



## Great Captains Island Heron and Egret Study

*Kathryn Heath and Michael Parkes  
Audubon Connecticut*

**August, 2002**

## **ABSTRACT**

Great Captains Island is located in Long Island Sound approximately one and a half miles off the coast of Greenwich, Connecticut and twenty miles from New York City. This 17-acre island is owned by the Town of Greenwich, and is managed by its Parks and Recreation Department as a multiple-use site emphasizing both conservation and recreation. Input concerning management is also contributed by the Town of Greenwich Conservation Commission. A three-year research project was designed to gather information concerning four of the colonial waterbird species that use the rookery located on the island, including, Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Black-crowned Night-Heron (*Nycticorax nycticorax*), and Little Blue Heron (*Egretta caerulea*). The primary objectives of the project were to estimate overall population sizes and nesting success for each species, and to document the behavior of adult and juvenile birds in the colony. Additional factors considered included foraging activity, predation, and the effects of human disturbance on the colony.

The estimated average population sizes for each species during the three years of the project were: Black-crowned Night-Herons – 130 pairs, Great Egrets – 92 pairs, Snowy Egrets – 27 pairs, and Little Blue Herons – 1 pair. Nesting productivity was relatively high in most cases, although low productivity occurred in some species in some years. Evidence of predation within the colony was limited, and the cause of most nest failures was not known. The absence of raccoons on the island is thought to be an important factor in the success of this rookery.

Analysis of flight-line data to determine foraging areas, as well as volunteer and researcher observations, indicated that these birds use foraging sites in Connecticut and New York equally. There was little difference between species in the direction taken on foraging flights, perhaps indicating significant overlap in habitat usage.

Management recommendations for the island include annual monitoring for raccoon presence, and removal of any raccoons from the island if they are detected. Audubon also suggests restricting access to the conservation area during the early nesting stages when the birds are most vulnerable to disturbance, better signage and enforcement of regulations, ensuring proper refuse disposal on the island, and rodent control. Continued colonial waterbird population monitoring is also suggested, at a minimum interval of once every three years. Additionally, it is recommended that efforts to identify key foraging areas are continued, and coupled with efforts to conserve and restore foraging habitats that are within the typical foraging distances of the species nesting in the colony.

***This project and report were made possible through funding from The Fairfield County Community Foundation, The Geoffrey Hughes Foundation, The Sounds Conservancy, and Town of Greenwich Conservation Commission.***



## CONTENTS

Abstract .....	1
List of Tables .....	3
List of Figures .....	3
Introduction .....	4
Study Goals .....	4
Study Area .....	5
Foraging .....	5
Predation and Competition .....	6
Human Disturbance .....	6
Materials and Methods .....	6
Population Census .....	6
Monitoring and Productivity .....	7
Foraging .....	8
Predation and Competition .....	9
Human Disturbance .....	9
Results .....	9
Population Census .....	9
Monitoring and Productivity .....	10
Foraging .....	10
Predation and Competition .....	11
Human Disturbance .....	11
Discussion .....	12
Population Census .....	12
Monitoring and Productivity .....	13
Foraging .....	14
Predation and Competition .....	14
Human Disturbance .....	15
Management Suggestions .....	16
Recommendations to limit the effects of human disturbance .....	17
Recommendations to limit predation .....	18
Other recommendations .....	18
Concluding notes of colonial waterbird conservation in Long Island Sound .....	19
Acknowledgements .....	20
Tables .....	21
Figures .....	27
Appendix A .....	38
Appendix B .....	43
References .....	46

## LIST OF TABLES

Table	Title	Page
1a	2002 Black-crowned Night-Heron monitored nest productivity	21
1b	2002 Great Egret monitored nest productivity	22
1c	2002 Snowy Egret monitored nest productivity	22
2	Nesting success rates in 2000, 2001, and 2002	23
3a	Foraging flight-lines of Black-crowned Night-Herons	24
3b	Foraging flight-lines of Great Egrets	24
3c	Foraging flight-lines of Snowy Egrets	25
3d	Foraging flight-lines of all species combined	25
4	List of foraging locations in each sector	26

## LIST OF FIGURES

Figure	Title	Page
1	Rookeries in the New York Harbor Area	27
2	Location of Great Captains Island	28
3	Overview of Great Captains Island and its uses	29
4	Nesting areas of Black-crowned Night-Herons, Great Egrets, and Snowy Egrets within the conservation area	30
5	Locations of monitored Black-crowned Night-Heron, Great Egret, and Snowy Egret nests in 2002	31
6	Locations of the colony center and the observation sites used for flight-line analysis	32
7	Numbers of nesting pairs for Black-crowned Night-Herons, Great Egrets, and Snowy Egrets in 2000, 2001, and 2002	33
8	Flight-lines observed for all Black-crowned Night-Herons, Great Egrets, and Snowy Egrets	34
9	Flight-lines observed for Black-crowned Night-Herons	35
10	Flight-lines observed for Great Egrets	36
11	Flight-lines observed for Snowy Egrets	37

## INTRODUCTION

Colonial waterbirds, including herons and egrets, are a revered element of wetland habitats. To many, these birds represent the essence of the shore scene. To scientists, they are often considered to be indicators of the general health of an ecosystem because of their position near the top the food chain (Kushlan 1993). Egrets have long been symbolic of the conservation movement in North America, and have served to focus attention on the importance of protecting wetlands and all species of native birds. This status stems from the public outcry in reaction to the plume trade of the late 19<sup>th</sup> Century, which decimated populations of colonial waterbirds, particularly egrets and terns. Tremendous pressures were put on populations of egrets and many other species of birds at this time, in order to provide feathers for the fashion industry. The slaughter of these birds and their chicks on their nests galvanized a movement for the protection of birds that is still felt today.

This movement resulted in the formation of the first state Audubon societies, and the incorporation of several of these societies into the National Association of Audubon Societies for the Protection of Wild Birds and Animals in 1905. This association later changed its name to the National Audubon Society in 1940 and the Great Egret continues to serve as its symbol. Grassroots pressure from this movement resulted in several important wildlife conservation laws, treaties, and programs, which have led to population recovery in many species of colonial waterbirds, including herons and egrets (Parnell et al. 1988).

Improved protection and the subsequent recovery of colonial waterbird populations have not eliminated the threats faced by these birds. For example, the Connecticut Department of Environmental Protection continues to list Great Egrets and Snowy Egrets as threatened and the Little Blue Heron as a species of special concern, primarily because breeding by these species is restricted to only a handful of sites. Great Captains Island is one of the few sites where state threatened egrets and herons currently nest in Connecticut. The site holds the largest colony in the state and is one of the largest within the New York Harbor region (Fig. 1) (Sommers et al. 2002, Jenny Dickson personal communication). The importance of Great Captains Island may be amplified due to continuing human disturbance at other colonies in Connecticut, such as Duck and Charles Islands, and continuing coastal development, which can limit suitable foraging and breeding areas (Jenny Dickson personal communication). The fact that it is relatively far from shore, limiting its accessibility to people and mammalian predators such as raccoons, seems to be an important factor in its stability and success. This report describes the results of a three year study that Audubon Connecticut conducted at Great Captains Island to assess the current status of the breeding colony and to produce recommendations for future management of the site.

### Study Goals

The primary goals of this three-year research project were to estimate population sizes, calculate nesting success rates, and identify key foraging areas for the four species of colonial waterbirds that breed on Great Captains Island. These birds are the Black-crowned Night-Heron, Great Egret, Snowy Egret, and Little Blue Heron (scientific names of species mentioned in this report are given in Appendix A). Other goals included: (a) documenting any effects of human disturbance on the colony, (b) describing the behavior of birds in the colony, and (c) assessing predator threats to the colony. This information was then used to produce a set of management recommendations.

## Study Area

Great Captains Island is located 2.50 km (1.35 nautical miles) from the shore of Greenwich, Connecticut (73° 38' W, 40° 59' N; Fig. 2). It has an area of 9.58 hectares (17 acres) and contains a variety of habitats including mixed woods, shrublands, fields, saltmarsh, and tidal lagoon. Great Captains Island is owned by the Town of Greenwich and is partitioned into a conservation area and a multi-use area (Fig. 3). In the multi-use area, active recreation is permitted, including swimming, camping, picnicking and shellfishing. A dock within this area is used by a ferry, which runs between the town and the island four days a week during the summer. Within the conservation area, walking and observing are permitted along a road up to a nineteenth century lighthouse and around a loop trail. The rookery is located within the conservation area at the eastern end of the island.

Heron and egret nest both in canopy trees and in lower shrubs. Great Egrets and occasionally other species nest in the canopy, which is dominated by sassafras, Norway maple, black cherry, and red maple trees. Black-crowned Night-Herons, Snowy Egrets, and Little Blue Herons more commonly nest in dense thickets of staghorn sumac, poison ivy, honeysuckle, common blackberry and other shrubby vegetation. Patches of common reeds (*Phragmites australis*) also occur adjacent to the beach and one patch is used for nesting by Snowy Egrets.

Colonial waterbird nesting was first recorded at Great Captains Island in 1986 when 10 pairs of Black-crowned Night-Herons bred there. By 1989 the night-herons has been joined by 10 pairs each of Great and Snowy Egrets, and by 1995 the colony had grown to include 110 pairs of Black-crowned Night-Herons, 45 pairs of Great Egrets, and 50 pairs of Snowy Egrets (Bull 1997).

## Foraging

Suitable colony sites are essential for successful breeding by herons and egrets, however, it is equally important for these sites to be near to productive foraging areas. Frequently, colonies are centrally located within suitable feeding grounds (Gibbs 1991). Access to suitable foraging habitat influences colony dynamics, and changes in wetland habitats that alter prey availability can affect population size and nesting distribution (Gibbs 1991, McCrimmon et al. 2001). While there is considerable overlap in the foraging behaviors and habits of the four species that nest at Great Captains Island, they also differ in some important ways. All four species forage in saltmarshes, mud and sandy flats, impoundments, and tidal creeks, as well as at freshwater sites (Willard 1977, Custer and Osborn 1978, Davis 1993, Rodgers and Smith 1995, Parsons and Master 2000, McCrimmon et al. 2001).

The Great Egret, is a generalist forager, eating a wide variety of fish, amphibians, crustaceans, insects, reptiles, and occasionally birds and mammals. Most prey, however, are fish (Smith 1997, McCrimmon et al. 2001). Their long legs enable Great Egrets to exploit deeper water than can smaller species (Custer and Osborn 1978, Willard 1977, Smith 1997). They are thought to forage, on average, closer to the colony than the other three species (Custer and Osborn 1978), although the maximum-recorded foraging flight is greater than 40 km (25 miles) (McCrimmon et al. 2001), which is farther than that of the other species.

Snowy Egrets tend to be more active foragers than Great Egrets, and use a wider variety of foraging methods (Parsons and Master 2000). Their activity is likely to be energetically expensive, perhaps requiring Snowy Egrets to spend proportionately more time foraging than similar species. The wide variety of foraging behaviors does not reflect a broad diet. For example, one study showed that four prey items made up over 75% of their diet (Willard 1977, Parsons and Master 2000). Such specialization may

make them particularly sensitive to changes in prey density and availability. Their maximum-recorded foraging flight distance is 29.8 km (18.5 miles) (Smith 1995).

Unlike the other species in the colony Black-crowned Night-Herons are crepuscular and nocturnal feeders. They are opportunistic, eating a wide variety of prey, and are more likely to consume nestlings of other birds than the other three species (Parnell et al. 1988, Davis 1993). Their maximum-recorded foraging flight distance is 24 km (14.9 miles) (Davis 1993).

Little Blue Herons tend to take more crustaceans than fish and are more selective in their diet than the other three species. They primarily use a “slow wading” technique when foraging and their longest reported foraging flight is 10.2 km (6.3 miles) (Rodgers and Smith 1995).

### **Predation and Competition**

Several different species prey upon the eggs or chicks of herons and egrets. A comprehensive list of those predators that reside in the vicinity of Great Captains Island is given in Appendix A. Raccoons are a predator of particular concern as shown by the historical events at Chimon Island in Norwalk, Connecticut. Fifteen years ago over 2,000 pairs of wading birds and gulls nested on Chimon Island. In 1991, increased numbers of raccoons were reported, predation was observed, and in 1993 all nesting colonial waterbirds abandoned the island. Similar occurrences have been recorded at other wading bird colonies in eastern North America (Bull 1997). This study has not recorded any evidence of raccoons on Great Captains Island in the last three years.

### **Human Disturbance**

Colonial-nesting birds are inherently more vulnerable to disturbance than many other types of birds because large numbers of nesting individuals gather in a small area. Consequently, activities that cause adults to leave the nest can leave large numbers of eggs and chicks vulnerable to predation, cannibalism, and the effects of weather (Burger 1982, Parnell et al. 1988, Rogers and Smith 1995). Thus, it is extremely important to limit human disturbance during the nest building, incubation, and early hatchling stages (Parsons and Burger 1982, Nisbet 2000). Although adult herons will seldom desert nests after chicks hatch, disturbance also can cause nestlings up to three weeks of age to fall from their nests and die (Parnell et al. 1988).

There are many forms of human disturbance. This project was mainly concerned with researcher, visitor, maintenance, and boater activity. In general, disturbances that actually affect population sizes (rather than just altering the behavior of the birds) are of greatest concern (Nisbet 2000).

## **MATERIALS AND METHODS FOR 2002**

Great Captains Island was visited as often as possible at varying tides and times of day with a total of 39 visits between 23 April and 7 August 2002. A public educational program was held on the island on 8 June 2002, and the researchers camped on the island on the night of 2 July 2002 in order to conduct nocturnal observations of the colony. A vegetation inventory of the island was performed in 2000 and is included in Appendix A. Visiting and nesting avian species were recorded each year and are also listed in Appendix A.

