1977

The Nesting Ecology of Several Species of Herons and the Glossy Ibis (Plegadis falcinellus) in Three Heronries in Virginia

Barbara Susan Warren
College of William & Mary - Arts & Sciences

THE NESTING ECOLOGY OF SEVERAL SPECIES OF HERONS AND THE GLOSSY IBIS (*PLEGADIS FALCINELLUS*) IN THREE HERONRIES IN VIRGINIA

A Thesis

Presented to

The Faculty of the Department of Biology

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

---

by

Barbara S. Warren

1977

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Master of Arts

Barbara Susan Warren

Barbara Susan Warren

Approved, November 21, 1977

Mitchell A. Byrd

Mitchell A. Byrd

Stewart A. Ware

Stewart A. Ware

Norman J. Fashing

Norman J. Fashing

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I thank Dr. Norman J. Fashing and Dr. Stewart A. Ware for serving on my thesis committee and for reading and commenting on earlier drafts of this paper. I especially thank Dr. Mitchell A. Byrd for his trust and advice throughout the research as well as for serving as chairman of my thesis committee.

The Virginia Institute of Marine Science, Eastern Shore Laboratory, provided boat and motors on occasion, as well as much mechanical assistance. Sue Ridd, Margi van Montfrans, Sonda Dawes, Heidi Morf, Betty Van Dyke, Chris Stinson, Dr. Mitchell Byrd, Greg Turner, and Jacques van Montfrans helped with the collection of data.

I am most grateful to Chris Stinson for his encouragement, intellectual stimulation, and constant reassurance that I was getting enough data and to David Reed for helping to unravel the ensuing mountain of information.

I owe a very special thanks to Sue Ridd for unselfishly giving her summer with many hours of work and patience.

This study was funded by the Patuxent Wildlife Research Center, United States Fish and Wildlife Service, under contract T-77-B with the College of William and Mary. Appreciation is extended to this agency.

LIST OF TABLES

LIST OF FIGURES

Figure

ABSTRACT

Colony utilization of three heronries near Wachapreague, Virginia, by several species of herons and the glossy ibis was examined in an attempt to determine if the ibis was using a portion of the colony site not used by the other species. Statistical tests were performed to determine if success differed with position in the colony, if position in the colony differed with time of nesting, and if success differed with time of nesting. None of these tests showed consistent and significant patterns for all species. In addition, a principal components analysis of 10 nest site variables was performed for each species at Club Point and for each species in the two Swash Bay colonies, combined. Differences in components were found, with the glossy ibis most different from the other species at Club Point. This suggests that they were utilizing a portion of the heronry not occupied by the other species nesting there in 1976.

Changes in colony composition from 1975 as well as changes in vegetation in the colony throughout the breeding season of the birds are examined and discussed. The vegetational changes are thought to be due, in part, to the effect of the nesting birds.

Trials were made of census techniques (various times of season and day for censusing and infrared aerial photography) in order to ascertain whether a ratio could be established between visible and total nesting birds. No conclusive results were obtained but all methods are discussed.

THE NESTING ECOLOGY OF SEVERAL SPECIES OF HERONS AND THE GLOSSY IBIS (*PLEGADIS FALCINELLUS*) IN THREE HERONRIES IN VIRGINIA

INTRODUCTION

The northward expansion of the breeding range of the glossy ibis (*Plegadis falcinellus*) in recent years (Williams, 1973; Byrd, 1977) has raised many interesting questions. One such question relates to the aspects of this bird's biology which have enabled it to move into established heronries where there may be three or four similar species already nesting and to breed successfully enough there to extend its range.

There were three main aspects of this study. The first was to investigate colony utilization to see if the glossy ibis were using a portion of the site for nesting that was not used, either temporally or spatially, by the other species there. McCrimmon (1975) and Custer and Osbourn (1977) both found differences in nest sites of different species of herons and Jenni (1961) found some vertical stratification in nest sites of the herons in the colony that he studied in 1958, suggesting that there may be some division of nesting resources in some heron colonies.

The second aspect of the study dealt with herons as environmental indicators: colony utilization--temporally and spatially; changes in colony composition from the previous year; changes in vegatation within the colonies throughout the breeding season of the birds, and whether this vegetational change was brought about by the nesting birds.

A third aspect involved trials of different census techniques in order to ascertain whether a ratio between visible birds and number of nests could be established. Infrared aerial photography also was investigated as a possible tool for censusing colonies.

MATERIALS AND METHODS

STUDY AREA

This study was conducted in three heron colonies during the period 8 May to 16 August, 1976, near Wachapreague, Virginia. The largest colony, Club Point, was at Clubhouse Marsh approximately 3.5 airline miles from Wachapreague and the smaller colonies, Swash Bay North and Swash Bay South, were on a sandy spoil island approximately 5 airline miles from Wachapreague. The two Swash Bay colonies were approximately 15 meters apart. Both sites could only be reached by boat.

Six bird species were found nesting at Club Point: snowy egrets (Egretta thula), Louisiana herons (Hydranassa tricolor), little blue herons (Florida caerulea), glossy ibis (Plegadis falcinellus), green herons (Butorides virescens), and a pair of great egrets (Casmerodius albus). Both Swash Bay colonies contained snowy egrets and Louisiana herons. The Swash North colony also had one pair of little blue herons nesting there.

The predominant vegetation utilized for nesting in all colonies was marsh elder (Iva frutescens), with groundsel-tree (Baccharis halimifolia) and red cedar (Juniperus virginiana) also being used at Club Point.

The Club Point heronry is spatially divided into north and south ends. For the comparison of 1975 and 1976 species composition, data from both parts of the colony were included. For all other analyses, only data from the north end were used. The greatest number of nests were in this area and it was the only area that was mapped and in which nest measurements were taken.

WEEKLY CENSUS

A weekly census of nests was taken in each colony. New nests were tagged with a number placed on surveyor's tape and tied around a branch near the nest. The number of eggs (good or damaged), chicks (dead or alive) in or out of the nest, species, and date that the nest was found were recorded for each nest.

The species occupying the nest was determined on the basis of chick color and morphology. If eggs failed to hatch, species for that nesting was recorded as unknown. Hatchling morphology of little blue herons and snowy egrets is very similar and identification was not always certain in very young birds. In these cases the nest was counted as unknown. One nest at Club Point contained two Louisiana heron chicks and one little blue heron chick. This nest was also counted as unknown.

The weekly census was made during one day per week for Swash Bay and during one to four days per week at Club Point, longer census time being necessitated at Club Point because of greater number of nests (977 as opposed to 168 and 87). A given area of the colony was visited only for a period of one to two hours in order that adults would not be away from eggs or chicks for excessive periods of time. The length of a visit depended somewhat on weather conditions, with less time being spent in any given area of the colony on cool or windy days.

When censusing took more than one day, the first day was counted as date of census for that week. All observations during that week were counted as seen on that date.

Three success figures were calculated for each nest of known species: hatching success (number hatched/number eggs laid); survival success (number of chicks alive and in the nest at two weeks/number hatched); and breeding success (number of chicks alive and in the nest at two weeks/number of eggs laid). Number of live chicks in the nest at two weeks was used instead of the number fledging or the total number alive either in or out of the nest because of the difficulty of following juvenile herons after they are able to leave the nest and run around the heronry. The figures calculated are, therefore, probably conservative, with the actual numbers of chicks alive at two weeks being greater than those used because of older chicks having left the nest. The week that the chicks were first found was designated as week one and the following week as week two.

The date that each nest was started was recorded as the week that it was first found with eggs or the date was extrapolated as three weeks before hatching date of the chicks. For those nests containing only chicks and no eggs on the first census date, date of hatching was unknown and, consequently, date of nesting was unknown.

For tests of differences in success between early and late nesters for each species, a Kruskal-Wallis oneway analysis of variance was performed. The nesting season was divided into early (22 April through 31 May) and late (6 June through 8 August) time periods and each success figure was tested for snowy egrets, Louisiana herons, and little blue herons at Club Point and snowy egrets and Louisiana herons at Swash North and Swash South. The glossy ibis at Club Point were tested by the Kruskal-Wallis procedure for differences in their success between 6 May and 13 May. These tests were made using programs from the Statistical Package for the Social Sciences (Nie & Hull, 1977, version H70), hereafter referred to as SPSS.

Graphs were made of the number of nests started each week by each species in each colony in order to detect temporal differences in the nesting of each species.

Also calculated from weekly censuses were the total number of nests used throughout the season and the approximate number of adult birds in the colony each week. The latter figure was obtained by multiplying the number of nests by two. The total number of nests used throughout the season was compared to 1975 data collected by Bill Williams, Tom Weibolt, and Bill Akers for Club Point and by similar figures from Custer and Osbourn (1977) for Swash Bay. The percentage composition for each species in each colony in 1975 and 1976 was calculated. A test for equality of two percentages (Sokal and Rohlf, 1969) was made to detect changes in relative composition from 1975 to 1976.

MAPS

Maps were made of both Swash Bay colonies and the north end of the Club Point colony. Parallel lines were set up in the colony four meters apart using a compass for direction and rope marked at 0.5 meter intervals. Width of the colony at each line was recorded and the outline of the colony was sketched in. Nests were placed on the map using the marks on the ropes as one reference and estimating to the nearest 0.5 meter the position between the ropes.

The maps were used for gaining an overall picture of the species distribution in the heronries; analyses of the independence of success and position in the colony; and regression analyses of time of nesting and position in the colony.

An R X C test of independence (Sokal and Rohlf, 1969) of success and position was performed for each success figure for each species in each colony. Position in the colony (inner portion or outer portion) was determined by an arbitrary line drawn 3 meters from and parallel to the perimeter of the colony (see Figs. 1-3). Unusable, grassy areas with no bushes were thus included in both portions and it was assumed that they would have the same effect in either area. Total number of eggs laid, number of chicks hatched, and number of live chicks in the nests at two weeks were calculated for each species in each area and success figures obtained using these totals.

A regression analysis (Sokal and Rohlf, 1969) of time of nesting and position in the colony was performed for each major species in each colony in an attempt to discern any temporal pattern of nest site selection. Position was determined by 1.5 meter lines drawn paralell to the perimeter of the colony and to each subsequent line until all area was used (see Figs. 4-6). Those contours with no nests, with only one nest, or with all nests built in the same week were excluded from the analyses proper, but are shown in the figures where appropriate. The glossy ibis at Club Point were not tested because all birds nested within a two week period. A Bartlett's test for homogeneity of variances was performed for each analysis.

NEST MEASUREMENTS

After most of the birds had finished nesting and a large number had left the colonies, ten nest site measurements were made for each nest of known species that was still intact. The variables were a combination of those used by McCrimmon (1975) and Custer and Osbourn (1977). Measurements for the following variables were taken: nest bush species (NBSP), coded for analysis as 1 = *Iva*, 2 = *Baccharis*, and

Figure 1. Map of the Club Point heronry showing inner and outer portions for testing independence of success and position in the colony. Shaded parts are grassy areas.


CLUB POINT
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
G GLOSSY IBIS
E GREAT EGRET
• UNKNOWN

Figure 2. Map of the Swash North colony showing inner and outer portions for testing independence of success and position in the colony. Shaded parts are grassy areas.


SWASH NORTH
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
• UNKNOWN

Figure 3. Map of the Swash South heronry showing inner and outer portions for testing independence of success and position in the colony. Shaded parts are grassy areas.

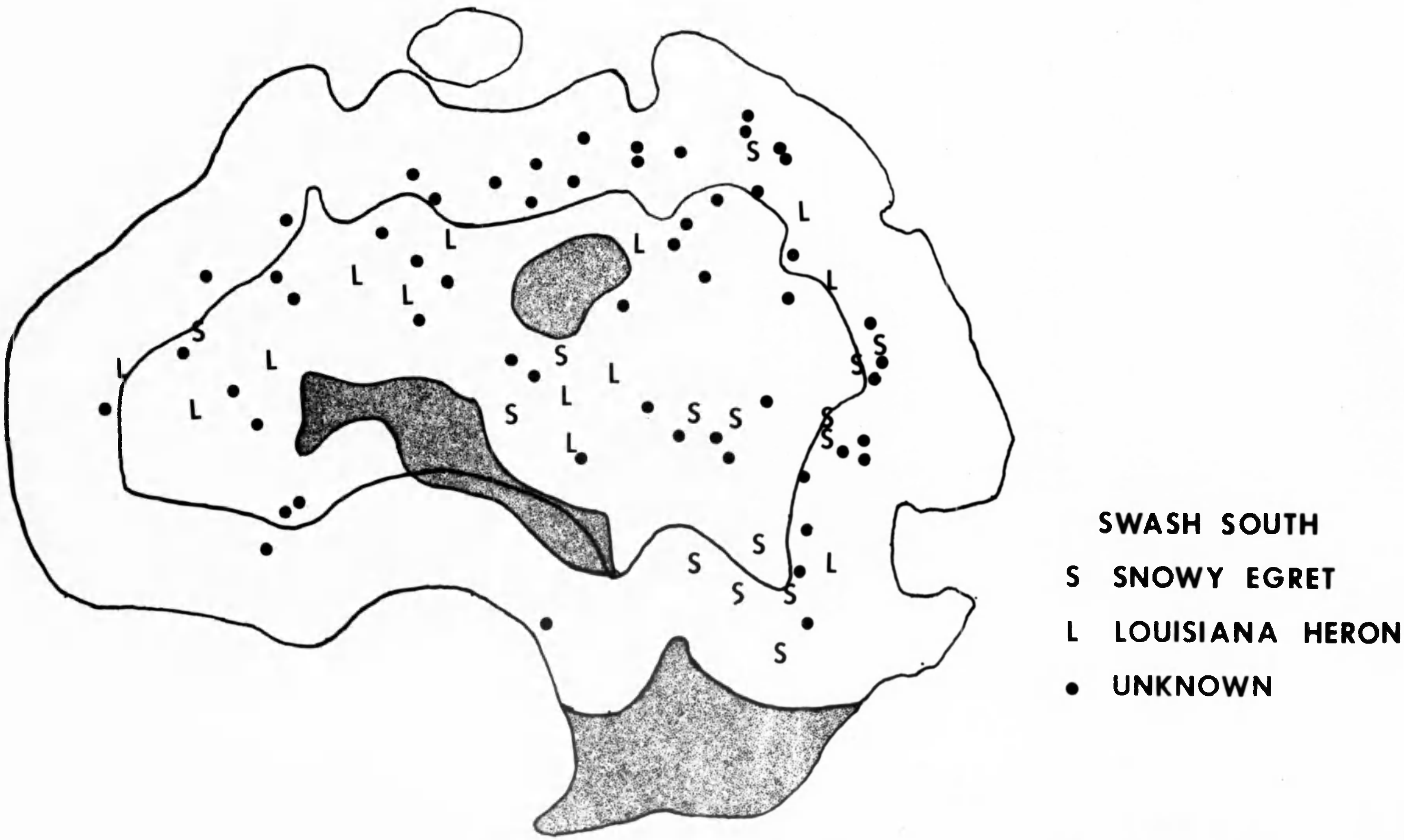

SWASH SOUTH
S SNOWY EGRET
L LOUISIANA HERON
• UNKNOWN

Figure 4. Map of the Club Point heronry showing contours drawn for regression analysis of time of nesting and position in the colony. Shaded parts are grassy areas.

