COLONY SITE AND NEST SITE SELECTION BY EARED GREBES IN MINNESOTA

FINAL REPORT submitted to the
NONGAME WILDLIFE PROGRAM of the
MINNESOTA DEPARTMENT OF NATURAL RESOURCES

31 May 1990

Prepared by
Janet Boe, M.S.
Graduate Student
Zoology Department
North Dakota State University
Fargo, ND 58105

Under the direction of
Gary L. Nuechterlein, Ph.D.
Associate Professor
Zoology Department
North Dakota State University
Fargo, ND 58105

INTRODUCTION

Objectives

Eared grebe (Podiceps nigricollis) colonies in Minnesota are located on prairie lakes, mostly in the western half of the state. In 1980 breeding was reported at eight locations (Guertin and Pfannmuller 1985).

Although not considered rare or threatened (except as all waterbirds are threatened by wetland loss), they are nevertheless vulnerable because of their habit of nesting colonially. This study was begun in 1986 to determine factors important in the selection of particular wetlands as nesting sites by eared grebes, to determine characteristics important in the selection of a colony site within the wetland, and to study the selection of nest sites within the colony.

Review of Eared Grebe Biology

Minnesota's eared grebe colony sites mark the eastern edge of this species' breeding range in North America. Eared grebes are found during the breeding season on wetlands throughout the prairie provinces of Canada, the Great Plains and Great Basin of the United States and, to a lesser extent, in Mexico.

Following a breeding effort many grebes make a molt migration in late July or August to invertebrate-rich, western lakes including Mono Lake in California and Great Salt Lake in Utah. At Mono Lake they congregate by the hundreds of thousands to feed on the abundant brine shrimp (Artemia sp.) and to molt (Jehl 1988). As the invertebrate food supply at these large staging lakes declines in late fall or early winter, grebes continue on to their wintering grounds, principally the Salton Sea in California, the Gulf of California, the Gulf coast of Texas, the southern California coast, and the Pacific and Gulf coasts of Mexico.

Jehl and Yochem (1985) analyzed eared grebe band returns and deduced that grebes breeding in central North America migrate south or southeasterly and winter in northeastern Mexico and along the Gulf Coast, that grebes from the central and eastern Great Basin stage at Great Salt Lake and winter at the Salton Sea or the Gulf of California, and that birds breeding in the western Great Basin and western Canada stage at Mono Lake and also winter on the Salton Sea or the Gulf of California.

Three subspecies have been described. These include P. n. californicus of North America, P. n. nigricollis of central and southern Europe and parts of Asia, and P. n. gurneyi of southern and eastern Africa. Outside of North America the species is often referred to as the black-necked grebe.

The eared grebe is one of 20 grebe species worldwide. Storer (1963) suggested that the silvery grebe (Podiceps occidentalis) and Puna grebe (Podiceps taczanowskii) of South America resulted from an invasion by the eared grebe from the north. He reports that they are members of a group of six closely related species that also includes the red-necked grebe (Podiceps grisegena), great crested grebe (Podiceps cristatus) and horned grebe (Podiceps auritus). Fjeldsa (1982) states that ethological data suggest that the eared, Puna, silvery, and hooded (Podiceps gallardoi; discovered in South America in 1974) grebes are more closely related to one another than this group of four is to the horned, red-necked and great crested grebes. These four species also share a similar small body size and the habit of nesting colonially.

Grebes are renowned for their elaborate courtship behavior. Nearly all species have been studied in this regard (see, e.g., Hartley 1937, Simmons 1954, Nuechterlein and Storer 1982, Storer 1969, Fjeldsa 1985, Storer 1975). McAllister (1958) and Storer (unpublished ms.) described eared grebe courtship behavior. Although McAllister (1958) observed courtship on the breeding grounds, much eared grebe courtship probably also takes place during migration (Palmer 1962).

The food of eared grebes throughout the year consists almost exclusively of invertebrates; during the breeding season they feed principally on insect adults or larvae (Cramp and Simmons 1977). Of 27 grebe stomachs collected at various localities in the western U.S., 40 % contained Heteroptera, including water boatmen (Corixidae), giant water bugs (Belostomatidae), and back-swimmers (Notonectidae) (Wetmore 1924). Other insects found in lesser amounts included dragonfly and damselfly nymphs (Odonata), caddisfly larvae (Trichoptera), and beetle (Coleoptera) adults and larvae such as predacious diving beetles (Dystiscidae) and water scavenger beetles (Hydrophilidae). Eared grebes usually dive to capture free-swimming prey or to remove invertebrates from firm substrates (Jehl 1988) but may also take food items from the surface of the water (Wetmore 1924) or catch flying insects just above the water surface (Cramp and Simmons 1977). Eared grebes use shallow, eutrophic wetlands for nesting. Faaborg (1976) found eared grebes using large, shallow potholes with abundant open water. Johnsgard (1979) observed that most nesting areas had extensive beds of submergent vegetation.

