United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

January 19, 2018

Memorandum

To: Karen Marlowe, Southeast Region Recovery Permit Coordinator, Ecological Services, Atlanta, Georgia

From: Roxanna Hinzman, Field Supervisor, South Florida Ecological Services Office, Vero Beach, Florida

Subject: Biological Opinion for Section 10(a)(1)(A) Permit Application from the Vero Beach Field Office for Dr. Frank Mazzotti , Permit Number TE077258-0, Service Consultation Code: 04EF2000-2017-F-0720

This document is the Fish and Wildlife Service's (Service) biological opinion per section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.) (Act) regarding our review of issuance of a Section 10(a)(1)(A) permit application by to Dr. Frank Mazzotti for research on the endangered American crocodile (*Crocodylus acutus*; crocodile). The proposed action will occur throughout the crocodile's range in Florida and include: Biscayne Bay, Biscayne Bay National Park, Biscayne Bay State Aquatic Preserve, the Charles Deering Estate in Miami, Florida, Crandon Park and Chapman Field in Key Biscayne, Florida, Crocodile Lake National Wildlife Refuge, Everglades National Park, Key West Naval Air Station, Florida Power and Light's Turkey Point Power Plant, Matheson Hammock Park in Coral Gables, Florida, and all suitable coastal and inshore waters (including canals) located in or adjacent to Broward, Charlotte, Collier, Lee, Miami-Dade, and Monroe (including the Florida Keys) Counties, and any other counties in Florida where crocodiles are reported to occur.

Name of Species affected by action: American crocodile

Status of Species affected by action: Please see Attachment for the Status of the Species of the crocodile.

Proposed Action: Pursuant to section 10(a)(l)(A) of the Act, the Service proposes to issue a recovery permit to the applicant, Dr. Frank Mazzotti, for take of crocodiles while doing research and monitoring as described below. The proposed research continues a long-term crocodile population and nest monitoring program, conducted by several different researchers and summarized in Brandt *et al.* 1995, Cherkiss 1999, Mazzotti 1989, Mazzotti 1999, and Moler 1991. The objectives of this research are to: 1) determine abundance, distribution, and habitat relationships of crocodiles; 2) monitor growth and survival of crocodiles; and, 3) monitor

crocodile nesting effort, success and failure. This work may take place throughout the year in the crocodile's range in Florida as listed above. The permit, if issued, would be valid for a period of 5 years.

The distribution, growth, survival, abundance, and habitat relations of crocodiles will be assessed by quarterly observational and capture-mark-recapture surveys. Crocodile surveys and captures will be conducted in estuaries, bays, lakes, ponds, canals, and any other natural or manmade salt or freshwater body where crocodiles may occur. Surveys and captures will be conducted during the day or night by experienced biologists travelling in motor boats, canoes, trucks, all- terrain vehicles, or on foot, depending on location and habitat. When surveys are conducted at night, observers will use spotlights to locate crocodiles. Observers will attempt to capture any crocodile that can be approached closely on foot or by boat. Small crocodiles, hatchlings to individuals $\leq$ 0.6 meters in total length, will be captured by hand or pillstrom® tongs. Larger specimens, > 0.6 meters, will be captured with rope or wire snares, net and box style live-traps (no more than 25 crocodiles $\geq$ 1 meter total length per year), capture harpoons or darts (no more than 25 crocodiles $\geq$ 1 meter total length per year) and snatch hooks consisting of treble hooks without barbs (no more than 50 crocodiles $\geq$ 1 meter total length per year). The latter two devices are used to attach a line to the crocodile so that it can be located and captured with a rope or snare. Capture harpoons and snatch hooks usually do not deeply penetrate the crocodile's skin and normally do not result in significant injury to the animal. Any wounds to the animals will be cleaned and treated with alcohol.

A variety of data will be recorded for each crocodile captured. Morphometric measurements (*e.g.*, total length, snout-vent length, weight etc.) will be taken and sex determined. The environmental conditions at each capture site will also be recorded. To assess the health and body condition of crocodiles, the general condition of each captured animal will be observed and recorded. In addition, for all crocodiles captured, except hatchlings, a blood sample, no more than 1 percent of the body mass of the animal, will be taken from the tail. In addition, for all crocodiles captured $\geq$ 1 meter total length, a sample of muscle or fatty tissue, no more than 2 grams in mass, will be taken from the base of the tail behind the left rear leg. All blood and tissue samples will be sent to a qualified laboratory for analysis. Captured crocodiles will be inspected to see if they were previously captured and marked. All unmarked animals will be marked by a unique clipping of the tail scutes. Passive-induced transducer tags will also be injected within captured crocodiles approximately 0.9 meters in total length or larger. To reduce the likelihood of bacterial infection, all blood and tissue sampling , marking, and tagging will be conducted with aseptic instruments and any wounds to the animals resulting from these activities will be cleaned and treated with alcohol.

