CHAPTER 4: COMPARATIVE SURVEYS OF BENTHIC SOFTBOTTOM HABITATS AND FAUNAL COMMUNITIES OF LAGOONS AND SHALLOW SHELVES OF THE ISLAND OF VIEQUES

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4.1 INTRODUCTION

In collaboration with NOAA's Office of Response and Restoration, the Center for Coastal Fisheries and Habitat Research (CCFHR) conducted surveys designed to assist in prioritizing conservation efforts of coastal waters around the Island of Vieques, Puerto Rico. Our focus was to identify and characterize areas of high ecological value by quantitatively sampling benthic habitats and their faunal communities. Annual surveys were conducted from 2005-2008 and were increasingly focused on the south coast of the island. This shift in focus was based on results that supported the hypothesis that the southern shelf represented a more complex ecological system. Evidence of this geographic difference is apparent in the species richness, diversity, abundance and the trophic structure of the fish communities and is detailed in Chapter 3 of this volume (Figures 3.17, 3.26). Such a difference might be expected based on the greater topographical complexity of the southern shelf (Chapter 2), including the presence of numerous bays and lagoons. This chapter focuses on the sampling conducted in four lagoon systems and two shallow shelf regions around the island.

A lagoon can be defined as a comparatively shallow, semi-protected salt or brackish water body separated from the deeper water by shallow or exposed features. Tropical lagoon systems range from brackish inland bodies of water receiving only intermittent exchange with the coastal ocean, to coastal bays whose seaward margins are bounded by a submerged barrier, either sand or reef. These protective features buffer the physical impact of the coastal ocean, providing an environment that differs from more exposed coastal areas and fostering the development of unique and complex habitats. The margins of lagoons often represent ecotones where trapped terrestrial sediment and the development of mangroves stands support diverse faunal and floral communities which serve as nurseries for many marine species. Lagoons are especially important to fisheries and wildlife providing food and shelter for a variety of ecologically and commercially important species. Four lagoons, Puerto Mosquito, Puerto Ferro, Ensenada Honda, Puerto Negro and two areas on the insular shelf of Vieques (Figure 4.1) were surveyed to provide data on the flora of benthic habitats and the composition and density of their faunal community. By comparing the physical and biological characteristics of these lagoons to similar communities of the open shelf, inference on the role of lagoons in Vieques' marine ecosystem is provided.

4.2 METHODS

Research cruises

Four research cruises were conducted aboard NOAA's RV Nancy Foster in the vicinity of southeastern Puerto Rico and Vieques (Table 4.1) between 2005 and 2008. The cruises were part of a large multi-disciplinary study of southeastern Puerto Rico designed to characterize benthic habitats, examine disturbance and recovery dynamics of seagrasses, and assess the use of benthic habitats by fish and wildlife resources (e.g., Manatees).

Table 4.1. Summary of the number of sites sampled to characterize the benthic habitat and associated faunal communities in lagoons (Ensenada Honda, Puerto Ferro, Puerto Mosquito and Puerto Negro) and the Northwest and Southern Shelf softbottom habitats during annual research cruises off the coast of Vieques, 2005 to 2008.

Cruise	Dates	Benthic Habitat				Epibenthic and Fish Community		
		Visual Surveys		Seagrass Biomass		SCUBA pushnet		Visual Surveys
		Lagoon	Shelf	Lagoon	Shelf	Lagoon	Shelf	Ensenada Honda
2005	Feb 18 - Feb 26	6	28	0	0	0	0	6
2006	Apr 05 - Apr 14	100	20	100	20	0	0	10
2007	Apr 28 - May 05	29	43	0	0	29	0	13
2008	Mar 27 - Apr 04	0	41	0	0	0	41	0

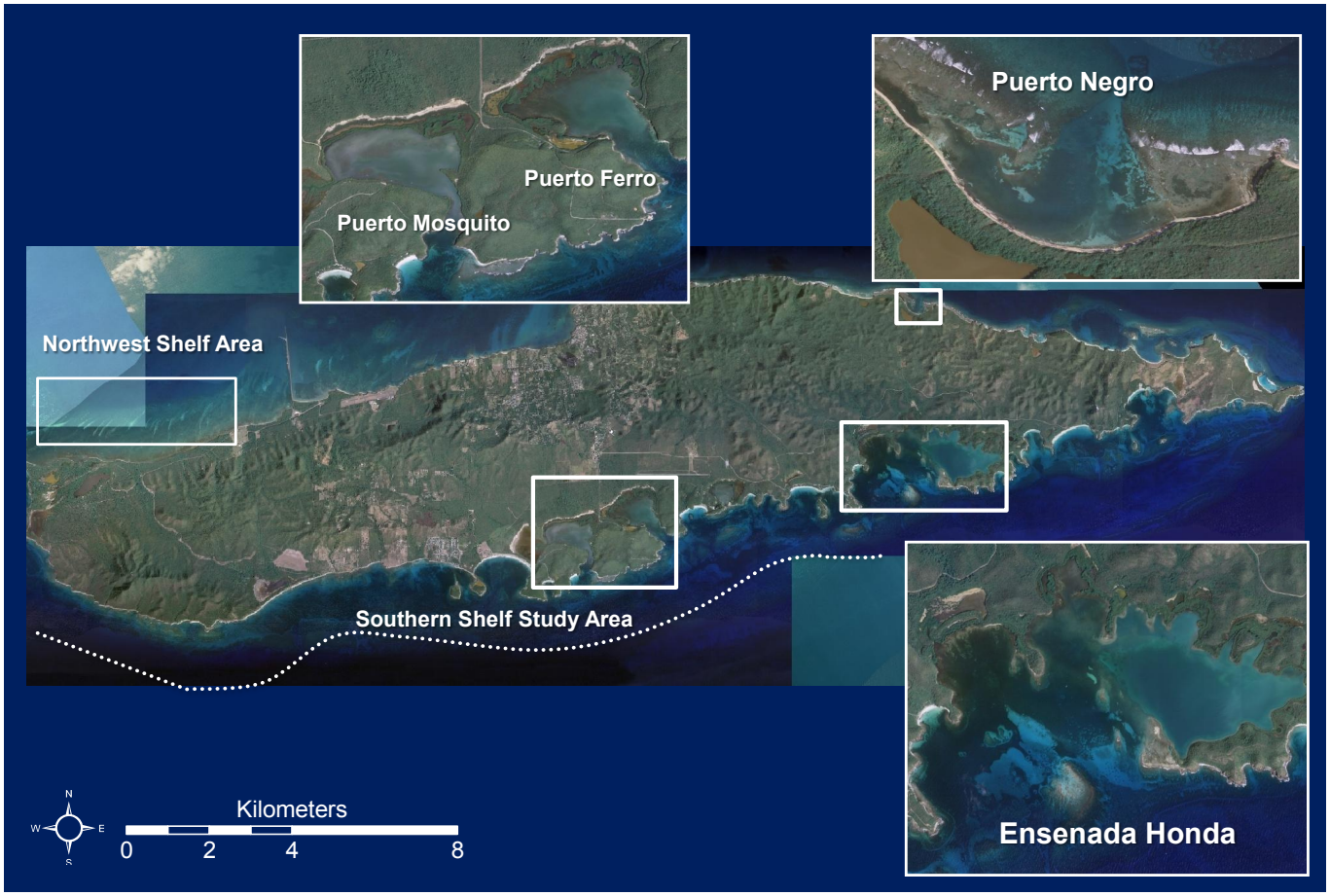

Figure 4.1. Aerial imagery showing study sites around the Island of Vieques. White rectangles indicate the four lagoons sampled to characterize benthic habitats and estimate fish density. Also indicated are the northwest and southern shelf study area.

