THE SUCCESSES AND LIMITATIONS OF USING NON-LETHAL PREDATOR CONTROL TO RESTORE A TERN COLONY

Country Island Tern Restoration Project

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ABSTRACT

The Country Island Tern Restoration Project was devised in 1998 to address the problem of heavy predation at a colony of Roseate, Arctic and Common Terns (*Sterna dougallii, S. paradisaea,* and *S. hirundo*, respectively) in Nova Scotia. Country Island is one of only three main breeding sites for the threatened Roseate Tern in Canada. In 1996, 45 pairs of Roseate, 330 pairs of Arctic, and 130 pairs of Common Terns nested on the island. Heavy predation on tern eggs and chicks by corvids and gulls likely led to the abandonment of this site by Roseate Terns in 1997. The number of breeding Arctic and Common Terns also dropped by 50% between 1996 and 1997. About 20 pairs of Great Black-backed Gulls (*Larus marinus*), 60-90 pairs of Herring Gulls (*L. argentatus*), two pairs of American Crows (*Corvus brachyrhynchos*) and one pair of Northern Ravens (*C. corax*) nested on Country Island in 1996 and 1997.

In 1998 we used non-lethal control to discourage gulls and corvids from breeding on the island. We maintained a human presence from 27 April to 27 July, shot noisemakers at the beginning of the gull breeding season, and destroyed all predator nests. We collected regurgitated gull pellets for analysis of gull diet. We monitored intrusion and predation rates by predators into the tern colony and compared pre-control (1997) rates with post-control (1998) rates. We also monitored clutch size, hatching success and productivity of terns for comparison with pre-control data. All pre-control data came from Whittam (1997).

Approximately 200 gulls were present when we arrived on Country Island on 27 April. After our initial noisemaker shots, gull numbers remained relatively low until 31 May, but peaked at 152 individuals on 2 June. Numbers declined thereafter, perhaps because we destroyed any nests that were initiated. We destroyed 23 gull nests (3 Black-backed, 18 Herring, 2 unknown) and 10 corvid nests (9 crows, 1 raven). The raven pair abandoned the island two days after we destroyed their nest, but the family of eight crows remained on the island throughout the breeding season. The number of tern eggs observed taken by corvids dropped from 48 to 2 between 1997 and 1998, and the number of tern chicks observed taken by gulls dropped from 53 to 27. Gulls took mainly older tern chicks (5-9 days, 15+ days) from the colony in 1998, and we estimated that at least 15% of tern fledglings were depredated by gulls. We believe that seven or eight individual specialist gulls were responsible for all predation observed in 1998. Tern chick remains made up 17.9% of gull pellets collected on the east beach, but Leach's Storm Petrels (*Oceanodroma leuchorhoa*) were the most common food item (72% of east beach pellets) found in gull pellets.

Three pairs of Roseate Terns nested on Country Island in 1998, two of which hatched a single chick each. We estimated that 217 pairs of Arctic Terns, and 120 pairs of Common Terns, also nested. Clutch size and hatching success of Common and Arctic Terns increased significantly between 1997 and 1998 (Common Terns: clutch size increased from 2.31 to 2.89 eggs/nest, hatching success from 1.83 to 2.68 chicks/nest; Arctic Terns: clutch size increased from 1.65 to 1.97 eggs/nest, hatching success from 0.96 to 1.67 chicks/nest). Productivity of Common Terns was estimated at 1.47 fledglings/nest in 1998, compared to 0-0.67 fledglings/nest in 1997. Arctic Tern productivity was estimated at 0.68 fledglings/nest in 1998, compared to 0.53-1.06 fledglings/nest in 1997. Unlike 1996 and 1997, predation was not the main source of chick mortality; in 1998 most chicks died from starvation or exposure likely due to cold, wet weather.

We made the following recommendations for future work on Country Island:

1. Predator control should be continued annually.

2. Gulls on Country Island should be banded in order to identify and kill any specialist predators.

3. Trapping and banding of adult Roseate Terns should be attempted 2 years after their re-establishment on Country Island.

4. Information should be gathered on the population dynamics of gull and tern colonies in the Country Harbour area.

INTRODUCTION

Predation is a common cause of reproductive failure in seabird colonies (Clode 1993). In some cases, anthropogenic factors have increased the number of predators, and hence, the effects of predation. For example, increasing numbers of *Larus* gulls in Europe and North America (Thomas 1972) have been associated with artificial food sources provided by humans (Pons 1992). Subsequent increases in gull predation have been implicated in the abandonment of numerous colony sites by terns over the last 50 years (Crowell and Crowell 1946, Burger 1984).

The tern species most at risk in northeastern North America is the Roseate Tern (*Sterna dougallii*), whose population underwent a major decline from 4800 pairs in 1972, to 2600 pairs in 1976 (Kress et al. 1983), partially as a result of increasing predation and displacement by gulls on the breeding grounds (Nisbet 1981). In Canada, where Roseate Terns are listed as Threatened (Kirkham and Nettleship 1987), only 87-137 pairs breed annually (Whittam 1998).

Country Island, Nova Scotia, is one of only three main nesting sites for Roseate Terns in Canada (Whittam 1998). In 1996 and 1997, predation by gulls (*Larus argentatus* and *L. marinus*) and corvids (*Corvus corax* and *C. brachyrhynchos*) seriously limited the reproductive success of Roseate, Arctic (*S. paradisaea*) and Common (*S. hirundo*) Terns nesting at this site. In 1996, corvids took 24% of Roseate Tern eggs, and gulls took 77% of Roseate Tern chicks. Only 0.08 Roseate Tern chicks per nest survived to fledging age, and no Arctic or Common Tern chicks appeared to fledge that year. Furthermore, predation may have been responsible for the abandonment of this colony by Roseate Terns in 1997 (Whittam 1997). In 1996, forty-five pairs of Roseate, 330 pairs of Arctic, and 130 pairs of Common Terns nested on Country Island. Only one pair of Roseate Terns attempted to breed on Country Island in 1997, and the number of Arctic and Common Terns dropped by more than 50%. Predation by corvids and gulls continued to be the primary source of egg and chick mortality in 1997 (Whittam 1997).

Predator management is necessary for the survival of Roseate Terns in northeastern North America (Nisbet 1981). Most of the U. S. population of Roseate Terns nests in colonies with active predator management. Such management includes harassing predators, destroying their

nests, and occasionally killing adults (Nisbet and Spendelow 1998). Predator control projects are time-consuming and expensive, however, making it important to ensure that the site chosen for management is a high-quality tern nesting area (i.e., it supports adequate breeding and foraging habitat for terns; Nisbet and Spendelow 1998). Assessing whether predator control will protect other sensitive species nesting nearby can also influence the suitability of a site for management (Anderson 1995).

In 1998 the Canadian Wildlife Service, in conjunction with the Canadian Roseate Tern Recovery Team and the Nova Scotia Department of Natural Resources, developed a Tern Restoration Plan for Country Island (Boyne 1998). This site was chosen for restoration because it is believed to be an ideal site for nesting terns, as its location far from the mainland makes it inaccessible to terrestrial predators and human visitors (Whittam 1997); large numbers of terns have nested there in the past (see Whittam 1998), suggesting that the area supports an adequate food supply; and anecdotal evidence suggests that Roseate Terns that abandoned Country Island in 1997 were not successful elsewhere (Whittam 1997). Finally, other seabird species nesting on Country Island, such as Common Eiders (*Somateria mollissima*) and Leach's Storm Petrels (*Oceanodroma leucorhoa*), are likely to benefit from predator control (Boyne 1998).

The tern restoration plan proposed a two-year pilot study using non-lethal control to prevent corvids and gulls from nesting on Country Island. This would presumably decrease predation on tern eggs and chicks, eventually making the site more attractive to Roseate Terns. Non-lethal control was chosen because it is the most humane manner of managing predators and will minimize negative public opinion (Boyne 1998). The plan was modelled after a similar successful project implemented by the New Hampshire Audubon Society on the Isle of Shoals in 1997 (D. Deluca, New Hampshire Audubon Society, pers. comm.).

The Country Island Tern restoration plan addressed the two major goals of the Canadian Roseate Tern Recovery Plan (Lock et al. 1993), which are to increase the number of Roseate Terns nesting in Canada, and to increase the productivity of Roseate Terns to at least one fledgling per pair per year. The restoration plan would be deemed successful if: a) no gulls nested

on Country Island in 1998; and b) the goal of one fledged tern chick (all tern species) per pair per year was not compromised by gull predation (Boyne 1998).

In this report we provide a detailed account of the methods and results of non-lethal gull and corvid control implemented on Country Island in 1998, and discuss the successes and limitations of non-lethal control. We also provide recommendations for future research and management at this site.

METHODS

Study Site

Country Island is a 19 ha island located approximately 8 km offshore from the coastal town of Drumhead, Guysborough County, Nova Scotia (45º06'N, 61º32'W) (Figure 1). It is surrounded by cobble beach and rocky shoals, and has organic soils supporting predominantly grasses, herbaceous plants and small copses of white spruce (*Picea glauca*). Two large forested areas ("east woods" and "west woods"), two abandoned lightkeepers' houses ("one-storey" and "two-storey" houses) and a functioning lighthouse are found on the island (Figure 1).

Arctic, Roseate and Common Terns breed on the south end of the island (Figure 1), on the "lighthouse beach", the "shore", the "east beach" and in the grid (see below, "tern reproductive success"). In 1996, 45 pairs of Roseate Terns nested with approximately 330 pairs of Arctic Terns and 130 pairs of Common Terns. In 1997, one pair of Roseate Terns bred among approximately 170 pairs of Arctic and 50 pairs of Common Terns. In 1996 and 1997 about 20 pairs of Great Black-backed Gulls, 60-90 pairs of Herring Gulls, two pairs of American Crows and one pair of Northern Ravens nested on the island. Common Eiders, Leach's Storm Petrels and various songbirds and shorebirds also nest on Country Island.

Study Summary

There were four aspects to this study: predator control, predator diet, predation observations, and monitoring tern reproductive success. *Predator control* involved patrolling the island and counting the number of gulls and corvids seen each day, shooting noisemakers to discourage predators from settling on Country Island, and destroying predator nests. *Predator diet* involved examining regurgitated gull and corvid pellets to determine what the predators were eating. *Predation observations* involved observing predator intrusions into the tern colony, and comparing intrusion and predation rates from 1998 (post-control) with those from 1997 (pre-control). *Monitoring tern reproductive success* involved determining the nesting success of Roseate, Arctic and Common Terns for comparison with pre-control data. All pre-control data are from Whittam (1997).

Two appendices summarize preliminary studies of: A) Arctic and Common Tern chick-feeding behaviour; and B) Common Eider nesting behaviour and reproductive success on Country Island. Appendix C summarizes banding information (band numbers, colour combinations, and re-sightings) for Roseate Terns banded on Country Island in 1996, and Appendix D gives specific recommendations for field work in future years.

Predator Control

I. General

We arrived on Country Island on 27 April 1998, 16 days before terns arrived. Ten people remained on the island for 24 hours to help set up camp. From 28 April to 27 July we maintained a crew of at least two people on the island at all times.

From 28 April to 13 May we patrolled the perimeter of the island every two hours from 0600 to 2000 (Atlantic Daylight Savings Time). During each patrol we walked one lap around the perimeter of the island and counted all Herring Gulls, Black-backed Gulls and corvids present both on the island and on Frying Pan Rock (a small rocky island located approximately 300 m

north of Country Island; Figure 1). Each patrol took approximately 0.5 hours. Counts included predators that were flying or loafing on the water within 50 m of the island. During each patrol we shot noisemakers from the north and south tips of the island. Noisemakers consisted of starter pistols adapted to hold bird-scaring cartridges. We used three types of cartridges (bangers, crackers, and whistlers) to prevent habituation. We noted the predators' response to each shot (i.e. left island, flew up then landed back on island, no response), and fired additional shots if predators remained on the island or continued to hover nearby. We fired an average of 2.3 ± 0.1 (n = 80) shots per patrol from 28 April - 11 May, after which we only fired shots if predators could not be scared off by walking toward them. When terns began arriving on 13 May we ceased firing shots at the south end of the island when terns were present. We also ceased patrolling the south end of the island and began counting the number of predators visible on this portion of the island from the two-storey house located roughly in the middle of the island (Figure 1).

From 18 May to 26 July we ceased patrolling the island perimeter to minimize disturbance to nesting terns (south end) and eiders (northeast end, near lagoon; see Figure 1 and Appendix B). We continued, however, to count the number of predators present on Frying Pan Rock, and on the north and south halves of the island from two vantage points (south end = two storey house or lighthouse, north end = north tip; see Figure 1). South end counts were made from the lighthouse when we began regular observations of the tern colony (see "predation observations"). Shots were fired from the center of the island only when 50 or more gulls were counted at the south end of the island. The reaction of the terns to these shots was closely monitored to ensure that the shots were not disturbing their nesting behaviour. We ceased shooting completely when tern chicks began to hatch (22 June), except for two shots fired on 9 and 17 July. These shots were fired to determine whether noisemakers could discourage the remaining gulls from preying in the tern colony. Because they had no apparent effect on gull behaviour no further shots were fired.