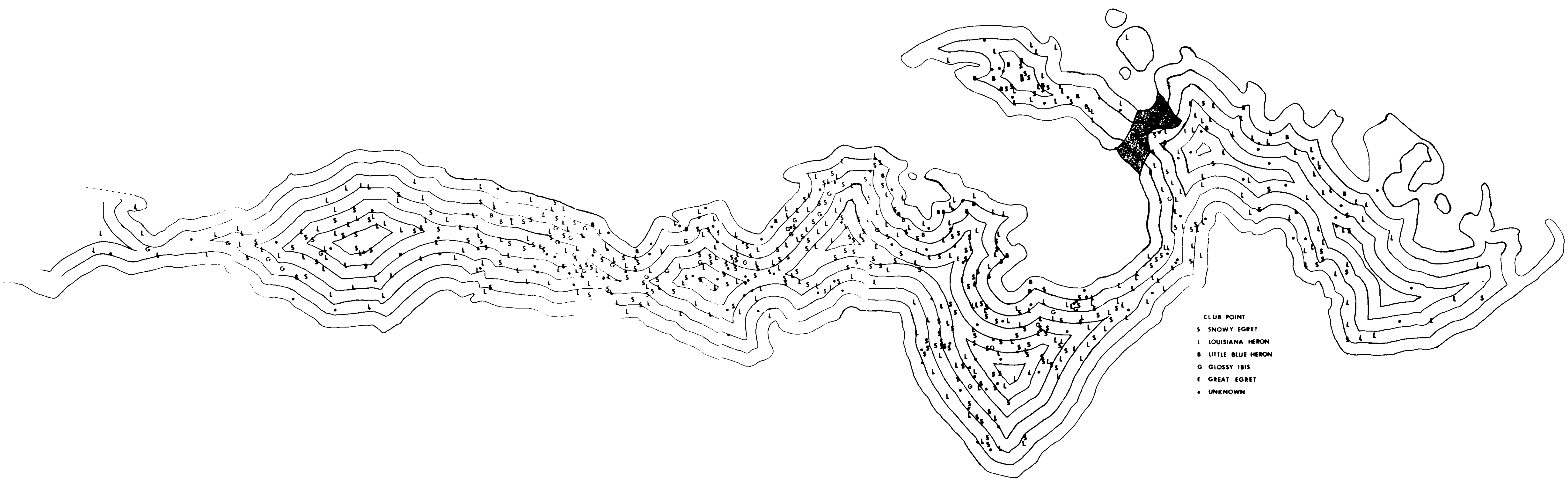
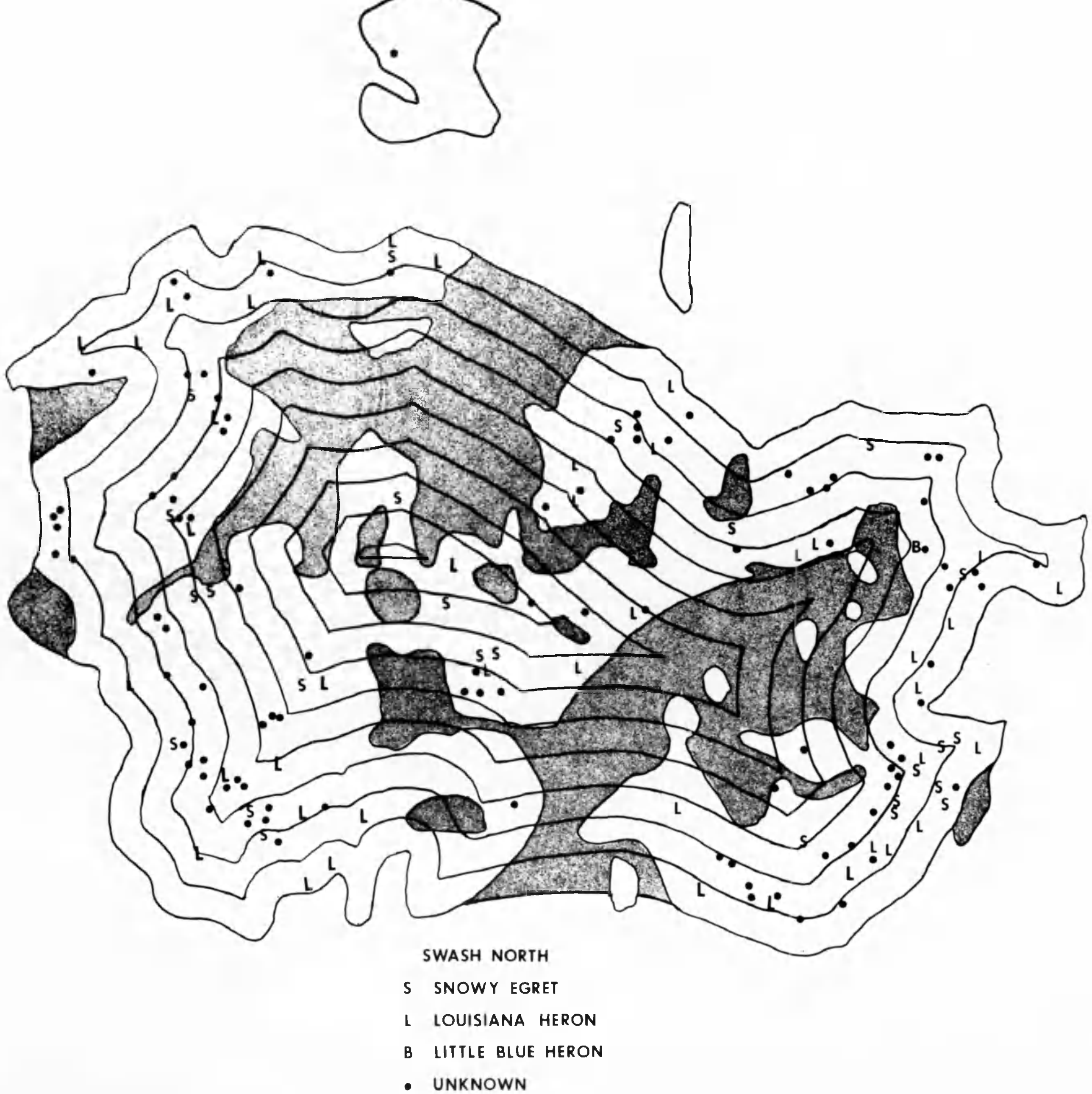
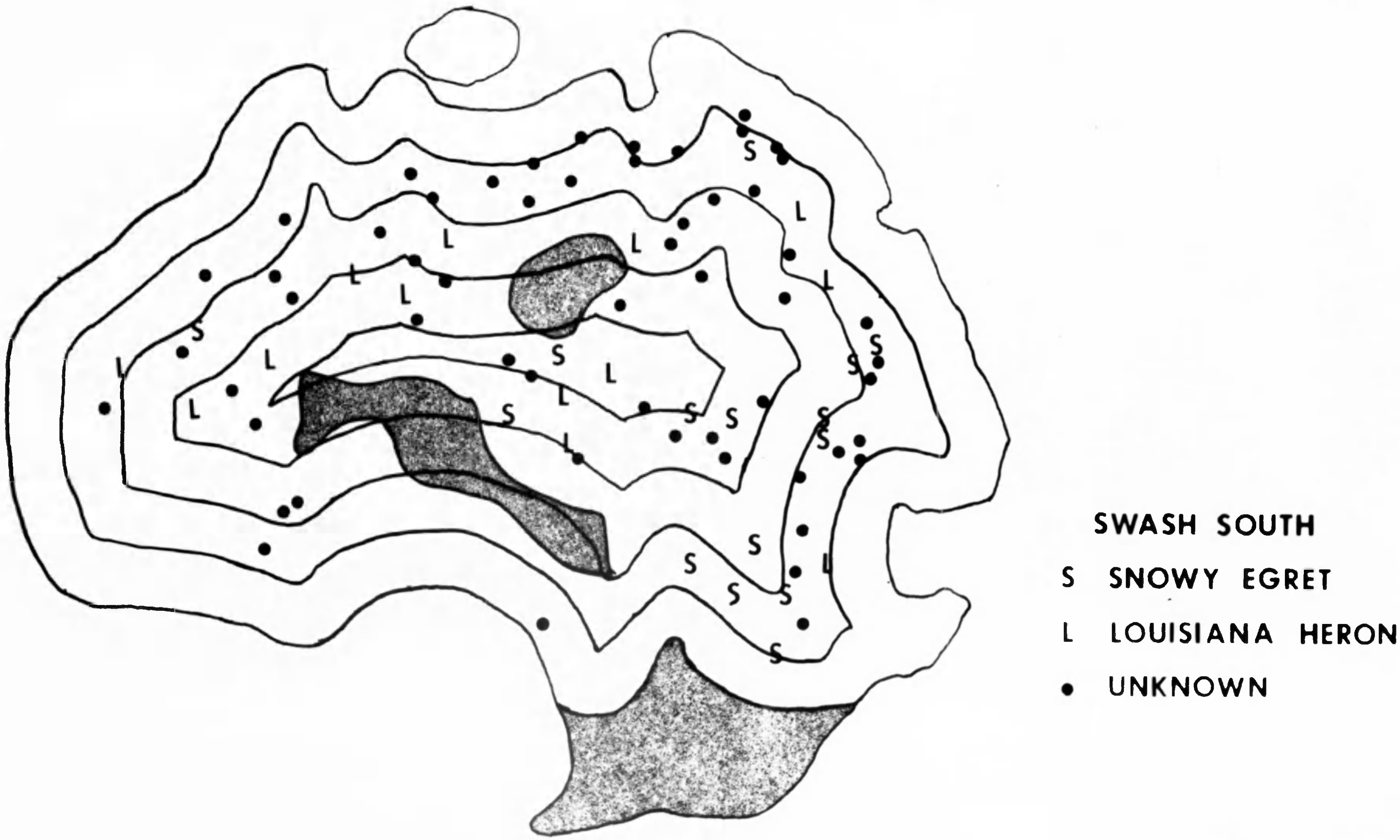

CLUB POINT
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
G GLOSSY IBIS
E GREAT EGRET
• UNKNOWN

Figure 5. Map of the Swash North heronry showing contours drawn for regression analysis of time of nesting and position in the colony. Shaded parts are grassy areas.



SWASH NORTH
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
• UNKNOWN

Figure 6. Map of the Swash South heronry showing contours drawn for regression analysis of time of nesting and position in the colony. Shaded parts are grassy areas.


SWASH SOUTH
S SNOWY EGRET
L LOUISIANA HERON
• UNKNOWN

3 = Juniperus; condition of nest bush (CNB)--dead, partially dead, or alive and coded 0, 1, and 2 respectively for analysis; distance of the nest to the ground (DG); distance of the nest to the canopy of the nest bush (DC); distance of the nest to the center, or the apparent center, of the nest bush (DCB); distance of the nest to the outside of the nest bush (DOB); nest deflection (ND)--amount the nest moved downward when a 1200 gram weight was placed in the center of the nest (1200 grams chosen to be consistent with the weight used by Custer and Osbourn (1977) for this variable); number of branches supporting the nest (SB); circumference of the main supporting branch (CMSB); and direction of opening of the vegetation around the nest (DO). DG, DC, DCB, and DOB were measured to the nearest 0.1 meter; ND in centimeters; CMSB to the nearest 0.5 centimeter; and DO to the nearest 10 degrees.

Each variable was tested for differences among species within each colony and among colonies within each species. Those with homogeneous variances (Bartlett's test, $P>0.05$) were tested by one-way analysis of variance and a Student-Newman Keuls *a posteriori* test (both using SPSS) if there was a significant difference. For those variables with heterogeneous variances, a Kruskal-Wallis one-way analysis of variance (SPSS) was performed. No *a posteriori* tests were made for these variables.

Since variances were heterogeneous for most variables when tested among species, a principal components analysis was done for each species separately rather than by pooling them. In tests among colonies, variances were homogeneous (F-max test, $P\geq0.05$; F-max used here instead of Bartlett's because there were only two colonies being tested in this case) for the Swash Bay colonies but were heterogeneous between Swash Bay and Club Point. Data from the two Swash Bay colonies were pooled for analysis.

The following principal components analyses for nest site variables were performed: snowy egrets, Louisiana herons, and little blue herons from Club Point, all variables (refer to Table I for a list of variables and their mnemonics); glossy ibis from Club Point and snowy egrets from Swash Bay, all variables except NBSP and ND; Louisiana herons from Swash Bay, all variables except NBSP. Variables NBSP and ND could not be used in cases where there was no variance for that sample.

The purpose of these analyses was to determine the most important components of nest site selection for each species utilizing the three heronries that I studied. These components could then be compared to possibly obtain a better understanding of the division, if any, of colony nesting resources.

Principal components analysis is an attempt to reduce the number of variables to a set of components with which these variables correlate highly and to delineate an underlying structure in the variables. A correlation matrix was calculated for the variables, from which the new components were then drawn. The variables were then rearranged so as to get the best linear combination of the variables. Best in this instance means that combination which accounted for more of the variance in the data than any other combination (Nie _et al_., 1975). This combination of variables is the first component. The second component is the best arrangement that explains that portion of the variance after the first component is removed (Nie _et al_., 1975). This continued until all or most of the variance in the data was accounted for, each

TABLE I. A listing of the nest site variables, with their unit of measurement and their mnemonics, and of the species and their mnemonics.

Mnemonic	Variables
NBSP	Nest bush species
CNB	Condition of nest bush
DG	Distance of nest to ground (to nearest 0.1 meter)
DC	Distance of nest to canopy (to nearest 0.1 meter)
DCB	Distance of nest to center of bush (to nearest 0.1 meter)
DOB	Distance of nest to outside of bush (to nearest 0.1 meter)
ND	Nest deflection (to nearest centimeter)
SB	Number of supporting branches
CMSB	Circumference of the main supporting branch (to nearest 0.5 centimeter)
DO	Direction of opening of the vegetation around the nest (to nearest 10 degrees)
	Species
SE	Snowy egrets
LAH	Louisiana herons
LBH	Little blue herons
GI	Glossy ibis

component being orthogonal (unrelated) to the others. Essentially, the correlation matrix has merely been rearranged to a more easily interpreted form, especially in cases where there are many variables. The factor matrices were then rotated to achieve components which are more useful in scientific description. Rotation of the factor loadings tends to bring out patterns better and to make the components simpler to interpret. A variable will usually load high on only one component, rather than on several as can be the case with an unrotated factor matrix. These new components are an exact mathematical transformation of the original ones.

SPSS (Nie _et al._, 1975) subprogram Factor was used to perform these analyses. The method of factoring was PA1, principal factoring without iteration. Unity was used in the main diagonal. The number of factors extracted was determined by Kaiser's criterion of an eigenvalue of greater than or equal to 1.0 for each factor kept. "This criterion ensures that only components accounting for at least the amount of total variance of a single variable will be treated as significant" (Nie _et al._, 1975). The extracted factors were then submitted to Varimax orthogonal rotation.

PLATFORM OBSERVATION

Hourly counts of birds visible in the colonies were taken on days, weather permitting, that were not used for weekly censuses in order to determine the best time of day and season to achieve the most accurate and consistent numbers without having to enter the colony. The counts were made from platforms at both sites, 1 meter from the edge of the colony and approximately 10 meters from nesting birds at Club Point and about 8 meters from each colony at Swash Bay. The number of birds seen with the telescope was recorded by species. By the end of the season, young little blue herons could not easily be distinguished from adult snowy egrets, hence, in the analyses, all species were pooled. Observations were grouped by weeks.

The percentage of birds visible each hour was computed as the number of adult birds seen divided by the total number of nesting birds in the colony that week. Only observations during May and June were used for comparisons. During these months an accurate count of birds in the colony could be made from the number of nests present each week. After June, however, the young birds are visible and obtaining accurate percentages is complicated by their presence. These figures are discussed subjectively. Lack of observations for each hour of each week prevents further quantitative analysis.

AERIAL PHOTOGRAPHS

Infrared photographs were made of each colony from a fixed wing aircraft in order to determine their value as a census technique and to detect changes in the vegetation, possibly caused by the herons, throughout the season. These photographs were taken with a Pentax 35 mm camera, yellow filter, and Kodak IE 135-20 Color Infrared film from altitudes of 150 to 800 feet. Dates of photography were 8 May, 5 July, and 7 August, 1976.

Changes in the vegetation from the first to the end of the season were subjectively examined for each colony. Analysis posed problems in that the pictures were taken at an angle to the colony from the airplane window rather than from a vertical mount. These angles varied with each photograph, and necessarily, with each session and caused differing amounts of vegetation and open areas to appear--even within the same session. To be entirely consistent and comparable, the camera should be mounted so that the photographs could be taken from a vertical position, from the same altitude(s), and at the same spot(s) in the colony each time.

Each of the Swash Bay colonies was used to determine the percent of birds visible in the slides. Number of birds in each slide was divided by the total number of adult birds nesting in the colony that week. Only the slides taken on 8 May were used. Young birds in the colonies after June complicated calculation of total number of birds present, so that an accurate number could be calculated only early in the season.

RESULTS

I. DIVISION OF NESTING RESOURCES

In tests performed to find differences among the species at Club Point for each of the nest site variables, the following tests were significant: DC[1], ND, NBSP, SB ($P \leq 0.001$ for each), and CMSB ($P \leq 0.01$). Tables II and III give results for these tests. In a Student-Newman-Keuls test on DC, the glossy ibis were found to nest further from the canopy than the other species. Nest deflection was greater for the Louisiana herons than for the glossy ibis or the snowy egrets but not different from the little blue herons (Table IV). Those variables analyzed by the Kruskal-Wallis procedure were not formally subjected to *a posteriori* testing, but the mean ranks given provide some indication of where the differences among the species lie. The mean ranks for the glossy ibis are much lower than for the other species for variables DG and CMSB, suggesting that this species nests closer to the ground and uses smaller branches to support its nest than do the other species. The mean rank for the number of supporting branches was also smallest for the glossy ibis, with little blue herons having an intermediate rank, and Louisiana herons and snowy egrets, the largest. For nest bush species, the little blue herons had a greater mean rank than the other species, suggesting that a greater number of these birds nested in the red cedars than did the other herons or the glossy ibis (Table III).

---

[1] Hereafter, in all references to the nest site variables, the mnemonics will be used. Table I should be referred to for an explanation of these.

In tests for differences in nest site variables between snowy egrets and Louisiana herons at Swash North, only CMSB ($P \leq 0.01$) and DC ($P \leq 0.05$) were significantly different for the two species (Tables II and III). The circumference of the main supporting branch was greater for snowy egrets than for Louisiana herons. The distance to the canopy was also greater for snowy egrets.

At Swash South, significant differences between the snowy egrets and Louisiana herons were found for the following nest site variables: DG ($P \leq 0.001$), DC, and CMSB ($P < 0.05$) (Table II). Louisiana heron nests were further from the ground and closer to the canopy than those of snowy egrets. The circumference of the main supporting branch was greater for snowy egret nests than for Louisiana heron nests.

In tests for differences among colonies in nest site variables of snowy egret nests, only condition of nest bush was significant ($P \leq 0.05$) (Tables II and III). However, in a Student-Newman-Keuls test (with $\alpha = 0.05$), this difference is not picked up. The means for this variable for each colony are given in Table IV.

The following nest site variables showed differences among the colonies for Louisiana heron nests in each: CNB, DC ($P \leq 0.01$), DCB, ND ($P \leq 0.05$), and CMSB ($P \leq 0.001$) (Tables II and III). A Student-Newman-Keuls test (Table IV) for condition of nest bush shows Swash North to have a significantly greater mean than Club Point, but neither of these

TABLE III. Kruskal-Wallis tests for differences in nest site variables with heterogeneous variances. (X^2 corrected for ties.) See Table I for variables and mnemonics.

Test	Variable		SE	LAH	LBH	GI	X^2	P	
Among species, Club Point	NBSP	N	149	199	13	23			
		$\bar{X}$	194.31	187.70	248.81	190.50	31.407	<0.001	***
	SB	N	157	205	16	23			
		$\bar{X}$	213.25	207.56	145.81	97.26	26.111	<0.001	***
	DG	N	157	205	16	23			
		$\bar{X}$	174.92	222.09	343.66	91.85	61.622	<0.001	***
	DCB	N	157	205	16	23			
		$\bar{X}$	187.66	206.48	238.94	216.87	5.297	0.151	ns
	CMSB	N	157	205	16	23			
		$\bar{X}$	207.56	199.92	253.16	129.59	12.621	0.006	**
Among species, Swash North	DC	N	17	40					
		$\bar{X}$	35.88	26.07	------	------	4.387	0.036	*
	DO	N	17	40					
		$\bar{X}$	32.53	27.50	------	------	1.098	0.295	ns
			CLUB POINT	SWASH NORTH	SWASH SOUTH				
Among colonies, Snowy egrets	DCB	N	157	17	7				
		$\bar{X}$	90.19	104.53	76.29		2.005	0.367	ns
Among colonies, Louisiana herons	DC	N	205	40	13				
		$\bar{X}$	137.39	103.89	83.92		12.120	0.002	**
	DCB	N	205	39	13				
		$\bar{X}$	123.13	152.53	150.92		6.927	0.031	*
	ND	N	204	40	12				
		$\bar{X}$	132.05	107.90	136.83		6.413	0.041	*
	CMSB	N	205	40	13				
		$\bar{X}$	139.47	92.46	86.19		18.180	<0.001	***

P = probability values, * $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$, ns = not significant at the 0.05 level

TABLE II. One-way analysis of variance for nest site variables with homogenous variances. See Table I for mnemonics.

Test	Variable	Ms Groups	df	Ms Error	df	F	P	
Among species, Club Point	CNB	0.1299	3	0.3214	397	0.404	0.7501	ns
	DC	0.6470	3	0.0466	397	13.879	<0.0001	***
	DOB	0.0523	3	0.0441	397	1.186	0.3147	ns
	ND	1.2854	3	0.2200	397	5.844	0.0006	***
	DO	19792.4258	3	9816.9180	397	2.016	0.1111	ns
Among species, Swash North	NBSP	0.0	1	0.0	54	-----	------	---
	CNB	0.0093	1	0.2301	55	0.040	0.8413	ns
	DG	0.0040	1	0.0288	55	0.138	0.7118	ns
	DCB	0.0290	1	0.0105	54	2.768	0.1020	ns
	DOB	0.0305	1	0.0254	55	1.200	0.2781	ns
	ND	0.0981	1	0.0706	51	1.390	0.2439	ns
	CMSB	24.3503	1	2.4488	55	9.944	0.0026	**
	DO	18213.75391	1	12066.7734	55	1.509	0.2245	ns
Among species, Swash South	NBSP	0.0	1	0.0	18	-----	------	---
	CNB	0.1407	1	0.2589	18	0.543	0.4705	ns
	DG	0.1860	1	0.0246	18	7.576	0.0131	**
	DC	0.1921	1	0.0376	18	5.106	0.0365	*
	DCB	0.0641	1	0.0249	18	2.575	0.1259	ns
	DOB	0.0539	1	0.0318	18	1.696	0.2093	ns
	ND	0.3333	1	0.1905	14	1.750	0.2071	ns
	SB	0.0445	1	1.4725	18	0.030	0.8639	ns
	CMSB	5.4945	1	0.8059	18	6.818	0.0177	*
	DO	36495.8555	1	9504.3867	18	3.840	0.0657	ns
Among colonies, Snowy egrets	NBSP	0.0040	2	0.0174	169	0.231	0.7939	ns
	CNB	1.1384	2	0.3170	178	3.592	0.0296	*
	DG	0.0173	2	0.0310	178	0.557	0.5739	ns
	DC	0.0068	2	0.0369	178	0.183	0.8326	ns
	DOB	0.0913	2	0.0423	178	2.157	0.1186	ns
	ND	0.1945	2	0.1346	171	1.445	0.2387	ns
	SB	0.7742	2	1.7281	178	0.448	0.6396	ns
	CMSB	0.2092	2	2.9801	178	0.970	0.9322	ns
	DO	11835.2813	2	10166.2266	178	1.164	0.3145	ns
Among colonies, Louisiana herons	NBSP	0.0049	2	0.0279	249	0.176	0.8385	ns
	CNB	1.5261	2	0.2993	255	5.099	0.0067	**
	DG	0.0504	2	0.0311	255	1.623	0.1993	ns
	DOB	0.0161	2	0.0396	255	0.406	0.6669	ns
	SB	3.5467	2	1.8262	255	1.942	0.1455	ns
	DO	15982.6836	2	10204.6758	255	1.566	0.2108	ns

P = probability values, ** $P \leq 0.01$, *** $P \leq 0.001$, ns = not significant at the 0.05 level.

