AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2012

TENTH ANNUAL REPORT

CHARLES B. JOHNSON
ANN M. WILDMAN
JULIE P. PARRETT
JOHN R. ROSE
TIM OBRITSCHKEWITSCH
PAMELA E. SEISER

PREPARED FOR

CONOCOPHILLIPS ALASKA, INC.
ANCHORAGE, ALASKA

AND

ANADARKO PETROLEUM CORPORATION
ANCHORAGE, ALASKA

PREPARED BY

ABR, INC.–ENVIRONMENTAL RESEARCH & SERVICES
FAIRBANKS, ALASKA

Front cover:
Incubating adults, top to bottom:
Spectacled Eider
Red-throated Loon
Brant
Sabine’s Gull
Greater White-fronted Goose

In water:
Red-necked Phalarope

Back cover:
Standing, Spectacled Eider female
In water, Brant

Cover photos © ConocoPhillips Alaska, Inc.
All rights reserved.

AVIAN STUDIES FOR THE ALPINE SATELLITE DEVELOPMENT PROJECT, 2012
TENTH ANNUAL REPORT

Prepared for

ConocoPhillips Alaska

P.O. Box 100360

Anchorage, AK 99510

and

Anadarko Petroleum Corporation

3201 C Street, Suite 603

Anchorage, AK 99503

Prepared by

Charles B. Johnson

Ann M. Wildman

Julie P. Parrett

John R. Rose

Tim Obritschkewitsch

Pamela E. Seiser

ABR, Inc.—Environmental Research & Services

P.O. Box 80410

Fairbanks, AK 99708

March 2013

Printed on recycled paper.

EXECUTIVE SUMMARY

Aerial surveys of bird populations were conducted in the Colville Delta and in the northeastern National Petroleum Reserve–Alaska (NE NPRA) in 2012 in support of the Alpine Satellite Development Project (ASDP) for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation. The surveys continued long-term data acquisition begun in 1992 on the Colville Delta and in 1999 in the NE NPRA. Surveys focused on the abundance, distribution, and habitat use of 5 focal species groups: Spectacled Eider, King Eider, Tundra Swan, Yellow-billed Loon, and geese. These 5 taxa were selected because of 1) threatened or sensitive status, 2) indications of declining populations, 3) restricted breeding range, and/or 4) concern of regulatory agencies regarding development impacts. Monitoring a collection of focal species with differing habitat requirements provides both in-depth data on species trends and responses to a changing environment and a general view of ecosystem health. Aerial surveys for eiders, swans, and geese were conducted from a fixed-wing airplane. Surveys for Yellow-Billed Loons were conducted from a helicopter.

The Colville Delta study area (552 km²) encompassed the entire delta from the East Channel of the Colville River to the westernmost distributary of the Niġliq Channel. The Alpine Facility (CD-1 and CD-2) began oil production on the Colville Delta in 2000. Two ASDP satellite drill sites were built in the winter of 2005: CD-3 was built as a roadless drill site to reduce its gravel footprint in Spectacled Eider (a federally listed threatened species) breeding habitat on the outer delta, and CD-4 was connected by a road on the south side of the Alpine Facility. The CD-3 site began producing oil in August 2006, and CD-4 began producing in November 2006. The NE NPRA study area (reduced in size to 322 km² in 2011–2012) abuts the western edge of the Colville Delta and encompasses 2 proposed development sites that are part of the ASDP: drill site CD-5 and the Clover A gravel mine site.

Most years, open houses were held in Nuiqsut to allow residents to visit with CPAI biologists and other scientists to discuss information and concerns about resources in the Colville Delta and NE NPRA areas. In October 2010, CPAI staff attended a science fair at the local school during the day, followed by a community meeting in the evening where they presented findings of recent monitoring efforts. During the summer field season in 2012, CPAI sent weekly updates to the Department of Wildlife of the North Slope Borough, various state and federal agencies, several environmental organizations, and key representatives of the Kuukpik Subsistence Oversight Panel (KSOP) and Kuukpik Corporation for distribution in Nuiqsut. The updates reported on surveys conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and the schedule of surveys for the upcoming week. Chris Long, a Nuiqsut resident flew along on several aerial surveys in 2011, providing assistance to our wildlife biologists and serving as a liaison between wildlife studies and the local community. CPAI also attends meetings with the Kuukpik Corporation board of directors twice annually. Attendance at open houses and board meetings, hiring subsistence representatives as part of the Studies program, and providing weekly updates are all strategies intended to keep local residents informed of study results as well as to provide opportunities for input on research designs for studies conducted in the area near Nuiqsut.

Results of aerial surveys in the Colville Delta study area in 2012 indicated that abundance of Yellow-billed Loons, Tundra Swans, Snow Geese, and Glaucous Gulls was above average, and abundance of Spectacled and King eiders and Brant was about average. Productivity in the Colville Delta study area was notably high for Snow Geese and Glaucous Gulls, but for the other species productivity was average or below average. In the NE NPRA study area, abundance of King Eiders, Yellow-billed Loons, and Snow Geese was above average, while abundance of Brant, Spectacled Eiders, and Tundra Swans was about average. Productivity was high for Snow Geese and Yellow-billed Loons in the NE NPRA study area in 2012, and low for Brant and Tundra Swans. A smaller area was surveyed in the NE NPRA study area in 2011 and 2012 when compared with previous years.

Spring weather was cool in mid-May through early June. Monthly temperatures for May and June were near average. Cumulative thawing

degree-days (an index to days with temperatures above freezing) were below the long-term means for the last half of May and the first half of June. Water levels on the Colville River peaked twice during the 2012 breakup season; the higher peak occurred on 27 May followed by a lower peak on 2 June. The peak water level on 27 May was below average and occurred 4 days earlier than normal (31 May). Peak discharge was above average and occurred on 1 June, only 1 day later than average. On 4 June, ice broke-up on the Colville River all the way to the ocean, slightly later than the average break-up date (1 June).

The indicated number of pre-nesting Spectacled Eiders on the Colville Delta in 2012 was slightly above the mean recorded over 19 years. As in previous years, Spectacled Eiders were found primarily in the CD North subarea. Some of the highest counts of Spectacled Eiders have been recorded on the Colville Delta study area over the last 5 years, reversing the depressed numbers recorded in this area during the early 2000s. The long-term trend for Spectacled Eiders on the Colville Delta is slightly positive whereas the trend for the entire Arctic Coastal Plain is slightly negative. Neither trend is significantly different from equilibrium, however, indicating the population likely is stable. During 2012, Spectacled Eiders in the NE NPRA also were recorded in average numbers, but as is typical, they occurred at <20% of the density found on the Colville Delta study area. Spectacled Eiders preferred 7 habitats on the Colville Delta study area, all consistent with their primarily coastal distribution: 3 coastal salt-affected habitats, 3 aquatic habitats, and 1 terrestrial habitat. Spectacled Eiders in the NE NPRA preferred 4 habitats, 3 of which were also preferred on the Colville Delta.

King Eiders were about half as numerous as Spectacled Eiders during pre-nesting on the Colville Delta in 2012 with densities below the long-term average. Annually we record high numbers of King Eiders on the Colville Delta in habitats unsuitable for nesting, particularly the eastern channels of the Colville River. Those records during pre-nesting and the low frequency of King Eider nests relative to Spectacled Eider nests in areas searched, lead us to conclude that King Eiders primarily use the Colville Delta as a stopover while moving to breeding areas farther east. In contrast, King Eiders breed in high numbers in the NE NPRA study area; in 2012 the density of King Eiders in the NE NPRA study area was about 13 times the density in the Colville Delta study area.

Fifty-nine Yellow-billed Loons were observed during the nesting survey in the Colville Delta study area in 2012 and 52 adults were observed during the brood-rearing survey, both of which were slightly above the 18-year mean. Thirty-two Yellow-billed Loon nests were found in 2012, which was the third highest number of nests found in the Colville Delta study area during 18 years of surveys. Two renesting attempts were recorded. Seventeen Yellow-billed Loon broods were found in the Colville Delta study area in 2012, which was above the 18-year mean.

In the NE NPRA study area, we recorded 18 Yellow-billed Loon nests and 12 broods. The numbers of nests and broods found in the Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas all were above average.

Most Yellow-billed Loon nests hatched between surveys on 11 and 19 July, which is similar to the timing of hatch in most years when nest monitoring occurred. In the Colville Delta study area, apparent nesting success was 53%, which was below the 8-year mean (58.7%). In the NE NPRA study area, apparent nesting success was 67%, which was the highest since nest monitoring surveys began in that area in 2008.

Despite below average nesting success and chick production at hatch on the Colville Delta in 2012, Yellow-billed Loon chick survival was high and the number of chicks was near average at the end of monitoring. During the monitoring surveys immediately post-hatch in 2012, 14 Yellow-billed Loon pairs and 17 chicks (0.83 chicks/nest) were observed in the Colville Delta study area. In the NE NPRA study area, 4 pairs and 6 chicks were observed (0.78 chicks/nest). On the last brood monitoring survey on 19 September, 3 pairs in the Colville Delta study area each had 2 chicks and 11 pairs each had 1 chick (0.53 chicks/nest). In the NE NPRA study area, all chicks observed survived to the final monitoring survey. Loon chicks in both study areas were 8–10 weeks old during the last monitoring survey and none were observed flying.

Nineteen Yellow-billed Loon nests on the Colville Delta were monitored with time-lapse cameras. Eighteen loons left nests during camera installation. Eleven nests were monitored with cameras in the NE NPRA study area and 10 loons left nests during camera installation. At least 29 loons returned to their nests after camera installation. The camera at 1 nest malfunctioned ~4 min after setup. Apparent nesting success for camera-monitored nests on the Colville Delta and NE NPRA was 52% and 81%, respectively. Of the 9 nests that failed in the Colville Delta study area, 3 failures were attributed to predation by Glaucous Gulls and 2 to red foxes; the predator was not captured on images at 4 failed nests. Of the 2 nests that failed in the NE NPRA study area, 1 was attributed to Parasitic Jaegers and 1 to a Golden Eagle. Yellow-billed Loons at hatched nests exhibited slightly higher nest attendance than those at failed nests, spending 97.6% and 96.3% of monitored time on nests, respectively. Similar nest attendance was recorded at hatched and failed nests in the NE NPRA study area (97.9 and 95.7%, respectively).

Thirteen nests and 20 broods of Pacific Loons were counted incidentally during Yellow-billed Loon surveys in the Colville Delta study area in 2012. In the NE NPRA study area, we counted 5 nests and 16 broods of Pacific Loons. Red-throated Loon adults were observed in both study areas, but no nests or broods were found because of the greater difficulty at detecting them from the air.

Swan productivity was average in 2012. Forty Tundra Swan nests were found in the Colville Delta study area, well above the 19-year mean of 34 nests/year, but nesting success (58%) was below average. Both number of broods and brood size in the Colville Delta study area were below long-term averages. In the NE NPRA study area, 19 Tundra Swan nests were found in June and 12 broods were seen in August, for an apparent nesting success of 63%; along with low nesting success, swans in NE NPRA also had small brood sizes.

Brant productivity was low in the Colville Delta and NE NPRA study areas in 2012. The count of adult Brant during brood-rearing surveys in the Colville Delta (776) was near average, but the number of goslings (369) was the fourth lowest ever recorded along the survey route. Similarly, the count of adult Brant during brood-rearing surveys in the NE NPRA study area (1,410) was near average, but the gosling count (274) was the lowest on record. In contrast to Brant, Snow Goose productivity was high in both study areas in 2012. In the Colville Delta, the total count of Snow Geese (4,035) and the number of adult Snow Geese (2,009) were the highest ever recorded. The number of goslings (2,026) was nearly twice the average since 2005, and was the second highest ever recorded in the study area. In the NE NPRA study area, the total count of Snow Geese (626) and the number of adult Snow Geese (289) were the highest ever recorded, and the number of goslings (337) was the second highest on record. Brant and Snow Geese favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta and NE NPRA study areas.

The number of Glaucous Gull nests and broods in the Colville Delta study area in 2012 was the highest in 13 years of records. Seventy-three Glaucous Gull nests were counted during loon aerial surveys in the Colville Delta study area in 2012. The number of nests in the CD North subarea was higher than the number recorded in any of the previous 12 years. All traditional nest locations were occupied in the CD North subarea and new nest locations were found. A new colony of 5 nests was observed north of the CD-3 drill pad where in past years only 1 or 2 nests had been observed. Based on 50 lakes monitored annually in the Colville River study area, the number of Glaucous Gull nests increased at a significant annual rate between 2002 and 2012.

In the NE NPRA study area, we found 25 Glaucous Gull nests in 2012. Seventeen of the 25 nests were in the Alpine West subarea, 14 of which were at 2 colony locations. One Sabine’s Gull colony of 3 nests and 2 separate nesting pairs were found in the NE NPRA study area during the loon nesting survey. No Sabine’s Gull nests were found in the Colville Delta study area.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGMENTS

A number of people contributed to the success of the 2012 avian studies in the Colville Delta and NE NPRA study areas. We thank our airplane pilots, Sandy Hamilton and Robert Eubank of Arctic Air Alaska, for keeping aerial surveys safely on course. Pilots Rory Kirkendall and Don Herbert of Bristow Alaska Inc. safely conducted the helicopter surveys. On the ground, Erik Burney and Ray Rush coordinated the helicopter flights. Justin Blank of Weston solutions provided all manners of logistical support before and during fieldwork. Alex Prichard and Joe Welch served as observers on swan nest and brood surveys. In our Fairbanks office, Allison Zusi-Cobb, Will Lentz, Matt Macander, Dorte Dissing, and Pam Odom provided expert support in data analysis, figure production, and report preparation. Matt Appling, Kristen Bartecchi-Rozell, Davya Flaherty, and Lauren Attanas helped review thousands of time-lapse camera images. Lauren Attanas digitized swan nest locations. In all phases of this study, we were assisted by our tireless expeditors, Tony LaCortiglia and Davya Flaharty. This study was funded by ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation and was administered by Caryn Rea, Senior Staff Biologist and Environmental Studies Coordinator for ConocoPhillips Alaska. We especially thank Caryn Rea for supporting the continuation of these long-term monitoring studies, the benefits of which are being realized in other biological studies, in past and future National Environmental Protection Act (NEPA) documents, in species status reviews, Section 7 consultations, and in permit applications. We appreciate the review and comments on this report made by Caryn Rea and ABR’s Bob Burgess. We thank all the other ConocoPhillips Alaska staff and contractors in the Alpine oilfield for their assistance in making 2012 a successful field season.

INTRODUCTION

The Colville River delta and Northeast Planning Area of the National Petroleum Reserve–Alaska (NE NPRA) have been a focal point of recent exploration and development for oil and gas since at least the 1990s. During 2012, ABR, Inc., conducted wildlife surveys for selected birds and mammals in the Colville River delta and NE NPRA in support of the Alpine Satellite Development Project (ASDP) of ConocoPhillips Alaska, Inc. (CPAI) and Anadarko Petroleum Corporation (APC). The avian studies in 2012 were a continuation of work initiated by CPAI's predecessors, ARCO Alaska, Inc., and Phillips Alaska, Inc., on the Colville River delta in 1992 (Smith et al. 1993, 1994; Johnson 1995; Johnson et al. 1996, 1997, 1998, 1999a, 1999b, 2000a, 2000b, 2001, 2002, 2003a, 2003b, 2004, 2005, 2006a, 2006b, 2007a, 2007b, 2008b, 2009, 2010, 2011, 2012; Burgess et al. 2000, 2002a, 2003a) and in the NE NPRA in 1999 (Anderson and Johnson 1999; Murphy and Stickney 2000; Johnson and Stickney 2001; Burgess et al. 2002b, 2003b; Johnson et al. 2004, 2005, 2006b, 2007b, 2009, 2010, 2011). Avian surveys in the NE NPRA were interrupted in 2007 due to delays in permitting for the CD-5 drill site. Permits for CD-5 still were unapproved in 2010; consequently, surveys were conducted in NE NPRA only for Spectacled Eiders and Yellow-billed Loons in 2010, because of their sensitive status under the Endangered Species Act. In 2011 and 2012, we resumed surveys for Tundra Swans, geese, and gulls along with eiders and Yellow-billed Loons, but those surveys were conducted only in the eastern portion of the study area.

The ASDP studies augment long-term wildlife monitoring programs that have been conducted by CPAI (and its predecessors) across large areas of the central Arctic Coastal Plain (ACP) since the early 1980s (see Murphy and Anderson 1993, Stickney et al. 1993, Stickney et al. 2012, Lawhead and Prichard 2012). The primary goal of wildlife investigations in the region since 1992 has been to describe the seasonal distribution and abundance of selected species before, during, and after construction of oil development projects. CPAI began producing oil on the Colville River delta in 2000 with the development of the CD-1 and CD-2 drill sites. Production was augmented in 2006 with construction of the CD-3 and CD-4 drill sites. CPAI has proposed additional oil and gas development sites in NE NPRA as part of the Alpine Satellite Development Project (BLM 2004) at CD-5 (Alpine West) (Figure 1). Readers are directed to prior reports for wildlife information from previous years.

In this report we present the results of avian surveys that were conducted in the Colville River delta and NE NPRA in 2012 along with brief comparisons of results from previous years and other surveys. The surveys were designed to collect data on the distribution, abundance, and habitat use of 5 focal taxa (common names followed by Iñupiaq names): Spectacled Eider (Qavaasuk), King Eider (Qiŋalik), Tundra Swan (Qugruk), geese (Niġliq), and Yellow-billed Loon (Tuullik) (scientific names and Iñupiaq names are listed in Appendix A). 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. Monitoring a collection of focal species provides in-depth data on individual species trends and responses to a changing environment, as well as a general overview of ecosystem health. Data collection for a suite of indicator species with diverse life histories and habitat needs is an efficient way to monitor a multi-species system without studying all species that breed in the study area. Ground-based surveys for nesting birds were conducted in select areas on the Colville River delta in 2012 as part of other studies (Seiser and Johnson 2012). Required state and federal permits were obtained for authorized survey activities, including a Scientific or Educational Permit (Permit No. 12-023) from the State of Alaska and a Federal Fish and Wildlife Permit—Threatened and Endangered Species [Permit No. TE012155-0 issued under Section 10(a)(1)(A) of the Endangered Species Act (58 FR 27474-27480)]. Similar avian species were monitored in the Kuparuk Oilfield on the eastern border of the Colville River delta in 2012 (Stickney et al. 2013).

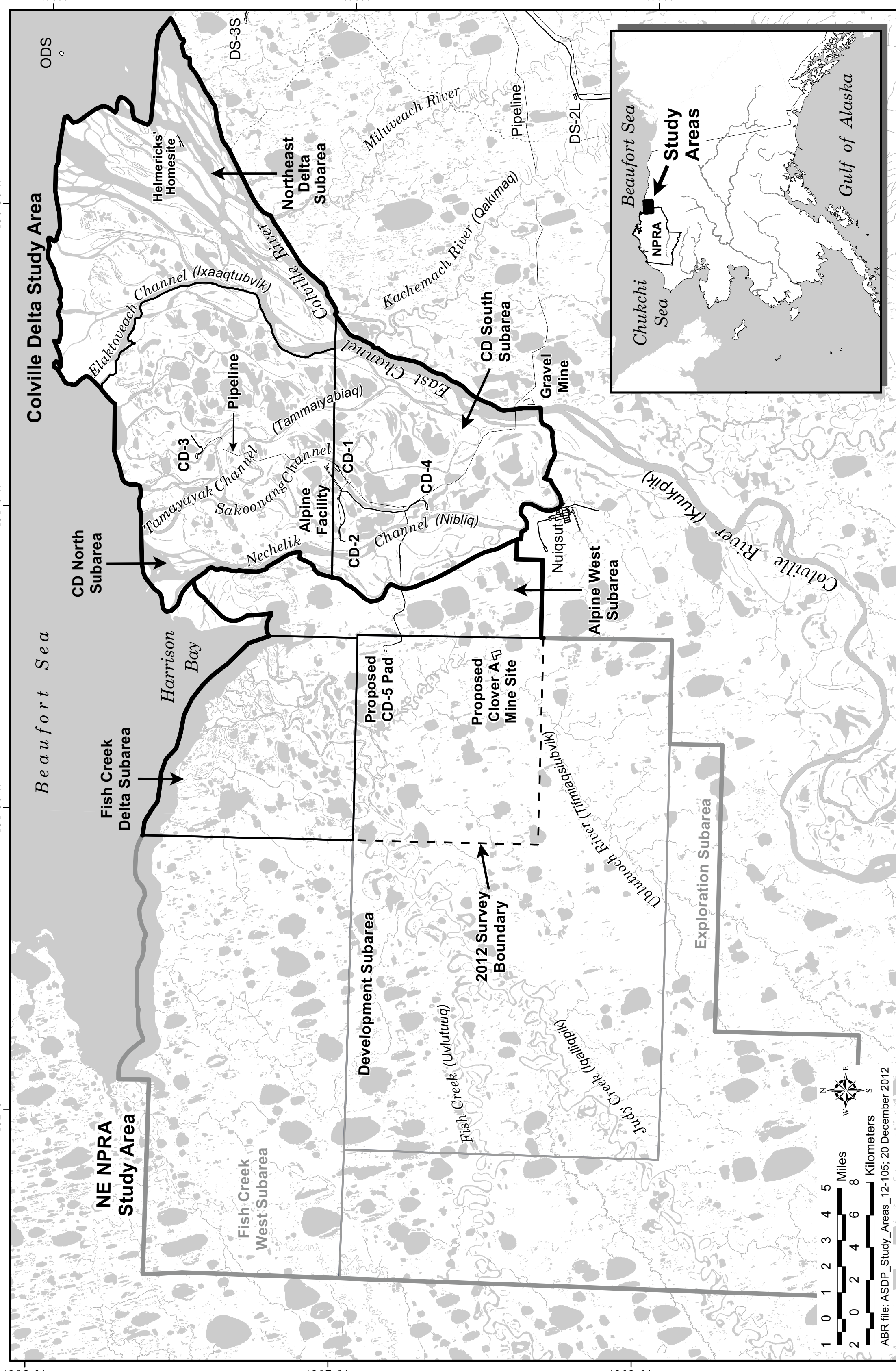


Figure 1. Wildlife study areas and subareas for the Alpine Satellite Development Project, northern Alaska, 2012.

CPAI supported other avian research on the Arctic Coastal Plain in 2012 including a collaborative study of Yellow-billed Loon lake habitat by the University of Alaska Fairbanks, U. S. Geological Survey (USGS), Bureau of Land Management (BLM), and the Alaska Department of Fish and Game and a study of the effects of forage phenology and timing of reproduction on juvenile growth in Brant by USGS.

Wildlife study objectives were developed and study progress was reported through a series of agency and community scoping and planning meetings, beginning in 2001. Annual informational meetings are held in Nuiqsut most years to allow residents to visit with CPAI biologists and other scientists to discuss information and concerns about resources in the Colville Delta and NE NPRA areas. CPAI attends meetings with the Kuukpik Corporation board of directors twice annually to share information on activities on the Colville River delta and in NE NPRA. In October 2010, CPAI staff attended a science fair at the local school during the day, followed by an open community meeting in the evening where they presented findings of recent monitoring efforts. In 2009, CPAI flew the late Joeb Woods, Sr., and Lydia Sovalik, 2 elders from Nuiqsut, and James Taallak as facilitator, to meet with biologists in the study site near Fiord West on 3 July. The elders reviewed the boundaries of their native allotments and described their family histories in the area. The locations of 2 grave sites in the area were discussed, and our study plans were adjusted to stay a respectful distance away from those locations. In many years, a subsistence representative from the village of Nuiqsut has joined biologists on various surveys. In 2011, Nuiqsut resident Chris Long flew along on several aerial surveys, sharing his local knowledge with biologists. During the summer field season in 2012, CPAI emailed weekly updates to the Department of Wildlife of the North Slope Borough, various state and federal agencies, several environmental organizations, and key representatives of the Kuukpik Subsistence Oversight Panel (KSOP) and Kuukpik Corporation for posting in Nuiqsut. The updates reported on surveys conducted the previous week (for example, type of aircraft used, altitude of aircraft, and species enumerated) and provided the schedule of surveys for the upcoming week. The open house meetings and weekly updates kept local residents informed on the progress and results of studies conducted by CPAI in the area near Nuiqsut.

STUDY AREA

The place names used throughout this report are those depicted on USGS 1:63,360-scale topographic maps, because they are the most widely available published maps of the region. The corresponding local Iñupiaq names for drainages (and wildlife species) are provided in parentheses at the first usage in text and on the study area map (Figure 1). Iñupiaq names are presented out of respect for local residents, to facilitate clear communication with Iñupiaq speakers, and because they pre-date the English names used on USGS maps. We acknowledge that the Iñupiaq names presented are not comprehensive, and we recognize that the published USGS names for some streams (notably the Ublutuoch and Tingmeachsiovik rivers) do not correctly reflect local usage. The Iñupiaq names we use for Fish and Judy creeks in NE NPRA are taken from the Iñupiat–English Map of the North Slope Borough (NSB Planning Department, Barrow, Alaska, May 1997). Additional information was supplied to CPAI in recent years by Nuiqsut elders. Even in cases where USGS attempted to use the correct Iñupiaq names, the anglicized spellings are outdated and so have been corrected to the modern Iñupiaq spellings through consultation with Emily Ipalook Wilson and Dr. Lawrence Kaplan of the Alaska Native Language Center (ANLC) at the University of Alaska Fairbanks. Marjorie Kasak Ahnupkanna and Archie Ahkiviana were consulted to confirm the names of channels on the Colville River delta (E. Wilson, ANLC, pers. comm.).

COLVILLE DELTA

The Colville River delta (henceforth, Colville Delta) is one of the most prominent and important landscape features on the ACP of Alaska, both because of its large size and because of the concentrations of birds, mammals, and fish that are found there. Two permanent human settlements occur on the Colville Delta—the Iñupiat village of Nuiqsut (population ~400) established in 1973 and Helmericks' family home site established in the 1950s, also known as "Colville Village".

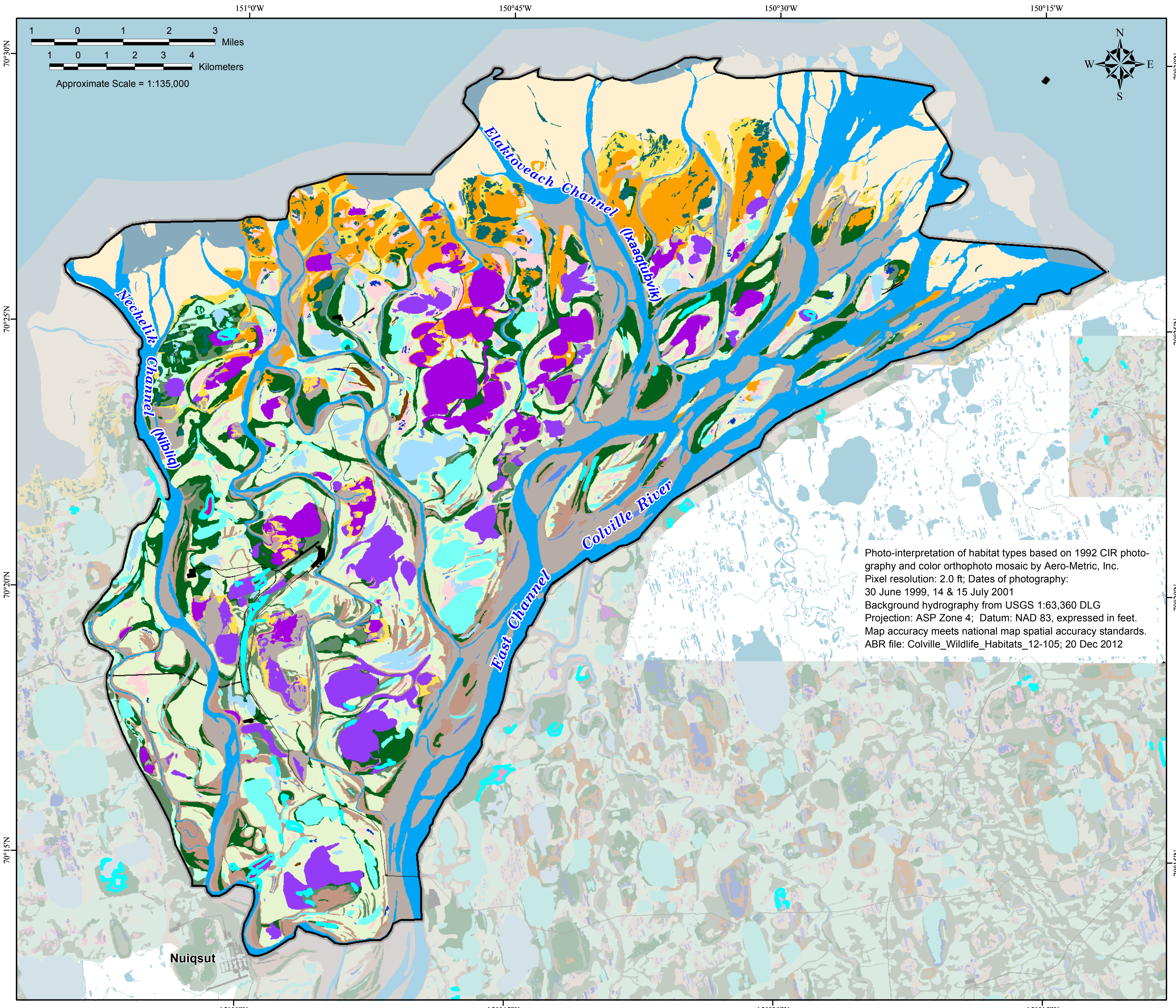
Oil development on the Colville Delta began in 1998 with construction of the Alpine Facility, a roadless oilfield including a full-production facility (comprising a processing plant, camp, airstrip, and the CD-1 and CD-2 drill sites) (Figure 1). Oil began flowing from Alpine east through the pipeline to Kuparuk in 2000. In 2005, construction began on 2 satellite drill sites, whose oil is also processed at Alpine. The CD-3 satellite is a roadless drill site accessible by aircraft and boat during the summer and fall and by ice roads during winter. Drilling at this satellite is conducted only during the winter months when ice roads are used for access. The CD-4 satellite is connected to Alpine by an all-season road. Both the CD-3 and CD-4 drill sites began producing oil in 2006.

Landforms, vegetation, and wildlife habitats in the Colville Delta were described in the Ecological Land Survey (Jorgenson et al. 1997), and the resulting habitat map was updated in 2004 to unify it with similar mapping of the surrounding Coastal Plain (Figure 2).

Coastal and riverine landforms dominate the delta. Fluvial processes are most prominent, although eolian and ice-aggradation processes are important to landscape development, as are lacustrine and basin-drainage processes. Of the 26 wildlife habitat types identified on the delta, 4 habitats are clearly dominant (Figure 2, Table 1): Patterned Wet Meadow (19% of the entire delta), River or Stream (15%), Barrens (14%), and Tidal Flat Barrens (11%). No other habitats comprise more than 8% of the delta. Aquatic habitats are a major component of the delta, comprising 33% of the total area. Coastal salt-affected habitats—Tidal Flat Barrens, Salt-killed Tundra, Salt Marsh, Moist Halophytic Dwarf Shrub, Open Nearshore Water, and Brackish Water—together compose 21% of the total area and contribute greatly to avian diversity. Tapped lakes (Tapped Lake with Low-water Connection and Tapped Lake with High-water Connection, so named because their connections to river channels are dependent on river levels) are unique to delta environments and also are important to the physical and biological diversity of the delta, although they occupy slightly less than 8% of the total area. Other important habitats for birds are those that contain emergent aquatic vegetation (Deep Polygon Complex, Grass Marsh, and Sedge Marsh) and waterbodies with islands or complex shorelines (Deep Open Water with Islands or Polygonized Margins and Shallow Open Water with Islands or Polygonized Margins), which account for a combined total of <5% of the delta. Wildlife habitat types are described in Appendix B. A strong north–south gradient occurs across the delta in the distribution of many of these habitats, with coastal habitats—Salt Marsh, Salt-killed Tundra, Brackish Water, and to a lesser extent, Deep Polygon Complex—decreasing in abundance with increasing distance from the coast, whereas Tapped Lakes with High-water Connections, Sedge Marsh, Grass Marsh, Patterned Wet Meadow, Moist Sedge-Shrub Meadow, and the non-halophytic shrub types are more prevalent away from the coast. These patterns of habitat distribution have strong effects on the distribution and abundance of various wildlife species in the delta.

As mentioned above, lakes and ponds are dominant physical features of the Colville Delta. The most abundant waterbodies on the delta are polygon ponds, which generally are shallow (i.e., ≤2 m deep), freeze to the bottom during winter, and thaw by June. Deep ponds and lakes (>2 m deep) with steep, vertical sides are more common on the delta than in adjacent areas of the ACP. Lakes >5 ha in size cover ~16% of the delta's surface (Walker 1978) and some of these lakes are deep (to 10 m), freezing only in the upper 2 m during winter and retaining floating ice until the first half of July (Walker 1978). Several other types of lakes occur on the delta, including oriented lakes, abandoned-channel lakes, point-bar lakes, perched ponds, thaw lakes, and tapped lakes (Walker 1983). Tapped lakes are connected to the river by narrow channels that result from thermokarsting of ice wedges and by the migration of river channels (Walker 1978). Channel connections allow water levels in tapped lakes to fluctuate with changes in coastal water level, resulting in barren or partially vegetated and often salt-affected shorelines. Because tapped lakes and river channels are the first areas of the delta to become flooded in spring, they constitute important stop-over habitat for migrating waterfowl in that season (Rothe et al. 1983).

