FINAL REPORT 2006

LONG-TERM (1985-2005) SPATIAL AND TEMPORAL PATTERNS OF AMERICAN ALLIGATOR NESTING IN EVERGLADES NATIONAL PARK, FLORIDA USA

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EXECUTIVE SUMMARY

BASIC DESCRIPTIONS

Alligator nest abundance was greatest in the Shark Slough basin (1985-2005) (85%) followed by East Slough. In **Dry years** (less than -1 stdev. from 20 year mean), nests were concentrated in the center of the slough near areas of longer hydroperiod;Whereas in **Wet years** (+1stdev. from 20 year mean), nests were spread across the slough with a greater proportion on tree islands than in dry years. I found no relationships between clutch size and female alligator size. Perhaps local yearly food accessibility may be a greater constraint on this relationship. Regionally, from North Carolina to South Florida, there is an inconsistent relationship between female size and clutch size of alligators this needs to be resolved. Either a larger sample size or greater range in females may clarify this relationship in ENP.

Clutch Sizes averaged from 1985 to 2005 (26.1), are slightly smaller than the 30 eggs that was reported by Kushlan and Jacobsen (1990). Patterns in clutch size varied within basins by year. **Proportion of viable eggs/clutch** appears to be decreasing, this is related to increased flooding of nests over the last five years.

Spatial patterns in clutch size vary by year and region, and needs further investigation, perhaps overlaying Remap Data from similar years, (Soil P, in lieu of productivity) could clarify these relationships. Current 400 m resolution of elevation was not sufficient in finding relationships between elevation and flooding. I used semivariograms that showed flooding was site-specific, in other words flooding did not vary by distance at the scale measured by SRF's. I suggest more water depth measurements at nest sites, four at every cardinal direction not averaged values, could capture more of the variability present at nest sites.

RELATIONSHIPS

Using a harmonic analysis of the 21 year data set, I found that mean annual water levels in Shark Slough (NP203) are related to mean annual discharge (S-12A-D) (Nuttle 1996). **American alligator annual nesting effort** is related (Adj. R2=0.56) to annual mean water level and periodicity of annual hydropattern. (More nests when there is a wet dry season, and greater annual mean water level). I examined Kushlans hypothesis of Predictability (that there was once an inherent linear relationship between average water levels during nest construction (June 15-30) and maximum water levels during incubation (July 1-September 15)). I found correlations from 1960-1969, a time period where minimum to no water was released into ENP. Correlations were lowest from 1993-2005. Using correlation coefficients as a measure of predictability does not appear to be a good metric to determine good from bad years, since correlations were relatively high in years with very low water levels during nest construction and very high water levels during peak water levels, (1960-69), I do not think this predictability is a good assessment of optimal conditions for nest flooding. Rather the slope, of the regressions would make a better metric. I assessed the relationship between the annual proportion of flooded alligator nests by the rate of change of water levels during incubation (June 15-September 15). There was a positive linear relationship between these two variables. There appears to be a trade off between abundance of nests in wet years and risk in losing clutches because of high water.

Nest flooding causes a large amount of nest failure, however nest failure is also high in years of drought. **Nest Failure** is related to **timing of discharge** (Adj. R^2=0.61). **Nest Flooding** is related to **timing of discharge** (Adj. R^2=0.65), **amplitude** and **periodicity**. Timing of discharge is especially important. Larger pulses of water earlier in the nesting season will lead to larger amounts of nest flooding, especially in years with very low water in late dry seasons. 2005 had the highest flooding of nests in 21 years of Alligator nest SRF's.

Both rainfall and altered flow into Everglades National Park influence water levels within the current main American alligator nesting habitat. **Timing of peak water levels and discharges, amplitudes, and periodicity of water discharge appear to influence nest flooding and failure**. The annual hydroperiod of this region impacts both American alligator nesting effort and success. Management of this cycle has clearly affected the

magnitude and timing of this annual pattern, which in turn has impacted the resident American alligator population. A large proportion of annual nest failure and flooding continue to occur in Everglades NP, specifically Shark Slough and East Slough. Although, annual variability in rain quantities (e.g., Hurricanes) have caused large flooding events as occurred in 2005, large discharges from the S-12s during egg incubation also appear to be largely responsible for failures.

INTRODUCTION

Every stage of the American alligator life-cycle is intimately tied to the local hydrology. Developing eggs will die if flooded for more than 12 hours (Fleming 1991). Juvenile body condition can deteriorate with extremely wet dry seasons; and under extremely low water conditions, individuals may be prone to cannibalism (Dalrymple, 1996). Adults may not feed well under high water conditions (Dalrymple, 1996); and under severely dry conditions, they may not have access to mates or food thereby affecting breeding success, or even die from dessication (Fleming 1991).

During the 1970's in Everglades National Park (ENP), Kushlan and Jacobson (1990) found nearly 100% alligator egg mortality/nest failure. This high proportion of nest failure led to the removal of certain size-classes from ENP alligator populations and thereby changed long-term population structure (Kushlan and Jacobson 1990). Altered water flow, and predictability between water levels during nest construction and maximum water levels during incubation (managed hydrologic regimes) were implicated for these high failure rates (Kushlan and Jacobsen, 1990; Dalrymple, 2001).

Alligators are considered keystone species in the seasonally fluctuating wetlands of the Florida Everglades because they modify the environment by maintaining alligator holes; relatively deep pools of water, that serve as dry season refugia for a variety of aquatic organisms (Craighead, 1968; Mazzotti and Brandt, 1994). Because of their links to local hydrology and ecologic importance, a hierarchical long-term alligator nest monitoring program (Systematic Reconnaissance Flights-SRF) was established in 1985 within ENP. Previous SRF data analyses by Fleming (1991) and Dalrymple (2001) found relationships between nesting effort and success and local hydrology. Fleming analyzed results from SRF data from 1985-1990, and Dalrymple from 1991-1998. Both researchers found that in wetter

years more nesting effort occurs and most nests are distributed within the central slough. Fleming found under very dry years both nesting and hatching is reduced. In addition, egg laying is delayed when rains are delayed (Kushlan and Jacobsen 1990).

Fleming (1991) found both rainfall and water management affected nest flooding. He found a greater proportion of nest flooding/egg mortality from nests just south of the S-12 control structures relative to nests further away from these structures. These previous analyses however, found weak relationships between hydrology and nesting. I analyzed SRF data from 1985-2005, and find stronger support that shows how a combination of hydrologic variables including discharge into ENP from the S-12 structures, rainfall, and water levels in Shark Slough (i.e. amplitude, annual timing of peak water, periodicity) can affect nest flooding and failure.

Herein, I report long-term trends in nesting effort, clutch size, egg viability, nest flooding, and nest failure from 1985-2005.

The objectives of this report are:

1. To describe the current sampling methodology and the dataset, and discuss problems and possible solutions to those problems.
2. To summarize American alligator SRF data from 1985-2005 and in doing so assess patterns both temporally and spatially of: nesting effort, clutch size, proportion of viable eggs, nest success, flooding across the 21 years of sampling and across hydrologic basins.
3. To examine hydrologic relationships between (discharge, rainfall and water levels) and yearly nest effort, flooding and failure.

WHAT ARE THE SYSTEMATIC RECONNAISSANCE FLIGHTS (SRF'S), AND WHAT ARE THE GOALS?

The Systematic Reconnaissance Flight's (SRF's) are a series of aerial surveys that occur over variable length transects across the marshes and wet prairies of Everglades National Park and portions of Big Cypress National Preserve (Fig. 1). In 1985, M. Fleming began the (SRF) initiative to measure regional and local level impacts of experimental water deliveries

into Everglades National Park (ENP) on alligator nesting, deer and wading birds (Fleming, 1991).

Alligator nesting success is affected by water management, as are long–term population parameters (Kushlan and Jacobsen, 1990; Fleming 1991; Dalrymple, 2001). Aerial surveys of alligator nests began in 1985 to: document nest abundance patterns, nesting success, and flooding in Shark Slough (SS) and Northeast Shark Slough (NES), two regions that would be impacted by modified water deliveries (Fleming, 1991; Dalrymple, 2001); identify environmental correlates (i.e., vegetation and hydrology) to nesting abundance, and nesting failures; and identify relationships between hydrology (stage, discharge, rainfall) nest failures, and flooding (Fleming, 1991; Dalrymple, 2001).

From 1985-1992 transects were sampled in SS and NESS basins only (Fig. 2,Table 1). In 1993 O.L. Bass began leading the SRF's, and in this year M. Fleming assisted in sampling. The sampling areas expanded in 1993 to include East Slough, Rocky Glades and Taylor Slough, and if surface water is present, the Panhandle (Fig. 1 and 2, Table 1). In fact, 1993 transects covered the largest areas of ENP in order to assess post Hurricane Andrew impacts on nesting (O.L. Bass pers comm.). Both Rocky Glades and Taylor slough basins were chosen because they have been overly drained and future restoration will be re-flooding these sites (CERP). Therefore there is hope that dispersal of alligators will occur into these areas as hydroperiods are increased. For more information see Fleming (1991) and Dalrymple (2001).

METHODOLOGY OF ALLIGATOR SRF'S

NESTING EFFORT

Courtship occurs through March and April, and mating occurs in mid-May to early June, with egg deposition occurring 3-4 weeks after mating (Fleming 1990) (Fig. 3). Alligator nest surveys via helicopter usually take place after the 1st week in July, when nest construction should be completed (Kushlan and Jacobsen, 1990). Two observers, one left front, another right rear in the helicopter count nests. Flights are standardized to flight speed of 50 knots and a height of 100-200 feet (Fleming 1990). Observers cue in on ponds and alligator activity (i.e. such as trails) to find nests. Originally Loran was used to record nest locations,

however GPS units replaced this technology as it was available. Transects are usually flown by hydrologic basin (eg., Shark Slough, Taylor Slough, Northeast Shark Slough, etc.). Once all nests are counted an estimated total number of nests are obtained by multiplying the counts of nests by 4, since ¼ of the park is sampled. Twenty-percent of the estimated total number of nests observed (N *4 *0.2) is used to select a subset of nests to visit (see Nest Visits) within each basin, each year.

There have been two main problems with this method over the years. The first problem is that there is no measure of the range in error, or measure of detection to estimate error. Setting confidence around estimates of abundance would be useful given the large number of individuals who participate in this project. Observer differences can produce substantial bias in estimates of abundance (Rice et al., 2000). The second problem, and more critical is the lack of consistency of transect length across years.

DETECTION OF ALLIGATOR NESTS

The SRF methodology inherently assumes that detection of alligator nests is constant across space and time. However there are no estimates of detection for alligator nests in ENP. Because multiple observers are used in the surveys, and considerable spatial variation exists across ENP, I felt it was important to determine general detection probability of nests in ENP. I used two methods, one, I used program DISTANCE 5.0 (Thomas et. al 2006) to estimate detection probabilities across years. Secondly, I used an independent double observer method to sample a subset of transects in 2005.

Most of the data (except 1989,1990, 1992, 2001) met the distance model assumptions that detection decreases with distance from the center of the transect. Using DISTANCE, I found that detection varied by year and was on average 20 percent (mean and standard error yearly detection varied from 0.63 ± 0.081 (1987) - 0.18 ± 0.016(1996)). It should be noted, however, that when the transects are actually flown, the helicopter zig-zags across the center from the northern and southern boundaries. The helicopter does not always fly straight from start to stop, therefore there are bound to be nests that are missed. However, because our data fit of the model in most years, I felt it should still provide an adequate estimate of detection.

I also used independent double observer methods (citation) to assess detection of nests in 2005 as a separate comparison. I selected seven transects (65-72) within Shark slough Basin - (each transects was at least 15 km) because there was a higher density of nests in this region and would allow estimation of detection. I had just flown the SRF's for 2005, and therefore had this information available. I had two independent observers (myself and another experienced wildlife biologist, B. Jeffery (UF)) spot nests according to the protocol for SRF surveys, height 200 m, and flight speed of 50 knots. Both observers had experience surveying nests. We flew the transects, refueled, switched sides of the helicopter and re-sampled the same area. GPS was used to maintain that both flights remained within the boundaries of the transect.

The tracks from both surveys were recorded and plotted using Mapsource Garmin™ and ArcGIS. Because there were technical difficulties during the trip (e.g.,in some cases flight lines did not overlay, one observer became sick) I was able to use only four transects and a smaller subset of each sampling unit.

DETECTION RESULTS

I used a modified Peterson estimator to estimate p for the observers (Table 2; Rice et al., 2000)

S1=Observer 1

S2=Observer 2

B=Both Observers

N=counts

N=estimate

$$\hat{N} = \frac{(n_1 + B + 1)(n_2 + B + 1)}{B + 1} - 1 \text{ (eq. 1)}$$

$$\text{Var}(\hat{N}) = \frac{S_1 S_2 (n_1 + B + 1)(n_2 + B + 1)}{(B+1)^2 (B+2)} \text{ (eq. 2)}$$

For the detection of nests:

$$p = \frac{n_i}{\hat{N}} \text{ (eq.3)}$$

$$S\hat{E}(\hat{p}_i) = \sqrt{\left[\frac{n_i}{\hat{N}}\right]^2 \left[\frac{VarN}{\hat{N}^2}\right] + \frac{pi(1-p2)}{\hat{N}}} \text{ (eq. 4)}$$

Each observer detection was estimated as Observer 1:p=0.2, SEp=0.02, Observer 2: p=0. 33 SE p= .034. We counted 8 of an estimated 15 nests, therefore our detection probability of alligator nests was 53.3% within the sampling unit (Table 2). The Distance sampling suggests on average that p=0.2, which is similar to those seen by one observer. This suggests that most likely we are underestimating total nesting and visiting approximately 10% of nests, a much smaller proportion of the annual nesting occurring in ENP. However, cost and time would not allow substantially more sampling, and in reality most of the observed nests are visited. Therefore if more precise estimates of total nesting are required, then detection should be incorporated into this sampling methodology.

DETECTION SOLUTION

Given the number of people involved in this study, and the low estimates of detection, personnel who regularly perform these surveys should have observer detection probabilities estimated every year. This would be very easy, perhaps when flying to and from a starting point of a basin, both observers carry a GPS, save the track and mark the nests they observe, then when ready to resample, observers switch sides and repeat process over the same area. Using the equations above one can then estimate detection and variance across this subsample of transects. Observers who regularly survey these transects can then count the number seen by each observer, by both observers, and using the above calculations, estimate their detection, this should account for observer effects, which often add large amounts of bias to count surveys.

Our nest detection of 53.3% was relatively lower than other aerial surveys of alligator nests in North-Central Florida. Rice et. al (2000) saw 73-75% of nests along lake edges and marsh). Rice et. al (2000) in North-Central Florida found little difference in detection of nests between years and habitat type, but observer experience did influence detection probabilities. Detection would probably be higher for permanent staff, given the frequency of surveys they perform, nonetheless annual estimates of detection should be performed.

TRANSECT LENGTHS

The second major error in this method, was that when additional basins were added to the survey in 1992 (Fig. 2), the lengths of the transects varied annually; because, the protocol was to stop sampling when no standing water was visible. Water levels vary annually however, and observers often did not consistently record the stopping point of the transects (Appendix 1 and 2). Therefore, it is difficult to assess the total area sampled in many years. To properly capture the spatial distribution of nesting relative to presence of water it would be best to monitor permanent transects regardless of presence of water.

Originally, hydropattern was recorded along transects for a few years, and this was to be used as a covariate to nesting distributions, this proved to be too difficult and therefore was abandoned. There remains ambiguity in sampling, although landscape features are used to distinguish regions, permanent start/stop points need to be established. This is especially a problem on the western side of East Slough Basin, and the western/eastern Rocky Glades. On the eastern side of the Rocky Glades Basin it is not clear where the surveys stopped for multiple years.

