentation and abrasion stress. These include some species that are commercially important, such as the Lane and mangrove snappers (*Lutjanus synagris, L. griseus*) present at Isla Cardona and Las Hojitas reefs. Also, Spiny lobsters, *Panulirus argus* were observed from Las Hojitas and Gatas Reefs.

The combined abundance of two species (e.g. Dusky Damselfish and Bluehead wrasse) represented more than 50 % of the total fish individuals within belt-transect areas at reefs surveyed in Ponce Bay. The Dusky damselfish is a small (< 10 cm) herbivorous fish that guards demersal territories in the reef. This species is numerically dominant in reefs of low live coral cover, where turf algae colonize most of the available hard substrate. This condition is typical of shallow near shore reefs exposed to high sedimentation and low light penetration, such as the inshore reefs in San Juan Bay (García and Castro, 1995), Jobos Bay (García and Castro, 1997), Mayaguez Bay (García, 1990) and Guayanilla Bay (Castro and García, 1996). The Bluehead wrasse is a small transitory species that feeds upon small benthic invertebrates in the reef. This fish inhabits almost all reefs at depths between one and 30 meters. Guilds of 20 – 30 females and one male are common. Large, adult, commercially important reef fishes were not observed. A small artisan fishing effort on Ponce Bay reefs was confirmed by the presence of wooden arrow fish traps at Las Hojitas. Spiny lobsters and parrot fishes were observed inside the fish traps during our survey.

Plate 1

Plate 2

Habitat Map and Characterization of Benthic Communities in Ponce Bay

The map of benthic habitats in Ponce Bay includes a total surveyed area of 3.882 km^2. Five main benthic habitats were recognized within the study area and classified as: 1) un-vegetated mud, 2) mud-*Halophila*, 3) *Halodule* , 4) reef, and 5) mixed seagrass & macroalgae. The total area covered by each benthic habitat is presented in Table 5.

Table 5. Preliminary distribution and area cover of benthic habitats in Ponce Bay.

	Area		
Benthic Habitat	**m^2**	**Km^2**	**% of Study Area**
Unvegetated Mud	2010501	2.001	51.5
Mud - *Halophila*	1213386	1.213	31.2
Halodule	325488	0.325	8.4
Reef	164405	0.164	4.2
Mixed Seagrass/Macroalgae	178797	0.179	4.6
Thalassia	2214	0.002	0.05
Sand	7472	0.007	0.18

<u>Un-vegetated Mud Habitat</u>

A flat, uniform and un-vegetated soft mud habitat prevails throughout the deeper sections of the study area in Ponce Bay between depths of 10 – 20 meters (Plate 1). This area includes the navigation channel and the existing harbor basin (Figure 7). The total area covered by the un-vegetated mud habitat was 2.001 km^2, representing 51.5 % of the total area surveyed (Table 5). There were no physical structures providing vertical relief that could serve as protective habitat for benthic populations. From the many holes present in the mud (Plate 2) it is evident that infaunal benthic invertebrates are present at the deep mud habitat. Although infaunal samplings were not performed as part of this study, it is possible that excavator crabs and worms are residents of the soft mud habitat. One Southern Logworm, *Arenicola cristata*, was collected and reported in a preliminary characterization of marine communities in the navigation channel of Ponce Bay (García, 2001).

The Albino gorgonian, *Stylatula* sp., was the numerically dominant component of the epibenthic community (Plate 3). Also present in the deep mud were a few colonies of the gorgonian *Leptogorgia* sp. Blue crabs (*Callinectes* sp.), which are motile, megabenthic invertebrates were collected by fish traps at this habitat during the present study. Juvenile Bearded fireworms (*Hermodice carunculata*) were observed over the deep mud in a preliminary characterization of marine communities at the navigation channel of Ponce Bay by García (2001). Associated with a sunken wood log, the Algae hydroid (*Thyroscyphus ramosus*), the Arrow crab (*Stenorhincus seticornis*) and the Banded coral shrimp (*Stenopus hispidus*) were (also) previously identified from the navigation channel (García, 2001).

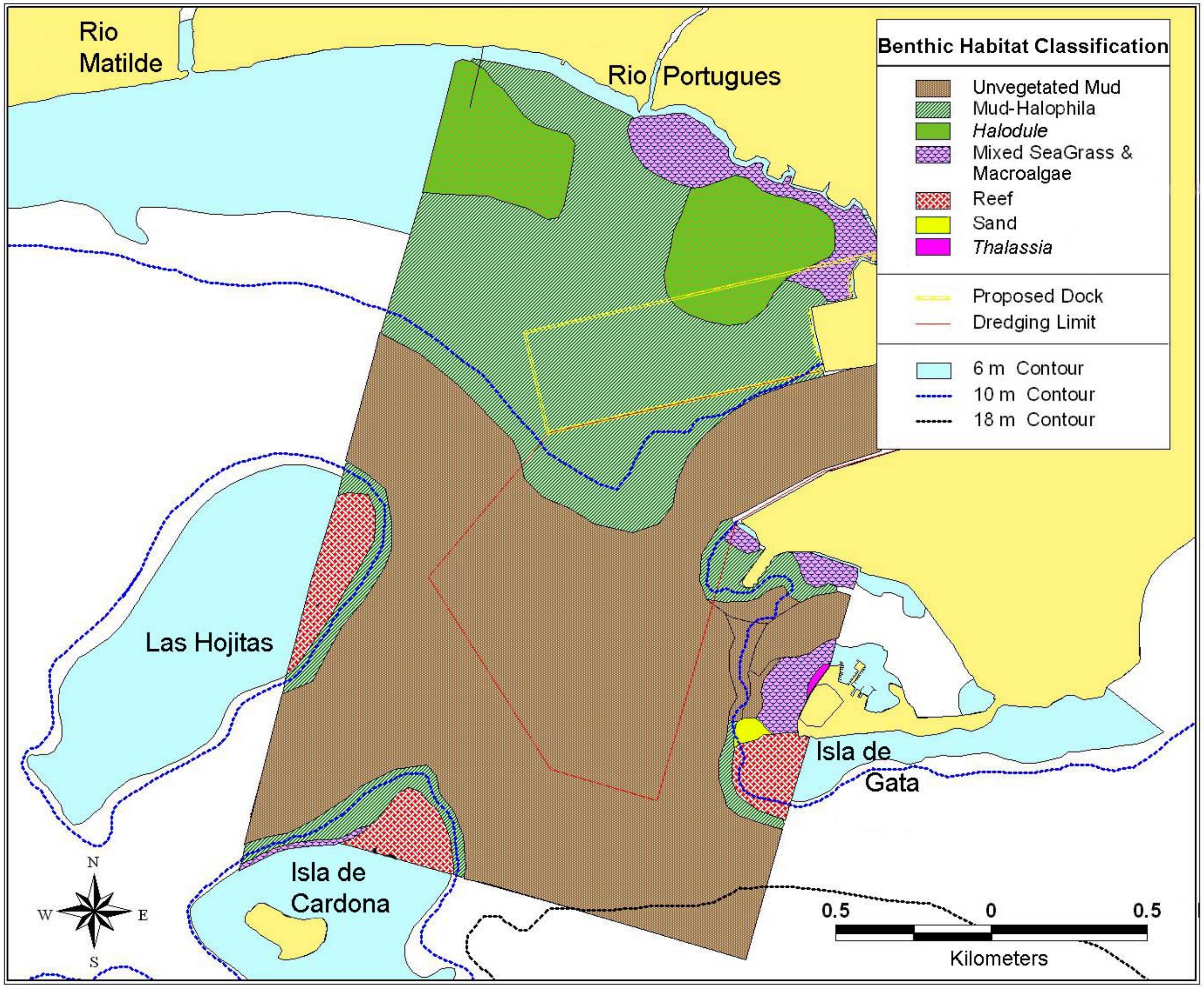

Figure 7. Benthic habitat map of Ponce Bay.

