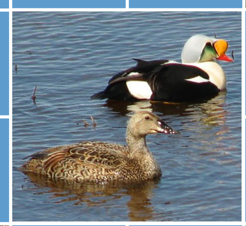
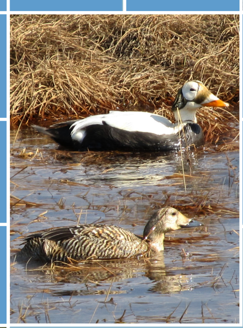
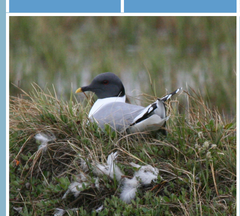
AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2016

FOURTEENTH ANNUAL REPORT







Prepared for
CONOCOPHILLIPS ALASKA, INC.
Anchorage, Alaska

and

ANADARKO PETROLEUM CORPORATION
Anchorage, Alaska

Prepared by
ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES
Fairbanks, Alaska

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2016

FOURTEENTH ANNUAL REPORT

Prepared for

ConocoPhillips Alaska, Inc.
P.O. Box 100360
Anchorage, AK 99510
and
Anadarko Petroleum Corporation
3201 C Street, Suite 603
Anchorage, AK 99503

Prepared by

Charles B. Johnson
Julie P. Parrett
Pamela E. Seiser

ABR, Inc.—Environmental Research & Services
P.O. Box 80410
Fairbanks, AK 99708

March 2017

Printed on recycled paper.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

Avian surveys for the Alpine Satellite Development Project were performed with the assistance of many people in the field and in the office. Pathfinder Aviation pilot Dave McKnight skillfully piloted us on loon surveys. On the ground, Mary Hrynyk and Candy FitzPatrick coordinated the helicopter flights and kept us on schedule. Tim Obritschkewitsch and John Shook of ABR spent long hours on the eider survey. In our Fairbanks office, Dorte Dissing and Pam Odom provided expert support in figure and report preparation, Tawna Morgan and Chris Swingley helped manage our data. Logistics were handled by Pam Odom and Tony LaCortiglia, and Will Lentz supported our electronic needs. We thank all the ConocoPhillips Alaska staff and contractors at the Alpine Oilfield for providing a safe and welcoming work environment, especially field environmental coordinator, Jessika Gonzalez. This study was funded by ConocoPhillips Alaska, Inc., and was administered by Robyn McGhee, Environmental Studies Coordinator for ConocoPhillips Alaska, Inc. We especially thank Robyn McGhee for supporting the continuation of these long-term monitoring studies, which have benefited other biological studies, past and future National Environmental Protection Act (NEPA) documents, species status reviews, Section 7 Consultations, and development permit applications. We appreciate the review and comments on this report made by Robyn McGhee and ABR’s Bob Burgess. We thank all the above for making 2016 a successful year for avian studies on the Colville River delta.

INTRODUCTION

The Colville River delta and Northeast Planning Area of the National Petroleum Reserve in Alaska (NE NPR-A) have been focal points of exploration and development for oil and gas since at least the 1990s. During 2016, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River delta in support of the Alpine Satellite Development Project (ASDP) of ConocoPhillips Alaska, Inc., (CPAI) and Anadarko Petroleum Corporation. Previous studies in the area are described by Johnson et al. (2015).

CPAI began producing oil on the Colville River delta in 2000 with the development of the CD-1 and CD-2 drill sites. The CD-3 and CD-4 drill sites were constructed in 2005 and winter of 2006, and CD-5 in NE NPR-A was constructed in 2014 and 2015. Readers are directed to prior reports for wildlife information from previous years and for all these sites.

In this report, we present the results of avian surveys that were conducted on the Colville River delta in 2016 along with tabular summaries of results from previous years. The surveys were designed initially to collect data on the distribution, abundance, and habitat use of 5 focal taxa (common names followed by Iñupiaq names; see Appendix A, Johnson et al. [2015], for scientific names) in support of permit applications: Spectacled Eider (Qavaasuk), King Eider (Qiŋalik), Tundra Swan (Qugruk), geese (Niġliq), and Yellow-billed Loon (Tuullik). These 5 taxa were selected in consultation with resource agencies and communities because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, 4) importance to subsistence hunting, and/or 5) concern by regulatory agencies for development impacts. In 2016, surveys targeting Spectacled Eiders and Yellow-billed Loons were conducted. Data were collected on other eider species concurrently during the Spectacled Eider survey and on other loon species, Glaucous Gulls, and Sabine's Gulls during Yellow-billed Loon surveys.

Required state and federal permits were obtained for all survey activities, including a Scientific Permit (Permit No. 16-118) from the State of Alaska and a Federal Fish and Wildlife Permit—Native Threatened Species Recovery—Threatened Wildlife; Migratory Birds [Permit No. TE012155-5 issued under Section 10(a)(1)(A) of the Endangered Species Act (58 FR 27474-27480)] from the U.S. Fish and Wildlife Service Endangered Species Permit Office. Nesting Spectacled and King eiders also were monitored in the Kuparuk Oilfield on the eastern border of the Colville River delta in 2016 (Morgan et al. 2017).

STUDY AREA

The ASDP study area comprises separate study areas on the Colville River delta and the easternmost portion of the NE NPR-A (Johnson et al. 2015). In 2016, only the Colville Delta study area was included in surveys (Figure 1).

Landforms, vegetation, and wildlife habitats in the Colville River delta were described in the Ecological Land Survey (Jorgenson et al. 1997), and the resulting habitat map has been updated several times to unify it with similar mapping of the surrounding Coastal Plain (see Johnson et al. [2015] for the current habitat map and descriptions).

The Colville Delta study area (552 km^2) comprises the CD North, CD South, and the Northeast Delta subareas (Figure 1). These subareas are useful in describing the distribution of birds on the delta, and together they encompass the entire delta from the eastern bank of the East Channel of the Colville River to the west bank of the westernmost distributary of the Niġliq (Nechelik) Channel and inland to where the Colville River divides into these channels.

METHODS

Aerial surveys were used to collect data on eiders, loons, and gulls in the Colville Delta study area, because of the large size of the study area and the short periods of time that each species is at the optimal stage for data collection. In 2016, 1 aerial survey for eiders during pre-nesting was conducted using fixed-wing aircraft and 2 aerial surveys (1 for nesting and 1 for brood-rearing) were conducted from a helicopter for Yellow-billed Loons. Nesting and brood-rearing gulls were recorded during loon surveys. Each of these surveys was scheduled specifically (see Table 1 for survey details) for the period when the species was most easily detected or when the species was at an important stage of its breeding cycle (nesting or raising broods).

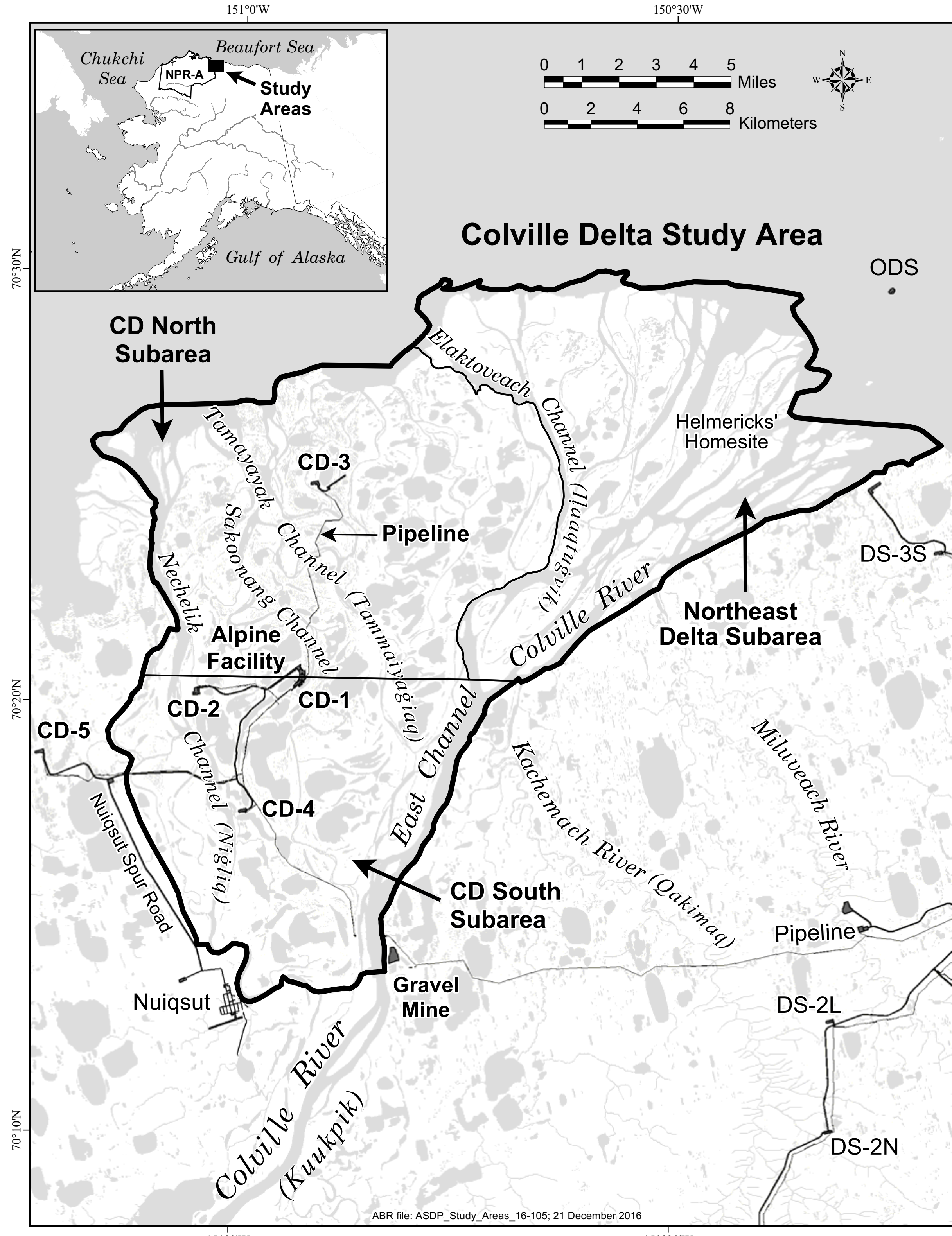


Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2016.

Table 1. Avian surveys conducted in the Colville Delta study area, Alaska, 2016.

SURVEY TYPE Season	Number of Surveys	Survey Dates	Aircraft[a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
EIDER SURVEY							
Pre-nesting	1	10, 12 June	C185	0.4	0.4	30–35	100% coverage
YELLOW-BILLED LOON SURVEYS[b]							
Nesting	1	20–21 June	206L	–	–	60–75	All lakes with adults, nests or broods inprevious years
Brood-rearing	1	22–23 Aug.	206L	–	–	60–90	All lakes with adults, nests or broods in previous years

[a] C185 = Cessna 185 fixed-wing airplane; 206L = Bell “Long Ranger” helicopter.
[b] Nests and broods of Pacific Loons, Red-throated Loons, Glaucous Gulls, and Sabine’s Gulls were recorded incidentally.

Concerns about disturbance to local residents and wildlife from survey flights have dictated that we conduct the fewest survey flights necessary and at the highest altitudes possible. Monitoring flights previously conducted for Yellow-billed Loons (up to 13/year) were discontinued in 2015. Flight altitudes were set at the maximum level at which the target species could be adequately detected and counted (see survey protocols for each species group below). Survey flights specifically avoided the areas around the village of Nuiqsut, the Helmericks' homesite, and any active hunting parties.

During the surveys, locations of eiders, loons, and gulls were recorded on digital orthophoto mosaics of 1 foot resolution natural color imagery acquired in 2004–2012 by Quantum Spatial (Anchorage, AK). Bird locations plotted on maps were reviewed before they were entered into a geographical information system (GIS) database.

In this report, we present data summaries with means plus or minus standard errors (mean ± SE), unless noted otherwise. Where appropriate, we report median values. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated. Analyses were conducted in Microsoft® Excel (Office 2010).

