Effects of Human Activities and Lake Characteristics on the Behavior and Breeding Success of Common Loons

Common Loons are more likely to be found on larger lakes with islands, hummocks and no nesting Canada Geese; loons nest more successfully on lakes with islands. The behaviors of loons on lakes with high use by people differed from those on lakes with low use by people. Conservation implications are discussed.

by Robin E. Jung

Populations of the Common Loon (Gavia immer) in the United States have been declining over the last half-century (Palmer 1962, McIntyre 1979), and the loon’s breeding range is receding northward. Several factors have been suggested as causes for decline in loon populations, including the loss of suitable breeding habitat due to shoreline development and increased harrassment of nesting loons as a consequence of greater human development and recreational pressure, especially boating activity (Plunkett 1979, McIntyre 1986, 1988a,b).

The first purpose of this study was to determine (1) what human use and environmental factors affect use of lakes by loons, and (2) how human activities might affect loon breeding success. I hypothesized that greater recreational use on a lake and lakeshore development would correlate with loon reproductive success (indexed as the number of chicks raised to 7-8 weeks of age, just 3-4 weeks prior to fledging). I hypothesized that high-use lakes (HU; lakes with motorboats) would tend to have no loons or nonbreeding and unsuccessful loons (lost all chicks), whereas low-use lakes (LU; no motorboats) would tend to have breeding loons.

Common Loons nesting on lakes with motorboats have been shown to suffer reduced hatching success and produce significantly fewer surviving young compared to loons on lakes
where motorboats were not allowed (Hammond and Wood 1976, Titus and Van Druff 1981). Common Loon hatching success was significantly lower on larger, less remote lakes in the Boundary Waters Canoe Area in northeastern Minnesota than on smaller, remote lakes with less recreational use (Titus and Van Druff 1981). Reduced hatching success for Common Loons has been related to increased cottage development on central Ontario lakes (Heimberger et al. 1983). Other studies also report that disturbance may negatively affect Common Loon reproduction (Sawyer 1979, Christenson 1981).

On the other hand, Common Loons might be expected to habituate to humans. Barr (1986) suggested that human disturbance did not influence the low breeding success of loons in Ontario, and Smith (1981) found that canoeing activity did not have a significantly negative impact on reproductive success.

The second purpose of the study was to determine how the recreational use of lakes may affect Common Loon behavior. I hypothesized that loons onHU lakes would show different frequencies of behavior compared to loons on LU lakes (e.g., less time foraging due to disruption by human activity).

The third part of the study focused on whether loons onHU lakes have become habituated to boating activity. I hypothesized that loons onLU lakes would react differently and respond at a different mean distance from an approaching kayak than loons onHU lakes. McIntyre (1979) and Titus and VanDruff (1981) reported that Common Loons onHU lakes are “tighter sitters” (not easily scared from their nests) and tolerate human presence at a smaller distance. Smith (1981) showed that Common Loons on lakes with canoes respond at lower mean distances when approached by canoe as compared to loons on non-canoelakes in the Kenai National Wildlife Refuge. The extent and significance of loon habituation to human disturbance has yet to be fully understood. In addition, the apparent curiosity of loons, which often approach humans, remains to be understood.

MATERIALS AND METHODS

Lake Survey—During July 1987, I surveyed 59 lakes in nine counties of the northern Lower and eastern Upper Peninsulas of Michigan for Common Loons (Table 1). Twenty-four of the lakes had historical records of breeding loons (Table 1). For each lake, I recorded numbers of Common Loon adults and chicks, if present, as well as presence or absence of bays, islands, bogs, marsh areas, hummocks, Canada Geese (Branta canadensis), and Mute Swans (Cygnus olor). If loons were observed on a lake, I roughly estimated, using a rangefinder, the closest distance between the loon(s) and the nearest access road and house. If I did not observe loons on a lake, I interviewed lake residents to ascertain whether breeding or visiting loons used the lake. On four lakes, information on chick mortality was available through the Michigan Loon Registry program or through subsequent observations.

