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RESOURCE EVALUATION REPORT

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Ecological Targets for Western Biscayne National Park

Ecological Targets for Western Biscayne National Park

April, 2006 Department of the Interior

EXECUTIVE SUMMARY

National Park Service staff developed descriptive ecological targets based on biological communities in Biscayne National Park. We selected biological indicators that include those described by the interagency RECOVER team to set environmental targets affected by inflows, primarily as measures of seasonal salinity patterns in key areas of the park. Other relevant indicators of bay health derived from previous and current studies in the entire Biscayne Bay area are also discussed in support of defining desired ecological conditions and the salinities needed to sustain them. The target area for the development of ecological and salinity performance measures is a 10,000 acre, primarily softbottom zone in the western zone of Biscayne National Park.

The productivity and richness of the estuarine communities of Biscayne National Park have significantly diminished, as have those throughout Biscayne Bay, as a result of channel creation and the diversion of water away from the natural systems in south Florida. The quantity of fresh water, the seasonal timing of inflows, and the distribution along the coast have been significantly altered, profoundly affecting the historic estuarine nature of the western half of the Bay. The alteration of the hydrology of south Florida has resulted in the near complete loss of estuarine habitats from the Bay, including Biscayne National Park, diminishing the ecological and economic value of this portion of the greater Everglades ecosystem.

This report describes the desired conditions of the park in terms of biology, ecology, and available historical record. The “desired condition” takes into account historical information about the ecosystem but is not necessarily equivalent to a pre-drainage state because significant portions of the original freshwater source area have been irreversibly developed. The desired condition for the Western Bay Zone of Biscayne National Park is a range of salinities that is consistently estuarine for support of a productive, diverse benthic community based on seagrass. These conditions also support Federally-listed endangered species, such as the American crocodile (*Crocodylus acutus*) and West Indian manatee (*Trichechus manatus*), and create productive nursery habitat that sustains local and regional (Florida Keys) fishery resources.

Considering the needs of many native species including the juvenile stages of crocodiles, gray snapper, seatrout, and pink shrimp, and populations of mojarras, pinfish, eastern oyster, and wigeongrass, the following salinity characteristics are required:

- Measured salinities should not exceed 30 ppt. This will be particularly critical to achieve in the dry season, from November to June.
- From March through August (late dry season - early wet season), average monthly salinities should range between 15-25 ppt in the Western Bay Zone.
- In the late wet season (September-October), the Coastal Mangrove Zone should be oligohaline (0-5 ppt), and the Western Bay Zone should average less than 20 ppt.
- Salinity changes should be gradual and reflect changes in coastal inflows that approximate those of an unregulated, natural system.

Flows that achieve these salinity targets will produce stable mesohaline conditions over the 10,000 acre nearshore Bay area of Biscayne National Park.

INTRODUCTION

The purpose of this document is to establish a set of scientifically based ecological and salinity targets in the western areas of Biscayne National Park.

Conservation Designations

Biscayne National Park comprises the majority of the central and southern portions of Biscayne Bay. It was originally designated by Congress in 1968 as Biscayne National Monument and later established as a National Park in 1980. Biscayne Bay, its tributaries, and Card Sound are also designated by the state of Florida as aquatic preserves, and Card and Barnes Sounds are part of the Florida Keys National Marine Sanctuary. Biscayne Bay was designated under the Surface Water Management and Improvement Act of 1987 as a priority water body by the Florida Legislature. The waters of Biscayne National Park, Biscayne Bay Aquatic Preserve, and the two sounds are classified as Outstanding Florida Waters and, as such, are subject to the most stringent regulations, including Florida antidegradation policies. Card and Barnes sounds are important for the endangered American crocodile because they contain one-third of all crocodile nesting in the continental United States, and the east shore of Barnes Sound is included within the Crocodile Lakes National Wildlife Refuge.

All of these areas, including those in the Coastal Mangrove Zone, are Essential Fish Habitat as described by a Federal mandate to improve fishery management plans in the United States (NOAA 1996). By definition, “essential habitat” incorporates habitat required by the full life cycle of a species, recognizing the need for protection of nursery and spawning habitats that are critical to the survival of a species.

Relationship to CERP Processes

In the drafting of this report, existing performance measures and targets developed through the CERP Restoration, Coordination, and Verification (RECOVER) team for Biscayne Bay were used as the basis for interim targets for desired conditions. Modifications were made based on results of studies conducted in the Bay or similar habitats in south Florida to improve the performance measures. In particular, we propose and use a modification of the RECOVER SE-6 performance measure for evaluation of 3,200 acres to evaluate 10,000 acres of potential seagrass habitat. There is abundant scientific data discussed later in this paper to support this expansion. In fact, it is our understanding that RECOVER may be considering the expansion of the area in SE-6 to 10,000 acres in response to considerations raised in this paper.

This report describes the desired conditions of the park in terms of biology, ecology, and available historical record. The “desired condition” takes into account historical information about the ecosystem but is not necessarily equivalent to a pre-drainage state because significant portions of the original freshwater source area have been irreversibly developed. Biological indicators that include those described by RECOVER are used to set environmental targets affected by inflows, primarily as measures of seasonal salinity patterns in key areas of the park. By using target values for salinity, hydrologic targets (freshwater inflows and their interaction with precipitation and circulation), can be estimated. Other relevant indicators of bay health derived from previous and current studies in Biscayne Bay are also discussed in support of defining desired conditions and the salinities needed to sustain them.

This report provides a description of ecological targets and targets for salinity for the Coastal Mangrove Zone and the Western Bay Zone. To do this, we begin with two basic ecological premises: 1) healthy seagrass communities are the basis for the support of diverse biological communities, and 2) components of the biological community are sensitive to salinity levels and salinity changes.

Area Description

Biscayne Bay is the largest estuary on the coast of southeast Florida and is continuous with the southern Everglades, separated from the Florida Bay system only by a narrow isthmus connecting Key Largo to the mainland. Naturally, freshwater flowed into Biscayne Bay from the Everglades through finger glades primarily in the wet season and through groundwater seepage year round.

This report focuses on the portion of Biscayne Bay within Biscayne National Park (Central and South Bay (Zone A); Figure 1). Though park waters are the primary concern of this report, similar methodology

