Appendix 5. Summary of PRDNER Laws and Regulations

	Management and Regulatory Authorities	Resources Protected
Commonwealth		
PRDNER		
General- Resources protection	Constitution of the Commonwealth of Puerto Rico	Guarantees the protection and use of natural resources. Applicable to all Commonwealth agencies, corporations and municipalities (Sec. 19 Part.VI)
	DNER Organic Act, Law Num. 23 of 1972 as amended	Designates the PRDNER as the Commonwealth agency responsible for the implementation of the constitutional mandate regarding the protection and use of natural resources.
	Environmental Public Policy Act" Act No. 416 of September 22, 2004, as amended	Establishes the environmental public policy of the Government and its municipalities for the promotion and protection of the environment.
Wildlife resources	New Wildlife Act of Puerto Rico, Law Num. 241 of August 15, 1999	Establishes the public policy for the protection of wildlife and their habitats in the Commonwealth of Puerto Rico, including jurisdictional waters.
	Regulation to govern the conservation and management of wildlife, exotic species, and hunting in the Commonwealth of Puerto Rico, Regulation Num. 6765 of February 11th, 2004.	Promotes the protection, conservation, and management of wildlife species. Establishes a mechanism to mitigate the modification of natural habitats. More rigorously regulates the granting of hunting licenses, the inscription of hunting weapons, and the renovation and suspension of these weapons for infractions set forth in the law and in this regulation.
	Regulation to govern vulnerable species and species in danger of extinction in the Commonwealth of Puerto Rico, Regulation Num. 6766 of February 11th, 2004.	The purposes of this regulation are: a) to identify, conserve, and preserve vulnerable and endangered species, b) to stimulate the propagation and survival of these species, c) to identify and promote the conservation of the critical natural habitats and essential critical natural habitats, d) to regulate the import and export of vulnerable or endangered species, e) to adopt the criteria used by the international scientific community to designate species whose population could rapidly become critically endangered or extinct within a very short time period.
Fisheries (including coral reefs)	Puerto Rico. Fisheries Act, Law Num. 278 of November 29, 1998, and its' respective amendments.	Promotes the use, management, and conservation of fishery resources and regulates activities that have an impact on these resources.
	Law for the protection, conservation, and management of coral reefs in Puerto Rico, Law Num. 147 of July 15th, 1999.	Declares as public policy the protection, preservation, and conservation of coral reefs in the territorial waters of Puerto Rico.
	Fishing regulations of Puerto Rico, Regulation Num. 7949 of 2010	Administers fisheries in the territorial waters of Puerto Rico. • Establishes the off-season for the capture of certain species; • Establishes the size limitations of the species that can be captured; • Identifies the species for which it is prohibited to capture, sell, or transport; • Establishes the provisions describing the appropriate methods of capture of aquarium fish that are permitted; • Identifies invasive species that can be fished or captured; • Establishes the requirements for the solicitation and renovation of commercial, recreational, and charter fishing licenses.
	Spiny Lobster Fishery Control Regulation, Regulation Num. 4087 of January 10, 1990.	Establishes the regulations to control the Spiny Lobster (*Panulirus argus*) fishery activities within the jurisdictional waters surrounding the Commonwealth of Puerto Rico.
	Regulation to control the extraction, possession, transportation, and sale of coral resources in Puerto Rico, Regulation Num. 2577, September 28, 1979	Regulates the extraction, possession, transportation, and/or sale of coral resources in Puerto Rico.

	Administrative Order 2016-08	Prohibits the harvesting of sea cucumbers (Holothuria spp.) and sea urchins (Class Echinoidea) in the jurisdictional waters of Puerto Rico
Habitat protection (forests, wetlands, watersheds)	Law for the Natural Heritage Program, Law Num. 150 of August 4th, 1988.	The purpose of the law is to identify and delimit land of natural value and prepare plans for the acquisition and protection of such territory, as well as mechanisms to strengthen non-profit organizations to share responsibilities for acquiring, restoring, and managing these lands.
	Law of Conservation Easements of Puerto Rico, Law Num. 183 of December 27 of 2001, as amended.	Develops incentives for the creation of easements for the protection in perpetuity of private lands that have natural, cultural, or agricultural value.
	Fund law for the Acquisition and Conservation of the Lands of Puerto Rico, Law Num. 268 of September 2003.	Approved for the acquisition, improvement, conservation, and maintenance of lands that are considered to have a high ecological value.
	Puerto Rico Forest Act, Law Num. 133 of July 1st, 1975, as amended.	Declares the public policy for the governance of the forests of Puerto Rico, which includes –among other subjects-- the maintenance, conservation, protection, and expansion of forests for use and enjoyment.
	Law for the Public Policy on Wetlands in Puerto Rico, Law Num. 314 of 1998, as amended.	Establishes the protection of wetlands as public policy in Puerto Rico. The law promotes the preservation, conservation, restauration, and management of natural wetland resources.
	Law for the Protection of Watersheds and for the Prevention of Flooding, Law Num. 47 of June 6th, 1963 (12 L.P.R.A. § 251-§254)	Declares, as a public policy of the Government of Puerto Rico, the preservation of rivers and streams as ecosystems that provide multiple benefits. Establishes as ministerial duties of the DNER the surveillance, conservation, and cleaning of beaches, as well as the conservation and cleaning of rivers.
	Law for the conservation, use, and development of water resources in Puerto Rico, Law Num. 136 of June 3rd, 1976.	This Law and its regulation, *Regulation for the enjoyment, use, conservation, and administration of the waters of Puerto Rico,* establishes control of the use, enjoyment, and development of the waters and water bodies of Puerto Rico.
Enforcement	Department of Natural and Environmental Resources Rangers Act, Law Num. 1 of June 27th of 1977. Regulation of the Ranger Corps of the Department of Natural and Environmental Resources, Regulation Num. 5916 of February 8th 1999.	Creates the Ranger Corps and establishes its tasks and responsibilities which include: protecting wildlife, policing activities and operations relating to the earth's crust, assuming park ranger responsibilities and inspecting fishing activities, among others. The rangers are responsible for carrying out arrests and enforcing the law, among other tasks.
Navigation	Law of Navigation and Aquatic Security of Puerto Rico, Law Num. 430 of 2000	Establishes the public policy for security in the aquatic and maritime recreational activities and practices.
	Regulation for the inscription, navigation, and aquatic security of Puerto Rico, Regulation Num. 6979, of May 31st 2005, as amended.	Regulates the inscription and enumeration of vessels, establishes security measures, regulates recreational practices in maritime and aquatic bodies of water, establishes the measures to protect fauna, flora and other natural resources that could be impacted by recreational activities, and establishes the infractions and administrative fines, among other subjects.
Uses	Regulation for the administration of uses through authorizations and concessions in Natural Protected Areas, Reg. 8013	This regulation establishes the criteria to determine the authorizations and concessions of the sale and the acquisition of products, embarkation and disembarkation, excursion services or the interpretation of designated areas, and the administration of recreational areas as well as camp sites and eco-lodges
Land Use/Watershed		
Land Uses	Joint Permit Regulation for the Evaluation and Issuance of Permits Related to Development and Land Use, Regulation No. 31	• Land-use and construction permits • Habitat modification • Extraction of materials from the earth's crust
	Puerto Rico Land Use Plan (2015) Salinas Territorial Plan (2012) Guayama Territorial Plan (2008)	Land use in the Reserve's watershed

Federal		
General	National Environmental Policy Act	All federal actions with the potential of impacting natural resources in Puerto Rico need to comply with NEPA.
Coastal protection	Coastal Zone Management Act	The (PRCMP) is a network program administered by the PRDNER, the PRPB and other Commonwealth entities. The PRCMP authorities were adopted in 1978 as the coastal component of the PR Land use plan.
Wildlife /Fisheries	Pittman-Robertson Wildlife Restoration Act de 1937	Provides federal assistance for the management and restoration of wildlife species populations and their habitats. This law also provides for the development of integrated management plans for species of fish and wildlife.
	Marine Mammal Protection Act of 1972 (MMPA), as amended, 16 U.S.C. §1361 et seq.	Protection of marine mammals and their ecosystems.
	Endangered Species Act of 1973 (ESA), as amended, 16 U.S.C. §1531 et seq	Conservation of vulnerable or endangered species and the protection of ecosystems that support these populations.
	Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended, 16 U.S.C. §1801 et seq **Regulations:** • Fisheries of the Caribbean, Gulf, & South Atlantic 50 CFR Part 622 • Atlantic Highly Migratory Species 50 CFR Part 635 • Spiny Lobster Fishery of the Gulf of Mexico & South Atlantic 50 CFR Part 640 • International Fisheries Regulations 50 CFR Part 300	Restoration of fisheries affected by overfishing; protection of essential habitat for fish species; reduction of incidental capture within the economic zone exclusive to the United States.
	Sport Fish Restoration Act, known as *Dingell-Johnson Act y/o Wallop-Breaux Act*.	This Law creates a program for the management, conservation, and restoration of fishery resources used for recreational purposes. Federal funds are assigned for the management and restoration of fish species with recreational value for the marine or river environments.
Habitat protection	**Clean Water Act** (CWA), Pub.L. 107-303 (33 U.S.C. 1251-1387).	Protection of waters and wetlands.

Appendix 6. Jobos Bay NERR Graduate Research Fellowship Projects

	Name **Research Topic**	**Year**	**University**	**Habitat & Ecosystem Processes**	**Anthropogenic Influences on Estuaries**	**Habitat Conservation & Restoration**	**Species Management**	**Social Science & Economics**
1	Ermelindo Banchs Plaza Status of the Groundwater Quality of the Jobos Bay Estuary Reserve	1997	UPR-M		X			
2	Carlos Altieri Determination of Pesticides in Surface and Interstitial Water Samples Discharged into JBNERR	1997	UPR-MC		X			
3	Amanda Jones-Demopoulos Black Mangrove Benthic Community Structure, Seedling Growth and Survival, and Sediment Characteristics in Anthropogenically Disturbed and Pristine Habitats	1999	Univ. Hawaii	X			X	
4	Abnery Picon A Protocol to Apply BASINS to Assess Non-point Sources of Pollution	2000		X				
5	Jennifer Bowen Contrasting Nitrogen Retention Rates in Watersheds: Using Nitrogen Isotopes to Compare Temperate and Tropical Estuarine Systems	2001	Boston Univ.	X				
6	Carlos Garcia-Quijano Resisting Extinction: The Value of Local Ecological Knowledge for Small-Scale Fishers in Southeastern Puerto Rico	2003	UPR-M		X			X
7	Ylva Olsen Distribution and Control by Nutrients and Manatees of Seagrasses in Jobos Bay, PR	2004	Boston Univ.	X	X		X	
8	Yogani Govender A Multidisciplinary Approach Toward Understanding the Distribution, Abundance and Size of the Land Crab *Cardisoma guanhumi* in PR	2004	UPR-RP	X	X	X	X	X
9	Michael Martinez Pollutants and Foraminiferal Assemblages in Jobos Bay: An Environmental Micropaleontology Approach	2007	USF	X	X			
10	Suhey Ortiz-Rosa Photochemical Response and Optical Properties of Colored Dissolved Organic Matter (CDOM)	2007	UPR-M	X				
11	Maytee Rodríguez Diversity and Distribution of Sulfate-	2009	Turabo Univ.	X	X			

	Name **Research Topic**	**Year**	**University**	**Habitat & Ecosystem Processes**	**Anthropogenic Influences on Estuaries**	**Habitat Conservation & Restoration**	**Species Management**	**Social Science & Economics**
	Reducing Bacteria at the Jobos Bay Reserve							
12	Ivelisse Rodríguez Inference of habitat connectivity via habitat use by resident and migratory birds between secondary dry forest and mangroves in Jobos Bay NERR.	2010	Turabo Univ.	X		X		
13	Virginia Schutte Effects of nutrients pollution on mangrove ecosystem functioning	2010	Univ. Georgia	X	X		X	
14	Britta Jessen	2014	Univ. Rhode Island	X	X			

Appendix 7. Detailed Reserve Attributes, Threats and Stressors

Jobos Bay NERR Attributes

Jobos Bay NERR is part of the NOAA's National System of Marine Protected Areas (MPA). The MPA System, composed of 437 areas, was established following Executive Order 13158. The purpose of the National System is to build management capacity among MPA programs, coordinate collaborative efforts to address common management issues and identify ecosystem-based gaps in the protection of significant natural and cultural resources for possible future action by the nation's MPA authorities. Each MPA is managed independently, but there's a framework to coordinate planning and management.[1]

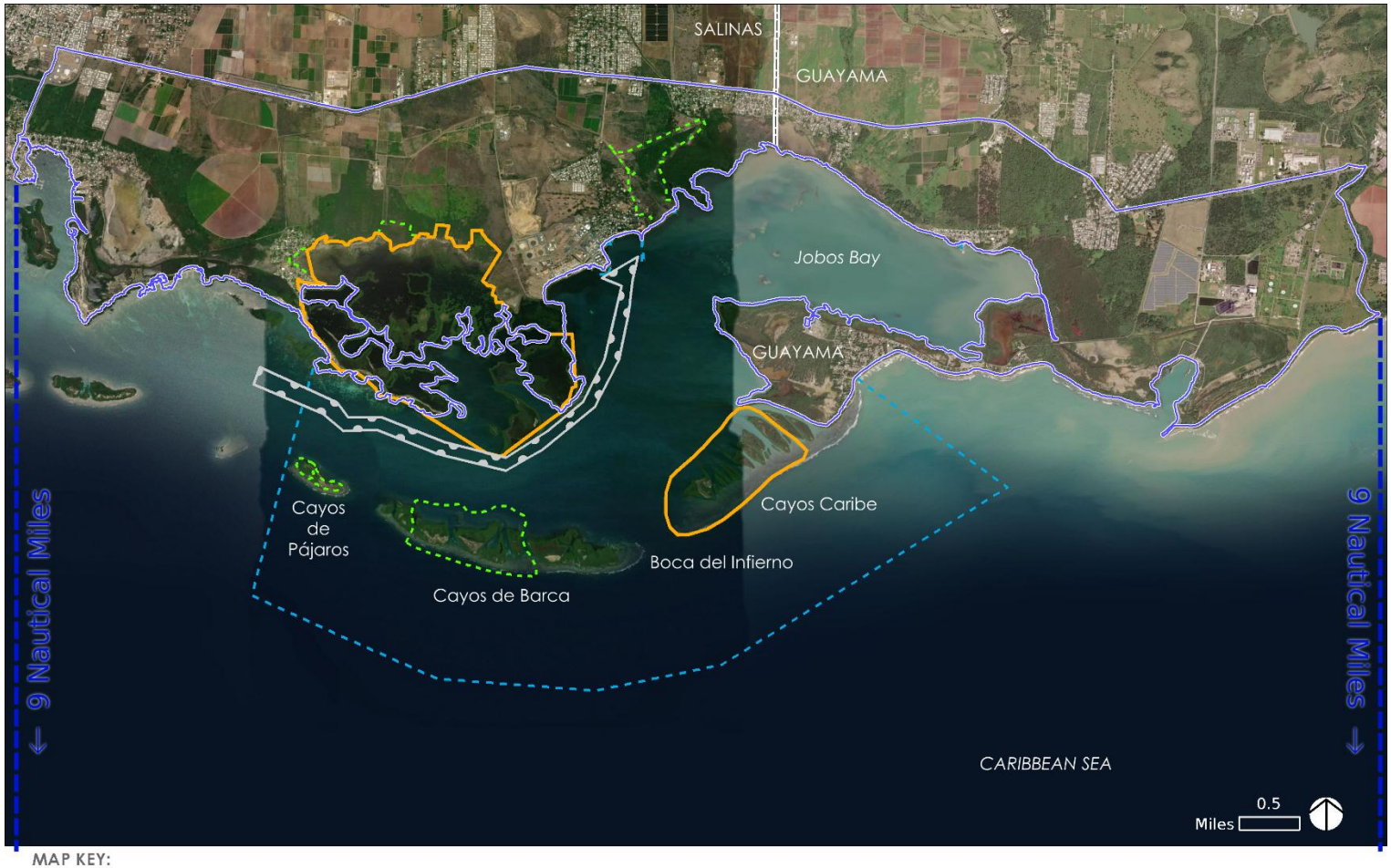
The Jobos Bay was designated as a Special Planning Area (SPA) in 1978, with the certification of the Puerto Rico Coastal Management Program (PRCMP) by the NOAA and its approval by the Commonwealth of Puerto Rico under Resolution PU-002 of 1978. SPAs are defined as "important coastal resource areas subject to serious present or potential use conflicts, and, therefore, require detailed planning".

The Jobos Bay SPA extends from Guamaní River in Guayama to Playa de Salinas, and covers an area of 67.46 km² (25.86 km² of land and 41.60 km² of water). This SPA has a management plan and a land use plan which are under the consideration for approval by the Puerto Rico Planning Board (PRPB).

Bahía de Jobos and Mar Negro were also identified in the PRCMP as "areas with important coastal resources subject to conflict due to its actual or potential usage and which should be substantially preserved in their actual condition (or in cases where restoration is viable, restored to their previous natural condition)". In Puerto Rico, these areas are known as Natural Reserves. The PRDNER submitted the designation of this area as a NR to the PRPB. This designation means greater protection for these coastal resources.

[1] 2015 Framework for the National System of Marine Protected Areas of the United States of America :http://marineprotectedareas.noaa.gov/nationalsystem/framework/final-mpa-framework-0315.pdf

Figure 1. Jobos Bay Special Planning Area



MAP KEY:

- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
- Future Incorporations Marine Boundary
- Aguirre Navigational Channel*
  *Not included within the boundary

Jobos Special Planning Area

- Land Boundary
- Marine Boundary

Source: DNER, Land Resources Planning Division.

Ecological attributes

Geomorphology

Geography

Jobos Bay NERR is located in the South coastal plain of Puerto Rico, between the Municipalities of Guayama and Salinas. The south coastal plain is narrower than the northern plain, with shorter and smaller rivers, and with an irregular insular shelf that extends two to five miles (3-8 km) seaward.

JBNERR is the second largest estuary in Puerto Rico, with three times as much shoreline as any other estuary on the Island. It is composed of mangrove forest and diverse habitats that vary from the coastal fan-delta and alluvial deposits of the landward transition zone, to offshore cays in the Caribbean Sea (Kuniansky, & Rodríguez, 2010).

