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MARINE RESOURCES ASSESSMENT: MARINA PUERTO REAL, FAJARDO, PUERTO RICO

BENTHIC COMMUNITIES WITHIN THE PROPOSED SEAWARD EXTENSION OF MARINA PUERTO REAL, FAJARDO, PUERTO RICO
APRIL 10-11, 2003

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JULY, 2003

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART I

MARINE RESOURCES ASSESSMENT: MARINA PUERTO REAL, FAJARDO, PUERTO RICO

BACKGROUND

Vicente and Associates, Inc., (V&A) continues to be retained by AVE Inc., partner of Marina Puerto Real, for the purpose of pursuing benthic studies within the proposed offshore extension of the existing Marina Puerto Real facilities in Fajardo, Puerto Rico.

At present, Marina Puerto Real is a land-based marina facility located on a small sector north of the mouth of Río Fajardo, on the east coast of Puerto Rico. This land-based marina facility has been in operation for fourteen (14) years. During these years, Marina Puerto Real has provided continuous marine services (ramp, storage etc.) to boat owners without incurring in environmental violations (DIA, 2000: Consulta # 2000-24-0437-JPU).

At present, AVE Inc. is proposing to expand its land-based facility into Bahía de Fajardo in order to provide additional marina-related services. Specifically the new marine expansion consists of the following principal components:

1. Construction of 193 concrete slips for vessels between 60 and 80-ft in length,
2. Dredging of 91,313 cubic meters,
3. Utilization of 155,250m^2 of submerged lands,
4. Construction of a platform with Finger Lifts and Travel Lifts,
5. Installation of floating docks,
6. Construction of two (2) breakwaters, a clubhouse, and a parking lot, and,
7. Other structures described in COE-1998-04900 (IP-DD), JP 1999-24-0710-JGU, ZMT-99-070.

An aerial photograph showing the existing conditions of the proposed expansion site is shown in FIGURE 1. The proposed project is also shown overlaid on the aerial photograph. As shown in the figure, the project will significantly enhance the proposed site and provide shoreline protection among other functions.

FIGURE 1. Aerial photograph of the proposed project location. The proposed project is located at the Maternillo Sector, Puerto Real Ward, Fajardo, east coast of Puerto Rico. Existing conditions of the site are shown on top of the page. The proposed project is overlaid in the picture below.

As shown in FIGURE 1, the proposed expansion includes the construction of two breakwaters which are necessary to provide adequate and safe navigable conditions within the marina. The original design of the breakwaters have been improved (i.e. three openings were introduced) in order to assure proper water quality conditions within the marina and in order to comply with USEPA Guidelines for marina basins (Moffat & Nichol, 2003; USEPA, 1985). The three segments of the southern breakwater arm run counterclockwise from shore. The northern breakwater arm runs clockwise from shore. These two breakwaters will protect the shoreline and the land based facility of Marina Puerto Real from apparent erosion conditions of the shore. The proposed development will also provide a refuge for local fishing boats and for the community if necessary, during storms events.

There are eight (8) reference points which mark the footprints of the two breakwaters. The specific locations (latitudes and longitudes) of these footprint points are given in TABLE 1.

TABLE 1. The locations and depths of the eight (8) specific footprint reference points of the proposed expansion of Marina Puerto Real, located in Fajardo Puerto Rico. All the locations of the reference points were documented in this study by using a global position instrument, specifically GPS#2V&A. RP = Reference point.

WPT # GPS2	DEPTH (ft)	LATITUDE (°)	LONGITUDE (°)	NOTES
189	1.0	18° 20' 00.6" N	65° 37' 45.3" W	RP1
190	10.0	18° 20' 09.3" N	65° 37' 40.0" W	RP2
191	9.2	18° 20' 08.3" N	65° 37' 36.1" W	RP3
192	8.2	18° 20' 07.2" N	65° 37' 34.4" W	RP4
193	5.1	18° 20' 10.8" N	65° 37' 35.8" W	RP5
194	8.0	18° 20' 07.8" N	65° 37' 31.5" W	RP6
195	3.9	18° 20' 01.3" N	65° 37' 31.1" W	RP7
196	2.5	18° 19' 53.6" N	65° 37' 36.0" W	RP8

Early in July 2002, V&A, Inc. proposed to conduct a series of underwater transects using SCUBA equipment and other underwater accessories in order to assess the benthic resources within the proposed marina site. Three underwater transects were performed in July 24, 2002: one within the proposed marina site and two off, but near the marina site (see Vicente & Associates, Inc., 2002).

Underwater transects within the proposed marina site although initiated in July 24, 2002 were later discontinued as a sampling tool due to the adverse conditions found within the proposed marina site. Some of the adverse and hazardous conditions found at the proposed marina site at the time of inspection were:

1. poor underwater visibility (<1.0ft),
2. high turbidity,
3. heavy, indiscriminant boat traffic,
4. presence of water pollution indicator organisms,
5. presence of sharp, rusted steel objects,
6. grounded, unregistered steel-hull vessels, steel cables, ropes,
7. near shore discharge waters,
8. feces.

Due to the repulsive, adverse, and hazardous diving conditions found at the site, the benthic assessments after the July 24, 2002 were conducted by minimizing human contact with the apparent contaminated waters of the site. Instead of conducting underwater transects, representative benthic grab samples were obtained as explained in the methodology section below (PART 2 of this report). It is noteworthy that Bahía Fajardo is an industrial bay which has been classified as an impaired water body by EPA (see EPA, 1992).

The three (3) underwater transects conducted consisted of: one near shore transect (within the proposed marina site); and of two offshore transects (close to but outside the marina construction site). In addition five (5) stations were inspected near shore by wading, hand-sampling and by photography.

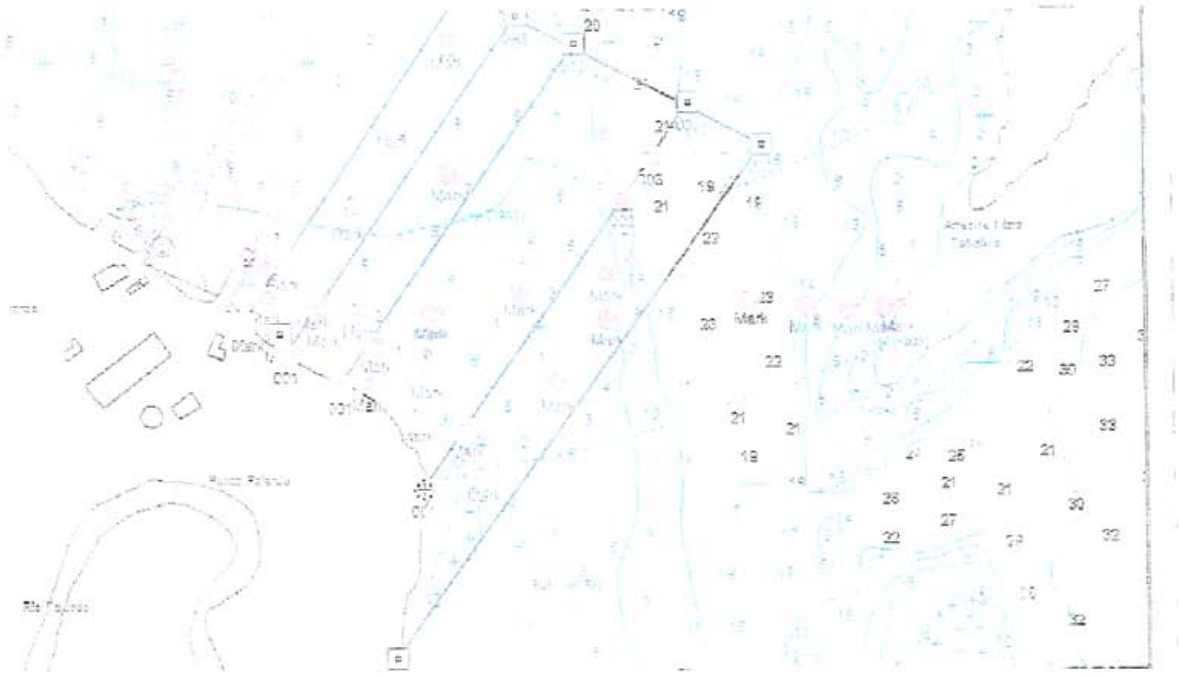
After the July 24, 2002 study, Vicente & Associates, Inc. concluded that:

- protected habitats such as coral reef ecosyatems are not found near shore;
- seagrass bed ecosystems do not occur close to shore within the proposed marina site;
- seagrass beds and corals do occur offshore the project limits.
- there were neither manatees nor sea turtles within the study site at the time.

Details of the July 24, 2002 benthic marine assessment of the proposed site are given in Vicente & Associates, Inc, (2002).

In August 21, 2002, a second benthic assessment was conducted by V&A, Inc. within the proposed marina site. The purpose of this second benthic sampling was to sample between the near shore stations which were sampled in July 24, 2002, and the offshore transects which were also examined in July 24, 2002.

The August 21, 2002 study concluded that there were some sparse seagrass patches which consisted specifically of *Halophila decipiens, Halodule wrightii* and *Syringodium filiforme* within the proposed marina site. FIGURE 2 shown below, indicates the locations of all stations sampled in July 24, 2002 and in August 21, 2002. The stations where seagrasses were found are shown by the colored (red) circles. Stations where no seagrasses were found are shown by the dive-flag symbols.



In view of the presence of some seagrasses found in some of the samples within the proposed offshore extension (during the August 21, 2002 sampling period), a third benthic study was conducted in April10-11, 2003.

The principal objectives of the April 2003 study, which is reported here, were to:

1. determine which species of seagrasses if any are found within the study site;

2. determine if turtlegrass (*Thalassia testudinum*), which is the most ecologically valuable seagrass species, are found in the proposed marina,

3. determine the general distribution patterns of seagrasses within the breakwater foot prints and within the proposed marina basin,

4. determine, in a preliminary fashion, the infauna associated with the marine sediments of the proposed marina site,

5. provide additional information on the sediments and depths found within the proposed marina site, and,

6. Evaluate if the proposed seaward extension of Marina Puerto Real would cause significant impacts to seagrass bed ecosystems, to coral reefs or to other sensitive habitats found within the proposed marina site.

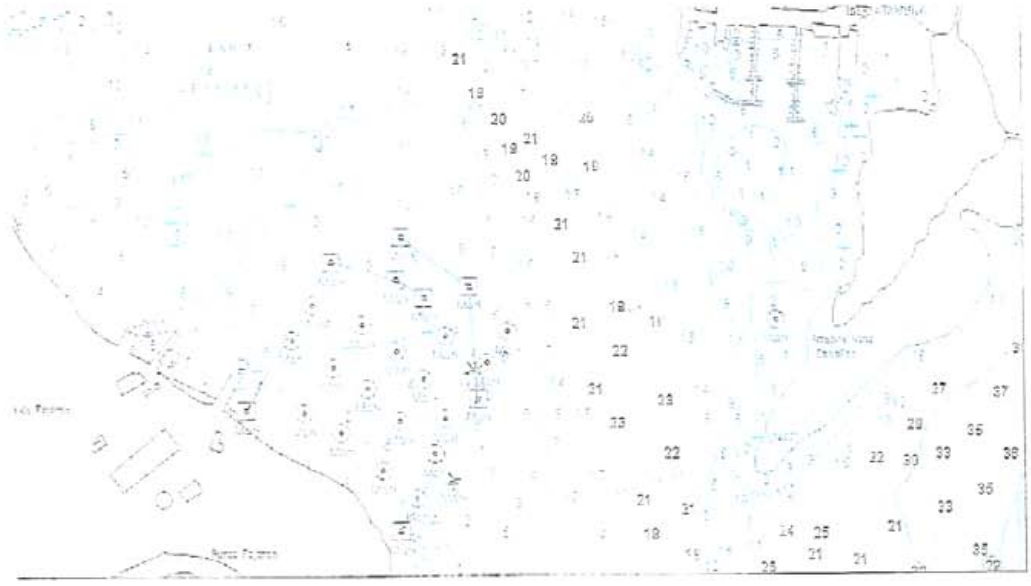
PART 2

MARINE RESOURCES ASSESSMENT: MARINA PUERTO REAL, FAJARDO, PUERTO RICO

In view of the unsafe conditions found within the proposed site, this study (the April 10-11, 2003 field studies) was conducted by using a bottom grab sampler as the principal sampling tool. *In situ* observations were also included as part of the sampling scheme.

Eight grab samples were taken within the breakwater footprint reference points (reference Points 1-8 in TABLE 1). In addition to these eight (8) samples, seventeen (n = 17) samples were taken within the breakwater enclosed portion of the proposed marina. Two (2) to three (3) grabs were taken at each sampling point but only one, the sample which had the greatest sampling volume, was quantified.

The specific locations where the samples were taken during the April 10-11, 2003 field studies are shown in FIGURE 3 below.



The eight reference points (see TABLE 1) of the breakwaters are shown as squares. The locations of the grab-sample stations within the protected breakwater zone (except three which are located east of the structures) are shown as circles. The specific location (latitude and longitude) of each sample collected within the enclosure zone (that is, the zone between the two breakwater arms shown in FIGURE 1) are given in TABLE 2.

The bottom grab sampler utilized consisted of the Wildco-Ponar bottom dredge. The Wildco-Ponar bottom dredge is design to reduce instability and frontal shock wave when lowered rapidly. The sampler is also designed to grab all benthos, including seagrasses or algae if present, from sediment substrates. The Wildco-Ponar bottom dredge has a unique closing mechanism, which is automatically released when the sampler hits the bottom.

The top surfaces of the sampler are covered with a stainless steel screen to reduce shock-waves and drift. In addition the screens prevent organisms from escaping when the sampler is shut. The side plates of the sampler prevent loss of sediments and of organisms when the jaws close. The sampling area of the Wildco-Ponar bottom dredge is 6" x 6" and the sampling volume is (145-in^3).

To increase sampling size accuracy, a biologist-diver sometimes (when the water is not contaminated) is used to first place the sampler on a horizontal, parallel position to the substrate. Once the sampler is perfectly horizontal to the substrate, the sampler is pushed into the sediments. Once the dredge is imbedded in the sediments to the prescribed sediment depth, the dredge is activated to close in order to collect the sample.