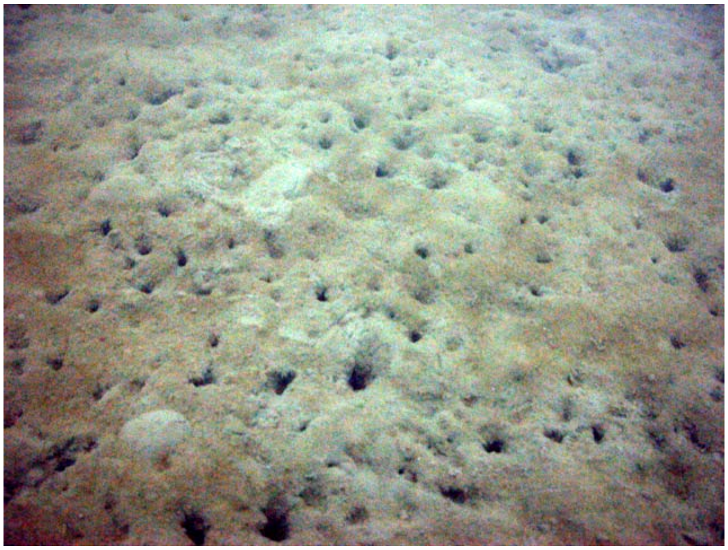

Plate 3

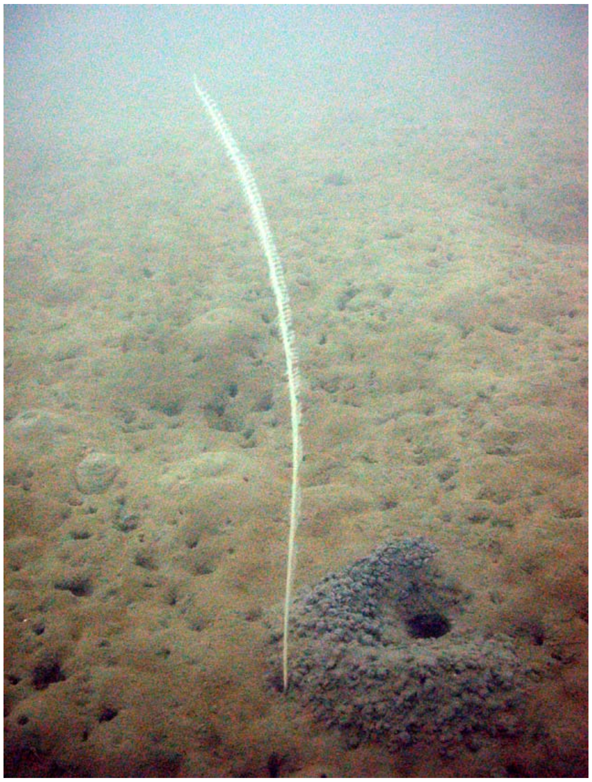

Plate 4

Mud-Halophila Habitat

A gradual transition towards a more compact (packed), darker and partially vegetated mud bottom was observed in the direction from deeper to shallower sections of the navigation channel and inner sections of the study area in Ponce Bay. The Midrib seagrass, *Halophila decipiens* was found patchily distributed and growing sparsely over the soft mud at depths between 4 and 10 meters, without forming a distinct carpet or "bed" on the soft mud substrate (Plates 5 & 6). The "Mud-Halophila" habitat includes sections of the navigation channel, turning basin and proposed pier facilities of the Ponce megaport (Figure 7). Sparse growth of *Halophila* over mud bottom was also present at the base of Las Hojitas and Isla Cardona fore reef slopes. The total area covered by the mud-Halophila habitat was estimated as 1.213 km^2, representing 31.2 % of the total area surveyed (Table 5). As in deeper sections of the soft mud bottom, there were no physical structures providing vertical relief that could serve as protective habitat for benthic populations.

Plate 5

Plate 6

The sessile-benthic community associated with the mud-Halophila habitat included the Midrib seagrass, *Halophila decipiens* and the gorgonians, *Stylatula sp.* and *Leptogorgia* sp. Infaunal organisms appear to be abundant, as suggested by the ubiquitous presence of holes in the bottom. These holes serve as residence habitat of the Hovering Goby, *Ioglossus helenae*. The (epibenthic) motile-megabenthic invertebrate biota associated with the mud-Halophila habitat included Blue crabs (*Callinectes* sp.) and also an aggregation of Caribbean fighting conch, *Strombus pugilis* distributed along a narrow fringe encompassing depths between 8-9 meters (Plates 5 & 6). Epibenthic invertebrates associated to the seagrass based food web may serve, in turn as food to a suite of larger benthic predators in Ponce Bay, including the Southern Stingray, *Dasyatis americana* and the Lane snapper, *Lutjanus synagris*.

Seagrass and Macroalgal Habitats

Seagrass beds within the study area occur as a discontinuous fringe along the sandy beach shoreline (north) of Ponce Bay, colonizing depths between 0.5 and 3 meters (Figure 7). A monotypic stand of the Shoal seagrass (*Halodule wrightii*) with few interspersed macroalgae prevailed along the 2 – 3 meter depth contour, whereas a mixed seagrass/macroalgal stand occupied the most shallow sections of the eastern shoreline. The Shoal seagrass stand (Plates 7-8) was found growing over a compacted, dark, sandy-silt substrate. The total area covered by the *Halodule* stand was estimated as 0.325 km^2, representing 8.4 % of the study area (Table 5). A gap along the Shoal seagrass bed was detected in front of the Río Portugués discharge, where the transition towards the mixed seagrass/macroalgal stand occurs (near the river mouth). An extension of the mud-Halophila habitat was observed along the western and southern (deeper) sections of the gap (Figure 7). In addition, a small, monotypic stand of Turtle Grass (*Thalassia testudinum*) was found growing in association with brown macroalgae (*Dyctiota sp.*) off from the gasoline station, on the eastern bay section (Plates 9-11).

The mixed seagrass/macroalgal habitat was distributed as a continuous fringe along the eastern beach shoreline at depths between 0.5 and 2 meters. The substrate was mostly silty-sand and mud, with sparse rocks, shells, coral rubble and metal debris. The sessile-benthic community was comprised of a mixed assemblage of Shoal seagrass

Halodule wrightii, Midrib seagrass, *Halophila decipiens* and small amounts of Turtle Grass, *Thalassia testudinum* intermixed with green (*Halimeda sp., Udotea flabellum, Penicillum sp., Caulerpa racemosa, Acetabularia sp.*), brown (*Dyctiota sp*., *Sargassum* sp.) and red macroalgae (*Gracilaria sp*.) (Plates 12-14). The percent substrate cover by sessile-benthic biota at the mixed seagrass/macroalgal habitat is presented in Table 6.

Solid structures among the seagrass/macroalgal bed create a protective habitat for an assemblage of juvenile reef fishes and invertebrates. Also small zooplanktivorous fishes that serve as forage for larger pelagic populations were observed to occur as transitory populations in the seagrass/macroalgal habitat (see previous section). A pair of Manatees (*Trichechus manatus*) were observed at the eastern section of Las Hojitas backreef. It is most likely that these manatees are associated to the seagrass habitats in Ponce Bay.

Table 6. Percent composition of sessile-benthic biota from video-transects at Seagrass station in Ponce Bay.

	Video Transects			Mean
Sessile-Benthic Biota	**Tr-1**	**Tr-2**	**Tr-3**	**%**
Mixed Seagrass& Macroalgae	26.2	81.6	46.4	51.4
Midrib Seagrass *(Halophila decipiens)*	48.8	0.0	37.6	28.8
Macroalgae	9.2	10.2	6.6	8.7
Abiotic	17.8	8.2	9.4	11.8

Plate 7


Plate 8

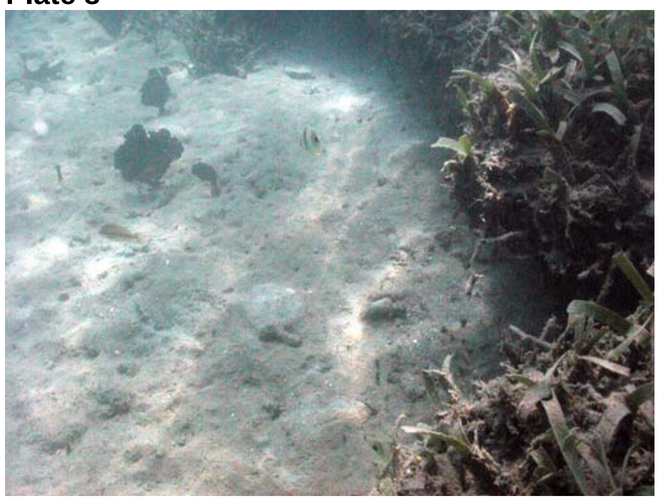
Plate 9

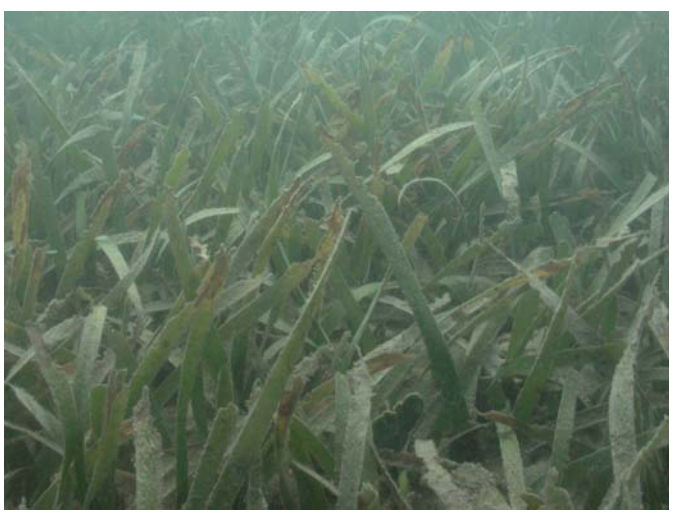
Plate 10


Plate 11


Plate 12


Plate 13

Plate 14

Reef Habitats

Three reef systems are present within the boundaries of the study area in Ponce Bay, these are: Isla de Gatas, Isla Cardona and Las Hojitas Reefs. Isla de Gatas and Isla Cardona are emergent reefs at the entrance of the bay, whereas Las Hojitas is a submerged reef platform. Isla de Gatas and Isla Cardona rise from an unconsolidated mud bottom at a depth of approximately 20 meters. The fore reef slope of both reef systems is mostly abrupt with few narrow terraces. Isla Cardona has a fairly wide reef crest along the southeastern section and an extensive back reef with seagrasses on the north western section. The island is flat and vegetated with a coralline sandy beach on its north-western side. Isla Gatas exhibits a fairly extensive reef crest on its south western border that leads to a fore reef slope which is a vertical wall down to its base. Several large dead coral boulders were observed at the base of Gatas Reef. Likewise, large dead colonies of Elkhorn Coral, *Acropora palmata* overgrown by algae and other encrusting biota were present at the reef crest of Gatas. Las Hojitas is a submerged reef platform, or patch reef, that rises to approximately two (2) meters from the surface. The reef structure is discontinuous, with many gaps filled with unconsolidated (mostly sandy-silt) sediments and has a rather low vertical relief associated with mostly encrusting growth of scleractinian corals.