II. Gulls

Counts

Gull counts were made most commonly at 0600, 0800, 1200, 1800 and 2000. To standardize our estimates of the number of gulls present on the island each day, we considered only those counts that occurred between 0600-0900 (morning), 1100-1400 (afternoon) and 1800-2100 (evening). For each of these three periods we considered the number of gulls present to be the greatest number counted during any individual count. For example, if 60 gulls were counted at 0600, 12 gulls at 0800 and 32 gulls at 0900, we considered the number of gulls present in the morning to be 60. The largest gull count from these three periods was considered to be the number of gulls present on the island that day.

Nests

We searched for gull nests in areas where gulls appeared to be loafing or setting up territories. All nests were marked with flagging tape. When we found nests prior to egg-laying we either kicked the nest material away or placed a rock in the nest site. When a nest contained eggs we counted the number of eggs, then dyed the eggs with a mixture of malachite green dye, petroleum jelly and isopropyl alcohol to mark the breast feathers of incubating adults (Belant and Seamans 1993). We returned within one day to remove the eggs and destroy the nest site. Territories were observed carefully for re-nesting (re-nests contained dyed feathers), and the behaviour of dyed gulls was noted when possible.

III. Corvids

Counts

Because the number of crows observed on the island was never greater than 8 individuals (probably representing a single crow family), and the number of ravens remained stable at two

individuals (prior to their abandonment; see results), we did not analyze changes in corvid numbers over the day or the season.

Nests

We began searching for corvid nests in the east and west wooded areas of the island (see Figure 1) upon our arrival on 27 April. When a nest was found we marked it with flagging tape, mapped its location, and noted its stage of development (complete = fully formed and lined nest cup; incomplete = nest cup not fully formed), its contents (empty, eggs, chicks), and its approximate height above the ground. We destroyed all nests and nest contents upon discovery. We searched for corvid nests in the wooded areas every two to three days until the middle of June. After this date we searched for nests only if we saw corvids carrying nesting materials into the woods, or if corvids were continuously flushed from the same area of the woods.

Predator diet

I. Gulls

Pellets

We examined five large rocks for the presence of gull pellets on 13 occasions between 11 June and 22 July. We chose these rocks as monitoring sites because gulls had been seen loafing on or near them. The mean time between examinations was 3.4 ± 0.6 days (range = 1-8 days). We counted all pellets on the rocks and classified them based on their major food component, then removed them from the rock surfaces. We defined a pellet as any regurgitated mass of food or otherwise indigestible animal remain (e.g. bird wings). If we found a set of bird wings and a pellet containing remains of the same bird type, we counted these items as two pellets, even though they may have come from the same prey item.

In addition to monitoring pellets on the five rocks, on 25 and 26 July, respectively, we counted and classified all gull pellets located on a 506m^2 portion of the east beach, and a 400m^2

portion of the north tip of the island. We had noted that these areas were commonly used as loafing sites by large numbers of gulls.

Any pellets that contained tern chick remains were carefully searched for bands.

Fishing boat interactions

We made opportunistic observations of the number of gulls feeding on discards from lobster boats from 28 April to 7 June, to estimate how many gulls in the vicinity of Country Island benefit from fisheries discards. When we noticed gulls congregating around a boat we noted the identity of the boat and the number of gulls present.

II. Corvids

While searching for corvid nests, we made casual observations of food items present in corvid pellets. Corvid pellets were smaller and more compact than gull pellets, and had a distinctive oval shape.

Predation observations

We observed intrusions by predators into tern nesting areas over the breeding season (as per Whittam 1997). An intrusion was considered to be a predator walking or flying over the grid, the east beach, the shore or the lighthouse beach (Figure 1). Observations were conducted from egg-laying through to fledging, three times daily from 0600-0800, 1100-1300 and 1800-2000. Observations took place from the lighthouse (12 m tall) at the edge of the colony. On foggy days, however, observations were made simultaneously by two observers located in two small blinds (3 m tall) within the colony (blinds 1 and 2; see Figure 1).

Each time a predator entered the colony we noted the time, species of predator, and outcome (took tern adult, egg or chick, left colony, or unknown). When possible, we also noted the age and species of tern chicks taken. If we did not know the chick's age, we estimated it

based on the chick's size. Age estimates fell into four categories: 0-4 days, 5-9 days, 10-14 days and 15 or more days.

To examine patterns of predation over the breeding season, we divided the season into three stages: egg-laying/incubation, hatching/chick-rearing, and fledging. We considered egg-laying/incubation to begin when the first egg was laid, hatching/chick-rearing to begin the day the first chick hatched, and fledging to begin the date the first chicks reached 20 days of age (see below, "Tern reproductive success"). Dates corresponding to these periods are given in Fig 6b. These periods are comparable to those used in Whittam (1997) to examine patterns of predation in 1996 and 1997 (see Figure 6a) on Country Island. Whittam, however, was able to separate egg-laying/incubation and hatching/chick-rearing into four separate stages based on clutch initiation dates, which we did not note in 1998. This was the first year that researchers were able to obtain data on predation during the fledging stage.

To examine whether predator control reduced predation and intrusion rates, we compared the number of intrusions/hour (by different predator species) and the number of chicks taken/ hour (by both gull species combined) between 1997 and 1998. The observation period for intrusion rates (egg laying/incubation to hatching/chick-rearing) was divided into 14 four-day periods (in 1997) and 13 four-day periods and one three-day period (in 1998). For each period we calculated the rates of intrusion by each species of predator, and compared the rates for corresponding periods between the two years. The observation period for predation rates (hatching/chick-rearing stages) was divided into 11 two-day periods (in 1997), and 10 two-day periods and one one-day period (in 1998). We calculated the predation rate for each period during each year, and compared the rates for corresponding periods between the two years.

While observing predator intrusions into the tern colony we also made opportunistic observations of gulls preying on petrels (and eiders; see Appendix B).

Tern reproductive success

We followed the methods of Whittam (1997) to measure tern reproductive success. All tern nests within a 110 m x 90 m grid consisting of 10 m x 10 m squares were marked with wooden tongue depressors and checked approximately every five days to determine clutch size and hatching success (eggs hatched/nest). Nests were not checked during periods of cold or wet weather. We did not attempt to determine clutch initiation dates, as this would have involved daily intrusions into the tern colony. Eggs which disappeared were assumed depredated. To determine whether non-lethal control affected tern reproductive success, we compared clutch size, hatching success and productivity of Arctic and Common Tern nests between 1997 and 1998.

To estimate productivity (fledglings/nest), we monitored the fates of chicks from a subsample of Arctic and Common Tern nests from seven areas in the colony. Five of the seven areas were discrete 100 m^2 areas, chosen using a stratified random procedure (excluding squares where Roseates nested in 1996) before the terns arrived. To prevent chicks from wandering from their nests, we enclosed these areas with 20 cm tall chicken wire fencing (see Whittam 1997), installed before the terns arrived. One of the randomly chosen areas could not be fenced due to rocky terrain; we therefore moved this fence to a neighbouring square. Another of the five fenced areas was not used by any terns, so we moved this fence to a square where terns were nesting densely. Because chicks were fenced, if they disappeared from enclosures we could conclude that they had been depredated. Older chicks (> 15 days) were occasionally seen climbing over fences; however chicks generally stayed within the fences until fledging.

The two additional areas where nests were monitored each consisted of a 20 m radius surrounding an observation blind (blinds 1 and 2, see Figure 1). Nests in these areas were used to gather information on chick-feeding behaviour (see Appendix A). While these nests were not fenced, chicks tended to remain at their original nest site for feedings and therefore we could monitor their survival.

The seven areas contained a total of 41 Arctic and 22 Common Tern nests, which represented approximately 24% of all Arctic and 31% of all Common nests in the grid. We compared clutch sizes of monitored and unmonitored Common and Arctic Tern nests to ensure that these nests adequately represented the colony. There was no difference in the distribution of clutch sizes among monitored and unmonitored nests for either Common or Arctic Terns (Common Terns: Chi-square test: $\chi^2 = 0.0001$, df = 1, $p = 0.99$; Arctic Terns: Chi-square test: $\chi^2 = 3.26$, df = 1, $p = 0.07$). One of the 41 Arctic Tern nests failed to hatch and was excluded from calculations of chick fates.

All fenced chicks were either banded at hatch with U.S. Fish and Wildlife Service bands, or marked with permanent, non-toxic markers on the wings, legs and/or belly using individually distinct colour-codes. We attempted to search for chicks every five days, however cold, wet or foggy weather often prevented us from searching at regular intervals. Chicks that were being watched from the blinds were not marked but were identified based on the site at which they were being fed. We assigned the fate of chicks to the following six categories: 1) dead from causes other than predation (body recovered); 2) assumed depredated (chick disappeared from the area); 3) fledged (chick was seen 20 days after hatching; see below); 4) depredated after fledging (chick band recovered in gull pellet); 5) died after fledging (fledgling found dead from causes other than predation); and 6) unknown (we left the island before the chick fledged). The number of chicks in the fourth category are likely to be underestimated because only 29 of 125 monitored chicks were banded, and not all gull pellets were examined.

We estimated fledging based on chick survival to 20 days. Survival to 20 days generally underestimates productivity because older chicks may wander from their nest site and be lost to researchers before reaching this age (Nisbet et al. 1990). In colonies where predation is high, however, it is best to monitor productivity based on an older age level (i.e. 20 days), so that chicks have less chance of being depredated after they have been considered fledged.

Tern population size

We estimated the total number of terns nesting in the colony by counting the number of nests found in the grid during ground searches, and adding this number to the number of nests outside the grid. The latter was estimated by counting the number of incubating birds on the east beach (from blind 3) and on the shore and the lighthouse beach (from the lighthouse; Figure 1) three to four weeks after the first egg was laid in the grid. It was difficult to identify the species of incubating birds on the shore and lighthouse beach due to tall vegetation later in the season, so we estimated the ratio of Arctic and Common Terns nesting in these areas at the start of the breeding season, then applied this ratio to our later counts of incubating birds.

RESULTS

Predator Control

I. Gulls

Figure 2 shows the maximum number of gulls sighted on Country Island per day, the number of noisemakers shot per day, and the number of gull nests found and destroyed, from 27 April to 26 July. When we first arrived approximately 200 gulls appeared to be setting up territories on the island. After shooting three noisemakers from the center of the island on 27 April all 200 gulls left the island and flew north. Many of the gulls from Country Island flew to Frying Pan Rock. The number of gulls on Frying Pan Rock exceeded 200 for the first three days, then dropped to near zero beginning 4 May (Figure 3). The minimum number of gulls per day on Country Island remained less than 25 for the first week, and generally less than 50 for the first month. Beginning on 31 May, however, the number of gulls increased again, and peaked at 152 gulls on 2 June. By 7 June gull numbers had declined again, averaging less than 75 per day for the remainder of the season (Figure 2).

Within individual daily count periods (i.e. morning, afternoon, evening, from 27 April to 27 July), Herring Gulls were more numerous than Black-backed Gulls (Paired t-test: $t = 8.56$, df

= 215, p = 0.0001), and the maximum number of both species of gulls was greater in the morning and evening than during the afternoon (Herring Gull: F = 7.15, df = 2, 165, p = 0.0011; Black-backed Gull: F = 7.6, df = 2, 168, p = 0.0007; Figure 4).

No gulls nested successfully on Country Island in 1998. We destroyed a total of three Black-backed, 18 Herring, and two unidentified gull nests (Figure 2). Nineteen nests contained eggs, and the average number of eggs destroyed per nest was 1.44 ± 0.19 (range = 0 - 3). Most Black-backed Gull nests were found on the north end of the island, near the lagoon, whereas most Herring Gull nests were found on the south end of the island, particularly to the south of the one-storey house (Figure 1). No gull nests were found after 20 June. Of the 18 Herring Gull nests, four belonged to a single pair that re-nested three times after we destroyed their original nest and eggs.

II. Corvids

One pair of Northern Ravens and one family of eight American Crows attempted to nest on Country Island in 1998. The raven nest was found in the east woods, 4.3 m high in a white spruce tree. The nest contained five chicks that were approximately 10 days old on 27 April. The nest, over 1 m in diameter and 0.5 m in height, had probably been used for several seasons. The nest and chicks were destroyed on 29 April, and the ravens abandoned the island by 31 April.

We destroyed nine crow nests, of which four were located in the "west woods", four in the "east woods" (see Figure 1) and one in a white spruce tree bordering the lagoon. Five crow nests were complete when destroyed, although only one contained eggs (4). We did not notice any crow nesting activity in the east woods until two weeks after the departure of the ravens, suggesting that the ravens may have prevented the crows from using the east woods habitat. All nests were located in white spruce trees at an average height of 3.4 ± 0.4 m (range 2.0 - 5.0 m). The crow family remained on Country Island for the duration of the field season, despite our persistent attempts to discourage them. No new crow nests were found after 9 June.

Predator Diet

I. Gulls

Pellets

Leach's Storm Petrels were the most common food item found in gull pellets from the five rocks, the east beach, and the north tip of the island (Figure 5). Other food items found in pellets included crab (*Brachyura*), fish (*Teleostei*), green sea urchin (*Strongylocentrotus droebachiensis*), tern chicks, eider eggs/chicks, mussels (*Mytilus* spp.), and berries (cranberry *Vaccinium macrocarpon* and *V. vitis-idaea*; crowberry *Empetrum nigrum*, and raspberry *Rubus* spp.). Of 17 pellets that contained tern chicks on the east beach, 14 contained the remains of tern chicks estimated to be older than 15 days, and three contained the remains of tern chicks estimated to be younger than 15 days. Age estimates were based on the size and feather structure of the regurgitated wings.

