THE FORSTER'S TERN IN MINNESOTA:

STATUS, DISTRIBUTION AND REPRODUCTIVE SUCCESS

AUTHORS:

Francesca J. Cuthbert
Department of Fisheries and Wildlife
University of Minnesota
St. Paul, MN 55108

Mei-Yao C. Louis
Department of Biology
University of Minnesota
Duluth, MN 55812

RUNNING HEAD: Tern Status and Reproductive Success

ABSTRACT

Forster's Terns (Sterna forsteri) were studied in Minnesota from 1985-1986 to determine abundance, breeding distribution, and reproductive success. In both years, the estimated breeding population was 900-1000 pairs. The Forster's Tern breeds throughout the western prairie wetlands and eastward through the prairie-woods transition including an extension into the central part of the state to the Twin Cities. The largest colonies were in Jackson, Nicollet, Todd, and Wright counties. Although the major colonies were found at sites traditionally used by Forster's Terns for most of this century, site occupancy in any given year was determined by water level and presence of suitable nest habitat. Reproductive success varied among colonies, ranging from 0.00 to 0.458 fledglings/breeding pair. High water levels, wind and wave damage and predation by Great Horned Owls (Bubo virginianus) were the primary factors that reduced reproductive success. Reproductive success recorded during this study was below that needed to maintain the population at its current size. To ensure conservation and appropriate management of this species in Minnesota, major colonies need to be monitored annually to estimate colony size and productivity.

ACKNOWLEDGMENTS

We thank R. Boerma and M. Brownrigg for assistance in the field. Additional help and advice were provided by: T. Anderson, F. Froelich, P. Kohring, L. Pfannmuller, J. Schladweiler, A. Sigford and J.L.D. Smith. We are greatful to K. Haws, N. Hiemenz, J. Mattsson and J. Schladweiler for collecting census data and G. Nuechterlein for sharing his design of the floating blind. We thank D. Christian, J. Eldridge, R. Green, D. Schimpf, and J.L.D. Smith for helpful criticism of the manuscript.

This project was funded by grants from the Minnesota Department of Natural Resources Nongame Wildlife Program, the Minnesota Chapter of the Nature Conservancy, the College of Science and Engineering (University of Minnesota-Duluth) and the Minnesota Agricultural Experiment Station.

INTRODUCTION

Of approximately 38 species of terns in the world (Edwards 1982), only four traditionally nest in salt or freshwater marshes; one of these is the Forster's Tern (Sterna forsteri). This species typically nests in large prairie marshes characterized by extensive areas of emergent vegetation or muskrat houses (Bergman et al. 1970). Breeding is restricted to North America and the Northern Great Plains compose the primary range (A.O.U. 1983). Since presettlement times, well over 50% of prairie wetlands in this region have been converted to agriculture (Leitch 1989). Despite this loss of habitat, there are no estimates of the total number of Forster's Terns in North America; estimates are crude even at regional, state, and provincial levels.

Although historical accounts of Forster's Terns in Minnesota exist from as early as 1894, population size and breeding success of this species was unknown prior to this study. In 1984 the Forster's Tern was designated a species of "Special Concern" in the state (Coffin and Pfannmuller 1988). This decision was based on records indicating this species does not occur as commonly on prairie marshes as it did 40-50 years ago and the observation that much apparently suitable habitat currently is not utilized. Our study examined the distribution, abundance and reproductive success of Forster's Terns in Minnesota in 1985 and 1986; we asked the following questions: (1) what is the breeding distribution of Forster's Terns in Minnesota, (2) how many pairs breed in Minnesota, (3) what is their reproductive success, and (4) what factors affect reproductive success?

STUDY AREA

Census sites were selected from records obtained from the Minnesota Department of Natural Resources Colonial Waterbird Data Base (MNDR CWDB). Breeding pair estimates were made at 16 sites during the two years of our study. We initially selected and visited 11 locations reported to have $\geq$ 10 breeding pairs between 1980 and 1984; all of these were important historical nesting sites in Minnesota (MDNR CWDB). Nesting was discovered at an additional five new sites during the study and estimates on colony size also were obtained for these sites.