All three reefs showed conditions of advanced degradation, which appears to be influenced by low light penetration and high exposure to sedimentation and abrasion stress. The reefs presented very low live stony coral cover (< 5%), standing dead coral colonies and high substrate cover by algae and other encrusting biota. Table 7 presents mean percentages of surface cover by sessile-benthic categories at the three reefs surveyed by video-transects. The highest live stony coral cover was measured from Las Hojitas Reef with 4.1 %. Isla Gatas presented a mean stony coral cover of only 1.9 %. Isla Cardona had a mean live stony coral of 3.3 %, but the density of soft corals, or gorgonians (Plates 15 – 18) was very high (mean: 63 colonies per transect). Great Star Coral (*Montastrea cavernosa* -- Plate 19) was the main stony coral in terms of percent cover at Las Hojitas and Gatas, whereas the Boulder Brain Coral (*Colpophyllia natans* - Plate 20) was the dominant coral at Cardona Reef (Table 7). Boulder Brain Coral, Symetrical Brain Coral (*Diploria strigosa*), Massive Starlet Coral (*Siderastrea* *siderea*) and Mustard Hill Coral (*Porites astreoides*) were present within video-transects at the three reefs. A total of 18 species of stony corals and 11 species of soft corals (gorgonians) were identified from the three reefs surveyed (Table 8). The Common Sea Fan (*Gorgonia ventalina*), Sea whips (*Pterogorgia spp*., *Ellisella sp*.), Sea Plumes (*Pseudopterogorgia spp*.) and Sea Rods (*Pseudoplexaura sp*, *Plexaurella sp*., *Eunicea spp*.) were highly abundant at fore-reef slope of Isla Cardona, but were present at Gatas and Las Hojitas Reefs in lower densities. The Flamingo Tongue snail (*Cyphoma gibbosum*) was abundant at Sea Fans from Cardona and Gatas Reefs. The Encrusting Gorgonian, (*Erythropodium caribaeorum*) was present at the three reefs surveyed (Plate 18).

Turf algae, a mixed assemblage of red, brown and green calcareous macroalgae growing as a carpet over hard ground (Plate 21) was the main biotic component in terms of substrate cover, representing more than 70 % at all three reefs surveyed (Table 7). Encrusting and erect sponges (Plates 22-25) followed in terms of substrate cover at Isla Cardona (7.4 %) and Las Hojitas (11.3 %), whereas the encrusting zoanthid, *Palythoa caribaeorum* (Plate 26), ranked second at Gatas Reef (20.9 %). The Giant Barrel sponge (*Xestospongia muta*), Black-Ball sponge (*Ircinia strobilina*), Orange ball sponge (*Cinachyra sp*.), Green Finger sponge (*Iotrochota birotulata*), and the Brown Variable sponge (*Anthosigmella varians*), were the most prominent sponge species at the reefs surveyed. Motile megabenthic invertebrates prominent at reefs from Ponce Bay include the Long-spined Urchin (*Diadema antillarum*), Bearded Fire Worm (*Hermodice carunculata*) and the Feather Duster (*Sabellastarte magnifica*). The Spiny lobster (*Panulirus argus*) was observed from Las Hojitas and Gatas reefs.

The sessile-benthic community structure of reef systems at Ponce Bay resembles that of inshore reefs in other coastal embayments of Puerto Rico, such as Guayanilla and San Juan bays (Matos et al., 2000). Available hard substrate in these reef systems is mostly colonized by turf algae and encrusting sponges. The presence of many dead stony coral colonies of moderate size now overgrown by encrusting biota suggests that at some previous time, conditions for scleractinian coral growth could have been more favorable in Ponce Bay. However, it is impossible from simple field observations to determine when many of these corals died. However, the poor development of reef systems in Ponce Bay were initially reported by Goenaga and Cintron (1979) and later confirmed by García et. al. (1985 a, b). The combined effects of sedimentation and eutrophication associated with river loadings, domestic and industrial inputs via sewage treatment plant submarine outfalls and dredging of the navigation channel represent potential causes for reef community degradation in coastal embayments. Mechanical damage caused by hurricanes and coral bleaching induced by elevated water temperatures and diseases represent natural causes of coral mortality that add to the overall reef community degradation (Matos et. al., 2000).

Table 7. Percent cover of sessile-benthic substrate categories surveyed by video-transects at reef systems in Ponce Bay.

	% Cover		
Substrate Categories	**Isla Cardona**	**Las Hojitas**	**Gatas**

Live Stony Corals			
Montastrea cavernosa	0.67	2.27	1.00
Diploria strigosa	0.13	0.27	0.67
Siderastrea siderea	0.13	0.80	0.13
Madracis decactis	0.40		
Colpophyllia natans	1.13		
Porites astreoides	0.60	0.27	0.07
Millepora alcicornis	0.20	0.47	0.00
Total Stony Corals	3.27	4.07	1.87
Turf Algae	83.60	74.40	72.47
Sponges	7.40	11.27	3.53
Zoanthids	4.40	3.47	20.93
Anemones	0.00	0.00	0.60
Abiotic	1.00	6.73	0.60
Unclassified	0.33	0.07	0.00
Octocorals (# colonies/transect)	63	27	15

Plate 15

Plate 16


Plate 17

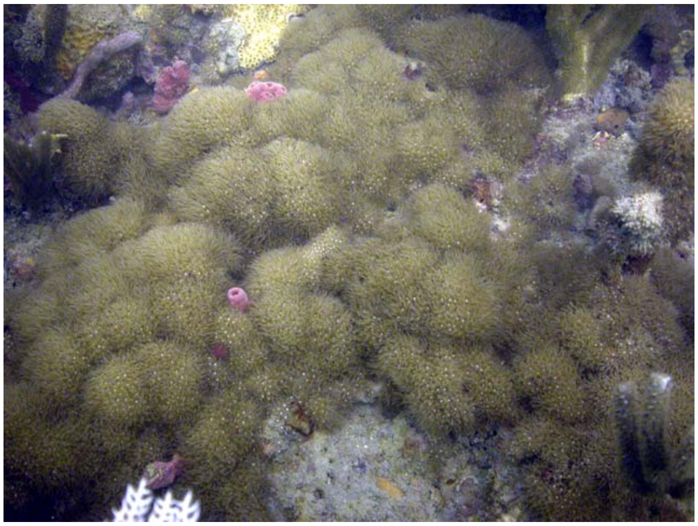
Plate 18


Plate 19

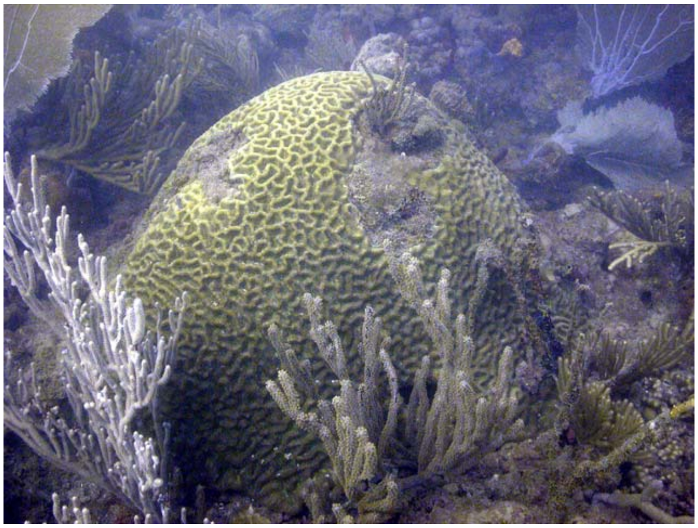
Plate 20


Plate 21


Plate 22


Plate 23

Plate 24


Plate 25

Plate 26

Conclusions

Water temperature, salinity and density profiles were mostly homogeneous from the surface to the bottom (max. depth 20m), indicative of a well mixed water column and absence of any significant processes influencing vertical stratification. Such conditions characterize the superficial water mass in the northern Caribbean (e.g. Caribbean Surface Mixed Layer).

