Breeding biology and effects of human disturbance on Piping Plovers (Charadrius melodus) on the Outer Banks of North Carolina.

Chapter V

by

Susan Philhower

Suzanne Wrenn

and

Jeffrey R. Walters

Department of Zoology
North Carolina State University
Raleigh, North Carolina 27695

and

Virginia Polytechnic Institute and State University
Department of Biology
Blacksburg, Virginia 24061

Due to its threatened status on the East Coast, the piping plover and its breeding success was of special interest to our study of shorebirds in CAHA and CALO. North Carolina's seashores represent the southern edge of the piping plover's breeding range, and plover productivity here historically has been low. Habitat and conditions for piping plovers breeding in North Carolina are different than those experienced by birds in northern regions, where most previous piping plover research has been conducted. Factors that affect reproductive success in northern regions involve human disturbance, habitat loss and predation. A major goal of our study was to determine how these and other factors may be influencing production by piping plovers on North Carolina seashores.

In addition to general monitoring of piping plover breeding activity, observations of breeding pairs were conducted to better understand the interaction of disturbance, foraging habitat use and predation in affecting productivity. We investigated the nature of interactions between adults and chicks during brood rearing in detail, in order to better understand the determinants of successful reproduction. These studies included examination of possible indirect effects, such as temperature, on chick survivorship. We will first present a brief summary of population dynamics, including reproductive success, during our study. Additional details were provided in project annual reports. We will then present and discuss our intensive studies of breeding biology.

Unlike other parts of our project, data collection for the piping plover study continued through the summer of 1994. The two students involved in other parts of the project have written and defended their theses, whereas the student conducting the piping plover work is still analyzing data and writing her thesis. What is reported here represents the final product of other components of the project, but for the piping plover study an additional product, a Ph.D. thesis, will be forthcoming at a later date. In this report we indicate additional analyses to be provided in this thesis, as well as results of analyses already completed. Although not included in our project, we present some additional data from the 1995 breeding season on CALO.

Summary of Population Dynamics

Population numbers of breeding piping plovers increased slightly over the duration of our study (Table 1). The slight growth comes from increases at CALO, whereas numbers at CAHA were steady. The reported increase from 1992 to 1993 on CALO may represent increased accuracy of censusing due to experience of researchers rather than actual population increase, but gains from 1993 to 1994 almost certainly are real. Distribution of pairs among different nesting areas of the parks remained fairly consistent (Table 1). The number of pairs nesting at Ocracoke declined with each year, and pairs increased at New Drum Inlet on both NCB and SCB, but declined in 1995. These two nesting areas at New Drum Inlet contained the highest density of pairs.

Reproductive success for the two seashores was quite low (Table 2) and was lower than the average for Atlantic coast plovers (1.33 chicks per breeding pair from 1988-1994, USFWS 1995). Plover productivity varied between years, locations and management strategies. Reproductive success on CAHA remained relatively constant, whereas success on CALO was markedly greater in 1993 than in the other two years. Use of predator exclosures and weather conditions were major determinants of productivity. On CAHA number of fledglings per nesting pair increased from 0.67 for the first two years to 0.82 in 1994 when predator exclosures were used (Table 2). Productivity was highest in 1993 on CALO when exclosures were used and storms were few. Frequent storms resulted in low productivity in 1994, in spite of use of exclosures. On CALO in 1995 when exclosures were used on all nests and storms were few, the highest hatching success (63%) was attained.

A total of 196 nests were monitored on CAHA and CALO from 1992-1994. Of these nests, 132 (67%) did not hatch, 47 (24%) produced fledglings, and 17 (9%) hatched but fledged no chicks. Of all hatched nests, 73% fledged at least one chick. These general statistics illustrate that on CAHA and CALO, piping plover reproductive success is most strongly affected by factors acting during the incubation period. Among shorebirds, rates of nest loss tend to be lower in Arctic regions and higher in the tropics compared to temperate areas. The proportion of chicks that fledge varies similarly, but less dramatically. Rates of loss of piping plover chicks in North Carolina are typical of what one expects of a shorebird at this latitude, but hatching success appears somewhat lower than expected. There is some evidence that beach-nesting species have lower hatching rates than other species, so whether the rates we observed are lower than they were historically is unclear. Predation and storm overwash are the primary causes of nest loss (Table 3). Frequent loss of nests to storms is a factor in which piping plovers and other beach-nesting species differ from other shorebirds, one which may have led evolutionarily to other, compensating differences in breeding biology, such as extended nesting seasons and frequent renesting. This factor might even restrict breeding range. High rates of nest predation, on the other hand, could be a more recent phenomenon linked to human influences.

There was consistently higher hatching success in some nesting areas (such as Cape Point and Power Squadron Spit) than in others (such as Ocracoke (CAHA), Ocracoke Inlet (CALO) and New Drum Inlet (Table 4). These differences may be due to variation in predator pressure or overwash frequency. Predation is high at Ocracoke, where 50% to 100% of nests are predated. Predators usually take a third to a half of the nests at Hatteras Spit. Predation frequency varies on NCB. Nests on Portsmouth Flats, Kathryn-Jane Flats and New Drum Inlet have had up to 40% predation rate during different years. Most flooding of nests occured on NCB. Flooding was prevalent on Portsmouth Flats, where 40% to 44% of nests failed from flooding each year. Nests along Portsmouth Flats are adjacent to expansive flats that are promptly flooded from Core Sound during northeast winds. About a third of nests (25% to 44%) at Kathryn-Jane and New Drum Inlet (NCB) flooded during stormy years. These two areas do not receive sound water as readily as Portsmouth Flats, yet the areas lie low and collect rainwater.

During the duration of our study, reproductive success has been generally low (Table 1) while population size has increased slightly (Table 2). This pattern is a curious one, and begs the question of how North Carolina populations are regulated. Individuals may continually immigrate from more productive populations to maintain the North Carolina population, or adult and/or juvenile survivorship may be substantially better for North Carolina populations than for others so that they maintain themselves with relatively low reproductive rates. Higher rates of survival and lower rates of productivity are typical of more southern bird populations compared to more northern ones. That an increase in population numbers occurred after a successful year of reproduction in North Carolina (1993) and that population numbers decreased on NCB after a poor year of reproduction (1994) illustrates that the population might be self-sustaining rather than dependent on immigration. It also suggests that population size might be limited by productivity. Yet whether the population is below carrying capacity due to low productivity or is limited by habitat availability is far from clear. If the former is the case, one expects population size to vary with previous productivity. The required level of productivity for stability must be quite low, given recent population behavior. Alternatively, if habitat is limiting one expects population levels to fluctuate as habitat changes due to losses to vegetative growth and gains from storm overwashes, rather than with variation in productivity. Determining how the population is regulated, including and understanding of differences in biology related to an extreme southern and peripheral location, is the key to devising appropriate management. We will return to this theme at the end of the piping plover section.

Factors affecting reproductive success on CAHA and CALO

<u>Human disturbance</u>:- With continuing increases in human activity at CAHA and CALO, study of the consequences of these activities on piping plovers breeding in these parks is critical. Humans and vehicles can flush adults from eggs or young, prevent access to preferred nesting or foraging habitat, crush eggs or young, and attract predators to areas that plovers utilize. Although we were unable to investigate the question of human disturbance directly through experimentation, observations of nesting adults and broods revealed the magnitude of human disturbance on our study sites.

During observations, records of intrusions and disturbance events were taken through "all-events" samples (Altmann 1974). All instances of intrusions were indicated during a ten-minute sampling period. Intruder type, behavior and distance from plovers were recorded, as well as any reaction by plover adults and chicks. Samples were taken at various time of day, breeding stage and chick age on CAHA and CALO. Further details of the methodology of our intrusion study are given in the 1994 project annual report.

Data from 73 "intense" ten-minute sampling periods were used to determine intrusion rate. During intense samples all intrusions within 50 meters of the focal bird(s) were recorded, as well as any birds flying high directly over the focal bird(s). Number of intrusions during these periods ranged from zero to 268, with a mean of 9.37 and median of two. The median is a more accurate depiction of average intrusion rate as the frequency distribution of number of intrusions per sample period is clearly skewed (Figure 1). Twelve samples had no intrusions, and 44 samples had three or fewer intrusions. Four samples with large numbers of intrusions (over 30) were obtained from groups located near tern colonies, and most intrusions consisted of nesting or flying terns. There were only three instances of human disturbance during intense samples, each involving one or more moving vehicles. There was no response to any of these intrusions.

Data from 708 intense and non-intense 10-minute sampling periods (118 hours) were used to analyze reactions of piping plovers to intrusions. In almost half of the samples (322) no intrusions were observed during the ten minutes. Of 687 intrusion episodes (which may include one or a group of intruders) 86 (13%) were considered human disturbance (aircraft, vehicles, humans, researchers) and 601 (87%) were "natural" intrusions (terns, gulls, shorebirds, crows, etc.). Most types of human intrusions (84%) consisted of passing vehicles or planes that elicited little or no response. There were 18 human intrusions that evoked a response (3% of all intrusion episodes). There were seven intrusions of planes, helicopters or boats to which plovers responded with calls or became alert. There were six intrusions of vehicles to which plovers responded with alert behaviors. The most extreme case involved a chick feeding at the ocean shore that was nearly hit by a passing truck. There were four instances of an observer evoking calls or defensive behaviors. In the final instance a group of five people standing over 50 meters away caused the tending adult to lead chicks away from the disturbance.

Most intrusions that elicited responses were by potential predators or competitors. Adult plovers were usually alert to crows and great black-backed gulls, and were aggressive towards other plovers, ghost crabs, gull-billed terns, great black-backed, herring and laughing gulls. Tables 5 and 6 provide detailed and consolidated summaries of the various types of intrusion encounters and reactions of piping plovers. Although only a few encounters with ghost crabs were recorded during disturbance sampling periods, observations of adult plovers with chicks indicate that adults will commonly leave chicks in order to chase away crabs.

Data from our intrusion samples indicate human disturbance is not a significant factor affecting reproductive success of piping plovers on CAHA and CALO within the areas the birds currently use. With the present rate and nature of human disturbance on these beaches, there is no need to terminate beach access to visitors. It is possible, however, that areas that might be used are avoided due to human disturbance, namely the ocean intertidal zone. We will return to this possibility later.

Further analyses of disturbance effects are presently being conducted. Scan sample data taken during observations of incubation and brood rearing will be used to compare behaviors of plovers breeding on CAHA (higher level of disturbance) and CALO (lower level of disturbance). This analysis will estimate time diverted from essential activities as a result of nesting in areas used heavily by humans compared to those used little. This analysis is part of the intensive time budget studies described below.

Predation:-Over the three years of our study, predation accounted for 34% of nest losses on CAHA and CALO (Table 3). Since nest predation is rarely witnessed directly, determination of causes of nest loss unfortunately requires inferences from evidence remaining at the nest site. We kept guesswork to a minimum. Losses that could not be reliably determined were designated as "unknown loss". By this method, the data on known losses serve as the best sample possible of causes of nest loss. We determine primary predators to be raccoons and crows. Predation by crows was witnessed on CALO in 1992. Since predator exclosures virtually eliminated predation on nests (see below), primary nest predators are likely those that can be physically barred from the nest with exclosure. Thus grackles, mice, crabs, and other small animals are probably not primary predators. Raccoon prints are commonly seen regularly in nesting areas on both CAHA and CALO, as well as cat and nutria prints. Mink tracks are regularly seen at the north end of Ocracoke, and mink have entered an exclosure to take eggs.

Although mink predation is limited to a small area (north end of Ocracoke), it is intense within that area, and appears to almost preclude successful reproduction. Mink are known to have similarly large effects on nesting success of other shorebirds, for example spotted sandpipers. Spread of mink within the seashores could be devastating to the piping plover population. The situation needs to be monitored, and management action may become necessary if the mink spread.

Predation of chicks is even more difficult to reliably determine than predation of eggs, as it normally occurs at night. A Herring gull was seen to eat two newly-hatched chicks at Portsmouth flats. There was some evidence of mink predation on chicks at the north end of Ocracoke in 1994. Cat tracks are seen commonly at Cape Point, Hatteras Spit and Ocracoke on CAHA, and Portsmouth Flats, Kathryn-Jane Flats and New Drum on CALO. Gull-billed terns were seen to take chicks on CAHA in 1995 (M. Lyons, pers. com.). Crows are likely to take piping plover chicks since crow predation on least tern chicks nesting near piping plovers was witnessed repeatedly at High Hills on CALO. There is unfortunately little information regarding activity, such as foraging, of piping plovers at night. Poor foraging habitat or restriction of foraging time by high daytime temperatures or storms may increase nighttime foraging and vulnerability to predation. Since chick mortality rates of piping plovers are not abnormal when compared to closely related and ecologically similar species, effective management measures to curb predation during incubation likely are more realistic than efforts to reduce chick mortality.

We can use reactions of plovers recorded during focal sampling and intrusion sampling (outlined previously) to indicate what species are considered to be a threat. Plovers with eggs or chicks normally react to crows with calling, alert behaviors and crouching over eggs. Gull-billed terns and great black-backed gulls were generally ignored during incubation, yet were chased in flight by adults tending chicks while the chicks crouched. Ghost crabs elicited unique chasing behaviors by adults that functioned to drive the crabs away from chicks. Herring and laughing gulls evoked chasing or alert behaviors from adults incubating or tending chicks, but only at close distances.

Placement of exclosures around some nests on CAHA and CALO allowed us to experimentally manipulate vulnerability of nests to predation. Details of the methodology for our exclosure study is given in the 1994 project annual report. Nests with exclosures experienced significant increases in hatching success (X2 = 18.88, p<.0001, df=1; exclosed N = 46, control N = 76), confirming that predation is a major factor affecting reproductive success on CAHA and CALO. Exclosures are recommended for both the parks to increase piping plover productivity. Since losses during incubation comprise the largest portion of reproductive failures and hatching success without exclosures is low, the use of exclosures is one of the most effective and most easily implemented possible methods to increase piping plover productivity on North Carolina seashores. In light of washover and predation probabilities and chick mortality rates, we can extrapolate the productivity to be expected when exclosures are used. On CAHA, about 10 chicks should be produced for every 10 exclosed nests. On CALO, about 4.5 chicks should be produced for every 10 exclosed nests.

These estimates will be lower if effectiveness of exclosures decreases with subsequent years, which would occur if predators learn to associate prey with exclosures. There is some preliminary indication that this is occuring on NCB. During the present breeding season (1995), raccoons have circled exclosures. This behavior has been evidenced at different nesting areas on the island, which would suggest it to be a general response among the raccoon population. A raccoon entered one exclosure by climbing the fence and crawling under the netting. Fixing the netting much more tightly to the exclosure fencing would alleviate this type of predation, yet the attraction of raccoons to nests no doubt harasses the plovers and may cause abandonment.

Weather:-Breeding success of plovers nesting on CALO fluctuated with weather. Hatching success in 1993, a year of relatively good weather, was markedly greater than in 1992 and 1994, years that had storms and flooding during May (Table 4). Accordingly, nest losses due to flooding or winds are greater in 1992 and 1994 on CALO (Table 3). On CALO, strong northeast winds raise tides in Core Sound and cause water to flow from the sound towards the sand flats where piping plovers nest. Contrary to the normal weather pattern, colder northeast winds continued to blow in early May of 1992, and caused the flooding of five nests and delayed many first nest attempts until late May. In 1994 a combination of northeast winds and a storm on May 21st caused the loss of 14 first nests.

In addition to its direct effects, adverse May weather has other deleterious effects. Cold and stormy weather will delay initiation of nests and force renesting. Nests initiated later in the breeding season appear to have diminished success compared to early nests. This is a common pattern in birds. Comparing nests during 1993, when losses to flooding did not occur, of 28 nests initiated in May, six nests fledged a total of 13 chicks (21% fledging success, 2.17 chicks per fledged nest). Of 16 nests initiated in June, four nests fledged a total of four chicks (25% fledging success, 1 chick per fledged nest). It is more likely for large broods to fledge if they hatch earlier in the breeding season. So it appears that on NCB a successful year requires favorable weather so that early nests hatch.

While weather effects can certainly be harmful, they cannot easily be managed and are little different than they were historically. Since severe storms are more prevalent along North Carolina shores than in other breeding areas along the east coast (D. Bartoff of NOAA weather, pers. com.), weather effects may have always limited productivity in North

Carolina compared to more northern areas, and may even limit the species' breeding distribution.

Temperature:-Piping plovers breeding at the southern end of the range presumably experience higher ambient temperatures than those in northern regions. When temperatures are high during incubation eggs must be shaded by adults to prevent death of embryos from overheating. In Wilson's plovers once temperatures rose above 31o C (87.8o F), incubation rates increased in order to shade eggs (Bergstrom 1982). Beach temperatures on CAHA and CALO frequently rise above this temperature starting in Mid-May. Increased time spent on incubation would likely decrease time available for foraging (Walters 1984) at a time when heat stress demands more energy resources. When precocial chicks such as those of piping plovers first hatch, they are unable to thermoregulate and depend on their parents to warm and cool them (Ricklefs 1983). During extremely high temperatures chicks may spend little time foraging and instead are brooded or crouch in the shade. In one instance at CALO when temperatures were above 90o F, two one-day old chicks and one egg were shaded constantly by both adults during observations in the heat of the day. The chicks were brooded continually for 5.5 hours and only foraged sporadically during the final half hour of an observation after temperatures declined. The adults foraged only briefly at the nearby ocean. During the next day, no chicks were found with the pair.

High temperatures encountered by piping plovers in the southern portions of the breeding range therefore are likely to have many indirect effects on chick foraging time, and perhaps consequently on mortality rate. On NCB, mortality rate increased for chicks hatched later in the breeding season (Figure 2). It is possible that high temperature shortens the effective breeding season of piping plovers nesting on North Carolina seashores. Mortality may be caused directly by insufficient foraging time, or indirectly by higher predation rates due to increased foraging at night.

Correlational analyses of temperature and time spent foraging by chicks are currently in progress. These analyses are a component of time budget studies described below. We will use our data to estimate the amount of foraging time available at favorable temperatures as a function of season.

<u>Habitat</u>:-A factor crucial to piping plover reproductive performance is the availability of suitable foraging habitat. Chicks foraging in habitats rich in resources travel less, forage more and have increased growth (Loegering 1992). We sought to identify habitats on CAHA and CALO that

In general, dry sand flats and interdunal areas (used for nesting) were widely available, yet were uncommonly used for foraging. These two habitat types were used by newly hatched chicks during their first foraging attempts near the nest site. Once all chicks were mobile, groups foraged at mudflats or wet flats. Mudflats were located at the west end of a pond at Cape Point, along the sound on Hatteras Spit, at the north end of NCB, behind wet flats on Portsmouth Flat and along the sound at New Drum Inlet. On CAHA, wet flats were located on the east end of the pond and within the interior of Cape Point, near the drain pond at the South Beach, along a tidal pond and within the interior of Hatteras Spit and on the north end of Ocracoke. On NCB, wet flats were generally located towards the sound from the nesting areas on Portsmouth Flat, Kathryn-Jane Flat, and Old Drum Inlet, and in the interior of New Drum Inlet. Access to the sound shore is limited; Hatteras Spit on CAHA and New Drum and Ocracoke inlets on CALO are the only sound shores available to plover groups.