The bands from three tern chicks were found in three separate gull pellets. Two of these pellets contained the remains of tern chicks, but the third pellet consisted mainly of crowberry seeds, and lacked any sign of tern remains except for the band. The bands were from chicks that had last been seen alive at 20, 20, and 23 days of age.

Fishing boat interactions

There were four boats that fished regularly around Country Island during the lobster season (last week of April to last week of June). The mean numbers of gulls seen feeding on discards from these four boats during opportunistic observations were 12.5 ± 1.4, 12.6 ± 3.7, 8.6 ± 1.3 and 11.3 ± 1.7.

II. Corvids

Opportunistic searches for crow pellets and other food remains in the wooded areas suggest that petrels and berries were commonly consumed by crows. Two eider eggs and a tern egg were also found in areas where crows were attempting to nest.

Predation observations

We observed 674 intrusions by predators over 258.5 hours of observation. Crows, Herring Gulls and Black-backed Gulls were the most common intruders, making 4.3%, 41.4% and 50.4% of intrusions, respectively. Other potential predators seen in the tern colony were: undifferentiated juvenile Black-backed or Herring Gull (n = 11); Great Blue Heron (*Ardea herodias*, n = 3); Osprey (*Pandion haliaetus*, n = 3); Merlin (*Falco columbarius*, n = 3); Black-crowned Night Heron (*Nycticorax nycticorax,* n = 1); Bald Eagle (*Haliaeetus leucocephalus*, n = 1); and Laughing Gull (*Larus atricilla*, n = 1).

Corvid intrusions did not peak at the beginning of egg-laying in 1998 as they did in 1997 (Figs. 6a and b). Corvid intrusion rates ranged from 0 - 1.95 intrusions/hour in 1997, compared with 0 - 0.5 intrusions/hour in 1998. Herring Gull intrusion rates ranged from 0.37 - 6.81 intrusions/hour in 1997, compared with 0 - 2.63 intrusions/hour in 1998 (Figs. 6a and b). Intrusion rates by Black-backed Gulls remained similar between the two years, ranging from 0.76 - 2.93 intrusions/hour in 1997, and 0.13 - 2.90 intrusions/hour in 1998 (Figs. 6a and b).

Between 1997 and 1998, the number of eggs observed depredated by corvids dropped from 48 to two, the number of chicks observed depredated by Black-backed Gulls dropped from 19 to 14, and the number of chicks depredated by Herring Gulls dropped from 34 to 13 (Table 1). This drop in predation is not due to a decrease in the number of eggs and chicks available to predators in the two years; in fact, the number of prey items increased in 1998 because more terns nested that year (see below). Chick predation rates calculated for 11 two-day periods during hatching/chick-rearing ranged from 0 - 3.27 chicks taken/hour in 1997, and 0 - 0.5 chicks taken/hour in 1998 (Figure 7).

We estimated the age of 63% (n = 27) of all chicks seen taken by gulls. Eight chicks were 5-10 days old, three were 10-14 days old, and six were over 15 days. This differs significantly from 1997, when most chicks taken were 0-4 days, and very few were older than 15 days (Chi-square test: $\chi 2 = 15.9$, df = 3, p = 0.001; see Figure 8, Whittam 1997).

We observed two instances of predation on adult terns. The first occurred on 3 June when a male merlin flew into the colony and attempted to fly away with an adult Arctic Tern. The merlin dropped the tern outside of the colony. The second instance occurred on 14 July when a Black-backed Gull preyed on an unidentified species of adult tern from the south end of the colony by the pond (see Figure 1). Twenty-four minutes later this same Black-backed Gull preyed on a tern chick that was greater than 10 days old.

We documented nine incidents of gull predation on Leach's Storm-petrels. These occurred on 3 June (n = 2), 9 June (n = 1), 11 June (n = 1), 27 June (n = 1), 28 June (n = 2) and 11 July (n = 2). Herring Gulls were responsible for six, and Black-backed Gulls for three, incidents. At least one additional gull was observed trying to pirate the petrel from the predator in eight of the nine incidents.

Tern reproductive success

Based on nests in the grid, mean clutch size for Arctic Terns on Country Island in 1998 was 1.97 ± 0.03 eggs per nest (range = 1-3), and for Common Terns was 2.89 ± 0.04 eggs per nest (range = 1-3) (Table 2). Clutch sizes for both species were significantly higher in 1998 than 1997 (Mann-Whitney U test: Arctic Terns, $Z_{corr} = -6.3$, p = 0.0001, n = 166, 169; Common Terns, $Z_{corr} = -5.4$, p = 0.0001, n = 51, 70; Table 2).

We determined hatching success for 63% of all Arctic, and 67% of all Common nests in the grid. Eighty-seven per cent of Arctic eggs, and 94% of Common eggs, hatched. Only one nest (Arctic Tern) suffered egg loss due to predation, and the major cause of hatching failure for both species was abandonment or infertility (difference not ascertained; Table 2). This differs from 1997, when predation was the major cause of hatching failure (Table 2). Hatching success (eggs

hatched/nest) for both species was significantly higher in 1998 than 1997 (Mann-whitney U test: Arctic Terns, Z_{corr} = -5.9, p = 0.0001, n = 127, 108; Common Terns, Z_{corr} = -4.1, p = 0.0001, n = 41, 47; Table 2).

In 1998, the majority of Arctic and Common Tern chicks whose fate was known fledged, whereas in 1997, the majority of chicks whose fate was known were depredated (Table 3). Predation was not the major cause of chick loss for either species in 1998. Exposure or starvation from several major rain storms during the first week after hatching was likely the major cause of chick mortality in 1998.

In 1998, 59 Common Tern chicks from 22 monitored nests hatched, and of these chicks, 25 (42%) reached 20 days and were assumed to have fledged (Table 3). Sixty-six Arctic chicks from 41 nests hatched, 26 (39%) of which were assumed to have fledged. Three Arctic Tern fledglings were subsequently depredated, as their bands were identified in regurgitated gull pellets (Table 3). A fourth Arctic Tern fledgling was found dead in the fenced area at 26 days of age. It had become tangled in the thread used to sew the landscaping fabric to the chicken wire fencing and had subsequently starved.

Based on monitored nests for which egg and chick fates were known (31/41 = 76% of Arctic nests; 17/22 = 77% of Common nests), productivity was estimated to be 0.68 ± 0.05 fledglings/nest for Arctic Terns (n = 31), and 1.47 ± 0.05 fledglings/nest for Common Terns (n = 17). Productivity was therefore more than 100% higher for Common Terns in 1998 than 1997, and about the same for Arctic Terns in both years (Table 2). Productivity data for 1997 were estimated based on the number of chicks still alive when researchers left the colony, and the probability that these chicks would be depredated before fledging (Whittam 1997).

Three pairs of Roseate Terns nested in 1998. These pairs each laid one egg four weeks after the first Arctic and Common Tern clutches were initiated. One pair abandoned their egg after one week, and the other two pairs each hatched a single chick on 21 and 23 July, respectively. These two pairs nested within 1 m of each other, at the base of a large rock located between the east end of the grid and the east beach (Figure 1). The younger of the two Roseate

chicks was found during a search on 25 July; however, the older chick could not be located. This may be because we only searched the area for approximately five minutes to minimize disturbance. Feeding by at least one pair of adult Roseate Terns was observed at the rock until we left the island on 27 July. A subsequent visit to Country Island on 20 August indicated that most terns had left the island, as only five adult terns (Common and Arctic, no Roseate) were seen. The Roseate chicks would have been 29 and 27 days old at the time of this visit, and while it is possible that these chicks fledged we have no way of knowing for certain.

Tern population size

We estimated that 217 pairs of Arctic Terns, 120 pairs of Common Terns, and three pairs of Roseate Terns nested on Country Island in 1998. Recall that 330 pairs of Arctic, 130 pairs of Common and 45 pairs of Roseates nested in 1996, and 170 pairs of Arctic, 50 pairs of Common, and 1 pair of Roseates nested in 1997.

DISCUSSION

No gulls or corvids nested successfully on Country Island in 1998. Most gulls abandoned the island after the first noisemakers were shot, and the ravens abandoned the island after their nest was destroyed. The crow family, however, did not leave the island despite our attempts to discourage them, and between 5 and 152 gulls remained on the island throughout the study period. We were able to startle these persistent gulls with noisemakers but they would generally settle back onto the island approximately two minutes after the shot was fired. Because these gulls were unmarked we were unable to determine if they were always the same individuals or if different gulls came and went from the island.

Clutch size and hatching success of Arctic and Common Terns both increased significantly after control was implemented. Removing predators usually results in increased hatching success of bird populations (Côté and Sutherland 1997). Productivity of Common Terns also increased after control was implemented. The increases in clutch size, hatching success and

productivity between 1997 and 1998 were likely due to a decrease in the number of eggs and chicks depredated by corvids and gulls. Corvid predation on tern eggs was reduced by nearly 100% between 1997 and 1998, as we only saw 2 eggs being depredated in 1998, compared with 48 eggs in 1997. Furthermore, only one monitored nest was lost due to egg predation. Gull predation on tern chicks was reduced by 50% between 1997 and 1998, as we saw 27 chicks being depredated in 1998, compared with 53 chicks in 1997. Furthermore, in 1997, the majority of chicks whose fate was known were depredated, whereas in 1998 most chicks died from starvation or exposure to cold, wet weather (Table 3).

The values of productivity calculated for Arctic (0.68 fledglings/nest) and Common (1.47 fledglings/nest) Terns on Country Island in 1998 were close to the mean value of productivity for other tern colonies in the Gulf of Maine (GOM) that year. Arctic Tern productivity at various sites in the GOM in 1998 averaged 0.66 ± 0.14 (range = 0.25 to 0.96, n = 5), and Common Tern productivity averaged 1.26 ± 0.10 fledglings/nest (range = 0.77 to 1.84, n = 12) (Monomoy NWR 1998).

It was interesting to note that corvid predation decreased despite the fact that the crow family remained on Country Island throughout the project period. Perhaps crows require the stimulus of their own begging chicks to search for eggs in a well-defended tern colony. Whatever the case, preventing corvids from nesting by destroying their nests and nest contents appears to be an efficient method of controlling this type of predator on Country Island. Removing adult crows by trapping or shooting (Boyne 1998) is probably not necessary so long as crows do not resume hunting in the tern colony.

Gull predation was still affected tern reproductive success on Country Island in 1998, and likely also affected the success of petrels at this site. We observed 27 tern chicks being taken by gulls during our predation observations, and 17.9% of gull pellets on the east beach contained tern chick remains. We made nine casual observations of gulls preying on petrels, and 72% of pellets from the east beach contained petrel remains. While we know that predation on tern chicks decreased in 1998, we have no quantitative information on gull predation on petrels from

previous years, so we are unable to draw a similar conclusion with respect to predation on petrels. Predation by Great Black-backed and Herring Gulls is believed to be a large problem at some Newfoundland petrel colonies, with mortality estimated in the thousands of individuals (W. A. Montevecchi pers. comm. in Huntington et al. 1996).

We were unable to determine whether the gulls responsible for predation on Country Island were coming from other nearby islands, or were simply non-breeding individuals that were attached to Country Island because they had bred there in the past. We did, however, observe a green-dyed gull making multiple intrusions into the tern colony during two separate two-hour observation periods (on 1 and 14 July, respectively). These observations suggest that the gulls that persisted in nesting on the island were the same gulls that were responsible for predation in the tern colony.

Because gulls were not individually marked, we were unable to determine how many individuals were preying on tern chicks, and whether some gulls were "specializing" on chicks (Spear 1993). Within two-hour watches we were often able to identify individual gulls that were making multiple hunting flights into the colony. We could not, however, identify individuals between watches. We believe that two or three Great Black-backed Gulls, and five or six Herring Gulls, were responsible for all predation on tern chicks observed in 1998. "Specialist" gulls were believed to be responsible for most petrel predation on Great Island, Newfoundland (Pierotti and Annett 1987).

We found that the age distribution of chicks seen depredated by gulls differed significantly between 1997 and 1998. In 1997, most chicks depredated were under the age of 5 days, whereas in 1998, no chicks under the age of five days were seen taken. In 1998, most chicks depredated were 5-9 days, or 15 or more days old. This was, however, the first year that observations were made during the fledging period, thereby providing the first opportunity to observe whether gulls preyed on older chicks. Whittam (1997) speculated that older chicks may have continued to have been taken by gulls after research ended in 1997. Indeed, in 1998 we observed six chicks over the age of 15 days being depredated by gulls, and the majority of gull

pellets on the east beach that contained tern chick remains were from tern chicks older than 15 days.

It is interesting that we found bands from three tern fledglings in gull pellets. We banded 29 chicks, 20 of which survived to fledging (20 days). Three of those 20 chicks were depredated after fledging, suggesting that at least 15% of fledglings from the Country Island colony were depredated by gulls in 1998. This is probably an underestimate, because not all gull pellets on the island were examined. Heavier predation on older chicks and fledglings may occur because it is easier for gulls to see and catch older chicks as opposed to younger chicks that remain hidden or immobile at their nest sites. Whatever the case, gulls do not appear to prey selectively on young individuals, as do many other types of predators (Taylor 1984). This makes gull predation a serious problem for the survival of tern populations (Whittam 1997).

