

Evaluation of Alligator Hatchling and Egg Removal from Three Florida Lakes

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Abstract: The removal of 50% annual alligator production over a 6-year period on 3 central Florida lakes did not appreciably change population size structures. On Lake Jessup, increases were found in the >0.6 m size classes, while on Lake Griffin no changes were found in any size classes. Lake Apopka experienced significant ($P < 0.05$) declines in all size classes, but these declines resulted from unexplained and unrelated mortality and reproductive failures and not from the early age-class harvest. No change in size structure was found for the control area, Lake Woodruff.

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The removal of juveniles from the wild is an important aspect of successful crocodylian management programs throughout the world. In 1972, Papua New Guinea began its commercial ranching program, which currently harvests wild salt-water crocodile (*Crocodylus porosus*) and New Guinea freshwater crocodile (*C. novaeguineae*) juveniles for captive rearing (Bolton and Laufa 1982, Natl. Resour. Counc. 1983, Rose 1984). In Zimbabwe, Nile crocodile (*C. niloticus*) eggs are collected from wild nests and incubated and reared on farms (Blake 1986). Similarly, in Louisiana, American alligator (*Alligator mississippiensis*) eggs are collected and incubated by the Louisiana Wildlife and Fisheries Commission and then distributed to qualified alligator farms (Joanen and McNease 1987). Governments in Australia (Onions 1982, Webb et al. 1987), Africa (Blake 1986), Asia (Devos

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1982, Whitaker 1982), and Central and South America currently are investigating the feasibility of commercial ranching of crocodilians.

Though the concept of juvenile or egg harvests is not new, uncertainties exist regarding impacts on harvested populations. In Florida, where demand for alligator young and eggs is expanding, identification of potential biological impacts is necessary to guide future management programs. The objective of this study was to evaluate the impacts on alligator populations when 50% of the annual estimated production was removed from 3 Florida lakes.

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Methods

Our criteria for selecting study areas were: 1) a relatively dense alligator population so that any changes in population demography could be adequately quantified; 2) sufficient nesting to satisfy sample size requirements (>50 nests/year); and 3) close proximity to each other to reduce environmental variation. Lakes Griffin (5,675 ha), Jessup (4,805 ha), and Apopka (12,809 ha) were chosen as harvest areas and Lake Woodruff (6,477 ha) was selected as a control.

Lakes Griffin and Apopka are eutrophic, hardwater natural lakes within the central physiographic region of Florida (Canfield 1981). Lake Griffin's southern shoreline is highly developed, while much of the eastern marsh has been drained and cleared for agriculture. Most of the 525-ha wooded marsh occurs in a narrow band proximal to open water in the northern half of the lake. True wet marsh (1,231 ha) communities exist beyond the wooded shoreline. About 96% of Lake Apopka's northern marsh (13,000 ha) has been diked and drained for agricultural purposes. Only a small remnant of the original marsh remains (89 ha). Much of the remaining shoreline is characterized by wooded marsh (692 ha).

Lakes Jessup and Woodruff are eutrophic alkaline, natural lakes in the St. Johns River drainage basin in east-central Florida (Canfield 1981). Much of Lake Jessup's western shore has been converted to improved pasture. The undisturbed northeastern marsh (996 ha) is dominated by sand cordgrass (*Spartina bakeri*) and giant reed (*Phragmites australis*), whereas much of the southern half of Lake Jessup is comprised of wooded marsh. Lake Woodruff's wetlands are characterized by *S. bakeri* (3,922 ha). Much of the remaining wetlands consist of wooded marsh and sloughs.

We attempted to remove 50% of estimated production on the 3 treatment lakes by collecting hatchlings during the fall and spring of the 1981 and 1982 nesting seasons, a combination of hatchlings and eggs in 1983, and eggs from 1984 to 1986. Egg collection was more effective and economical than hatchling collection in these

habitats (Hines et al. 1986). Techniques for both procedures are discussed in detail by Percival and Jennings (1986).

Removal Rate

Based on nest success and hatchling survival data, we expected that a 50% experimental harvest rate was sufficient to impact alligator populations via changes in population size and structure. Specifically, we were interested in harvesting from the total surviving production on each study area from 1981 to 1986. This necessitated adjustments of production estimates to account for natural mortality of eggs and hatchlings due to predation.