For each site we obtained information on wetland size and classification from MDNR Division of Waters. The MDNR classifies Minnesota's wetlands into five types, as defined by Shaw and Fredine (1956): Type 1 (seasonally flooded basin or flat), Type 2 (inland fresh meadow), Type 3 (inland shallow fresh marsh), Type 4 (inland deep fresh marsh), or Type 5 (inland open fresh water). In Minnesota, Forster's Terns nest in wetland types 3,4 and 5. A newer classification, adopted by the U.S. Fish and Wildlife Service, is described in Cowardin et al. (1979). Under this system, Type 3 is characterized by the habitat class Emergent Wetlands; Type 4 includes habitat classes Emergent Wetlands and

Aquatic Beds; Type 5 is composed of habitat classes Aquatic Beds and Unconsolidated Bottoms.

The census sites are listed in Table 1. These locations are described in greater detail in Louis (1989).

METHODS

Census techniques.--We completed most census activities during the first week of June in 1985 and 1986; efforts were timed to coincide with late incubation. Colonies were reached either by boat or wading from shore. Nests containing one or more eggs or young were counted.

Estimating breeding success.--To estimate reproductive success, we selected three colony sites in 1985 (Clearwater Lake, Mother Lake, and Swan Lake) and two colony sites in 1986 (Mother Lake and Swan Lake) to monitor on a regular schedule. Nests were visited weekly from late incubation through fledging or disappearance of the offspring. To minimize investigator disturbance, a floating muskrat house blind was used to observe nests at Swan and Clearwater lakes (Nuechterlein 1980). At Mother Lake, thick emergent vegetation prohibited use of the blind and we waded to each nest to check its contents.

A sample of nests was selected for study: Clearwater Lake (24 in 1985), Mother Lake (11 in 1985; 7 in 1986), and Swan Lake (45 in 1985; 45 in 1986). Nests were marked with numbered wooden stakes tied to nearby cattail (*Typha augustifolia*) leaves.

During each visit, the number of eggs and chicks was recorded in each monitored nest. The fate of each egg (e.g., nonviable, hatched, disappeared) and each chick (e.g., died, disappeared, fledged) was also recorded, as was any evidence of factors or agents that may have affected reproductive success (e.g., weather, predators, human disturbance). Chicks were banded with a USFWS aluminum leg band.

Three variables were used to measure breeding success: hatching success (chicks hatched/total eggs laid), fledging success (fledglings/total eggs laid), and reproductive success (fledglings/ breeding pair).

Statistical analysis.--None of the data was distributed normally, so non-parametric tests (chi-square test; Fisher's Exact Test) were used to analyze the data (Sokal and Rohlf 1981).

RESULTS

Population Distribution and Size

We recorded 817 and 893 Forster's Tern nests in Minnesota in 1985 and 1986 (Table 1). Because Forster's Terns may nest in small colonies and often change sites between years we recognize that our coverage of all potential breeding sites was incomplete. We are confident that the major colonies were visited. To account for small colonies not discovered or reported during our study, we estimate the total breeding population in Minnesota to be fewer than 1,000 pairs in both years.

While no major difference was found in the size of the total population between the two years, interseasonal variation in colony size occurred. The nests at Lake Osakis and Clearwater Lake comprised 40% of the total 1985 population (Table 1). In 1986, there were no Forster's Tern nests at those sites. The largest colony in 1985 (326 pairs), located at Swan Lake, was approximately the same size in 1986 (316 pairs). At the same time, ANWR and North Heron Lake colonies greatly increased in number from 1985 to 1986. ANWR increased by about 250 pairs and North Heron Lake by almost 180. The other sites varied by fewer than 30 nests between years.

Colony sites in Minnesota were limited to wetland types 3 (1 site), 4 (9 sites), and 5 (6 sites). Of the non-urban sites used in 1985 or 1986, only one, Coon Creek, was small (207 ha). The rest were 700 ha or larger. The urban sites, Mother Lake and Wood Lake, were both small (55 and 49 ha, respectively).

The colony sites were located in the southern and western portions of the state, from as far north as Thief Lake to southernmost North Heron Lake, west as far as Coon Creek, with Wood Lake at the eastern edge of the range.

