Habitat, Fish, & Wildlife

Cattle egrets (Bubulcus ibis) at *Martín Peña Channel*.

Chapter Four: Habitat, Fish, and Wildlife Action Plan

GOAL

Enhance and maintain an ecosystem which supports an optimum diversity of living resources on a sustained basis.

OBJECTIVE 1

Preserve and restore ecologically important habitat.

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Objective 2

Protect species relative abundance and diversity.

Action HW-9 Establish management measures within the SJBE system for the land crab *Cardisoma guanhumi*. Page 146

Action HW-10 Implement a sea turtle recovery plan. Page 149

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Action HW-14 Protect existing populations of endangered and threatened bird species and protect and restore their habitat within the SJBE system. Page 159

Action HW-15 Estimate the population and habitat use of the West Indian manatee within the SJBE and establish manatee protection zones. Page 162

Action HW-16 Substitute cayeput trees (*Melaleuca quinquenervia*) with native species and prohibit planting of the tree in the SJBE. Page 165

Objective 3

Enhance economically valuable fisheries resources and ensure their sustainability.

Action HW-17 Determine historic and present recreational fishing areas in the SJBE and develop a plan to adequately manage recreational fishery resources. Page 170

Action HW-18 Support enactment of the new fisheries law by the legislature and the governor. Page 173

HW-1 Plant Mangroves Along the Western Shoreline of San Juan Bay.

Background

Historically, the western shore of San Juan Bay, especially the area between Punta Cataño and Punta Palo Seco (known previously as Playa de las Mazas), consisted of an impressive sandy beach that in some areas reached more than 120 feet (40 m) in width (Seguinot-Barbosa, 1983). The shore between Punta Cataño and the area known as the Army Terminal was occupied by a dense mangrove forest (U.S. Department of Commerce, 1976), providing valuable fish and wildlife habitat and protection against coastal erosion.

Modifications to the western shoreline of San Juan Bay began with sand mining during the early decades of the 20th century. Over the years, alterations to the natural features of the area increased as the mangroves were covered with fill material to provide areas for development. By 1939, the Sabana community was established at the southwestern part of the bay over previously filled mangrove areas (Ramos-Vélez, 1995). The remaining mangroves fringing this section of the bay were filled with the material that was dredged for construction of the Army Terminal and its channel during the 1940s. During the 1960s, a rice mill and the Vietnam community were established on the filled area (Ramos-Vélez, 1995). These activities eliminated the mangroves and the protection they previously provided against coastal erosion on this section of the bay.

Today, ocean swells and waves entering San Juan Bay are not being dissipated as they were prior to the various dredging events related to port activities. The bay's bottom, being deeper, is not as effective as it was originally in reducing the energy of the incoming waves. In addition, the relocation of the outlet of the Puerto Nuevo River during the 1950s and the Bayamón River in 1980 may have diminished the amount of sediments nourishing the Cataño and Guaynabo coastline (Seguinot-Barbosa, 1983). These factors, along with the elimination of fringing mangroves, have increased coastal erosion along San Juan Bay's western shoreline. Although the placement of a rock revetment in the 1970s helped stabilize the rate of erosion, this method of protection is aesthetically displeasing and does not provide quality habitat for fish and wildlife.

The Cataño Municipality is currently constructing a waterfront development project that will include a pedestrian sea wall. This type of development could eliminate the potential for habitat enhancement along San Juan Bay. In addition, the Guaynabo shoreline is being filled by local residents with debris and other materials as a means to stop erosion, diminishing the environmental and aesthetic value of this area.

Please see map for this action in Appendix A.

Strategy

1.1 Identify those areas with suitable conditions (depth, substrate, wave energy, etc.) for mangrove forestation.

Implementing partners: DNER (lead), SJBE Program
Schedule: Long-term
Cost: $8,000

1.2 Coordinate the integration of a mangrove planting project with the Cataño Waterfront Development Project. The same effort should be coordinated with the Guaynabo municipality.

Implementing partners: DNER (lead), SJBE Program, Municipalities of Cataño and Guaynabo, USACE, PRPA, Local Communities
Schedule: Long-term
Cost: $3,500

1.3 Initiate the mangrove planting project.

Implementing partners: DNER (lead), SJBE Program, Municipalities of Cataño and Guaynabo, Local Communities
Schedule: Long-term
Cost: $82,280

1.4 Monitor mangrove survival rate and replace seedlings as necessary.

Implementing partners: DNER (lead), SJBE Program, Municipalities of Cataño and Guaynabo, Schools, Universities, Local Communities
Schedule: Long-term. Coordination of monitoring efforts should be initiated immediately after planting.
Cost: $40,000

Expected Benefits

The establishment of mangroves along the shorelines of San Juan Bay will provide improved habitat for the living resources of the estuary. The fisheries of the bay and nearby ocean waters will benefit from this action. A fringe of mangroves will provide a self-sustaining structure for protection against coastal erosion. Water quality will improve through the functions provided by the mangroves such as sediment stabilization and nutrient removal. The aesthetics of the area will be enhanced.

Monitoring Environmental Response/Programmatic Implementation

The survival rate of mangrove propagules will be monitored, and those that die or have been washed away by currents will be replaced. This will be done until the seedlings are of sufficient size to ensure their establishment.

Regulatory Needs

Coastal zone consistency certification should be obtained.

Acronyms
PR = Puerto Rico
SJBE = San Juan Bay Estuary
USACE = United State Army Corps of Engineers
DNER = Department of Natural and Environmental Resources
PRPA = Puerto Rico Ports Authority

HW-2 Restore Seagrass Beds in the Condado Lagoon.

Background

The Condado Lagoon covers an area of 102 acres (39.5 ha). Originally, it had an average depth of 7.6 feet (2.3 m) and did not exceed 23 feet (7 m) (U.S. Department of Commerce, 1976; Ellis, 1976; Ellis and Gómez-Gómez, 1976). It is believed that the environmental conditions in the lagoon, including its protected, calm, shallow waters; a substrate composed of dark silt, clay, and sand; and freshwater inflow which was limited to stormwater runoff from the limited adjacent uplands, should have created the necessary requirements for the establishment of seagrasses (Blest, 1966).

Modifications to the Condado Lagoon began as early as the 18th century, but the activities that had the most significant impacts on its living resources occurred during the first half of the 20th century. The construction of the Dos Hermanos Bridge, upgrades to the San Antonio Bridge, and filling of the extreme northwestern part of the lagoon for the placement of military quarters during the first decades of this century were probably the first activities that could have eliminated seagrasses. However, urban development adjacent to the Condado Lagoon has had the most widespread effect on the health of its biological communities.

By 1908, the establishment of a residential district was already in progress in the lands between the lagoon and the ocean (Sepúlveda-Rivera and Carbonell, 1988). This community, together with subsequent structures built in nearby areas, such as Miramar, discharged raw sewage directly into the lagoon or to storm drains that eventually reached the water body. The Condado Lagoon, already affected by poor water circulation due to the placement of rocks for the construction of the causeway in the eastern abutment of the Dos Hermanos Bridge, began experiencing water quality problems. By 1955, this situation was so severe that the lagoon was considered an open sewer (Rivera-Cabrera, 1990).

In the late 1950s, the Condado Lagoon was dredged to approximately 36 feet (11 m) in depth (Ellis and Gómez-Gómez, 1976). This event took place in the eastern section of the lagoon, and, as a result, 20 percent of its total area was dredged (Ellis, 1976).

It is believed that benthic communities, such as seagrass beds, were significantly affected by the poor water quality conditions. Remaining seagrass beds would have been destroyed from the dredging activities.

The health hazards associated with the water quality of the Condado Lagoon prompted the government to construct a sanitary sewer system in 1969 to service the structures that were discharging their raw sewage into the water body (Rivera-Cabrera, 1990). This effort, and the enlargement of the Dos Hermanos Bridge to increase water flow into the lagoon, significantly improved the water quality of the area. In addition, in the late 1970s, the EQB issued cease and desist orders to those discharging into the lagoon or storm sewers. As a result, seagrass beds have been established in the western half of the lagoon and in a narrow fringe across its northern shore. However, seagrasses have not been successfully established in the deeper dredged area; this area may be too deep for sunlight to reach the bottom and allow the development of this benthic community.

Please see map for this action in Appendix A.

Strategy

2.1 Conduct a survey of the depression to determine the presence of biological communities that could be affected by the filling of the area. A study to identify the benthic communities found in the estuary, including those found in the Condado Lagoon, is being conducted as part of the characterization process of the SJBE Program. Further actions will depend on the findings of this study.

Implementing partners: NMFS, USEPA (lead parties), DNER, SJBE Program
Schedule: Ongoing
Cost: Included as part of the SJBE Program Benthic Study.

2.2 Conduct a detailed survey of the present extension and depth of the depression to determine the volume of material needed to fill it. The USACE, as part of the hydrodynamics/water quality model project for the SJBE Program, developed a bathymetric map of the estuary. If this map has enough detail, no further survey should be required.

Implementing partners: DNER (lead), USACE, EQB
Schedule: Long-term
Cost: $20,000

2.3 Identify source(s) for suitable fill material. Perform sampling and laboratory analysis to evaluate toxicity of fill material. Potential sources of fill include dredged material from San Juan Bay's Navigational Channel Project and the navigational channel that will be constructed for the Convention Center to be located in Isla Grande, as part of the Golden Triangle project.

Implementing partners: DNER (lead), USEPA, EQB, USACE
Schedule: Long-term
Cost: $260,000

2.4 Initiate filling of the dredged depression once the necessary permits have been obtained.

Implementing partners: DNER (lead), PRPB, USACE, USEPA, EQB
Schedule: Long-term
Cost: $1,332,000

Expected Benefits

An increase in the area occupied by seagrasses will enhance the fisheries of the Condado Lagoon, including species of commercial importance. Sport fishermen who currently use the San Antonio Bridge will benefit significantly from this action. Endangered species such as the green turtle and the manatee, which depend almost exclusively on seagrasses for their dietary needs, will be positively affected from an increase in their food supply. An increase in the living resources of the lagoon will enhance the recreational activities that can be performed (e.g., scuba diving, snorkeling) by local residents and the tourists staying at nearby hotels. The reduction in the water volume of the lagoon

is expected to reduce the time needed by the lagoon to renew its waters, and thereby improve water quality. Water quality also will improve through the functions provided by the seagrasses, such as sediment stabilization and oxygen production.