Another example of this problem is if one uses the transect guide sheet, transect 73 and 74 stop at the main park road, however, from 1985 through 2004, nests have been recorded west of these regions along these transects (Fig. 2; Appendix 1 and 2; Table 2). Therefore, it is not clear when these transects were or were not surveyed.

In consultation with O. Bass changes were made to the transect guide sheet. First transect placement and start and stop points reflect hydrologic basin shapefile. Transects 73 and 74 have in some years stopped on the west boundary at the park road and in other years stopped at the SS basin, which lies west of the park road. Because the sampled start and stop points were not always written down this is difficult to discern in which years this was done after 1992. In 1993 transects were sampled farther west given the number of nests counted west of the SS western boundary. In other years, nests continue to plot in this region, however in 2005, for example, we did not sample 73 and 74 in SS basin because the transect field sheet specifically stated that 73 and 74 were not sampled in SS basin. Because previous years (1985-1992, off and on afterwards) followed basin boundaries (eg. see Fleming report), and transects 73 and 74 stop at the SS western basin boundary west of research road, 73 and 74 should be sampled in SS basin (pers. comm. O. Bass; Appendix 2).

Secondly, Transect 64 was added to North east Shark Slough since this falls within the NES basin. Thirdly, I removed T 55 and 56 from East Slough since technically the western boundaries of these really end at the Shark Slough Basin. I added transect 69 within East Slough, since it is sampled, but was never labeled within this basin. Therefore, transects 57-69 really fall within east slough basin (Appendix 3).

TRANSECT LENGTH SOLUTION

We used the transect guide sheet (this sheet the latitudes of each transect with corresponding northern and southern boundaries) and, recorded east and west start and stops for each transect in 2005. At the time of the survey in 2005, July 5-7, the water was quite high. Sampling occurred across basins until we reached the tree lines, development, canals or roads. The survey was done with L. Oberhofer who has been surveying nests almost every year sine 1993. I used these transect lengths to establish permanent stop and starting points. As mentioned above, the transects do not always reach the border of the basin, and therefore the 2005 lengths were used for this, and in some cases the transects occur outside of the basins. I therefore used ArcGIS and the basin shapefile, to clip transects where they occur outside of the basins, so sampling only occurs within the basins. The maximum length out of the basins in 2005 was 8.4 km, this occurs in East Slough, and a total of 54.612 km were clipped and removed from transects (Fig. 2; Table 3). I used ET Geowizard to obtain stop points between basins therefore there are distinct longitude and latitudes to each basin boundary. This is useful for observers because ambiguous areas such as the western side of East Slough, and the Western side of Rocky Glades are always assessed based on observer judgment. These points will make it easier for the observer and ensure standardized sampling. These points have been added to each SRF transect sheet, and are separated by basin. The field guide sheet also has the eastern and western start/stop points for each transect, so observers know where to begin and stop in these areas and within each basin (Appendix 2).

Vegetation at present is vaguely recorded (i.e. next to pond, small tree) solely as an identifier. If more accurate information is collected, this may be useful in assessing yearly changes in nest selection relative to hydrologic conditions. I added to nest visit sheets a

check box for the following categories: 1) wet forested and open wetland (cypress, pond apple, willow, buttonbush, sole pond); 2) moderate hydroperiod prairie (sawgrass, grasses); 3) shorter prairie: bayhead, ferns 4); upland,edge (tree island).

NEST VISITS

Nests (20% of estimated total) are visited repeatedly throughout the nesting season until nest success (hatching) or failure (eg. flooding, depredation, etc.). In the early years visits varied from 1-7 times. At each visit eggs were counted and classified as viable, rotten, nonviable, flooded, unknown, and depredated. Water levels were collected at most nest visits but were not consistently recorded, other variables were measured throughout the years (Table 1). Please see appendix for QA/QC of data. Notes accompany each visit and all raw data is currently stored in SFNRC in the care of O.L. Bass.

After 2001, O.L. Bass standardized the visits to nests to 3 times, or approximately one visit every 2 weeks. This was changed to avoid over-handling of eggs, in addition, little new data was obtained from additional visits. Once a nest was classified as totally flooded, it was not visited again (failed). Partially flooded nests were revisited since these nests may have hatched. All partially flooded and intact nests were visited until hatching in early to mid September.

In 2005, I classified each nest per visit by adding a Nest Status category to the nest visit table. Based on a number from 1-11 (Table 4), these numbers mostly correspond to current statewide codes from the Florida Fish and Wildlife Conservation Commission (see Rice database, copy in j drive ENP). In multiple years, eggs were collected and sent to Dr. P. Cardiliehac at the University of Florida, these removals were also added to the database. P. Cardiliehac currently has this data, and it would be very useful for ENP to obtain this data to note errors in classifications of viability.

STANDARDIZATION

Because over the years many different people have been involved in this project there have been multiple side projects and different measurements made over time. I have added a table that lists differences in sampling area, sampling units, etc. (Table 1). For example, in some years water levels were recorded in inches, in some years eggs were removed from clutches, and in other years additional regions were sampled. I incorporated these changes

into the nest location database, and nest visit database (i.e., I converted inches to centimeters, added columns for removal of viable/ nonviable eggs, and added in Nest location table, an area code). H. Fitting is currently compiling all the Metadata for this project. Anyone interested in analyzing this data needs to understand what changes occurred over time, so before any analysis is attempted, please obtain Metadata.

NEST VISITS-HOW MANY VISITS IS ENOUGH?

I examined the number of viable eggs (banded/fertile) eggs that are not flooded or display arrested development) in a nest between 3 consecutive visits where all eggs were ground checked (N=174) from 1985-2004. I wanted to see how viability differed between visits. I used paired t-tests to see how the mean number of viable eggs differed between first and second, and second and third visits. All visits were significantly different, with the largest mean number of viable eggs always occurring at the first visit t= ($\bar{x}$ 24.5, SE 1.77). The mean decreased through the third visit ($\bar{x}$ 8.29, SE 2.05), most likely because of flooding. Because the number consistently decreased from early to late visits the middle visit could be removed, however I do not recommend this; the reason being that the survey will not capture short-term events. For example, in 2005, I was able to assess that a greater proportion of nest flooding occurred between Visit 2 and Visit 3, when Hurricane Katrina passed over Shark Slough. Removing an aerial visit would remove a level of temporal resolution that would make it more difficult to link or separate water management and rainfall events to nesting.

ANALYSIS USING HYDROLOGIC DATA

HYDROLOGY DATA

I used ENP stations NP203 and P33 to obtain daily data series (1985-2005) of water stage. This data was corrected to water level (cm) by subtracting ground surface elevation measured at the station, and converting stage (ft) to centimeters. P33 was used to obtain rainfall (in). I primarily used NP203 because previous work by Dalrymple had focused on this station. Most of the center slough stations are correlated, and these stations have some of

the longest records of continuously recorded data within the region. When data was missing at NP203 I estimated missing data from P33 based on the linear regression equation:

Water Level at NP203=1.1112 (water level at P33)-25.365 (cm) (R^2=0.97) (eq.5)

I converted stage to water level by subtracting ground elevation at the station. Any negative values were given a zero value meaning no standing water was present. Daily sum water discharge (1985-2005)(Cf/s) into Shark Slough was obtained from South Florida Water Management District (SFWMD) DB Hydro for S12A-D stations (Fig. 4).

NESTING EFFORT AND SPATIAL DISTRIBUTION OF NESTS

From 1985-2005 a total of 1,491 American alligator nests were observed of which 1,038 were visited at least once. Eighty-five percent of all nests from 1985-2005 occurred within Shark Slough (Fig. 3). Fleming (1991) found the higher average nest densities in the slough (1.5-1.9/km^2), which is characterized by organic soils and long hydroperiods. The lowest average nest densities (0.2- 0.4/km^2) were characterized by marl and dry prairie.

Nesting was highest in Shark Slough Basin in 1993, the year after Hurricane Andrew and lowest in 1985 (Table 5 and Table 6). Although 1993 transects were longer than other years, the counts remained higher when these additional transect lengths were removed. From 1985-1991 nesting was low, most likely due to water management related dry-downs in the late 1970's, and the drought periods of 1985, 1989, and 1990. Numbers of nests were much higher in 1992 and stayed higher throughout the nineties, when annual water levels were relatively higher than the 20-year average (Fig. 5). In Shark Slough, the numbers have been variable throughout the 2000's. What remains unclear is if the abrupt increase in counts of nests from 1991 to 1992 was due to a sudden response to renewed high water levels in the slough, or changes in monitoring effort and personnel (Oberhofer pers com.).

Nesting effort varied temporally but not consistently by basin. In NES it was highest in 2003, and in Taylor and East Slough, as well as Rocky Glades, in 2005. It was lowest in NES in both 1992 and 2005, and in East and Taylor both in 1999. Rocky Glades often had few to no nests, as well as the Panhandle (Fig. 6; Table 5). Although both RG and PAN are being sampled to observe dispersal into these areas as a response to increased water flows.

Although there are such few nests in both (PAN) or (RG) over 10 years of sampling, we may see changes increases in nesting once more water is introduced into these areas. Because PAN is sampled only when there is surface water present, and therefore it is not sampled every year, this method seems appropriate.

Looking at SS and NES basins across all years, I found that under dry years (-1 stdev. below the 20 year average water level (June15-June 30), all nesting occurs in the central slough. When water levels were above one standard deviation of the 20 year average during nest construction, nests had a wider distribution across these basins (Fig. 7). This suggests more successful reproduction occurred during years with greater than average water levels. I also used 2*2 km cell shapefiles to obtain the sum of nests, and the probability that a nest would be found within a given cell under dry, moderate and wet years. There appears to be regions of denser nesting regardless of water year within the slough itself. It is unclear at this time what makes some of these regions more suitable than others, however, perhaps newest vegetation maps of ENP in combination with DEM's may provide some insight. I used the elevations from the most current Digital Elevation Model at 400 m resolution and obtained an average, lowest, or highest elevation per cell. I wanted to see if the sum number of nests in a 2 X 2 km cell in wet, dry, or moderate years was related to elevation, however there were no significant relationships observed. Perhaps no relationships were found because of the small-scale heterogeneity in elevation near alligator holes.

Distribution of Nests in Relation to Habitat

Based on my experience with wetland vegetation and in consultation of additional botanists (K. Whelan (NPS), J. Taylor (ENP)), I categorized all vegetation notes written at each viable nest as: forested wetlands and open pond (cypress, willow, airboat trail, and pond; long hydroperiod), grass dominated marshes (sawgrass, and other forbs; long-medium hydroperiod), bayheads and ferns (moderate hydroperiod), and tree island-(short-no hydroperiod). I then examined the proportion of nests constructed in each of the vegetation types by year. Years were classified as wet, dry, or moderate by observing water levels during nest construction (above 1 st. dev (Wet), below –1 stdev (Dry) from June 15-30). I used chi-square tests to see if nests were randomly distributed among vegetation classes or if

there was any non random pattern by wet, moderate, or dry year. Not surprisingly, I found that when water levels were low at nest construction, a greater proportion of nests were near ponds, or longer hydroperiod habitats. If water levels were high during nest construction, there were a greater proportion of nests on or adjacent to tree islands. (Table 7, Fig. 8).

CLUTCH SIZE PATTERNS IN TIME AND SPACE

American alligator clutch sizes are smallest in the southern portion of their range relative to northern populations (Brandt unpubl. data). To obtain average clutch sizes for Everglades alligators, I removed all false and old nests and used clutch sizes from only visit 1. The 21-year average clutch size for Everglades National Park was 26.1 eggs/clutch. This number is slightly lower than the 30 eggs/clutch mean reported from Kushlan and Jacobson 1990. It has been proposed that either differences in female breeding size or food resource availability explain the difference. Clear patterns exist in clutch sizes over time. Clutch sizes decreased during the nineties (1990-1999), then clutch sizes begin to increase, dropped again in 2002, and are currently increasing (Fig. 9).

I was interested in seeing if clutch sizes vary spatially throughout ENP. I classified years by wet (+1 stdev. from the 20 year mean (March-June), moderate (<1>-1 stdev.) and dry (-1stdev). I used S-Gems©, Stanford to create semivariograms, that were used for simple kriging. Variograms assess if your dependent variable (clutch size) varies with distance. In dry years there was often not enough data across all areas of the park to examine patterns, however there was a relationship between distance of nests and clutch size in years with abundant nests, in other words do nests in closer proximity have similar clutch sizes than nests. I originally was interested in assessing patterns in clutch size between wet and dry years, however in some years the spatial variability was too great at local scales to find relationships by distance.

Across analyzed years there was a large Nugget Effect, or substantial small-scale variability. This suggests that small-scale heterogeneity in resources may be responsible. Across most years, the center slough had the smaller clutch sizes whereas larger clutch sizes were found in nests along the periphery of the slough, especially closer to the mangrove zone (Fig. 10). Because female size clutch-size relationships are unknown for ENP, and may shed

light on some of the clutch size patterns, I captured females at nests in 2005 to address the hypothesis that there is a positive linear relationship between American alligator female size and their clutch size.

FEMALE SIZE-CLUTCH SIZE

Dalrymple (2001) examined Everglades National Park (ENP) American alligator nesting effort from 1985-1998 and found a decreasing trend in clutch size. He suggested that a lack of larger females (killed off from droughts of late 70's and 80's) and a new cohort of smaller breeding female alligators could explain this trend. Although this may be true, poor body condition of females prior to nesting also may be responsible (Dalrymple, 1996). The objectives of this study were to determine if there are relationships among female American Alligator size (SVL), body condition, clutch size, and egg size in Everglades National Park. I was interested in examining clutch-female size relationships in American alligators because: (1) It is not known if clutch size of American alligators in ENP is a function of female size (SVL), body condition, or both; (2) This information is known from only five individuals throughout 1,398,617.13 acres of ENP; and, (3) We would like to compare these relationships regionally to examine any patterns.

I expected relationships between female size and clutch size, as had been found in more northern regions of the alligators range. I also expected egg size to be correlated with female size. If there are relationships among these variables, one may be able to predict body condition or female breeding size in ENP over time with the previous data collected since 1985. Finally, I can compare these relationships with other Florida alligator populations from A.R.M. Loxahatchee NWR to South Carolina. I looked at the range in female sizes, and the range in body condition to look for patterns. Currently, the only relationship between clutch size and female alligator size that exists for both Everglades National Park (ENP) and Water Conservation Area alligators combined is based on 13 nests (Percival et al., 2000). Obtaining a female size-clutch size relationship specific to ENP is necessary because these areas are ecologically distinct.

Clutches varied in size from 8 eggs to 37 ($\bar{x}$ = 25.22, sd= 10.99). The average clutch size from our nine sampled females was slightly smaller than the 21 year SRF average clutch size of 26.1 in Everglades. Clutch weight and Clutch size were correlated (R^2=0.85, $F_{1,7}$ = 40.286, $p < 0.003$)

$$\text{Clutch weight (kg)} = 0.071(\text{clutch size}) + 0.923 \quad \text{(eq. 6).}$$

I obtained an additional data set of six nesting females in shark river slough, ENP captured in 1998, however I used only four of the six due to missing data and one was an outlier. I pooled data because relationships were not different once I removed the outlier. I found slight relationships between clutch size and body mass ($y = 17.977\ Ln(x) - 34.743$, $R^2 = 0.272$, n=15) and clutch size and tail girth ($y = 30.434Ln(x) - 89.201$, $R^2 = 0.26$), however none were significant to $p < 0.05$) however tail girth and body mass are significantly correlated ($y = 1.0238x - 15.4$, Adj. $R^2 = 0.7902$). I did not find relationships between any factors; neither egg clutch nor egg size with female size.