Grebes build overwater nests of available materials. Nests may be built on a bed of floating vegetation or anchored to emergent stems. Both members of the pair build the nest, incubate the usually 3-4 eggs for 21-22 days, and back-brood and feed the precocial, seminidifugous young. Since incubation begins with the first egg, hatching is asynchronous. Nests are abandoned shortly after hatching is complete.

Colony locations change frequently and are influenced greatly by changes in water level (Cramp and Simmons 1977). Colony sizes vary from a few nests to hundreds or thousands. The size of a colony may be related to the size of the wetland used (Breault, 1987).

For excellent reviews of eared grebe biology, see Johnsgard (1987), Cramp and Simmons (1977), or Palmer (1962).

II. METHODS AND STUDY SITES

A. SURVEYS

In 1987, 1988, and 1989 I surveyed western wetlands for eared grebe colonies. Surveys were conducted in late May, June, and early July. In some cases I enlisted the help of Department of Natural Resources (DNR) or U.S. Fish and Wildlife Service (USFWS) employees. Surveys were completed by airboat (Agassiz National Wildlife Refuge (NWR)), canoe with 3-6 hp gas motor (Thief Lake, Swan Lake), or canoe (with or without electric motor) and/or 15-60X spotting scope (all other lakes). Initially I focused on checking previously recorded colony sites, but I also consulted with area wildlife managers for other likely candidate lakes.

B. WETLAND SELECTION

In 1986 I compared the group of wetlands that had been used for nesting by eared grebes in one or more years since 1979 to a stratified random sample of unused wetlands in western and southern Minnesota. First a county was selected randomly from a pool of counties containing used wetlands or very similar in location and topography to those counties. Next, the selected county's lake file at the DNR's Division of Waters office in St. Paul was pulled, and an unused lake matching the used wetland group in size and type was randomly selected by lake number. This process was repeated until 27 unused lakes had been chosen. Fifty wetlands were visited during 1986; of these, 27 were unused and 23 were used. Of the 23 used, 9 had nests or young in 1986.

I made one visit to each used and unused lake from late June to early August, starting in the south. Since Agricultural Stabilization and Conservation Service (ASCS) photography was to be used to make some of the comparisons between used and unused lakes, visits were planned to coincide approximately with ASCS flights in the area. At each lake, crude maps of vegetation were made to aid in interpretation of ASCS aerial photography.

Notes on lake use, surrounding land use, and birds present were made at each wetland.

After receipt of ASCS aerial slides later that fall, a projector mounted vertically and manual or computerized planimeters were used to determine the amount of open water and emergent vegetation at each lake. Topographic maps and aerial slides were used to determine cultural features of the lake. DNR lake files were consulted for lake depths.

Characteristics of used lakes were compared to those of unused lakes, and nonparametric statistical tests were used to determine the significance of any differences. Only lakes used by eared grebes in 1986 were used in the comparison of characteristics that might be expected to change from year to year.

C. COLONY SITE SELECTION

In 1987-1989 low level 35 mm aerial photography was used to document vegetation conditions on 9 wetlands soon after colonies were established, and at 2 colonies not found until July ASCS photography was used. Mosaics were then constructed from the low level photographs, and black and white prints were made of these mosaics at Northern Prairie Wildlife Research Center (NPWRC) in Jamestown, N.D. The location of the colony or colonies was marked on each mosaic or ASCS photograph, and in future analyses the location of each colony will be compared to randomly selected locations.

D. NEST SITE SELECTION

Each nest was marked using 2 m long, 1 cm diameter steel rods. Eggs were counted, numbered with waterproof black ink (at 9 of 12 colonies), and floated (Westerkov, 1950; Schreiber, 1970; Nuechterlein, 1975) to determine stage of incubation and order of laying. Nests were checked at least twice (once after discovery of the colony, once shortly after colony abandonment). At each visit, new eggs were recorded and floated, old eggs were floated, and nests were checked for evidence of hatch (shell fragments without membranes; Girard 1939). Estimated distance and direction from at least one other nest were also recorded for each nest, to help locate the individually numbered nests on aerial photos (see below).

Following colony abandonment, the marking posts were fitted with spray painted plastic gallon milk bottles and a low-level aerial photograph was taken of each "bottle colony". Information recorded earlier in the colony was used to match each bottle in the photo to the numbered nest that it represented. In several cases I took the finished aerial photo of the colony onto the lake to match the bottle in the photo to the numbered post/bottle on the lake.

