THESIS

EFFECTS OF CANOEING ON COMMON LOON PRODUCTION AND SURVIVAL ON THE KENAI NATIONAL WILDLIFE REFUGE, ALASKA

Submitted by

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In partial fulfillment of the requirements

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY ELIZABETH LYNN SMITH ENTITLED EFFECTS OF CANOEING ON COMMON LOON PRODUCTION AND SURVIVAL ON THE KENAI NATIONAL WILDLIFE REFUGE, ALASKA BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

Effects of Canoeing on Common Loon Reproduction and Survival on the Kenai National Wildlife Refuge, Alaska

Impacts of recreational canoeing on common loon (*Gavia immer*) nesting on canoe systems of the Kenai National Wildlife Refuge, Alaska, were investigated during the summers of 1979 and 1980. Ten canoe system lakes (high use) were studied and paired with 10 similar lakes receiving little canoe use (low use). Chick production was similar between the 2 areas during 1979 and 1980: 0.67 fledglings per territorial pair for canoe system lakes and 0.64 for control lakes in 1979 and 0.33 fledglings per territorial pair for canoe system lakes and 0.30 for control lakes in 1980. Changes in defense behaviors, noted in 1979 were evaluated in 1980. When defense behaviors occurred distances between source of human disturbance and a loon were measured. The penguin dance, splash dive and flushing off the nest occurred at shorter distances on canoe system lakes. Population estimates for the Kenai National Wildlife Refuge were 1,668 loons in 1979 and 1,655 loons in 1980. Although fledglings per territorial pair were similar between high and low use areas indicating no impact, changes in behavior on canoe system lakes due to recreational canoeing were evident. It appears impacts of recreational canoeing have not reached critical levels since common loons are still nesting successfully on the canoe system.

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INTRODUCTION

The common loon (*Gavia immer*) has been characterized as a symbol of wilderness in the northern latitudes (Olson and Marshall 1952). Its interesting habits, eerie calls, and unique relationship with lakes and waterways of undisturbed northern forest areas contribute to the pristine quality of these areas. The loon, according to Breckenridge (1949), "...expresses the essence of unrestrained wildness and seems to put the stamp of genuineness on a north country setting like 'Sterling' does on silver."

Palmer (1962) reported the breeding range of the common loon extended from the Aleutian Islands, northwestern Alaska, northern Yukon and Banks Island to Barrow Strait, Baffin Island and Greenland south to northeastern California, northwestern Montana, North Dakota, northern Iowa (formerly), northern Illinois (formerly), northern Indiana, northern Ohio, northern Pennsylvania (casually), northern New York, Massachusetts (formerly), Connecticut (casually), New Hampshire, Maine, Nova Scotia and Newfoundland (Fig. 1).

Current status of the common loon varies throughout its range. Data from Minnesota, Wisconsin, Michigan, New York, Vermont, New Hampshire, Massachusetts and Maine suggest a northward shrinkage of the historically occupied breeding range. This trend has been characterized by continual reduction in numbers of nesting pairs, abandonment of traditional nesting sites and/or abandonment of known loon breeding lakes in the more eastern portions of the range, and severe reproductive difficulty in certain portions of the range (Palmer 1962, Hammond and Wood 1977, Cross 1979, Fair 1979, Metcalf 1979, Plunkett 1979,

Fig. 1. Distribution of the common loon in North America from Palmer (1962).

Sutcliffe 1979, Trivelpiece et al. 1979). The decline has been attributed to the increased disturbance of nesting loons by recreationists spreading into previously remote areas, and loss of nesting habitat due to vacation homes being built in those areas (Plunkett 1979). These 2 trends prompted formulation of a formal petition requesting threatened or endangered species status for the common loon in critical portions of its range in northeastern United States (McIntyre 1979).

Effects of human activity on loons have been examined but are not well quantified. Ream (1976) showed increased camping on islands limited common loon reproduction. In most cases campers did not actually destroy the eggs or even locate the nests but kept birds off the nest merely by their presence. Disturbance caused by slow boat traffic of canoes and rowboats, near shore and potential nest sites are often more detrimental than occasional momentary disturbances caused by motorboats which stay in open water and therefore farther from loon nests (McIntyre 1975, Sutcliffe 1978). A disturbance ratio (disturbance units/lake size) was developed in Alberta to compare human disturbance with the number of breeding pairs of common loons on a lake (Vermeer 1973). Disturbance units included resorts, cottages and campsites on a lake's shoreline. A significant inverse correlation ($r=0.57$; $P<0.05$) resulted between number of pairs of breeding loons and the disturbance ratio for the lakes. Robertson and Flood (1980) found higher success with loons nesting in undisturbed areas than disturbed areas of southern Ontario, but did not have sufficient data to test the difference statistically.

Titus (1979) found human intrusion on remote lakes (undisturbed) generally stimulated different behavioral responses from breeding pairs than it did on more heavily used lakes on the Boundary Waters Canoe Area (BWCA), Minnesota. Loons on remote lakes exhibited a greater level of anxiety, vocalized more rapidly for a longer time, and displayed more aggressively when territories or nests were approached. Vocal or behavioral displays by loons on heavily used lakes were rare when intrusions occurred. Loons which refused to flush off the nest were found on heavily used lakes but not on undisturbed lakes.

Titus (1979) described the differences in loon behavior qualitatively but measured only flushing distances. Mean flushing distances for heavily used lakes (41.6 m; n=9) and remote lakes (23.1 m; n=11) were significantly different ($P<0.10$) (Titus 1979). He described 2 strategies being used by nesting loons with repeated human contact. "They either stuck tight to the nest or they quietly slipped into the water while the disturbance was still distant, swam a moderate distance under water, and resurfaced away from the nest without any commotion." On remote lakes loons flushed with greater commotion and stayed off their nests longer. This allowed more time for predators to destroy nests and for eggs to cool excessively (Titus 1979).

The common loon is a good species with which to evaluate impacts of human activity on wilderness areas. Its presence is indicative of the quality of northern wilderness areas because it is highly sensitive to human disturbance.

The Problem

The northern portion of the Kenai National Wildlife Refuge (KNWR) is characterized by lowland spruce forest dotted with numerous lakes and marshy areas. Two canoe systems were established within this area during 1965 and 1966 and were officially designated as wilderness areas in late 1980. They also were designated as National Recreation Trails and are the first such trails under U.S. Fish and Wildlife Service jurisdication. The canoe systems were managed as wilderness from creation and no motors were allowed within the systems.

Lakes located in this lowland spruce forest support a sizeable common loon population. The popular canoe system lakes provide an ideal location to study the effect of human disturbance, in the form of canoeing and related activities, on common loon production and survival. This study was undertaken to determine if the level of human use on the canoe systems is having a detrimental effect on common loon reproduction. To accomplish this, a group of canoe system lakes and a group of lakes largely inaccessible to public use were selected for study.

Specific objectives were to: (1) quantify nesting success in terms of fledglings per territorial pair and relate to intensity of use by canoeists; (2) quantify differences in behavior of nesting common loon pairs between intensively used lakes and similar lakes receiving little use; (3) relate flushing distances to level of human use; and (4) estimate the size of the common loon population on the Kenai National Wildlife Refuge.

METHODS

Study Area

The KNWR is located in south central Alaska and it encompasses 700,000 ha of the Kenai Peninsula (Fig. 2). The northern 230,000 ha is part of the Kenai lowland which consists of low hills, broad level plains, bogs, muskegs and numerous lakes. Elevations range from 0 to 153.8 m (500 ft.) above sea level (USDA Soil Conservation Survey 1962). Vegetation is typical of the northern boreal forest which is primarily open, slowly growing spruce interspersed with bogs and well-drained upland sites containing well-developed forests (Viereck 1973). Annual rainfall averages 48 cm (18.93 inches) while snowfall averages 168 cm (66.3 inches) (USDA Soil Conservation Survey 1962). Some 1,700 lakes over 0.5 ha in size exist in this area (J. Lewandowski pers. commun.).

The 2 established canoe systems within this area encompass 17,000 ha and include 70 lakes ranging in size from 8 to 360 ha. The 10 most intensively used lakes of the Swan Lake Canoe System (SLCS) (Fig. 3) were paired with 10 control lakes on the basis of similarity in size, depth, water clarity and presence of fish (Table 1). These 10 control lakes are located within 10 km of the SLCS (Fig.4) and human use of these lakes was so minimal that the lakes were considered unused. Use of the SLCS has increased from about 500 individuals in 1965 (KNWR unpubl. annual rep.) to 4200 individuals in 1975 (L.A. Shon unpubl. data).

Study lakes were classified as permanent lakes using the criteria of Stewart and Kantrud (1971). Limnological information on these lakes was limited to alkalinity, conductivity, pH, water color and temperature (Table 2) which were available courtesy of the U.S. Fish and Wildlife Service's Division of Fish Resources in Kenai, Alaska. Alkalinity values