As used in this report, the Colville Delta study area (552 km²) comprises the CD North, CD South, and the Northeast Delta subareas (Figure 1). These



Wildlife Habitat Type

- Open Nearshore Water
- Brackish Water
- Tapped Lake with Low-water Connection
- Tapped Lake with High-water Connection
- Salt Marsh
- Moist Halophytic Dwarf Shrub
- Tidal Flat Barrens
- Salt-killed Tundra
- Deep Open Water without Islands
- Deep Open Water with Islands or Polygonized Margins
- Shallow Open Water without Islands
- Shallow Open Water with Islands or Polygonized Margins
- River or Stream
- Sedge Marsh
- Deep Polygon Complex
- Grass Marsh
- Young Basin Wetland Complex
- Old Basin Wetland Complex
- Nonpatterned Wet Meadow
- Patterned Wet Meadow
- Moist Sedge-Shrub Meadow
- Moist Tussock Tundra
- Moist Low Shrub
- Dry Dwarf Shrub
- Barrens
- Human Modified

Note: Areas mapped outside the study area boundary are shown in muted colors.

Figure 2. Wildlife habitats in the Colville Delta study area, Alaska, 2012

Table 1. Habitat availability in the Colville Delta and the NE NPRA study areas, Alaska, 2012.

Habitat	Colville Delta Area (km²)	Colville Delta Availability (%)	NE NPRA Area (km²)	NE NPRA Availability (%)
Open Nearshore Water	10.12	1.8	8.73	2.7
Brackish Water	6.55	1.2	9.47	2.9
Tapped Lake with Low-water Connection	22.28	4.0	6.20	1.9
Tapped Lake with High-water Connection	20.77	3.8	4.87	1.5
Salt Marsh	16.31	3.0	16.51	5.1
Moist Halophytic Dwarf Shrub	0.14	<0.1	0.40	0.1
Dry Halophytic Meadow	0	0	0.21	0.1
Tidal Flat Barrens	58.42	10.6	11.56	3.6
Salt-killed Tundra	25.63	4.6	6.49	2.0
Deep Open Water without Islands	18.42	3.3	20.68	6.4
Deep Open Water with Islands or Polygonized Margins	9.55	1.7	15.84	4.9
Shallow Open Water without Islands	2.01	0.4	2.95	0.9
Shallow Open Water with Islands or Polygonized Margins	0.54	0.1	5.49	1.7
River or Stream	82.79	15.0	6.17	1.9
Sedge Marsh	0.13	<0.1	4.91	1.5
Deep Polygon Complex	13.17	2.4	0.35	0.1
Grass Marsh	1.44	0.3	1.03	0.3
Young Basin Wetland Complex	<0.01	<0.1	0.63	0.2
Old Basin Wetland Complex	0.14	<0.1	22.33	6.9
Riverine Complex	0	0	0.49	0.2
Dune Complex	0	0	1.25	0.4
Nonpatterned Wet Meadow	41.50	7.5	8.96	2.8
Patterned Wet Meadow	102.45	18.6	37.45	11.6
Moist Sedge–Shrub Meadow	12.25	2.2	57.62	17.9
Moist Tussock Tundra	3.24	0.6	58.39	18.1
Moist Tall Shrub	0	0	0.33	0.1
Moist Low Shrub	27.10	4.9	4.09	1.3
Moist Dwarf Shrub	0	0	1.05	0.3
Dry Tall Shrub	0	0	0.26	0.1
Dry Dwarf Shrub	0.47	0.1	3.31	1.0
Barrens	76.11	13.8	4.11	1.3
Human Modified	0.66	0.1	0	0
Total	552.19		322.15	

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 Nechelik (Niġliq) Channel and inland to the juncture of these channels.

NE NPRA

The NE NPRA study area (1,571 km²) abuts the western edge of the Colville Delta and comprises 5 subareas, which are useful sub-divisions for comparisons with past years: the Development, Exploration, Alpine West, Fish Creek Delta, and Fish Creek West subareas (Figure 1). The NE NPRA study area is located 6–39 km west of the village of Nuiqsut and 1–43 km west of the Alpine Facility. The NE NPRA study area encompasses 2 proposed development sites (CD-5 and the Clover A mine site) and exploration sites that may be proposed for development in the future. The CD-5 pad will connect to the Alpine Facility near CD-4 by an all-season gravel road and a bridge across the Niġliq channel (Figure 1). In 2011 and 2012, avian surveys were conducted in the eastern portions of the NE NPRA study area; the Fish Creek Delta and Alpine West subareas were surveyed in their entirety, whereas only the northeast corner was surveyed in the Development subarea. Neither the Fish Creek West nor the Exploration subareas were included in the avian studies in 2011 or 2012.

Three major streams flow through the NE NPRA study area (Figure 1). On USGS topographic maps (Harrison Bay Quad, 1:63,360 series, 1955) these drainages are labeled as Fish Creek, Judy Creek, and the Ublutuoch River, but they are commonly known by other names among Iñupiat residents: Fish Creek is called Uvlutuuq, Judy Creek is Iqalliqpik, and the Ublutuoch River is Tiŋmiaqsiuġvik.

Landforms, vegetation, and wildlife habitats in the NE NPRA were described in the Environmental Impact Statement for the lease area and the Alpine Satellite Development Project (BLM 1998, 2004) and in Jorgenson et al. (2003, 2004). Coastal plain and riverine landforms dominate the NE NPRA. Coastal landforms are present but limited to the northeast corner of the study area (i.e., the Fish Creek Delta; Figure 1). On the coastal plain, lacustrine processes, basin drainage, and ice aggradation are the primary geomorphic factors that modify the landscape. In riverine areas along Fish and Judy creeks, fluvial processes predominate, although eolian and ice-aggradation processes also contribute to ecological development (Jorgenson et al. 2003).

Six of the 31 wildlife habitats identified in the NE NPRA study area are not present on the Colville Delta study area (Figure 3, Table 1). Three habitats dominate the NE NPRA landscape: Moist Tussock Tundra (18% of area), Moist Sedge-Shrub Meadow (18%), and Patterned Wet Meadow (12%; Table 1). Aquatic habitats comprise 27% of the study area. Although the NE NPRA study area includes some coastal habitats in the Fish Creek Delta, they are much less abundant than in the adjacent Colville Delta (Table 1). Riparian habitats also are much less common in the NE NPRA than they are on the Colville Delta.

Like the Colville Delta, the NE NPRA is an important area for wildlife and for subsistence harvest activities. The NE NPRA supports a wide array of wildlife, providing breeding habitat for geese, swans, passerines, shorebirds, gulls, and predatory birds, such as jaegers and owls. The Fish Creek and Judy Creek drainages in the NE NPRA study area are a regionally important nesting area for Yellow-billed Loons, annually supporting a similar number of nesting pairs as does the Colville Delta (Burgess et al. 2003b, Johnson et al. 2004, Johnson et al. 2009, 2010, 2011).

METHODS

Aerial surveys were the primary means for collecting data on bird species using the Colville Delta and NE NPRA because of the large size of the study areas and the short periods of time that each species is at the optimal stage for data collection. In 2012, 4 aerial surveys were conducted using fixed-wing aircraft: 1 for Spectacled Eiders (pre-nesting), 2 for Tundra Swans (nesting and brood-rearing), and 1 for geese (brood-rearing). Each of these surveys was scheduled specifically (see Table 2 for survey details) for the period when the species was most easily detected (for example, when Spectacled Eider males in breeding plumage were present) or when the species was at an important stage of its breeding cycle (nesting or raising broods). Fifteen aerial surveys (1 per week) for loons were conducted from a helicopter, targeting specific lakes suitable to Yellow-billed Loons. The NE NPRA study area was surveyed in 2011 and 2012 for eiders, loons, swans and geese, but the area surveyed was reduced from that surveyed earlier to the Alpine West and Fish Creek Delta subareas and the northeastern corner of the Development subarea (total area = 322 km², Figure 1). 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. 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 avoid the areas around

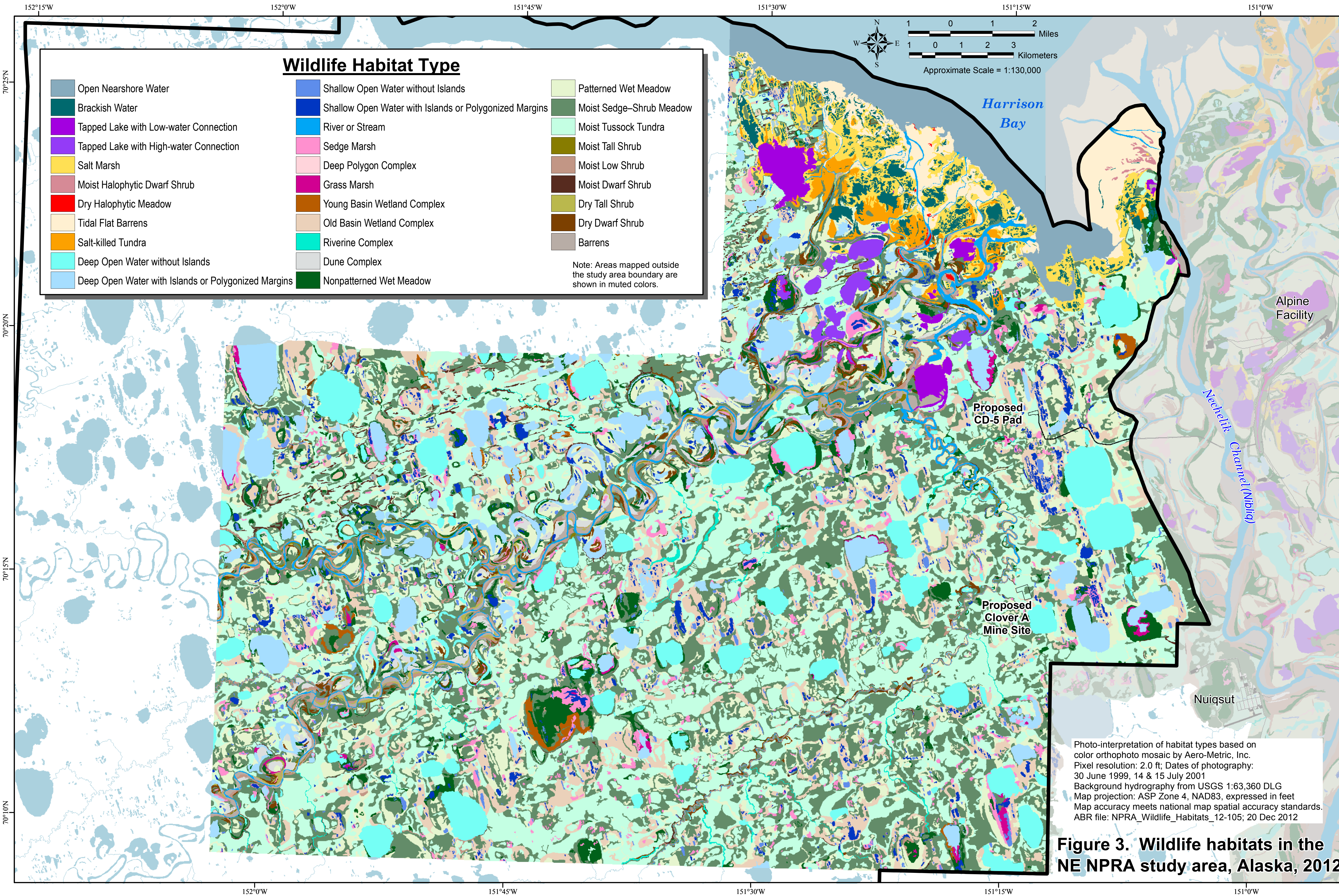


Figure 3. Wildlife habitats in the NE NPRA study area, Alaska, 2012.

Table 2. Avian surveys conducted in the Colville Delta and the NE NPRA study areas, Alaska, 2012.

Survey Type / Season / Survey Area	Number of Surveys	Survey Dates	Aircraft [a]	Transect Width (km)	Transect Spacing (km)	Aircraft Altitude (m)	Notes
Eider survey							
Pre-nesting							
Colville Delta	1	13, 14 June	C185	0.4	0.4	30–35	100% coverage
NE NPRA	1	15, 16 June	C185	0.4	0.8	30–35	50% coverage
Yellow-billed Loon surveys[b]							
Nesting	2	13 June and 19–20 June	206L	–	–	60-75	All lakes ≥5 ha and adjacent lakes
Brood-rearing	1	22 Aug.	206L	–	–	60–90	Yellow-billed Loon territory lakes
Nest and brood monitoring	13 (1/week)[c]	27 June–19 Sept.	206L	–	–	60–90	Lakes with active nests and broods
Tundra Swan surveys							
Nesting	1	22–26 June	C185	1.6	1.6	150	100% coverage
Brood-rearing	1	16–17 Aug.	C185	1.6	1.6	150	100% coverage
Goose surveys							
Brood-rearing	1	26 July	PA-18	–	–	75–150	Coastal and lake-to-lake pattern

[a] C185 = Cessna 185 fixed-wing airplane; 206L = Bell "Long Ranger" helicopter; PA-18 = Piper PA-18 "Super Cub" fixed-wing airplane
[b] Pacific and Red-throated loons, nests, and broods, and Glaucous and Sabine's gull nests and broods were recorded incidentally
[c] Total includes the brood-rearing survey conducted on 22 August

the village of Nuiqsut, the Helmericks' home site, and any active hunting parties. All survey flights are reported to local residents the week before and after in weekly updates submitted to the Kuukpik Corporation and the Kuukpik Subsistence Oversight Panel.

During the surveys, locations of eiders, loons, and swans were recorded on digital orthophoto mosaics of 1-ft resolution natural color imagery taken in 2004–2010 (Colville Delta and Alpine West subarea in NE NPRA, by AeroMetric, Inc.), 2-ft resolution natural color imagery taken in 1999–2004 (Development Area and Fish Creek Delta subareas in NE NPRA, by AeroMetric, Inc.), or 8.2-ft resolution color infrared imagery taken in 2002 (Fish Creek West and Exploration subareas in NE NPRA, by USGS). Bird locations plotted on maps were reviewed in the field and later in the office before they were entered into a GIS database. See Data Management, below, for data management protocols.

In this report, we typically present data summaries with means plus or minus standard errors (mean ± SE). In some cases we report the median values. Statistical significance is assigned at $P \leq 0.05$ unless otherwise stated. Analyses were conducted in Microsoft® Excel (Office 2010) and SPSS 18 (IBM SPSS Inc., Chicago, IL).

EIDER SUREYS

We evaluated the regional abundance, distribution, and habitat selection of 2 species of eiders with data collected on 1 aerial survey flown during the pre-nesting period (Table 2), when male eiders (the more visible of the 2 sexes in breeding plumage) were still present on the breeding grounds. Spectacled and King eiders are the only species that are consistently abundant in the Colville Delta and NE NPRA; Common Eiders and Steller's Eiders are seen infrequently. The pre-nesting survey in 2012 covered the same areas surveyed in 2011 and prior years in the Colville Delta. In the NE NPRA, the survey area for eiders in 2011 and 2012 was contracted eastward from the survey boundary in 2010 (Figure 4). We conducted the pre-nesting survey during 13–16 June using the same methods that were used on the Colville Delta in 1993–1998 and 2000–2011 and in the NE NPRA study area in 1999–2006, 2008, 2010, and 2011 although the survey areas and survey coverage differed among years (see Anderson and Johnson 1999; Burgess et al. 2000, 2002a, 2003a; Johnson 1995; Johnson and Stickney 2001; Johnson et al. 1996, 1997, 1998, 1999a, 2000a, 2002, 2003b, 2004, 2005, 2006b, 2007b, 2008b, 2009, 2010, 2011; Murphy and Stickney 2000; Smith et al. 1993, 1994). The survey was flown in a Cessna 185 airplane at 30–35 m above ground level (agl) and approximately 145 km/h. An observer counted eiders in a 200-m-wide transect on each side of the airplane and the pilot viewed the area ahead of the aircraft. A Global Positioning System (GPS) receiver was used to navigate pre-determined east–west transect lines that were spaced 800 m apart achieving 50% coverage in the NE NPRA study area and 400 m apart achieving 100% coverage over the Colville Delta study area (Figure 4). The lower coverage in the NE NPRA was intended to sample the larger area with its lower densities of Spectacled Eiders relative to the Colville Delta study area. Three areas were not surveyed on the Colville Delta: 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' home site, and the extreme southern delta near Nuiqsut (Figure 4). The latter 2 areas were avoided to limit disturbance to residents. Eider locations were recorded on color photomosaic maps (1:63,360-scale) and tape recorders were used to record species, number of identifiable pairs, and the sex and activity (flying or on the ground) of each individual.

We recorded the observed number of birds and pairs and calculated the "indicated" number of birds and densities (number/km²), following the USFWS (1987a) protocol. The total indicated number of birds excludes flying birds and is twice the number of males in singles, pairs, or flocks (flocked males are 2–4 males with no females), plus the number of birds in groups (groups are defined as >3 birds of mixed sex that cannot be separated into singles or pairs; however, 1 female with 2 males are a pair and single male, and 1 female with 3 males is considered a pair and 2 single males). Annual growth rate for pre-nesting adults was calculated with log-linear regression on adjusted counts for the period from 1993–2012.

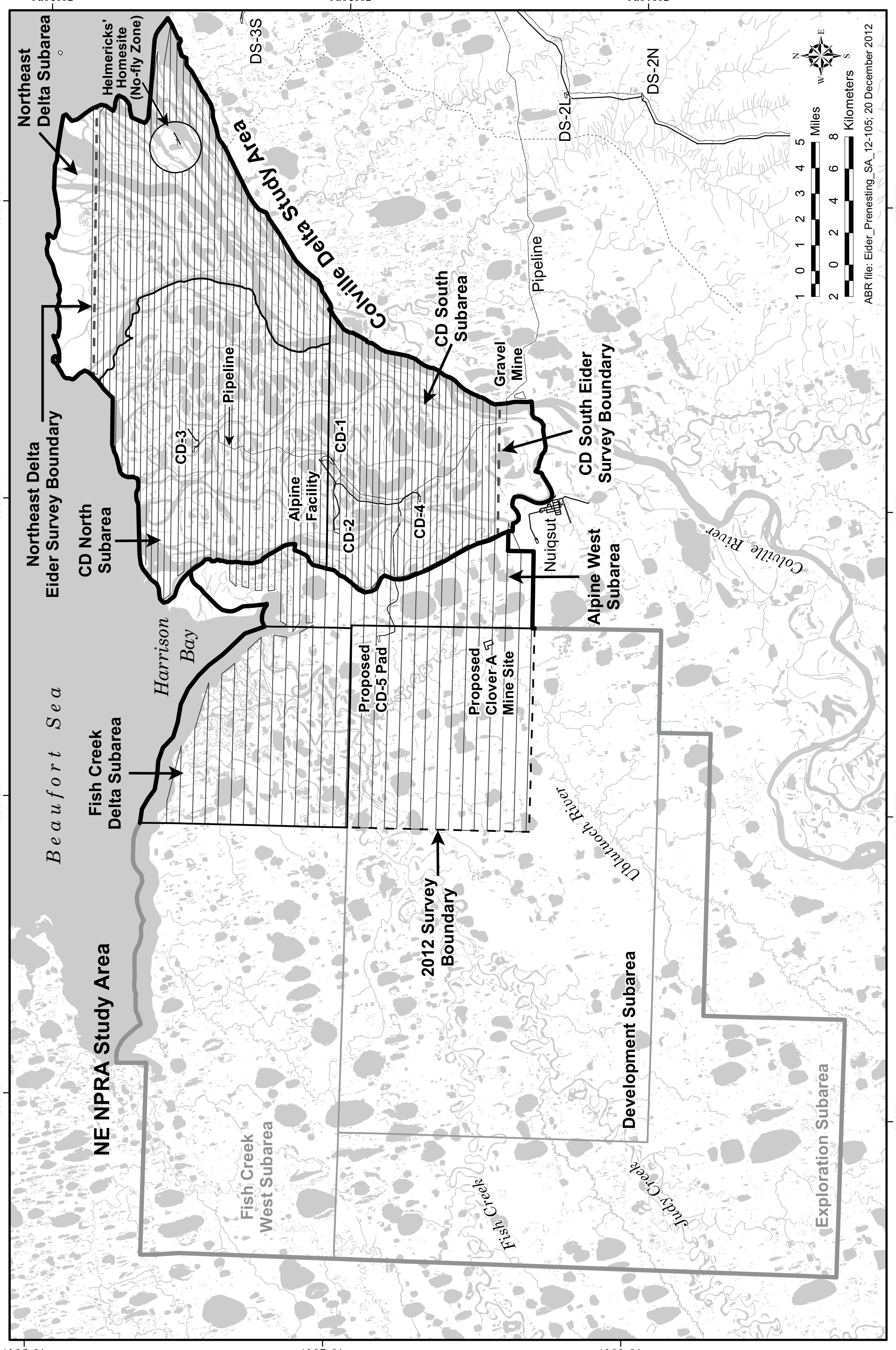


Figure 4. Transect lines for aerial surveys of pre-nesting eiders, Colville Delta and NE NPRA study areas, Alaska, 2012.

Adjusted counts were calculated from the density of indicated birds, multiplied by the maximal area surveyed in all years (501 km²).

LOON SURVEYS

We conducted 1 aerial survey for nesting Yellow-billed Loons and 1 for brood-rearing loons on the Colville Delta during 18 years from 1993 to 2012; surveys were not conducted in 1994 or 1999. The CD North and CD South subareas were surveyed each year and part of the Northeast Delta subarea was surveyed in all survey years except 2000. The number of lakes surveyed increased in 2002 because of a small expansion in the study area to include lakes between the eastern boundary of the NE NPRA and the Nechelik Channel, and again in 2008 because the minimum size of lakes surveyed was reduced from 10 ha to 5 ha. In 2012, 260 lakes were surveyed on 19–20 June for nesting Yellow-billed Loons and 166 lakes were surveyed on 22 August for brood-rearing loons (Figure 5, Table 2).

We conducted surveys for nesting and brood-rearing Yellow-billed Loons in the NE NPRA in all years during 2001–2012 except for 2007. During these 11 years of surveys, we surveyed 5 different subareas in the NE NPRA study area: the Development subarea in 2001–2004, the Exploration subarea in 2002–2004, the Alpine West subarea in 2002–2006 and 2008–2012, and the Fish Creek Delta subarea in 2005–2006 and 2008–2012 (Figure 5). The fifth subarea, the Fish and Judy Creek Corridor subarea, was created in 2008 only for loon surveys and it comprises a series of deep lakes adjacent to Fish and Judy creeks within the Development and Exploration subareas. In 2008–2010, we surveyed the Fish and Judy Creek Corridor subarea along with 4 Yellow-billed Loon territories in the Development and Exploration subareas that were identified in previous years. In 2011–2012, we surveyed just the eastern quarter of the Fish and Judy Creek Corridor subarea for Yellow-billed Loons, along with the Alpine West and Fish Creek Delta subareas (Figure 5).

Each year the nesting survey was conducted during 19–30 June and the brood-rearing survey during 15–27 August. In 2011 and 2012, we added a survey for nests on 13 June, 1 week prior to the nesting survey, to document early nesting phenology and nest survival. During the 13 June survey, only lakes where Yellow-billed Loons nests had been recorded in previous years were surveyed. Nesting surveys were conducted from a Cessna 185 or PA-18 Super Cub fixed-wing airplane during 1993–1998 and a Bell 206L during 2000–2012. Brood-rearing surveys were conducted from a Cessna 185 in 1993 and a Bell 206L in all other years. All surveys were flown in a lake-to-lake pattern at 60–90 m above ground level. The perimeter of each lake was circled while 1 observer searched lake surfaces and shorelines for loons and nests during the nesting survey and loons and young during the brood-rearing survey. 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 2008–2012. We reduced the minimum survey lake size to 5 ha for nesting surveys to increase survey efficiency. During nesting surveys each year, 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). 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. 2003b).

We recorded incidental observations of Pacific (Malġi) and Red-throated loons (Qaqsrauq) during all nesting and brood-rearing surveys. All locations of loons and their nests were recorded on USGS maps (1:63,000) in 1993, 1995–1998, and 2000–2002, and on color photomosaics (1:30,000 scale) in 2003–2012. In 2005–2012, Yellow-billed Loon nest locations also were marked on high resolution color images of nest site areas (~1:1,500). All loon locations were digitized into a GIS database.

We summarized numbers of adults, nests, broods, and young for each species counted on aerial surveys. Densities of adults, nests, and broods were calculated only for Yellow-billed Loons because Pacific and Red-throated loons commonly nest on lakes <5 ha in size and only a subset of lakes that size were included in the survey. Counts of Yellow-billed Loon adults,

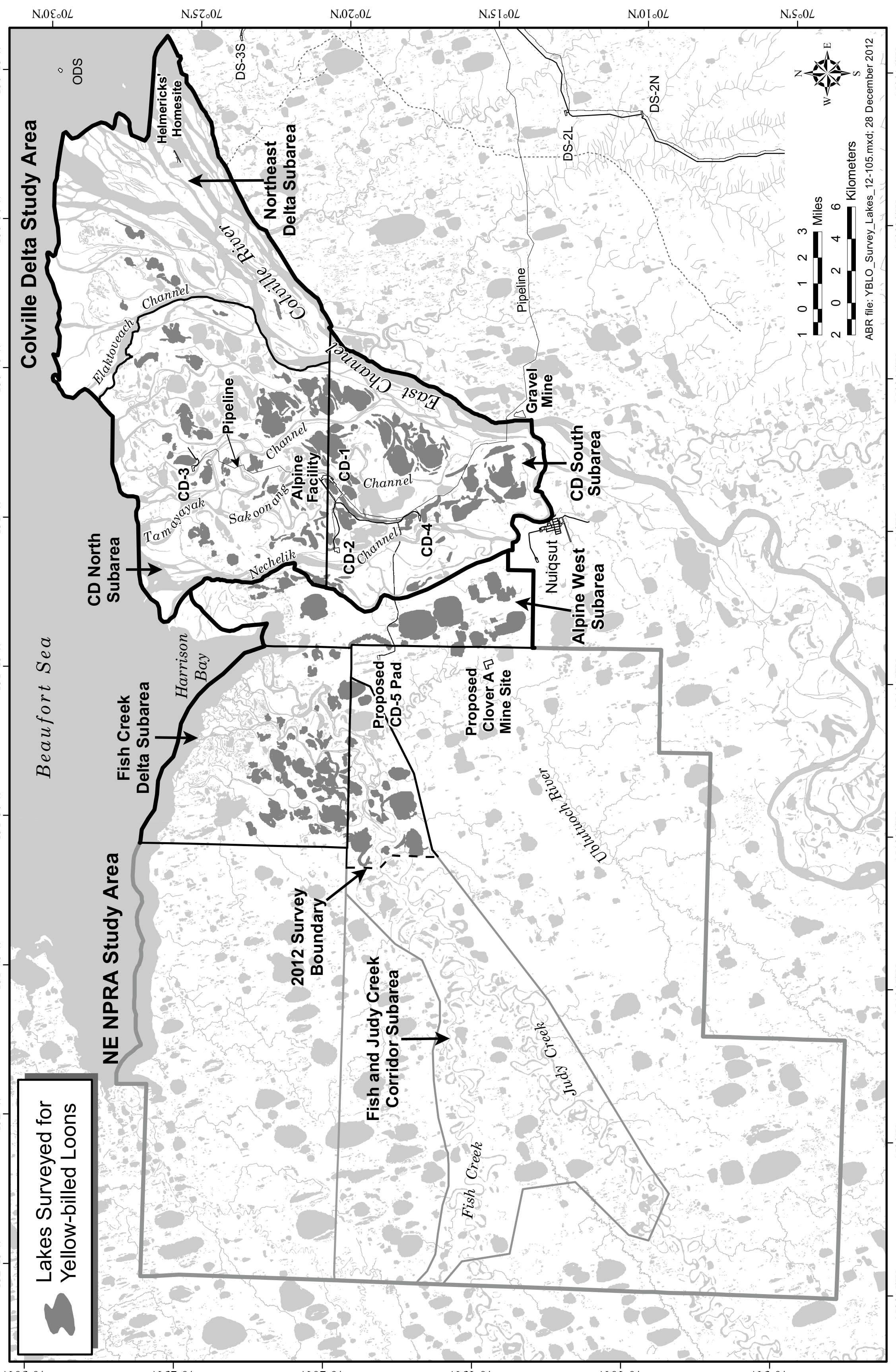


Figure 5. Lakes included in aerial surveys for Yellow-billed Loons, Colville Delta and NE NPRA study areas, Alaska, 2012.

young, nests, and broods are presented from previous years of nesting and brood-rearing surveys, and additionally, from ground-based, revisit, and monitoring surveys. Ground-based surveys mostly occurred near drill sites and facility areas and were conducted within a week of the nesting survey during 1992–2007 in the Colville Delta study area and 1999–2004 and 2009 in the NE NPRA study area. Revisit and monitoring aerial surveys occurred after the nesting survey. We conducted revisit surveys in 1996–1998 and 2000–2002 to search for nests on previously identified Yellow-billed Loon breeding lakes where no nest was found on the nesting survey. Revisit surveys consisted of 1 or more surveys that took place anywhere from 3 to 12 days after the nesting survey. Weekly monitoring of active nests began in 2005, but lakes without nests identified on the nesting survey were not resurveyed that year. From 2006 on, all previously identified Yellow-billed Loon breeding lakes plus other lakes where Yellow-billed Loons were observed during the nesting survey were surveyed weekly for 2 weeks after the nesting survey to search for nests that were initiated later or were missed on previous surveys. To make annual comparisons among years when different numbers of territories were sampled, we calculated territory occupancy by dividing the number of territories with nests, adults, or broods by the number of territories surveyed. Additionally, to adjust counts of adults, nests, and young for the number of territories surveyed, we divided those counts by the number of territories surveyed and multiplied by 43, the highest number of territories surveyed in all years. Annual growth rates for adults, nests, and young were estimated with log-linear regression on adjusted counts for the period from 2000–2012, when helicopters were used for all surveys.

NEST MONITORING AND NEST FATE

Weekly monitoring surveys were conducted in the Colville Delta and NE NPRA study areas in 2005–2012 to monitor the fate of Yellow-billed Loon nests, in addition to the objective listed above, which was to find nests that may have been missed or that were initiated later in the season. In 2005, we monitored the lakes with active nests. From 2006 on, we resurveyed lakes with active nests and all other lakes previously identified as breeding lakes or lakes occupied by Yellow-billed Loons for 2 weeks after the nesting survey. After 2 weeks, we continued to monitor lakes with confirmed nests, but no attempt was made to search for additional nests.

Each active nest was surveyed weekly from a helicopter until the nest was no longer active. Active nests had an incubating adult or a nest with eggs, whereas inactive nests lacked both. When a nest appeared inactive, we immediately searched the nesting lake for a brood by scanning along the shoreline and across the lake. Adjacent lakes known from previous surveys to be brood-rearing lakes or part of a pair's territory also were searched.

Camera-monitored nests (see below) were not included in weekly surveys, because we used camera images to determine nest status. The weekly status of camera-monitored nests was determined from the camera images taken at 14:00 on the day of the monitoring survey, which approximated the middle of the period when we typically flew our aerial surveys. For monitoring surveys that spanned multiple days, we used camera data from the first survey day. We resumed visiting camera-monitored nests during the week of hatch, which was estimated from the nest age at the time of camera installation (see below).

We inspected the contents of inactive nests to confirm nest fate. The nest and the surrounding area within 5 m, including the water adjacent to the nest, were examined closely for the presence of egg remains, including eggshell fragments, egg membranes, and broken eggs. Loons may reuse nests from previous years, so only the current year's layer of loose vegetation on top of the nest was inspected, to avoid recording evidence from previous years. 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. We used egg fragments in addition to the presence of broods to classify nest fate because some broods may not survive the period between hatch and the following monitoring survey. If egg fragments were found, they were counted and, based on the length of their longest side, placed into 3 approximate size categories: 1–10, 11–20, and 21–30 mm. Egg membranes or pieces of membranes also were counted and measured.

TIME-LAPSE CAMERAS

We began using time-lapse digital cameras in the Colville Delta and NE NPRA study areas in 2008 and 2010, respectively, primarily to monitor nest survival and, secondarily, to record nest attendance patterns and identify causes of nest failures. In 2012, we deployed cameras at 19 Yellow-billed Loon nests in the Colville Delta study area and 11 in the NE NPRA study area. We used 3 models of Silent Image® Professional cameras: 8 PM35 cameras with custom 8× telephoto lens taking 0.3-megapixel images, and 9 each of PC85 and PC800 cameras with custom 2.5× and 2× telephoto lens taking 3.1-megapixel images (Reconyx, Lacrosse, WI). We attempted to install cameras at all of the nests that were active during the nesting survey. Nests were not monitored if they lacked suitable views for camera-monitoring or if they were close to a nesting Glaucous Gull. Cameras were installed within 1–14 d (median = 5 days, n = 30) of nest discovery. The cameras were mounted on tripods that were tied down to stakes to stabilize them against the wind. The PM35 cameras were equipped with 2-GB memory cards and programmed to take 1 image/ 60 sec. The PC85 and PC800 cameras were equipped with 32-GB memory cards and programmed to take 1 image/30 sec. All cameras were run on external 12V sealed lead acid batteries. We chose settings, memory cards, and batteries so that cameras could take the maximum number of photos possible for 23–28 d without requiring maintenance (e.g., battery or memory card changes). We removed cameras when nests were no longer active.

