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Effects of marsh size on incidence rates and community organization within the lower Chesapeake Bay

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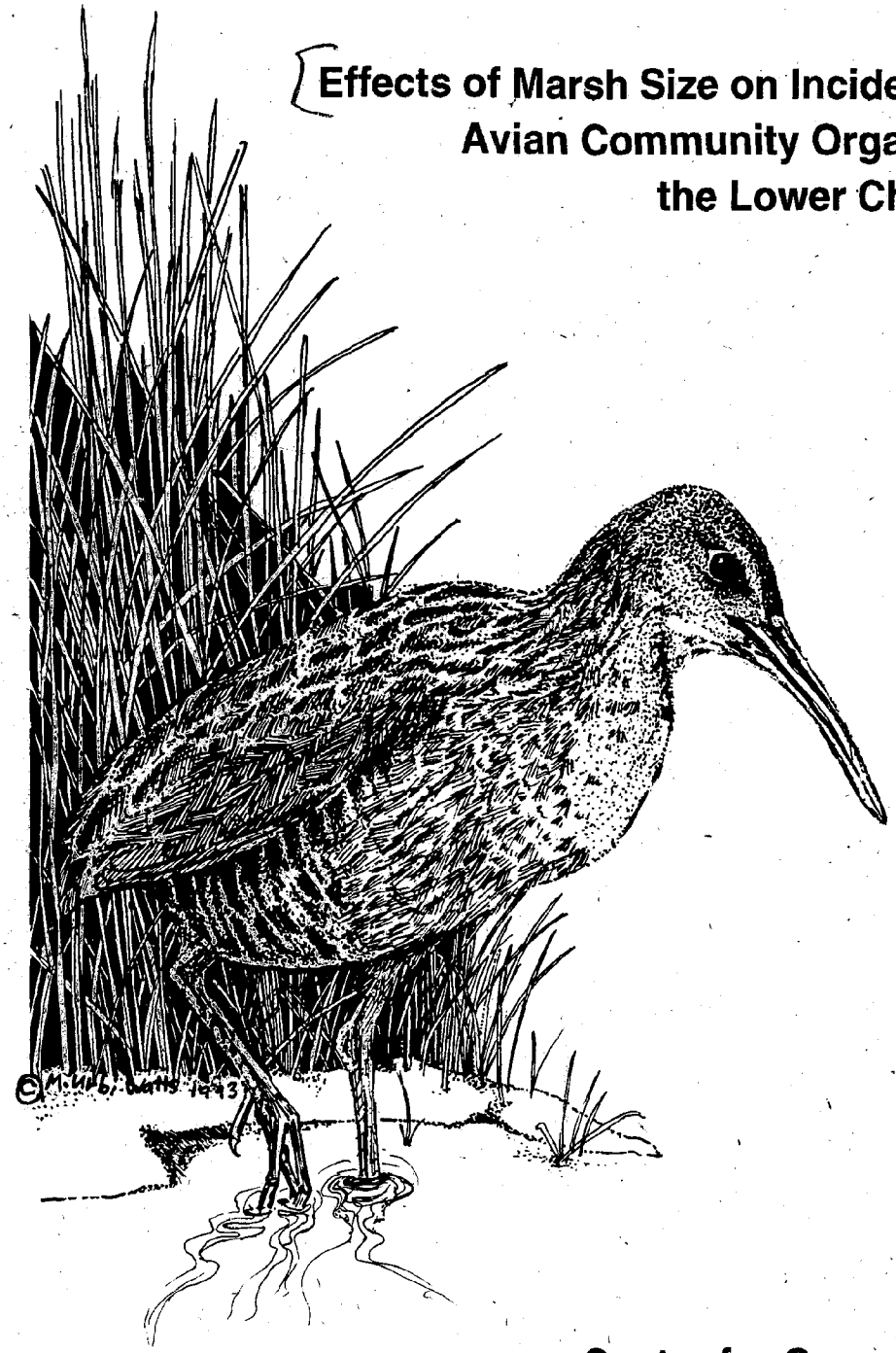

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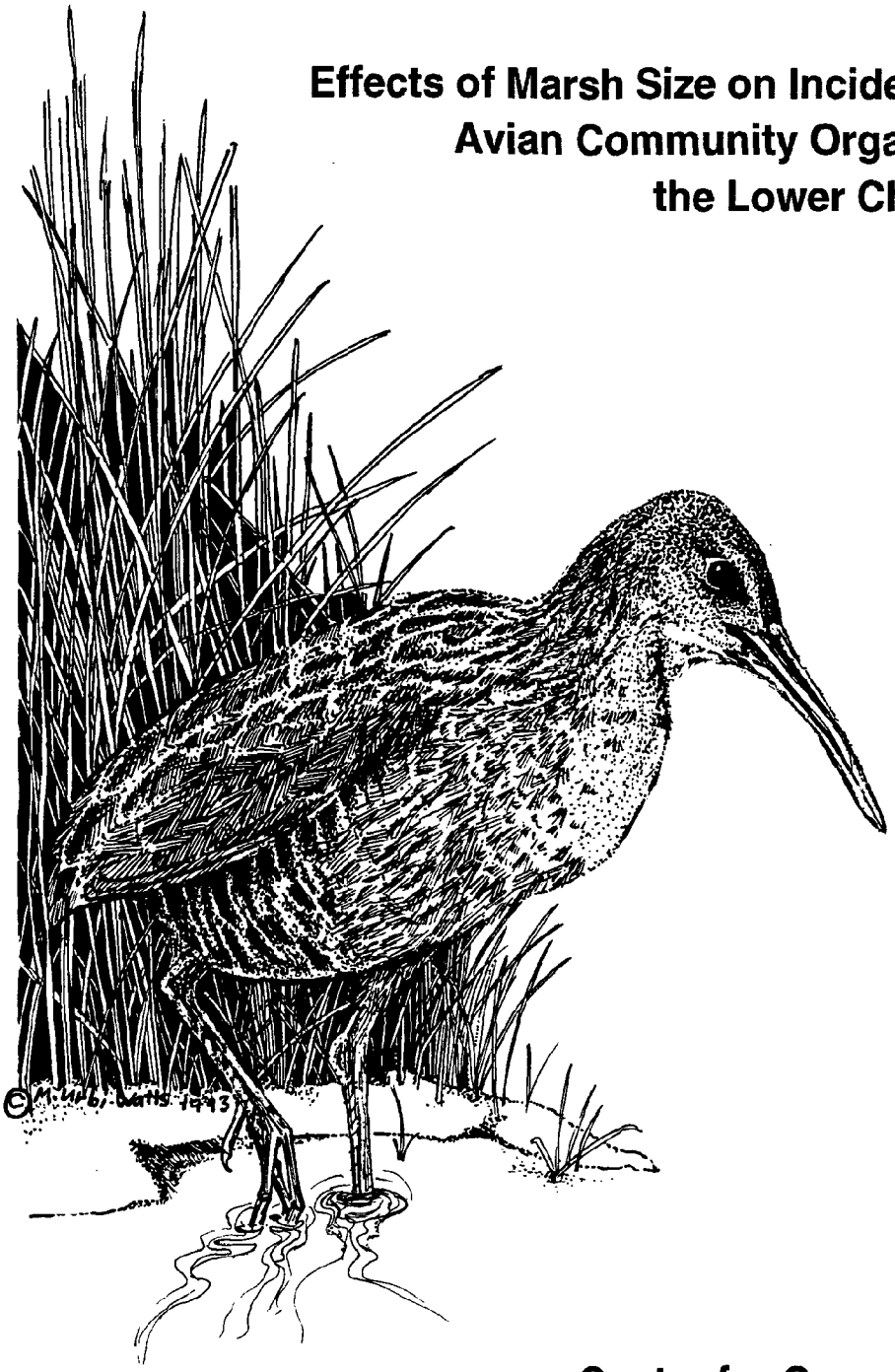

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Effects of Marsh Size on Incidence Rates and Avian Community Organization within the Lower Chesapeake Bay

(Final Report)

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ABSTRACT

Bird abundance and species richness was assessed in 50 salt marshes located in the lower Chesapeake Bay. Ten spatial replicates of 1, 2, 3, 4, and 5 ha marshes with similar vegetational composition were included. Over 4,800 observations were made of 100 species. Marsh area was a good indicator of overall species richness and bird abundance. The slopes of species-area relationships were consistent with those derived in an earlier study involving a broader range of marsh sizes. Species loss rates were highest for those species using the marsh directly. Of all primary users, obligate species showed the most dramatic declines with decreasing marsh size. Differences between obligate and facultative species in loss rates resulted in a directional shift in community composition with increasing marsh size. The form of incidence functions varied between species and species groups. Increases in incidence rates ranged from 40 to 70% for obligate breeders and 20 to 40% for facultative breeders. Species that used marshes as primary or alternate foraging areas exhibited variable incidence patterns.

Patterns in both species-area relationships and marsh availability were used to formulate size-specific management recommendations. Marshes greater than 50 ha. in size generally support the best examples of unique marsh-bird communities. Because these marshes are rare, they should be the focus of acquisition and management programs. Marshes between 5 and 50 ha. are also relatively rare and likely support the bulk of all obligate marsh users. Marshes of this size should be formally recognized and given special

attention when considering requests for marsh alteration. Marshes between 1 and 5 ha are relatively common and have variable value depending on actual size and particular species of interest. Marshes of this size should be considered on an individual basis taking into account specific species of concern and the local context of the marsh.

INTRODUCTION

The widespread conversion of natural land for human use has resulted in the fragmentation and insularization of many formerly continuous habitats as well as the reduction in size of natural habitat patches. Fragmentation and its consequences has been studied in many habitats within North America by inspecting species-area curves (e.g. Forman et al. 1976, Robbins 1980, Coleman et al. 1982) or by documenting faunal relaxation within recently isolated patches (e.g. Whitcomb et al. 1981, Lynch and Whigham 1984, Wilcove et al. 1986). In general, bird species richness increases with habitat size often due to the elevation of incidence rates for area-sensitive species. Understanding the extent to which size alone may limit diversity within patches or the distribution of species between patches is critical to designing habitat management plans or selecting conservation areas to protect avian communities.

Tidal salt marshes form an important transition zone between shallow water habitats and a host of upland types. Throughout most of our history, societal views of these habitats have led to enormous investments in their destruction. Consequently, only half of all historic marshes remain. Over the past thirty years, several important socioeconomic services have been attributed to tidal salt marshes including among others: 1) water quality protection, 2) flood damage protection, 3) erosion control, and 4) habitat for fish and wildlife. Enumeration of these benefits has, over time, led to a shift in societal perceptions resulting in the enactment of protective legislation. However, the ultimate success of these programs in

preserving unique marsh communities, depends, to a great extent, on our understanding the species involved.

Relatively few studies have examined avian community dynamics within tidal salt marshes. In 1992, species/area relationships were investigated within salt marshes of the lower Chesapeake Bay (Watts 1992). This study documented that patch size was one of the single best indicators of species richness for a number of bird groups and that many individual species were area-sensitive. Results also suggested that the marsh-bird community observed in large marshes appeared to collapse as marsh size was reduced from 5.0 to 1.0 ha. Because marshes within this size range are relatively common, refinement of occupancy patterns would allow projection of marsh values to a much larger fraction of the total marshes. This information need was the impetus for the current study.

The primary objectives of the study were:

1) To examine the relationship between marsh-bird communities and patch size between 1 and 5 ha.

2) To examine patterns of community organization related to patch size.

3) To refine incidence functions for obligate marsh users across the range of marsh sizes.

4) To investigate the use of selected marsh components by common marsh-bird species.

STUDY SITE

This study was conducted along the western shore of the lower Chesapeake Bay between Grandview Beach (city of Hampton) and New Point Comfort (Mathews County), (see Figure 1). The broad land arc within these boundaries contains some of the most extensive wetlands remaining in the lower Bay including over 1300 tidal marshes with a total area of approximately 6,200 ha. Adjoining uplands remain rural with only scattered population centers.

METHODS

This study was conducted within 50 tidal marshes ranging in size from 0.8 to 6.1 ha. Marshes included 10 spatial replicates of 5 different size categories (size categories include 1, 2, 3, 4, and 5 ha). Wetland inventory maps and summaries (Barnard 1975, Moore 1976, Silberhorn 1981a, 1981b) were used to screen all marshes within the study area for potential study sites. The list of total marshes ($N > 1300$) was initially reduced based on compliance with the general size categories outlined above. Because adequate marshes of exact sizes did not exist, non-overlapping ranges were established for each of the 5 size categories. Size ranges employed were 0.8 - 1.2 ha, 1.6 - 2.4 ha, 2.8 - 3.2 ha, 3.6 - 4.5 ha, and 4.9 - 6.1 ha for size classes 1, 2, 3, 4, and 5 respectively. Area means for marshes actually used were 0.92 ± 0.193 (mean $\pm$ 1S.E.), 1.96 ± 0.350, 2.96 ± 0.207, 3.94 ± 0.987, and 5.42 ± 0.424 for classes 1, 2, 3, 4, and 5 respectively.

Because vegetation type is likely a primary factor in determining marsh use for many bird species, vegetational composition was controlled for in the selection process. Marshes were considered for use only if they were dominated (greater than 90% coverage) by and

Figure 1: Map of study area and Chesapeake Bay region. Black dots indicate the location of individual study marshes.