To determine the movements of crocodiles, a tracking device (*i.e.,* Global Positioning Sytem, Very High Frequency, satellite, or acoustic type) will be attached to up to 50 crocodiles per year. The method used to attach the device will vary with the type of tracking device and the size of the crocodile. In general, the devices will be attached to the dorsal side of the animal with either a backpack/collar or with dental quality acrylics (Mazzotti 1983). Tracking device size and weight will be matched to crocodile size, and a crocodile will not be equipped with a device that would restrict its mobility or pose a danger to the animal. Tracking devices will not be attached permanently. Modern tracking collars are equipped with a device that allows researchers to

preset the release time so the collars will fall off the crocodile on a specific date, or detach on their own after a reasonable time period. The size of batteries used will be dependent on the tracking device used and will vary with crocodile size. Most tracking device batteries last for at least one year, depending upon the number of location points programmed to be recorded. The weight of the transmitter device will be less than 10 percent of the crocodile's body weight. Methods of transmitter attachment and package design and weight will be field tested on alligators prior to field use with crocodiles. Movements of crocodiles broadcast by tracking devices will be recorded by observers in planes, boats, trucks, all-terrain vehicles, or on foot depending on their location.

Stress to crocodiles to be captured crocodiles will be minimized to the greatest extent practicable. Crocodiles to be captured will not be pursued or harassed for extended periods of time when the animal is found to be wary and cannot be captured during initial attempts. Each captured crocodile will be handled as quickly as possible while maintaining a safe environment for both crocodiles and researchers, and reducing stress to the crocodile to the greatest extent practicable. To minimize the likelihood of nest-site abandonment, large adult crocodiles will not be captured prior to or immediately after the breeding season. After completion of the activities described above, crocodiles will be released at the point of capture.

Surveys will be conducted to determine crocodile nesting effort and success. Searches of suitable nesting habitat will occur annually during April and May to locate the sites of active nests with eggs, and July and August to locate hatchlings. For each nest site, a variety of information will be recorded (*e.g.* vegetation present, substrate type, distance from shore, type of nest [either mound or hole], size of the nest [*e.g.*, diameter, height], salinity of waters adjacent to the nest *etc.*). In addition, the presence of eggs, egg shells from hatched crocodiles, and hatchling crocodiles will be noted, and the latter two shall be considered evidence of a successful nest. The number and causes of failed eggs will also be recorded. More detailed monitoring of crocodile eggs will occur at up to 60 nests per year. This will include the temporary removal of eggs from the nest to allow for counting, and close inspection and candling to determine the banding status of each egg. The eggs will be handled carefully and not rotated to ensure that their alignment is maintained when removed from the nest, placed in a suitable container, and kept out of direct sunlight through the use of an umbrella or other structure that provides adequate shade. Within one hour of removal (upon the conclusion of the inspection), the eggs will be carefully replaced in the egg cavity and covered with the nesting material originally removed from the nest to access the clutch of eggs. At this time a data logger to measure the temperature and humidity of the egg clutch may also be installed. Up to 75 eggs that failed to hatch or are considered to be non-fertile may be collected and maintained by the researchers per year for analysis of Deoxyribonucleic Acid and/or contaminants by a qualified, professional laboratory.

Up to five carcasses of crocodiles found dead during the field work may be collected for educational purposes. The carcass of any dead crocodile encountered that is not collected will be moved away from visible open areas of waters or shoreline and into the nearest area of mangroves or other woody vegetation cover for disposal.

Effects Analysis

Beneficial effects: Beneficial effects are those effects of an action that are wholly positive. The activities associated with the proposed action are not expected to result in beneficial effects to crocodile.

Direct effects: Direct effects are those effects that are caused by the proposed action, at the time of construction, are primarily habitat based, and are reasonably certain to occur. The direct effects resulting from various aspects of the action are discussed below.

Capture and handling of crocodiles – The capture and handling of crocodiles during the study has the potential to injure or kill these animals. However, the Service finds it unlikely that the methods employed will result in injuries or mortalities. We note that the researcher and his associates have considerable expertise and experience in the capture and handling of crocodiles. Dr. Mazzotti has been conducting research on American crocodiles is south Florida since the 1980s, and an injury or mortality of a crocodile due to capture and handling has never been observed during his research efforts. The proposed capture techniques are known to be non-lethal and are widely used in crocodilian research to safely capture crocodiles. Capture harpoons and snatch hooks usually do not deeply penetrate the crocodile's skin and normally do not result in significant injury. Any wounds will be cleaned and treated with alcohol. Finally, once captured, crocodiles will be well-secured to minimize the risk of injury during handling.

Capture myopathy, a non-infectious metabolic muscle disease resulting from physiological stress experienced during capture and restraint (Fernandez et al. 2017), is thought to occasionally result in the death of large crocodilians. Consequently, it is possible that a crocodile captured during the proposed research could die due to the stress of capture and handling during these events or at some unknown time after release. To minimize stress on crocodiles during capture and handling, animals will not be pursued or harassed for extended periods if capture is not successful during the initial attempts, the duration of handling will be minimized to the greatest extent practicable, and large crocodiles that may be breeding will not be captured immediately prior to the nesting season. The Service notes that all measures have been taken in association with the action to minimize the likelihood that a crocodile will be injured or killed during the capture and handling activities. However, due to the stress experienced by crocodiles, the Service expects that on rare occasions, crocodile mortalities related to capture and handling are reasonably certain to occur. Consequently, these activities will adversely affect crocodiles.

The experience of being captured and handled is also likely to change their behavior of the crocodiles caught during the study to some extent. The Service envisions that these encounters will make these animals more likely to avoid humans in the future. However, we find that this minor change in behavior is not likely affect their ability to feed, reproduce, or survive in the wild, and will not adversely affect the crocodile.