We reviewed digital images on personal computers with Irfanview software (version 4.33). Loon activity was classified into 3 major types of activity: incubation, break, and recess. Incubation included sitting postures of normal incubation (head up and posture relaxed, or head resting on back), alert incubation (head up in a rigid, attentive posture), concealed incubation (head and body down and flattened in vegetation), and gathering nest material while on the nest. Break activities included brief standing activities at the nest, including changing positions, settling on the nest after changing position, standing over the nest, and egg moving. Recess activities were absences from the nest, including incubation exchanges, sitting beside the nest, and those activities immediately preceding and following the recess or incubation exchange, including egg moving, swimming beside the nest, flying, and gone from view. We identified predators in camera view to species, estimated their distance from the nest, and described their behavior.

Nest images were reviewed from the day of camera set-up through nest failure or when the loons and their young were observed leaving the nest. Day of hatch was defined as occurring when the first chick was seen at the nest or when adults were seen removing egg membranes from the nest, whichever was observed first. Sometimes young were not detectable on images due to thick sedge around the nest or a narrow camera field of view. If eggshell evidence and/or aerial surveys indicated hatch, the day of hatch was identified by the increased presence of the non-incubating loon at the nest as it begins to feed the hatchlings. If the mate's presence also was obscured, then egg floatation data were used to estimate hatch date. A nest was failed if the loons did not resume incubation after a predator was seen at the nest. The time of failure was taken from the first image containing the predator. Not all predation events were captured on images, and in those cases we assigned nest failure as the time when the loons stopped incubating the nest. After predation, loons swim next to the nest, often in alert posture, followed by frequent trips back to the nest before ending nest attendance. Eggshell evidence was used to confirm failure at such nests.

The date incubation started was estimated for successful nests by backdating 28 d from the day of hatch. North (1994) reported 27 and 28 days for the incubation period of Yellow-billed Loons, which begins with laying of the first egg. For failed nests, we estimated the start of incubation by using nest ages derived from an egg-floatation schedule that we developed from known-age Yellow-billed Loon nests in 2008–2012 (using a method developed for Semipalmated Sandpipers by Mabee et al. [2006]). During visits to Yellow-billed Loon nests to set up cameras in 2008–2011, we floated eggs in water and recorded the position of the egg in the water column (on the bottom [all eggs in 2012], suspended in the water column, or on the surface), measured the angle between the central axis of the egg and the water surface (from 0º when egg is first laid to a maximum of 90º when the egg is vertical in the water column), and estimated the percent volume of the egg above the surface (none in this study). For nests that were observed hatching on camera images in 2008–2012 (known-age nests; n = 44 nests), the clutch age on the day of egg floating was determined by backdating from hatch date to the day the eggs were floated. The relationship between the float angle and clutch age was plotted, and the correlation provided an egg-floatation schedule that could be used to estimate the start of incubation ± 2 days. For nests with 2 eggs, an average of the float angle or position of the 2 eggs was used for dating. Because we did not revisit active nests after camera installation in June, eggs were floated only once and only in the early stages of incubation.

The number of days monitored and incubation parameters (constancy, recess and exchange frequency, and recess length) were calculated for each nest from the time the loon returned to the nest after camera installation to the day before hatch, or to the time of nest failure. Periods of time when images could not be interpreted because of poor weather conditions were excluded. Mean daily number of recesses and exchanges were calculated as the sum of that activity divided by number of days monitored. Incubation constancy was compared between successful and failed nests with a Mann-Whitney U test; nests monitored for <1 day were excluded from analysis.

BROOD MONITORING

We conducted weekly brood monitoring surveys after hatch to estimate chick survival and document juvenile recruitment of Yellow-billed Loons during 2008–2012 in the Colville Delta and 2009–2012 in NE NPRA. Brood-monitoring surveys were flown in a manner similar to the brood-rearing survey described above. We surveyed all lakes known to have pairs with nests or broods by flying above the shoreline and scanning for loons on the water. If no young were seen, lakes were circled 2–3 more times, and for some large lakes, a transect was flown down the center of the lake at a higher altitude. If young still were not seen, the territory was revisited at the end of the survey, if time allowed. We considered a brood failed if no young were observed during 2 consecutive weekly surveys, unless conditions on those surveys may have prevented detection of young. Windy conditions with waves breaking in whitecaps during the surveys can hide young loons. When >2 adult Yellow-billed Loons (e.g., the breeding pair and intruding adults) are present on a brood lake, young often hide in shoreline vegetation. When either of these conditions occurred on a lake previously containing young, brood detection was reduced, and the lake was resurveyed the following week. Brood locations were mapped by hand and recorded with the number of adults and young.

The final age of each brood was calculated by subtracting the date of initial observation of the first chick from the date of the last observation, adjusting for the uncertainty of the actual dates. To account for the unknown number of days the brood was alive before the first observation, we used the midpoint between the date of first observation of young and the last observation of incubation. Similarly, to account for the number of days the brood was alive after its last observation, we used the midpoint of the interval between the date of its last observation alive and the first observation of its loss (absence). In the case of the typical 7-day interval between surveys, each chick was assumed to be 4 days old when first observed, and for the same interval, the date of death was assumed to be 4 days after it was last observed.

Chick production was estimated at hatch and again during the final monitoring survey in mid-September. Chick production at hatch was estimated as the number of chicks seen during the monitoring survey following hatch divided by the number of nests found. If a nest was classified as successful based on eggshell fragments and no chicks were observed, we assumed 1 chick was produced. Because only a sample of nests were monitored with a camera and because the images often revealed additional chicks at hatching that were not observed during surveys, we present chick production at hatch both with and without chicks only seen on images. Chick production in September is estimated as the number of chicks seen on our last survey divided by the total number of nests found.

TUNDRA SWAN SURVEYS

We flew 1 aerial survey for nesting Tundra Swans on 22–26 June and 1 survey for brood-rearing Tundra Swans on 16–17 August 2012 (Table 2). With the exception of an area within ~1.6-km radius of the Helmericks' family homesite on Anachlik Island in the northeastern Colville Delta, each aerial survey covered the entire Colville Delta and NE NPRA study areas (Figure 6). We conducted the surveys in accordance with USFWS (1987b, 1991) protocols, using the same methods employed for 20 years during 1992–2012 on the Colville Delta and 10 years during 2001–2012 in the NE NPRA. We followed east–west transects spaced 1.6-km apart in a Cessna 185 fixed-wing airplane that was navigated with the aid of a GPS receiver. Flight speed was 145 km/h and altitude was 150 m agl. Two observers each searched 800-m-wide transects on opposite sides of the airplane while the pilot navigated and scanned for swans ahead of the airplane, providing 100% coverage of the surveyed area. Locations and counts of swans and their nests were recorded on color photomosaics (1:63,360-scale). Each nest was photographed for site verification using a Canon PowerShot SX10 IS (10 megapixel) or a Canon PowerShot SD850 IS (8 megapixel).

Numbers of swans, nests, and broods were summarized and densities were calculated for subareas and the larger study areas. Apparent nesting success was estimated from the ratio of broods to nests counted in each study area during aerial surveys only. The accuracy of these estimates can be affected by differential detection, predation, and movements of broods; therefore, the calculated estimates of nesting success should be considered relative indices. Annual growth rates for adults, nests, broods, and young on the Colville Delta study area were calculated with log-linear regression for the period from 1992 to 2012.

GOOSE SURVEYS

We conducted 1 survey for brood-rearing and molting Brant and Snow Geese on 26 July 2012 in the coastal zone of the Colville Delta and NE NPRA study areas (Table 2). We used similar methods for surveys conducted in prior years beginning in 2005. The survey was flown in a Piper PA-18 “Super Cub” aircraft at 75–150 m agl and approximately 100–120 km/h along the coast and in a lake-to-lake pattern (Figure 7). One pilot and 1 observer searched appropriate habitats along the coast, rivers, channels, and lakes. The numbers of adults and young Brant and Snow Geese were recorded and their locations were saved on a GPS receiver. Most groups were counted on photographs taken with a Nikon D80 digital SLR camera (10.2 megapixel) equipped with a 17–85-mm image-stabilizing lens. Geese in some small groups were counted visually from the airplane. All groups that contained ≥50 geese and included goslings were counted on photographs.

GULL SURVEYS

We recorded Glaucous Gulls during the nesting and brood surveys conducted for Yellow-billed Loons in the Colville Delta and NE NPRA study areas (see Loon Surveys, above, for methods). Nests and broods were recorded incidentally as they were encountered and traditional nest locations, including colony sites, within the study areas were checked for activity. We considered a collection of 3 or more Glaucous Gulls nests occurring in close proximity on the same lake or wetland complex to be a colony.

Sabine’s Gulls (Iqirgagiak) that were confirmed or suspected to be nesting also were recorded opportunistically during the loon nesting survey. Sabine's Gull nests are difficult to detect during aerial surveys because of their relatively small size compared to Glaucous Gulls; therefore, the number of Sabine's Gulls nesting in the study areas is underestimated, because colony locations rather than single nesting pairs comprise most of the observations. All nest and brood observations of both Glaucous and Sabine's gulls were recorded on color photomosaic field maps (1:30,000 scale) and later entered into a GIS database.

We chose 50 lakes that were surveyed annually over 11 years since 2002 during the nesting survey for Yellow-billed Loons in the Colville Delta study area to serve as index lakes monitored for the presence of Glaucous Gull nests. Lakes selected included lakes with previously identified Glaucous Gull colonies, all Yellow-billed Loon breeding lakes, and lakes with Glaucous Gull nests near Yellow-billed Loon

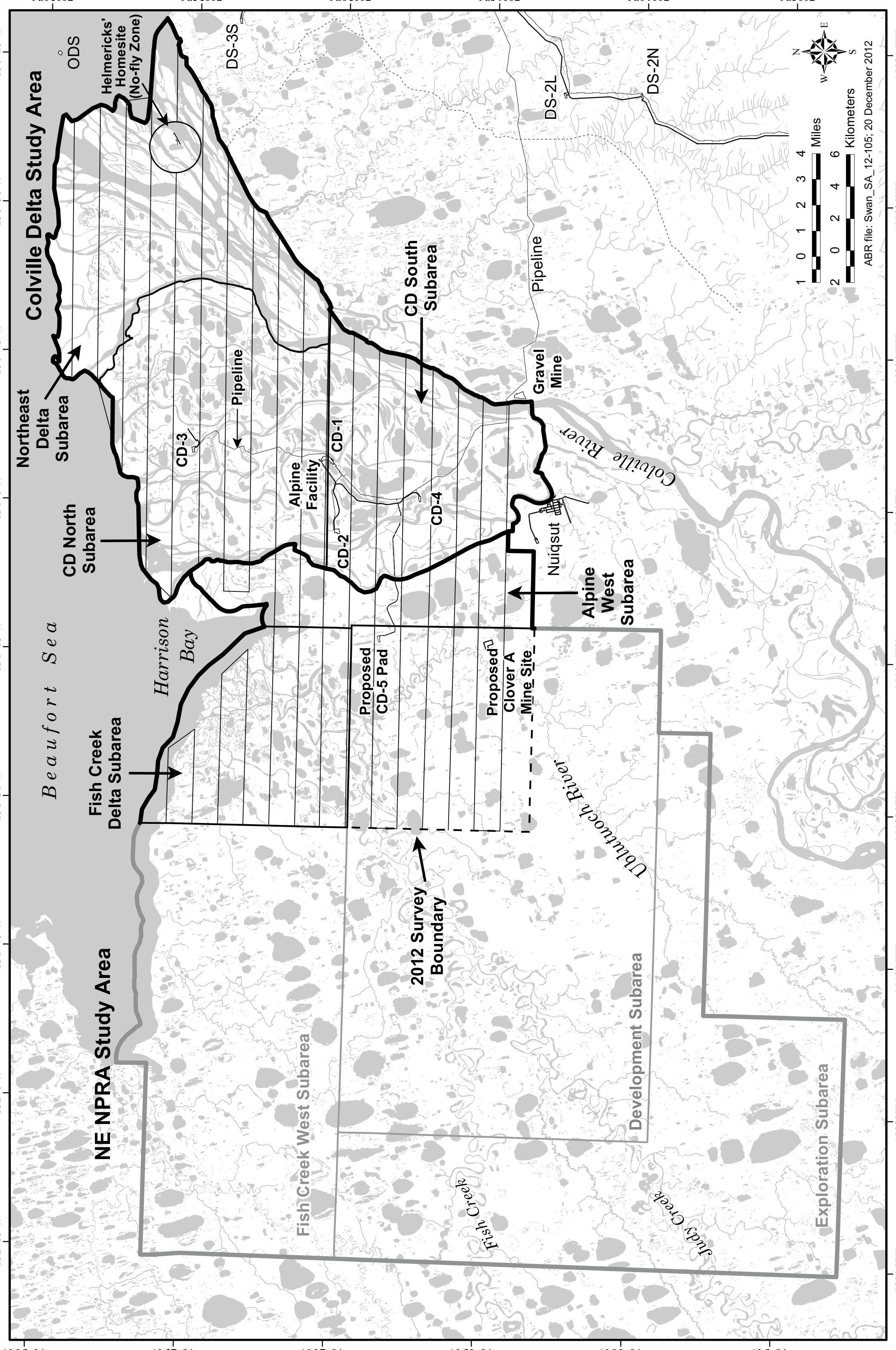


Figure 6. Transect lines for aerial surveys of nesting and brood-rearing Tundra Swans, Colville Delta and NE NPRA study areas, Alaska, 2012.

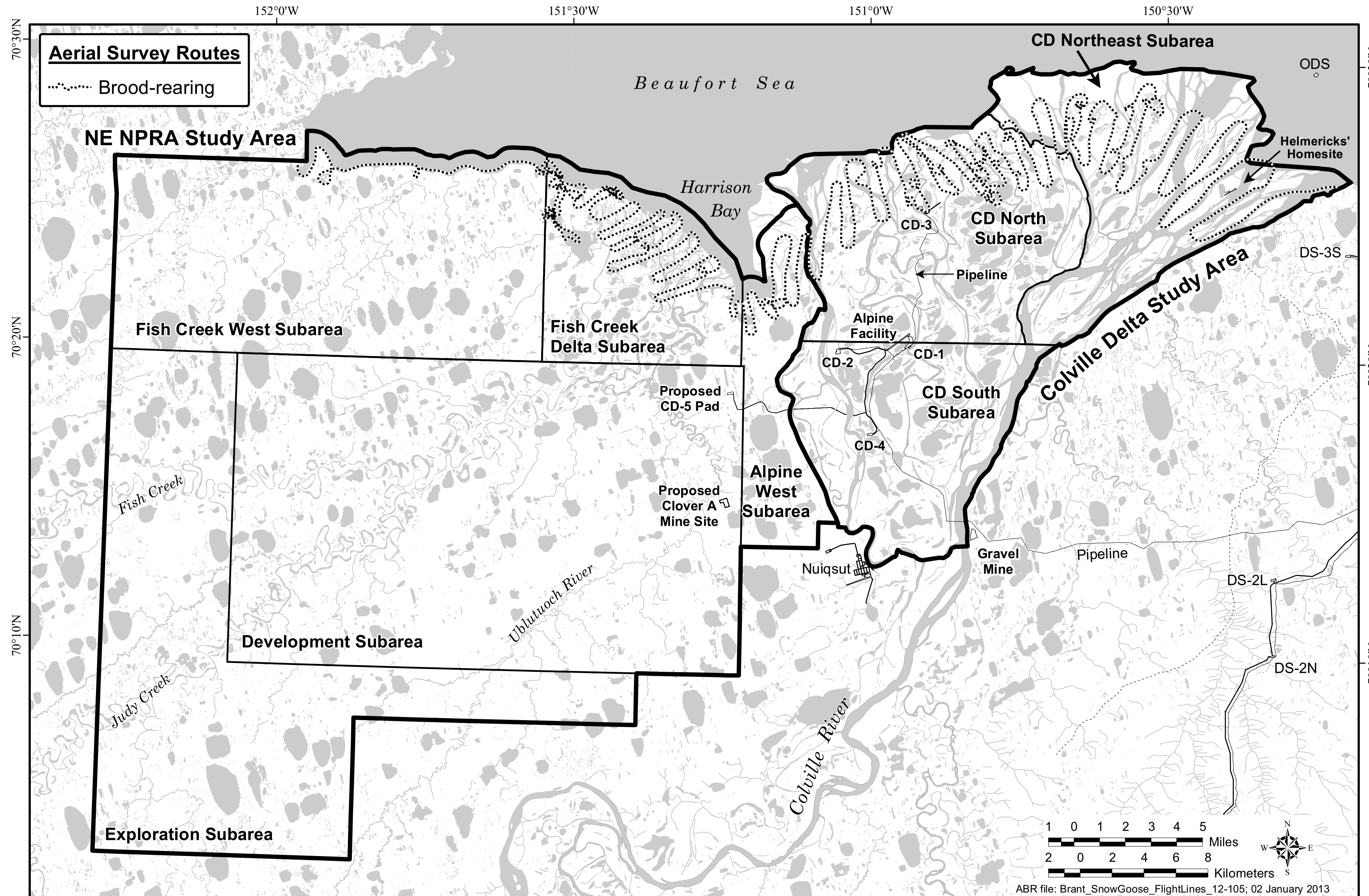


Figure 7. Flight lines for aerial surveys of brood-rearing Brant and Snow Geese, Colville Delta and NE NPRA study areas, Alaska, 2012.

breeding lakes. Of the 50 lakes, 2 were in the Northeast Delta subarea, 20 in the CD South subarea, and 28 in the CD North subarea. The number of Glaucous Gull nests was summarized annually by subarea as an index for monitoring the population of nesting Glaucous Gulls in the Colville Delta study area.

HABITAT MAPPING AND ANALYSIS

A wildlife habitat was assigned to each observation of birds, nests, or broods by plotting its coordinates on the wildlife habitat maps (Figures 2 and 3). We merged several habitats, based on similar composition or physiography and low areal coverage, to reduce the number of classes. For example, Moist Halophytic Dwarf Shrub (≤0.1% of both study areas; Table 1) was merged into Salt Marsh, Dry Halophytic Meadow (<0.1% of NE NPRA) was merged into Tidal Flat Barrens, and all non-halophytic shrub types (all but 1 occupied <1% of each study area) were merged into Tall, Low, or Dwarf Shrub.

For each 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/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 or seasons when birds were in pairs, flocks, or broods, because individuals in groups are not likely to be independent in location, habitat use, or habitat selection (i.e., a few large groups could bias results). We also calculated habitat availability, the percent of each habitat in a survey area, separately for each species and season because the survey areas often differed among species, seasons, and years.

For a subset of species/surveys, a statistical analysis of habitat selection was used to evaluate whether habitats were used in proportion to their availability. When multiple years of survey data were available, all comparable data were used in the analysis of habitat selection. For this purpose, annual surveys were considered comparable only when the survey areas were similar in habitat composition, because habitat availability was calculated by summing annual habitat availability over years.

Habitat selection was evaluated for the following species, seasons, and years:

- pre-nesting Spectacled Eiders and King Eiders (Colville Delta 1993–1998 and 2000–2012 and NE NPRA study area 2001–2006 and 2008–2012)
- nesting and brood-rearing Tundra Swans (Colville Delta 1992–1998 and 2000–2012 and NE NPRA study area 2001–2006, 2008–2009 and 2011– 2012)
- nesting and brood-rearing Yellow-billed Loons (Colville Delta nests 1993–1998 and 2000–2012 and Colville Delta broods 1995–1998 and 2000–2012, and NE NPRA nests and broods 2008–2012).

For other species, the number of observations from comparable annual surveys was inadequate for statistical analysis.

We inferred habitat selection from comparisons of observed habitat use with random habitat use. Random habitat use was based on the percent availability of each habitat. Monte Carlo simulations (1,000 iterations) were used to calculate a frequency distribution of random habitat use, with the sample sizes in each simulation equaling the number of observed nests or groups of birds in that season. The resulting distribution was used to compute 95% confidence intervals around the expected value of habitat use (Haefner 1996, Manly 1997). We defined habitat preference (i.e., use > availability) as observed habitat use greater than the 95% confidence interval of simulated random use, which represents an alpha level of 0.05 (2-tailed test). Conversely, we defined habitat avoidance (i.e., use < availability) as observed habitat use below the 95% confidence interval of simulated random use. The simulations and calculations of confidence intervals were conducted with Microsoft® Excel.

DATA MANAGEMENT

All data collected during surveys for CPAI were compiled into a centralized database following CPAI's data management protocols (ver. 7.9, CPAI 2013). Locations of geese were recorded on a GPS receiver with decimal-degree coordinates in the WGS 84 map datum and later transferred into the NAD 83 map datum. All other 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 in GIS-ready format with corresponding metadata.

RESULTS AND DISCUSSION

CONDITIONS IN THE STUDY AREAS

During the period of waterfowl arrival and peak nest initiation (15 May–15 June) birds returning to the Colville Delta and NE NPRA experienced cool conditions that extended into early June (Figure 8). The number of thawing degree-days (TDD) measured at Colville Village that accumulated between mid-May and mid-June 2012 (18 TDD) was well below the long-term mean (36 ± 5.8 TDD [mean ± SE]; *n* = 16 years). Not until 6 June did daily mean temperatures remain above freezing. The relatively warm ambient temperatures that did occur in early May and late June raised mean monthly temperatures for May (–5.8º C) and June (4.6º C) close to normal (May: –5.6 ± 0.6º C; June 3.5 ± 0.4º C; *n* = 16).

The 25 cm of snow present at Colville Village on 15 May melted away by 7 June 2012, 3 days later than the mean snow-free date (4 June ± 2 days, *n* = 16 years). The volume of runoff from snowmelt entering the Colville River in 2012 was average (National Weather Service, http://aprfc.arh.noaa.gov/data/breakup.php). Water levels on the Colville River peaked twice during the 2012 breakup season; the higher peak occurred on 27 May followed by a lower peak on 2 June. The peak water level on 27 May was still below average and occurred 4 days earlier than normal (31 May, *n* = 18 years, gauge Monument 1; Michael Baker Jr. Inc. 2012). Peak discharge of 366,000 cfs was above average, and occurred on 1 June, only 1 day later than the mean date of peak discharge (Michael Baker Jr. Inc. 2012). On 4 June, ice broke-up on the Colville River all the way to the ocean, slightly later than the average break-up date (1 June ± 2 days; *n* = 16) (National Weather Service, http://aprfc.arh.noaa.gov/data/breakup.php).

During the eider pre-nesting surveys on 13–16 June 2012, ice cover in polygon ponds and small

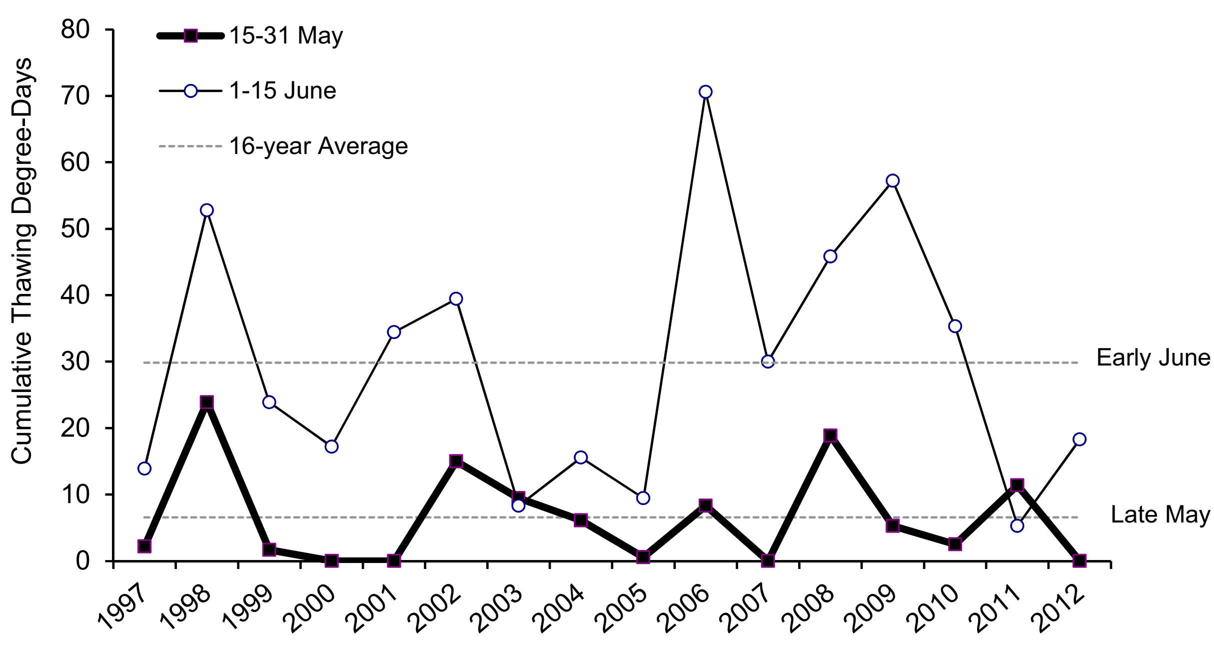


Figure 8. Cumulative number of thawing degree-days recorded 15 May–15 June at Colville Village, Colville Delta, Alaska, 1997–2012.

shallow lakes was variable and patchy, while deep lakes were mostly ice-covered with moats around the margins. Deep lakes across the Colville Delta retained high amounts of ice-cover through mid-June (~80% ice cover on 20 June) until warm temperatures in late June accelerated the loss of ice (~60% ice cover on 27 June) resulting in ice-free lakes by 4 July.

EIDERS

Four species of eiders may occur in the ASDP study areas, but each occurs at different frequencies and widely varying numbers. Of the 2 species of eiders that commonly occur in the Colville Delta and NE NPRA study areas, the Spectacled Eider has received the most attention because it was listed as "threatened" in 1993 (58 FR 27474) under the Endangered Species Act of 1973, as amended. The outer Colville Delta is a concentration area for breeding Spectacled Eiders relative to surrounding areas; nonetheless, Spectacled Eiders nest there at low densities and nest at even lower densities at inland parts of the delta and in scattered wetland basins in the NE NPRA study area (Burgess et al. 2003a, 2003b; Johnson et al. 2004, 2005). The King Eider is more widespread and generally more numerous than the Spectacled Eider, although their relative abundance varies geographically. Steller's Eiders (also a threatened species, listed in 1997) are rare on the Colville Delta and NE NPRA study areas as these areas are east of their current range. Both study areas are within the range of Common Eiders, which nest primarily on barrier islands and coastlines but are seen rarely on surveys of the Colville Delta and NE NPRA study areas.

SPECTACLED EIDER

Colville Delta

Distribution and Abundance

The indicated total of Spectacled Eiders recorded during pre-nesting aerial surveys in 2012 was lower than the record numbers in 2010 and 2011, yet calculated density was slightly above the 19-year mean values in the CD North subarea and the larger Colville Delta study area (Figure 9, Table 3). In 2012, we recorded 59 Spectacled Eiders on the Colville Delta, of which 51 were on the ground and 8 were in flight (Table 4). All observations of Spectacled Eiders in the Colville Delta study area

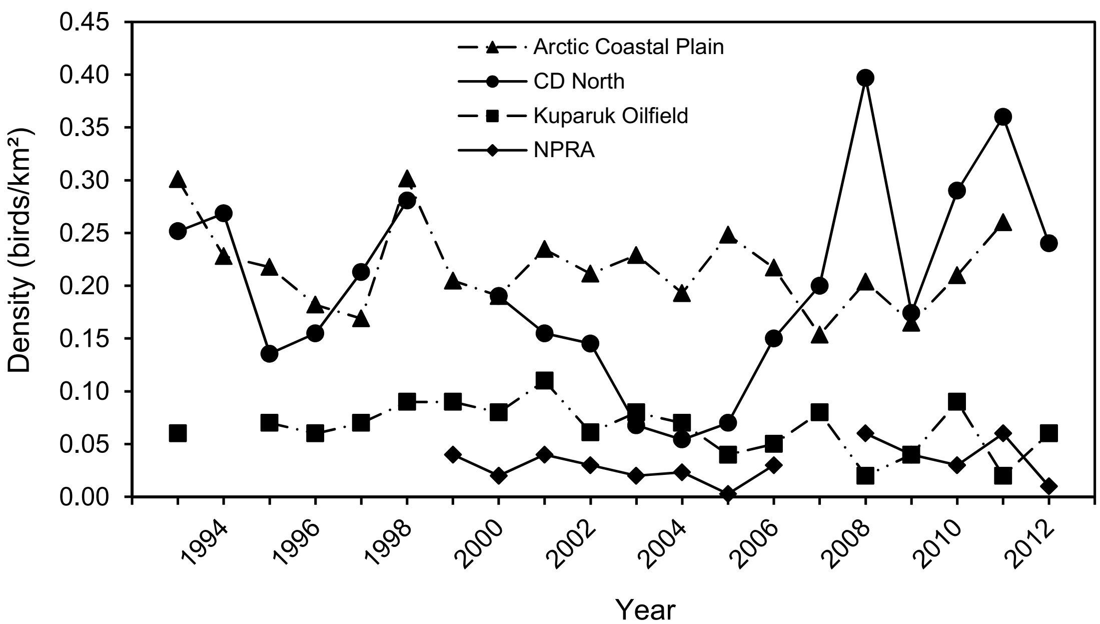


Figure 9. Density of indicated total Spectacled Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2012. Arctic Coastal Plain data from Larned et al. 2012, Kuparuk data from Stickney et al. 2013, and CD North and NE NPRA data from this study.

Table 3. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 1993–2012.

Year	Surveyed Area (km²)	SPECTACLED EIDER Total[a] Observed	SPECTACLED EIDER Total[a] Indicated	SPECTACLED EIDER Density[b] Observed	SPECTACLED EIDER Density[b] Indicated	KING EIDER Total[a] Observed	KING EIDER Total[a] Indicated	KING EIDER Density[b] Observed	KING EIDER Density[b] 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
Mean				0.11	0.10			0.10	0.08
SE				0.01	0.01			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)
[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area

Table 4. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2012.

SPECIES Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
On ground	30	21	51	21	60	0.10	0.12
In flight	4	4	8	3	–	0.02	–
All birds	34	25	59	24	–	0.12	–
KING EIDER							
On ground	10	8	18	8	20	0.04	0.04
In flight	5	2	7	2	–	0.01	–
All birds	15	10	25	10	–	0.05	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)
[b] Numbers not corrected for sightability. Density based on 100% coverage of 501.4 km²

during the pre-nesting survey in 2012 were in small groups of 1–3 birds, and 83% of those counted were found in the CD North subarea, where Spectacled Eiders traditionally have been most concentrated (Figure 10, Appendix C). Both the density of observed birds (birds on ground and in flight) and the density of indicated birds (USFWS 1987a) in the CD North subarea were 0.24 birds/km². The density of Spectacled Eiders in the CD North subarea was twice that in the entire Colville Delta study area: 0.12 observed birds/km² and 0.12 indicated birds/km².

Habitat Use

Pre-nesting Spectacled Eiders used 17 of 24 available habitats during 19 years of aerial surveys on the Colville Delta study area (Table 5). Seven habitats were preferred (i.e., use significantly greater than availability) by pre-nesting Spectacled Eiders: 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 its disproportionate use; it was used by 28% of the Spectacled Eider groups yet was available on only 2.7 % of the delta. Deep Polygon Complex is also preferred during the nesting season (Johnson et al. 2008a). Patterned Wet Meadow also had high use (18% of Spectacled Eider groups) but was not preferred because of its higher availability (19%). All other habitats were avoided or used in proportion to their availabilities.

NE NPRA

Distribution and Abundance

Relative to the Colville Delta, the reduced study area for the NE NPRA in 2012 had low numbers and low densities of Spectacled Eiders, a geographic difference that has been consistent during all years that both areas have been surveyed (Figure 10, Table 6). Similar to the Colville Delta in 2012, NE NPRA had near average densities. Over the entire NE NPRA study area, we counted only 4 observed (on ground and in flight) and 2 indicated Spectacled Eiders resulting in a density of 0.02 observed birds/km² and 0.01 indicated birds/km², <20% of the densities on the Colville Delta study area in 2012 (Tables 3 and 7). The only subarea in which Spectacled Eiders were found in the NE NPRA in 2012 was the Fish Creek Delta (0.03 indicated birds/km²; Appendix D).

Habitat Use

Pre-nesting Spectacled Eiders used 12 of 26 available habitats in the NE NPRA study area over 11 years of aerial surveys that were used for the selection analysis (Table 8). Spectacled Eiders preferred 4 habitats in NE NPRA, 3 of which also were preferred in the Colville Delta survey area: Brackish Water, Shallow Open Water with Islands or Polygonized Margins, and Grass Marsh. The other preferred habitat was Shallow Open Water without Islands. However, the sample size remains small (only 1 group was added in 2012 to make 48 groups total) resulting in low power in the selection analysis; we expect that additional habitats will become preferred as more Spectacled Eiders are added to the selection analysis in the future.