Nearest neighbor distances were calculated using MIPS (Map and Image Processing System; MicroImages, Inc., Lincoln, NE) at NPWRC.

Using these colony maps in conjunction with the egg information recorded at each nest site makes it possible to determine the pattern of colony establishment, to compare the nest success (hatching of at least one egg) of interior nests to peripheral nests, to compare the success of early nests to late nests, and to relate nest placement and success to vegetation features.

E. STUDY SITES

Surveys were conducted statewide. Individual nests were marked in 12 colonies on 9 lakes in 7 western or southern Minnesota counties during the 3 field seasons of 1987-1989 (Table 1).

III. RESULTS AND DISCUSSION

A. Survey Results

Surveying for eared grebe colonies is like playing an enormous version of the shell game. Colony locations change from year to year as conditions in wetlands change. A marsh holding a colony in one year may be too deep or too shallow the following year. Or, if a marsh system is colonized in consecutive years, the colony location within the marsh will likely change. All this site shifting serves to make surveying for these colonies a very time- and energy-consuming process.

Eared grebes appear to sample a variety of lakes upon returning from their wintering grounds. Bird watchers often see grebes on lakes in early May on which they have never been known to nest. During summer as well grebes may occasionally be seen on lakes on which no nesting will occur; these birds may be late nesters or may have had their colony washed out elsewhere and are between nesting attempts. In any case, the presence of eared grebes on a lake, even in a group, does not necessarily mean that nesting has taken or will take place there.

Figure 1 shows the location of colonies found in 1986-1989. At least 650-1050 pairs nested in the state each year.

B. Wetland Selection

Used wetlands were significantly ($P < 0.05$) shallower than unused wetlands. They also received less human disturbance during the breeding season than did unused wetlands and were less lkely to have designated public accesses. The presence of a town nearby didn't seem to interfere with grebe use of the wetland, as long as humans stayed off the water. There was no significant difference in the percent of emergent fringe (almost exclusively _Typha_ sp.) between the two groups.

Submerged vegetation did not show reliably on aerial photography. However in a comparison of ratings given each lake in the field (low, medium, high), originally intended as a check on the aerial photos, the used wetlands tended to have more submergent vegetation.

Most wetlands used by grebes for nesting are Type 4 semipermanent wetlands, with 80 acres (about 32 ha) as a lower limit in size and no upper limit. They are shallow, often with a maximum depth of 3 m; have emergent vegetation or do not; have abundant submerged vegetation, or, as found in 1989, have no submerged vegetation following a recent drawdown but have some sort of emergent vegetation; include from 50 to 100 % open water; and have little or no human disturbance during the breeding season (no swimming beaches, waterskiing or motorized fishing boats).

C. Colony Site Selection

Mosaics of study lakes were composed using aerial photos taken soon after discovery of a colony. Photocopies of black and white prints of colony lakes are included in Appendix A, with the location of the colony indicated by a "C".

Swenson Lake-1987

Twenty nests were built on a floating mat of the filamentous green alga _Spirogyra_ sp. toward the south end of the lake. The nests were washed out in a storm that came through about two weeks into incubation.

West Toqua Lake-1987

Seventy three nests were built in a bed of stubby, dead cattail stems.

West Toqua Lake-1988

One hundred and twenty nests were built in a bed of stubby, dead cattail stems; note the location was not the same as 1987.

Salt Lake-1988

Fifteen nests were built on a dense mat of sago (Potamogeton pectinatus).

Thief Lake-1988

About 600 nests were strung out in bulrush (Scirpus sp.) islands and nearby beds of submerged vegetation in the northeast part of the lake. A storm came through, some nests were washed out, renesting ensued, and the total number of marked nests reached 876.

Swan Lake-1988

About 325 nests were packed into a bulrush island in the northeast part of the lake.

Ash Lake-1989

About 90 nests were built in a flooded cottonwood (Populus deltoides) and willow (Salix interior and S. amygdaloides) stand that came up during a recent drawdown.

Lane Lake-1989

Eighteen nests were built on a floating mat of bladderwort (Utricularia vulgaris) and filamentous green algae.

Harstad Slough-1989

About 30 nests were built in stubby, dead cattails in a mixed colony with western grebes (Aechmophorus occidentalis; 5 nests.) These nests washed out in high winds, and, the following day, renesting took place farther out on the lake in a bed of coontail (Ceratophyllum demersum) and dead cattail stems and rhizomes. Eventually about 90 nests were marked in that colony, although washout and renesting rates were high on the lakeward side of the colony.

Thief Lake-1989

About 400 nests were located in a few adjoining bulrush islands in the northeast part of the lake.