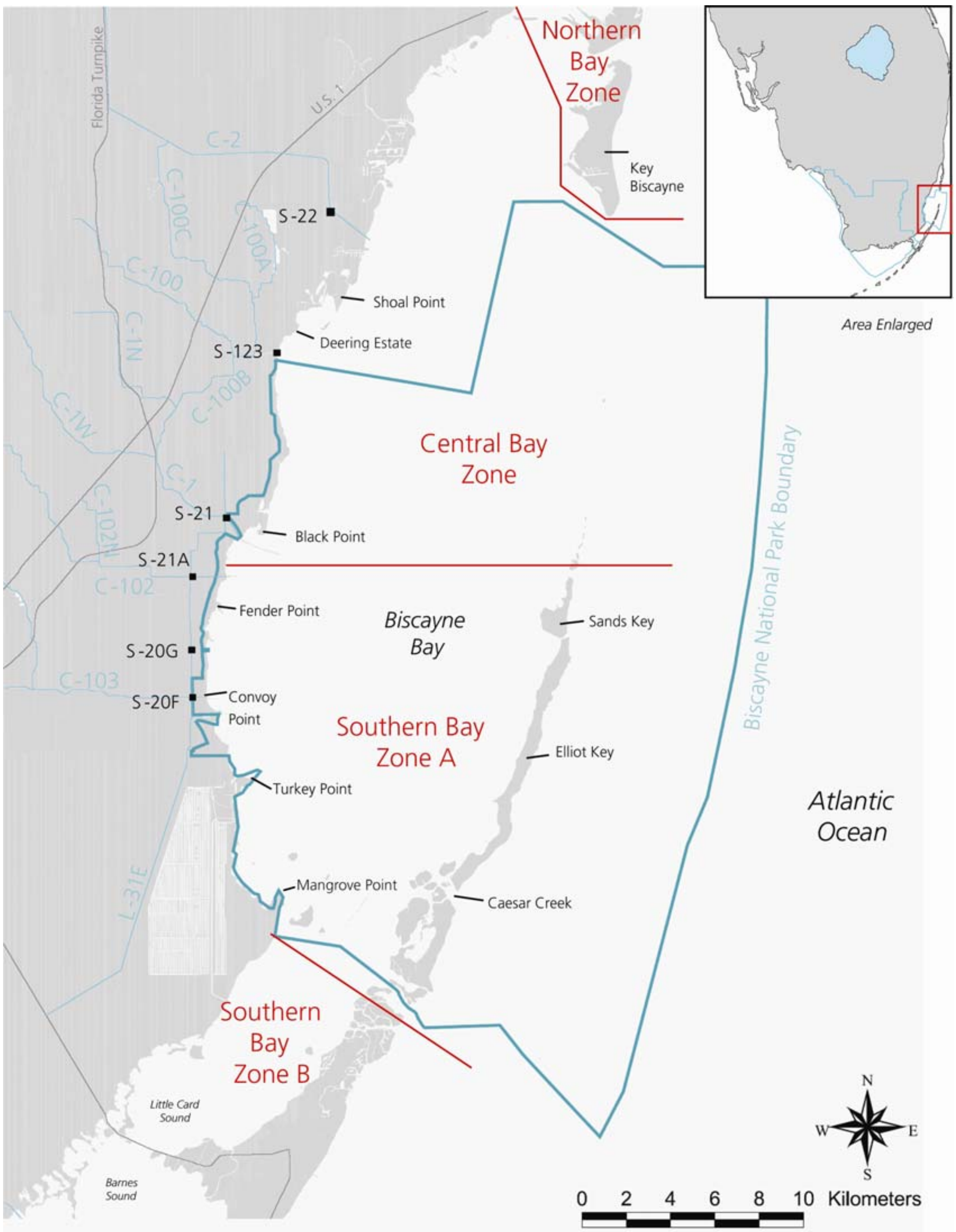

Figure 1. Biscayne National Park regional setting and Bay Zone definitions.

can be applied in northern Biscayne Bay by agencies which are more familiar with conditions there and which are responsible for its protection.

Biscayne Bay has been divided in various ways but the most useful has been based on hydrodynamic circulation as used by the Metro-Dade County Planning Department (1986) and used by the South Florida Water Management District in the Surface Water Improvement Plan for Biscayne Bay (1994). In this report we divide Biscayne Bay into three sections (North Bay, Central Bay, and South Bay) based on dominant circulation patterns driven by proximity to oceanic inlets (Wang et al. 2003). These circulation patterns strongly influence salinity, and therefore the ecology of the different regions of the Bay. A newer and alternate delineation of the Bay was created based on analysis of water quality data by Joe Boyer at Florida International University (Boyer 2004). Boyer groups areas based on similarities in water quality conditions composed primarily of nitrogen and phosphorus compounds as well as other nutrients. Since water quality in Biscayne Bay is largely dependant on canal discharge, which was not present historically, we have chosen to use the designation based upon physical circulation patterns.

These divisions form the basis for oceanographic, geologic, and hydrologic factors that influence salinity and therefore ecology. Dominant circulation patterns vary based on local effects within four major hydrodynamic regions:

- North Bay (from Dumfoundling Bay south to Rickenbacker Causeway)
- Central Bay (from Rickenbacker Causeway south to Black Point)
- South Bay (from Black Point south to Jewfish Creek) (SFWMD 1995)
    a. The South Bay Section, from Black Point to Mangrove Point, the southwest corner of Biscayne National Park (Southern Bay Zone A)
    b. The Extreme Southern Bay Section from Mangrove point to Jewfish creek, (Card Sound and Barnes Sound, and the associated bay, Manatee Bay) which are within the boundary of the Florida Keys National Marine Sanctuary, and the Biscayne Bay Aquatic Preserve (Southern Bay Zone B).

The general circulation within Central and South Bay (Figure 2) is driven by the large tidal flow in and out of the Bay across an area known as the Safety Valve, and modified by the tidal flows through the five small creeks bisecting the island chain north of Key Largo and by the large tidal oscillation in and out of the enclosed southern basins, Card and Barnes Sounds. Circulation and water exchange in North Bay has little to no influence on the circulation in Central Bay. This tidally driven flow pattern is based on unpublished salinity monitoring data collected by Biscayne National Park and staff observations. The resulting current pattern is consistent with the circulation models developed for Biscayne Bay by the U.S. Army Corp of Engineers (Dr. Rob MacAdory) and the University of Miami (Dr. John Wang). Freshwater from the mainland enters South Bay directly along the western coastline, and indirectly through Card and Barnes Sounds and Central Bay. The net effect is that the western part of the Bay, the area between Turkey Point and Black Point, is the area most influenced by freshwater flows. In terms of desired conditions for Biscayne National Park, and taking into account all source waters, this area of fresher water would extend along the mainland shoreline to the isthmus bounding the southern end of Barnes Sound.