### **Population Census**

Population counts were conducted twice a week for the first three weeks of the study, and were based on standard techniques described by Steinkamp et al. (2000). Since each species nested in different areas

with varying accessibility, survey methods differed among species. In order to reduce researcher disturbance, the number of intrusions and their duration were limited, and the researchers moved slowly and quietly.

***Black-crowned Night-Heron*** Initially, ground-based nest counts were attempted to census Black-crowned Night-Heron nests. However, these ground based nest counts were discontinued after the 2000 field season because the vegetation in which this species nested had become too thick. Because of the thick vegetation and the ensuing inability to conduct an accurate count, as well as the degree of disturbance a count of this type would cause, these ground-based counts were discontinued. Therefore, the birds were flushed by one researcher and counted by the other. There is no evidence that occasional flushing of adult birds from their nests produces adverse effects on breeding, except in circumstances where they allow predators to gain access to eggs or chicks (Nisbet 2000). Since night-herons are largely nocturnal feeders, the assumption was made that both parents were on or near the nest during the day throughout the incubation period. The area occupied by night-herons was subdivided into three sections (west side of the lagoon, east side of the lagoon, and the conservation loop; Fig. 4) and each section was flushed at separate times. Each area was surveyed three times in order to determine the best estimate of the number of nesting pairs. These methods are similar to those used in 2001. Ground-based nest counts were used to count Black-crowned Night-Heron nests during 2000.

***Great Egret*** Great Egret nests were counted as early in the season as possible before leaf emergence was completed, in order to maximize visibility of the nests. The nests on the east side of the lagoon were counted from across the lagoon, and the nests in the conservation loop area were counted by walking the loop trail. The two researchers independently visited each area three times to count the number of active nests; the researchers compared numbers and resolved discrepancies by recounting. These methods were the same as those used in 2000 and 2001.

***Snowy Egret*** To count the Snowy Egrets, one researcher entered the nesting area to count nests and flush the birds while the other researcher counted the number of Snowy Egrets that flew out. These numbers were compared to determine the total number of Snowy Egret nests. Nest counts alone could not be used because the vegetation was too thick to see all nests without causing excessive disturbance. In previous years the researchers determined the number of nests by counting the number of adults present.

***Little Blue Heron*** Since Little Blue Herons are rare at Great Captains Island, population estimates were based strictly on incidental observations made during other research activities.

### **Nest monitoring and Productivity**

A total of 16 Black-crowned Night-Heron nests (11% of total), five Great Egret nests (6%), and four Snowy Egret nests (20%) were monitored throughout the breeding season, using methods similar to those used in previous years. Nests were chosen that were easily accessible, which may bias the results. Black-crowned Night-Heron nests were chosen on 7 May, Great Egret nests on 8 May, and – due to their later arrival – Snowy Egret nests on 14 May. Each nest was marked with flagging or a natural marker and the location was documented (Fig. 5). Minimal flagging tape was used so that the attention of predators would not be drawn to the specific location of nests. Additionally, a description was made of each nest including its height from the ground, and the vegetation that was used for nesting.

Nests were checked to determine the numbers of eggs, hatchlings, or fledglings once a week. In order to monitor nests that were too high to look directly into, one researcher held a long pole with a mirror attached at one end above the nest while the other researcher used binoculars to look into the mirror to determine nest contents.

As in previous years, the following measures of reproductive success were calculated: (1) mean hatching rate (number of hatchlings divided by the number of eggs laid), (2) mean fledging rate (number of birds that fledged divided by the number of hatchlings), (3) mean overall nesting success rate (number of birds that fledged divided by the number of eggs laid). In 2002, a fourth measure was also calculated: (4) mean nest productivity (total number of birds fledged from all monitored nests divided by the number of monitored nests).

Chicks were assumed to have fledged if they survived a given number of days in the nest. Young were assumed to have died if they disappeared from a nest within 21 (Black-crowned Night-Heron), 35 (Great Egret), or 14 (Snowy Egret) days of hatching. This period differed among species for two reasons. First, development rate differed; for example, Snowy Egret chicks leave nests earlier than do Great Egret chicks. Second, the ease with which chicks could be detected varied due to differences in nesting habitat (e.g., nest height, vegetation density) and nestling behavior (e.g., propensity to clamber out of a nest as a researcher approached). It is not known how fledging was defined in previous years of the study.

During the first year of this study (2000), there was high mortality of Black-crowned Night-Heron chicks. Consequently, researchers were instructed to collect all dead chicks that were discovered in subsequent years for post-mortem testing by the Connecticut Department of Environmental Protection. No deceased chicks were collected in the 2002 field season.

### **Foraging**

Foraging locations used by the three common species were identified using a combination of direct observations of foraging birds and flight-line analysis. Observations were made by both volunteers and researchers. Volunteers used standardized log sheets to record their sightings (see Appendix B). This volunteer system was also used in the previous two field seasons. When time allowed, researchers made trips by boat or car to various known or assumed feeding locations in Fairfield County, CT, Westchester County, NY, and Long Island, NY.

***Flight-Line Analysis*** The principal method used to determine foraging locations and frequency of use was flight-line analysis (Erwin 1983). This method involves recording the direction taken by birds leaving or arriving at a colony, and assumes that birds fly in a straight line between foraging sites and the colony. Some flights to foraging areas were observed in 2000 and 2001. However, a more extensive analysis using standardized protocol was implemented during the 2002 research season.

To determine flight directions, the center of the colony was located and compass bearings were taken from the colony center to obvious landmarks on the shore of Fairfield County, Westchester County, Long Island, and other islands visible from Great Captains Island. Next, two sites on the shore of the island were selected, from which to record flight-lines (Fig. 6). These sites were chosen so that all birds arriving at, or departing from, the rookery could be seen. Each researcher remained at a site for one hour and using the previously identified landmarks recorded the direction taken by all herons and egrets flying to and from the colony. In addition to flight direction, information on the size of the group, the species involved, whether birds were approaching or leaving the colony, tidal stage, and weather conditions, were recorded (see Appendix B). Departing birds were observed for as long as possible because some birds changed course from their initial heading.

Flight-lines were observed during 24 1-hr periods between 30 May and 25 July 2002. Observations were made at a variety of times of day and tide conditions (see also Erwin 1983, 1984, Maccarone and Parsons 1986, Wong et al. 1999). Eight observations were made during ebbing high tide, six during ebbing low tide, two during rising high tide, and eight during rising low tide. The times of observations varied as

well, with seven observations in the morning (0500-0900), twelve observations in the middle portion of the day (0900-1700), and five observations in the evening (1700-2100).

The flight-line directions were grouped into eight 45° sectors of a circle, centered on the middle of the colony. The proportion of flights that lay within each sector was then calculated for each species and for all species combined.

### **Predation**

As in 2000 and 2001, all observations of predators and their interactions with egret and heron species on Great Captains Island were recorded. For example, tracks and droppings were noted, owl pellets were collected and dissected to identify prey items, and the presence and behavior of possible predators were observed.

### **Human Disturbance**

Effects of human activities were studied by observing the birds' responses to humans on the days the island was visited by the researchers. Potential sources of disturbance considered included the activities of researchers, visitors to the island, and Parks and Recreation employees. Effects of boat disturbance on the nesting birds were also recorded.

## **RESULTS**

### **Population Census**

As in 2000 and 2001, Black-crowned Night-Herons were present on the first day the island was visited (23 April) in 2002. Nests containing eggs were discovered soon after the first visits were made, confirming that nest building and incubation were already in progress. Black-crowned Night-Herons nested on the eastern and western sides of the lagoon and in the conservation loop area (Fig. 4). Generally, nests were found in thickets of poison ivy, honeysuckle, greenbrier, and Asiatic bittersweet, among other vines and shrubs. In the conservation loop area, some nests were also located higher up in sassafras trees. There were approximately 150 nesting pairs of Black-crowned Night-Herons on Great Captains Island during the 2002 breeding season. 150 nesting pairs were reported in 2001, and 90 nests in 2000 (Fig. 7).

Great Egrets were also present on the island on 23 April 2002 and nests were located on the eastern side of the lagoon and in the conservation loop area (Fig. 4). This species nested higher up (5 meters and higher) than did Black-crowned Night-Herons, in mature trees (e.g., sassafras and black cherry), and were incubating their eggs upon first observation. This was consistent with activities in 2000 and 2001. Eighty-two Great Egret nests were counted in 2002 compared with 98 in 2001 and 97 in 2000 (Fig. 7).

Snowy Egrets were present on Great Captains Island on 23 April 2002 and nests were discovered in a *Phragmites* patch at the southern end of the lagoon on 26 April (Fig. 4). In 2001 this species nested in the same patch of *Phragmites*, however, in 2000 they nested in scrubby understory below the lighthouse. There were approximately 20 nesting pairs of Snowy Egrets in 2002 compared with 40 in 2001 and 20 in 2000 (Fig. 7).

In 2002, one Little Blue Heron was flushed twice from the *Phragmites* patch at the southern end of the lagoon. Little Blue Herons were also seen roosting on the edge of the lagoon and one foraging flight was recorded. From these observations, it was inferred that at least one pair nested in the *Phragmites*

patch in 2002. One pair of Little Blue Herons was also believed to be nesting on the southeastern end of the island in 2000 and 2001.

### **Nest monitoring and Productivity**

The numbers of eggs, hatchlings, and fledglings, along with measures of reproductive success for each monitored nest are given in Table 1. Monitoring data for all years of the study are summarized in Table 2.

The average clutch size of monitored Black-crowned Night-Heron nests was 3.3 eggs in 2002, compared with 3.3 in 2001 and 3.6 in 2000. Hatching rate was marginally lower than in previous years, but fledging rate (calculated either per egg or per hatchling) was distinctly higher (Table 2). On average, 1.9 young fledged from each monitored nest (Table 1). The high mortality of Black-crowned Night-Heron chicks in 2000 was not repeated in 2002, and no dead chicks were collected for post-mortems.

On average, monitored Great Egret nests held 3.6 eggs in 2002. This clutch size was intermediate between those of the previous two years (Table 2). Hatching success rate was slightly lower than in previous years, and fledging rate was considerably lower, with only about a quarter of all eggs producing fledglings (Tables 1 and 2). On average, 1.0 chicks fledged from each Great Egret nest in 2002. Three of the five monitored nests, however, failed completely. Two were discovered abandoned (G2 on 3 June and G5 on 18 June), and one was found with three dead chicks inside (G1 on 10 June). These chicks were probably about three weeks old. The exact cause of death was not known. Other Great Egret chicks were also observed dead within the vines and vegetation surrounding their nests.

In 2002 Snowy Egret clutch size was also intermediate between that found in 2000 and 2001, with 3.8 eggs per nest (Table 2). Hatching success in monitored nests was lower than in 2001, but higher than in 2000, and every chick that hatched also survived until fledging. Overall, an average of 2.8 young fledged per monitored nest.

### **Foraging**

Results from the 1922 flight-line observations obtained in 2002 are summarized in Figures 8-11 and Table 3. The figures show the relative sector use for each species and for all species combined. Table 3 shows the raw data upon which these figures are based. Table 4 lists the confirmed and possible foraging locations within each sector.

Flights to and from the colony were evenly split between sectors facing Connecticut and those facing New York. Approximately half of the flights observed were made in the three Connecticut-facing sectors (1, 2, and 8). Important foraging areas within these sectors are Little Captains Island, Calf Island, Greenwich Pt. Park, Cos Cob Harbor, and Byram Harbor. Inland freshwater sites, such as the Myannis River and Byram River, might be important sources of fresh water for drinking.

The two Westchester County-facing sectors (6 and 7) accounted for 35.0% of the flights. Playland Park Lake, Marshlands County Park, and Mamaroneck Harbor are sites located within these sectors where significant levels of egret activity have been noted. The Long Island-facing sectors (3, 4, and 5) contained 14.3 % of the total flights, indicating the birds' willingness to fly over 10 km in each direction to forage. Sector 3, however, which required the longest over-water flights, received very little use. Some of the important foraging sites within the Long Island sectors include West Harbor, Mill Neck Creek, Glen Cove, and Stanco Memorial Park.

Foraging locations identified in 2000 and 2001 were Great Captains Island, Grass Island, Byram Harbor, Port Chester, Greenwich Cove, Pelican Island, Woodside Lake, Mianus River, Byram River, Greenwich Point, and Calf Island.

Subdividing the data to show flight-lines taken by each of the three species, did not reveal any obvious differences among species (Figs. 9-11). One possible exception was that Snowy Egrets seemed more inclined to fly towards Long Island than the other two species. The magnitude of this difference, however, was not great (21% of flights for Snowy Egrets vs. 11% and 13% for Black-crowned Night-Heron and Great Egret respectively), and its statistical significance is unclear.

### **Predation**

Evidence of predation was rarely observed on Great Captains Island in 2002. Two adult and two juvenile Great Horned Owls were observed along the conservation loop on several occasions at the end of April and again on 22 July. However, no direct evidence of predation on eggs, chicks or adults were observed. Great Horned Owls were also seen on the island in 2000, and nested on the island in 2001.

In 2002 crows were often seen flying over and in the colony, but no aggressive acts were witnessed towards the colonial waterbirds. At least 100 pairs of Great Black-backed Gulls and Herring Gulls nested on the southeastern coast of Great Captains Island, in close proximity to the *Phragmites* patch where the Snowy Egrets and Little Blue Heron nested. In 2000 a Herring Gull was observed swooping down on an adult Great Egret sitting on chicks in the nest. A similar event witnessed in 2002 resulted in a Great Black-backed Gull being successfully repelled from an occupied Great Egret nest.