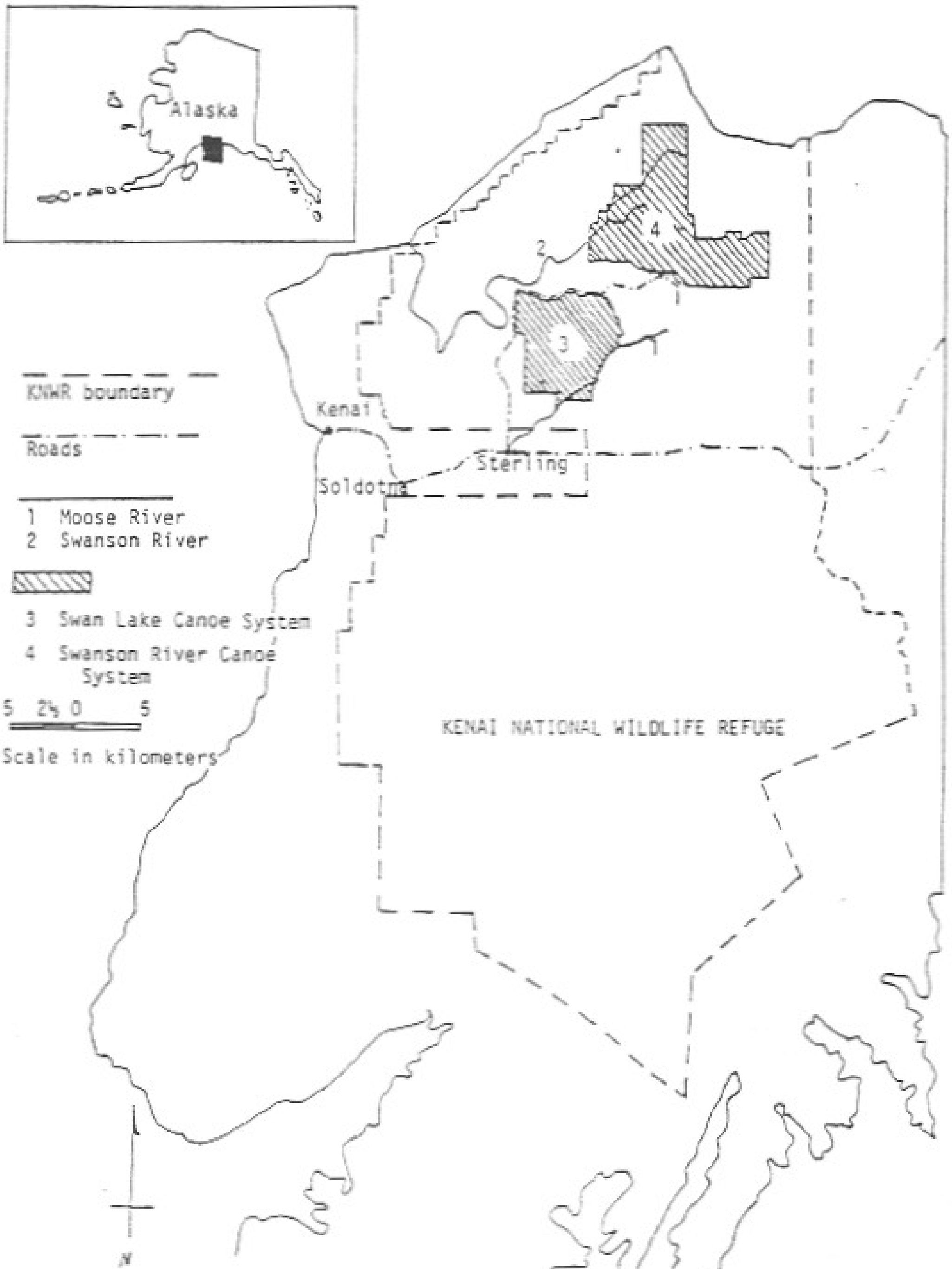

Fig. 2. Wilderness canoe systems within the Kenai National Wildlife Refuge, Alaska.

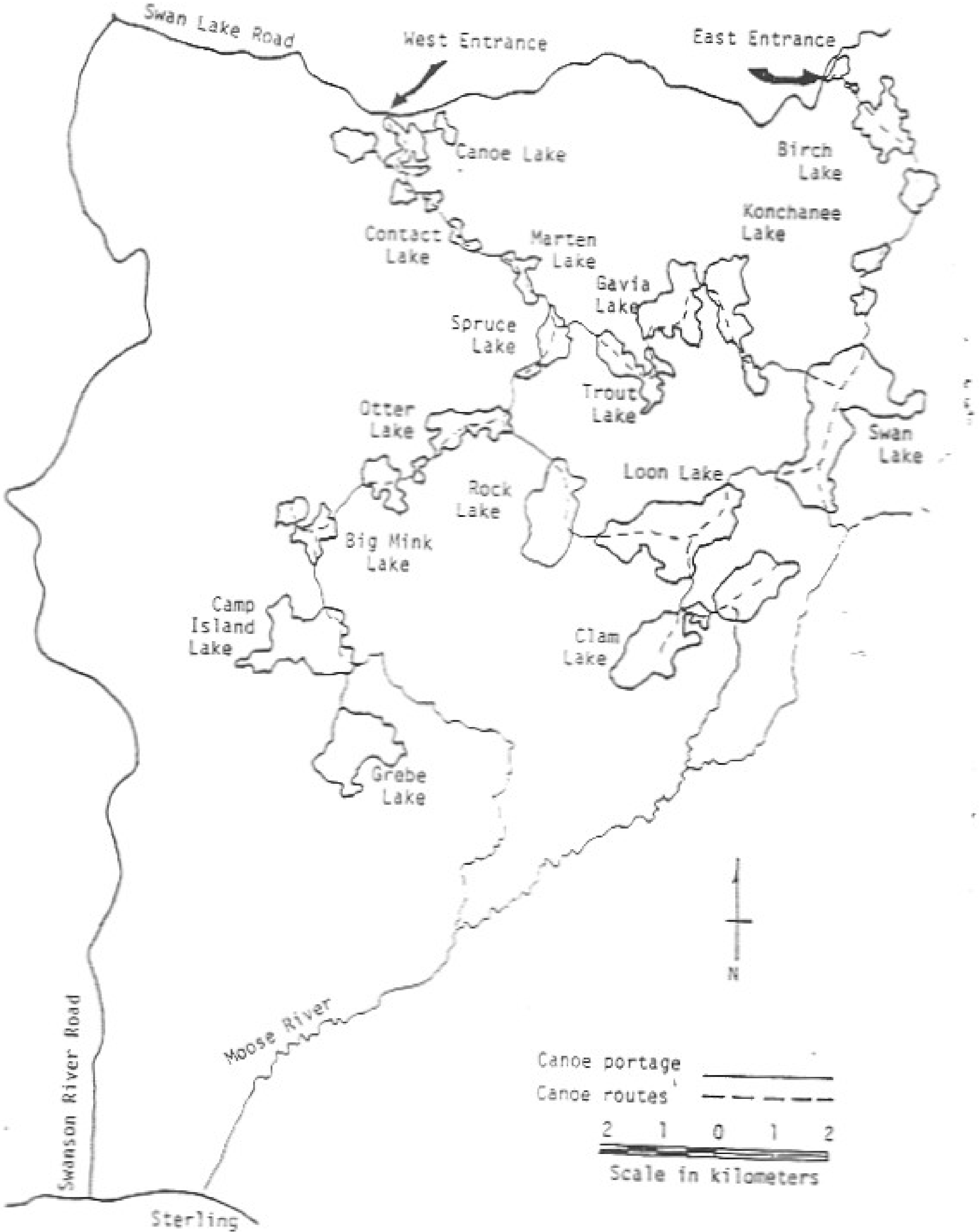

Fig. 3. Lakes included in the Swan Lake Canoe System and routes between lakes, Kenai National Wildlife Refuge, Alaska.

Table 1. Area (ha), depth (m), and fish species present on study lakes of the Kenai National Wildlife Refuge, Alaska. Lakes of the canoe system are paired with control lakes across the page.

Canoe System Lakes	Area	Maximum Depth	Fish Species Present[a]	Control Lakes	Area	Maximum Depth	Fish Species Present[a]
Canoe Lake	42	9	AC, LSK, RB, RS, SB, SS	Jigsaw	53	15	SB
Canoe Lakes Chain 1	14	22	AC, LSK, RB, SB, SS	Arrow	12	14	SB
Canoe Lakes Chain 2	10	6	AC, LSK, RB, SB, SS	Bratlie	11	4	SB
Contact	12	9	AC, LSK, RB, RS, SB, SS	Calf	8	5	SB
Marten	28	14	AC, LSK, RB, SB, SS, SU	Ice	25	14	AC, RB, SB
Spruce	45	11	DV, LSK, RB, RS, SB, SS, SU	Cow	29	12	SB
Trout	69	12	DV, RB, SB, SU	Vixen	61	14	SB
Gavia	121	19	AC, RB, SB, SU	Middle-West Finger	99	20	AC, LSK, SB
Kouchanee	76	28	AC, LSK, RB, SS, SU	South Finger	89	25	AC, LSK, SB
Cygnet	20	10	RB, SB	Longhike	28	18	SB

[a] AC = Arctic Char (*Salvelinus alpinus*)
DV = Dolly Varden (*Salvelinus malma*)
LSK = Longnose Sucker (*Catostomus catostomus*)
RB = Rainbow Trout (*Salmo gairdneri*)
RS = Red Salmon (*Oncorhynchus nerka*)
SB = Stickleback (*Gasterosteus aculeatus*)
SS = Silver Salmon (*Oncorhynchus kisutch*)
SU = Slimy Sculpin (*Cottus cognatus*)