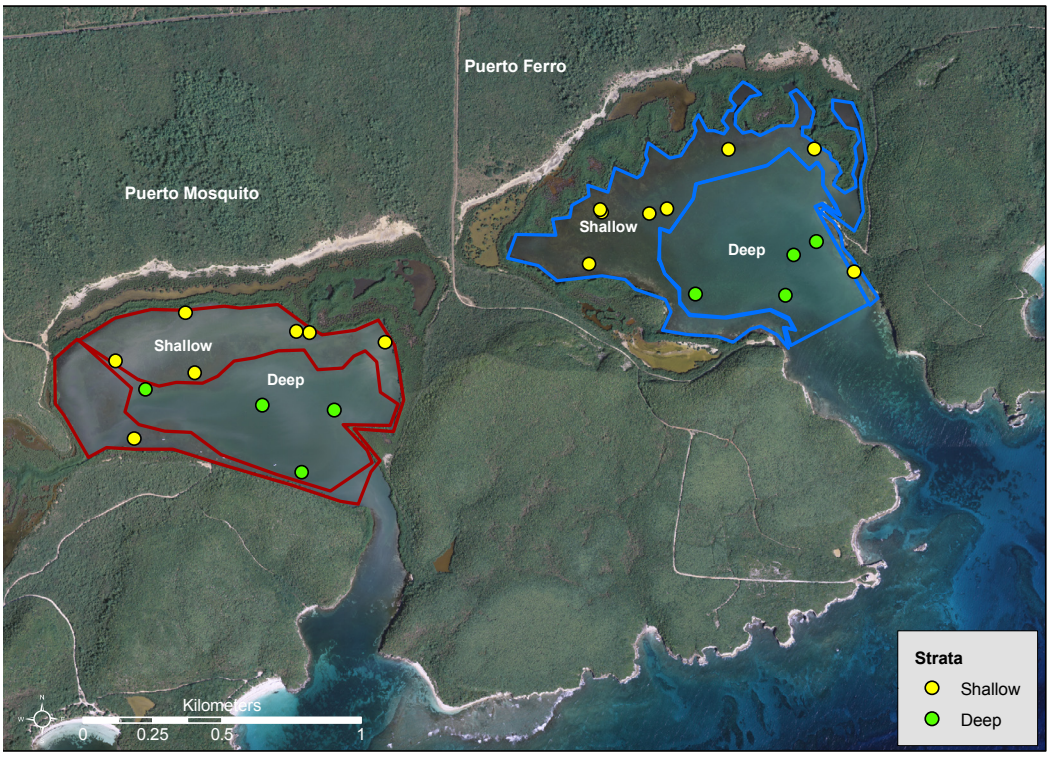

Figure 4.2. Aerial photograph of Puerto Ferro (0.656 km^2) and Puerto Mosquito (0.655 km^2) showing deep and shallow sampling strata and location of randomly selected stations.

Study Areas

Lagoon sites

Puerto Mosquito and Puerto Ferro, adjacent lagoons on the south coast of Vieques (Figure 4.1), are managed by the Puerto Rico Department of Natural Resources (PRDNR) and the US Fish & Wildlife Service (USFWS) as part of one of the largest wildlife reserves in the Caribbean (http://www.fws.gov/caribbean/Refuges/PDF/vieques_factsheet.pdf). Differences in water clarity and benthic habitats are apparent between these lagoons. Puerto Mosquito is a relatively shallow lagoon (< 4 m) surrounded almost entirely by mangroves (Figure 4.2). It has a narrow mouth that restricts exchange with coastal waters and provides a unique

physical environment for the bioluminescent dinoflagellate, *Pyrodinium bahamense*. High densities of this dinoflagellate make Puerto Mosquito one of the brightest bioluminescent bays (biobays) in the world (Mitchell 2005). Puerto Ferro, located just east of Puerto Mosquito, is slightly deeper (4-5 m) with a wider mouth and channel that provides greater water exchange with the Caribbean Sea. Consequently, waters within Puerto Ferro are less turbid than Puerto Mosquito.

Benthic habitats are inherently altered by variations in light penetration to the bottom due to variation in depth, shading and water clarity. Difference in water clarity is likely responsible for differences in the benthic habitats of the two lagoons. Much of the deeper basin of Puerto Mosquito is un-vegetated whereas Puerto Ferro supports a more diverse benthic flora that changes with depth. Shading from the mangrove canopy plays an important role in habitat structure at the margins of these two lagoons. Where the mangrove stands have extended into relatively deep water (>1 m) and the canopy is thick, the substrate largely lacks vegetation. In contrast, where the mangrove margin is shallow and sufficient light penetrates the canopy, macro-algal beds develop among the prop roots (Figure 4.3). As the lagoon margins extend out into shallow flats they are carpeted with seagrasses. Both lagoons support mixed species communities dominated by *Thalassia testudinum* (turtle grass), but the turbid water of Puerto Mosquito support more *Halodule wrightii* (shoal grass) and *Ruppia maritima* (widgeon grass). The latter two species are more tolerant to lower light conditions and fluctuating environments than *T. testudinum.* In deeper zones of Puerto Mosquito, light levels diminish and a shift from seagrass to bare bottom occurs. In contrast, in the relatively clear waters of Puerto Ferro where seagrass beds extend into deeper water, macroalgae replaces seagrass beds as dense stands of calcareous species *Udotea*, *Penicillus* and *Halimeda sp.* (Figure 4.4). In still deeper waters, where the bottom is subjected to intense bioturbation and light is limiting, dense meadows of the small, opportunistic sea grass *Halophila decipiens* (paddle grass) develop on the sediment mounds and pits resulting from burrowing shrimp (*Callianassa sp*., Figure 4.5).

The third lagoon studied, Ensenada Honda, is a large and complex system located to the east of Puerto Ferro and protected from the open sea by promontories, islands and a shallow barrier of reefs. The degree of protection varies spatially resulting in a range of environmental conditions (Figure 4.6). The system has two rather distinct zones. The eastern zone is largely isolated from the sea by a promontory of land and from the western zone by a shallow sill. Water in the eastern zone is relatively turbid reducing light penetration so that the mud bottom of the deep central basin lacks vegetation. The western zone receives

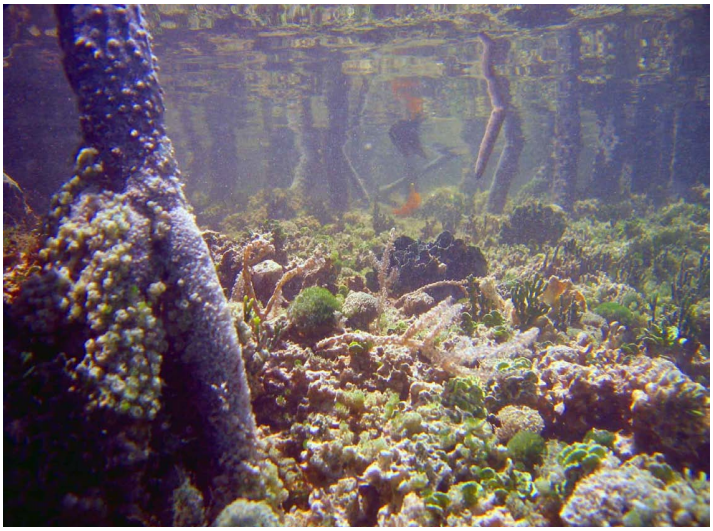

Figure 4.3. Underwater photograph of macroalgae growing among red mangrove prop roots along the lagoon margin.