The dredge (with the sample) is then brought to the boat. Once the sample is brought to the surface, the contents of the sample are carefully and slowly poured inside a No. 18, 1.0mm Newark Standard Testing Sieve (30cm diameter x 10cm height or equivalent). The sample is washed with seawater repeatedly assuring that no fauna or flora sampled material becomes lost.

Some representative photos of the grab sampling process in the project site are shown in FIGURE 4 below.

TABLE 2. The location and depth of the eight specific footprint reference points of the proposed expansion of Marina Puerto Real located in Fajardo Puerto Rico. All the locations of the reference points were documented in this study by using a global position instrument, specifically GPS#1V&A. BET = between; NE = northeast; E = east; N = north.

WPT # GPS1	DEPTH (ft)	LATITUDE (°)	LONGITUDE (°)	NOTES
254	9.8	18° 20' 04.7" N	65° 37' 42.4" W	BET RP1-RP2
255	9.0	18° 20' 06.8" N	65° 37' 41.2" W	BET RP1-RP2
256	2.0	18° 20' 00.4" N	65° 37' 41.8" W	BET RP1-RP8
257	6.5	18° 20' 03.1" N	65° 37' 39.9" W	NE of 256
258	7.8	18° 20' 05.6" N	65° 37' 38.1" W	NE of 257
259	5.6	18° `19' 59.3" N	65° 37' 39.5" W	E of RP1
260	5.1	18° 20' 01.9" N	65° 37' 37.8" W	NE of 259
261	6.0	18° 20' 04.0" N	65° 37' 36.1" W	NE of 260
262	6.8	18° 19' 57.1" N	65° 37' 37.0" W	N of RP8
263	5.0	18° 20' 00.0" N	65° 37' 35.9" W	N of 262
264	6.0	18° 20' 02.4" N	65° 37' 34.4" W	N of 263
265	6.6	18° 20' 04.9" N	65° 37' 33.1" W	N of 264
266	3.3	18° 19' 55.5" N	65° 37' 34.9" W	BET RP8-RP7
267	3.0	18° 19' 58.1" N	65° 37' 33.8" W	N of 266
268	5.0	18° 20' 00.1" N	65° 37' 33.1" W	BET 267-RP7
269	6.0	18° 20' 03.4" N	65° 37' 30.5" W	NE of RP7
270	6.6	18° 20' 05.2" N	65° 37' 29.2" W	N of 265

FIGURE 4. Photographs of the Wildco-Ponar bottom dredge sampling scheme.

The seagrasses and/or other macrophytic, epibenthic vegetation as well as the infauna (≤ 1.0 mm) are retained by the sieve after washing the sample. In this study samples were not stained (although the whole procedure is explained below) and were mostly quantified *in situ*. Digital images of infaunal elements were also documented by specific video frames. In addition each whole sample was photographed, and only specimens which could not be identified in the field were brought to the laboratory for taxonomy.

Unidentified specimens intended for *in vitro* taxonomic verification are pickled with a 10 % buffered formaline solution. Two to three (2-3) drops of Rose Bengal-alcohol dye solution are normally added when necessary to the sample almost immediately after pouring the formaline into the sample bag. The Rose Bengal-alcohol dye solution stains the tissues and organs of specimens to be classified. Coloring the specimen facilitates the microscopic inspection of soft translucent invertebrate body parts which often, like in polychaetes, are key elements in properly classifying specimens to species level. Sometimes the soft shell invertebrates need to be anesthetized with magnesium chloride ($MgCl_2$) in order to examine relaxed (un-contracted) parts such as the proboscis. Each sample is properly labeled in the field before becoming transported to the laboratory.

Once in the laboratory, for taxonomic processing, each sample is placed inside a white enamel tray (30 cm x 20 cm x 4cm). The sample is dispersed in the tray for sorting using a 1.75X illuminated magnifying glass. Specimens are placed in shell vials, labeled, and preserved with 70% ethyl alcohol. Each vial is capped with cotton and then placed together in a large glass jar with enough alcohol to cover all the vials to prevent desiccation.

All the unidentified specimens collected are then taxonomically classified to the lowest possible taxon using a Zeiss dissecting stereo-microscope and an American Optical compound stereomicroscope. After positive identification of the specimens, the samples are returned to the vial and saved for future reference. The references utilized in order to identify specimens to the lower taxonomic level are listed under the reference section (PART 4 in this report).

The location of all inspected stations were registered with a global positioning system (V&A/GPS#2), which is a 12 channel global positioning instrument (GARMIN GPS 48) with an EPE of 10-20-ft at the site. At each inspection point, notes on the depth, substrate, and of the flora and fauna in the sample were taken *in situ*.

A digital Sonny PC-100 and a PC-110 camcorder camera were used for filming the samples. The camcorder camera is first placed inside a specially designed underwater housing unit, which electronically or mechanically controls all the principal functions of the camera system. The underwater housing is made of a fully anodized marine grade aluminum casting. The lens used for filming has a view angle of 90° with full macro and zoom capability. The lens also has a focus distance from 0 to infinity. Prior to filming each sample, all U/W equipment filming control units are tested and a short strip of the tape is shot to inspect if the system was functioning adequately.

The video-sample tapes and *in situ* annotations are brought to the laboratory for analysis. Representative video-frames are frozen on a SONY 4MB Memory Stick. The images are integrated into the final report by using a SONY Memory Stick Reader/Writer MSAC-US1.

Taxonomy of the flora and fauna.

The species composition found in a given sample and their relative distributions within a given location reflect the relative stability of a given environment. Heavily polluted environments generally support few species, and sensitive species such as corals are generally absent. In addition specific species such as the sea-lettuce *Ulva* spp. are indicators of organically polluted marine habitats especially when this type of algae becomes disproportionately abundant in a given area. Therefore, proper taxonomic determinations of flora and fauna are crucial in environmental assessments studies, such as the one conducted in Bahía Fajardo where Marina Puerto Real is proposing to expand its facilities.

All taxonomic determinations in this study were made *in situ* only by specialized taxonomists (the PI). High quality digitized video images of individuals or specimens are also interpreted by the principal investigator (PI) with assistance when necessary.

External morphological criteria are the primary basis used for taxonomic classification. When necessary, close-up (up to 1 cm of distance between lens and subject) footage which captures fine external morphological features (e.g. conules in sponges, septae in corals) is taken for species confirmation in the laboratory. When necessary, the PI consults another taxonomist for a second opinion on a given species identification.

The general criteria and references utilized for identifying the benthic taxa which could potentially be found in the study site (within and near the proposed breakwater structures of Marina Puerto Real) are described below.

CORALS and GORGONIANS. Corals and gorgonians are identified to the lowest taxonomic level possible by using the following criteria: shape patterns (e.g. branching, encrusting, pillar, brain), corallite characteristics (embedded, protruded, porous, septa, callice), habitat (e.g. relative depth, light conditions, exposed, cryptic), color (including fluorescence), and others (e.g. behavior, symbionts). Most coral species are identified to a species level by the principal investigator (PI) and when necessary coral taxonomic references are consulted (these are: Colin, 1978; Human, 1993; Cairns, 1982; Almy and Carrión-Torres, 1963; George and George, 1979; Bouchon, 1990).

