Observations on Arctic and Red-throated Loons at Storkersen Point, Alaska

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ABSTRACT. Habitat requirements of arctic loons (*Gavia arctica*) and red-throated loons (*Gavia stellata*) were studied at Storkersen Point on the Arctic coastal plain of Alaska from 1971 to 1975. Nest success ranged from 28 to 92 per cent and 33 to 78 per cent for arctic and red-throated loons, respectively. Loons were ecologically isolated in their feeding habits and use of wetlands. Arctic loons fed to their young invertebrates captured in the nest pond, and red-throated loons fed to theirs fish captured from the Beaufort Sea. Both species preferred islands as nest substrates, but arctic loons utilized large ponds with stands of *Arctophila fulva* wetlands for nesting, whereas, red-throated loons used smaller, partially-drained basins most frequently.

RÉSUMÉ. *Observations sur le huard arctique et sur le huard à gorge rousse, à Storkersen Point, en Alaska.* Entre 1971 et 1975, on a mené des études sur les conditions d'habitat du huard arctique (Gavia arctica) et du huard à gorge rousse (Gavia stellata), à Storkersen Point, dans la plaine côtière de l'Alaska. Vingt-huit à quatre-vingt-douze pourcent des huards arctiques, et trente-trois à soixante-dix-huit pourcent des huards à gorge rousse ont réussi à établir leurs nids en cet endroit. Les deux espèces de huard étaient isolées, du point de vue écologique: chacune avait ses habitudes d'alimentation et habitait un type particulier de marécage. Les huards arctiques ont nourri leurs couvées d'invertébrés capturés dans l'étang près du nid; les huards à gorge rousse ont donné à leurs petits des poissons pêchés dans la mer de Beaufort. Les deux espèces d'oiseaux ont préféré construire leurs nids sur des îles, mais les huards arctiques ont établi leurs nids dans de grands étangs où poussait l'*arctophila fulva,* alors que les huards à gorge rousse ont la plupart du temps utilisé de plus petits étangs partiellement asséchés.

Резюме. *Наблюдения за чернозобой и краснозобой гагарой в пункте Сторкерсена на Аляске.* В период 1971-75 гг. в пункте Сторкерсена, расположенном на равнинной части арктического побережья Аляски, изучались условия обитания чернозобой (Gavia arctica) и краснозобой (Gavia stellata) гагары. Доля услешно законченных гнезд колебалась в пределах от 28% до 92% для чернозобой и от 33% до 78% для краснозобой гагары. Гагары были экологически изолированы в своем образе питания и обитания на заболоченной местности. Чернозобые гагары кормили птенцов вылавливаемымн из местных прудов беспозвоночными, а краснозобые гагары приносили своему потомству рыбу из моря Бофорта. Оба вида предпочитали гнездоваться на островах, причем краснозобые гагары выбирали большие поросшие арктофилой рыжей пруды, а краснозобые гагары чаще селились на частично дренированных водоемах меньших размеров.

INTRODUCTION

This paper appraises habitat requirements and discusses facets of the breeding biology of arctic loons (*Gavia arctica*) and red-throated loons (*Gavia stellata*) on the Arctic coastal plain of Alaska. The impetus for the study was the impending development of petroleum resources in the area. Because of their large size and abundance, loons may be valuable indicators of changes in water-bird populations on the coastal plain. For this reason, information about habitat preferences of these loons during their reproductive cycle was needed.

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STUDY AREA AND METHODS

The study area is located at Storkersen Point (70°25′N, 148°15′W) and occupies 18 km^2. It is bordered on the north by the Beaufort Sea coast and extends 7 km inland. The Kuparuk and Sagavanirktok Rivers form large deltas approximately 8 km northwest and 25 km southeast, respectively, of Storkersen Point. Elevation in the study area ranged from sea level at coastal lagoons to 10 m on pingos a few kilometres inland.

Abundance and distribution of loons at Storkersen Point were appraised by weekly ground surveys conducted by two or three men. Birds were counted on two 2.6-km^2 plots in 1971 and on the same two areas and an additional area of the same size from 1972 to 1975. Base maps prepared from U.S. Geological Survey orthographic maps were used to record locations of loons.