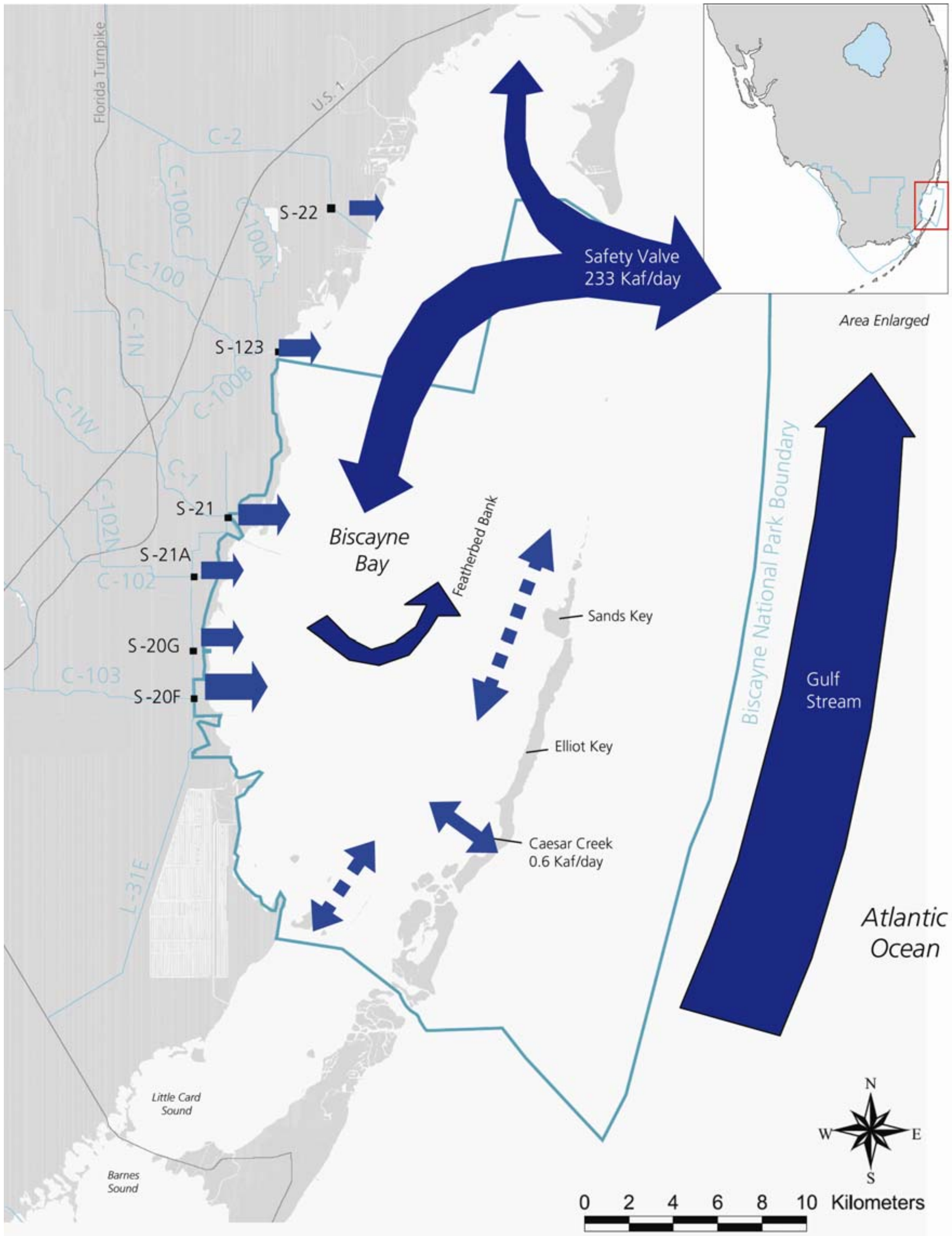

Figure 2. Biscayne National Park general water circulation and sources.

When considering questions related to water management and freshwater flows from the mainland, the focus within these regions shifts westward to water and habitats nearest the coast which provide the most sensitive indicators of Bay conditions. For the purposes of this report, the focus for development of targets for ecological restoration is placed on two areas: the Coastal Mangrove Zone (CMZ) on the mainland of Biscayne National Park, and the Western Bay Zone (WBZ), including the seagrass bottom which occurs in the western portion of the South Bay Section (Figure 3).

Western Bay Zone Target Area. RECOVER has developed a performance indicator (SE-6) for CERP restoration efforts in Biscayne Bay that describes indicator organisms, salinity conditions, and the "nearshore" area in which the performance measure will be applied. The area defined in SE-6 has lost historical oyster (*Crassostrea virginica*) colonies and no longer sustains red drum (*Sciaenops ocellatus*), species that could be restored if habitat conditions were made suitable. Performance measure SE-6 defines "nearshore" as 250 meters from shore during the dry season and 500 meters from shore during the wet season (Figure 3). The definition of these longitudinal bands of estuarine habitat is based on a simple consideration of a volume of water entering the bay edge as uniform flow; however, there is no analysis in the performance measure that explains why 250 and 500 meters were chosen as target areas.

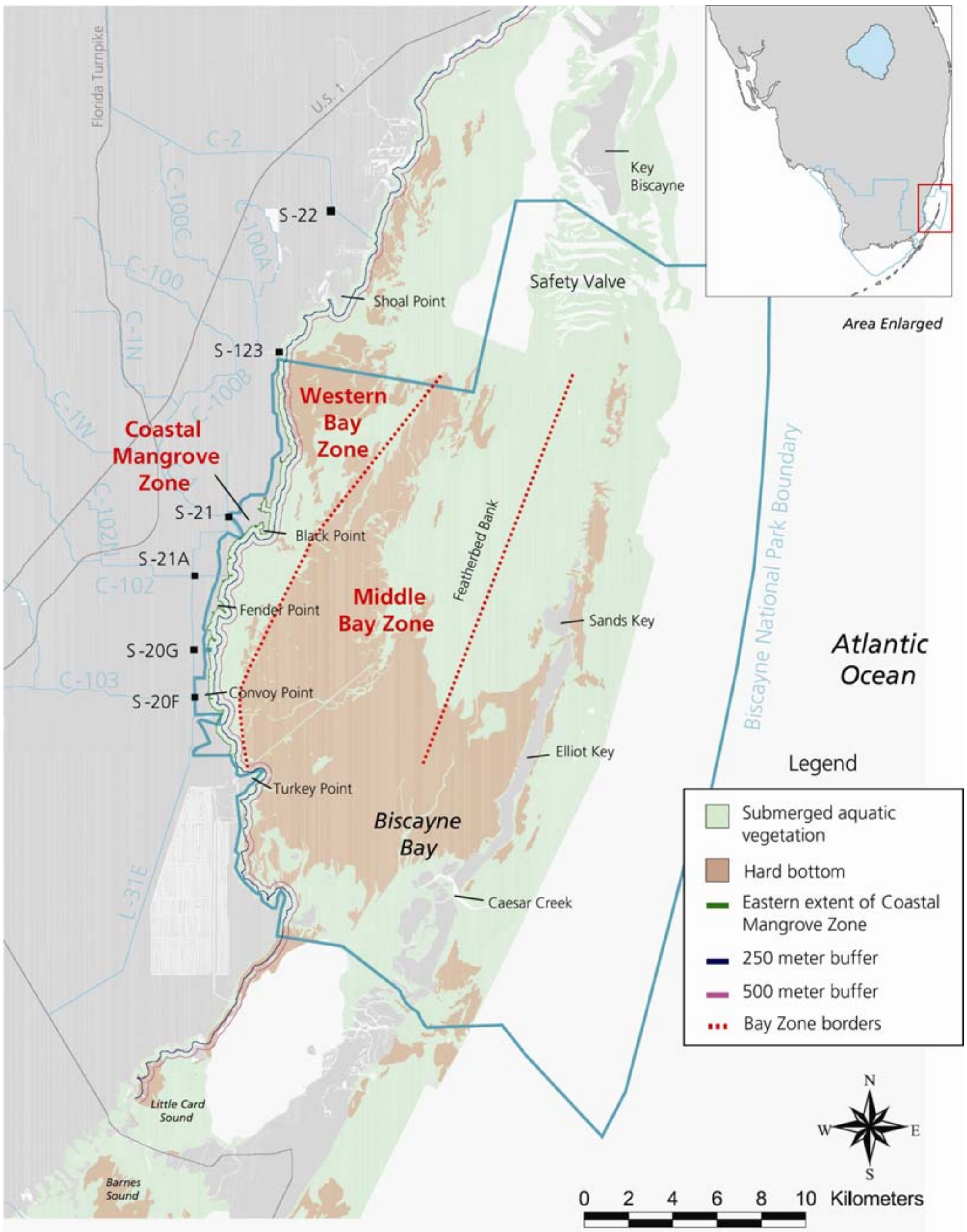

Figure 3. RECOVER performance measure focus areas and alternative Western Bay Zone focus area based on submerged aquatic vegetation on the bay bottom.

Because the characteristics of the benthic community depend on bottom type, we chose to use existing but stable physical characteristics of the Bay bottom to assist in the definition of a target area for restoration. Based on benthic mapping and evaluation of abundance and distribution of benthic community types, the ecology of Biscayne Bay as a whole is dominated by the soft bottom (approximately 64% of the bottom) and hard bottom (17%) benthic communities (NOAA 1996). Soft bottom, shallow areas promote seagrass communities, whereas hard bottom areas, which occur where sediment is non-existent or very thin over a rocky substrate, are characterized by soft corals (i.e., sea fans), sponges, and isolated coral colonies.