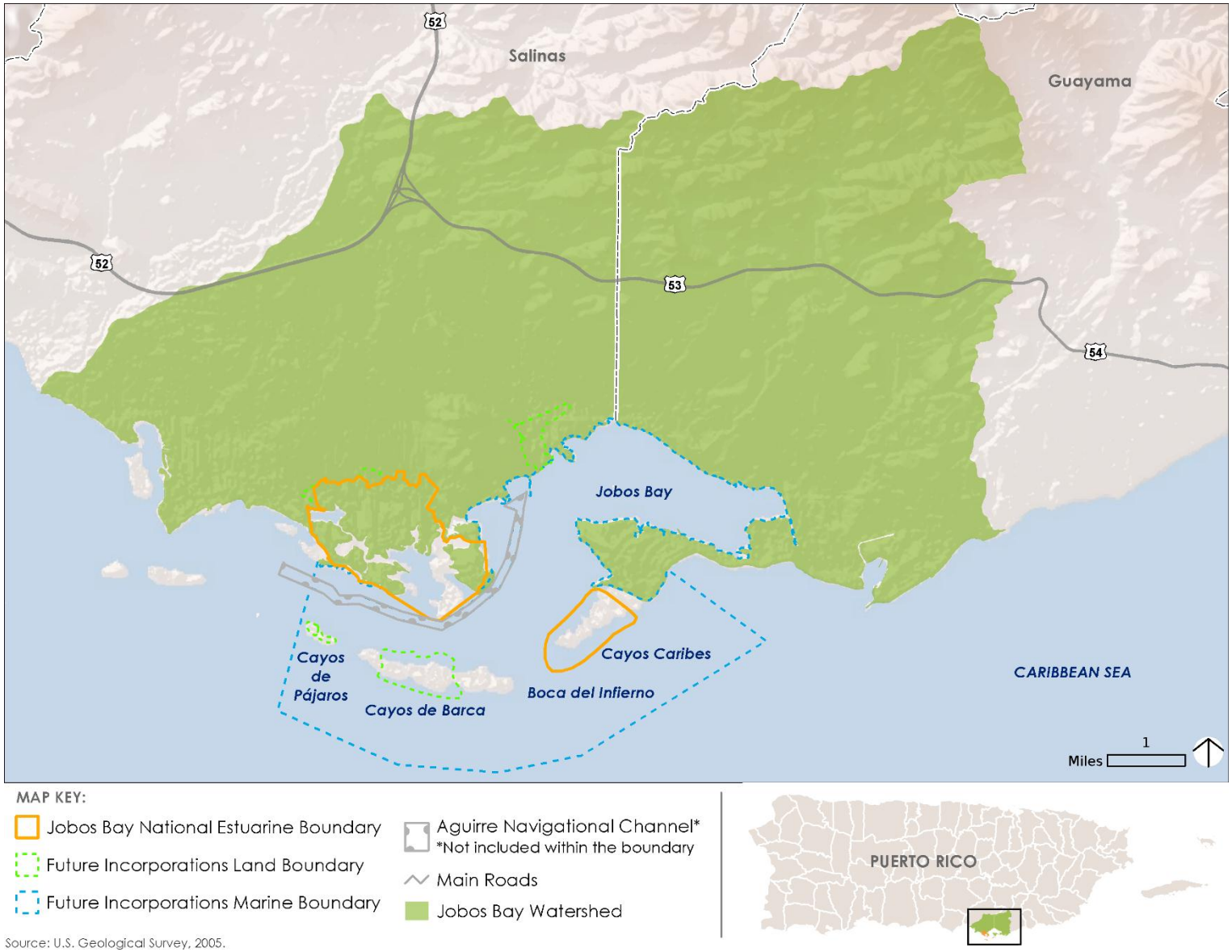
The Jobos Bay watershed covers 137.3 km² (34,000-acre) of the South coastal plain (Whitall, Costa, Bauer, Dieppa & Hile, 2011). The watershed's northern boundary begins in the foothills of the Central Interior Mountain Range and extends about 6 km to 11 km seaward to the shoreline of Jobos Bay. It reaches elevations of greater than 700 m at its landward boundary (Whitall et al., 2011). The watershed is framed by two perennial stream networks; Río Nigua to the West and Río Guamaní to the East. Its altitude ranges from sea level, to approximately 130 ft. above sea level along the northern edge of the foothills (Kuniansky, E. & Rodríguez J, 2010).

Bathymetry

Jobos Bay is a shallow embayment with maximum depths of around 30 ft (10 m). It is a semi-enclosed body of water separated from the open ocean by barrier reefs (Morelock, Bunkley & Acevedo, n.d.). Connection to the open ocean is via a few channels cutting across the barrier reef and mangrove complex of Cayos Caribe, Cayos de Barca, Cayo Morrillo and Cayos de Pájaros (Morelock et al., n.d.).

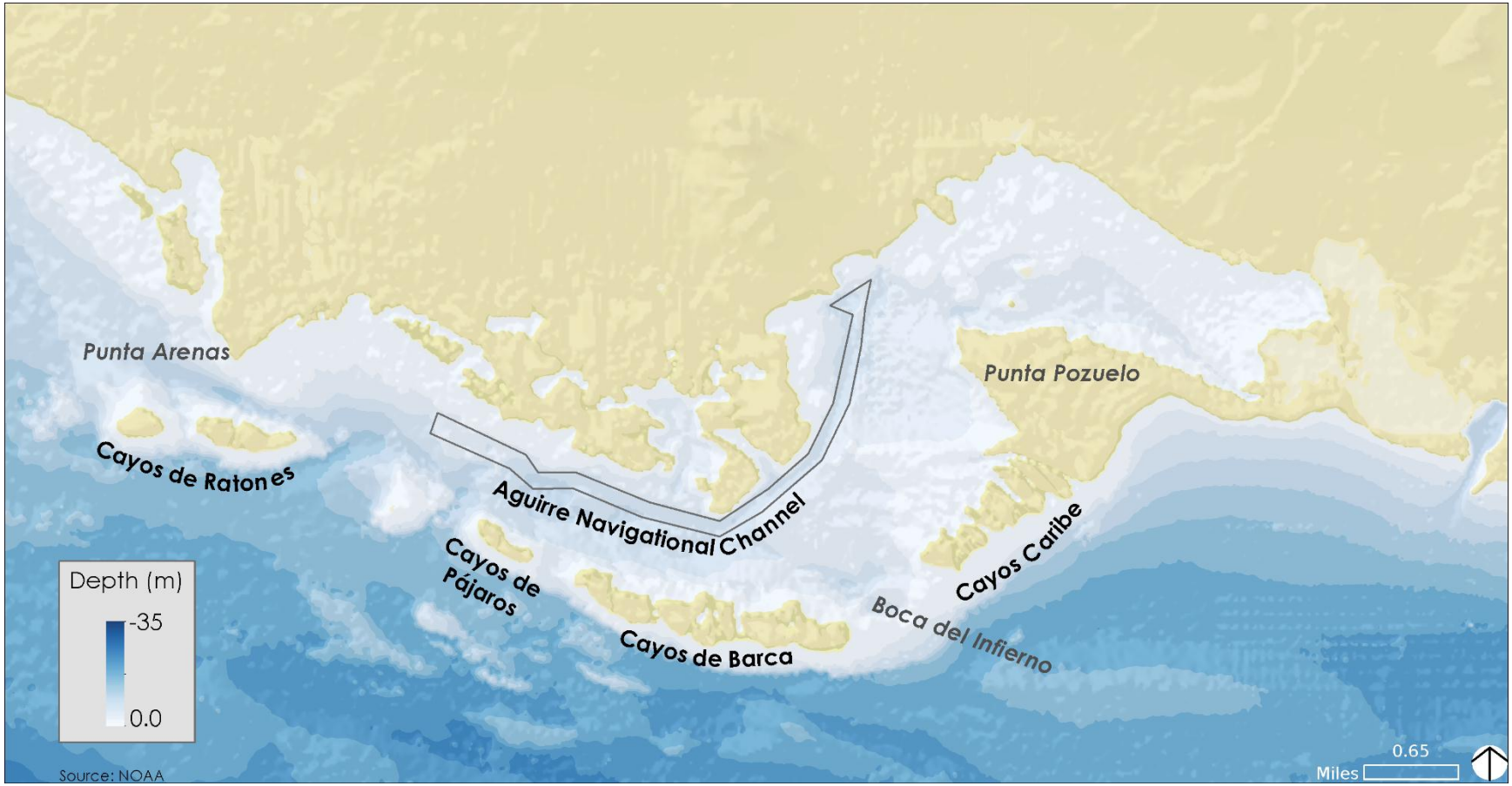
The Aguirre Navigational Channel is the most distinct bottom feature in Jobos Bay, although outside of the Reserve's boundaries. At 30' to 45' (10 m to 15 m) deep, the channel is open to the Caribbean Sea in the west between Cayos de Ratones and Cayos de Pájaros, and runs east until it reaches Central Aguirre (Zitello et al., 2008).

Figure 2. Geography



Source: U.S. Geological Survey, 2005.

Figure 3. Bathymetry of Jobos Bay (Zitello et al. 2008)



Currents

The North Equatorial Current, flowing in a west-northwesterly direction, dominates the entire south coast of Puerto Rico (Laboy, 2009). Surface currents within the Jobos Bay and the tide channel range between 0.1 and 0.6 mph (0.3 and 1.0 km/h) and in a generally west to east direction, with an average value of approximately 0.2 mph (0.3 km/h) observed throughout the year (FERC, 2015). Currents are deflected by the labyrinth of mangrove channels and roots from mangrove trees and speeds are higher within the surge channels.

Tides

Tides at Jobos Bay are mixed, but primarily diurnal, with a mean of approximately 5.5 in (13.7 cm) and range from 6.7 in (17.0 cm) to 14.2 in (36.0 cm) (Lugo et al., 1987). Lowest tides occur early in the year, while the highest water levels occur around October, a period that coincides with higher rainfall water storage in the mangrove forest (Robles et al., 2002).

Geology

Jobos Bay NERR watershed is mostly underlain by 10 to 200 ft. thin fan delta and alluvial deposits that are predominantly Quaternary in age. Deposits within Jobos Bay NERR consist predominantly of swamp, beach and alluvial deposits as depicted in the figure below.

Swamp deposits cover most of the surface of the Reserve. They consist of unconsolidated clay, silt and organic matter. These deposits are covered almost entirely by mangroves. Beaches along the coastal margin consist primarily of carbonate sand derived from nearby fringing reefs. Alluvial plain deposits (Alluvium) dominate the northern part of the Reserve and consist of unconsolidated sand, gravel and pebbles.

Along the coast, the surface of the fan-delta sequence is separated from the Caribbean Sea by a narrow land-marine transition zone of marsh and mangrove swamps, tidal and supratidal salt flats, and beach deposits. In the Jobos Bay area, mangroves, marshes, and tidal flats are mostly restricted to those areas protected by offshore, fringing reefs. Within the marsh and mangrove swamp area, the fan-delta deposits are mostly overlain by organically rich clay deposits.

The cays are composed of sand, gravel, volcanic rock cobble and shell fragments. Beaches along the coastal margin consist primarily of carbonate sand derived from nearby fringing reefs.

Figure 4. Geology

MAP KEY:

- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
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- Aguirre Navigational Channel*
  *Not included within the boundary

Geologic Unit

- Kr Robles Formation
- Qa Alluvium
- Qb Beach Deposits
- Qs Swamp Deposits
- Tra Raspaldo Formation
- N/A Not Available

Source: U.S. Geological Survey, 2005.

Climate and weather

Jobos Bay NERR is on the leeward side of the Island. It lies in the South coastal plain within the Subtropical Dry Forest Zone, characterized by a mean annual rainfall that ranges from a minimum of about 600mm to a maximum of 1,000-1100mm (Ewel and Whitmore, 1973).

The South coastal plain is warmer and drier than the rest of the island. The mountains of the Cordillera Central serve as a barrier to the moisture-laden northeast trade winds. Orographic factors give rise to a zone of low precipitation throughout the entire length of the South coast (Whitall et al., 2011).

Data from NOAA's climatological stations indicate that the 30-year normal precipitation for the period 1991–2010 was about 37.74 inches in the South Coastal and 61.61 inches in the Southern Slopes (Torres & Rodríguez, 2016). The 30-year moving average precipitation for the period 1985–2014 was 37.94 in the South Coast and 61.80 inches in the Southern Slopes. The mean annual precipitation during 2012–2014 was 13 percent below the 30-year moving average for the South Coastal climatological region and 7.7 percent below for the Southern Slopes climatological region (Torres & Rodríguez, 2016).

September and October have been recorded as the wettest months, with an average rainfall of 6.6 inches (167 mm), while January was the driest month, with an average rainfall of 0.8 inches (20 mm). (NCDC, 2010 as cited in Whitall et al., 2011)

Temperature at Jobos Bay NERR shows little seasonal fluctuation. The mean annual temperature is 78.8° F (26° C), with a maximum of 81.6° F (27.5° C) in August and a minimum of 75.7° F (24.3° C) in January (NCDC, 2010, as cited in Whitall et al., 2011).

Trade winds in the Reserve blow regularly (46.8%) from an easterly direction, averaging six to seven knots (7-8 mph) (Laboy, 2009; Whitall et al., 2011). The strongest winds occur in the winter with a slight decrease in strength during the summer (FERC, 2015).

In Puerto Rico rainfall declines significantly during the months of December to April. Drought periods typically begin to be observed during the months of April-May and may be extended until August, due to changes in the regional climate of the Caribbean (Quiñones, 2010). Orographic differences between the basins also cause regional droughts across the island.

Hydrology

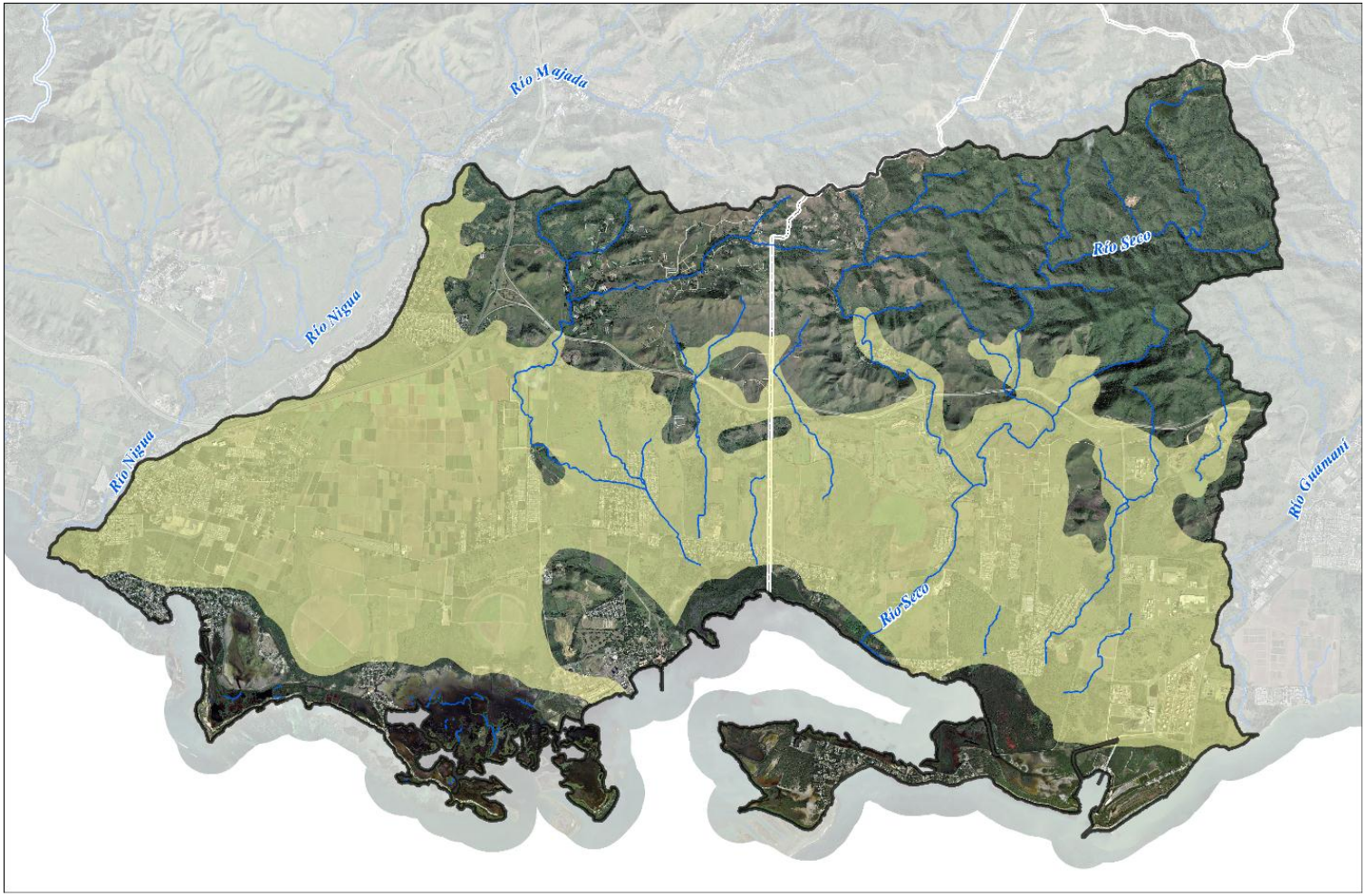
The hydrologic conditions of the area are typical of a semiarid region. The Jobos Bay watershed does not contain one single river network that accumulates surface water flow throughout the basin. This watershed contains a variety of distinct pathways by which surface waters are contributed to Jobos Bay. These include perennial stream discharges, intermittent stream discharges that join and flow directly into the Bay, and diffuse overland runoff (Whitall et al., 2011).

The Río Seco, in the east, is the only major river that discharges seasonally into Jobos Bay through the Reserve (Whitall et al., 2011). Many streams do not reach the coastal systems because they percolate into the aquifer in the upper valley, limiting freshwater inflows to the downstream estuaries.

Groundwater is the main source of freshwater for the Jobos Bay estuary. JBNERR is located along the South Coastal Plain aquifer, which extends from the municipalities of Ponce to Patillas. The source of fresh water to this aquifer resides further up, in the high-rainfall Cordillera Central mountain slopes where the aquifer is unconfined. Freshwater inflow to the mangrove wetlands occurs through groundwater seepage from the shallow aquifer and the adjacent watershed (Quiñones-Aponte and Gómez-Gómez, 1987).

Prior to industrial and urban development, the aquifer was recharged mainly by stream seepage and rainfall. Runoff from heavy rains in the mountains recharged the aquifer by percolation through riverbeds. Irrigation practices, principally for sugar cane cultivation, have resulted in modifications to the natural hydrology. A series of irrigation canals were constructed early in the 20th century to convey surface water to the agricultural areas. The most important irrigation canals in the watershed are the Patillas and Guamaní. The Canal de Patillas conveys water from the Patillas Reservoir, east of the watershed. Water for the Canal de Guamaní is diverted from Carite Reservoir, located in the headwaters of the Río de La Plata on the northern side of the Central Mountain Range, to the Río Guamaní in Guayama in the eastern part of the watershed (Kuniansky & Rodríguez, 2010).

Figure 5. Hydrology



MAP KEY:

Miles 20

Jobos Bay Watershed — Streams and Rivers South Coast Aquifer --- Municipal Boundaries

Source: U.S. Geological Survey, National Geospatial Program.

Groundwater from the South Coast aquifer is the principal source of potable water for towns along the southern coast of the island and also is a primary source of water for agricultural irrigation (Torres & Rodríguez, 2016).

A study conducted by the USGS in cooperation with the PRDNER found that below-average rainfall during 12 years (1986-2004) in conjunction with a general reduction in surface-water irrigation deliveries from Canal de Patillas and Canal Guamaní, have contributed to aquifer storage depletion and reduced water levels in the aquifer. (Kuniansky & Rodríguez, 2010). The replacement of sugarcane cultivation with truck-farm crops, sorghum, and corn, and the concurrent change from furrow to micro irrigation substantially reduced recharge to the aquifer (Kuniansky & Rodríguez, 2010). The study also indicated that if pumpage from the aquifer is not reduced and conditions are slightly drier than average during a given period, then little freshwater discharge to the Mar Negro at JBNEER will occur, and saline water from the estuary may move into the aquifer.

Another study conducted by the USGS in cooperation with the PRDNER, indicated that during 2012–2014: (1) groundwater levels declined as much as 40 feet in the Salinas area and 11 feet in the Guayama area; (2) from 2010 to 2012, groundwater withdrawals for agricultural irrigation increased from 6.0 to 10.5 million gallons per day (mgd) or a 75% rise; and (3) from 2010 to 2014, total groundwater withdrawals decreased from 29.3 to 23.8 mgd (Torres & Rodríguez, 2016). This study indicates that diminished aquifer recharge during 2012 to 2015 and, to a lesser extent, increased groundwater withdrawals have resulted in a reduction in the freshwater saturated thickness of the aquifer, which may affect the availability of freshwater for agriculture and public water supply. A prolonged time period with reduced aquifer recharge may have substantial implications for groundwater levels and fresh groundwater availability.