Figure 4.4. Underwater photograph of the mid–depth zone of Puerto Ferro where the benthic habitat transitions from seagrass into a lush bed of macroalgae visited by a school of spotfin moharra.

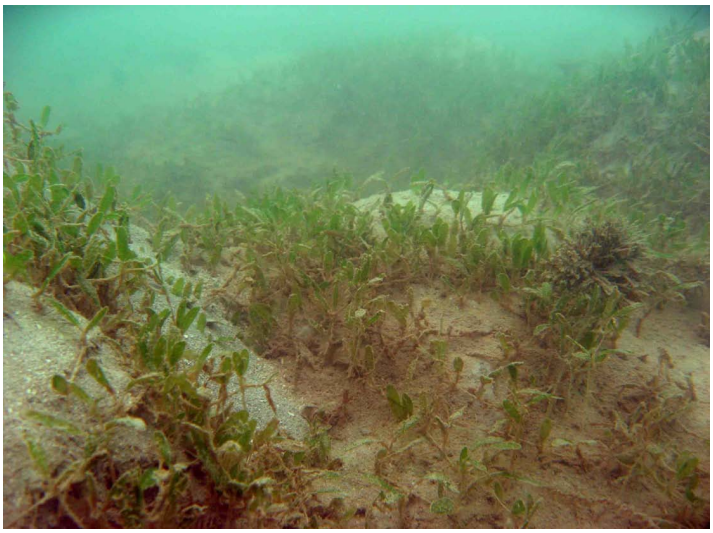

Figure 4.5. Underwater photograph of the deepest regions of Puerto Ferro where *Halophila decipiens* grows on mounds of sediment excavated from shrimp burrows.

protection from the sea by a shallow reef and islands; however, several deep channels ensure water exchange. Waters of the western zone are clear and the bottom supports dense seagrass beds and scattered patch reefs. The landward margin of the lagoon of both zones supports a mangrove fringe.

The fourth lagoon site, Puerto Negro, is on the north coast of Vieques and provides a contrast to those on the south coast. Puerto Negro is an open coastal lagoon protected by a fringing reef divided by a deep central channel (Figure 4.7). The landward margin of the lagoon is a beach feature which separates the inner portion of the lagoon from a mangrove wetland. Waters of the lagoon are very clear and much of the bottom is covered with dense seagrass beds that consist primarily of *T. testudinum* with lesser amounts of *Syringodium filiforme* (manatee grass). This lagoon appears to provide ideal habitat for manatees, which were observed on all visits to the site.

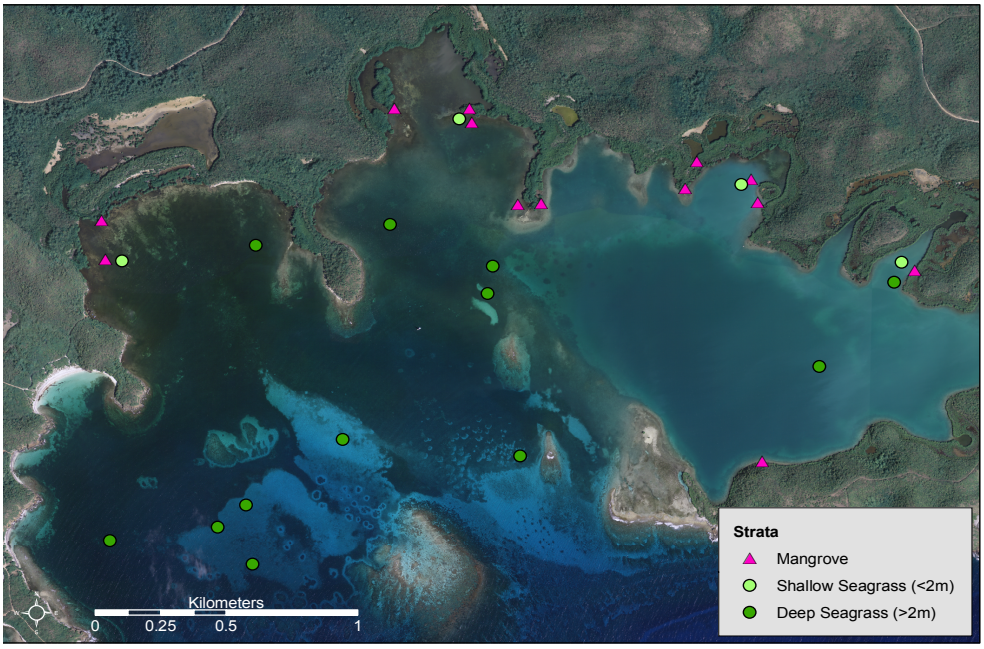

Figure 4.6. Aerial photograph of Ensenada Honda (4.9 km^2) showing sampling stations in three different habitat strata: 1) mangrove fringe, 2) shallow seagrass (<2m), and 3) deep seagrass (>2m).

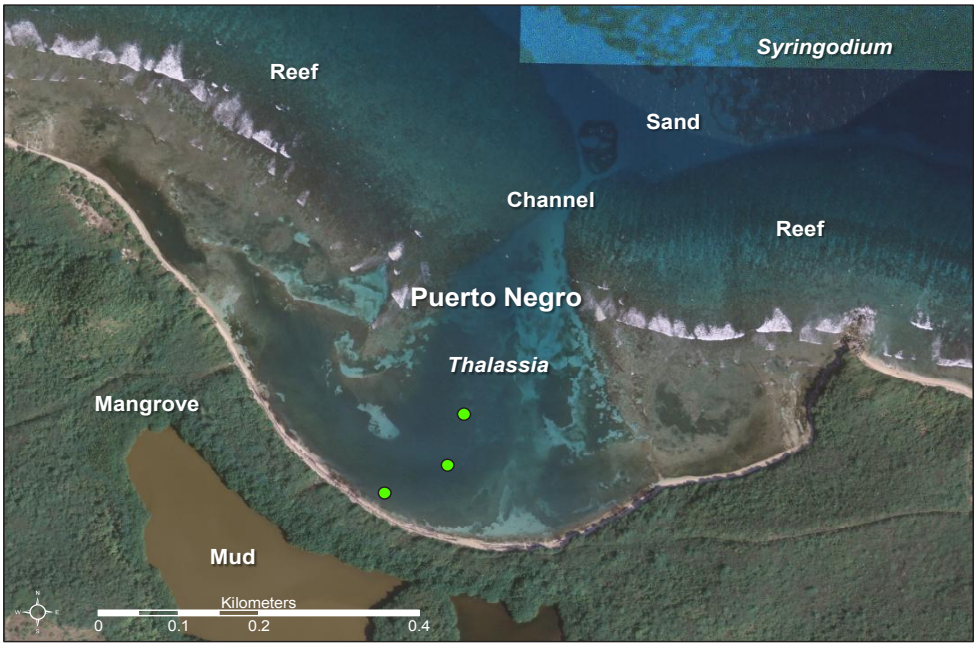

Figure 4.7. Aerial photograph of Puerto Negro (0.22 km^2) showing study locations and the general distribution of habitat types including reef, sand, *Thalassia*, *Syringodium*, mangrove and mud.