While we hoped to have greater numbers of Roseate Terns breeding on Country Island in 1998, it is encouraging that three pairs returned to breed, and that the number of Arctic and Common Terns increased to near-1996 levels. Furthermore, eight of 17 adult Roseate Terns that were banded on Country Island in 1996 (Whittam 1997) have been re-sighted on the island during the 1997 and/or 1998 breeding seasons (Appendix C). It is also encouraging that both gull and corvid predation on tern chicks and eggs decreased after control was implemented. Roseate Terns generally require a large, stable colony of conspecifics and low levels of predation before they will nest in large numbers (Nisbet 1981). Furthermore, tern restoration is generally most successful when carried out at sites that have been recently abandoned (Kress 1997). It has only been two years since Roseate Terns last nested at Country Island. Roseate Terns are therefore likely to return to Country Island if the population of Arctic and Common Terns continues to increase and the effects of predation continue to decrease. Ongoing predator management is required to meet these criteria.

CONCLUSION

Recall that this project would be deemed successful if: a) no gulls nested on Country Island in 1998; and b) if the goal of one fledged tern chick (all tern species) per pair per year was not compromised by gull predation (Boyne 1998).

The first criterion was met, as no gulls or corvids nested successfully at this site in 1998. To determine whether the second criterion was met, we removed the effects of death due to causes other than predation in our calculation of productivity. That is, we assumed that every chick that died from other causes would have had an 83% (Common Terns) or 85% (Arctic Terns) chance of fledging if predation was the only cause of chick loss. This is based on the fact that 17% of Common, and 15% of Arctic chicks, were depredated before fledging (Table 3). If this was the case, productivity of Arctic Terns would be 0.93 fledglings/nest, and Common Terns would be 1.76 fledglings/nest. Therefore, at least for Common Terns, our goal of one fledged tern chick per pair was not compromised by gull predation.

Despite our positive results, predation was still the second largest factor affecting survival to fledging, and at least 15% of tern chicks continued to be depredated by gulls after fledging. We believe that seven or eight individual gulls were responsible for all predation on tern chicks observed in 1998.

RECOMMENDATIONS FOR FUTURE YEARS

1. Predator control should be continued annually on Country Island.

This was the first year of a two-year pilot project to be implemented on Country Island by the Canadian Wildlife Service (Boyne 1998). In order to restore Roseate Terns to this site, and to maintain their presence into the future, after 1999 a long-term strategy for managing predators on Country Island must be developed and implemented (see U.S. Fish and Wildlife Service 1998). Ongoing management is required to prevent gulls from moving back onto Country Island (Blokpoel et al. 1997). This would not necessarily require a large, expensive project each year. At

the least, management of predator populations would require maintaining a human presence in late April and early May, when gulls are attempting to set up territories, and visits to the island once or twice a week from May to July to remove predator nests. At the most, predator management would require maintaining a human presence throughout the tern breeding season to allow the immediate detection and prevention of predation. Maintaining a human presence, especially while gulls are initiating breeding, is believed to be an essential restoration technique (Kress 1997).

The implementation of this strategy could be carried out most efficiently by researchers studying terns on Country Island. In the United States, research biologists at tern colonies serve as managers by controlling predators, guiding visitors, managing habitats, and planning restoration projects (Nisbet and Spendelow 1998). Biologists from Dalhousie University and the Nova Scotia Department of Natural Resources have been involved in research on Country Island in the past (Whittam 1997), and continued work at this site should be encouraged. Furthermore, a local stewardship group could be formed with members from Guysborough County. These people could help implement non-lethal control on Country Island by destroying gull and corvid nests when researchers are unavailable.

2. Gulls on Country Island should be banded in order to identify and kill any specialist predators.

Gull banding should be attempted late in April, when researchers first arrive on the island, prior to the implementation of gull-scaring techniques. As many gulls as possible should be banded to monitor movement between nearby colonies and to identify any specialist gulls that continue to prey on tern chicks from Country Island. If gulls cannot be banded at this time, gulls that persist on the island and continually attempt to nest (i.e. those that began nesting around 2 June this year) should be trapped on their nests and banded. Every attempt should be made to band gulls so that specialist predators can be identified. Gulls that are found to specialize on tern chicks should be killed immediately.

3. Trapping and banding of adult Roseate Terns should be attempted 2 years after their re-establishment on Country Island.

Banding adult Roseate Terns can provide important information on survival and dispersal of these birds. However, we believe that trapping and banding should not occur until Roseate Terns have been re-established on Country Island (with a human presence) for two years. Banding could occur during the third year. Roseate Terns are sensitive to human disturbance, but will eventually habituate to the presence of humans so that handling can be attempted (Nisbet and Spendelow 1998). We strongly caution against trapping adult Roseate Terns in the first year that they return to Country Island. In the meantime, any Roseate Tern chicks that hatch on Country Island should be banded as this involves much less disturbance than trapping and banding adults, and will eventually provide information on survival, dispersal and return rates of chicks hatched from this colony.

4. Information should be gathered on the dynamics of gull and tern colonies in the Country Harbour area.

It would be interesting to learn whether gulls from other nearby colonies (i.e., on Goose or Harbour Islands; A. Boyne unpubl. data) are preying on Country Island terns. If so, the problem of predation on tern chicks, and predator control, would be much more complex. Furthermore, knowledge of tern productivity, survival, and movement rates between local colonies (e.g. Fisherman's Harbour, Charlos Cove, Bird Island; see Whittam 1998) could provide information on the quality of habitat at various sites (Spendelow et al. 1995), and allow us to target our management strategy accordingly. This information cannot be gathered unless more Roseate Terns from this population are banded (see above). An indepth knowledge of local gull and tern population dynamics will take years to accumulate; however, surveying local gull and tern colonies two or three times during the breeding season, beginning in 1999, could provide a preliminary estimate of breeding success and provide a baseline for annual or biennial research.

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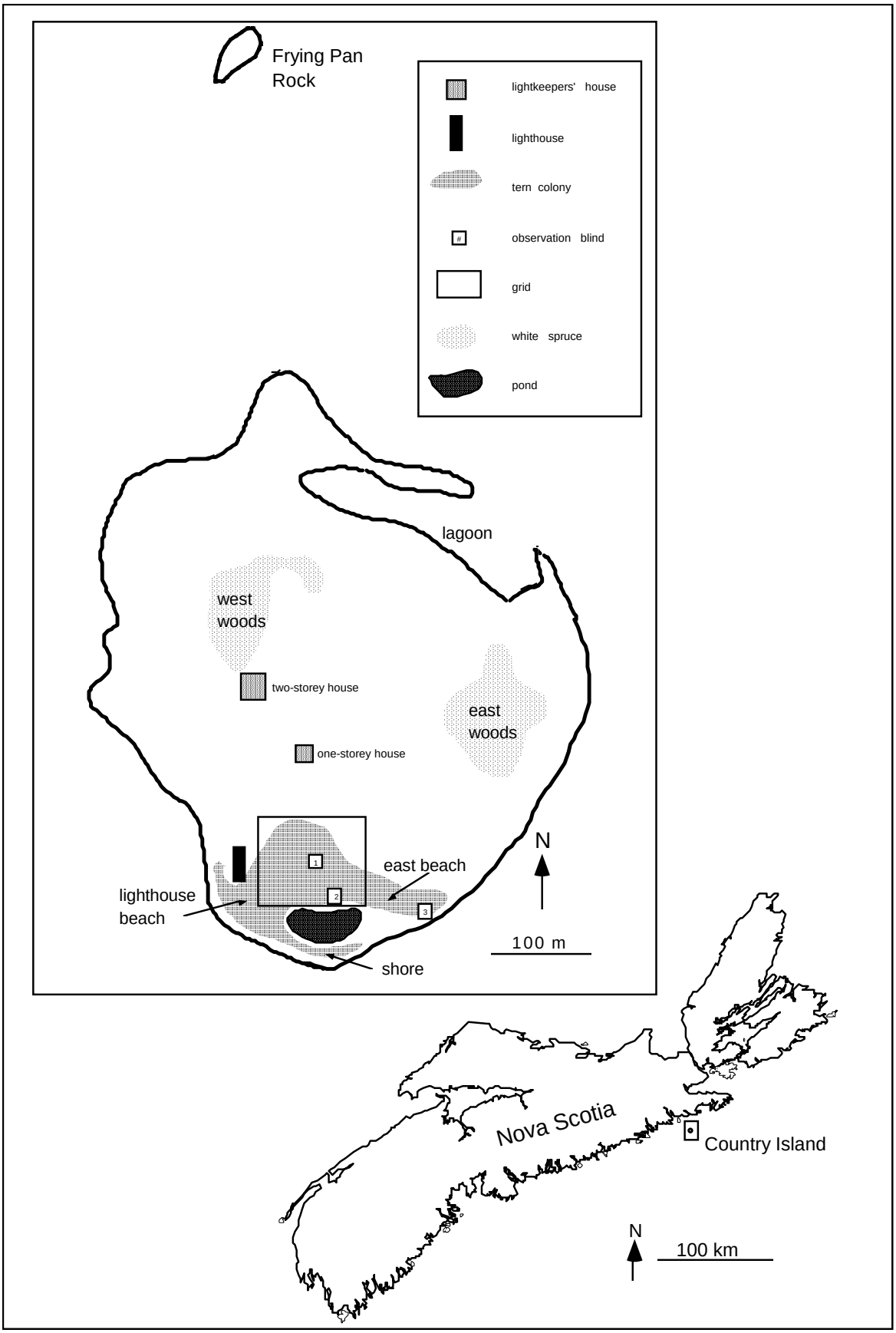

Figure 1. Country Island, Nova Scotia (reprinted from Whittam 1997).

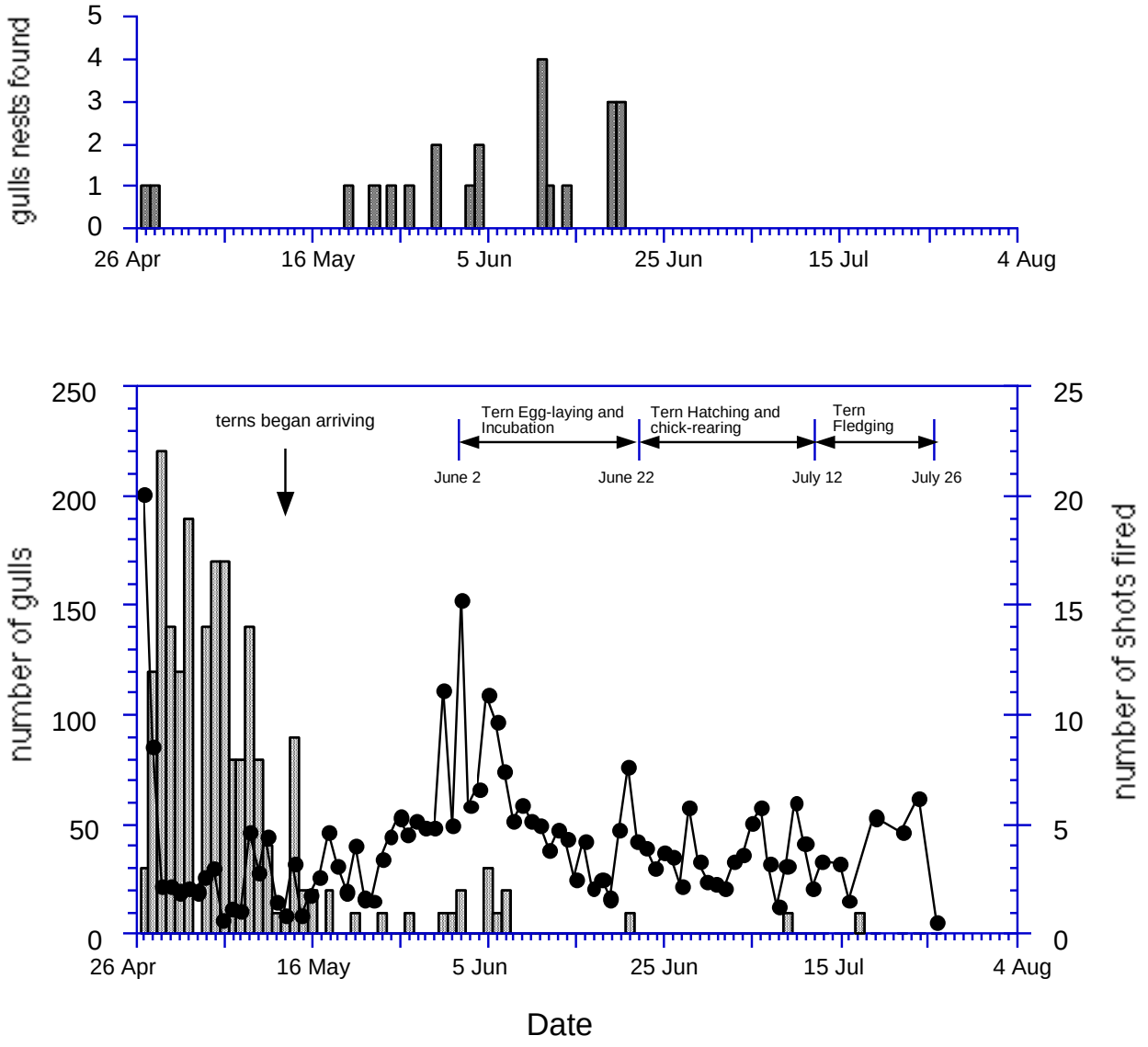

Figure 2. Number of gull nests found and subsequently destroyed (dark bars; top graph), number of gulls present (circles), and number of noisemaker shots fired (light bars; bottom graph) daily from 27 April to 26 July 1998 on Country Island.

