THE CROCODILIAN INDICATOR IN THE GREATER EVERGLADES

2006 ASSESSMENT REPORT

UNIVERSITY of FLORIDA

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AMERICAN ALLIGATOR AND CROCODILE

LOCATION	LAST STATUS [a]	CURRENT STATUS [b]	2-YEAR PROSPECTS [c]	CURRENT STATUS [b]	2-YEAR PROSPECTS [c]
American Alligator					
A.R.M. Loxahatchee National Wildlife Refuge	🟡	🟡	🟡	Relative density (component score = 0.83) and body condition (component score = 0.17) combined for a location score of 0.5 and so current conditions do not meet restoration criteria, signifying that this area needs further attention.	A.R.M. Loxahatchee National Wildlife Refuge and management objectives play an important part in determining success here. If conditions remain constant, prognosis for the future will be stable.
Water Conservation Area 2A	🔴	🔴	🔴	Relative density (component score = 0.17) and body condition (component score = 0.5) combined for a location score of 0.34 and so current conditions are below restoration criteria.	With the stable body condition and low relative density of alligators observed here, status will remain substantially below restoration objectives.
Water Conservation Area 3A	🟡	🔴	🔴	Relative density in two of the three locations within WCA 3A is low (northern and southern areas) and higher (yellow) in the central area; body condition scores yellow in the north and central areas, and red in the south. The combined score of both components for the overall area is 0.31, which is well below restoration goals.	This is the only area in which status declined between 2005 and 2006. With the central area of WCA 3A having the highest status (yellow), it can be used a guide for raising the northern and southern areas (both currently red).
Water Conservation Area 3B	🔴	🔴	🔴	Relative density (component score = 0.17) and body condition (component score = 0.5) combined for a location score of 0.34 and so current conditions are below restoration criteria.	With the stable body condition and low relative density of alligators observed here, status will remain substantially below restoration objectives.
Everglades National Park	🔴	🔴	🔴	Relative density in all three locations within Everglades National Park is low. Body condition is higher (yellow) in Shark Slough and estuarine areas, but low (red) in northeast Shark Slough. The combined score of these two components for the overall area, and alligator hole occupancy in the inaccessible areas, is 0.35, which is well below restoration goals.	Everglades National Park management objectives will play a direct role in determining success here. If conditions remain as they currently are, restoration goals will not be met.
Big Cypress National Preserve	insufficient data	🔴	🔴	Relative density (component score = 0.17) and body condition (component score = 0.5) combined for a location score of 0.34 and so current conditions are below restoration criteria.	Only one year of relative density data has been collected, and body condition has been stable since surveys began in 2004. It is expected that If conditions remain constant, status will remain below restoration objectives.
American Crocodile					
Everglades National Park	🟡	🟡	🟡	Juvenile growth (component score = 0.67) and survival (component score = 0.5) combined for a location score of 0.59 and so current conditions do not meet restoration criteria.	Everglades National Park management objectives will play a direct role in determining success here. If conditions remain constant, prognosis for the future will be stable.
Biscayne Bay Complex	🟡	🟡	🟡	Juvenile growth (component score=0.67) does not meet restoration criteria. There currently is not enough data to calculate a survival component for this area.	Management objectives play an important part in determining success here. If conditions remain constant for growth, prognosis for the future will be stable for this component. Data on survival needs to be collected and figured into the equation.

[a] Data in the Last Status column reflect data prior to calendar year 2006.
[b] Data in the Current Status column reflect data inclusive of calendar year 2006.
[c] The 2-Year Prospect forecast assumes that no large scale hydrological restoration projects are implemented during this time period which would result in significant ecological response of this indicator. The occurrence of significant climatological events during this period may affect the forecast.

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KEY FINDINGS – AMERICAN ALLIGATOR AND CROCODILE

SUMMARY FINDING: On the whole, alligator and crocodile status remained constant during 2006, with only one area (Water Conservation 3A) showing a decline in status compared to previous years. However, the majority of locations show substantial deviations from restoration targets. Status of alligators and crocodiles are expected to improve if hydrologic conditions are restored to more natural patterns.

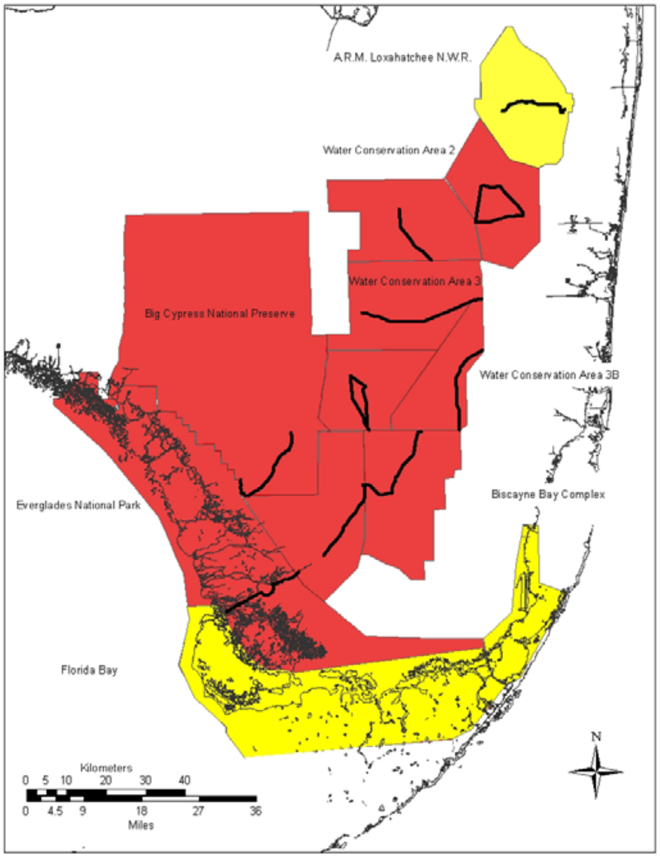

Figure 1. Map of Greater Everglades regions with stoplight ratings by region.

KEY FINDINGS:

1. Alligator overall status at the A.R.M. Loxahatchee National Wildlife Refuge is the highest in South Florida and remains stable.
2. Overall status of alligators throughout the Water Conservation Areas is substantially below restoration targets and requires action in order to meet restoration goals.
3. While body condition of alligators is higher in the southern portion of Everglades National Park (ENP) than in other areas, overall status of alligators throughout ENP is below restoration targets and requires action in order to meet restoration goals.
4. Growth and survival components for crocodiles, while below restoration targets, appear stable at this time and are expected to increase given proper hydrologic conditions through restoration.
5. Restoration of patterns of depth and period of inundation and water flow is essential to improving performance of alligators in interior freshwater wetlands.
6. Restoration of patterns of freshwater flow to estuaries will improve conditions for alligators and crocodiles.
7. Continued monitoring of alligators and crocodiles will provide an indication of ecological responses to ecosystem restoration.

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Introduction

Crocodilians (alligators and crocodiles) are the charismatic megafauna of the Everglades. They capture the public's attention and also play central roles in three aspects of Everglades ecology:

1) Alligators and crocodiles are critical in the food web as top predators, influencing abundance and composition of prey (Mazzotti and Brandt 1994).
2) Alligators are ecosystem engineers that create conditions that provide habitat for plants and animals, thereby increasing diversity and productivity of Everglades marshes (Campbell and Mazzotti 2004).
3) Distribution and abundance of crocodilians in estuaries are directly dependent on and immediately responsive to timing, amount, and location of freshwater flow (Dunson and Mazzotti 1989).

Because of these key ecological relationships, monitoring alligators and crocodiles can indicate the overall health of Everglades environments. Status of crocodilian populations relative to hydrologic changes can represent positive or negative trends in restoration.

A system-wide monitoring and assessment plan (MAP) has been developed that describes the monitoring necessary to track ecological responses to Everglades restoration (U.S. Army Corps of Engineers 2004). Included in the MAP are descriptions of selected indicators, how those indicators are linked to key aspects of restoration, and performance measures (monitoring parameters) that are representative of the natural and human systems found in South Florida. The MAP identified crocodilians as one of the indicators, and established the performance measures described in this report.