Shelf Sites

Investigations of two shallow shelf areas (Figure 4.1) are presented: 1) an extensive seagrass bed on the northwest coast, and 2) the shallow shelf extending from just offshore of Ensenada Honda to the western end of the island of Vieques (Figure 4.8). On the northwest shelf our objective was to characterize the benthic vegetation (species composition, density and biomass of seagrass and density of macroalgae). On the south coast we provide a more general characterization of benthic vegetation on the shallow softbottom (density estimates of seagrasses and macroalgae) and estimates of the epibenthic fauna that utilize this habitat. In both shelf areas, sites were randomly selected from depth strata of 0 to 10 m. For benthic habitat characterization, twenty sites were chosen from the 12.8 km^2 area of the northwest shelf and 43 sites from the 22.4 km^2 area on the southern shelf.

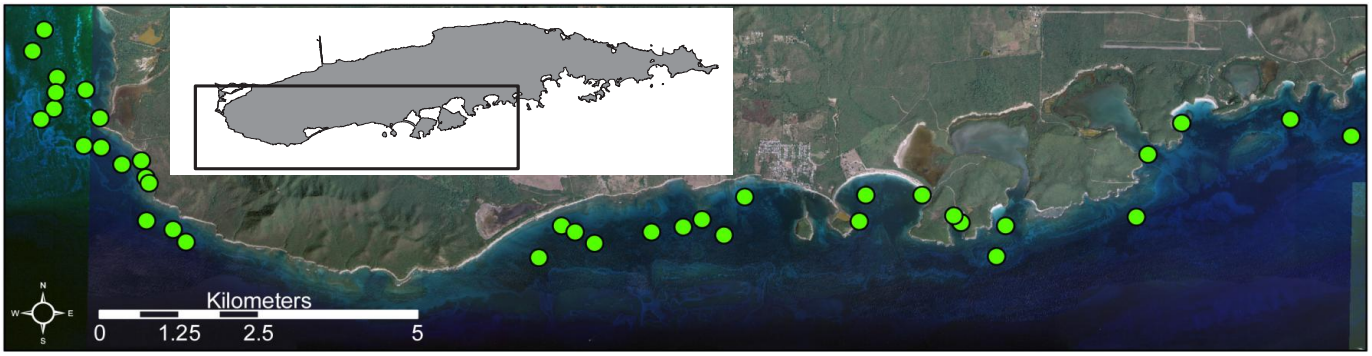

Figure 4.8. Aerial photograph showing location of study sites sampled visually for habitat characteristics and with the SCUBA pushnet to characterize the benthic fauna of seagrass beds on the Southern Shelf of Vieques.

Epibenthic Community Sampling

Benthic plant communities

During the 2006 cruise benthic plant communities were characterized in Puerto Ferro, Puerto Mosquito and the northwest coast by: 1) visually assessing the plant cover and density in 0.25 m^2 quadrats at pre-selected random points using a modified Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974; Fourqurean et al. 2001), and 2) measuring shoot density and biomass in 15 cm diameter sediment cores at pre-selected random points (n = 50 for Puerto Mosquito and Puerto Ferro and n = 20 for the northwest coast).

On the southern shelf (n=43), in Ensenada Honda (n=13) and Puerto Negro (n=16) we visually characterized the benthic plant communities by the Braun-Blanquet method at randomly selected locations in the same manner as for Puerto Ferro, Puerto Mosquito, and the northwest Vieques coast. No biomass or shoot density samples were collected at Puerto Negro, Ensenada Honda or the southern shelf study area.

Figure 4.9.Two divers conducting SCUBA pushnet sampling in a mixed seagrass/macroalgae bed on the southern shelf of Vieques.

Benthic fauna SCUBA pushnet survey

During the 2007 and 2008 cruises epibenthic faunal communities were sampled with a 2 m wide, fine mesh (3 mm) SCUBA pushnet (Table 4.1). The SCUBA pushnet (Figure 4.9) was used to sample epibenthic fauna from seagrass beds of lagoons in 2007 (Figures 4.2, 4.7) and the southern coast shelf (Figure 4.8) during our 2008 cruise. The SCUBA pushnet effectively samples cryptic species that shelter in the macrophytes and are therefore under-sampled by visual techniques. During a standard sample, a pair of divers pushed the net over the substrate for a distance of 30 m, thus sampling an area of 60 m^2. To account for depth-related habitat differences, Puerto Mosquito and Puerto Ferro were both stratified with respect to depth and sampling locations were randomly selected from deep (>2 m) and shallow (<2 m) strata (Figure 4.2). On the southern shelf of Vieques sampling locations were randomly selected from the shelf area less than 10 m in depth. SCUBA pushnet collections were sorted in the field and fishes that could be identified to species were measured for total length and released. Animals whose identification could not be determined in the field were preserved in 70% alcohol and returned to the laboratory for positive identification.

Fish community visual survey

During the 2005, 2006 and 2007 cruises, visual survey samples of fish communities were collected from Ensenada Honda. The lagoon was stratified by habitat type and depth. Three softbottom strata including mangrove margins, shallow (<2 m) and deep (2-10 m) softbottom vegetated substrate were sampled using a band transect visual survey method. Divers counted and estimated lengths of fishes along a 30 m x 2 m band

transect following the temporal stratification transect method outlined by Samoilys and Carlos (2000). Counting was temporally stratified to capture those fish most likely to flee at the approach of a diver. Looking ahead over a section of the band transect, divers first counted large fishes and then counted the cryptic and small sedentary fishes while slowly swimming that section. This methodology provided estimates of both sedentary fishes, which ignore a diver's presence and can only be accurately counted from a small area, and large fishes, that often distance themselves from an approaching diver and will be missed in counts when area is strictly limited. Visual identification of fishes was made to species or the lowest taxonomic group possible based on criteria provided by Humann and Deloach (2002). Lengths of all fishes counted were estimated by tallying fish to length intervals; 1-2 cm, 2-3, 3-5, 5-10, 10-15, 15-20, 20-30, 30-35 cm. Lengths of fishes greater than 35 cm were visually estimated to the nearest decimeter.

Data Analysis

Where appropriate, statistics for macrophyte and faunal abundance are presented graphically as means ± their standard errors. For SCUBA pushnet samples family diversity was calculated using the Shannon index (Pielou 1977).

4.3 RESULTS AND DISCUSSION

Benthic Plant Communities

Overall, the highest relative abundance of total seagrass cover was recorded in Puerto Negro, followed closely by the northwest Vieques and southern Vieques shelves, Ensenada Honda, Puerto Ferro and finally, Puerto Mosquito (Figure 4.10).

