COMMON LOON (*Gavia immer*) DENSITY, PRODUCTIVITY, AND NESTING REQUIREMENTS ON THE WHITEFISH CHAIN OF LAKES IN NORTH-CENTRAL MINNESOTA

A field study (senior thesis) submitted
to the Nongame Wildlife Program
of the Minnesota Department
of Natural Resources

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December 1985

ABSTRACT:

From 15 April to 25 August 1985, a field study of the common loon (*Gavia immer*) was conducted on the Whitefish Chain of Lakes in north-central Minnesota. The primary objectives of this study were to determine common loon densities on the ten lakes in the study area, inventory loon breeding pairs, and monitor their productivity. In conjunction with these principal activities, habitat characteristics and other factors which may affect common loon nest location and success were evaluated; and loon behaviors such as courtship, nest building, incubation, parental care of chicks, feeding, and intra- and interspecific associations were observed.

A total of 49-56 loons (2.7-3.1 loons/mile^2) were located, including 19 breeding pairs, 2-4 non-breeding pairs, 5-8 single loons, and 2 loons in immature plumage. Nineteen chicks were hatched to 12 breeding pairs, 16 of which successfully fledged. Loon nests were commonly protected from the wind and waves, and were located away from direct human impact. Loons preferred to nest on deeper and larger lakes, or more significantly, on lakes of longer shorelengths. Those that nested in less disturbed areas had significantly higher hatching success than those in more disturbed areas, and hatching success for two-egg clutches was significantly greater than that of one-egg clutches.

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INTRODUCTION:

The common loon, Minnesota's state bird, is one of four species belonging to the order Gaviiformes and family Gaviidae. Common loons breed across much of Alaska, Canada (except north-central Arctic), New York, New England, the northern halves of Michigan, Wisconsin, and Minnesota, extreme northern North Dakota, and northwest Montana (Farrand 1983, Klein 1985). Minnesota's common loon population is estimated at 10,000 by the state's Department of Natural Resources (Klein 1985).

Loons are specialized for swimming and diving with large webbed feet and powerful legs attached near the rear of their bodies. This allows for rapid underwater movement and quick changes of direction, enabling loons to more efficiently capture their prey. It is quite an effort, however, for loons to take to the air. They often flap and "run" on the water for up to a quarter of a mile (though usually less) before becoming airborne, but once in flight, they are graceful and can fly from 75-100 mph (Klein 1985).

Common loons are thought to mate for life and usually occupy the same territories each season. Although evidence concerning this conjecture is limited at best, one study conducted in Roseau County, Minnesota (McIntyre 1974) provided the first positive proof of territorial affinity in common loons. They return to the northern lakes, usually alone, soon after the ice melts off the lakes in the spring.

Personal observation and documented studies have confirmed that common loons nest in pairs and strictly defend their territories (Munro 1945, Olson and Marshall 1952, Rummel and Goetzinger 1975 and 1978, Titus and VanDruff 1981, Vermeer 1973a). Loon nests are located on the shorelines or in the water fairly close to shore, supported by various types of vegetation, and usually utilize some sort of vegetative cover (Brown 1923, Munro 1945, Olson and Marshall 1952, Titus and VanDruff 1981, Vermeer 1973a).

It has been observed that common loons can be quite sensitive to human disturbance (pers. obs., Hammond and Wood 1976, Klein 1985, McIntyre 1975, Ream 1976, Sutcliffe 1978, Sutcliffe et al. 1981, Titus and VanDruff 1981, Vermeer 1973a, Wood 1979). Shoreline development and recreational pressure from motorboats, waterskiers, fishermen, and canoeists are increasing on the Whitefish Chain, leaving less undisturbed space for nesting loons.

Although similar studies involving density, productivity, and the common loons' adaptability to a man-altered environment have been conducted in other areas of Minnesota, northeastern United States, and Canada (Hammond and Wood 1976, McIntyre 1975, 1978 and 1979, Metcalf 1979, Munro 1945, Olson and Marshall 1952, Ream 1976, Sutcliffe 1978, Titus and VanDruff 1981, Trivelpiece et al. 1979, Vermeer 1973a and 1973b), caution should be taken when comparing them with this study. Most other studies have been conducted in regions that might be considered secluded or "wilderness areas", while this study was conducted in an area with a significant amount of recreational pressure.

This represented a good baseline study which can be repeated in the future, serving as a comparison for population trends. It promoted public awareness and, if necessary in the future, could help in the development of management strategies for the common loon.

STUDY AREA:

This study was conducted on the Whitefish Chain of Lakes near Pequot Lakes, Minnesota, about thirty miles north of Brainerd (Figure 1, E-4). Specifically, the study area lakes were located in Crow Wing County: T 137,138 and R 27, 28, 29 and included Arrowhead, Bertha, Big Trout, Clamshell, Island, Loon, Lower Hay, Lower Whitefish, Pig, and Upper Whitefish lakes (Figure 2). The lakes are eutrophic (Frey 1963), some more than others, and contain a variety of fish species. Because all the lakes are connected, they essentially contain the same species of fish, with a few exceptions. The lakes' physical and biotic factors are listed in Table 1.

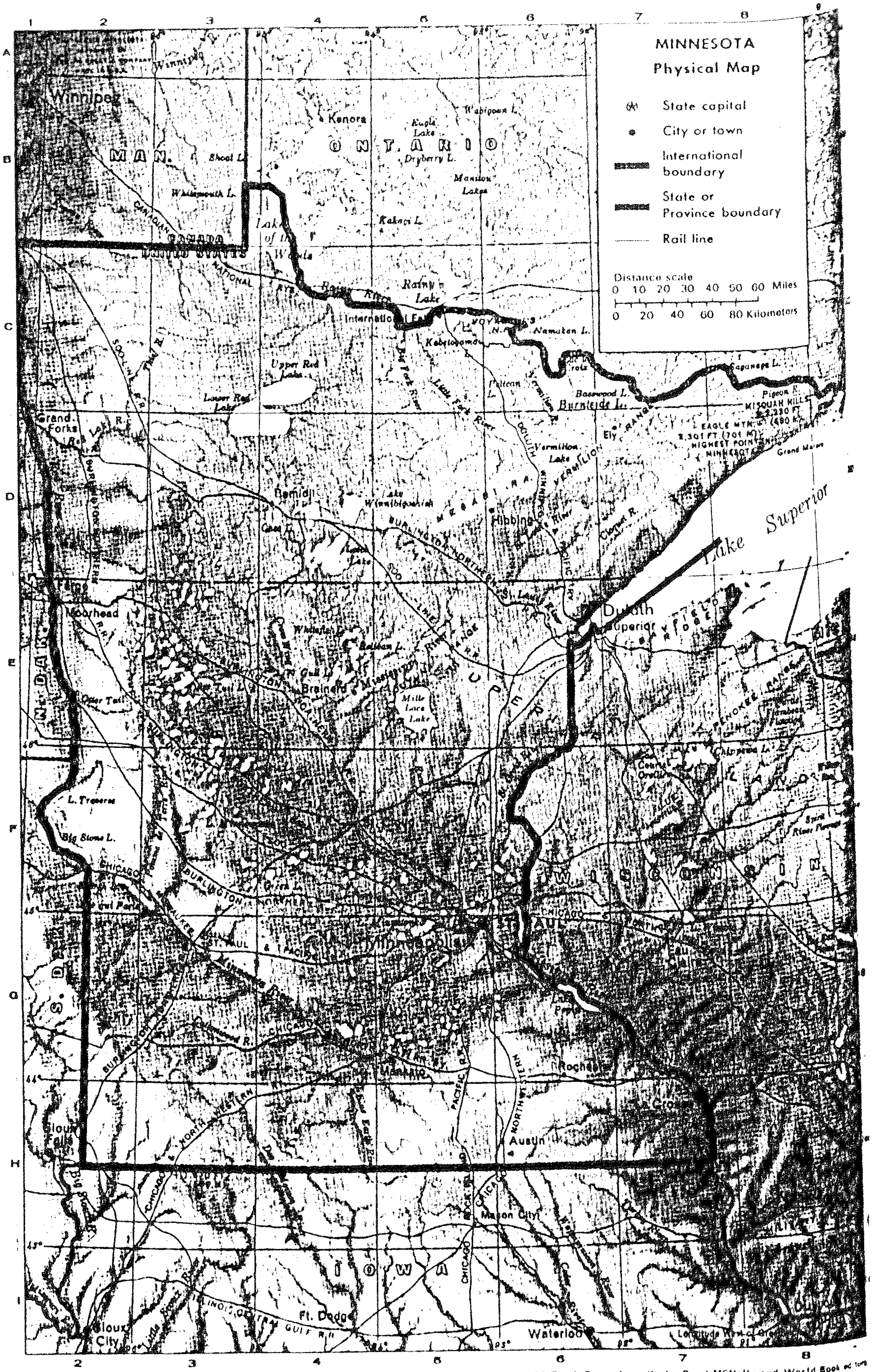

Figure 1. Minnesota physical map showing general study area in quadrant E-4.

World Book Encyclopedia. 1983. M Volume 13, p. 508. World Book, Inc., Chicago, IL.