DISCUSSION

I found no relationships between female body size or condition with clutch or egg size. I believe that female breeding size probably does not explain the pattern in clutch sizes that I see from 13 years. I believe food access or availability during which the female is obtaining resources for nesting is limiting reproductive output. Although our sample size was limited, in other areas (i.e., A.R. M. Loxaahatchee NWR, and North Florida) where similar relationships were examined, small sample sizes were sufficient in finding relationships.

On a regional scale from the Carolinas to South Florida, there is no apparent north – south trend in clutch size- female size relationships, even though there is a decreasing trend in female size from North to South (Brandt unpublished data; Fig. 12). This is especially apparent in Central Florida, where across three lakes there are differences not only in female-clutch relations but overall clutch size (Hall, 1991; Dietz and Hines, 1980;Woodward et al., 1992b) . Why are relationships so inconsistent and variable? Part of the reason, is that multiple studies never measured actual female size, but footprint size, or estimated lengths. There are a few plausible explanations for the variation: 1. Perhaps sample sizes were not

success (Nott et al. 1998). Herein lies a clear example of one major dilemma facing restoration success: management of a system that has differing requirements for the diverse flora and fauna. Temporal patterns of the proportion of nest flooding that occurs in a basin within years is very different (Fig. 15). Only east slough and shark slough appear to follow a positive linear pattern in nest flooding between years (Fig. 16; eq. 7)

% Flooded nests in SS = % Flooded nests in ES *(.814)+ .0496

($p < 0.01$) adj. $R^2 = 0.72$) (eq. 7)

If there is a high percent of nests flooded in Shark Slough, there may be a high percent of nests flooded in East Slough. I used semivariograms to assess more precise spatial patterns in nest flooding within basins. I could only use SS basin to assess flooding spatial patterns however, because this is where most of the nests occur, and variograms cannot extrapolate over too large of an area where no nesting occurs. I used the number of visits in which there was flooding as my dependent variable. If total flooding occurred at the first visit, the nest was coded as flooded at each nest visit, because nests were not visited again once they were determined as totally flooded. There was a large nugget effect, suggesting that small scale variation in topography (most likely) did not allow a pattern to emerge (Fig 16b.). Either finer scale resolution (<400m) in elevation data is needed to clarify any patterns, or a different method of defining flooding may show some patterns.

PREDICTABILITY, DISCHARGE AND RAINFALL AFFECTS ON WATER LEVELS IN SHARK SLOUGH

To examine restoration of the predictability between water level at time of nest construction, and maximum water levels during incubation, I performed separate regressions for four time periods. I wanted to see if mean water levels from June15-July 1st (time of nest construction) could be used to predict maximum water levels during incubation of nests (from July1st-Sept15) (Fig. 17). I used hydrologic station P33 in Shark Slough ENP, from 1960-1969, 70-82, 83-93, 94-05,.

HARMONIC ANALYSIS

I used a Harmonic Analysis to characterize the annual hydropattern in Shark Slough, Everglades National Park (Nuttle 1996). I fit annual water level data series from 1985 to 2005, to a harmonic model (eq. 8) (Fig. 18). The harmonic represents the mean of the data plus its sum components. This allowed me to obtain annual average water level, amplitude of fluctuating water levels, timing, and period for each year. This analysis was done independently for discharge and rainfall as well. I aggregated daily values for discharge and rainfall to monthly totals because daily values did not fit the model well, especially for rainfall. I therefore obtained mean annual water level, discharge, and rainfall, amplitude, timing and fit to harmonic model (Nuttle 1996). The fit to the model was used as a measure of data fit to a sinusoidal curve, with a distinct wet and dry season.

$$y_j = \bar{y} + \sum_{k=1}^{N} A_k \cos\left(\frac{2\Pi j}{2N} - \phi_k\right) \text{(eq. 8)}$$

I used a calendar year (Jan-Dec) rather than a water year (Apr.-Mar). This decision was based on the logic that females in the Everglades may breed and nest yearly (Howarter unpublished data). Therefore, some time period prior to courtship (Mar-Apr.), the female begins acquiring resources to invest in reproduction. During the dry season, when food is concentrated, usually body condition is highest for alligators (Rice pers. comm). I also used this time period so that one distinct peak occurred during each year. I determined normality by inspecting the data graphically. I used a backward stepwise regression analysis to examine relationships. To see how rainfall and discharge influenced water levels in Shark Slough, I examined how amplitude, and mean water levels were affected by amplitude and monthly discharge and rainfall (Table 11). I then examined individually if the dependent variables (nesting effort, proportion of annual nests flooded and proportion of annual nest failure) were correlated to independent variables [harmonic components (annual mean, time to maximum peak, amplitude, period of annual water levels and rainfall), discharge totals from S-12's, water levels at NP203, and rainfall at NP203). I used a backward stepwise multiple regression to remove insignificant variables.

Mean water levels at NP 203 SS were affected primarily by mean Surface water discharge from the S-12's (1985-2004):

$$\text{Ln(Mean Water level in Shark Slough) cm} = \text{LN(Mean Discharge from S-12's)} * 0.351 + 1.614 \quad (R^2=0.84) \qquad \text{(eq. 9)}$$

Because rainfall is so variable both spatially and temporally, I also looked at how the sum rainfall on a weekly and biweekly time interval were related to the difference in waterlevel from p33. Rainfall did not appear to influence annual stage harmonic components, however on a weekly to biweekly time scale, rainfall explained 43.0 % of the difference in stage.

I revisited Kushlan and Jacobsons' hypotheses and assessed if any restoration to the seasonal predictability exists in the Everglades. I followed Kushlans' example to examine predictability, I performed separate regressions for four time periods using station P33 in Shark Slough, from 1960-1969, 70-82 (minimum water deliveries), 83-93 (modified water deliveries (MODwaters), 94-05 (IOP, ISOP). I wanted to see if mean water levels from June 15-July 1st (time of nest construction) could be used to predict maximum water levels during incubation of nests (from July15-Sept15). From 1960-69, the correlation coefficient was 0.82, from 70-82, it was 0.45, from 83-93 it was 0.76, and from 94-05 it was 0.24.

This indicates that there was some predictability restored from mid- 80's to early-90's, this interestingly corresponds to the testing periods of MODWATERS. IOP and ISOP years however do not appear to have improved predictability, since this predictability no longer remains during these time periods. Especially since 2000 large numbers of nests continue to flood and fail to hatch to this day in part this may be because of both management, as well as greater numbers of hurricanes.

I do not think the predictability is a useful measure of successful restoration because according to this philosophy, the 1960's had a greater predictability (r^2 value), during this time however, very little water was being released into the park. Using the r^2 would falsely suggest a measure of predictability. Perhaps the slope measurements of these linear models would be a better measure. I examined the proportion of nests flooded as a function of the slope of the water levels during incubation (Fig. 19). I found greater slopes, or greater rate of change in water levels during incubation led to greater proportion of nest flooding in Shark Slough.

RELATIONSHIPS BETWEEN NESTING EFFORT, FLOODING AND FAILURE OVER TIME

NESTING EFFORT RELATIONSHIPS

For all analysis I used only nests from Shark Slough because 85% of all the nests occur within this basin. Also I only used those within 500 m of each transect to compare nesting effort across years (Table 5).

Fleming, Dalrymple, and I all found that in wetter years more nesting effort occurs and most nests are distributed within the central slough. Previous studies found a positive linear relationship (Adj. R^2=0.39) between nest effort and mean water level in during April 15-May 15 (Dalrymple 2001). I used Dalrymple's approach which focuses on water levels, with the additional data set and found correlations that were consistent with what he found. Water levels, however, do not necessarily represent the complexity of hydropattern. By ignoring the timing and periodicity that are important components of annual hydropattern, and may affect nesting, considerable variation among these relationships remains unexplained (eg. Nest flooding as a function of discharge amplitude and timing). I used a different approach by using a harmonic analysis to examine hydropattern correlates of abundance to see if I could improve fit of the data. To do this, I fit rainfall (in.), and water level (cm) to a sinusoid model and obtained yearly mean, amplitude, timing to peak and fit of the data to harmonic as a measure of the periodicity of the year. Although the nesting season only occurs during a part of the year, water levels are often correlated between peak water levels (a time period that falls outside the flooding and nesting season) and water levels during nest construction. I also used as a separate independent variable regional rainfall from four hydrologic stations from January to June, this would cover courtship, breeding, and sometime prior to this period. I graphed each component and transformed them if necessary. I found mean annual water levels, and periodicity explained 56.0 % of the variation in yearly nesting effort (Fig.20; Table 12; eq. 10).

Number of annual alligator nests counted in SRF's in Shark Slough = mean annual water levels (cm)* 1.103 – periodicity (r^2) * 93.939+ 53.438 (eq. 10)

In other words, a wet dry season, and overall wetter years usually led to more nests (I had to remove 1992 and 1993 from analysis because of incomplete water or rainfall data).

NEST FAILURE AND FLOODING

NEST FAILURE

Nest failure is mostly caused by flooding, (Fig. 21). However, in years of drought nest failure also occurs. Nest failure during very dry years was not because of depredation. It appears that of the few nests found during these years (i.e. 1989) eggs laid had either arrested development or were not viable. It is unknown why this occurs. Depredation, is a minor cause of nest failure (less than 5% of annual nest failure) in ENP. I examined both the relationships between the annual proportion of nests flooded and failed in Shark Slough Basin, as a function of the harmonic components (amplitude, mean, timing and rsq) for annual S-12 discharge (aggregated by month), water levels in Shark Slough (NP 203) (daily)centimeters, and rainfall (aggregated by month) inches. I also had to remove 1992 (Hurricane Andrew destroyed several water stations) and 1993 from the analysis since there were continuous months of missing daily water level, and or rainfall data. Annual percent of nests flooded was correlated to the annual percent of nests that failed (R^2 adj.= 0.41). Using the harmonic components in a backward multiple stepwise regression analysis I found that most importantly timing of discharge, and to a lesser extent amplitude and mean water levels were correlated to nest failure (Adj. R^2=0.61; Table 13;Fig. 22; eq. 11).

Annual proportion of total American alligator nest failure = mean annual water levels x1 *0.004 + Amplitude of Slough water levelsx2* 0.007+ timing to peak discharge x3*-.002 + 0.734 (eq. 11)

NEST FLOODING

Not surprisingly, the correlates were similar between nest failure and flooding (Table 14). I found a negative linear relationship among the proportion of annual nests flooded with timing of peak discharge, a positive logistic relationship with amplitude and positive

Some errors I encountered are noted on three hard copy proofs of data which will be filed in the SRF file cabinet with the other data in the last row. Each hard copy has a brief explanation to changes. I have had to find nest locations where they were not input in the database tables. Some location data in tables did not match field sheets, this was usually due to data entry problems. For example one year, all the transects were off by one. In another year the coordinates were slightly off in the computer by .01 degrees at least. In some cases Elaine reentered the data to make sure it matched the field sheets. Some field sheet data specifies nests in sampled areas (eg. NESS, SS, etc) yet when plotted it does not occur in the area mentioned, therefore this was fixed according to recorded long and lats. Also found errors when plotted, some nests were plotted by lake Okeechobee or in the EAA. I checked to see where the problem was, usually it was some data entry error. When visualizing data in GIS it was apparent that transect shapefiles did not match transects from field sheets. It turns out that these transects were made in UTMS not projected from the decimal degree minutes and did not convert to the correct numbers, therefore I made a new transect shapefile and jpg (basins06transectsroadscanals06). I have checked the data several times. H. Fitting and I went over new changes, therefore the most recent file is in the wildlife drive.

Some data in the Oracle tables is not recorded on the field sheets (i.e. observer). I did not put anything in this field. Previous records state that one should put R for all.

THE NEST CHECK DATA

All data has been checked and hard copies have been proofed 2 times. Proof 3 has the most recent corrections. Hard copies of these proofs will be kept in the back of file cabinet with SRF data I added corrections into the nest visit table. Although a query was used to proof data, corrections will be made to individual predefined tables with date of modification in title. Several inconsistencies exist in this data such as confusing infertility and nonviability, fate of eggs, measuring in inches rather than centimeters, I converted all inches to centimeters-to keep consistent. Aerial checks and ground checks will be defined. I added several columns to the nest visit table, including type of visit-ground (G) aerial check (A), or

was nest seen later not in SRF (NOT). I also added a viable and nonviable column, viable removed and nonviable removed. All egg categories (viable +nonviable=total, also all flooded, crushed, infertile, fertile, etc together equal total eggs counted). Because both viable and nonviable eggs were removed in some years (Table 2), I placed the number removed under either viable or nonviable removed (how they were classified at time of removal), and I placed this number in the subsequent visit. For example if eggs were removed at visit one, I put the number removed, let's say 3, at visit 2. I did this since the eggs seen at visit one were classified including the removed ones. Therefore one needs to subtract viable removed from viable, and nonviable removed from nonviable. I also added columns for presence of juveniles, turtle eggs, presence of female, estimated size and rating of aggression. I added the female information because the female table that was created previously in Oracle was inconsistent. Sometimes females not present but given numbers, there were female sequence numbers in the female table that were absent in the nest visit table, therefore not allowing a complete link between the two tables. Most importantly I added a column designated as nest status. This column numerically assigns each nest at each visit a category (see Metadata). I modified Mazzotti and Rice's access database of Statewide Alligator nesting data to base my categories for nest status (Table 4).

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Table 1. Data collected each year for SRF 1985-2005

Year	Survey Types	Egg Removal	Basins Sampled	Recorded	Water Depth
1985	g	0	sn	nr	nr
1986	g	0	sn	nh, naw	cm
1987	g	0	sn	nh, naw	cm
1988	g	0	sn	nr	cm
1989	g	0	sn	ck	cm
1990	g	R	sn	nh=nest height	cm
1991	g	0	sn	nh=nest height	nr
1992	g	0	snte	nr	nr
1993	g	0	sntep	nr	nr
1994	g	0	sntep	nr	cm
1995	g	R	sntep	nr	cm
1996	g	R	sntep	nr	cm
1997	g	R	sntep	nr	cm
1998	g	R	sntep	nr	inches
1999	g	R	snte	nr	cm
2000	g	R	snte	ch, topc, h=nh,d	no units, prob. Cm
2001	g	R	snte	ch,top	inches
2002	ag	0	snte	nh	inches
2003	ag	0	snte	nr	inches
2004	ag	0	sntep	nh	inches
2005	ag	0	sntep	ch,nh, females,d	cm

Codes:	a=aerial g=ground	R=removed	s=srs n=nes t=ts e=es p=PANHANDLE	ch=clutch height nh=nest height naw=nest above water females=captured at nest d= nest diameter	converted to cm in nest visit table

Table 2. Nests seen by each observer, both, and an estimate of total nests.

Transect	Obs. 1	Obs.2	Both	Nhat
65	3	1	1	3
66	0	3	0	3
70	3	4	2	5.666667
68	1	1	1	1

Table 3. Length of each transect sampled by basin in 2005.