Mud Lake-1989

About 140 nests were located in a stand of what appeared to be dead willow that was exposed by the low water levels. Although still officially in drawdown, about 50 cm of water flooded the stand.

Appendix B contains photos of nests at each of the colonies marked and includes anecdotal information about the colonies.

D. Date of Initiation

Table 2 summarizes information on the onset of egg-laying for colonies marked in 1987-89. The earliest nests marked were those at West Toqua Lake on 25 May 1988. About half of the marked colonies were found and marked during the last 3 weeks of June.

E. Length of Laying

Darling (1938) predicted an increase in nesting synchrony with an increase in colony size. In three colonies for which I have evaluated nesting synchrony (Swenson 1987, West Toqua 1987, and Swan Lake 1988) this increase is not apparent. However, there is considerable intercolony variability in this characteristic, and it might be that a pattern will appear with evaluation of the remaining colonies.

F. Colony substrate and water depth

Because of the close proximity of nests, there is little variation in water depths measured at nests within a colony. There is, however, some variation among colonies in the average depths at their nests. The deepest water was at Swenson Lake in 1987 where the average depth was 114 cm. The shallowest was at Mud Lake in 1989 where the average depth at a representative sample of nests was 50 cm. Table 3 gives the average depth at a representative sample of nests in each marked colony.

A variety of nesting substrates was used. Some colonies of nests were built in the open on mats of filamentous green algae (Swenson Lake 1987) or mats of aquatic macrophytes (Salt Lake 1988, Lane Lake 1989, Harstad Slough renesting 1989). Others were located in open situations with stubby, dead cattails to anchor nests (West Toqua 1987, Harstad Slough original 1989, West Toqua 1988). The remainder of the marked colonies were in bulrush islands (Thief Lake 1988, Thief Lake 1989, Swan Lake 1988), stands of flooded cottonwood and willow saplings (Ash Lake 1989), or dead willow exposed following a drawdown (Mud Lake 1989).

G. Pattern of colony establishment

Territoriality (nest defense), social attraction, and vegetation structure play important roles in determining the pattern of colony establishment. While some colonial species have been shown to nest from the center outward, at least some of the grebe colonies I studied were formed by filling in a skeleton established by the earliest nests.

H. Clutch size

Both Palmer (1962) and Cramp and Simmons (1977) reported that eggs per clutch ranged from 1 to 6 with a mean of between 3 and 4. The mean number of eggs per clutch ranged from 2.6 to 3.5 for colonies in this study (Table 4), and individual clutch sizes ranged from 1 to 7. In a few cases one or two eggs in large clutches were markedly different in size and shape from the rest of the clutch, suggesting that more than one female contributed to the nest.

Occasionally, in the very early stages of colony establishment, I found dump nests, where various females had laid eggs in a common nest. Those I found held about 10 eggs, while other nests in the colony were still only platforms or held 1 or 2 eggs.

I. Nest success

Nest success varied widely from colony to colony (Table 1). Some colonies were completely destroyed before any eggs hatched (Harstad Slough I-1989, unmarked colonies at Thief Lake and the East Grand Forks sewage lagoon, and Swenson Lake-1987). Others were abandoned before most eggs hatched (Mud Lake-1989), suffered one or more partial but major washouts (Thief Lake-1988, Thief Lake-1989) or were plagued by chronic, small-scale washouts or abandonments, with or without renesting (Harstad Slough II-1989, Lane Lake-1989, Salt Lake-1988). Other colonies were quite successful (West Toqua Lake-1987 and 1988, and Swan Lake-1988).

J. Causes of nest destruction

Most destroyed nests were washed out by wave action resulting from high winds with or without accompanying rain or hail. In some cases nests were deserted after storms severe enough to wash eggs out of nests but not so severe that nests were destroyed; the deserted nests, lacking the required daily upkeep, soon disintegrated under normal wind conditions.

K. Nest site selection

Timing of laying at peripheral nests was compared to that of inner nests at three lakes. Peripheral nests were no more likely to be late nests than were inner nests at Swenson Lake or West Toqua Lake 1987. At Swan Lake, however, earlier nests tended to be on the inside.

Although analyses have not been completed, it is apparent that vegetation pattern plays an important role in nest site selection within most colonies. For example, on aerial photographs of the West Toqua colonies in 1987 and 1988 and the Harstad Slough colonies in 1989, it is quite apparent that nests were placed in clumps of dead cattail. Any role of vegetation pattern at colonies on mats of dense submergent vegetation will be more difficult to discern, however; one spot on the mat looks very much like every other spot. At these colonies social attraction and territoriality may be more important in determining nest site selection than vegetation pattern.

Appendix C contains photocopies of overlays showing the pattern of nests at each colony.