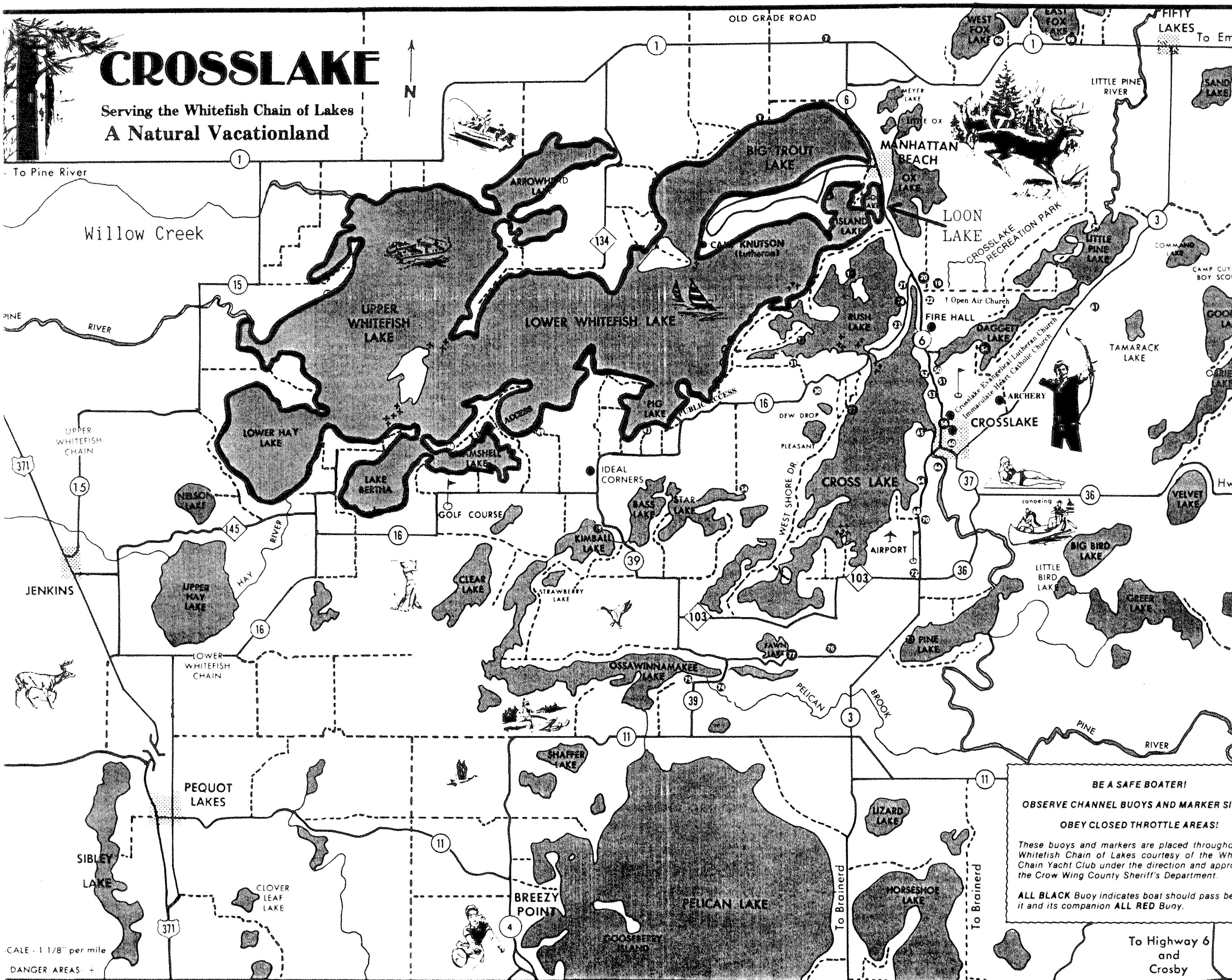

Figure 2. Study area enclosed in bold borders

Table 1: Physical and biotic parameters for the Whitefish study area lakes

A. Physical parameters and fish species
Source: Minnesota Department of Natural Resources

Lakes	Acreage	Shorelength (miles) (islands included)	Number of islands	Maximum depth (feet)	Median depth (feet)	Water clarity (feet) (Secchi disk readings)	Primary fish species (see Table 1, B)	Number of breeding pairs
Arrowhead	285	4.4	4	12	0	4.0	2,3,4,5,7,8, 9,11,13,15,16	2
Bertha	353	4.7	4	64	29	10.2	1,2,3,4,5,6, 7,9,11,12,13, 14,15,16	1
Big Trout	1486	8.6	0	128	54	12.8	1,2,3,6,7,8, 9,11,12,16	3
Clamshell	238	6.3	6	44	5	15.7	1,2,3,5,6,7,8, 9,10,11,12,13, 15,16	2
Island	193	4.8	3	76	13	14.8	1,2,3,6,7,8,9, 11,12,13,15,16	2
Loon	50	1.6	0	32	NA	14.8	NA	0
Lower Hay	720	4.0	0	100	51	12.0	1,2,3,4,6,7,8, 9,11,12,15,16	0
Lower Whitefish	4321	15.8	1	140	47	11.6	1,2,3,4,5,6,7, 8,9,10,11,12, 13,15,16	4
Pig	213	2.6	1	60	NA	5.6	1,3,4,7,9,12, 13	1
Upper Whitefish	3648	15.7	9	90	47	11.6	see Lower Whitefish data	4

NA: information not available

B. Code for fish species (see Table 1, A)
Source: Minnesota Department of Natural Resources

1.	Northern Cisco	(*Coregonus artedii*)
2.	Lake Whitefish	(*Coregonus clupeaformis*)
3.	White Sucker	(*Catostomus commersoni*)
4.	Redhorse	(*Moxostoma* spp.)
5.	Brown Bullhead	(*Ictalurus nebulosus*)
6.	Yellow Bullhead	(*Ictalurus natalis*)
7.	Northern Pike	(*Esox lucius*)
8.	Yellow Perch	(*Perca flavescens*)
9.	Walleye	(*Stizostedion vitreum*)
10.	Largemouth Bass	(*Micropterus salmoides*)
11.	Sunfish	(*Lepomis* spp.)
12.	Rock Bass	(*Ambloplites rupestris*)
13.	Black Crappie	(*Pomoxis nigromaculatus*)
14.	Smallmouth Bass	(*Micropterus dolomieui*)
15.	Johnny Darter	(*Etheostoma nigrum*)
16.	several species of minnows	

C. A listing of the most common dryland and emergent vegetation within twenty feet of the loon nests, in approximate descending order of abundance

several species of grass	
Yellow Waterlily	(*Nuphar variegatum*)
White Waterlily	(*Nymphaea tuberosa*)
Sandbar Willow	(*Salix interior*)
Speckled Alder	(*Alnus rugosa*)
Bulrush	(*Scirpus* spp.)
Common Cattail	(*Typha latifolia*)
Narrowleaf Cattail	(*Typha angustifolia*)
Paper Birch	(*Betula papyrifera*)
Iris	(*Iris* sp.)
Wild Rice	(*Zizania aquatica*)
Greenfruited Burreed	(*Sparganium chlorocarpum*)
White Pine	(*Pinus strobus*)
Red-osier Dogwood	(*Cornus stolonifera*)
several species of ferns	
Dwarf Birch	(*Betula pumila*)
Aspen	(*Populus tremuloides*)
Norway Pine	(*Pinus resinosa*)
Sedge	(*Carex* sp.)
Jack Pine	(*Pinus banksiana*)
Poison Ivy	(*Rhus toxicodendron*)

METHODS:

Loons and nests were located by boating along the mainland and island shorelines in a 65-horsepower aluminum runabout and using 7 x 35 extra wide angle binoculars and a 12-36 X spotting scope. Loons established their territories starting about 23 April, soon after the ice melted off the lakes, so finding definite breeding pairs and nests was somewhat simplified by observing loon pairs during that time. Most loons became rather conspicuous and vocal when I entered their territories, especially near the nests. This behavior also aided in nest location. Single loons, however, were more difficult to monitor because they did not occupy specific territories. Sighting reports and information from area residents were also noted and verified by myself.

Territories were checked an average of three to four times a week. Eggs were counted by approaching nests by boat when the nests were unoccupied, which was rare, or when loons were incubating. In the latter case, loons were flushed off their nests, the eggs were counted, followed by a quick retreat. This was performed once per nest, sometimes twice as necessary, and every effort was made to be as careful as possible to prevent nest abandonment.

After hatching, verification of the presence and number of chicks from successful nests continued with each outing for the duration of the study. Breeding pairs with chicks surviving after four weeks were termed reproductively successful.

McIntyre (1983a) indicated that mortality is very rare after young are four weeks old, so reproduction may be considered successful at that time.

Loons are sexually monomorphic, so determining sex in the field was difficult. Males are generally larger than females, but this is not always the case (Klein 1985, McIntyre 1975, Olson and Marshall 1952). The male, however, is the only member of the pair that uses the yodel vocalization (see Table 2 in RESULTS AND DISCUSSION). This was the only definite way to distinguish males from females, since neither copulation nor egg-laying was observed.

Water depths near the nests were measured using a canoe paddle and tape measure, and angles of decline from the nests (lake bottom slopes) were calculated from a series of depth measurements. Loon nests' depths and diameters were also determined using a tape measure.

The sizes of territories and nurseries were determined by mapping the location of the loons each time they were checked, and by using known lake sizes and a grid. Grids were also used for determining the sizes of islands.

Recreational pressure was assessed primarily by means of disturbance ratios (Vermeer 1973a). The method of calculating these ratios, however, was modified somewhat. The total number of disturbance units per lake was divided by the lake's "adjusted area" rather than just acreage.

A lakefront home survey was conducted, including resorts, camps, boat marinas, and public accesses. A boat count was also conducted to arrive at an approximation of the amount of boating activity on the lakes. Disturbance units were acquired from these surveys, with each home and boat designated by one unit, each resort of ten cabins or less designated by five units, and each camp, marina, public access, and resort of over ten cabins designated by ten units.

Instead of dividing the total disturbance units per lake by the lake acreage as Vermeer did, the units were divided by an adjusted area which took into account the total shorelength (mainland and island) as well as acreage. The total shorelength was divided by the ideal shorelength (if the lake were a perfect circle) and multiplied by the acreage to arrive at the adjusted area. This revealed a more meaningful figure concerning the potential for disturbance. The disturbance units divided by the adjusted area of each lake determined the disturbance ratios.