EIDER SURVEYS

We evaluated the regional abundance, distribution, and habitat selection of 2 species of eiders (Spectacled and King eiders) with data collected on 1 aerial survey flown annually during the pre-nesting period (Table 1), when male eiders were still present on the breeding grounds. In 2016, we conducted the pre-nesting survey during 10 and 12 June using the same methods that were used on the Colville Delta study area since 1993 (for details, see Johnson et al. [2015]). The survey was flown in a Cessna 185 airplane at 30–35 m above ground level (agl) and approximately 145 km/h. Two observers each counted eiders in a 200 m wide transect on each side of the airplane (400 m total transect width). A Global Positioning System (GPS) receiver was used to navigate east–west transect lines that were spaced 400 m apart achieving 100% coverage. Three areas were not surveyed in the Colville Delta study area: the extensive tidal flats and marine waters on the northernmost delta (Spectacled and King eiders rarely use those habitats during the survey time period; Johnson et al. 1996), a ~1.6 km radius circle around the Helmericks' homesite, and the southernmost portion of the delta near Nuiqsut (see Appendix B in Johnson et al. 2016). The latter 2 areas were avoided to reduce disturbance to residents.

LOON SURVEYS

On the Colville Delta study area in 2016, we conducted 1 aerial survey for nesting Yellow-billed Loons on 20–21 June and 1 aerial survey for brood-rearing Yellow-billed Loons on 22–23 August (Table 1). We surveyed 120 lakes for nesting loons and 117 lakes for brood-rearing loons (Appendix A). Both nesting and brood-rearing surveys have been conducted annually in the Colville Delta study area during 22 years from 1993 to 2016, with the exception of 1994 and 1999, when no surveys were conducted. The CD North and CD South subareas were surveyed each year, and part of the Northeast Delta subarea was surveyed in all years except 2000.

Methods for the nesting and brood-rearing survey were the same as in previous years (for details, see Johnson et al. [2015]). Each year the nesting survey was conducted between 18 and 30 June and the brood-rearing survey between 15 and 27 August. Additional surveys were flown in 1996–1998, 2000–2002, and 2005–2014 (for details, see Johnson et al. [2015]). All surveys were flown in a lake-to-lake pattern at 60–90 m above ground level. Survey lakes were selected before each survey and included most lakes ≥10 ha in size in 1993–2007 and most lakes ≥5 ha in size in 2008–2015. We also surveyed small lakes (1–10 ha) and aquatic habitats adjacent to survey lakes because Yellow-billed Loons sometimes nest on small lakes next to larger lakes that are used for brood-rearing (North and Ryan 1989, Johnson et al. 2014a). During 2016, however, we only surveyed lakes where Yellow-billed Loon adults, nests, or broods had been seen during the previous 21 years of surveys. Tapped Lakes with Low-water Connections (lakes whose levels fluctuate with changing river levels) were excluded from surveys during all years because Yellow-billed Loons do not use such lakes for nesting (North 1986, Johnson et al. 2003a).

We recorded incidental observations of Pacific Loons (Malġi) and Red-throated Loons (Qaqsrauq) during all nesting and brood-rearing surveys. All locations of loons and their nests and broods were recorded on color photomosaics (1:30,000 scale). In 2005–2016, Yellow-billed Loon nest locations also were marked on high resolution color images of nest site areas (~1:1,500 scale).

To make annual comparisons among years when different numbers of Yellow-billed loon breeding territories were surveyed, we calculated territory occupancy by dividing the number of territories with nests or broods by the number of territories surveyed. We defined a territory as a single lake, several lakes, or portion of a lake occupied exclusively by a breeding pair with a nest or brood in at least 1 year. Territories were identified using data from all years; boundaries between territories were determined by nest and brood locations.

Population growth rates were calculated for Yellow-billed Loons with counts of adults and nests from the nesting survey and young seen on the brood-rearing survey. Counts were adjusted for the number of territories surveyed by dividing counts by the number of territories surveyed and multiplying by the highest number of territories surveyed in all years (45). Population growth rates were estimated with log-linear regression on adjusted counts for years when helicopters were used for all surveys (2000–2016).

NEST FATE

Absence of broods is not a reliable indicator of nest failure because broods can disappear in the months between hatch and the brood survey. Therefore, we inspected the contents of nests at territories where a brood was not seen during the August survey to determine nest fate (for details, see Johnson et al. [2015]). Nests were assumed failed if they contained <20 egg fragments, eggshells had signs of predation (i.e., holes, albumen, yolk, or blood), or if eggs were unattended and cold (Parrett et al. 2008). Nests were assumed successful if a brood was present, or if the nest contained ≥20 egg fragments.

GULL SURVEYS

We recorded nests and broods of Glaucous Gulls during the nesting and brood surveys conducted for Yellow-billed Loons in the Colville Delta study area (see LOON SURVEYS, above). Glaucous Gulls nest singly and in loose aggregations or colonies. We considered a group of 3 or more nests occurring in proximity on the same lake or wetland complex to be a colony. Nests and broods of gulls were recorded incidentally as they were encountered, whereas traditional nest or colony locations within the study areas were checked systematically for activity. Once a Glaucous Gull colony was identified, we used 1 central location to map all nests, even though some nests may be as far as 350 m apart. All nest and brood observations were recorded on color photomosaic field maps (1:30,000 scale) and later entered into a GIS database.

We monitored trends in nest numbers for Glaucous Gulls using a subset of 50 lakes annually surveyed for Yellow-billed Loons in the Colville Delta study area since 2002. At that time, index lakes included 15 lakes with at least 1 year of gull nesting history, and 35 lakes with no history of nesting gulls. Of the 50 lakes, 28 are in the CD North subarea, 20 are in the CD South subarea, and 2 are in the Northeast Delta subarea.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to each observation of birds, nests, or broods by plotting their coordinates on the wildlife habitat maps (see Figure 2 in Johnson et al. [2015]). For each bird species, habitat use (% of all observations in each identified habitat type) was determined separately for various seasons (e.g., pre-nesting, nesting, and brood-rearing), as appropriate. For each species and season, we calculated 1) the number of adults, flocks, nests, or broods in each habitat, and 2) the percent of total observations in each habitat (habitat use). Habitat use was calculated from group locations for species when birds were in pairs, flocks, or broods. Habitat availability was calculated as the percent of each habitat in the survey area. A statistical analysis of habitat selection was used for Spectacled Eiders, King Eiders, and Yellow-billed Loons, to evaluate whether habitats were used in proportion to their

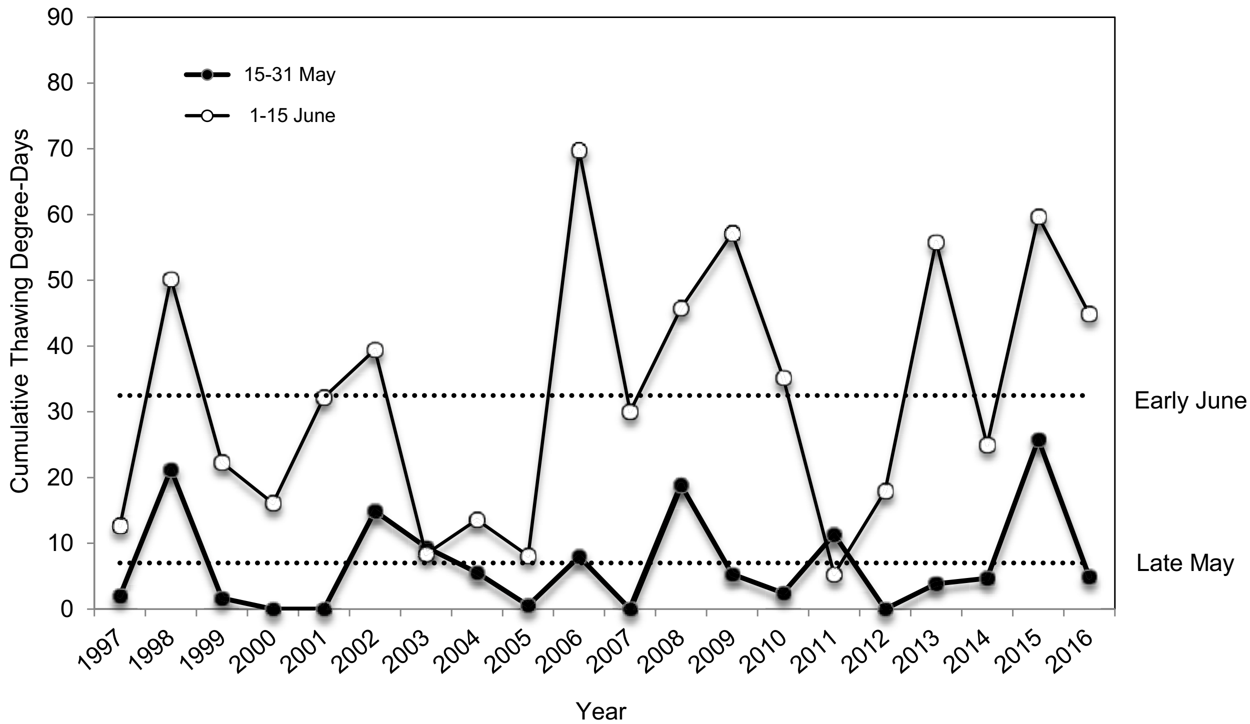


Figure 2. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville River delta, Alaska, 1997–2016. Means indicated by dotted lines.

availability. Methods were explained in more detail by Johnson et al. (2015).

DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into a centralized database following CPAI's data management protocols (version 9.6, CPAI 2016). All nest, brood, bird, and bird group locations were digitized from survey maps directly into the NAD 83 map datum. Uniform attribute data were recorded for all observations and proofed after data collection and proofed again during data entry. Survey data were submitted to CPAI in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

SEASONAL CONDITIONS IN THE STUDY AREA

For the second year in a row, May was unseasonably warm, and breakup on the Colville River was early. However, the snow pack in the Brooks Range was below average in 2016 (Natural Resources Conservation Service 2016) resulting in lower water discharge and moderate overbank flooding in contrast to the extensive flooding experienced in 2015. The peak discharge in 2016 was 9,854 cubic meters per second, only 74% of that recorded in 2015 (Michael Baker Jr. 2016). Melt water first reached the head of the Colville River delta (Monument 1) on 15 May, just as temperatures dropped below freezing. Warm weather brought a second surge of melt water a few days later. Water stage (5.3 m above mean sea level) and discharge peaked at Monument 1 on 23 May, 7 d earlier than average (Michael Baker Jr. 2016). Colville Village (Monument 35) experienced peak water stage on 26 May, at 1.1 m above mean sea level, just below flood stage for the site (Michael Baker Jr. 2016).

Water clarity in Yellow-billed loon lakes was moderately affected by overbank flooding of sediment laden waters in 2016. Only 34% of 50 lakes surveyed during loon nest surveys on 20 June were obviously murky from flooding in 2016, roughly half the percentage of lakes reported murky during the same time period in 2015.

Spring temperatures were warm on the Colville River delta in 2016. During the period of waterfowl arrival and peak initiation of nests (15 May–15 June), 50 cumulative thawing degree-days were measured at Colville Village, above the long-term mean of 40 ± 5 cumulative thawing degree-days (mean ± standard error; n = 20 years) (Figure 2). The mean temperatures in May (–1.7 °C) and June (4.6 °C) were warmer than the 20-year means (–5.1 ± 0.6 °C and 3.8 ± 0.4 °C, respectively).

For the first time in 20 years, there was no measurable snow cover when birds arrived in the spring of 2016. The 20-year mean for snow depth on 15 May was 23 ± 2 cm at Colville Village. In 2016, snow cover disappeared on 13 May, which was 19 d earlier than the long-term mean date for Colville Village (1 June ± 1 d).

Ice coverage on large lakes (>5 ha) was estimated visually during aerial surveys for eiders and loons. On 10–12 June, shallow waterbodies were open, and ice cover on deep waterbodies was low compared to past years. By 20 June, mean ice cover was 52%, well below the 3-year average (65 ± 7%; n = 27 lakes). Average ice cover on lakes was 19% lower in 2016 than in 2015, even though spring was cooler in 2016. The winter of 2015–2016 was one of the mildest for the Arctic Coastal Plain (Brettschnieder 2016), and Barrow had the warmest May on record (Wendler et al. 2016).