Use of wetlands by loons was determined by weekly ground surveys on the 2.6-km^2 plots during 1971 through 1973. Preference for a wetland class was tested using a chi-square 1 x 2 contingency table. The number of birds observed using wetlands on surveys was compared to the number of birds expected on those wetlands. Expected values were calculated by multiplying the total number of birds using a wetland class by the per cent of the total wetland area covered by that class.

Nest searches were conducted throughout the 18-km^2 study area during 1971-73, with less intensive coverage during 1974 and 1975. Nests were marked with a garden wand and their locations recorded on a base map. The following measurements were made at each nest pond: (1) surface area, maximum water depth, and emergent cover of nest ponds, (2) area of nest islands, (3) distance of nest rim to water, (4) height of nest bottom above water, and (5) depth and diameter of nest bowls. During 1971 to 1974, nests were checked about once a week to determine clutch size and nest success. Nests were checked less frequently in 1975 to minimize disturbance. Any nest in which at least one egg hatched was considered successful.

RESULTS

Spring arrival

Arctic and red-throated loons arrived at Storkersen Point concurrently with thawing of wetlands later used for nesting. First sightings in the study area varied in date from 5 June in 1971 to 11 June in 1974 for red-throated loons, and from 7 June in 1971 and 1973 to 12 June in 1972 for arctic loons. Earlier, pairs and small flocks of both species used open water in the Kuparuk River delta and adjacent Beaufort Sea. Loons were frequently observed in flight over the study area before wetlands thawed completely.

Abundance and production

Densities of breeding loons on the 2.6-km^2 plots were relatively constant during the five years of the study. Arctic loons averaged 1.6 birds per km^2 each year, and the average density of red-throated loons ranged from 1.2 to 1.6 birds per

km^2. Non-breeding loons were not noted in the area during the pre-nesting and nesting periods.

Clutch size of both species usually was two eggs. All 23 arctic loon nests checked for clutch size contained two eggs. Eighteen of 21 red-throated loon nests had two eggs, and three nests contained one. Davis (1972) found arctic and red-throated loons laid clutches of one or two eggs, but two-egg clutches were most common.

TABLE 1. Nest success of arctic and red-throated loons.

Year	Percentage success (no. of nests in brackets)	
	Arctic loon	Red-throated loon
1971	28(14)	33(6)
1972	92(12)	78(9)
1973	53(15)	45(9)
1974	40(7)	50(2)
1975	56(9)	50(2)

Nest success of arctic and red-throated loons for the five years is shown in Table 1. The cause of nest failures was not determined for most nests. However, arctic foxes (*Alopex lagopus*) were observed hunting on the study area almost daily in 1971, 1973 and 1975, but little fox activity was seen in 1972. This may account for the higher nest success for both species in 1972. Loon nests also were destroyed by jaegers (*Stercorarius* spp.) and glaucous gulls (*Larus hyperboreus*), but numbers and activities of these predators appeared stable during the five years (see Bergman *et al.* 1976).

Renesting was probably done by arctic loons that lost their first clutch early in the incubation period. In two cases where arctic loon nests were destroyed during the first week of incubation, new nests were found at the same nest pond within one week. Both presumed renesting attempts were unsuccessful, and one involved an infertile or undeveloped egg. The authors found no evidence of renesting by red-throated loons.

Although most loon nests contained two eggs, only one of the two young in each family survived. For example, in 1972, 12 arctic loon nests had clutches of two eggs where both young hatched successfully. However, one young from each brood died before the age of seven days. Similarly, one young red-throated loon from each of nine two-chick broods died by the age of 15 days. Davis (1972) found that the young hatch asynchronously, usually 24 hours apart, and only after the first-hatched young receives sufficient food does the younger loon get fed.

Production by loons during 1971 to 1973 ranged from an average of 0.4 to 0.7 young per km^2 for arctic loons, and from 0.3 to 0.6 young per km^2 for red-throated loons. Highest production by both species occurred in 1972 when fox activity was lowest.

Distribution of nests

The mean density of arctic loon nests was 0.8 per km^2 for 1971 through 1973. Distance between nests ranged from 250 to 1,100 m, with a mean distance of 640 m (no. of nests N=41). Average red-throated loon nest density was lower

(0.4 nests per km^2) and the mean distance between nests was 530 m (range = 80 − 1,820 m, N=24) calculated for 1971 through 1973. Because several pairs of nesting red-throated loons used the same partially drained lake, the mean distance between nests was less than for arctic loons. Most nest ponds were used by the same species each year and occasionally the same nest site was reused.

