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ABUNDANCE OF FEMALE CARETTA CARETTA (LOGGERHEAD TURTLES) NESTING ALONG THE SOUTHEAST U.S. COAST 1982 NESTING SEASON

by

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Executive Summary

- The estimate of abundance of female loggerhead turtles nesting along the southeast U.S. coast is 28,884 with a standard error of 6,572.
- Approximate 95% confidence intervals for the estimate is 15,740 $<x<$ 42,028).
- This estimate was derived using aerial and ground survey data collected under NMFS contract beginning in May 1982 and ending in August 1982.

INTRODUCTION

Monthly nesting surveys were conducted under contract to the National Marine Fisheries Service in 1982 by Aero-Marine Surveys, Inc. (Dr. C.R. Shoop, principal investigator), from Cape Hatteras North Carolina to Key Biscayne, Florida. Three monthly surveys were flown with the first in May, the second in June and a third in July (Table 1). The coastal barrier islands and beaches of Georgia were flown daily in a replicate survey for ten successive days from July 24 to August 3, 1982. The June survey included a continuous aerial survey from the Florida west coast to Brownsville, Texas. All monthly surveys included a continuous aerial reconnaissance over all the beaches and barrier islands of the southeast U.S. In Georgia and Florida ground surveys were completed the same day as the aerial survey. No ground truthing was provided in North or South Carolina for the 1982 nesting season. Results of these nesting surveys provide data which are used to derive an index of the number of nesting females in the region.

METHODS

Aerial Surveys

Aerial surveys were flown in a Cessna 182 at altitudes between 250-350 feet offshore at speeds of 70-120 knots. A pilot sits in the left front seat, an observer in the right front seat and a recorder in the right rear seat. The same persons performed these roles on all surveys.

The southeast U.S. coast and islands were subdivided into and identified as distinct zones in which crawl activity was observed. The observer identified crawls to species level when possible. Crawls were differentiated as one of the following crawl types:

(1) FALSE FRESH CRAWL - a crawl not terminating in a nest and less than 24 hours old.

(2) TRUE FRESH CRAWL - a crawl terminating in a nest and less than 24 hours old.

(3) FALSE OLD CRAWL - false crawl more than 24 hours old.

(4) TRUE OLD CRAWL - nesting crawl more than 24 hours old.

(5) UNKNOWN FRESH CRAWL VS. UNKNOWN OLD CRAWL - unknown if false or true.

(6) UNKNOWN IF FRESH CRAWL VS. OLD CRAWL - unknown crawl age.

(7) UNKNOWN - a crawl of unknown type or age.

Ground Surveys

Ground truth surveys were completed on selected islands of Georgia and on a selected beach in Florida. Ground truthing was conducted on a monthly basis on the following Georgia islands:

(1) Wassau

(2) Jekyll

(3) Little Cumberland

(4) Cumberland

The July replicate aerial surveys were complemented by ground surveys in Georgia on the following beaches:

(1) Wassau

(2) Ossabaw

(3) Blackbeard

(4) Sapelo

(5) Little St. Simons

(6) Sea St. Simons

(7) Jekyll

(8) Little Cumberland

(9) Cumberland Island

In Florida, ground surveys were completed along 70 miles of beach in Brevard County, where the greatest frequency of loggerhead nests occurs in the U.S. (Draft Recovery Plan for Marine Turtles, 1981).

Estimation Methods

Counts of crawls from aerial surveys were compared by month and by state of the southeast U.S. to determine if mo .ly differences and/or state differences in crawl frequen..y existed in 1982. The nesting season and areas were stratified temporally and spatially based upon significant differences between crawl frequency in states and months.

A temporal scheme yields a definition of the actual number of days in the nesting season in 1982. However, our nesting surveys were not initiated until May 26, 1982. Our monthly surveys terminated July 23, 1982 and the replicate surveys ended August 3, 1982. Utilizing these dates to define the loggerhead nesting

season would result in an arbitrarily truncated season both at the beginning and end. An examination of these data, and results from previous nesting seasons were used to better define the nesting season and minimize the negative bias introduced from potential seasonal truncation.

