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Papers From The 1987 Conference On Loon Research and Management

Edited by: Paul I. V. Strong

North American Loon Fund
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PAPERS FROM THE 1987 CONFERENCE ON COMMON LOON RESEARCH AND MANAGEMENT

September 18-19, 1987
Laboratory of Ornithology
Cornell University
Ithaca, NY

Edited by: Paul I.V. Strong, Ph.D.

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The North American Loon Fund (NALF) was organized in 1979 to provide a financial and informational clearinghouse for research, management, and educational efforts on behalf of the Common Loon. NALF is a non-profit education and research fund supported by contributions and the sale of records, books, and loon artifacts. NALF does not receive financial support from state or federal agencies.

Each year, NALF solicits and funds proposals for research, management, and public education projects. Since its inception, it has sponsored three major conferences and has organized numerous state and regional workshops. NALF maintains a file of technical and popular articles about loons and loon preservation and distributes these on request. An annotated bibliography on Common Loons is expected to be completed in 1990. In 1986, NALF was recognized for its efforts in loon preservation when it received a Chevron Conservation Award.

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PREFACE

The North American Loon Fund convened the third North American Conference on Common Loon Research and Management September 18-19, 1987 at the Laboratory of Ornithology at Cornell University in Ithaca, New York. The purpose of the conference was to update the state of knowledge on loon ecology and population status since the last conference in 1979. Sixty researchers, managers, educators, and loon enthusiasts participated in the two-day session during which 27 papers were presented. Additionally, conference participants were treated to two special presentations: one by Jeff Fair, director of the Loon Preservation Committee of New Hampshire, on 10 years of loon preservation in that state; and the other by Dennis Olson, coordinator of Minnesota Loon Watch. Dennis portrayed Dr. Gavin Immer, a slightly "loony" loon biologist from Sweden who has come to North American to study Common Loons.

The conference was organized by Scott Sutcliffe of the Laboratory of Ornithology. Session coordinators and chairpersons were Judith McIntyre of Utica College and Paul Strong of the Sigurd Olson Environmental Institute of Northland College. Charles Walcott, director of the Laboratory of Ornithology was a gracious host and made the lab available for the conference.

This document is a collection of all of the papers presented at the conference plus a report from New Hampshire. Some are in full-length form while others are presented as summaries only. Papers in summary form may appear in technical journals or some other publication in full length. Additional information on the subjects presented may be obtained by contacting individual authors or the North American Loon Fund.

As editor, I am ultimately responsible for the format and contents of the following papers. Any errors are mine. I thank the North American Loon Fund for their confidence in my editorial abilities, Julie Gleeson and Arnell Lavasseur of the Sigurd Olson Environmental Institute for their patience and efforts in typing the manuscripts, and Mark Peterson, director of the Sigurd Olson Environmental Institute for allowing me to work on this project. Erica Peterson provided the artwork and helped with design and layout.

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January, 1988

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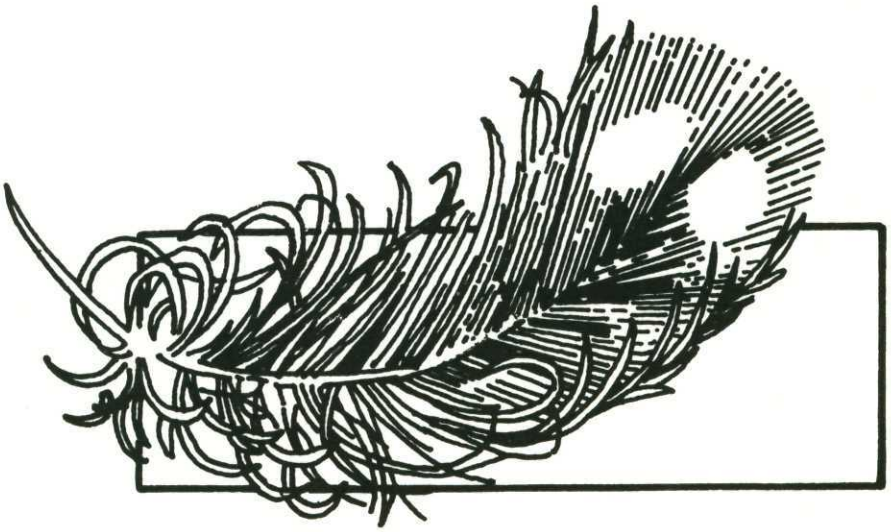

TERRITORIAL DEFENSE OF MULTIPLE LAKES BY COMMON LOONS: A PRELIMINARY REPORT

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Research on Common Loons (Gavia immer) has expanded in recent years, due in great part to an increasing awareness that U.S. populations of these birds may be dwindling to a critical level. Survey studies have attempted to quantify population status and changes (McIntyre 1979, Metcalf 1979, Sutcliffe 1979). One assumption of such studies has been that a given loon pair maintains 1 lake, or 1 lake area, as its territory.

To our knowledge, there have been no reported observations of Common Loon systematically using bodies of water other than their identified "territories". However, some birds spend considerable time away from their territories, during both pre-nesting and early nesting phases (Miller 1988). There are no good indications of where this time away is spent. General consensus is that the birds go to other lakes, probably larger ones, for feeding and/or socializing.

In May and June of 1986, during the course of a vocal-tagging project (Miller 1988), it was noted that the territorial pair which was known and previously vocal-tagged on Grass Lake was rarely to be found on the lake. In late June we heard yodeling from a nearby lake that sounded similar to that of the Grass Lake male. In August, 1986, another researcher heard yodels from loons on both Scout and Grass Lakes and thought the yodels sounded very much alike (Steve LaValley, pers. comm.).

There would be many important implications of finding multi-lake territorial defense among Common Loons. This project was conducted to systematically dismiss or confirm the possibility that the loons defending Grass and Scout Lakes were the same birds.

METHODS

We conducted daily observations on Grass (T-44-N, R-11-E) and Scout (T-44-N, R-11-E) Lakes, Gogebic County,

in Michigan's Upper Peninsula April 27-May 13, 1987. Both are small oligotrophic lakes and are less than one-quarter mile apart. Grass (31 acres) has 7 cabins, most built within the past decade, occupying approximately 50 percent of its shoreline. Only one of these cabins is used year-round. Scout (23 acres) has no cabins. Grass receives very light fishing pressure, while Scout has moderate activity.

An observer was stationed on each lake 0600-0900 and 1700-2000 each day. The observers used 2-way radios to report loon arrivals and departures to each other. Panasonic microcassette recorders were used to record behavior of any loons present. Simultaneous 10-minute observations on both lakes were made at the beginning of each hour 1000-1600.

Yodel recordings were collected for tagging purposes. On May 1, at 1810, 7 yodels were recorded from the pair on Grass Lake. On May 3, at 1000, 4 yodels were recorded from the pair on Scout Lake. All recordings were made using a Uher 4000L reel-to-reel recorder, at 19 cps, through an AKG-CK9 shotgun microphone. Calls were elicited by playing 1 or more unfamiliar yodel recordings at the birds (see Miller 1988 for detailed methods).

On the morning of May 7, having found no loons present on either Grass or Scout, the senior author's private plane was used for spotting loons on small lakes nearby. At 1030, 8 yodels were recorded from a pair on Sharptail Lake (T-44-N, R-11-E), an 11-acre eutrophic, remnant bog lake, and the nearest contiguous neighbor to Grass and Scout, approximately one-half mile to the west. Sharptail underwent the observation regimen described above from May 8-13.

Four 3-day observation sessions were conducted on all 3 lakes May 14-July 13. These were spaced at intervals of about 2 weeks. The 3 lakes were visited on a rotating basis approximately every 2 hours from 0600 to 2000. Presence or absence of loons was noted, and 10 minutes of continous observations were made, using a Panasonic microcassette recorder, of any bird(s) present.

In addition to noting natural movements of loons among the lakes, we studied the response of the pair on 1 lake to yodel broadcasts from another lake. On May 3, at 1824, 3 yodels were broadcast from Grass Lake toward the pair on Scout.

On May 15 we observed what appeared to be dual-lake usage by another pair. On that date, 7 yodels were recorded from the pair on Black Oak Lake (T-43-N, R-9-E), a 549-acre drainage lake in Vilas County, Wisconsin. On May 16, 1 yodel was recorded from the pair on George Lake (T-42-N,

R-9-E), a 12-acre seepage lake, located just across County Road B from Black Oak.

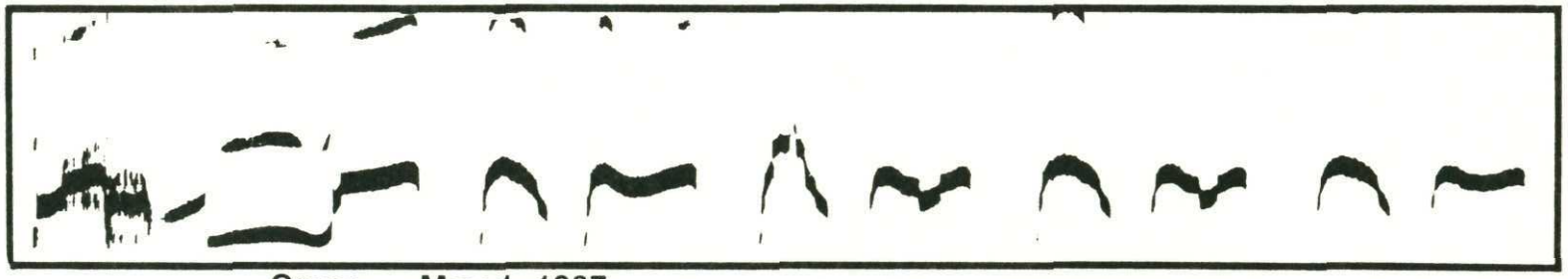
RESULTS

Relevant features of yodel calls recorded on Grass, Scout, and Sharptail Lakes are identical (Fig. 1) confirming that the male loon involved was the same on all 3 lakes. The occupancy pattern on the 3 lakes (Graph 1) clearly shows that for 77-97 percent of any given day during the entire period, a loon pair was observed on only 1 of the 3 lakes. The data also show a strong partitioning of lake usage, with a large proportion of 1 day spent on Grass, 6 days on Scout, and all of the final 4 observation days spent on Sharptail. On 3 separate days prior to the discovery of use of Sharptail, no pair was observed on either Grass or Scout (i.e., April 30, May 2, and May 7). The pair either had split up temporarily or was on some unknown lake(s).

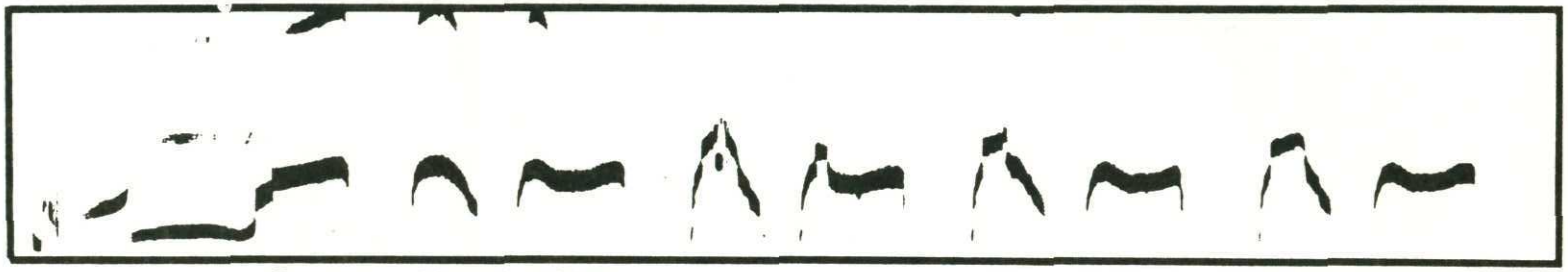
Single loons were observed infrequently on the lakes (Graph 2). On only 2 days was there appreciable time spent on any lake by singles. The 2 days coincide with those on which no pair was seen. However, time spent was less than 50 percent in both cases, and for the third day on which no pair was seen on either lake (April 30) no singles were seen either.

There were several instances of overlapping lake use between a pair and a single. On 3 occasions we observed a pair on one lake and a single bird on a second lake. Total overlap time was 79 minutes. On 4 separate occasions, a single bird was observed on the same lake as a pair, with total overlap time of 112 minutes. However, on no occasion did we observe more than 1 pair on the 3 lakes at the same time, nor did we ever find a pair on one lake and single birds on both of the others.

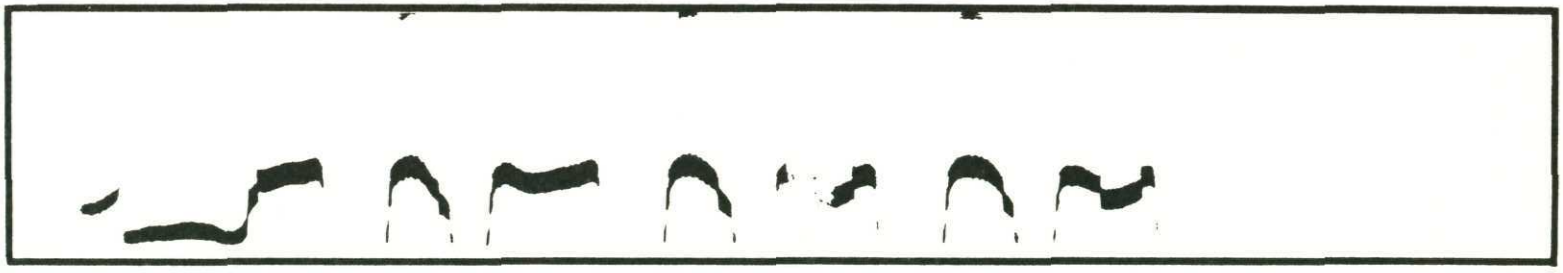
Specific flight movements among the lakes and behaviors of the birds while on specific lakes strongly suggest just 1 pair using all 3 lakes. On May 3, 0627, the 2 loons on Grass Lake flew directly to Scout, where they fed until 1820. We broadcast 3 yodels from Grass lake toward Scout 1824-1832. The male on Scout responded with 2 yodels to the third of these broadcasts. At 1855 a single loon landed near the pair on Scout. After circle dancing (McIntyre 1975) with the pair, the single bird left Scout 13 minutes later. Four yodels were given by the male on the water as the single flew out. At 1920 the pair left Scout and flew directly back to Grass Lake, where at 1940 they copulated on a mud beach at the west end of the lake. They remained on Grass until at least 2300 and had several calling bouts that included yodels, tremolo duets and wails.



Grass — May 1, 1987

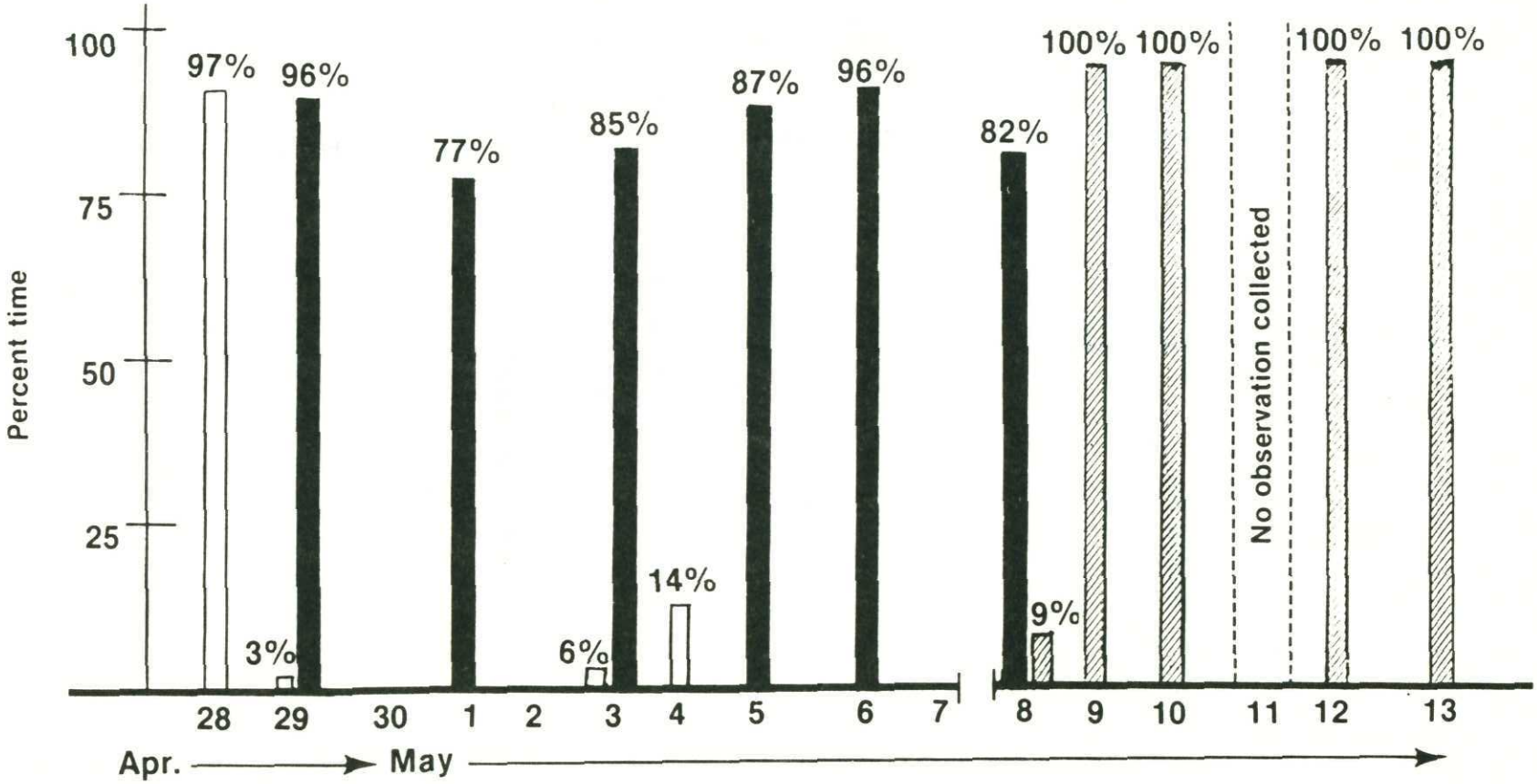


Scout — May 3, 1987



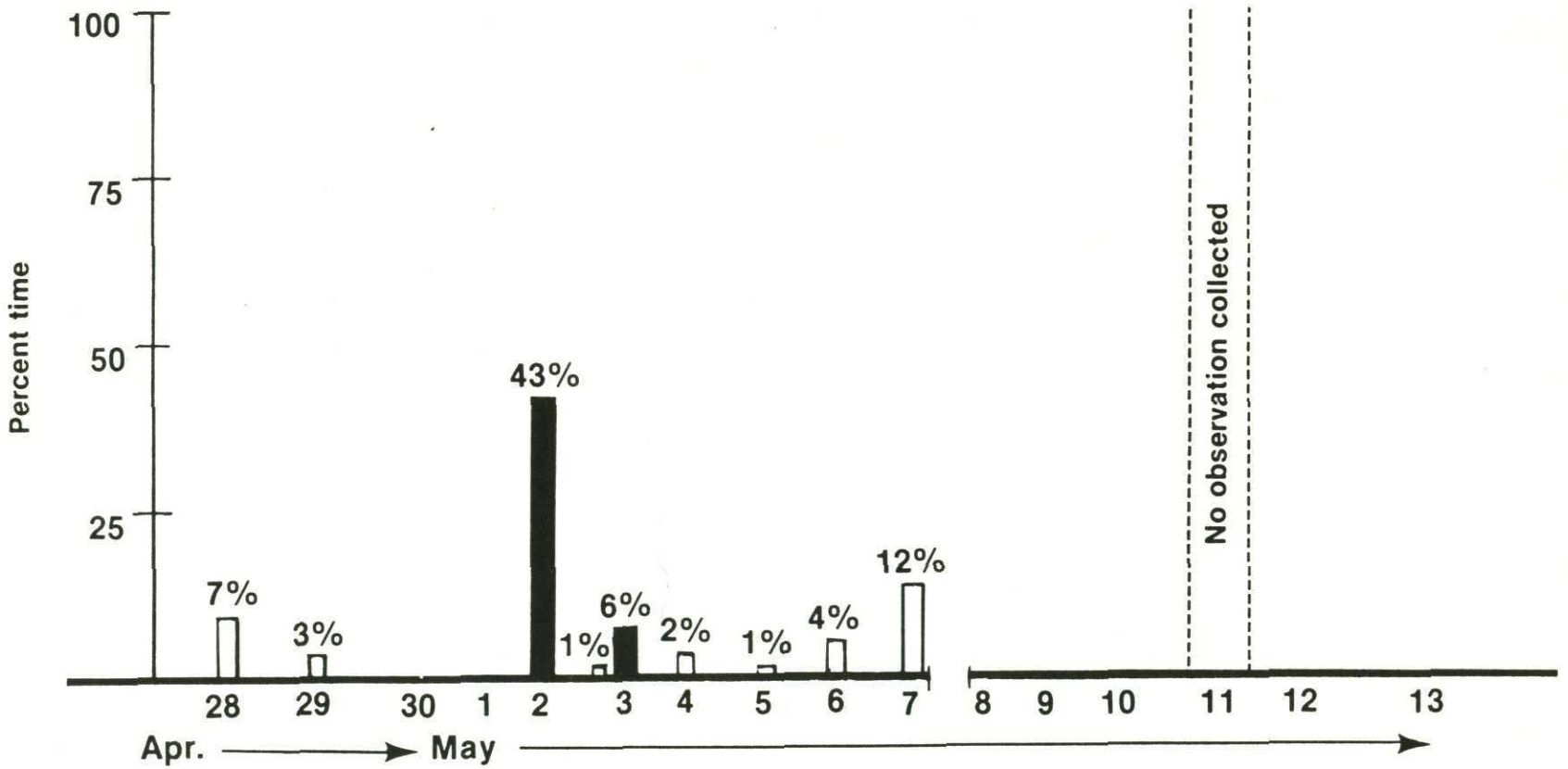
Sharptail — May 7, 1987

Fig. 1-Wide-band sound-spectrographs of Common Loon yodel calls recorded on Grass, Scout and Sharptail Lakes, 1987.



GRAPH 1-Percent time for each observation-day that a loon pair was present on each lake.

Grass Lake Scout Lake Sharptail Lake



GRAPH 2-Percent time for each observation-day that a single loon was present on each lake.

Grass Lake Scout Lake Sharptail Lake

The pair was again present on Grass the next morning, At 0702 they copulated again, in the same spot as on the evening before, but for a much longer time. At 0813 both loons flew off the lake to the northwest. The pair was not seen on either Grass or Scout for the remainder of the day.

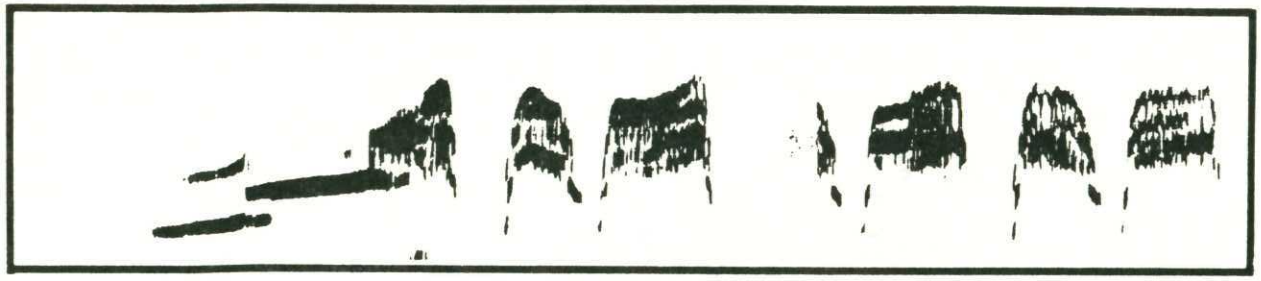
On May 16, the pair began nesting on Sharptail Lake. On May 23, at 2031, 1 bird was incubating, but the second was absent. At 2044, a single bird was observed on Grass Lake. At 2054, a second bird flew into Grass, arriving with flight tremolos from the direction of Sharptail. On Sharptail, the nest with 2 eggs was left unattended. There were no loons on the lake. Eleven yodels were heard from Grass Lake 2053-2107. The yodeling male was unquestionably the same bird we had vocal-tagging several times earlier in the season. At 2110 we heard flight tremolos from the direction of Grass, and at 2112 a single loon flew in from that direction, landed on Sharptail, and reoccupied the nest at 2116. At 2159, and again at 2244, the single loon remaining on Grass yodeled 3 times, confirming that he had remained and the female had returned to the nest on Sharptail.

The nest failed sometime between May 26 and June 6 and a second nest was established in a different location. This nest also failed after an attack by a Bald Eagle (*Haliaeetus leucocephalus*). Lake use following the second nest failure was very different from that seen earlier. We conducted 2 sets of 3-day observations in which all 3 lakes were visited approximately every 2 hours. For 45 lake visits July 1-3, 1 bird was found on only 3 (7%) visits, and 2 birds were found on only 4 (9%) visits. For July 11-13, 20 (32%) of 63 visits found single birds and only 1 (1.5%) of 63 found two birds together. The birds spent little time on any of the 3 lakes and almost none as a pair.

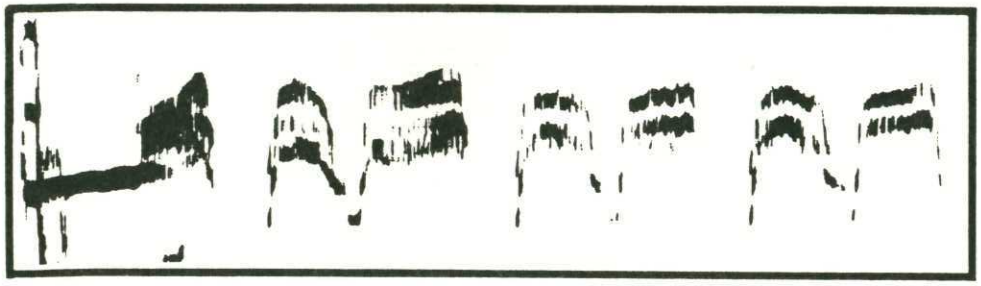
We found multi-lake defense on Black Oak and George Lakes also. On May 15, a pair was vocal-tagged on Black Oak. As we left the lake, both birds began to fly. One flew directly across County Road B and landed on George Lake. The other circled Black Oak once, then flew to George. On the evening of May 16, there were no birds on Black Oak. The yodels recorded from the 2 lakes show a very distinctive pattern, and unquestionably are from the same bird (Fig. 2). We have no further data on this pair except the observation that they successfully raised 2 young on George Lake.

DISCUSSION

The vocal-tagging results, lake use patterns, and visual observations leave no doubt that the same loon pair actively used and defended Grass, Scout and Sharptail Lakes.



Black Oak — May 15, 1987



George — May 16, 1987

Fig. 2-Wide-band sound-spectrographs of Common Loon yodel calls recorded on Black Oak and George Lakes, 1987.

The case for territorial defense is made both by the male's yodel response to our broadcasts and by observations of natural yodeling on all 3 lakes. The observation of a 2-lake territorial pattern by a second pair on Black Oak and George Lakes effectively eliminates the possibility that these observations may have been a special case unique to only 1 pair.

The findings are surprising given that no similar observations have been reported, or even hinted at, in the literature. However, these finding were a direct result of vocal-tagging, a technique which is only now being worked out (Miller 1988). Without reliable means for identifying individual birds, unsuspected multi-lake usage patterns would be very difficult to detect.

The findings also raise many questions which have no easy answers. Principal among these are questions of possible function(s) and of the implications of such behavior, especially if found to be relatively common, for current estimates and future studies of loon population status. Although our observations involve only 2 pairs at this time, we have evidence that several other pairs in the same geographic area also demonstrate multi-lake territoriality. While the following discussion focuses only on the 2 pairs we observed, the ideas presented may have general relevance to other such pairs discovered in the future.

Possible functions/explanations include food needs and complex patterns of nest-site selection among others. The Grass/Scout/Sharptail and Black Oak/George pairs may require more food than is available on a particular single lake to feed themselves and their potential chicks. A defended lake(s) separate from the nesting lake may serve as separate feeding area for the adults, helping to maintain a sufficient food supply for the chick(s) on the nesting lake. Feeding lakes away from nesting lakes are known for Arctic (G. arctica) and Red-throated Loons (G. stellata) although feeding lakes were not defended (Bundy 1976; Dunker and Elgmork 1973).

This explanation may fit the Black Oak/George pair. The pair nested on George Lake. The male was vocal-tagged on Black Oak in 1986 and 1987. In 1986, tagging was done in early June while a nest was known to be in progress on George Lake. The bird was recorded on 2 separate occasions, both times after being interrupted from long feeding bouts, and was alone on the lake. In 1987, the pair was feeding together on Black Oak when vocal-tagging took place on May 15, prior to the onset of nesting.

A food resources explanation seems inadequate for Grass/Scout/Sharptail pair. Although we do not have quantitative information on fish, food did not seem to be in

short supply on any of the 3 lakes. All showed an apparent abundance of fingerling/small fish visible in shallow water along shore. Also, fishermen were observed on Scout Lake on 6 occasions. Simple "paper-dip" tests for acidity showed all three lakes to be within currently acceptable range pH 5.3-6.8) for fish survival. While much better observations are needed to support or dismiss a food-base explanation, food shortage did not seem to be a primary cause for the observed behavior of this pair for this particular year.

That adult loons may leave nesting lakes to feed on larger, apparently less-occupied, lakes has prima facie great appeal because such an arrangement would not require the invested energy of defending a separate feeding area(s). The notion that larger lakes are less occupied may be an illusion, however. For example, Strong (1985) found that the majority of feeding on large lakes took place in shallow-water areas near shore. Resident pairs seemed to use these areas more and possibly exclude non-residents from these areas. Thus, large lakes may only appear to be less occupied.

The Grass/Scout/Sharptail complex lies within 1 mile of Lac Vieux Desert, a 2,853 acre drainage lake known for fishing, yet our observations suggest that the pair spent little time, if any, on that lake during the study period. It may be, therefore, that in some populations, additional feeding areas, if they are necessary, must be defended. This may be the case even in geographic areas where larger lakes are present. The discovery of these 2 pairs suggests that there may yet be a great deal to learn about feeding strategies of Common Loons.

A second possible explanation is that the birds may have taken over potentially higher quality neighboring lakes as they became available, yet through traditional site tenacity were unwilling to rescind territorial rights on initially-held sites. The Grass/Scout/Sharptail pair, for instance, seem to be long-term residents, first vocal-tagged in 1981. Such an explanation would seem to require either diminished competition for available lakes or a capacity for territory-holders to adequately defend lakes on which they are present only a fraction of the time. We presently have no basis for evaluating these possibilities.

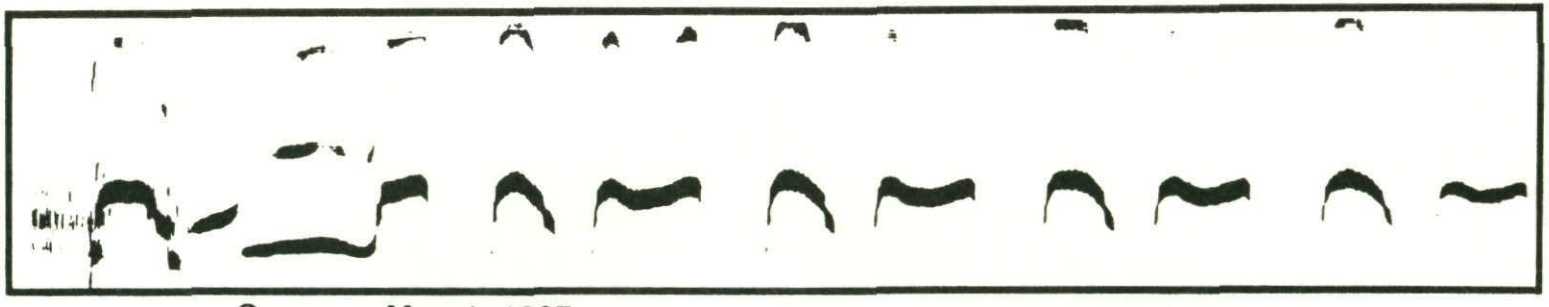
A third potential explanation, stemming from the second, is that the population in our study area already had dwindled to a point at which there were not sufficient numbers of mature, breeding birds to occupy available habitat. Vacant lakes may have been taken over and held with a minimal need for active defense. While we do not have population data adequate to assess this possibility, we observed only 3 occasions when another loon visited a lake that was unguarded while the pair was on either of the other 2 lakes.

On each of these occasions, the single loon seemed "apprehensive", showing a great deal of defensive upright behavior, and stayed for only a short time (average 26 minutes). Unguarded lakes did not appear to be contested, even during the early pre-nesting period.

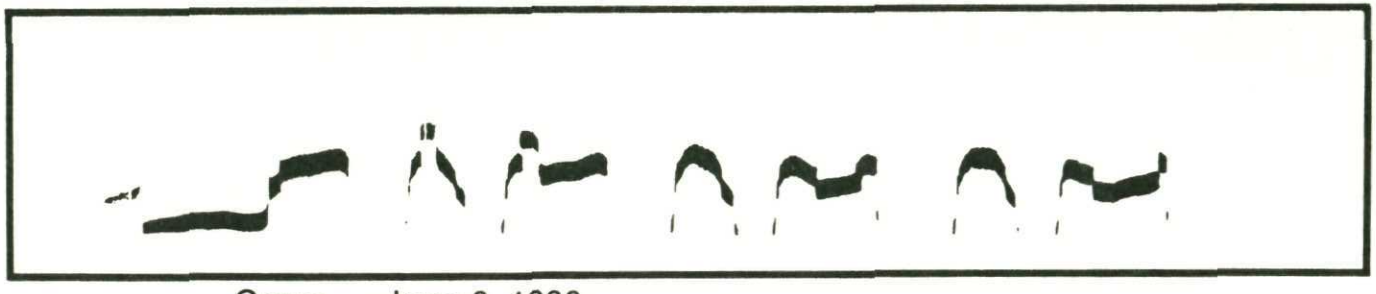
Finally, a diversity of lakes may be necessary for successful reproduction by the 2 pairs we observed. One lake may have a good food base but no suitable nesting sites, while another may have sufficient food and available nest sites but heavy predator pressure or recreational traffic leading to repeated nest failures. Known history of the Grass/Scout/Sharptail pair somewhat supports this idea. While the pair has never been reported nesting on Grass Lake, it was vocal-tagged on that lake in 1981, 1986 and 1987 (Fig. 3). The observations of 2 copulations and of the female leaving Sharptail to visit the male on Grass are possible indications that Grass was at one time a primary territory. The recent construction of cabins on this lake may have destroyed a traditional nesting site, as the entire leeward end of the lake now is developed. In 1985 and 1986, the pair on Scout Lake, presumably this same pair, attempted nesting, failing in both years (James Caron, pers. comm.). Our 1987 observations on this lake noted the presence of 5 River Otters (Lutra canadensis), seen as a group on 3 different occasion, once circumnavigating about two-thirds of the lake just off shore. In addition, small-boat fishing parties were seen on this lake on 6 different occasions. This pair may be trying other lakes after repeated nest failures at earlier sites, or may be choosing the "best" lake of the 3 for nesting in a given year.

Distinguishing among these possible functions and others will take a thorough analysis of spatial and temporal multi-lake usage. A pattern in which the birds paid little attention to non-nesting lakes after the onset of nesting, for example, might suggest a lake diversity explanation, while one in which the adults systematically used the additional defended lake(s) for feeding purposes after hatching of the young might support food as a function.

The implications for population studies of finding even minimally widespread multi-lake territorial defense seem straightforward. In those areas where such behavior may be found, current population estimates may be high due to some double- or even triple-counting. The possibility of multiple counting of some birds has been recognized and discussed by others (Fair 1985, McIntyre 1975). However, it has been viewed primarily as a problem for gaining reliable estimates on numbers of mobile, single birds. Present results suggest the potential for multiple counting of territorial pairs as well. Given this potential, the use of simultaneous, fixed-time observations for estimates of population size now seen essential. Likewise, estimates such as



Grass — May 1, 1987



Grass — June 3, 1986

Grass — June 3, 1981

Fig. 3-Wide-band sound-spectrographs of Common Loon yodel calls recorded on Grass Lake, 1987, 1986 and 1981.

"new birds in the population" or "lakes newly occupied" need to be collected and interpreted very carefully. During pre-nesting, the Grass/Scout/Sharptail pair spent entire days on a specific lake leaving the others unattended, and apparently unoccupied, only to return to these lakes 1, 2, or more days later and show classic territorial behavior. A 1- or even 2-day study during a given year could easily have counted these lakes as unoccupied.

CONCLUSION

The finding of multi-lake defense is both very exciting and somewhat frightening. It is exciting given the possibilities for new insights into loon biology it suggests, especially if confirmed for a large number of other loons. It is frightening given that some of our population estimates may be overestimates, depending on field methods used. For these reasons, we believe that it behooves loon biologists to be very alert to the possibility of this phenomenon, especially in those areas which have predominantly small lakes. The ease with which we discovered a second pair showing this behavior, once we realized the possibility, suggests that many other loon pairs may be showing similar patterns of resource use. Finally, these findings are an excellent indication of the practical usefulness of individual tagging for gaining new insights into loon biology.

ACKNOWLEDGMENTS

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PRODUCTIVITY AND NEST SITE SELECTION OF COMMON LOONS IN A REGULATED LAKE SYSTEM

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SUMMARY

In recent years, declines in Common Loon (Gavia immer) productivity have been linked to increased lake shore development, increased acidity of lakes, and manipulation of water levels. I studied the effects of regulated water levels on the productivity and nest site selection in a Common Loon population in Voyageurs National Park (VNP), Minnesota.

VNP is located along the U.S. - Canada border in northern Minnesota. The park contains over 34,000 ha of water area which is 40 percent of the total park area. The 4 largest lakes have been regulated by dams since 1914. The regulation regime has caused both less than natural (Rainy Lake) and greater than natural water fluctuations (Kabetogama, Namakan, and Sand Point Lakes) and has delayed the timing of peak water levels. Twenty-eight small lakes (5% of the total water area), located within the interior and mainland park areas, fluctuate naturally.

From May to September, 1983-1986, survey crews traveled throughout the park's water areas via canoe, motorboat, and floatplane. Intensive shoreline searches for nests were conducted in occuppied loon territories from early June to early July. Nesting attempts were followed until the final outcome could be determined. Potential outcomes were predation, flooding-out, abandoned, successful, and unknown. (A successful nesting attempt was defined as the presence of at least 1 young older than 2 weeks.) At each nest site nesting substrate was noted along with the following parameters: territory area and shorelength, the number of islands/territory, island area and shorelength, and bog vegetation shorelength.

The estimated annual population of loons in VNP was 219 adults and a mean annual production of 32 fledged young. Only 15 percent of the total adult population were young

versus 27 percent for populations breeding on completely naturally fluctuating lake systems. The overall reproductive rate in VNP was only 0.15 fledged young/adult. Lake type (less than, greater than, or natural fluctuations) had a significant effect ($p=0.0002$) on the reproductive rate, but there was no overall year and lake interaction ($p=0.5431$) on productivity levels.

Reproductive rates were compared to populations occurring on naturally fluctuating lakes in northeastern and north-central Minnesota, and east-central Saskatchewan. These 3 populations collectively had a mean reproductive rate of 0.58 fledged young/pair/year versus 0.30 fledged young/pair/year in VNP ($p < 0.05$).

The majority of the reproductive output in VNP was contributed by a small proportion of the loon population (annual mean of 13 pairs). These pairs represented only 19 percent of the total population nesting on the large regulated lakes. Their reproductive rate was 0.80 which accounted, on average, for 40 percent of the young produced on the regulated lakes. These pairs nested exclusively on bog vegetation. Bog mats rise and fall with lake levels reducing the probability of flooded nests.

Forty-percent of all nesting attempts on the regulated lakes were on bog substrate and 80 percent of these attempts were successful. Although islands are considered to be the nest site of choice by loons (83% of nesting attempts on natural lake systems), only 50 percent of the nesting attempts on regulated lakes in VNP were on islands. Nest success on islands was 54 percent.

Discriminant function analysis was performed on the structural components measured on loon territories. Nest site substrate was the only predictor variable used by the DFA program to classify successful and unsuccessful nesting attempts. At this writing, however, habitat data for <u>all</u> territories were not available for analysis. It is likely that the proportion of bog vegetation to island shoreline will be an important variable.

The Common Loon population of VNP has a significantly lower reproductive rate than other populations on naturally fluctuating lake systems. The rapid and protracted rise in water levels during the nesting season accounted for an estimated 40 percent nest loss. Bog nesting pairs which comprised 12 percent of the total population on the large regulated lakes, produced an average of 40 percent of the young 1983-1986. Without these bog-nesters within VNP, the park's loons would only have produced 0.23 fledged young/pair/year. The high success rate of these bog-nesters in the artificially regulated lakes of VNP is probably responsible for the maintenance of this Common Loon population.

THE RISE AND FALL OF A LOON LAKE

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SUMMARY

The Stillwater Reservoir is a man-made lake, formed by damming Beaver River downstream from Nehasne Lake in the Adirondack Park of New York. Like many similar impoundments subjected to artificial fluctuations produced by water management practices, this reservoir varies between 6 and 7 m in height during the year. It has been apparent to many workers that such extreme fluctuations can be disastrous for nesting Common Loons (Gavia immer) if part of it happens during the nesting season.

Population numbers and reproductive success of Common Loons were monitored during the past decade and compared to water level fluctuations during the breeding season, 12 May-11 August. Although some loons deserted nests during severe draw-downs, reproductive success of the population as a whole did not fluctuate as the water level did. Nest tenacity varied among pairs, as it related both to the stage of incubation and overland distance between nest and water.

Rising waters caused a more uniform response, because nests were almost always initiated at the water's edge, and thus all subject to destruction from the same rise in water level. Loons continued to build for 2-3 days and could save their nests during a rise of about 15 cm. No loons could maintain nests when water rose more than 20 cm. If flooding happened early in the breeding season, loon re-nested, thus the season's productivity was unaffected. However, if flooding happened later, especially during mid to late June, loons not only lost their nests, but did not re-nest. In 1986, productivity was 0.07 fledged young per pair, a highly significant difference from the 0.72 young per pair averaged 1977-1985.

Available loon habitat at this site was compared prior to and after dam impoundment. There were 4 potential territories before water levels were raised after the 1887 dam was completed. Afterwards, there was sufficent habitat for 8 pairs. Following completion of the most recent dam in 1926, the number of potential sites was more than doubled. Sixteen territories have been used at one time or another during the past 10 years. Three other prospective sites have

been identified, meaning that available habitat was increased from 4 prospective territories 100 years ago, to 19 today.

Productivity during the last 10 years, if dam impoundments had not been built, may have been 25 young loons, based on actual productivity rates of the current population extrapolated to the maximum territorial pairs. Instead, 83 young loons have been raised on the Stillwater Reservior during the last decade, nearly three and a half times as many as possible before the river was dammed. Even with controlled fluctuations, this reservior has provided superb habitat. Its loon population density, the largest in New York, attests to the quality of this lake.

This and another reservior study in the northeastern U.S. show that lakes with manipulated water levels offer advantages for loons, as well as the negative effects ususally attributed to them. Flooding and draw-downs lead to nest loss from time to time, but the transformation of rivers to lakes has provided excellent new loon habitat.