Lake access was categorized as: 1) no access or access by foot path only, 2) private or 3) public. Each lake was as-
signed a highest recreational use range: 1) no use, 2) people on shore or swimmers, 3) non-motorized craft, 4) motorized craft, or 5) motorized craft with waterskiers. Twenty-eight lakes were classified as low-use and 31 lakes as high-use. An estimate of rate of lake use was determined by dividing the total number of boats observed by length of observation period (boats/time).

A 15–45 power zoom spotting scope was used to count numbers of homes, cottages, and campgrounds visible around the circumference of the lake. If a house was not visible, I used docks and pathways as evidence that a house was present. If I could not see the entire shoreline, I drove around the lake, when possible, to estimate number of dwellings. Information on the number of homes around fifteen lakes was available from Gannon and Paddock (1974). H/A (number of homes and campgrounds/lake area) served as a rough index of the extent of lake development. Lake area and water depth data were available from the Michigan United Conservation Clubs (1979).

For analyses, lakes were recorded as having loons present or absent, and as having (1) no loons, (2) nonbreeding or unsuccessful loons, or (3) breeding loons (loon status). Chi-square, Mann-Whitney U tests, and logistic multiple-regression analyses were used to test for relationships between loon presence/absence and loon status and lake characteristics. Logistic multiple regression analyses estimates the probability of an either-or event occurring, such as a lake having loons or not having loons, or having non-breeding or unsuccessful loons versus breeding loons, based on multiple independent variables.

**Time-Budget Analysis**—To determine whether loon behavior was influenced by human lake-use factors, behavioral time-budquets were collected for breeding Common Loons on four LU (Dingman Marsh, Galloway, Malony, Roberts) and five HU (Frenchman Farm Lake Flooding, Indian River Spreads, Twin, Wycamp, Douglas) lakes in Cheboygan and Emmet counties. Preliminary time budgets, not used in subsequent analyses, were collected on HU and LU lakes to develop a reasonable ethogram and sampling time-frame. I collected 35 time budgets (17 for LU, 18 for HU) between 1–27 July 1987. For most lakes, four time budgets were collected, one in each of the periods from 0700–1000, 1000–1300, 1300–1600, and 1600–dusk. Loons were observed from a distance of at least 100 meters using a 15–45 m zoom spotting scope. Any of thirty-five behaviors (see Sjolander and Agren 1972, McIntyre 1979; Table 2) exhibited by all individuals of a family present on the lake were tallied every fifteen seconds during a one-hour period. These included: swimming, stationary/driftling, flying, surface dive, splash dive, tremolo, wail, hoot, yodel, doze (tuck head), head over back, wings outspread, wiggle tail, hunched posture, head/bill snake, bill open, preening, belly up, flap wings, splash wings in water, bill up, head over back, low in water, eating, adult feeding chick, adult carrying food, peering, bill in water (semi-peer), chick diving, chick foraging, adult absent from lake, adult away from chick, chick on adult’s back, chick pokes adult, and touch bills.

The number of loons observed ranged from one adult and one chick
to two adults and two chicks. According to descriptions of chick plumage and behavior (Bent 1919, Olson and Marshall 1952), chicks were two to three weeks old at the beginning of the study. Behaviors were not exclusive, i.e., I assigned more than one behavior on the 15th second to a loon if it was exhibiting more than one behavior. Except for adult absent from lake and total behaviors, frequencies for each behavior in a time budget were figured by summing the number of times a specific behavior was recorded and dividing by the number of loons observed.

In the text, behaviors and lake use factors preceded by “total” indicates the total number of times this behavior or lake use variable was observed during the hour-long time budget period. The lake use factors recorded during the time budget included the numbers of non-motor boats (sailboats, rowboats, canoes) and motorboats using the lake, as well as numbers of people swimming or on shore.