OTHER EIDERS

Colville Delta

Distribution and Abundance

The number of King Eiders recorded on the Colville Delta in 2012 was below average (Figure 11). The indicated density of King Eiders (0.04 birds/km²) in 2012 was about half the 19-year mean (Table 3). King Eiders (20 indicated birds) also were less numerous than Spectacled Eiders (60 indicated birds) during the 2012 pre-nesting period (Table 3). The largest flock consisted of 6 male King Eiders and the largest number of King Eiders was seen in the CD North subarea, which is atypical for King Eiders on the delta (Figure 10, Appendix C). In most years, King Eiders are more abundant in the Northeast Delta subarea. Few King Eiders nest on the Colville Delta, so we assume most of those observed during pre-nesting are in transit to other breeding areas (Johnson et al. 2003b).

No Steller's or Common eiders were seen on the Colville Delta in 2012. Steller's Eiders rarely are seen in the vicinity of the Colville Delta, but a pair was spotted on the ground in the CD North subarea in 2001, single flying males were seen in

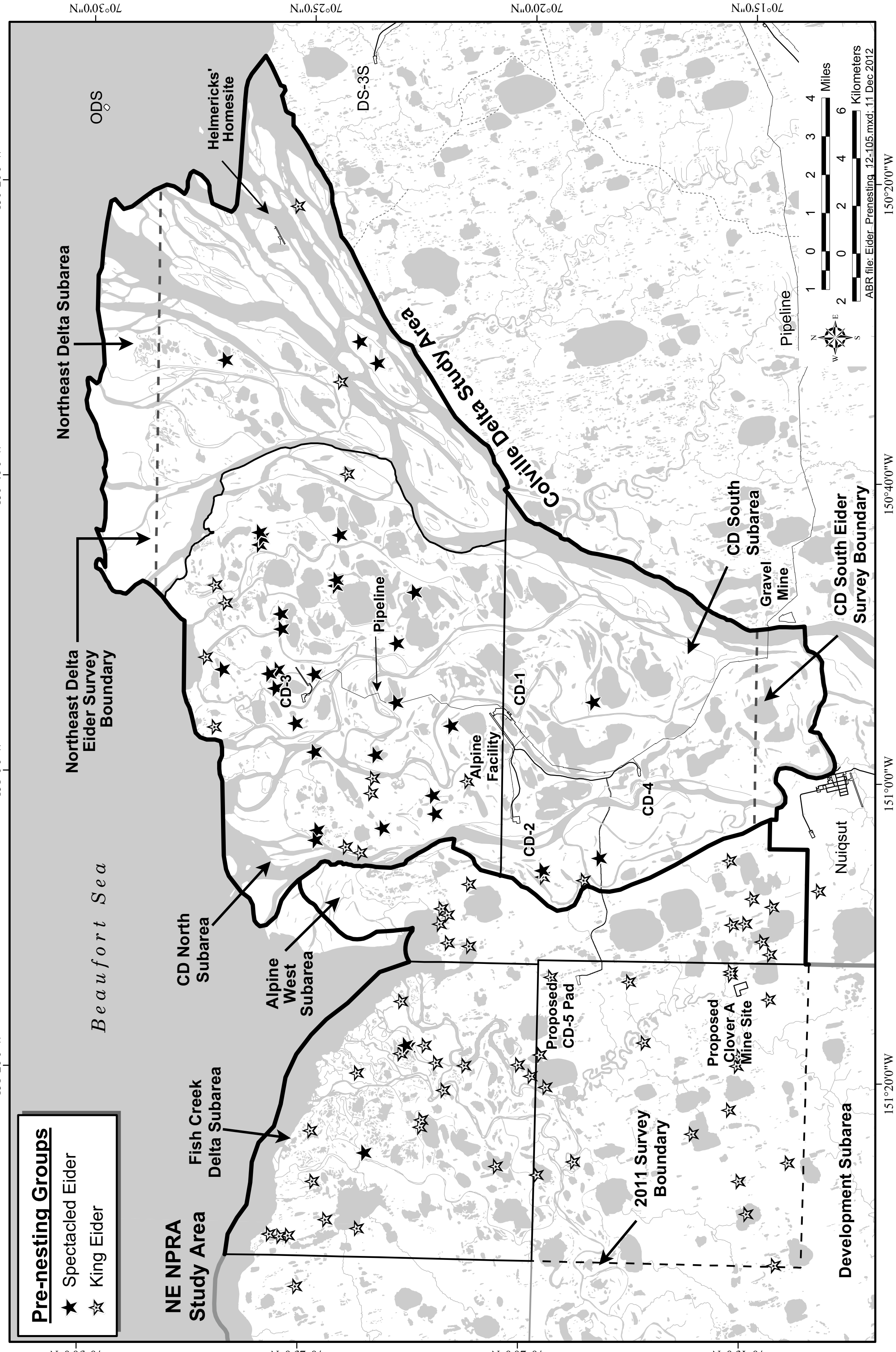


Figure 10. Spectacled and King eider groups during pre-nesting, Colville Delta and NE NPRA study areas, Alaska, 2012.

Table 5. Habitat selection by Spectacled and King eider groups during pre-nesting, Colville Delta study area, Alaska, 1993–1998 and 2000–2012.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	0	0	0	1.6	avoid	
Brackish Water	75	33	8.3	1.3	prefer	
Tapped Lake with Low-water Connection	31	13	3.3	4.5	ns	
Tapped Lake with High-water Connection	19	11	2.8	3.7	ns	
Salt Marsh	52	29	7.3	3.2	prefer	
Tidal Flat Barrens	2	1	0.3	7.0	avoid	
Salt-killed Tundra	62	34	8.5	5.1	prefer	
Deep Open Water without Islands	29	18	4.5	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	29	15	3.8	2.0	prefer	
Shallow Open Water without Islands	5	3	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	6	5	1.3	0.1	prefer	low
River or Stream	20	10	2.5	14.4	avoid	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	199	113	28.3	2.7	prefer	
Grass Marsh	8	5	1.3	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	73	37	9.3	8.2	ns	
Patterned Wet Meadow	133	70	17.5	19.4	ns	
Moist Sedge-Shrub Meadow	0	0	0	2.3	avoid	
Moist Tussock Tundra	1	1	0.3	0.6	ns	low
Tall, Low, or Dwarf Shrub	0	0	0	4.9	avoid	
Barrens	2	1	0.3	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	746	399	100	100		
KING EIDER						
Open Nearshore Water	11	3	1.2	1.6	ns	low
Brackish Water	33	18	7.3	1.3	prefer	low
Tapped Lake with Low-water Connection	25	12	4.9	4.5	ns	
Tapped Lake with High-water Connection	8	3	1.2	3.7	ns	
Salt Marsh	29	14	5.7	3.2	prefer	
Tidal Flat Barrens	4	2	0.8	7.0	avoid	
Salt-killed Tundra	47	25	10.1	5.1	prefer	
Deep Open Water without Islands	22	10	4.0	3.5	ns	
Deep Open Water with Islands or Polygonized Margins	11	5	2.0	2.0	ns	
Shallow Open Water without Islands	4	2	0.8	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	1	0.4	0.1	ns	low
River or Stream	324	92	37.2	14.4	prefer	
Sedge Marsh	0	0	0	<0.1	ns	low
Deep Polygon Complex	36	20	8.1	2.7	prefer	
Grass Marsh	8	3	1.2	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	10	7	2.8	8.2	avoid	
Patterned Wet Meadow	38	23	9.3	19.4	avoid	
Moist Sedge-Shrub Meadow	2	1	0.4	2.3	avoid	
Moist Tussock Tundra	0	0	0	0.6	ns	low
Tall, Low, or Dwarf Shrub	2	1	0.4	4.9	avoid	
Barrens	13	5	2.0	14.8	avoid	
Human Modified	0	0	0	0.1	ns	low
Total	629	247	100	100		

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

Table 6. Annual number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPRA study area, Alaska, 1999–2012.

		SPECTACLED EIDER				KING EIDER			
		Total[a]		Density[b]		Total[a]		Density[b]	
Year	Surveyed Area (km²)	Observed	Indicated	Observed	Indicated	Observed	Indicated	Observed	Indicated
1999	143.4	4	6	0.03	0.04	41	16	0.29	0.11
2000	278.3	6	6	0.02	0.02	68	44	0.24	0.16
2001	511.0	14	14	0.03	0.03	134	98	0.26	0.19
2002	550.1	12	14	0.02	0.03	208	211	0.38	0.38
2003	557.6	10	12	0.02	0.02	191	128	0.34	0.23
2004	430.3	14	10	0.03	0.02	168	130	0.39	0.30
2005	755.1	9	2	0.01	<0.01	253	192	0.34	0.25
2006	755.1	31	26	0.04	0.03	318	332	0.42	0.44
2007	–	–	–	–	–	–	–	–	–
2008	755.1	41	46	0.05	0.06	489	506	0.65	0.67
2009	755.1	29	30	0.04	0.04	387	360	0.51	0.48
2010	755.1	23	24	0.03	0.03	617	457	0.82	0.61
2011	172.0	9	10	0.05	0.06	119	94	0.69	0.55
2012	172.0	4	2	0.02	0.01	81	90	0.47	0.52
Mean				0.03	0.03			0.45	0.38
SE				<0.01	<0.01			0.05	0.05

[a] Observed total includes flying and non-flying eiders. Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Numbers not corrected for sightability. Density (birds/km²) based on 100% coverage of surveyed area. Some numbers and densities differ from those in original reports because they refer to different study areas or because minor corrections were made in future years

Table 7. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPRA study area, Alaska, 2012.

SPECIES Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
On ground	1	1	2	1	2	0.01	0.01
In flight	1	1	2	1	–	0.01	–
All birds	2	2	4	2	–	0.02	–
KING EIDER							
On ground	45	24	69	23	90	0.40	0.52
In flight	9	3	12	3	–	0.07	–
All birds	54	27	81	26	–	0.47	–

[a] Indicated total birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Numbers not corrected for sightability. Density based on 50% coverage of the area; surveyed area = 172.0 km². Fish Creek West, Exploration, and the western portion of the Development subareas were not surveyed in 2011

Table 8. Habitat selection by Spectacled and King eider groups during pre-nesting, NE NPRA study area, Alaska, 2001–2006 and 2008–2012.

SPECIES Habitat	No. of Adults	No. of Groups	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
SPECTACLED EIDER						
Open Nearshore Water	0	0	0	0.7	ns	low
Brackish Water	11	6	12.5	1.2	prefer	low
Tapped Lake with Low-water Connection	0	0	0	0.8	ns	low
Tapped Lake with High-water Connection	0	0	0	0.5	ns	low
Salt Marsh	8	4	8.3	2.3	ns	low
Tidal Flat Barrens	0	0	0	1.3	ns	low
Salt-killed Tundra	0	0	0	0.7	ns	low
Deep Open Water without Islands	4	2	4.2	6.5	ns	low
Deep Open Water with Islands or Polygonized Margins	10	5	10.4	5.3	ns	low
Shallow Open Water without Islands	5	4	8.3	1.0	prefer	low
Shallow Open Water with Islands or Polygonized Margins	15	7	14.6	1.6	prefer	low
River or Stream	1	1	2.1	1.2	ns	low
Sedge Marsh	1	1	2.1	1.7	ns	low
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	3	2	4.2	0.3	prefer	low
Young Basin Wetland Complex	0	0	0	0.3	ns	low
Old Basin Wetland Complex	13	8	16.7	8.2	ns	low
Riverine Complex	0	0	0	0.3	ns	low
Dune Complex	0	0	0	1.0	ns	low
Nonpatterned Wet Meadow	4	2	4.2	3.2	ns	low
Patterned Wet Meadow	14	6	12.5	11.1	ns	low
Moist Sedge-Shrub Meadow	0	0	0	21.5	avoid	
Moist Tussock Tundra	0	0	0	25.2	avoid	
Tall, Low, or Dwarf Shrub	0	0	0	3.1	ns	low
Barrens	0	0	0	1.1	ns	low
Human Modified	0	0	0	0	ns	
Total	89	48	100	100		
KING EIDER						
Open Nearshore Water	12	6	1.1	0.7	ns	low
Brackish Water	58	30	5.3	1.2	prefer	
Tapped Lake with Low-water Connection	45	15	2.6	0.8	prefer	low
Tapped Lake with High-water Connection	9	3	0.5	0.5	ns	low
Salt Marsh	70	32	5.6	2.3	prefer	
Tidal Flat Barrens	10	4	0.7	1.3	ns	
Salt-killed Tundra	5	3	0.5	0.7	ns	low
Deep Open Water without Islands	180	62	10.9	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	137	55	9.6	5.3	prefer	
Shallow Open Water without Islands	95	49	8.6	1.0	prefer	
Shallow Open Water with Islands or Polygonized Margins	202	80	14.0	1.6	prefer	
River or Stream	103	40	7.0	1.2	prefer	
Sedge Marsh	51	24	4.2	1.7	prefer	
Deep Polygon Complex	0	0	0	<0.1	ns	low
Grass Marsh	17	5	0.9	0.3	ns	low
Young Basin Wetland Complex	0	0	0.0	0.3	ns	low
Old Basin Wetland Complex	190	93	16.3	8.2	prefer	
Riverine Complex	6	3	0.5	0.3	ns	low
Dune Complex	0	0	0	1.0	avoid	
Nonpatterned Wet Meadow	32	18	3.2	3.2	ns	
Patterned Wet Meadow	59	35	6.1	11.1	avoid	
Moist Sedge-Shrub Meadow	17	8	1.4	21.5	avoid	
Moist Tussock Tundra	9	5	0.9	25.2	avoid	
Tall, Low, or Dwarf Shrub	1	1	0.2	3.1	avoid	
Barrens	0	0	0	1.1	avoid	
Human Modified	0	0	0	0	ns	
Total	1308	571	100	100		

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

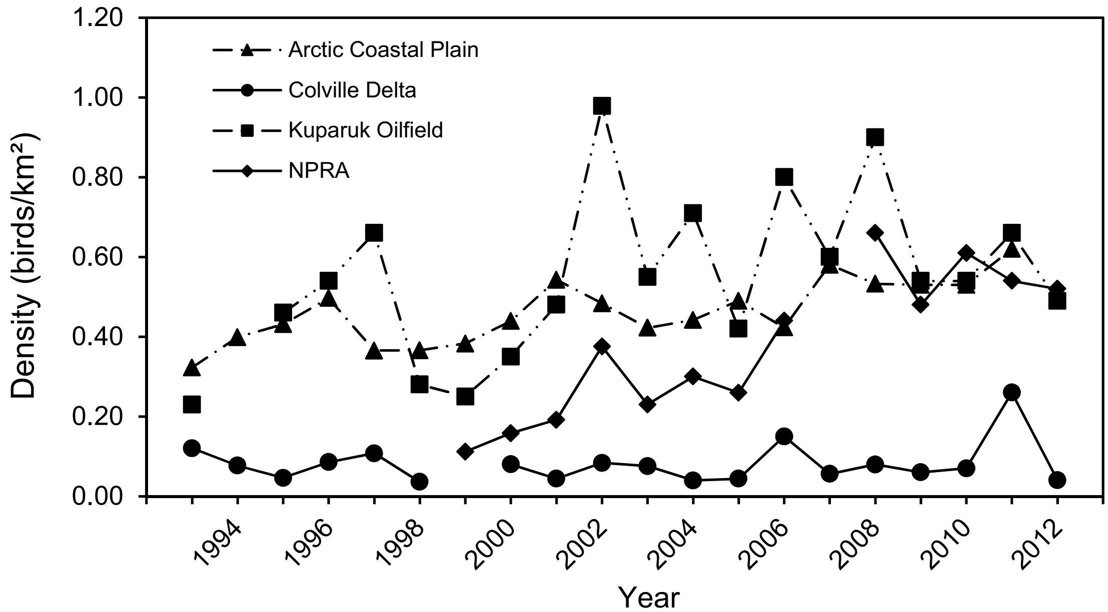


Figure 11. Density of indicated total King Eiders during pre-nesting aerial surveys in 4 study areas on the Arctic Coastal Plain, Alaska, 1993–2012. Arctic Coastal Plain data from Larned et al. 2012, Kuparuk data from Stickney et al. 2013, and CD North and NE NPRA data from this study.

the NE NPRA in 2001 and on the Colville Delta in 2007 (Johnson and Stickney 2001, Johnson et al. 2008b), and several sightings singles or pairs were reported in the Kuparuk Oilfield during 1995, 2000, 2001, and 2007 (not all sightings in the Kuparuk Oilfield were confirmed; see Anderson et al. 2008). Since 1992, nest searches have been conducted in multiple locations on the Colville Delta, in the Kuparuk Oilfield, and, during a subset of years, in NE NPRA; in almost 2 decades of nest searches in those study areas, no nests or indications of breeding by Steller's Eiders have been observed.

Common Eiders are seen infrequently on the Colville Delta, but are more common in the nearshore marine waters and barrier islands that are mostly outside the survey area. One pair of Common Eiders was observed in 2007 in the nearshore marine water just northwest of the study area boundary (Johnson et al. 2008b). Pairs also have been recorded during pre-nesting in 1992, 1998, and 2001, and a nest was found near the coastline in 1994 (Johnson 1995).

Habitat Use

Steller's and Common eiders have not been numerous enough to enable evaluation of habitat preferences on the Colville Delta. Pre-nesting King Eiders used 19 of 24 available habitats in the Colville Delta study area over 19 years of aerial surveys (Table 5). King Eiders preferred 5 of the same habitats preferred by pre-nesting Spectacled Eiders on the Colville Delta: Brackish Water, Salt Marsh, Salt-killed Tundra, Deep Polygon Complex, and Grass Marsh. King Eiders also preferred River or Stream, where the largest percentage (37%) of the groups was found. The high percentage use of River or Stream, which includes river channels, suggests that many King Eiders were in transit 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 relative concentrations on the outer Colville Delta (0.8–1.0 nests/km², ABR unpubl. data) avoid River or Stream. Moreover, King Eiders nest at very low densities on the Colville Delta in the several locations where intensive nest searches have been conducted (Burgess et al. 2003a, Johnson et al.

2003a, Johnson et al. 2008a, Seiser and Johnson 2010, 2011a, 2011b, 2012), affirming that most of the pre-nesting King Eiders seen on the delta are stopping over during migration.

NE NPRA

Distribution and Abundance

King Eiders were abundant in the NE NPRA study area in 2012, occurring at 13 times the density recorded on the Colville Delta (Tables 3 and 6). The indicated total of King Eiders in the NE NPRA study area was 90 birds, and the density was 0.52 indicated birds/km², the fourth highest density in 13 years of surveys (Figure 11, Table 6). King Eiders were 20–40 times more abundant than Spectacled Eiders in the NE NPRA study area in 2012 (Table 7), which is typical for these species in this area. The ratio of King Eiders to Spectacled Eiders (indicated birds) averages about 20:1 in the NE NPRA (Table 6). The highest number of King Eiders was seen in the Fish Creek Delta subarea (44 indicated birds; 0.77 indicated birds/km²), but the densities also were high in the Development and Alpine West subareas (0.44 and 0.33 indicated birds/km², respectively; Figure 10, Appendix D).

Habitat Use

King Eiders used 21 of 26 available habitats and preferred 10 habitats in the NE NPRA study area during the set of 11 years of pre-nesting surveys that were used to evaluate habitat selection (Table 8). Old Basin Wetland Complex and both types of Deep and Shallow Open Water were the most frequently used habitats and also were preferred. The habitats preferred by King Eiders overlap with those preferred by Spectacled Eiders, but King Eiders have a broader array of preferences. River or Stream and Tapped Lake with Low-water Connection are likely being used by birds in transit or not yet settled into nesting habitat, because the fluctuating water levels of these waterbodies make their shorelines poor locations for nesting.

DISCUSSION

The annual number of pre-nesting Spectacled Eiders on the Colville Delta has displayed dramatic swings over the last 19 years, particularly in the CD North subarea, which is the core of their distribution on the delta (Figure 9, Appendix C). (To simplify this discussion, all numbers and densities refer to indicated total birds.) The 2012 breeding season was the sixth year in a row of relatively high numbers of pre-nesting Spectacled Eiders on the Colville Delta. Our long-term records show 3 periods of high numbers: the early 1990s, the late 1990s, and the recent period of 2007–2012 (Figure 9). These fluctuations in abundance are unexplained, but the recent upswing in Spectacled Eiders is encouraging because numbers were quite low during 2003–2005. The overall population trend for Spectacled Eiders in the CD North subarea exhibits a slightly positive slope ($\ln(y) = 0.008x - 12.499$, $R^2 = 0.008$, $P = 0.72$, $n = 19$ years), which translates to an annual growth rate of 1.008. The growth rate (1.003) for the larger Colville Delta study area is similar ($\ln(y) = 0.003x - 1.9$, $R^2 = 0.001$, $P = 0.90$, $n = 19$ years). A slightly negative growth rate of 0.992 was calculated up through 2011 for Spectacled Eiders across the Arctic Coastal Plain (SE = 0.008, $n = 19$ years; Larned et al. 2012). None of these growth rates is significantly different from 1.0 (a growth rate of 1.0 equals 0% annual change or equilibrium), however, which suggests that the breeding population of Spectacled Eiders is relatively stable.

The NE NPRA study area appears to be less important than the Colville Delta to breeding Spectacled Eiders. The density of Spectacled Eiders in the NE NPRA study area has been consistently low (0.03 ± 0.005 indicated birds/km², $n = 13$ years). The Spectacled Eider density in NE NPRA averages 38% ($n = 12$ years) of the density in the Colville Delta study area and 19% of the density in the CD North subarea. An evaluation of the regional distribution of Spectacled Eiders shows that the NE NPRA study area is not a significant concentration area for Spectacled Eiders on the ACP (Figure 17 in Larned et al. 2006, Figure 19 in Larned et al. 2011). The population trend for Spectacled Eiders in NE NPRA is slightly positive (1.02), but not significantly different from 1.0 ($\ln(y) = 0.020x - 37.16$, $R^2 = 0.007$, $P = 0.805$, $n = 11$ years).

Unlike Spectacled Eiders, King Eiders are clearly increasing on the breeding grounds. On breeding pair surveys of the ACP, the growth rate for King Eiders is 1.027, which is significantly different from 1.0 (SE = 0.006, $n = 19$ years; Larned et al. 2012.). Similarly, our surveys have recorded a significantly positive growth rate (1.091) for King Eiders in the NE NPRA study area (ln(y) = 0.091x – 177.77, R^2 = 0.685, P = 0.002, n = 11 years). However, the growth rate on the Colville Delta (1.003) is not significantly different from 1.0 (ln(y) = 0.003x – 2.45, R^2 = 0.001, P = 0.885, n = 19 years). The abundance of King Eiders in the 2 study areas is the reverse of that observed for Spectacled Eiders. NE NPRA supports high densities of King Eiders (0.38 ± 0.05 indicated birds/km², n = 13 years), in contrast to low densities on the Colville Delta (0.08 ± 0.01 indicated birds/km², n = 19 years). Breeding Spectacled Eiders appear to prefer the aquatic and halophytic habitats that are relatively abundant on the Colville Delta, whereas King Eiders use a broader range of habitats, and nest farther from waterbodies (Anderson and Cooper 1994). Although there is extensive overlap in habitat use by these 2 species, breeding season concentration areas for each species appear to be separated at the regional scale, with Spectacled Eiders most prevalent in the coastal regions of the ACP west of Harrison Bay and King Eiders most prevalent in more inland areas south of Teshekpuk Lake and to the east, where lower densities of Spectacled Eiders occur (see Figures 17 and 19 in Larned et al. 2006 and Figures 19 and 21 in Larned et al. 2011). The exception to this generalized distribution pattern of the 2 species is the Colville Delta. Thus, the differences in densities of these 2 eider species observed between the Colville Delta and NE NPRA study areas are reflective of the regional patterns of distribution these 2 species that have been documented on breeding pair surveys across the entire ACP for approximately 20 years.

LOONS

YELLOW-BILLED LOON

Colville Delta

Distribution and Abundance

In 2012, we conducted a survey on 13 June, 1 week earlier than the nesting survey to better document Yellow-billed Loon nesting phenology and to record nests that fail prior to the nesting survey normally conducted during the 3rd week of June. On 13 June, we found 5 Yellow-billed Loon nests in the Colville Delta study area. All 5 nests still were active at the time the nesting survey was conducted on 19–20 June 2012. During the nesting survey, we counted 59 Yellow-billed Loons and 25 nests (Figure 12, Table 9). Three additional nests were found on the 27 June monitoring survey and 4 additional nests on the 4 July monitoring survey. Five of those 7 additional nests were apparent late nesting attempts and 2 nests were renesting attempts of territories whose nests failed between 20 and 27 June. Of the 32 nests found in the Colville Delta study area in 2012, 19 nests were located in the CD North subarea, 11 nests in the CD South subarea, and 2 nests in the Northeast Delta subarea (Figure 12, Appendix E). The number of nests found during nesting and monitoring surveys in 2012 (32 nests) was the third highest number of nests in 18 years of surveys in the Colville Delta study area. The count of 59 adults in 2012 on the nesting survey was higher than the long-term mean (55 ± 2.6 adults) recorded in the Colville Delta study area, but lower than the counts recorded the previous 6 years (Table 9).

The density of Yellow-billed Loon adults in the Colville Delta study area during the nesting survey in 2012 was 0.15 birds/km², which was the same as the 18-year mean (0.15 ± 0. 006 birds/km²), whereas the density of nests (0.06 nests/km²) was nearly the same as the 18-year mean (0.05 ± 0.004 nests/km²; Appendix F). The density of loons was similar in the CD North (0.16 birds/km²) and the CD South subareas (0.15 birds/km²; Appendix E), whereas the density of nests found in 2012 was slightly higher in the CD North subarea (0.09 nests/km²) than the CD South subarea (0.07 nests/km²; Appendix E).

Thirty-one of the 32 Yellow-billed Loon nests recorded in the Colville Delta study area in 2012 were on lakes where Yellow-billed Loons have nested previously (Figure 12) (Johnson et al. 2009, 2010, 2011, 2012). One nest was found on a small lake (3.6 ha) where nesting by Yellow-billed Loons had not been previously documented. This small lake is adjacent to a large lake (60 ha) that was used by breeding Yellow-billed Loons until it drained in August 2009. The small lake has been occupied by Pacific Loons in most years since nesting surveys began in 1993. Of the other 31 nests, 12 were located at the same nest sites used in 2011, 13 were at or very close to nest sites used in

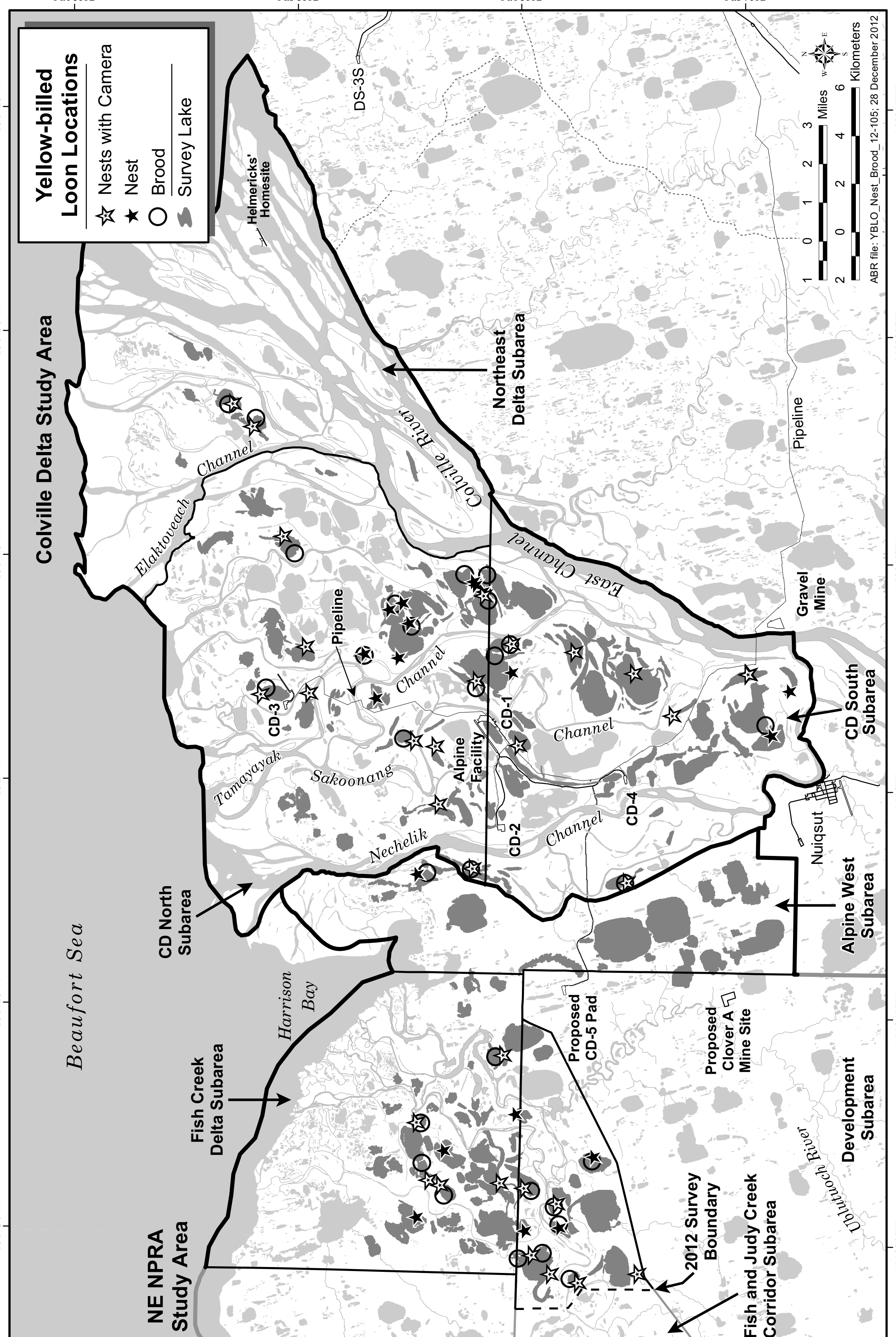


Figure 12. Yellow-billed Loon nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2012.

Table 9. Number of Yellow-billed Loons, nests, and territory occupancy by nests, Colville Delta (1993–2012) and NE NPRA (2001–2012) study areas, Alaska.

STUDY AREA Year	Nesting Survey[a] No. Adults	Nesting Survey[a] No. Nests	All Surveys[b] No. Nests	No. Territories Surveyed	Territory Occupancy (%)[c]
COLVILLE DELTA[d]					
1993	50	10	16[e, f]	39	41
1995	42	12	21[e, f]	39	54
1996	45	11	21[e, f, g]	37	57
1997	48	10	18[e, g]	38	47
1998	36	17	24[e, f, g]	40	60
2000	53	16	16	37	43
2001	54	19	20[e]	37	54
2002	47	18	22[e, f, g]	41	54
2003	53	25	27[f]	41	66
2004	41	24	26[f]	41	63
2005	58	30	31[f]	40	78
2006	65	24	28[g]	41	68
2007	66	27	31[g]	42	71
2008	69	33	38[g]	42	90
2009	67	27	30[g]	43	70
2010	69	23	35[g]	42	83
2011	72	23	29[g]	42	67
2012	59	25	32[g]	43	70
Mean	55.2	20.8	25.8		63.1
SE	2.6	1.6	1.5		3.1
NE NPRA[h]					
2001	44	20	23[e]	36	64
2002	65	27	27	42	64
2003	53	26	28[e, f]	41	66
2004	60	23	24[e]	42	57
2005	23	8	8	13	62
2006	23	8	8	13	62
2008	82	23	29[g]	51	57
2009	66	27	29[g]	51	57
2010	76	29	36[g]	51	71
2011	30	8	13[g]	21	62
2012	36	15	18[g]	21	86
Mean[i]					64.2
SE					2.5

[a] Nesting survey was conducted sometime between 19–30 June
[b] Includes all nests found on nesting survey and any additional nests found during other types of surveys as footnoted
[c] Calculated as the number of nests from all surveys divided by the number of territories surveyed. Excludes 1 renest in 2007 and 2011 and 2 renests in 2012 in the Colville Delta study area, and 1 renest in 2003 in the NE NPRA study area
[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 (2006–2012), and early nesting (2011) surveys
[h] Survey area included 5 subareas: Development surveyed in 2001–2004, Exploration in 2002–2004, Alpine West in 2002–2006 and 2008–2012, Fish Creek Delta in 2005–2006 and 2008–2012, and Fish and Judy Creek Corridor in 2008–2010. In 2008–2010, 4 Yellow-billed Loon territories were surveyed outside of the Fish and Judy Creek Corridor subarea but within the Development and Exploration subareas. In 2011 and 2012, 11 Yellow-billed Loon territories in the eastern part of the Fish and Judy Creek Corridor were surveyed
[i] Mean numbers not calculated because survey area differed among years

years prior to 2011, and 6 were at new nest sites on lakes previously used for nesting.

During the 18 years of nesting surveys in the Colville Delta study area, the lowest number of nests recorded was 10 nests in 1993 and 1997 and the highest was 33 nests in 2008 (Table 9). In most years, an additional 1–12 nests were found during ground, revisit, and/or monitoring surveys. With the addition of these nests, the counts of nests ranged from 15 in 1993 to 38 in 2008 (Table 9). These counts of nests are not directly comparable because survey coverage varied annually from 37 to 43 territories. To adjust for variable coverage, we used territory occupancy, calculated as the number of nests found divided by the number of territories surveyed, to compare annual occupation by nests. Based on counts of all nests found, territory occupancy was 41–60% during the first 8 years of surveys, while during the last 10 years territory occupancy was 63–90% (Table 9). We estimated population trends using territory occupancy by adults and territory occupancy by nests found only during the nesting survey in regressions for the years when we used a helicopter as the survey platform (2000–2012). Based on those analyses, the number of both adults and nests on the Colville Delta appears to have increased since 2000 (Figure 13).