In addition, when groundwater levels decline, water quality may deteriorate with lateral intrusion of seawater and saline waters near the coast that can migrate toward pumping wells. Groundwater quality data from selected wells indicate small but steadily increasing trends in total dissolved solids concentrations from the 1980s to 2014 in various areas, including Salinas and Guayama (Torres & Rodríguez, 2016). Nitrate concentrations in wells in the coastal plain in the Salinas area ranged from 3.7 to 11.7 mg/L NO_3-N in 2014. Nitrate concentrations in natural ground waters are typically less than 2 mg/L NO_3-N (Mueller et al., 1995, as cited in Torres & Rodríguez, 2016). Elevated concentrations can occur as a result of inorganic fertilizer application, seepage from septic systems, and manure from domestic animal operations (Torres & Rodríguez, 2016).

Biological Resources

Habitats

According to the General Habitat Classification developed for JBNERR in 2012, most of the Reserve is classified under the Estuarine Habitat (subtidal and intertidal) (48%). It is followed by Marine Habitat (39.1%), and palustrine wetlands (11.6%). The figure below shows the Reserve's ecosystems.

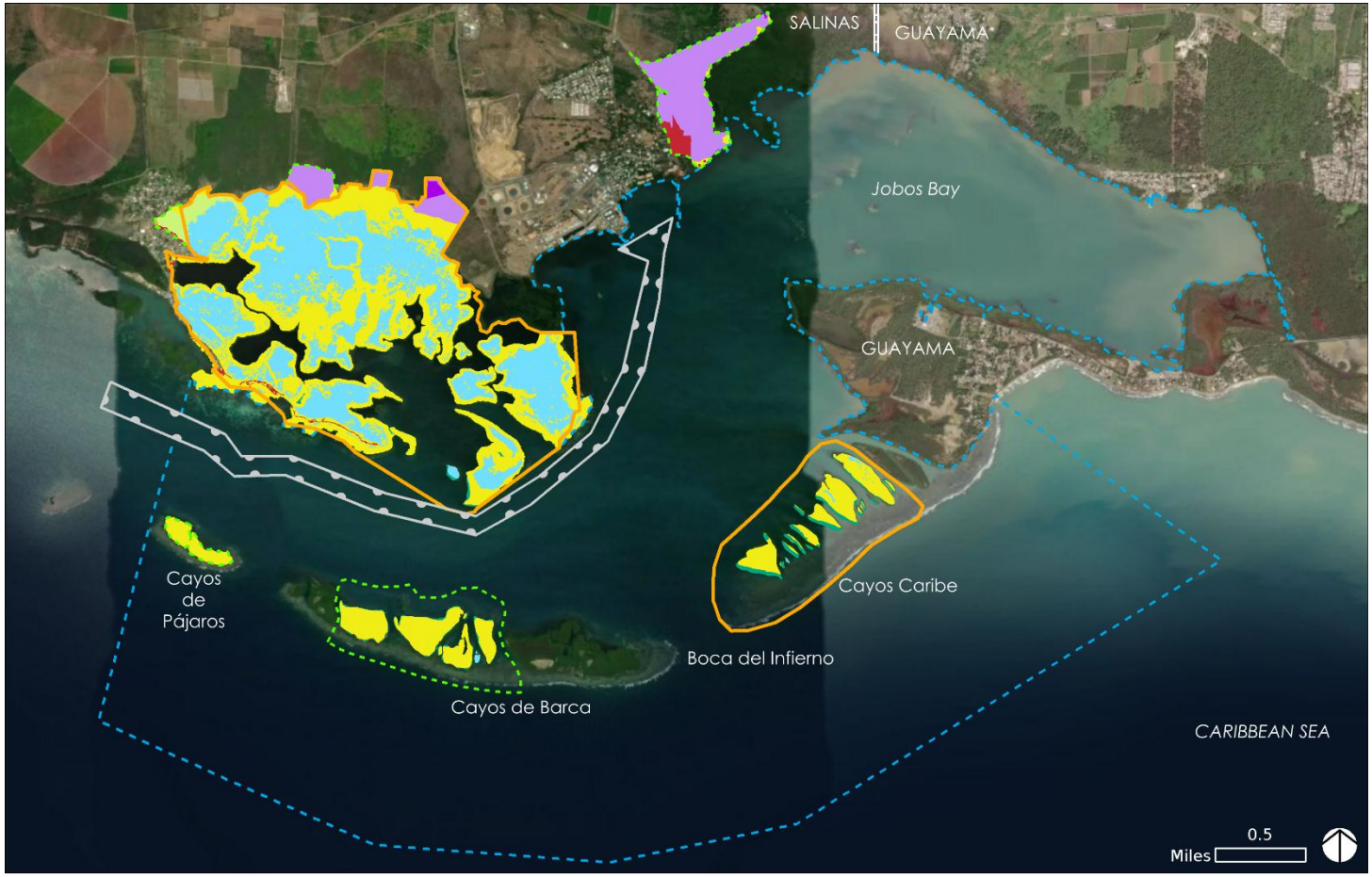
The biggest change in the distribution of these habitats between 2012 and 2002 was the loss of Upland Habitats, which decreased in -90%. The estuarine habitat increased in 42%.

Table 1. Habitat classification in JBNERR

2012		
Habitat	Area m²	%
Cultural Land Cover	81,609	1.3%
Estuarine Habitats	2,999,901	48.0%
Marine Habitats	2,439,168	39.1%
Palustrine Habitats	723,042	11.6%
Upland Habitats	2,440	0.0%
Grand Total	6,246,160	

Source: Puerto Rico Water Resources Environmental Research Institute. (2013). Detailed Land Use and Habitat Inventory, 2012 of the Jobos Bay National Estuarine Research Reserve Watershed

Figure 6. Habitat classification JBNERR 2012



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Detailed Habitats

- Estuarine Habitats, Intertidal Haline
- Estuarine Habitats, Subtidal Haline
- Marine Habitats, Subtidal
- Marine Habitats, Intertidal
- Palustrine Habitats, Intermittent or Saturated
- Palustrine Habitats, Perennial Water
- Upland Habitats, Inland Upland
- Cultural Land Cover, Developed Upland

Source: JBNERR. Puerto Rico Water Resources and Environmental Research Institute (PRWRERI) of the Univesity of Puerto Rico at Mayaguez (UPRM), 2012.

Uplands

Upland vegetation in the Reserve is characteristic of the Subtropical Dry Forest. Gleason and Cook (1927) described the original vegetation types of the area surrounding Jobos Bay NERR as a semi-evergreen seasonal forest type, dominated by *Bucida buceras* (úcar) and *Guazuma ulmifolia* (guácima). Small variations in elevation, hydrology and climate, and pulses from catastrophic events, such as hurricanes, seem to be responsible for the physiographic diversity of the Jobos Bay upland (Laboy, 2009).

More recently, grasslands were described as the most representative community in the upland of Jobos Bay (Laboy, 2009). These consist mostly of the shortgrass type and occur in the sparsely forested savanna of the southern coastal plain.

Littoral woodland on Jobos Bay is represented by more than 220 species of which 26% are trees and the majority are native. Fifty seven species of trees were identified inhabiting the Jobos Bay littoral woodland. The dominant species identified were black olive *(Bucida buceras)* and West Indian elm *(Guazuma ulmifolia)* (Laboy, 2001). Anthropogenic and natural phenomena have continuously disturbed this habitat. Only a single individual of the native milktree *(Plumeria alba)* has been found within the entire Reserve, and Royen's tree cactus *(Pilosocereus royenii)* is rarely found on either Cayo Caribe or Camino del Indio (Laboy, 2009).

In some areas at the Aguirre Unit, the wild tamarind (*Leucaena leucocephala)* is among the most dominant species due to anthropogenic disturbances. In the most seaward area halophytes dominate the zone which is subject to high salt concentrations ranging from average seawater salinity (~35 PSU) to hypersaline conditions (>70 PSU).

In the Mar Negro Unit, toward the mangrove ecotone, the area is dominated by evergreen flora such as wild tamarind, and mesquite (*Prosopis spp*.), although they are not native species, both flowering shrubs-trees provide shelter and food for many bird species. The West Indian elm is found toward the upland area of the forest, as well as the portia tree (*Thespesia populnea*), trumpet tree (*Tabebuia spp.)* and shortleaf fig *(Ficus laevigata)*.

The littoral or coastal scrub (lacustrine habitat) is a dry, mainly evergreen community that sustains a coastal strand with trees like sea grape *(Coccoloba uvifera)*, white cedar *(Tabebuia spp.)*, manchineel *(Hippomane mancinella)*, and gumbo limbo *(Bursera simaruba)*. It resembles the hedge of coastal scrub that develops behind the mangrove edge, trimmed by the wind and salt environment. It may include clumps of pipe organ cactus *(Pilosocereus royenii)*.

Globally, dry forests represent a threatened ecosystem and dry forests in the Caribbean have come under intense pressure from agricultural and urban development (Genet et

al. 2001). Paradoxically, in Jobos Bay the abandonment of sugarcane crops and the increase of urbanization have promoted the maturation of remnant stands of native flora and the proliferation of exotic species (40% of all trees). With many protected and endemic species using this habitat, including neotropical migratory birds and several species of lizards, protection and restoration of dry forest communities is essential.[4] Due to the extreme environmental conditions, natural dry forest regeneration is very slow, and disturbed habitats remain degraded with little wildlife value for very long periods, making protection much more critical.[5]

Estuarine habitats

- **Mangrove Forests**

Mangroves are a dominant biological cover of the JBNERR ecosystem, although during the 1990's hydrological changes in the watershed affected the mangrove forest. Of the 8.3 km^2 area inside the JBNERR boundaries mapped in the Whitall *et al., 2011* study, approximately 41% is colonized by mangroves.

Of the six physiographic types of mangrove forests (Lugo and Snedaker, 1974), three are found in Jobos Bay: basin, fringe and overwash forests (Laboy, 2009).

- Basin forests develop inland and are characterized by slow sheet flows over wide areas of low topographic relief. This forest is normally separated from direct contact with the ocean, except during high tides or storm surges.
- The fringe forest at Jobos Bay shows a salinity gradient from the ocean (35%) to the salt flat (100%) and the basin (Lugo et al., 2007).
- Overwash mangrove forests (mangrove islands) develop offshore over shallow calcareous deposit platforms. These are islands frequently inundated or washed over by tides, resulting in high rates of organic matter. They usually contain red mangroves.

Four species of mangroves are found within Jobos Bay NERR; red mangrove, black mangrove, white mangrove, and buttonwood mangrove. The majority of the shoreline in the Jobos Bay is dominated by red mangrove. This species is the most water-tolerant of the four mangrove species and borders all of Jobos Bay's undisturbed shoreline. It represents the transition between the bay and the upland (Zitello et al., 2008).

The rich protected substrate provides habitat for a large variety of organisms, which in turn serve as the food base for the marine environment. Many commercially and recreationally important finfish and shellfish spend a portion of their life cycles in this nursery habitat. Mangroves also provide nesting sites for both native and migratory

[4] (http://www.fws.gov/southeast/partners/StateFactSheets/Caribbean_longv.pdf
[5] (http://www.fws.gov/southeast/partners/StateFactSheets/Caribbean_longv.pdf

birds. Mangroves support higher fish densities and biomass than unconsolidated sediments. Snappers, grunts, schoolmasters are most abundant in mangroves and nearshore environments (Whitall et al., 2011). Mar Negro mangroves also provides habitat for the endangered yellow-shouldered black bird (*Agelaius xanthomus*).

- ***Salt Flats***

Hyper saline lagoons and salt flats occur inland from the mangrove forests, and border the Reserve's western boundary north of Mar Negro (Field et al., 2008). They are formed as a result of reduced inland runoff, limited tidal flushing, and high evaporation rates and reduced rainfall.

The area experiences water exchange during spring tides. During this period, salt crystals accumulate and leave particular conditions including hypersaline regimes that reach over 100 PSU. High organic matter transported to the area during this time also results in low oxygen in the sediments, and consequently inhibits most of the plant growth.

Vegetation is limited mostly to the black mangrove that in turn struggles with such high concentrations of salts. Where additional vegetation does exist, it is dominated by salt-tolerant species, such as saltwort *(Batis maritima)* and sea purselane *(Sesuvium portulacastrum)*, which have thick fleshy leaves adapted for water storage. Generally, these species are not intermixed. Sea purselane prefers drier soils and typically grows on higher ground, while saltwort is often found in wetter substrates, like those associated with the mangrove fringe forests. Both saltwort and sea-purslane are low shrubs that stabilize the soil, thereby preventing erosion.

Among the faunal species, birds such sandpipers, great egrets, blue herons among other duck migratory species can be observed during drought periods. Arthropods such the land crab and the fiddler crab can be found in the area and at their larval stage, they provide a food source for birds.

- ***Mud Flats***

Mudflats are important soft-bottom littoral systems formed inland from the mangrove forest as a result of reduced water runoff, higher evaporation rates, and drought (Laboy, 2009). Mudflats are exposed at low tide and contain considerable quantities of detritus, a mixture of sand, mud, and plant and animal remains. The moist humid bottom supports bacteria, fungi, diatoms and a spectrum of marine animals, including clams, worms and nematodes, from ¼" (2-3 mm) below the surface of the mud flat, sometimes to more than 3 ft (1 m) down. These mud flats are especially important forage areas for wading birds and shorebirds.

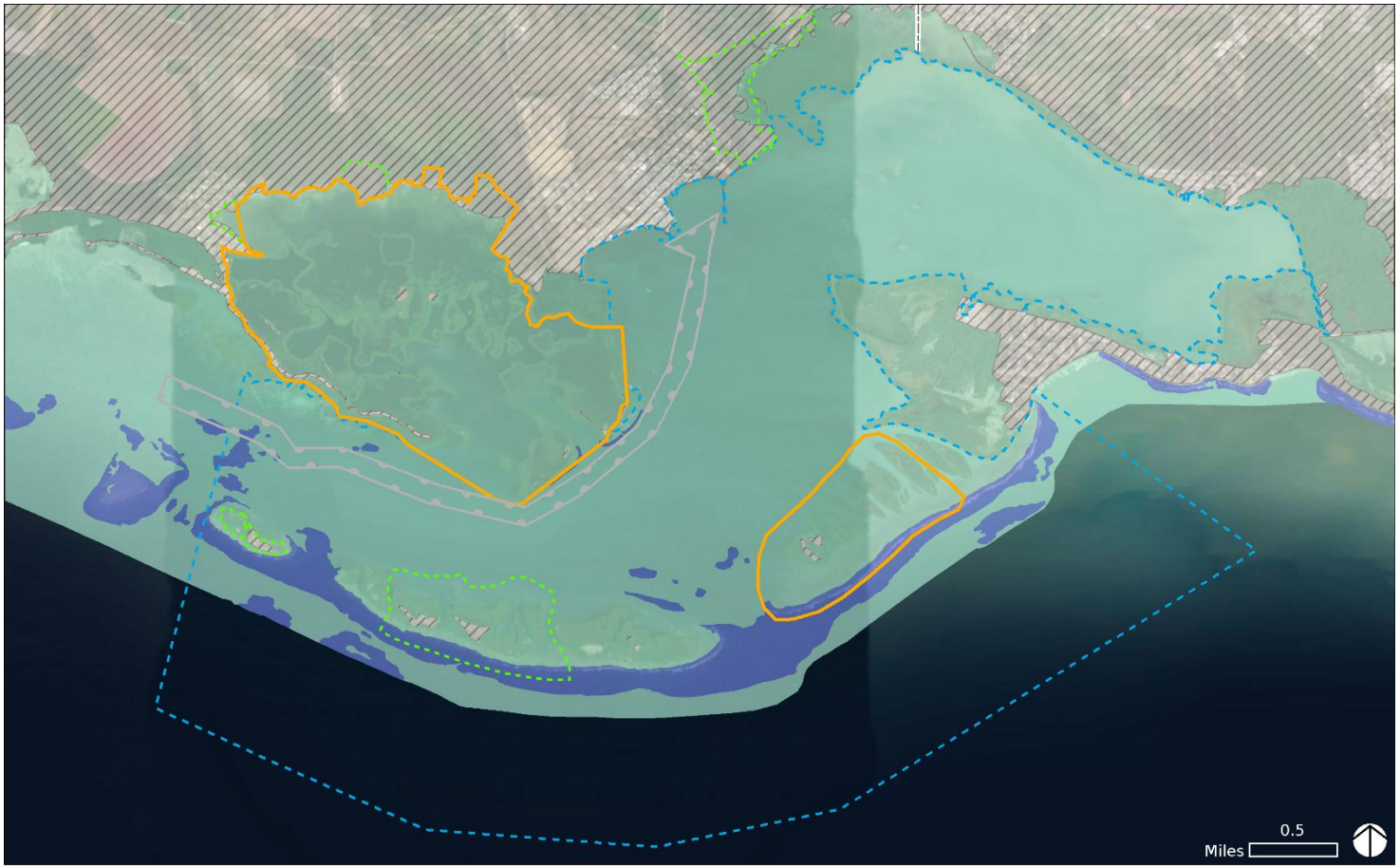
Mud flats are the least-studied community in Jobos Bay NERR. A detailed analysis of aerial photographs from 1937 and 2004, revealed that the surface area of mud flats is increasing behind the mangrove fringes of Jobos Bay, particularly in Mar Negro and Punta Pozuelo (Laboy, 2009).

Marine Habitats

According to Whitall et al., 2011, the unconsolidated sediments in the Jobos Bay are colonized most commonly by Seagrass (31%), followed by No Cover (28%), and Algae (20%). Percent live coral cover was <10% for 95% of the mapped area, while the remainder was mapped as 10% ≤ 50%.

Unconsolidated sediments refers to an area on the seafloor consisting of small particles (<0.25 m) with less than 50% cover of large stable substrate. Fish abundance and biomass are variable but generally low compared to the other habitats. Groupers, Hamlets and Seabasses (*Serranidae*) mean density is higher on unconsolidated sediment. The unconsolidated sediments stratum comprised seagrasses and macroalgal beds, as well as uncolonized sand and mud (Whitall et al., 2011).

Figure 7. Major benthic structure



MAP KEY:

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- Future Incorporations Marine Boundary
- Aguirre Navigational Channel*
  *Not included within the boundary

Benthic Habitats: Major Structure

- Coral Reef and Hardbottom
- Unconsolidated Sediment
- Other Delineations

Source: NOAA/NOS/NCCOS/CCMA Biogeography Branch, 2010. CEAP.

- ***Algae***

Coral reef and hardbottom comprised around 7% of the area surveyed by Whitall et al., 2011. On hardbottom, turf algae accounted for the highest overall mean percent cover, followed by macroalgae, hard coral, sponges, and gorgonians and zoanthids. Other algae groups included crustose coralline algae, cyanobacteria and filamentous algae and rhodoliths (Whitall et al., 2011). From the 8.3 km^2 area inside the JBNERR boundaries mapped in the mentioned study, approximately 5 % is colonized by algae, as a biological cover. This included any combination of numerous species of red, green, or brown algae, and may be turf, fleshy, or filamentous species.

Green algae *(*Chlorophyta*)* grow in stressful environments where nutrients are high and herbivory low. Other species of algae are calcified (e.g. *Halimeda* spp.) and contribute heavily to the sandy sediments of reef areas. Brown algae *(*Phaeophyta*)* may range in color from beige to almost black, however, their abundance and diversity in tropical seas is lower. Some of the most common tropical genera include *Sargassum* and *Turbinaria* which are often associated with reef flats, and *Lobophora* which is fairly ubiquitous.

The red algae *(*Rhodophyta*)* are the largest and most diverse group. Red algae are extremely important reef-building organisms, which may form reef crests (e.g. *Lithophyllum* spp.) and large calcareous plates (*Sporolithon spp*.).