American alligators (*Alligator mississippiensis*)
Photo: Mike Rochford, University of Florida

American crocodile (*Crocodylus acutus*)
Photo: Wellington Guzman, University of Florida

Crocodilians in South Florida

American Alligator

The American Alligator (*Alligator mississippiensis*) once occupied all wetland habitats in South Florida, from sinkholes and ponds in pinelands to mangrove estuaries during periods of freshwater discharge (Craighead 1968). Alligators are a *keystone species* in the Everglades, meaning they affect nearly all aquatic life in the ecosystem in some way. As top predators, alligators consume a wide variety of prey. They also create trails and holes that provide aquatic refugia for other species during the dry season, and nests that provide elevated areas for turtles, snakes, and plants that are less tolerant of flooding (Enge et al. 2000).

As a result of land development and water management practices in South Florida, alligators are now less numerous than they were historically in prairies, Rocky Glades, and mangrove fringe areas. Canal construction has further altered alligator habitat: unlike alligator holes, canals are not suitable for small alligators, small marsh fish, or foraging wading birds. Restoration of pre-canal hydropatterns and ecological function in the Everglades is underway as part of the Comprehensive Everglades Restoration Plan (CERP, U.S. Army Corps of Engineers 1999). Because of the alligator's ecological importance and sensitivity to hydrology, salinity, habitat, and total system productivity, the species was chosen as an indicator for restoration assessment. The relative density of alligators is expected to increase as hydrologic conditions improve in over-drained marshes and freshwater tributaries. As canals are removed, alligator density in adjacent marshes and use of alligator holes are expected to increase. As hydroperiods and depths approach natural patterns, alligator growth, body condition, and hole occupancy should improve.

American Crocodile

The American crocodile (*Crocodylus acutus*) is a primarily coastal crocodilian that occurs in parts of Mexico, Central and South America, the Caribbean, and, at the northern extent of its range, in South Florida. This species thrives in healthy estuarine environments and is particularly dependent on natural freshwater deliveries. Habitat loss, due to development supporting a rapidly growing human population in coastal areas, has been the primary factor endangering the crocodile in Florida. Loss of habitat restricted nesting to a small area of northeastern Florida Bay and northern Key Largo by the early 1970s (Kushlan and Mazzotti 1989). After crocodiles were declared endangered in 1975, a crocodile sanctuary in northeastern Florida Bay was established, Crocodile Lake National Wildlife Refuge was created on Key Largo, and Florida Power and Light Company began a long-term management and monitoring program.

Crocodiles are a *flagship species* for southern estuaries, meaning they represent the ecological importance of restoring freshwater flow. Survival of crocodiles has been linked to regional hydrologic conditions, especially rainfall, water level, and salinity (Dunson and Mazzotti 1989) . Alternatives for improving water delivery into South Florida estuaries may change salinities, water levels, and availability of nesting habitat. It is expected that restoration of freshwater flows and salinity regimes will improve conditions for crocodiles. Nesting, growth, and survival of crocodiles can be used to evaluate restoration alternatives and establish criteria for successful restoration efforts in Florida and Biscayne Bay. Crocodiles can also indicate the impacts of freshwater diversion due to coastal development in Miami-Dade, Collier, and Lee Counties.

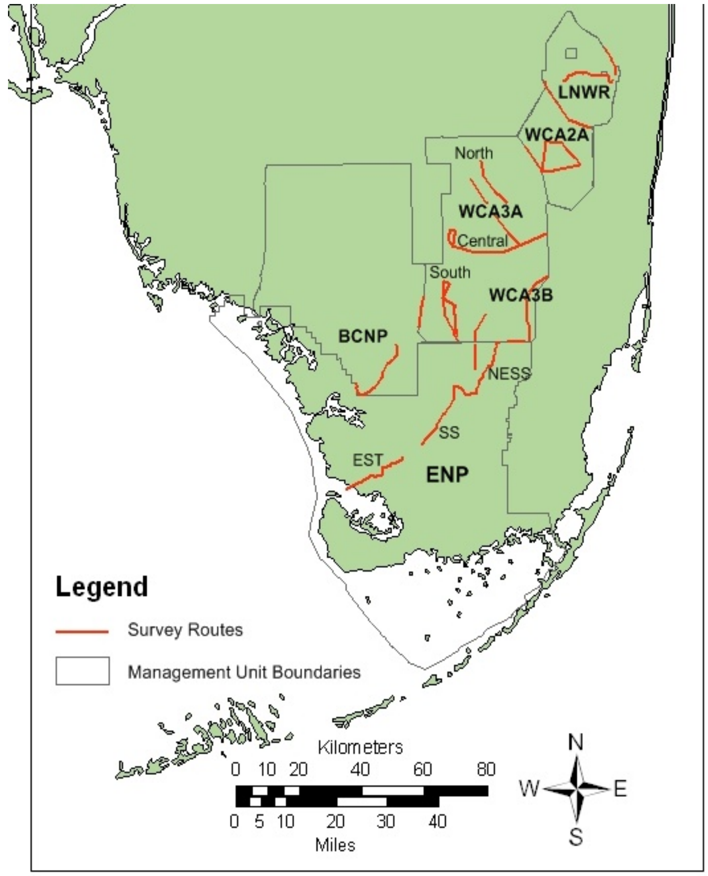

Figure 1. American alligator spotlight survey routes in South Florida, 1999-2006. LNWR = A.R.M. Loxahatchee National Wildlife Refuge, WCA = Water Conservation Area, ENP = Everglades National Park, NESS = Northeast Shark Slough, SS = Shark Slough, EST = Estuarine, BCNP = Big Cypress National Preserve. Source: University of Florida

Study Areas

Alligator monitoring was performed in six management units (two of which were divided into subunits) (Figure 1). Alligator hole occupancy monitoring was only performed in ENP-IA; relative density and body condition were monitored in all other areas.

- Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR)
- Water Conservation Area 2A (WCA 2A)
- Water Conservation Area 3A – *three subunits*:
  - North (WCA 3A-North)
  - Central (WCA 3A-Central)
  - South (WCA 3A-South)
- Water Conservation Area 3B (WCA 3B)
- Everglades National Park – *four subunits*:
  - Northeast Shark Slough (ENP-NESS)
  - Shark Slough (ENP-SS)
  - Estuarine (ENP-EST)
  - Inaccessible Areas (ENP-IA; includes areas in Rocky Glades/Southern Marl Prairies and Northeast Shark Slough)
- Big Cypress National Preserve (BCNP)

Crocodile monitoring was performed in two management units (Figure 2):

- Everglades National Park Complex (ENP)
- Biscayne Bay Complex (BBC)

Surveying American alligators by airboat
Photo: Mike Rochford, University of Florida

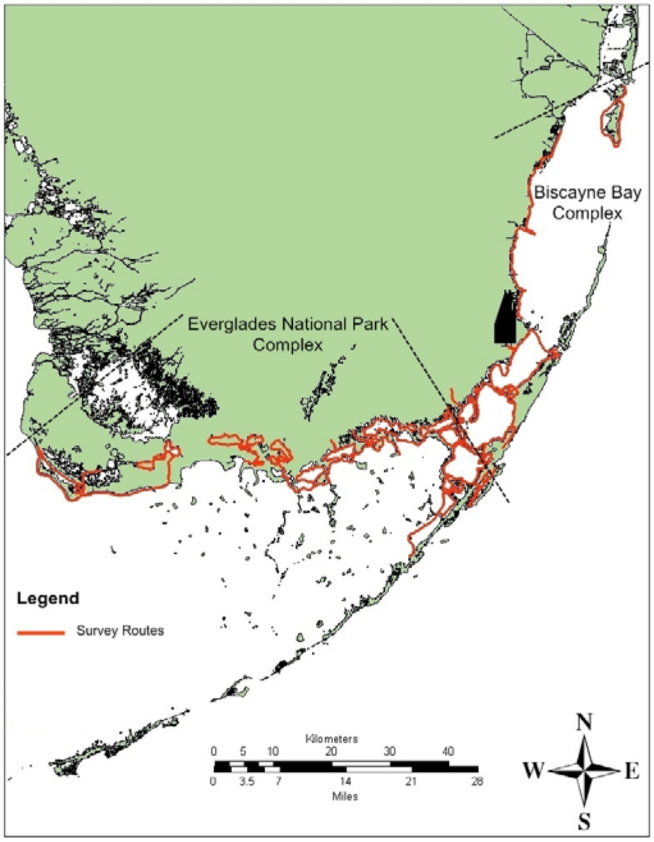

Figure 2. American crocodile spotlight survey routes in South Florida, 2006. Source: University of Florida

Stoplight Restoration Report Card

The stoplight restoration report card translates results for each performance measure into a suitability index representing progress toward meeting restoration targets. For most crocodilian performance measures, targets were established using empirical data from reference sites in the Everglades, except occupancy rate of alligator holes for which the upper target was based on historical information. Targets are presented in the *Methods* sections for each performance measure, below (also see Mazzotti et al. in press, Table 1).