Transect	Length of Shark Slough basin(Km)	Northeast Shark Slough	East Slough	RockyGlades	Taylor	Panhandle
55	16.00004	18.00004				
56	14.00012	17.73863				
57	14.00003	17.73851	7.11207			
58	14.00004	18.00005	9.21264			
59	14.00003	18.00004	12.00002			
60	18.00000	17.31745	10.00000			
61	18.00003	14.27204	11.51136			
62	18.00003	13.25677	11.51098			
63	18.00002	13.77102	16.00002			
64	18.00003	13.82512	13.78611			
65	20.00003		8.00001	11.37394		
66	22.00003		4.00001	11.27579		
67	24.00004		4.00001	11.38190		
68	24.00003		2.00000	12.68421		
69	24.00003		3.70520	13.22924		
70	20.00003			14.79824		
71	16.00003			15.18966		
72	10.00002			17.16247		
73				9.16594	8.00001	
74				4.79923	16.00007	
75					22.81188	
76					24.82954	
77					26.00015	10.15926
78					26.00001	10.36972
79					24.00084	10.79112
80					24.00000	11.21176

Table 4. Nest Visit Table codes

NEST STATUS

1=HIGH INTACT
2=PARTIALLY FLOODED
3= COMPLETELY FLOODED
4=DEPRADATED
5=FALSE NEST
6=UNDER CONSTRUCTION
7= OLD NEST
8=hatched
82=hatched and partially flooded
84=hatched and predated
9=unknown
10=not found
11=not a nest

negative (-999)= not reported

NEST CHECK TYPE

1= GROUND
2= AERIAL
3=NOT=not seen at SRF but seen at nest check

JUVENILES SEEN

1=YES
HATCHED
YES/ NO

VIABLE=FERTILE+HATCHED +KB
NONVIABLE=INFERTILE, ARRESTED DEVELOPMENT, FLOODED, CRACKED, OTHER

To obtain the number at the nest after removal subtract total viable minus viable removed, and nonviable=nonviable removed.

REMOVED VIABLE MINUS VIABLE
REMOVED NON VIABLE MINUS NONVIABLE

80	**25**	**17.97**	18.12	17.82	**26.84**	**48.08**

Survey Areas:

Shark Slough = Tr. 55 - 72, L67 to just west of Tram Rd. at approx. 80' 49.00 or to end of high water.
NE Shark = Tr. 55 - 63, L31 N canal to L67
Taylor Sl. = Tr. 74 - 76 eastern boundary to Park Road and Tr. 77 - 80 U.S. 1 to Park Road if there's H20.
East Sl. = approx. Tr. 57 - 69, within slough high H20 areas
Rocky Glades = Tr. 64 - 73 to edge of Shark Sl.

Appendix 2. Corrected to be used 2006

Transect	Basin	East	West
55	NES	80 29.889	80 40.845
56	NES	80 29.803	80 40.848
57	NES	80 29.752	80 40.851
58	NES	80 29.742	80 40.853
59	NES	80 29.874	80 40.850
60	NES	80 30.905	80 40.86
61	NES	80 32.329	80 40.86
62	NES	80 32.940	80 40.865
63	NES	80 32.637	80 40.868
64	RG	80 32.609	80 40.87
65	RG	80 34.077	80 40.87
66	RG	80 34.140	80 40.87
67	RG	80 34.080	80 40.88
68	RG	80 34.500	80 42.08
69	RG	80 34.179	80 42.08
70	RG	80 34.440	80 43.27
71	RG	80 35.404	80 44.47
72	RG	80 35.424	80 45.68
73	RG	80 35.425	80 40.91
55	SS	80 40.845	80 50.417
56	SS	80 40.848	80 49.222
57	SS	80 40.851	80 49.222
58	SS	80 40.853	80 49.226
59	SS	80 40.850	80 49.227
60	SS	80 40.86	80 51.62
61	SS	80 40.86	80 51.62
62	SS	80 40.865	81 51.62
63	SS	80 40.868	80 51.62
64	SS	80 40.871	80 51.62
65	SS	80 40.874	80 52.82
66	SS	80 40.869	80 54.017
67	SS	80 40.879	80 55.212
68	SS	80 42.079	80 56.407
69	SS	80 42.079	80 56.408
70	SS	80 43.276	80 55.214
71	SS	80 44.472	80 54.021
72	SS	80 45.668	80 51.635
73	SS	80 45.670	80 51.635
74	SS	80 46.87	80 51.635
57	ES	80 49.23	80 53.475
58	ES	80 49.23	80 54.733
59	ES	80 49.23	80 56.41
60	ES	80 51.63	80 57.61
61	ES	80 51.62	80 58.500
62	ES	80 51.62	80 58.500
63	ES	80 51.62	81 01.195
64	ES	80 51.62	80 59.86
65	ES	80 52.82	80 57.611
66	ES	80 54.01	80 56.42

67	ES	80 55.22	80 57.61
68	ES	80 56.41	80 57.61

Transect	Basin	East	West
69	ES	80 56.41	80 58.62
73	TS	80 40.91	80 45.68
74	TS	80 34.35	80 46.87
75	TS	80 34.35	80 49.26
76	TS	80 33.76	80 49.27
77	TS	80 33.76	80 49.27
78	TS	80 33.77	80 48.08
79	TS	80 33.77	80 48.08
80	TS	80 33.77	80 48.08
77	PAN	80 27.57	80 33.77
78	PAN	80 27.30	80 33.77
79	PAN	80 27.07	80 33.77
80	PAN	80 26.84	80 33.77

Alligator Longitude start and stops

Corrected transects with basin boundaries, includes new SS Transect 73 and 74 west of park road

Original transect guide sheet used in 2005 and "some" previous years

SS=shark slough transects 55-72, L67 to west of tram road

ES= called east slough transects 55-63

RG=Rocky glades transects 64-73 to edge of shark slough

TS=Taylor Slough Transects 74-76 eastern boundary of park road and transects 77-80 US1-park road

NES=Northeast Slough, transects 55-63, L31-L67 canal

problem is in multiple years 73 and 74 were surveyed west of park road in SS (i.e.1992 and 1993)

NES transect 63 is in RG, transect 55 and 56 not in East Slough, therefore now stops at SS basin

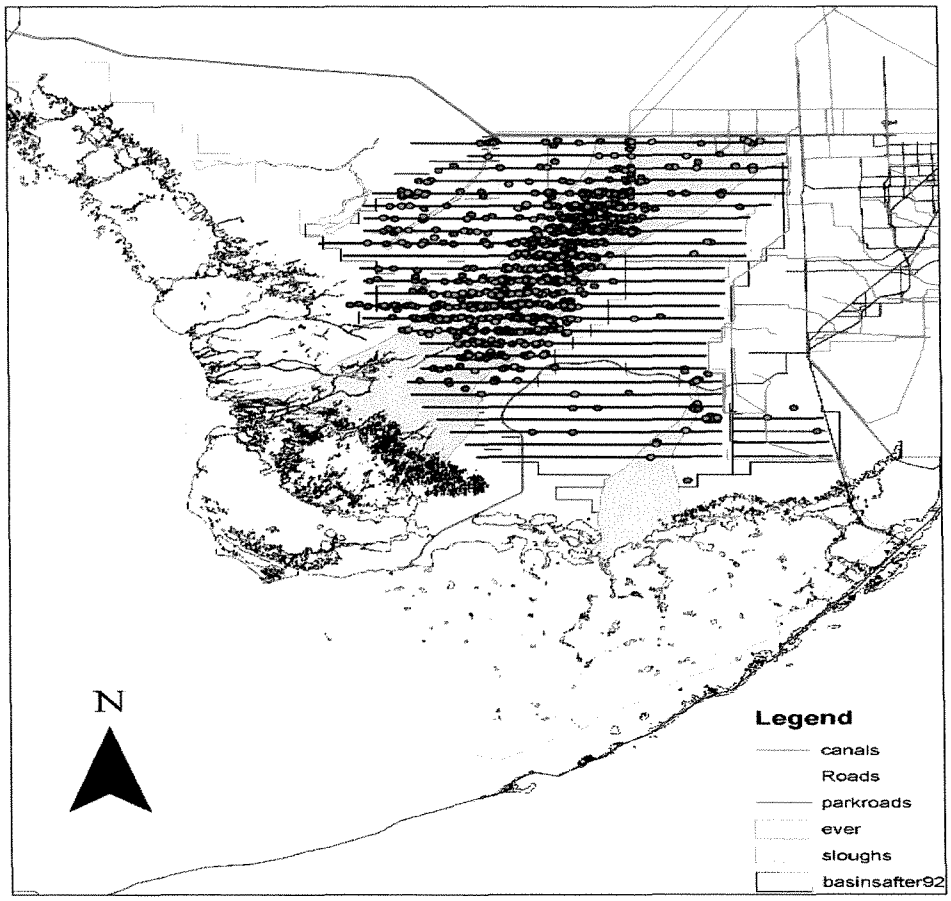

Figure 1. Map of American alligator nesting Systematic Reconnaissance Flight transects and nests observed from 1985-2005.

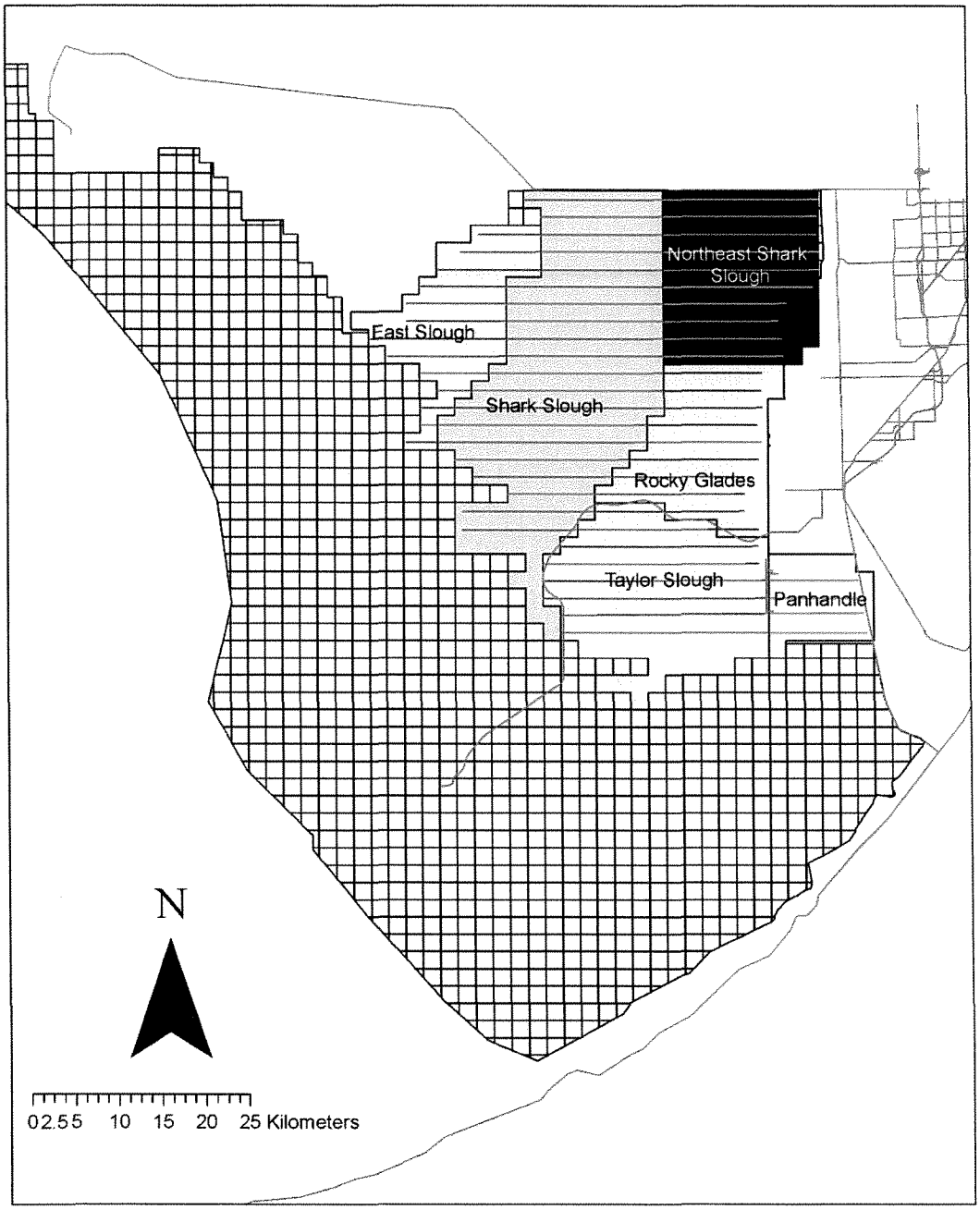

Figure 2. Basins sampled from 1985-1992, Northeast shark slough (NES)and Shark Slough (SS); 1993-2005, NES, SS, East Slough (ES), Taylor Slough (TS), Rocky Glades (RG), and off and on Panhandle (PAN). Transects (73-80) not consistently sampled, 73 and 74 often stopped at park road however there were years where they were sampled west of park road in SS (see Fig.1).

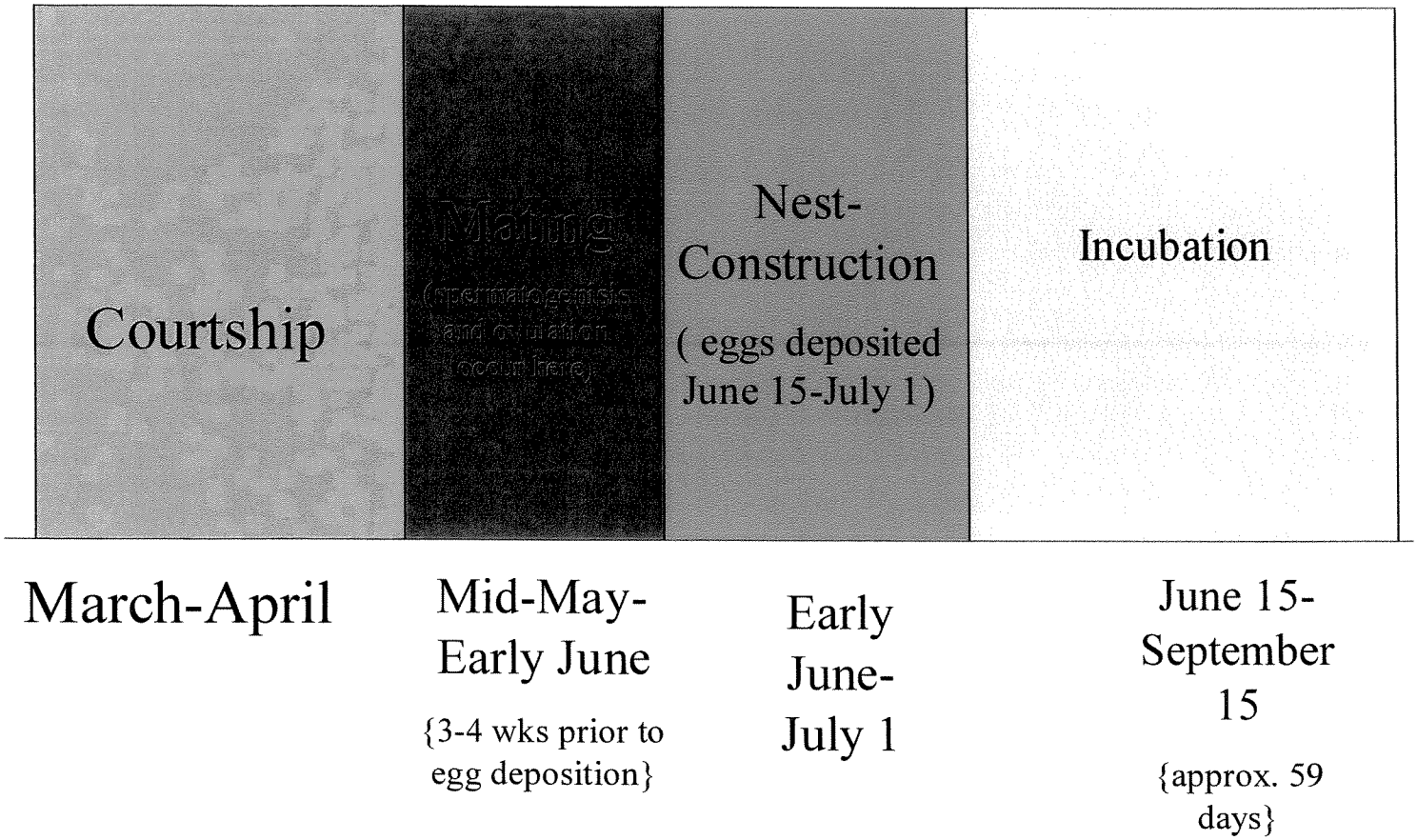

Figure 3. Alligator breeding and nesting timeline.