Examination of geological maps of the Bay bottom shows that areas affected by freshwater inflows along the coast of Biscayne National Park comprise a zone of soft bottom seagrass habitat that extends from Turkey Point to about 1,000 m off shore at Convoy Point to some 6,500 m off shore at the northern mainland boundary of the park (Figure 3). The northern sector of this zone is a mix of both soft and hard bottom communities. This zone is bounded by the CMZ at the western shore of central and southern Biscayne Bay and by an area of hard bottom that occupies the Middle Bay Zone to the east. This WBZ historically received freshwater flow through coastal marshes and creeks and groundwater recharge, correlated with the wet and dry seasons.

The bottom type and location of the WBZ relative to historical freshwater inflows define a target area of 10,000 acres of functional, seagrass-based estuarine habitat in Biscayne National Park. In contrast, the RECOVER dry season target of 250 meters from shore covers about 1,600 acres, or only 16% of functional estuarine habitat that could be restored. The RECOVER wet season target of 500 meters from shore covers about 3,200 acres, or less than 1/3 of the estuarine habitat that could be restored. It is our understanding that RECOVER may consider revising SE-6 in response to the considerations discussed here.

Our description of desired conditions, and the analyses of ecological and salinity targets in the WBZ focus on this 10,000 acre area of submerged aquatic vegetation (SAV) habitat at the western edge of Central and South Bay, within Biscayne National Park. Historically, the volume, timing and distribution of water flows to Biscayne National Park created natural coastal marsh hydroperiods and provided for estuarine salinities in the western part of the Bay. We propose that the ecological requirements of the coastal wetlands, and especially the ecological requirements of the estuarine western bay zone, should drive the quantity, timing and distribution of water deliveries to this area. This change would reestablish high quality nursery habitat for important fish and invertebrates in a band of soft bottom/SAV habitat from the northern boundary of Biscayne National Park south to Turkey Point (Figure 3).

ECOLOGICAL TARGETS FOR BISCAYNE NATIONAL PARK

Historical Conditions

Coastal Mangrove Zone. What we now call the Coastal Mangrove Zone was formerly composed of freshwater marsh species. Historically, fresh surface water flowed to the Bay through natural sloughs, rivers, and wetlands, and fresh groundwater flowed through the Biscayne Aquifer (Parker et al. 1955; Kohout and Kolipinski 1967; Buchanan and Klein 1976) and seeped into the bay along the coast and through the bay bottom. At the southern end of the Miami Rock Ridge, freshwater wetlands in the Biscayne Bay watershed occupied extensive coastal marl prairies that were east of the Ridge where it curves westward away from the coast. Prior to drainage and land development, these marshes were dominated by sawgrass (*Cladium jamaicense*), spike rush (*Eleocharis cellulosa*), and other freshwater graminoids, including grasses and herbs (Gaiser and Ross 2004). The hydropattern depended on direct precipitation, surface flow from the Everglades through breaks in the Ridge called "transverse glades," or rising groundwater when the regional water table was high (Wanless 1976). In a study of the paleoecology using soil cores along the coast, Gaiser and Ross (2004) showed that prior to 100 years ago, salinities in the coastal wetlands of Biscayne Bay were in the range of 0-10 ppt, whereas at the present time the range is about 8-17 ppt.

The transverse glades and freshwater forests and wetlands drained into a transition zone of coastal creeks and a mix of herbaceous freshwater-brackish wetlands, tidal marshes, and mangrove forests on the edge of the coast. These supported the Bay ecosystem by spreading freshwater inflow, absorbing excess nutrients, and providing habitat—including critical nursery habitat—for fish and shellfish, as well as feeding habitat for wading birds. Local rainfall, groundwater seepage, overland sheet flow and small coastal rivers fed water to the Bay all along its mainland margins. The flow of fresh water through the forested wetlands and fresh water marshes provided dynamic storage of water and a buffer to reduce the amplitude of rainfall runoff events, and moderated the transition from fresh water inflows to estuarine and marine conditions in the Bay (Wanless 1976; Browder and Wanless 2001). Egler (1952) documents the distinct vegetation bands parallel to the coast prior to construction of major drainage canals. He concluded that changes in vegetation composition were a result of increases in salinities between freshwater wetlands and saline wetlands near the coast. The area was still largely dominated by graminoid freshwater wetland, followed by dwarf mangrove scrub, and a narrow band of coastal mangroves in the 1940's and early 1950's. Kohout and Kolipinski (1997) found a distinct biological zonation of flora and fauna in nearshore Biscayne Bay based on salinity in the area around the old Cutler power plant north of the old Burger King headquarters site. Ishman et al. (1998) documents increasing salinity with distance offshore in predrainage Biscayne Bay. They also compare historical salinities from 1850-1900 to salinities in 1996. Gaiser and Ross (2004) also document the historic salinity gradients in the remnant coastal wetlands. Average annual mean predrainage salinities were less than 2 ppt and freshwater marshes and associated forest units covered 90% of the area, with only a narrow band of mangroves along the coastline. Today that same area has a mean salinity of 13.2 ppt, and is 95% covered by mangroves.

Western Bay Zone. Many different estuarine species flourished in the western part of Biscayne Bay. Miami-Dade County was at the core of the American crocodile (*Crocodylus acutus*) geographic range in the U.S. (Kushlan and Mazzotti 1989), with the coastal wetlands along the western shore of Biscayne Bay providing important habitat. Oyster reefs and associated fauna could be found in the Bay (Smith 1896; Meeder et al. 2001). A large number of fish species could also be found in Biscayne Bay, with Smith (1896) listing 95 fish taxa. The presence of several species of drum (family Sciaenidae), which prefer brackish conditions, and the description of some of these species as either abundant or common, is particularly revealing of more estuarine conditions over 100 years ago (Serafy et al. 2001).

Recent paleoecological research conducted by the U.S. Geological Survey provided insight into predrainage conditions and general trends in Bay salinities since 1900 (Ishman et al. 1998; Wingard et al. 2003, 2004). Results from sediment cores showed a long-term trend of increasing salinity at virtually all sites studied in Biscayne Bay, particularly since 1900. In the vicinity of Black Point these data indicated that mid-level mesohaline conditions existed prior to 1900, tending toward more polyhaline conditions after that time. Sediment core data indicated that since 1950 salinities have increased to mostly polyhaline conditions at these sites. Middle Key and Manatee Bay sites to the far south (Barnes Sound area) are farthest from the influence of Everglades transverse glades drainage but are under the influence of the eastern margin of the Taylor Slough drainage system. Sediment cores from these two sites indicated conditions were predominantly fresh water (0 ppt) until about 1900. After that, oligohaline and low-end mesohaline conditions appeared, possibly in response to construction of the Flagler railroad, initial land drainage activities, and the construction of roadways (Wingard et al. 2004). The final shift occurs around the 1960's to mid-1970's when marine conditions (30-40 ppt) appear in the sediment record, as evidenced by the remains of invertebrate species that can tolerate high salinities in areas that were once estuarine in nature. Clearly, since 1900, a significant amount of fresh water inflows to Biscayne Bay have been diverted, converting what were once fresh to brackish, estuarine habitats in the nearshore areas to marine conditions, with the loss of estuarine productivity and function.

Current Conditions

Hydrology has been altered by regional drainage, canal construction and operation, and urban development, as well as by construction of roads, levees, and other hydrologic barriers to surface flow. The Bay currently receives freshwater inflow as canal flow, with only minor overland flow, and occasional groundwater seeps (Kohout and Kolipinski 1967; Buchanan and Klein 1976; SFWMD 1995). Freshwater flow to the Card Sound and Barnes Sound section comes only through moderate to light discharges from the C-111 Canal, and from overland runoff from extensive freshwater and coastal wetlands contiguous with the mainland shoreline of these two basins.