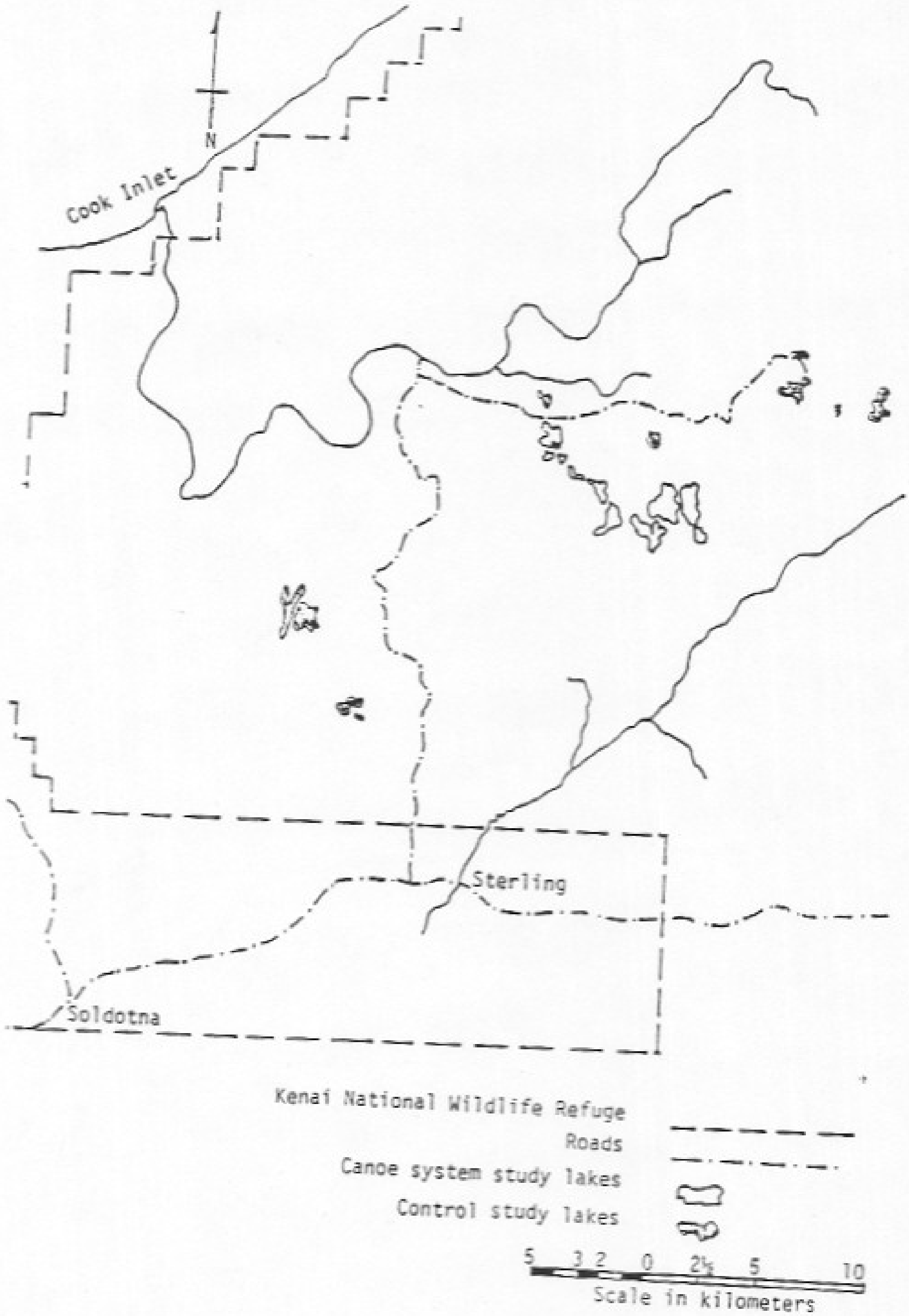

Fig. 4. Locations of common loon study lakes on the Kenai National Wildlife Refuge, Alaska.

ranged from 0.5 to 83 mg/l. Conductivity values ranged from 9 to 165 mmhos/cm. PH values ranged from 4.6 to 8.2 while temperatures ranged from 6 to 19°C. Water color was generally clear with yellow color absorbance ranging from 0.03 to 0.60 absorbance units.

Nesting Success

Each lake was searched for loon nests by canoeing within 2 m of the shore around the lake's edge. Island edges were searched similarly. Nest searches began in mid to late May and terminated when all nests were located, or in mid July when I felt the resident pair would not nest that season. Loon nests on control lakes were observed 3 to 4 times during the incubation period while loon nests on the canoe system were observed 6 to 8 times due to the nature of the canoe route. Number of eggs was recorded for each nest. All common loons present on a lake during a visit were recorded.

The number of eggs which hatched was recorded and chick survival monitored through August. Chicks alive at the end of August or 2/3 adult size were considered fledglings (Olson and Marshall 1952) and were used to calculate fledglings per territorial pair.

Behaviors

I used a Leitz Rangefinder Model 3390, which measures from 13-1000 m, to measure distances between the source of human disturbance and the displaying loons and between the disturbance and the nest when the following loon behaviors occurred: surface rush, penguin dance, jerk dive, and splash dive. These behaviors are associated with interspecific territorial defense especially nest defense and were described by McIntyre (1975). The tremolo call, also associated with territorialism

Table 2. Mean values and ranges of alkalinity, conductance, pH, color and temperature for canoe system and control lakes on the Kenai National Wildlife Refuge, Alaska.

Sample Depth		Alkalinity ($mg l^{-1}$)		Conductivity (mmhos/cm)		pH		Color[a]		Temperature (°C)	
		Canoe System	Control Lakes	Canoe System	Control Lakes	Canoe System	Control Lakes	Canoe System	Control Lakes	Canoe System	Control Lakes
Surface	mean	51.8	13.7[b]	103.9	30.7[b]	7.6	6.5[b]	0.21	0.23	14.4	17.3[b]
	range	39-61	1-74	85-125	10-145	7.2-8.0	4.9-8.2	0.03-0.15	0.06-0.52	13-16	16-19
Mid-depth	mean	50.5	13.9	104.5	31.8[b]	7.4	6.4[b]	0.09	0.25[b]	12.4	15.5[b]
	range	39-61	2-80	80-136	9-158	6.9-7.9	4.9-7.6	0.03-0.15	0.04-0.60	7-14	11-18
Bottom	mean	61.7	14.9[b]	123.1	34.2[b]	7.2	6.2[b]	0.32	0.24[d]	9.7	12.4[b]
	range	41-68	0.5-83	76-132	10-165	6.7-7.7	4.6-7.3	0.04-0.27	0.04-0.58	6-12	6-18

[a] absorbance units measured at 410 nanometers

[b] significantly different at $p < 0.05$

[c] $p = 0.45$

[d] $p = 0.25$

was described by Olson and Marshall (1952). Occurrences were noted and distances measured as with above behaviors.

Flushing distance was defined as the distance between an intruding human and a nest when an incubating bird left its nest due to the disturbance. The source of human disturbance in all instances was a canoe operated by me and my assistant. The disturbance sequence consisted of approaching the active nest at an angle greater than 45^{o} from shoreline, at a speed which was neither rushed nor prolonged. We approached to within 2 m of the nest and after a 2-3 minute pause retreated from the nest. I attempted to keep the length of disturbance within 30 to 45 minutes each visit. If the nest was not active, either the eggs had hatched or had been destroyed, the pair or family was approached. Since the loons were mobile I standardized the approach by paddling directly toward them and allowing 45 minutes for approach and retreat.

The number of occurrences of each behavior and the distances at which they occurred were measured. Where sufficient data existed, the Mann-Whitney U-test (Mosteller and Rourke 1973) was used to determine if distances were the same between canoe system lakes and control lakes, successful and unsuccessful nesters, pre- and post-hatching, and nesting and non-nesting birds. The significance level used was α=0.05.

Canoe System Use

In 1979 I attempted to use 2 Minolta super 8 mm movie cameras equipped with precision programmable intervalometer/sequence systems by Telonics, to evaluate human use of the study lakes as it related spatially to common loon nests. Both cameras were positioned to view a loon nest and the portion of the lake most likely to be used by canoeists. Camera timers were set to take 3 exposures, 1 second apart every 20 minutes. One camera, located on a canoe system lake, was operated from 31 May to 17 July. The other camera, located on a control lake, was operated from 3 to 27 June. Operation dates depended upon nest discovery and hatching times. The films were edited using a Super-8 Moviscop. Very little useful data resulted from the films as the distant canoes could not be distinguished from arctic terns (*Sterna paradisaea*) flying above the loon nests or spots on the films.

Total numbers of individuals using the Swan Lake Canoe System during 1979 and 1980 were obtained from KNWR personnel. The estimates were based on the number of persons who registered at SLCS trailheads times 3 since only 33% of the users actually registered in the registration boxes used by KNWR personnel to monitor canoe system use (R. Johnston pers. commun.).

Canoe use surveys were instituted in 1980 to measure intensity of human use on the 10 SLCS study lakes in terms of canoes per day. Canoes on each lake were counted on 15 randomly chosen non-holiday days and on 4 holiday weekend days. Each survey consisted of 2 sampling periods - evening of the survey day and early morning of the next day in which all 10 lakes were surveyed by canoe. Most canoeists camp during these times so repeat counts were minimized. Information about the number of lakes canoeists had traveled through was obtained through informal conversations and by noting their camping locations.

<u>Population Estimate</u>

Lakes of the KNWR northern lowlands were stratified into 3 size categories based on territory sizes reported by Barr (1973), Vermeer (1973), McIntyre (1975), and Petersen (1976):

1. Small 2.5 - 20 ha
2. Medium 20.5 - 80 ha
3. Large Larger than 80 ha

The sample of lakes in 1979 was comprised of 10% of lakes in each stratum. Strata variances from the 1979 survey were used to reallocate sample sizes in 1980 to obtain more precise estimates. Total sample size for the aerial survey was still 10% of total number of lakes. Lakes were chosen by using a random numbers table.

Survey flights were made on calm mornings with wind less than 10 mph to aid in spotting the loons. Counts in 1979 were begun in late July and finished in August. All counts in 1980 were made in late July. This time was most advantageous for counting both chicks and adults since the birds were more likely to be on open water rather than on nests, the chicks were large enough to spot easily, and this time was before pre-migration flocking occurred (McIntyre 1975).

Counts were made from a Cessna supercub with 1 observer. Flight altitude was about 91 m (300 ft.) above the lakes. Each lake was circled twice following approximately the lake's perimeter. This procedure reduced aircraft disturbance which caused some loons to dive (Zimmer 1979).

Survey results were expanded to estimate the loon population according to the following equation (Scheaffer et al. 1971):

$$T_y = \sum_{i=1}^{\ell} N_i \bar{y}_i$$

where: T_y = estimated total number of loons;

ℓ = number of strata;

N_i = number of lakes per stratum;

$\bar{y}_i$ = average number of loons per lake per strata.

A confidence interval for the population estimate was calculated as follows:

$$T_y \pm t_{\frac{\alpha}{2}} \sqrt{\sum_{i=1}^{\ell} N_i^2 \left(\frac{N_i - n_i}{N_i}\right) \left(\frac{S_i^2}{N_i}\right)}$$

where: t = Student's t-value at α = 0.05 with 2 degrees of freedom;

n_i = number of lakes surveyed in each stratum;

S_i^2 = variance of $\bar{y}$ for each stratum.

Loon numbers were known for 20 of the survey lakes. Survey results for these lakes were compared to the known numbers to establish reliability of the survey. The aerial counts agreed with the known numbers so no correction factor was used.