Blood and tissue sample collection and marking - For all crocodiles captured, except hatchlings, a blood sample, no more than 1 percent of the body mass of the animal, will be taken from the tail. In addition, for all crocodiles captured $\geq$ 1 meter total length, a small sample of muscle or fatty tissue ($\leq$ 2 grams) will be taken from the base of the tail behind the left leg and the

abdomen. Additionally, each new crocodile caught will be marked by clipping of the tail scutes. The areas where the tissue sample is taken and the scutes are clipped will be treated with alcohol to reduce the likelihood of infection. The small amount of blood and tissues taken from these animal and the clipping of tail scutes is not expected to affect the health or mobility of these animals. Therefore, the Service finds that blood and tissue sampling and scute clipping will not adversely affect crocodiles.

Tracking devices - To determine the movements of crocodiles, a tracking device will be attached to up to 50 of the captured crocodiles per year. The tracking device size and weight will be matched to crocodile size, and a crocodile will not be equipped with a device that would restrict its mobility or pose a danger to the animal. The tracking devices will not be attached permanently and will be equipped with a device that allows the collars to fall off the crocodile on a specific date, or detach on their own after a reasonable time period. The tracking devices are not expected to hinder the animal's movement or ability to feed in any way. Therefore, the Service finds that the attachment and use of tracking devices will not adversely affect crocodiles.

Nest monitoring and manipulation - Handling of crocodile eggs during nest monitoring may result in the death of the developing embryo. It is possible that the developing embryos could be killed due to accidental rotation of an egg when placed in a storage tray. For crocodilians and most species of reptiles, it is widely thought that once the embryo has attached to the inner membrane of the egg shell (usually within 24 hours of laying), rotation of the egg could cause the yolk to impede normal development or tear both the vitelline and extra-embryonic membranes (Ferguson 1985, Webb et al. 1987) leading to death or malformation of the embryo (Ferguson 1985). Further studies are needed to determine if this is actually the case (Aubret et al. 2015). Crocodile embryos could also be killed during handling if accidentally dropped or damaged during handling, or if over-exposure to the sun occurs. To minimize the potential for mortalities of eggs, care will be taken when removing eggs from nest, placing in storage trays and maintaining their alignment, and replacing the eggs. The eggs will also be shaded from direct sunlight and replaced in the nest cavity no later than one hour after removal. The Service notes that all appropriate protective measures have been taken to minimize the likelihood that a crocodile eggs will be killed or damaged during nest monitoring and manipulation. However, on rare occasions an egg could be accidentally rotated or damaged resulting in the death of a crocodile embryo. Therefore, the Service finds that the handling of eggs associated with monitoring and manipulation of crocodile nests is likely to adversely affect crocodiles.

The monitoring of crocodile nests could potentially increase the risk of predation of crocodile eggs. Nest monitoring requires that the nest be opened and eggs temporarily removed to determine the number of eggs present and their fertility, and to allow the installation of data loggers and sensors to monitor the environmental conditions of the nest. Although the eggs are replaced and covered with soil, the opening of the nest could increase the olfactory cues available to egg predators indicating the presence of eggs. The Service notes that the raccoon (*Procyon lotor*) is the primary predator of crocodile eggs in south Florida. However, the rate of crocodile nest predation is known to be low, and these events only occasionally occur (Mazzotti 1989). The low rate of predation by raccoons may be related to the low density of crocodile nests in South Florida (Mazzotti 1989). Dr. Mazzotti has indicated that predation of a crocodile nest by raccoons following nest monitoring has never been documented during his many years of

studies. Therefore, the Service finds that the proposed nest monitoring is unlikely to increase the risk of nest predation by raccoons.

The presence of humans during nest monitoring activities could increase the risk of abandonment of the nest by the attending female prior to hatching. Abandonment could result because the females may perceive human presence at a nest site as a potential threat to the survival of her eggs. The presence of the female at the nest site is important because the hatchlings are not able to exit the nest by themselves after hatching and require the female to open to nest. Consequently, if the female abandons the nest site, the hatchlings will not survive. Dr. Mazzotti has never observed a female abandon a nest that was visited by researchers during his many years of past nest monitoring activities. Consequently, the Service finds it unlikely that nest monitoring activities will result in the abandonment of a nest by a female crocodile.

Indirect effects: Indirect effects are those effects that result from the proposed action and are reasonably certain to occur. Indirect effects are not likely to result from the proposed action

Interrelated and interdependent actions: An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. Interrelated or interdependent actions are not expected to result from the proposed action.

Species' response to a proposed action: The proposed action will result in the occasional mortality of a crocodile during or following its capture and handling, most likely due to physiological stress. The project will also result in the occasional accidental death of a crocodile egg due to handling during nest monitoring activities. These adverse effects are not expected to reduce the rangewide population size of the crocodile. Captured crocodiles may also become more wary of humans, but this change in behavior is not expected to adversely affect the crocodile.

Any Incidental Effects to Other Species or Critical Habitats: The proposed action is not expected to affect critical habitat designated for the crocodile or other species of fish and wildlife.

Cumulative Effects: Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Act. Cumulative effects are not expected to result from the proposed action.

Conclusion

After reviewing the current status of the crocodile and the effects anticipated from implementing actions described in the 10(a)(1)(A) permit application, it is the Service's biological opinion that the Section 10(a)(1)(A) permit, as proposed, is not likely to jeopardize the continued existence of the crocodile, and is not likely to destroy or adversely modify designated critical habitat.