Aerial counts of crawls were corrected for age (fresh vs. old) using ground truth data. Aerial fresh crawls observed were also corrected for crawl type errors (i.e., false vs. true) using the ground truth data. Because no ground truth data were available for North and South Carolina, the observed nesting frequencies in these states were compared to those of Georgia and Florida, and to those presented for the Carolinas in the Draft Recovery Plan for Marine Turtles (1981) to determine which correction factors to use.

The corrected aerial counts for fresh, true crawls were estimated by state and expanded temporally to derive an estimate of the total nests per state. Dividing this by the average number of nests per female in that state yields the number of females nesting in that year for a given state.

The formulation used was:

$$N_i = \frac{(gc_i/ac_i)(fn_i/tc_i)[\Sigma(d_{ij})(c_{ij})]}{f} \qquad (1)$$

Where:

i = spatial stratum or state (North Carolina, South Carolina, Georgia, Florida)

j = temporal stratum or month

N_i = estimate of nesting females for spatial stratum i

ac_i = aerial survey fresh crawls

gc_i = ground truth fresh crawls

fn_i = aerial survey crawls

tc_i = ground truth true crawls

d_{ij} = days in temporal stratum j

c_{ij} = crawls in temporal stratum j

f = nests/females

These methods yield an estimate for N_i with the following assumptions:

(1) The value for nests per season is a point estimate and does not include any likely spatial or temporal variability, or any variability between individuals nesting within a given temporal/spatial stratum.

(2) Estimates of nests per season assume females are specific within a nesting season.

(3) The ratio of total aerial crawls to total ground crawls is unvarying between beaches within a state and within a temporal stratum.

(4) The ratio of aerial true crawls to ground true crawls is unvarying in each state, and within a temporal stratum.

Variance estimates, confidence limits and further assumptions are discussed below.

RESULTS AND DISCUSSION

Definitions of Nesting Season

The dates of the actual beginning and end of the nesting season for *Caretta* was not known. Our nesting surveys were

initiated May 26, 1982. However, the observers on our pelagic survey reported turtle crawls/activity on the Cape Canaveral seashore on April 26, 1982, suggesting the nesting season started before May 26, 1982. From the nesting survey, the 134 old crawls reported on May 27, 1982 (of a total 913 crawls) for the Florida east coast represent an accumulation of crawl activity from May 12 (the previous high tide) to the 26th. Thus, it is assumed the nesting season began in Florida on May 12, 1982. In Georgia, only 2 old crawls (of the total 23 observed crawls) were reported on the May 26, 1982 survey. The nesting season in Georgia is treated as beginning on May 26, 1982. In South Carolina 18 old crawls (of 79 total crawls or 23%) were reported May 26, 1982, therefore the South Carolina nesting season was assumed to begin by May 12, 1982. In North Carolina no crawls were reported in May with the first crawls observed during the June 26, 1982 nesting beach aerial survey. With only 2 old crawls reported (of a total 14 crawls) on June 26, it was assumed the North Carolina loggerhead nesting season began June 26, 1982.

Our monthly surveys terminated July 24, 1982. However our replicate aerial surveys were completed over Georgia beaches from July 25 to August 3, 1982. During the replicate survey period crawls were observed throughout the sampling period on beaches considered to have low nesting frequency indicating the nesting season continued at least to August 3, 1982 (Figure 1). According to Ehrhart (personal communication, July 5, 1983), on the Cape Canaveral Seashore - Melbourne Beach area of the

Florida east coast, loggerhead nesting continued at high levels through the first week in August (August 7 1982) with diminished activity (1-3 nests per night) continuing through August 30. Thus, in Florida, it is assumed the season terminates August 7, 1982. In all other states the nesting season is assumed to end August 3, 1982. Thus, the nesting season is treated as beginning and ending with non-decreasing activity over time because of lack of any available data on the actual frequency distribution of nests throughout the nesting season.

Spatial/Temporal Aggregations

The frequency of crawls by type recorded for each state pooled over the three survey months are presented in Table 2. A comparison of cell frequencies was completed using a chi-square test and these results indicate a significant difference between the frequency of crawl types between states (x^2 = 782.10949, df = 24, p <.00005). The total crawls recorded for each of the three states pooled over the three survey months and types were also compared with the X^2 contingency test and results demonstrate significant differences between states (Table 3). These results indicate that each state be treated as a distinct spatial unit.