SEAGRASSES. Experts utilize leaf characteristics to identify most of the 49 species of seagrasses. Sometimes additional plant components need to be inspected (e.g. reproductive bodies such as buds, flowers, and fruits, as well as rhizome and root characteristics). The species found in Puerto Rico and in the West Indian Region in general are well known and are described in Vicente (1992). Some references used for confirmation were Phillips (1992) and Hartog (1975) among others (Littler and Littler, 2000). In addition to classifying the species of seagrasses in a sample, the shoots are inspected for fish-bite scars and for other indications which could suggest that the seagrasses in a given site are being utilized as a food source for reef fish and other herbivores typical of the system in question.

SPONGES. Sponges are identified using several criteria including shape (e.g. vase-shape, encrusting, dendritic, massive etc); color of the ectosome and of the meschyl, consistency (e.g. spongy, solid, crumbly), texture (velvety, slimy), exudates, stellate surface patterns, ecology and habitat. Sponges are almost all identified to a species level when found using the author's field taxonomic knowledge of this taxon.

When necessary, the following taxonomic references are utilized to confirm in situ identifications: Alcolado, 1986; Hechtel, 1965; Human, 1992; Laubenfels, 1936; Pang, 1973; Rutzler, 1981; Soest 1978, 1980, 1984, 1988; unpublished, Vicente, 1982; Wiedenmeyer, 1977; Zea and van Zoest, 1986; Zea, 1987.

ALGAE. Algae are classified under the following categories proposed in the Coral Reef Monitoring Manual for the Caribbean and Western Atlantic (see Rogers et al., 1994). These categories are FLESHY ALGAE, CALCAREOUS ALGAE, CRUSTOSE CORALLINE, ARTICULATED CORALLINE RED, and TURF ALGAE (= thin algal mat). The category FLESHY ALGAE are utilized in this study as a synonym of the MACROALGAE category.

FLESHY ALGAE. Fleshy red algae include species, which are large, branching, and are not calcified. Macroalgae with minor calcifications, such as those found in *Liagora* spp. are not considered significant and therefore, this genus is kept under the fleshy alga category.

The following species are included under this category: red algae (Rhodophyta) such as *Acanthophora spicifera, Hypnea musciformis, Gracilaria dominguensis* (found previously in marina Puerto Real proposed site). *Hypnea musciformis* and brown algae (Phaeophyta) such as *Dictyota* spp. and green algae (Chlorophyta) such as *Caulerpa* spp. and *Ulva* spp. were found in this study and fall under the fleshy algae category.

CALCAREOUS ALGAE. Calcareous algae include red (RHODOPHYTA), calcareous, segmented algae such as the genera *Amphiroa, Galaxaura, Jania* and *Corallina*. These algae also are referred to as "articulated coralline red algae".

This category also includes green algae (CHLOROPHYTA) such as the various common tropical species under the genus *Halimeda* (e.g. *Halimeda opuntia, Halimeda incrassata, Halimeda monile* and *Halimeda discoidea*). Dead fragments of *Halimeda* result in the formation of calcareous sand.

CRUSTOSE CORALLINE ALGAE. This category includes red algal species, which form smooth pavements over dead coral bottoms, and includes genera such as *Peyssonnelia, Sporolithon,* and *Mesophyllum, Cruoriella.* These genera may invade cryptic or illuminated habitats.

TURF ALGAE. This taxon includes a variety of species, which do not develop much tissue above the substrate. In coral reef habitats, these species normally include rhodophytes such as *Coelothrix irregularis, Gelidium pusillum, Ceramium,* and *Polysiphonia.*

Turf algae (thin algal mats) have become the principal benthic component of many reefs since *Diadema antillarum* populations became ecologically extinct throughout the Caribbean Region between 1983-87 (see Vicente and Goenaga, 1985).

References which will be consulted to verify species of marine plants are Littler et al., (1989), Woelkerling (1976) and Dawson, (1956). Other lesser abundant benthic species are identified by using the following references: Colin, (1978); George and George, (1979); Human (1992) among others (e.g. Tucker and Morris, 1995; Warmke and Abbot, 1962).

REEF FISH. Reef fish are identified when required using the following references listed in the reference section Robins et al., (1986); Fischer, (1978); Human, (1992); Idaz and Greenberg, (1986).

PART 3

MARINE RESOURCES ASSESSMENT: MARINA PUERTO REAL, FAJARDO, PUERTO RICO

RESULTS

The depth, substrate composition, vegetation (flora) and infauna found within the eight (8) reference breakwater footprint points of Marina Puerto Real (WPTS 189-196, GPS#2), Fajardo, Puerto Rico are given in TABLE 3. The depth of these eight (8) stations ranged between 1-ft (intertidal or littoral) and 10-ft (first column of TABLE 3). Except for the sandy bottom found in the very shallow stations in less than three feet of depth (WPTS 189 and 196) all other stations consisted of very fine anoxic (without oxygen) mud.

Two seagrass species (Anthophyta: Helobiae) were found in 3 of the 8 breakwater reference stations (38%). The seagrass species found were *Halophila decipiens* (Helobiae: Hydrocharitaceae) and *Syringodium filiforme* (Helobiae: Pomatogetonaceae). *Halophila decipiens* was found in 2 of the eight samples (25%) and *Syringodium filiforme* was found in 1 of the eight samples (12%).

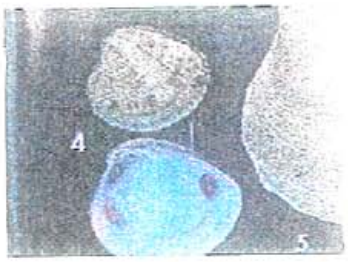
None of the seagrass plants sampled exhibited scars or specific ecophenotypic expressions which would indicate that that these seagrasses, at the time collected, are ecologically functioning as a food resource to herbivorous fish (e.g. *Sparisoma radians*), sea urchins (e.g. *Lytechinus variegatus* and *Tripneustes esculentus*), sea turtles (specifically the herbivorous green turtle or "peje blanco" *Chelonia mydas*) or manatees (specifically the West Indian manatee *Trichechus manatus*).

Seagrass abundance, which is normally estimated by marine ecologists as standing crop (g-DW/m^{-2}) was not determined. However, seagrass cover within the breakwater footprint stations was qualitatively estimated as sparse. As previously mentioned, most of the bottom consisted of black or gray anoxic mud as shown in FIGURE 5. The apparent most abundant fleshy red alga was *Hypnea musciformis* which was found in a shallow (2.5-ft of depth) sandy station (WPT196). The other fleshy red algae commonly found growing over hard substrata within the Marina Puerto Real site is *Gracilaria dominguensis*.

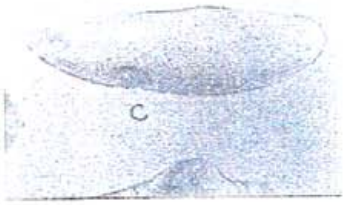
Within the eight footprint reference station, the infauna (those macro-invertebrates dwelling inside the mud) was also found in low abundances. For example, 6 of the 8 samples (75%) did not contain infauna. The infauna was only found in two of the eight samples (25%) and consisted of pelecypods and polychaetes.