We reached this opinion based on the following factors:

1. Capture and handling of crocodiles is expected to only rarely result in a mortality of a crocodile.

2. The collection of blood and tissue samples and marking of crocodiles is not expected to adversely affect crocodiles.

3. The attachment of tracking devices to crocodiles is not expected to adversely affect their movement, feeding, reproduction or ability to survive.

4. Nest monitoring and handling of crocodile eggs is expected to only rarely result in damage to an egg that would result in the death of a crocodile embryo, and this is not expected to reduce the reproductive potential of the species.

5. Nest monitoring is not expected to increase the rate of nest predation by raccoons.

6. Human activity at the nest site during nest monitoring is not expected to cause female crocodiles to abandon their nests.

7. Adverse effects and minor changes in behavior resulting from the action are not expected to reduce the rangewide population of this species.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulations under section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Service so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption of section 7(o)(2) to apply. The Service has a continuing duty to regulate the activity covered by this incidental take statement. If the Service (1) fails to assume and implement the terms and conditions or (2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the

permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Service and the applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(I)(3)]

Amount or Extent of Take Anticipated

The Service expects two crocodiles per year (i.e., two percent of the individuals captured per year and one nest per year containing approximately 45 eggs (roughly the mean size of a crocodile nest) could be taken as a result of this proposed action. The incidental take is expected to be in the form of harm and harassment from capture and nest manipulation. Crocodiles and eggs may be handled and held temporarily.

Effect of the Take

In the accompanying biological opinion, the Service determined that this level of expected take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Reasonable and Prudent Measures

The Service finds the applicant has already designed the Project to minimize take resulting from the action as described in the "Description of the Proposed Action" section of this Biological Opinion. Therefore, additional reasonable and prudent measure and their implementing terms and conditions are not necessary to reduce take of the crocodile resulting from the action and will not be provided.

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made as described in any 10(a)(1)(A) permit issued to the applicant. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

As stated above, the Service believes that no more than two crocodiles captured per year and one nest per year containing approximately 45 eggs of the crocodile will be incidentally taken. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Reinitiation Notice

This concludes formal consultation on the action(S) outlined in the consultation. As written in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Service involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the

Service action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the Service action is later modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease until reinitiation.

Attachment

Literature cited

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STATUS OF THE SPECIES/CRITICAL HABITAT – American crocodile (*Crocodylus acutus*)

Legal Status – The American crocodile (*Crocodylus acutus*; crocodile) was listed as endangered throughout its range in 1975 under the authority of the Endangered Species Act of 1973, as amended (40 CFR 44151). Critical habitat for the crocodile was established in 1979 (Figure 1) (44 CFR 75076). In 2007, the U.S. Fish and Wildlife Service (Service) reclassified the distinct vertebrate population segment (DPS) of the crocodile in Florida from endangered to threatened. Downlisting of the DPS was based on available data that indicated that since 1975 the population had more than doubled, and expanded its range

Species Description

The crocodile is a large greenish-gray reptile. At hatching, crocodiles are yellowish-tan to gray in color with vivid dark bands on the body and tail. As they grow older, their overall coloration becomes more pale and uniform and the dark bands fade. All adult crocodiles have a hump in front of the eye, and tough, asymmetrical armor-like scutes (scale-like plates) on their backs. The American crocodile is distinguished from the American alligator (*Alligator mississippiensis*) by a relatively narrow, more pointed snout and by an indentation in the upper jaw that leaves the fourth tooth of the lower jaw exposed when the mouth is closed. Moreover, alligators have two nostrils separated by a bony septum covered in skin, while American crocodiles have two nostrils that touch each other in a single depression on the tip of the snout (Ross 2005). In Florida, the crocodile ranges in total length from 26.0 centimeters (10.3 inches) at hatching to 3.8 meters (m) (12.5 feet [ft]) as adults (Moler 1991a). Larger specimens in Florida were reported in the 1800s (Moler 1991a) and may occur in south Florida currently, and individuals as large as 6 to 7 m (19.7 to 23.0 ft) have been reported outside the United States (Thorbjarnarson 1989).

Life history

Reproductive biology

Female crocodiles reach sexual maturity at approximately 10 to 13 years of age (about 7.38 ft [2.25 m] total length) (Mazzotti 1983; LeBuff 1957). The size and age that male crocodiles reach sexual maturity is not currently known (Ogden 1978).

Courtship and breeding occur in late winter and early spring, and nests are usually built in late April or early May (Moler 1992). Females will only produce one clutch of eggs per year, although it is not known if a female will produce clutches in consecutive years. Nests are constructed on beaches, stream banks, and levees, and many nest sites are used recurrently. Female crocodiles usually dig a hole at the nest site, but may construct a nest mound at the nesting site by scraping together soil. If a mound is constructed, a hole is dug in the middle of the nest mound prior to egg laying. Approximately 30 to 60 eggs are deposited in the nest hole. Following laying, the female covers up the eggs with soil and the eggs incubate at the nest site for approximately 85 to 90 days (Moler 1992). In Florida, female crocodiles have not been

observed defending their nest during incubation (Kushlan and Mazzotti 1989). Once the eggs begin hatching, the female usually opens the nest and carries the hatchlings to water in her mouth. Hatchlings are not able to escape the nest cavity without assistance from their mother. Crocodile hatchlings remain together in a loose aggregation for several days to several weeks following hatching. Parental care of young crocodiles has not been observed in Florida, although it has been reported in other parts of the American crocodile's range (Moler 1992).

