American crocodile
(Crocodylus acutus)

5-Year Review:
Summary and Evaluation

Photo: John Wrublik, USFWS

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U.S. Fish and Wildlife Service
South Atlantic–Gulf and Mississippi Basin Regions
Florida Ecological Services Office
Vero Beach, Florida

September 2022

STATUS REVIEW
American crocodile (*Crocodylus acutus*)

GENERAL INFORMATION

Current Classification: Threatened

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Date of original listing: September 25, 1975 (40 FR 44149)

Additional reclassification rules: Reclassified from endangered to threatened, March 20, 2007 (72 FR 13027)

Critical Habitat/4(d) rule/Experimental population designation/Similarity of appearance listing: Critical habitat final rule: September 24, 1976 (41 FR 41911).

Methodology used to complete the review: In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants (50 CFR 424.11). The U.S. Fish and Wildlife Service (Service) evaluated the biology, habitat, and threats of the American crocodile to inform this status review. Our sources for this 5-year review include: the species' recovery plan; the last 5-year review for the species completed in 2007 (provided in the final rule for reclassification from endangered to threatened; 72 FR 13027); peer reviewed scientific publications; unpublished field observations by Service, State, and other experienced biologists; unpublished survey reports; and notes and communications from other qualified biologists or experts. Literature and documents used for this review are on file at the Florida Ecological Services Field Office. We announced initiation of this review and requested information in a published Federal Register notice with a 60-day comment period in 2018 (83 FR 38320). We received one public comment during the open comment period (see Appendix A). We evaluated and incorporated the comment as appropriate in this review. All recommendations resulting from this review are a result of thoroughly reviewing the best available scientific information on the American crocodile. The Service did not seek additional peer review for this updated 5-year review.

FR Notice citation announcing the species is under active review:
August 06, 2018 (83 FR 38320)

Species' Recovery Priority Number at start of 5-year review (48 FR 43098):
2c. American crocodile is a species with a high degree of threat and a high degree of recovery potential. A degree of conflict also exists

Review History:
Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations such as "Stable, Decreasing or Increasing" for this animal. We continue to show that species status recommendation as part of our 5-year reviews. The most recent evaluation for this animal was completed in 2007 as part of the reclassification notice in the Federal Register dated March 20, 2007 (40 FR 44149), whereby the Service downlisted the American crocodile from endangered to threatened.

On November 17, 2019, the Service approved an amendment to the original recovery plan for the American crocodile dated May 18, 1999. The amendment (Service 2019) provides the criteria, that if met, would allow the species to be delisted. The original recovery plan only included criteria for when the species could be downlisted from endangered to threatened (i.e., the American crocodile population contains as least 60 breeding females: Service 1999).

REVIEW ANALYSIS

Listed Entity

United States Population of American Crocodile

Taxonomy and nomenclature
We are not aware of any changes to the taxonomy of this entity, and it is still considered valid by the Service.

Distinct Population Segment (DPS) (61 FR 4722)
The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This species was listed as a DPS on March 20, 2007 (72 FR 13027).

Recovery Criteria

Recovery Plan or Outline
Final Recovery Plan for the American crocodile (*Crocodylus acutus*), May 18, 1999

Revised Recovery Plan, November 07, 2019

Recovery plans are not regulatory documents and intended to provide guidance to the Service, States, and other partners on methods of minimizing threats to listed species and on criteria that may be used to determine when recovery is achieved. If the recovery criteria defined in the plan are still valid, meeting recovery criteria can indicate that the species no longer requires protections under the Act. However, when recommending whether a listed species should be delisted, the Service must apply the factors in section 4(a) of the Act (84 FR 45020).

The three recovery criteria, as presented in the 2019 amendment to the 1999 recovery plan (Service 2019), are listed below. These criteria address listing factors A) the present or threatened destruction, modification, or curtailment of its habitat or range; C: Disease or predation, and E) other natural or manmade factors affecting its survival. As described below, factor B (overutilization for commercial, recreational, scientific, or educational purposes) and factor D (inadequacy of existing regulatory mechanisms are not currently threats to the American crocodile.

Recovery Criterion 1. At least three of the five nesting areas defined below (Figure 1) show stable or increasing trends in nesting (or other suitable parameters) and natural recruitment.

a) Florida Power and Light' (FPL) Turkey Point Power Plant Site (TPPP)
b) North Key Largo including the Crocodile Lake National Wildlife Refuge (CLNWR)
c) Northeast Florida Bay in Everglades National Park (ENP)
d) Flamingo/Cape Sable in ENP
e) Other (nesting occurring north of the TPPP, within the Florida Keys south of North Key Largo, and along the west Coast of Florida from north of Highland Beach to Sanibel Island)

Subpopulations that exhibit a stable or increasing trend in nesting (or other suitable parameters) and natural recruitment demonstrate that the population is secure and will be resilient to stochastic events. For the Distinct Population Segment of the American crocodile in Florida, we find that at least three subpopulations (as defined by the nesting areas listed above) exhibiting these traits are necessary to provide sufficient redundancy to ensure the Distinct Population Segment of the species will no longer require protection under the Endangered Species Act of 1973, as amended in 1998 (Act) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*). The Service defines the baseline period for assessment of trends in nesting (or other suitable parameters) and natural recruitment as the 5-year period from 2013 through 2017.

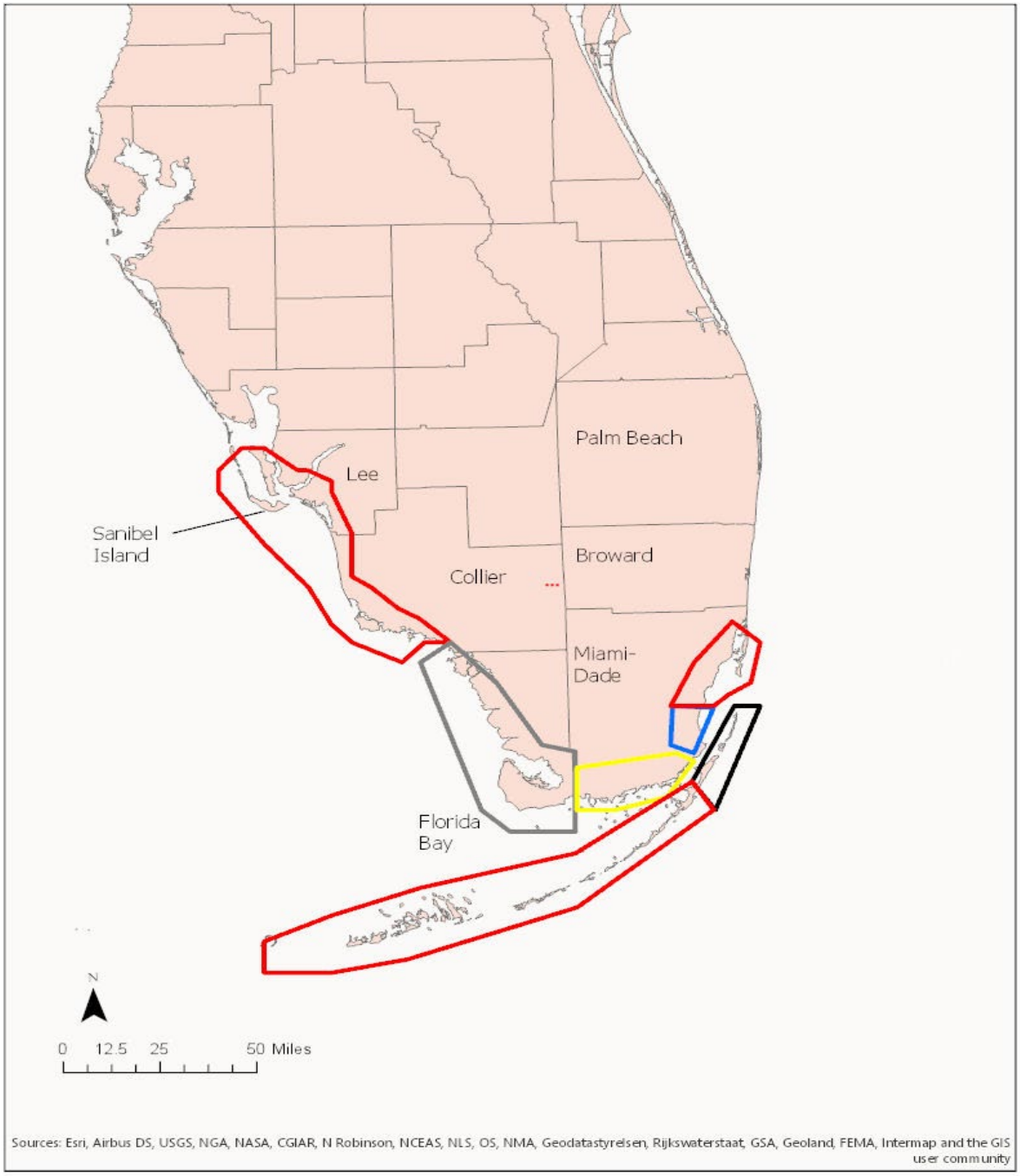

Figure 1. General locations of the primary nesting areas of the American crocodile in south Florida (Blue polygon = TPPP; Black polygon = North Key Largo including CLNWR; Yellow polygon = Northeast Florida Bay in ENP; Gray polygon = Flamingo/Cape Sable in ENP; Red polygons = Other (nesting occurring within three non-contiguous areas consisting of Biscayne Bay from North of the TPPP to Virginia Key, Florida's Keys from south of CLNWR to Key West, and the west Coast of Florida from North of Highland Beach to Sanibel Island).

With respect to Recovery Criterion 1, we chose nesting to assess the status of the American crocodile population in Florida because nesting data has been collected since the time of listing and is readily available. Moreover, the number of nests constructed each year can be used to estimate the size of the population. To determine if stable or increasing trends in nesting are

occurring within the subpopulations defined in Figure 1 and the American crocodile population rangewide in Florida, we conducted a trend analysis on the nesting data using a generalized linear model in R(R Core Team 2021). Nest data from 2013 through 2021 was used because this period encompasses the base line for the assessment (2013 – 2017) and the most current nesting data available (2018-2021). We then use the nesting information to estimate the current size of the rangewide population of the American crocodile in Florida.

The current known nesting range of the American crocodile in Florida (Figure 1) is largely still restricted relative to its reported historic range (Kushlan and Mazzotti 1989a), with most nesting occurring on the mainland shore of Florida Bay in ENP within the Northeast Florida Bay and Flamingo/Cape Sable areas. Nesting also occurs in two other primary locations: Key Largo at the CLNWR, and the Cooling Canal System (CCS) of FPL's TPPP. Finally, occasional nesting occurs at: Biscayne Bay North of the TPPP to as far North as Virginia Key; throughout the Florida Keys south of North Key Largo, and the southwest coast of Florida from north of Highland Beach to Sanibel Island (the areas collectively defined as "Other" in Figure 1).