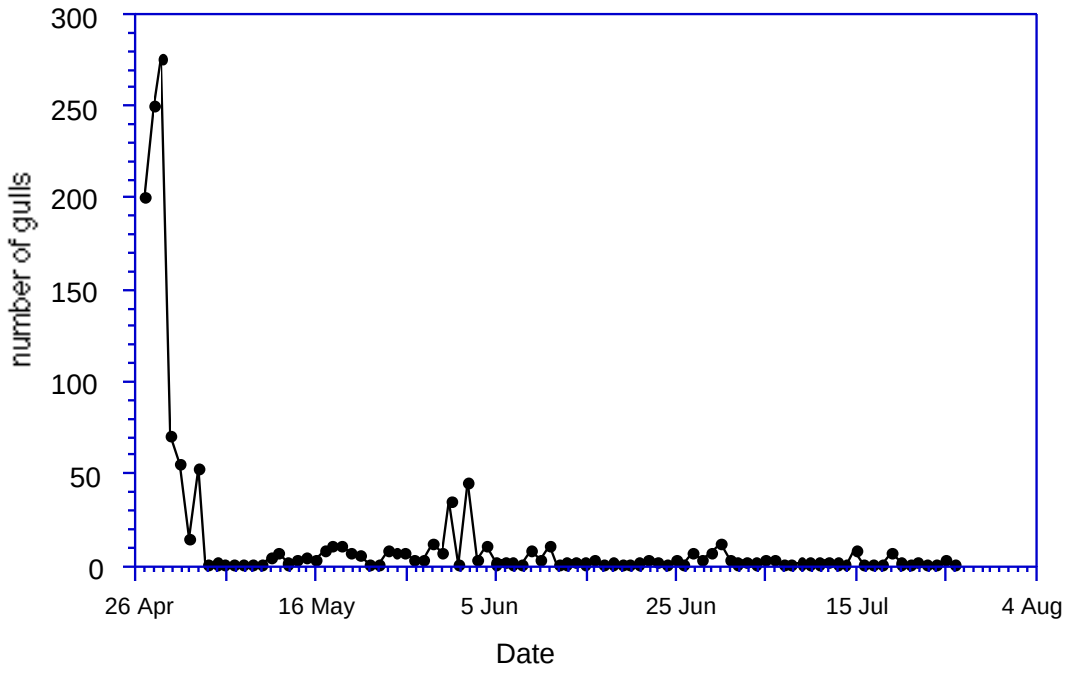

Figure 3. Minimum number of gulls present per day on Frying Pan Rock from 27 April to 26 July, 1998.

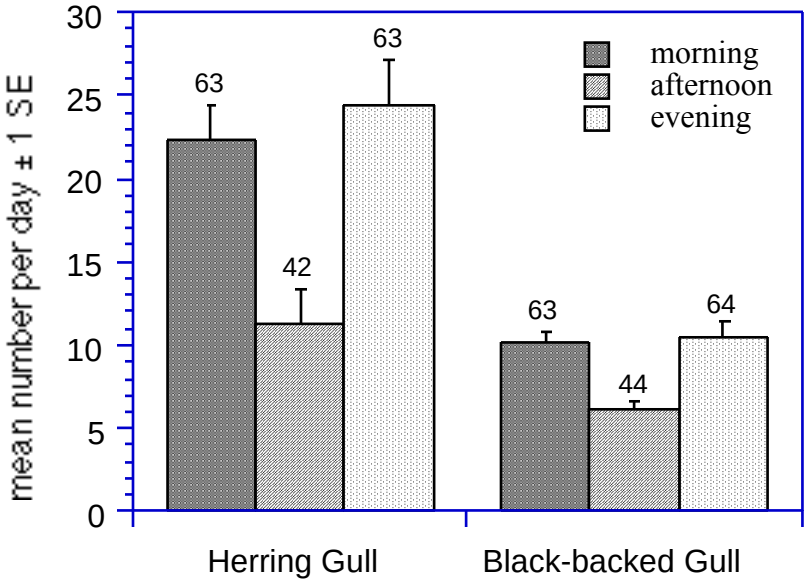

Figure 4. The mean number of Herring and Great Black-backed Gulls present on Country Island during three times of day from 27 April - 26 July, 1998. Error bars represent standard error. Sample sizes are shown above bars. Morning = 0600-0900; afternoon = 1100-1400; evening =1800-2000.

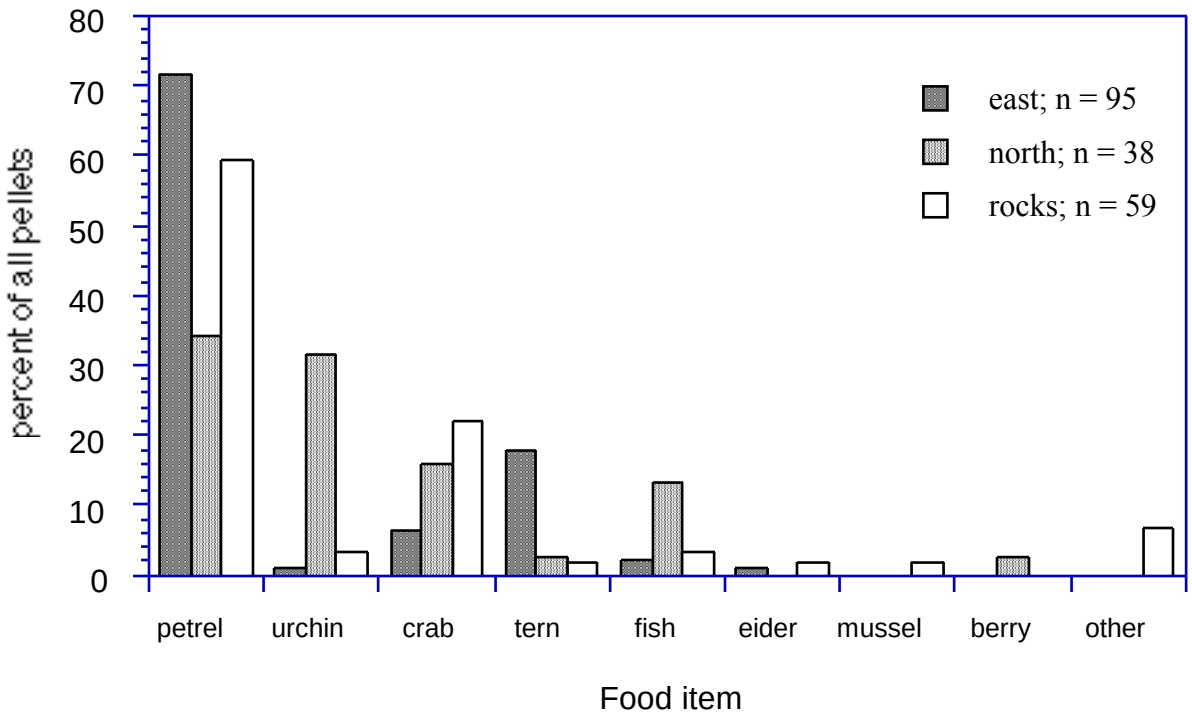

Figure 5. Food items identified in gull pellets found on the east beach of the island (25 July), the north tip of the island (26 July), and the five monitored rocks (11 June - 22 July) in 1998. "Tern" pellets contained tern chick remains. "Eider" pellets contained eider chick or egg remains. "Other" refers to pellets containing unidentifiable food item(s).

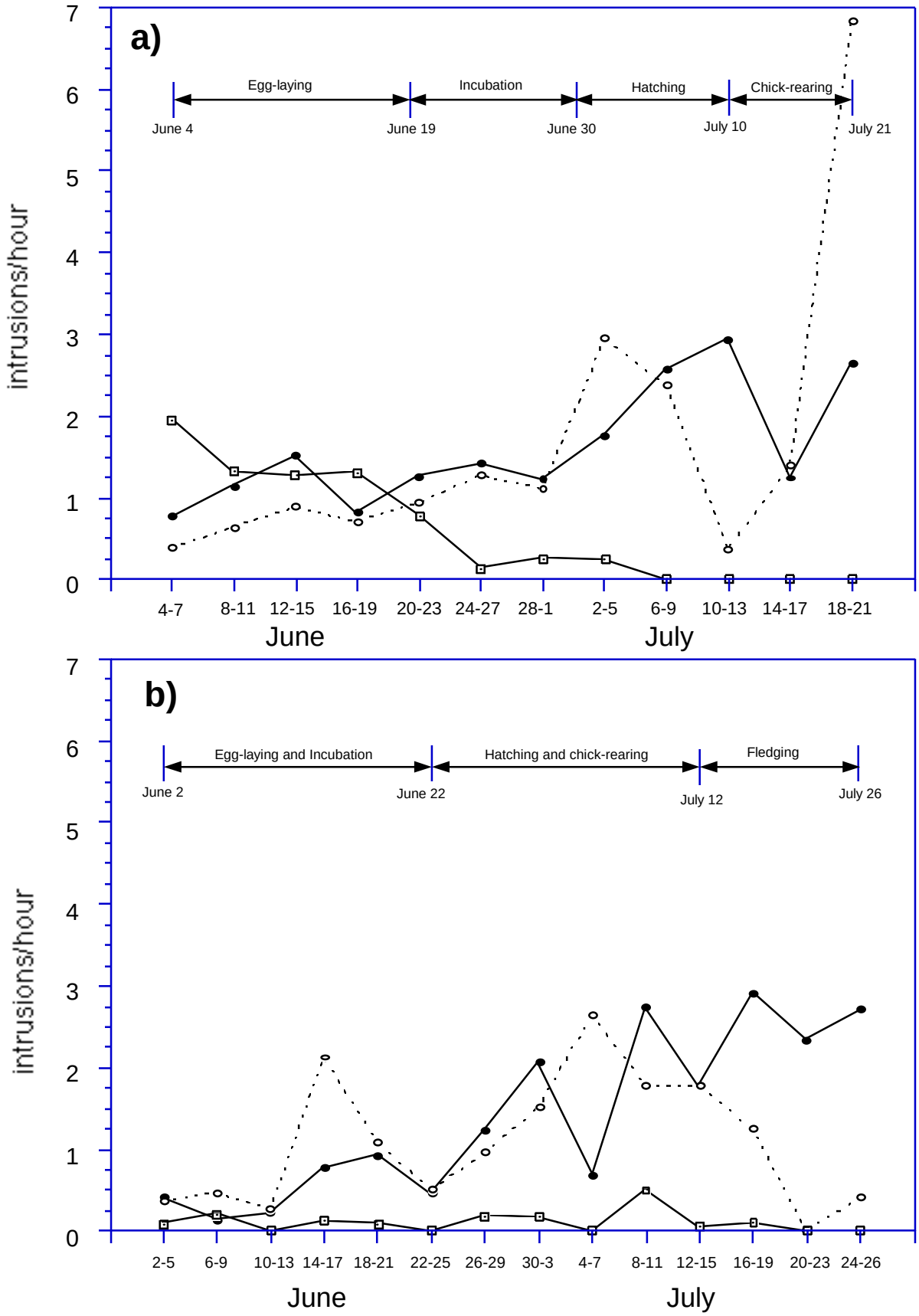

Figure 6. Intrusion rates of Black-backed Gulls (filled circles), Herring Gulls (open circles) and Corvids (squares) during four-day periods over the a) 1997 and b) 1998 breeding season. The breeding phenology is for Arctic and Common Terns, and the dates mark the start of each breeding stage. a) is reprinted from Whittam(1997).

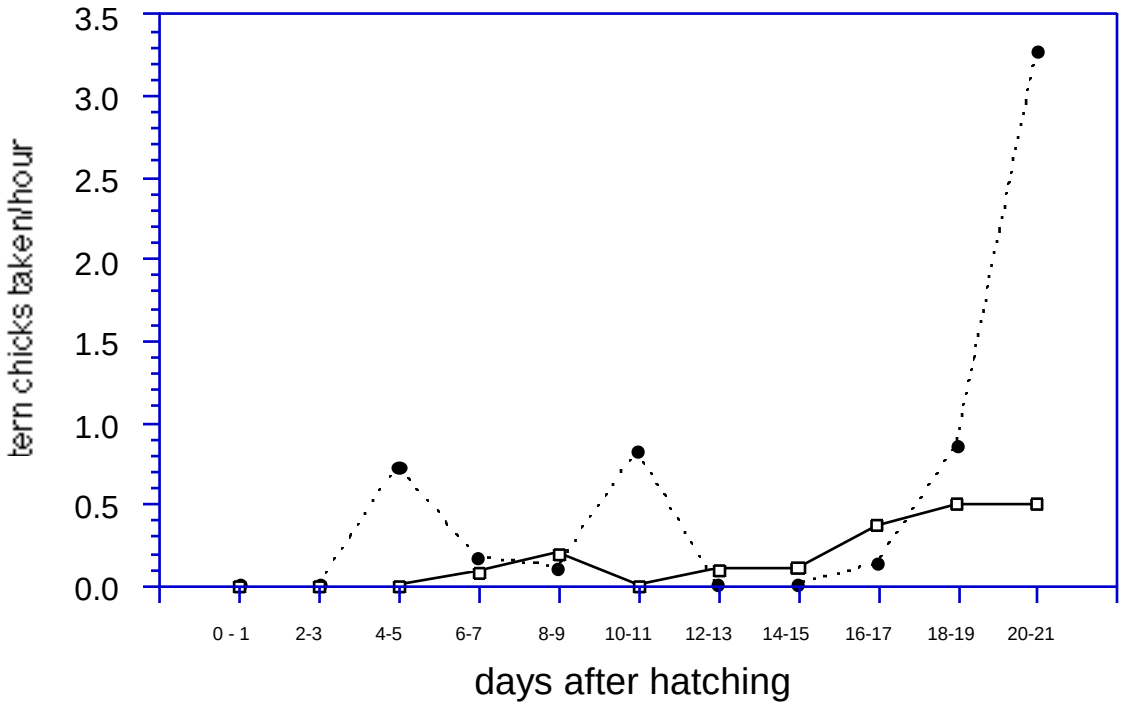

Figure 7. Rates of observed gull predation on tern chicks (chicks seen taken/hours of observation) before control (1997; dotted line) and after control (1998; solid line). The day the first egg hatched in the colony was 30 June in 1997, and 22 June in 1998.