Four channel surveys were conducted in which the boats going through various channels were counted. This revealed the extent of boat traffic affecting nearby loons. The seven channels surveyed were ranked from 1 to 7, with 1 being the busiest and 7 being the least busy. Visibility indices (Titus and VanDruff 1981) were also assigned to nests on a scale of 1 to 5, with 1 being conspicuous (almost completely visible to an observer on the water ten yards away from the nest) and 5 being not visible.

When analyzing the many factors which may affect loon nest location and success, statistics were used to reveal more concretely their levels of significance. Specifically, the chi-square method and correlation analysis were applied.

RESULTS AND DISCUSSION:

Life History of the Common Loon:

Arrival:

Loons were seen flying over the study area as early as 13 April 1985 while the ice was still thick on the entire chain of lakes. By 18 April, the ice was entirely melted off the smaller lakes, and by 23 April, no ice remained on any study area lakes. On 15 April, one area resident spotted a loon swimming along a ten-foot strip of open water just off from shore on Clamshell Lake. I first observed loons on the water 17 April. Loons generally arrived on the lakes within a few days after the ice melted, migrating north from the Gulf of Mexico as the open water permitted (McIntyre 1975).

Courtship:

Since loons are thought to mate for life (Klein 1985, McIntyre 1974 and 1975, Sjolander and Agren 1972), the need for a lengthy and elaborate courtship would not seem necessary. And, indeed, that seems to be the case. Low-intensity pre-copulatory displays such as bill-dipping, mutual splash dives, preening, and head-rubbing (loon rubbing back of head against its own back) were observed and described by McIntyre

(1975), Sjolander and Agren (1972), and Tate and Tate (1970). Similar displays were observed by myself but copulation did not follow. Thus it was difficult to determine whether or not I observed courtship behavior.

On 20 April, and three times thereafter, I observed what was thought to be courtship behavior. Typically, one member of a loon pair slapped its wings against the water 5-10 times, then rolled over on its back, still slapping its wings and now flapping its feet. The loon dove from this position, stayed under water for three seconds, then barely broke the surface of the water three times as a whale commonly does. Coming up for the fourth time, it completely broke the surface and "ran" on the water, flapping its wings against the water for 10-15 yards ("surface rush", McIntyre 1975). After this sequence, the two loons, about ten yards apart, simply preened and "peered" into the water. Although this was thought to be courtship behavior at the time, no copulation followed. This behavior was also observed as late as July, indicating that it was probably not courtship behavior. Instead, this behavior could be interpreted as pair bonding behavior or aggressive preening. Klein (1985) also observed this behavioral sequence and believed it to be nothing more than aggressive preening.

Nest Building and Maintenance:

Only one pair was observed building a nest, and actually, they were simply improving their nest that had already been built the spring of 1984 (pers. obs.). In this case observed on 11 May, one loon, adjacent to the nest, retrieved some muck (decomposed aquatic vegetation) from the lake bottom with its bill and tossed the muck over its back toward the nest. The loon's mate then took the muck in its bill and threw it on the nest with a quick toss of the head. This continued for about ten tosses each; then the two loons swam away from the nest.

Nest maintenance was frequently observed when loons were incubating. When on the nest, the incubating loon often reached over the edge of the nest, retrieved some muck or other aquatic vegetation, and tossed it over its back onto the nest.

As indicated by Olson and Marshall (1952), many materials are used for nest construction and maintenance. In fact, Sigurd Olson once dissected some loon nests and did not find a single nest material common to all the nests (Klein 1985). Similarly, the type of nest material varied and did not affect the nesting success of loons on the Whitefish Chain. Klein (1985) further stated that loons, most likely, first select a site and then utilize whatever materials are available. Materials used for nest construction and maintenance by loons on the Whitefish Chain included muck, grasses, dirt, cattails, twigs, wild rice, burreeds, various weeds, pine needles, leaves, and bulrushes.

Measurements of nests were also taken for comparative purposes. After hatching, the nests' depths, inner diameters, and outer diameters were determined. The average measurements were 2.5" (inches), 12", and 26" respectively. McIntyre (1975) reported average measurements of 1.22", 9.59", and 22.4" while Olson and Marshall (1952) reported averages of 3", 13", and 22". All three sets of data, although from different study areas, correspond well.

Eggs:

Eggs were typically subelliptical and oval in shape. Exact sizes of eggs were not determined, but generally loon eggs measure about 3.38" long and 2.25" in diameter (Klein 1985). Eggs varied in color from olive green to brown, typically possessing a brownish olive ground color with dark brown splotches. As McIntyre (1975) also indicated, egg color varied within a clutch and from one individual to another.

Incubation:

Incubation is shared by both males and females (pers. obs., Klein 1985, McIntyre 1975). More than once, nest relief by the non-incubating mate was observed. The reliever commonly plopped up the back of the nest (side closest to shore) while the incubating mate slid slowly off the other side. The incubating loon often gave the wail or "mew" call (see Table 2) when its mate was nearby, possibly requesting nest relief.

Table 2: Primary call types (pers. obs., Klein 1985, McIntyre 1975)

Call Type	Given By	Meaning
tremolo	both sexes	all-purpose; signals alarm, annoyance, worry, or greeting; used in night chorusing
yodel	male only	aggressive; used in territorial confrontations
wail	both sexes	used to re-establish contact with mate or chicks; used when a loon on the nest wants to exchange places with its mate; used in night chorusing and to contact other loons
mew	both sexes	used to communicate with chicks; used during nest relief
hoot	both sexes	used by family members as a location call

When nests were approached during incubation to determine clutch size, incubating loons often flushed off their nests, approached the boat, gave the tremolo call (see Table 2), and treaded water almost to the point of standing up. Some loons were "stickers" (Klein 1985), however, not flushing off the nest even when approached to within ten feet. Those nests observed with stickers were located in areas of relatively higher recreational pressure, and successfully hatched chicks. Titus and VanDruff (1981) indicated, and I agree, that the loons' refusal to leave their nests when approached by humans was a highly adaptive behavior mechanism in areas of higher recreational pressure in that all such stickers were usually successful nesters.

The average incubation period of those nests known to within 72 hours was 29 days. There was only one nest known to the exact day, and it had an incubation period of 28 days. Other biologists (Bent 1919, Hollatz and Dwyer 1984, Klein 1985, McIntyre 1975, Olson and Marshall 1952, Roberts 1932, Sjolander and Agren 1972) reported similar average incubation periods of 29, 29, 28, 28, 29, 29, and 28.5 days respectively.

The Young:

Loon chicks are precocial, leaving the nests with their parents shortly after hatching and spending the next several weeks in what are termed nurseries, rearing sites for chicks (McIntyre 1983a). During the first two weeks of their lives, chicks are especially vulnerable to hypothermia and fatigue (Alvo 1985, Olson and Marshall 1952), and extra care and protection are given them by the adults. Chicks from this study area were often seen riding on their parents' backs. This kept the chicks warm and prevented exhaustion. The chicks were fed small pieces of vegetation and small fish; and as they grew, the sizes of their food items increased.

Nurseries were located within the loon territories, usually not far from the nests. The average nursery size was 95 acres, ranging from 25 to 200 acres. Nurseries studied by McIntyre (1983a) were quite consistent, usually found in shallow areas of uniform depth, areas protected from the wind and waves, and areas with an ample food supply.

Variations were found, however, in the nursery characteristics of this study area. Some nurseries were in shallow areas while others were in relatively deep areas, some were in protected areas while others were in windy areas, and some lake bottoms were uniform while others varied in depth. The most important limiting factor, however, was probably food. The chicks, as well as the adults, must have had a substantial fish supply in order to support themselves throughout the summer. Rearing site areas did increase somewhat as the summer progressed, but loon families continued to maintain their same territories.

When families were approached during the study, one adult usually swam slowly toward the boat tremoloing and occasionally treading water. These exhibitions were probably efforts to draw attention to the displaying adult loon rather than to its mate and chicks.

The following time table presented by Klein (1985) describes the first few months of a chick's life.

12-24 hours:	leave nest with adults
first days:	shallow dives
first week:	begin diving for food
first month:	dependent on adults for food
6-8 weeks:	reach adult size and attain self-sufficiency
11 weeks:	initial flight

Feeding:

Loons are voracious feeders. They feed on sight, grasp the prey with their bills, and usually swallow their meals underwater (Klein 1985). On the Whitefish Chain, however, loons were occasionally observed bringing their prey to the surface and swallowing it there. The prey identified in the loons' bills were sunfish, bullheads, perch, and minnows. Loons are primarily fish-eaters, but will also eat frogs, salamanders, crayfish, leeches, aquatic insects, and aquatic greens (Klein 1985, Olson and Marshall 1952).

Although they eat a variety of fish, the most common species include cisco, bullhead, sunfish, perch, crappie, small walleye, small bass, and small northern pike (Olson and Marshall 1952). These species, and many more, are found in the lakes of this study area (Table 1), providing a wide variety of possible food sources.

When parental feeding was observed, the food item (small fish, usually minnows; or vegetation) was presented to the chick in the adult's bill, and the chick then reached for and took the food. As the chick grew, the adult often dropped an injured fish near it, which allowed the chick to retrieve the fish itself. If the prey swam away, the adult recaptured it and presented it to the chick again.

Intraspecific Associations:

As previously indicated, loons are territorial birds. They will confront an intruding loon with aggressive displays (Rummel and Goetzinger 1975 and 1978) in an effort to drive the intruder out of its territory. Unexpectedly, no intra-specific aggression was observed on the water during this study. When loons flew over another loon territory, however, the occupants often gave the yodel call, probably communicating to the loons flying over that this area of water was "taken".