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TERRITORIAL ACTIVITIES OF COMMON LOONS ON MULTIPLE-PAIR LAKES

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The concept of territoriality is widely used and accepted in studies of animal behavior (Alcock 1979). Biologists recognize different types of territories dependent on the resources defended. Common Loons are typically considered Type A territory owners although recent observations suggest that they may split feeding activities among lakes (Parker 1985), may raise chicks on lakes other than the nesting lake (James Kessel, pers. comm.) and may defend more than one lake (Miller and Dring 1988).

Perhaps due to the obvious aggressive displays and calls of Common Loons (Rummel and Goetzinger 1975, 1978) and the number of studies and observations of loons on lakes occupied by only 1 nesting pair, Common Loons have been considered aggressively territorial birds. Loon biologists have used the term "territorial pair" as a parameter to be measured in population surveys (McIntyre 1979, Metcalf 1979, Sawyer 1979, Sutcliffe 1979) and they often define areas used by loons during the breeding season as "territories" (Olson and Marshall 1952, McIntyre 1975).

We began studies of habitat selection by Common Loons in northern Maine in 1982 with the idea that we would be able to map territorial boundaries by observing aggressive displays at territory borders and plotting the location of individuals assuming that they would not trespass into neighboring territories. This paper describes an apparent lack of aggressive territorality by loons on multiple-pair lakes and discusses the conditions that might result in variable territorial behavior by Common Loons.

STUDY AREA AND METHODS

We observed patterns of loon activity on large, remote lakes in northern Maine May-August 1982-1984. We focused our attention on 3 large lakes: Grand Lake Seboeis (GLS) -

1006 ha; Snowshoe Lake (SL) - 258 ha; and Millinocket Lake - 1094 ha. There was little or no cottage development on the lakes and recreational use was light or absent.

We began each spring by observing loons that seemed to be paired as mates. After a few days of casual observations, we were able to identify individual pairs and general areas on the lakes that they were most likely to be found in. At that point, we began collecting data on locations and activities of individual pairs. Each year we conducted 10-15 1-hour observation periods on each pair and in 1983 and 1984 we conducted 3 3-hour observation periods on each pair. The observation periods were distributed equally through the summer and throughout the daylight hours (see Strong (1985) for more details).

RESULTS

There were 8 pairs of Common Loons on MLL, 6 on GLS, and 2 on SL that seemed to be occupying breeding territories. Each lake had 2-8 adult loons that were unpaired and apparently without core areas of activity. In addition to the lake residents, there were often visitors from other lakes. On any 1 day, there might be many adult loons on the lakes. The maximum number recorded on the 3 lakes during the study were 32 on MLL, 13 on SL, and 21 on GLS.

Territorial boundaries, if they existed, were not obvious. Resident pairs were found most often in core areas, but they frequently swam into areas occupied by other residents even during nesting and chick rearing. Aggressive territorial behavior was observed infrequently during these trespasses. Instead, their presence was tolerated by the other pair or non-aggressive behaviors like circle dances occurred.

We observed very few aggressive territorial displays (Table 1). Crouch-and-yodel displays, penguin dances, and other aggressive displays typically comprised less than 1 percent of all recorded activities. Non-aggressive interactions made up 8 to 34 percent of observed activities for the 16 resident pairs with a mean of 17 percent for all 3 lakes.

Interactions occurred throughout the breeding season and not just during late summer flocking. On numerous occasions we observed loons leaving nests or chicks to interact with singles or groups of loons. Nest and eggs were sometimes left unattended for 1 hour. Non-aggressive interactions occurred anywhere on the lake and not just in areas that might be considered neutral ground. Although we observed less than 100 aggressive displays, most of them occurred in areas that might have been predicted as territorial boundaries.

Table 1. Number of aggressive and non-aggressive interactions for 16 resident Common Loon pairs on 3 lakes in northern Maine 1982-1984. Numbers in parentheses are percentage of total observations of all activities during the same period.

	Interactions with other loons	
Pair	Aggressive	Non-Aggressive
Snowshoe Lake		
SC	1 (0.1)	109 (9.5)
FI	4 (0.3)	226 (16.4)
Grand Lake Seboeis		
CC	18 (1.1)	139 (8.6)
BC	7 (0.4)	143 (8.2)
WB	3 (0.3)	149 (13.6)
LI	3 (0.2)	215 (14.4)
BB	1 (0.1)	268 (29.0)
HH	4 (0.3)	281 (17.9)
Millinocket Lake		
RC	6 (0.4)	330 (23.8)
AB	9 (0.5)	311 (18.2)
CB	6 (0.4)	249 (17.5)
BI	0 (0.0)	75 (6.9)
LB	21 (1.6)	348 (26.7)
NI	10 (0.7)	327 (22.7)
SI	2 (0.2)	460 (34.5)
MP	2 (0.2)	87 (10.2)
3-Lake Total	97 (0.5)	3717 (17.3)

DISCUSSION

The loons we observed were less territorial and aggressive than we expected. The paucity of aggressive encounters suggests that resident nesting pairs were tolerant of other resident pairs and visitors from other lakes.

Common Loons need large areas to feed themselves and their chicks on the relatively unproductive freshwater lakes they use for nesting (Barr 1973). Concurrent observations of feeding activity during this study strongly suggest that the outer edge of the littoral zone is important for feeding (Strong 1985). Exclusive use of these areas, particularly those that are important during the early chick-rearing period may be a driving force in territorial behavior by Common Loons, although there may be other reasons.

It seems likely that it is advantageous for resident loons to be territorial and exclude other loons from preferred feeding areas and during chick-rearing away from young chicks. However, the advantage of doing this may vary by lake size, configuration, and number of resident pairs and visitors.

On small lakes occupied by just 1 pair, aggressive territorial defense may be energy-efficient. The probability of other loons visiting the lake may be low and these lakes may be easily defended from intruders. Residents are often able to keep potential intruders from landing by yodeling (Edward Miller, pers. comm.).

On large lakes occupied by multiple pairs, extreme aggression toward intruders may or may not be advantageous. If the lake is highly convoluted and has very well defined coves or bays, the probability of visitation by other loons into a loon pair's activity area may be low and the ease of territory defense may be high. In this case, aggression may pay off also.

On large lakes that have large open-water areas and resident loons that have neighbors on 2 or 3 sides, visitation rates my be high and the ease of defending boundaries may be low. Under this set of conditions, aggressive territorial behavior may be disadvantageous and energy expensive.

There may be some advantage to maintaining non-aggressive social relations with neighbors and visitors on large lakes with relatively few good feeding areas. For example, social tolerance may allow residents to use feeding areas outside their core area of activities.

We suspect that Common Loons have a spectrum of territorial activity possibilities that are dictated by pre-

vailing environmental conditions. There are no comparable data for small, 1-pair lakes and large, convoluted lakes with multiple resident pairs. However, it seems likely that aggressive territoriality increases when conditions are more favorable for energy-efficient territorial defense.

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NOCTURNAL VOCAL BEHAVIOR OF THE COMMON LOON

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Many animals produce communal vocalizations, or choruses (Armstrong 1947, Lanyon and Tavolga 1960, Smith 1977, Chalmers 1980, Falls 1982). Smith's (1977) comprehensive review of the function of chorusing suggests that chorusing serves a mate-attraction function for many animals (e.g., some insects, frogs, and lek-forming birds). Other possible functions include predator avoidance, as in the confusion choruses of small songbirds (Grinnell 1914, cited in Smith 1977), defense of group territories, as in the Australian magpie (Gymnorhina tibicen) (Carrick 1963), and the assembly of widely separated group members, as in wolves (Harrington and Mech 1979) and some primates (Chalmers 1980, Raemakers and Raemakers 1985).

The Common Loon (Gavia immer) is well-known for its nocturnal choruses, described by Yeates (1950) as "fiendish and blood-curdling." Olson and Marshall (1952) and Titus and Van Druff (1981), among others, have referred to these choruses as "social choruses", suggesting that the occurrence of communal vocalization reflects social interaction between or among vocalizing birds. In this paper, I present the preliminary results of an investigation of Common Loon chorusing and its possible roles in the social behavior of loons. Throughout the paper, the term "chorus" will refer to any bout of communal vocalization involving 2 or more birds, exclusive of tremolo or wail duets and any interaction involving vocalizations and/or visual displays given at close range, such as intrapair hooting, boundary disputes, or interactions between flying birds and territory-holding pairs. Because chorusing is only 1 aspect of the Common Loon's nocturnal behavioral repertoire, I will discuss non-choral vocalizations as well.

Ultimately, the objective of the project is to study the adaptive significance of chorusing and its possible role in the social behavior of Common Loons. To that end, I have focused so far on the following 4 goals: 1) to describe the structure of a "typical" chorus in terms of acoustic, temporal and seasonal parameters; 2) to obtain information on the abiotic factors that may influence chorusing; 3) to obtain information on the biotic factors that may influence chorusing, and 4) to use this information as the basis for one or more hypotheses about the adaptive significance of chorusing.

METHODS

The study was conducted 22 April-1 August, 1987 in Gogebic County, in the western Upper Peninsula of Michigan. This area is characterized by a large number of glacially-formed, mostly oligotrophic lakes, 17 of which were chosen for this study (Fig. 1). The area supports a fairly stationary population of loons (Robinson et al. 1985, Caron and Heitman 1987) about which a great deal is known in terms of history of lake residence and reproductive history. In several instances, the identity of several individual males is known (Miller, pers. comm.).

Regular diurnal checks were made of study lakes to ascertain the presence and location of pairs, nest sites, and chicks. Of the 17 focal pairs chosen for this study, 7 had 0-1 known neighboring pairs within a 1.6-km radius, 6 pairs had 2-3 known neighbors, and 4 pairs had 4 or more known neighbors within the 1.6-km radius. The 1.6-km radius was chosen as it represented the maximum distance over which I could hear and accurately identify calls.

Systematic nocturnal observations were conducted over 3 3-hr blocks of time (2000-2300, 2300-0200, and 0200-0500 CST) at 2-3 different observation areas each night. Observations consisted of continuous, all-occurrences sampling (Altmann 1974) of nocturnal vocalizations. At each site, observations were made from shore or from a canoe. Over 500 hours were spent in field observation.

Vocalizations were recorded onto 1 channel of a 90-minute cassette tape using a Sony Pro Walkman DC-M6 cassette recorder equipped with either a Sony ECM-170 or TEAC PE-125 electret condenser microphone mounted in a 46.8-cm plastic or 62.4-cm aluminum parabola. Spoken notes were recorded onto the other tape channel with a Sony DR-200 headset microphone. Notes included comments on weather conditions, time at which each vocalization occurred, direction from which vocalizations originated, actual identity of vocalizing birds, when possible, and any unusual behaviors, disturbances, or unusual circumstances. Tapes were transcribed on a regular basis while in the field. Original recordings are housed in the collection of the Borror Laboratory of Bioacoustics, The Ohio State University, Columbus, Ohio.

Weather data gathered in the field included air temperature, wind speed (measured in mph with an Airguide handheld anemometer) and observations of any precipitation, lightning, or other weather phenomena. Summary data on relative humidity were provided by the Watersmeet District Ranger's Office, Ottawa National Forest.

RESULTS

One hundred five choruses were recorded over the course of the season; 99 of these were analyzable. Choruses were recorded on 31 of 90 nights of observation. All 4 of the major vocalization types (wail, tremolo, yodel, and hoot) (Barklow 1979) were heard during choruses (n = 1488). For analysis, I considered only long-distance vocalizations and vocalization patterns, including wails, tremolos, yodels, and tremolo duets.

Acoustic features

Of the 4 long-distance call categories, wails were recorded in 91.8 percent of all choruses, yodels in 71 percent, tremolos in 66 percent and tremolo duets in 46 percent. Within individual choruses, wails were heard most frequently, followed by yodels, tremolos, and tremolo duets (Fig. 2). The frequency of call types differed significantly from expected ($P < 0.05$; Chi-square goodness-of-fit test). A wail was most frequently heard at the beginning of any single chorus; tremolos and tremolo duets (lumped in this specific analysis) or yodels occurred less frequently at the beginning of any single chorus. Hoots are included here as well because on the occasions when hoots were recorded (n=3), the hooting pair was always the first to vocalize in the subsequent chorus (Fig. 3a). The last call heard during choruses was more frequently a wail; tremolos, yodels, and tremolo duets, respectively, concluded choruses significantly less often than did wails ($P < 0.05$; Chi-Square goodness-of-fit) (Fig. 3b).

Temporal features

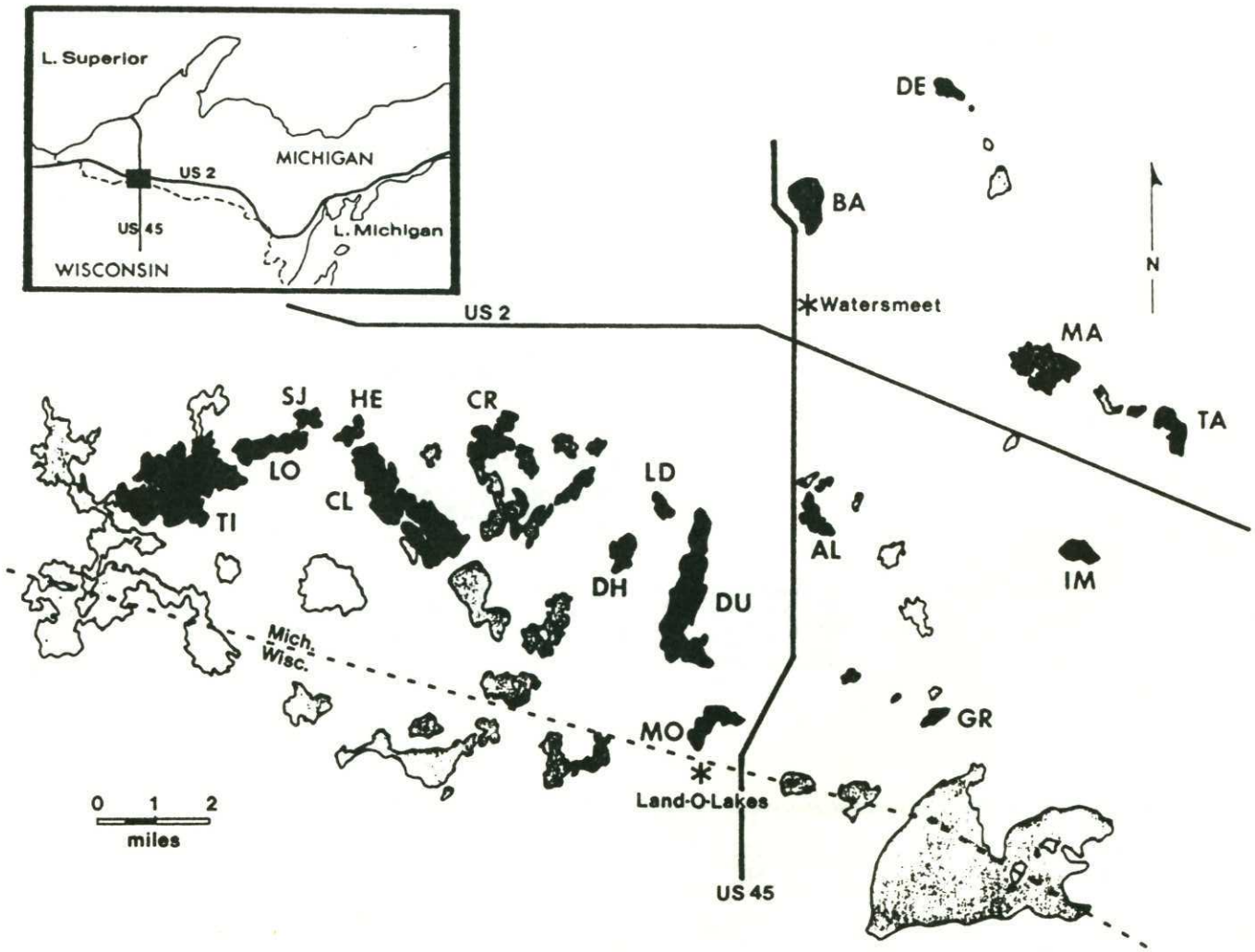
A nightly peak in choral activity occurred between 2130 and 2230 with a secondary peak just before daybreak between 0330 and 0500 CST. The earliest recorded chorus was heard at 2000 CST on 23 May; the latest chorus was recorded at 0430 CST on 1 June. Mean chorus duration was 202 sec. Choruses were separated by a mean interval of 57.6 min (range 4-146 min).

Seasonal features

Choruses were first recorded on 22 April but may have occurred several days earlier. The last recorded chorus was on 28 June. No choruses were recorded after this date, but Miller (pers. comm.) reported hearing a chorus at Clark Lake at approximately 2000 CST on 2 August.

Chorus frequency (i.e., choruses/night) peaked 2-12 May, just prior to the population's mean egg-laying date (MED) of 20 May (Fig. 4). Chorusing became less frequent

Figure 1. Map of study area, Gogebic County, Michigan. (Study lakes: AL - Allen; BA - Bass; CL - Clark; CR - Crooked; DE - Deadman; DH - Devil's Head; DU - Duck; GR - Grass; HE - Helen; IM - Imp; LD - Little Duck; LO - Long; MA - Marion; MO - Moon; SJ - Snap Jack; TA - Taylor; TI - Thousand Island.)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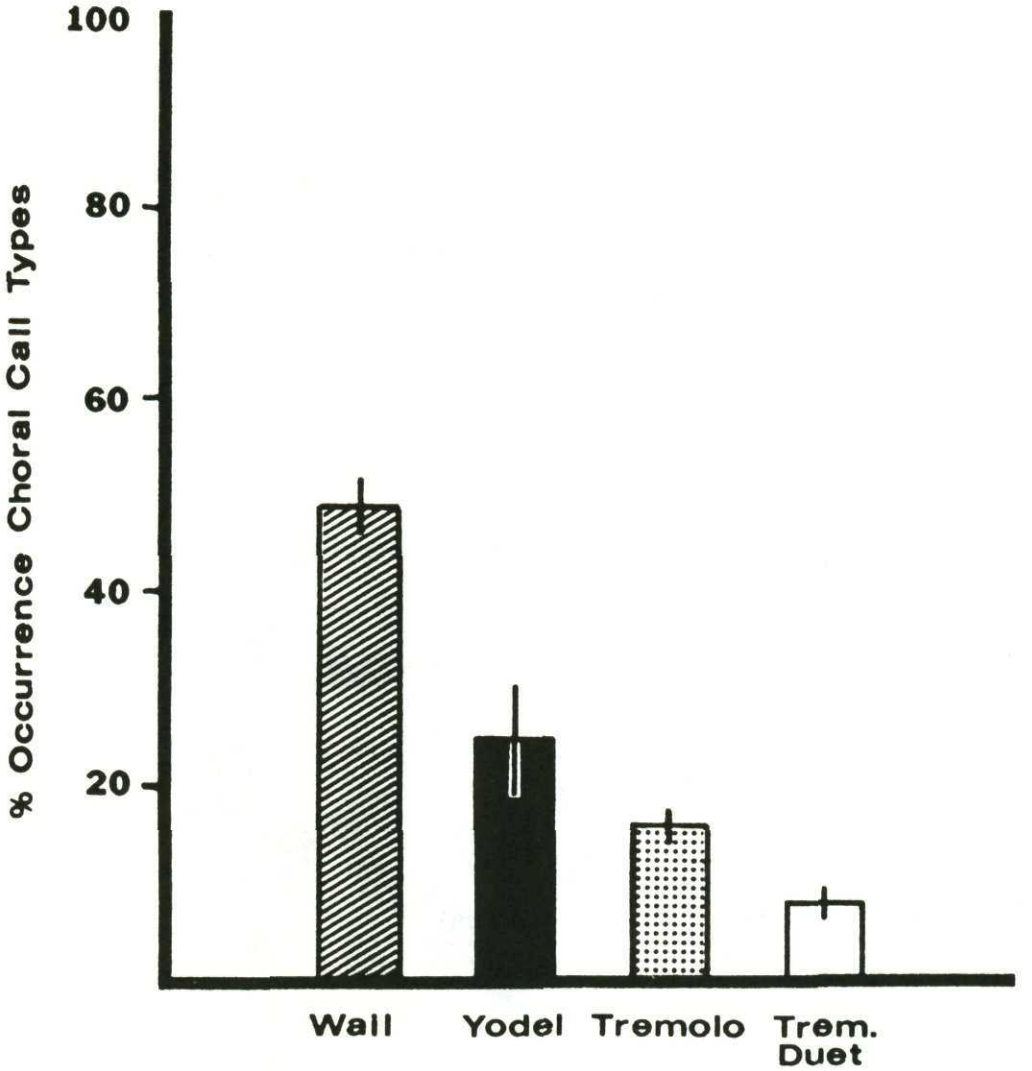
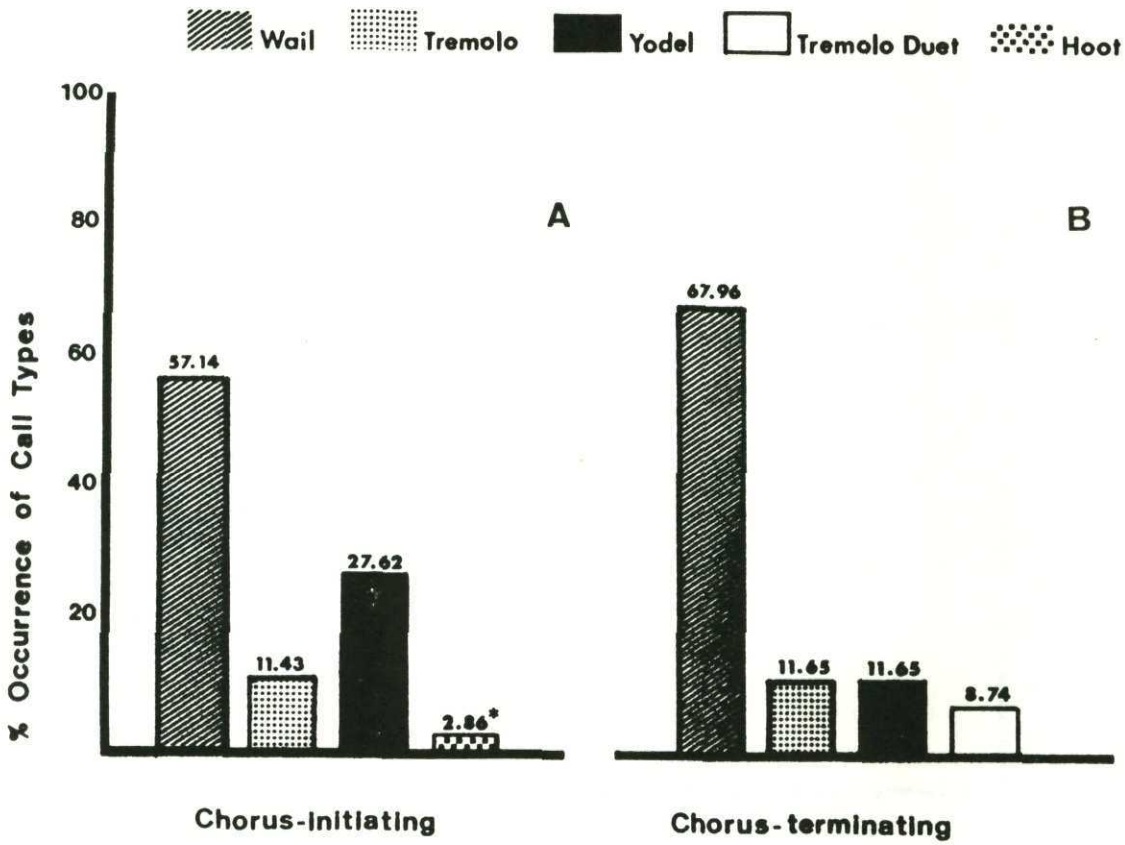


Figure 2. Frequency of occurrence of the four long-range call types recorded during choruses. Bars represent the mean percentage of standardized call frequencies, i.e., the mean of the N=99 ratios: (number of calls of a particular type/total calls in a given chorus. Vertical lines represent ± 1 SE.



*See text for explanation

Figure 3. Frequency of occurrence of call types in various contexts. 3a: occurrence of each call type at the beginning of choruses (tremolo and tremolo duet considered jointly, depicted as "tremolo"); 3b: occurrence of each call type at the end of choruses.

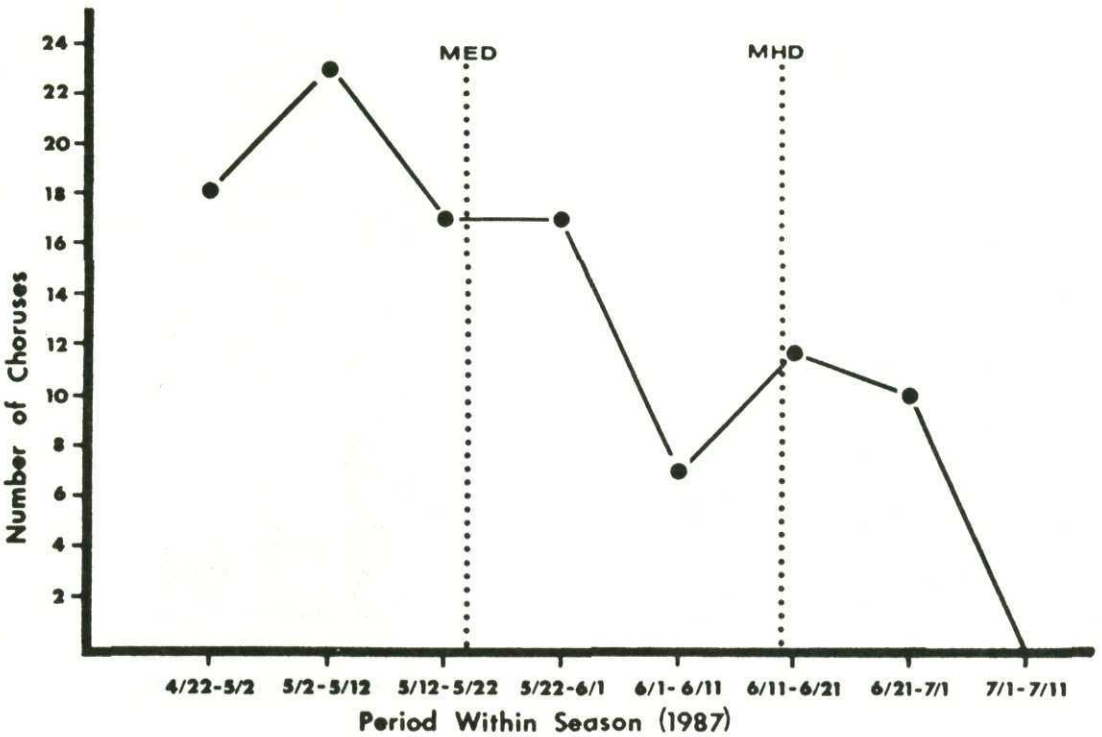


Figure 4. Seasonal occurrence of chorusing, 22 April-1 July, 1987. (MED = mean egg-laying date for population; MHD = estimated mean hatching date for population).

as the season progressed, with only a slight increase subsequent to the population's estimated mean hatching date (MHD) of 18 June.

The number of wails, tremolos and tremolo duets heard per chorus reflected a seasonal pattern nearly identical to that of overall chorus frequency (Fig. 5). Yodels, however, peaked between 1-11 June, just prior to the estimated MHD.

Non-choral vocalizations

Nocturnal vocalizations produced in non-choral contexts ($n = 955$) were most frequent between 11-21 June, although there were no significant differences in frequency between the periods 11-21 June, 21 June-1 July, and 1-11 July ($P < 0.05$; Chi-square goodness-of-fit). The overall frequency of occurrence of each long range call type given non-chorally was similar to that for chorus calls in that wails, again, were the most frequently heard vocalizations (Fig. 6). However, the occurrence of tremolos, tremolo duets and yodels given in non-choral contexts is significantly different from the frequency of occurrence of these calls during choruses. Seasonally, non-choral vocalizations showed a somewhat different trend than chorus calls (Fig. 7). It should be noted that the increase in non-choral vocalization once nesting began was less than that prior to nesting.

Abiotic Factors

Weather

Temperature and relative humidity, although reported to have an influence on the vocal behavior of some other species (Henwood and Fabrick 1979), were not related to the frequency with which chorusing occurred. Wind speed, though, did seem to affect chorusing: 98 percent of all choruses recorded were recorded at wind speeds of less than 5 mph.

Spatial relationships

The number of neighbors within a 1.6-km radius of a given pair of loons seemed to affect the frequency with which a target pair participates in nocturnal choruses. Pairs with 4 or more known neighbors participated significantly more often than those with 0-3 neighboring pairs and, similarly, pairs with 2-3 neighbors were much more chorally vocal than those with 0-1 neighbors (Fig. 8) (one-way analyses of variance based on the Kruskal-Wallis test for general alternatives and the Jonckheere test for ordered alternatives) (Hollander and Wolfe 1973). This trend is reflected in patterns of non-choral vocalization as well.

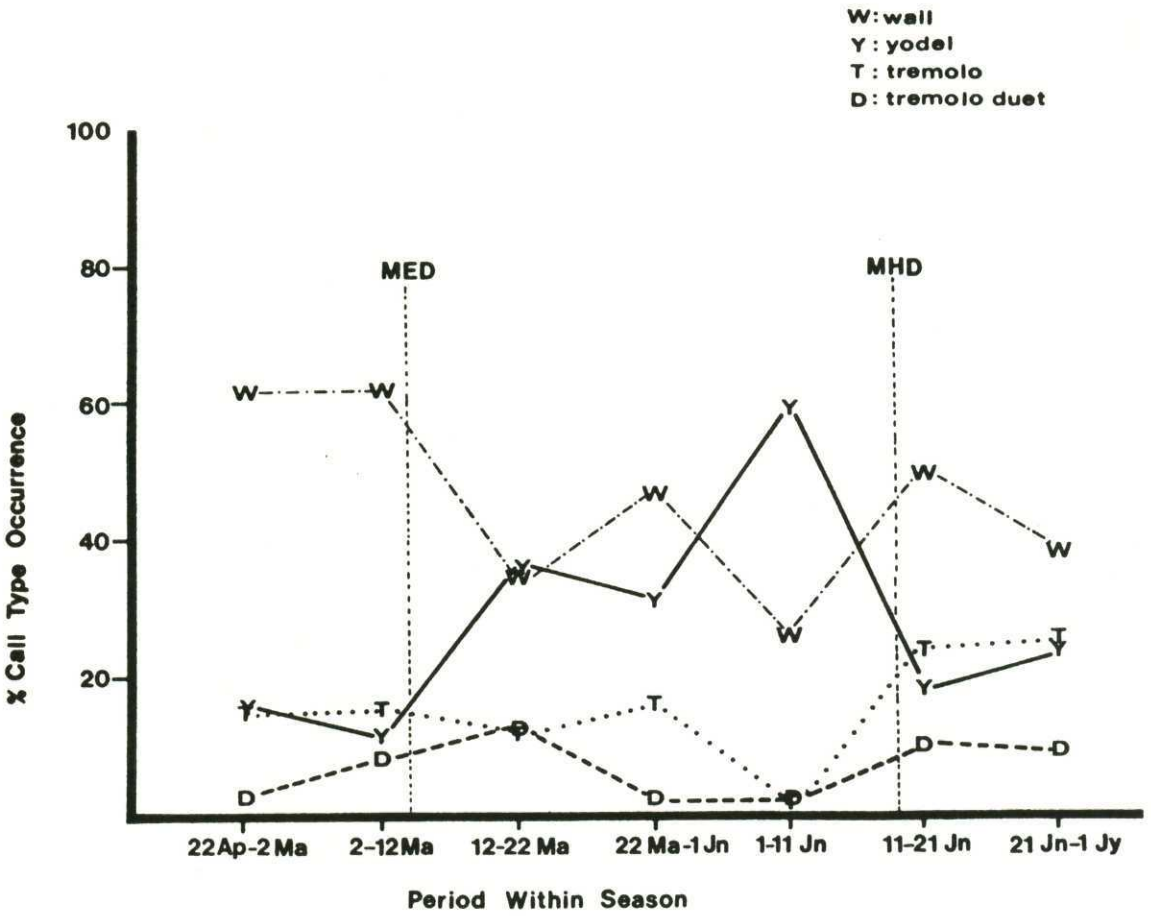


Figure 5. Occurrence of each long-range call type recorded during choruses, 22 April-1 July, 1987. Call type occurrence standardized by calculating $\sum_{i=1}^{n}(N_c/C_k)/n$, where n = number of choruses per 10-day period, N_c = number of calls of a specified type, and C_k = total calls in a given chorus.

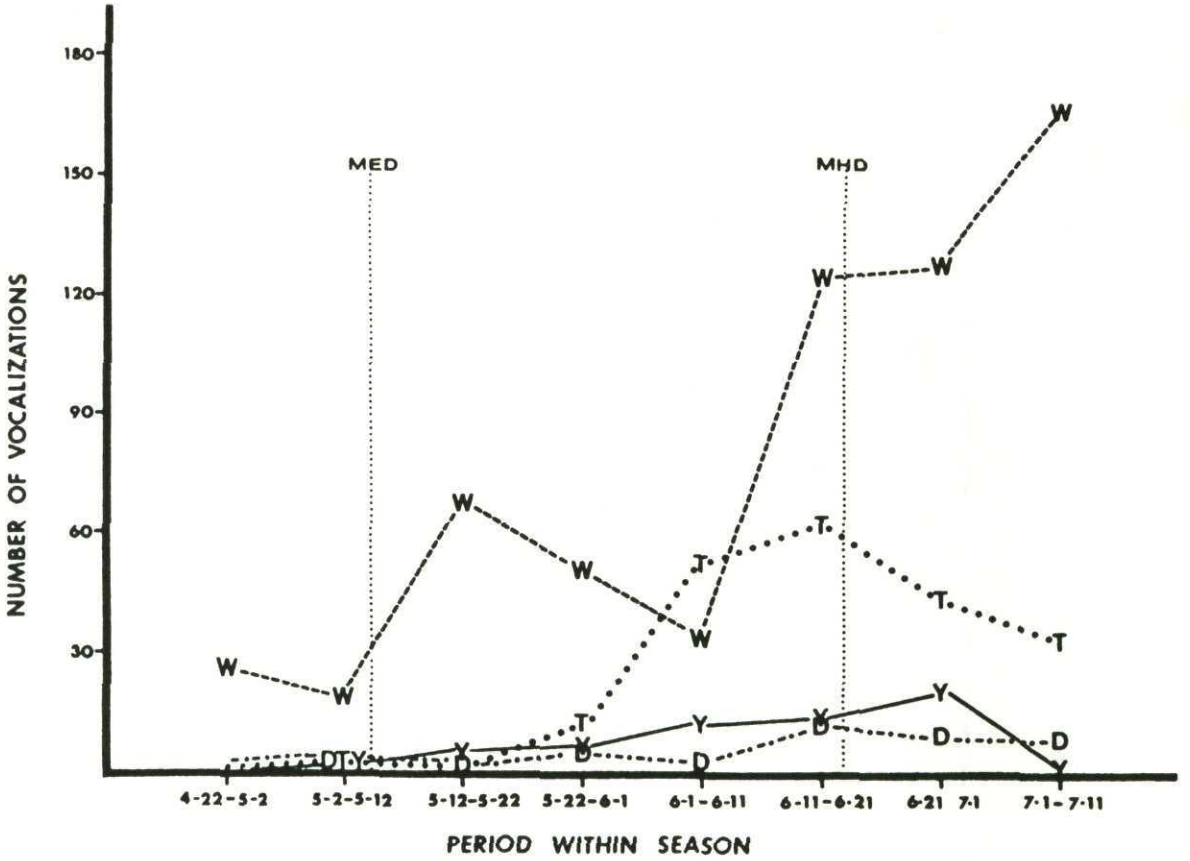


Figure 6. Frequency of occurrence of non-choral long-range calls, 22 April - 11 July, 1987. (W = wail; T = tremolo; D = duet; Y = yodel).

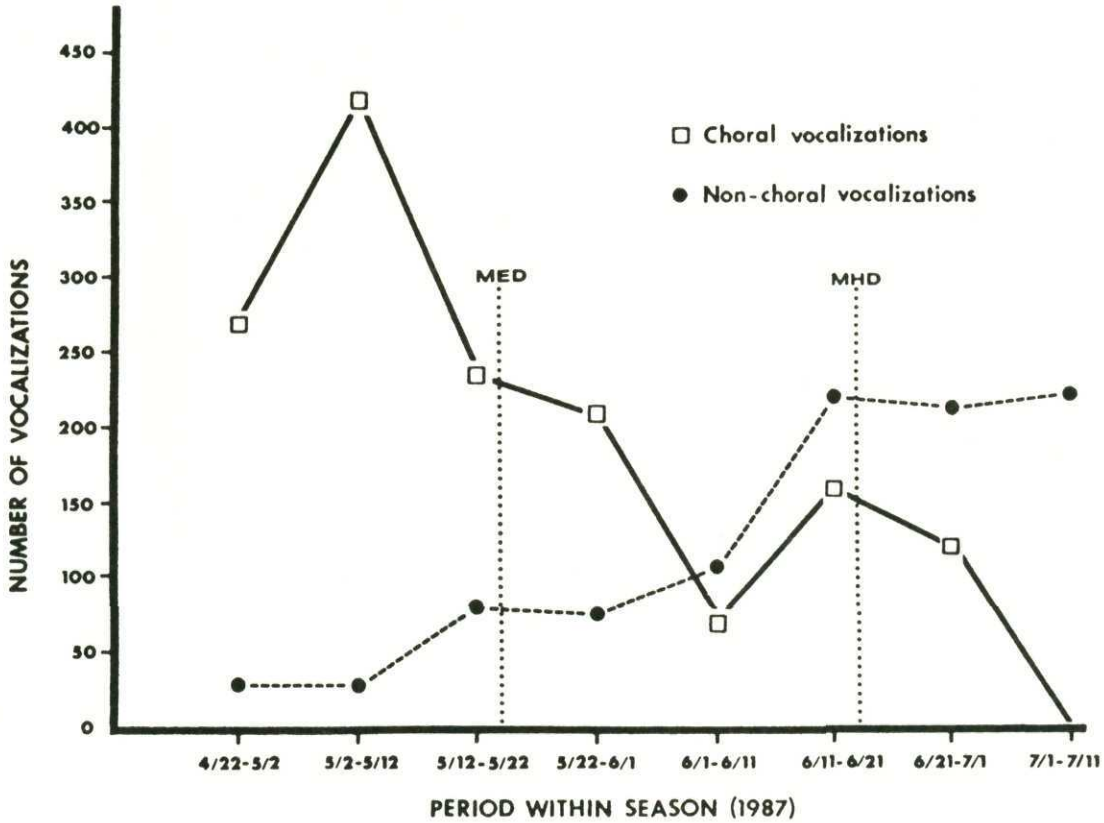


Figure 7. Comparison of seasonal occurrence of all choral and non-choral vocalizations.

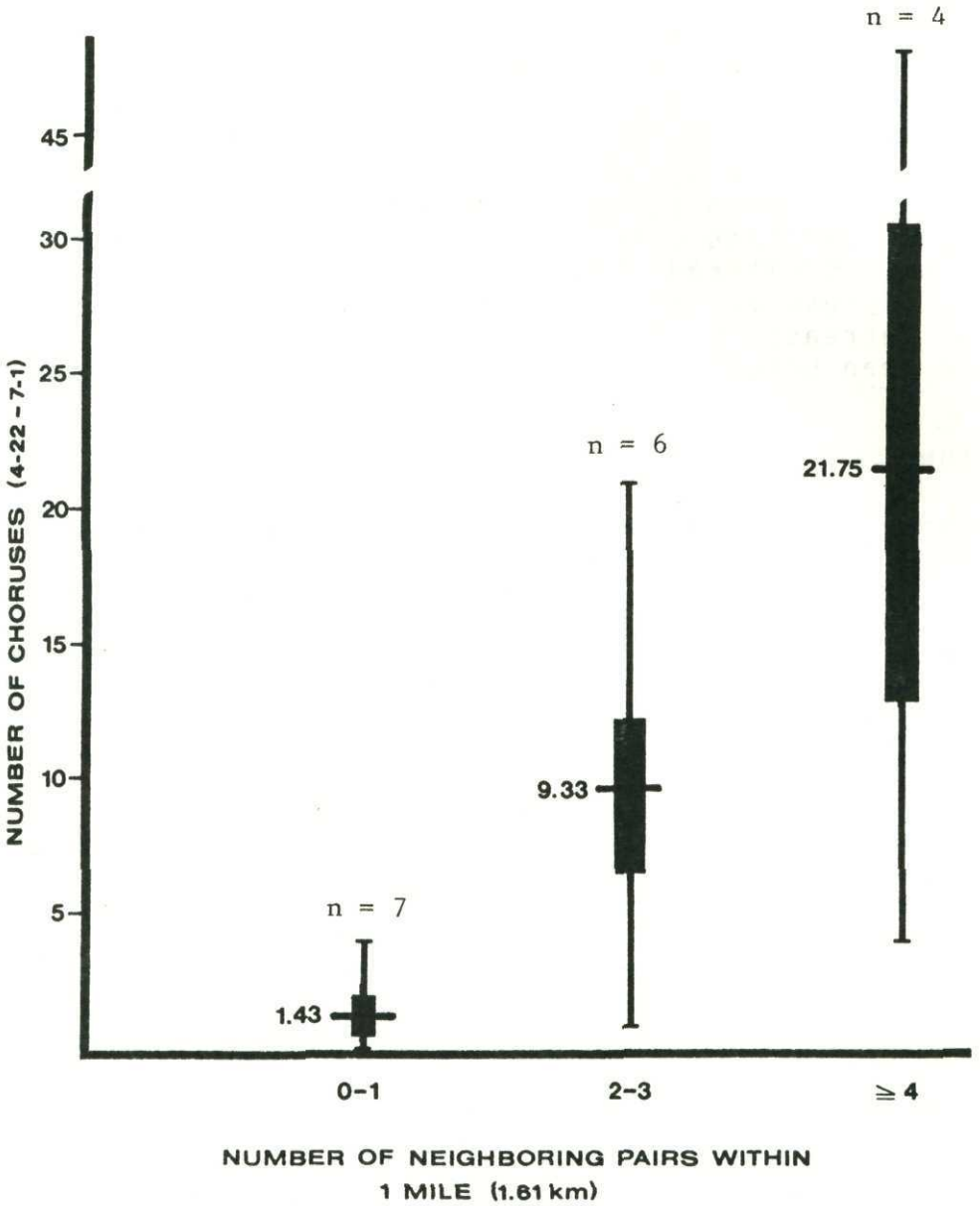


Figure 8. Choral participation in relation to number of known neighbors. Vertical lines represent range of values (number of choruses recorded between 4-22-87 and 7-1-87), horizontal lines represent medians, and bars represent ± 1 SE).

Members of isolated pairs, such as those on Deadman, Bass, Marion, and Imp Lakes (Fig. 1) were heard vocalizing in non-choral contexts on only 4 occasions, whereas birds on Clark and Helen Lakes were quite vocal throughout the night.

Biotic factors

As far as could be determined, paired birds were the primary participants in nocturnal choruses. In only 1 case could vocalization by a single bird be verified; a single bird was known to be consistently present in the vicinity of the Grass Lake/Sharptail Lake pair. Miller (pers. comm.) monitored the activities of this bird, confirming its presence on several nights of observation. Chorusing decreased significantly after eggs were laid and after the mean hatching date for first nests (Fig. 3).