In total, four (4) pelecypods were found. The four (4) pelecypods were found in RP2 (station 190, see FIGURE 5). One polychaete worm was found in RP4 (station 192, column 5 in TABLE 3). The pelecypod species (Mollusca: Pelecypoda) found within the eight breakwater footprint stations were:

- One juvenile Cross-barred Venus clam: *Chione cancellata* (Linné)



- two Long Yoldia clams: *Yoldia perprotracta* (Dall)



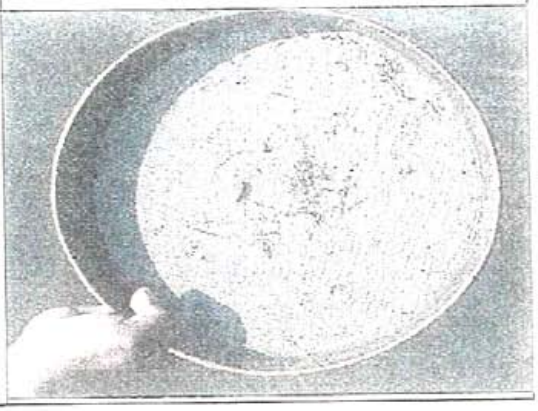
- One Watermelon Tellin clam: *Tellina punicea* (Born)

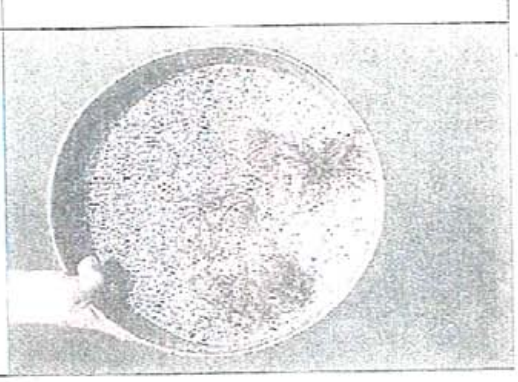
The mean population density of pelecypods (= clams) within the footprint stations was 0.5individuals per sample (0.5/36in^{-2}) which is a very low population density value for infauna ($\bar{x}$ = 0.5ind/36in^{-2}, s = 1.4, n = 8).

TABLE 3. Depth, substrate composition, vegetation and infauna found within the eight reference breakwater footprint points of Marina Puerto Real (WPTS 189-196, GPS#2), Fajardo Puerto Rico. All samples were taken during April 10-11, 2003. The location of stations is given as waypoint numbers in the first column (see TABLE 1 for specific Mercatorial positions). The depth measurements are in feet (ft). RP = reference points of the breakwater footprints of Marina Puerto Real.

WPT # GPS2	DEPTH (ft)	SUBSTRATE	SEAGRASSES & MACROPHYTES	INFAUNA	NOTES
189	1.0	Black sand.	No seagrasses. No macrophytes.	NONE	RP1
190	10.0	Fine mud.	No seagrasses. No macrophytes.	4 pelecypods	RP2 Apparent Cyanophyta layer.
191	9.2	Fine mud.	No seagrasses. No macrophytes.	NONE	RP3 Apparent Cyanophyta layer.
192	8.2	Fine mud.	*Halophila decipiens*	1 polychaete	RP4 Apparent Cyanophyta layer.
193	5.1	Fine mud.	No seagrasses. No macrophytes.	NONE	RP5 Apparent Cyanophyta layer.
194	8.0	Fine mud.	*Halophila decipiens*	NONE	RP6 Apparent Cyanophyta layer.
195	3.9	Fine mud.	*Syringodium filiforme*	NONE	RP7 Apparent Cyanophyta layer.
196	2.5	Fine sand. Magnetite.	Rhodophyte *Hypnea musciformis*	NONE	RP8 No apparent cyanophytic layer.

FIGURE 5. Benthic samples taken during April 10-11, 2003 within the footprints (WPTS189-196, GPS#2) of Marina Puerto Real, Fajardo, Puerto Rico. Digital images of samples are shown at the moment of collection and after the samples were sieved.

STATION (GPS2)	Z (ft)	PRE-SEIVED SAMPLE	POST-SEIVED SAMPLE
189	1.0	PREVIOUSLY SAMPLED	PREVIOUSLY SAMPLED
190	10.0		
191	9.2		No Infauna
192	8.2		

STATION (GPS2)	Z (ft)	PRE-SEIVED SAMPLE	POST-SEIVED SAMPLE
193	5.1		No Infauna
194	8.0		No Infauna
195	3.9		No Infauna
196	2.6		

The results of the seventeen (n = 17) benthic samples taken within the enclosed portion of the proposed extension of Marina Puerto Real are shown in TABLE 4. The depths at which each sample was taken as well as the type of substrate found in each sample are presented in columns 2 and 3 of TABLE 4. The macrophytes (submerged vegetation such as seagrasses and or algae or thallophytes) as well as the infauna found in each sample are presented in columns 4 and 5.

The depths within the enclosed portion of the proposed seaward extension of Marina Puerto Real are, like the breakwaters footprints, shallow. The minimum depth found during the sampling was 2.0-ft (WPT 256). The maximum depth was 9.8-ft found in (WPT 254). The substrate within the proposed site consists mostly of black or gray anoxic mud.

Seagrasses were found in ten (10) of the seventeen (17) samples (59% of the samples) taken within the proposed breakwater enclosure zone. WPT 269 and WPT 270 are outside (northeast) of the proposed breakwaters and of the proposed marina basin.

The four seagrass species were found:

- Paddle grass or *Halophila decipiens*;
- Shoal grass or *Halodule wrightii*;
- Manatee grass or *Syringodium filiforme*; and,
- Turtle grass or *Thalassia testudinum.*

Shoal grass or *Halodule wrightii* (Helobiae: Pomatogetonaceae) was found in five (5) of the 10 seagrass stations (50%). These five stations are:

- WPT 260 (where *Halodule wrightii* was found together with *Halophila decipiens*);
- WPT 263 (where *Halodule wrightii* was also found together with *Halophila decipiens*);
- WPT 264, WPT 265, and WPT 269 (monotypic stands).

This finding suggests that shoal grass (*Halodule wrightii*) may be the most frequently occurring seagrass within the enclosure zone of the proposed marina site.

Paddle grass or *Halophila decipiens* (Helobiae: Hydrocharitaceae) was the second most frequent seagrass found appearing in four (4) of the 10 seagrass stations (40%). These four stations are:

- WPT 260 (with *Halodule wrightii*),
- WPT 261 (monotypic stand)
- WPT 263 (with *Halodule wrightii*), and,
- WPT 266 (monotypic stand).

It is important to note that both of these species (*Halophila decipiens* or paddle grass, and the shoal grass *Halodule wrightii*), according to the literature, can penetrate into contaminated areas with poor water quality conditions (den Hartog, 1970; McNulty; 1961, in den Hartog, 1970; Vicente, pers.obs.).

The distribution of seagrasses within the proposed seaward extension of Marina Puerto Real, Fajardo, Puerto Rico is shown graphically in FIGURE 6 below. Most of the stations where seagrasses were found were located within the center and along the northeastern portion of the proposed enclosed marina basin.

It is important to note that the single location where turtle grass (*Thalassia testudinum*) was sampled was just outside (northeast) the proposed development site. Turtle grass according to marine ecological wisdom, is the most ecologically valuable seagrass species, and, according to the study presented here this species will not become directly impacted by the project.