During the brood-rearing survey on 22 August 2012, 52 Yellow-billed Loons, 14 broods, and 19 young were recorded in the Colville Delta study area (Figure 12, Table 10). We determined 3 additional broods hatched based on eggshell fragments at the nest, but these 3 broods did not survive until the brood-rearing survey in August (see *Nest Monitoring and Nest Fate* below). Of the 17 broods recorded in the Colville Delta study area, 11 broods were found in the CD North subarea, 4 in the CD South subarea, and 2 in the Northeast Delta subarea (Appendix E). The count of 52 adults on the 2012 brood-rearing survey was nearly the same as the 18-year mean (50.1 ± 3.4), and the number of broods observed (14) was higher than the 18-year mean (11.2 ± 1.2; Table 10).

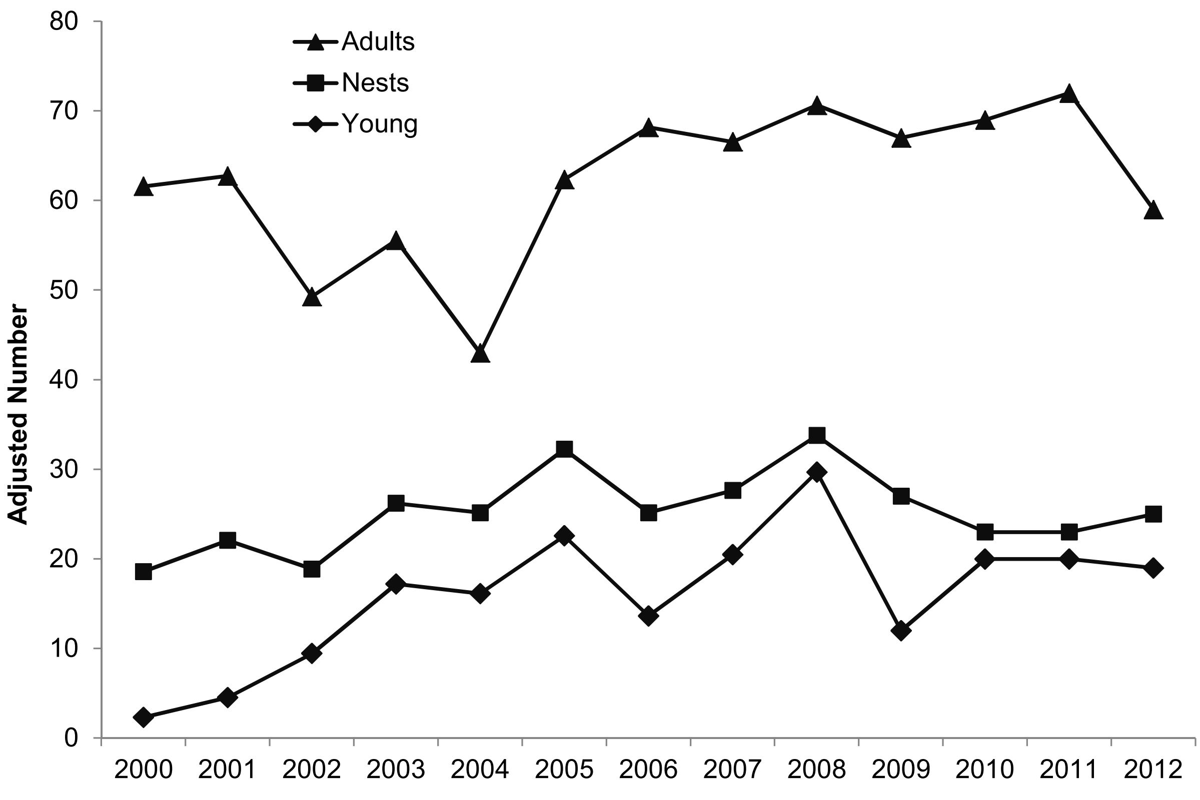


Figure 13. Annual numbers of Yellow-billed Loon adults and nests during the nesting survey and young during the brood-rearing survey, 2000–2012. Numbers are adjusted for the number of territories surveyed each year.

Table 10. Number of Yellow-billed Loons, broods, and territory occupancy by broods, Colville Delta (1993–2012) and NE NPRA (2001–2012) study areas, Alaska.

	Brood-rearing Survey[a]			All Surveys[b]		
STUDY AREA Year	No. Adults	No. Young	No. Broods	No. Broods	No. Territories Surveyed	Territory Occupancy (%)[c]
COLVILLE DELTA[d]						
1993	29	7	7	10[e]	34	29
1995	53	15	11	12[e]	40	30
1996	62	6	6	10[e]	37	27
1997	66	8	5	5	38	13
1998	55	15	12	12	40	30
2000	16	2	2	3[f]	37	8
2001	26	4	4	4	38	11
2002	66	9	8	9[e]	41	22
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]	42	55
2008	57	29	22	27[f, g]	42	64
2009	56	12	11	13[g]	43	30
2010	59	20	14	15[g, h]	42	36
2011	45	20	12	15[f, g, h]	42	36
2012	52	19	14	17[g,, h]	43	40
Mean	50.1	13.9	11.2	13.2		32.6
SE	3.4	1.6	1.2	1.5		3.5
NE NPRA[i]						
2001	47	5	5	7[e]	29	24
2002	47	7	6	6	34	18
2003	54	18	16	16	33	48
2004	67	12	10	10	36	28
2005	12	3	3	3	13	23
2006	16	2	2	2	12	17
2008	70	15	12	19[f, g]	50	38
2009	85	17	12	15[g]	51	29
2010	70	18	15	17[g]	49	35
2011	31	5	4	4	21	19
2012	42	14	12	12	21	57
Mean[j]						30.6
SE						3.9

[a] Brood-rearing surveys were conducted sometime between 15–27 August
[b] Includes all broods found on brood-rearing survey and any additional broods found during other types of surveys as footnoted
[c] Calculated as the number of broods from all surveys divided by the number of territories surveyed
[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 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 on camera images
[i] Survey area included 5 subareas: Development surveyed in 2001–2004, Exploration in 2002–2004, Alpine West in 2002–2006 and 2008–2012, Fish Creek Delta in 2005–2006 and 2008–2012, and Fish and Judy Creek Corridor in 2008–2010. In 2008–2010, 4 Yellow-billed Loon territories were surveyed outside of the Fish and Judy Creek Corridor subarea but within the Development and Exploration subareas. In 2011 and 2012, 11 Yellow-billed Loon territories in the eastern part of the Fish and Judy Creek Corridor were surveyed
[j] Mean numbers not calculated because survey area differed among years

The density of Yellow-billed Loon adults in the Colville Delta study area during the brood-rearing survey in 2012 was 0.14 birds/km², which was similar to the long-term mean (0.13 ± 0.009; Appendix F). The density of broods found in 2012 in the Colville Delta study area was 0.03 broods/km², which was the same as the 18-year mean (0.03 ± 0.003; Appendix F).

During the 18 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 10). 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 Monitoring and Nest Fate* below). With the addition of these broods, the range of brood counts was 3–27 between 1993 and 2012. These raw counts are not directly comparable because survey coverage varied annually from 34 to 43 territories (Table 10). We calculated territory occupancy by broods (the number of all broods seen divided by the number of territories) to adjust brood counts by survey coverage and facilitate annual comparisons. The lowest territory occupancy by broods was 8% in 2000 and the highest occupancy was 64% in 2008.

Habitat Use

During 18 years of nesting aerial surveys in the CD North and CD South subareas, 409 Yellow-billed Loon nests were found in 11 of 24 available habitats on the Colville Delta (Table 11). Six habitats were preferred for nesting (Patterned Wet Meadow, Grass Marsh, Sedge Marsh, Deep Polygon Complex, Deep Open Water with Islands or Polygonized Margins, and Deep Open Water without Islands), altogether supporting 327 of 409 nests. Within these habitats, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. All nests were on shorelines of lakes, but only nests on islands or in emergent vegetation were assigned to the aquatic habitat of the lake; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Patterned Wet Meadow was the habitat used most frequently for nesting (36% of all nests), and it also was the most abundant habitat on the delta (25% of the loon survey area; Table 11). Nesting Yellow-billed Loons avoided 11 habitats, which together occupied 50% of the CD North and CD South subareas.

All Yellow-billed Loon broods (195 broods over 18 years) were found in 4 habitats, 3 of which were preferred: Deep Open Water without Islands, Deep Open Water with Islands or Polygonized Margins, and Tapped Lake with High-water Connection (Table 11). No shallow-water habitats were used during brood-rearing. The selection analyses for nesting and brood-rearing reaffirm the importance of large, deep waterbodies to breeding Yellow-billed Loons.

Nest Monitoring and Nest Fate

Overall, 17 of 32 Yellow-billed Loon nests hatched in the Colville Delta study area in 2012 for an apparent nesting success of 53% (Table 12). The number of nests found in 2012 during nesting and monitoring surveys was near the 8-year mean (31.3 ± 1.4 nests; Table 13) but nesting success was below the 8-year mean (58.7 ± 4.2%; Table 13). Two of the 32 nests found in 2012 were from pairs that failed and presumably renested. Both pairs had a nest on 20 June that was failed by the following week. Both renested by 4 July. The renest location at territory 20 was 37 m from the location of the first nest and at territory 33 the distance between the first nest and the renest location was 172 m. By 1 August, 1 nest had hatched and the other had failed (Table 12).

Most (15) of the 17 successful nests in 2012 hatched in July; 2 (12%) hatched by 11 July, 10 (59%) hatched between 11 July and 19 July, and 3 (17%) hatched by 25 July. The remaining 2 (12%) hatched by 1 August (Table 12). At 3 hatched nests, young loons survived <1 week and were not observed during the following monitoring survey (Table 14). All 3 nests were camera monitored; a chick was detected on images at only 1 of those nests (see *Time-lapse Cameras* below) but hatch was confirmed by eggshell fragments at all 3 nests. Fifteen of 32 Yellow-billed Loon nests on the Colville Delta failed to hatch (Table 12). Most nests were ≤14 d old at the time of nest failure. Six of 32 nests (19%) failed between the nesting survey on 19–20 June and the first monitoring survey on 27 June. Four nests (13%) failed by 4

Table 11. Habitat selection by nesting (1993–1998 and 2000–2012) and brood-rearing (1995–1998 and 2000–2012) 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	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	26	6.4	5.4	ns	
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	37	9.0	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	113	27.6	2.4	prefer	
Shallow Open Water without Islands	0	0	0.3	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.5	0.1	ns	low
River or Stream	0	0	8.8	avoid	
Sedge Marsh	5	1.2	<0.1	prefer	low
Deep Polygon Complex	19	4.6	2.8	prefer	
Grass Marsh	7	1.7	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	46	11.2	8.7	ns	
Patterned Wet Meadow	146	35.7	24.6	prefer	
Moist Sedge–Shrub Meadow	6	1.5	3.2	avoid	
Moist Tussock Tundra	0	0	0.9	avoid	low
Tall, Low, or Dwarf Shrub	2	0.5	6.5	avoid	
Barrens	0	0	12.1	avoid	
Human Modified	0	0	0.1	ns	low
Total	409	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	2.0	avoid	low
Brackish Water	1	0.5	1.1	ns	low
Tapped Lake with Low-water Connection	0	0	5.4	avoid	
Tapped Lake with High-water Connection	42	21.5	5.4	prefer	
Salt Marsh	0	0	2.6	avoid	low
Tidal Flat Barrens	0	0	3.5	avoid	
Salt-killed Tundra	0	0	4.2	avoid	
Deep Open Water without Islands	88	45.1	4.9	prefer	
Deep Open Water with Islands or Polygonized Margins	64	32.8	2.5	prefer	low
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	2.8	avoid	
Grass Marsh	0	0	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	8.7	avoid	
Patterned Wet Meadow	0	0	24.6	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	195	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] Expected number < 5

Table 12. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, Colville Delta study area, Alaska, 2012. Status (A = active, I = inactive) determined from camera-monitored nests is presented in parentheses where it differed from status determined from aerial surveys.

	June			July				August	
Territory	13	19–20	27[a]	4[a]	11	18–19	25	1	Fate/Total
1[b]	I	A	A	A	A (I[c])	I	–	–	Hatched
2[b]	A	A	A	A	A (I[c])	I	–	–	Hatched
4[b]	I	A	A	A	A	I	–	–	Hatched
6[b]	I	A	I	–	–	–	–	–	Failed
8[b]	A	A	A	A	I	–	–	–	Hatched
11	I	A	A	A	A	I	–	–	Hatched
12	I	I	A	I	–	–	–	–	Failed
13[b]	A	A	A	A	I	–	–	–	Hatched
14[b]	I	A	I	–	–	–	–	–	Failed
15[b]	I	A	A	I	–	–	–	–	Failed
18[b]	I	A	A	I	–	–	–	–	Failed
20[b]	I	A	I	–	–	–	–	–	Failed
20[d]	–	–	–	A	A	A	A	I	Failed
21	I	I	A	A	A	A	I	–	Hatched
22[b]	I	A	I	–	–	–	–	–	Failed
25[b]	I	A	A	I[e]	I	–	–	–	Failed
26[b]	I	A	A	A	A	I	–	–	Hatched[f]
27	I	A	A	A	A	I	–	–	Hatched
29[b]	I	A	A	A	A	I	–	–	Hatched
31	I	I	A	A	A	A	A	I	Hatched
33	I	A	I	–	–	–	–	–	Failed
33[d]	–	–	–	A	A	A	A	I	Hatched
34[b]	I	A	A	A	A	A (I[c])	I	–	Hatched
36	I	A	I	–	–	–	–	–	Failed
37	A	A	A	A	A	I	–	–	Hatched
38	I	I	I	A	I	–	–	–	Failed
39	I	A	A	A	A	A	I	–	Hatched
42[b]	A	A	A	A	A	I	–	–	Hatched[f]
43	I	I	I	A	I	–	–	–	Failed
45[b]	I	A	A	A	A	I	–	–	Hatched[f]
46[b]	I	A	A	A	A (I[g])	A (I)	A (I)	I	Failed
47[b]	–[h]	A	A	A	I	–	–	–	Failed
No. Active	5	25	22	22	17 (14)	7 (5)	4 (3)	0	32
No. Hatched	0	0	0	0	2 (4)	10 (11)	3	2	17
No. Failed	0	0	6	4	3 (4)	0	0	2 (1)	15

[a] Camera-monitored nests not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Camera images show young being brooded in nest during this survey
[d] Second nesting attempt after first nest failed
[e] Camera malfunctioned 27 June; date of failure unknown but counted as inactive 4 July, the midpoint between last known status on 27 June and 11 July
[f] No brood seen but nest classified as hatched based on eggshell fragments at the nest; at territory 45, chick confirmed on camera images
[g] Predator seen on camera images at nest 7 July; probably damaged eggs because they should have hatched ~11 July based on the egg-floatation schedule. Nest assumed failed on 7 July
[h] Territory not surveyed

Table 13. Number of nests, apparent nesting success, and number of chicks of Yellow-billed Loons observed during aerial monitoring surveys or determined from nest fate visits, Colville Delta (2005–2012) and NE NPRA (2008–2012) study areas, Alaska.

				At Hatch		Mid-September	
STUDY AREA Year	No. Territories Surveyed	No. Nests	Nesting Success (%)	No. Chicks	Chicks/Nest	No. Chicks	Chicks/Nest
COLVILLE DELTA							
2005	40	31	68	29	0.94	–	–
2006	41	28	57	22	0.79	–	–
2007	42	31	74	36	1.16	–	–
2008	42	38	71	43	1.13	24[a]	0.63
2009	43	30	43	14	0.47	11	0.37
2010	42	35	43	22	0.63	17	0.49
2011	42	25[b]	60	24	0.96	19	0.76
2012	43	32	53	25	0.78	17	0.53
Mean		31.3	58.7	26.9	0.86	17.6	0.55
SE		1.4	4.2	3.2	0.08	2.1	0.07
NE NPRA							
2008	51	29	66	27	0.93	–	–
2009	51	29	52	24	0.83	15	0.52
2010	51	36	47	22	0.61	17	0.47
2011[c]	21	12[d]	33	6	0.50	5	0.42
2012[c]	21	18	67	14	0.78	14	0.78
Mean		–	46.3	–	0.73	–	0.55
SE		–	12.1	–	0.08	–	0.08

[a] Data are from 8 September because survey conditions were poor on 16 September
[b] Total does not include 4 nests that were only seen prior to the nesting survey
[c] Data included in mean and standard error calculations but the study area was different from previous years
[d] Total does not include 1 nest that was only seen prior to the nesting survey

July and 3 more by 11 July. The remaining 2 failures occurred by 1 August, including 1 of the renesting attempts.

The contents of 31 of 32 Yellow-billed Loon nests were examined after nests were no longer active. Sixteen nests were classified as successful based on the presence of >20 eggshell fragments and at some nests, egg membranes. One successful nest was not inspected but was associated with a brood. Fifteen nests were judged failed based on the absence of eggshell fragments, or the presence of <20 eggshell fragments. Successful nests contained 28–105 eggshell fragments. Broods were observed at all but 3 of the hatched nests. Of ~950 eggshell fragments found and measured within 5 m of successful nests, 93% were ≤10 mm in length. Eleven of 16 hatched nests contained pieces of membrane that were either separate or loosely attached to fragments. Two nests contained an entire membrane. The majority of egg membranes and eggshell fragments were found in nest bowls; only 130 fragments were found in the water or on shore adjacent to successful nests. Three of the 15 failed nests that were inspected contained 2–18 egg fragments. The remaining 12 nests were empty.

Time-lapse Cameras

We monitored 19 of 32 Yellow-billed Loon nests in the Colville Delta study area with time-lapse cameras in 2012 (Table 15).

Table 14. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, Colville Delta study area, Alaska, 2012. Status and number of chicks determined by camera-monitoring presented in parentheses where it differed from counts determined during aerial surveys.

	July			August					September					
Territory	11	18–19	25	1	8	15	22	29	4	13	19	No. Chicks Hatched	Age (d) When Last Seen	Brood Fate[a]
1[b]	Inc[c] (2[d])	1	1	1[e]	1	1	1	1[e]	1	1[e]	1	1 (2)	67	A
2[b]	Inc (2[d])	2	2	2	2	2	2	2	2	1	1	2	67	A
4[b]	Inc	2	2	2	2	1	1	1	1	1	1	2	67	A
8[b]	1	1	1	1	1	1	1	1	1	1	1	1	74	A
11	Inc	1	1	1	1	1	1	1	1	1	1[f]	1	67	A
13[b]	2	2	2	2	2	2	2	2	2	2	2	2	74	A
21	Inc	Inc	2	1	1	1	1	1	1	1[e]	1	2	60	A
26[b]	Inc	0[g]	–	–	–	–	–	–	–	–	–	1	4	F
27	Inc	2	2	2[e]	2[h]	2	2	2	2	2[h]	2	2	67	A
29[b]	Inc	2	2	2	2	1[e]	1	1	1[e]	1	1	2	67	A
31	Inc	Inc	Inc	1	1	1	1	1	1[e]	1	1	1	53	A
33	Inc	Inc	Inc	Inc	2	2	2	2	2	2[h]	2	2	53	A
34[b]	Inc	Inc (1[d])	2	2	2	2[h]	2	2	1	1	1	2	60	A
37	Inc	1	1	1	1	1	1	1	1	1	1	1	67	A
39	Inc	Inc	1	1	1	1	1	1	1	1	1	1	60	A
42[b]	Inc	0[g]	–	–	–	–	–	–	–	–	–	1	4	F
45[b]	Inc	0[g]	–	–	–	–	–	–	–	–	–	1 (1[i])	4	F
Totals														
Broods of 2	1 (3)	5	7	6	7	5	5	5	4	3	3	–	–	–
Broods of 1	1	4 (5)	5	7	7	9	9	9	10	11	11	–	–	–
Chick Loss	0	3 (4)	0	1	0	2	0	0	1	1	0	–	–	–

[a] A = active, young present on 19 September, F = failed
[b] Nest monitored by camera
[c] Inc = loon incubating at the time of the survey
[d] Adult brooding chick(s)
[e] No chick observed; chick assumed present based on subsequent aerial surveys
[f] Chick observed in river channel adjacent to territory
[g] No chick observed during monitoring surveys; assume 1 chick hatched based on egg fragments at the nest
[h] Only 1 chick observed; 2 chicks assumed present based on subsequent aerial surveys
[i] Camera images confirm that 1 chick hatched on 13 July but did not survive until 18 July monitoring survey

Table 15. Nest history and incubation activity of Yellow-billed Loon nests monitored by time-lapse digital cameras, Colville Delta study area, Alaska, 2012.

Territory	Fate[a]	Incubation Start Date[b]	Predator	No. Eggs[c]	Date Camera Setup	Date of Hatch or Failure	No. Days Monitored[d]	Incubation Constancy[d] (%)	Exchange Frequency[d] (no/d)	Recess Frequency[d] (no/d)	Recess Length[d] (min/recess)
1	S	13 June		2	24 June	11 July	16.2	99.1	2.4	1.6	6.3
2	S	12 June		2	24 June	10 July	15.4	98.8	2.0	2.2	6.9
4	S	14 June		2	24 June	12 July	17.4	97.4	1.4	2.9	11.7
6	F	12 June	Glaucous Gull	2	24 June	26 June	2.1	87.1	3.3	11.9	16.4
8	S	11 June		–[e]	23 June	9 July	15.1	98.9	1.4	2.2	5.7
13	S	20 June		2	24 June	10 July	15.4	98.4	1.1	2.7	8.1
14	F	13 June	Red Fox	2	24 June	26 June	1.4	98.5	2.2	1.5	19.0
15	F	–	Red Fox	1[e]	22 June	3 July	10.7	96.6	1.1	3.9	11.7
18	F	14 June	Unknown	2	24 June	2 July	8.3	98.6	1.7	2.2	6.9
20	F	19 June	Unknown	2	23 June	24 June	0.5	98.4	2.0	4.0	3.5
22	F	13 June	Unknown	2	23 June	24 June	0.8	96.2	4.0	4.0	32.0
25	F	21 June	Unknown	1	27 June	–[f]	<0.1	–	–	–	–
26	S	14 June		2	25 June	12 July[g]	18.3	96.0	1.2	3.3	16.5
29	S	16 June		2	22 June	14 July[f,h]	5.8	97.8	2.6	2.3	10.2
34	S	20 June		2	23 June	18 July	24.2	97.0	1.5	3.1	11.9
42	S	16 June		2[e]	27 June	14 July[g]	15.4	98.2	1.4	2.5	13.4
45	S	15 June		2	22 June	13 July[h]	20.1	94.3	1.1	5.0	15.3
46	F	13 June	Glaucous Gull	2	23 June	7 July	13.4	97.3	0.9	3.9	9.9
47	F	15 June	Glaucous Gull	2	23 June	9 July	16.0	97.5	0.9	3.3	8.2

[a] S = successfully hatched, F = failed to hatch
[b] Incubation start dates for successful nests estimated by subtracting 28 d from date chick first observed on camera images; for failed nests, nest age estimated using egg floatation (see Methods: Loon Surveys)
[c] As known from aerial surveys, on day of camera setup, or maximum number of eggs seen on camera images
[d] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions
[e] Eggs not floated
[f] Camera malfunctioned prior to hatch or failure
[g] Unable to detect chicks on camera; hatch date estimated by non-incubating adult's increased presence at the nest
[h] Hatch date estimated from float data

Eight-power telephoto cameras were placed 60–83 m from nests (74 ± 4.2 m, n = 5) and 2× and 2.5× telephoto cameras were placed 31–54 m from nests (39 ± 1.8 m, n = 14). Two researchers were transported to and from nesting lakes by helicopter for camera setup; 1 nesting lake was reached on foot from Alpine. Researchers were at nests an average of 54 min (SE = 2.9 min, range = 28–77 min, n = 19 nests). At 18 of 19 nests, an adult was incubating upon our arrival. Of those that were incubating, 17 left the nest during camera setup: 9 swam away from the nest as researchers approached the camera setup location, 7 left as the helicopter landed, and 1 left as researchers exited the helicopter. One loon remained on its nest during camera setup. At the remaining nest, the loon was off its nest when researchers arrived, but an adult was seen on the nest lake about 50 m from the nest while researchers installed the camera.

Eighteen loons were not incubating during camera installation and at least 17 returned to incubate after installation; at the remaining nest, the camera malfunctioned within 4 min of setup so it is unknown whether that loon returned to incubate because that nest later failed. Seven returned before we departed in the helicopter, whereas the remaining 10 returned an average of 13 min (SE = 4 min, range = 1–53 min) after we departed in the helicopter. Excluding the 1 loon already off its nests when we arrived, loons were absent from nests an average of 51 min during camera installation (SE = 4 min, range = 25–96 min, n = 16 nests).

Cameras successfully recorded daily nest survival at the 17 of 19 nests. Cameras malfunctioned at 2 nests. One did so within minutes of setup and that nest failed; the other malfunctioned after ~5.5 d and that nest hatched. Of the 17 cameras that functioned for the entire nesting period, we were able to use camera images to identify the day of hatch or failure at 15 nests (Table 15). The fate of 2 nests was ambiguous judging by images but both hatched based on eggshell evidence at the nest. Although chicks were not seen on images, thick sedge growth around those nests likely prevented the detection of chicks; for 1 nest, we used float data to estimate the day of hatch and for the other, we used the increased presence of the mate at the nest. Of the 19 nests that were monitored, 10 hatched and 9 failed for an apparent nesting success of 52%. The median initiation date of camera-monitored nests was 14 June (range = 11–20 June, n = 18), and the median hatch date was 12 July (range = 9–18 July, n = 9). That hatch date agrees with the peak period of hatch determined from monitoring surveys, which indicated that most nests hatched between visits on 11 and 19 July. Loons at hatched and failed nests exhibited fairly high nest attendance, spending an average of 97.6% (SE = 0.5, n = 10) and 96.3% (SE = 1.3, n = 8) of the time incubating, respectively.

Since camera monitoring began in 2008, predation of 1 or both eggs has been documented at 36 of 86 nests, including 7 nests where predators were not captured on images (Figure 14). The majority (47%) of identified predators were Glaucous Gulls and Parasitic Jaegers, which take advantage of unattended nests. Of the 9 nests that failed to hatch in 2012, 3 failures were attributed to predation by Glaucous Gulls and 2 to a red fox; the predator at 4 nests was not captured on images (Table 15). All 3 nests that failed because of gull predation were unattended at the time of predation. At 1 of these nests, the incubating loon left the nest to interact with an intruding Yellow-billed Loon in the nesting lake before a gull landed at the nest for ~30 sec. The loon resumed incubation ~5 min later and the pair continued to attend the nest until 25 July, or ~15 d after its estimated hatch date based on nest age from egg floatation. On 25 July, the loons appeared to abandon the nest. The nest was empty upon inspection during the nest fate visit. Since no other predators were recorded on camera, we assumed the gull damaged the egg(s) and caused nest failure despite the loon's continued nest attendance. At the remaining 2 nests that suffered gull predation, gulls attacked the nest while loons were on recess. One gull appeared to eat the eggs at the nest and when the loon returned, the loon removed a broken egg from the nest; at the other nest, a gull was seen flying away from the nest with an entire egg in its bill. In contrast, at 2 nests taken by red foxes, loons were incubating <1 min prior to the appearance of each fox in the camera view, suggesting that the foxes flushed the loons. Each fox was recorded at the nest for 30–60 seconds. During both events, loons attempted to defend their nests by splashing and rushing toward the fox.

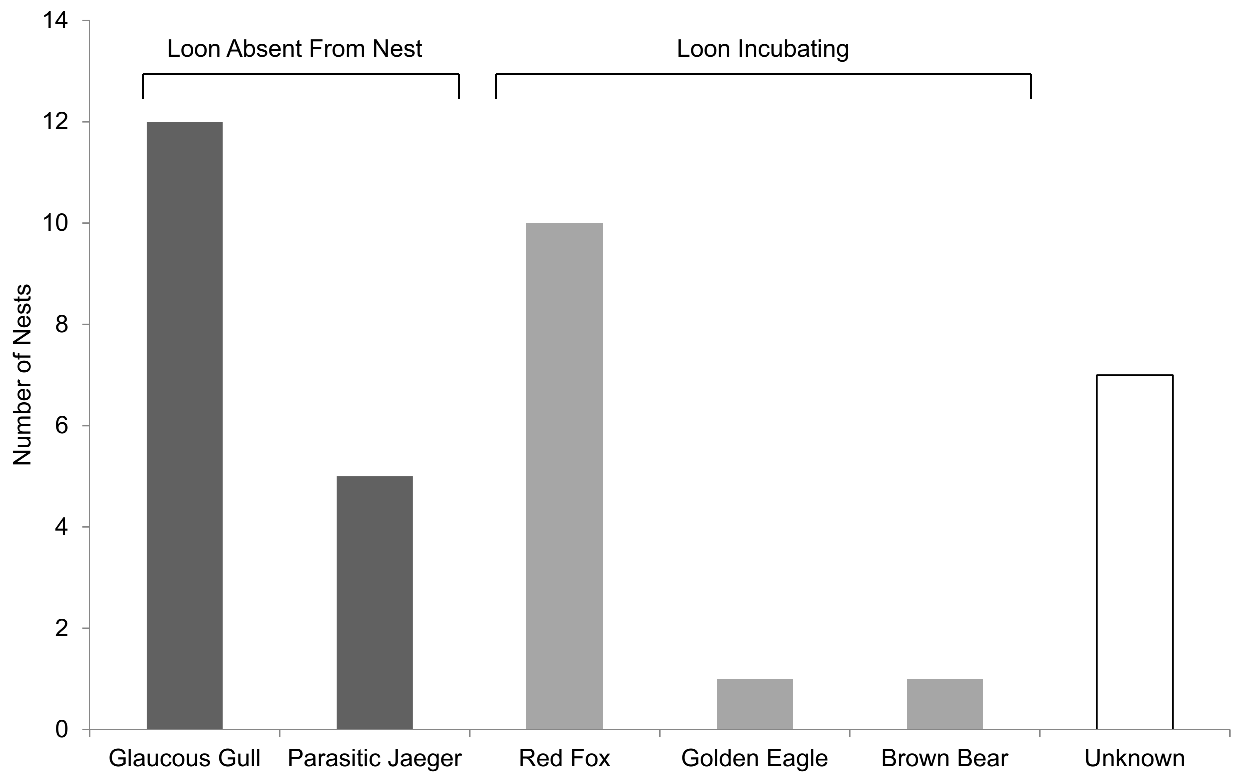


Figure 14. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (n = 86 nests), Colville Delta study area, Alaska, 2008–2012.

A Golden Eagle perched near an incubating loon for >1 h but did not appear to prey on the nest. The loon remained on its nest in an alert posture until the eagle left, at which point the loon got off the nest and swam next to it for ~10 min before resuming incubation. The nest eventually hatched 1 chick but it did not survive to be seen on monitoring surveys.

As mentioned above in descriptions of predation events, cameras often recorded other Yellow-billed Loons intruding into occupied territories. Intruders were identified by the presence of >2 adults or by aggressive interactions between 2 Yellow-billed Loons. In most cases, the appearance of an intruding loon elicited defensive behaviors among the birds such as fencing, rushing, and physical contact (for descriptions see Sjölander and Ågren 1976). In 2010 and 2011, such interactions were recorded at 63–70% of camera-monitored nests (n = 19 and 20 nests, respectively). In 2012, however, intruders were only seen at 38% of monitored nests (n = 18 nests). In nearly all cases, the incubating loon left the nest to interact with the intruder.

Brood Fate

During monitoring surveys following hatch, we observed 2 chicks with 8 of 17 (47%) Yellow-billed Loon pairs that hatched young, and a single chick with 6 (35%) pairs (Table 14). Three additional pairs hatched ≥1 chick based on the presence of eggshell fragments at the nest, but the chick did not survive to the following monitoring survey. At 1 of those nests, a chick also was confirmed on camera images. The other 2 nests were surrounded by thick sedge, which likely prevented chick detection. We found 32 nests in the Colville Delta study area in 2012, including 2 that were from pairs presumably renesting after their first nest failed. Based on monitoring surveys and eggshell evidence, a minimum of 25 chicks were produced at 32 nests (0.78 chicks/nest; Table 13). Images from camera-monitoring confirmed the presence of a second chick at 1 nest that was not seen on monitoring surveys and could not be ascertained from eggshell evidence. Based on all available sources of data (camera, eggshell evidence, and monitoring surveys), a minimum of 26 chicks were produced by 32 nests (0.81 chicks/nest).

Eleven of 17 (64%) Yellow-billed Loon pairs that hatched at least 1 egg retained 1 chick on the final monitoring survey on 19 September; 3 pairs retained both chicks (Table 14). Three pairs suffered complete brood loss, all within 1 week of hatch. One goal of brood monitoring was to estimate juvenile recruitment, or how many chicks survived to fledging. Seventeen chicks from 32 nests (0.53 chicks/nest) survived until the last survey on 19 September (Table 14). Although we detected an average number of nests in 2012, nesting success (53%) and chick production at hatch (0.78 chicks/nest) were below mean values (58.7% and 0.86 chicks/nest, respectively; n = 8 years). The number of chicks that survived to the final monitoring survey was near the 8-year mean (0.55 chicks/nest), indicating that chick survival was fairly high through the summer compared to previous years. On the final survey on 19 September, most loon chicks were 9–10 weeks old and none were observed flying (Table 14). One chick, however, was found in a channel of the Colville River adjacent to its territory. Whether the chick flew to the channel, walked over land, or swam there during a flood event (the nesting lake is connected to the river by a high-water connection) is unknown. The length of time from hatch to fledging is not reported for Yellow-billed Loons, but is assumed to be similar to Common Loons, which make their first flights at ~11 weeks (McIntyre and Barr 1997, North 1994). Chicks on our final survey were likely 1–2 weeks from becoming flight capable.