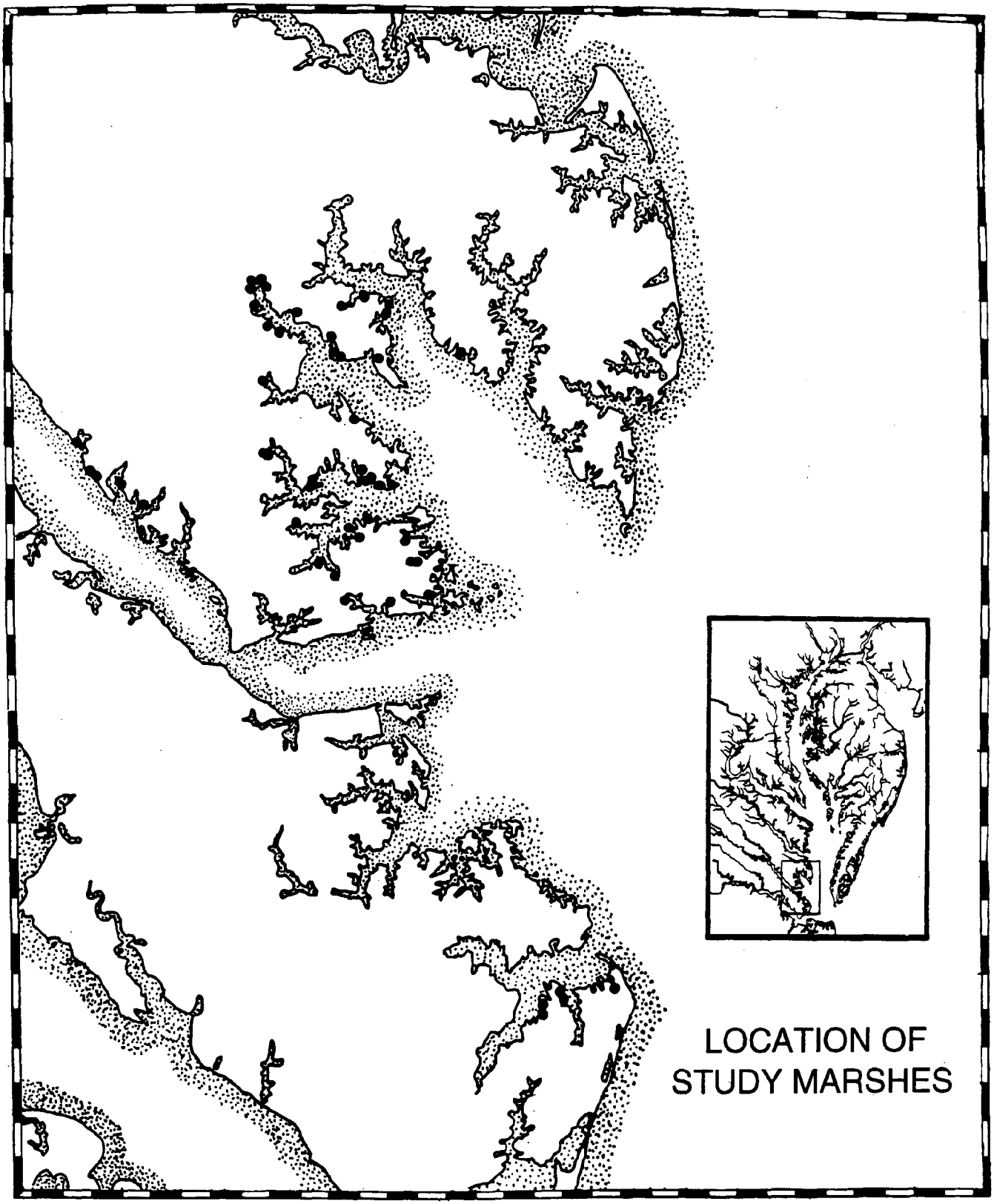


Figure 1

contained the five target plant forms including: smooth cordgrass (Spartina alterniflora), black needlerush (Juncus roemerianus), saltgrass (Distichlis spicata), saltmeadow hay (Spartina patens), and salt bush (either Iva frutescens or Baccharis hamilifolia). These plant forms were chosen because they were locally common and representative of marsh vegetation on a regional scale. All of the study marshes chosen met the following composition requirements: smooth cordgrass ($\geq$ 30%), black needlerush ($\geq$ 20%), saltgrass and saltmeadow hay combined ($\geq$ 15%), and salt bush ($\geq$ 10%). Controlling for vegetational composition in this way allows for the direct assessment of size effects and provides an opportunity to more closely examine bird/vegetation relationships. In addition to selecting for size and vegetational composition, an attempt was made to locate marshes on points of land extending out into the bay proper rather than along the headwaters of small tributaries. However, because of the large number of marshes needed, some marshes of each size group were located a considerable distance from the Bay's edge.

All potential study marshes were visited between early April and early May to determine the feasibility of accessing and surveying the marsh. Marshes that were difficult to survey or reach were eliminated from further consideration. After all study marshes had been selected, a scaled field map of each marsh was produced. Maps were generated electronically by digitizing the outline of marsh inventory maps into a computer graphics program and then annotating prominent landmarks (see Figure 2 for example). To set up study marshes, two census points were established within each study marsh. Two points were used here because it was determined in a previous study (in similar marshes) that this

Figure 2: Illustration of example marsh field map. Note the location of survey points within the marsh.

Example Marsh Map

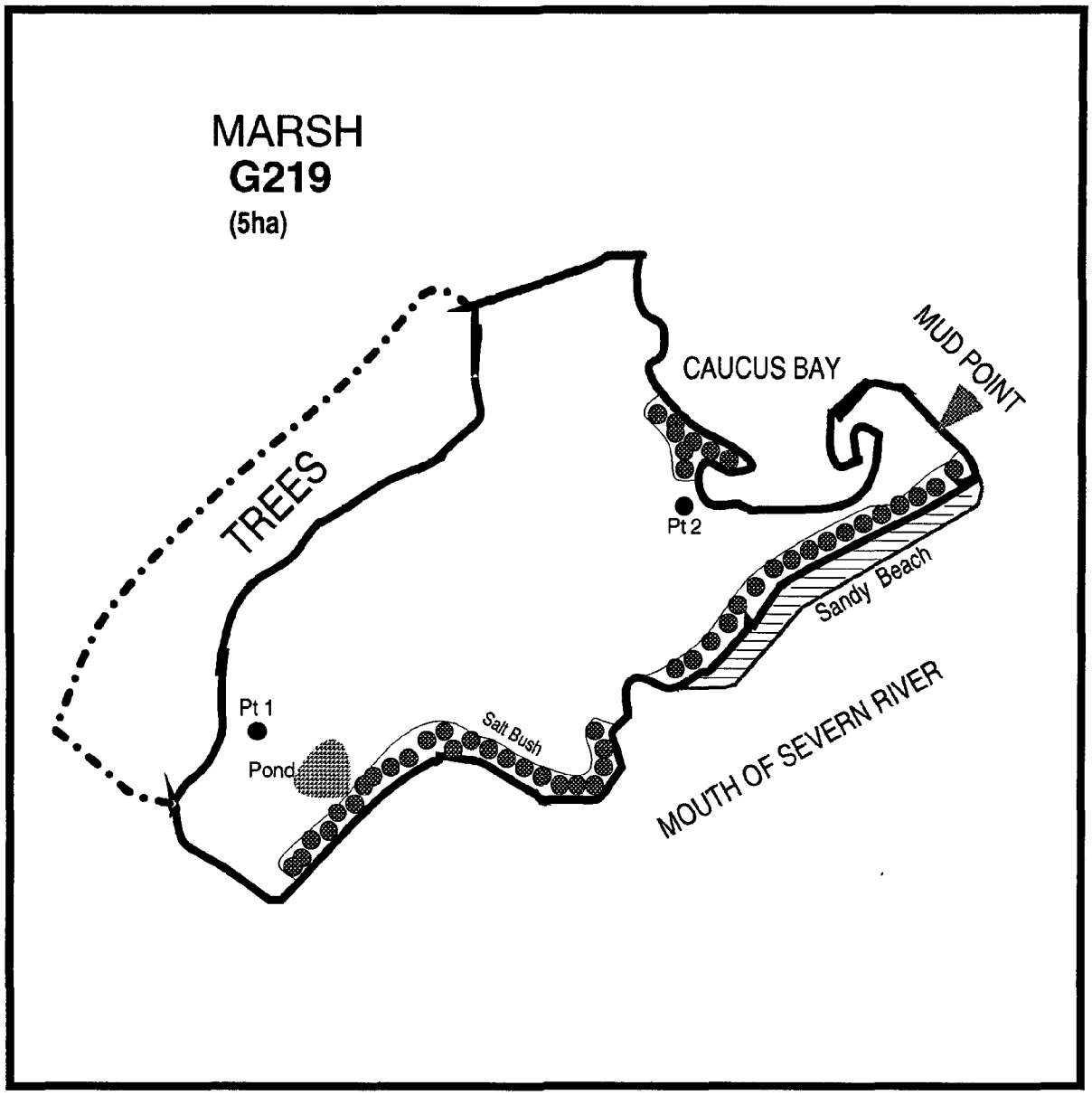


Figure 2

would be enough to saturate marshes within this size range. Census points were placed in prominent positions within the marsh to make coverage as even as possible.

To survey birds within study marshes a combination of the line transect (Emlen 1971, 1977) and point count (Blondel et al. 1981, Morrison et al. 1981) method was used. The observer began the survey upon entering the marsh and walked a prescribed route stopping at both census points to listen and watch for birds. Playbacks were used during point counts to increase the detection rates for Clapper and Virginia Rails. Survey tapes were produced that consisted of 50 sec of male advertisement calls for both species separated by 10 sec of quite. Each point count consisted of 4 min of the tape recorded calls (including 2 50 sec periods for each species) followed by a 4 min listening period. Each marsh survey lasted approximately 40 min. This amount of time was more than adequate to provide a complete accounting of all birds utilizing the marsh. Throughout the study, an attempt was made to spend the same amount of time in each marsh. This procedure ensured that sampling effort was comparable between surveys regardless of marsh size.

All 50 focal marshes were surveyed 4 times over the three month study period. To reduce seasonal bias, marshes were surveyed in 4 rounds where all marshes were surveyed in each round and the survey order was randomly determined. Because many of the birds of interest in this study exhibit distinctly different peaks of calling and residency, a split approach to surveys was used. Two survey rounds were conducted between 8 May and 31 May. This early period is the time when rails of interest are most vocal on territories and when many transients utilize marshes. Because many passerines have spring migration periods that extend into early June, the later survey rounds were not begun until 18 June.

Late surveys were delayed until this date in an attempt to minimize the number of birds detected that really represented transients. Two survey rounds were conducted between 18 June and 18 July.

In addition to differences in the seasonal timing of breeding, rails and passerines differ in their daily activity patterns. During the breeding season, rails call most intensively from about 12:00 to 4:00 AM. However, birds also call during the early morning and late evening, and playback studies conducted during the early morning have had relatively good response rates (e.g. Glahn 1974, Repking and Ohmart 1977). Just after dawn is the optimum activity period for most passerines and other birds of interest. For this reason, all marsh surveys were conducted within the time window between dawn and 5 hrs after dawn. This time period was believed to be the best compromise for the various bird groups of interest.

Data Collected

All birds detected during formal surveys were placed in one of three "user" categories. These included: category 1 - bird in direct contact with marsh (e.g. Seaside Sparrow perched in salt bush), Category 2 - bird not in direct contact with marsh but foraging on prey just over the marsh surface (e.g. Barn Swallow foraging over marsh), category 3 - bird flying over marsh but under 50 m in altitude (e.g. Laughing Gull milling around over marsh), or associated with water within 50 m of shoreline (e.g. Osprey foraging for fish in shallows next to marsh).

Before the beginning and after the completion of each survey, several environmental parameters were measured. These included: time of day, ambient temperature, estimated

wind speed, percent cloud cover, and current tide height. A full analysis of these variables and their influence on survey results will not be presented here.

Substrate Use

In order to examine how species used the marsh and, in addition, how different marsh features contributed to overall species richness, marshes were subdivided into 15 "marsh components" (description and code name given in Table 1). Marsh components were then grouped loosely according to hydrology and topography (marsh zones and associated components shown in Table 1). It should be noted that these groupings were established as a convenience for presentation and that many marsh components may be located in various places within a specific marsh. A generalized marsh profile illustrating the approximate location of marsh zones is given in Figure 2. Figure 3 illustrates, in more detail, the various components included in each marsh zone. All observations of birds considered to be using the marsh directly were placed in 1 of the 15 marsh components.

RESULTS

Marsh surveys resulted in the detection of over 4,880 birds of 100 species (see Appendix I for a complete list of species and scientific names). Although species richness was high overall, relatively few species accounted for the majority of observations. For example, two species (Red-winged Blackbird and Laughing Gull) accounted for greater than 25% of the total observations and 7 species represented greater than 50%.

The majority of species observed used the study marshes directly (i.e. were category 1 species) as nesting and or as foraging habitat. Using a criterion of $\geq$ 50% to place species

Table 1: Descriptions of marsh components and sections.

Marsh Section	Code/ Name	Component Description
Water Components		
	OW	Open Water: Open water along margin of marsh.
	MF	Mudflat: Exposed mud along margin of marsh.
	TG	Tidegut: Narrow tidegut extending into marsh.
	TP	Tidepool: Permanently or regularly filled depression with no direct connection to tidegut.
Low Marsh		
	TC	Tall Cordgrass: Tall, dense form of Spartina alterniflora.
	LC	Low Cordgrass: Low, sparse form of S. alterniflora.
	SL	Wet Slew: Regularly inundated low depression typically surrounding a shallow tidepool or terminus of a small tidegut. Depression is dominated by sparse, mixed stands of S. patens, Distichlis spicata, and Salicornia virginica.
	BN	Black Needlerush: Dense stands of Juncus roemerianus.
High Marsh		
	SG	Saltgrass: Dense upper stands of D. spicata.
	SM	Saltmeadow Hay: Dense upper stands of S. patens.
	SB	Saltbush: Live standing plant of Iva frutescens or Baccharis hamilifolia.
	SN	Dead Pine Snag: Dead standing pine snag.
Marsh-upland Transition Zone		
	WM	Wax Myrtle: Shrub of Myrica cerifera.
	DS	Deciduous Saplings: Hummock or clump of small deciduous saplings.
	LP	Live Pine: Live pine (Pinus taeda) along marsh edge.

Figure 3: Illustration of general marsh profile showing the relationship between hydrology, topography and marsh zones.

Figure 3

GENERAL MARSH PROFILE

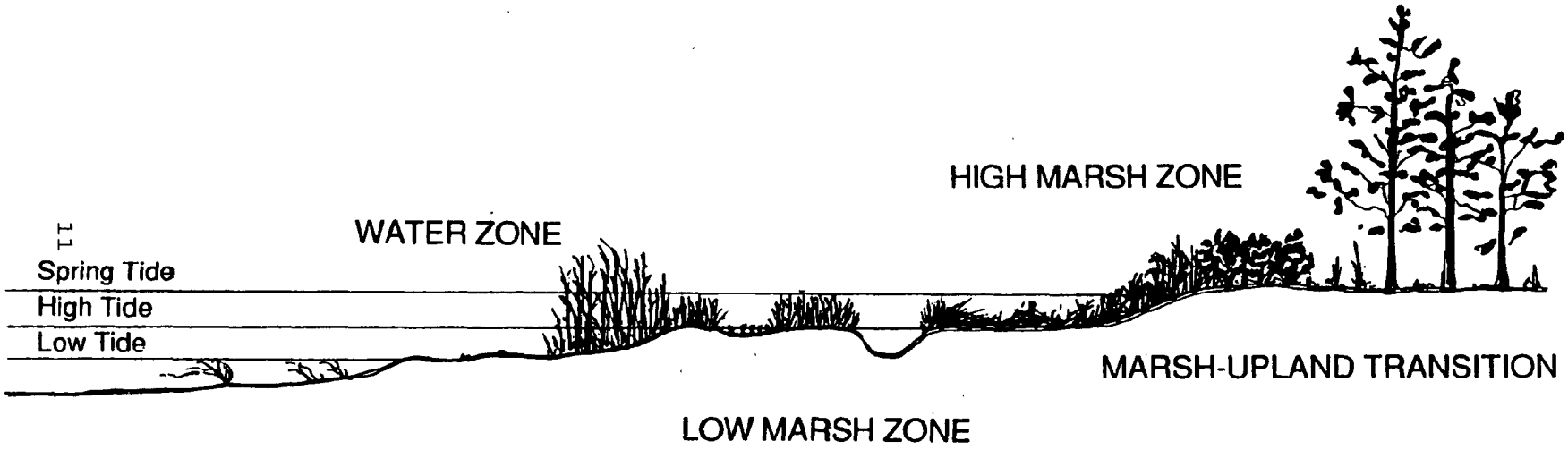


Figure 4: Illustration showing the 4 marsh zones and their respective marsh components. Key to marsh component codes is given in Table 1.