The frequency of total crawls between months for each state were compared utilizing the X^2 statistic (Table 4). In South Carolina, Georgia and Florida, a significant difference between months was demonstrated (p <.005). In North Carolina no significant difference in crawl frequency between months was

demonstrated. Thus, in South Carolina, Georgia and Florida, temporal strata were established. In North Carolina the season is treated as a single, continuous temporal stratum.

	1982 SEASON	TOTAL DAYS/STRATUM
North Carolina	June 26-Aug 3	39
South Carolina	May 12-May 31	20
	June 1-June 30	30
	July 1-Aug 3	34
Georgia	May 26-May 31	6
	June 1-June 20	30
	July 1-Aug 3	34
Florida (east coast)	May 12-May 31	20
	June 1-June 30	30
	July 1-Aug 7	38

Correction for Crawl Counts and Types

Each crawl was identified to crawl type when possible. However, errors during the aerial surveys occur in counts of crawls, the aging of crawls (fresh vs. old) and crawl type (false vs. true). Ground truth surveys were used to correct aerial counts, error in crawl age and errors in identification of crawl type. Each error or source of potential bias is treated as if derived from independent sampling distributions. Thus, in the procedure used to estimate variances each source of error is treated as a separate component which is linearly incorporated into an estimate of variance.

The number of total fresh crawls counted during ground and aerial surveys were compared for each month and temporal stratum. This ratio of ground fresh crawls to aerial fresh crawls (GC/AC) was used to correct for a) crawl miscounts and b) errors made in

aging crawls during the aerial effort. Values of GC/AC were computed for each month. The ratios were normalized by logarithmic transformation to allow for comparisons between months (May, June and July). Because no significant differences were observed between months, a mean value (using normalized data) for GC/AC was derived and used in subsequent analyses.

The value of GC/AC for Georgia using log transformed data is 0.56 (SE = 0.57) and for Florida is 0.89 (SE = 1.19). These values were used for each state although they are not significantly different (Table 5).

A correction factor was derived for the proportion of total fresh crawls that were verified as fresh nests (i.e. true) from the ground survey data (FN/TC). Ratios were computed for each month for Georgia and Florida and monthly ratios were normalized as above for comparative purposes. For Georgia, the proportion of fresh crawls that were verified as fresh nests is 0.54 (SE = 1.20). This value for Florida is 0.49 (SE = 1.16). These values were not significantly different as for the values GC/AC but were used respectively for each state to be consistent with the spatial stratification scheme utilized in the present analysis (Table 6).

Powers (1981) utilizing aerial and ground truth results from surveys conducted in 1980, derived estimates for FN/TC and GC/AC. The value of FN/TC that Powers (1981) used was 0.5921 (SE = 0.0202) for all states because no significant differences between states was demonstrated. Powers (1981) estimated the value of GC/AC as

0.8428 (SE = 0.0622) for all states because no significant differences were demonstrated between Florida and Georgia. The magnitude of the standard errors around the 1982 ratio estimates results in no significant differences demonstrated between those ratios of Powers (1981) and those computed herein.

Estimates of Total Nests and Nesting Females

Using the correction factors for each state as described previously, the following estimates were calculated.

North Carolina

Low density in nesting of loggerheads has been observed in North Carolina (1982 NMFS survey; Draft Recovery Plan for Marine Turtles, 1981). Rather than relying on correction factors derived from surveys conducted in years other than 1982, by different investigators using varying methodologies, I assumed the correction factors derived for Georgia were the same as in North Carolina, based on the similarity in nest density between these states.