NE NPRA

Distribution and Abundance

During the survey conducted on 13 June in 2012, we found 4 Yellow-billed Loon nests in the NE NPRA study area. All 4 nests were active at the time the nesting survey was conducted on 19 June 2012. During the nesting survey, we counted 36 Yellow-billed Loons and 15 nests in the 3 subareas surveyed: Alpine West, Fish Creek Delta, and the eastern part of the Fish and Judy Creek Corridor (Figure 12, Table 9). Three additional nests were found during monitoring surveys, 1 nest on 27 June, 1 nest on 4 July, and 1 nest on 11 July. At each of these territories, pairs were observed near the eventual nest location either during the nesting survey or the previous monitoring survey. Of the 18 nests found in the NE NPRA study area in 2012, 1 nest was located in the Alpine West subarea, 8 nests in the Fish Creek Delta subarea, and 9 nests in the Fish and Judy Creek Corridor subarea (Appendix E).

Seventeen of the 18 Yellow-billed Loon nests recorded in the NE NPRA study area in 2012 were on lakes where Yellow-billed Loons have nested previously (Figure 12) (Johnson et al. 2007b, 2010, 2011, 2012). One nest was found on a small lake (0.4 ha) where nesting had not been previously documented, but it was adjacent to a large lake (25 ha) where nesting by Yellow-billed Loons occurred in previous years. Of the other 17 nests found, 3 were located at the same nest site used in 2011, 8 were at nest sites or very close to nest sites used in years prior to 2011, and 6 were at new nest sites on lakes where nesting had occurred in previous years.

The density of Yellow-billed Loon adults and nests in the NE NPRA study area during the nesting survey in 2012 was near average at 0.14 birds/km² and 0.07 nests/km² (Appendix E). The density of loons and nests in the Alpine West subarea in 2012 (0.03 birds/km² and 0.01 nests/km²) was similar to the 10-year means (0.02 ± 0.003 birds/km² and 0.01 ± 0.002 nests/km²; 2002–2004 and 2006–2012); no more than 1 Yellow-billed Loon nest has been recorded in the Alpine West subarea. The density of loons and nests in the Fish Creek Delta subarea in 2012 (0.15 birds/km² and 0.06 nests/km²) was higher than the 7-year mean (0.13 ± 0.009 birds/km² and 0.04 ± 0.005 nests/km²; 2005–2006 and 2008–2012).

We surveyed 21 territories in NE NPRA in 2012 and found 18 nests resulting in a territory occupancy by nests of 86%, which was the highest occupancy recorded for the NE NPRA and much higher than the 11-year mean (64.4 ± 2.5%; Table 9). Nesting surveys for Yellow-billed Loons in the NE NPRA were most extensive in 2008–2010, when 51 territories were surveyed. During those 3 years, the highest number of Yellow-billed Loons recorded during nesting surveys was 82 adults in

2008 and the highest number of nests was 29 in 2010 (Table 9). An additional 7 nests were found in 2010 during monitoring surveys resulting in a total of 36 nests that year for the NE NPRA study area. The range of Yellow-billed Loon territory occupancy by nests was 57–71% during 2008–2010.

During the brood-rearing survey on 22 August 2012, 42 adult Yellow-billed Loons and 12 broods with 14 young were observed in the NE NPRA study area (Figure 12, Table 10). One brood was found in the Alpine West subarea, 4 broods were found in the Fish Creek Delta, and 7 broods were found in the Fish and Judy Creek Corridor (Appendix E). The densities of adults and broods in the Alpine West subarea in 2012 (0.03 birds/km² and 0.01 broods/km²; Appendix E) were similar to the 10-year means (0.02 ± 0.005 birds/km² and 0.01 ± 0.002 broods/km²; 2002–2004 and 2006–2012). The densities of adults and broods in the Fish Creek Delta during the brood-rearing survey in 2012 (0.10 birds/km² and 0.03 broods/km²; Appendix E) was similar to the 7-year mean for that area (0.10 ± 0.009 birds/km² and 0.02 ± 0.003 broods/km²; 2005–2006 and 2008–2012).

In 2012, we surveyed 21 territories containing 12 broods resulting in 57% territory occupancy by broods, which was the highest occupancy recorded for the NE NPRA and much higher than the 11-year mean (30.6 ± 3.9%; Table 10). During our most extensive brood-rearing surveys for Yellow-billed Loons in 2008–2010, 49–51 territories were surveyed each year. The highest number of Yellow-billed Loons recorded during brood-rearing surveys in these 3 years was 85 adults in 2009 and the highest number of broods was 15 in 2010 (Table 10). Additional broods were recorded during monitoring surveys in 2008–2010, and with the inclusion of those broods, the highest number occurred in 2008, when 19 broods were found. The range of Yellow-billed Loon territory occupancy by broods was 29–38% during 2008–2010.

Habitat Use

Habitat selection was evaluated for nesting and brood-rearing Yellow-billed Loons in the 3 subareas surveyed for loons in 2008–2012 (Alpine West, Fish Creek Delta, and Fish and Judy Creek Corridor subareas). Yellow-billed Loon nests were found in 12 of 26 available habitats in the NE NPRA study area (Table 16). Four habitats were preferred for nesting (Tapped Lake with High-water Connection, Deep Open Water with Islands or Polygonized Margins, Sedge Marsh, and Deep Polygon Complex), altogether supporting 67 of 108 (62%) total nests. Within these areas, nests were built on peninsulas, shorelines, islands, or in emergent vegetation. Although all nests were on islands or shorelines of lakes, only nests on islands or in emergent vegetation were assigned to the aquatic habitat of the lake; otherwise nests were assigned to the terrestrial habitat on the lakeshore. Deep Open Water with Islands or Polygonized Margins was the most frequently used habitat for nesting (35% of all nests; Table 16). Nesting Yellow-billed Loons avoided 7 habitats composing 55% of the loon survey area in the NE NPRA.

Fifty-three Yellow-billed Loon broods were found in 3 habitats in the NE NPRA study area, 2 of which were preferred: Tapped Lake with High-water Connection and Deep Open Water with Islands or Polygonized Margins (Table 16). Deep Open Water with Islands or Polygonized Margins also was the most frequently used habitat for brood-rearing (74% of all broods). No shallow-water habitats were used during brood-rearing. The selection analyses for loons in the NE NPRA, like those conducted for the Colville Delta, highlight the reliance on large, deep waterbodies by breeding Yellow-billed Loons.

Nest Monitoring and Nest Fate

Overall, 12 of 18 Yellow-billed Loon nests hatched in the NE NPRA study area in 2012 for an apparent nesting success of 67%, which was the highest observed since monitoring surveys began in 2008 (Tables 13 and 17). The number of nests found in 2012 (18) also was the highest number found during 5 years of surveys when only lakes within the 2011–2012 study area are used for annual comparisons. During the 4 previous years, 12–13 nests were found in that area. Of the 12 successful nests in 2012, 4 (33%) hatched between visits on 4 and 11 July and 5 (42%) hatched by 19 July (Table 17). After that survey, 3 more nests hatched; 2 by 25 July and 1 by 1 August.

Six of 18 Yellow-billed Loon nests in the NE NPRA study area failed to hatch (Table 17). After the nest survey on 19–20 June, approximately 1

Table 16. Habitat selection by nesting and brood-rearing Yellow-billed Loons, NE NPRA study area, Alaska, 2008–2012.

SEASON Habitat	No. of Nests or Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	6.4	avoid	
Brackish Water	0	0	2.7	ns	low
Tapped Lake with Low-water Connection	0	0	1.8	ns	low
Tapped Lake with High-water Connection	15	13.9	1.4	prefer	low
Salt Marsh	0	0	4.9	avoid	
Tidal Flat Barrens	0	0	4.9	avoid	
Salt-killed Tundra	0	0	1.9	ns	low
Deep Open Water without Islands	4	3.7	5.6	ns	
Deep Open Water with Islands or Polygonized Margins	38	35.2	6.2	prefer	
Shallow Open Water without Islands	0	0	0.7	ns	low
Shallow Open Water with Islands or Polygonized Margins	4	3.7	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	11	10.2	1.5	prefer	low
Deep Polygon Complex	3	2.8	0.1	prefer	low
Grass Marsh	2	1.9	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.1	avoid	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	3	2.8	1.6	ns	low
Nonpatterned Wet Meadow	4	3.7	3.2	ns	low
Patterned Wet Meadow	18	16.7	11.8	ns	
Moist Sedge-Shrub Meadow	5	4.6	15.5	avoid	
Moist Tussock Tundra	1	0.9	15.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	4.1	avoid	low
Barrens	0	0	2.0	ns	low
Human Modified	0	0	0	ns	
Total	108	100	100		
BROOD-REARING					
Open Nearshore Water	0	0	6.4	ns	low
Brackish Water	0	0	2.7	ns	low
Tapped Lake with Low-water Connection	0	0	1.8	ns	low
Tapped Lake with High-water Connection	10	18.9	1.4	prefer	low
Salt Marsh	0	0	4.9	ns	low
Tidal Flat Barrens	0	0	4.9	ns	low
Salt-killed Tundra	0	0	1.9	ns	low
Deep Open Water without Islands	4	7.5	5.6	ns	low
Deep Open Water with Islands or Polygonized Margins	39	73.6	6.2	prefer	low
Shallow Open Water without Islands	0	0	0.7	ns	low
Shallow Open Water with Islands or Polygonized Margins	0	0	1.5	ns	low
River or Stream	0	0	2.2	ns	low
Sedge Marsh	0	0	1.5	ns	low
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	0	0	0.4	ns	low
Young Basin Wetland Complex	0	0	0.3	ns	low
Old Basin Wetland Complex	0	0	4.1	ns	low
Riverine Complex	0	0	0.1	ns	low
Dune Complex	0	0	1.6	ns	low
Nonpatterned Wet Meadow	0	0	3.2	ns	low
Patterned Wet Meadow	0	0	11.8	avoid	
Moist Sedge-Shrub Meadow	0	0	15.5	avoid	
Moist Tussock Tundra	0	0	15.0	avoid	
Tall, Low, or Dwarf Shrub	0	0	4.1	ns	low
Barrens	0	0	2.0	ns	low
Human Modified	0	0	0	ns	
Total	53	100	100		

[a] use = (groups / total groups) x 100

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

[c] Expected number < 5

Table 17. Weekly status and fate of Yellow-billed Loon nests monitored by aerial surveys, NE NPRA study area, Alaska, 2012. Status (A = active, I = inactive) determined from camera-monitored nests is presented in parentheses where it differed from status determined from aerial surveys.

	June			July				August	
Territory	13	19–20	27[a]	4[a]	11	18–19	25	1	Fate/Total
51	A	A	A	A	I	–	–	–	Hatched
52	I	A	I	–	–	–	–	–	Failed
53[b]	A	A	A	A	I	–	–	–	Hatched
54	I	I	I	A[c]	A	A	A	I	Hatched
55[b]	A	A	A	A	I	–	–	–	Hatched
56	A	A	A	A	I	–	–	–	Hatched
57[b]	I	I	A	A	A	A	I	–	Hatched
58[b]	I	A	A	A	A (I[d])	I	–	–	Hatched
59[b]	I	A	A	A	A	I	–	–	Hatched
61[b]	I	A	A	I	–	–	–	–	Failed
88[b]	I	A	A	A	A	I	–	–	Hatched
90[b]	I	A	A	A	I[e]	–	–	–	Failed
91	I	A	A	A	A	A	A	I	Failed
92[b]	I	A	A	A	A	A (I[d])	I	–	Hatched
93[b]	I	A	A	A	A	I	–	–	Hatched
96[b]	I	A	A	A	A	I	–	–	Hatched
97	I	I	I	A	A	I	–	–	Failed
100	I	A	I	–	–	–	–	–	Failed
No. Active	4	15	14	15	10 (9)	4 (3)	2	0	18
No. Hatched	0	0	0	0	4 (5)	5 (6)	2	1	12
No. Failed	0	0	2	1	1	1	0	1	6

[a] Camera-monitored nests were not surveyed by helicopter; nest status determined from camera images
[b] Nest monitored by camera
[c] Adult swimming next to island where nest was eventually found; nest assumed active this visit
[d] Camera images show young were being brooded in nest during this survey
[e] Golden Eagle eating eggs in loon nest at time of monitoring survey; camera confirmed that event as nest failure

nest failed each week. The last nest failure occurred by 1 August.

The contents of 16 Yellow-billed Loon nests were examined after nests were no longer active. Ten nests were classified as successful based on the presence of eggshell fragments in the nest and a brood; an additional 2 hatched nests were not examined but were associated with a brood. Successful nests contained 38–84 small eggshell fragments within 5 m of the nest. Of >600 eggshell fragments found in successful nests, 63% were ≤10 mm in length and 30% were 11–20 mm in length. Two successful nests also contained entire egg membranes; an additional 6 contained pieces of membrane, usually loosely attached to eggshell fragments. The majority of egg membranes and eggshell fragments were found in nest bowls, but <55 fragments were found in the water or on shore adjacent to successful nests. All 6 failed nests were examined for fate evidence; 3 were empty and 3 had 2–13 pieces of eggshell in or near the nest. Two of those nests contained a few pieces of thickened membrane loosely attached to egg fragments but both nests were confirmed failed. One was camera-monitored and failed ~2 days prior to hatch; the other was only active for ~2 weeks, which is less than the incubation period (27–28 days; North 1994) for Yellow-billed Loons.

Time-lapse Cameras

We monitored 11 of 18 Yellow-billed Loon nests in the NE NPRA study area with time-lapse cameras in 2012 (Table 18). Eight-power telephoto cameras were placed 47–142 m from nests (83 ± 14.1 m, n = 6 nests) and 2× and 2.5× telephoto cameras were placed 36–52 m from nests (47 ± 2.8 m, n = 5 nests). Two researchers were transported to and from nesting areas by helicopter for camera setup and were at nests an average of 61 min (range = 38–128 min, n = 11 nests). Ten loons left their nest during camera setup (5 swam away as researchers approached the camera setup location, 3 left as researchers exited the helicopter, and 2 left as the helicopter landed), and 1 loon was swimming near its nest when researchers arrived.

All 11 loons returned to incubate after camera installation. Two returned before we departed the area in the helicopter. The remaining 9 loons returned to their nests an average of 9 min after we departed in the helicopter (SE = <1 min, range = 4–21 min, n = 9 nests). Excluding the loon that was swimming next to its nest when we arrived, loons were absent from nests during camera installation for a mean of 54 min (SE = <1 min, range = 31–84 min, n = 10 nests).

Cameras successfully recorded daily nest survival and we were able to use images to identify the day of hatch or failure at 10 of 11 camera-monitored nests. The camera at 1 nest malfunctioned ~7 days prior to hatch. Nine of the nests hatched and 2 failed for an apparent nesting success of 81%. The median initiation date of camera-monitored nests was 16 June (range = 12–21 June, n = 11) and the median hatch date was 12 July (range = 10–19 July, n = 8; Table 18). Hatch dates determined from camera images agree with the hatch dates determined from monitoring surveys, which indicate that most nests hatched between 11 and 19 July (Table 17). Loons at hatched and failed nests exhibited high nest attendance (97.9 ± 0.4% of time incubating, n = 9 successful nests, and 95.7 ± 0.8%, n = 2 failed nests; Table 18).

Since camera monitoring began in 2010 in the NE NPRA study area, we have identified predators at 14 of 27 (52%) monitored nests and all were avian predators that, except for Golden Eagles, took eggs while nests where unattended. Over half (57%) of the 14 events occurred while loons were absent from nests. Predators were not captured on images at 2 nests and the timing of predation could not be determined with certainty (Figure 15). In 2012, 1 failure was attributed to Parasitic Jaegers and 1 to a Golden Eagle. The nest that failed due to jaeger predation was unattended at the time of predation. The jaegers appeared at the nest ~2 min after the loon left. The jaegers made at least 3 separate visits to the nest totaling ~7 min in duration. When the loon returned, it removed a broken egg from its nest before ending nest attendance. In contrast, the Golden Eagle flushed the loon from its nest and ate the eggs at the nest for 15 min.

Yellow-billed Loon eggs hatch asynchronously. Adults brood and swim with the first hatched chick while the second egg is hatching, which can take 1–3 d. At 1 Yellow-billed Loon nest which hatched 1 egg, camera images suggested predation of the second egg. Adults left the nest with 1 chick and ~8 h later, a Parasitic Jaeger landed at the nest and appeared to eat the second egg. The loons did not return to the nest after leaving with the first chick and it is possible that they abandoned the second egg.

In 2010 and 2011, we observed intruding loons on images at 50–80% camera-monitored territories during the nesting period (n = 10 and 6 nests, respectively). In 2012, however, we did not observe intruders on images at any of the 11 camera-monitored nests. As reported above, intruding loons also were seen at nests in the Colville Delta study area and similarly were not as commonly seen on images in 2012 as they were during the preceding 2 years. These interactions may reflect attempts at territorial takeover by the intruders. Territorial fights and subsequent takeovers have been observed in Common Loons (Piper et al. 2000) but it is unknown whether this behavior also plays an important role in the establishment of Yellow-billed Loon territories (North 1994).

Brood Fate

During the monitoring survey following hatch, 2 of 12 (17%) successful Yellow-billed Loon pairs in the NE NPRA study area were observed with 2 chicks and 10 pairs (83%) had 1 chick (Table 19). Chicks were observed at all

Table 18. Nest history and incubation activity at Yellow-billed Loon nests monitored by time-lapse digital cameras, NE NPRA study area, Alaska, 2012.

Territory	Fate[a]	Nest Initiation Date[b]	Predator	No. Eggs[c]	Date Camera Setup	Date of Hatch or Failure	No. Days Monitored[d]	Incubation Constancy[d] (%)	Exchange Frequency[d] (no/d)	Recess Frequency[d] (no/d)	Recess Length[d] (min/recess)
53	S	13 June		2	27 June	11 July	13.4	98.1	1.3	1.9	13.1
55	S	12 June	Parasitic Jaeger[e]	2	25 June	10 July	14.1	98.9	1.8	1.3	9.7
57	S	24 June		2	27 June	22 July[f]	16.7	96.2	0.8	3.4	17.6
58	S	12 June		2	26 June	10 July	13.3	98.8	1.4	2.0	7.1
59	S	18 June		2	26 June	16 July	19.2	97.5	1.4	3.9	10.4
61	F	21 June	Parasitic Jaeger	2	26 June	28 June	2.1	96.5	0	4.4	15.0
88	S	14 June		2	23 June	12 July	17.6	98.3	1.0	2.3	9.7
90	F	16 June	Golden Eagle	2	27 June	11 July	13.9	95.0	1.8	3.6	18.5
92	S	21 June		–[g]	26 June	19 July	21.2	96.4	1.0	3.2	15.3
93	S	16 June		1	25 June	14 July	18.3	97.1	1.2	3.6	11.6
96	S	14 June		2	25 June	12 July	16.4	99.4	2.4	1.0	6.1

[a] S = successfully hatched, F = failed to hatch

[b] Incubation start dates for successful nests estimated by subtracting 28 d from date chick first observed on camera images; for failed nests, nest age estimated using egg floatation (see Methods: Loon Surveys)

[c] As known from aerial surveys, on day of camera setup, or maximum seen on camera images

[d] Summarized from time loon returns to nest after camera installation to day before hatch, or to time of nest failure; excludes period of time when photo images could not be interpreted because of poor weather conditions

[e] Predation occurred on the second egg during hatch

[f] Camera malfunctioned prior to hatch; hatch date estimated from float data

[g] Eggs not floated

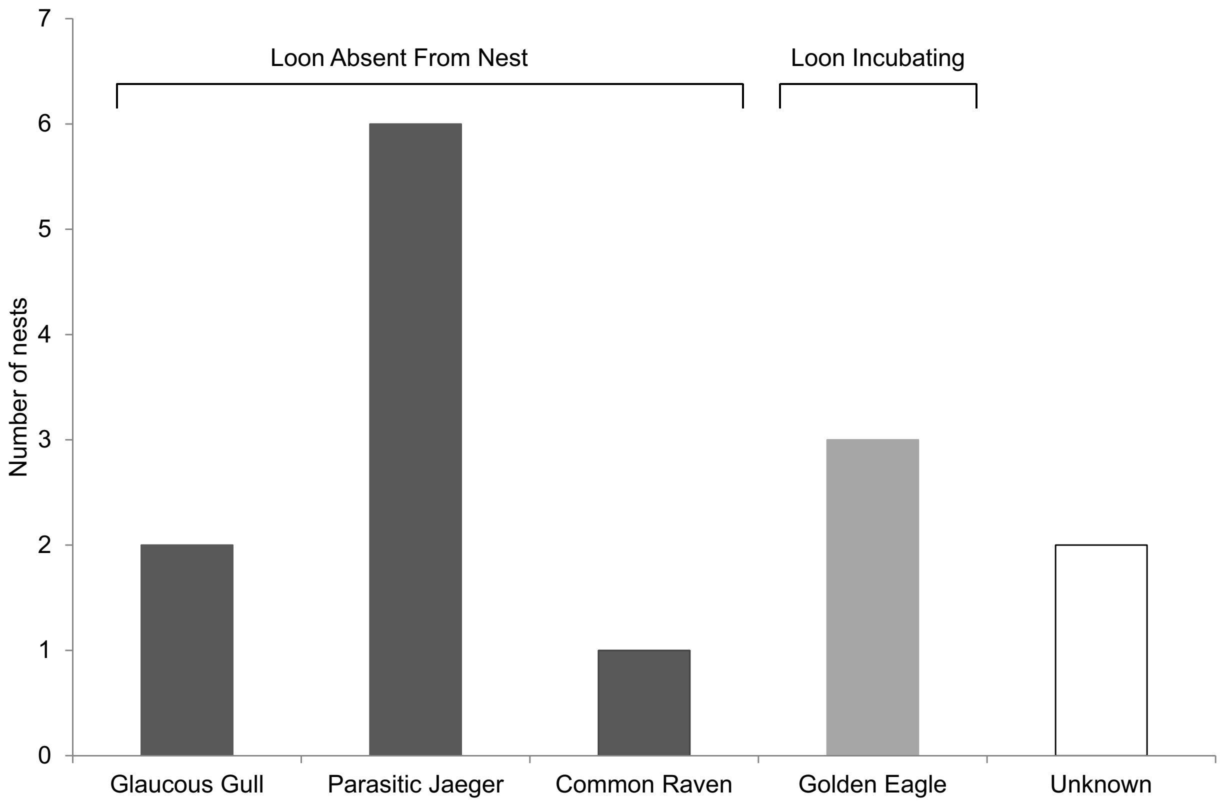


Figure 15. Predators seen taking eggs at camera-monitored Yellow-billed Loon nests (n = 27 nests), NE NPRA study area, Alaska, 2010–2012.

hatched nests during an aerial survey; however, at 2 nests, a second chick was seen on camera images where only 1 was seen during surveys. Based on monitoring surveys and eggshell evidence, a minimum of 14 chicks were produced at the 18 nests found in the NE NPRA in 2012 (0.78 chicks/nest; Table 13). Images from camera-monitoring confirmed the presence of second chicks at 2 nests where they were not seen on monitoring surveys. Based on all available sources of data (camera, eggshell evidence, and monitoring surveys), a minimum of 16 chicks were produced by 18 nests (0.89 chicks/nest).

All 14 chicks we observed on the aerial survey following hatch survived to the final monitoring survey on 19 September. The combination of high nesting success and high chick survival throughout the summer resulted in the highest number of chicks/nest on our final survey in September (0.78 chicks/nest, n = 18 nests) since monitoring surveys began in 2009 (0.55 ± 0.08 chicks/nest; Table 13). However, the sample size of nests in 2011 and 2012 was much smaller than in previous years, making annual comparisons less reliable. Most loon chicks in 2012 were 8–10 weeks old and none were observed flying by the time of the last survey in mid-September (Table 19). Assuming the fledging period is similar to that of Common Loons, which is ~11 weeks (McIntyre and Barr 1997, North 1994), the chicks were 1–3 weeks from fledging during our final survey in mid-September.

PACIFIC AND RED-THROATED LOONS

Colville Delta

We counted 156 Pacific Loons and 13 nests, and 5 Red-throated Loons in the Colville Delta study area during the nesting survey for Yellow-billed Loons in 2012 (Figure 16, Appendix E). During the brood-rearing survey, we recorded

Table 19. Number of Yellow-billed Loon chicks observed during weekly aerial surveys, NE NPRA study area, Alaska, 2012. Status and number of chicks determined by camera-monitoring presented in parentheses where it differed from counts determined during aerial surveys.

	July			August					September					
Territory	11	18–19	25	1	8	15	22	29	4	13	19	No. Chicks Hatched	Age (d) When Last Seen	Brood Fate[a]
51	2	2	2	2	2	2	2	2	2	2	2	2	74	A
53[b]	1	1	1	1	1	1	1	1	1[c]	1[c]	1	1	74	A
54	Inc[d]	Inc	Inc	1	1	1[c]	1	1[e]	1	1	1	1	53	A
55[b]	1	1	1	1	1	1	1	1	1	1	1	1	74	A
56	1	1	1	1[c]	1	1	1	1	1	1	1	1	74	A
57[b]	Inc	Inc	1	1	1	1	1	1	1	1[c]	1	1	60	A
58[b]	Inc (1[f])	1	1	1[c]	1	1	1	1	1	1	1	1(2)[g]	67	A
59[b]	Inc	1	1	1	1	1	1	1	1	1	1	1	67	A
88[b]	Inc	1	1	1	1	1	1	1	1	1	1	1(2)[g]	67	A
92[b]	Inc	Inc (1[f])	1	1[c]	1	1	1	1	1	1	1	1	60	A
93[b]	Inc	1[c, f]	1	1	1	1	1	1	1	1	1	1	67	A
96[b]	Inc	2	2	2	2	2	2	2	2	2[h]	2	2	67	A
Totals														
Broods of 2	1	2	2	2	2	2	2	2	2	2	2	–	–	–
Broods of 1	3 (4)	7 (8)	9	10	10	10	10	10	10	10	10	–	–	–
Chick Loss	0	0	0	0	0	0	0	0	0	0	0	–	–	–

[a] A = active, young present on 19 September
[b] Nest monitored by camera
[c] No chick observed; chick assumed present based on subsequent surveys
[d] Inc = loon incubating at the time of the survey
[e] Territory not surveyed; chick assumed present based on subsequent aerial surveys
[f] Adult brooding chick(s)
[g] Second chick observed on camera images on 14 July, but did not survive until 18 July monitoring survey
[h] Only 1 chick observed; 2 chicks assumed present based on subsequent aerial surveys

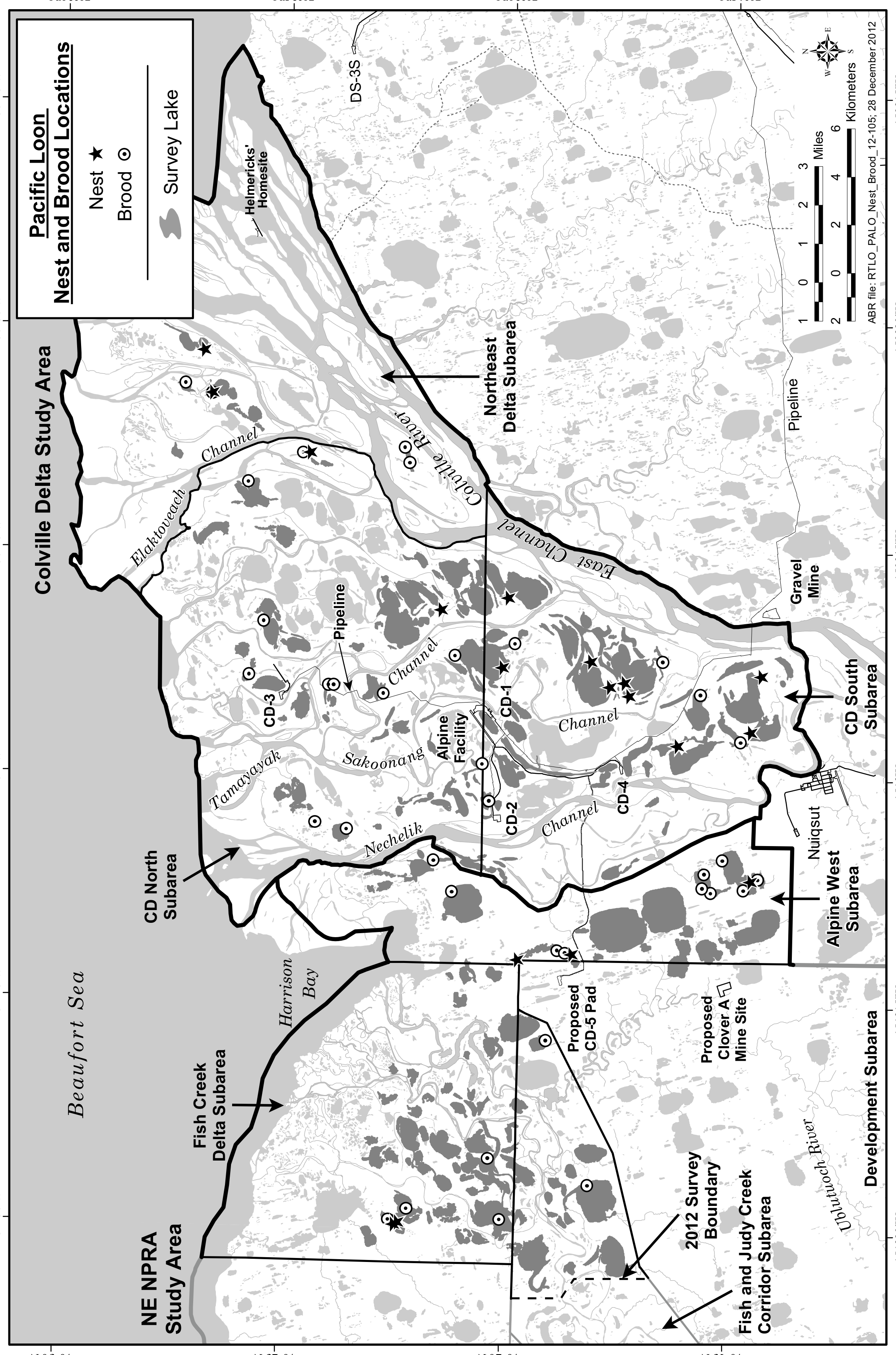


Figure 16. Pacific Loon nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2012.

58 adult Pacific Loons and 20 broods (Figure 16, Appendix E). No nests or broods of Red-throated Loons were observed in the Colville Delta study area in 2012. Because these counts of Pacific and Red-throated loons were recorded incidentally during Yellow-billed Loon surveys, they reflect the general distribution of these species on the Colville Delta but are not accurate estimates of the abundance of these species (due to differences in species detectability). Nests of Red-throated Loons are not easily detected from the air and are found on small ponds, which were not surveyed systematically in this study. Pacific Loons breed on small and large lakes and were clearly the most abundant loon on the delta in 2012 and in previous years. Because the survey focused on lakes larger than those typically occupied by Pacific and Red-throated loons for nesting and brood-rearing, densities have not been calculated for these 2 species.

NE NPRA

Pacific Loons also were the most abundant and widespread loon species breeding in the NE NPRA study area in 2012. On the loon nesting survey, we recorded 180 adult Pacific Loons and 5 nests, and 2 Red-throated Loons with no nests (Figure 16, Appendix E). During the brood-rearing survey, 92 adult Pacific Loons and 16 broods were found (Figure 16, Appendix E). No Red-throated Loons or broods were found in the NE NPRA study area during the brood-rearing survey.

DISCUSSION

The annual numbers of Yellow-billed Loon adults and nests recorded during nesting surveys the Colville Delta study area have displayed slightly increasing trends since surveys began 18 years ago. When the numbers of adults and nests recorded during helicopter surveys (2000–2012) are adjusted by the number of territories surveyed, the annual growth rate for adults is positive but not significant at 1.019 ($\ln(y) = 0.019x - 33.272$, $R^2 = 0.233$, $P = 0.095$, $n = 13$). The growth rate for nests (1.018) is also positive but not significant ($\ln(y) = 0.018x - 33.1$, $R^2 = 0.161$, $P = 0.17$, $n = 13$). The low rate of increase in the local population on the Colville Delta study area appears to fit into the slope-wide trend. The Colville growth rate is similar to the annual growth rate (1.020, SE = 0.008, $n = 20$ years) measured for Yellow-billed Loons on the entire Arctic Coastal Plain (Larned et al. 2012). Likewise, the number of young produced on the Colville Delta study area has increased; since 2000, the number of young counted during brood-rearing surveys has grown significantly at an annual rate of 1.127 ($\ln(y) = 0.127x - 251.9$, $R^2 = 0.487$, $P = 0.008$, $n = 13$).