Monitoring Environmental Response/Programmatic Implementation

Water quality will be monitored periodically, and the filled area will be surveyed to determine if it is being colonized by seagrasses. Planting of seagrasses would be desirable in order to accelerate the establishment of this benthic community. Sewage discharges due to overflows and malfunctioning sewage pumps in the area must be resolved. These incidents occur mostly along the eastern and southern shores of the lagoon.

Regulatory Needs

A Clean Water Act Section 404 permit and associated coastal zone and water quality certifications should be obtained.

Acronyms
DNER = Department of Natural and Environmental Resources
EQB = Environmental Quality Board
NMFS = National Marine Fisheries Service
PRPB = Puerto Rico Planning Board
SJBE = San Juan Bay Estuary
USACE = United States Army Corps of Engineers
USEPA = United States Environmental Protection Agency

HW-2

HW-3 Plant Mangroves Along the Shores of the Condado Lagoon.

Background

The Condado Lagoon, with its protected, calm waters, historically provided the appropriate conditions for the establishment of mangroves along its shores. However, due to the slope of the adjacent uplands, only a narrow fringe of mangroves developed in the lagoon (Sepúlveda-Rivera, 1989), with the exception of the area east of the lagoon where approximately 15 acres (6 ha) of mangrove forest existed on relatively level lands (Lebrón Associates, 1988).

The first human impacts to the Condado Lagoon may have been related to the development of subsistence activities such as fishing and the clearing of vegetation for agriculture (e.g., coconut plantations) and charcoal production (Seguinot-Barbosa, 1983; Sepúlveda-Rivera and Carbonell, 1988). However, it was not until the present century that the landscape of the region experienced changes that had a permanent negative effect on its biological communities, especially those associated with wetlands. During 1915, the mangrove forest at the east end of the lagoon was cut down and the area was filled. During the 1930s, the south side of the lagoon began to be cut and filled for the establishment of small private piers and cabins (Seguinot-Barbosa, 1983). In the late 1950s, the south side of the Condado Lagoon was dredged and significantly filled for the construction of Baldorioty de Castro Avenue. During the early 1960s, most of the north shore was filled for the development of tourism-related facilities. Together, these activities caused the destruction of almost all of the mangroves that bordered the lagoon.

Today, the only extensive area in which mangroves can be found is on the northeast side of the lagoon in a small tidal creek where a storm sewer discharges. This site is possibly one of the few areas shallow enough to allow the establishment of mangrove propagules. In addition, it is one of the few areas where the shoreline has not been significantly altered or hardened. Along the south shores of the lagoon, only a few small mangroves were able to grow between the riprap placed along the shoreline.

The Department of Sports and Recreation, through the Park Trust, proposes to extend the Condado Park located on the south side of the Condado Lagoon to other areas surrounding this waterbody. The proposed extension may require the placement of fill material along the northern shoreline and the northeastern-most area, where the most significant mangrove stand exists, for the construction of a pedestrian seawall. This could further impact the limited living resources found in the lagoon and eliminate the opportunity for mangrove enhancement in the area.

Please see map for this action in Appendix A.

Strategy

3.1 Identify those areas along the Condado Lagoon with conditions (depth, substrate, wave energy, etc.) suitable for mangrove forestation.

Implementing partners: DNER (lead), SJBE Program
Schedule: Long-term
Cost: $8,000

3.2 Coordinate the integration of a mangrove planting project with the government agencies involved with the extension of the Parque Laguna del Condado.

Implementing partners: DNER (lead), Puerto Rico Park Trust, SJBE Program, USACE, Municipality of San Juan
Schedule: Long-term
Cost: $3,500

3.3 Initiate the mangrove planting project.

Implementing partners: DNER (lead), SJBE Program, Municipality of San Juan, Local Communities
Schedule: Long-term
Cost: $18,000

3.4 Monitor mangrove survival rate and replace seedlings as necessary.

Implementing partners: DNER (lead), Puerto Rico Park Trust, SJBE Program, Community Groups
Schedule: Long-term
Cost: $14,000 (not including seedling replacement)

HW-3

Expected Benefits

An increase in the area occupied by mangroves will enhance the fisheries and wetland and arboreal wildlife of the Condado Lagoon. Water quality will improve through the functions provided by the mangroves such as sediment stabilization and nutrient removal. An increase in the living resources and water quality of the lagoon will enhance the potential for recreational activities for residents and tourists staying at nearby hotels, such as fishing from the San Antonio Bridge, scuba diving, and birdwatching. A fringe of mangroves will provide a self-maintainable structure for protection against coastal erosion. The aesthetics of the area will be enhanced, since at the present time most of the western and northern banks of the Condado Lagoon are bordered with a concrete wall and rubble.

Monitoring Environmental Response/Programmatic Implementation

The survival rate of mangrove propagules will be monitored, and those that die or have been washed away by currents will be replaced. This will be done until the seedlings are of sufficient size to ensure their establishment.

Regulatory Needs

Compatibility with the Planning Board's Special Zoning Regulation for the Condado Area should be ensured, and coastal zone consistency certification should be obtained.

Acronyms
DNER = Department of Natural and Environmental Resources
SJBE = San Juan Bay Estuary
USACE = United States Army Corps of Engineers

HW-4 Designate a Section of the Martín Peña Channel and Lands Adjacent to the Puerto Nuevo River as a Nature Reserve.

Background

The Martín Peña Channel-Puerto Nuevo River Wetland Complex has endured many decades of human interference. This area has been significantly altered by the disposal of dredged material, the discharge of raw sewage, the placement of a sanitary landfill, the construction of housing and industrial and port facilities, and the realignment of this section of the river. These activities have destroyed more than 70 percent of the wetlands that once occupied this segment of the estuary (Coastal Environmental, Inc., 1997).

In spite of these impacts, the Martín Peña Channel-Puerto Nuevo River Wetland Complex continues to be recognized as one of the most important natural sites in Puerto Rico (Raffaele, 1979; Cardona and Rivera, 1988; U.S. Department of Commerce and PR Department of Natural Resources, 1978). Once, this area was noted for sustaining the greatest diversity and concentration of birds anywhere on the Island (Raffaele, 1979). The area still provides spawning grounds for fisheries and controls floods that affect the Puerto Nuevo-Bechara-Kennedy area. In addition, the wetlands filter out nutrients and contaminants from runoff before it reaches San Juan Bay. The area along the Martín Peña Channel also provides recreational activities at places like Parque Central and the Enrique Martí Coll Lineal Park, where thousands of people practice sports and other recreational activities every day.

Today, the Martín Peña Channel-Puerto Nuevo River Wetland Complex is under severe development pressure which threatens to permanently destroy most, if not all, of its functions.

Please see map for this action in Appendix A.

Strategy

4.1 Compile the necessary information (i.e., proposed limits, natural resources inventory, land ownership, and acquisition costs) to designate the Martín Peña Channel-Puerto Nuevo River Complex as a Nature Reserve.

Implementing partners: DNER (lead)

Schedule: Short-term. A Martín Peña Channel Reserve designation document has been submitted by the DNER to the relevant agencies for comment. The next step is for the DNER to submit the final designation document for PRPB consideration. DNER's proposed Martín Peña Channel Reserve does not include lands adjacent to the Puerto Nuevo River. However, a wetland area of approximately 71 acres (29 ha) associated with the Puerto Nuevo River (Rupert Armstrong Farm) is already under a conservation easement.

Cost: $40,000 (Cost does not include land acquisition.)

4.2 Seek endorsement by government agencies that have land ownership rights in the proposed area.

Implementing partners: DNER (lead), PRPA, Municipality of San Juan, PR Land Administration, PR Industrial Development Corporation
Schedule: Short-term
Cost: $15,000 to $20,000 (Cost does not include land acquisition.)

4.3 Designate the Martín Peña Channel-Puerto Nuevo River Complex as a Nature Reserve.

Implementing partners: PRPB (lead), DNER
Schedule: Short-term
Cost: $5,000 to $7,000 (Cost does not include land acquisition.)

4.4 Manage the nature reserve. This should include establishing the carrying capacity of the nature reserve and creating buffer zones as transition areas between urban areas and the reserve.

Implementing partners: DNER (lead), Municipality of San Juan
Schedule: Short-term
Cost: $120,000 per year (Cost does not include land acquisition.)

Expected Benefits

The designation of the Martín Peña Channel-Puerto Nuevo River Wetland Complex as a Nature Reserve will unify a region that is being gradually segmented, optimizing its management. The protection of the Wetland Complex will help to create a corridor that will allow the movement or dispersion of flora and fauna through the various waterbodies that comprise the estuary. This designation will protect most of the services intrinsically provided by the natural systems found in the proposed area and will help satisfy the need for nature-oriented activities, currently the most demanded type of recreational activity in Puerto Rico (Marvel, Flores, Cobian and Associates, 1994). For example, the designation will promote the enhancement of highly degraded areas such as the San Juan Sanitary Landfill. After its imminent closure, the Municipality of San Juan plans to turn the landfill into a park to be known as Parque de la Paz. The park could be forested and developed with amenities related to active and passive nature-oriented activities, such as observation towers and hiking and biking trails.

Monitoring Environmental Response/Programmatic Implementation

The carrying capacity of the lands included in the nature reserve should be determined to protect the area from overuse or from activities being developed in adjacent areas. Buffer zones should be established where only those land uses that produce a transition between the urban and the natural landscape will be permitted.

Regulatory Needs

The PR Coastal Zone Management Program should be amended to include the Martín Peña Channel and the Puerto Nuevo River complex as a Nature Reserve. The Martín Peña Channel-Puerto Nuevo River Complex Nature Reserve should be incorporated in the land use plans of the PRPB.

Acronyms
DNER = Department of Natural and Environmental Resources
PR = Puerto Rico
PRPB = Puerto Rico Planning Board
PRPA = Puerto Rico Ports Authority

HW-5 Plant Mangroves Along the Shores of the San José and Los Corozos Lagoons.

Background

The San José and Los Corozos Lagoons, the estuary's waterbodies most affected by fresh water inflows, have approximately 8.4 miles (13.5 km) of shoreline (Negrón-González, 1986). Based on their natural characteristics, these lagoons were probably fringed by mangrove trees prior to development and modification of the shoreline.

The first human impacts occurred along the southwestern shores of these two lagoons during the beginning of this century with the filling of wetlands for the construction of housing. Development in these segments of the San José and Los Corozos Lagoons has almost completely eliminated the mangrove vegetation and the valuable functions provided by this type of natural community, including habitat for fish and wildlife as well as sediment stabilization and nutrient removal.

Please see map for this action in Appendix A.

Strategy

5.1 Coordinate the integration of a mangrove planting project with the urban renewal project, known as the New Gate of San Juan and the CPP.