Monitoring of American crocodile nesting in Florida began prior to listing of the species and is currently ongoing. The first systematic survey of American crocodile nesting in South Florida was conducted in Florida Bay in ENP and the upper Florida Keys from 1970 - 1975 (Ogden 1978). Subsequently, nest surveys have been conducted largely on an annual basis at the TPPP, North Key Largo at the CLNWR, and Northeast Florida Bay and Flamingo/Cape Sable in ENP, through efforts of FPL, the Service, and the University of Florida's Fort Lauderdale Research and Education Center in coordination with the National Park Service (NPS). Nesting was first observed in 1970 at the Northeast Florida Bay area, 1978 at the TPPP and CLNWR areas, and 1987 at the Flamingo/Cape Sable Area. Comprehensive nest surveys of the areas collectively designated as "Other" in Figure 2 have not been undertaken. Records of crocodile nesting in the "Other" area are obtained opportunistically by the Florida Fish and Wildlife Conservation Commission (FWC) and other entities and provided to the Service. Nesting was first documented in the "Other" area in 1997. Below, we present the available American crocodile nesting data for each of the nesting areas defined in Figure 1 (Figures 2 - 6). We also provide a summary of total nests that were observed within all areas defined in Figure 1 from 1970 - 2021 (Figure 7). We assume that most nests that occur in each area searched are found and recorded, and that the search effort is consistent from year to year. However, nests could have been missed during the surveys and comprehensive surveys of the area designated as "Other" were not conducted. Therefore, we acknowledge that these data represent minimum estimates of nesting within these areas (Figure 1) and throughout the range of the American crocodile in Florida, and actual nesting may be somewhat higher.

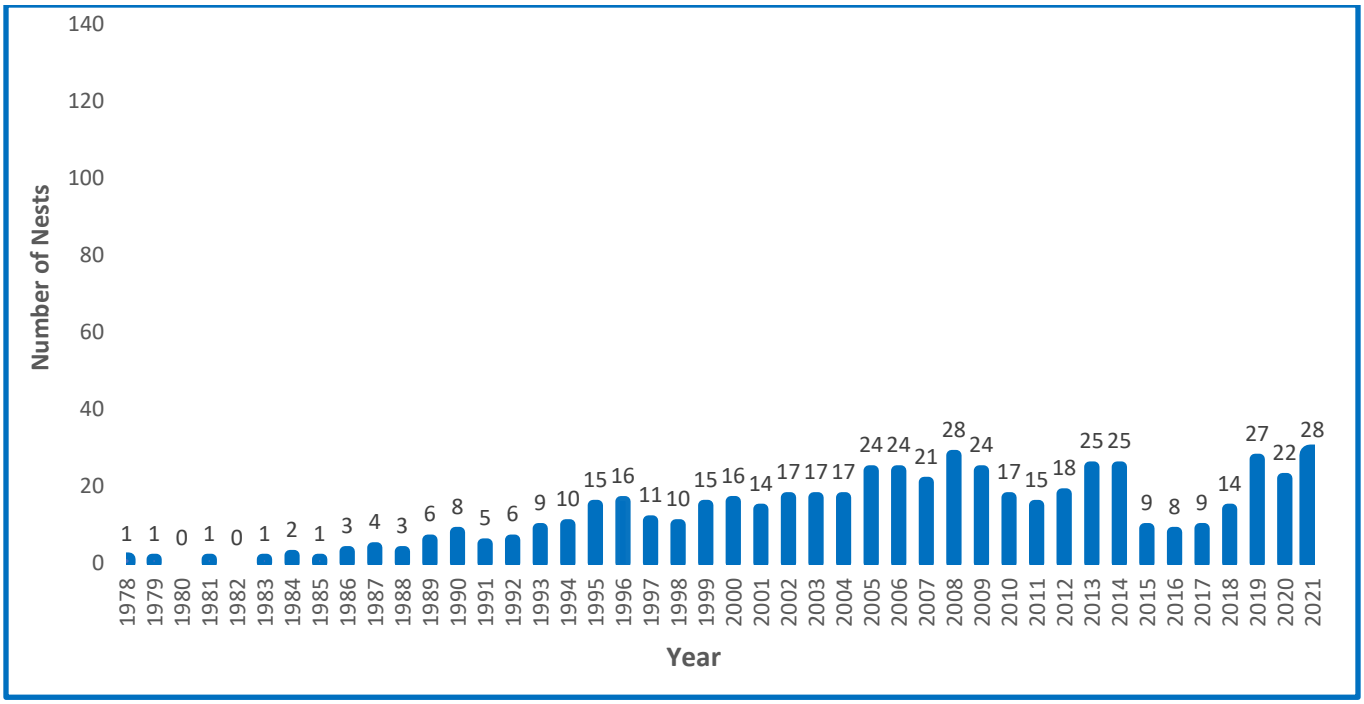

Figure 2. The number of American crocodile nests observed per year at the TPPP from 1978 - 2021.

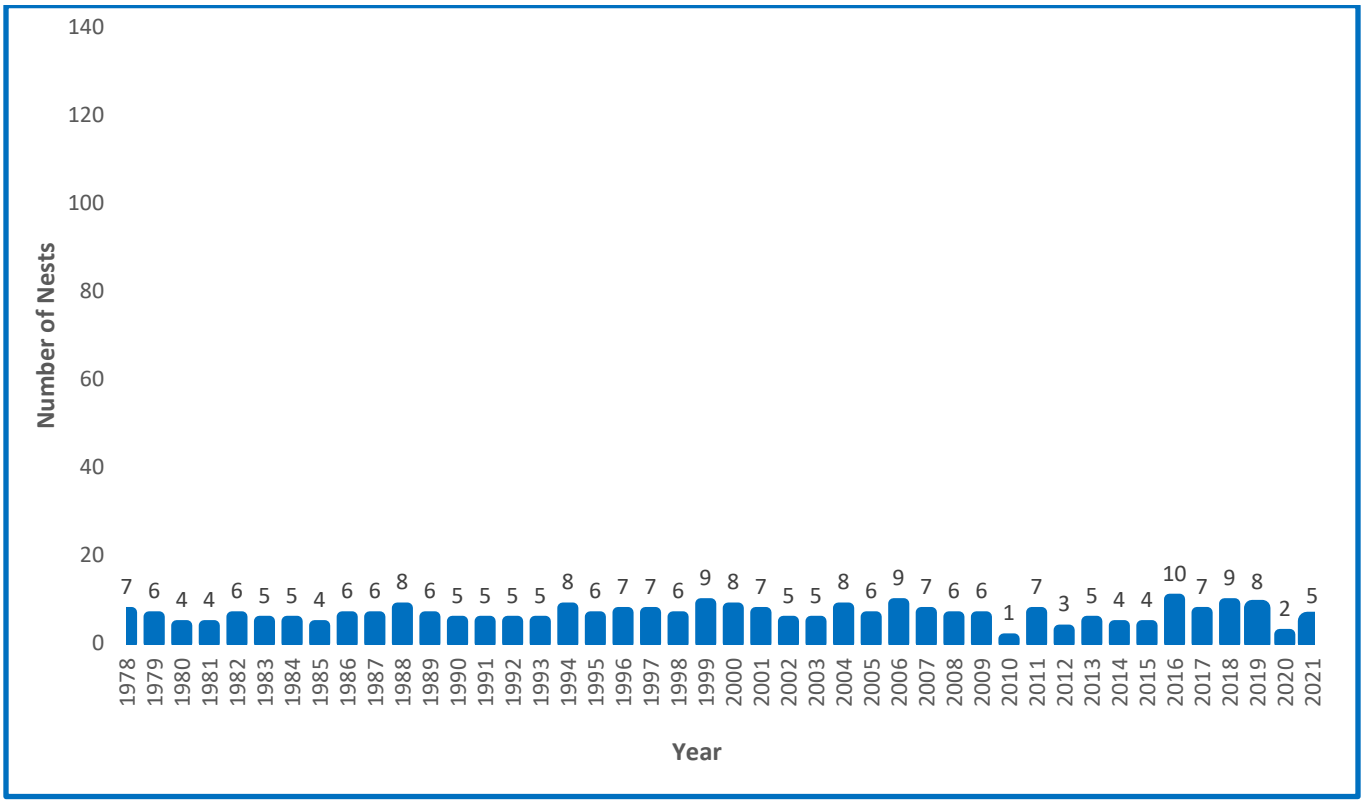

Figure 3. The number of American crocodile nests observed per year at North Key Largo and the CLNWR from 1978 - 2021.

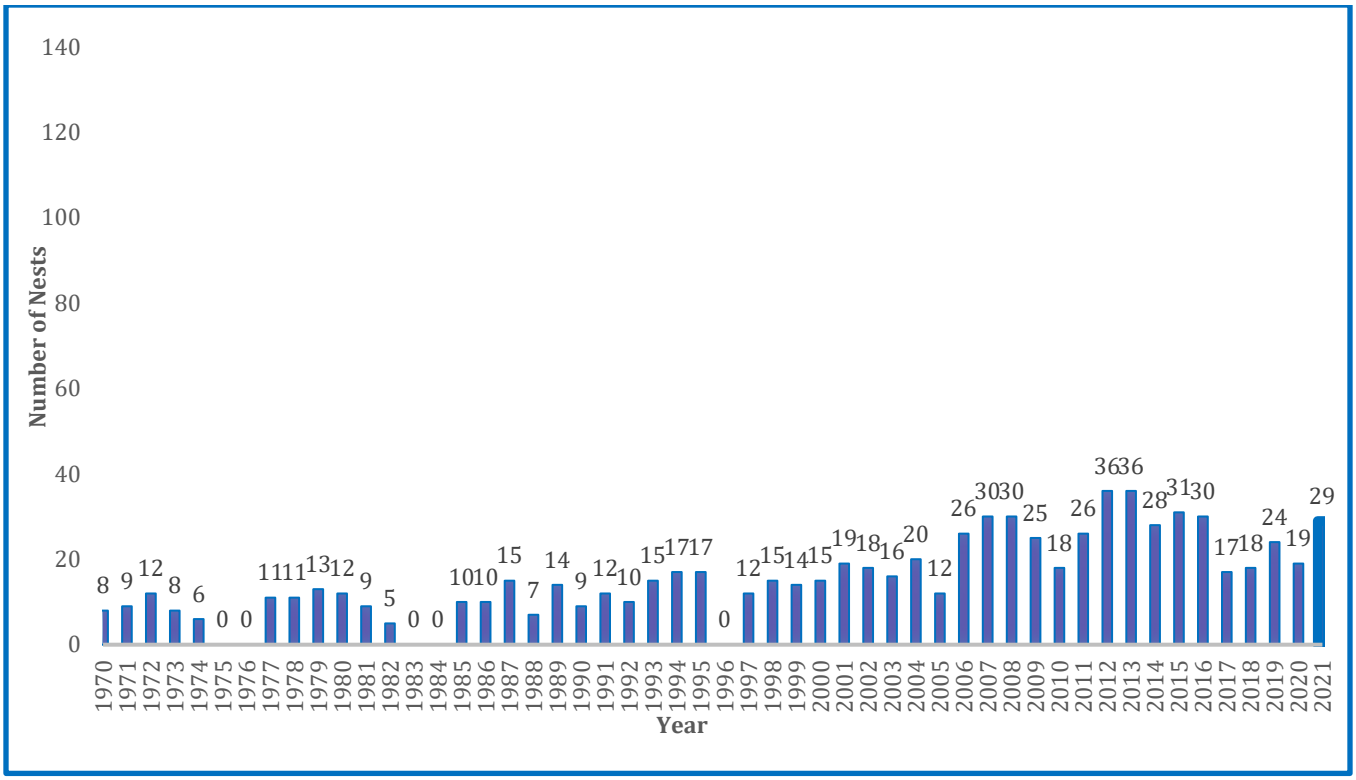

Figure 4. The number of American crocodile nests observed per year at Northeast Florida Bay in ENP from 1970 – 1974 and 1977 -2021 (nest surveys were not conducted in 1975, 1976, 1983, 1984, 1996).

