

**Responses of wading birds
to natural and unnatural
disturbances in Cumberland Sound**

CPSU Technical Report No. 53

Susan P. Bratton
US National Park Service
Cooperative Studies Unit
Institute of Ecology
University of Georgia
Athens, GA 30602

March 1989

***U.S. National Park Service
Cooperative Studies Unit
Institute of Ecology
University of Georgia
Athens, GA 30602***

Purpose and Content of the Report Series

In order to make data and results from research and monitoring projects more easily and quickly available to interested scientists and National Park Service staff, the Cooperative Park Studies Unit at the Institute of Ecology, University of Georgia, has initiated a numbered *Technical Report* series. This series produces limited printings of scientific project reports, data matrices, bibliographies, species check lists, review papers and summaries of resources management activities which concern U.S. National Park Service areas and park-related problems. The reports are from various sources, not all federally funded. These reports are not intended to determine park policy, but rather to distribute information to interested scientists and managers.

CPSU Technical Reports are sent to at least two reviewers for technical editing and evaluation for scientific accuracy. They are not necessarily reviewed for their importance to the national scientific community, but rather for their usefulness in park management.

Bratton, S.P. 1989. Responses of wading birds to natural and unnatural disturbances in Cumberland Sound. *Institute of Ecology, NPS-CPSU Technical Report No. 53*, 24 pp.

Abstract

Disturbance data were collected during the spring and fall sampling periods of a wading bird survey on Cumberland Island and during an experimental series of small boat runs along the shore of Cumberland Sound and in Old House and Beach Creek estuaries. Researcher initiated disturbances were the most common during the wading bird survey. Natural disturbance agents such as racoons and hawks were more common than unnatural disturbance agents, such as boats and vehicles, but unnatural agents elicited greater response. Five percent of groups of waders present flushed in response to ungulates, 36% flushed in response to birds of prey, 70% flushed in response to boats and 62% flushed in response to other human disturbances. Waders along the Sound shore were much less likely to respond to the small boat than wading birds in the estuary. From Sea Camp to Beach Creek 15% of the groups of wading birds encountered were disturbed, whereas in Beach Creek 74% were disturbed. Wading birds in trees or on docks were less likely to respond than birds in the water, on the shore or in *Spartina*. There were between species differences in response to the small boat. Snowy egrets responded 43% of the time when in the water or along the shore, great egrets 62%, wood storks 86% and white ibises 93%. Birds disturbed in the estuaries were more likely to fly away from the point where they encountered the boat and dispersed further within the local area. On the average, the boat was closer to the birds in the estuaries, but birds in the creeks were also more sensitive to the presence of the boat than birds on the shore of the Sound and flushed when the boat was further away. The percentage of the birds flying in response to the boat was a function of distance from the boat, up to an estimated distance of 60 meters. The data imply an increase in naval traffic along the present Intracoastal Waterway will probably result in little increased disturbance of wading birds. Increases in recreational boating traffic in the estuaries may have an adverse impact on foraging and resting wading birds, however, and should be monitored to prevent deterioration of estuarine habitats.

Introduction

As the coasts of the United States undergo ever-expanding development for human residential, industrial and recreational use, the habitats for wading birds have become increasingly subject to human disturbance. The Cumberland Sound, located in Camden County, Georgia, and Nassau County, Florida supports some of the most extensive salt marshes to be found anywhere in the world and feeds a diverse wading bird fauna, approaching the Florida Everglades in the number of species present. Although part of the Cumberland Sound ecosystem is protected by Cumberland Island National Seashore, industrial and military use of the region are expanding, and with them, commercial and recreational use of the Sound. The construction of the King's Bay Naval Submarine Base has not only increased dredging activities and military boat traffic, it has stimulated the local economy, thus producing more recreational boaters. The purpose of this study is:

- 1) to evaluate present levels of disturbance to wading birds on Cumberland Island National Seashore,
- 2) to determine what percentage of present disturbances are unnatural,
- 3) to determine the potential impact of increasing boat traffic in the Intracoastal Waterway on wading birds, and
- 4) to determine the potential impact of increased recreational boating traffic in the estuaries of Cumberland Sound.

The literature has already documented the sensitivity of wading and shore birds to disturbance during breeding and nesting, with the possibility for resulting nest failure. Kury and Gochfield (1975) found human intrusion encouraged gull predation on double-crested cormorant (*Phalacrocorax auritus*) nests, and Ellison and Cleary (1978) found frequent human visits caused cormorant nest abandonment and gull predation on nests. Tremblay and Ellison (1979) found research visits to black-crowned night heron (*Nycticorax nycticorax*) colonies just prior to or during nesting caused abandonment of eggs and encouraged predation. Parsons and Burger (1982) found black-crowned night heron chicks which had been handled did not move from the nest when disturbed, whereas control chicks did. Werschkul *et al.* (1979) found nest occupancy for great blue herons (*Ardea herodias*) was 67% in disturbed areas, whereas it was 93% in areas with low human disturbance. The further a nest was located from a point of human disturbance (primarily logging in this study), the more likely it was to be occupied. Vos *et al.* (1985) found 67% of human intrusions into a great blue heron rookery caused the birds to flush from their nests. Their data indicate human intrusions from land are more likely to cause disturbance than those from the water. Boats passing the heronry caused minimal responses 92% of the time, moderate responses 8% of the time and no general responses (the entire heronry flushed), whereas land based motor

vehicles caused moderate responses 55% of the time and general responses 27%. This pattern applied to all three heron rookeries surveyed. Vos *et al.* (1985) also found herons were most sensitive to human initiated disturbances early in the breeding season. Burger (1981) examined the response of several species of shore and wading birds to human intrusion in foraging as well as nesting areas. She found joggers and walkers more likely to disturb birds than worm-diggers and horse back riders. Birds were present at her sample sites 42% of the time when people were present, but were present 72% of the time when people were absent. Muller and Glass (1988) found drilling of oil wells caused wading birds to temporarily abandon a nearby rookery. The literature lacks detailed studies of human interference with foraging behavior, or of boat disturbance of feeding or resting birds away from rookeries.