Implementing partners: DNER (lead), SJBE Program, USACE, Municipality of San Juan, Community Groups
Schedule: Long-term
Cost: $8,000

5.2 Identify those areas along the southwest shore of the San José Lagoon and the western shore of Los Corozos Lagoon with conditions (depth, substrate, wave energy, etc.) suitable for mangrove forestation.

Implementing partners: DNER (lead), SJBE Program
Schedule: Long-term
Cost: $3,500

5.3 Initiate the mangrove planting project.

Implementing partners: DNER (lead), SJBE Program, Municipality of San Juan, Local Communities, Community Groups
Schedule: Long-term
Cost: $41,000

5.4 Monitor mangrove survival rate and replace seedlings as necessary.

Implementing partners: DNER (lead), Municipality of San Juan, Community Groups
Schedule: Long-term
Cost: $25,000

Expected Benefits

An increase in mangroves in the area will enhance the fisheries and wildlife of the San José and Los Corozos Lagoons. Water quality will improve through the functions provided by the mangroves, such as sediment stabilization and nutrient removal, and the fringe of mangroves will act as a buffer zone for floods. An increase in the living resources and water quality of the lagoons will enhance the potential for recreational activities for residents and tourists, such as sport fishing, kayaking, the use of small sailboats, and birdwatching. The aesthetics of the area will be enhanced, since at the present time most of the southwestern shorelines of the San José and Los Corozos Lagoons are bordered with rubble. This is very important since this area is being planned for a major urban renewal project, the New Gate of San Juan.

Monitoring Environmental Response/Programmatic Implementation

The survival rate of mangrove propagules will be monitored, and those that die or have been washed away by currents will be replaced. This will be done until the seedlings are of sufficient size to ensure their establishment.

Regulatory Needs

A Clean Water Act Section 404 permit and associated coastal zone and water quality certifications should be obtained.

HW-5

Acronyms
DNER = Department of Natural and Environmental Resources
SJBE = San Juan Bay Estuary
USACE = United States Army Corps of Engineers
CPP = Cantera Peninsula Project

HW-6 Designate the Torrecilla Alta-Vacía Talega Area as Part of the Piñones State Forest Nature Reserve.

Background

The Torrecilla Alta-Vacía Talega area (hereafter referred to as Torrecillas) is perhaps the region most studied and recognized for its natural importance in the SJBE system. Since the 1970s, efforts have been underway to designate this area as a Nature Reserve (U.S. Department of Commerce and PR Department of Natural Resources, 1978; Coastal Zone Management Program, 1983).

The Torrecillas region is located on a major flood plain and has most, if not all, of the emergent types of wetlands found in Puerto Rico. Together with the Piñones Forest, the Torrecillas region contains the largest mangrove forest on the Island. The endangered yellow-shouldered blackbird has been reported in this mangrove forest. The Torrecillas area also includes one of the few Bloodwood (*Pterocarpus officinalis*) forests remaining in Puerto Rico. This forest is known for supporting the West Indian whistling duck and the masked duck, two of the Commonwealth's threatened species (Coastal Zone Management Program, 1983). The Torrecillas area also includes a large freshwater marsh where various small pools can be found, making it an ideal habitat for waterfowl and other species of birds (Raffaele, 1979). The southern end of Torrecillas is formed by a chain of haystack hills (mogotes) where Commonwealth and federal threatened and endangered species such as the Puerto Rican boa (*Epicrates inornatus)* and the white crowned pigeon have been reported (Raffaele, 1979; Pérez and Howard, 1980). The northern end of Torrecillas consists of a system of sandy beaches where the leatherback and hawksbill sea turtles, two Commonwealth and federal endangered species, nest (Cardona and Rivera, 1988). Along with the rocky coast comprised by the various headlands found in the region (e.g., Punta Vacía Talega), the northern Torrecillas area serves as habitat for rare, threatened, and endangered species such as the brown pelican, the roseate tern, the least tern, and various plants (i.e., *Schoepfia arenaria*, *Coccoloba sintenissii*, *Manilkara pleeana*, etc.) (Rivera-Herrera, 1996).

The natural systems found in Torrecillas provide important functions for both the living resources of the region and the residents of the SJBE and nearby municipalities. The wetlands of the Torrecillas store and filter flood waters produced by the Río Grande de Loíza and by heavy seas, as well as the runoff from adjacent uplands, such as the leachate produced by the Carolina Regional Sanitary Landfill. The sand dunes protect residences and other structures from the floods generated by swells, especially those produced during hurricanes and cold front events. The forested or vegetated areas of the Torrecillas region act as a "lung" and help regulate the temperature of the highly urbanized areas of San Juan and Carolina located to the west.

The very diverse natural resources found in the Torrecillas area support many recreational activities enjoyed by tourists and residents of the San Juan Metropolitan Area. Most of the approximately 7 miles (12 km) of beaches in the area are intensively used for activities such as picnicking, bathing, surfing, and other related water sports (Junta de Planificación, 1992). The natural landscape provides the perfect setting for the development of these and other recreational activities. Due to this setting,

the Torrecillas area has been under severe development pressure for many years. The development of intensive land use activities such as condos, hotels, and housing units would certainly degrade the area's natural resources, which, in turn, would negatively impact present and proposed uses, impairing the benefits currently enjoyed by all SJBE citizens.

Please see map for this action in Appendix A.

Strategy

6.1 Compile the necessary information (i.e., proposed limits, natural resources inventory, land ownership, and acquisition costs) to designate the area comprised by the Torrecilla Alta and Vacía Talega areas as part of the Piñones State Forest Nature Reserve.

Implementing partners: DNER (lead)
Schedule: Short-term. Step 1 was partially developed in 1983 by the DNER; however, this information should be updated (Coastal Zone Management Program, 1983).
Cost: $65,000 (Cost does not include land acquisition.)

6.2 Seek endorsement by government agencies and private citizens that have land ownership rights in the proposed nature reserve. It will be preferable to purchase land subject to designation.

Implementing partners: DNER (lead)
Schedule: Short-term
Cost: $20,000 (Cost does not include land acquisition.)

6.3 Expand the Piñones State Forest Nature Reserve through designation of the Piñones-Torrecilla-Vacía Talega Nature Reserve. The proposed area is shown on the map in Appendix A. The area currently zoned as Desarrollo Turistico Selectivo (DTS) is not included.

Implementing partners: PRPB (lead), DNER
Schedule: Short-term
Cost: Costs included under Steps 6.1 and 6.2.

6.4 Manage the nature reserve. A plan should be developed that incorporates the community's needs and ensures its participation in the management of the reserve.

Implementing partners: DNER (lead), Local Communities
Schedule: Short-term
Cost: $50,000 per year (Management costs will include patrolling, enforcement, and other administrative costs. Cost does not include land acquisition.)

Expected Benefits

The designation of the Torrecillas area as part of the Piñones State Forest Nature Reserve will protect and conserve its natural resources and its overall benefits. The current proposed land uses for most of the area, determined by its zoning (i.e., CR-1, CR-2 (Resource Conservation) and B-2

(Mangrove forest)) will be highly strengthened (Negociado de Planes de Usos de terrenos, 1995). Environmentally sound tourist and recreational activities will be enhanced through this action, since the area will have the potential to provide the kind of amenities that are not available in urbanized areas such as the Isla Verde Tourist District. The management of this area as a nature reserve will also help satisfy the need for nature-oriented activities, currently the most demanded type of recreational activity in Puerto Rico (Marvel, Flores, Cobian and Associates, 1994). Torrecillas could host activities such as horse back riding and camping that the other proposed nature reserves (Martín Peña Channel-Río Puerto Nuevo Wetland Complex, Las Cucharillas Marsh) can not provide. The efforts conducted for the recovery of rare, threatened, or endangered species in Puerto Rico which are found in Torrecillas will be more effective and efficient, since a considerable area comprising the habitats on which most of these species depend will be protected. Also, the fish nursery function of the wetland will be conserved.

Monitoring Environmental Response/Programmatic Implementation

The carrying capacity of the reserve will be determined so its main amenities, its habitats and living resources, will not be degraded from overuse or other activities being developed in adjacent areas. Buffer zones will be established where only those land uses that produce a transition between the urban and the natural landscape will be permitted.

Regulatory Needs

Development in areas such as segments south of Road PR-187 and the northeastern segment of Torrecillas should be limited to protect the aesthetic and natural values of the region. The Piñones Special Planning Area Management Plan and Land Use Plan should be amended as necessary. The PR Coastal Zone Management Program should be amended to include the Torrecilla Alta and Vacía Talega areas as part of the Piñones State Forest Nature Reserve.

HW-6

Acronyms
DNER = Department of Natural and Environmental Resources
PR = Puerto Rico
PRPB = Puerto Rico Planning Board
SJBE = San Juan Bay Estuary

HW-7 Restore Seagrass Beds within the SJBE.

Background

Seagrasses are one of the most important types of bottom habitats found in estuaries. Because of their dependency on light, seagrass meadows are restricted to shallow areas within estuaries. Seagrasses provide shelter and serve as nurseries and feeding habitats for different species of fish and invertebrates during different stages of their life cycle (Laegdsgaard and Johnson, 1995). Seagrasses also are the main food source for endangered species such as manatees and sea turtles. Endangered brown pelicans prey on fish that feed in the shallow waters of seagrass meadows.

Preliminary studies have documented seagrasses in the Condado and La Torrecilla Lagoons, as well as San Juan Bay. However, according to anecdotal information, other areas within the SJBE supported this type of habitat in the past. Dredging and filling throughout the estuary system is thought to be one factor responsible for the disappearance of seagrass beds. Another reason for the loss of seagrass cover in the SJBE may have been a reduction in water transparency. Much of the color and turbidity in the water column is caused by phytoplankton (algae) whose growth is accelerated by high nutrient levels in the water. These high nutrient levels are brought into the system by sewage and storm runoff. Seagrasses have some capacity to settle inorganic sediments, but they have no capacity to decrease plankton concentrations in the water column. Thus, when actions concerning water quality improvement are well underway, reintroduction of seagrasses to areas where they were formerly found, or in other areas with proper conditions for their establishment, will be viable through natural or artificial restoration.

Strategy

7.1 Determine areas within the SJBE historically associated with seagrasses.

Implementing partners: DNER (lead), NOAA, USFWS
Schedule: Long-term
Cost: $50,000 to $65,000

7.2 Monitor seagrass growth once the water quality is sufficient to support the continued existence of seagrasses.

Implementing partners: DNER (lead), NOAA, USFWS, USEPA
Schedule: Long-term
Cost: $40,000

7.3 Determine what, if any, factors other than water quality could be inhibiting seagrass growth.

Implementing partners: DNER (lead), EQB, USEPA
Schedule: Long-term
Cost: Costs dependent on information gathered in Step 7.2.