Three aerial nest surveys were conducted annually from late June to early July (early incubation), late July (mid incubation), and late August to early September (late incubation), to determine nest status and total nesting effort. Helicopters were used for nest searches in all years except 1982 when a fixed-wing aircraft modified for slow flight (approximately 96 kph) was used. Early and mid-incubation and post-hatching surveys were flown on each study site to determine nest locations and their status (active or successfully hatched, depredated, false, flooded, or unknown fate). To circumvent overestimation of predation in years when eggs were removed, 2 separate predation rates were evaluated. Overall predation rate (D_o) was estimated by:

$$D_o = (D_1/A_1)(D_2/A_2)$$

where D_1 = total number of depredated nests observed from the air before egg removal; A_1 = total nests observed from the air during the first survey; D_2 = number of nests sighted from the air that were depredated after egg removal and; A_2 = number of nests remaining after egg removal. A_2 was calculated by:

$$A_2 = [(A_1 - D_1) - R] + A_3$$

where R = number of clutches removed and A_3 = number of nests found on the second survey that were not found on the first survey. On Lake Woodruff, and in years where eggs were not removed from lakes Griffin, Jessup, or Apopka, annual predation rates were calculated by dividing the total number of depredated nests observed by the number of nests observed from the air. Nests that lost identifiable visual characteristics or were located in dense vegetative cover that obscured visibility in later surveys were considered to have incurred predation rates in proportion to those nests with known final status. Therefore, the minimum number of nests that were not observed from the air (H) was estimated by:

$$H = P/(1 - D_o)$$

where P = number of hatchling pods found during post-hatching night-light surveys that were not associated with a nest observed from the air.

Total nesting estimates (N) were calculated by:

$$N = A_1 + A_3 + H$$

We assumed that nest success was independent of nest density and that nest survival for unobserved nests equalled observed nests.

Night-light Counts

We evaluated non-hatchling population trends on all study areas by conducting night-light counts during late May and June 1980 through 1986. One survey per year was conducted on lakes Griffin and Apopka from 1980 to 1982, and on lakes Jessup and Woodruff from 1981 to 1982. Two independent surveys (Harris 1986) were conducted annually on all lakes from 1983 to 1986 with the exception of a single survey on Lake Griffin in 1985. Surveys were conducted within a 1-month period to reduce variation of environmental factors such as water temperature and level (Woodward and Marion 1978, Wood et al. 1985), and seasonal behavioral influences (Woodward and Marion 1978).

Standard survey routes were conducted from airboat or outboard motor boat at about 10 km/hour with a 200,000 candlepower, hand-held light to detect alligator eye reflections. Because trees or dense vegetation dominated the shore margins on all 4 lakes, surveys were conducted about 30 m from, and parallel to, the shore and included the periphery of each study area. Where emergent vegetation existed, transects were employed to cover as much of the habitat as possible. On all study areas, water extended beyond the shore margin (treeline), but these habitats could not be surveyed. Once spotted, each animal was approached and its size estimated in 0.3 m-length categories. Animals that were observed only briefly and therefore could not be reliably placed into one of the 0.3-m categories, were classified in general size classes 0–0.6, 0.6–1.2, 1.2–1.8, and >1.8 m based on the type of habitat, depth of water, size of eye reflection, or disturbance created by the animal. In cases where no estimate of size could be obtained, the observation was recorded as “unknown.” For analytical purposes, animals occurring in the unknown category were placed into 1 of the 4 general size classes based on the proportions of known-size animals occurring in those classes. Total length estimates were based on the relationship that snout-length in inches equalled total length in feet (Chabreck 1966). To reduce potential observer bias (Magnusson 1983), several alligators were sized by sight and then caught and measured before surveys began.

Log-transformed count data from 3 size classes (0.6–1.2 m, 1.2–1.8 m and >0.6m) were analyzed for trends while accounting for the effects of water level as a covariable (Wood et al. 1985). Regression analyses were conducted to test the null hypothesis that the number of animals in each size class remained equal during the study.

We emphasized evaluation of trends in the 0.6–1.2 m and 1.2–1.8 m size classes for which harvested cohorts were likely to be represented. The >0.6 m category was evaluated to better understand total population response to other unre-

lated demographic and environmental factors that may have resulted in population size structure changes.

Results and Discussion

Nest Production Estimates

Over the course of this study, 4,120 hatchlings and 9,238 eggs that produced hatchlings were removed from the 3 study areas (Table 1). A wide range of actual removal rates occurred because of differences in nesting habitat among lakes. On Lakes Griffin and Apopka, where dense canopy cover limited visibility of nests from the air, minimum estimates of production (and therefore removal rates) were most variable (Table 2). Conversely, nesting effort on Lake Jessup occurred primarily among giant reed (*Phragmites* spp.) in an open marsh system, resulting in more observable nests. Consequently, removal rate estimates tended to be consistently closer to the targeted 50% rate.