RESULTS

Habitat Suitability

A basic difference existed between the canoe system lakes and the control lakes. The canoe system lakes are interconnected flow-through lakes while all but 1 of the control lakes are seepage or pothole lakes. The flow-through lakes are connected to major rivers on the Kenai Peninsula (Fig. 4) in which several species of fishes spawned. These fishes had access only to flow-through lakes which caused a greater variety of fish species to be present in the canoe system lakes than in the control lakes (Table 1). Several of the pothole lakes supported only the threespine stickleback (*Gasterosteus aculeatus*). However, fishes are not necessary for loon nesting (Munro 1945) so all study lakes should be suitable for nesting based on fish presence.

Mean pH values for the canoe system lakes ($\bar{x}$=7.6) were significantly higher ($P<0.05$) than control lake values ($\bar{x}$=6.5) (Table 2). Eighty percent of the study lakes (16) had pH values ranging from 6.1 to 8.0. Zimmer (1979) found 85.7% of Wisconsin lakes used by loons for nesting had pH values ranging from 6.1 to 8.0.

Alkalinity values for the canoe system lakes ($\bar{x}$=51.8 mg/l) were significantly higher ($P<0.05$) than control lakes ($\bar{x}$=13.7 mg/l) (Table 2). All 20 study lakes had alkalinity values less than 75 mg/l. Zimmer (1979) found lower alkalinity values for Wisconsin lakes with adult loons (30.26 ppm $CaCO_3$, ppm equal to mg/l) than lakes without loons (38.22 ppm $CaCO_3$). Ninety-one percent of Wisconsin lakes with loon nests (135) had alkalinity levels less than 75 ppm $CaCO_3$.

Conductivity values for canoe system lakes ($\overline{x}$=103.9 mmhos/cm) were significantly higher ($P<0.05$) than for control lakes ($\overline{x}$=30.7 mmhos/cm) (Table 2). Fourteen (70%) of the study lakes had conductivity levels less than 100 mmhos/cm. Zimmer (1979) found similar conductance values for Wisconsin lakes with and without nesting loons (68.95 and 82.28 mmhos respectively). Eighty-three percent (122) of Wisconsin lakes used by loons for nesting had conductance values less than 100 mmhos.

Water temperatures were significantly cooler ($P<0.05$) in canoe system lakes ($\overline{x}$=14.4^{o}C) than in control lakes ($\overline{x}$=17.3^{o}C) (Table 2). Water color of canoe system lakes was not significantly different ($P>0.05$) from control lake water color except at mid-depth (Table 2).

In summary, although the chemical parameters for the 2 lake groups are different, the ranges of values fall within the ranges reported by Zimmer (1979) for Wisconsin lakes which supported nesting common loons. On the basis of the characteristics discussed above, all 20 study lakes should be suitable for successful nesting.

Often the configuration of a lake provides natural boundaries, such as points, bays or islands to delineate territories. A highly configurated lake, with many points, bays, and/or islands, would allow more territories than a round lake of the same area. Shoreline development factor (SDF) compares the surface area of a lake to the length of the shoreline. Hutchinson (1967) gave the following equations for SDF:

$$SDF = \frac{\text{shoreline length}}{2\sqrt{(\pi)\ \text{area}}}$$

A perfectly round lake would have a SDF of 1.00. There was no difference in SDF ($P>0.30$) between canoe system ($\bar{x}$=1.66) and control lakes ($\bar{x}$=1.88)(Table 3). Zimmer (1979) found a significantly greater mean SDF ($P<0.05$) for lakes with nesting loons ($\bar{x}$=1.99) than lakes with nonbreeding loons ($\bar{x}$=1.88) on Wisconsin lakes.

There was a significant difference ($P<0.05$) in the total length of shoreline between canoe system lakes and control lakes (Table 3). The amount of shoreline judged suitable for nest sites included only the shoreline of islands, points and marshy areas. Over 36% of the shoreline of canoe system lakes was judged suitable for nesting while almost 35% of control lake shoreline was suitable for nest sites. There was no difference in percent of suitable shoreline for nest sites between the 2 groups ($P>0.35$).

Olson and Marshall (1952) and Vermeer (1973) reported finding 92% (50) and 96% (25) of nests, respectively, on islands. Yeates (1950) suggested loons prefer the security of nesting on an island. Only 1 lake of the canoe system lakes had any islands while 5 control lakes had islands. Total length of island shoreline was significantly longer ($P<0.05$) on control lakes (0.19 km) than on canoe system lakes (0.04 km).

The canoe system lakes appeared to be slightly more suitable as loon habitat based on the diversity of fish species and limnological characteristics which fit more closely with Zimmer's (1979) findings, while the control lakes appeared to be more suitable loon habitat as far as availability of preferred island nest sites. As best as I can determine the main difference between the 2 groups of lakes was the element of human disturbance; there was continual disturbance by recreational canoeists on the canoe system lakes while the only

Total shoreline length (km), percent of shoreline judged suitable for common loon nesting and shoreline development factor (SDF)[a] for paired study lakes of the Kenai National Wildlife Refuge, Alaska.

Canoe System Lakes	Total Shoreline	% Suitable Shoreline[b]	SDF	Control Lakes	Total Shoreline	% Suitable Shoreline[b]	SDF
Canoe Lake	5.95	35.2	2.58	Jigsaw	7.23	31.0	2.79
Canoe Lakes Chain 1	1.65	20.8	1.23	Arrow	2.01	33.3	1.61
Canoe Lakes Chain 2	1.37	33.3	1.23	Bratlie	1.91	56.8	1.65
Contact	2.10	10.5	1.72	Calf	1.13	20.8	1.14
Marten	3.29	60.8	1.75	Ice	2.56	56.9	1.45
Spruce	3.04	57.1	1.28	Cow	3.63	46.7	1.89
Trout	7.20	43.3	2.44	Vixen	7.61	51.3	2.76
Gavia	5.90	38.7	1.51	Middle-West Finger	10.30	20.6	2.92
Konchanee	4.96	18.8	1.61	South Finger	4.69	23.4	1.40
Cygnet	2.04	23.2	1.29	Longhike	2.12	26.5	1.14
Total	37.50[d]	36.4[c]	$\bar{X} = 1.66$		43.19[d]	34.9[c]	$\bar{X} = 1.88$

[a] $SDF = \frac{\text{shoreline length}}{2\sqrt{(\pi)\,\text{area}}}$

[b] includes shoreline of islands, points and marshy edges.

[c] no significant difference in percentages of suitable shoreline between canoe system and control lakes ($P > 0.35$).

[d] there is a significant difference in total amount of shoreline between canoe system and control lakes ($P < 0.05$).

disturbances on the control lakes occurred when I made 1 of my 5 to 7 short visits during the summer.

Nesting Success

Seventeen adult common loons were regularly observed on the 10 canoe system study lakes in both 1979 and 1980. Twenty-five adult common loons were regularly observed on the 10 control lakes in 1979 while only 22 were considered resident in 1980.

Territories were established on 6 of the 10 canoe system lakes during both the 1979 and 1980 breeding seasons (Table 4). Eleven pairs established territories on control lakes in 1979 while in 1980 only 10 territories were occupied. Sizes of territories on canoe system lakes were the same during 1979 and 1980 averaging 47 ha. There was an average of 71 ha of water available for each territorial pair on the canoe system lakes (Table 4). Territory sizes averaged 37 ha on control lakes in 1979 while in 1980 they averaged 41 ha. There were approximately 38 ha of water available for each territorial pair on the control lakes in 1979 and 41 ha in 1980.

Three of the canoe system lakes (Canoe Lakes Chain 1 and 2, 14 ha and 10 ha respectively, and Contact Lake, 12 ha) did not support resident loon pairs. They were smaller than any study lake on which chicks were raised successfully. No loons were observed on Calf Lake, a control lake 8 ha in size. Two other control lakes, Bratlie (11 ha) and Arrow (12 ha) supported loon pairs although nesting occurred only on Arrow Lake during both 1979 and 1980. In 1978, prior to my study, 2 loon chicks were successfully raised on Bratlie Lake. McIntyre (1975) reported loons nesting on 4 ha lakes in Itasca Park, Minnesota while Barr (1973) reported loons nesting on 9 ha lakes in Ontario.

Table 4. Reproductive results from 1979 and 1980 for common loons nesting on study lakes of the Kenai National Wildlife Refuge, Alaska.

	1979		1980	
	Canoe System	Control	Canoe System	Control
Territorial pairs	6	11	6	10
Nesting pairs	4	9	4	8
Nests	4	9	4	8
Nests destroyed	2	2	2	4
Renests	2	0	2	3
Eggs laid	8	17	9	19
Eggs hatched	4	10	4	5
Hatching success	50%	59%	44%	26%
Chicks fledged[a]	4	7	2	3
Chick survival	100%	70%	50%	60%
Reproductive success	0.67	0.64	0.33	0.30
Hectares of water/ territorial pair	71	38	71	41

[a] chicks alive as of mid-August

[b] fledglings/territorial pair

Four of the 6 territorial pairs (67%) nested on the canoe system lakes in both 1979 and 1980 (Table 4). The pair on Spruce Lake in 1979 nested but the pair on that lake in 1980 did not nest. The pair on Cygnet Lake in 1979 did not nest but the pair present in 1980 did nest. Nine of the 11 territorial pairs on the control lakes (82%) nested in 1979 (Table 4). In 1980 on the control lakes, eight of the 10 territorial pairs nested. The pair on Longhike Lake in 1979 nested but the pair present in 1980 did not nest.

Nesting territories on the canoe system lakes averaged 55 ha in 1979 and 48 ha in 1980. Nesting territories on the control lakes averaged 44 ha in 1979 and 46 ha in 1980.

The first canoe system nest in 1979 was initiated 17 May on Trout Lake about 3 weeks after ice break-up. The first nests on control lakes were initiated 23 May 1979 on Middle-West Finger and Longhike Lakes. Three of the nests on canoe system lakes (75%) were initiated prior to Memorial Day weekend in 1979 (26-28 May). Four of the nests on control lakes (50%) were initiated by that time in 1979. All but 1 of the nests on control lakes (89%) were initiated by 8 June in 1979 (Fig. 5).

The sequence for nesting was similar in 1980. The pairs on Trout Lake laid an egg on 17 May, approximately 3 weeks after break-up. Two other nests were initiated on canoe system lakes prior to Memorial Day weekend (24-26 May). Three nests were initiated 19 May 1980 on Vixen and Middle-West Finger control lakes. Another 3 loon pairs on control lakes nested prior to 8 June.

