Prepared in Cooperation with the U.S. Fish and Wildlife Service

Status Assessment and Conservation Plan for the Yellow-billed Loon (*Gavia adamsii*)

Scientific Investigations Report 2004-5258

U.S. Department of the Interior
U.S. Geological Survey

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By Susan L. Earnst
U.S. Geological Survey

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Photographs on back cover by Paul Anderson (airplane over North Slope lakes), Charles Eldermire (loon landing on the Colville River Delta), and NASA (infrared imagery of the Colville River Delta purchased from AirMap U.S., Inc, Anchorage, Alaska). Other photographs taken by the author on the Colville River Delta. Thanks to Jeff Stephens for the illustration of the adult and chicks on page 36.

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Status Assessment and Conservation Plan for the Yellow-billed Loon (*Gavia adamsii*)

By Susan L. Earnst [1]

Abstract

Because of its restricted range, small population size, specific habitat requirements, and perceived threats to its breeding habitat, the Yellow-billed Loon (*Gavia adamsii*) is a species of conservation concern to the U.S. Fish and Wildlife Service and the subject of a petition for listing under the Endangered Species Act. This **Status Assessment** synthesizes current information on population size, trends, and potential threats to Yellow-billed Loons, and the **Conservation Plan** identifies research and monitoring activities that would contribute to the conservation of this species. The preparation of this report was requested and funded by the U.S. Fish and Wildlife Service, Nongame Bird Office, Region 7.

The **Status Assessment and Conservation Plan for the Yellow-billed Loon** can be summarized as follows:

- Northern Alaska breeding grounds support an average of 3,369 individuals, including <1,000 nesting pairs in most years. The Yellow-billed Loon ranks as one of the 10 rarest birds that breeds regularly within the mainland U.S. and one of only 20 with a North American population <16,000 individuals (Section 6-E).

- There is no evidence of a long-term trend in the Yellow-billed Loon population index since 1986 (-0.9% annual change), but interpretation of surveys is complicated by changes in observers and high annual variation, and the 95% confidence interval is large (-3.6% to +1.8% annual change). The low reproductive potential of Yellow-billed Loons suggests that recovery from a substantial decline would not occur rapidly. There are no systematic surveys of Canadian and Russian breeding populations (Section 6-F).

- The expansion of the oil industry into prime Yellow-billed Loon breeding habitat is a recent occurrence and we lack the necessary information to accurately predict its effect on the population. Most of northern Alaska's Yellow-billed Loons (91%) occur on the National Petroleum Reserve–Alaska, virtually all of which is open or proposed to be opened to development and where there is no permanent or legal protection of Yellow-billed Loon habitat (Section 7-A).

- Other potential factors affecting the population are also addressed, such as contaminants, subsistence hunting, bycatch in subsistence and commercial fisheries on the breeding and wintering grounds, and health of the marine ecosystem off the coast of East Asia where Alaska's Yelllow-billed Loons winter, but data are lacking to reach strong conclusions on most issues.

- The conservation goal adopted by the Alaska Loon and Grebe Working Group for the Yellow-billed Loon is to maintain a stable breeding population, of current size and distribution, across the extent of the loon's breeding range in Alaska. The **Conservation Plan**, designed to provide information necessary to meet this goal, puts forth seven objectives: **1**) Conduct annual population surveys having negligible bias and 80% statistical power to detect a 3.4% annual decline, a decline that would result in a 50% loss of the population within 20 years; **2**) Obtain an unbiased and reliable estimate of the size of Alaska's breeding population; **3**) Identify geographic regions and habitats of importance during breeding, staging, and wintering periods; **4**) Use demographic models to evaluate risks to the population; **5**) Identify potential effects of oil development on the breeding grounds and measures necessary to minimize the effects; **6**) Evaluate the magnitude of subsistence harvest and bycatch and their potential effects on the population; **7**) Develop a continent-wide and range-wide context for Alaska's population and habitat objectives.

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Status Assessment

Northern Alaska breeding grounds support an average of 3,369 Yellow-billed Loons (*Gavia adamsii*), and about 780 more occur in western Alaska, making this species one of the least common regularly breeding birds in the mainland United States (Section 6–E). Because of its restricted range, small population size, specific habitat requirements, and the potential for oil development throughout its U.S. breeding range, the Yellow-billed Loon has been a Species of Management Concern, or Bird of Conservation Concern, to the U.S. Fish and Wildlife Service since 1995 (USFWS 1995, 2002a) and is the subject of a recent petition for listing under the Endangered Species Act (Center for Biological Diversity 2004).

The first part of this publication, the **Status Assessment**, provides a comprehensive and critical review of the published and unpublished data on Yellow-billed Loon population size, population trend, and potential threats to the population and its breeding and wintering habitat. The literature review relies heavily on that presented in North (1994), Barr (1997), and Fair (2002). The Status Assessment identifies gaps in our knowledge and in current monitoring programs. The last section of the publication, the **Conservation Plan**, details 7 objectives and 29 specific strategies to fill gaps identified in the Assessment.

The format of the Status Assessment follows that suggested by the U.S. Fish and Wildlife Service (USFWS 2000). The preparation of this document was requested and funded by the Nongame Bird Office, Division of Migratory Birds, Region 7, U.S. Fish and Wildlife Service. This document is a compilation of biological data and a description of past, present, and potential future threats to the Yellow-billed Loon. It does not represent a decision by the U.S. Fish and Wildlife Service, nor a policy statement by the U.S. Geological Survey or its scientists, on whether this taxon should be designated as a candidate species for listing as threatened or endangered under the Federal Endangered Species Act. That decision will be made by the Service after reviewing this document, other relevant biological and threat data not included herein, and all relevant laws, regulations, and policies. Regardless of the decision concerning candidate status, the species should benefit from the conservation recommendations that are contained in this document.

1. Taxonomy

The Yellow-billed Loon and Common Loon (G*avia immer*) are considered by the American Ornithologists' Union (1998) to constitute a superspecies. It is likely that the Yellow-billed Loon and Common Loon shared a common ancestor as late as the Pleistocene, one million years ago (Storer 1978). No subspecies are recognized.

The Yellow-billed Loon is known as the White-billed Diver in Eurasia (Cramp and Simmons 1977) and the Inupiat refer to it as *tuutlik* or King Loon (Georgette 2000).

2. Legal Status

The Yellow-billed Loon is protected in the United States under the Migratory Bird Treaty Act, and in Canada under the Migratory Birds Convention Act; thus, like all nongame migratory birds, it technically is protected from take and undue harassment within these countries and their coastal waters. Although various government agencies and conservation groups have listed the Yellow-billed Loon as in need of special attention (see Section 8–A), these labels do not impart legal protection.

3. Description

The Yellow-billed Loon is distinguished from the world's other four loon species by the color of its bill, which is yellow in breeding plumage and a pale yellow to ivory in wintering plumage. In breeding plumage, worn from late April to October or later, upperparts are black with striking white spots, the neck and head are black with purple and green gloss, and the chest and abdomen are white. Breeding plumage is similar to that of the Common Loon, except that the Yellow-billed Loon has a yellow rather than black bill, fewer and broader white lines in the necklace and upper foreneck, and fewer but larger white spots on upperparts. In their gray-brown winter plumage, the pale bill of the adult Yellow-billed Loon can be distinguished from the gray bill of the Common Loon, and the two species differ in various aspects of bill and head shape and the distinctness of the white auricle patch (Palmer 1962, and reviewed in North 1994). Male and female plumages are similar.

Chicks are completely downy and initially dark brown with some white on lower breast and abdomen, becoming lighter brown with more pronounced white underparts as they mature, particularly by about their third week. Juvenile plumage, acquired by about 10 weeks, is gray-brown and resembles adult winter plumage. Immature plumage differs among age classes, and from that of the Common Loon, but can probably only be distinguished by experienced observers at close range. Immatures are thought to acquire adult-like winter plumage (Basic) and then summer plumage (Definitive Alternate) at approximately age 3 (Palmer 1962, and reviewed in North 1994).

The Yellow-billed Loon is larger than the sympatric Red-throated Loon (*Gavia stellata*) and Pacific Loon (*Gavia pacifica*). The body masses reported for male and female Yellow-billed Loons fall within a similar range (about 4.0–6.4 kg), but males are longer (838–920 mm vs. 774–831 mm) (reviewed in North 1994). Presumably average male body mass and size is greater than that of females within a given breeding site, but information on variation within and among sites has not been published. Yellow-billed Loon body mass also falls within the range reported for Common Loons, with the average adult mass of the latter varying widely with geographic location (4.4–6.0 kg for males, 3.3–4.7 kg for females) and migratory distance (reviewed in Evers 2004).

Yellow-billed Loons, like other loons, have a highly modified leg and pelvic structure that is well adapted for swimming but allows only the most rudimentary form of standing and almost no ability to walk. Thus, loons must place nests at the water's edge and must land and take flight from water.

4. Range

Breeding

The Yellow-billed Loon breeds patchily throughout the subarctic and arctic tundra of northern Alaska, Canada, and Eurasia (Fig. 1). In Alaska, the range extends from the Canning River westward to Point Lay; it also includes St. Lawrence Island and the coastal areas of the Seward Peninsula (Fig. 2). However, most of the breeding population lies in the central portion of this area, between the Colville River and Meade River, and breeding elsewhere is sparse. The breeding range in Canada and Russia has not been as well defined as in Alaska, where large-scale aerial surveys are used. Thus, although the Canadian and Russian ranges appear large, they may include large areas with few or no birds (Fig. 1). In Canada, the breeding range extends from just east of the MacKenzie River Delta to Hudson Bay, including the northern islands. It is most common on Banks Island and Victoria Island, and the lake district from Great Slave Lake northeast to northern Hudson Bay, and breeding elsewhere is sparse. In Russia, the Yellow-billed Loon breeds in the relatively narrow strip of coastal tundra from the Chukchi Peninsula in the east to the Taymyr Peninsula and the areas of the Novaya Zemlya River and Pechora River in the west. Its status from the Pechora River west to Finland is unclear. In Europe, small numbers have been reported breeding in northern Finland and Norway. This summary was based on North (1994), Barr (1997), and Fair (2002). Also see Sections 6–A to 6–C.

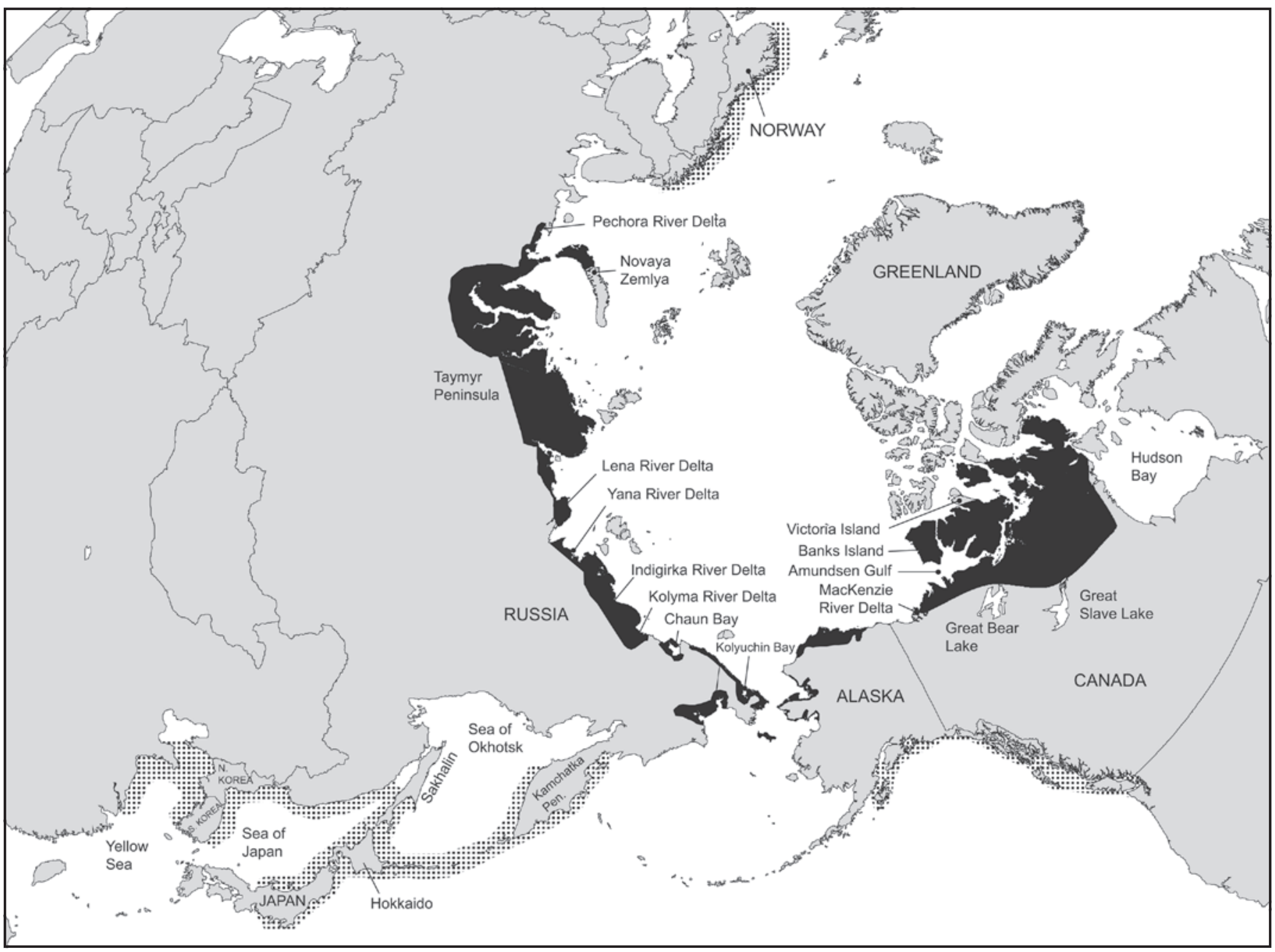

Figure 1. World-wide Yellow-billed Loon breeding (black) and wintering (hatched) range. From McIntyre (1991), North (1993), and Barr (1997) except for the following modifications: Alaska breeding range reduced based on data in Earnst et al. (in review) and Fig. 3 and southern extent of wetlands; Russian breeding range reduced based on the southern extent of tundra wetlands; and Asian wintering range extended based on Schmutz (written commun. 2003)

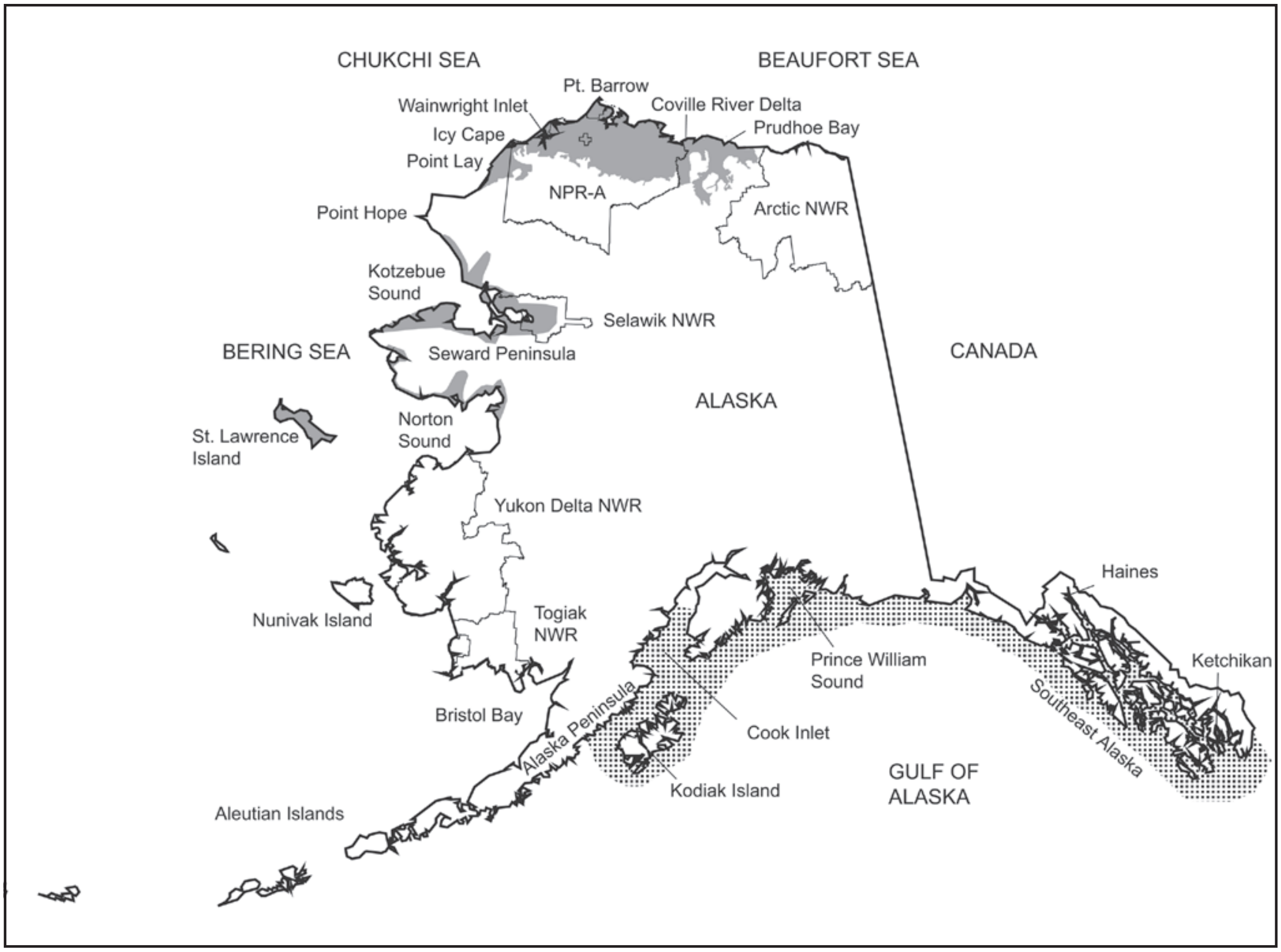

Figure 2. Yellow-billed Loon breeding (dark gray) and wintering (hatched) range in Alaska in relation to areas mentioned in the text.

Migration

The Yellow-billed Loon is a regular migrant along the coastlines of northern Canada (MacKenzie River Delta, Banks Island, Amundsen Gulf), northern Alaska (Icy Cape, Barrow, and Oliktok Point just east of the Colville River Delta), and northwestern Alaska (St. Lawrence Island and off the western tip of Seward Peninsula), and is a rare migrant along the western Alaska coastline (Yukon-Kuskokwim Delta, Bristol Bay, Aleutian Islands, Alaska Peninsula) (reviewed in North 1993 and 1994). Also see Section 5–E.

Winter

Yellow-billed Loons winter regularly but sparsely in nearshore marine waters from Kodiak Island through Prince William Sound, and throughout southeast Alaska and British Columbia (Fig. 2). Irregular wintering occurs southwest of Kodiak Island along the Aleutian Islands and along the coast of Washington to Baja California. Also, several reliable sightings of migrating and wintering loons have been recorded in inland areas (reviewed in North 1994). Immatures and possibly some nonbreeding adults remain on wintering grounds throughout the year. In Eurasia, Yellow-billed Loons winter off the coast of Norway, the Kamchatka Peninsula of Russia, northern Japan, North Korea, and China (Fig. 1; reviewed in Barr 1997). Recent evidence suggests that Alaskan breeders winter off the coast of North Korea, Japan, and China (see Section 6–D).

5. Life-history Summary

A. Habitat Requirements

The nesting and brood-rearing lake

Yellow-billed Loons require nesting and brood-rearing lakes that a) are large enough to allow easy take-off from open water; b) form an ice-free moat around shore in early spring that is large enough to protect nests from wind-blown ice and to allow adults to take flight; c) have clear water with a substantial population of small fish which can be eaten by adults and fed to chicks; d) have segments of gently sloping shoreline on which nesting and brooding can occur; and e) have sheltered areas, often vegetated, where young chicks can rest and take refuge during disturbances. Yellow-billed Loons are larger and heavier than the other tundra-breeding loons and so require a larger area of open water to ensure safe take-off and landing. More importantly, young are fed entirely from the brood-rearing waterbody; thus, successful reproduction apparently is restricted to lakes deep and large enough to support overwintering fish. The smallest brood-rearing waterbody recorded on the Colville River Delta is 13.4 ha (North and Ryan 1989); however, in a few cases, nests are placed on a waterbody as small as <1 ha from which very young chicks (<3 days of age) are moved overland to a nearby larger waterbody for the duration of brood-rearing (occurred in some years on 3 of 26 monitored territories on the Colville River Delta; Earnst unpubl. data).