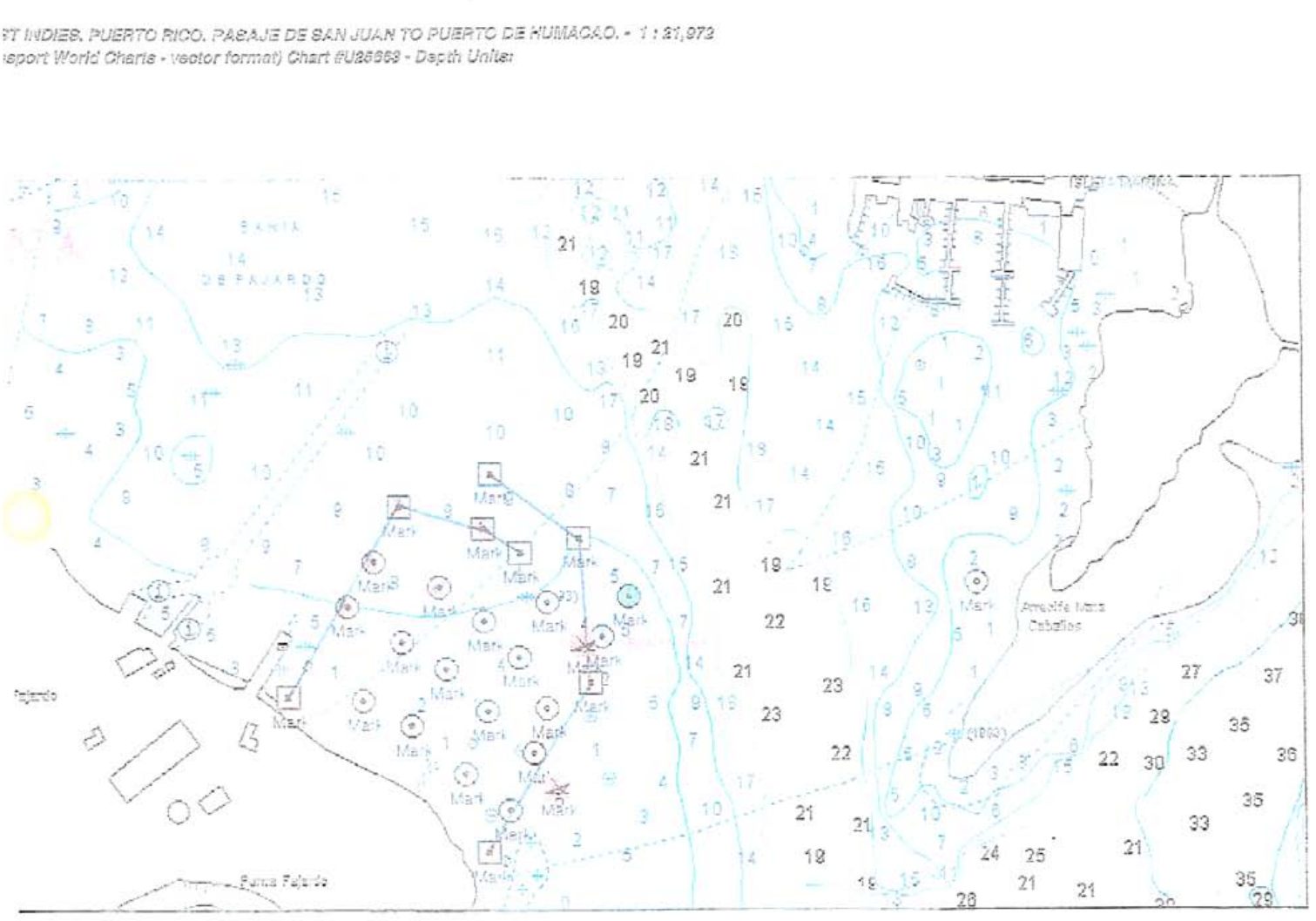
TABLE 4. Depth, substrate composition, vegetation and infauna found within the proposed breakwaters of Marina Puerto Real (WPTS 254-270, GPS#1), Fajardo Puerto Rico. All samples were taken during April 10-11, 2003. The location of stations is given as waypoint numbers in the first column (see TABLE 1 for specific Mercatorial geographic positions). The depth measurements are in feet (ft).

WPT # GPS1	DEPTH (ft)	SUBSTRATE	SEAGRASSES & MACROPHYTES	INFAUNA	NOTES
254	9.8	Fine mud.	No seagrasses. No macrophytes.	NONE	Between RP1-RP2 Cyanophyta
255	9.0	Fine mud.	No seagrasses. No macrophytes.	4 pelecypods 1 ophiuroid	Between RP1-RP2 Cyanophyta
256	2.0	Very fine black sand	No seagrasses. No macrophytes.	2 polychaetes 4 gastropods	Between RP1-RP8 Cyanophyta
257	6.5	Fine black mud	No seagrasses. No macrophytes.	4 pelecypods	Northeast of 256 Cyanophyta
258	7.8	Dark gray mud	No seagrasses. No macrophytes.	1 pelecypod 1 Chione cancellata	Northeast of 257
259	5.6	Black anoxic mud	No seagrasses. No macrophytes.	3 gastropods	East of RP1 Cyanophyta
260	5.1	Very fine sand silt	*Halophila decipiens* *Halodule wrightii* Rhodophyte, *Spyridia*, *Caulerpa* sp.	NONE	Northeast of 259
261	6.0	Very fine black mud	*Halophila decipiens*	NONE	NE of 260 Dive assisted sampling
262	6.8	Dark gray mud	No seagrasses. No macrophytes.	1 Pelecypod 1 gastropod	N of RP8 Cyanophyta

TABLE 4 (continued). Depth, substrate composition, vegetation and infauna found within the proposed breakwaters of Marina Puerto Real (WPTS 254-270, GPS#1), Fajardo Puerto Rico. All samples were taken during April 10-11, 2003. The location of stations is given as waypoint numbers in the first column (see TABLE 1 for specific Mercatorial geographic positions). The depth measurements are in feet (ft). N/O/M = No other macrophytes.

WPT # GPS1	DEPTH (ft)	SUBSTRATE	SEAGRASSES & MACROPHYTES	INFAUNA	NOTES
263	5.0	Grey Mud	*Halodule wrightii* *Halophila decipiens* *Hypnea musciformis* *Spyridia*-like algae *Caulerpa prolifera*	1 green gastropod. 2 Pelecypods 1Chione cancellata.	North of 262
264	6.0	Black mud	*Halodule wrightii* No other macrophytes.	1 Sipunculid 1 Pelecypod	North of 263
265	6.6	Black mud	*Halodule wrightii* No other macrophytes.	NONE	North of 264
266	3.3	Gray mud	*Halophila decipiens* Unid. Rhodophyte	1 *Cerythium*-like gastropod	Between RP8-RP7
267	3.0	Gray Brown Mud	*Syringodium filiforme* N/O/M	NONE	North of 266 Cyanophyte layer
268	5.0	Black Mud	*Syringodium filiforme* N/O/M	NONE	Between 267-RP7 Cyanophyte layer
269	6.0	Black Mud	*Halodule wrightii* *Halimeda opuntia*	NONE	Northeast of RP7 Cyanophyte
270	6.6	Black Mud	*Thalassia testudinum*	1 solitary ascidian	North of 265 Cyanophyte layer

FIGURE 6. The distribution of seagrasses within the proposed seaward extension of Marina Puerto Real, Fajardo, Puerto Rico. Samples where only mud or sand (no seagrasses) was found are shown in brown. Light green circles or squares represent Halophila *decipiens* and/or *Halodule wrightii*. The single dark green circle represents *Thalessia testudinum*. The yellow circles or squares represent the stations where *Syringodium filiforme* was found. The red squares represent two grounded/sunken steel-hauled vessel unregistered in NOAA chart U25663 and found in this study.