L. Predation

Table 5 gives an indication of the amount of predation noted at each marked colony.

Breault and Cheng (1988) reported significant mink (Mustela vison) predation at an eared grebe colony in British Columbia. Predation rates were very low at all of the colonies in this study, however, and I saw no evidence of mink predation. At most, 1 or 2 eggs from a relatively few nests were destroyed, usually by American coots (Fulica americana). Occasionally, when I was checking eggs and the grebes were off their nests, yellow-headed blackbirds (Xanthocephalus xanthocephalus) would travel from grebe nest to grebe nest, searching for the invertebrates that always seemed to be in the vegetation of the nest. Once or twice, as I reached a nest that a blackbird had just left, I noticed a single, fresh, very small peck in one egg and was convinced that the blackbird had made it. Oring (unpublished, in Pickett et. al. 1988) also suspected predation of spotted sandpiper (Actitis macularia) eggs by yellow-headed blackbirds.

At Thief Lake I observed harassment of eared grebes by both Franklin's gulls (Larus pipixcan) and Forster's terns (Sterna forsteri). One or two gulls or terns would swoop low and fast over a grebe, causing the grebe to "crash dive".

One or two dead adult grebes were found at a few colonies in this study. A few were intact; the remaining few were in various states of dismemberment or stages of decomposition.

M. Colony abandonment

Usually the birds abandoned the colony when all or most eggs had hatched. In a few cases, one or two pairs remained, incubating the last of their eggs while other colony members were with their young in another part of the lake. At West Toqua in 1987 a storm came through when some nests had one egg remaining; although nests were not destroyed, the disturbance seemed to be enough to cause the birds to abandon the colony (G. Nuechterlein, pers. comm.). At Mud Lake in 1989 the colony was abandoned before all eggs hatched in most nests. When checked on 6 July water depths at nests had dropped 16 cm from the already low depths on 21 June (see Table 3) when the nests were marked. In addition, a group of black-crowned night herons (Nycticorax nycticorax) was seen near the colony around the time it was abandoned. Although the reason for colony abandonment is not known, the combination of low water levels and heron disturbance may have contributed to the move.

In some colonies storms severe enough to damage nests caused abandonment and perhaps renesting elsewhere, while in other colonies birds revamped what remained of the original nests and started laying eggs again.

O. Weather/destruction of nests (Thief Lake)

In 1988 a storm came through after nests in a large colony at Thief Lake were marked. Information obtained by checking nests and marking new nests on subsequent visits should allow a determination of "safe" nest locations during that storm. It appears that, not surprisingly, nests built on submergent beds and those in the smallest, sparsest bulrush (Scirpus acutus) islands were the hardest hit.

P. Mixed colonies

Occasionally colonies were found that included other species. The grebe colony at Swan Lake in 1988 included a discrete group of 8 Forster's tern nests. The original Harstad Slough colony in 1989 included 5 western grebe nests. An unmarked colony at Thief Lake in 1987 was located immediately adjacent to a black-crowned night heron colony and a Franklin's gull colony.

Q. Human disturbance/ Nest checks

Colonies varied in the excitability of their members. At some colonies the birds seemed quite tolerant and patient, while at others they were off their nests before I entered the colony and were reluctant to return until I left. The degree of excitability seemed to be a colony characteristic and seemed to depend in part on the location and configuration of the nests.

Grebes (not necessarily nesting colonies) and other birds at water treatment ponds were very "nervous", moving to the far end of the cells when a car entered the area. This is probably due to frequent harassment by persons with shotguns, judging by the spent shells lying on the dikes. At other colonies, e.g. those at West Toqua and Swenson lakes, birds were quite tame and allowed relatively close approach before leaving their nests. Birds at these colonies would then return to their nests when we were far enough away (usually about 20-30 m, but variable) from their nest, even while still working in the colony. At other colonies, when the human disturbance was in the colony but far enough away (about 40-50 m at Swan Lake) from their nests, birds might return to incubate or might just check their eggs, then leave again. Birds off their nests congregated in a group not far from the nests, which allowed us to monitor their activity and assess their tolerance level.

In large colonies with tightly packed nests, a mass exodus ensued when humans approached; birds slipped off the nest into the water and formed a group nearby. At colonies where nests were farther apart, those distant from the disturbance seemed to bide their time until the disturbance reached a certain minimum distance from them, then they too left their nests.

Although 1/2 hour was set as an upper limit of time for individual birds to be off nests, this was not always met in large colonies, especially those with tightly packed nests. It was important to keep an eye on the grebes to determine their "state of mind"; If birds became quite agitated I hurried to finish my work in the colony and allow birds back on their nests. In some cases, I left a large colony with my nest check unfinished because of the time it was taking but returned later in the day to finish.

