Aerial and Ground Surveys of

Marine Turtle Nesting Beaches

in the Southeast Region, U. S.

Final Report to the National Marine Fisheries Service

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Table of Contents

List of Tables

List of Figures

Executive Summary

- Flight schedules based on tidal cycles were found to be successful throughout the southeast region as only 2.4% of the tracks were not aged correctly, based on the ground truth sample.
- Ground truth on 10 areas was adequate, providing a 16.6%sample of total turtle activity for 18 flight days.
- While sequential ground truth indicated an overall error rate of 26.3%, the net bias for nests between aerial and ground counts was only –4.27%.
- The 6 – 4 – 2 flight schedule for the four states represented a 5.65% sample of the total nesting effort of loggerhead turtles in the region during 1983, based on an estimate derived from a composite nesting frequency distribution.
- Estimates of the total number of nesting female loggerhead turtles for l983 varied widely when different values for mean number of nests per female per season were used. Given our estimate of 58,016 nests, previously used values of 2.0 results in an estimate of 29,008 females. The most recent estimate of 3.46 nests per female per season is given by Richardson (1982). This value results in an estimate of 16,768 females. Finally, a empiracal estimate of 4.1 nests per female per season in this report results in an estimate of 14,150 females in l983.
- A TRS-80 Pocket Computer with printer cassette interface was tested as an aerial event recorder. The program supplied was modified to increase the maximum number of events to be recorded from 12 to over 120 per minute.
- Flights were made on 5 consecutive days to determine the relationship between air to ground counts of both fresh and old tracks. High variance within day, between days, between observers and between areas makes this approach of little value and limits the density of nesting effort that could be counted.

Introduction

There is a need by both the National Marine Fisheries Service and the U. S. Fish and Wildlife Service to have a range wide estimate or index of abundance for marine turtle species in the United States. These estimates are needed to determine trends in populations. These trends should dictate the level of management required to recover the species. Population trend and status information may also be used to evaluate negative impacts and should be incorporated into status reviews required under the Endangered Species Act. Status reviews can then be used to justify the level of classification and to reclassify the species as justified. It was with this focus on status and population trend of nesting marine turtles that this project was conducted. The primary objective was to obtain a numerical sample from the nesting beaches in the southeastern U. S. which was reliable and reproducible during subsequent seasons. Aerial surveys of marine turtle nesting activity have been conducted in the southeastern U. S. in 1976-77 (Carr and Carr 1977), in 1980 (Richardson et al. 1980), and in 1982 (Shoop and Ruckdeschel 1983). Aerial survey appears to be the only reasonable means of gathering data on nesting activity over a large area.

The data presented in this report represents the best known survey methodology for attaining these data. This methodology was developed and refined in South Carolina during three years of research (Hopkins and Murphy 1984 in prep.). It is based upon precise ground truth and a rigorously standardized method of data collection. It is these improvements, based on our previous surveys, which set this survey apart from those that have been conducted in the past. It is only with accurate ground truth that aerial counts are meaningful, and it is only with standardized data collection that surveys are reproducible for comparison in future years. The data are also presented in a variety of ways so that population trends can be measured by several criteria.

Acknowledgements

There are many people to thank who contributed to the success of this project. First our pilot, D. Scott for his skillful flying, coordination with military flight personnel and reprogramming the TRS-80. J. Coker for accurate data recording and dedication to learning new skills. A special thanks to all who provided information on turtle activity in their study areas: D. Crouse, L. Ehrhart, G. Garris, K. Kriet, J. McMurtray, M. Murphy, W. Oldland, J. Provanka, J. Richardson, W. Seyle, R. Wilcox and R. Wolf. Thanks are also expressed to M. Latto and K. Swanson for typing of reports and preparation of maps, respectively.

Methods and Materials

Preliminary flights were made on 17-18 May to establish zone landmarks and to determine military restricted areas. Surveys were conducted in a stratified schedule from Cape Hatteras, N. C. to Key Biscayne, Fla. Florida was flown 6 times, Georgia and South Carolina 4 times, and North Carolina twice. The dates of the Florida surveys were 5/26 and 27, 6/11 and 12, 6/25 and 26, 7/10 and 11, 7/24 and 25, and 8/8 and 9. North Florida (Sebastian Inlet to the St. Mary's River) was flown on the first day of the paired flights and south Florida (Sebastian Inlet to Key Biscayne) was flown the second day. Georgia and South Carolina were flown on 6/10, 6/24, 7/9 and 7/26, and the survey dates for North Carolina were 6/23 and 7/8. These dates were chosen based on the tidal cycle in order to count only fresh tracks. This methodology is described in Pritchard et al. (1983). The tidal cycle in Florida was given first priority and the schedule was adjusted backwards from those dates for the other three states. However, because of the orientation of the southeastern U. S. coastline, these dates also proved to be the correct ones for each of these surveys as it related to tide. The time of the evening high tide also varied from north to south in Florida and thus dictated that the northern half of the state should be flown first.

A Cessna 182 or a 172 RG (wing-over-cockpit) were used in all surveys. It was flown at 200 feet and the speed varied from 60-100 knots depending upon the density of tracks. The primary observer counted tracks in the entire region. Observer 2 served as data recorder and also counted tracks on all ground truth areas. Tape recorders were used to record track counts on ground truth areas. Tape recorders were used to record track counts on ground truth areas and digital counters and the TRS-80 were used elsewhere. The use of the TRS-80 automatic data recorder will be discussed in a separate section. Only fresh tracks were counted and were recorded as nests, false crawl or unknown. Tracks of species other than loggerhead were recorded in the same way.

Ground truth was obtained from 11 areas and is noted on the zone maps (Figures 1-14). All ground truth used in this survey was obtained in the manner described in the S.O.P. (see Appendix 1). All ground truth participants were given this S.O.P. and conferred with the principal investigator regarding procedures prior to the surveys. Ground truth surveys recorded all fresh tracks sequentially and by segment, as well as total by area, in order to examine type and sources of errors. Although ground truth was obtained from zone F05, it could not be included in the analysis because permits to probe nests were not received until after all surveys were completed.

Five consecutive flights were made on 24 June to 28 June, inclusive. The survey area selected was 10 km of Canaveral National Seashore (F06) in Volusia and Brevard Counties, Florida. This area was selected as representative of an average turtle-nesting beach with a moderate density of turtle nesting and a moderate level of human activity. Ground truth was collected each day at approximately the same time as the surveys were flown. Five replicate flights were also made during one survey day to determine the variability in counts due to observers, under the same flight and beach conditions. Aerial observers classified turtle tracks as: fresh nesting, fresh false, old nesting, and old false. Ground truth included all tracks visible during the ground survey prior to the first flight and all daily activity during each of the 5 flight days. More extensive ground records were made of track class and track quality during flights #4 and #5 to aid in analysis of errors in aerial counts and to estimate potential efficiency.

Results and Discussion

Aerial Surveys

The descriptions of each zone surveyed appear in Table 1. These descriptions provide a point-in-time reference to the relative quality of nesting habitat. Beaches in northern Florida (zones F07-F20) tended to be developed, fairly side and flat with good dunes present. However, high use by vehicles probably deters nesting. Canaveral National Seashore (zones F04-F06) has no structures directly behind the dunes. The beach is much steeper with heavy foot traffic in some areas near beach access points. South central Florida (zones F01-F03 and F21-F27) has moderately developed beaches, or in some areas in wildlife refuges there are no structures near the dunes. The beaches are steep with deep sand and therefore there is no vehicular traffic. South Florida (zones F28-F37) is highly developed with wider beaches, most of which undergo beach cleaning on a daily basis.

Georgia and South Carolina beaches (zones G01-G18 and S01-S34) are on beach ridge barrier islands. In Georgia, tidal amplitudes are greatest in the region and the barrier islands are larger. South Carolina is in the mesotidal range with shorter barrier islands. Almost all barrier islands in these two states are erosional on the northern or central portions with recurved spits on the downdrift or southern portion. Relatively few are developed.

North Carolina's outer banks (N11-N17) are narrow, sandy barrier islands with little or no maritime forest. They are subject to a great deal of overwash and have extensive grass flats instead of dune fields. The southern beaches (N01-N08) in North Carolina and the northern zones in South Carolina (S35-S38) have moderate to high development. Almost all North Carolina beaches have high use by vehicles.

Table 2 shows the total count by zones for all surveys. Zones F21, F22 and F23 had to be combined in the totals column because landmarks were missed in the first two surveys. The difference between zones F06 and F07 is striking, as is the difference between F30 and F31. The extremely high counts on Melbourne Beach F01, Jupiter F27 and Juno F28 stand out from the zones on either side and cannot be explained by any of the criteria used to define beach nesting habitat.

Counts in South Carolina were slightly below what was expected based on surveys from previous years. All of North Carolina had extremely low counts despite that both surveys were made during the peak of the season. This is probably due to North Carolina being on the northern limits of the range of the species rather than related to beach quality.

In Table 3, the percentage of nesting crawls for Florida only were determined for each zone for each survey. Melbourne and Juno Beaches were the most consistent throughout the summer. There was quite a bit of variation in the other zones. Table 4 presents the percent distribution for Georgia and South Carolina in two ways. The "subtotal" column compares the zones in the two states relative to each other. The "total" column compares these same zones relative to zones in all three states. Table 5 compares the percent distribution of nesting relative to only North Carolina and northern South Carolina zones in the “subtotal” column. The “total” column compares the same zones relative to the rest of the region.

In Table 6, the zones are compared in several ways, all of which are adjusted to account for the different number of times the areas were surveyed. These indices will be useful comparisons in future years on range wide surveys. The R.I. value or Relative Importance index provides more information about a zone than does density. An R.I. value of 1.00 would be the average for a beach in the region, i.e., the same percent of the nesting for the percent of the region which that beach comprised. Those beaches with R.I. values above 1.00 are above average. Only the two surveys made at the peak of the season when the entire region was flown were used to calculate R.I. values. Some of the islands in South Carolina with normally good nesting had very low counts during these two surveys (see Table 2). Thus the ranking in Table 7 could change order as additional surveys are made. The R.I. values for F28, F01 and F27 mean that these three beaches are 10 times more important than the average beach in the region. The list of beaches in Table 7 could be used when areas of Critical Habitat are designated. Table 8 shows that Florida is more than 13.7 times more important than the other states in the region.

Ground Truth

Ten ground truth areas were used in the region in order to adjust serial counts. Table 9 shows the comparison of Observer 1 with ground truth by zone. Total nests were under by 11.11% because of the net effect of missed observations and the nest to false crawl bias. There was a slight under count of all tracks by 6.63%. Observer 1 also under counted false crawls by 4.35%. The reasons for under counting varied on different zones. On high density beaches the tracks were seen in such rapid order that some were missed. There was very little under counting on low-density beaches except for Boca Raton. Here the total coverage of the beach by foot traffic left little contrast between flipper marks and footprints. On beaches with less human foot traffic, the flipper marks were quite distinct. Also by the time the survey reached Boca Raton, the sun angle was higher and very little intertidal zone remained.

Table 10 shows the comparison between Observer 2 and ground truth areas. Observer 2 had a bias of 7.00% in over counting nests and a slight under count of all tracks by 5.6%. He under counted false crawls by 16.67%. Since the under counts of total tracks for both observers were similar (6.63% and 5.67%) the difference in over counting nests by Observer 2 and under counting nests by Observer 1 was mainly caused by misidentification of tracks rather than missed observations or ageing errors (see Table 12). Beaches with high nesting densities resulted in the greatest bias for both observers. Table 11 is a comparison of Observers 1 and 2 by survey. Again the degree of bias was directly related to the density of tracks. Surveys 1 and 6 had very little bias while surveys 2, 3, 4 and 5 had varying degrees of bias. The percent of turtle activity represented by ground truth areas ranged from a 14.1% sample to a 21.0% sample.

Table 12 is a summary of the types of errors made by each observer. Of the total number of errors made by Observer 1, 58.7% were misidentification errors, 32.2% were missed observations, and 9.1% were ageing errors. These categories for Observer 2 were: misidentification 60.9%, missed observations 27.6% and ageing errors, 11.6%. Of the total tracks which could have been seen (N=1206) by Observer 1 on ground truth areas, only 2.4% were misaged, 8.5% were not seen and 15.4% were misidentified. This gave an overall error rate on ground truth areas of 26.3%. Of the total tracks that Observer 2 could have counted (N=812), only 3.2% were misaged, 7.6% were not seen and 16.9% were misidentified. His overall error rate was 27.7%. This overall error rate is based on the individual identification of each track. More than one error can be recorded per track. Errors were identified in order to refine and improve the techniques of aerial counts. Of more significance to adjusted counts and air to ground count ratios is the bias. Bias is the net product of all error types as it relates to air to ground counts. The bias for nest counts for Observer 1 was only –4.27%. That is, Observer 1 under-counted nests by only 4.27% of the total count on ground truth areas.

Data Extrapolation

Aerial counts were adjusted based on the 16.6% ground truth sample obtained from 10 study areas. Aerial under counts were adjusted based on Observer 1's percent under count. This percent was expressed as the difference between total tracks seen from the air and total tracks counted on ground truth areas (Tables 9 and 11). There was an under count of 80 tracks by Observer 1. These 80 tracks were distributed in the same proportion as aerial counts and then added to the aerial total. Thus the totals became:

Nests = 456 + 32 = 488; False Crawls = 660 + 47 = 707; Unk. = 10 + 1 = 11; Total = 1206. These adjustments are necessary to account for missed observations and misaged errors. The 11 unknowns were then distributed between the nest and false crawl counts based on the ratio of aerial observation. Thus 5 nests were added to 488 to give 493 and 6 false crawls were added to 707 to give 713 false crawls. The unknowns for ground truth (N=3) were distributed in the same way to give 515 nests and 691 false crawls for ground truth. After adjusting for under counting and distributing the unknowns, there remained a 22 nests under count by Observer 1, or a –4.27% bias. This bias is the net result of both positive and negative errors in identification of nests and false crawl tracks.

Using these adjusted values, the air to ground correction constant of 1.0446 was used to adjust all aerial nests counts after the unknowns were distributed.

Florida	(2848 nests counted + 46 unknown added) X (1.0446) = 3023
S. C. & Ga.	(220 nests counted + 5 unknowns added) X (1.0446) = 235
N. C.	(20 nests counted + 0 added) X (1.0446) = 21

In order to extrapolate from survey counts to total nesting effort in the region, data on frequency of nesting by day was needed. Both published and unpublished data on daily nesting for 7 different islands over 29 seasons was obtained. This data was summed to form a composite frequency distribution of nests by day in this composite is assumed to be the seasonal distribution of nesting for loggerhead turtles in the southeast. Based on this composite, the ratio of expected nesting effort on the survey days to total nesting during the season should be in the same ratio as the aerial counts for survey days is to total nesting effort.

$$\frac{\text{Expected \# nests for survey days from composite}}{\text{17,654 (total nests used in composite distribution)}} = \frac{\text{Adjusted aerial counts}}{\text{X (total nest estimate)}}$$

For example: during the 6 paired flights for Florida, a total count of 1021.5 nests of 17,654 would be expected based on the composite distribution. This ratio is the same as 3023 (the adjusted aerial count) is to X (the total nest estimate for Florida). The 6 surveys conducted in Florida required 12 days to complete. Therefore the mean of the two paired days for each survey was accumulated to obtain the expected sample (1021.5). Using this proportion, the following estimates were calculated for nests laid during 1983:

Florida	(6 surveys)	$\frac{1021.5}{17,654} = \frac{3023}{X}$ = 52,245 nests (range 39,797-59,496)
S. C. & Ga.	(4 surveys)	$\frac{839}{17,654} = \frac{235}{X}$ = 4,945 nests (range 4,012-5,802)
N. C.	(2 surveys)	$\frac{449}{17,654} = \frac{21}{X}$ = 826 nests (range 690-956)

Total Estimated Nests = 58,016

The seasonal distribution of nesting in loggerheads is a non-normal curve and therefore confidence limits have not been calculated. However ranges of nest estimates are given based on daily variability in nesting. That is, the maximum and minimum values for each survey interval plus two days prior to and two days after were taken from the composite distribution to calculate the ranges. Thus the total estimated number of nests in the study area is 58,016 (range equal to 44,499-66,254).

The mean number of nests per female per season has generally been estimated at 1.9 - 2.2. This, however, is a minimum estimate because of an effect of edge and/or transient turtles. In every study there is a group of turtles that are monitored at the edges of the study area. Some of those turtles will subsequently nest outside of the study area. They may actually have a center of nesting activity that is well outside of the study area. In addition, there is a significant number of turtles which nest only one time on an area and are either site non-specific or fail to complete their return to the nesting beach prior to the time of re-nesting.

The edge effect is dependent on the length of the study area and the mean distance between nests for loggerheads. If the study area is large and the mean distance between nests is small, the majority of nestings by a female should be observed. This assumes nearly 100% coverage for the entire duration of the season and no tag loss. The derivation of the two nests per female per season statistic may be largely a function of the similar length of study areas involved. Study areas tend to be 5 – 10 miles in length and would result in a consistent number of nests per female per season if other conditions were the same. When recoveries from a large area are obtained, such as in Georgia where almost all nesting beaches are monitored, the minimum number of nests per female rises to over three.

In an effort to empirically obtain an estimate of nests per female, we plotted the date of initial nesting in a season for all turtles encountered over an 8 year period on Little Cumberland Island, N=427. This distribution was shifted and replicated every 13 days, the mean number of days between nestings. This created a frequency distribution which was similar to that established by accumulating all nests for all areas over all years (the composite nesting frequency distribution) except that it had no end point. We therefore examined the seasonal composite nest distribution and observed that the season began to decline after 20 July and was the mirror image of the onset. Therefore the empirical seasonal distribution based on initial nestings was adjusted to reflect a declining season that was similar to the onset. This resulted in a calculated 1,759 nests for 427 turtles, or 4.1 nests per female per season. Thus the estimate of 58,016 nests represents 14,150 nesting female loggerheads (range of 10,853-16,160) estimated for the 1983 nesting season in the southeast region.

