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CHARACTERISTICS OF LAKES AND NEST SITES USED BY YELLOW-BILLED LOONS IN ARCTIC ALASKA

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Abstract.—We located 19 Yellow-billed Loon (*Gavia adamsii*) nests in 1983 and 20 nests in 1984 in the Colville River delta, Alaska. All nests occurred on lakes with water levels that did not fluctuate with river flows. Nests were situated on low shorelines, within 1 m of water, and in locations that afforded the incubating loon good visibility over land and water. Nests were protected from shifting ice and waves generated by the prevailing northeast winds. Wetlands on which Yellow-billed Loons nested ranged from 0.1 to 229 ha. All core-use areas used by breeding pairs in 1983 were reoccupied in 1984. Any habitat alterations that cause fluctuations in water-level at nesting wetlands will lower the carrying capacity of the delta for Yellow-billed Loons. Thus oil development activities could threaten the Yellow-billed Loon population in the Colville River delta.

CARACTERÍSTICAS DE LOS LAGOS Y EL LUGAR DE ANIDAMIENTO UTILIZADO POR *GAVIA ADAMSII* EN ALASKA

Resumen.—En el delta del Río Colville, Alaska, se localizaron 19 y 20 nidos del somormujo *Gavia adamsii* en el 1983 y 1984, respectivamente. Todos los nidos se encontraron en lagos cuyo nivel de las aguas no fue afectado por el flujo de sus afluentes. Las estructuras fueron localizadas cerca de la orilla, aproximadamente a un metro de profundidad, y en lugares en donde las aves que incubaban tenían buena visibilidad sobre tierra y agua. Los lugares en donde fueron construidos los nidos estaban protegidos de pedazos de hielo y las olas generadas por los vientos. Los anegados en donde anidaron las aves variaron en tamaño entre 0.1 y 229 ha. Las mismas áreas utilizadas por las aves para anidar en el 1983 fueron re-ocupadas en el 1984. Cualquier alteración del habitat de anidamiento de estas aves, causado por fluctuaciones en los niveles de agua, disminuirá la capacidad de acarreo del área estudiada para somormujos. Es muy probable entonces, que actividades relacionadas con explotaciones petroleras puedan amenazar la población de somormujos en el delta del Río Colville.

Yellow-billed Loons (*Gavia adamsii*) occur sporadically throughout their high-arctic breeding range from central Canada west to Finland (see North [1986] for a summary and sources). Because of the remoteness of their range and the low densities at which they occur, little is known of Yellow-billed Loon breeding ecology or habitat use. Limited data on the size of nesting wetlands (Sage 1971, Sjolander and Agren 1976) and incidental observations on wetland types used (Derksen et al. 1981) have been reported.

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The Colville River delta, one of two primary breeding concentrations of Yellow-billed Loons in Alaska, has been explored for oil resources and development is imminent. Because Yellow-billed Loons are rare and there is a paucity of data on their breeding biology, we initiated a study of loon breeding ecology in the Colville River delta in 1983 (see also North and Ryan 1988). Here we present data on nest-site characteristics and sizes of wetlands used by breeding Yellow-billed Loons.

STUDY AREA

The Colville River forms a 575-km^2 delta 260 km southeast of Point Barrow, Alaska at 70°19′N, 150°30′W. The delta is a region of dendritic river channels, fluvial deposits of various ages, low relief, and numerous thaw lakes at different stages of development. Lakes larger than 5 ha cover 16% of the delta's surface (Walker 1978). Wetlands on the delta range from ubiquitous, 0.1-ha pools in polygon basins to a few tapped and untapped wetlands larger than 100 ha.

Tapped lakes connect to river channels through direct breaches or a series of channels running from lake to lake and eventually into the river. Water levels of tapped lakes fluctuate with river-level changes associated with snow melt upstream. Tapped lakes are further characterized by high turbidity and sediment loads (Walker 1978, 1983), shallow water, and low densities of fish, invertebrates, and macrophytes (North 1986).