Human disturbance in a colony leaves the door open for coots to harass off-nest birds or to peck eggs of unattended nests. This was more of a problem at the periphery of colonies, particularly in dense emergent vegetation.

R. Interactions with waterfowl, other waterbirds

Although tending to feed with other grebes, occasionally one or a few grebes would form feeding assemblages with (especially) ruddy ducks (Oxyura jamaicensis), mallards (Anas platyrhynchos), blue-winged teal (Anas discors), and other ducks. Interactions with waterfowl were rarely antagonistic. I did observe, however, a ruddy duck thoroughly intimidated by a grebe defending its nest as the duck tried to pass through the colony.

Some interactions with Franklin's gulls, Forster's terns, yellow-headed blackbirds, and coots were mentioned earlier in this report.

All told, coots interfered the most with eared grebes, likely because of their preference for and abundance on the same semipermanent wetlands. Coots may "steal" a newly built nest from a grebe to use as a roosting platform. Occasionally eggs pecked by a coots were found (see discussion of predation). At Swan Lake coots built a nest over a grebe nest with eggs in it, and, in the same colony, a few grebe nests contained a coot egg in addition to grebe eggs. As the last eggs were hatching in some colonies, numerous coots swam through and took over abandoned nests as roosting platforms. Disputes between such roosting coots may have contributed to early abandonment of some late nests (G. Nuechterlein, pers. comm.).

S. Drought effects

The severe drought in western Minnesota in 1988 provided an opportunity to observe activities of grebes during a dry year. Although grebes were present on smaller wetlands early in the season (May), as hot, dry conditions persisted they congregated on the largest wetlands (Thief Lake, Swan Lake, probably Agassiz National Wildlife Refuge), forming large colonies there. Nesting also started earlier at Thief Lake and West Toqua Lake than in other years; the earliest nests marked in this study were at West Toqua Lake in May 1988.

T. Management recommendations

In addition to basic wetland conservation (i.e., a "no net loss" policy and control of pollution and erosion), I would like to make the following recommendations regarding eared grebe management:

1) Reinstitute game lake surveys.

Justification: The most recent information in DNR lake files on depth, vegetation, and other characteristics of some non-fishing lakes comes from 1949-1950 game lake surveys. Given the critical status of wetlands, more up-to-date information is needed. The invertebrates and vegetation found in these lakes are important to waterbirds as well as waterfowl. In addition to gathering information that would increase our understanding of wetland dynamics, trained observers could record wildlife and note human impact on these wetlands periodically.

2) Enlist the help of field biologists in other disciplines and agencies in the location of waterbird colonies, especially those species with unstable colony locations. A supply of postcard forms could be distributed to cooperating agencies.

Justification: Surveys for colonial waterbirds can be time- and labor- intensive. More information could be gathered with little or no additional expense if the help of others already in the field for other reasons could be requested.

3) Survey for eared grebe colonies during the last three weeks of June. In hot, dry years shift one week earlier; in years with late springs shift one week later.

Justification: Most colonies that I marked were active during the last three weeks of June. In waterfowl, and apparently in eared grebes as well, nesting begins earlier in warm years. Colonies tend to begin nesting later at Thief Lake and Agassiz NWR than at other locations. Those colonies nesting solely on submerged vegetation beds (e.g., Salt Lake and the water treatment ponds at Breckenridge and East Grand Forks) tend to establish later than other colonies.

4) Keep a record of surveyed lakes on which grebes were not found in a given year as well as those on which colonies were found.

Justification: This information will give a better estimate of the number of grebe nests in the state in a given year. It will also, over the years, help to predict which lakes might be used under differing spring water conditions.

5) Record as a colony only those lakes on which nests or birds with back-brooded or downy young are found.

Justification: Grebes may feed on various lakes before nesting on a particular lake. A group of grebes on a lake may indicate an interest in nesting on the lake, but if conditions do not prove right, they may abandon the lake for another within a few weeks. I observed this at the Breckenridge Water Treatment Ponds, Salt Lake, and Clear Lake.

At Clear Lake and the Breckenridge Water Treatment Ponds I also observed adults with about 3/4 grown young in years in which I had watched each waterbody closely during the summer and had seen no nesting. Although the age of fledging is not known for eared grebes, it is likely that these flew from a colony elsewhere. Unlike ducks, grebes will not walk young from one wetland to another, hence the presence of flightless young indicates a colony site.

6) Large colonies may be censused by using aerial photography, possibly while doing other survey or photography work. Once a colony is located, flight guides marking the limits of the colony could be placed, then a low level pass made over the colony to photograph the nests. This was done at Thief Lake in 1988 and 1989. Birds could be seen on the nest, or, if off the nest, eggs could be seen.