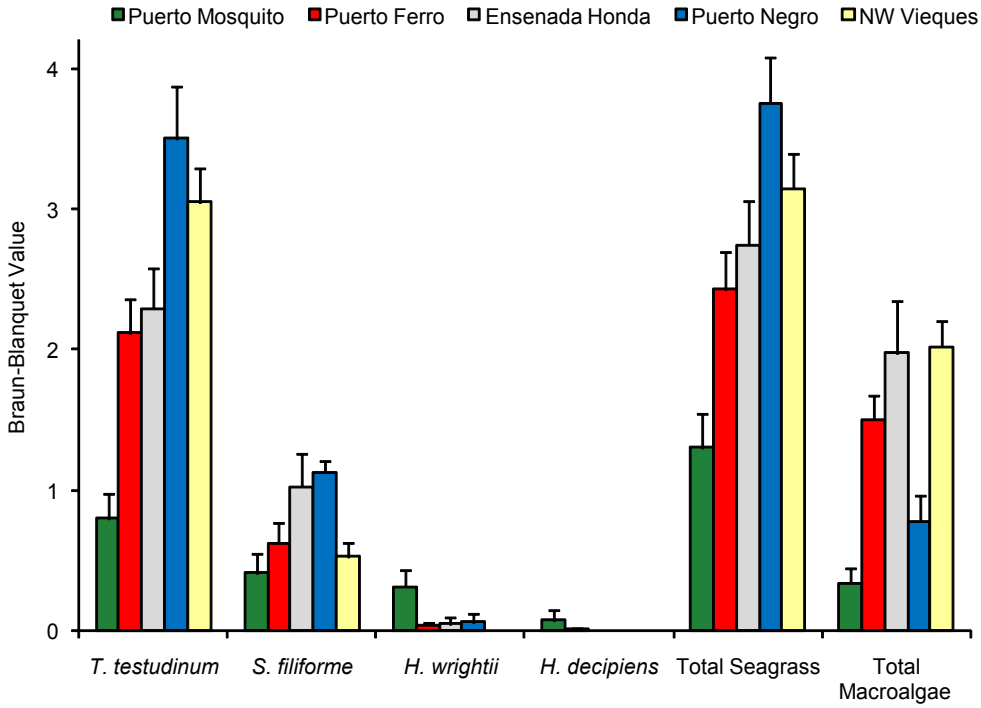

Figure 4.10. Mean (± SE) Braun-Blanquet cover scores for seagrasses and total macroalgae from the northwest shelf study areas and four lagoon systems ordered by increasing turbidity: Puerto Negro, Ensenada Honda, Puerto Ferro and Puerto Mosquito.

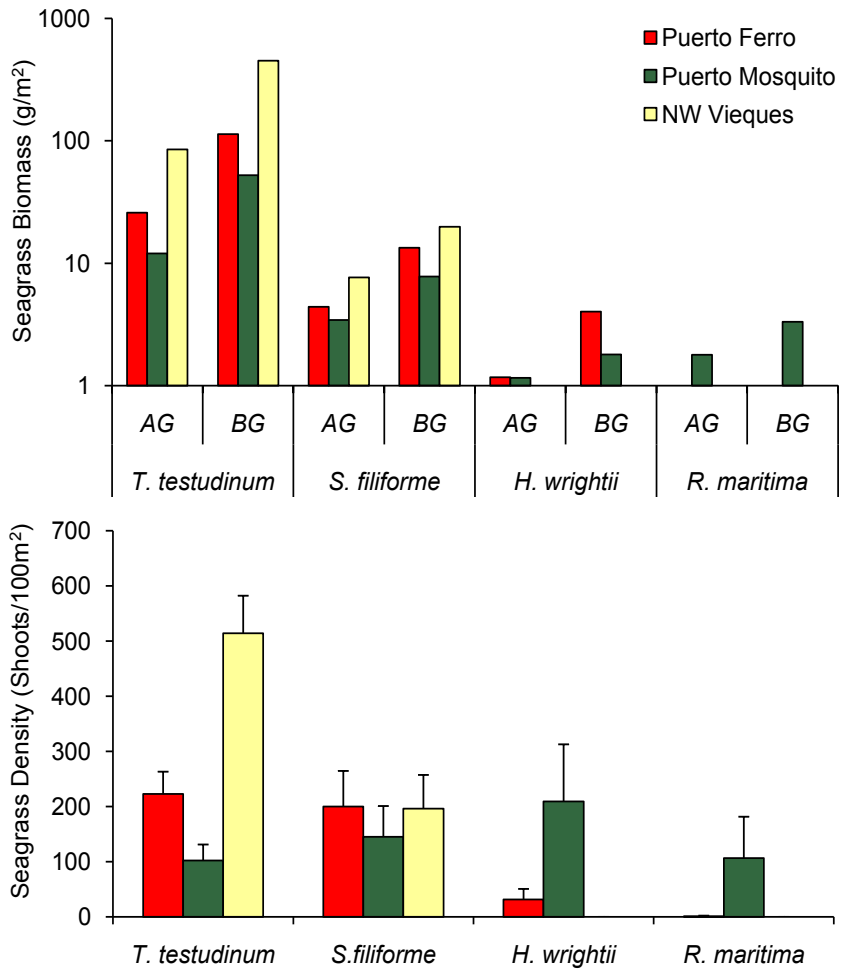

Figure 4.11. Seagrass biomass (gdw/m²) and density (shoots/m²) (±SE) from Puerto Ferro, Puerto Mosquito, and the northwest Vieques coast. The top graph shows seagrass biomass on a log scale and therefore does not include standard error values. AG and BG refer to above and below ground biomass.

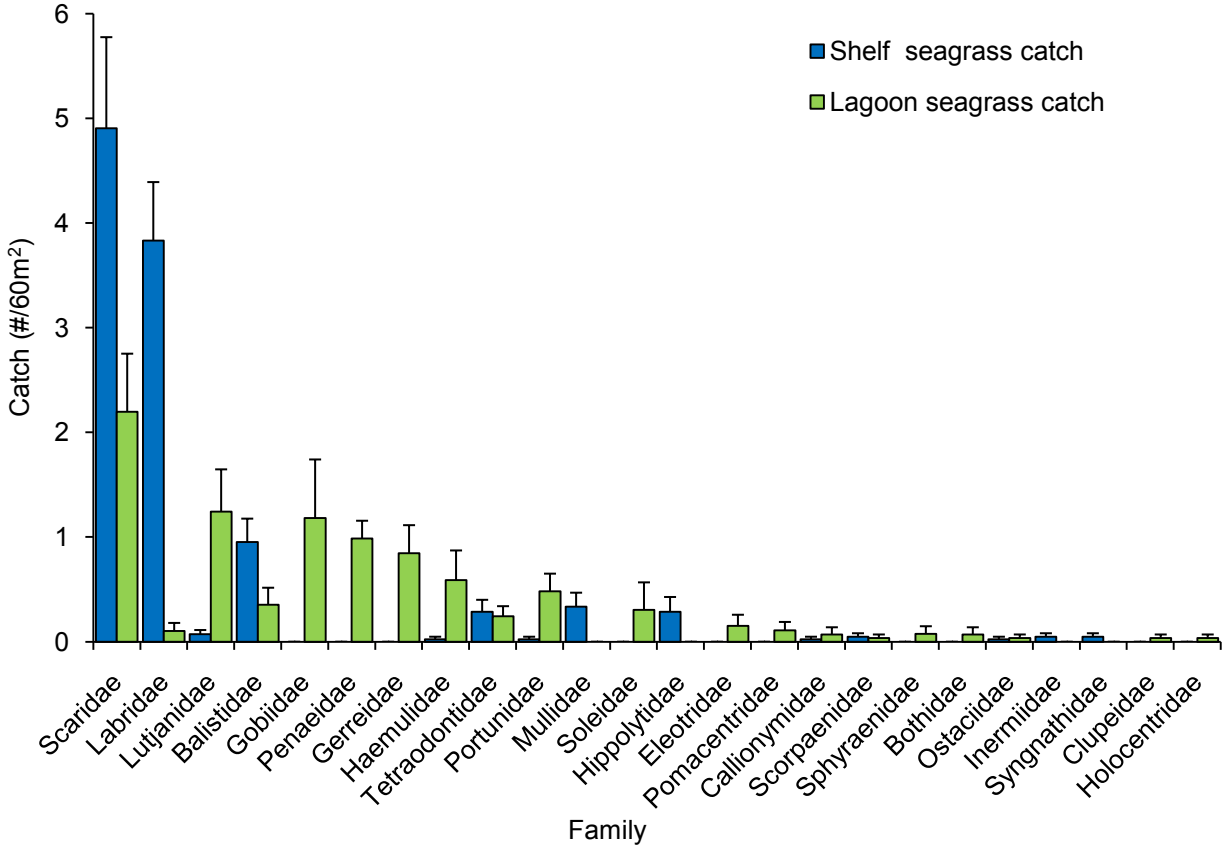

Figure 4.12. Comparison of SCUBA pushnet catch from southern shelf seagrass beds and lagoon seagrass beds. Mean (±SE) catches are presented for all families sampled in the surveys.