The monthly aerial counts of fresh crawls for North Carolina were:

MONTH	FRESH CRAWLS	DAYS IN STRATUM
June	12	5
July-August	45	34

These counts were corrected using the ratios from Georgia for GC/AC of 0.56 and of FN/TC of 0.54. The total days in the

nesting season for 1982 was 64. Thus, the total nests excavated in North Carolia from Cape Hatteras, to the South Carolina border was, with approximate 95% confidence intervals (± 2 SE):

$$\text{Nests} = [39(57)]\ (0.56)(0.54) = 672$$

$$SE = 37 \quad 95\%\ CI = \pm\ 74$$

The standard error was computed using the Cox Direct Method (Land, 1972). This method assumes the variables are normally distributed after logarithmic transformation and thus are linearly related. This method further assumes the variables are measured independently and have unequal sample sizes. Approximate 95% confidence intervals were computed as ± 2 SE of the mean as estimated.

South Carolina

The aerial counts of fresh crawls from South Carolina were:

	FRESH CRAWLS	DAYS IN STRATUM
May	60	20
June	155	30
July	143	34

No ground surveys were conducted under NMFS contract in South Carolina in 1982. The Draft Recovery Plan for Marine Turtles (1981) indicates that nesting density in South Carolina is as high as along portions of the Florida east coast. Thus, the Florida correction factors were used to adjust the South Carolina counts as follows:

$$\text{Nests} = [20(60) + 30(155) + 34(143)](.89)(.49) = 4672$$

$$SE = 275 \quad 95\%\ CI = 550$$

Georgia

The Georgia fresh aerial crawl counts by month were:

	FRESH CRAWLS	DAYS IN STRATUM
May	17	6
June	40	30
July	11	34

These results give an estimate of nests of:

$$\text{Nests} = [6(17) + 30(40) + 34(11)](.56)(.54) = 507$$

$$SE = 32 \qquad 95\% \ CI = \pm 64$$

Florida East Coast

The fresh crawl aerial counts for the Florida east coast were:

	FRESH CRAWLS	DAYS IN STRATUM
May	779	20
June	1350	30
July-Aug 7	1657	38

The number of nests estimated for the Florida east coast was:

$$\text{Nests} = [20(779) + 30(1350) + 38(1657)] \ (0.89)(0.49) = 51{,}916$$

$$SE = 3117 \qquad 95\% \ CI = \pm 6234$$

Nest Per Female

The most recent estimate of the number of nests per female was presented in the Draft Recovery Plan for Marine Turtles (1981). The value of two (2) nests per female is the most recent available estimate (range = 1 to 7, no variance estimates available) and is used to compute the number of female *Caretta caretta* nesting on southeast U.S. beaches in 1982.

Summing the total nests from Cape Hatteras, N.C. to Key

Biscayne, Fla. results in a value of 57,767 (SE = 7,181, 95% CI = ± 14,362).

Dividing the total nests deposited by 2 results in an estimate of 28,884 (SE = 6,572, 95% CI ± 13,144) female loggerhead turtles nesting on the southeast U.S. in 1982.

Comparison with Previous Estimates

In 1980, Powers (1981) estimated the nesting *Caretta* population within the same area as 18,297 (approximate 95% CI = ± 13,032). The 1982 estimate from the present paper is 28,884, ± 13,144, which is not significantly different ($p \leq .05$) from that of Powers (1981) for the 1980 nesting season. No other estimates exist for the southeastern U.S. although it was previously estimated (based on unpublished data, Draft Recovery Plan for Marine Turtles, 1981) that no more than 10,000 females nested annually on the southeast U.S. coast from North Carolina to Florida.

According to various investigators (L. Ehrhart, personal communication, S. Hopkins, personal communication) 1982 was considered a "good" year for nesting by loggerhead turtles, i.e., one in which there was considerable nesting activity. According to S. Hopkins (personal communication) many investigators believe that two good years are often followed and preceeded by a nesting year not considered to be good, giving a three-year cycle of two good years followed by a subnormal year. Given this hypothesized 3-year cycle, 1980 would be treated as a subnormal year, whereas 1981 and 1982 would be treated as good years. Therefore, 1983 would be predicted to be a subnormal year. It appears that

the 1983 nesting season for Caretta was initiated later than usual, perhaps even as late as June 1, 1983 at least in South Carolina (T. Murphy, personal communcation). However, while the season started later than last year, nesting during the peak period (June-July) may be as great as last year. Thus, results of the 1983 season may not be consistent with the hypothisized three-year cycle in nesting frequency.