Breeding Success

Overall mean clutch size was identical in the two years (TAble 2). Mean clutch size varied among sites from 1.07 at Mother Lake in 1985 to 2.74 at Clearwater Lake in 1985. There were significant differences in clutch sizes among sites. Clutch size was smaller at Mother Lake than at Clearwater Lake (X^2 = 106.39, df = 2, $p < 0.001$) or Swan Lake (X^2 = 55.32, df = 2, $p < 0.001$). Clutches at Swan Lake were smaller than at Clearwater in 1985 (X^2 = 46.61, df = 3, $p < 0.001$). There also was a significant difference in clutch size between years at Mother Lake (X^2 = 19.02, df = 2, $p < 0.001$), and at Swan Lake (X^2 = 13.14, df = 3, $p < 0.005$). Larger clutches were recorded at both sites in 1986.

During the study hatching success ranged from 0-33% (Table 3). In 1985, hatching success was significantly lower at Mother Lake than at Clearwater Lake (X^2 = 9.55, df = 1, $p < 0.005$), and Swan Lake (Fisher's Exact Test, p = 0.012), but there was no significant difference between hatching success at Clearwater and Swan lakes that year (Table 2) (X^2 = 3.76, df = 1, $0.1 > p > 0.05$). In comparing the 1985 Clearwater Lake data with 1986 data from Swan and Mother lakes, there was no significant difference in hatching success between Clearwater Lake and Swan Lake (X^2 = 0.0042, df = 1, $p < 0.9$), and the difference in success at Clearwater Lake was not significant from Mother Lake (X^2 = 3.28, df = 1, $0.10 > p > 0.05$). In 1986 hatching success at Swan Lake was not significantly different from Mother Lake (X^2 = 3.48, df = 1, $0.10 > p > 0.05$).

Fledging success varied from 0-17% during the two breeding seasons (Table 3). Fledging success at Clearwater Lake was significantly different from Swan Lake in 1985 ($X^2 = 0.570$, df = 1, $p < 0.025$), and was significantly greater than Mother Lake (Fisher's Exact Test, $p = 0.030$). In comparing Clearwater Lake results in 1985 with 1986 data from Swan and Mother Lakes, Clearwater Lake was significantly higher than Swan Lake in fledging success ($X^2 = 5.04$, df = 1, $p < 0.025$), but there was no significant difference from Mother Lake (Fisher's Exact Test, $p = 0.053$). In 1986 fledging success at Swan Lake was not significantly different (Fisher's Exact Test, $p = 0.416$; Table 3) from that at Mother Lake despite the fact that no chicks fledged at Mother Lake.

Reproductive success ranged from 0.458 chicks produced/pair at Clearwater Lake in 1985 to 0 chicks/pair at Mother Lake in both years (TAble 3). In 1985 reproductive success at Clearwater Lake was significantly higher than at Swan Lake (Fisher's Exact Test, $p = 0.005$) and Mother Lake (Fisher's Exact Test, $p = 0.000$). The 1985 reproductive success at Clearwater Lake was significantly higher than 1986 success at Swan Lake (Fisher's Exact Test, $p = 0.004$), but not the 1986 Mother Lake success (Fisher's Exact Test, $p = 0.065$).

Factors Causing Reproductive Failure

The most common fate of unhatched eggs during the two years of the study was disappearance (Tables 4,5). Of 282 unhatched eggs, 172 (61%) disappeared In 1985, Mother Lake had a significantly higher number of eggs that disappeared compared to both Swan and Clearwater lake (Fisher's Exact Test, $p = 0.004$, $p < 0.001$; $X^2 = 25.71$, df = 1, $p < 0.001$); in 1986, Mother Lake did not have a significantly higher number of missing eggs than Swan Lake ($X^2 = 1.45$, df + 1, $p = 0.10$). Deserted eggs (36) accounted for 13% of the unhatched eggs. This category included clutches found intact but cold and eggs displaced from the nest following a storm or rise in water level. In 1985 a significantly greater number of eggs was deserted at Clearwater Lake than Swan Lake (Fisher's Exact Test, $p = 0.00$); a significant difference in deserted eggs found at Clearwater and Mother lakes that year was also found (Fisher's Exact Test, $p = 0.043$). Only four eggs (<2%) were nonviable.