Chlorophyll-a concentrations ranged between 1.5 and 2.0 ug/l throughout most of the inshore stations in Ponce Bay. These concentrations are typical in coastal embayments of Puerto Rico during the dry season.

A marked gradient of decreasing chlorophyll-a towards the mouth of the bay was observed. The minimum concentrations (0.5ug/l) at the entrance of the bay reflect the influence of open oceanic waters of lower phytoplankton productivity.

Soft mud bottoms, seagrass beds and reefs are the main benthic habitats within the study area in Ponce Bay. The estimated percent cover by the different benthic habitats is the following :

Soft mud habitat – 83 %
Seagrass beds – 13 %
Reefs – 4 %

An un-vegetated soft mud bottom habitat prevails in regions deeper than 10 meters throughout the study area, including the entire navigation channel and the main existing pier basin. The un-vegetated soft mud bottom represents approximately 51.5 % of the study area (~ 2.001 km^2).

The epibenthic community of the deep soft bottom habitat is depauperate (of very low species richness and diversity), comprised by gorgonaceans (*Stylatula sp*., *Leptogorgia* *sp*.), epibenthic crabs (including *Callinectes* spp.) and the Hovering goby (*Ioglossus helenae*).

Infaunal (excavator) crabs and burrowing worms (e.g. *Arenicola sp*.) appear to be abundant in the deep soft mud habitat, as inferred by the many holes present.

At depths between 4 -10 meters, the soft mud habitat is sparsely vegetated by the Midrib Grass, *Halophila decipiens*. The benthic community shares the same biological components of the deeper soft mud habitat, along with a population of the West Indian Fighting Conch (*Strombus pugilis*) that appears to be associated with the seagrass.

Seagrass beds within the study area occur as a narrow fringe along the sandy beach shoreline (north), colonizing depths between 0.5 and 3 meters. Along the eastern boundary, a monotypic stand of the Shoal Seagrass (*Halodule wrightii*) with interspersed macroalgae was found. On the eastern section of the beach, there was a mixed seagrass/macroalgal stand that includes *Halodule wrightii*, *Halophila decipiens* and small amounts of Turtle Grass, *Thalassia testudinum*. Also, a small fringe of Turtle Grass was found growing off from the gasoline station, on the eastern section of Ponce Bay.

Three reef systems are present within the boundaries of the study area in Ponce Bay, Gatas, Isla Cardona and Hojitas Reefs. All three reefs show conditions of advanced degradation, which appears to be influenced by low light penetration and high exposure to sedimentation and abrasion stress. The reefs present very low live stony (scleractinian) coral cover (< 5%), standing dead coral colonies and high substrate cover by algae and other encrusting biota.

Although reef building (scleractinian) coral colonies are small, scarce and mostly appear with encrusting growth patterns, the reef habitat at Isla Cardona presents a very high density of soft corals (gorgonians). Many colonies have attained large sizes and provide substantial topographic relief (rugosity) along the fore reef slope. The relatively high rugosity of the structural habitat allows for substantial biological complexity and makes Isla Cardona Reef consistent with the definition of a coral reef system.

A total of 75 (non-criptic) juvenile and/or adult fishes were identified from the study area during our snapshot survey of Ponce Bay. The highest density of fishes (26.6 Ind/30 m^2) and mean number of species present within transect areas (11 spp/30 m^2) was observed from Isla Cardona Reef. Gatas and Hojitas Reefs presented mean densities of 23.5 Ind/30 m^2 (4.3 spp/30 m^2) and 15.5 Ind/30 m^2 (6.3 spp/30 m^2).

Fish densities and species richness from reef habitats in Ponce Bay characterize the poorly developed and/or highly stressed shallow reefs located close to the shoreline along the south coast of Puerto Rico.

Soft mud habitats were depauperate with respect to demersal fish populations, presenting very low densities and species richness. Nevertheless, species of high commercial value, such as the Lane and Mutton snappers (*Lutjanus synagris, L. analis*) were collected and appear to represent an assemblage of transitory species that forage for epibenthic invertebrates in the soft mud habitat.

The fish community present along the navigation channel is mostly comprised by pelagic populations. Small zooplanktivore species, such as sardines (*Jenkinsia lamprotaenia.,* *Harengula spp., Opisthonema oglinum*), anchovies (*Anchoa spp*.) and silversides (Fam. Atherinidae) serve as forage for an assemblage of pelagic predators that include mackerels, tarpoon, jacks and barracudas.

The main existing pier structure in Ponce Bay, which comes out of a soft mud habitat, serves as an important nursery habitat for Lane snappers, as inferred from the relatively large collection of juveniles that were collected from hook and line samplings at that station.

Juvenile reef fishes were common in shallow sections of seagrass beds at Ponce Bay, where abundant debris and rocks provide protective habitat close to their feeding ground.

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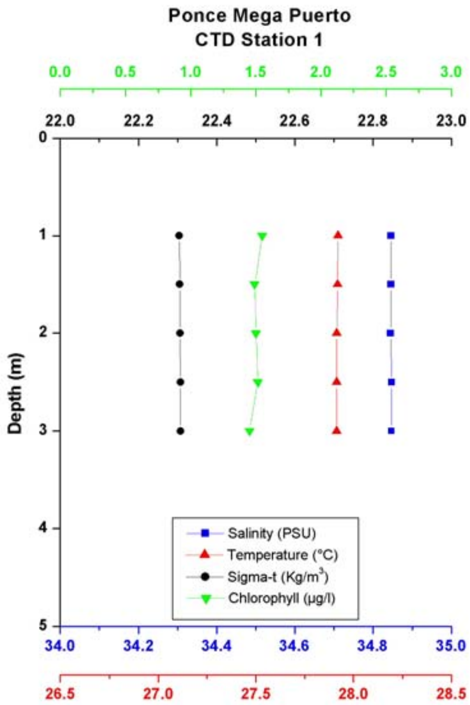
Appendix 1. Water temperature, salinity, density and chlorophyll-a profiles from Ponce Bay during December 2002.

Appendix 1.1



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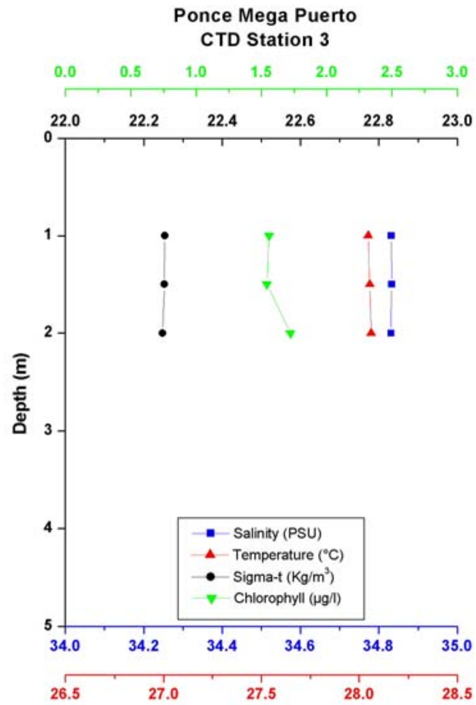

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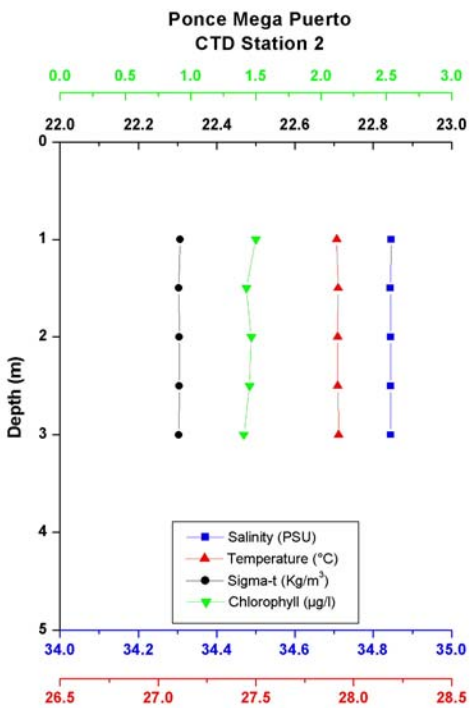

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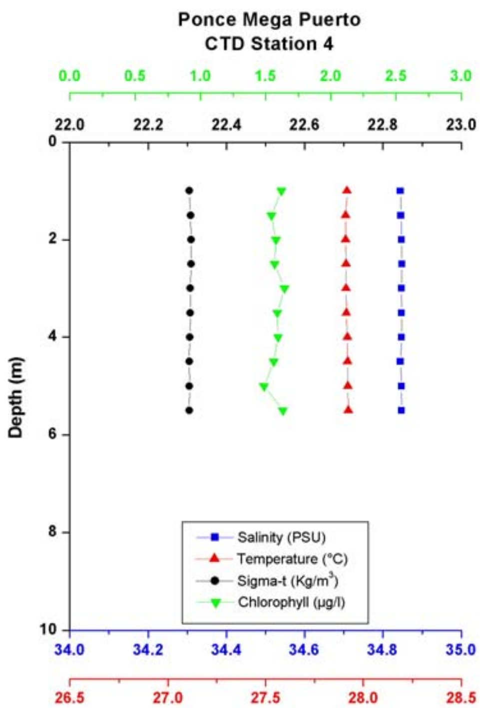