There are generally three components for each performance measure: current status (results from 2006 survey year), the five-year or three-year running average (depending on expected power to detect changes), and the most recent trend (positive, negative, or stable). Alligator hole occupancy, however, has only been monitored since 2005 and thus has only one component (current year percent occupancy).

For each performance measure, the value of each component was compared to the target values to yield a suitability index score (0, 0.5, or 1) with a corresponding color for an easily interpreted "stoplight display:" a value of 0 = red = substantial deviation from restoration targets, 0.5 = yellow = targets have not been reached, and 1 = green = targets have been reached. The most recent trend was determined by regression analyses of data through 2005, as described in each *Methods* section below; stoplight scores were set as 0 = negative trend, 0.5 = no trend, and 1 = positive trend.

Suitability index scores were calculated for each performance measure as the arithmetic mean of the components of the performance measure. Next, a management unit suitability index score was calculated as the arithmetic mean of the performance measures in the given management unit. Calculated index scores were translated to stoplight colors as follows: $0 \leq$ score ≤ 0.4 = red, $0.4 <$ score ≤ 0.8 = yellow, and $0.8 <$ score ≤ 1 = green. A system-wide score was generated for alligators as the geometric mean of all six management unit scores, and a system-wide score for crocodiles was calculated as the geometric mean of the two management unit scores. Finally, a Crocodilian Index Final Score was calculated as the geometric mean of the system-wide alligator and crocodile scores (Appendix 1).

Performance Measures

The stoplight restoration report card includes three performance measures for alligators and two performance measures for crocodiles.

Alligator Performance Measures

- Relative density (number of non-hatchling alligators per kilometer)
- Body condition (length/volume ratio, calculated by Fulton's K)
- Alligator hole occupancy (percent occupied)

Crocodile Performance Measures

- Juvenile growth (centimeters per day total length for crocodiles < 0.75m)
- Hatchling survival (percent monthly fall survival)

These performance measures are hypothesized to be affected by changing hydrologic conditions (depth, duration, timing, spatial extent, water quality, and salinity) (U.S. Army Corps of Engineers, 2004). For crocodiles, nesting effort and success are also important indicators of the status of the population. Although nesting is not yet included in the performance measures for the stoplight score card, we include a discussion of crocodile nesting results (1978-2006) in this report.

American crocodile hatchlings
Photo: Mike Rochford, University of Florida

American Alligator Monitoring

Alligator Relative Density

Methods

Alligators were counted via spotlight surveys along routes in six management units (Figure 1), following guidelines in the Alligator Survey Network Spotlight Survey Protocol (Rice and Mazzotti 2007, Appendix 1). This report presents results from estuarine transects in ENP-EST and marsh transects in all other management units; surveys in canals were also conducted and are reported elsewhere (Rice and Mazzotti 2007). Surveys were conducted twice in each area in both spring and fall, at least 14 days apart to achieve independent counts (Wood et al. 1985). Alligator locations were recorded using global positioning systems (GPS). Body lengths were estimated in quarter-meter increments, and alligators were placed into the following categories: hatchling (< 0.25 m), juvenile (0.25-1.24 m), subadult (1.25-1.74 m), and adult (≥ 1.75 m). Relative density was calculated by dividing the total number of non-hatchling animals encountered on each survey by the total length (in kilometers) of the survey route.

Three components were used to calculate the stoplight score for relative density: current year status, five-year running mean, and most recent trend. The current status component was defined as mean non-hatchling alligators per kilometer during the spring 2006 survey. Preliminary power analyses demonstrated that we can detect a 5% change in relative density over a five-year period (Rice and Mazzotti 2006). If five years of data were not available, the three-year or four-year mean was used. In BCNP, only one year of data was available because relative density was monitored there for the first time in 2006.

Targets for relative density were developed based on the distribution of relative densities from all spring night surveys conducted on Everglades marsh transects from 1999-2006 (individual replicates of 10 areas over four to eight years; Rice and Mazzotti 2006). This distribution was divided into quartiles; stoplight scores were set as 0=first and second quartiles (density ≤ 1.47 animals/km), 0.5=third quartile (1.47 < density ≤ 2.70 animals/km), and 1=fourth quartile (density > 2.70 animals/km).

Trends in count densities were assessed through 2005 in each management unit. Trends were assessed by loglinear regression of counts of alligators on elapsed time (year) and the quadratic (year + year^2) where appropriate, with mean measured water depth as a covariate.

Results

The average relative density (mean non-hatchling animals per km in spring survey) was much higher in LNWR (6.57, fourth quartile) than in any of the other management units. Density was 2.07 (third quartile) in WCA 3A-Central, and less than 1.47 animals per kilometer (first-second quartiles) in all other areas. The lowest densities were in WCA 3B (0.21) and ENP-SS (0.68) (Figure 3). The five-year running mean followed a similar pattern, with 5.63 animals per km in LNWR (fourth quartile), 2.05 in WCA 3A-Central (third quartile), and values in the first-second quartiles in all other areas. The lowest mean relative density (0.42) was in WCA 3B (Figure 3).

Decreasing trends in total alligator populations were detected in two management units: WCA 3A-North (-0.56 animals/km/year) and ENP-EST (-0.64 animals/km/year). In addition (although not included in the performance measure), decreasing trends in juvenile populations were detected in WCA 2A, WCA 3A-North, and ENP-SS, and a decreasing trend in the adult population was detected in WCA 3A-North. An increasing trend was found for the adult population in LNWR. There was either no trend or insufficient data to detect a trend in all other areas.

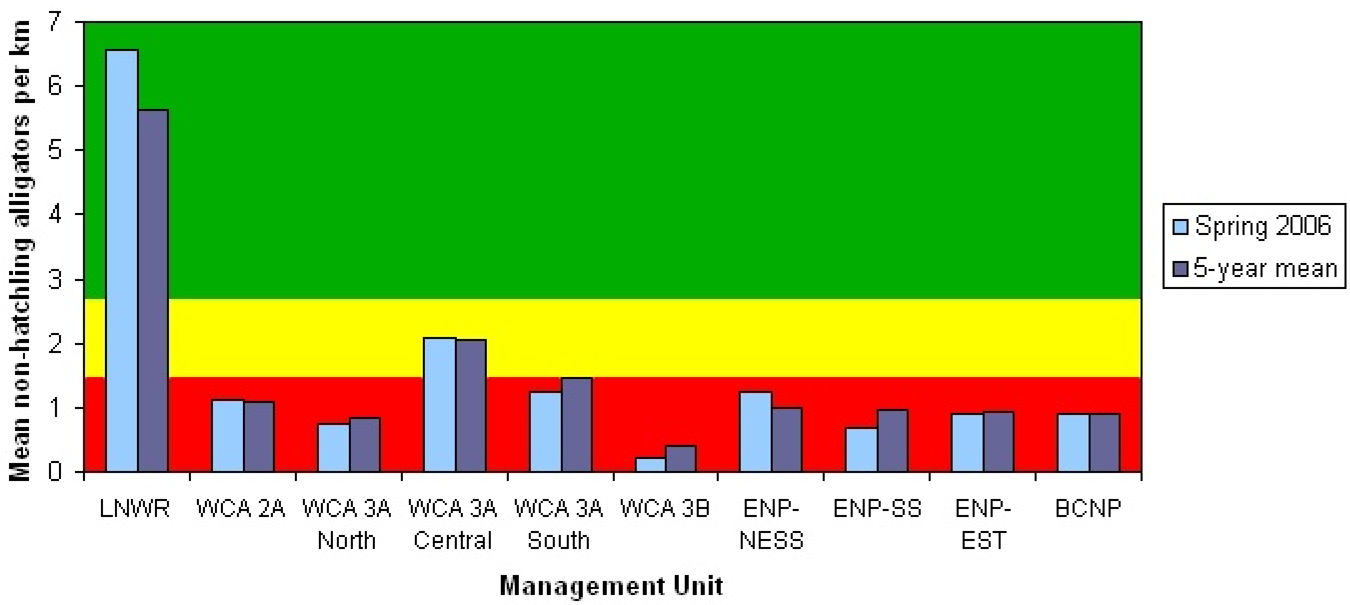

Figure 3. Mean relative density of alligators in Greater Everglades. LNWR = A.R.M. Loxahatchee National Wildlife Refuge, WCA = Water Conservation Area, ENP = Everglades National Park, NESS = Northeast Shark Slough, SS = Shark Slough, EST = Estuarine, BCNP = Big Cypress National Preserve. The background shading refers to the stoplight scores: red = substantial deviation from restoration targets, yellow = targets have not been reached, green = targets have been reached.
Source: University of Florida

Alligator Body Condition

Body condition (a ratio of body length to body volume) is of interest to researchers because of its potential for assessing how crocodilians are "coping" with their environment (Brandt 1991). Body condition can provide a measure of ecosystem condition and a measure of the quality and accessibility of prey species.