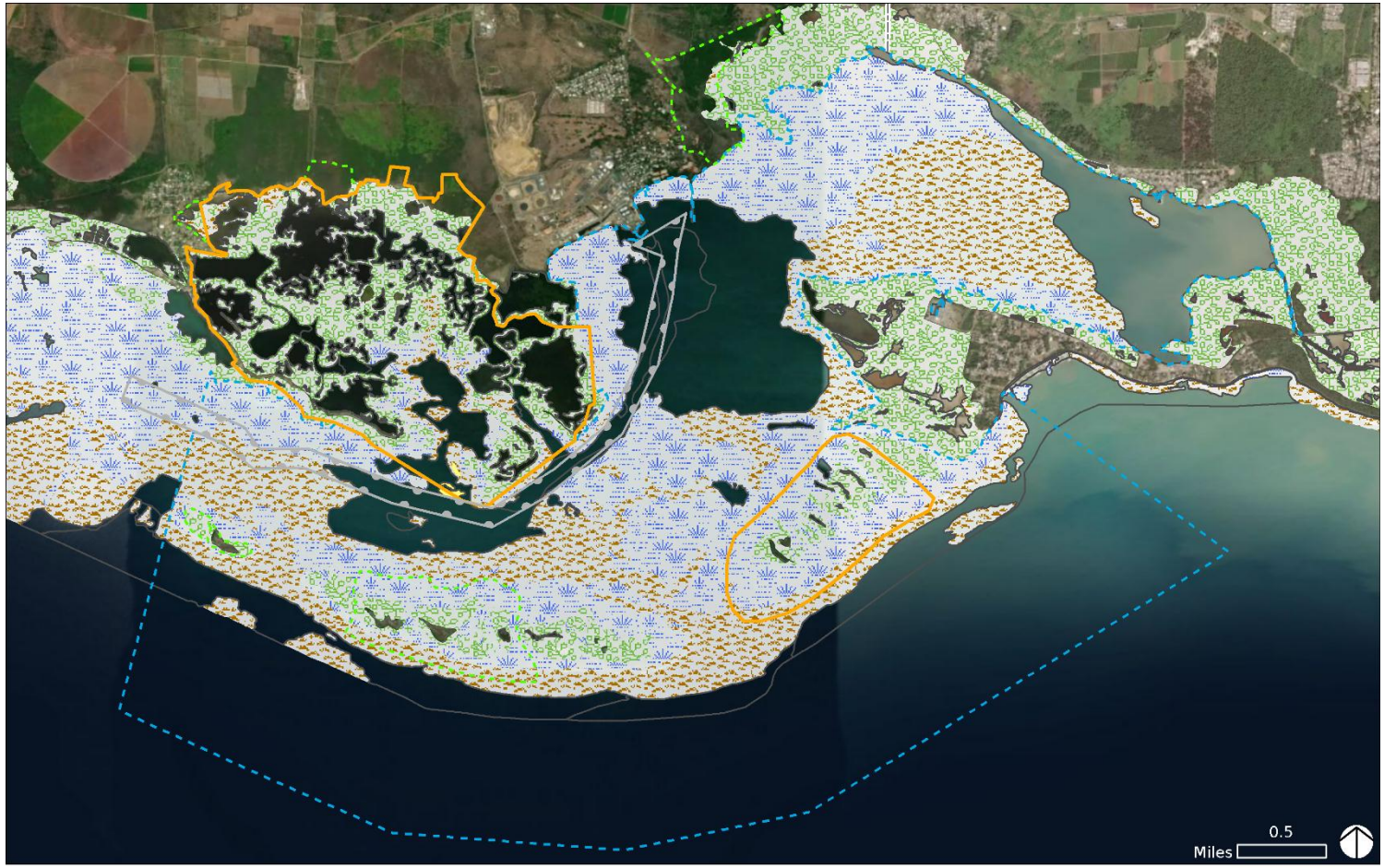
- ***Seagrass***

From the 8.3 km^2 area inside the JBNERR boundaries mapped by Whitall et al., 2011, approximately 18 % is colonized by seagrass, as a biological cover. Seagrasses provide food and shelter to commercial and recreational fishery species as well as invertebrates, and birds (FERC, 2015). Seagrasses also reduce wave and current action and improve water clarity and quality.

Seagrass is present primarily within Jobos Bay across unconsolidated sediment habitat. Four types of seagrasses have been observed in Jobos Bay: Turtle grass (*Thalassia testudinum*) accounted for the highest mean percent cover on unconsolidated sediments, followed by paddle grass (*Halophila decipiens*), manatee grass (*Syringodium filiforme*), and shoal grass (*Halodule wrightii)* (Whitall et al., 2011).

The presence of seagrass is limited to locations where there is an adequate amount of sunlight to support photosynthesis (Zitello et al 2008). Areas immediately east of Punta Arenas experienced some loss and regrowth of seagrass between 1999 and 2007 (Whitall et al., 2011).

Figure 8. Benthic Habitat: Major Cover



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Benthic Habitats: Major Cover

- Algae
- Mangrove
- Seagrass
- No Cover
- Unknown

Source: NOAA/NOS/NCCOS/CCMA Biogeography Branch, 2010. CEAP.

- ***Coral Reefs***

Coral reefs, in conjunction with mangroves and seagrass beds, form one of the most complex, diverse and productive marine communities in the world. Most of Jobos Bay's coral reefs are linear in formation, running along cays encircling the central bay (García-Sais et al., 2003).

Whitall et al., 2011, reported that Individual Patch Reefs, Aggregated Patch Reefs and Aggregate Reef comprised 3.1% of the total mapped area: sea floor and intertidal shoreline in and around JBNERR. These constituted 3.5% of the mapped area outside JBNERR, and 0.1% of the mapped area inside the JBNERR. In this baseline assessment, in terms of coral cover, the majority (>94%) of the areas inside and outside JBNERR were colonized by 0%≤10% live scleractinian and/or soft corals. However, the mapped area outside the JBNERR had 2.46 km^2 of sea floor with 10%≤50% live coral.

Hard coral cover averaged 6.5%, with higher amounts occurring on aggregate reef on the fore reef adjacent to the cays. The most abundant coral was mustard hill coral (*Porites astreoides)*, followed by massive starlet coral (*Siderastrea sidereal)*, great star coral *(Orbicella cavernosa)*, and the boulder star coral (*Orbicella annularis)* complex (Whitall et al., 2011).

According to Laboy (2009), bladed fire coral *(Millepora complanata)* and the elkhorn coral (*Acropora palmata*) were the dominant coral species in this area. However, neither *Acropora palmata* (elkhorn coral) or *Acropora cervicornis* (staghorn coral), both of which are listed as threatened under the Endangered Species Act (ESA), were observed, according to Whitall et al., 2011.

Elkhorn coral and staghorn coral, were observed at two sites along the fore reef of Cayos Caribe. The presence of *Acropora* rubble at several locations observed during a study by García-Sais et al., 2003 is additional evidence of their former abundance (Whitall et al. 2011).

Sedimentation, thermal and chemical pollution, and mechanical damage due to anchoring and overfishing are the main factors that have almost exterminated the coral reefs in the Mid Bay zone of the Jobos Bay (Laboy, 2009). Recent hurricanes have broken massive pieces of the typical surf zone corals. Extreme flooding discharges from Río Seco, Río Melanía and Río Guamaní, associated to abnormal rainfall, seems to have lowered the physiological limits for transparency and salinity that corals can tolerate, producing an extended mass mortality, similar to that reported by Laboy-Nieves and Conde, 2001 (Laboy, 2009).

In addition, JBNERR has been subject to region-wide stresses that have affected the wider Caribbean in the last few decades, including a widespread die-off of *D.*

antillarum in the 1980s, mass *Acropora* species mortality due to white band disease, and coral bleaching (Whitall et al., 2011). All of these factors have led to a significant reduction in live coral cover.

Fauna

- **Invertebrates**

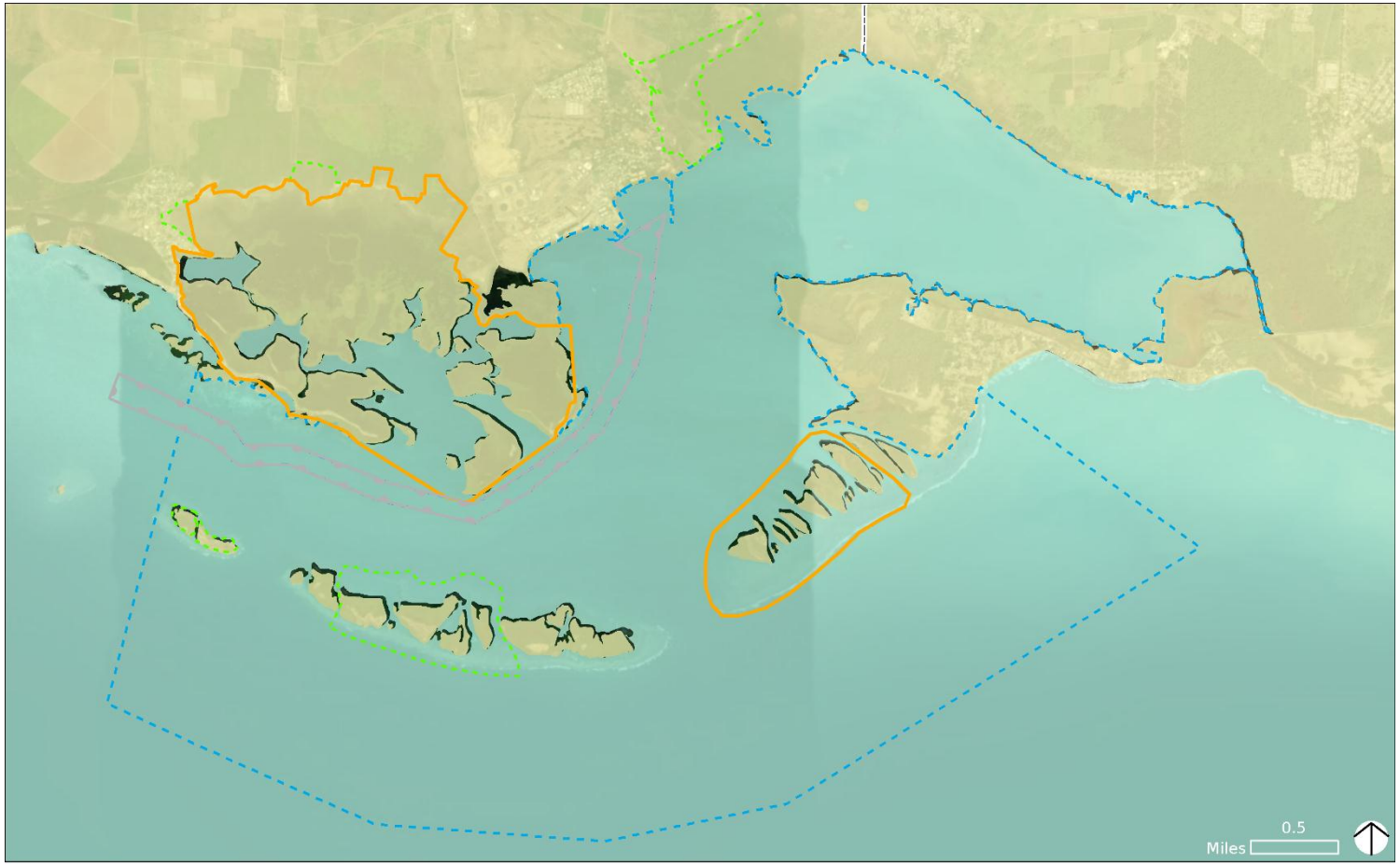
Jobos Bay is enriched by a wide variety of endemic, native, migrant and exotic species. Associated with the submerged prop roots of the red mangrove is a rich epibiota. Competition for space on these roots is high (Kolehmainen, 1972). Among the most abundant groups are oysters, tunicates, sponges, crustaceans, cnidarians, and algae (Laboy, 2009). In 2001, Laboy reported 16 species of holothurians. Crustaceans (brachyuran larvae, amphipods and copepods), tunicates and gastropod larvae compose most of the zooplankton in Jobos Bay (PRWRA, 1972).

Mangroves are commonly inhabited by snails (*Melampus coffeus*), termites (*Coptotermes brevis*) and bees (*Apis melliphera*). The littoral woodland shows more biodiversity. Among the most conspicuous invertebrates are black tarantula (*Avicularia laeta*), hairy spider (*Cyrtopholis portoricae*), giant millipede (*Orthocricus arboreus*), centipede (*Scolopendra alternans*), giant ant (*Odontomachus raematoda*), black butterfly (*Calisto nubila*) and ground wasp (*Stictia signata*) (Laboy, 2009).

Two threatened coral species inhabit the marine waters adjacent to the Reserve. They belong to the *Acropora* genus: elkhorn coral (*A. palmata)* and the staghorn coral (*A. cervicornis)*. Neither *A. palmata* or *A. cervicornis,* both of which are listed as threatened under the Endangered Species Act (ESA), were observed in any survey managed by NOAA in 2011; however *A. palmata* and *A. cervicornis* were observed outside survey quadrats at one and two sites, respectively.

Critical habitat for *A. palmata* and *A. cervicornis* has been designated and includes marine areas around Puerto Rico with suitable requirements for these to thrive (e.g. heavy surf, clear-low nutrient ocean-water salinity conditions).

Figure 9. Critical habitats



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Critial Habitats

- Yellow Shouldered Blackbird
- Elkhorn & Staghorn Coral

Source: NOAA National Marine Fisheries Service, 2008. USFWS ECOS, 2016.

- **Vertebrates**

Because of the predominantly saline and xeric environmental conditions, few amphibians inhabit Jobos Bay, compared to the rest of the Island. The dominant species identified by Laboy, 2001 are two tree frogs (*Eleutherodactylus antillensis* and *E. coqui*), a toad (*Bufo marinus*) and the white-lipped frog (*Leptodactylus albilabris*).

Among the reptiles are the endemic garden snake (*Alsophis portoricensis*) and the snapping turtle (*Pseudemys terrapen*), that share the land habitat in Jobos Bay with 11 lizards. Other include the teiid (*Ameiva exsul*), anoles (*Anolis cristatelus, A. poncencis*, *A. pulchellus*, and *A. stratulus*), two geckos (*Hemidactylus brooki* and *Phyllodactylus wirshingi*), worm lizard (*Amphisbaena caeca)*, the exotic green iguana (*Iguana iguana*), and two dwarf geckos (*Sphaerodactylus macrolepis* and *S. nicholsi*).

Three federally listed species of reptiles have been documented in the Reserve and Jobos Bay: one threatened, green sea turtle (*Chelonia mydas*); and two endangered, leatherback sea turtle (*Dermochelys coriacea)* and hawksbill sea turtle (*Eretmochelys imbricata)*.

The suite of aquatic habitats provides for a diversity of fish species. In the survey conducted by Whitall et al., 2011, the fish community consisted of 34 taxonomic families and 112 species. The fish community varied by habitat type. Wrasses and damselfishes were most numerically abundant on hardbottom, whereas surgeon-fishes, parrotfishes, and snappers accounted for the highest proportion of biomass. Large schools of clupeiids, which were absent in other habitats, were present at several mangrove sites. Fish abundance and biomass in unconsolidated sediments were variable, but generally low compared to the other habitats. Overall, groupers (*Cephalopholis* and *Epinephelus* spp.) were infrequent across the study area and generally small in size. The majority of observed snappers were also juveniles.

The Reserve also provides an important habitat for the nurse shark (*Ginglymostoma cirratum*). Jobos Bay NERR is host of one of the few reproduction sites for the nurse shark in Puerto Rico. This species has been observed arriving to the Reserve during the summer to a specific area in the eastern coastal waters of Mar Negro Unit. This species is often found on rocky and coral reefs, in channels between mangrove keys and on sand flats (FAO, 2001), making Jobos Bay an excellent habitat.

Only six species of mammals inhabit the Jobos Bay upland. These are the fruit bat (*Artibeus jamaicencis*), fishing bat (*Noctilio leporinus*), mongoose (*Herpestes javanicus*), house bat (*Molosus molosus*), mice (*Mus musculus*), and rat (*Rattus norvegicus*). Cats, dogs, pigs and goats also roam in the upland of Jobos (Laboy, 2009).

One federally endangered species of marine mammal, the Antillean manatee (*Trichechus manatus manatus*), frequently forages in the seagrass beds of Jobos Bay. The most recent available count of Antillean manatees in Puerto Rico is 142 animals, based on the January 2013 complete island-wide aerial survey (USFWS, 2014). According to the USFWS Stock Assessments Reports, the Antillean manatee population in Puerto Rico is considered, at least, stable. Jobos Bay is one of four areas in Puerto Rico with relatively higher concentrations of manatees (USFWS, 2014). The reason for which manatees prefer this area is unknown and needs to be addressed, but it is evident that the conservation of this ecosystem is critical for the conservation and survival of the species.

The bottlenose dolphin (*Tursiops truncatus*), is another marine mammal that has been documented in the area.

1. Antillean manatee in the Mar Negro Unit 2. Bottlenose dolphin 3. Nurse shark
Source: Jobos Bay NERR staff

Birds are the most prominent vertebrate fauna in Jobos Bay (Laboy, 2009). In fact, JBNERR is an Important Bird Area (IBAPR-013), according to Bird Life International.[6] The relatively undisturbed mangrove system of Jobos Bay NERR makes it an important area for pelicans, herons, shorebirds and waterfowl, with a total of 87 bird species identified in Jobos Bay.

There are two federally endangered bird species found in JBNERR: the Puerto Rican plain pigeon *(Columba inornata wetmorei*) and the yellow-shouldered blackbird. Both are endemic. The yellow-shouldered black bird (*Agelaius xanthomus*) is often found in coastal dry forests and forested coastal wetlands.[7] It has been documented in the Mar Negro mangroves.

The following table presents listed species present in Jobos Bay NERR that are protected under the Endangered Species Act and the New Wildlife Act of Puerto Rico, Law Num.

[6] See: http://www.birdlife.org/datazone/sitefactsheet.php?id=19902
[7] Other habitat types include the Tabonuco and secondary wet forest; Non-calcareous moist forest; Dry limestone forest and serpentine forest and Non-calcareous lowland.

241 of 1999, as amended, and the PRDNER Regulation Num. 6766. There is a total of 14 federally listed species that has been identified in the Jobos Bay NERR and its surrounding waters.

Table 2. Federal and Commonwealth listed Species in the Jobos Bay NERR and future incorporations

	Common Name (English)	Common Name (Spanish)	Scientific Name	Federal Status	Local Status
1	Puerto Rican plain pigeon	paloma sabanera	*Columba inornata wetmorei*	E	E
2	Roseate tern	palometa	*Sterna dougallii*	T	V
3	Yellow-shouldered blackbird	mariquita	*Agelaius xanthomus*	E	E
4	Hawksbill sea turtle	carey	*Eretmochelys imbricata*	E	E
5	Green sea turtle	tortuga verde	*Chelonia mydas*	T	E
6	Leatherback sea turtle	tinglar	*Dermochelys coriacea*	E	E
7	Antillean manatee	manatí Antillano	*Trichechus manatus manatus*	E	E
8	Elkhorn coral	coral cuerno de alce	*Acropora palmata*	T	T, CH
9	Staghorn coral	coral cuerno de ciervo	*Acropora cervicornis*	T, CH	T, CH
10	Lobed star coral	coral estrella	*Orbicella annularis*	T	T
11	Pillar coral	Coral pilar	*Dendrogyra cylindrus*	T	T
12	Rough cactus	Coral cactus áspero	*Mycetophyllia ferox*	T	T
13	Mountainous star coral	Coral estrella laminar	*Orbicella faveolata*	T	T
14	Knobby star coral	Coral estrella masivo	*Orbicella franksi*	T	T

E=Endangered T=Threatened CH= Critical Habitat NL= Not Listed V =Vulnerable
Sources: PRDNER 2009, NOAA, 2011, and USFWS, 2014. FERC. (2015). Benthic Resources Mitigation Plan, prepared by Tetra Tech (2014) in the Final Environmental Impact Statement. Vol II.