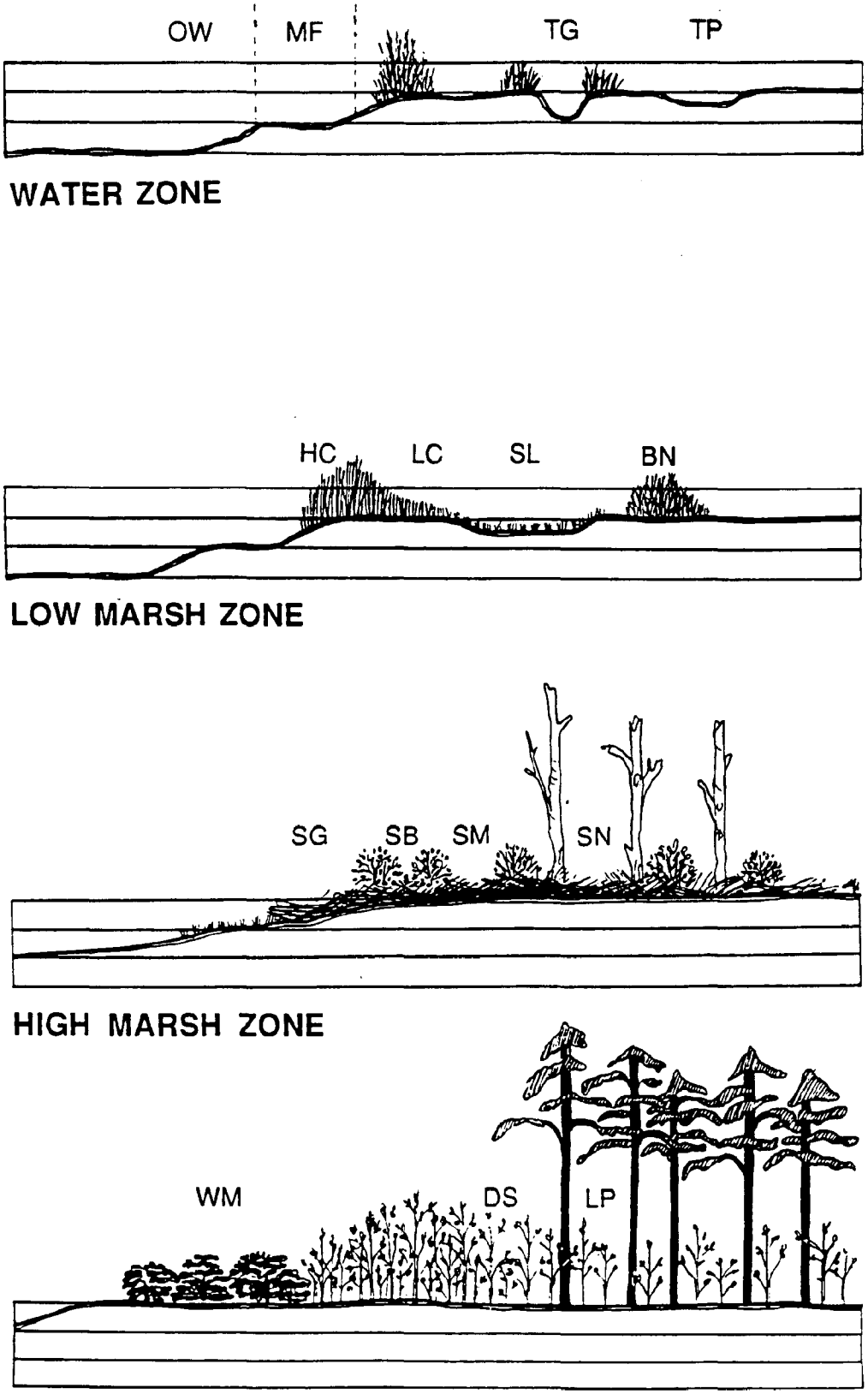

OW
MF
TG
TP
WATER ZONE
HC
LC
SL
BN
LOW MARSH ZONE
SG
SB
SM
SN
HIGH MARSH ZONE
WM
DS
LP
MARSH-UPLAND TRANSITION

Figure 4

in user categories, 71.0% of the species were classified as category 1, 5.0% as category 2, and 24.0% as category 3 (Appendix II gives a complete breakdown of marsh use by species). For all species combined, 62.0% of the total observations were of birds directly contacting the marsh, 9.6% were of birds foraging over the marsh surface and 28.4% were of birds associated with the marsh.

All species observed were placed in one of four different categories based on their primary relationship to the marsh during the study period (category designations were based on 1992 habitat results and various accounts within the literature). Categories used include: Obligate Breeder - those species that breed exclusively or nearly so in tidal salt marshes, Obligate Forager - those species for which the salt marsh represents a primary foraging habitat but nest outside the marsh, Facultative Breeder - those species that nest within the salt marsh but may also be found nesting in one to several upland habitats, Facultative Forager - those species that breed outside the marsh and for whom the marsh represents an occasional or alternate foraging habitat.

The majority (81.0%) of species observed using marshes directly were actually facultative users. Observations were dominated by primarily upland species that utilize marshes as alternative breeding and or foraging habitat. Facultative users were mostly incidental foragers (59.0%) but also contained breeding species (22.0%). Although obligate users accounted for only 19.0% of the species observed, they accounted for over 35.0% of the total individuals.

Temporal Patterns

For all study marshes combined, species richness declined only modestly (10%) over the study period. Apparently, relatively few transient species utilized these smaller marshes during spring migration. In fact, only 18% of the species detected were exclusive to the early surveys compared to 10% for later surveys. Overall species richness was not significantly different (G-statistic < 2, $P > 0.05$, testing the null hypothesis that early = late) between early and late surveys.

Like species richness, overall bird abundance was relatively stable over the study period. This result points again to the lack of transient user species during the early period. Overall abundance was not significantly different (G-statistic < 2, $P > 0.05$, testing the null hypothesis that early = late) between early and late surveys. However, the majority (61%) of species exhibited a substantial ($\geq$ 50% change in abundance) increase or decrease in abundance between the early and late periods (see Appendix III for seasonal occurrence patterns). In general, most of the species that were detected in greater numbers during early surveys were winter residents that moved out of the local area or transients that moved through the study marshes in relatively low numbers. Species that showed substantial increases throughout the season were dominated by facultative users that moved into marshes during early June to nest or forage.

Effects of Marsh Size

Community Response

For all bird groups combined, species richness was positively related to marsh size (see TOTAL BIRDS in Figure 5). Although the form of this relationship differed between user categories, all groups exhibited similar trends. All groups except category 2 users showed statistically significant increases (see Table 2, Figure 5) in average species richness across the range of marsh sizes. Similarly, all groups except category 2 species showed significant Log/Log regressions between species richness and actual marsh size (see Table 3). Species/area slopes were similar between bird groups (Table 3) with category one species showing the greatest declines with decreasing marsh size. This result is consistent with their direct relationship to the marsh. The nonsignificant results for category two species were likely due to the very small pool of species within the group (primarily 2-3 species of swallows). Like species richness, total bird abundance increased along with marsh size (Figure 6). However, patterns were significant for total abundance and category one species only (Table 2).

Dividing the bird community into functional groups, obligate users were influenced to a greater extent by marsh size than facultative users with regard to both species richness (Figure 7) and abundance (Figure 8). Both obligate breeders and foragers exhibited significant trends with increasing marsh size (Table 4). Neither facultative breeders or foragers showed significant trends at the 0.05 level (although facultative breeders did show a trend in this direction). The result of differences between facultative and obligate species in their response to marsh size was that the composition of the marsh-bird community changed

Figure 5: Average accumulated species richness for all species, broken down into species categories. Data points are means of ten replicate marshes $\pm$ 1 S.E. unit.

SPECIES RICHNESS FOR USER CATEGORIES

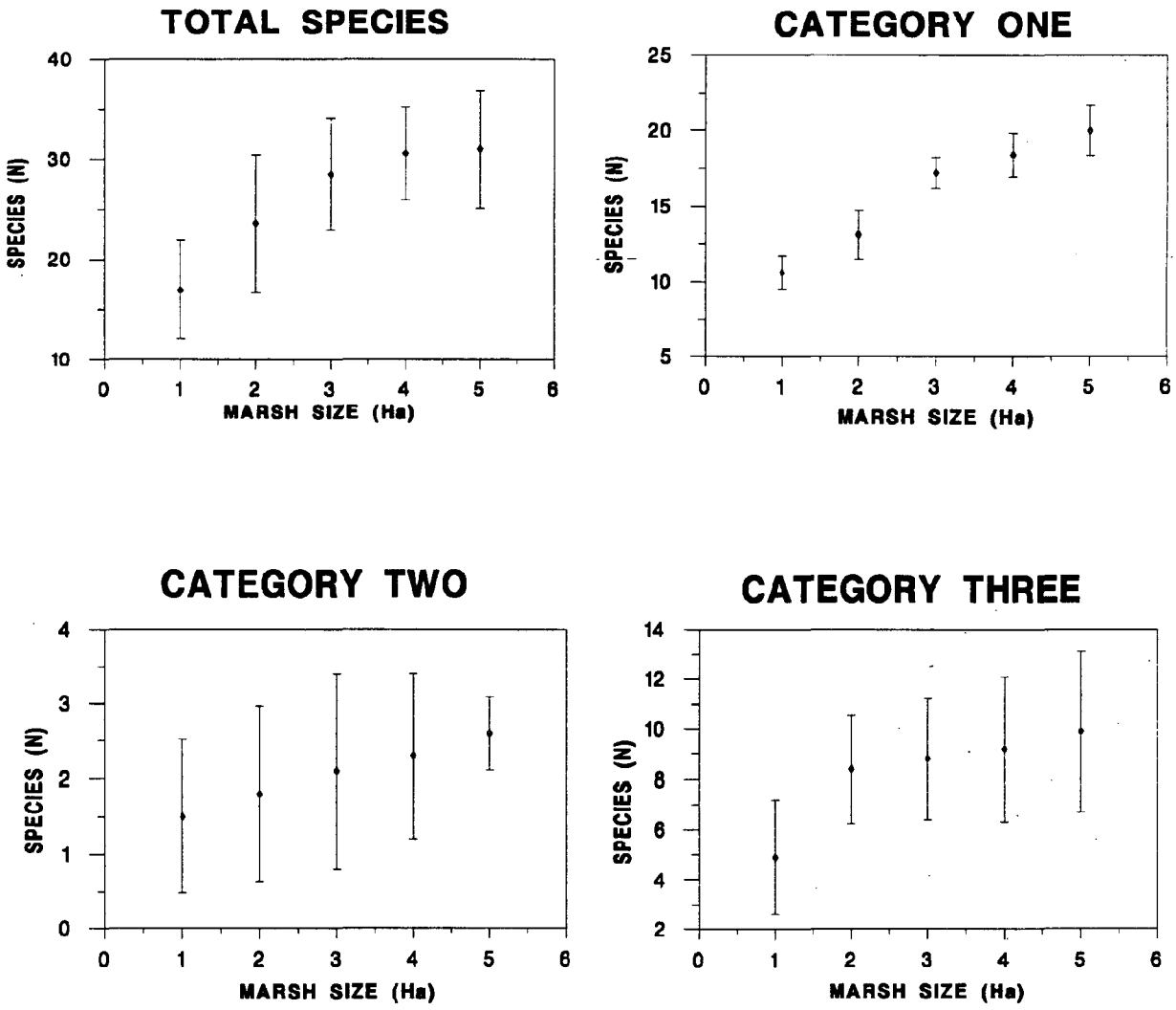


Figure 5

Table 2: ANOVA results for species categories (testing between size categories).

Species Group	F-value	P
Species Richness		
Total User Species	9.87	<0.001
Category 1 Species	7.71	<0.001
Category 2 Species	1.48	NS
Category 3 Species	4.97	<0.01
Abundance		
Total User Individuals	8.57	<0.001
Category 1 Individuals	12.26	<0.001
Category 2 Individuals	1.03	NS
Category 3 Individuals	1.67	NS

Table 3: Results of Log/Log regressions for various species groups.

Species Group	Regression Equation	R	F	P
Total Users	LSpecies = Log2.88 + .35LogArea	.68	41.4	<.001
Category 1	LSpecies = Log2.34 + .38LogArea	.61	28.7	<.001
Category 2	LSpecies = Log0.51 + .20LogArea	.28	3.7	<.1
Category 3	LSpecies = Log1.80 + .28LogArea	.46	12.8	<.01
Obl. Users	LSpecies = Log0.66 + .67LogArea	.68	41.5	<.001
Fac. Users	LSpecies = Log2.14 + .20LogArea	.30	4.7	<.05

Figure 6: Average bird abundance for all species, broken down into species categories. Data points are means of ten replicate marshes $\pm$ 1 S.E. unit.

BIRD ABUNDANCE FOR USER CATEGORIES

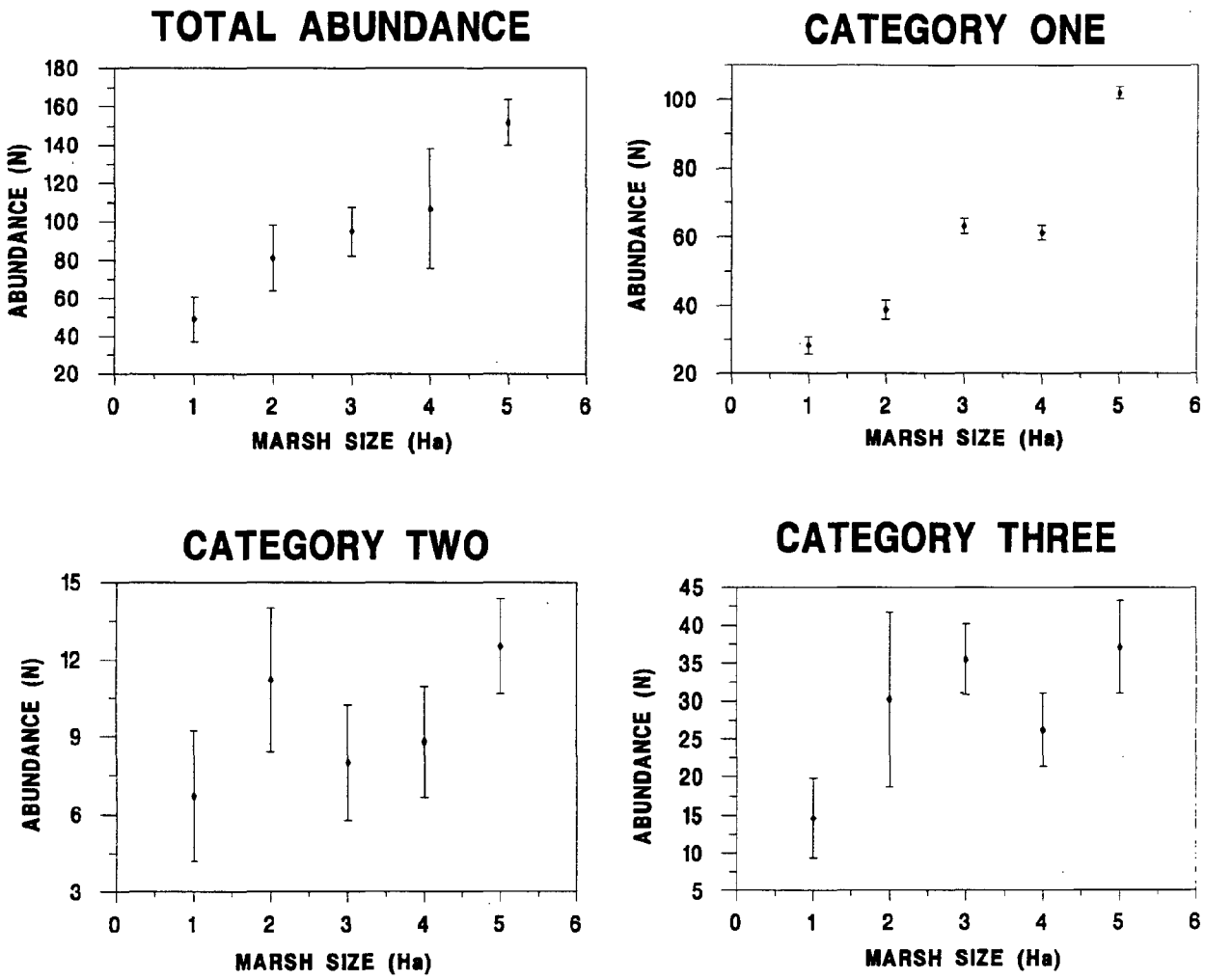


Figure 6

Figure 7: Average accumulated species richness for obligate and facultative marsh users. Data points are means of ten replicate marshes $\pm$ 1 S.E. unit.