Other species

Green turtle tracks were not seen on the May survey flights. There was increased activity in June and the most tracks were seen on the survey in late July. There was no problem associated with discerning fresh C. mydas tracks from those of C. caretta, even for new observers who had not seen green turtle tracks before. Since the nesting season is later for green turtles, no direct estimate can be made based on the loggerhead survey dates.

The one hawksbill track recorded was observed directly beside a loggerhead track. Although the flipper marks were both alternating, the size difference was noticeable. There was probably more hawksbill nesting activity in south Florida, but tracks observed in isolation or in areas of extremely dense loggerhead nesting would be difficult to speciate.

No leatherback tracks were visible during our surveys although nesting occurred on some of our ground truth areas during the season.

Consecutive flights

The consecutive flights were originally designed to be initiated the day after all old tracks were erased from the study areas using a hand rake and/or a drag towed behind an all terrain vehicle. However, a very heavy rack of sargassum that made erasure impossible covered the beach. Thus on consecutive flight #1, all tracks visible to the ground observer were recorded. This included fresh nests (N=14), fresh false crawls (N=15), old raccoon depredated nests with no associated track (N=36), old raccoon depredated nests with track present (N=19), old false crawls (N=25), old nests with body pit only (N=33), and old nests with associated tracks (N=22), for a total of 163 observations. Of these, 97 had visible track associated with them. During the remaining consecutive flights, an additional 100 tracks were added to the study area by daily turtle activity. Each consecutive flight was expected to yield the net difference between tracks obliterated over time and new ones gained by nesting activity. This net difference should be the average daily rate of loss (decay rate) for all tracks on the beach. This decay rate was obscured by the high variability of aerial counts for all tracks (Tables 14 and 15). Difficulties were encountered in obtaining agreement on what was to be counted because of all the various categories of tracks. Old tracks were: old but fresh looking, old and faint, intermittent, had body pits only or had eggshells at an old nest site. Flight conditions such as light quality varied from day to day and may have affected counts more than the daily changes in the appearance of tracks on the beach.

In order to discern the difference between daily variability and observer variability with a day, five replicate passes were made during consecutive flight #4 (Table 15). During consecutive flights #4 and #5, ground truth of old tracks was documented more extensively. Nesting crawls of known age were classified as: distinct, moderate or faint, based on their visibility to the ground observer. It was concluded that only distinct and moderate tracks were visible from the air, and a maximum visibility of tracks was calculated based on ground surveys (Table 16).

Variability of counts between flights was also high because the flights were made under different tidal conditions and were generally outside the preferred tidal window. More time had to be spent by aerial observers discerning fresh from old tracks and usually resulted in purely subjective classifications being made. This additional time per observation limited the track density at which the surveys could be done accurately. Counting all tracks (fresh and old) served to increase the density of turtle activity present on the beach, and thus resulted in an elevated variability in counts. Even on this moderately used nesting beach, the observation time per track was inadequate. Not only was discerning the crawls more complex, but when using tape recorders the entry of two or more words per observation as opposed to one word per observation was required. This limited the track density that could be recorded.

The visibility of tracks from the air is dependent on many factors such as sun angle, shadowing, cloud conditions, tide and beach debris. Selecting the proper time of survey may standardize many of these factors. The complex and varying effects of tide, wind (both in direction and speed), beach slope, sand grain size, moisture content, beach activity, and a variety of other factors affect track decay rate. For example, during our regular surveys, fresh tracks were lost before 0530 hours on Cumberland Island, while segment lines drawn on Melbourne beach for one survey were still clearly visible two weeks later during the following survey.

In summary, attempts at identifying both fresh and old tracks limit the track density that may be surveyed accurately. Decreased accuracy would be evident even on moderate density nesting beaches. More importantly, the overall efficiency of observations of fresh tracks was dramatically reduced. Observers #1 and #2 had an efficiency of 93% and 94%, respectively, when counting fresh tracks on ground truth areas during regular surveys. This fell to 60% and 65%, respectively, during the consecutive flights when old tracks were also counted. Counting all tracks not only produced errors in counts of old tracks, but compromised counts of fresh tracks as well.

Evaluation of Automatic Event Recorder

The event recorded evaluated was a Radio Shack TRS-80 Pocket Computer (Model PC-2) with a printer cassette interface. The event recorder was programmed with the Sea Turtle Nesting Survey program Version 1. During the first of six surveys of sea turtle nesting beaches in the southeast region, an evaluation of the event recorded was conducted on all areas except ground truth areas. The observer verbally relayed observed track signs to the recorder.

Flight #1 resulted in a complete computer survey but required the recorder to remember track calls for entry on areas of moderate density. Flight #2 was of areas of higher density even early in the nesting season. Two failures of the event recorder occurred. First, the small character key was inadvertently depressed while trying to add crawls to the tape longhand. This written entry was necessary as the event recorder was hopelessly behind the observations. The event recorder was frequently behind the observer over beaches with moderate to high densities. In addition, the summary time at the end of zones was excessive. Flight #3 was conducted with the event recorder programmed with version 1. The low density of track except on Cape Island was expected to enable the use of the recorder. However, battery failure in the printer precluded its use.

The event recorder was reprogrammed with version 2 prior to Flight #4. This included adding wind speed and direction to the header, thus allowing for use of more than one weather variable. Version 2 also used the F keys to record the species and track type with a single key entry for *Caretta* and *Chelonia*. The J, K, and L keys were used for *Dermochelyes.* The use of the enter key was also eliminated. The F keys were used as they are slightly larger and conveniently placed. Define S provided the summary. Thus, version 2 allowed the crawl type and species to be entered by operation of a single key. The keys that were used facilitated use under the frequently turbulent conditions of flight. There was, however, no printed tally of events and inadequate memory for anything more than a running total that provided a zone summary. Thus, if an error occurred in operation, the data for an entire zone would be lost. Version 2 also added a location start time in green and a finish time in red.

Flight #5 initiated program version 3. Version 3 added the printing of events without time entry. The smallest print size was used to increase speed of printing. Version 3 also added a time reference key (Define Z). This key could be used on a time available basis to provide a time element to the event tape. The failure of the event recorder during flight #5 was a result of attempting to enter events while the computer was busy. This occurred only on very high track density beaches.

Program Version 4 was next prepared for use. This improved Version 3 by printing single integer entries for *Caretta* and expressing Define Z in minutes and seconds only. In addition, the colored pens were rearranged to eliminate unnecessary motion (Blue – Green – Blue – Red).

In summary, program Version 1 allowed for 12 event entries per minute and Version 4 allows in excess of 120 event entries per minute. Version 4 also expands the header information and provides end times of locations. Version 4 now has the speed to keep up with all but the highest density beaches. Malfunctions are still possible, and a backup means of data recording should always be available if the TRS-80 is used.

Literature Cited

Carr, D. and P. Carr. 1977. Survey and reconnaissance of nesting shores and coastal habitats of marine turtles in Florida, Puerto Rico, and the U. S. Virgin Islands. Report to NMFS under Contract No. 03-6-042-35129, 54 pp. mimeo.

Hopkins, S. and T. M. Murphy. 1984. Aerial survey methodology for loggerhead turtle nesting activity in South Carolina. Study Completion Report. in prep.

Pritchard, P. C. H., P. Bacon, F. Berry, A. Carr, J. Fletemeyer, R. Gallagher, S. Hopkins, R. Lankford, R. Marquez, L. Ogren, W. Pringle, Jr., H. Reichart and R. Witham. l983. Manual of Sea Turtle Research and Conservation Techniques. Prepared for WATS. 126 pp.

Richardson, J. 1982. A population model for adult female loggerhead sea turtles (*Caretta caretta*) nesting in Georgia. Ph.D. Dissertation University of Georgia, Athens, GA. 221 pp.

Richardson, J., G. Williamson and C. Graves. l980. An aerial survey of sea turtle nesting activity in Georgia. Report to Fish and Wildlife Service Contract No. 14-16-0004-53, Atlanta. 48 pp. mimeo. plus maps.

Shoop, R. and C. Ruckdeschel. 1983. Nesting surveys. Final Report to NMFS under Contract No. NA82-GA-C-00012. 90 pp. mimeo.

Appendix 1 S.O.P.

Ground Truth of Aerial Counts of Sea Turtle Tracks on Nesting Beaches

Objective

To quantify the errors and biases of aerial track counts in order to determine the type of error and to adjust counts to account for bias.

Introduction

Much of the difficulty in utilizing aerial track counts has involved track generation interval. This is the number of days a track remains visible to the aerial observer. This generation time has been found to be highly variable. Total counts of tracks therefore result in a sample of the total nesting effort that cannot be quantified with much precision. In order to quantify what is being sampled, the current survey counts fresh (previous night) tracks only. These tracks are aged using the tides. Surveys are flown on the morning after a high tide that occurs between 2100-2130 hours and before the next high tide of the following morning. This results in only fresh tracks in the intertidal zone. It also tends to produce a differential track (entrance and exit crawls of different length) for turtles that nested on a dropping tide. The effects of regular sampling on a tidal cycle has been tested and found to be non-significant.

Previous surveys have identified three major sources of errors from aerial counts. The first type of error is the misidentification of the outcome of the emergence. Some false crawls (non-nesting emergences) may be identified as nesting crawls and vice-versa. The second type of error is a missed observation where a fresh track is somply not observed. Finally, the third type is a track that is inaccurately aged. A missed observation results in an under count but has been documented as occurring at a low frequency. Misidentification and aging errors in both a positive and negative direction and represent the most frequent errors. The net effect of the sum of negative and positive error is bias. The bias had been found to be much less than the rate of error. To quantify error rates and bias requires sequential ground truth as well as totals for each type of track. Thus we have developed the following ground truth procedures.

Procedures

A total of ten ground truth areas will be used to validate aerial counts from Cape Hatteras to Key Biscayne. These areas are selected to represent examples of various nesting densities, geographic areas, management practices, and levels of development.

Each ground truth area will be divided into ten segments. Each segment will be 0.5 mile or after each ten fresh tracks. Thus a maximum of five miles or 100 tracks will be used on each area. A double line drawn in the sand will be used at the beginning and end of each ground truth area. Each segment will be marked by a line drawn in the sand to just below the high water mark with a segment number drawn below it. Dragging any object, such as the handle of a probe stick or the heel of your foot in the sand may draw lines. The segment number below this line should be about five feet high and just below the previous night's high water mark. Within each segment all fresh crawls are recorded by location to 0.1 of a segment, i.e., halfway through segment 2 would be 2.5. The result of the emergence (nesting or non-nesting), the presence of one or more body pits, species, and a brief description of the track are recorded. Example: Caretta; nest; differential; long direct crawl. Record a number for each fresh track to denote their sequential order on the beach. This procedure allows for a determination of specific errors as well as bias.

<u>List of characteristics useful in coordinating ground to air counts</u>

1) Differential – nested on a receding tide that resulted in the outgoing track being much longer than the incoming track.

2) Depredated by raccoons.

3) Dug but failed to lay (did not cover).

4) Entire track below high water mark – may be lost to tide before aerial pass.

5) Loops or aberrant meanderings generally occur after nesting or during a false crawl.

6) Presence of an apparent body pit but no eggs.

7) Interaction of fresh and/or old tracks and body pits which may confuse aerial observers.

8) Relative length of tracks – short or long.

Determination of whether the emergence resulted in egg deposition
(Nesting or false crawl)

The lack of any body pit on a track is a false crawl. Similarly the presence of a body pit with thrown sub surface sand is a nest. In addition, there will be a small percentage of crawls that are not clearly in either class and these must be carefully probed. These uncertain crawls result under a variety of circumstances such as tracks crossing body pits, or sand falling from a scarped dune into the body pit. With care no damage to eggs should result. It is critical that all ground truth information be completely accurate, as it is the basis for evaluating all aerial counts. The coordination of aerial and ground counts should result in a reproducible point in time index to the distribution and level of nesting along the east coast.

Appendix II

Table 1. Zone description for aerial surveys, 1983.

Zone Name	Zone No.	Kms Surveyed	Characteristics
Amelia Island (N)	F20	12.0	Moderate development with good dunes and white sand.
Amelia Island (S)	F19	8.3	Same as above
Little Talbot	F18	14.4	Low development with good dunes and white sand
Jacksonville Beach	F17	19.2	High development with single homes and hotels, orange sand, vehicle traffic
Palm Valley	F16	20.8	Undeveloped with good dunes and orange sand
South Ponte Vedra	F15	12.8	Moderate development with single family homes and orange sand
Anastasia Island	F14	24.0	Moderate development with single homes, good dunes but vehicle traffic
Marineland	F13	10.4	Low to moderate development with worm reefs fronting the beach
Palm Coast	F12	8.8	No development with good dunes, but with worm reefs near beach
Flagler (N)	F11	9.6	Moderate development with single homes, vehicle traffic
Flagler (S)	F10	19.2	High development with wide beach and vehicle traffic
Ormond Beach	F09	12.8	Same as above
Daytona Beach	F08	16.8	Same as above
New Smyrna	F07	24.8	Same as above
Canaveral National Seashore (N)	F06	28.8	No development, short beach with public walkways, orange sand
Canaveral National Seashore (M)	F05	24.8	Same as above
Canaveral National Seashore (S)	F04	8.3	Military installations behind beach, slightly wider beach
Cocoa Beach	F03	16.0	Moderate development with single homes, short fairly steep beach
Satellite Beach	F02	20.8	Same as above
Melbourne Beach	F01	28.0	Same as above
Pelican Island NWR	F21	12.0	No development, steep beach with Australian pines behind dunes
Vero Beach (N)	F22	12.8	Moderate development with single homes, short beach
Vero Beach (S)	F23	22.4	Same as above
Hutchinson Island (N)	F24	20.0	Moderate development with single homes and some condos
Hutchinson Island (S)	F25	17.6	Same as above
Hobe Sound NWR	F26	8.8	No development, eroding beach into the pines, steep beach

Table 1. Continued

Zone Name	Zone No.	Kms Surveyed	Characteristics
Jupiter Island	F27	17.6	Moderate development with single homes, rock and seawalls present, beach nourishment underway
Juno Beach	F28	20.8	High development with hotels and homes with beach cleaning
Palm Beach	F29	25.6	Same as above
Boca Raton	F30	24.0	Same as above
Deerfield Beach	F31	9.6	Same as above
Ft. Lauderdale	F32	20.0	Same as above
Hollywood Beach	F33	19.2	Same as above
Miami Beach	F34	19.2	Same as above
Fisher Island	F35	1.6	Industrial facilities, very short beach
Virginia Key	F36	6.4	High development with narrow beach
Key Biscayne	F37	7.2	High development with hotels, beach wider at park
Florida Zone Total		605.4	

Zone Name	Zone No.	Kms Surveyed	Characteristics
Savannah Beach	G01	5.6	Moderate development with single homes, sea walls and rip rap
Little Tybee Island	G02	5.3	No development, low dunes and no maritime forest
Wassaw Sound Islands	G03	4.2	Three small marsh type islands subject to over wash
Wassaw Island	G04	10.5	Undeveloped with good dunes but with erosion at the north end
Pine & Little Wassaw Islands	G05	3.8	Undeveloped islands with eroding banks
Raccoon Key	G06	1.8	Undeveloped marsh island subject to over wash
Ossabaw Island	G07	18.7	Undeveloped, middle 1/3 washing but 2/3 good dunes
St. Catherine's Island	G08	21.1	Undeveloped, large creek cuts through the center of the beach, cows present
Blackbeard Island	G09	13.2	Undeveloped with erosion along some portions of north end
Sapelo Island	G10	9.7	Undeveloped with prograding beach is most sections
Wolf Island	G11	5.6	Marsh type island subject to overwash
Egg Island	G12	2.9	Same as above
Little St. Simons	G13	11.4	Undeveloped with some erosion
Sea Island	G14	9.6	Moderate development with single homes, sea walls and horses
St. Simons Island	G15	6.5	Moderate development with single homes and rip rap on south end

Table 1. Continued

Zone Name	Zone No.	Kms Surveyed	Characteristics
Jekyll Island	G16	14.6	Moderate development with rip rap along center portion
Little Cumberland Island	G17	5.8	Low development with homes well back from beach, high dunes
Cumberland Island	G18	29.7	Low development behind dunes, wide beach with high dunes
Georgia Zone Total		180.0	

Zone Name	Zone No.	Kms Surveyed	Characteristics
Waites Island	S38	6.4	No development, good dunes at both ends, erosion in center
North Myrtle Beach	S37	20.8	High development with hotels, condos and campgrounds
Myrtle Beach	S36	21.8	Same as above plus sea walls
Garden City	S35	20.8	Wide beach, good dunes, moderate development with campgrounds
Huntington Beach	S01	2.2	Flat wide beach, no houses but state park, light grey sand
Litchfield Beach	S02	7.2	Good dunes, last beach, moderate development with single homes
Pawleys Island	S03	5.8	Moderate development, single homes, only a few dunes present
Debidue Island	S04	7.1	Low development, wide flat beach, center 1/3 has sea wall
North Island	S05	13.5	No development, high dunes with mostly stable beach, erosion at north end
Sand Island	S06	4.0	No development, mostly over wash, steep beach
South Island	S07	4.0	No development, wide flat beach with erosion in the center, good dunes at both ends
Cedar Island	S08	4.3	No development, erosion in the center and north end, flat beach
Murphy Island	S09	9.0	No development, intermittent erosion along the beach, low wave energy
Cape Island	S10	8.0	No development, steep beach with many wash over areas
Lighthouse Island	S11	3.0	No development, wide flat beach, no trees present
Raccoon Key	S12	9.0	No development, short beach, mostly shell, low wave energy
Bulls Island	S13	10.5	No development, wide flat beach, good dunes except at north end
Capers Island	S14	5.2	No development, erosion in center, good dunes at both ends