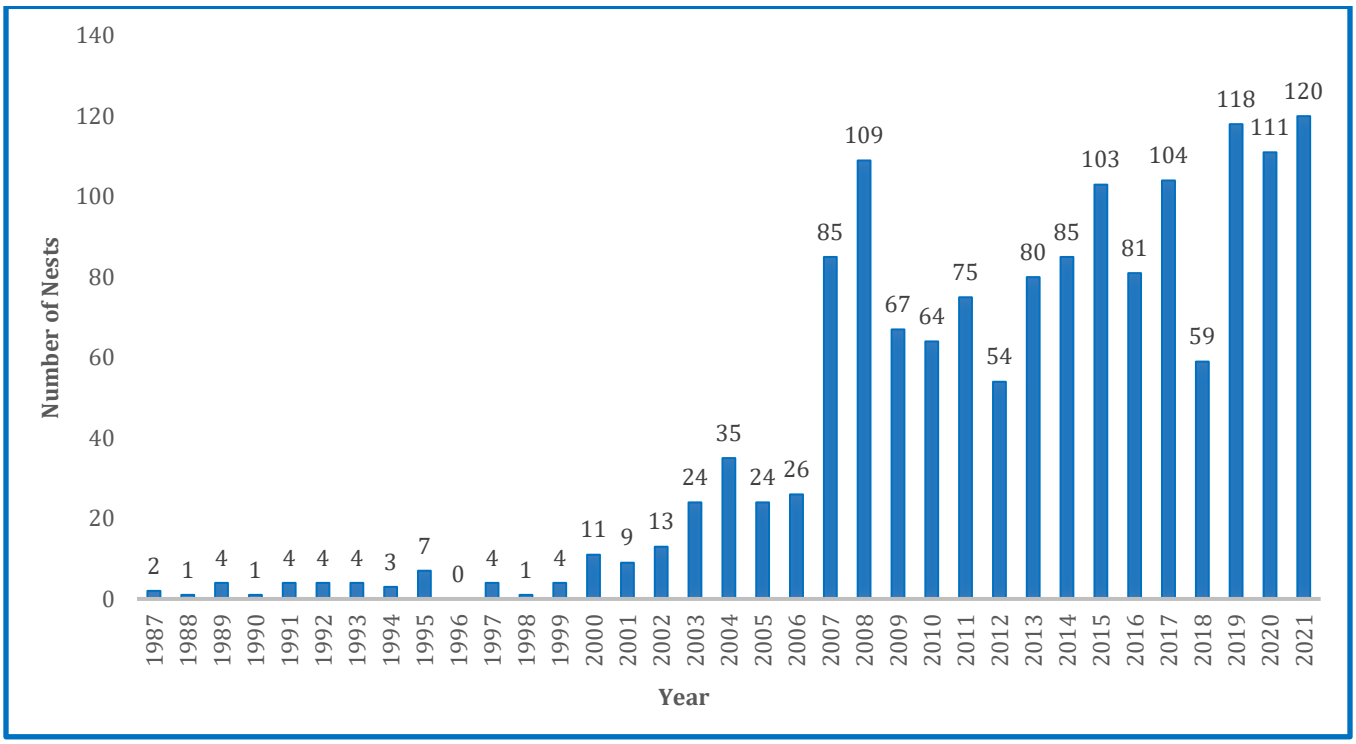

Figure 5. The number of American crocodile nests observed per year at Flamingo/Cape Sable in ENP from 1987 – 2021 (nest surveys were not conducted in 1996).

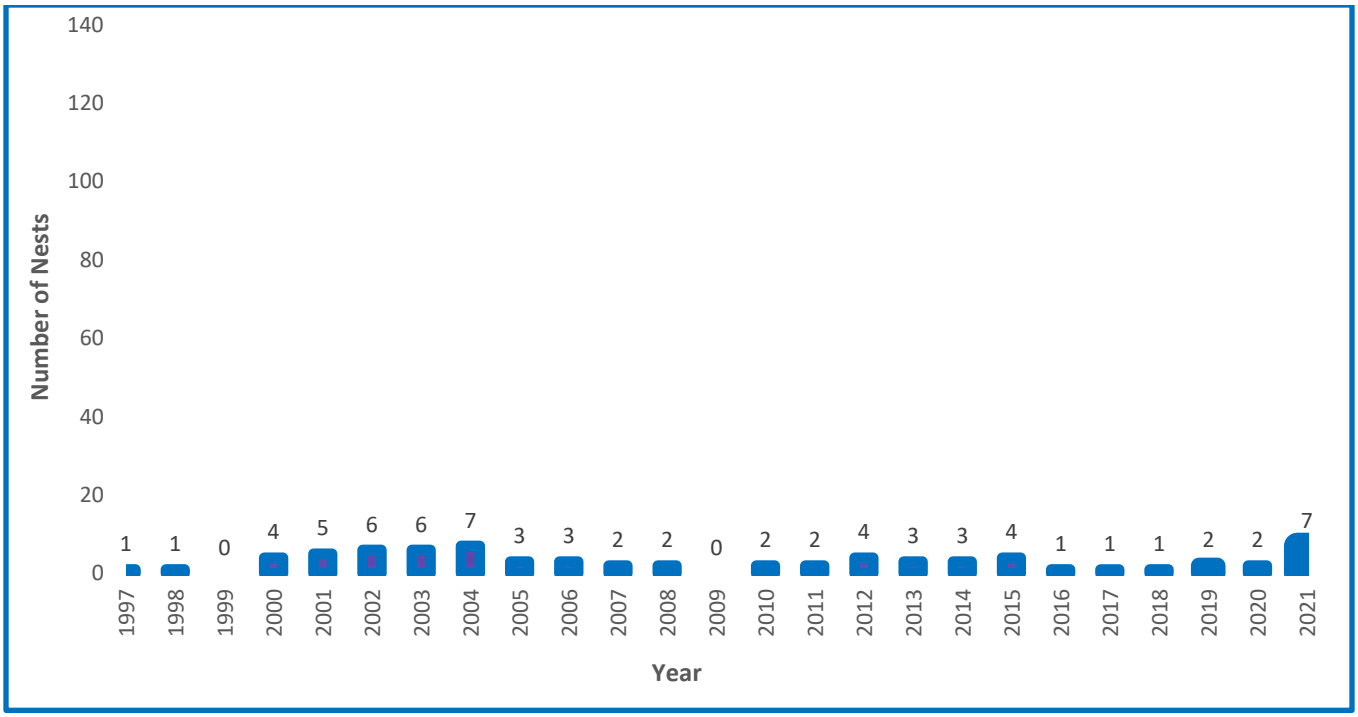

Figure 6. The number of American crocodile nests observed per year at the nesting areas described as "Other" from 1997 - 2021.

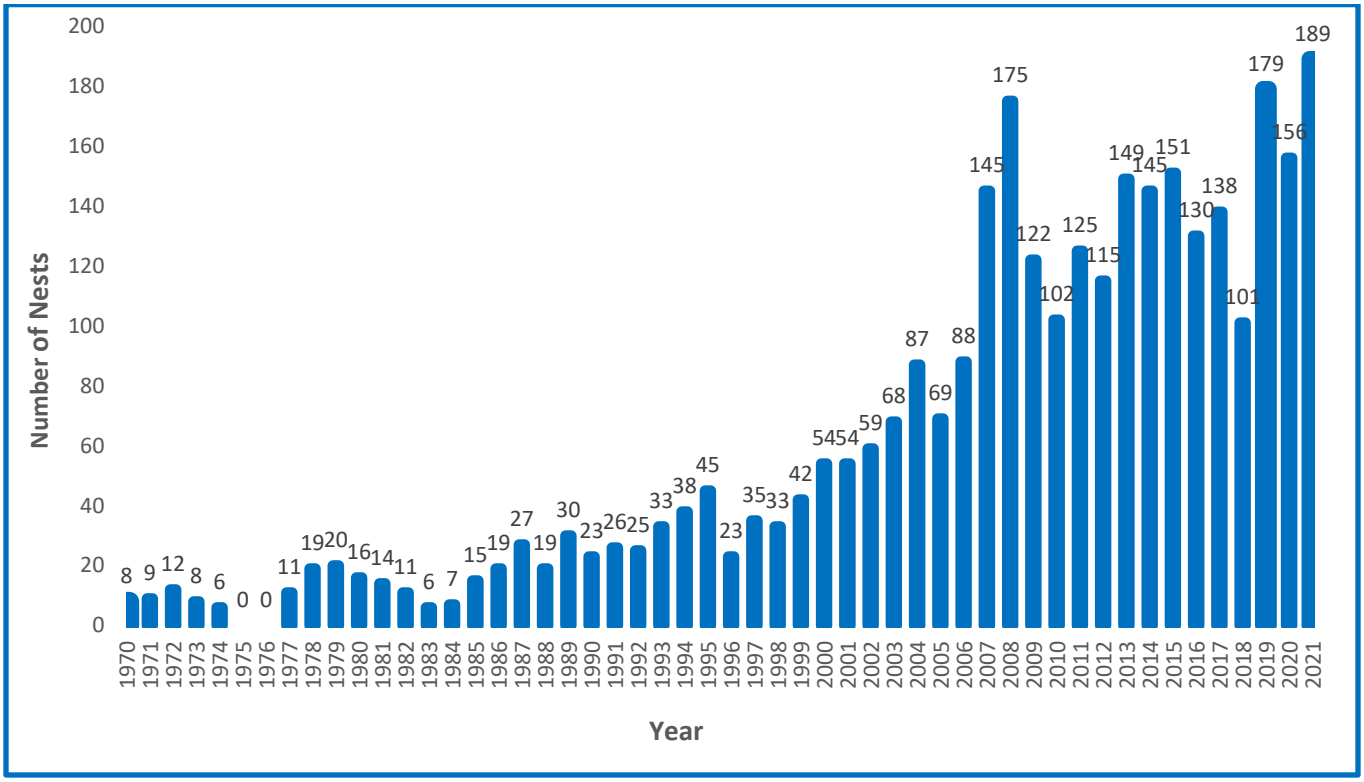

Figure 7. The total number of American crocodile nests observed per year at all five nesting areas described in Figure 2 from 1970 – 2021 (nest surveys were not conducted in 1975, 1976, 1983, 1984, 1996 in Northeastern Florida Bay and 1996 in Flamingo/Cape Sable).