Alligator capture to monitor body condition
Photo: Mike Rochford, University of Florida

Methods

To determine condition of alligator populations, semi-annual capture surveys were performed in the same areas as described for spotlight surveys (Figure 1). A minimum of 15 alligators greater than 1 meter total length were captured by hand, noose or tongs in the fall and spring of each year. Total length (TL), snout-vent length (SVL), head length (HL), tail girth (TG), and weight were measured, sex determined, and any abnormalities noted. To identify recaptures, alligators were marked using Florida Fish and Wildlife Conservation Commission web tags or by clipping scutes (the ridges on alligators' tails). Geographic location, habitat characteristics, and environmental characteristics (air/water temperature, water depth, muck depth, and salinity) were recorded where applicable.

Calculating body condition requires a body length indicator and a volumetric measurement. Head length (HL), snout-vent length (SVL) and total length (TL) are suitable for body length indicators; tail girth (TG), neck girth (NG), chest girth (CG), and weight can all be used as volumetric measurements. In this study, we used a condition factor analysis (Fulton's K; Zweig 2003). Fulton's K uses the ratio of HL/weight and has been evaluated as the best condition index to spatially compare populations of the American alligator (Zweig 2003).

Three components were used to calculate the stoplight score for alligator body condition: current year status, three-year running mean, and most recent trend. The current status indicator was defined as the lowest spring or fall mean condition during the 2006 survey year. A three-year (instead of five-year) running mean was used because expected power should enable trends to be detected in one to three years.

Targets for body condition were developed based on the distribution of body condition (Fulton's K) of all alligators captured and assessed in the Everglades from 1999-2006 (n=1755). This distribution was divided into quartiles; stoplight scores were set as 0=first quartile (Fulton's K $\leq$ 9.31), 0.5=second and third quartiles (9.31 < Fulton's K $\leq$ 11.27), and 1=fourth quartile (Fulton's K > 11.27).

Trends in body condition were assessed through 2005 in

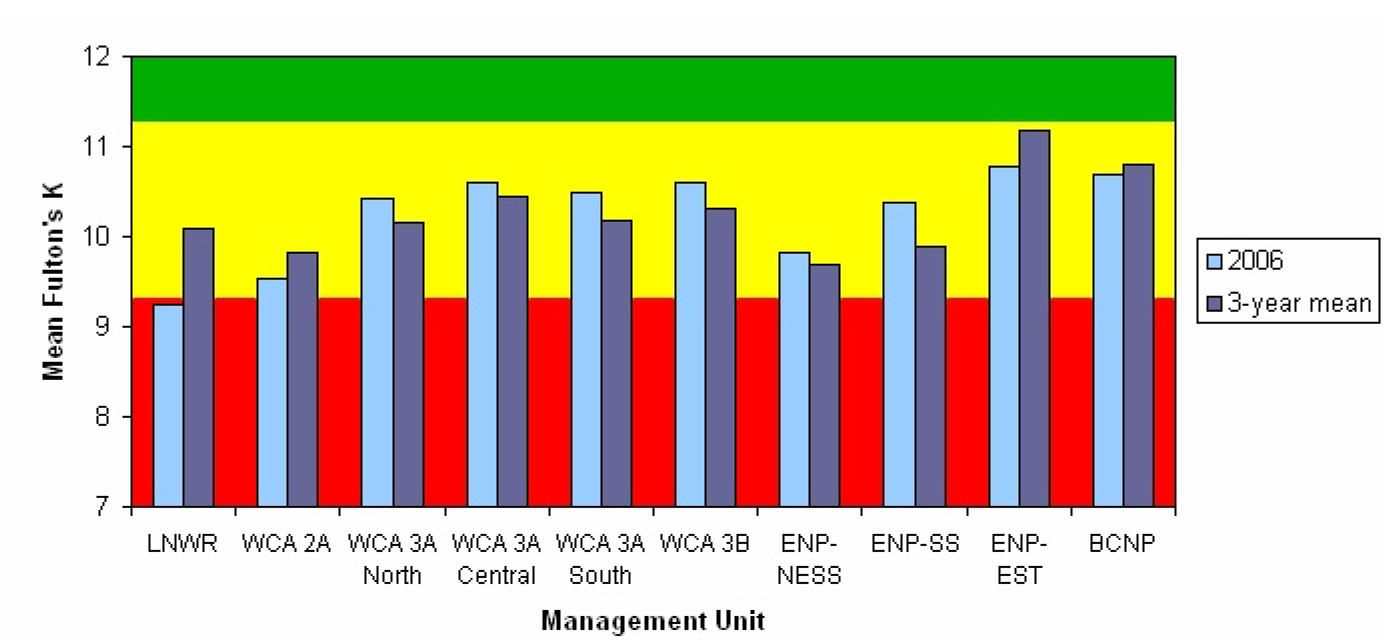

Figure 4. Mean body condition (Fulton's K) of alligators in Greater Everglades. 2006 measure is lowest spring or fall mean. LNWR = A.R.M. Loxahatchee National Wildlife Refuge, WCA = Water Conservation Area, ENP = Everglades National Park, NESS = Northeast Shark Slough, SS = Shark Slough, EST = Estuarine, BCNP = Big Cypress National Preserve. The background shading refers to the stoplight scores: red = substantial deviation from restoration targets, yellow = targets have not been reached, green = targets have been reached. Source: University of Florida

each management unit by loglinear regression of Fulton's K on elapsed time (year) and the quadratic (year + year^2) where appropriate, with three covariates: season (fall or spring), sex (male or female) and animal length (SVL).

Results

The condition factor of captured alligators (lowest mean spring or fall Fulton's K) was lower (9.25, first quartile) in LNWR than all other management units, where it was in the second-third quartiles; the highest value was 10.77 in ENP-EST. The three-year running mean was in the second-third quartiles in all areas, ranging from 9.70 in ENP-NESS to 11.18 in ENP-EST (Figure 4).

We were able to detect decreasing annual trends in body condition in WCA 3A-South (5.6%), ENP-NESS (3.7%), and LNWR (1.4%). In one area, ENP-EST, we observed an increasing trend of 8% per year. There was either no trend or insufficient data to detect a trend in all other areas.

Females were in better condition than males in four areas ($p_{sex} \leq 0.003$, ENP-SS, LNWR, WCA 3A-Central, WCA 3A-North) but this did not vary between seasons ($p_{sex*season} > 0.05$). Males were captured more frequently over time in WCA 2A ($p_{sex*year} = 0.0002$). Larger animals were in better condition than smaller animals in five areas ($p_{svl} \leq 0.005$, ENP-SS, LNWR, WCA 2A, WCA 3A-Central, WCA 3A-North). Smaller animals were captured more frequently over time in ENP-SS and WCA 3A-North ($p_{svl*year} \leq 0.09$) and larger animals were captured more frequently over time in WCA 3A-South ($p_{svl*year} < 0.0001$). We observed higher body conditions in spring in ENP-SS, WCA 2A and WCA 3A-North ($p_{season} \leq 0.035$) and in fall in WCA 3B ($p_{sex} = 0.002$).