Lake size, depth, connectivity to streams, shoreline complexity, and proportion of shoreline in moist to aquatic cover types were each significant predictors of Yellow-billed Loon presence during intensive aerial surveys providing complete coverage of 757 lakes between the Colville and Meade rivers (Earnst et al. in press; also see Influence of habitat preferences on breeding distribution). Presence of low-lying cover types along the shore may be an indication of a gradually sloping shoreline and convoluted shorelines provide nesting and brood-rearing sites. Lake depth and connectivity are interpreted as measures of fish availability. Although connectivity is generally favorable for loons, lakes on the Colville River Delta that have large connections to a major river channel are susceptible to fluctuating water levels (and often have high turbidity) and are avoided for nesting (North and Ryan 1989); however, lakes with smaller connections that have flowing water only during high water events are not avoided on the Colville River Delta or elsewhere. Similarly, Common Loon presence has been correlated with connectivity at more southerly latitudes (Ruggles 1994).

Nests are placed at the water's edge, typically in a low-lying, gently sloping area. Of the 11–18 nest sites investigated each year on the Colville River Delta, on average, 55% were on islands, 27% on peninsulas, 14% on lake shores other than peninsulas, and 4% on rafts or underwater hummocks formed from peat and emergent vegetation (Earnst unpubl. data). Similarly, among 20 nests in a previous study, 35% were on islands, 45% on lake shores including peninsulas, and 20% on hummocks surrounded by shallow water (North and Ryan 1989). It is likely that islands are preferred relative to their availability. Although it is difficult to estimate island availability per se, an analysis based on waterbody types indicates that waterbodies with "deep open water with islands" are preferred for nesting over other waterbodies relative to their availability (Johnson et al. 2000). Nests sometimes are crushed by wind-blown ice and flooded by wind-induced waves, and presumably as a mechanism to minimize this threat, most nests are placed on the leeward lake or island shore (North and Ryan 1989).

Chicks often remain in sheltered, vegetated areas of large lakes when young (<1 week) but by 2–3 weeks of age are spending much time in the deep, open water of large lakes while parents make extensive dives throughout the lake and return with fish. When disturbed by the approach of humans, young chicks either hide in emergent vegetation (typically *Carex aquatilis* or *Arctophila fulva*) or follow their parents to the deep, open water of the lake's center. Chicks continue to use sheltered bays for resting through at least the end of August (approx. 6 weeks of age). Young chicks are brooded on gently sloping shorelines and sometimes on the nest.

Territory composition and defense

Most breeding territories consist of one waterbody, usually 17 ha to >100 ha, that is used for nesting and brood-rearing (e.g., North and Ryan 1989). A few territories consist of a section of 1 or more waterbodies. On the Colville River Delta, a few extremely large lakes with multiple bays and inlets, which provide visual isolation and multiple brood-rearing sites, may support more than one Yellow-billed Loon territory or a combination of Yellow-billed Loon and Pacific Loon territories (North 1994, Earnst pers. obs.).

Yellow-billed Loons attempt to expel all other loons from territories, but on larger waterbodies, Red-throated Loons and Pacific Loons are sometimes able to forage for several hours before being discovered and expelled. In some cases, territory ownership has shifted between species (Earnst unpubl. data). For example, a nest bowl and breeding territory occupied by a Pacific Loon in 1996, 1998, and 2000 was occupied by a Yellow-billed Loon in 1997. In a second case, a lake used for brood-rearing by a pair of Pacific Loons in 1996, 1998, and 2000, was used by a breeding pair of Yellow-billed Loons in 1999. In both cases, the Yellow-billed Loon nest failed, and the pair was not observed on the territory in subsequent years, suggesting that it may have been a young pair attempting to establish a breeding territory and/or may have been a territory of marginal quality for Yellow-billed Loons.

Territory holders engage in intense fights, involving chases on the water's surface and prolonged dives, with conspecifics and Pacific Loons (Earnst pers. obs.). It is well documented that loons kill and injure other loons and waterfowl by piercing them from beneath the water's surface, or from above, by forcing the opponents neck and head underwater (e.g., McIntyre and Barr 1997). In fact, necropsies of 200 Common Loons indicated that >50% had healed sternal punctures (McIntyre and Barr 1997). Yellow-billed Loons have been observed to kill waterfowl on the Colville River Delta (J. Helmericks pers. comm.), and a recently killed Pacific Loon with a fresh sternal puncture was found on the nesting lake of a Yellow-billed Loon (Earnst pers. obs.).

Influence of habitat preferences on breeding distribution

Some sections of the Arctic Coastal Plain do not contain lakes of sufficient size and depth to be suitable for Yellow-billed Loons, and this habitat distribution explains, in part, the distribution of the species in Alaska. It is less clear how well the attributes of lakes explain Yellow-billed Loon abundance at smaller geographic scales. In an attempt to model Yellow-billed Loon distribution and relative abundance in relation to habitat characteristics, intensive aerial surveys were conducted between the Colville and Meade rivers in 1998–2000 (Earnst et al. in press). Complete coverage of 21 plots, totaling 2,300 km^2, provided locations of 211 Yellow-billed Loons across the 757 surveyed lakes. Lake attributes available on Geographic Information System (GIS) were used to identify Yellow-billed Loon habitats. Satellite imagery was used to classify lake depth as shallow (freezing entirely to the bottom) or deep (not freezing entirely) (Mellor 1987, Jeffries et al. 1996). Logistic regression analyses indicated that Yellow-billed Loons were more likely to be present on larger and deeper lakes, those within 100 m of a stream (a measure of connectivity), those with more complex shorelines, and those with a higher proportion of shoreline in aquatic or flooded vegetation (Earnst et al. in press). Yellow-billed Loon presence was negatively related to Pacific Loon presence, which could be due to the two species having different habitat associations or some degree of competitive exclusion. Not surprisingly, these variables did not predict Yellow-billed Loon presence perfectly. It is likely that attributes available from GIS data are imperfect correlates of factors important to loons, such as fish abundance, and that lakes judged to be 'suitable' based on GIS attributes alone are sometimes not suitable. It is also possible that Yellow-billed Loons tend to establish territories near conspecifics, and perhaps exhibit limited adult and juvenile dispersal (as do Common Loons; Evers 2004), thus creating a distribution more clumped than would be predicted based on resource availability, although this has not been quantified explicitly.

Although it would be useful to know whether breeding habitat availability is a factor limiting population size in Yellow-billed Loons, such a determination is problematic even in well-studied populations, and not possible with our current knowledge of Yellow-billed Loons.

Use of marine waters during winter months

Yellow-billed Loons spend roughly eight months exclusively in marine environments, and the health of this ecosystem is likely to have substantial (and largely unstudied) effects on population health. Population declines in other marine birds, such as Red-throated Loons (Groves et al. 1996) and sea ducks, are calling attention to the potential link between health of the marine ecosystem and avian population dynamics. Although habitat preferences or requirements on the wintering grounds have not been studied, it is clear that Yellow-billed Loons tend to occur near shore (rather than off the continental shelf), in waters protected by bays or archipelagos, and from 50 to 61 degrees N latitude (North 1994). They winter primarily in the Gulf of Alaska, down the coastline of southeast Alaska to northern Washington, and off the Pacific Coast of Russia and East Asia (see below).

Use of marine waters during staging and migration

Most observations of migration are made from shore, and thus, probably underestimate the importance of offshore ice-leads. Yellow-billed Loons appear to prefer open-water leads for resting and refueling rather than extensive open water (Searing et al. 1975), and large numbers of loons, eiders, and other marine birds have died in years when leads did not form (Barry 1976). Major ice-leads are known to form in the Chukchi Sea west of Barrow, Alaska, to Banks Island, Canada. In northern Canadian waters, three important spring staging areas in open-water leads have been identified (reviewed in Barr 1997): 1) offshore from the eastern edge of the MacKenzie River Delta eastward about 200 km to the Bathurst Peninsula; 2) off the west coast of Banks Island; and 3) the Lambert Channel polynya, which is at the southeast end of Amundsen Gulf. Alexander et al. (1997) conducted aerial surveys over the open-water leads described above and those elsewhere in the Amundsen Gulf during June 1986, 1987, 1992, and 1993. Yellow-billed Loons were abundant in the Lambert Channel polynya in both years it was surveyed (peak numbers of 259 in 1992 and 332 in 1993), but were abundant in other leads during only one of four survey-years (1992), a year of little open water in the region. In addition, concentrations of staging Yellow-billed Loons have been observed off the mouths of the Anderson, Mason, and Horton rivers in Canada in years of late spring thaws (unpublished reports reviewed in Barr 1997). Individuals marked with satellite transmitters on Alaska's North Slope staged for several days just north of St. Lawrence Island before continuing their migration down the Kamchatka Peninsula to wintering grounds off of East Asia (J. Schmutz pers. comm., see Section 5–E).

Use of marine waters during summer months by immatures, nonbreeders, and breeders

If Yellow-billed Loons have a demography similar to that of Common Loons (see Section 5–C and 6–E), then nearly 20% of the population may be in 1–2 year-old age classes (Earnst et al. in review). In Yellow-billed Loons, 1–2 year-olds are thought to remain in immature plumage and to summer on traditional marine wintering grounds (Palmer 1962, North 1994) as do Common Loons (Evers 2004). On traditional wintering grounds in Alaskan waters, Yellow-billed Loons are regularly recorded at low densities during surveys of southeast Alaska, Lower Cook Inlet, and Prince William Sound during June and July (Agler et al. 1995a,b and Lance et al. 1999; see Section 6–A). It is not clear whether these observations were of individuals in immature plumage (presumably <3 years of age) or whether nonbreeders in adult plumage also were seen.

In far northern marine waters, concentrations of nonbreeding Yellow-billed Loons also have been reported during summer months, for example, in ice-free leads off the coasts of Canada's arctic islands (Parmelee et al. 1967, Searing et al. 1975, McLaren and Alliston 1981, and unpublished reports reviewed in Barr 1997).

In addition, offshore of breeding grounds, aerial surveys have documented the regular occurrence of adult-plumaged Yellow-billed Loons. These sightings probably represent a mix of a) individuals that hold territories within a few kilometers of the coast and make brief foraging trips to marine waters (Earnst pers. obs.), and b) young nonbreeding, nonterritorial birds (presumably 3–5 year olds) that sometimes summer on lakes near established breeding territories (e.g., North 1986), as do young nonterritorial Common Loons (Evers 2004), but may also spend parts of some summers offshore (Earnst et al. in review). Fischer et al. (2002) conducted offshore surveys up to 60 km from the shore between Harrison Bay and Brownlow Point (west edge of Arctic National Wildlife Refuge) in June–August of 1999–2000, and they conducted nearshore surveys in barrier island lagoons between Oliktok Point (east edge of Colville River Delta) and Brownlow Point in July–August of 1999–2000 (see place names in Figs. 2 and 3; also see Section 6–A). During nearshore surveys, 67 Yellow-billed Loons were recorded and were more common near barrier islands (within 400 m of island on mainland side) than along the mainland coastline (within 400 m of coastline), in mid-lagoon (between the barrier island and mainland strata), or in the marine strata (from barrier islands to 1.5 km seaward). During offshore surveys, 27 Yellow-billed Loons were recorded and were more common in the Harrison Bay Shallow Stratum, which borders high-density mainland sites (see Fig. 3), than elsewhere (18 loons in 693 km^2 surveyed vs. 9 loons in 4,747 km^2 surveyed, respectively). Taken together, these results suggest that Yellow-billed Loons in marine waters are more common in shallow nearshore waters (<10 m, corresponding to roughly 0–20 km offshore) than in deeper water; near barrier islands (when present) than in other nearshore habitats; and adjacent to mainland concentration areas than elsewhere.

Yellow-billed Loons were fairly uncommon compared to other species recorded during nearshore and offshore surveys (comprising 0.06% and 0.14% of observations, respectively). However, a relatively small fraction of the study area bordered areas where Yellow-billed Loons are common breeders (Fig. 3), and the total North Slope population size of Yellow-billed Loons is much smaller than that of the other focal species. The potential importance of marine habitat to Yellow-billed Loons in some areas is illustrated by the fact that density in the Harrison Bay Shallow Stratum (0.026 loons/km^2) was comparable to that recorded during mainland aerial surveys in the same years (0.033 loons/km^2 in the Arctic Coastal Plain study area and 0.027 loons/km^2 in the North Slope Eider study area, 1999–2000; based on data in Earnst et al. in review).

The importance of marine habitat to Yellow-billed Loons relative to other species may be more meaningfully interpreted relative to the species' relative abundance on the breeding grounds. For example, in nearshore and offshore surveys combined, 997 Pacific Loons, 230 Red-throated Loons, and 94 Yellow-billed Loons were recorded. When considered as a proportion of the six-year population index (1997–2002) for these species (based on data in Mallek et al. 2004), the proportion is 0.04 for Pacific Loons, 0.06 for Red-throated Loons, and 0.04 for Yellow-billed Loons, suggesting a similar importance of the marine environment during the summer. Although this illustrates the value of considering overall population size, a more extensive marine survey would be needed to rigorously quantify the relative importance of marine habitat to these three species.

B. Reproductive Ecology

Pairs apparently form or re-form upon arrival on the breeding territory or while staging on adjacent rivers. Most males and females are thought to return to breeding territories used in past years (see Section 5–F) and established territory-holders occupy territories each year whether or not they attempt to breed (North and Ryan 1988). Individuals may arrive on the breeding grounds before an ice-free moat forms on their breeding lake, stage on open river channels, and make forays with vocalizations over breeding lakes (North and Ryan 1988). Breeding lakes appear to be occupied as soon as open water is available to allow safe take-off, and eggs are laid a few to several days thereafter. Annual dates of hatch are variable. On the Colville River Delta, in the early spring of 1983 and the late spring of 1984, Yellow-billed Loons first arrived at the end of May, breeding pairs first occupied territories 4 to 11 June, and began incubation 15 to 23 June (N = 2 pairs; North and Ryan 1988). Similarly, in 1995–1999, average onset of incubation was 14 to 23 June (back-dated 28 days from average hatch dates of 11 to 20 July, N = 7 to 10 pairs) and reflected, in part, the timing of spring ice melt (Earnst unpubl. data). In 2000, after a late spring and a 100-year flood event which temporarily flooded many nest bowls, a small fraction of territorial pairs nested, and average hatch date was 6 days later than previously recorded averages (Earnst unpubl. data).

Copulation occurs on land and may be followed by stylized nest-building movements. Nest bowls are typically bulkier than those of the sympatric Red-throated Loon and Pacific Loon (outer diameter 63 cm; bowl depth 3.8 cm) and constructed of peat, pendant grass (*Arctophila fulva*), and sedge species (usually *Carex* spp.) (North and Ryan 1989). Vegetation may be added during incubation. Nest sites from previous years often are reused.

Clutch size is almost always two eggs, and although two young typically hatch, most successful pairs rear only one chick (North and Ryan 1988, Earnst unpubl. data). Eggs are medium brown or olive brown with dark brown to black spots. Eggs are larger than those of sympatric breeding Pacific Loons (Earnst unpubl. data). Egg membranes and large shell pieces from successfully hatched eggs almost never are found in the nest but sometimes are found in deep water several meters from the nest, presumably placed there by parents, as occurs in Common Loons (McIntyre and Barr 1997). Both sexes incubate, nest attendance is very high (eggs covered 95.3% of the time, based on 12 pairs over 216 hours; North unpubl. data, cited in North 1994), and the incubation period is 27–28 days (N = 3; North and Ryan 1988). Chicks are dry and active within hours of hatch and are capable of following parents onto water but will remain in the nest for many hours if undisturbed. On the few territories where chicks are moved from a small nesting waterbody to a large brood-rearing waterbody, chicks are moved when very young (1–3 days of age).

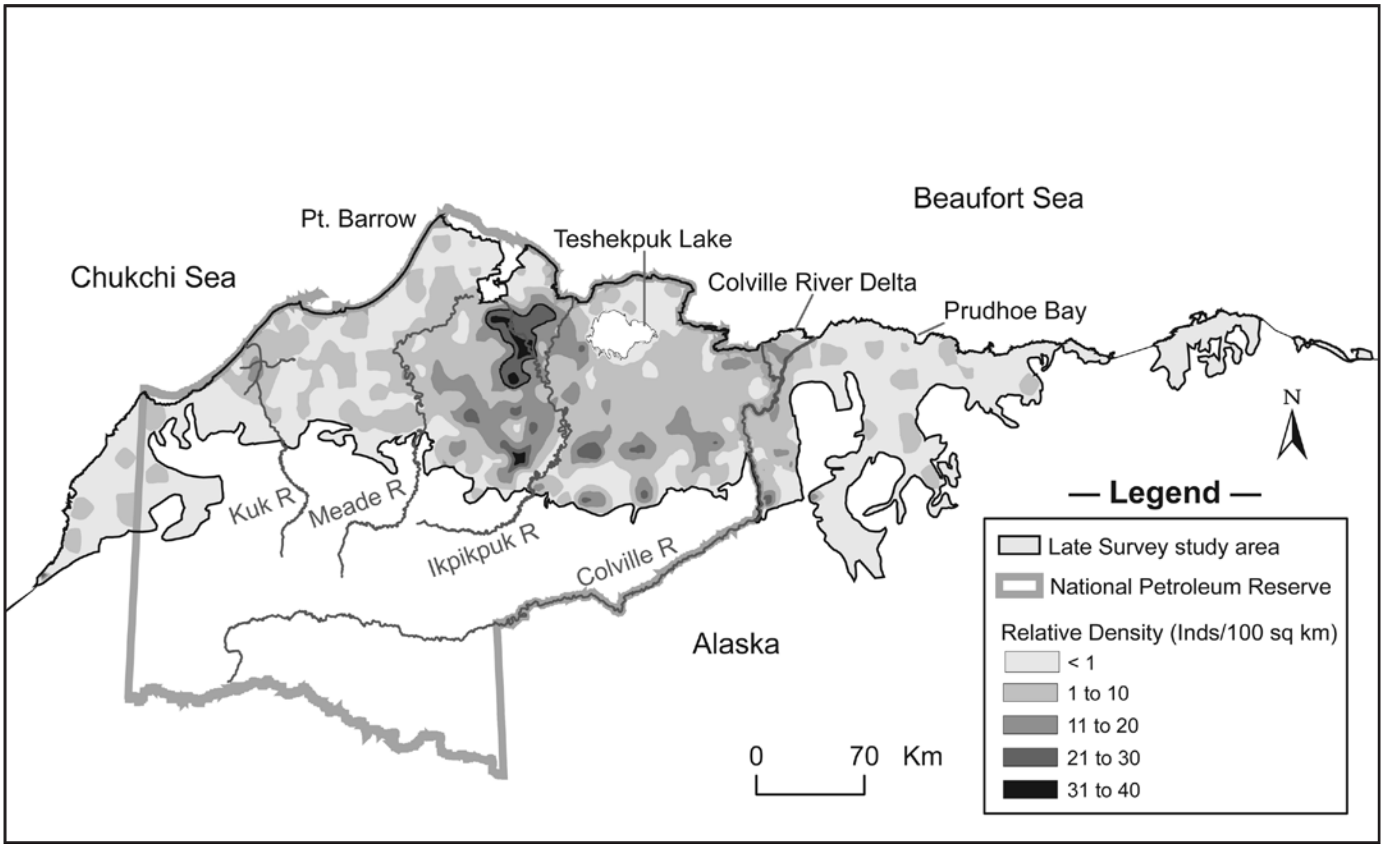

Figure 3. Relative density of Yellow-billed Loons on the North Slope of Alaska during 1992–2003. Based on the North Slope Eider and Arctic Coastal Plain aerial surveys. Relative density is not corrected for visibility bias. Modified from Earnst et al. (in review).

Although behavior during the move itself has not been directly observed in Yellow-billed Loons, Pacific Loon parents in similar habitats move chicks by actively leading them across land to the destination waterbody (Bergman and Derksen 1977, Earnst pers. obs.). The adult or chick uses its feet to thrust itself breast-first across the vegetation.

Brooding occurs in the nest and on other gently sloping, easily accessible shorelines throughout the first 10 days of age (Sjölander and Ågren 1976, North 1994). In poor weather, older chicks sometimes are brooded, and chicks may be brooded on land by one parent while being simultaneously brought fish by the second parent (Earnst pers. obs.). Chicks of one pair reportedly were brooded while riding on a parent's back at a more southerly site (Sjölander and Ågren 1976), but back-riding was observed only once in a two-year study on the Colville River Delta (North 1994) and was not observed in a six-year study at the same site (Earnst unpubl. data). Chicks up to 45 days old rarely feed themselves (Sjölander and Ågren 1976, North 1994, Earnst unpubl. data, but see Sage 1971). In one study, parents fed chicks from 0.30 to 1.43 food items/chick/minute (North unpubl. data, cited in North 1994). Often both parents feed chicks during feeding bouts and both are often present on the waterbody, especially parents of two-chick broods. For example, on the Colville River, both parents were present during 82% of brood checks and 70% of time-budget observations on two-chick broods and during 47% of brood checks and 51% of observations on one-chick broods (based on 132 visits to 23 broods, and 230 hours of observation on 10 broods; Earnst unpubl. data). Feeding rates, and a measure of fish availability from fyke-net sampling, will also be available from the latter study.