Table 1. Twenty-three variables measured for 59 lakes in nine counties of Michigan.

| Variable | ALGER | CHARLEVOIX | Cheboygan | Chippewa | Crawford | Doughty | Eaton | Genesee | Huron | Jackson | Lapeer | Lenawee | Livingston | Macomb | Marquette | Muskegon | Oakland | Osceola | River | Saginaw | St. Clair | Shiawassee | Washtenaw | Wayne |
|----------|-------|------------|------------|----------|----------|---------|-------|--------|-------|---------|--------|--------|-----------|--------|-----------|---------|---------|--------|-------|---------|---------|-----------|--------|
| Farmers  | 59.6  | 57.0       | 62.2       | 58.6     | 64.8     | 50.2    | 61.8  | 58.6   | 59.6  | 63.8    | 58.6   | 64.8   | 58.6      | 60.0   | 58.6      | 58.6   | 62.2    | 58.6   | 60.0   | 58.6   | 62.2    | 58.6   |
| Gallons  | 10.5  | 10.5       | 10.5       | 10.5     | 10.5     | 10.5    | 10.5  | 10.5   | 10.5  | 10.5    | 10.5   | 10.5   | 10.5      | 10.5   | 10.5      | 10.5   | 10.5    | 10.5   | 10.5   | 10.5   | 10.5    | 10.5   |
| Loons    | 1.1   | 1.1        | 1.1        | 1.1      | 1.1      | 1.1     | 1.1   | 1.1    | 1.1   | 1.1     | 1.1    | 1.1    | 1.1       | 1.1    | 1.1       | 1.1    | 1.1     | 1.1    | 1.1    | 1.1    | 1.1     | 1.1    |
| Netts    | 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Rutted   | 5.0   | 5.0        | 5.0        | 5.0      | 5.0      | 5.0     | 5.0   | 5.0    | 5.0   | 5.0     | 5.0    | 5.0    | 5.0       | 5.0    | 5.0       | 5.0    | 5.0     | 5.0    | 5.0    | 5.0    | 5.0     | 5.0    |
| Sargasso | 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Sargasso | 1.1   | 1.1        | 1.1        | 1.1      | 1.1      | 1.1     | 1.1   | 1.1    | 1.1   | 1.1     | 1.1    | 1.1    | 1.1       | 1.1    | 1.1       | 1.1    | 1.1     | 1.1    | 1.1    | 1.1    | 1.1     | 1.1    |
| Sediments| 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Seaweed  | 1.1   | 1.1        | 1.1        | 1.1      | 1.1      | 1.1     | 1.1   | 1.1    | 1.1   | 1.1     | 1.1    | 1.1    | 1.1       | 1.1    | 1.1       | 1.1    | 1.1     | 1.1    | 1.1    | 1.1    | 1.1     | 1.1    |
| Situ    | 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Spread  | 1.1   | 1.1        | 1.1        | 1.1      | 1.1      | 1.1     | 1.1   | 1.1    | 1.1   | 1.1     | 1.1    | 1.1    | 1.1       | 1.1    | 1.1       | 1.1    | 1.1     | 1.1    | 1.1    | 1.1    | 1.1     | 1.1    |
| Stami    | 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Stem    | 0.1   | 0.1        | 0.1        | 0.1      | 0.1      | 0.1     | 0.1   | 0.1    | 0.1   | 0.1     | 0.1    | 0.1    | 0.1       | 0.1    | 0.1       | 0.1    | 0.1     | 0.1    | 0.1    | 0.1    | 0.1     | 0.1    |
| Stroke  | 1.1   | 1.1        | 1.1        | 1.1      | 1.1      | 1.1     | 1.1   | 1.1    | 1.1   | 1.1     | 1.1    | 1.1    | 1.1       | 1.1    | 1.1       | 1.1    | 1.1     | 1.1    | 1.1    | 1.1    | 1.1     | 1.1    |

(continued)
Spearman rank correlations were used to test relationships between behavioral frequencies and number of motorboats and total boats (non-motorized plus motorized craft). Nested ANOVAs, nesting lakes within HU and LU categories, were used to test for significant differences in behavioral frequencies on HU versus LU lakes.