TABLE IV. Student-Newman-Keuls tests for nest site variables. Vertical lines connect means which are not significantly different ($\alpha = 0.05$).

Test	Variable	Species	Means
Among species, Club Point	DC	LAH	0.7634
		SE	0.7898
		LBH	0.8000
		GI	1.0696
	ND	GI	0.0
		SE	0.1592
		LBH	0.3125
		LAH	0.3235
		Colony	
Among colonies, Snowy egrets	CNB	Club Point	1.3376
		Swash North	1.6471
		Swash South	1.7143
Among colonies, Louisiana herons	CNB	Club Point	1.3805
		Swash South	1.5385
		Swash North	1.6750

to be different from Swash South. More Louisiana herons nest in live bushes at Swash North than at Club Point. The mean rank for distance to the canopy is less at Swash South (Table III), suggesting that the Louisiana herons there nest closer to the canopy than at the other colonies. The DCB mean rank is smaller, and that for CMSB is larger at Club Point than at Swash North or South. The Louisiana herons at Club Point seem to nest closer to the center of the bush and use larger supporting branches than the Louisiana herons at Swash North or South. The nest deflection of Louisiana herons at Swash North is smaller than at the other two colonies.

Table V gives sample size, mean, standard deviation, and coefficient of variation for each nest site variable that is used in a principal components analysis. The correlation matrix, unrotated factor matrix, and transformation matrix for each analysis is given in Appendix I, Tables A-F. The results of the varimax rotated factor matrices are given in Table VI. The table is broken down by components, with the resultant loadings on that component for each variable from each analysis given.

FIRST PRINCIPAL COMPONENT

The snowy egrets, Louisiana herons, and little blue herons at Club Point all have high loadings on their respective components I for nest bush species and distance to the center of the bush. Little blue herons at Club Point also have a high negative loading for SB, which is interpreted as a low number of supporting branches. The first components for these three species have been called horizontal placement.

The glossy ibis at Club Point and the snowy egrets at Swash Bay

TABLE V. Sample size, mean, standard deviation, and coefficient of variation for each variable used in the Principal Components Analysis. See Table I for explanation of mnemonics.

Species		NBSP	CNB	DG	DC	DCB	DOB	ND	SB	CMSB	DO
CLUB POINT	N	146	146	146	146	146	146	146	146	146	146
Snowy	$\overline{X}$	2.02	1.41	0.39	0.79	0.20	0.64	0.16	3.39	4.81	167.05
egrets	s.d.	0.14	0.49	0.17	0.20	0.19	0.21	0.39	1.29	1.74	99.77
	C.V.	6.93	34.75	43.59	25.32	95.00	32.81	243.75	38.05	36.17	59.72
	N	195	195	195	195	195	195	195	195	195	195
Louisiana	$\overline{X}$	1.98	1.42	0.45	0.77	0.24	0.61	0.32	3.37	4.67	168.38
herons	s.d.	0.19	0.52	0.18	0.23	0.24	0.21	0.55	1.30	1.91	98.94
	C.V.	1.60	36.62	40.00	29.87	100.00	34.43	175.00	38.58	40.90	58.75
	N	13	13	13	13	13	13	13	13	13	13
Little blue	$\overline{X}$	2.31	1.54	0.86	0.80	0.50	0.72	0.31	2.77	6.08	207.69
herons	s.d.	0.63	0.52	0.31	0.22	0.53	0.20	0.48	0.83	2.26	95.49
	C.V.	27.27	33.77	36.05	27.50	106.00	27.78	154.84	29.96	37.17	45.98
	N	----	21	21	21	21	21	-----	21	21	21
Glossy	$\overline{X}$	----	1.24	0.24	1.03	0.22	0.50	-----	1.38	2.48	212.86
ibis	s.d.	----	0.44	0.19	0.26	0.16	0.24	-----	1.77	3.07	89.73
	C.V.	----	35.48	79.17	24.07	72.73	48.00	-----	128.26	123.79	42.15
SWASH BAY	N	----	23	23	23	23	23	-----	23	23	23
Snowy	$\overline{X}$	----	1.65	0.39	0.78	0.19	0.57	-----	3.13	4.83	195.22
egrets	s.d.	----	0.49	0.18	0.18	0.08	0.17	-----	0.97	1.63	107.36
	C.V.	----	29.70	46.15	23.08	42.11	29.82	-----	30.99	33.75	54.99
	N	----	50	50	50	50	50	50	50	50	50
Louisiana	$\overline{X}$	----	0.45	0.45	0.64	0.25	0.58	0.16	3.14	3.61	138.40
herons	s.d.	----	0.16	0.16	0.15	0.13	0.17	0.37	1.54	1.25	105.99
	C.V.	----	35.56	35.56	23.44	52.00	29.31	231.25	49.04	34.63	76.58

TABLE VI. Factor loadings for each component. See Table I for explanation of mnemonics.

Species	NBSP	CNB	DG	DC	DCB	DOB	ND	SB	CMSB	DO
Component I										
Club Point										
SE	0.73	0.48	-0.02	0.33	0.80	0.00	0.12	-0.06	0.05	0.39
LAH	0.75	0.14	-0.004	0.04	0.69	-0.08	0.39	-0.14	0.15	-0.37
LBH	0.95	0.40	-0.05	-0.32	0.82	-0.15	0.14	-0.74	-0.10	-0.16
GI	----	-0.28	0.95	-0.62	-0.35	0.09	----	0.87	0.92	0.03
Swash Bay										
SE	----	0.60	0.80	-0.94	0.03	-0.01	----	0.48	-0.81	-0.14
LAH	----	-0.19	-0.31	0.77	-0.19	0.60	-0.04	0.09	0.40	-0.51
Component II										
Club Point										
SE	0.09	-0.56	0.05	0.61	-0.05	0.59	-0.22	-0.12	0.68	0.18
LAH	0.08	0.85	-0.09	-0.07	-0.09	-0.01	0.27	0.07	-0.68	0.28
LBH	0.10	0.80	0.11	0.08	0.24	-0.35	0.30	0.58	0.83	-0.05
GI	----	0.39	-0.05	-0.12	0.54	0.07	----	-0.26	-0.16	0.94
Swash Bay										
SE	----	-0.33	0.41	0.04	0.09	0.73	----	0.47	0.20	0.85
LAH	----	0.15	0.67	-0.09	-0.15	0.21	0.01	0.75	0.62	0.46
Component III										
Club Point										
SE	0.01	0.08	0.85	-0.27	-0.02	0.32	0.78	-0.06	-0.07	0.17
LAH	-0.03	0.03	0.89	-0.49	0.25	0.24	0.58	0.02	0.01	0.15
LBH	0.09	0.31	0.91	-0.81	0.05	0.38	0.26	-0.04	-0.15	-0.09
GI	----	0.26	0.12	0.53	0.42	0.89	----	-0.14	-0.07	-0.12
Swash Bay										
SE	----	0.25	-0.04	0.03	0.91	0.12	----	-0.56	0.20	-0.11
LAH	----	0.02	0.36	-0.37	0.75	0.02	0.81	-0.19	-0.06	-0.06
Component IV										
Club Point										
SE	-0.27	0.08	0.04	0.01	0.01	0.41	-0.06	0.89	-0.17	0.18
LAH	-0.07	0.16	0.11	0.70	0.06	0.82	-0.10	-0.01	0.35	-0.02
LBH	0.10	0.0006	0.06	0.05	-0.31	0.23	0.55	-0.05	0.16	0.93
GI	----	----	----	----	----	----	----	----	----	----
Swash Bay										
SE	----	----	----	----	----	----	----	----	----	----
LAH	----	0.86	0.19	0.03	-0.37	-0.23	0.24	-0.08	0.31	-0.50

both have high positive loadings for DG and high negative loadings for DC, counter-balancing each other for vertical placement in the bush. Glossy ibis also have high positive loadings for SB and CMSB. The Swash Bay snowy egrets have a moderate positive loading for CNB and a high negative loading for CMSB. The first components have been called stability for these two populations.

The Louisiana herons at Swash Bay are most different from the other species for component I. They have high positive loadings for DC (the glossy ibis and the Swash Bay snowy egrets were both negative) and DOB. The amount of protection for the nest describes this component.

SECOND PRINCIPAL COMPONENT

The second principal component seems to be more varied in its pattern of variables for the different species than component I. The snowy egrets at Club Point have positive, moderate loadings for DC, DOB, and CMSB and a negative moderate loading for CNB. For this population, component II has been described as one of protection. The Club Point Louisiana herons have a high positive loading for CNB and a moderate negative loading for CMSB, with very low loadings for all other variables. Little blue herons have a high positive loading for CNB and CMSB and a moderate positive loading for SB. The second principal component for these two populations has been called stability.

The glossy ibis at Club Point and the snowy egrets at Swash Bay both load high for DO. The glossy ibis also have a moderate loading for DCB. The snowy egrets have a moderate positive loading for DOB. I have named component II for these two populations protection also, even though the variables loading on it are different from those of the snowy egrets at Club Point.

Again, the Swash Bay Louisiana herons load differently from the others, with moderate positive loadings for DG and CMSB and a slightly higher factor loading for SB. This seems to be a stability component.

THIRD PRINCIPAL COMPONENT

Snowy egrets, Louisiana herons, and little blue herons at Club Point all load high on their respective components III for DG. The snowy egrets and Louisiana herons both load for ND but with Louisiana herons loading at a lower magnitude that the snowy egrets. The Louisiana herons and littl blue herons both load negatively for DC but with Louisiana herons again having a lower loading. This component has been called vertical placement.

Glossy ibis have a high positive loading on component III for DOB and a moderate positive loading for DC.

The snowy egrets and Louisiana herons at Swash Bay both load positively for DCB. The Louisiana herons also have a high positive loading for ND, while the snowy egrets load negatively, and moderately, for SB. For all three of these populations, horizontal placement describes component III.

FOURTH PRINCIPAL COMPONENT

The snowy egrets at Club Point load high for SB on component IV. This has been called stability.

The Louisiana herons at Club Point have high positive loadings for DC and DOB, a protective component.

The little blue herons load high for DO and moderate for ND.

The Louisiana herons at Swash Bay have a high positive loading for CNB. This component has not been named for these last two populations

The glossy ibis and the Swash Bay snowy egrets have no component IV.

Table VII gives each species in each colony and their variables which load on each component.

TIME OF NESTING

All species nesting at Club Point seem to have nested during approximately the same weeks (Fig. 7). Peak nesting times were from 29 April through 13 May and on 22 June. The glossy ibis only nested during the weeks of 6 May and 13 May, when the peak was declining for the snowy egrets and the Louisiana herons. The only great egret nest was started on 13 May. Although numbers of nests are different for the different species, peak nesting times are about the same but with the glossy ibis arriving after the other species.

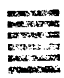
At the Swash North colony, Louisiana herons started nesting on 29 April with a peak on 13 May (Fig. 8a). The snowy egrets started nesting on 13 May with peak numbers of nests on 20 May and 6 June, thus showing some degree of temporal differences from Louisiana herons in nesting time. Both species had late nesters or renesters on 18 and 24 June.

In the Swash South colony, Louisiana herons, again, started nesting before the snowy egrets, 29 April as opposed to 13 May (Fig. 8b). The overlap in time by the two species is the same as for Swash North, 13 and 20 May, but with the peak number of snowy egret nests built on 13 may and the peak number of Louisiana heron nests built on 6 May.

Both of the Swash Bay colonies were started later than Club Point and had peak numbers of nests in later weeks. As Club Point nesting

Figure 7. Number of nests built each week by each species at Club Point. A key to the species is provided below.

Snowy egrets 

Louisiana herons 

Little blue herons 

Glossy ibis 

Great egret 

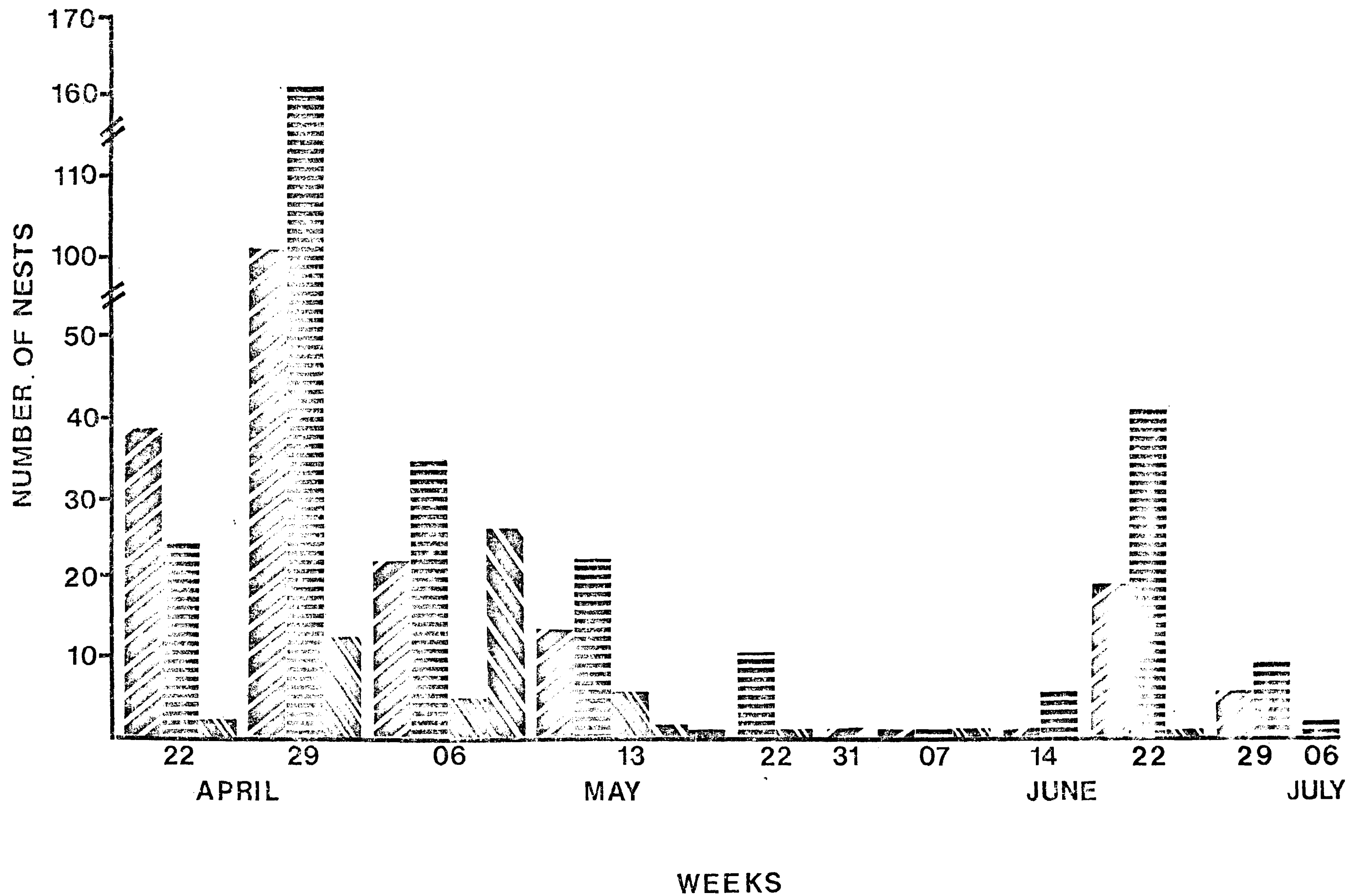
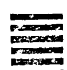

NUMBER. OF NESTS
170
160
110
100
50
40
30
20
10
22
29
06
13
22
31
07
14
22
29
06
APRIL
MAY
JUNE
JULY
WEEKS

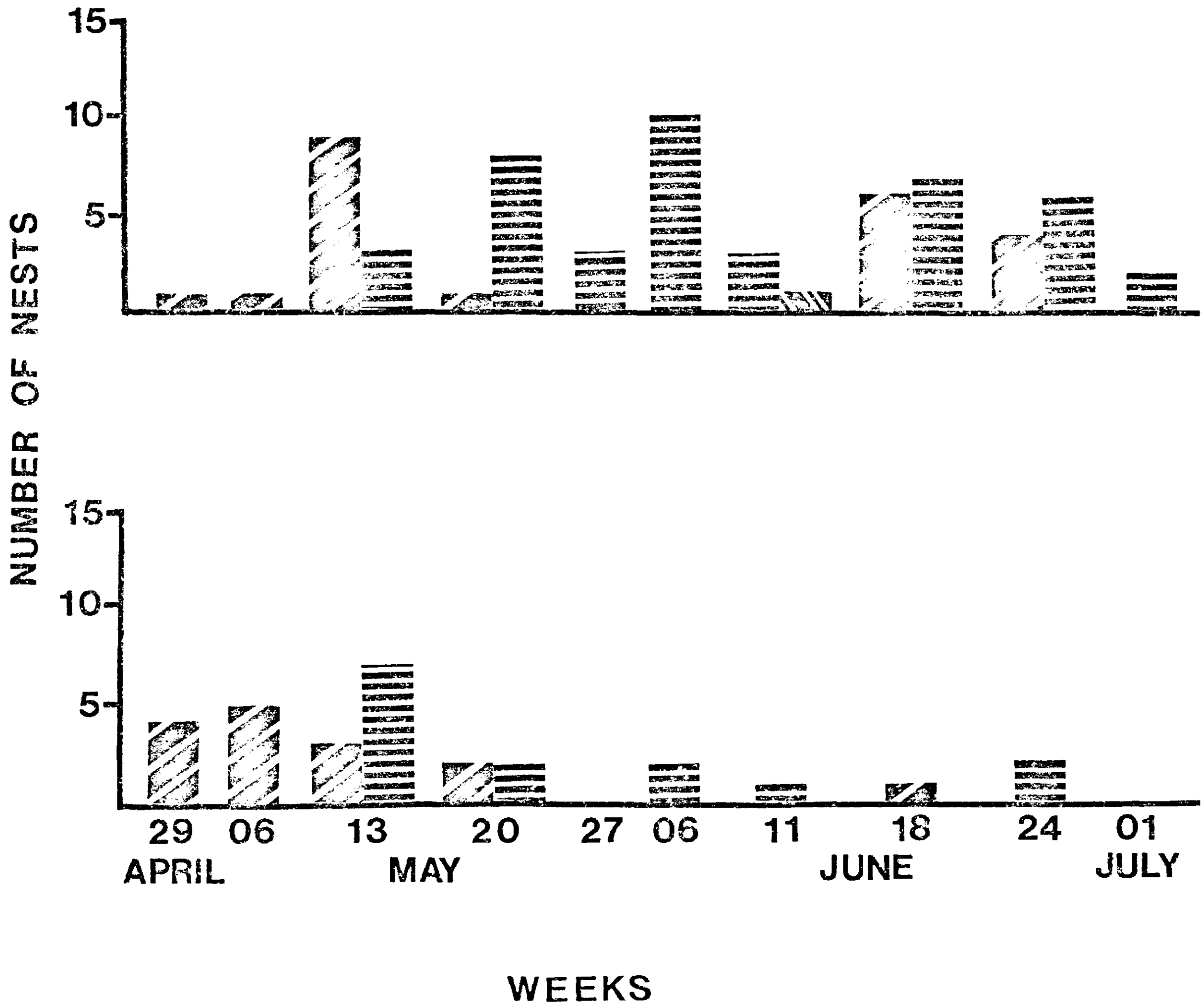
Figure 8(a). Number of nests built each week by each species at Swash North. A key to the species is provided below.