Clutch replacement after predation has been reported in one possible case on southeast Victoria Island (Parmelee et al. 1967), and once near Alaktak, Alaska (Sjölander and Ågren 1976), but not on the Sagavinertok River (one year, Sage 1971) or the Colville River Delta (two years, North and Ryan 1988; and six years, Earnst unpubl. data). Replacement clutches, if they occur, are probably not successful unless laid very early in the season. For example, replacement clutches of Red-throated Loons, although common, rarely fledge young on the Colville River Delta (Earnst unpubl. data).

C. Demography

Yellow-billed Loons reach maturity at age 3 but probably do not obtain a territory and nest until age 4–7 (North 1994). The proportion of nonterritorial adults and the survival rates of immatures and adults are unknown. A comparison to the closely related Common Loon may provide some insights into those demographic parameters that are poorly studied in Yellow-billed Loons. In Common Loons, the average age at first breeding is 6 (range 4–11 years), 19% of 3+ year-olds are nonterritorial on average, and annual survival is 70%, 80% and 92% for ages 1, 2–3, and >3 years of age, respectively (Evers 2004, M. Mittro, D. Evers, and M. Meyers, unpubl. data).

In a two-year study (1983–1984) of Yellow-billed Loons on the Colville River Delta, 76%–79% of territorial pairs nested (North 1986), average clutch size was 1.88 and 1.89, and nesting pairs raised 1.29 and 0.94 chicks to age 2 weeks (North 1986, North and Ryan 1988). At the same site in 1989 and 1990, 42% and 67–71% of territorial pairs nested, respectively (Field et al. 1993, North 1993).

In a six-year study (1995–2000) of Yellow-billed Loons on the Colville River Delta, 39%–89% of territorial pairs nested, and annual average clutch size was 1.63–2.0. Based on Mayfield survival rates, 4%–60% of individuals survived from laying to age 6 weeks each year, corresponding to an average of 0.08 to 1.20 chicks per nesting pair raised to age 6 weeks each year (Earnst unpubl. data). These productivity estimates are not directly comparable to North's because he reports apparent nesting success rather than Mayfield-adjusted success. Combining the 10 years of data available for the Colville River Delta (all studies described above), the proportion of territorial pairs nesting ranged from 39% to 89% and averaged 59%.

Much of the variation in reproductive success in the six-year study was due to years of late ice melt or extreme flooding, during which Yellow-billed Loon pairs hatched eggs up to two weeks later than in other years and had poorer brood-rearing success. High annual variation in productivity also has been noted in the other arctic-breeding loons—Pacific Loons and Red-throated Loons (e.g., Petersen 1989, Eberl and Picman 1993, and Earnst unpubl. data). In the more temperate-breeding Common Loon, annual variability within one well-studied site (0.30–0.73 fledged young per territorial pair) and variability among sites (0.28–0.96 fledged young per pair) is also pronounced (reviewed in Evers 2004). In a 25-year study of Common Loons in New Hampshire, an average of 68% of territorial pairs attempted to nest, and they produced 0.52 fledged young per territorial pair (Taylor and Vogel 2000).

In order to evaluate the potential demographic risks associated with the small population size in Alaska and world-wide, long-term studies of color-marked individuals are needed to ascertain immature and adult survival rates, age at first breeding, and patterns of breeding philopatry (return of a breeder to the same breeding site) and juvenile dispersal (distance from natal lake to site of first breeding). Telemetry studies would be useful in documenting the degree to which individuals from disparate breeding sites winter together and the size and location of the nonterritorial, nonbreeding component of the population. Genetic studies are needed to quantify the discreteness of various breeding concentrations across Alaska, Canada, and Russia. Long-term studies of nesting and brood-rearing success at multiple sites are needed to identify the causes of variation and to set the stage for investigations into the effects of oil-related development and global climate change.

D. Feeding Ecology

Adults on breeding territories typically forage in deep, open water where they make repeated, lengthy dives (average duration = 47.1 seconds, maximum 108 seconds; North 1994). Yellow-billed Loons are probably opportunistic foragers, taking prey in relation to their availability and ease of capture, and consuming most prey underwater (Barr 1997). When foraging in shallow water, as adults with young chicks often do, adults submerge bill and eyes beneath the surface, and move the neck and body forward in jerking motions as they probe the substrate, vegetation, and water column; a similar behavior has been described in Common Loons (Barr 1996, McIntyre and Barr 1997).

Yellow-billed Loon chicks are fed small, minnow-sized fish throughout July and August (age approximately 6–7 weeks). Ninespine sticklebacks (*Pungitius pungitius*) and least cisco (*Coregonus sardinella*) are thought to be the primary foods of chicks on the Colville River Delta based on time-budget observations of adults feeding chicks and subsequent sampling of fish availability at sites where loons forage (Earnst unpubl. data). Alaska blackfish (*Dallia pectoralis*), fourhorn sculpin (*Myoxocephalus quadricornis*), isopods, and amphipods also are available and probably utilized to some extent on breeding territories. In 230 hours of time-budget observations, Yellow-billed Loon parents only once brought a fish back from areas off the brood-rearing waterbody, and chicks rarely attempted to feed themselves (Earnst in prep). This is similar to the parental feeding strategy of Pacific Loons on the Colville River Delta, but in contrast to that of the smaller Red-throated Loon, which brings fish back from the ocean or river channel, and provides large fish at the upper bounds of the chick's ability to swallow, perhaps as a means to optimize energy delivered relative to distance flown. Yellow-billed Loon adults on the Colville River Delta often feed themselves from the brood-rearing waterbody, probably mostly on ninespine sticklebacks and least cisco since that is what is most available (see above), but parents also sometimes forage in nearby river channels or Harrison Bay where a larger variety of fish species are available (Earnst pers. obs.).

There is little direct data on diet from stomach contents. In three specimens from marine waters, stomach contents included the following: Pacific staghorn sculpin (*Leptocottus armatus*), sculpin species (*Myoxocephalus* sp.), Pacific tomcod (*Microgadus proximus*), amphipods (*Orchomonella* sp., *Anonyx nirgax*), isopods (*Idothea* sp.), shrimp (*Pandalus* *danae*, *Spirontocaris ochotensis*), hermit crabs (*Pagarus* sp.), and marine worms (*Nereis* sp.) (reviewed in North 1994).

Yellow-billed Loon adults and chicks regularly climb onto shore and face the water before defecating. Defecation by one family member is often followed by the same behavior in other members, and can be initiated by either a parent or chick (Earnst pers. obs.). A few locations on the brood-rearing waterbody tend to be used repeatedly, perhaps because they are low and easy to access. This behavior has been observed in other species that feed chicks from the brood-rearing waterbody—Common Loons (McIntyre and Barr 1997) and Pacific Loons (Earnst pers. obs.)—but not Red-throated Loons, which feed chicks from elsewhere. Some have speculated that this might be an adaptation to mark territories (e.g., North 1994, McIntyre and Barr 1997), since the white streaks are visible from the air, or a means of avoiding fouling of the water, perhaps as a disruption to the life cycle of a yet unidentified parasite (North 1994). It is unknown how often defecation occurs in the water.

E. Movements and Migration

Pair members are thought to migrate separately from one another and to establish or re-establish pair bonds soon after arrival on the breeding grounds. North (1993) provides a thorough review of spring arrival and spring and fall migration dates across Alaska and Canada. First arrival in northern Alaska is usually the last third of May, and peak arrival is somewhat later. First arrival is later in Canada (1–15 June). Individuals and small groups may occupy open river channels before breeding lakes are sufficiently free of ice. Larger flocks may stage in marine bays. For example, a flock of 60 was reported staging in spring at Shishmaref Inlet on the Seward Peninsula (Kessel 1989). During June, large numbers also stage in open-water leads off the northern coast of Canada along the mainland east of the MacKenzie River Delta, off western Banks Island, and in Lambert Channel at the southeast corner of Amundsen Gulf (Alexander et al. 1997). Also see Section 5–A.

Adults usually leave territories in northern Alaska during late August to mid-September but appear to remain on sites in Canada longer (North 1993). Breeders are reported to leave territories soon after fledging, sometimes moving to open rivers until forced out by ice (Sage 1971). Adults are thought to migrate separately from their offspring. Fall staging of 30–300 individuals in late August to mid-September has been reported in Wainwright Inlet in Alaska, on Banks Island, in Yellowknife Bay on Great Slave Lake, and the area southwest of the breeding grounds around the Thelon Game Sanctuary in Canada (reviewed in North 1994).

Migratory routes are poorly known. During spring migration, Yellow-billed Loons are known to follow leads in pack ice far from shore in the Chukchi Sea and Beaufort Sea (Richardson et al. 1975, Divoky 1984). Because most observations have been from shore, it is likely that we underestimate the importance of migration along ice-free leads away from shore. North (1994) cites the Yellow-billed Loon as a regular migrant along the northern Canada coastline, the northern Alaska coastlines of the Beaufort and Chukchi Seas (Icy Cape, Barrow, Oliktok Point), and along the northwestern Alaska coastline of the Bering Strait (St. Lawrence Island and western tip of Seward Peninsula). It is a rare migrant along the western Alaska coastline (Yukon-Kuskokwim Delta, Bristol Bay, Aleutian Islands, and Alaska Peninsula). Inland migration also has been reported in Alaska and elsewhere.

North (1993) suspected that most Yellow-billed Loons that breed in northern Alaska and the Canadian arctic islands migrate across the Bering Sea to winter along the coast of Siberia or Japan, whereas birds from eastern mainland Canada migrate across an inland route, perhaps via Great Slave Lake, to winter in southeastern Alaska or British Columbia. His suspicion was based on the scarcity of observations of Yellow-billed Loons migrating along the coast of western and southwestern Alaska (i.e., Norton Sound to Alaska Peninsula), the correlation between the timing of arrival and departure from Canadian mainland breeding grounds with the timing of migratory sightings across inland Canada, and the shorter distance between breeding and wintering sites over an inland route. In July 2002, 5 Yellow-billed Loons were fitted with satellite transmitters while nesting near Inigok, approximately 75 km inland from the Colville River Delta (J. Schmutz pers. comm.). They moved westward to the Chukchi Sea off the coast of Alaska's Icy Cape between 20 and 30 September, moved slowly southward through the Bering Strait, and staged for several days just north of St. Lawrence Island. Most then migrated along the Kamchatka Peninsula, and once reaching the end, cut through the Kuril Islands towards Hokkaido Island (Japan), Sakhalin Island (Russia), and eventually the Sea of Japan and the Yellow Sea. Loons seemed to become stationary for the winter by the end of November, or perhaps December. As of mid-March 2003, the four individuals whose transmitters were still emitting a signal were wintering off the coast of Hokkaido, Japan (two), North Korea (one), and in the Yellow Sea between North Korea and China (one). The fifth loon was off the coast of North Korea when its transmitter failed in November. An additional six loons were fitted with transmitters in 2003 and showed similar patterns of movement and wintering sites (J. Schmutz pers. comm.).

F. Breeding Philopatry and Juvenile Dispersal

There have been no studies of color-banded individuals, thus nothing is known of breeding philopatry or juvenile dispersal. Researchers suspect that breeding philopatry is high, based on observations of repeated use of nests and territories (e.g., North 1994); however, the identity of individuals using those sites has not been confirmed.

Given the scarcity of data on Yellow-billed Loons, some insights may be gained from philopatry in Common Loons. However, the degree of philopatry is likely affected by the degree of saturation of suitable breeding habitats, which is thought to be high in Common Loons (Evers 2001) and is unknown in Yellow-billed Loons. In Common Loons, between-year territory fidelity was 80% for males and 82% for females. Of the loons that moved, 68% established new territories and moved 3.0 km on average; 32% became non-breeders and moved 4.5 km on average (Evers 2001). Most between-year movement was thought to result from usurpation of the breeding territory by a competitor (see also Piper et al. 2000). Average juvenile dispersal was 13 km (N = 45) (Evers unpubl. data).

G. Mortality

Estimates of adult and subadult annual mortality rates are not available due to the lack of studies on individually marked Yellow-billed Loons. Known sources of adult mortality include oil-spill related mortality (see Section 7–A), subsistence harvest for food and skins (see Section 7–B), bycatch in commercial and subsistence fisheries (see Section 7–B), die-offs during spring migration in years when open-water leads are not available (Barry 1976), and aspergillosis (Remsen and Binford 1975), but the relative importance of these sources cannot be estimated with existing data. Predation on nests and young chicks is fairly common, but predation on adults is thought to be uncommon. See Section 7–C for a review of predation.

6. Population Distribution, Size, and Trends

A. Relative Abundance and Distribution in Alaska

Most Yellow-billed Loons on Alaska breeding grounds occur between the Colville River and Meade River but are distributed patchily therein. Yellow-billed Loons also breed sparsely east of the Colville River to the Canning River, and sparsely west of the Meade River to Point Hope, near the coast of Kotzebue Sound and the northern Seward Peninsula, and on St. Lawrence Island.

In the following paragraphs, the mean ± standard error is given except where use of the mean ± 95% confidence interval (CI) half-width is noted.

Breeding grounds – Arctic Coastal Plain of Alaska

The relative density of Yellow-billed Loons in northern Alaska has been well documented by ongoing U.S. Fish and Wildlife Service aerial waterfowl surveys—the Arctic Coastal Plain Breeding Pair Survey and the North Slope Eider Survey (described in Section 9–B), which were used to produce the relative density polygons illustrated in Fig. 3. The following description of this species' patchy distribution is taken from Earnst et al. (in review). Most of the population (53% of sightings recorded during the Arctic Coastal Plain Breeding Pair Surveys, 1992–2003) occurs within "concentration areas" (i.e., >11 individuals/100 km^2, Fig. 3) that encompass only 12% of the study area. The largest is the contiguous concentration area between the Meade and Ikpikpuk rivers, which encompasses 38% of Yellow-billed Loon sightings in 8% of the study area. The highest density subset therein (i.e., >21 individuals/100 km^2) encompasses 10% of sightings in only 2% of the study area (outlined in black in Fig. 3). The corrected population size estimate for North Slope breeding grounds is 2,221 (± 460) Yellow-billed Loons in early June and 3,369 (± 663) in late June (Earnst et al. in review; Section 6–E).

Breeding grounds – northwestern Alaska

The wetlands of Seward Peninsula and Selawik National Wildlife Refuge (Fig. 4) are not included in the annual surveys of the Arctic Coastal Plain (above), but were surveyed during early to mid-June in 1992–1993 and 1996–1997 using standard waterfowl breeding pair survey methods. Surveys of the two areas combined, which encompassed all likely Yellow-billed Loon breeding habitat on the Seward Peninsula and from Selawik National Wildlife Refuge to Point Hope yielded a population index of 730 ± 126 Yellow-billed Loons. When combined with an estimate of 50 loons on St. Lawrence Island (Fair 2002), the total population index for Yellow-billed Loons in western Alaska is 780 individuals. The two surveys are described in more detail below.

Selawik National Wildlife Refuge contains numerous large thaw lakes, estuaries, and brackish lakes along the Selawik and Kobuk river deltas. In early to mid-June in 1992–1993 and again in 1996–1997, about 200 km^2 and 800 km^2, respectively, of the 15,000 km^2 of the refuge and adjacent wetlands along the Noatak River to the northwest were surveyed for waterbirds using typical breeding pair survey methods. Only 4 Yellow-billed Loons were seen (Fig. 4), resulting in a population index of 47 ± 25 individuals (Platte 1999, USFWS unpubl. data).

Seward Peninsula coastal wetlands, from the north edge of the Yukon Delta to the Baldwin Peninsula in Kotzebue Sound, were surveyed during 1992–1993. Approximately 1,320 km^2 were sampled across the 25,700 km^2 study area, and 61 Yellow-billed Loons were observed (Fig. 4) for a total population index of 683 ± 124 individuals in the study area (based on stratified sampling; USFWS unpubl. data). These sightings, which occurred along both the northern and southern coasts of the Seward Peninsula, constitute the southern-most sightings on Alaskan breeding grounds except for the few on St. Lawrence Island.

Marine habitat during summer – southern Alaska

Immatures (1–2 year-olds) are thought to remain on the wintering grounds during the summer, as do Common Loons (Evers 2004). Of the known wintering areas off the shore of Alaska, marine boat-based surveys have been conducted in southeast Alaska, Lower Cook Inlet, and Prince William Sound. The combined population estimate for these areas was only 339 Yellow-billed Loons, but many loons were not identified to species. The large confidence intervals associated with these estimates indicate that the true number of Yellow-billed Loons summering in southern Alaska, and any temporal or spatial patterns in abundance, are poorly known. The surveys are described below.

Southeast Alaska. Boat-based surveys conducted off the coast of the southeast Alaska archipelago (approximately Haines to Ketchikan) indicate a total abundance of 267 ± 422 (CI) Yellow-billed Loons in this area in June–July 1994 (Agler et al. 1995a). The surveyed area extended to 5.6 km offshore, and was divided into a shoreline stratum <200 m from land (4,690 km^2 with 3.2% of the area surveyed) and an offshore stratum >200 m from land (30,778 km^2 with 0.5% of the area surveyed). Loons (all species combined) tended to occur at higher density in the shoreline stratum, but were seen throughout the area in low densities, usually in flocks of less than 6 individuals. Population indices (individuals ± CI) for other species included Red-throated Loons 212 ± 195, Pacific Loons 1,329 ± 990, Common Loons 1,639 ± 1,123, and unidentified loons 1,420 ± 1,527.

Aerial surveys were conducted over coastal marine areas of southeast Alaska during late July to early August in 1998–2002. Although loons were not identified to species, the surveys will indicate general patterns of loon habitat use when analyses are completed (J. Hodges pers. comm.).

Lower Cook Inlet. During boat surveys during the summer of 1993 in the Lower Cook Inlet of southern Alaska, 63 ± 124 (CI) individual Yellow-billed Loons were estimated to be present in the 13,800 km^2 study area (Agler et al. 1995b). Only about half of all loons observed were identified to species.

Prince William Sound. During eight years of July boat surveys of Prince William Sound during the period 1972–1998, the average population index for Yellow-billed Loons was only 9 individuals (range 0–51) (summarized in Lance et al. 1999). The study area included all of the Sound, with the shoreline stratum sampled at 25%, the coastal pelagic stratum at 22%, and the pelagic stratum at 29%.

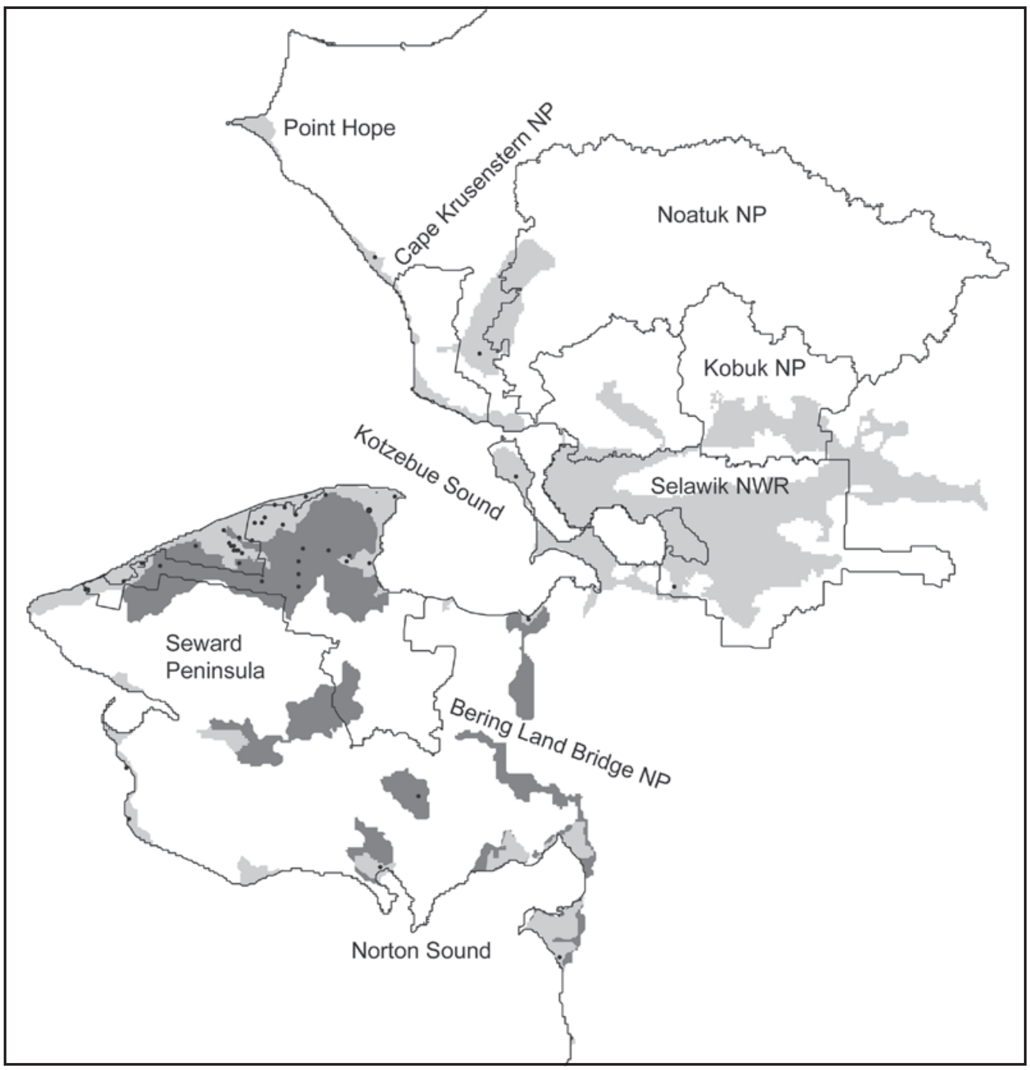

Figure 4. Yellow-billed Loon sightings and areas surveyed on the Seward Peninsula in 1992–1993 and from the Selawik National Wildlife Refuge (NWR) to Point Hope in 1996–1997. Light gray areas were surveyed in two years; dark gray areas in one year. National Wildlife Refuges and National Parks (NP) are indicated. Based on Platte 1999.