Social attributes

The Jobos Bay watershed covers large areas of five wards in the municipality of Salinas and four wards in the municipality of Guayama.

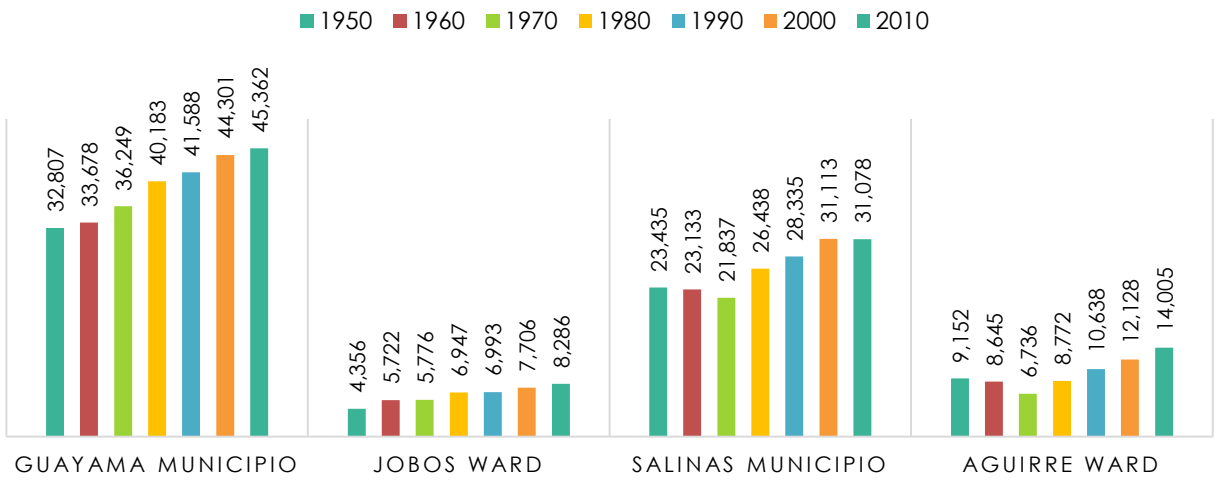
To describe the population demographics of the watershed, the 2014 American Community Survey (ACS) was used, since this is the most recent US Census Bureau data available. Other data sources used are cited in the discussion.

Population

The municipality of Salinas has a population of 30,506 inhabitants and Guayama 44,261. The watershed has a population of 30,811 which constitutes approximately 41% of the population of both municipalities.

44.3% of the Salinas population lives in Aguirre, while 17.0% of the Guayama's population lives in Jobos. During the past decades, the population in Guayama and Jobos continuously increased. In Salinas and Aguirre the population had fluctuations, possibly as a result of changes in the sugar industry. Overall, the 2010 Census reported an increase in the population of these areas.

Chart 1. Population 1950-2010



Source: US Census Bureau. Puerto Rico Census 1950-2010 and Puerto Rico Planning Board. Social and Economic Planning Program, Census Office.

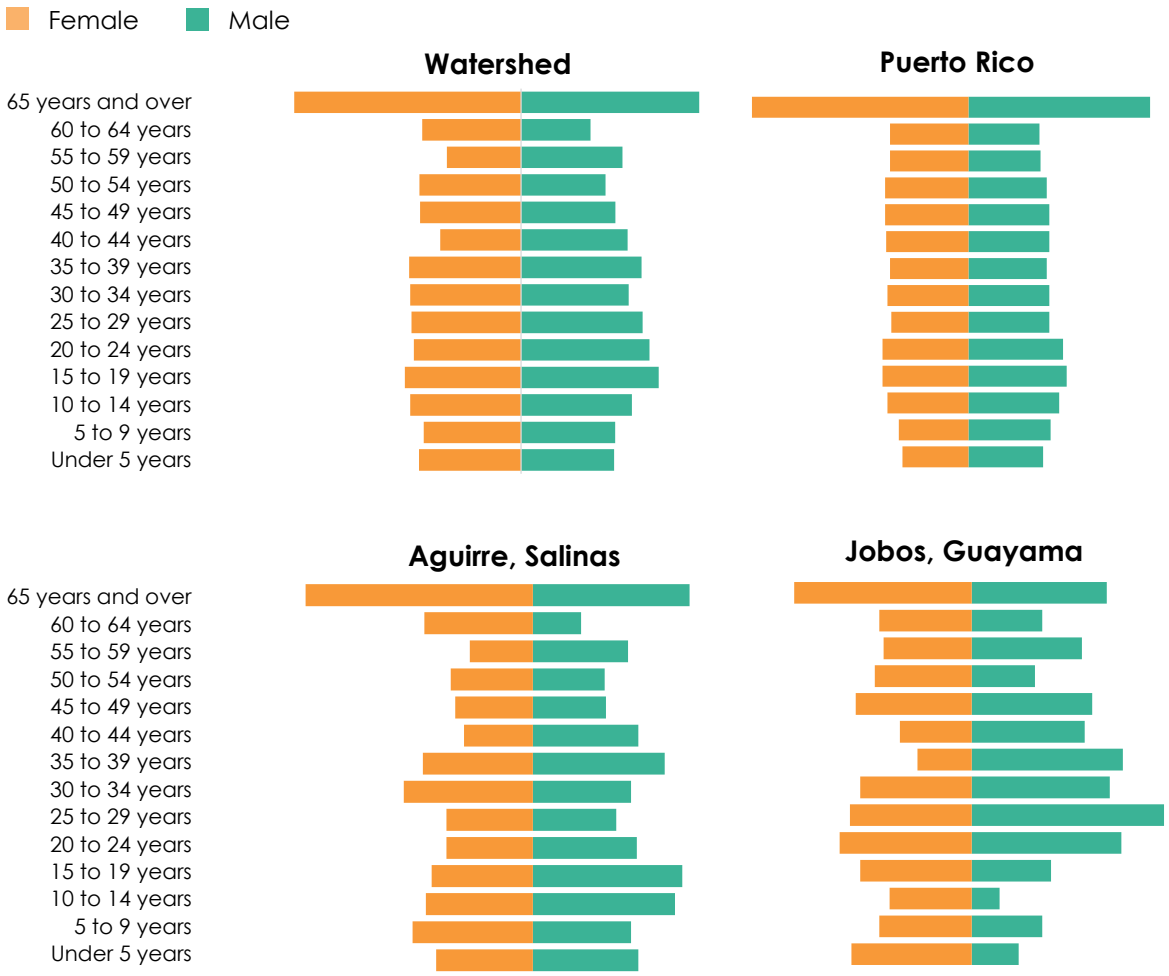
The population density of the watershed is 225 inhabitant per km^2, greater than the one estimated for Salinas.

Population age and sex

The median age for the watershed's population is 36 years, with women having a slightly higher median age (37.8) than men (34.7). The gender ratio of the watershed is balanced, with the population divided evenly between female (50%) and male (50%).

The population distribution by age and sex in the watershed suggests a reduction in the number of children and a marked aging of the population: in other words, the population is growing very slowly. The following figure presents a comparison of the population distribution by age and sex in the watershed, as well as Jobos and Aguirre wards. This has implications on education strategies and access, among other aspects of management.

Chart 2. Population distribution by age and sex



Source: ACS 2014: 5 year estimates.

Education level

In the watershed, the majority of the population (67%) has a high-school degree or higher, with 16% having obtained a bachelor's degree or higher. However, 20% of the population did not reach the 9th grade.

According to the SocMon conducted for the Reserve in 2009, the school dropout rate is high in the watershed (CIEL, 2009).

Households and families

There are about 10,500 households in the watershed, and the median household income is $16,323 per year. There are 7497 families in the watershed, of which 54.1% lives under poverty level, above the average for Puerto Rico (41.3%).

Jobs and employment trends

Within the watershed, 61% of the population is not in the labor force. This includes all people 16 years old and over who are students, housewives, retired workers and seasonal workers who are not looking for work, institutionalized people, and people who are doing only incidental unpaid family work. 39% of the population in the watershed is in the labor force. This population is classified as employed or unemployed but actively looking for work and available to accept a job. Of these, only 33% are employed and the estimated unemployment rate for the watershed is at 6% (unemployment rate in Salinas is 16.1% and Guayama is 20%, according to the 2014 ACS).

The wards of Jobos and Aguirre have significantly higher unemployment rates, at 16.8% and 14.8% respectively, though still below the average for Puerto Rico, at 18.3%.

Table 3. Summary of selected socioeconomic characteristics for the watershed

Population	**Total Population**	**30,811**
	Population Density	225.2 persons /km^2
	Median Age	36.2
	Median Age Male	34.7
	Median Age Female	37.8
	Male Population	15,369
	Female Population	15,442
	% Male Population	50%
	% Female Population	50%
Households and families	Households	10,537
	Median Household Income	16,323
	Families	7,497
	% Families below poverty level	54.1%
Education level for the population 25yr or more	Total population equal to or greater than 25 years of age	19,890
	Less than 9th grade	20%
	9th to 12th grade, no diploma	13%
	High school graduate (includes equivalency)	33%
	Some college, no degree	11%
	Associate's degree	8%
	Bachelor's degree	12%
	Graduate or professional degree	4%
	Percent high school graduate or higher	67%
	Percent bachelor's degree or higher	16%
Employment	Population 16 years of age or greater	24,302
	In the labor force	39%
	Employed	33%
	Unemployment rate	6%

Source: ACS 2014: 5 year estimates.

There are 13 coastal communities neighboring the Reserve: Las Mareas, Aguirre, Central Aguirre, Montesoria, Hacienda Vieja, López, Mosquito, Comunidad Chun Chin, Sector el Pescao, Sector Mosquito, Comunidad Puerto de Jobos, and Comunidad Pozuelo. There are additional communities dependent on Reserve resources within the Jobos Bay watershed, as presented in the following figure.

The Reserve and its associated ecosystems are important as a source of income for the local fishermen, restaurants and local small businesses. Although commercial fishing is an important activity in Jobos Bay and offshore waters, there's not enough specific information for this area. A spatial characterization of Puerto Rican commercial fisheries conducted in 2011, indicated that the South coast of Puerto Rico, which includes the municipalities of Guayama and Salinas, is the second most populated in terms of *villas pesqueras* (fishing villages), with twenty (20) *villas* amounting to approximately 27% of the total in Puerto Rico (Koeneke, 2011).

The study concluded that fishers choose the gear type on the basis of target species, whose habitats are depth correlated. Between Salinas and Guayama, there was an abundance of traps for fish and lobsters (Koeneke, 2011). This type of gear was more common in this area than in any other area in Puerto Rico. However, other gear were also commonly used by fishers along the South coast, including fish trammel nets, vertical longline with buoys, fishing grounds for the other trolling gear, gillnets, SCUBA and nets (Koeneke, 2011).

A study published in 2013, also found that Reserve is of social, cultural, and economic significance in the daily lives of neighboring communities (García et al., 2013). The study was conducted to explore the relationships between the use of coastal resources and the well-being and quality of life of people living along the coast of Southeastern Puerto Rico. [8]

[8] Based on an extensive, three year-long research project conducted by García et al., funded by the University of Puerto Rico Sea Grant Program. The study, published in 2013, includes communities located in the JBNERR region, specifically the communities of Pozuelo, Jobos, and surroundings in Guayama, and Playa, Playita, Aguirre and surroundings in Salinas. The study included extensive field research and analysis, including ethnographic field work, cultural mapping, interviews, workshops and meetings, among other methods.

Figure 10. Jobos Bay and Surrounding Communities

ID	Nombre	ID	Nombre
	COMMUNITIES	44	Villas de Lanusse
1	Coquí	45	Hacienda la Carmen
2	López	46	Jardines de Salinas
3	Playa	47	Paseo Costa del Sur
4	Carmen	48	Francisco M. Cintrón
5	Jaguas	49	Mansiones de Salinas
6	Conuco	50	LLanos de Providencia
7	Estero	51	Comunidad Pozuelo
8	Salimar	52	Comunidad Chun Chin
9	Godreau	53	Comunidad Cimarrona
10	Cabazas	54	Comunidad Palmas Alta
11	Playita	55	Villas El Legado
12	Arboleda	56	Urb. Caribe Mar
13	González	57	Comunidad Villodas
14	Villa Sol	58	Valle Guamaní
15	Evelymar I	59	Comunidad Puerto de Jobos
16	San Felipe	60	Comunidad Las Mareas
17	Mosquito	61	Comunidad Pozo Hondo
18	Las Mareas	62	Comunidad Miramar
19	Evelymar II	63	Sector Mosquito
20	Villa Verde	64	Comunidad Santa Ana
21	Las Antillas	65	Valle Guamaní
22	Bellla Vista	66	Urb. Jardines de la Reina
23	Las Mercedes	67	La Puente
24	Montesoria I	68	Comunidad San Martí
25	Montesoria II	69	Sector Guamaní
26	El Coco Viejas	70	Sector El Pescao
27	El Coco Nuevas	71	Sector Reunión
28	Colonia Teresa	72	Parque Gabriela II
29	Las Margaritas		INDUSTRIAL USES
30	Brisas del Mar	73	Aguirre Power Plant
31	Coco Margarita	74	AES Power Plant
32	Hacienda Vieja	75	Baxter
33	Ranchos Guayama	76	Pfizer Pharmaceutical
34	Parque Gabriela	77	PREPA Power Station
35	Paseo Horizonte	78	Eli Lilly
36	Colonia Fortuna	79	Municipal Landfill
37	Finca La Carmen		FISHING VILLAGES
38	Corales del Mar	80	Playa Fishing Village
39	Las Trinitarias	81	Playita Fishing Village
40	Central Aguirre	82	Las Mareas Fishing Village
41	Villas del Coquí	83	Aguirre Fishing Village
42	Arcadio Maldonado	84	Puerto de Jobos Fishing Village
43	Prados de Salinas	85	Pozuelo Fishing Village

MAP KEY:

- Communities
- Industrial Uses
- Fishing Villages
- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
- Future Incorporations Marine Boundary
- Aguirre Navigational Channel* *Not included within the boundary
- Jobos Bay Watershed
- Municipal Boundaries
- Wards

Source: U.S. Geological Survey, National Geospatial Program. POT Guayama, 2008. POT Salinas, 2012.

In Guayama, the community of Pozuelo has an active fishing industry. It is a center for seafood restaurant and eateries. The study determines that there is an "obvious link" between the fishing industry and the restaurant business, where fresh catch is sold. Pozuelo is home to both recreational and security-based boating in the area: there exist two fishing associations, with a total of at least 50 fishers, the Guayama Yatch Club, the maritime police, and Puerto Rico's elite anti-drug-smuggling unit (FURA). The Pozuelo community has been active in protecting the estuary in order to preserve ecosystem health, which they perceive as essential to their livelihood and well-being (García et al., 2013).

The study also encountered areas in Guayama where "extensive use of mangrove and coastal forest products, especially land crabs and mangrove oysters and clams". It was observed that many houses have land crab pens, and there were signs throughout the area indicating that land crabs are commonly sold in local stands (García et al., 2013).

In Salinas, the community of Aguirre directly neighbors the Reserve. The study identifies the following principal human dwellings associated to Aguirre: El Coquí, houses that used to belong to the Aguirre Sugar Mill Complex, Montesoria I and II and Eugene Rice.

The study documented 10-12 active fishers from Aguirre, though the number is on the decline. Nevertheless, the study observed a lot of fishing activity in Aguirre and a sea-oriented community and lifestyle (García et al., 2013).

The communities of Playa and Playita also lay within the Jobos Bay watershed, though they are not direct neighbors of the Reserve. The seafood industry, land-crab hunting, boating, and recreational fishing are important industries in these communities, providing "an abundance of economic opportunities". With regard to coastal forest resources, communities were observed using mangroves, tidal flats, channels, and lagoons to harvest land crabs, mangrove clams and oysters, coconuts, and maví tree bark.

Las Mareas, which was not described in the study, is a small, economically depressed fishing community, adjacent to the west end of Jobos Bay. It also has an active fishing community.

Archeological and Cultural Resources

The Reserve and adjacent areas contain important cultural resources. The Central Aguirre Historic District was included in the National Register of Historic Places in October of 2002. In 1898, an American company bought the Aguirre central properties. They modernized sugar technology and developed the only company town in Puerto Rico, legacy of the sugar mill companies. The Aguirre Historic District is a corporate complex that included the sugar mill and refinery, as well as administrative, commercial, institutional, recreational (golf course, hotel, swimming pool and social club) and residential areas.

Some of the Central Aguirre sugar mill (Central sector) buildings, structures, and facilities have been demolished after the period of significance. Only a few have been remodeled after the closing of the mill, some of them are located within the Reserve boundaries, such as the Visitor Center, formerly the American Club and the train station. These are located in the Aguirre Management Unit.

Historic house in the Aguirre Historic District
Source: Ernesto M. Olivares and Víctor Cuadrado

In addition, the casual discovery of stone figurines, (known as 'Cemí'), in the Central Aguirre area reflects settlements of the Taíno Indians, the most important indigenous cultural group of the Island.

According to the Puerto Rico State Historic Preservation Office (PRSHPO) archeological records, there are seven archeological sites within the Reserve boundaries, as seen in the following figure. Cayo Cofresí, which is located in the Mar Negro unit, belongs to the archaic period with a date 300BC. It is considered as part of site diagnosis to understand the archaic human occupation (SHPO, n.d.).

Figure 11. Archeological and cultural resources

MAP KEY:

- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
- Future Incorporations Marine Boundary
- Aguirre Navigational Channel*
  *Not included within the boundary

Arqueological Sites

- Sites

National Register of Historic Places

- Central Aguirre Historic District

Source: State Historic Preservation Office. National Register of Historic Places.

Threats and stressors

This section describes natural and anthropogenic stressors that affect the Reserve. Some of these stressors occur inside the Reserve. Others take place in the watershed and surrounding waters. These are summarized in the following figure and the most critical are explained in the following sections.

Figure 12. Summary of threats and stressors

Illegal practices and lack of proper enforcement:
- Overfishing
- Use of illegal fishing gears
- Human-induced fires
- Illegal interactions with manatees
- Festivals celebrated in the cays
- Use of ATVs
- Vandalism and destruction of property
- Cutting and filling of mangroves
- Harvesting of crabs
- Trash Left Behind by users/visitors

Degraded water quality:
- Sewage discharges
- Sedimentation from land-use practices
- Use of pesticides
- Industries in the watershed

Sargassum accumulations

Critcal status of the South Coast Aquifer
- Change in irrigation practices
- Extractions
- Reduced precipitation

Climate change effects:
- Tropical systems
- Coastal flooding
- Increase in surgace and sea temperature
- Ocean Acidification
- Drought
- Extreme weather events
- Sea level rise

Invasive Species

Illegal activities and lack of proper enforcement

The incidence of illegal practices in the Jobos Bay NERR, the lack of proper enforcement and processing of violators, are important issues that have affected the Reserve resources over the past years. Violations include illegal fishing practices, cutting of mangroves, improper interaction with manatees and vandalism of property. This is exacerbated by the fact that at present, there's only one Ranger assigned by the PRDNER to the Reserve, significantly hindering proper enforcement of environmental laws.

Use of illegal fishing gears and methods: Illegal fishing practices have been documented in Mar Negro Unit and within Jobos Bay. The illegal use of nets across the Mar Negro waters has been observed. The hook and line is the only fishing method legally allowed.