During behavioral observations, habitat use by foraging piping plover adults and chicks was recorded with scan samples. If any plovers were foraging during the scan, the habitat type, distance from vegetation, density of vegetation and other distance estimates were noted. The 1994 project annual report provides more detail of methods. Initial analyses of

1993 data indicate that plovers foraging on CAHA use either wet or mud flats, and CALO plovers forage primarily on wet flats. On CAHA, there were 38 instances (51%) of use of mudflats and 31 instances (42%) of use of wet flats (N = 74). On CALO, there were 252 instances of wet flat use (or wet flat habitat in combination with other habitats such as dry or mud flats) (90%, N = 279). These differences between CAHA and CALO may be due to differing availability of habitats in the two parks. Mudflats on CALO are only available at Portsmouth flats and small areas of New Drum Inlet. Samples from CAHA were taken from groups located in various areas, but were mainly taken at either Hatteras Spit or Ocracoke. Samples from CALO tended to come from groups in New Drum or Kathryn-Jane Flats. On CAHA, plovers tended to forage less than five meters from dense or moderately dense vegetation. Plovers foraging on CALO tended to be either within sparse vegetation or less than five meters from dense vegetation.

Data from other years will be entered and analyzed, and a more definitive assessment of foraging habitat selection will be provided in the thesis. Also, we intend to link foraging data from scan samples to peck rate data from chicks collected during focal samples in order to gain some understanding of foraging rates in different habitat types. Finally, data from focal samples and scan samples will be used to compare time spent foraging and traveling by chicks in different habitats. These analyses will enable us to assess habitat quality in greater detail than reported here.

Use of ocean intertidal zone by plover chicks is of special interest because of possible conflicts with park visitor use. Although mudflats and wet flats are more commonly used, chicks were seen at the ocean shore at Hatteras Spit, Cape Point and Ocracoke on CAHA during our study. Chicks seen at the ocean were usually around fledging age. On CALO, most frequent use of the ocean shore by chicks occurred at Kathryn-Jane Inlet and Portsmouth Flats after the chicks had fledged. Some use by young chicks at Portsmouth Flats also was witnessed, and in one instance a chick was nearly struck by a vehicle. Chicks at New Drum have very rarely fed along the ocean shore. More often older chicks feed at the sound. Thus slightly more use of the ocean intertidal zone was observed at CALO compared to CAHA, but use was still infrequent.

Since vehicles are frequent along the shores of CAHA and infrequent along CALO, and use of the ocean intertidal zone by young chicks was observed more at CALO, one might conclude that human disturbance reduces use of this habitat. This idea can best be tested experimentally by closing portions of outer beach to visitors. Without such a study, only a very general comparison of highly used (CAHA) and infrequently used

(CALO) habitats is possible. Since use of the ocean intertidal zone by piping plover broods on CALO, where there are more breeding pairs than CAHA, is not substantially more frequent than on CAHA, it can be concluded that reduced human disturbance does not greatly alter habitat use. Either adults have little inclination to bring their broods to the shore, or even minimal disturbance is sufficient to discourage them from doing so. This suggests that the ocean intertidal zone is not highly preferred habitat for brood rearing in North Carolina. The preferred habitat appears to be mudflats and wet sandflats, habitats that are much more prevalent on CALO due to the absence of dune stabilization measures.

Geographic location:-Our brief study of piping plover breeding biology has revealed that factors affecting reproductive success in North Carolina are different than those in northern regions. Being along the edge of the piping plover's breeding range, the environment at North Carolina seashores is likely to have more unfavorable conditions for reproduction (e.g. predators, diseases and weather conditions). Storms in the early part of the breeding season cause breeding losses and delays, and high temperatures, especially late in the breeding season, impose heat stress that may indirectly cause chick mortality. For these reasons, productivity goals set in the recovery plan (1.5 fledged chicks/pair/year), established from studies of more northern populations, are probably unrealistic for

North Carolina. Still, productivity can be improved over current levels, especially through use of predator exclosures. The little information that exists suggests that more realistic productivity levels may be sufficient to increase the population.

To provide additional perspective on piping plover reproductive success within the seashores, we provide comparative data we collected from Wilson's plovers. Wilson's plovers are an ecologically similar species and North Carolina is in the middle of their breeding range. We estimate hatching success of Wilson's plovers to be 23%-50%, compared to 33% for piping plovers. The two species appear to be experiencing similar, high levels of nest loss within the seashores.

Nesting habitat

On CAHA and CALO, piping plovers nest in the vicinity of the wet sandflats and mud flats in which their broods forage. Nest locations tend to be in drier areas, often on dry sandflats or even interdunal area adjacent to wet flats or mud flats. One of our objectives was to provide the Park Service with locations of nests and foraging areas in a form that could be used both to locate sites in the field and incorporate locations into GIS data bases. We previously provided nest locations and foraging area locations plotted on copies of aerial photographs in our project annual reports. Unfortunately aerial photos, while ideal for mapping exact nest locations, have not proven suitable for digitized mapping for GIS, and GIS maps suitable for field use are not yet available. The locations plotted on aerial photography provided previously are the best source of precise information for field use currently. We have mapped nest locations and foraging area locations onto topographic maps of portions of CAHA and CALO. Unfortunately, due to the age of the maps, locations could not be exactly mapped. Some nesting areas (such as the overwash area at Kathryn-Jane Inlet on NCB) were not present on the topographic maps, making accurate mapping difficult. We feel that these maps are inadequate for input of GIS data, and attempts to plot locations on GIS habitat maps currently available were equally imprecise. We recommend using a GPS (global positioning system) unit to obtain locations for use in GIS data bases.

Intensive studies of breeding biology

A total of about 1000 hours of observational data has been collected: 270 hours from CAHA, and 665 hours from CALO. The data consist of: 1) scan samples indicating adult and chick behavior, distances between adults and chicks, and foraging locations; 2) all-events samples recording type and behavior of intruders, distances between plovers and intruders and reactions of plovers to intruders; 3) focal samples of chick and adult behavior measuring time budgets and peck rates of chicks, and providing additional information concerning interactions with intruders and competitors. In association with these samples we recorded general information such as temperature, wind speed, tide, weather, age of chicks, number of chicks, date and time of day.

These observational data will allow us to examine interactions of adults with their broods in detail. We will determine how time budgets and distance relationships (which determine how well adults can protect their chicks) vary with factors such as brood size, habitat and temperature. A goal of these analyses is to better understand determinants of chick survival. These analyses will comprise the bulk of the material to be reported later in Susan Philhower's dissertation.

Conclusions

Most frequently cited causes of the decline of piping plovers are habitat loss or degradation and human disturbance. Human development has replaced former nesting and foraging habitat of plovers throughout their breeding range, especially in the northeastern United States (USFWS

1995). Dune stabilization inhibits the formation of washover areas, and causes the loss of wide flats for nesting and foraging. Plovers nesting in degraded habitat are usually closer to human activity. With no access to sound or moist flats, the only foraging habitat available in many areas is along ocean intertidal zone.

In CAHA and CALO, nesting areas are usually adjacent to wet flats, mud flats or sound flats and these areas are favored for foraging by adults and chicks. Because of the availability and protection of these wide flats, plovers are not generally near human activity. Indeed, our observations suggest human disturbance does not significantly affect piping plover breeding activity. An important conclusion is that conditions in North Carolina are very different than those in other areas, notably the northeast, in which piping plovers have been studied, and based on which the species recovery plan has been structured (USFWS 1995). Effective management likely will differ between North Carolina and other areas as a result. For example, beach closures, which are effective in other areas, likely will have little impact in North Carolina. It is not clear that ocean intertidal zone will be used much even if such habitat is closed to humans. At the very least, experimental closures should be conducted before adopting closure as a general policy.

There are very few breeding areas for the species in which habitat is as little altered, or little disturbed, by humans as CALO. Yet here, in the absence of the problems to which the decline of the species generally is attributed, the dynamics of the population appear less favorable than in areas to the north, and no better than those observed at CAHA, where habitat alteration and human presence are greater. We must search for other factors to explain the exceptionally low productivity of the North Carolina populations.

There is a critical need to understand the population dynamics of piping plovers in North Carolina, both in terms of how they differ from historical dynamics on site, and from the dynamics of populations in other areas. There are two important reasons to suspect that population dynamics in North Carolina are different than those observed in the northeast, (1) the southern location of the North Carolina population and (2) the fact that the North Carolina population represents the limit of the species' range. It is likely that due to the first factor productivity will be lower and survival higher in North Carolina, and from the second factor that conditions will be less favorable for the species in North Carolina. Presumably whatever factors limit the range of the bird impact them much more on the edge of the range than elsewhere.

The most critical step in understanding population dynamics will be to determine how the population is regulated, specifically whether the small population reflects limited habitat, or is due to poor productivity, such that the population is below carrying capacity. This can be assessed by closely tracking whether populations fluctuate according to variation in productivity, or according to changes in availability of habitat. Without this knowledge, it will be difficult to set reasonable population objectives, or formulate effective management strategies.

We suspect that productivity is limited in North Carolina by the relatively high frequency of storm overwash in nesting areas. This is the type of factor, since it varies in a clinal fashion, that could limit the breeding distribution. High temperatures, by restricting foraging time during the day, could directly or indirectly limit productivity, and breeding range, as well. Such factors may constrain the potential for positive impacts of management. That is, it may be unreasonable to expect to increase productivity as much, or increase populations as fast, as can be accomplished elsewhere. However, we also suspect, based on the population increases observed despite very low levels of productivity, that mortality rates of adults may be lower in North Carolina, and thus that a small increase in productivity in North Carolina may have as big an effect on population size as a larger increase elsewhere. We can only hypothesize about survival rates, though, because relevant data on survival of North Carolina birds do not exist. Equally important is the lack of data on return rates. Without these data, one can not determine whether the North Carolina populations are self-sustaining, or represent sinks dependent on immigration from elsewhere for their continued existence.

We conclude that the most effective means to influence population dynamics in a favorable way is to reduce predation. Predation on chicks is more difficult to affect, and the data do not indicate predation rates to be abnormally high during the chick stage. We therefore favor attempts to reduce predation during the egg stage, and have shown that this can readily be accomplished with predator exclosures. We also recommend that mink be prevented from spreading to other plover nesting areas. The major predators of piping plover eggs appear to be crows and raccoons, species whose abundance clearly has increased due to human presence. This fact is another reason to suspect that if piping plover populations in North Carolina are suffering from reduced productivity compared to historical levels, that it is predation on eggs that has increased, rather than other sources of nest loss.

A major difference between the two seashores is that dune stabilization characterizes one (CAHA) but not the other (CALO). Dune stabilization reduces availability of nesting habitat, and this is probably the reason the population on CALO is so much larger than that on CAHA. On the other hand, dune stabilization probably also accounts for reduced levels of nest loss to flooding on CAHA. That the population trend on CALO is more positive than that on CAHA argues for habitat availability being limiting on CAHA rather than productivity. On CALO the number of breeding pairs on NCB from 1993-1995 (28, 32, 29, respectively) is to some extent related to reproductive success of the previous year (.27, .68, .19, respectively), which suggests that the population may be limited by productivity.

In conclusion, the conservation of piping plovers in the North Carolina seashores is more complicated than it at first appears. A simple view is that the population is small because productivity is so much lower than elsewhere. There is no doubt that productivity is extremely low, yet the population currently is increasing. Two explanations are possible. First, the dynamics of the North Carolina populations might be very different from those of more northern populations, so that only low levels of productivity are necessary to maintain fairly closed populations. Second, the North Carolina populations might depend on immigration from better areas elsewhere for their continued existence, thus acting as sinks that drain birds from healthier source populations. If this is the case, these dynamics may be recent, arising from greatly reduced levels of productivity that have produced a problem that needs to be fixed through management. Or North Carolina, at the limits of the species' distribution where conditions are always marginal, may always have been a sink, in which case efforts to manage for healthy populations will be ineffective. One may pick one of these scenarios as most likely, and manage accordingly. The alternative is to conduct the studies of survivorship and return rates necessary to determine which is accurate.

Literature cited

Altmann, J. 1974. Observational study of behavior sampling methods. Behaviour, 49: 227-267.

Bergstrom, P. W. 1982. Ecology of incubation in Wilson's plover (*Charadrius wilsonius*). Ph.D. dissertation, University of Chicago. Chicago, Illinois.

Loegering, J. P. 1992. Piping plover breeding biology, foraging ecology and behavior on Assateague Island National Seashore, Maryland. MS Thesis, Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

Ricklefs, R. E. 1983. Avian postnatal development. pp. 1-83 in D. S. Farner, J. R. King, and K. C. Parkes, eds. Avian Biology, vol. 7. Academic Press, New York.

U.S. Fish and Wildlife Service. 1995. Piping plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Technical/Agency Draft. Hadley, Massachusetts.

Walters, J. R. 1984. The evolution of parental behavior and clutch size in shorebirds. In Shorebirds: Breeding Behavior and Populations. (J. Burger and B. L. Olla, Eds.). Plenum Press, New York, New York.

Table 1. Numbers and distribution of breeding pairs of piping plovers on CAHA and CALO, 1992-1995.

Location	Number of pairs *			
	1992	1993	1994	1995
CAHA				
Bodie Island	0	0	0	~
Cape Point	4	5	5	~
South Beach	0	1	1	~
Hatteras Spit	4	3	3	~
Ocracoke	4	3	2	~
CAHA TOTAL	12	12	11	~
CALO				
Ocracoke Inlet	2	0	2	2
Portsmouth Flat	8	9	7	8
Kathryn-Jane Flat	11	9	12	11
Old Drum	2	1	1	2
New Drum Inlet (NCB)	5	9	10	6
New Drum Inlet (SCB)	3	4	5	4
Power Squadron Spit	2	3	2	2
CALO TOTAL	33	35	39	35
TOTAL	45	47	50	~

* Includes pairs that did not nest but held territories

Table 3. Causes of piping plover nest loss on Cape Hatteras National Seashore and North Core Banks, 1992-1995.

Year/Location	Total # of nests	Total # of losses	Predator		Flooding/Sand		Human		Abandoned		Unknown	
			N	%	N	%	N	%	N	%	N	%
1992 CAHA	14	6	3	50	0	0	0	0	0	0	3	50
NCB	39	30	6	20	11	37	0	0	0	0	13	43
TOTAL	53	36	9	17	11	21	0	0	0	0	16	30
1993 CAHA	21	12	5	42	0	0	0	0	0	0	6	50
NCB	48	30	10	30	5	15	0	0	4	13	11	37
TOTAL	69	42	15	36	5	12	0	0	4	10	17	41
1994 CAHA	18	8	7	88	1	12	0	0	0	0	0	0
NCB	56	46	14	30	19	41	0	0	4	9	9	20
TOTAL	74	54	21	39	20	37	0	0	4	7	9	17
1995 NCB	38	14	5	36	5	36	0	0	2	14	2	14
92-95 TOTAL	234	146	50	34	41	28	0	0	10	7	44	30

Table 4. Numbers, distribution and hatching success of piping plover nests on CAHA and CALO, 1992-1995.

Location	Number of nests and hatching success							
	1992	Hatch %	1993	Hatch %	1994	Hatch %	1995	Hatch %
CAHA								
Bodie Island	0	~	0	~	0	~	~	~
Cape Point	5	80	6	83	6	83	~	~
South Beach	0	~	2	50	1	100	~	~
Hatteras Spit	5	40	4	50	6	50	~	~
Ocracoke	4	50	6	11	5	20	~	~
CAHA TOTAL	14	57	21	42	18	56	~	~
CALO								
Ocracoke Inlet	2	0	0	~	1	0	3	33
Portsmouth Flat	12	33	14	36	8	38	8	63
Kathryn-Jane Flat	14	29	17	41	25	12	16	69
Old Drum	2	0	2	50	2	0	2	100
New Drum Inlet (NCB)	9	11	15	33	20	20	9	56
New Drum Inlet (SCB)	N/A	~	3	66	9	11	~	~
Power Squadron Spit	N/A	~	5	80	1	100	~	~
CALO TOTAL	39	23	56	43	66	20	38	63
TOTAL	53	32	77	43	84	27		

Table 5. De. summary of type of intruder and response of piping plovers during . on episodes.

Type of intruder	None	Slight alert	Alert	Call	Lead chicks	Crouch Run	Head Bob	False Incub	Broken Wing	Run to	Hunch Run	Agressn	Fly Chase	Fight	Avoid	Run	Fly	Unkn	Total
Least tern	29	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	32
> 10 LT	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
2-10 LT	17	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
Common tern	67	1	0	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	76
2-10 Com. terns	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
30-44 Com terns	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Black Skimmer	8	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
2-10 Black Skim	9	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
24 Black Skim	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1-3 Gull-billed terns	25	1	0	3	0	0	0	1	0	0	0	0	6	1	0	0	0	0	41
Laughing Gull	32	1	2	1	0	0	0	0	0	0	0	0	10	1	0	0	0	1	49
2-5 Laugh gull	6	1	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	11
Herring gull	5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	8
Great blackb. gull	3	1	2	1	0	0	0	0	0	0	1	0	4	0	0	0	0	0	12
Unspec. gull	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4
2-5 Gulls	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Willet	23	1	1	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	29
2-4 Willets	4	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	7
Black bellied plover	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1-4 Sanderlings	3	2	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	7
1-3 Piping plovers	1	0	0	1	0	0	0	0	0	0	6	5	7	3	0	0	0	0	23
1-2 Wilson's plovers	7	0	1	0	1	0	0	0	0	0	0	3	4	1	0	0	0	0	17
Amer. Oysterc.	26	0	4	2	0	0	0	1	0	0	0	0	3	0	0	1	0	0	37
2-10 Amer Oyst	11	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	13
Turnstone	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Osprey	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ghost crab	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	4
2-4 Rabbits	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Crow	8	1	5	19	0	1	0	0	0	0	1	0	7	0	0	1	0	0	51
2-4 Crows	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
1-3 Grackles	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Red-winged Blkbd	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Meadowlark	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
2 Swallows	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cormarant(s)	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Egret	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Glossy Ibis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Human(s)	6	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Plane(s)	38	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43
Vehicle(s)	24	3	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	30
Other	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2
Observer	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
Unspec. gull	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Unspec. tern(s)	26	0	0	1	0	0	0	0	0	0	1	0	15	1	1	1	0	0	47
Unknown	2	0	1	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	10
Unknown shorebd	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
None	322	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	322
Total	773	16	30	41	3	1	2	4	1	2	13	10	66	11	1	8	1	1	1009