Loons nesting on control lakes showed a significant preference ($P < 0.05$) for choosing nest sites on islands as opposed to points and marshy edges (Table 5). Sixteen (76%) of the nests on control lakes were on

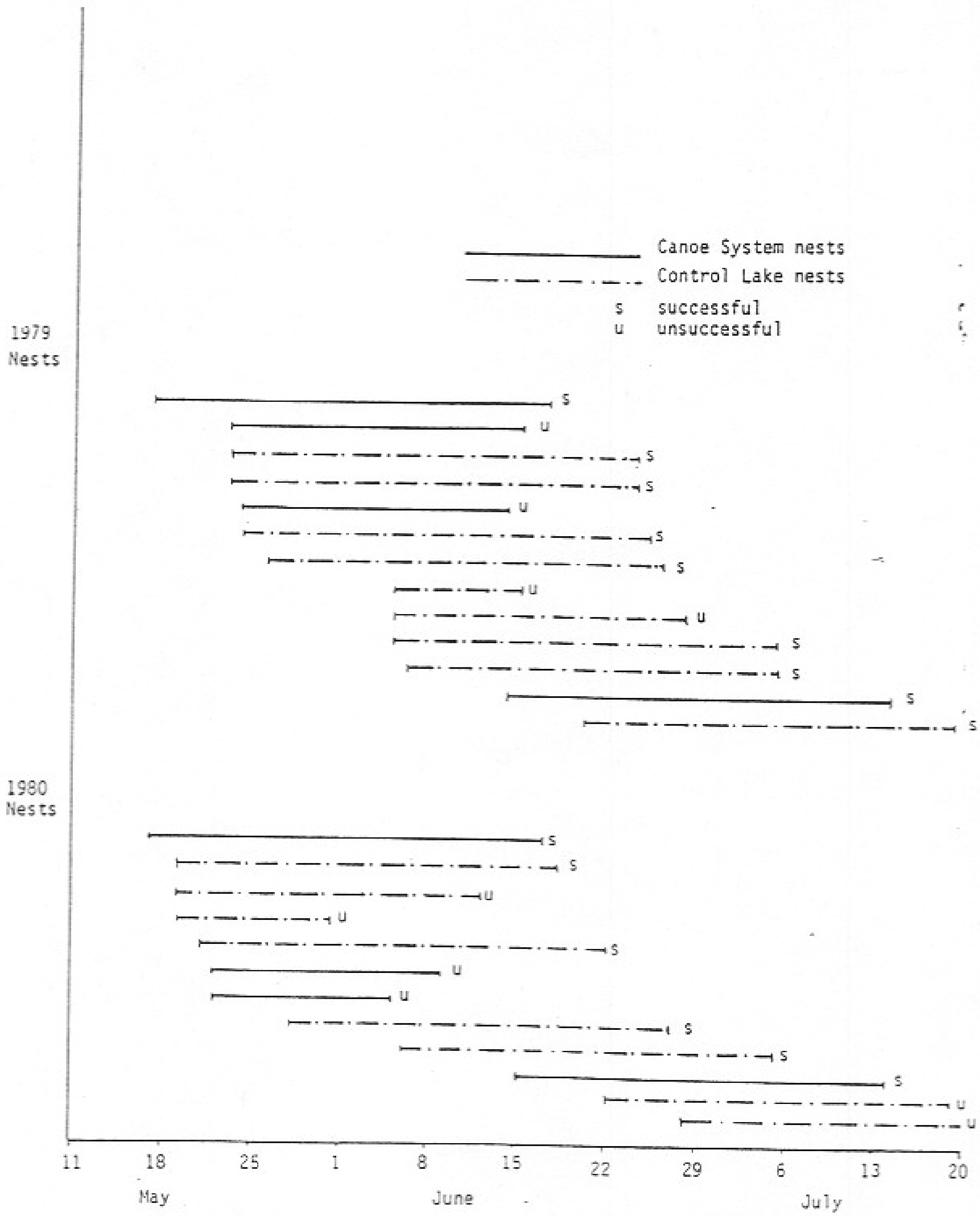

Fig. 5. Phenology of common loon nests on canoe system and control lakes during 1979 and 1980 on the Kenai National Wildlife Refuge, Alaska. Beginning of lines show when eggs were laid. End of lines show when eggs hatched or were destroyed.

Table 5. Sites selected for nesting by common loons on the Kenai National Wildlife Refuge, Alaska. Number of nests include nests from 1979 and 1980. Site preference was tested using a Chi-square test. Expected values were calculated from percentages of availability of islands, points and marshy edges for canoe system and control study lakes (shown in parenthesis).

		Island	Point	Marshy Edge
Canoe System Nests	Observed	0	4	8
	Expected	0 (3%)	6 (46%)	6 (51%)
Control Lake Nests	Observed	16[a]	2	3
	Expected	2 (11%)	8 (40%)	10 (49%)

[a] significant site preference for island nest sites ($p < 0.05$).

islands. No nests were placed on islands on the canoe system lakes since no nesting occurred on the only lake with any islands. There was no significant site preference showed for points or marshy edges as nest sites on the canoe system lakes (Table 5).

In 1979, 2 nests were destroyed on the canoe system lakes (Table 4). Cause of nest destruction could not be determined but in both cases the eggs were completely removed from the nest and no eggshells were found within 1.5 m of the nest. Two of the nests on control lakes were destroyed and no cause of destruction determined. While no re-nests occurred on the control lakes, both pairs that lost nests on the canoe system lakes renested and were successful.

Two nests on the canoe system lakes were destroyed in 1980 in the same fashion as those in 1979 (Table 4). Both pairs renested but only 1 was successful. Four nests were destroyed on control lakes in 1980. Cause of nest destruction remains undetermined. Two pairs renested with 1 renesting a second time after the first renest was destroyed. All 3 renests on the control lakes were unsuccessful.

Eight eggs were laid in canoe system nests during 1979 (Table 4). Four eggs hatched resulting in 50% hatching success for the canoe system study lakes. On the control lakes in 1979, 17 eggs were laid of which 10 hatched. Hatching success for control lakes was 59%.

In 1980, 9 eggs were laid in nests on canoe system lakes (Table 4). Only 4 hatched for a hatching success of 44% on canoe system lakes. Of 19 eggs laid in nests on the control lakes, a mere 5 hatched resulting in 26% hatching success on control lakes.

All 4 chicks fledged on the canoe system lakes in 1979 for 100% chick survival (Table 4). This resulted in a reproductive success of

0.67 fledglings per territorial pair on the canoe system lakes. Reproductive success on the control lakes in 1979 was 0.64 fledglings per territorial pair as only 70% (7) of the chicks fledged. There was no significant difference (P>0.45) in reproductive success between the canoe system and control lakes in 1979.

Fifty percent (2) of the chicks fledged on canoe system lakes in 1980 resulting in only 0.33 fledglings per territorial pair (Table 4). Three chicks fledged (60%) on the control lakes in 1980. Reproductive success was only 0.30 fledglings per territorial pair for the control lakes. There was no significant difference (P>0.45)in fledglings per territorial pair between the canoe system and control lakes in 1980.

Behavioral Differences

Several differences occurred in loon behaviors associated with nest defense that appear to be caused by man's presence on the canoe system lakes. The penguin dance and splash dive behaviors occurred closer to my canoe (P<0.05) on canoe system lakes than on control lakes (Fig. 6). The mean distance for the penguin dance on canoe system lakes was 16.2 m (n=70) with a range of 1-105 m while on control lakes it was 63.6 m (n=27) with a range of 2-134 m. Occurrences of the splash dive were less numerous. The mean distance was 12.0m (n=9) on canoe system lakes with a range from 4-28 m and 64.8 m (n=18) on control lakes and a range of 2-131 m.

These 2 behaviors along with the surface rush and tremolo call are employed by adult loons when defending nest and chicks against humans and other animals (McIntyre 1975). Titus (1979) felt nesting loons were adapting to repeated human contact by using 1 of 2 strategies -