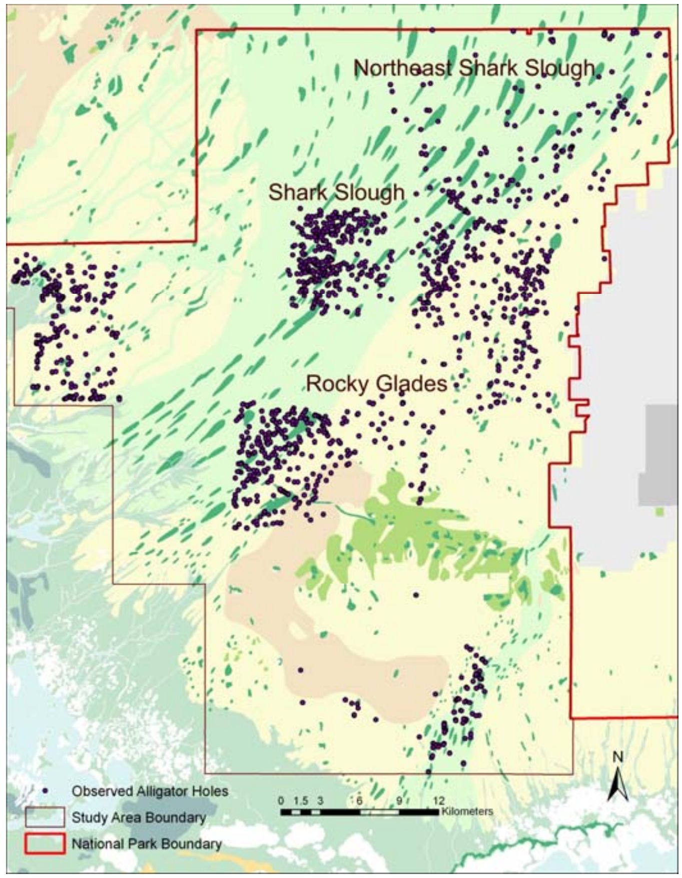

Figure 5. Alligator holes observed in Everglades National Park (ENP) during 2005 and 2006 Standard Reconnaissance Flights (SRFs). (Base-map is Everglades physiographic areas courtesy of ENP.) Source: Rice and Mazzotti, 2007

Alligator Hole Occupancy

Although alligator holes and other dry season refugia have long been recognized as a critical component of the Everglades ecosystem (Craighead 1968, Mazzotti and Brandt 1994), until recently only one alligator hole had been studied in detail (Kushlan 1972). We began to map and characterize alligator holes in parts of the Everglades (Campbell and Mazzotti 2004); however, there is still a lack of data about alligator holes in Shark Slough and the Rocky Glades.

Alligator hole seen from the air in Everglades National Park
Photo: Wellington Guzman, University of Florida

Methods

Surveys for alligator hole occupancy were conducted via Standard Reconnaissance Flights (SRF) in four areas of ENP during five days in May 2006 (May 3 through May 9, 2006). Transects were flown through areas of the Northeast Everglades that had not been visited during a previous accuracy assessment, as well as in an area of Northeast Shark Slough surveyed in April 2005 and area in Shark Slough surveyed in June 2005. Transects were flown at 500-meter east-west intervals. Observers sat on both sides of the helicopter and it was assumed that an observer could identify an alligator hole up to a distance of 250 meters, thus being able to capture all alligator holes within a given area of flown transects. The helicopter flew at an average height of 150 feet above ground, hovering to 50 feet for closer observations. Transects were flown in both the morning and afternoon. When an alligator hole was detected, the pilot navigated from the transect to the observed hole. At each observed alligator hole, the following information was recorded: presence or absence of alligators, size(s) of observed alligator(s), and presence or absence of water in the hole. A GPS location and a photograph were taken of every alligator hole. Holes were considered occupied if the alligator was in the hole or located within a short distance from the hole (e.g., in a trail or basking next to the hole).

Crocodile capture to monitor growth
Photo: Mark Parry, University of Florida

A single component was used to calculate the stoplight score for hole occupancy: the current year mean proportion of alligator holes (in ENP-IA only) occupied by at least one alligator. As this component was assessed for the first time in 2005, we used additional sources of data to develop targets for stoplight scores. We combined results from our 2005 survey with a study of alligator holes in WCA 3 by Campbell and Mazzotti (2004) and historical information from Craighead (1968), and set values at 0=low (occupancy ≤ 30%), 0.5=medium occupancy (30% < occupancy ≤ 70%), and 1=high (occupancy > 70%). This component is applicable to areas of Northeast Shark Slough, Rocky Glades, and Southern Marl Prairies. These areas are collectively referred to as Inaccessible Areas (ENP-IA) because they are not accessible by airboat and must be monitored by helicopter.

Results

As a result of both 2005 and 2006 SRFs, a total of 1,495 alligator holes in Everglades National Park have now been observed and verified with a GPS location (Figure 5). In 2006, alligators were observed in a total of 269 holes in a surveyed area of 306 km^2. Occupancy ranged from 30% in Shark Slough alligator holes to 72% in the top right corner of ENP in Northeast Shark Slough. It was determined from the surveys that Northeast Shark Slough contained the lowest density of alligator holes (0.5 holes/km^2) while Shark Slough contained the greatest density of alligator holes (7.0 holes/km^2). Not including Shark Slough (which is not part of the inaccessible areas), alligators were observed in 184 holes in Northeast Shark Slough and the Rocky Glades/Southern Marl Prairies (49.9% of observed alligator holes in those areas). This is the value used in the stoplight assessment for ENP-IA. The two-year running mean (2005-2006) is 50.4%, and there is not yet enough data to detect a trend.

Water level appears to influence occupancy of alligator holes. Northeast Shark Slough and the Rocky Glades both had higher occupancy of alligator holes than central Shark Slough, and both were extremely dry at the time of the surveys. With little water in the surrounding marsh, alligator holes were the only refuge from the sun. These conditions may explain the higher occupancy of alligator holes in these areas. In central Shark Slough, on the other hand, holes still contained water, and water was present in some surrounding marsh habitats. Detectability of alligators was not evaluated in 2006 but will be considered in future surveys, because it was generally more difficult to detect an alligator at a hole with deeper water.

American Crocodile Monitoring

Crocodile Juvenile Growth

Methods

Juvenile growth was determined by periodic efforts throughout 2006 to recapture crocodiles that had been marked in previous captures. Stoplight assessments are based on capture areas in ENP (Buttonwood Canal) and Biscayne Bay Complex (BBC; does not include Florida Power & Light's Turkey Point Plant) (Figure 2). Non-hatchling crocodiles (> 50 cm) were captured by hand, tongs, net, or by wire-noose as described by Mazzotti (1983). All crocodiles were weighed and measured for total length (TL) and snout-vent length (SVL). (Head length, tail girth, hind foot length, mass, and other body measurements were recorded occasionally.) Hatchlings were defined as animals < 50 cm in total body length, juveniles were defined as 50–150 cm, sub-adults were defined as 150-175 cm, and animals greater than 175 cm in total body length were classified as adults.

To assess juvenile growth, we measured growth that occurred during the first year of an animal's life, and therefore only analyzed captures of animals less than or equal to 75 cm total length. We defined average growth rate as change in total length between two capture events divided by the number of days between two capture events. Growth was measured in cm/day over the longest period between captures for animals recaptured at least once.

Three components were used to calculate the stoplight score for juvenile growth: current year average growth rate (cm/day for animals ≤75 cm), three-year running mean, and most recent trend. A three-year (instead of five-year) running mean was used because expected power should enable trends to be detected in one to three years. Targets for juvenile growth were developed based on the distribution of growth rate of all crocodiles captured and measured in Everglades National Park and Biscayne Bay from 1978-2006 (n=498; Mazzotti et al.

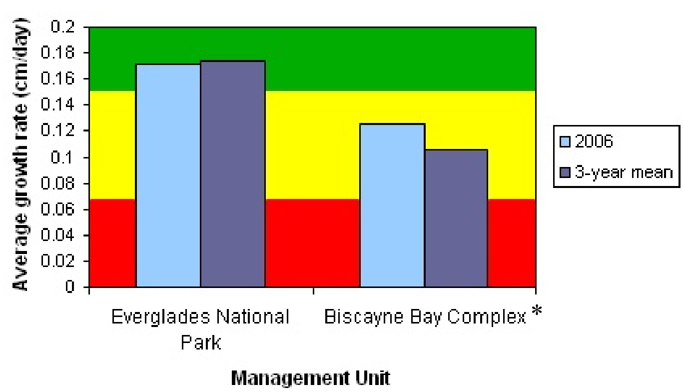

Figure 6. Average growth rate of juvenile (≤75 cm) crocodiles in Greater Everglades. The background shading refers to the stoplight scores: red = substantial deviation from restoration targets, yellow = targets have not been reached, green = targets have been reached. *Growth depicted in this figure does not include hatchlings from the Turkey Point site, for which data were not available. Source: University of Florida

Weighing an American crocodile hatchling
Photo: Mike Rochford, University of Florida

2007). This distribution was divided into quartiles; stoplight scores were set as 0=first quartile (growth ≤ 0.068 cm/day), 0.5=second and third quartiles (0.068 < growth ≤ 0.15 cm/day), and 1=fourth quartile (growth > 0.15 cm/day).