Figure 1.Frequency distribution of number of intrusions in ten minute periods

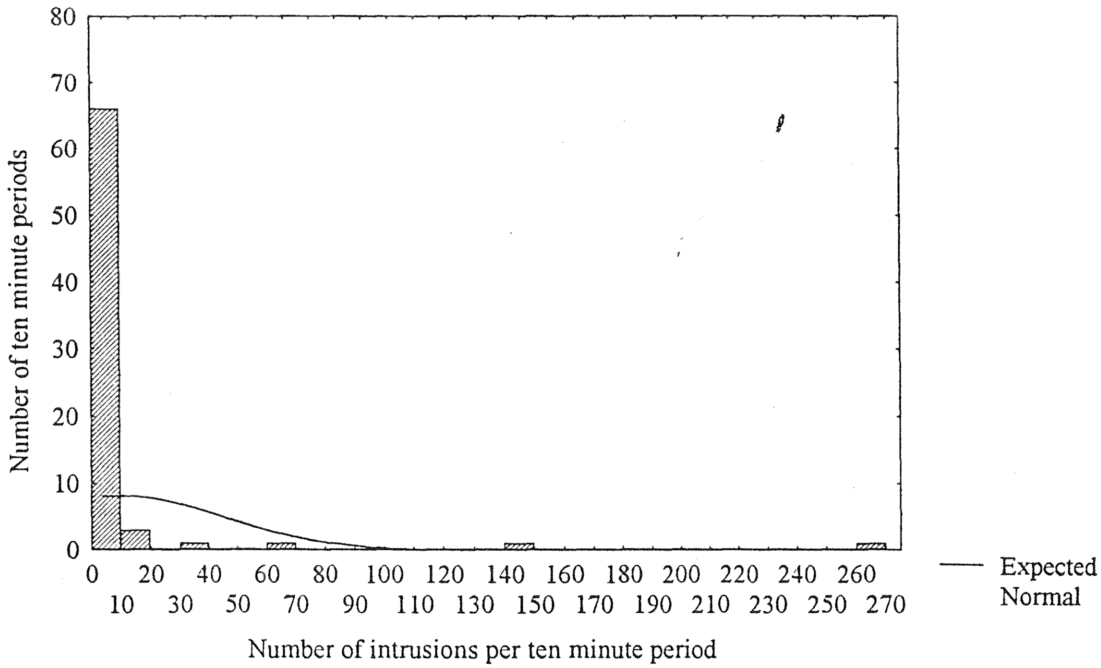
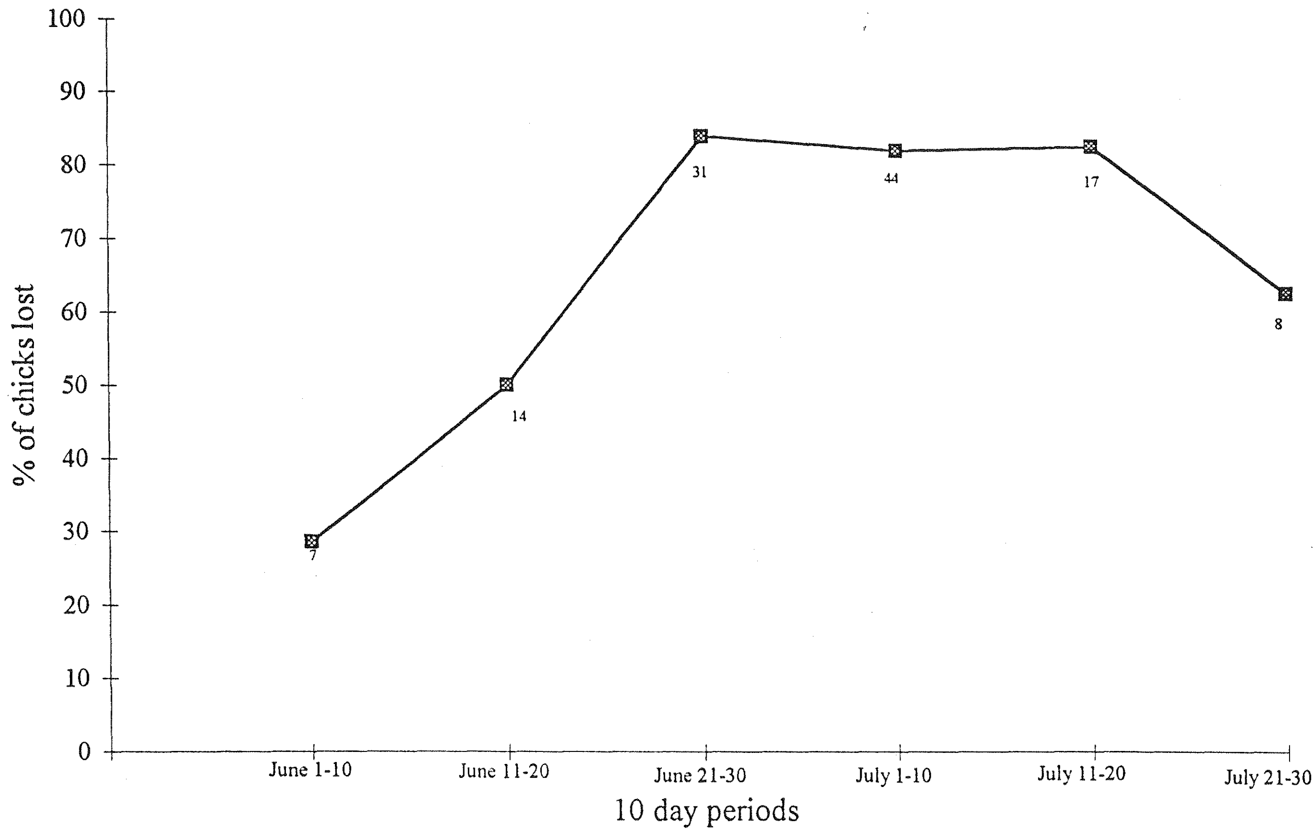


Figure 2. Mortality rate of piping plover chicks hatched in different 10 day periods on NCB, 1992-1994. Numbers indicate sample size.



Species composition and seasonal numbers of shorebirds, gulls, terns and wading birds on the Outer Banks of North Carolina with especial emphasis on selected locations at Lookout National Seashores.

Chapter VI

by

Stephen J. Dinsmore

Suzanne Wrenn

Jaime A. Collazo

Jeffrey R. Walters

North Carolina State University
Department of Zoology
Raleigh, NC 27695

and

Virginia Polytechnic Institute and State University
Department of Biology
Blacksburg, Virginia 24061

Dinsmore and Collazo (Chapter 1, This Report) documented seasonal and distribution patterns of the eight most abundant species of shorebirds counted on the Outer Banks of North Carolina. These especies were the focus of attention because numbers allowed rigorous analysis, and because they included species of special concern (e.g., declines; Howe et al. 1989). Another 14 species of shorebirds, 9 species of gulls and 11 species of terns were recorded during beach censuses. Censuses were also conducted at Portsmouth Flats and at three locations along the Core Sound side of Lookout National Seashores. Here we summarize those data. It is hoped that these data, coupled with cumulative information (e.g., Tove 1989), will aid in establishing the status of the species represented by the avian groups reported herein.

Study Area

The Outer Banks are located along the east-central coast of North Carolina (34°34'-35°50' N lat., 75°27'-76°39' W long., Figure 1). The area consists of a series of narrow barrier islands of approximately 228 km in length, stretching from just north of Oregon Inlet in Dare County to Beaufort Inlet in Carteret County. Much of the area is included in Cape Hatteras and Cape Lookout National Seashores. Portsmouth Flats, located on the northern portion of North Core Banks. Three locations, namely, Old Drum Inlet, Mile Post 9 and High Hills, were also monitored in North Core Banks.

Censuses

From March 1992 to December 1993, five outer beach sites ranging from 9-34 km in length were surveyed. Bodie Island (9 km) extended from the south edge of Nags Head south to Oregon Inlet. North Beach (28 km) extended from the Rodanthe pier south to a point 1 km north of the Buxton town limit. South Beach (24 km) extended from just south of the Cape Hatteras lighthouse south to Cape Hatteras point, then west to Hatteras Inlet. Ocracoke Island (28 km) included the entire island from Hatteras Inlet south to Ocracoke Inlet. North Core Banks (34 km) included the entire island from Ocracoke Inlet south to New Drum Inlet. The total amount of outer beach surveyed monthly for shorebirds was 123 km.

Surveys were conducted twice per month by vehicle. All surveys were begun 1.5 h before low tide, except for two counts on North Core Banks in July and August 1992 that were begun 1.5 h before high tide. Numbers of all shorebirds present on the outer beach were recorded. Outer beach is defined as the area from the base of the dune line to the ocean edge, including that portion of the intertidal zone exposed at low tide. Outer beach did not include soundside tidal flats at inlets or other tidal flat habitats. Flying birds were not recorded, unless they were clearly disturbed by the person(s) conducting the census. Since large shorebird concentrations (>500 birds) were rare, data here represent actual counts and not estimates.

Censuses were conducted on Portsmouth Flats nearly monthly from May 1992 to December 1993. The only months missed were December 1992 and October and November 1993. In most months, two censuses were conducted. Most censusing was done at low tide, though single counts in June, July, and September 1992 were done at high tide. While the flats themselves are not influenced by lunar tides, birds using adjacent outer beach habitats would be expected to be more numerous at the time of hight tide as they are driven off beaches during this time. Because of the extent of the flats, only the area north of the trail to Portsmouth Village and the first inlet south of that trail were censused. Coupled with these censuses at Portsmouth, censuses were also conducted along the "Sound" side of North Core Banks. These consisted of visiting each of three locations (i.e., Old Drum Inlet, Mile 9, High Hills) and counting all birds.

Abundance was expressed as the mean of the two monthly censuses. This minimized variance problems associated with repeated measures within month. For a few sites, there was only one count in a given month and this was treated as the estimate for that month. Annual and seasonal numbers were obtained by summing monthly counts. Abundance data were expressed in two ways. First, annual patterns of abundance are described for shorebirds, herons, gulls, and terns. Second, a model was developed to test for seasonal patterns in abundance for selected groups or species. In this model, seasons were defined as spring (April-June) and fall (July-November). These seasons span the major migration periods for the species examined. The effects of site and year on the variability of monthly counts were tested. Month, a repeated measure within season, was nested under the appropriate factor in the nested factorial ANOVA model. To reduce count variance, data were log or square root transformed. The most appropriate transformation was determined by examining plots of residuals.

<u>Group and Species Accounts</u>

<u>Shorebirds</u>

A total of 22 species of shorebirds were detected on beach censuses. Of these, the eight most common species were examined in Chapter 1 (Dinsmore and Collazo 1995, This Report). The seasonal abundances of another 11 species are depicted graphically here. The remaining 4 species were recorded on beach censuses fewer than 5 times; data were not graphed but date and location of sighting is provided.

The Semipalmated Sandpiper (Calidris pusilla), Western Sandpiper (Calidris mauri), Short-billed Dowitcher (Limnodromus grisseus) and Semipalmated Plover (Charadrius semipalmatus) exhibited seasonal trends typical of species using the Outer Banks as migratory stopover areas (Figures 2, 3). These species were most abundant during fall migration (Aug-Nov.) and the short spring migration period (late April - June). Wilson Plovers (Charadrius wilsonia), in contrast, are a resident species which seems to absent in the area for most of the late fall and early winter (Figure 2). Numbers were highest from April through August. Dunlins (Calidris alpina) appear to use the Outer Banks as both migratory and wintering grounds (Figure 3). Numbers were highest in November, but the species was detected through winter, remaining on the area through early spring. Finally, Short-billed Dowitchers were most abundant during July, but was detected through most of the fall in each of the two years of surverys (Figure 3).

Five other species were recorded but there numbers are substantially lower than for the species accounted above. Great Yellowlegs (Tringa melanoleuca), Lesser Yellowlegs (Tringa flavipes), Spotted Sandpiper (Actitis macularia), and Least Sandpiper (Calidris minutilla) were also recorded during the migratory periods, that is, spring and fall each year. Their mean numbers, however, ranged from 0.5 to 10 individuals per month (Figures 4, 5). Marbled Godwitts (Limosa fedoa) also was recorded during censuses in low numbers, but mostly during late fall (Figure 5).

The following are records of species that were recorded 5 or fewer times on beach censuses.

American Avocet (Recurvirostra americana): One was recorded on 23 August 1992 on South Beach.

Killdeer (Charadrius vociferus): From 1-3 were recorded at Bodie I. on 23 February 1993, South Beach on 9 March 1993, North Core Banks on 19 March 1992, North Beach on 13 October 1992, and North Core Banks on 15 November 1992.

White-rumped Sandpiper (Calidris fuscicollis): From 1-2 were recorded at South Beach on 2 June 1993, Ocracoke on 8 September 1992, and South Beach on 14 September 1992.

Pectoral Sandpiper (Calidris melanotos): From 2-4 were recorded at South Beach on 3 August 1993, South Beach on 4 August 1993, and Bodie Island on 24 September 1993.

Gulls

A total of 9 species of gulls was recorded on beach censuses. The seasonal abundances of the 7 most common species were graphed here. The "basic" five species of gulls, namely, Herring (Larus argentatus), Great Black-backed (L. marinus), Ring-billed (L. delawarensis), Laughing (L. atricilla), and Bonaparte's (L. philadelphia) were, as expected, the most common species recorded during censuses (see Tove 1989). These species were recorded in the throusands of individuals on any given census day (Figures 6, 7). Ring-bills, Herrings, and Great Black-backs were significantly ($P < 0.05$) more abundant during spring censuses (Table 1). Consistent with Tove (1989), Lesser Black-backed Gulls (L. fuscus) were recorded from September on through April (Figure 6). Counts were highest in February, averaging 13 individuals. Laughing Gulls, not surprisingly, were abundant from spring through fall (Figure 7). No seasonal differences were detected for this species. Bonaparte's Gulls were detected only during winter (Figure 7). Two species were recorded 5 times. Location and date of sighting is provided below.

Iceland Gull (L. glaucoides): One was recorded on 16 February 1993 on North Beach.

Glaucous Gull (L. Hyperboreus): One was recorded on 3 March 1992 on North Beach.

Terns

A total of 11 species of terns were recorded on beach censuses. The seasonal abundances of the 9 most common species were graphed here. Least Terns (Sterna albifrons), Black Skimmers (Rynchops niger), Gull-billed Terns (Gelochelidon nilotica), Sandwich Terns (Sterna sandvicensis), Common Terns (Sterna hirundo), and Royal Terns (Sterna maxima) were most abundant from late spring through early fall (Figures 8, 9, 10). Common and Least Terns were significantly ($P < 0.05$) more abundant during fall (Table 1). Black Skimmers and Sandwich Terns had a significant site by season interaction. Skimmers were more abundant at North and South Beach and Ocracoke during fall, and at Bodie

Island and North Core Banks during spring (Table 2). Sandwich Terns also followed a similar pattern of abundance by site and season. The obvious exception was the Royal Tern, which was detected throughout the year with high mean counts during April, August and September.

Forster's Tern (Sterna forsteri) were more abundant during fall, with highest mean counts averaging about 700 individuals in October (Figure 9). Caspian Terns (Hydroprogne caspia) also exhibited strong seasonal patterns with highest numbers recorded during the fall (e.g., September, October) (Figure 10). Two 2 species were recorded fewer than 5 times. Location and date of sighting is provided below.

Roseate Tern (Sterna dougallii): One was recorded on 30 July 1992 on North Core Banks.

Sooty Tern (Sterna fuscata): Two were recorded on 1 July 1993 on South Beach.

Portsmouth Flats

A total of 27 species of shorebirds, 5 species of gulls, and 9 species of terns were detected on censuses. Additional species observed were Brown Pelican (Pelecanus occidentalis), Double-crested Cormorant (Phalacrocorax auritus), Great Blue Heron (Ardea herodias), Snowy Egret (Egretta thula), Little Blue Heron (Hydranassa caerulea), Tricolored Heron (Hydranassa tricolor), White Ibis (Eudocimus albus), Canada Goose (Branta canadensis), American Black Duck (Anas rubripes), and Clapper Rail (Rallus longirostris).

Shorebirds were most numerous on the flats from November to May (Figure 11). This was because large numbers of Western Sandpipers and Dunlin wintered in the area. The high May counts include large numbers of Semipalmated Sandpipers. Several shorebird species found on the flats in moderate to large numbers (i.e. Greater Yellowlegs (Tringa melanoleuca), Marbled Godwit, Semipalmated Sandpiper, Western Sandpiper, Short-billed Dowitcher) were scarce on the beaches, probably because these species preferred tidal flats over sandy beaches.

Gulls were most numerous on the flats from July to November, though numbers were low compared to beach counts (Figure 11). Laughing Gulls were the most numerous species, with good numbers of Herring Gulls as well. Gull species composition was similar to that of outer beaches, except that Bonaparte's Gulls did not occur on the flats. Most gulls seen on the flats were probably using the area as a roosting spot.

Terns were most numerous on the flats from May to October (Figure 11). Most were Forster's and Least terns and Black Skimmers. As with the gulls, they were probably using the flats as a roosting place.

North Core counts - Sound side

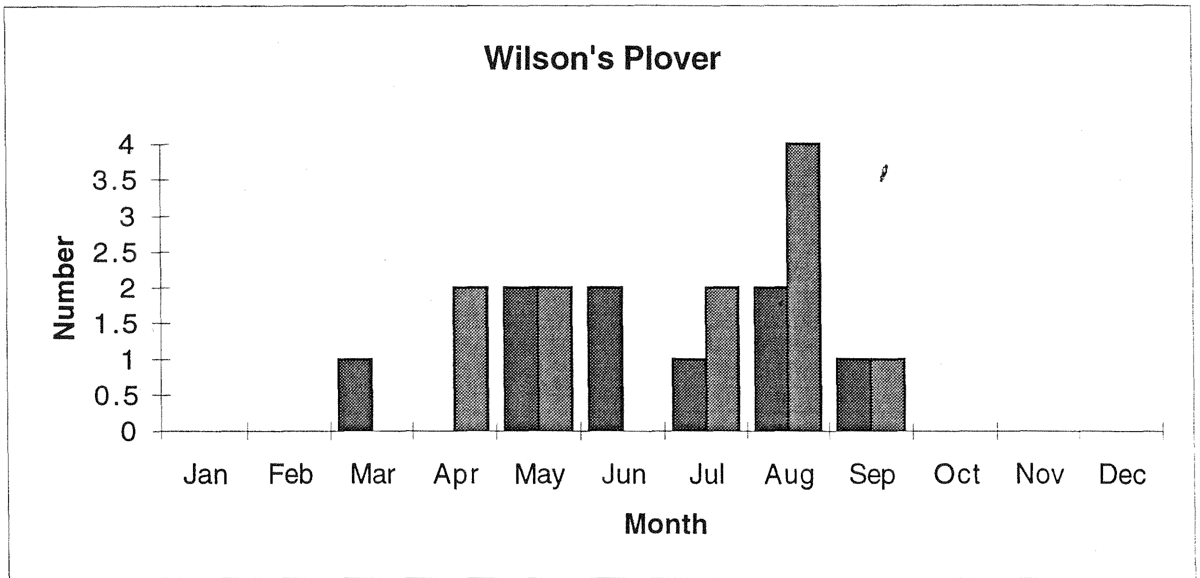
Overall, High Hills was the location where the highest numbers of any aquatic group was recorded (Figures 12, 13, 14, 15). Shorebirds were most during spring, probably because it included species not found commonly on beach habitats (e.g., Semipalmated and Western Sandpipers) (Figure 12). Peak counts were recorded in 20 of April and May. Gulls did not exhibit strong seasonal patterns, with counts ranging from 50 to 100 individuals (Figure 13). Counts were, by and large, evenly distributed among the three count locations. The clear exception was on 11 Septembers when over 600 individuals were counted. Terns, in contrast, exhibited strong seasonal trends. Highest counts were recorded in spring and fall (Figure 14). With this group, however, we recorded substantially high numbers in Old Drum Inlet. Herons also presented strong seasonal patterns of high counts during spring and fall (Figure 15). For this group of species, Mile 9 emerged as one where counts were as high or higher than High Hills or Old Drum Inlet. Two of the four highest counts (>30 individuals) were recorded in Mile 9.