TPPP: The number of American crocodile nests observed annually at FPL's TPPP from 1978 through 2021 is presented in Figure 2. The first nest constructed at the site was observed in 1978 and over the ensuing years nesting increased to a maximum of 28 nests in 2008 and 2021. The number of crocodile nests observed annually at the TPPP during the baseline period (2013 – 2017) described for recovery criterion 1 was 25 in 2013, 22 in 2014, 9 in 2015, 8 in 2016 and 9 in 2017. The number of crocodile nests observed annually during the last four years (2018 – 2021) was 14, 27, 22, and 28 respectively. The Service conducted a trend analysis on the nesting data from 2013 -2021 using a generalized linear model in R (R Core Team 2021), and a statistically significant trend was not found (P=0.18).

North Key Largo including the CLNWR: The number of American crocodile nests observed annually at North Key Largo from 1970 through 2021 are presented in Figure 3. Monitoring of American crocodile nests in this area began in 1978, and a total of 7 nests were observed during that year. The number of crocodile nests observed from 1978-2020 has ranged from 1 nest in 2010 to a maximum of 10 nests in 2016. The number of crocodile nests observed annually at the North Key Largo during the baseline period (2013 – 2017) described for recovery criterion 1 was 5 in 2013, 4 in 2014, 4 in 2015, 10 in 2016 and 7 in 2017. The number of crocodile nests observed annually during the last four years (2018 – 2020) was 9, 8, 2, and 5, respectively. The Service conducted a trend analysis on the nesting data from 2013 -2021 using a generalized linear model in R (R Core Team 2021), and a statistically significant trend was not found (P=0.96).

Northeast Florida Bay in ENP

The number of American crocodile nests observed annually at Northeast Florida Bay for the years 1970 through 2021 are presented in Figure 4. The first documented nesting of American crocodiles in the Northeast Florida Bay occurred in 1970, when two nests were located. The number of annual nests observed has increased markedly to a maximum of 36 in 2012 and 2013. The number of crocodile nests observed annually at the Northeast Florida Bay during the baseline period (2013 – 2017) described for recovery criterion 1 was 36 in 2013, 28 in 2014, 31 in 2015, 30 in 2016 and 17 in 2017. The number of crocodile nests observed annually during the last four years (2018 – 2021) was 18, 24, 19, and 29, respectively. The Service conducted a trend analysis on the nesting data from 2013 -2021 using a generalized linear model in R (R Core Team 2021), and a statistically significant decreasing trend in nesting was found (Slope = -0.05, P=0.04).

Flamingo/Cape Sable in ENP: The number of American crocodile nests observed annually at Flamingo/Cape Sable for the years 1987 through 2020 are presented in Figure 5. The first documented nesting of American crocodiles in the Northeast Florida Bay occurred in 1987, when two nests were located. The number of nests observed has increased markedly to a maximum of 120 in 2021. The number of crocodile nests observed annually at the Northeast Florida Bay during the baseline period (2013 – 2017) described for recovery criterion 1 was 80 in 2013, 85 in 2014, 103 in 2015, 81 in 2016 and 104 in 2017. The number of crocodile nests observed annually during the last four years (2018 – 2021) was 59, 118, 111, and 120 respectively. The Service conducted a trend analysis on the nesting data from 2013 -2021 using a generalized linear model in R (R Core Team 2021), and a statistically significant increasing trend in nesting was found (Slope = 0.04, P =0.001).

Other: The number of American crocodile nests observed annually within the areas defined as "Other" in Figure 6 for the years 1997 through 2020 is presented in Figure 15. As illustrated in Figure 1, the "Other" designation is comprised of three non-contiguous areas consisting of Biscayne Bay from North of the Turkey Point Power Plant Site to Virginia Key, Florida's Keys from south of CLNWR to Key West, and the west Coast of Florida from north of Highland Beach to Sanibel Island. Systematic surveys of American crocodile nesting have not been conducted in these areas. Therefore, the nest records provided are opportunistic observations of American crocodile nests, reported to the Service from sources deemed reliable. The Service received its first report of a nest occurring in these areas in 1997 and the number of reported nests ranged from 1 in 1997, 1998, 2016, and 2017, to 7 reported in 2004 and 2021. Because nest surveys were not conducted within suitable habitat within the areas defined as "Other," the Service finds that the nesting data collected it is not suitable for statistical analysis and we did not conduct a trend analysis on the data.

Total Nesting in South Florida: The number of American crocodile nests observed yearly from 1970 through 2021 (except for 1975, 1976, 1983, 1984, 1996 because surveys were not conducted in ENP) for all nesting areas defined in Figure 1 combined are presented in Figure 7. Nesting has increased from 8 nests in 1970 to a maximum of 189 nest in 2021. Collectively, 2,992 crocodile nests were documented in Florida during this period. The number of crocodile nests observed throughout the American crocodile's range during the baseline period (2013 – 2017) described for recovery criterion 1 was 149 in 2013, 145 in 2014, 151 in 2015, 130 in 2016 and 138 in 2017. The number of crocodile nests observed annually during the last three years (2018 – 2021) was 101, 179, 156, and 189 respectively. The Service conducted a trend analysis on the nesting data from 2013 -2021 using a generalized linear model in R (R Core Team 2021), and a statistically significant increasing trend was found (Slope = 0.02, P= 0.02).

Size of current population

We used nesting data to estimate of the current size of the population of American crocodiles in Florida. Our population estimate was derived with an equation devised by Chabrek (1966), P = N /(A x F x E), where P = population size (i.e., the number of non-hatchling individuals in the population), N = the number of nests observed in a nesting season, A = the percentage of adults in the population, F = the percentage of females in the adult population, and E = the percentage of females nesting. We calculated P for each year from 2013 through 2021 as this period includes the baseline period (2013 -2017) described in Recovery Criterion 1 and the most current nest data available (2018 – 2021). For each estimate of P, we defined N as the total number of nests observed during the year and used the nest data provided in Figure 7. We used values of A, F and E reported in the literature by Kushlan and Mazzotti (1989b; A = 0.3, F = 0.67, E = 0.72) for American crocodiles at Northeast Florida Bay, and Wasilewski and Enloe (2006; A = 0.16, F = 0.75, and E = 0.5) for American crocodiles at the TPPP. Because these values differ, we calculated two estimates of population size for each year, one based on A, F, and E values taken from Kushlan and Mazzotti, (1989a) and the other based on A, F, and E values taken from Wasilewski and Enloe (2006). Using this information, we calculated an annual population estimate (P) for the American crocodile in Florida for each year from 2013 – 2021 (Table 1). Based on our calculations, we estimate the current non-hatchling population size of American crocodiles in Florida during the baseline period of 2013 – 2017 defined in recovery criterion number 1 ranges from a minimum of 898 non-hatchling individuals (based on 130 nests observed

in 2016 and A, F, and E values presented in Kuslan and Mazzotti 1989) to maximum of 2517 non-hatchling individuals (based on the 151 nests observed in 2016 and A, F, and E values presented in Wasilewski and Enlow 2006). We also estimate the current non-hatchling population size of American crocodiles in Florida during the last four years, 2018 – 2021, from a minimum of 698 non-hatchling individuals (based on 101 nests observed in 2018 and A, F, and E values presented in Kuslan and Mazzotti 1989b) to maximum of 3,150 non-hatchling individuals (based on 189 nests observed in 2021 and A, F, And E values presented in Wasilewski and Enloe 2006).

Table 1. Estimated population size of the American crocodile population in Florida (i.e., number of non-hatchling individuals). The estimates were calculated using the method described by Chabreck 1966 (P = N /(A x F x E) and parameters presented in Kushlan and Mazzotti (1989b) and Wasilewski and Enloe (2006) (see text for details). Each value was rounded to the nearest single digit.

Year	Total Number of Nests Observed	Estimated Population Size (P) based on demographic parameter reported in Kushlan and Mazzotti 1989b	Estimated Population Size (P) based on demographic parameter reported in Wasilewski and Enloe, 2006
2013	149	1030	2483
2014	145	1002	2417
2015	151	1043	2517
2016	130	898	2167
2017	138	954	2300
2018	101	698	1683
2019	179	1237	2983
2020	156	1078	2600
2021	189	1306	3150

Natural Recruitment

Natural recruitment of the American crocodile is defined as the process by which new individuals are added to the population (i.e., through reproduction) and subsequently survive to become reproductively active themselves. The rate of recruitment in the American crocodile population affects its population size with a high rate of recruitment increasing the population size and a low rate of recruitment decreasing it. Recruitment is difficult to assess due to the many factors that affect it (e.g., nesting and hatching success, predation, environmental factors such as temperature, salinity etc.).

Studies specifically estimating recruitment in the American crocodile in Florida have not been conducted. In lieu of any other available information, the Service has chosen to use the annual nesting data provided above for each of the four of the five nesting areas (Figures 2-5) defined in Figure 1 and the total number of annual nests observed throughout the species nesting range in Florida (Figure 7) of the crocodile to be representative of natural recruitment in each of these areas. Because systematic nesting surveys were not conducted in the area defined in Figure 1 as "Other," we do not use nesting data in the "Other" area to infer recruitment. As discussed above, the Service found no trend in annual nesting from 2013 to 2021 at the TPPP, North Key Largo and CLNWR areas. Annual nesting was found to decrease at Northeast Florida Bay in ENP and to increase at Flamingo/Cape Sable from 2013 – 2021. Finally, nesting within all 5 nest areas collectively was observed to increase. Consequently, the Service finds that natural recruitment within these nesting areas and throughout the entire current range of crocodile in Florida mirror the trends in nesting discussed.

In summary, based on systematic monitoring of four of the five nesting areas of the American crocodile in Florida we find that three are exhibiting stable or increasing trends in nesting and natural recruitment. Moreover, the trend in total nesting and in turn natural recruitment for the range wide population of the crocodile in Florida appears to be increasing. Therefore, we conclude that Recovery Criterion 1 for the American crocodile has been met.

Recovery Criterion 2. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A and E).

Sea level rise (SLR) due to Climate Change is expected to affect the American crocodile in the foreseeable future and represents a new threat to the species. As defined by the Intergovernmental Panel on Climate Change (IPCC), "climate" refers to average weather, typically measured in terms of the mean and variability of temperature, precipitation, or other relevant properties over time. Therefore, "climate change" refers to a change in such a measure that persists for an extended period, generally decades or longer, due to natural conditions (*e.g.,* solar cycles) or human-caused changes in the composition of the atmosphere or in land use (IPCC 2013, p. 1450). Based on the observed trends in the instrumented climate record and changes observed in physical and biological systems, the scientific community is certain that that the earth's climate is changing and a warming trend in the climate is occurring (USGS 2019). Climate change may result in SLR, altered weather patterns, and an increase in the intensity of tropical storms and hurricanes in Florida. The increase in SLR results from the increase in surface temperatures. This factor causes seawater to expand and take up more space in ocean

basins, and results in the addition of water to the oceans due to the melting of polar ice (both sea ice and ice over land).