Feeding habits of loons

At Storkersen Point, foods consumed by adult arctic loons were taken both at sea and from wetlands in the study area, whereas adult red-throated loons seemingly fed only at sea. This is noteworthy, since red-throated loons nest in large inland freshwater lakes in the Northwest Territories (Weller *et al.* 1969). Feeding flights by both species to sea were commonly observed throughout the summer, but only adult arctic loons were seen feeding in wetlands in the study area. The birds fed in ponds and lakes by diving or by submerging head, neck, and sometimes most of the body. Depth of water appeared to dictate the feeding method employed. When loons fed from the surface, the water was shallow and the birds appeared to capture organisms on or near the bottom. Occasionally, individuals disturbed the bottom sediments by "ploughing" with the bill, probably to expose organisms. Due to the absence of fish in wetlands, invertebrates were the principal foods available for arctic loons. On 5 August 1972, one adult female was collected from a pond while diving in water 70 cm deep. Caddisfly larvae (Trichoptera), tadpole shrimps (Notostraca), fairy shrimps (Anostraca) and water fleas (Cladocera) were recognizable in the stomach.

Three pairs of red-throated loons were observed from blinds during the nesting and post-nesting periods of 1972 and 1973, including two 24-hour periods in 1973 when activities were determined every 30 minutes. Individuals never fed from wetlands in the study area, and feeding flights to sea were common. Foods consumed by adult red-throated loons were not determined near the study area, but one adult taken 30 km northwest of Storkersen Point in coastal sea water near Pingok Island on 2 August 1972 contained remnants of arctic cod (*Boreogadus saida*) in its gizzard (G. J. Divoky, personal communication).

Adult arctic loons almost always obtained food for their young from the wetlands that both parents and young inhabit. Twenty-four feeding episodes involving eight family groups on 18 different days were observed between 23 July and 10 August of 1972 and 1973. Each feeding episode lasted at least five minutes, and young were fed several times during each episode. Only one episode included food captured from the sea: on 23 July 1972, an adult brought a small fish to the brood pond and fed it to the young loon. During the same period, however, the chick also was fed pond organisms by the other parent. Upper digestive tracts of three young arctic loons collected on brood ponds were examined. Two contained tadpole shrimps and the third had dominantly Trichoptera larvae. The two young fed with tadpole shrimps were two- and three-week-old males collected from large ponds containing stands of *Arctophila fulva*. Food volume in a two-day-old male, collected on a partially-drained lake basin, consisted of over 95 per cent Trichoptera larvae, with the remainder consisting of Mallophaga and vegetation.

Red-throated loons are predominantly ichthyophagus throughout their breeding and winter ranges (Madsen 1957). During summer, fish are obtained for young from source areas such as the sea, as shown by Davis (1972) or from lakes and rivers (Braun *et al.* 1968). While on brood ponds, immature red-throated loons at Storkersen Point were always fed fish captured in the Beaufort Sea by their parents. Eighteen feeding exchanges involving six families on 12 different days were observed between 22 July and 11 August in 1972 and 1973. At each exchange, one parent arrived on the pond from the direction of the coast with a fish held crosswise in the bill. The fish subsequently was placed into the mouth of a young loon. Two young red-throated loons, one less than one day old and the other three days old, were captured immediately after being fed. Each contained one arctic cod that was removed from the esophagus without apparent injury to either bird. The decapitated cod bodies were approximately 8 cm long. Colour and shape of these fish were similar to those of the unidentified fish seen during other feeding exchanges, suggesting that arctic cod is the major food fed to young red-throated loons near Storkersen Point.

During fish-netting operations in areas of the Beaufort Sea, where loons commonly feed, H. Sears (personal communication) captured only arctic cod and sculpins (Cottidae) off Storkersen Point. Because of their spines, sculpins may be less acceptable to loons than cod (Munro 1930).

Use of wetlands

Bergman *et al.* (1976) have classified the wetlands of the Arctic coastal plain.

Those used most frequently by loons include: Shallow-*Arctophila* — ponds, or streams, with a central zone of *Arctophila fulva* and shoreward stands of *A. Fulva* or *Carex aquatilis;* Deep-*Arctophila* — large ponds or lakes without emergents in the central zone and *A. fulva* near the shore; and Basin-complex — large partially-drained basins containing pools of various depths with diverse plant communities.