DISCUSSION

Although detailed analysis of the nocturnal chorusing behavior of Common Loons has just begun, it is possible to question some suggested functions of chorusing as related to loon vocal behavior. It seems unlikely that loons chorus to attract mates. Available evidence suggests that pair bonds are established well before pairs return to their summer territories (Sjolander and Agren 1972, McIntyre 1975), and loons are thought to retain the same mates for life (McIntyre 1975). Further, as my observations show, the frequency with which loons participate in choruses peaks several weeks after pairs are established. This observation is corroborated by Young (1986).

An anti-predation function seems equally unlikely. There are few known predators on adult loons (McIntyre 1977) and, indeed, the periodicity and frequency with which choruses occur seem to be more likely to attract a predator's attention rather than creating confusion or distraction. Although it was difficult to determine the presence of potential predators during this study, choruses followed within 3-5 minutes for those occasions when coyote (*Canis latrans*) or raven (*Corvus corax*) vocalizations were heard (n=2). Fair (pers. comm.) reported hearing choruses almost immediately after bouts of coyote howling were heard at a New Hampshire study area. It is difficult to infer any association between chorusing and the vocalization of potential predators at this time, but analysis of the loons' responses to playback of predator vocalizations is certainly worth investigating. Finally, if loons respond chorally to the threat of predation, it probably would be most likely after chicks have hatched. However, during this period the amount of conspicuous choral vocalization decreased sharply.

Thus, the absence of nocturnal choral activity may, in turn, be a means of avoiding the attention of potential chick predators.

Group territories are not known for any of the gaviids, so the group territorial defense hypothesis does not seem to apply to Common Loon chorusing. Breeding loons do not associate in groups until late in the breeding season when they assemble on premigratory staging grounds (McIntyre and Barr 1979, 1983). Croskery (1988) and Strong (1985) reported that small flocks of loons, thought to be non-breeders, may assemble during the summer, but this behavior was not observed on my study area. Nonetheless, chorusing decreases rapidly after breeding pairs produce chicks and, certainly, well before premigratory assembly begins.

There is no supporting evidence for the hypothesis that chorusing serves to assemble widely separated group members. As far as is known, Common Loons do not associate as members of discrete groups (such as those formed by canids or primates). Although Young (1986) contends that wails may function to decrease distance between members of a pair and, possibly, between pairs or individuals, it is difficult to say with any certainty that this is what happens during chorusing. However, loons may retain a loose flock structure (Miller, pers. comm.) that could be maintained through choral interaction. Clearly, the possibility that group interaction is chorally mediated deserves closer attention.

The most commonly expressed hypothesis regarding the function of Common Loon choruses is that of territorial defense (Olson and Marshall 1952, Rummel and Goetzinger 1975, Titus and Van Druff 1981). If it is assumed that loud, long-range vocalizations are an efficient means of defending one's territory (Green and Marler 1979, Krebs and Davies 1981), then this hypothesis seems reasonable. Clearly, chorus calling occurs during a time of day when the opportunity for long-range communication is the greatest. There is little background noise from wind or waves and environmental conditions are less likely to attenuate or degrade signals (Henwood and Fabrick 1979, Wiley and Richards 1982, Gerhardt 1983). Several other avian species, such as the Marsh Wren (Cistothorus palustris), are known to produce nocturnal songs that may serve a territorial function (Barclay et al. 1985). Behaviorally, the nocturnal vocal repertoire of Common Loons is predominated by long-distance call types that are broadcast frequently, repetitively, and at a time of the season when the advantages of such signaling (e.g., contact with mates, territorial defense) possibly outweigh the disadvantages incurred (e.g., attraction of predators or energetic expense).

The territorial defense hypothesis is strengthened by

the observation that yodels peak just prior to hatching. Yodels are thought to be territorial defense signals (Rummel and Goetzinger 1985, Barklow 1979). This peak in choral yodels just prior to hatching may reflect an increased tendency toward territorial defense at a time when nesting females and developing chicks are perhaps most vulnerable. The incidence of tremolo duets during choruses also may reflect, if only indirectly, territorial occupancy. Short and Horne (1983) found that in certain species of barbets (Passeriformes: Capitonidae) only paired duetting birds hold territories. Farabaugh (1982) cites a number of examples from a wide variety of species in which duets may function in coordinated maintenance of territory as well.

Although Common Loon territories may be defended by choral vocalization, there may be alternative or complementary explanations as well. Choruses may be the product of a vocal "chain reaction" wherein the vocalization of 1 or a pair of birds acts as a stimulus for neighboring birds to vocalize. To that end, there may be very little interpair communication occurring.

Choruses may be the result of attempts by territory holders to detect intruders. Assuming that intruders represent threats to the reproductive success of territory holders, it may be to a territory holder's advantage to force potential intruders to reveal themselves. Chorus calls may serve as stimuli eliciting vocal responses or other reactions from intruders.

Although tremolo duets were not the most frequent call types heard during choruses, that they occurred at all in this context suggests that intrapair communication may be quite important. The preponderance of long-range vocalizations, however, makes it difficult to entirely dismiss the possibility that at least some interaction is occurring among pairs or pairs and individual birds. As suggested by Olson and Marshall (1952), perhaps choruses are indeed "social choruses" and represent the non-aggressive interactions of acquainted birds. Future field seasons will address these possibilities.

ACKNOWLEDGMENTS

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COLLECTION OF YODEL CALLS FOR INDIVIDUAL IDENTIFICATION OF MALE COMMON LOONS

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Marking Common Loons (Gavia immer) for determination of winter feeding areas, migratory routes, and yearly return rates to summer breeding lakes has been given a high priority in recent years (Plunkett 1979). Dwindling U.S. populations of these birds (McIntyre 1979, Metcalf 1979, Sutcliffe 1979) indicate a need for systematic studies of population dynamics. However, such studies can only be conducted if individual loons, or at least 1member of known loon pairs, can be identified. Recently, I established that male Common Loons can be individually recognized on the basis of visual and statistical analyses of sound spectrographs made from tape-recorded yodel calls (unpubl. data). However, "vocal-tagging" must be shown to be practical in the field to have value as a marking technique. The purposes of this project were to study the feasibility of collecting a pre-set minimum number of yodel recordings from a sample of loon pairs, and to identify general factors related to the efficiency of such collection.

METHODS

The study was conducted May 22-June 19, 1986 and April 27-May 25, 1987 on lakes in the contiguous counties of Gogebic, in Michigan's Upper Penninsula and Vilas, in northeastern Wisconsin. Eighteen loon pairs were studied on 16 lakes. Five pairs (* in list of lakes below) had been recorded in previous years during initial phases of developing a "broadcast elicitation" method and confirming that yodel calls were useful as individual identifiers. The remaining 13 pairs had not previously been tape-recorded. The lakes and number of pairs studied were: Allen (1), Bass (1), Black Oak (1), *Clark (1), *Crooked (2), *Deadman (1), *Devilshead (1), Dinner (no stable pair located), Duck (2), *Grass (1), Imp (no stable pair located), Little Duck (1), Landing (1), Long (1), Marion (1), and Moon (1). Lakes were chosen on the basis of observed loon presence and accessibility. They constituted a mixture of sizes, single and multiple territories, degrees of recreational use, and degrees of human development.

During the 1986 season, broadcast-elicitation sessions were conducted 0500-1100 and 1600-2200. During 1987, only 1600-2200 h sessions were done. A set goal of 5 yodels per pair, per year, was established prior to beginning the project. This number was chosen as the minimum needed for future statistical analyses of the calls.

Each pair was visited on a rotating basis until 5 yodel recordings had been collected, or until 4 morning and 4 evening lake visits had been made for 1986, or 4 evening visits for 1987. I attempted to elicit yodels when either 1 or 2 birds were present on a given lake/lake area.

Elicitation sessions were conducted from a 16-foot johnboat powered by a 5-hp outboard, or from shore on small lakes which could be seen in their entirety without going onto the water. When using the boat, a lake was cruised until either 1 or 2 loons had been spotted. If a single bird was seen, the remainder of the lake/lake area was cruised in an attempt to locate a second bird. Single birds were worked only after confirmation that no other loon was present in the same general lake area. For those lakes on which active nesting was known to be in progress, we did not broadcast until both birds were on the water of their own accord.

Once a pair or single had been confirmed, it was slowly approached using an electric trolling motor. The boat was steered in a zig-zag manner, never directly toward the birds. During the approach, approximately 5 minutes of observations on behavior of the pair were spoken into a Panasonic microcassette recorder which was left running so that diving times, behavioral sequences, etc. could be obtained for future additional confirmation, if necessary, of pair identity. Approach was halted approximately 25-35 m from the birds. The boat was oriented so that the left side faced the birds, and was kept in this position using the lowest setting of the trolling motor.

If the birds were not disturbed by our presence, an unfamiliar yodel call was broadcast directly toward them. If the birds were feeding, the broadcast was made as soon as possible after they had surfaced from a dive. Equipment used for the broadcasts included a small Panasonic cassette recorder connected to a Bogen MA-40, 40-watt, variable output amplifier and a Speco SPC-10, 15-watt outdoor speaker. The amplifier was powered off the trolling motor battery. During broadcast, the speaker was held over the side of the boat just above water level. Yodel responses to the broadcast were recorded using a Uher 4000L or 4000IC reel-to-reel recorder through an AKG-CK9 shotgun microphone, tripod mounted. After the birds had calmed down and resumed pre-broadcast behavior, a second broadcast was made. This cycle of broadcast followed by a period to allow the birds

to completely calm down typically took 6-9 minutes. Broadcasts were continued until 5 yodel calls had been recorded. If a bird did not give a yodel response in 2 successive yodel broadcasts, the session was ended. When working from shore the strategy was the same except that the birds were lured to within 25-35 m from the microphone by broadcasting 1 or more unfamiliar wail calls. These were broadcast at relatively high volume (approximately 7 on the Bogen's 10-point volume scale). Only one wail was broadcast at a time. If the birds did not come to within 50 m of shore, or appeared to have lost interest while swimming in, a second or third wail, as needed, was broadcast. Once near shore the loons were allowed to "patrol" until they seemed to have relaxed and to have concluded that there was no threat. At that time the first yodel broadcast was made. Subsequent yodel broadcasts followed the same pattern as from the boat.

In addition to recording yodel calls and behavior, data were kept on number of loons present, overall field time, total time spent on each lake and time spent working the birds during each lake-visit.

RESULTS

Several factors were related to field collection of yodels. Most important were time of day (morning compared with evening), time of season (pre-nesting compared with nesting), and number of birds present. However, no specific hypotheses were tested, no inferential statistical comparisons are appropriate, and the data are presented as descriptive only.

One hundred yodel calls were collected in 1986 and 99 in 1987 (Table 1). For both years the pre-set minimum of 5 calls was collected from 15 of 18 pairs. During 1986, 1 yodel was recorded from a sixteenth pair, on Moon Lake, and in 1987, 3 yodels were obtained from a sixteenth pair, on Duck Lake, north section. In both years the 2 remaining lakes, Dinner and Imp, had only single birds or 3-bird groupings, respectively, and no yodels were obtained.

The number of lake visits necessary to collect the yodels decreased from 86 in 1986 to 32 in 1987. Total field time decreased by slightly more than half, however mean hours of field time per visit showed a moderate increase. Yodels were collected more efficiently in 1987, with mean number of visits per lake decreasing from 4.8 in 1986 to 1.8. Consequently, more yodels were collected per hour of field time and per lake visit.

The likelihood of finding a given number of loons present during lake visits appears to differ for the 2 obser-

Table 1. General summary of data collected during vocal-tagging activities 1986-1987.

	1986			1987
	Morning	Evening	Total	(Evening)
No. Lakes/Lake Areas studied	(18)	(18)	18	18
No. yodels Collected	34	66	100	99
No. Lake Visits	47	39	86	32
Hrs. Field Time	68.1	58.5	126.6	62.1
Mean Hrs. Field Time/Visit	1.4	1.5	1.5	1.9
Mean No. Visits/ Lake	2.6	2.2	4.8	1.8
Mean No. Yodels Collected/Hr.	0.5	1.1	0.8	1.6
Mean No. Yodels Collected/Lake Visit	0.7	1.7	1.2	3.2
Percent of "Bird(s) Present" Visits at Least One Yodel Collected	39	56	46	77
Percent of "Bird(s) Present" Visits Five or More Yodels Collected	10	28	18	68

vation years (Table 2). Zero loons present was equally likely for both years, as was the presence of either 1 or 2 loons, during morning and evening, in 1986. However, in 1987, when lakes were visited before nesting began, 2 loons were 6 times more likely to be found than only 1. Three or more loons were observed infrequently in both years.

On visits when at least 1 loon was present, at least 1 yodel was collected nearly half the time in 1986 and slightly more than three quarters of the time in 1987 (Table 1). Five or more yodels were collected on 10 (18%) of 56 visits in which at least 1 loon was present in 1986. This increased greatly in 1987 when 15 (68%) of 22 visits resulted in 5 or more yodels collected.

The number of yodels collected was a function of the number of birds present (Table 3). One or more yodels were most likely to be collected when 2 loons were present. No yodels were collected when more than 2 loons were on the lake. When only 1 loon was present, 0 yodels were the most likely outcome, but 1 or more yodels were collected occasionally.

DISCUSSION

Results from both years show a high success rate for collection of loon yodel recordings. They demonstrate both the feasibility of collecting yodel recordings for vocal-tagging purposes and the field practicality of a broadcast-elicitation method. Although descriptive only, the corollary observations form a pattern which strongly suggests that certain factors may increase the likelihood of efficient field collection of calls.

First, yodels were more efficiently collected during evening hours than during the morning. There is no clear explanation for such a "time of day" effect. Yodels can be collected in the morning, and a third of the 1986 calls were taken during these hours. However, the birds seemed less and less willing to respond as morning hours passed. In the evening this pattern seemed to run in reverse sequence, the birds becoming more willing to call as sunset and darkness approached. This observation supports the general notion the many territorial birds call at sunset as a "last opportunity" to auditorily and visually advertise territory residency. For a male loon, the yodel of an unseen intruder at dusk may be more threatening and provocative than at other times of the day. Thus broadcasts given at this time might have greater effect than those given earlier.

Second, collection of calls during pre-nesting in 1987 was more efficient and more likely to be successful than

Table 2. Percentage of lake/lake area visits in which zero, one, two, or more than two loons were found present.

No. Loons Present	1986 Morning	1986 Evening	1987 (Evening)
0	34	36	31
1	30	28	3
>2	34	33	56
2	2	3	3

Table 3. Percent yodel-collection success as a function of number of loons present (combined data 1986-1987).

No. Yodels Recorded	No. Loons Present 1 (n=28)	2 (n=47)	> 2 (n=3)
0	79	21	100
1-4	14	30	0
5	7	49	0

that done during nesting in 1986. This finding is easier to interpret, and 2 elements seem to have been involved. First, the birds were more likely to be found as pairs on the lakes during pre-nesting. Table 2 shows a 22 percent increase in likelihood of finding 2 birds on a particular visit, with a concomitant 20 percent decrease in likelihood of finding only 1. Second, the birds seemed to be more willing to yodel as evidenced by the dramatic increase in percent of "Bird(s) present" visits (Table 1) resulting in 1 or more yodels. The overall probability of obtaining 1-4 yodels was 2.1 times greater, and for 5 or more yodels 7.0 times greater if 2 birds were present rather than 1 (Table 3).

One would expect to collect more yodels from 2 birds than from 1, given that some proportion of single bird sessions would involve non-calling females. However, based on the unsubstantiated presumption that single birds encountered are male about half the time, 2-birds sessions should be approximately twice as successful as those involving single birds. That 2-bird sessions were several times more successful suggests that many male loons were not yodeling when approached as singles, but were much more easily provoked to yodel when in the presence of the female. An obvious alternative explanation is that a high percentage of single birds found alone on the territories were females. Regardless, the result remains the same for our purposes. Two-bird sessions were several times more likely to result in successful yodel collection. Overall, this apparent "early season" effect is not particularly surprising. Reestablishment of a pair bond and of territorial rights might make it more likely that both birds would be found together early in the season.

That yodels were more easily collected during the pre-nesting phase is a very positive finding in at least 1 respect. There has been some concern about the possibility of disrupting incubation through use of call-broadcasting. While our limited observations strongly suggest that no negative effects follow the broadcast sessions even if a bird leaves the nest, it is possible that yodel collecting could negatively affect some pairs under some conditions. Collecting all yodel recordings during pre-nesting would circumvent this potential problem entirely.

An additional aspect of collecting yodel calls deserves comment. It became increasingly apparent during the course of this study that a strategy of allowing the birds to relax and resume pre-broadcast behavior following each broadcast/response is very important. The element central to success seems to be surprise. If a second yodel broadcast is made immediately following a bird's yodel response to an initial broadcast, there seems to be a reduced chance that the bird will respond again. The first broadcast seems

to "catch the birds off guard", but the second has much less effect, as if the birds have concluded that there is no actual threat. However, if a pair is allowed to calm down and resume pre-broadcast activity, the second broadcast yodel seems to affect them as much or more than the first yodel. While the second procedure requires more time on a given lake visit, it probably pays time dividends in the long run, especially if all 5 yodels can be collected at once.

CONCLUSION

Field use of a broadcast method for vocal-tagging seems to be far less time- and labor- consumptive than initially suspected, especially if done in the evening, early in the season. My results suggest that 1 well-trained field-team could easily collect 5 or more yodel recordings from 20 to 25 pairs within 1 pre-nesting period. There is every reason to expect that this method will provide a great deal of much-needed information about individuals and pairs as well as populations, and I now can strongly recommend its use.

ACKNOWLEDGMENTS

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THE STRUCTURE AND FUNCTION OF THE WAIL CALL OF THE COMMON LOON

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SUMMARY

The wail call has a very general message that reflects an appetitive motivation. Appetitive behavior refers to activity associated with searching to release a drive. Because this type of behavior can be linked to virtually any of the fundamental motivations in animals (fear, aggression, mating, etc.), the wail can be expected in a wide variety of contexts. The call is often heard, for example, in situations in which one loon wants to interact in some way with another loon, but at that moment the interaction is thwarted for some reason. Separation from a mate or chick, counter-singing, and night chorusing are common examples.

The message of the wail is not discrete. Its interpretation depends on the context in which it is given. Thus, the results of playback experiments are difficult to evaluate because it is usually impossible to determine how the receiver perceives the context. In my experience, the birds react with a mixture of curiosity and confusion.

The structure of the wail is built from a simple monotone with few if any harmonics. The tones can be added at progressively higher frequencies to form 3 call types. There is, however, much variation within each call type and the entire system appears to represent a code. Intensity grading (similar to the tremolo call) is the most likely hypothesis to explain the code, but the details are still unclear.

The acoustic properties of the wail seem appropriate to its function. Its tonal structure provides for efficient long range transmission, an important feature in appetitive signals. Although differential attenuation of frequency levels may provide distance information, the ventriloquil nature of pure tones makes this function unlikely.

Finally, unusual forms of the wail are not uncommon presumably because of the tendency to grade into other calls in the repertoire. This occurs occasionally in aggressive situations when the wail approaches the form of the introduction to the yodel. This has been observed in both males and females.

VARIATION IN THE COMMON LOON (*GAVIA IMMER*)

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In addition to their intrinsic interest to evolutionary biologists, studies of geographic variation in birds may have a more practical value. Known patterns of variation over the breeding range of a species may allow determination of the source of populations of migrating and wintering birds (Storer 1951). This approach differs from that used in banding in that is uses populations rather than individuals. The usefulness of this approach depends on quantifying variation and thus on sample sizes. For the Common Loon, these samples are disappointingly small.

In an early analysis, Bishop (1921) described a new, small subspecies of the Common Loon as *Gavia immer elasson* from the Turtle Mountains of North Dakota. His analysis was based on 25 sexed specimens of adults taken on the breeding grounds and 34 unsexed or non-breeding birds. He also used measurements of 5 sets of eggs.

Twenty-six years later, Rand (1947) analyzed geographic variation in the Common Loon using data from 32 sexed and 18 unsexed breeding adults. He found considerable overlap between the "subspecies" and recommended that none be recognized.

In his book on the birds of Labrador, Todd (1963) reported finding "no significant pattern . . . other than a tendency for Greenland birds to run slightly larger than average, and for Michigan and North Dakota birds to run slightly smaller." His results were based on data from 86 adults, the number of sexed specimens unspecified.

Assuming that egg size is correlated with body size, Anderson, Lumsden, and Hickey (1970) published an analysis based on measurements of 302 eggs. In general, their results agreed with those of Rand based on measurements of body size, that is, birds are smallest in North Dakota and the adjacent parts of Manitoba and increase in size to the east, north, and west.

The purposes of this paper are to determine the degree of sexual dimorphism and the amount of age variation in the Common Loon, to describe the geographic variation in greater

detail than was hitherto possible, and to try to determine from this the sources of birds on the wintering grounds.

I have examined and measured 926 Common Loon skins, 245 of them of breeding adults. This has included specimens from all the major museums and many small collections in Great Britain, Canada, and the United States. While the number of specimens seems large compared with the numbers used by earlier workers, they are small compared with those used in studying geographic variation of small birds. For example, Miller (1941) used specimens of 4552 breeding birds in his study of the juncos.

Reasons for the paucity of specimens of loons from the breeding grounds are fairly obvious. Loons are large birds, time-consuming to prepare, costly to ship and store, breeding populations are thinly distributed over much of the range, and most collectors are reluctant to take them.

A second reason why analysis of variation in this bird is difficult is the lack of a sufficiently large sample from any one area to determine the variation within a single population so that differences among populations can be assessed. Of first importance is the degree of sexual dimorphism. If the sexes do not differ significantly, they can be combined and unsexed birds can be used with them in an analysis. On the other hand, if sexual dimorphism is large enough, as is the case with most grebes, sex can be assigned to unsexed birds and missexed birds can be spotted with a high degree of confidence. The degree of sexual dimorphism in the Common Loon lies in the gray area between. There is so much dimorphism that the sexes cannot be combined for analysis, but the overlap between the sexes is so great that missexed birds frequently cannot be identified and sex cannot be assigned to birds not sexed by examination of the gonads. This results in minimal sample sizes and a likelihood of error resulting from the inclusion of missexed birds that cannot be detected.

METHODS

Five measurements were taken on the study skins: 1) length of the wing (to the nearest mm) from the wrist to the tip of the longest primary, measured with the wing flattened against the ruler (arc); 2) length of the tarsus measured from the notch of the ankle to the end of the trochlea for the third toe; 3) culmen length measured from the end of the feathering to the bill tip; 4) bill from nostril measured from the anterior edge of the nostril to the tip; 5) bill depth measured at the level of posterior edge of the nostril. The last 4 measurements were taken to the nearest tenth of a millimeter with a dial caliper. To avoid redundancy in the 2 measures of bill length, the bill-from-

nostril measurement was subtracted from the culmen length providing a measurement of bill to nostril. Age was determined by plumage characters, the juvenal plumage being quite different from that of the second and subsequent winters (Palmer 1962).

The range of the Common Loon consists of an Old World population breeding in Greenland and Iceland and wintering on the coasts of Europe, and a New World population which is widespread in the United States and Canada. For purposes of analysis, breeding loons from south of Latitude 55° were divided into five sample areas: 1) 55° - 70°; 2) 75° - 85°; 3) 87° - 95°; 4) 97° - 107°; and 5) 110° - 140° west longitude. Gaps were left between adjacent sample areas so geographically contiguous populations were not compared and to reduce the amount of overlap in measurements. Latitude 55° was selected arbitrarily to include the largest samples. Means, standard deviations, and coefficients of variation were calculated for each measurement by sex and area. Significant differences between the means were tested by pair-wise t-tests (Scheffe comparisons). The 2 largest samples, those from areas 2 and 3 were used to provide figures for sexual dimorphism. This was expressed as a Dimorphism Index, that is, the difference between the means for the sexes expressed as a percent of the mean for the means of the sexes. Because Common Loons do not return to the area where they were hatched in their first year and because samples from the wintering grounds seem to be composites from several breeding grounds, I derived figures for age differences from data for the closely related Yellow-billed Loon (*Gavia adamsii*), which shows no significant geographic variation throughout its breeding range (Storer, unpublished data).

RESULTS

The degree of sexual dimorphism in the 2 largest samples is shown in the right-hand column of Table 1. The indices for the 2 populations are quite similar. Of particular interest is the greater part of the dimorphism in bill length occurring in the basal part. Bill depth is also strongly dimorphic. However, in all measurements there is considerable overlap between the sexes.

Age variation in the Yellow-billed Loon is shown in Table 2. The difference in wing length is due to the shorter primaries carried by young loons for their first year. (They are molted and replaced in the summer when they are 1 year old, Palmer 1962.) The lack of difference in tarsal measurements is a result of these bones' reaching full growth in the fall of the birds' first year. The bill differences reflect the continued growth of the bill throughout at least the first year of life. The small

Table 1. Sexual dimorphism in the Common Loon.

	Area 2						
	Males			Females			
Measurement (mm)	N	Mean	CV[a]	N	Mean	CV	DI[b]
Wing length	24	363.1	3.9	24	347.5	2.9	4.4
Tarsus length	23	90.5	4.7	24	85.7	4.8	5.5
Bill to nostril	22	19.1	7.8	22	17.8	10.2	6.9
Bill from nostril	22	63.3	6.7	22	62.5	5.2	1.3
Bill depth	23	24.7	8.2	22	23.0	6.7	7.3

	Area 3						
	Males			Females			
Measurement (mm)	N	Mean	CV	N	Mean	CV	DI
Wing length	22	361.2	3.4	13	346.9	4.9	4.1
Tarsus length	22	89.7	4.9	13	85.1	4.3	5.2
Bill to nostril	20	18.8	9.7	12	17.5	10.7	7.4
Bill from nostril	20	63.7	4.5	12	62.7	5.0	1.7
Bill depth	16	24.0	1.1	12	22.6	6.0	6.0

[a] CV = Coefficient of variation.

[b] DI = Dimorphism index = the difference between the means for the sexes expressed as a percent of the mean for the means for the sexes.

Table 2. Age Dimorphism in female[a] Yellow-billed Loons.

	Adult		Yearling		
Measurement (mm)	N	Mean	N	Mean	DI
Wing length	54	380.9	10	357.5	6.2
Tarsus length	54	88.8	12	89.1	-0.2
Bill to nostril	42	16.0	12	15.3	4.5
Bill from nostril	42	74.5	12	57.6	24.2
Bill depth	50	25.4	11	21.4	17.1

[a] Sample of immature males too small for meaningful comparison.

figure for bill to nostril suggests that this portion of the bill may reach its full length before that of bill from nostril and bill depth.

The geographic variation in North America south of latitude 55° is shown in Table 3. In size, expressed by wing and tarsus length, there is a gradual decrease from eastern Canada and New England to area 4, that centering about North Dakota and southern Manitoba, and then an increase to the west. Bill measurements seem to follow this pattern, but the results are not conclusive, owing in large part to the smallness of some of the samples.

A comparison of 2 samples from north of latitude 55° with those directly to the south is shown in Table 4. The birds whose measurements are shown in the upper left columns are from Baffin Island, where the birds are large and similar in size to those of the Old World. Bill measurements, however, do not follow any trend, including an indication of decreasing bill size to the north. Unfortunately, sample sizes are too small to show definitive results.

A comparison of birds taken outside the breeding season east and west of longitude 100° is shown on Table 5. Longitude 100° was selected arbitrarily to separate the Atlantic and Pacific wintering grounds. The only significant difference is in the measurement of bill from nostril in males. This may be a statistical artifact and should be checked with a larger sample. Further analysis of birds wintering on the Atlantic and Gulf coasts was not feasible because of small sample sizes. However, a comparison of birds wintering from Alaska to Washington with birds taken in fall, winter, and spring in California (Table 6) showed that the northern birds had consistently longer wings and tarsi than those from California. Adults also had larger bill measurements. Larger sample sizes are needed for further testing of the statistical significance of differences between these wintering populations.

It is clear that there is not sufficient material nor sufficiently well-defined breeding populations to determine the sources of wintering populations of Common Loons using this method. The small amount of variability between populations also indicates that more sophisticated techniques of analysis such as principal components would presumably do little to clarify the situation.

CONCLUSIONS

1. Sexual dimorphism in the Common Loon ranges approximately 4-7.5 percent, except in bill from nostril, in which it is considerably less. The greatest dimorphism in bill measurements is that of bill to nostril (the basal portion).

Table 3. Geographic variation in Common Loons taken on the breeding grounds south of latitude 55°.

BREEDING GROUNDS SOUTH OF LATITUDE 55°

Measurement (mm)		Area 1[a]	2	3	4	5
Wing Length	Male	368.7	363.1	361.2	353.0	362.5
	Females	353.6	347.5	346.9	342.3	365.5[b]
Tarsus Length	Male	91.4	90.5	89.7	85.7	86.7
	Females	85.3	85.7	85.1	80.8	87.0[b]
Bill to Nostril	Male	18.0	19.1	18.1	19.2	17.3
	Females	17.6[b]	17.8	17.5	17.3	17.1[b]
Bill from Nostril	Male	64.5	63.3	63.7	58.4	61.3
	Females	60.1[b]	62.5	62.7	59.0	59.1[b]
Bill Depth	Male	24.6	24.7	24.0	22.7	23.3
	Females	23.7[b]	23.0	22.6	20.9	24.2

[a] Area 1 = 55° to 70° Long.; 2 = 75° to 85° Long.; 3 = 87° to 95° Long.; 4 = 97° to 107° Long.; 5 = 110° to 140° Long.

[b] Sample size less than 5.

Table 4. Measurements of Common Loons taken on the breeding grounds; north-south comparison.

	55°-70° Long.		110°-150° Long.			
	Males[a]		Males		Females	
Measurement (mm)	N	Mean	N	Mean	N	Mean
Wing length	5	373.6	8	369.0	4	359.0
Tarsus length	4	92.4	8	90.4	4	86.8
Bill to nostril	4	17.6	8	17.7	4	17.3
Bill from nostril	4	64.5	8	61.8	4	60.1
Bill depth	5	24.8	7	24.2	4	23.1
	Below Latitude 55°					
Measurement (mm)	N	Mean	N	Mean	N	Mean
Wing length	11	368.7	4	362.5	8	365.5
Tarsus length	11	91.4	3	86.7	8	87.0
Bill to nostril	9	18.0	3	17.3	7	17.1
Bill from nostril	9	64.5	3	61.3	7	59.1
Bill depth	10	24.6	4	23.3	7	24.2

[a] Samples of females were too small for meaningful analysis.

Table 5. Measurements of adult Common Loons taken outside the breeding season

Measurement (mm)	Longitude 50° to 100° N	Mean	CV	Longitude 100° to 150° N	Mean	CV
Males						
Wing length	81	357.7	4.0	19	363.3	4.3
Tarsus length	83	87.9	4.9	21	88.8	4.4
Bill to nostril	74	18.2	12.9	17	17.8	7.4
Bill from nostril	74	63.4	5.4	17	59.9[a]	5.9
Bill depth	62	23.1	6.6	18	23.2	6.5
Females						
Wing length	67	347.0	3.9	16	345.6	4.3
Tarsus length	70	84.8	4.9	18	83.2	5.6
Bill to nostril	63	17.5	13.5	17	17.3	9.9
Bill from nostril	64	60.6	8.2	17	59.0	6.2
Bill depth	55	22.2	7.2	15	22.1	8.7

[a] Significant difference (p=0.003) between means.

Table 6. Measurements (mm) of Common Loons wintering on the Pacific Coast.

	Alaska to Washington			California[a]		
Adult males	N	Mean	CV	N	Mean	CV
Wing length	14	371.0	5.7	11	355.6[b]	4.1
Tarsus length	14	91.2	6.2	13	87.6	4.3
Bill to nostril	13	18.4	11.2	11	17.5	7.1
Bill from nostril	13	61.3	6.7	11	59.7	6.2
Bill depth	13	24.9	6.8	11	22.5[c]	5.5
Yearling males						
Wing length	5	348.8	6.6	18	344.6	3.2
Tarsus length	5	91.3	5.8	18	87.0[b]	4.1
Bill to nostril	4	16.3	10.5	16	17.3	11.0
Bill from nostril	4	53.9	12.6	16	56.6	8.0
Bill depth	5	21.9	11.3	15	20.8	8.4
Adult females						
Wing length	6	365.5	4.7	10	340.3[c]	2.3
Tarsus length	8	88.6	6.6	10	80.8[c]	1.9
Bill to nostril	8	17.6	10.1	8	17.3	8.3
Bill from nostril	8	60.5	6.5	8	56.5[b]	1.8
Bill depth	7	23.1	7.0	8	21.2[b]	5.0
Yearling females						
Wing length	4	334.8	1.9	16	326.1	3.9
Tarsus length	4	85.5	6.7	18	82.5	3.0
Bill to nostril	3	16.4	6.7	17	16.8	10.4
Bill from nostril	3	56.2	4.9	17	53.5	8.2
Bill depth	4	20.4	3.7	13	19.3	5.2

[a] Sample includes birds taken in spring and fall as well as winter.
[b] Significantly different from the northern birds at the 0.05 level.
[c] Significantly different from the northern birds at the 0.01 level.

2. First-year individuals of the Yellow-billed Loon (and presumably the Common Loon) have shorter wings (ca 6%) than older ones, because the young birds have shorter primaries. First-year birds also have smaller bills, an expression of the continued growth of the bill for at least the first year.

3. The pattern of variation of the Common Loon across the United States and Canada south of latitude 55° runs from large in eastern Canada to small in North Dakota and the adjacent part of Manitoba, then large to the west. This is probably true of all measurements; the apparent discrepancies are probably the result of small samples or missexed specimens. Differences between populations are so small and overlap in measurements so great that no subspecies should be recognized.

4. There is a tendency for birds from north of latitude 55° to have longer wings and tarsi than those from further south, but bill measurements do not differ significantly and sample sizes are small.

5. With the single exception of bill from nostril in males, no significant differences were found between adults taken in the fall, winter, and spring east and west of longitude 100°. The exception is probably a statistical artifact stemming from the number of pair-wise comparisons performed. The samples from the breeding grounds do not appear sufficiently differentiated to permit identifying the sources of birds taken on the wintering grounds.

6. Because of the paucity of sexed specimens, it is urged that special effort be made to preserve loons found dead on the breeding grounds or taken for studies of food habits, pesticide contamination, and other purposes.

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FLOCKING BEHAVIOR OF COMMON LOONS (*GAVIA IMMER*) IN NORTHWEST ONTARIO: EARLY-SUMMER SITES.

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Summer flocks of Common Loons (*Gavia immer*) have been reported for a variety of locations throughout North America. Locations include the Queen Charlotte Islands of British Columbia (Reimchen and Douglas 1980), Minnesota (Olson and Marshall 1952), Alberta (Munro 1945), Manitoba (Predy 1972, Nero 1974), northwestern Ontario (Nero 1972), and Saskatchewan (Yonge 1981). There is no clear explanation of this behavior during the breeding season (Rand 1948).

Migratory fall flocking is a common phenomenon occurring at traditional staging areas (McIntyre 1975) along migration routes and at local sites prior to migration (Olson and Marshall 1952, Yonge 1981). Pre-migratory flocking behavior is initiated during late summer. However, it does not account for early and mid-summer flocking. Olson and Marshall (1952) and Yonge (1981) suggested that early summer flocks were comprised of non-breeders and unsuccessful breeders that left their territories to form daytime flocks. The flocks broke up in late afternoon as birds returned to their territories. McIntyre (1978) reported a reversed behavioral pattern for Common Loon aggregations on their winter range. Loons were in groups during the evening and fed as individuals during the day. An intermediate pattern has been reported for fall migration (McIntyre and Barr 1983). Loons spent the night offshore in large rafts which broke down into several smaller feeding associations (<20 birds) during the day.

Surplus non-breeding individuals exist within many bird populations (Tompa 1962, Brewer 1963) and often appear as an organized non-territorial group. They may appear as a "floating population" (Payne and Groschnupf 1984), "replacement pool" (Tompa 1962) or "floaters" (Smith 1984). Often, surplus individuals can breed and establish territories if the restriction inhibiting their breeding is removed (Watson 1967, Smith 1984, Stutchbury and Robertson 1985).

The existence of surplus birds in Common Loon populations has not been well documented although Croskery (1987) demonstrated that suitable vacant territory quickly becomes occupied by other birds. The purpose of this study was to

examine sites selected for flocking by Common Loons, to determine whether these sites were traditional or annual in use, and to describe flocking behavior throughout the summer.

METHODS

The study was conducted in a 200 km^2 area located in northwestern Ontario near Ignace, Canada (approx. 49° N 91° W) (Figure 1). I monitored 50 lakes during the study, but report the results from the only 5 lakes (Cecil-1616 ha; Indian-3966 ha; Mameigwess-5314 ha; Paguchi-2449 ha; Sandbar-1292 ha) that regularly supported groups of Common Loons.

Each lake was surveyed approximately once every 10 days May-September 1982-1986 except for Cecil Lake which was surveyed only 1982-1983. Two other large lakes adjacent to the study area, Sowden and Lake of Bays, were checked for the presence of large groups in 1984. Surveys involved traveling by boat over the entire lake and mapping the locations and number of all observed Common Loons. The number and locations of loon territories for each lake was determined by compiling survey data within a year, tracking individual birds, plotting locations of broods, and locating active nest sites. For each group sighted, information was collected on the number of birds within the group, the general organization of the group and the degree of behavioral coordination exhibited by individuals within the group.

I classified each group as an aggregation or flock using definitions of Emlen (1952) and Moriarty (1976). Birds in the same area that did not interact to maintain a cohesive unit were considered "aggregations". "Flocks" were groups of loons which demonstrated coordinated interactive behavior. Neither aggregations nor flocks were limited in size and the potential for a group to change status from an aggregation to a flock, or vice versa, was possible.

Only groups recorded prior to 15 July were considered early-summer groups. July 15 was selected because in all years, loons were found incubating and were territorial within the study area until this date.

For 3 consecutive days in June, July, and August, 1986, a summer flock was monitored. Monitoring was continuous and carried out in 3 sampling periods: early morning (0530-1000), mid-day (1200-1600), and late afternoon (1700-2130). In each 3-day period, 2 early morning, 1 mid-day, and 2 late afternoon monitoring periods were conducted except when weather conditions were unfavorable. I recorded flock build-up or breakdown, arrival and/or departure of

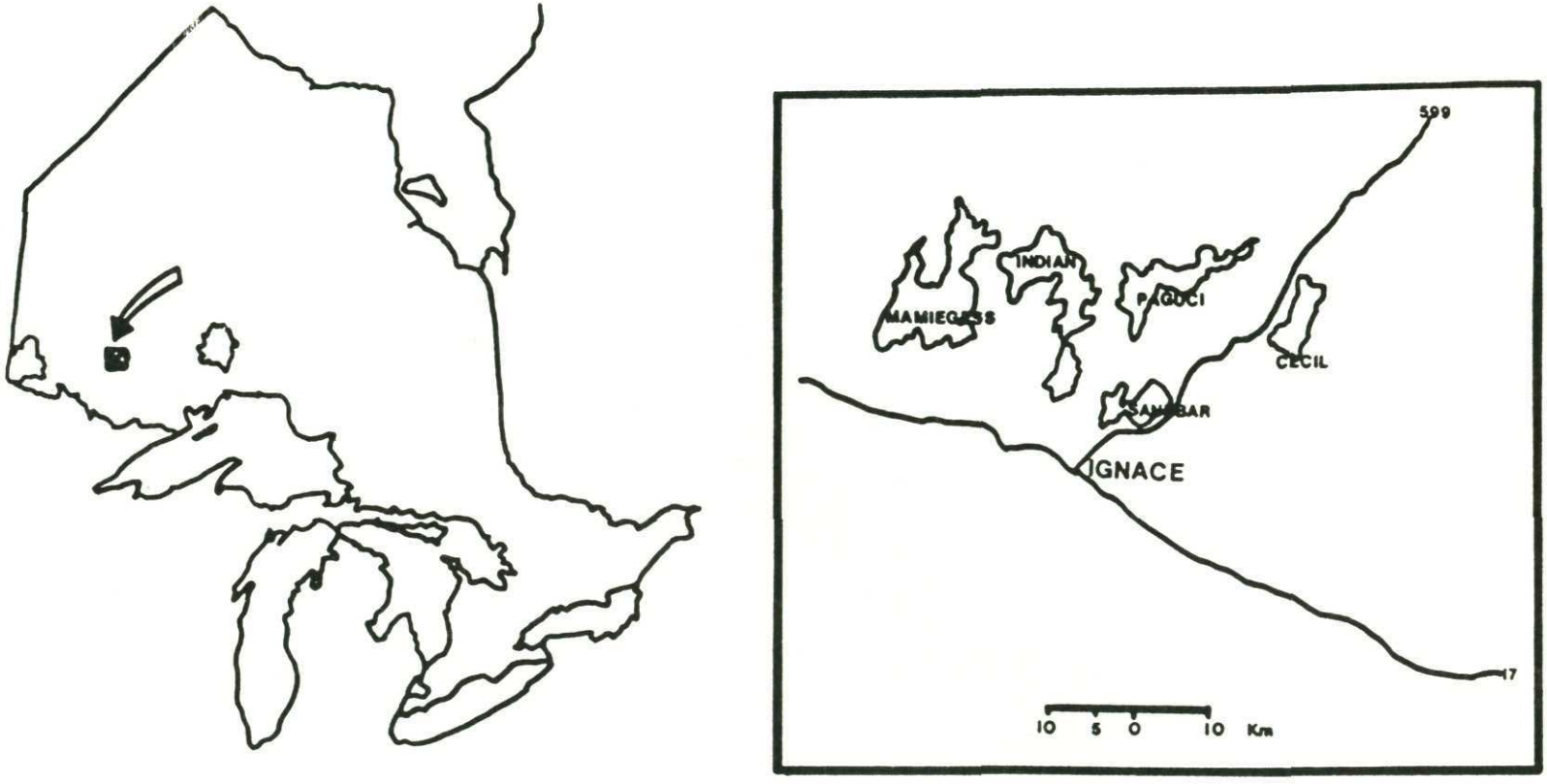

Figure 1. Location of the study area in northwestern Ontario, Canada.

loons from flocks, general behavior, travel and area used by the flock, and reaction of flocks to territorial loons.

To examine how members of a group might differ from territorial birds, observational data on territorial loons were collected. Only territorial birds on large lakes that did not have an early summer flock were monitored. Monitoring was conducted during regularly scheduled counts.

RESULTS

Two lakes, Mameigwess and Indian, had summer-long flocks of Common Loons all 5 years of the study (Table 1). A flock became established in late May-early June of each year and remained into October when field work was discontinued. For the 2 years it was monitored, Cecil Lake supported summer flocks. Paguchi Lake had an early summer flock in 1982 but in all other years only aggregations were noted. In 1984, Lake of Bays had an early summer flock, Sowden Lake showed no evidence of either a flock or aggregations although thoroughly checked on 5 different occassions.

For 4 years, Sandbar Lake supported early summer flocks. However in 1986, aggregations were observed more frequently in early-summer. By late summer, the aggregations had become a flock. Numbers of loons on the lake were the same in early and late summer. Only the organization of the birds differed. Once the Sandbar Lake flock was established, it remained through the rest of the summer.