7.4 Correct factor(s) inhibiting seagrass development identified in Step 7.3 (if applicable).
Implementing partners: DNER (lead), EQB, USEPA
Schedule: Long-term
Cost: Costs dependent on information gathered in Step 7.2.

7.5 Repeat step 2 (if applicable).
Implementing partners: DNER (lead), EQB, USEPA
Schedule: Long-term
Cost: Costs dependent on information gathered in Step 7.2.

7.6 Conduct an artificial restoration pilot study (if applicable).
Implementing partners: DNER (lead), EQB, USEPA
Schedule: Long-term
Cost: Costs dependent on information gathered in Step 7.2.

Expected Benefits

The restoration of seagrass beds and overall benthic communities in certain areas will directly benefit a variety of living resources in the estuary, including a variety of fish species that depend on seagrass beds for nurseries, food, and shelter. An increase in these species will benefit local fishermen and communities by enhancing fishery resources within and outside of the SJBE. Improvements in water clarity and quality associated with the development of seagrass beds will aesthetically enhance tourist areas and enhance internal and external tourism activities. Improvements in water quality will maximize the ecosystem potential of the estuary. Seagrass beds will provide a needed source of food for endangered species such as manatees and sea turtles.

Monitoring Environmental Response/Programmatic Implementation

Appropriate agencies will coordinate to assess seagrass recovery and monitor seagrass beds.

Regulatory Needs

None.

Acronyms
DNER = Department of Natural and Environmental Resources
EQB = Environmental Quality Board
NOAA = National Oceanic and Atmospheric Association
SJBE = San Juan Bay Estuary
USEPA = United States Environmental Protection Agency
USFWS = United States Fish and Wildlife Service

HW-8 Designate Las Cucharillas Marsh as a Nature Reserve.

Background

Las Cucharillas Marsh is located in the municipalities of Cataño and Guaynabo. It covers approximately 1,236 acres (500 ha), consisting mostly of herbaceous wetlands, but also includes mangroves and open water areas. The area serves as a floodplain for the Santa Catalina, Lajas, and Diego creeks that are connected to San Juan Bay by means of the Malaria Canal. The Aguas Frías Channel, which connects to the original Bayamón River channel, and the severely constricted San Fernando Channel also drain the marsh.

Ecologically, the marsh contains the highest diversity of waterfowl documented in all the SJBE. Migratory species such as the American black duck (*Anas rubripes*), the green-wing teal (*Anas crecca*), and the northern shoveler (*Anas clypeata*) have been reported. Native species considered by the DNER as critical elements and that thrive in considerable numbers include the ruddy Duck (*Oxyura jamaicensis*), the white-cheeked pintail (*Anas bahamensis*), the West Indian whistling-duck (*Dendrocygna arborea*), and especially the Caribbean coot (*Fulica caribaea*). The yellow-shouldered blackbird (*Agelaius xanthomus*), an endemic and endangered species, has been consistently observed in the marsh in recent years.

As important as it is for wildlife, Las Cucharillas Marsh has an equally or superior role regarding flood protection and water quality improvement. The communities of Puente Blanco, Las Cucharillas, Juana Matos, and Reparto El Paraíso are located in a highly flood prone area and therefore rely on the marsh for flood water storage. In addition, many of these communities lack sanitary sewer systems and discharge raw sewage either directly into the drainage creeks of the marsh or to inefficient household septic systems. Runoff waters from the industrial parks of Las Palmas, Amelia, and Luchetti, the latter of which has a petroleum refining facility, end up in the marsh. Las Cucharillas Marsh serves as a filter and provides water treatment for these discharges before they enter the estuary.

In order to preserve these important functions, the DNER designated part of Las Cucharillas Marsh as a Wildlife Reserve in 1979. However, since that time, filling for residential, industrial, and storage facilities has continued in the marsh, threatening its fragile integrity. Also, the disposal of solid wastes has been taking place at several sites within the marsh. Las Cucharillas Marsh is being fragmented by these activities and is specially endangered by the proposed improvements to the Malaria Canal, which will increase its capacity for draining the wetlands.

In response to the current threats to the area and in recognition of its economic importance, several community organizations, such as the Comité Pro Rescate de Juana Matos and the Comité de Vecinos de Puente Blanco, have expressed their interest in managing the marsh as an ecotourism resource. The SJBE Program has been assisting these groups through an action plan demonstration project that provides the basic tools and encourages community involvement in the sustainable development of the marsh. Implementing these techniques would not only protect the ecology of Las Cucharillas Marsh and that of the SJBE, but also could create a much needed source of revenue for the citizens of the low-income communities in Cataño.

Please see map for this action in Appendix A.

Strategy

8.1 Compile the necessary information (i.e., proposed limits, environmental impact of air pollutants, natural resources, land ownership, and acquisition costs) to designate the area as a nature reserve. As part of this step, a detailed study of the Ciénaga de las Cucharillas flora and fauna will be performed to assess the possible impact of pollution on this ecosystem.

Implementing partners: DNER (lead), SJBE Program, Local Communities
Schedule: This step was partially completed by the PR Conservation Trust between 1996-1997.
Cost: $65,000 (Cost does not include land acquisition.)

8.2 Seek endorsement by government agencies and private citizens that have land ownership rights in the proposed nature reserve. It would be preferable to purchase the lands subject to designation. Urban development in the Cucharillas wetland area should not be allowed.

Implementing partners: DNER (lead)
Schedule: Short-term
Cost: The PREPA, through a fine imposed by USEPA, is obligated to provide funds for efforts involving the conservation of Las Cucharillas Marsh; these funds could be used to partially finance this step.

8.3 Designate Las Cucharillas Marsh as a nature reserve.

Implementing partners: PRPB (lead), DNER
Schedule: Short-term
Cost: Costs included under Steps 8.1 and 8.2

8.4 Manage the nature reserve. A plan should be developed that incorporates the community needs and their participation in the management of the reserve. Recommendations from the action plan demonstration project, once completed, could be implemented through this step. A native species wetland restoration program should be initiated at this stage.

Implementing partners: DNER (lead), Local Communities
Schedule: Short-term
Cost: $50,000 per year (Management costs will include patrolling, enforcement and other administrative costs. Cost does not include land acquisition.)

Expected Benefits

The designation of Las Cucharillas Marsh as a nature reserve will protect and conserve its natural resources and its overall benefits. The zoning proposed by the Municipality of Cataño's Territorial Plan for those lands considered for conservation would be highly strengthened. Environmentally sound tourist and recreational activities will be provided through this action. Cruise ship tourists visiting Old San Juan, as well as those resulting from the Golden Triangle Initiative, will have an adjacent,

highly accessible nature attraction, one that is not presently available. New economic or employment opportunities could arise that would benefit Cataño's residents. The tourist industry in Cataño, mostly limited to the Bacardí Rum Distillery facilities, would be greatly enhanced. This increase in tourist facilities would help meet the goal of diversifying the economy of the Island as mandated by the Government of Puerto Rico. The management of this area as a nature reserve will also help satisfy the need for nature-oriented activities, currently the most demanded recreational activity in Puerto Rico (Marvel, Flores, Cobian and Associates, 1994). The protection of the marsh as a green area will help buffer air emissions produced by several facilities such as the Puerto Nuevo and Palo Seco power plants in the Cataño area, where many residents suffer from asthma and other respiratory conditions. The efforts conducted for the recovery of rare, threatened, or endangered species in Puerto Rico which are found in Las Cucharillas Marsh will be more effective and efficient, since a considerable area comprising the habitats on which most of these species depend will be protected.

Monitoring Environmental Response/Programmatic Implementation

The SJBE Program tracking system will be used to monitor implementation of this action (programmatic in nature). Please see Volume II for details.

Regulatory Needs

The municipal territorial plans for Cataño and Guaynabo should be amended as necessary.

Acronyms
DNER = Department of Natural and Environmental Resources
PR = Puerto Rico
SJBE = San Juan Bay Estuary
USEPA = United States Environmental Protection Agency
PREPA = Puerto Rico Electric Power Authority
PRPB = Puerto Rico Planning Board

HW-8

HW-9 Establish management measures within the SJBE system for the Land Crab *Cardisoma guanhumi*.

Background

The land crab, *Cardisoma guanhumi*, is an important component of mangrove swamps, muddy shores, grasslands, and the saline lowland soils near the coast in the tropics and subtropics of the Western Hemisphere. *Cardisoma* is a semiterrestrial species, depending on water for its respiration and breeding.

In Puerto Rico, this species has considerable economic and dietary importance (Feliciano, 1962; Rojas, 1978; Canals, 1982). However, habitat destruction, control programs using pesticides to minimize crab damage to sugar cane fields, and over-exploitation have led to a significant decline in the crab population over the last twenty years. Feliciano (1962) stated that *Cardisoma* accounted for 7 percent of the total value of fishery landings in 1957, with a total catch of 672,000 individuals. Data collected by the Fisheries Research Laboratory, DNER, indicate a reduction from a high of 95,700 pounds (2.5% of total landings reported) in 1971 to 12,928 pounds (0.36% of total landings reported) in 1996 (Matos-Caraballo, 1997). The price of a dozen live crabs has increased from $1.25 in 1957 to $12.00 in 1984 and $25.00-$30.00 in 1997. The mean size (carapace width) of the Puerto Rican crabs marketed today is markedly smaller than it was one or two decades ago.

To satisfy consumer demand, Venezuela and other countries began exporting crabs to Puerto Rico in 1971. In 1973, Venezuela exported 812,135 individuals to Puerto Rico and New York (Taissoun, 1974). The number of *C. guanhumi* actually imported to Puerto Rico, and the countries involved in this trade, needs to be determined. At the present time, as a consequence of the scarcity of *Cardisoma*, other crabs, including the ghost crab ("juey pelú" or "zambuco"), *Ucides cordatus*, and the blue crab ("cocolía"), *Callinectes* sp., are being subjected to intense fishing pressure. This is particularly true in the north coast municipalities closer to the metropolitan area. The Vacía Talega-Piñones Torrecillas, Suárez Canal, Martín Peña Channel, Los Corozos Lagoon, and the northern parts of San José Lagoon are the areas within the SJBE system known to contain different species of land crabs.