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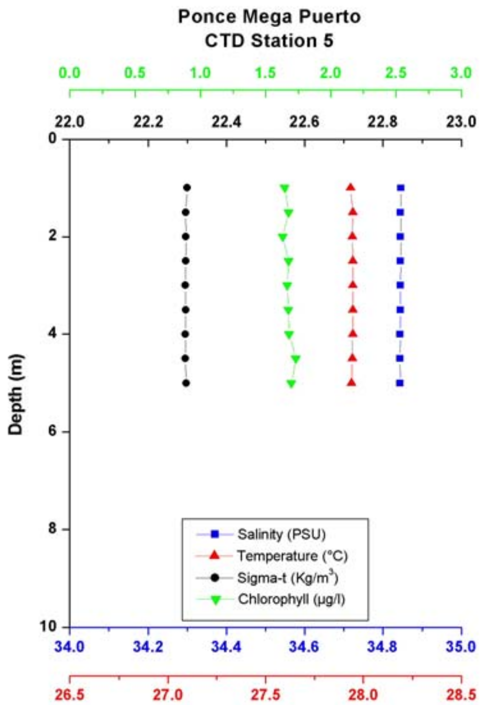

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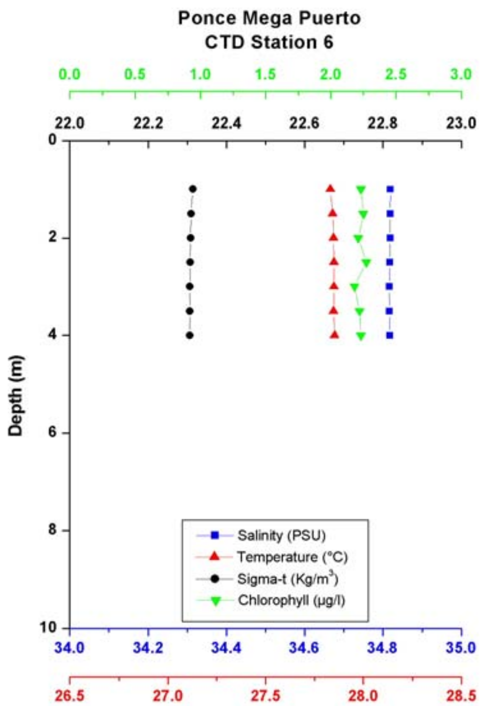

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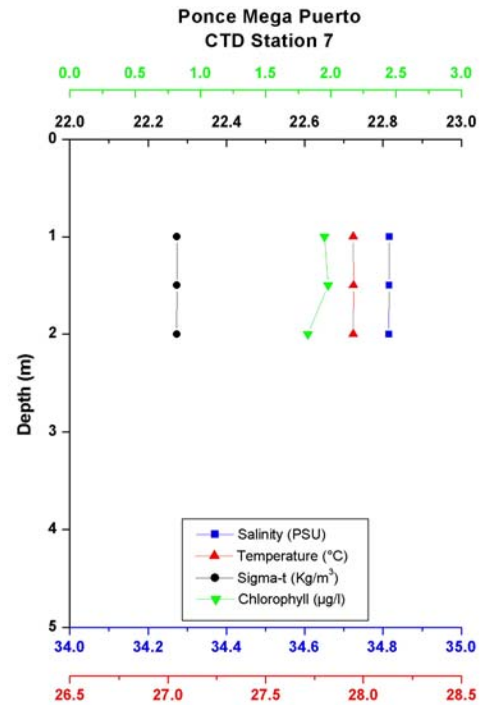

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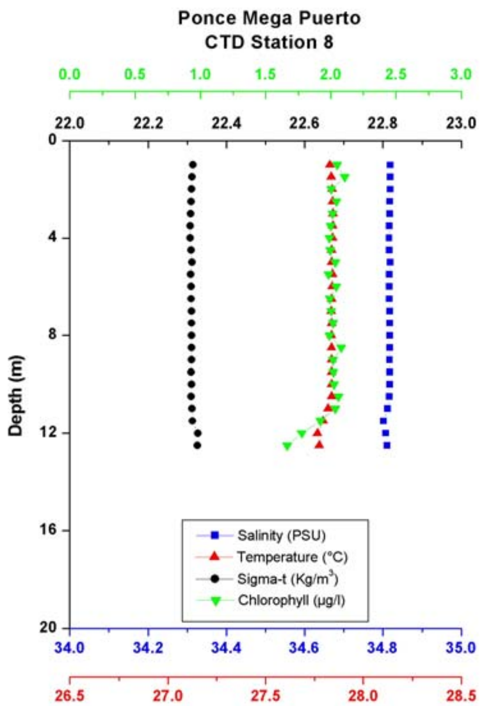

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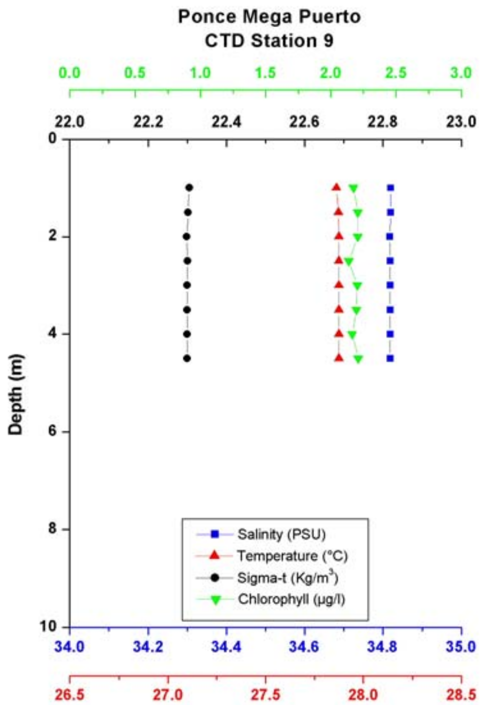

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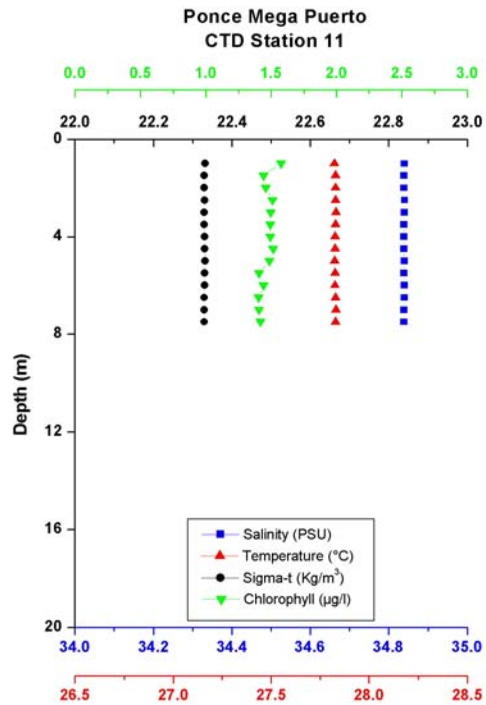

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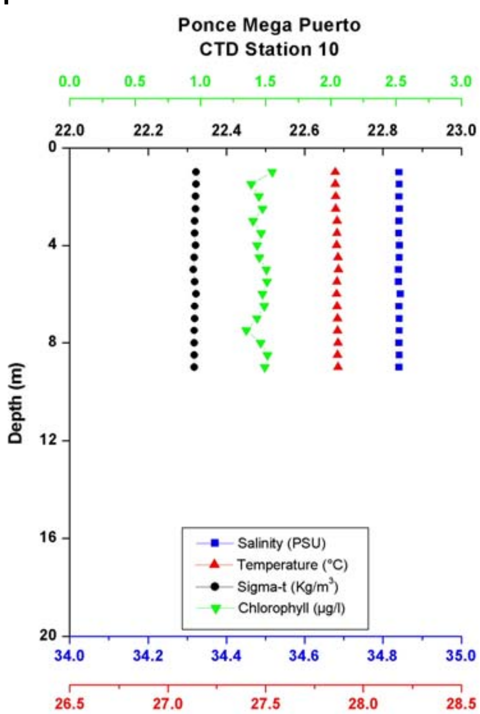

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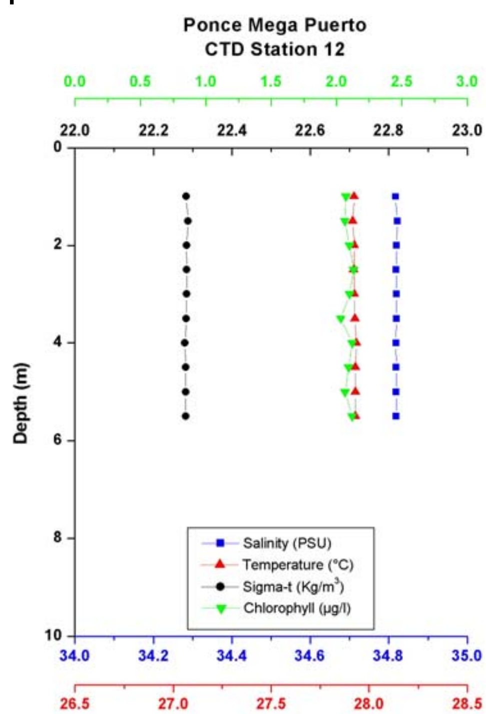