No observations of predation by one study species on another were recorded during the three research years. Intraspecific predation, however, was observed in 2000 when an adult Black-crowned Night-Heron was seen killing a chick (not its own) and carrying it away from the nest.

In 2002 one headless dead Norway Rat was discovered near the lagoon on the road leading to the lighthouse. Live rats were not observed in any year of the study. However, Norway Rats have been reported on the island by town maintenance staff in the past. No evidence was detected during the research project that would indicate the presence of raccoons on the island.

### **Human Disturbance**

**Research-related** The most pronounced effects of disturbance recorded in the course of fieldwork in 2002 were related to the research itself.

Adult Black-crowned Night-Herons were especially susceptible to disturbance during the incubation period. Almost all adults would flush as a result of even minimal noise or movement, but would return within 5-10 minutes after the disturbance had passed. In the first few days after hatching, chicks would show little response to the researchers checking the nests. At two to three weeks of age, they would remain motionless in the nests when approached. After this age, however, chicks would vacate the nest by moving into the vegetation surrounding the nests, thus making it difficult to count the number of fledglings.

Adult Great Egrets seemed to be less affected by disturbance than Black-crowned Night-Herons and would only flush in response to loud noise or vigorous movement. Typically adult Great Egrets would return within 5-10 minutes of a disturbance. Great Egret chicks remained in and around the nest for about 6 weeks after hatching. During the first few weeks after hatching they did not move when approached, but there were signs of stress or agitation when researchers used a mirror on a pole to

observe the nest's contents. After this period, with their increased mobility, chicks would move away from the mirror and onto the sides of the nest. At six weeks after hatching, chicks would venture out onto the branches and vegetation away from the nest, which made counting fledglings difficult.

Snowy Egrets appeared to be extremely prone to disturbance. The entire population would flush when approached and either roost in nearby trees or fly away from the colony entirely. Adults would begin to return within 10 minutes after the disturbance ended. Snowy Egret chicks also appeared to be highly susceptible to disturbance. At about 2 or 3 weeks after hatching the chicks would vacate the nest upon human intrusion. They would often stumble around in the reeds below their nests. This made it difficult to determine the number of hatchlings and fledglings associated with each nest.

***Disturbance related to maintenance activities*** Another form of human disturbance noted in the course of this season's fieldwork was maintenance-related disturbance. Specifically, disturbances were caused by the mowing activities of maintenance staff when driving their tractor along the path from the dock to the lighthouse.

***Other anthropogenic disturbances*** Recreational visits to the colony site by members of the public also caused some disturbances, especially when visitors walked along the path to the lighthouse or the conservation loop. On these occasions, the birds' response was similar to their reaction to researcher disturbance. Higher levels of disturbance were noted when visitors walked on the conservation loop trail than when they used the trail to the lighthouse. Little disturbance to the colony was noted as a result of boating activity around the island. Birds did not leave their nests when boats motored close to the rookery or when moored off the coast of Great Captains Island.

Several instances of human disturbance were observed in 2001. Several Snowy Egret nests were destroyed by what appeared to the researchers to be a man walking through the egret's nesting area. Also, the researchers believed that the mowing of the conservation trail in early July significantly disturbed the birds, and may have even caused the death of a few chicks and the abandonment of some nests. Finally, a party was held on the island on 7 and 8 July. The researchers were not able to record the immediate effects, but a few days later they noticed that the "Do Not Enter" signs had been knocked down.

The researchers in 2000 did not report on the effects of human disturbance on the birds nesting on Great Captains Island.

## **DISCUSSION**

### **Population Census**

Population censuses from this study and previous research suggest that heron and egret populations at the Great Captains Island colony increased following colonization in the mid-1980s until the late 1990s. Since then, numbers have fluctuated from year to year, but there is little evidence of a consistent trend in colony size (Fig. 7). Given differences among census techniques in each year, and the inherent difficulty in obtaining exact nest counts for these species (Parnell et al. 1988), it is unclear whether these fluctuations reflect true population changes.

Black-crowned Night-Herons were the first species to colonize the island in 1986 and their numbers have generally increased since that time. Censuses during 2000-2002 resulted in estimates of 90, 150, and 150 pairs respectively. In 1995, 110 pairs were counted (Bull 1997). During 2000, ground-based nest

counts were used and researchers estimated that about 30% of the nests were missed. In subsequent years flush counts were added in order to improve accuracy compared to ground-based counts alone. The relatively low numbers in 2000 are likely due, at least in part, to this difference in census technique. All indications are that Black-crowned Night-Heron populations are stable on this island and within the surrounding region (Sommers et al. 2002).

Population estimates for Great Egrets are thought to be more accurate than for the other two species, due to the high visibility of Great Egret nests, which are placed in the tops of trees. Estimates of 98, 97, and 82 active nests in 2000-2002 respectively, suggest a marked increase in the population since the census of 1995, which located 45 pairs (Bull 1997).

Snowy Egret numbers for the years 2000-2002 were 20, 40, and 20 pairs respectively, compared to a peak count of 50 in 1995 (Bull 1997). This species was counted by watching the coming and going of adults during 2000 and 2001. In 2002, ground-based nest counts were supplemented by counts of adults flushed from their nests. During this study, the location of the Snowy Egret nests moved from an area of shrubby underbrush in 2000, to exclusive use of a patch of *Phragmites* in 2001 and 2002. Although there is no strong evidence of a long-term decline in Snowy Egret numbers at Great Captains Island, the low number of nests in 2002, when the more intensive census method was used, is cause for concern. Continued monitoring of this population, using more sophisticated methods for estimating population size, would improve knowledge concerning the status of this species.

The Little Blue Heron is at the edge of its range and is not found in large numbers in New England (Rodgers and Smith 1995, Sommers et al. 2002). There were no reports of any nesting on Great Captains Island prior to 2000 when one nest was reported. Single nesting pairs were also thought to be present in 2001 and 2002.

### **Nest monitoring and Productivity**

All measures of reproductive success, as well as general observations within the colony, indicate that the Great Captains Island rookery has been relatively productive. In all three years of this study, clutch sizes were within the typical range for each species (3-5 for all species) and hatching rates always exceeded 60%, and were normally much higher (Table 2). Fledging rates were generally high, 50% or more in most cases (Table 2). Exceptions occurred in 2000, when nearly all Black-crowned Night-Herons failed to fledge, and in 2001 when little more than a quarter of the Snowy Egret chicks fledged (Table 2). The cause of the low survival rate for night-heron chicks in 2000 is unknown, but fledging rates increased markedly in 2001 (50%) and 2002 (77%). The apparently low Snowy Egret fledging rate in 2001 was attributed to destruction of two of the monitored nests, possibly due to human disturbance, and may be an artifact of a sample size in that year. Measures of mean nest productivity for monitored nests in 2002 also indicate a productive rookery with at least one chick produced per nest for each species.

Evaluations of these nest productivity data should be made cautiously for four reasons. First, determining the number of fledglings produced from each nest is inherently difficult in studies of colonial waterbirds, because nests are often hard to see into, and older chicks are inclined to clamber away from their nests as researchers approach. Ideally, one would assess colony production by counting the total number of fledglings produced by an entire colony and the total number of adults breeding at the site, and examining the ratio of these two numbers. Unfortunately, this method is not practical for most colonies (Kushlan 1992).

A second potential problem was that the number of nests that were monitored in each year was small. This was especially true for Snowy Egrets, for which only four nests were monitored each year. Third, the inaccessibility of most nests made it impossible to randomly select nests for monitoring.

Consequently, the monitored nests might be a biased sample and may not be representative of the entire colony. Most monitored Black-crowned Night-Heron nests, for example, were located close to a trail or road, and those placed deep within the thickets were avoided. Similarly only the lowest Great Egret nests could be monitored since it was impossible to see into higher nests. Accessing Snowy Egret nests also was very difficult, especially in 2001 and 2002 when they primarily nested in dense *Phragmites* stands. Although the small sample sizes and potential biases are serious concerns, attempts to increase the number of nests monitored and to sample throughout the colony would have greatly increased disturbance levels and thus compromised protection of the site.

The final problem with the interpretation of productivity data from this study, is that different researchers worked on the project each year and no standard monitoring protocol was defined at the beginning of the study. Consequently, study techniques varied somewhat among years, complicating year to year comparisons.

Despite these concerns, all available evidence suggest that Great Captains Island achieved relatively high productivity during the course of this study.

### **Foraging**

The results of the extensive flight-line analysis performed in 2002 revealed that all three species studied used a wide variety of foraging locations. No single forty-five degree sector registered more than 21% of the total flights (Fig. 8 and Table 3) and five of the eight sectors contained at least 10% of the flights. Only sector 3, which presented birds with the longest flight over open water, received little use.

Given the observed distribution of flight-lines it is clear that foraging sites in both Connecticut and New York state are used by birds from the Great Captains Island colony. Egret and heron foraging was confirmed at many different sites within the vicinity of the colony during the course of this study (Table 4). Most of these birds can be assumed to be Great Captains Island breeders, since there are so few colonies in the vicinity. The southerly portions of the sectors facing Westchester County (6 and 7), however, lie within the range of birds nesting at Huckleberry Island, making confirmation of the use of these sites by birds from Great Captains Island difficult. More effort needs to be made to identify inland sites in this area.

Another notable observation was that the island itself was not often used by adults for foraging. Juveniles of all three species, however, extensively used the lagoon and island shore for foraging. It has been hypothesized by Rodgers and Nesbett (1979) that adults reserve resources proximate to the colony for their young. Similar observations were made by Custer and Galli (2002).

### **Predation and Competition**

Based on the current high productivity, and the few observed predation events, it appears that the Great Captains Island colony is not suffering from serious levels of nest predation at present. Nonetheless, predation rates can increase rapidly in colonial waterbird colonies, either due to a change in predator behavior or exposure to new predators, so future monitoring of the predator situation is warranted.

Although raccoons are not currently present on Great Captains Island, it seems that the increase in the raccoon population in eastern states over the past fifteen years has impacted other colonial waterbird populations (Bull 1997). Particularly vulnerable are islands close enough to the mainland shore for raccoons to access at low tide, or by swimming. The absence of raccoons seems to be an integral part of the success of the Great Captains Island rookery. It is important to monitor the colony for raccoons, and take action if they are found.

Norway Rats are known to inhabit Great Captains Island, based on conversations with island maintenance staff and lifeguards, the examination of owl pellets, and the discovery of a half-eaten rat in 2002. Rats frequently prey on the contents of bird nests, although they are not known to have substantial effects on herons or egrets (e.g., see Davis 1993, Parsons and Master 2000, McCrimmon et al. 2001).

Great Horned Owls, another known predator of heron and egret nests (Davis 1993, Parsons and Master 2000, McCrimmon et al. 2001), were seen in all three years of the study. Their activity was especially prevalent in 2001, when a nest was discovered on the island. Pellets were collected containing rat skulls and bird bones in the 2001 season. Great Horned Owls were only seen occasionally during the other two seasons, although the presence of a family group in 2002 suggests that they bred again on the island. Their impact on the rookery is unknown. Since Great Horned Owls also prey on potential predators of heron and egret nests, their presence could even benefit colony members.

Great Black-backed Gulls and Herring Gulls both nest on the island with an estimated total of over 100 gull pairs. Two instances of apparent predation attempts by gulls were documented during the three year study. Each species was once seen swooping repeatedly on an occupied Great Egret nest. On both occasions, the gull was successfully repelled after each swoop by a beak poke and squawk from the Great Egret, and eventually left. Otto Lauersdorf, who has been caretaker of the island for sixteen years, also reported having seen a Herring Gull successfully kill and eat a Great Egret chick. Despite these isolated incidents, the effect of gull predation on this colony is not thought to be significant.

Competition between the species of interest is difficult to quantify, but important to mention. It is possible that Black-crowned Night-Herons and Snowy Egrets compete for nesting sites. The Black-crowned Night-Herons nesting in the scrubby underbrush along the lagoon may have caused Snowy Egrets to relocate their nests to the *Phragmites* patch, where they did not originally nest. Snowy Egrets, however, appear to be nesting successfully in the reeds, and it is typical in the Northeast for these two species to nest together in the same colony.

Black-crowned Night-Heron predation of nestlings of their own and other species is well documented (Parnell et al. 1988, Davis 1993), and one instance of Black-crowned Night-Heron infanticide was witnessed on the island in 2000. An apparent instance of brood parasitism of a Snowy Egret nest by Black-crowned Night-Herons was documented in 2002. During a nest check, a Black-crowned Night-Heron chick was observed leaving a Snowy Egret nest. This same chick was observed under this nest for the next three weeks, apparently being fed by its adopted Snowy Egret parents.

### **Human Disturbance**

Inherent in this project was disturbance caused by the activities of researchers. This disturbance manifested itself in squawking, gular fluttering, and abandonment of nests for short periods, but usually lasted less than ten minutes. Throughout the study, attempts were made to minimize research-related disturbance by limiting the number of intrusions and their duration, by moving deliberately and quietly when in the colony, and by avoiding disturbance during inclement or hot weather (see also Parnell et al. 1988). During flush counts the goal was to disturb quickly and profoundly in order to flush every bird in an area and get an accurate count. There is no evidence that periodic disturbances such as those used adversely effect reproductive productivity, except when they allow predators to gain access to eggs or chicks (Nisbet 2000). There was no evidence of predation during research activities and the birds returned to their nests soon after the disturbance ended. Therefore, it is believed that the effect of research-related disturbance on reproductive success was minimal in this study.