Table 1. Frequency of observed predation by corvids, Black-backed Gulls and Herring Gulls on tern adults, eggs and chicks in 1996, 1997 and 1998. Observation were made during 236 hours in 1996, 319 hours in 1997 and 258.5 hours in 1998.

	Corvid			Black-backed Gull			Herring Gull		
	1996	1997	1998	1996	1997	1998	1996	1997	1998
Adults taken	0	0	0	2	0	1	0	0	0
Eggs taken	N/A	48	2	1	7	3	0	2	0
Chicks taken	0	0	0	69	19	14	124	34	13

Table 2. Summary of nest data for Arctic and Common Terns nesting on Country Island in 1997 and 1998. All data except productivity are taken from nests located within the grid. Productivity data are estimates based on chick survival in the four (in 1997) and seven (in 1998) subsampled areas (see text). * represents a significant difference between years. Productivity data for 1997 were estimated based on the number of chicks still alive when researchers left the colony, and the probability that these chicks would be depredated before fledging (Whittam 1997).

	Arctic Terns		Common Terns	
	1997	1998	1997	1998
1-egg nests	58	15	6	0
2-egg nests	108	144	23	8
3-egg nests	0	10	22	62
Mean clutch size	1.65	1.97*	2.31	2.89*
Modal clutch initiation date	June 11	N/A	June 12	N/A
Number of nests for which hatching success was determined (%)	127 (77)	108 (63.9)	42 (80)	47(67.1)
Hatching success (eggs hatched/nest)	0.96	1.67*	1.83	2.68*
Eggs hatched (%)	122(59.5)	179 (86.9)	76 (80)	126 (94)
Eggs depredated (%)	77 (37.5)	2 (1)	13 (14)	0
Unhatched eggs (%)	6 (3)	25 (12)	6 (6)	8 (6)
Nests where at least one egg hatched (%)	71 (56)	123 (94)	33 (79)	58 (100)
Productivity (fledglings/nest)	0.53 - 1.06	0.68	0 - 0.67	1.47

Table 3. Fates of Arctic and Common Tern chicks on Country Island in 1997 and 1998. "Died" refers to chicks that died of causes other than predation. "Fledged then fate unknown" refers to chicks that reached 20 days of age, but whose fate there after is unknown (not calculated in 1997). “Fledged then died” refers to chicks that reached 20 days but subsequently died of causes other than predation (not calculated in 1997). "Depredated after fledging" refers to chicks that reached 20 days of age but whose bands were subsequently found in regurgitated gull pellets (not calculated in 1997). The numbers in this category are likely to be underestimates because not all chicks were banded nor were all gull pellets examined. Sample sizes (n) refer to the number of chicks included in the study.

Species	n		depredated (%)		died(%)		fledged then fate unknown (%)		died after fledging (%)		depredated after fledging (%)		unknown (%)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Arctic	24	66	6 (25)	10 (15)	0	15 (23)	N/A	22 (33)	N/A	1 (1.5)	N/A	3 (4.5)	18 (75)	15 (23)
Common	24	59	13 (54)	10 (17)	1(4)	11 (19)	N/A	25 (42)	N/A	0	N/A	0	10 (42)	13 (22)

APPENDIX A: A Preliminary Analysis Of Chick-Feeding Behaviour By Arctic And Common Terns On Country Island

INTRODUCTION

Tern colonies require a reliable food source near their colony sites to be successful (Austin 1932). If tern breeding success is limited by food availability, tern colonies become vulnerable to any changes (natural or anthropogenic) that may alter the availability, quantity or quality of their food supplies. Furness (1982) reviews how food shortages caused by over-fishing and human-induced foraging habitat degradation has lowered the reproductive success of several seabird populations. Information on the feeding ecology of a tern colony is therefore important to develop sound management plans aimed at increasing their reproductive success.

Our purpose was to gather baseline information on the feeding ecology of Arctic and Common Terns on Country Island by examining chick feeding rates and the size and species of prey items delivered to chicks. This baseline information can then be used in conjunction with future data, to determine annual variations in prey preference, prey size, and chick feeding rates. Such collective information may be instrumental in developing a long term management plan for terns on Country Island and in detecting potential impacts from the Sable Offshore Energy Project on prey fish populations, and tern chick feeding behaviour. We also highlight areas where data are lacking in hopes that future research may fill these gaps.

METHODS

We observed prey deliveries from 26 June to 26 July, during three two-hour observation periods daily (0600-0800, 1100-1300, and 1800-2000 ADST). Observations were made with binoculars from three blinds located throughout the tern colony, and were not made during rainy weather. One to three observers (RW, CM, TG) were active during each observation period. The close proximity of nests allowed us to follow two to seven nests per blind during one watch period. We observed chick feeding at 40 nest sites (20 Arctic, 20 Common), all of which were located within a 10 m radius of a blind. For each prey item delivered to a chick, we noted the nest, time, species of fish, and length of fish (in bill lengths).

Chick feeding rate and prey size

We attempted to watch each nest for at least two, two-hour periods during each of five age categories (0-4 days, 5-9 days, 10-14 days, 15-19 days and 20+ days old). Ages were calculated based on the date of hatching (= day 0) of the first chick in a nest. This allowed us to examine chick feeding rate and prey size relative to chick age. Some nests could not be watched at necessary times due to inclement weather. We calculated feeding rates per nest for each two-hour period in "feedings per chick per hour". If a chick did not eat the prey item that was delivered to the nest site, the data from that prey delivery was not used for feeding rate calculations but was used to determine the species composition and size of fish brought to chicks. For each nest, we calculated the feeding rate and fish size per age category by averaging all feeding rates and fish sizes from two-hour watches within that age category.

If a chick or chicks from a nest died before data on all age categories could be collected for that nest, or if we left the island prior to chicks reaching the final age category, we still used all previous data up until that point for that nest. Similarly, if the number of chicks per nest changed before data on all age categories had been collected, we continued to monitor feeding for the remaining chick(s), and adjusted the number of chicks per nest when calculating feeding rates.

Fish species composition

We used prey deliveries observed during the period 26 June to 3 July to familiarize ourselves with the different prey species and to collect and identify several prey samples dropped in the colony. Despite this effort, we were unable to identify many fish after 3 July due to tall vegetation that blocked our field of view, the orientation of the adult and/or chick during prey delivery, and the speed with which chicks consumed prey. When a fish could not be identified it was classified as unknown. One fish, which we refer to as "mottled fish" (Figure A1), could be individually identified during feeding watches but was never classified to species. While we suspect that this fish was the neustonic juvenile stage of white hake (Markle et. al 1982), we were unable to obtain a dropped sample for identification. Since this fish may be properly identified in future years, it was not classified as “unknown”.

Because there are three species of hake (*Phycis* and *Urophycis*) and a species of rockling *(Enchelyopus*) that can all occur off northern Nova Scotia and be easily confused with one another (D. Methven, Memorial University of Newfoundland, pers. comm.), we collected a sample of eight "hakes" that had been dropped in the tern colony for identification. All eight specimens were identified as pelagic juvenile white hake *(Urophycis tenuis*) (Methven, pers. comm.). We therefore classified all hake species seen during feeding watches as white hake. It should be noted, however, that red hake (*(Uro)Phycis chuss*), longfin hake (*Urophycis chesteri*) and fourbeard rockling (*Enchelyous cimbrius*) may occur in this area. Fourbeard rockling is known to be a prey item of terns in Maine (Steve Kress, Maine Audubon Society, pers. comm.) and on Machias Seal Island, New Brunswick, (Krista Amey, University of New Brunswick, pers. comm.). Therefore, in future studies of tern prey choice on Country Island, all dropped fish should be identified by close examination of the epibranchial gill rakers (see Table A1).

RESULTS

Chick feeding rate and prey size

We eliminated two nests from this part of the study (one Arctic and one Common) because chick age was unknown. Therefore, a total of 38 nests were monitored for 666.5 nest hours for chick feeding rate and prey size calculations. We observed each nest for an average of 17.53 ± 1.26 hours (range 2-30, n = 38). The average number of hours watched per nest during each age category were; 0-4 days: 4.58 ± 0.64 hours (range 0-22 hours), 5-9 days: 4.99 ± 0.51 hours (range 0-16 hours), 10-14 days: 4.67 ± 0.57 hours (range 0-16 hours), 15-19 days: 4.15 ± 0.60 hours (range 0-14 hours) and 20+days: 3.41± 0.66 hours (range 0-12 hours).

We recorded 1522 prey deliveries that could be used in the feeding rate portion of this study. Of the 1522 items, 1477 (96.65%) were successfully fed to chicks and 51 (3.35%) were either eaten by one of the providers, dropped at the nest, or pirated by another tern at the nest site. Chick feeding rates increased over the first three age categories then declined over the last two

(Table A2). Size of prey items delivered to chicks increased between the first two age categories but then remained stable near 1.25 bill lengths (Table A2).

Fish Species Composition

We determined fish species composition from 686.5 hours of chick feeding observations at 20 Arctic and 20 Common Tern nests. We observed 650 feedings to Arctic chicks and 560 feedings to Common chicks. Thirty-eight per cent of prey deliveries to Arctic chicks, and 44% of prey deliveries to Common chicks, were identified to species. The species composition of prey brought to Arctic and Common Terns differed significantly ($\chi^2 = 30.96$, df = 4, p = 0.0001), with Common Terns bringing more sandlance than Arctic Terns, and Arctic Terns bringing more white hake than Common Terns (Figure A1). The main species brought to chicks of both species was white hake (Figure A1). Other prey items taken included invertebrates (unidentified species); lumpfish (*Cyclopterus lumpus*); mummichog (*latin*); Atlantic saury (*latin*); three-spined stickleback (*Gasterosteus aculeatus*); and American sandlance (*Ammodytes americanus*).

DISCUSSION AND RECOMMENDATIONS

White hake appears to be the predominant prey item fed to Arctic and Common Tern chicks on Country Island in the month of July. Because we were unable to identify 58.8% of prey items, it is possible that another species may have been utilized to a greater extent than white hake. This is unlikely, however, because an earlier study showed that white hake was the primary prey species fed to Roseate Tern chicks on Country Island (Whittam and Leonard 1996), and similar studies at various islands in the Gulf of Maine (e.g. Machias Seal Island, Petit Manan Island, Ship Island, Seal Island, Matinicus Rock, Eastern Egg Rock, Pond Island NWR and Stratton Island) have shown white hake to be a predominant prey species for terns (Monomoy NWR 1998).

The apparently strong reliance of Country Island terns on white hake could put these terns at risk from factors affecting this species of prey fish. While adult white hake are demersal at depths of 200-1000m, the larval and juvenile stages (usually less than 80mm) are pelagic and found nearshore in depths of approximately 1 m (Scott and Scott 1988). As juvenile white hake grow, they descend to the bottom of shallow water and eventually move into deeper water zones. Any activities (fishing, pipeline laying, increased boat traffic, etc.) that could potentially affect the population of juvenile white hake in the Country Island area should be carefully regulated and monitored.

It should not be overlooked that increases in food supplies in 1998 would have had the same positive effects on the tern colony as some of those being associated with the non-lethal control program. Brood size reduction is a strategy employed by a number of seabird species during food shortages (Furness 1982). The significant increases in brood size for both Arctic and Common terns from 1997 to 1998 (see main document) may be a reflection of greater food availability in 1998. Safina et al. (1988) found a significant increase in clutch size for Common Terns in the better food year of a two year study. A greater food supply may also lead to a decrease in age of first breeding (Furness 1982), thereby resulting in more breeding individuals. The increased numbers of nesting Arctic and Common Terns could also be a result of greater food supplies in 1998. We do not have quantitative evidence to support these hypotheses.

We cannot draw any conclusions from our data on the diversity or abundance of prey fish in the foraging waters around Country Island. To do so, seining sites would need to be established in areas where Country Island terns are seen foraging. Distribution of species and size frequencies among seine samples and chick-feeding observations could then be compared, as outlined in Fraser (1997). Fraser (1997) looked at four criteria to measure food abundance at a Forster's tern colony in Minnesota. These were: i) feeding rates to mates and chicks; ii) abundance of prey species through direct seine sampling; iii) incubation changeover frequencies; and iv) qualitative observations of decreased nest attendance and numbers of starving chicks. A similar approach to evaluate food abundance around Country Island could be used in future studies. Furness (1982) also outlines several methods of studying food consumption by seabird populations.