Untapped lakes occupy discrete basins with no stream inlets or outlets. Infiltration, runoff, and evaporation are negligible in the arctic (French 1976, Walker 1983), thus water levels of untapped lakes remain fairly constant. We observed no seasonal changes in water levels of untapped lakes in the Colville River delta (North 1986). Untapped wetlands have clear water, relatively high densities of fish, invertebrates, and macrophytes (North 1986), and water depths of at least 2.5 m. The period of ice melt on untapped lakes extends from early June to mid July. Melt water accumulates adjacent to shore, forming leads between shore and the central ice pack. These leads may completely encircle the lake, depending on date and extent of ice shifting.

Shorelines exposed to prevailing northeasterly winds (the predominant direction 60% of the days [North 1986]) tended to have lake ice pushed onto or against them during July when lake-ice break-up progresses rapidly. Shifting winds, however, can blow lake ice against any unprotected shore. Shifting ice pushed the peat shoreline upward, creating relatively high shorelines. Shorelines of small bays, small lakes, and areas protected by peninsulas or islands are not influenced by shifting ice and therefore are usually low.

METHODS

Field studies were conducted 12 May–15 Aug. 1983, and 15 May–29 Aug. 1984. We located loon nests by observing pairs or by walking shorelines. At each nest we measured shore height (the vertical distance from the lake surface to a flat land surface that could support a loon nest), distance from the center of a nest to water, height of nest above water, and water depth 1 m from the shoreline. Measurements were made along the route used most frequently by loons getting on and off the nest. Those routes were evident because of trampled vegetation. We also estimated the degrees of visibility to 100 m and 200 m from 0.3 m above the nest (approximately "loon-eye level"). We estimated the wave fetch to which each nest was exposed and assessed whether the nest site was protected from shifting ice by islands, peninsulas, or other shoreline irregularities. Data were not collected at one island nest site and only partial data collected at another site because of their inaccessibility. In 1983, nest-site measurements were obtained in late July after hatch occurred. In 1984, measurements were obtained in July. Some nests were measured before hatch occurred. Water levels at untapped lakes where nests were located did not change appreciably and vegetation growth near nests was minimal over the summer. Therefore, the timing of data collection should not have affected our measurements.

We considered the nest site to be the nest bowl, the land between the nest and water, and the water within a 3-m radius of the nest. However, if a 1984 nest was within 25 m of a 1983 nest, and both nests appeared equally influenced by any wind or wave conditions and were equally accessible and visible to mammalian predators, we considered both nests to be at the same general site.

We collected similar data at 10 points located around each nest lake and/or core-use area. We considered a core-use area to be the area defended against intruders and all area regularly used by the resident pair. At each point, selected by pacing an estimated one-tenth of the way along the lake and/or core-use area, we measured the height of the shoreline and the depth of the water 1 m from shore. Depth of water was measured along a line perpendicular to shore. At each point we estimated the degrees of visibility to 100 m and 200 m from 0.4 m above the point to which we measured the height of the shore (0.4 m is about eye level for a loon sitting upright on a 10-cm nest mound). Measurements were obtained at systematically-located points only in 1983 because of time constraints in 1984. We considered nest lakes and core-use areas separately because a nest lake could comprise part of a core-use area, a core-use area could occupy only part of a nest lake, or an entire nest lake could comprise an entire core-use area.

We used t-tests to compare measurements between nest sites and points around core-use areas and nest lakes. Because t-tests showed no difference in visibility (to 100 m: $t = 0.47$, df = 34, $P = 0.64$; to 200 m: $t = 0.50$, df = 34, $P = 0.62$) between 1983 and 1984 nests, data from both years were combined to increase sample size for comparison with data collected at points around core-use areas and nest lakes. For nest sites used by loons both years, we used the 1984 data. We used t-tests to compare the visibility over the surrounding lake and landscape at nests located on islands, mainland shores, and hummocks surrounded by water.

Sizes of lakes $\geq$1.0 ha were measured from U.S. Fish and Wildlife

TABLE 1. Dimensions (cm) of Yellow-billed Loon nests, Colville River delta, Alaska, 1983 and 1984.