Methods

Wading bird survey

This disturbance study had two parts. The first was conducted in conjunction with a general survey of wading bird habitat use on Cumberland Island National Seashore. The wading bird survey as a whole attempted to compare both salt and freshwater habitats at four seasons, at different times of day, and at different tides. Beach Creek marsh and South End Ponds, areas liable to disturbance by dredging to deepen the channels for the Trident submarines, served as key study areas. Four major wading bird study locations were selected on Cumberland Island. Two of these, the South End Ponds (including the mouth of Beach Creek) and Beach Creek marsh are liable to disturbance from boats and from dredges. The other two, Lake Whitney ponds and lakes and Table Point marsh, are liable to local human disturbance but do not adjoin any actively dredged channels and are subject to occasional small boat use. In each study area several observation points were chosen, usually based on the presence of representative habitats and breadth of view (Table 1, Figure 1). The survey included a variety of tidal creek and salt marsh habitats as well as freshwater ponds of various sizes. Sampling was conducted at four seasons, but disturbance data were formally collected only during summer and fall. Summer sampling extended from June 17 to Sept. 1, and fall sampling extended from Oct. 5 to Nov. 4, 1987. An attempt was made to sample each location three or four times a day for each of two days within a four day period. This was repeated four times for fall and seven times for summer. Generally there was a four to six day break between these four day sampling sessions. Sampling began in the early morning (an attempt was made to start one half hour after sunrise, but transportation availability and tides sometimes slowed the initiation) and ended about one half hour before sunset.

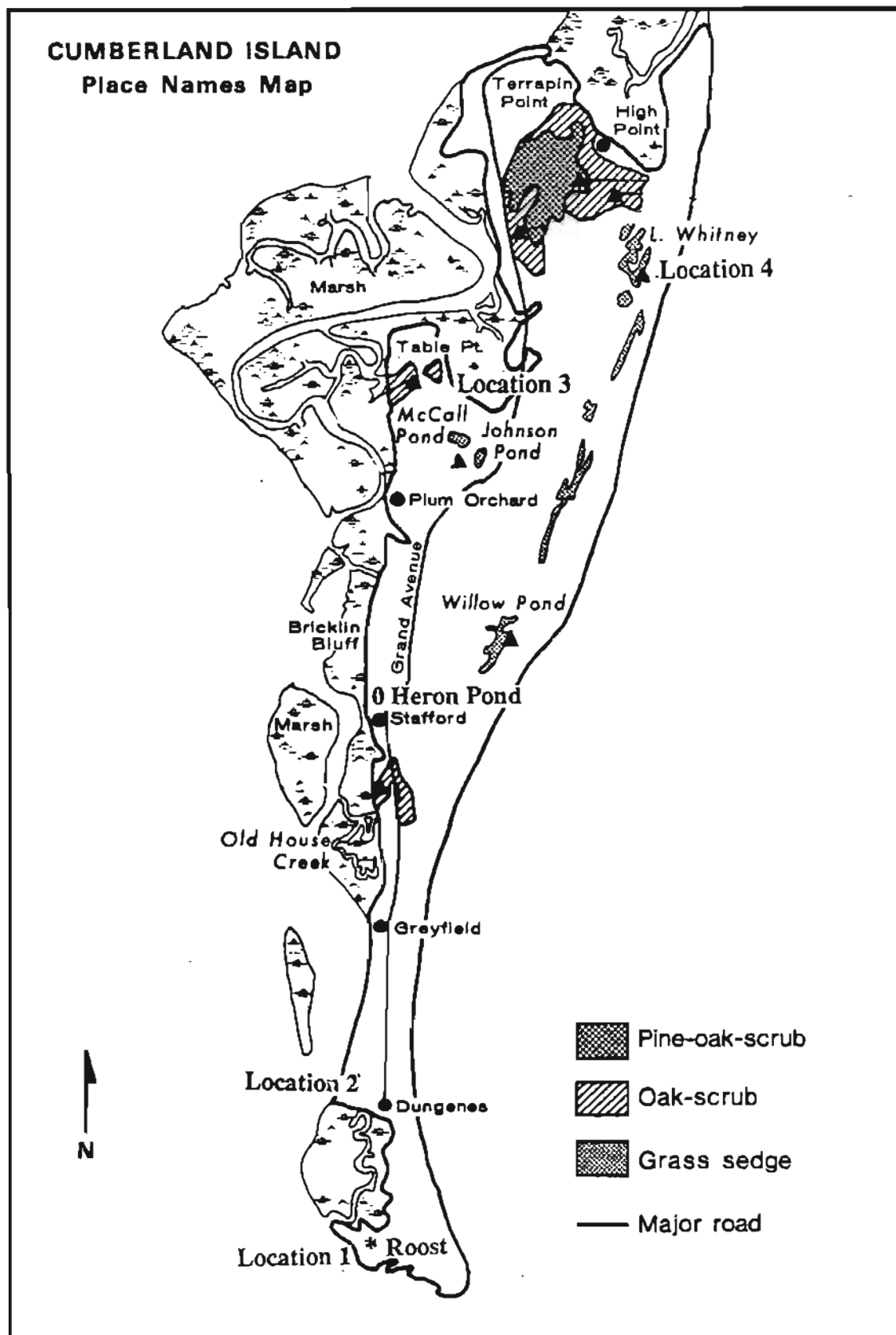


Figure 1: The four major sampling locations, the nesting area at Heron Pond and the roost at South End Ponds.

Table 1: Study locations

Location 1 - South End Ponds

- Site 1 - The outer most pond (towards Cumberland Sound), blind at the east end, the pond is brackish
- Site 2 - The largest (middle) pond, blind on the west end (entire pond not visible), the pond is fresh
- Site 3 - The mouth of Beach Creek, from a blind near the south west bank, salt water creek and tall *Spartina* marsh

Location 2 - Dungeness shore and Beach Creek marsh

- Site 1 - Dungeness Dock, viewing the shoreline of Cumberland Sound from Racoon Keys to Sea Camp Dock, all tidal flat
- Site 2 - The shore of Beach Creek below the Park Maintenance Building, this has a view of the main branch of Beach Creek with tall *Spartina* and mud banks
- Site 3 - Beach Creek marsh from the high dune just below Dungeness Beach Trail, this has a view of the upper end of the marsh and second and third order creeks, and of the low *Spartina* flats along the east edge of the marsh

Location 3 - Table Point marsh and Hawkins Creek

- Site 1 - Table Point marsh from a blind at the forest edge on the east side, a view of low *Spartina* flats at the south end of the marsh and second and third order tidal creeks of Malkintoo Creek
- Site 2 - A small slough crossed by the Main Road at Red Bridge (the second slough south of South Cut Road), the slough is tidal but has fresh water draining into it
- Site 3 - The Brickhill River from a blind just south of Brickhill Campsite, the shores are lined by mud banks and oyster bars similar to the edge of Cumberland Sound
- Site 4 - Hawkins Creek at the Boat Dock and at a point just to the north of the Dock on a pile of sawdust from an old mill, the view is of tall and short *Spartina*, and the mud banks of a medium sized primary tidal creek