8(b). Number of nests built each week by each species at Swash South. A key to the species is provided below.

Snowy egrets 

Louisiana herons 

Little blue herons 



NUMBER OF NESTS
15
10
5
15
10
5
29
06
13
20
27
06
11
18
24
01
APRIL
MAY
JUNE
JULY
WEEKS

was tapering off, Swash Bay nesting activity was greatest.

TIME-SUCCESS

In tests for differences in success of early or late nesters for each species in each colony, only the snowy egrets at Club Point showed significant differences in survival and breeding success ($P \leq 0.01$). They did significantly better later in the season. Table VIII gives the mean ranks and X^2 for each test.

POSITION AND TIME OF NESTING

Bartlett's tests for homogeneity of variances was performed prior to the regression analyses of time of nesting and position in the colony. The variances for time of nesting among the contours were homogeneous for all species except for the snowy egrets at Club Point ($P \leq 0.01$) and the snowy egrets at Swash South ($P \leq 0.05$). They were subjected to the regression analysis anyway, as this was the only test of which I was aware to give the information needed.

In the regression analyses of time of nesting and position in the colony, linear regressions were found for the Louisiana herons at Club Point ($P \leq 0.01$ that $\beta = 0$) and for the snowy egrets at Swash North ($P \leq 0.01$ that $\beta = 0$) and at Swash South ($P \leq 0.05$ that $\beta = 0$) (Table IX).

Figures 9-16 show mean time of nesting for each species, range of weeks, and n for each contour in each colony.

In the initial analyses of variance for each of these, there was a significant difference in time of nesting among contours only for the snowy egrets at Swash North ($P \leq 0.01$) (Table IX).

For the Louisiana herons at Club Point, early nesters showed a tendency to nest in the center of the colony with later nesters building toward the edges (Fig. 10).

TABLE VIII. Kruskal-Wallis tests for differences in success for early or late nesters for each species in each colony (X^2 corrected for ties).

Test	Time	N	$\bar{X}$ ranks	X^2	P	
Snowy egrets, Club Point						
Hatching success	Early Late	166 26	96.71 95.17	0.030	0.862	ns
Survival success	Early Late	166 26	92.25 123.62	7.931	0.005	**
Breeding success	Early Late	166 26	92.75 120.44	6.138	0.013	**
Louisiana herons, Club Point						
Hatching success	Early Late	243 50	146.44 149.73	0.088	0.767	ns
Survival success	Early Late	243 50	148.28 140.78	0.355	0.551	ns
Breeding success	Early Late	243 50	148.38 140.30	0.395	0.530	ns
Little blue herons, Club Point						
Hatching success	Early Late	26 3	14.25 21.50	2.385	0.123	ns
Survival success	Early Late	26 3	15.42 11.33	0.656	0.418	ns
Breeding success	Early Late	26 3	15.33 12.17	0.382	0.537	ns
Glossy ibises, Club Point						
Hatching success	6 May 13 May	25 2	13.78 16.75	0.306	0.580	ns
Survival success	6 May 13 May	25 2	13.90 15.25	0.072	0.789	ns
Breeding success	6 May 13 May	25 2	13.82 16.25	0.232	0.630	ns
Snowy egrets, Swash North.						
Hatching success	Early Late	12 10	13.25 9.40	2.032	0.154	ns
Survival success	Early Late	12 10	10.96 12.15	0.208	0.649	ns
Breeding success	Early Late	12 10	11.33 11.70	0.018	0.893	ns
Louisiana herons, Swash North						
Hatching success	Early Late	14 27	22.50 20.22	0.395	0.530	ns
Survival success	Early Late	14 27	22.64 20.15	0.510	0.475	ns
Breeding success	Early Late	14 27	23.43 19.74	0.920	0.337	ns
Snowy egrets, Swash South						
Hatching success	Early Late	14 1	8.36 3.00	2.232	0.135	ns
Survival success	Early Late	14 1	7.57 14.00	2.762	0.097	ns
Breeding success	Early Late	14 1	7.64 13.00	1.904	0.168	ns
Louisiana herons, Swash South						
Hatching success	Early Late	9 5	8.33 6.00	1.201	0.273	ns
Survival success	Early Late	9 5	8.17 6.30	1.008	0.315	ns
Breeding success	Early Late	9 5	8.22 6.20	0.825	0.364	ns

P = probability level, ** $P < 0.01$, ns = not significant at the 0.05 level.

TABLE IX. Regression analysis of position and date of nesting for each species in each colony.

	Source of Variation	MS	df	Fs	P	
Club Point Snowy egrets	Groups	6.8534	5	0.8914	$0.5<P<0.75$	ns
	Linear	0.0929	1	0.0109	$P>0.75$	ns
	Deviation	8.5435	4	1.1113	$0.25<P<0.5$	ns
	Error	7.6880	194			
Louisiana herons	Groups	14.1394	6	1.7837	$0.05<P<0.1$	ns
	Linear	65.0199	1	16.4054	$0.005<P<0.01$	**
	Deviation	3.9633	5	0.5000	$P>0.75$	ns
	Error	7.9271	303			
				$Y = 1.92104 + 0.34710X$		
Little blue herons	Groups	0.2494	2	0.0610	$P>0.75$	ns
	Linear	0.1914	1	0.6226	$0.5<P<0.75$	ns
	Deviation	0.3075	1	0.0752	$P>0.75$	ns
	Error	4.0869	26			
Swash North Snowy egrets	Groups	19.7625	4	5.2485	$0.005<P<0.01$	**
	Linear	72.7135	1	34.4264	$0.005<P<0.01$	**
	Deviation	2.1121	3	0.5609	$0.5<P<0.75$	ns
	Error	3.7654	13	$Y = 11.13928- 0.182629X$		
Louisiana herons	Groups	2.1001	4	0.4725	$P>0.75$	ns
	Linear	0.0006	1	0.0003	$P>0.75$	ns
	Deviation	2.7999	3	0.6299	$0.5<P<0.75$	ns
	Error	4.4448	33			
Swash South Snowy egrets	Groups	0.9841	2	0.2648	$P>0.75$	ns
	Linear	1.9662	1	947.4668	0.005 P 0.01	*
	Deviation	0.0021	1	0.0006	$P>0.75$	ns
	Error	3.7172	11	$Y = 3.61370- 0.29284X$	$P>0.75$	ns
Louisiana herons	Groups	2.7250	2	0.7168	$0.5<P<0.75$	ns
	Linear	5.2368	1	24.5581	$0.1<P<0.25$	ns
	Deviation	0.2132	1	0.0561	$P>0.75$	ns
	Error	3.8018	9			

P = probability level, * = $P \leq 0.05$, ** $P \leq 0.01$, ns = not significant at the 0.05 level.

Figure 9. Mean and range of date of nesting in each contour by snowy egrets at Club Point. Contour 1 is not used in the regression analysis because there was no variance in that sample.

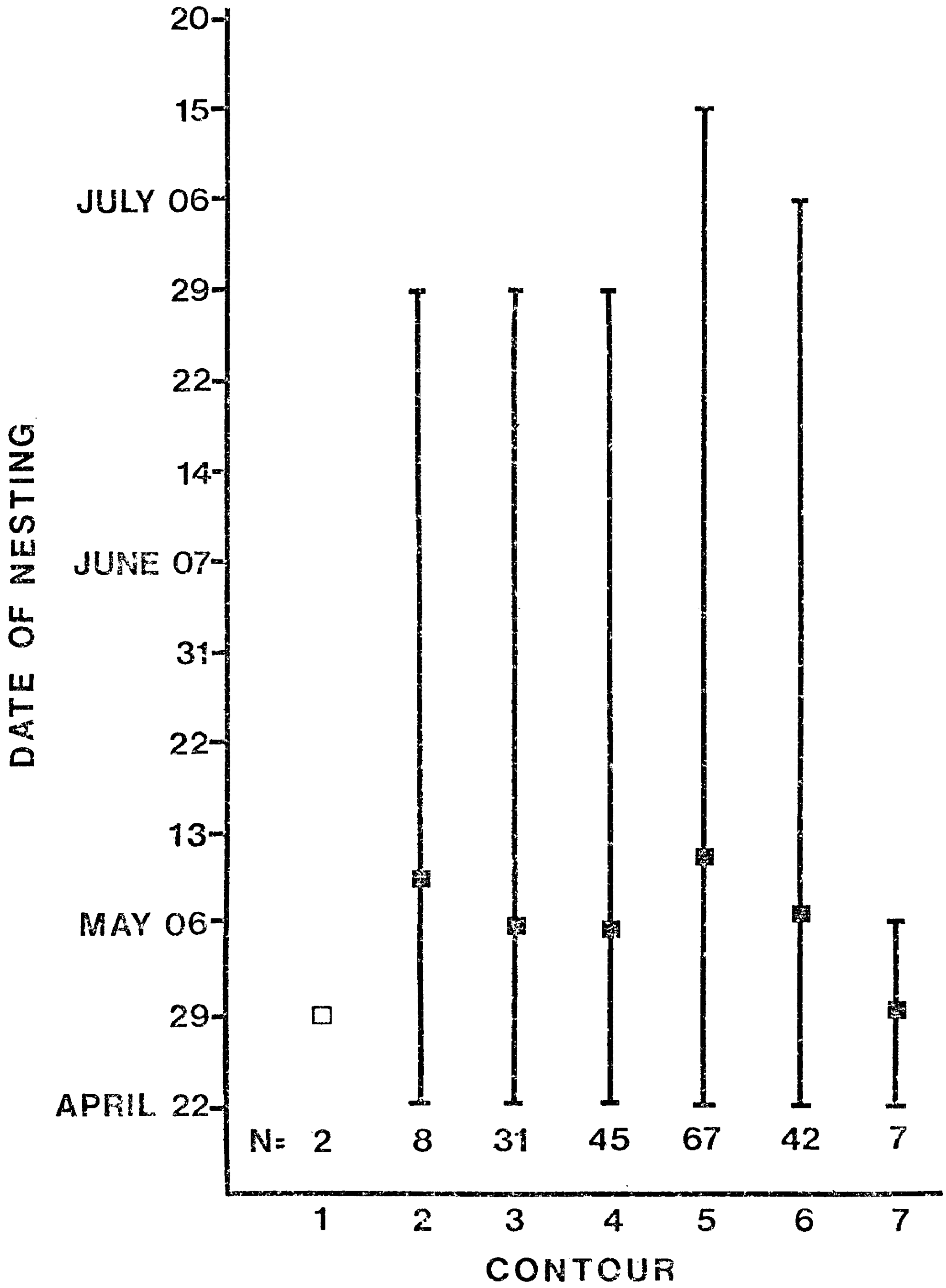
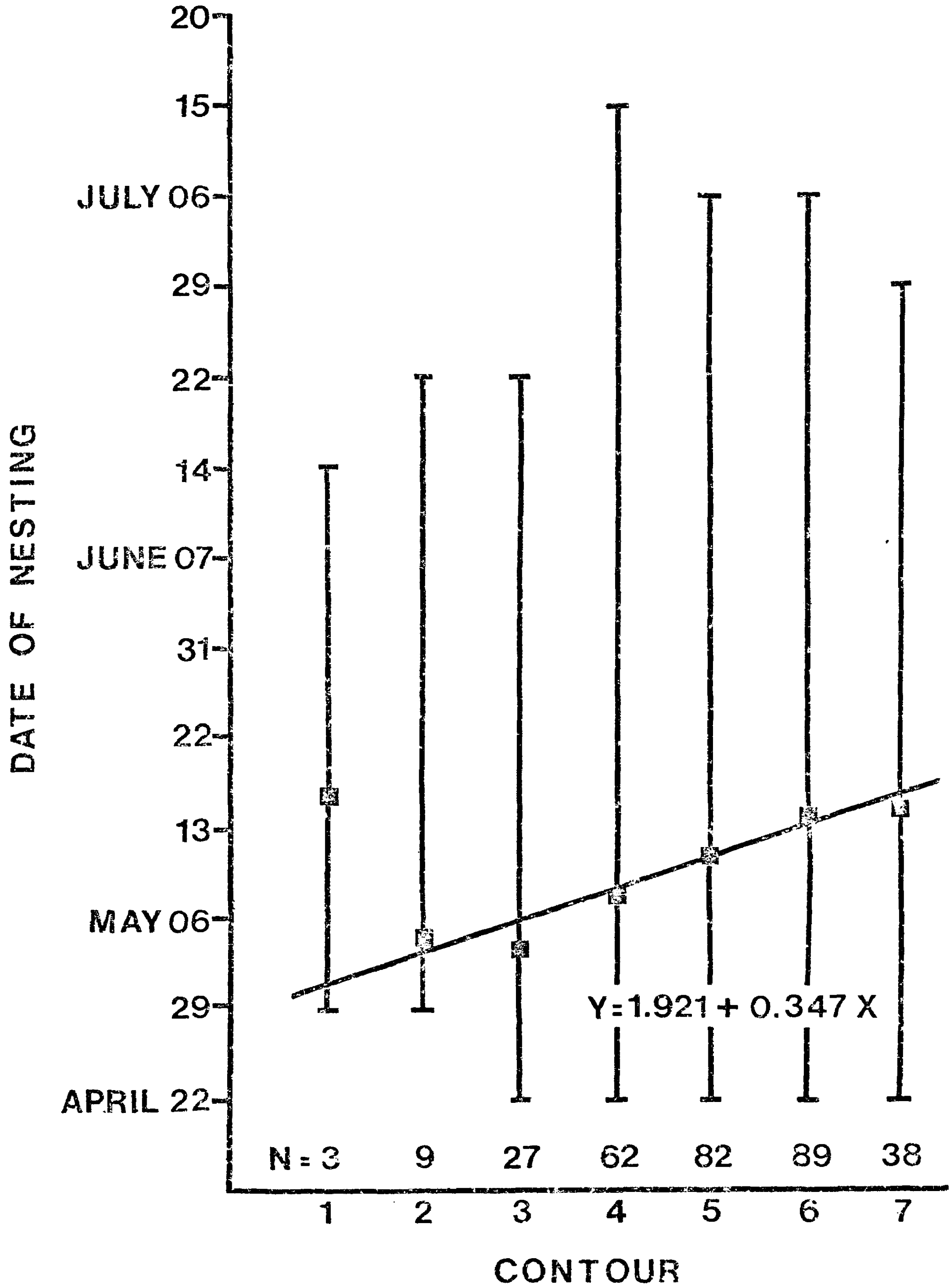

20
15
JULY 06
29
22
14
JUNE 07
31
22
13
MAY 06
29
APRIL 22
DATE OF NESTING
N: 2 8 31 45 67 42 7
1 2 3 4 5 6 7
CONTOUR

Figure 10. Mean and range of date of nesting in each contour by Louisiana herons at Club Point.



DATE OF NESTING
20
15
JULY 06
29
22
14
JUNE 07
31
22
13
MAY 06
29
APRIL 22
Y=1.921 + 0.347 X
N = 3
9
27
62
82
89
38
1
2
3
4
5
6
7
CONTOUR

Figure 11. Mean and range of date of nesting in each contour by glossy ibis at Club Point. No regression anaylsis was performed for this species because of lack of variance in the samples.

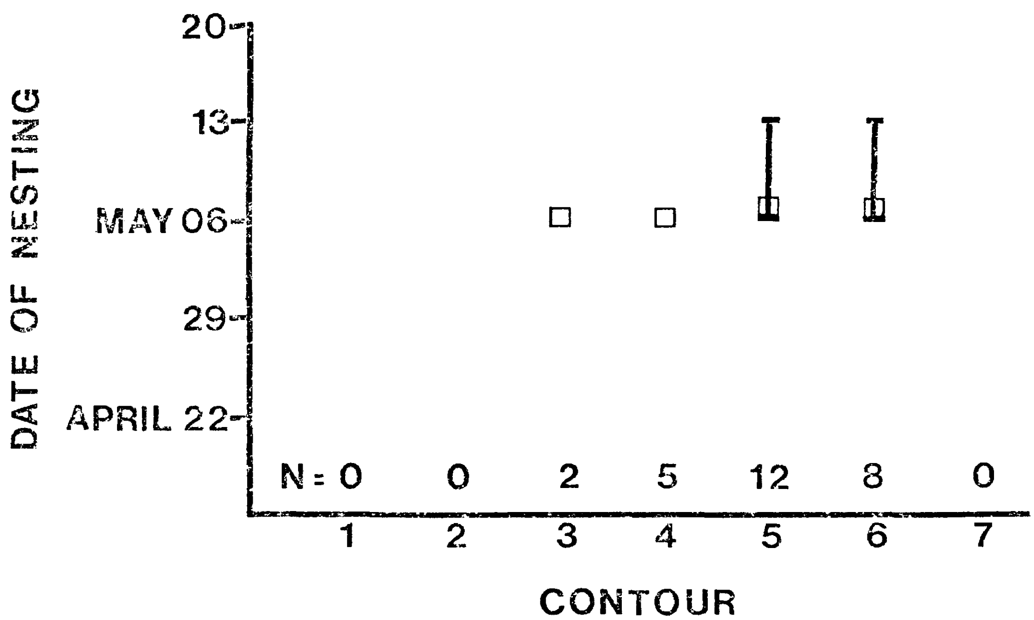

DATE OF NESTING
20
13
MAY 06
29
APRIL 22
N = 0
0
2
5
12
8
0
1
2
3
4
5
6
7
CONTOUR

Figure 12. Mean and range of date of nesting in each contour by little blue herons at Club Point. Contours 1-3 were not used in the analysis because no nests were built there by little blue herons. Contour 4 was not used because there was no variance for that sample.