From 1 June to 9 July, nine small flocks were observed on the water, ranging from 3-5 loons. These loons could have been "socializing" or were related loons (Klein 1985). In most cases, the loons involved were probably non-breeding pairs and single loons. On 30 July, however, a loon pair that successfully fledged two chicks left their chicks (5 weeks old) and joined a single loon that flew in and landed nearby. The three adults swam around together for about ten minutes, then the two parents took to the air, circled, and rejoined their young. Summer flocking of loons in large numbers has been observed (Nero 1972 and 1974, Predy 1972, Rand 1948), but gatherings, large or small, are more common on the autumn staging grounds shortly before migration (McIntyre 1983b).

From June through August, loons increased their flight time. Most often, single loons were observed overhead, but flocks of 2-6 were seen flying over the study area. Whether these loons were from the Whitefish Chain or another area was not determined.

Interspecific Associations:

No interspecific associations, other than two cases of aggression, were observed during the study. On 10 May, an American crow (*Corvus brachyrhynchos*) flew about twenty feet above the loon nest on Lake Bertha containing one egg. The adult loon, swimming nearby, surface-rushed toward the nest and cried out using the yodel vocalization. The crow then flew away and the loon drifted calmly near its nest.

On 21 May, an immature bald eagle (Haliaeetus leucocephalus) soared over the nest near the mouth of Willow Creek on Upper Whitefish. The incubating loon quickly slid off the nest, treaded water, and cried out using the tremolo vocalization. The eagle flew toward and landed on the nest containing two eggs. The loon then surface-rushed the eagle and screeched wildly, at which point the eagle flew off leaving the eggs untouched.

Associations with ducks, mergansers, grebes, and geese have been reported by others (Brooks 1941, Kennedy 1981, McIntyre 1975, Olson and Marshall 1952, Zicus 1975), but none were observed in this study.

Density, Productivity, and Nest Failures:

Density:

Nineteen breeding pairs, 2-4 non-breeding pairs, 5-8 single loons, and 2 loons in immature plumage were located over the 11,507 acre expanse of water. This total of 49-56 loons represented 2.7-3.1 loons per square mile or 206-235 acres per loon. The density of the breeding pairs alone was 1.1 pairs/mile^2.

Since this was a baseline study, there was no available earlier information concerning common loon density on the Whitefish Chain. There were, however, more loons than either Pam Perry, Nongame Wildlife Specialist for the Minnesota Department of Natural Resources, or I expected. Compared to this study's total loon density (2.7-3.1 loons/mile^2), Munro (1945) reported 2.1 loons/mile^2 in Alberta, Canada, and McIntyre (1978) reported an average of about 9.3 loons/mile^2 over a five-year period in Itasca State Park in northern Minnesota.

The density of breeding pairs alone on the Whitefish Chain (1.1 pairs/mile^2) was comparable to 0.9 pairs/mile^2 in the Knife Lake Study Area of the Boundary Waters Canoe Area (BWCA) (Olson and Marshall 1952) and 0.75 pairs/mile^2 in Alberta (Vermeer 1973a). The density differences between the studies probably reflect the areas' physical and recreational differences, or may reflect little more than the study areas' carrying capacities.

The two loons in immature plumage were observed in May, June, and July on Upper and Lower Whitefish Lakes. Klein (1985) also observed a loon in immature plumage in June 1982 on Lake Tomahawk in northern Wisconsin. He believed that it was either an adult which would acquire its breeding plumage unusually late, or it was an immature loon of one or two years which migrated north earlier than usual. Since I observed the two loons as late as July, the latter explanation seems more plausible.

Clutch Initiation and Size:

The initiation of clutches started 4 May and continued to 28 June (Figure 3). Many pairs failed (lost their eggs) and renested as often as twice, accounting for the later clutch initiation dates. The total number of clutches was 31, 8 one-egg clutches, 19 two-egg clutches, and 4 clutches of unknown size. The average clutch size was 1.7 eggs.

Loons usually lay two eggs per clutch, sometimes one, and rarely three (Henderson 1924, McIntyre 1975, Vermeer 1973b). Fewer cases of four eggs in a clutch have been reported (Nelson 1983, Zicus et al. 1983). The average clutch size of nests on the Whitefish Chain was similar to averages of 2.1, 1.6, and 1.8 reported by Henderson (1924), Olson and Marshall (1952), and Vermeer (1973a) respectively. Physiology differs very little between individual loons, thus these similar clutch size reports would be expected.

Twelve two-egg clutches and 6 one-egg clutches were counted in the original 19 nests (one nest's clutch size was not determined). Seven two-egg clutches and 2 one-egg clutches were found in all determinable renests. Although not statistically significant, two-egg clutches outnumbered one-egg clutches for original nests (2:1) and renests (3.5:1) (X^2=2, df=1, $P>0.10$ and X^2=2.8, df=1, $P>0.05$ respectively).

Of all clutches, 70% had two eggs and 30% had one egg. McIntyre (1975), Olson and Marshall (1952), and Titus and VanDruff (1981) reported percentages of 64%/36%, 50%/50%,

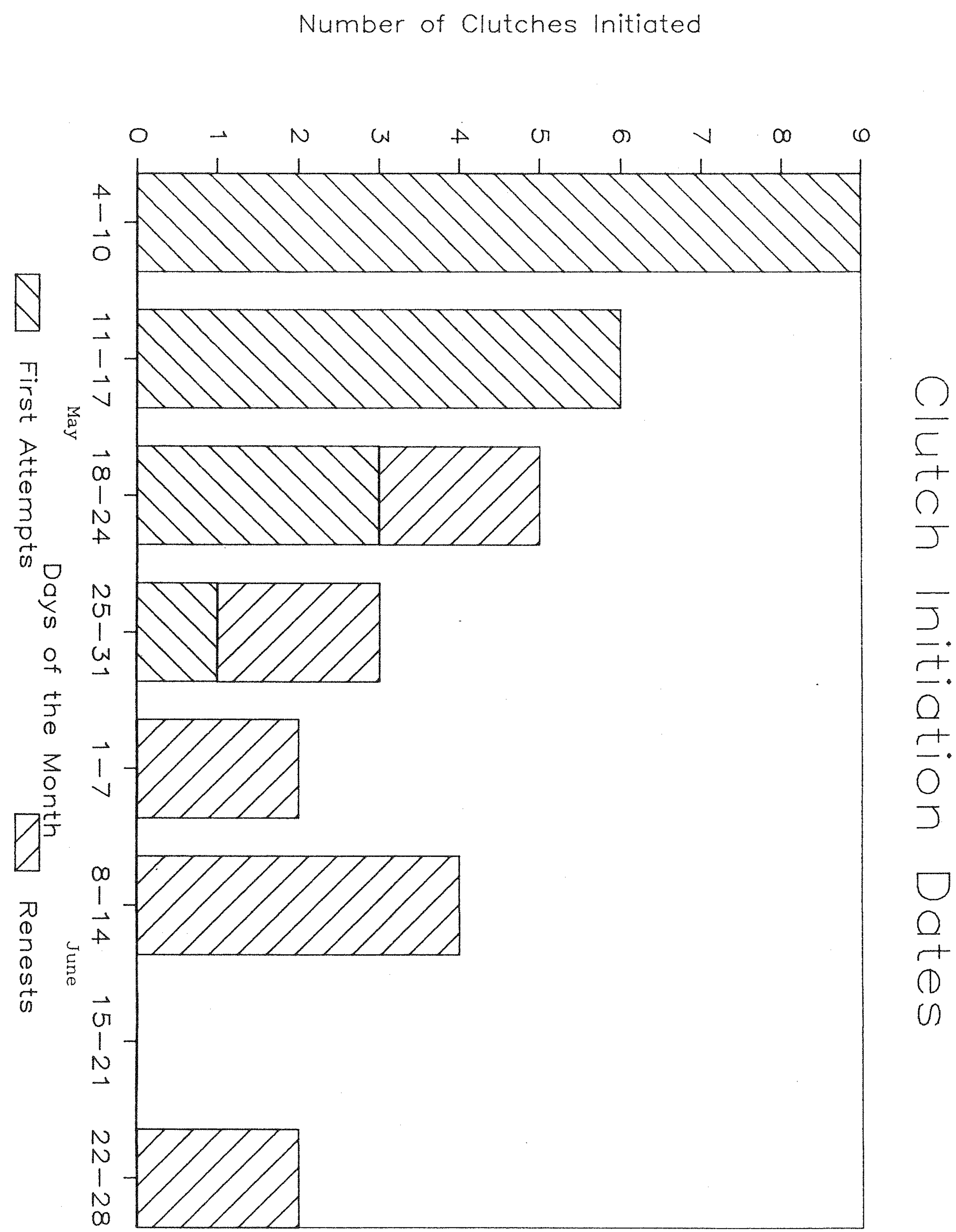
Clutch Initiation Dates
Number of Clutches Initiated
0
1
2
3
4
5
6
7
8
9
4–10
11–17
18–24
25–31
1–7
8–14
15–21
22–28
May
June
Days of the Month
First Attempts
Renests

Figure 3

and 63%/37% respectively. Titus and VanDruff (1981) also reported that one-egg clutches were significantly more common in renests than in original nests ($P<0.05$), but that was not the case in this study. Two-egg clutches potentially have a greater chance of hatching chicks than do one-egg clutches. Hence this study's higher percentage of two-egg clutches may reflect an adaptation to the increasing amount of recreational pressure.

Nest Failures and Renesting:

Twelve of the original 19 breeding pairs (63%) failed in their first nesting attempt, 6 because of a severe water level increase caused by 4.5 inches of rain over a four-day period, and 6 because of predation. Two of the 12 losses never attempted to renest, while 6 renested but failed a second time. Two of the pairs that failed a second time nested a third time. Of these, 1 failed yet a third time and 1 successfully hatched a chick. Of the other 4 pairs that failed at their first nesting attempt, all successfully hatched chicks, but 1 pair lost its chick 1-2 days after hatching. Adults did not renest when chicks were lost.