Coastal Mangrove Zone. The L31E levee and canal run parallel to the coast about 2 km inland and intercept the local sub basin drainages and transverse glades that used to discharge water to southern Biscayne Bay. As a result, a narrow strip of isolated coastal stream remnants and coastal fringe mangrove forest, most of which is within the park, is disconnected from the regional hydrology. The loss of freshwater inflows has resulted in the expansion of the fringing mangrove forest to the eastern side of the levee system (Ross et al. 2000; Gaiser and Ross 2004).

Currently, the hydrologic conditions within the CMZ are dependent upon canal stages and local rainfall. Because there are no current freshwater deliveries to this area, water levels in the canals determine the adjacent water table and, therefore, the water level in the CMZ. Water enters the area as groundwater seepage and as rainfall. These changes in surficial drainage have affected surface and groundwater hydrology (Parker et al. 1955; Parker 1974), reducing or eliminating coastal creek function and productivity. West of the L31E levee, the landscape is drained and compartmentalized by a network of mosquito control ditches, wetland drainage ditches, and flood control canals (e.g., Ruiz and Ross 2004). Although the wetland value of this area has decreased substantially because of increasing salinities and drainage, the ecological function of habitat created by the invasion of salinity tolerant coastal mangroves remains particularly important to Biscayne Bay (Odum and Heald 1975; Teas 1976).

The area between Convoy Point and the northern mainland extent of the park covers some 1,500 acres of potentially high value fish and wildlife habitat that forms the longest contiguous coastal mangrove forest on the east coast of Florida. It is comprised of coastal fringe forest (primarily red mangroves), interior transitional forest (red and white mangroves), dwarf mangrove forest (red mangroves), and a mosaic of relict stream channels and coastal wetlands. This area provides food, shelter and nursery habitat, critical to sustaining the recreational and commercial fisheries in south Florida (Teas 1976; Serafy et al. 2003). Salinity fluctuations imposed by water management operations and loss of water to coastal creeks that once created brackish conditions in the prop root zone have created impaired fishery habitat with impaired nursery function.

Western Bay Zone. East of the mangroves, the WBZ is dominated by the seagrass (approximately 64% of the bottom) and hard bottom (17%) benthic communities (NOAA 1996). Submerged aquatic vegetation (SAV) in the Bay is typically a mixed species community that may include shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*), wigeon grass

(*Ruppia maritime*), and three species of an uncommon SAV *Halophila.* Freshwater algae (*Chara spp.*) may also be found in low salinity coastal streams, tidal creeks, ponds, and around canal and creek outlets where fresher water predominates. The distribution of *Chara* in the WBZ is limited by its intolerance of the marine conditions now common in nearshore areas of the Bay. Currently, the SAV community is dominated by turtle grass (Christian et al. 2004), an indicator of true marine conditions because of its low tolerance of brackish conditions.

The CERP Monitoring and Assessment Plan conceptual models identify salinity as the primary stressor in the WBZ, affecting biology when conditions deviate from a natural range. Salinity in this area is controlled by tidal circulation, which tends to increase salinities toward an offshore level (33-35 ppt), and by canal discharge, which is a function of canal operations and introduces freshwater (<1 ppt). To a lesser extent, salinity in this zone is affected by local rainfall (SFWMD 1995; Lirman and Cropper 2003; Faunce et al. 2003; Serafy et al. 1997). Another stressor is poor-quality water containing nutrients and contaminants (SFWMD 1995), carried by the six canals discharging into this zone (Black Creek (C-1), Princeton Canal (C-102), Military Canal, and Mowry Canal (C-103), C-111, Snapper Creek (C-2) and the Coral Gables Waterway (C-3)).

Indicator Species: Benthic Community, Endangered Species, and Important Fishery Resources

Many of the species described in this report are considered to be dependent on estuarine conditions. They require a brackish environment or they are reliant on estuarine salinities at specific stages in their life cycle. The presence of these species both historically and at present supports the importance of maintaining and restoring the estuarine nature of the WBZ. Many of these species are declining presumably because of the lack of freshwater currently reaching the bay. Therefore, the salinity range of these organisms can be used to define a beneficial salinity range for Biscayne Bay. Many species including stone crab, Spanish mackerel, Crevalle jack, grey snapper, and tarpon are either recreationally or commercially important within the WBZ fishery. However, historical data and site-specific information on preferred salinity ranges are not available for all of these important species. We found more historical information and field studies with site-specific information on preferred salinity ranges for six species and chose to use these as biological indicators. These species, American crocodile, spotted seatrout, mojarras, silver perch, pink shrimp, and eastern oyster, and the specific reasons for their importance, are presented in Table 1.

Table 1. Fish and wildlife indicators in Biscayne Bay.

Organism	Zone	Importance	Source
American crocodile (*Crocodylus acutus*)	Mangroves	Endangered Species	Mazzotti and Cherkiss 1998; Kushlan and Mazzotti 1989; Kushlan 1988; Mazzotti 1983
Spotted seatrout (*Cynoscion nebulosus*)	Western Bay Zone	Commercial value, recreational fishing	Patillo, et al. 1997; Bortone, 2003
Mojarras (*Eucinostomus spp.*)	Western Bay Zone	Forage base species	Serafy, et al., 1997
Silver perch (*Bairdiella chrysoura*)	Western Bay Zone	Forage base species	Serafy, et al., 1997
Pink shrimp (*Farfantepenaeus duorarum*)	Western Bay Zone	Keystone species, commercial value	Bielsa et al., 1983; Serafy et al., 2001; Browder et al., 1999; Gunter et al., 1964
Eastern oyster (*Crassostrea virginica*)	Mangroves	Commercial value	Meeder et al., 2001; Wells, 1961

Biscayne National Park’s creel data (based on interviews of anglers when they return from fishing to local marinas) has been collected since about 1976. Most of the data pertain to reef fish, since a majority of the anglers fish on the reef, and are therefore less useful in this paper, which focuses on the near-shore area. The bay species that might be affected by salinity changes near the coast (i.e., snook, spotted sea trout, red drum) are now landed infrequently in the areas we survey, making it impossible to identify trends in population abundance from the creel data. The only species that are affected by salinity changes and are frequently reported are snappers and grunts which utilize bayside seagrass beds as juvenile habitat. Also, it is impossible to distinguish the effects of salinity changes over time from fishing effects over time. For all these reasons, the Biscayne National Park creel data set was used to provide supporting evidence of the continued presence of the biological indicator species in the Bay, and was not used for more quantitative analyses of the effects of salinity changes.

The American crocodile (*Crocodylus acutus*) is primarily found in areas characterized by brackish estuarine conditions and average salinities of 14 ppt (Mazzotti 1983; Kushlan 1988; Kushlan and Mazzotti 1989). Hatchling crocodiles are particularly reliant on low salinities, generally 0 to 5 ppt (Mazzotti and Cherkiss 1998). Mazzotti and Cherkiss also determined that all size classes (hatchlings, juveniles and adults) favor water bodies with an intermediate salinity of 20 ppt. Juvenile crocodiles, in particular, seek out and seem to require a mesohaline (<20ppt with an optimum of 9 ppt) habitat for survival (Mazzotti et al. 2002).