Wetland classes used less frequently include: Shallow-*Carex* — shallow ponds containing emergent *C. aquatilis* with a central open-water zone; Deep-open — deep lakes with abrupt shores, sublittoral shelves, and a deep central zone; Beaded stream — small streams composed of a series of pools linked by channels formed in ice-wedges; and Coastal wetland — ponds or lagoons directly influenced by sea water.

Wetlands selected by red-throated loons were predominantly those found in large and shallow, partially-drained lakes (Basin-complex). Arctic loons most frequently used relatively deep ponds containing shoreward stands of *Arctophila fulva.* A further contrast between the two species was the red-throated loon's greater use of relatively small Shallow-*Carex* ponds and Shallow-*Arctophila* ponds for nest sites (Tables 2A and 2B).

The frequency of use of Deep-*Arctophila* wetlands by arctic loons was highly significant ($P < 0.01$) in all periods (Table 2A). This class of wetlands contained from 52 per cent of all arctic-loon sightings in the pre-nesting and post-nesting periods to 66 per cent of wetlands used for nesting. Use of Basin-complex lakes by arctic loons was significant (P < 0.01) only during the pre-nesting period, because such wetlands provided the earliest large body of open water. Later, the largest pools within these basins were used for nesting and brood rearing. Frequency of use of Deep-open lakes by arctic loons was significant (P < 0.05) in the post-nesting period when adults without young formed small flocks on these lakes.

TABLE 2A. Percentage frequency of use of wetlands by arctic loons from 1971 through 1973.

	Pre-nesting N = 31	Nesting[1] N = 79	Post-nesting[2] N = 57	Nest site[3] N = 22
Flooded tundra	0	0	0	0
Shallow-*Carex*	0	5	9	5
Shallow-*Arctophila*	0	3	0	5
Deep-*Arctophila*	52*	59**	52**	66**
Deep-open	0	5	16*	5
Basin-complex	36**	18	16	9
Beaded stream	6	5	2	5
Coastal wetland	6	5	5	5
TOTALS	100	100	100	100

N = number of birds.
[1]The nesting period includes all loons, regardless of whether actually nesting or not.
[2]The post-nesting period includes adults and young.
[3]The nest-site category includes those wetlands containing nests.
*Chi-square test significant (P < 0.05) with one degree of freedom.
**Chi-square test highly significant (P < 0.01) with one degree of freedom.

Use of Basin-complex lakes by red-throated loons was highly significant (P < 0.01) in all periods (Table 2B) and ranged from 39 per cent of wetlands selected as nest sites to 73 per cent used during pre-nesting. Pairs usually inhabited only one of the pools comprising the Basin-complex lake; consequently, a single basin contained up to five pairs of nesting red-throated loons. The frequency of use of Deep-*Arctophila* ponds by red-throated loons was significant throughout

TABLE 2B. Percentage frequency of use of wetlands by red-throated loons from 1971 through 1973.

	Pre-nesting N = 25	Nesting[1] N = 115	Post-nesting[2] N = 65	Nest site[3] N = 18
Flooded tundra	0	0	0	0
Shallow-*Carex*	2	6	2	21
Shallow-*Arctophila*	3	8	3	11*
Deep-*Arctophila*	22**	33**	24**	23*
Deep-open	0	0	3	0
Basin-complex	73**	51**	65**	39**
Beaded stream	0	2	3	6
Coastal wetland	0	0	0	0
TOTALS	100	100	100	100

N = number of birds.
[1]The nesting period includes all loons, regardless of whether actually nesting or not.
[2]The post-nesting period includes adults and young.
[3]The nest-site category includes those wetlands containing nests.
*Chi-square test significant (P < 0.05) with one degree of freedom.
**Chi-square test highly significant (P < 0.01) with one degree of freedom.

summer, but use of ponds in this class was considerably less than shown by arctic loons.

