POPULATION BIOLOGY AND STATUS OF THE AMERICAN CROCODILE IN SOUTH FLORIDA

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Introduction

The Florida population of the American crocodile occupies the northernmost point of the species range and is the only population in the United States. The status of this population has been a matter of concern because it has been believed to be relatively rare, to be subject to encroachment by human development, and to have suffered reductions in population size since the mid 1800's. Its status was initially evaluated by Moore (1953) and by Ogden (1978). From 1977 to 1982, we have studied the population biology and status of crocodiles occuring near Florida Bay, on the southern tip of the Florida peninsula. In this study we have particularly attempted to test various hypotheses of population limitation suggested by the work of Ogden in the early 1970's.

Ours was a collaborative effort involving several colleagues including Drs. William Dunson, Peter Lutz, Robert Menzies, and John Behler and assistants including Robert Austin, Amanda Muller, and Terri Jacobsen. At the same time other segments of the south Florida crocodile population were being studied by Paul Moler and by Ronald Gaby.

In this paper we briefly abstract some of the findings of our study with particular attention to providing new information on the various hypotheses previously suggested to account for presumed population decreases. The full reports on these studies will be published elsewhere (Kushlan and Mazzotti in prep.,Mazzoti and Dunson in press, Mazzotti and Kushlan in prep, Mazzotti, et al. in prep.).

Historic Population Status: The historic presence of the American crocodile in south Florida is well documented after 1869, when a specimen was collected in the Miami River (Wyman 1870). Although observed occasionally as far north as Lake Worth and West Palm Beach on the east coast, crocodile sightings historically were concentrated from Biscayne Bay through northeastern Florida Bay. Dimock (1918) provided the most definitive statement of its early range as, "definitely limited to the region at the extreme southern end of the peninsula of Florida, a strip of ten miles long by three miles wide". Only infrequent records occurred outside this area. There is no reason to suspect that the core of the crocodile population ever extended much north of Biscayne Bay. Similarly there is no substantive evidence to indicate a permanent presence in the lower Florida Keys (Jacobsen 1983) or on the Florida west coast.

Published reports provide little information on numbers of crocodiles historically present. They were said to be "common", seen in certain places, but no contemporary statement as to numbers is available. Ogden (1978) in reviewing such accounts suggested that "the number of crocodiles in south Florida at the end of the 19th century was not more than five time the present population, probably between 1.000 and 2.000 animals". We however, believe that available reports provide insufficient information on which to base any such guess and that it is therefore impossible to estimate the number of crocodiles present historically in southern Florida.

Population distribution

We have evaluated the present distribution of the American crocodile in Florida from reports and from our extensive aerial surveys conducted over all potential crocodile habitat. The range of the crocodile can best be understood as consisting of three components. The overall range is the area in which crocodiles are occasionally reported. This is from Sanibel Island on the west coast of Florida, along the south and east coast to Fort Lauderdale, and southward to the lower Florida Keys. The core range is the area in which crocodiles occur continuously. This is from the lakes on Cape Sable along the north shore of Florida Bay to lower Biscayne Bay and Key Largo. The nesting range is the area in which nesting occurs regulary. This is along northeastern Florida Bay to Turkey Point and northern Key Largo. Within this range, our aerial surveys have shown that crocodiles are most abundant inland of northeastern Florida Bay and on Key Largo (Fig. 1).

Presently nesting occurs in three areas, northeastern Florida Bay, Turkey Point, and northern Key Largo. We have been able to locate records for 187 clutches of eggs deposited in southern Florida since the 1930's. Eighty clutches are known to have been deposited during the study period, 1978-82. Of these 54 were along northeastern Florida Bay, which must be considered the center of the nesting distribution.

Ogden (1978) concluded that a major reduction in breeding range has occurred in Florida Bay with the "gradual disappearance of nesting on islands in Florida Bay". His depiction of range reduction showed isolines that implied a concentric reduction of range into northern Florida Bay. We however do not interpret the loss of nesting sites to be a gradual retreat of animals into the northeastern bay. We agree with Ogden (1978) that most logical explanation for the loss of crocodile nest sites in eastern Florida Bay is the development of the islands of the upper Florida Keys. The bay islands where nesting had been recorded do not appear to provide year-round habitat for either adult or hatchling crocodiles, and we believe that females on these islands moved there from the Florida Keys only during the nesting season. Thus we suspect that it is the loss of the year-round habitat on the keys that adversely affected these females. Such island nests were probably always peripheral to

the population core and not highly productive owing to their exposed locations. Nesting on islands in the northeastern bay, used by females from the coastal mainland swamps has continued, and the known nest sites used has increased over the study period.

Population size and structure

We have found all size classes represented in the population, with a slight relative under-representation of juvenile animals. We interpret this result to be caused by high hatchling mortality, rapid growth rates, and a bias of survey data against juvenile animals. It is important that existence of juveniles indicates that survival is occurring, although perhaps not at the level found in the protected habitats on northern Key Largo (Moler pers. comm.).