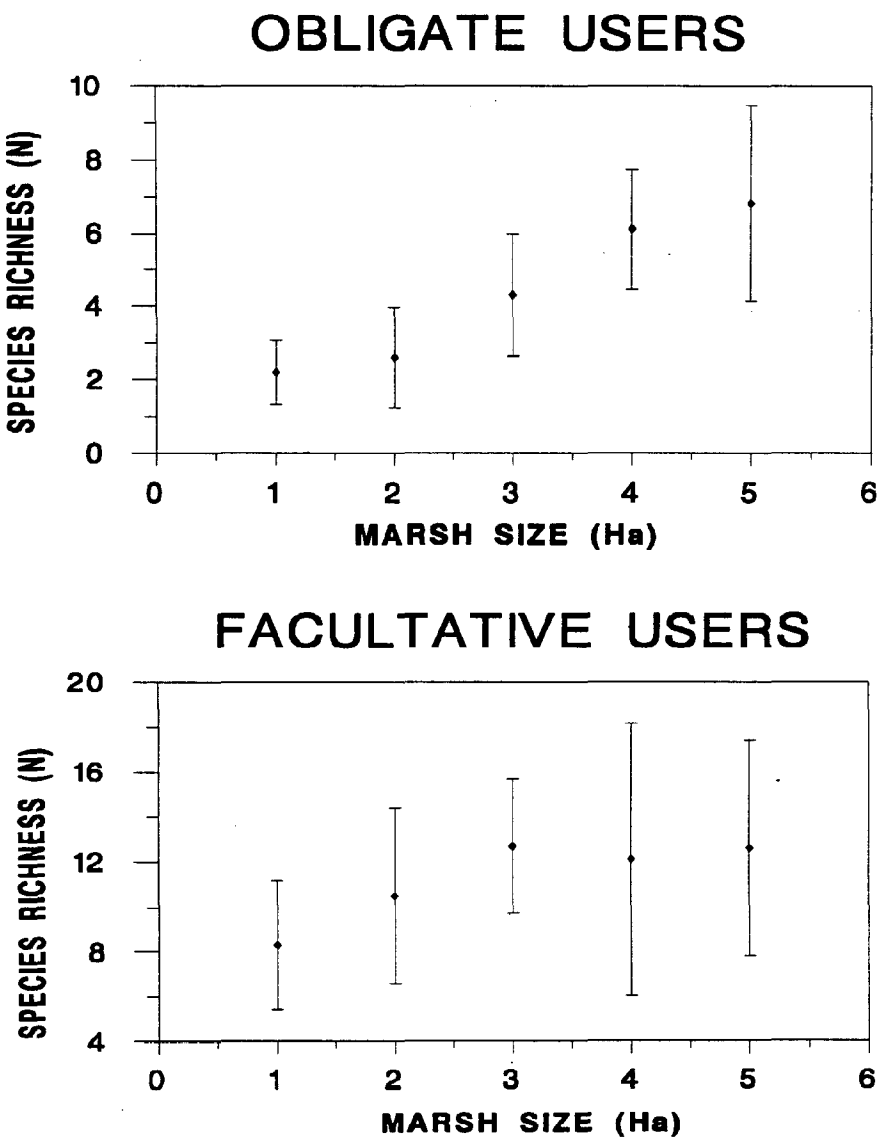

OBLIGATE USERS
SPECIES RICHNESS (N)
0
2
4
6
8
10
0
1
2
3
4
5
6
MARSH SIZE (Ha)
FACULTATIVE USERS
SPECIES RICHNESS (N)
4
8
12
16
20
0
1
2
3
4
5
6
MARSH SIZE (Ha)

Figure 7

Figure 8: Average bird abundance for obligate and facultative marsh users. Data points are means of ten replicate marshes $\pm$ 1 S.E. unit.

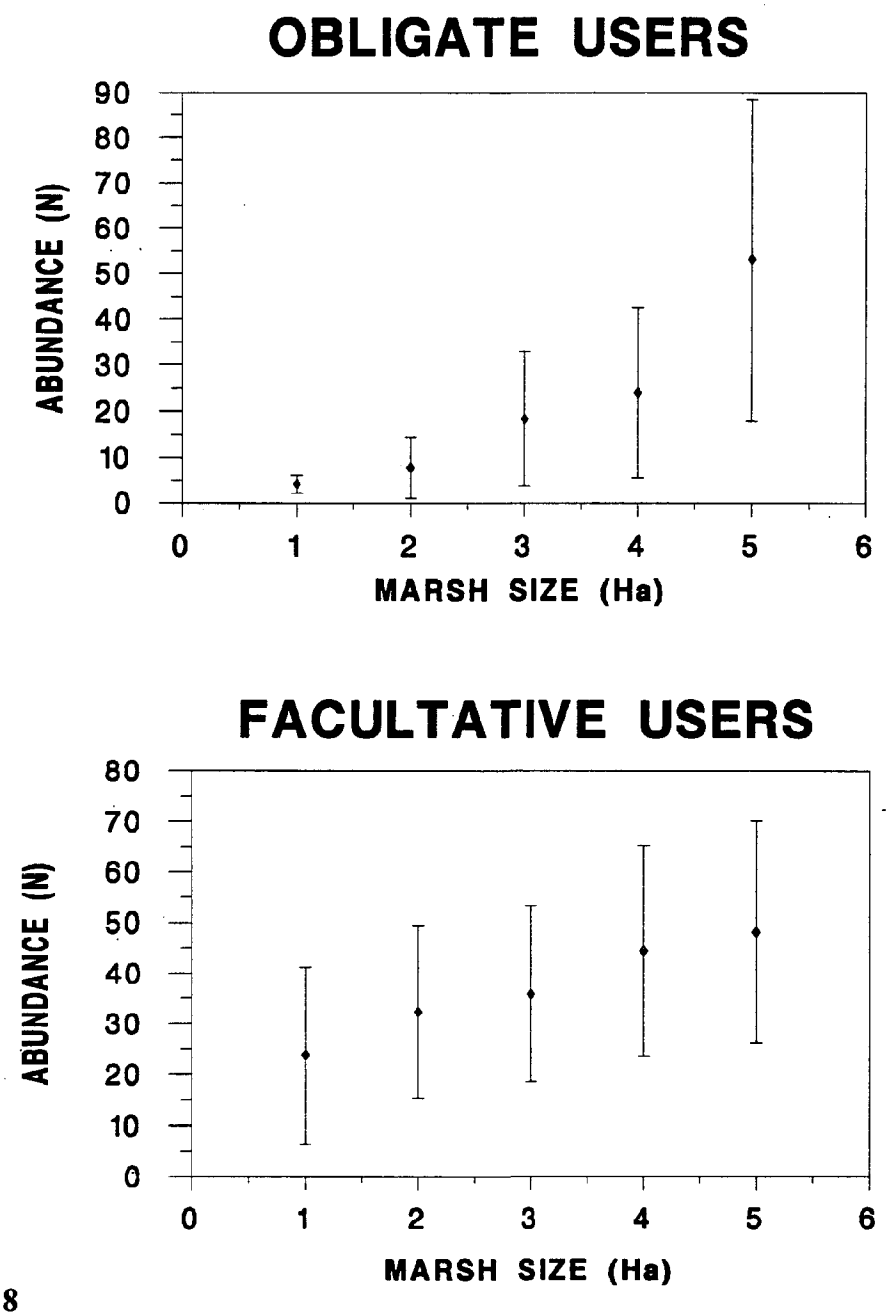

OBLIGATE USERS
ABUNDANCE (N)
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
MARSH SIZE (Ha)
FACULTATIVE USERS
ABUNDANCE (N)
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
MARSH SIZE (Ha)

Figure 8

Table 4: ANOVA results for functional bird groups (testing between marsh size categories).

Species Group	F	P
Species Richness		
Obligate Users	12.34	<0.001
Facultative Users	1.69	NS
Abundance		
Obligate Breeders	8.05	<0.001
Obligate Foragers	4.90	<0.01
Facultative Breeders	2.92	0.1>P<0.05
Facultative Foragers	0.90	NS

between small and large marshes. Whereas obligate users accounted for only 14.4% of all birds detected within 1 ha marshes they accounted for 52.6% of birds detected within 5 ha marshes.

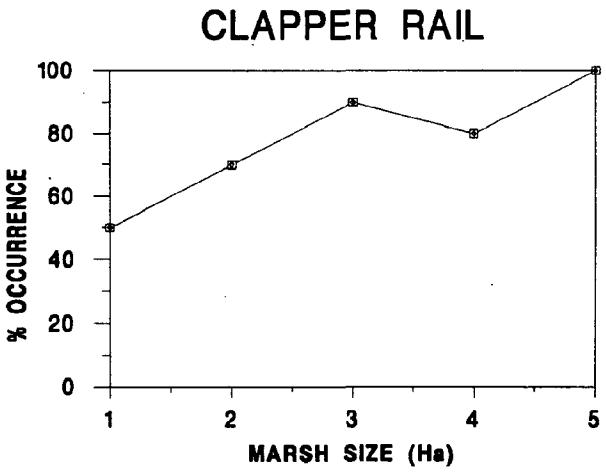
Incidence Patterns

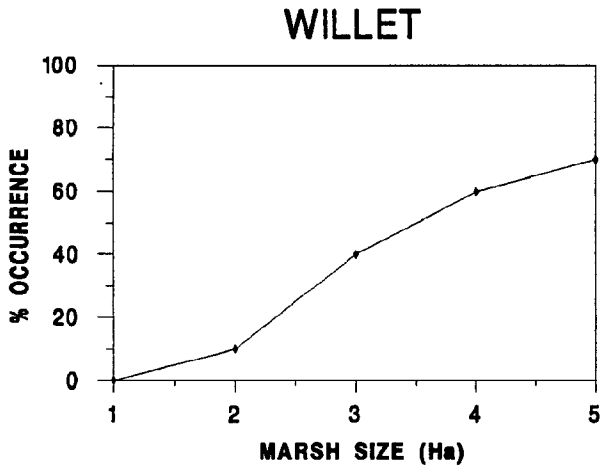
Incidence functions represent the probability that a species will occur in a patch of a given type or size. Incidence patterns were examined for selected species representing each of the four functional bird groups (Figures 9 - 12). All of the obligate breeders within the 50-marsh system showed a significant increase in incidence across the range of marsh sizes. Willets, Seaside Sparrows, and Boat-tailed Grackles each showed increases in incidence of 60 to 70% between 1 and 5 ha marshes. Marsh Wrens seemed to be the most area sensitive, reaching only 50% occurrence even within the largest marshes. In contrast, Clapper Rails were the least area sensitive occurring in 50% of the 1 ha marshes and all of the 5 ha marshes.

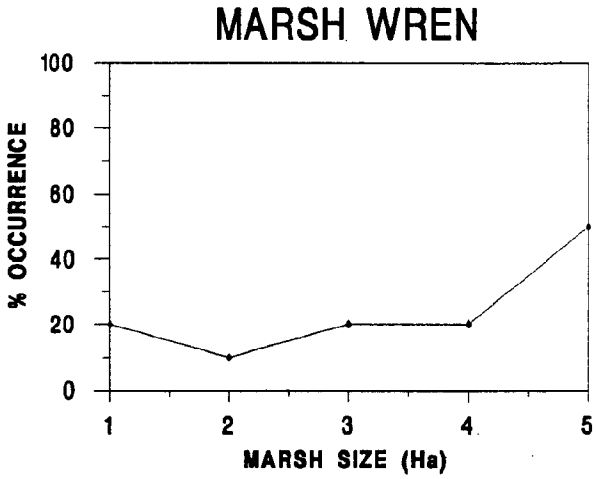
Incidence patterns for the three remaining bird groups were variable. Of the four common obligate foragers, only the Great Egret and Sharp-tailed Sparrow (actually a transient species) appear to be area sensitive over the size range examined. Great-blue and Green-backed herons both appear to occur in marshes with relatively high frequency regardless of size. All of the facultative breeders exhibited some level of area sensitivity, however none were dramatic. All of these species occurred in all size categories with relatively high frequency but did show an increase in incidence of between 20 and 40%. None of the facultative foragers showed any definite tendency toward area sensitivity. The Northern Flicker occurred in approximately 40% of the marshes surveyed regardless of size.

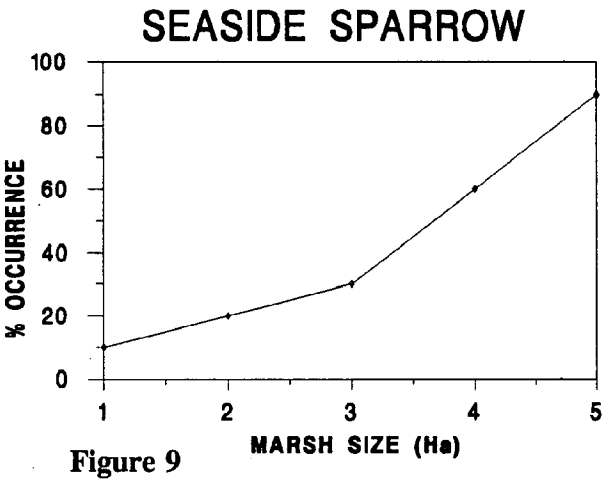
Figures 9 - 12: Incidence functions for selected obligate breeders, obligate foragers, facultative breeders, and facultative foragers. Data points indicate the proportion of ten replicate marshes in which the species was observed.