Table 1. Dates of aerial surveys for 1982 nesting season by state.

Survey No.	Dates	States Surveyed
1	May 26, 27	N.C. to Fla., Key West
2	June 23-26	N.C. To Brownsville, Tex.
3		
4	July 22, 23	N.C. to Fla., Key Biscayne
5-14	July 25-Aug.3	Georgia

Table 2. Numbers of crawls by type for each state for the 1982 aerial surveys. The 10-day replicate surveys in Georgia are not included. The beaches of Alabama, Louisiana, Texas and for Florida west coast were sampled only on June 25-26, 1982.

Crawl Type	N.C.	S.C.	Ga.	Fla. East Coast	Ala.	La.	Fla. West Coast	Tex.	Row Total
Unknown	2[1]	1	0	0	0	0	0	0	3
	66.7[2]	33.3	0.0	0.0	0.0	0.0	0.0	0.0	
	3.2[3]	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
Fresh False	7	162	12	753	3	2	62	0	1001
	0.7	16.2	1.2	75.2	0.3	0.2	6.2	0.0	
	11.1	42.0	14.5	19.5	60.0	100.0	42.8	0.0	
Fresh True	50	196	67	2899	2	0	72	0	3286
	1.5	6.0	2.0	88.2	0.1	0.0	2.2	0.8	
	79.4	50.8	80.7	75.0	40.0	0.0	49.7	0.0	
Old False	1	3	1	47	0	0	1	0	53
	1.9	5.7	1.9	88.7	0.0	0.0	1.9	0.0	
	1.6	0.8	1.2	1.2	0.0	0.0	0.7	0.0	
Old True	3	24	3	166	0	0	10	0	206
	1.5	11.7	1.5	80.6	0.0	0.0	4.9	0.0	
	4.8	6.2	3.6	4.3	0.0	0.0	6.9	0.0	
Total No. Crawls	63	386	83	3865	5	2	145		4549

1 total crawls recorded
2 percent of recorded
3 percent of recorded frequency by crawl type

Table 3. Comparison of frequency of total crawls between states for each survey month. Comparisons were made using a Chi-square test with the null hypothesis that crawl frequencies are equal between states within a month.

Month	χ^2	df	Prob.
May	23.92341	8	0.0024
June	113.89010	15	0.00005
July	803.67662	12	0.00005

Table 4. Comparison of frequency of total crawls betweeen three survey months for each state. Comparisons were made using a chi-square test with the null hypothesis that crawl frequencies are equal for each month, within each state.

State	χ^2	df	Prob.
N.C.	6.37714	4	0.1727*
S.C.	48.39426	8	0.00005
Ga.	20.52715	6	0.0022
Fla. (east coast only)	435.37137	6	0.00005

* Not significant

Table 5. Total fresh crawls counted during monthly aerial surveys (AC) and ground surveys (GC) conducted on same day. The ratio GC/AC is included. Counts were totalled over all months and are included. Data are presented only for Georgia (GA and the Florida east coast (FLA) where ground surveys were conducted. Data are not normalized with a logarithmic transformation.

	May			June			July			Total		
State	GC	AC	GC/AC	GC	AC	GC/AC	GC	AC	GC/AC	GC	AC	GC/AC
GA	2	13	0.15	21	18	1.17	5	5	1.00	28	36	0.78
FLA	375	306	1.23	386	423	0.91	475	677	0.70	1179	1406	0.84

Table 6. Total fresh nests and total fresh crawls counted during ground truth surveys for Georgia and Florida by month. Included is the ratio of fresh nests to total fresh crawls (FN/TC) and totals over all months. Data are not normalized.