Eastern oysters (*Crassostrea virginica*) have long been recognized as an indicator of estuarine conditions (Dean 1892; Oemier 1894, Ritter 1896; Grave 1905; Pearse and Wharton 1938; Nelson et al. 1991; Estevez 2000; Meeder et al. 2001). The life cycle of oysters occurs entirely within estuaries. Oysters are capable of surviving salt concentrations from 5 to 40 ppt, however the optimum range for oyster reef growth is 10-20 ppt (Stenzel 1971; Meeder et al. 2000). This allows for oyster reproduction while decreasing predation rates (Grave 1905; Gunter 1950; Wells 1961).

Spotted sea trout (*Cynoscion nebulosus*) and mojarras (*Eucinostomus spp.*) are important fish species in Biscayne Bay. Serafy et al. (1997) found that populations of these two species in Biscayne Bay prefer salinities less than 20 ppt. They also found that there was a significant decline in the abundance of these two species from 20 to 30 ppt. A re-examination of these data, with the addition of silver perch (*Bairdiella chrysoura*), was conducted to focus on evaluating the relationship between salinity and juvenile abundance (Figure 4.) A clear pattern of selection of salinities less than 20 ppt was observed in the data, with significant declines in abundance from 20 to 30 ppt. The pattern of declining fish density with increasing salinity was also observed by Campos (1985) in another study conducted in Biscayne Bay.

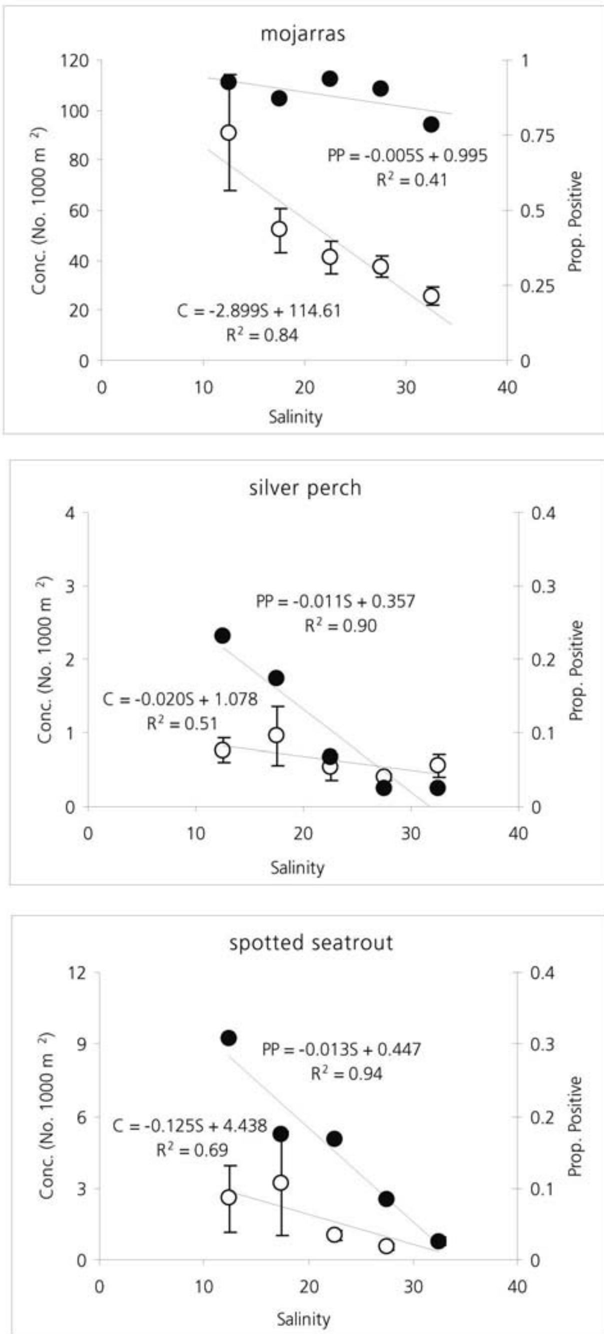

Figure 4. Abundance of key indicator fish relative to salinity. (from Serafy et al. 1997)

Pink shrimp (*Farfantepenaeus duorarum*) comprise the most economically important fishery in Biscayne Bay as well as being a key species in the marine food chain (Bielsa et al. 1983; Berkley and Campos 1984; Markley and Milano 1985; Browder et al. 1999; Serafy et al. 2001). Estuaries, and the seagrass communities found there, are important nursery habitats for pink shrimp and offer the most favorable food and shelter conditions for juvenile and post larval pink shrimp (Bielsa et al. 1983; Ault et al. 1999). Young shrimp find their way into the estuary by detecting lower salinity and a high amount of organic material (Lindall 1971; Odum and Heald 1975; Ault et al. 1999). These shrimp spend 2-6 months in estuarine areas before entering offshore water (Costello and Allen 1966; Bielsa et al. 1983; Ault et al. 1999). Post-larval pink shrimp are most often found in the nearshore seagrass on the western side of the central and southern portions of Biscayne Bay (Ault et al. 1999). Since this species is critically important to the Bay and the regional fishery, estuarine conditions and SAV habitat must be preserved. This can only be accomplished by the stabilization and persistence of mesohaline conditions.

Salinity Characteristics to Support Ecological Communities

Evidence of the requirements of a number of species presented previously demonstrates that salinity is a key habitat factor for the Bay ecosystem. Figure 5 summarizes the optimal salinity ranges for Biscayne National Park ecosystem indicators, including primary producers, primary consumers, and predators. The majority of these indicator species prefer salinities between 5 and 20 ppt. Based on this observation and taking into account that other species (such as seatrout and oysters) may require periods of time with slightly higher or lower salinities, we propose the following salinity targets for the CMZ and WBZ of Biscayne National Park.

- At no time should measured monthly salinities exceed 30 ppt. This will be particularly critical to measure in the dry season, from November to March.
  - Direct benefit to important fishery species with a life cycle stage that does best at estuarine salinities, oysters, fish that serve as sport fish forage, and post larval juvenile shrimp that rely on brackish water as a refuge from marine predators.
  - Indirect benefit to recreational and commercial fish species that rely on the forage base produced by estuarine conditions, such as adult sea trout, snapper, and grouper fish stocks.
- From March through August (late dry season - early wet season), average monthly salinities should range between 15-25 ppt in the WBZ.
  - Direct benefit to spawning habitat for sea trout, adult habitat for forage species (mojarras, silver perch), and conditions that foster a healthy and diverse seagrass community that can be sustained in a zone that is subject to fresh water runoff.
  - Indirect benefit to nursery habitat for important juvenile fish species (productive seagrass beds and an extensive brackish water refuge from marine predators).
- In the late wet season (September-October), the CMZ should be oligohaline (0-5 ppt), and the WBZ should average less than 20 ppt.
  - Direct benefit to juvenile crocodiles that have a physiological requirement for low salinity conditions.
  - Direct benefit to important forage fish species in coastal mangroves that do best at oligohaline to mesohaline conditions (such as sheepshead minnow, gold-spotted killifish).
  - Indirect benefits to all species that consume forage species that support upper trophic levels in the mangrove zone, including wading birds, mammals, and crocodiles.
- Salinity changes should be gradual and reflect changes in hydropattern that approximate a natural system. All vegetation, fish, and invertebrate species benefit from gradual changes in salinity that avoid physiological stress.
- Salinity gradients should always consist of lowest salinities near the coast and highest salinities in the ocean.

Restoration of freshwater inflows to reach these salinity targets should result in a highly productive SAV community that will support desired ecological characteristics of Biscayne National Park.