Comparison of dimensions and vegetation of ponds, or of pools in Basin-complex lakes, used for nesting by the two species indicates that arctic loons select larger and more open waters than do red-throated loons (Table 3). Mean area of wetlands selected by arctic loons was 3.0 hectares (range 0.7 to 12.1) compared to 0.4 hectares (range 0.1 to 0.8) for those wetlands used by red-throated loons ($P < 0.01$). Arctic loons also selected significantly larger — or deeper — ($P < 0.05$) wetlands than red-throated loons; therefore, the shallow water emergents *Arctophila fulva* and *Carex aquatilis* were less abundant in arctic loon nest ponds. These data support evidence presented by Lindbergh (1968) and Davis (1972) that the two species have evolved patterns that reduce competition for habitat.

TABLE 3. Comparison of vegetation, mean depth, and area of wetlands[1] selected for nesting by loons.

	Arctic loon (N=22)			Red-throated loon (N=18)			
	Mean	Standard deviation	Range	Mean	Standard deviation	Range	t-value
Percentage cover							
Arctophila fulva	13.7	(14.9)	0-60	30.5	(29.2)	0-75	2.2*
Carex aquatilis	5.0	(11.4)	0-50	9.2	(7.7)	1-25	1.4
Mean depth (cms)	36.9	(12.4)	20-55	27.6	(12.8)	11-60	2.3*
Surface area (hectares)	3.0	(8.4)	0.7-12.1	0.4	(0.5)	0.1-0.8	3.5**

N = number of nest ponds.
[1]Pools used for nesting in Basin-complex lakes were measured rather than the entire basin.
*"Student's" t-test significant ($P < 0.05$).
**"Student's" t-test highly significant ($P < 0.01$).

Arctic loon families often moved from nest ponds to nearby wetlands. On 7 August 1973, an adult and three-week-old young were observed during a 150-m journey on land. Both birds moved surprisingly well by sliding motions that involved thrusting the breast upward and forward using propulsion provided by the feet. Olson and Marshall (1952) noted that common loon (*Gavia immer*) chicks were much more agile on land than their parents. Most arctic loon families in the study area made moves on land of less than 150 m. Young usually were over two weeks of age, although two families moved short distances over land when the young were approximately one week old. Most moves were to the same class of wetland, principally the Deep-*Arctophila* type.

Such moves make adult and young arctic loons vulnerable to predators. Possibly, a minimum threshold of feeding efficiency was exceeded, followed by a move to the adjacent wetland where food was more abundant. Feeding episodes involving one adult and one young were watched on 28 and 30 July 1972 at the nest pond. During two periods totaling 45 minutes, a range of two to six feedings per minute occurred. The family moved to another pond on 6 August, and on 7 August a 10-minute feeding episode involved eight to ten feedings per minute.

The single observed case of movements on land by red-throated loons involved two young moving a distance of 200 m. Because of the proximity of the nest to frequent human activity, disturbance may have caused the move. Braun *et al.* (1968) considered disturbance the primary factor influencing a parent red-throated loon to guide its young 310 m to a different lake. Presumably, the lack of dependence of red-throated loons on nest ponds for food allows the birds to remain on the same pond throughout the brood-rearing period.

Nest sites of arctic loons

Nest ponds and nest substrates often were used in subsequent years, probably by the same pair of arctic loons (Lindberg 1968). Of 41 nests found near Storkersen Point, 27 were found at the same wetland in either two or three summers from 1971 to 1973. Use of land islands for nesting in these ponds usually was repeated, and nests placed on mainland shores or islands (platforms) of vegetation frequently occurred close to the nest site used the previous year.

Islands were preferred nest substrates of arctic loons in Sweden (Lindberg 1968), in Finland (Lehtonen 1970), near Hudson Bay (Davis 1972), and near Storkersen Point (Table 4). Use of land islands was greatest (61.0 per cent), while islands constructed of dead emergents by loons comprised six (14.6 per cent) of the 41 substrates. Nest islands averaged 106.9 m^2 in area (range from less than one up to 600 m^2) (Table 4), but no preference by pairs for islands of a particular size was determined. Islands composed of aquatic vegetation always were less than 1 m^2, and protruded a few centimetres above the water surface.

TABLE 4. Characteristics of nest sites of arctic and red-throated loons (1971 through 1973).