Calculation of removal rates were based on the sum of nests observed from the air, and those unobserved nests that were represented by hatchling pods located during night surveys. The importance of unobserved nesting was evidenced by the large proportion of total nesting accounted for by this parameter (Table 2). In general, unobserved nests were documented during night surveys only by locating hatchling pods in areas where nests had not been found from the air or in locations where eggs had been collected from all nests that were observed from the air. We considered this approach to be conservative since it ignored those pods from hidden nests that may have been indistinguishable from pods associated with nests observed from the air. Additionally, it did not account for pods from unobserved nests that were not seen during night surveys.

Nesting on Lake Griffin ranged from a low of 95 during a lake drawdown in 1984 to a high of 166 in 1983. Nesting increased in 1985 and 1986, indicating that negative effects of the drawdown on the breeding population was short-term. Nesting estimates on Lake Jessup ranged from 17 to 129. Though removal rates were

Table 1. Number of hatchlings and viable eggs removed from 3 Florida lakes from 1981 to 1986.

Year	Lake Griffin	Lake Jessup	Lake Apopka
1981 ^a	1,303	317	411
1982 ^a	858	0	83
1983 ^b	1,007/998	0/390	144/265
1984 ^c	869	870	115
1985 ^c	1,936	572	239
1986 ^c	1,986	942	56

^aOnly hatchlings removed.

^bHatchlings and eggs removed (hatchlings/eggs).

^cRemoval comprised exclusively of eggs (reported values represent those collected eggs that resulted in hatchlings).

Table 2. Alligator nesting effort, nest success, and estimated removal rates for 4 lakes in central Florida from 1981–1986.

Year	Nests observed (A)	Hidden nests (H)	Total nests (N)	Nest predation rate (%) (D _o)	Removal rate (%)
<i>Lake Woodruff</i>					
1981	18	3	21	33	
1982	27 ^a	1	28	11	
1983	43	1	44	30	
1984	43	0	43	33	
1985	36	0	36	19	
1986	52	0	52	52	
<i>Lake Griffin</i>					
1981	53	53	106	8	48
1982	59 ^a	47	107	36	66
1983	111	55	166	7	34
1984	76	19	95	21	53
1985	154	10	164	9	54
1986	140	25	165	12	48
<i>Lake Jessup</i>					
1981	50	0	50	10	53
1982	17 ^a	0	17	0	0
1983	74	0	74	14	52
1984	93	0	93	19	57
1985	80	0	80	0	52
1986	129	0	129	23	49
<i>Lake Apopka</i>					
1981	14	39	53	7	59
1982	3 ^a	15	18	0	50
1983	29	12 ^b	41	13	36
1984	24	10 ^b	34	22	37
1985	21	23 ^b	44	24	85
1986	29	19 ^b	48	23	51

^aSurvey conducted from fixed-wing aircraft.

^bEstimate based on subsample of nests.

consistently close to the targeted rate, high water in 1982 resulted in the flooding and eventual demise of all nests observed from the air. Nesting effort and success varied annually on lakes Woodruff and Apopka but could not be attributed to environmental parameters we monitored.

Night-light Counts

Since most animals in all harvested cohorts remained within the 0.6–1.2 m size class throughout the study (Percival, unpubl. data), we expected this size class to be most affected by early age-class harvest. However, to use trends in this size class as an index required an accurate assessment of all 0.6–1.2 m animals, even those that could not be classified in general size classes. Because the proportion of alligators

occurring in unknown and known-size categories changed with water levels and environmental conditions (Woodward and Marion 1978), we elected to use unknowns by apportioning them into size classes in proportion to the distribution of known size-alligators. The distribution of unknowns was representative of all size classes observed because animals occurring in the unknown category generally resulted from observations in habitats that were used by all size classes.