Table 1: Study locations (continued)

Location 4 - Lake Whitney

Site 1 - The small pond at the intersection of South Cut Road and Roller Coaster Trail to the north east of South Cut Road, all these sites are fresh water

Site 2 - A small pond to the east of Roller Coaster Trail before reaching Lake Whitney

Site 3 - The south end of Lake Whitney from a blind just to the west of Roller Coaster Trail, the site includes floating mat vegetation

Site 4 - The north end of Lake Whitney from a blind on the dune where Roller Coaster Trail veers away from the lake edge and heads out into the sand dune area, the site includes floating mat vegetation

The time taken to complete observations at each station was variable, but the sampling periods (the time taken to visit all locations within a study area) generally lasted about one and a half to two hours each. Observers were required to stay ten minutes at each location even if no birds were present. If birds were present, observers stayed about twenty minutes, recording feeding and other activities. Early morning, late morning, early afternoon and evening sampling periods were completed. The time between sampling periods was shorter in the fall, due to the shorter day length.

On each sampling day, either South End Ponds and Beach Creek were sampled, or Table Point and Lake Whitney were sampled. Thus, sampling of freshwater sites was conducted at the same time as estuarine sites. On some occasions, some sample periods were missed because of weather. This happened several times in late afternoon in late summer, due to violent thunderstorms. Sampling was conducted during rain when there was no threat of lightning.

At each location the observer recorded all species of wading birds present on arrival, and recorded others as they flew in during the first ten minutes. The observers took environmental information, including date, cloud cover, wind direction, wind speed, amount of rainfall in the last twenty four hours, air temperature, water depth (on depth markers placed on the sites), time of day, and time of the next high tide. Water temperature was collected periodically through the season. Each wading bird species noted was recorded by number of individuals present, micro-habitat used, and behavior. Important micro-habitats included open water, mud flat, mud bank, low *Spartina*, high *Spartina*, (sitting in) trees, floating mat of vegetation, and open sky. Behaviors included: unknown, inactive, preening, flying, courtship, passive hunting (stationary), active hunting (eg. walking slowly) and aggressive hunting (eg. foot stir, fast walk). Notes were

of service.

The intent was to complete 20 runs on each sample route, but Beach Creek was closed in September, due to dredging activity, so 20 runs were completed on Old House Creek and 17 runs were completed on Beach Creek. The boat was run as close to the Sound shore as possible, generally following the line of crab traps set in shallow water about 25 to 35 meters from the bank. In the estuary the boat followed the pattern of local fishermen, who move to the outside of the meanders to avoid running aground on the bars. It should be noted large craft, such as barges, could not safely navigate the shore of the Sound as close to the bank as these small boat runs. The study had a policy of stopping the boat if wood storks (*Mycteria americana*), an endangered species, were seen in trees ahead, but this did not prove to be a problem since wood storks visible from a distance were usually south of the Old House Dock. Wood storks were flushed from the estuaries on a few occasions.

Each sampling run began as soon as the boat left Sea Camp dock. The starting time and the time to the nearest high tide were recorded as were the date, the observers, the weather conditions and the presence of any other craft along the route. Any wading birds spotted within 50 meters of the shore line were included in the survey and were recorded initially by species, number of individuals in a group, the behavior when first seen, and the habitat when first seen. Behaviors included resting, walking, foraging, and preening. Habitats included in water, on bank or oyster beds, in *Spartina*, in trees or shrubs and on docks, pilings or boats. The recorder then estimated the probable minimum passing distance for the boat in five meter increments (ie. 5, 10, 15, etc.). An attempt was made to use a range finder, but the birds flushed too quickly so estimation was employed. All recorders had experience using metric distances up to 50 meters for vegetation sampling. The recorder then noted the response behavior (none, startled or aware, or flushed), and the time of the response relative to the distance from the boat (sound [prior to the boats being seen by the bird], sight or approach, parallel, or wake). The recorder watched the bird as it flew and tried to determine where it landed. The displacement categories were: none, nearby on the same side of the creek or sound (less than 50 meters), nearby on the same side of the creek or sound (less than 200 meters), same side of the creek or sound (greater than 200 meters), opposite side of the creek (less than 200 meters), opposite side of the creek (greater than 200 meters), to the tree line at the edge of the marsh, out of the marsh or away from the bank of the sound, or undetermined. An attempt was usually made to estimate the total distance flown. On the return trip the recorder noted the species seen, their group size, and their behavior and habitat when first encountered by the boat. Analysis of the data was via Cricket Graph on an Apple Macintosh micro-computer and through use of Chi-Square tables found in Snedecor and Cochran (1971).