Nineteen of the total 31 nests did not hatch chicks, yielding a 61% failure rate. Ten of the 19 unsuccessful nests were located on islands. Half of these failed because of predation, 3 were caused by a sudden water level increase, and 2 were caused by human disturbance near the nests followed by predation. The other 9 unsuccessful nests, 5 caused by a sudden water level increase and 4 caused by predation, were located on the mainland. Predation accounted for 47% of all nest failures, while 42% were caused by a sudden water level increase and 11% were caused by human disturbance followed by predation.

Sutcliffe (1978) similarly reported a failure rate of 63% in his New Hampshire study, holding humans and predators responsible for the failures. Predation was the major cause of all nest failures on the Whitefish Chain (47%), and was also the primary cause in two other studies. McIntyre (1975) and Olson and Marshall (1952) reported predation percentages of 75% and 71% respectively. Fewer predators per area or the severe water level increase causing the failure of many nests may be the reasons for this study's lower predation percentage.

Forty-two percent of all renests successfully hatched chicks. Of the mainland renests, 3 nested on the same nest and 3 occupied different sites. Of the island renests, 1 nested on the same nest and 5 occupied different sites. Of those that renested because of a sudden water level increase, 57% chose a new site, and of those that renested because of predation, 80% chose a new site. Once a predator finds a nest with eggs, it will probably be back in the future looking for another meal. It is, therefore, probably advantageous for unsuccessful loon pairs to renest on different sites.

The most common predators of loon eggs are the raccoon

(Procyon lotor), American crow, common raven (Corvus corax), striped skunk (Mephitis mephitis), gull (Larus spp.), humans (Homo sapiens), and, although not documented, possibly the muskrat (Ondatra zibethica) and beaver (Castor canadensis) (Klein 1985, McIntyre 1975 and 1977, Olson and Marshall 1952, Titus and VanDruff 1981). Possible mammalian predators on the Whitefish Chain include the raccoon, striped skunk, muskrat, beaver, and humans. The probable avian predators sighted in the area were the ring-billed gull (Larus delawarensis), American crow, bald eagle, and Caspian tern (Sterna caspia). Although Caspian terns were not reported as loon egg predators by other biologists, they are known to eat eggs (Robbins et al. 1983).

Although no predation was observed during the study, evidence was noticeable. Many cracked and crushed eggshells were found, and one predated egg had claw marks on the shell membrane, probably caused by a raccoon or skunk. No positive evidence of avian predation was discovered, but gulls, eagles, crows, and terns were often seen near loon nests that were preyed upon.

Loon chicks, as well as eggs, are also preyed upon. Although this was not observed, 3 chicks were lost, most likely to predators. Probable loon chick predators in the study area, also indicated by Klein (1985) and Titus and VanDruff (1981), were the northern pike, largemouth bass, snapping turtle (Chelydra serpentina), bald eagle, and humans.

Hatching:

Hatching began about 31 May and continued through 26 July. The last hatch was a Clamshell Lake pair's third nesting attempt. Hatchings this late are uncommon since the chicks must grow and develop enough to migrate in the fall. This pair's fledgling must grow fast if it is to be strong enough for migration.

Thirty-six percent of all eggs hatched. (In the four cases where clutch size was unknown, 1.7, the average clutch size, was used as their egg numbers). Of known one-egg clutches, 38% of the eggs hatched, and of known two-egg clutches, 84% of the eggs hatched (Figure 4). Hatching success for two-egg clutches was significantly greater than that of one-egg clutches (X^2=4.46, df=1, $P<0.05$).

McIntyre (1975) also reported that hatching success for two-egg clutches was significantly greater than that of one-egg clutches (X^2=4.607, $P<0.05$), as did Titus and VanDruff (1981) ($P<0.01$). As indicated by Olson and Marshall (1952), the attachment for the nest and eggs increased as incubation progressed. Six of the 10 nest desertions recorded by Olson and Marshall took place soon after incubation began. Because of this and the speculation that the loons' attachment to two eggs is greater than to one egg, two-egg clutches would be expected to be more successful than one-egg clutches.

Titus and VanDruff (1981) reported that nests rarely lost a single egg without total failure and abandonment.

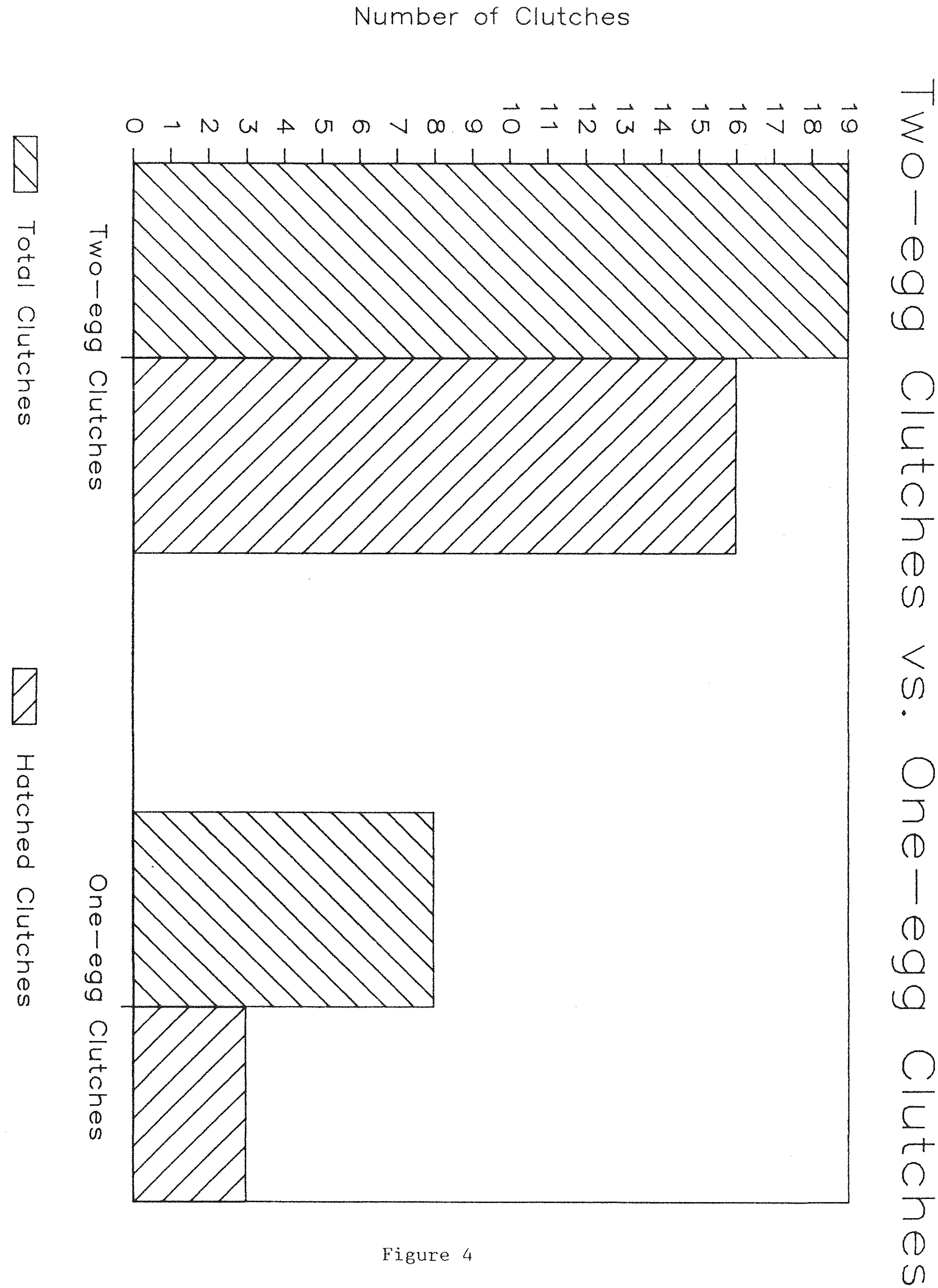
Two-egg Clutches vs. One-egg Clutches
Number of Clutches
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
Two-egg Clutches
One-egg Clutches
Total Clutches
Hatched Clutches

Figure 4

In all but two cases in this study, no eggs were lost to breeding pairs that successfully hatched chicks. In those two cases, each pair lost one egg (unknown cause) while the second egg hatched.

Productivity and Mortality:

Of the 19 breeding pairs, 12 successfully hatched a total of 19 chicks (63% hatching success rate). Seven pairs hatched 2 chicks each and 5 pairs hatched 1 chick each. One pair, however, lost both their chicks at 12 days after hatching, probably to a predator, and another pair lost their 1 chick 1-2 days after hatching. Four weeks after the last hatching, when all breeding pairs with fledglings were termed reproductively successful, 16 of the original 19 chicks remained, yielding a chick mortality rate of 15.8%. Other studies reported mortality rates of 5.6% (McIntyre 1975), 22% (Olson and Marshall 1952), and 11.6% (Sutcliffe 1978).

The fledging rate of loon chicks per egg laid was 30%, while the rate per egg hatched was 84%. The number of chicks fledged per successful hatching pair was 1.33. Whether this figure is relatively high or low cannot be determined since no past data from the Whitefish Chain are available for comparison. Other studies (McIntyre 1975, Olson and Marshall 1952, Sutcliffe 1978, Trivelpiece et al. 1979, Zimmer 1982) recorded similar figures of 1.4, 1.2, 1.48, 1.47, and 1.41 respectively.