Analyses of night-light counts indicated no significant trends in any of the size classes for alligators on Lake Woodruff (Fig. 1) or Lake Griffin (Fig. 2). Stable population numbers on Lake Griffin suggested that recruitment into the 0.6–1.2 m size classes remained constant and thus unaffected by the harvest level. We had anticipated a decline in the number of animals entering the 0.6–1.2 m size classes during 1985 and 1986 since fewer nests were produced in 1984 and the remaining 1984 cohort was expected to suffer higher mortality during the period of low water. That declines in the 0.6–1.2 m size classes were not observed in the years immedi-

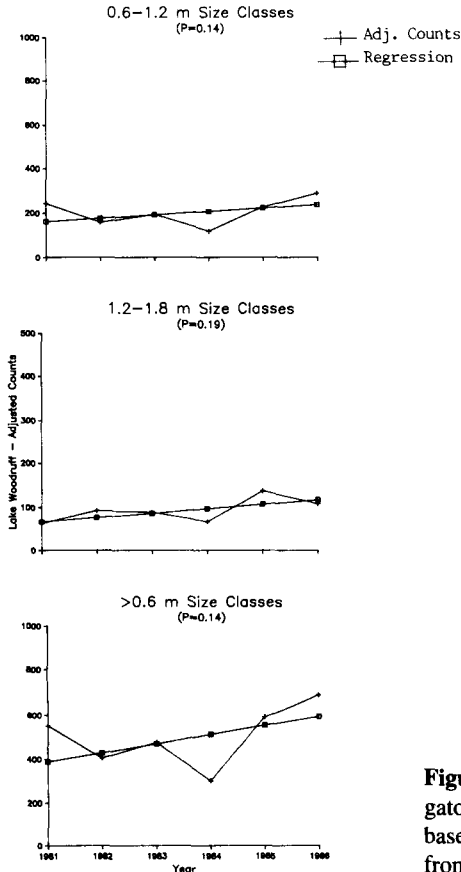


Figure 1. Adjusted and predicted alligator population trends on Lake Woodruff based on night-light surveys conducted from 1981–1986.

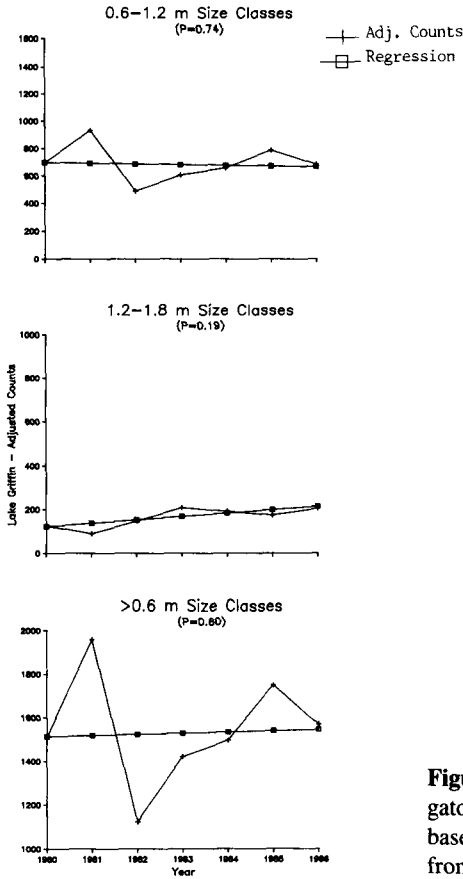


Figure 2. Adjusted and predicted alligator population trends on Lake Griffin based on night-light surveys conducted from 1980-1986.

ately following low nesting (Fig. 2), suggests compensatory mechanisms (e.g., survival and growth) were functioning to a greater extent than previously thought.

Trends on Lake Jessup indicated significant increases ($P = 0.018$) in animals >0.6 m, and only slight increases for animals in 0.6-1.2 and 1.2-1.8 m size classes (Fig. 3). This suggests the overall population increase probably was attributed to increases in the numbers of alligators >1.8 m. Although animals >1.8 m probably have not directly been affected by the removal treatment (e.g., they do not belong to cohorts hatching after 1981), their increase is difficult to explain. Because the number of animals in the 0.6-1.8 m size classes increased only slightly over the past 6 years, it is unlikely that the observed increase in alligators >1.8 m is a function of animals maturing faster and entering the larger size classes. Though our data are limited, we surmise that immigration may be partially responsible for this increase since Lake Jessup is connected directly to the St. Johns River drainage basin.