Sea level is expected to rise substantially in the future due to climate change. Mitchum et al. (2017) noted that the last assessment by the U. S. National Climate Assessment and IPCC suggested a 2 to 3 foot rise of sea level globally over the next 50 to 100 years but expected their next assessments to double these numbers. Mitchum et al. (2017) recommended planning for a 4 to 6 ft increase in sea level for Florida during this period. These estimates are comparable with the SLR projections developed by the Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact 2020; 17 to 41 inches [in] above 1992 mean sea level by 2060, and 32 to 103 in above 1992 mean sea level by 2100) and projections made by Sweet et al. (2017; by 2100 according to their Intermediate [3.3ft.SLR], Intermediate-High [4.9 ft] SLR) and High [6.6 ft. SLR] scenarios).

Climate change is expected to affect the American crocodile and its habitat in Florida in the future. To determine how climate change, and specifically SLR, is likely to affect this species, we reviewed recent vulnerability assessments prepared by Dubois et al. (2011) and Flaxman and Vargas-Moreno (2011).

Dubois et al. (2011) used an existing vulnerability assessment tool, the NatureServe Climate Change Vulnerability Index (CCVI) (Young et al. 2010), to assess the vulnerability to climate change for 21 species in Florida, including the American crocodile. Based on input from species experts regarding the effects of climate change, including SLR, on crocodiles, the CCVI generates an index score that corresponds to one of five categorical ranks ranging from "Extremely Vulnerable" to "Not Vulnerable." The CCVI was also used as framework to identify factors contributing to vulnerability; elucidate hypothesized relationships among these factors and the potential impacts on species and their habitats; and differentiate among sources of uncertainty.

The CCVI assessment categorized the American crocodile in Florida as "Extremely Vulnerable" to climate change. The most important climate related threats and associated threats identified by species experts were:

1. SLR resulting in inundation and habitat loss and generating changes in vegetation (i.e., mangroves). Species experts estimated that a 1-meter rise in sea level would affect 90 percent of the current nesting habitat of the American crocodile in Florida.

2. Water management practices that alter hydrologic regimes and exacerbate the impacts of SLR.

3. The potential for increased frequency of cold snaps resulting in direct morality of crocodiles

Other factors identified as contributing to the vulnerability of crocodiles to climate change included: anthropogenic barriers that may inhibit the species ability to track climatic shifts and limit expansion of the species northward along the east and west coasts of Florida; changes in the timing/intensity of hurricanes that might affect nest success; changes to hydrology that might affect salinity; and the potential for lower-than-average genetic variability.

In association with the CCVI assessment described above, Flaxman and Vargas-Moreno (2011) used a scenario-based modelling approach to assess the vulnerability of wildlife (including the American crocodile) in South Florida to the future effects of climate change (primarily SLR). They focused on the effects to areas where crocodiles are commonly sighted and where most nesting is known to occur (coastal South Florida from just north of Everglades City to northern Biscayne Bay and the northern half of the Florida Keys). Flaxman and Vargas-Moreno (2011) estimated future available nesting habitat in the year 2060 for the American crocodile in Florida under three scenarios of SLR: low (an increase of 3.6 in), medium (an increase of 18.4 in), and high (an increase of 39.1 in). They determined that approximately 30 percent of existing habitat would be inundated by low SLR, and 82 and 98 percent of existing crocodile habitat would be inundated by the medium and high increases in SLR, respectively.

The areas to be inundated by SLR include localities (Cape Sable/Flamingo, Northeastern Florida Bay, and Northern Key Largo) where most of the current nesting for species occurs. Consequently, inundated areas would no longer provide suitable nesting habitat for American crocodiles. Water levels at the CCS of the TPPP would rise under all three scenarios. However, due to the current height of the berms at the CCS, nesting habitat at the CCS would not be inundated (Eaton 2019 Personal Communication) and still be available to crocodiles under each of the three SLR scenarios. The species experts that reviewed the Flaxman and Vargas (2011) mapping analysis expected the American crocodile in Florida to adapt to inundation and loss of nesting habitat by shifting nesting activities further inland to uplands along the newly established shorelines. Based on the expected behavioral response of crocodiles, the availability of crocodile nesting habitat was expected to remain stable under all three scenarios of SLR.

The Service questions the conclusion that the amount of crocodile nesting habitat and ultimately the crocodile population would remain stable following SLR. We note that many uncertainties remain. It is not known if the new nesting habitat will be created by natural processes to offset the loss of existing nesting habitat lost to SLR. For example, will the newly established shorelines located inland in the Flamingo/Cape Sable areas of ENP following SLR contain sandy beaches that would be desirable as crocodile nesting habitat, or will they become heavily vegetated with mangroves or other vegetation types that would likely preclude nesting? Nesting sites could be established artificially though the placement of sand or other suitable nesting material adjacent to open water, but it is not known if funds would be available for such an undertaking. Moreover, construction of newly fabricated nesting sites within ENP seems unlikely based on the NPS's policy of maintaining native habitat types in their existing states and not allowing the construction of artificial habitats. Will the aquatic habitats established adjacent, or near newly established suitable nesting habitats be suitable for hatchlings? Finally, it is currently not known how crocodile will choose to respond to SLR or if they will locate and choose to use newly created nesting habitat following SLR. Due to these factors, the ultimate effects of SLR on the viability of the American crocodile in Florida remain unclear. The worst-case scenario would be that SLR would result in large reduction in crocodile nesting from its current levels and this would result in a substantial reduction in the crocodile population in Florida. Based on the uncertainties associated with SLR from climate change, we conclude it remains a significant threat to the viability of the American crocodile in the foreseeable future and that Recovery Criterion 2 has not been met.

Recovery Criterion 3. When, in addition to the above criteria, it can be demonstrated that despite sea level rise and other environmental influences, sufficient suitable habitat remains for the American crocodile to be viable in Florida for the foreseeable future (Factors A and E).

As described above, much of the existing nesting habitat currently used by crocodile is expected to be inundated due to SLR from climate change and will be lost due to the species. Moreover, it is unknown if new suitable nesting habitat (i.e., nesting habitat resulting from natural processes or created artificially) will be available to crocodile s or if crocodiles will choose to use this habitat. Based on the uncertainties associated with the loss of nesting habitat due to SLR, we conclude that Recovery Criterion 3 has not been met.

Biology and Habitat Summary

General information on the biology and life history of the American crocodile is presented in the Service's Multispecies Recovery Plan (Service 1999), and the previous status review and reclassification (40 FR 44149). New information pertinent to the species is presented below.

Genetics

Currently, it is unclear if the American crocodile in Florida can be considered a single species (i.e., C. acutus) or is comprised of more than one species. Recent genetic analysis of the American crocodile throughout its range has revealed two paraphyletic lineages of C. acutus (Milan-Garcia et al. 2018). One lineage, found in the continental Americas (as determined from published data on C. acutus from Colombia, Jamaica, and the Cayman Islands) is the sister taxon to C. intermedius. While the Greater Antillean lineage, (derived from genetic samples taken from animals from Cuba, Belize, and Florida; Ray et al. 2004; Rodriguez et al. 2011; Man et al. 2011, Milián-García et al. 2011; Bloor et al., 2015) is most closely related to C. rhombifer. Milan-Garcia et al. (2018) noted that the reconstructed paraphyly, distinct phylogenetic affinities, and high genetic divergence between the Antillean and continental C. acutus populations are consistent with interspecific differentiation within the genus and suggest that the current taxon recognized as C. acutus is more likely a complex of cryptic species. As such, it is possible that natural hybridization occurred more often than previously thought. Milan-Garcia et al. (2018) concluded that the observed genetic differences in the species warrant a reassessment of its current taxonomy rangewide. A reassessment may reveal that C. acutus in Florida is comprised of more than one species. This assumption is supported by past studies that found genetic differences among American crocodiles sampled from West Florida, Biscayne Bay, and East Florida (Rodriquez 2007, Rodriquez et al. 2011). Rodriquez et al. (2011) attributed the differences to hybridization and suggested that it may have resulted from human-mediated introduction of conspecifics (i.e., American crocodiles from other parts of their range) and heterospecific crocodiles (i.e., C. rhombifer), or from an historic hybridization event. Rodriquez et al. (2011) suggested that due to hybridization, the effective population size of American crocodiles in Florida (i.e., those American crocodiles native to Florida) might be smaller than the population size currently estimated and recommended that the size of the crocodile population native to Florida be reevaluated.

Distribution and trends in spatial distribution

A map of the current range of the American crocodile in Florida is presented in Figure 8. The current range was estimated through a computer modelling effort conducted by the Service. Modelling incorporated: 1) known locations of crocodiles taken from reliable sources (e.g., museum records, University of Florida surveys, FWC etc.), 2) land cover types known to be preferred by crocodiles, and 3) and minimum ambient winter air temperature data from Florida. A detailed discussion of our modelling effort is presented in Appendix A.

The current known core range (defined as the area where most of the current population occurs) of the American crocodile in Florida consists of coastal areas of central and Southern Broward, Miami-Dade, Monroe, Collier, and Lee Counties. Crocodiles are regularly observed in ENP along the shorelines of Florida Bay, Biscayne Bay, and the upper Florida Keys, and within the CCS and adjacent canals and wetlands at FPL's TPPP. Sightings of crocodiles on the southwest coast of Florida are becoming more common, and individuals occur as far North as Sanibel Island in Lee County. Sightings of American crocodiles now occur with increasing frequency in many of the lower Keys. A small population of crocodiles (at least 21 individuals) has been observed using wetlands adjacent to the airfield at the Key West Naval Air Station on Stock Island in 2014 (Mazzotti 2014).

Crocodiles are being observed outside their current core range with greater frequency (See occurrence records in Figure 8) since the last review of the species in 2007 (40 FR 44149). Individuals have been observed as far north as Tampa Bay in Hillsborough County and Satellite Beach and Melbourne Beach in Brevard County on the west coast of Florida (Figure 8). These observations may represent transient individuals but suggest that American crocodiles are beginning to reoccupy much of their historic range and may be in the process of expanding their range northward. Based on records of American crocodile within and outside its current core range in Florida, it appears that its current overall range of the species is now comparable to its historic range. However, we acknowledge that such a comparison may be misleading based on the paucity of records available on the American crocodile in Florida during the 1800s and early 1900s, and the uncertainty of how hunting conducted at this time may have affected the historic range of the species. The northward expansion of the crocodile population could also be a response to increasing annual ambient winter temperatures in coastal central Florida due to global warming. The northward expansion of the population in Florida was previously limited by minimum ambient air temperatures during winter because the species cannot tolerate cold. Global warming is expected to result in higher ambient minimum winter temperatures in central Florida and more equable winter temperature conditions for crocodiles.