The warm spring weather promoted the early emergence of midges and mosquitoes. Birds experienced pulses of warm weather (mean daily temperatures >10 °C) and mosquito activity was noticeable in the latter half of June. Nest-search crews arriving on 20 June reported mosquitoes were at mild to severe levels in the CD-5 area on 22 June. In most years, mosquitoes do not emerge in great numbers before late June or early July.

Many birds nested early in 2016, as was the pattern in 2015. Greater White-fronted Goose goslings were seen on 20 June, the first day nest-search crews were on the tundra. More goslings were seen as the week progressed. Peak hatch of goslings was not measured in 2016, but the ratio of hatched to active nests suggested that peak hatch was near the date reported in 2015 (24 June; Rozell and Johnson 2015). With the exception of 2015 and 2016, we typically do not observe goslings until the end of the June (ABR unpublished data).

EIDERS

Four species of eiders may occur in the ASDP area, but each occurs at different frequencies and abundance. Of the 2 species of eiders that commonly occur in the Colville Delta study area, the Spectacled Eider has received the most attention because it was listed as "threatened" in 1993 (58 FR 27474–27480) under the Endangered Species Act of 1973, as amended. The outer Colville River delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest there annually at low densities and nest at even lower densities at inland portions of the Colville River delta (Burgess et al. 2002, 2003; Johnson et al. 2004, 2005). The King Eider, which is not protected under the Endangered Species Act, is an annual breeder that is more widespread and generally more numerous than the Spectacled Eider across the Arctic Coastal Plain, although their relative abundance varies geographically. The Steller's Eider was listed as a threatened species in 1997 (62 FR 31748–31757). Steller's Eiders are rare on the Colville River delta and immediate surroundings as these areas are east of their current Alaska breeding range centered around Barrow. The Colville Delta study area is within the range of Common Eiders, which nest primarily on barrier islands and coastlines but are seen rarely on surveys of the Colville Delta study area.

SPECTACLED EIDER

Distribution and Abundance

We recorded 88 Spectacled Eiders (on the ground and flying) and 89 indicated total Spectacled Eiders during the pre-nesting aerial survey in 2016 on the Colville Delta study area (Table 2). Indicated total is a standardized method of counting ducks, which doubles the number of males in singles, pairs, and small groups (no flying birds are included) to compensate for the lower detectability of females (USFWS 1987). Spectacled Eiders were above average in abundance on the Colville Delta study area in 2016, with the third highest count recorded in 23 years of surveys (Table 2). All observations

Table 2. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2016.

		Spectacled Eider				King Eider			
	Area Surveyed	Total[a]		Density[b]		Total[a]		Density[b]	
Year	(km²)	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1993	248.8	31	32	0.12	0.13	39	30	0.16	0.12
1994	455.7	79	57	0.17	0.13	58	35	0.13	0.08
1995	501.4	61	40	0.12	0.08	34	23	0.07	0.05
1996	501.4	41	40	0.08	0.08	59	43	0.12	0.09
1997	501.4	59	58	0.12	0.12	49	54	0.10	0.11
1998	501.4	71	70	0.14	0.14	57	18	0.11	0.04
2000	300.0	40	38	0.13	0.13	22	24	0.07	0.08
2001	501.4	38	36	0.08	0.07	35	22	0.07	0.04
2002	501.4	26	30	0.05	0.06	61	42	0.12	0.08
2003	501.4	24	20	0.05	0.04	50	38	0.10	0.08
2004	353.0	12	10	0.03	0.03	17	14	0.05	0.04
2005	501.4	16	14	0.03	0.03	46	22	0.09	0.04
2006	501.4	31	30	0.06	0.06	63	60	0.13	0.12
2007	501.4	52	48	0.10	0.10	30	28	0.06	0.06
2008	501.4	80	89	0.16	0.18	33	40	0.07	0.08
2009	501.4	41	42	0.08	0.08	33	30	0.07	0.06
2010	501.4	103	78	0.21	0.16	57	34	0.11	0.07
2011	501.4	99	95	0.20	0.19	133	129	0.27	0.26
2012	501.4	59	60	0.12	0.12	25	20	0.05	0.04
2013	501.4	63	66	0.13	0.13	38	24	0.08	0.05
2014	501.4	69	68	0.14	0.14	71	66	0.14	0.13
2015	501.4	59	54	0.12	0.11	57	42	0.11	0.08
2016	501.4	88	89	0.18	0.18	82	79	0.16	0.16
Mean		56.7	53.1	0.11	0.10	53.3	42.8	0.11	0.08
SE		5.7	5.5	0.01	0.01	5.7	6.2	0.01	0.01

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a). Mean and standard error calculated for total observed or indicated when survey area = 501.4 km², n = 19 years.

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Means calculated for all years, n = 23 years.

of Spectacled Eiders in the Colville Delta study area in 2016 were of small groups of 1–5 birds. The CD North subarea contained 84% of the Spectacled Eiders observed, whereas the CD South subarea contained none (Figure 3, Appendix B). The density of Spectacled Eiders in the CD North subarea during 2016 (0.36 indicated birds/km²) was twice the density recorded on the much larger Colville Delta study area (0.18 indicated birds/km²). The distribution of Spectacled Eiders in 2016 was typical of previous years, when densities were highest north of Alpine and low south and northeast of Alpine (Figure 3). Over the 23 years that ABR and others have monitored Spectacled Eiders, their population trend has been relatively stable (Figure 4). In the CD North subarea, the annual growth rate is 2% (logarithmic growth rate of 1.02; ln(adults) = 0.023 (year) – 42.50, R^2 = 0.091, P = 0.16). The growth rate for the entire Colville Delta study area is similar at 2% (ln(adults) = 0.017 (year) – 30.58, R^2 = 0.051, P = 0.30, n = 23 years). A recent reanalysis combining 2 separate datasets of pre-nesting Spectacled Eiders, the ACP breeding pair waterfowl survey conducted in late June with North Slope eider surveys conducted in early–mid June, estimated a slight annual decline (–1%) in Spectacled Eiders for the entire ACP (logarithmic growth rate = 0.99, n = 30 years; Wilson et al. *in prep.*). However, none of the above growth rates differs significantly from 0% (a logarithmic growth rate of 1.0 equals 0% annual change, or equilibrium).

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 23 years of aerial surveys on the Colville Delta study area (Table 3). Seven habitats were preferred (i.e., use significantly greater than availability, $P \leq 0.05$) including 3 primarily coastal, salt-affected habitats (Brackish Water, Salt Marsh, and Salt-killed Tundra), 3 aquatic habitats (Deep Open Water with Islands or Polygonized Margins, Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh), and 1 terrestrial habitat (Deep Polygon Complex). Deep Polygon Complex, which consists of a mosaic of small, deep, polygon ponds with relatively narrow vegetated rims and sometimes with islets, is notable because of its disproportionate use; Deep Polygon Complex was used by 29% of the Spectacled Eider groups, yet occurred on only 2.7% of the study area. Deep Polygon Complex also is a preferred habitat during the nesting season (Johnson et al. 2008). Patterned Wet Meadow was second highest in use (19% of Spectacled Eider groups) during pre-nesting but was not preferred because its use and availability were essentially equal. Six habitats were avoided (use significantly less than availability), including Open Nearshore Water; Tidal Flat Barrens; River or Stream; Moist Sedge-Shrub Meadow; Tall, Low, or Dwarf Shrub; and Barrens. All other habitats were used in proportion to their availability.

OTHER EIDERS

Distribution and Abundance

We recorded 82 observed (on the ground and flying) and 79 indicated total King Eiders on the 2016 pre-nesting aerial survey of the Colville Delta study area (Table 2). The number of King Eiders recorded in 2016 was the second highest recorded in 23 years (Table 2). As for most years in the Colville Delta study area, King Eiders (79 indicated birds) were less numerous than Spectacled Eiders (89 indicated birds). Unlike the King Eiders on the ACP, which have been increasing (Figure 5; Wilson et al. *in prep.*, Johnson et al. 2015), King Eiders on the Colville Delta study area have an annual growth rate of only 1%, which is not significantly different from equilibrium (ln(adults) = 0.013 (year) + 3.46, R^2 = 0.034, P = 0.40, n = 23 years). King Eiders were seen in all 3 of the subareas, but they achieved their highest density (0.28 indicated birds/km²) in the Northeast Delta subarea in 2016 (Figure 3, Appendix B). The highest densities occur on the East Channel of the Colville River near the coast, where flocks of King Eiders collect in open water; lower densities are seen elsewhere on the delta. Relatively few King Eiders nest on the Colville River delta, suggesting that most of those observed during pre-nesting are in transit to other breeding areas (Johnson et al. 2003a).

No Steller's or Common eiders were seen in the Colville Delta study area in 2016. Steller's Eiders rarely are seen in the vicinity of the Colville River delta (Johnson et al. 2016). Common Eiders are seen infrequently on the Colville River delta,

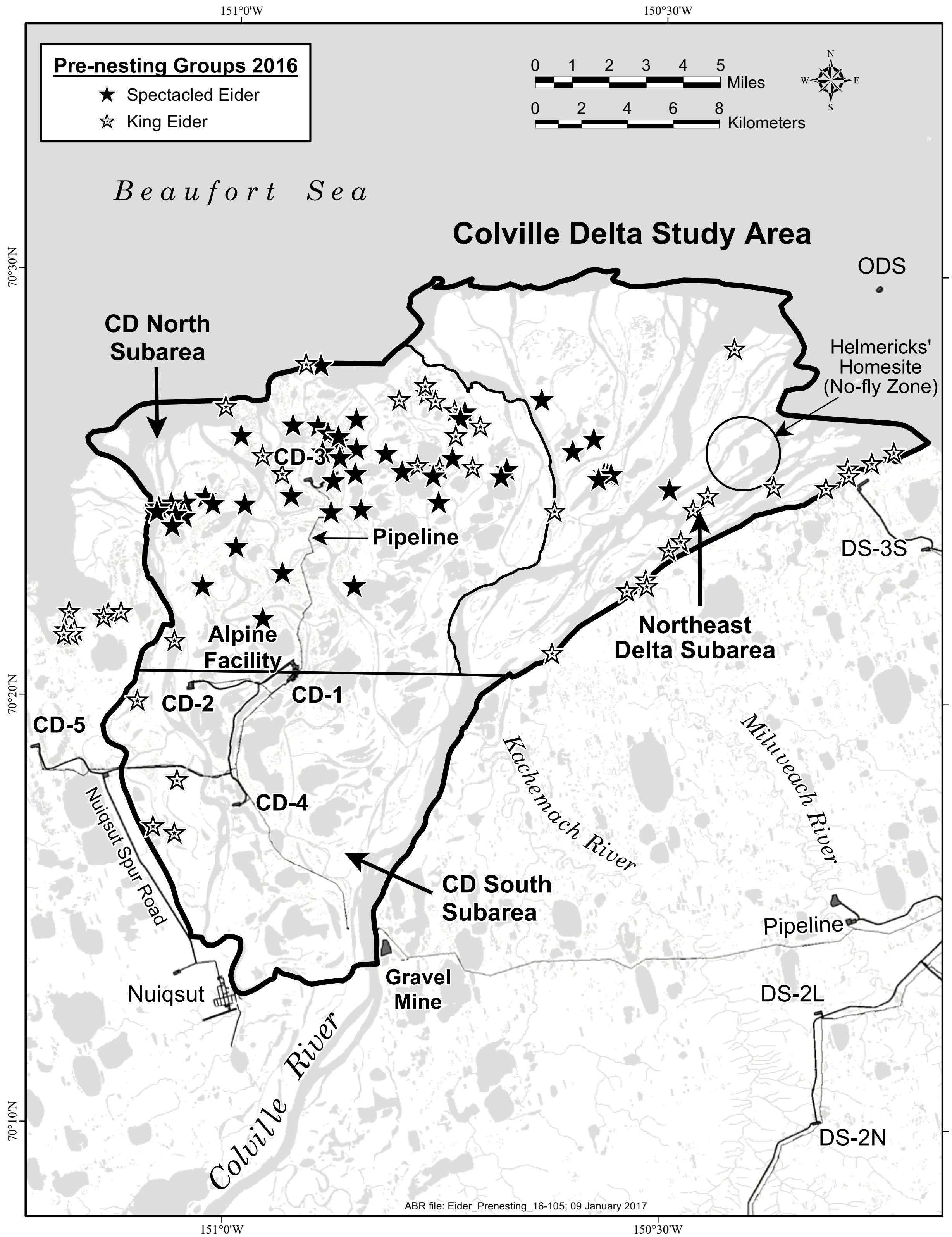


Figure 3. Spectacled Eider and King Eider locations during pre-nesting in 2016, Colville Delta study area, 2016.