The number of loons fledged per breeding pair, however, was only 0.84. Similar studies reported figures of 0.60 (Hammond and Wood 1976), 0.77 (McIntyre 1975), 0.98 (McIntyre 1979), 0.50 (Olson and Marshall 1952), 0.63 (Sutcliffe 1978), 0.83 (Trivelpiece et al. 1979), and 0.40 (Vermeer 1973a). Each study area's physical characteristics, amount of recreational pressure, weather, and predation all play a part in their loon productivity.

Habitat Selection and Nesting Requirements:

General Nest Site Locations:

Loon nests were located on almost all sides of the lakes. They were either on the N-NW shoreline, protected from the prevailing winds, or were protected from the wind and waves by islands or points of land.

Territories varied in size, probably due in large part to the physical characteristics of the lakes. Bays, inlets, and natural separations such as islands allowed for smaller territories. The average territory size was about 194 acres, ranging from 80 to 340 acres.

Water depths were determined at five feet from the nests, and approximate angles of decline were calculated to determine the severity of drop-offs by the nests. As indicated by Olson and Marshall (1952), it was thought that deeper water close to the nests and steeper drop-offs afforded good underwater exits for incubating loons. Loons on the Whitefish Chain, however, did not favor areas with these characteristics, as many nests had virtually no angle of decline for up to 15 feet away from the nest, and the water was often shallow. The median drop-offs for nests that hatched chicks and those that failed were 5.7° and 6.2° respectively. The median depths at five feet from successful and unsuccessful nests were 13" and 12" respectively. No significant correlation was found between hatching success and water depth (r=-0.17) or between hatching success and angles of decline (r=-0.37). Most often, when loons were flushed off their nests, they "ran" across the surface of the water and made no attempt to dive. Deep water and steep drop-offs, then, did not seem to play a part in loon nest location or success.

Because of predation, it was predicted that there would be significant positive correlations between hatching success and distances of nests to land. The median distance between successful nests and land (island or mainland) was 3.5 feet, ranging from -3 to 100 feet, while the median distance for unsuccessful nests was 15 feet, ranging from -4 to 150 feet. No significant correlation was found between hatching success and distances of nests to land (r=-0.002). Attentive nesting or nesting in areas of fewer predators, then, must be the loons' mechanisms against predation.

Using lake maps, distances of nests to the next nearest loon nest were also estimated. The median distance for successful nests was 4250 feet, ranging from 1980 to 10,560 feet, and the median distance for nest failures was 3300 feet, with the same range as successful nests. No significant correlation was found between hatching success and distances of nests to the next closest nest (r=-0.24). The average distance between nests was 5254 feet, and those that were closest to each other (1980 feet) were separated by islands. Again, no confrontations between loon pairs were observed during the study.

Lake Characteristics:

To help determine why loons nest on certain lakes and not on others, the number of breeding pairs was compared with size, shorelength, maximum and median depths, water clarity, and the number of islands of each lake (Table 1, A). There were significant positive correlations between the number of breeding pairs and lake size (r=0.81), the number of breeding pairs and shorelength (r=0.91), and the number of breeding pairs and maximum lake depth (r=0.52).

Yeates (1950) found that loons avoided small lakes and appeared to nest only on waters of considerable acreage. Exactly what Yeates meant by "considerable acreage" is not known, but loons on the Whitefish Chain nested on lakes ranging from 193 to 4321 acres. Loon Lake (50 acres), ironically, was not occupied by any loons. Vermeer (1973a), however, found no significant correlation between breeding pairs and lake size (r=0.36). Although a positive correlation was found between breeding pairs on the Whitefish Chain and maximum lake depth, the relationship was not exceptionally strong and some nests were located on relatively shallow lakes.

No significant correlations were found between the number of breeding pairs and either median lake depth (r=0.19), water clarity (most lakes were quite clear) (r=0.14), or the number of islands (r=-0.09). Vermeer (1973a), however, found a significant positive correlation between the number of breeding pairs and islands (r=0.78). Differences between this study's and Vermeer's results probably reflect differences in the study areas as indicated earlier. Furthermore, Vermeer's study area in Alberta may have had more islands suitable for nesting than the Whitefish Chain.

As indicated by Olson and Marshall (1952), the character of the lake bottom at the nest site was unimportant. The lake bottoms near the nests on the Whitefish Chain varied from sand and rocks to weeds and muck.

It appears from this study that loons preferred to nest on deeper and larger lakes, or more significantly, on lakes of longer shorelengths. Large lakes and long shorelengths did not go together exclusively. Some smaller and shallower lakes had many bays, islands, and jagged shorelines, thus longer shorelengths (e.g. Clamshell Lake; see Tables 1 and 3). The two breeding pairs on Clamshell Lake successfully hatched three chicks. Nests on larger lakes were commonly protected by points of land, islands, or small bays.

McIntyre (1975) reported in her study that lakes not used for nesting were turbid and more than 10 feet deep. A shallow lake with high turbidity, however, still permitted visibility to the bottom. Arrowhead Lake on the Whitefish Chain had a maximum depth of 12 feet and was turbid (Secchi disk reading of only 4.0 feet). Evidence of the lake's turbidity was observed on the loons themselves. The bright white breasts of the adult loons in Arrowhead had turned to a dull yellowish-tan by the end of the study. Even though Arrowhead was turbid, the two breeding pairs on the lake were able to capture their prey because the lake was shallow.

Islands:

Of the total 31 nesting attempts, 16 were on the mainland, 14 were on islands, and 1 was built up in the middle of a small bay. Four of the successful nests were on islands and 7 were on the mainland (Figure 5). The nests on the mainland were not significantly more successful than those on islands (X^2=0.82, df=1, P>0.30).

Contrary to these data, other studies have shown a preference of loons to nest on islands, and it has been proposed that island nesting may be a mechanism against predation by land mammals (Alvo 1981, Vermeer 1973a). Olson and Marshall (1952) reported that 50 of 54 nests in their northern Minnesota study area were located on islands, Ream (1976) reported that all nests (18 of 18) in her northern Minnesota study area were on islands or sedge mats, and Vermeer (1973a) reported that 25 of 26 nests in his Alberta study area were located on islands. McIntyre (1975), however, reported that half of the nests in her study area were located on islands

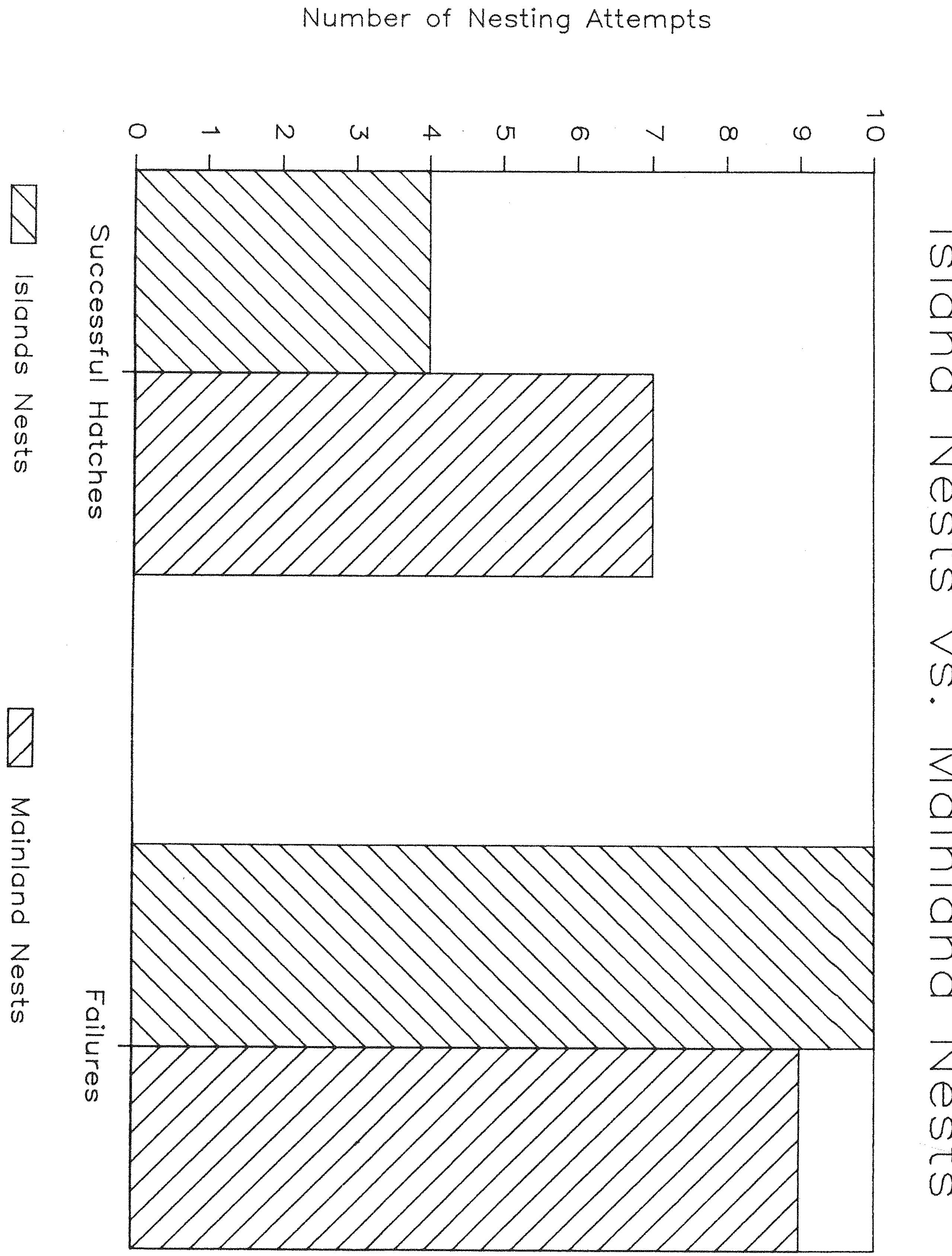
Island Nests vs. Mainland Nests
Number of Nesting Attempts
0
1
2
3
4
5
6
7
8
9
10
Successful Hatches
Failures
Islands Nests
Mainland Nests

Figure 5

and half were on the mainland. Although loons nested on 9 of the 28 islands on the Whitefish Chain, few islands were suitable for nesting because of human impact (i.e. recreational pressure). It was suggested by Alvo (1981), and I agree, that loons in developed areas are giving up their favored island nesting sites to escape such impact.