Ensenada Honda and the northwest Vieques coast study area had similar and relatively high cover of macroalgae followed by Puerto Ferro, the southern coast, Puerto Negro and then Puerto Mosquito. *Thalassia testudinum* dominated the seagrass cover at most of the sites, as is typical of tropical oligotrophic seagrass ecosystems found throughout the Caribbean. The one exception was the southern shelf where *S. filiforme* densities were slightly higher. Comparison of seagrass biomass between the enclosed lagoons of Puerto Ferro and Puerto Mosquito and the northwest Vieques coast study area shows biomass was also dominated by *T. testudinum* at all three areas and *T. testudinum* biomass was highest in the northwest Vieques coast study area (Figure 4.11). The largest difference between the sites was seen in *H. wrightii* biomass; it was relatively more abundant in Puerto Mosquito than Puerto Ferro and completely absent from the northwest Vieques shelf. Another important difference between these lagoons is the presence of *R. maritima* in Puerto Mosquito but nowhere else. *Halophila decipiens* was observed in the seagrass cover in the enclosed lagoons of Puerto Ferro and Puerto Mosquito (Figure 4.10), but not in the northwest Vieques coast, Puerto Negro or Ensenada Honda.

Figure 4.13. SCUBA pushnet sample of juvenile fishes from Puerto Mosquito. Numbered fishes include: 1) *Ocyurus chrysurus*, 2) *Monacanthus sp*., 3) *Lutjanus apodus*, 4) *Haemulon plumeri*, 5) *Lutjanus synagris*, 6) *Lutjanus griseus*, 7) *Haemulon scirius*, 8) *Sparisoma radians*, 9) *Scarus iseri*, 10) *Eucinostomus melanopterus*.

Lagoon and Shelf Fauna

SCUBA pushnet surveys

Comparison of SCUBA pushnet samples from lagoon seagrass beds and those of the open southern shelf of Vieques indicate a striking difference in the composition of their faunal assemblages (Figure 4.12). Although both

assemblages were similar in density (lagoon: 9.2±1.1/60m^2, shelf: 10.9±1.4/60m^2) and consisted almost entirely of juveniles, the Shannon diversity index indicated that the lagoon assemblage was more diverse at the family level (1.2±0.1 vs 0.8±0.1). The shelf seagrass bed assemblage was dominated by two reef fish families, Scaridae and Labridae, whose densities appear to be higher on the shelf than in lagoons. Though Scaridae were also abundant in lagoons, a wide variety of other families were also common. Common species included both softbottom and reef associated animals that were either absent or rare in shelf samples. Compared to the shelf, lagoons had a high proportion of juveniles representing commercially important fish and crustacean families including four snapper species, three grunts, great barracuda, a Penaid shrimp and a Portunid crab species.

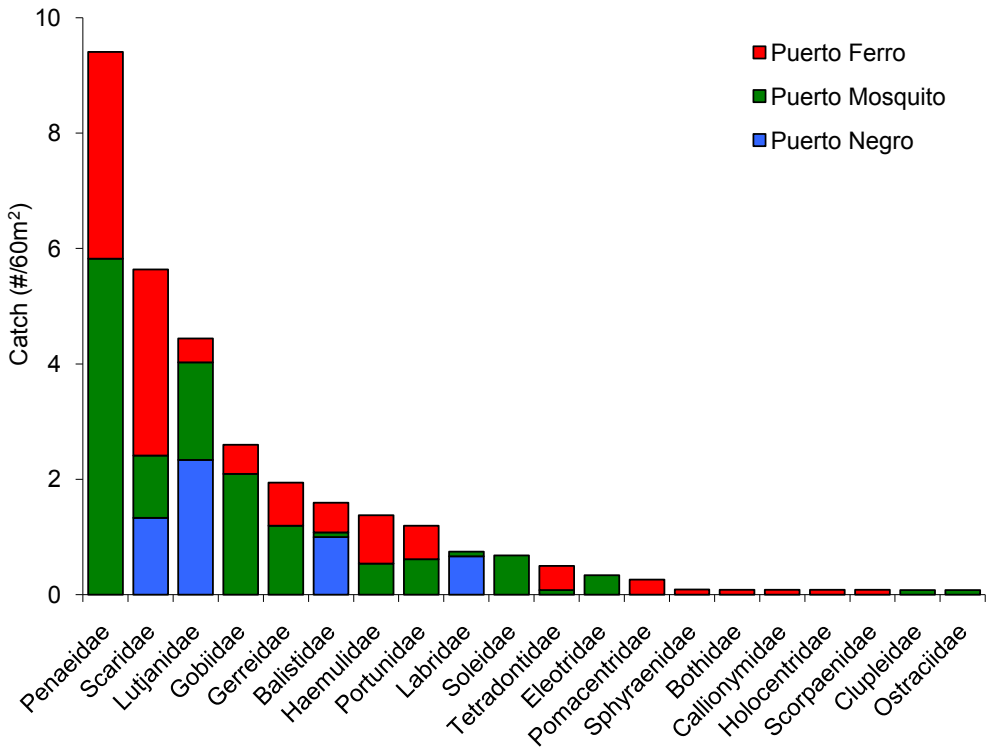

Figure 4.14. Comparison of animal densities (catch/60 m^2) in SCUBA pushnet samples by family for three lagoons (Puerto Ferro, Puerto Mosquito, Puerto Negro).

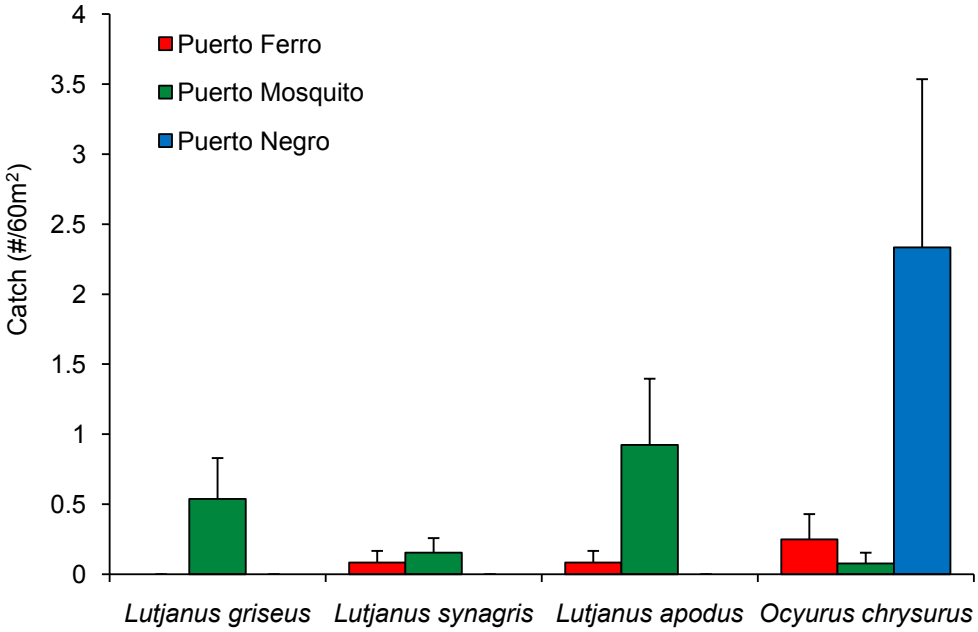

Figure 4.15. Comparison of mean density (±SE) of four Lutjanid species between three lagoons (Puerto Ferro, Puerto Mosquito, Puerto Negro).