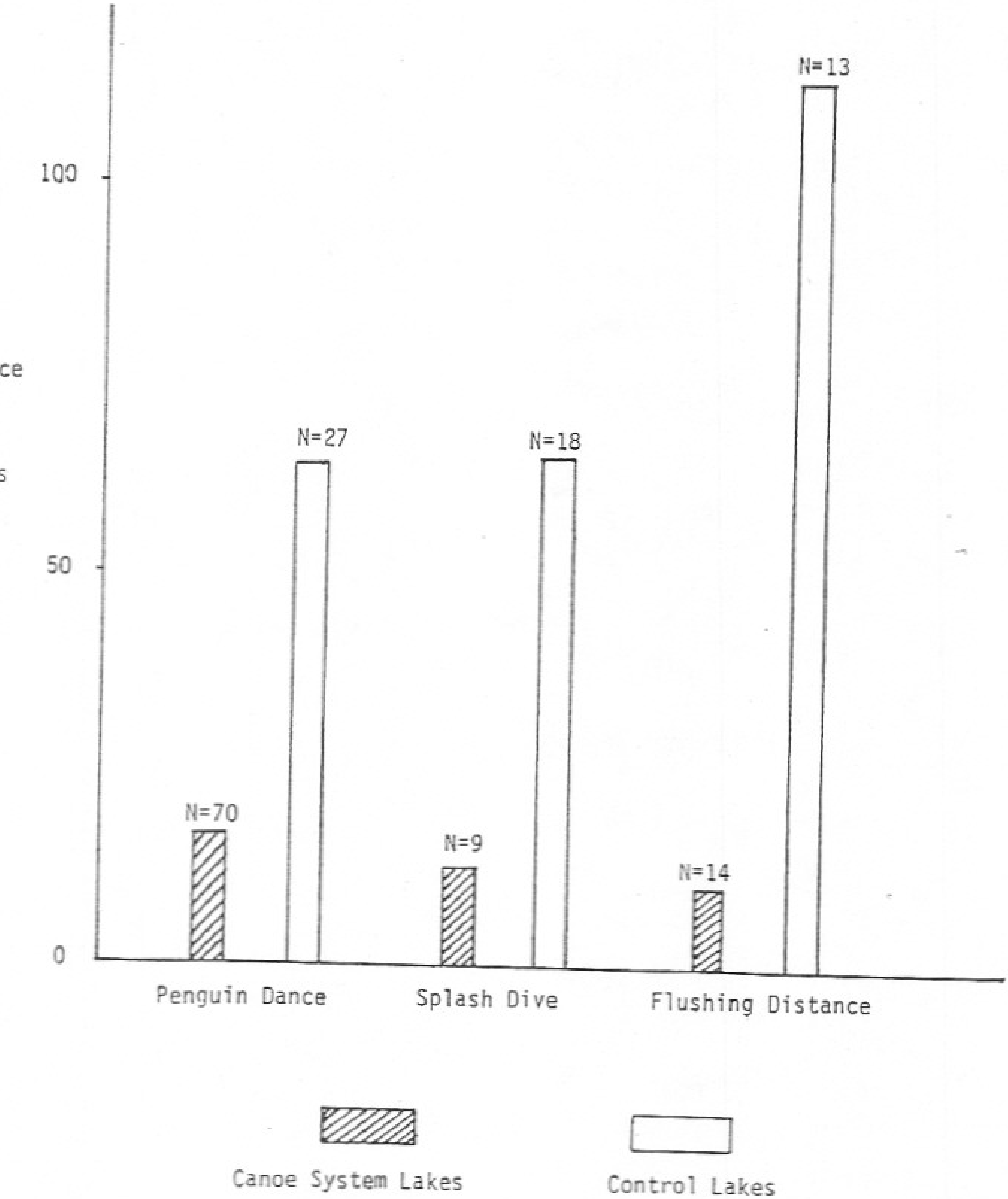

Fig. 6. Mean distances for occurrences of penguin dance, splash dive and flushing on canoe system and control study lakes of the Kenai National Wildlife Refuge, Alaska during 1980.

either sticking tight to the nest or quietly diving and surfacing away from the nest without commotion. If such strategies are indeed being used then there should be differences in those behaviors associated with nest and chick defenses between an area with repeated human use and a control area. In this study loons were generally more protective of the nest and chicks on the canoe system lakes than on control lakes supporting the idea that they have made adjustments to deal with the presence of canoeists on the canoe system lakes.

Significantly shorter ($P<0.05$) flushing distances on canoe system lakes than control lakes support the adoption of this strategy by loons. The mean flushing distance on the canoe system lakes was 8.5 m (n=14) with a range from 0-55 m (Fig. 6). For control lakes the mean flushing distance was 112.6 m (n=13) with a range from 7-273 m. Titus (1979) found a significant difference ($P<0.10$) in flushing distances between used and unused areas but found the mean flushing distance to be greater on heavily used lakes (41.6 m; n=9) than on remote lakes (23.1 m; n=11). Although Titus (1979) observed loons which never flushed due to his presence he had few observations on the same nest. In this study 50% of the 4 canoe system nests were attended by loons with stong tendencies to remain on the nest even when we approached within 1 m. Six of the 14 observations were on 1 nest with 4, 3 and 1 observations on the other 3 nests.

Different adaptive strategies may be responsible for the difference in mean flushing distances on the intensively used lakes. In this study the loons appear to have adopted the strategy of sticking tight to the nest as indicated by the short flushing distances. The loons studied by Titus (1979) in the BWCA appear to be using the other strategy - that of quietly diving while the disturbance was still far off and surfacing away from the nest without commotion.

Only 1 other behavior was found to occur at significantly different distances between the 2 areas. The penguin dance occurred at significantly shorter distances during the prehatching period ($P<0.05$) than during the posthatching period. This was expected as it is more difficult to approach mobile chicks than a stationary nest.

A freidman statistic (Mosteller and Rourke 1973) was calculated to determine if a correlation existed between flushing distance and stage of incubation. After accounting for area - canoe system or control lakes - the Freidman statistic was not significant ($P<0.50$) indicating no correlation between flushing distance and stage of incubation. It had been postulated that egg fidelity increased as incubation progressed (Olson and Marshall 1952). My data contradict this theory; however, the sample sizes were so small that more data should be collected before conclusions are reached.

<u>Canoe System Use</u>

Based on information gathered in the Swan Lake Canoe System registration boxes, total estimated number of individual users was 1,540 in 1979 and 2,519 in 1980. This use was down from Shon's (unpubl. data) 1975 figure of 4,200 visitors.

The 1980 canoe use survey indicated a high peak of use over Memorial Day weekend with 2 smaller peaks - 1 in early June and the other over July 4th weekend (Fig. 7). Canoe use was by far the greatest over Memorial Day weekend when 77 canoes were present on the lakes. This flurry of activity occurred during the period 18-28 May, when 67% of nests on both canoe system and control lakes were being initiated. According

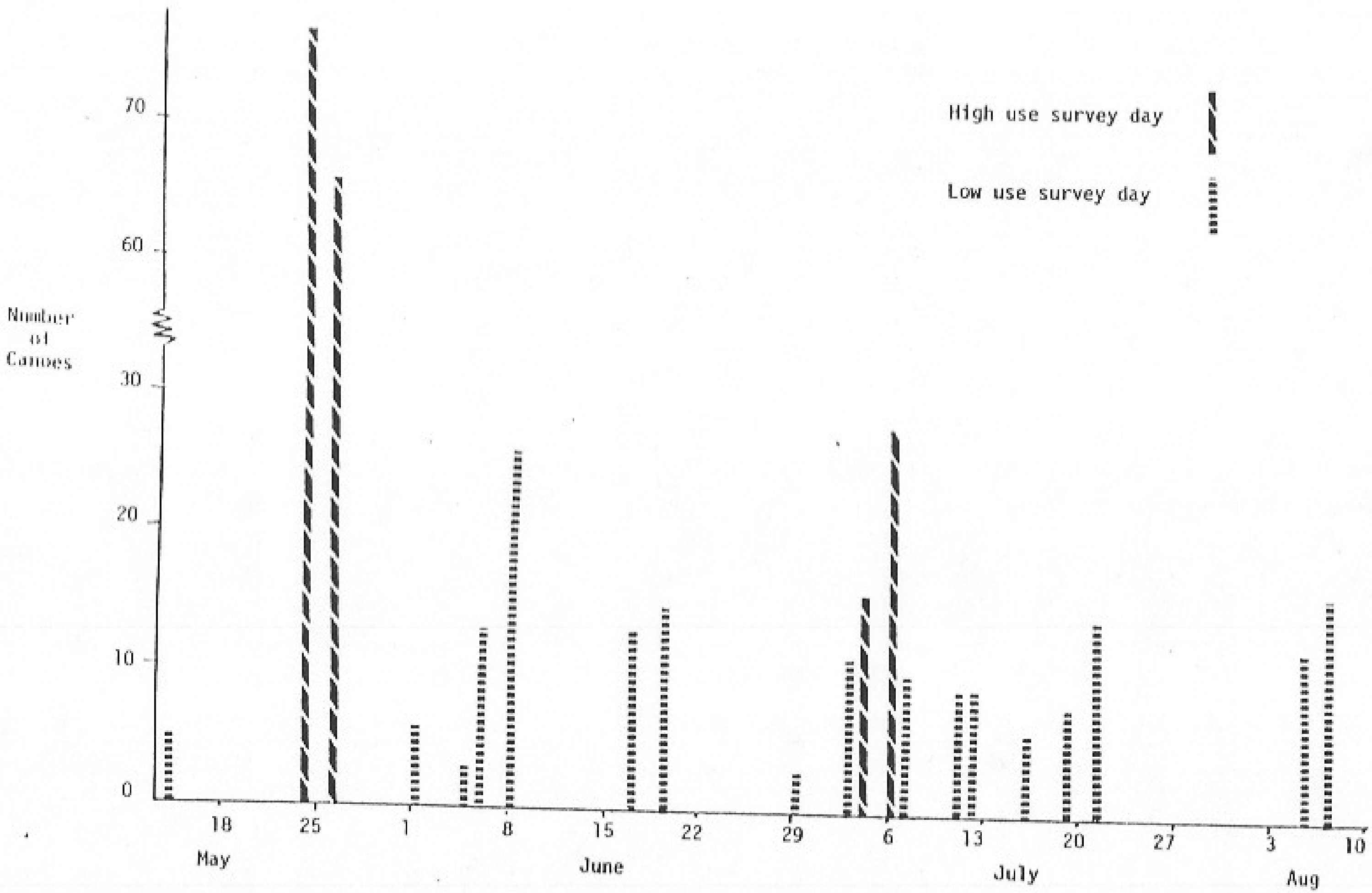

Fig. 7. Total number of canoes on Swan Lake Canoe System study lakes during the summer of 1980, Kenai National Wildlife Refuge, Alaska.

to Olson and Marshall (1952) this is a critical time during incubation when loons are most prone to abandon nests due to harrassment. Of the 3 canoe system nests initiated prior to peak use, 2 were destroyed. However, the destruction was in early June (Fig. 5) and therefore not associated with peak use over Memorial Day weekend. This does not mean that intensive use is not detrimental to successful nesting. Two territorial pairs plus 3 to 5 single loons were present on canoe system lakes but never nested. Another pair delayed nest initiation until after the second peak of high use. The cause of delay cannot be ascertained but one possible explanation is disturbance caused by the presence of canoeists. However, 2 territorial pairs on the control lakes did not nest so disturbance due to canoeists is not definitely the cause for failure to nest.

Five of 8 common loon nests on control lakes were initiated during the 10-day period from 18-28 May (Fig. 5). One nest was initiated a week after this period while the remaining 2 were delayed over a month. Accepting the assumptions that human disturbance on these lakes was caused only by my visits and that my visits, short and infrequent, were not enough to deter nesting suggests that human harrassment is not responsible for the delays in nesting, either on these control lakes or canoe system lakes.

The pattern of recreational use on the 10 canoe system lakes was highly variable (Appendix A). For example, on 1 survey day, Canoe Lake had 64 canoes present while Cygnet had no canoes. The time spent on each lake depended largely on fishing potential, campsite availability, distance from canoe system entrance and either past personal experience or past experience of friends (L.A. Shon pers. commun.). One canoe passing through a lake caused less disturbance to loons than 1 canoe engaged in fishing or exploring the lake. Camping on a lake also increased disturbance to loons. The number of campsites varied among the lakes as did popularity of the campsites.