Disturbances caused by visitors other than researchers to a colony are difficult to study because of the unpredictable nature of their occurrence. The conservation area on Great Captains Island is open to the public for walking to the lighthouse and around the conservation loop trail. The signage at the entrance to this area is unclear about what restrictions exist and what activities are permitted, only indicating “No Picnicking” and “Conservation Area.” When visitors walk through this area the birds are disturbed and leave their nests. These disturbances were typically brief and birds recovered within a short period of time. In some colonial waterbird species low intensity visits by people may habituate birds to people (Nisbet 2000), but the fact that birds continued to respond to intrusions throughout this study suggests that this has not happened on Great Captains Island.

Most visitors to the island stay in the recreation area in order to picnic and swim. There was a large disturbance within this area in the summer of 2001. This included a large group of people (approximately 100), a band, and vandalism to the existing signage. It is this type of large, high intensity disturbance that is of greatest concern when considering visitor disturbance. Bonfires and large, loud gatherings are thought to be the cause of significant disturbances at rookeries on Charles Island in Milford, CT and Duck Island in Westbrook, CT during the summer of 2002. These events caused partial or total abandonment of these rookeries (Jenny Dickson personal communication). The best place for similar events on Great Captains Island is within the recreation area rather than the conservation area, which may prevent large-scale colony abandonment as witnessed on the other Connecticut islands. Preventing large disturbances, however, should be a priority to encourage rookery expansion into the western portion of the conservation area and into the recreation area.

Disturbances incurred because of maintenance activities are inevitable, considering the current management scheme. Use of mowers, tractors, generators and the like can produce significant amounts of noise, which is known to contribute to disturbance levels (Burger 1982). Researchers in 2001 reported mortality of chicks near recently mowed areas. It was also suggested that the mowing width of the conservation loop trail was much wider than necessary. In 2002, it was evident that there was more caution used when mowing, and it is hoped that this will continue in the future. As with other disturbances, it is most important to limit activities during the critical period consisting of nest building, incubation, and the first few weeks after hatching (Parnell et al. 1988). On Great Captains Island, this period extends from March 1 until mid-July. Adult herons will seldom desert nests after chicks hatch. Therefore it would be best to limit mowing, especially of the conservation trail, until after mid-July, or until as late in the season as possible.

## **MANAGEMENT RECOMMENDATIONS**

The importance of the Great Captains Island heron and egret rookery is clear: it is currently the largest such colony in Connecticut and one of the largest in the Long Island Sound region. As such, Audubon Connecticut has identified Great Captains Island as an Important Bird Area. Connecticut has relatively few uninhabited coastal islands with suitable vegetation to support nesting herons and egrets, and the proper conservation and management of the few areas where nesting occurs is a high priority of conservation officials in the state. Undeveloped islands are critical to the survival of the Long Island Sound nesting population of colonial-nesting wading birds, but these same islands are also in high demand for recreational activities. Increasing competition from humans for space, and other coastal resources, as well as increasing demand for shoreline development and water based recreational uses puts these birds in a precarious position. In order to sustain the Connecticut/Long Island populations of these birds it is critical that existing colonies such as that on Great Captains Island are protected and managed to maximize the number of nesting pairs.

Without management of Great Captains Island to accommodate the nesting requirements of herons and egrets, the survival of this important rookery is uncertain. When considering actions to ensure the future stability of the Great Captains Island rookery two factors are of paramount consideration:

- a) limiting human disturbance, especially during the critical period of nest building, incubation, and early hatching, and;
- b) preventing raccoons and other known predators from colonization the island.

## **Recommendations to limit the effects of human disturbance**

### **1. Close the conservation loop from March 1 to mid-July.**

In order to limit the impact of public access to the island's conservation area, we recommend closing the conservation loop trail between March 1 and mid-July when the colony would be most susceptible to disturbance. The conservation trail winds through a portion of the island that is used by nesting egrets, and researchers have noted that visitors cause higher levels of disturbance to nesting birds when using this path than when walking the road to the lighthouse. Since disturbance levels are lower along the road to the lighthouse, we recommend keeping this trail open. This action will have three benefits:

- Visitors will still be able to enjoy the historic lighthouse building up close;
- It will promote public interest in the conservation of the colony by allowing visitors to enjoy views of the birds from a satisfactory distance, and;
- It may promote habituation of the birds to the presence of people.

### **2. Postpone mowing near the colony until after mid-July.**

It is important to eliminate mowing of the loop trail and the field next to the lighthouse until after the critical disturbance period ends (mid-July), or until as late in the season as possible. To limit disturbance, the mowing protocol should minimize the area mowed in order to maintain a trail. The protocol of the 2002 nesting season, in which the trail was not mowed until mid-July and was narrower than in past years, was more considerate to the well-being of the nesting birds than past protocols. We encourage the continued use of this protocol.

### **3. Improve signage describing the colony's importance and provide better viewing opportunities.**

Effective conservation and management measures are most likely to be followed and supported by the public if they are combined with better signage to inform and encourage stewardship of the colony. Better opportunities for public viewing of the colony that simultaneously minimize the disturbance to the nesting birds also would be beneficial. A viewing platform on the opposite side of the lagoon, an observation blind near the lighthouse, or both, would encourage enjoyment of the colony by visitors to the island and would also serve to reduce disturbance to the colony by such viewing activities. These measures are crucial because visitors and town residents are more likely to support restrictions if they understand how wildlife will benefit. Moreover, many visitors to the island probably do not recognize the potentially harmful effects of their activities. Information on foraging areas should be included on any signs describing the colony in order to emphasize the fact that this colony cannot continue to be successful without adequate feeding grounds away from the rookery.

### **4. Shoreline clean-up.**

An additional action that would foster a conservation ethic at Great Captains Island would be to perform an extensive clean up of the maintenance shed area and the shoreline in general. The maintenance area

contains old boats, buoys, construction materials, beach goers' flotsam, etc. This area is located at the entrance of the conservation area and emits the feel of a dump rather than a conservation area. After the initial removal of some of the bigger objects, it would be important to perform periodical removal of additional washed up items.

### **5. Enforce existing regulations.**

Existing rules and regulations regarding the island should be clearly posted and enforced. Eliminating parties, such as the one in the summer of 2001, which involved over 100 people as well as amplified music and resulted in some vandalism, should be a high priority. This type of disruption significantly affected the productivity of other Connecticut island rookeries (Duck and Charles Islands) during 2002. Although no serious boat disturbance was detected in this study, boating has been shown to affect the behavior of nesting egrets and herons in other areas (e.g., Bratton 1990). Hence, the Town of Greenwich and the Connecticut Department of Environmental Protection should be reminded annually of the importance of this rookery and encouraged to increase patrols and vigorous enforcement of speed limits in the area by local marine police. Additionally, it would be valuable to post speed limits near the shoreline of the rookery.

## **Recommendations to limit predation**

### **6. Ensure that raccoons do not become established on the island.**

There are several species of potential predators that could affect the colony on Great Captains Island, but none are known to cause such high levels of nest failure and abandonment of Long Island Sound colonies as do raccoons. Several islands in the Norwalk, CT, group were abandoned by nesting wading birds after raccoon colonization and have remained mostly unproductive since (Bull 1997). Precautions should be taken to ensure that raccoons do not colonize Great Captains Island and are promptly removed if colonization does occur. Precautions should include:

- yearly monitoring of the island for raccoon presence prior to each breeding season,
- trapping and removal if necessary,
- secure trash disposal and frequent removal of trash,
- signage explaining the importance of proper trash disposal, and
- signage indicating that the release of mammals, particularly raccoons, on the island is prohibited.

### **7. Monitor effects of the rat population.**

Additional predators with potential to affect the colony, although to a lesser extent, include Norway Rats and Black Rats. Town efforts to monitor and control rodents on the island should continue. Rodenticide and/or traps should be used if evidence is found that rats are causing excessive egg or nestling mortality. Secure trash disposal and removal of trash will also benefit efforts to control rodent populations on the island.

### **8. Monitor effects of the gull population.**

Concern has been expressed about predation from nesting gulls impacting the heron and egret colony. The size and extent of the gull colony should be monitored for any adverse impacts on nesting herons and egrets. Gulls are not anticipated to be a serious problem, however, because populations are declining in the northeastern US, and are expected to continue to decline with the closing of large landfills in the eastern US. Any evidence that the gull colony is causing adverse impacts on nesting herons and egrets should be reported to the Connecticut Department of Environmental Protection and the Town of Greenwich.

## **Other recommendations**

### **9. Document and report any evidence of cormorants nesting on the island.**

Establishment of nesting Double-crested Cormorants within heron and egret rookeries can damage vegetation and might subsequently displace nesting herons and egrets (e.g., Alvo 1996). The colony should be closely monitored for the presence of nesting Double-crested Cormorants, with any evidence of nesting by cormorants reported to the Connecticut Department of Environmental Protection and the Town of Greenwich.

### **10. Expand efforts to identify and protect foraging areas and prey populations.**

In addition to requiring safe sites for nesting colonies, breeding herons and egrets also require adequate foraging areas near to nesting sites. Therefore, efforts need to continue to identify existing foraging sites, and to prioritize, protect, and restore these sites. Local regulatory agencies should be informed of the importance of this resource for the conservation of the Great Captains Island rookery. State efforts to protect and monitor populations of fishes that are frequently eaten by herons and egrets should continue in order to maintain an adequate prey base for nesting birds.

### **11. Conduct invasive plant management on the island cautiously.**

The birds of interest in the study, especially the Snowy Egrets and Black-crowned Night-Herons, frequently use invasive plant species for nesting and cover. These plants include Eurasian bitterweet, honeysuckle, and *Phragmites*. These birds also use poison ivy as nesting cover. Any movement to eliminate invasive plant species or poison ivy from Great Captains Island should be carefully weighed against the potential impacts to the colony. If undertaken, any such efforts should be done very gradually, and only in conjunction with native plantings that will quickly provide similar cover to any vegetation removed.

### **12. Develop a standardized program for monitoring colony size and productivity at least every three years.**

Given its regional importance, the rookery and surrounding foraging habitat should continue to be monitored at regular intervals. A standardized protocol should be developed based on the methods used in this study and those outlined in the document “Breeding season population census techniques for seabirds and colonial waterbirds throughout North America” (Steinkamp et al. 2000). Difficulties that have arisen when comparing previous monitoring data clearly demonstrate the need for a fully documented protocol that can be easily repeated by whoever is responsible for monitoring during future surveys. Future monitoring should aim to estimate population size and nest success for each heron and egret species at least every three years. Any apparent population declines in excess of 20% should be further investigated. Future studies of nesting success should monitor a minimum of 10 nests for each species (Katharine Parsons personal communication). Colony monitoring should be combined with intensive surveys for signs of raccoons and additional efforts to identify and prioritize foraging habitats.

## **Concluding notes on colonial waterbird conservation in Long Island Sound**

Colonial waterbirds are known to abandon sites at any time, sometimes for unknown reasons (Bull 1997). Therefore, multiple alternative sites must exist if regional populations are to remain viable. Management of the resources necessary to ensure viable future colonial waterbird populations within the highly developed Long Island Sound/New York Harbor region will likely need to include:

- Protection and management of existing colonies such as Great Captains Island.
- Identification, acquisition and protection of potential colony locations.

- Habitat manipulation and restoration of potential colony sites, in order to optimize habitat for nesting waterbirds.
- Efforts to promote the colonization of alternative nesting sites, such as Calves Island, by wading birds, through the use of decoys and other methods of conspecific attraction.
- Identification, protection, and restoration of foraging habitat.

## **ACKNOWLEDGEMENTS**

### **This project was made possible by funds from:**

The Geoffrey Hughes Foundation

Fairfield County Community Foundation

Town of Greenwich Conservation Commission

The Sounds Conservancy

### **Thanks to:**

The Staff of Audubon Greenwich

Patrick Comins

Town of Greenwich Parks and Recreation Department

Bob Crawford

Katharine Parsons

Keelian Wardle

Chris Elphick

Our Dedicated Volunteers

## TABLES

**Table 1a.** Productivity of monitored Black-crowned Night-Heron nests in 2002. Total number of nests was estimated to be 150. On average 1.93 chicks survived to 21 days per nest.

<b>Nest</b>	<b>Number of Eggs</b>	<b>Number of Hatchlings</b>	<b>Number of Fledglings</b>	<b>Chicks Hatched/ Eggs Laid</b>	<b>Chicks Fledged/ Chicks Hatched</b>	<b>Chicks Fledged/ Eggs Laid</b>
B1	4	1	0	25%	0%	0%
B2	2	2	2	100%	100%	100%
B3	4	3	2	75%	67%	50%
B4	3	2	1	67%	50%	33%
B5	3	3	1	100%	33%	33%
B7	3	3	3	100%	100%	100%
B8	3	2	2	67%	100%	67%
B9	4	2	2	50%	100%	50%
B10	3	3	2	100%	67%	67%
B11	3	2	2	67%	100%	67%
B12	3	2	2	67%	100%	67%
B13	4	3	2	75%	67%	50%
B14	4	4	3	100%	75%	75%
B15	3	2	2	67%	100%	67%
B16	4	3	3	75%	100%	75%
Mean	3.3	2.5	1.9	75.7%	77.3%	60.1%

**Table 1b.** Productivity of monitored Great Egret nests in 2002. Total number of nests was 82. On average 1.0 chick survived to 35 days per nest.

<b>Nest</b>	<b>Number of Eggs</b>	<b>Number of Hatchlings</b>	<b>Number of Fledglings</b>	<b>Chicks Hatched/ Eggs Laid</b>	<b>Chicks Fledged/ Chicks Hatched</b>	<b>Chicks Fledged/ Eggs Laid</b>
G1	3	3	0	100%	0%	0%
G2	3	1	0	33%	0%	0%
G3	4	3	3	75%	100%	75%
G4	4	2	2	50%	100%	50%
G5	4	3	0	75%	0%	0%
Mean	3.6	2.4	1	60.6%	40.0%	25.0%

**Table 1c.** Productivity of Snowy Egret nests in 2002. Total number of nests was estimated to be 20. On average 2.75 chicks survived to 14 days per nest.