	May			June			July			Total		
State	FN	TC	N/TC	FN	TC	FN/TC	FN	TC	FN/TC	FN	TC	FN/TC
GA	1	2	0.50	8	21	0.38	4	5	0.80	12	28	0.46
FLA	142	75	0.30	200	386	0.52	279	475	0.59	591	1206	0.49

Literature Cited

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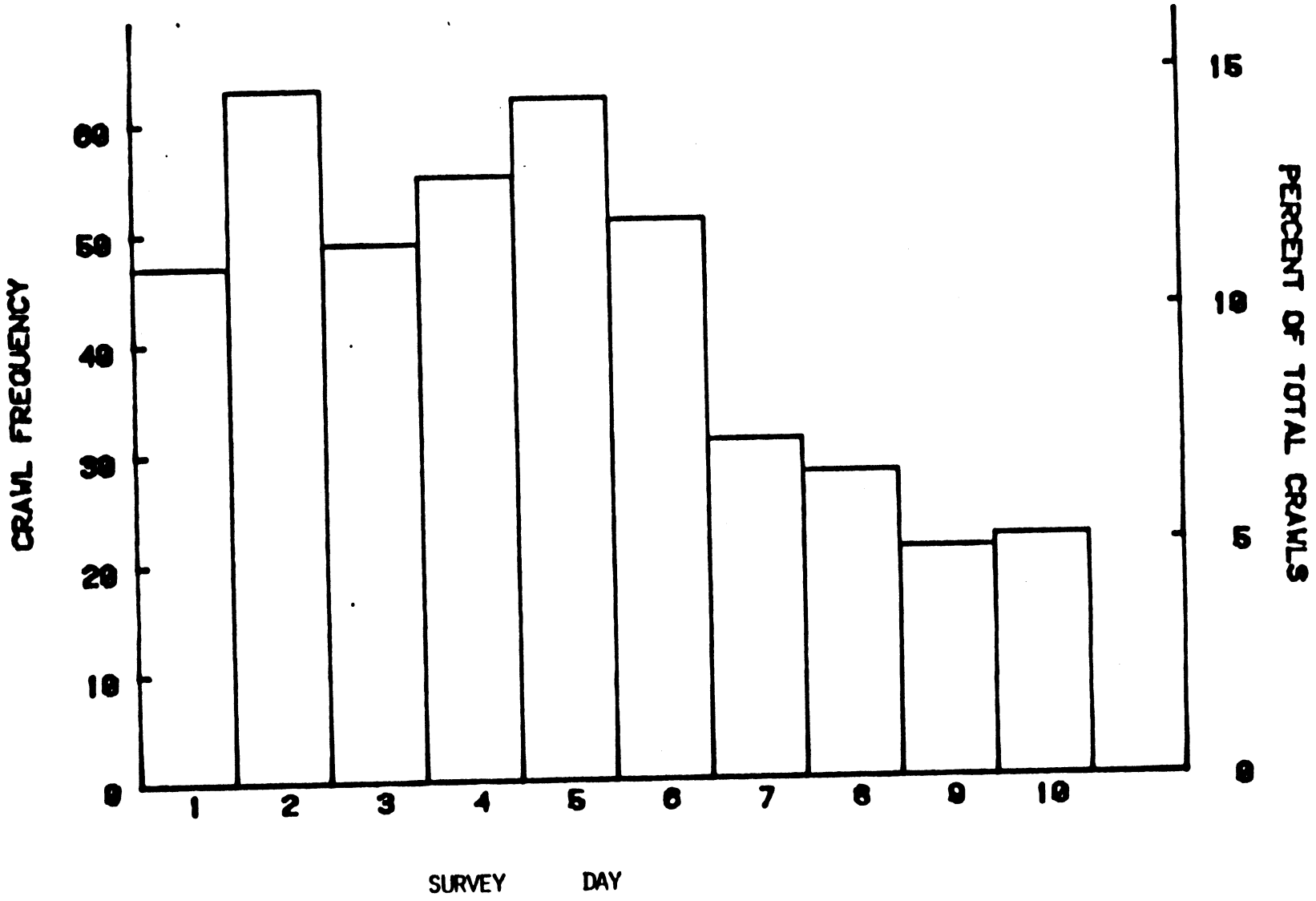
Figure 1. Frequency of nesting crawls by survey day for the 10 successive replicate surveys of selected Georgia beaches, July 25-Aug. 3, 1982.


CRAWL FREQUENCY
0
10
20
30
40
50
60
PERCENT OF TOTAL CRAWLS
0
5
10
15
1
2
3
4
5
6
7
8
9
10
SURVEY DAY