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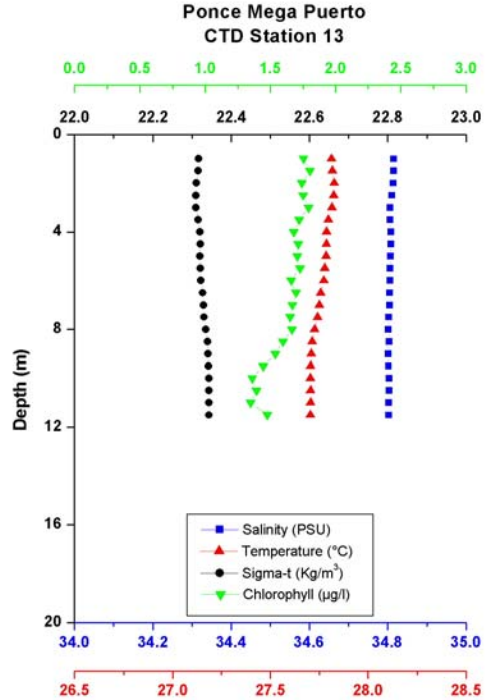

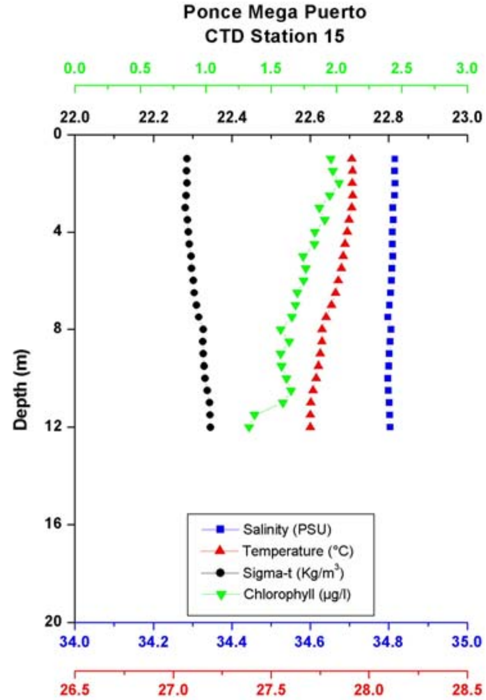

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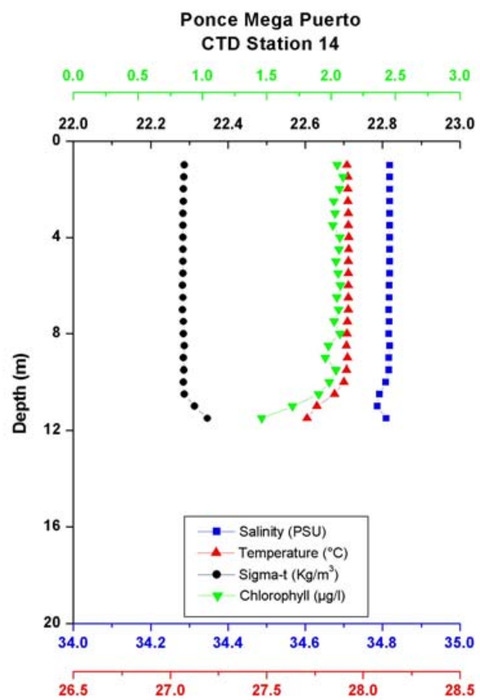

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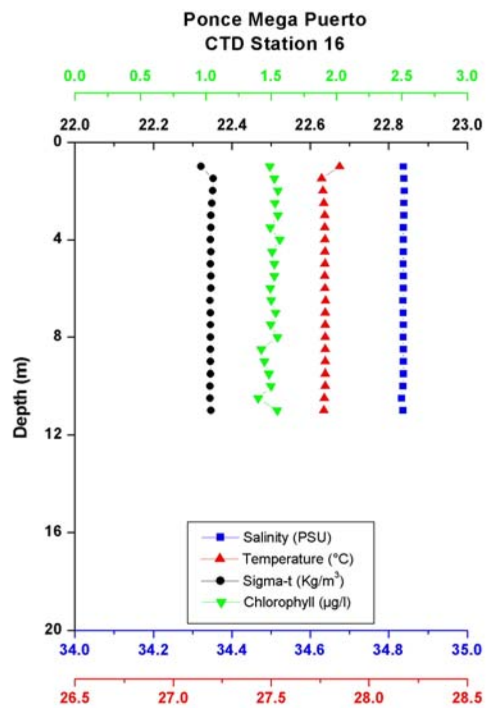

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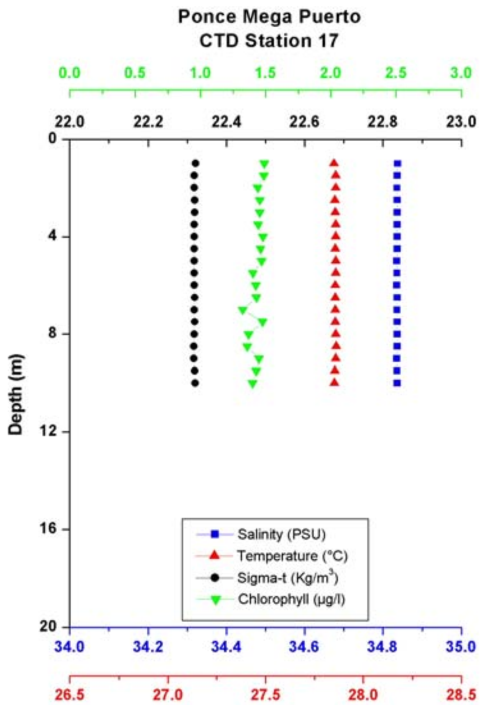

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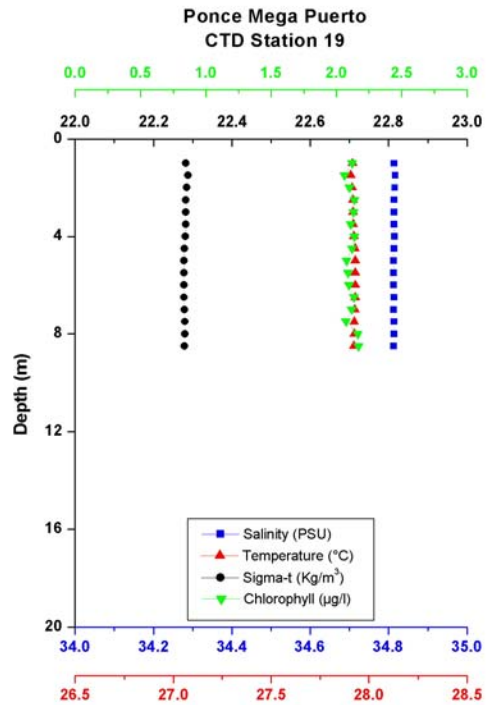

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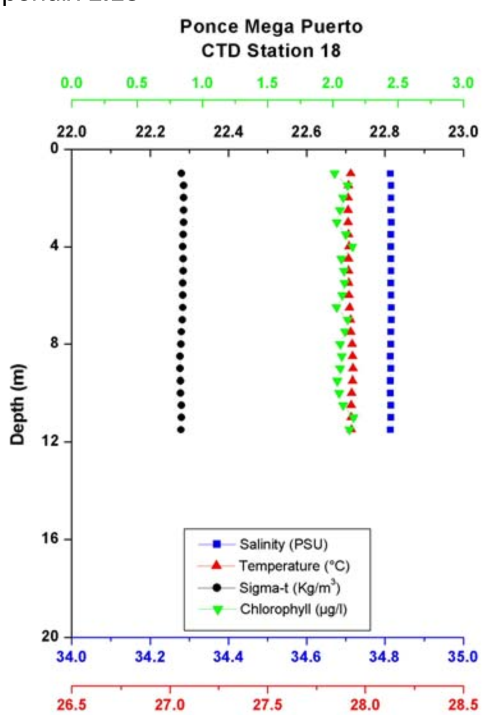