INCIDENCE FUNCTIONS FOR OBLIGATE BREEDERS









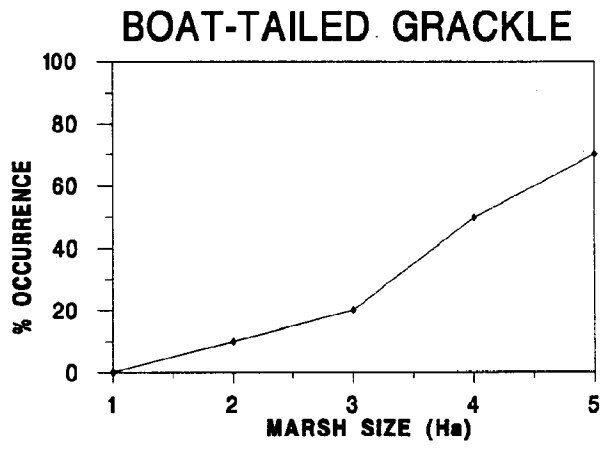


Figure 9

INCIDENCE FUNCTIONS FOR OBLIGATE FORAGERS

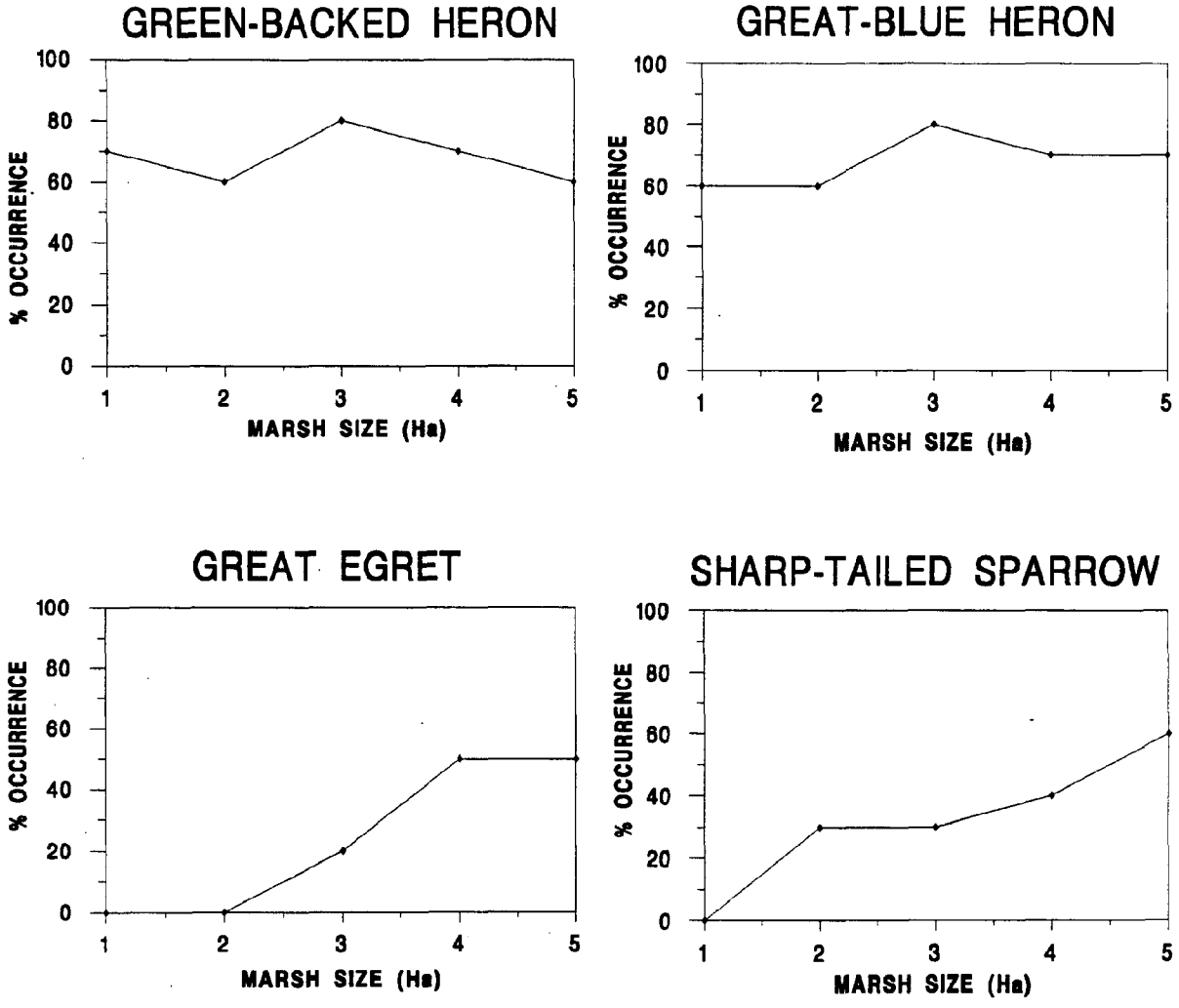


Figure 10

INCIDENCE FUNCTIONS FOR FACULTATIVE BREEDERS

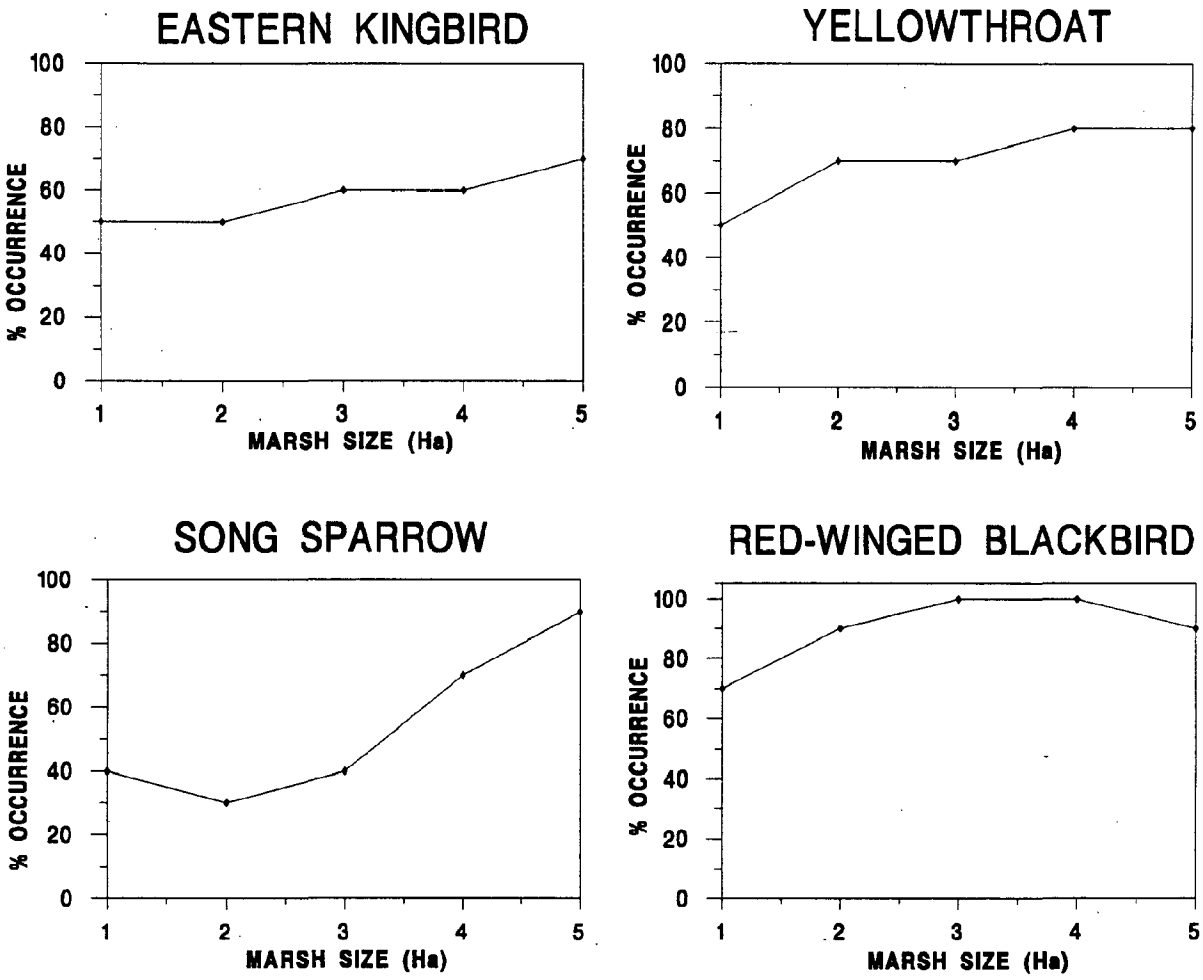


Figure 11

INCIDENCE FUNCTIONS FOR FACULTATIVE FORAGERS

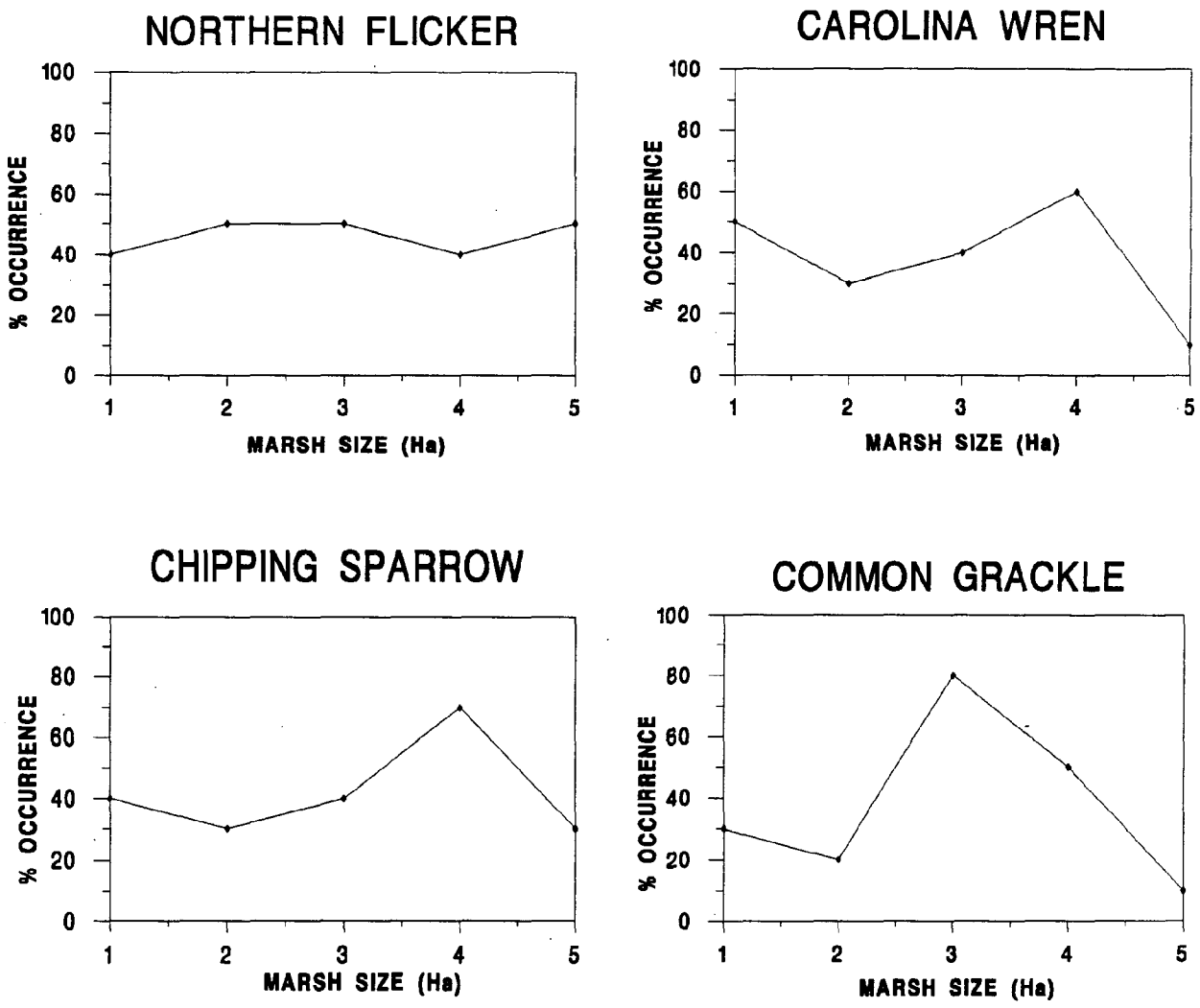


Figure 12

The three remaining species exhibited somewhat erratic patterns over the size range suggesting that some factor other than size is determining marsh use.

Patterns of Vegetation Use

Species richness and total bird numbers were compiled for the four marsh zones (Figure 13). Species richness was found to be highest in the high marsh zone followed closely by the marsh-upland transition. Sixty-four and 61% of all birds detected were found in these two zones respectively at least once during the study. The water zone had the fewest number of species with the low marsh zone being intermediate. Patterns in overall bird abundance paralleled those of species richness closely. Over 68% of all birds detected were observed in either the high marsh zone or marsh-upland transition. This is compared to only 32% in the water and low marsh zones combined. The water components combined only accounted for 10% of the individuals detected.

The majority of species detected were in the marsh-upland transition zone and were associated with either deciduous saplings (52%) and or live pines (50%), (Figure 13). These two marsh components also accounted for over 25% of the birds detected overall. Within the high marsh zone, many species were associated with either dead snags (42%) or salt bush (39%). Combined these two components accounted for 29% of all birds detected. Of all water and low marsh components, only black needlerush contained over 20% of the species detected. Likewise, black needlerush is the only component that individually accounted for over 5% of the total individuals.

Figure 13: Relative species richness and abundance for individual marsh zones and marsh components. Relative species richness values calculated as accumulated richness/100 (total species detected within marsh system). Relative abundance values calculated as total individuals/N (total individuals observed within the entire marsh system).