Results

Average growth rate in 2006 was in the fourth quartile (stoplight = 1) in both ENP (0.171 cm/day) and BBC (0.174 cm/day). The three-year running mean was higher in ENP (0.126 cm/day) than in BBC (0.105), and both fell into the second-third quartiles (stoplight = 0.5). The trend stoplight score was 0.5 (no trend) for both management units because there are not yet enough years of data to detect trends (i.e., there is only one three-year running mean, 2004-2006, because data collection started in 2004) (Figure 6).

Crocodile Hatchling Survival

Methods

Hatchling survival was determined by efforts in the fall (August-December, 2006) to recapture hatchling crocodiles (< 50 cm in total body length) that had been captured and marked during the preceding summer. Fall was defined as the critical monitoring period because most hatchlings are born in summer and grow to juvenile size by their first winter. Hatchlings were captured by hand or tongs and marked by removing tail scutes according to a prescribed sequence (Mazzotti 1983). Stoplight assessments are based on capture areas in ENP and BBC (Figure 2), where data on hatchling survival has been collected since 2002.

Three components were used to calculate the stoplight score for hatchling survival: current year survival rate (mean monthly fall survival), five-year running mean, and most recent trend. Targets for hatchling survival were developed by two methods. First, we used the minimum known alive analysis of Mazzotti et al. (2007) to develop a range of possible survival probabilities. Second, we performed multi-state (size class x management unit) capture-recapture survival analyses (Nichols and Kendall 1995) of all captures (n=3981) from 1978-2004 using Program Mark (White and Burnham 1999). The best model of fall hatchling survival included a management unit effect, a period effect (dry years vs. wet years), and a management unit x period interaction. This model had an Akaike weight of 0.96, indicating very strong support (Burnham and Anderson 2002). Targets for stoplight scores were developed by division along the mean estimates of survival from these analyses, with 0 = low survival (<65%), 0.5 = medium survival (65-85%), and 1 = high survival (>85%).

Results

In ENP, mean monthly fall survival in 2006 was 70%, and the five-year running mean was 69%. The trend stoplight score was 0.5 (no trend) because there are not yet enough years of data to detect trends (i.e., there is only one five-year running mean, 2002-2006, because data collection started in 2002). In BBC, no recaptures of hatchlings were made in 2006, so none of the stoplight indicators for hatchling survival could be calculated (Figure 7).

Crocodile Nesting Effort and Success

Nesting is not included in the stoplight performance measures because it responds over a longer time scale than growth and survival (decades vs. years). However, nesting is an important indicator of the status of crocodile populations that has been monitored in South Florida since 1978.

Methods

Monitoring crocodile nests was performed in concert with finding and marking hatchling crocodiles to assess growth and survival. Surveys for nests were conducted from June to August (hatching period), every year from 1978 to 2006. Nests were located from evidence of crocodile activity (tail drags, digging, and scraping); successful nests were determined by presence of one or more hatchlings or hatched shells.

We examined records of crocodiles nesting for numbers, locations, habitat, and fate of nests for the period of 1978-2006. Linear regression models were used for Turkey Point

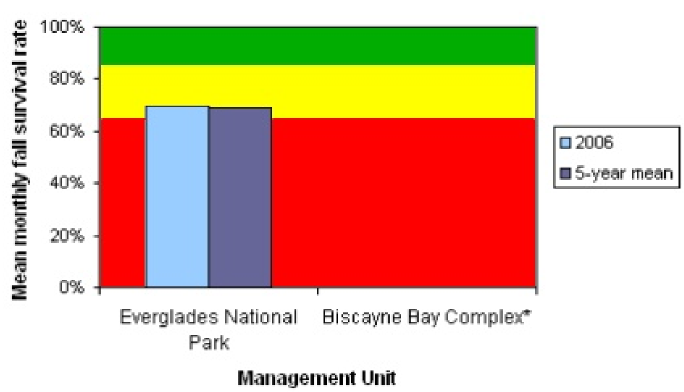

Figure 7. Survival rate (mean monthly fall survival) of hatchling crocodiles in Greater Everglades. The background shading refers to the stoplight scores: red = substantial deviation from restoration targets, yellow = targets have not been reached, green = targets have been reached. *No recaptures of hatchlings in Biscayne Bay Complex in 2006. Source: University of Florida

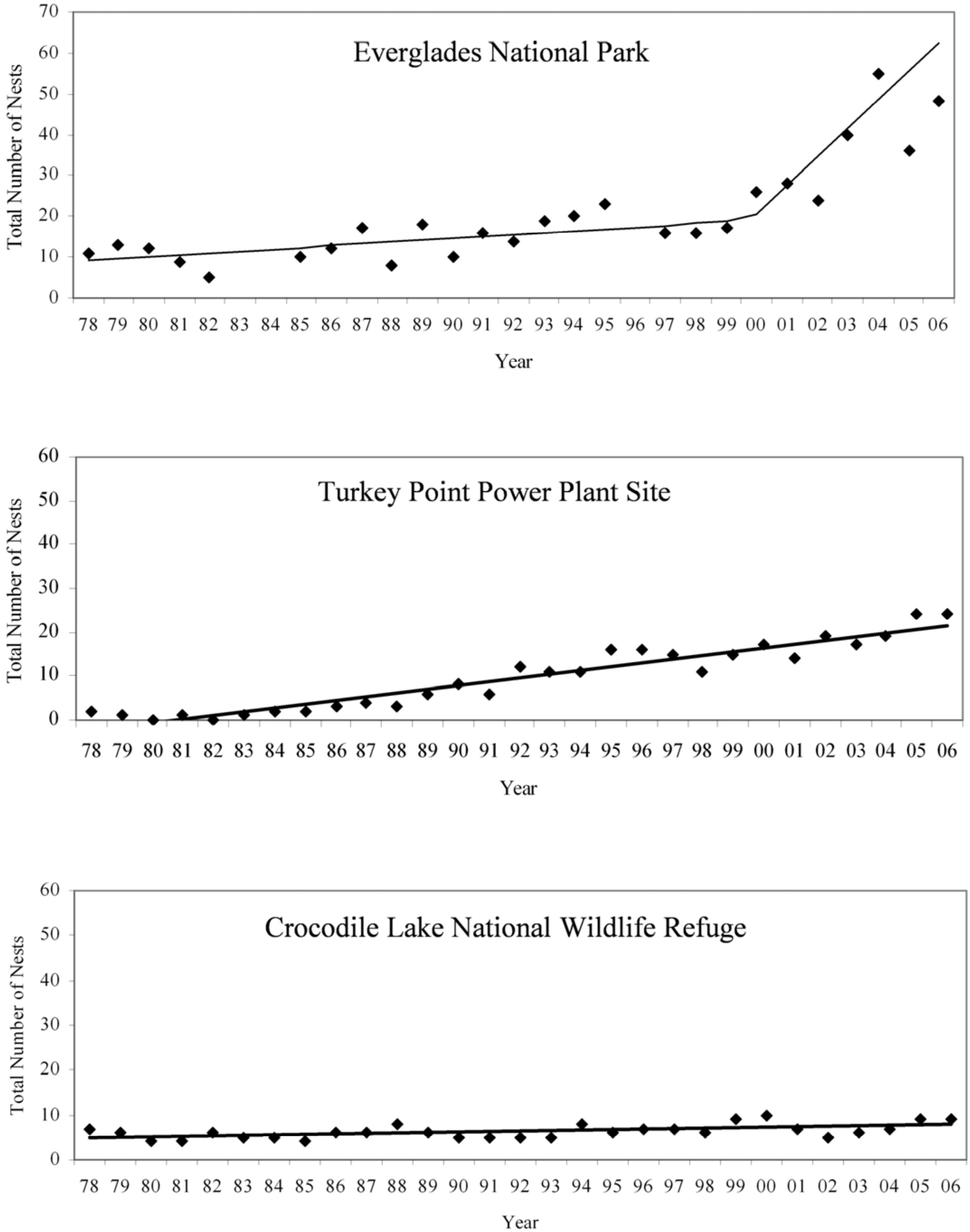

Figure 8. Linear regression for total number of American Crocodile nests found between 1978 and 2006 in the three primary nesting areas (A) Everglades National Park ($R2 = 0.6528$; $p = 0.0001$; nests = 523), (B) Turkey Point Power Plant ($R2 = 0.920$; $p = 0.0001$; nests = 280) and (C) Crocodile Lake National Wildlife Refuge ($R2 = 0.315$; $p = 0.0015$; nests = 183). Source: Rice and Mazzotti, 2007

(TP) and Crocodile Lake National Wildlife Refuge (CLNWR) nest data. The Gauss-Newton non-linear regression model was employed for ENP.