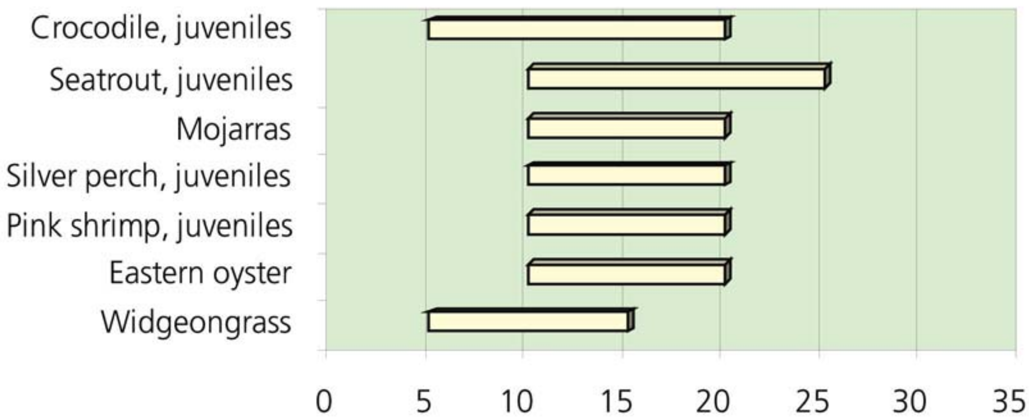

Figure 5. Optimal salinity ranges (units in ppt) for Biscayne National Park ecosystem indicators.

Desired Ecological Conditions for Biscayne National Park

Coastal Mangrove Zone. In the CMZ, these low salinity values will sustain a fully functional tidal wetland transition zone, including the estuarine creeks that provide fresh water to the bay, and result in stable estuarine conditions for nearshore habitats. Coastal creeks, currently intercepted by the L31E levee, should have a normal seasonal hydrograph, with flows in the wet season that are dominated by local rainfall, and declining flows in the dry season, dominated by base flows from inland drainage. The level of fresh water discharged into Biscayne National Park should support SAV dominated by wigeon grass and *Chara spp*., Emergent vegetation should consist of cord grass (*Spartina spp.*), salt grass (*Distichlis spicata*), and black rush (*Juncus roemerianus*). The existing mangrove forest should remain similar to what it is now, but consist of a more spatially distinct buttonwood, black mangrove and white mangrove transition zone, with red mangroves at the edges of creeks and at the bay's shoreline.

The faunal composition in the mangrove zone should be similar to that described in historical documentation of pre-drainage conditions, and where it is not detailed, composition should be similar to fauna characteristic of less impacted estuarine mangrove forests in south Florida. The desired species are those common to coastal streams and inland brackish marsh flats, such as the sailfin molly (*Poecilia latipinna*), gold-spotted killifish, (*Floridichthys carpio*) sheepshead minnow (*Cyprinodon variegatus*), and eastern mosquitofish (*Gambusia holbrooki*) (Lorenz 1999; Serafy et al. 2003).

In the sub tidal area of the CMZ, which is dominated by mangrove prop roots, permanent, healthy oyster communities should be common, both on the prop roots and as oyster reefs where the creeks enter the bay. Although oysters were once common in the Bay and are characteristic of similar habitats in south Florida, they are only found in very low numbers today. Establishment of more natural volumes, timing, and distribution of water deliveries will foster the restoration of oyster colonies and the estuarine biota associated with them.

Western Bay Zone. Estuarine conditions in the WBZ will maximize SAV coverage and diversity, a key component of critical nursery and juvenile fishery habitats. Under appropriate salinity and water quality conditions, it is expected that the WBZ will sustain excellent SAV growth where sediment and water depth are appropriate. These salinities should also create a more diverse seagrass community, dominated by species that do well under estuarine conditions. Wigeon grass will be the dominant species at the mangrove/nearshore ecotone and shoal grass co-dominant with turtle grass throughout the WBZ. Maintaining estuarine salinity will sustain larval and juvenile red drum and provide good habitat conditions for sustaining a forage base for red drum, including oyster, shrimp, and forage fish populations.

In general, water deliveries to Biscayne National Park should not result in damage to natural resources including extreme salinity conditions that adversely affect fishery and wildlife resources. The preferred salinity ranges for the indicator species presented above help determine freshwater needs and define conditions that cause impairment of natural resources. The daily mean salinity for the CMZ should fall within the 0-5 ppt in the late wet season (October and November) and average less than 20 ppt annually. A natural gradient of salinity should exist between the mangrove zone and the eastern edge of the WBZ throughout most of the year. Although the extent and character of the gradient is influenced by a variety of factors including the rate of fresh water arrival, evaporation and plant transpiration rate, and tidal mixing, water management operations should not result in any unnatural extremes in salinity and should approximate natural inflows. The WBZ should have salinities between 5 and 20 ppt throughout the year, allowing for only short term excursions (10 days or less) to higher salinities (not exceeding 30 ppt) as a result of water management. Longer hypersaline events because of intercepted coastal inflows must be avoided, and sustained periods of relatively low salinity are considered essential for sustaining key estuarine species. Unnatural pulse discharges of fresh water that cause rapid and significant decreases in salinity that damage benthic habitats must also be avoided.

Summary of Ecological Performance Measures

The productivity and richness of the estuarine communities of Biscayne National Park have significantly diminished, as have those throughout Biscayne Bay, as a result of channel creation and the diversion of water from the natural systems in south Florida. The quantity of fresh water, the seasonal timing of inflows, and the distribution along the coast have been significantly altered, profoundly affecting the historic estuarine nature of the western portion of the Bay. The alteration of the hydrology of south Florida has resulted in the near complete loss of estuarine habitats from the Bay, including Biscayne National Park, diminishing the ecological and economic values of this portion of the greater Everglades ecosystem.

Additional water losses that may result from future demands for water supply and flood control will exacerbate existing impacts. Fresh water inflows during the dry season months are particularly important for protection of fish and wildlife resources. Without these fresh water inflows rainfall on the bay is insufficient to compensate for evaporation in moderating salinity. Not only has the system become more marine in salinity, but the increased frequency and duration of hypersaline events adversely impacts even marine biota, most of which have very narrow salinity and temperature tolerances.

At present, the water that is released to Biscayne National Park provides marginal estuarine benefits, far short of those that would result from a more natural, historic hydropattern. The timing of current water releases differs significantly from a natural pattern, with large freshwater pulses during the wet season that drive salinities too low, and minimal flows in the dry season that allow salinities to greatly exceed the predrainage environment. The location of current water deliveries also differs from a natural pattern, in that the CMZ no longer receives any significant overland flow, and water inputs to the WBZ arrive as point discharge from canals. In short, the quantity, timing, and delivery of water currently arriving at Biscayne National Park is not adequate to provide stable estuarine conditions.

DISCUSSION

Prior to the significant changes in the freshwater flow patterns in south Florida caused by the creation of a water control system upon the landscape in the early 20th century, Biscayne Bay was a true estuarine system. Significant amounts of fresh water in the form of both surface and ground water were present throughout most of the year and supported a wide range of flora and fauna. When these freshwater sources were diminished and their distribution altered by water management practices, the vegetation in the Bay as well as the juveniles of many fish and invertebrate species were adversely affected, and the ecosystem in the Bay changed drastically. The ecosystem that exists today in Biscayne Bay is largely marine in nature, as the volume, timing and distribution of the freshwater flows are insufficient to maintain an estuarine environment over ecologically-significant temporal and spatial scales. In keeping both with the Everglades restoration efforts and the National Park Service mandate to preserve unimpaired the nation's natural resources within the parks, this document provides ecological and physical targets for desired conditions in Biscayne National Park, and attempts to quantify the existing freshwater flows that are necessary for the protection of fish and wildlife within the park.