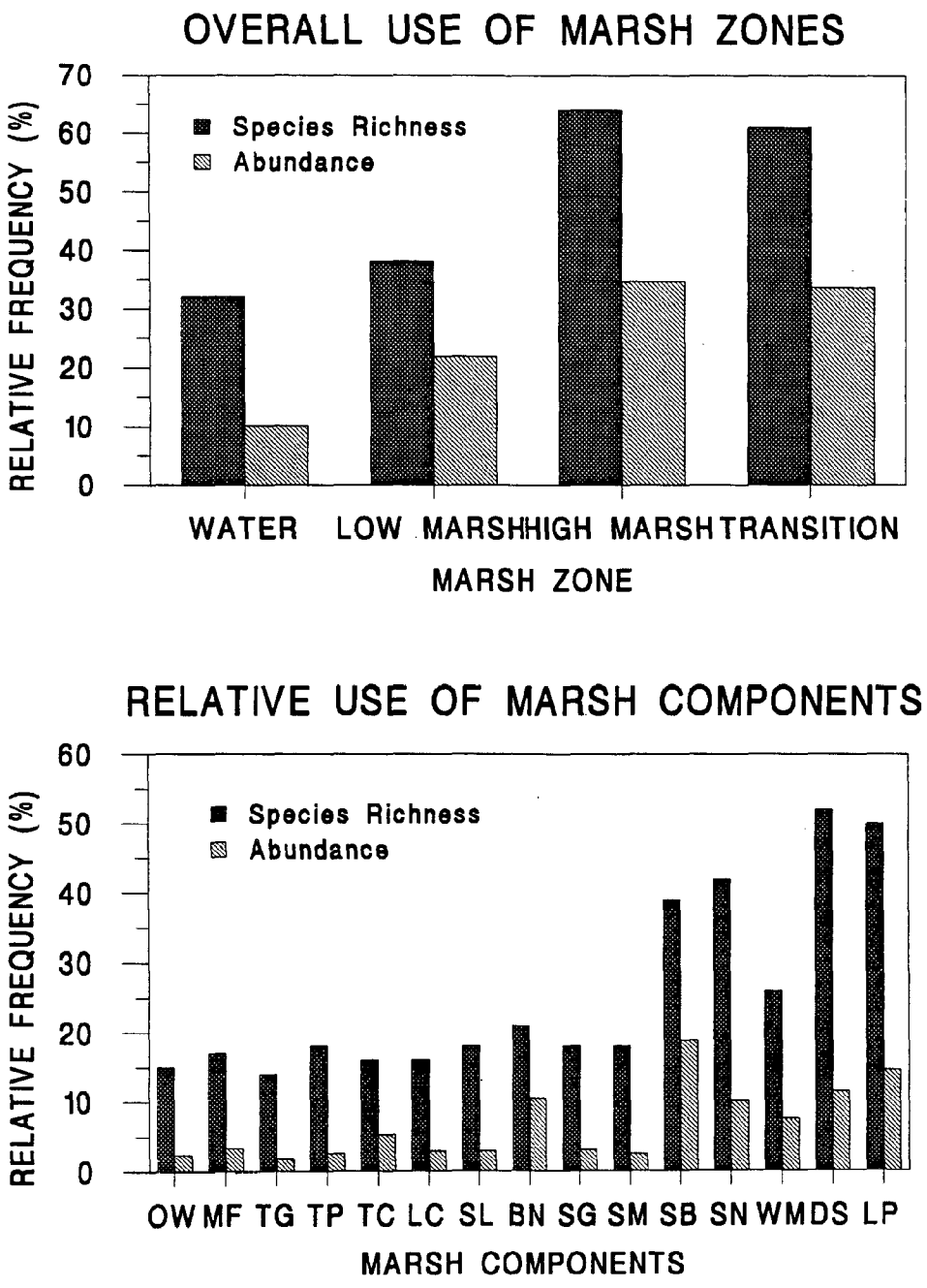

OVERALL USE OF MARSH ZONES
RELATIVE FREQUENCY (%)
70
60
50
40
30
20
10
0
Species Richness
Abundance
WATER
LOW MARSH
HIGH MARSH
TRANSITION
MARSH ZONE
RELATIVE USE OF MARSH COMPONENTS
RELATIVE FREQUENCY (%)
60
50
40
30
20
10
0
Species Richness
Abundance
OW MF TG TP TC LC SL BN SG SM SB SN WM DS LP
MARSH COMPONENTS

Figure 13

Patterns of marsh use were compiled for individual species. Information for common obligate breeders, obligate foragers, facultative breeders, and facultative foragers is presented in figures 14 through 17 respectively. In general, the obligate breeders were distributed widely across the marsh. Seaside Sparrows and Marsh Wrens utilized black needlerush and salt bush extensively. Both of these species utilize dense stands of vegetation for cover and singing posts within breeding territories. Clapper Rails also depend on the dense vegetation for cover throughout the day and are seen only sporadically foraging in the low marsh during the light hours. Willets utilize the entire marsh, foraging widely within the low marsh and using the high marsh for nesting and roosting. Boat-tailed Grackles are similar, feeding within the low marsh and roosting within the marsh-upland transition zone where they typically nest.

Observations of the common obligate foragers were skewed to the water and low marsh areas. All of the heron and egret species observed utilize the marsh primarily as foraging habitat and are typically seen hunting in the water components or low marsh depending on tide level. However, these species may also be observed roosting around the periphery of the marsh particularly during high tide periods. The Sharp-tailed Sparrow is an obligate marsh user that, within the lower Chesapeake Bay, is a transient species and winter resident. Sharp-tails were observed within the dense vegetation but also in foraging areas within the low marsh. All common, facultative species were observed most frequently within the high marsh or marsh-upland transition zones. The vegetative structure of these portions of the marsh are similar to early successional upland habitats where these species are more commonly found during the breeding season.

Figures 14 - 17: Relative occurrence of selected species within the 15 focal marsh components. Selected species are presented for obligate breeders, obligate foragers, facultative breeders, and facultative foragers. Values indicate number of individuals observed within specific marsh component/total number of individuals observed directly using study marshes. Only relatively common category 1 species (those species with greater than 50% of individuals observed directly using the marsh) are presented.