Of chicks that did not fledge, disappearance also was the most common fate. Seventy chicks hatched and 47(67%) disappeared (Tables 4,5). There was no significant difference between the number of chicks that disappeared at Clearwater Lake and Swan Lake in 1985 ($X^2 = 3.19$, df = 1, 0.10 p 0.05. Almost a third of the chicks (32%) fledged. Only one chick (< 2% of all chicks from monitored nests) was known to be killed by a predator. The chick was found with a neck wound and other chicks from adjacent unmonitored nests were found decapitated. Another 1.4% of the chicks were found dead of unknown causes.

Forster's Tern has not been given a special status designation in South Dakota and no population estimate is available for this state (G. Vandel, South Dakota DNR, pers. comm.).

Forster's Tern population estimates are available for the Canadian provinces of Ontario and Manitoba. Ontario population estimates range from 200 pairs (C. Weselow pers. comm.) to 300-400 pairs (M. McNicholl pers. comm.). Manitoba's most recent population estimate for Forester's Terns, based on an aerial survey, was approximately 1,100 pairs (Koonz and Rakowaski, 1985).

There are several reasons for the paucity of accurate population estimates for this species. Their nests can be difficult to census because they often are spread out among emergent vegetation, requiring investigators to walk or pole a boat through areas unsuited for a motor or oars. The nests also may be distributed over a large wetland complex so that censusing can be very time-consuming, sometimes taking several days for a particularly large area such as Swan Lake. In addition, because birds may change colony sits from year to year (McNicholl 1975) it may be difficult to locate all active colonies on an annual basis. Finally, Forster's Terns usually nest in colonies, but they also may nest singly or in very small groups. In an area with many wetlands, it is difficult to find all nesting pairs. In Minnesota, the Forster's Tern has been one of the leastthoroughly censused colonial waterbird species (Guertin and Pfannmuller 1985).

Although Forster's Terns utilized a range of wetland type colonies they were most often found in Type 4 wetlands which are characterized by large stable stands of dense emergent vegetation and extensive water for foraging. Nests were almost always constructed on rooted cattail bases but at several lakes (e.g. Thief, Upper Rice Lake) they were located in dense stands of bulrush (Scirpus sp.). Our study and historical data indicate that Forster's Terns appear to select Type 5 wetlands when there are large floating mats or other suitable nesting habitat. The deeper water and more open expanses of type 5 wetlands provide a large food resource and greater protection from mammalian predators. Two of the largest and densest colonies were found on floating cattail mats in lakes Osakis and Clearwater. MDNR CWBDB records show these lakes have been used many years during this century. The reproductive success estimate for Clearwater Lake was the highest recorded for all sites measured as well as the highest we found reported for this species. MNDR CWBB records show these lakes have been used many seasons during this century. Despite intermittent favorable conditions these sites are susceptible to change when lake levels rise or vegetation mats are destroyed by storms as occurred between 1985 and 1986. When available, Forester's Terns prefer large mats of vegetation in large lakes with open water. Breeding success is probably very high at these sites on a periodic basis. The middle class of wetlands is consistently used and may on average have much lower reproductive success. These sites appear very vulnerable to several species of predators and nest destruction by major summer storms. Although Forster's Terns periodically utilize small wetlands characterized by shallow water and emergent vegetation these sites appear less than ideal because of increased risk of predators, poor food base and greater sensitivity to drought.

Although the population estimates for Minnesota were similar in 1985 and 1986, distribution of the birds was different for each year, especially at lakes Osakis and Clearwater, where water levels rose in 1986 about the time Forster's Terns initiated nesting. For example, the water level in Clearwater Lake and Lake Osakis was approximately 0.40 m higher in spring 1986 than in 1985. We believe the high water levels at Clearwater Lake and Lake Osakis either submerged the mats or caused them to break apart and float away. In 1980 similar mats broke loose from the substrate in Clearwater Lake and clogged the outlet, causing flooding (R. Froyen, pers. comm.). We searched Lake Osakis and Clearwater Lake for alternative colony sites, and it was apparent that other nesting habitat was not available; most of the area of the two lakes was open water.

In 1986, it appeared that some terns changed colony sits from the previous year. The three largest colonies in 1986 were at Swan Lake, ANWR, and North Heron Lake. Estimates at the latter two sites were notably larger (approximately 6x) then those recorded in 1985. Additionally a colony of approximately 100 pairs was reported (Sheed and Wilson 1987) at Lake Reno in Pope County and J. Hushagen, MDNR wildlife technician, found 205 adults and nests at Thief Lake more than a month after only one nest was recorded at the same site (K. Haws, pers. comm.); apparently late or renesting occurred here. Although we do not know if any of the approximately 300 pairs from Clearwater Lake and Lake Osakis moved to ANWR, North Heron Lake, Lake Reno, or Thief Lake, it appears to be a reasonable possibility.