Marine habitat during summer – northern Alaska

In addition, to the boat-based surveys in southern Alaska, aerial surveys have been conducted over Harrison Bay, offshore from the breeding grounds, where sightings presumably consisted of individuals holding territories nearby and probably some nonbreeders (described below).

Harrison Bay. Adult Yellow-billed Loons holding territories near the coast often commute to marine waters, where they are known to forage. Nonbreeders, particularly 3–5 year-olds that are not yet holding territories, may also frequent marine waters off the breeding grounds. Lysne et al. (2004), in an early August aerial survey of all nearshore habitat from Kasegaluk Lagoon to the Canadian border, recorded 86 and 210 Yellow-billed Loons in 2002 and 2003, respectively. Likewise, Fischer et al. (2002) gives the relative abundance of Yellow-billed Loons during June–August 1999–2000 from Harrison Bay to Brownlow Point. The survey is described in detail in Section 5–A. Yellow-billed Loons were more common in shallow nearshore water (<10 m, corresponding to roughly 0–20 km offshore) than deeper offshore water; near barrier islands (when present) than in other nearshore habitats; and adjacent to mainland concentration areas. For example, Yellow-billed Loons were several times more common in the Harrison Bay Shallow Stratum than elsewhere. In fact, density in the Harrison Bay Shallow Stratum (i.e., shallow water offshore of the Colville River Delta and area immediately west) was comparable to that on adjacent mainland breeding grounds (see Section 5–A).

B. Relative Abundance and Distribution in Canada

In Canada, the Yellow-billed Loon breeds from the Alaska border to Hudson Bay and is most common on Banks Island and Victoria Island, and the lake district from Great Slave Lake northeast to northern Hudson Bay (Fig. 1). It breeds uncommonly on the Melville Peninsula and Adelaide Peninsula, in the vicinity of Queen Maud Gulf and Amundsen Gulf, and on Prince of Wales Island, Somerset Island, and King William Island. It breeds casually on Baffin Island, Devon Island, and south to Churchill, Manitoba. Five areas of breeding concentration have been identified (reviewed in North 1993, Barr 1997): 1) Banks Island; 2) western Victoria Island; 3) mainland south of the Kent Peninsula, east of Bathhurst Inlet, and to west of Ellice River; 4) west side of the Boothia Peninsula; 5) the lake district between Great Slave Lake and Baker Lake, including Thelon Game Sanctuary. Breeding is thought to be sparse outside these areas.

Fair (2002) provides a reasonable rationale for applying density estimates from various density strata on Victoria Island, the only large area that has been surveyed systematically (Cornish and Dickson 1996), to the other known concentration areas in Canada and arrives at a total Canadian population estimate of 8,000.

A better estimate of the size of the Canadian breeding population possibly could be derived by comparing GIS-based waterbody availability in areas with well-quantified estimates of loon density, such as those on Victoria Island, with areas of unknown density throughout the loon's range in Canada. However, any estimate will continue to be coarse until systematic surveys are flown throughout the range of the Yellow-billed Loon.

C. Relative Abundance and Distribution in Russia

The primary concentration areas in Russia (Fig. 1) appear to be on the Chukchi Peninsula, where Kondratiev (1989) estimated 2,000 individuals, and the Taymyr Peninsula (Rogacheva 1992). Fair (2002) argues convincingly that extrapolating densities from concentration areas to the entire Russian range would lead to unreasonably high total population size estimates. Based on 2,000 individuals on the Chukchi Peninsula, 2,000 on the Taymyr Peninsula, and 1,000 throughout the remainder of the range in Russia, Fair (2002) arrives at a more reasonable estimate of 5,000 Yellow-billed Loons in Russia.

The only systematic aerial surveys of Russian breeding grounds were conducted by Hodges and Eldridge (2001), who surveyed during 1993–1995 from Kolyunchin Bay on the Chukchi Peninsula in the east to the Lena River Delta in the west, a distance of 2,340 km (see place names in Fig. 1). The total study area size was 157,611 km^2, or about 2.5 times the size of the Arctic Coastal Plain Survey study area in Alaska, and 2.1% of the area was sampled. The area included 4 major river deltas (Kolyma, Indigirka, Yana, and Lena) and much of the intervening coastline (extending up to 200 km inland). Yellow-billed Loons were observed sporadically from the Kolyunchin Bay to the Indigirka River Delta, but not further west. The estimated population size for the entire study area was 674 individuals, which corresponds to an observed density of 0.0043 loons/km^2, compared to an average overall observed density of 0.047 loons/km^2 on Alaska's Arctic Coastal Plain Survey (1992–2003; Earnst et al., in review). If this density is extrapolated to the approximate breeding range in Russia (Fig. 1), which appears to be 18–19 times the size of the range in northern Alaska, then one arrives at a very rough estimate of 4,800–5,000 loons in Russia. Thus, until further information is available from systematic surveys or from lake availability, Fair's (2002) estimate of 5,000 seems reasonable.

D. Relative Abundance and Distribution on Wintering Sites

The relative abundance of Yellow-billed Loons on wintering sites is poorly known. It winters regularly, but sparsely, in nearshore marine waters from Kodiak Island through Prince William Sound, and throughout southeast Alaska and British Columbia (Figs. 1 and 2). It winters irregularly southwest of

Kodiak Island along the Aleutian chain and along the coast of Washington to Baja California. Of the 11 birds marked with satellite transmitters on Alaskan breeding grounds, all wintered off the coast of North Korea, Japan, or China (J. Schmutz pers. comm.). Yellow-billed Loon relative abundance on wintering sites has been quantified only in Alaska's Lower Cook Inlet and Prince William Sound, and a combined estimate for Yellow-billed Loons and Common Loons is available for the bays of Kodiak Island (described below). The large confidence intervals associated with these estimates indicate that the true number of Yellow-billed Loons wintering near Alaska's shores is poorly known. The surveys are described below.

Lower Cook Inlet. During boat surveys during the winter of 1994 in the Lower Cook Inlet of southern Alaska, 38 ± 74 (CI) Yellow-billed Loons were estimated in the 3,700 km^2 study area (Agler et al. 1995b).

Prince William Sound. During 8 years of March boat surveys of Prince William Sound between 1972 and 1998, estimated abundance of Yellow-billed Loons was 20–50 individuals in 3 years, 51–150 in 4 years, and 426 in 1 year (summarized in Lance et al. 1999). The high annual variation in number recorded is probably more due to sampling error and variation in percent of Yellow-billed Loons classified as unidentified loons rather than variation in number actually present. The average annual percentage of loons unidentified was 51% (range 5%–83%). The study area included all of the Sound with 13% of the shoreline stratum sampled, 14% of the coastal pelagic stratum, and 29% of the pelagic stratum.

Kodiak Island. During 1979–1984, marine birds in selected bays of Kodiak Island were surveyed in the fall (November) and in the winter (February) using strip transect surveys from a boat (Zwiefelhofer and Forsell 1989). Common Loons and Yellow-billed Loons were not identified separately, but together made up more than 95% of the loons identified. Presumably the vast majority were Common Loons. Average loon density during winter was 1.23 loons per km of shoreline sampled. Density was twice as high in the shallow Sitkalidak Strait area as compared to the deep Uyak Bay and Uganik Bay. Comparison of November and February estimates indicated that loons were still moving into the bays of Kodiak Island during November. The surveys have continued since 1984 and will provide further information on relative abundance around Kodiak Island (Zwiefelhofer pers. comm.).

Southeast Alaska. Aerial surveys were conducted over coastal marine areas of southeast Alaska during late February to early March in 1998–2002. Analyses are in progress and should indicate general patterns of loon habitat use, although loons were not identified to species (J. Hodges pers. comm.).

E. Population Size

The small population size and patchy distribution of the Yellow-billed Loon has caused concern about this species' vulnerability to changes in its environment (Center for Biological Diversity 2004). It is one of the rarest species breeding regularly in the mainland U.S. (Table 1). The Yellow-billed Loon corrected population size on northern Alaska breeding grounds during the early June North Slope Eider Survey is estimated at 2,221 (± 460) individuals, with a 95% confidence interval of 1,209 to 3,233 individuals (Earnst et al. in review). Some fraction of nonbreeding loons may arrive by the late June Arctic Coastal Plain Survey, when the corrected population estimate of 3,369 (± 663) individuals (95% CI: 1,910–4,828) is somewhat, but not significantly, higher than in early June (Earnst et al. in review). These estimates incorporate a correction factor to reduce bias. The correction factor, based on the ratio of loons observed during intensive lake-circling aerial surveys to the number observed during the North Slope Eider and Arctic Coastal Plain surveys, indicates that intensive surveys detect only 16% more individuals than the traditional waterfowl surveys (Earnst et al. in review). Further work is needed to obtain a correction factor based on a larger sample of years and aerial transects, and one that incorporates the ratio between the number of loons observed on an intensive aerial survey and ground surveys. The early June estimate corresponds well with a preliminary estimate of 2,129 (± 342) individuals from the first year of the two-year Yellow-billed Loon Survey (USFWS, unpubl. data; see Section 9–B for survey description).

The North Slope is estimated to support <1,000 nesting pairs in most years (range 437 to 1,214 pairs; Earnst et al. in review), based on 81% of the 3,369 present in late June being territorial (as in Common Loons, Evers 2004) and 39%–89% of territorial Yellow-billed Loons attempting to breed per year (Section 5–C). Even if all of the 3,369 Yellow-billed Loons were territorial, the expected range would be only 593 to 1,499 nesting pairs. Most nesting pairs have probably arrived by the time of the early June survey since nesting pairs arrive in late May or as soon as the first melt water appears on rivers (North and Ryan 1988, Earnst pers. obs.), and later arriving individuals are probably nonbreeders or younger, nonterritiorial birds as they are in Common Loons (Evers 2004). This estimate of <1,000 nesting pairs should be of particular interest in the conservation of Yellow-billed Loons.

A reasonable estimate for all Yellow-billed Loons on Alaskan breeding grounds is 4,149 individuals (3,369 on the Arctic Coastal Plain in late June, this section, plus 780 in western Alaska, Section 6–A). Another population of interest includes any birds that remain at sea and thus are not counted during breeding ground surveys. All 1–2 year-olds are assumed to remain at sea, as is true in Common Loons (Evers 2004), since no immature-plumaged individuals have been observed on the breeding grounds. Earnst et al. (in review) use Common Loon demographic rates (reviewed in Section 5–C) and a simple stable-age population matrix, to estimate that approximately 19.8% of the June population (or 969 individuals) is 1–2 years of age. Also, the number of adult-plumaged birds present on breeding grounds in late June varies with spring temperatures such that approximately 14.1% of adult-plumaged birds present during the warmest springs are predicted to be absent during an average spring (Earnst in review, and see Section 6–F). Thus, the total number of Yellow-billed

Loons on Alaska breeding grounds plus cohorts at sea is estimated to be 6,024 individuals (Earnst et al. in review).

The Yellow-billed Loon is one of the rarest birds that breeds regularly in the mainland U.S. (Table 1). A reasonable range-wide estimate for North American breeding grounds plus cohorts at sea is 16,000 individuals (Earnst et al. in review). This includes 6,024 individuals associated with Alaska (i.e., breeding grounds and at sea) and 9,975 individuals associated with Canada (i.e., 8,000 on breeding grounds [Fair 2002] plus 19.8% at sea). Among landbird, shorebird, waterfowl, and other waterbird species having >10% of their global population within the mainland U.S. (i.e., excluding Hawaiian and other island species), the Yellow-billed Loon is estimated to be among the 10 rarest in the U.S. and one of only 20 with a North American population estimate ≤ 16,000 (Table 1).

F. Population Trends

There is no evidence of a long-term trend in Yellow-billed Loons over the 18-year Arctic Coastal Plain Survey or the 12-year North Slope Eider Survey (Fig. 5). Earnst et al. (in review) estimated the trend using multivariate, mixed effects regression models that included data from both surveys and found no evidence of a statistically significant population trend since 1986 (annual change = -0.9% ± 1.2%). However, the 95% CI was large (-3.6% to +1.8%), indicating that the estimated trend is not statistically distinguishable from a total 18-year population change of either -48% or +38%. The multivariate approach incorporated variables that were potential sources of bias in the trend, such as observer experience and spring weather, and variables that might reduce the variance in the trend, such as survey identity and observer type (pilot vs. passenger). It was particularly important to include observer experience, because observers saw more loons as they became more experienced, and average observer experience has increased since 1986. Spring weather was also important because more loons were recorded during warm springs (as measured by thaw-degree days) than cold springs on the Arctic Coastal Plain Survey. Springs tended to become warmer from 1986 to 1996 but were variable thereafter, so thaw-degree days were a source of noise in the 18-year trend, rather than bias.

It is important to ask how likely existing surveys are to detect a substantial long-term decline if it were occurring. Both the 18-year Arctic Coastal Plain Survey and the 12-year North Slope Eider Survey had low power to detect a 3.4% decline, which would result in a 50% decline in 20 years (power = 62% and 26%, respectively, using simple log-linear regression; Earnst et al. in review). When multivariate models were used to combine the two surveys and incorporate covariates, power to detect a 3.4% decline was 81% (Earnst et al. in review). However, given the likelihood of additional sources of bias and the imperfect nature of our multivariate model of bias, actual power to detect a trend is probably lower (Bart et al. 2004). In addition, any declines more gradual than 3.4% would be more difficult to detect as statistically significant;

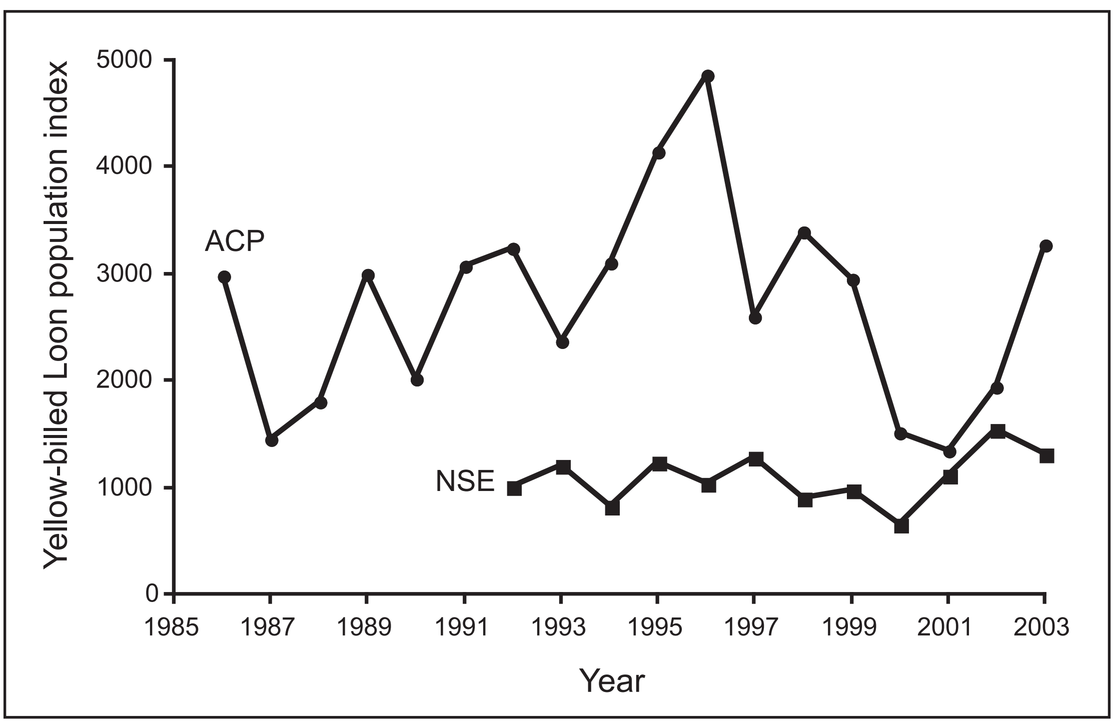

Figure 5. Annual population indices for Yellow-billed Loons in the Arctic Coastal Plain (ACP) and North Slope Eider (NSE) surveys. Indices are not corrected by a visibility correction factor. The NSE covers a smaller area and thus has smaller annual indices. The population trend for 1986–2003 is near zero (-0.9% ± 1.2% annual change) with a 95% CI of 3.6% to 1.8% when multivariate models are used to combine the surveys and incorporate potential sources of bias and noise. Modified from Earnst et al. (in review).

Table 1. Species as rare as the Yellow-billed Loon (i.e, having population estimates ≤16,000 individuals). List derived from all full species recognized by the American Ornithologists' Union having >10% of their global population within the mainland U.S. (i.e., excluding Hawaiian and other island species)[a].

Species[b]	Population Size Estimate[c]		Status
	United States	North America	
1. California Condor (*Gymnogyps californianus*)[d]	150	150	Endangered
2. Whooping Crane (*Grus americana*)[e]	312	312	Endangered
3. Gunnison Sage-Grouse (*Centrocercus minimus*)[f]	2,000	2,000	Candidate
4. Kirtland's Warbler (*Dendroica kirtlandii*)[f]	2,100	2,100	Endangered
5. Piping Plover (*Charadrius melodus*)[g]	3,800	5,900	Endangered
6. Black-capped Vireo (*Vireo atricapillus*)[f]	4,800	4,800	Endangered
7. Wandering Tattler (*Heteroscelus incanus*)[g]	5,000	10,000	
8. Wilson's Plover (*Charadrius wilsonia*)[g]	6,000	6,000	
9. Yellow-billed Loon (*Gavia adamsii*)[h]	6,000	16,000	Petition Pending
10. Gull-billed Tern (*Sterna nilotica*)[i]	7,000	7,000	
11. Black Oystercatcher (*Haematopus bachmani*)[j]	8,700	10,800	
12. American Oystercatcher (*Haematopus palliatus*)[g]	8,800	8,800	
13. Rufous-winged Sparrow (*Aimophila carpalis*)[f]	9,600	9,600	
14. Bristle-thighed Curlew (*Numenius tahitiensis*)[g]	10,000	10,000	
15. Florida Scrub-Jay (*Aphelocoma coerulescens*)[f]	10,000	10,000	Threatened
16. Spotted Owl (*Strix occidentalis*)[f]	10,500	10,500	Threatened[k]
17. White-tailed Kite (*Elanus leucurus*)[f]	10,900	10,900	
18. Mountain Plover (*Charadrius montanus*)[l]	11,000	11,000	--[l]
19. Reddish Egret (*Egretta rufescens*)[i]	12,000	12,000	
20. Pacific Golden-Plover (*Pluvialis fulva*)[g]	16,000	16,000	

[a]Rare island-breeding species not in this table include Dovekie (*Alle alle*), Xantus's Murrelet (*Synthliboramphus hypoleucus*), Ashy Storm-Petrel (*Oceanodroma homochroa*), McKay's Bunting (*Plectrophenax hyperboreus*), Island Scrub-Jay (*Aphelocoma insularis*), and several Hawaiian-breeding seabirds. Rare species not included in this table because ≤10% of the global population breeds in the U.S. include, among others, Steller's Eider (*Polysticta stelleri*), Buff-breasted Sandpiper (*Tryngites subruficollis*), Sharp-tailed Sandpiper (*Calidris acuminata*), Snowy Plover (*Charadrius alexandrinus*), California Gnatcatcher (*Polioptila californica*), Aplomado Falcon (*Falco femoralis*), and Montezuma Quail (*Cyrtonyx montezumae*). Kittlitz's Murrelet (*Brachyramphus brevirostris*), a recent addition to the Candidate species list, has population estimate of 9,505–26,767 with a mid-point of 18,136 (USFWS 2004), just over the 16,000 cut-off. This table does not include species thought to be extinct in the wild, such as Ivory-billed Woodpecker (*Campephilus principalis*) and Eskimo Curlew (*Numenius borealis*). In addition, 15 avian subspecies or races listed as Threatened or Endangered have North American populations ≤ 16,000 (http:/ecos.fws.gov/tess_public, accessed 15 September 2004).

[b] Population estimates for species not meeting the criteria for this list (i.e., those with >16,000 individuals in North America) taken from the sources listed in footnotes c-f below plus the North American Waterfowl Management Plan Committee (1998), Wetlands International (2002), and numerous species accounts in The Birds of North America series (A. Poole and F. Gill, editors).

[c] Mean estimate if available, otherwise the midpoint of range used.