<b>Nest</b>	<b>Number of Eggs</b>	<b>Number of Hatchlings</b>	<b>Number of Fledglings</b>	<b>Chicks Hatched/ Eggs Laid</b>	<b>Chicks Fledged/ Chicks Hatched</b>	<b>Chicks Fledged/ Eggs Laid</b>
S1	4	3	3	75%	100%	75%
S4	4	3	3	75%	100%	75%
S5	5	3	3	60%	100%	60%
S6	2	2	2	100%	100%	100%
Mean	3.75	2.75	2.75	77.5%	100%	77.5%

**Table 2:** Average success rates of monitored (a) Black-crowned Night-Herons, (b) Great Egrets, and (c) Snowy Egrets nests in 2000, 2001, and 2002.

**a. Black-crowned Night-Herons**

	<b>2000</b>	<b>2001</b>	<b>2002</b>
Clutch size	3.6	3.3	3.3
Chicks Hatched/Eggs (%)	81.4	79.0	75.7
Chicks Fledged/Chicks Hatched (%)	5.5	50.0	77.3
Chicks Fledged/Eggs (%)	5.5	41.0	60.1

**b. Great Egrets**

	<b>2000</b>	<b>2001</b>	<b>2002</b>
Clutch size	3.2	3.8	3.6
Chicks Hatched/Eggs (%)	64.0	69.0	60.6
Chicks Fledged/Chicks Hatched (%)	57.0	70.0	40.0
Chicks Fledged/Eggs (%)	48.8	54.0	25.0

**c. Snowy Egrets**

	<b>2000</b>	<b>2001</b>	<b>2002</b>
Clutch size	3.0	4.3	3.8
Chicks Hatched/Eggs (%)	68.8	94.0	77.5
Chicks Fledged/Chicks Hatched (%)	50.3	28.0	100
Chicks Fledged/Eggs (%)	46.0	28.0	77.5

**Table 3:** Flight-lines observed in each sector for (a) Black-crowned Night-Herons, (b) Great Egrets, (c) Snowy Egrets, and (d) all three species combined, going to and from Great Captains Island in 2002. Each sector contains 45 degrees, with the colony center being at the center of an imaginary circle. See Figures 8-11.

**a. Black-crowned Night-Herons**

<b>Sector</b>	<b># Flights</b>	<b># Flights/Total Flights (%)</b>
1	207	27.0
2	125	16.3
3	1	0.1
4	29	3.8
5	59	7.7
6	173	22.5
7	74	9.6
8	100	13.0
TOTAL	768	100

**b. Great Egrets**

<b>Sector</b>	<b># Flights</b>	<b># Flights/Total Flights (%)</b>
1	127	15.6
2	175	21.4
3	6	0.7
4	62	7.6
5	37	4.5
6	155	19.0
7	153	18.8
8	101	12.4
TOTAL	816	100

**c. Snowy Egrets**

<b>Sector</b>	<b># Flights</b>	<b># Flights/Total Flights (%)</b>
1	58	17.2
2	49	14.5
3	2	0.6
4	53	15.7
5	25	7.4
6	68	20.1
7	50	14.8
8	33	9.8
TOTAL	338	100

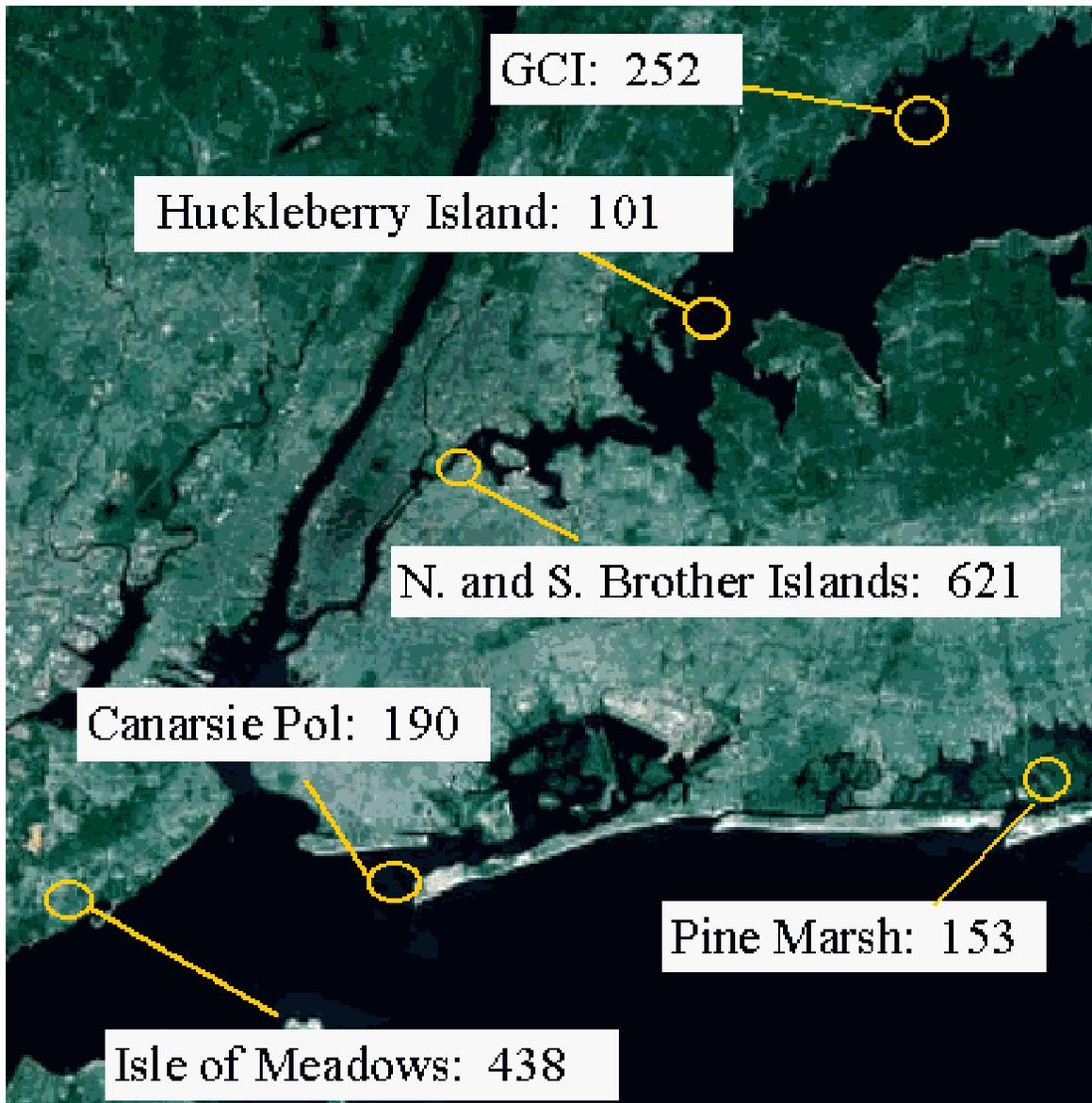
**d. All species combined**

<b>Sector</b>	<b># Flights</b>	<b># Flights/Total Flights (%)</b>
1	392	20.4
2	349	18.2
3	9	0.47
4	144	7.5
5	121	6.3
6	396	20.6
7	277	14.4
8	234	12.2
TOTAL	1922	100

**Table 4:** Confirmed (\*) and possible foraging locations of Black-crowned Night-Herons, Great Egrets, and Snowy Egrets in each sector.

<b>Sector</b>	<b>Degrees in each sector</b>	<b>Geographical Location</b>	<b>Foraging Locations</b>
1	0-45	Greenwich Cove and Inland	Belle Haven* Tweed Island* Gamecock Road* Steamboat Road* Indian Harbor* Smith Cove* Shore Road*
2	46-90	CT Coast (Old Greenwich and Stamford)	Little Captains Island* Stamford Harbor* Dyke Park Rippowam River, W. Branch Ledge Road* Greenwich Point Park* Tod's Point* Cos Cob Harbor* Horse Island* Binney Park Tomac Cove* Harbor Point*
3	91-135	Long Island Sound and Huntington, Long Island NY	Northport Bay Fresh Pond
4	136-180	Oyster Bay and Bayville, Long Island, NY	Bayville* Mill Neck Creek* Frost Creek Stanco Memorial Park Oyster Bay* Upper Francis Pond Glen Cove West Harbor*
5	181-225	Western Long Island, Port Washington, NY	
6	226-270	Coast of Westchester (Rye, Mamaroneck)	Playland Park Lake* Marshlands County Park* Rye Town Park
7	271-315	Westchester and Inland (Port Chester, White Plains)	Calf Islands*
8	316-360	Western Greenwich and Inland	Round Hill Road* Byram Park* Byram River*

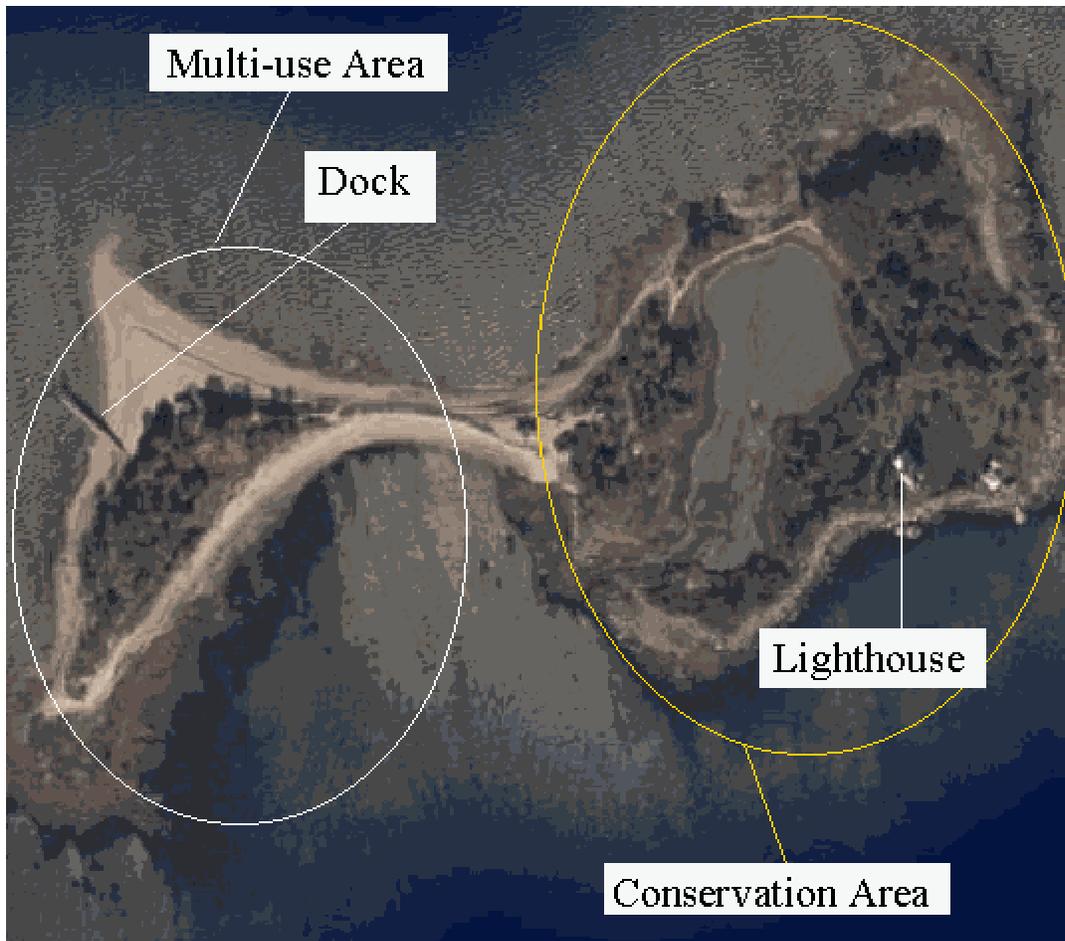
## FIGURES



**Figure 1.** Rookeries in the New York Harbor area and western Long Island Sound that contain at least 100 pairs of Black-crowned Night-Herons, Great Egrets, and Snowy Egrets combined. Population numbers represent total nesting pairs of all three species combined, and are the most recent available for each rookery. Data provided by the New York State Department of Environmental Conservation, New York City Parks and Recreation Department, and New York City Audubon Society. Note: The North and South Brother Islands rookery contains only 95 pairs of Great and Snowy Egrets combined.