Foraging

Crocodiles are opportunistic feeders and will eat whatever they can catch and consume. Hatchlings feed largely on small fish but will also eat crabs, snakes, insects, and other invertebrates (Moler 1992). Adult crocodiles are capable of taking large prey but generally do not capture prey larger than a raccoon (*Procyon lotor*) or cormorant (*Phalacrocorax auritus*). The diet of adult crocodiles consists of snakes, fish, crabs, small mammals, turtles, and birds (Moler 1992). Crocodiles usually forage from immediately prior to sunset to just after sunrise (Lang 1975; Mazzotti 1983).

Relationships with other species

Under certain circumstances the crocodile may co-occur with the American alligator in south Florida. Co-occurrence of these species is most likely during the non-nesting season or when salinities are low. Most crocodilians are known to tolerate the presence of other crocodilian species provided food and other habitat requirements are not limiting (Service 1999). However, little is known concerning the interspecific interactions that occur between crocodiles and alligators. Alligators and crocodiles both occur within the vicinity of the 5,900-acre (ac) (2,388 hectare [ha]) Cooling Canal System (CCS) at Turkey Point Power Plant. Anecdotal evidence suggests that crocodiles may aggressively exclude alligators from using a brackish water canal favored by crocodiles known as the Interceptor Ditch (Wasilewski and Lindsay 2004). Nevertheless, crocodiles and alligators have both been reported to construct nests on the same canal berm located in the vicinity of Marco Island in Collier County, Florida (Service 1999).

Crocodiles are most susceptible to predation during incubation and as juveniles. Eggs are taken primarily by raccoons, although depredation rates of crocodile nests are typically low in south Florida. Hatchlings and subadults are known to be taken by a variety of predators including wading birds, gulls, crabs, sharks, alligators (in areas where they co-occur), and adult crocodiles (Service 1999). Adult crocodiles have no known predators other than humans.

Habitat

The crocodile in south Florida occurs primarily in mangrove swamps and along low-energy mangrove-lined bays, creeks and inland swamps (Kushlan and Mazzotti 1989). Deep water habitats (>1.0 m [3.3 ft]) are also known to be an important component of crocodile habitat (Mazzotti 1983). Crocodiles exhibit seasonal differences in habitat use. In the breeding season, during spring and summer, crocodile commonly occur along coastal shorelines and coves.

However, during fall and winter, (the non-breeding season), crocodiles were likely to occur more inland within swamps, bays and creeks (Kushlan and Mazzoti 1989).

Nesting habitat includes sites with sandy shorelines or raised marl creek banks adjacent to deep water (Service 1999). Crocodiles also nest on berms and other sites, such as canal banks where sandy fill has been placed (Dixon 2014). Sites optimal for nesting provide appropriate soils for incubation, are generally protected from wind and wave action, and have access to deeper water (Service 1999).

Distribution

The present distribution of the crocodile includes coastal wetlands and rivers of south Florida, Cuba, Jamaica, and Hispaniola (along the Caribbean coast from Venezuela north to the Yucatan peninsula, and along the pacific coast from Sinaloa, Mexico to the Rio Tumbes of Peru [Moler 1992]).

Within Florida, the crocodile historically occurred as far north as Indian River County on the east coast and Tampa Bay on the west coast, and as far south as Key West (DeSola 1935; Hornaday 1914; Kushlan and Mazzotti 1989; Allen and Neill 1952; Neill 1971). The current range of the crocodile in Florida largely consists of coastal areas of Miami-Dade, Monroe, Collier, and Lee Counties. Crocodiles are regularly observed in the Everglades National Park (ENP) along the shoreline of Florida Bay, in the Florida Keys (primarily on northern Key Largo), and within the CCS and adjacent canals and wetlands at the Florida Power and Light (FPL) Turkey Point Nuclear Power Plant. Crocodiles are still known to occur on the west coast of Florida as far north as Sanibel Island. Sightings of crocodiles are also infrequently reported north of Miami-Dade County on the east coast (a crocodile was documented in Indian River County in October 2004)). Confirmed sightings have been reported with increasing frequency in many of the lower Keys, and the Service suspects that these observations may indicate that crocodiles are expanding their range back into the 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). Moreover, a single crocodile has been commonly observed over the past several years at the Dry Tortugas National Park about 68 miles west of Key West (Parry 2017). Although this individual was relocated to ENP following concerns of human safety at the Dry Tortugas National Park.

The breeding range of the crocodile in Florida is still restricted relative to its reported historic range (Kushlan and Mazzotti 1989), with most breeding occurring on the mainland shore of Florida Bay between Cape Sable and Key Largo (Mazzotti *et al.* 2002). Nesting occurs in three primary locations: Key Largo at the Crocodile Lake National Wildlife Refuge, ENP, and the CCS of the FPL's Turkey Point Power Plant. The observed increase in nesting during the last 30 years (see below) is largely due to increased nesting at the Turkey Point Power Plant site (Tucker *et al.* 2004). Nesting has also been recently documented in the Keys. A crocodile nest has been observed on Lower Matecumbe Key during 2003, 2004, and 2005 (Cherkiss 2005). In 2015, a nest was located in Virginia Key in northern Biscayne Bay (Mazzotti 2015a).

