

## EXECUTIVE SUMMARY

Since the 1940s, portions of the Island of Vieques, Puerto Rico have been used by the United States Navy (USN) as an ammunition support detachment and bombing and maneuver training range. In April 2001, the USN began phasing out military activities on the island and transferring military property to the U.S. Department of the Interior, the Municipality of Vieques, and the Puerto Rico Conservation Trust. A small number of studies have been commissioned by the USN in the past few decades to assess selected components of the coral reef ecosystem surrounding the island; however, these studies were generally of limited geographic scope and short duration. The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Coastal Ocean Science (NCCOS), in consultation with NOAA's Office of Response and Restoration (OR&R) and other local and regional experts, conducted a more comprehensive characterization of coral reef ecosystems, contaminants, and nutrient distribution patterns around Vieques. This work was conducted using many of the same protocols as ongoing monitoring work underway elsewhere in the U.S. Caribbean and has enabled comparisons among coral reef ecosystems in Vieques and other locations in the region.

This characterization of Vieques' marine ecosystems consists of a two part series. First, available information on reefs, fish, birds, seagrasses, turtles, mangroves, climate, geology, currents, and human uses from previous studies was gathered and integrated into a single document comprising Part I of this two part series (Bauer et al. 2008). For Part II of the series, presented in this document, new field studies were conducted to fill data gaps identified in previous studies, to provide an island-wide characterization, and to establish baseline values for the distribution of habitats, nutrients, contaminants, fish, and benthic communities. An important objective underlying this suite of studies was to quantify any differences in the marine areas adjacent to the former and current land-use zoning around Vieques. Specifically of interest was the possibility that either Naval (e.g., practice bombing, munitions storage) or civilian activities (e.g., sewage pollutants, overfishing) could have a negative impact on adjacent marine resources. Measuring conditions at this time and so recently after the land transfer was essential because present conditions are likely to be reflective of past land-use practices. In addition, the assessment will establish benchmark conditions that can be influenced by the potentially dramatic future changes in land-use practices as Vieques considers its development.

This report is organized into seven chapters that represent a suite of interrelated studies. Chapter 1 provides a short introduction to the island setting, the former and current land-use zoning, and how the land zoning was used to spatially stratify much of the sampling. Chapter 2 is focused on benthic mapping and provides the methods, accuracy assessment, and results of newly created benthic maps for Vieques. Chapter 3 presents the results of new surveys of fish, marine debris, and reef communities on hardbottom habitats around the island. Chapter 4 presents results of flora and fauna surveys in selected bays and lagoons. Chapter 5 examines the distribution of nutrients in lagoons, inshore, and offshore waters around the island. Chapter 6 is focused on the distribution of chemical contaminants in sediments and corals. Chapter 7 is a brief summary discussion that highlights key findings of the entire suite of studies.

The main findings of each Chapter are as follows:

### Chapter 1: Introduction

- From west to east, the former land-use zones used to stratify adjacent marine areas and guide sampling for many components of these studies were: 1) Naval Ammunition Support Detachment, 2) Civilian Area, 3) Eastern Maneuver Area/Secondary Impact Area, 4) Live Impact Area, and 5) Punta Este Conservation Area.
- The 3 generalized objectives shared by the studies were: 1) quantify differences in marine environments offshore from the various land-use zones, 2) compare environmental values in Vieques to those available elsewhere in Puerto Rico and the US Virgin Islands, and 3) establish baseline values to compare with future studies as land-use practices and resource conditions change around Vieques.

### Chapter 2: Benthic Habitat Maps

- The objective was to create updated and improved benthic habitat maps of Vieques. Relative to the latest comprehensive maps available, a smaller mapping unit (1000 versus 4000 m<sup>2</sup>), more recent satellite and aerial imagery (2006-2008 versus 1999), and more detailed classification scheme were used.
- Benthic features were classified according to five attributes: 1) geographic zone, 2) habitat structure, 3) dominant cover, 4) live coral cover, and 5) percent hardbottom.
- 350 km<sup>2</sup> of seafloor features around Vieques were mapped. Unconsolidated Sediments and Hardbottom accounted for 66.6% and 33.4% of the mapped area, respectively. Algae was the dominant cover on hardbottom and seagrass dominated softbottom.
- Percent live coral cover was <10% for 93% of the mapped area, while the remainder was mapped as 10% -<50%.

- Classification accuracy was 89% correct for detailed habitat structures.

#### Chapter 3: Reef/hardbottom habitats, fish and marine debris

- Objectives were to characterize benthic and fish communities on hardbottom around Vieques, identify differences in communities adjacent to former land use zones, and to establish baseline values for change detection.
- A stratified random design was used to select 75 sites for benthic and fish community surveys around Vieques. Former land-use zones and north/south coasts of Vieques were used as strata.
- Turf algae accounted for the highest overall mean percent cover, followed by macroalgae, gorgonians, crustose/calcareous algae, hard coral, and sponges. Hard coral cover was generally low, with an overall mean of 3.4 ( $\pm 0.5$ )%. Sites with the highest coral cover were generally located on reefs southwest of the island.
- The fish community observed in the study consisted of 34 taxonomic families and 110 species. While individuals from the families Labridae (wrasses) and Pomacentridae (damselfishes) were the most numerically abundant, surgeonfishes (Family Acanthuridae) and parrotfishes (Family Scaridae) accounted for the highest proportion of biomass.
- Several fish metrics varied on a north-south and/or east-west gradient, although there was a high degree of variability among strata. Differences in fish communities on the north vs. south side of the island were attributed partly to predominant habitat structure.
- Vieques is similar in terms of benthic cover, total fish abundance and biomass to other nearby locations in Southwest Puerto Rico, St. Croix, and St. John in the USVI.
- Differences in fish and benthic communities among strata could not be conclusively linked to former land use patterns.