USE OF MARSH COMPONENTS BY OBLIGATE BREEDERS

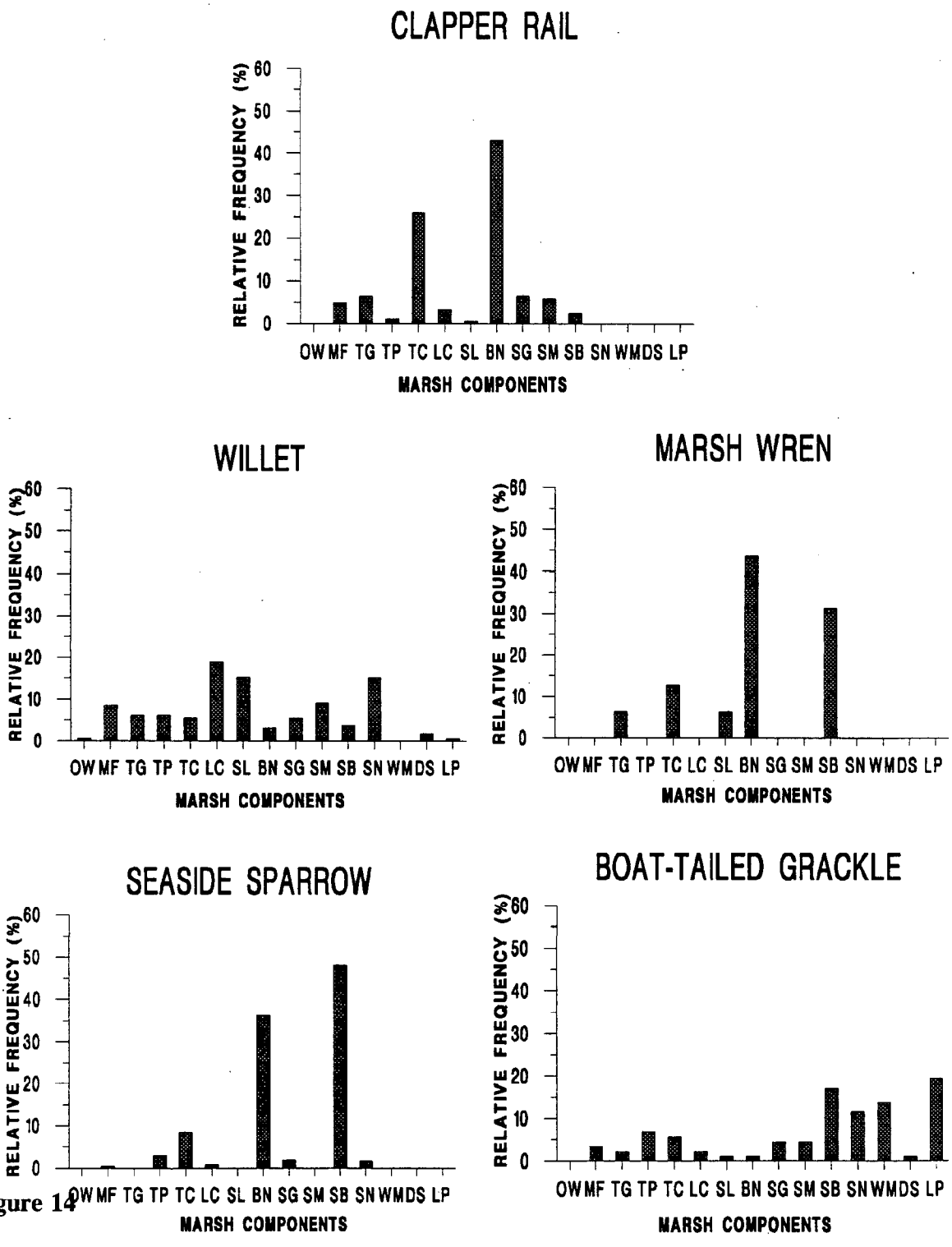


Figure 14

USE OF MARSH COMPONENTS BY OBLIGATE FORAGERS

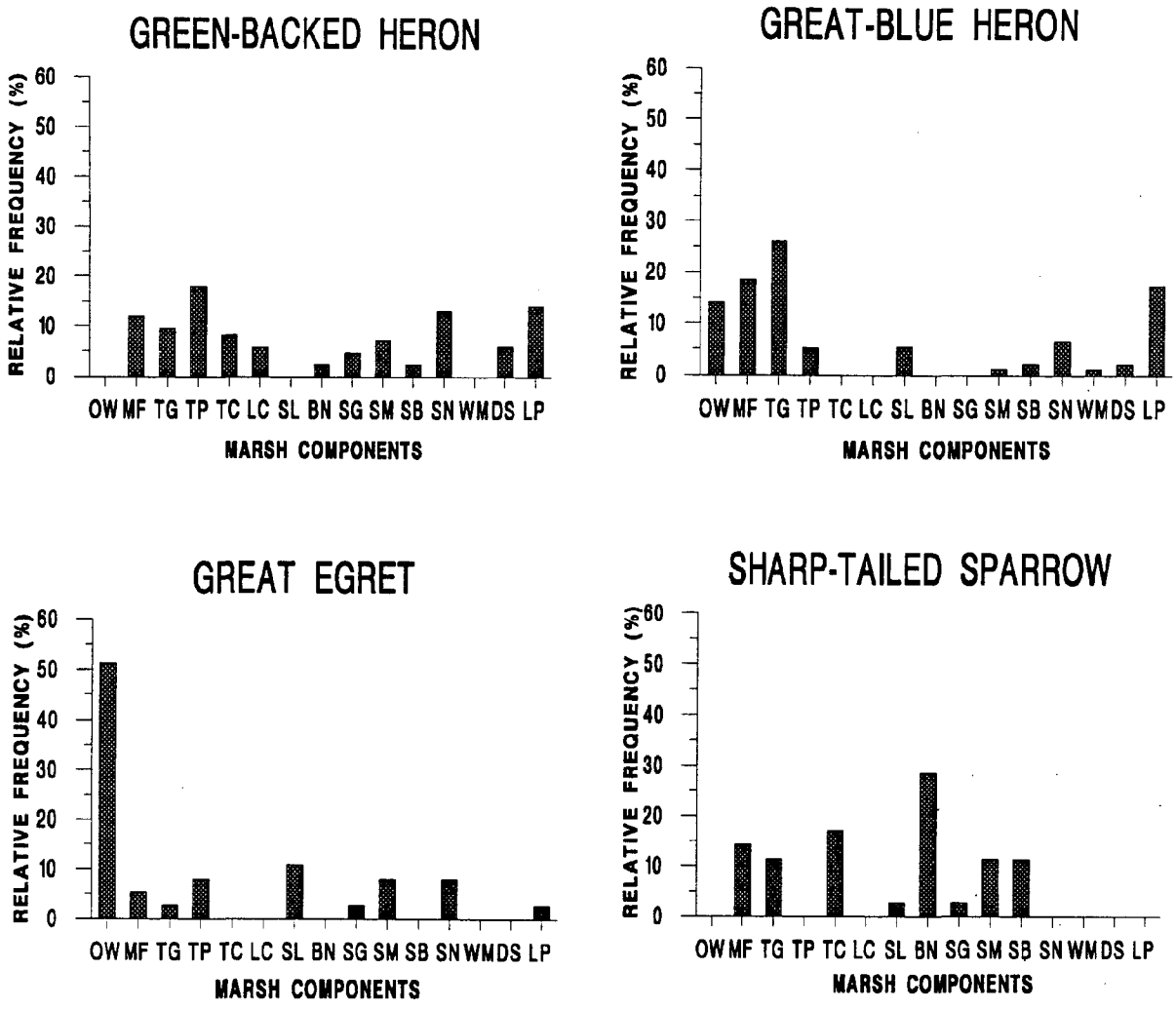


Figure 15

USE OF MARSH COMPONENTS BY FACULTATIVE BREEDERS

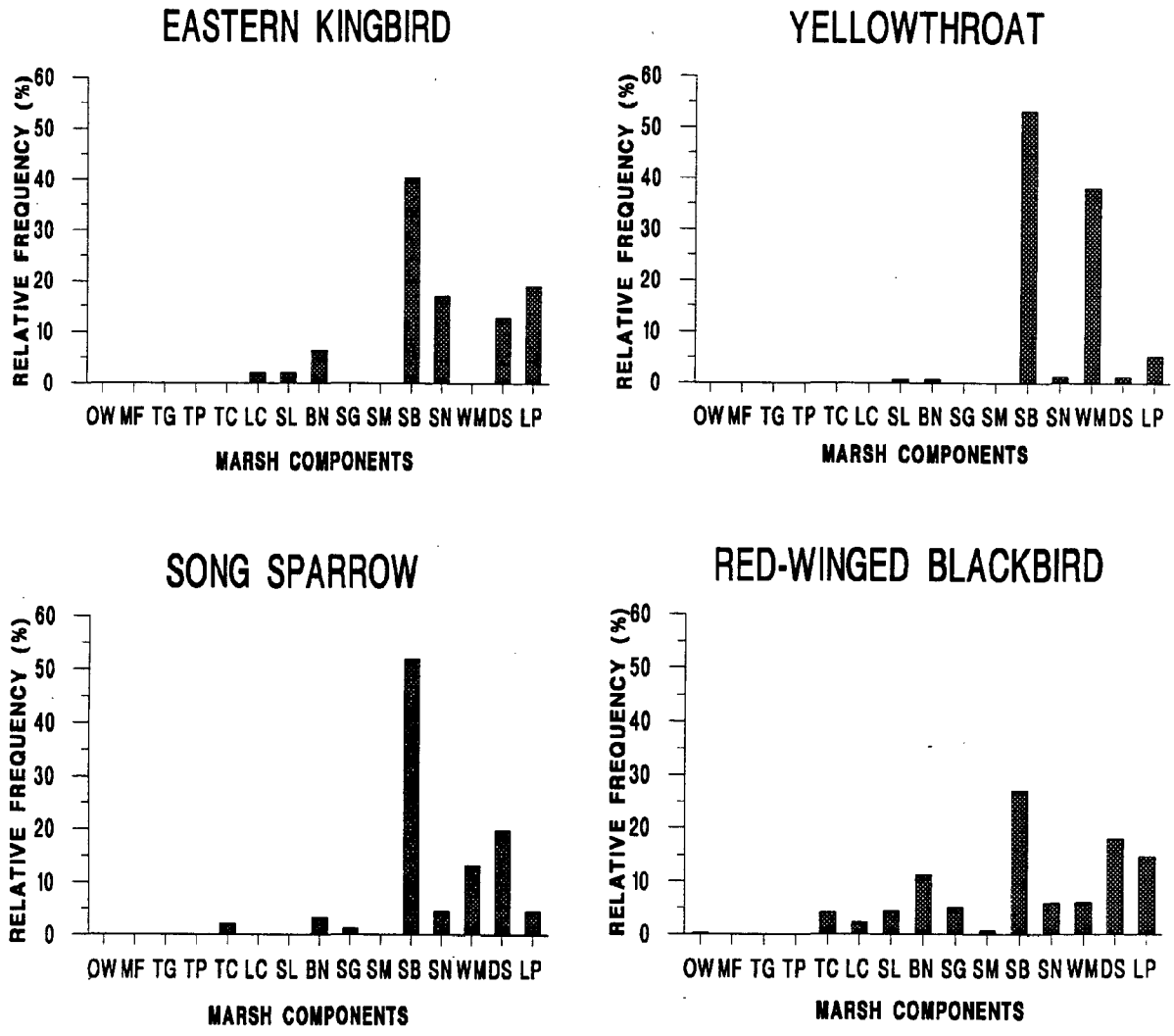


Figure 16

USE OF MARSH COMPONENTS BY FACULTATIVE FORAGERS

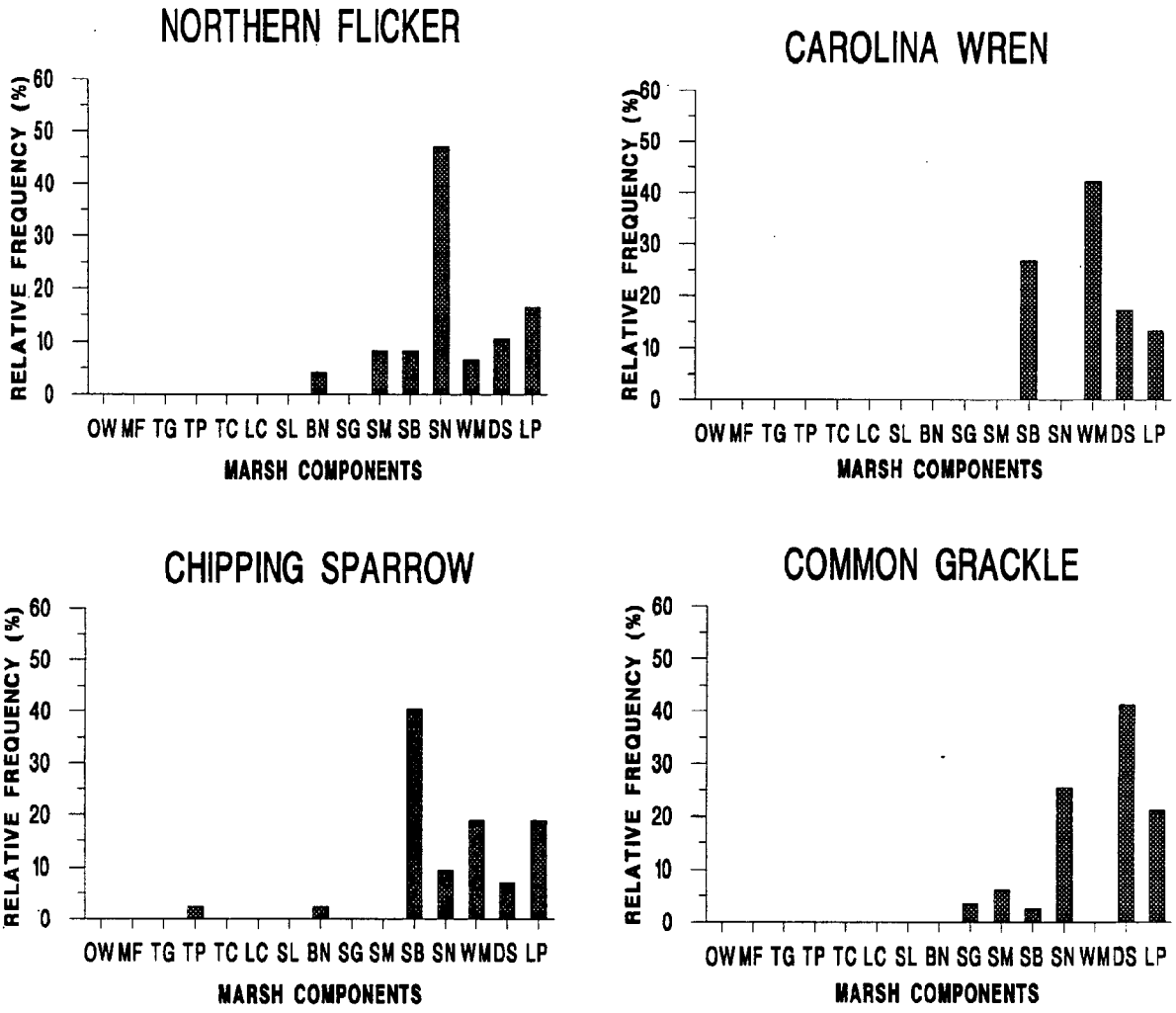


Figure 17

DISCUSSION

Patch area/community breadth relationships have been documented in prairie marshes (Brown and Dinsmore 1986) and various upland habitats (e.g. Forman et al. 1976, Lynch and Whigham 1984). In 1992, Watts documented a strong relationship between overall species richness and patch area for tidal salt marshes of the lower Chesapeake Bay. The same study documented that the marsh bird community observed in large marshes appeared to collapse as marsh size was reduced from 5 to 1 ha. Results from the current study confirm this critical size range and further refine the patterns for various species and species groups.

Across the range of sizes included, marsh area appears to be a good indicator of species richness and abundance for all birds as well as for particular species groups. Species that actually used the marshes directly showed the most rapid decline with marsh size followed by all species combined. Results were similar to those observed in the 1992 study with slopes of 0.38 and 0.35 for category one species and total species respectively compared to 0.46 and 0.42 for the same species groups in 1992 (over a much larger range in marsh sizes). Also consistent with the 1992 study, category two and three species exhibited comparatively weaker responses to marsh size.

Subdividing category one species according to their functional relationship to the marsh, obligate users exhibited the strongest response to marsh size. Species within this group showed the most rapid decline (slope = 0.67) with decreasing marsh size and likely were the underlying reason for the relationship for all category one species. In contrast, facultative users showed only a weak (slope = 0.20) response to decreasing marsh size. The

differences between facultative and obligate species in their response to marsh size, resulted in a shift in community composition with increasing marsh size.

Whereas obligate species accounted for only 14% of birds observed within 1 ha marshes they accounted for over 50% of birds within 5 ha marshes. In 1992, obligate users accounted for over 90% of birds observed within the largest (>65 ha) marshes. This general pattern suggests that the marsh-bird community becomes increasingly pure (dominated by species unique to the habitat) as patch size increases.

Incidence patterns for individual species generally reflected patterns observed for functional bird groups. All of the obligate breeding species showed considerable increases in the probability of occurrence with increasing marsh size. For obligate foragers, only Great Egrets and Sharp-tailed Sparrows appeared to be area sensitive over the range of marsh sizes examined. Great-blue and Green-backed herons appeared to be area-insensitive within the study marshes. All of the facultative breeders were area sensitive but patterns were not as profound as for obligate breeders. None of the facultative foragers exhibited tendencies toward area sensitivity.

Across all levels of organization, the same general pattern was observed. Species and species groups that were most closely tied to the marsh were most influenced by patch size. Those species that are unique to and characteristic of the salt marsh ecosystem are rapidly lost as marsh size is reduced from 5 to 1 ha. This pattern is consistent with results from the 1992 study and suggest that the marsh-bird community loses its integrity as marsh size is reduced below 3 to 4 ha. Clapper Rails are the only species that could be expected with any reliability within 1 to 2 ha marshes.

Overall, components within the high marsh and marsh-upland transition zones supported the greatest number of species and individuals. However, obligate species tended to utilize water and low marsh areas or the entire marsh surface. This result is in agreement with patterns observed during 1992. Facultative species used the high marsh and transition zones almost exclusively. This result is consistent with the similarity of the high marsh zone to early successional upland habitats (the more traditional breeding habitats for these species). The most striking contrast between these results and the 1992 study was the relatively low use of tidepools and other water/low marsh habitats. This difference is likely due to the lack of significant tidepools within the 50 study marshes. Greater than 95% of the transient shorebirds as well as many of the obligate foragers observed in large marshes (> 10 ha) during 1992 were associated with tidepools. Several of the most abundant species that appeared to be obligate tidepool users in 1992 (e.g. Snowy Egrets, Semipalmated Sandpipers) were not prominent members of the community within the system of smaller marshes. It appears that significant tidepools are less common as marsh size declines such that the suite of species that depends on them is not present.

SUMMARY

1. Patch size is a good indicator of species richness and abundance for salt marshes within the lower Chesapeake Bay.

2. Species and species groups that were obligate marsh users showed the strongest response to marsh size and the highest loss rates.

3. The form of the incidence function for area sensitive species is variable and species specific. In general, obligate breeders showed the greatest decline in occupancy rates with decreasing marsh size.

4. Due to differences in the species/area slopes between facultative and obligate users, community composition shifted toward obligate species as marsh size increased.

5. Marsh components within the high marsh and marsh-upland transition zones supported the greatest number of both species and individuals. However, many of the obligate users were associated with components of the water and low marsh zones.

MANAGEMENT IMPLICATIONS

Results presented here and for the 1992 study indicate that many marsh-bird species are area sensitive and that overall species richness declines as marsh area is decreased. Although overall species richness is a legitimate management consideration, it should not always receive the highest priority in structuring criteria for habitat protection. Consideration should be given to species that are unique to or characteristic of the habitat. Both studies suggest that obligate species were by far the most area-sensitive. The composition of bird communities within study marshes changed from being dominated by facultative species to obligate species as patch size approached 4 or 5 ha. The pattern continues as patch size is increased beyond 5 ha finally reaching a near pure community as marsh size reaches 50 - 60 ha. This suggests that only marshes of a certain size support intact examples of marsh-bird communities. Because of this, area-specific recommendations

should be constructed and considered when making decisions concerning proposals for marsh alteration.

In order to structure area-specific recommendations, it is first necessary to place the bird/area relationships in context with the availability of different sized marshes. Figure 18 illustrates the frequency of specific marsh size categories derived from over 1300 marshes within the study area. Clearly, marshes within the lower Chesapeake Bay are skewed to small sizes and large marshes are extremely rare. Combining the marsh-bird results with patterns in marsh availability, it is now possible to formulate area-specific recommendations.

MANAGEMENT RECOMMENDATIONS

Large Marshes - Marshes that exceed 50 - 60 ha in area are extremely rare and appear to be required by particular species (e.g. Sedge Wren, Northern Harrier) that are highly area-sensitive. This result suggests that relatively few locations may support the bulk of the population for these species. All marshes within this size category should be identified and surveyed for sensitive species. Because these marshes have regional significance they should be targeted for acquisition and easement programs. Marsh management practices should be examined relative to their impact on sensitive populations and management strategies should be drafted for individual marshes.

5 - 10 ha Marshes - Marshes that are between 5 and 65 ha are also relatively rare. These marshes support the bulk of the individuals for those species that are unique to and most identified with the salt marsh ecosystem. Marshes within this size range should be identified and given special attention when considering requests and proposals for marsh

Figure 18: Relative abundance of marsh sizes (within particular categories) located with the study area (N > 1300). Size distribution data was compiled from tidal marsh inventories covering the area (Barnard 1975, Moore 1976, Silberhorn 1981a, 1981b).

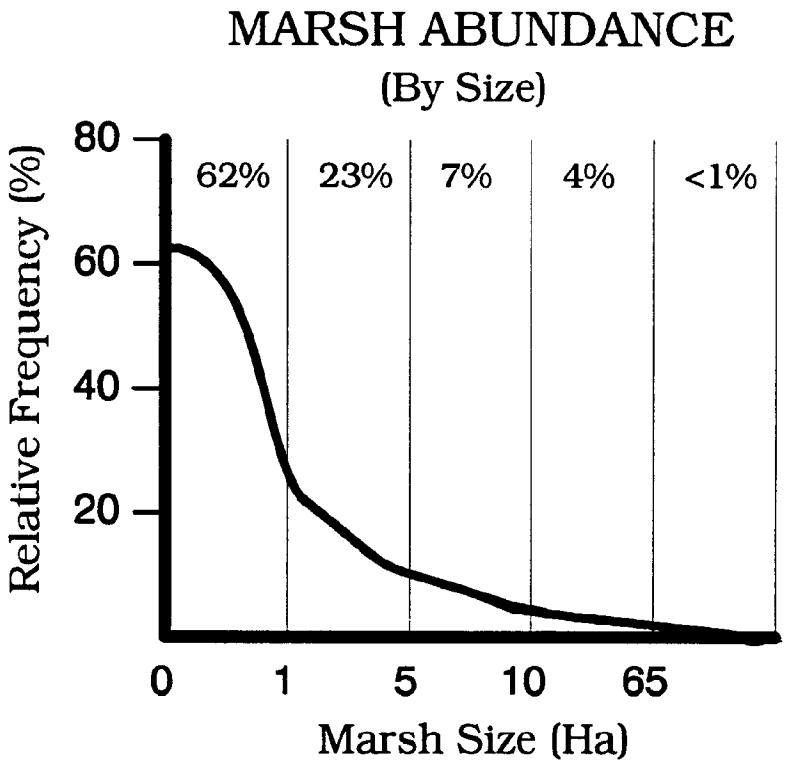

MARSH ABUNDANCE
(By Size)
Relative Frequency (%)
80
60
40
20
62%
23%
7%
4%
<1%
0
1
5
10
65
Marsh Size (Ha)

Figure 18

alteration. The location of these marshes relative to other large marshes should also be taken into consideration.

1 - 5 ha Marshes - Marshes that are between 1 and 5 ha represent a substantial portion of the total marshes found within the lower Bay. The value of these marshes to the overall obligate bird community is variable and increases with size. The relationship between marsh size and value is also species-specific. In general, however, 4 - 5 ha marshes have a high probability of supporting obligate marsh users compared to 1 - 2 ha marshes and should be given greater consideration when making management decisions. When the goal is to manage individual species, the form of appropriate incidence functions should be examined.

ACKNOWLEDGEMENTS

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Appendix I: List of scientific names for species detected.