Breeding Success

Clutch size.--Nests at Mother Lake had the lowest mean clutch size of any censused colony in both years. It is unclear why this was so. Reasons for small clutch size at the time of the census may include: (1) significant egg predation prior to the census, (2) birds were in the process of relaying after losing an earlier clutch, (3) the constant disturbance of low-flying airplanes disrupted laying. Clutch sizes recorded at the other colonies are comparable to those reported in Iowa colonies (Bergman et al. 1970).

Hatching Success.--In this study, hatching rate was as high as 33%

(Swan Lake, 1986) and as low as 0% (Mother Lake, 1985). McNicholl (1982) found hatching rates of ony 5-15% in Manitoba. In South Dakota, Houston (1962) reported 66% hatching success, and in California, Coulter found that 65% of the eggs hatched (McNicholl 1982). Results from this and other studies indicates high variability in hatching rate for this species. Although we documented egg loss to predators and during storms, this component of breeding success needs additional study.

Fledging success.--Fledging success in Minnesota was variable among sites and between years. The success (approximately 40%) recorded at Clearwater Lake in 1985 is the highest estimate in the literature for this species. Bergman et al. (1970) reported 12% nest success, and McNicholl (1982) found 14% nest success in 1968 but only 1% in 1969.

Reproductive success.--Fledging and reproductive success figures were probably under estimated in this study. If disturbed, chicks may permanently leave the nest soon after hatching (Rockwell 1911) and can be very difficult to locate in the surrounding vegetation (Peabody 1896). We did not document the construction of auxillery nests as reported by Cuthbert (1954) for Black Terns (Chlidonias niger) but believe Forster's Terns may also build these structures. In addition Forster's Terns are thought to leave the colony soon after fledging (McNicholl 1971; Techlow 1983).

The highest estimate recorded in this study, 0.458 fledglings/pair, is below the 1.1 fledglings/pair needed to maintain a population of Common Terns at its current size (Nisbet 1978; DiCostanzo 1980). Because no data are available on Forster's Tern life expectancy and mortality rates the actual level of reproductive success required to sustain the Minnesota Forster's Tern population is not known. Other Forster's Tern researchers report reproductive success rates of 1.33 fledglings/pair (Techlow 1983) (this includes artificial nesting platform nests), and 0.143 fledglings/pair (MCCaskie and Pugh 1964). McNicholl (1982) found that 7% of all eggs fledged in 1968; 0% survived to this stage in 1969.

Because few studies have estimated reproductive success in Forster's Terns it is difficult to generalize about chick survival to fledging; survival does, however, often appear to be below 1 fledgling/pair. Data on other species of marsh nesting terns also indicate low fledging success for terns nesting in wetland habitats. For example McCaskie and Pugh (1964) reported reproductive success of Black Terns at 0.833 fledglings/pair. Burger and Lesser (1979) found marsh-nesting Common Terns (S. hirundo) from only two of 11 colonies approached a reproductive success rate of one fledgling/pair; they suggested that marsh-nesting Common Terns may have lower reproductive success than terns that utilize the typical terrestrial habitat. In contrast, fledging success rates of 0.61 to 1.61 fledglings/pair have been reported for ground nesting colonies of Common Terns in California (Ohlendorf et al. 1985) and Nisbet (1978) found that Common Terns in Massachusetts produced 1.1 fledglings/pair between 1940-1956.

Factors Influencing Breeding Success

Storms.--Wave action, storms and rain caused the loss of a number of nests. This was most noticeable at Swan Lake in 1986 when 16 of 19 nests in one sub-colony disappeared during a four day period in mid-June when two major storms occurred.