Justification: Counting nests in large colonies from the ground can be very time consuming and provide a major disturbance to birds in the colony. Aerial photography could be used if more accuracy than that given by an estimate is desired.

7) Lakes with abundant submerged vegetation and lakes recently flooded following a drawdown (thus lacking submerged vegetation but containing above-water vegetation of some sort) are both good candidates for eared grebe colonies, given that they are larger than about 80 acres (32 ha) and receive minimal human traffic during the summer. When surveying for eared grebe colonies, these, in addition to traditional colony sites, are the types of wetlands that should be checked.

Justification: Lakes with these characteristics provide a nesting substrate, abundant invertebrate food, and minimal disturbance to nesting birds.

IV. ACKNOWLEDGEMENTS

I thank the following current or former DNR employees for help in the field at one time or another during this project: Fred Bengtson, Thom Soule, Katie Haws, Martha Marquardt, Mike Moeller, Larry Petersen, Lee Westfield, Paul Telander, Dennis Simon, Dave Heinzen/Forest Inventory, Cathy Fouchi, John Schladweiler, Todd Eberhardt/Wetland Wildlife Populations Research Group, John Scharf, Dave Soehren, Bob Kirsch, Jon Parker, and Tod Tonsager. This study was supported from 1987-1989 in large part by a grant from the Nongame Wildlife Program, for which I am grateful.

V. LITERATURE CITED

Breault, A.M. 1987. Reproductive success as a function of colony size and breeding chronology in eared grebes in British Columbia. Poster. Symposium on the Ecology and Management of Breeding Waterfowl, Winnipeg, Manitoba.

--- and K.M. Cheng. 1988. Surplus killing of eared grebes, *Podiceps nigricollis*, by mink, *Mustela vison*, in central British Columbia. Can. Fld. Nat. 102:738-739.

Cramp, S.C. and K.E.L. Simmons, eds. 1977. Handbook of the birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic. Vol. 1. Oxford Univ. Press, London.

Darling, F.F. 1938. Bird flocks and the breeding cycle. Cambridge Univ. Press, Cambridge, England.

Faaborg, J. 1976. Habitat selection and territorial behavior of the small grebes of North Dakota. Wils. Bull. 88: 390-399.

Fjeldsa, J. 1982. Some behaviour patterns of four closely related grebes, *Podiceps nigricollis, P. gallardoi, P. occipitalis, P. taczanowskii*, with reflections on phylogeny and adaptive aspects of the evolution of displays. Dansk. Orn. Foren. Tidsskr. 76: 37-68.

---. 1985. Displays of the two primitive grebes *Rollandia rolland* and *R. microptera* and the origin of the complex courtship behavior of the *Podiceps* species (Aves: Podicipedidae). Steenstrupia 11: 133-155.

Girard, G.L. 1939. Notes on life history of the shoveler. Trans. N. Am. Wildl. Conf. 4: 364-371.

Guertin, D.S. and L.A. Pfannmuller. 1985. Colonial waterbirds in Minnesota. Loon 57: 67-78.

Hartley, P.H.T. 1937. The sexual display of the little grebe. Brit. Birds 30: 266-275.

Jehl, J.R.,Jr. 1988. Biology of the eared grebe and Wilson's phalarope in the nonbreeding season: a study of adaptations to saline lakes. Studies in Avian Biology No. 12. Cooper Ornith. Society.

---- and P.K. Yochem. 1986. Movements of eared grebes indicated by banding recoveries. J. Field Ornith. 57: 208-212.

Johnsgard, P. 1979. Birds of the Great Plains. U. Nebr. Press, Lincoln.

--- 1987. Diving birds of North America. U. Nebr. Press, Lincoln.

McAllister, N.M. 1958. Courtship, hostile behavior, nest-establishment and egg laying in the eared grebe (Podiceps caspicus). Auk 75: 290-311.

Nuechterlein, G.L. 1975. Nesting ecology of western grebes on the Delta Marsh, Manitoba. M.S. thesis. Colorado State Univ., Ft. Collins.

--- and R.W. Storer. 1982. The pair-formation displays of the western grebe. Condor 84: 350-369.

Palmer, R.S., ed. 1962. Handbook of North American birds. Vol. 1. Yale Univ. Press, New Haven.

Pickett, P.E., S.J. Maxson, and L.W. Oring. 1988. Interspecific interactions of spotted sandpipers. Wils. Bull. 100: 297-302.

Schreiber, R.W. 1970. Breeding biology of western gulls (Larus occidentalis) on San Nicolas Island, California, 1968. Condor 72: 133-140.

Simmons, K.E.L. 1954. The advertising behavior of the great crested grebe. Bird Study 1:53-56.