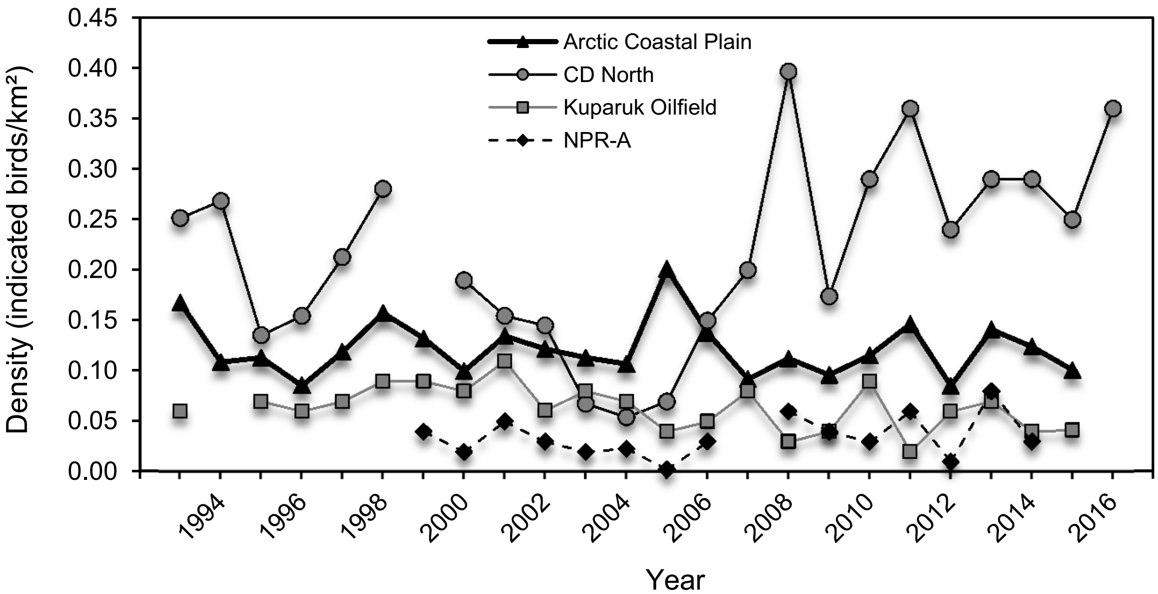


Figure 4. Annual densities of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2016. Arctic Coastal Plain data from USFWS (2016, unpubl. data), Kuparuk data from Morgan et al. (2016), and CD North and NE NPR-A data from this study.

but are more abundant in the nearshore marine waters and barrier islands that are mostly outside the survey area.

Habitat Use

Steller's and Common eiders have not been numerous enough to warrant evaluations of habitat preferences on the Colville River delta. King Eiders used 20 of 24 available habitats in the Colville Delta study area over 23 years of pre-nesting aerial surveys (Table 3). King Eiders preferred 4 of the same habitats preferred by pre-nesting Spectacled Eiders in the Colville Delta study area: Brackish Water, Salt Marsh, Salt-killed Tundra, and Deep Polygon Complex. In addition to those 4 habitats, King Eiders preferred River or Stream and Shallow Open Water with Islands or Polygonized Margins. The high use of River or Stream, which includes the river channels primarily in the Northeast Delta subarea (Figure 3), suggests that many King Eiders were moving through to breeding areas farther east, because River or Stream is not potential breeding habitat. In contrast, Spectacled Eiders, which occur in high numbers during pre-nesting and nest in relatively high concentrations on the outer Colville River delta (0.8–1.0 nests/km²; ABR, unpublished data), avoid River or Stream. Moreover, King Eiders nest at very low densities on the Colville River delta in the several locations where intensive nest searches have been conducted (Burgess et al. 2003; Johnson et al. 2003b, 2008; Seiser and Johnson 2010; 2011a, b; 2012; 2014a, b), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

YELLOW-BILLED LOON

DISTRIBUTION AND ABUNDANCE

Eighteen Yellow-billed Loon nests were found during Yellow-billed Loon surveys in 2016 (Figure 6, Table 4). One of those nests was unoccupied during the nesting survey and later confirmed as failed during the August nest fate visit. Of the 18 nests found in 2016, 11 nests were located in the CD North subarea, 6 nests in the CD South subarea, and 1 nest in the Northeast Delta subarea (Appendix C). The total number of nests found on the nesting survey was below the long-term mean (20.5 ± 1.4 nests, $n = 22$ years; for densities see Appendix D) and among the lowest counts since 2000. The count of 68 adults on the

Table 3. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2016.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	2	1	0.2	1.6	avoid	
Brackish Water	83	38	7.2	1.3	prefer	
Tapped Lake with Low-water Connection	38	16	3.0	4.5	ns	
Tapped Lake with High-water Connection	21	12	2.3	3.7	ns	
Salt Marsh	63	35	6.6	3.2	prefer	
Tidal Flat Barrens	2	1	0.2	7.0	avoid	
Salt-killed Tundra	93	52	9.9	5.1	prefer	
Deep Open Water without Islands	35	22	4.2	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	40	21	4.0	2.1	prefer	
Shallow Open Water without Islands	6	4	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	9	7	1.3	0.1	prefer	low
River or Stream	34	16	3.0	14.4	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	268	153	29.0	2.7	prefer	
Grass Marsh	10	6	1.1	0.2	prefer	low
Young Basin Wetland Complex	0	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	87	44	8.3	8.2	ns	
Patterned Wet Meadow	178	96	18.2	19.3	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid	
Barrens	6	2	0.4	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	976	527	100	100		
KING EIDER						
Open Nearshore Water	27	8	2.4	1.6	ns	
Brackish Water	56	28	8.4	1.3	prefer	low
Tapped Lake with Low-water Connection	31	14	4.2	4.5	ns	
Tapped Lake with High-water Connection	14	6	1.8	3.7	ns	
Salt Marsh	51	20	6.0	3.2	prefer	
Tidal Flat Barrens	4	2	0.6	7.0	avoid	
Salt-killed Tundra	51	27	8.1	5.1	prefer	
Deep Open Water without Islands	22	10	3.0	3.4	ns	
Deep Open Water with Islands or Polygonized Margins	19	9	2.7	2.1	ns	
Shallow Open Water without Islands	5	3	0.9	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	5	3	0.9	0.1	prefer	low
River or Stream	419	122	36.5	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	53	30	9.0	2.7	prefer	
Grass Marsh	8	3	0.9	0.2	ns	low
Young Basin Wetland Complex	0	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	17	11	3.3	8.2	avoid	
Patterned Wet Meadow	51	29	8.7	19.3	avoid	
Moist Sedge-Shrub Meadow	2	1	0.3	2.3	avoid	
Moist Tussock Tundra	1	1	0.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.3	4.9	avoid	
Barrens	15	6	1.8	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	853	334	100	100		

[a] Use = (groups/total groups) × 100.
[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.
[c] Low = expected number < 5.

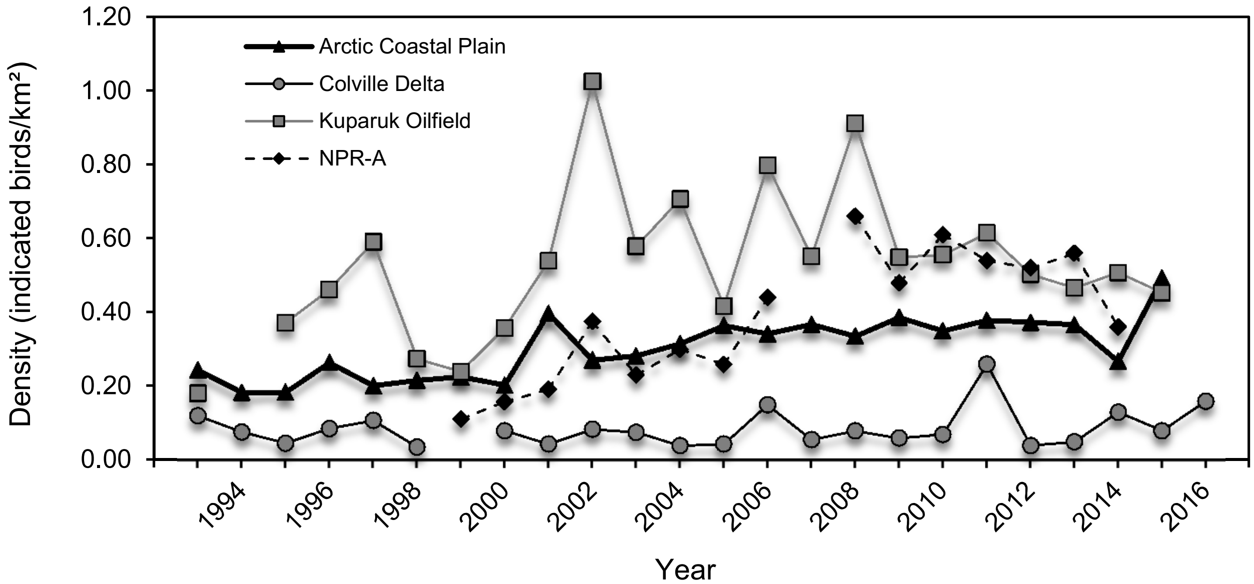


Figure 5. Annual densities of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2015. Arctic Coastal Plain data from USFWS (2016, unpubl. data), Kuparuk data from Morgan et al. (2016), and Colville Delta and NE NPR-A data from this study.

nesting survey, however, was higher than the long-term mean (57.3 ± 2.4 adults). The density of adults was lower in the CD North subarea (0.15 birds/km²) than in the CD South subarea (0.21 birds/km²), but the density of nests was similar (0.05 nests/km² and 0.04 nests/km², respectively; Appendix C). Incidental records of Pacific and Red-throated Loon nests and broods are presented in Appendices C and E.

All but 1 of the 18 Yellow-billed Loon nests recorded in the Colville Delta study area in 2016 were on lakes where Yellow-billed Loons have nested previously (Figure 6; Johnson et al. 2009, 2010, 2011, 2012, 2013, 2014b, 2015). The addition of the lake where we had not documented breeding in previous years (but have observed a pair of loons there for 2 years) increases the number of known breeding territories from 44 to 45. The nest was on a lake classified as Deep Open Water with Islands or Polygonized Margins and was <5 ha in size (4.4 ha). Although this lake was not included in aerial loon surveys until 2015, its shoreline was searched on foot during CD-3 nest searches (2000–2007). During that time, the lake was occupied by a pair of nesting Pacific Loons. Twelve of the 17 other Yellow-billed Loon nests were located at the same nest sites used in previous years, 4 were very close (≤50 m) to nest sites used in previous years, and 1 was at a new nest site on a lake previously used for nesting.

Since 1993, the number of nests recorded during the nesting survey in June ranged from 10 nests in 1997 to 33 nests in 2008 (Table 4). In all years but 2016, additional surveys for nests occurred during ground, revisit, and/or monitoring surveys, resulting in 1–12 additional nests. Because we only conducted a single nesting survey in 2016, nest counts from the nesting survey, as opposed to all surveys, provide the best metric for comparing nesting effort in 2016 with previous years. These nest counts, however, are not directly comparable among years because survey coverage varied annually from 35 to 45 identified territories. To adjust for variable coverage, we used territory occupancy by nests, calculated as the number of nests found on the nesting survey divided by the number of territories surveyed. Only 40% of the territories surveyed in 2016 were occupied by nests during the nesting survey, which is among the lowest occupancy estimates and well below the long-term mean (49.7 ± 3.3%, n = 22 years; Table 4).