Table 1. Continued

Zone Name	Zone No.	Kms Surveyed	Characteristics
Dewees Island	S15	4.0	Under development, very little good beach, extensive erosion
Isle of Palms	S16	10.0	Moderate development, rip rap along northern 1/3
Sullivans Island	S17	6.3	Moderate development, single homes, good dunes
Morris Island	S18	5.4	No development, short beach, mostly shelly with some erosion
Folly Beach	S19	10.4	Moderate development, single homes, severe erosion with sea wall along most of beach
Kiawah Island	S20	15.0	Moderate development, wide flat beach with good dunes
Seabrook Island	S21	6.4	Moderate development, ½ of beach in rip rap
Edisto Island	S22	18.3	A three-island complex, 2/3 not developed, 1/3 moderate development, steep shell beach
Pine Island	S23	4.1	No development, pocket beaches fronted by marsh, low wave energy
Otter Island	S24	4.3	No development, minor erosion, good dunes, low wave energy
Harbor Island	S25	2.0	Under development, erosion at north end, low wave energy
Hunting Island	S26	7.0	Low development with state park at north end, renourished in 1980
Fripp Island	S27	6.0	Moderate development, single homes and condos, ½ of beach is rip rap
Pritchards Island	S28	4.0	No development, severe erosion, few good dunes
Little Capers	S29	4.0	No development, shelly beach with severe erosion
St. Phillips	S30	1.3	One house, short beach, low wave energy
Bay Point	S31	5.0	One house, erosion at north end, good dunes at south end
Hilton Head Island	S32	29.0	High development, wide flat beach, rip rap in the center portion
Daufuskie Island	S33	8.1	Low development in inland areas, erosional beach with few dunes
Turtle Island	S34	4.0	No development, pocket beaches fronted by marsh, low wave energy
South Carolina Zone Total		317.2	

Table 1. Continued

Zone Name	Zone No.	Kms Surveyed	Characteristics
Hatteras Island	N17	21.0	Low development, good dunes, high vehicle use
Ocracoke Island	N16	35.0	Same as above
Core Banks (N)	N15	36.0	Same as above
Core Banks (S)	N14	40.0	Same as above
Cape Lookout	N13	12.0	Same as above
Shackleford Banks	N12	14.5	Same as above
Bogue Banks	N11	39.0	Same as above
Bear & Brown Islands	N10	11.0	No development, good high dunes
Onslow Beach	N09	11.5	Low development but high vehicle by army tanks
Topsail Beach	N08	35.0	Moderate development, single homes
Figure 8 Island	N07	11.2	No development, low marsh island with good dunes
Wrightsville Beach	N06	19.0	Moderate development, single homes
Kure Beach	N05	20.0	High development, single homes and condos, nourished beach
Smith Island	N04	13.0	Under development, good dunes on east side
Long Beach	N03	21.0	Moderate development, single homes, good dunes
Holden Beach	N02	12.0	Moderate development, single homes, campground, good dunes but with vehicle traffic
Sunset Beach	N01	8.8	Moderate development, single homes, good dunes
North Carolina Zone Total		360.0	

Table 2. Aerial count summaries by zone and survey for each state.

Zone Number		Survey #1 5/26			Survey #2 6/11			Survey #3 6/25			Survey #4 7/10			Survey #5 7/24			Survey #6 8/8			Zone Totals		
		N	F	U	N	F	U	N	F	U	N	F	U	N	F	U	N	F	U	N	F	U
Amelia Island (N)	F20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amelia Island (S)	F19	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Little Talbot	F18	0	0	0	0	0	0	0	2	0	1	2	0	1	2	0	0	0	0	2	6	0
Jacksonville Beach	F17	0	0	0	1	0	0	2	1	0	3	0	0	0	1	0	0	0	0	6	2	0
Palm Valley	F16	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0
S. Ponte Vedra	F15	3	0	0	2	0	1	1	0	0	2	1	0	1	0	0	0	0	0	9	1	1
Anastasia	F14	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Marineland	F13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Palm Coast	F12	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2	1	0
Flagler Beach (N)	F11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0
Flagler Beach (S)	F10	0	0	0	1	0	0	0	2	1	2	2	0	1	4	0	1	0	0	5	8	1
Ormond Beach	F09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Daytona Beach	F08	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
New Smyrna Beach	F07	0	0	0	1	0	0	0	2	0	1	3	0	1	0	0	1	2	0	4	7	0
Canaveral (N)	F06	13	3	0	36	16	3	23	34	0	43	43	0	29	50	1	11	5	0	155	151	4
Canaveral (M)	F05	13	6	0	48	35	0	24	30	0	36	65	0	30	67	1	12	6	0	163	209	1
Canaveral (S)	F04	0	0	0	4	7	0	7	6	0	1	8	0	6	2	0	1	1	0	19	24	0
Cocoa Beach	F03	5	3	0	5	3	0	9	12	0	3	3	0	11	19	0	3	4	0	36	44	0
Satellite Beach	F02	12	4	0	20	9	0	17	44	1	15	36	0	14	39	0	9	14	0	87	146	1
Melbourne Beach	F01	51	14	0	82	44	3	111	216	0	191	320	1	146	308	3	48	31	1	629	933	8

Table 2. Continued

Zone Number		Survey #1 5/27 N	F	U	Survey #2 6/12 N	F	U	Survey #3 6/26 N	F	U	Survey #4 7/11 N	F	U	Survey #5 7/25 N	F	U	Survey #6 8/9 N	F	U	Zone Totals N	F	U
Pelican Island	F21	7	4	0				27	27	0	25	39	0	20	32	0	5	4	0	84	106	0
Vero Beach (N)	F22				10	34	3	11	25	0	19	51	0	18	27	0	2	1	0	60	138	3
Vero Beach (S)	F23	16	5	0	7	17	0	12	12	2	17	37	0	10	16	0	3	4	0	65	91	2
Hutchinson Is. (N)	F24	1	4	0	3	4	0	10	8	0	15	18	0	18	24	0	5	0	0	52	58	0
Hutchinson Is. (S)	F25	14	16	2	19	25	0	37	49	3	60	67	1	55	52	0	13	9	0	198	218	6
Hobe Sound	F26	4	8	0	7	4	0	22	18	1	21	9	0	35	18	0	4	2	0	93	59	1
Jupiter Island	F27	37	38	1	22	37	2	45	96	1	116	170	53	140	140	1	22	13	0	382	494	58
Juno Beach	F28	33	42	3	41	84	2	82	87	0	148	171	1	81	111	0	17	15	0	402	510	6
Palm Beach	F29	11	22	0	11	29	0	27	38	0	47	62	0	34	48	0	5	6	0	135	205	0
Boca Raton	F30	14	21	3	16	34	1	33	28	0	57	54	0	32	38	0	3	3	0	155	178	4
Deerfield Beach	F31	6	6	0	4	7	0	12	19	1	8	5	0	9	17	0	2	4	0	41	58	1
Ft. Lauderdale	F32	3	3	0	9	19	1	5	12	1	17	24	2	10	32	0	2	0	0	46	90	4
Hollywood	F33	1	0	0	0	2	1	1	0	0	1	0	1	0	6	1	1	0	1	4	8	4
Miami	F34	0	0	0	1	3	0	0	2	0	2	1	0	1	1	1	0	0	0	4	7	1
Fisher Island	F35	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0
Virginia Key	F36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Key Biscayne	F37	0	0	0	0	3	0	0	0	0	3	1	0	1	3	0	0	0	0	4	7	0
Fl. Survey Totals		244	199	9	351	416	17	519	771	11	855	1193	59	709	1060	8	170	124	2	2848	3763	106

Table 2. Continued

Zone Number		Survey #2 6/10 N	F	U	Survey #3 6/24 N	F	U	Survey #4 7/9 N	F	U	Survey #5 7/26 N	F	U	Zone Totals N	F	U
Savannah Beach	G01	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Little Tybee Island	G02	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0
Wassaw Sound Is	G03	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Wassaw Island	G04	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
Pine & L. Wassaw	G05	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0
Raccoon Key	G06	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0
Ossabaw Island	G07	1	0	0	3	1	0	2	1	0	3	1	0	9	3	0
St. Catherine's Is.	G08	0	0	0	1	6	0	1	0	0	3	0	0	5	6	0
Blackbeard Is.	G09	1	0	2	0	0	0	4	0	0	1	0	0	6	0	2
Sapelo Island	G10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wolf Island	G11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egg Island	G12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little St. Simons	G13	0	0	0	0	1	0	1	0	0	0	1	0	1	2	0
St. Simons Island	G15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jekyll Island	G16	1	0	0	1	2	0	3	1	0	0	0	0	5	3	0
L. Cumberland Is.	G17	0	0	1	1	3	0	0	0	0	1	0	0	2	3	1
Cumberland Island	G18	0	2	2	3	1	0	6	2	0	0	0	0	9	5	2
Sea Island	G14	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Ga. Survey Totals		3	2	5	10	18	0	17	5	0	12	3	0	42	28	5

Table 2. Continued

Zone Number		Survey #2 6/10 N	F	U	Survey #3 6/24 N	F	U	Survey #4 7/9 N	F	U	Survey #5 7/26 N	F	U	Zone Totals N	F	U
Huntington Beach	S01	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Litchfield Beach	S02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pawleys Island	S03	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Debidue Island	S04	0	0	0	1	0	0	0	0	0	1	0	0	2	0	0
North Island	S05	1	1	0	3	1	0	1	0	0	1	1	0	6	3	0
Sand Island	S06	0	0	0	2	8	0	5	3	0	4	6	0	11	17	0
South Island	S07	1	1	0	1	3	0	3	6	0	4	7	0	9	17	0
Cedar Island	S08	0	0	0	2	3	0	2	1	0	1	2	0	5	6	0
Murphy Island	S09	2	2	0	0	0	0	1	0	0	1	1	0	4	3	0
Cape Island	S10	1	12	2	19	21	0	13	43	0	7	24	0	40	100	2
Lighthouse Island	S11	0	3	0	0	1	0	1	5	0	2	1	0	3	10	0
Raccoon Key	S12	0	1	0	5	5	0	1	4	0	3	4	0	9	14	0
Bulls Island	S13	1	0	0	1	0	0	1	0	0	1	3	0	4	3	0
Capers Island	S14	0	0	0	2	0	0	0	0	0	1	0	0	3	0	0
Dewees Island	S15	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0
Isle of Palms	S16	0	0	0	0	1	0	1	0	0	0	1	0	1	2	0
Sullivans Island	S17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Morris Island	S18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Folly Beach	S19	0	0	0	0	2	0	1	0	0	0	1	0	1	3	0
Kiawah Island	S20	3	0	0	1	0	0	1	0	0	0	0	0	5	0	0
Seabrook Island	S21	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Edisto Island	S22	3	4	0	1	4	0	3	4	0	9	9	0	16	21	0
Pine Island	S23	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Otter Island	S24	3	2	0	5	3	0	0	0	0	2	0	0	10	5	0
Harbor Island	S25	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Hunting Island	S26	0	0	0	1	5	0	3	1	0	1	0	0	5	6	0

Fripp Island	S27	1	2	0	0	1	0	4	1	0	1	0	1	6	4	1
Pritchards Island	S28	0	2	0	0	2	0	0	1	0	3	4	1	3	9	1
Little Capers Is.	S29	0	0	0	0	0	0	0	0	0	3	2	0	3	2	0
St. Phillips Island	S30	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Bay Point	S31	1	1	0	1	9	0	2	0	0	11	3	0	15	13	0
Hilton Head Island	S32	1	1	0	4	4	2	3	0	0	3	2	1	11	7	3
Daufuskie	S33	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Turtle Island	S34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC Survey Totals		20	32	2	50	74	2	47	70	0	61	73	3	178	249	7

Table 2. Continued

Zone	Number	Survey #3 6/23			Survey #4 7/8			Zone Totals		
		N	F	U	N	F	U	N	F	U
Cape Hatteras	N17	0	0	0	1	0	0	1	0	0
Ocracoke	N16	0	0	0	1	0	0	1	0	0
Core Banks North	N15	0	1	0	0	4	0	0	5	0
Core Banks South	N14	0	0	0	0	0	0	0	0	0
Cape Lookout	N13	0	0	0	0	0	0	0	0	0
Shackleford Bank	N12	1	2	0	0	0	0	1	2	0
Bogue Bank	N11	0	1	0	0	1	0	0	2	0
Bear & Brown Isl.	N10	1	1	1	2	1	0	3	2	1
Onslow Beach	N09	0	0	0	0	0	0	0	0	0
Topsail Beach	N08	2	0	0	0	2	0	2	2	0
Wrightsville Beach	N07	2	0	0	0	0	0	2	0	0
Masonboro Beach	N06	0	1	0	0	2	0	0	3	0
Kure Beach	N05	2	0	0	0	2	0	2	2	0
Smith Island	N04	1	1	0	2	3	0	3	4	0
Long Beach	N03	1	5	0	0	1	0	1	6	0
Ocean Isle Beach	N02	0	0	0	1	1	0	1	1	0
Sunset Beach	N01	2	0	0	0	0	0	2	0	0
Waites Island	S38	0	0	0	1	0	0	1	0	0
N. Myrtle Beach	S37	0	0	0	0	0	0	0	0	0
Myrtle Beach	S36	0	0	0	0	0	0	0	0	0
Garden City Beach	S35	0	0	0	0	0	0	0	0	0
Survey Totals		12	12	1	8	17	0	20	29	1

Table 3. Percent distribution of nesting crawls by zone for Florida (6 surveys) N=2870*

Zone		Survey #1	Survey #2	Survey #3	Survey #4	Survey #5	Survey #6	Total
Amelia Island (N)	F20							
Amelia Island (S)	F19							
Little Talbot	F18				0.11	0.14		0.07
Jacksonville	F17		0.29	0.39	0.34			0.21
Palm Valley	F16				0.11	0.14		0.07
S. Ponte Vedra	F15	1.23	0.57	0.19	0.23	0.14		0.31
Anastasia Island	F14							
Marineland	F13		0.29					0.04
Palm Coast	F12			0.19		0.14		0.07
Flagler (N)	F11					0.14		0.04
Flagler (S)	F10		0.29		0.24	0.14	0.59	0.17
Ormond Beach	F09							
Daytona	F08					0.14		0.04
New Smyrna	F07		0.29		0.12	0.14	0.59	0.14
Canaveral (N)	F06	5.32	10.26	4.43	4.91	4.09	6.47	5.40
Canaveral (M)	F05	5.32	13.67	4.62	4.12	4.23	7.06	5.68
Canaveral (S)	F04		1.14	1.35	0.12	0.85	0.59	0.66
Cocoa Beach	F03	2.10	1.43	1.73	0.35	1.55	1.77	1.25
Satellite	F02	4.91	5.70	3.28	1.72	1.98	5.29	3.03
Melbourne	F01	20.89	23.35	21.39	21.80	20.59	28.23	21.91
Vero Beach	F21-23	9.42	4.84	9.63	6.73	6.77	5.88	7.28
Hutchinson (N)	F24	0.41	0.86	1.93	1.72	2.54	2.94	1.81
Hutchinson (S)	F25	5.74	5.41	7.13	6.85	7.76	7.65	6.90
Jupiter Island	F26-27	16.79	8.26	12.91	18.16	24.68	15.28	17.32
Juno Beach	F28	13.52	11.67	15.81	16.90	11.43	10.00	14.01
Palm Beach	F29	4.51	3.13	5.20	5.38	4.80	2.94	4.70
Boca Raton	F30	5.74	4.56	6.36	6.52	4.51	1.77	5.40
Deerfield	F31	2.46	1.14	2.31	0.92	1.27	1.18	1.43
Ft. Lauderdale	F32	1.23	2.56	0.96	1.95	1.41	1.18	1.60
Hollywood	F33	0.41		0.19	0.12		0.59	0.14
Miami	F34		0.29		0.24	0.14		0.14
Fisher Island	F35					0.14		0.04
Virginia Key	F36							
Key Biscayne	F37				0.34	0.14		0.14
		100.00	100.00	100.00	100.00	100.00	100.00	100.00

*Includes 22 from Jupiter Island on Survey 4 from unknown category based on nest to false crawl ratio.

Spaces represent zeros.