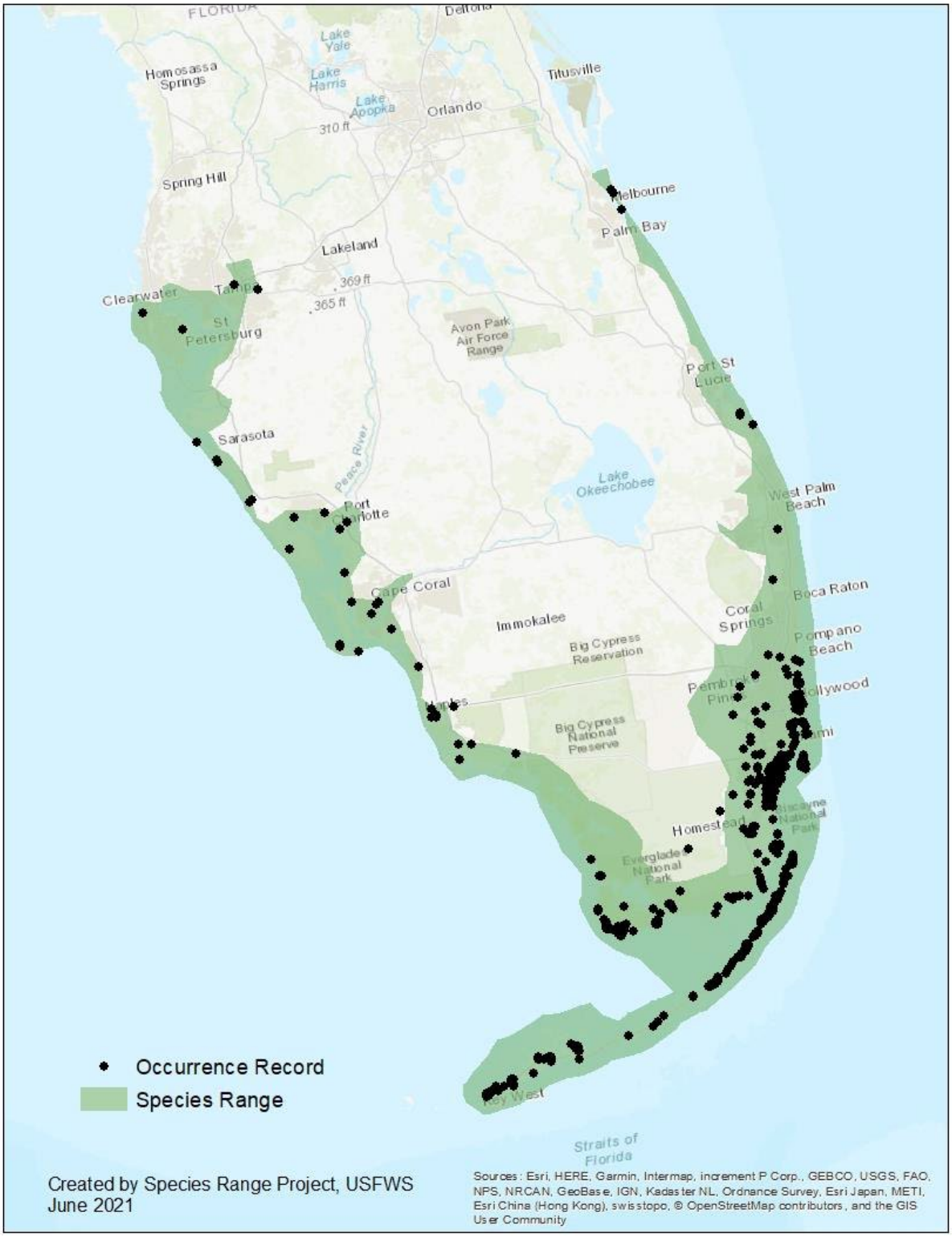

Figure 8. Map of the current range of the Distinct Population Segment of the American crocodile in Florida (as denoted by shading).

Habitat or ecosystem conditions

The American crocodile in Florida occurs in brackish, freshwater, and saltwater aquatic habitats, and adjacent upland shorelines, primarily in coastal areas. Suitable natural aquatic habitats consist of mangrove swamps and mangrove-lined bays, creeks, and inland swamps (Kushlan and Mazzotti 1989b) protected from wave and wind action (Mazzotti and Cherkiss 2003). Crocodiles have adapted to increasing development and urbanization in Florida and are now commonly observed in artificial habitats such as canals and man-made ponds in commercial and residential areas.

The status of crocodile habitat protected for conservation purposes has not changed significantly since the last review of the species was conducted in 2007 (40 FR 44149). Most of the crocodile habitat that has been protected for conservation purposes is still located along the coast of the southern tip of the Florida peninsula from just east of Marco Island to east of U.S. Highway 1 and within north Key Largo. These lands include public conservation lands within the Ten Thousand Islands National Wildlife Refuge, ENP, and CLNWR, and privately owned conservation land within FPL's Everglades Mitigation Bank. Management activities within these lands (e.g., treatment of exotic vegetation and animals, enhancement of nesting sites) also have also benefited the survival and recovery of the crocodile.

American crocodiles are an adaptable species in terms of habitat use and continue to use the many altered and artificial habitats (e.g., canals, berms, and borrow lakes etc.) constructed in Florida to meet human needs. Artificial habitat within the CCS of FPL's TPPP continues to provide important nesting habitat for the crocodile. Although, not protected for conservation purposes, this area receives some protection from human activities since it is closed to public. Moreover, FPL continues to manage the CCS to benefit the crocodile.

Crocodiles have adapted to increasing development and urbanization in Florida and observations of the species within in highly urbanized areas of coastal central and South Florida are increasing. The complex canal systems constructed in association with residential and commercial development provide suitable travel corridors and prey for crocodiles in urban areas. Moreover, canal banks, seawalls, piers, and other structures provide basking sites. To date, nesting within urbanized areas appears to be rare, although nests surveys within urban areas have not been conducted. Crocodile nesting has not been documented north of Virginia Key on the east coast of Florida or north of Marco Island of the west coast of Florida. As such, the importance of urbanized habitats to the overall crocodile population in Florida is not clear.

As discussed above, American crocodiles may be in the process of expanding its range northward. However, much of east and west coast of Florida located north of the crocodile's core range has been developed to meet the needs of its burgeoning human population. Consequently, these areas are highly urbanized and little native habitat remains. The urbanized nature of these areas provides a challenging environment to a species attempting to expand its range northward.

Degradation of water quality at the CCS of the TPPP

The CCS at FPL's TPPP provide valuable nesting habitat for the American crocodile, and roughly 10 to 15 percent of annual crocodile nesting occurs at this area. However, a reduction in water quality observed within the CCS that has occurred within recent years represents a potential new threat to American crocodiles and crocodile nesting at the site that did not previously exist at the time of the last five-year review for the species conducted in 2007.

The 5,901-ac CCS contains water used to cool the two nuclear generating units at the TPPP during operation and consists of 32 discharge canals and 6 return canals interspersed with earthen berms comprised of materials removed during the construction of the canals. The construction of the berms in the CCS constructed in the late 1960s and early 1970s in association with the TPPP, unintentionally provided crocodiles with ideal habitat for nesting. Crocodiles were first observed in the CCS in 1976 and began building nests on the berms in 1978 (Mazzotti and Cherkiss 2003). Nesting effort has increased significantly since this time (Figure 2).

The water in the CCS is hypersaline, with salinities reaching 46 ppt or higher depending on time year, making it a challenging osmoregulatory environment especially for hatchlings. Salinity levels within the waters of the CCS exhibit seasonal variation, peaking at the end of the dry season, and falling at the end of the wet season. Nonetheless, prior to 2010, the CCS contained clear water and a healthy seagrass community that helped to maintain good water quality and low nutrient concentrations. However, from 2000 through 2009, the maximum salinity of water in the CCS observed during the dry season steadily increased. By 2010, seagrasses were dying off, and by 2012, little seagrass remained in the CCS. The system-wide seagrass die-off and subsequent decomposition of the seagrasses released a significant volume of previously bound and sequestered nutrients over a multi-year period. The increase of nutrient levels facilitated seasonal algae blooms, resulting in high turbidity and generally degraded water quality. A reduction in the diversity and abundance of fish and other potential crocodile prey species within the CCS was also observed. The reasons for these changes are not clear but may have resulted from the increase in the level of power production (uprate) from the two nuclear generating units that was instituted by FPL during this time (this action was expected to increase the salinity and temperature of the waters of the CCS). Other contributing factors likely included localized drought, or sedimentation that has occurred within the CCS over time reducing the amount of water in the system. The decrease in nesting observed from 2015 through 2017 (9 in 2015, 8 in 2016 and 9 in 2017; compared to 25 nests per year in 2013 and 2014; Figure 2) is likely associated with observed degradation in water quality and increases in salinity within the waters of the CCS that began prior to 2010. Decreased water quality also resulted in a significant reduction in body condition of crocodiles, and the total number of crocodiles observed in and around the CCS (Squires et al. 2016).

FPL has implemented multiple efforts to improve the water quality in the waters of the CCS including the addition of brackish and fresh water to the system to lower salinity, chemical treatment of algal blooms, dredging of the canals, and sea grass plantings. Due to these measures, salinity has been reduced from > 90 ppt recorded in 2015 to a mean of 39.2 ppt in 2021 (Arlene 2021) and water quality appears to improving to some extent.

This corresponded with an increase in nesting from 2018 through 2021 (Figure 2; 14, 17, 22 and 28 nests were observed respectively) and an increase in the body condition of crocodiles from the CCS (Arlene 2021). Based on this information, it appears that this threat has been addressed and/or managed to the extent that it will not affect crocodile reproduction and survival at the TPPP or reduce the range wide population.

Threats (Five-Factor Analysis) Summary

The status of a species is determined from an assessment of factors specified in section 4 (a)(1) of the Act, including: Factor A: the present or threatened destruction, modification, or curtailment of its habitat or range; Factor B: overutilization for commercial, recreational, scientific, or educational purposes; Factor C: disease or predation; Factor D: the inadequacy of existing regulatory mechanisms; Factor E: other natural or manmade factors affecting its continued existence. A summary of this assessment is detailed below.

Present or threatened destruction, modification or curtailment of its habitat or range: Sea level rise due to climate change – As previously discussed, SLR due to global warming is expected to result in the inundation and loss of existing nesting habitat currently used by American crocodiles. Sea level is expected to rise substantially over the next 50 to 100 years, at least 17 to 41 in above the 1992 mean sea level by 2060 and 32 to 103 in above 1992 mean sea level by 2100 (Compact 2020).

Flaxman and Vargas-Moreno (2011) estimated inundation of known nesting habitat is South Florida that would result from these levels of SLR. Their analysis addressed the nesting areas defined in Figure 1 (Northeast Florida Bay in ENP; Flamingo/Cape Sable in ENP, the TPPP and North Key Largo including CLNWR) where most of the documented crocodile nesting is known to occur. Flaxman and Vargas-Moreno (2011) estimated that rises in sea level of 3.6 in, 18.4 in, and 39.1in would inundate (and result in the loss) of 30, 82, and 98 percent of existing nesting habitat, respectively. Flaxman and Vargas-Moreno (2011) noted that species experts that reviewed their analysis expected the American crocodile to adapt to inundation and loss of nesting habitat by shifting their nesting activities further inland and the availability of crocodile nesting habitat was expected to remain stable under all three levels of SLR. However, the Service finds that many uncertainties remain. It is not known if the newly established shorelines will provide suitable nesting habitat for crocodiles or if crocodiles will choose to nest in these areas. Monitoring will be needed to determine if crocodiles are establishing new nesting sites. Although monitoring of crocodile nesting has occurred in the past, it is not known if funding will be available to support future nest monitoring efforts. Furthermore, it is not clear if funds would be available to construct new artificial nesting sites should they become necessary due to the lack of natural nesting areas. Moreover, construction of new fabricated nesting sites within ENP seems unlikely based on the NPS's policy of maintaining native habitat types in their existing states. Due to these factors, the ultimate effects of SLR on the viability of the American crocodile in Florida remains unclear. The worst-case scenario would be that SLR would result in large reduction in crocodile nesting from its current levels and this would result in a substantial reduction in the crocodile population in Florida. Based on the uncertainties associated with SLR from climate change, we conclude it remains a threat to the viability of the American crocodile in the foreseeable future.