Several studies have pointed out the urgent need to establish some management measures for the land crab in an attempt to control the drastic population decline observed during the past decades in Puerto Rico (Rojas, 1978; Canals, 1982). Such measures range from closing the fishery for a period of ten years, as proposed by Senator Norma Carranza de León (P. del S. 474, May 12, 1997) to regulating fishing methods and size limits, protecting gravid females, and establishing protected areas or reserves. In 1998, in an effort to protect land crabs within the SJBE system, the SJBE Program recommended the creation of reserves for land crabs as a Management Plan action. In 1999, DNER enacted an Administrative Order (99-08), which established a closed season on land crab harvest island-wide from July 15 to October 15 each year. The Administrative Order establishes that crabbers have until August 15 to sell their stock. In natural reserves, the ban is permanent and year round.

This Management Plan action has been recently modified to reflect the protection provided to the land crab by Administrative Order 99-08 and in recognition of DNER's current efforts to obtain approval of the new Fisheries Law Regulations which propose protective measures for other land crab species. (See Action HW-18.)

Strategy

9.1 Identify alternatives for management measures for land crabs in the SJBE system.

Implementing partners: DNER (lead)
Schedule: Completed (several meetings were held between the period of May 1997 - June 1999).
Cost: No cost – step completed.

9.2 Implement selected management measures.

Implementing partners: DNER (lead)
Schedule: Completed (Administrative Order 99-08 took effect on June 24, 1999.)
Cost: No cost – step completed.

9.3 Post signs in land crab reserve and non-reserve areas to educate crabbers and the general public about crabbing prohibitions and /or regulations and the fines for violations.

Implementing partners: DNER (lead), USFWS, NMFS, ARPE
Schedule: Short-term
Cost: $500 to $1000 per sign

Expected Benefits

Permanent bans and sign posting offer several benefits not found with traditional approaches to resource management (applicable to land crabs and/or other fisheries as well an non-fishery resources).

- A permanent ban in reserves will provide protection for a portion of the spawning stock, and larvae produced in reserves can be transported by currents to both exploited and protected areas.
- Reserves can act as reservoirs for rebuilding a collapsed stock and can increase biodiversity.
- Posting notices will help educate the public.

Monitoring Environmental Response/Programmatic Implementation

A monitoring program or project will be implemented from the beginning of the prohibition. Surveys will be conducted to determine population density, size distribution, sex, etc. (Socioeconomic and environmental impact assessments will be included as part of the monitoring activities.)

Regulatory Needs

None.

ACRONYMS
DNER = DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES
NMFS = NATIONAL MARINE FISHERIES SERVICE
PRHD = PUERTO RICO HEALTH DEPARTMENT
SJBE = SAN JUAN BAY ESTUARY
USFWS = UNITED STATES FISH AND WILDLIFE SERVICE
ARPE = PERMIT AND REGULATIONS ADMINISTRATION

HW-10 Implement a Sea Turtle Recovery Plan.

Background

On September 19, 1984, the NMFS Assistant Administrator for Fisheries approved the first Recovery Plan for Marine Turtles. The plan was developed to outline the recovery needs for the loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and Kemp's ridley (*Lepidochelys kempi*) sea turtles.

The main goal of the recovery plans is to delist a particular species once various conditions are met. Different threat factors considered in recovery plans include illegal exploitation, beach erosion, erosion control methods, sand mining, landscaping, artificial lighting, beach cleaning, increased human presence, beach vehicular driving, nest predation, entanglement at sea, ingestion of marine debris, commercial and recreational fisheries, watercraft collision, sedimentation and siltation, agricultural and industrial pollution, sewage, oil and gas exploration, anchoring, and vessel groundings (NMFS and USFWS, 1992, 1993).

Within areas associated with the SJBE system, DNER has reported leatherback and hawksbill turtle nesting activities in Isla de Cabras, Old San Juan, Condado, Ocean Park, Isla Verde, and Piñones. The importance of Puerto Rico as a nesting area for these two species within the Caribbean is clearly stated in their recovery plans. Therefore, implementation of recovery plans for leatherback and hawksbill sea turtles in Puerto Rico will contribute significantly to their overall recovery.

The major actions to achieve recovery for leatherbacks include: 1) providing long- term habitat protection for important nesting beaches; 2) ensuring at least 60 percent hatch success on major nesting beaches; 3) determining distribution and seasonal movements for all life stages in the marine environment; 4) reducing threats from marine pollution; and 5) reducing incidental capture by commercial fisheries.

For hawksbill turtles, a 75 percent hatch success rate is desired. In addition, hawksbill recovery actions include minimizing threats from illegal exploitation, ending international trade of hawksbill products, and ensuring long-term protection of important foraging habitats.

Since 1990, DNER has been collecting data on the nesting biology of leatherback turtles in beaches associated with the SJBE system. The project concentrates its efforts and personnel on the leatherback nesting season which occurs between February and June. Hawksbill turtles nest all year long, thus, for this species, nesting biology data has been mainly opportunistic.

The USFWS and NMFS share the responsibility for the recovery of these sea turtles under the authority of the Endangered Species Act of 1973, as amended. But for the species population to recover and be delisted, a joint effort among private enterprise, government, and citizens is necessary.

Strategy

10.1 Identify all areas within or associated with the SJBE that are currently used or that have the potential to be used by marine turtles as nesting areas.

Implementing partners: DNER (lead), USFWS, NMFS, Municipalities
Schedule: Mid-term
Cost: $32,000

10.2 Monitor identified areas in Step 10.1 throughout the year. Additional personnel are needed in order to monitor nesting areas throughout the year. This approach will provide more accurate information regarding the nesting biology of the different sea turtle species.

Implementing partners: DNER (lead), USFWS, NMFS, Municipalities
Schedule: Mid-term
Cost: $40,000

10.3 Coordinate the design, manufacture, installation, and maintenance of signs in order to inform the general public about sea turtle nesting areas, threats associated with humans, turtle protection laws, and the fines associated with violating those laws. Signs should be posted near known and potential nesting areas.

Implementing partners: DNER (lead), USFWS, NOAA, Municipalities, ARPE
Schedule: Mid-term
Cost: $25,000

10.4 Coordinate with marine turtle conservation entities to develop and conduct workshops to train volunteer groups to assist in the protection of these species during nesting season.

Implementing partners: DNER (lead), USFWS, Municipalities, NGOs
Schedule: Mid-term
Cost: $10,000

10.5 Coordinate with municipal authorities to ensure that urban development plans avoid habitat destruction and adverse impacts to turtle nesting behavior.

Implementing partners: DNER (lead), USFWS, PRPB, USACE
Schedule: Mid-term
Cost: $25,000 to $30,000

10.6 Coordinate with USFWS to survey turtle nesting areas within the SJBE and associated beaches to determine present and future violations based on specific recovery plans affecting present and potential nesting areas, sea turtles, and their hatchlings.

Implementing partners: DNER (lead), USFWS
Schedule: Mid-term
Cost: $5,000

Expected Benefits

The benefits of a sea turtle recovery plan include increased protection of sea turtles, hatchlings, and nests which should contribute significantly to the recovery of leatherback and hawksbill turtles. Increased monitoring should facilitate enforcement activities. Data regarding population densities, dispersion patterns, and habitat preferences of the different sea turtle species will be obtained.

Monitoring Environmental Response/Programmatic Implementation

The DNER will continue monitoring nesting activity within the SJBE. Volunteer groups will need to be coordinated to ensure that beaches are patrolled during nesting seasons.

Regulatory Needs

Endangered sea turtles are protected by the Endangered Species Act of 1973, as amended. Measures should be taken to strengthen enforcement of this law and related regulations.

Acronyms
DNER = Department of Natural and Environmental Resources
NGO = Non-Governmental Organization
NMFS = National Marine Fisheries Service
NOAA = National Oceanic and Atmospheric Administration
PRPB = Puerto Rico Planning Board
SJBE = San Juan Bay Estuary
USACE = United States Army Corps of Engineers
USFWS = United States Fish and Wildlife Service
ARPE = Permit and Regulations Administration

HW-10

HW-11 Assess the Impacts of Power Plant Entrainment on Fishery Resources.

Background

The Puerto Rico Electric Power Authority (PREPA) owns and operates two power plants on San Juan Bay with open-cycle cooling systems. The San Juan Power Plant's intake is located on the southeastern corner of San Juan Bay. The Palo Seco Power Plant's intake is located in Ensenada Boca Vieja, on the western side of the Palo Seco Peninsula. The cooling water intakes at the plants capture planktonic eggs and larval fish and shellfish. This process, called entrainment, can lead to high mortality rates from physical and thermal stress and may be resulting in an adverse cumulative effect on the estuary's fisheries. However, in the absence of sufficient baseline information on the fisheries, such as current stock sizes, natural survival rates, and losses caused by habitat degradation, fishing pressure, and other factors, it is extremely difficult to assess the impact of power plant entrainment on overall fishery populations.

A comprehensive study to assess cumulative impacts of the San Juan and Palo Seco Power Plant operations on the SJBE's fish and shellfish populations may be needed. If a study is warranted and shows cumulative adverse impacts, plant operations will need to be adjusted as appropriate to reduce entrainment.

Strategy

11.1 Conduct a joint workshop involving regulatory agencies, fisheries scientists, and PREPA to evaluate the need, costs, cost/benefit ratios, and ramifications of conducting a study of the impacts of power plant operations on fishery resources. (In coordination with HW-12.1.)

Involved parties: USEPA (lead), PRPB, EQB, USFWS, NMFS, PREPA, UPR-Marine Sciences Department, SJBE Program, Community Groups
Schedule: Short-term
Cost: $2,500

11.2 Design the scope of the study, identify potential data needs and funding sources, and conduct an impact study (if deemed necessary under Step 11.1). Based upon the results of the study, a plan should be developed and implemented to control the adverse impacts associated with the intakes, if needed.

Involved parties: USEPA (lead), PRPB, EQB, USFWS, NMFS, PREPA, UPR-Marine Sciences Department, SJBE Program
Schedule: Short-term
Cost: $35,000 to $40,000

Expected Benefits

This study will provide new data on the potential impacts of power plant operations on fishery resources. Implementing plans to control adverse impacts associated with intakes will enhance fish stocks in San Juan Bay and Boca Vieja Bay.

Monitoring Environmental Response/Programmatic Implementation

Presently, fish stocks are not monitored in the SJBE. Field inspections should be conducted regularly to detect the effects of entrainment on species over time.

Regulatory Needs

None.