Table 4. Percent distribution of nesting crawls by zone for South Carolina, Georgia and Florida (4 surveys) N=220 for S. C. & Ga. N=2676 all three states

Zone		Survey #2	Survey #3	Survey #4	Survey #5	Subtotal	Total
Huntington Beach	S01				1.37	0.45	0.04
Litchfield Beach	S02						
Pawleys Island	S03	4.35				0.45	0.04
Debidue	S04		1.67		1.37	0.91	0.07
North Island	S05	4.35	5.00	1.56	1.37	2.73	0.22
Sand Island	S06		3.33	7.81	5.48	5.00	0.41
South Island	S07	4.35	1.67	4.69	5.48	4.09	0.34
Cedar Island	S08		3.33	3.13	1.37	2..27	0.19
Murphy Island	S09	8.70		1.56	1.37	1.82	0.15
Cape Island	S10	4.35	31.67	20.31	9.59	18.18	1.49
Lighthouse	S11			1.56	2.74	1.36	0.11
Raccoon Key	S12		8.33	1.56	4.11	4.09	0.34
Bulls Island	S13	4.35	1.67	1.56	1.37	1.82	0.15
Capers Island	S14		3.33		1.37	1.36	0.11
Dewees Island	S15				1.37	0.45	0.04
Isle of Palms	S16			1.56		0.45	0.04
Sullivans Island	S17						
Morris Island	S18						
Folly Beach	S19			1.56		0.45	0.04
Kiawah Island	S20	13.04	1.67	1.56		2.27	0.19
Seabrook Island	S21	4.35	1.67			0.91	0.07
Edisto Island	S22	13.04	1.67	4.69	12.33	7.27	0.60
Pine & Otter	S23-24	13.04	8.33	1.56	2.74	5.00	0.41
Harbor & Hunting	S25-26		1.67	4.69	1.37	2.27	0.19
Fripp Island	S27	4.35		6.25	1.37	2.73	0.22
Pritchards Island	S28				4.11	1.36	0.11
Little Capers	S29				4.11	1.36	0.11
St. Phillips/Bay Pt.	S30-31	4.35	1.67	3.13	15.07	6.82	0.56
Hilton Head Island	S32	4.35	6.67	4.69	4.11	5.00	0.41
Daufuskie Island	S33						
Turtle Island	S34						
Savannah Beach	G01						
Little Tybee Island	G02				1.37	0.45	0.04
Wassaw Snd Is.	G03				1.37	0.45	0.04
Wassaw Island	G04						
Pine & L. Wassaw	G05				1.37	0.45	0.04
Raccoon Key	G06		1.67			0.45	0.04
Ossabaw Island	G07	4.35	5.00	3.13	4.11	4.09	0.34
St. Catherine's	G08		1.67	1.56	4.11	2.27	0.19
Blackbeard Island	G09	4.35		6.25	1.37	2.73	0.22
Sapelo Island	G10						
Wolf Island	G11						
Egg Island	G12						
Little St. Simons	G13			1.56		0.45	0.04
Sea Island	G14				1.37	0.45	0.04
St. Simons Island	G15						
Jekyll Island	G16	4.35	1.67	4.69		2.27	0.19
Little Cumberland	G17		1.67		1.37	0.91	0.07
Cumberland Island	G18		5.00	9.38		4.07	0.34
All Florida							91.78
		100.02	100.03	100.00	100.01	97.64	100.02

Spaces represent zeros.

Table 5. Percent distribution of nesting crawls by zone for North Carolina, South Carolina, Georgia and Florida. (2 surveys) N=20 for N. C. N=1540 for all four states.

Zone		Survey #3	Survey #4	Subtotal	Total
Cape Hatteras	N17		12.50	5.00	0.06
Ocracoke	N16		12.50	5.00	0.07
Core Banks North	N15				
Core Banks South	N14				
Cape Lookout	N13				
Shackleford Bank	N12	8.33		5.00	0.06
Bogue Bank	N11				
Bear & Brown Isl.	N10	8.33	25.00	15.00	0.19
Onslow Beach	N09				
Topsail Beach	N08	16.67		10.00	0.13
Wrightsville Beach	N07	16.67		10.00	0.13
Masonboro Beach	N06				
Kure Beach	N05	16.67		10.00	0.13
Smith Island	N04	8.33	25.00	15.00	0.19
Long Beach	N03	8.33		5.00	0.07
Ocean Isle Beach	N02		12.50	5.00	0.06
Sunset Beach	N01	16.67		10.00	0.13
Waites Island*	S38		12.50	5.00	0.07
N. Myrtle Beach*	S37				
Myrtle Beach*	S36				
Garden City Beach*	S35				
S.C., Ga. & Florida					98.70
		100.00	100.00	100.00	99.99

*Northern coast of South Carolina

Spaces represent zeros.

Table 6. Index of relative importance by zone.

(a) Zone Name & Number		(b) Kms	c Mean # Nests/Flight	(d) Density c/b	(e) % of Nesting N=1540	(f) % of Area 1462.6 km	(g) R. I. e/f
Sunset Beach	N01	8.8	1.00	0.11	0.13	0.60	0.22
Holden Beach	N02	12.0	0.50	0.04	0.06	0.82	0.07
Long Beach	N03	21.0	0.50	0.02	0.07	1.44	0.05
Smith Island	N04	13.0	1.50	0.12	0.19	0.89	0.21
Kure Beach	N05	20.0	1.00	0.05	0.13	1.37	0.09
Wrightsville Beach	N06	19.0	1.00	0.05		1.30	
Figure 8 Island	N07	11.2	1.00	0.09	0.13	0.77	0.17
Topsail Beach	N08	35.0	1.00	0.03	0.13	2.39	0.05
Onslow Beach	N09	11.5				0.79	
Bear & Brown Islands	N10	11.0	1.50	0.14	0.19	0.75	0.25
Bogue Banks	N11	39.0				2.67	
Shackleford Banks	N12	14.5	0.50	0.04	0.06	0.99	0.06
Cape Lookout	N13	12.0				0.82	
Core Banks (S)	N14	40.0				2.74	
Core Banks (N)	N15	36.0				2.46	
Ocracoke Island	N16	35.0	0.50	0.01	0.07	2.39	0.03
Hatteras Island	N17	21.0	0.50	0.02	0.06	1.44	0.04
Huntington Beach	S01	2.2	0.25	0.11		0.15	
Litchfield Beach	S02	7.2				0.49	
Pawleys Island	S03	5.8	0.25	0.04		0.40	
Debidue Island	S04	7.1	0.50	0.07	0.07	0.49	0.14
North Island	S05	13.5	1.50	0.11	0.26	0.92	0.28
Sand Island	S06	4.0	2.75	0.69	0.46	0.27	1.70
South Island	S07	4.0	2.25	0.56	0.26	0.27	0.96
Cedar Island	S08	4.3	1.25	0.29	0.26	0.29	0.90
Murphy Island	S09	9.0	1.00	0.11	0.07	0.62	0.11
Cape Island	S10	8.0	10.00	1.25	2.08	0.55	3.78
Lighthouse Island	S11	3.0	0.75	0.25	0.07	0.21	0.33
Raccoon Key	S12	9.0	2.25	0.25	0.39	0.62	0.63
Bulls Island	S13	10.5	1.00	0.10	0.13	0.72	0.18
Capers Island	S14	5.2	0.75	0.14	0.13	0.36	0.36
Dewees Island	S15	4.0	0.25	0.06		0.27	
Isle of Palms	S16	10.0	0.25	0.03	0.07	0.68	0.10
Sullivans Island	S17	6.3				0.43	
Morris Island	S18	5.4				0.37	
Folly Beach	S19	10.4	0.25	0.02	0.07	0.71	0.10
Kiawah Island	S20	15.0	1.25	0.08	0.13	1.03	0.13

Table 6. Continued

(a) Zone Name & Number		(b) Kms	c Mean # Nests/Flight	(d) Density c/b	(e) % of Nesting N=1540	(f) % of Area 1462.6 km	(g) R. I. e/f
Seabrook Island	S21	6.4	0.50	0.08	0.07	0.44	0.16
Edisto Island	S22	18.3	4.00	0.22	0.26	1.25	0.21
Pine Island	S23	4.1	0.25	0.06	0.07	0.28	0.25
Otter Island	S24	4.3	2.50	0.58	0.33	0.29	1.14
Harbor Island	S25	2.0				0.14	
Hunting Island	S26	7.0	1.25	0.18	0.26	0.48	0.54
Fripp Island	S27	6.0	1.50	0.25	0.26	0.41	0.63
Prichards Island	S28	4.0	0.75	0.19		0.27	
Little Capers Island	S29	4.0	0.75	0.19		0.27	
St. Phillips Island	S30	1.3				0.09	
Bay Point Island	S31	5.0	3.75	0.75	0.20	0.34	0.59
Hilton Head Island	S32	29.0	2.75	0.09	0.46	1.98	0.23
Daufuskie Island	S33	8.1				0.55	
Turtle Island	S34	4.0				0.27	
Garden City Beach	S35	20.8				1.42	
Myrtle Beach	S36	21.8				1.49	
North Myrtle Beach	S37	20.8				1.42	
Waites Island	S38	6.4	0.50	0.08	0.07	0.44	0.16
Savannah Beach	G01	5.6				0.38	
Little Tybee Island	G02	5.3	0.25	0.05		0.36	
Wassaw Sound Islands	G03	4.2	0.25	0.06		0.29	
Wassaw Island	G04	10.5				0.72	
Pine & L. Wassaw	G05	3.8	0.25	0.07		0.26	
Raccoon Key	G06	1.8	0.25	0.14	0.07	0.12	0.58
Ossabaw Island	G07	18.7	2.25	0.13	0.33	1.28	0.26
St. Catherine's Island	G08	21.1	1.25	0.06	0.13	1.44	0.09
Blackbeard Island	G09	13.2	1.50	0.11	0.26	0.90	0.29
Sapelo Island	G10	9.7				0.66	
Wolf Island	G11	5.6				0.38	
Egg Island	G12	2.9				0.20	
Little St. Simons Island	G13	11.4	0.25	0.02	0.07	0.78	0.09
Sea Island	G14	9.6	0.25	0.03		0.66	
St. Simons Island	G15	6.5				0.44	
Jekyll Island	G16	14.6	1.25	0.09	0.26	1.00	0.26
Little Cumberland Island	G17	5.8	0.50	0.09	0.07	0.40	0.18
Cumberland Island	G18	29.7	2.25	0.08	0.58	2.03	0.29
Melbourne Beach	F01	28.0	104.83	3.74	19.61	1.91	10.27

Table 6. Continued

(a) Zone Name & Number		(b) Kms	c Mean # Nests/Flight	(d) Density c/b	(e) % of Nesting N=1540	(f) % of Area 1462.6 km	(g) R. I. e/f
Satellite Beach	F02	20.8	14.50	0.70	2.08	1.42	1.46
Cocoa Beach	F03	16.0	5.80	0.36	0.78	1.09	0.72
Canaveral (S)	F04	8.3	3.17	0.38	0.52	0.57	0.91
Canaveral (M)	F05	24.8	27.17	1.10	3.90	1.70	2.29
Canaveral (N)	F06	28.8	25.83	0.90	4.29	1.97	2.18
New Smyrna	F07	24.8	0.67	0.03	0.07	1.70	0.04
Daytona Beach	F08	16.8	0.17	0.01		1.15	
Ormond Beach	F09	12.8				0.88	
Flagler (S)	F10	19.2	0.83	0.04	0.13	1.31	0.10
Flagler (N)	F11	9.6	0.17	0.02		0.66	
Palm Coast	F12	8.8	0.33	0.04	0.07	0.60	0.12
Marineland	F13	10.4	0.17	0.02		0.71	
Anastasia Island	F14	24.0				1.64	
South Ponte Vedra	F15	12.8	1.50	0.12	0.19	0.88	0.22
Palm Valley	F16	20.8	0.33	0.02	0.07	1.42	0.05
Jacksonville Beach	F17	19.2	1.00	0.05	0.33	1.31	0.25
Little Talbot Island	F18	14.4	0.33	0.02	0.07	0.99	0.07
Amelia Island (S)	F19	8.3				0.57	
Amelia Island (N)	F20	12.0				0.82	
Pelican Island	F21	12.0			3.38	0.82	4.12
Vero Beach (N)	F22	12.8	34.83	0.74	1.95	0.88	2.22
Vero Beach (S)	F23	22.4			1.88	1.53	1.23
Hutchinson Island (N)	F24	20.0	8.67	0.43	1.62	1.37	1.18
Hutchinson Island (S)	F25	17.6	33.00	1.88	6.30	1.20	5.25
Hobe Sound NWR	F26	8.8	15.50	1.76	2.79	0.60	4.65
Jupiter Island	F27	17.6	63.67	3.62	11.88	1.20	9.90
Juno Beach	F28	20.8	67.00	3.22	14.94	1.42	10.52
Palm Beach	F29	25.6	22.50	0.88	4.81	1.75	2.75
Boca Raton	F30	24.0	25.83	1.08	5.84	1.64	3.56
Deerfield Beach	F31	9.6	6.83	0.71	1.30	0.66	1.97
Ft. Lauderdale	F32	20.0	7.67	0.38	1.43	1.37	1.04
Hollywood Beach	F33	19.2	0.67	0.04	0.13	1.31	0.10
Miami Beach	F34	19.2	0.67	0.04	0.13	1.31	0.10
Fisher Island	F35	1.6	0.17	0.11		0.11	
Virginia Key	F36	6.4				0.44	
Key Biscayne	F37	7.2	0.67	0.09	0.19	0.49	0.39
		1462.6			100.10	100.01	

Table 7. Ranking of zones in order of Relative Importance for all zones above the average value of 1.00.

Zone Name & Number		Relative Importance Value
Juno Beach	F28	10.52
Melbourne Beach	F01	10.27
Jupiter Island	F27	9.9
Hutchinson Island (S)	F28	5.25
Hobe Sound NWR	F26	4.65
Pelican Island NWR	F21	4.12
Cape Island NWR	S10	3.78
Boca Raton	F30	3.56
Palm Beach	F29	2.75
Canaveral Nat'l Seashore (M)	F05	2.29
Vero Beach (N)	F22	2.22
Canaveral Nat'l Seashore (N)	F06	2.18
Deerfield Beach	F31	1.97
Sand Island	S06	1.7
Satellite Beach	F02	1.46
Vero Beach (S)	F23	1.23
Hutchinson Island (N)	F24	1.18
Otter Island	S24	1.14
Ft. Lauderdale Beach	F32	1.04

Table 8. Index of Relative Importance by state based on surveys 3 and 4. N=1540

State	Kms	% of Area	Total Nests	% Nests	R.I.
North Carolina	360.0	24.63	19	1.23	0.05
South Carolina	317.2	21.68	98	6.36	0.29
Georgia	180.0	12.30	27	1.75	0.14
Florida	605.4	41.40	1396	90.65	2.19
Totals	1462.6	100.01	1540	99.99	

Note: Total Nests for Florida includes 22 from Jupiter Island unknown category based on nest to false crawl ratio.

Table 9. Comparison of Observer 1 with ground truth by zones. (Unadjusted)

Zone Name & Number		Survey #	Observer 1 Nests	Observer 1 Non-Nesting Emergence	Observer 1 Unknown	Observer 1 Total	Ground Truth Nests	Ground Truth Non-Nesting Emergence	Ground Truth Unknown	Ground Truth Total
Melbourne Beach	F01	1	33	7	0	40	30	12	0	42
		2	36	16	0	52	22	32	0	54
		3	46	108	1	155	63	95	0	158
		4	90	158	1	249	79	177	0	256
		5	40	113	0	153	60	103	1	164
		6	22	15	0	37	25	13	0	38
Totals			267	417	2	686	279	432	1	712
Canaveral National Seashore	F06	1	3	0	0	3	2	1	0	3
		4	8	6	0	14	10	10	0	20
		6	0	2	0	2	0	1	0	1
Totals			11	8	0	19	12	12	0	24
Hobe Sound/Jupiter Island	F26-27	1	10	21	0	31	19	15	0	34
		2	11	14	0	25	11	17	0	28
		3	11	28	0	39	16	32	0	48
		4	21	28	0	49	28	24	0	52
		5	47	22	0	69	49	27	0	76
		6	8	3	0	11	10	1	0	11
			108	116	0	224	133	116	0	249
Boca Raton	F30	1	1	5	0	6	1	4	0	5
		2	4	3	0	7	7	4	0	11
		4	4	2	1	7	7	4	0	11
		5	6	0	0	6	6	3	0	9
		6	1	1	0	2	1	1	0	2
Totals			16	11	1	28	22	16	0	38
Cape Island	S10	2	1	12	2	15	5	20	0	25
		3	19	19	2	40	20	21	0	41
		4	13	43	0	56	17	42	0	59
		5	7	24	0	31	6	25	0	31
Totals			40	98	4	142	48	108	0	156
Smith Island	N04	2	3	2	2	7	3	2	2	7
Kiawah Island	S20	3	2	3	0	5	4	0	0	4
Cumberland Island	G18	4	9	5	1	15	11	3	0	14
Wassaw Island	G04	5	0	0	0	0	1	1	0	2
Totals			14	10	3	27	19	6	2	27

Table 9. Continued

Zone Name & Number	Survey #	Observer 1				Ground Truth			
		Nests	Non-Nesting Emergence	Unknown	Total	Nests	Non-Nesting Emergence	Unknown	Total
Totals for all areas		14	10	3	27	19	6	2	27
		16	11	1	28	22	16	0	38
		108	116	0	224	133	116	0	249
		40	98	4	142	48	108	0	156
		267	417	2	686	279	432	1	712
		11	8	0	19	12	12	0	24
		456	660	10	1126	513	690	3	1206

Table 10. Comparison of Observer 2 with ground truth by zones. (Unadjusted)

Zone Name & Number		Survey #	Observer 2				Ground Truth			
			Nests	Non-Nesting Emergence	Unknown	Total	Nests	Non-Nesting Emergence	Unknown	Total
Melbourne Beach	F01	1	29	5	0	34	30	12	0	42
		2	38	15	0	53	22	32	0	54
		3	81	82	0	163	63	95	0	158
		5	57	102	0	159	60	103	1	164
		6	25	13	0	38	25	13	0	38
Totals			230	217	0	447	200	255	1	456
Canaveral National Seashore	F06	1	2	0	0	2	2	1	0	3
		6	1	0	0	1	0	1	0	1
Totals			3	0	0	3	2	2	0	4
Hobe Sound/Jupiter Island	F26-27	1	17	13	0	30	19	15	0	34
		2	10	15	0	25	11	17	0	28
		3	16	26	0	42	16	32	0	48
		5	54	18	0	72	49	27	0	76
		6	7	4	0	11	10	1	0	11
			104	76	0	180	105	92	0	197
Boca Raton	F30	1	2	4	0	6	1	4	0	5
		2	4	3	0	7	7	4	0	11
		3	10	7	0	17	10	8	0	18
		5	6	0	0	6	6	3	0	9
		6	2	1	0	3	1	1	0	2
Totals			24	15	0	39	25	20	0	45
Cape Island	S10	2	2	13	2	17	5	20	0	25
		3	20	21	0	41	20	21	0	41
		5	10	21	0	31	6	25	0	31
Totals			32	55	2	89	31	66	0	97
Smith Island	N04	2	3	1	0	4	3	2	2	7
Kiawah Island	S20	3	3	1	0	4	4	0	0	4
Cumberland Island	G18									
Wassaw Island	G04	5	0	0	0	0	1	1	0	2
Totals			6	2	0	8	8	3	2	13