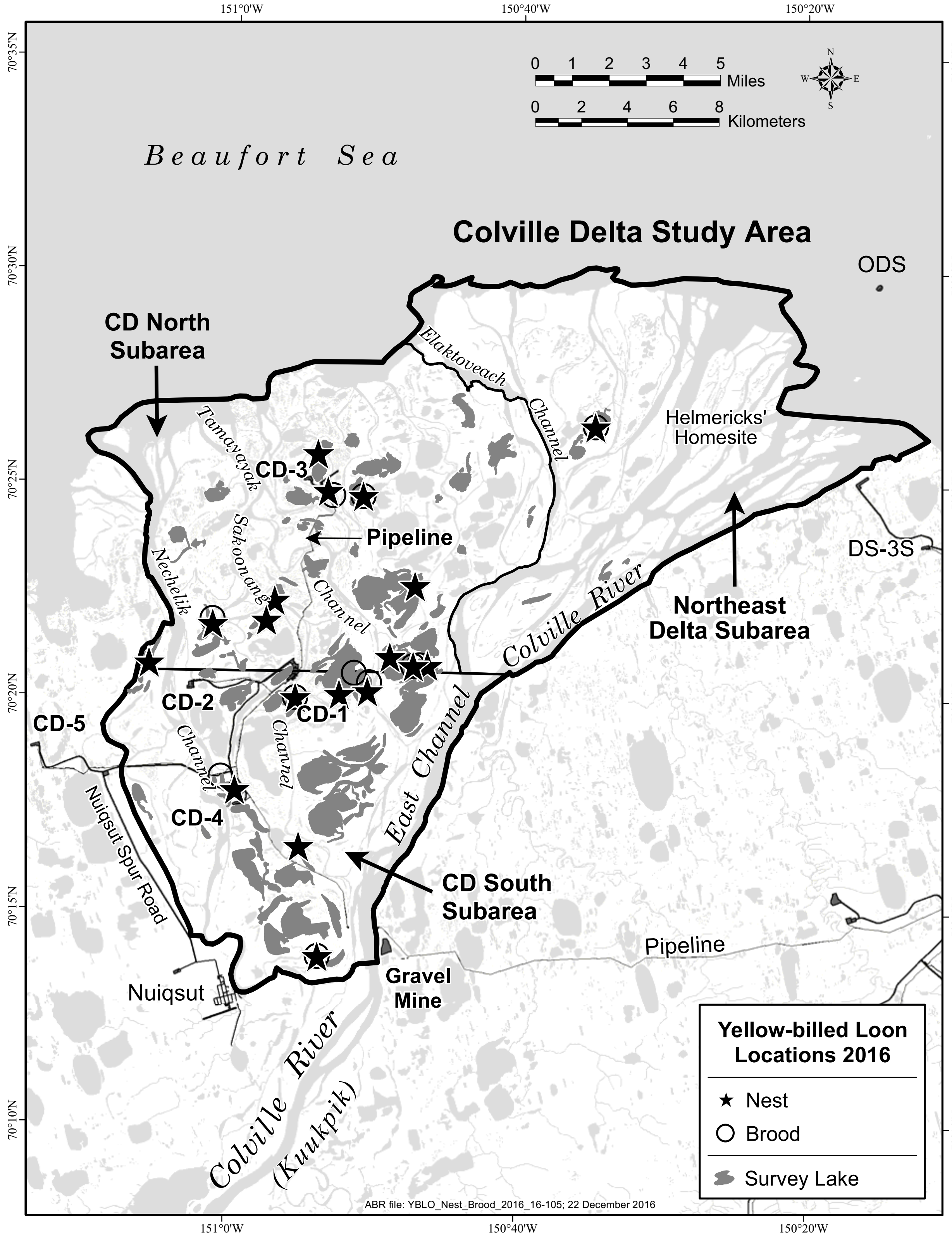


Figure 6. Yellow-billed Loon nest and brood locations, Colville Delta study area, Alaska, 2016.

Table 4. Number of Yellow-billed Loons and nests, and territory occupancy by nests, Colville Delta study area, Alaska, 1993–2016.

	Nesting Survey[a]		All Surveys[b]		
Year	No. Adults	No. Nests	No. Nests	No. Territories Surveyed	Nest Occupancy (%)[c]
1993	50	11	16[e,f]	41	26.8
1995	42	12	21[e,f]	39	30.8
1996	45	11	20[e,f,g]	35	31.4
1997	48	10	18[e,g]	38	26.3
1998	35	17	24[e,f,g]	40	42.5
2000	53	16	16	37	43.2
2001	54	19	20[e]	37	51.4
2002	46	17	22[e,f,g]	41	41.5
2003	53	25	27[f]	41	61.0
2004	41	24	26[f]	41	58.5
2005	56	30	31[f]	40	75.0
2006	63	24	28[g]	41	58.5
2007	66	27	31[g]	41	65.9
2008	69	33	38[g]	42	78.6
2009	67	27	30[g]	43	62.8
2010	69	23	35[g]	42	54.8
2011	70	23	29[g]	42	54.8
2012	57	25	32[g]	43	58.1
2013	67	12	17[f,g,h]	43	27.9
2014	78	26	32[g,h]	43	60.5
2015	63	19	25[f,h]	44	43.2
2016	68	18	18[i]	45	40.0
Mean	57.3	20.5	25.3	–	49.7
SE	2.4	1.4	1.4	–	3.3

[a] Nesting survey is limited to survey conducted between 18 and 30 June.
[b] Observation effort varied between years. Includes all nests found on loon aerial surveys, ground surveys, camera images or inferred by brood observations. Observation methods other than nesting survey are footnoted.
[c] Calculated as the number of nests found on the nesting survey divided by the number of territories surveyed. Excludes 1 renesting in 2007, 2011 and 2016 and 2 renestings in 2012 and 2015.
[d] Survey area included CD North, CD South, and Northeast Delta subareas for all years except 2000, when only CD North and CD South were surveyed.
[e] Includes nest(s) found during ground surveys.
[f] Includes nest(s) inferred by the presence of a brood observed on a territory lake during ground or aerial surveys.
[g] Includes nest(s) found during revisit (1996–2002), monitoring (2006–2014), and early nesting (2011) surveys.
[h] Includes nest(s) documented on camera images only or nest(s) found after the nesting survey during camera setup.
[i] No surveys for nests were conducted in addition to the single June survey.

During the brood-rearing survey on 22–23 August, 43 Yellow-billed Loons, 6 broods, and 6 young were recorded in the Colville Delta study area (Figure 6, Table 5). We inferred 5 additional broods based on eggshell fragments at nests. Of the 11 broods, 5 were found in the CD North subarea, 5 were found in the CD South subarea, and 1 was found in the Northeast Delta subarea (Appendix C). The count of 43 adults on the brood-rearing survey was lower than the long-term mean (50.5 ± 2.7 adults) and the number of broods detected (11) was slightly lower than the long-term mean (12.6 ± 1.3 broods, n = 22 years; Table 5; for densities, see Appendix D). In contrast to the nest survey, the density of adults during the brood-rearing survey was slightly higher in the CD North subarea (0.13 birds/km²) than in the CD South subarea (0.10 birds/km²), but the density of broods was

Table 5. Number of Yellow-billed Loons and broods, and territory occupancy by broods, Colville Delta study area, Alaska, 1993–2016.

Year	Brood-rearing Survey[a] No. Adults	Brood-rearing Survey[a] No. Young	Brood-rearing Survey[a] No. Broods	All Surveys[b] No. Broods	No. Territories Surveyed[c]	Brood Occupancy (%)[d]
1993	29	7	7	10[e]	34	29
1995	51	13	10	13[e]	42	32
1996	62	6	6	10[e]	36	28
1997	66	8	5	5	38	13
1998	55	15	12	12	41	30
2000	21	2	2	3[f]	36	8
2001	33	4	4	4	37	11
2002	66	9	8	9[e]	40	23
2003	47	16	14	14	40	35
2004	54	15	12	12	40	30
2005	39	21	17	21[f,g]	40	53
2006	66	13	13	16[f]	41	39
2007	53	20	17	23[f,g]	41	56
2008	57	29	22	27[f,g]	42	64
2009	56	12	11	13[g]	43	30
2010	59	19	13	15[f,g,h]	42	36
2011	45	20	12	15[f,g,h]	42	36
2012	52	19	14	17[g,h]	43	40
2013	43	9	7	7	43	16
2014	48	4	4	8[f,g]	43	19
2015	58	10	9	10[h]	44	23
2016	43	6	6	11[g]	45	24
Mean	50.5	12.9	10.4	12.6		30.6
SE	2.7	1.5	1.1	1.3		3.0

[a] Brood-rearing surveys were conducted sometime between 15 and 27 August.
[b] Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted.
[c] Survey area included CD North, CD South, and Northeast Delta subareas for all years except 2000, when only CD North and CD South were surveyed.
[d] Calculated as the number of broods from all surveys divided by the number of territories surveyed.
[e] Includes brood(s) found during ground surveys.
[f] Includes brood(s) found during monitoring surveys.
[g] Includes broods from territories where no brood was seen but presence of a brood was determined from eggshell evidence.
[h] Includes broods from territories where broods were seen only on camera images.

similar (0.02 broods/km² and 0.03 broods/km², respectively; Appendix C).

During the 22 years of brood-rearing surveys in the Colville Delta study area, the lowest number of broods recorded was 2 broods in 2000 and the highest was 22 broods in 2008 (Table 5). In most years, an additional 1–6 broods were found during ground and/or monitoring surveys, or were determined by eggshell fragments at the nest indicating that hatching occurred (see *Nest Fate,* below). With the addition of these broods, the range of brood counts was 3–27. Like nest counts, these raw counts of broods are not directly comparable because survey coverage varied annually from 34 to 45 territories (Table 5). We calculated territory occupancy by broods (the number of broods seen on all surveys divided by the number of territories surveyed) to standardize for survey effort. Brood occupancy was 24% in 2016, and for the fourth year in a row, brood occupancy was well below the long-term mean (30.6 ± 3.0%, n = 22 years). The low productivity observed in 2016 does not appear to be related to the reduction in nest survey effort. Restricting brood occupancy estimates to the subset of broods seen at nests found during the single nesting survey standardizes survey effort among years. After standardizing for survey effort, brood occupancy in 2016 (13%) was still well below average (20.6 ± 2.3%, n = 22 years).

Over 17 years of study, Yellow-billed Loons on the Colville Delta study area have exhibited population growth, but indices of productivity have not followed that trend. The number of adults (adjusted by the number of territories surveyed; Figure 7) has increased at 1.4% annually (ln(adults) = 0.014 (year) – 24.68, R^2 = 0.238, P = 0.047). The long-term reproductive effort has been more variable; neither nests nor young (both adjusted for the number of territories surveyed) show significant change. Growth indices over the last 10 years, however, have shown a dramatic decline. The growth rate of adults did not differ significantly from 0% (ln(adults) = –0.007 (year) + 18.39, R^2 = 0.006, P = 0.495) and productivity has declined. Since 2007, the number of nests declined by 6.6% annually (ln(nests) = –0.066(year) +135.17, R^2 = 0.449, P = 0.034), while the number of young declined by 16.6% annually (ln(young) = –0.166(year) + 335.79, R^2 = 0.611, P = 0.007). Reduced nesting and low nest and/or brood survival appear to be causing this decline. As the population growth rate indicates, adult Yellow-billed Loons are present on territories during the nesting survey. The number of breeding territories occupied by at least 1 loon during the nesting survey is consistently high (mean = 83.1 ± 1.9%, range = 71–100%, n = 17 years), however, not all adults that are present during June attempt to breed. Territory occupancy by nests is much lower and more variable (mean = 63.8 ± 3.6%, range = 40–90%, n = 17 years) than occupancy by adults. In addition to low occupancy by nests, Yellow-billed Loons have experienced below average nest and/or brood survival during the past 4 years (see Nest Fate, below).