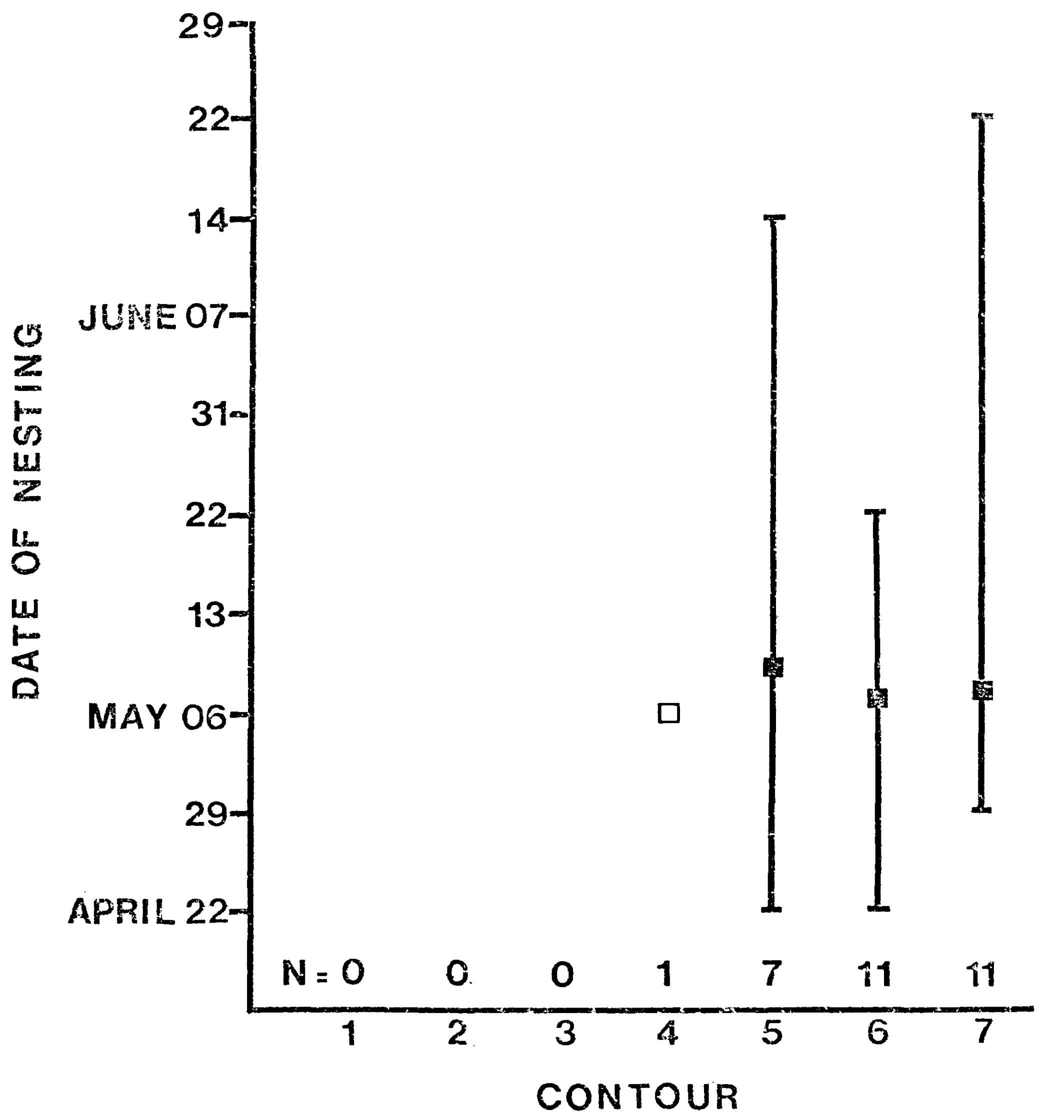

DATE OF NESTING
29
22
14
JUNE 07
31
22
13
MAY 06
29
APRIL 22
N = 0
0
0
1
7
11
11
1
2
3
4
5
6
7
CONTOUR

Figure 13. Mean and range of date of nesting in each contour by snowy egrets at Swash North. Contours 1, 2, 5, 6 and 7 are not included in the analysis because of lack of variance for those samples, or no nests.

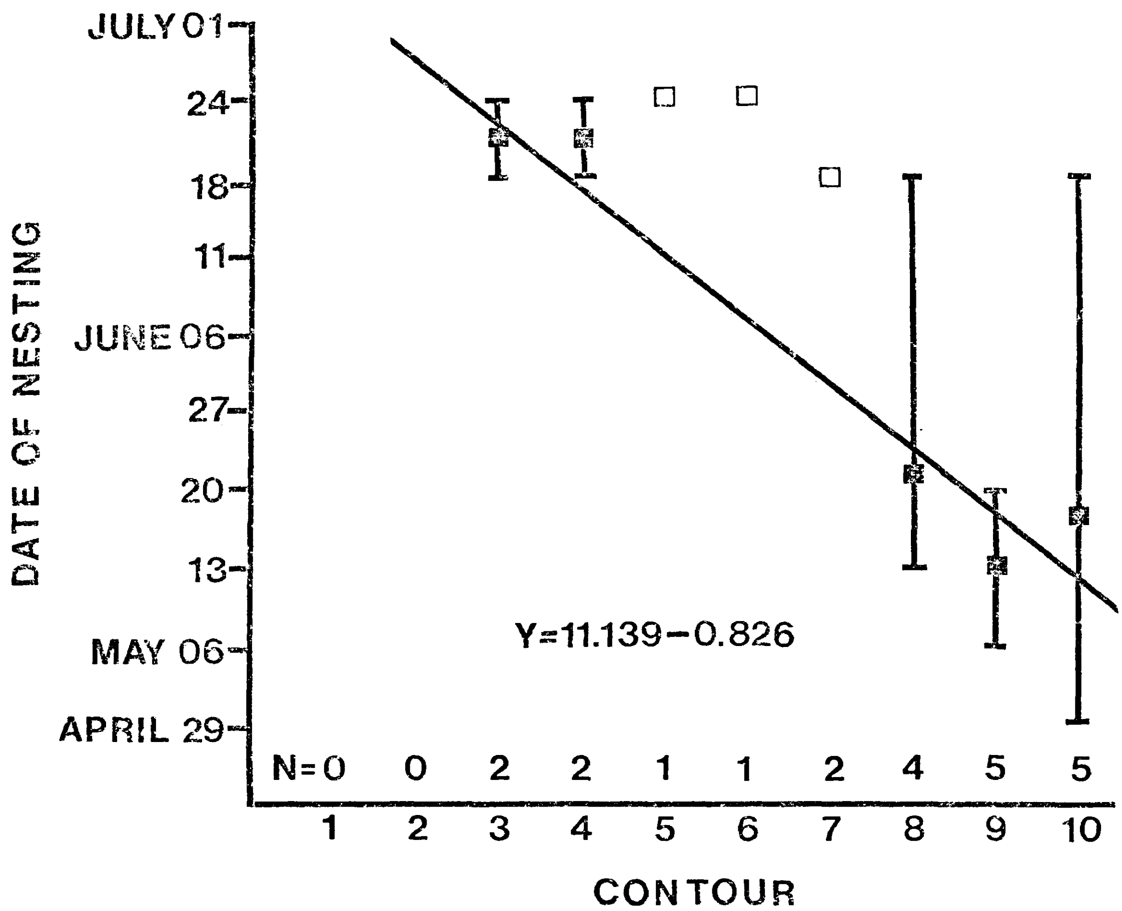
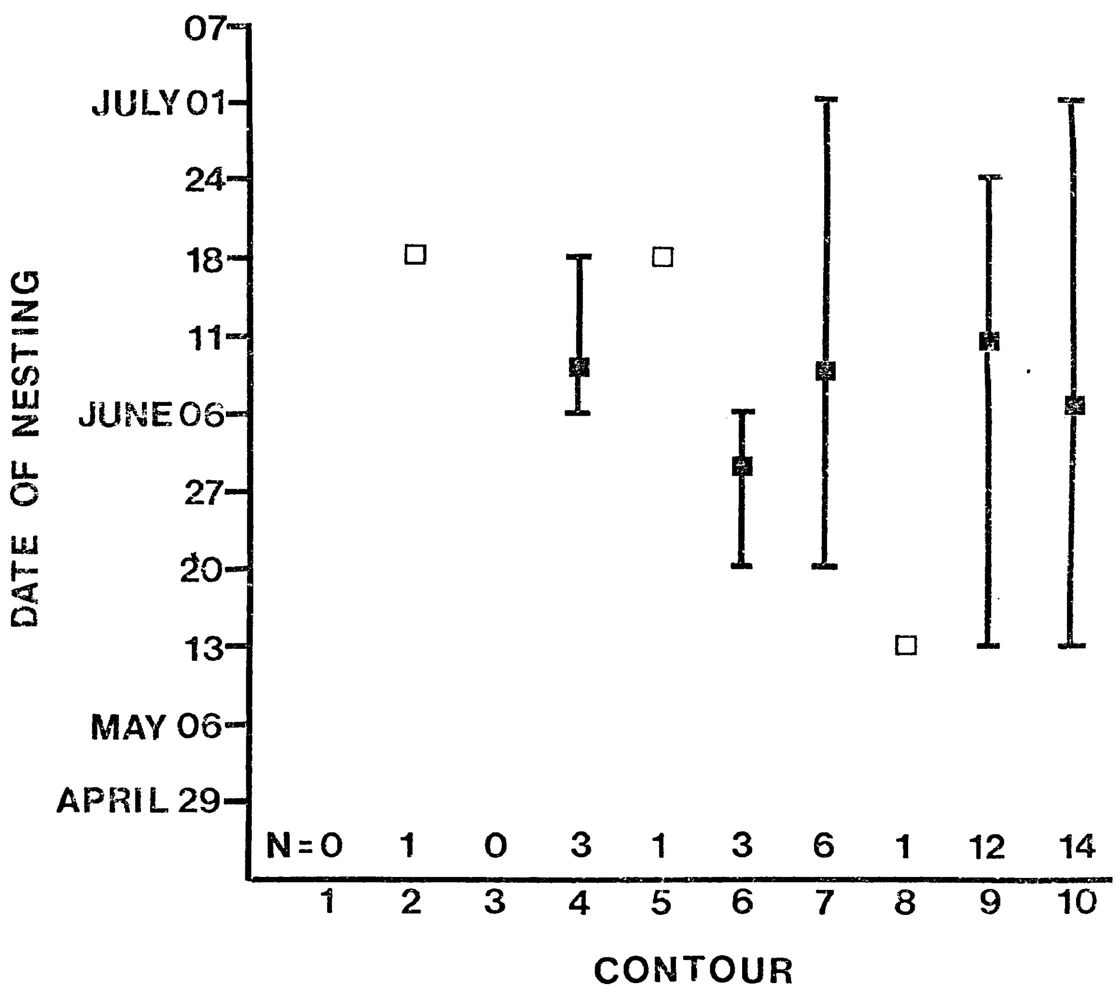
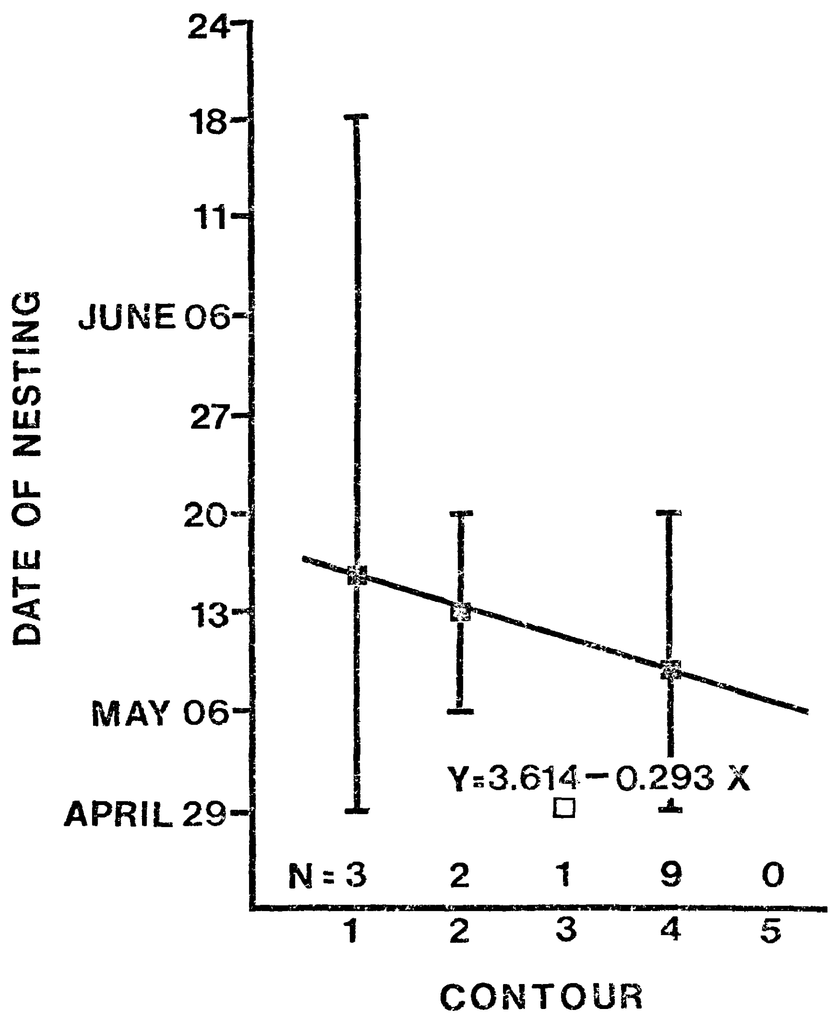

JULY 01
24
18
11
JUNE 06
27
20
13
MAY 06
APRIL 29
DATE OF NESTING
Y=11.139−0.826
N=0
0
2
2
1
1
2
4
5
5
1
2
3
4
5
6
7
8
9
10
CONTOUR

Figure 14. Mean and range of date of nesting in each contour by Louisiana herons at Swash North. Contours 1-3, 5, and 8 not included because of lack of variance or no nests.



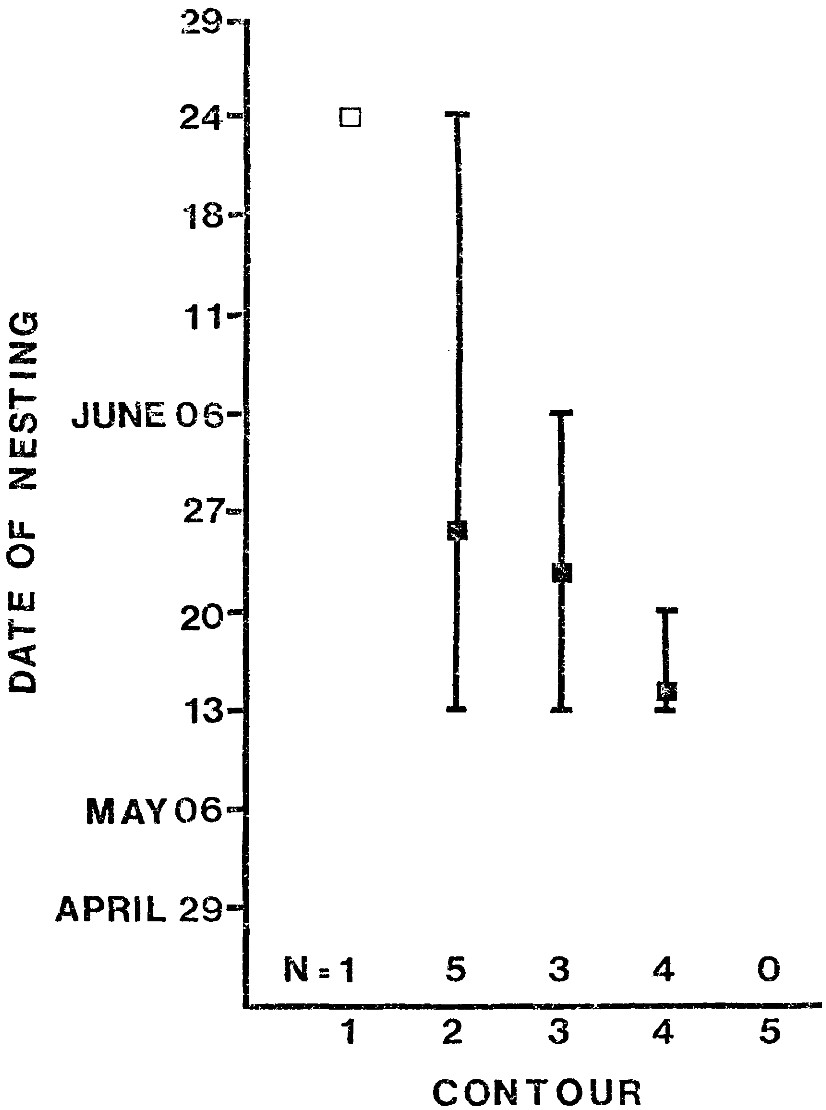
DATE OF NESTING
07
JULY 01
24
18
11
JUNE 06
27
20
13
MAY 06
APRIL 29
N = 0
1
0
3
1
3
6
1
12
14
1
2
3
4
5
6
7
8
9
10
CONTOUR

Figure 15. Mean and range of date of nesting in each contour by snowy egrets at Swash South. Contours 3 and 5 not used in analysis because of lack of variance or no nests.



DATE OF NESTING
24
18
11
JUNE 06
27
20
13
MAY 06
APRIL 29
Y=3.614−0.293 X
N = 3
2
1
9
0
1
2
3
4
5
CONTOUR

Figure 16. Mean and range of date of nesting in each contour by Louisiana herons at Swash South. Contours 1 and 5 not used because of lack of variance or no nests.


DATE OF NESTING
29
24
18
11
JUNE 06
27
20
13
MAY 06
APRIL 29
N = 1
5
3
4
0
1
2
3
4
5
CONTOUR

The snowy egrets at Swash North and at Swash South nested in the outer contours during the early weeks and in the center of the colony later (Figs. 13 and 15).

The glossy ibis at Club Point were not tested because all nests were built during one of two weeks (predominantly 6 May) in contours 3-6 (Fig. 11).

SUCCESS AND POSITION

In tests of independence of success and position in the colony (inner and outer contours) for each species (Tables X-XII), the Louisiana herons at Swash North and the snowy egrets at Swash South had significantly higher ($P \leq 0.05$) survival and breeding success in the inner portions of the colonies. All tests for other species were not significant, indicating that success was independent of position in the colony.

Although no quantitative analyses of species distribution were made for the colonies, visual analyses of the Club Point and Swash North maps do not suggest a clumping of conspecifics (Figs. 17 and 18). In the Swash South heronry, there seems to be some segregation of snowy egrets and Louisiana herons, but not a total one (Fig. 19).

TABLE X. R X C tests for independence of success and position for each species at Club Point.

Snowy egrets							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	393	433	91	1.6247	0.1<P<0.5	ns
	Outer	121	140	86			
	Contour	# Chicks	Total (# hatched)	%CH/H	G	P	
Survival	Inner	152	393	39	0.3313	0.5<P<0.9	ns
	Outer	51	121	42			
	Contour	# Chicks	Total (# eggs)	%CH/E	G	P	
Breeding	Inner	152	433	35	0.0335	0.5<P<0.9	ns
	Outer	51	140	36			
Louisiana herons							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	449	513	88	0.3824	0.5<P<0.9	ns
	Outer	303	353	86			
	Contour	# Chicks	Total (# hatched)	%CH/H	G	P	
Survival	Inner	240	449	53	3.6142	0.05<P<0.1	ns
	Outer	184	303	61			
	Contour	# Chicks	Total (# eggs)	%CH/E	G	P	
Breeding	Inner	240	513	47	2.178	0.1<P<0.5	ns
	Outer	184	353	52			
Little blue herons							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	28	32	88	0.0385	0.5<P<0.9	ns
	Outer	62	74	84			
	Contour	# Chicks	Total (# hatched)	%CH/H	G	P	
Survival	Inner	17	28	61	0.3308	0.5<P<0.9	ns
	Outer	32	62	52			
	Contour	# Chicks	Total (# eggs)	%CH/E	G	P	
Breeding	Inner	17	32	53	0.5242	0.1<P<0.5	ns
	Outer	32	74	43			
Glossy ibis							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	39	53	74	0.8530	0.1<P<0.5	ns
	Outer	19	22	86			
	Contour	# Chicks	Total (# hatched)	%CH/H	G	P	
Survival	Inner	7	39	18	1.5120	0.1<P<0.5	ns
	Outer	7	19	37			
	Contour	# Chicks	Total (# eggs)	%CH/E	G	P	
Breeding	Inner	7	53	13	2.2810	0.1<P<0.5	ns
	Outer	7	22	32			

P = probability level, ns = not significant at the 0.05 level.