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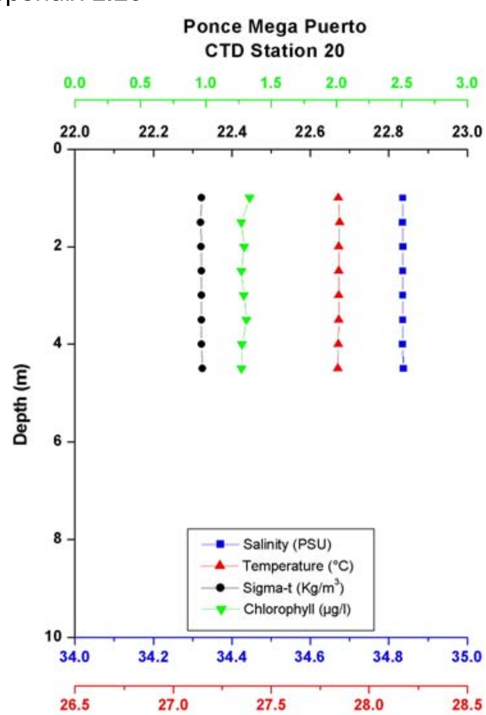

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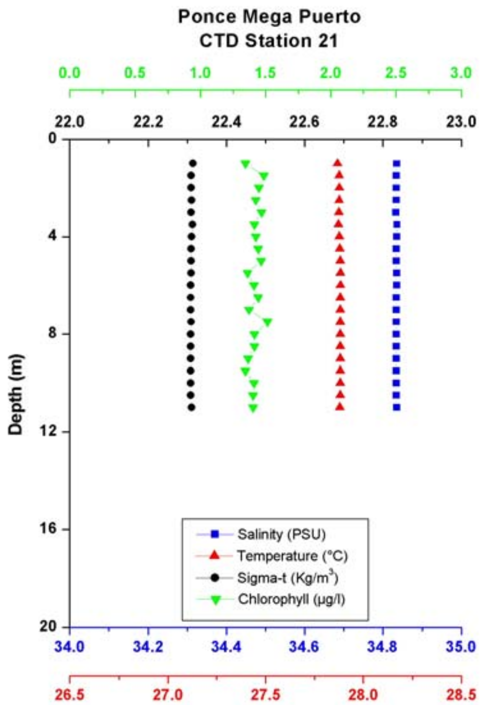

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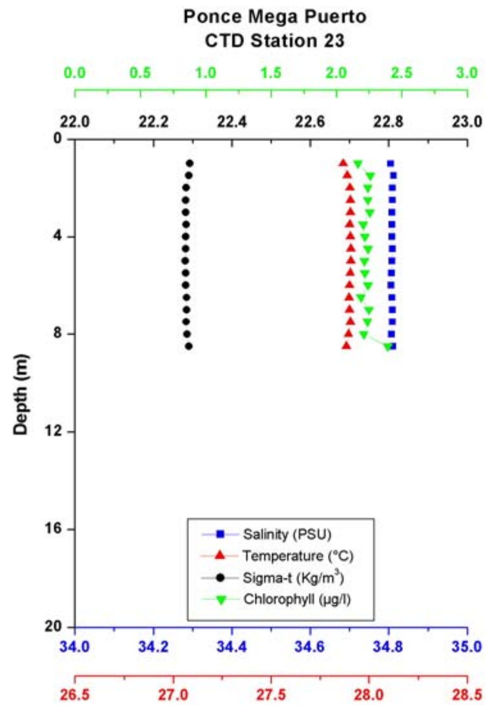

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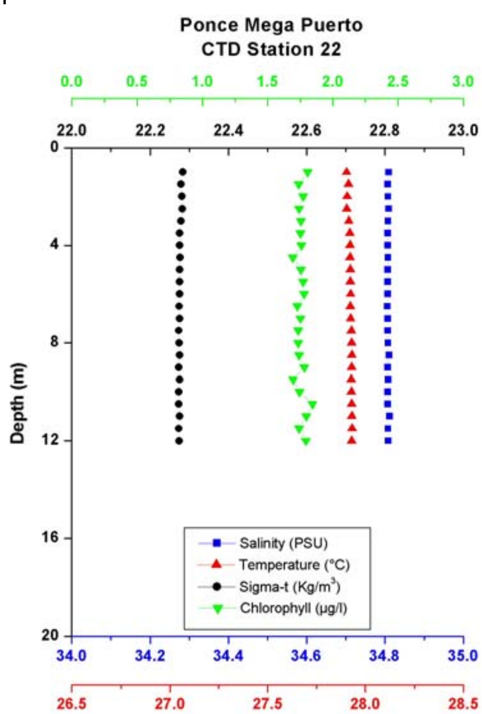

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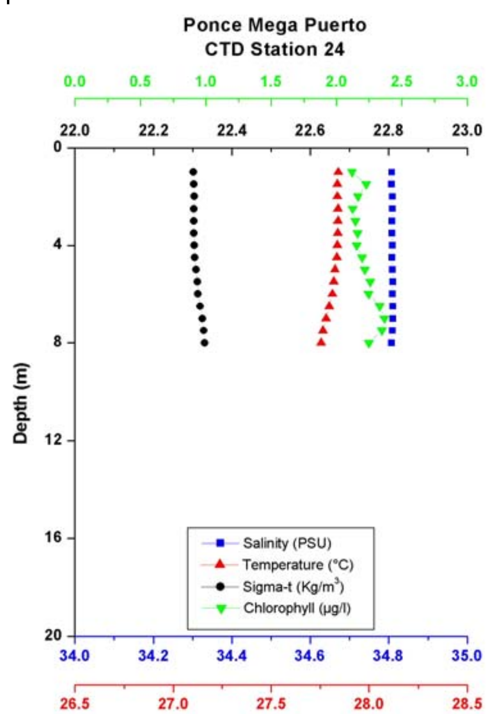

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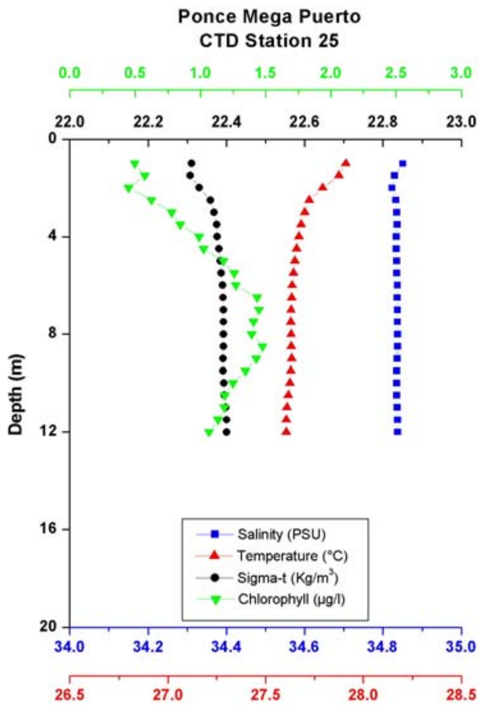

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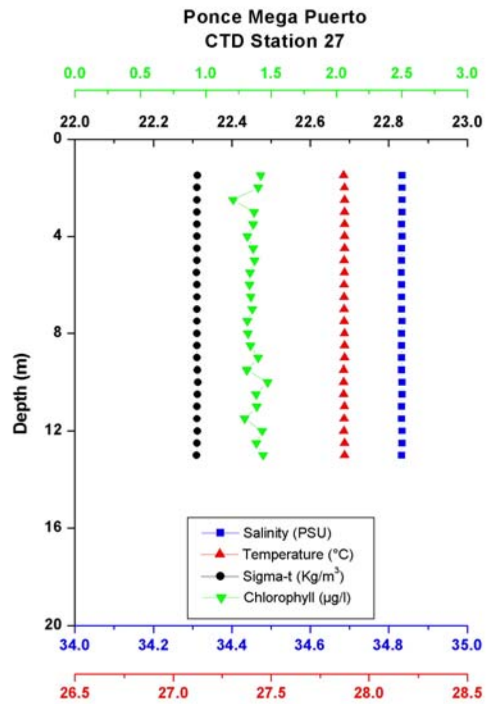

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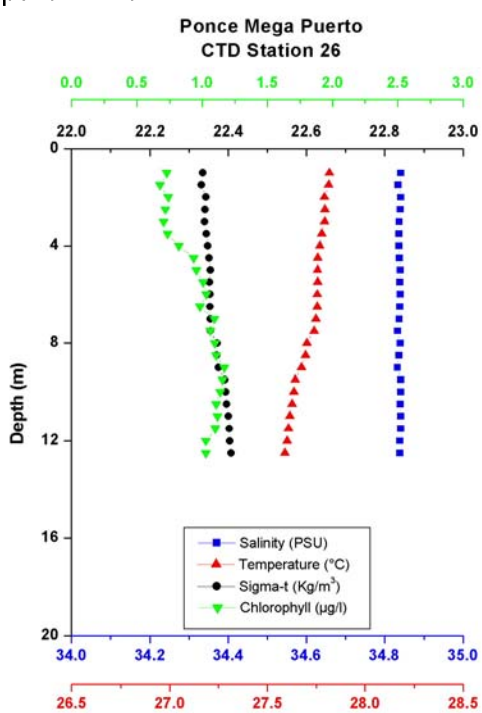