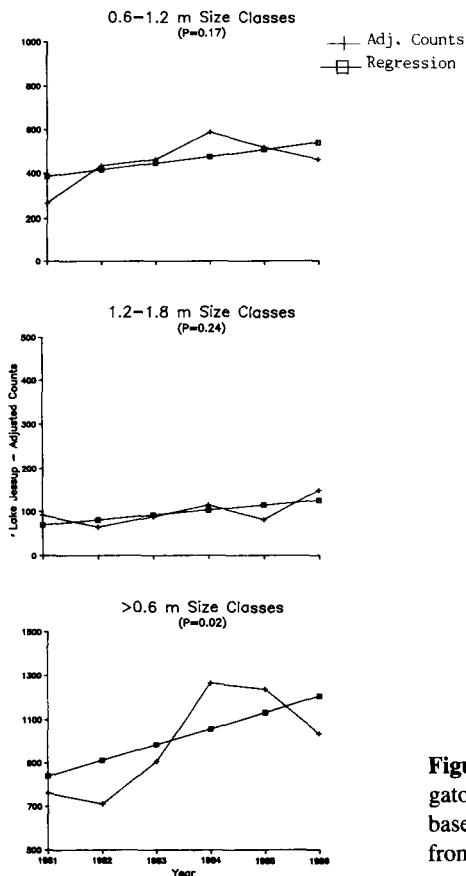


Figure 3. Adjusted and predicted alligator population trends on Lake Jessup based on night-light surveys conducted from 1981-1986.

Another perplexing problem is the stability of the 0.6-1.2 m size classes in lieu of total failure of the 1982 cohort. We believe that these results, like those on Lake Griffin, are indicative of compensatory mechanisms for which we currently have insufficient data to quantify.

Analyses of trend data for Lake Apopka indicate significant decreases ($P = 0.004$) in population numbers (Fig. 4). The removal treatment was likely not responsible for the observed population decline as evidenced by decreases in all size classes (including >1.8 m). Current data strongly suggest that extensive reproductive failures have occurred on Lake Apopka since 1982 (Percival and Jennings 1986). Additionally, numerous observations of large dead alligators indicate mortality of adults may partially explain the population decline. These factors confounded interpretation of juvenile removal by masking population reactions to our treatment harvest.

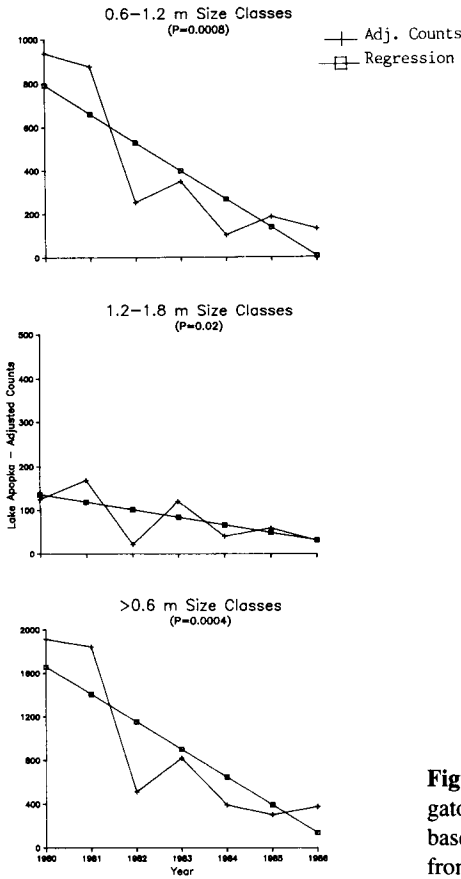


Figure 4. Adjusted and predicted alligator population trends on Lake Apopka based on night-light surveys conducted from 1980-1986.

Conclusions

Crocodilian management programs that include harvesting from the juvenile segment of populations must identify that portion of production considered surplus. Harvest rates of eggs and juveniles depend largely on the degree to which compensatory mechanisms function in alligator populations. Density independent and density dependent mechanisms likely are functioning in alligator populations from the egg stage through the first few years of life because all production is not needed to maintain populations. The effects of these mechanisms on populations ultimately will provide a guide for management decisions regarding the establishment of harvest programs.

Our study demonstrates that within very productive systems in Florida, intensive juvenile harvests can be a viable management strategy. Caution should be exercised when applying this management approach to alligator populations occupying marginal habitats or habitats significantly different than our study areas.

Additionally, demographic differences in alligator populations within the United States and other crocodilian populations worldwide necessitate evaluation of specific habitats or species to develop appropriate harvest strategies and monitoring programs.

The only tools currently available for monitoring harvested populations are night-light and nest counts. Both of these techniques are expensive and replete with statistical problems (Wood et al. 1985, Harris 1986). Though continuing efforts are being made in Florida to improve them (A. Woodward pers. commun.), these indices should be employed. Without monitoring at this level, an understanding of the effects of egg and hatchling collections on crocodilian populations is impossible.

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