The sex structure of crocodiles captured is biased in favor of females. Our best estimate of the sex ratio is 2:1 (n=24). It is not possible to determine whether the bais is real or the result of differential catchability. The lower proportion of males does not limit breeding, as we found a very limited occurrence of infertility (see beyond).

To estimate the size of the Florida population of the American crocodile we followed the method devised by Chabreck (1966), using population parameters derived from capture, survey, and nesting data. In our primary study area in northeastern Florida Bay, we estimate the nonhatchling population to consist of 90 individuals. We can extrapolate this figure to the remainder of the range using survey and nesting data. Our estimate for the south Florida population as a whole then is 220 nonhatchlings. Because of the seasonal addition of hatchling animals, we estimate the population seasonally can increase to about 570 animals, averaging over the course of the year about 400 animals of all age classes.

Nesting Biology

The average nesting date is May 5 (s=12.1 days) and the average hatching date is July 29 (s=6.7 days, n=27, The average incubation period is 85 days, rather than the 90 usually reported. The nesting cycle of Florida crocodiles avoids the low temperatures of winter and the high temperatures of late summer. It also avoides in most years, the potentially desiccating conditions of the dry season and the potentially flooding conditions of the peak of the rainy season. The average clutch size, based on 46 clutches, is 38.0 (s=9.45). This is less than the 44 previously reported by Ogden (1978), who inadvertently included double clutches in his calculations.

The fertility rate was high, only 10% of 314 eggs being unbanded (infertile or very early embryo death). The fertility of eggs in individual nests ranged from 46 to 100%; in all but one nest the fertility exceeded 84%.

Racoons (Procyon lotor) were the only nest predators. We found that racoon predation was relatively infrequent and unpredictable. From 1971 to 1982, 14% of 99 clutches were depredated. We found that individual clutches could be protected, if desired, by placing racoon traps at specific nest sites where sign is observed. There do not appear to be individual predators that have learned to seek out and depredate crocodile nests.

Ogden (1978) concluded that an important factor regulating the number of American crocodiles was "mediocre nesting success, caused primarily be failure of eggs to hatch". He suggested that embryonic mortality was the result of low temperatures in marl nests. We closely examined nest temperatures to test this hypothesis and found that they were not low enough to inhibit development. Clutch temperatures averaged 31.6°C (28.4-35°C) in nests in marl substrate and 30.0°C (26.7-33.6°C) in nests in sand substrate.

Lutz and Dunbar-Cooper (1984), as part of our overall study, examined the gaseous environment of the egg chamber. They found that concentrations of O_2 and CO_2 and humidity were all within expected ranges under usual circunstances.

In investigating the egg chamber environment, we discorvered that the cause of embryonic mortality was subterranean flooding, that is a rise of ground water into the egg cavity causing asphixiation of the embryos. Such flooding is not recognizable above ground. Subterranean flooding occurs in low-lying nests, particularly along creeks, during very high water conditions. We also found that some embryonic mortality can result from dessication. This occurs only during very dry periods in relatively high sand nests. Overall, embryonic mortality occurred in 14% of all known clutches.

Habitat and activity areas

Habitat use and activity areas were determined by aerial and boat surveys and by radio telemetry. Ten nonhatchling animals were telemetered and followed for periods ranging to over one year. The mean activity range was 107.5 ha (s=71.3 ha). The largest activity area was 262 ha. The activity areas of different animals overlapped substantially.

Use of available habitat was statistically non-random and crocodiles remained for most of the year in coastal mangrove swamps. Crocodiles primarily used protected ponds and small streams rather than open water or the bay. Females moved from the mangrove swamps into Florida Bay only during the nesting season when some nested on bay islands. Because of this inland pattern of habitat use, we found crocodiles in salinities averaging 14ppt.

Mortality

Documented cases of mortality of crocodiles larger than hatchlings appear to be primarily man-caused. Of 25 known mortalities from 1971 to 1984, all but six were related to human activities. Most deaths were caused by automobiles along highways, on U.S. 1, the main road in Everglades National Park, and the road over Card Sound to northern Key Largo. Ten adult animals were known to have died in 12 years, a rate slightly less than one per year.

Management needs

Our studies have failed to demostrate that the crocodile population in Florida is decreasing. We have, in fact, evidence to suggest that recruitment to the breeding population occurs periodically. Although the population remains small and isolated, it is not in immediate danger of extinction. Most potential constraints on population growth are relatively minor and natural. As a whole, however, these natural constraints inhibit any rapid population increase, as would be expected at the northern limits of the range of an otherwise tropical species.

The population's range in Florida has decreased somewhat from historic times due to the loss of habitat in northern Biscayne Bay and Miami Beach. It is possible that this loss has been compensated by the artificial habitats on northern Key Largo and Turkey Point. This habitat modification has been of benefit to crocodiles in producing nesting sites where such previously were scarce or nonexistent.