**Human-Disturbance Experiment—**
Between 23–31 July 1987, I approached loons in a kayak on three LU and four HU lakes. The distance at which single and breeding pairs of loons first reacted (for example, by swimming away, diving, or vocalizing) to an approaching kayak was determined using a rangefinder. I recorded the first detectable behavioral re-

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**Table 1. (Continued)**

| County and Lake | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
| LUCE            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Bodl            | 125.8 | 0 | 0 | 1 | 3 | 2 | X | 1 | 0 | 0 | 1 | 0 | 0 | 0 | X | X | X | 1 | 2 | X | X | X | 0.0 |
| Cove            | 30.7 | 0 | 0 | 0 | 0 | 1 | 2 | 22.5 | 1 | 0 | 0 | 0 | 0 | X | 0 | 0 | 0 | 3 | X | X | X | 0.0 |
| Creek           | 59.7 | 1 | 1 | 1 | 3 | 2 | 15.2 | 1 | 0 | 0 | 0 | 1 | 0 | X | 0 | 0 | 1 | 10 | X | X | X | 0.0 |
| Pond            | 51.0 | 0 | 0 | 1 | 1 | 3 | 2 | 15.2 | 1 | 0 | 0 | 0 | 0 | X | 0 | 0 | 1 | 10 | X | X | X | 0.0 |
| Pike            | 23.0 | 1 | 1 | 0 | 1 | 1 | 2 | 22.7 | 0 | 0 | 0 | 0 | 0 | X | 0 | 0 | 1 | 10 | X | X | X | 0.0 |
| MACKINAC        |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Cranberry       | 9.7 | 0 | 0 | 0 | 0 | 0 | X | 0 | 0 | 0 | 1 | 0 | 0 | 0 | X | 0 | 0 | 0 | 0 | X | X | X | 0.0 |
| PRESQUE ISLE    |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Loon1           | 27.1 | 1 | 1 | 0 | 1 | 2 | X | 0 | 0 | 0 | 1 | 0 | 1 | 0 | X | 0 | 0 | 0 | 2 | 1 | 402 | 402 | 6.0 |
| Shopack         | 18.2 | 0 | 0 | 0 | 1 | 3 | 2 | 6.1 | 1 | 0 | 1 | 0 | 1 | 0 | X | 0 | 0 | 0 | 1 | 5 | X | X | X | 18.0 |
| Tomahawk        | 16.2 | 1 | 1 | 1 | 1 | 3 | 2 | X | 0 | 0 | 0 | 1 | 0 | X | 0 | 0 | 1 | 0 | 1 | 0 | 44.0 |
| SCHOOLCRAFT     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| A-1 Pool        | 101.2 | 0 | 0 | 0 | 0 | 2 | 3.1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | X | X | X | 1 | 0 | X | X | X | 6.0 |
| G-1 Lake        | 103.8 | 1 | 1 | 0 | 0 | 1 | 3.1 | 1 | 1 | 1 | 0 | 1 | 2 | 0 | X | 1 | 0 | 0 | 0 | X | X | X | 6.0 |
| Casino          | 56.7 | 1 | 1 | 0 | 1 | 2 | 11.0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | X | 0 | 0 | 1 | 0 | X | X | X | 6.0 |
| F-Pool          | 108.3 | 0 | 0 | 0 | 2 | 2 | 3.1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | X | 0 | 0 | 1 | 0 | X | X | X | 6.0 |
| G-2 Pack        | 56.9 | 1 | 2 | 0 | 0 | 2 | 3.1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | X | 0 | 0 | 1 | 0 | X | X | X | 6.0 |
| M-2 Pool        | 292.8 | 1 | 2 | 0 | 2 | 3.1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 0 | X | 0 | 0 | 1 | 0 | X | X | X | 6.0 |
| Bass            | 7435 | 1 | 1 | 1 | 1 | 3 | 2 | 6.1 | 1 | 1 | 0 | 1 | 0 | 0 | X | X | X | 0 | 0 | 1 | 0 | X | X | X | 100.0 |

1Historical record of breeding loons on the lake.

X = Missing data.

A = Lake area (ha).

B = Loon: 0 = absent, 1 = present.