Variable	1983			1984		
	n	x̄ ± SE	Range	*n*	x̄ ± SE	Range
Nest height above water	18	18.7 ± 1.5	8–33	14	15.2 ± 1.3	8.5–24
Bowl depth	17	4.1 ± 0.4	1.5–7.5	14	3.5 ± 0.2	1–4.5
Inner diameter	18	30.6 ± 0.6	26–37	14	27.4 ± 0.5	24–30
Outer diameter	18	63.7 ± 2.2	41–78	14	62.1 ± 3.7	38–82
Center of nest to water	18	50.1 ± 3.1	30–78	14	51.2 ± 3.9	26.5–76

Service (USFWS) maps (scale = 1:33,540) with a Houston Instruments HIPAD digitizer. Lake sizes obtained from USFWS maps were verified from USGS maps (scale = 1:63,360) that showed less detail.

RESULTS AND DISCUSSION

Nest site use.—We located 39 Yellow-billed Loon nests (19 in 1983, 20 in 1984) that probably belonged to a total of 23 different pairs. Six nest bowls used in 1983 also were used in 1984. At eight other sites nests were discovered in the same vicinities in 1983 and 1984, but we could not determine if the same nest bowls were used. Another 1984 nest was 12.0 m from a 1983 nest. On core-use areas occupied both years, we suspect at least one member of each pair occupied that territory both years (North and Ryan 1988).

Nest characteristics and locations.—Nests were composed primarily of peat, pendant grass (*Arctophila fulva*), and *Carex* spp. Traces of moss and *Salix reticulata* were present in some nests. Yellow-billed Loon nests (Table 1) were approximately 1.2 times the size of Common Loon nests described by McIntyre (1975). All nests were located within 1 m of shore (Table 1).

All nests were located on untapped lakes. Nests were situated on islands, hummocks surrounded by water, or along mainland shorelines (Table 2). Only two nests in 1983 and one nest in 1984 occurred along mainland shores when islands with low shorelines were available. Islands are preferred nest sites for all other species of loons (Bergman and Derksen 1977, Bundy 1976, Davis 1972, Lehtonen 1970, McIntyre 1975, Olson and Marshall 1952, Petersen 1976, Strong 1985, Yonge 1981).

TABLE 2. Locations of Yellow-billed Loon nests, Colville River delta, Alaska, 1983 and 1984.

Nest site	1983 (n = 19)	1984 (n = 20)
Island shoreline	6	7
Mainland shoreline	9	9
Shallow-water hummock	4	4

TABLE 3. Mean (±SE) water depth and shore height at Yellow-billed Loon nests and systematically located points around nest lakes and core-use areas, and results of *t*-tests, Colville River delta, Alaska, 1983 and 1984.

	Water depth (cm) off shore		
	at 0 m	at 1 m	Shore height (cm)
Nest sites			
1983 (n = 17[a])	5.6 ± 1.1	33.9 ± 4.3	9.6 ± 1.7
1984 (n = 15)	3.0 ± 0.2	37.7 ± 5.8	3.2 ± 1.1
Points around			
Nest lakes (n = 127)	7.9 ± 1.0	31.6 ± 1.7	11.0 ± 1.5
Core-use areas (n = 136)	8.5 ± 0.8	28.9 ± 1.4	16.9 ± 1.9
Results of *t*-tests			
1983 nests vs. nest lakes	t = 1.55[b] df = 142	t = 0.48 df = 142	t = 0.63 df = 133
1984 nests vs. nest lakes	t = 4.92** df = 140	t = 1.16 df = 140	t = 4.29** df = 133
1983 nests vs. core-use areas	t = 2.09* df = 151	t = 1.19 df = 151	t = 2.86** df = 142
1984 nests vs. core-use areas	t = 6.32** df = 149	t = 1.47 df = 149	t = 6.30** df = 142

[a] n = 8 for shore height.
[b] * = $P < 0.05$, ** = $P < 0.001$, no asterisk = $P > 0.05$.