In addition, the illegal practices of harvesting land crabs with traps and even burning the mangrove forest in order to force the crabs to leave their caves have also been observed, mainly in Mar Negro. Both practices are prohibited by PRDNER Regulation Num. 7949.

Overfishing: Overfishing is a concern in the Jobos Bay NERR, and is happening despite staff efforts to implement management plans for certain species like the queen conch (*Strombus gigas*) and the spiny lobster (*Panulirus argus*), which limits species catch per day. Recent assessments concluded that the queen conch is undergoing overfishing and approaching an overfished state (Valle et al., 2011). These findings coincide with Whitall el al., 2011 observations for the same species, as only two queen conch were observed in two of 45 surveyed transects and no spiny lobster were observed.

In addition, the Reserve staff have been noticing a significant reduction in benthic species such as sea cucumber (*Isostichopus badionotus)* in the Jobos Bay NERR waters. Although the density of these species has not been documented, recent observations combined with significant extractions by fishermen witnessed by the staff, point to possible overfishing. This species has been widely marketed for medical use and Asian cuisine, which has put substantial pressure on these resources in Jobos Bay NERR and other areas in Puerto Rico. To address this issue, the PRDNER issued an Administrative Order (2016-08) in June to prohibit the capture, selling, buying or export of sea urchins and sea cucumbers in Puerto Rico. However, proper surveillance is needed to enforce compliance with this AO.

Human- induced fires: The Reserve and its watershed has been affected by human induced fires. In 2014-2015, these induced fires were exacerbated by extraordinarily dry conditions. In the Jobos Bay NERR, these fires have occurred principally in the Aguirre Unit. Fires have been induced as a method to capture crabs or as a result of simple negligence. These fires are not caused by nature, but are aggravated by the prevalence of extremely dry vegetation, a result of the persistent lack of precipitation.

Fire in the Aguirre Unit
Source: Jobos Bay NERR Staff

The Reserve staff has estimated that Jobos Bay NERR has more than 77 hectares susceptible to fires. These include areas composed of sub-tropical dry forest, as well as areas in the cays of the bay, accessible to visitors.

Improper and illegal interactions with manatees in the Jobos Bay: Community members have expressed concern that there have been inappropriate interactions with manatees in the Jobos Bay waters. Interactions include feeding manatees, which can result in behavior modification and changes to their natural feeding patterns.

Numerous festivals and activities celebrated in the Jobos Bay NERR cays: In discussions with the various advisory committees, participants constantly raised their concern about the numerous festivals celebrated in the private cays in the Jobos Bay and its periphery (such as Cabezas de Cayo Caribe and Cayo Matías). These events put substantial pressure on marine resources within the Reserve and its periphery. They are a concern for the Reserve staff who have consistently opposed the celebration of these activities in the area.

Use of ATV inside the Reserve: Illegal use of trails by off-road vehicles continues to be a problem in Mar Negro (Jagüeyes trail) and Aguirre Units, even though barriers were installed to prevent their entrance. These barriers reduced the amount of vehicles entering the trails, but the problem continues. Trails will be targeted for enhancements to prevent access by ATV's.

Vandalism and destruction of the Reserve's property: The Reserve also experiences safety problems. Some of the Reserve's infrastructure has been destroyed and vandalized. For example, the barriers installed to prevent the entrance of ATVs were vandalized; signs that were installed in the cays indicating illegal activities and speed limits, among other, have been removed; the antennas for the wireless connection were destroyed; and the electrical wiring and the rods from the historical structures have been stolen.

Degraded water quality

The PREQB classifies the waters of Jobos Bay as SB, which corresponds to "coastal waters and estuarine waters intended for use in primary and secondary contact recreation, and for propagation and preservation of desirable species, including threatened or endangered species". Despite this classification, in the Puerto Rico 305(b)/303(d) Integrated Report, the PREQB states that the waters of Jobos Bay are impaired.

Indicators of impairment include low dissolved oxygen, oil and grease, pH, thermal modifications, and turbidity. Additional causes of impairment observed in the 2010 and 2012 assessment cycles include *Enterococcus* bacteria. According to the

305(b)/303(d) Integrated Report, potential sources of pollution include agriculture, major industrial point sources, onsite wastewater systems, urban runoff/storm sewers, and upstream impoundment. Some are described in the following subsections:

Lack of proper infrastructure to manage sewage discharges in surrounding communities: This is a major cause of water impairment. Water quality in the Mar Negro Unit is characterized by high nutrients, resulting from lack of proper infrastructure to manage sewage in Las Mareas and Camino del Indio communities. The conditions are further exacerbated by restricted tidal exchange due to the construction of an access road to Camino del Indio, which filled in low-lying areas and water passages between Mar Negro and Jobos Bay.

Sedimentation from land-use practices: The watersheds of the Salinas and Guayama wards provide freshwater flow into Jobos Bay and into Mar Negro wetland and mangrove forest. These sources carry sediments to the estuary. There has been an increase of sediments arriving in the bay due to uncontrolled agricultural and land-use practices upstream. These sediments have negative impacts on diverse coastal and marine ecosystems. Due to the prevailing North Equatorial Current on the southern side of Puerto Rico, it seems that sedimentation from watersheds, particularly on the east side of the Jobos Bay is impacting the Reserve's coastal resources.

Sedimentation can have direct impacts on coastal and submerged resources, and thus on species distribution and survival. The Reserve staff has been working extensively within these watersheds to address these impacts. However, recent observations from mapping efforts conducted by NOAA's National Center for Coastal and Ocean Science (NCCOS) revealed that the corals offshore of Jobos Bay are being impacted by severe sedimentation, which have led to decreased growth rates, and reduced recruitment, but the effects vary among coral species, sediment types, and environmental conditions (Whitall et al., 2011).

Use of pesticides in surrounding agricultural lands: Research conducted as part of the CEAP Project detected a pesticide spike in water samples after a storm event, confirming a direct link between nonpoint source runoff from the watershed and water quality in the Reserve.

The study, published in 2013, reported a site in JBNERR with a high concentration of the pesticide atrazine after a rain event (Potter et al., 2013).[9] Atrazine can cause DNA damage in neotropical fish species (Santos & Martínez, 2012), and may have contributed to high DNA damage levels in *B. exustus*. As tropical storm systems moved through the area, resulting surface runoff appeared to have a high potential for transporting atrazine. The researchers indicated that the potential for rapid atrazine

[9] Atrazine is an herbicide use to stop pre- and post-emergence broadleaf and grassy weeds in crops.

degradation in soil also has implications for future management decisions within the farm field as well as impacts on water quality within Bay. Achieving effective weed control will probably require the replacement of the pesticide atrazine.

Also, mussels showed the highest concentrations of copper (Cu) in their mantle tissue. Copper does not cause direct damage to DNA, but aids the formation of oxygen radicals, which cause single strand breaks and attack on DNA bases (Bernstein and Bernstein, 1991).

Long-term weather records show that tropical storm systems commonly pass through the area during the wet season, May to November, and that such events can generate large amounts of runoff in coastal areas (Kuniansky and Rodríguez, 2010; NERRS-CDMO, 2012). As such, once farming operations are resumed at the study site, there is a need to further examine rainfall-runoff relationships and the potential for pesticide transport to the estuary.

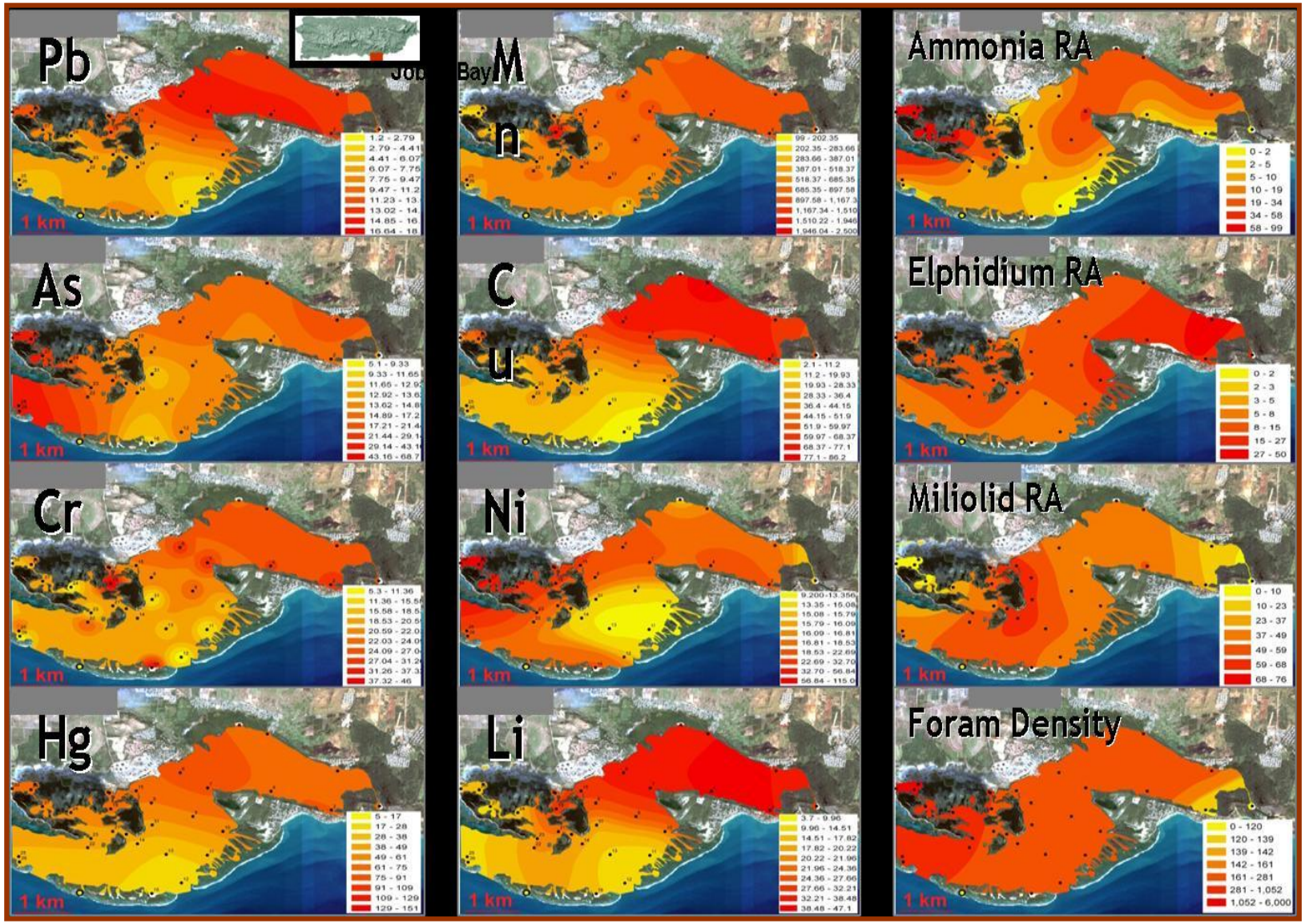
Industries in the watershed: There are industrial activities in the Jobos Bay NERR watershed that may impact the Reserve's resources. Concerns about the actual and the potential impacts were expressed by the Jobos Bay NERR Stewardship Advisory Committee (STAC).

As previously described, the North Equatorial Current, flowing west-northwest, influences the marine current coming from the eastern side of Jobos Bay that runs along the coast, coming into contact with potential pollution sources, such as agricultural fields, a coal power plant, a Phillips Core oil refinery (closed in 2005) and other industries (NERRS, 2011).

As part of the habitat characterization conducted by NOAA's-NCCOS and with the collaboration of a GRF, a database on contaminants was developed. As evidenced by the following figure, there are very high concentrations of metals in the sub-watersheds. It is possible that this is related to the high concentration of industries in the area.

There are two power plants in the Jobos Bay NERR watershed that may be affecting the Reserve's ecosystems. The thermal discharges from the PREPA Aguirre Power Plant are an anthropogenic stressor to the Jobos Bay marine environment (Whitall et al., 2011), and is a stressor for the manatee population. This power plant has a navigation channel, used by barges to bring oil and gas into the power plant pier. This area is exposed to barge strandings and sediment re-suspension. Oil spills are a consistent threat (NERRS, 2011).

Figure 13. Heavy Metals in Jobos Bay (from Michael Martinez, 2009 GRF)



PREPA is proposing the development of the Aguirre Offshore Gasport for the purpose of receiving, storing, and re-gasifying Liquefied natural gas (LNG) that will be used in the Aguirre Power Plant. The proposed project includes the construction and operation of an offshore marine LNG receiving facility (Offshore GasPort) located in the south side of Cayo de Barca and Cayo Caribe and a 4.0-mile-long (6.4 km) subsea pipeline connecting the Offshore GasPort to the Aguirre Plant, through the Boca del Infierno pass. Concerns are mainly related to the potential impacts of the pipeline on marine ecosystems and livelihoods. These were expressed by community members during STAC. The Environmental Impact Statement prepared by the Federal Energy Regulatory Commission (2015), informed that the construction of the Project would temporarily disturb approximately 131.4 acres of land, surface water, and the seafloor, including 1.5 acres of land within the existing Aguirre Plant property. As proposed, the construction of the offshore facilities, including the Offshore GasPort, subsea interconnecting pipe, and lay barge construction areas, would directly impact approximately 129.9 acres of the seafloor. Operation of the offshore facilities would permanently impact approximately 22.9 acres of seafloor. This project involves the passage of vessels which may disrupt and divide the landscape, besides impacting the development of ecotourism in the area.

The other power plant is located at the North-east side of Jobos Bay NERR and uses coal as fuel to produce electricity. There is lack of information about the effects of coal combustion residuals on the Jobos Bay NERR ecosystems. However, available data suggests potential effects on marine ecosystems that should be further studied.

Withall et al., 2011, reported arsenic (As) concentrations in coral tissues in the Jobos Bay that were higher than other studies in Puerto Rico. Arsenic concentrations in corals were higher in the offshore stratum than inshore. This pattern could be a result of atmospherically deposited As from fossil fuel combustion at the nearby power plants (coal and oil fired). Relative to other regions in Puerto Rico, concentrations of metal in airborne particles were higher in the Salinas watershed, which incorporates Jobos Bay (Jiménez-Vélez et al., 2003 cited in Withall et al., 2011).

Critical status of the South Coast Aquifer

Groundwater is the main source of freshwater for the Jobos Bay estuary. It is also the single source of water supply for the municipality of Salinas. Various factors like water extraction from the aquifer for industrial purposes, impermeabilization of the land surface due to urbanization and changes in agricultural practices, combined with a reduction in rainfall has significantly diminished aquifer recharge. This has caused the death of mature black mangrove forest in the Mar Negro Unit.

Pumping wells near the Salinas fan delta are capturing groundwater flow that would otherwise discharge through the mangroves. The United States Geological Survey (USGS) indicated that without a reduction in pumping rates, slightly dryer than average

periods would result in almost no freshwater discharge to the mangroves at JBNERR and potential saline-water movement from the estuary into the aquifer (Kuniansky, 2010).

This situation may continue to worsen due to the effects of climate change. As indicated, rainfall has been below average; as a result, recharge diminishes and groundwater levels decline.

Aquifer levels as measured with the USGS piezometers at JBNERR were below the minimum average since the end of 2014 and the water level in the confined or deep aquifer had remained below sea level since the end of 2012 (Dieppa, 2015). Even a rationing of potable water took effect in the region.

Droughts

Lack of precipitation and very dry seasons also affect biodiversity. In 2015, the US Drought Monitoring Program changed the classification of the Southeastern portion of Puerto Rico, where the Reserve is located, from Unusually Dry (D0) in July 2015 to Severe Drought (D2), and then to Extreme Drought (D3) in the latter half of the month, a classification which persisted throughout August 2015.

Dry patterns in vegetation, minimum flow in streams and increase in fugitive dust were observed at JBNERR. Migratory birds were not observed in areas, such as salt flats due to a very dry year, but were observed on wet areas like Mar Negro (Dieppa, 2015). Manatees were barely observed and the blue land crab (*Cardisoma guanhumi*) was not observed mating while dry conditions were present at JBNERR (Dieppa, 2015).

1. Defoliated white mangrove North of Mar Negro Unit, due to extreme drought in 2015
2. Aerial view of white mangrove stands impacted by the severe drought

Source: Angel Dieppa

Sargassum accumulations

Sargassum sp. arrivals to the Caribbean shores is an emerging phenomenon and not enough research has been conducted about it. Recent hypotheses suggest that it is due to changing weather patterns and warmer temperatures in the region.

Since June 2012 large amounts of *Sargassum* arrived to the Jobos Bay NERR coasts at proportions that even local residents said they have never seen in the area (Dieppa & Muñoz, 2015). The Reserve's Research and Stewardship coordinators have been documenting arrivals and potential effects on ecosystems. On July 2015, significant reductions in the amount of dissolve oxygen (from 40% to 1%) in the water was observed, and a considerable amount of *Tetraodon sp.* (31 individuals) were found dead in the Sargassum floating mass (Dieppa & Muñoz, 2015). Another observation was nurse sharks (*Ginglymostoma cirratum*) withdrawing from their aggregation and seasonal breeding area.

It is most likely that if Sargassum stays floating for a long period of time it will cut down light penetration to underwater communities, causing seagrass and bottom algae mortalities. The Sargassum that gets trapped in mangrove forests for a medium to a long period are most likely to have a significant negative impacts on many aspects of this ecosystem structure and function, including the survival of trees. Once the Sargassum dies it will decay, introducing dissolved chemicals and decreasing water oxygen levels, affecting the mangrove roots and the animals living on them. Large

deposits on the beaches can also make it difficult for tiny sea turtle hatchlings to find their way to the ocean.

Further documentation and research is needed to understand the effects and changes caused by Sargassum arrival to JBNERR coasts.

1. **Aerial view of Sargassum acumulations in Station 10 at Mar Negro, July 2015**
2. **Aerial view of Sargassum acumulations from Mar Negro fishing pier, Las Mareas Community**

Source: Angel Dieppa

Invasive Species

Four species of problematic fauna were identified in the confines of the Reserve. These are the small Indian mongoose (*Herpestes auropunctatus*), the green iguana ((*Iguana iguana*), the black rat (*Rattus rattus*) and the lionfish (*Pterois volitans*).

- The small Indian mongoose (*Herpestes auropunctatus*) was first brought to Puerto Rico to control the black rat (*Rattus rattus*) infestation in the sugar cane plantations.[10] Feeding on insects, frogs, snakes, birds, other small animals and fruit, mongooses are reported to live up to 20 years.[11] This species is a threat for public health and the safety of users.
- The green iguana (*Iguana iguana*) is an herbivorous specialized species. Although, there is lack of information about its impact on the Reserve, other estuarine areas in Puerto Rico have informed that the greatest impact has been the defoliation of mangroves, particularly the black mangrove (*Avicennia germinans*) Carlo & García, 2008. Iguanas are territorial species and like to live in groups, so its herbivory diet could have negative consequences on the trees within their habitat.
- The black rat (*Rattus rattus*) and mice have been observed near the trash cans located in the Cays. These species may have adverse impacts on wildlife, particularly birds, as they are predatory species. In addition, they are a threat for public health and the safety of users.

[10] http://www.fs.fed.us/r8/el_yunque/wildlife-facts/2002/wildlife-facts-august-2002.shtml
[11] (http://www.fs.fed.us/r8/el_yunque/wildlife-facts/2002/wildlife-facts-august-2002.shtml

- The lionfish is an invasive species found in the U.S. south Atlantic and Caribbean Sea including Puerto Rico. Lionfish are predatory in nature and have very few known natural predators. Lionfish are known to greatly reduce fish populations in reefs where they become established. Lionfish are habitat generalists and can be found in most marine habitat types found in warm waters of the tropics from one (1) to 1,000 feet (0.3 m to 305 meters) deep including on hard bottom, mangrove, seagrass, as well as coral and artificial reefs.