C = Loon status: 0 = none, 1 = nonbreeding or unsuccessful, 2 = breeding.

D = LU/HU: Low use = 0, High use = 1.

E = Use Range: 0 = no use, 1 = people on shore or swimmers, 2 = nonmotorized craft, 3 = motorized craft, 4 = motorized craft and waterskiers.

F = Access: 0 = no access or foot path only, 1 = private access, 2 = public access.

G = Water depth (m).

H = Bay: 0 = absent, 1 = present.

I = Island: 0 = absent, 1 = present.

J = Bog: 0 = absent, 1 = present.

K = Marsh: 0 = absent, 1 = present.

L = Hummock: 0 = absent, 1 = present.

M = Number of adult loons.

N = Number of chicks.

O = Number of chicks lost.

P = Canada Geese: 0 = absent, 1 = present.

Q = Mute Swan: 0 = absent, 1 = present.

R = Number of campgrounds.

S = Number of homes.

T = Number of homes within 500 meters of loons.

U = Distance from loons to nearest house (m).

V = Distance of loons to nearest road (m).

W = Boats/time.
response and noted whether the loon(s) dove or tremoloed. On two occasions, I measured distance to first response to motorboats. A Wilcoxon rank-sum test was used to compare the loon’s mean distance to first response on LU versus HU lakes.

**Results**

**Lake Survey**—Lakes which had loons \((n = 30)\) were more likely to have islands \((\chi^2 = 5.396, \text{d.f.} = 1, P = 0.0202)\) and hummocks \((\chi^2 = 5.676, \text{d.f.} = 1, P = 0.0172)\) and were less likely to have Canada Geese \((\chi^2 = 5.371, \text{d.f.} = 1, P = 0.0205)\) than were lakes without loons. Loon status was related in a similar way to islands, hummocks and Canada Geese \((\chi^2 = 18.49, \text{d.f.} = 2, P = 0.0001; \chi^2 = 16.27, \text{d.f.} = 2, P = 0.0003; \chi^2 = 7.31, \text{d.f.} = 2, P = 0.0259, \text{respectively})\). The presence or absence of bays, bogs, marsh areas, Mute Swans, as well as HU vs. LU lakes, lake access, and boats/time were not related to loon presence or absence or loon status.

The number of loons on a lake correlated positively with lake area \((r = 0.322, n = 59, P = 0.013)\). Correlations between lake area and distance of loons to nearest house or access road were not significant. Lakes occupied by loons tended \((U = 320, n = 59, P = 0.081)\) to be larger \((173.7 + 223.15 \text{ ha}); (106.4 + 190.98 \text{ ha})\), and larger lakes were significantly more often HU lakes \((U = 157, n = 59, P < 0.0001)\). Lakes occupied by loons did not differ significantly \((U = 352, n = 59, P = 0.205)\) in lakeshore development \((\text{H/A mean} + \text{SD} = 0.24 + 0.36)\) from lakes not occupied by loons \((0.35 + 0.54)\).

Loons with one-chick broods were found on lakes similar in size \((126.9 + 127.24 \text{ ha})\) to lakes with two-chick broods \((182.1 + 122.15 \text{ ha})\) \((U = 21, P = 0.479)\). There also was no difference \((U = 22, n = 15, P = 0.535)\) in lakeshore development for lakes with one- vs. two-chick broods \((\text{one-chick broods: } \text{H/A} = 0.28 + 0.443; \text{two-chick broods: } 0.14 + 0.342)\). Over one-third of the loon pairs with one-chick broods and two-thirds of the loon pairs with two-chick broods were found on lakes with no shoreline development \((\text{H/A} = 0.00)\). Mean brood size in this study was \(1.4 + 0.51\) chicks, which corresponds with results from other Michigan loon reproduction studies \((\text{Robinson et al. 1987})\).