Storer, R.W. 1969. The behavior of the horned grebe in spring. Condor 71: 180-205.

--- 1975. The behavior and relationships of the hooded grebe. Natl. Geog. Research Reports.

Westerkov, K. 1950. Methods of determining the age of game bird eggs. J. Wildl. Manage. 14: 56-67.

Wetmore, A. 1924. Food and economic relations of North American grebes. Bull. 1196. U.S. Dept. Agric.

Table 1. Marked eared grebe colonies: nests and nest success.

COUNTY	LAKE	YEAR	# NESTS	% NEST SUCCESS*
Big Stone	Swenson	1987	20	0
Big Stone	W. Toqua	1987	73	85
Marshall	Thief	1988	876	+
Nicollet	Swan	1988	325	75
LacQuiParle	Salt	1988	15	20
Big Stone	W. Toqua	1988	120	75
Grant	Ash	1989	93	57
Marshall	Thief	1989	396	66
Traverse	Mud	1989	147	18
Big Stone	Lane	1989	18	44
Stevens	Harstad Slough I (orig.)	1989	29	0
Stevens	Harstad Slough II (renest.)	1989	88	46

* Nest success = at least one egg hatched or one egg in late stages of incubation at last nest check.

\+ 70 adults, 35 young counted on lake 7/31; many nests destroyed in storm.

Table 2. Colony initiation.

COLONY	DATE MARKED	ESTIM. DATE ONSET LAYING*
Swenson Lk.-1987	7 June	1 June
W. Toqua Lk.-1987	11 June	4 June
Thief Lk.-1988	16 June	10 June
Swan Lk.-1988	7 June	1 June
Salt Lk.-1988	16 July	1 July
W.Toqua Lk.-1988	25 May	6 May
Ash Lk.-1989	27 June	7 June
Thief Lk.-1989	8 July	30 June
Mud Lk.-1989	21 June	1 June
Lane Lk.-1989	13 July	23 June
Harstad Sl.I-1989	11 June	7 June
Harst. Sl.II-1989	23 June	22 June

*Based on flotation of oldest egg.

Table 3. Depth at nests*.

COLONY	n	MEAN DEPTH IN CM.
Swenson Lk.-1987	19	114
W. Toqua Lk.-1987	20	100
Thief Lk.-1988	20	113
Swan Lk.-1988	20	62
Salt Lk.-1988	13	61
W. Toqua Lk.-1988	20	65
Ash Lk.-1989	20	87
Thief Lk.-1989	20	110
Mud Lk.-1989	17	50
Lane Lk.-1989	12	78
Harst. Sl.I-1989	20	93
Harst. Sl. II-1989	16	105

*Depth measured when nests marked.

Table 4. Mean number of eggs per clutch.

COLONY	n	# EGGS
Swenson Lk.-1987	20	3.32
West Toqua Lk.-1987	73	3.59
Thief Lk.-1988	77	2.60*
Swan Lake-1988	325	3.01
Salt Lake-1988	15	3.30
West Toqua Lk.-1988	120	2.66
Ash Lake-1989	93	3.01
Thief Lk.-1989	50	2.80*
Mud Lake-1989	147	3.00
Lane Lake-1989	18	2.85
Harstad Sl.I-1989	29	3.25
Harstad Sl.II-1989	88	2.73

* 77 and 50 representative nests

Table 5. Predation at marked colonies.

COLONY	# PREDATED EGGS	# PREDATED NESTS	PREDATOR
Swenson Lk.-1987	0	0	
W. Toqua Lk.-1987	2	2	? coot
Thief Lk.-1988	15	12	? coot
Swan Lk.-1988	6	6	coot, blackbird
Salt Lk.-1988	2	2	coot
W. Toqua Lk.-1988	2	2	coot
Ash Lk.-1989	0	0	
Thief Lk.-1989	1	1	coot
Mud Lk.-1989	5	4	coot
Lane Lk.-1989	0	0	
Harst. Sl. I-1989	2	1	coot
Harst. Sl. II-1989	1	1	coot

Figure 1. Location of eared grebe colonies reported one or more years 1986-1989. 1=Roseau River Wildlife Management Area (WMA), 2=Thief Lake WMA, 3=Agassiz National Wildlife Refuge, 4= East Grand Forks Water Treatment Ponds, 5= Breckenridge Water Treatment Ponds, 6= Mud Lake, 7= Ash Lake, 8= Helgerson Lake, 9= Harstad Slough, 10= Clear Lake, 11= West Toqua Lake, 12= Lane Lake, 13= Barry Lake, 14= Swenson Lake. 15= Pelican Lake. 16= Shible Lake, 17= Tiger Lake, 18= Salt Lake