[d] Snyder and Schmitt 2002. Includes birds in captivity.

[e] Stehn 2004.

[f] Rich et al. 2003.

[g] Morrison et al. 2001.

[h] Earnst et al. in review.

[i] Kushlan et al. 2002.

[j] Andres and Falxa 1995.

[k] Threatened status applies to the Northern Spotted Owl (*Strix occidentalis caurina*) and the Mexican Spotted Owl (*Strix occidentalis lucida*).

[l] USFWS 2002b. Proposed for listing in 1999; withdrawn in September 2003 due to new information.

for example, power to detect a 2.5% annual decline was only 55%.

The population trend described above is based only on the breeding component of the population—ongoing breeding ground surveys do not monitor trends in immature or nonbreeding Yellow-billed Loons that remain in marine waters. Thus, to the extent that individuals from this nonbreeding pool replace individual territory holders as they die, this unmonitored pool masks, or delays the detection of, any trend on the breeding grounds.

There are no data on historical or recent population trends in Canada or Russia, but the literature provides no evidence for a large change in the breeding population in Canada (Barr 1997).

7. Potential Threats to the Population

There are good reasons to be concerned about any potential threat to Alaska's breeding population of Yellow-billed Loons. Northern Alaska's breeding population is small, with probably fewer than 1,000 pairs attempting to breed in an average year, and the low reproductive potential of Yellow-billed Loons means that the population will not recover from perturbations rapidly. It seems valuable, then, to consider carefully and research thoroughly each potential threat, and to monitor likely effects on survival and reproduction. At present, we lack the information necessary to predict the effect of potential habitat loss and other potential threats to local or range-wide populations.

In Yellow-billed Loons, as in other long-lived organisms, the growth rate of the population is most sensitive to factors that affect adult survival rather than those affecting rates of reproduction or chick survival (e.g., Caswell 1978, Brault and Caswell 1993). In other words, a proportionate change in adult survival will have a larger effect than the same proportionate change in reproduction or chick survival (see Caswell 1989). Thus, we would be most likely to see population declines that result from adult deaths, for example, due to oil spills, contaminants, subsistence harvest, fisheries bycatch, or disease. However, population declines due to a decline in reproduction or chick survival are also possible, especially if the declines in reproduction are large or persist over several years, as might occur if breeding habitat were lost or nest predators increased steadily over the course of oil development in previously undisturbed sections of the breeding range.

Sections 7–A, C, D, E, and F represent categories of potential threats typically addressed in Status Assessments (USFWS 2000). Although these categories correspond to the five listing criteria considered under the Endangered Species Act, this document does not make or imply a recommendation concerning listing, instead, these criteria are used as a framework to describe existing knowledge and identify research needs.

A. Habitat Loss on the Breeding Grounds

A potential source of Yellow-billed Loon breeding habitat loss is the continued expansion of the oil industry across the North Slope of Alaska and Canada, particularly within the National Petroleum Reserve-Alaska (NPR-A), which is home to approximately 91% of the Yellow-billed Loons on Alaska's North Slope (Earnst et al. in review, and Fig. 3). Virtually all Yellow-billed Loon breeding areas are open or proposed to be opened to development (BLM 1998a,b, 2003, 2004a,b,c) and no permanent protection of Yellow-billed Loon habitat is proposed. About 23% of Yellow-billed Loons within the NPR-A are in the area of High Oil Potential which is likely to be developed first (Fig. III-A–29 in BLM 1998a, and Map 105 in BLM 2003, Earnst et al. in review). Large-scale development may proceed rapidly in previously pristine environments and produce cumulative effects that are difficult to predict or reverse (National Research Council 2003). In addition to any habitat lost directly to gravel pads, habitat loss may arise from oil spills, roads, environmental contaminants, noise, changes in hydrology, increases in predator populations, and increased human activity in previously remote areas (BLM 1998a and 2003, National Research Council 2003). It is difficult to predict the potential impact to Yellow-billed Loons within the NPR-A because very few individuals breed in the previously industrialized Kuparak and Prudhoe Bay Oilfields, and data on their response to disturbance is lacking. Likewise, it is difficult to predict the proportion of the population that might be affected because the proposed footprint of development changes (e.g., BLM 2004b,c), and cumulative effects of development are not always predictable or well quantified (National Research Council 2003).

This section (7–A) considers potential sources of direct and indirect habitat loss associated with oil-field development. I emphasize that there are no data on the nature nor magnitude of effects of development or disturbance on Yellow-billed Loons, and there are few relevant data from other species. This section simply uses knowledge of Yellow-billed Loon ecology to identify topics on which data are needed. None of the statements below provide evidence that effects on loons will occur.

Overview of planned or existing development

Northeast NPR-A. The original Record of Decision opened 87% of the 4.6 million acres of the Northeast NPR-A to oil and gas leasing (BLM 1998b). Of those areas where permanent surface structures were not to be allowed, the following are of particular relevance to Yellow-billed Loons: near Fish and Judy creeks, near Ikpikpuk and Miguakiak rivers, and within 0.25 mile of fish-bearing lakes within the Deep-Water Lake Zone. However, the Draft Amended EIS for the Northeast NPR-A would open 97% of the area (Preferred Alternative, BLM 2004b). In particular, the Preferred Alternative would allow drilling within all parts of the Teshekpuk Lake Surface Protection Area of any importance to Yellow-billed Loons (the Surface Protection Area encompasses 6% of Yellow-billed Loons recorded during Arctic Coastal Plain surveys, 1992–2003).

Northwest NPR-A. The Record of Decision opened all 8.8 million acres of the Northwest Planning Area to oil and gas leasing (BLM 2004a).

Alpine and Alpine Satellite Developments. The Colville River Delta and Fish Creek area contain a multitude of fish-bearing, deep lakes that are used regularly by breeding Yellow-billed Loons. Most of the land is managed by BLM under the guidance of the Record of Decision for the Northeast Planning Unit (described above). Between 1998 and 2001, the beginning of development on the Delta resulted in two production pads, a 2- to 3-mile gravel road, a 1-mile airstrip, processing facilities, a drilling mud plant, a maintenance complex, warehouse buildings, disposal wells, a large camp facility with waste and wastewater utilities, and a 34-mile long pipeline that connects to the Kuparuk Oilfield (BLM 2004c).

In addition, the Preferred Alternative in a recent EIS accepts the key elements of ConocoPhillips' proposed action for further development, including five new satellite drilling pads on the Colville River Delta and adjacent Fish Creek area, a bridge across the main channel of the Colville, a road system that connects to that outside the NPR-A, a drilling pad within the 3-mile setback that was designed to protect Fish Creek, and oil infrastructure within 500 feet of certain waterbodies (BLM 2004c). The latter three activities are requested exemptions to existing stipulations. The EIS also describes a scenario of Full Field Development for the next 20 years involving 22 new production pads, up to 190 miles of new roads, 2 new processing facilities, multiple airstrips, and further exceptions to stipulations.

Relevance of specific activities to Yellow-billed Loon habitat

Roads and gravel pads. Roads and gravel pads, and the associated increase in dust dispersion, have profound direct and indirect effects on hydrology, snow-melt patterns, and thermokarst action of the tundra (Walker 1987, National Research Council 2003, also see review in BLM 1998a). Thermokarst erosion and water impoundment is estimated to affect twice the area directly covered by the footprint of the gravel. For example, the chosen alternative for the Northwest Planning Area (BLM 2004a), is expected to result in the long-term loss of 2,500 acres of tundra: 400 acres due directly to gravel placement on pads and roads, 800 acres due to thermokarst erosion and water impoundment, 400 acres due to docking or staging areas, 400 acres due to gravel mining from borrow pits, and 500 acres due to oil pipeline construction (p. V-23, BLM 2003). Roads also increase noise and provide access to previously remote sites, thus increasing the frequency of human disturbances in surrounding areas.

Oil spills near breeding territories. BLM (1998a) estimates that 20%–35% of crude-oil spills occur on or reach the tundra surrounding gravel pads, and it acknowledges that the spills most likely to damage large areas are those that enter a river or waterbody. Thus, the areas preferred by breeding loons—areas with high interconnectivity among waterbodies and river channels (as indicated by habitat preferences within the NPR-A, see Section 5–A)—are the areas where an oil spill is most likely to spread widely and rapidly. For example, within the Northeast Planning Area, BLM (1998a) considers the possible contamination of the Colville River and its tributaries to be one of the greatest concerns.

Oil spills in the coastal Beaufort Sea. Yellow-billed Loons are regularly documented in the coastal Beaufort Sea during the breeding season (Fischer et al. 2002, Lysne et al. 2004). The species is sometimes described as at low risk from a marine oil spill, relative to other species, because there are few individuals concentrated in one location at one time (BLM 1998a, Stehn and Platte 2000). However, individuals holding territories near the coast commute from marine foraging sites to territories; thus, many loons are likely to cycle through the marine habitat daily and this provides the opportunity for a spill off the coast of an important breeding concentration area to affect a substantial proportion of the local population. Similarly, when the number of Yellow-billed Loons present in coastal waters is considered in relation to this species' small breeding population size, the impact of coastal oil spills appears greater (see also Section 5–A).

Yellow-billed Loons may also be vulnerable to nearshore oil spills during spring staging when they appear to use open-water leads off the northern coast of Alaska and Canada. Although spring staging is not well studied, and presumably the extent of open water and degree of congregation of loons varies annually, large numbers of Yellow-billed Loons have been reported in open-water leads in some years (Alexander et al. 1997).

Ice roads. Ice roads, which are used by heavy machinery during the winter, are constructed by spraying water (pumped from nearby deep lakes or river channels) onto frozen tundra and wetlands to form multiple layers of ice into a thick roadbed. Ice roads that pass over lakes compact lake ice, and increase lake-ice depth, and thus delay melt (BLM 1998a). Because the timing of Yellow-billed Loon nest initiation is closely tied to ice melt on their breeding lake (North and Ryan 1988), and productivity appears to be reduced in years with delayed nest initiation (Section 5–B), ice roads passing over breeding lakes may affect nest success if ice melt is delayed, although no studies have addressed this question. In addition, the increase in lake-ice depth and concomitant decrease in open water under the ice may affect overwintering fish populations (BLM 2003).

Ice roads built over land may persist for as much as a month into the snow-melt period (BLM 2003) and cause melt water to persist even later into the spring (BLM 1998a). This is likely to affect only nest bowls and shorelines that lie within a few meters of the ice-road bed (ice-road location will be offset each year). The presence of melt water in a traditional nest bowl during the egg-laying period may reduce the territorial pair's probability of breeding in the year in question, although no studies have addressed this specific question.

Pumping water from lakes and rivers. During oil-field development and operation, a considerable amount of water is pumped from freshwater lakes and rivers to construct ice roads and for use by facilities. For example, water requirements are 1.0 to 1.5 million gallons per mile of ice road, 2 million gallons per ice pad, and 1.6 million for drilling and camp use per site. In total, 295 million gallons of water, acquired from 90 lakes, could be required each winter during exploration of the Northwest Planning Area (p. V-20, BLM 2003).

Yellow-billed Loons could be affected by pumping water from freshwater lakes in two ways. First, reducing the free-water volume of lakes during the winter decreases the amount of water and oxygen available to overwintering fish populations on which Yellow-billed Loons depend during the breeding season. Second, loon species, including Yellow-billed Loons, appear sensitive to changes in water levels on nesting lakes. Typical nest placement in loon species is such that individuals can swim directly to, or very near, the nest bowl. The effect of water withdrawal may depend on whether it occurs *during* or *prior to* incubation. If water withdrawal causes a nest to become stranded away from the water *during* incubation, it appears more likely to be abandoned or predated than other nests. For example, in a study of Pacific Loons in the Prudhoe Bay Oilfield, only 15% (2/13) of nests were successful on impoundments with large water-level drawdowns during the breeding season compared to 41% on natural ponds (Kertell 1996). Similarly, in a study of Common Loons on two lakes in New Hampshire, water-level fluctuations during incubation caused failure of all nine active nests in one year (seven were abandoned and two were predated) (Fair 1979, see also Barr 1986, McIntyre 1994). If water withdrawal causes a traditional nest bowl to be stranded *prior to* incubation, a potential (but currently uninvestigated) effect may be to decrease the pair's probability of nesting in the year in question. Although a pair is certainly capable of building a new nest bowl close to water, the stranding of the traditional bowl may serve as a cue that breeding conditions are undependable and result in deferment of reproduction to future years. Whether it occurs prior to or during incubation, the effect on nesting loons of withdrawing a given percentage of a lake's free water volume will depend on the bathometry of the lake bottom and the slope of the shoreline near the nest. In the New Hampshire study, failed nests were stranded 0.61 m–30 m (2 feet–100 feet) from water horizontally and 0.33 m–0.91 m (16 inches–36 inches) vertically (Fair 1979); in the Prudhoe Bay study, the eight impoundments with low nest success had incurred surface area reductions of 25% to 69% (Kertell 1996).

In Yellow-billed Loons, water-level fluctuations are cited as one reason that individuals do not nest on those lakes with water levels that fluctuate with the river level (North and Ryan 1989). One might expect Yellow-billed Loons to be even less adapted to fluctuating water levels than Common Loons, because Yellow-billed Loons have not evolved with rainfall patterns and topography that produce naturally fluctuating water levels and do not have the same opportunity to re-nest or delay nest initiation as do more temperate-breeding Common Loons.

Increase in predator abundance. An increase in nest predators is a likely and potentially serious side-effect of development that needs further study (BLM 2003, National Research Council 2003). Potential nest predators such as Glaucous Gull (*Larus hyperboreus*), Common Raven (*Corvus corax*), arctic fox (*Alopex lagopus*), red fox (*Vulpes vulpes*), and grizzly bear (*Ursus horribilis)* are known to be attracted to human facilities, in part due to uncontained refuse. The breeding distribution of Common Raven in the arctic appears to be expanding parallel to that of human-made structures, which provide nesting sites (Day 1998). Arctic fox also benefit from food, shelter, and den sites associated with oil-field facilities and pipelines (Eberhardt et al. 1982), resulting in higher fox density and pup production in the Prudhoe Bay oil field than in surrounding areas (Burgess et al. 1993).

An increase in nest predators could have an important effect on Yellow-billed Loon productivity. Predation is probably the primary cause of egg loss and is responsible for some fraction of chick mortality. Any increase in predator abundance may be exacerbated by an increase in human activities near loon territories (see next paragraph).

Noise and visual disturbance from aircraft, ground vehicles, and human presence. The potential negative impacts on wildlife due to human presence and persistent noise from aircraft, ground vehicle traffic, housing facilities, or oil production facilities is well recognized (e.g, Bowles 1995, BLM 1998a, National Research Council 2003), but there are no relevant data on Yellow-billed Loons. Undisturbed loons have high nest attendance (North 1994) and are able to protect chicks from aerial predators (Earnst pers. obs.), but loons disturbed by human presence may leave nests and chicks exposed to predators. Increased predation of eggs and chicks due directly to human disturbance is well known in other northern-breeding waterbirds (e.g., Aahlund and Goetmark 1989, Keller 1991) and human use of lakes has been associated with poorer productivity in Common Loons in some studies (e.g., Titus and VanDruff 1981). Additional behavioral responses to disturbance that have been documented in other species, and are worthy of investigation in Yellow-billed Loons, include nest abandonment (White and Thurow 1985), decreased prey delivery to young (Fernández and Azkona 1993, Delaney et al. 1999), avoidance of otherwise favorable nesting or foraging habitat (Thorson et al. 2002), increased energy expenditure due to escape, wariness, or inefficient foraging (Knight et al. 1991), a change in territorial intrusions and defense (Fort and Otter 2004), and various physiological responses to stress (Washburn et al. 2003).

Data are needed on both short-term behavioral responses and long-term effects of disturbance. At the behavioral level, some individuals, probably over the course of multiple breeding seasons, may habituate to nearby human activity and become less likely to exhibit a behavioral response (see Section 9–D). At the population level, because loons are long-lived and may be slow to abandon established territories even if breeding conditions become unfavorable, documenting any population-level effects of chronic disturbance on loon abundance will require many years of detailed data. The Common Loon literature includes both examples of habituation at the behavioral level and of reduced productivity attributed to disturbance (reviewed in Evers 2004), but as a whole, it exemplifies the necessity of carefully designed studies to rigorously quantify disturbance and its effect on loons.

B. Habitat Conservation on the Breeding Grounds

No laws or agency regulations specifically protect Yellow-billed Loons from potential breeding habitat loss arising from oil development. Although EISs include stipulations designed to reduce the environmental impacts of oil exploration and development (BLM 1998a,b, 2003, 2004a,b,c), stipulations are not considered to provide guaranteed, permanent, or legal protection for Yellow-billed Loon habitat. Stipulations are often worded vaguely and are "not intended as a prohibition of petroleum and related activities" (p. B-2, BLM 2004a), exceptions can be granted for a variety of reasons, including economic or logistic feasibility (p. 29, BLM 1998b; p. B-2, BLM 2004a), and stipulations and Protected Area designations can be revoked in subsequent documents, as evidenced by the Draft Amended EIS for the Northeast Planning Area (BLM 2004b). Although typically written to protect other resources (e.g., fish), some stipulations, if followed, could provide incidental benefits to Yellow-billed Loon habitat and those stipulations are described below.

Potential habitat conservation at the territory scale

Most stipulations would provide protection at the territory rather than landscape scale (i.e., protection of individual lakes rather than large areas).

Buffers relevant to oil spills. In recognition of the risk that any deterioration in water quality poses to fish, the EIS for the Northeast Planning Unit stipulated no permanent facilities within 0.25 miles of a fish-bearing waterbody within a geographic area called the Deep Water Lake Zone nor within 500 feet from the high water mark of other lakes (BLM 1998b). In more recent EISs, the 0.25-mile set-back is applied to all lakes >4 m (BLM 2004a, and Preferred Alternative in BLM 2004b). The definition of "deep lake" in this context as one >4 m deep, rather than >2.1 m deep as is used in the context of water withdrawal (see below), affords less protection to Yellow-billed Loon habitat, because lakes between 2.1 m and 4 m deep typically do not freeze solid in the winter, may support overwintering fish (e.g., ninespine sticklebacks), and are used for nesting and brood-rearing by Yellow-billed Loons. For example, in a recent study, Yellow-billed Loons in the NPR-A preferred both lakes 2–4 m and those >4 m over shallower lakes, but because lakes >4 m are quite rare on the North Slope, 64% of Yellow-billed Loon sightings were on lakes 2–4 m and only 27% were on lakes >4 m (Earnst et al. in press).

Some protection from oil spills also would be afforded by stipulations prohibiting permanent facilities within 0.5 to 1 mile of selected creeks and rivers (and within 3 miles of a small section of Fish Creek) in the Northeast and Northwest NPR-A (BLM 1998a, 2004a,b). Adult Yellow-billed Loons sometimes make forays from breeding territories to nearby rivers for foraging, thus these stipulations may reduce the likelihood of oil contamination and other disturbance for these foraging loons. Because the proposed corridors are narrow, they will encompass few nesting and brood-rearing lakes, but the tendency for loon habitat to have hydrological connectivity to streams (e.g., Earnst et al. in press) suggests that any protection to streams within breeding concentration areas is beneficial.

Buffers relevant to overwintering fish. Protection to overwintering fish populations and thus Yellow-billed Loon breeding and foraging sites could be afforded by those stipulations that a) restrict ice-road placement on deep lakes and deep-water pools in rivers (BLM 1998b), and b) limit water withdrawal to 15% of the estimated free-water volume from lakes 2.1 m or deeper and prohibit withdrawal from rivers, streams, shallow lakes, or any lake connected to a fish-bearing stream (BLM 1998b). More recent EISs include similar stipulations, but also allow withdrawal of up to 30% from lakes 1.5 to 2.1 m if they contain only ninespine stickleback or Alaska blackfish (BLM 2004a, and Preferred Alternative in BLM 2004b).

Buffers specific to Yellow-billed Loons. The EIS for the Northwest Planning Area and the Preferred Alternative in the Amended Draft EIS for the Northeast Planning Area includes a stipulation that encourages the industry to conduct aerial surveys for 3 years before construction of facilities within 1 mile of a lake >25 acres (10.1 ha) in size and to consider a 1-mile buffer around recorded nest sites and a minimum 500-meter buffer around the remainder of the lake shoreline (BLM 2004a, and Preferred Alternative in BLM 2004b). The extent to which the stipulation recommends a reduction in development within this buffer is not clear. On the Colville River Delta (Alpine), a large housing facility and airstrip were placed within 1 mile of previously known Yellow-billed Loon nests (see maps in Burgess et al. 2000), but the development occurred before these recent stipulations were released.