The 4 successful island nests were all on islands of 8000 ft^2 (about .2 acres) or less, while the failures were on islands of 20,000 ft^2 to 2,000,000 ft^2 (about .5-45 acres). Loons nesting on smaller islands (<10,000 ft^2) were significantly more successful than those on larger islands (X^2=4, df=1, $P<0.05$). Vermeer (1973a) reported that 19 of the 25 island nests in his study area were located on islands less than 2 acres in size. This preference, however, was not statistically significant. Smaller islands were probably preferred because fewer predators and humans occupy them.

Because of predation, it was also expected that there would be a significant positive correlation between hatching success and distances of nesting islands to the mainland. The median distance between successful nesting islands and the mainland was 200 feet, ranging from 80 to 1000 feet, while the median distance for unsuccessful nesting islands was 250 feet, ranging from 100 to 1000 feet. Contrary to the expected, no significant correlation was found between hatching success and these distances ($r=0.14$).

Recreational Pressure:

Recreational pressure was assessed primarily by means of disturbance ratios (Vermeer 1973a, see METHODS and Table 3). As indicated earlier, loons can be quite sensitive to human disturbance, and it was expected that more nests would succeed on lakes with lower disturbance ratios. And, indeed, there were significant inverse correlations between the number of successful hatches and disturbance ratios ($r=-0.73$) and between the number of breeding pairs and disturbance ratios ($r=-0.69$). Vermeer (1973a) also reported the same correlation between breeding pairs and disturbance ratios ($r=-0.57$). Olson and Marshall (1952) indicated that recreational pressure in the BWCA was detrimental to loon productivity, and Ream (1976) stated that the main factor limiting reproduction in the BWCA appears to be the disturbance of nesting sites by canoeists.

Other biologists' data, however, showed little or no effects of recreational pressure on loon productivity (Christenson and Sherburne 1981, McIntyre 1975 and 1978, Titus and VanDruff 1981). McIntyre (1975) stated that the positive correlation of productivity with increased recreational use in her study area did not support previous opinions concerning the adverse effects of human disturbance on loons. In fact, lakes with heavy recreational fishing pressures had the greatest proportion of reproductive success. As McIntyre (1975) put it, "If loons and humans both prefer

Table 3: Disturbance ratios (modified from Vermeer 1973a)

Lakes	Homes and cabins	Boats and empty docks	Resorts (10 units or less)	Resorts (greater than 10 units)	Camps	Public accesses and marinas	Total number of disturbance units	Lake acreage	Lake area in $miles^2$	Actual shorelength and "ideal" shorelength (if lake were a perfect circle) in miles	Adjusted area (actual shorelength divided by the ideal shorelength, then multiplied by the lake acreage)	DISTURBANCE RATIO (disturbance units divided by adjusted area)	Hatching successes	Number of breeding pairs
Arrowhead	24	23	0	0	0	0	47	285	.445	4.4/2.4	530.1	.0887	2	2
Bertha	123	260	2	0	0	1	403	353	.552	4.7/2.6	629.9	.6398	1	1
Big Trout	275	476	1	0	2	1	786	1486	2.322	8.6/5.4	2365.8	.3322	2	3
Clamshell	104	252	2	1	0	1	386	238	.372	6.3/2.2	681.6	.5663	2	2
Island	54	97	0	0	0	0	151	193	.302	4.8/2.0	475.9	.3173	1	2
Loon	32	25	0	0	0	0	57	50	.078	1.6/1.0	80.7	.7063	0	0
Lower Hay	120	229	1	0	0	1	364	720	1.125	4.0/3.8	766.0	.4752	0	0
Lower Whitefish	346	597	3	2	1	0	988	4321	6.752	15.8/9.2	7412.0	.1333	2	4
Pig	101	163	3	0	0	1	289	213	.333	2.6/2.0	270.8	1.0672	0	1
Upper Whitefish	209	350	1	3	0	0	604	3648	5.700	15.7/8.5	6767.3	.0893	2	4

clear lakes with an abundant supply of fish, then these data may represent a requirement overlap and not a cause-effect relationship."

Titus and VanDruff (1981) reported that from 1950 to 1976 there was an approximate 800%-900% increase in recreational use in the BWCA, accompanied by a 35% increase in the adult loon population. The recreational patterns and effects on loons in these wilderness areas, however, are probably different than those of the Whitefish Chain, a nonwilderness area. Loons on the Whitefish Chain preferred nesting in areas where there was a minimum amount of human disturbance, and were more successful in doing so.

Studies in northeastern United States (Hammond and Wood 1976, Metcalf 1979, Sutcliffe et al. 1981, Wood 1979) have also reported an increase in recreational pressure, especially in New Hampshire. During the past several years, however, their loon populations have drastically declined because of the human impact. Today, through management strategies and increased public awareness, their loon populations have stabilized and are on the upswing.

Recreational pressure was also evaluated by counting boats that traveled through seven main channels in the study area (see METHODS and Figure 6). It was expected that loons near areas with heavy boat traffic would not be as successful as those near areas with little boat traffic, but this was not the case. Unlike disturbance ratios, the channel surveys

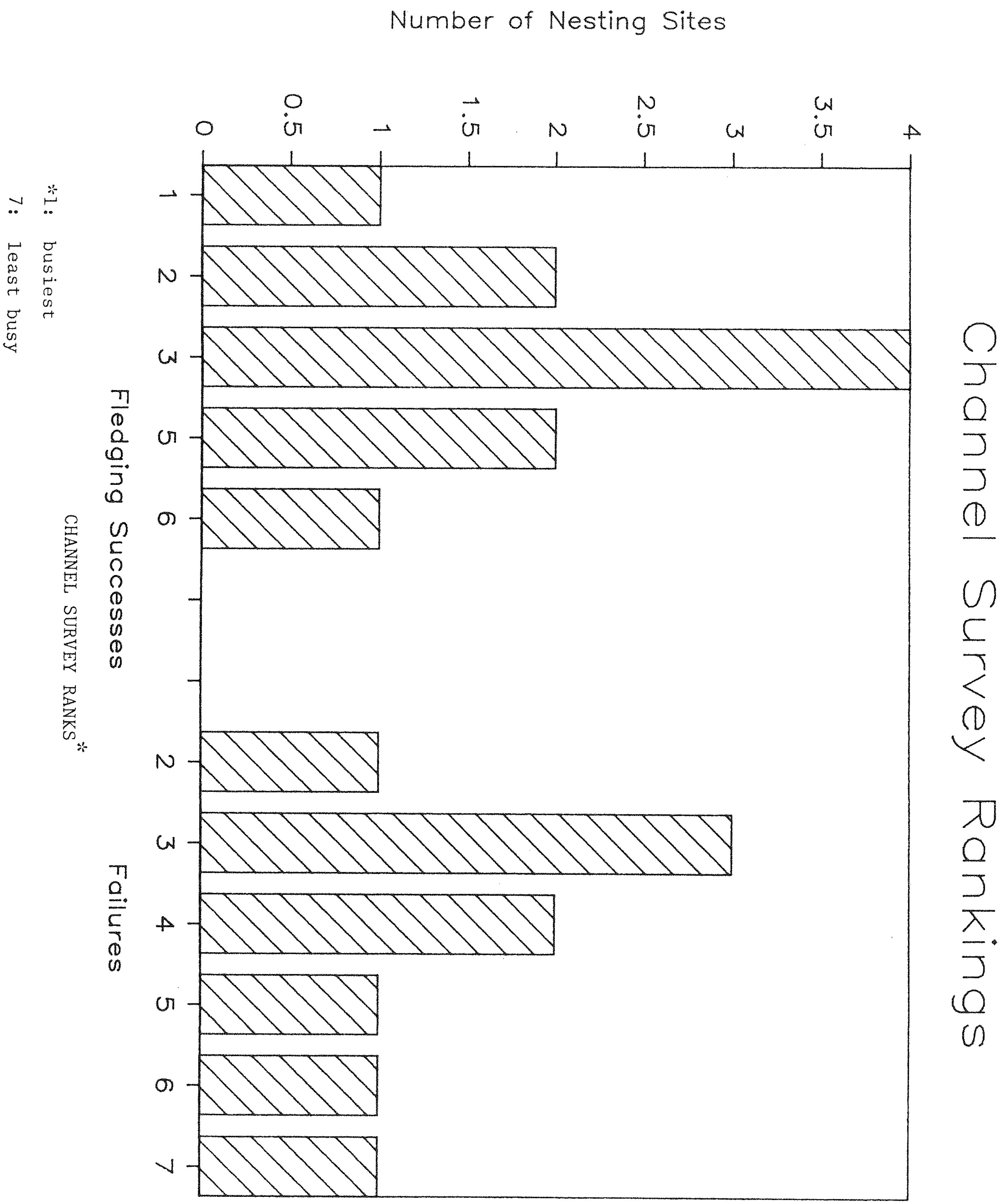
Channel Survey Rankings
Number of Nesting Sites
0
0.5
1
1.5
2
2.5
3
3.5
4
1
2
3
5
6
2
3
4
5
6
7
Fledging Successes
Failures
CHANNEL SURVEY RANKS*
*1: busiest
7: least busy

Figure 6

did not help to determine why some loon pairs were successful and others were not. Loon pairs that successfully fledged chicks had channel survey rankings from 1 to 6, with the majority of successes in areas with a channel survey rank of 3 (relatively heavy boat traffic). No significant correlation was found between the number of breeding pairs that successfully fledged chicks and channel survey ranks ($r=-0.39$). Christenson and Sherburne (1981) also reported in their Maine study that boating activity had little effect on incubating loons or nest outcome.