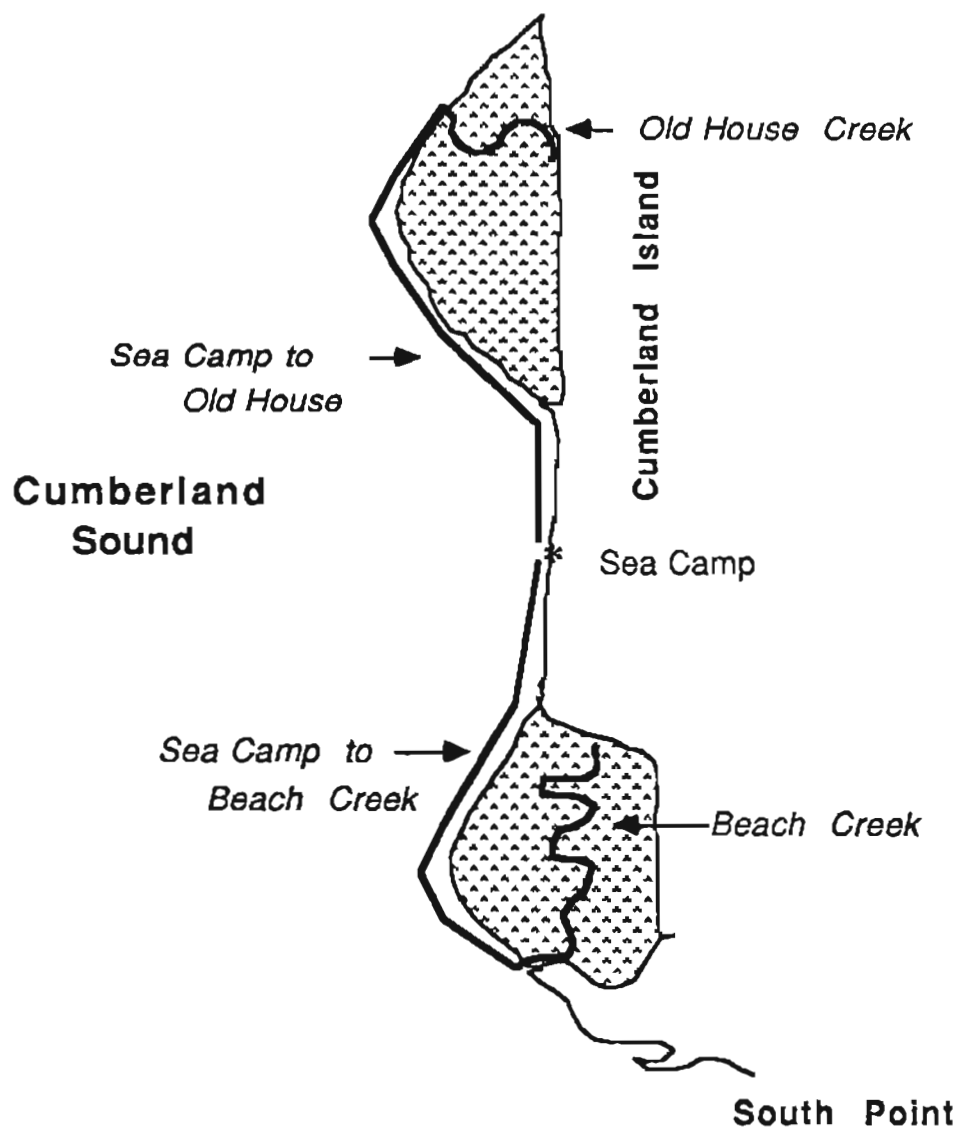


Figure 2: The four routes used in the bird disturbance study: Sea Camp to Beach Creek, Beach Creek, Sea Camp to Old House, and Old House Creek.

Results

The wading bird survey

Formal sampling collected a total of 2004 observations of the 14 sampling sites: 369 in winter, 448 in spring, 739 in summer and 448 in the fall. Forty one percent of the summer observations and 49% of the fall observations did not encounter any wading birds. Of the observations with birds present, researchers were the most important source of disturbance, being always on site during the sampling interval and causing some reaction from the birds during 90 observations or 13% of the observations with birds present. (Note, there may be several disturbed groups of wading birds during one observation.) Boats were the next most common source of unnatural disturbance, present during 12 observations (five when no birds were present), and pedestrians were the third most common, present during six observations (four when no birds were present.) Terrestrial vehicles and low flying aircraft were noted during three and two observations respectively. (Fig. 3) Among possible natural disturbance factors horses and other ungulates were noted during 30 observations, birds of prey during nine, interactions between wading birds during six, raccoons or otters during six, a turkey during one and an alligator during one. (Figure 3).

The unnatural disturbances (other than researcher presence) were much more common at midday - in the second (late morning) and the third (mid-afternoon sampling period) - whereas natural disturbances were more dispersed during the day (Fig. 4). Chi-square tests indicate a significant difference at $p > .05$ among the four sampling periods for unnatural disturbances, but no significant differences in time of day for natural disturbances ($X^2 = 13.38$ and $X^2 = 4.63$ for d.f.=3.)

Natural disturbances, with the exception of birds of prey caused very little reaction from the wading birds. The waders foraged freely among feral horses and other ungulates. Cattle egrets were observed standing on feral horses. Only three of 67 sightings of groups of wading birds near ungulates noted waders flying because of disturbance by the ungulates. Sixty-one of the sightings of groups indicated no response, and three groups changed in posture but did not move from the site. Otters, raccoons and alligators, all potential predators, did not draw strong responses. Birds did change posture as raccoons or otters approached, but only one was recorded as flying. In one case, a little blue heron (*Florida caerula*) was observed fishing next to an otter, apparently using the otter as a "beater" for prey. Birds of prey caused stronger responses, nine groups did not show any change in behavior, three changed posture, two stopped feeding, three flew and returned to the area and five flew and did not return.

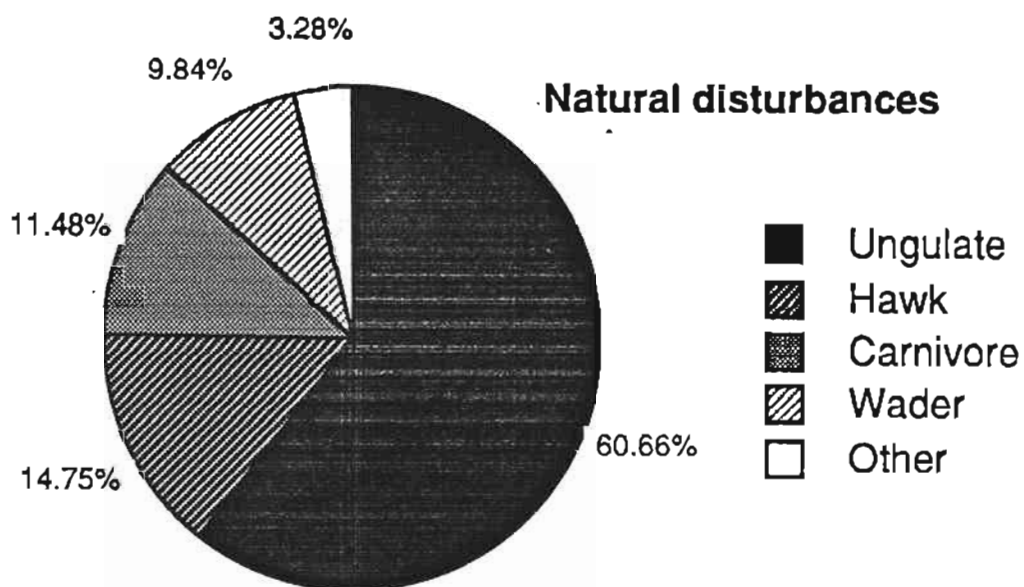
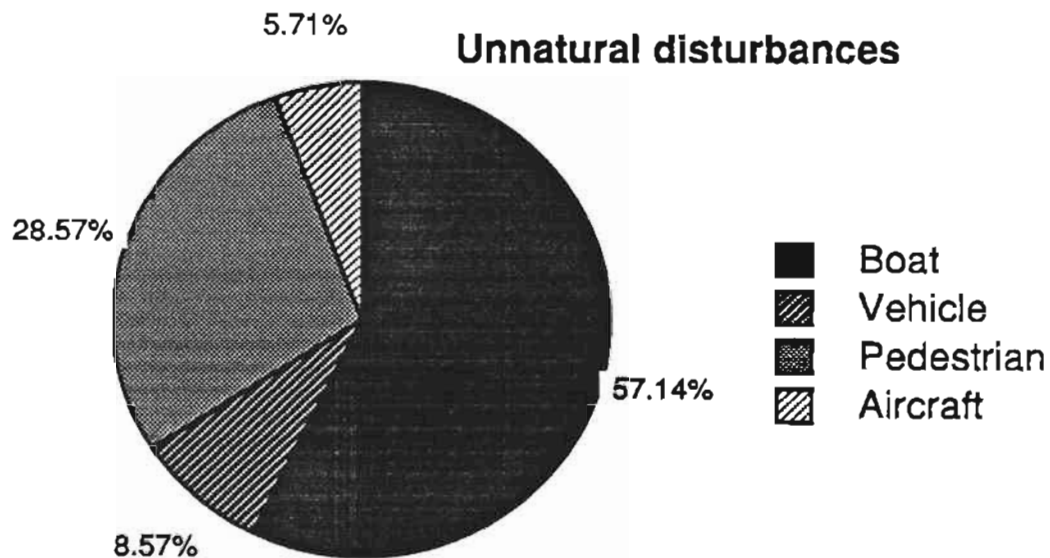