Acronyms
EQB = Environmental Quality Board
NMFS = National Marine Fisheries Service
PREPA = Puerto Rico Electric Power Authority
PRPB = Puerto Rico Planning Board
SJBE = San Juan Bay Estuary
UPR = University of Puerto Rico
USEPA = United States Environmental Protection Agency
USFWS = United States Fish and Wildlife Service

HW-12 Assess the Impact of Thermal Discharges on Biological Communities in San Juan Bay.

Background

The Puerto Rico Electric Power Authority (PREPA) owns and operates two power plants on San Juan Bay which discharge thermal effluents. The San Juan Power Plant's intake is located on the southeastern corner of San Juan Bay. The Palo Seco Power Plant's intake is located in Ensenada Boca Vieja, on the western side of the Palo Seco Peninsula. Together, these plants discharge approximately 1,377 million gallons per day of heated water into the bay. The impact of these effluents on the bay's fisheries and benthic communities has not been assessed.

A comprehensive study to assess the cumulative impacts of the San Juan and Palo Seco Power Plant operations on the SJBE's fish and shellfish populations may be needed. If a study is warranted and shows cumulative adverse impacts, plant operations will need to be adjusted as appropriate.

Strategy

12.1 Conduct a joint workshop involving regulatory agencies, fisheries scientists, and PREPA to evaluate the need, costs, cost/benefit ratios, and ramifications of conducting a study of the impacts of power plant operations on fishery resources. (In coordination with HW-11.1.)

Involved parties: USEPA (lead), PRPB, EQB, USFWS, NMFS, PREPA, UPR-Marine Sciences Department
Schedule: Short-term
Cost: $2,500

12.2 Design the scope of the study, identify potential data needs and funding sources, and conduct a thermal effluent impact analysis (if deemed necessary under Step 12.1). Based upon the results of the study, a plan should be developed and implemented to lower the temperatures of the discharges.

Involved parties: USEPA (lead), PRPB, EQB, USFWS, NMFS, PREPA, UPR-Marine Sciences Department
Schedule: Short-term
Cost: $35,000 to $40,000

Expected Benefits

This study will provide new data on the potential impacts of power plant operations on fishery resources. Implementing plans to control adverse impacts associated with thermal discharges will enhance fisheries and habitats.

Monitoring Environmental Response/Programmatic Implementation

PREPA's Discharge Monitoring Reports (DMRs) will be reviewed on a regular basis. Field inspections will also be conducted regularly to detect the effect of thermal discharges over time.

Regulatory Needs

The need for more stringent temperature standards in EQB's Water Quality Certificates and USEPA's NPDES permits should be evaluated. A waiver to section 316 of the Clean Water Act is currently under consideration by USEPA.

Acronyms
DMR = Discharge Monitoring Report
EQB = Environmental Quality Board
NMFS = National Marine Fisheries Service
NPDES = National Pollutant Discharge Elimination System
PREPA = Puerto Rico Electric Power Authority
PRPB = Puerto Rico Planning Board
SJBE = San Juan Bay Estuary
UPR = University of Puerto Rico
USEPA = United States Environmental Protection Agency
USFWS = United States Fish and Wildlife Service

HW-13 Enhance and Protect Critical Plant Species within the SJBE.

Background

Over 300 species of flora have been reported within the SJBE's wetlands, mangrove forests, marshes, and other coastal habitats (Rivera-Herrera, 1996). The status of 17 of these species is considered critical. Two species, *Schoepfia arenaria* and *Stahlia monosperma*, are respectively listed as endangered and threatened by the USFWS and DNER. The Torrecilla - Vacía Talega - Piñones area serves as habitat for 11 of these critical plant species, of which 4 are endemic and 8 are not found anywhere else in the system. Four other critical species are restricted exclusively to Las Cucharillas Marsh: two vines (*Aniseia martinicensis* and *Ipomoea tiliacea)* and two herbaceous species (*Hyptis verticillata* and *Scleria mitis*).

Most of the remaining critical plant species are restricted to some of the less impacted areas of the estuary. These include a water fern (*Marsilea polycarpa*); an endemic shrub (*Schoepfia arenaria*); the endemic trees (*Coccoloba sintenissi*), (*Manilkara pleeana*), and Maga wood (*Thespesia grandiflora*); the sea-purslane (*Sesuvium maritimum*); a water-lily (*Nymphaea pulchella*); the gray nickers (*Caesalpinia bonduc*); certain herbaceous species (*Paronia paniculata*) and (*Hyptis spicigera*); and the intermediate arrowhead (*Sagittaria intermedia*).

Intense development in areas surrounding the estuary system in recent decades has resulted in the deforestation of vast areas of land. Dredging, channelization, sand mining, filling, and construction have significantly reduced the original limits of the estuarine system, restricting the historical range of flora and fauna species and correspondingly decreasing their numbers in the area. Water pollution and the presence of debris also have played a role in degrading habitats.

Endangered and threatened species are protected under laws such as the Endangered Species Act of 1973, as amended, and the Commonwealth Department of Natural and Environmental Resources Act of 1985, which provide for criminal penalties for illegal taking of these species. Other laws and regulations are in place which help to protect habitat areas, including Commonwealth State Forests, wetlands, and coastal areas, from impacts associated with human uses and development. Measures should be taken to ensure compliance with these laws and regulations.

An assessment of the causes contributing to the decline of these species probably would reveal that conservation efforts must be directed towards management of existing populations and habitat protection. Part of the Piñones-Torrecillas complex is protected by the boundaries of the Piñones State Forest. Unfortunately, this region, as well as the areas surrounding the San José Lagoon, Martín Peña Channel, Las Cucharillas Marsh, and the Puerto Nuevo River, is still under significant development pressure.

The USFWS has developed recovery plans for *Schoepfia arenaria* and *Stahlia monosperma*. Both plans focus on monitoring and protecting existing populations to prevent further habitat loss and population decline. Similar actions should be encouraged with respect to all other critical elements extending throughout the estuarine system.

Strategy

13.1 Develop measures for the protection of existing populations and habitats in addition to the those addressed by the Endangered Species Act.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $25,000 to $30,000

13.2 Develop and implement management plans for existing populations of critical species. Existing USFWS Recovery Plans recommendations should be followed as appropriate.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $65,000 to $70,000 per year

13.3 Establish protection zones around areas of existing populations of flora species catalogued as critical elements. These zones should be designed to prevent human disturbance by limiting recreational uses, posting informational signs, and assigning regular patrols.

Implementing partners: DNER (lead), USFWS, Municipalities, ARPE, PRPB
Schedule: Short-term
Cost: $25,000 to $30,000

13.4 Evaluate the necessity and feasibility of propagation for each species.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $25,000

13.5 Conduct research on the species' methods of propagation and possible introduction sites within the estuary system.

Implementing partners: DNER (lead), USFWS
Schedule: Short-term
Cost: $130,000 for first year.

13.6 Conduct a species propagation process to enhance existing populations. (Dependent on results of Steps 13.4 and 13.5.)

Implementing partners: DNER (lead), USFWS
Schedule: Short-term
Cost: Dependent on information gathered in Step 13.5.

B.7 Conduct an educational campaign for the general public directed towards conservation of endangered species and regulations pertaining to the survival of these species.

Implementing partners: DNER (lead)
Schedule: Short-term
Cost: $30,000 per year

Expected Benefits

The historical range of critical species within the estuary system will be restored by the protection and propagation of stable and self-sustaining populations.

Monitoring Environmental Response/Programmatic Implementation

Population censuses and regular surveys of each species' range should be conducted.

Regulatory Needs

None.

Acronyms
DNER = Department of Natural and Environmental Resources
SJBE = San Juan Bay Estuary
USFWS = United States Fish and Wildlife Service
ARPE = Permit and Regulations Administration
PRPB = Puerto Rico Planning Board

HW-13

HW-14 Protect Existing Populations of Endangered and Threatened Bird Species and Protect and Restore their Habitat within the SJBE System.

Background

Over 160 bird species have been reported within the limits of the SJBE system. Of these species, several are listed as federally threatened (FT), federally endangered (FE), or by the Commonwealth as threatened (CT) or endangered (CE). These include the brown pelican (FE, CE), the roseate tern (FE, CE), the peregrine falcon (FT, CE), the least tern (CT), the West Indian whistling duck (CT), the masked duck (CT), the Caribbean coot (CT), the snowy plover (CT), the ruddy duck (CT), and the yellow-shouldered blackbird (FE, CE), which is endemic to Puerto Rico. Some of these birds, such as the brown pelican, are found throughout the estuary, but others have a more restricted range. Wetlands at Las Cucharillas, the Torrecillas-Piñones Lagoons complex, the mangroves at the Martín Peña Channel, and the La Esperanza Peninsula are the primary areas where these species have been reported in the past.

In recent decades, vast areas of land have been deforested in the estuary's watershed to make room for development. The original limits of the estuary system have been significantly modified and reduced by dredging, channelization, sand mining, filling, construction, and pollution. Sewage and chemical discharges, sedimentation, and debris also have contributed to the degradation of habitat and associated species within the SJBE. As a result, the number and range of fauna and flora associated with the estuary system have decreased.

Preventing further habitat loss and degradation and protecting species from human-related disturbances are essential for the recovery of most of these species. For example, residential, commercial, and recreational activities in proximity to bird feeding and nesting grounds are known to hinder reproduction and displace colonies. Environmental pollutants can also adversely affect bird populations by poisoning food sources and causing high rates of reproductive failure.

Endangered and threatened species are protected under laws such as the Endangered Species Act of 1973, as amended, and the Commonwealth Department of Natural and Environmental Resources Act of 1985, which provide for criminal penalties for illegal taking of these species. Other laws and regulations are in place which help to protect habitat areas, including Commonwealth State Forests, wetlands, and coastal areas, from impacts associated with human uses and development. Measures should be taken to ensure compliance with these laws and regulations.

Strategy

14.1 Enforce existing regulations concerning habitat and bird species found within the SJBE.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $20,000 per year

14.2 Develop and implement management plans for existing populations of endangered and threatened bird species. USFWS Recovery Plan recommendations should be followed as appropriate based on existing regulations.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: There are insufficient data to provide a cost estimate at this time.

14.3 Enhance biodiversity by protecting breeding and nesting areas through limiting access and recreational use, posting signs, and conducting regular patrols.

Implementing partners: DNER (lead), USFWS, Municipalities, ARPE, PRPB
Schedule: Short-term
Cost: $40,000

14.4 Develop and implement alternative management measures to increase nesting in natural habitats.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $25,000

14.5 Develop alternative measures to control the introduction of exotic species into the estuary system.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $30,000

14.6 Conduct educational campaigns for the general public to increase awareness about management measures and regulations for the protection and conservation of endangered species.