Since there are no published data on distances at which human activity causes Yellow-billed Loons to depart from nests or exhibit other responses, a well-designed experiment would aid the industry and U.S. Fish and Wildlife Service in quantifying appropriate buffer widths (e.g., Blumstein et al. 2003). It is logical that different buffer widths are appropriate for different types of disturbance, and this is reflected in the variety of buffers that have been proposed. For example, a relatively small buffer may minimize the probability that an oil spill will reach a traditionally occupied lake (e.g., the 0.25-mile buffer around fish-bearing lakes; BLM 1998b), but a buffer of 1 mile or more may be necessary to minimize effects of human presence on nests and young broods (e.g., the 1-mile buffer around recorded nest sites; BLM 2004a), and permanent, large geographic preserves of no development may be necessary to avoid landscape-scale effects such as an increase in predators (e.g., the Teshekpuk Lake Special Area and Atqasuk Wetlands; Schoen and Senner 2002).

Potential habitat conservation at the landscape scale

Audubon's Alternative Plan for the Western Arctic is the only plan that proposes permanent protection or protection at the landscape scale (Schoen and Senner 2002). The plan calls for long-term, coordinated conservation in the western arctic and proposes substantial habitat protection in two large areas of the NPR-A that together encompass 27% of Yellow-billed Loons recorded during the Arctic Coastal Plain aerial survey during 1992–2003. These areas are described more fully below.

In Audubon Alaska's alternative plan, abundance data for key fish, mammal, and bird species were synthesized into "biological hotspots" and special protection was proposed within five Special Areas (Schoen and Senner 2002). Protection within two of these areas would be of importance to breeding Yellow-billed Loons. Audubon's alternative plan proposes that all known high-density Yellow-billed Loon nesting areas within the Teshekpuk Lake Special Area receive permanent habitat protection and that all nesting areas within the Atqasuk Wetlands be protected from effects of oil development. The Teshekpuk Lake Special Area, designated by the Secretary of Interior in 1977, encompasses 1.7 million acres (one-third of which is water) centered around Teshekpuk Lake (see Fig. I–8 in Schoen and Senner 2002). The Teshekpuk Lake Special Area contains 14% of the Yellow-billed Loons recorded during the Arctic Coastal Plain Survey during 1992–2003.

Audubon also proposes that all Yellow-billed Loon nesting areas within the 2.1 million acre Atqasuk Weltands area be protected from effects of oil development (habitat alteration, pollution, predator increases, and disturbance during the nesting season). The Atqasuk Wetlands lie south of the Barrow peninsula and between Teshekpuk Lake on the east and Wainwright and Peard Bay on the west (see Fig. I–8 in Schoen and Senner 2002). The Atqasuk Wetlands area contains numerous deep lakes and encompasses 13% of Yellow-billed Loons recorded during the Arctic Coastal Plain Survey during 1992–2003.

C. Habitat Loss and Mortality on the Wintering Grounds

The vulnerability of marine wintering habitat to oil spills was illustrated in late March 1989 when the *Exxon Valdez* spilled 11 million gallons of oil into Prince William Sound. Loons and other diving species are among those that may be particularly susceptible to oil-spill mortality because they often rest on the water and are likely to resurface in oil when they dive for food and to escape disturbance, including oil (King and Sanger 1979). Over 30,000 oiled bird carcasses were recovered, and total mortality was estimated at 250,000 birds (Piatt and Ford 1996). Originally, 87 Yellow-billed Loon carcasses were reported (Piatt et al. 1990, McIntyre 1991), but most were later discovered to be Common Loons. The corrected number of Yellow-billed Loon carcasses was thought to be about 5 (J. Barr pers. comm., cited in Fair 2002), which would result in a total mortality estimate of 17–50 individuals if a 10%–30% carcass recovery rate is assumed (Piatt et al. 1990). In a comparison of pre- and post-spill avian densities in oiled and unoiled areas of Prince William Sound, Irons et al. (2000) concluded that loons (all species combined) exhibited a weak negative effect from the oil spill in the year of the oil spill (1989) and in 1993. In another analysis by the same authors (Lance et al. 1999), a taxon was considered recovering from effects of the oil spill if densities in the oiled areas were increasing at a significantly greater rate than densities in the unoiled areas. Based on winter but not summer surveys, loons showed trends consistent with a recovery. Presumably the statistical power to detect a trend was substantially lower during the summer when relatively few loons remained in the area.

There is also reason for concern about potential oil-related effects on wintering grounds off the coasts of Russia, Japan, North Korea, and China (Center for Biological Diversity 2004), where Alaska's breeding Yellow-billed Loons appear to winter (Section 5–E) and where pollution and other effects may be less regulated than in the United States.

D. Human Utilization: Subsistence Harvest and Fisheries Bycatch

Subsistence harvest

Approximately 1,331 adult loons were harvested annually in the four regions from northwestern to southwestern Alaska surveyed from 1987 to 2000 (Table 2). Of those harvested, 207 per year were reported as Yellow-billed Loons; however, this estimate is not reliable due to problems with species identification (e.g., Fair 2002). For example, Yellow-billed Loons were reported harvested from the Yukon-Kuskokwim Delta (110 individuals and several eggs per year) and Togiak National Wildlife Refuge (52), but Yellow-billed Loons do not breed in these areas and are thought to be relatively uncommon migrants (see Section 4). Yellow-billed Loons were also taken from St. Lawrence and Diomede islands (37) and the Bering Strait mainland (2) where they are uncommon breeders but common migrants. Across all sites, most take occurred during spring and fall when this species was likely passing through on migration.

Compared to other areas of Alaska, the opportunity for subsistence harvest of Yellow-billed Loons is greatest on the North Slope of Alaska where they are more common during summer months, but there is little data from North Slope villages. In northern Canada, this species is hunted throughout its breeding range by Native hunters and may be a regular source of food in a few regions (reviewed in Barr 1997).

In conclusion, because of the uncertainty of species identification and especially the scarcity of harvest surveys on the breeding grounds, the magnitude and potential impact of subsistence harvest on Alaska's population of Yellow-billed Loons is uncertain. Improving the identification guide used during interviews and distributed to subsistence hunters, and tailoring some questions specifically to address loon take and identification, would be an inexpensive means of providing valuable data on the harvest of Yellow-billed Loons and other loon species. See Section 9–C and **Conservation Plan**, *Strategy 6.1*.

Bycatch in commerical fisheries

Loons are known to be susceptible to bycatch (entanglement and accidental drowning) in near-shore gillnets. For example, Red-throated Loons and Common Loons accounted for 68% (1,633 birds) and 21% (503 birds), respectively, of all birds drowned in gillnets off the mid-Atlantic coast from New Jersey to North Carolina during the winter of 1998 (Forsell 1999). However, Yellow-billed Loons in Alaska waters are probably less susceptible to commercial fisheries because the salmon gillnet fishery occurs in southern Alaska during the summer (April–September), especially in June and July, when most Yellow-billed Loons are on northern breeding grounds in Alaska and Canada. In over 9,000 active and drift gillnet sets observed during the summers of 1990 and 1991 in Prince William Sound and the Unimak Island area, only seven loons were killed: two Common Loons, four Red-throated Loons, and one unidentified loon (Wynne et al. 1991, 1992). Similarly, in over 4,200 active and drift gillnet sets observed during the summers of 1999 and 2000 in Cook Inlet, loons (species combined) were observed within 10 m of only 17 sets, and only two loons became entangled, one in Kachemak Bay and one on the Kenai Peninsula (Fadely 2002).

Alaskan longline, pot, and trawl fisheries are conducted during the winter (September–April) on the wintering grounds of the Yellow-billed Loon, but because they are conducted offshore of the Continental Shelf, they do not often take Yellow-billed Loons. The longline fishery is unlikely to attract loons (unlike surface-feeding seabirds), and this is confirmed by the low average annual take of "other" species (i.e., loons, grebes, cormorants, waterfowl, storm-petrels, shorebirds, jaegers, and kittiwakes) during 1993–1999, which was estimated as 1.9 individuals per year in the Gulf of Alaska fishery and 29.1 per year individuals in the Bering Sea/Aleutian Island longline fishery. Pot and trawl fisheries sometimes take diving birds, but no loons were captured during the 1993–1999 observed pot fisheries in either region, and trawl fisheries took an estimated total of anywhere from 2 to 860 "other" individuals during 1997–1999. This summary is based on data from the National Marine Fisheries Service (NMFS 2001).

In conclusion, bycatch in commercial fisheries in southern Alaskan waters does not appear to be a threat to Yellow-billed Loons, because gillnet fisheries occur during the summer when Yellow-billed Loons are rare. However, more information is needed on the extent of winter gillnet fisheries, and thus the potential for bycatch, in East Asian waters.

Bycatch in subsistence fisheries

Unlike bycatch in commercial fisheries, bycatch of Yellow-billed Loons in subsistence gillnet fisheries on the breeding grounds may be substantial. For example, Parmelee et al. (1967) suggest that many may die in fish nets each year on Victoria Island, where seven dead adults were found in the few nets checked by the research party. In Alaska, bycatch is particularly likely near large rivers such as the Meade River (J. King pers. comm.) and Colville River, where Yellow-billed Loons frequently fish in river channels and subsistence fishing is common. Bycatch in subsistence fisheries is not currently monitored by U. S. Fish and Wildlife Service or Alaska Department of Fish and Game programs; however, it seems that loon bycatch could be monitored easily and efficiently using the same monitoring program as that used for the fishery itself.

In conclusion, bycatch of Yellow-billed Loons (and Red-throated Loons) in summer subsistence fisheries in northern Alaska warrants monitoring by agency programs, at least until its magnitude has been estimated (see Section 9–C, and **Conservation Plan**, *Strategy 6.4*).

E. Disease or Predation

Predation is probably the primary cause of egg loss, which is as high as 77% some years, and the cause of some fraction of chick mortality, although starvation also plays an important role in reduction of two-chick to one-chick broods during early brood-rearing (Earnst in prep). In northern Alaska, nest predators known to prey on Yellow-billed Loon nests include Glaucous Gull, Parasitic Jaeger (*Stercorarius parasitica*), and arctic fox (North and Ryan 1988, Earnst pers. obs.). Other predators that coexist with Yellow-billed Loons include Snowy Owl (*Nyctea scandiaca*), Pomarine Jaeger (*Stercorarius pomarinus*), Common Raven, red fox, and grizzly bear. Although parents use repeated jabs from their sharp bills to defend chicks from predators, young chicks (primarily those <2 weeks of age) sometimes are taken by Glaucous Gulls and Parasitic Jaegers (Earnst pers. obs). Chicks may be left exposed when parents are disturbed by human activities, in foraging dives elsewhere on the brood-rearing waterbody, or engaged in territorial interactions with other loons (Earnst pers. obs.). Increased predation of nests and chicks due to an increase in predator abundance is a likely and potentially serious risk associated with encroaching human activities including oil development (see Section 7–A).

Predation on adult Yellow-billed Loons is thought to be uncommon. The potential threat of disease to adults and young is unknown. Die-offs on the breeding or wintering grounds have not been reported, but given the remoteness of marine wintering areas and most breeding areas, it is unlikely any such die-offs would be noted. For example, in Common Loons, die-offs due to botulism and aspergillosis are not uncommon; exposure to mercury and subsequent microphallid trematode infestation has been implicated in the mortality of

Table 2. Average annual subsistence harvest of loons in villages from northwestern to southwestern Alaska[a]. Yellow-billed Loon status is designated as breeding (B) or migrating (M). For locations of sites, see Fig. 2.

Site and years	Status	Yellow-billed Loons	Common Loons	Pacific or Arctic Loons	Red-throated Loons	Unidentified Loons	Total Loons
Bering Strait Mainland[b], 1995	B, M	2	20	4	0	4	30
St. Lawrence Island[c], 1995–96	B, M	37	195	66	0	8	306
Northwest Arctic[d], 1996–97	B, M	0	71	2	6	1	80
Yukon-Kuskokwim Delta[e], 1987–97	M	110	567	59	96	0	832
AK Pen./Becharof NWR[f], 1995–99	M	0	0	0	0	0	0
Aleutian Islands[g], 1996–97	M	0	0	0	0	0	0
Togiak NWR[h], 1995–99	M	52	26	0	3	0	81
Dillingham area[h], 1995, 1997, 1999	M	0	2	0	0	0	2

[a] Loons were not addressed in survey questionnaires in the Galena-Ruby area (Webb 1999) or Allakaket-Bettles area (Wong et al. 2000), but Yellow-billed Loons are not expected to be common in either area.

[b] Paige et al. 1996.

[c] Paige et al. 1996; Kawerak, Inc and Alaska Department of Fish and Game 1997. Diomede Island also included in 1996.

[d] Georgette 2000. The Northwest Arctic includes the Selawik National Wildlife Refuge, Kobuk National Park, and Cape Krusenstern National Park areas.

[e] Wentworth 1998.

[f] USFWS, unpubl. data.

large numbers of loons; and infestations of cryptocotyle flukes were found in 30,000 emaciated loons (reviewed in McIntyre and Barr 1997).

F. Other Anthropogenic and Natural Factors—Contaminants

Although loons are susceptible to contaminants because of their top position in the food chain, contaminants are not known to be a problem in loons breeding in northern Alaska. Bioaccumulation of mercury has been documented in Common Loons in the eastern U.S. and Canada (reviewed in McIntyre and Barr 1997, Evers 2004), where air pollution and acid rain have led to mercury accumulation in fish and their predators, such as loons. Similarly, lead poisoning, from ingestion of lead sinkers attached to fish jigs, is a leading cause of adult mortality in some places (McIntyre and Barr 1997, Scheuhammer et al. 2003, Evers 2004).

Mercury contamination in Common Loons breeding in Alaska is less elevated than elsewhere in North America, as indicated in blood and feathers (Evers et al. 1998) and eggs (Evers et al. 2003). None of the individuals sampled in Alaska, which were primarily from the Kenai National Wildlife Refuge and the Matanuska-Susitna Valley, had mercury levels likely to cause adverse effects. Similarly, preliminary data from egg and blood samples of Red-throated Loons from the Copper River Delta, Yukon-Kuskokwim Delta, Cape Espenberg, and the Colville River Delta indicate no obvious elevation of mercury or lead. Selenium levels were similar to other marine birds in the region, and it is unclear whether such levels might have negative effects (Schmutz 2002). Polychlorinated biphenyl (PCB) levels were low in the 40 eggs analyzed except for three individual Red-throated Loons from the Copper River and Yukon-Kuskokwim Delta that had high PCB concentrations. Similarly, necropsies on >300 loons (Common Loons and Yellow-billed Loons) dying during the *Exxon Valdez* oil spill revealed no ingested lead (McIntyre and Barr 1997). Nonetheless, it would be worthwhile to obtain data on heavy metal loads in Yellow-billed Loons breeding at several locations throughout northern Alaska to assess current risks and provide a baseline for comparison to future years.

8. Current Protection of Populations and Habitats

A. Current Protective Status of Yellow-billed Loons

Other than being protected under the Migratory Bird Treaty Act, as are all migratory birds, the Yellow-billed Loon and its habitat receive no special legal protection. The U.S. Fish and Wildlife Service was petitioned to consider the Yellow-billed Loon for listing under the Endangered Species Act in April 2004 (Center for Biological Diversity 2004). The U.S. Fish and Wildlife Service has considered the Yellow-billed Loon a Species of Management Concern since 1995 (USFWS 1995) and now includes it on the similar list of Birds of Conservation Concern (USFWS 2002a) (Table 3). This designation implies that research and monitoring of this species is given priority over that of species not on the Birds of Conservation Concern list. Similarly, an internal nomination has been drafted within the State of Alaska Department of Fish and Game to consider listing the Yellow-billed Loon as a Species of Special Concern under which the agency would review the loon's population status and would consider giving Yellow-billed Loons special consideration during monitoring, management, and land use planning processes (T. Rothe pers. comm.). Based on the Yellow-billed Loon's current population status and concern about oil and gas exploration and development in the National Petroleum Reserve-Alaska, the National Audubon Society included it in the highest category of concern in its national "Audubon Watchlist 2002" (www.audubon.org/bird/watchlist) and in the "Alaska WatchList" (Audubon Alaska 2002). The WatchList highlights species believed to be vulnerable or declining and helps to identify priorities for research, monitoring, and conservation. The Natural Heritage Program lists the Yellow-billed Loon as "Vulnerable" in the United States and "Apparently Secure" in Canada (NatureServe 2001). The Committee on the Status of Endangered Wildlife in Canada lists the Yellow-billed Loon as a species "Not at Risk," although the status report submitted to the Committee recommended that it be listed as "Vulnerable" (Barr 1997). In Russia, the Yellow-billed Loon is listed in the Red Book of the Russian Soviet Federation of the Socialist Republics and the Yakutian Republic, the official government list of rare and endangered species (reviewed in Fair 2002).

B. Land Ownership and Existing Habitat Protection

Throughout its range in Alaska, Canada, and Russia, the Yellow-billed Loon breeds almost exclusively on lands without special protection. In Alaska, most of the breeding range is under federal ownership, although some is owned by the State of Alaska and Native Corporations. Although a few pairs are known to breed on Selawik National Wildlife Refuge and the Bering Land Bridge National Monument (Fig. 4 and Platte 1999) in western Alaska, the number of Alaska's Yellow-billed Loons breeding on protected lands is negligible. None are known to breed on the Arctic National Wildlife Refuge. In northern Alaska, 91% of individuals on the breeding grounds occur within the National Petroleum Reserve of Alaska (NPR-A)(Earnst et al. in review), which is managed by the Bureau of Land Management and on which oil development is planned (e.g., BLM 1998b, 2004a,b). No legal or permanent provisions for Yellow-billed Loon habitat protection have been made in any part of the species' range on the North Slope (but see Section 7–D).

In Canada and Russia, the amount of Yellow-billed Loon habitat under government protection is thought to be insignificant, although in Canada some is likely protected on Migratory Game Sanctuaries and other protected areas on Banks Island, and Queen Maud Gulf Lowlands (Barr 1997).

Similarly, the marine wintering grounds of Yellow-billed Loons, which are heavily used by commercial and subsistence fisheries and as oil transportation corridors, receive no special habitat protection, and the Migratory Bird Treaty Act extends only to loons within 3 miles (4.8 km) of the coast. The health of the marine ecosystem in U.S. waters is monitored by various National Oceanic and Atmospheric Administration and National Marine Fisheries Service programs. Little is known of marine environmental conditions and potential threats off the coast of Russia, Japan, China, and the Korean Peninsula (but see Center for Biological Diversity 2004) where Alaska's breeding Yellow-billed Loons likely winter (see Section 5–E).

9. Current Conservation, Monitoring, and Research Actions

A. Conservation and Education

Several conservation and education programs have highlighted Alaska's five species of breeding loons, including Yellow-billed Loons.

Alaska Loon and Grebe Working Group

The Alaska Loon and Grebe Working Group is a collection of biologists, managers, and enthusiasts interested in working together to elevate the status of loons in Alaska. The goals of the Working Group are to 1) facilitate exchange of information among biologists, managers, and the public; 2) identify conservation and management issues faced by Alaska's loons; 3) review and identify gaps in knowledge of loon distribution, status, and ecology; and 4) facilitate collaborative projects among agencies and others. The Working Group was first convened in December 1997 and has met annually.

Table 3. Conservation status of the Yellow-billed Loon as assigned by various conservation and governmental organizations. The categories reported here do not carry legal protection.

Organization	State/Country	Status	Reference
U.S. Fish & Wildlife Service	U.S.A.	Species of Management Concern, 1995 Bird of Conservation Concern, 2002 Petition pending for listing under E.S.A.	USFWS 1995. USFWS 2002a. Center for Biological Diversity 2004.
State of Alaska	Alaska	yet to be determined	---
National Audubon Society	Alaska	Watchlist species	Audubon Alaska 2002
Natural Heritage Program	U.S.A. Canada	Vulnerable Apparently Secure	NatureServe 2001
Committee on the Status of Endangered Wildlife in Canada	Canada	Not at Risk	NatureServe 2001
Yakutian Republic and Russian Soviet Federation of the Socialist Republics	Russia	Red Book listing	Reviewed in Fair 2002

North American Loon Fund

Although most efforts of the North American Loon Fund concentrated on Common Loons in the northeastern United States, it also provided resources relevant to educators and biologists in Alaska, and helped fund some loon research in Alaska, including the Alaska Loon Watch Survey (see next paragraph).

Alaska Department of Fish and Game, Division of Wildlife; and the Audubon Society, Alaska Chapter

Together these organizations produced the Alaska Loon Festival, a one-day event designed to educate the public about loon conservation, celebrate the arrival of loons in Anchorage, raise funds for loon conservation, and recruit volunteers for the Loon Watch Program (a survey of Common Loons, Pacific Loons, and Red-throated Loons nesting in the Matanuska-Susitna Valley, Anchorage area, and Kenai Peninsula). The Alaska Loon Festival was held annually in most years during 1989–2002 and grew substantially in attendance during that period.

The Alaska Center for the Environment, Valley Chapter

The Alaska Center for the Environment also has been active in loon education and provided support for the Alaska Loon Festival and the Alaska Loon Watch Program in past years.

The Nongame Migratory Bird Program of the U.S. Fish and Wildlife Service, Region 7

The Nongame Migratory Bird Program office has coordinated the Alaska Loon Watch Program since 2000 and continues to produce and fund loon-specific educational materials while working closely with the Alaska Loon and Grebe Working Group.