Table 10. Continued

		Observer 2				Ground Truth			
Zone Name & Number	Survey #	Nests	Non-Nesting Emergence	Unknown	Total	Nests	Non-Nesting Emergence	Unknown	Total
Totals for all areas		6	2	0	8	8	3	2	13
		32	55	2	89	31	66	0	97
		104	76	0	180	105	92	0	197
		24	15	0	39	25	20	0	45
		230	217	0	447	200	255	1	456
		3	0	0	3	2	2	0	4
Totals		399	365	2	766	371	438	3	812

Table 11. Comparison of Observers 1 and 2 with ground truth by survey. (Unadjusted)

Survey	Ground Truth		Observer 1	Observer 2
Survey #1 (18.3% sample)				
Nests	52		47	50
Non-nesting Emergences	32		33	22
Unknown	0		0	0
Total	0		80	72
Survey #2 (14.7% sample)				
Nests	48		55	57
Non-nesting Emergences	75		47	47
Unknown	2		4	2
Total	125		106	106
Survey #3 (14.1% sample)	Obs. 1	Obs. 2		
Nests	103	113	78	130
Non-nesting Emergences	148	156	158	137
Unknown	0	0	3	0
Total	251	269	239	267
Survey #4 (21.0% sample)				
Nests	152		145	Incomplete
Non-nesting Emergences	260		242	Data by
Unknown	0		3	Alternate
Total	412		390	Obs. 2
Survey #5 (18.1% sample)				
Nests	122		100	127
Non-nesting Emergences	159		159	141
Unknown	1		0	0
Total	282		259	268
Survey #6 (19.9% sample)				
Nests	36		31	35
Non-nesting Emergences	16		21	18
Unknown	0		0	0
Total	52		52	53
Totals for all surveys (16.6% sample)	Obs. 1	Obs. 2		
Nests	513	371	456	399
Non-nesting Emergences	690	438	660	365
Unknown	3	3	10	2
Total	1206	812	1126	766

Table 12. Summary of types of errors for Observers 1 and 2 by survey. (Unadjusted)

Survey #1	Observer 1	Observer 2	# of Crawls	Mean % Error
Missed observations	6	13		
Misidentification	11	9	N=84	25.6
Misaged	2	2		
Total	19	24		
Survey #2				
Missed observations	22	19		
Misidentification	15	19	N=125	31.2
Misaged	2	1		
Total	39	39		
Survey #3				
Missed observations	14	12	Obs. 1 Obs. 2	
Misidentification	32	43	N=251 N=269	22.3
Misaged	8	7		
Total	54	62		
Survey #4				
Missed observations	33	Incomplete		
Misidentification	66	Data by	N=412	27.2
Misaged	13	Alternate		
Total	112	Obs. 2		
Survey #5				
Missed observations	26	16		
Misidentification	53	58	N=282	30.3
Misaged	3	15		
Total	82	89		
Survey #6				
Missed observations	1	2		
Misidentification	9	8	N=52	21.2
Misaged	1	1		
Total	11	11		
Grand Total All Surveys				
Missed observations	102	62	Obs. 1 Obs. 2	
Misidentification	186	137	N=1206 N=812	26.8
Misaged	29	26		
Total	317	225		

Table 13. Summary of *Chelonia mydas* tracks in Florida.

	Fresh Nests	Fresh False	Total Fresh	Old Tracks
Survey #1	0	0	0	0
Survey #2	3	0	3	0
Survey #3	4	0	4	3
Survey #4	3	3	6	3
Survey #5	16	11	27	2
Survey #6	5	7	12	14
Totals	31	21	52	22

Table 14. Summary of five replicate flights.

		Ground Truth		Observer #1		Observer #2	
Replicate #		Fresh	Old	Fresh	Old	Fresh	Old
1	Nests	14	41	14	6	13	5
	False Crawls	16	27	4	0	2	0
	Unknown	0	0	1	0	0	0
	Totals	30	68	19	6	15	5
2	Nests	13	ND	6	88	7	26
	False Crawls	9		9		7	
	Unknown	0		0		0	
	Totals	22		15	88	14	26
3	Nests	10	ND	8	14	10	11
	False Crawls	6		2		2	
	Unknown	0		0		0	
	Totals	16		10	14	12	11
4	Nests	17	33	8	27	7	22
	False Crawls	14		4		6	
	Unknown	0		0		0	
	Totals	31	33	12	27	13	22
5	Nests	14	28	11	33	18	18
	False Crawls	17		11	18	12	3
	Unknown	0		0	0	0	0
	Totals	31	28	22	51	30	21
5-Day Total	Nests	68		47	168	55	82
	False Crawls	62		30	18	29	3
	Unknown	0		1	0	0	0
	Totals	130		78	186	84	85

Table 15. Comparison of two observers on replicate flight #4 for 5 trial passes.

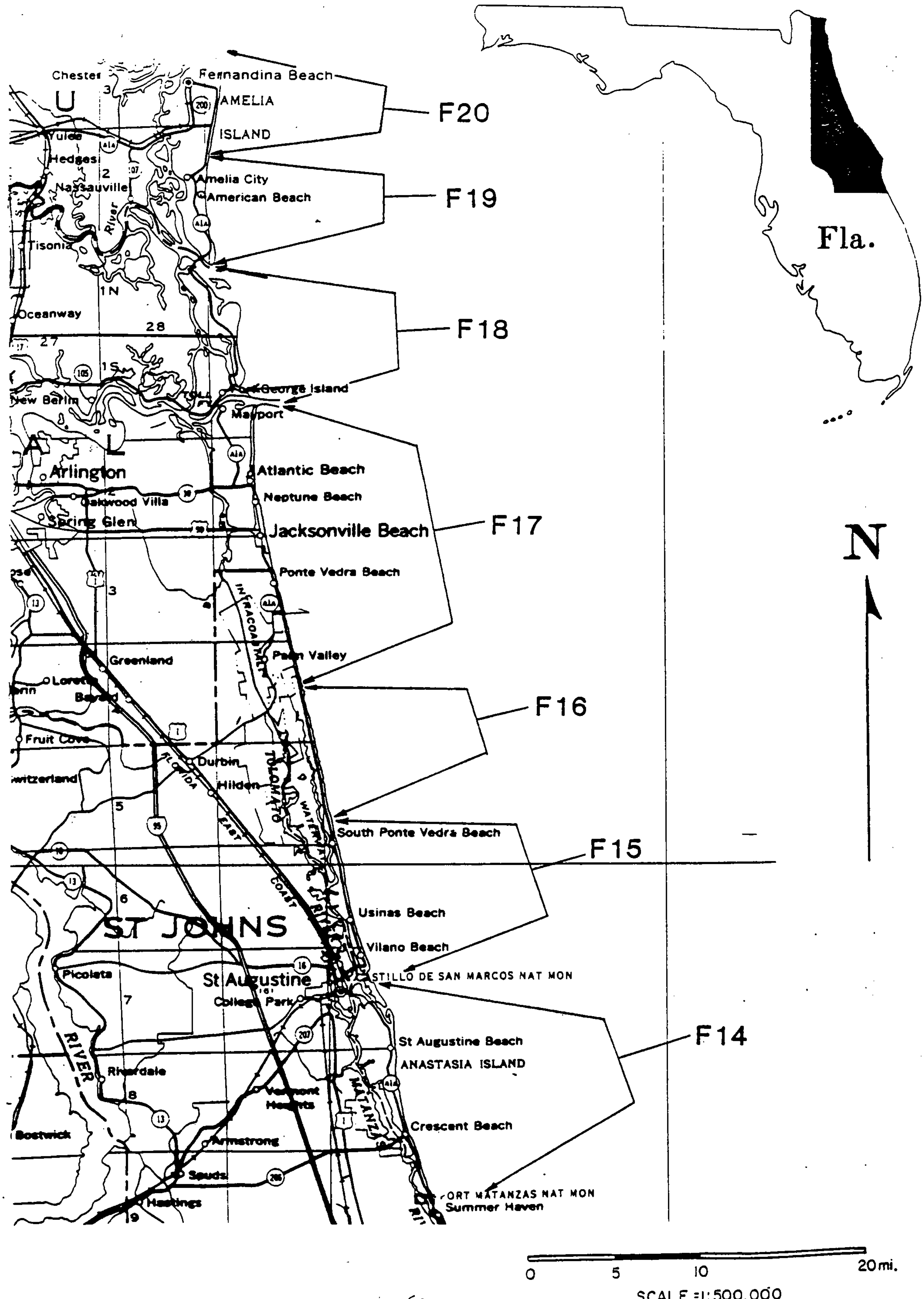
Observer #1	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Fresh Nests	8	8	8	8	9
Fresh False Crawls	4	4	5	6	4
Old Nests	27	30	34	37	39
Totals	39	42	47	51	52
Observer #2					
Fresh Nests	7	11	12	19	17
Fresh False Crawls	6	6	7	8	4
Old Nests	22	24	27	23	33
Totals	35	41	46	50	54
Ground Truth					
Fresh Nests	17				
Fresh False Crawls	14				
Old Nests	33				
Totals	64				

Table 16. Estimates of track visibility as it relates to track age. N=89

Track Age	(a) Distinct	(b) Moderate	c Faint	(d) Body Pit Only	(e) Totals	Est. % Visible* (a + b / e)
1 Day = Fresh						100.0
2 Days	3	14	1	0	18	94.4%
3 Days	1	13	5	0	19	73.7%
4 Days	1	9	9	0	19	52.6%
5 Days	0	1	5	5	11	9.1%
6+ Days	0	0	5	17	22	0.0%

* See text.

Appendix III


Fernandina Beach
AMELIA
ISLAND
F20
Chester
Yulee
Hedges
Nassauville
Amelia City
American Beach
F19
Tisonia
Oceanway
F18
New Berlin
George Island
Mayport
Arlington
Atlantic Beach
Neptune Beach
Oakwood Villa
Spring Glen
Jacksonville Beach
F17
Ponte Vedra Beach
INTRACOASTAL
Greenland
Palm Valley
F16
Fruit Cove
Durbin
Hilden
Switzerland
TOLOMATO
FLORIDA
EAST
COAST
South Ponte Vedra Beach
F15
Usinas Beach
ST JOHNS
Vilano Beach
STILLO DE SAN MARCOS NAT MON
St Augustine
College Park
Picolata
F14
St Augustine Beach
ANASTASIA ISLAND
RIVER
Riverdale
Vermont Heights
MATANZAS
Crescent Beach
Bostwick
Armstrong
Spuds
Hastings
FORT MATANZAS NAT MON
Summer Haven
Fla.
N
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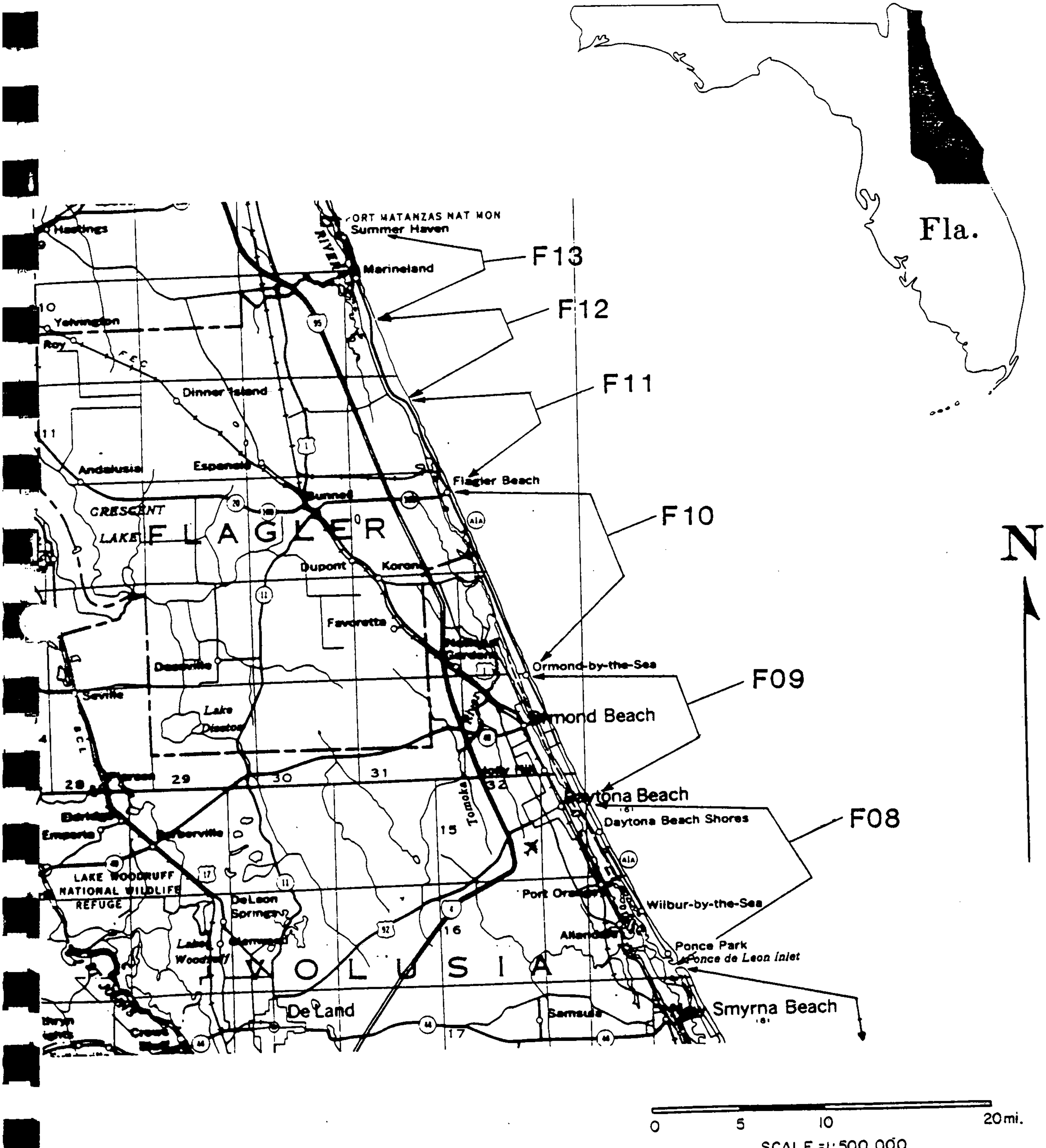
5
10
20 mi.
SCALE =1:500,000