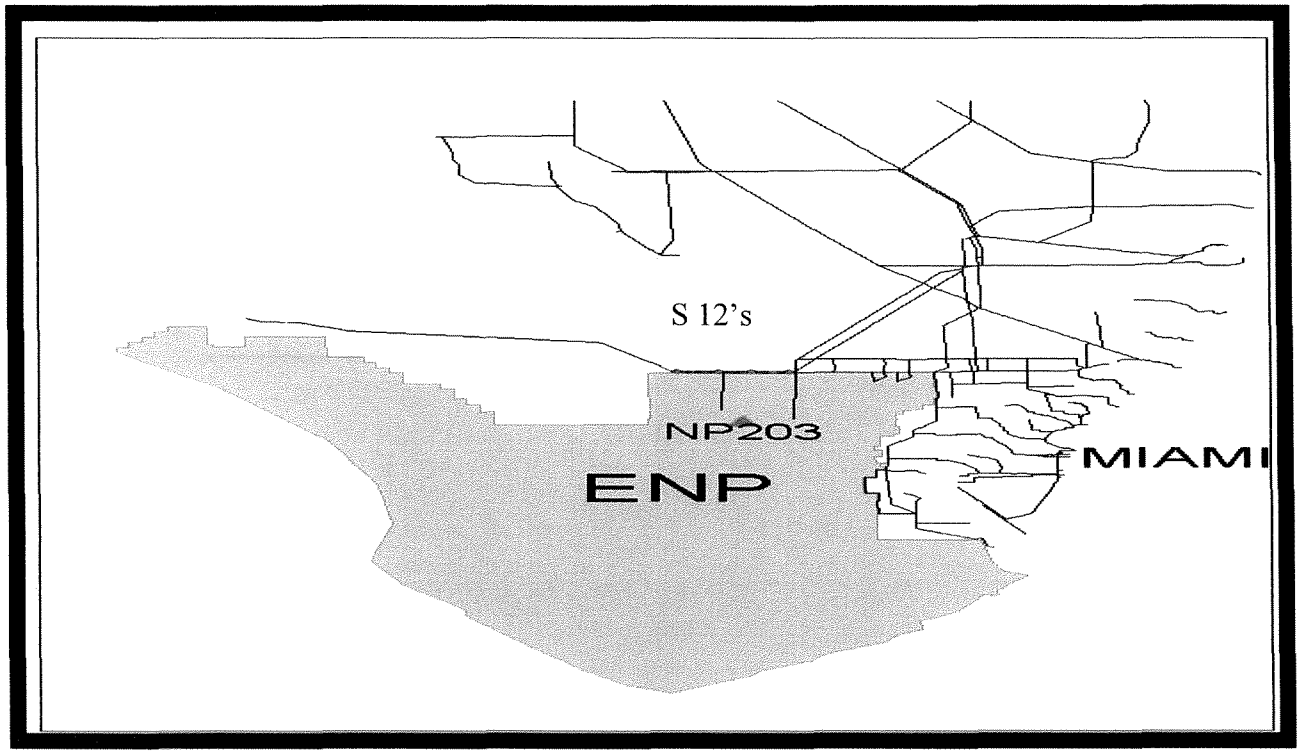

Figure 4. Map of water station NP 203 and S12 control structures.

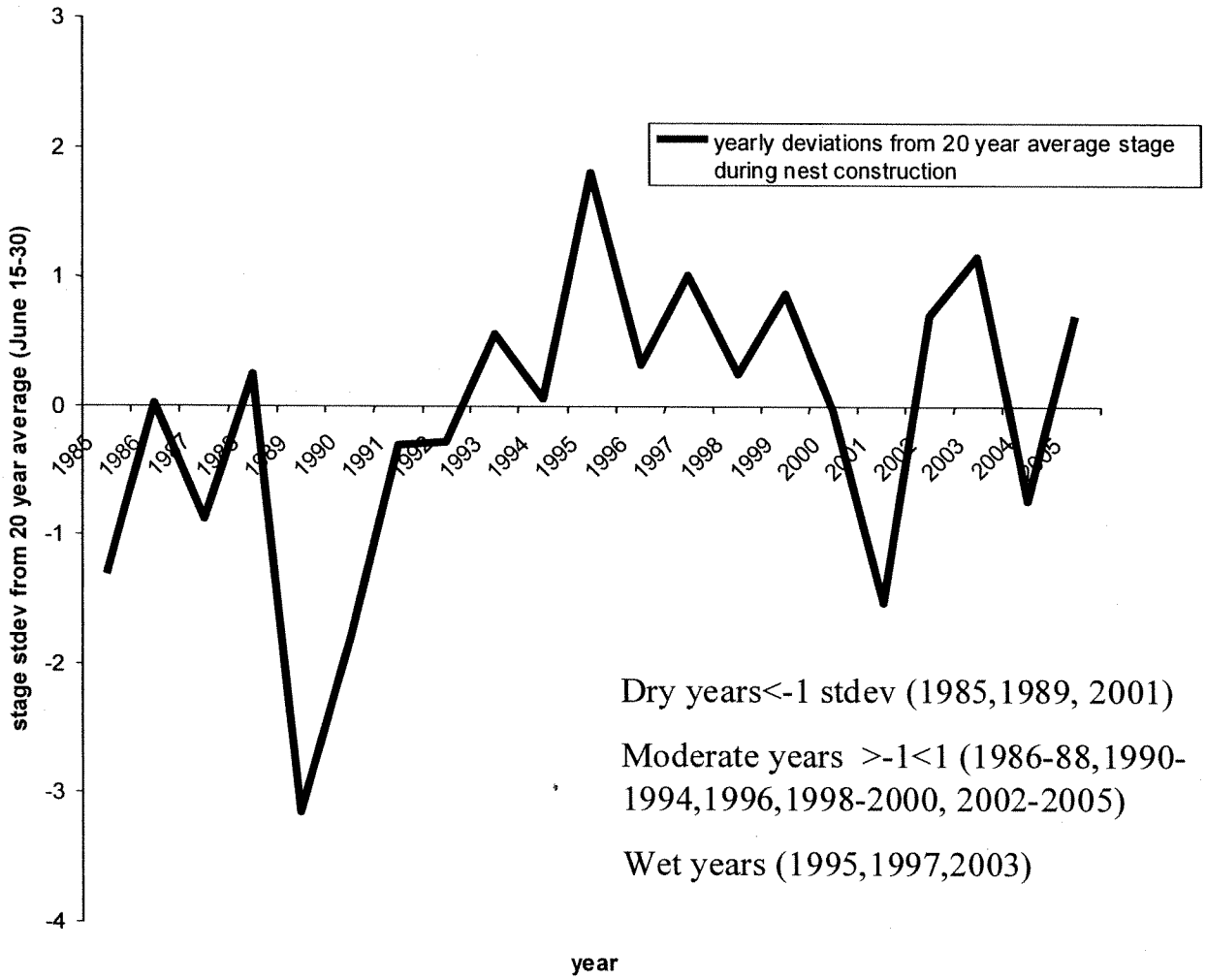

Figure 5. Deviations from the 20 year mean water levels from

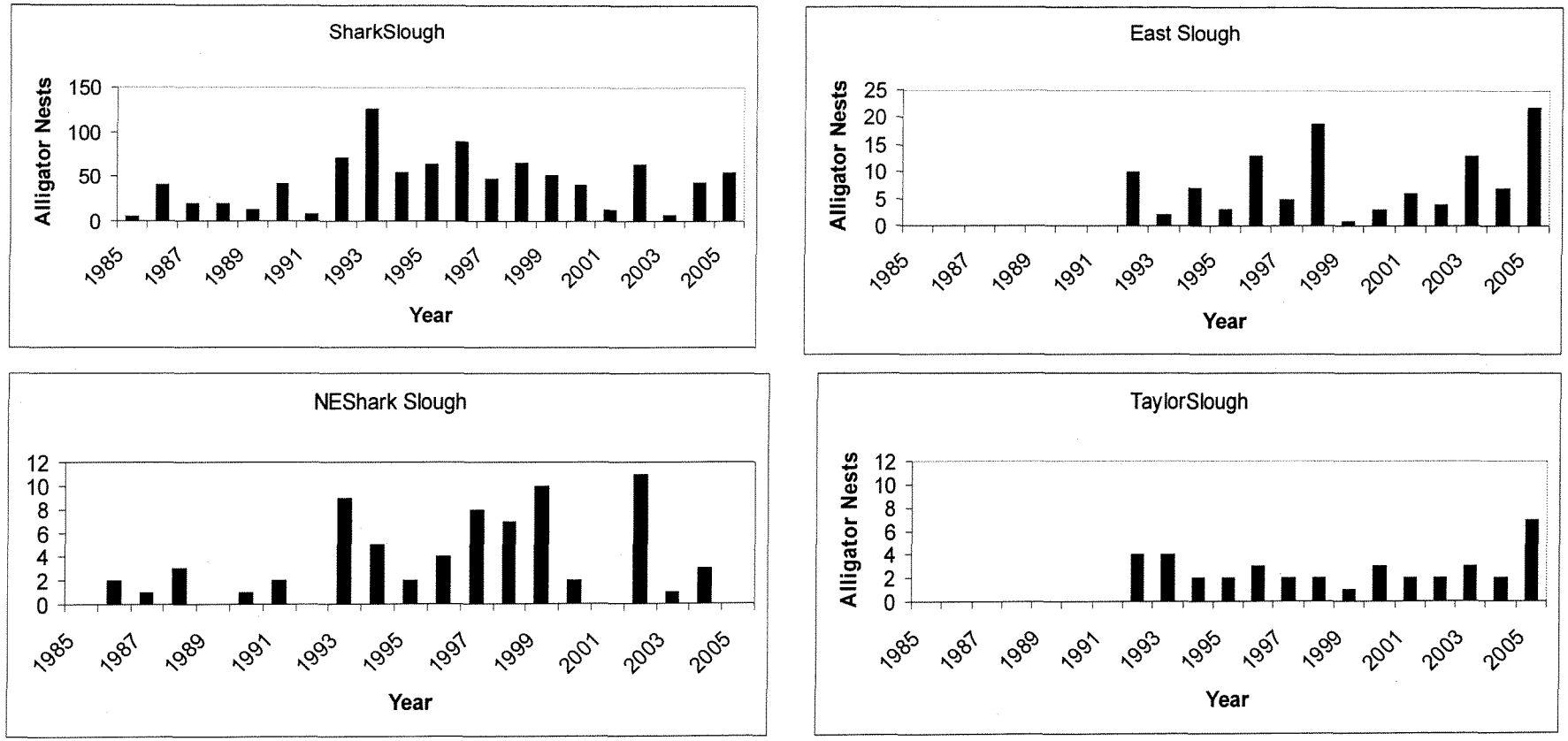

Figure 6. Alligator Nests counted within 500m belt transects (1985-2005) across Basins: SS-Shark Slough, ES-East Slough, NES-NorthEast Shark Slough, TS-Taylor Slough.

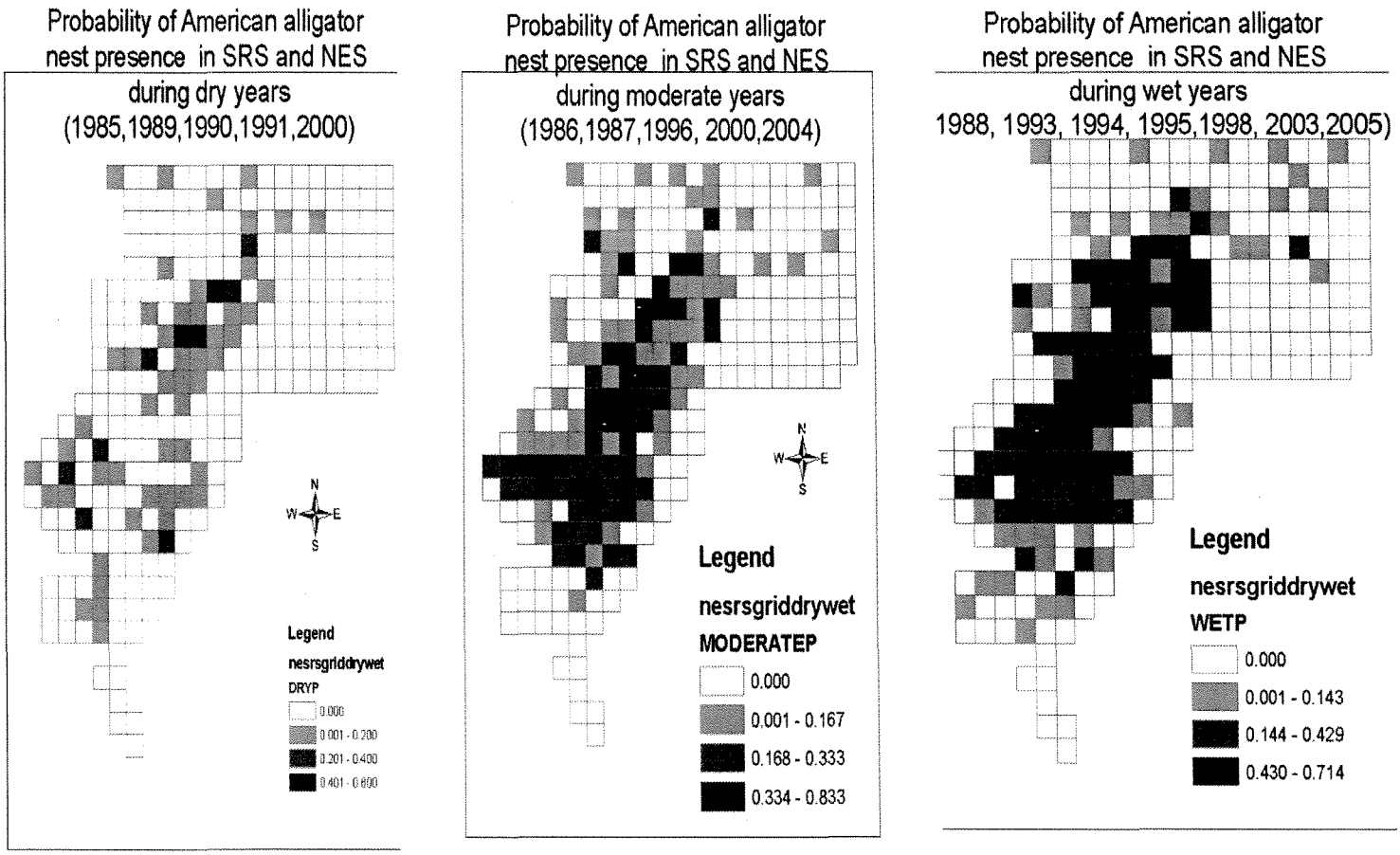

Figure 7. The annual probability of American alligator nests across Shark Slough and Northeast Shark Slough by moderate, dry and wet years (1985-2005) (2*2 km cell).