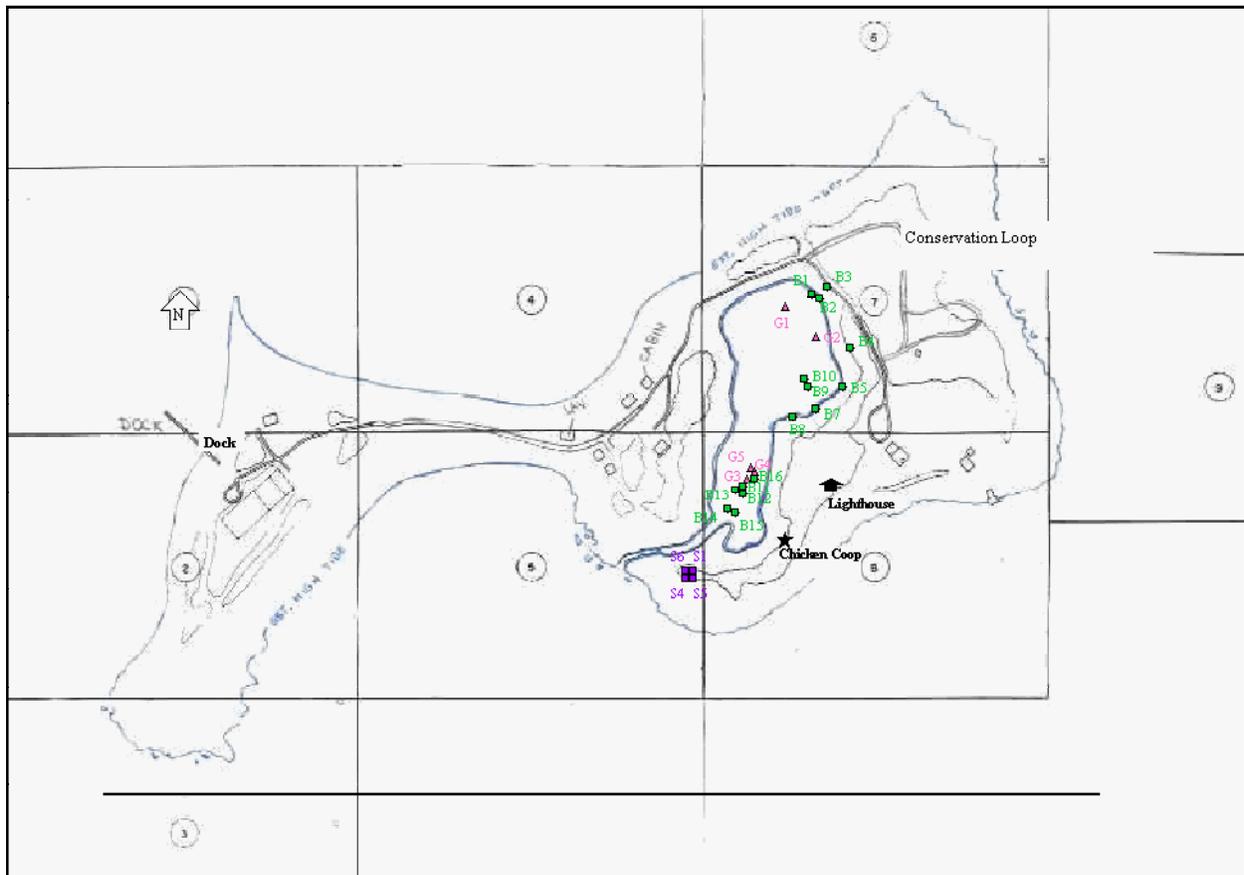
Figure 2. Location of Great Captains Island.



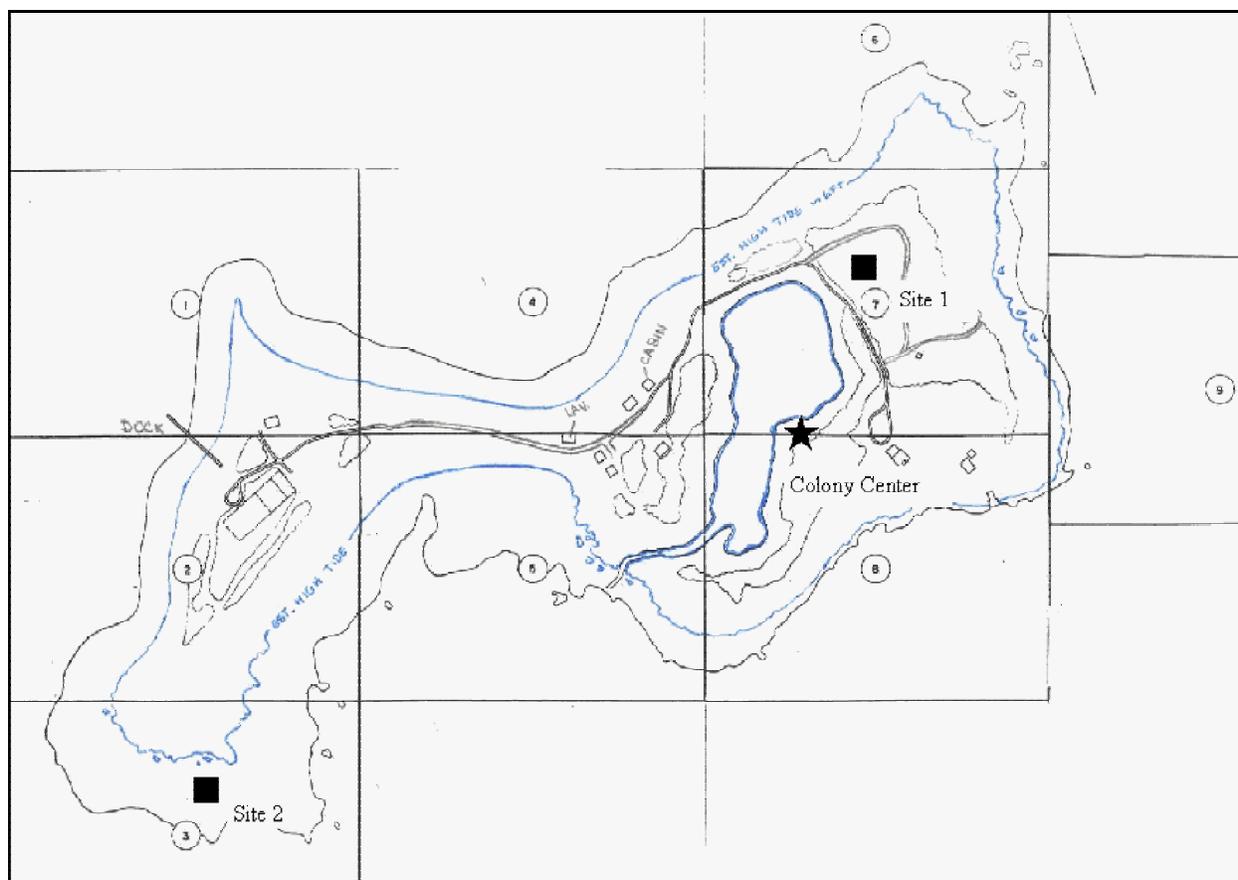
**Figure 3.** Overview of Great Captains Island and its uses.



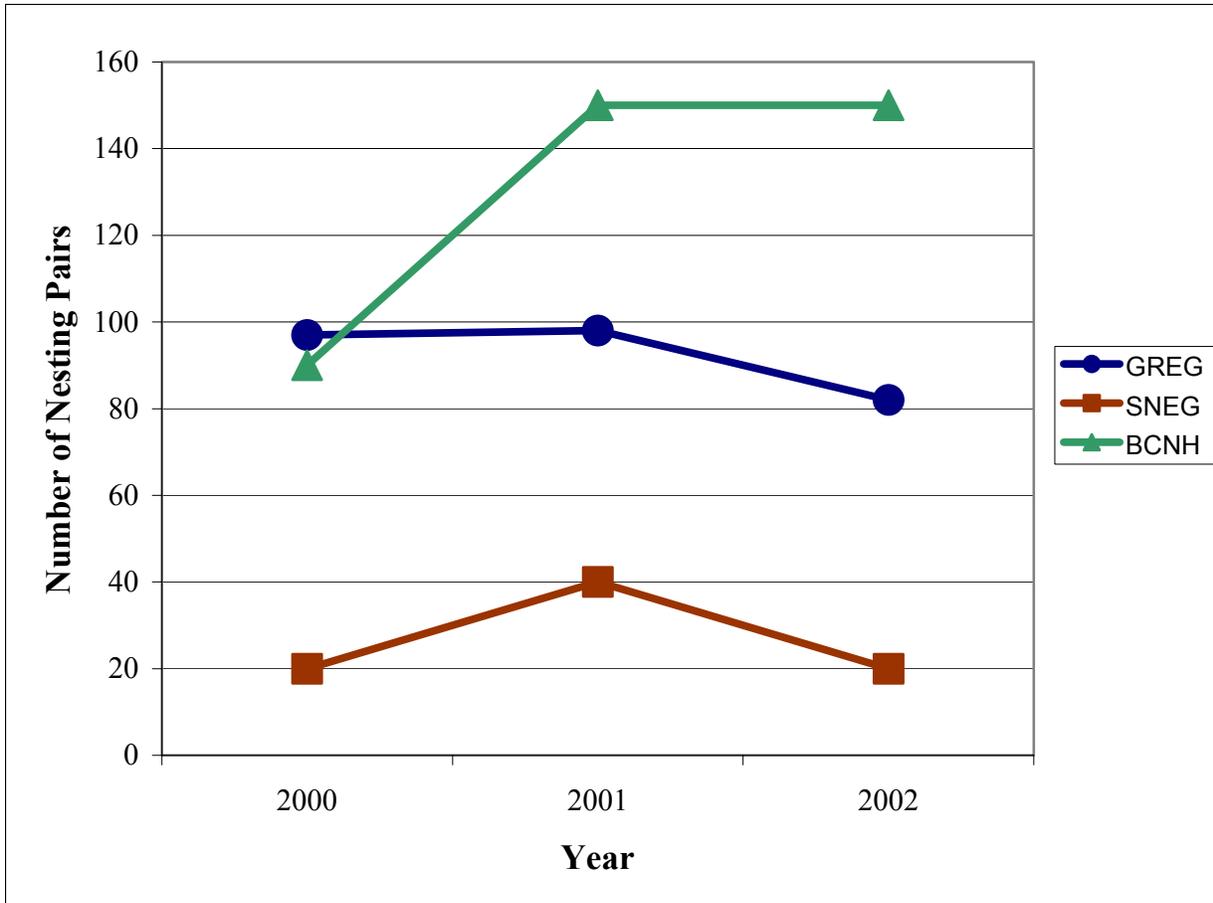
**Figure 4.** Nesting locations of Black-crowned Night-Herons, Great Egrets, Snowy Egrets, and Little Blue Herons within the conservation area of Great Captains Island.



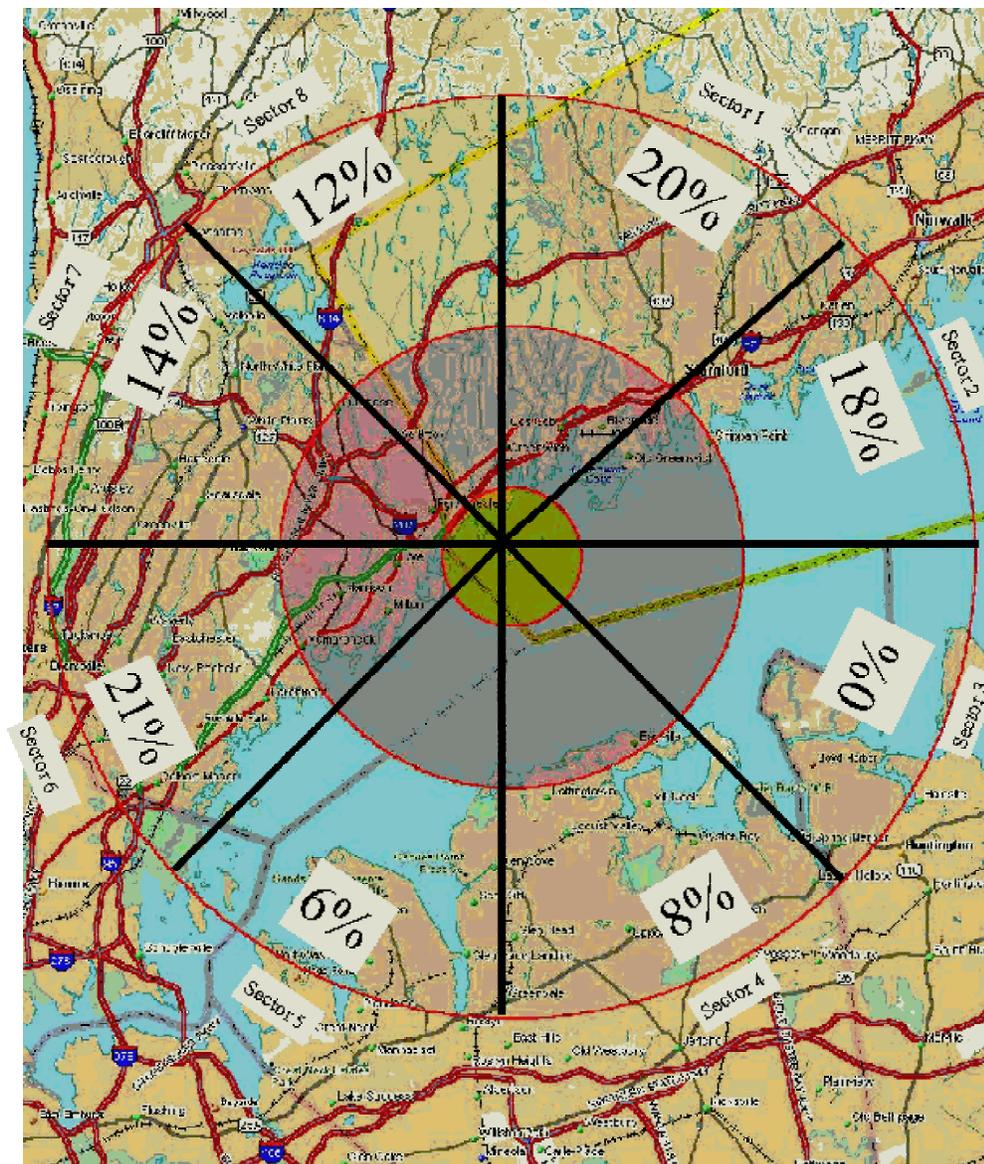
**Figure 5.** Locations of monitored nests on Great Captains Island in 2002. Black-crowned Night-Heron nests are represented by green circles, Great Egret nests are represented by pink triangles, and Snowy Egret nests are represented by purple squares.