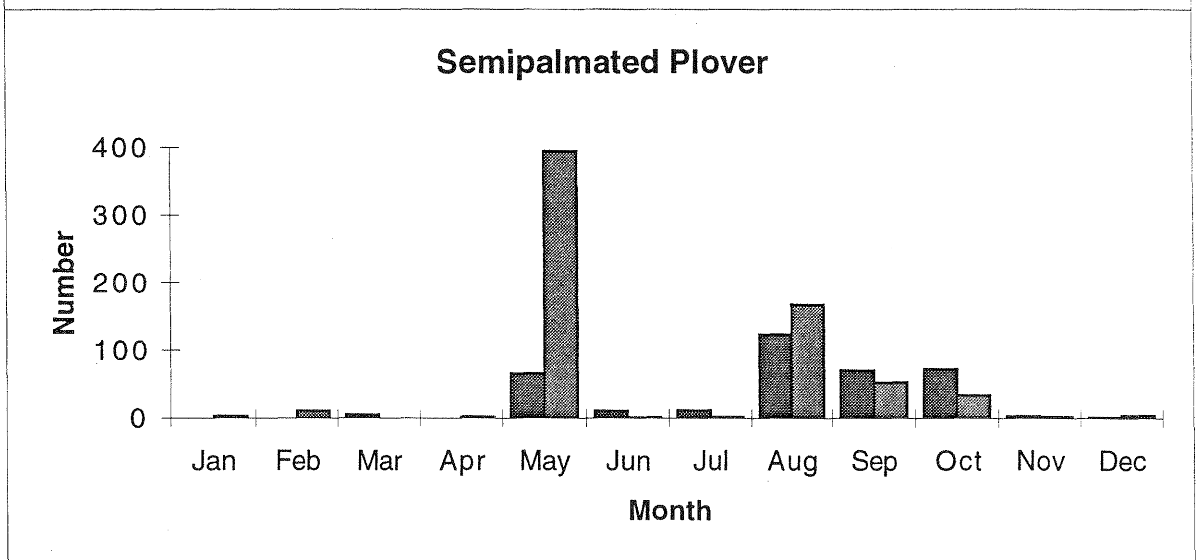
Literature Cited

Dinsmore, S. J. and J. A. Collazo. 1995. Seasonal distribution and numbers of shorebirds on North Carolina's Outer Banks. Chapter 1, Final Report, National Park Service.

Tove, M. Reappraisal of the status of gulls in the Carolinas. The Chat 53:53-63.

Figure 2. Seasonal numbers of Wilson's Plovers, Semipalmated Plovers and Semipalmated Sandpipers counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Wilson's Plover
Number
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month


Semipalmated Plover
Number
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

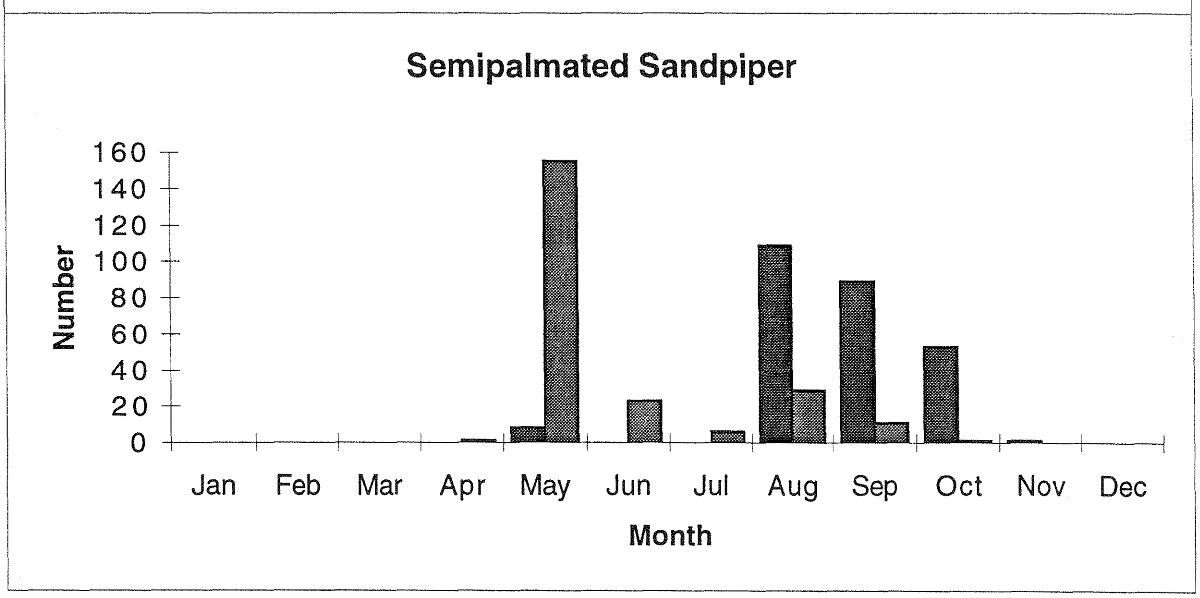
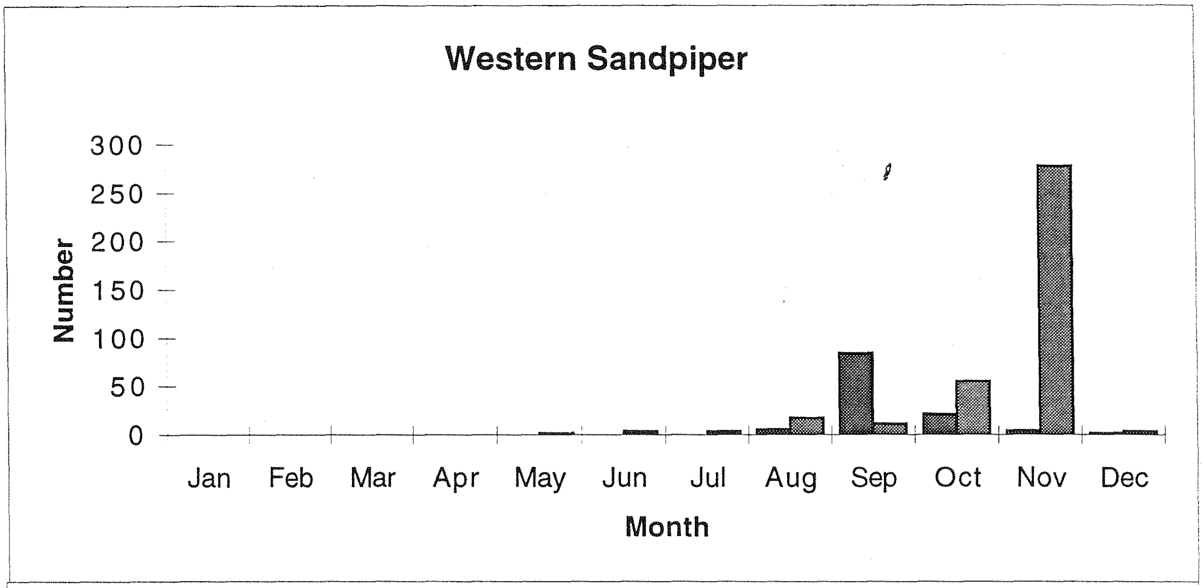
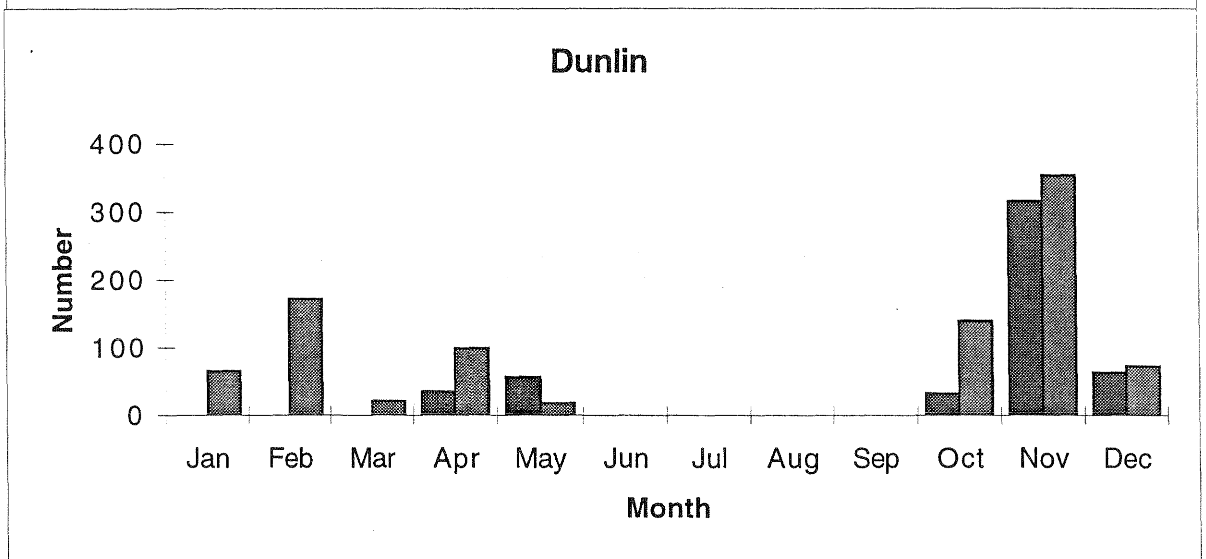

Semipalmated Sandpiper
Number
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

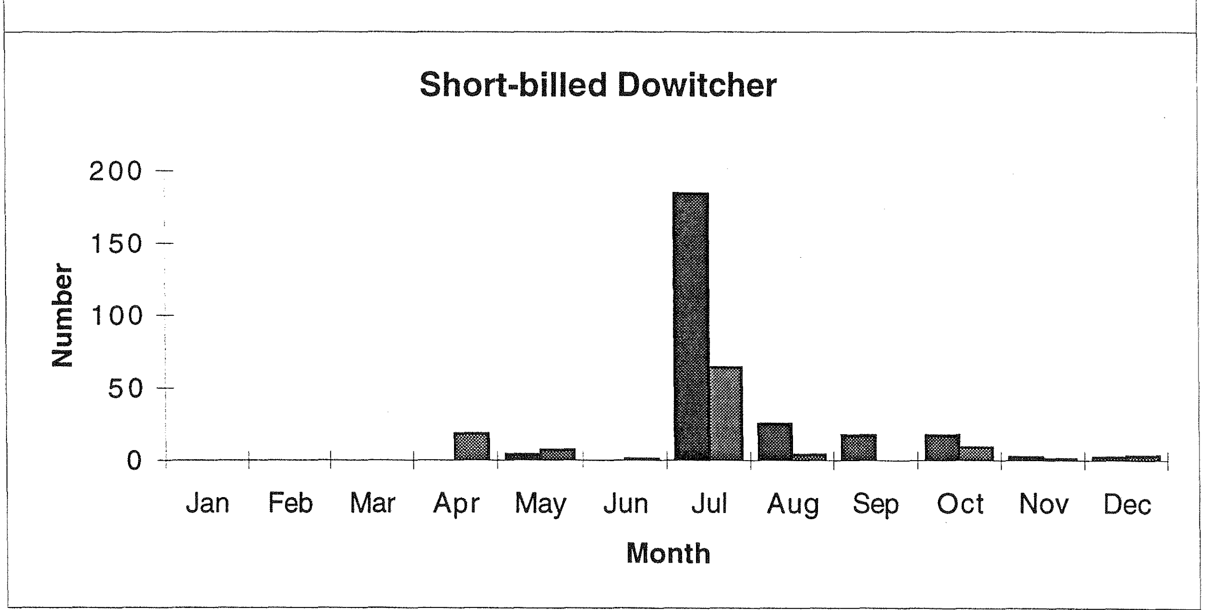
Figure 3. Seasonal numbers of Western Sandpipers, Dunlins and Short-billed Dowitcher counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.



Western Sandpiper
300
250
200
150
100
50
0
Number
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

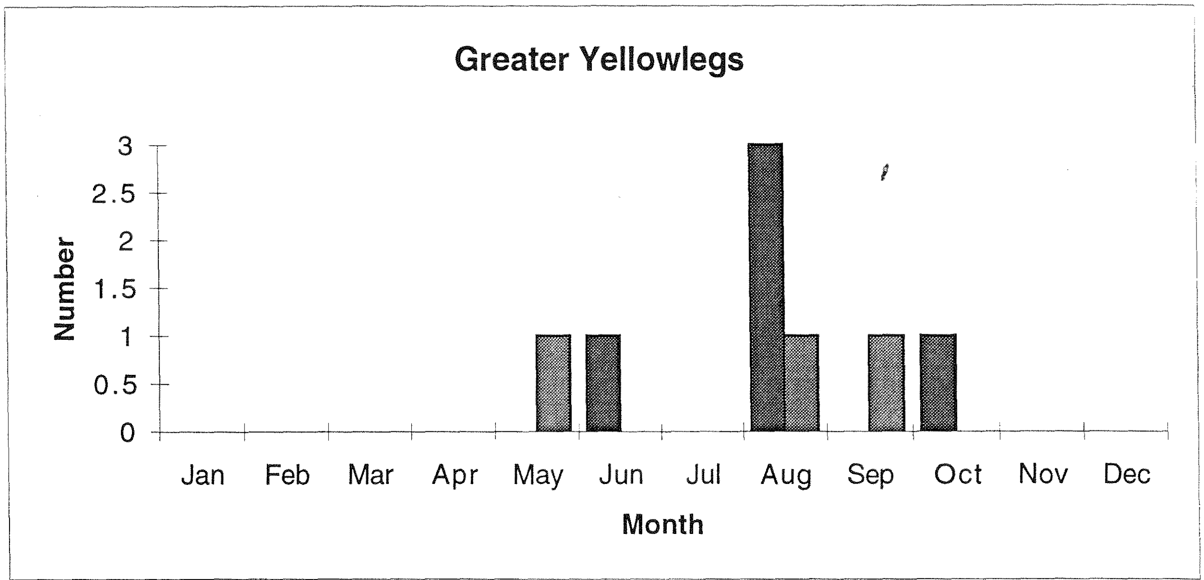


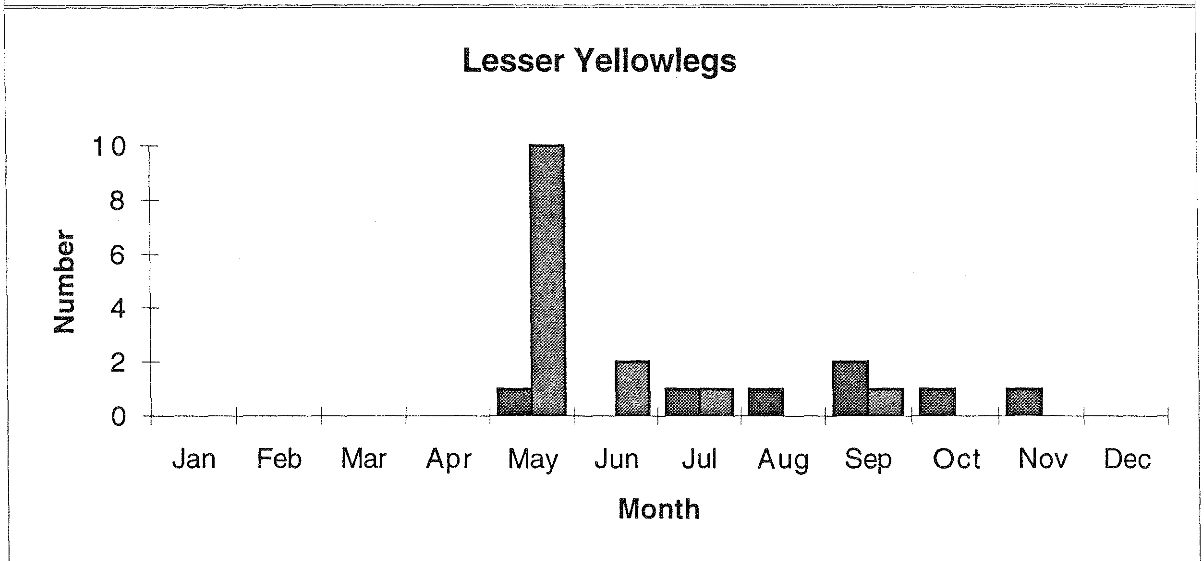
Dunlin
400
300
200
100
0
Number
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month



Short-billed Dowitcher
200
150
100
50
0
Number
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 4. Seasonal numbers of Greater Yellowlegs, Lesser Yellowlegs and Spotted Sandpipers counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Greater Yellowlegs
Number
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Lesser Yellowlegs
Number
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

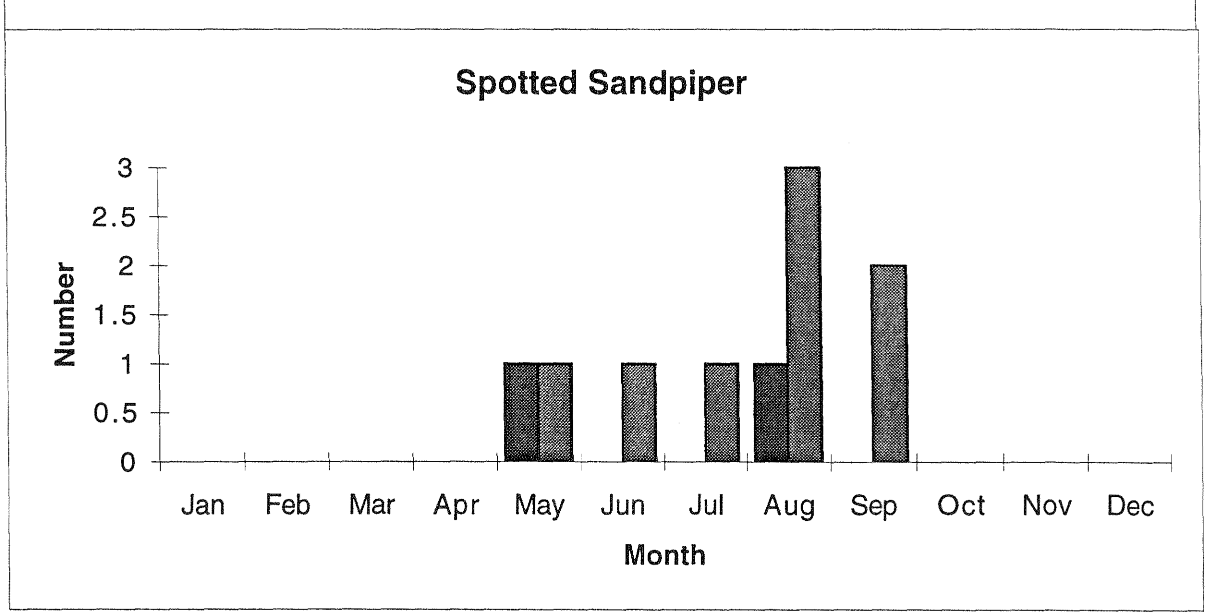
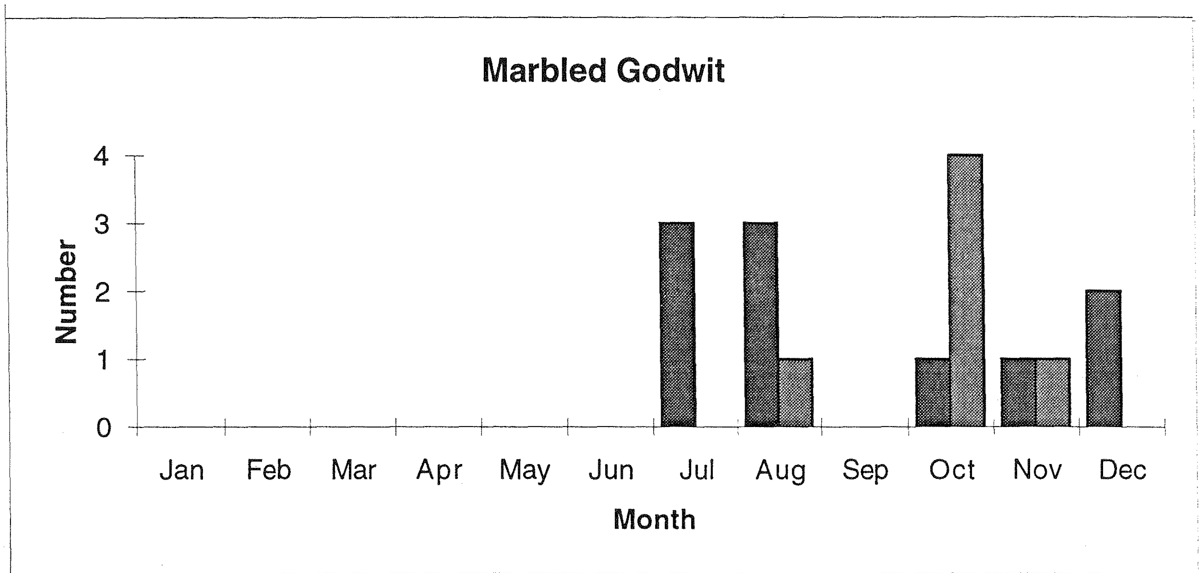