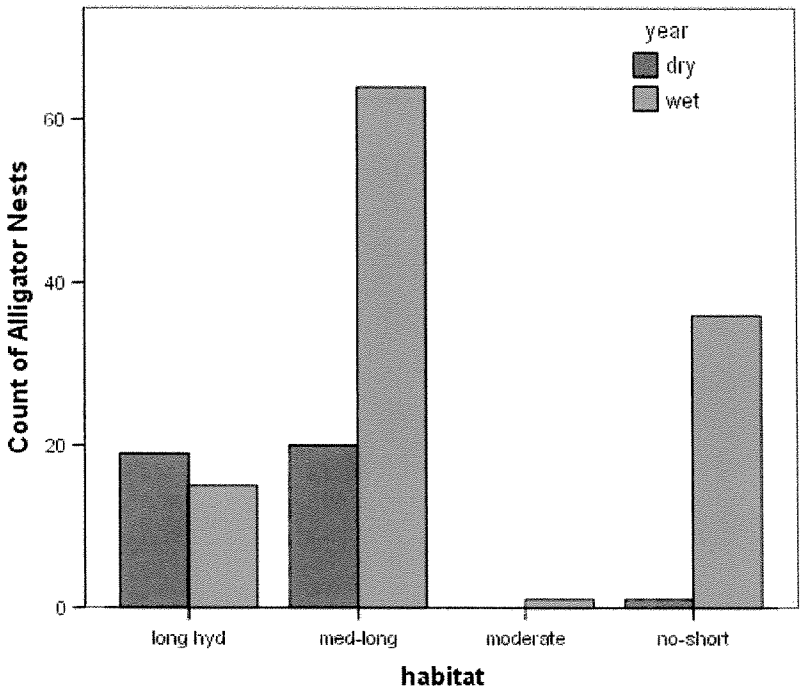

Figure 8. The proportion of American alligator nests found in dry to wet habitats by wet, moderate, and dry years.

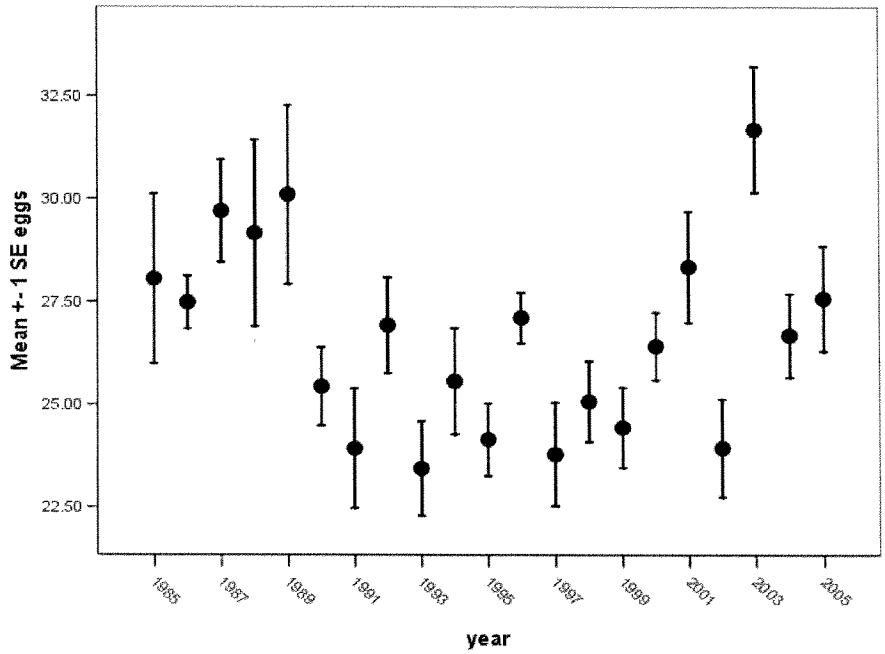

Figure 9. Average American alligator Clutch Size in Everglades National Park (1985-2005).

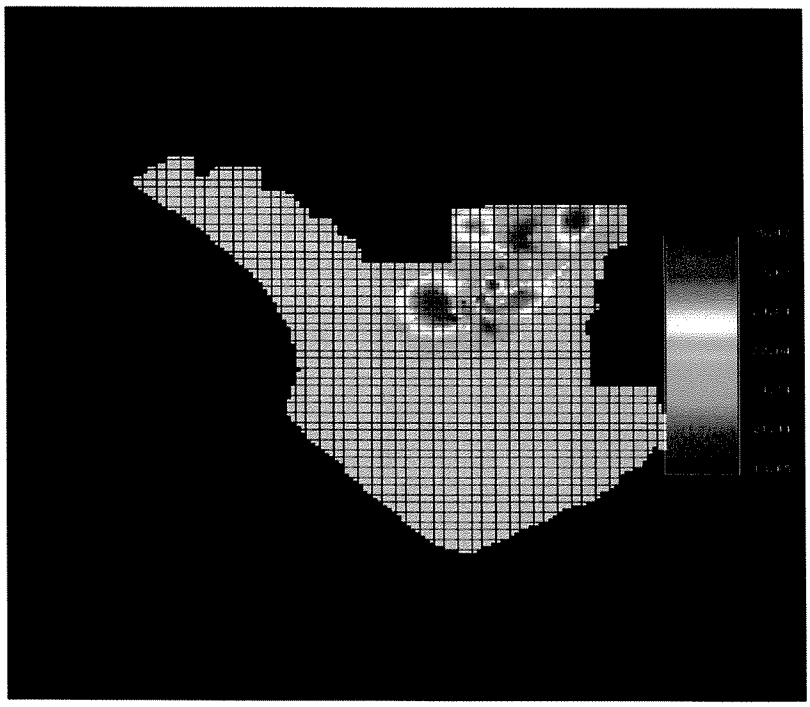

Figure 10. Clutch spatial patterns across Shark Slough Basin and NorthEast Shark Slough.

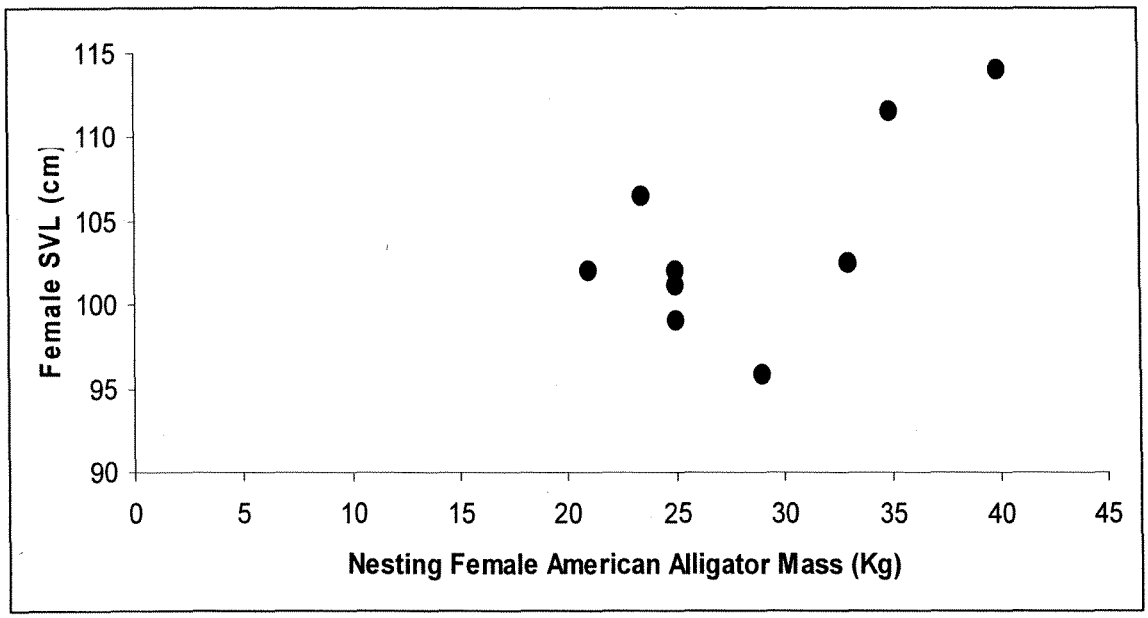

Figure 11. SVL as a function of body mass of captured Nesting Female American Alligator in 2005 (n=9).

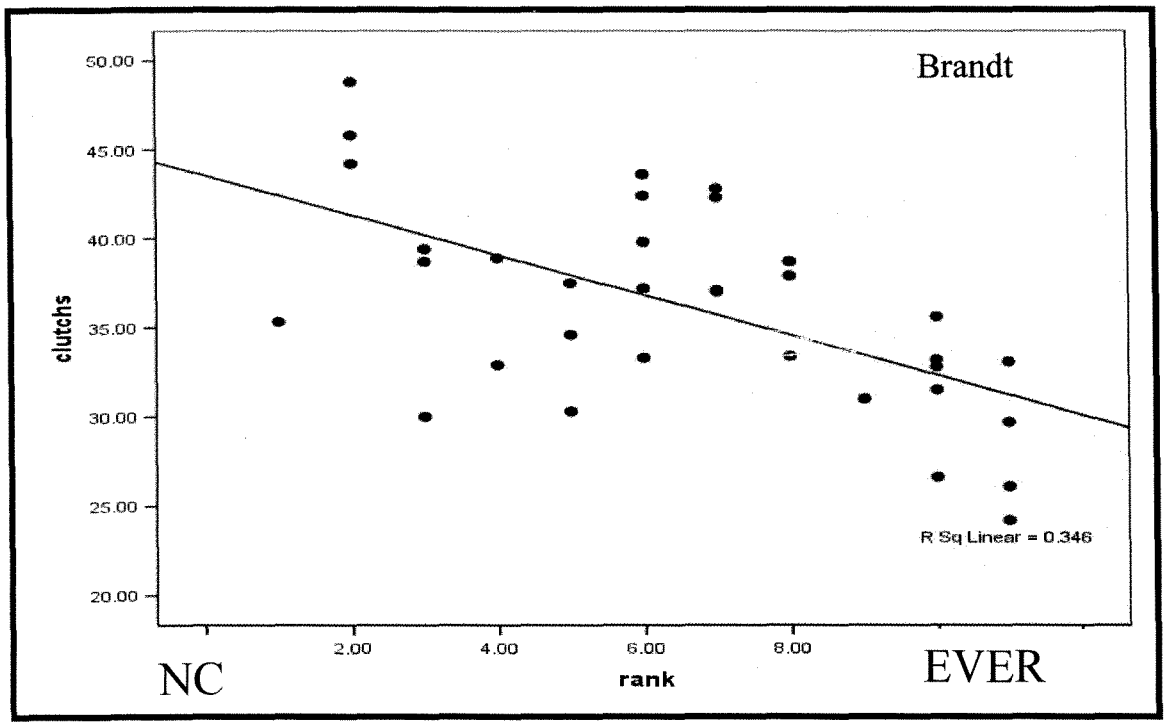

Figure 12. Decreasing trend in female body size from North Carolina to South Florida (Brandt unpublished data).

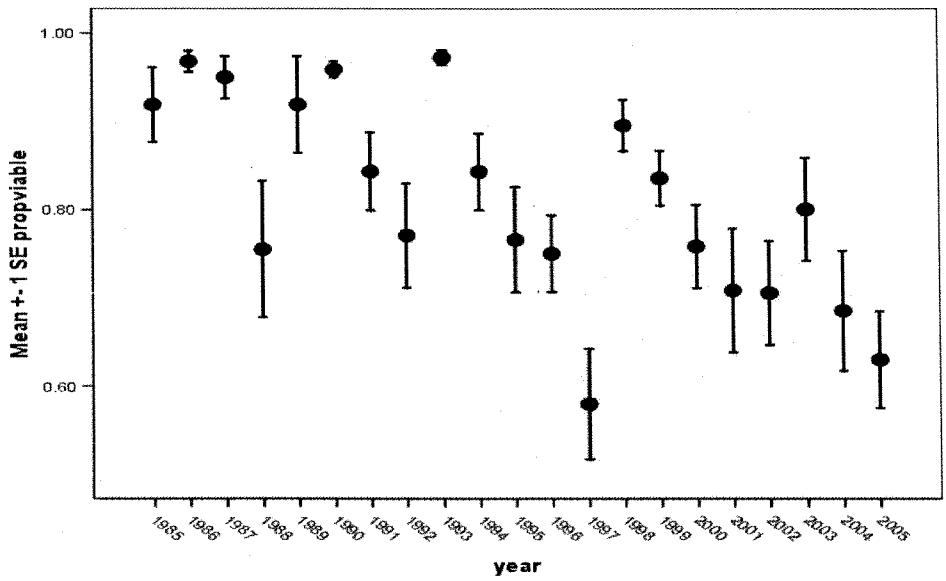

Figure 13. Average proportion of viable eggs per clutch at time of first visit from 1985-2005.

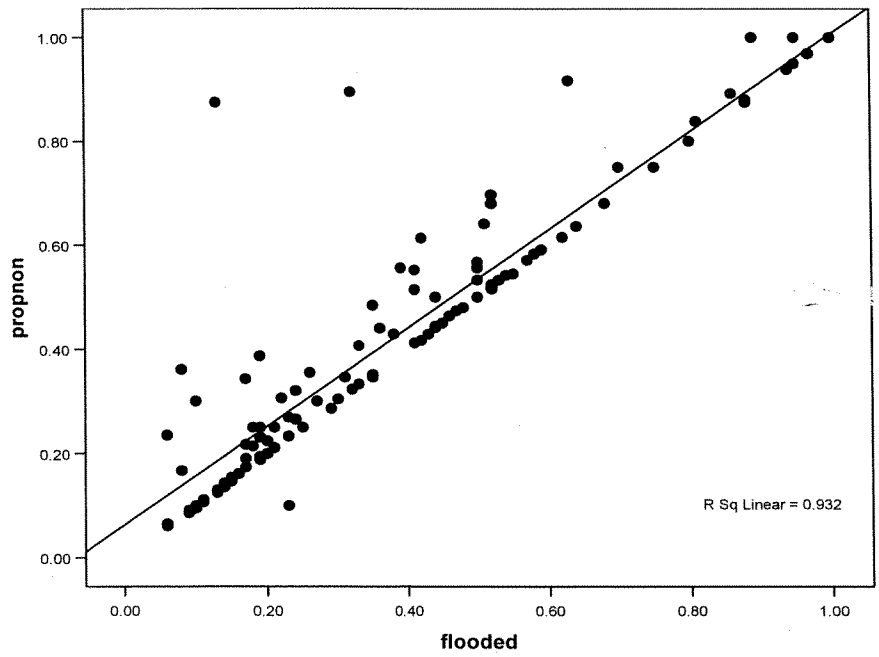

Figure 14. Proportion of flooded eggs in American alligator nests from 1985-2005 as a function of the total proportion of nonviable eggs in a clutch.