Climate phenomena and impacts

Tropical systems

JBNERR is exposed to the effects caused by weather systems that have the potential to create higher than average rainfall and flooding in short periods of time, as well as strong winds and storm surges. The hurricane season in the Atlantic and the Caribbean is from June to November. Hurricane trajectories and the shallow coasts makes Puerto Rico's Southern and Eastern coasts the most vulnerable areas for storm surges, as shown in figure 18.

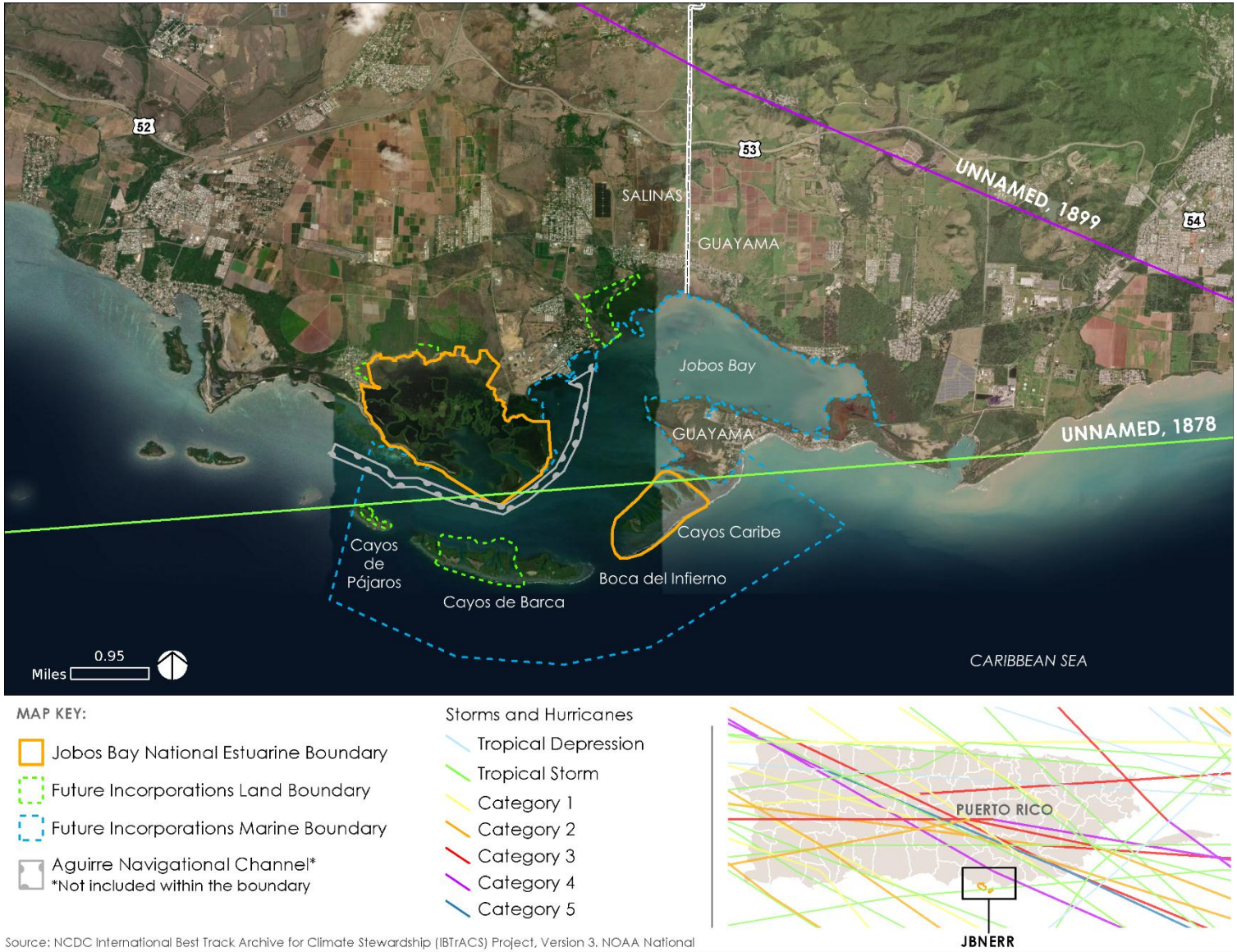
Coastal flooding

According to maps prepared by the Federal Emergency Management Agency (FEMA), known as the Flood Insurance Rate Maps (FIRM), revised in 2014, JBNERR is mostly classified as AE and VE zones. The Reserve has approximately 1,016.74 acres classified as AE, which correspond to the floodway. On the other hand, VE zones (440.17 acres) are areas subject to storm surge. Table 4 summarizes the acreage of each flood zone in the Reserve and the following figure presents their distribution.

Table 4. FEMA flood zones in JBNERR

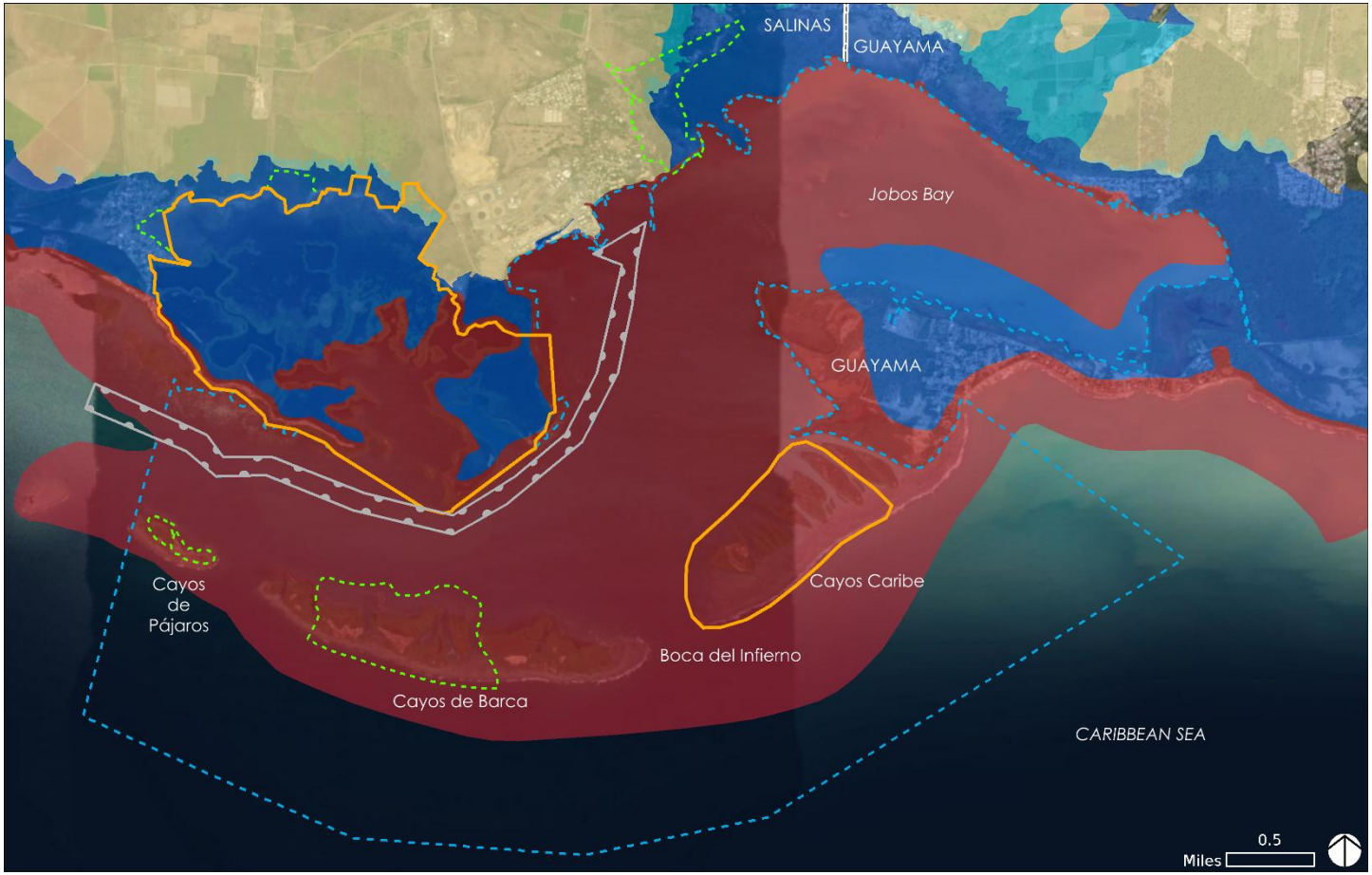
FLOOD ZONE	ZONE DESCRIPTION	AREA (KM2)	AREA (ACRES)	PERCENT
A	1-percent-annual-chance flood event generally determined using approximate methodologies.	0.03	7.63	0.5%
AE	1-percent-annual-chance flood event determined by detailed methods.	4.11	1,016.74	65.9%
VE	1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action	1.78	440.17	28.5%
X	0.2-percent-annual-chance flood hazard	0.06	14.11	0.9%
X	Area of minimal flood hazard	0.26	63.78	4.1%
TOTAL		6.24	1,542.44	100.0%

Figure 14. Hurricane trajectories



Source: NCDC International Best Track Archive for Climate Stewardship (IBTrACS) Project, Version 3. NOAA National Centers for Environmental Information, 2015.

Figure 15. Jobos Bay Flood Zones (FEMA, 2014)



MAP KEY:

- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
- Future Incorporations Marine Boundary
- Aguirre Navigational Channel*
  *Not included within the boundary

Flood Zones

- VE
- AE
- A
- X, 0.2 % annual chance flood hazard
- X, Area of minimal flood hazard

Source: FEMA, National Flood Hazard Layer, 2014.

Climate change effects

Climate change impacts affecting JBNERR ecosystems and surrounding communities include: increases in temperature, including sea-surface temperature, increases in extreme weather events, sea level rise, and ocean acidification.

According to Robinson *et al*., 2013, the key ecological stressors identified as impacting the System's Reserves include: toxic contaminants, storm impacts (not including flooding), invasive species, habitat fragmentation, sediment loading, coastal shoreline erosion, nutrient loading/eutrophication and habitat loss. Key stressors include residential development, past land use, population growth, wastewater treatment, and sea level rise. All these apply to JBNERR at various levels of magnitude. The report also indicates that social sensitivity is of particular concern in JBNERR.

Although JBNERR lacks a vulnerability assessment, available information in the "*Puerto Rico's State of the Climate* (2010-2013)", prepared by the Puerto Rico Climate Change Council (PRCCC), was used to describe a general overview of the Reserve's situation.

- **Increase in surface temperature**

Extreme temperature events are likely to lead to an increase in the number of hotter days and a decrease in the number of cooler days (PRCCC, 2013). Wildlife, particularly ectothermic species, are more vulnerable to an increase in surface temperature. An increase in temperatures may alter adult nest attendance and prey fish behavior, and indirectly contribute to nest failure (PRCCC, 2013). Mean higher sand temperatures can lead to changes in sex ratios of marine turtles or prevent eggs from hatching.

- **Increase in sea surface temperature**

The PRCCC (2013) reported that higher incidents of this trend are being observed in the South coast of Puerto Rico. A common effect of warmer ocean temperatures is coral bleaching and disease.

A simulation model study showed that increased sea surface temperature causes shifts in faunal communities and heightens the possibility of invasive species among species of barnacles (Svensoon et al., 2006, as cited in PRCCC, 2013). Mollusks, particularly in the earlier stages of life, are particularly vulnerable to changes in UV radiation, pH, and water temperature (Przeslawski et al., 2005, as cited in PRCCC, 2013).

According to the report, marine mammals are most vulnerable to the effects of climate change related to increasing temperatures and habitat degradation. Impacts may include: changes in abundance, distribution, timing and range of migration, community structure, the presence and species composition of competitors and predators, prey availability and distribution, timing of breeding, reproductive success and, ultimately,

survival (Defra 2005, as cited in PRCCC, 2013). This report states that combined with toxicological stress, thermal stress may increase mortality. In addition, warmer temperatures may increase toxicity of pollutants that already exist in coastal waters.

In the Reserve this is a matter of concern, given that current stressors, such as thermal discharge from the power plant and the pollutants entering from the watershed may exacerbate the warm water conditions.

- **Ocean acidification**

Ocean acidification could interfere with critical processes such as reef building, carbon sequestration via phytoplankton sedimentation, and consumer-resource interactions, due to the increase in CO_2 concentrations and subsequent decreasing pH in seawater.

In the Reserve, the species most affected by this impact are coral reefs and other organisms such as the queen conch and many other mollusks, polychaetes, coralline algae, barnacles and a wide variety of species that produce calcium carbonate shells or skeletons.

- **Decrease in precipitation**

Current evidence suggests that drier conditions are more likely than wetter conditions in Puerto Rico (PRCCC, 2013). A reduction in precipitation, which has been documented in the watershed, will worsen recharge of the South coast aquifer. Droughts can affect aquifer water depletion by prompting excessive extraction, which can cause its subsidence, a situation that could be worsened by sea level rise. Saline intrusion could also occur, which could in turn impact the water balance needed by species such as mangroves. In addition, the amount of freshwater entering the Bay could be reduced, impacting the manatees. These are only two examples of the many potential impacts of decreased rainfall on the Reserve's flora and fauna.

A study published in 2016 that explores the implications of various climate change projections for Puerto Rico, shows temperatures increasing from 4.6 °C to 9 °C (8 °F to 16 °F), and rainfall decreasing up to 50% by the end of the century (Khalyani et al., 2016). The study shows trends of increasing cooling degree days, increasing annual number of days without rain, and shifting ecological life zones as temperature and rainfall patterns change over the next century.

The implications of these results for the Reserve and its watershed would be devastating. Results of this study show that the subtropical dry forest will change to tropical dry forest in 2040 and to tropical very dry forest in 2099 (Khalyani et al., 2016).

- **Increase in extreme weather events**

Extreme weather events include an increase in the frequency and intensity of heavy downpours and an increase in the intensity of hurricanes and tropical storms.

Natural disturbances, such as hurricanes, can alter both the physical and biological structure of coral reefs. Although the reef, in the absence of additional stressors, can recover through growth and recruitment, intense events can cause severe, long-lasting damage.

Other effects include: coastal floods and potential damage to vegetation due to wind and surges, and an increase in coastal erosion, which can be severe in the Reserve's cays and cause a reduction of habitat for sea turtle nesting.

- **Sea level rise**

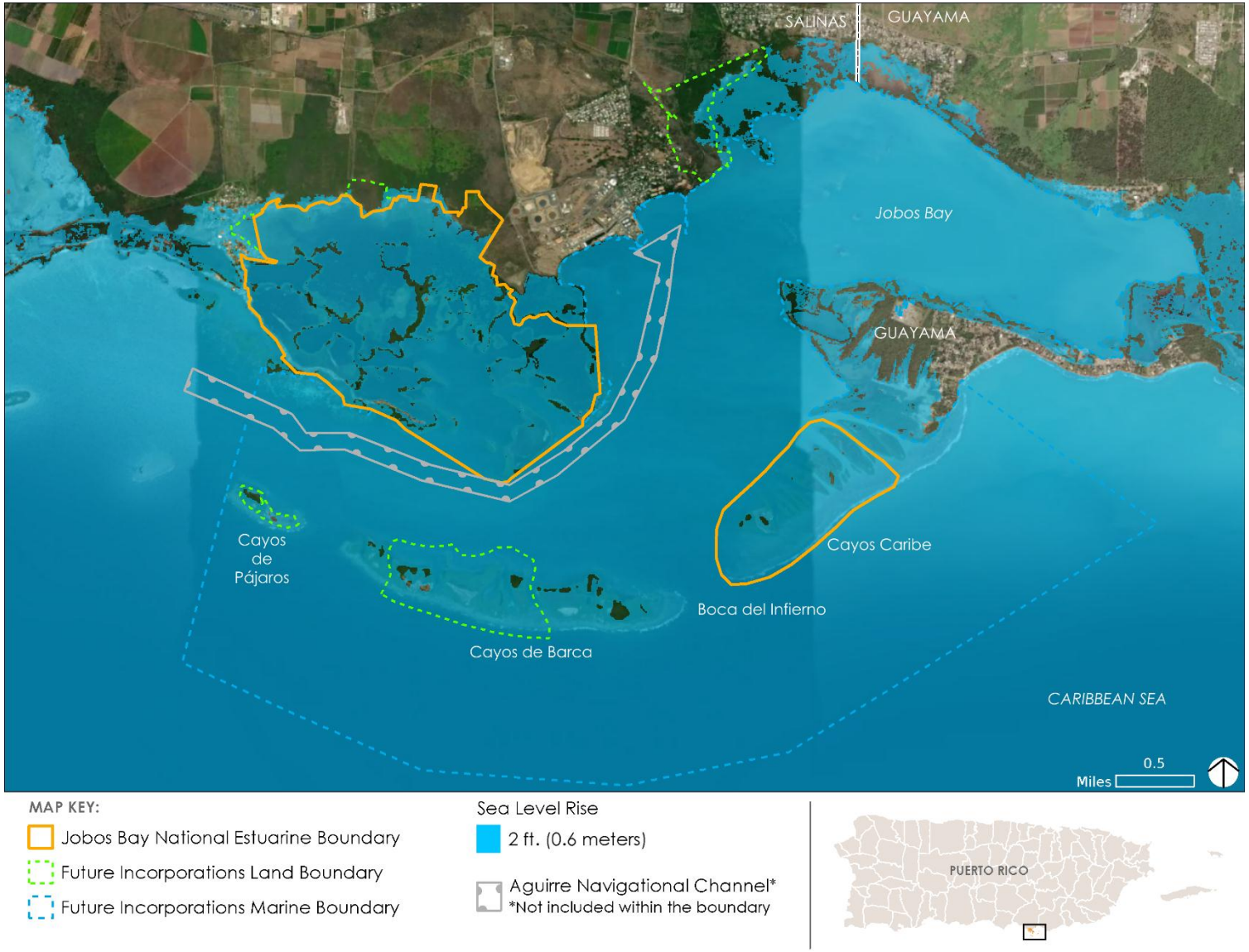
The Reserve is highly vulnerable to sea level change. According to the NOAA sea level rise model, an increase of two (2) feet would inundate 82% of the Reserve's lands, particularly the cays and the Mar Negro Unit, as presented in the following figure.

Effects include saline intrusion in the South coast aquifer and the resulting impacts on ecosystems, agriculture and livelihoods. The rise in sea levels will cause changes in mangrove forest structure and migration. It is possible that red mangroves will migrate inland as sea levels rise, replacing black mangroves.

If the mangrove and the dry forest located north of the Reserve do not expand at the same rate, migratory songbirds that depend simultaneously on both habitats will be affected (Rodríguez, 2012).

Finally, the Reserves' ecosystems loss and degradation will have adverse impacts on the economically disadvantaged communities surrounding the Reserve, which depend on the ecosystems for protection, fisheries, tourism, among other services. Economic activities that depend on the aquifer will also be adversely impacted.

Figure 16. Sea level rise 2ft. (0.6meters) –NOAA estimates



Source: NOAA Digital Coast, Office for Coastal Management, 2013.

Information gaps: climate change effects on Reserve's ecosystems

The cumulative effects of climate change stressors and multiple anthropogenic sources of environmental change on marine mammals are unknown (PRCCC, 2013). According to the PRCCC (2013), there is a need to understand marine mammal life histories, contaminant exposure, how to predict and prevent diseases, and how marine mammals respond to long-term environmental changes. The group identified that more research is needed to determine to what extent marine mammals must contend with an increasingly stressed ecosystem. The report indicates that research should be focused on predictive modelling of ecosystems, based on data from a suite of species selected for their life history characteristics.