Spotted Sandpiper
Number
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 5. Seasonal numbers of Marbled Godwits, Least Sandpipers counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Marbled Godwit
Number
0
1
2
3
4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

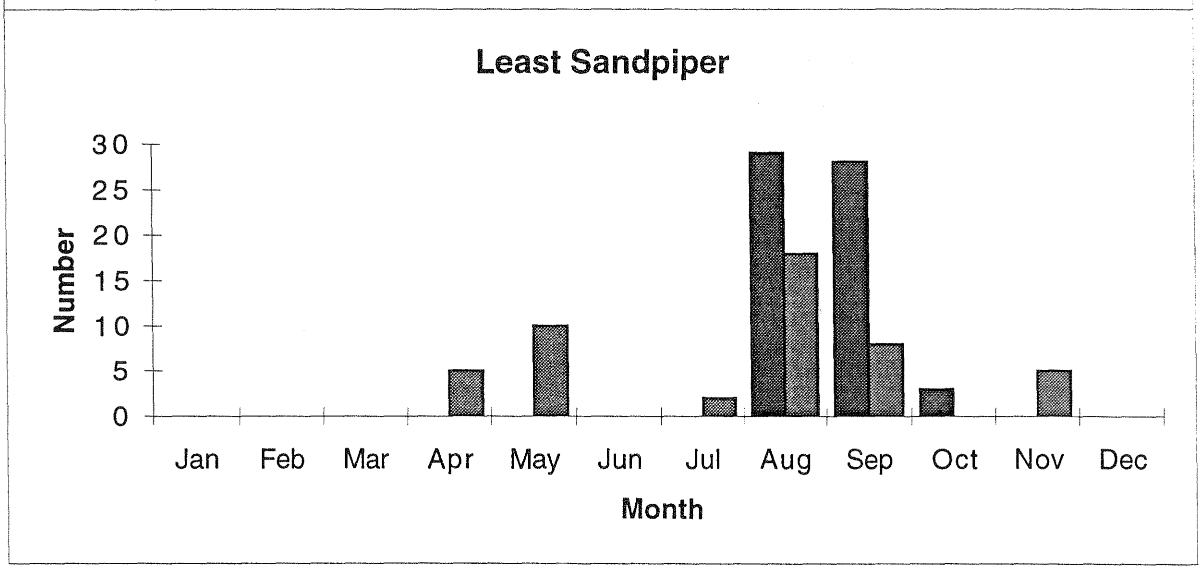
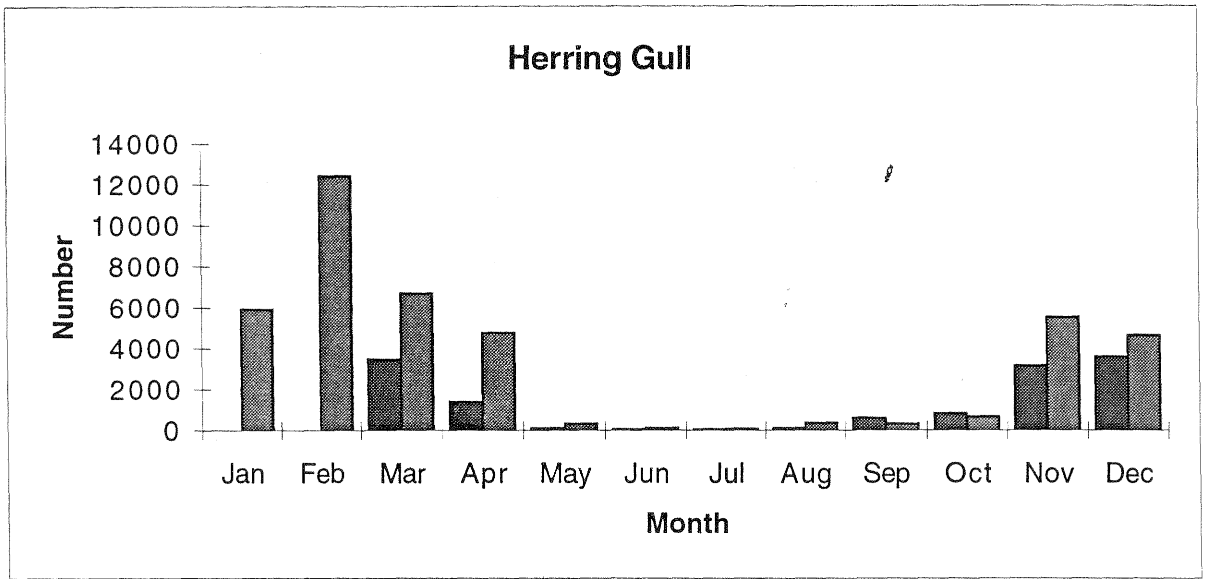
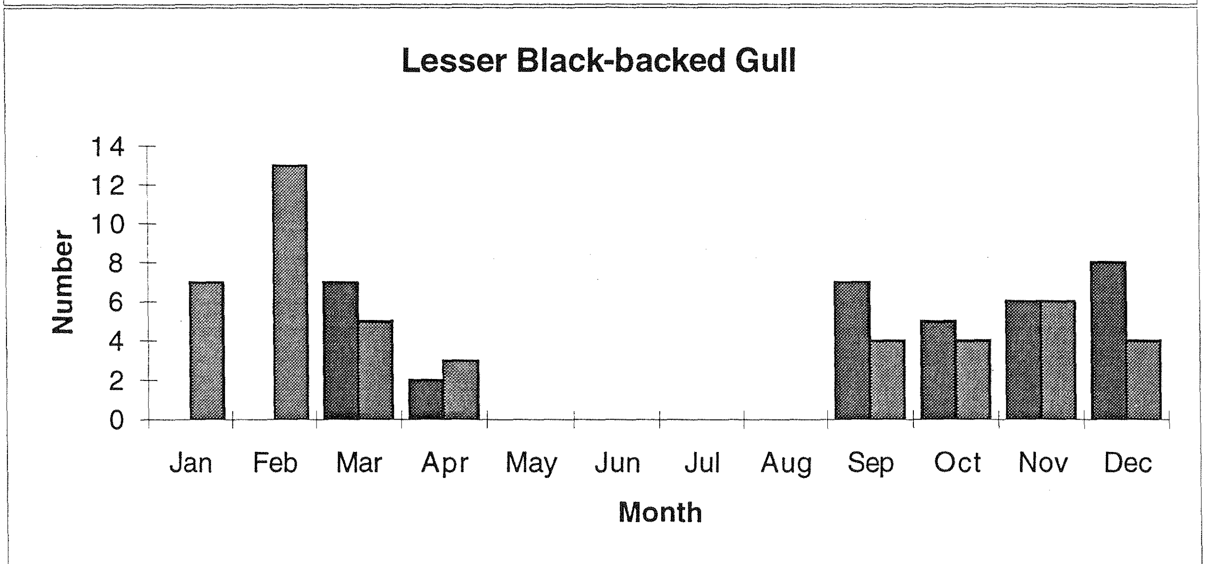

Least Sandpiper
Number
0
5
10
15
20
25
30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 6. Seasonal numbers of Herring Gulls, Lesser Black-backed Gulls and Greater Black-backed counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Herring Gull
Number
14000
12000
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Lesser Black-backed Gull
Number
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

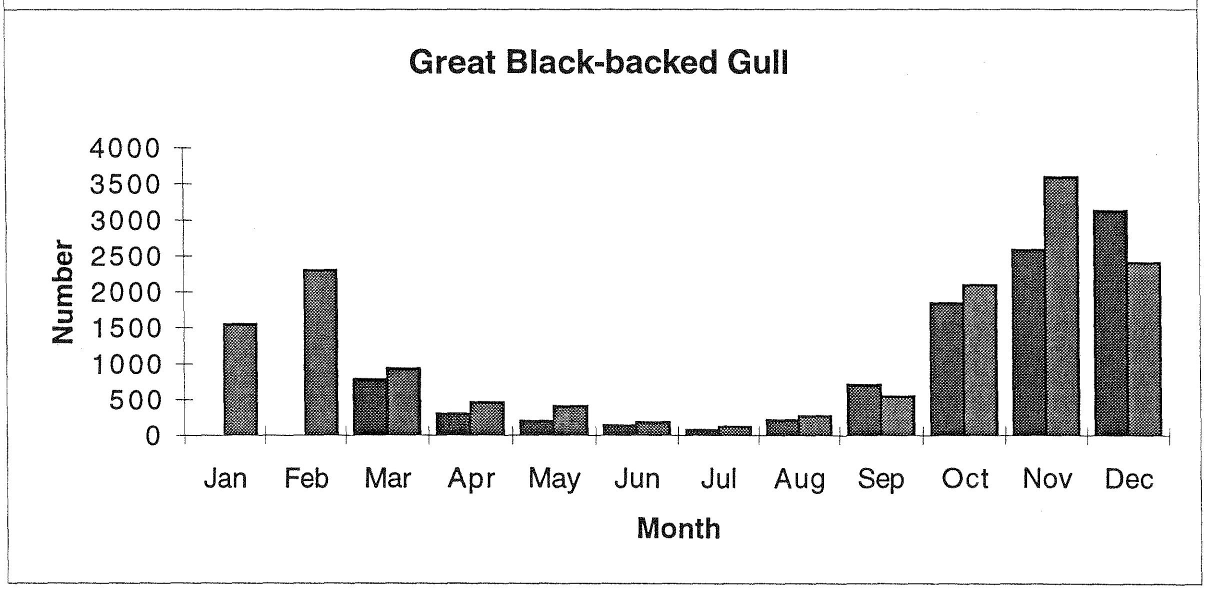
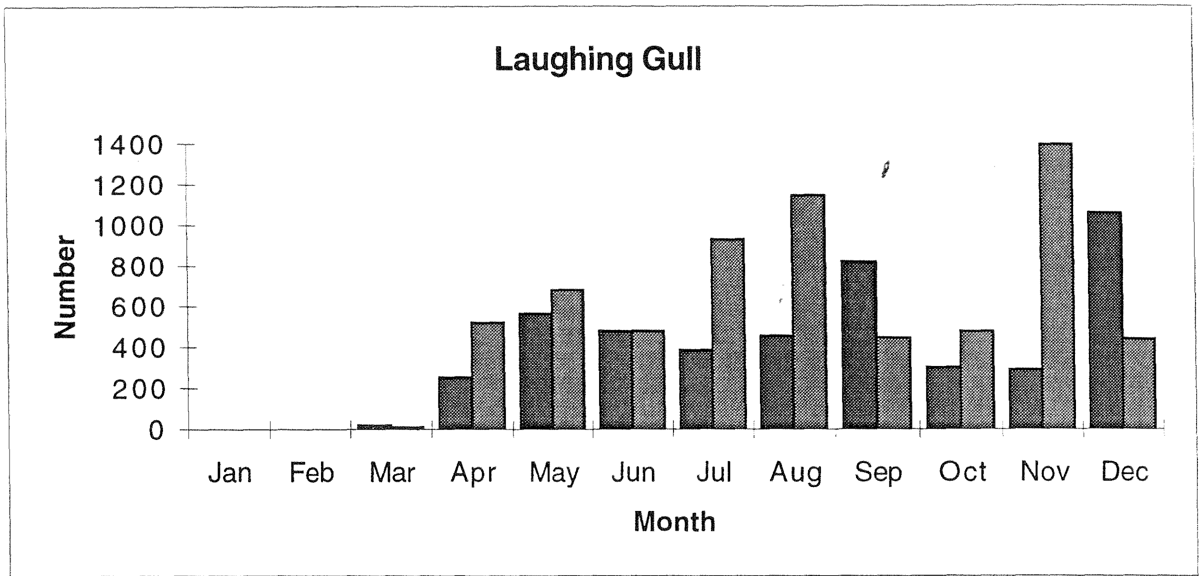
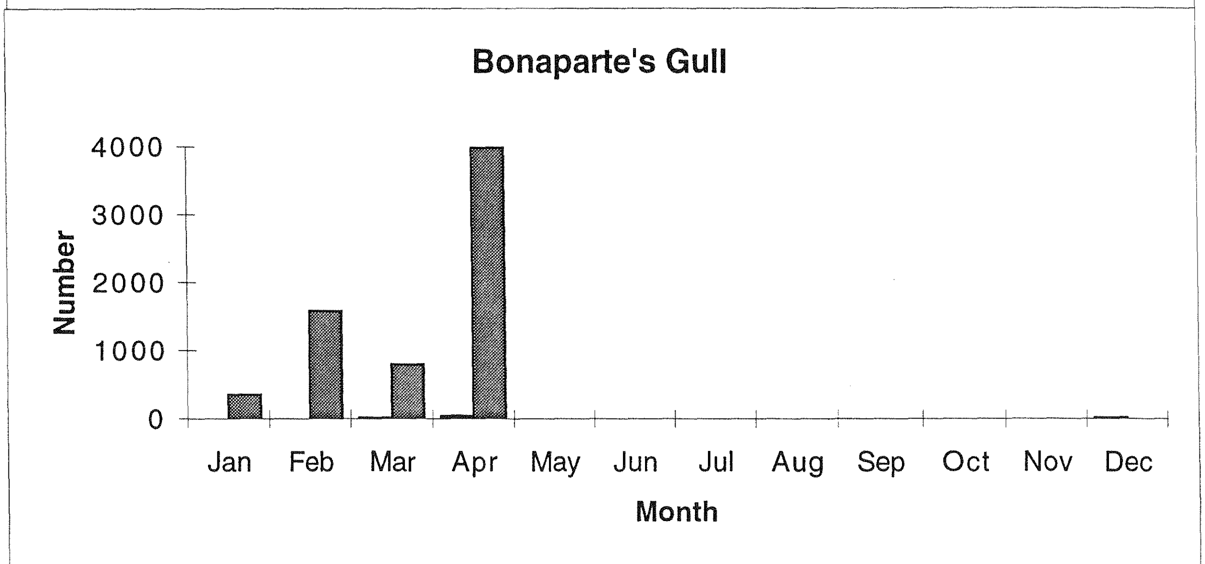

Great Black-backed Gull
Number
4000
3500
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 7. Seasonal numbers of Laughing Gulls, Bonaparte's Gulls and Ring-billed Gulls counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Laughing Gull
Number
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Bonaparte's Gull
Number
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

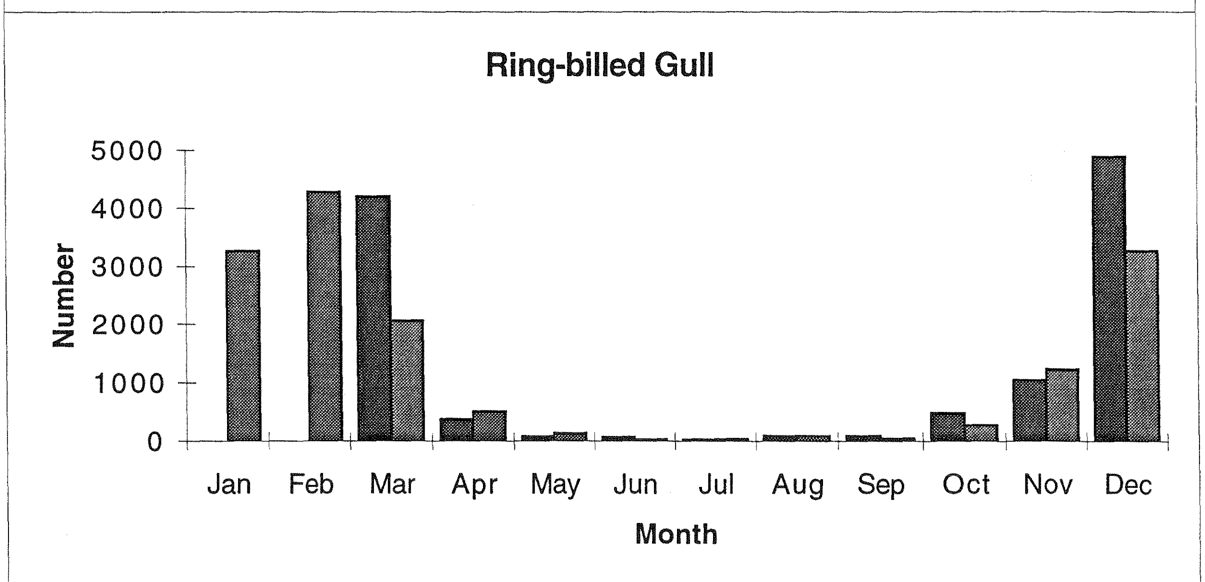
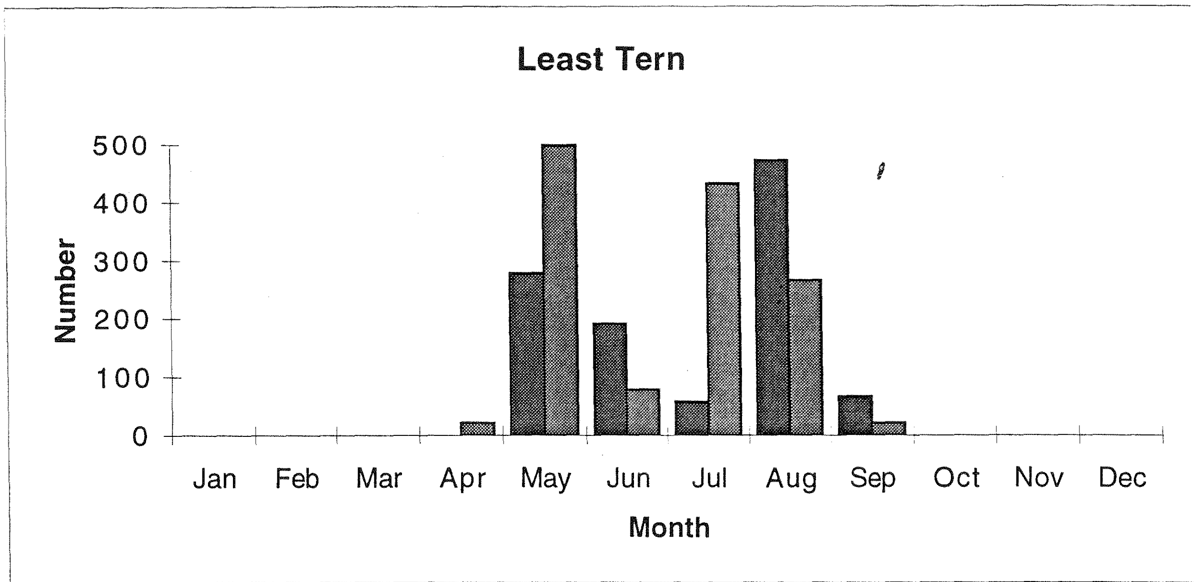
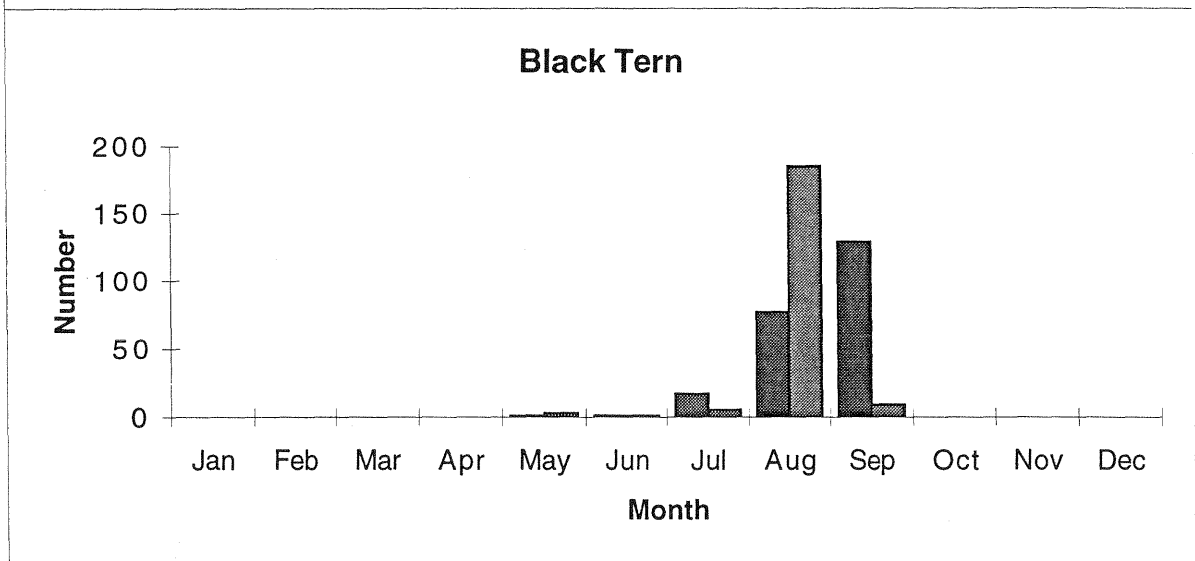