Nests at 14 of 24 (58%) sites were protected from shifting ice except under unusual combinations of changing wind directions. Nine of ten other sites were protected from shifting ice if northeasterly winds prevailed. Nests considered protected from shifting ice were located on leeward sides of islands, along bays or coves protected by peninsulas, or along small lakes where ice-melt progressed rapidly. One Yellow-billed Loon nest may have been destroyed by ice action (North 1986). Twenty-one of 24 nests (87.5%) were protected from northeast fetches more than 50 m. Natural and man-made wave action are causes of Common Loon egg loss (Fox et al. 1980). On the Colville River delta, extensive ice cover prevents wave action from occurring during much of the nesting season. The fastest thawing lakes could be ice-free two weeks before hatch occurs. In 1983 and 1984, hatching occurred on the largest lake before it was ice-free. Protection from shifting ice may be more important than protection from wave action.

Characteristics of nest and non-nest sites.—Shore heights at nests were lower than at points around nest lakes and core-use areas and most differences were significant (Table 3). Because of their anatomy, loons must build their nests on sites with low shorelines. Fair (1979) reported that vertical rises of 25 cm prevented Common Loons from getting to their nests. This limitation probably disposes Yellow-billed Loons to selecting sites that are low, and therefore usually protected from shifting ice.

TABLE 4. Visibility at Yellow-billed Loon nest sites and systematically located points around nest lakes and core-use areas, Colville River delta, Alaska, 1983 and 1984.

		Degrees of visibility	
		To 100 m	To 200 m
Site	*n*	x̄ ± SE	x̄ ± SE
All nest sites	23	347 ± 7	343 ± 8
Shore nest sites	11	346 ± 14	339 ± 14
Hummock nest sites	5	360 ± 0	354 ± 6
Island nest sites	7	341 ± 12	341 ± 12
Points around nest lakes	127	296 ± 7	285 ± 8
Points around core-use areas	132	286 ± 8	278 ± 8

Deep-water escape routes from nests have been cited as an important factor in Common Loon nest-site selection (McIntyre 1983, Munro 1945, Olson and Marshall 1952, Vermeer 1973), although no researchers have compared water depths at nests with water depths around core-use areas. Water depths along shore were shallower at Yellow-billed Loon nest sites than at points around core-use areas and nest lakes and most differences were significant (Table 3). Water depths 1 m from shore did not differ between nest sites and points around core-use areas of nest lakes (Table 3).

Visibility from nest sites, over surrounding water and landscape to 100 m and 200 m, was extensive (Table 4). Visibility did not differ among nest sites (t-values ranging from 0.07–1.51 with df 10–16, $P > 0.1$) located on islands, hummocks, and mainland shores (Table 4). Visibility was greater from nest sites than from sample points around core-use areas (to 100 m: $t = 5.69$, df = 153, $P < 0.001$; to 200 m: $t = 5.81$, df = 153, $P < 0.001$) or nest lakes (to 100 m: $t = 5.11$, df = 148, $P < 0.001$; to 200 m: $t = 5.34$, df = 148, $P < 0.001$).

These data suggest Yellow-billed Loons select nest sites that afford good visibility over their surroundings. Sage (1971) also arrived at this conclusion. Good visibility would allow the incubating loon to observe potential mammalian predators and to slip off the nest or lie flat to avoid being seen. Despite the abundance of predators on the delta, nest success was 94% ($n = 17$) both years (North and Ryan 1988). We observed no evidence of arctic fox (*Alopex lagopus*) predation on loon eggs, but fox predation on loon eggs may vary between years (Bergman and Derksen 1977).

Nest lake sizes.—Of 27 pairs known to have nested on the delta, including four for which we observed only broods, 12 (44.4%) used all or portions of two wetlands, and six (22.2%) used only one lake. Although we infrequently visited the lakes used by the other nine pairs, seven (25.9%) probably confined their activities to one lake because no wetlands larger than 1.0 ha were near the lakes on which they nested. Of the 18 pairs observed frequently, seven (38.9%) shared lakes with other pairs of