Logistic-multiple regression analyses were conducted to determine lake characteristics associated with loon presence vs. absence as well as breeding vs. nonbreeding or unsuccessful loons. Factors used in the analysis were lake area, LU vs. HU, lake access, use range, presence or absence of bays, islands, bogs, marshes, hummocks, Canada Geese, Mute Swans, H/A, and boats/time. The best predictors of loon presence vs. absence were hummocks and Canada Geese \((\text{model } \chi^2 = 13.635, \text{d.f.} = 2, P = 0.0011)\). Non-breeding or unsuccessful loons were distinguished from breeding loons on the basis of islands \((\text{model } \chi^2 = 6.499, \text{d.f.} = 1, P = 0.0108)\).

**Time-Budget Analysis**—Loons showed significant differences on LU vs. HU lakes in the following behaviors \((n = 35 \text{ in all cases})\): swimming \((F = 12.55, P = 0.002)\), stationary \((F = 7.75, P = 0.01)\), adult carrying food \((F = 5.81, P = 0.023)\), peering \((F = 6.79, P = 0.015)\), adult away from chicks \((F = 18.91, P < 0.001)\), preening \((F = \ldots\))
10.68, \( P = 0.003 \)), dozing (\( F = 4.96, \ P = 0.035 \)), flapping wings (\( F = 11.01, \ P = 0.003 \)), chick foraging (\( F = 68.32, \ P < 0.001 \)), and total fed chick (\( F = 6.10, \ P = 0.02 \)). Swimming, adult carrying food, peering, preening, flapping wings, and chick foraging showed higher frequencies by loons on the HU lakes, whereas loons showed higher frequencies of stationary, adult away from chicks, dozing, and total fed chick on the LU lakes. Of 40 (including total) behavioral variables analyzed, one could expect at least two behaviors to be significantly different (at \( P = 0.05 \)) between LU and HU lakes by chance alone. Twenty-three of the behaviors also showed significant differences among lakes within the LU and HU categories; this indicates either significant differences among lakes or among loon families, since only one family of loons was observed on each lake.

Several behaviors were positively correlated with total boats (number of non-motor boats plus motorboats) on a lake, including swimming (\( r = 0.350, \ P = 0.039 \)), wailing (\( r = 0.394, \ P = 0.019 \)), splash diving (\( r = 0.431, \ P = 0.01 \)), and preening (\( r = 0.364, \ P = 0.031 \)) (n = 35 in all cases). Adult absent from lake (\( r = -0.330, \ P = 0.053 \)) was almost significantly negatively correlated with total boats.

Wailing (\( r = 0.430, \ P = 0.01 \)) and splash diving (\( r = 0.363, \ P = 0.032 \)) were positively correlated with number of motorboats, whereas hunched posture (\( r = -0.374, \ P = 0.027 \)) and eating (\( r = -0.352, \ P = 0.038 \)) were negatively correlated with motorboats. Swimming (\( r = 0.329, \ P = 0.053 \)), preening (\( r = 0.305, \ P = 0.075 \)), total wailing (\( r = 0.317, \ P = 0.064 \)), and bill up (\( r = 0.325, \ P = 0.057 \)) showed a tendency to be positively related to the number of motorboats.

**Loon Response to Approaching Kayak**—Loons on LU lakes responded to a kayak at a mean distance approximately twice that of loons on HU lakes (distance at first response for LU: 140 + 40 m, range = 100–180 m, n = 3; HU: 74 + 43 m, range = 39–180 m, n = 10) (Wilcoxon rank sum test, \( W = 32.5, \ P = 0.049 \)). Loons on HU lakes appeared to tremolo less (40% of trials vs. 67%) and dive more frequently (50% vs. 0%) in response to the approaching kayak than loons on the LU lakes, although sample sizes were small. On two occasions on HU lakes, loons first responded to motorboats by swimming away rapidly when motorboats were 180 and 260 m away.

**Discussion**

**Correlates of Loon Presence and Breeding Success**—Most historical accounts specify that loons prefer large, deep lakes devoid of emergent vegetation (Bent 1919, Olson and Marshall 1957, Vermeer 1973, Alvo 1981, Yonge 1981). However, Common Loons in northern Michigan are found on a wide range of lake types (bogs, marshes, reservoirs, etc.), which corresponds with McIntyre’s (1979) findings for loons in Minnesota.