Ring-billed Gull
Number
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 8. Seasonal numbers of Least Terns, Black Terns and Black Skimmers counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Least Tern
Number
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Black Tern
Number
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

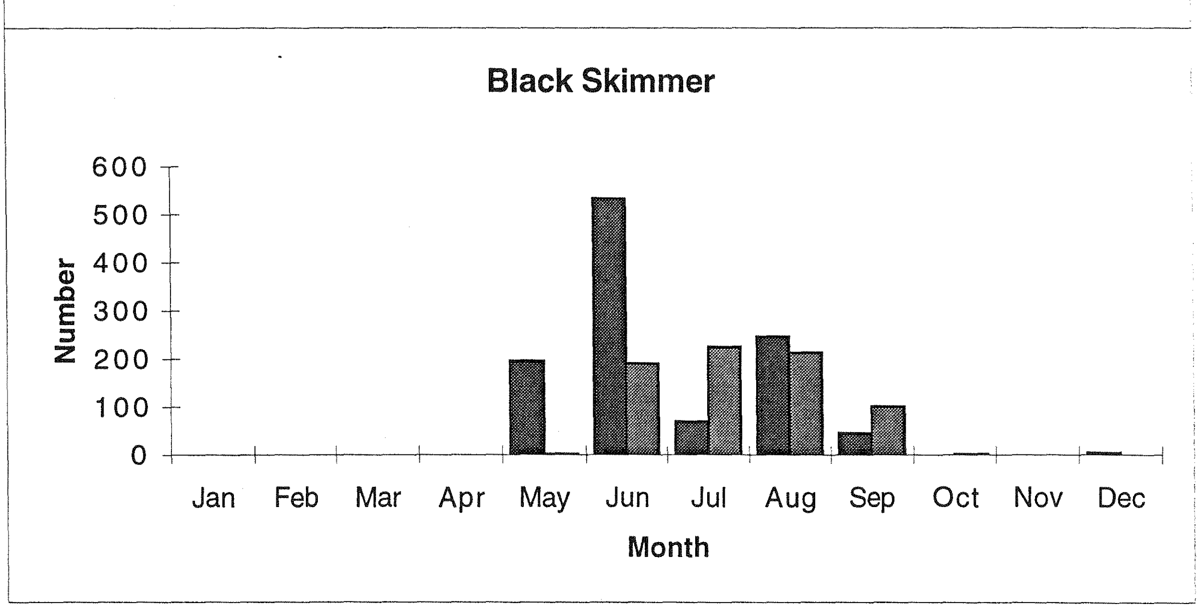
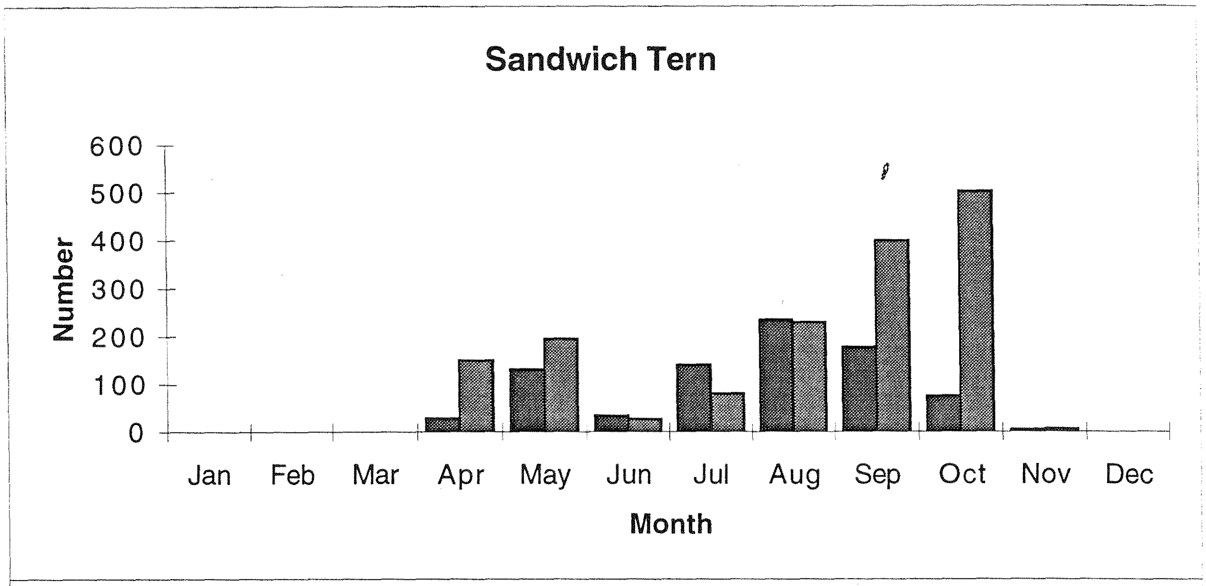
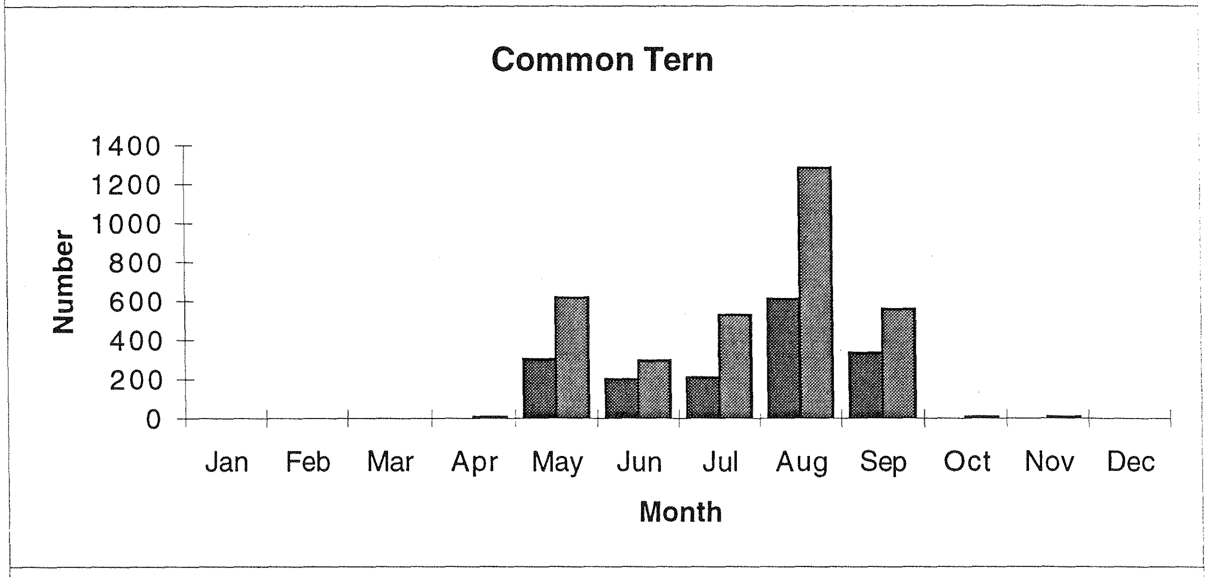

Black Skimmer
Number
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure 9. Seasonal numbers of Sandwich Terns, Common Terns and Forster's Terns counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Sandwich Tern
600
500
400
300
200
100
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month


Common Tern
1400
1200
1000
800
600
400
200
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

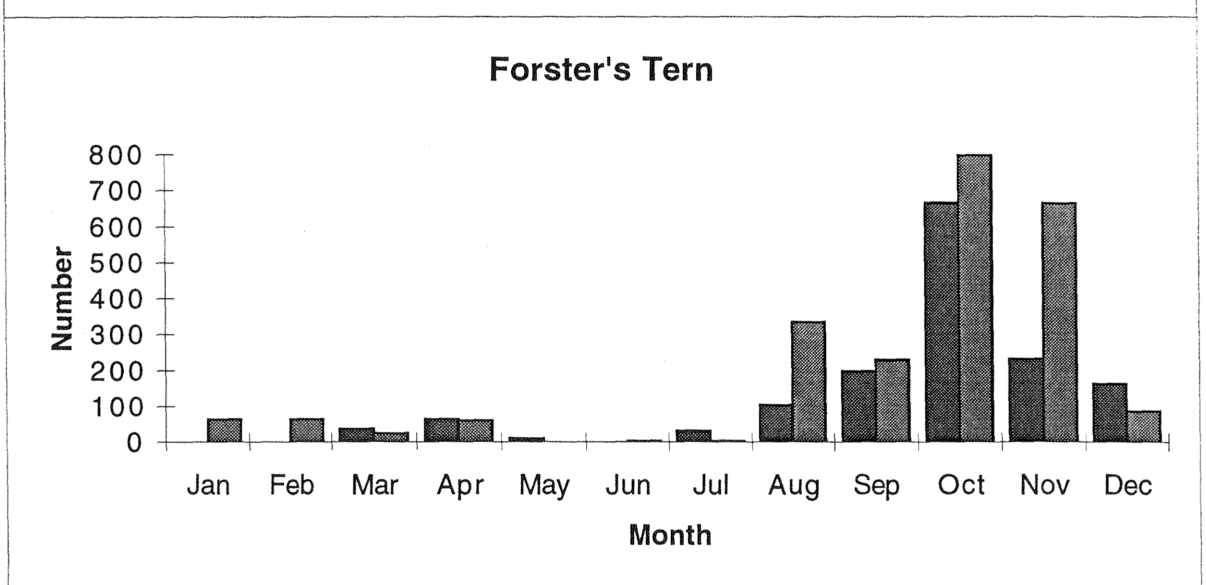
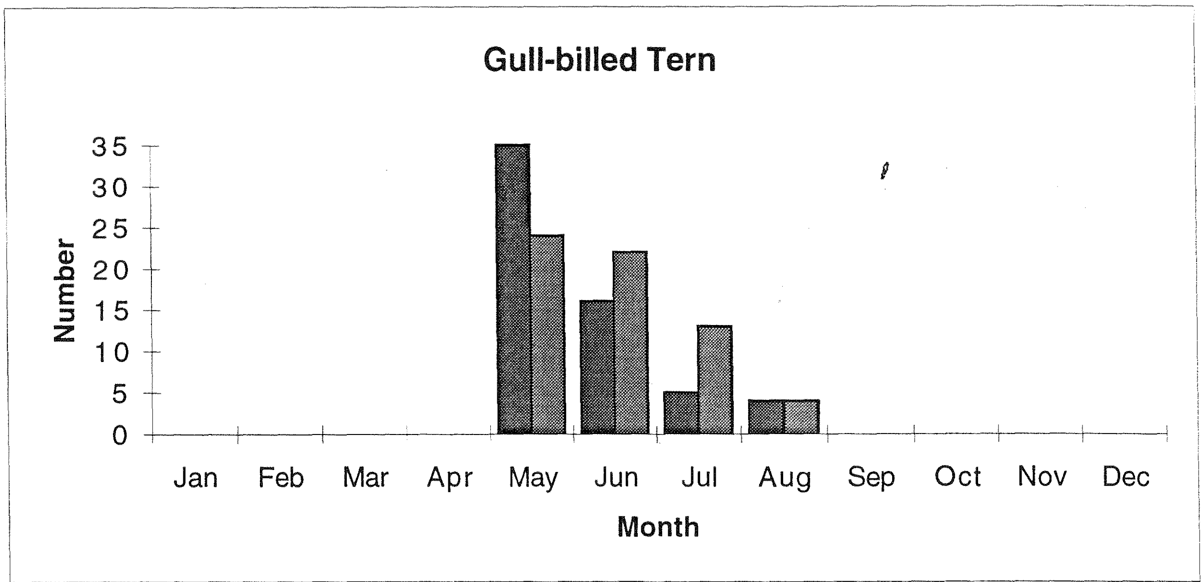
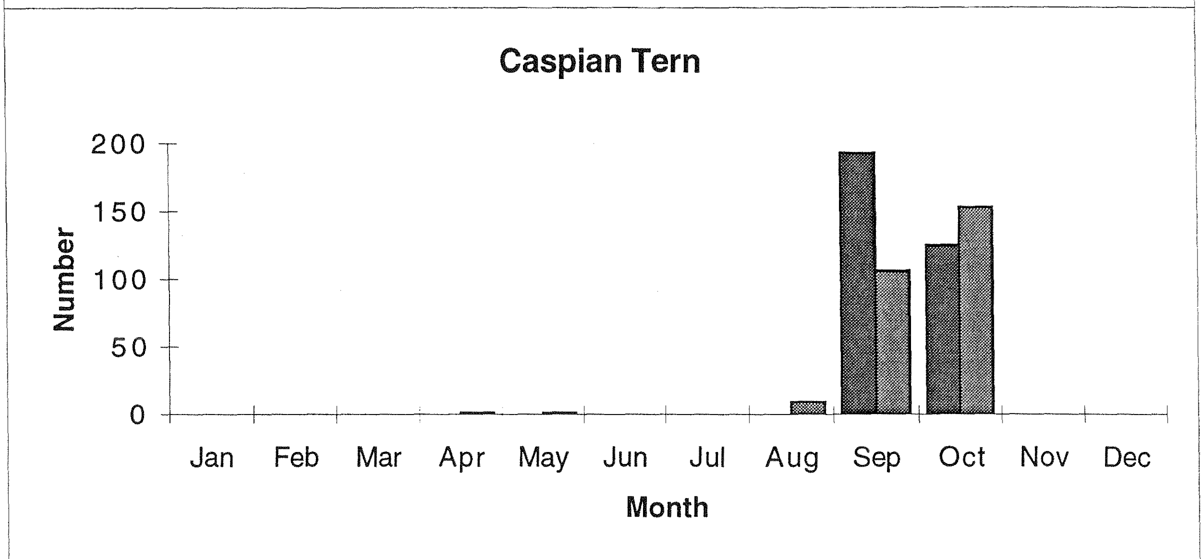

Forster's Tern
800
700
600
500
400
300
200
100
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

Figure 10. Seasonal numbers of Gull-billed Terns, Caspian Terns and Royal Terns counted during beach censuses in 1992 (dark bar or left of pair) and 1993 (right of pair) at the Outer Banks of North Carolina.


Gull-billed Tern
Number
35
30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month


Caspian Tern
Number
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

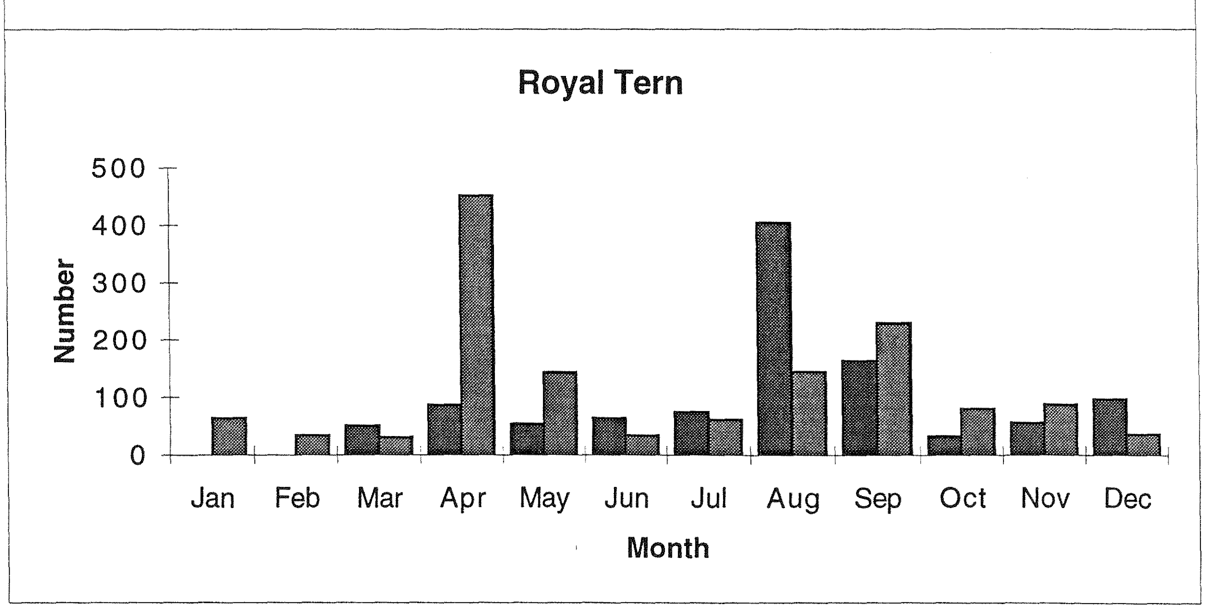
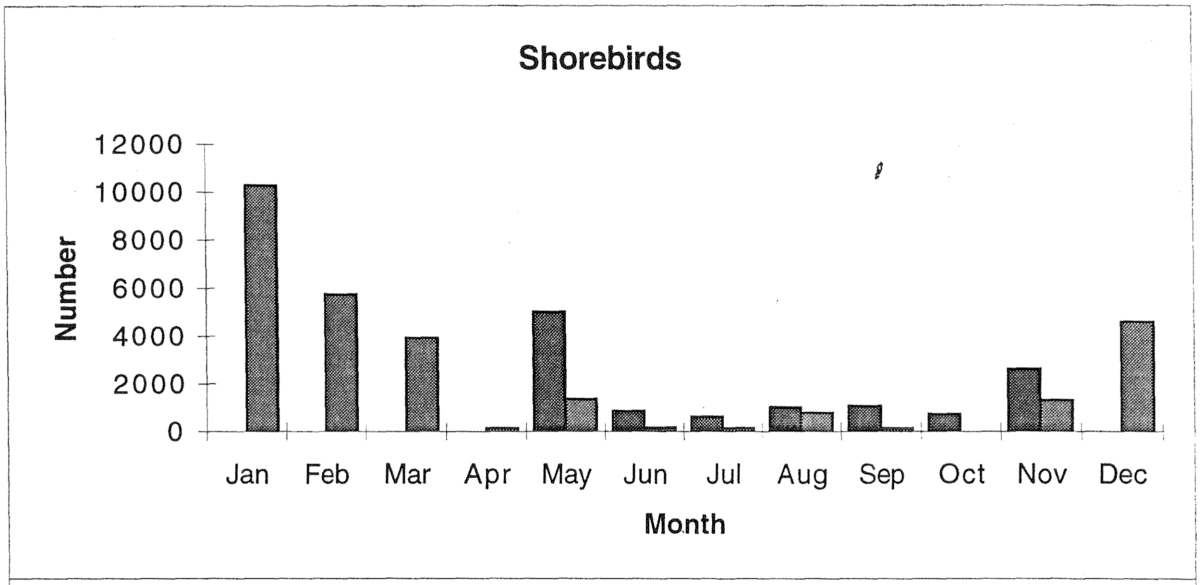
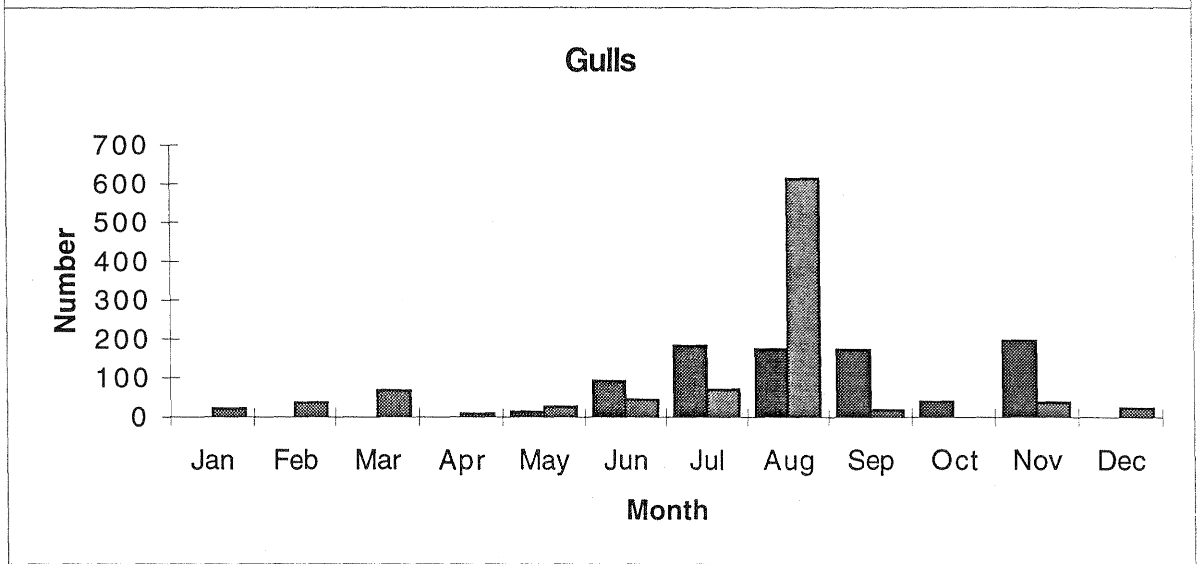