TABLE XI. R X C tests for independence of success and position for each species at Swash North.

	Contour	# Hatched	Total (# eggs)	% H	G	P	
Snowy egrets							
Hatching	Inner	24	36	67	0.0811	0.5<P<0.9	ns
	Outer	24	33	73			
	Contour	# Chicks	Total (# hatched)	% CH/H	G	P	
Survival	Inner	17	24	71	3.0829	0.05<P<0.1	ns
	Outer	10	24	42			
	Contour	# Chicks	Total (# eggs)	% CH/E	G	P	
Breeding	Inner	17	36	47	1.4285	0.1<P<0.5	ns
	Outer	10	33	30			
Louisiana herons							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	32	41	78	0.0030	0.5<P<0.9	ns
	Outer	59	77	77			
	Contour	# Chicks	Total (# hatched)	% CH/H	G	P	
Survival	Inner	29	32	91	15.3110	P<0.005	*
	Outer	29	59	49			
	Contour	# Chicks	Total (# eggs)	% CH/E	G	P	
Breeding	Inner	29	41	71	10.6260	P<0.005	*
	Outer	29	77	38			

P = probability level, * $P \leq 0.05$, ns = not significant at the 0.05 level.

TABLE XII. R X C tests for independence of success and position for each species at Swash South.

	Contour	# Hatched	Total (# eggs)	% H	G	P	
Snowy egrets							
Hatching	Inner	16	19	84	0.0044	0.5<P<0.9	ns
	Outer	25	28	89			
	Contour	# Chicks	Total (# hatched)	% CH/H	G	P	
Survival	Inner	8	16	50	5.3210	0.01<P<0.025	*
	Outer	3	25	12			
	Contour	# Chicks	Total (# eggs)	% CH/E	G	P	
Breeding	Inner	8	19	42	4.5565	0.025<P<0.05	*
	Outer	3	28	11			
Louisiana herons							
	Contour	# Hatched	Total (# eggs)	% H	G	P	
Hatching	Inner	20	26	77	0.0005	0.9<P<0.975	ns
	Outer	10	12	83			
	Contour	# Chicks	Total (# hatched)	% CH/H	G	P	
Survival	Inner	14	20	70	2.5271	0.1<P<0.5	ns
	Outer	10	10	100			
	Contour	# Chicks	Total (# eggs)	% CH/E	G	P	
Breeding	Inner	14	26	54	2.0379	0.1<P<0.5	ns
	Outer	10	12	83			

P = probability level, * $P \leq 0.05$, ns = not significant at the 0.05 level.

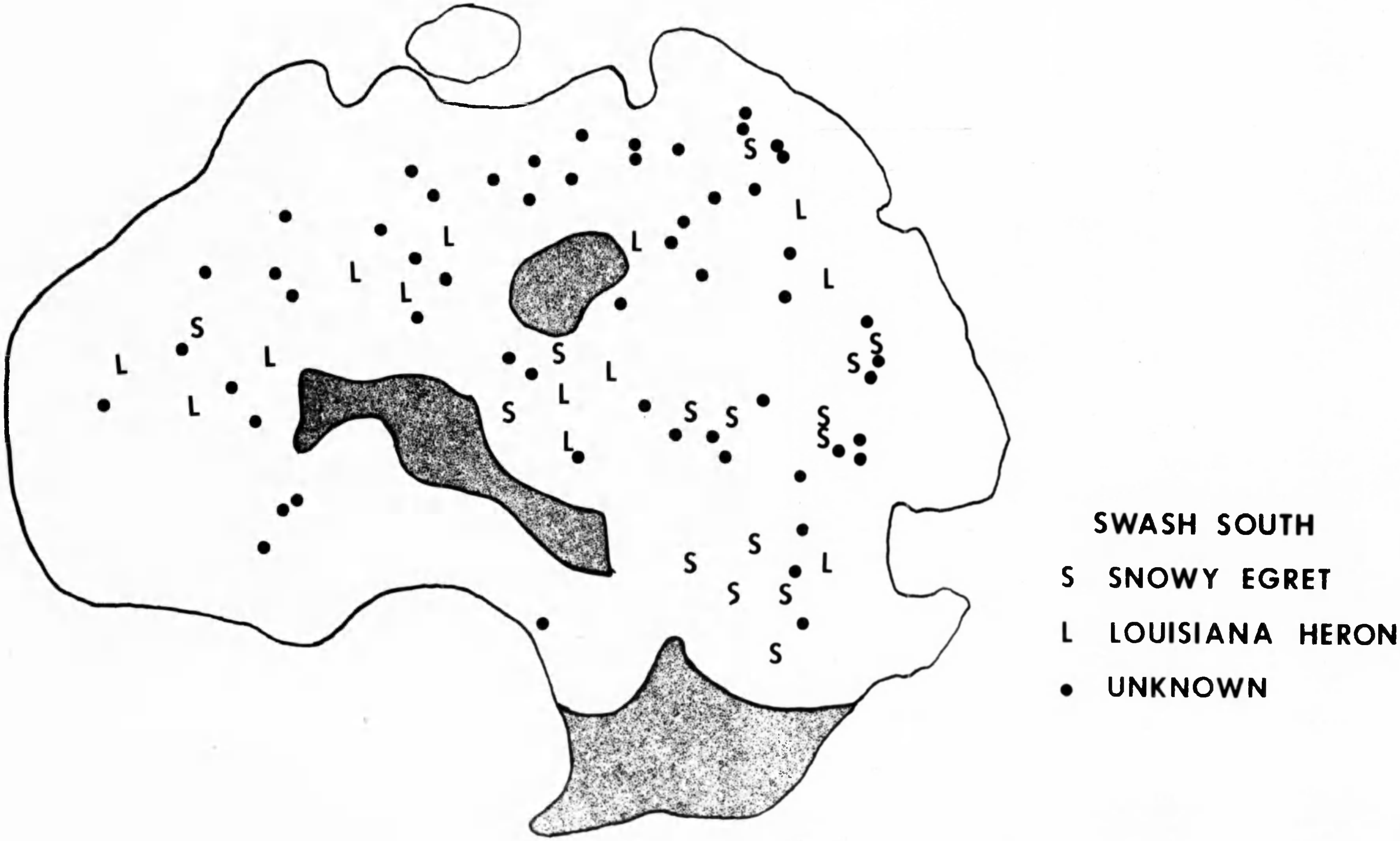
Figure 17. Map of the Club Point heronry showing nesting distribution for the species. Shaded parts are grassy areas.


CLUB POINT
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
G GLOSSY IBIS
E GREAT EGRET
• UNKNOWN

Figure 18. Map of the Swash North heronry showing nesting distribution for the species. Shaded parts are grassy areas.


SWASH NORTH
S SNOWY EGRET
L LOUISIANA HERON
B LITTLE BLUE HERON
• UNKNOWN

Figure 19. Map of the Swash South heronry showing nesting distribution for the species. Shaded parts are grassy areas.


SWASH SOUTH
S SNOWY EGRET
L LOUISIANA HERON
• UNKNOWN

HERONS AS ENVIRONMENTAL INDICATORS

COLONY UTILIZATION

Results of analyses of nest site selection, success and time, position and time, and position and success have been given as well as comments on qualitative differences in peak nesting times for each species and on species distribution in each colony. In addition, a comparision of the 1975 and 1976 species composition was made for each colony (Table XIII). At Club Point, the percentage of each species was not significantly different for the two years, except for Louisiana herons, which composed a greater percentage of the total number of birds in 1976 ($P \leq 0.05$) and the glossy ibis, which had a greater percentage in 1975 ($P \leq 0.001$). The portion of snowy egrets in the Swash North colony was greater in 1975 ($P \leq 0.001$) while the percentage of Louisiana herons in that colony was greater in 1976 ($P \leq 0.001$). There were 8 pairs of glossy ibis in 1975 and none in 1976 at the Swash North colony. The Swash South colony also had a greater percentage of snowy egrets in 1975 ($P \leq 0.001$).

CHANGES IN VEGETATION

A visual analysis of the change in vegetation as the season progressed was made. In infrared slides of each colony, the vegetation looks lusher and denser, with more ground cover and fewer, smaller open areas in July than in May or August. Slides taken in May show more green and blue and not as much vivid red as do slides taken in July. Quality of the slides differed, however, making if difficult to compare May and July with August.

At the south end of Club Point, where there were few birds nesting, the vegetation in the slides taken in August looks fuller and

TABLE XIII. Differences in percentage composition of each colony in 1975 and 1976. See Table I for explanation of species mnemonics.

Colony	Species	Year	# Birds	Total	p	ts	P	
Club Point	SE	1975 1976	229 310	760 977	0.301 0.317	-0.722	0.2<P<0.4	ns
	LAH	1975 1976	276 407	760 977	0.363 0.417	-2.287	0.01<P<0.05	ns
	LBH	1975 1976	30 44	760 977	0.039 0.045	-0.620	0.5<P<0.9	ns
	GI	1975 1976	107 33	760 977	0.141 0.034	8.247	P<0.001	***
	GRH	1975 1976	1 4	760 977	0.001 0.004	-1.313	0.1<P<0.2	ns
Swash North	SE	1975 1976	99 24	211 168	0.469 0.143	7.090	P<0.001	***
	LAH	1975 1976	25 42	211 168	0.118 0.250	-3.346	P<0.001	***
Swash South	SE	1975 1976	51 15	96 87	0.531 0.172	5.250	P<0.001	***
	LAH	1975 1976	17 14	96 87	0.177 0.161	0.288	0.5<P<0.9	ns

P = probability level, * $P \leq 0.05$, *** $P \leq 0.001$, ns = not significant at the 0.05 level.

denser than in those for the other areas.

CENSUS TECHNIQUES

The percentage of birds visible in the colony was calculated for hourly observations through May and June. The percentages seen for each colony over the hours in observation days are much more consistent than the percentages seen over all weeks for each hour. There is a considerable scatter of points for both seasonal and hourly percentages, but the scatter for seasonal is much less.

At Club Point, very low percentages of the birds were visible on all dates. The lowest percentages seen are on 6/11 May and 27/28 May. The percentage of birds is slightly higher on 16 June and 26 June with 9% and 20% seen respectively (Fig. 20). The hourly checks reveal very little pattern but with a slightly higher percentage of birds visible in the early evening (20%) (Fig. 21).

In the Swash North colony, a very large percentage of birds was seen (100-350%) on 5/10 May, an indication of many more birds present than were actually using the colony for nesting. A sharp decline to 25% was seen in the next weeks (21 May and 30 May). The percentage was a little higher on 12 June (43%) but drops again on 25/26/30 June (21%) (Fig. 22). The hourly checks showed very scattered results with no apparent pattern. (Fig. 23).

The Swash South colony showed the same general pattern as the Swash North colony for the percentage of birds visible over the season: high on 5/10 May (100%), lower on 21 May (19%) and 30 May (16%), high again on 12 June (63%), and another drop on 25/26/30 June (19%) (Fig. 24). The hourly checks here also revealed no patterns (Fig. 25).

The infrared slides from May were used to calculate the percentage

Figure 20. Percentage of birds visible at Club Point on observation days. Replicates are hourly observations for each date.

Census date	Number of nesting adults
May 6	978
31	1,282
June 14	472
28	440

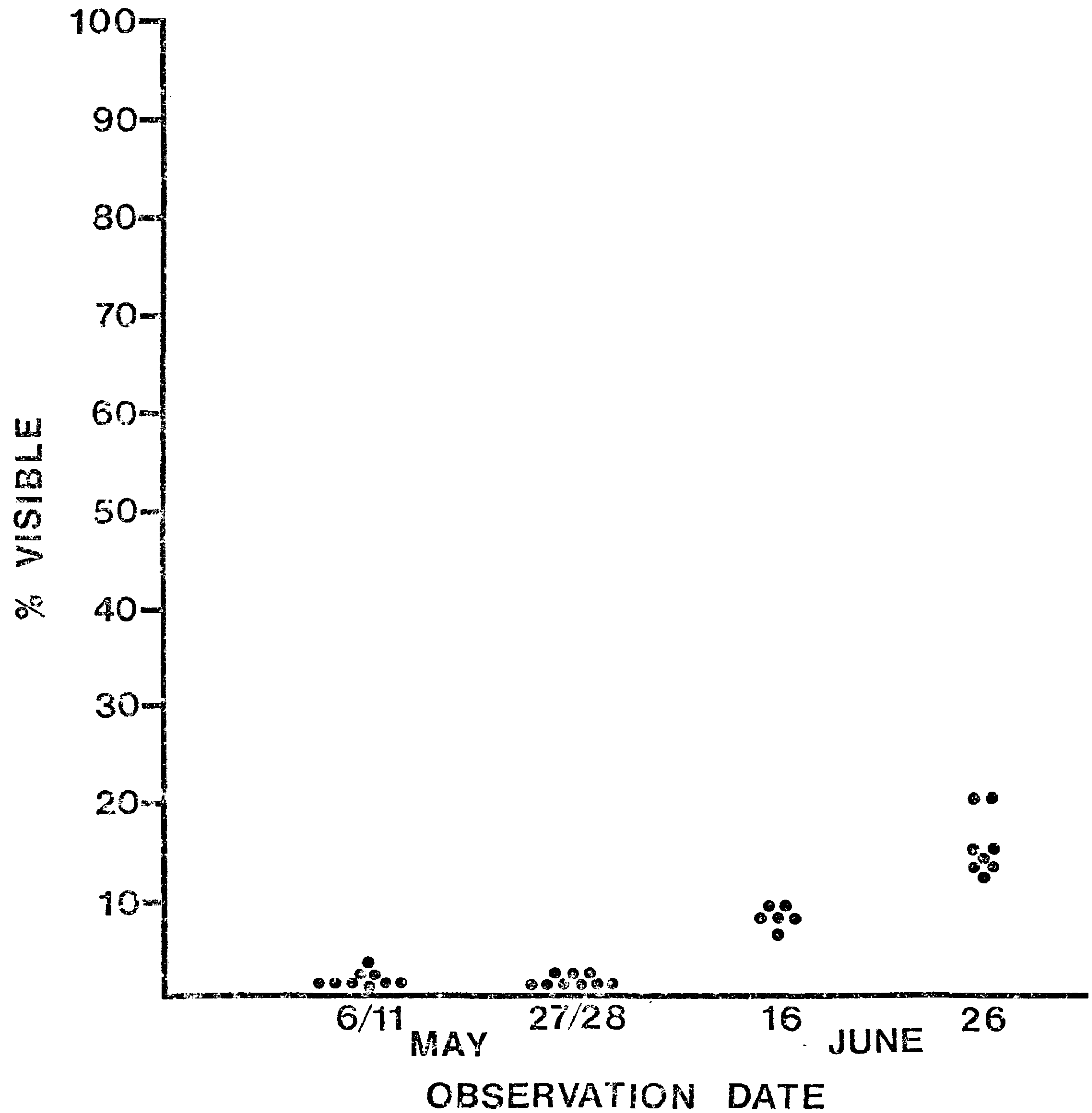

100
90
80
70
60
50
40
30
20
10
% VISIBLE
6/11
27/28
MAY
16
26
JUNE
OBSERVATION DATE

Figure 21. Percentage of birds visible at Club Point at hourly checks. Replicates are observation dates, 6 May – 26 June.

Census date		Number of nesting adults
May	6	978
	31	1,282
June	14	472
	28	440

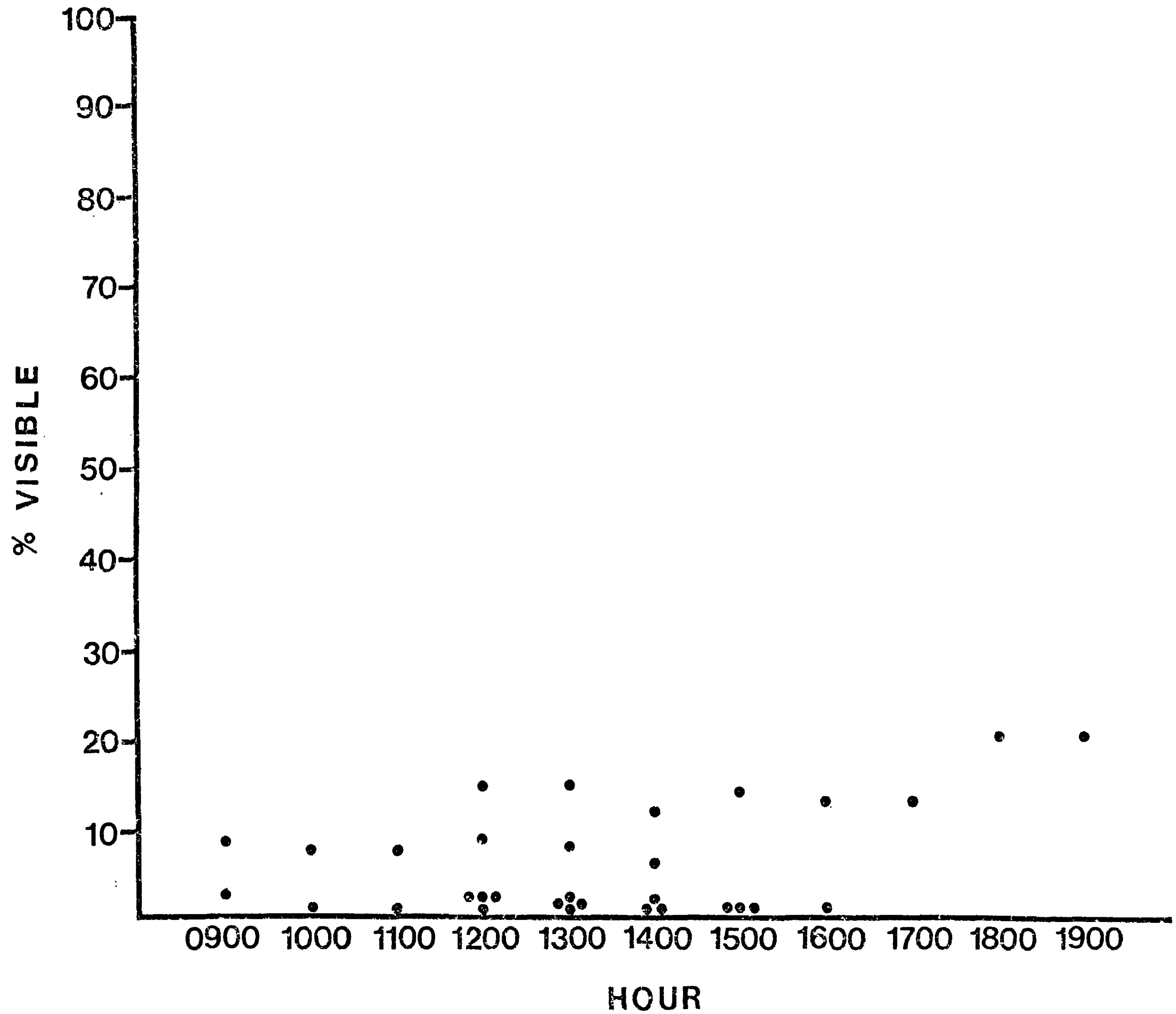

100
90
80
70
60
50
40
30
20
10
% VISIBLE
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
HOUR

Figure 22. Percentage of birds visible at Swash North on observation days. Replicates are hourly observations for each date.