Other information is still needed to provide a clearer picture of the health of the prey population around Country Island. Future studies should examine the foraging distance of terns by making daily observations of the "beeline" direction taken by foraging terns, and the amount of time elapsed between leaving and returning. Boat surveys to locate foraging areas would also be useful (A.G. Horn, pers. comm.). Information on the nutritional value of fish species being fed to tern chicks with respect to their nutritional requirements should be gathered (A. Boyne, pers. comm.). By examining prey size data, feeding rates, foraging distances, and nutritional value of prey fish, we could have a better understanding of the feeding ecology of Country Island terns.

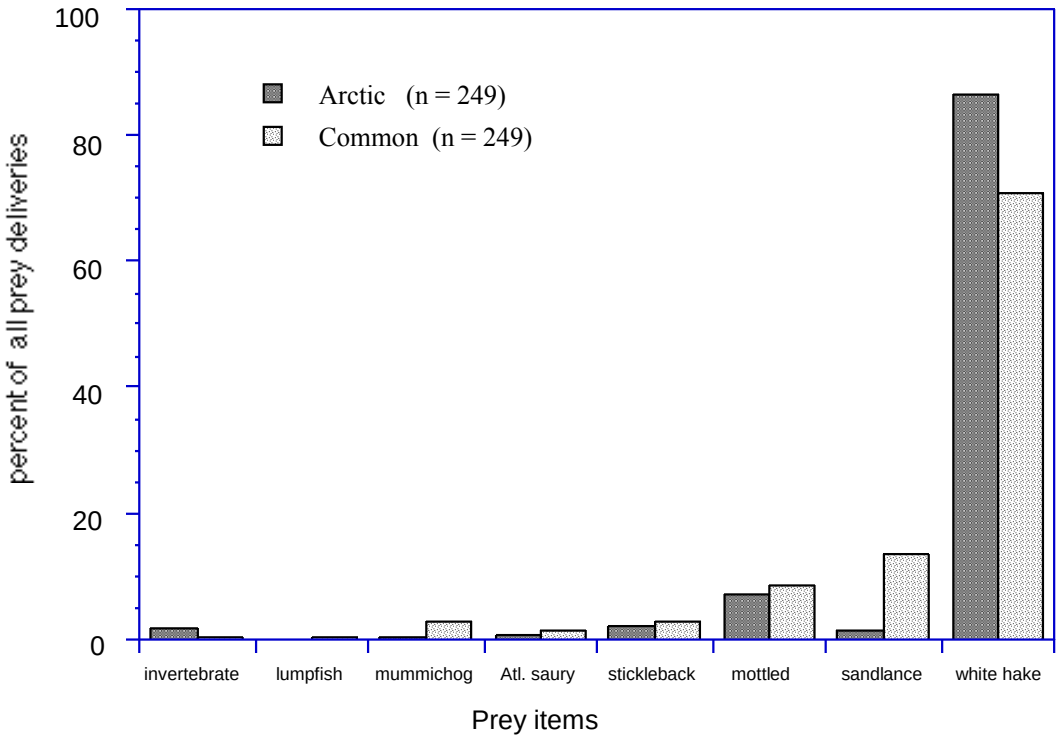

Fig A1. Prey items fed to Arctic and Common Tern chicks on Country Island in 1998.

Table A1. Key for identifying three species of hake and one species of rockling (at sizes > 40 mm SL) that potentially occur in the waters surrounding Country Island.

Enchelyopus cimbrius - does not have pelvic fins that reach the vent. The pelvic fins are not well pigmented as they are in *Urophycis tenuis*. Also the number of pelvic fin rays is >4. Most important is the modified first dorsal fin and the 4 barbels (beards) at the very front of the head. All *Urophycis* spp. have only one barbel.

(Uro)Phycis chesteri - has 4-5 gill rakers. It is also deeper bodied than *either Urophycis chuss* or *U. tenuis*. Pelagic juveniles of *Urophycis chesteri* "seem" to be rare on the continental shelf and are usually found along the edge of the shelf or further offshore.

Urophycis chuss - has 3 epibranchial gill rakers and is not as deep bodied as *Urophycis chesteri* and *U. Tenuis*. It is usually only pelagic up to 30-35 mm SL.

Urophycis tenuis - has 2 epibranchial gill rakers and is deep bodied relative to *U. chuss*. *Urophycis tenuis* remains pelagic to a much larger size than *U. chuss* and *E. cimbrius* (though not *U. chesteri*). It has a black pigment on the outer 1/3 of the pelvic fins but when *U. tenuis* is c. 55-65 mm SL the black pigment disappears.

Courtesy of D. Methven, Memorial University of Newfoundland.

TABLE A2. Chick feeding rate (mean ± SE) and prey size (mean ± SE) for prey delivered to Arctic and Common Tern chicks of various ages on Country Island in 1998. *n* refers to the number of nests observed for each age category.

Age Category (days old)	feeding rate (feeds/chick/hour)	*n*	prey size (bill lengths)	*n*
0-4	1.11 ± 0.11	24	1.14 ± 0.04	28
5-9	1.62 ± 0.16	27	1.21 ± 0.04	31
10-14	2.00 ± 0.30	25	1.29 ± 0.09	26
15-19	1.76 ± 0.18	19	1.27 ± 0.08	21
20+	1.67 ± 0.18	14	1.23 ± 0.09	15

APPENDIX B: A Preliminary Study Of The Breeding Biology Of Common Eiders On Country Island

INTRODUCTION

Approximately 50 pairs of eiders were known to nest on Country Island in 1996 and 1997 (Whittam 1997). Given the amount of gull predation observed on tern chicks on Country Island in those years, and given the large body of evidence for gull predation on Common Eider ducklings (reviewed in Mawhinney and Diamond 1996), it is likely that eiders have also been affected by gull predation on Country Island.

Our goal was to determine: a) an estimate of the number of nesting pairs of eiders on Country Island; b) whether eiders are affected by predation on Country Island; and c) whether predator control had any effect (positive or negative) on the nesting behaviour of Common Eiders. Because we have no quantitative information on the nesting behaviour and success of eiders on Country Island prior to the implementation of gull control, it is difficult to draw any definitive conclusions from our results; however, we hope the information gathered in this study can be used as a baseline for future work.

METHODS

We gathered two types of data. First, we searched for and monitored the success of eider nests on Country Island. Second, we made casual observations of the number of eider ducklings present around the island, and noted any predation attempts made by gulls.

Eider nests

To minimize disturbance to the eider population on Country Island, we did not actively search for eider nests until 20 June when we estimated that the peak of egg-laying had occurred (based on observations of females moving from water to land). Some nests were found prior to this date due to accidental flushing of incubating females. Planned nest searches occurred during sunny days with light winds and no precipitation (fog or rain) to ensure that exposed eggs would not become cold or wet. We also covered eggs with nest down if females had not done so prior to flushing. When a nest was found, we marked it with flagging tape (tied to a nearby tree or shrub) and recorded the number of eggs and/or any signs of nest predation.

Nests were considered depredated if we saw an intruder at a nest site and the nest was subsequently empty, or if depredated shells with yolk residue were found at or near the nest site. Eggs depredated by crows had a characteristic hole in one side of the egg (pers. obs.). Nests were considered hatched if starred and/or pipped eggs, chicks, or hatched egg shell pieces were found in undisturbed nests. Hatching success was considered unknown if we could not ascertain whether a nest was empty from predation or hatching. Most nests were revisited at least once, 1-2 weeks after the first visit.

Crèche/brood counts

A crèche is a group of ducks containing any number of adult females and ducklings, two or more of which are parentally unrelated (Munro 1975). In this study, females and chicks were unmarked, so we could not differentiate between a brood and crèche. Therefore, we will use the term "crèche/brood" as in Munro and Bédard (1977).

We began monitoring eider crèches/broods following our first sighting of eider ducklings on 18 June. From 18 June to 26 July casual observations of eider ducklings were made from the lighthouse and blind 3 while conducting predator and tern chick-feeding watches, and while carrying out gull patrols (see main document). When a crèche/brood was sighted we recorded the time of day, number of ducklings, duckling size (small, medium or large), number of adult females, their location, and any predation attempts.

Crèches represent an unstable group wherein exchanges of both ducklings and adult females are common when two or more crèches come into contact with one another (Swennen 1989). Furthermore, Munro and Bédard (1977) observed that some females show transitory broodiness by being only temporarily attracted to a brood. Because individual eiders were not marked we could not monitor this mixing behavior. Individual observations were therefore subject to overlapping effects. For example, a crèche/brood seen at 0600 with 10 females+5 ducklings, and a sighting of two crèche/broods (3 females+2 ducklings, 7 females+3 ducklings) at 1200 may have consisted of the same individuals.

Because of the potential problem of overlapping observations, we were only able to determine a minimum number of ducklings seen per day for each day observations were made. During blind and lighthouse watches any ducklings seen within a one hour period were likely not overlap sightings as observers were stationary and therefore able to monitor the locations of the various crèches/broods. Ducklings counted in the lagoon following these watches were considered new (separate) ducklings since the lagoon appeared to be an area wherein newly-hatched ducklings were led to the ocean (pers. obs.). Therefore, to obtain a minimum daily total of ducklings around Country Island, we added all sightings within a one hour period from the lighthouse or blind, and any sightings on the lagoon that followed these watches. The largest number of the day was considered the minimum number of ducklings present on that day.

RESULTS

Eider nests

We found 16 Common Eider nests on Country Island in 1998. The first nest was found on 18 May with a complete clutch of five eggs. The last nest was found on 10 July. Three of the 16 nests were depredated, six were recorded as hatched and the fates of seven nests were unknown. Nests were found primarily around the lagoon and east woods (see Figure 1, main document). These were the areas of the island that we visited the least during our predator control work. Nests were well-hidden, and females often did not flush until we were directly over their nests. For this reason, we probably did not find many of the nests that were present on the island. We did not search more thoroughly for nests because we felt that the disruption caused by our presence might cause females to abandon their nests, especially given the disturbance already caused by the predator control work.

Many nests were empty (due to predation or hatching) between the first and second nest check. Since incubation begins after the second or third egg has been laid, and average clutch

size is 4-5 eggs (Environment Canada 1989), clutch size could not be determined with just one visit. We were only sure of the complete clutch size of three nests. Two of these nests had four eggs, and one had five eggs.

Crèche/brood counts

The first sighting of eider chicks occurred on 9 June by local lobster fisher Archie Manthorne. Back-calculating based on a 26 day incubation period (Chaote 1966, Milne 1974) and an interval of 24 hours between the laying of eggs (Mawhinney and Diamond 1996) indicates that incubation for this brood started around 7 May, within two weeks of our finding the first eider nest on the island (18 May). Using a minimum daily total of eider ducklings from all crèche/broods observed, an average of 11 ducklings (range = 1-26) were seen each day around the island, from 18 June to 26 July. The maximum number of eider ducklings (26) was observed on 28 June. The range of ducklings per crèche/brood was 1 to 13. Small (recently hatched) ducklings were still observed on 25 July, suggesting that nests were still being initiated in late June. The number of females attending crèche/broods ranged from 1 to 18.

We observed two incidences of attempted gull predation on eider ducklings, one of which was successful. The successful attempt was made by a Black-backed Gull on a crèche/brood of three ducklings and 18 females. All three ducklings were depredated over a four-minute period. The other predation attempt noted was also by a Black-backed Gull on a crèche/brood of two ducklings and four females, but no ducklings were taken.

DISCUSSION AND RECOMMENDATIONS

The number of eiders nesting on Country Island seemed to decrease in 1998 compared to 1996 and 1997. In 1998 eider nests were restricted almost entirely to the lagoon and east woods. In previous years eider nests were observed over the entire island; every patch of cover (spruce copses, fallen logs, driftwood) provided a nest site for eiders (R.W. pers. obs.). Because eider nest counts were not conducted in 1996 or 1997, it is impossible to be certain that numbers declined in 1998. It is possible that eider numbers did not decrease from past years and that nest activity was simply concentrated around a single area (the lagoon, where disturbance was lowest) rather than spread across the island.

Human disturbance increased in 1998 due to frequent noisemaker shots and gull patrols during the early part of the season (late April to early June; see main report). In past years humans have not inhabited the island until late May, and most human activity was restricted to the south end of the island. In 1998 we arrived on the island during a critical time when eiders were establishing nesting territories. Eiders may have been deterred from nesting due to our disturbances. On the Isle of Shoals non-lethal predator control early in the breeding season prevented eiders from nesting until later in the season, when they nested in equal numbers to past years and had greater success due to the removal of predators (D. Deluca, pers. comm. in Boyne 1998).

We recommend that predator control procedures be restricted to outside the lagoon area, so that eiders have an opportunity to nest in that location. Noisemakers should not be fired from the north end of the island after the last week of April. Shots should be restricted to the west and south ends of the island (until terns arrive). The lagoon area should only be patrolled once a week to destroy gull nests. Once it appears that eiders have been incubating for one week, a thorough

nest search should be made by four or five observers. In 1998, searches were made by only two observers, making it difficult to locate all nests in a short time period (i.e. less than one hour). Bringing additional observers onto the island for one day to carry out a nest search would be worthwhile.