Royal Tern
Number
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

Figure 11. Seasonal numbers of shorebirds, gulls and counted during censuses from May 1992 to November 1993 at Portsmouth Flats, North Core Banks, North Carolina.


Shorebirds
12000
10000
8000
6000
4000
2000
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month


Gulls
700
600
500
400
300
200
100
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

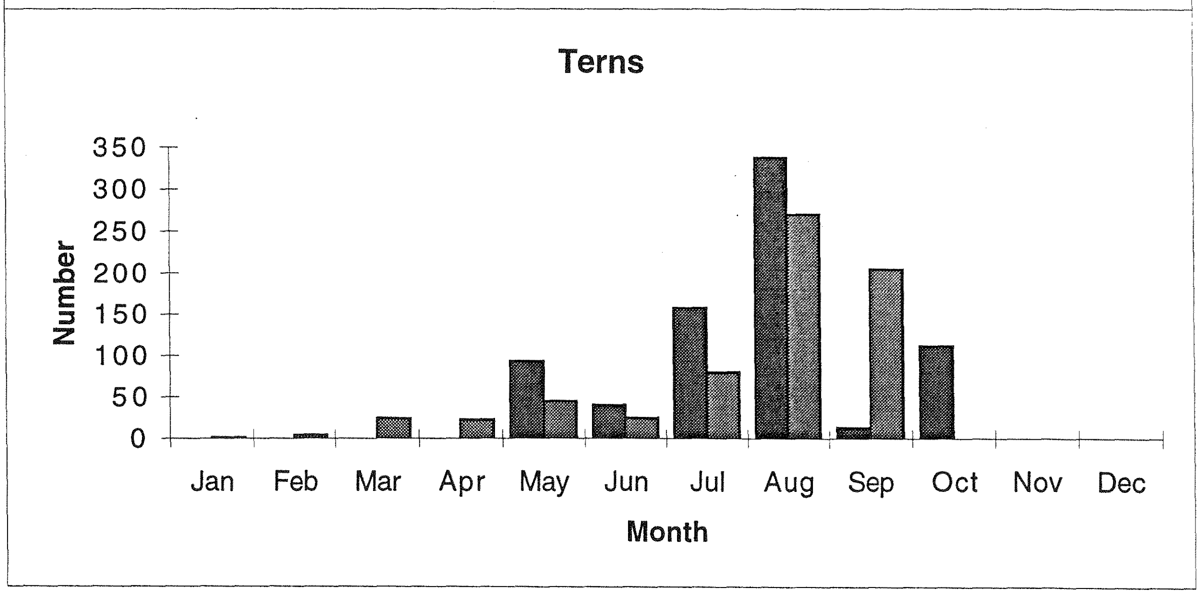
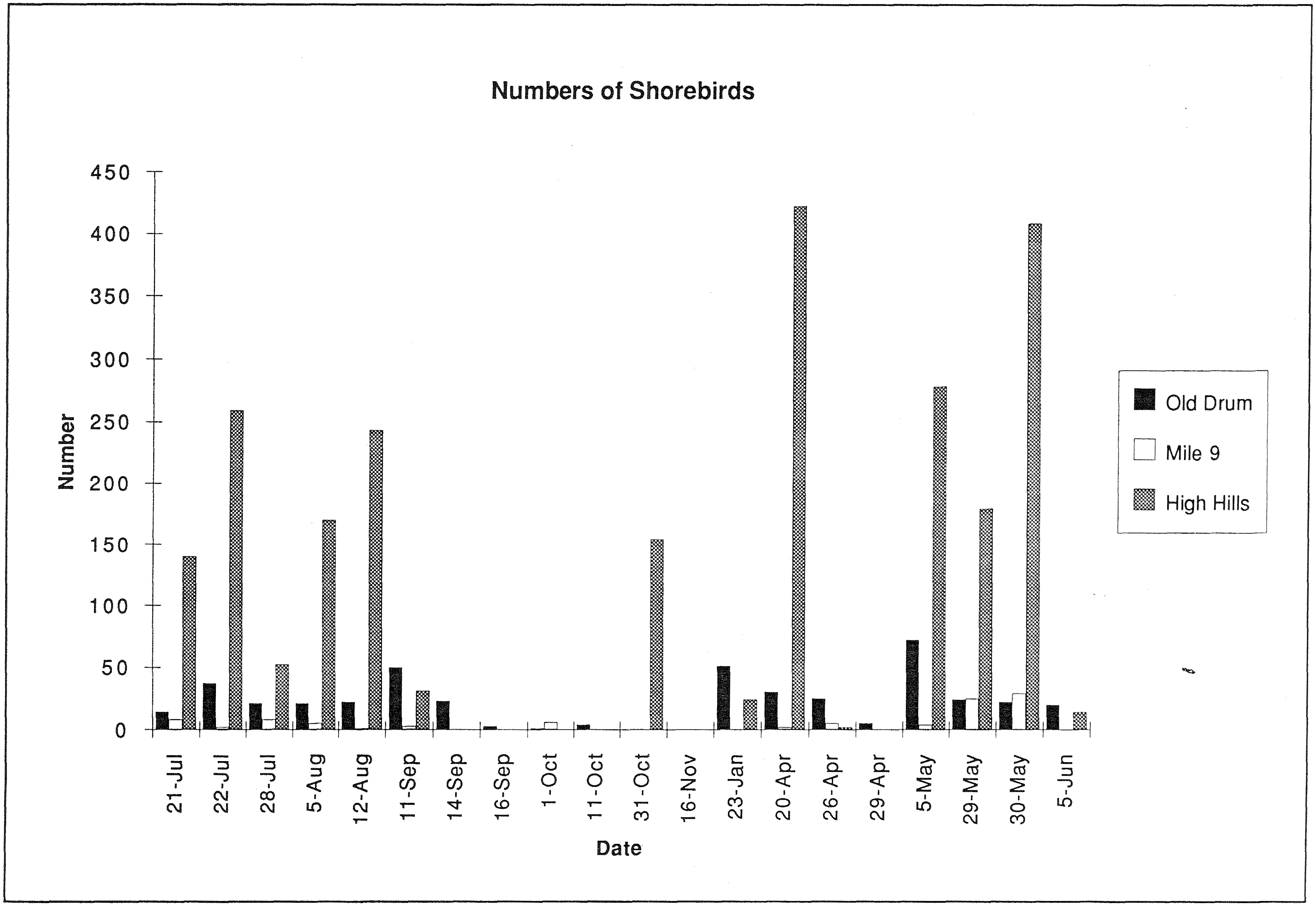

Terns
350
300
250
200
150
100
50
0
Number
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month

Figure 12. Seasonal numbers of shorebirds counted during censuses from May 1992 to November 1993 at Old Drum Inlet, Mile 9 marker and High Hills along the Core Sound side of North Core Banks, North Carolina.



Numbers of Shorebirds
Number
450
400
350
300
250
200
150
100
50
0
21-Jul
22-Jul
28-Jul
5-Aug
12-Aug
11-Sep
14-Sep
16-Sep
1-Oct
11-Oct
31-Oct
16-Nov
23-Jan
20-Apr
26-Apr
29-Apr
5-May
29-May
30-May
5-Jun
Date
Old Drum
Mile 9
High Hills

Figure 13. Seasonal numbers of gulls counted during censuses from May 1992 to November 1993 at Old Drum Inlet, Mile 9 marker and High Hills along the Core Sound side of North Core Banks, North Carolina.

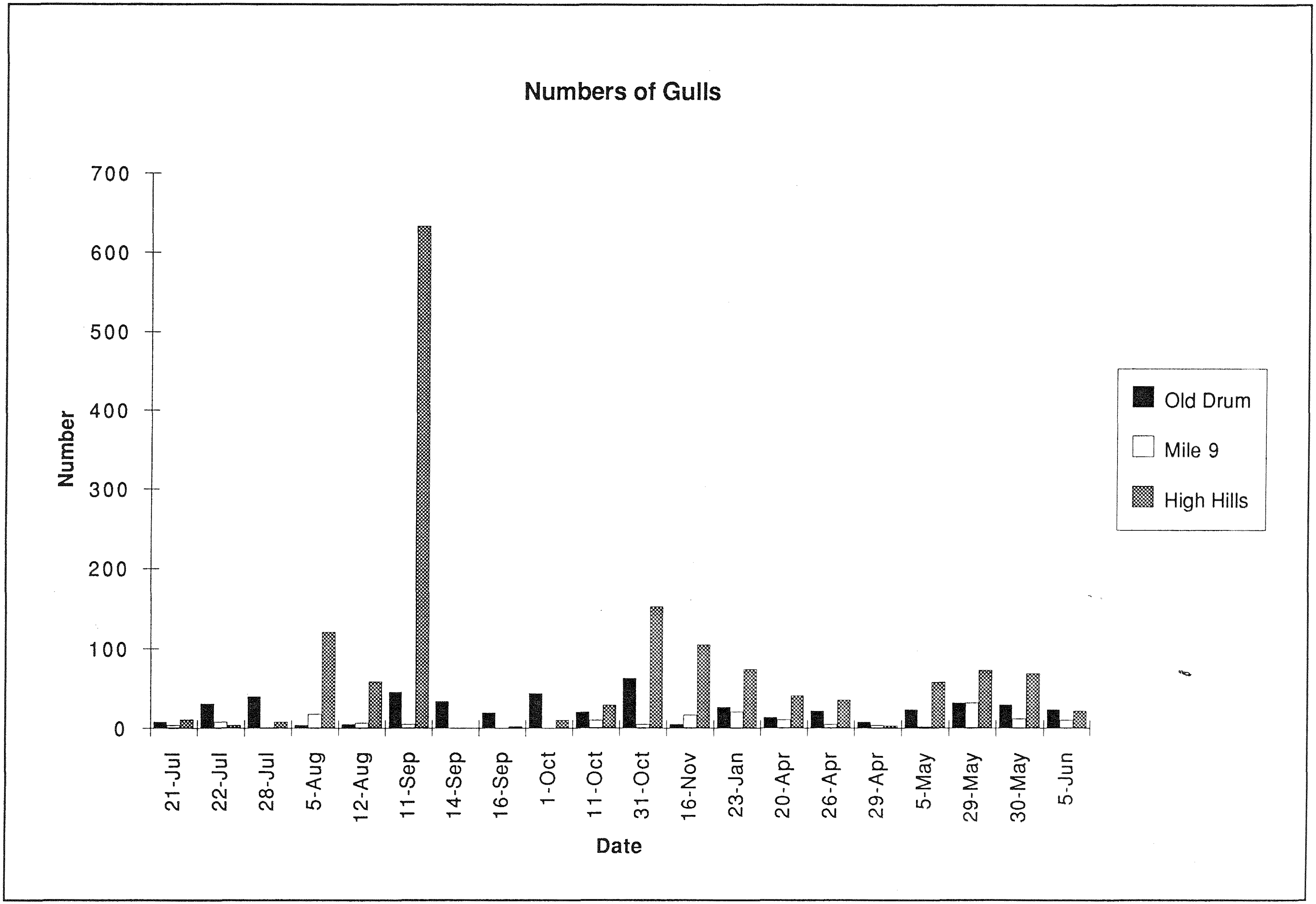

Numbers of Gulls
Number
700
600
500
400
300
200
100
0
21-Jul
22-Jul
28-Jul
5-Aug
12-Aug
11-Sep
14-Sep
16-Sep
1-Oct
11-Oct
31-Oct
16-Nov
23-Jan
20-Apr
26-Apr
29-Apr
5-May
29-May
30-May
5-Jun
Date
Old Drum
Mile 9
High Hills

Figure 14. Seasonal numbers of terns counted during censuses from May 1992 to November 1993 at Old Drum Inlet, Mile 9 marker and High Hills along the Core Sound side of North Core Banks, North Carolina.

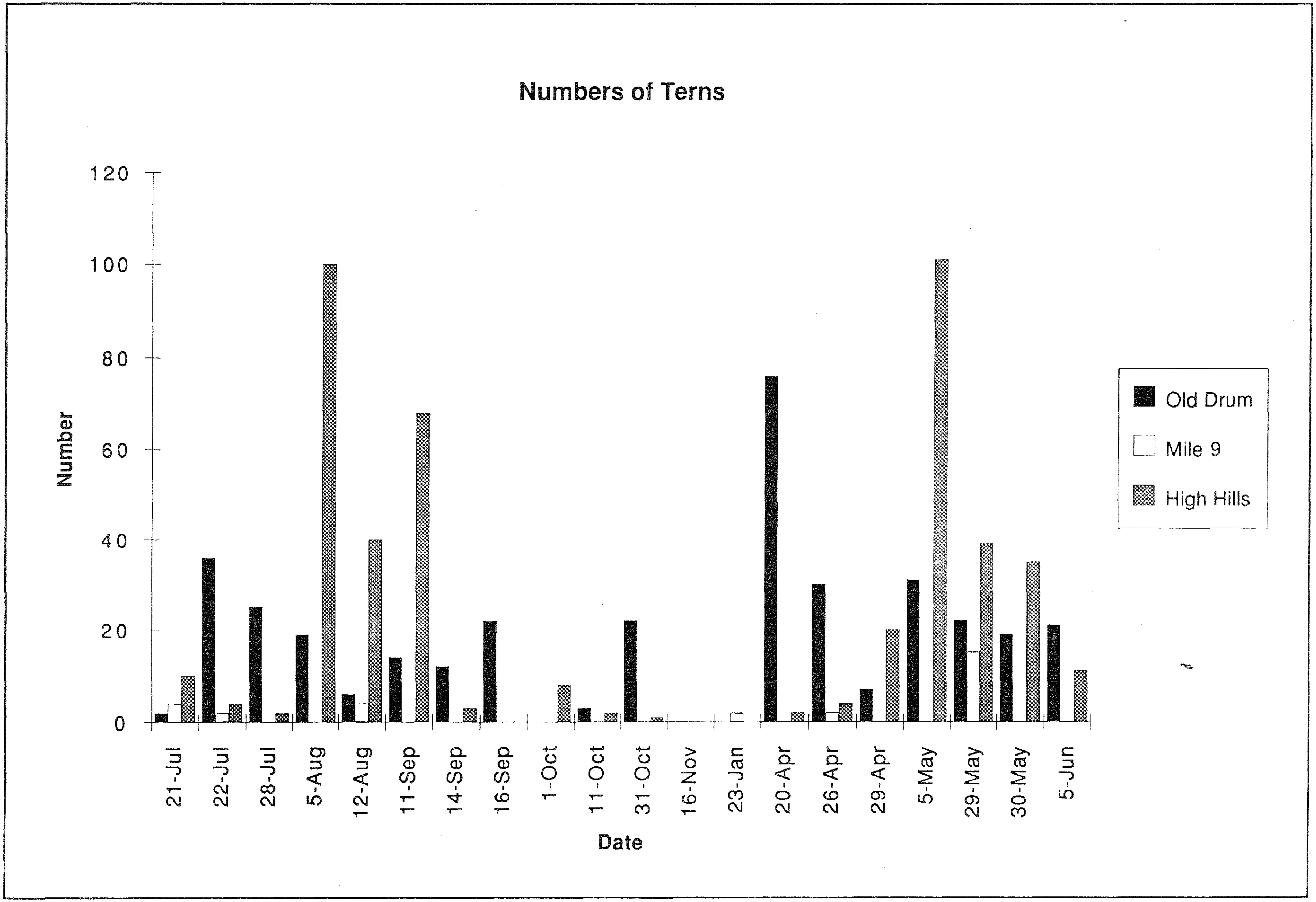
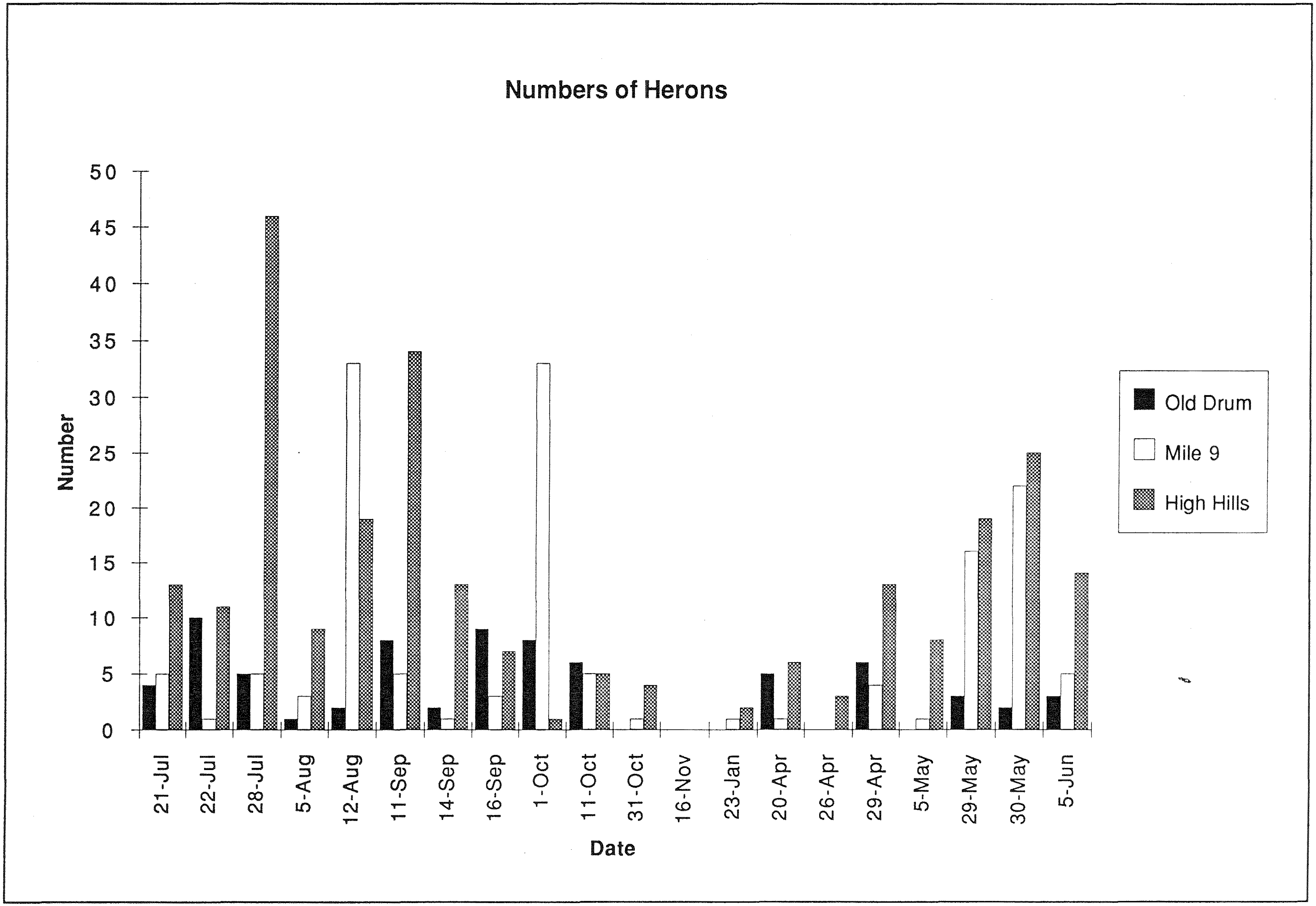