	Arctic loon	Red-throated loon
Nest substrate[1]*		
Land island	61.0(25)	40.7(11)
Vegetation platform	14.6(6)	48.2(13)
Mainland shore	24.4(10)	11.1(3)
Island area (m^2)**	106.9 ± 34.1(21)	4.1 ± 1.3(17)
Distance to water (cm)**	30.9 ± 10.7	21.0 ± 3.1
Height of nest above water (cm)**	9.0 ± 0.8	7.9 ± 0.7
Nest-bowl depth (cm)**	2.6 ± 0.2	2.8 ± 0.2
Nest-bowl diameter (cm)**	22.6 ± 0.6	22.0 ± 0.7

[1]Significant difference between species ($\chi^2=7.1$, $P<0.05$).
*Figures indicated are percentages of use of total nest substrate (and numbers of nests in parentheses).
**Figures indicated are mean values with respective standard errors (and numbers of nests in parentheses).

Mainland shores of wetlands constituted the remaining 24.4 per cent of the nest substrates selected. These sites, however, frequently were on narrow peninsulas which, in effect, provided the incubating bird with an island-like environment.

Nest success was highest at sites in the same nest pond that were used more than one year. Seventy-eight per cent of the nests at wetlands used in two or three summers were successful, in contrast to 22 per cent success of nests at wetlands used once. Nest success also was slightly higher on islands (62 per cent) than on pond shores (50 per cent) and may be due to greater accessibility of mainland nests to arctic foxes.

All nests were shallow depressions in the substrate, usually lined with pieces of vegetation, and located at water edge. Mean dimensions of nests and distances to water appear in Table 4.

Extensive plant cover around nests occurred only where pairs constructed vegetation islands. Materials for structures were taken from nearby stands of aquatics. Emergents probably reduce wave action at the low nest platform.

Nest sites of red-throated loons

Nineteen of the 27 red-throated loon nests found occurred at ponds used by pairs during more than one summer. Nest sites in these wetlands were usually in proximity to the nest constructed the previous year.

Red-throated loons prefer islands for nest substrates (Table 4). Thirteen nests (48.2 per cent) were placed on small vegetation platforms built of aquatics, and 11 nests (40.7 per cent) occurred on land islands. Only three nests (11.1 per cent) were on mainland shores. Lindberg (1968) and Davis (1972) reported red-throated loons favouring islands for nest sites.

Although arctic and red-throated loons utilized the same types of substrates (Table 4), frequency of substrate selection between these species was significantly different ($P < 0.05$). Contributing most to the difference was the preference of red-throated loons for vegetation islands which arctic loons used least often. Vegetation islands were constructed where loons nested in shallow areas of wetlands with dense stands of emergents. Consequently, preference by red-throated loons for extensively vegetated pools of Basin-complex lakes resulted in pairs nesting on islands of vegetation most frequently. Arctic loons, in contrast, most frequently selected Deep-*Arctophila* wetlands containing land islands.

The mean area of red-throated loon nest islands was 4.1 m^2 (range 1 to 20 m^2, $N = 17$) (Table 4). The smaller mean size of these substrates compared to those chosen by arctic loons resulted principally from red-throated loons favouring small vegetation islands.

Nest success was 63.2 per cent ($N=19$) for pairs nesting at wetlands used in more than one summer, compared to 37.5 per cent ($N=8$) success at wetlands used only once during the study. The difference is not statistically significant by the chi-square test ($P > 0.1$). Nest success was also higher for pairs nesting on islands (58.3 per cent, $N=24$) than for nests placed on mainland shores (33.3 per cent, $N=3$), but this difference is not significant ($P > 0.3$).

Dimensions of the nest bowl, proximity of the nest to water, and plant protection around nests were similar for arctic and red-throated loons (Table 4).

DISCUSSION

MacArthur (1971) stated that "species differ both in food and habitat rather than either separately", whereas Lack (1971) emphasized that more congeneric species of birds are segregated by feeding than in any other way. An example of ecological isolation in water-birds is provided by Weller (1972) who studied eleven species of breeding waterfowl in the Falkland Islands. He found that where two species used the same general habitat, they tended to differ in food use.

Arctic and red-throated loons coexist throughout much of their range during the reproductive period (Dement'ev *et al.* 1968). Davis (1972) demonstrated that separation of arctic and red-throated loons in Canada was associated with selection of nest-pond size. He tested the importance of other pond parameters such as depth, bottom type, food supply and water clarity, and showed that these were similar in most ponds and therefore not important in selection by loons. The present study at Storkersen Point demonstrated that arctic loons prefer wetlands of larger area than those selected by red-throated loons, which agrees with Davis (1972). However, at Storkersen Point arctic loons showed a distinct preference in all periods for the Deep-*Arctophila* wetlands, whereas red-throated loons used Basin-complex wetlands most frequently from pre-nesting to post-nesting. Some overlap of the two species occurred in use of Deep-*Arctophila* wetlands (Tables 2A and 2B).