An attempt was made to evaluate loon presence and nesting success on the 10 canoe system lakes with respect to average number of canoes, peak number of canoes, number of camps during peak use, hours of canoeist use, lake area, shoreline length, percent of shoreline judged suitable for nesting, and/or SDF. No relationship was discovered among any of the variables or any combination of the variables with respect to presence of loons or nesting success. I hoped to develop a ratio that would be of assistance in regulating levels of recreational use on canoe system lakes so that presence of loons nesting on the lakes would be assured for the public to enjoy. Additional data from future years may lead to some relationship which may assist in management of wilderness areas.

Population Estimate

Common loon population estimates for the KNWR were 1,668 in 1979 and 1,655 in 1980 (Table 6). The number of lakes in each stratum surveyed was slightly different between years (Table 7). Confidence intervals for the 2 estimates are:

1979	1,668 $\pm$ 643
1980	1,665 $\pm$ 381

The slightly altered sample sizes in 1980 increased reliability of the population estimate as demonstrated by the narrower confidence interval. In 1979 stratification increased precision of the survey by

Table 6. Aerial survey results of Kenai National Wildlife Refuge lakes (Alaska) for 1979 and 1980.

Strata	Total number lakes	Number lakes surveyed		Number of loons seen		Loons per lake		Estimated number loons per strata		Number of chicks seen	
		1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
Small (2.5-20 ha)	1600	162	150	122	112	0.75	0.75	1205	1195	14	13
Medium (20.5-80 ha)	130	15	18	41	44	2.70	2.44	351	318	10	7
Large (larger than 80 ha)	28	3	11	12	56	4.00	5.09	112	142	1	5
Totals	1758	180	179	175	212			1668	1655	25	25

Table 7. Strata allocations of aerial survey lakes for 1979, 1980 and future surveys to estimate the size of the common loon population on the Kenai National Wildlife Refuge, Alaska.

Strata	Total Number Lakes	Sample Sizes 1979	1980[a]	future surveys[b]
Small (2.5-20 ha)	1600	162	150	155
Medium (20.5-80 ha)	130	15	18	18
Large (larger than 80 ha)	28	3	11	7

[a] 1980 optimal allocation based on variances of 1979 aerial survey results.

[b] future surveys optimal allocation based on variances of 1980 aerial survey results.

40%. Although only 2 years of data are available the closeness of the population estimates indicates a high degree of stability in the population.

Density of adult common loons on KNWR lakes was 0.09 loons per hectare of water or 10.7 hectares per adult loon. Compared with loon densities from other areas (Table 8), KNWR lakes support a high density of loons. The low levels of human disturbance in this area after years of practically no disturbance may be responsible for this high density of loons. Other areas have been subject to high levels of human disturbance for many years.

Follow up surveys every 5 years are recommended to monitor the status of the common loon population. The best possible population estimate would require a small adjustment in strata allocations based on the variances from the 1980 survey (Table 7). The sample lakes and survey results are included in Appendix B.

Hampshire, Northcentral Minnesota, Northeast Minnesota, Saskatchewan, and Alaska.

	New Hampshire[a]		Northcentral Minnesota[b]		Northeastern Minnesota[c]		Saskatchewan[d]		Alaska[e]	
	1976	1977	1972	1976	1975	1976	1973	1974	1979	1980
Total Adult Loons	210	213	54	68	151	151	193	208	1452	1453
Water area (ha)	44739	44739	1057	1139	5304	5304	4123	4123	15500	15500
Area/Adult Loon (ha)	213.0	210.0	19.6	17.5	35.1	35.1	21.4	19.8	10.7	10.7

[a] Hammond and Wood (1977).

[b] McIntyre (1978).

[c] Titus (1979).

[d] Yonge (cited in Titus).

[e] This study.

DISCUSSION

The similar fledglings per breeding pair between the canoe system lakes and control lakes (Table 4) would indicate that presence of canoeists on the canoe systems is not having a detrimental effect on common loon reproduction. However, there were almost twice as many territorial pairs on the 10 control lakes as were on the 10 canoe system lakes, 11 and 6 in 1979 and 10 and 6 in 1980 respectively (Table 4). The same was true for nesting pairs as there were 9 and 4 in 1979 and 8 and 4 in 1980 for control lakes and canoe system lakes respectively (Table 4). Numbers of chicks produced on canoe system lakes were greater both years. This indicates that there was twice the breeding potential on the control lakes as on canoe system lakes despite similar habitats between the 2 lake groups. I believe this difference to be related to human disturbance on the canoe system lakes.

The changes in loon behavior which appear to be caused by the presence of canoeists on the canoe system (Fig. 6) appear also to have increased hatching success and chick survival on those lakes. In 1979 hatching success was 50% with 100% chick survival for canoe system lakes. Although hatching success was higher on the control lakes only 70% of the chicks survived in 1979 (Table 4). In 1980 production was down for both areas with 44% hatching success and 50% chick survival on canoe system lakes. Only 26% of the eggs hatched on the control lakes with 60% chick survival. The average for both years indicates higher success on canoe system lakes, 47% hatching success and 75% chick survival with 42% hatching success and 65% chick survival on control lakes. The adaptive strategy of sticking tight to the nest and chicks appears to have compensated for the reduced reproductive potential with increased reproductive success.

The disturbance caused by canoeists may reduce the suitability of canoe system lakes for nesting. That same disturbance may reduce the number of predators using the area thereby reducing loss of loon nests to predators. This in addition to the increased attentiveness of adult loons on canoe system lakes may account for the increased reproductive success.

The level of recreational use on the canoe system has not reached critical levels since loons are still nesting successfully. High use over Memorial Day weekend (Fig. 7) did not cause any loons to abandon nests which indicated that intensity of canoeists may not have even approached the critical level. Reproductive success on the canoe system lakes has adequately compensated for reduced reproductive potential. This also indicates that canoe system use is well within the levels tolerated by nesting loons.

The loon population estimates for 1979 and 1980 (Table 6) indicate a stable population. Twenty-five chicks were counted each year indicating production for the total population was similar during both 1979 and 1980. Study lake reproduction was 50% less in 1980 than in 1979 with 0.33 and 0.30 fledglings per territorial pair for canoe system lakes and control lakes respectively in 1980 and 0.67 and 0.64 fledglings per territorial pair for canoe system and control lakes respectively in 1979 (Table 4). I may have underestimated the effect my infrequent visits to control lakes had so that reproductive success was hindered on these lakes without the benefit of behavioral changes that loons on the canoe systems had. In 1980 the increased disturbance of taking behavior measurements may have contributed to the reduced reproduction on both lake groups.

Reproduction on lakes outside the 2 canoe systems has the potential to compensate for decreased nesting on canoe system lakes which might be caused in the future by increased recreational use of the canoe systems (McIntyre 1975). Refuge personnel have planned to limit group size on the canoe systems to 15 individuals to preserve the element of a wilderness experience that deals with getting away from other people (R. Johnston pers. commun.). This should be beneficial to loons as it should help keep noise and intensity of disturbances more constant.

At the current levels of recreational use on the canoe systems I see no major detrimental impacts occurring on common loon production and survival. Provided the KNWR lakes that are now remote, stay remote, this loon population should not be subjected to the problems that have caused declines in loon populations in northeastern and midwestern United States (Plunkett 1979).

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Appendix A. Results of the 1980 canoe use survey of Swan Lake Canoe System [illegible] National Wildlife Refuge, Alaska.

Lake	Number of Canoes for each survey date																				
	5/14	5/24[a]	5/26[a]	6/1	6/5	6/6	6/8	6/17	6/19	6/29	7/3	7/4[a]	7/6[a]	7/7	7/11	7/12	7/16	7/19	7/21	8/5	8/7
Canoe Lake	5	64	64	3	2	6	24	6	6	3	7	16	6	5	7	6	2	4	14	3	3
Canoe Lakes Chain(1)	5	66	58	1	2	2	24	4	6	2	7	16	6	5	7	6	2	4	12	2	3
Canoe Lakes Chain(2)	5	66	58	1	3	2	24	3	6	2	7	16	6	5	7	5	2	3	12	2	3
Contact	5	70	56	4	3	2	24	3	6	2	7	16	8	5	7	5	3	3	12	2	3
Marten	5	70	52	1	3	1	24	3	6	2	7	16	9	5	7	5	1	4	12	3	3
Spruce	3	71	46	1	2	3	26	10	12	1	12	16	6	4	7	7	3	3	7	5	9
Trout	2	48	30	0	0	2	2	1	3	1	4	7	1	5	1	2	2	2	0	1	7
Gavia	2	42	30	0	0	5	2	1	1	1	7	12	1	5	2	3	3	3	0	6	7
Konchanee	0	10	0	0	0	5	2	0	1	0	4	5	0	2	1	1	0	1	0	1	5
Cygnet	0	8	0	0	0	5	2	0	0	0	4	5	0	2	1	1	0	1	0	1	5
Total[b]	5	77	66	6	3	13	26	13	15	3	16	28	11	10	9	9	6	8	14	12	16

[a] Holiday weekend survey dates

[b] Total canoes may not be the sum of canoes on each lake since one canoe may be on more than one lake.

Appendix B. Location of Kenai National Wildlife Refuge lakes surveyed to estimate the loon population with 1979 and 1980 results.