HABITAT USE

Yellow-billed Loons nested in 12 of 24 available habitats during nesting surveys conducted in the Colville Delta study area over 22 years (Table 6). Seven habitats, supporting 450 of 499

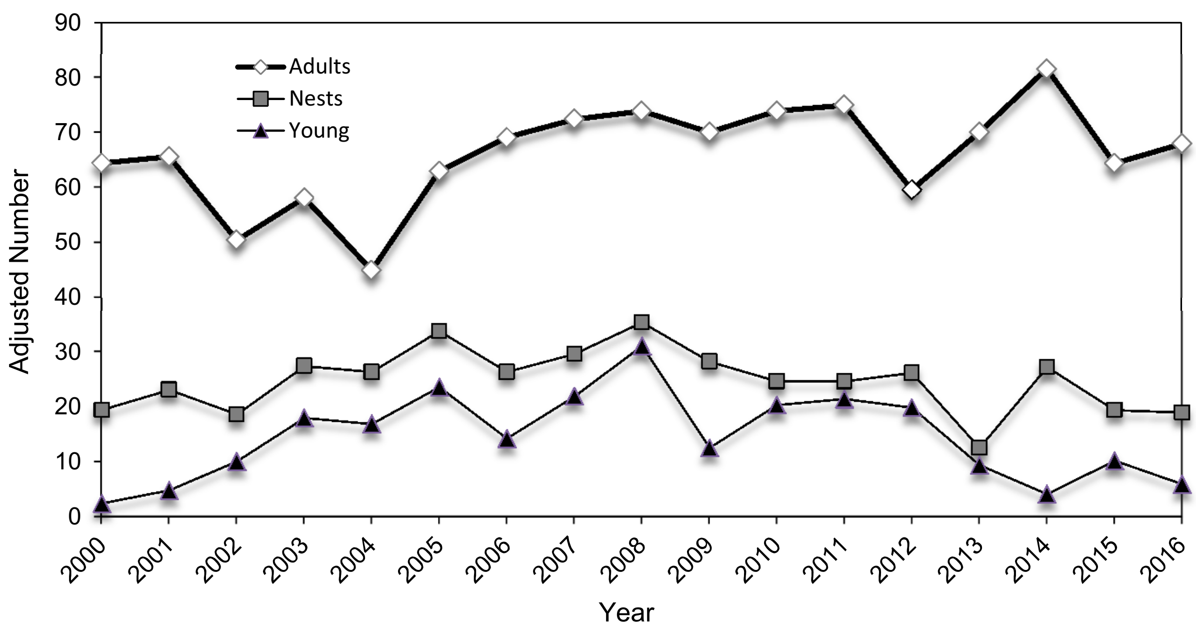


Figure 7. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, Colville Delta study area, 2000–2016. Adjusted numbers were standardized for the number of territories surveyed each year (number observed/number of territories surveyed × 45 territories [maximum number of territories surveyed]).

Table 6. Habitat selection by nesting (1993–1998 and 2000–2016) and brood-rearing (1995–1998 and 2000–2016) Yellow-billed Loons, Colville Delta study area, Alaska.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	2.0	avoid	
Brackish Water	0	0	1.1	avoid	
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	34	6.8	5.3	ns	
Salt Marsh	4	0.8	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	50	10.0	4.8	prefer	
Deep Open Water with Islands or Polygonized Margins	133	26.7	2.5	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.4	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	1.0	<0.1	prefer	low
Deep Polygon Complex	24	4.8	2.9	prefer	
Grass Marsh	9	1.8	0.3	prefer	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	57	11.4	8.8	prefer	
Patterned Wet Meadow	172	34.5	24.4	prefer	
Moist Sedge-Shrub Meadow	6	1.2	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	low
Tall, Low, or Dwarf Shrub	3	0.6	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	499	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	2.0	avoid	low
Brackish Water	1	0.4	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	48	21.3	5.3	prefer	
Salt Marsh	0	0	2.6	avoid	
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	102	45.3	4.8	prefer	
Deep Open Water with Islands or Polygonized Margins	73	32.4	2.5	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	0	0	2.9	avoid	
Grass Marsh	1	0.4	0.3	ns	low
Young Basin Wetland Complex	0	0	<0.1	ns	low
Old Basin Wetland Complex	0	0	<0.1	ns	low
Nonpatterned Wet Meadow	0	0	8.8	avoid	
Patterned Wet Meadow	0	0	24.4	avoid	
Moist Sedge-Shrub Meadow	0	0	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	ns	low
Tall, Low, or Dwarf Shrub	0	0	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	225	100	100		

[a] % use = (nests / total nests) × 100 or (broods / total broods) × 100.

[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; ns = not significant, prefer = significantly greater use than availability, avoid = significantly less use than availability.

[c] Low = expected number < 5.

total nests, were preferred for nesting (Deep Open Water with Islands or Polygonized Margins, Deep Open Water without Islands, Sedge Marsh, Grass Marsh, Deep Polygon Complex, Nonpatterned Wet Meadow, and Patterned Wet Meadow). Within these habitats, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. All nests were on shorelines of lakes, but were assigned to the terrestrial habitat on the lakeshore except where nests were on islands or in emergent vegetation, in which case they were assigned to the aquatic habitat of the lake. Patterned Wet Meadow was the habitat used most frequently for nesting (35% of all nests), and it also was the most abundant habitat on the delta (24% of the loon survey area; Table 6). Nesting Yellow-billed Loons avoided nesting in 11 habitats, which together occupied 50% of the Colville Delta study area.

Yellow-billed Loons were highly selective in their use of brood-rearing habitat. All Yellow-billed Loon broods (225 broods over 22 years) were found in 4 lake habitats, only 3 of which were preferred: Tapped Lake with High-water Connection, Deep Open Water without Islands, and Deep Open Water with Islands or Polygonized Margins (Table 6). The preferred habitats occupied only 13% of the delta. Brackish Water was the only shallow-water habitat used during brood-rearing and was used by 1 brood. The selection analyses for nesting and brood-rearing highlight the importance of large, deep waterbodies to breeding Yellow-billed Loons.

NEST FATE

During the brood-rearing survey, 6 of 18 Yellow-billed Loon nests had broods. Because the absence of a brood does not always indicate nest failure, all 12 nests without broods were visited on the ground to determine nest fate. Five of the 12 nests contained >20 egg fragments (range 22–99 fragments), indicating that at least 1 egg hatched. The remaining 7 nests lacked evidence of hatch; 2 contained broken egg(s), 2 had <8 egg fragments, and 3 nests contained no egg remains. Overall, we determined that in addition to the 6 nests that had broods during the brood-rearing survey, 5 nests had broods that did not survive, resulting in a total of 11 successful nests.

We began visiting inactive nests to verify nest fate in 2005. During 2005–2014, we also conducted weekly nest and brood monitoring surveys, which provide better estimates of the total number of nests and broods. Because of lower survey effort in 2015 and 2016, nesting success based on the total number of nests detected is not directly comparable to previous years. Restricting the annual data to nests found only on nesting surveys allows a standardized comparison of apparent nesting success among years when nest fate data were collected. Based on nest fate data and the presence of broods, 11 of the 18 nests hatched in 2016 for an apparent nesting success of 61%. This estimate was well above the 12-year mean (53.4 ± 4.5%) and was the fourth-highest nesting success observed since 2005. Despite above average nesting success, brood survival, however, was extremely low. The number of young alive during the brood-rearing survey (6) was less than half of the 12-year mean (15.2 ± 2.1 young).

GULLS

DISTRIBUTION AND ABUNDANCE

The count of Glaucous Gull nests on the Colville Delta study area during 2016 was the highest in 15 years of surveys. We recorded 89 Glaucous Gull nests during the aerial survey for nesting loons; 46 of those nests were in the CD North subarea, 37 nests in the CD South subarea, and 6 nests in the Northeast Delta subarea (Figure 8). The number of Glaucous Gull colonies in 2016 increased to 7 with the addition of a 3-nest colony in the Northeast Delta subarea. The largest of the 7 colonies contained 20 nests and was located ~6 km northeast of the CD-4 drill pad. The maximum number of nests we have seen at this colony over 15 years of monitoring was 23 nests in 2013 (Table 7). Other colonies in the Colville Delta study area include 2 with 4–7 nests in the northeastern part of the CD North subarea, 1 with 5 nests north of the CD-3 drill pad, 1 with 3 nests north of the CD-2 drill pad, and 1 with 4 nests south of the CD-4 drill pad (Figure 8). Glaucous Gull colonies remain uncommon in the study area; only 18% of the 38 waterbodies occupied by nesting gulls held a colony in 2016.

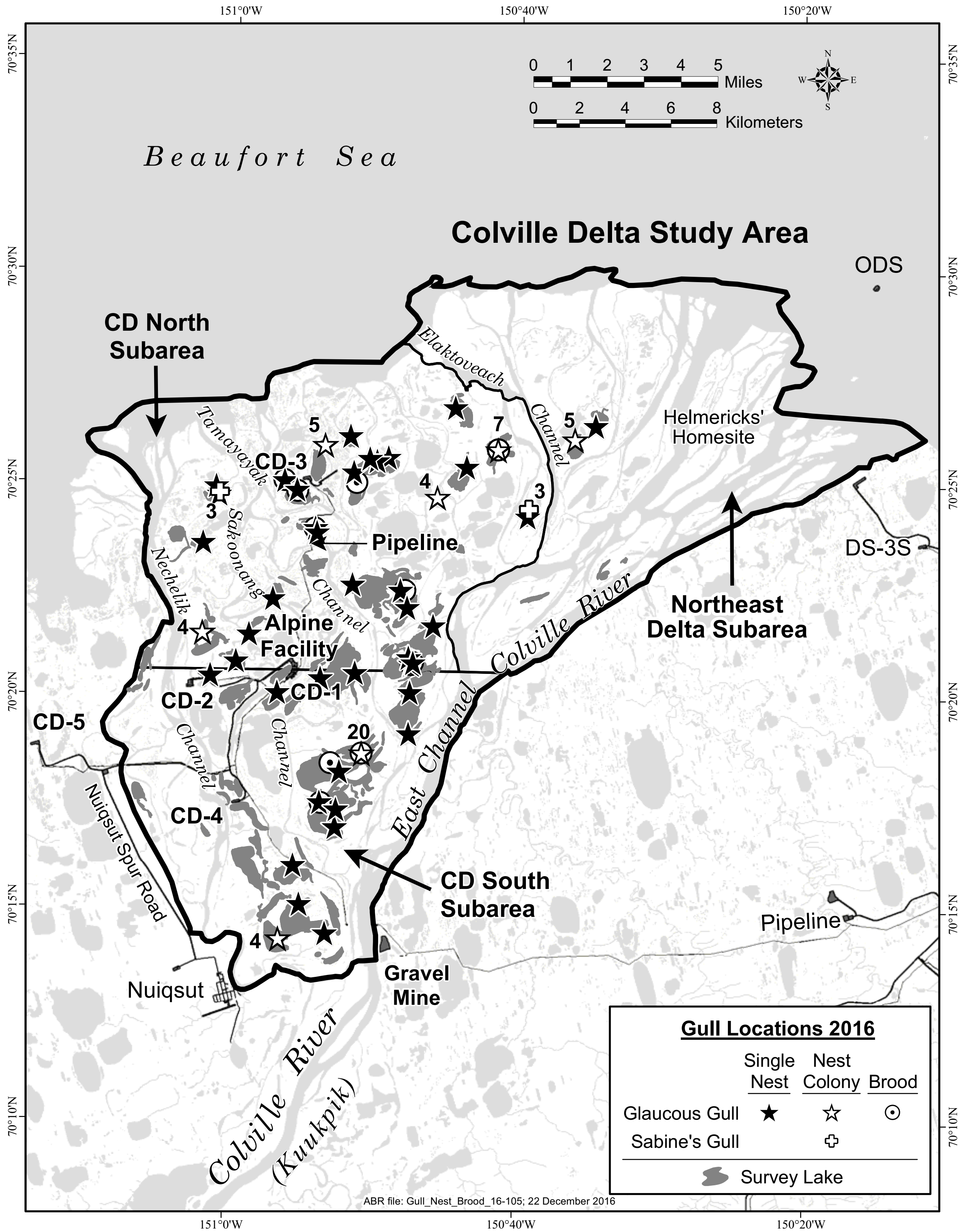


Figure 8. Glaucous Gull and Sabine's Gull nest and brood locations, Colville Delta study area, Alaska, 2016. Numbers of nests are listed for colony locations.