Runoff also affected nesting areas after initial storms were over. Although flash flooding may occur soon after a storm we found that water levels often continued to rise for days after the storm. High water levels were an important factor influencing breeding success at several Minnesota colonies. Forster's Terns nested at Mother Lake in 1986, but after heavy rains and an increase of 18 cm in water depth eight days after the previous nest check, eight monitored nests were lost. Many nests were built on the lower portions of muskrat houses and were flooded. A few eggs at Clearwater and Swan lake also were submerged. In 1985, six eggs were submerged at Clearwater Lake after water levels rose. A two egg clutch fell into the water in 1986 at Swan Lake when the cattail base on which the nest was built turned over. At lakes Clearwater and Osakis, high spring water levels apparently prevented Forster's Terns from breeding in 1986. Mitchell (1941) also documented a Forster's Tern nest that was destroyed by a rise in the water level and wave action. Fox (1960) reported that a Forster's Tern nest on an island was destroyed when the island was completely innudated by water after a heavy rain. However, Zuranich (1963) found that 20 Forster's Terns nests in Kansas were unaffected by gradually rising water. Although water levels rose 0.7 m, the nests floated freely and rose with the water level.

Predators.--Although only one chick from monitored nests was found dead from predation we observed other evidence of predation during general field observations during both years of the study. In 1985 one chick was found dead with a neck wound; another chick was found decapitated. Both chicks were nearly fledged and were found at Clearwater Lake. Four dead chicks were found at Swan Lake in 1985, one with two puncture wounds approximately 2.5 cm apart. The same day, an egg was found with a single puncture. At the same site, a decapitated adult was found. In 1986, pieces of two adults were found at Swan Lake: one head, three wings and two backs with tails. Decapitated birds are characteristic of Great Horned Owl kills. Vermeer (1970) found seven decapitated adults in a California (*L. californicus*) and Ring-billed gull colony, and feathers of a Great Horned Owl in the same area. In 1986 a Great Horned Owl was seen once at Swan Lake during the breeding season, and several were seen at Mother Lake both during and after the breeding season. Mink and Black-crowned Night Herons (*Nyctocorax nycticorax*) were present at all study sites and also may have consumed Forester's Terns (Errington 1967; Collins 1970).

Although nests located in wetlands are vulnerable to wave and storm damage and to aquatic and aerial predators, natural selection theory predicts that individuals utilizing this habitat encounter greater benefits than costs (Burger 1974; McNicholl 1982). For example, marshes provide an abundant and diverse food supply (e.g. fish, insects) (Weller 1981). Nesting in marshes over water also decreases the chance of predation from mammals such as foxes (*Vulpes vulpes*) and skunks (*Mephitis mephitis*). The advantages of abundant food and protection from mammalian predators presumably outweigh the disadvantages of avian predation and wave and storm damage for marsh-nesters.

Conservation of Forster's Terns in Minnesota.--The current status of Forster's Terns in Minnesota is that of "Special Concern". Our estimate of 900 to 1000 pairs is significantly lower than the largest previous estimate of 2500 pairs in 1942 (MDNR CWDB). We recommend annual spring visits and nest censuses of the historically important breeding sites (e.g.*Swan Lake, Clearwater Lake,*Lake Osakis, Agassiz National Wildlife Refuge, and North Heron Lake), and late June to mid-July fledgling counts. These visits will result in an estimate of reproductive success for each site and for the state breeding population. Aditionally, we recommend protecting traditional colony sites against permanent drainage so that Forster's Terns will continue to have alternative nesting habitat available during a range of environmental conditions. Finally, we encourage a coordinated census effort by all states and provinces in the Northern Great Plains region to evaluate the current status of this species throughout its primary breeding range.

LITERATURE CITED

American Ornithologists' Union. 1983. Checklist of North American Birds. 6th Ed. Lawrence, Kansas, USA: Allen Press

Austin, O.L. 1942. The life span of the Common Tern (Sterna hirundo). Bird-Banding 13:159-176.

Bent, A.C. 1917. Life histories of North American marsh birds. Smithsonian Institution U.S. Nat. Museum, Bull. 135.

Bergman, R.D., P. Swain, and N.W. Weller. 1970. A comparative study of nesting Forster's and Black Terns. Wilson Bull. 82:435-444.

Burger, J. 1973. Competition between American Coots and Franklin Gulls for nest sites and egg predation by the coots. Wilson Bull. 85:449-451.