Implementing partners: DNER (lead), USFWS, Municipalities
Schedule: Short-term
Cost: $10,000

Expected Benefits

Species and habitat protection measures will lead to the development of stable and self sustaining populations. Habitat protection and restoration measures will help to restore the historical range of endangered and threatened species within the estuary system.

Monitoring Environmental Response/Programmatic Implementation

The status and trends of the populations of the different bird species will be monitored.

Regulatory Needs

None.

Acronyms
CE = Commonwealth Endangered
CT = Commonwealth Threatened
DNER = Department of Natural and Environmental Resources
FE = Federal Endangered
FT = Federal Threatened
SJBE = San Juan Bay Estuary
USFWS = United States Fish and Wildlife Service
ARPE = Permit and Regulations Administration
PRPB = Puerto Rico Planning Board

HW-15 Estimate the Population and Habitat Use of the West Indian Manatee within the SJBE and Establish Manatee Protection Zones.

Background

At the present time, the West Indian manatee (*Trichechus manatus*) is considered the most endangered mammal in Puerto Rico, but little is known about the number of manatees associated with the SJBE. According to the Caribbean Stranding Network (CSN), several sightings and strandings of the West Indian manatee have been recorded within the SJBE and its associated coastal areas. For example, an adult manatee was seen in the Puerto Nuevo River, and an adult female gave birth in San Juan Bay near the Guaynabo coastline during October 1999.

Data indicate that the West Indian manatee accounts for 38 percent of all marine mammal mortalities recorded in Puerto Rico (Mignucci-Giannoni, *et al.*, 2000). These mortality records indicate up to 6 reported deaths each year for the last 15 years. Capture by humans and collisions with watercraft account for over 48 percent of all manatee deaths, while just over 37 percent of all manatee deaths can be attributed to natural causes. The causes of the remaining manatee deaths remain undetermined (Mignucci-Giannoni, *et al.*, 2000).

Once the use and preferred habitats of manatees within and associated with the SJBE system are identified, protection zones can be established. Within these zones, restrictions concerning fishing activities and the entry and speed of boats and jet skies should be regulated and enforced.

Strategy

15.1 Continue manatee salvage program to assess mortality factors.

Implementing partners: DNER (lead), CSN
Schedule: Mid-term
Cost: $25,000

15.2 Perform aerial surveys with the use of helicopters to establish the population of the West Indian manatee and other protected marine mammals and sea turtles within the SJBE and associated areas.

Implementing partners: DNER (lead), USFWS, CSN
Schedule: Mid-term
Cost: $60,000

15.3 Perform boat surveys and utilize a network of public informers to document sightings and to establish the total number of West Indian manatees and other protected marine mammals and sea turtles within the estuary and areas associated with the SJBE system.

Implementing partners: DNER (lead), USFWS, CSN
Schedule: Mid-term
Cost: $40,000

15.4 Establish a radio telemetry study of West Indian manatee movements in areas within and associated with the SJBE.

Implementing partners: DNER (lead), USFWS, CSN, USGS-Sirenia Project
Schedule: Mid-term
Cost: $116,000

15.5 Establish restrictive measures concerning fishing activities as well as boat and jet ski entries and speed limits in designated manatee protection zones.

Implementing partners: DNER Navigation Commission Office (lead)
Schedule: Mid-term
Cost: $25,000

15.6 Coordinate the design, manufacture, installation, and maintenance of signs to identify manatee protection zones.

Implementing partners: DNER Navigation Commission Office (lead), ARPE
Schedule: Mid-term
Cost: $33,000

15.7 Establish an education and public outreach program.

Implementing partners: DNER (lead), CSN, USFWS
Schedule: Mid-term
Cost: $72,000

Expected Benefits

Research on the population and habitat use of the West Indian manatee will lead to scientific information which can be used for related matters such as enforcement and developing planning activities. Establishing manatee protection zones will protect manatees as well as other endangered mammals within the SJBE and associated areas.

Monitoring Environmental Response/Programmatic Implementation

The local CSN office currently conducts scientific research and monitors manatee mortality in Puerto Rico. Support of this program will be continued.

Regulatory Needs

None.

ACRONYMS
CSN = CARIBBEAN STRANDING NETWORK
DNER = DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES
SJBE = SAN JUAN BAY ESTUARY
USFWS = UNITED STATES FISH AND WILDLIFE SERVICE
USGS = UNITED STATES GEOLOGICAL SURVEY
ARPE = PERMIT AND REGULATIONS ADMINISTRATION

HW-16 Substitute Cayeput Trees (*Melaleuca Quinquenervia*) with Native Species and Prohibit Planting of the Tree in the SJBE.

Background

The cayeput tree is native to the South Pacific region, including Australia (Little, *et al.*, 1988; Liogier, 1994), where it grows along coastal streams and swamps. In Puerto Rico, it was probably introduced as an ornamental species sometime after the 1920s (Liogier and Martorell, 1982). Due to its size, appearance, fast development, and ability to grow in confined spaces, it has become one of the most popular species for reforesting urban areas on the Island.

One of the main concerns in establishing species of plants and animals outside their natural range is the potential for vigorous reproduction of the introduced species and the resulting displacement of native species. Exotic species are often able to spread quickly because natural population controls (i.e., diseases, predators) are not found in the area where they are being introduced. Until recently, it was believed that this behavior would be extremely improbable for the cayeput tree because it is very difficult for the seeds to germinate in the urban environment. The seeds of this tree require wet or very saturated soil conditions in order to germinate and become established (Laroche, 1994; Quevedo-Bonilla, 1995). In addition, appropriate soil characteristics should be present within approximately 560 feet (171 m) from the bearing tree, since most seeds are not dispersed by wind farther than this distance during normal weather conditions (Browder and Schroeder, 1981). However, if the seeds find an appropriate site for their development, this species has many adaptations that could turn it into an extraordinary pest and make it practically impossible to control. An individual cayeput tree may flower within 3 years after germinating and as many as 5 times per year; seeds are stored in capsules that protect viability for up to 10 years; and estimates of seed storage range from 2 to 20 million seeds per tree (DeVries and Doren, 1992; Laroche, 1994). If the tree is subject to any stress factors such as extreme droughts or fires, this will trigger a rapid release of most of the seeds contained in the capsules (Woodall, 1983). The bearing tree may not be damaged at all after being burned, since it is well protected from extreme heat by its thick, papery bark (Wade, 1980). In addition, if the tree is cut, there may be prolific sprouting from the base, as well as extensive rooting and sprouting from the fallen trunk or branches. Soil types fail to limit its ability to develop since it grows well in deep peat or in inorganic, calcareous areas (Laroche, 1994).

The cayeput tree is known to aggressively invade freshwater herbaceous wetlands outside its natural range (Hofstetter, 1991; Cost and Craver, 1981; Laroche and Ferriter, 1992). The same characteristics that have made the cayeput tree such an extremely enduring species have led to a massive infestation of the species in freshwater wetlands in southern Florida, where the species is expanding at an estimated rate of 50 acres (20 ha) per day (Mairson, 1994). The economic losses (i.e., tourist, recreational activities) in the state of Florida due to this phenomenon are estimated at approximately $168 million per year (Jewell, 1997). The cayeput tree has an equally impressive capacity for changing freshwater wetlands into a completely different natural landscape. Cayeput trees grow very near to each other, eventually displacing shorter native species by blocking available sunlight. Once the trees have been established, they continuously shed an impressive quantity of

leaves and small branches. This action, in areas where fires are not a recurrent event, helps to gradually fill the surrounding wetland in a relatively short period of time by creating an elevated island of litter (Laroche, 1994). In addition, the cayeput trees transpire more water than other plants found in non-woody wetlands, possibly lowering the water level in the area (Hofstetter, 1991). In the end, a wetland area could eventually be filled and drained by the trees, taking on the characteristics of an upland site.

Unfortunately, as the cayeput tree has gained popularity among gardeners in Puerto Rico during recent years, it has been unknowingly planted near areas favorable to its germination. This has led to the first three known accounts of natural propagation by the cayeput tree in freshwater wetlands on the Island. In 1995, a pure stand of cayeput trees that covered an area of 5 acres (2 ha) was found in the Tortuguero Lagoon Nature Reserve in the municipality of Vega Baja (Quevedo-Bonilla, 1995). An even bigger stand of over 1,000 trees was found in 1996 at a 4 to 6 acre (1.6 - 2.4 ha) wetland in Cabo Caribe, northeast of Tortuguero Lagoon, in the same municipality (Eileen Ortíz, DNER, personal communication, 1998). Personnel from the DNER and the SJBE Program confirmed the existence of a stand of approximately 200 trees east of Ciudad Deportiva Roberto Clemente and south of the Suárez Canal in the SJBE during 1997.

Human activities in the SJBE have not impacted all habitat types equally; that is, there has been a disproportionate loss of herbaceous wetlands over mangrove habitats. From 1936 to 1995, 776.4 hectares or 49.5 percent of the total herbaceous wetland area in the SJBE was lost (Coastal Environmental, Inc., 1997). Although the habitat requirements of the cayeput are not adequately known, it has been described as a species which prefers disturbed sites (Hofstetter, 1991; Ewel, *et al.*, 1976). Since the remaining 1,959 acres (793 ha) of freshwater herbaceous wetlands found in the SJBE have been modified in some way, these habitats have a high potential of being extensively invaded in the near future. Even if most of the existing herbaceous wetlands were once occupied by another type of wetland, their restoration would be extremely difficult in the event of invasion by cayeput trees. Although undisturbed ecosystems are to a large degree resistant to colonization by cayeput trees, it does not necessarily make them immune (Ewel, *et al.*, 1976). As a result, swamp bloodwood forests that are currently a rare ecosystem in Puerto Rico and that are extremely limited in the SJBE, could be at great risk of being infested by cayeput trees. Because the invasion of cayeput trees into the freshwater wetlands of the estuary will negatively affect their diversity and value to society, it is necessary to prohibit the planting of the cayeput tree and prevent its further propagation in the SJBE.

Strategy

16.1 Issue an administrative order to prohibit the importation, planting, and propagation of cayeput trees in the SJBE. Initiate a program to buy those *Melaleuca* trees available in nurseries when the administrative order takes effect.

Implementing partners: DNER (lead), PR Department of Agriculture, USDA, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: $300,000 to start program

16.2 Begin a public education campaign about the dangers of cultivating *Melaleuca* and efforts to eliminate the tree within the SJBE.