Differences among faunal communities were also evident in the three lagoons sampled with the SCUBA pushnet. Catches in all three lagoons were dominated by juveniles fishes (Figure 4.13). Fish communities, similar in Puerto Mosquito and Puerto Ferro, differed markedly from Puerto Negro (Figure 4.14). Only four families, all representing reef fish, were caught in Puerto Negro and the catch was dominated by yellowtail snapper (*Ocyurus chrysurus*), a commercially important member of the family Lutjanidae. The higher richness at the family level of Puerto Mosquito and Puerto Ferro was also evident at the species level. The snapper family represented by a single species in Puerto Negro was represented by four species in Puerto Mosquito and three in Puerto Ferro (Figure 4.14). In addition to these commercially important species that are associated with coral reef as adults, the rich faunas of Puerto Mosquito (14 families) and Puerto Ferro (15 families) also included relatively high densities of juvenile crustaceans such as the commercially important southern brown shrimp that as an adult associates with softbottom habitats (Grady 1971). Similar scuba net surveys of a range of lagoon and shelf habitats in the Bay of La Parguera in South Western PR yielded similar results. While the juvenile fish community observed in lagoons varied relative to specific habitat characteristics, fish diversity and the number and density of commercially important species was higher in lagoon than shelf habitats.

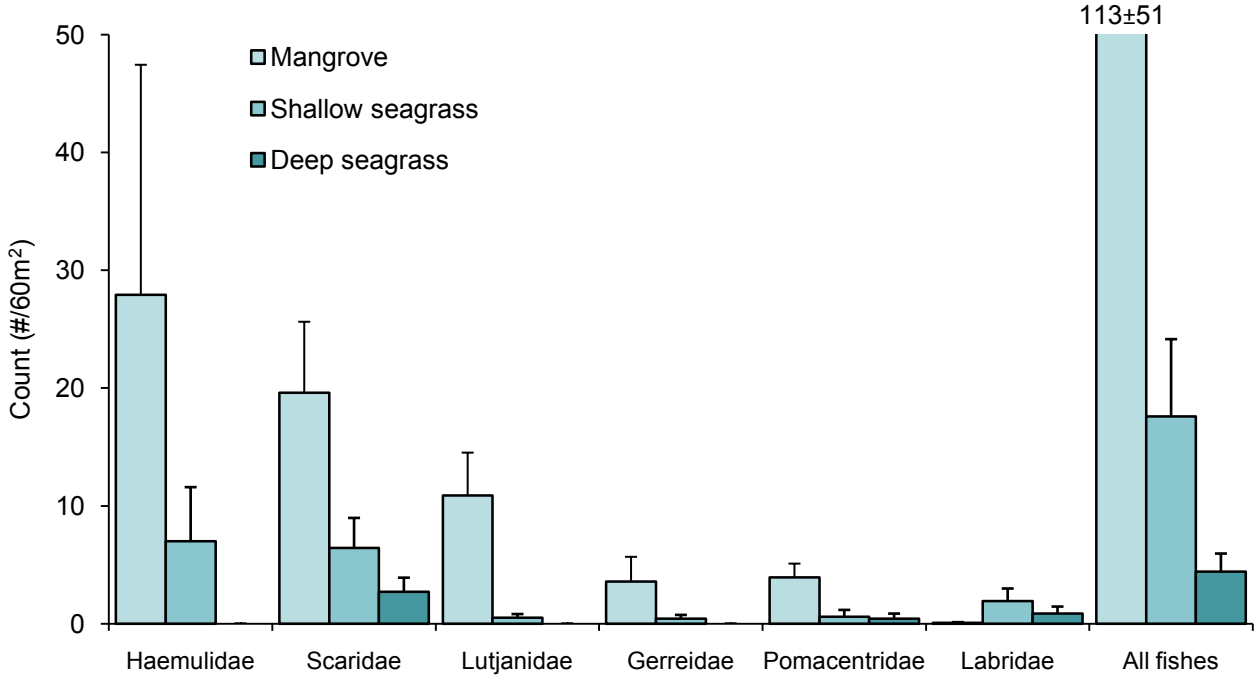

Figure 4.16. Comparison of counts in visual surveys of important reef fish families and total fish counts from three habitat strata (mangrove fringe, shallow seagrass, deep seagrass) sampled in the Ensenada Honda lagoon system.

Visual surveys

Visual survey data from Ensenada Honda showed that densities of fishes differed among the softbottom habitats of the lagoon (Figure 4.16). For major reef fish families present in the lagoon, highest densities were observed at the mangrove fringe among and adjacent to the mangrove prop roots, intermediate densities in shallow seagrass beds and lowest densities in deep seagrass beds. The sole exception to this generalization was for wrasses (Labridae), which appeared to avoid the mangrove fringe. On average, total fish counts were much higher from the mangrove habitat due to the contribution of forage fishes, including juveniles of the families Gerridae, Clupeidae (herrings) and Engraulidae (anchovies), which were seldom observed over open seagrass beds.

4.4 SUMMARY AND CONCLUSIONS

The seagrass habitats that characterize the softbottom communities of Vieques are of outstanding quality and appear to play a critical role in the ecology of the island's coastal system. The diversity and abundance of seagrass meadows in the lagoons and on the shelves of Vieques are comparable to seagrass ecosystem elsewhere in the Caribbean Sea (Green and Short 2003). While the broad extent of the northern shelf supports more extensive sea grass beds than the narrower southern shelf (Chapter 2), the presence of numerous lagoons along the southern shore fosters greater variation in softbottom environments and seagrass habitats. These lagoons and the adjacent shelf are linked by the abundant seagrass meadows that provide continuous corridors of benthic habitat connecting the two systems.

Seagrass habitat variation among the lagoons surveyed in Vieques is largely dependent on variation in their connection to the coastal ocean and the amount of water exchanged between the shelf and the lagoons. Highest seagrass species richness was observed in Puerto Mosquito and Puerto Ferro whose exchange with the shelf was constrained relative to other lagoons surveyed. In the tropical seagrass ecosystem, these less oligotrophic conditions allow for the development of opportunistic species such as *H. wrightii* and ruderal species such as *H. decipiens*. In the most extreme case, Puerto Mosquito, we observed *Ruppia maritima* which is a ruderal species capable of growing in a wide range of salinities from nearly fresh water to 60 ppt. Ensenada Honda and Puerto Negro represent relatively open lagoon systems and their softbottom flora was similar to that of the shelf, more typical of the shallow water oligotrophic climax seagrass communities dominated by *T. testudinum* (Williams 1990) (Figures 4.10, 4.11).