Figure 3. The percentage of disturbances from different sources during the wading bird study.

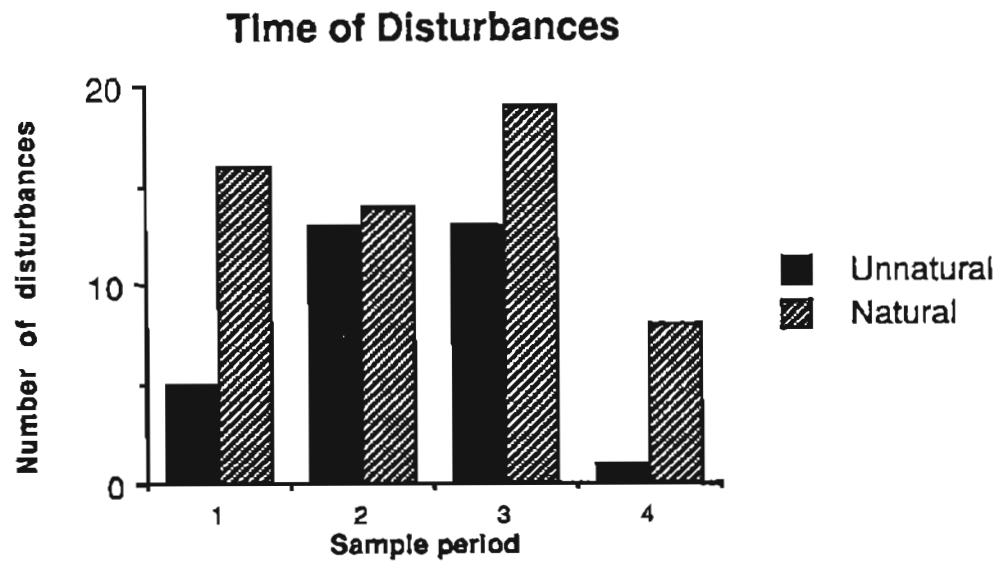


Figure 4: The distribution of disturbances during different sampling periods for the wading bird study. Note the first period was just after dawn, the second was mid-morning, the third mid-afternoon and the fourth just before sunset.

Waders were very responsive to unnatural disturbances of all sorts. (Table 2) During the 90 observations where birds noticed researchers, there was negligible response from 10 groups, and two groups changed posture and one stopped feeding. Twenty-six groups flew and returned and 93 flew away and did not return. Of groups disturbed by boats, two had no noticeable response, four changed posture, one walked away, six flew away and returned and eight flew away and did not return. The response to boats was thus stronger than the response to birds of prey. In the case of other human disturbances, in eight of thirteen groups, the birds flushed. It should be noted boats only appeared at some of the survey sites (several are not passable to boats), primarily the mouth of Beach Creek, Hawkins Creek and Dungeness Dock. Most of the survey sites were not easily accessible to vehicles.

In comparing the number of groups which flushed to those remaining on the ground, there was no significant difference between boats and other human caused disturbances (summed, excluding researchers, $X^2=1.67$, $p<.90$). There was also, needless to say, a significant difference between birds of prey and ungulates ($X^2=35.78$, $p<.005$), but no significant difference between birds of prey and boats ($X^2=4.80$, $p<.10$), although there was a trend towards boats as the more serious disturbance. The disturbances thus could be divided into two general categories: those agents frequently causing the birds to flush, which included birds of prey, boats and people, and those agents infrequently causing the birds to flush, which included ungulates and terrestrial carnivores. (Table 2)

Table 2: Percentage of groups flushed by different disturbances

<i>Disturbance</i>	<i>Percentage of groups</i>		
	<i>No response</i>	<i>Behavior change</i>	<i>Flushed</i>
Ungulate	91.0	4.5	4.5
Carnivore*	16.6	66.7	16.7
Bird of prey	40.9	22.7	36.4
Boat	10.0	20.0	70.0
Other human	30.7	7.6	61.5

*Very low sample size

Boat disturbance study

The Sound shore versus the estuaries

The primary species encountered on the boat disturbance study were snowy egrets (*Egretta thula*), great egrets (*Casmerodius albus*) and white ibises (*Eudocimus albus*) (the latter primarily on Old House Creek). Other species recorded included great blue herons (*Ardea herodias*), little blue herons (*Florida caerula*), wood storks, tricolored herons (*Hydranassa tricolor*), green herons (*Butorides virecens*) and cattle egrets (*Bubulcus ibis*). Other wading species, such as glossy ibis (*Plegadis falcinellus*), were present in the Cumberland Sound area during the study period but were not encountered on sample runs. The percent of wading bird groups responding to the boat differed by the route and the habitat (Table 2). From Sea Camp to the mouth of Beach Creek 15% of the total groups encountered were disturbed (showed reaction to the boat or flew), from Sea Camp to the mouth of Old House Creek 34% of the groups encountered were disturbed, in Beach Creek 74% of the total groups were disturbed, and in Old House 83% were disturbed. Almost all the birds recorded as responding to the boat flushed; less than 5% showed changes in posture without flying.

Table 3: The percentage of groups of wading birds disturbed by a small boat by route and by habitat

Route	Percentage of groups encountered which were disturbed by habitat				TOTAL
	Trees & dock	In water	Bank	Spartina	
Sea Camp to Beach Creek	0.0	9.6	20.9	21.4	15.2
Sea Camp to Old House	0.0	31.4	34.1	50.0	34.1
Beach Creek	36.7	87.5	87.3	83.1	73.6
Old House Creek	23.1	84.6	89.7	90.3	83.2

Note: The total is not an average of the habitats, since there were not equal numbers of groups distributed among the habitats, but is based on the sum of all sightings along a route.