Results

Fifty-three nests were located in 2006, of which 48 were in Everglades National Park, two were in the Keys (Lower Matecumbe Key, just outside of ENP), and three were in the Biscayne Bay Complex. Of the total 53 nests, 34 (64%) were successful, 17 (32%) were depredated by raccoons, and two (4%) failed for unknown reasons. Thirty-one of the 34 successful nests were in ENP, one was in the Biscayne Bay Complex at Ocean Reef on North Key Largo, and both nests on Lower Matecumbe Key were also successful. The 17 depredated clutches were all located within the boundaries of Everglades National Park, and the two that failed for unknown reasons were both in Biscayne Bay Complex: one at Deering Bay and one at Montgomery Gardens. In addition to the above totals, in 2006, 24 nests were located by Florida Power & Light personnel at TP (also in BBC), and nine nests were found by U.S. Fish & Wildlife Service personnel at CLNWR (also in BBC).

Nine hundred eighty-six crocodile nests were located between 1978 and 2006. Five hundred eighty-nine (71 %) were successful. Turkey Point had the highest rate of nest success at 99% (range 91-100%; N = 276). In ENP, 65% of nests were successful (range 36–100 %; N = 523), and at CLNWR 46% of nests (range 0-100%; N = 183). The number of crocodile nests increased at the TP site, where two nests were discovered in 1978 and 24 were observed in 2006 (Figure 8), all on artificial substrates. The number of nests at CLNWR fluctuated between four and 10 (Figure 8). The number of nests also increased in ENP, from 11 in 1978 to 48 in 2006 (Figure 8). Most of the increase in nesting in ENP occurred on Cape Sable. Nests were also found outside of the three primary nesting areas in or near two Miami-Dade County Parks (eight nests, six successful, 1997–2006), a private residence on Lower Matecumbe Key (six nests, five successful, 2002–2006), and a private resort on northern Key Largo (two successful, 2004-2006).

Crocodile nest on the shoreline
Photo: Michael Cherkiss, University of Florida

American crocodile (*Crocodylus acutus*)
Photo: Mike Rochford, University of Florida

Final Stoplight Scores

Stoplight scores for each management unit and subunit were generated as the arithmetic mean of the component scores, and are presented in Appendix 1. The system-wide alligator index score was calculated as the geometric mean of all six management unit scores, and the system-wide crocodile index score was calculated as the geometric mean of the two management unit scores. Finally, the system-wide crocodilian stoplight score was calculated as the geometric mean of the alligator and crocodile index scores.

- System-wide alligator index score = 0.36 (stoplight = red)
- System-wide crocodile index score = 0.63 (stoplight=yellow)
- System-wide crocodilian stoplight score = 0.47 (stoplight = yellow)

The stoplight scores for both species combined are presented by management unit in Figure 9.

Discussion

On the whole, alligator and crocodile status in the Greater Everglades is substantially below restoration targets (Figure 9). Alligator status is highest at the A.R.M. Loxahatchee National Wildlife Refuge, but still below restoration criteria (yellow); throughout the Water Conservation Areas and Everglades National Park, alligator status is well below restoration targets (red). The low relative density and poor body condition (Figures 3 and 4) of alligators in the Everglades is what we expect in hydrologically altered Everglades ecosystems. Our findings confirm earlier observations that alligators are not doing well in the Everglades (Mazzotti and Brandt 1994).

We hypothesize that alligators do better in areas with less extreme human-caused hydrological alterations, such as the central portion of LNWR. This hypothesis would explain the higher status of alligators in LNWR than in other areas of the Everglades, and suggests that restoration of patterns of depth and period of inundation and water flow would improve performance of alligators in interior freshwater wetlands.

Throughout their range, alligators are typically abundant in coastal wetlands (e.g., Rice and Averitt 1999); thus the low abundance of alligators in Everglades estuaries appears exceptional. Earlier accounts described the oligohaline-freshwater portion of estuaries as important alligator habitat (e.g., Craighead 1968). However, our finding of low relative density of alligators in estuaries (Figure 3) confirms that diminished freshwater flow is a major stressor for Everglades alligators. We expect that restoration of patterns of freshwater flow to estuaries will improve conditions for both alligators and crocodiles.

Unlike American alligators, American crocodiles are successful in South Florida in comparison to other portions of their range (Mazzotti et al. 2007). Growth and survival of crocodiles, however, are below restoration targets (yellow) in both Everglades National Park and Biscayne Bay Complex (Figure 9). Diminished rates of crocodile growth and survival have been related to regional hydrologic patterns (Mazzotti et al. 2007, Rice and Mazzotti 2006). These performance measures for crocodiles appear stable at this time and are expected to increase given proper hydrologic conditions through restoration. Moreover, our ability to monitor growth and survival will improve, as 63% of crocodiles captured in 2006 were recaptures (Rice and Mazzotti 2007). However, differences in current monitoring methods employed at Turkey Point limit comparisons with growth and survival within the BBC and between the BBC and ENP.

The high recapture rate demonstrates the effectiveness of current survey techniques at finding and catching crocodiles, and supports the use of growth and survival as performance measures for Everglades restoration. As body condition can be determined from the same morphometric measurements as growth rates, we recommend that condition also be considered as a performance measure of crocodile responses to ecosystem changes.

As Figure 8 shows, crocodile nesting has increased in South Florida since 1978. More nests were found in each area in 2006 than in previous years, except in ENP where the 2006 count of 48 nests fell short of the record of 55 set in 2004. We attribute this temporary drop in number of nests in part to the impact of two hurricanes in 2005.

Mazzotti (1989) defined optimal nesting habitat for American crocodiles as presence of elevated, well-drained nesting substrate adjacent to relatively deep (> 1 meter), low to intermediate salinity (< 20 ppt) water, protected from effects of wind and wave action, and free from human disturbance. Human-made areas along canal banks (berms) at CLNWR, East Cape Canal in ENP, and the cooling canal system at TP provide nearly ideal nesting conditions. In fact, virtually the entire increase in crocodile nesting in South Florida is due to nesting on artificial substrates in the Cape Sable/Flamingo area of ENP, at CLNWR, and at TP. The rapid increase in nesting in Figure 9A corresponds to the plugging of Buttonwood and East Cape canals in Everglades National Park to reduce saltwater intrusion into interior areas of Whitewater Bay and Cape Sable (Mazzotti and Cherkiss 2003). This finding suggests that restoring salinity patterns in estuaries can have a positive effect on crocodile nesting, leading us to recommend that nesting effort and success should be added to growth and survival as crocodile performance measures.

In 2006, we surveyed more than 292 km of airboat trails and canals for alligators and more than 550 kilometers of shoreline for crocodiles and crocodile nests. We observed 359 crocodiles and captured 161, with a recapture rate of 63% that is unprecedented in crocodilian studies. The crocodile monitoring program is effective at detecting impacts of short-term disturbances that may impact population responses to ecosystem restoration. Using a combination of condition, growth, survival, and nesting of crocodiles allows for monitoring response of crocodile populations at different temporal scales.

Since 1999, we have captured more than 1,700 alligators to monitor body condition. Our current survey program has sufficient power to detect a 5% decrease in the alligator population over five years. We continue to improve alligator survey methods through studies of alligator submergence and detection, which will decrease the amount of time required to detect trends. In 2005-2006, we began monitoring alligator hole occupancy, which is proving to be an excellent performance measure in areas inaccessible to ground-based monitoring.