Population Dynamics

The number of crocodiles that occurred historically in south Florida is difficult to determine because many records are anecdotal and observers may have confused crocodiles with alligators. Moreover, the remoteness and inaccessibility of estuarine habitats to humans made obtaining a reliable estimate of the crocodile population problematic. Ogden (1978) estimated a population of 1,000 to 2,000 crocodiles within south Florida during the early 1900s. The crocodile population was depleted due to hunting (crocodiles were legally hunted until 1962), and habitat modification and destruction due to on-going urbanization of south Florida by humans. By the mid-1970s the crocodile population was thought to be reduced to about 100 to 400 animals (not including hatchlings) (Ogden 1978).

In south Florida the crocodile population has increased substantially during the last 40 years. The most recent population estimate suggests that the crocodile population contains 1,200 to 2,000 individuals (not including hatchlings)(Brandt 2017). This estimate was derived using crocodile nesting data and by applying demographic characteristics observed in other crocodilian species (*i.e.,* Nile crocodiles [*Crocodylus niloticus*] and American alligators) suggesting that breeding females make up 4 to 5 percent of the non-hatchling population and about 75 percent of reproductively mature females breed and nest each year. However, Mazzotti (2015b) states that based on his recent observations in the field, he now believes that the crocodile population may now be beginning to decline. The Service will monitor results of crocodile surveys conducted over the next few years closely to determine if a downward trend is occurring.

Nest survey data collected in south Florida also suggest that the crocodile population has increased. Nesting effort has increased from about 20 nests per year in the late 1970s to at least 144 nests in 2014 (Mazzotti *et al.* 2014a, Lindsay 2014). Surveys detect approximately 80 to 90 percent of nests. A single nest site can contain several nests from different females in close proximity to each other (University of Florida, undated). Observers are generally unable to distinguish those nests that contain more than one clutch of eggs without excavating the nests. In some instances, surveyors are able to determine that more than one female has laid eggs at a communal nest by visiting the nest over a series of days and observing hatching of separate nests. Communal nests that are not distinguishable result in a possible underestimation of nests and/or females. Available nesting data for 2016 indicate that at least 128 nests producing 1,266 hatchlings were observed within designated critical habitat for the crocodile (Mazzoti 2016).

In the early 1970s, the construction of the nearly 6,000- ac CCS, associated with the FPL's Turkey Point Nuclear Power Plant, created a system of berms that contained soils favorable for crocodile nesting. The number of nests observed within the CCS increased from 2 nests in the late 1970s to 25 in both 2013 and 2014. However, beginning in 2013 water quality conditions at the CCS deteriorated resulting in warmer temperatures, extreme salinities (> 90 ppm), an outbreak of blue-green algae, and a significant increase in turbidity. The reason for these conditions is unclear, but may have been the cumulative results of FPL's recent increase in power production within nuclear Units 3 and 4, the discharge of vegetative cuttings from berm maintenance into the CCS, and the drought experienced in the region. Adverse conditions in the

water of the CCS likely resulted in: (1) the significant reduction in nesting effort observed in the CCS during 2015 and 2016 (*i.e.*, only 9 and 8 nests observed, respectively); (2) the reduction in number of crocodiles observed in the CCS; and (3) the poor condition of some of the crocodiles observed in the CCS (Mazzotti 2015b). FPL is working with the Service to address the adverse conditions in the CCS and return the CCS to high quality nesting habitat for crocodiles. Current efforts seem to be effective and the water quality appears to be improving as of spring 2017. It is unclear how the current conditions in the CCS will affect the overall crocodile population, or if crocodiles that would normally nest in the CCS will attempt to nest in other locations.

Critical Habitat

Critical habitat was designated in one large unit in Miami-Dade County and Monroe County, and includes approximately 768,000 ac (310,799 ha) of lands and waters within coastal south and southeast Florida, and the northern keys (Figure 1). The rule describing critical habitat for the crocodile considered it to include all land and water within the following boundary:

> Beginning at the easternmost tip of Turkey Point, Dade County, on the coast of Biscayne Bay; thence southeastward along a straight line to Christmas Point at the southernmost tip of Elliott Key; thence southwestward along a line following the shores of the Atlantic Ocean side of Old Rhodes Key, Palo Alto Key, Anglefish Key, Key Largo, Plantation Key, Windley Key, Upper Matecumbe Key, Lower Matecumbe Key, and Long Key; thence to the westernmost tip of Middle Cape; thence northward along the shore of the Gulf of Mexico to the north side of the mouth of Little Sable Creek; thence eastward along a straight line to the northernmost point of Nine-Mile Pond; thence northeastward along a straight line to the point of beginning.

Roughly half of this acreage has been protected in perpetuity for conservation purposes in ENP. The number of crocodiles that currently occur within designated critical habitat has not been determined. However, because this area contains much of the known nesting habitat in south Florida, it is reasonable to assume that a large portion of the current crocodile population (estimated to be 1,200 to 2,000 individuals) likely occurs within the designated critical habitat. Available nesting data for 2016 indicate that at least 128 nests producing 1,266 hatchlings were observed within designated critical habitat for the crocodile (Mazzoti 2016).

Physical and biological features of crocodile critical habitat were not described when it was designated. However, the Service considers aquatic foraging habitat and suitable nesting substrate within adjacent uplands to be essential habitat features for the crocodile within designated critical habitat. Aquatic foraging habitat includes areas of coastal and near coastal waters (salt, brackish, and fresh) such as bays, canals, marsh, and mangrove swamps containing an adequate prey base including fish, crustaceans, reptiles, birds, and mammals. Nesting habitat is characterized as uplands adjacent to aquatic habitats with sandy or marl soils such as beaches, raised marl creek banks, and artificial berms that are generally protected from wind and wave action, and have access to deeper water (Service 1999).

