Using a Spatially Explicit Crocodile Population Model to Predict Potential Impacts of Sea Level Rise and Everglades Restoration Alternatives

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As part of the USGS Priority Ecosystems Science (PES) initiative, we integrated regional hydrology models with American Crocodile (*Crocodylus acutus*) research and monitoring data to model the impact of potential CERP restoration efforts and sea level rise on the American Crocodile population in the United States.
Crocodiles are an indicator of the ecological condition of mangrove estuaries due to their reliance upon estuarine environments characterized by low salinity and adequate freshwater inflow.

Restoration efforts will cause changes to salinity levels throughout the habitat of the American crocodile and the response to these restoration efforts will provide a quantifiable measure of restoration success.
CERP Restoration will likely be impacted by sea level rise

Rising sea levels will likely increase salinity within crocodile habitat and submerge historic nesting habitat.
Model Input and Structure

Habitat Map: Based on A Natural History Based Model of Potential Habitat for the American Crocodile (Mazzotti et al., 2006)
Hydrology Model

_Tides and Inflows in the Mangroves of the Everglades (TIME)_

Application of the Flow and Transport in a Linked Overland/Aquifer Density Dependent System (FTLOADDS)

Capability to link to the SFWMM (South Florida Water Management Model), the primary regional tool used to assess Everglades restoration scenarios.
Model Parameters: Growth and Survival

Adapted from an American Crocodile Habitat Suitability Index

Maximum hatchling and juvenile survival when salinity is less than 20 ppt

Maximum mortality when salinity is greater than 40 ppt.

Growth rates are greatest on dry flats and in shallow water where prey is most concentrated.
Within the model, growth rates determine the percentage of crocodiles that advance to the next stage of development.

Hatchlings that grow rapidly within the first four months have a much greater chance of survival.
Spatially Explicit Stage-based Population Model

Interactions between crocodile growth, survival, hydrology, and habitat

3-D matrix records the density of each crocodile stage in each 500 x 500m spatial location on a daily basis

Evaluate environmental effects on each life stage and predict spatial density patterns and relative changes in population size
Density-dependent Interactions

Aggressive interactions between crocodiles of different size classes regulate population growth.

When density becomes too large adult crocodiles kill younger crocodiles.
Dispersal

Crocodiles disperse toward areas with low salinities and shallow water depths

Disperse daily except in winter when temperatures are cooler

Rate is different for each age class
Reproduction and Female Dispersal

During the nesting season the majority of females move toward and stay around nesting habitat.

Females disperse toward nesting locations irrespective of salinity or water depth.

Once eggs hatch females disperse back toward more favorable habitat.
Hatchling Dispersal

Hatchlings born on shoreline nests far from nursery habitat spend more time in unfavorable conditions.

Reaching a critical mass within the first four months helps hatchlings survive during the cooler dry season when dispersal is limited, growth is minimal, predators are concentrated, and salinity is higher.
Model Output

Percent Change Between CERP Scenarios

- 1 foot SLR (1996 - 2002)
- 2 foot SLR (1996 - 2002)
- Cerp0 (1996 - 2000)
- CERP Scenario A (2007 – 2051)
Sum of All Crocodile Stages: Percent Change between CERP0 and CERP2050 after 10 years
Sum of All Crocodile Stages: Percent Change between CERP0 and CERP2050 after 25 years
Sum of All Crocodile Stages: 10 years of Sea Level Rise

% Change with 1 foot SLR

% Change with 2 foot SLR
Sum of All Crocodile Stages: 25 years of Sea Level Rise

- R158
- 1 foot SLR
- 2 foot SLR

% Change with 1 foot SLR

% Change with 2 foot SLR
Sum of All Crocodile Stages: 50 years of Sea Level Rise
CERP Scenario A

Full CERP implementation by 2025 with sea level rising linearly to 60 cm by 2047
2 foot SLR without Restoration (2051)

Scenario A: SLR with Restoration (2051)
West Lake / Northeast Florida Bay
West Lake / Northeast Florida Bay
Scenario A with 2 ft SLR
Scenario A: CERP Restoration with 2 foot SLR (2051)

1 foot SLR without restoration

2 foot SLR without restoration
Questions?