Manatee grass (*Syringodium filiforme*) and Turtle grass (*Thalassia testudinum*) were the least abundant of the seagrasses in the enclosure zone of the proposed marina site. *Syringodium filiforme* (Helobiae: Pomatogetonaceae) was found forming monotypic stands in two stations (WPT 267 and 268) on the southernmost end of the proposed marina site.

Thalassia testudinum (Helobiae: Hydrocharitaceae), considered to be the seagrass of most ecological value, was the rarest seagrass species within the sampling site.

Similar to the grab samples taken within the breakwater footprints of the proposed marina extension, the samples taken within the breakwater-enclosed region of the marina rendered little seagrass biomass. The relative abundance of seagrasses within the enclosed portion of the proposed seaward extension of Marina Puerto Real was qualitatively evaluated as scarce.

The relative low seagrass biomass found in the 10 seagrass samples can be observed in FIGURE 7. As shown in FIGURE 6, most of the samples consist of anoxic mud with none or little seagrass, and with no typical seagrass-associated invertebrates such as sea urchins (*Lytechinus variegatus*) seagrass-associated corals such as *Manecina areolata* and *Oculina diffusa* and others.

The infauna (invertebrates dwelling in the interstice of the mud particles), such as pelecypods or clams, polychaetes, alphaeid shrimps and other borrowing organisms normally common in unpolluted mud sediments were scarce in the proposed marina site.

Mollusks such as clams (pelecypods) and some snails (gastropods) are typically common in mud and sandy bottoms in all natural marine environments. The mean population density of pelecypods found within the zone enclosed by the breakwater structures was 0.88 individuals per sample or $0.88/36in^{-2}$ ($x = 0.88/36in^{-2}$, $s = 1.45$, $n = 17$) which is a low population density value for this taxon.

The list of gastropods and pelecypod species found in the mud samples (grab samples) taken within the area enclosed by the two proposed breakwater structures are given below with an illustration of each species. The illustrations were copied from Abbot and Morris (1995) and from Warmke and Abbot (1962).

The three pelecypod species found in the breakwater footprint stations (the Watermelon Tellin clam (*Tellina punicea*), the Cross-barred Venus clam *Chione cancellata* and the Long Yoldia clam *Yoldia perprotracta* were also found within the proposed marina basin.

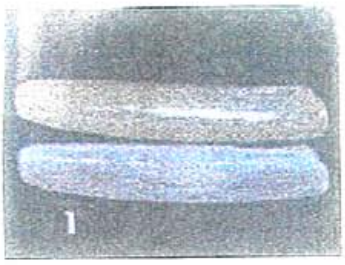
The following mollusk species were found within the enclosed portion of the two proposed marina breakwaters (the north breakwater and the south breakwater):

- the Cross-barred venus clam *Chione cancellata* (Linné)

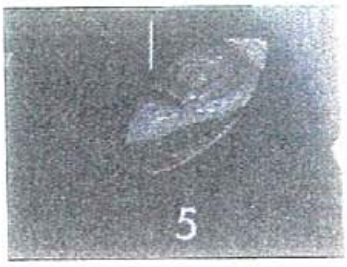
- the Long Yoldia clam: *Yoldia perprotracta* (Dall)

- the Watermelon Tellin clam: *Tellina punicea* (Born)

-the Jackknife clam *Solen* sp. and,

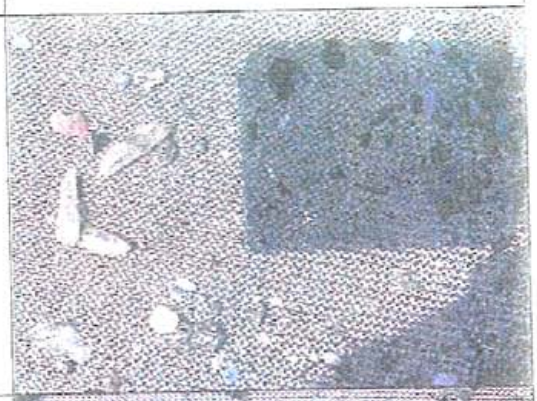
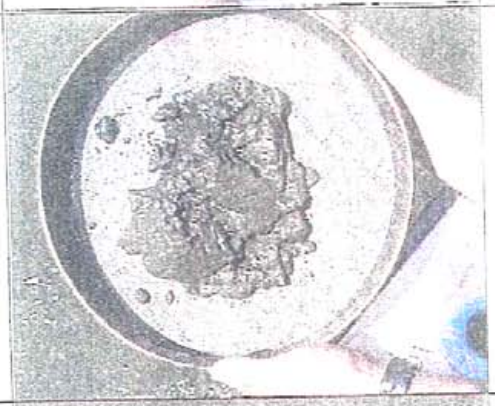
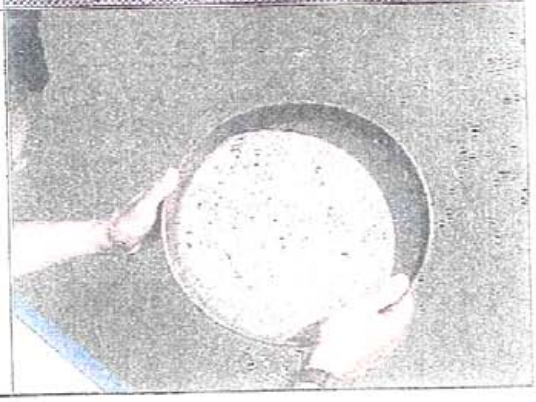