Fla.
N
F13
F12
F11
F10
F09
F08
FORT MATANZAS NAT MON
Summer Haven
Marineland
Flagler Beach
Ormond-by-the-Sea
Ormond Beach
Daytona Beach
Daytona Beach Shores
Wilbur-by-the-Sea
Ponce Park
Ponce de Leon Inlet
Smyrna Beach
FLAGLER
VOLUSIA
CRESCENT LAKE
Hastings
Yelvington
Roy
Dinner Island
Andalusia
Espanola
Bunnell
Dupont
Favoretta
Seville
Lake Disston
LAKE WOODRUFF NATIONAL WILDLIFE REFUGE
DeLeon Springs
Lake Woodruff
DeLand
Samsula
Port Orange
Allandale
Tomoka
Emporia
Barberville
0
5
10
20mi.
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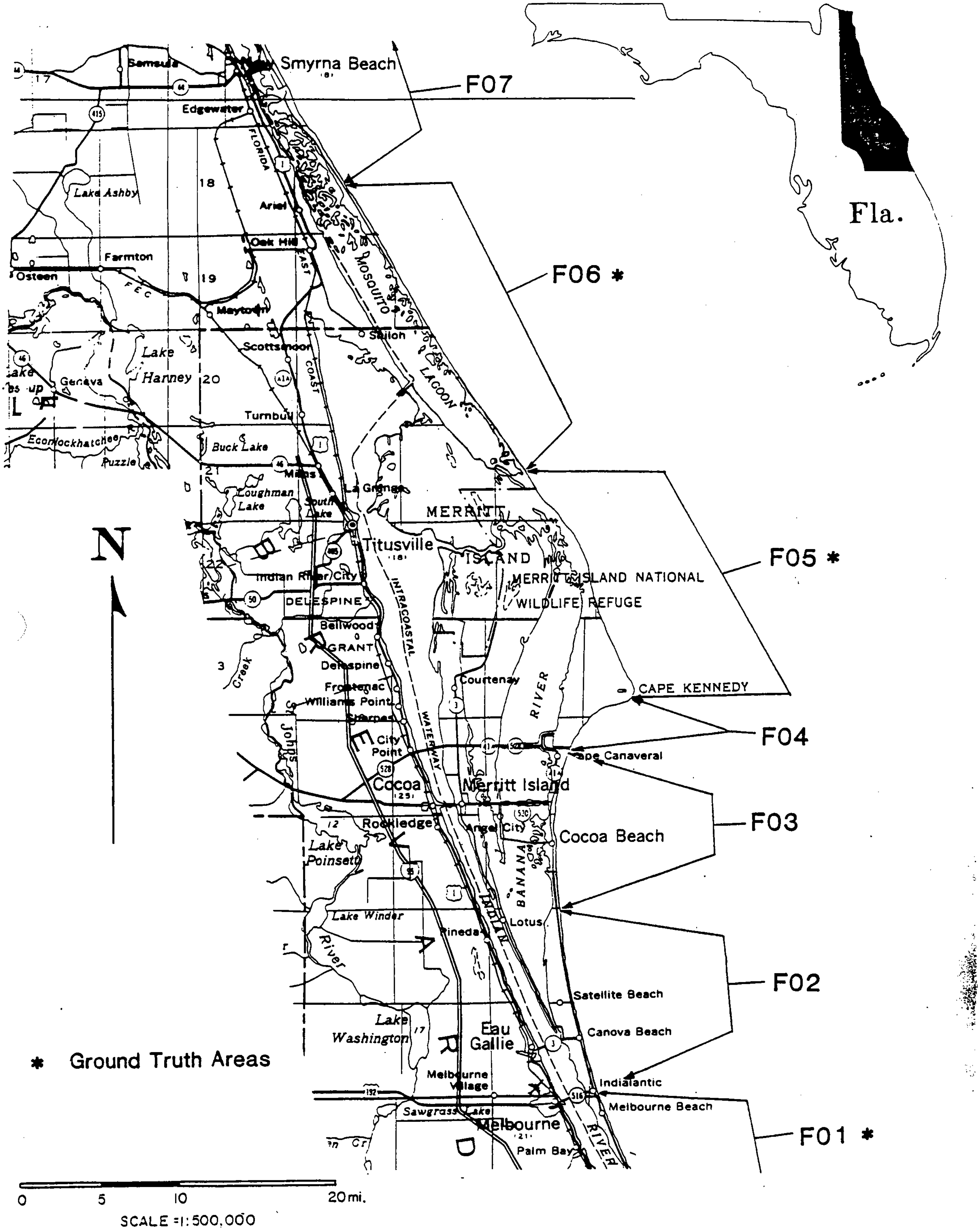
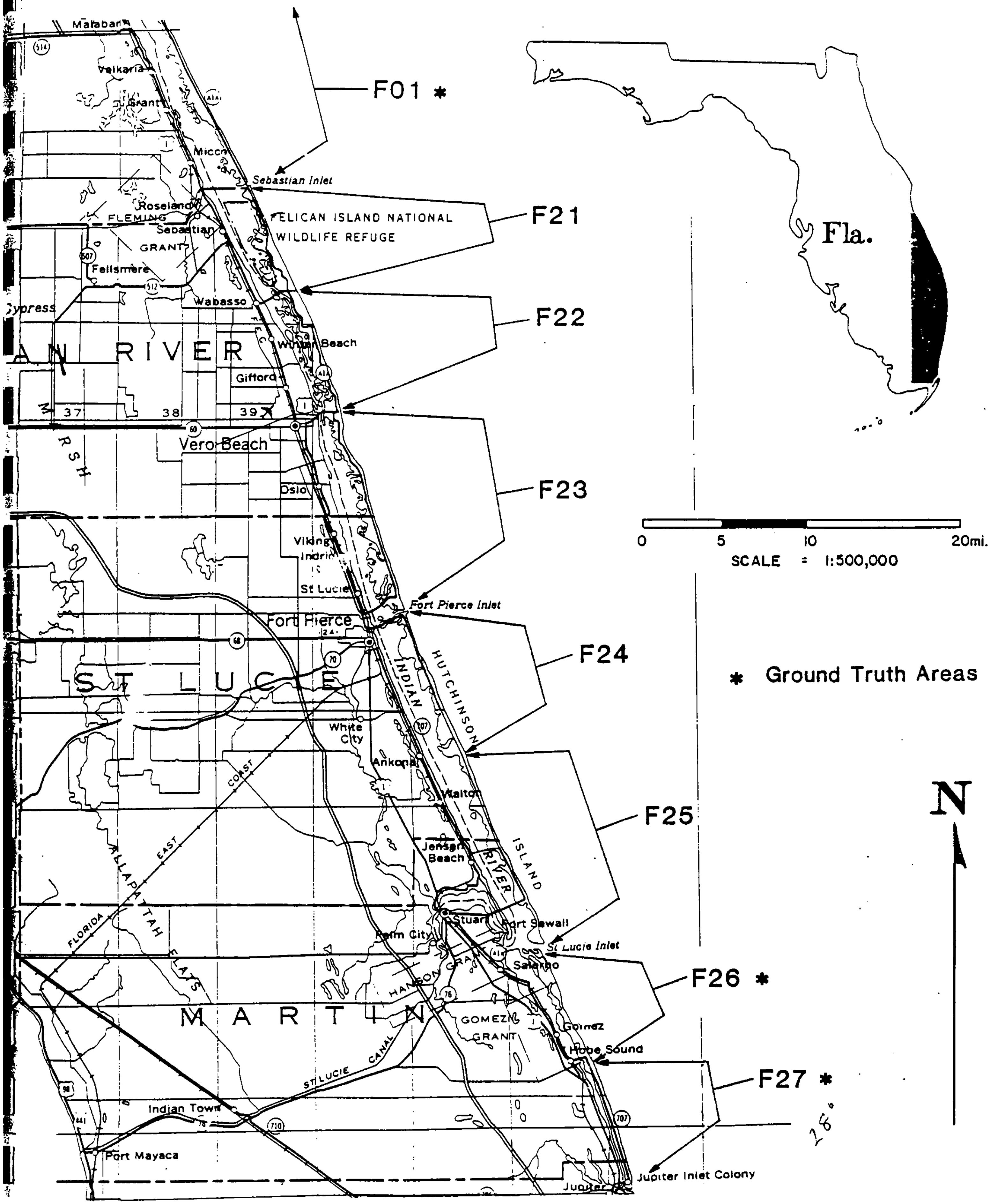
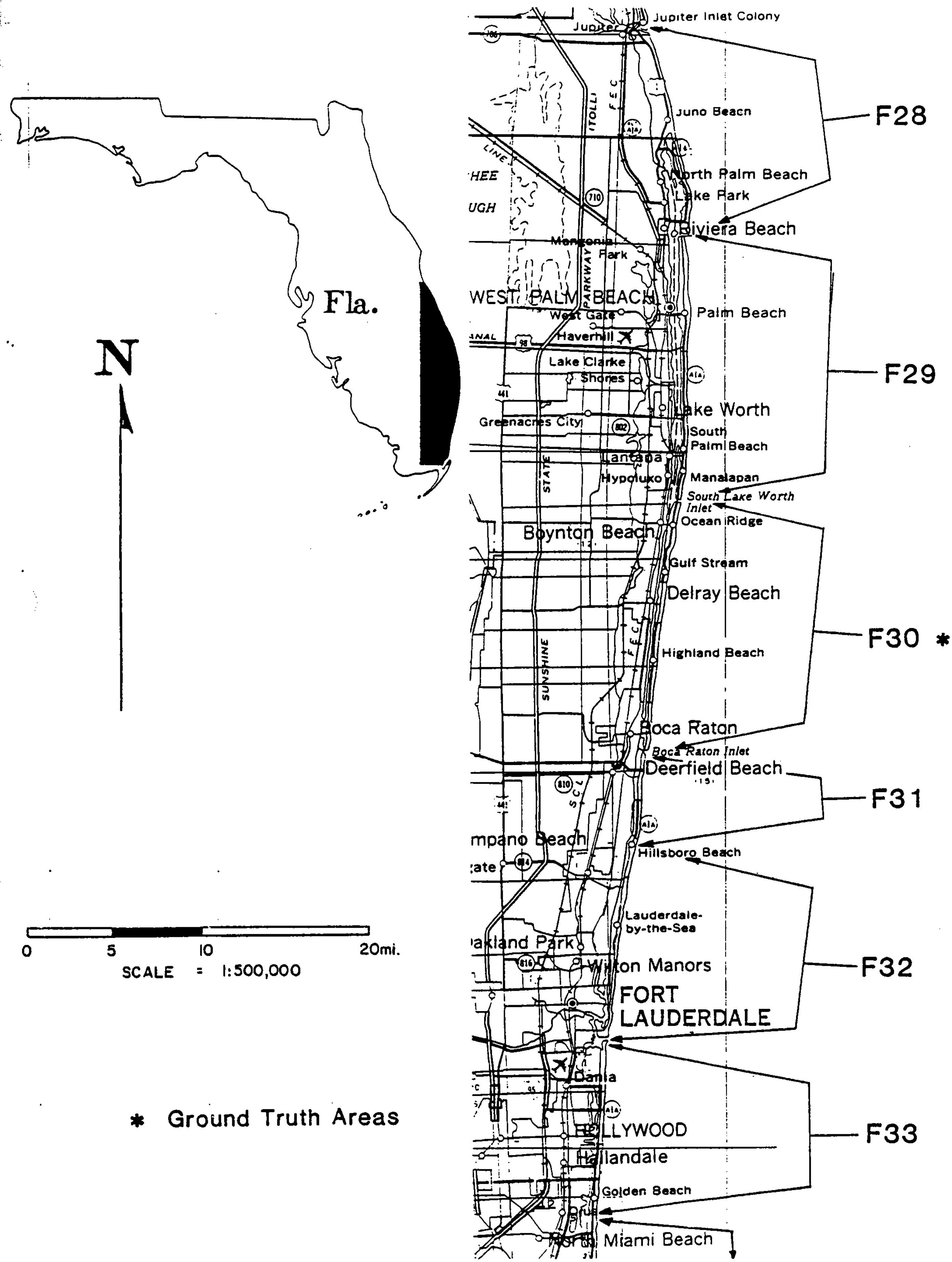


Fla.
N
New Smyrna Beach
Edgewater
Samsula
Lake Ashby
Ariel
Oak Hill
Farmton
Osteen
Maytown
Shiloh
Scottsmoor
MOSQUITO LAGOON
Lake Harney
Geneva
Turnbull
Buck Lake
Econlockhatchee
Puzzle
Mims
La Grange
Loughman Lake
South Lake
MERRITT ISLAND
Titusville
MERRITT ISLAND NATIONAL WILDLIFE REFUGE
Indian River City
DELESPINE
Bellwood
GRANT
Delespine
Frontenac
Williams Point
Sharpes
City Point
INTRACOASTAL WATERWAY
Courtenay
RIVER
CAPE KENNEDY
Cape Canaveral
Cocoa
Merritt Island
Rockledge
Angel City
Cocoa Beach
Lake Poinsett
BANANA
INDIAN
Lake Winder
Lotus
Pineda
River
Satellite Beach
Canova Beach
Lake Washington
Eau Gallie
Melbourne Village
Indialantic
Melbourne Beach
Sawgrass Lake
Melbourne
Palm Bay
RIVER
F07
F06 *
F05 *
F04
F03
F02
F01 *
* Ground Truth Areas
0 5 10 20 mi.
SCALE =1:500,000



F01 *
F21
F22
F23
F24
F25
F26 *
F27 *
Fla.
0
5
10
20mi.
SCALE = 1:500,000
* Ground Truth Areas
N
Malabar
Valkaria
Grant
Micco
Sebastian Inlet
Roseland
FLEMING
Sebastian
GRANT
PELICAN ISLAND NATIONAL
WILDLIFE REFUGE
Fellsmere
Wabasso
Cypress
AN RIVER
Winter Beach
Gifford
37
38
39
Vero Beach
Oslo
Viking
Indrio
St Lucie
Fort Pierce Inlet
Fort Pierce
ST LUCIE
INDIAN
HUTCHINSON
White City
Ankona
Walton
Jensen Beach
RIVER
ISLAND
Stuart
Port Sewall
Palm City
St Lucie Inlet
Salerno
HANSON GRANT
FLORIDA EAST COAST
ALLAPATTAH FLATS
MARTIN
GOMEZ GRANT
Gomez
Hobe Sound
ST LUCIE CANAL
Indian Town
Port Mayaca
Jupiter
Jupiter Inlet Colony
28°


Fla.
N
0 5 10 20mi.
SCALE = 1:500,000
* Ground Truth Areas
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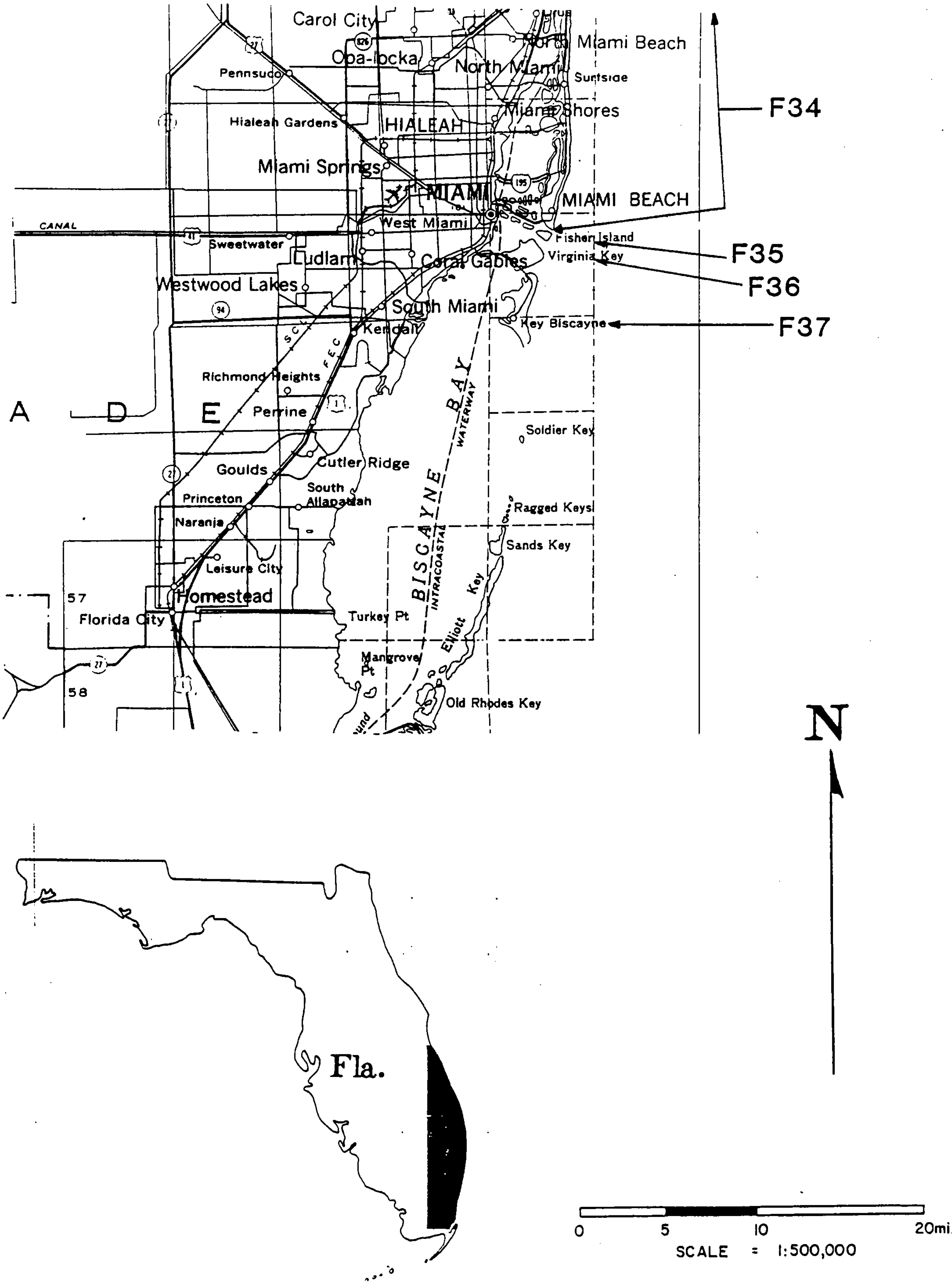
Jupiter
Juno Beach
North Palm Beach
Lake Park
Riviera Beach
Mangonia Park
WEST PALM BEACH
West Gate
Palm Beach
Haverhill
Lake Clarke Shores
Lake Worth
Greenacres City
South Palm Beach
Lantana
Hypoluxo
Manalapan
South Lake Worth Inlet
Ocean Ridge
Boynton Beach
Gulf Stream
Delray Beach
Highland Beach
Boca Raton
Boca Raton Inlet
Deerfield Beach
Pompano Beach
Hillsboro Beach
Lauderdale-by-the-Sea
Oakland Park
Wilton Manors
FORT LAUDERDALE
Dania
HOLLYWOOD
Hallandale
Golden Beach
North Miami Beach
SUNSHINE STATE PARKWAY
F28
F29
F30 *
F31
F32
F33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North Miami Beach
Opa-locka
North Miami
Pennsuco
Suniside
F34
Miami Shores
Hialeah Gardens
HIALEAH
Miami Springs
MIAMI
MIAMI BEACH
CANAL
West Miami
Fisher Island
Sweetwater
F35
Ludlam
Coral Gables
Virginia Key
Westwood Lakes
F36
South Miami
Kendall
Key Biscayne
F37
Richmond Heights
A D E
Perrine
BAY
INTRACOASTAL WATERWAY
Soldier Key
Goulds
Cutler Ridge
South Allapattah
Princeton
Ragged Keys
Naranja
BISCAYNE
Sands Key
Leisure City
57
Homestead
Key
Florida City
Turkey Pt
Elliott
Mangrove Pt
58
Old Rhodes Key
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Fla.
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20mi.
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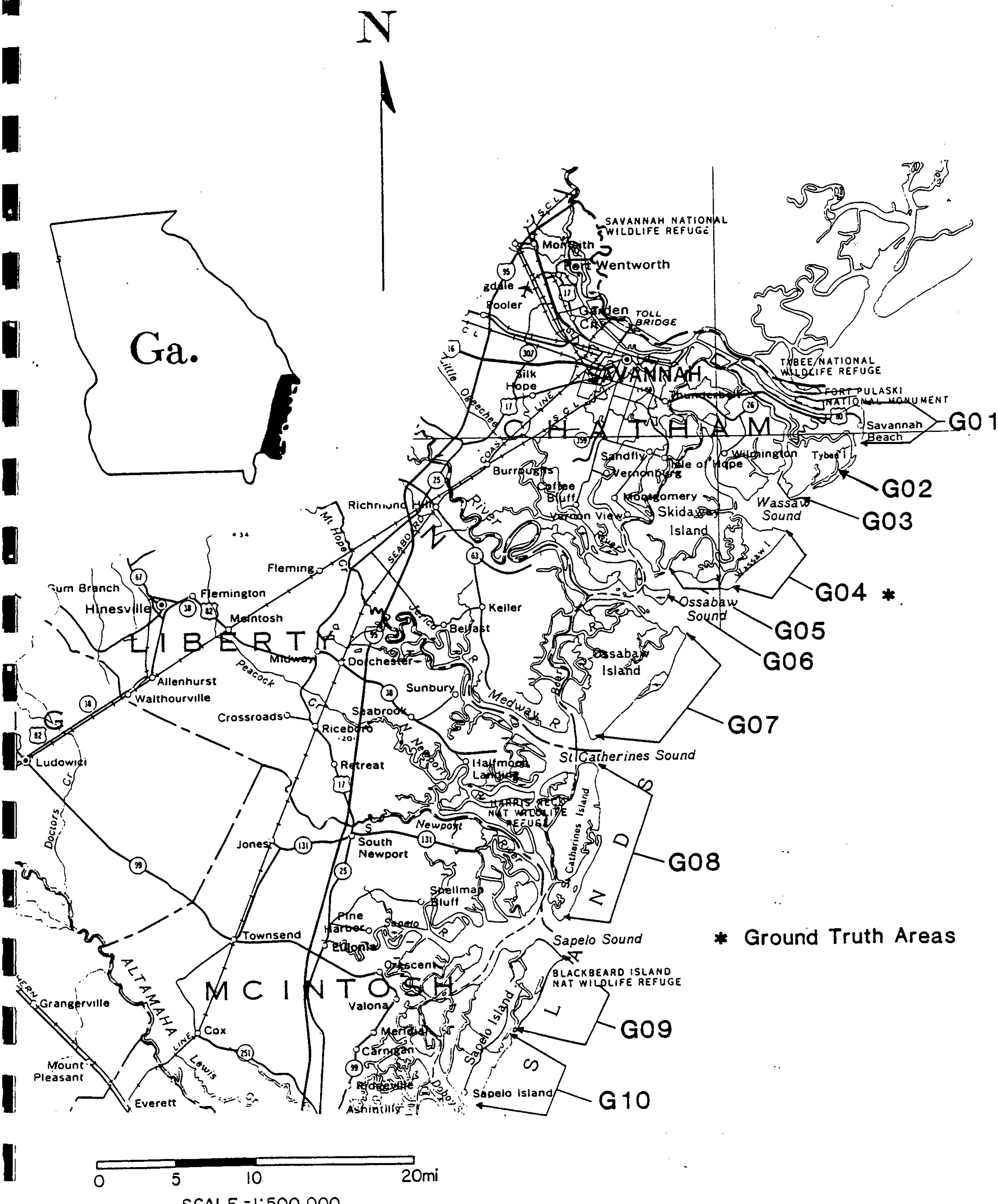
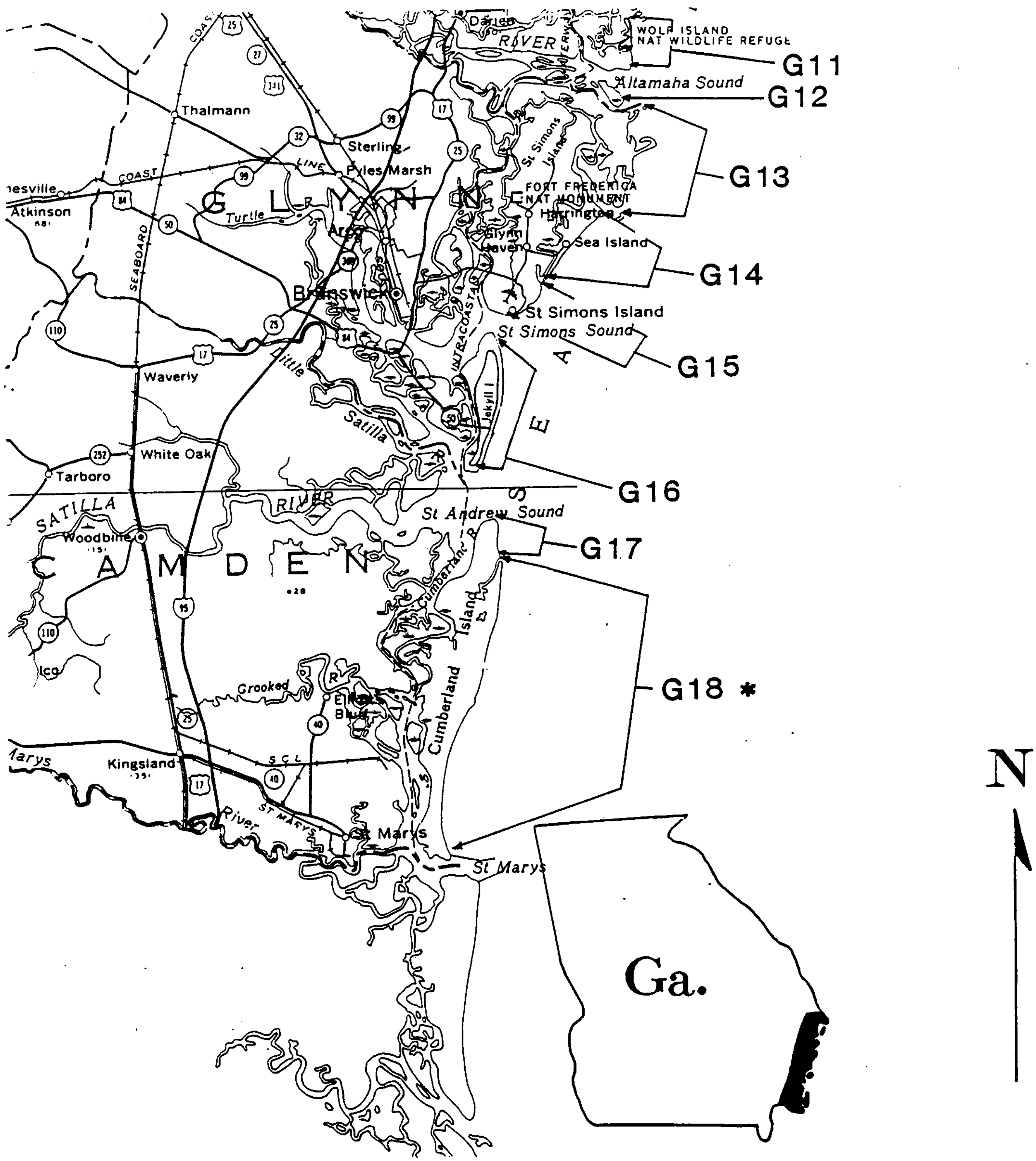