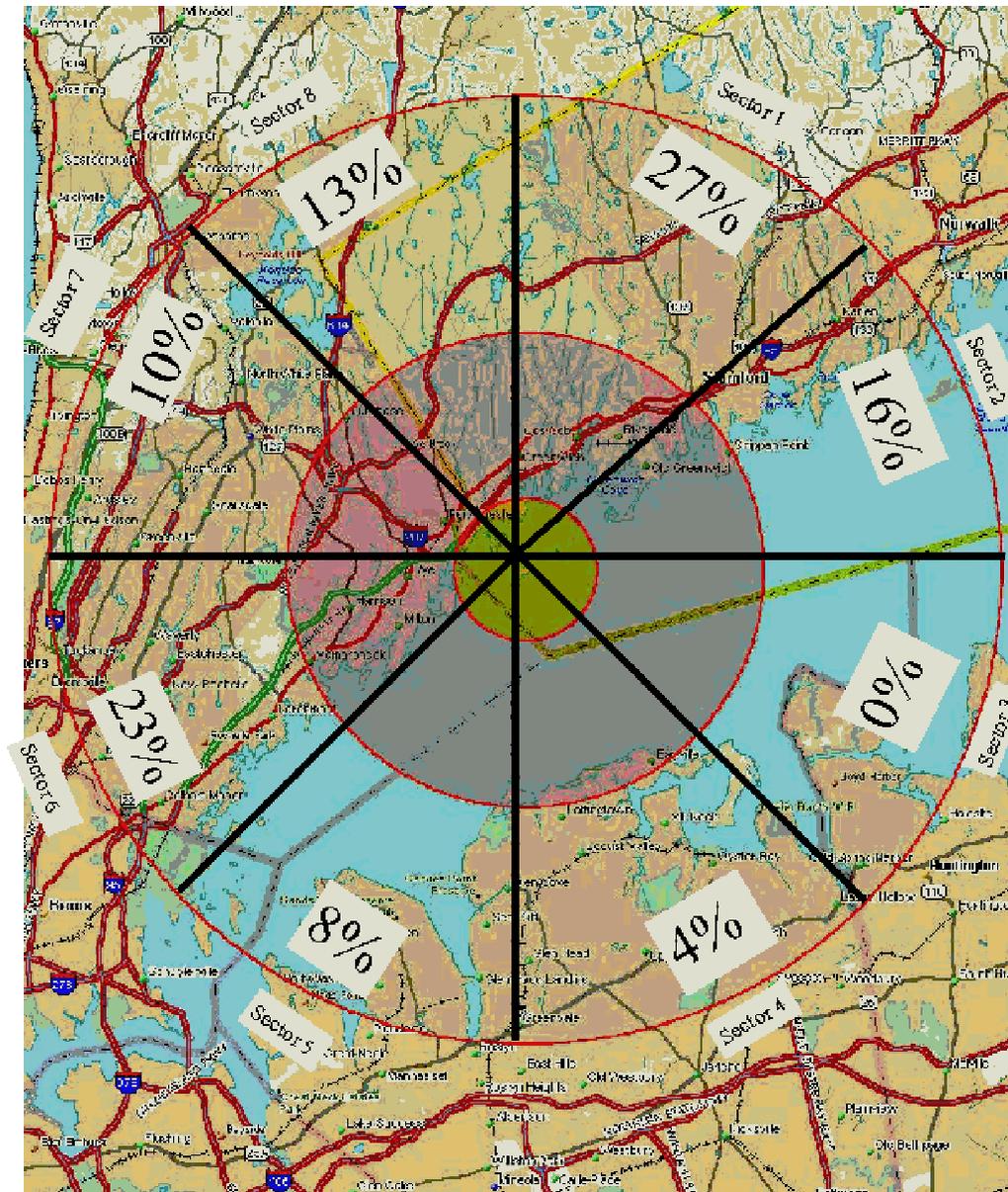
**Figure 6.** Location of the colony center and the observation sites used for flight-line analysis on Great Captains Island in 2002. Sites were chosen so that all incoming and outgoing birds could be seen.



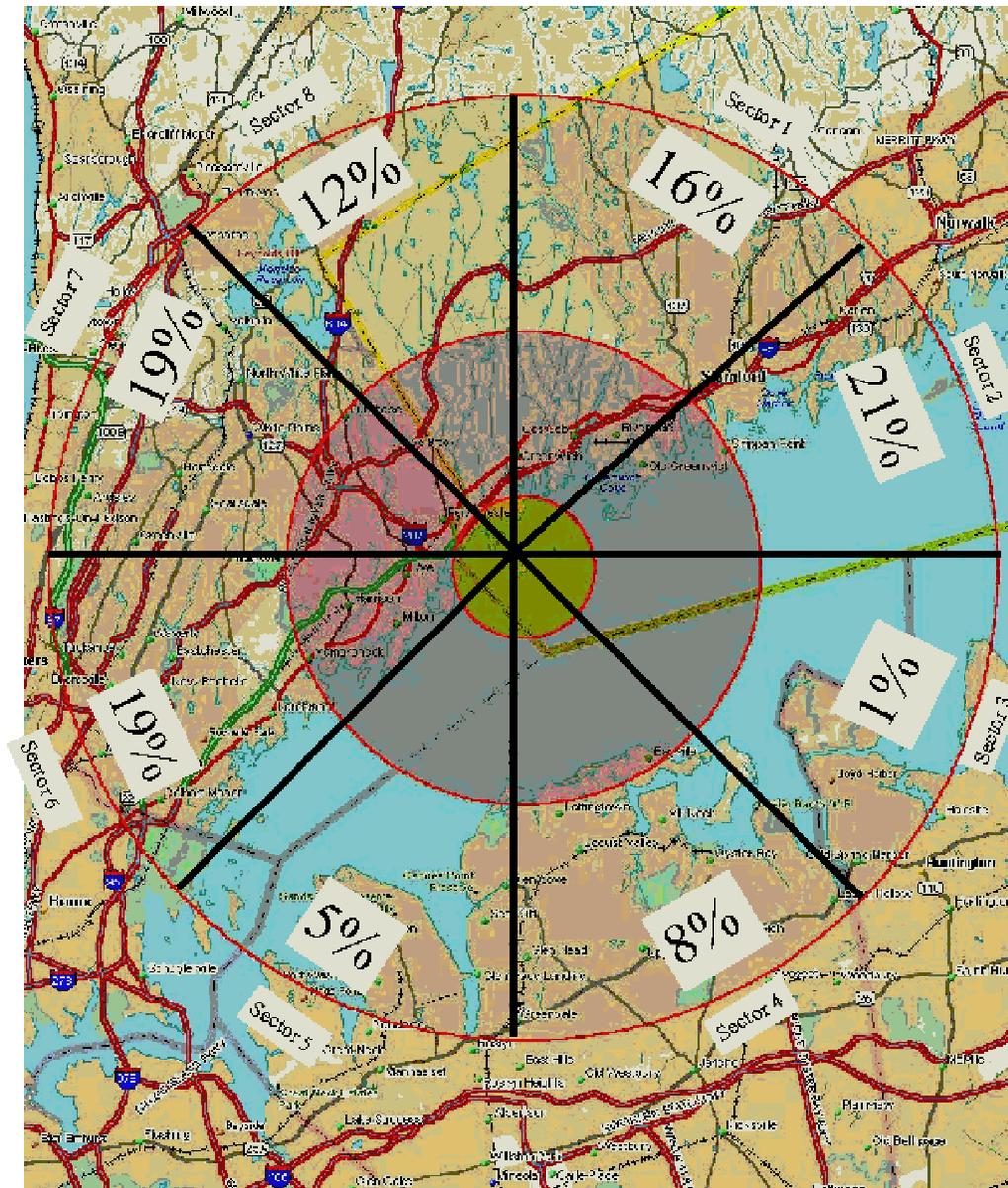
**Figure 7.** Number of nesting pairs of Black-crowned Night-Herons (BCNH), Great Egrets (GREG), and Snowy Egrets (SNEG) in 2000, 2001, and 2002 on Great Captains Island.



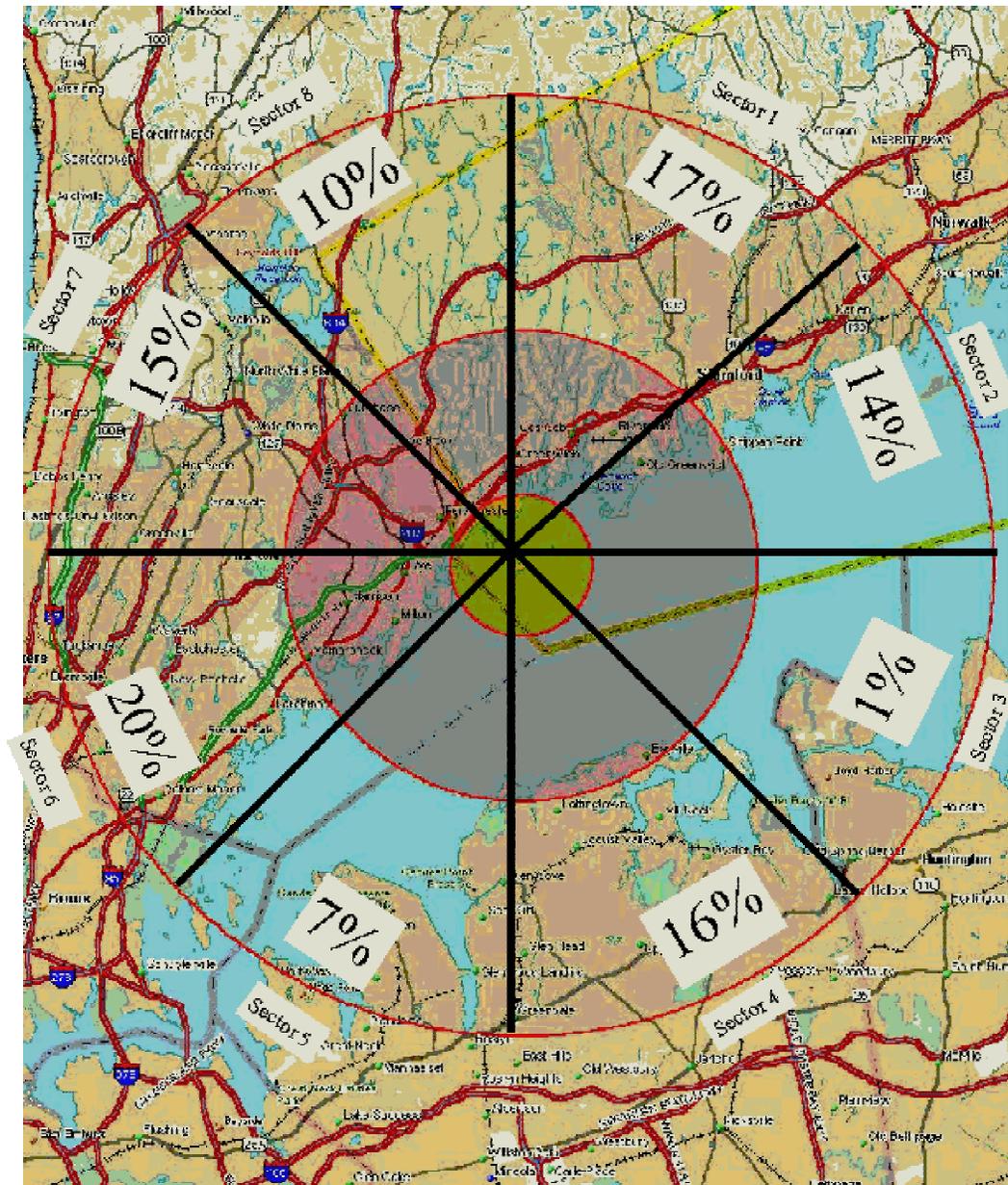
**Figure 8.** Proportion of foraging flight-lines observed in each 45-degree sector by all herons and egrets flying to and from Great Captains Island in 2002. Shaded circles surrounding the colony show distances from the colony, 3 km, 10 km, and 25 km. See Table 4 for a list of foraging locations within each sector.



**Figure 9.** Proportion of foraging flight-lines observed in each 45-degree sector by Black-crowned Night-Herons flying to and from Great Captains Island in 2002. Shaded circles surrounding the colony show distances from the colony, 3 km, 10 km, and 25 km. See Table 4 for a list of foraging locations within each sector.



**Figure 10.** Proportion of foraging flight-lines observed in each 45-degree sector by Great Egrets flying to and from Great Captains Island in 2002. Shaded circles surrounding the colony show distances from the colony, 3 km, 10 km, and 25 km. See Table 4 for a list of foraging locations within each sector.



**Figure 11.** Proportion of foraging flight-lines observed in each 45-degree sector by Snowy Egrets flying to and from Great Captains Island in 2002. Shaded circles surrounding the colony show distances from the colony, 3 km, 10 km, and 25 km. See Table 4 for a list of foraging locations within each sector.

## APPENDIX A

Avian species observed visiting and nesting on Great Captains Island during the 2000, 2001, and 2002 research seasons. “N” in the second column indicates nesting species.