Flocks were sighted within the study area approximately 250 times over the 5 years of this study. In all cases flocks were found on the main basin of a lake. Flocks did not restrict themselves to a mid-lake location and commmonly were seen close to shore (within 3 m). Although they traveled widely, they never left the lake's main basin as a group. The area used for flocking on a lake was constant throughout each year and among all years.

Sites used by Common Loons flocks were similar among lakes. All were large, open-water basins, free of islands, and associated with the deepest water in the lake. The shorelines of these areas offered poor nesting opportunities due to exposure to prevailing winds. These features were shared by Sowden Lake which did not support summer loon groups. Sowden differed from the flock lakes in that it had few nearby water bodies that might provide suitable loon habitat.

Water depth and fish communities in flock site areas were dissimilar among lakes. The deep-water basins on Indian, Mameigwess and Paguchi were > 30 m deep and supported coldwater fish species. Sandbar Lake's deepest basin was < 15 m deep and supported a warmwater fish community.

Table 1. Mean early summer group size for Common Loons on 5 lakes near Ignace, Ontario 1982-1986.

Lake	X Flock Size 1982	1983	1984	1985	1986	Maximum Depth (m)	Area (ha)
Cecil	31	23				24.0	1616
Indian	30	40	30	26	17	35.4	3966
Mameigwess	70	50	61	55	57	49.2	5314
Paguchi	9	(8)	(8)	(9)	(7)[a]	29.7	1225[b]
Sandbar	15	16	19	20	(24)	16.5	1292

[a] () = birds organized as aggregations

[b] area of main oligitrophic basin only

Annual within-flock variation was similar for all flocks (Figure 2). In early-summer (until 15 July), numbers remained relatively constant. During late-summer (16 July-31 Aug), flock size had greater day to day variation suggesting that birds were more actively leaving and returning to the flock. In some instances, total flock size increased during this period but size increases were generally small. In fall (1 Sept-onwards), flocks increased most dramatically. For example, the 1982 Mameigwess flock increased 300% (50-195) during this period.

Flock members flew more often than non-flock members (Table 2). Flights/100 h were 7 times greater for flock members. Flying activity peaked in late summer in both groups, approximately half of all flying occurring during this time.

Although stable over time, flocks were dynamic entities. Individuals regularly left the flocks and flew off the lakes. Flocks broke down frequently into smaller subgroups that often traveled and behaved independently. In many cases flocks broke down to individual birds. Flock build-up occurred as regularly as flock breakdown. Subgroups and/or individuals joined together until flocks again approximated pre-breakdown size.

DISCUSSION

Because not all large open water basins within the study area supported flocks of Common Loons (e.g. Sowden Lake), proximity to suitable habitat may be a stronger influencing factor on flock site location than availability of large, open-water areas. This may be unique to northwestern Ontario where lakes are numerous and a choice for flock sites is available.

Flocks inhabited Indian and Mameigwess Lakes during each of the 5 years of the study. Flock size declined on both lakes during the study. Paguchi Lake had a small flock early, but that failed to continue through the study. It is possible that the Paguchi Lake flock became too small to maintain a flock identity. In the absence of a nuclear or core flock, loons either searched elsewhere for a flock to join or wandered through the area as single non-territorial birds.

When flocks broke down, strong subgrouping tendencies resulted in groups of loons remaining within the flocking area. These subgroups later became the nuclei for re-establishing flocks. When a flock was small, such as on Paguchi Lake, breakdown resulted in sub-groups so small that they were not distinguishable from territorial birds. Observations of arriving and departing birds suggests group

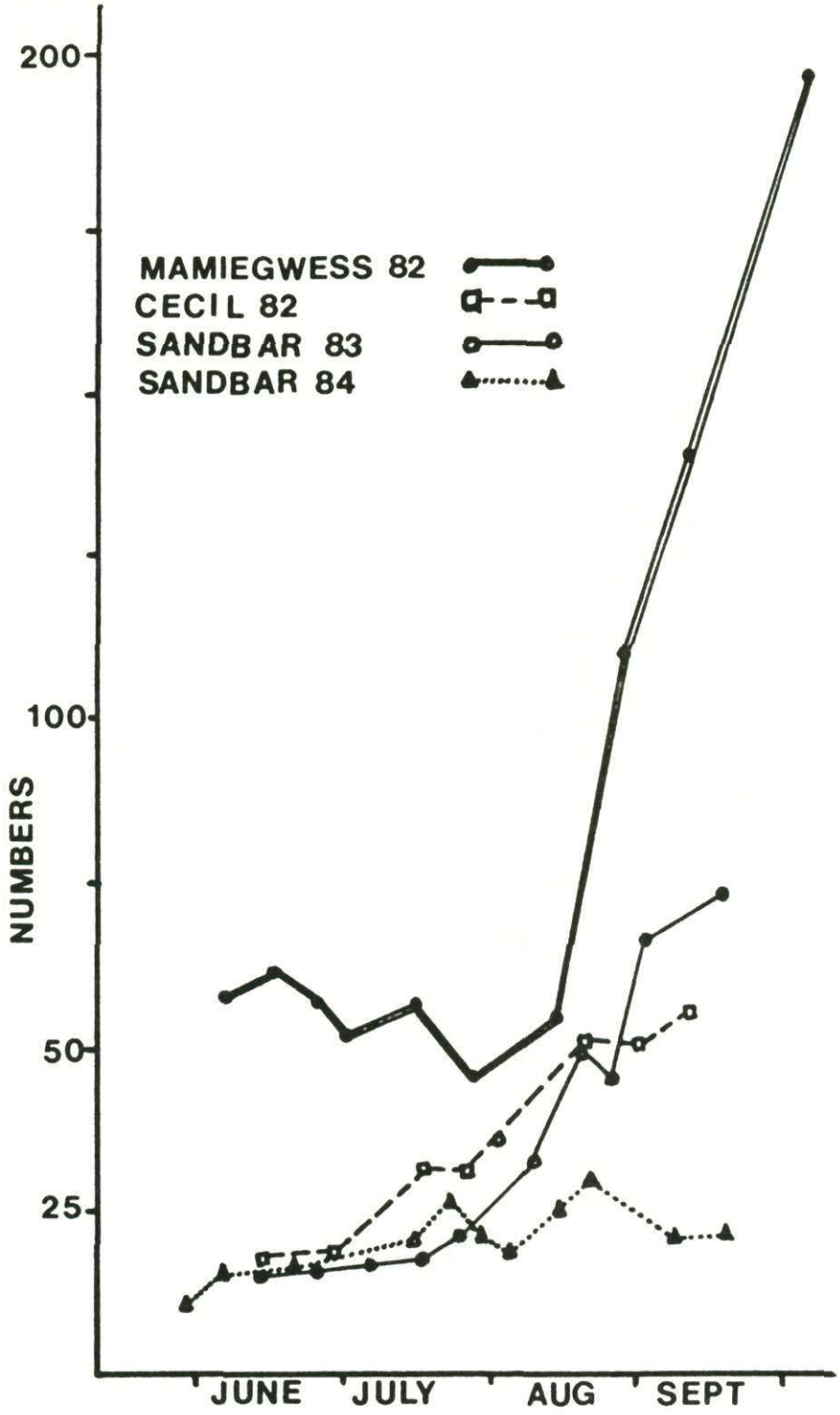

Figure 2. Summer flock size of Common Loons in northwestern Ontario, Canada.

Table 2: Comparison of flying behavior between territorial and non-territorial Common Loons, Ignace, 1986.

	Territorial individuals or pairs					Flocks				
Month	Hours Observ.	No. Arrivals	No. Departures	Total Flights	Flights/ 100 Hrs.	Hours Observ.	No. Arrivals	No. Departure	Total Flights	Flights/ 100 Hrs.
June	39	1	4	5	12.8	31	3	7	10	32.2
July	87	3	3	6	6.9	9	4	6	10	111.1
Aug.	47	6	3	9	19.1	27	13	19	32	118.5
Total	173	10	10	20	11.6	67	20	32	52	77.6

size may play a role in attracting (or rejecting) flying loons to a particular site. Singles and pairs did not seem to have the attracting influence of groups of 4 or more.

Large, open-water lake areas provided the spatial requirements necessary for maintaining flocks. These areas enhanced flock buildup because subgroups were restricted in their travel. Visual and vocal communication was facilitated by the absence of physical barriers and the open mid-lake area preferred for overnight rafting was limited to 1 area so that birds which moved to open water came in contact with other birds.

If flocks included non-territorial "surplus" adult birds, they should have been searching actively for suitable breeding habitat by flying frequently to nearby lakes. The tendency for flocked birds to fly more frequently than territorial residents (Table 2) suggests that active searching was occurring.

CONCLUSIONS

Whereas in early summer the flock size of any particular lake showed some annual (between year) variation, generally this was not the case for within year sightings. The size of the flock associated with any particular lake showed remarkable consistency through early summer. The increased flock size in late summer coincided with the reduced numbers of birds resident on territories (unsuccessful breeders). In early fall, the dramatic flock size increases seen probably represented pre-migratory groupings.

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BEHAVIOR OF COMMON LOONS (*GAVIA IMMER*) IN WINTER

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SUMMARY

Common Loons (*Gavia immer*) wintering at Weekapaug, Rhode Island were studied to gather information on social behavior, habitat use, human disruption, and any behavioral changes with changes in tide, time of day, and depth of water. The study was conducted January 31 - April 3, 1987 at the Weekapaug beach. Observations were made from the beach using a 20x spotting scope. Locations were determined from a compass reading and a distance measurement. Activities of an individual loon or a group of no more than 5 individuals were recorded at 60 second intervals for a duration of 5 minutes.

Drifting, feeding, and preening were the most frequent activities of Common Loons. Drifting occurred in 37 percent of observations, diving and feeding in 23 percent, and maintenance in 18 percent. Feeding occurred most often in water depths of 1.5-5.5 m, while drifting and preening occurred more frequently in depths of 5.5-9.0 m. No significant relationship was found between loon activities and time of day. Loons occupied shallower waters at low tide and deeper waters at mid and high tide.

Common Loons consumed large numbers of small crabs and most food consumption occurred below the surface of the water. Occurrences of kleptoparasitism by Herring Gulls (*Larus argentatus*) were observed. There were no signs of territoriality and Common Loons behaved primarily as individuals. No signs of human disruption were observed and no loon mortalities were witnessed.

Feeding activities in shallow water may have been related to accessibility of prey items. Drifting and preening occurred in deeper waters greater distances from shore. The average rise and fall of the tide at Weekapaug is 0.76 m. The small change in depth perhaps explains why Common Loons showed no tendency to change behavior with the tide; prey items may have been equally concentrated at all tidal periods.

PATTERNS OF MORTALITY IN WINTERING COMMON LOONS

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SUMMARY

Dead and moribund Common Loons (Gavia immer) were collected systematically from study sites in the northern Gulf of Mexico October-June 1983-1987. Nearly 700 Common Loons were collected or examined. Common Loons were the most abundant dead or moribund species at all study sites for all years and had a greater mortality rate than all other species combined.

The onset of mortality was typically in January and was strongly correlated with the onset of the molt of flight feathers. Rates of mortality were non-random and periodic from year to year at all sites, suggesting that the same factors influenced mortality. Rates of mortality were not different between sexes, but were significantly different for adults versus juveniles. Adult loons were found 10 times as frequently as juveniles.

Natural levels of winter mortality may be the consequence of the energetic cost of feather replacement. High mercury levels found in many specimens may be intensifying mortality rates and suggest that this population of loons is experiencing a disturbance of normal patterns of survirorship.

LOON CONSERVATION IN THE BRITISH ISLES

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Although concern about the breeding status of loons in the British Isles has been evident for many years, no concerted program of research and conservation action was undertaken until the late 1970's, when systematic monitoring and survey work was started in several parts of Scotland. The scale and intensity of work has developed since then, but loon conservation in the British Isles is still at a relatively early stage.

This paper describes the status and distribution of loons in the British Isles and presents an assessment of the range of threats that they now face. Current research and conservation action that is being undertaken to protect and enhance loon population is described.

Unless otherwise noted, the data presented in this paper for Arctic Loons (*Gavia arctica*) are derived from the results of current and, as yet unpublished, work carried out by the Royal Society for the Protection of Birds (RSPB) since 1984. Data for Red-throated Loons (*G. stellata*) are also from work carried out by the RSPB and published by Gomersall et al. (1984) and Gomersall (1987).

DISTRIBUTION AND STATUS

Three species of loons breed in western Europe. The Common Loon (*G. immer*) is confined to Iceland, but Arctic and Red-throated Loons are widespread from northwest Britian through northern Scandinavia, Finland, and Russia. The Arctic Loon, which has a predominantly boreal distribution, is absent from Iceland and extends further south than the Red-throated Loon which, in turn, occurs in Iceland and the northernmost arctic regions, such as Svalbard (Cramp and Simmons 1977).

Common Loons have been confirmed as breeding in the British Isles on only 1 occasion in 1970 (Thom 1986), although a mixed Common/Arctic pair has laid eggs at 1 site in several recent years. Arctic and Red-throated Loons are found throughout northern and western Scotland, although the former do not breed in Orkney and Shetland. A few pairs of Red-throated Loons also breed in the northern part of the Irish Republic. A comprehensive survey in 1985 concluded

that there were only 150 pairs of Arctic Loons summering in Britain, mainly concentrated in northwestern Scotland (Campbell and Talbot 1987). No equivalent comprehensive survey of Red-throated Loons has been undertaken, but a full survey in their main stronghold, Shetland, produced an estimate of approximately 700 breeding pairs in 1983 (Gomersall et al. 1984). Limited unpublished survey data from the rest of Scotland suggest that the total population is 1200-1500 pairs. Although there has been some concern that breeding loon populations may be declining (e.g. Thom 1986), available data suggest that there has been no major decrease this century in Arctic Loons and that Red-throated Loons have probably increased (Campbell and Talbot 1987, Gomersall et al. 1984).

British coastal waters are important for wintering loons. Surveys by ship and plane have been carried out off the eastern coast resulting in estimates of 1000 Common, 100 Arctic, and 3100-4200 Red-throated (Tasker et al. 1987), but there are no comparable data for the rest of Britain. Estimates of wintering populations of 3500-4500 Common, 1300 Arctic and 12,000-15,000 Red-throated for the entire British Isles in Lack (1986) seem rather high.

BREEDING HABITAT

Arctic Loons breed on lochs (lakes) throughout northern and western Scotland, very few being found on lochs of less than 25 ha. Overall densities are low. During the 1985 survey, only 6 lochs held more than a single pair. One of these held 3 pairs and the other has a long history of multiple occupancy, up to 10 pairs being present in recent years. Nests are located on loch shores or on islands; 76 percent (n = 175) of nests in 3 study areas in 1986 and 1987 were on islands. Throughout the breeding season Arctic Loons obtain their food either from the breeding loch or from similar adjacent lochs nearby. Coastal feeding is not resumed until chicks have fledged or breeding has been otherwise terminated.

By contrast, although a few pairs regularly nest on large lochs, Red-throated Loons prefer smaller lochs and moorland pools. Eighty-eight percent of breeding pairs found in the 1983 survey of Shetland were on lochs of less than 5 ha., 64 percent being on pools of 1 ha. or less. Similar preferences are evident elsewhere in Scotland and the Red-throated Loon is clearly a species of the more open and wet peatland habitats, which are extensive in northern Scotland. Almost half the population is found in Shetland, where the average density in 3 study plots totalling 8700 ha was 0.92 pairs/100 ha. Although there may be some overlap in inland areas where Red-throated Loons feed on lochs used for breeding and feeding by Arctic Loons, very

few lochs are known to hold breeding pairs of both species at the same time.

In coastal areas Red-throated Loons obtain all their own food and most of that for their chicks from the sea, apparently even on larger lochs with freshwater fish populations. In inland areas, they commute from their breeding lochs to feed on larger lochs nearby. There are several records for both species of chicks being moved overland from breeding sites to other lochs nearby.

BREEDING PERFORMANCE

There is a contrast in the breeding performance of the two species. The hatching success of Arctic Loons within a detailed study area in northwestern Scotland, which held up to 32 pairs, was 29-44 percent 1984-1987. Each year several clutches were suspected to have been lost before they could be discovered by the observers, although any underestimation was probably offset by a number of failures soon after hatching, which were recorded as clutch failure. Clutches lost early in the season were usually replaced by a second and, on at least 4 occasions in the last 2 years, 3 separate clutches have been laid, apparently by the same pair, within the same territory.

Overall productivity was low also. For the years 1984-1987 the mean number of chicks fledged per summering pair ranged from 0.17 to 0.28. This is within the range of figures cited by Nilsson (1977) for studies in Sweden and Finland, but much lower than the 0.4 found by Eriksson (1987) in a more recent Swedish study.

In a 2-year study in Shetland, Red-throated Loons hatched 50.6 and 57.0 percent of clutches. Clutches which failed early in the season were usually replaced and fledging rates were estimated to be 0.51 and 0.36 per pair. A review of all available field data for Shetland gave a mean productivity value of 0.45 chicks per pair and there was no evidence to suggest that this had changed since at least 1918 (Gomersall 1987). There are few published data for other European studies although in southern Finland Lokki and Eklof (1984) recorded values as high as 1.15 chicks per pair.

Few long-term banding studies of loons have been undertaken in Europe and from these, Nilsson (1977) calculated that a reproductive rate of 0.4-0.5 fledged young per pair would be necessary to maintain stationary Arctic Loon populations. The observed rates for the British Isles are well below this level, although there is no evidence that the population is declining. No comparable data are available for Red-throated Loons, but the observed productivity rates

for Shetland seem to be above the likely level required to maintain a stationary population.

CAUSES OF BREEDING FAILURE

While the main causes of loon clutch failure are known, the relative importance of each remains unclear. Over 4 years in the detailed study area, 8-12 percent of Arctic Loon clutches were lost as a result of flooding, and in 1 year an additional 12 percent were lost when stranded by falling water levels. Hydro-electric and water extraction schemes may have exaggerated the effects of water level fluctuations on some lochs, but seasonal variations in rainfall were clearly their main cause. One site, where clutches are regularly laid each year, has been known to escape flooding only once in the last 15 years.

Flooding seems to be less of a problem for Red-throated Loons, only 4.5 percent of eggs being lost in a 2-year period in study plots in Shetland. Receding water levels were considered unimportant.

The majority of failed loon clutches were recorded simply as empty nests or nests with broken egg fragments, where predators had removed or eaten the eggs. In such instances it was impossible to determine whether predation was the cause of failure or whether it was consequence of voluntary or involuntary desertion of the nest by the adult.

Available data for Arctic Loons suggest that in many cases, predation by birds, such as gulls and crows, occurred after the adults had been disturbed by fishermen or other human intruders. Direct action by predators, particularly otters, is also suspected particularly in a few instances when dead adults were found close to empty nests.

The importance and precise role of disturbance is still being assessed, but there seems to be no simple relationship between frequency of disturbance and breeding success. Despite regular and prolonged disturbance, some pairs of Arctic Loons succeed in hatching clutches, while others permanently deserted their clutches after a single disturbance incident. In the last 2 years, 6 clutches, which were deserted, remained untouched in the nest for several weeks.

Red-throated Loons often breed in close proximity to breeding skuas (Catharacta sp.) and large gulls (Larus sp.) and may be particularly susceptible to direct predation or disturbance. Disturbance by fishermen and other intruders is a potential problem at some sites, but most Red-throated Loons nest on lochs that are too small to have much interest for fishing or to attract other recreational interests.

Theft of eggs by egg-collectors is a persistent feature, Arctic Loon being among the more prized target species. During the course of its species protection and investigation activities, the RSPB has regularly detected and occasionally helped to apprehend and prosecute egg collectors visiting the main loon breeding areas. In 1986, 2 men were apprehended with 5 recently taken Arctic Loon clutches from known sites and in 1987, intruders were photographed by an automatic camera, when they visited a nesting island at the time that the clutch disappeared. Many egg collections discovered and confiscated during police investigations in recent years have contained at least 1 Arctic Loon clutch. Red-throated Loon clutches are also known to have been stolen by collectors in recent years.

The exact causes of losses of chicks after hatching are unknown. Strong winds and rain appear to be important during the first few weeks but larger chicks also disappear. Predation by large gulls and skuas is undoubtedly a problem for Red-throated Loons in some areas of Shetland.

CONSERVATION ASSESSMENT

Three main factors, water level fluctuations, disturbance, and predation, which may directly reduce loon breeding success by causing clutches to fail, have been discussed above. Of these, only disturbance is likely to increase in the immediate future as more people participate in traditional activities such as fishing and pressures increase for new activities such as sailing, which are at present relatively uncommon in loon breeding areas.

On a more general level, loons may be threatened by a variety of other land use developments. For instance, continuing widespread afforestation of northern and western Scotland may destroy Red-throated Loon breeding pools and affect food resources of Arctic Loons as invertebrate and fish populations are affected by consequent increased acidification of watercourses as has been described for Dippers (*Cinclus cinclus*) in Wales (Ormerod et al. 1985). It has already been suggested that poor survival of Arctic Loon chicks may be a result of poor loch productivity resulting from centuries of over-burning and over-gazing of adjacent moors and mountains. Acidification as a result of sulfur and nitrogen emissions from electricity and other industrial plants has affected some lakes in southwestern Scotland, but not yet within the main loon breeding areas.

Oil pollution continues to be a potential threat to loon populations not only in coastal waters during winter, but also for breeding Red-throated Loons in their strongholds in Shetland. Illegal discharges of oil by

shipping into British coastal waters seem to have decreased in frequency in recent years, but accidental spillage may increase. Within a month of the opening of the North Sea Oil terminal at Sullom Voe in Shetland in 1979, oil spillage occurred killing over 3700 other seabirds and seaducks including 146 Common Loons (Heubeck and Richardson 1980). Twenty-seven percent of the Shetland population (12% of the British) of Red-throated Loons breed within the immediate vicinity of this terminal and the associated inshore shipping lanes used by visiting tankers.

CONSERVATION ACTION

The RSPB and other ornithologists are currently involved in a varied program of research and conservation activity, which is described briefly below.

Population Monitoring

A study area in northwestern Scotland, holding approximately one third of the breeding population of Arctic Loons, is now monitored annually. Data are collected on the total numbers of pairs present, hatching success, and the number of chicks fledged.

Monitoring plots have been established in Shetland to assess population trends in breeding Red-throated Loons in the vicinity of the oil terminal. Repeat surveys are planned for 3 consecutive years at 5 year intervals.

Banding

A banding program for Red-throated Loons has been undertaken by the Shetland Ringing Group; 577 chicks and 73 adults were caught and banded 1979-1986. Recovery and control data, which will eventually lead to better estimates of loon survival, are beginning to accumulate and the banding program continues (Okill 1986).

Detailed Research

A research program on aspects of the basic breeding biology of the Red-throated Loon was conducted in 1981 and 1982 and has been described by Gomersall (1987). A study to measure and assess the effect of disturbance on breeding Arctic Loons was conducted during 1986 and 1987 and the data are currently being analyzed. In addition to obtaining data on breeding performance and loch characteristics, this study had made use of automatic cameras to record patterns of disturbance and loon attendance at selected sites.

Education

Attempts have been made within parts of the Arctic Loon study area to reduce the levels of disturbance caused by fishermen. Landowners and others responsible for controlling fishing have been approached and asked to request fishermen to keep away from traditional loon sites. A special information leaflet has been produced for distribution to fishermen. Although those approached have been sympathetic, it is not yet clear that this work has had any effect in reducing the incidence of disturbance to loons and improving hatching success. The use of marker posts and warning boards in the vicinity of loon nests has been so far ruled out because of the fear that this might simply attract the attention of egg-collectors.

Nesting Rafts

Nesting rafts were first used in western Scotland in 1976. From 1976 to 1981, rafts were used on 10 occasions by Red-throated Loons and once by Arctic Loons (D. Merrie, unpubl. data). More recently, 16 rafts were put out in 1986 and 1987 on various Scottish lochs by the RSPB and the Forestry Commission, although none has yet been used.

CONCLUSIONS

The British Isles hold small but important breeding populations of Arctic and Red-throated Loons, which lie at the extreme southwest end of each species range in western Europe. Both populations seem to be relatively secure, although the small population of Arctic Loons may be threatened by flooding of nests, disturbance and predation. Active conservation measures and population monitoring are continuing.

ACKNOWLEDGMENTS

A wide range of RSPB staff and other ornithologists have been involved in Loon research in Britain and their contributions are gratefully recognized. Particular thanks are due to Roy Dennis, Chris Gomersall, and Dr. Greg Mudge, who each made available unpublished data from their various studies. Tom Talbot was responsible for much of the routine Arctic Loon monitoring work for 5 consecutive years. Andy Webb (Nature Conservancy Council) made available data in advance of publication and Dave Okill (Shetland Bird Club) provided general advice and details on loon banding. The work in Shetland was partly funded by the Shetland Oil Terminal Environmental Advisory Group on behalf of the Sullom Voe Association.

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MODELING COMMON LOON POPULATIONS - IMPLICATIONS FOR RESEARCH AND MANAGEMENT

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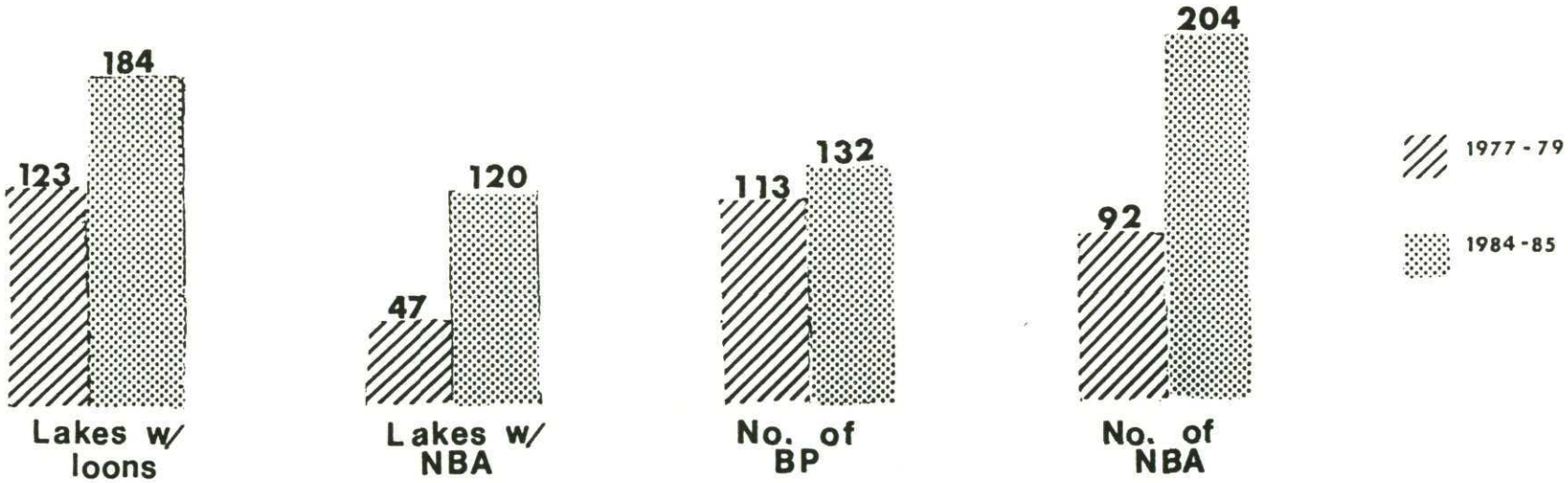
Wildlife managers have long been interested in predicting future levels of game populations. Information such as population size, rate of increase, sex ratio, age- and sex-specific mortality rates, and age-specfic reproductive rates are vitally important in determining the health of a particular population and if, and at what level, future harvest can occur without affecting the stock necessary to maintain desired population size. With the advent of the computer age, the field of population modeling took a quantum leap forward. The elimination of the tedium and potential errors associated with pencil and pad calculations made the use of population models easier and more reliable. Calculations that formerly took an entire day to do by hand can now be accomplished in a few minutes with greater accuracy, reliability and repeatability.

Although originally developed for, and applied to, game species, population models have been used as predictive tools in restoration of endangered species such as Bald Eagles (*Haliaeetus leucocephalus*) (Nye 1986) and Peregrine Falcons (*Falco peregrinus*) (Eastern Peregrine Falcon Recovery Team 1979). Explosive or unexplained increases in the populations of nongame species such as Double-crested Cormorants (*Phalacrocorax auritus*) (Price and Weseloh 1986) have also been investigated with population models.

Common Loon (*Gavia immer*) populations in northern U.S. and southern Canada have been of concern to researchers since the 1970's. Early data suggested a decline in numbers and distribution throughout the southern edge of its range (McIntyre 1975, Hammond and Wood 1976, Sutcliffe 1978). This concern prompted the first intensive survey of northern New York for Common Loons, conducted 1977-1979. A follow-up survey of 384 of the same lakes 1984-1985 revealed that both the number of lakes with loons and total number of loons observed on these lakes had increased significantly ($P < 0.05$, Parker et al. 1986). The greatest increase was found in the number of nonbreeding adults (adults for which no evidence of breeding - a nest or flightless young - was found). The numbers of this group had increased by a factor of 2.2, from 92 in 1977-1979 to 204 in 1984-1985. A similar increase was found in the number of lakes supporting 1 or more nonbreeders (Fig. 1).

Figure 1. Comparison of two surveys of 384 Adirondack lakes for Common Loons. NBA = non-breeding adults. BP = breeding pairs.



The Loon Preservation Committee (LPC) of New Hampshire has conducted complete counts of loons during the past 11 years. Since 1980 they have noted a large increase in the number of nonbreeding adults with moderate increases in the number of breeding pairs also recorded (Wood et al. 1986). Parker et al. (1986) used this as support for their belief that the observed increase in nonbreeding adults on Adirondack lakes was not a product of survey error, net immigration or reproductive problems (loons occupying territories but unable to breed). Still, the parallel increase in New Hampshire can do little more than suggest these other explanations are unlikely. In order to test the validity of the remaining explanation - natural population expansion, a population simulation model was developed.

METHODS

I conducted a literature search for data on Common Loon life history parameters (results summarized in Table 1). A computer-based, interactive, deterministic population model was developed using dBASE III Plus software on an IBM PC-XT. The population simulation had two goals: 1) to determine what levels of the variables were required to achieve a stationary population, and 2) to determine what levels were required to duplicate the 7 percent annual growth rate observed in New York between the 2 loon surveys.

The initial population used for zero growth models was 100 breeding age females with other age classes vacant. To allow the populations to attain a stable age distribution, the simulation was run for 20 years; the value of lambda over the final 10 years was used to assess the simulation's growth characteristic. For the analyses aimed at achieving a 7 percent annual growth, an initial population of 100 breeding females was used in a preliminary run. Age distribution was checked for the final years of the 20 year simulation and a second run was done, this time populating the other age classes with a number of birds proportionate to the final age distribution.

Population Assumptions

A 1:1 sex ratio and equal survivorship was assumed, as was first appearance on the breeding grounds at age 3. Age of first breeding was varied from ages 3 to 5. Because the New York surveys showed that productivity of loons during both the surveys was close to 1.0 (Parker et al. 1986), a fledging rate of 0.96 (that of the latter survey) was used in all simulations. Data on post-fledging mortality are lacking for Common Loons but Lehtonen (1970) recorded a 24 percent mortality rate from fledging to fall migration for Arctic Loons (*Gavia arctica*). A figure of 30 percent was used as the starting point for most simulations. This was revised up or down to achieve the desired growth rate.

Table 1: Common Loon population data and sources. Not all these data were incorporated in the population models.

Variable	Value(s)	Reference
Sex ratio	1:1	assumed
Age attain breeding plumage	2+	Bent (1919) Palmer (1962)
	3	Strong (pers. comm.)
Age first appear on breeding grounds	3 ?	Palmer (1962)
Age of first breeding	2 ("at least")	Palmer (1962)
	2 ("about")	Bent (1919)
	3 ? (*G. arctica*)	Nilsson (1977)
	5 ? (*G. arctica*)	Lehtonen (1970)
Avg. % of adult females breed/yr.	65% (1977-79, 84-85)	Parker et al. (1986)
	57% (1977-86)	LPC (1986)
Avg. % of terr. females breed/yr.	72% (1977-86)	LPC (1986)
	73% (1973-74)	Fox et al. (1980)
Fledging rate (young/breed female)	0.96 (1984-85)	Parker et al. (1986)
	0.61-0.93 (1977-86)	LPC (1986)
Ann. adult mortality	11% (*G. arctica*)	Nilsson (1977)
Ann. juv. mortality	22% (2x adult mort.)	Ricklefs (1973)
Post-fledging mortality	24% (*G. arctica*)	Lehtonen (1970)
	8% (min. recovery)	Eberhardt (1984)
Observed ann. rate of increase	7.7% (1979-85)	LPC (1986)
	6.7% (1979-85)	Parker et al. (1986)

RESULTS

Results of the population simulations are presented in Tables 2 and 3. The zero-growth simulations indicate that total prebreeding mortality rates (from fledging to age of first breeding) of 57-67 percent, depending on age of first breeding, can be sustained by a stable population if 60-65 percent of all females on the breeding grounds nest annually. A 7 percent annual growth rate can be achieved if 70 percent of the breeding-plumaged females nest annually and total prebreeding mortality falls to 35-58 percent depending on age of first breeding.

DISCUSSION

The levels of population parameters needed to achieve a 7 percent annual growth rate, that observed in field studies in New York, seem to be well within the loon's capability. In New Hampshire, an average of 58 percent of all breeding-plumaged (age unknown) females (assuming a 1:1 sex ratio of unpaired birds) were known to reproduce each year; in New York the figure was 65 percent for the 2 surveys. This represents a minimum figure for New York because of the infrequent visits and strict criteria for confirmation of breeding (Parker et al. 1986).

Stable Double-crested Cormorant (*Phalacrocorax aurtitus*) populations, an ecological equivalent of the Common Loon, experience prebreeding mortality rates of approximately 70 percent (Hickey 1952, Price and Weseloh 1986). During periods of population expansion, this rate would probably decrease to 50 percent or lower (Price and Weseloh 1986). Thus, the loon mortality rates used in these models closely mirror those known or assumed for a similar species for which a great deal more data are available.

Unlike Price and Weseloh (1986), who found that in some years increases in the Double-crested Cormorant population of eastern Lake Ontario could be explained only through immigration, there is no reason to believe that the loon population increases observed in New York or New Hampshire are the results of anything but natural population expansion. Indeed, the recent establishment of breeding pairs in Massachusetts and the presence of nonbreeders in northern Pennsylvania (Browning, pers. comm.) may be additional evidence of population increases.

The modeling exercise has important implications for Common Loon research and management. First, it requires an evaluation and compilation of current knowledge of the species. The population data summarized in Table 1 show how woefully deficient current knowledge is concerning some areas of Common Loon population biology. Although excellent

Table 2. Results of 3 simulations of a stable population. The initial population consisted only of breeding age adults. The simulation was run for a period of 20 years and growth assessed over the final 10-year period.

Age of first breeding	Initial population (total)[a]	MA[b]	MPB[c]	Fraction of all adults breeding	Stabilized population[a]	
					Adiron.	Total
3	100	.11	.60	.60	83	111
4	100	.11	.67	.65	93	130
5	100	.11	.57	.65	73	125

[a] Only the female population is shown.

[b] MA = annual adult mortality rate.

[c] MPB = total prebreeding mortality rate (post-fledging to breeding).

Table 3. Results of 5 models simulating a population with 7 percent annual growth. The models assume that loons return to the breeding grounds at age 3. Simulations were run for 20 years.

Age of first breed.	Initial population[a]				Fraction breeding	
	Adiron.	Coast	MA[b]	MPB[c]	Breed age adults	All adults
3	100	(20-24)	.10	.35	.70	.70
4	100-22	(24-27)	.10	.40	.70	.58
	100-23	(27-32)	.10	.51	.86	.70
5	100-19-21	(24-27)	.07	.47	.70	.48
	100-22-28	(34-40)	.10	.58	1.05	.70

[a] Numbers of females given by age class, with the first 2 year classes summering on the coast.

[b] MA = annual adult mortality rate.

[c] MPB = total prebreeding mortality rate (post-fledging to breeding).

data are available on fledging rates, information on percentage of adult females or territorial females breeding/year and annual rates of increase had to be calculated from other data in the literature. Other data critical to understanding loon population dynamics, especially age- and sex-specific mortality rates and age-specific reproductive rates, are totally lacking; these data were guessed at or borrowed from other species. Though it is often repeated, based on Nilsson's (1977) paper on Arctic Loons, that Common Loons may live 20-30 years, the current Common Loon longevity record is but 12 years (DesGranges and LaPorte 1979). It is apparent that the additional data required can be only attained from marked birds. Unfortunately, there are few banded Common Loons at large; as of December 1981 the Bird Banding Laboratory had records of only 624 banded loons, 82 of which had been recovered (Clapp et al. 1982). If nothing else, this exercise highlights the critical need for a Common Loon banding program.

On a problem-specific level, modeling permits an investigator to test data reliability under specific conditions that are easily varied - a fledging rate of X, prebreeding mortality of Y, and Z percent of adult females breeding. The value of this to the wildlife manager must not be underestimated. This exercise tested whether the population increase observed in New York could naturally have occurred. As mentioned, this hypothesis was not rejected in favor of the alternate hypothesis that immigration or observer biases were needed to account for the increase. Had the original hypothesis been rejected, the New York State Department of Environmental Conservation may have had to re-evaluate its conclusion that the New York loon population is stable and possibly increasing. This, in turn, may have suggested the need for additional monitoring or research activities, or at least, a careful review of survey procedures.

The recent massive die-off of Common Loon on the Florida coast (Lange and Stroud 1983) has had the positive effect of focusing additional attention on loon wintering grounds, an area that until recently has been "out of sight, out of mind" to all but a few loon researchers. A population model has the advantage of forcing a focus on the entire population; those individuals that remain on coastal waters are vitally important because they represent future breeders. The simulation run in conjunction with this exercise show that, depending on age of first breeding and other population dynamics, from 24 to 33 percent of the total loon population is absent from the breeding grounds during the summer. In New York, where the total summer population is estimated at 800-1000 adults (Parker et al. 1986), this means that 200-400 immature loons summer on coastal waters or large inland lakes outside the breeding grounds.

Wildlife managers and researchers can and have used population models for predictive and exploratory analyses. Questions such as "What should the population size be in 5 years, given a continuation of current conditions?" or "What was the population 20 years ago if current conditions existed then?" are useful in establishing population trends and evaluating potential or actual impacts of recreational pressure, lake acidification, habitat saturation, toxic chemicals and other factors that influence loon populations.

Computer-supported, interactive population modeling is an extremely useful tool for testing data reliability and examining population trends under various conditions. It can be readily used by professional wildlife managers or anyone with access to a personal computer. Unfortunately, this tool has not heretofore been used to examine Common Loon populations in different areas of their range. This initial attempt has shown that data on important population parameters such as age- and sex-specific mortality and age-specific reproductive rates are currently lacking. Despite this, the models permitted the New York State Department of Environmental Conservation to satisfactorily test its survey data and helped permit informed allocation of limited research funds and staff time.

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A COMMON LOON MANAGEMENT GUIDE

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Common Loon (Gavia immer) management is and will continue to be a challenge. Biological physical, chemical, and social factors combine to determine the needs of Common Loons. The following guide helps address key concerns in management of the species. It was designed as a practical tool to aid biologists, lake associations, lake shore owners, and concerned individuals in understanding and managing the Common Loon in northern Wisconsin.

The guide is structured as a dichotomous key with 16 main steps. Each numbered step requires an either/or selection. After having done so, proceed on to the next numbered step as indicated on the far right. Depending upon the lake in question, you may complete the guide in 2 steps or as many as 8.

1A. Lake with loons present throughout the summer . . 2
1B. Lake with no loons or loons are infrequent visitors 6

2A. Observed loons exhibit territorial behavior in May or June 3
2B. Observed loons are non-territorial (lake is used for feeding and/or staging) 7

3A. Observed loons are successful freeders 4
3B. Observed loons are unsuccessful breeders 11

4A. Habitat changes or increased human disturbance not expected. Blue Ribbon Lake! - DO NOT TOUCH . . . . . Continue to monitor
4B. Habitat changes or increased human disturbance expected. RED ALERT LAKE! 5

5A. Lake Association present. Contact and inform. Attempt to reduce human disturbance and detrimental habitat changes through education and landowner cooperation. Alert conservation warden . . . . . Continue to monitor

4A. Habitat changes or increased human disturbance not expected. Blue Ribbon Lake! - DO NOT TOUCH . . . . . Continue to monitor

4B. Habitat changes or increased human disturbance expected. RED ALERT LAKE! 5

5A. Lake Association present. Contact and inform. Attempt to reduce human disturbance and detrimental habitat changes through education and landowner cooperation. Alert conservation warden . . . . . Continue to monitor

5B. No Lake Association present. Contact resource manager and local cooperators. Educate landowners and other lake users to reduce disturbance and detrimental habitat changes. Alert conservation warden. . . . . Continue to monitor

6A. Habitat conditions favorable. Identify level of human disturbance and distance to other "territorial" lakes, (management may increase use) . . . . . Continue to monitor

6B. Habitat conditions unfavorable. (Lakes with high human use or poor water quality fit this category.) . . . . . Continue to monitor

7A. Nest and brood habitat available 8

7B. Nest and/or brood habitat unavailable 10

8A. Human disturbance high 5

8B. Human disturbance low 9

9A. Established loon territory on adjacent lake(s). Territorial birds may depend on this lake as an important feeding or staging water. Management to be directed at maintaining lake use for feeding and staging . . . . . Continue to monitor

9B. No established loon territory on adjacent lake(s). Increase observations during May and June. Review all physical parameters, especially water quality, to determine limiting factors . . . Continue to monitor

10A. Nest habitat lacking, quality brood habitat available. Potential for installation of nesting platform. (Public awareness important prior to platform installation.) Maintenance and observation of platform use is critical . . . . . Continue to monitor

10B. Brood habitat lacking, nest habitat available. Do not install nesting platform. Maintain lake as loon feeding or staging area . . . . . Continue to monitor

11A. Nest attempts documented (in recent years) . . . 12

11B. Nest attempts not documented 15

12A. Nest and brood habitat favorable 13

12B. Nest and/or brood habitat unfavorable 14

13A. Human disturbance is high 5

13B. Human disturbance is low. Increase observations during nesting season. (Predation may be causing loss of nests.) Document unsuccessful nesting for three consecutive years before considering placement of nest platform . . . . . Continue to monitor

14A. Nest habitat lacking, brood habitat available. Loons may be nesting in poor habitat, resulting in low nest success. (Areas with high levels of disturbances.) Management may include closing areas near nest sites to human use during nesting. Installation of artificial nest platform should be considered as last solution. Maintenance and observation of platform is critical. Alert conservation warden . . . . . Continue to monitor

14B. Brood habitat lacking. Nest habitat available. Do not install nesting platform. Maintain lake for loon use. (Some lakes in this category do produce young but in most cases have low fledging rates. Reduction of human disturbance is essential to enable young to survive.) Contact and inform landowners, lake users and conservation warden . . . . . Continue to monitor

15A. Nest and brood habitat favorable 16

15B. Nest and/or brood habitat unfavorable 10

16A. Human disturbance high. Reduction of disturbance may increase nest success. Potential nest areas may be closed to human use during nesting. Inform lake association, lake users and conservation warden. (Probability of success - low.) . Continue to monitor

16B. Human disturbance low. Reevaluate all parameters to determine reason for lack of nesting. (Lake may be used as feeding or staging area only.) . . . . . Continue to monitor

GLOSSARY

Brood habitat - shallow coves or bays protected from prevailing winds, having ample supplies of small fish, and a portion of the shoreline in wetland vegetation (for cover). Usually they are an area lacking lakeshore development and heavy recreational use.