B. Monitoring Abundance on the Breeding Grounds

Yellow-billed Loons are monitored in Alaska during two annual aerial waterfowl surveys conducted by U. S. Fish and Wildlife Service—the Arctic Coastal Plain and North Slope Eider surveys. In addition, a two-year lake-circling survey, designed specifically for Yellow-billed Loons, was conducted during June 2003–2004. Yellow-billed Loons are not recorded during aerial waterfowl surveys in Canada or Russia.

Arctic Coastal Plain and North Slope Eider aerial waterfowl surveys

The two ongoing, annual aerial waterfowl surveys conducted in northern Alaska, described in detail below, differ primarily in area covered, timing, and survey intensity.

Description of surveys. The Arctic Coastal Plain Breeding Pair Survey has been flown annually since 1986 and encompasses the 61,645 km^2 of contiguous wetland habitat north of the Brooks Range and from Point Lay in the west to Kaktovik in the east (Fig. 3). Average initiation and completion dates were 26 June and 3 July, respectively, during 1986–2003, with timing adjusted annually to account for snow-melt phenology. The survey, which was designed to monitor all waterfowl, closely follows the design and protocol of the North American Waterfowl Breeding Pair Survey (Smith 1995). Transects are 0.4 km wide, 18.5 km apart, and flown in an amphibious Cessna aircraft at 30–45 m above ground level and 145–170 km/hr. Beginning in 1998, survey lines have been offset from the previous year's lines, such that a set of lines is repeated every fifth year. In all, 10 different sets of survey lines were used during 1986–2003. For more details, see King and Brackney (1997) and Mallek et al. (2004).

The North Slope Eider Survey has been flown annually since 1992 and encompasses the 30,755 km^2 of wetland habitat on the North Slope from approximately Icy Cape in the west to the Canning River in the east (Fig. 3). Average initiation and completion dates were 10 June and 18 June, respectively, during 1992–2003. The survey was designed to monitor male Spectacled Eiders (*Somateria fischeri*) which remain on the breeding grounds only during a narrow two- to three-week window between the onset of melt and the end of egg-laying. Survey timing is adjusted annually relative to ice melt on shallow wetlands and the arrival of eiders. Transects are 0.4 km wide with center lines 9.6 km apart; in 1998 and 1999, transects in a study area around Teshekpuk Lake were placed 4.8 km apart. Flight altitude, speed, and data recording is similar to that described above for the Arctic Coastal Plain Survey. Beginning in 1998, survey lines were offset 2.4 km from the previous year's lines, such that a set of lines is repeated every fifth year. In all, eight different sets of survey lines were used during 1992–2003. For more details see Larned et al. (2003).

Power to detect a trend. Power can be thought of as the probability of detecting a given true decline of interest as statistically significant with the current dataset. For the purpose of the Yellow-billed Loon Status Assessment, a decline of interest is considered to be 3.4%, which would result in an overall decline of 50% in 20 years; and the desirable degree of power, or probability of detecting the decline as statistically significant (at P = 0.05), is considered to be 80% (Bart et al. 2004). The 3.4% annual decline is used as a compromise between smaller annual declines that would be of interest, but difficult to detect with reasonable expenditure of effort and money, and higher annual declines that would be easier to detect logistically but would result in a population size from which it may be difficult for a long-lived bird with low annual productivity to recover. Both the 18-year Arctic Coastal Plain Survey and the 12-year North Slope Eider Survey had low power to detect a 3.4% decline (power = 62% and 26%, respectively; Earnst et al. in review), and survey intensity was such that few Yellow-billed Loons were observed each year ($\overline{x}$ = 45.7 and 57.5 individuals, respectively). When multivariate, mixed effects models were used to combine the two surveys and incorporate thaw-degree days and observer experience as covariates, power to detect a 3.4% decline was 81% (Earnst et al. in review). However, if other potential sources of bias, or the imperfect nature of this model of bias, are acknowledged, the actual power to detect a trend is probably lower (Bart et al. 2004). More gradual annual declines would be more difficult to detect as statistically significant; for example, power to detect a 2.5% annual decline (40% total decline in 20 years) was only 55%.

Assessing potential bias in the population trend. Bias in a trend estimate is caused by a trend in the detection ratio (i.e., the ratio between number observed and number actually present). The presence of bias reduces power to detect a trend and makes interpretation of the trend problematic (Bart et al. 2004). In analysis of Arctic Coastal Plain and North Slope Eider survey data it was important to account for observer experience because 12 different passenger-observers have participated in the two surveys, and evidence suggests that average observer experience increased over the survey period (1986–2003) and that observers detected more loons as they became experienced (Earnst et al. in review). As a result, observer experience produced a positive bias in the population trend. This bias was further evidenced by a change in population trend from positive to negative when observer experience was added to multivariate models. Spring weather was also a potential source of bias, because more birds were observed during warm springs than cold springs on the Arctic Coastal Plain survey. However, there was not a consistent trend in early spring temperature from 1986 to 2003, instead springs tended to become warmer from 1986 to 1996 but were variable thereafter, so spring temperatures were a source of noise in the 18-year trend, rather than bias (Earnst et al. in review).

Lake-circling aerial surveys for Yellow-billed Loons

In 2003 and 2004, U. S. Fish and Wildlife Service conducted lake-circling surveys to quantify Yellow-billed Loon habitat preferences and population size. The study area, which was equivalent to that of the Arctic Coastal Plain Survey and the Yellow-billed Loon's range on the North Slope, was divided into one high- and one low-density stratum based on observed density during Arctic Coastal Plain and North Slope Eider surveys. Plots were placed randomly within the strata, and each lake >7 ha and having its centroid inside the plot was surveyed by circling the lake's perimeter and also flying down the center of larger lakes. Lakes were re-circled if necessary to confirm species identification or presence of nests. A pilot- and passenger-observer recorded each loon's location on a topographic map and in a GIS-based computer system. A total of 141 plots were surveyed during the two-year survey (2003 and 2004). In addition, the study design called for rivers and lakes of all sizes to be surveyed on 6 plots to confirm that the vast majority of loons were sighted on lakes >7 ha, and 8 plots were surveyed by the two aerial crews in rapid succession to confirm that the crews were detecting similar numbers of loons.

Although originally designed primarily to quantify habitat preferences and population size, it would be useful to repeat the survey periodically to estimate population trend.

Survey design considerations

For the purpose of obtaining a more precise and less biased estimate of population trend, a lake-circling survey has several advantages over a multi-species transect survey. First, because detection rates are high in lake-circling surveys, there is less potential for large differences between observers or other factors affecting visibility, and thus less potential for a trend in the detection ratio and a bias in the population trend estimate. This approach of directly reducing bias is likely to be more stable than using multivariate models to tease apart sources of bias and noise from the real trend as described above. Second, the lake-circling survey samples a higher proportion of loon habitat (i.e., lakes) and records many times more loons than transect surveys, thus providing more precise annual estimates of abundance that contribute to more precise trends across time. Third, the lake-circling method as used in Earnst et al. (in press) was cost-effective (9.4 sightings/survey-hour compared to 5.6 sightings/survey-hour on traditional flight lines within intensive plots), and provided presence/absence on a lake-by-lake basis which was useful for other objectives, such as understanding habitat preferences.

If ongoing transect surveys are to be used rather than lake-circling surveys, modifications to existing surveys could be used to decrease bias and increase precision in the trend estimate. To increase precision, one possibility is to increase number of transects flown annually, particularly if proportionately more lines are flown in high-density loon strata. Simulations based on existing data could be used to predict the gain in precision resulting from adding a given number of transects. To reduce bias in the transect surveys, it would be worthwhile to incorporate a measure of the detection rate into the survey design (Anderson 2001, Thompson 2002, Bart et al. 2004). One possibility is the use of formal double sampling in which intensive lake-circling is conducted along a subset of extensive survey lines each year (Cochran 1977, Bart and Earnst 2002). However, the current low sampling intensity on the North Slope Eider and Arctic Coastal Plain surveys (only 46–58 Yellow-billed Loons observed each year) would necessitate double sampling over most of the transects to provide a suitable sample. If more survey lines were added to increase precision, as discussed above, then the use of double sampling with lake-circling surveys over a subset of transects might become a statistically feasible means of reducing bias, but simulations would be needed to determine whether this approach would be any more cost-effective than simply implementing the lake-circling survey across the full study area.

Other means of reducing bias, such as distance sampling (Quang and Lanctot 1991, Lanctot and Quang 1992, Buckland et al. 2001), could be investigated. Recommended sample sizes for distance sampling would only be met if enough transects were added to approximately double the number of loons observed per year. If distance sampling is considered, it is critical to first conduct a well-designed study to determine whether assumptions of the method are met. In particular, it is unlikely that all loons at 0 distance from the transect line are detected, because failing to detect individuals beneath the plane is a well-known problem. In addition, accurately estimating distance and angle of detections from the plane is difficult and time-consuming and competes with the need to record all individuals of all species on fast-moving, multi-species surveys, such as the North Slope Eider and Arctic Coastal Plain surveys (Caughley 1974).

The timing of surveys is another important consideration. Yellow-billed Loons arrive on breeding grounds as soon as melt water is available on rivers (often late May), and begin occupying territories a few to several days later or as soon as lakes within their territory attain a suitable moat of open water (North and Ryan 1988). Because the annual timing of ice melt on lakes is highly variable in the arctic and directly affects Yellow-billed Loon nesting phenology (see Section 5–B), the optimal window for survey initiation will also vary. On the Colville River Delta in 1995–1999, average onset of incubation was 14 to 23 June (Section 5–B; Earnst in prep). If breeding pairs were on territories 7–9 days prior to incubation and on the breeding grounds several days prior to that (as in North and Ryan 1988), both the North Slope Eider and Arctic Coastal Plain survey probably were timed appropriately to monitor breeding pairs in most years (average survey initiation 8 and 27 June, respectively, during 1995–1999). Because some nonbreeders apparently arrive during the interval between the two surveys, and additional nonbreeders (presumably non-territorial 3–5 year-olds that have not yet established territories) come to the breeding grounds in some years but not others (Earnst et al. in review), the Arctic Coastal Plain Survey results in a higher estimate of population size and a population trend that is more variable and difficult to interpret. To investigate effect of survey timing, surveys could include a formal sampling of snow or lake-ice cover across geographic strata to provide a quantitative measure of relative timing between regions and years. Measures of snow and lake-ice cover could be estimated from satellite imagery or aerial photographs taken concurrently with the avian survey. Similarly, a subset of plots could be surveyed at regular intervals throughout the breeding season to document the regularity with which breeders, nonbreeders, and failed breeders are present on traditional lakes throughout the season. Further ground studies, especially of marked birds, also would be helpful in relating breeding status to lake occupancy.

C. Other Monitoring

Monitoring abundance in marine waters during summer months

Southern Alaska. Summer boat surveys for seabirds were conducted in southeast Alaska in 1994 (Agler et al. 1995a), in Lower Cook Inlet in 1993 (Agler et al. 1995b), and throughout Prince Williams Sound for eight years during July 1972–1998 (Lance et al. 1999). The surveys were designed to assess seabird populations, and only about half of all loons were identified to species because their diving behavior made identification difficult. Yellow-billed Loon population indices were low, and confidence intervals were large. For example, in southeast Alaska, the Yellow-billed Loon population index was 267 ± 422 (95% CI) individuals, but 1,420 loons were unidentified (Agler et al. 1995b), making the population index too imprecise to be useful. Since similar surveys probably will be repeated periodically (K. Wohl pers. comm.), investigations are needed into the feasibility of survey methods that would improve loon species identification during boat-based seabird surveys. If surveys were substantially improved, annual estimates of the number of juveniles and adults remaining in southern wintering areas during the breeding season might be useful in understanding annual variation in number of adults present on breeding grounds and their productivity.

Northern Alaska. Fischer et al. (2002) conducted aerial surveys for waterbirds during the summers of 1999 and 2000 off the coast of northern Alaska from Harrison Bay to Brownlow Point (also see Section 5–A). A total of 27 and 67 Yellow-billed Loons were recorded during offshore and nearshore surveys, respectively. In addition, aerial surveys for molting sea ducks have provided partial (1999 and 2001) or complete (2002 and 2003) coverage of nearshore habitat off the Arctic Coastal Plain, from the Canadian border in the east to Kasegaluk Lagoon, south of Point Lay, in the west (Lysne et al. 2004). A total of 210 and 86 Yellow-billed Loons were observed in 2002 and 2003, respectively. Both sets of surveys (Fischer et al. 2002, Lysne et al. 2004) seem useful in identifying the relative importance of various nearshore areas, and this information is particularly pertinent given that some will be affected by oil development. However, the use of marine surveys to identify spatial patterns in relative abundance and monitor trends through time is limited unless they use standardized survey lines and an effort per unit area that is consistent across areas and years. High annual variation in number using marine waters is expected (e.g., see Earnst et al. in review) and will hamper detection of any change in abundance across years.

Monitoring abundance in marine waters during winter months

Winter boat surveys for seabirds were conducted during 1972–1998 throughout Prince William Sound (Lance et al. 1999), during 1979–2002 in the bays of Kodiak Island (Zwiefelhofer and Forsell 1989, D. Zwiefelhoffer pers. comm.) and during 1993 in the Lower Cook Inlet (Agler et al. 1995b). Winter surveys are plagued by the low percentage of individual loons identified to species. In the Prince William Sound surveys, the percentage of unidentified loons varied substantially between years (5%–83%), indicating that observers probably varied in identification skills. If these surveys are to be repeated on an intermittent basis, it would be useful to investigate methods that might allow more accurate loon identification. More accurate loon identification, and thus a better estimate of Yellow-billed Loon abundance, would aid in evaluating the proportion of the North American population that winters in Alaskan waters.

The abundance and distribution of Yellow-billed Loons has not been investigated off the coast of East Asia where much of Alaska's breeding population may winter (see Section 5–E).

Monitoring productivity

In long-lived species with delayed reproduction, a decline in productivity may not be detectable in indices of adult abundance until after a several year delay. Monitoring productivity may thus provide an early warning of potential population declines, but only if the sampling design and protocol have high power to detect a trend despite the high annual variability in productivity exhibited by this species. Also, monitoring productivity in addition to adult abundance provides an opportunity to identify which demographic parameters, if any, are changing and thus producing the overall population trend. Currently, there are no ongoing efforts for long-term monitoring of productivity; however, eight years of detailed productivity data are available for the Colville River Delta (for 1983–1984, in North and Ryan 1988, and for 1995–2000 in Earnst unpubl. data), with less detailed data available for several intervening years (McIntyre 1991, Field et al. 1993, Smith et al. 1993, 1994).

Two objectives for collecting long-term productivity data can be distinguished: 1) to identify changes (i.e., trends) in productivity across time; and 2) to identify factors affecting productivity, including differences across geographic areas and years, and thus better understand factors affecting population dynamics and the locations of demographic sources and sinks. The first is a form of monitoring and the second is a research objective, but both are discussed here because they are closely linked conceptually and logistically. For the first objective, the minimum information needed is the number of chicks present in an area at a time near fledging. For the second objective, it is valuable to consider the individual components of productivity (proportion of pairs nesting, clutch size, nesting success, and brood-rearing success).

If we are interested primarily in detecting trends in productivity (first objective, above), annual monitoring of a large sample of pairs likely will be required in order to detect a trend amidst the high annual variability typical of Yellow-billed Loons and other loon species (Section 5–C). Monitoring should be conducted across a large geographic area or at several individual sites, because it is likely that some regions or habitats are acting as demographic sinks and others as sources. Monitoring on an annual basis, rather than every five years or so, would provide more ability to distinguish annual variability from a long-term trend in productivity. A powerful monitoring scheme would be intensive ground monitoring of 20–30 territorial pairs at each of five sites, or more, each year. This approach would provide considerable power to detect a trend in productivity and would provide the detailed information necessary to address the second objective (see above) of understanding the cause of changes in productivity. The disadvantage of this approach, of course, is that it requires substantial funding on a continuous basis. Two alternate approaches are considered here.

Annual aerial surveys. The advantage of annual aerial surveys is that a large geographic area can be covered each year, but the disadvantages are that a) the trend in the indices will be difficult to interpret due to low detection ratios and b) the indices will provide little information relevant to factors affecting productivity (the second objective). First, experience during intensive, lake-specific surveys for Yellow-billed Loons indicates that broods are difficult to detect (Earnst pers. obs.).

The location of the more visible parent is not a reliable indicator of the brood's location because parents sometimes swim away from chicks when the plane approaches, chicks often dive or hide in vegetation while the parent remains visible, and even if undisturbed, chicks are sometimes left alone on open water while the parent is diving for food. As a result, detection ratios are likely to be low, and there will be significant opportunity for bias in a trend estimate caused by such things as a) changes in average observer skill or within-observer improvement, or b) changes in survey timing relative to chick size and thus visibility. Although helicopter surveys may provide a higher detection ratio, they also are more expensive and cause more disturbance to loons. Given the detection rate issue and the problem of high annual variability in productivity, any trend will be difficult to detect and a power analysis should be conducted for any proposed survey design before implementation is considered.

The best timing for brood-rearing surveys is late in brood-rearing when chicks are larger and thus more visible. Late surveys also provide the most ecologically meaningful index to final productivity (i.e., number fledging). However, late-brood rearing may not be a good time to obtain an estimate of adult abundance if adult occupancy of territorial lakes becomes less reliable as brood-rearing progresses or if the number of nonbreeders present varies among years (e.g., Earnst et al. in review). Thus, in addition to any productivity survey, a lake-circling survey or intensive transect survey during early nesting is needed to adequately monitor adult abundance (see Survey design considerations). If only one survey is affordable, the relative importance and likelihood of success of quantifying trend in abundance versus trend in productivity should be carefully weighed.

If aerial surveys are used, the parameter being estimated should be the number of broods (or chicks) per lake or per km^2. Estimates of other parameters, such as the proportion of adults having chicks or the proportion of nests producing chicks, have more potential for bias because detection ratios of the numerator and denominator are unlikely to be the same and unlikely to vary together. Also, annual variation in both the numerator and denominator will contribute to noise in the trend, decreasing statistical power to detect a trend. Thus, to estimate broods/km^2, an appropriate sampling design and protocol would be lake-circling of lakes chosen systematically or randomly, perhaps including more intensive sampling in high-density strata, rather than a sample restricted to lakes known to have had loons or nests during earlier aerial surveys.

Repeated ground-based monitoring. A second alternative is to conduct intensive ground work at several sites for several years (say, five sites for five years), and to repeat the work at the same sites every 4–5 years. The advantage of this approach is that it provides dependable estimates of each component of productivity and a firm foundation with which to investigate factors affecting productivity. Intensive ground work also would lend itself well to studies of foraging ecology, habitat use, and the survival and site-fidelity of banded individuals (see Section 9–C). The disadvantages are that the sampling is less frequent and covers less area. Ground-based monitoring may result in monitoring fewer pairs than would intensive aerial surveys (but more than transect-based surveys which detect <60 individuals per year, Section 9–B), but would be less subject to visibility biases and observer differences. More detailed work on statistical power and potential biases in trend estimates may help resolve the issue of which approach is best for monitoring only (first objective), but any interest in understanding causes of variation in productivity (second objective) will tip the scales towards ground-based monitoring. A combination of aerial and ground-based productivity monitoring may prove most desirable.

Monitoring subsistence harvest

Alaska Department of Fish and Game and U. S. Fish and Wildlife Service monitor subsistence harvest by conducting personal interviews or providing survey forms to families within native villages. Within each village, the survey goal is a complete census in small villages or a randomly drawn sample of 25%–50% of households in larger villages. The interviewer, who is typically a local resident, asks the primary hunter in the sample household to identify species taken on the basis of an identification card (a color photocopy of the relevant page from the National Geographic Guide to Birds) and a list of Native names for those species that occur in the area. There appear to be significant problems in identification of loons (S. Georgette pers. comm., Fair 2002), perhaps especially between Yellow-billed Loons and Common Loons, as suggested by the extraordinarily large take of Yellow-billed Loons (1,100 over 10 years on the Yukon-Kuskokwim Delta), including eggs, in a region where Yellow-billed Loons do not breed and only rarely occur during migration. The problem is compounded by the lack of a known Yup'ik name for the Yellow-billed Loon. To alleviate this and other identification problems, U. S. Fish and Wildlife Service recently has begun to use a color identification card (rather than the previous black-and-white version) during interviews. Other potential means of improving data quality include a) providing seminars to educate interviewers about species identification, and b) asking specific questions about loon species identification during the interview. See **Conservation Plan**, *Strategy 6.l.*

Monitoring bycatch

Waterbird bycatch in Alaska's salmon gillnet fishery is monitored by the National Marine Fisheries Service's observer program with assistance from U. S. Fish and Wildlife Service. The program consists of a series of two-year projects that are rotated among geographic areas. Trained observers are placed on a sample of fishing vessels where they monitor the number (per set-hour) of seabirds entangled, released alive, and drowned in both drift and active gillnet sets. In a subsample of nets, observers also record number of seabirds in the vicinity of nets. Loons are recorded to species. Sites completed to date include Prince William Sound and South Unimak (1990–1991; Wynne et al. 1991, 1992), and Cook Inlet (1999–2000; Fadely

2002), and those underway or planned include Kodiak Island (2002–2003) and southeast Alaska (2004–2005). Bycatch is not monitored in gillnet fisheries on East Asian wintering grounds where much of Alaska's breeding population may winter (see Section 5–E and **Conservation Plan**, *Strategy 6.2* and *6.3*).