In Wisconsin, Blair (1990) found that various lake-quality variables—elevation, extractable aluminum, level of ammonia, and surface area—explained 68.2% of the variance in predicting the presence or absence of Common Loons. In the present study, Common Loons were present on lakes with hummocks and Canada Geese, and successfully breeding as compared to non-
breeding or unsuccessful loons were found more frequently on lakes with islands (see also Dahmer 1986).

Many previous studies also show that the majority of loons prefer to nest on islands, where they may be protected from such predators as mink, skunks, and raccoons (Yeates 1950, Olson and Marshall 1952, Vermeer 1973, McIntyre 1975, Titus and VanDruff 1981). Vermeer (1973) found a positive correlation between numbers of breeding loon pairs and islands, and McIntyre (1977) showed that loons had higher nesting success on islands compared to the mainland. Although I did not locate nests, most of the breeding loons in this study probably nested on islands. Although three of 15 pairs of breeding loons were found on lakes without islands, for two of these pairs hummocks were available on which to nest. Loons have also been shown to prefer nesting in marsh (Alvo 1981) and backwater areas (Strong 1985), but marshes were not significantly preferred by breeding loons in this study.

Vermeer (1973) found a negative correlation between numbers of breeding loon pairs and “disturbance ratio,” which is similar to my H/A variable. However, in my study, recreational and shoreline development factors (HU vs. LU, H/A) did not significantly predict loon presence or absence or status. McIntyre (1979) also found no relationship between loon presence or absence and amount of recreational use. She did, however, report a surprising positive relationship between proportion of nesting pairs with young and recreational use. McIntyre (1979) also suggested that the probability of raising a two-chick brood was greater on larger lakes; in the present study, two-chick broods (n = 6) were also found on relatively larger lakes than were one-chick broods (n = 9), although the difference was not significant.

Two loon pairs which lost their single-chick broods were on relatively small lakes (89.8 and 133.1 ha) which had waterskiiers, as well as extensive shoreline development (H/A ratios of 0.61 and 0.41). Although the exact locations of nests were unknown, they were presumably close to homes and human activities. Dahmer (1986) reported that proximity to human activity was the factor most closely related to loon nesting failure.

In contrast, the breeding pairs on two of the large, HU lakes (Indian River Spreads, French Farm Lake Flooding) successfully raised two chicks. Both of these lakes had areas away from boating traffic where loons could raise their chicks with little probability of disturbance. For example, although approximately 20 boats/hr and up to 140 boats/day on weekends passed through a narrow waterway on the Indian River Spreads, the loons stayed within the relatively undisturbed confines of a shallow bay approximately one-half mile from the boating route. It appears, therefore, that the presence of a refuge in a large lake can mask the negative effects of HU and human disturbance (McIntyre 1979).

My results suggest (see also Dahmer 1986) that breeding loons on larger lakes may locate nests further away from areas of human activities than do unsuccessful loons on smaller lakes. I could not determine whether breeding loons were using areas on lakes furthest away from potential human activity. The lack of significant
differences between lake area and distance to nearest house or road access for nonbreeding and unsuccessful loons vs. breeding loons suggested that requirements of Common Loons for nesting, feeding, nursery areas or avoiding predators may override avoidance of human disturbance.

**Correlates of Behavior**—Ten significant behavioral differences were noted between loons on HU and LU lakes. Loons were less stationary and wailed more on HU than on LU lakes. This difference is presumably due to greater disturbance on HU lakes, since wailing and swimming were significantly positively correlated with total boats on the lake. Wailing, used by a loon if it is separated from a mate or chicks (Barklow 1988), was significantly more common on HU lakes, probably because interactions between loons are more commonly disturbed on HU lakes. Also, chicks on LU lakes were fed more, and chicks on LU lakes foraged significantly more than did chicks on HU lakes. Whether these behavioral differences translate into differences in reproductive success for loons on HU vs. LU lakes is unknown.