Continue to monitor - maintain observations of lake and loon with increased emphasis upon determining the "fitness" of a water body for common loons. Such factors as human disturbance, shoreline vegetation, water clarity, and fish presence are a few examples.

Favorable food conditions - the presence of the naturally - occurring and size class distribution of fish in a lake. Loons need an ample supply of small fish to feed their young and themselves.

Nest habitat - a shoreline site suitable for nesting. Generally a gentle slope and located on an island, a marshy cove, or a backwater, preferably away from human disturbance. Overhead cover, substrate, and water depth near the nest are variable.

Nest platform - an artificial structure resembling a small log raft designed of wooden poles, floatation material and quantities of nest material. Platforms are designed and placed as a substitute nesting island for Common Loons. In Wisconsin a permit is required for placement.

Poor water quality - high acidity (low pH), turbidity, heavy algal blooms, and/or toxic pollution leading to sparse or absent fish populations, or significantly reducing water clarity to hinder loon feeding.

Staging - the loose flocking of loons (and other waterfowl) during the late summer or fall. Flock size varies from 5 to over 100 and generally persists less than 1 week.

Successful breeder - a pair of loons that hatches at least 1 egg.

Territorial behavior - a defense of all or part of a lake by an individual loon or mated pair. Activities include patrolling, aggressive interactions with other loons, and frequent calling (especially yodels) in late April, May, and June. A territorial pair of loons will maintain their presence most or all of the summer.

ACKNOWLEDGMENTS

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CREATION OF A MANAGEMENT PLAN FOR THE COMMON LOON IN MONTANA

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SUMMARY

The Montana Loon Study has been collecting data on Common Loons since 1982. The Montana loon population is estimated to be 150-200 birds. This estimate is supported, in part, by an intensive one-day census (7/11/87) that counted 148 birds (adults and chicks). Approximately 25-30 pairs are known to nest successfully each year, and with few exceptions, there is only 1 nest per lake. Since 1982, nesting has been documented on 60 lakes.

The initial impetus for creating an agency-sponsored mangement plan came in 1986 when the Northern Region of the U.S. Forest Service released a "sensitive species" list, which included the Common Loon. This list provides a certain degree of protection for the loon on Forest Service lands in situations where conflicts arise with other Forest uses and activities. At a February 1987 meeting, the Forest Service indicated the need for a loon mangement plan. Using the Forest Service's Challenge Grant program I began to write the plan. Matching funds were secured from the Montana Department of Fish, Wildlife and Parks and the North American Loon Fund.

Land-use patterns and property ownership of land surrounding nesting lakes dictated the appropriate format and emphasis of the management plan. Unidentified private owners hold land on 36 (60%) of the 60 lakes. Federal and state government agencies and private companies hold land on 2-42 percent of the nesting lakes. Access to the public is allowed on 81 percent of the lakes, 50 percent of the lakes have spots where the public an launch boats, and 34 percent have a designated public campground on their shores. This diversity of land ownership and widespread use by the public indicates how important it will be to involve a wide variety of agency personnel, industry representatives, and recreational user groups in the creation and review of the management plan.

The population goal for the Plan is to be a number of nesting pairs, which will be calculated by multiplying the number of potential - and known-nesting lakes by the frequency of nesting for a stationary population. "Potential" lakes will be chosen from the list of lakes where loons have

not nested since 1982, but have been observed in non-migration periods. Selection as a potential lake will be based on: (1) an objective determination of whether the lake provides the physical and biological conditions necessary for successful nesting, and (2) a subjective, on-site analysis of the suitability of each lake for nesting--taking into account conditions that were not considered in (1), but may be significant. I will conduct a statistical analysis to identify significant relationships that exist between successful nesting and variables such as lake size, lake depth, shoreline development by humans, fishing pressure, fish species present, etc.

An important management objective will be to establish site-specific management plans for each known-nesting lake, which will include recommendations for protecting nesting and chick-rearing areas. Another important objective will be to provide recommendations on how to maintain the suitability of potential-nesting lakes.

Implementation of the Management Plan will probably require a cooperative effort between agencies and volunteers. It is suggested that agencies handle enforcement/education efforts, with the volunteers handling the monitoring efforts and liaison work between agencies and private landowners.

STATUS OF THE MICHIGAN LOON REGISTRY PROGRAM IN 1987

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SUMMARY

The Common Loon (Gavia immer) once bred throughout Michigan. By 1986, the number of breeding loons dwindled to approximately 350 pairs and only 2 pairs bred in southern Michigan. Although sporadic protection efforts on behalf of the loon had been made in Michigan, no systematic, statewide protection program was developed until establishment of the Loon Registry Program. Initiated in 1986, the Loon Registry Program is a joint effort of the Nongame Program of the Michigan Department of Natural Resources, The Michigan Field Office of The Nature Conservancy, and the North American Loon Fund.

The Michigan Loon Registry Program, modeled after the Loon Preservation Committee of the New Hampshire Audubon Society and Wisconsin Project Loon Watch, was implemented to increase protection of breeding loons by recruiting volunteers to identify threats to loons, educate others, and protect the birds from direct harassment. Registrants were carefully screened before being enrolled in the program. Most lived on a lake with breeding loons. Registrants were given literature on loons, data forms, and guidelines for monitoring loons. Efforts focused on areas where extant loon populations have apparently declined the most, the northern Lower Peninsula and eastern Upper Peninsula.

In 1986, 51 Loon Registrant participants monitored 56 lakes. Gary Dulin, the first registrar of the program, selected registrants well as 88 percent submitted data forms. Only 25 of 56 lakes had confirmed nesting attempts although lakes were selected that had a recent history of breeding by loons. Lakes with little development or that had protected coves with suitable nest sites were favored by loons. Many registrants knew the location of nests although nest searches were not encouraged.

Development of shorelines, boating activity, fluctuating water levels, high water levels, harassment by humans, Mute Swans (Cygnus olor), and Canada Geese (Branta canadensis), and predation were among the problems encountered by breeding loons. Boating activity was the problem

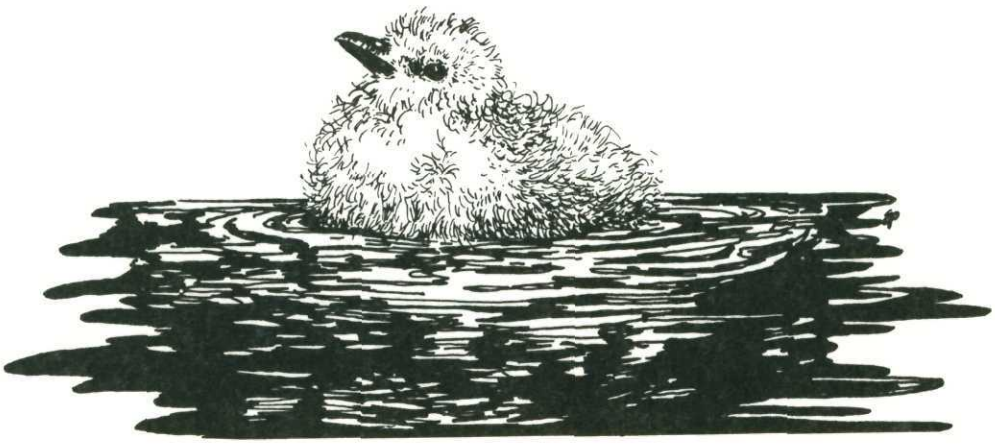
most cited to be detrimental to loons. Fewer problems were noted on private lakes than those with public access but it is not known if productivity or density of nesting pairs differs between private and public access lakes.

Arlene Westhoven, 1987 registrar, registered 50 participants, visited approximately 30 of the 1986 registrants, and coordinated her work with others recruiting registrants in other parts of the state. Her findings paralleled those of Gary Dulin; half the lakes had breeding loons and boating activity was perceived to be a major threat to the loons. Arlene also found that the commitment of registrants was strengthened upon receiving a newsletter that summarized the program results.

Over the 2 years, registrants monitored loons, publicized the status of loons to lake associations and the general public, installed nesting platforms, placed loon watch signs at public access sites, freed birds from monofilament lines, talked with people harassing loons, and conducted detailed monitoring of boat/loon interactions.

After 2 field seasons, the Loon Registry Program has succeeded in locating approximately 110 carefully selected residents to monitor breeding loons in Michigan. Changes in activities by local residents, governmental agencies, and others are resulting from the information gained from this program and other loon protection efforts by state and federal governments.

POPULATION STATUS PAPERS



STATUS AND POTENTIAL FOR BREEDING OF THE COMMON LOON IN THE PACIFIC NORTHWEST

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Very little is known about the status of the Common Loon (Gavia immer) in the Pacific Northwest. However, increasing reports of summer sightings of Common Loons in Washington, Oregon, and California suggest that they may begin or already be nesting in areas of historical occupancy.

The legal status of the Common Loon varies under the different jurisdictions in the Pacific Northwest, confounded by its abundance and widespread range along the coast in winter, while generally considered extirpated as a breeding species in Washington, Oregon, and California. It is listed as a Sensitive Species in Region 6 by the U.S. Forest Service, and Region 1 by the U.S. Fish and Wildlife Service. Although it is protected as nongame wildlife, it is not specifically classified in either Oregon or California, but it has been proposed recently for Threatened listing by the state of Washington. Ironically, if the biological status of Common Loons is found to be improving, with nesting discovered in Oregon or California, its legal status would decline from merely Protected to Threatened or even Endangered in those states.

HISTORY

Early records of the occurrence of Common Loons in the Pacific Northwest are rare. Munro's (1945) study in the Cariboo Parklands of British Columbia may be the only extensive research on loons from Alaska to California. He reported a spring concentration of loons on a large lake in southern British Columbia and nesting on many of the lakes in that region. Common Loons once nested in many areas of Washington, especially the northern and western sections (Jewett et al. 1953). Gabrielson and Jewett (1940) indicated discontinuous but widespread summering in Oregon, in both the Cascade and Coast Ranges, as well as in southern and southeastern portions of the state, with nesting presumed but never confirmed. McAllister (pers. comm.) found a nest with 2 young at Waldo Lake in central Oregon in 1947.

Newberry (1857) reported summer sightings on many lakes in the Oregon Cascades and in northern California, even though most of the high elevation lakes did not contain native fish populations (Haight, pers. comm.). Bent (1919) reported Common Loons breeding from northwestern Alaska to northeastern California. According to all of these authors, large numbers of loons wintered off the coast from Alaska or British Columbia to southern California.

By the turn of the century, numbers of Common Loons seemed to be declining. Woodcock's (1902) compilation of reports from Oregon suggested that incidental capture of loons in commercial salmon fishing nets and intentional killing of loons for use as bait by commercial crab fishermen were contributing to a decrease in the loon population in Oregon. Presumably, these same factors affected loons on other sections of the west coast. In addition to commercial fishing, it is probable that human disturbance and settlement at nesting lakes and extensive use of pesticides were also factors in the decline. While I have found few references describing recreational shooting of loons on the Pacific coast, one verbal description (Kneeland, pers. comm.) and a brief reference to shooting parties on tugboats massacring seabirds (Sharp 1926), indicate that this may have been a widespread phenomenon, and one that may have contributed significantly to the decrease in loon numbers.

By the 1930's there had been a major recession northward of the loons' breeding range, and, by the 1950s, the Common Loon had apparently been extirpated as a breeding species from California, Oregon, and Washington (Oregon Natural Heritage Data Base, unpubl. data, Smith, pers. comm., Taylor, pers. comm.).

CURRENT STATUS

British Columbia

I know of no estimate of the present nesting or wintering population size of Common Loons in British Columbia, but available data indicate that the numbers are large. Records on file at the British Columbia Provincial Museum include several hundred nest sites, and nesting seems to be increasing (Campbell, pers. comm.). In contrast to published records of nest site selection elsewhere (Olson and Marshall 1952, Vermeer 1973, McIntyre 1975, Alvo 1981), the majority of nests in British Columbia occur on mainland peninsulas rather than on islands (Munro 1945, Campbell et al., unpubl. data). Increasing numbers of nests are being found in marsh sites in areas of human disturbance. Because nets used for commercial fishing generally are tended continuously, rather than being left in place, few loons are being entangled. There are fewer reports of loons caught in

nets than on fishing lures. The prognosis for loons in British Columbia seems to be very good.

Washington

The survey of Richard and Musche (1985) of lakes in the northeastern corner of Washington recorded successful nests on 2 adjacent lakes. There have been numerous other reports of sightings of loons with chicks from lakes in the northern counties in recent years, however none confirmed by trained observers (Tank, pers. comm., Kuntz, pers. comm., Taylor, pers. comm.). The number of reports seems to be increasing. I know of no estimate of loons wintering on the Washington coast, but the number seems to be large. No data are currently available on numbers of loons caught in commercial fishing gear, but there is a potential problem which the Washington Wildlife Department may investigate in the near future (Owens, pers. comm.). The prospects for Common Loons in Washington are good, with the possibility of an increasing trend in nesting in the state.

Oregon

While there is considerable information on wintering loons in Oregon, there is no comprehensive estimate of the population size. Bayer's and Pickering's unpublished surveys of Yaquina, Salmon, and Siletz estuaries and Devil's Lake on the central Oregon coast indicate consistent use of the areas from late September through May, with slight peaks in numbers in October, February, and April (Bayer, pers. comm., Pickering, pers. comm.). The heaviest concentrations were near the mouths of the estuaries. Fishing by the loons was most frequently observed at high tide. The loons were regularly seen forming rafts just prior to sunset in Yaquina Bay, the largest estuary surveyed. Winter use seems to be even heavier on the ocean than in the bays (Nehls, pers. comm., Oregon Natural Heritage Data Base, unpubl. data). Commercial fishing is not thought to be causing significant mortality to loons in Oregon at this time, because large-mesh nets are most commonly used and are generally tended continuously (Brown, pers. comm.).

Loons are frequently seen inland. Most sightings are in spring and most birds are clearly migrants that move out of the state by the end of May (pers. observ., Oregon Natural Heritage Data Base, unpubl. data). Isaacs (pers. comm.) has recorded loons in spring on 25 freshwater lakes, mostly in central and western Oregon, 1981-1987. Isaacs reported more than 170 loons on Wickiup Reservior on April 26, 1985. A flock of 20 was seen at Timothy Lake in spring of 1987 (Auler, pers. comm.). Most observations are of single loons or groups of 2 or 3. The great majority of

loons seen inland in spring are in breeding plumage (pers. observ., Isaacs, pers. comm., Nehls, pers. comm.). Monitoring of spring activity in the Bull Run Watershed will be discussed below.

Sightings of loons on freshwater lakes in Oregon in summer are infrequent but possibly increasing. No nests or chicks have been reported from the state but, as in Washington, knowledgeable observers are just beginning to look. Isaacs (pers. comm.) obtained summer sightings from 5 Oregon lakes, most of which were of birds in basic plumage from the southern half of the state. Nehls (pers. comm.) reported loons in breeding plumage yodeling on Siltcoos Lake near the central Oregon coast for 3 years 1960-62, and there is the strong possibility that they nested there. There are several recent sightings of loons in breeding plumage in summer from the Bull Run Watershed in northern Oregon, including a vocalizing pair seen throughout one summer (Kennedy, pers. comm., Shaver, pers. comm.). The outlook for loons in Oregon is good, with numbers probably increasing and the exciting possibility that direct evidence of nesting will be found soon.

California

Common Loons winter along the full length of the California coast, but no estimate of their number is available. A nearshore commercial fishery that uses untended, small mesh nets is currently causing significant mortality of seabirds, a very small percentage of which are loons (Brown, pers. comm., Schultz, pers. comm.). Legislation to be enacted soon will probably reduce this problem. Inland sightings of loons are fairly common in spring, but also regular in summer, occurring occasionally even south of Mono Lake (Bailey, pers. comm.). Sightings from Eagle Lake and several in the Mt. Lassen area are of particular interest because of historical reports of loon nests at those lakes (Bent 1919). The majority of inland summer sightings in California are of loons in basic plumage (Bailey, pers. comm.). Although there are no known reports of loon nests or chicks from California in recent years, there is the potential for their discovery, and the prognosis for loons in winter is good.

To summarize, the Common Loon population on the west coast seems to be in very good shape in British Columbia, and numbers are probably increasing at least in British Columbia, Washington, and Oregon. Entanglement in commercial fishing gear is causing some mortality to wintering loons, but does not seem to be greatly affecting the population. I have found no reports of heavy winter mortality anywhere on the Pacific coast. Loons currently breeding in the Pacific Northwest seem to be increasing their use of

marsh nest sites in response to human disturbance. There is the possibility that loons are beginning to nest again in Oregon, and may be nesting in increasing numbers in Washington.

An interesting phenomenon noted in the status information was the difference in plumages reported on inland lakes in Oregon and California. The preponderance of birds in breeding plumage noted in spring in both states undoubtedly reflects the migration of mature loons to nesting lakes farther north or northeast. However, the majority of summer sightings from California and the southern half of Oregon were of loons in basic plumage, presumably immature birds. That all of the summer sightings from northern Oregon were of loons in breeding plumage could be a further indication of potential nesting reestablishment in this part of their former breeding range.

Increasing numbers of loon sightings in spring and summer in Oregon and Washington have encouraged the initiation of lake surveys in both states, and the beginning of a study of Common Loon distribution and behavior in northern Oregon. The specific objectives of this study are to: 1) determine whether loons are attempting to nest, 2) identify locations or habitats important to the loons for use in pair formation or migration stopovers, and 3) develop recommendations for management of potential nesting areas or other important habitat.

STUDY AREAS

Portland's Bull Run Watershed in the Mt. Hood National Forest in northern Oregon was chosen as a study site because of the frequency of loon sightings there, and because, being closed to the public, it is relatively undisturbed by human activity. Several natural ponds and 3 large reservoirs contain fish populations. Steep, forested shorelines predominate, but marshy areas also occur.

Tillamook Bay, on the northern Oregon coast, was chosen for the coastal study site. It supports large numbers of loons in winter and particularly during spring migration. One of the largest Oregon estuaries, it is prodigiously productive of fish and shell-fish, and receives considerable human use for recreational and commercial harvest.

METHODS

Systematic observations were initiated in the Bull Run Watershed in 1986, with twice weekly visits from the end of March through June in 1986 and 1987. The coastal portion of the study was started in 1987, with weekly visits to

Tillamook Bay from mid-March into May. Lack of funding curtailed all phases of the study. Common Loons were censused on each visit to each site, but most time was spent observing behavior, particularly interactions between loons.

In addition to the observations, habitat improvement projects have been undertaken in the Bull Run Watershed which should improve conditions for loons. Two floating nest platforms have been placed in one of the reservoirs. Work parties of students from the Catlin Gabel High School in Portland have improved habitat at three of the ponds to increase availability of small fish. Spawning gravel beds and small rearing pools have been added to inlet and outlet streams. Logs have been placed around the shores and several log rafts have been placed for hiding cover for small fish, but could also serve as loon nest sites.

SUMMARY OF PRELIMINARY RESULTS

In the Bull Run Watershed, primarily on the 2 largest reservoirs, 4-11 loons were present during April and May of both years, with peak numbers in early April. There was an apparent establishment and maintenance of a territory at the North Fork of the Upper Reservoir for 6-8 weeks in each of the last 4 years. No nests or chicks have been observed, nor any loons during June or July. Various individuals working in the watershed during 1984 and 1985 reported sightings of "the North Fork pair." In 1986, a pair was observed in that same area on nearly all visits between the first of April and mid May. Courtship or pre-copulatory displays, as described in Tate and Tate (1970), Sjolander and Agren (1972), and McIntyre (1975), were seen on 3 occasions at the North Fork in 1986, but each time the birds swam out of view. Copulation has not been observed. In both 1986 and 1987, aggressive interactions between loons were regularly observed, as described in Sjolander and Agren (1972), McIntyre (1975), Rummel and Goetzinger (1975, 1978), and Barklow (1979). These interactions seemed to be defense of the North Fork territory. Several fights and rushing have been seen, but no yodeling has been heard. Other loons invariably have left this area after a confrontation. Loons which have approached the presumed boundary of this territory while fishing have frequently been seen to assume a "hunched" or "anxiety upright" posture, or to emerge with only the head above water, before retreating farther down the reservoir. These types of behavior were observed in 1986 when a pair was in residence, and also in 1987, even though only a single loon was resident there. This loon was seen apparently courting an immature loon (in basic plumage) that remained in the watershed for only a few days. A trio of loons and several other pairs have been observed also apparently displaying courtship or pair formation behavior.

In Tillamook Bay, 20-60 loons were present during March and April of 1987, with the highest number seen on the earliest visit. No loons were seen in mid-May. Loose aggregations of 5-40 loons were seen occasionally, but generally loons were scattered at high tide, with low tide concentrations in areas of deep water. No cooperative feeding was observed. No 2 loons were seen close together for more than a few seconds. All interactions were aggressive and ended with both loons leaving the area of contact. During one very low tide, 16 loons concentrated in the only deep water took turns performing spectacular, individual displays of mock fighting and other aggressive behavior.

At both study sites, "head tossing" (Tate and Tate 1970) was observed several times, but never in the context of courtship or pre-copulatory display. In the Bull Run Watershed, it was performed by non-resident loons when they were near the territorial boundary. In Tillamook Bay, it was performed by loons when they were approached by other loons, or when fishing loons surfaced near them. Usually it was performed while swimming away from the other loon. It seemed to function as an appeasement gesture that perhaps avoided aggression, which could also explain its use in courtship.

A display not found in the literature reviewed was observed at both study sites. The loon suddenly snapped its neck back, pointing the head straight up, with the bill gaped open widely, then snapped back to a normal posture. The motion was repeated 3-8 times, approximately once per second. This "gaping" display was observed in several situations, for example, when 2 or 3 fishing loons surfaced nearby, when the single, resident loon was cruising near the territory boundary, and when the North Fork pair were courting near the boundary with another loon nearby. Only 1 loon has been seen giving the gaping display on any one occasion. It seems to be a mildly aggressive gesture.

DISCUSSION

The timing, distribution, and behavior of Common Loons seem to differ between Tillamook Bay and the Bull Run Watershed. Although observations began in Tillamook Bay after the loons were already present, loon numbers appear to peak earlier there than in the watershed. In Tillamook Bay, loon distribution was randomly scattered at high tide and concentrated by the availability of deep water at low tide. In contrast, in the Bull Run Watershed, 1 or 2 loons showed a marked affinity for 1 area, the North Fork territory, while all other loons avoided it or were chased away from it. Defense of personal space or of a temporary fishing spot seemed to be the motivation for all interactions

observed in spring in Tillamook Bay. In the Bull Run Watershed, however, defense (or avoidance) of a specific, large territory, and courtship or pair formation seemed to be the predominant motivations.

Interpretation is speculative until I have carried out further observations and comparison of behavior in the Bull Run Watershed with concurrent behavior at known nesting lakes in southern British Columbia. Nevertheless, it seems possible that attempted nesting could have been the ultimate motivation for behavior observed in the Bull Run Watershed. On the other hand, it is highly probable that use of Tillamook Bay was largely for resting and feeding during individual or group migration to breeding lakes, with lesser use for feeding by immature loons that would spend the summer on the coast. Whether the sequential, individual displays of aggression seen on one occasion at Tillamook Bay should be interpreted as release of tension in a confined situation, or display to impress prospective mates (or other males migrating to the same nesting lakes), or merely an excess of hormones on a spring afternoon, is open to conjecture.

CONCLUSION

Increasing numbers of spring and summer sightings of loons and increasing interest in the status of loons are encouraging surveys, research, and management in the Pacific Northwest. Lake surveys have been initiated in parts of Oregon and Washington, with 2 nests found so far. Habitat improvement projects have been carried out or are planned for several areas in both Oregon and Washington. Investigation of spring distribution and behavior in northern Oregon has begun with preliminary results indicating potential nesting in 1 study area.

It is likely that the creation of numerous, large reservoirs and fish stocking of these and higher elevation lakes may be some of the reasons for increased spring and summer sightings of loons in Oregon and Washington. Fluctuations in water levels at these same reservoirs may have deterred loons from successfully utilizing the new habitat for nesting, in which case a more widespread program of floating nest platform placement may be appropriate.

A reestablished population of Common Loons nesting in Washington, Oregon, and possibly northern California could serve an important backup function if anticipated increases in energy, mineral, and other development in Alaska result in loss of current breeding areas. Continuing problems of pesticides and entanglement in commercial fishing gear, and the increasing threat of acid rain and mercury in the eastern United States and Canada make it imperative that

loons be protected, managed, and encouraged in all parts of the continent where appropriate breeding habitat exists.

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STATUS OF THE COMMON LOON IN YELLOWSTONE NATIONAL PARK

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SUMMARY

There is little historical information on Common Loons (Gavia immer) in Yellowstone National Park (YNP). The park is one of the most remote areas in the contiguous United States, encompassing approximately 3472 square miles. Information was gathered on nesting Common Loons during aerial surveys of Trumpeter Swans (Cygnus buccinator) 1986-1987. Additional data were collected during ground observations.

A small population of nesting Common Loons exists in the park. Nesting loons were found on large and small lakes, some completely devoid of fish. To date, 10 nesting territories have been identified in YNP. Human activities, such as wildlife photography and float-tube fishing, are potential threats to nesting loons. It is important that the location of nesting territories in the park remain unknown. The nesting loons in YNP may be unique by being the highest elevation nesting population of Common Loons in North America.

Loons occur in YNP throughout the ice-free season. Yellowstone Lake is a focal point of loon activity. During the summer breeding and non-breeding adults and immature Common Loons are present. During September, October, and November, hundreds of loons are observed in the park. Most of these birds are migrants. The primary use area for migrants is Yellowstone Lake. However, small numbers of loons are seen on many other lakes in the park at this time also.

A management plan for Common Loons in YNP will be developed and implemented by 1988. Protection of nesting territories will be closely tied to protection afforded by Grizzly Bear (Ursus arctos) area closures and/or the late opening of back country areas in the spring due to snow conditions. The future for the protection of Common Loons in YNP is extremely promising, especially if loon populations and human activities are closely monitored.

THE MINNESOTA REPORT: A 15-YEAR SURVEY COMPARISON

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Organized counts of Minnesota's Common Loon (Gavia immer) population started in 1971. The first surveys began by asking volunteers from throughout the state to help by monitoring a lake or lakes of their choice from the time of arrival of loons in the spring until their departure for the wintering grounds in the fall.

Impetus for the loon surveys came about in two ways: 1) I wanted to discover whether or not recreational use and shoreline development had an effect on the use of lakes by breeding loons, and 2) I thought a survey by volunteers would stimulate an interest in loons and promote their conservation and preservation of their breeding habitat.

Participants in the first Project Loon Watch (PLW) responded with enthusiasm, and returned questionnaires providing information on loon arrival and departure times, reproductive success of territorial pairs, and the extent of recreational use and shoreline development on the lake they were watching. The first year provided reports for 324 lakes.

During the following years, volunteers continued to help by recording and reporting data on loon populations and productivity, as well as the use and developmental status of lakes. Annual surveys continued until 1979 and were resumed in 1982 and 1983. Summaries of each survey were sent to participants at the beginning of the following year's assessment period. Questionnaires were designed following a format developed by Chandler Robbins of the U.S. Fish and Wildlife Service in Patuxent.

Beginning in 1979, the Nongame Wildlife Program of Minnesota's Department of Natural Resources initiated a separate volunteer survey program. With help from the public, as well as assistance by DNR staff, they collected data on loon numbers and productivity in the state.

In 1985 plans began to combine DNR and PLW surveys into a single cooperative project with the intent to examine what changes might have occurred during the 15 years of Minnesota loon counts. This effort was called the "Love a Loon Watch", appropriate to the date of the first press release, Valentine's Day 1986. Letters to all who had participated with either survey followed, asking for help in monitoring

just those lakes in 1986 which had been checked in 1971.

Public response was excellent. It is not possible to report how many individuals actually helped with the reports, because some lakes were checked by groups of volunteers. For example, Lake Vermillion in St. Louis County is a huge lake (19,865 ha) yet could be surveyed 3 times during the summer because a group of 20 volunteers from the local lake association were co-participants in the loon survey. Because this happened on many lakes, we have no idea how many people may have been actively involved in the 1986 Loon Watch. In all, 230 lakes, or 71 percent of the original number, were monitored in 1986. Doubtless, there were hundreds of people helping in this work.

The 2 questions asked were designed to provide information on the following general topics: 1) What are the trends in Minnesota's loon population?; 2) Have there been major changes in the public's use of our lakes, and in the development of shoreline, resulting from the building of homes, resorts and campgrounds?; 3) What is the productivity of Minnesota's loons? That is, how does it compare with 1971 productivity? (Defined as number of fledged young per territorial pair); and 4) What is the average brood size of fledged young? How does it compare with brood size in 1971?

METHODS

All 324 lakes reported following the original 1971 survey were compiled, together with their location, size, and code number. Letters and the list of lakes from which reports were needed were sent to all who had helped with loon surveys in Minnesota since 1971. In addition, press releases sought help from others who might not have previously participated in loon surveys. Each participant was then asked to sign up for a lake or lakes for which he could be responsible throughout the summer. A list of those lakes not assigned to volunteers were then distributed to DNR staff, together with questionnaires, asking for their help in completing the assignments. In all, there were reports submitted for 230 lakes, or 71 percent of the earlier survey sample.

Questionnaires were in general the same as those in use for many years. The only major change was in the developmental section. I therefore re-read all original 1971 reports and re-coded them to comply with the 1986 format. In some cases, verifying the status of development involved including notes on the back of 1971 forms, reading letters from participants, and/or reviewing 1972 questionnaires, because the format for that year was nearly the same as used in 1986.

The 1986 questionnaire included requests for information concerning development and recreational use of the lake, spring arrival and fall departure times of loons, the presence of loons on the lake, the number of territorial pairs and their reproductive success, the number of fledged juveniles for each brood hatched, and the causes of nest failure. Some questions could not be answered, and the questionnaire did not have to be fully answered to be included in my calculations. This paper does not attempt to summarize all questions asked; it only addresses the status of development and use of the lakes, presence or absence of loons during the summer, reproductive success of territorial pairs, and brood size.

Evaluation of answers to these questions assumes there may be an error factor, but if so, it should not be significantly different than it was during the 1971 survey. Cooperators are more confident when reporting "one pair", "two chicks", or "one fledged young: than reporting "nothing". When loons are seen and can be counted, there is little doubt they are there. But unless participants are conducting intensive and periodic searches over a prolonged time, they are frequently reticent to state "none" and more likely to mark "unknown" in response to questions of presence/absence or success/failure. I have taken that into account, and present this as a study which seeks trends and comparisons rather than absolute numbers. Statistics were computed using a Cricket StatWorks program; graphs were made with a Cricket Graph program. A significance level of $P < 0.05$ was accepted.

RESULTS

Use

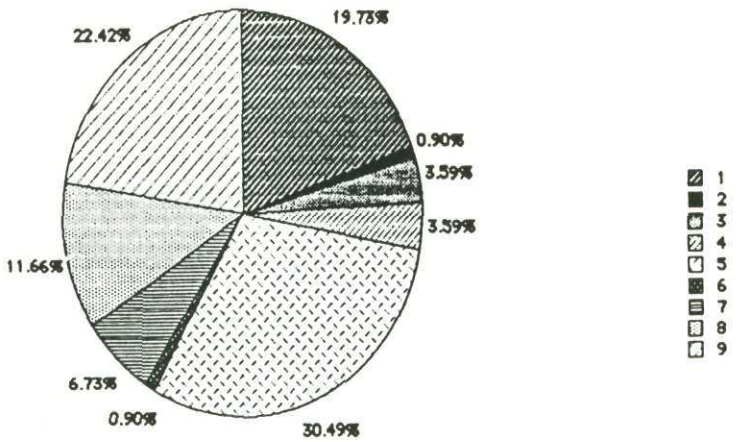
Overall, there was not a significant change in the amount of human use of the lakes ($P=0.405$; Fig. 1). However there were many shifts of lakes from one category to another. There were fewer lakes in both the highest and lowest categories (those with no use by people; those with frequent water skiing and/or boat racing), in 1986 than in 1971. More than 40 percent of all lakes were in one of the 2 in 1971, while only 17 percent were in 1986, a drop of more than half. Lakes with no boat use or only infrequent use by boats or canoes with no motors, increased from 4.49 percent to 20.67 percent.

The greatest change happened to lakes that had occasional use by motorboats; 10.8 percent in 1986, down from 30.59 percent 15 years earlier. The next 3 categories, each indicating varying degrees of daily use by motorboats, included 47.42 percent of 1986 lakes, but only 19.29 percent of lakes in 1971.

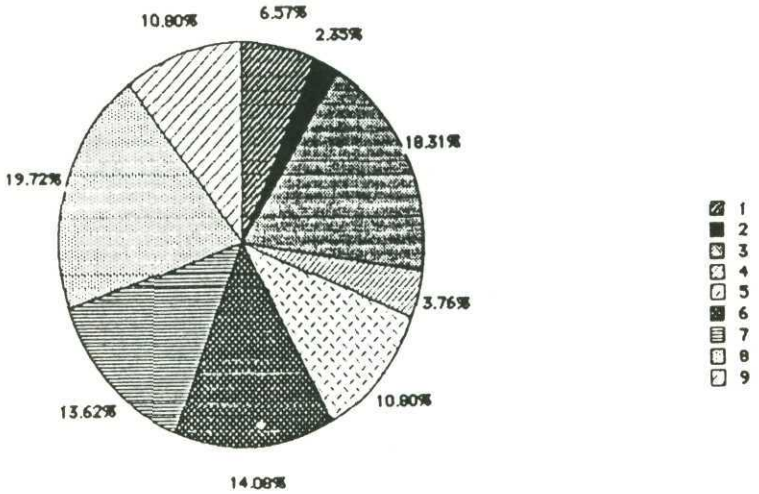
Figure 1. Recreational use on Minnesota lakes in 1971 and 1986. Use category codes are:

1) no use
2) some use, but no boats
3) occasional boat use; no motors
4) daily use by boats; no motors
5) occasional use by motorboats
6) one or a few motorboats daily
7) daily motorboat use
8) frequent high speed boat use
9) boat racing and/or waterskiing

USE 1971



USE 1986



Development

Shoreline development did not change significantly (P=0.713, Fig. 2). However, there were changes in the relative proportion of lakes within each category. Surprisingly, there was even a slightly lower proportion of lakes with no development in 1986 than there were 15 years earlier.

There were also fewer lakes with many homes and a resort, from 34 percent in 1971 to slightly more than 16 percent in 1986, but nearly twice as many lakes with 2 or more homes. Nearly one-third more lakes had all 3 types of development: homes, resort, and campground; and there was a nearly 6-fold increase in the proportion of lakes with both homes and a campground.

Lake Use by Loons

The presence of loons was assigned to 1 of 4 categories: 1) no loons, 2) loons stopping only during migration, 3) adults irregularly present during the summer, or 4) territorial pairs. More lakes had no loons at all in 1986 than in 1971; a very tiny percent had loons only on migratory stops during 1986; 3 times as many had irregular visits by loons during the summer; and there were 10 percent fewer lakes with territorial residents in 1986 than in 1971.

Lake use by loons did not show a significant change over time (P=0.067, Fig. 3). However, the difference was marginally insignificant and it is clear that there were some real changes over the past 15 years.

In all, 46 lakes (20%) changed loon-presence status during the interim. Eight (4%) lakes acquired greater loon use. Three lakes which had no loons in 1971, hosted territorial pairs in 1986, a change from category 1 to 4. The 8 lakes were in various parts of the state, from southern counties such as Stearns and Todd, to St. Louis county in the northeastern part of the state (Appendix 1).

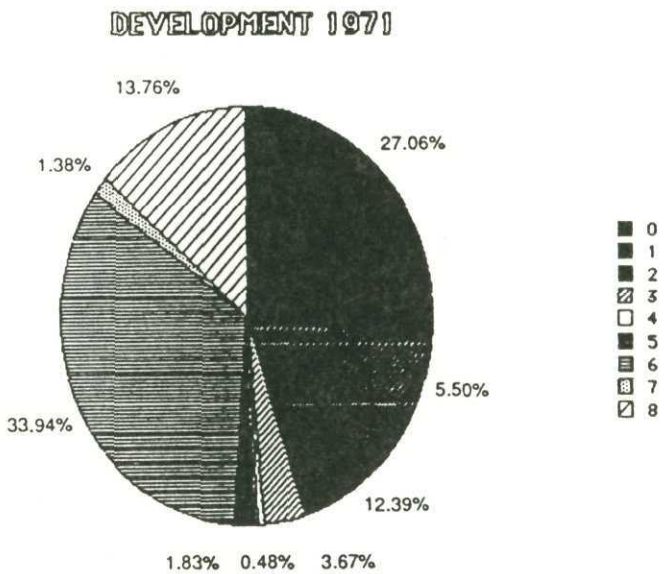
There were 38 lakes (17%) from 18 counties with less loon use. Ten had territorial pairs in 1971, but had none during 1986 (a change of status from 4 to 1). A summary of these changes is shown in Appendix 1.

Productivity and Brood Size

Neither number of young per territorial pair nor brood size were significantly different between the two surveys (P=0.695 - productivity; P=0.410 - brood size). Both were slightly lower in 1986 than in 1971 (Fig. 4).

Figure 2. Lakeshore development on Minnesota lakes in 1971 and 1986. Development category codes are:

0) nothing
1) one home
2) two or more homes
3) resort only
4) campground only
5) resort and campground
6) homes and resort
7) homes and campground
8) homes, resort, and campground



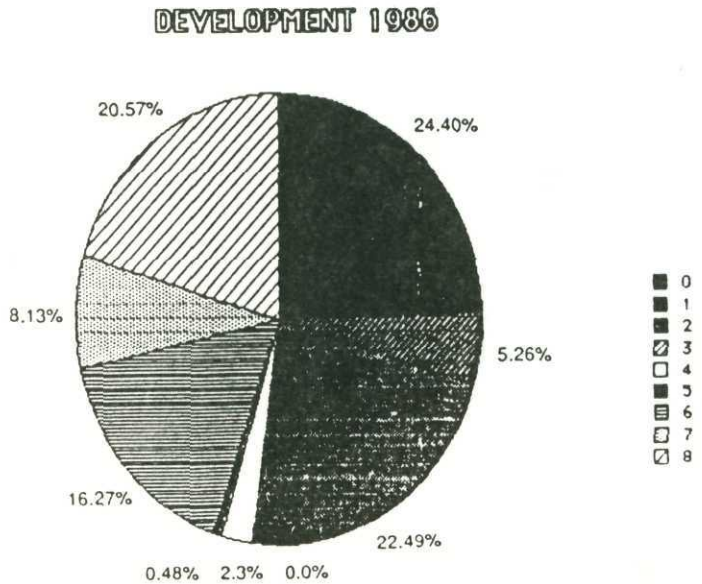
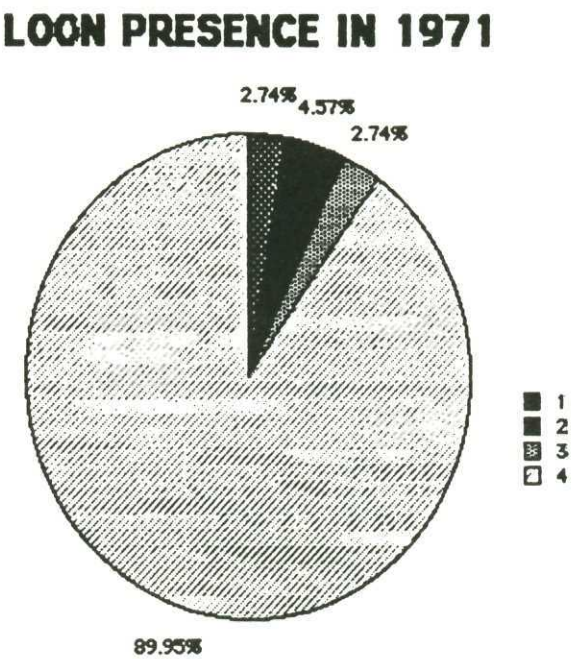


Figure 3. Loon use on Minnesota lakes 1971 and 1986. Codes are:

1) no loon use
2) migratory stops only
3) irregular use during the summer
4) territorial residents



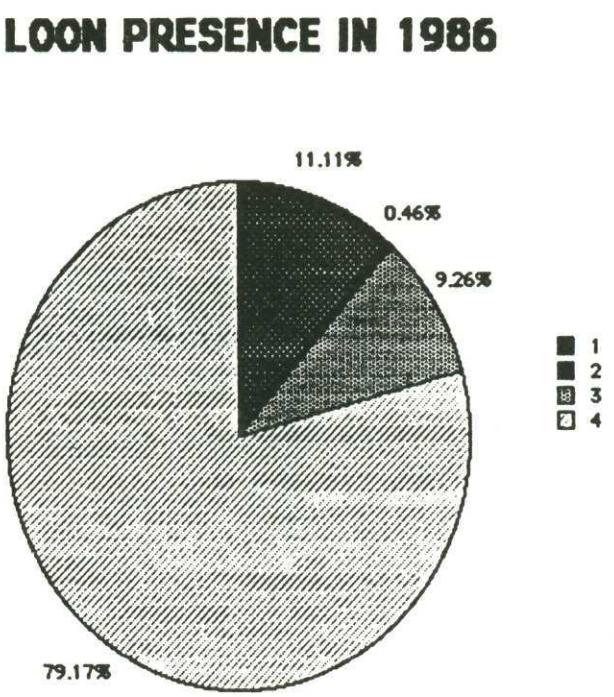
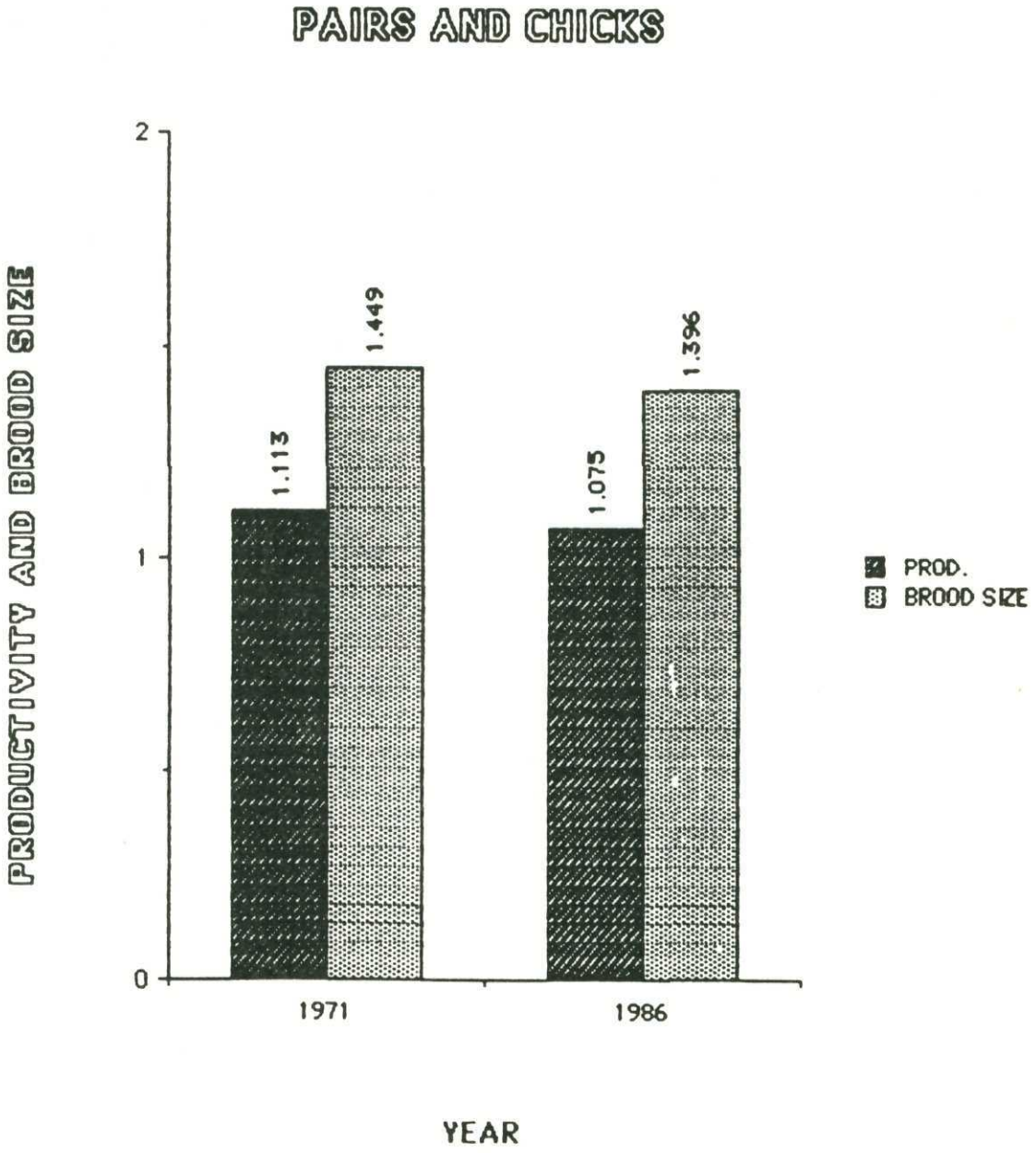


Figure 4. Reproductive success and brood size for Common Loons in Minnesota 1971 and 1986.