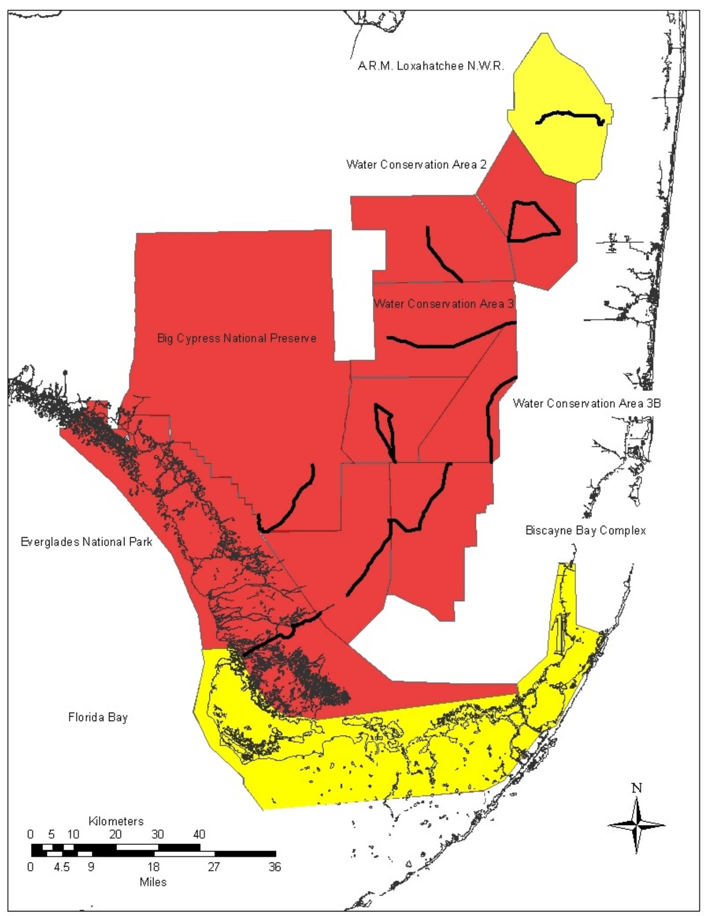

Figure 9. Map of Greater Everglades regions with stoplight ratings by region. Red = substantial deviation from restoration targets, yellow = targets have not been reached. Source: University of Florida

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American alligator hatchlings
Photo: Howard Suzuki, University of Florida

Appendix 1. 2006 translation of crocodilian performance measures into stoplight display.

Alligators

ARM Loxahatchee National Wildlife Refuge

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	6.57	1		5.63	1		±	0.5		(1+1+0.5)/3=0.83	
Body Condition Fulton's K	9.25	0		10.10	0.5		-	0		(0+0.5+0)/3=0.17	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.83 + 0.17)/2 = 0.5											
Final **ARM Loxahatchee National Wildlife Refuge** Alligator Index Score = 0.5											

Water Conservation Area 2A

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	1.13	0		1.09	0		±	0.5		(0+0+0.5)/3=0.17	
Body Condition Fulton's K	9.53	0.5		9.82	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.5)/2 = 0.34											
Final **Water Conservation Area 2A** Alligator Index Score = 0.34											

Water Conservation Area 3A North

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	0.75	0		0.85	0		-	0		(0+0+0)/3=0	
Body Condition Fulton's K	10.43	0.5		10.16	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0 + 0.5)/2 = 0.25											
Final **Water Conservation Area 3A North** Alligator Index Score = 0.25											

Water Conservation Area 3A Central

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	2.08	0.5		2.05	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Body Condition Fulton's K	10.59	0.5		10.45	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.5 + 0.5)/2 = 0.5											
Final **Water Conservation Area 3A Central** Alligator Index Score = 0.5											

Water Conservation Area 3A South

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	1.23	0	🔴	1.45	0	🔴	±	0.5	🟡	(0+0+0.5)/3=0.17	🔴
Body Condition Fulton's K	10.48	0.5	🟡	10.17	0.5	🟡	-	0	🔴	(0.5+0.5+0)/3=0.33	🔴
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.33)/2 = 0.25											
Final **Water Conservation Area 3A South** Alligator Index score = 0.25										🔴	

Geometric Mean of Water Conservation Area 3A Alligator Index Scores $(0.25 \times 0.5 \times 0.25)^{1/3} = 0.31$	
Final Water Conservation Area 3A Alligator Index score = 0.31	🔴

Water Conservation Area 3B

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	0.21	0	🔴	0.42	0	🔴	±	0.5	🟡	(0+0+0.5)/3=0.17	🔴
Body Condition Fulton's K	10.61	0.5	🟡	10.32	0.5	🟡	±	0.5	🟡	(0.5+0.5+0.5)/3=0.5	🟡
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.5)/2 = 0.34											
Final **Water Conservation Area 3B** Alligator Index Score = 0.34										🔴	

Everglades National Park – Northeast Shark Slough

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	1.25	0	🔴	1.00	0	🔴	±	0.5	🟡	(0+0+0.5)/3=0.17	🔴
Body Condition Fulton's K	9.83	0.5	🟡	9.70	0.5	🟡	-	0	🔴	(0.5+0.5+0)/3=0.33	🔴
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.33)/2 = 0.25											
Final **Everglades National Park – Northeast Shark Slough** Alligator Index Score = 0.25										🔴	

Everglades National Park – Shark Slough

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	0.68	0	🔴	0.95	0	🔴	±	0.5	🟡	(0+0+0.5)/3=0.17	🔴
Body Condition Fulton's K	10.37	0.5	🟡	9.89	0.5	🟡	±	0.5	🟡	(0.5+0.5+0.5)/3=0.5	🟡
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.5)/2 = 0.34											
Final **Everglades National Park – Shark Slough** Alligator Index Score = 0.34										🔴	

Everglades National Park – Estuarine

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	0.90	0		0.92	0		-	0		(0+0+0)/3=0	
Body Condition Fulton's K	10.77	0.5		11.18	0.5		+	1.0		(0.5+0.5+1.0)/3=0.67	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0 + 0.67)/2 = 0.34											
Final **Everglades National Park – Estuarine** Alligator Index Score = 0.34											

Everglades National Park – Inaccessible Areas

Performance Measure	Component 1: Current status			Component 2: 5-year mean			Component 3: Most recent trend			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	N/A										
Body Condition Fulton's K	N/A										
Occupancy Rate %	49.9%	0.5		50.4%	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Final **Everglades National Park – Inaccessible Areas** Alligator Index score = 0.5											

Geometric Mean of Everglades National Park Alligator Index Scores $(0.25 \times 0.34 \times 0.34 \times 0.5)^{1/4} = 0.35$	
Final Everglades National Park Alligator Index score = 0.35	

Big Cypress National Preserve

Performance Measure	Component 1: Current status			Component 2: 5-year mean*			Component 3: Most recent trend*			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Relative Density (alligators/km)	0.91	0		0.91	0		±	0.5		(0+0+0.5)/3=0.17	
Body Condition Fulton's K	10.69	0.5		10.80	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Occupancy Rate %	N/A										
Mean of Alligator Performance Measure Scores = (0.17 + 0.5)/2 = 0.34											
Final **Big Cypress National Preserve** Alligator Index score = 0.34											

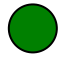
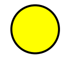
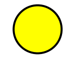
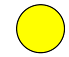
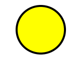
* The mean and trend for relative density in Big Cypress National Preserve are based on only one year's data because monitoring of relative density began in 2006.

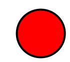
Crocodiles

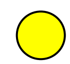
Everglades National Park

Performance Measure	Component 1: Current status			Component 2: 5-year mean*			Component 3: Most recent trend*			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Juvenile Growth (cm/day)	0.171	1		0.126	0.5		±	0.5		(1+0.5+0.5)/3=0.67	
Fall Monthly Hatchling Survival (%)	0.70	0.5		0.69	0.5		±	0.5		(0.5+0.5+0.5)/3=0.5	
Mean of Crocodile Performance Measure Scores = (0.67 + 0.5)/2 = 0.59											
Final **Everglades National Park** Crocodile Index score = 0.59											

Biscayne Bay Complex

Performance Measure	Component 1: Current status			Component 2: 5-year mean*			Component 3: Most recent trend*			Mean of Component Scores	Performance Measure Stoplight
	Value	Index Score	Stoplight	Value	Index Score	Stoplight	Trend	Index Score	Stoplight		
Juvenile Growth (cm/day)	0.174	1		0.105	0.5		±	0.5		(1+0.5+0.5)/3=0.67	
Fall Monthly Hatchling Survival (%)	Insufficient Data as of 2006.										
Final **Biscayne Bay Complex** Crocodile Index score = 0.67											

Geometric Mean of 6 Alligator Management Unit Scores = $(0.5 \times 0.34 \times 0.31 \times 0.34 \times 0.35 \times 0.34)^{1/6}$ = 0.36	
System-wide Alligator Index Score = 0.36	

Geometric Mean of 2 Crocodile Management Unit Scores = $(0.59 \times 0.67)^{1/2}$ = 0.63	
System-wide Crocodile Index Score = 0.63	

Geometric Mean of Alligator and Crocodile Index Scores = $(0.36 \times 0.63)^{1/2}$ = 0.47	
System-wide Crocodilian Stoplight Score = 0.47