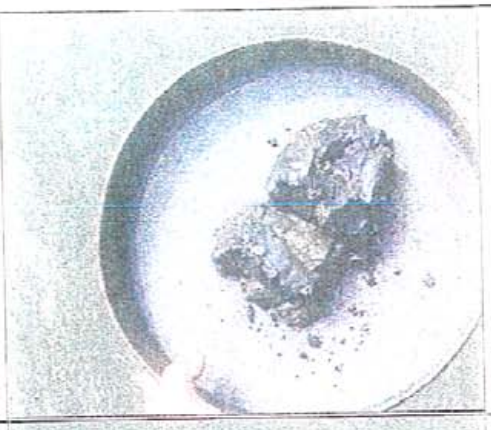
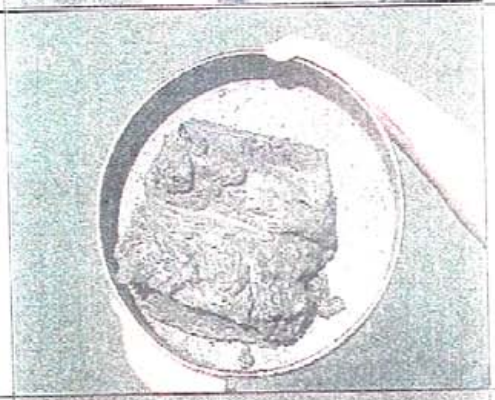
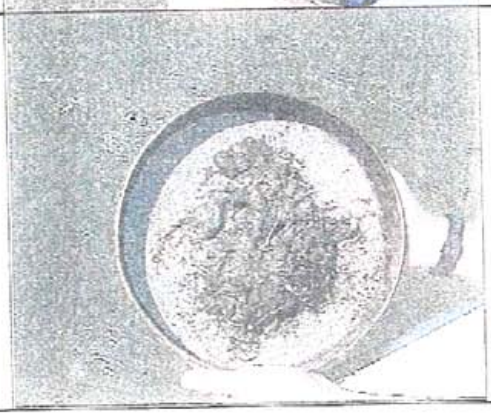
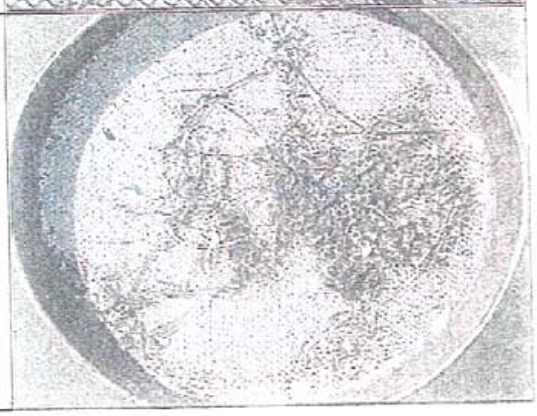
-the Minute dwarf olive *Olivella minuta* (Link)

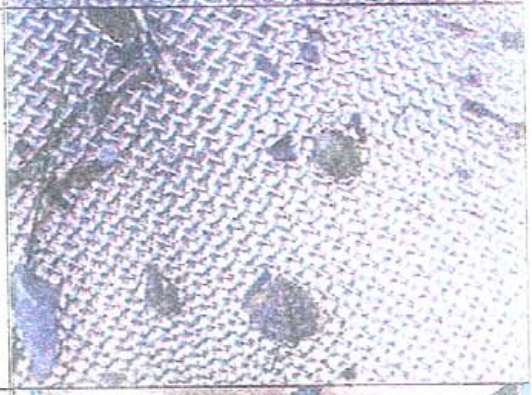


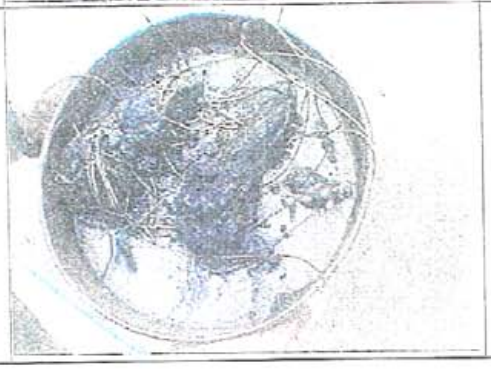
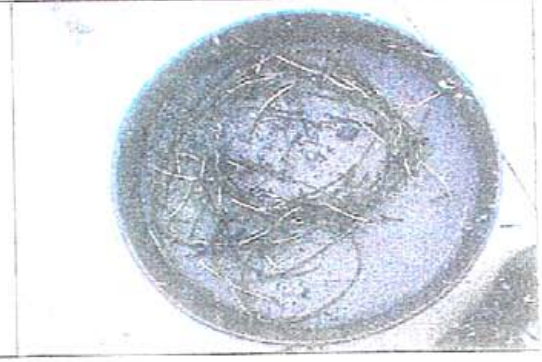
Two other Mollusca species were found within the enclosed portion of the proposes breakwaters and which are not illustrated here. These are two gastropod snails: *Cerythium* sp. and *Smaragdia viridis*.

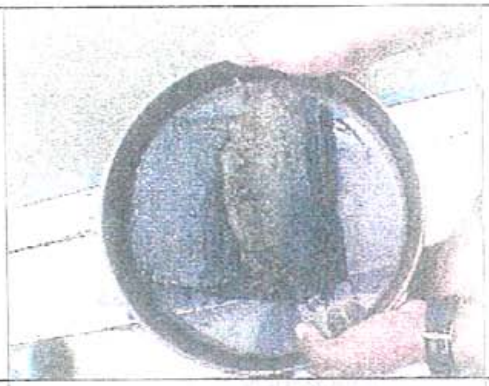
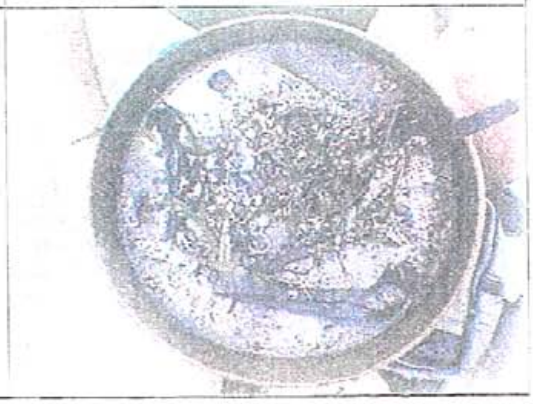
URE 7. Benthic samples taken during April 10-11, 2003 within the proposed breakwaters of Marina Puerto Real (WPTS 254-270, GPS#1), Fajardo Puerto Rico. Digital images of samples are shown at the moment of collection and after the samples were sieved.

STATION (GPS1)	Z (ft)	PRE-SEIVED SAMPLE	POST-SEIVED SAMPLE
254	9.8		
255	9.0		
256	2.0		

257	6.8		
258	7.8		
259	5.6		
260	5.1		

261	6.0		
262	6.8		
263	6.0		
264	6.0		

265	6.6		
266	3.3		
267	3.0		
268	5.0		

269	6.0		No Infauna
270	6.6		

PART 4

MARINE RESOURCES ASSESSMENT: MARINA PUERTO REAL, FAJARDO, PUERTO RICO

CONCLUSIONS

1. There were three seagrass species (Anthophyta: Helobiae) found within the proposed marine extension of Marina Puerto Real: Paddle grass or *Halophila decipiens*; Shoal grass or *Halodule wrightii*; and Manatee grass or *Syringodium filiforme*.

2. The abundance of seagrasses within the proposed marina site is scarce. The paucity of seagrasses within the site is probably due to the prevailing poor water quality condition of the site and of the sediments.

3. There were no turtle grass (*Thalassia testudinum*) beds, locally known as "praderas de talasia" found within the proposed marina extension. Turtle grass is generally considered to be the seagrass species of most ecological value in the West Indian region.

4. The seagrasses found within the proposed marine extension of Marina Puerto Real, because of the generally poor water and sediment quality conditions of this industrial site, may play a minor ecological role in this system.

5. Because of: the scarceness of seagrasses , the absence of *Thalassia* beds, the paucity of infauna, the absence of conchs, sea urchins or of other typical seagrass bed ecosystem components within the proposed marina basin, V&A, Inc. believes that the proposed extension to Marina Puerto Real will have no major consequence to the overall ecological integrity of Bahía Fajardo.

PART 5

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