DISCUSSION

Comparison between the 2 surveys reveals there have been some changes in Minnesota's loon population and its habitat during the last 15 years. Shoreline development and recreational use have increased, there has been a downward trend in the number of lakes with resident loons, and productivity and brood size are slightly smaller.

There are fewer lakes with intensive boat racing and/or waterskiing now than there were 15 years ago, but there is also a smaller proportion that have no use by people. In most other categories of recreational use, there has been an increase in the proportion of lakes used for boating activities. The intensity of boating has increased too, with a startling drop in the number of lakes used only occasionally by motorboats, and twice as many lakes encountering boat traffic.

My earlier work showed that nesting loons are more severely affected by slow-moving boats, especially canoes and fishing boats that hug the shoreline, than they are by motorboats (McIntyre 1975). However, I also suggested at that time that loon chicks were more vulnerable to motorboats than they were to canoes. Several boat-caused deaths have been verified in New Hampshire because drivers have picked up chick carcasses and discussed the accidents with Loon Preservation Committee personnel (Jeff Fair, pers. comm.). Sadly, then, loons are potentially vulnerable to many kinds of boat traffic. The relative threat posed by any one type depends on the stage of the breeding cycle. Because canoe and motorboat use are both on the increase in Minnesota, loons have been doubly affected.

Although there was a substantial decrease in the proportion of lakes with a resort as the only development, there was also an increase in lakes with several homes and those with all 3 kinds: homes, resorts, and campgrounds. Camping has increased in popularity in the last few years, and consequently so have the number of campgrounds. There has also been a trend away from spending summer vacations at a resort in favor of owning a summer home. In fact, there is a phenomenon now occurring in New York state which may also be happening in Minnesota, that of purchasing resorts for use as private summer homes (Gerald Orsaeo, pers. comm.). Human impact on lakes would not be expected to lessen under these circumstances, and in fact, might even increase.

Many more lakes with a decline in loon presence were reported than were lakes with greater loon activity. Many, but not all, of these lakes, are close to the southern limit of the breeding range, and may not represent the most opti-

mal loon habitat. If Minnesota's population is shrinking, then the region expected to exhibit a decline soonest is the one at the edge of the breeding range. Half these lakes are located at or near the edge.

Problems with the survey method, and not with the loon population, may be skewing the results. I noted initially that more positive than negative data could be expected from these surveys. Only a few negative results were submitted in 1971 (categories 1,2,3), and so fewer increases could be reported in 1986. If there is a pattern of fluctuation in the use of individual lakes by loons, caused by old loons dying and young ones becoming first-time breeders, then in a stationary population, there should be decreases balanced by approximately the same number of increases.

As an example, 8 losses were from lakes in Itasca State Park, in the region where I had conducted studies in the 1970's. The most surprising were Mary Lake and Deming Lake, where there had "always" been nesting pairs. Resident pairs have been reported from at least the past 30 years (Krause and Chambers 1957). Deming Lake was even taken over in the early 1970's by new residents after they killed a widowed female near her nest (McIntyre 1975) which would suggest Deming Lake is considered by loons to be prime habitat.

The year after this survey was made, both lakes had loons again (Ben Thoma, pers. comm.). In 1987, Mary Lake had a territorial pair, although no young were raised, and a non-nesting pair was seen periodically throughout the summer on Deming. In 1986, when reports were requested from specific lakes, negative data were readily obtained. It would be advisable to survey the same lakes again during 2 successive summers, in 1990 and 1991, to verify whether the apparent decline is a real trend, or only the result of an error factor in the initial survey.

The numbers of young per pair provided by this report (1.113 and 1.075) are difficult to accept because they are so much higher than the values secured through non-manipulated research studies in Minnesota (0.50 - Olson and Marshall 1952; 0.29 - McIntyre 1978; 0.46 - Titus and VanDruff 1981). They are higher than studies in other regions where the populations are considered stationary and reproductive success good, as in northern Saskatchewan (0.54 - Yonge 1981), or where populations are small, territorial competition reduced, and productivity considered to be very high, for example, New York (0.83 - Trivelpiece et al. 1979; 0.95 - Parker et al. 1986; 0.73 - McIntyre 1986).

Productivity was 3.4 percent lower in 1986 than in 1971. Assuming that error factors are not significantly different between the 2 surveys, the decline of 0.38 young per pair suggests a downward trend. Brood size of fledged young was

also slightly smaller. Even though slight, there are findings from other parts of the range that indicate this small change may be important to note. In a recent study in Michigan, Dulin (1987) reported that loss of 1 young from 2 chick broods was becoming common. Dulin found that young were dying at older ages than previously reported, and that fledging of 1, rather than 2, young from each brood was common.

I also found a dramatic drop in the numbers of young per brood which survived to fledge during a New York study (McIntyre 1986a). I had worked with the same population for 10 years, and found chick mortality was usually low, from 2 to 4 deaths in most years among a population of 12 to 15 pairs. However, in 1986 only 1 pair of siblings was raised among the 10 broods, the other 9 each losing 1 of 2 chicks prior to fledging. The other surprise was that several chicks died when older than previously noted; the oldest was 5 weeks. If brood size is declining due to causes as yet unknown in other parts of the range, even such a slight decline as shown by these Minnesota surveys suggests brood size should be monitored in Minnesota during the next few years.

In summary, although statistical analysis suggests Minnesota's loon population is stable and healthy, there were small declines among residents and their productivity, and increased human disturbance within each lake assessment category. This suggests periodic surveys should continue.

ACKNOWLEDGMENTS

This study was funded by the Minnesota Department of Natural Resources and the Oikos Research Foundation. Lee Pfanmuller and Mary Miller of the Minnesota DNR did the bulk of the work to secure volunteers, distribute questionnaires and collate the reports. Bret Danilowicz of Utica College computerized the results from 1986. Ben Thoma was of great assistance in helping me with the Itasca Park surveys. I would like to thank the many volunteers and DNR Non-Game staff, who, after all, did the bulk of the work.

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Appendix 1. Lakes and their locations by county for which changes in the extent or type of use by Common Loons was reported between 1971 and 1986 Minnesota surveys. The categories of use are the same as used in the legend for Figure 3.

Lakes with More Loon Use

County	Lake Name	Category of Change
Beltrami	Rice Lake	1 to 4
Cass	Sanburn	1 to 4
Douglas	North Kron	1 to 3
Marshall	Mud	2 to 3
Pope	Amelia	1 to 4
St. Louis	Eagles Nest	3 to 4
Stearns	Kraemer	3 to 4
Todd	Rice	2 to 4

Lakes with Less Loon Use

Aitkin	Pine	4 to 1
Anoka	Moore	2 to 1
Becker	Aspinwall	4 to 3
	Pine	4 to 3
	Buck	4 to 3
Beltrami	Holland	4 to 3
	Carl's	4 to 3
	Bemidji	4 to 3
Cass	Marion	4 to 1
Douglas	Grants	4 to 3
	South Kron	4 to 3
	Echo	4 to 3
	South Oscar	4 to 3
Hennepin	Harriet	3 to 1
	Crystal	2 to 1
	Twin	4 to 1
Hubbard	Mud	4 to 1
	Twin	3 to 1
	Mary	4 to 3
	Deming	4 to 3
	Josephine	4 to 1
Itasca	Beatrice	4 to 1
	Section Twenty-six	4 to 1
	Kremer	4 to 3
	Marie	4 to 1
	Coleman	4 to 3
Kanabec	Knife	2 to 1
Kandiyohi	George	4 to 3
Lake	Topez	4 to 3
McLeod	Silver	2 to 1
Marshall	Thief	2 to 1
Meeker	King	4 to 3
Murray	Sarah	2 to 1
Pine	Olive	4 to 3
Ramsey	Pike	2 to 1
Stearns	Sylvia	3 to 1
Washington	St. Croix	4 to 1
Wright	Pleasant	4 to 1

THE POPULATION AND DISTRIBUTION OF COMMON LOONS IN WISCONSIN

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SUMMARY

Wisconsin's summer Common Loon population is monitored annually by volunteers, but their data do not allow for a statewide estimate. In 1985, I conducted a census of loons on approximately 8 percent of Wisconsin's 2457 lakes over 10 ha in the 29 northernmost counties of the state and estimated the statewide summer population.

Lakes were chosen randomly within a cross-stratified scheme based on lake size and geography. Two hundred nine volunteers were assigned to the lakes and given specific instructions on censusing methodology. The count took place 0500-1000 on July 6. Observers were cross-checked for accuracy by duplicate counts on 24 lakes.

Observers counted 180 adults and 38 chicks on 190 lakes. Adults were seen on 89 (47%) and chicks on 25 (13%) lakes. The estimated population was 2334 +/- 197 adults and 491 +/- 98 young.

There was no clear relationship between lake size and the number of loons seen. However, there seemed to be a pattern of single loons on lakes 10-29 ha and 2 loons on lakes 30-60 ha. The largest number of loons seem on 1 lake was 6. The number of loons or pairs of loons on a lake were not related to shore length, shoreline development factor, maximum depth, water clarity, number of fish species present, a rough index of fish abundance, or alkalinity. This suggested that either other factors determine lake nesting preference and/or the selection of lakes is more random than previously thought, and the "persistent nesting hypothesis" is accurate.

The geographic distribution of loons followed the distribution of lakes in the state. A ratio of the percentage of adult loons in the sample count to the percent of lakes in the sample by county indicated greatest loon concentrations in Bayfield, Washburn, Iron, Price, and Oneida Counties.

THE STATUS OF THE COMMON LOON IN MICHIGAN

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Historical records of the Common Loon (Gavia immer) in Michigan are not plentiful. Gibbs (1879) stated that loons were common in most regions of Michigan, and Barrows (1912) noted that loons formerly "nested abundantly on most of the ponds and lakes of the state, even to the southernmost border", but that loons by then had begun to become less common in the southeastern part of the state. Cahn (1918) reported, after a survey of vertebrates in Houghton and Iron Counties in the western Upper Peninsula (U.P.), that it was usual to find at least 1 pair of loons on each lake that had shorelines affording nesting sites. From these few records it appears that in the nineteenth century the Common Loon was widely distributed throughout Michigan, with some declines occurring in the southern portion of the state as human populations increased.

Recognizing the shortage of quantitative information on the Common Loon, and heeding signs that its numbers may be declining, Hammill et al. (1984) began a systematic survey of lakes throughout the U.P. in 1983. For 2 years before this, lakes in the western and central U.P. had been surveyed. The results of the 1983 survey suggested that loon numbers were less than what might be expected in a thriving population. An estimated 100 nesting pairs were found on about 1200 lakes judged on the basis of size and suitable nest sites to have medium or high potential for loon occupancy, thus only 1 in 12 apparently habitable lakes was occupied by breeding loons. This alarming situation prompted further and more detailed surveys to be conducted 1985-1987. The objective of the surveys was to obtain an estimate of the number of breeding loons in Michigan, to describe where they are found, and to report the results of these surveys and to discuss the current status and the

future of loons in Michigan.

METHODS

Because Michigan has more than 11,000 inland lakes, a stratified random sampling scheme was developed to obtain statistically reliable data on loon numbers and distribution. Lakes originally were classified into 4 strata as follows:

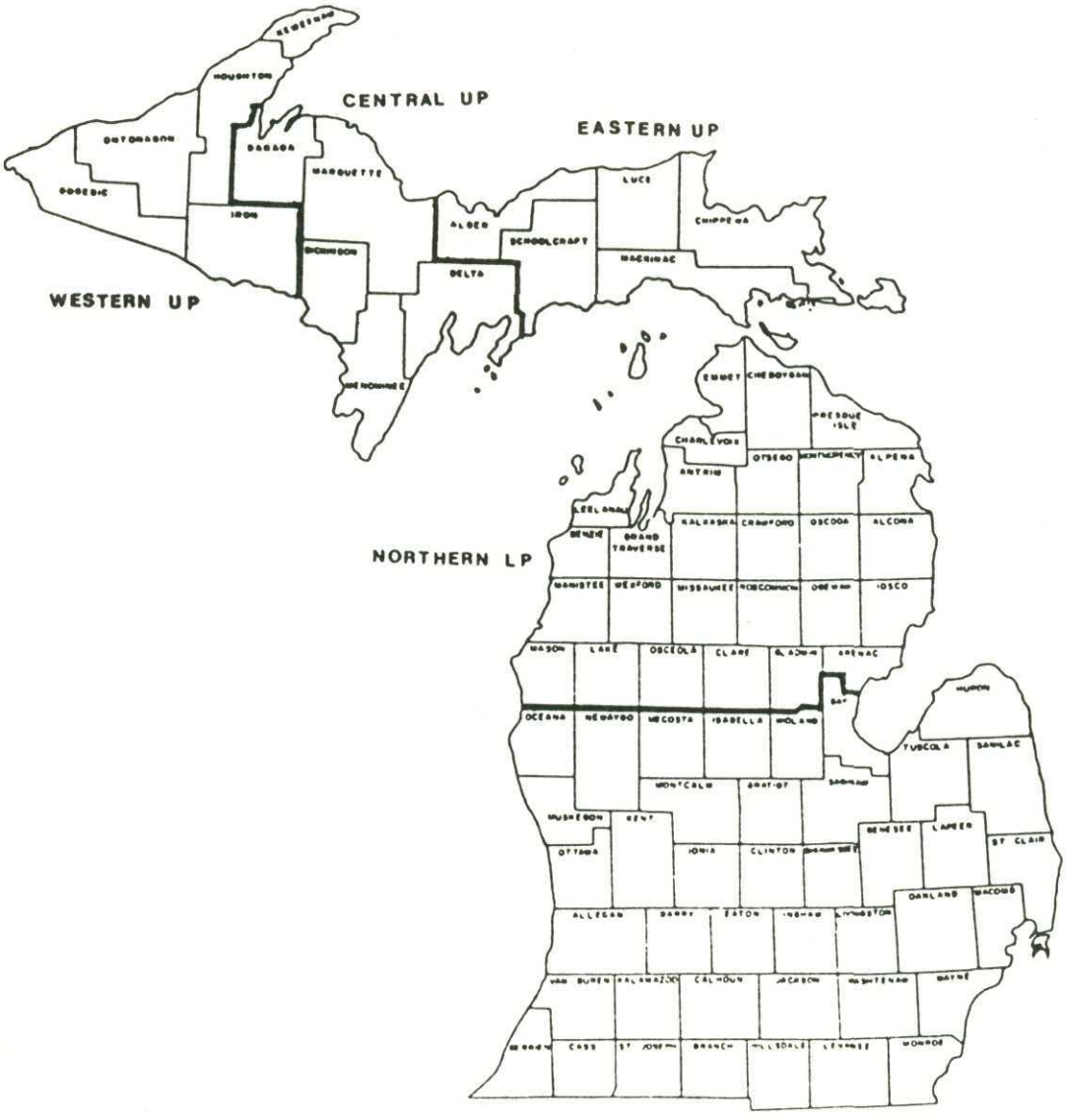
I. lakes with a known recent history of loon nesting;
II. lakes larger than 40 acres (16 ha) and having an island or bog shoreline for nesting (high potential);
III. lakes larger than 40 acres (16 ha) without an island or bog shoreline (medium potential);
IV. lakes between 10 and 40 acres (4-16 ha) (low potential).

Lakes smaller than 10 acres were not sampled because of the extremely low probability of use by breeding loons. Presence of islands and bog vegetation was determined from aerial photos. All Stratum I lakes, at least 20 percent of Stratum II and III lakes, and a small percentage (3-10%) of Stratum IV lakes were surveyed. Lakes were selected by assigning each lake a number and selecting those to be surveyed by use of random numbers. If nesting loons were found on a lake in Strata II, III or IV it was assigned to Stratum I the succeeding year.

Beginning in 1986, Strata II and III were combined into Stratum II, and Stratum IV became Stratum III. After surveys of 1983-1986, it was determined that about 3 percent of the Stratum III lakes (10-40 acres) were occupied by nesting loons. Because of the expense of surveying these numerous and frequently remote lakes, with small probability of finding loons, surveying such lakes was discontinued and a constant of 0.03 was applied to estimate the number of breeding loons pairs on such lakes. Loon range in Michigan was divided into 6 geographic areas for sampling purposes: Isle Royale, Western U.P., Central U.P., Eastern U.P., Northern Lower Peninsula (L.P.), and Southern L.P. (Fig. 1).

A lake survey consisted of an experienced observer visiting the lake between May 25 and July 10, the nesting and early brood-rearing period. The observer would scan the lake with binoculars, looking for loons and, using a canoe, thoroughly search the shoreline and islands for a nest. The number of adult loons, chicks, and eggs was recorded on standard data forms. A pair of breeding loons was recorded only if a nest with an egg or adult loon with 1 or 2 chicks were seen. Two loons suspected of being a mated pair would not be counted as breeders, nor would a nest with no sign of

Figure 1. Locations and boundaries of sampling areas. Isle Royale (not shown), a part of Keweenaw County, lies approximately 64 km northwest of the mainland portion of that county.



eggs or chicks.

In the southern half of the Lower Peninsula estimates of breeding loon numbers were obtained not from random sampling of lakes, but from informal polling of persons familiar with birds in the area and its geography. Such data are being gathered for a Michigan breeding bird atlas, and for the Michigan Natural Features Inventory and have been supplied by various observers.

RESULTS

The numbers of lakes surveyed in the various geographic areas are presented in Table 1. The estimated number of pairs of loons in each sampling area is presented in Table 2. The distribution of loons in the state and an assessment of their densities are as follows: Isle Royale, with an estimated 40 nesting pairs in 34 lakes and 19 bays appears to be practically saturated with loons, resembling areas of northern Minnesota (McIntyre 1987) to which it is geographically closer than Upper Michigan. The western U.P. supports reasonably healthy populations with 60 percent of lakes larger than 40 acres occupied. Likewise about 60 percent of Stratum I lakes were occupied each year (Table 3). Other studies in areas of moderate densities of loons such as Montana (Skaar, unpubl. rep.) have shown a similar proportion of annual reoccupancy of breeding lakes. In the central U.P. the estimate of about 20 breeding pairs on 229 lakes (9%) indicates a less than thriving condition. Annual reoccupancy of Stratum I lakes was 58 percent. In the eastern U.P. only 5-20 pairs on 160 lakes (3-12%) larger than 40 acres indicates a very sparse population. The average reoccupancy of Stratum I lakes of only 31 percent further suggests a struggling population.

In the northern L.P. about 20 percent of the lakes larger than 40 acres have been occupied by loons in 1986 and 1987. Annual occupancy of Stratum I lakes was a healthy 61 percent. In the southern L.P. only 14 lakes of several hundred were occupied by loons. This appears to be a relict population, with no known recent expansion of breeding loon range in that area.

To summarize the pattern of loon abundance in Michigan in the mid-1980's, Isle Royale supports a thriving and apparently stable population. In the western U.P., loons appear to be reasonably secure. Proceeding east in the Upper Peninsula a picture of severely diminishing numbers occurs. In the northern L.P. loon densities are moderate while in the southern L.P. a small population appears to be hanging on in scattered locations. Figure 2 is a map depicting general loon densities in the state.

Table 1. Number of lakes sampled for Common Loons in 5 Regions of Michigan 1983-1987.

	Western U.P.	Isle Royale	Central U.P.	Eastern U.P.	Northern U.P.	Total
1983	79	---	92	81	---	252
1984	---	---	---	---	---	---
1985	96	53[a]	86	70	106	411
1986	72	---	---	105	152	329
1987	105	---	47	38[b]	226	416

[a] On Isle Royale 53 sites included 34 lakes and 19 bays of Lake Superior.

[b] Does not include various connected pools in Seney National Wildlife Refuge.

Table 2. Estimated numbers of loon nesting attempts in Michigan 1983 and 1985-1987.

	1983	1985	1986	1987
Isle Royale	---	40	---	40[a]
Western U.P.	52	56	90	95
Central U.P.	17	20	---	20
Eastern U.P.	36	5	15	20[b]
Seney Refuge	---	5	4	4
Northern L.P.	---	(84)[b]	84	81
Southern L.P.	---	(15)[b]	15	15
Total Breeding Population Estimate		225		275

[a] No data from 1987; Figures from 1985 are used to make rough comparisons of totals.

[b] No data from 1985; Figures from 1986 are used to make rough comparisons of totals.

Table 3. Percent of Stratum I lakes in Michigan occupied by breeding loons 1985-1987[a].

	1985	1986	1987	Average
Western U.P.	47	70	58[b]	58
Central U.P.	60	---	56	58
Eastern U.P.	24	40	29	31
Northern L.P.	50	62	72	61
Unweighted Average	45%	57%	40%	47%
Weighted Average	46%	60%	53%	53%

[a] Not including Isle Royale.

[b] Does not include laks surveyed in Keweenaw County.

Figure 2. Distribution and estimated abundance of breeding Common Loons in Michigan, 1982-1986. Key: 0 = less than 10 percent of potential breeding lakes (Strata I and II) occupied by breeding loons; 1 = 10-20 percent occupied; 2 = 21-40 percent occupied; and 3 = greater than 40 percent occupied.

This picture of current loon densities is not likely to remain constant, as wildlife populations in general seldom do. In recent years some trends have been observed. In the western U.P. the estimate of 52 nesting pairs in 1983 increased to 90-95 pairs in 1986-87. Because of sampling error, these figures are by no means totally accurate, but there does seem to be an increase in breeding loons in that area. The central U.P. has shown little change since 1983, while the eastern U.P. showed extremely low numbers in 1985 with some apparent recovery occurring in 1986 and 1987. Because of even smaller sample sizes than in the other parts of the U.P., however, confidence in these estimates is low. The northern L.P. appears to be the second best mainland loon nesting area (behind the western U.P.) with relatively stable numbers. In the southern L.P. data have not been available to show trends, but there is a little reason to believe that loon numbers are increasing in that area. Statewide it appears that there has been a slight increase in loon numbers over the past 4 years from about 225 to 275 nesting pairs (Table 2). These figures compare with estimated numbers of about 2300 loons in Wisconsin (Olson 1988), and 10,000 in Minnesota (McIntyre 1988).

Nesting success and chick production of Michigan loons seems comparable to those of most populations. Nest success averages abut 70-80 percent, and brood size (at various ages) averages about 1.5 chicks (Robinson et al. 1986, 1987). Human disturbance, however, can be a factor, particularly during the nesting season (Caron and Heitman 1987). Human disturbance may increase in the future, particularly in the northern L.P., where recreational development and human numbers are increasing rapidly. It appears at present, however, that breeding of most Michigan loon populations is successful without serious problems caused by humans. This indicates the prime cause for the slowness of recovery of loons in some portions of the state is mortality of birds between fledging and breeding, and perhaps of adult loons.

Whether the increase we have witnessed in Michigan loon numbers in the past few years is a short-term or long-term phenomenon remains to be seen. Optimistically, the gradual increase might represent a slow recovery from some widespread disaster that occurred some time in the past. Because of the low reproductive potential (2 eggs per pair) and the several years it takes for young loons to reach breeding age, rapid recovery (as might be seen in such birds as ducks or grouse with large clutch sizes and breeding at 1 year of age) is not possible in loons. We do not know for certain what such a disaster may have been, but 2 possibilities are losses to botulism and commercial fish nets. From the 1960's through 1983 several large-scale losses of loons to type-E botulism occurred on Lake Michigan (Kaufman and Fay 1964), Fay 1966, 1969; Brand no date, Brand et al. no date, Table 4). More than 8000 loons died in these autumn

Table 4. Botulism poisoning and loon losses on Lake Michigan (from various sources).

Year	Time of Year	Estimated Numbers of Loons Killed	Location
1963	Nov. - Dec.	3,300	Southern
1964	Fall	3,570	Northern
1965	October	"significant numbers"	Northern
1976	Fall	592	Northern
1983	Fall	582	Northern
Total		8,000+	

epidemics, with over 500 in 1983. Because these outbreaks occurred in the fall, the victims probably represent birds from several breeding areas. What proportion of them were Michigan breeders is unknown.

Significant numbers of loons, probably in the hundreds per year, are killed in commercial trap net sets in the Great Lakes for whitefish (Coregonus clupeaformis) (Michigan Department of Natural Resources unpubl. data). The breeding origin of the loons and their relationship to Michigan breeding population is unknown. The hypothesis that loons using the Great Lakes in early summer are nesting birds flying from inland lakes to feed on the Great Lakes was not supported by observations (Robinson 1987). Of 23 flights made by 41-45 loons, only 5 (22%) were from lake to inland or inland to lake. In no case was a loon seen to fly from an inland area (lake), land on the Great Lakes, then return inland (Robinson 1987). It appears that the majority of loons using the Great Lakes in late spring and summer are non-breeders. It is possible that they are young birds in adult plumage (a few loons in immature plumage are also seen on the Great Lakes in summer) not yet ready to breed. If so, loss of these birds may represent loss of future breeders. Commercial trap netting has been a relatively constant factor over the past few decades (Richard Schorfhaar, Michigan DNR Fisheries Biologist, pers. comm.). The slow recovery of loons presently occurring suggests that losses to fish nets (which are continuing) are not insurmountable, although more data are necessary to determine times and location of net mortality.

A shortage of information on life histories of loons hampers the development of an effective management plan for loons in Michigan. For example, we know nothing of where loons that breed in Michigan spend the winter, and next to nothing about their migratory routes. Losses on the wintering grounds and in the places where young loons spend their first few summers may be significant, but we do not know where these places are. We have little inforation on survival rates of adult loons, and whether pairing is seasonal or for life. It will be necessary to develop effective methods of capture so that large numbers of loons can be banded and given distinctive individual markings, such as floating colored leg bands. Continued monitoring of populations is necessary to detect population trends. Necessary habitat features for loons must be identified, so that areas possessing them may be protected for the benefit of loons.

A Michigan Loon Recovery Plan is being developed by a committee of scientists appointed by the Department of Natural Resources. The plan is expected in early 1988. In addition, a citizens Loon Preservation Committee has been chartered under the auspices of the Michigan Audubon

Society, with the purpose of promoting public awareness of loons and using the power of citizens to protect habitat and to advocate appropriate research and management. In 1987 the Michigan Legislature approved Threatened Status for the Common Loon under the Michigan Endangered Species Act. This makes it illegal to destroy habitat and focuses additional attention to the potential for the loss of the loon as a breeding bird in Michigan.

In conclusion, we may take an attitude of very cautious optimism for the future of the loon in Michigan. Much work remains to be done. But with additional knowledge of the basic biology of loons, effective protection of their breeding habitat, migratory routes, and wintering grounds, assisted by public cooperation, the call of the loon may once again become a common sound on the lakes of Michigan.

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STATUS OF NEW YORK'S COMMON LOON POPULATION - COMPARISON OF TWO INTENSIVE SURVEYS

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Common Loon (Gavia immer) populations in southern Canada the and northern United States have been the focus of increased attention during the past 10-15 years (McIntyre 1975, Hammond and Wood 1976, Trivelpiece et al. 1979, Titus and VanDruff 1981, Yonge 1981). However, with the exception of Titus and VanDruff's (1981) work in the Boundary Waters Canoe Area of northeastern Minnesota and McIntyre's work at Itasca State Park, Minnesota (1978), there are no reports in the literature concerning changes in loon populations over time. This is partially due to the generally incomplete and therefore unreliable historical accounts of loon distribution and abundance. Its status as a nongame species has, until recently, meant that little attention has been paid to the bird by state or provincial conservation agencies; in many areas the task of monitoring loon populations is largely left to the private sector.

The Common Loon population in New York State has been restricted primarily to the Adirondack region since the early 1900's (Arbib 1963, New York State DEC 1979). Historic information on breeding loon distribution in New York is incomplete but it is apparent that their range and numbers declined in the face of human exploration and expansion (McIntyre 1979).

Arbib (1963) compiled information from the literature, ornithologists, bird clubs, and conservation officers to publish the first specific account of Common Loon distribution in New York. He listed over 90 waters where loon pairs had been recorded and estimated the total state breeding population to be about 240 pairs.

The first intensive lake-by-lake survey to document loon distribution, numbers, and productivity in New York was initiated in 1977 by Trivelpiece and Volkman (Trivelpiece et al. 1979). Field work in 1978 and 1979 to complete the survey was funded by the New York State Department of Environmental Conservation (DEC). This initial survey covered 420 lakes over 10 ha, revealing 114 breeding pairs on 91 lakes. The total New York breeding population was estimated at less than 200 pairs (Trivelpiece et al. 1979).

In 1984, the DEC initiated a second intensive Common Loon survey that was completed in 1985. Its purpose was to compare loon presence, productivity, and total population size with those data collected on the same set of lakes in the 1977-79 survey. Additional lakes were surveyed as time and staffing allowed. A separate but complementary survey project, known as the Adirondack Loon Preservation Project (ALPP) was conducted by volunteers who gathered information on loon presence at various lakes during the summers of 1983-1985. In order to standardize methods between the 1977-1979 and 1984-1985 surveys, only data gathered by DEC personnel are included in this report.

STUDY AREA AND METHODS

The Adirondack Forest Preserve was established as a "forever wild" state forest preserve by legislative act in 1895 (New York State Conserv. Dep. 1968). Its boundaries were subsequently enlarged by the creation of the Adirondack Park. At 2.4 million ha, it comprises almost one-fifth the area of New York State (Miller 1917). The park is a mosaic of privately owned (62%) and publicly owned (38%) land. Most of the park is heavily wooded with second-growth northern hardwoods. Lands in private holdings are primarily devoted to forestry and recreational use (Adirondack Park Agency, unpubl. data). The Adirondack Park Agency, which oversees land use in the park, has strict zoning laws regulating use of private land, including permitted forestry practices.

Over 2000 ponds, lakes, and reservoirs are found in the Adirondack Ecological Zone (which essentially coincides with the political boundaries of the Adirondack Park but encompasses all lands above 305 m elevation, Figure 1), many of which are extremely oligotrophic. The slowly weathering granitic bedrock which underlies this region yields thin, acidic, and infertile soils (Van Diver 1980). Thus, the nutrient-poor waters have depressed levels of calcium, magnesium, and bicarbonate ions. These factors, along with steep slopes and quick runoff, contribute to the poorly buffered condition of many Adirondack waters, make them particulary vulnerable to acidification (Pfeiffer and Festa 1980).

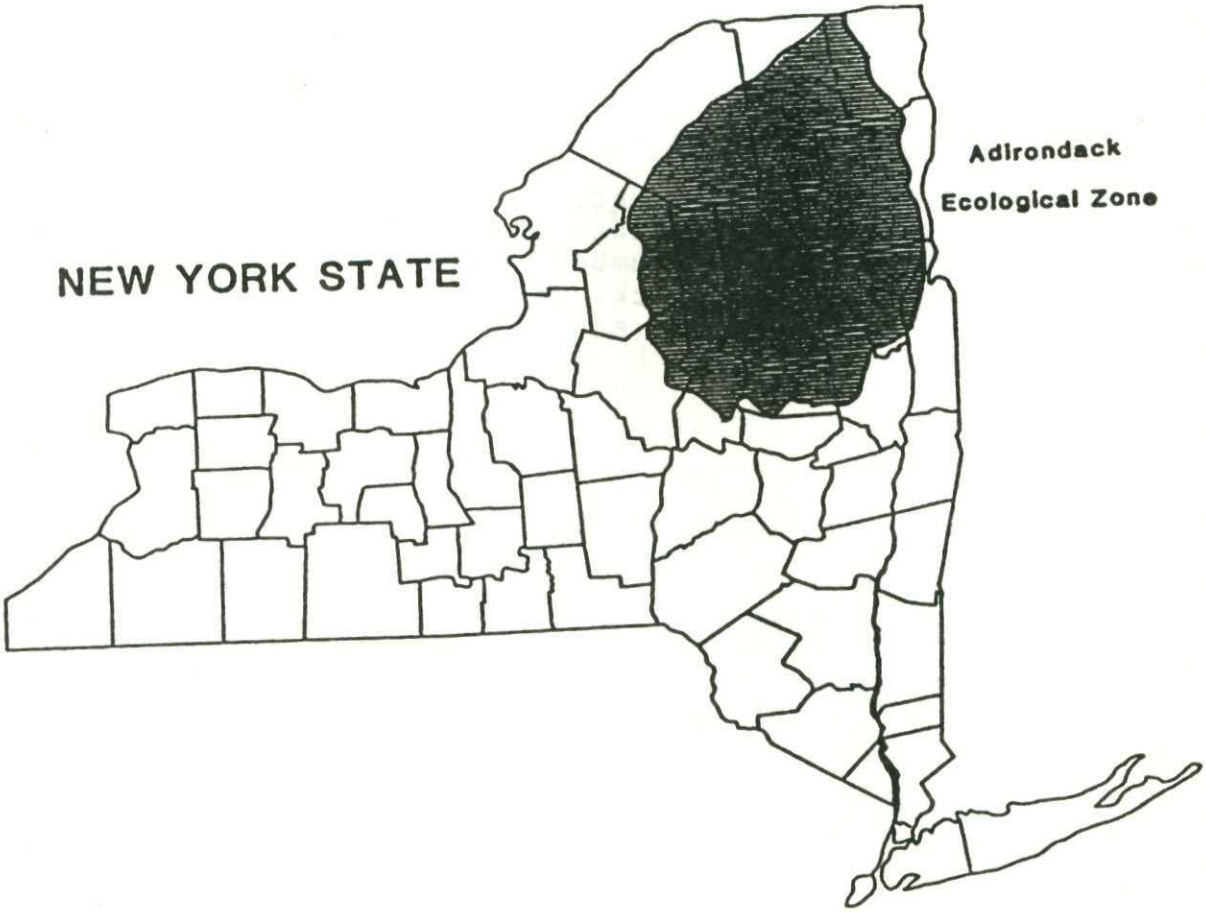

Figure 1. Boundary of the Adirondack Ecological Zone.

A master list of lakes was compiled from the list of lakes covered during the 1977-1979 survey and other lakes of sufficient size to support loons. (Those lakes which were covered in both surveys are hereafter referred to as "core lakes".) Lakes on the list were assigned to the survey crew whose base camp was nearest the lake. The field season for the 3 2-person crews extended from early June until late August of 1984 and 1985.

Lake and island perimeters were canoed to check for evidence of nesting. Edges of bog mats and floating vegetation were also carefully checked. The criteria for verification of breeding was the presence of a nest of the year or of flightless young. The number, color (black vs. brown), and relative size of any chicks observed was recorded. Eggshell fragments and non-viable eggs were collected when found. The number of adult (in breeding plumage) loons was recorded; loons for which no evidence of breeding was found were designated as nonbreeding adults.

Lakes where a pair of loons, a nest of the year, or chicks less than one-half adult size were observed received a second visit to determine whether expected or existing chicks has survived to fledging. Although loon chicks do not actually fledge until 10 to 12 weeks of age (Olson and Marshall 1952, McIntyre 1975), chicks were considered to have successfully fledged when they were known to be 3 weeks old, or if they were at least one-half adult size (Olson and Marshall 1952).

Subsequent to the completion of the survey, all data were entered into a custom-designed loon survey database using dBASE III software on an IBM PC-XT. Data from the 1977-1979 survey were incorporated into this database also.

When a lake was visited during 2 or more years of a survey, loons were classified as a breeding pair if evidence of breeding was found on at least 1 occasion. To avoid double-counting, loons observed at a lake more than 1 year were assumed to be the same individuals. Fledging rate was calculated by summing the number of breeding pairs found each year of the survey, subtracting the number of breeding pairs for which the outcome of the season's reproductive efforts was unknown, and lastly, dividing the total number of fledged chicks by this "adjusted" number of breeding pairs.

RESULTS

Results of the 2-year survey are summarized in Tables 1 and 2 and Figure 2. The surface area of all lakes completely searched ranged from 2.5-2507 ha, with a mean of 130.1 ha. Lakes on which loons were present averaged 167.2 ha and

Table 1. Summary of common loon presence, reproductive success, and density in New York State.

	All lakes		Core lakes[a]			
	Survey period		Survey period			Test
	1977-79	1984-85	1977-79	1984-85	df	statistic
Lakes searched	420	557	384	384		
(Incomplete search[b])	(3)	(39)				χ^2
Lakes w/ loons	126	232	123	184	1	20.2 *
Lakes w/ breeding pairs	91	128	90	103	1	0.8
Lakes w/ chicks	73	93	72	76	1	1.0
Lakes w/ nonbreeding adults	49	149	47	120	1	40.8 *
Breeding pairs	114	157	113	132		
Nonbreeding adults	96	247	92	204		
Chicks < 1/2 adult size	128[c]	19	126[c]	17		
Chicks ≥ 1/2 adult size	36	177	36	154		
Fledging rate[d]	1.03	0.96	1.02	0.97		
						Paired t
Mean breed pair/ lake			0.29	0.34	383	1.88
Mean nonbreed adult/ lake			0.28	0.64	383	4.91 *
Area searched (ha)	53,298	64,460	51,770	51,770		
Adults/ 100 ha	0.61	0.87	0.62	0.91		
Breeding pairs/ 100 ha	0.21	0.24	0.22	0.26		

[a] Number of lakes not included in the analysis due to incomplete survey.

[b] Core lakes were completely surveyed during both 1977-79 and 1984-85.

[c] Size was not recorded for most of these chicks.

[d] Chicks fledged/ adjusted breeding pair. For the 1977-79 survey, chicks of unknown size were considered to have survived. This may inflate the fledging rate for 1977-79.

* $P < 0.01$

Table 2. Distribution, by lake size, of Common Loons in northern New York, 1984-85, and estimates of the total loon population. Only DEC data are included.

	Lake surface area (acres) hectares						
	(4-10)	(11-25)	(26-100)	(101-250)	(251-500)	(>500)	
	1.5-4.5	4.6-10.5	10.6-41.0	41.1-102	102-203	>203	Totals
Total lakes in AEZ[a]	634	550	526	155	75	61	2001
Lakes surveyed	8	38	208	128	73	57	512[b]
Percent surveyed	1.3	6.9	39.5	82.6	97.3	93.4	25.6
Lakes w/ loons	2	7	82	66	38	36	231[b]
Percent w/ loons	25.0	18.4	39.4	51.6	52.1	63.2	45.1
Ave. adults/lake with loons	2.0	2.14	1.90	2.0	2.45	4.35	2.43
Lakes w/ breed. pr.	2	3	42	35	23	23	128
Percent w/ breed. pr.	25.0	7.9	20.2	27.3	31.5	40.4	25.0
Ave. breed. pr./ lake with breed. pr.	1.0	1.0	1.0	1.0	1.0	2.18	1.23
Estimate no. 1[c]							
Lakes w/ loons		101	207	80	39	39	466
Total no. loons		216	394	160	96	170	1036
Lakes w/ breed. pr.		43	106	42	24	25	240
Total no. breed. pr.		43	106	42	24	55	270
Estimate no. 2[d]							
Lakes w/ loons		54	145	73	38	38	348
Total no. loons		116	275	146	93	174	804
Lakes w/ breed. pr.		23	74	39	23	26	185
Total no. breed. pr.		23	74	39	23	57	216

[a]*AEZ = Adirondack Ecological Zone, which consists of all lands in the Adirondack region above 305 m (1000 ft).*

[b]Surface area was not available for six lakes that were completely surveyed, one of which had loons present. These lakes are omitted from this table.

[c]Estimate no. 1 - Loons were assumed to be present on unsurveyed lakes at the same frequency and abundance as found for surveyed lakes.

[d]Estimate no. 2 - Loons were assumed to be present on unsurveyed lakes at 50% of the frequency found for surveyed lakes. The number of loons, and breeding pairs, per lake was assumed to be the same as for surveyed lakes.