Seabird bycatch also is monitored in Alaska's groundfish fisheries which include trawl, longline, and pot fisheries in the Gulf of Alaska and Bering Sea/Aleutian Island regions. Groundfish fisheries are conducted offshore of the Continental Shelf, making interactions with loons less likely. Loons are categorized as "other birds" (along with grebes, cormorants, waterfowl, storm-petrels, shorebirds, jaegers, and kittiwakes) in printed reports, but the electronic database can be searched for numbers of Gaviidae (all species combined) captured. The number of observed captures is extrapolated to the entire annual fishery on the basis of set-hours or number of baited hooks.

Bycatch in subsistence gillnet fisheries on Yellow-billed Loon breeding grounds is not currently monitored, but is of particular importance because the timing of fishing coincides with peak loon abundance (unlike fisheries on the wintering grounds). In most areas on Alaska's breeding grounds, the subsistence harvest of fish is monitored annually, and it seems that loon bycatch could be monitored concurrently with little additional effort or expense. This would be particularly useful if careful attention were paid to species identification. See **Conservation Plan**, *Strategy 6.4*.

D. Research

Yellow-billed Loons are the least studied of the world's five species. This section identifies important gaps in our knowledge of Yellow-billed Loon ecology and demography; results of past research are reviewed throughout the Status Assessment. Two types of studies are needed to address the gaps identified below: 1) long-term research on banded individuals conducted concurrently at several sites to estimate demographic parameters (e.g., survival of adults and immatures, age of first-breeding) and to investigate causes of spatial and temporal variation in productivity; and 2) studies on marine wintering grounds to investigate foraging ecology, diet, energetics, and exposure to contaminants.

Breeding ecology and demography

More is known about factors affecting productivity and habitat requirements during the breeding season than about other aspects of Yellow-billed Loon ecology, but key pieces to the puzzle remain missing. For example, the eight years of productivity data from the Colville River Delta suggest high annual variability, depending in part on the timing of spring, and this is consistent with studies of other loon species. This variability, however, makes problematic something as simple as obtaining a baseline annual average of chicks fledged per pair, for a pre- versus post-development comparison. Furthermore, it is possible that processes influencing productivity operate differently in other North Slope breeding areas, and multi-year data sets from other areas are lacking. Similarly, data are available to investigate whether some lake or habitat types are associated with consistently high annual productivity on the Colville study site, but not elsewhere.

On a larger scale, it is also useful to identify habitat characteristics correlated with Yellow-billed Loon distribution across the North Slope. An initial model, based on variables available from GIS, has been developed (see Section 5–A; Earnst et al. in press) and a more powerful modeling effort is underway by the same collaborators (USFWS, unpubl. data), but ground-based habitat work at key sites is an important, missing link at present. A combination of intensive aerial surveys, GIS analyses, and ground-based surveys and habitat work at several sites could address the following questions. How well do lake characteristics discernable from GIS data correlate with fish presence? How much does fish abundance vary (as opposed to mere presence), and does it correlate with Yellow-billed Loon presence or productivity? What lake characteristics are important other than presence of fish, stable water levels, the availability of gently sloping shoreline for nesting, and the availability of protected, vegetated bays for brood-rearing? Is the clumped nature of Yellow-billed Loon distribution due to the distribution of available habitat, or is a social phenomenon at play, such as a tendency to hold territories within hearing/vocalization distance of other Yellow-billed Loons? Why are unoccupied lakes that appear to have appropriate characteristics (based on GIS data) unoccupied? Possible answers to the latter question include the possibility that Yellow-billed Loons are not abundant enough to saturate the habitat, relevant habitat features have not been identified or adequately measured, or some sort of competition with Pacific Loons is preventing the typically dominant Yellow-billed Loon from becoming established in a high-density Pacific Loon area.

Spatially explicit demographic models can be used to evaluate a population's response to perturbation in specific demographic parameters (e.g., survival or productivity) across varying temporal and geographic scales. For example, one could ask whether a 50% reduction in productivity of loons within the High Oil Potential zone (Fig III–A–29 in BLM 1998b; Map 105 in BLM 2003) is likely to have an important impact on population stability. Such models can be misleading or little more than guesswork unless based on a large and rigorously collected dataset (e.g., Beissinger and Westphal 1998). Studies of banded individuals are needed to estimate the demographic parameters that comprise the model: annual survival rates of adults and immatures, age of first breeding, and age-specific productivity. Information is needed on productivity from different regions of the breeding grounds and across many years to evaluate the extent to which some regions serve as demographic sources or sinks. Such information also would serve as baseline data for evaluating effects on productivity of changes in habitat or environmental stressors such as noise and pollution.

One approach for meeting these multi-year, multi-location objectives is to do intensive work during five years at each of five sites and to repeat the study at regular intervals (say, every 4–5 years). The approach of a five-year, five-site study is attractive because it could meet several objectives simultaneously: a) obtain ground-based detection ratios of adults and broods; b) quantify the consistency of territory occupancy from the early stages of spring ice melt through late brood-rearing; c) monitor productivity; d) estimate demographic variables and establish a color-marked population that can be revisited periodically to assess adult survival, philopatry, and age-specific productivity; e) assess spatial and temporal variation in productivity; and f) assess spatial variation in habitat preferences and the habitat-productivity relationship. The five-year, five-site study would need to be repeated periodically to meet several of its purported objectives (i.e., monitoring productivity, estimating detection ratios as part of double sampling, and resighting banded individuals), but even one set of five years at five sites would substantially increase understanding of Yellow-billed Loon breeding ecology.

Effects of anthropogenic disturbance

There are no data on how Yellow-billed Loons will respond to disturbance at the local population level or at the individual behavioral or physiological level. Research is needed on both short- and long-term effects of disturbance. To address effects at the local population level, a high priority should be placed on monitoring lake occupancy and productivity in designated areas for several years before and after development. Because only a few loons will be available at a given site, it will be necessary to design a large study that allows combining of data across sites. Although aerial surveys are useful in establishing patterns, ground studies are also needed to identify processes by which development affects productivity. For example, is the change in productivity associated with changes in rate of nest predation, nest abandonment, chick predation, chick starvation, prey delivery, or percent of time parents spend incubating or on the lake?

Addressing effects of disturbance at the individual level may reveal effects that are masked at the local population level. Relevant parameters to quantify include time and energy expended fleeing or alert, foraging efficiency, possible avoidance of otherwise favorable nesting or foraging habitat, prey delivery to young, incubation constancy, and physiological indicators of stress (Knight et al. 1991, Delaney et al. 1999, Thorson et al. 2002, Washburn et al. 2003, see Section 7–A). A typical approach is to measure an individual's response to a well-quantified disturbance event (e.g., a 70 decibel noise at 500 m lasting for 5 minutes) using either "naturally" occurring or experimentally introduced disturbance events. Disturbance studies must overcome several design issues. For example, few Yellow-billed Loons are likely to be available at a given site, especially for "natural" episodes of disturbance, thus arguing in favor of combining data across sites. More importantly, an individual's response to disturbance is expected to vary dynamically with the perceived cost of remaining relative to leaving (Ydenberg and Dill 1986) and thus to be highly variable among individuals and situations. For example, flushing distance is known to vary with angle of approach and starting distance of the observer, stage of incubation, time of day, distance to refuge, type of disturbance, and extent to which individuals have been previously exposed to similar disturbance (reviewed in Blumstein 2003 and Blumstein et al. 2003). Similarly, loons might react differently to a noise or other disturbance emanating from across a large expanse of open water than to the same disturbance at the same distance, but across land. Likewise, loons on smaller lakes may perceive a given event as a greater danger than those on larger lakes.

The conditions under which individuals habituate to a specific type of disturbance is also highly variable and will affect the results and interpretation of studies designed to measure response to disturbance. Habituation is the tendency, over the course of multiple weeks or multiple breeding seasons, for an individual to become less likely to respond to a given disturbance. Habituation is more likely with predictable, low-level disturbances and is typically specific to a disturbance type (e.g., Anthony et al. 1995). Thus an individual habituated to mechanical noise might continue to respond strongly to human presence. Individuals engaged in different behaviors, or at different stages of the nesting cycle, might exhibit different tendencies to habituate. During habituation or apparent habituation, individuals may become less likely to flee (Keller 1989) but continue to exhibit more subtle signs of behavioral and physiological stress (Fowler 1999).

There are no published data on distances at which human activity causes Yellow-billed Loons to depart from nests or interrupt normal chick-rearing behavior. Incidental observations suggest that parents may leave the nest when an approaching human is as much as 1 mile away or as close as a few meters, depending on the size of the waterbody, topography, stage of incubation, and a multitude of other factors (Earnst pers. obs.). A well-designed study, using the approaches discussed above, is needed to determine a buffer width that will reduce various types of impacts on nests and young broods.

At the population level, quantifying the extent to which a given development scenario will affect Yellow-billed Loons is even more problematic. Our understanding of the effect at the population level is only as valid as our knowledge about how loons react to disturbance at the individual level, at what distance they react, and how their reaction translates into decreased productivity or survival (e.g., Pereira et al. 2004). The validity also depends on how well the development footprint used in the model corresponds with actual changes to the landscape. For example, the final predicted footprint changes as the expanding oilfield infrastructure and the market-price of oil make previously remote areas logistically and economically accessible (see BLM 2004b,c).

Wintering ecology

Evidence of widespread declines in sea duck populations, and of large-scale changes in the marine ecosystem, highlight the importance of wintering ecology to population dynamics. Information is needed on Yellow-billed Loon diet during the winter, factors that affect winter survival and body condition, and how winter body condition affects the probability of successful reproduction the following spring. There is growing evidence that climate can effect a rapid shift in the organization of marine ecosystems, and that annual and decadal patterns in marine fish abundance correspond to climate phenomena, such as the Pacific Decadal Oscillation (reviewed in Francis et al. 1998). However, we have no information on whether Yellow-billed Loon overwinter survival, or their abundance and productivity in the following spring, is related to winter forage fish availability.

In order to relate wintering ecology to breeding population dynamics, we need to identify the wintering sites of known breeding populations. Based on distributions and observations during migration, North (1994) surmised that Yellow-billed Loons breeding in northern Alaska may winter in eastern Asia while Canadian breeders may winter off the Pacific coast from southern Alaska to California. An ongoing study using satellite transmitters is providing the first substantiated evidence that individuals nesting on the North Slope of Alaska spend the winter off the coast of East Asia (J. Schmutz pers. comm., see Section 5–E).

Conservation Plan

The conservation goal of maintaining a stable breeding population of current size and distribution was established by the Alaska Loon and Grebe Working Group during its 2000 Annual Meeting. The **Conservation Plan** identifies the information necessary to achieve, and evaluate progress towards achieving, the conservation goal. Recommendations are based on published literature, unpublished reports, unpublished data and personal observations, the opinion of loon biologists, discussions by the Alaska Loon and Grebe Working Group at annual meetings in 1997–2002 (especially 2000), and from that group's first status assessment, Status of Loons in Alaska (McCaffery 1998).

Three-fourths of the strategies have been designated high priority. In most cases, the lack of a high-priority designation stems from the difficulty of gathering and interpreting relevant data (e.g., strategies pertaining to effects of disturbance and monitoring of wintering populations). Note that many of the high-priority strategies could be addressed within the framework of a multi-year, multi-location study (see Section 9–D).

Conservation Goal

Maintain a stable breeding population, of current size and distribution across the loon's breeding range in Alaska (Alaska Loon and Grebe Working Group, 2000 annual meeting).

Research and Monitoring Goal

Obtain the information necessary to achieve, and evaluate progress towards achieving, the Conservation Goal.

Research and Monitoring Objectives and Strategies

OBJECTIVE 1. **Conduct annual population surveys having negligible bias and 80% statistical power to detect a 3.4% annual decline, a decline that would result in a 50% loss of the population within 20 years.** (Rationale in Sections 6–D, 6–F, 9–B, 9–C, and Earnst et al. in review.)

Strategy 1.1. Consider implementing an annual aerial survey with appropriate timing, survey methods (e.g., lake circling), sampling intensity, and stratification designed specifically for monitoring the population trend of Yellow-billed Loons. **High Priority.**

Strategy 1.2 Continue to use the North Slope Eider Survey and the Arctic Coastal Plain Breeding Pair Survey to estimate temporal trends and distribution on the breeding grounds. Consider improvements to the surveys that would provide more precise and less biased temporal trends. **High Priority.**

a. Consider increasing the number of transects in both surveys, particularly in strata of high loon concentration.
b. To reduce potential sources of bias, consider means of reducing observer turnover, increasing observer skill, and decreasing variability among observers.
c. Consider incorporating visibility correction factors or a form of double sampling to estimate biases.
d. Consider quantifying annual snow-melt phenology and conducting repeated surveys over a subset of the area to document loon arrival in conjunction with ongoing surveys.

Strategy 1.3. Use existing data to compare the statistical power and feasibility of ground-based and intensive aerial surveys, and combinations thereof, to detect temporal trends in productivity. Incorporate a study design that would identify environmental factors affecting temporal and spatial variation in productivity. (See also *Strategy 3.3* and *4.3*.) **High Priority.**

OBJECTIVE 2. **Obtain an unbiased and reliable estimate of the size of Alaska's breeding population.** (Rationale in Sections 5–A, 6–A, 6–E, and 9–B.)

Strategy 2.1. Consider conducting a one-time, intensive aerial survey that incorporates a visibility correction factor, is designed specifically for Yellow-billed Loons, and is conducted across the breeding range in Alaska, to estimate population size on Alaskan breeding grounds. **High Priority.**

a. Continue to analyze data from the 2003–2004 lake-circling surveys to evaluate whether this objective has been met or whether additional data for a more robust visibility correction factor are needed.

Strategy 2.2. As more demographic data and therefore more sophisticated population models become available, continue to use models to estimate size of the 1–2 year-old age class which presumably remains at sea.

Strategy 2.3. Use long-term banding and telemetry studies across multiple sites to estimate the fraction of young, nonterritorial adults (presumably 3–5 year-olds) and any older, nonnesting, territorial adults that remain at sea. Also estimate the proportion of time that territory holders, both those nesting and not nesting in the year in question, are temporarily absent from their traditional breeding lake at different stages of the breeding season. **High Priority.**

OBJECTIVE 3. **Identify geographic regions and habitats of importance during breeding, staging, and wintering periods.** (Rationale in Sections 5–A, 5–B, 5–E, 6–A, 9–B, and 9–C.)

Strategy 3.1. Continue to use the North Slope Eider and the Arctic Coastal Plain Breeding Pair surveys to quantify regions of high breeding density. In addition, consider using a periodic intensive survey to identify more precisely areas of concentration. **High Priority.**

Strategy 3.2. Quantify habitat preferences and continue to develop a habitat-based model of distribution using available GIS layers and results of intensive aerial surveys for Yellow-billed Loons. The model could estimate the probability of Yellow-billed Loon presence based on lake characteristics and other features of the landscape. **High Priority.**

Strategy 3.3. Determine differences in productivity among habitats and among geographic locations. **High Priority.**

Strategy 3.4. Continue to identify staging and wintering sites and migratory pathways of known breeding populations. **High Priority.**

Strategy 3.5 Design and implement a survey, or modify existing surveys, to estimate relative abundance and thereby identify key wintering sites in southern Alaska waters. Likewise, consider innovative collaborations to estimate relative abundance among wintering sites in the Yellow Sea and Sea of Japan, where Alaska's breeding population appears to winter. (See also *Strategy 7.3*.)

OBJECTIVE 4. **Use demographic models to evaluate risks to the population.** (Rationale in Sections 5–B, 5–C, 5–F, and 9–D.)

Strategy 4.1. Develop spatially-explicit demographic models to estimate the population's response to varying degrees of perturbation to adult survival and productivity across varying geographic scales. **High Priority.**

Strategy 4.2. Quantify age-specific productivity and survival and other demographic parameters necessary for the model. Investigate patterns in and factors causing spatial and temporal variation in productivity and other demographic parameters. **High Priority.**

Strategy 4.3. Determine whether areas of breeding concentration, and particular habitats within those areas, function as population sources and evaluate whether they warrant special protection to maintain population stability. **High Priority.**

Strategy 4.4. Develop genetic markers that can be used to evaluate the degree of genetic overlap among breeding concentrations, and thus the extent to which such concentrations should be considered discrete population segments in demographic models and conservation efforts.

Strategy 4.5. Estimate overwinter survival, its annual variation, and the effects of ice conditions and forage fish availability. Design programs to monitor relevant components of the wintering ecosystem once factors that affect overwinter survival have been identified. **High Priority.**

OBJECTIVE 5. **Identify potential effects of oil development on the breeding grounds and measures necessary to minimize the effects.** (Rationale in Sections 7–A, 7–B, and 9–D.)

Strategy 5.1. Obtain baseline data that can be used to evaluate the impact of oil development. **High Priority.**

a. Gather pre- and post-development data on productivity, factors affecting productivity, and lake occupancy in the vicinity of proposed industrial development. (See also *Strategy 5.4*.)

b. Obtain baseline data on the abundance of nest and chick predators.

c. Obtain baseline data on the contaminant loads of adults and eggs on key breeding areas.

d. Obtain baseline data on water quality in large lakes near proposed industrial development.

Strategy 5.2. Evaluate the potential effects of various types of disturbance on territorial loons.

a. Quantify effects of noise from vehicles, aircraft, and humans on breeders during incubation and brood-rearing.

b. Quantify effects of proximity to housing facilities, runways, roads, and pipelines on breeders during incubation and brood-rearing.

c. Quantify the effects mentioned above on various components of loon productivity and behavior—lake occupancy, probability of initiating a nest, clutch size, number of young fledged, time-budgets, energy expenditure, and stress-induced hormonal changes.

Strategy 5.3. Evaluate whether a 1-mile (1.6–km) no-disturbance buffer around traditional nest sites sufficiently minimizes disturbance to breeding pairs (BLM 2004a,b), whether a similar buffer around breeding lakes is also needed, and whether buffers of different size are needed for different types of disturbance.

Strategy 5.4. Develop site-specific maps detailing traditional nesting, foraging, and wintering sites near existing and proposed oil developments and pipelines. The maps should be useful to government agencies in issuing permits and to the industry in identifying priorities in spill prevention and response plans. (See also *Strategy 5.1a*.)

a. Conduct intensive, species-specific aerial surveys during at least three years to map traditional nesting lakes, foraging sites (including river channels and off-shore waters), and wintering sites in locations specifically targeted for development. Use a well-designed sampling plan that allows estimation of number of individuals and nests, changes through time, and a comparison to other sites.

b. Continue the surveys during and after development to assess potential impacts of development.

Strategy 5.5. Determine the effect of reduced water levels in traditional Yellow-billed Loon breeding lakes resulting from ice-road and ice-pad construction. Quantify effects on subsequent lake occupancy, probability of nest initiation, productivity, and forage fish populations. **High Priority.**

Strategy 5.6. Identify high-density breeding areas in which protective measures deemed useful for Yellow-billed Loons (see above) could benefit a large fraction of the breeding population. (See also *Strategy 3.1*.) **High Priority.**

OBJECTIVE 6. **Evaluate the magnitude of subsistence harvest and bycatch and their potential effects on the population.** (Rationale in Sections 7–D and 9–C.)

Strategy 6.1. Improve the reliability of estimates from the Subsistence Harvest Survey by providing educational and outreach programs that emphasize species identification to hunters and those conducting the survey.

Strategy 6.2. Continue to evaluate bycatch of Yellow-billed Loons in commercial gillnets on the wintering grounds in Alaska.

Strategy 6.3. Work with experts in other countries to evaluate the magnitude of bycatch in commercial gillnets on non-U.S. wintering grounds. (See also *Strategy 7.3*.)

Strategy 6.4. Initiate a program to monitor bycatch of Yellow-billed Loons in subsistence gillnets on northern Alaska breeding grounds. Bycatch on the breeding grounds is likely to be more important than that on wintering grounds, because the fishery occurs during peak loon abundance. **High Priority.**

OBJECTIVE 7. **Develop a continent-wide and range-wide context for Alaska's population and habitat objectives.**

Strategy 7.1 Work with experts in Canada and Russia to evaluate threats to breeding populations and to encourage future monitoring of temporal trends. **High Priority.**

Strategy 7.2. Work with experts in Canada and Russia to use digitized topographic maps, aerial photographs, satellite imagery, and habitat models (the latter derived from Alaskan surveys) to estimate breeding population size and distribution in Canada and Russia. The resulting map of predicted relative abundance could aid in identifying strata for systematic surveys and could be updated when results of such surveys become available. **High Priority.**

Strategy 7.3. Work with experts in Canada, Russia, Japan, China, and North and South Korea to evaluate wintering distribution, connections between breeding and wintering areas, and threats to wintering populations. **High Priority.**

Illustration by Jeff Stephens

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