Human-related development – Development of coastal areas of Florida for commercial, residential, and other purposes continues to be a threat to remaining crocodile habitat that has not been protected. Demand for development of remaining coastal habitats persists due to the ongoing growth in the human population in Florida. Loss of native habitat types due to development has been alleviated to a minor extent due to the adaptability of the species and its ability to use altered or artificial habitats in highly urbanized areas. However, most crocodile nesting currently occurs on lands either protected for conservation purposes or on private lands closed to public access (i.e., the CCS within the TPPP). As described above, sea level is expected to rise substantially over the next 50 to 100 years. Inundation of coastal urbanized areas is expected to force humans living in those areas to relocate inland. It remains unclear on how human relocation and development due to SLR will affect crocodile habitat on both protected and unprotected lands.

The original listing rule noted that the restricted flow of fresh water to the Everglades and coastal South Florida due to past development related activities and the concomitant increase in salinity in aquatic crocodile habitats represented a potential threat to the American crocodile in Florida. Several studies report the negative effects of salinity on the American crocodile, particularly in hatchlings and juveniles (Ellis 1981, Mazzotti and Dunson 1984, Mazzotti et. al 1986, Dunson and Mazzotti 1989, Briggs-Gonzalez et al. 2015, Briggs-Gonzalez et al. 2017). Both growth and survival of American crocodiles decrease with increasing salinity (Moler 1992, Mazzotti and Cherkiss 2003, Mazzotti et al. 2007, Briggs-Gonzalez et al. 2015, Briggs-Gonzalez et al. 2017). Mazzotti et al. (2019) reported that the relative density of American crocodiles in ENP decreased with increases in salinity. Although not the primary cause of historic decline of the American crocodile in Florida, increased salinity in the coastal wetlands of Florida Bay likely accelerated the reduction of the population. Moreover, high salinities in these wetlands may limit the growth of the crocodile population and affect the recovery and viability of the American crocodile in Florida. As noted in our last review for the species competed in 2007 (40 FR 44149), the construction and implementation of the Comprehensive Everglades Restoration Plan is expected to enhance the delivery of freshwater into coastal wetlands and Florida Bay, reduce salinity, and improve ecological conditions for crocodiles. These changes are anticipated to increase the growth, body condition, reproduction, and survival of crocodiles, and ultimately increase the crocodile population.

Overutilization for commercial, recreational, scientific, or educational purposes:
Prior to listing in 1975, crocodiles were occasionally shot for sport or for their skins and meat or collected as specimens for museums or zoos. Illegal shootings and poaching of crocodiles are currently very uncommon but still occurs on rare occasions. Since the last review of the species in 2007, the Service is aware of five reports of malicious injuries or killings of crocodiles by humans. Three crocodiles were killed and one injured from gunshots in 2014, 2016, 2017, and 2021, and a crocodile also died from injuries it sustained after being hooked by a baited line intentionally set in a canal to capture the animal in 2016. These events all appear to be the result of fear or intolerance for the species. In addition, the Service has received only one report (in 2008) where a crocodile was illegally killed for its meat or other body part. In this case both the head and tail were removed from the carcass. Removal of the tail is commonly observed when American alligators are poached for meat. Finally, the Service has not received any reports of American crocodiles illegally being removed from the wild in Florida to meet the needs of zoos, museums, or for the pet trade. Efforts by the FWC, environmental groups, television and radio

stations and other entities through the internet, social media, radio and television news stories and videos have aided in educating the public about the status and legal protection of American crocodiles and helped minimize the illegal killing of species by humans.

The Service only receives a few requests for recovery permits during any given year for scientific or educational purposes related to the crocodile in Florida. In general, the scientific studies allowed through the issuance of these permits increases our knowledge of the species and improves its management. Any permit allowing the possession of live specimens, skull or skins for educational purposes would only be issued on the condition whereby it would increase the general public's knowledge of this valuable species and not affect the crocodile population. Ultimately, the issuance of these permits benefits the survival and recovery of the American crocodile in Florida.

Based on the available information, the Service finds that the current levels of utilization of the American crocodile in Florida for commercial, recreational, scientific, and educational purposes do not represent a threat to the survival and recovery of the species.

Disease or predation:
The Service's last review of the crocodile in 2007 (40 FR 44149) indicated that depredation by raccoons (*Procyon lotor*) posed a threat to nests and developing eggs and 20.1 percent of nests at ENP were lost annually. Our analysis of recent nest surveys reports from ENP (Mazzotti et. al 2015, Mazzotti 2017, 2018, 2020) determined that 2.2, 4.1, 5.2, and 2.3 percent of nests were depredated (most likely by raccoons) in 2015, 2017, and 2018. Depredation of crocodile nests at the TPPP and CLNWR appears be uncommon or non-existent. Lloret (2022) reported that one nest was depredated in 2017 and one in 2020 at the TPPP. Dixon (2022) stated that depredation of crocodile nests at the CLNWR has not been documented, although raccoons may dig up and consume nests that have failed because they can easily smell the rotting eggs. The current level of nest lost due to raccoon depredation is not expected to significantly affect the crocodile population.

Predation of crocodile nests by the exotic fire ant (*Solenopsis invicta*) was reported in the species last status review and a small number of nests were affected. Fire ants can sting and kill hatchlings upon emergence from the egg. The Service has not received any recent reports of nests or hatchlings been lost due to predation from fire ants, although we assume it continues to occur on rare occasions. Nonetheless, we find that fire ant predation of hatchlings is not likely to significantly affect the crocodile population in Florida.

As discussed below, the exotic Burmese python (*Python bivittatus*) and Argentine black and white tegu (*Salvator merianae*; tegu) have become established in South Florida since the last review of the species was completed in 2007 (40 FR 44149). These species represent potential predators of crocodiles, eggs, and hatchlings. To date, predation by these species not been documented. However, it is unclear if they will become a threat to the crocodile population in the future. Efforts are currently underway to control Burmese pythons and Argentine black and white tegus in Florida.

Currently, there is no evidence that disease or predation presents a threat the American crocodile population in Florida.

Inadequacy of existing regulatory mechanisms:
The Act currently provides protection for the American crocodile as a threatened species. Any violation of the Act with respect to the American crocodile is subject to civil and criminal penalties. The Service's law enforcement conducts law enforcement activities associated with the Act. In addition, pursuant to Section 7 of the Act, the Service's Ecological Service's Office in Florida reviews actions proposed or authorized by Federal agencies to ensure that these actions do not jeopardize the continued existence of the American crocodile in Florida.

The State of Florida provides legal protection for the crocodile within its boundaries. In 1967, the State listed the crocodile as "protected." This status was revised in 1972, when the crocodile was listed as "endangered" under Chapter 68A-27 of the Florida Administrative Code. Following downlisting to threatened by the Service in 2007, the state of Florida changed the American crocodile's state status to "Federally-designated threatened" on November 8, 2010 (Florida Administrative Code 68A-27.003). Chapter 372.0725 of the Florida Statutes state "it is unlawful for a person to intentionally kill or wound any fish or wildlife of a species designated by the FWC as endangered, threatened or of special concern or to intentionally destroy the eggs or nest of any such fish or wildlife, except as provided for in the rules of the commission. Violation of these prohibited acts can be considered a third-degree felony and is punishable by up to 5 years in prison and a $10,000 fine (Florida Statutes 372.725, 775.082, 775.083 and 775.084). Enforcement activities associated with state-listed species are conducted the FWC's division of Law Enforcement.

On June 38, 1979, the American crocodile was added to Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). This designation reflected that the species, while not currently threatened with extinction, may become so without trade controls. On June 6, 1981, the crocodile was moved to Appendix I, indicating that it was in danger of extinction. Generally, no commercial trade is allowed for Appendix I species. Effective February 17, 2005, the Cuban population of the American crocodile was downlisted to Appendix II. CITES is a treaty established to monitor international trade to prevent further decline in wild populations of plant and animal species. CITES permits may not be issued if import or export of the species may be detrimental to the species' survival, or if specimens are not legally acquired. CITES does not regulate take or domestic trade, so it would not apply to take within Florida or the United States.

Based on the information described above, the Service finds that the current regulatory mechanisms are adequate to protect the American crocodile.

Other natural or manmade factors affecting its continued existence:
Human disturbance to nesting - The Service's last review of the crocodile in 2007 (40 FR 44149) reported that human disturbance may be a threat to crocodiles because it can cause abandonment of nests or nests sites. We now know that crocodiles will tolerate some level of human presence when choosing a nesting site as nests have been observed along roadways in ENP (Parry 2019) and in the back yard of a home in a residential area in the Florida Keys (Ford 2021).

Complaints from the public regarding crocodiles - As the crocodile population has increased in Florida, the number of human -crocodile interactions have increased as has the number of complaints to the FWC from the public regarding observations or encounters with crocodiles.

Response agents from the FWC address complaints from the public regarding American crocodiles. Complaints originate primarily from persons in South Florida (i.e., Miami-Dade County, and the Florida Keys), although, a complaint has been recorded as far north as Sarasota County (Ford 2019a). Most of the complaints relate to observations of American crocodiles in residential areas, and the complainant usually expresses fear of the crocodile's presence and request action to eliminate the perceived problem. Although, crocodiles are large predators and physically capable of injuring or killing a human, there has only one been confirmed case of an American crocodile attacking a person in Florida. The attack occurred in 2014 and resulted in minor injuries from crocodile bites to two humans when they swam at night in a canal known to be inhabited by crocodiles.

When responding to a complaint, the FWC response agent provides education regarding the species and promotes coexistence among crocodiles and humans, including methods that can reduce the potential for adverse interactions. However, in some cases, education alone does not satisfy the complainant. If the complainant insists that the crocodile is a threat to safety, the FWC may choose to capture and translocate the crocodile (pursuant to 50 CFR 17.21(c)(3)). In 2018, the FWC translocated 11 crocodiles based on complaints from the public. Translocations are not always effective. In some cases, the translocated crocodile returns to the site of the complaint. Moreover, the fate of translocated crocodiles and the effects of translocating crocodiles on the crocodile population is largely unknown. If a crocodile continues to return to the site of the original complaint or is involved in a complaint in another area, it may be captured and put into captivity, and this animal is lost to the population. However, only one nuisance American crocodile has been put into captivity from 2014 to the present (Ford 2019b). Therefore, it appears that the placement of nuisance crocodiles into captivity is not currently adversely affecting the crocodile population in Florida.