Table 7. Number of Glaucous Gull nests recorded during aerial surveys for nesting loons on 50 index lakes, Colville Delta study area, Alaska, 2002–2016.

Year	Number of Nests				No. of Lakes with Nests[c]
	CD North Subarea[a]	CD South Subarea[b]	Northeast Delta Subarea	Total	
2002	11 (2, 1)	24 (18)	1	36	15
2003	11 (1, 1)	17 (14)	0	28	14
2004	19 (7, 1)	17 (13)	0	36	16
2005	18 (5, 1)	22 (15)	0	40	19
2006	15 (4, 1)	21 (16)	1	37	19
2007	16 (5, 1)	21 (13)	2	39	19
2008	19 (5, 1)	26 (18)	2	47	22
2009	17 (6, 1)	27 (19)	2	46	21
2010	17 (5, 2)	16 (6)	2	35	21
2011	17 (5, 2)	36 (17)	2	55	24
2012	26 (7, 5)	34 (17)	2	62	28
2013	19 (5, 4)	35 (23)	3	57	22
2014	27 (6, 5)	34 (18, 3)	2	63	27
2015	29 (6, 5)	29 (15, 4)	2	60	27
2016	29 (7, 5)	37 (20, 4)	4	70	26
Mean	19.3	26.4	1.7	47.4	21.3
SE	1.6	2.1	0.3	3.6	1.2

[a] First number in parentheses is the number of nests at the colony site in the northeastern part of the CD North subarea and second number is the number of nests at the site north of the CD-3 drill pad (see Figure 102).

[b] First number in parentheses is the number of nests at the colony site northeast of CD-4 drill pad and second number is the number of nests at site south of CD-4 drill pad (see Figure 10).

[c] Of 50 lakes monitored annually for the presence of Glaucous Gull nests, 2 occur in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea.

For the past 15 years, numbers of Glaucous Gull nests have increased on the 50 index lakes in the Colville Delta study area that are monitored annually during the aerial survey for nesting loons (Figure 8, Table 7). Counts of Glaucous Gull nests at the index lakes previously ranged from 28 to 63 nests. In 2016, 70 nests were found on 26 index lakes. The annual growth rate for nests on the index lakes was 6% (ln(nests) = 0.055 (year) – 107.12, R^2 = 0.81, P = <0.001). The number of index lakes occupied by nesting gulls has also increased (Table 7). One lake was occupied for the first time in the 15-year survey period. Gull nests were not evenly distributed among lakes. The 4 colonies on the 50 index lakes contained 51% of nests (36 nests), but occupied only 8% of the lakes (4 lakes).

In 2016, 13 groups of Glaucous Gulls with young were recorded on 9 waterbodies in the Colville Delta study area during the survey for brood-rearing loons (Figure 8). Broods totaled 16 adults and 32 young. The majority of the young were found in colonies. Six young were observed at the colony site in the northeastern part of the CD North subarea. Ten young were counted at the large colony site northeast of the CD-4 drill pad, where young were not recorded in the previous 2 years. The 2 other colonies in CD South subarea also did well, producing 4 young each. Young gulls had varying degrees of flight capability at the time of the loon survey, and some may have moved out of our survey area.

Table 8. Habitat use by nesting Glaucous Gulls, Colville Delta study area, 2016.

Habitat	Nests	Use (%)
Tapped Lake with High-water Connection	17	19.1
Deep Open Water without Islands	5	5.6
Deep Open Water with Islands or Polygonized Margins	30	33.7
Shallow Open Water with Islands or Polygonized Margins	2	2.3
Deep Polygon Complex	1	1.1
Grass Marsh	6	6.7
Nonpatterned Wet Meadow	3	3.4
Patterned Wet Meadow	21	23.6
Moist Sedge-Shrub Meadow	4	4.5
Total	89	100

HABITAT USE

Glaucous Gull nests and colonies were found in 9 different habitats in the Colville Delta study area (Table 8). The 4 most commonly used habitats also contained colonies: Deep Open Water with Islands or Polygonized Margins (34% of nests), Patterned Wet Meadow (24%), Tapped Lake with High-water Connection (19%), and Grass Marsh (7%). The largest Glaucous Gull colony (20 nests) was located primarily on a large island classified as Patterned Wet Meadow. The remaining nests were found on islands or complex shorelines in 5 other habitats.

LITERATURE CITED

Brettschnieder, B. 2016. The new winter severity index in Alaska. Pages 1–5 *in* Alaska Climate Dispatch, Winter 2015–16. <https://accap.uaf.edu/winter_2015_16_Dispatch>. Accessed 12 December 2016.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2002. Wildlife studies in the CD South study area, 2001. Second annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 98 pp.

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, P. E. Seiser, A. A. Stickney, and J. R. Rose. 2003. Wildlife studies in the CD South study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 126 pp.

CPAI (ConocoPhillips Alaska, Inc.). 2016. Data management protocols North Slope Field Surveys, Version 9.6.

Johnson, C. B., M. T. Jorgenson, R. M. Burgess, B. E. Lawhead, J. R. Rose, and A. A. Stickney. 1996. Wildlife studies on the Colville River delta, Alaska, 1995. Fourth annual report for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. P. Parrett, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003a. Wildlife studies in the CD North study area, 2002. Third annual report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 104 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. Neville, J. P. Parrett, A. K. Prichard, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003b. Alpine Avian Monitoring Program, 2001. Fourth annual and synthesis report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 194 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P. E. Seiser, B. E. Lawhead, T. J. Mabee, J. R. Rose, and J. E. Shook. 2004. Wildlife studies for the Alpine Satellite Development Project, 2003. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 155 pp.

Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P.E. Seiser, B. E. Lawhead, T. J Mabee, A. K. Prichard, and J. R. Rose. 2005. Wildlife studies for the Alpine Satellite Development Project, 2004. Second annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 129 pp.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2008a. Spectacled Eider monitoring at the CD-3 development, 2007. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and J. E. Shook. 2008. Avian studies for the Alpine Satellite Development Project, 2007. Fifth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and A. A. Stickney. 2009. Avian studies for the Alpine Satellite Development Project, 2008. Sixth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and T. Obritschkewitsch. 2010. Avian studies for the Alpine Satellite Development Project, 2009. Seventh annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 71 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and P.E. Seiser. 2011. Avian studies for the Alpine Satellite Development Project, 2010. Eighth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 69 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and P.E. Seiser. 2012. Avian studies for the Alpine Satellite Development Project, 2011. Ninth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 91 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, T. Obritschkewitsch, and P.E. Seiser. 2013. Avian studies for the Alpine Satellite Development Project, 2012. Tenth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 92 pp.

Johnson, C. B., A. M. Wildman, A. K. Prichard, and C. L. Rea. 2014a. Yellow-billed Loon territory occupancy near a new oil development. Report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 27 pp.

Johnson, C. B., J. P. Parrett, T. Obritschkewitsch, J. R. Rose, K. B. Rozell, P. E. Seiser, and A. M. Wildman. 2014b. Avian studies for the Alpine Satellite Development Project, 2013. Eleventh annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 115 pp.

Johnson, C. B., J. P. Parrett, T. Obritschkewitsch, J. R. Rose, K. B. Rozell, and P. E. Seiser. 2015. Avian studies for the Alpine Satellite Development Project, 2014. Twelfth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 124 pp.

Johnson, C. B., J. P. Parrett, J. R. Rose, and P. E. Seiser. 2016. Avian studies for the Alpine Satellite Development Project, 2015. Thirteenth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 47 pp.

Jorgenson, M. T., J. E. Roth, E. R. Pullman, R. M. Burgess, M. Raynolds, A. A. Stickney, M. D. Smith, and T. Zimmer. 1997. An ecological land survey for the Colville River delta, Alaska, 1996. Report for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 160 pp.

Michael Baker Jr., Inc. 2016. Colville River delta spring breakup monitoring and hydrological assessment. Report for ConocoPhillips Alaska, Inc., Anchorage, AK, by Michael Baker, Jr., Inc., Anchorage, AK.

Morgan, T. C., and L. B. Attanas. 2017. Eider surveys in the Kuparuk Oilfield, 2016. Data report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Natural Resources Conservation Service. 2016. Alaska Snow Survey Report May 1, 2016. USDA, Palmer Alaska. 35 pp

North, M. R., and M. R. Ryan. 1989. Characteristics of lakes and nest sites used by Yellow-billed Loons in arctic Alaska. Journal of Field Ornithology 60:296–304.

Parrett, J., A. Wildman, and C. Johnson. 2008. Using evidence found at the nest to judge nest fate for Yellow-billed Loons (*Gavia adamsii*). Page 35 *in* Proceedings of the 2008 Alaska Bird Conference, 3–7 March 2008, Fairbanks, AK. [abstract only]

Rozell, K. B., and C. B. Johnson. 2016. Nesting Greater White-fronted Goose study at CD-5, 2015. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Seiser, P. E., and C. B. Johnson. 2010. Eider nest searches at the CD-3 pad, ice road, and spill-response sites on the Colville delta, 2009. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Seiser, P. E., and C. B. Johnson. 2011a. Eider nest searches at the CD-3 pad, ice road, spill-response sites, and pipeline bridges on the Colville River delta, 2010. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Seiser, P. E., and C. B. Johnson. 2011b. Eider nest searches at the CD-3 pad, ice road, and spill-response sites on the Colville River delta, 2011. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 14 pp.

Seiser, P. E., and C. B. Johnson. 2012. Eider nest searches at the CD-3 pad, ice road, and spill-response sites on the Colville River delta, 2012. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 14 pp.

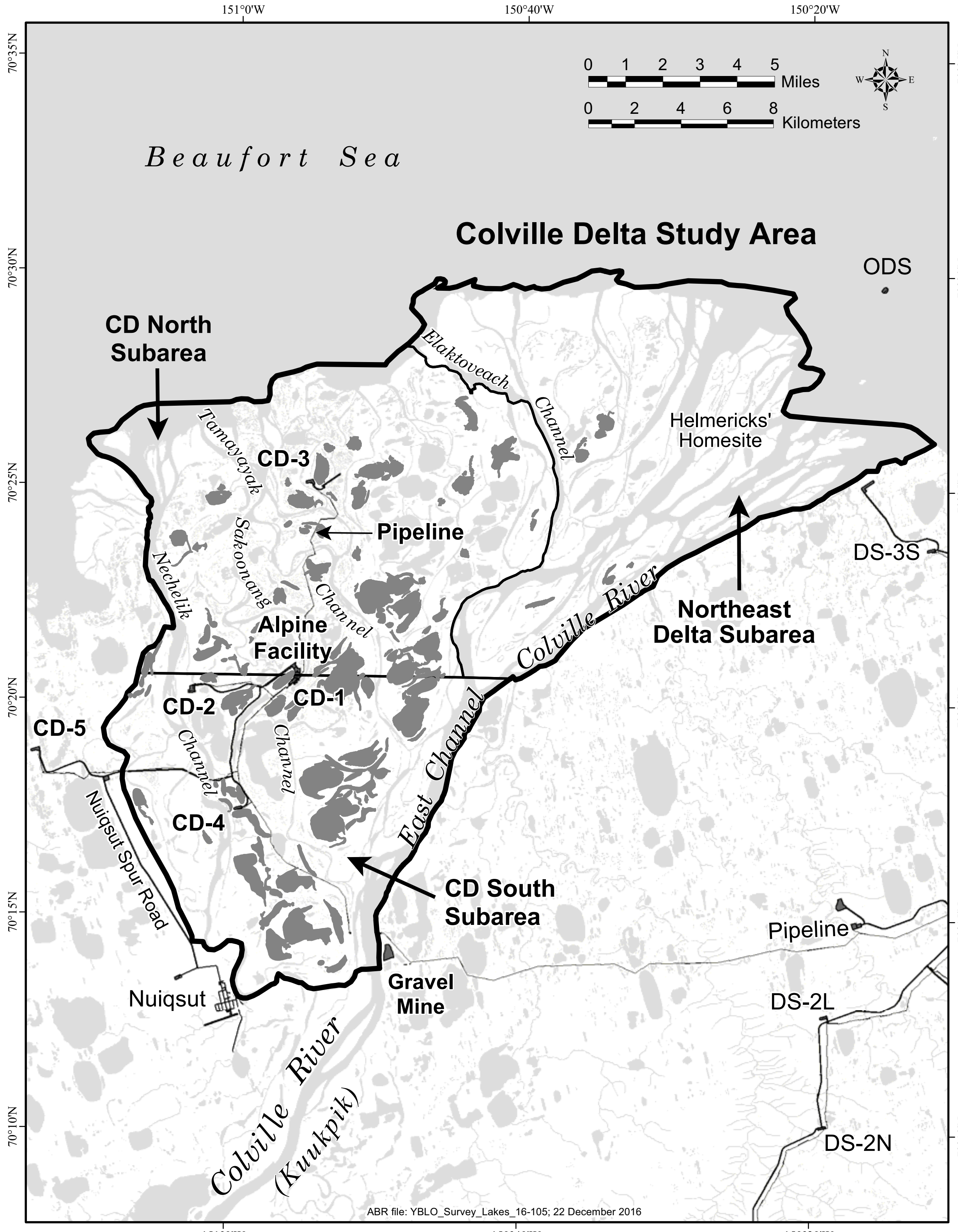
Seiser, P. E., and C. B. Johnson. 2014a. Eider nest searches at the CD-3 pad, ice road, and spill-response sites on the Colville River delta, 2013. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 13 pp.