The spatial focus of the discussion of ecologic targets includes the Coastal Mangrove Zone (CMZ) of mainland Biscayne National Park in this report and the adjacent Western Bay Zone (WBZ). The shallow waters of the WBZ contain thousands of acres of seagrasses as well as a fringing mangrove forest. The desired condition, or over arching goal, for the 10,000 acre western zone of Biscayne National Park is the existence of stable estuarine conditions that persist through the dry season, to be achieved through more natural timing and distribution of freshwater flows. These stable estuarine conditions support a productive, diverse benthic community based on seagrass. These conditions will also support endangered species and sustain productive nursery habitat for local and regional fishery resources.

The appropriate restoration area to consider was discussed in this document. The existing RECOVER performance measures focus on a narrow (500m) strip of coastline that encompasses 3200 acres of Park waters. The alternate approach used here is to focus on existing geomorphological information to define an area of soft bottom suitable for seagrasses: this habitat in the WBZ includes roughly 10,000 acres of park area. This larger region was chosen as the target area for stable estuarine conditions because it is based on Bay geomorphology, a factor that is fundamental to Bay ecology.

The ecological targets for the WBZ were based upon an approach that includes the benthic community, endangered species and important fishery resources in the western bay. Because seagrass is important nursery and growth habitat for indicator species, a fundamental resource management and restoration goal is to maximize coverage by SAV beds at sustainable levels. Under appropriate salinity and water quality conditions, it is expected that this area will support excellent SAV growth where sediment and water depth are appropriate for such growth. One explicit restoration target is an increase in the vitality and diversity of the WBZ seagrass community, with wigeon grass as the dominant SAV species at the mangrove edge within the nearshore ecotone and shoal grass becoming co-dominant with turtle grass through much of the rest of the WBZ. Another explicit target is the restoration of the community of seagrass-associated fauna which have been largely extirpated from South Bay, and the enhancement of habitat for others, such as crocodiles and pink shrimp that will likewise benefit significantly from the target salinity conditions.

These ecological targets require freshwater flows that produce mesohaline conditions throughout most of the year at the bottom of the Bay, with salinities ranging from 5 to 20 ppt over the soft bottom areas of the WBZ that have the substrate necessary to sustain SAV. In particular, measured dry season salinities (November through May) should not exceed 30 ppt anywhere in the zone. The ecological and salinity targets that link mesohaline conditions and associated seagrass and faunal communities for this area are not currently being met because current freshwater deliveries are insufficient in terms of quantity, timing, and distribution.

This paper has discussed ecological targets for Biscayne National Park. Further analysis is needed to develop metrics associated with hydrologic restoration targets for the park. These ecological and hydrologic targets will be critical to evaluate potential benefits of restoration projects for Biscayne National Park and to assess progress toward ecosystem restoration. We look forward to working with SFWMD staff in further developing these performance measures and targets.

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United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

June 14, 2006

Executive Office
JUN 15 2006

Ms. Carol Ann Wehle
Executive Director
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

Dear Ms. Wehle: Carol

I am pleased to transmit to you the attached report, entitled *Ecological Targets for Western Biscayne National Park*. The report was developed by the National Park Service in support of the District's efforts to develop water reservations for Biscayne National Park under Florida law. An excellent synthesis of the scientific underpinnings for the ecological targets is provided in the report. The establishment of initial reservations for Biscayne National Park simultaneously with those for the Greater Everglades, Florida Bay, and Northern Biscayne Bay, is an important step towards protecting the foundation water for South Florida Ecosystem restoration. We have spoken with your staff on moving ahead with a collaborative effort to refine the hydrologic parameters to achieve the ecological targets described in the report. We look forward to working with you and your staff in this process.

Sincerely,

Terrence C. Salt
Director of Everglades Restoration Initiatives

Attachment

Cc:. Kameran Onley, U.S. Department of the Interior
Michael Collins, SFWMD Governing Board Member
John Mulliken, SFWMD Director, Water Supply
Dennis Duke, U.S. Army Corps of Engineers
Beth Carlson Lewis, U.S. Army Corps of Engineers
Robert Johnson, U.S. Department of the Interior
Paul Souza, U.S. Fish and Wildlife Service
Barry Rosen, U.S. Fish and Wildlife Service
Kim Shugar, Florida Department of Environmental Protection
Dave Swift, South Florida Water Management District

United States Department of the Interior
National Park Service
Biscayne National Park
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February 28, 2006

Ms. Carol Ann Wehle
Executive Director
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

Dear Ms. Wehle:

In response to the letter from your agency received April 18, 2005, and to commitments by the South Florida Water Management District to establish Initial Reservations for Biscayne National Park concurrent with Initial Reservations for the Greater Everglades, Florida Bay and Northern Biscayne Bay, the National Park Service has developed the attached document, entitled "Ecological Targets for Western Biscayne National Park." This document is designed to assist your agency in the effort to develop water reservations for Biscayne National Park. The technical analysis in the attached document also supports the National Park Service's broad responsibility for the preservation of our nation's natural and cultural resources.

The attached document represents a joint effort by Biscayne National Park resource management staff and staff at the South Florida Natural Resources Center at Everglades National Park. During the evolution of this document, valuable comments and input were received from staff at the U.S. Fish and Wildlife Service Office of Ecological Services in Vero Beach.

We have carefully reviewed and incorporated most of the technical comments from an earlier draft of this paper which we received from your agency in November 2005. Responses to the general comments contained in the same letter follow:

1. We determined that the establishment of a stable range of estuarine conditions in an area of 10,000 acres in western Biscayne National Park represents a desired ecological condition for that area of the Park. The 10,000 acre area is a softbottom seagrass habitat adjacent to a section of the shoreline that historically received substantial freshwater inflows; this concept is developed further in the text. Information received from your technical staff was important in the development of specific ecological targets, and we thank you and your staff for your assistance.

2. We further determined that a more diverse seagrass community, and in general, a more diverse benthic community, do promote enhanced habitat values for the faunal communities that exist within the Bay. Biscayne National Park historically was home to a greater diversity of benthic flora and fauna than exist today; trends in resource condition are more fully explained in the document. Re-establishment of that historic diversity represents another desired restoration condition within the Park.

3. The Park Service is currently developing targets for Florida Bay and for Everglades National Park. Our preliminary analyses indicate that water needed to support ecological targets for both National Parks is available, especially when the entire ecosystem from Lake Okeechobee southward is included in the analysis. As the ecosystem was historically connected all the way from the Kissimee chain of lakes to the chain of coastal basins framing south Florida, we believe the water budget for the entire basin is an appropriate basis for this analysis.

We anticipate that continuing collaboration with your staff will be beneficial in developing further metrics associated with the hydrologic restoration targets for Biscayne National Park, including measures of seasonal and interannual variability, and the development of a timeline of infrastructure implementation and associated salinity changes. We are looking forward to continued cooperation in the establishment of restoration targets for our South Florida National Parks, and to working with your agency to provide the needed water for restoration of these nationally important natural areas.

Sincerely,

Mark Lewis

Dan B. Kimball

Mark Lewis, Superintendent
Biscayne National Park

Dan B. Kimball, Superintendent
Everglades National Park

Cc: Kameran Onley, U.S. Department of the Interior
Michael Collins, SFWMD Governing Board Member
John Mulliken, SFWMD Director, Water Supply
Dennis Duke, U.S. Army Corps of Engineers
Joan Lawrence, U.S. Department of the Interior
Terrence "Rock" Salt, U.S. Department of the Interior
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