Visibility indices (Titus and VanDruff 1981, see METHODS and Figure 7) were assigned to all nests under the assumption that nest visibility played an important role in the potential for predatory and recreational impact on nests. The successful nests had visibility indices from 1 to 3, and the median indices for both successful and unsuccessful nests were 2 (quite visible). Of all the nests, successful or not, only one had an index of 4 and none had an index of 5. No significant correlation was found between hatching success and visibility indices ($r=-0.02$).

Titus and VanDruff (1981), however, reported in their BWCA study that the less visible nests were significantly more successful ($P<0.05$) when compared to those with greater visibility. Olson and Marshall (1952) also indicated that loons showed a preference for some sort of nest cover. It appears, though, that nest visibility did not play an important

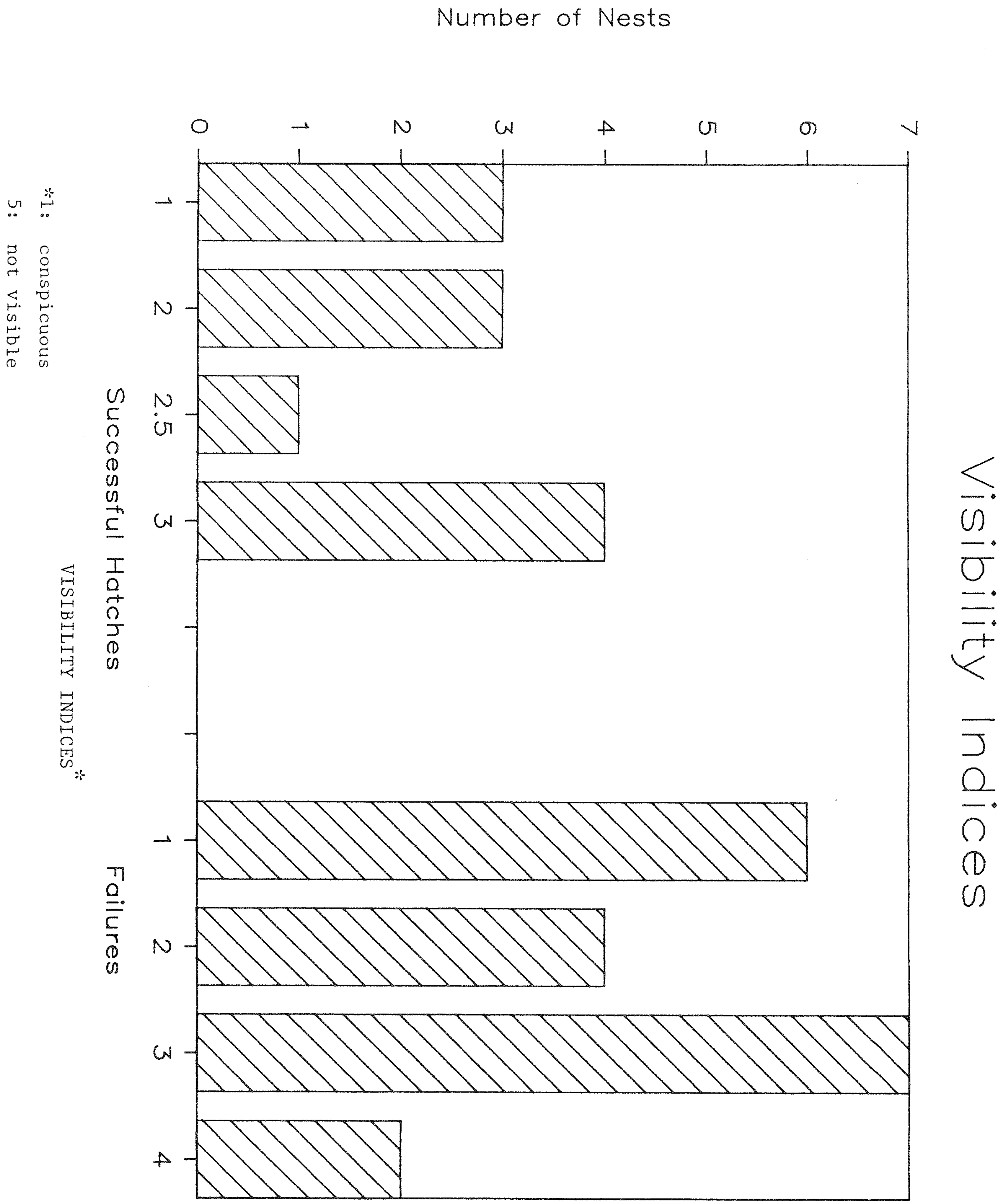
Visibility Indices
Number of Nests
0
1
2
3
4
5
6
7
1
2
2.5
3
1
2
3
4
Successful Hatches
Failures
VISIBILITY INDICES*
*1: conspicuous
5: not visible

Figure 7

part in nest location and success of loons on the more disturbed Whitefish Chain. Some loons' lack of concern about nest visibility probably reflects their habituation to the recreational pressure.

Because of recreational impact, it was also expected that distances of loon nests to docks or buildings would be greater for successful nests. No significant correlation was found, however, between hatching success and these distances (r=-0.09). The median distance between successful nests and docks or buildings was 350 feet, ranging from 100 to 1000 feet, while the median distance for nest failures was 300 feet, ranging from 100 to 1200 feet. No nest disturbances by neighboring people were observed during the study.

Most area residents are concerned about the well-being of the common loons, and they do their part to help protect them. But the Whitefish Chain also boasts over 20 resorts and camps; thus many tourists utilize the lakes for boating, canoeing, fishing, and waterskiing. These tourists seem to do the most damage since many of them do not realize the impact they have on the environment and, specifically, on the loons.

SUMMARY:

1. A study of common loon density, productivity, and nesting requirements was conducted on a chain of ten eutrophic fishing lakes in north-central Minnesota. A total of 49-56 loons (2.7-3.1 loons/mile^2) were located, including 19

breeding pairs, 2-4 non-breeding pairs, 5-8 single loons, and 2 loons in immature plumage.

2. The average clutch size per nest attempted was 1.7 eggs and a total of 19 chicks were hatched to 12 breeding pairs. Sixteen of the 19 chicks survived, amounting to 0.84 chicks fledged per breeding pair or 1.33 chicks fledged per hatching pair.

3. Predation accounted for almost half of all nesting failures, while a severe water level increase caused by a rainstorm and human disturbance followed by predation accounted for the other failures. Ten of the 12 breeding pairs that originally failed renested, 5 of which successfully hatched chicks.

4. No one factor determined loon nest location. Nests were commonly protected from the wind and waves, and were located away from direct human impact. Loons preferred to nest on deeper and larger lakes, or more significantly, on lakes of longer shorelengths. Some smaller and shallower lakes with relatively longer shorelengths were preferred because they had many bays, islands, and jagged shorelines. These characteristics provided natural boundaries for territories and offered protection from humans and predators.

5. The ultimate factor in habitat selection by common loons, according to McIntyre (1975), is for lakes with an abundant supply of small fish and water sufficiently clear to permit efficient foraging. The lakes on the Whitefish

Chain fulfilled these two requirements.

6. Nesting success was also dependent on several factors. Predation was perhaps the most important obstacle for breeding pairs to overcome. Attentive nesting or nesting in areas of fewer predators, such as on small islands, were probably the two main ways of preventing predation. It was also advantageous to lay clutches of two eggs since hatching success for two-egg clutches was significantly greater than that of one-egg clutches. Pairs that nested in less disturbed areas also had significantly higher hatching success than those in more disturbed areas.

7. Although loons were more successful on lakes with lower disturbance ratios, they do appear to be adapting to the recreational pressure. Contrary to the expected, loons near areas with little boat traffic were not more successful than those near areas with heavy traffic.

8. Also contrary to the expected, no significant positive correlation was found between hatching success and higher visibility indices. Some loons' lack of concern about nest visibility probably reflects their habituation to the recreational pressure.

9. Shoreline development and recreational pressure have noticeably increased on the Whitefish Chain over the past several years. If this human impact continues to increase, the effects on the loon population may be detrimental and irreversible. Since no other loon survey has been conducted

in this study area, population trends cannot be determined at this time.

10. Studies in northeastern United States have also reported an increase in recreational pressure. During the past several years, their loon populations have drastically declined because of the human impact. Today, through management strategies and increased public awareness, their loon populations have stabilized and are on the upswing. The extent to which increasing shoreline development and recreational pressure on the Whitefish Chain are affecting its loon population is uncertain. Future surveys and comparisons should afford a more complete answer to this question.

ACKNOWLEDGEMENTS:

I wish to thank Lee Pfannmuller and the Nongame Wildlife Program of the Minnesota Department of Natural Resources, Victor Nelson-Cisneros and the Venture Grant Committee of Colorado College, and Duane H. DeBower and the Minnesota Loon Appreciation Project for their financial assistance, without which this study could not have been undertaken.

For their concern, support, suggestions, and assistance, I also wish to thank Richard G. Beidleman, Alan S. Davis, Thomas A. Hughes, Mark D. Larson, Cliff and Betty Skoning, Michael T. Valley, Michelle M. Valley, Barbara L. Winternitz, the Department of Biology of Colorado College, and the many area residents on the Whitefish Chain.

Special appreciation goes to Pam Perry, Nongame Wildlife Specialist for the Minnesota Department of Natural Resources and to my parents, Leonard and Mary Ann Valley. Their assistance, support, and advice were invaluable.

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