Birds in trees or resting on docks or pilings were much less likely to be disturbed by the passing boat than those in the water, on the banks, or in *Spartina alterniflora*. Interestingly, birds in *Spartina*, which is further from the boat than the edge of the water and offers some visual cover, were as likely to be disturbed as birds in the water or on the bank.

Differences between species

Between species differences could not be computed for some of the waders, as counts were too low. Overall, however, snowy egrets appeared to be the least sensitive to the boats with 43% of the groups responding. (These figures do not include birds on docks or in trees.) Great egrets and great blue herons were more easily disturbed with 62% and 69% of the groups responding respectively. White ibises were very sensitive with 93% of the groups (often large flocks of 50 birds) responding. Tricolor herons were also very sensitive with 95% of groups (primarily individual birds) observed responding, as were green herons at 88%, and little blue herons at 93%. (It should be noted the three latter species were more common in the estuaries, where disturbance rates were higher overall.) The number of wood storks seen in the water or along the banks was low, but six groups out of seven observed flushed, indicating a response rate of 86%, and a high sensitivity to boat disturbance. The differences between the snowy egrets, great egrets and white ibises will, for example, provide a $X^2=35.51$, $p < .005$. The differences do not appear to be due to differences between the numbers of egrets and ibises occurring along the banks of the sound as opposed to the estuaries. Ibises encountered on the Sea Camp to Old House route, for example, had a 100% flushing rate (eight of eight encounters), indicating they are also sensitive when near the Sound.

Degree of dispersion

In terms of dispersion after disturbance, there was very little difference between the two estuarine sampling routes. (Table 4) The comparison between the two estuaries was not significant ($X^2= 7.64$, $p < .50$). A comparison between the two routes along the shore of the Sound, with the three most distant displacement categories summed due to low counts, did indicate significantly less displacement for the Sea Camp to Beach Creek route than for the Sea Camp to Old House Route ($X^2= 18.18$, $p<.005$), whereas a comparison of Sea Camp to Old House and the route within

the Old House estuary indicated less displacement along the Sound shore ($X^2=55.96$, $p<.005$). An overall average of 10% of the birds disturbed in the estuaries flew to the trees at the edge of the marsh or out of the area, while a somewhat greater percentage, 14%, of the birds along the Sound shore flew into trees or out of the area. Birds along the edge of the sound did not cross to the opposite shore, and on the Sea Camp to Beach Creek route relatively few moved an estimated 200 meters or more along the shore line. Overall, boats in the estuaries not only displace a greater percentage of the birds, but the birds in the estuaries are likely to move greater distances and are more likely to leave the bank where they were feeding or resting to escape the boat.

Table 4: The displacement of groups of wading birds disturbed by a small boat

Route	<i>Degree of displacement of disturbed groups</i>				
	<i>Percent of groups</i>				
	<i>Negligible</i>	<i><200m</i>	<i>>200m</i>	<i>Opp. shore</i>	<i>Further</i>
Sea Camp to Beach Creek	66.7	4.8	9.5	-	19.0
Sea Camp to Old House	50.0	10.0	24.0	-	16.0
Beach Creek	6.8	32.6	24.2	24.2	12.1
Old House	6.7	45.6	13.6	27.1	6.8

Passing distance versus flushing rates

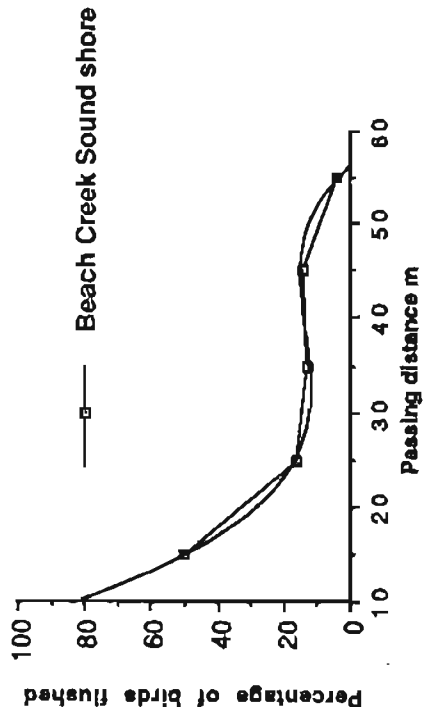
An important question is: why are the waders more easily disturbed in the creeks? Is it because the boat approaches more closely? Are waders less accustomed to boats in the creeks? Or is there some other factor involved? One clue is the boat encounter records from the survey. Although, in 17 runs, the experimental craft encountered no boats running close to the Sound shore between Sea Camp and Beach Creek, they encountered a total of five boats in the mouth of Beach Creek (part of the creek route) and five running in the creek. Three of these craft were sighted on one run and all the other runs had single sightings, so eight of 17 runs found boats present in the estuary. On the Old House to Sea Camp route there were always boats anchored along the Sound shore. The Sound route encountered three boats running near the the Sea Camp to Old House route, and none

in Old House Creek. In an examination of data collected by Debbie Allen and Robert Becker (in press) during July through Sept. of 1988, nine aerial overflights located seven moving and twenty stationary craft between Sea Camp and Beach Creek (these boats were generally further off-shore than the bird disturbance survey route), seven moving and eight stationary craft in the area of the mouth of Beach Creek, and two moving and five stationary craft in Beach Creek. The route from Beach creek to Old House had sixty-five craft total, but only three of them were moving. Three stationary craft were observed in Old House Creek. These two sources of information suggest Beach Creek is busier than Old House (yet bird responses are very similar for both sites) and although Beach Creek may have less traffic than the Cumberland Sound, the moving nearshore traffic is roughly equal near the mouth of the creek, and the in-creek traffic is perhaps a third to a quarter of the Sound shore volume away from the creek mouth. In terms of total boats present, the route along the Sound shore, Sea Camp to Old House, had more boats than the Sea Camp to Beach Creek route. It should be noted Allen and Becker's survey included low tide overflights, whereas the bird disturbance study did not run at or near low tide because the tidal creeks were too shallow (thus the proportionately higher rates of boat contact in Beach Creek for the bird disturbance study).