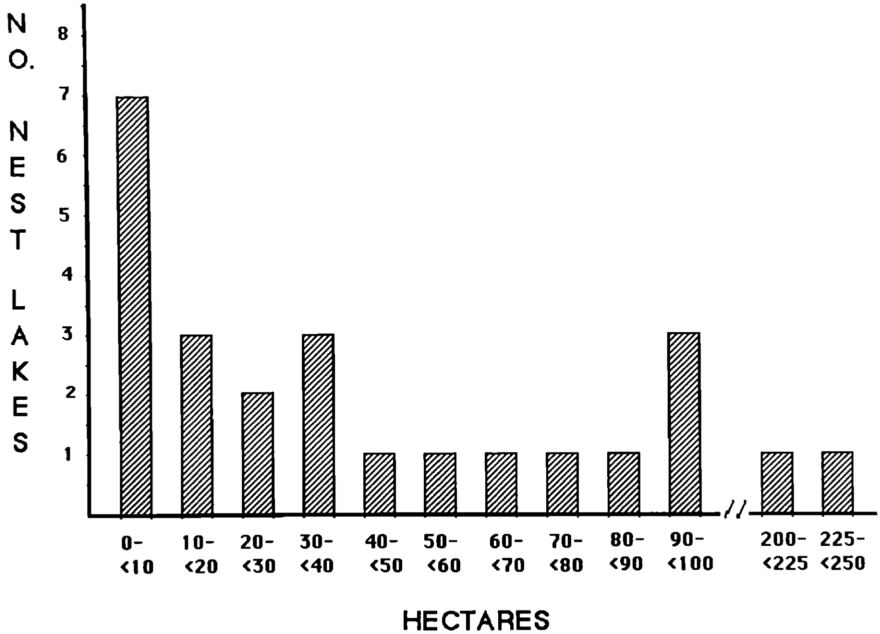

FIGURE 1. Sizes of 25 lakes on which Yellow-billed Loons nested, Colville River delta, Alaska, 1983 and 1984.

Yellow-billed and Pacific Loons. Eleven pairs (61.1%) were the sole inhabitants of lakes they used, although core-use areas did not always encompass the entire wetland. Three pairs nested on lakes smaller than 2.0 ha, but reared their chicks exclusively on larger lakes within 70 m of the nest lake.

Sage (1971) recorded two pairs of Yellow-billed Loons nesting on lakes of 8 ha and 43 ha. On a study area near Alaktak, 160 km west of the Colville River delta, Sjolander and Agren (1976) reported 14 Yellow-billed Loon pairs nesting on lakes ranging from 20–150 ha, with 10 (71.4%) of those lakes in the 30–50-ha range. At the Colville River delta, smaller lakes were used frequently for nesting by Yellow-billed Loons (Fig. 1). The smallest pond used was 0.1 ha. Each nest lake contained one Yellow-billed Loon nest, except for a 229-ha wetland that contained 2 nests. Ten of 26 nests (38.5%) were located on lakes smaller than 20 ha. The smallest lake on which we observed a brood was 13.4 ha, but the nest of this pair was on an adjacent 9.0 ha lake.

The seemingly more frequent use of smaller lakes by Yellow-billed Loons on the Colville River delta versus those near Alaktak may be the result of Sjolander and Agren (1976) not finding or reporting the locations of nests for 19 of 33 breeding pairs they observed; differences in proximity of small and large lakes in the two areas; or, the high frequency of tapping of large lakes on the Colville River delta. On the Colville River delta, over half (1983, 45%, $n = 44$; 1984, 60%, $n = 49$) of the randomly sampled wetlands ≥ 100 ha were tapped by the river and not suitable as Yellow-billed Loon nest sites because of fluctuating water levels.

Yellow-billed Loons breeding on the Colville River delta avoided tapped lakes for nesting. All nests were located on low shorelines and most were protected from shifting ice and wave action. All nest sites afforded maximum visibility. Islands were usually used as nest sites when available.

The greatest threat to breeding Yellow-billed Loons in the delta are human-related activities that could result in the river channels tapping additional lakes. Tapped lakes are unsuitable for nesting and brood-rearing and the resultant loss of habitat could reduce the carrying capacity of the area for Yellow-billed Loons. Displacement of loons from former breeding lakes could also disrupt nesting by pairs whose lakes are untapped. Disruptions to the tundra that could cause melting of the permafrost near lakes adjacent to river channels would facilitate lake tapping and should be avoided.

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