Census date	Number of nesting adults
May 6	4
13	36
20	96
27	102
June 11	146
24	194

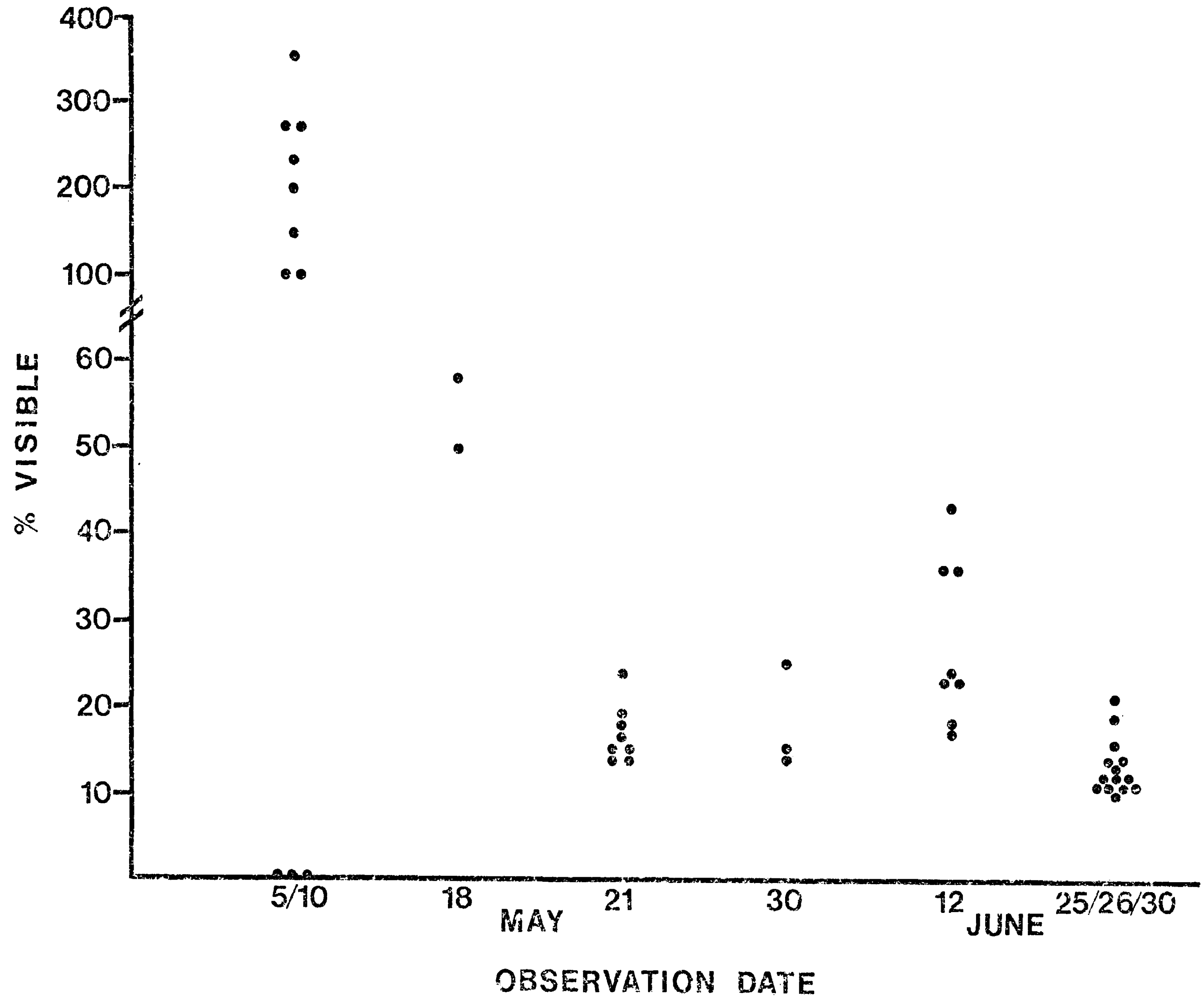
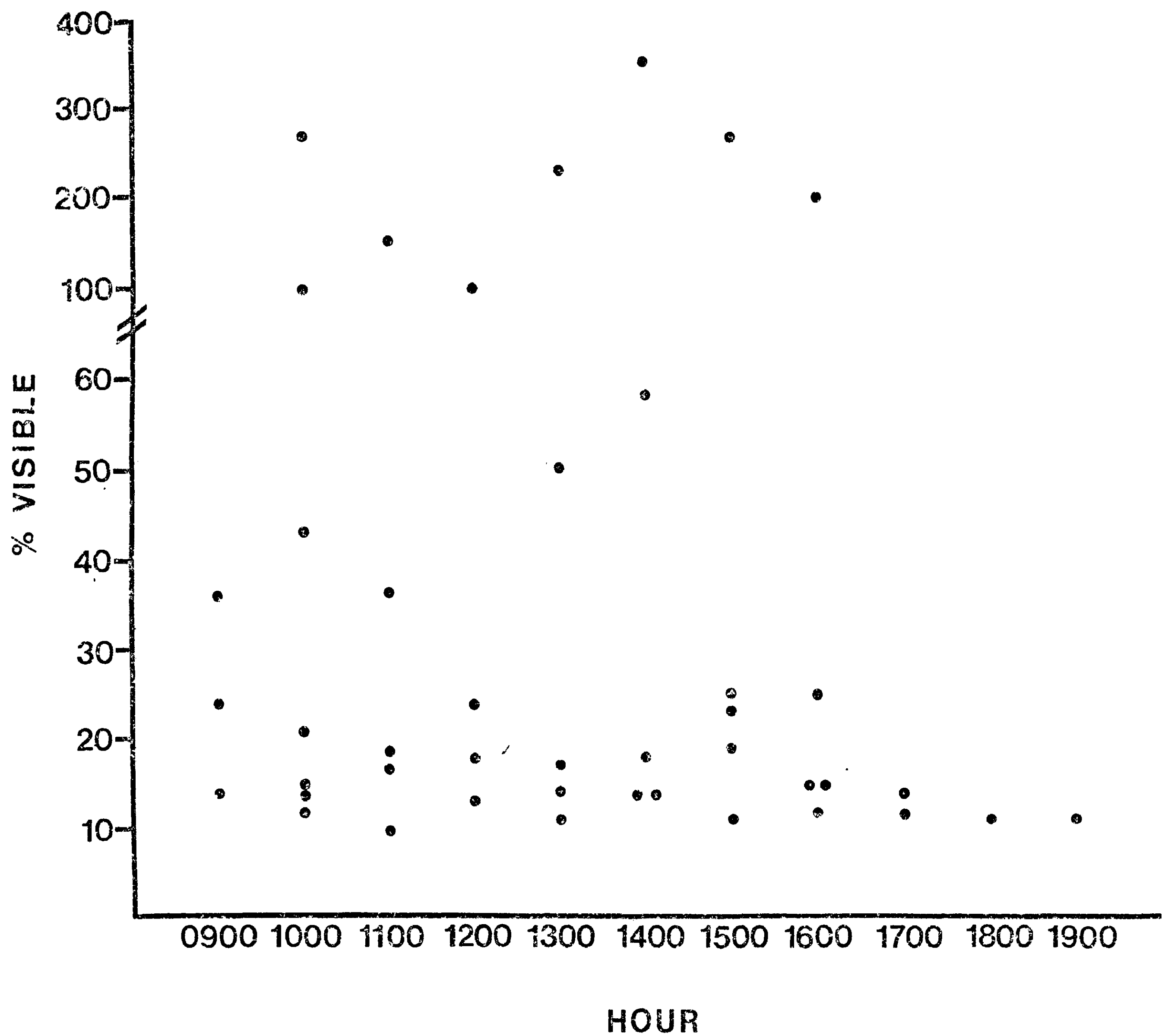

% VISIBLE
400
300
200
100
60
50
40
30
20
10
5/10
18
MAY
21
30
12
JUNE
25/26/30
OBSERVATION DATE

Figure 23. Percentage of birds visible at Swash North at hourly checks. Replicates are observation dates, 5 May - 30 June.

Census date	Number of nesting adults
May 6	4
13	36
20	96
27	102
June 11	146
24	194



400
300
200
100
60
50
40
30
20
10
% VISIBLE
0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900
HOUR

Figure 24. Percentage of birds visible at Swash South on observation days. Replicates are hourly observations for each date.

Census date		Number of nesting adults
May	6	16
	13	52
	20	86
	27	100
June	11	62
	24	58

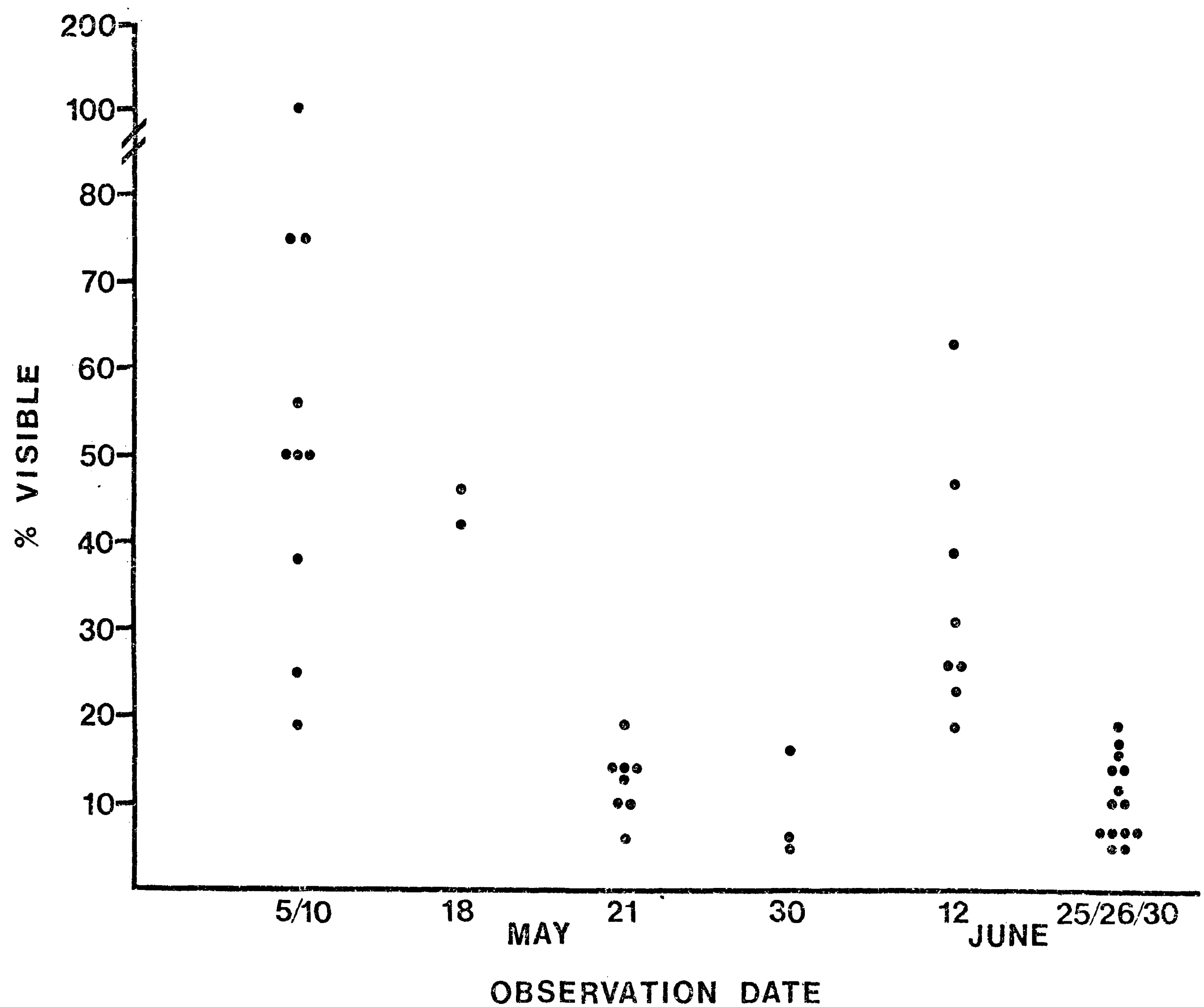
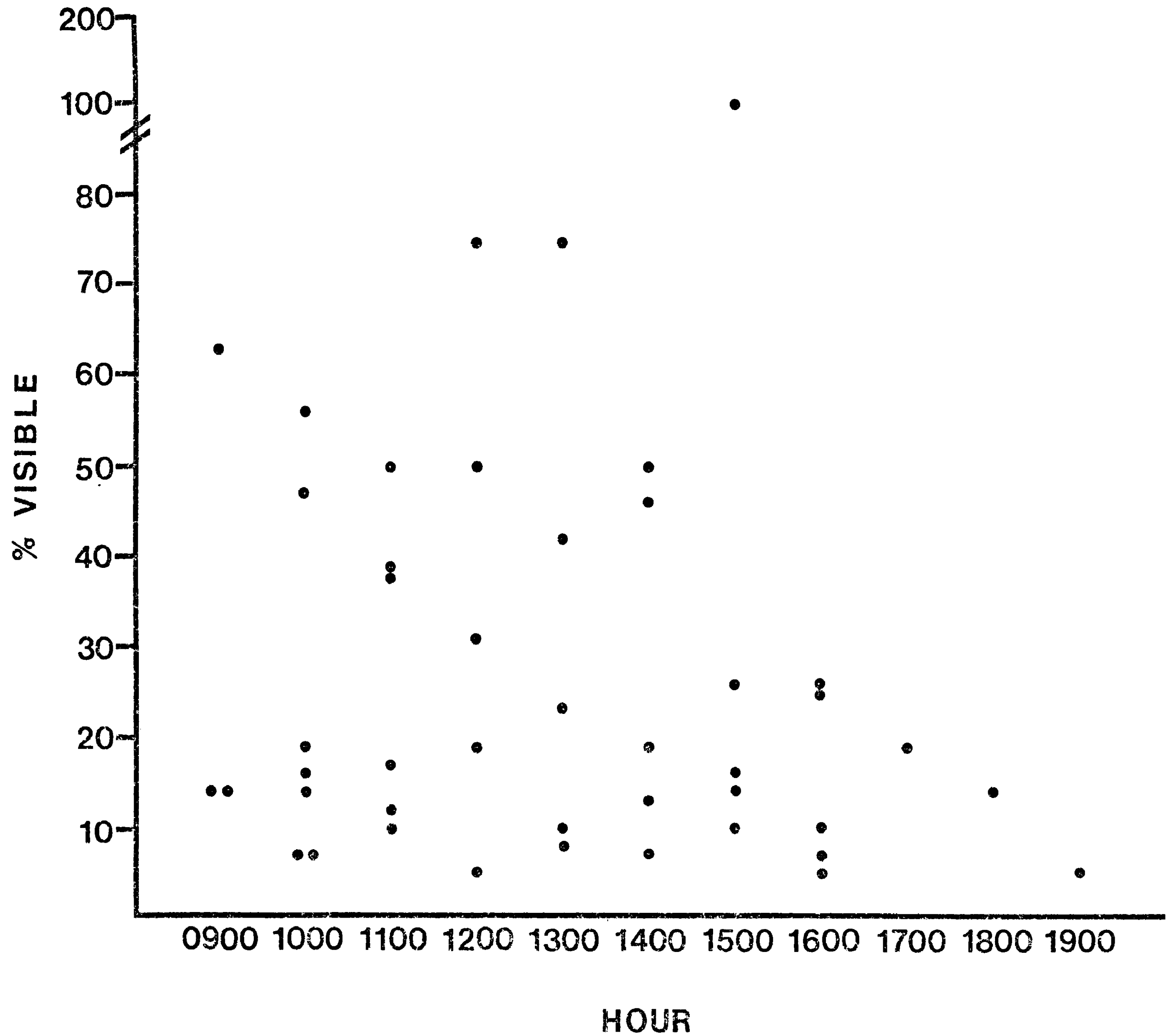

% VISIBLE
200
100
80
70
60
50
40
30
20
10
5/10
18
MAY
21
30
12
JUNE
25/26/30
OBSERVATION DATE

Figure 25. Percentage of birds visible at Swash South at hourly checks. Replicates are observation dates, 5 May - 30 June.

Census date		Number of nesting adults
May	6	16
	13	52
	20	86
	27	100
June	11	62
	14	58


% VISIBLE
200
100
80
70
60
50
40
30
20
10
0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900
HOUR

of birds visible in the Swash Bay colonies. In the Swash North colony, 175%, 350%, and 225% were seen (Table XIV). (Here, again, indicative of a greater number of birds in the colony than were actually nesting there.) In the Swash South colony, 19% were seen in each of two slides (Table XIV).

TABLE XIV. Percentage of birds visible in May on infrared photographs.

Colony	Slide	(8 May) # Birds in slide	(6 May) # of nesting birds in colony	% Visible
	1	7		175
Swash North	2	14	4	350
	3	19		225
Swash South	1	3	16	19
	2	3		19

DISCUSSION

I. HABITAT UTILIZATION

The principal components analyses and the tests for differences in nest site variables have suggested that in 1976 at the Club Point heronry, glossy ibis were utilizing a portion of the heronry not being used by the other species. The first component, the most important one for nest site selection, was very different for the glossy ibis from that for the other species at Club Point, being one of stability instead of horizontal placement. Each of the variables which loaded on the first component for the ibis was significantly different from those of the heron species there. The fact that the ibis arrived as the peak of nesting was declining for the other species suggests that they did not displace herons from these sites.

In other tests to establish the possible existence of temporal or spatial patterns (does success differ with time of nesting?; does position in the colony differ with time of nesting?; and does success differ with position in the colony?), the seeming lack of any consistent patterns for all of the species leads me to believe that those few found were peculiar to the 1976 season. Only one population, the snowy egrets at Club Point, showed a significant difference in success with time. The snowy egrets at Swash North were the only population showing a significant, clear-cut regression of position in the colony and time of nesting. Success varied with position only with the Louisiana herons at Swash North and with the snowy egrets at Swash South. If temporal or spatial considerations strongly influenced nest placement and success, one would expect significant relationships between the above variables for all or most of the species, either each showing a different temporal and/or spatial pattern or different combination of patterns from the other species to divide colony nesting resources or all species and populations showing consistently the same patterns.

The snowy egrets at Swash North exhibited a very strong trend for early nesters to build in the outer areas of the colony. This could have been due to the relatively poor quality of the vegetation in the center (personal observation; Custer and Osbourn, 1977) of the colony. The Louisiana herons, however, did not show this same trend. Further, the Louisiana herons in that colony were more successful (survival and breeding) in the center of the heronry. If a significant pattern were already established here, it would be expected that the snowy egrets would be more successful in the outer areas since they utilize those nest sites first and that Louisiana herons would occupy the center portion of the colony first, since they were more successful there; the two species thus complementing each other in spatial and temporal nesting arrangement for this colony.

Although the overall patterns of temporal or gross spatial utilization of the colonies seem to be of little importance here, the birds do seem to be dividing the nesting resources at the finer spatial level. The distance to the ground for nests at Club Point was significantly different for all species tested, with the glossy ibis nesting lowest, snowy egrets and Louisiana herons next, and little blue herons highest. At Swash South, the snowy egrets nested significantly lower there than the Louisiana herons. No difference in nest height was found between species at Swash North.

The differences in components for the two species at Swash Bay suggests that in these colonies the snowy egrets and Louisiana herons are choosing nest sites on the basis of different criteria.

Jenni (1961) found that in the Lake Alice heronry, the herons were somewhat stratified in their nesting in 1958, but less so in 1959 or 1960. McCrimmon (1975) and Custer and Osbourn (1976) found differences in nest sites of herons with principal components analyses and both have suggested that the birds respond to the structure of the vegetation in each heronry in this division. Jenni's (1961) discussion of the wide range of nest heights of herons indicates that a response based on the individual heronry is indeed a possibility.