Comparable data for estimating growth rates in Yellow-billed Loons in NE NPRA are unavailable. The survey area for loons in the NE NPRA study area has not been consistent for enough years to allow a meaningful evaluation. As a general observation, the number of adults and nests found in each subarea has varied but the population along the Fish and Judy creek corridor appears stable.

The increase in the numbers of Yellow-billed Loons in the Colville Delta study area may be due to multiple factors: a higher annual occupation of territories by adults, an increase in adult loons not associated with territories, and a higher detection of adults on territories. Since 2000, the number of territories occupied by adults has increased and since 2010 there also has been an increase in the number of loons that are not associated with territories. During 2005–2008, a total of 83 young were recorded during brood-rearing surveys in the Colville Delta study area; the survivors from these cohorts would be at breeding age (3–6 years, Barr 1997) in 2012. Assuming that young return to natal grounds for breeding, as has been documented in Common Loons (McIntyre and Barr 1997), the return of these cohorts of birds to the study area could account for the increase in adults observed. Additional evidence of growing numbers of breeding aged Yellow-billed Loons is the number of intruding loons has increased on camera images since cameras were first used in 2008. These visiting loons may be new or failed breeders. The increase in interactions between territory holders and intruders that we have observed since 2008 may be an attempt by intruders to usurp desirable territories. Territorial takeover through usurpation has been documented in Common Loons and, along with passive occupation of territories left vacant by a previous resident, is thought to be an important means of territory acquisition (McIntyre and Barr 1997, Piper et al. 2000).

The timing of nest initiation and the number of nests occurring in both the Colville Delta and NE NPRA study areas during the study years appear to be largely influenced by the extent of flooding during breakup and by climatic conditions in mid-May to mid-June (Earnst 2004, this study). Conditions in 2012 were favorable for nesting Yellow-billed Loons and the number of nests recorded in the Colville Delta and NE NPRA study areas was well above average. In years when flooding resulted in high water levels on nesting lakes, as happened in 2011, some loons could not occupy traditional nest sites and either waited for water levels to drop before nesting, nested at alternate sites, or failed to nest (Johnson et al. 2012). The start of incubation for the nests monitored with cameras occurred between 12 June and 21 June in both 2011 and 2012. Nesting was later than normal in 2010 on the Colville Delta (between 17 June and 22 June) as a result of late thaw and late formation of moats around ice on nesting lakes (Johnson et al. 2011), which delayed access to lakes. In sharp contrast, most Yellow-billed Loons initiated nesting early on the Colville Delta in 2008 (between 7 June and 15 June) when May and June were warm and breakup on the Colville River was average (Johnson et al. 2009). Thirty-eight nests were found in the Colville Delta study area in 2008, the highest number recorded during 18 years of surveys.

In 2011 and 2012, we conducted a survey for nesting Yellow-billed Loons 1 week earlier than the nesting survey to better understand nesting phenology and to document nests that fail prior to the nesting survey. In 2011, 4 of 6 nests detected on the early survey failed by the nesting survey whereas in 2012, none of the 9 nests detected failed. To detect nests that are initiated after the nesting survey, we revisit territories on monitoring surveys where no nest was detected during the nesting survey. During these monitoring surveys we have detected a total of 33 additional nests in the Colville Delta study area during 7 years (2006–2012) and a total of 19 additional nests in the NE NPRA study area during 5 years (2008–2012). Together, the early survey and the monitoring surveys have increased the number of nests detected, improved estimates of nesting success, and have documented 4 renesting attempts. Although we have suspected in previous years that Yellow-billed Loons renest after failure early in the season, the data from weekly resurveys in 2011 and 2012 have provided strong evidence that renesting occurs with this species.

We began monitoring a sample of Yellow-billed Loon nests with cameras in the Colville Delta and NE NPRA study areas in 2008 and 2010, respectively. From all the nests monitored with cameras, predators took 1 or both eggs from 44% of 113 nests. Glaucous Gulls and Parasitic Jaegers were the most commonly recorded nest predators, taking eggs at 50% of the nests that lost eggs (n = 50 nests). Those avian predators, along with Common Ravens, preyed exclusively on unattended nests. Golden Eagles were the only avian species that flushed Yellow-billed Loons from nests to take eggs. Although avian predation was the most common reason for egg loss in both study areas, the predatory species differed between areas. Glaucous Gulls most frequently caused predation in the Colville Delta study area, whereas Parasitic Jaegers and Golden Eagles caused most predation in the NE NPRA study area. Red foxes were the second most commonly recorded predator. From our observations, red foxes always flushed loons from attended nests when taking eggs; however, red foxes were seen preying on nests only in the Colville Delta, not in the NE NPRA study area.

A preliminary comparison of incubation constancy between successful and failed nests shows that loons at successful nests spent a higher percentage of time on nests (mean = 97.8%) than those at failed nests (mean = 93.9%; Mann-Whitney U test, n = 103, P < 0.001). This behavioral difference appears to be important given the fairly high rate of egg loss that occurs when nests are unattended. Reasons for poor attendance were unknown at many nests, but at some nests we observed predation when resident loons were off nests while interacting with intruding loons or during periods of warm weather (i.e. > 15° C; this study, unpublished data).

A study conducted in 1983 and 1984 in a portion of our Colville Delta study area found that Yellow-billed Loons had high reproductive success compared to other loon species, as a result of low egg loss and high chick survival (North 1986). In both 1983 and 1984, apparent nesting success was 94% and only 1 nest failed each year. One nest was crushed by shifting ice and the other nest failed from avian predation. We observed a much higher rate of nest predation on the delta than did North (1986). During our study, apparent nesting success averaged 59% (n = 8 years). Data from camera-monitored nests indicated that predation was the main cause of nest failure, with Glaucous Gulls and red foxes being the primary predators. The high nesting success that North (1986) observed was reflected in chick productivity of 1.29 and 0.94 chicks/nest in 1983 and 1984, respectively (North 1986). Because we observed more nest failures, our productivity at hatch was lower, ranging from 0.47 to 1.16 chicks/nest (mean = 0.87 chicks/nests, n = 8 years). In our study, chick survival seems fairly high, but we are unaware of comparable data for Yellow-billed Loons (see North 1986, North 1994, Earnst 2004).

An increase in the number of Glaucous Gulls and red foxes on the Colville Delta may be partly responsible for the increase in nest predation rates since the study by North (1986). In our Colville Delta study area, gulls took eggs in 33% of the predation events. Although gull numbers across the Arctic Coastal Plain have been variable and fairly stable over the last 19 years, data from the last 10 years suggest that numbers have increased (Larned et al. 2012). Since 2002, the number of gull nests seen in the Colville Delta study area also has increased (see GLAUCOUS AND SABINE'S GULLS below). An increase in gull abundance could reduce nest or chick survival, because gulls prey on eggs as well as young loon chicks (Johnson et al. 2010).

The number of red foxes probably has increased on the Colville Delta since the 1980s. In our Colville Delta study area, red foxes caused nest failure in 28% of the predation events since camera monitoring began in 2008 (n = 36 events). North (1986) did not observe predation by red foxes and only mentions that they were uncommon on the delta. Although we lack survey data, anecdotal evidence collected during our avian studies suggests that red foxes have become more common on the delta. During the Alpine Avian Monitoring Program (1998–2001), arctic foxes were seen almost daily, whereas red foxes were uncommon and first observed in 1999 (Johnson et al. 2003a). During that study, video cameras were deployed to monitor swan and goose nests (1998–2001); 72% of foxes seen on camera were identified as arctic fox, 16% as red fox, and 12% were unidentified. In 2010–2012, over half (56%) of the foxes seen on images from cameras monitoring loon nests in the Colville Delta study area were identified as red fox (n = 59 fox occurrences). An increase in the number of red foxes would likely have a negative effect on nest productivity because red foxes appear to be more effective predators of Yellow-billed Loon nests than arctic foxes. Camera images from this study have shown arctic foxes passing by Yellow-billed Loon nests and, less frequently, trying (unsuccessfully) to flush loons from nests, but they have not been documented taking eggs. In contrast, red foxes frequently have been successful at flushing loons from nests to steal eggs.

TUNDRA SWAN

COLVILLE DELTA

Distribution and Abundance

Tundra Swan abundance was higher but productivity was lower on the Colville Delta study area in 2012 compared with long-term mean values. During the swan nesting survey, we counted 505 swans, including 117 pairs, in the Colville Delta study area (Figure 17). The number of swans in 2012 was notably greater than the 19-year mean of 384 swans, but well within the range of previous records (range = 208–749, SE = 36.1). Forty swan nests were found in the Colville Delta study area in 2012 (Table 20), which also was higher than the long-term mean of 34 nests (range = 14–55, SE = 2.2). Eighteen nests were located in the CD North subarea, 14 were in the CD South subarea, and 8 were in the Northeast Delta subarea. Eleven additional swan nests were discovered during helicopter-based loon surveys of portions of the Colville Delta study area and are not included in the swan survey total (Table 20), for consistency with data presentations from previous years; however, all swan nests are displayed in Figure 17.

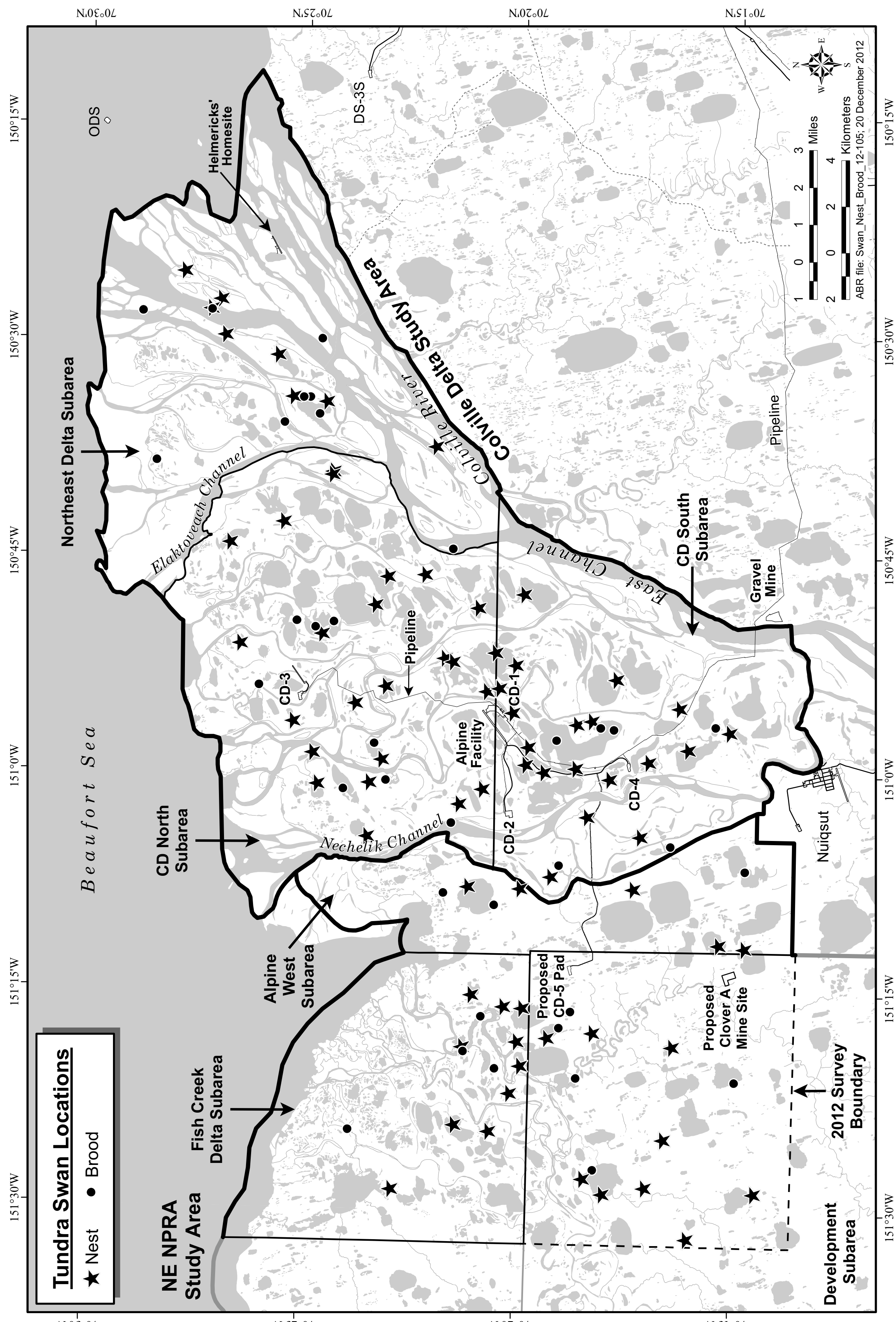


Figure 17. Tundra Swan nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2012.

Table 20. Number and density of Tundra Swan nests and broods during aerial surveys, Colville Delta study area, Alaska, 1992–2012.

Year	No. Nests	Density[a] (nests/km²)	No. Broods	Density[a] (broods/km²)	Mean Brood Size	Nesting Success (%)
1992	14	0.03	15	0.03	2.5	100
1993	17	0.04	14	0.03	2.6	82
1995	38	0.07	25	0.05	3.7	66
1996	45	0.08	32	0.06	3.4	71
1997	32	0.06	24	0.04	2.5	75
1998	31	0.06	22	0.04	2.4	71
2000	32	0.06	20	0.04	1.9	63
2001	27	0.05	22	0.04	1.7	81
2002	55	0.10	17	0.03	3.2	31
2003	43	0.08	27	0.05	2.4	63
2004	37	0.07	42	0.08	2.1	100
2005	35	0.06	36	0.07	2.3	100
2006	29	0.05	35	0.06	2.0	100
2007	42	0.08	33	0.06	2.6	79
2008	36	0.07	23	0.04	2.5	64
2009	40	0.07	17	0.03	2.8	43
2010	25	0.04	15	0.03	2.5	60
2011	35	0.06	29	0.05	2.8	83
2012	40	0.07	23	0.04	2.2	58
Mean	34	0.06	25	0.04	2.5	73
SE	2.2	<0.01	1.8	<0.01	0.1	0.04

[a] Area surveyed = 552.2 km²

Productivity of Tundra Swans was below average on the Colville Delta in 2012. During the brood-rearing survey, we counted 23 Tundra Swan broods in the Colville Delta study area, slightly less than the 19-year mean of 25 broods (SE = 1.8, Table 20). Nesting success was 58%, in contrast to the long-term mean of 73% (SE = 0.04). Nesting success in the adjacent Kuparuk oilfield during 2012 (71%) also was lower than the 24-year mean for that study area (79%; Stickney et al. 2013). In addition to fewer broods, mean brood size on the Colville Delta was slightly smaller (2.2 young) than the long-term mean of 2.5 (SE = 0.1), and overall production of 51 young on the delta was lower than the long-term mean of 62 (SE = 5.0) young per year.

Habitat Use

Habitat selection was evaluated for 655 Tundra Swan nests recorded on the Colville Delta since 1992 (Table 21). Although some nest sites were used in multiple years (and thus not annually independent locations), we were not able to distinguish these sites objectively from others where nests were close, but not in exactly the same location, in consecutive years. None of the nest sites were used in all the years that surveys were conducted. Previous investigations have reported that 21–49% of swan nests are located on mounds used during the previous year (Hawkins 1986, Monda et al. 1994) and that nest sites reused from previous years were slightly more successful than new nest sites (Monda et al. 1994). Therefore,

Table 21. Habitat selection by nesting and brood-rearing Tundra Swans, Colville Delta study area, Alaska, 1992, 1993, 1995–1998, and 2000–2012.

SEASON Habitat	No. of Nests/Broods	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	1.8	avoid	
Brackish Water	8	1.2	1.2	ns	
Tapped Lake with Low-water Connection	2	0.3	4.0	avoid	
Tapped Lake with High-water Connection	5	0.8	3.8	avoid	
Salt Marsh	40	6.1	3.0	prefer	
Tidal Flat Barrens	6	0.9	10.6	avoid	
Salt-killed Tundra	68	10.4	4.6	prefer	
Deep Open Water without Islands	16	2.4	3.3	ns	
Deep Open Water with Islands or Polygonized Margins	41	6.3	1.8	prefer	
Shallow Open Water without Islands	4	0.6	0.4	ns	low
Shallow Open Water with Islands or Polygonized Margins	2	0.3	0.1	ns	low
River or Stream	0	0	15.0	avoid	
Sedge Marsh	2	0.3	<0.1	prefer	low
Deep Polygon Complex	87	13.3	2.4	prefer	
Grass Marsh	13	2.0	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	50	7.6	7.5	ns	
Patterned Wet Meadow	246	37.6	18.6	prefer	
Moist Sedge-Shrub Meadow	31	4.7	2.2	prefer	
Moist Tussock Tundra	8	1.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	11	1.7	5.0	avoid	
Barrens	15	2.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	655	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.2	1.8	avoid	
Brackish Water	28	5.9	1.2	prefer	
Tapped Lake with Low-water Connection	67	14.2	4.0	prefer	
Tapped Lake with High-water Connection	50	10.6	3.8	prefer	
Salt Marsh	31	6.6	3.0	prefer	
Tidal Flat Barrens	4	0.8	10.6	avoid	
Salt-killed Tundra	34	7.2	4.6	prefer	
Deep Open Water without Islands	39	8.3	3.3	prefer	
Deep Open Water with Islands or Polygonized Margins	16	3.4	1.8	prefer	
Shallow Open Water without Islands	6	1.3	0.4	prefer	low
Shallow Open Water with Islands or Polygonized Margins	2	0.4	0.1	ns	low
River or Stream	27	5.7	15.0	avoid	
Sedge Marsh	0	0	<0.1	ns	low
Deep Polygon Complex	14	3.0	2.4	ns	
Grass Marsh	10	2.1	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	25	5.3	7.5	ns	
Patterned Wet Meadow	62	13.2	18.6	avoid	
Moist Sedge-Shrub Meadow	7	1.5	2.2	ns	
Moist Tussock Tundra	1	0.2	0.6	ns	low
Tall, Low, or Dwarf Shrub	8	1.7	5.0	avoid	
Barrens	39	8.3	13.8	avoid	
Human Modified	0	0	0.1	ns	low
Total	471	100	100		

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

deletion of multi-year nest sites from selection analysis could bias the results towards habitats used by less experienced or less successful pairs. Instead, we have chosen to include all nest sites, while recognizing that all locations may not be annually independent.

Tundra Swans on the Colville Delta used a wide range of habitats for nesting. Over 19 years of surveys, Tundra Swans nested in 19 of 24 available habitats, of which 8 habitats were preferred and 7 were avoided (Table 21). Eighty percent of the nests were found in the preferred habitats: Salt Marsh, Salt-killed Tundra, Deep Open Water with Islands or Polygonized Margins, Sedge Marsh, Grass Marsh, Deep Polygon Complex, Patterned Wet Meadow, and Moist Sedge–Shrub Meadow. Nests occurred most frequently in Patterned Wet Meadow (38% of all nests), Deep Polygon Complex (13%), and Salt-killed Tundra (10%).

Habitat selection also was evaluated for 471 Tundra Swan broods recorded on the Colville Delta since 1992 (Table 21). Nine habitats were preferred: Brackish Water, both types of Tapped Lakes, both types of Deep Open Water, Salt Marsh, Salt-killed Tundra, Shallow Open Water without Islands, and Grass Marsh. Broods were seen most frequently in Tapped Lake with Low-water Connections (14% of all broods), Patterned Wet Meadow (13%), and Tapped Lake with High-water Connections (11%).

The high use of salt-affected or coastal habitats (e.g., Brackish Water, Salt Marsh, Salt-killed Tundra, Tidal Flat Barrens, and Tapped Lake with Low-water Connection) by brood-rearing swans reflects an apparent seasonal change in distribution or habitat preference, in that approximately 35% of all swan broods on the delta were in salt-affected habitats, compared with only 19% of all nests (Table 21). Similar patterns have been reported by previous investigators (Spindler and Hall 1991, Monda et al. 1994).

NE NPRA

Distribution and Abundance

During the 2012 nesting survey, 157 swans were counted in the NE NPRA study area, including 61 pairs, of which 19 pairs were nesting (Table 22). An additional 5 nests were discovered during helicopter-based loon surveys of limited portions of the NE NPRA study area. Apparent nesting success in 2012 was 63% (12 broods/19 nests,). Nesting success in the NE NPRA study area surpassed the success rate in the adjacent, much larger Colville Delta study area (58%) but fell below that of the GKA study area lying between the Kuparuk and Colville rivers (71%,

Table 22. Number and density of Tundra Swan nests and broods during aerial surveys, NPRA study area, Alaska, 2001–2012.

	Nests		Broods			
Year[a]	No.	Density (nests/km²)	No.	Density (broods/km²)	Mean Brood Size	Nesting Success (%)
2001	32	0.03	21	0.02	2.5	66
2002	43	0.04	27	0.02	2.0	63
2003	43	0.04	18	0.02	2.3	42
2004	63	0.06	37	0.03	2.1	59
2005	48	0.03	37	0.02	2.1	77
2006	72	0.05	50	0.03	2.0	69
2008	69	0.04	34	0.02	2.6	49
2009	73	0.05	52	0.03	2.3	71
2011	12	0.04	10	0.03	1.9	83
2012	19	0.06	12	0.04	2.0	63

[a] Survey area differed among years: 2001–2003 = 1091.6 km², 2004–2009, 1571.1 km², and 2011–2012 = 322.1 km²

Stickney et al. 2013). Mean brood size in the NE NPRA study area was 2.0 young, slightly smaller than the 2.2 young/brood produced in the Colville Delta study area in 2012.

Habitat Use

We evaluated habitat selection for 318 Tundra Swan nests recorded in the NE NPRA study area since 2001 (Table 23). Tundra Swans nested in 21 of 26 available habitats, but preferred only 4 habitats—Salt Marsh, Shallow Open Water with Islands or Polygonized Margins, Grass Marsh, and Young Basin Wetland Complex—in which 43 nests were located.

Swan broods in NE NPRA were attracted to large, deep water bodies, similar to the habitats where swan broods were found on the Colville Delta. Habitat selection was evaluated for 197 Tundra Swan broods recorded in the NE NPRA study area since 2001 (Table 23). Tundra Swan broods used 22 of 26 available habitats. We recorded 123 broods (62%) in the 5 preferred habitats: Tapped Lake with Low-water Connection, both types of Deep Open Water, River or Stream, and Grass Marsh.

DISCUSSION

Since we began aerial surveys for Tundra Swans on the Colville Delta in 1992, counts of pairs, nests, and brood numbers have shown a fair degree of variability, but the overall trend has been one of slow increase. The lowest count of nests was 14 in 1992, the first year of surveys and the highest count of nests was 55 in 2002, producing a growth rate of 1.021, which was almost significantly different from 1.0 (equilibrium) ($\ln(y) = 0.021x - 38.00$, $R^2 = 0.171$, $P = 0.078$, $n = 19$). The total number of pairs counted during nesting surveys has increased more strongly, from a low of 42 in 1992 to a high of 118 pairs in 2011. The number of pairs has grown significantly at an annual rate of 1.033 ($\ln(y) = 0.033x - 61.358$, $R^2 = 0.539$, $P < 0.001$, $n = 19$). The trends for numbers of adults, broods, and young also have increased at low rates, but none have grown significantly ($P \geq 0.306$), probably because of high annual variation in the number of non-breeding adults and in reproductive success in the cases of broods and young. The increase in Tundra Swans appears to be widespread; the growth observed on the Colville Delta generally matches the growth seen to the east in the Kuparuk Oilfield (Stickney et al. 2013). Moreover, the growth rate for Tundra Swans across the Arctic Coastal Plain (1.038) also is statistically significant (Larned et al. 2012). The trend in these several areas probably tracks the population status of Tundra Swans wintering on the East Coast of the United States, which is where swans from the Arctic Coastal Plain return after breeding and where long-term growth has been recorded from 1955 to 2000 (Serie and Bartonek. 1991, Serie et al. 2002).

Aerial surveys for nesting and brood-rearing Tundra Swans in NE NPRA have been flown during 10 years since 2001; no surveys were flown in 2007 or 2010. The area surveyed has varied widely during that period. Out of the 5 subareas of NE NPRA, only Alpine West has been flown every survey year (Appendix G). Swan surveys in 2011 and 2012 were flown over a much smaller area than in previous years (Appendix G). Thus, comparisons of nest and brood counts in NE NPRA among years are not very meaningful because of differing survey areas that support varying densities of breeding swans.

GEESE

COLVILLE DELTA

Distribution and Abundance

During the goose brood-rearing aerial survey in 2012, we counted 1,145 Brant (776 adults and 369 young) in 7 groups in the Colville Delta study area (Figure 18, Table 24). All Brant groups included broods, and goslings comprised 32% of the total number of birds. Surveys producing comparable data on the total number of Brant (adults + goslings) have been conducted in the area for 15 years (this study, Bayha et al. 1992) and the total count in 2012 was near the long-term mean (1,290 ± 279 adults + goslings) (Table 24). The percentage of goslings in 2012 was below average, and the total count of goslings was the fourth lowest in 13 years that goslings were recorded (Table 24). Six groups containing 798 Brant (570 adults and 228 goslings) were located in the CD North subarea, and 1 group of 347 Brant (206 adults and 141 goslings) was located in the Northeast Delta subarea.

Table 23. Habitat selection by nesting and brood-rearing Tundra Swans, NE NPRA study area, Alaska, 2001–2006, 2008, 2009, 2011and 2012.

SEASON Habitat	No. of Adults	Use (%)[a]	Availability (%)	Monte Carlo Results[b]	Sample Size[c]
NESTING					
Open Nearshore Water	0	0	0.9	ns	low
Brackish Water	4	1.3	1.0	ns	low
Tapped Lake with Low-water Connection	1	0.3	0.7	ns	low
Tapped Lake with High-water Connection	2	0.6	0.5	ns	low
Salt Marsh	13	4.1	1.9	prefer	
Tidal Flat Barrens	1	0.3	1.3	ns	low
Salt-killed Tundra	2	0.6	0.7	ns	low
Deep Open Water without Islands	13	4.1	6.5	ns	
Deep Open Water with Islands or Polygonized Margins	25	7.9	5.2	ns	
Shallow Open Water without Islands	3	0.9	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	18	5.7	1.6	prefer	
River or Stream	0	0	1.2	avoid	low
Sedge Marsh	6	1.9	1.7	ns	
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	6	1.9	0.3	prefer	low
Young Basin Wetland Complex	6	1.9	0.3	prefer	low
Old Basin Wetland Complex	26	8.2	8.1	ns	
Riverine Complex	1	0.3	0.3	ns	low
Dune Complex	1	0.3	1.0	ns	low
Nonpatterned Wet Meadow	15	4.7	3.0	ns	
Patterned Wet Meadow	39	12.3	11.3	ns	
Moist Sedge-Shrub Meadow	53	16.7	21.7	avoid	
Moist Tussock Tundra	78	24.5	25.4	ns	
Tall, Low, or Dwarf Shrub	5	1.6	3.1	ns	
Barrens	0	0	1.1	ns	low
Human Modified	0	0	0	ns	
Total	318	100	100		
BROOD-REARING					
Open Nearshore Water	1	0.5	0.9	ns	low
Brackish Water	5	2.5	1.0	ns	low
Tapped Lake with Low-water Connection	7	3.6	0.7	prefer	low
Tapped Lake with High-water Connection	0	0	0.5	ns	low
Salt Marsh	2	1.0	1.9	ns	low
Tidal Flat Barrens	1	0.5	1.3	ns	low
Salt-killed Tundra	0	0	0.7	ns	low
Deep Open Water without Islands	54	27.4	6.5	prefer	
Deep Open Water with Islands or Polygonized Margins	43	21.8	5.2	prefer	
Shallow Open Water without Islands	2	1.0	1.0	ns	low
Shallow Open Water with Islands or Polygonized Margins	3	1.5	1.6	ns	low
River or Stream	14	7.1	1.2	prefer	low
Sedge Marsh	3	1.5	1.7	ns	low
Deep Polygon Complex	0	0	0.1	ns	low
Grass Marsh	5	2.5	0.3	prefer	low
Young Basin Wetland Complex	1	0.5	0.3	ns	low
Old Basin Wetland Complex	7	3.6	8.1	avoid	
Riverine Complex	1	0.5	0.3	ns	low
Dune Complex	1	0.5	1.0	ns	low
Nonpatterned Wet Meadow	8	4.1	3.0	ns	
Patterned Wet Meadow	10	5.1	11.3	avoid	
Moist Sedge-Shrub Meadow	17	8.6	21.7	avoid	
Moist Tussock Tundra	6	3.0	25.4	avoid	
Tall, Low, or Dwarf Shrub	5	2.5	3.1	ns	
Barrens	1	0.5	1.1	ns	low
Human Modified	0	0	0	ns	
Total	197	100	100		

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

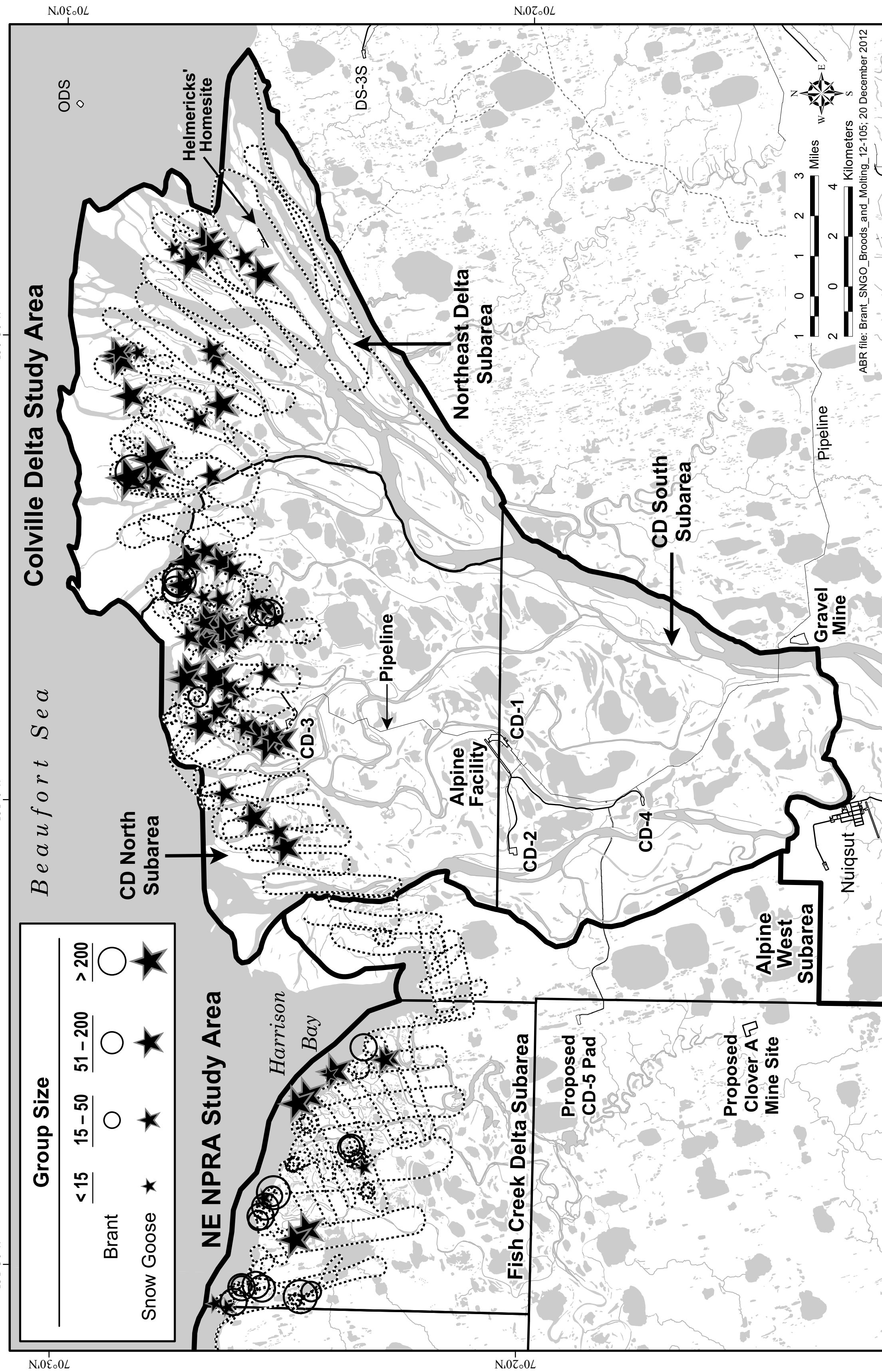


Figure 18. Brant and Snow Goose brood-rearing groups, Colville Delta and NE NPRA study areas, Alaska, 2012.