The diversity of the epibenthic fauna of softbottom communities of Vieques corresponds with the richness of their flora. SCUBA pushnet samples from the shelf and lagoons suggest that the more diverse vegetated

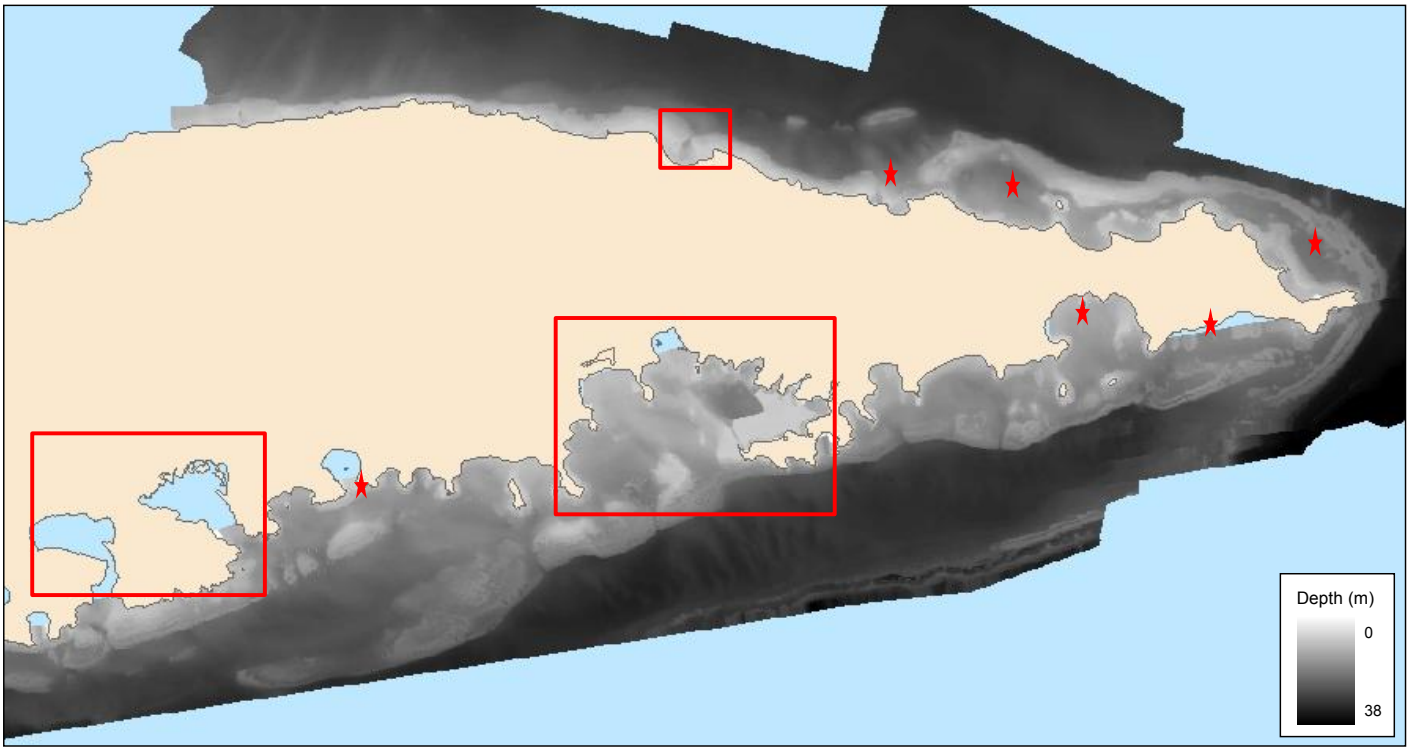

Figure 4.17. Coastal bathymetry from Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) data for eastern Vieques, collected at 400 soundings per second. The data shown were resampled to a 5 x 5 m pixel size. Lagoons sampled during our surveys are enclosed by boxes. Relative depths are represented by shading; light gray indicates shallower water, dark gray, deeper. Stars indicate additional lagoon systems that are relatively unknown.

habitats of the lagoons (Figures 4.3, 4.4, 4.5) shelter a more diverse faunal community (Figure 4.12). A similar relationship is evident within the lagoons themselves. The more diverse floral habitats of Puerto Mosquito and Puerto Ferro supported richer softbottom fauna than Puerto Negro (Figures 4.13, 4.14). Differences in the faunal communities among the three lagoons may relate in part to differences in turbidity levels, apparent in the aerial photography (Figures 4.2, 4.6, 4.7). Much of this variation in turbidity among lagoons results from differences in exchange with the shelf and subsequent effects on plankton densities and suspended materials; for example, dinoflagellate densities can be two orders of magnitude higher in Puerto Mosquito than Puerto Ferro and three orders greater compared to a well flushed lagoon (Gasparich 2007). The relatively dense plankton community of lagoons can be expected to enhance food availability and affect the foraging efficiency of both juvenile fishes and their predators. Turbidity levels appear to influence faunal composition of the lagoons at the family level. Although flatfish were sampled in both Puerto Mosquito and Puerto Ferro, members of the family Soleidae, which sense prey by taste and touch, were sampled in Puerto Mosquito while Bothid flounders, which are visual feeders, were collected in Puerto Ferro. Turbidity levels may also have influenced abundance and diversity within the family Lutjanidae. Grey, lane, and schoolmaster snappers had highest densities in Puerto Mosquito while yellowtail snapper were most abundant in Puerto Negro (Figure 4.14). This may relate to differences in feeding habits between these fishes as the yellowtail snapper feeds diurnally while the other three species are primarily benthic nocturnal feeders.

The concentrations of juveniles within lagoons of a variety of species whose adults occupy the shelves indicate that lagoons serve as nursery areas (Adams and Ebersole 2002; Nagelkerken 2007; Burke et al. 2009). Within Ensenada Honda a gradient in density of fishes relative to depth was apparent suggesting that the shallow vegetated habitats of this lagoon are of particular importance as nurseries (Figure 4.16). The shallow regions of the lagoons may be selected by juvenile fishes due to its quality in terms of providing shelter from predators as well as the availability of food resources. The presence of submerged mangrove root habitat at the margins of lagoons bordering the southern shelf appeared to attract juvenile fishes as seen in other locations throughout the Caribbean (Rooker and Dennis 1991; Nagelkerken 2007). The presence within lagoons of high concentrations of early juvenile stages of ecologically and commercially important species rare or absent from reef and hardbottom habitats (Chapter 3) and from shelf seagrass beds (Figure 4.12) indicates that the lagoons of Vieques are an integral part of the life history of these species and critical to their recruitment as advanced juveniles and adults to shelf habitats. Similar results, showing the importance of shallow lagoon systems as critical nursery areas, have been provided from mainland Puerto Rico (Burke et al. 2009) and elsewhere in the Caribbean (Adams and Ebersole 2002).

Although much remains to be learned about the lagoons of Vieques, we believe there is strong evidence that they play a vital role in the ecology of the coastal ecosystem. All lagoons share the characteristic of a connection to the adjacent shelf. Variation in this connectivity fosters variation in physical conditions that allow development within lagoon systems of a particularly broad range of tropical marine habitats. Another common attribute of the majority of lagoon habitats is the presence of seagrasses. This common structural component dominates the benthic landscape, providing important ecological services to and linkage between softbottom habitats that extends from the mangrove communities of the lagoons across the adjacent shelf to depths of >20m.

The high floral and faunal diversity of lagoons and evidence of their role as nursery areas for commercially and ecologically important species suggest these systems should receive protection from activities that would threaten their physical structure and environmental quality. From the perspective of conserving marine biodiversity and fostering sustainable fisheries, the distribution of lagoons and near-shore habitat generally has led us to conclude that the southern shelf and eastern end of the island appear particularly valuable. The bathymetry of this region is complex and possesses a wide variety of lagoon like systems in addition to those described in this study (Figure 4.17). Further studies are needed to more completely characterize the lagoons of Vieques, their linkage to the insular shelf and their role in sustaining the resources of the island's marine ecosystem.

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