Numbers of Terns
Number
120
100
80
60
40
20
0
21-Jul
22-Jul
28-Jul
5-Aug
12-Aug
11-Sep
14-Sep
16-Sep
1-Oct
11-Oct
31-Oct
16-Nov
23-Jan
20-Apr
26-Apr
29-Apr
5-May
29-May
30-May
5-Jun
Date
Old Drum
Mile 9
High Hills

Figure 15. Seasonal numbers of herons counted during censuses from May 1992 to November 1993 at Old Drum Inlet, Mile 9 marker and High Hills along the Core Sound side of North Core Banks, North Carolina.



Numbers of Herons
Number
50
45
40
35
30
25
20
15
10
5
0
21-Jul
22-Jul
28-Jul
5-Aug
12-Aug
11-Sep
14-Sep
16-Sep
1-Oct
11-Oct
31-Oct
16-Nov
23-Jan
20-Apr
26-Apr
29-Apr
5-May
29-May
30-May
5-Jun
Date
Old Drum
Mile 9
High Hills

Table 1. Seasonal numbers (mean ± SE) of selected species of gulls and terns during 1992 and 1993 beach censuses in the Outer Banks of North Carolina. Seasons are spring (April-June) and fall (July-November).

Species	Spring	Fall
Ring-billed Gull	69.43 ± 15.22*	40.70 ± 10.34
Herring Gull	1,905.00 ± 11.69*	34.67 ± 1.54
Great Black-backed Gull	45.70 ± 1.43*	13.06 ± 1.36
Common Tern	0.82 ± 1.82	21.37 ± 1.69*
Least Tern	1.22 ± 1.79	9.60 ± 1.64*

* = significantly higher ($P < 0.05$)

Table 2. Numbers (mean ± SE) of Black Skimmers and Sandwich Terns counted during 1992 and 1993 beach censuses in the Outer Banks of North Carolina. Seasons are spring (April-June) and fall (July-November).

Species	Location	Season	Numbers
Black Skimmer	Bodie Island	Spring	11.09 ± 2.88
	North Core Banks	Spring	10.42 ± 4.14
	North Beach	Fall	12.19 ± 2.49
	South Beach	Fall	2. 00 ± 2.49
	Ocracoke	Fall	0.40 ± 2.88
Sandwich Tern	Bodie Island	Spring	15.03 ± 3.04
	North Core Banks	Spring	25.70 ± 4.26
	North Beach	Fall	5.36 ± 2.56
	South Beach	Fall	6.31 ± 2.56
	Ocracoke	Fall	8.26 ± 2.56

Birds of Cape Lookout National Seashore: a checklist.

Chapter VII

by

Stephen J. Dinsmore

North Carolina State University
Department of Zoology
Raleigh, NC 27695

Species	Sp	Su	F	W
Red-throated Loon	C		F	C
Common Loon	C	R	F	C
Pied-billed Grebe	U		U	U
Horned Grebe	F	R	U	F
Red-necked Grebe	R			R
Cory's Shearwater	R	U	U	
Greater Shearwater		R		
Sooty Shearwater	U	R		
Audubon's Shearwater	R	U	U	
Wilson's Storm-Petrel	U	U	U	
Northern Gannet	C	R	C	C
Brown Pelican*	C	C	C	C
Great Cormorant	U	R	U	U
Double-crested Cormorant	C	U	C	C
Magnificent Frigatebird	R	R	R	
American Bittern			U	R
Least Bittern			R	
Great Blue Heron	F	U	F	F
Great Egret*	C	C	C	U
Snowy Egret*	C	C	C	R
Little Blue Heron*	C	C	C	R
Tricolored Heron*	C	C	C	U
Reddish Egret	R	R	R	
Cattle Egret*	C	C	C	
Green Heron*	U	U	U	
Black-crowned Night-Heron*	F	U	F	U
Yellow-crowned Night-Heron	U	U	U	
White Ibis	U	U	U	R
Glossy Ibis	U	U	U	
Tundra Swan	R		R	U
Brant	U	R	U	U
Canada Goose	U	R	U	U
Green-winged Teal	U		U	F
American Black Duck*	C	U	C	C
Mallard	U	R	U	U
Northern Pintail	U		U	F
Blue-winged Teal	U		U	R
Northern Shoveler	U		U	U
Gadwall	U		F	C
American Wigeon	C		C	C
Canvasback	R		U	R
Redhead	U		U	F
Ring-necked Duck			R	R
Greater Scaup	R		U	U
Lesser Scaup	U		U	F
Common Eider	R	R	R	R
Oldsquaw	U		U	U
Black Scoter	U	R	U	F
Surf Scoter	U	R	U	U
White-winged Scoter	R		U	U
Common Goldeneye	U		U	U

Species	Sp	Su	F	W
Bufflehead	F		U	C
Hooded Merganser	U		U	F
Red-breasted Merganser	F	R	U	C
Ruddy Duck	R		R	U
Black Vulture			R	
Turkey Vulture	R	R	R	
Osprey*	F	F	F	
Am. Swallow-tailed Kite	R	R		
Bald Eagle	R	R	R	
Northern Harrier*	C	R	C	C
Sharp-shinned Hawk	U		C	U
Cooper's Hawk	R		U	R
Red-shouldered Hawk	R		R	R
Broad-winged Hawk	R			
Red-tailed Hawk	R	R	R	R
American Kestrel	F		C	F
Merlin	U		F	U
Peregrine Falcon	U		F	U
Ring-necked Pheasant*	U	U	U	U
Northern Bobwhite*	U	U	U	U
Black Rail*	U	U	U	
Clapper Rail*	C	C	C	C
King Rail		R		
Virginia Rail*	F	U	F	F
Sora	U		F	U
Common Moorhen			R	R
American Coot	R		R	R
Black-bellied Plover	C	F	C	F
American Golden-Plover	R	R	U	
Wilson's Plover*	F	F	F	R
Semipalmated Plover	C	F	C	U
Piping Plover*	F	F	F	U
Killdeer	R	R	U	U
American Oystercatcher*	C	C	C	U
Black-necked Stilt	R	R		
American Avocet	R	R		
Greater Yellowlegs	F	U	F	F
Lesser Yellowlegs	U	R	U	
Solitary Sandpiper	U	U	U	
Willet*	C	C	C	F
Spotted Sandpiper	U	F	F	
Upland Sandpiper	R	R		
Whimbrel	F	F	F	R
Long-billed Curlew	R	R	R	R
Hudsonian Godwit			R	
Marbled Godwit	U	U	F	U
Ruddy Turnstone	C	F	F	U
Red Knot	C	U	F	U
Sanderling	C	F	C	C
Semipalmated Sandpiper	C	F	U	
Western Sandpiper	F	C	C	F

Species	Sp	Su	F	W
Least Sandpiper	F	F	F	U
White-rumped Sandpiper	U	U	U	
Baird's Sandpiper			R	
Pectoral Sandpiper	U	U	F	
Dunlin	C	R	C	C
Curlew Sandpiper	R	R	R	R
Stilt Sandpiper	R	U	U	
Buff-breasted Sandpiper		R	R	
Ruff			R	
Short-billed Dowitcher	C	F	C	U
Long-billed Dowitcher	R		R	
Common Snipe	U		U	U
American Woodcock	U	R	U	U
Wilson's Phalarope	R	U	U	
Red-necked Phalarope	R	R		
Red Phalarope	R		R	
Pomarine Jaeger	U	U	U	U
Parasitic Jaeger	U	U	U	
Long-tailed Jaeger	R			
Laughing Gull*	C	C	C	U
Little Gull	R			R
Bonaparte's Gull	F		U	C
Ring-billed Gull	C	U	C	C
Herring Gull*	C	C	C	C
Iceland Gull			R	R
Lesser Black-backed Gull	U	R	U	U
Glaucous Gull				R
Great Black-backed Gull*	C	F	C	C
Black-legged Kittiwake	R		R	U
Gull-billed Tern*	F	F	F	
Caspian Tern	U	U	F	
Royal Tern*	C	C	C	F
Sandwich Tern*	C	C	C	
Roseate Tern	U	R	R	
Common Tern*	C	C	C	
Forster's Tern*	F	F	C	F
Least Tern*	C	C	C	
Sooty Tern*	R	R	R	
Black Tern	U	F	F	
Black Skimmer*	F	C	C	R
Dovekie			R	R
Razorbill			R	R
Rock Dove	R	R	R	
Mourning Dove*	C	C	C	C
Yellow-billed Cuckoo*	U	U	C	
Common Barn-Owl*	U	R	U	U
Short-eared Owl			U	U
Common Nighthawk*	F	F	U	
Chuck-wills-widow*	U	U	U	
Chimney Swift	U	U	U	
Ruby-throated Hummingbird		R	R	

Species	Sp	Su	F	W
Belted Kingfisher*	U	U	U	U
Red-headed Woodpecker	R		R	
Red-bellied Woodpecker			R	
Yellow-bellied Sapsucker			U	R
Downy Woodpecker			R	
Northern Flicker	C	R	C	F
Eastern Wood-Pewee	U		F	
empidonax sp.			U	
Eastern Phoebe			C	R
Great-crested Flycatcher*	F	F	F	
Western Kingbird			U	
Eastern Kingbird*	F	U	C	
Purple Martin	U	U	R	
Tree Swallow	U		C	U
Northern Rough-winged Swallow	R	R		
Bank Swallow	R	U		
Cliff Swallow		R		
Barn Swallow*	C	C	C	
Blue Jay	R		R	
Fish Crow*	C	C	C	U
Carolina Chickadee		R		
Red-breasted Nuthatch			F	U
Brown Creeper			U	
Carolina Wren*	F	F	F	F
House Wren	U		F	U
Winter Wren			U	R
Sedge Wren	U		U	U
Marsh Wren*	U	U	F	F
Golden-crowned Kinglet			C	U
Ruby-crowned Kinglet			F	U
Blue-gray Gnatcatcher	U	R	U	
Eastern Bluebird	R		R	
Veery	R			
Gray-cheeked Thrush	R		U	
Swainson's Thrush			U	
Hermit Thrush			U	R
Wood Thrush			U	
American Robin	U		C	U
Gray Catbird*	U	U	F	U
Northern Mockingbird*	U	U	U	U
Brown Thrasher*	U	U	U	U
American Pipit			U	
Cedar Waxwing	U	R	U	U
European Starling*	U	U	U	U
White-eyed Vireo	U	U	U	
Solitary Vireo			U	R
Philadelphia Vireo			R	
Red-eyed Vireo	R	R	F	
Blue-winged Warbler			R	
Tennessee Warbler			U	
Orange-crowned Warbler	U		U	U

Species	Sp	Su	F	W
Nashville Warbler			R	
Northern Parula	U	R	U	
Yellow Warbler	U	U	F	
Chestnut-sided Warbler			R	
Magnolia Warbler			F	
Cape May Warbler	R		C	
Black-throated Blue Warbler	R		C	
Yellow-rumped Warbler	C		C	C
Black-throated Green Warbler	R		U	
Blackburnian Warbler	R		R	
Yellow-throated Warbler	R	R		
Pine Warbler			U	R
Prairie Warbler*	F	F	C	R
Palm Warbler	U		C	U
Bay-breasted Warbler			R	
Blackpoll Warbler	U		F	
Black-and-white Warbler	R	U	F	
American Redstart	R	U	C	
Prothonotary Warbler	R	U		
Ovenbird			F	
Northern Waterthrush	R	U	U	
Connecticut Warbler			R	
Common Yellowthroat*	F	F	C	U
Hooded Warbler	R		R	
Wilson's Warbler			R	
Canada Warbler	R			
Yellow-breasted Chat*	U	U	U	
Summer Tanager	R			
Scarlet Tanager	R		U	
Northern Cardinal*	F	F	F	F
Rose-breasted Grosbeak	R		F	
Blue Grosbeak	U	U	F	
Indigo Bunting	U		F	
Painted Bunting	R	R		
Rufous-sided Towhee*	F	F	F	F
Chipping Sparrow		R	U	
Clay-colored Sparrow			R	
Field Sparrow			U	
Lark Sparrow		R	R	
Savannah Sparrow	C		C	C
Grasshopper Sparrow			R	
Sharp-tailed Sparrow	F		F	F
Seaside Sparrow*	F	F	F	F
Fox Sparrow			U	U
Song Sparrow*	F	F	C	C
Lincoln's Sparrow			R	
Swamp Sparrow	F		F	F
White-throated Sparrow	U		F	U
White-crowned Sparrow	R		F	R
Dark-eyed Junco	U		F	U
Lapland Longspur			R	

Species	Sp	Su	F	W
Snow Bunting			R	R
Bobolink	U	U	F	
Red-winged Blackbird*	C	C	C	C
Eastern Meadowlark*	C	C	C	C
Boat-tailed Grackle*	C	C	C	F
Common Grackle	U	U	U	
Brown-headed Cowbird*	U	U	U	R
Orchard Oriole*	U	U		
Northern Oriole	U	U	F	
Purple Finch	R		R	U
House Finch	R	R	U	U
Pine Siskin			R	
American Goldfinch	R	R	U	U
Evening Grosbeak	R			R

Legend

C=Common
F=Fairly Common
U=Uncommon
R=Rare
*=Nesting documented or suspected

Seasons

Sp=Spring (March-May)
Su=Summer (June-August)
F=Fall (September-November)
W=Winter (December-February)

Shorebird Habitat Mapping on the Outer Banks of North Carolina: an attempt to evaluate changing habitats with aerial photography.

Chapter VIII

by

William Slocumb
Research Analyst

North Carolina State University
College of Forest Resources
Computer Graphics Center
Raleigh, NC 27695

Objective

At the request of Dr. Jaime Collazo and Dr. Ted Simons, a pilot project was undertaken to develop a geographical information system (GIS) containing historic shorebird habitat gain or loss on the outer banks of North Carolina.

Procedure

STEP 1: Determine what existing digital information was readily available from various state and federal agencies. Existing digital data was not available that met the study objective because of the spatial resolution of Landsat Thematic Mapper imagery ,28.5 meters, and the currentness of existing digital vector data ,12/12/82. Existing aerial photographs were available and chosen for the project.

STEP 2: Delineate land use and land cover types on black and white aerial photographs taken on January 24, 1945. The classification was based on the vegetation scheme outlined in "'Vegetation Mapping and GIS for the Cape Hatteras National Seashore.' Barrier Island Ecology of the Mid-Atlantic Coast: A Symposium. Technical Report NPS/SERCAHA/NRTR-93/04. December 1992."

STEP 3: Georeference the delineated photographs and transfer the information via a zoom transfer scope onto a digital basemap.

Results

Existing digital geospatial data were available from the North Carolina Center for Geographic Information and Analysis (NCCGIA). The Landsat Thematic Mapper imagery available covers the entire study area. However, the spatial resolution, 28.5 meters, and the date of the imagery, December 5, 1988, did not meet the specifications of the study objective. First, because of the spatial resolution, it is not possible to delineated specific land cover types in the classified imagery. Second, it was determined that the currentness of the data set, December 1988, was to recent to create a historic shorebird habitat gain or loss database.

A second alternative data set was available from the North Carolina State University, Computer Graphics Center (CGC). These data were based on aerial photographs taken December 12, 1982. Again, the date of the aerial photographs did not comply with the study objective, the data was determined to be too recent to provide a historical study. As a result, black and white aerial photographs taken January 24, 1945 were used to begin the development a GIS.

The photographs were obtained by Dr. Jaime Collazo. A portion centered around Ocracoke, NC was used as a test site. The photographs were delineated based on the chosen classification scheme. When the delineation was complete, 1:24000 topographic maps were obtained to georeference the delineated photographs via a zoom transfer scope. It was determined that there was insufficient data to georeference the photographs to the basemaps. This is because there were not enough static features present on the photographs and basemaps to ensure the entire study area was georeferenced. For example, the transfer was possible in areas around Ocracoke because of existing roads on the photographs and basemaps. However, in the areas away from Ocracoke, no roads were present on the photographs or the basemaps. For this reason, it was not possible to remove the distortion inherent in the aerial photographs. The procedure and results were verified by Dr. Hugh Devine and Dr. H.M. Cheshire of CGC. It was concluded that it was not possible to quantify the degree of historic change of selected shoreline habitats based on the 1945 aerial photographs and other available resources.

Recommendations

Because of the nature of aerial photographs, it is recommended that a database of shorebird habitat be developed based on existing digital geospatial data collected by the North Carolina State University Computer Graphic Center. This database should be used as a base to determine shorebird habitat gain or loss over time. Also, recent photography should be used because, usually, the quality is better than earlier photography, 1945 for example. It is also recommended that global positioning systems (GPS) be used to develop shorelines. This information could be used to develop basemaps if the area is GPSed at the same time the area is flown to take aerial photographs. The GPSed shore line could be used to georeference the photographs if static features, such as roads are not present.

Another possibility to assist in georeferencing aerial photographs of areas without static features is with the use of monuments. Monuments could be placed in areas void of static features and GPSed. It would be imperative that the monuments be visible on the aerial photographs. This would allow the distortion in the photographs to be removed and allow the photographs to be georeferenced. It is important to remember that the GPS data would need to be differentially corrected to reduce the inherent error inserted into the GPS signal by the Department of Defense.