Threats

Modification and destruction of nesting habitat was the primary threat to the crocodile during the 20th century. The listing of the crocodile and protection of crocodile habitat was due to significant population declines likely associated with habitat alternations and direct human disturbances to crocodiles and their nests. Nesting habitats that were formerly occupied (*e.g.,* Lake Worth, Palm Beach County, central Biscayne Bay, middle and lower Keys *etc.*) were destroyed or degraded due to urbanization, and the crocodile has been largely extirpated from many of these areas (DeSola 1935; Service 1984). Although, observations of crocodile nesting at Chapman Field Park (Maquire 1998) indicate that crocodiles may be reoccupying portions of their former range in central Biscayne Bay. However, continued habitat loss and degradation reduces the likelihood that crocodiles will be able to persist in these areas.

Disturbance due to human encroachment into crocodile habitat may alter normal behavioral patterns of crocodiles. Observations suggest that repeated human disturbances of crocodiles may cause females to abandoned nests or relocate nest sites (Kushlan and Mazzotti 1989). The rising demand for recreational opportunities (*e.g.,* camping, boating, and fishing) is expected to bring more people into contact with crocodiles. Pressure on Federal and State agencies to provide more recreational opportunities on public lands that provide habitat for crocodiles is also expected to increase. An increase in human disturbance due to recreational activities could adversely affect the crocodile.

Crocodile mortality due to collisions with vehicles has been an ongoing problem along U.S. Highway 1 and Card Sound Road in Miami-Dade and Monroe Counties (Service 1999). This problem has been particularly acute within the segment of U.S. Highway 1 from Florida City to Key Largo where wetlands providing habitat for crocodiles are located on both sides of the roadway. The only structures that allowed movement of crocodiles under this roadway were three small culverts that are usually submerged. Consequently, three to four crocodiles per year have been killed while attempting to cross the roadway (Mazzotti 1983; Moler 1991a). The Florida Department of Transportation reduced vehicle-related crocodile mortality along this section of U.S. Highway 1 by installing a series of wildlife underpasses consisting of large culverts, bridges, and associated fencing. The locations for these structures were determined from discussions with the Service and the Florida Fish and Wildlife Conservation Commission (FWC) and were installed as part of roadway improvements constructed along U.S. Highway 1 from the C-111 Canal to the Lake Surprise Bridge.

Exotic animal species pose a threat to the survival of the crocodile. Specifically, the Burmese python (*Python bivittatus*) and the Argentine black and white tegu (*Salvator merianae* = *Tupinambis merianae*; tegu), two reptile species that have recently been introduced and established in south Florida. The Burmese python is a large constrictor snake (normally 10 to 12 ft [3 to 3.7 m] in total length, or larger), and is native to Southeast Asia. The tegu is a medium size (2 to 3 ft [0.6 to 0.9 m] in total length), heavily bodied lizard, native to South America. 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. Burmese pythons are also likely to compete with crocodiles for prey. The tegu is known to eat reptile eggs and has been photographed by motion sensitive cameras consuming alligator eggs and loitering at a crocodile nest site (Mazzotti *et al.* 2014b). Both of these exotic species have been documented to occur in or near the CCS at the Turkey Point Power Plant. The Service is concerned that predation on and competition with crocodiles by Burmese pythons and tegus could significantly reduce the current crocodile population, and potentially affect the survival and recovery of the species. The FWC has conducted a monitoring, capture, and eradication programs for the tegu in south Florida near Homestead and captured and euthanized more than 400 tegus. FPL has also agreed to monitor and trap tegus in their Everglades mitigation bank located adjacent to the CCS at their Turkey Point Power Plant. The FWC has also organized public python hunts within south Florida to help control this exotic species.

Natural climatic events also have the potential to affect the crocodile. For example, tropical storms and hurricanes affecting south Florida can result in high winds, large waves, and tidal surges that could result in either direct mortality of adults, and/or the loss of nests, nesting habitat, and other important habitat features (Service 1999). Ogden (1978) suggested hurricanes occurring at regular intervals may serve to regulate the crocodile population in Florida. South Florida infrequently experiences cold fronts where ambient temperatures drop below 0°C. Such temperatures are likely lethal to crocodiles, although the effects of subfreezing temperature are not well known because crocodiles killed during freezes are rarely found (Dimock 1915; Barbour 1923; Mazzotti 1983). Moler (1991b) suggested that a decline in crocodile nesting effort observed in 1989 may have been the result of adult mortality due to a hard freeze that occurred during the previous winter. In 2010, more than 200 crocodiles were estimated to have died from an extreme cold spell that affected south Florida. Drought may also adversely affect crocodiles. Mazzotti and Dunson (1984) suggest that hatchling crocodiles are susceptible to osmotic stress and require access to low salinity water. The freshwater needs of hatchlings are usually met by rainfall depositing a lens of freshwater on the water surface of estuarine environments that may last for days. Hatchlings are likely stressed and occasionally die during periods of low rainfall. Crocodiles greater than 200 grams (0.44 pounds) have sufficient mass to withstand osmoregulatory stress and are not believed to be affected by drought.