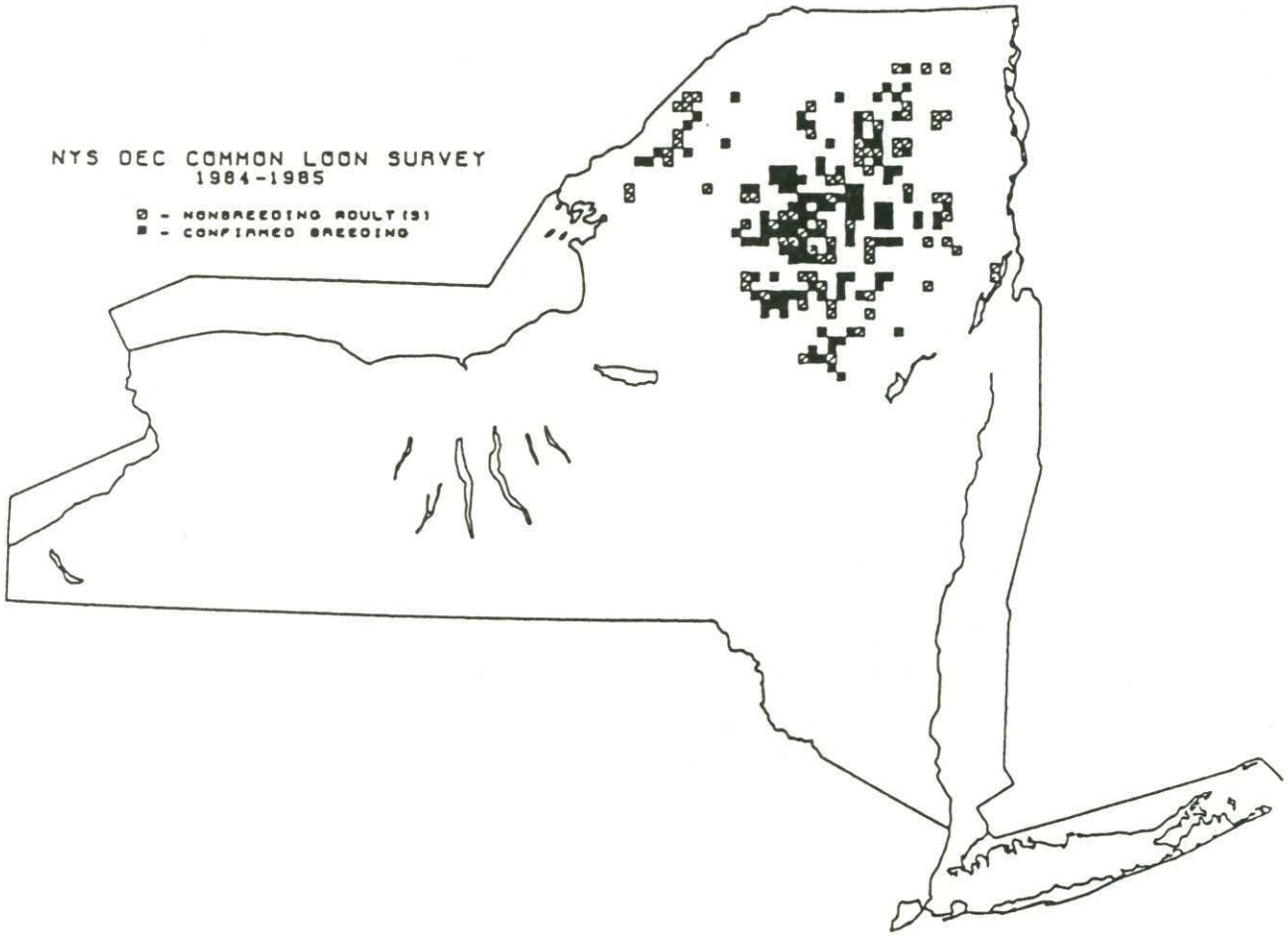

Figure 2. Distribution of Common Loons in northern New York, 1984-1985, by Breeding Bird Atlas blocks. Each block equals 25 square kilometers. Only DEC data are shown.

were 67.9 percent larger than lakes on which no loons were observed ($t = 2.17$, $P < 0.05$). Lakes with evidence of breeding were 11.4 percent smaller, averaging 158.4 ha, than lakes with only nonbreeding adults ($t = 0.37$, $P > 0.05$).

At least 1 loon was observed at 232 (44.8%) lakes visited during the survey. Evidence of breeding was found at 24.7 percent (128) of all lakes visited and at 55.2 percent of the lakes with loons present. Almost 95 percent (121) of the lakes with breeding loons supported only a single breeding pair. All the lakes with multiple breeding pairs in 1984 or 1985 exceeded 180 ha in surface area. Loon chicks were observed on 17.9 percent (93) of all lakes and on 72.7 percent of lakes with evidence of breeding.

The frequency of occurrence of loons by lake size, the total number of lakes within each size category, and the percentage of lakes surveyed were used to estimate the total loon population in the Adirondack Ecological Zone. Assuming that birds would be found on unsurveyed lakes at the same frequency and abundance they were encountered on surveyed lakes, 1036 adult loons, including 270 breeding pairs were estimated to summer in the Adirondack Ecological Zone. A more conservative approach assumed that additional loons would be encountered only half as frequently as they were found on the surveyed lakes. In this case, it was estimated that 804 loons, including 216 breeding pairs, would be present (Table 2).

Comparison with Historical Records

The 1984-85 survey included 70 lakes that were identified from Arbib's (1963) list of lakes which supported loon pairs prior to 1963. Loons were found on 46 (65.7%) of these lakes, breeding loons on 34 (48.6%), and loon pairs without evidence of breeding on another 7 (10%). Major differences in methods of data collection preclude the use of a statistical test for significance.

Comparison with the 1977-1979 Survey

There was no significant difference ($P > 0.05$) between the 1977-79 and 1984-1985 surveys in the number of core lakes with breeding loon (chi square = 0.76, 1 df), the number of core lakes with chicks (chi square = 1.04, 1 df), or the number of breeding pairs found on core lakes (paired t-test, $t = 1.88$, 383 df; Wilcoxin signed-ranks test, $z = 1.78$), although slight increases were observed for all these variables in the recent survey. However, the number of core lakes with nonbreeding adults in the recent survey was 2.5 times that found in 1977-1979 (chi square = 40.78, 1 df, $P < 0.01$).

The number of nonbreeding adults per core lake was also significantly greater (paired t-test, $t = 4.91$, $P < 0.01$; Wilcoxin signed-ranks test, $z = 4.00$). Density of adult loons on core lakes increased 46.8 percent from 1977-1979 to 1984-1985 while the density of breeding pairs increased by 17.0 percent over the same period. Calculated fledging rate differed little between the 2 surveys (Table 1).

DISCUSSION

The New York loon population can be characterized as one of low density but whose breeding pairs have a high productivity rate. Despite the apparent increase in loon density between the 2 survey periods, the density of all loons in New York (0.87 loons/100 ha) is only 17, 19, and 33 percent of that reported for loons in Itasca State Park (5.12 loons/100 ha, McIntyre 1978), Saskatchewan (4.92 loon/100 ha, Yonge 1981), and the Boundary Waters Canoe Area (2.85 loons/100 ha, Titus 1978), respectively. It is, however, almost double the density of 0.47 loons/100 ha reported for New Hampshire (Hammond and Wood 1977). By contrast, the productivity figure, 0.96 fledged young per breeding pair, is one of the highest reported in North America for a loon population. We recognize that the survey methods, involving only 1 or 2 visits to a lake, make the likelihood of recognizing a failed nesting attempt less than that of recognizing a successful attempt. However, the tendency of chicks to hide along the shoreline upon the approach of surveyors made it probable that some successful attempts were not identified as such. Whether these 2 biases cancel each other out is not known, but caution must be exercised when comparing this productivity figure with figures obtained through summer-long monitoring.

Because Arbib (1963) did not include in his list lakes that had no loons present, it is not possible to determine whether the loss of loons from one lake has been compensated for by the presence of loons at a lake that previously had none. In 1984-1985, loons were absent from 13 percent of the core lakes surveyed 5-7 years earlier, a time period much briefer than that between Arbib's report and the present. It was also found, however, that the number of core lakes with loons and the total number of loons increased between the survey periods. Thus, the disappearance of loons from many lakes listed by Arbib does not necessarily indicate a population decline, but may indicate a change in the lakes chosen by loons for breeding. Possible reasons for such a change are speculative, but in the 24 years since Arbib's list was published, there has been a considerable increase in recreational use and lakeshore development of Adirondack lakes. Changes in other habitat variables, particularly prey availability, may have occurred as well. In addition, recolonization of a lake subsequent to the natural

loss of loons may take years when there is an abundance of suitable nesting habitat. Given the increased numbers and density of loons in the Adirondacks over the period of the 2 intensive surveys, the apparent loss of loons from lakes listed by Arbib does not appear as ominous as it once did.

The question remains whether we have documented a real increase in the number of nonbreeding adults or whether the data are a reflection of differing methods between the 1977-79 and 1984-85 surveys. Members of the early survey teams who were contacted indicated that they routinely recorded the presence of nonbreeding adult loons. However, some observations probably were not noted because the data sheet used in the 1977-79 survey did not specifically request this information. In spite of this minor difference in the data sheets, we feel reasonably confident that real increases in the number of lakes with nonbreeding adults and in the number of nonbreeding adults have occurred.

Given the low density of loons in New York, it is unlikely that the large number of nonbreeding birds is due to a lack of suitable breeding habitat. Although some habitat degradation has occurred due to human disturbance and lake acidification (Parker 1985), many lakes are unoccupied by loons and many large lakes have only a single pair.

Some of the loons, particularly the nonbreeders (McIntyre 1975) may have been double-counted if they happened to be at one lake when surveyors arrived and were later observed on a second lake. For this reason, we cannot unequivocally say that 561 different individuals were observed. However, this number can be used as a point of reference for future surveys. The problem of double-counting loons is not unique to New York (McIntyre 1975, Fair 1985) and has been the impetus for conducting a single-hour, statewide loon count in New Hampshire (Fair 1985).

The high proportion of nonbreeders found in New York may indicate a growing population if many of these birds are young adults establishing territories. Alternatively, it could indicate 1) low availability of suitable nesting areas, 2) problems with behavioral or physiological aspects of reproduction, possibly resulting from contaminant loads or inadequate food supply, or 3) net immigration of loons from some other region. New Hampshire has conducted complete counts of loons within their borders during the past 10 years and has likewise noted, since 1981, a large increase in the number of nonbreeding adults (Wood et al. 1986). While this parallel occurrence does not prove or disprove any of these theories, it suggests that the increases in nonbreeding adults result from increases in population. An important question, that will hopefully be answered during a future survey, is whether the large cohort of nonbreeders will establish themselves as breeders within the next few years.

The available data suggest that the loon population in New York is stationary or slightly increasing compared to levels at the time of the 1977-1979 survey. However, the lack of long-term information concerning loon population trends necessitates continued monitoring. A repeat survey is tentatively scheduled for the early 1990's; in the interim the loon will remain on New York's Special Concern list. The continued vigilance and concern of not only the DEC, but of the recreationist who visits an Adirondack lake, and of the citizen who cares about this mysterious and beautiful birds will help ensure the continued existence of the Common Loon in New York State.

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THE STATUS OF COMMON LOONS IN VERMONT, 1978-87

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SUMMARY

The Common Loon is classified as an endangered species in Vermont. Ten years of survey data have documented an initially stationary population of 15-19 known nesting pairs 1978-82, a sharp decline to 8 pairs in 1983 and 1984, and a subsequent gradual recovery to 12 pairs in 1987 (Table 1). The mean for the 10-year period was 12.9 nesting pairs and 9.0 successful nesting pairs (at least 1 chick fledged). The statewide population estimated by the annual Loon Watch has nearly doubled in 5 years (69 birds in 1987). Increased numbers of unpaired adults and subadults have contributed the most to this increase, suggesting higher immigration or recruitment. The sudden decline in numbers of nesting and territorial pairs in 1983 is difficult to explain. Extremely wet spring weather might have caused widespread, undetected failure by early nesters, but this can not account for the twofold decrease in territorial pairs between 1982 and 1983. An interesting (but purely speculative) connection may exist between the massive Gulf Coast die-off of 5000-10,000 Common Loons during winter 1983 and Vermont's population decline the following spring. However, other Northeast states did not observe a similar decline.

Nest success has ranged from 50-90 percent, with a 10-year mean of 72 percent. Survival of Vermont loon chicks is fairly high and has ranged from 81-92 percent in the 4 years for which data are available. Productivity is also relatively high. Vermont's 10-year average is very close to 1.0 surviving chick per nesting pair. Productivity has increased substantially from 0.79 surviving chicks per nesting pair 1978-82 to 1.10 1983-87. Most breeding failure occurs during incubation. Of 44 known nest losses during the past 10 years, 15 (34%) resulted from flooding and 11 (25%) were due to predation, mostly by Raccoons (Procyon lotor). The remaining nest failures were due to human disturbance (9%), stranding (5%), or unknown factors (27%).

Patterns of lake use are difficult to interpret. Despite an apparent high degree of annual site fidelity (9 of 12 1987 nesting lakes were used in at least 6 of the previous 10 years, 4 in all 10 years), there have been a disturbing number of lakes used only 1, 2, or 3 years, and lake use shows an overall negative trend. Thirteen lakes with nesting loons in 1978-79 lost their pairs by 1986-87,

Table 1. Common Loon reproductive success in Vermont, 1978-87[a].

	1978	1979	1981	1982	1983	1984	1985	1986[b]	1987
No. of territorial pairs	21	29	24	24	12	17	16	15	15
No. nesting pairs	16	18	15	19	8	8	10	10	12
No. successful nestings	8	12	11	12	6	6	8	9	9
No. adults observed during breeding season	56	68	56	52	36	32	37	43	45
No. chicks hatched					11	7		16	12
No. chicks surviving	12	14	15	14	10	6	13	13	11
No. chicks surviving per nesting pair	0.63	0.78	1.00	0.74	1.25	0.75	1.30	1.30	0.92
Percent chick survival to fledging					0.91	0.86		0.81	0.92
No. lakes with nesting pairs	14	17	14	19	7	8	10	10	11

[a] Survey data from 1980 are incomplete and are not included.

[b] Data do not include 2 pairs each with 2 chicks found on Lake Champlain, allowing for the possibility that nesting occurred in New York State.

while only 4 lakes gained pairs during this period. There seem to be a number of lakes suitable for loon nesting (some of them historically used) that have not been used in recent years. Fish populations seem to be adequate and many of these lakes have experienced little development or recreational pressure. It may be that site tenacity and low recruitment rates inhibit active recolonization.

Vocal-tagging research on breeding males was initiated in 1987. Yodel recordings were collected from 4 males. VINS expects to obtain recordings in 1988 and beyond from all of Vermont's breeding males, as well as some non-breeders.

THE NEW HAMPSHIRE COMMON LOON RECOVERY PROGRAM

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In 1987, the Loon Preservation Committee (LPC), a non-profit, self-funded project of the Audubon Society of New Hampshire, completed its twelfth year of loon recovery efforts. LPC's goal is to stop the state's loon population decline and restore the loon to its original numbers and distribution. This goal is being realized through programs of research, management, and education.

Public education, LPC's most important management tool, remains a top priority for LPC as use of the state's lake/pond resource continues to grow dramatically. LPC continues research into the causes of mortality, causes of nest failure, new construction methods for artificial nesting islands, and recording loon yodels, and takes a first look at the effects of non-territorial loons on the breeding population in N.H.

The following report summarizes LPC's activities in 1987. Most of these activities involve staff and volunteers and are closely related to one another. This paper will highlight each major effort, but it cannot reflect the high magnitude of intersections among programs

POPULATION STATUS

LPC employed its largest seasonal field staff ever in 1987. Eight full-time biologists, working from late May to mid August, conducted the annual statewide biological survey of the loon population in N.H. Each biologist was responsible for 1 of 6 distinct territories of the state, with 2 additional staff members covering the immense single territory of Lake Winnipesaukee. The biological survey consisted of 10-12 weeks of data accumulation. Data and observations were gathered for each loon sighting, and all loon occupied lakes/ponds in the state. Data recorded for each lake/pond included: number of resident adult loons; number of territorial pairs; number of nesting pairs; number of pairs producing young; number of chicks hatched; number of chicks fledged; number of nest failures; causes for next failure and chick mortality; and other pertinent observations. Weekly reports were submitted outlining the breeding status of each territorial loon pair within the state, expected hatch dates, etc.

On July 18th, from 0800-0900 LPC held the 5th annual

statewide Loon Census. The Loon Census provides a simultaneous look at all the loon-occupied lakes/ponds and as many neighboring lakes/ponds as possible during the peak period of chick hatching. Volunteers are assigned a lake/pond or portion of a lake/pond to monitor for the entire hour. Volunteers record any loon sightings as well as the time and direction of any immigration/emigration. Data sheets are filled out in the field, returned to LPC, and compiled by LPC biologists to complete the statewide loon count. One hundred fifty-six lakes/ponds were included in the 1987 census. Over 750 volunteers participated, counting 344 adult loons, 67 chicks, and 5 immature loons. The census does not provide final population numbers but rather gives a close look at the mid-summer loon productivity within the state. Census figures are used to refine trouble areas for the end of the year population numbers.

Results of the 1987 New Hampshire Loon Survey (Table 1) indicate some positive trends toward the recovery of the threatened loon population in this state. The total loon population (410) remained relatively constant compared with 1986 (414) and 1985 (415). The distribution of loons throughout the state appears to be growing. The number of paired adult loons grew to a record high in 1987 while the number of unpaired adult loons decreased. This suggests that some previously unpaired adult loons have been recruited into the breeding population. Concomitant with this trend was the increase in the total number of nesting pairs, the number of lakes supporting nesting pairs, and the number of lakes yielding successfully nesting pairs, all to record high levels.

POPULATION AND HABITAT PROTECTION AND MANAGEMENT

Forty-one artificial nesting islands (Table 2) were floated on 11 lakes and ponds in 1987. Nesting islands were not re-floated in territories where the loons had nested successfully on natural sites the previous year or where the loon pair had not returned to the territory. Twenty-one (51%) of the nesting islands were used by nesting loons. This represents a high utilization rate accomplished in N.H. through trials for accurate placement and strict adherence to the guidelines established by LPC for placement of the nesting islands. Seven (33%) of the established nests failed to hatch chicks. Nest failures were attributed to many factors including high levels of disturbance from neighboring unmated loons, infertile eggs, and avian predation (gulls). Of 22 chicks hatched from artificial nesting islands (22% of the N.H. total), 14 survived to fledge (21% of the N.H. total); resulting in a 64 percent survival rate, jut below the statewide rate of 69 percent. The number of chicks surviving to fledge per raft-nesting pair was 0.66, below the statewide average of 0.76, due to greater mor-

Table 1. Common Loon population and productivity data from New Hampshire 1976-1987. * indicates highest value recorded during the period.

YEAR	76	77	78	79	80	81	82	83	84	85	86	87
Lakes with TP	58	48	44	52	50	62	57	68	65	70	77*	75
Lakes with NP	NA	34	36	39	37	47	45	47	39	46	48	50*
Lakes w/succ NP	23	21	25	28	33	34	37	34	26	38	36	40*
Adults - paired	186	178	164	188	174	190	208	230	236	234	244	260*
Adults - unprd.	28	39	50	24	32	59	49	49	76	100	102*	81
TOTAL NUMBER ADULTS	214	217	214	212	206	249	257	279	312	334	346*	341
Immatures	6	4	4	4	5	8*	5	1	1	4	3	1
Chicks (Aug.)	51	40	36	55	52	51	76	83*	60	77	65	68
TOTAL LOON POPULATION	271	261	254	271	263	308	338	363	373	415*	414	410
Territorial Prs	93	89	82	94	87	95	104	115	118	117	122	130*
Nesting Prs.	NA	62	59	67	61	74	82	89	80	83	86	90*
Succ. Prs.	41	31	31	42	41	42	61	67*	50	59	60	60
Chicks Hatched	57	45	46	67	65	62	91	102*	77	94	95	99
Chicks Surv'd	51	40	36	55	52	51	76	83*	60	77	65	68
REPRODUCTIVE SUCCESS												
#CH/TP	.61	.51	.56	.71	.75	.65	.88	.89	.65	.80	.78	.76
#CS/NP	NA	.65	.61	.82	.85	.69	.93	.93	.75	.93	.75	.76
% Chick Surv.	89	89	78	82	80	82	84	81	78	82	68	69

TP = territorial pairs
NP = nesting pairs
CH = chicks hatched
CS = chicks surviving

Table 2. Summary data for artificial nest island use in New Hampshire, 1987.

Nesting Islands

41 islands floated
21 islands used for nesting
20 islands not used for nesting
50% usage
7 nest failures = 33%

Chicks

22 chicks hatched from islands
22% of N.H. state total
14 chicks survived to fledge
21% of N.H. state total

Survival Rates

64% survival of raft-hatched chicks
36% mortality of raft-hatched chicks
0.66 chicks survived to fledge/raft-nesting pair

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tality rate of chicks from artificial nesting islands in 1987.

Active nesting and brooding territories are protected by staff and volunteers from human disturbances wherever necessary. Protection efforts include monitoring nest sites from boat and shoreline areas, warning away potential disturbers (canoeists, fisherman, waterskiers, etc.), educating others in the vicinity regarding the presence of the loons and the importance of an undisturbed nesting and brooding period to the success of the pair. Other protection efforts include roping off nesting and brooding areas and placing floating signs (LOON NESTING SANCTUARY/PLEASE STAY AWAY) to discourage entrance. In high traffic and/or critical areas (Lake Winnipesaukee), larger, more forceful signs are posted (LOON NESTING AREA/KEEP OUT). LPC also continues site protection through encouragement of land protection by cooperation with private owners and with the newly formed Trust For New Hampshire Lands (TNHL), TNHL is a limited term, non-profit organization created to use state funds for the acquisition and protection of critical land areas in N.H. Upon initiation of the TNHL, LPC created a Nest and Chick Fund as a means of raising matching funds to help TNHL protect land areas with special concern to loon nesting and brooding territories.

RESEARCH AND DETERMINATION OF MANAGEMENT REQUIREMENTS

LPC continued the Yodel Recording Project started in 1985. In this third year of the project, 20 recordings were submitted to the Dane-Murdough Bioacoustic Laboratory for analysis. Comparison of these recordings with yodel recordings on the same territories from previous years will allow biologists to recognize the return of individual male loons and provide valuable data toward investigations in areas such as longevity, breeding ecology, and factors of mortality. Volunteer assistance has been an important factor, and LPC is presently refining its guidelines for the use of volunteers in the Yodel Recording Project. New recording methods have recently been developed and tested in northern Michigan. LPC successfully tested this method in 1987, and will continue to utilize it in chosen areas in N.H. during the 1988 breeding season.

LPC continued research into the causes of adult/chick mortality and nest/egg failure. Loon carcasses were collected by LPC staff and delivered to the University of New Hampshire's Veterinary Diagnostic Lab for postmortem examination. Results of these exams are kept on file by LPC. These reports show that the greatest source of mortality in adult loons is lead poisoning from lead fishing sinkers left in the water. Loons pick up these toxic sinkers along with other gravel used in their gizzard.

This heavy metal is fast acting and highly lethal to loons and other wildlife species.

Failed loon eggs and eggshell fragments from successful hatches were collected by LPC staff wherever possible. Eggs and shell fragments are held by LPC for future analysis.

Research continues in the modification of artificial nesting islands. Bottle-type or "jug" rafts continue to be used, but have been limited to specific areas where their use in previous years has been successful. LPC piloted a slightly modified version of the original log raft design. On some lakes/ponds the water's chemical make-up has resulted in corrosion of the wire mesh used to hold the nest bowl above water. In 1987, LPC replaced the wire mesh with a heavy plastic mesh (snow fencing) in an attempt to increase the lifespan of the log rafts. Rafts built in this fashion were successful in 1987. LPC will continue to use this model.

As a result of many observations of intense territorial defense encounters between loon pairs and intruding, unpaired loons, LPC has begun efforts toward a new research project. In 1988, LPC will begin an intense look at the effect of non-territorial loons on the breeding population in New Hampshire. Funding for this project will be generated through grants and foundations.

EDUCATION

LPC's educational efforts are aimed at reaching as many communities and people as possible in an attempt to inform the public and change human attitudes and behaviors which negatively affect loon success. Educational opportunities arise in all forms, from informal discussions between staff and lake residents to organized "loon watches" during critical nesting/brooding periods, presentations for children's groups, and formal lectures for clubs and colleges. LPC staff biologists practice "people management" throughout the summer as often as loon management. Biologists post educational posters on public landings, beach areas, and local businesses. They distribute literature on LPC and the biology of the Common Loon. News releases and newsletters are written and distributed regularly. Because of the high visibility of LPC staff both in the field and office, behavior and attitude are themselves sources of education for the public. Youth For Loons, a children's program, was held for the second year this summer. Over 20 children participated in the program, which was developed and run by LPC staff.

1987 was the pilot year for LPC's "Loon Educational Unit" for N.H.'s public school system. Working in concert

with Audubon Society of N.H. teacher/naturalists, LPC has developed an 8-lesson program designed to introduce students to the life requirements, morphological characteristics, and habitat demands of the Common Loon. Students study problems and questions presented by the program and discover answers through a series of investigations involving worksheet activities, educational games, field trips, experiments, and active discussions. The program was successfully presented to three elementary and junior high school classes in 1987. Plans for the Loon Unit include formal publication of a teacher's manual and student workbook, additional classroom presentations, and docent training workshops. Ultimately, the Loon Unit will be available to all schools within the N.H. Public school system, and distributed primarily through trained docents. The project was completely funded by matching grants from members of the Mudd Family of Whitton Pond, N.H.: Dr. Emily B.H. Mudd, S. Harvey & Marion H. Mudd, John H. Mudd, and Edward Chapman. Our deepest gratitude for their generosity which has made this invaluable project possible.

ADMINISTRATION AND FUND RAISING

Since 1982, LPC has received no government funding. Fund raising for the Committee is completely provided by individuals and private sector granting organizations. Major fund raising sources for LPC are The Loon's Feather shop at LPC headquarters, and the annual Loon Festival. LPC wishes to extend a heartfelt thank you to all contributors, Loon Festival Sponsors, and the following grantors for their valued support:

> William G. and Elizabeth J. Barnhart Foundation, Clark Charitable Trust, Henry F. Hurlburt III Charitable Trust, Robert H. and Gertrude E. Sedgley Charitable Foundation, Squam Lakes Association.

MEMBERSHIP

LPC's mailing list if continually growing, reaching almost 3500 names in 1987 with an active volunteer network of over 4000. Volunteer efforts and commitment continue to grow, contributing enormously to the success of the statewide loon recovery effort.

MAINE COMMON LOONS: A GLANCE BACK AND AN EYE TOWARD THE FUTURE

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Common Loons (Gavia immer) have been an integral part of the Maine landscape for thousands of years. Studies in recent years have supported early findings (Knight 1908, Bent 1919:47-62, Palmer 1949) of statewide loon distribution and the increasingly serious threat that lakeshore development poses to loon productivity. The Maine Audubon Society and the Maine Department of Inland Fisheries and Wildlife (IF&W) initiated a joint study in 1977 and 1978 to determine the general status of loons in Maine. Maine Audubon has continued yearly censusing, working cooperatively with the University of Maine 1983-1985. Several research projects have been conducted through the University of Maine at Orono (Christenson 1981, Strong 1985), in part to determine the effects of human disturbance on loons.

Our knowledge of Maine's loon population, of loon behavior, and response to human encroachment into their habitat, has expanded over the past 10 years. A variety of methods have been used to determine population status. The Maine Audubon Loon Count combines aerial surveys with a ground count conducted by volunteers coordinated on lakeshores for a simultaneous count in mid-July. A Winter Loon Count spanned 3 years to discover locations of wintering birds and the coastal areas with concentrated loon populations. Reports from interested individuals are compiled for information on lake populations and productivity, to direct attention to lakes with problems, and to keep communication open between involved, interested citizens and environmental organizations in the state such as Maine Audubon, IF&W, and the Department of Environmental Protection. Since the Loon Project began in 1977, the Maine Audubon Society has served as a clearinghouse for a variety of loon information, including arrival dates, nest locations, presence or absence of loons and chicks on many lakes, hatching dates, chick mortality, the location of large groups of rafting loons in the fall and wintering loons. The dedication of a tremendous network of volunteers has been the major force responsible for our greater understanding of the status of loons in the state of Maine.

METHODS

The Loon Count, the primary tool used to obtain population data in a standarized manner, has been conducted from 1983-1987. The Count methodology has 2 distinct segments, a ground count and an aerial count. The ground count is designed to be easily reproduced by a large group of volunteers from year to year. All chosen lakes are censused during one half-hour period (0700-0730) on the third Saturday in July. The results, therefore, are expected to be relative to previous years' counts rather than an actual representation of the number of loons on a given lake. To compensate for the sparse human population on northern lakes, an aerial survey was also conducted for several years (1984-1986).

The purposes of the Aerial Count are two-fold: 1) to obtain a count of loons on lakes which are too distant or too remote to be adequately covered by volunteer ground counters and, 2) to develop a formula to determine the difference between the number of loons counted when surveyed by the ground count as compared to the numbers of loons counted by the aerial count. Over 3 years, 99 lakes were surveyed by both count methods to arrive at a conversion factor.

A computer-selected random sampling list of 200 lakes was broken down into 7 size categories which represent all the lakes from the IF&W lakes list for Maine. These were further subdivided into a northern and a southern region, with the dividing line running approximately west to east from Rangeley to Calais. Only the results of the random sample lakes are extrapolated each year to estimate the loon population for the entire state, though 200-300 additional lakes are surveyed annually. The extrapolation formula used for each of the 7 lake size classes is:

$$\frac{\text{\# random lakes sampled}}{\text{\# loons counted}} \qquad \frac{\text{total lakes}}{\text{(population estimate)}}$$

Northern and southern size classes were calculated separately, then the totals added together. Population estimates from 3 years (1983-1985) were averaged to create a baseline number with which to compare future count results.

To better understand the status of loons during the winter months, a Winter Loon Count was conducted 1983-1985. For the first 2 years, volunteers were responsible for surveying a span of the coast from Kittery to Lubec during the second week of February. Each participant followed the same route each year. During the third and final year, observers counted loons during February, March and April. Approximately 60 people participated in the census which gave baseline data and an indication of wintering patterns of loons.

Productivity data, including nesting and hatching success has been collected from interested lake dwellers and visitors over a period of years with increased emphasis in 1987. Nesting data from 1985 through 1987 have been collated.

An increasing number of artificial nesting islands have been built and maintained on Maine lakes. Nest platform building plans with siting information have been widely distributed and records maintained on all known islands.

RESULTS

Population Estimates

The Maine breeding Common Loon population estimate is 3498 adults, the mean of 1983-1985 data. The actual number of adults and chicks on random and non-random lakes counted during Loon Counts increased by over 400 1983-1986 while the number of lakes surveyed remained nearly constant (Table 1). This is probably the result of increasingly organized coordinators and counters rather than actual an increase in the number of loons.

Data for 1987 were not directly comparable to data from previous years. In 1987, all but 2 of the lakes were from the southern region. Therefore the population extrapolation for the whole state was derived by using a slightly different formula than in previous years. Results of all surveyed lakes were extrapolated for the entire state by adding the number of northern and southern lakes, though only southern lakes were actually counted. The result of this analysis from random lake figures was 4746 adults and 728 chicks. This compared favorably to the analyzed result of all the lakes (random and non-random) surveyed: 4635 adults and 702 chicks. When southern random data from 1986 were extrapolated in the same manner, the result was 4352 adults and 707 chicks, a higher result than obtained by analyzing northern and southern populations separately.

Aerial-Ground Survey Comparisons

A comparison of the 2 survey methods showed that aerial counts of lakes underestimated the number of adult loons. The difference between aerial and ground counts varied greatly among lakes in 1985 and 1986. However, when the sums of the ground counts were compared to the sums of the aerial counts, the span of variation was not as great. Aerial counts underestimated ground counts by a factor of 3.51 in 1985 and 2.02 in 1986 with a two year average of 2.77 (Table 2).

Table 1. Numbers of adult and chick Common Loons counted and estimated adult population in Maine 1983-1986.

	No. Lakes	No. Adults	No. Chicks	Estimated Adult Pop
1983	285	833	124	3012
1984	306	1000	108	3531
1985	295	1036	159	3951
1986	296	1283	180	3367

Table 2. Factor of difference between aerial and ground counts of adult loons in Maine by lake size.

Lake Size (Acres)	# Lakes	1985	1986	85+86
All Lakes	53	3.51	2.02	2.77
201-500	17	2.83	1.33	2.08
501-2000	20	3.78	2.21	3.00
2001-4000	10	4.03	2.37	3.20
4001+	6	3.40	2.15	2.77

Nesting Data

Since 1985 more than 350 nests have been located. Nest success data is as yet in formative stages and will be studied more closely in the coming years.

Nest failure and chick mortality data were compiled from 14 lakes in 1987. The lake list was not a random collection, but came from reports from loon activists, skewing the applicability for the rest of the state. All 16 nests reported failed due to water level fluctuation, primarily water level rise. Reported chick mortality (n=16) fell into 3 categories: motor boats or jet skis (n=7), predation (n=7), and other causes (n=2). Suspected predators included turtle, gull, osprey, and raccoon. One loon chick was found with thorns in its throat and another was killed by adult loons.

Since the first Maine artificial island nesting platforms were built in 1981, at least 23 artificial platforms have been put into place. Use of the islands has been 25-50 percent in all years even as the number of islands has risen (Table 3).

Population Density

Loon densities have been calculated and mapped for the 14 southern count regions by determining the number of loons per 100 acres of lake surface area surveyed for each region (Figure 1). Density figures from 1987 range from 0.076 loons per hundred acres in Cumberland County, which surrounds Portland, the largest city in the state, to 1.12 loons per hundred acres in Lincoln and Waldo Counties. Density figures vary somewhat from year to year but basic generalizations have held true. In areas of dense human population, such as York, Cumberland and Kennebec Counties, lower Common Loon population densities were found. There were some surprising findings, however, that point to the distinct need for further research. One discrepancy was found in the Washington County area, Region 13. This is an area of many lakes and a fairly low human population, yet the density figures for that region were equal to or lower than the southwestern (and most populated) corner of the state. The reasons for this are not clear. They may merely point to an altered method of censusing from the standard, or they may be an indication of serious environmental problems in the region. The sample size of the northern lakes was too small for meaningful density estimates.

Winter Counts

The greatest number of wintering Common Loons was recorded in 1985 when 478 loons were counted. The 1983 total was 361 and the 1984 total was 284 loons. Most of the

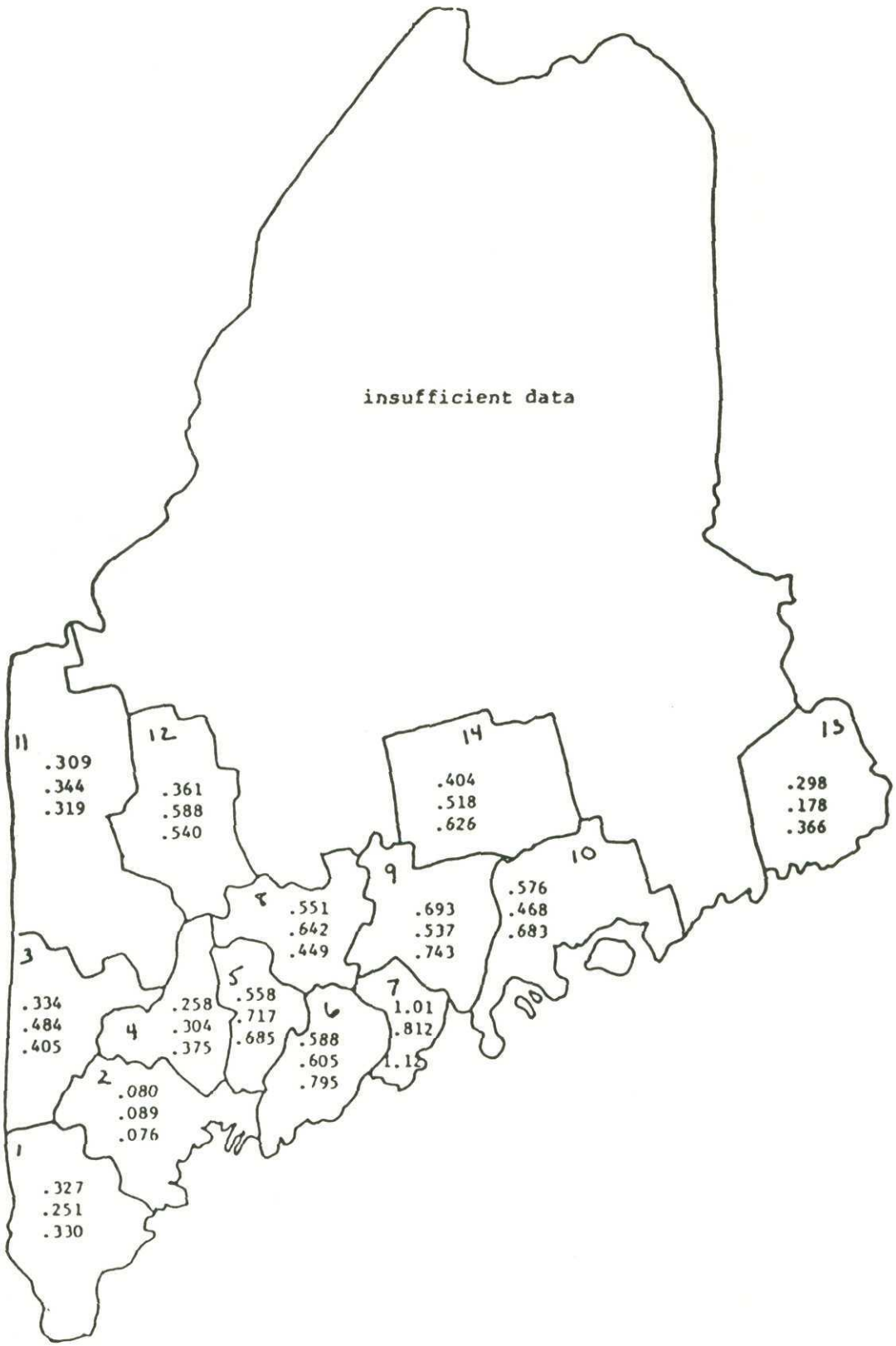
Table 3. Use of artificial nesting islands by Common Loons in Maine.

Year	No. Placed	No. Used	No. Successful	No. Chicks	Percent Used
1981	4	1	1	2	25%
1982	4	2	2	4	50%
1983	4	2	1	2	50%
1984	4	2	2	1	50%
1985	12	3	2	1	25%
1986	19	5	5	8	25%
1987	23				

Table 4. Number of Common Loons counted during February along the coast of Maine 1983-1985

Area	1983	1984	1985
Kittery-Saco River	37	33	53
Saco River-Portland Head Light	88	41	40
Portland-Freeport	4	0	23
Brunswick-Boothbay Harbor	43	39	79
South Bristol-Stockton Springs	34	57	99
Buckport-Blue Hill	33	11	18
Blue Hill-Mt. Desert Island	64	47	48
Frenchman Bay-Red Beach	58	56	117
Total	361	284	478

Figure 1. Summer densities of Common Loons (birds/100 acres) in Maine 1985-1987. Values for each region read chronologically from top to bottom.



sightings were of 1-3 loons although several concentrations of loons were seen in roughly the same locations all 3 years. Areas of the greatest concentrations of loons were Saco Bay, Port Clyde to Spruce Head, and Mount Desert (Table 4).

DISCUSSION

Knowledge of lakes on which loons are seen must be supplemented by more productivity data. Clearly, with the abundance of adult loons and more than 2700 lakes greater than 10 acres in size in the state, the population surveys are not fully assessing the number of chicks produced each year.

The population assessment for northern Maine is also probably underestimated. The cost of aerial surveys and the elusive nature of a ground count/aerial count conversion formula have hindered comprehensive surveys in northern Maine. Remote northern lakes with prime loon nesting habitat combined with the data gathered indicate a healthy population, indeed the bulk of Maine loons, on northern lakes.

The trend which has seen the southern edge of the loons breeding range move increasingly north is most likely continuing in Maine. With upward spiraling costs of waterfront property in Maine, development pressures on loons, other waterbirds, fish and other animals dependent on lake ecosystems are great. Countless acres of lakeshore containing suitable loon nesting habitat have been lost to development, the effects on loons indicated by the low loon densities in highly developed areas. Not only are shorelines being developed, but lakes within easy commuting distance of major human population centers are experiencing many-tiered development. Layers of homes surround lakes with public access points exponentially increasing seasonal recreational use of the lake. Direct habitat loss, flooding of nests, and nest abandonment due to human disturbance influence successful cohabitation between loons and people. Indirect factors such as degraded water quality, and an increase in predators such as raccoons attracted to human debris also come into play as lakeshores are developed.

Lake protection is gaining momentum in Maine. Private organizations such as the Maine Audubon Society, the Lakes Environmental Association and individual lake associations are working through education and legislative channels to protect lakeshores and foster wise recreational use of lakes. Some public agencies are making some moves in the same direction. The Maine Department of Environmental Protection's Environmental Evaluation of Lakes Study has developed a lake vulnerability index for all Maine lakes based on their ability to withstand phosphorus. A recent

Maine study found phosphorus concentrations in run-off from a residential development 5 to 10 times greater than from a similar forested piece of land. The vulnerability index model can be utilized in several ways to base local planning on water quality-limiting criteria.

Public awareness of loons' special needs has grown. One town's Planning Board used loon data from the Maine Audubon Society Loon Project in the review of a subdivision proposal. An Augusta area town included loon data when reviewing and rewriting their comprehensive plan. Loon interest groups, such as lake associations are developing political sophistication and clout, making them better able to play a vital role in local and regional decision-making. Lake associations are able to conduct inventories of natural resources, including close monitoring of the loons and their nesting success and are organized for political action when called for. Environmental concerns which affect loons are being extended to the concerns of all residents and visitors. Loon data are often incorporated into arguments of control of lake development. Kezar Lake, Hobbs Pond, Damariscotta Lake, Lake Saint George, and Parker Pond are but a few of the lakes on which loon data have played a role in local decisions concerning alterations to the lakeshore.

Artificial islands remain an important tool for increasing loon productivity on lakes with water level fluctuation on predation problems. They have been used in 2 Maine/New Hampshire border lake agreements negotiated with Union Water Power Companies on Lake Umbagog and the Androscoggin Reservoir Company on Aziscohos Lake through the Loon Preservation Committee of The Audubon Society of New Hampshire. These artificial islands should in no way be looked at as solutions to the serious and complicated problems involved in negotiating stable water level regimes or protection of tradition nesting habitat for loons, but serve a valuable function when no reasonable alternative exists.

While strides have been taken towards sustainable lake management, many of the factors influencing loons in Maine are beyond the control of concerned groups and individuals. By petitioning IF&W, towns are able to get motorboat horsepower or speed restrictions imposed, but the benefits are extremely localized. Even with educational efforts, individuals still perceive a conflict with loons for fish. In 1987 a young man shot 2 loons, killing 1, because of this perceived conflict. The man was caught and fined the maximum allowed by the law, a rare victory. Incentives to develop lakeshores are very powerful and the cumulative impacts are poorly measured and difficult to address.

Many questions concerning the status of loons in Maine remain unanswered. More study must be conducted to determine an accurate assessment of productivity patterns and their relationship to human population, migration, winter biology and behavior, tolerance levels to recreational vehicles, percentage of breeding to non-breeding adults and many other issues. With greater public understanding and more involvement in political action, environmental protection may be forced to become a primary consideration for future actions.

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THE RECOLONIZATION OF MASSACHUSETTS BY THE COMMON LOON (*Gavia immer*)

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The Common Loon has experienced reductions in its breeding range across the northern tier of the lower 48 United States (Plunkett 1979). In Massachusetts, Common Loons have recolonized parts of the state after extirpation nearly a century ago. This paper describes the history of nesting Common Loons in Massachusetts since the late 1800's, recent breeding population data, and efforts to enhance the survival of loons in the state.

HISTORY

Pre-1926

Forbush (1912, 1925) stated that "probably the Common Loon once bred in suitable locations throughout Massachusetts." Forbush himself found breeding loons in northern Worcester County, circa 1880, though the specifics of his records are unknown. He was unable to learn of any definite loon nestings in 1912, and by 1925, considered them "gone, perhaps never to return." Allen (1864) reported nesting in the Springfield vicinity, while Morris (1901) recorded them as a "former resident" there. Bent (1919) mentioned that he found a pair nesting at Quittacas Pond, Lakeville, Plymouth County in 1872. He related that the eggs were stolen and the birds shot by vandals. Brewster (1888) noted that 1-3 pairs regularly nested in the neighborhood of Winchendon, Worcester County. Ingalls (1889) gave Ballou's and Wellington's Reservoirs in Winchendon and Otter River Reservoir in Templeton as nesting stations. Stone (1937) considered the last authentic nesting record in the Lunenburg, Worcester County region to be at Lake Naukeag, Ashburnham in 1884. Bagg and Eliot (1937) suggest the species once nested in Franklin County. Common Loons may have nested on Cape Cod ponds (Hill, 1965) though specific data are lacking and this seems rather unlikely.