It also indicates that the understanding of diseases in marine mammals is poor, specifically regarding what the normal components of a healthy marine ecosystem are, versus which are a consequence of anthropogenic factors. It is also unknown if there is a real increase in diseases in marine mammals or how to control/prevent them.

The report also indicates that the general lack of understanding of marine mammal health and physiology, among other factors, has led to the inability to properly assess the effects of contaminants on these mammals. Monitoring was identified as a required action to determine whether management changes result in decreased, unchanged, or increased burdens in tissues.

Appendix 8. Public participation opportunities & public meeting comments and responses

The revision process of the Jobos Bay NERR management plan occurred over two years (from 2015-2017) and included direct input from all Reserve staff members, the Puerto Rico Department of Natural and Environmental Resources, the community, four advisory committees and the National Oceanic and Atmospheric Administration's Stewardship Division staff and the Legal Counsel.

During that time, various public participation opportunities were provided for input on the plan that included:

Design of a project's web page which provided information on the project, the process, and alternatives for participation and to provide comments.

First community meeting- November 7, 2015 at Ángel "Cholo" Espada basketball court in Salinas.

- Purpose: To publicize the Management Plan revision process, the work team involved, available participatory methods and gather participant's opinion, expectations and concerns. The power point presentation used for the meeting is included in Appendix 8-A.
- There were 18 participants that included hunters, community leaders, and researchers.

Visitor survey

- Purpose: Participant's relation with the Reserve, activities carried out in the area, Factors that they like or dislike the most and problems or needs.
- Method: A non- probabilistic survey that was available through various methods including web based, and printed copies were available at the Reserve, where it was administered with the help of community volunteers.
- There were 198 respondents. Results are included in Appendix 8-B.

Meetings with advisory committees

- There were four meetings with the advisory committees, composed of Commonwealth, Federal and Municipal representatives, scientists and community leaders. The purpose of these meetings was to assess issues identified in the previous plan, as well as goals objectives and actions. In addition new issues and required actions were identified and discussed. Meetings were held in the Reserve's Visitor Center:

- Stewardship Advisory Committee- January 18, 2016. There were seven representatives of the following entities: USDA: International Institute of Tropical Forestry (IITF), Natural Resources Conservation Service (NRCS), NOAA- National Marine Fisheries Service (NMFS) and the community based organization, IDEBAJO.
- Education Program- March 4, 2016 – There were representatives from: Woodrow Wilson School-Salinas, San Conrado Private School-Ponce, a retired teacher from Guayama, the Sea Grant Program, DNER Education and Community Relations Office, and a consulting expert from Consultores Educativos.
- Coastal Training Program- March 29, 2017- There were representatives from nine entities: DNER- Coastal Management Program, Sea Grant Program, Puerto Rico Permits Management Office (OGPe by its Spanish acronym), Environmental Quality Board, Puerto Rico Electric Power Authority (PREPA), University of Puerto Rico Mayagüez Campus-Agricultural Extension Service-Guayama Region, Municipality of Guayama., US Coast Guard and USDA-NRCS.
- Research Advisory Committee- April 6, 2016 – There were representatives from CariCOOS, the US Geological Survey, DNER Northeast Reserve's Manager and collaborator in the Sentinel Site project; Public Health School researchers and a USGS retired employee.

- Presentations and minutes are included in Appendix 8-C.

Draft revisions

- A first draft of the document was submitted to the PRDNER staff, the NOAA's Stewardship Division, and the four Advisory Committees in June 30, 2016. Subsequent revisions took place in September and December 2016 and February, June and August 2017 by the Reserve's staff and the NOAA's Stewardship Division, previous to the public comment period.

Public comment period

Inviting comments

NOAA's Estuarine Reserves Division reviews and approves the plan after ensuring sufficient opportunity for comment by the public, per 15 Code of Federal Regulations 921.33. Once the management plan was approved by NOAA's ERD, a Federal Register Notice announcing a 30 day public comment period was published. The public comment period for this plan was published in the Federal Register on Monday, August 21, 2017 and the comment period ended on September 22, 2017. The draft of the plan

was available online [http://drna.pr.gov/jbnerr/] and comments could be provided by email to the Reserve's Manager, Aitza Pabón [apabon@drna.pr.gov].

In addition, a public notice was published in the local newspaper, El Nuevo Día on August 21, 2017, announcing the beginning of the public comment period and the information for a public meeting. The public comment period extended until September 22, 2017. The notice indicated that the plan was available online and a written copy was also available at the Reserve's Visitor Center. In addition to the email address, a postal address was provided and the public could also provide comments at the public meeting.

A total of three (3) people provided comments during the public comment period. Two provided verbal comments during the public meeting and the other were written comments sent by email to the Reserve's Director.

Public meeting comments and responses

The public meeting was held at the Jobos Bay NERR Visitor Center on August 29, 2017 at 5:00pm. There were seven participants in the meeting, in addition to the Reserve's staff, a representative of the Ranger Corps and the consultants. The meeting was audio recorded and minutes were taken. The attendance list is included in Appendix 8-D.

The Reserve Director gave a presentation using power point and encouraged participants to intervene and make questions and comments during her presentation. This promoted audience participation in a more informal and community oriented approach.

Two attendees provided oral comments:

- Mr. Jorge Ortiz Colón, Institute of Puerto Rican Culture
- Mr. Ray Rodriguez Colón, Puerto Rico al Sur, Inc.

Specific comments received on the plan are noted below in bold and are followed by a description of how the Jobos Bay NERR addressed the comment.

<u>Comments provided by Mr. Jorge Ortiz Colón, Institute of Puerto Rican Culture</u>

Comment 1: Commentator indicated that under the Social Sciences, Historical Sciences should also be included, being a little explored subject.

Reserve response: The comment corresponds to action 2 under Objective 1, "Convene social science researchers to discuss research needs and opportunities". The action was modified as follows to address the comment:

"2. Convene social science researchers and historians to discuss research needs and opportunities".

The Reserve will convene social scientists and historians that are knowledgeable in the Reserve to identify: future research needs and topics, infrastructure, equipment and materials as well as the potential for collaboration.

Comment 2: Indicated that there are multiple historic resources in the area and a little research has been done. There are archeological and subaquatic elements, and historic rails. The Institute of Puerto Rican Culture has an Underwater Research Council and there is a probability of underwater elements in the Jobos Bay and the Caribbean. He indicated that the agency will submit written comments.

Reserve Response: No change made to the Plan. The concern expressed verbally was addressed in the previous comment, by acknowledging the need for additional research in the social science as part of the Research program during the next planning period.

Comments provided by Mr. Ray Rodriguez Colón, Puerto Rico al Sur, Inc.

Comment 3: The participant asked if the Reserve has considered establishing a citizen Science Program. Indicated that the National Science Foundation funds this type of initiative. He also offered to help with this voluntary effort.

Reserve response: The following action was added under Objective 2 in the Education Program: (Develop a Conservation Action Education Program to increase knowledge and engagement among community members as well as to increase the volunteer base).

"**5. Develop a Citizen Science Program at the Reserve"**

The Reserve will be more successful in protecting its natural resources if the local community is educated, begin to develop a sense of ownership, and becomes actively engaged. The Education program Coordinator will lead, the development of a citizen science monitoring program that can involve community members, visitors, and local schools in the long-term monitoring of water-quality and specific species populations. To reach this end, all program coordinators must be involved, but ultimately a Volunteer Coordinator is needed to organize logistics.

Comment 4. Indicated that he is interested in helping strengthening volunteers in the areas of: birds, sea turtles and citizen science.

Reserve response: No change made to the Plan. The Reserve will continue working with collaborators to strengthen the volunteer base.

Comment 5: Participant asked if the buffer zone for the nurse shark mating grounds includes the maritime terrestrial zone.

Reserve response: No change made to the Plan. An oral response was provided by the Reserve staff during the meeting. They indicated that the buffer zone closest to land is part of the Reserve and these are mangroves and wetlands whose access is very limited.

Comment 5: Commentator indicated that the nurse shark is a protected species by the International Union for Conservation of Nature (IUCN) -Red List.

Reserve response: No change made to the Plan. The Plan describes the species in the Biological resources section, and states that Regulation No. 7949, Puerto Rico Fishing Regulation Num. 7949 of 2010 protects the species by prohibiting its harvesting in the Commonwealth's territorial waters (Section of Allowable and Unallowable Uses).

Additional comments received during the public comment period

Comments from Comité Diálogo Ambiental, Inc.-Iniciativa de Eco Desarrollo de Bahía de Jobos (IDEBAJO) were received via email on Monday, September 18, 2017. Comments are summarized below and the written communication is included in Appendix 8-E.

Comment 1. Refers to enforcement and security issues, such as: illegal cutting of mangroves, filling of wetlands, construction of structures and blocking public access. Indicates that Reserve's Natural Interpreter Guide Program participants have been intimidated and threatened and fear for their safety. The need for enforcement in this case cannot be emphasized enough and should be emphasized in the Draft Management Plan.

Reserve response: These issues have been identified in "Section 3.3 Summary of threats and stressors, Illegal and conflictive uses and activities". In Section 4.3 Jobos Bay NERR Priority Issues, the text explaining the issue referring to Habitat loss and degradation was modified to include the illegal cutting of mangroves, filling of wetlands and development in the maritime terrestrial zone as some of its causes.

The Reserve's Resources Protection Plan addresses these concerns in Objective 1. Improve law enforcement in the Reserve and its watershed. Actions include: continue implementing the Surveillance and Prevention Enforcement Strategic Plan of the PRDNER at JBNERR; request at least two additional Rangers for the Reserve; continue coordinating efforts to implement the legal strategic plan for the removal of illegal

structures; and provide technical and scientific opinion on authorizations or permits that have the potential to impact the Reserve and its watershed.

Comment 2. Refers to current and potential collaboration between IDEBAJO and the Reserve in research, education and outreach areas**.** Indicates that IDEBAJO has previously suggested certain issues as possible research topics at the Reserve and the willingness to collaborate in that area. In addition that Dialogo youth group and other members do water monitoring and participate in coastal training program workshops. Diálogo Ambiental and IDEBAJO have organized multiple environmental awareness activities. The Committee would hope to continue collaborating with the Reserve by enabling local youth access to the Reserve. Indicates that Dialogo has a workshop program known as "Convivencia Ambiental", and an education commission was formed to plan the promotional, financial and logistical aspects of each of the one week long intensive workshops which are conducted in different Reserve facilities, including the offshore cays.

Reserve response: During the next management period, the Reserve will strengthen and improve initiatives to increase the participation of communities in research and education. The Conservation Action Education Program will serve to increase knowledge and engage community members as well as to increase the volunteer base. An action under this program is the Development of a Citizen Science Program at the Reserve, which is well aligned with IDEBAJO and Diálogo initiatives. The Reserve also plans to recruit a Volunteer Coordinator to support volunteers and community NGO, such as IDEBAJO in a number of projects and initiatives pertinent to Reserve themes and needs, in order to truly maximize the potential of a solid Volunteer Program.

Comment 3. Details Dialogo efforts to improve air and water quality in the Reserve, its surrounding communities and the watershed. It is currently working on issues related to the AES coal combustion plant located in the Jobos Bay watershed. In particular, a Coal Ash Campaign which is a collaborative effort with local and U.S. groups on issues related to "the indiscriminate use and accumulation of coal ash in flood prone areas, over sole source aquifers and in proximity to marginalized communities and sensitive environmental areas such as the Jobos Bay NERR". Details instances in which the company AES has been fined by the USEPA and the PREQB. Another projects include the protection of the South Coast Aquifer from garbage dump contamination, sprawling construction over Aquifer recharge areas and a large tire fire that contaminated Jobos Bay with PAHs, and most recently with the proposed Aguirre Offshore GasPort project.

Reserve response: Section 3.3 **"**Summary of threats and stressors- Degraded water quality" discusses impacts and concerns of industrial contamination on Reserve's habitats and proposed projects in the Reserve and its watershed. Jobos Bay NERR

Priority Issues also addresses these concerns under the "Habitat loss and degradation" section.

The Reserve staff will continue working with other DNER units (Legal Office, Permits, Ranger Corps among other) to address issues affecting the Reserve. For the next management period, the Reserve Research Program will continue monitoring water quality and will seek resources and collaboration to establish a ground-water quality monitoring program. In addition the Coastal Training Program will work with industries to address coastal management issues identified in this Plan.

Comment 4. Proposes to include additional results of the document "A Baseline Assessment of the Ecological Resources of Jobos Bay, Puerto Rico" from Whitall, D.R., B.M. Costa, L.J. Bauer, A. Dieppa, and S.D. Hile (eds.). 2011.

Reserve response: Information was added to the following sections of the Management Plan: Biological Resources-habitats-Coral Reefs and also in the Social Attributes section.

Comment 5. Refers to the ESA and ESA proposed species section of the Revised Alternative Pass Benthic Baseline Characterization Report for the Aguirre Offshore Gas Port project.

> "ESA and ESA proposed stony corals were regularly observed throughout the mapped hardbottom (reef) communities. *Acropora* (ESA-threatened and proposed for ESA-endangered) along with all seven ESA-proposed stony corals were observed during the survey. We must emphasize that frequency of observations during towed-diver surveys is a defensible indication of abundance; but these observations are not equivalent to abundance or density. *Acropora cervicornis* was only observed in the consolidated reef habitat (ESA reef #6) associated pipeline corridor segment 2 (see Figure 3-2). The seven ESA-proposed species were common throughout and often observed on multiple reef sites. The most frequent of the ESA-proposed species is *Montastraea faveolata* and the least frequent is *Mycetophyllia ferox*. Figure 3-2 delineates and enumerates (for cross- reference with Table 3-6) the reef sites where ESA and/or ESA proposed species were observed. Table 3-6 provides a summary of the listed and proposed coral species observations by rank order of frequency and by the corresponding reef site number presented in Figure 3-2.

Reserve response: The following paragraph was included in the description of coral habitats.

> The baseline benthic characterization for the Aguirre Offshore GasPort identified all seven ESA threaten listed species south of the cays, at the entrance of Boca del Infierno. These are elkhorn coral, staghorn coral, boulder star coral,

mountainous star coral (*Orbicella faveolata*), knobby star coral (*Orbicella franksi*), rough cactus coral (*Mycetophyllia ferox*) and pillar coral (*Dendrogyra cylindrus*).

Comment 6. Expresses concerns related to the Aguirre Offshore Gasport and resulting impacts on ESA coral listed species and benthic habitats. Indicates that the discussion in the Management Plan requires greater detail on additional imminent threats to JBNERR. Discusses the findings of the Laney Horizontal Directional Drill Preliminary Feasibility Study and its potential impacts on the Reserve's resources.

Reserve response: A more detailed discussion has been included in Section 3.3 Summary of threats and stressors.

Comment 7. Repeated references in the JBNERR Draft Management Plan to illegal fishing practices and over fishing are controverted. Comments make reference to the Tetra Tech, Inc., Jan. 2014, Aguirre GasPort Project ESA Coral Mapping and Demography, (p.4-3) study which indicates that the lack of habitat is the reason why few spiny lobsters were observed, and it does not mention overfishing.

Reserve response: The document does not mention overfishing or illegal fishing practices of spiny lobster. Overfishing and illegal fishing practices do occur and have been documented by the Reserve staff. Illegal fishing practices refer to the capture of land crabs and the use of nets in the Mar Negro area, among other. Recently a commercial fisher was intercepted with 412 sea cucumbers (*Holothuria Spp*.) in the Mar Negro Area. As a result, the DNER issued an Administrative Order (AO 2016-08) to prohibit the capture and possession of sea cucumbers (*Holothuria Spp*.) and sea urchins (*Class Echinoidea*) in territorial waters.

Comment 8. IDEBAJO and Dialogo contend that livelihood opportunities for local coastal communities seem more likely in ecotourism and value added activities such as seafood processing and/or restaurants as all local fishing groups have started to implement. To that end, IDEBAJO and Dialogo have collaborated extensively with Reserve management and staff on community outreach, capacity building and socio-productive alternatives including promotion of ecotourism and other sustainable activities. IDEBAJO and Dialogo have proposed the restoration and development of fish hatcheries according to traditional custom as described by Don Celedonio in "Los Placeres". This practice included selective trimming of mangrove roots, creating canals with access to the Bay. This allows small fish access to the Bay during low tide avoiding fish kills due to high heat and low oxygen levels of trapped water in congested mangrove canals. Host communities can be involved in managing these mangrove canals. A new

Reserve response: The Reserve will continue working with IDEBAJO and with local communities and partners to promote ecotourism and sustainable fishing practices, while balancing the need for resources protection.

Comment 9. New research area previously suggested by IDEBAJO and Diálogo is the carbon storage capacity of the Reserve. Wetland areas are generally able to sequester carbon at higher rates than other land-based systems. Research could be conducted on the current Reserve baseline and the potential for additional carbon storage. Wetlands such as those in the Jobos Bay NERR can be a tool in combating climate change. Biomass baselines should be determined for the Reserve. Performance goals for additional carbon storage can be established in collaboration with community NGO's who can provide surveillance and maintenance to ensure permanence and protection against carbon leakage. Perpetual conservation easements, land trusts or payment for ecosystem services can be used to create buffer zones for the Reserve.

Reserve response: Research on the Jobos Bay NERR blue carbon processes has been included in the Research component, Objective 1, Action 7 of the Management Plan.

Comment 10. Ongoing massive mangrove cutting and destruction, filling of wetlands and construction of structures in Camino del Indio in Las Mareas reflects the urgent need for Federal and Commonwealth agency enforcement action against the alleged owners of the summer homes and properties which requires further emphasis in the Draft Management Plan. Similarly, although the Draft Management Plan indicates that the use of jet skis is prohibited in all Reserve waters, jet skis operating at high speeds are commonly seen in Jobos Bay.

Reserve response: The Reserve's Director is requesting that additional enforcement staff is assigned to the Reserve. She will continue coordinating with the DNER legal and enforcement units as well as with other federal agencies to implement the Surveillance and Prevention Enforcement Strategic Plan of the PRDNER at JBNERR, and the legal strategic plan for the removal of illegal structures.

Comment 11. As noted in comments to a previous draft of the Management Plan, the community of San Felipe was omitted from the list of neighboring communities and the spelling of La Margarita should be corrected.

Reserve response: Corrections and additions made to Figure 4.

Comment 11. The unemployment rate in the Municipality of Salinas cited in the Draft Management Plan seems to be substantially understated.

Reserve response: The draft management plan does not include the unemployment rate for the Municipality of Salinas. It does include the rate for the watershed. However, this data was substituted with the population in the labor force, which is more representative of the employment situation in the watershed, where 61% of the population is not in the labor force (is not working and not actively looking for a job), according to the 2014 ACS. Unemployment rate for Salinas was included in the Jobs and employment trends section in Appendix 7. To be consistent with the data presented in the Management Plan, the 2014 ACS was used: unemployment rate in Salinas is 16.1% and Guayama is 20%. Recent data from the Puerto Rico Department of Labor and Human Resources reported that, as of July 2017, unemployment rate in Salinas is 19.3% and Guayama is 17.1%.

Comment 11. The JBNERR Management Plan should include information on air emissions and impacts in the Jobos Bay airshed. Discusses the emissions from Aguirre complex and AES Puerto Rico LLC and potential contaminants resulting from the construction and operations of Aguirre Offshore Gasport.

Reserve response: A section on the air quality was included in Section 3.3, Summary of threats and stressors. USEPA's Toxic Release Inventory: Facility Report was used as well as the information from the Reserve's profile that was updated in 2008. As indicated in the description, there's a need for additional studies and monitoring. This need was addressed in the Research Program section. Objective 3, action 7, which relates to monitoring of key species, includes the following:

> "The Reserve will also play an important role in closing the knowledge gaps and research needs related to: (1) the relation between airborne toxic compounds and their effects on the Reserve's species and habitats, and (2) the effects of climate change in marine mammals."