As a result of our findings, we see no need for any drastic manipulative management of the southern Florida crocodile population. Several conservation concerns remain however. The first and most important is the protection of habitat on northern Key Largo.The acquisition of this land as part of the Crocodile Lake Wildlife Refuge by the US Fish and Wildlife Service is continuing. A second concern is the continuing mortality of crocodiles, especially adults, along highways. The future revamping of US Highway 1 from Miami to Key Largo provides an opportunity to halt such mortality by placing the roadbed on trestles as it passes through mangrove swamps. This is much preferred to simply installing culverts, as has been done as an intermediate measure, in that crocodiles mortalities have occurred as individuals crossed the highway not far from such culverts. The third concern involves plans to increase the flow of water to the eastern reaches of Everglades National Park. Such flows may raise water levels in creeks in northern Floridad Bay, thereby threatening the crocodile nests along these creeks. The threat of further increasing subterranean flooding of such crocodile nests needs to be alleviated.

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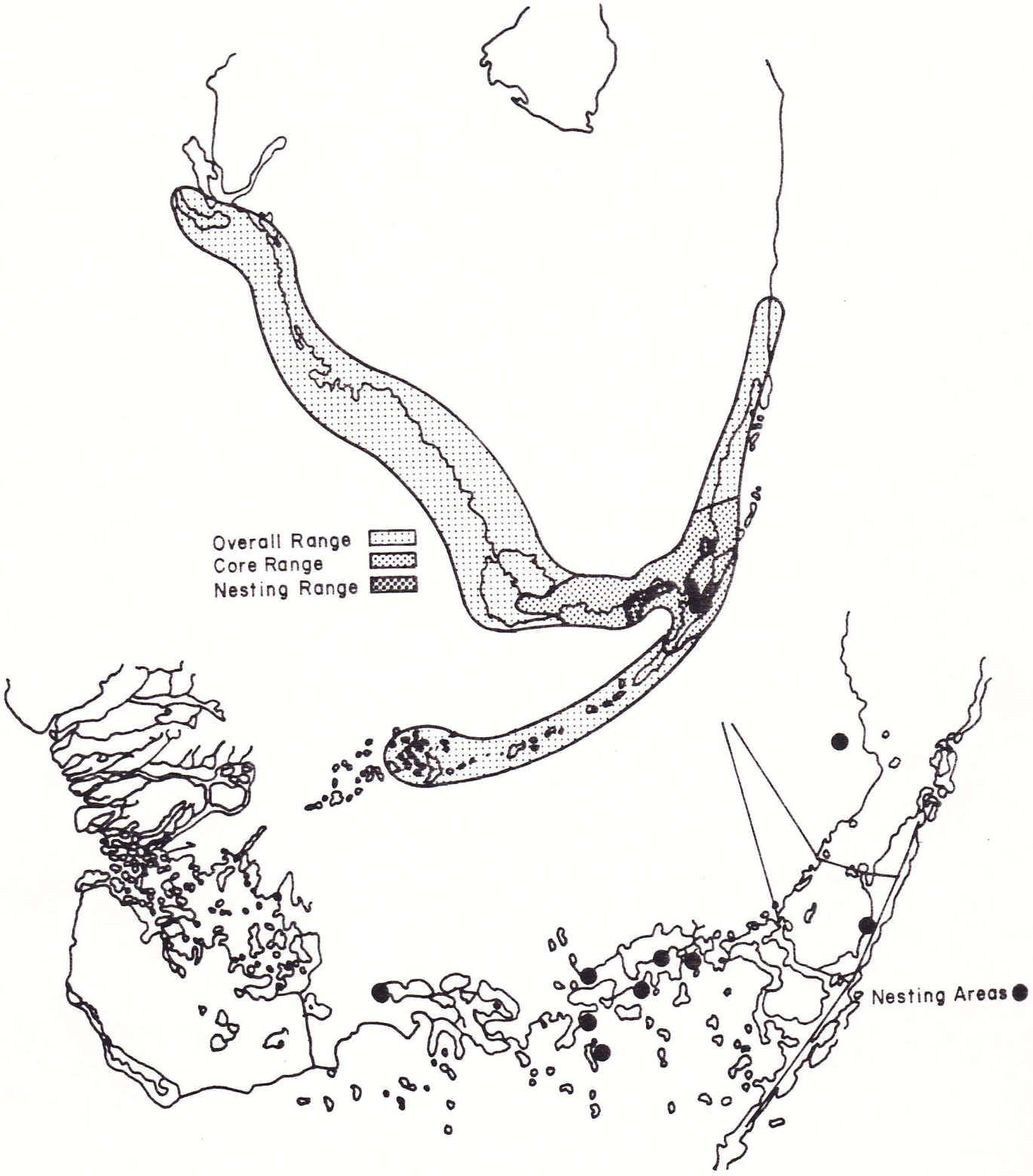
Figure 1.: Range of the American crocodile (Crocodylus acutus) in southern Florida, USA.



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