Seiser, P. E., and C. B. Johnson. 2014b. Eider nest searches at CD-3, spill-response sites, and the CD-3 and CD-5 ice roads, in the Alpine Oilfield, 2014. Report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 16 pp.

USFWS (U.S. Fish and Wildlife Service). 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. Unpublished report by the Migratory Bird and Habitat Research Laboratory, Patuxent Wildlife Research Center, Laurel, MD. 96 pp.

Wilson, H. M., W. W. Larned, and M. A. Swaim. *In prep*. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2012–2016. Unpublished report by U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska.

Wendler, G., B. Moore, and K. Galloway. 2016. Spring 2016 weather conditions in Alaska. Pages 20–23 *in* Alaska Climate Dispatch, Winter 2015–16. <https://accap.uaf.edu/winter_2015_16_Dispatch>. Accessed 12 December 2016.



Appendix A. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta study area, Alaska, 2016.

Appendix B. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2016.

SPECIES Subarea Location	Observed				Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
	Males	Females	Total	Pairs			
SPECTACLED EIDER							
CD North							
On ground	36	27	63	23	75	0.30	0.36
In flight	6	3	13	2	–	0.06	–
All birds	42	30	76	25	–	0.37	–
Northeast Delta							
On ground	7	3	10	3	14	0.06	0.09
In flight	0	0	2	1	–	0.01	–
All birds	7	3	12	4	–	0.08	–
CD South							
On ground	0	0	0	0	0	0.00	0.00
In flight	0	0	0	0	–	0.00	–
All birds	0	0	0	0	–	0.00	–
Total (subareas combined)							
On ground	43	30	73	26	89	0.15	0.18
In flight	6	3	15	3	–	0.03	–
All birds	49	33	88	29	–	0.18	–
KING EIDER							
CD North							
On ground	13	10	23	10	26	0.11	0.13
In flight	0	0	4	2	–	0.02	–
All birds	13	10	27	12	–	0.13	–
Northeast Delta							
On ground	16	14	42	20	44	0.27	0.28
In flight	1	2	5	1	–	0.03	–
All birds	17	16	47	21	–	0.30	–
CD South							
On ground	4	4	8	3	9	0.06	0.07
In flight	0	0	0	0	–	0.00	–
All birds	4	4	8	3	–	0.06	–
Total (subareas combined)							
On ground	33	28	73	33	79	0.15	0.16
In flight	1	2	9	3	–	0.02	–
All birds	34	30	82	36	–	0.16	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a).
[b] Density based on 100% coverage of subareas: CD North = 206.7 km²; Northeast Delta = 157.6 km², CD South = 137.2 km², all subareas combined = 501.4 km²; numbers not corrected for sightability.

Appendix C. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta study area, Alaska, 2016.

STUDY AREA / Subarea[b] / Survey Type	Yellow-billed Loon					Pacific Loon[a]			Red-throated Loon[a]		
	Number			Density (number/km²)		Number			Number		
	Adults	Nests/ Brood	Young	Adults	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
COLVILLE DELTA											
CD North											
Nesting	32	11	–	0.15	0.05	69	16	–	11	0	–
Brood-rearing	26	5[c]	5	0.13	0.02	63	12	13	5	0	0
CD South											
Nesting	33	6	–	0.21	0.04	45	13	–	3	0	–
Brood-rearing	15	5[c]	5	0.10	0.03	21	1	1	2	0	0
Northeast Delta[d]											
Nesting	3	1	–	–	–	8	1	–	2	0	–
Brood-rearing	2	1[e]	1	–	–	1	0	0	0	0	0
Total (subareas combined)[f]											
Nesting	68	18	–	0.18	0.05	122	30	–	16	0	–
Brood-rearing	43	11	11	0.11	0.03	85	13	14	7	0	0

[a] Densities of Pacific and Red-throated loons were not calculated because detectability differed from that of Yellow-billed Loons and surveys did not include smaller lakes (<5 ha) where those species commonly nest.
[b] CD North = 206.7 km², CD South = 155.9 km²; see Figure 7.
[c] Number includes 2 broods (assume 1 young each) determined only by eggshell evidence.
[d] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed.
[e] Number includes 1 brood (assume 1 young) determined only by eggshell evidence.
[f] Total is the sum of all subareas but density calculations included only CD North and CD South for Colville Delta.

Appendix D. Annual density (number/km²) of Yellow-billed Loons, nests, and broods in the CD North and South subareas, Colville Delta study area, Alaska, 1993–2016.

STUDY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.02 (0.04)	0.08	0.02
1995	0.11	0.03 (0.05)	0.14	0.02
1996	0.12	0.03 (0.05)	0.17	0.02
1997	0.13	0.03 (0.04)	0.18	0.01
1998	0.09	0.04 (0.06)	0.14	0.03
2000	0.15	0.04 (0.04)	0.04	0.01
2001	0.15	0.05 (0.05)	0.07	0.01
2002	0.13	0.05 (0.06)	0.18	0.02
2003	0.14	0.07 (0.07)	0.13	0.04
2004	0.11	0.07 (0.07)	0.14	0.03
2005	0.15	0.08 (0.08)	0.10	0.04 (0.05)
2006	0.17	0.06 (0.07)	0.18	0.03 (0.04)
2007	0.17	0.07 (0.08)	0.14	0.05 (0.06)
2008	0.18	0.09 (0.10)	0.15	0.06 (0.07)
2009	0.17	0.07 (0.08)	0.15	0.02 (0.03)
2010	0.18	0.06 (0.09)	0.16	0.04 (0.04)
2011	0.19	0.06 (0.07)	0.12	0.03 (0.04)
2012	0.15	0.06 (0.08)	0.14	0.03 (0.04)
2013	0.18	0.03 (0.04)	0.11	0.02 (0.02)
2014	0.22	0.07 (0.09)	0.13	0.01 (0.02)
2015	0.16	0.05 (0.06)	0.15	0.02 (0.03)
2016	0.18	0.05 (0.05)[d]	0.11	0.02 (0.03)
Mean	0.15	0.05 (0.08)[e]	0.13	0.03 (0.04)
SE	<0.01	<0.01 (<0.01)[e]	<0.01	<0.01 (<0.01)

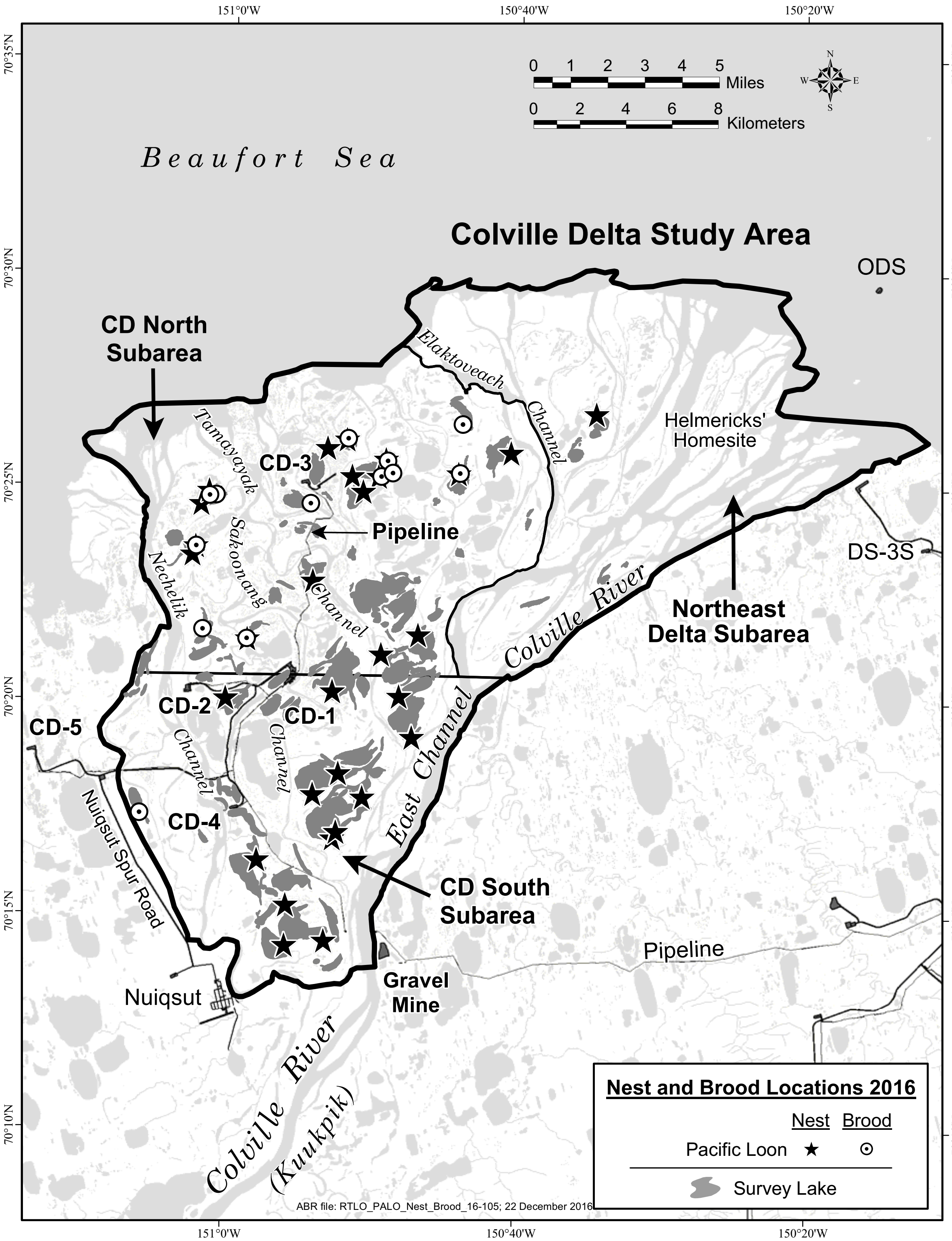
[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found during revisit (1996–2002), monitoring (2006–2014), and early nest surveys (2011, 2012, 2014), early camera monitoring (2013–2015), and nests inferred from the presence of broods where no nest was found during other surveys (1993–2016).

[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods found during monitoring surveys (2005–2014) or inferred from eggshell fragments at the nest (2008–2016).

[c] Colville Delta study area = 362.6 km² and includes CD North and CD South subareas combined.

[d] No additional surveys were conducted for nests.

[e] Mean density and SE with additional nests and broods includes only years when monitoring surveys were conducted: 2006–2014 for nests, 2005–2014 for broods.



Appendix E. Pacific Loon nests and broods, Colville Delta study area, Alaska, 2016.