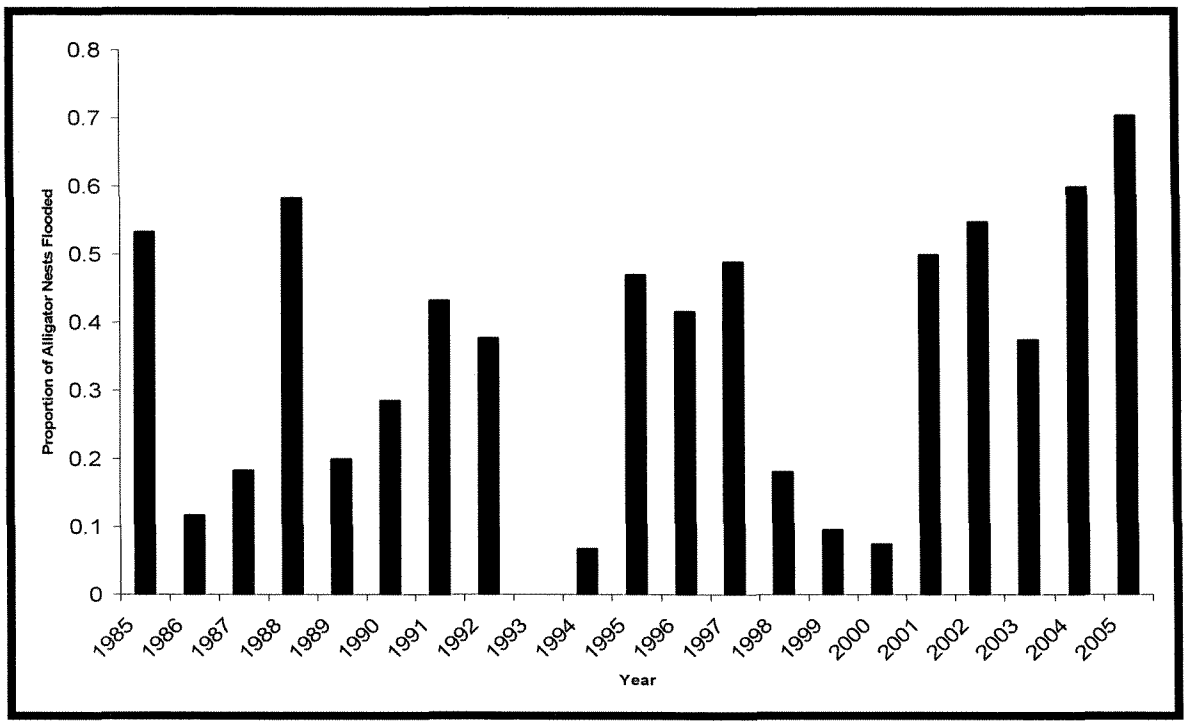

Figure 15a. Proportion of American alligator annual nest flooding during SRF nest visits 1985-2005.

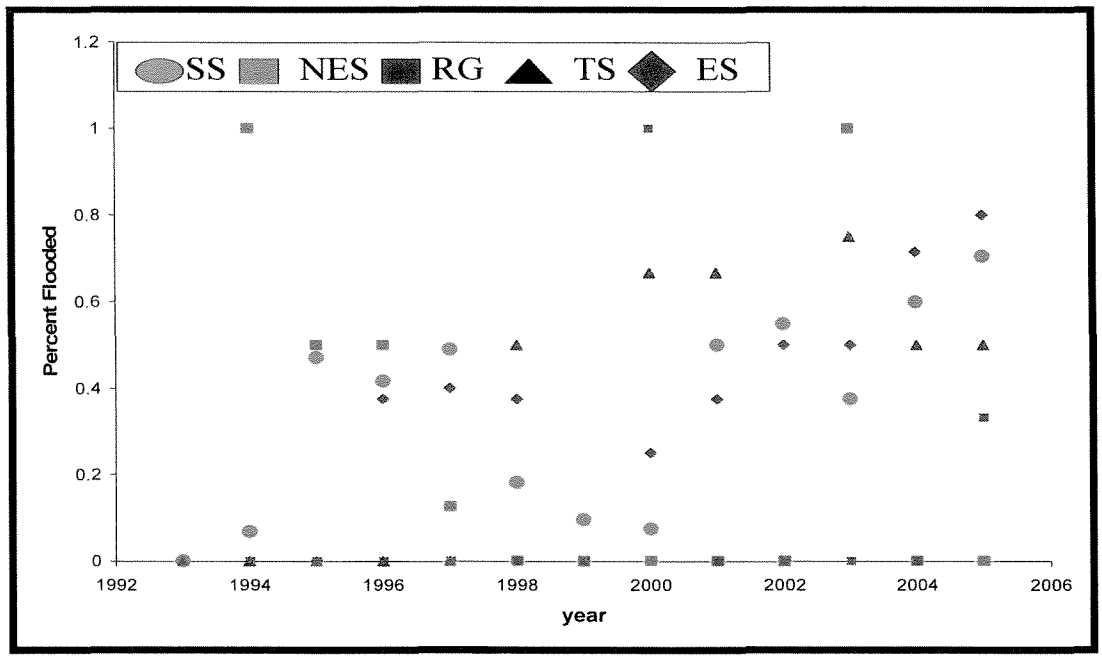

Figure 15b. Proportion of annual nest flooding by basin (ES- East Slough, NES-Northeast, PAN-Panhandle, RG-Rocky Glades, SS-Shark Slough, TS-Taylor Slough) from 1985-2005.

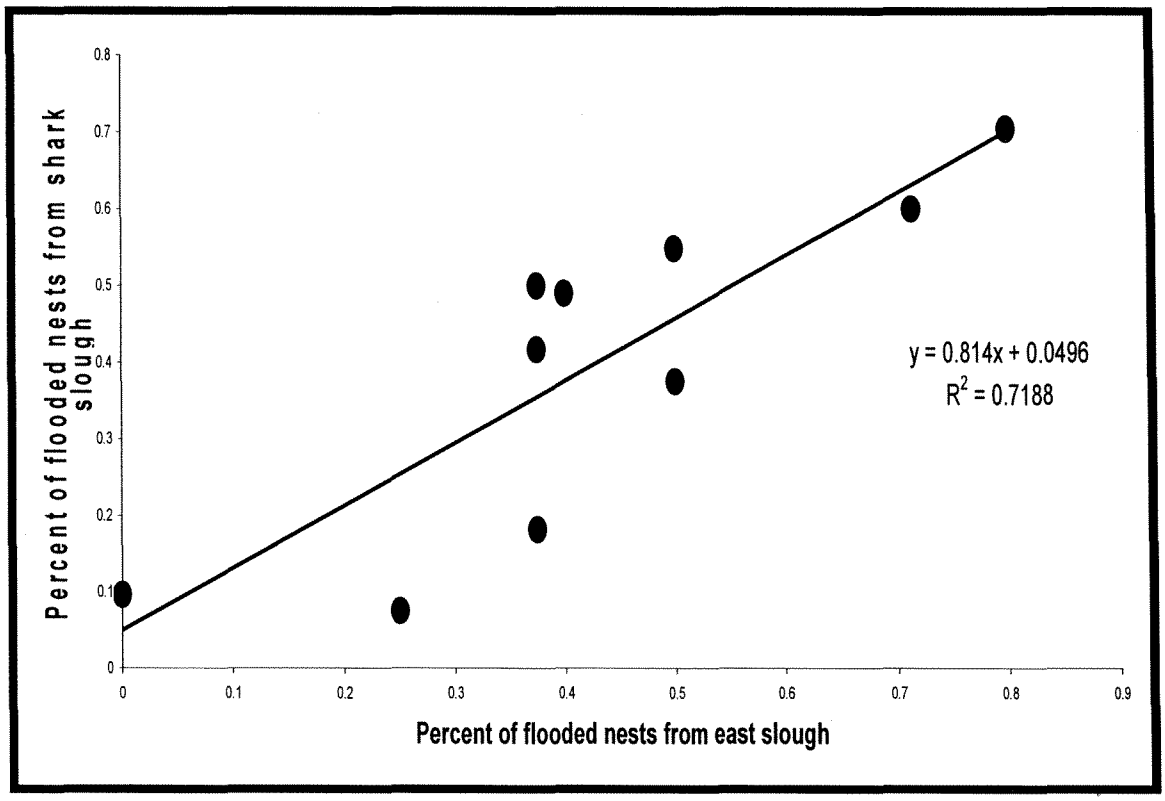

Figure 16a. The relationship of annual proportion of American alligator nest flooding between East and Shark Slough (1985-2005). ArcSintransSSES% Linear regression df 1,8 F=12.248 p< 0.008

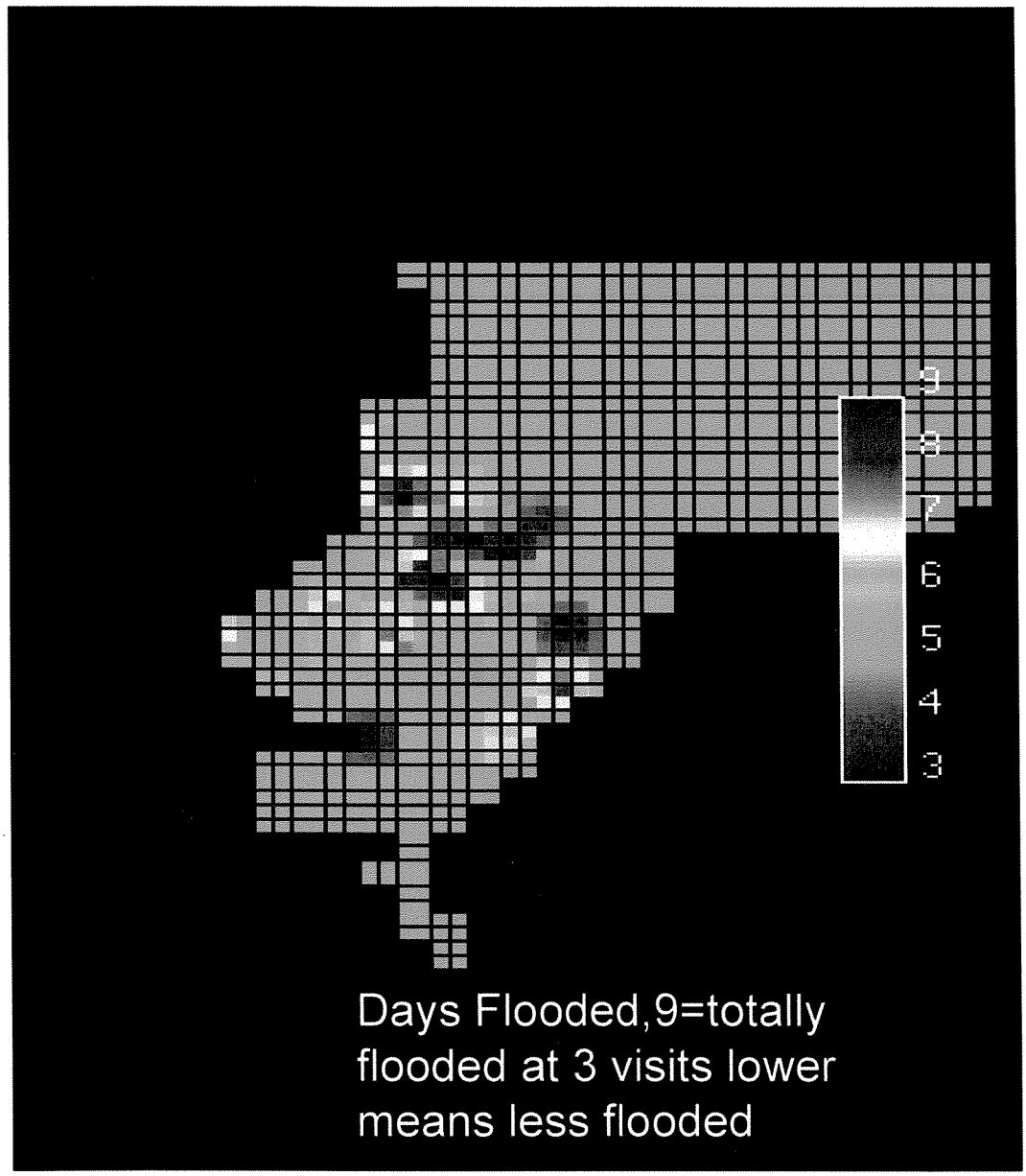

Figure 16b. A kriged map of Shark Slough showing no distinct patterns between the flooding of American alligator nests and geographic location within Shark Slough and Northeast Shark Slough.

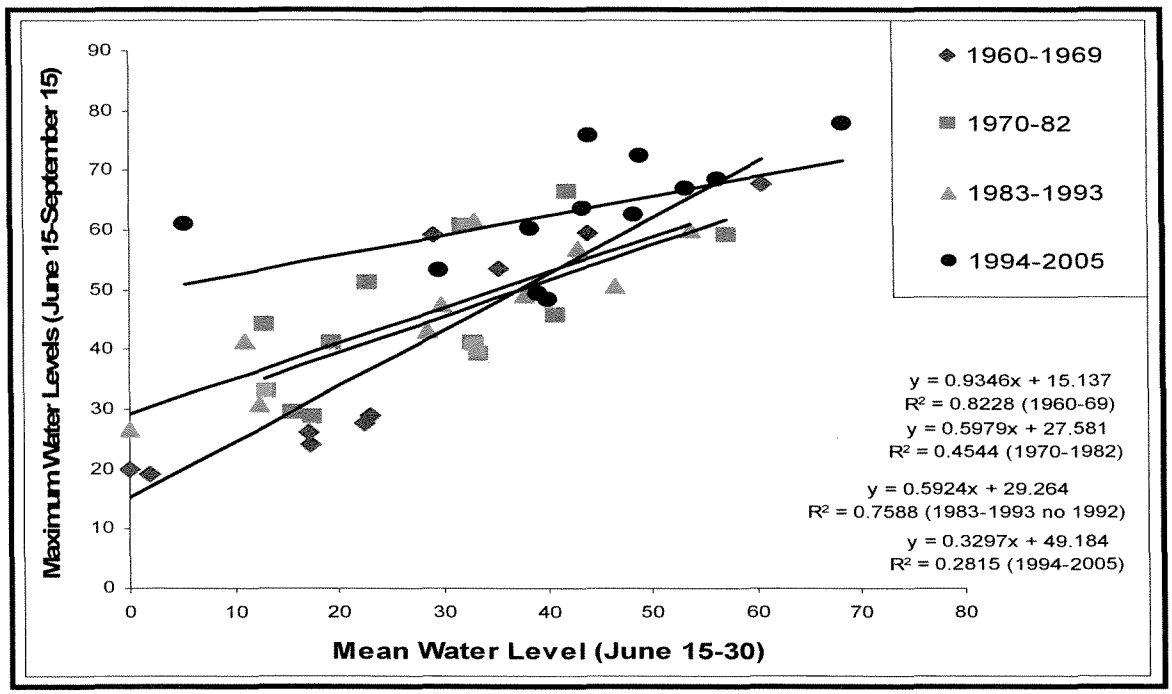

Figure 17. Mean water levels from June15-July 1st (time of nest construction) could be used to predict maximum water levels during incubation of nests (from July1st-Sept15).

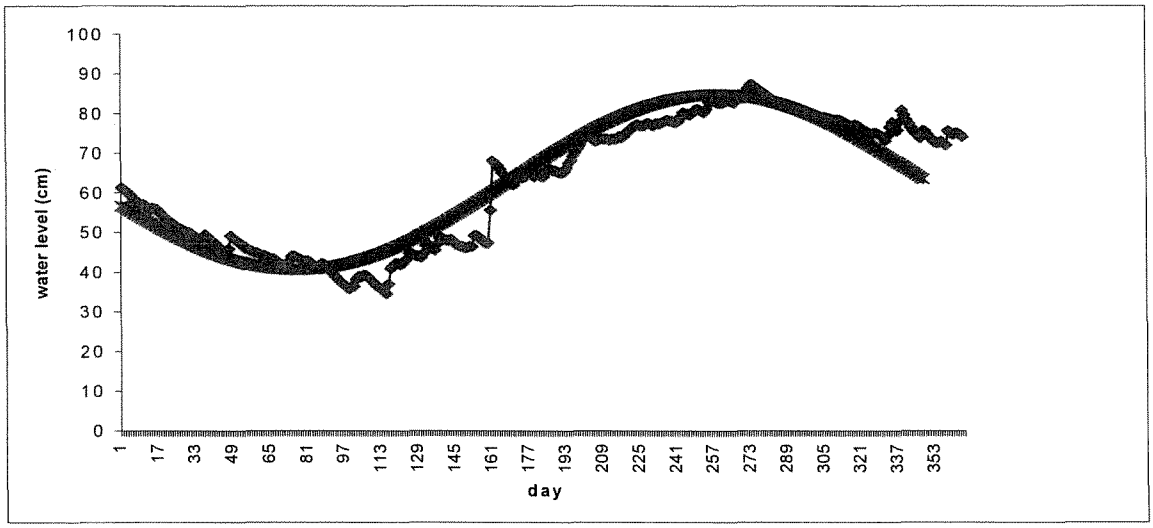

Figure 18. Example of a harmonic model characterized by the annual hydropattern in Shark Slough, Everglades National Park using water levels (cm) from Station NP 203.