Common Name		Scientific Name
American Crow		<i>Corvus brachyrhynchos</i>
American Goldfinch		<i>Carduelis tristis</i>
American Kestrel		<i>Falco sparverius</i>
American Oystercatcher		<i>Haematopus palliatus</i>
Barn Swallow		<i>Hirundo rustica</i>
Belted Kingfisher		<i>Ceryle alcyon</i>
Black-bellied Plover		<i>Pluvialis squatarola</i>
Black-crowned Night-Heron	N	<i>Nycticorax nycticorax</i>
Brant		<i>Branta bernicla</i>
Brown-headed Cowbird		<i>Molothrus ater</i>
Canada Goose	N	<i>Branta canadensis</i>
Common Grackle	N	<i>Quiscalus quiscula</i>
Common Tern		<i>Sterna hirundo</i>
Common Yellowthroat	N	<i>Geothlypis trichas</i>
Double-crested Cormorant		<i>Phalacrocorax auritus</i>
Dunlin		<i>Calidris alpina</i>
Eastern Kingbird	N	<i>Tyrannus tyrannus</i>
Eastern Phoebe		<i>Sayornis phoebe</i>
European Starling		<i>Sturnus vulgaris</i>
Fish Crow		<i>Corvus ossifragus</i>
Glossy Ibis		<i>Plegadis falcinellus</i>
Gray Catbird	N	<i>Dumetella carolinensis</i>
Great Black-backed Gull	N	<i>Larus marinus</i>
Great Blue Heron		<i>Ardea herodias</i>
Great Egret	N	<i>Ardea alba</i>
Great Horned Owl	N	<i>Bubo virginianus</i>
Green Heron		<i>Butorides virescens</i>
Herring Gull	N	<i>Larus argentatus</i>
House Finch		<i>Carpodacus mexicanus</i>
Killdeer	N	<i>Charadrius vociferus</i>
Laughing Gull		<i>Larus atricilla</i>
Least Sandpiper		<i>Calidris minutilla</i>
Least Tern		<i>Sterna antillarum</i>
Little Blue Heron	N	<i>Egretta caerulea</i>
Mallard	N	<i>Anas platyrhynchos</i>
Northern Cardinal		<i>Cardinalis cardinalis</i>

Northern Flicker		<i>Colaptes auratus</i>
Long-tailed Duck		<i>Clangula hyemalis</i>
Osprey		<i>Pandion haliaetus</i>
Red-winged Blackbird	N	<i>Agelaius phoeniceus</i>
Rock Dove		<i>Columba livia</i>
Ruddy Turnstone		<i>Arenaria interpres</i>
Savannah Sparrow		<i>Passerculus sandwichensis</i>
Scarlet Tanager		<i>Piranga olivacea</i>
Semipalmated Plover		<i>Charadrius semipalmatus</i>
Short-billed Dowitcher		<i>Limnodromus griseus</i>
Snowy Egret	N	<i>Egretta thula</i>
Solitary Sandpiper		<i>Tringa solitaria</i>
Song Sparrow	N	<i>Melospiza melodia</i>
Yellow Warbler	N	<i>Dendroica petechia</i>

Tree and shrub species present on Great Captains Island:

<b>Common name</b>	<b>Scientific name</b>
Ash leaf maple	<i>Acer negundo</i>
Bigtooth aspen	<i>Populus grandidentata</i>
Black cherry	<i>Prunus serotina</i>
Pin cherry	<i>Prunus pennsylvanica</i>
Black locust	<i>Robinia pseudoacacia</i>
Chokeberry	<i>Pyrus arbutifolia</i>
Common purple lilac	<i>Syringa vulgaris</i>
Dawn-redwood	<i>Metasequoia glyptostroboides</i>
Elm	<i>Ulmus spp</i>
False indigo	<i>Amorpha fruticosa</i>
Hercules' club	<i>Aralia spinosa</i>
Honey locust	<i>Gleditsia triacanthos</i>
Honeysuckle	<i>Lonicera spp</i>
Marsh elder	<i>Iva frutescens</i>
Mockernut hickory	<i>Carya tomentosa</i>
Multiflora rose	<i>Rosa multiflora</i>
Norway maple	<i>Acer platanoides</i>
Paper birch	<i>Betula papyrifera</i>
Poison ivy	<i>Rhus radicans</i>
Pussy willow	<i>Salix discolor</i>
Red maple	<i>Acer rubrum</i>
Red oak	<i>Quercus rubra</i>
Red pine	<i>Pinus resinosa</i>
Rugosa rose	<i>Rosa Rugosa</i>
Sassafras	<i>Sassafras albidum</i>
Shagbark hickory	<i>Carya ovata</i>
Spruce	<i>Picea spp.</i>
Staghorn sumac	<i>Rhus typhina</i>
Tree-of-heaven	<i>Ailanthus altissima</i>
White mulberry	<i>Morus alba</i>
White oak	<i>Quercus alba</i>

Herbaceous species present on Great Captains Island:

<b>Common name</b>	<b>Scientific Name</b>
Asiatic bittersweet	<i>Celastrus orbiculatus</i>
Beach pea	<i>Lathyrus japonicus</i>
Bittersweet nightshade	<i>Solanum dulcamara</i>
Common blackberry	<i>Rubus allegheniensis</i>
Common mallow	<i>Malva neglecta</i>
Curled dock	<i>Rumex crispus</i>
Field chickweed	<i>Cerastium arvense</i>
Field thistle	<i>Cirsium discolor</i>
Greenbrier	<i>Smilax rotundifolia</i>
Hedge bindweed	<i>Convolvulus sepium</i>
Oxeye daisy	<i>Chrysanthemum leucanthemum</i>
Salt-marsh grass	<i>Spartina alterniflora</i>
Slender glasswort	<i>Salicornia europaea</i>
St. Johnswort	<i>Hypericum perforatum</i>
Stinging nettle	<i>Urtica dioica</i>
Virginia creeper	<i>Parthenocissus quinquefolia</i>

Known predators of Great Egrets, Snowy Egrets, Black-crowned Night-Herons, their eggs, or their chicks.

<b>Avian Predators</b>	<b>Scientific name</b>
American Crow	<i>Corvus brachyrhynchos</i>
Fish Crow	<i>Corvus ossifragus</i>
Common Raven	<i>Corvus corax</i>
Boat-tailed Grackle	<i>Quiscalus major</i>
Black Vulture	<i>Coragyps atratus</i>
Turkey Vulture	<i>Cathartes aura</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
Peregrine Falcon	<i>Falco peregrinus</i>
Great Horned Owl	<i>Bubo virginianus</i>
Herring Gull	<i>Larus argentatus</i>
Great Black-backed Gull	<i>Larus marinus</i>
Black-crowned Night-Heron	<i>Nycticorax nycticorax</i>
<b>Mammalian Predators</b>	
Opossum	<i>Didelphis virginiana</i>
Raccoon	<i>Procyon lotor</i>
Bobcat	<i>Felis rufus</i>
Black Rat	<i>Rattus rattus</i>
Norway Rat	<i>Rattus norvegicus</i>
Red Fox	<i>Vulpes fulva</i>
Gray Fox	<i>Urocyon cinereoargenteus</i>
<b>Reptilian Predators</b>	
Black Rat Snake	<i>Elaphe obsoleta</i>

# APPENDIX B

## Volunteer Information Sheets

Names(s) \_\_\_\_\_  
Location \_\_\_\_\_  
Date \_\_\_\_\_  
Bird Arrival Time \_\_\_\_\_  
Bird Departure Time \_\_\_\_\_  
Bird Species \_\_\_\_\_  
Direction They Came \_\_\_\_\_  
Direction They Went \_\_\_\_\_  
Notes \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Names(s) \_\_\_\_\_  
Location \_\_\_\_\_  
Date \_\_\_\_\_  
Bird Arrival Time \_\_\_\_\_  
Bird Departure Time \_\_\_\_\_  
Bird Species \_\_\_\_\_  
Direction They Came \_\_\_\_\_  
Direction They Went \_\_\_\_\_  
Notes \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Foraging Flight-line Data Sheet**

State: \_\_\_\_\_ Year: \_\_\_\_\_  
 Colony: \_\_\_\_\_ Site: \_\_\_\_\_  
 Date \_\_\_\_\_ Observer: \_\_\_\_\_  
 (mdy):

OFFICE (initial and date)

Checked:	Week:	of
Entered:		
Proofed:		

Start time: \_\_\_\_\_

Cloud cover (%): 00 01 02 03 04 05 06 07 08  
 09 10

Precipitation: N D L M H F  
 Z

(N=none, D=drizzle, L=light rain, M=moderate,  
 H=heavy, F=fog, Z=haze)

End time (start time + 60 min): \_\_\_\_\_

Cloud cover (%): 00 01 02 03 04 05 06 07 08  
 09 10

Precipitation: N D L M H F  
 Z

(N=none, D=drizzle, L=light rain, M=moderate,  
 H=heavy, F=fog, Z=haze)

Wind speed (mph): 0 (0-5) 1 (6-15) 2  
 (>15)

Wind direction \_\_\_\_\_  
 (°): \_\_\_\_\_

Temperature \_\_\_\_\_  
 (°F): \_\_\_\_\_

Tide: Rise high Ebb high Rise low Ebb  
 low

Wind speed (mph): 0 (0-5) 1 (6-15) 2  
 (>15)

Wind direction \_\_\_\_\_  
 (°): \_\_\_\_\_

Temperature \_\_\_\_\_  
 (°F): \_\_\_\_\_

Tide: Rise high Ebb high Rise low Ebb  
 low



## REFERENCES

- Alvo, R. 1996. Double-crested cormorant (*Phalacrocorax auritus*). Pp. 232-235 in J. Gauthier and Y. Aubry, editors, The breeding birds of Quebec: atlas of the breeding birds of southern Quebec. Association québécoise des groupes d'ornithologues, Province of Quebec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Quebec Region, Montreal.
- Bratton, S.P. 1990. Boat disturbance of Ciconiiformes in Georgia estuaries. *Colonial Waterbirds* 13: 122-128.
- Bull, M.G. 1997. Conservation and management plan for colonial nesting wading birds in Connecticut. Unpublished report to the Department of Environmental Protection, Wildlife Division. Hartford CT, 1-57 pp.
- Burger, J. 1982. An overview of proximate factors affecting reproductive success in colonial birds: Concluding remarks and summary of panel discussion. *Colonial Waterbirds* 5: 58-65.
- Custer, C.M. and J. Galli. 2002. Feeding habitat selection by Great Blue Herons and Great Egrets nesting in east central Minnesota. *Waterbirds* 25: 115-124.
- Custer, T.W. and R.G. Osborn. 1978. Feeding habitat use by colonially- breeding herons, egrets, and ibises in North Carolina. *Auk* 95: 733-743.
- Davis, W.E., Jr. 1993. Black-crowned Night Heron (*Nycticorax nycticorax*). In *The Birds of North America*, No. 74 (A. Poole and F. Gill, eds) The Birds of North America Inc., Philadelphia, PA.
- Erwin, R.M. 1983. Feeding habitats of nesting and wading birds: Spatial use and social influences. *Auk* 100: 960-970.
- Erwin, R.M. 1984. Feeding flights of nesting wading birds at a Virginia colony. *Colonial Waterbirds* 7: 74-79.
- Gibbs, J. P. 1991. Spatial relationships between nesting colonies and foraging areas of Great Blue Herons. *Auk* 208: 764-770.
- Kushlan, J. A. 1992. Population biology and conservation of colonial wading birds. *Colonial Waterbirds* 15: 1-7.
- Kushlan, J. A. 1993. Colonial waterbirds as bioindicators of environmental change. *Colonial Waterbirds* 16: 223-251.
- Maccarone, A.D. and K.C. Parsons. 1986. Differences in flight patterns among nesting ibises and egrets. *Waterbirds* 11: 67-71.
- McCrimmon, D.A., Jr., J.C. Ogden, and G.T. Bancroft. 2001. Great Egret (*Ardea alba*). In *The Birds of North America*, No. 570 (A. Poole and F. Gill, eds) The Birds of North America Inc., Philadelphia, PA.
- Nisbet, I.C.T. 2000. Disturbance, habituation, and management of waterbird colonies. *Waterbirds* 23: 312-322.

- Parnell, J.F. et al. 1988. Colonial waterbird management in North America. *Colonial Waterbirds* 11: 129-169.
- Parsons, K.C. and J. Burger. 1982. Human disturbance and nestling behavior in Black-crowned Night Herons. *Condor*. 84: 184-187.
- Parsons, K.C. and T.L. Master. 2000. Snowy Egret (*Egretta thula*). *The Birds of North America*, No. 489 (A. Poole and F. Gill eds.) The Birds of North America Inc. Philadelphia, PA.
- Rodgers, J.A., Jr, H. T. Smith. 1995. Little Blue Heron (*Egretta caerulea*). *The Birds of North America*, No. 145 (A. Poole and F. Gill eds.). The Birds of North America Inc. Philadelphia, PA.
- Smith, J.P. 1995. Foraging flights and habitat use of nesting wading birds (Ciconiiformes) at Lake Okeechobee, Florida. *Colonial Waterbirds* 18: 139-158.
- Smith, J.P. 1997. Nesting season food habits of four species of herons and egrets at Lake Okeechobee, Florida. *Colonial Waterbirds* 20: 198-120.
- Sommers, L., D.L. Rosenblatt, and M.J. Del Puerto. 2002. 1998-1999 Long Island colonial waterbird and Piping Plover survey. New York State Department of Environmental Conservation, Stony Brook, NY.
- Steinkamp, M.J., B. Peterjohn, V. Byrd, and R. Lowe. 2000. Breeding season population census techniques for seabirds and colonial waterbirds throughout continental North America – 25 October 2000 draft. ([www.nawcp.org/plan/toolbox.html](http://www.nawcp.org/plan/toolbox.html)), North American Waterbird Conservation Plan, Washington, DC.
- Willard, D.E. 1977. The feeding ecology and behavior of five species of herons in southeastern New Jersey. *Condor* 79: 462-470.
- Wong, L.C., R.T. Corlett, L. Young, and J.S.Y. Lee. 1999. Foraging flights of nesting egrets and herons at a Hong Kong egretty, South China. *Waterbirds* 22: 424-434.