STRATA 1

Lake Number	Location				Results[a]	
	T	R	Sec.	Topo Map[b]	1979	1980
1	T11N	R6W	29	A-2	0	2i
2	T7N	R11W	23	C-4	0	0
3	T8N	R5W	20	D-1	1i+c	2i
4	T9N	R7W	34	D-2	1i	0
5	T11N	R6W	32	A-2T	3i	2i
6	T9N	R9W	33	D-3	0	2i
7	T5N	R6W	7	C-2	0	2i+1c
8	T7N	R8W	5	C-2	0	0
9	T7N	R7W	30	C-2	3i+c	2i
10	T11N	R6W	31	D-2	1i+c	2i
11	T7N	R6W	17	C-2	2i	2i+1c
12	T9N	R8W	15	D-2	2i	0
13	T6N	R8W	34	C-2	0	2i
14	T6N	R6W	33	C-2	0	2i
15	T5N	R6W	2	C-2	0	1i
16	T6N	R6W	34	C-2	0	2i
17	T9N	R6W	29	D-2	0	1i
18	T10N	R7W	27	D-2	0	0
19	T7N	R9W	35	C-3	6i	2i+1c
20	T7N	R9W	1	C-3	0	0
21	T6N	R11W	2	C-4	0	0
22	T6N	R6W	30	C-2	0	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
23	T7N	R10W	1	C-3	0	1i+1c
24[d]	T10N	R6W	17	D-2	0	0
25	T6N	R7W	20	C-2	0	0
26	T8N	R9W	25	D-3	2i+c;2i+2c	3i
27	T8N	R8W	5	D-2	1i	0
28	T10N	R8W	36	D-2	1i	0
29	T8N	R9W	20	D-3	1i	0
30	T8N	R5W	4	D-1	1i	2i+1c
31[c]	T7N	R7W	16	C-2	0	-
32	T7N	R8W	9	C-2	1i	1i
33	T7N	R8W	9	C-2	0	0
34	T7N	R8W	15	C-2	2i	2i
35	T7N	R7W	19	C-2	2i	3i
36	T7N	R7W	2	C-2	2i	1i
37	T8N	R7W	27	D-2	2i	2i
38	T6N	R9W	22	C-3	0	0
39	T7N	R11W	36	C-4	0	2i
40	T7N	R8W	12	C-2	0	-
41	T6N	R7W	25	C-2	0	0
42	T8N	R8W	5	D-2	2i	1i
43	T9N	R6W	4	D-1	0	0
44	T7N	R7W	16	C-2	1i+c	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
45	T6N	R10W	35	C-3	0	1i
46	T7N	R11W	36	C-4	2i	1i
47	T7N	R8W	12	C-2	0	0
48	T8N	R5W	22	D-1	2i	0
49	T6N	R8W	15	C-2	0	2i
50	T6N	R6W	31	C-2	0	1i
51	T8N	R10W	20	D-3	0	0
52	T10N	R8W	36	D-2	0	-
53[c]	T5N	R7W	2	C-2	0	-
54	T10N	R8W	35	D-2	0	0
55	T10N	R7W	29	D-2	0	1i+1c
56	T10N	R8W	35	D-2	0	0
57	T9N	R6W	36	D-1	0	0
58	T9N	R9W	27	D-3	0	0
59	T6N	R7W	25	C-2	0	1i
60	T8N	R10W	12	D-3	0	0
61	T11N	R6W	20	A-2	0	0
62	T10N	R8W	34	D-2	2i+2c	1i
63	T6N	R9W	3	C-3	2i	2i
64	T7N	R6W	7	C-2	2i	2i+1c
65[c]	T6N	R9W	23	C-3	0	-
66	T7N	R10W	21	C-3	2i+c	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
67[c]	T6N	R11W	2	C-4	0	-
68[e]	T9N	R9W	27	D-3	0	-
69	T10N	R5W	32	D-1	1i	2i
70	T7N	R8W	17	C-2	1i	2i+1c
71	T10N	R8W	34	D-2	1i	0
72	T8N	R9W	20	D-3	0	0
73	T8N	R10W	33	C-3	0	0
74	T10N	R8W	36	D-2	1i+c	0
75	T6N	R7W	35	C-2	0	0
76	T8N	R6W	19	D-2	0	0
77	T10N	R7W	21	D-2	0	0
78	T7N	R10W	22	C-3	0	0
79	T8N	R6W	6	D-2	3i	0
80	T6N	R8W	12	C-2	2i	1i
81	T8N	R9W	15	D-3	0	0
82	T7N	R8W	20	C-2	0	1i
83[d]	T7N	R10W	33	C-3	0	0
84	T9N	R5W	6	D-1	1i	2i+1c
85	T7N	R10W	4	C-3	2i	0
86	T6N	R9W	4	C-3	0	0
87	T8N	R7W	6	D-2	2i	3i
88	T8N	R7W	16	D-2	3i	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
89	T8N	R8W	20	D-2	1i	1i
90	T8N	R5W	19	D-1	1i	0
91	T10N	R8W	35	D-2	0	0
92	T6N	R7W	36	C-2	0	0
93	T9N	R8W	22	D-2	0	0
94	T6N	R11W	2	C-4	0	0
95	T5N	R7W	10	C-2	0	0
96	T11N	R6W	28	A-1T	2i+c	1i
97	T8N	R5W	15	D-1	0	1i
98	T11N	R6W	32	A-1T	1i	0
99	T5N	R7W	9	C-2	0	0
100	T8N	R9W	16	D-3	0	0
101	T8N	R5W	8	D-1	1i	1i
102	T6N	R10W	13	C-3	0	2i
103	T6N	R8W	6	C-3	1i+c	2i+1c
104	T7N	R8W	6	C-2	0	2i
105	T7N	R10W	15	C-3	0	0
106	T8N	R6W	28	D-1	1i	1i
107	T10N	R8W	35	D-2	0	0
108	T10N	R7W	35	D-2	0	0
109	T11N	R6W	31	A-2T	1i	0
110	T8N	R8W	28	D-2	1i	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
111[d]	T7N	R9W	35	C-3	0	0
112	T9N	R9W	27	D-3	2i	0
113[d]	T7N	R11W	26	C-4	1i	0
114	T8N	R10	23	D-3	0	0
115	T8N	R5W	21	D-1	0	0
116	T8N	R7W	6	D-2	0	0
117	T9N	R9W	24	D-3	3i	0
118	T8N	R7W	22	D-2	1i	0
119	T10N	R8W	36	D-2	0	-
120	T6N	R11W	1	C-3	0	3i
121	T8N	R5W	35	C-1	0	0
122	T8N	R10W	14	D-3	0	1i
123	T5N	R6W	2	C-1	2i	0
124	T8N	R7W	36	C-2	0	1a+1c
125	T8N	R9W	17	D-3	1i	1i
126	T10N	R5W	30	D-1	0	0
127	T5N	R7W	1	C-2	0	0
128	T7N	R7W	17	C-2	0	-
129	T7N	R8W	17	C-2	0	0
130	T11N	R6W	33	A-1T	0	0
131	T6N	R9W	29	C-3	0	0
132	T5N	R6W	10	C-1	0	0

Appendix B. Continued

STRATA 1

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
133	T7N	R7W	15	C-2	0	0
134	T7N	R10W	17	C-3	1i	-
135	T8N	R8W	33	C-2	2i	2i
136	T9N	R8W	18	D-3	0	0
137	T11N	R6W	32	A-1T	0	1i
138	T7N	R8W	31	C-3	0	0
139	T6N	R9W	9	C-3	0	0
140	T5N	R7W	11	C-2	0	0
141	T7N	R10W	9	C-3	2i	0
142	T7N	R6W	9	C-1	0	0
143	T11N	R6W	21	A-1T	0	-
144	T8N	R5W	3	D-1	1i	3i+1c
145	T6N	R10W	1	C-3	1i	2i
146	T5N	R6W	8	C-2	0	2i
147	T9N	R7W	3	D-2	2i+c	-
148	T8N	R7W	18	D-2	0	0
149	T5N	R6W	2	C-1	1i	1i
150	T8N	R6W	18	D-2	0	1i
151	T7N	R7W	5	C-2	0	0
152	T7N	R9W	21	C-3	0	0
153	T10N	R5W	31	D-1	1i	0
154	T8N	R8W	22	D-2	2i	0

Appendix B. Continued

Lake Number	Location T	R	Sec.	Topo Map[b]	Results 1979	1980
STRATA 1						
155	T8N	R9W	14	D-3	2i	1i
156	T9N	R6W	19	D-1	2i	0
157	T7N	R6W	6	C-2	2i	0
158	T7N	R8W	3	C-2	0	0
159	T7N	R9W	36	C-3	0	0
160	T9N	R7W	33	D-2	1i	0
161	T7N	R9W	31	C-3	0	0
162	T10N	R6W	18	D-2	1i	2i+1c
STRATA 2						
200	T7N	R8W	24	C-2	2i+c;1i	3i
201	T5N	R7W	3	C-2	0	3i
202	T6N	R7W	1	C-2	2i	3i
203	T6N	R7W	36	C-2	2i	1i
204	T6N	R10W	15	C-3	2i+c	5i
205	T6N	R8W	3	C-2	-	0
206	T7N	R6W	8	C-2	3i	2i+1c
207	T7N	R8W	9	C-2	1i	1i
208	T7N	R8W	15	C-2	1i+c	1i+1c
209	T7N	R8W	23	C-2	2i+c	0
210	T7N	R7W	18	C-2	2i+c	4i
211	T7N	R8W	4	C-2	2i	2i+1c
212	T7N	R7W	1	C-2	2i+c;2i+c	3i+1c

Appendix B. Continued

STRATA 2

Lake Number	Location				Results	
	T	R	Sec.	Topo Map[b]	1979	1980
213	T7N	R8W	12	C-2	2i+c	2i
214	T6N	R9W	15	C-3	2i+2c	2i+1c
218	T8N	R7W	34	C-2	3i	0
219	T10N	R6W	35	D-1	-	2i+1c
220	T10N	R7W	36	D-2	-	3i+1c

STRATA 3

Lake Number	T	R	Sec.	Topo Map	1979	1980
215	T7N	R8W	18	C-2	2i	2i
216	T6N	R9W	5		6i	4i+1c
217	T6N	R9W	5		3i+c	10i
221	T10N	R6W	8	D-1	-	2i
222	T8N	R6W	27/34	C-1/D-1	-	2c
223	T7N	R8W	35/26	C-2	-	3i
224	T10N	R6W	33	D-1	-	5i+1c
225	T7N	R8W	15	C-2	-	9i
226	T10N	R6W	31/30	D-2	-	6i+1c
227	T9N	R8W	33	D-2	-	5i
228	T9N	R6W	23	D-1	-	5i

[a] coding for the results are:
- a = *Gavia arctica* adult
- i = *G. immer* adult
- c = chick

[b] topographic maps are in the Kenai series (T indicates Tyonic series).
[c] dried up lake in 1979
[d] dried up lake in 1980
[e] lake choked with weeds