N
Ga.
SAVANNAH NATIONAL WILDLIFE REFUGE
Port Wentworth
SAVANNAH
TYBEE NATIONAL WILDLIFE REFUGE
FORT PULASKI NATIONAL MONUMENT
CHATHAM
LIBERTY
MCINTOSH
ISLANDS
Savannah Beach
Wassaw Sound
Skidaway Island
Ossabaw Sound
Ossabaw Island
St Catherines Sound
HARRIS NECK NAT WILDLIFE REFUGE
Sapelo Sound
BLACKBEARD ISLAND NAT WILDLIFE REFUGE
Sapelo Island
Hinesville
Ludowici
Townsend
G01
G02
G03
G04 *
G05
G06
G07
G08
G09
G10
* Ground Truth Areas
0 5 10 20mi
SCALE =1:500,000



* Ground Truth Areas

0 5 10 20mi

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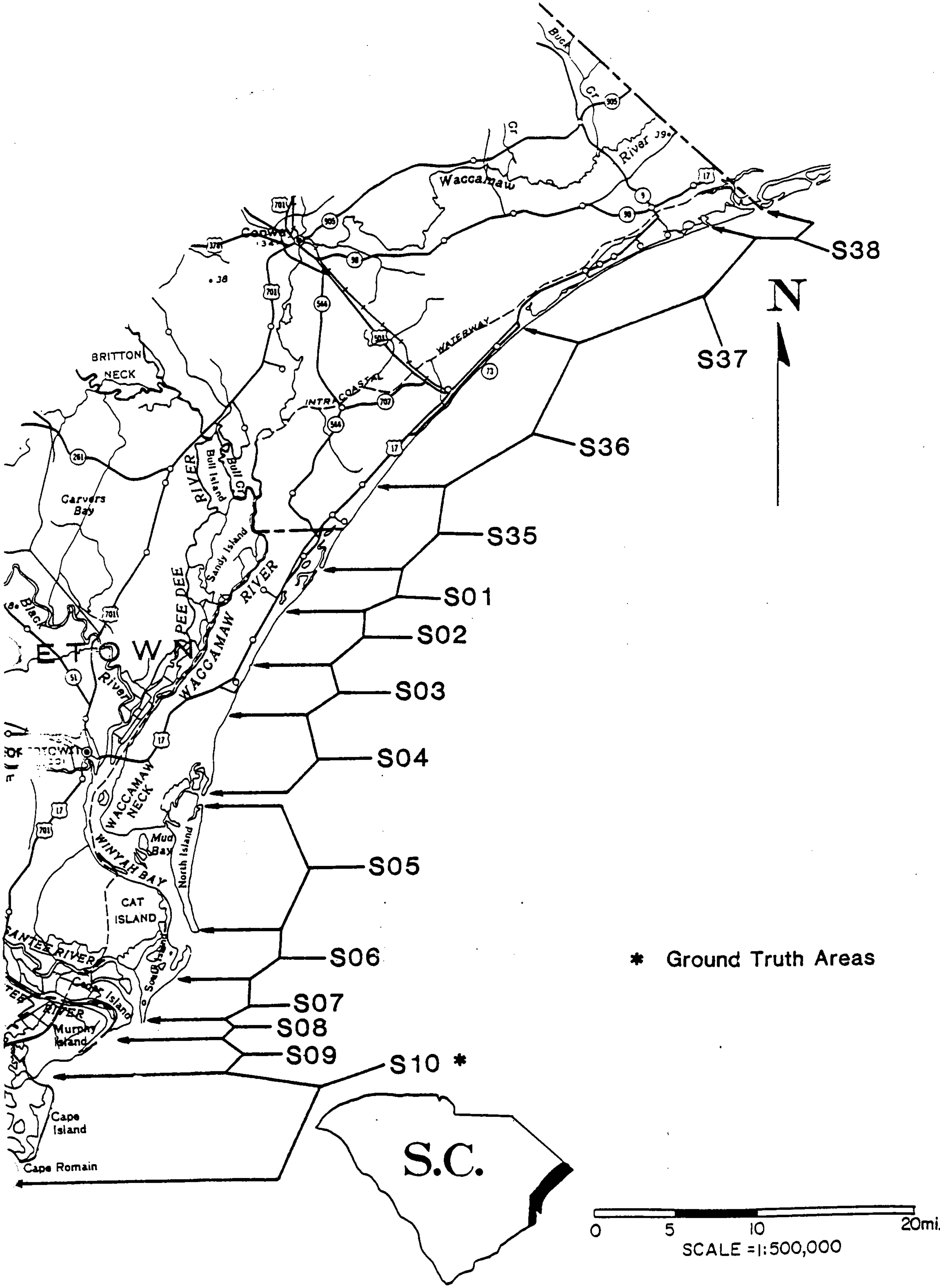
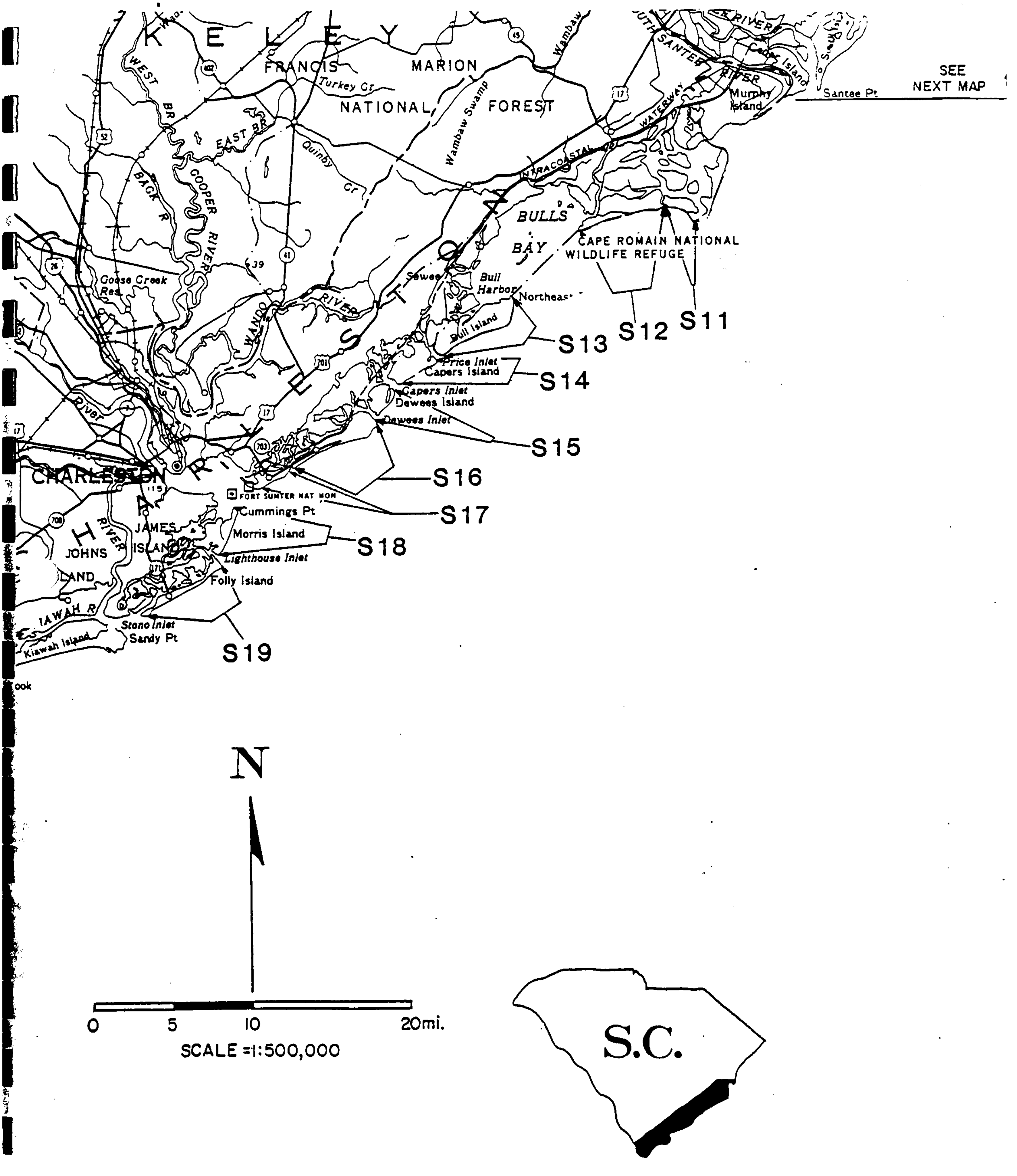

S38
N
S37
S36
S35
S01
S02
S03
S04
S05
S06
S07
S08
S09
S10 *
* Ground Truth Areas
S.C.
0
5
10
20mi.
SCALE =1:500,000
Waccamaw
River
INTRACOASTAL
WATERWAY
BRITTON
NECK
Carvers
Bay
Bull Island
Sandy Island
PEE DEE
RIVER
WACCAMAW
RIVER
WACCAMAW
NECK
WINYAH BAY
Mud
Bay
North Island
CAT
ISLAND
SANTEE RIVER
Cedar Island
South Island
Murphy
Island
Cape
Island
Cape Romain