_____. 1974. Breeding adaptations of Franklin Gull (Larus pipixcan) to a marsh habitat. Anim. Behav. 22:521-567.

_____. and F. Lesser. 1979. Breeding behavior and success in salt marsh Common Tern colonies. Bird-Banding 50:322-337.

Coffin, B. and L. Pfannmuller, eds. 1988. Minnesota's Endangered Flora and Fauna. U of MN Press, Minneapolis.

Collins, C.T. 1970. The Black-crowned Night Heron as a predator of tern chicks. Auk 87:584-586.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, Fish and Wildlife Service, United States Department of the Interior, United States Government Printing Office.

Cuthbert, N.L. 1954. A nesting study of the Black Tern in Michigan. Auk 71:36-63.

DiCostanzo, J. 1980. Population dynamics of a Common Tern colony. J. Field Ornith. 51:229-243.

Edwards, E.P. 1982. A coded workbook of birds of the world, vol. 1. Sweet Briar, VA.: Ernest P. Edwards.

Errington, P. 1967. Of Predation and Life. Ames, Iowa: Iowa State University Press.

Fox, E. 1960. Forster's Tern and Western Grebe nest at Regina. Blue Jay 18:156.

Guertin, D.S. and L.A. Pfannmuller. 1985. Colonial waterbirds in Minnesota: An update of their distribution and abundance. Loon 57:67-78.

Houston, C.S. 1973. Hazards found by colonial birds. Blue Jay 20:74-77.

Kearns, S.K., ed. 1985. Bureau of Endangered Resources Annual Report. Wisconsin Endangered Resources Report 20.

Koonz, W.H. and P.W. Rakowaski. 1985. Status of colonial waterbirds nesting in southern Manitoba. Canadian Field-Nat. 99:19-29.

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

McCaskie, R.G. and E.A. Pugh. 1964. Regional Reports: Nesting season, June 1 - Aug. 15, 1964. Audubon Field Notes 22:586-650.

McNicholl, M.K. 1971. The breeding biology and ecology of Forster's Tern (Sterna forsteri) at Delta, Manitoba. University of Manitoba, unpubl. M.S. thesis.

______. 1975. Larid site tenacity and group adherence in relation to habitat. Auk 92:98-104.

______, 1982. Factors affecting reproductive success of Forster's Terns at Delta Marsh, Manitoba. Col. Waterbirds 5:32-38.

Minnesota Conservation Department, Division of Waters, Soils, and Minerals. 1968. An Inventory of Minnesota lakes. St. Paul, Minnesota.

Mitchell, E.T. 1941. Nesting of Forster's Tern in Hennepin County. Flicker 13:19.

Nickell, W.P. 1964. Some mammal predators in a colony of Common Terns. Bird-Banding 35:40.

Nisbet, I.C.T. 1978. Population models for Common Terns in Massachusetts. Bird-Banding 49:50-58.

Nisbet, I.C.T. and W.H. Drury. 1972. Measuring breeding success in Common and Roseate terns. Bird-Banding 43:97-106.

Nuechterlein, G. 1980. Courtship behavior of the Western Grebe. University of Minnesota, Unpubl. Ph.D. thesis.

Ohlendorf, H.M., F.C. Schaffner, T.W. Custer and C.J. Stafford. 1985. Reproduction and organochlorine contaminants in terns at San Diego Bay. Col. Waterbirds 8:42-53.

Peabody, R.P.B. 1896. A tern study. Osprey 1:1-3.

Pessino, C.M. 1968. Red-winged Blackbird destroys eggs of Common and Roseate Terns. Auk 85:513.

Provost, M.W. 1947. Nesting of birds in marshes of northwest Iowa. Am. Midland Nat. 38:485-503.

Rockwell, R.B. 1911. Notes on the nesting of the Forster's and Black Terns in Colorado. Condor 13:57-63.

Schultz, D.F. 1985. The Swan Lake waterfowl study. Minneapolis, Minnesota; Minnesota Waterfowl Association, Inc.

Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. Their extent and their value to waterfowl and other wildlife. U.S. Fish and Wildlife Service. Circular 39.

Shedd, M. and S. Wilson. 1987. The summer season: June 1-July 1, 1986. Loon 59:19-35

Sokal, R.R. and F.J. Rohlf. 1981. Biometry. New York, New York: W. H. Freeman and Company.

Stewart, R.E. 1975. Breeding Birds of North Dakota. Fargo, North Dakota: Tri-college Center for Environmental Studies.