Despite the fact that no corvids or gulls nested successfully on Country Island in 1998, eiders still suffered from egg and duckling predation. At least 19% of eider nests were depredated as eggs (probably by crows), and we know of at least one incidence of gull predation on ducklings. Unfortunately we are unable to specify whether predation was higher or lower in 1998 due to our lack of data from previous years.

To obtain better estimates of eider productivity and gull predation on eider ducklings around Country Island, specific observation periods should be allocated for crèche/brood watches, preferably during low tide when ducklings are most active and easily visible (Swennen 1989). A viewing area at the south tip of the island should be defined in which all ducklings can be counted from the lighthouse every 10 minutes, during a one to two hour watch period (Mendenhall and Milne 1985). All predator intrusions can be recorded and converted to attacks/30 minutes/"X" ducklings (Mendenhall and Milne 1985). Weather should be recorded at every half hour interval. All ducklings should be aged by appearance at each watch using the table outlined in Mendenhall and Milne (1985). Marking females and ducklings of some broods with field readable tags (Mendenhall and Milne 1985) would enable individual ducklings and crèche/broods to be continuously monitored, thereby providing additional information on eider success.

APPENDIX C: Roseate Tern Band Combinations Used On Country Island In 1996, And Re-Sightings Made In 1997 And 1998

COMBO	Al band no.	FR band no.	Nest no. (1996)	Resightings on Country Island (M/D/Y)
r/al-lgdg/fr	80268301	H151	L*	05/29/98, 07/20/98
y/al-dgo/fr	305	H153	13*	05/29/98, 07/20/98
lg/al-lgdg/fr	313	H158	14	07/19/97, 05/29/98
dg/al-lgdg/fr	306	H154	G	
db/al-lgo/fr	307	H155	A	07/02/98
p/al-lgo/fr **olg	304	H152	8	
w/al-lgdg/fr	308	H156	Q	
bk/al-dgo/fr	312	H157	M	07/18/97
lgdg/fr-y/al	314	H159	4b	07/20/97
lgdg/fr-dg/al	323	H165	3	
lgdg/fr-db/al	358	H168	26b	
lgdg/fr-w/al	321	H162	10	
lgo/fr-r/al	330	H167	25	07/20/97, 06/24/98
lgo/fr-db/al	317	H160	4	06/04/97
lgo/fr-p/al	322	H163	11	
dgo/fr-r/al	320	H161	5	
dgo/fr-w/al	329	H166	26	

Reading UL/LL - UR/LR, codes are based on 9 solid colours (red, orange, yellow, light green, dark green, dark blue, purple, white, black) and 3 bicolours (light green/dark green, light green/orange, dark green/orange)

* = seen paired in 1998
** olg = colour band upside down
Al = aluminum
FR = field readable

APPENDIX D: Specific Recommendations For Field Work

• Fencing off grid squares to determine chick survival is not necessary if chick-feeding observations are being made (see Appendix A). Nests can be followed from the blinds for both chick-feeding and productivity. Chicks can be marked at hatch with coloured markers so they can be identified from the blinds and their survival monitored. Additional nests that are visible from the lighthouse can also be followed during predation observations. Nests to be followed from the blinds and the lighthouse should be chosen before hatching. This technique is less labour-intensive than fencing grid squares, and involves less disturbance to the colony because chicks do not have to be actively searched for. If chick-feeding observations are not being made then fencing squares is an appropriate and valuable method of obtaining productivity data. We recommend, however, that fences either be lined completely with landscaping fabric, and that the fabric be attached with duct tape rather than thread, or that a different material, such as window screening, be used for fencing. The likelihood of chicks harming themselves by becoming entangled in the thread or lattice holes of the chicken wire would thus be eliminated.

• Gull counts should be standardized to occur at only three times of day, in the morning, afternoon and evening. Counts should take place from the lighthouse and the north tip of the island so that all gulls present are counted. Predator patrols should continue to occur regularly (i.e. every two hours), but should bypass the lagoon area to reduce disturbance to nesting eiders (see Appendix B). This area should be visited once a week to destroy any gull nests that may have been initiated.

• Gull pellets should be collected on the east beach and the north tip of the island starting at the beginning of the breeding season and continuing throughout the summer (as was done with the five monitored rocks). Corvid pellets should be collected and classified in a systematic manner, similar to that used for gull pellets, in order to quantify corvid diet.

• To facilitate nest checks, nest markers (tongue depressors) should be placed on the same side of every nest (e.g., to the east). This should reduce the time spent searching for nest markers and thereby decrease disturbance to the colony.

• The grid should be changed slightly to encompass the lighthouse beach. Stakes can be removed from the northeast corner of the grid, where tall vegetation prevents terns from nesting, and moved to the lighthouse beach, where terns nest at apparently high densities.

• Every effort should be made to reduce disturbance to the tern colony early in the breeding season. Researchers should stay out of the colony (i.e. the lighthouse and blinds should not be used, and nests should not be searched for) until after the peak of egg-laying has occurred (around 5 June in 1998, but varies annually). This would reduce the likelihood that Roseate Terns are being deterred from this site by research activity early in the season. Terns can be monitored from the small house until this point, and Roseate presence can be monitored by listening for calls. After egg-laying has peaked the colony can be monitored from the lighthouse for predation observations and nest-mapping. Small blinds should not be used until hatching.

• If Roseates are found nesting within 20 m of an observation blind, this blind should not be visited until at least 15 days of incubation have passed. The Roseate pair that abandoned their egg in 1998 nested within 5 m of blind 3, at the east beach. We visited this blind three times (for less than half an hour each time) during the week between discovering the Roseate nest and its abandonment. It is possible that our use of this blind caused the Roseates to abandon their nest, as they hesitated to incubate while we were in the blind. This pair, however, nested very late compared to the rest of the colony, and their nest was located on the edge of the colony (at the east beach, see Figure 1), suggesting that they may have been unsuccessful regardless of our presence.

• A pair of Lambourne's pliers (from England) should be obtained to close field readable bands and USFWS bands on Roseate Terns.

REFERENCES

Anderson, J. G.T. 1995. Ecosystem ecology and conservation biology: a critique. pp. 45-49 *In*: Ecosystem monitoring and protected areas. Proc. sec. int. con. sci. mgmt. prot. areas. Wolfville, Nova Scotia: Science and management of protected areas association.

Austin, Jr., Olicer Luther. 1932. The Birds of Newfoundland Labrador. Memoirs Nuttall Ornithological Club, No. VII, p. 39.

Belant, J. L. and T. W. Seamans. 1993. Evaluation of dyes and techniques to color-mark incubating Herring Gulls. J. Field Ornithol. 64: 440-451.

Blokpoel, H., G. D. Tessier and R. A. (Bud) Andress. 1997. Successful restoration of the Ice Island common tern colony requires on-going control of Ring-billed Gulls. Colon. Waterbirds 20: 98-101.

Boyne, A. 1998. Tern restoration plan for Country Island, Nova Scotia. Unpublished Canadian Wildlife Service proposal, Environment Canada, Atlantic Region.

Burger, J. 1984. Colony stability in least terns. Condor 86: 61-67.

Chaote, J. S. 1966. Factors influencing nesting success of Eider in Penobscot Bay, Maine. M. Sc. thesis. University of Maine, Orono, Maine. 173 pp.

Clode, D. 1993. Colonially breeding seabirds: predators or prey? Trends Ecol. Evol. 8: 336-338.

Côté, I. M. and W. J. Sutherland. 1997. The effectiveness of removing predators to protect bird populations. Conservation Biology 11: 395-405.

Crowell, E. M and S. Crowell. 1946. The displacement of terns by herring gulls at the Weepecket Islands. Bird-banding 17: 1-10.

Environment Canada. 1989. Common Eider. Hinterland Who's Who Series, Canadian Wildlife Service, Ottawa, Ontario.

Fraser, G. 1997. Feeding Ecology of Forster's Terns on Lake Osakis, Minnesota. Colonial Waterbirds 20:87-94.

Furness, R. W. 1982. Competition between fisheries and seabird communities, p225-307. *In* J.H.S. Blaxter, F. S. Russell, and M. Young [eds.], Advances in marine biology. Vol. 20. Academic Press, New York.

Huntington, C. E., G. Butler, and R. A. Mauck. 1996. Leach's Storm-Petrel (*Oceanodroma leucorhoa*). *In* A. Poole and F. Gill (eds.), The Birds of North America, No. 233. The

Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Kirkham, I. R. and D. N. Nettleship. 1987. Status of the roseate tern in Canada. J. Field Ornithol. 58:505-515.

Kress, S. W., E. H. Weinstein and I. C. T. Nisbet. 1983. The status of tern populations in northeastern United States and adjacent Canada. Colon. Waterbirds 6: 84-106.

Kress, S. W. 1997. Using animal behavior for conservation: case studies in seabird restoration from the Maine Coast, USA. J. Yamashina Inst. Ornithol. 29: 1-26.

Lock, A. R., S. Boates, S. Cohrs, T. C. D'Eon, B. Johnson, and P. LaPorte. 1993. Canadian roseate tern recovery plan. Recovery of Nationally Endangered Wildlife Report No. 4. Ottawa: Canadian Wildlife Federation.

Markle, D. F., D. A. Methven, and L. J. Coates-Markle. 1982. Aspects of spatial and temporal cooccurrence in the life history stages of the sibling hakes, *Urophycis chuss* and *Urophycis tenuis*. Can. J. Zool. 60: 2057-2078.

Mawhinney, K. and A. W. Diamond. 1996. The effects of limited Great Black-backed Gull control on the recruitment of Common Eider ducklings in the Bay of Fundy. Unpublished report, University of New Brunswick, Fredericton, N. B. 20 pp.

Mendenhall, V. M. and H. Milne. 1985. Factors affecting duckling survival of Eiders *Somateria mollissima* in northeast Scotland. Ibis 127: 148-158.

Milne, H. 1974. Breeding numbers and reproductive rate of Eiders at the Sands of Forvie nature reserve, Scotland. Ibis 116: 135-152.

Monomoy NWR, 1998. Minutes of the Gulf of Maine Seabird Working Group. Bremen, Maine. August 10, 1998.

Munro, J. 1975. L'élevage des jeunes l'Eider Commun *Somateria mollissima* dans l'estuaire du Saint-Laurant. M. Sc. thesis, Université Laval, Québec.

Munro, J., and Bédard, J. 1977. Gull predation and crèching behavior in the common eider. J. Anim. Ecol. 46: 799-810.

Nisbet, I. C. T. 1981. Biological characteristics of the roseate tern *Sterna dougallii.* Unpublished report to the U.S. Fish and Wildlife Service office of Endangered Species, Newton Corner, Massachusetts.

Nisbet, I. C. T., J. Burger, C. Safina and M. Gochfeld. 1990. Estimating fledging success and productivity in roseate terns (*Sterna dougallii*). Colon. Waterbirds 13:85-91.

Nisbet, I. C. T. and J. A. Spendelow. 1998. Research and conservation of the Roseate Tern: a view from North America. *In*: J. Greenwood (ed.), Proceedings of the BOU/RSPB Conference, Belfast, September 1997.

Pierotti, R. and C. Annett. 1987. Reproductive consequences of dietary specialization and switching in an ecological generalist. *In* A.C. Kamil, J. Krebs, and R. Pulliam (eds.), Foraging Behaviour. Plenum Press, New York.

Pons, J. M. 1992. Effects of changes in the availability of human refuse on breeding parameters in a herring gull *Larus argentatus* population in Brittany, France. Ardea 80: 143-150.

Safina, C., J. Burger, M. Gochfeld and R. H. Wagner. 1988. Evidence for prey limitation of common and roseate tern reproduction. Condor 90: 852-859.

Scott. W. B. and M. G. Scott. 1988. Atlantic Fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219:731pp.

Spear, L. B. 1993. Dynamics and effects of western gulls feeding in a colony of guillemots and Brandt's cormorants. J. Anim. Ecol. 62: 399-414.

Spendelow, J. A., J. D. Nichols, I. C. T. Nisbet, H. Hays, G. D. Cormons, J. Burger, C. Safina, J. E. Hines, and M. Gochfeld. Estimating annual survival and movement rates of adults within a metapopulation of Roseate Terns. Ecology 76: 2415-2428.

Swennen, C. 1989. Gull predation upon eider *Somateria mollissima* ducklings: Destruction or elimination of the unfit? Ardea 77: 21-43?

Taylor, R.J. 1984. Predation. New York: Chapman and Hall.

Thomas, G. J. 1972. A review of gull damage and management methods at nature reserves. Biol. Conserv. 4: 117-127.

U.S. Fish and Wildlife Service. 1998. Roseate Tern Recovery Plan - Northeastern Population, First Update. Hadley, MA. 97 pp.

Whittam, R. M. 1997. The effects of predation on the breeding biology and behaviour of Roseate, Arctic and Common Terns nesting on Country Island, Nova Scotia. Unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia. 101 pp.

Whittam, R. M. 1998. Updated status report on the Roseate Tern, *Sterna dougallii*. Unpublished report to the Committee on the Status of Endangered Wildlife in Canada. 31 pp.

Whittam, R.M. and M. Leonard. 1996. Breeding biology of Roseate Terns (*Sterna dougallii*)on Country Island, Nova Scotia. Unpublished report to the Endangered Species Recovery Fund, World Wildlife Fund Canada. 19 pp.