FRANCIS MARION NATIONAL FOREST
Turkey Cr
Wambaw Swamp
Wambaw
Quinby Cr
WEST BR
EAST BR
BACK R
COOPER RIVER
Goose Creek Res.
WANDO RIVER
INTRACOASTAL WATERWAY
SOUTH SANTEE RIVER
Cedar Island
Murphy Island
Santee Pt
SEE NEXT MAP
BULLS BAY
CAPE ROMAIN NATIONAL WILDLIFE REFUGE
Sewee
Bull Harbor
Northeast
Bull Island
Price Inlet
Capers Island
Capers Inlet
Dewees Island
Dewees Inlet
CHARLESTON
FORT SUMTER NAT MON
Cummings Pt
Morris Island
Lighthouse Inlet
Folly Island
JAMES ISLAND
JOHNS ISLAND
RIVER
IAWAH R
Kiawah Island
Stono Inlet
Sandy Pt
S11
S12
S13
S14
S15
S16
S17
S18
S19
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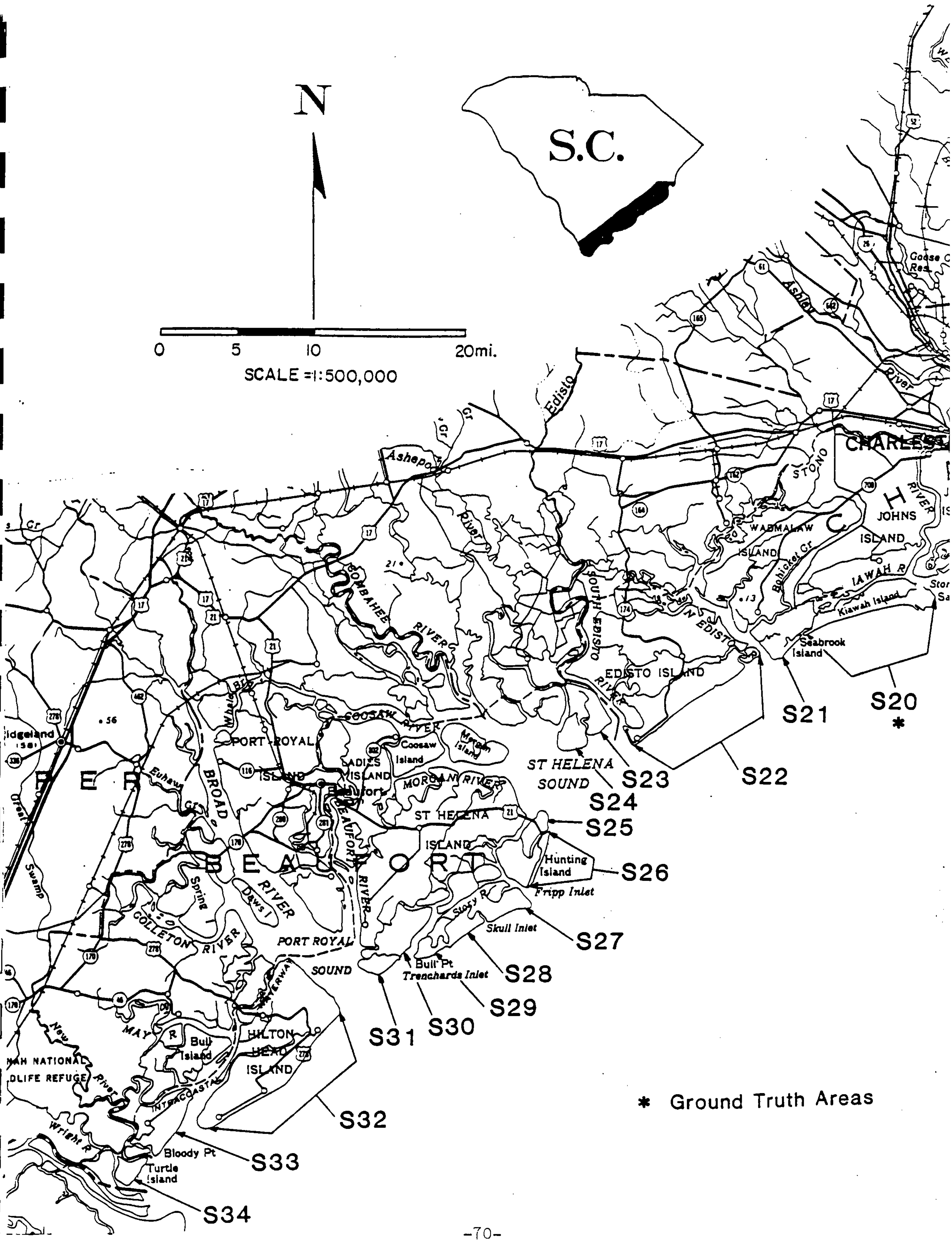
20mi.
SCALE =1:500,000
S.C.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S.C.
0 5 10 20mi.
SCALE =1:500,000
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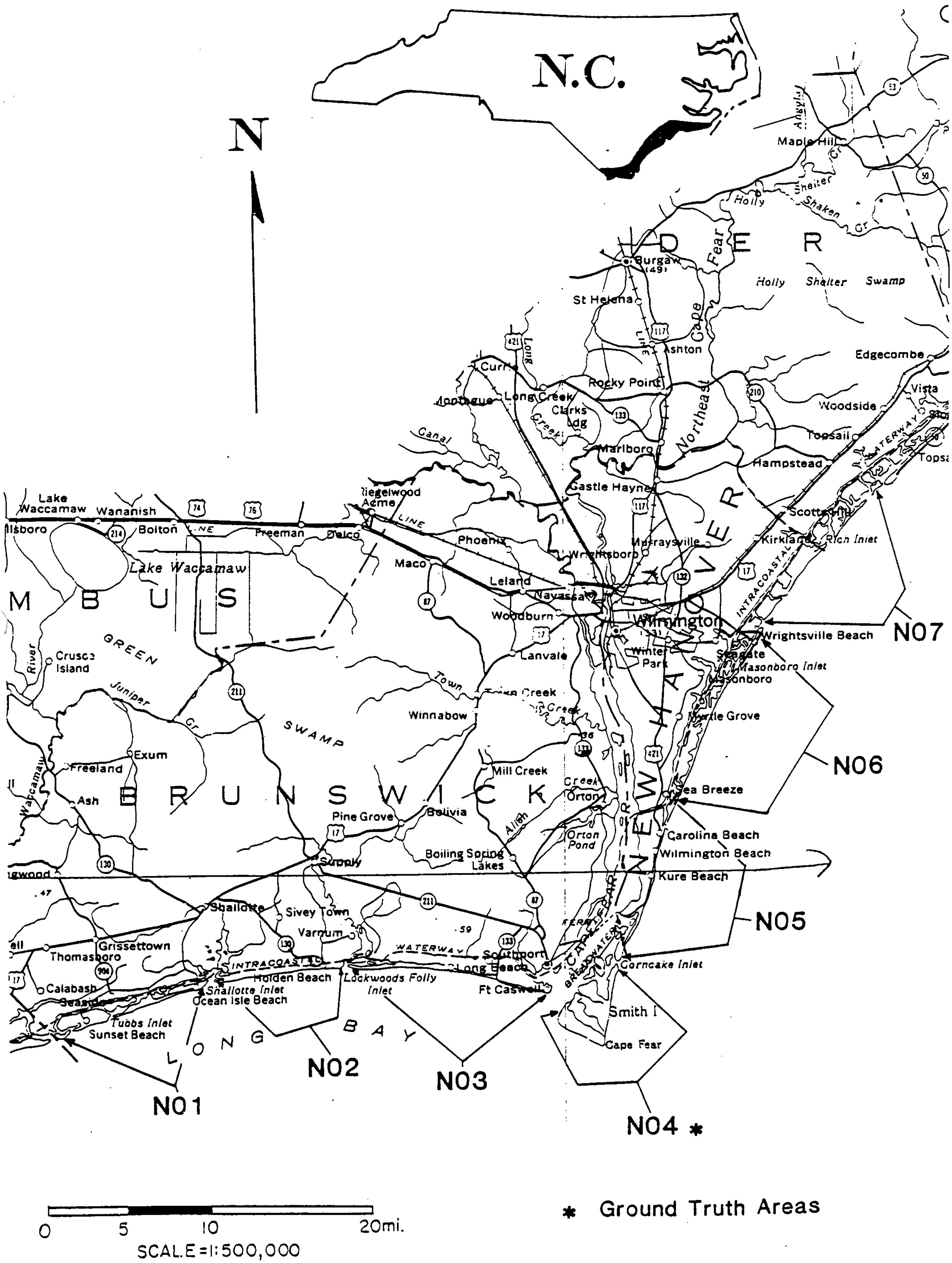
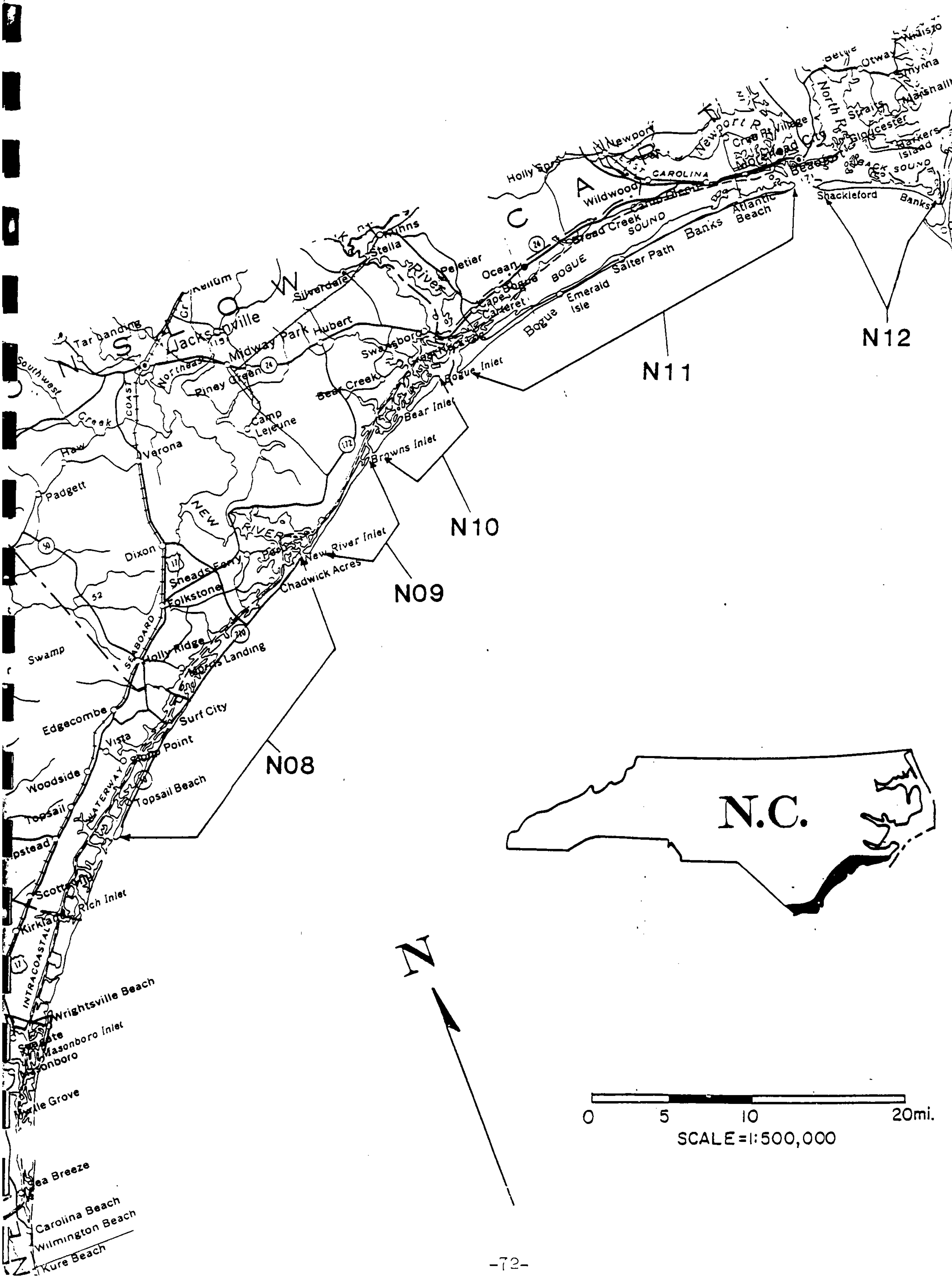
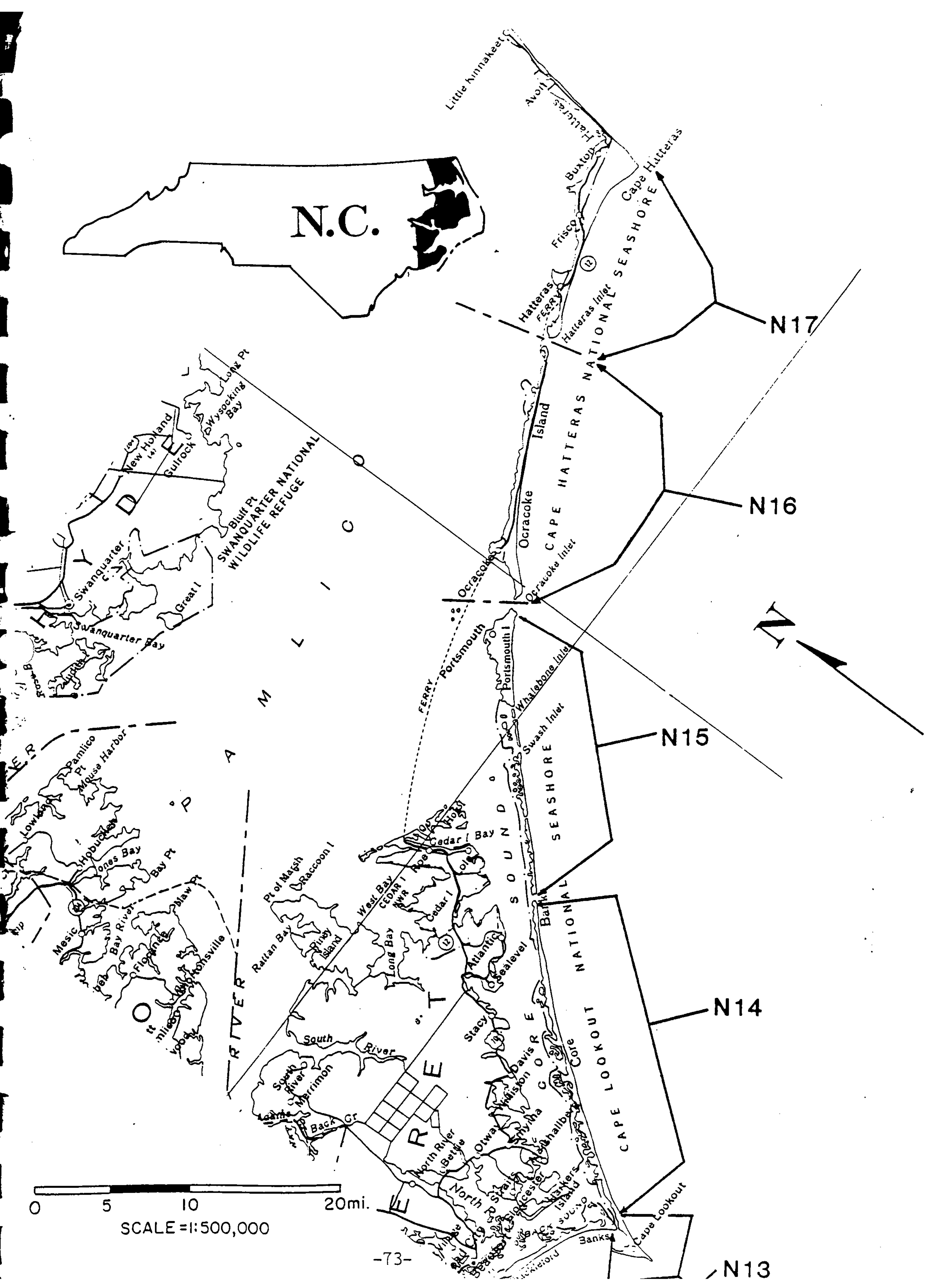
S21
S22
S23
S24
S25
S26
S27
S28
S29
S30
S31
S32
S33
S34
ST HELENA SOUND
PORT ROYAL SOUND
EDISTO ISLAND
Seabrook Island
Kiawah Island
Hunting Island
Fripp Inlet
Skull Inlet
Bull Pt
Trenchards Inlet
HILTON HEAD ISLAND
Bull Island
Bloody Pt
Turtle Island
Beaufort
CHARLESTON
JOHNS ISLAND
WADMALAW ISLAND
PORT ROYAL ISLAND
LADIES ISLAND
ST HELENA ISLAND
Coosaw Island
Morgan Island
BROAD RIVER
COLLETON RIVER
COMBAHEE RIVER
COOSAW RIVER
MORGAN RIVER
BEAUFORT RIVER
SOUTH EDISTO RIVER
STONO RIVER
KIAWAH R
* Ground Truth Areas


N.C.
N
N01
N02
N03
N04 *
N05
N06
N07
* Ground Truth Areas
0 5 10 20mi.
SCALE=1:500,000
B R U N S W I C K
N E W H A N O V E R
L O N G B A Y
Wilmington
Wrightsville Beach
Masonboro Inlet
Masonboro
Myrtle Grove
Sea Breeze
Carolina Beach
Wilmington Beach
Kure Beach
Southport
Long Beach
Ft Caswell
Corncake Inlet
Smith I
Cape Fear
Lockwoods Folly Inlet
Holden Beach
Shallotte Inlet
Ocean Isle Beach
Tubbs Inlet
Sunset Beach
Calabash
Thomasboro
Grissettown
Shallotte
Sivey Town
Varnum
Supply
Boiling Spring Lakes
Bolivia
Pine Grove
Ash
Freeland
Exum
Mill Creek
Orton
Orton Pond
Winnabow
Town Creek
Lanvale
Woodburn
Leland
Navassa
Maco
Phoenix
Riegelwood
Acme
Delco
Freeman
Bolton
Wananish
Lake Waccamaw
Crusco Island
Green Swamp
Wrightsboro
Murraysville
Castle Hayne
Marlboro
Clarks Ldg
Long Creek
Currie
Rocky Point
Ashton
St Helena
Burgaw
Holly Shelter Swamp
Maple Hill
Edgecombe
Vista
Woodside
Topsail
Hampstead
Scotts Hill
Kirkland
Rich Inlet
Winter Park
Seagate
Intracoastal Waterway



N08
N09
N10
N11
N12
N.C.
N
0 5 10 20mi.
SCALE=1:500,000
Topsail Beach
Surf City
New River Inlet
Chadwick Acres
Browns Inlet
Bear Inlet
Bogue Inlet
Emerald Isle
Salter Path
Atlantic Beach
Shackleford Banks
Wrightsville Beach
Masonboro Inlet
Carolina Beach
Wilmington Beach
Kure Beach
Rich Inlet
Jacksonville
Swansboro
Sneads Ferry
Holly Ridge
Camp Lejeune
Morehead City
Beaufort


N.C.
N17
N16
N15
N14
N13
CAPE HATTERAS NATIONAL SEASHORE
CAPE LOOKOUT NATIONAL SEASHORE
SWANQUARTER NATIONAL WILDLIFE REFUGE
Cape Hatteras
Little Kinnakeet
Avon
Buxton
Frisco
Hatteras
FERRY
Hatteras Inlet
Ocracoke Island
Ocracoke
Ocracoke Inlet
Portsmouth
Portsmouth I
Whalebone Inlet
Swash Inlet
Cedar I Bay
Core Banks
Cape Lookout
Swanquarter
Swanquarter Bay
Wysocking Bay
New Holland
Gulrock
Bluff Pt
Great I
Long Pt
Pamlico Pt
Mouse Harbor
Jones Bay
Bay Pt
Bay River
Mesic
Raccoon I
Pt of Marsh
Rattan Bay
West Bay
Long Bay
Atlantic
Sealevel
Stacy
Davis
Smyrna
Otway
South River
Merrimon
Back Cr
North River
Harkers Island
Cape Lookout
Banks
0
5
10
20mi.
SCALE =1:500,000