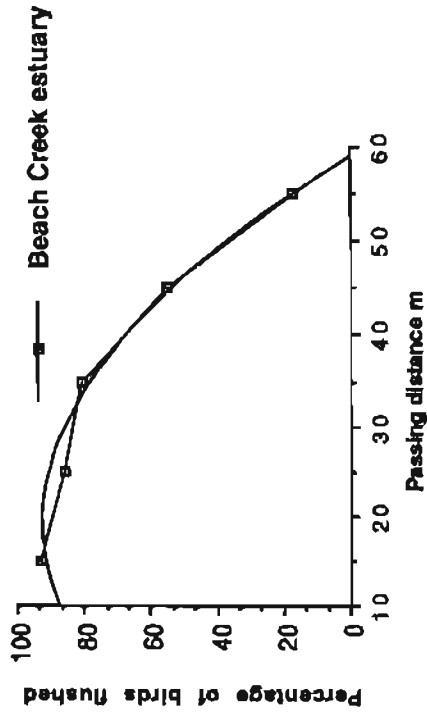
Analysis of the estimated passing distances for the birds suggests the small boats do, on the average, have a closer approach distance to the birds in the estuaries. For Sea Camp to Old House 21% of the groups of waders were estimated to be within 20 meters of the passing boat, while in the Old House estuary 37% were estimated to be within 20 meters. For the former route, the average estimated passing distance of birds that flushed was 29 meters and of birds that didn't was 31 meters. In the latter route, the average estimated distance of birds that flushed was 22 meters, and of birds that did not flush it was 37 meters. The results for the Beach Creek runs were very similar. On the Sea Camp to Beach Creek route, 16% of the waders were within 20 meters passing distance of the boat, while for Beach Creek estuary 54% were within 20 meters. For the former route, the average estimated passing distance of birds that flushed was 30 meters and for birds that didn't was 30 meters, whereas for the latter estuarine route, the average estimated passing distance for birds that flushed was 22 meters and for birds that didn't was 40 meters. The boat thus not only approached the birds more closely in the estuary, the birds were also more sensitive to the boat and flew when the boat was further away.

These patterns may also be seen in regressions of the proportion of birds flying at different passing distances. As the passing distance approaches zero meters, the percentage of birds flushed approaches 90 to 100 for all routes, except for the Sound shore between Sea Camp and Old House. (Fig. 5) As the distance from the boat increases, the flushing rate drops more quickly on the Sound shore and proportionately fewer birds are flushed at intermediate distances such as 25 or 30 meters.

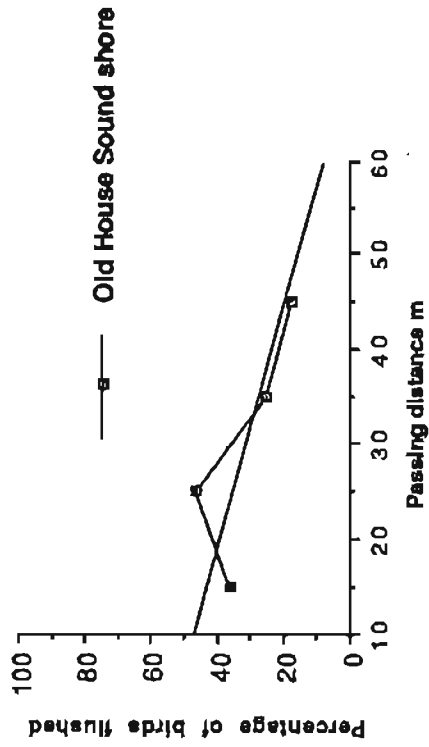
$$y = 198.78 - 15.212x + 0.40464x^2 - 3.5000e-3x^3 \quad R^2 = 0.998$$



$$y = 69.682 + 2.3200x - 5.9286e-2x^2 \quad R^2 = 0.991$$



$$y = 54.400 - 0.78000x \quad R^2 = 0.631$$



$$y = 114.05 - 1.0300x \quad R^2 = 0.980$$

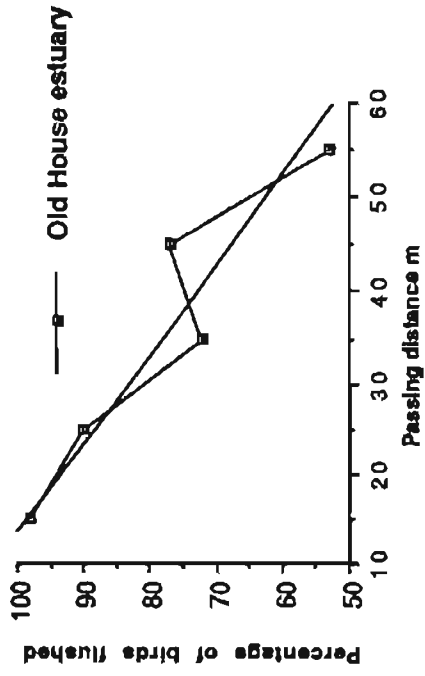


Figure 5: Percentage of birds responding to the boat by survey route and passing distance. Regressions were computed by Cricket Graph.

As the passing distance approaches about 60 meters, however, the percentage of birds flushed approaches zero for all routes. At typical small boat passing distances (15 to 40 meters) birds in the estuary are thus much more sensitive to the presence of the boat than birds on the Sound shore. The greater sensitivity combined with closer average approach distances accounts for the high rate of flushing in the estuaries.

There is some limited evidence foraging birds may be less liable to flushing than birds originally observed as resting. Sampling crews noted that birds foraging on exposed banks at low tide were less likely to respond to the boat. The flushing rates for the estuaries were too high to determine differences and the flushing rates for Sea Camp to Beach Creek were too low. For Sea Camp to Old House, 38% of resting birds responded to the boat and 16% of foraging or walking birds responded. This difference does not provide a significant Chi-square, however ($X^2 = 5.31$, $p < .10$).

Recovery period

Data taken on the return trips indicated an average of 58% of the number of groups seen on the outgoing run from Sea Camp up Beach Creek estuary were seen on the return trip and an average of 69% of the number of groups seen on the trip from Sea Camp up Old House Creek were seen on the return trip. Of the 17 return runs on Beach Creek, three had the same number or a greater number of groups than the outgoing run, and on the Old House return, only one had more birds than the outgoing run. These data do not provide recovery times, but they suggest, with field observations, that it takes at least 15 to 20 minutes for the birds to return to the shoreline after flushing.

Discussion

Although the results from the wading bird survey cannot be used to compute disturbance rates for the entire of Cumberland Island National Seashore, they imply human initiated disturbances are already frequent, at least in the study areas. Natural disturbance agents were present more frequently than human disturbance agents (other than researchers), but human disturbances were more likely to initiate flushing or to interfere with foraging. Although natural disturbance agents were approximately twice as common as human disturbance agents, humans caused 60 to 70% of the groups of wading birds encountered to flush, while natural agents caused 5 to 36% of the groups to flush.