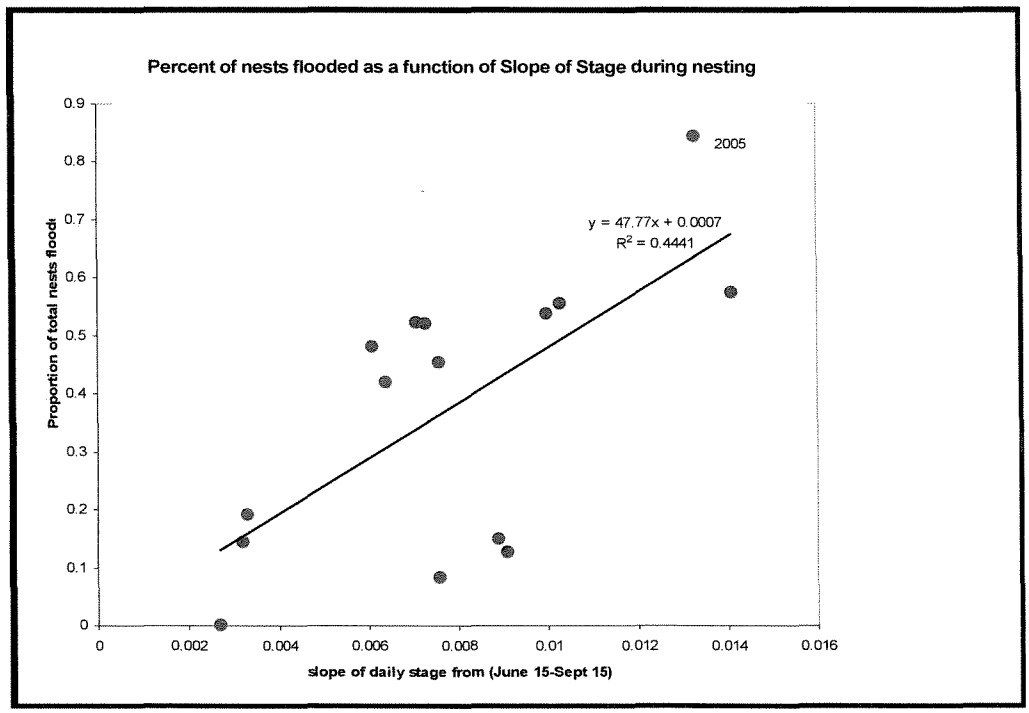

Figure 19. The proportion of annual American alligator nests flooded as a function of the slope of the water levels during annual incubation (July 15-Sept. 15).

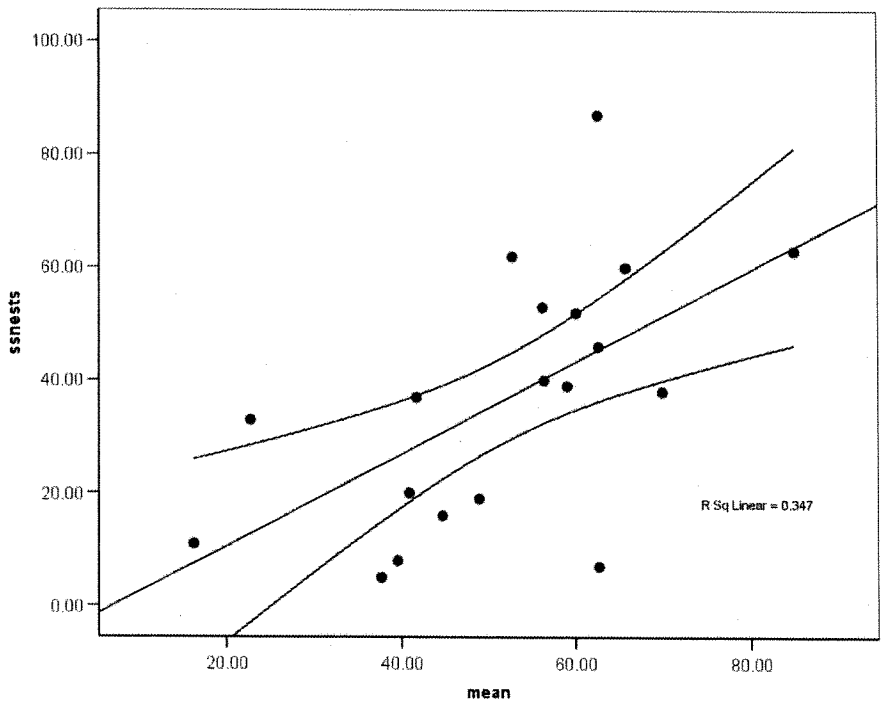

Figure 20. Annual number of American alligator nests counted within transects in Shark Slough Basin as a function of annual mean water levels in Shark Slough (NP 203).

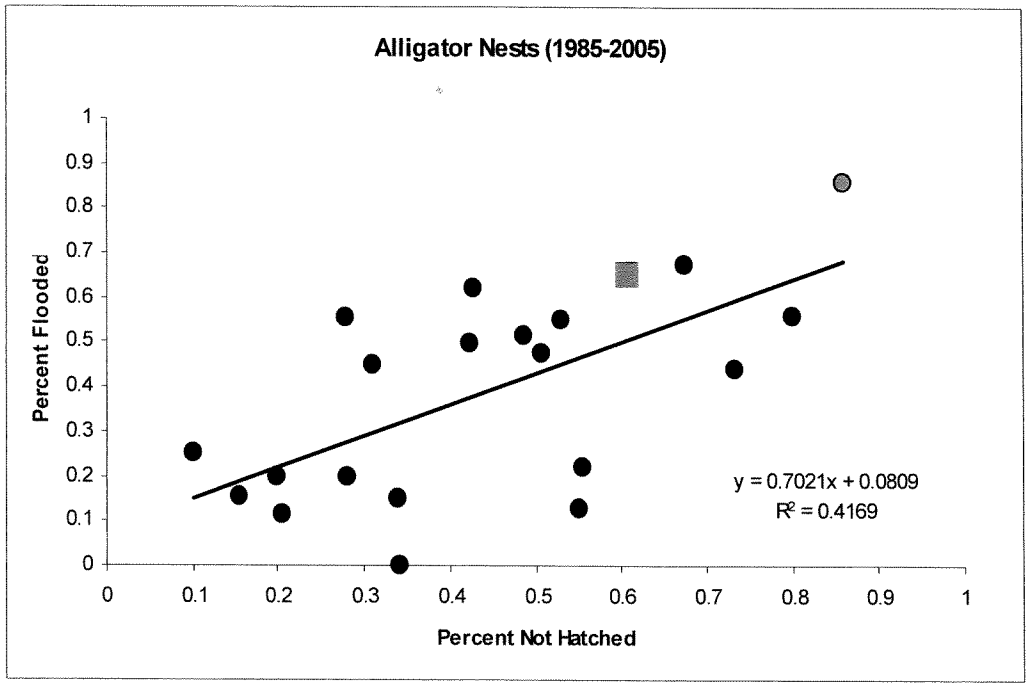

Figure 21. The relationship between the proportion of annual flooded American alligator nests and the proportion of annual failed American alligator nests.

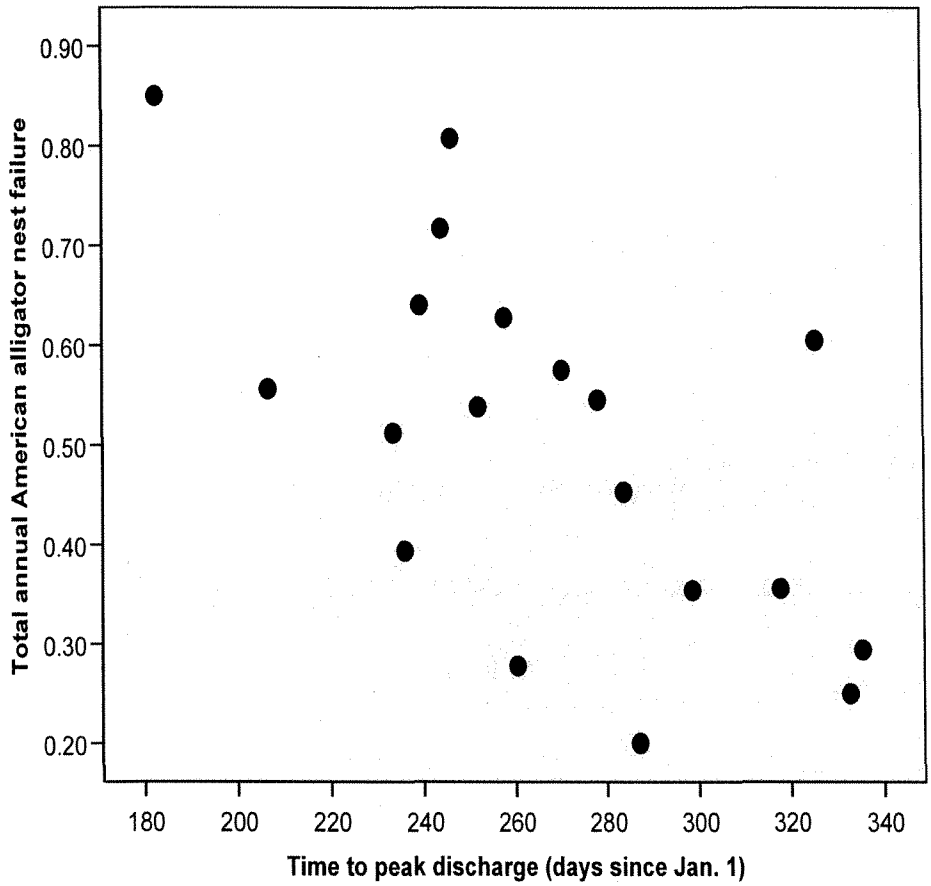

Figure 22. The relationship between the annual proportion of American alligator nest failure and the timing of peak discharge through the S-12 structures (Cf/s).

NO 92 & 93, timing of discharge alone explains 66% of variation in flooded nests

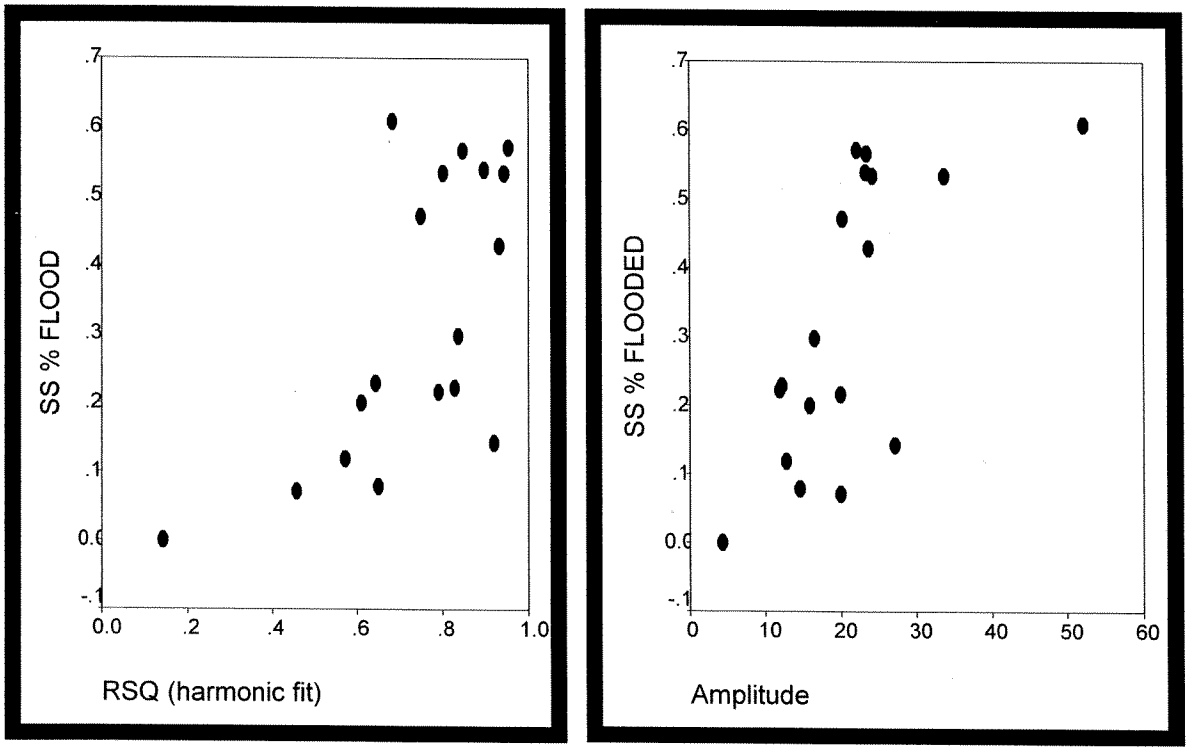

Figure 23. The relationships between the annual proportion of American alligator nest flooding the annual amplitude of Shark Slough water levels (cm) and periodicity (r^2).

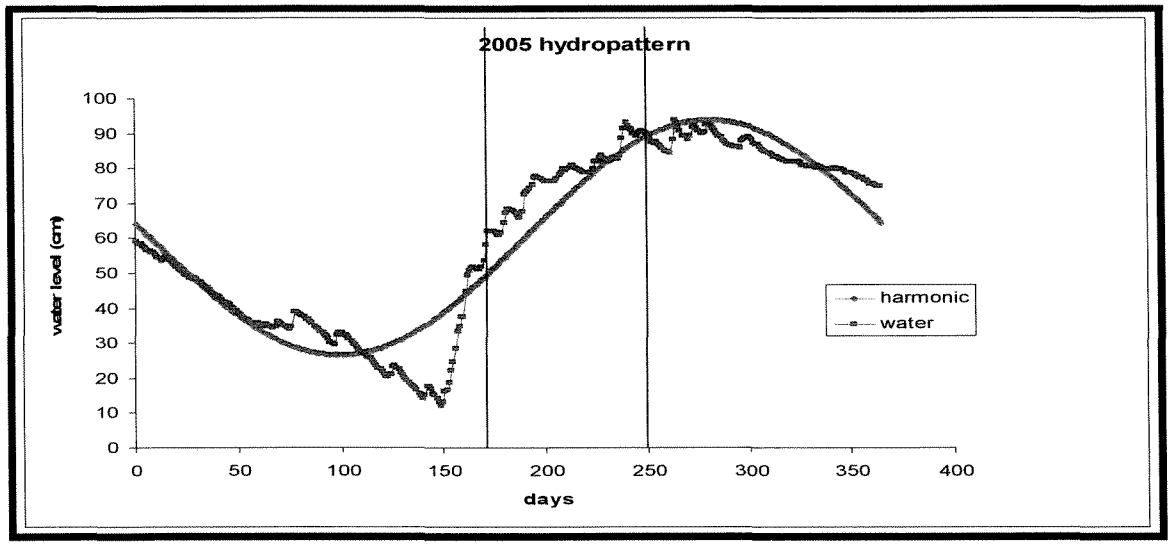

Figure 24. The hydrograph from NP 203, 2005 showing changes in stage during American alligator nest incubation because of Hurricanes Dennis and Katrina.