My study was conducted when the chicks were already two weeks old, beyond the critical stage of mortality (McIntyre 1988a) and after the point at which adult loons are presumably most sensitive to human disturbance. The results of this study, therefore, do not preclude the possibility that more significant behavioral difference between loons on HU vs. LU lakes may be evident earlier in the breeding season.

The mean distance to first reaction of loons on LU lakes (140 + 40 m) corresponds with the mean flushing distance (110 m) reported by Smith (1981) for loons in response to canoes on lakes normally without canoes. As in my study, Titus and Van Druff (1981) approached nesting loons in a canoe and found that loons on lakes with motorboats flushed from their nests at a significantly lower average distance (11.2 m, n = 6) than loons on lakes without motorboats (32.7 m, n = 20). Titus and Van Druff (1981) concluded that loons on LU lakes tended to flush more frequently and to a further distance from the nest, vocalize more and show a greater degree of agitation than loons on HU lakes. In my study, loons tremoloed in a greater percentage of trials on the LU lakes as compared to HU lakes. The tremolo is the loon alarm call associated with a tendency to flee (Barklow 1979). In contrast, loons on HU lakes tended to dive or to swim away less quickly. On certain occasions, loons on HU lakes actually approached the kayak.

I observed two loons (on Wycamp and Twin lakes) swimming rapidly and running across the water while tremoloing (McIntyre 1988a) when motorboats came within 180 and 260 m, respectively. It appeared that these behavioral responses were much more extreme than any observed in response to non-motorized craft. Although not quantified in the present study or in any other of which I am aware, the noise, number of people in, and size of a motorboat might also influence the reaction of loons to motorboats.

**Implications for Conservation**—Common Loon population recovery plans have concentrated on public education and protection of existing nest sites (Sutcliffe 1979, Wood 1979). The latter is important, because Strong et al.
(1987, p. 123) report a 78–88% reuse of nesting areas and 57–86% “year-to-
year spatial overlap of nurseries in indi-
vidual territories.” Thus, if records of
loon nesting and nursery areas are avail-
able, protection of known nesting
and nursery areas is an appropriate
management strategy. Substantial
information has also been compiled to
indicate which lake characteristics and
human use factors correlate with the
presence of breeding loons. In the
present study, for example, lakes with
islands seem to be preferred by loons
for nesting. Thus, lakes with islands
might be particularly appropriate for
protection efforts.

In my study, loons were sighted a
mean distance of 1,200 m from the
nearest house, and roads closest to the
lake and/or boating ramps were lo-
cated a mean distance of 1,423 m from
loons. Heinberger et al. (1983) found
that increasing numbers of cottages
within 150 m of a loon nesting site
decreased loon hatching and nest suc-
cess. More information concerning
where loons situate their nests in re-
lation to lake developments is needed
in order to determine the size of buffer
zones.

Loon recovery programs should also
consider boating traffic on a lake dur-
ing the loon reproduction season.
Chicks tend to stay in shallow water
areas, less than 150 m from shore, and
Strong and Bissonette (1989, p. 72)
suggest that “near-shore recreation
may be more detrimental to loons than
man’s activities in deep, open water.”
Thus, water depths of less than 3
meters, which constitute chick-rearing
habitat, could be designated off-limits
to recreational users during the loon
breeding season (Strong and Bisso-
nette 1989). Keeping boats 150 m
from shores of lakes or islands would
help to ensure that adult loons are not
ousted from their nests (potentially
damaging eggs or causing parents to
abandon nesting efforts), and that
chicks are not separated from adults
or forced into deep, open waters
where they are in danger from pike
and other predators, as well as motor-
boats.

Another population recovery strate-
gy for loons involves artificial islands.
Artificial islands have been used suc-
cessfully as nest sites by loons, in-
creasing nesting success by as much as 59%
(McIntyre and Mathisen 1977, Sut-
cliffe 1979). Therefore, lakes which do
not have islands or hummocks, but are
low use, have low H/A ratios and fa-
vorable lake qualities (i.e., little water
fluctuation, high fish numbers, water
clarity, pH > 6.0), and are larger than
25 acres (McIntyre 1979) would be
good candidates for artificial islands.

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