The concentration of human disturbance agents in the second and third sampling periods is probably desirable. Bratton (1988) suggests wood storks may spend more time foraging in the early morning, thus the present pattern of human use may present minimum interference with stork feeding activities. These data also indicate some of the study sites used by storks (ie. Beach Creek marsh) are already regularly disturbed by people. The high tidal amplitude in the Cumberland Sound region is probably providing some protection for the estuaries, since many cannot be navigated at low tide, and boats cannot be safely docked in their upper reaches.

The boat disturbance study indicates that additional traffic along the present Intracoastal Waterway is unlikely to directly disturb birds foraging between Sea Camp and the mouth of Beach Creek. The addition of large naval vessels in the existing channel probably causes little reaction from waders. Establishment of a new channel between Sea Camp and the mouth of Old House Creek could interfere with foraging and resting waders, and would cause more disturbance than an increase in traffic on existing routes. The primary area of sensitivity, however, is the estuaries. Only 5% of the groups of wading birds encountered on the sample run from Sea Camp to Beach Creek flew away from the point where they were originally encountered, 69% of the groups in Beach Creek estuary moved away from the point of contact (or 14 times as many groups were displaced to some extent in the estuary). Regional increases in small boat traffic and increased use of the Sound estuaries by small boats would be much more disruptive to waders than an increase in large craft along the Intracoastal Waterway. Waders in the estuaries are more sensitive to boats and displace longer distances from their resting and foraging sites once disturbed. These data suggest use rates of one boat per hour in an estuary may substantially disrupt the activities of waders. At rates of three to four boats per hour (randomly spaced), it may be impossible for waders to forage along the larger tidal creeks without frequent flights back to trees or protected small tributaries.

The differences between the Sound shoreline and the estuaries do not appear to be solely the result of a developed tolerance for boats. First, the Sound shore did not have fourteen times more traffic than Beach Creek during the study. Second, there was little difference in bird response between Beach Creek and Old House Creek, and the former has greater traffic. Closer passing distance in the estuaries was a factor, thus the width of the channel makes a difference. The waders react to boats at greater distances in the estuaries, however, suggesting the configuration of the banks may also have an effect. Due to the meandering shoreline, the boat in the estuary frequently points directly at groups of birds, even though the boat will eventually pass them at an angle. Further, the exposed banks of the estuaries are narrow and the birds have no room to walk away from the boat or to fly without hitting vegetation. The route from Sea Camp to Beach Creek had the best developed beach and also the lowest rate of flushing. Sixty meters (obtained by estimates) is the approximate distance, along both the Sound shore and in the estuaries, at which

most of the wading birds will not flush if a boat passes.

Vos et al.(1985) found great blue herons in a heronry were less responsive to boats than to terrestrial vehicles. This present study did not find great differences between boats and humans on the ground. The rate of flushing from foraging areas in the boat disturbance study was higher than Vos et al. (1985) found for nesting sites. It should be noted this study found birds in trees along the Sound shore were not disturbed by the boat, and birds in trees along the estuaries were much less disturbed than birds at the water's edge. It is important, therefore, not to assume disturbance rates or distances for rookeries are applicable to foraging sites. Birds may actually be more sensitive to human agents when on the ground or in the water. This study agrees with Burger's (1982) results indicating continued human presence may discourage wading birds from using an area.

The results of this study reinforce the available information on wood storks (Bratton 1988) which suggests protection of the estuaries may be important to foraging storks. Wood storks are likely to use the larger tidal creeks passable to boats, and appear to be very sensitive to boat disturbance. Zoodsma and Bratton (1987) and Zoodsma (unpublished data) suggest endangered manatees may also be using tidal creeks including Beach Creek and Old House Creek. In terms of protecting endangered and sensitive vertebrates, the amount of traffic on the creeks will be far more critical than the amount of traffic on the present Intracoastal Waterway. The National Park Service should attempt to monitor potential increases in boat traffic in the estuaries, and should avoid any management action which encourages increased traffic in these areas. Construction of docks which will stimulate increased boat use of estuaries within the National Seashore should be avoided. Changes in bank configurations in the estuaries due to dredging may influence bird response to boat traffic and should be monitored.

Acknowledgements

I thank Val Sewell, Andrew Bergeron, Lynn Roberson and Barb Zoodsma for assistance with field data collection. Jim Kushlan reviewed a draft of this report. I also thank Zack Kirkland and Dick Newgren and the ranger staff of Cumberland Island National Seashore for help with small boat management, and for providing a back-up vessel when the research craft was under repair.

References

Allen, D. and R. Becker. in press. Boat distribution analysis of the Intracoastal Waterway in the Cumberland Island National Seashore area using aerial photographs. Technical Report. Regional Resources Development Institute, Clemson University, Clemson, SC.

Bratton, S.P. 1988. Wood stork use of fresh and salt water habitats on Cumberland Island National Seashore. *Institute of Ecology, NPS-CPSU Technical Report No. 50*, 24 pp.

Burger, J. 1981. The effect of human activity on birds at a coastal bay. *Biological Conservation* 21: 231-241.

Ellison, L.N. and L. Cleary. 1978. Effects of human disturbance on breeding of double-crested cormorants. *Auk* 95: 510-517.

Kury, C.R. and M. Gochfield. 1975. Human interference and gull predation in cormorant colonies. *Biological Conservation* 8: 23-34.

Mueller, A.J. and P.O. Glass. 1988. Disturbance tolerance in a Texas waterbird colony. *Colonial Waterbirds* 11(1): 119-122.

Parsons, K.C. and J. Burger. 1982. Human disturbance and nestling behavior in black-crowned night herons. *Condor* 84: 184-187.

Snedecor, G.W. and W.G. Cochran. 1971. Statistical methods. Ames, Iowa: The Iowa State University Press, 593 pp.

Tremblay, J. and L. N. Ellison. 1979. Effects of human disturbance on breeding black-crowned night herons. *Auk* 96: 364-369.

Vos, D.K., R.A. Ryder and W.D. Gaul. 1985. Response of breeding great blue herons to human disturbance in Northcentral Colorado. *Colonial Waterbirds* 8:13-22.

Werschkul, D.F., E. McMahon, and M. Leitschuh. 1976. Some effects of human activities on the great blue heron in Oregon. *Wilson Bulletin* 88: 660-662.

Zoodsma, B. and S.P. Bratton. 1987. Cumberland Island Manatee Watch 1986. *Institute of Ecology, NPS-CPSU Technical Report* , No. 37. 13 pp.