It has been suggested that young birds imprint on (Lack, 1933; Lack and Venables, 1939; Thorpe, 1945) or respond to (see James, 1971 for a discussion of niche-gestalt in bird habitat selection) the gross physical structure of their habitat. This could indeed be the case with the glossy ibis, with the young birds returning to heronries of similar structure to the one in which they were reared. If their range of nesting sites, or their virtual niche (Colwell and Futuyma, 1971), within this structure were broad enough, they could find portions of the colony in which to nest with relatively little, if any, competitive energy expenditure. If the species diversity or density were different in any given case, this space available for the glossy ibis in the colony might well be different (Diamond, 1970). I believe that the division of nesting resources may vary from year to year and colony to colony, giving each year and colony a unique nesting structure dependent upon the physical aspects of the colony, the amount of suitable nesting resources, and the species density and diversity.

In this regard, the similarity of the components for the snowy egrets at Swash Bay and the glossy ibis at Club Point (Table 7) might possibly be the reason that there were no glossy ibis at Swash North in 1976. This is, however, merely a possibility and I have no specific evidence with which to support this hypothesis.

II. HERONS AS ENVIRONMENTAL INDICATORS

In addition to the division of nesting resources in the three colonies studied, differences in peak nesting times of the colonies and the changes in colony composition from 1975 to 1976 are important in understanding colony utilization for these heronries.

The peak week of nesting at Club Point was 29 April while at the two Swash Bay colonies, nesting was just beginning that week. The peak weeks at Swash North were 13 May and 6 June, and at Swash South, 13 May. Nesting at Swash Bay has also been observed to be later than at Club Point in previous years (M.A. Byrd, pers. comm.).

The overall numbers of herons was greater in 1976 than in 1975 at Club Point and less in 1976 at each of the Swash Bay colonies. Based on data for only two years, it is difficult to detect trends in the changes in the percentages of the total composition of each species. Most likely they are just annual fluctuations, with the factors involved in colony utilization, which have been discussed above, playing a role.

Absolute numbers of glossy ibis were lower at both Club Point and Swash North and, consequently, their percentage contribution to the colony population was also lower. This could be due to the factors already discussed, the continued northward expansion of this species (Byrd, 1977), or, more probably, a combination of the two.

The infrared slides taken of the two colonies suggest that changes in vegetation do occur during the breeding season. The fact that the vegetation in early July slides looks lusher and fuller is probably due to the natural growing season of the plants. By August, however, the vegetation did not look as healthy. This could be due to the nesting herons. McDonald (1971) found a decrease in understory vegetation beneath the colony she studied and a directly proportional increase of nutrients in the swamp where the heronry was located with the numbers of herons present. Weseloh and Brown (1971) found an inverse relationship between the concentration of heron nests and the percentage ground cover. The south end of the Club Point colony looks healthier in the August slides than do the other areas. There were virtually no herons nesting there in 1976. This further supports the theory that the herons have somewhat of a detrimental effect on their habitat. Jenni (1961) states that "the herons may be an important factor in altering their own breeding habitat and making it unfit."

CENSUS TECHNIQUES

At Club Point, the lowest percentages of birds visible were recorded when most of the birds would have been incubating eggs. As eggs hatched and adults were off the nest and sitting in the open more often, a slightly higher percentage was seen. This same pattern was exhibited in both of the Swash Bay colonies, with the exception of very high percentages seen early in the season. These could have been due to birds which were using the colony merely as a place to rest, and not to nest.

The variability in the percentage of birds visible during hourly observations prevents any speculation about the best time of day to carry out visual censuses.

The importance of knowing the time of nesting and the relative progress of nesting for each colony censused is obvious here. Either this must be assumed from past observation or the colonies must be entered. The establishment of ratios of birds visible to total number of nests for future use in censusing is not possible with these data, although certain trends do exist.

The value of using infrared photography as a census technique is certainly not supported by the percentages of birds seen in slides of the Swash Bay colonies. In the Swash North slides, there were far more birds visible than actually nesting there (again, probably due to birds utilizing the colony as a resting place) and far fewer in the Swash South colony.

Infrared aerial photography might possibly be a valuable means of censusing heron colonies if done with the consistency of technique and quality already discussed.

In conclusion, one important concept seems to underlie this entire study: every colony in each year is an individual and unique community, with changes in vegetation and nesting species composition, density and timing of nesting, and subsequent division, if any, of nesting resources all acting to create the unique community of that year.

APPENDIX

Table A-1. Correlation matrix from the principal components analysis for snowy egrets, Club Point. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	NBSP	CNB	DG	DC	DCB	DOB	ND	SB	DMSB	DO
NBSP	1.000	0.173	-0.016	0.104	0.433	-0.026	0.063	-0.156	0.183	0.140
CNB	0.173	1.000	0.082	0.092	0.231	-0.196	0.184	0.049	-0.180	0.014
DG	-0.016	0.082	1.000	-0.190	-0.003	0.182	0.429	0.033	0.041	0.114
DC	0.104	-0.092	-0.092	1.000	0.171	0.205	-0.156	-0.120	0.274	0.130
DCB	0.433	0.231	-0.003	0.171	1.000	0.017	0.078	-0.066	-0.042	0.125
DOB	-0.026	-0.196	0.182	0.205	0.017	1.000	0.078	0.115	0.135	0.043
ND	0.063	0.184	0.184	-0.156	0.078	0.078	1.000	-0.032	-0.197	0.062
SB	-0.156	0.049	0.033	-0.120	-0.066	0.115	-0.032	1.000	-0.046	-0.001
CMSB	0.183	-0.180	0.041	0.274	-0.042	0.135	-0.197	-0.046	1.000	0.008
DO	0.140	0.014	0.114	0.130	0.125	0.043	0.062	-0.001	0.008	1.000

APPENDIX

Table A-2. Unrotated factor matrix from the principal components analysis for snowy egrets, Club Point. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
NBSP	0.390	0.664	-0.137	-0.070
CNB	0.608	0.010	-0.364	0.231
DG	0.510	-0.212	0.614	-0.204
DC	-0.292	0.653	0.166	0.109
DCB	0.474	0.583	-0.171	0.228
DOB	-0.102	0.152	0.734	0.231
ND	0.685	-0.213	0.342	-0.211
SB	-0.038	-0.307	0.168	0.834
CMSB	-0.350	0.471	0.333	-0.191
DO	0.236	0.307	0.233	0.202

APPENDIX

Table A-3. Transformation matrix from the principal components analysis for snowy egrets, Club Point. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	0.577	-0.505	0.641	-0.030
Factor 2	0.757	0.555	-0.255	-0.233
Factor 3	-0.157	0.654	0.671	0.313
Factor 4	0.264	-0.099	-0.271	0.920

APPENDIX

Table B-1. Correlation matrix from the principal components analysis for Louisiana herons, Club Point. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	NBSP	CNB	DG	DC	DCB	DOB	ND	SB	DMSB	DO
NBSP	1.000	0.067	-0.006	-0.108	0.269	0.004	0.147	-0.018	0.041	-0.065
CNB	0.067	1.000	0.020	-0.017	0.014	-0.005	0.209	-0.005	-0.273	0.100
DG	-0.006	0.020	1.000	-0.259	0.223	0.194	0.336	-0.023	0.065	0.068
DC	-0.108	-0.017	-0.259	1.000	0.036	0.265	-0.229	-0.024	0.230	-0.045
DCB	0.269	0.014	0.223	0.036	1.000	-0.013	0.314	-0.145	0.087	-0.026
DOB	0.004	-0.005	0.194	0265	-0.013	1.000	-0.025	-0.033	0.151	-0.018
ND	0.147	0.209	0.336	-0.229	0.314	-0.025	1.000	-0.141	-0.121	0.027
SB	-0.018	-0.005	-0.023	-0.024	-0.145	-0.033	-0.141	1.000	0.015	-0.072
DMSB	0.041	-0.273	0.065	0.230	0.087	0.151	-0.121	0.015	1.000	-0.137
DO	-0.065	0.100	0.068	-0.045	-0.027	-0.018	0.027	-0.072	-0.137	1.000

APPENDIX

Table B-2. Unrotated factor matrix from the principal components analysis for Louisiana herons, Club Point. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
NBSP	0.357	0.245	-0.436	0.414	0.220
CNB	0.355	-0.337	0.356	0.425	0.463
DG	0.562	0.299	0.223	-0.591	0.091
DC	-0.508	0.403	0.347	0.459	0.073
DCB	0.524	0.488	-0.160	0.269	-0.118
DOB	-0.104	0.520	0.572	-0.087	0.350
ND	0.770	0.091	0.050	-0.006	0.044
SB	-0.236	-0.170	-0.258	-0.329	0.696
DMSB	-0.288	0.687	-0.150	-0.169	-0.086
DO	0.159	-0.284	0.510	-0.030	-0.332

APPENDIX

Table B-3. Transformation matrix from the principal components analysis for Louisiana herons, Club Point. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1	0.481	0.377	0.703	-0.264	-0.251
Factor 2	0.469	-0.595	0.205	0.616	-0.072
Factor 3	-0.484	0.393	0.209	0.629	-0.414
Factor 4	0.541	0.415	-0.641	0.166	-0.310
Factor 5	0.149	0.421	0.097	0.356	0.815

APPENDIX

Table C-1. Correlation matrix from the principal components analysis for little blue herons, Club Point. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	NBSP	CNB	DG	DC	DCB	DOB	ND	SB	DMSB	DO
NBSP	1.000	0.470	0.108	-0.355	0.718	-0.197	0.212	-0.648	-0.018	-0.056
NCB	0.470	1.000	0.399	-0.215	0.542	-0.132	0.283	0.119	0.565	-0.107
DG	0.108	0.399	1.000	-0.614	-0.091	0.166	0.198	-0.008	-0.061	0.019
DC	-0.355	-0.215	-0.614	1.000	-0.258	-0.151	-0.155	0.314	0.115	0.125
DCB	0.718	0.542	-0.091	-0.258	1.000	0.016	0.097	-0.375	0.059	-0.466
DOB	-0.197	-0.132	0.166	-0.152	0.016	1.000	0.007	-0.067	-0.164	0.199
ND	0.212	0.283	0.198	-0.155	0.097	0.007	1.000	0.192	0.015	0.253
SB	-0.648	0.119	-0.005	0.314	-0.375	-0.067	0.192	1.000	0.453	-0.018
DMSB	-0.018	0.565	-0.061	0.115	0.059	-0.164	0.015	0.453	1.000	0.221
DO	-0.056	-0.107	0.019	0.125	-0.466	0.199	0.253	-0.018	0.220	1.000

APPENDIX

Table C-2. Unrotated factor matrix from the principal components analysis for little blue herons, Club Point. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
NBSP	0.870	-0.119	-0.178	0.367
CNB	0.664	0.665	-0.090	-0.082
DG	0.391	0.198	0.722	-0.359
DC	-0.624	0.111	-0.536	0.266
DCB	0.809	-0.062	-0.409	-0.018
DOB	-0.060	-0.194	0.545	0.016
ND	0.253	0.404	0.343	0.369
SB	-0.511	0.709	-0.002	-0.344
DMSB	0.018	0.826	-0.243	0.077
DO	-0.279	0.227	0.438	0.765

APPENDIX

Table C-3. Transformation matrix from the principal components analysis for little blue herons, Club Point. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	0.856	0.228	0.453	-0.098
Factor 2	-0.255	0.927	0.072	0.265
Factor 3	-0.286	-0.277	0.782	0.479
Factor 4	0.347	-0.110	-0.421	0.831

Table D-1. Correlation matrix from the principal components analysis for glossy ibis, Club Point. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	CNB	DG	DC	DCB	DOB	SB	DMSB	DO
CNB	1.000	-0.191	0.355	0.131	0.108	-0.381	-0.238	0.250
DG	-0.191	1.000	-0.490	-0.338	0.150	0.756	0.904	-0.049
DC	0.355	-0.490	1.000	0.362	0.237	-0.491	-0.453	-0.121
DCB	0.131	-0.338	0.362	1.000	0.296	-0.462	-0.396	0.366
DOB	0.108	0.150	0.237	0.296	1.000	-0.102	-0.117	-0.002
SB	-0.381	0.756	-0.491	-0.463	-0.102	1.000	0.864	-0.177
DMSB	-0.238	0.904	-0.453	-0.396	-0.117	0.864	1.000	-0.129
DO	0.250	-0.049	-0.121	0.366	-0.002	-0.177	-0.129	1.000

APPENDIX

Table D-2. Unrotated factor matrix from the principal components analysis for glossy ibis, Club Point. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:

	Factor 1	Factor 2	Factor 3
CNB	-0.451	0.305	-0.062
DG	0.850	0.434	0.127
DC	-0.672	-0.018	0.479
DCB	-0.607	0.480	-0.042
DOB	-0.185	0.629	0.626
SB	0.912	0.097	0.070
DMSB	0.908	0.232	0.052
DO	-0.230	0.586	-0.715

APPENDIX

Table D-3. Transformation matrix from the principal components analysis for glossy ibis, Club Point. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3
Factor 1	0.910	-0.312	-0.275
Factor 2	0.416	0.682	0.602
Factor 3	0.000	-0.661	0.750

APPENDIX

Table E-1. Correlation matrix from the principal components analysis for snowy egrets, Swash Bay. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	CNB	DG	DC	DCB	DOB	SB	DMSB	DO
CNB	1.000	0.278	-0.441	-0.005	0.012	-0.092	-0.451	-0.329
DG	0.278	1.000	-0.724	0.054	0.127	0.613	-0.458	0.238
DC	-0.441	-0.723	1.000	-0.048	0.086	-0.462	0.764	0.179
DCB	-0.005	0.054	-0.048	1.000	-0.001	-0.323	0.187	-0.065
DOB	0.012	0.127	0.086	-0.001	1.000	0.198	0.085	0.478
SB	-0.092	0.613	-0.462	-0.323	0.198	1.000	-0.272	0.256
CMSB	-0.451	-0.458	0.764	0.187	0.085	-0.272	1.000	0.165
DO	-0.329	0.238	0.179	-0.065	0.478	0.256	0.165	1.000

APPENDIX

Table E-2. Unrotated factor matrix from the principal components analysis for snowy egrets, Swash Bay. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:	Factor 1	Factor 2	Factor 3
CNB	0.516	-0.473	0.214
DG	0.828	0.288	0.229
DC	-0.926	0.162	-0.107
DCB	-0.139	-0.202	0.884
DOB	0.033	0.654	0.352
SB	0.614	0.554	-0.290
DMSB	-0.812	0.238	0.124
DO	-0.049	0.852	0.156

APPENDIX

Table E-3. Transformation matrix from the principal components analysis for snowy egrets, Swash Bay. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3
Factor 1	0.978	0.082	-0.194
Factor 2	-0.141	0.939	-0.312
Factor 3	0.157	0.333	0.930

Table F-1. Correlation matrix from the principal components analysis for Louisiana herons, Swash Bay. See Table 1 for explanation of variable mnemonics.

Correlation coefficients:

	CNB	DG	DC	DCB	DOB	ND	SB	DMSB	DO
CNB	1.000	0.257	-0.074	-0.179	-0.231	0.198	0.066	0.183	-0.160
DG	0.257	1.000	-0.492	0.095	-0.028	0.197	0.247	0.237	0.209
DC	-0.074	-0.492	1.000	-0.351	0.446	-0.208	0.136	0.248	-0.282
DCB	-0.179	0.095	-0.351	1.000	-0.149	0.378	-0.167	-0.271	0.144
DOB	-0.231	-0.028	0.446	-0.149	1.000	-0.167	0.132	0.238	-0.193
ND	0.198	0.197	-0.208	0.378	-0.167	1.000	-0.076	-0.017	-0.004
SB	0.066	0.247	0.136	-0167	0.132	-0.076	1.000	0.300	0.238
DMSB	0.184	0.237	0.248	-0.271	0.238	-0.017	0.300	1.000	-0.014
DO	-0.160	0.209	-0.282	0.144	-0.193	-0.003	0.238	-0.014	1.000

APPENDIX

Table F-2. Unrotated factor matrix from the principal components analysis for Louisiana herons, Swash Bay. See Table 1 for explanation of variable mnemonics.

Unrotated factor matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
CNB	0.136	0.479	-0.704	-0.244
DG	0.452	0.694	0.045	0.136
DC	-0.836	-0.095	-0.080	0.161
DCB	0.620	-0.289	0.155	0.517
DOB	-0.618	0.074	0.192	0.562
ND	0.513	0.089	-0.365	0.555
SB	-0.188	0.656	0.376	0.007
DMSB	-0.365	0.676	-0.079	0.209
DO	0.377	0.243	0.690	-0.199

APPENDIX

Table F-3. Transformation matrix from the principal components analysis for Louisiana herons, Swash Bay. See Table 1 for explanation of variable mnemonics.

Transformation matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	-0.793	-0.006	0.608	-0.029
Factor 2	-0.035	0.919	-0.017	0.392
Factor 3	-0.118	0.376	-0.193	-0.899
Factor 4	0.596	0.119	0.790	-0.194

LITERATURE CITED

Byrd, M. A. 1977. Dispersal and movements of six North American Ciconiiformes. Nat. Aud. Soc. Res. Rept. No. 7. National Audubon Society, New York (in press).

Colwell, R. K and D. J. Futuyma. 1971. On the measurement of niche breadth and overlap. Ecology 52:567-576.

Custer, T. and R. G. Osbourn. 1977. Wading birds as biological indicators: 1975 colony survey. U.S. Fish and Wildl. Ser., Spec. Sci. Rep. Wild. (in press).

Diamond, J. M. 1970. Ecological consequences of island colonization by Southwest Pacific birds. I. types of niches shifts. Proc. Nat. Acad. Sci. 67:529-536.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bull. 83:215-236.

Jenni, D. A. 1961. The breeding ecology of four species of herons at Lake Alice, Alachua County, Florida. Ph.D. thesis, University of Florida, Gainesville. 116 p.

Lack, D. 1933. Habitat selection in birds with special reference to the effects of afforestation in the Breckland avifauna. J. Anim. Ecol. 2:239-262.

Lack, D. and L. S. Venables. 1939. The habitat selection of British woodland birds. J. Anim. Ecol. 8:39-71.

McCrimmon, D. A. 1975. Nest-site selection among five species of herons on the North Carolina coast. Ph.D. thesis, North Carolina State Univ., Raleigh. 61 p.

McDonald, C. A. 1971. Some ecological aspects of a nesting colony of herons. Ph.D. thesis, Auburn Univ., Auburn. 118 p.

Nie, N. H. and H. Hull. 1977. SPSS Batch 7.0 Update Manual. (unpublished). 135 p.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Stein-brenner, and D. H. Bent. 1975. Statistical Package for the Social Sciences. 2nd ed., McGraw-Hill Book Co., New York. 675 p.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco. 776 p.

Thorpe, W. H. 1945. The evolutionary significance of habitat selection. J. Anim. Ecol. 14:67-70

Weseloh, D. V. and R. T. Brown. 1971. Plant distribution within a heron rookery. Am. Midl. Nat. 86:57-64.

Williams, J. W. 1973. Growth rate and nesting aspects for the glossy ibis in Virginia - 1972. Master's thesis, College of William and Mary. 62 p.

VITA

Barbara Susan Warren

Born in Kinston, North Carolina on 12 May 1953. Graduated from Arendell Parrott Academy, Kinston, North Carolina in 1971. Graduated from Atlantic Christian College, Wilson, North Carolina in June, 1974 with a B.S. in Biology. Entered the College of William and Mary in September, 1974. Currently a candidate for a M.A. degree in Biology.