Techlow, A.F. III. 1983. Forster's Tern nesting platform study. Madison, Wisconsin, Wisconsin Department of Natural Resources Bureau of Research. Unpubl. report.

Vermeer, K. 1970. Breeding biology of California and Ring-billed Gulls: A study of ecological adaptation to the inland habitat. Canadian Wildlife Serv. Report Series. #12.

Weller, M.W. 1981. Freshwater Marshes: Ecology and Wildlife Management. Minneapolis, Minnesota: University of Minnesota Press.

Zuranich, J.R. 1963. Forster's Terns breeding in Kansas. Kansas Ornithological Society Bulletin 14:1-3.

TABLE 1

Forster's Tern colony sizes in Minnesota: 1985-1986

Site	County	1985		1986	
		Census Date	No. Nests	Census Date	No. Nests
Agassiz NWR[1]	Marshall	June	50	June	300
Clearwater Lake	Wright	6/3	132	6/4	0
Coon Creek	Lyon	6/2	0	6/24	5
Fisher Lake	Scott	6/3	0	6/3	0
Lake Osakis	Todd	6/5	198	6/4	0
Lake Reno[2]	Pope	--	--	June	100
Marsh Lake[3]	Big Stone	--	--	June	6
Monogalia[3]	Kandiyohi	June	9	--	--
Mother Lake	Hennepin	6/4	27	6/7	43
N. Heron Lake	Jackson	6/2	29	6	207
N. Middle Lake[3]	Nicollet	June	5	7/11	0
Swan Lake	Nicollet	6/12-19	326	6/9-13	318
Tamarac Lake[4]	Becker	June	28	6/5	2
Thief Lake	Marshall	6/6	0	6/5	1
Upper Rice Lake	Clearwater	6/6	13	6/5	1
Wood Lake	Hennepin	6/4	0	6/7	10
Total Nests			817		893

1 censused by J. Mattson
2 censused by N. Hiemenz
3 censused by J. Schladweiler
4 censused by K. Haws

TABLE 2

Clutch size of Forster's Terns in Minnesota in 1985, 1986

Colony Site	Date	No. Nests	Clutch Size
Clearwater Lake	6/3/85	134	2.74
Lake Osakis	6/5/85	198	2.47
Mother Lake	6/4/85	27	1.07
	6/7/86	43	1.79
N. Heron Lake	6/2/85	29	2.28
Swan Lake	6/12/85	254	2.20
	6/9/86	318	2.41
Upper Rice Lake	6/6/85	13	2.54
Wood Lake	6/7/86	10	2.50
TOTAL SAMPLE SIZE	1985	655	
	1986	371	
TOTAL MEAN CLUTCH SIZE	1985	2.22	
	1986	2.23	
TOTAL MODAL CLUTCH SIZE	1985	3	
	1986	3	

TABLE 3

Forster's Tern breeding success in 1985, 1986

Colony Site	Year	Hatching Success	Fledging Success	Reproductive Success
Clearwater Lake	1985	0.328	0.172	0.458
Mother Lake	1985	0.000	0.000	0.000
	1986	0.200	0.000	0.000
Swan Lake	1985	0.198	0.060	0.156
	1986	0.333	0.053	0.125

TABLE 4

Fates of unhatched Forster's Tern eggs and unfledged chicks: A summary

Site	Year	Monitored nests	Total eggs	Unhatched eggs	Chicks hatched	Unfledged chicks
Clearwater Lake	1985	24	64	43	21	10
Mother Lake	1985	11	22	22	0	0
	1986	2	5	4	1	1
Swan Lake	1985	45	116	93	23	16
	1986	32	75	50	25	21
TOTAL		149	282	212	70	48

TABLE 5

Fates of unhatched Forster's Tern eggs and unfledged Common Tern chicks

Colony Site	Year	Unhatched Eggs			Unfledged Chicks	
		Disappeared	Deserted	Nonviable	Disappeared	Dead
Clearwater Lake	1985	24	18	1	9	1
Mother Lake	1985	22	0	0	0	0
	1986	3	1	0	1	0
Swan Lake	1985	88	3	1	16	0
	1986	34	14	2	21	0
TOTALS	1985	134	21	2	25	1
	1986	37	15	2	22	0