Implementing partners: DNER (lead), SJBE Program, USFS, USFWS, PR Conservation Trust, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: $30,000 per year

16.3 Initiate a demonstration project to remove the stand of cayeput trees found in the Suárez Canal wetlands. This project will not only eliminate the progressive invasion of *Melaleuca* trees in this area but will also produce information to be incorporated in a control program in the SJBE, including information on effective control methods and proper disposal. The coordination initiated among the different entities in charge of developing the demonstration project should facilitate the control program.

Implementing partners: DNER (lead), SJBE Program, USFS, USFWS, USACE, PR Conservation Trust, PR Land Administration, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: Costs included in Step 16.1

16.4 Identify and establish a buffer zone of 1,640 feet (500 m) adjacent to the wetlands of the SJBE to establish a control program for cayeput trees once the stand of cayeput trees in the Suárez Canal has been eliminated. The removal of cayeput trees in this area will eliminate nearby sources of seeds and prevent an immediate invasion of the SJBE freshwater wetlands.

Implementing partners: DNER (lead), SJBE Program, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: $75,000 per year

16.5 Identify those species of trees, preferably native to Puerto Rico, that could be grown in the same conditions (mostly urban) where cayeput trees are normally planted. The selected species would be used to replace those cayeput trees that would be cut.

Implementing partners: DNER (lead), SJBE Program, USFS, USFWS, PR Conservation Trust, International Society of Arboriculture, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: Costs included in Step 16.1

16.6 Initiate the cultivation of the selected replacement species if the variety and quantity of native trees currently available at public and private nurseries are not sufficient to replace the cayeput trees that would be removed.

Implementing partners: DNER (lead), PR Department of Agriculture, DTPW, USFS, PR Conservation Trust, Municipalities, Garden Nurseries
Schedule: Short-term
Cost: $75,000 per year

16.7 Begin replacing the cayeput trees with native species in the wetlands buffer zone. Private land owners with cayeput trees should be compensated for the removal of the cayeput trees by providing native replacement trees.

Implementing partners: DNER (lead), SJBE Program, DTPW, USFS, PR Conservation Trust, Municipalities, Private Entities, Local Communities, Garden Nurseries
Schedule: Short-term
Cost: $30,000 per year

16.8 Continue the control program in the rest of the SJBE's watershed, beginning with those areas adjacent to its tributaries once the wetlands buffer zone has been established and cayeput trees are removed from the buffer zone.

Implementing partners: DNER (lead), SJBE Program, PR Department of Agriculture, USFS, PR Conservation Trust, Municipalities, Private Entities, Local Communities, Garden Nurseries
Schedule: Short-term
Cost: Depends on previous steps

Expected Benefits

Banning the cultivation and establishing a control program for the cayeput tree will significantly diminish the threat of a massive invasion of this species in the freshwater wetlands of the SJBE as well as other wetlands on the Island. The protection of the integrity of freshwater coastal wetlands will help preserve one of the estuary's most important wildlife habitats, since these wetlands may support the largest and most diverse populations of birds (Mitsch and Gosselink, 1993). The implementation of this action at this time is far more cost effective than addressing the impact of a widespread infestation of *Melaleuca*. Replacing cayeput trees with a variety of native tree species will increase the biological diversity of plants at many sites in the SJBE and will protect these species from becoming threatened or endangered in the future by increasing their population and distribution across the Island.

Monitoring Environmental Response/Programmatic Implementation

Areas scheduled for the removal of the cayeput tree will be mapped and surveyed following removal to ensure that no cayeput trees remain.

Regulatory Needs

An administrative order should be issued to prohibit the planting and propagation of cayeput trees in the SJBE. The PR Regulation for the Conservation and Management of Wildlife, Exotic Species, and Hunting in the Commonwealth of Puerto Rico should be amended to prohibit the planting and propagation of cayeput trees in the SJBE. Planning Regulation No. 25 ("Reglamento de Siembra, Corte y Forestación para Puerto Rico") should be amended to require the planting of only one tree for each *Melaleuca* that is removed, in order to promote cayeput removal by private landowners.

Acronyms
DNER = Department of Natural and Environmental Resources
DTPW = Department of Transportation and Public Works
PR = Puerto Rico
SJBE = San Juan Bay Estuary
USDA = United States Department of Agriculture
USFWS = United States Fish and Wildlife Service
USACE = United States Army Corps of Engineers
USFS = United States Forest Service

HW-17 Determine Historic and Present Recreational Fishing Areas in the SJBE and Develop a Plan to Adequately Manage Recreational Fishery Resources.

Background

The SJBE system is enjoyed by many recreational fishers, and the north coast of Puerto Rico, including four coastal municipalities within the SJBE (San Juan, Cataño, Loíza, and Carolina) is an important base for commercial fishing. Although commercial fishing is banned from the SJBE system, with the exception of San Juan Bay, approximately 50 percent of all commercial fishermen on the north coast of the Island are based out of these four municipalities (Matos-Caraballo, 1997).

Information regarding commercial fisheries in Puerto Rico has been documented for the last 30 years. There is little data on recreational fisheries despite anecdotal information that a large number of people participate in this sport and may have a great impact on recreational fishery resources. In addition, not all preferred fishing sites within the SJBE system are known. In an attempt to establish this type of information, a creel survey was performed within the SJBE system, specifically in San José Lagoon, the Suárez Canal, and La Torrecillas Lagoon (Yoshiura and Lilyestrom, 1999). Results indicated a high variability in terms of age groups, preference of species and bait used, economics, mode of harvest, and needs.

Other aspects of the study indicated that user groups are site specific and live close to their preferred fishing sites. From a biological perspective, results indicated a wide range of species composition within the recreational fishery, with striped mojarra, common snook, checkered puffer, blue crabs, dog snapper, and yellow fin mojarra as the dominant species.

Although an overall goal is to improve the diversity and abundance of these resources, there is an urgent need to establish the quality of targeted species in the SJBE system before their recreational potential is promoted. The SJBE system's present use and future potential for recreational fishing is threatened by a long history of pollution. Preliminary information on fish and blue crabs from the San José Lagoon indicates that concentrations of mercury and lead are above USFDA consumption levels in some samples of the striped mojarra (Delgado-Morales, *et al.*, 1999). A previous study by Webb and Gómez-Gómez (1998) indicated the presence of toxics (lead, mercury, PCBs, and semi-volatile compounds) in the water and sediments of some areas of the SJBE system that could potentially threaten human health through direct contact with water and sediments and through ingestion of harvested organisms. Again, there is a need to assess this problem before encouraging recreational fishery activities in the SJBE.

Fishery resources are protected by the Fisheries Law of Puerto Rico and its regulations. Measures should be taken to strengthen enforcement of these laws and regulations.

Strategy

17.1 Identify areas within the SJBE historically and currently used by sportfishers.

Implementing partners: DNER (lead)
Schedule: Short-term. Completed for the Suárez Canal and San José and La Torrecilla Lagoons.
Cost: $6,000 to $8,000

17.2 Identify the main sportfishing resources in the areas determined in Step 17.1.

Implementing partners: DNER (lead)
Schedule: Short-term. Completed for the Suárez Canal and San José and La Torrecilla Lagoons.
Cost: $12,000

17.3 Determine if USEPA fish and shellfish quality standards for toxics are met by targeted species.

Implementing partners: DNER (lead), PRHD
Schedule: Short-term
Cost: $1,500 per sample and lab analysis

17.4 Compile the necessary data that will provide information regarding the relative abundance, fecundity, annual reproductive cycle, minimum size of sexual maturation, and spawning frequency of the most important recreational fish and shellfish species.

Implementing partners: DNER (lead)
Schedule: Short-term
Cost: There are insufficient data to provide a cost estimate at this time.

17.5 Based on the collected information, prepare and implement a management plan, if necessary.

Implementing partners: DNER (lead)
Schedule: Short-term
Cost: $25,000

Expected Benefits

Management of recreational fishing resources within the estuary system will result in direct recreational benefits to local sportfishers and the general community. Indirect economic benefits will be achieved for commercial fishery resources. Data collection efforts will support the formation of management measures, such as seasonal regulations, minimum catch sizes, restricted fishing areas, and fishing gear restrictions. This action will result in improvements in water quality and habitat enhancement.

Monitoring Environmental Response/Programmatic Implementation

Creel surveys will be performed to establish trends in fishing area and species preferences and abundance of fish. Scientific studies will be conducted to assess parameters such as species diversity and relative abundance.

Regulatory Needs

None.

Acronyms
DNER = Department of Natural and Environmental Resources
PCBs = Polychlorinated Biphenyls
PRHD = Puerto Rico Health Department
SJBE = San Juan Bay Estuary
USFDA = United States Food and Drug Administration

HW-18 Support Enactment of the New Fisheries Law by the Legislature and the Governor.

Background

In 1936, Law No. 83, known as the Fisheries Act of Puerto Rico, was enacted to promote the consumption of species found in the jurisdictional waters of the Commonwealth of Puerto Rico. The purpose of this law was to guarantee a source of income to fishermen while protecting fishery resources. Amendments to Law No. 83 were authorized in 1972, 1979, and 1986, but none of the amendments addressed new strategies for the conservation and management of fishery resources. On November 11, 1998, a new bill was approved which revoked Law No. 83 and instituted more restrictive and protective fishery management measures.

The DNER has been working on consolidating existing regulations related to this matter into one document. The DNER held public hearings on this new document during 1999. The approval of the new regulations under this Law will enhance submerged aquatic vegetation, invertebrates, reef fishes, the West Indian manatees, and other marine organisms which are directly related to the different habitats associated with the SJBE. These regulations will have a broad impact, benefiting not only the SJBE but also the whole island of Puerto Rico.

Strategy

18.1 Obtain the approval of the Legislature and the Governor for the new bill.

Implementing partners: Legislature (lead), Governor of Puerto Rico
Schedule: Bill 696 was instituted as Law on November 29, 1998.
Cost: No cost - this step has been completed.

18.2 Approve the final version of the regulations once the Bill is signed into law by the Governor.

Implementing partners: Legislature (lead), DNER
Schedule: Short-term
Cost: None

Expected Benefits

The approval of the new Bill and associated regulations strongly contributes to the enhancement of the different natural resources within the SJBE and Puerto Rico. The law also performs its original purpose of guaranteeing a source of income to fishermen while at the same time protecting resources on behalf of present and future generations.

Monitoring Environmental Response/Programmatic Implementation

Laws and regulations should be periodically evaluated to ensure they are meeting current needs.

Regulatory Needs

None.

Acronyms
CFMC = Caribbean Fisheries and Management Council
DNER = Department of Natural and Environmental Resources
SJBE = San Juan Bay Estuary