Common Name	Scientific Name
Common Loon	Gavia immer
Double-crested Cormorant	Phalacrocorax auritus
Mute Swan	Cygnus olor
Canada Goose	Branta canadensis
Mallard	Anas platyrhynchos
Black Duck	Anas rubripes
Clapper Rail	Rallus longirostris
Virginia Rail	Rallus limicola
American Oystercatcher	Haematopus palliatus
Piping Plover	Charadrius melodus
Killdeer	Charadrius vociferus
Willet	Catoptrophorus semipalmatus
Greater Yellowlegs	Tringa melanoleuca
Lesser Yellowlegs	Tringa flavipes
Spotted Sandpiper	Actitis macularia
Semipalmated Sandpiper	Calidris pusilla
Laughing Gull	Larus atricilla
Ring-billed Gull	Larus delawarensis
Herring Gull	Larus argentatus
Common Tern	Sterna hirundo
Forster's Tern	Sterna forsteri
Little Tern	Sterna albifrons
Royal Tern	Sterna Maxima
Black Skimmer	Rynchops niger
Bald Eagle	Haliaeetus leucocephalus
Turkey Vulture	Cathartes aura
Northern Harrier	Circus cyaneus
Red-tailed Hawk	Buteo jamaicensis
Osprey	Pandion haliaetus
Northern Bobwhite	Colinus virginianus
Least Bittern	Ixobrychus exilis
Yellow-crowned Night-heron	Nyctanassa violacea
Green-backed Heron	Butorides striatus
Snowy Egret	Egretta thula
Great Egret	Casmerodius albus
Great Blue Heron	Ardea herodias
Glossy Ibis	Plegadis falcinellus
Rock Dove	Columba livia
Mourning Dove	Zenaida macroura
Yellow-billed Cuckoo	Coccyzus americanus
Chimney Swift	Chaetura pelagica
Ruby-throated Hummingbird	Archilochus colubris
Belted Kingfisher	Megaceryle alcyon
Red-headed Woodpecker	Melanerpes Erythrocephalus
Red-bellied Woodpecker	Melanerpes carolinus
Common Flicker	Colaptes auratus

Appendix I: ---continued---

Pileated Woodpecker	Dryocopus pileatus
Downy Woodpecker	Picoides pubescens
Eastern Kingbird	Tyrannus tyrannus
Great-crested Flycatcher	Myiarchus crinitus
Eastern Pewee	Contopus virens
Tree Swallow	Iridoprocne bicolor
Purple Martin	Progne subis
Rough-winged Swallow	Stelgidopteryx ruficollis
Barn Swallow	Hirundo rustica
American Crow	Corvus brachyrhynchos
Fish Crow	Corvus ossifragus
Tufted Titmouse	Parua bicolor
Carolina Chickadee	Parus carolinensis
White-breasted Nuthatch	Sitta carolinensis
House Wren	Troglodytes aedon
Carolina Wren	Thryothorus ludovicianus
Marsh Wren	Cistothorus palustris
Sedge Wren	Cistothorus platensis
Blue-gray Gnatcather	Polioptila caerulea
Eastern Bluebird	Sialia sialis
Gray Catbird	Dumetella carolinensis
Mockingbird	Mimus polyglottos
Brown Thrasher	Toxostoma rufum
American Robin	Turdus migratorius
European Starling	Sturnus vulgaris
Cedar Waxwing	Bombycilla cedrorum
White-eyed Vireo	Vireo griseus
Red-eyed Vireo	Vireo olivaceus
Yellow-rumped Warbler	Dendroica coronata
Blackpoll Warbler	Dendroica striata
Prairie Warbler	Dendroica discolor
Pine Warbler	Dendroica pinus
Louisianna Waterthrush	Seiurus motacilla
Common Yellowthroat	Geothlypis trichas
Yellow-breasted Chat	Icteria virens
Summer Tanager	Piranga rubra
Northern Cardinal	Cardinalis cardinalis
Blue Grosbeak	Guiraca caerulea
Indigo Bunting	Passerina cyanea
House Finch	Carpodacus mexicanus
American Goldfinch	Carduelis tristis
Rufous-sided Towhee	Pipilo erythrophthalmus
Sharp-tailed Sparrow	Ammospiza caudacuta
Seaside Sparrow	Ammospiza maritima
Song Sparrow	Melospiza melodia
Chipping Sparrow	Spizella passerina
Field Sparrow	Spizella pusilla
Swamp Sparrow	Melospiza georgiana

Appendix I: ---continued---

Eastern Meadowlark	Sturnella magna
Red-winged Blackbird	Agelaius phoenicius
Brown-headed Cowbird	Molothrus ater
Common Grackle	Quiscalus quiscula
Boat-tailed Grackle	Quiscalus major
Orchard Oriole	Icterusspurius

Appendix II: Breakdown of marsh use categories by species. Categories include: one - bird in direct contact with marsh, two - bird not in direct contact with marsh but foraging on prey just over or on marsh surface, three - bird flying over marsh but under 50 m in altitude and or associated with water within 50 m of shoreline.

Species	N	User Category		
		one	Two	Three
Common Loon	2	-----	-----	100.0
Double-crested Cormorant	10	-----	-----	100.0
Mute Swan	4	100.0	-----	-----
Canada Goose	5	40.0	-----	60.0
Mallard	88	34.1	-----	65.9
Black Duck	8	87.5	-----	12.5
Clapper Rail	205	99.5	-----	0.5
Virginia Rail	6	100.0	-----	-----
American Oystercatcher	2	-----	-----	100.0
Piping Plover	2	100.0	-----	-----
Killdeer	21	66.7	-----	33.3
Willet	245	71.4	2.0	26.5
Greater Yellowlegs	7	100.0	-----	-----
Lesser Yellowlegs	1	100.0	-----	-----
Spotted Sandpiper	28	75.0	-----	25.0
Semipalmated Sandpiper	3	100.0	-----	-----
Laughing Gull	394	6.6	2.3	91.1
Ring-billed Gull	1	-----	-----	100.0
Herring Gull	2	-----	-----	100.0
Common Tern	12	41.7	-----	58.3
Forster's Tern	55	-----	-----	100.0
Least Tern	11	9.0	-----	91.0
Royal Tern	2	-----	-----	100.0
Black Skimmer	5	-----	60.0	40.0
Bald Eagle	3	66.7	-----	33.3
Turkey Vulture	2	-----	-----	100.0
Northern Harrier	9	22.2	22.2	55.6
Red-tailed Hawk	9	44.4	11.2	44.4
Osprey	103	28.2	1.0	70.8
Northern Bobwhite	12	-----	-----	100.0
Least Bittern	1	100.0	-----	-----
Yellow-crowned Night-heron	34	100.0	-----	-----
Green Heron	108	82.4	-----	17.6
Snowy Egret	9	66.7	-----	33.3
Great Egret	59	49.2	-----	50.8
Great Blue Heron	174	50.0	-----	50.0
Glossy Ibis	1	-----	-----	100.0
Rock Dove	2	50.0	-----	50.0
Mourning Dove	50	58.0	-----	42.0
Yellow-billed Cuckoo	6	66.7	-----	33.3

Appendix II: ---continued---

Chimney Swift	29	-----	96.6	3.4
Ruby-throated Hummingbird	10	30.0	10.0	60.0
Belted Kingfisher	9	33.3	11.1	55.6
Red-headed Woodpecker	10	70.0	-----	30.0
Red-bellied Woodpecker	3	100.0	-----	-----
Common Flicker	59	83.1	-----	16.9
Pileated Woodpecker	1	-----	-----	100.0
Downy Woodpecker	9	88.9	-----	11.1
Eastern Kingbird	59	86.4	6.8	6.8
Great-crested Flycatcher	14	100.0	-----	-----
Eastern Pewee	7	85.7	-----	14.3
Tree Swallow	26	3.8	96.2	-----
Purple Martin	78	-----	66.7	33.3
Rough-winged Swallow	1	100.0	-----	-----
Barn Swallow	339	3.8	94.7	1.5
American Crow	103	71.8	-----	28.2
Fish Crow	25	64.0	-----	36.0
Tufted Titmouse	14	100.0	-----	-----
Carolina Chickadee	22	95.5	-----	4.5
White-breasted Nuthatch	1	100.0	-----	-----
House Wren	17	100.0	-----	-----
Carolina Wren	52	100.0	-----	-----
Marsh Wren	16	100.0	-----	-----
Sedge Wren	1	100.0	-----	-----
Blue-gray Gnatcatcher	4	100.0	-----	-----
Eastern Bluebird	25	92.0	-----	8.0
Gray Catbird	10	90.0	-----	10.0
Mockingbird	39	82.1	-----	17.9
Brown Thrasher	7	100.0	-----	-----
American Robin	47	59.6	-----	40.4
European Starling	83	80.7	-----	19.3
Cedar Waxwing	1	100.0	-----	-----
White-eyed Vireo	7	100.0	-----	-----
Red-eyed Vireo	3	100.0	-----	-----
Yellow-rumped Warbler	4	100.0	-----	-----
Blackpoll Warbler	1	100.0	-----	-----
Prairie Warbler	8	100.0	-----	-----
Pine Warbler	9	88.9	-----	11.1
Louisianna Waterthrush	1	100.0	-----	-----
Common Yellowthroat	155	100.0	-----	-----
Yellow-breasted Chat	16	93.8	-----	6.2
Summer Tanager	10	90.0	-----	10.0
Northern Cardinal	50	88.0	-----	12.0
Blue Grosbeak	3	100.0	-----	-----
Indigo Bunting	8	100.0	-----	-----
House Finch	25	44.0	-----	56.0
American Goldfinch	20	75.0	-----	25.0

Appendix II: ---continued---

Rufous-sided Towhee	47	95.7	-----	4.3
Sharp-tailed Sparrow	36	97.2	-----	2.8
Seaside Sparrow	328	87.2	-----	12.8
Song Sparrow	85	100.0	-----	-----
Chipping Sparrow	55	78.2	-----	21.8
Field Sparrow	9	100.0	-----	-----
Swamp Sparrow	2	100.0	-----	-----
Eastern Meadowlark	12	100.0	-----	-----
Red-winged Blackbird	671	87.6	-----	12.4
Brown-headed Cowbird	15	86.7	-----	13.3
Common Grackle	294	38.8	-----	61.2
Boat-tailed Grackle	120	69.2	-----	30.8
Orchard Oriole	10	100.0	-----	-----

Appendix III : Total frequency of birds observed during each survey period for all marshes combined (list of scientific names given in appendix I).

Species	Census Number				Total
	one	two	three	four	
Common Loon	2	0	0	0	2
Double-crested Cormorant	2	7	0	1	10
Mute Swan	0	0	4	0	4
Canada Goose	3	2	0	0	5
Mallard	23	20	22	23	88
Black Duck	0	0	1	7	8
Clapper Rail	66	53	51	35	205
Virginia Rail	6	0	0	0	6
American Oystercatcher	2	0	0	0	2
Piping Plover	2	0	0	0	2
Killdeer	2	3	5	11	21
Willet	82	71	67	25	245
Greater Yellowlegs	5	0	0	2	7
Lesser Yellowlegs	1	0	0	0	1
Spotted Sandpiper	13	14	0	1	28
Semi-palmated Sandpiper	0	3	0	0	3
Laughing Gull	124	87	71	112	394
Ring-billed Gull	0	1	0	0	1
Herring Gull	0	1	1	0	2
Common Tern	4	5	2	1	12
Forster's Tern	12	0	11	32	55
Least Tern	7	2	1	1	11
Royal Tern	2	0	0	0	2
Black Skimmer	0	0	0	5	5
Bald Eagle	0	0	1	2	3
Turkey Vulture	0	1	1	0	2
Northern Harrier	2	1	4	2	9
Red-tailed Hawk	0	3	3	3	9
Osprey	28	17	35	23	103
Northern Bobwhite	2	3	6	1	12
Least Bittern	0	1	0	0	1
Yellow-crowned Night-heron	12	10	6	6	34
Green Heron	12	17	35	44	108
Snowy Egret	4	3	0	2	9
Great Egret	10	11	15	23	88
Great Blue Heron	39	43	46	46	174
Glossy Ibis	0	0	0	1	1
Rock Dove	0	1	0	1	2
Mourning Dove	7	7	14	22	50
Yellow-billed Cuckoo	1	0	4	1	6
Chimney Swift	13	2	14	0	29
Ruby-throated Hummingbird	2	0	2	6	10

Appendix III: ---continued---

Belted Kingfisher	1	2	5	1	9
Red-headed Woodpecker	8	0	1	1	10
Red-bellied Woodpecker	1	1	0	1	3
Northern Flicker	15	19	10	15	59
Pileated Woodpecker	0	0	1	0	1
Downy Woodpecker	0	2	3	4	9
Eastern Kingbird	15	19	18	7	59
Great-crested Flycatcher	5	1	6	2	14
Eastern Wood Pewee	2	1	0	4	7
Tree Swallow	15	5	3	3	26
Purple Martin	1	1	8	68	78
Rough-winged Swallow	0	0	1	0	1
Barn Swallow	83	57	113	86	339
American Crow	11	47	10	35	103
Fish Crow	8	4	10	3	25
Tufted Titmouse	1	1	7	5	14
Carolina Chickadee	8	7	6	1	22
White-breasted Nuthatch	0	0	0	1	1
House Wren	1	4	7	5	17
Carolina Wren	8	6	23	15	52
Marsh Wren	5	4	4	3	16
Sedge Wren	1	0	0	0	1
Blue-gray Gnatcatcher	3	1	0	0	4
Eastern Bluebird	7	5	10	3	25
Gray Catbird	6	2	2	0	10
Mockingbird	6	9	8	16	39
Brown Thrasher	1	1	3	2	7
American Robin	7	7	8	25	47
European Starling	11	27	17	28	83
Cedar Waxwing	1	0	0	0	1
White-eyed Vireo	1	2	1	3	7
Red-eyed Vireo	0	2	0	1	3
Yellow-rumped Warbler	4	0	0	0	4
Blackpoll Warbler	0	1	0	0	1
Prairie Warbler	6	1	1	0	8
Pine Warbler	3	2	4	0	9
Louisianna Waterthrush	0	0	0	1	1
Common Yellowthroat	42	22	41	50	155
Yellow-breasted Chat	6	5	3	2	16
Summer Tanager	3	3	2	2	10
Northern Cardinal	12	6	19	13	50
Blue Grosbeak	3	0	0	0	3
Indigo Bunting	0	0	4	4	8
House Finch	5	10	8	2	25
American Goldfinch	13	4	3	0	20
Rufous-sided Towhee	10	7	10	20	47
Sharp-tailed Sparrow	22	14	0	0	36
Seaside Sparrow	114	62	81	71	328

Appendix III: ---continued---

Song Sparrow	30	23	17	15	85
Chipping Sparrow	21	10	16	8	55
Field Sparrow	0	2	2	5	9
Swamp Sparrow	2	0	0	0	2
Eastern Meadowlark	4	5	3	0	12
Red-winged Blackbird	184	171	176	140	671
Brown-headed Cowbird	10	2	2	1	15
Common Grackle	45	69	88	92	294
Boat-tailed Grackle	36	45	17	22	120
Orchard Oriole	2	0	4	4	10