Food specialization in breeding arctic and red-throated loons at Storkersen Point appears to be based on prey type. Arctic loons fed their young from invertebrates captured in the nest pond, whereas red-throated loons flew to the Beaufort Sea for fish. Davis (1972) found that some arctic loons nesting near the McConnell River, N.W.T., captured fish and invertebrates for the young from the nesting territories, while other pairs nesting in ponds with little food used Hudson Bay as a source of fish. He found that red-throated loons fed exclusively on fish gathered from areas other than nesting territories, which concurs with the present findings. At Storkersen Point fish are absent in all wetland classes except Beaded streams (Howard 1974). Use of this class of wetland by loons was minimal (Tables 2A and 2B). Therefore, if arctic loons were to secure sufficient quantities of fish to feed young, they would have to rely on the Arctic Ocean as do red-throated loons. Although food items differ between the McConnell River and Storkersen Point, it is apparent that these two loons exhibit some degree of trophic niche separation at both locations. In conclusion, direct competition for resources between arctic and red-throated loons during the breeding season at Storkersen Point is avoided by separation in both habitat and trophic niches. It would seem that these two species might be useful in reflecting changes in habitat resulting from either natural or artificial means, and that pollution of fresh waters will influence arctic loons most while pollution of the sea will affect red-throated loons.

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REFERENCES

BERGMAN, R. D., HOWARD, R. L., ABRAHAM, K. F. and WELLER, M. W. 1976. Water birds and their wetland resources in relation to oil development at Storkersen Point, Alaska. *U.S., Department of the Interior, Fish and Wildlife Service, Resource Publication* 129.

BRAUN, C. VON, HESSLE, A. C. and SJOLANDER, S. 1968. Smalommens (*Gavia stellata* L.) beteende under ungvardnadstiden. *Zoologisk Revy*, 30: 94–95.

DAVIS, R. A. 1972. A comparative study of the use of habitat by arctic loons and red-throated loons. (Unpublished Ph.D. thesis, University of Western Ontario, London, Canada.)

DEMENT'EV, G. P., MEKLENBURTSEV, R. N., SUDILOVSKAYA, A. M. and SPANGENBERG, E. P. 1968. *Birds of the Soviet Union, Vol. II*. Jerusalem: Israel Program for Scientific Translations.

HOWARD, R. L. 1974. Aquatic invertebrate–waterbird relationships on Alaska's Arctic Coastal Plain. (Unpublished M.S. thesis, Iowa State University, Ames, Iowa, U.S.A.)

LACK, D. 1971. *Ecological Isolation in Birds*. Cambridge, Mass.: Harvard University Press. p. 261.

LEHTONEN, L. 1970. Zur Biologie des Prachttauchers, *Gavia a. arctica* (L.). *Annales Zoologici Fennici*, 7: 25–60.

LINDBERG, P. 1968. Nagot om storlommens (*Gavia arctica* L.) och smalommens (*Gavia stellata* L.) ekologi. *Zoologisk Revy*, 30: 83–88.

MADSEN, F. J. 1957. On the food habits of some fish-eating birds in Denmark. *Danish Review of Game Biology*, 3: 19–83.

MACARTHUR, R. 1971. Patterns of terrestrial bird communities. In: Farner, D. S. and King, J. R. (eds.), *Avian Biology*. New York: Academic Press. pp. 189–221.

MUNRO, J. A. 1930. Water fowl and sculpins. *Condor*, 32: 261.

OLSON, S. T. and MARSHALL, W. H. 1952. *The Common Loon in Minnesota*. Minneapolis: University of Minnesota Press (Minnesota Museum of Natural History, Occasional Paper no. 5). pp. 1-77.

WELLER, M. W. 1972. Ecological studies of Falkland Islands' waterfowl. *Wildfowl*, 23: 25–44.

————, TRAUGER, D. L. and KRAPU, G. L. 1969. Breeding birds of the West Mirage Islands, Great Slave Lake, N.W.T. *Canadian Field-Naturalist*, 83: 344–60.