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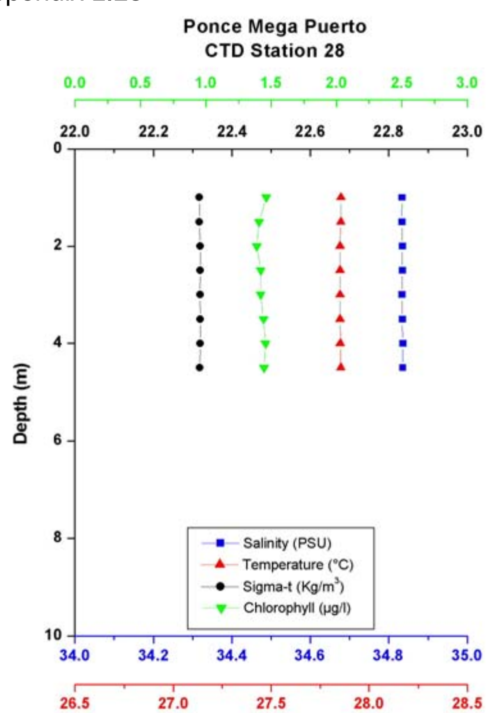

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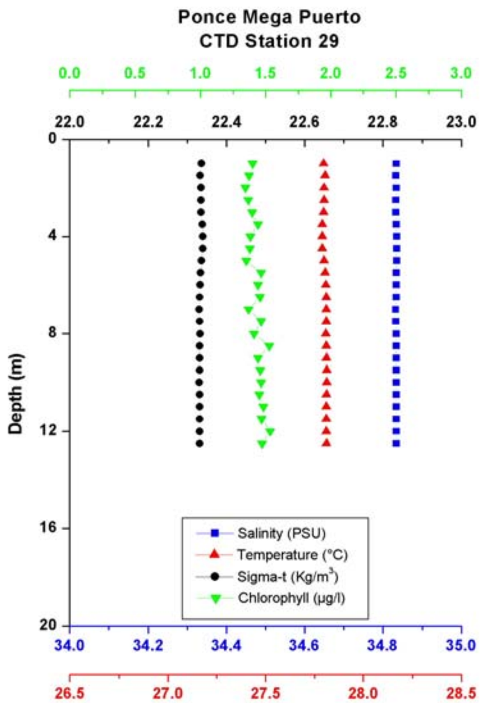

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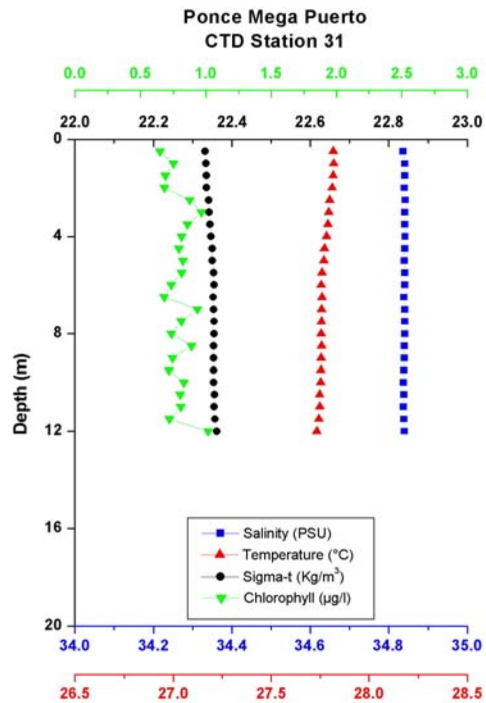

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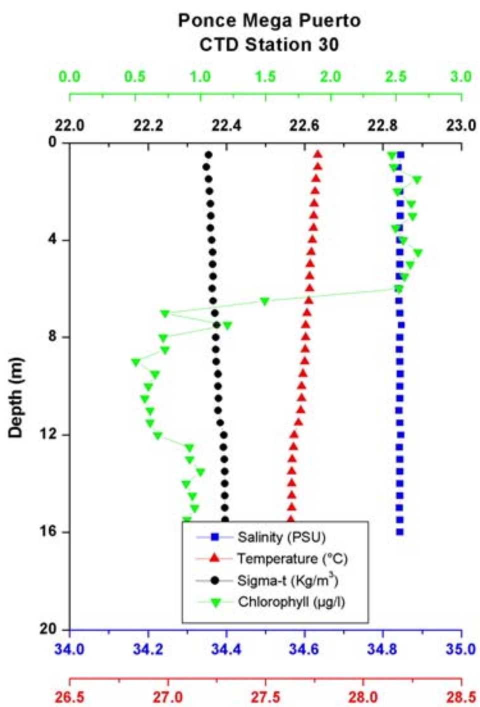

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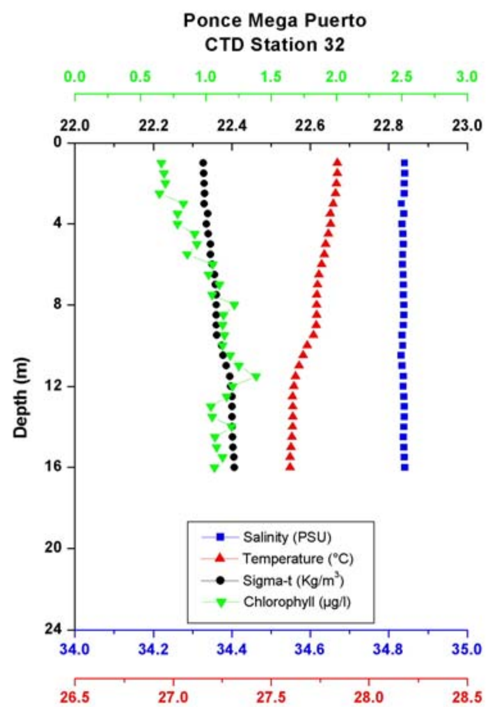

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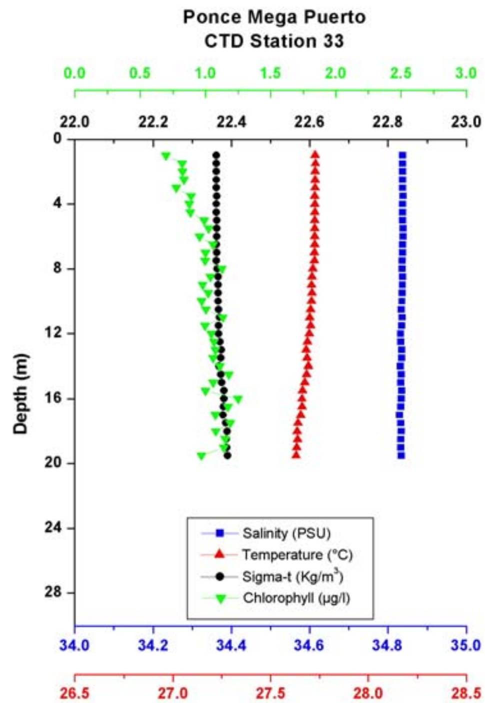

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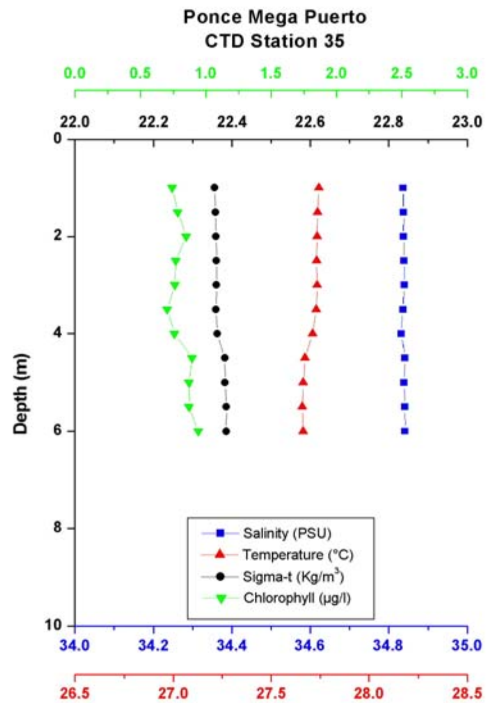

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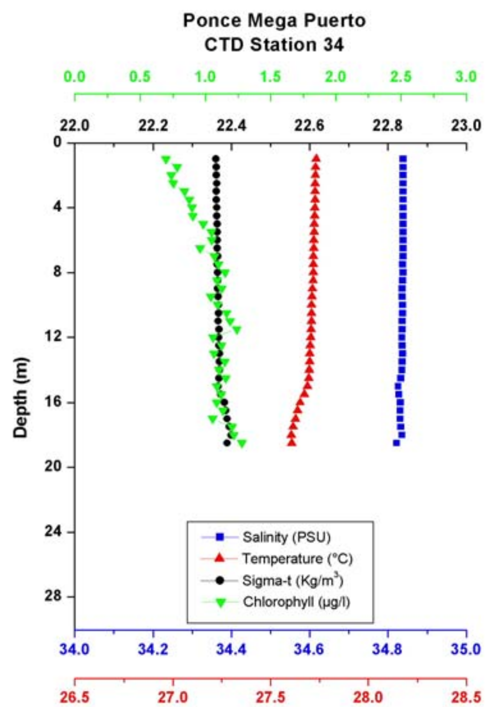

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