#### Chapter 4: Marine flora and fauna of four lagoons

- Objectives were to characterize the flora and fauna of four lagoons (Puerto Mosquito, Puerto Ferro, Ensenada Honda, and Puerto Negro), compare these communities to those of the insular shelf, and identify critical ecosystem services provided by these habitats.
- A stratified random design across depths and habitat types was used to position diverse sampling activities including quadrats, sediment cores, visual fish surveys, and push nets.
- Differences in flora and fauna of lagoons appear driven partly by turbidity and openness or degree of water exchange with adjacent shelf habitats. Turbid bays like Puerto Mosquito and Puerto Ferro are contrasted with more open lagoons like Ensenada Honda and Puerto Negro.
- Seagrass cover was higher in vegetation beds of the open lagoons and the shelf compared to lagoons with restricted circulation. In contrast seagrass species richness was higher in lagoons with restricted circulation than in open lagoons or the shelf.
- Soft-bottom faunal communities of both lagoons and the shelf were dominated by juveniles however the lagoon community was more diverse and included commercially and ecologically important species absent as juveniles from the shelf.
- The high floral and faunal diversity of lagoons and evidence of their role as nursery areas indicates that lagoons are a critical component of the Vieques coastal ecosystem.

#### Chapter 5: Contaminants

- Objectives were to characterize chemical contamination in the nearshore waters and lagoon areas of Vieques, identify differences in contamination based on former land-use, establish baseline values for change detection, and identify sites where sediment contamination exceeds established guidelines.
- A stratified random design was used to select 78 sites for sediment and 35 sites for coral tissue sampling around Vieques. Former land-use zones, lagoon versus offshore, and north/south coasts of Vieques were used as strata.
- 150 chemical contaminants including metals, pesticides, and energetic compounds (explosives) were analyzed.
- Overall, contaminant concentrations were below established sediment quality guidelines, sediments from lagoons typically had higher concentrations than offshore sites, and sediments had higher concentrations of trace and major elements (mostly metals) than corals.
- DDT (at four sites) and chromium (at one site) were detected in sediment samples above established sediment quality guidelines. At one site near Blue Beach, the concentration of DDT was over an order of magnitude higher than the established NOAA sediment quality guideline.
- Sediment concentrations of polycyclic aromatic hydrocarbons were significantly higher in the strata that included the former Naval Ammunition Support Detachment. The concentration of cadmium was significantly higher in the former Live Impact Area. No sites, however, had concentrations that were likely to affect sediment-dwelling biota.
- Sediment samples analyzed for 14 energetics yielded no confirmed detections.

#### Chapter 6: Nutrients

- Objectives were to identify localized hot spots of nutrient levels, north/south or east/west gradients in nutrient concentration, and to establish baseline values for change detection.

- A stratified random design was used to select 40 sampling stations with lagoon, inshore, and offshore waters as spatial strata. Sampling was repeated at each station approximately monthly from July 2007 to March 2008.
- Water samples were analyzed for nitrate, nitrite, silicate, orthophosphate, ammonium, urea, total nitrogen, and total phosphorus.
- There was no evidence of anthropogenic over-enrichment of nutrients.
- Nutrient concentrations were generally low and similar in magnitude to those measured elsewhere in Puerto Rico at La Parguera and Jobos Bay.
- Nitrogen and phosphorus concentrations were below published threshold values considered threatening for macroalgal overgrowth on coral reef ecosystems.
- The highest concentrations of nutrients were found in mangrove lined lagoons. It is hypothesized that this is a natural condition rather than nutrient pollution because the lagoons are shallow, poorly flushed, and naturally high in organic matter.

#### Chapter 7: Conclusions

- Overall, there was little evidence of any difference in marine resources, nutrients, or contaminants around Vieques offshore of the various former land-use zones.
- Chemical contaminant and nutrient levels, with a few localized exceptions, were generally below known levels of concern.
- There was no evidence of a statistical relationship between any of the spatial patterns in fish distribution, nutrient, or contaminant levels.
- Nutrient and contaminant values established in this study will serve as a baseline to evaluate the potential future development pressure on the island may have on the increased flux of these materials to coastal waters, thereby increasing stressors to coral reefs.
- It has been hypothesized that naval activities negatively impacted marine environments around Vieques. Conversely, the lack of residential and commercial development on two-thirds of the island formerly owned by the USN may have been a positive influence by preventing anthropogenic activities that are well documented elsewhere to harm marine environments. Although there were some differences found in biota among sampling strata and some elevated levels of contaminants and nutrients around the island, the results of this study do not support either of these hypotheses as a major factor structuring the marine environment of Vieques.
- Biota, nutrients, and contaminant levels around Vieques generally match those for other coral reef ecosystems in the Puerto Rico and US Virgin Islands region and appear to be shaped primarily by regional-scale processes rather than local factors.