Translocation of animals from areas considered to be "outside of the current range" (i.e., north of the current core range of crocodiles in Florida) back to South Florida may be minimizing the ability of the species to adapt to changing environmental conditions. We expect crocodiles to continue to disperse northward along the east and west coasts of Florida as minimum winter temperatures increase due to global warming. Continuing to move crocodiles back to what recently has been considered their core habitat in South Florida will limit natural dispersal and potentially the long-term sustainability of the species. There is not enough information available to determine if translocation as a management tool is currently adversely affecting the viability of the crocodile population. To provide more information on the fate of translocated crocodiles, the FWC is conducting a satellite tracking study of crocodiles translocated in response to complaints.

Road-related Mortality - Roads and highways represent a potential threat to the American crocodile because individuals venturing onto roadways can be injured or killed due to collisions with motor vehicles. The growth of the human population in South Florida has increased the number of motor vehicles on existing roadways and necessitated the widening of existing roads and the building of new roads that occur in and adjacent to crocodile habitat. Consequently, the potential for injuries and mortalities of crocodiles due to motor vehicle collisions has increased considerably since the time of listing. Reports from the FWC and records from other sources indicate that at least 119 American crocodiles were killed and 3 were injured due to collisions with motor vehicles from January 1, 1975, through August 31, 2021, on roadways in South

Florida. The actual number of road-related crocodile mortalities in Florida may be slightly higher because the mortalities of smaller crocodiles (*i.e.*, hatchlings and juveniles), or individuals who are injured and crawl away from the road before dying, are less likely to be detected and may go unreported. Crocodile mortality due to vehicle collisions occurred at rate of approximately 2.6 deaths per year over this period. When road-related mortality is considered in 10-year increments, the annual mortality rate appears to be increasing slightly since listing. Approximately 1.5 crocodiles were killed per year from 1975 through 1984, 2.1 from 1985 through 1994, 3.3 from 1995 through 2004, and 2.9 from 2005 through 2014. The annual vehicle-related mortality rate of crocodiles from January 1, 2015, to July 30, 2021, is 3.2 deaths per year.

Roadway underpasses have been employed to reduce the likelihood that crocodiles will be injured or killed due to collisions with motor vehicles. Road-related mortality of crocodiles had been an ongoing problem on the segment of U.S. Highway 1 from south of Florida City to Key Largo in Miami-Dade and Monroe Counties where wetlands providing habitat for crocodiles is located on both sides of the roadway (Service 1999, Mazzotti 1983; Moler 1991). The Florida Department of Transportation (FDOT) reduced vehicle-related crocodile mortality along this section of U.S. Highway 1 by installing a series of 16 wildlife underpasses consisting of large culverts and barrier fencing in association with planned improvements to the roadway that were completed in 2011. Initially, the entire west side of the roadway was fenced, and wing-fences about 100 feet long were installed along the east side of the road at the each of the culvert locations. Because crocodiles could still access the roadway, the FDOT graciously agreed to fence the entire eastern side of the roadway based on a request from the Service and that work was completed a few years later. Currently, the FDOT conducts ongoing inspections and maintenance of the fence to ensure that it continues to function properly.

Mazzotti and Cherkiss (2003) listed collisions with automobiles as the major documented cause of mortality of crocodiles in Florida. Even though the rate of crocodile mortalities due to vehicle collisions appears to have increased slightly since listing, our data suggest that it is currently only a small portion of annual crocodile mortality (*i.e.,* 2 to 3 deaths per year in a population of 698 to 3,150 non-hatchling individuals). In addition, the installation of underpasses and barrier fencing along U.S. Highway 1, as described above, has helped to reduce the potential for injuries and deaths of crocodiles due to vehicle collisions. Road-related mortality does not appear to be limiting the crocodile population currently. However, it could become a greater threat if currently elevated areas that provide nesting habitat are lost to sea level rise, erosion, or development, and crocodiles begin to use elevated roadbeds for nesting.

Adverse Effects from Exotic Animals - Two recently established exotic animal species, the Burmese python and the Argentine black and white tegu, have the potential to be significant predators of American crocodiles in Florida. The Burmese python is a large constrictor snake, up to 23 ft in total length (Harvey et. al 2008), native to Southeast Asia. The tegu is a medium-sized lizard, 2 to 3 ft in total length, native to South America. The size of the Burmese python and tegu populations in South Florida are not known, but the former has been estimated to number in the thousands (Snow et al. 2007). Burmese pythons have been documented to feed on a variety of animal species in Florida, including the American alligator. Although predation of crocodiles has not yet been documented, Burmese pythons are certainly capable of killing and consuming hatchling, juvenile, and sub-adult crocodiles. The tegu is known to eat reptile eggs

and has been photographed by motion sensitive cameras consuming American alligator eggs and loitering at a crocodile nest site (Mazzotti *et al*. 2014). Both exotic species have been documented to occur in or near the CCS at the TPPP. Predation of crocodiles and competition with crocodiles by Burmese pythons and egg predation by tegus could significantly reduce the current crocodile population, and potentially affect the survival and recovery of the species. To reduce Burmese python and tegu numbers in South Florida, monitoring and eradication programs are being conducted by the FWC, Service, University of Florida, U.S. Geological Survey, NPS and FPL. This effort includes public python hunts administered by the FWC.

The green iguana (*Iguana iguana*), native to central and South America, is another exotic reptile species established in Florida that could become a potential threat to the American crocodile. The population of green iguanas in South Florida has significantly increased in recent years and now iguanas commonly occur in areas inhabited by crocodiles. Iguanas have been observed digging up American crocodile nests in Panama when attempting to lay their eggs and exposing crocodile eggs in the process (Dugan et al. 1981). Uncovering eggs following deposition in the nest results in mortality of at least some and potentially all the eggs in the nest due to exposure to the elements. It also increases the likelihood that predators will find the eggs and eat them. Mazzotti (2019 personal communication) stated that a green iguana was recently observed digging into an American crocodile nest in ENP. In addition, diggings from iguanas are commonly observed in and around crocodile nests at the CLNWR (Dixon 2019 personal communication). The CLNWR has established a program to monitor and remove green iguanas and other species of exotic lizards within the refuge.

There is currently no evidence available to conclude that the presence and activities of exotic animals are affecting the viability the American crocodile population in Florida.

Synthesis

The American crocodile in Florida is a large reptile that occurs in suitable aquatic and adjacent shoreline habitats in coastal central and south Florida. The Service notes that range of the DPS of the American crocodile in Florida has increased since the last review of the species in 2007 (40 FR 44149). Crocodiles have been observed as far north as Tampa Bay on the west coast of Florida and Brevard County on the east Coast of Florida.

However, most of the crocodile population still occurs within coastal areas of central and southern Broward, Miami-Dade, Monroe, Collier, and Lee Counties. The current known nesting range of the American crocodile in Florida (Figure 1) is largely still restricted relative to its reported historic range (Kushlan and Mazzotti 1989a), with most nesting occurring on the mainland shore of Florida Bay in ENP within the Northeast Florida Bay and Flamingo/Cape Sable areas, Key Largo at the CLNWR, and the CCS of FPL's TPPP. Occasional nesting occurs at: Biscayne Bay north of the TPPP to as far north as Virginia Key; throughout the Florida Keys south of North Key Largo, and the southwest coast of Florida from north of Highland Beach to Sanibel Island (the areas collectively defined as "Other" in Figure 1).

Crocodile nesting in Florida has increased substantially since the species was listed (11 nests were recorded in 1977 compared with 189 nests in 2021, Figure 7). Approximately 60 to 70 percent of the current total nesting occurs within the Flamingo/Cape Sable area of ENP (e.g., 120 of 189 nests [63.4 percent] in 2021) with the remainder of nesting occurring primarily at

northeast Florida Bay, the TPPP, and Key Largo at the CLNWR. A small number of nests are constructed annually in the other area (Figure 6). Total crocodile nesting in Florida has remained stable or increased since the last review of the crocodile was completed in 2007 (40 FR 44149). For the period from 2007 to 2021 the total number of nests has ranged from a low of 101 in 2018 to a high of 189 in 2021 (Figure 7).

The Service used an equation devised by Chabrek (1966) that incorporates the total nesting data listed in Figure 7 and information regarding the crocodile population in Kushlan and Mazzotti, (1989b) and Wasilewski and Enloe (2006) to estimate the population size of the American crocodile in Florida from 2013 – 2021 (Table 7; this period encompasses the baseline period of 2013 – 2017 defined in recovery criterion number 1 and the most current nesting data available from 2018 – 2021). Based on this method, the Service estimates the population of the American crocodile in Florida for the baseline period for recovery criterion 1 from 2013 through 2017 as ranging from 898 to 2,517. We further estimate the current population (based on nesting data from 2018 through 2021) as containing 698 to 3,150 non-hatchling individuals. The range of the current population size of the American crocodile in Florida is comparable to and encompasses the population estimate of 1,400 to 2,000 non-hatchling individuals reported in the Service's 2007review of the species (40 FR 44149) but contains a lower minimum estimate and a higher maximum estimate.

We have carefully assessed the best scientific and commercial data regarding the status of the American crocodile in Florida and the current and future threats that are likely to affect the species. The Service notes that the species appears to be increasing its range in Florida, its population appears to be stable or increasing, and that Recovery Criterion 1 has been met. Nonetheless, SLR due to climate change has emerged as a threat to the American crocodile since the last review of species occurred in 2007 (40 FR 44149) and has the potential to significantly reduce nesting habitat and the viability of the population in the foreseeable future. Therefore, Recovery Criteria 2 and 3 have not been met. Consequently, we find that the American crocodile in Florida continues to meet the definition of threatened pursuant to the Act.

RECOMMENDED FUTURE ACTIVITIES

- Maintain nesting sites and create new nesting sites where possible thorough the addition of sand or other materials suitable as nesting substrate.
- Continue annual monitoring of crocodile nesting and establish monitoring in currently potential nesting areas that are not surveyed.
- Continue to implement projects associated with Comprehensive Everglades Restoration Program or other measures as needed to reduce salinity of waters in adjacent to Florida Bay to improve conditions for crocodiles.
- Continue education efforts to increase public awareness of the conservation and habitat needs of the crocodile.
- Promote safe passage of crocodiles under roads through installation of culverts and barrier fencing as needed.
- Develop a data management system to collate and store American crocodile data (e.g., nesting data) from all sources in a consistent manner.

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RECOMMENDATIONS / SIGNATURES

U.S. Fish and Wildlife Service
Status Review of American crocodile (*Crocodylus acutus*)

Status Recommendation:

On the basis of this review, we recommend the following status for this species. A 5-year review presents a recommendation of the species status. Any change to the status requires a separate rulemaking process that includes public review and comment, as defined in the Act.

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist:
____ *The species is extinct*
____ *The species does not meet the definition of an endangered or threatened species*
____ *The listed entity does not meet the statutory definition of a species*
__X__ No change needed

FIELD OFFICE APPROVAL:

Division Manager, Classification and Recovery, Florida Ecological Services Field Office, Fish and Wildlife Service*

Approve LOURDES MENA Digitally signed by LOURDES MENA Date: 2022.09.09 13:25:55 -04'00' Adobe Acrobat version: 2022.002.20191

*In 2021, the Classification and Recovery Division Manager in the Florida Ecological Services Field Office was delegated authority to approve 5-year reviews that do not recommend a status change.