Clearly, the Common Loon was never a common nesting species in Massachusetts. The historical record, though scant, suggests it bred principally in northern Worcester County at least to the late nineteenth century. After 1900, the species is presumed to have been extirpated and there are no reports of nesting until mid-century.

1926-Present

In 1926, the Metropolitan District Water Supply Commission began land acquistion in the Swift River Valley for creation of the Quabbin Reservoir (Quabbin). Flooding of the valley began in August 1939, and the water reached spillway level (159.72 m above sea level) in May 1946, creating an immense 100 square-km reservoir. Nesting of loons was suspected here off and on from as early as 1949 (field records, The Chickadee, 1931-present). However, nesting confirmation proved elusive owing to remoteness, restricted access, the limited number of persons deliberately searching for loons, and probably a certain element of casual indifference at the time. Meanwhile, a documented nesting occurred at nearby South Spectacle Pond, New Salem, Franklin County in 1943 (Allison and Allison 1943). Nesting was eventually confirmed at Quabbin in 1975 (Lafountaine 1976) and has been documented there regularly in all subsequent years except for a lapse in 1978-1980 for which data are lacking. It seems a reasonable presumption that nesting occurred in these years as well as at least sporadically in the pre-1975 period,

Since 1975, a gradual expansion and increase of the state's loon population has occurred. The number of territorial loons at Quabbin increased to 6 pairs during 1985-1987. In 1984, a nesting pair was confirmed at Wachusett Reservoir, and during 1985-1987, confirmed nesting pairs turned up at 3 additional lakes (Table 1). One of the lakes, Upper Naukeag Reservoir is a documented historical station (Stone 1937). Interestingly, all 5 nesting stations are public drinking water reservoirs with restrictions on watershed access and use. No boating is allowed except at Quabbin Reservoir (motorboats, maximum 20 hp) and Upper Naukeag Reservoir (rowboats).

MANAGEMENT ACTIVITIES

A small management program for loons was begun in 1982. Efforts have been concentrated on population monitoring and enhancement of nesting success through nesting raft deployment and public education.

Table 1. Distribution of territorial pairs of Common Loons (*Gavia immer*) in Massachusetts, 1975-1987 (no data were collected 1978-1980).

Water Body	1975	1976	1977	1981	1982	1983	1984	1985	1986	1987
Quabbin Reservoir	1	1	1-2	4	5	5	5-6	6	6	6
Wachusett Reservoir							1	1	1	1
Upper Naukeag Reservoir										1
Bickford Pond										1
Fitchburg Reservoir										1
Total	1	1	1-2	4	5	5	6-7	7	7	10

Monitoring Program

In 1984, the Metropolitan District Commission, Massachusetts Division of Fisheries and Wildlife, and the Massachusetts Audubon Society initiated a joint monitoring program. Start-up of the program (1984-1986) was funded in part by grants from the North American Loon Fund. Loon wardens and observers were assigned to the Quabbin where the loon population was characterized in detail for the first time, nest sites monitored, threats documented, behavioral observations made, and productivity data collected (Lyons and Ehrhardt 1984; Lyons and Weaver 1985; Lyons and Rezendes 1986).

In 1987, a major reconnaissance effort was undertaken for the first time. Forty-four water bodies, spread over 11 USGS quadrangles, generally in northern Worcester County, were examined July 5-11. More than half (25) of the water bodies were reservoirs totally closed to boating and with generally restricted access. Nesting loons were encountered on 3 of these reservoirs.

Nesting Raft Deployment

In 1982, a pilot project was launched by the Division of Fisheries and Wildlife in conjunction with a student at Worcester Polytechnic Institute and the City of Worcester Department of Public Works, Water Operations. Rafts constructed of wood and screening were deployed at three Worcester-owned reservoirs--Pine Hill in Rutland, Kendall in Holden, and Quinapoxet in Princeton. None of the rafts were used by loons. Although the reservoirs appeared suitable for loon nesting, none harbored any resident pairs and no loons were seen. Considerable experience in raft construction and deployment was gained in this initial field season that proved helpful in subsequent seasons.

The following year (1983), two 1.2 square-m cedar log, "conventional" rafts (Sutcliffe 1979) were floated at the Quabbin. Since 1983, additional rafts have been added. In 1987, 6 rafts--5 "conventional" and a 2.5 square-m model equipped with sloping ramps on all 4 sides--were deployed at Quabbin, and a single "conventional" raft was floated at the Wachusett Reservoir. In addition, an experimental, 2.7 m diameter, saucer-shaped fiberglass model was field tested in 1987. One pair of loons used a "conventional" raft at Quabbin in 1986 and 1987, hatching one chick each year.

Public Education

Information on loon biology, behavior, and nesting requirements has been disseminated to boaters and to the general public since 1984. This effort has involved personal contacts, information postings, brochures and slide

presentations. A library of photographic slides has also been developed and is now being used to produce slide shows and displays.

Media coverage of management activities has greatly aided our efforts. Periodic press releases and personal presentations have generated interest in Massachusetts loons by several television stations and various local, regional and even national publications.

Public education activities have played a major role in building support and acceptance for loon management efforts. In addition, agency image has been enhanced through these activities, resulting in further, often indirect benefits.

SUMMARY AND OUTLOOK

Common Loons are slowly, but clearly reoccupying historical range in Massachusetts. This trend may have begun as early as 1943, but has become evident only since 1975. The Massachusetts population has grown from 1 known pair in 1975 to 10 known pairs on 5 water bodies in 1987. A 10 year (1975-1987, except 1978-1980) mean of 2.5 chicks have fledged (survival to 1 September) annually in Massachusetts with a range between 0 in some (3) years to 7 in 1987 (Table 2). In the same period, a mean of 0.81 chicks per nesting pair have fledged.

Because Massachusetts is located at the southern fringe of the loon's natural range and the number of pairs in Massachusetts is small, no conclusions can be drawn for the population as a whole. However, its solid reestablishment here is suggestive of a generally stationary or increasing core population further north, which has perhaps heightened availability of potential colonists.

Field reconnaissance indicates substantial habitat supplying the necessary requisites for loon nesting remains available in Massachusetts. These areas are primarily surface water reservoirs which are closed to boating of any sort and with watersheds highly restricted or closed entirely to public access. Many of these reservoirs have no shoreline development and offer pristine, undisturbed conditions for nesting loons. Recent trends and the availability of such additional unoccupied water bodies suggest that continued gradual increase in the Massachusetts loon population is likely through the remainder of this century.

Table 2. Selected summary data for Common Loons (*Gavia immer*) nesting in Massachusetts, 1975-1987 (no data were collected 1978-1980).

Year	No. Lakes	Terr. Pairs	Nest Pairs	Nest Attempts	Succ. Nests	Chicks Hatched	Chicks Alive 1 Sept.	Chicks Fledged/ Nest Pair
1975	1	1	1	1	1	2	2	2.00
1976	1	1	1	1	0	0	0	0.00
1977	1	1-2	1	1	1	2	2	2.00
1981	1	4	3	3	3	5	5	1.67
1982	1	5	3	3	0	0	0	0.00
1983	1	5	3	3	0	0	0	0.00
1984	2	6-7	5	7	3	4	4	0.80
1985	2	7	3	4	1	1	1	0.33
1986	2	7	6	8	4	5	3	0.50
1987	5	10	9	10	5	8	7	0.77

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THE ONTARIO LAKES LOON SURVEY - STATUS REPORT

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The Common Loon (Gavia immer) is a common breeding species throughout most of Ontario, particularly in the Precambrian Shield area (Cadman et al. 1987). It formerly bred in the extreme southwestern portion of the province, but populations there were probably never very substantial (Peck and James 1983).

Acid precipitation has become a serious environmental threat in eastern North America, particularly in its effects on aquatic ecosystems. The pH of rain falling in the Shield area of Ontario ranges from 5.0 in the northern areas to as low as 4.2 in the southeast. Similarly, sulfate depositions range from 10 kg/ha/yr in the unaffected north to 20, 30, or 40 kg/ha/yr in the Shield and southern area. These depositions have been linked to changes in the abundance, composition, and distribution of biota in various levels of the aquatic food chain.

Recently, acid precipitation has been suggested as posing a threat to loons (Barr 1986). Among other effects, increased acidity of lakes with naturally high levels of mercury may increase uptake of mercury by fish, and hence loons (Barr 1986). Consequently, the Common Loon may be used as a biomonitoring species for studying the effects of acid rain on aquatic ecosystems.

The loon seems ideally suited to a biomonitoring study for 3 reasons. First, it is part of a higher trophic level, and should therefore reflect broad changes in aquatic ecosystems. Second, the loon is a conspicuous breeding species in Ontario. Finally, its symbolic importance to Canadians, environmentalists, and all nature lovers makes it a "high-profile" species which is capable of generating sufficient interest on the part of volunteers. In 1980, the Long Point Bird Observatory initiated the Ontario Lakes Loon Survey (OLLS).

RESULTS OF THE SURVEY (1981-1986)

The survey was originally designed to have volunteers across Ontario monitor loons at their cottages or homes or while vacationing. Volunteers filled in questionnaires and returned them at the end of the summer. The questionnaires asked participants to make notes on the numbers of adult and

young loons they observed on the lakes and also to comment on human disturbance in the form of development and recreational activities.

Although the first year was hampered by a nation-wide mail strike, over 330 lakes were surveyed by volunteers and survey staff. Observers reported 247 pairs of adults and 214 young.

For adults with young, mean brood size was 1.5 (Table 1, Silieff and Hussell 1982). The amount of recreational boat use on a lake seemed to have no significant effect on the presence of loons with young (Table 2). This was also true for the effects of shoreline development on loon productivity. Reports of the historical effect of shoreline development indicated that numbers of loons had declined over the years with increases in numbers of cottages. Some local effects of recreational use were also observed. For example, boat routes on large lakes left bays and inlets relatively undisturbed for nesting loons. In contrast, nests on small lakes that were part of canoe routes were more prone to disturbance (Silieff and Hussell 1982).

Lakes in Ontario are divided into 5 acid sensitivity classes based on Ministry of the Environment (MOE) classifications. These classifications define alkalinity as the acid neutralizing capacity of an aquatic ecosystem (Anonymous 1987). The classifications range from level 5 (lakes not sensitive to acid loadings and capable of withstanding heavy acid loadings during spring run-off without biological damage) to level 1 (lakes which have zero or negative alkalinity and have already become acidic). These acidic lakes may have many or all fish species absent. Volunteer lakes were matched to a sensitivity level using available MOE results. Results from 1981 revealed decreasing chick production with increasing acid sensitivity (Silieff and Hussell 1982). These results, however, were not statistically significant ($p > 0.25$, Table 3).

In 1982, 456 lakes were surveyed by volunteers. Again, inconclusive results were obtained regarding the effects of human activity on loon breeding success. However, an analysis of 211 lakes indicated a significant decline in breeding success with increasing acidity ($p < 0.05$, Table 4). An analysis of 66 staff-surveyed lakes indicated lower breeding success rates on lakes with alkalinities less than 130 ueq/l and on lakes with pH's less than 6.0. Other factors were analyzed, but their effects on loon breeding success were not significant (Alvo and Hussell 1983).

In the third year of the study, 409 lakes were surveyed by volunteers. Again, a lower success rate for acidic lakes versus non-acidic lakes was indicated in an analysis of 213 lakes (Table 5). However, these results were not siginifi-

Table 1. Summary of loon abundance and breeding data in 1981.

	Data Source			Totals
	A	B	C	
# lakes surveyed	81	70	188	339
# adults sighted	295	125	475	897
# of loon pairs	130	34	83	247
Average # loon pairs/lake	1.6	0.5	0.4	0.7
# young sighted	84	20	110	214
Average # young/loon pair with young				1.5

Data Source A - Volunteer response
B - OLLS field work
C - Casual reports

Table 2. 1981 data on boat use and presence of young loons.

	No boating/ Boating irregularly (No Motors)	Boating Regularly (No Motors)/ Infrequent Motorboats	Frequent Motorboats
% of lakes with loons which also have young	65	50	63

Table 3: Common Loon productivity vs. lake sensitivity for lakes surveyed in 1981.

	Lake Sensitivity Classification[a]				
	NS	LS	MS	ES	A
# lakes with loon sightings	31	9	42	11	4
# lakes with adults only	15	6	24	10	1
# lakes with young	16	3	18	1	3
% with young	52		41		27

[a] Lake Sensitivity Classifications:
NS - not sensitive to acid loadings, with considerable buffering capacity
LS - low sensitivity to acid loadings and likely little biological damage
MS - moderately sensitive to acid loadings
ES - extremely sensitive with heavy acid loadings
A - acidified with zero or negative alkalinity.

Table 4: Reproductive success[a] vs. acid senstivity for 211 lakes surveyed in 1982.

	Lake Sensitivity Classification[b]				
	NS	LS	MS	ES	A
Successful lakes	29	11	50	16	5
Unsuccessful lakes	10	12	48	22	8
% successful	74	48	51	42	38

[a] success defined as the presence of at least 1 loon chick
[b] Lake Sensitivity Classifications:
NS - not sensitive to acid loadings, with considerable buffering capacity
LS - low sensitivity to acid loadings and likely little biological damage
MS - moderately sensitive to acid loadings
ES - extremely sensitive with heavy acid loadings
A - acidified with zero or negative alkalinity.

Table 5: Breeding success[a] vs. acid sensitivity for 213 lakes surveyed in 1983.

	Lake Sensitivity Classification[b]				
	NS	LS	MS	ES	A
Successful lakes	12	9	51	12	1
Unsuccessful lakes	10	12	82	24	0
% successful	55	43	38	33	(100)

[a] success defined as the presence of at least 1 loon chick

[b] Lake Sensitivity Classifications:

NS - not sensitive to acid loadings, with considerable buffering capacity

LS - low sensitivity to acid loadings and likely little biological damage

MS - moderately sensitive to acid loadings

ES - extremely sensitive with heavy acid loadings

A - acidified with zero or negative alkalinity.

Table 6: Loon productivity of lakes with known pairs vs. acid sensitivity, 1984-1986.

	Lake Sensitivity Classification[a]				
	NS	LS	MS	ES	A
1984 % of lakes with young	53	50	65	50	-
1985 % of lakes with young	68	62	61	55	-
1986 % of lakes with young	71	83	64	40	-

[a] Lake Sensitivity Classifications:

NS - not sensitive to acid loadings, with considerable buffering capacity

LS - low sensitivity to acid loadings and likely little biological damage

MS - moderately sensitive to acid loadings

ES - extremely sensitive with heavy acid loadings

A - acidified with zero or negative alkalinity.

cant. A staff survey of 29 lakes revealed a significant negative relationship between loon productivity and lake acidity. Also, juvenile loons disappeared from 3 of the acidic lakes, possibly in response to improverished food resources (Alvo 1983).

From 1984 to 1986, the Long Point Bird Observatory did not obtain sufficient funding to hire a coordinator for the loon survey. Consequently, participation dropped during this period. Significantly fewer lakes in the acidic category were surveyed (Table 6). However, results obtained again suggested lower production on lakes of higher acid sensitivity (McNicholl 1987).

THE 1987 STUDY

In 1987, Long Point Bird Observatory received major funding from the Canadian Wildlife Service to continue the study. However, guidelines were set to streamline the survey so it would become a long-term biomonitoring program for acquatic ecosystems in Ontario using the Common Loon as an indicator species. The survey goals were as follows:

1) to continue the volunteer effort to investigate the reproductive success of Common Loons throughout Ontario,

2) to standardize and store the existing data and any future data so that trends in breeding success may be investigated,

3) to improve the methods of data collection by volunteers and involve more reliable participants spendings large amounts of time on the lakes during the breeding season and into the fall, and

4) to expand the survey to involve many more volunteers and survey more lakes in the sensitive and acidic levels.

In early May 1987, flyers were sent to potential volunteers across Ontario and in the northeastern United States. Mailing lists from other organizations were utilized to solicit volunteers. These included the LPBO membership, the Ontario Bird Feeder Survey, past participants in OLLS, participants in the Ontario Breeding Bird Atlas and naturalists' groups. The flyer asked potential volunteers to indicate either the lake(s) they chose to survey or if they wished to be assigned lakes by OLLS. It was hoped to target volunteers to specific lakes which met guideline criteria of the survey. These criteria were as follows: 1) lakes should be less than 75 ha (these would probably be more easily and more reliably surveyed than larger lakes);

2) lakes of higher acid sensitivity were to be assigned first; and 3) lakes should be easily accessible to volunteers.

Recording sheets were also redesigned to encourage volunteers to fully investigate breeding success. A coding system was outlined so volunteers could indicate pairs and their young, as well as types of behavior associated with pairs. The codes allowed volunteers to approximate the age of the young they observed by their size in comparison to the adults. The codes were as follows:

Adults: 1A = 1 adult; 2A = 2 Adults, etc.
Adult Behavior: P = pair behavior, including close association of presumed male and female, courtship, copulation or a pair interacting or defending territory against neighboring loons; D = distraction display; rearing up in water and other conspicuous behavior near intruders.
Nest: NA = adult sitting on nest; NU = nest without adult on it, contents unknown; NE = nest, containing eggs; NY = nest, containing young.
Young: 1DY, 2DY = 1 or 2 downy young, these are chicks that are less than 1/3 the length of the adult (including its bill), have rather uniform dark grey down, may be riding on the parents back (so can be difficult to see without binoculars) and which are less than 3 weeks old; 1SY, 2 SY = 1 or 2 small young, 1/3 to 2/3 the length of the parent, have mottled light and dark grey feathers and down, do not ride on parent's back, and are between 3 and 6 weeks old; 1LY, 2LY = 1 or 2 large young, 2/3 the length of the parent or larger, are well-feathered (brownish grey above, lighter below), are still attended and fed by parents, do not fly, at least 6 weeks old.

Volunteers were discouraged from searching for nests because of the potential for disturbance, but if nests were known or happened upon, they were encouraged to report this information. Volunteers were asked to report human disturbance on the lake and the amount of shoreline development. Any cases of known predation or harassment were also to be reported. A section was also included for recording other waterbird observations.

Participants were asked to interpret their data in a summary sheet, indicating answers to 3 important questions: 1) were loons present on the lake? 2) if present, did they attempt to breed? and 3) if breeding was attempted, did any pairs successfully raise chicks to the LY stage, or at least 6 weeks old? Because volunteers were spending large amounts of time on the lakes, it was felt their interpretation of breeding success would be valuable to future analysis of the data.

Volunteer response was very good in 1987. Over 550 respondents volunteered to survey lakes and over 100 others asked for information on the survey. In the southern part of the province, response was highest in the areas of high cottage density such as Muskoka, Hailburton, Nipissing, Peterborough, and Parry Sound districts. In the northern part of the province, participation was lower but the districts of Sudbury, Cochrane and Thunder Bay had reasonably good coverage. These data are not compiled at present.

DISCUSSION AND CONCLUSIONS

The first 6 years of the Ontario Lakes Loon Survey showed that a volunteer work force is available and willing to do this type of work. In 1987, an expanded advertising campaign evoked the response of over 500 volunteers.

From 1981 to 1986, volunteers collected data on Common Loons across Ontario, but breeding success was not fully stressed and some data were not suited to a biomonitoring scheme. In 1987, the survey reporting forms were changed to help volunteers more accurately investigate breeding success on lakes in Ontario. As well, an emphasis was put on assigning volunteers to lakes, so that a larger number of acidic or acid-sensitive lakes could be sampled. In this way, any relationships between breeding success and acid sensitivity can be more fully investigated.

Results from the first 6 years indicated that no clear relationship existed between loon breeding success and human disturbance in the form of recreational boating and lakeshore development. However, localized effects were seen and historic effects of shoreline development were noted by volunteers.

In 1982, volunteer-surveyed lakes showed a significant decline in loon breeding success with increasing acidity. This was also true of staff-surveyed lakes in 1983. In 1981 and 1983-1986, the volunteer-surveyed lakes showed a trend of decreasing productivity with increasing acidity, but the trend was not significant. The presence of loons and attempted breeding on lakes of higher acidity raises questions about loon behavior. Most important, if loons are breeding on these lakes, then they may be forced to travel long distances to find sufficient food for themselves and their offspring. If loons are modifying their feeding habits by increasing their foraging time, how long can they continue to do this and maintain their productivity levels?

The most important results of the first 6 years were:

1) human disturbance showed no clear relationship to loon production, but some localized affects may occur;

2) breeding success seemed to be lower on lakes of higher acid sensitivity;

3) documented nest failures reported by volunteers were attributed to predation and high water levels; and

4) notes by volunteers on aggregations of loons suggested lakes of possible importance as staging areas in Ontario.

With an increase in sample size and volunteer coverage in 1987, a significant trend may become apparent in the biomonitoring data. In the next 2-4 years, it should become apparent whether Common Loon populations in Ontario are significantly affected by acid sensitivity. At the same time, an informational base for the population and distribution of the Common Loon in Ontario will be available. Volunteers may provide important information on the effects of human disturbance and development on lakes, as well as notes on nesting behavior and important staging areas. With volunteers across Ontario eagerly awaiting instructions on surveying, the Ontario Lakes Loon Survey has become a valuable educational link, and hopefully a reliable method for the biomonitoring of aquatic ecosystems.

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COMMON LOON DISTRIBUTION AND CONSERVATION PROBLEMS IN CANADA

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Of the 5 species of loons, the Common Loon (Gavia immer) is the most Nearctic, breeding from southern Alaska and the northern contiguous United States east to Greenland and Iceland (Sjolander 1985). Most of its breeding range is thus in Canada (Palmer 1962) where it is absent only from the High Arctic, the open plains of the prairie provinces, and the heavily settled parts of Ontario (Godfrey 1986). Much of this vast breeding range is sparsely settled by humans and filled with numerous lakes well suited to breeding loons. Thus, the species is not threatened with immediate endangerment in Canada as a whole, although it faces a variety of threats locally (McNicholl 1985a).

The purpose of this paper is to provide an outline of the known distribution of Common Loons in Canada, followed by an overview of hazards to loons that have been identified in Canada. Comments on other loon species are included where relevant.

BREEDING RANGE

Little is known of breeding numbers of Common Loons in Canada. The only long-term breeding bird assessment of the entire country has been the Breeding Bird Survey, based on vehicular travel (Erskine 1978). Although Erskine (1978) was able to examine trends in some areas from these data, vast portions of the breeding range of loons are crossed by few, if any roads. Thus, this species is among those listed by Robbins et al. (1986) as "poorly sampled" by this method. Though not taxonomically waterfowl, loons are sometimes included in waterfowl surveys, but not with sufficient consistency to document trends on other than a local scale. The recently completed breeding bird atlas in Ontario (Cadman et al. 1987) has provided the most detailed information on breeding distribution to date, and as similar projects are planned or in progress for most other provinces and even the Northwest Territories, we can expect much more detailed information in the near future.

British Columbia

Godfrey (1986) mapped the Common Loon as breeding throughout British Columbia, where Brooks and Swarth (1925) considered it as a common "summer visitant." Although widespread, Brooks and Swarth (1925) commented that only a small proportion of summering birds breed, and Campbell and Gibbard (1981) presented evidence suggesting that it may be less widespread and common than generally believed. There have been declines at least locally in the past (Johnstone 1949), but Breeding Bird Survey data from 1973 through 1975 west of the Rocky Mountains showed no significent differences among those years (Erskine 1978). Campbell and Gibbard (1981) considered the south-central portion of the province as the provincial center of abundance. They also breed commonly on Vancouver Island and the Queen Charlottes (Stirling 1972, Campbell and Gibbard 1981), but are scarce on coastal islands north of the Queen Charlottes (Godfrey 1986). Pacific Loons (Gavia pacifica) have recently been shown to nest in 3 disjunct areas of the province, 2 along the northern border, and 1 along the central mainland coast (Campbell et al. 1985).

Yukon and Northwest Territories

Godfrey (1986) mapped the Common Loon as breeding throughout Yukon Territory except at the northern tip, and it is considered frequent or fairly common in southern parts of the territory (Rand 1946, Hoefs 1973), where it is found on lakes both below and above timberline (Godfrey 1951). In the Northwest Territories, it breeds through much of Mackenzie and Keewatin territories, but is absent from most of the High Arctic islands of Franklin Territory, except southern Baffin Island (Godfrey 1986). The northern limit of its range coincides generally with the treeline. It remains common in Nahanni National Park (Scotter et al. 1985), but is almost absent outside the timberline in Thelon Game Sanctuary, where the Yellow-billed Loon (G. adamsii) is common (Clarke 1940), and all 4 Canadian breeding species can be found (Barry 1984). It also breeds on islands in James Bay (Manning 1981), Its breeding range in all 4 territories overlaps the breeding ranges of the other 3 species (Godfrey 1986).

Prairie Provinces

Both Salt and Salt (1976) and Godfrey (1986) mapped Common Loons as breeding throughout the non-prairie portions of the prairie provinces, and Salt and Salt (1976) considered it widely distributed in northern Alberta, and fairly common in the Rocky Mountains. Even on the prairies, it is fairly common well into the aspen parkland and nesting pairs occur wherever islands or strips of forest habitat encompass suitable lakes (Godfrey 1950, 1953, Nero and

Lein 1971, Salt and Salt 1976, Knapton 1979, Callin 1980). Summer birds at Churchill, Manitoba on the Hudson Bay coast seem to be non-breeding (Jehl and Smith 1970). Although numbers seem to have declined in more populated areas (Spalding 1974, Salt and Salt 1976), its status in the prairie provinces has not been documented in detail (McNicholl 1982a). As expected, Pacific Loons breed regularly on tundra ponds near Churchill (Jehl and Smith 1970), but they are now also known to breed well inland in northern Alberta (Hohn 1972, Kuyt and Goossen 1986) and possibly Saskatchewan (Nero 1963). Red-throated Loons (G. stellata) have also been found nesting at northern sites in both of these provinces (Nero 1963, Hohn 1976).

Ontario and Quebec

Godfrey's (1986) map shows the Common Loon as breeding throughout these 2 vast provinces, although it no longer breeds regularly in the more settled parts of southern Ontario (Peck and James 1983, Speirs 1985, Godfrey 1986, Dunn 1987). Although widespread in northern Quebec (Todd 1963), it is less common in the Ungava Peninsula than potential breeding habitat would suggest (Harper 1958), and Red-throated Loons outnumber it north of James Bay along the Quebec coast of Hudson Bay (Todd 1963). Breeding Bird Surveys in road-accessible parts of these provinces indicated a significant drop between 1969 and 1970 (Erskine 1978), but numbers fluctuated around the 1969 level 1971-1975. In northern Ontario, it was recorded in the second most number of squares during recent breeding bird atlas research (Cadman et al. 1987) and in central Ontario 8 survey blocks averaged 12.82 breeding loons per 100 square km (McNicol et al. 1987).Both Pacific and Red-throated Loons have been found nesting in northern Ontario (Simkin 1968, Peck 1970), and atlas results suggest that both probably nest regularly along the Ontario coast of Hudson Bay (Peck 1987a,b).

Maritimes

Godfrey (1986) also mapped Common Loons as breeding throughout the Maritimes, although Harper (1958) found them fairly scarce on the Ungava Peninsula, and Todd (1963) indicated Hopedale as the transition point along the Labrador coast north of which the Red-throated Loon outnumbers the Common as a breeding species. Both species nest throughout the island portion of Newfoundland (Peters and Burleigh 1951). Oddly, though both also nest on the French islands of St. Pierre and Miquelon just off the southern coast of Newfoundland, the Red-throated outnumbers the Common there (Cameron 1967). Only the Common breeds in the other 3 Maritime provinces (Squires 1952, Godfrey 1954, Tufts 1986). Erskine (1978) found no significant differences among years in numbers recorded on Breeding Bird Surveys in the

Maritimes 1966-1975.

MIGRATION AND WINTERING

Although there have been few detailed studies of loon migration and wintering in Canada, they are generally known to winter along the entire Canadian portion of the Pacific coast, along the Atlantic coast from the insular portion of Newfoundland south (Palmer 1962, Godfrey 1986), and less commonly on the lower Great Lakes (Speirs 1985, Godfrey 1986). Large groups of both Common and Red-throated Loons congregate on at least 1 lake in the Queen Charlottes, with Commons peaking in late July and August, and Red-throateds showing relatively steady numbers from late March through September (Reimchen and Douglas 1980). All 4 Canadian breeding loons can be found in winter off Victoria Island in late summer (Brooks and Swarth 1925, Stirling 1972, Hatler et al. 1978, Godfrey 1986). Very large numbers of Pacific Loons often congregate in Active Pass during the winter (Vermeer 1977, Edwards 1984). Common Loons are generally absent from interior B.C. in the winter, but occasionally stay during mild winters (Brooks and Swarth 1925, Campbell 1987). Loons do not normally winter in the prairie provinces, but large numbers congregate on several lakes in Saskatchewan and Manitoba within about a 50-mile radius of Flin Flon, Manitoba during summer and fall (Rand 1948, Wade and Wade 1963, Nero 1972, 1974, Predy 1972, Lysack 1985). Similar concentrations have been reported on lakes in Whiteshell Provincial Park in southeastern Manitoba and adjacent areas of Ontario (Nero 1972, Taylor 1985, Croskery 1988). Farther east in Ontario, large rafts of loons have been reported on Lake Superior (Baxter 1985, McNicholl 1987), the North Channel of Lake Huron (Nicholson 1972), off Long Point on Lake Erie (Whelan 1987), and on Charleston, Manitou, Mipissing, Temagami and Timiskaming Lakes (McNicholl 1987). Little is known of migration patterns in Ontario, but a Common Loon banded in Pennsylvania was found dead at Brighton on Lake Ontario (Sutton 1927), and studies in Michigan and New York (Ewert 1982, Kerlinger 1982) give a good idea of possible routes. A migration study on the Ontario Great Lakes (Nisbet 1983) has not yet been published in detail. Along the Ontario-Quebec border area, numbers of loons have been reported gathering in James Bay (Milko 1986), and large flocks of both Common and Red-throated Loons have been observed in the Ottawa area, with 2000-3000 at one site on a single November day (Ladouceur 1985). Both these species winter in moderate numbers throughout the Maritimes (Peters and Burleigh 1951, Squires 1952, Godrey 1954, Cameron 1967, Tufts 1986). Marked migrations of Common Loons occur off Nova Scotia (Tufts 1986), while large concentrations of Red-throateds occur in the Strait of Belle Isle, between insular Newfoundland and the Quebec-Labrador coast (Anonymous 1984).

HAZARDS FACED BY COMMON LOONS IN CANADA

Table 1 summarizes hazards faced by Common Loons throughout their range, as reviewed in McNicholl (1987), which included some non-Canadian studies not cited specifically below. The following review emphasizes findings to date within Canada, and is divided into hazards which are natural and those that are human-induced.

Natural Hazards

The anatomical specialization for diving that limits loons to nesting in close proximity to water restricts them to nesting habitat in which nesting success is frequently low (McNicholl 1982b). Loon nests are predictably highly susceptible to flooding in natural situations (Vermeer 1973a, Fox et al. 1980, McNicholl 1987). Like other species nesting in such unstable habitats (McNicholl 1975, 1985b, Buckley and Buckley 1980), loons are well adapted to natural fluctuations in water levels, showing adaptability in nest site selection (Henderson 1924, Munro 1945, Vermeer 1973a, Alvo 1981, Barr 1986), choosing sheltered sites when available (Vermeer 1973a), varying amount of nest material with the nature of the substrate (Munro 1945, Alvo 1986b), varying time of nest initiation with water levels (Barr 1986), apparently renesting when the first clutch is lost (McNicholl 1987), and showing variable degrees of nest-site tenacity (Barr 1986). As loons are known to live until at least 7 years 10 months (Clapp et al. 1982) and can probably attain older ages, they can withstand several seasons of nest loss, and still replace themselves. Human activities, however, may exacerbate the effects of water level fluctuations beyond the ability of loons to adapt to them. Swamping by power boats was considered responsible for 5 percent of nest loss on a Saskatchewan lake (Fox et al. 1980), and is a widely cited cause of nest failure throughout the breeding range of Common Loons. Ontario Lakes Loon Survey results have not shown a clear relationship between levels of disturbance from boats and nesting population levels (Silieff and Hussell 1982, Alvo and Hussell 1983, McNicholl 1987), but did provide several local examples of such losses in Ontario and adjacent parts of Quebec. Artificial manipulation of water levels has also been responsible for flooding nests in some areas, and for leaving them "high and dry," too far above the water level for adults to reach them (Barr 1979, 1986, McNicholl 1987). Increased turbidity from such developments adds an additional stress in reducing the ability of adults to catch fish (Barr 1979, 1986).

As loons are large birds, predation on adults has been primarily by humans. Deliberate killing of adults by "over-zealous and misinformed fishermen" has historically reduced numbers of loons in some areas (Johnstone 1949), and

Table 1. Hazards Imposed on Common Loons

I. Natural Hazards

1. Water level fluctuations - exacerbated by: a. motorized boats
   b. water level management

2. Predation - exacerbated by: a. hunting (mainly historical)
   b. disturbance
   c. increase/range expansion of predators
   d. lake subsidence
   e. decline of food in lake, requiring loons to hunt further from nest site

3. Disease - exacerbated by chemical contamination

II. Unnatural Hazards

1. Human disturbance

2. Accidents involving mechanical devices:
   a. fish hooks
   b. fish nets

3. Chemical pollutants:
   a. natural substances in unnatural places or concentrations:
      i. oil
      ii. lead
      iii. mercury - exacerbated by acid precipitation reservoir formation

   b. man-made substances:
      i. DDT/DDE
      ii. Dieldrin
      iii. Endrin
      iv. Heptachlor epoxide
      v. Benzene hexachloride
      vi. Chlordane
      vii. PCBs
      viii. Mirex

   c. acid precipitation

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still occurs occasionally, as on Lake Nipissing, Ontario in 1985 (North Bay Nugget, 12 July 1985). However, such incidents are now comparatively rare and localized, and counterbalanced by incidents of fishermen releasing loons found alive in fish nets (Vermeer 1973b). Some traditional hunting by native Canadians still reduces numbers of loons near Indian communities in Ontario (Speirs 1985), and in parts of northern Quebec and Labrador, loons are used for food and/or feather ornaments (Todd 1963). Nesting on islands and in marshes and bogs reduces the chances of mammalian predation on eggs (Henderson 1924, Munro 1945, Vermeer 1973a, Alvo 1981, Barr 1986), but avian egg predation can be considerable (Fox et al. 1980), and the shallow nature of some marsh sites (Alvo 1981) may make them more vulnerable than island sites (Alvo 1984). Known and suspected predators of eggs and/or young in Canada include Muskellunge (Esox mosquinongy), Northern Pike (E. lucius), Snapping Turtle (Chelydra serpentina), Bald Eagle (Haliaeetus leucocephalus), Herring Gull (Larus argentatus), Common Raven (Corvus corax), Muskrat (Ondatra zibethicus), Mink (Mustela vison), Raccoon (Procyon lotor) and Black Bear (Ursus americana), (Fox et al. 1980, McNicholl 1987). Disturbance from some human activities, keep loons off nests, likely increases predation incidents, and may also influence adults to choose more hazardous nest sites (Alvo 1981). Cottage developments, encouraging the spread of omnivorous predators through increased garbage (McNicholl 1985a) likely increases the chance that loon eggs will be predated, especially in areas where Raccoons are undergoing a range expansion (e.g. Friesen 1983 and references therein). Lowered water levels on manipulated lakes sometimes exposes eggs to predators when adults loons can not reach the nest (McNicholl 1987), but as such eggs are essentially lost through forced abandonments, the predator in such cases is acting as a scavenger (McNicholl 1977). The increasing depletion of fish through effects of acidification of lakes may also increase nest exposure to predation by forcing adults to hunt further from nest sites.

A variety of diseases have been recorded in Common Loons, with cases of aspergillosis and haemorrhagic enteritis or peritonitis documented in Canada (Frank et al. 1983). Although most disease conditions affect only a few birds locally, botulism outbreaks can be widespread, and have been known to result in deaths of large numbers of loons in the U.S. Great Lakes (Terres 1981, Brand et al. 1983). Loons weakened by chemical contaminants may be more susceptible to diseases or parasites, as exemplified by high levels of mercury in 2 loons also infected by haemorrhagic enteritis or peritonitis (Frank et al. 1983), and the large numbers of fluke-infested loons found dead in Florida, apparently from mercury poisoning (Alexander 1985).

Unnatural Hazards

Although a small amount of human disturbance to nesting sites can be considered a natural hazard, equivalent to that caused by a predator wandering nearby, many modern human activities associated with cottage development, boating (especially waterskiing), and even canoe trips and picnics can raise disturbance levels considerably. Studies in Alberta (Vermeer 1973a) and Ontario (Rummel and Goetzinger 1975, Heimberger et al. 1983) are consistent with others in the U.S. in indicating significantly lower hatching success on lakes with considerable cottage development, sport fishing, and/or canoe traffic than on similar lakes with little disturbance. Vermeer (1973a) considered loons to be intolerant of human disturbance, and Alvo (1981) suggested that repeated use of ideal island sites for picnics or camping may cause loons to nest in less ideal sites. Heimberger et al. (1983), however, found some degree of habitution by loons to moderate levels of disturbance on some lakes in Ontario, suggesting that loons can co-exist with moderate cottage development if people are educated to avoid deliberate and inadvertent harassment of birds. As indicated above, Ontario Lakes Loon Survey results have not shown a clear relationship between loon nesting success and level of disturbance on a broad scale, but have provided several examples of nest loss from suspected or known disturbance to nests or adults with young, including incidents of young being injured by boats (Silieff and Hussell 1982, Alvo and Hussell 1983, McNicholl 1987).

Sport fishermen sometimes present loons with an additional hazard in the form of fish hooks that can cause fairly serious injuries to individual adults, fishing line that becomes entangled around birds, and hooks and sinkers that become lodged internally in the birds, potentially contributing to starvation or lead poisoning (Anonymous 1982, Di Labio 1985, McNicholl 1987). Entanglement in the nets of commercial fishermen poses a much greater threat at a population level and has been recorded as a cause of death of Common Loons in the Lac La Biche - Cold Lake - St. Paul region of Alberta (Vermeer 1973b), Lake Winnipegosis, Manitoba (Bartonek 1965) and Lakes Huron, Nipigon and Superior, Ontario (Snyder 1928, R. Tozer in Goodwin 1981, Baxter 1985, G. Walker in McNicholl 1987). Red-throated and Yellow-billed Loons have also been recorded drowning in fish nets in the Northwest Territories (Vermeer 1973b). Netting has caused significant rates of mortality of various seabirds along both the Atlantic and Pacific coasts of Canada (Nettleship 1977, Brown and Nettleship 1984, Sealy and Carter 1984, and several papers in Nettleship et al. 1984), and undoubtedly poses a significant hazard to migrant and wintering loons there.

Natural substances in unnatural places and/or con-

centrations, such as oil, lead and mercury can also pose serious environmental threats to loons. Vermeer and Vermeer (1975) included loons among birds threatened by increased oil tanker traffic along the Pacific coast, and oiled loons have also been found off the Canadian Atlantic coast (Brown et al. 1973). Lead poisoning in waterfowl and other birds is well known, and lead has been recorded in high levels in loon livers in the U.S. Great Lakes (Locke et al. 1982), apparently resulting from ingesting lead sinkers, such as the case documented by Di Labio (1985) near Ottawa, Ontario. Mercury is found naturally in many lakes without affecting the aquatic fauna, but at unnaturally high levels can lower nesting success of loons and other birds high on the aquatic food web. Studies in Saskatchewan and Ontario have indicated lowered nesting success, territory abandonment, and other behavioral anomalies, and emaciation of adults as a result of mercury contamination (Fimreite 1974, Price 1977, Barr 1979, 1986, Fox et al. 1980, Frank et al. 1983). Although problems were initially discovered in areas polluted by industrial sources of mercury, enhanced mercury bioaccumulation is known to result from reservior formation (Bodaly et al. 1984) and acid precipitation also accelerates mercury uptake in at least some fish (Barr 1986). Thus, as more rivers are dammed and acid precipitation worsens, mercury poisoing may become more widespread. Emaciated birds containing high levels of mercury on their wintering grounds (Alexander 1985) might have acquired the pollutant in Canadian waters.

Synthetic chemicals used as pesticides and in industrial applications are well known as hazards to top "food chain" predators, such as Common Loons. Studies in Alberta, Saskatchewan and Ontario, as well as several U.S. states, have shown weakened eggshells, reduced hatching success, and behavioral problems, with apparent recovery of loon populations when the use of the culprit chemical is discontinued or reduced. Pesticide residues identified in loons and/or their eggs in Canadian studies include DDT and its metabolites DDE and DDD (Vermeer 1973b, Price 1977, Vermeer and Peakall 1977, Fox et al. 1980, Frank et al. 1983), dieldrin (Vermeer 1973b, Fox et al. 1980, Frank et al. 1983), endrin (Vermeer 1973b), heptachlor epoxide (Vermeer 1973b, Fox et al. 1980, Frank et al. 1983). Residues of polychlorinated biphenyls (PCB's) have also been found in loon material in Ontario and Saskatchewan (Price 1977, Fox et al. 1980, Frank et al. 1983), and mirex in Ontario (Frank et al. 1983).

In recent years, acid precipitation has been identified as one of Canada's most significant environental problems (Irwin et al. 1981), and has been suggested as a possible threat to loons through reduction in food supply in contiminated lakes. Studies in Quebec have indicated that loons there favor large, low altitude lakes, some of which show low acidity, others high acid levels (DesGranges and

Darveau 1985). Comparisons of lake acidity levels with nesting success on lakes in the Ontario Lakes Loon Survey have consistently suggested lower success on lakes with greatest acidity (Silieff and Hussell 1982, Alvo and Hussell 1983, Alvo 1984, McNicholl 1987), though sample size of lakes with various acid levels have been insufficient to allow definite conclusions, but McNicol et al. (1987) found fewer broods per nesting pair on acid-stressed lakes in central Ontario than on unaffected lakes. The survey is currently being expanded to increase sample size (Ashenden 1988) in conjunction with other studies being conducted by Donald K. McNicol of Canadian Wildlife Service. Alvo's (1985, 1986a,b, 1987a,b) studies in Ontario have indicated higher mortality rates of pre-fledging loon chicks hatched on lakes with higher acidity than on those hatched on lakes that rate higher in alkalinity. In addition to reducing food supply on given lakes, acid precipitation seems to mobilize mercury in some lakes (Barr 1986), thus adding to contamination of what food remains available.

LOON CONSERVATION

Most conservation efforts for loons in Canada are incidental to more generalized efforts at preserving wetlands, limiting developments in wilderness or semi-wilderness areas, halting hydroelectric developments, and reducing chemical contamination of the environment. Most of the scientific studies cited above have been conducted wholly of partly because of such conservation concerns. The Ontario Lakes Loon Survey is the only provincial effort involving large numbers of volunteers, and has been embraced enthusiastically (McNicholl 1987, Ashenden 1988), especially as a potential method of monitoring acid precipitation. Public enthusiasm for loons is high, and is encouraged by "popular" articles in nature and general interest magazines (e.g. Raffan 1984, Alvo 1986b, 1987a,b), as well as newspapers. Although organized "loon patrols" and the use of artificial nest sites for loons are not widespread in Canada, some cottage associations keep close watch on "their" loons, and at least 2 cooperators of the Ontario Lakes Loon Survey have experimented with artificial nest structures, one of which hosted successful nesting loons for 3 consecutive years (McNicholl 1986, 1987).

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