Climate change also has the potential to adversely affect the crocodile. Sea level rise associated with climate change may inundate existing crocodile nesting habitat and result in habitat loss. Sea level rise may also result in habitat loss or degrade existing aquatic habitats by changing salinities within existing coastal freshwater and brackish water habitats due to the influx of sea water.

Ongoing Conservation Efforts

As indicated above, construction of the CCS at FPL's Turkey Point Power Plant in the early 1970s created berms with favorable soil conditions for crocodile nesting. Following the discovery of the first nest in 1976, FPL has worked with the Service to initiate a management programs for the crocodile at the CCS since 1983. The management program includes: creation and preservation of suitable nesting and basking habitat for crocodiles; removal of exotic

vegetation on the berms of the CCS; the capture and microchip tagging of hatchlings, the construction of freshwater ponds on the CCS berms as refugia for hatchlings, the relocation of hatchlings form the hypersaline waters of the CCS to adjacent lower salinity habitats; and the monitoring of nesting and growth and survival of crocodiles occurring in the CCS. FPL has also instituted an extensive awareness program to educate the public on the status and conservation of the crocodile. Overall, the management program has been very successful and crocodile nesting has increased from 2 nests in 1978 to 20 to 25 nests during the early 2010s, and the site has become an important nesting area for the American crocodile in terms of its recovery, resulting in the production of thousands of hatchlings since it was established. As discussed above, there has been a reduction in nesting at the CCS over the past few years, and FPL is working with the Service to address the adverse environmental conditions in the waters of the CCS that have likely resulted in the nesting decrease and return the nesting productivity at the site to its previous levels.

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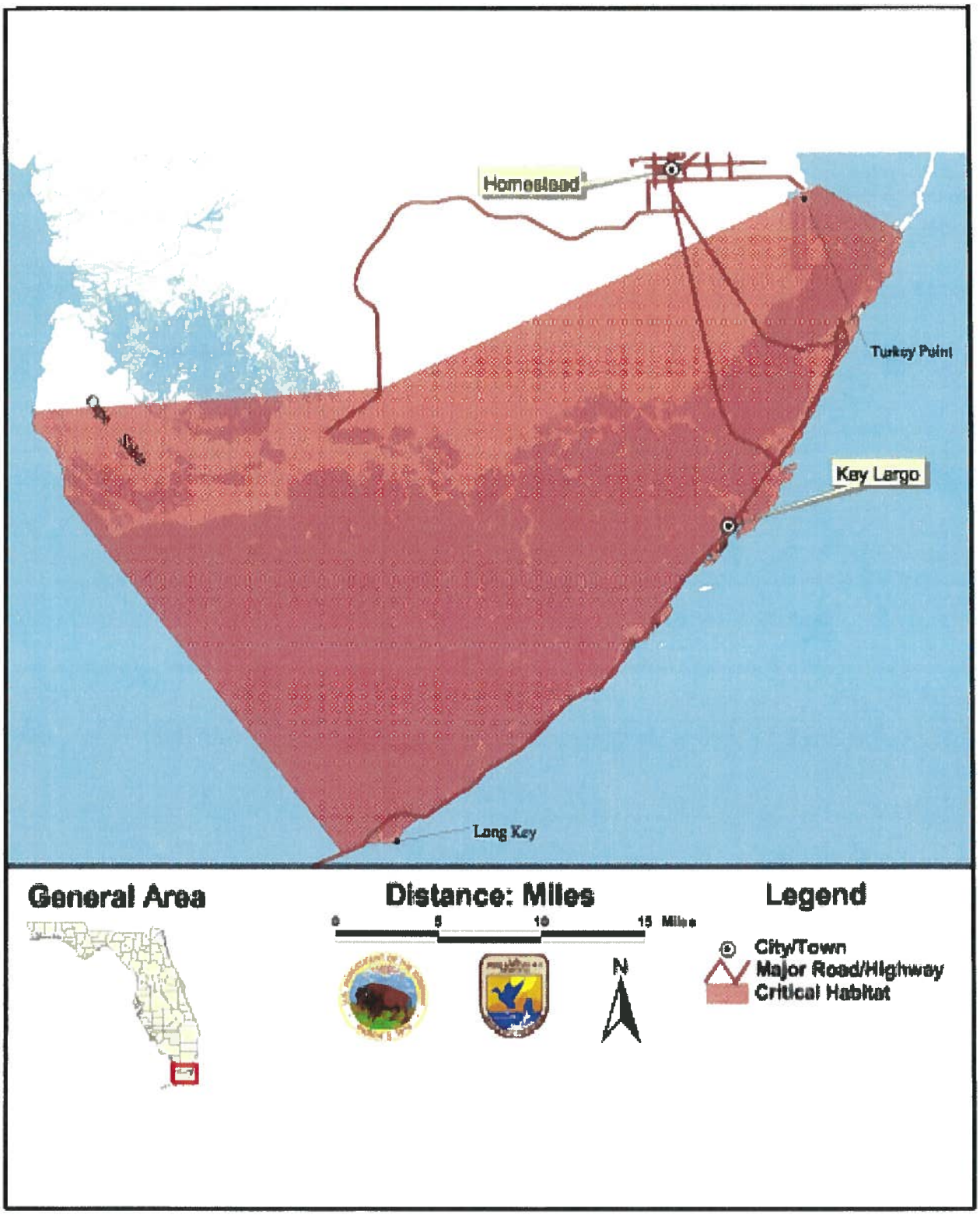

Figure 1. Map of designated critical habitat for the American crocodile.