Table 24. Number of Brant adults and goslings during aerial surveys, Colville Delta study area, Alaska, 1998–2012. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
1988[a]	no data	173[b]	no data	no data	no data	25, 26 July
1989[a]	197[c,d]	no data	no data	no data	no data	12, 13 August
1990[a]	628[c]	no data	no data	no data	no data	2, 9 August
1991[a]	460[c,d]	no data	no data	no data	no data	1, 7 August
1992	0	0	0	-	0	27 July
1993	720	347	373	51	5	27 July
1995	1,480	768	712	48	6	4 August
1996	993	478	515	52	7	25 July
1998	1,974	836	1,138	58	13	27 July
2005	3,847	2,360	1,487	39	16	30 July
2006	438	296	142	32	4	29 July
2007	980	446	534	54	6	30 July
2008	3,637	1,839	1,798	49	22	29 July
2009	679	501	178	26	6	29 July
2010	1,474	746	728	49	11	28 July
2011	1,986	1,221	765	39	10	28 July
2012	1,145	776	369	32	7	26 July
Mean	1,290	771	672	44.2	8.7	
SE	279	174	146	3.0	1.6	

[a] Data are from an average of 2 surveys (Bayha et al. 1992)
[b] Only adults were counted. Goslings were observed but were not enumerated
[c] Adults and goslings were not differentiated by the observer
[d] Includes birds in flight (90 on 12 August 1989, and 50 on 7 August 1991)

In 2012, a record 4,035 Snow Geese (2,009 adults and 2,026 goslings) were counted in 57 groups in the Colville Delta study area (Figure 18, Table 25), similar to the total of 4,023 Snow Geese (1,745 adults and 2,278 goslings) counted in 2011. Fifty-four groups (95%) contained broods, and goslings comprised 50% of the total number of birds, indicating that 2012 was a highly productive year for Snow Geese on the Colville Delta. Thirty-eight groups (1,114 adults and 1,126 goslings) were found in the CD North subarea, and 19 groups (895 adults and 900 goslings) were found in the Northeast Delta subarea.

Habitat Use

Brant brood groups occupied coastal salt-affected habitats in the Colville Delta study area (Table 26). The 7 Brant groups recorded during aerial surveys were found in 4 salt-affected habitats: Salt Marsh (3 groups), Brackish Water (2 groups), Salt Marsh (1 group) and Tidal Flat Barrens (1 group).

Snow Geese were found in a wider range of habitats than Brant, but they also favored coastal salt-affected habitats for brood-rearing and molting in the Colville Delta (Table 26). Of 57 Snow Goose groups observed, 36 groups (63%) were found in salt-affected habitats, including Salt-killed Tundra (16 groups), Brackish Water (8 groups), Salt Marsh

Table 25. Number of Snow Goose adults and goslings during aerial surveys, Colville Delta study area, Alaska, 2005–2012.

Year	Total Birds	Adults	Goslings	% Goslings	No. Groups	Survey Date(s)
2005	972	412	560	58	11	30 July
2006	997	421	576	58	9	29 July
2007	1,154	596	558	48	13	30 July
2008	1,967	834	1,133	58	22	29 July
2009	678	463	215	32	15	29 July
2010	1,873	883	990	53	19	28 July
2011	4,023	1,745	2,278	57	36	28 July
2012	4,035	2,009	2,026	50	57	26 July
Mean	1,962	920	1,042	51.8	22.8	
SE	477	219	263	3.1	5.7	

Table 26. Habitat use by brood-rearing/molting Brant and Snow Geese, Colville Delta and NE NPRA study areas, Alaska, 2012.

	Colville Delta				NE NPRA			
	Brant		Snow Geese		Brant		Snow Geese	
Habitat	No. of Groups	Use (%)	No. of Groups	Use (%)	No. of Groups	Use (%)	No. of Groups	Use (%)
Open Nearshore Water	0	0	1	1.8	7	46.7	7	58.3
Brackish Water	2	28.6	8	14.0	5	33.3	3	25.0
Tapped Lake with Low-water Connection	0	0	3	5.3	0	0	0	0
Tapped Lake with High-water Connection	0	0	1	1.8	0	0	0	0
Salt Marsh	3	42.9	6	10.5	1	6.7	1	8.3
Tidal Flat Barrens	1	14.3	2	3.5	2	13.3	0	0
Salt-killed Tundra	1	14.3	16	28.1	0	0	0	0
Deep Open Water without Islands	0	0	1	1.8	0	0	0	0
River or Stream	0	0	4	7.0	0	0	0	0
Deep Polygon Complex	0	0	4	7.0	0	0	0	0
Nonpatterned Wet Meadow	0	0	2	3.5	0	0	0	0
Patterned Wet Meadow	0	0	2	3.5	0	0	0	0
Moist Sedge–Shrub Meadow	0	0	1	1.8	0	0	1	8.3
Barrens	0	0	6	10.8	0	0	0	0
Total	7	100	57	100	15	100	12	100

(6 groups), Tapped Lake with Low-water Connection (3 groups; this habitat typically has brackish water and salt marsh vegetation along the shoreline; Appendix B), Tidal Flat Barrens (2 groups), and Open Nearshore Water (1 group). Snow Geese were also found in 8 other habitats, most frequently Barrens (6 groups), River or Stream (4 groups) and Deep Polygon Complex (4 groups) (Table 26).

NE NPRA

Distribution and Abundance

During the aerial brood-rearing survey in 2012, we counted 1,684 Brant (1,410 adults and 274 goslings) in 15 groups in the NE NPRA study area (Figure 18, Table 27). The number of adults was near the 8-year mean (1,463 ± 215 adults) but the number of goslings was the lowest on record (Table 27). Seven of 15 Brant groups contained only adults, and goslings comprised only 16% of the total number of birds in all groups, indicating low productivity for Brant in 2012. All 15 Brant

Table 27. Numbers of Brant and Snow Goose adults and goslings during aerial surveys, NE NPRA study area, Alaska, 2005–2012.

SPECIES Year	Total Birds	Adults	Goslings	% Goslings	No. of Groups
BRANT					
2005	1,634	1,003	631	39	11
2006	2,235	1,350	885	40	17
2007[a]	1,512	1,185	327	22	8
2008	4,012	2,617	1,395	35	36
2009	2,628	2,161	467	18	12
2010[a]	1,565	1,073	492	31	8
2011	1,756	906	850	48	14
2012	1,684	1,410	274	16	15
Mean	2,128	1,463	665	31.1	15.1
SE	301	215	130	4.1	3.2
SNOW GEESE					
2005	32	13	19	59	1
2006	713	270	443	62	9
2007[a]	145	78	67	46	5
2008	234	107	127	54	5
2009	102	60	42	41	4
2010[a]	105	85	20	19	3
2011	388	142	246	63	8
2012	626	289	337	54	12
Mean	293	131	163	49.8	5.9
SE	91	35	57	5.1	1.3

[a] Surveys in 2007 and 2010 were conducted by ABR for the North Slope Borough Department of Wildlife Management (Ritchie et al. 2008, Appendix H; Burgess et al. 2011, Appendix G)

brood-rearing and molting groups were located in the Fish Creek Delta subarea.

In 2012, a record 289 adult Snow Geese were counted in 12 groups in the NE NPRA study area (Figure 18, Table 27). The number of goslings and the total number of Snow Geese were the second highest on record. Nine of 12 groups included broods, and goslings comprised 54% of the total number of birds in all groups. As with Brant, all 12 Snow Goose groups were located in the Fish Creek Delta subarea.

Habitat Use

As on the Colville Delta, Brant and Snow Goose brood groups primarily used salt-affected habitats in the NE NPRA study area (Table 26). All 15 Brant brood groups were found in 4 salt-affected habitats: Open Nearshore Water (7 groups), Brackish Water (5 groups), Tidal Flat Barrens (2 groups) and Salt Marsh (1 group). Eleven of 12 Snow Goose brood-rearing and molting groups were located in coastal salt-affected habitats: Open Nearshore Water (7 groups), Brackish Water (3 groups), and Salt Marsh (1 group).

DISCUSSION

The number of adult Brant present in the Colville Delta during the brood rearing period is not a reliable measure of the size of the local breeding population. Some successful breeders from the Colville Delta rear their broods on coastal salt marshes outside the delta, at least as far east as Kavearak Point in the Kuparuk oil field (Sedinger and Stickney 2000) and likely to the west in the adjacent Fish Creek Delta. Additionally, failed nesters typically depart the Colville Delta prior to the brood rearing period and molt in other areas on the ACP, including the large molting area northeast of Teshekpuk Lake (Lewis et al. 2009). Nest success in large Brant colonies is variable, and tends to be either high or very low (see Sedinger and Stickney 2000). The presence of predators in a breeding colony during nest initiation can result in very low nesting effort, as was seen in 1991 and 1992 when arctic foxes disrupted breeding on Howe Island in the Sagavanirktok Delta (Stickney and Ritchie 1996). During incubation, predators such as brown bears and arctic foxes can remove substantial numbers of nests (Smith et al. 1993). Furthermore, unfavorable weather conditions such as persistent snow and ice or cool temperatures can limit availability of nesting habitat or reduce nesting effort and nest success in some years (Barry 1962, Stickney and Ritchie 1996).

Results from our surveys show the number of adult Brant on the Colville Delta during the brood rearing period has been growing at a rate of 1.118 (11.8% annually) since 1988 (Figure 19), but that rate is not quite significant ($\ln(y) = 0.118x - 230.5$, $R^2 = 0.264$, $P = 0.060$, $n = 14$ years). Numbers vary widely from year to year, probably due to factors discussed above, including variation in nesting effort and nesting success, and variable movements of broods out of the Colville Delta prior to our survey. These factors may make trends difficult to detect or interpret.

On the ACP, Brant can be found in large breeding colonies on deltaic islands, such as those on the Sagavanirktok, Colville, and Kuparuk river deltas, and in numerous smaller colonies in basin-wetland complexes primarily between the Sagavanirktok River and Barrow. Broad regional surveys conducted during early- to mid-June since 1992 show a statistically significant annual growth rate of 1.093 for Brant on the ACP over the past 2 decades (SE = 0.013, $n = 20$ years; Larned et al. 2012), however this trend may have resulted in part from an influx of early failed breeders from other breeding areas, such as the Yukon-Kuskokwim Delta where numbers of nesting Brant have been decreasing in some colonies in recent years (Wilson 2011, Larned et al. 2012). Trends are not uniform across the ACP. Nest numbers have dropped substantially since 1993 on the Sagavanirktok River Delta (A. Stickney, ABR, pers. comm.). In contrast, numbers of Brant nests appear to have remained stable or increased since 1995 in 23 small colonies between Fish Creek and Barrow (Burgess et al. 2012). Data from Larned et al. (2012) suggest that Brant may have begun expanding their range inland from the coast in parts of the ACP.

Snow Goose nests have been found in small numbers on the Colville Delta at least as far back as 1994, and brood rearing Snow Geese have been observed in small numbers at least as far back as 1996 (Johnson et al. 2003b). Numbers of brood rearing Snow Geese have steadily increased in recent years, reaching record numbers in 2012.

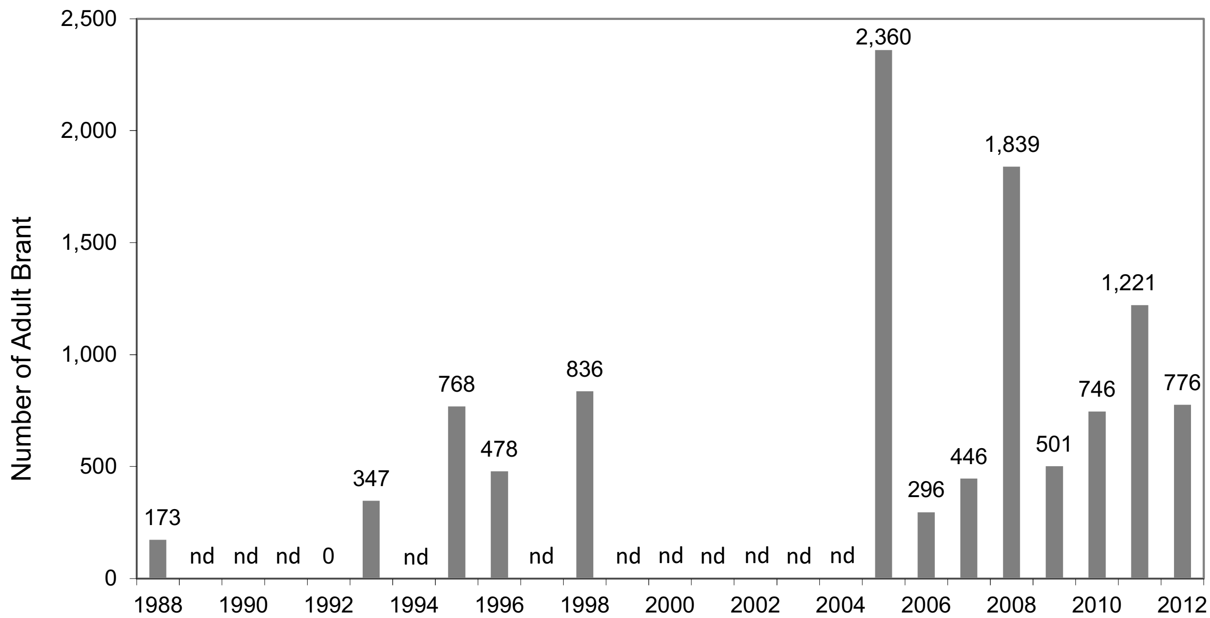


Figure 19. Number of adult Brant during the brood-rearing period, Colville Delta study area, Alaska, 1988–2012. Data for 1988–1991 are from Bayha et al. 1992; subsequent data are from this study.

Similarly, numbers have increased sharply on the Ikpikpuk River delta (to the west of the Colville) since surveys began there in 1994 (Burgess et al. 2012).

Snow Goose breeding populations have been expanding in North America since at least the 1960s (Kerbes 1983, Kerbes et al. 1983, McCormick and Poston 1988, Alisauskas and Boyd 1994) perhaps due to increased availability of agricultural resources in wintering areas (Davis et al. 1989). Snow Geese forage by grubbing for roots and rhizomes during spring prior to emergence of above-ground vegetation (Kerbes et al. 1990). This behavior, coupled with high fidelity to breeding areas (Ganter and Cooke 1998) has resulted in long-term degradation of some nesting areas and arctic coastal salt marshes used for brood-rearing (Kerbes et al. 1990, Ganter et al. 1995, Srivastava and Jefferies 1996). Over-population of breeding colonies has led to decreased growth and survival of goslings (Cooch et al. 1991, Williams et al. 1993, Gadallah and Jefferies 1995), and eventual dispersal of young breeders to higher quality breeding areas (Ganter and Cooke 1998). In the long term, one might predict a negative impact on Brant from a substantial increase in Snow Goose numbers due to degradation of salt marsh habitats used by both species during brood rearing. Intense grazing by Brant, focusing exclusively on above-ground biomass, appears to have no lasting deleterious effects on salt marsh grazing lawns (Person et al. 1998). Snow Geese, however, remove rhizomes and meristematic tissue by grubbing in the spring, which can result in long-term declines of these plant communities in the vicinity of nesting colonies (e.g., Kerbes et al. 1990, Abraham and Jefferies 1997).

GLAUCOUS AND SABINE'S GULLS

COLVILLE DELTA

Distribution and Abundance

We recorded 73 Glaucous Gull nests in the Colville Delta study area during the aerial survey for nesting loons in 2012 (Figure 20, Table 28), the highest number of nests found in the study area since counts began in 2000. Thirty-seven of those nests were in the CD South subarea, 33 in the CD North subarea, and 3 in the Northeastern Delta. Glaucous Gulls nest singly or in colonial groups. The largest colony on the Colville Delta is a site in

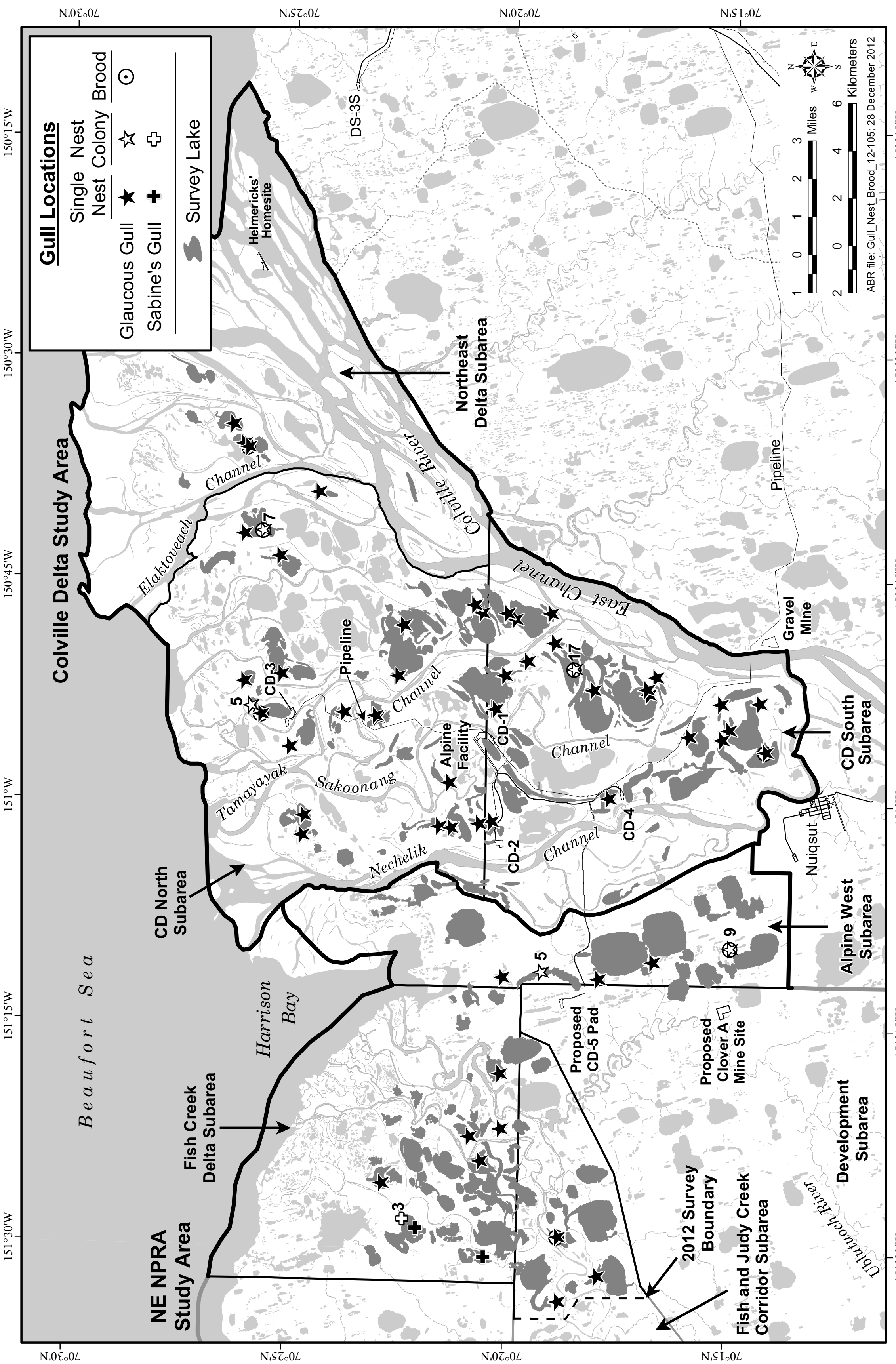


Figure 20. Glaucous and Sabine's gull nests and broods, Colville Delta and NE NPRA study areas, Alaska, 2012. Numbers of nests are listed for colony locations.

Table 28. Number of Glaucous and Sabine's gull nests, Colville Delta and NE NPRA study areas, Alaska, 2012.

STUDY AREA[a] Subarea	Sabine's Gull	Glaucous Gull
COLVILLE DELTA		
CD North	0	33
CD South	0	37
Northeast Delta	0	3
Total	0	73
NE NPRA		
Alpine West	0	17
Fish Creek Delta	5	5
Fish and Judy Creek Corridor	0	3
Total	5	25

[a] Data for Colville Delta and NE NPRA study areas were collected during aerial surveys for nesting Yellow-billed Loons

the CD South subarea, located ~5 km southeast of Alpine; this colony supported 17 nests in 2012 (Figure 20; Table 29), but has ranged from 6 to 19 nests since 2002 (mean = 15 nests, SE = 1.0, n = 14 years). Another colony site in the northeastern part of the CD North subarea supported 7 nests in 2012. This site had 0–2 nests in 2000–2003 and since 2004 has had 4–7 nests each year. A new colony site was designated in 2012 at a lake located ~1.7 km north of the CD-3 drill pad because it supported 5 nests (Figure 20; Table 29). That lake supported 1 Glaucous Gull nest each year from 2000 to 2009 and 2 nests in both 2010 and 2011.

The count of 73 Glaucous Gull nests in 2012 includes nests from traditional nest locations that are checked annually and any other nests encountered incidentally during the loon surveys. To measure annual trend in nests, we tallied the nests from 50 lakes in the Colville Delta study area that were surveyed annually since 2002. The number has ranged from a low of 27 nests in 2003 to a high of 61 nests in 2012 (Table 29). Glaucous Gull nests were found at only 13–15 of the 50 monitored lakes in 2002–2004, 18–23 of the lakes in 2005–2011, and at 27 lakes in 2012 (Table 29).

Five groups of Glaucous Gulls with young were recorded incidentally during the survey for brood-rearing loons in 2012 (Figure 20). Thirteen adults and 24 young were recorded in the Colville Delta study area, of which 8 adults and 7 young were in the CD North subarea and 5 adults and 17 young were in the CD South subarea. No Glaucous Gull broods were observed in the Northeast Delta subarea. Four young were counted at the colony site in the northeastern part of the CD North subarea and 15 young were recorded at the colony site in the CD South subarea. Young from some nests were flight capable at the time of the loon brood-rearing survey, and consequently some young may have been missed because they were no longer near their nest site.

No Sabine's Gull nests were observed in the Colville Delta study area during the aerial survey for nesting loons in 2012. The number of Sabine's Gull nests has ranged from 1 to 16 nests during the years 2003–2010.

Habitat Use

Glaucous Gull nests were found in 9 different habitats in the Colville Delta study area in 2012 (Table 30). Twenty of the 73 Glaucous Gull nests (27%) were in Deep Open Water with Islands or Polygonized Margins and 19 nests (26%) were in Patterned Wet Meadow, most of which were part of the colony in the CD South subarea that is located on a large island within a lake classified as Deep Open Water with Islands or Polygonized Margins. Another 16 nests (22%) were on islands in Tapped

Table 29. Number of Glaucous Gull nests on 50 monitored lakes, Colville Delta study area, Alaska, 2002–2012.

	Number of Nests[a]				
Year	CD North Subarea[b]	CD South Subarea[c]	Northeast Delta Subarea	Total	No. of Lakes with Nests[d]
2002	10 (2, 1)	24 (18)	1	35	14
2003	10 (1, 1)	17 (14)	0	27	13
2004	18 (7, 1)	17 (13)	0	35	15
2005	17 (5, 1)	22 (15)	0	39	18
2006	14 (4, 1)	21 (16)	1	36	18
2007	16 (5, 1)	21 (13)	2	39	19
2008	18 (5, 1)	26 (18)	2	46	21
2009	16 (6, 1)	27 (19)	2	45	20
2010	16 (5, 2)	16 (6)	2	34	20
2011	16 (5, 2)	36 (17)	2	54	23
2012	25 (7, 5)	34 (17)	2	61	27
Mean	16.0 (4.2, 1.5)	23.7 (14.8)	1.3	41.0	18.9
SE	1.2 (0.6, 0.3)	2.0 (1.0)	0.3	3.0	1.2

[a] Data was collected during aerial surveys for nesting Yellow-billed Loons
[b] First number in parenthesis 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 CD3 drill pad (see Figure 20)
[c] Number in parenthesis is the number of nests at the colony site in the CD South subarea (see Figure 20)
[d] 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

Table 30. Habitat use by nesting Glaucous Gulls, Colville Delta and NE NPRA study areas, Alaska, 2012.

	Colville Delta		NE NPRA	
Habitat	Nests	Use (%)	Nests	Use (%)
Brackish Water	1	1.4	1	4.0
Tapped Lake with High-water Connection	16	21.9	1	4.0
Deep Open Water without Islands	6	8.2	0	0
Deep Open Water with Islands or Polygonized Margins	20	27.4	0	0
Shallow Open Water with Islands or Polygonized Margins	1	1.4	20	80.0
Sedge Marsh	0	0	2	8.0
Deep Polygon Complex	1	1.4	0	0
Grass Marsh	5	6.8	0	0
Nonpatterned Wet Meadow	4	5.5	0	0
Patterned Wet Meadow	19	26.0	1	4.0
Total	73	100	25	100

Lake with High-water Connection. The remaining 18 nests were found on islands or complex shorelines of 6 other habitats. Glaucous Gull broods observed during aerial surveys were located near nests and in the same habitats as were the nests.

NE NPRA

Distribution and Abundance

We counted 25 Glaucous Gull nests in the NE NPRA study area during aerial surveys for loons in 2012 (Figure 20, Table 28). We recorded 17 nests in the Alpine West subarea, 5 in the Fish Creek Delta subarea, and 3 in the Fish and Judy Creek Corridor subarea. Of the 17 nests found in the Alpine West subarea, 14 nests were in 2 colonies: 1 colony of 5 nests was near the proposed CD-5 pad site and another colony of 9 nests was in the southern part of the subarea (Figure 20, Table 31). During 11 previous years of surveys, annual counts have ranged from 0 to 7 nests at the CD-5 colony and from 4 to 11 nests at the colony site in the southern part of the subarea (Table 31). All other Glaucous Gull nests found in the NE NPRA study area in 2012 were solitary nest locations. Incidental counts of Glaucous Gull nests in the Alpine West and Fish Creek Delta subareas have been highly variable (Table 31). The lowest count of nests was 12 nests in 2009, when a grizzly bear took all nests in the colony near the proposed CD-5 pad site prior to our surveys (Johnson et al. 2010). The highest count of 28 nests occurred in 2006. Because Glaucous Gulls were counted on aerial surveys designed to survey loons, some nests undoubtedly were missed.

During the loon brood-rearing survey in 2012, 2 Glaucous Gull brood-rearing groups were observed; a single brood of 2 young was recorded in the Fish and Judy Creek Corridor and 10 adults and 6 young were counted at the colony site in the southern part of Alpine West. Young from some nests were flight capable at the time of the brood-rearing survey, and consequently some young may have been missed because they were no longer near their nest site.

We recorded 5 Sabine's Gull nests in the NE NPRA study area during the loon nesting survey in 2012 (Table 28). Two single nests and 1 colony with 3 nests were in the Fish Creek Delta subarea (Figure 20). No nests were found in the Fish and Judy Creek Corridor subarea. We did not calculate densities of Sabine's Gull nests for the NE NPRA study area because sightings were incidental and not comprehensive for that area. The distribution and number of Sabine's Gull nests found each year during loon surveys is highly variable. The highest number of Sabine's Gull nests recorded on loon nesting surveys in the NE NPRA study area was 53 nests in 2008 (Johnson et al. 2009).

Table 31. Number of Glaucous Gull nests[a] in the Alpine West and Fish Creek Delta subareas, NE NPRA study area, Alaska, 2005–2012.

Year	Alpine West Subarea[b]	Fish Creek Delta Subarea	Total
2005	13 (5, 6)	4	17
2006	17 (7, 6)	11	28
2008	19 (7, 6)	7	26
2009	9 (0, 5)	3	12
2010	12 (5, 4)	2	14
2011	19 (5, 11)	4	23
2012	17 (5, 9)	5	22

[a] Data was collected during aerial surveys for nesting Yellow-billed Loons

[b] First number in parenthesis is the number of nests at the colony site near the proposed CD-5 Pad and second number is the number of nests at the site in the southern part of the subarea (see Figure 20)

Habitat Use

Glaucous Gulls nested in 5 different habitats in the NE NPRA study area (Table 30). We recorded 20 of the 25 nests (80%) on islands in Shallow Open Water with Islands or Polygonized Margins. The remaining 5 nests were found on islands or complex shorelines of 3 other aquatic habitats and 1 terrestrial habitat. Glaucous Gull broods were found in aquatic and terrestrial habitats near nest locations, often in the same habitat as the nest. The Sabine's Gull colony of 3 nests was found on an island in Shallow Open Water with Islands or Polygonized Margins. One Sabine's Gull nest was in Sedge Marsh and another was in Patterned Wet Meadow.

DISCUSSION

Glaucous Gull nests have increased over the last 11 years in the Colville Delta study area. The highest number of Glaucous Gull nests (73) was recorded in the Colville Delta study area in 2012. Increases in nests are evident from counts that have been made consistently at 50 lakes monitored for Yellow-billed Loons since 2002. The number of Glaucous Gull nests on the monitored lakes has grown significantly at an annual rate of 1.055 ($\ln(y) = 0.055x - 105.9$, $R^2 = 0.642$, $P = 0.003$, $n = 11$). The large increase in the number of Glaucous Gull nests in the Colville Delta study area in 2011 and 2012 is mostly from an increase in the number of solitary nests found at locations where nesting gulls have not been recorded in previous years and not an increase in number at the 3 colony sites. However, in 2012, a new colony of 5 nests was observed north of the CD-3 drill pad where in past years only 1 or 2 nests had been observed.

The trend for Glaucous Gulls in the NE NPRA study area is less clear. Glaucous Gull nests have been recorded in the NE NPRA study area when Yellow-billed Loon nesting surveys were conducted in 2001–2006 and 2008–2012, but survey areas were not the same more than 3 years in a row, so a trend is not discernible. Total counts have ranged from 17 nests when the survey area included only the Alpine West and Fish Creek Delta subareas to 93 nests when it was more expansive comprising the Development, Exploration, and Alpine West subareas.

Sabine's Gulls are found as solitary nesting birds or in loose nesting colonies. Single nests are hard to detect during loon surveys and nesting colonies are usually only detected because some birds are flying near the colony site. Recorded observations are most often colony sites and single nesting birds are likely under-reported. Counts of Sabine's Gull nests have varied annually in both the Colville Delta and NE NPRA survey areas largely because of the variability in detection rates but also possibly because of the timing of their nesting relative to the timing of loon survey.

LITERATURE CITED

Abraham, K. F., and R. L. Jefferies. 1997. High goose populations: causes, impacts and complications. Pages 7–72 in B. D. J. Batt, ed. Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120 pp.

Alisauskas, R. T., and H. Boyd. 1994. Previously unrecorded colonies of Ross' and Lesser Snow Geese in the Queen Maud Gulf Bird Sanctuary. Arctic 47: 69–73.

Anderson, B. A., and B. A. Cooper. 1994. Distribution and abundance of Spectacled Eiders in the Kuparuk and Milne Point oilfields, Alaska, 1993. Final report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 71 pp.

Anderson, B. A., and C. B. Johnson. 1999. Baseline avian surveys in four lease blocks within the National Petroleum Reserve–Alaska, 1999. Report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 18 pp.

Anderson, B. A., A. A. Stickney, T. Obritschkewitsch, and J. E. Shook. 2008. Avian studies in the Kuparuk Oilfield, Alaska, 2007. Data Summary Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Barr, J. F. 1997. Status report on the Yellow-billed Loon Gavia adamsii in arctic Canada. Report to Committee on Status of Endangered Wildlife in Canada. Guelph, Ontario, Canada.

Barry, T. W. 1962. Effect of late seasons on Atlantic Brant reproduction. Journal of Wildlife Management 26:19–26.

Bayha, K., R. Meehan, and T. Jennings. 1992. Synthesis of Brant data for the Colville Delta. Unpublished draft report by U.S. Fish and Wildlife Service, Anchorage. AK.

BLM (Bureau of Land Management). 1998. Northeast National Petroleum Reserve–Alaska: Final Integrated Activity Plan / Environmental Impact Statement. Vol. 1. U.S. Department of the Interior, Bureau of Land Management, with assistance from Minerals Management Service, Anchorage, AK.

BLM (Bureau of Land Management). 2004. Alpine Satellite Development Plan Final Environmental Impact Statement. U.S. Department of the Interior, Bureau of Land Management, with assistance from Minerals Management Service, Anchorage, AK.

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

Burgess, R. M., C. B. Johnson, B. E. Lawhead, A. M. Wildman, A. A. Stickney, and J. R. Rose. 2000. Wildlife studies in the CD South study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 84 pp.

Burgess, R. M., C. B. Johnson, P. E. Seiser, A. A. Stickney, A. M. Wildman, and B. E. Lawhead. 2002b. Wildlife studies in the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2001. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 71 pp.

Burgess, R. M., C. B. Johnson, A. M. Wildman, P. E. Seiser, J. R. Rose, A.K. Prichard, T. J. Mabee, A. A. Stickney, and B. E. Lawhead. 2003b. Wildlife studies in the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2002. Report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 126 pp.

Burgess, R. M., T. Obritschkewitsch, R. J. Ritchie, J. E. Shook, and L. B. Attanas. 2012. Surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, Alaska, 2011. Draft Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 89 pp.

ConocoPhillips Alaska. 2013. Data Management Protocols, North Slope and Chukchi Sea Field Surveys,Version 7.9.

Cooch, E. G., D. B. Lank, R. F. Rockwell, and F. Cooke. 1991. Long-term decline in body size in a Snow Goose population: evidence of environmental degradation? Journal of Animal Ecology 60: 483–496.

Davis, S. E., E. E. Klaas, and K. J. Koehler. 1989. Diurnal time-activity budgets and habitat use of Lesser Snow Geese Anser caerulescens in the middle Missouri River Valley during winter and spring. Wildfowl 40: 45–54.

Earnst, S. 2004. Status assessment and conservation plan for the the yellow-billed loon (Gavia adamsii). U.S. Geological Survey, Scientific invetigations Report 2004-5258.

Gadallah, F. L., and R. L. Jefferies. 1995. Forage quality in brood rearing areas of the Lesser Snow Goose and the growth of captive goslings. Journal of Applied Ecology 32: 276–287.

Ganter, B., and F. Cooke. 1998. Colonial nesters in deteriorating habitat: site fidelity and colony dynamics of Lesser Snow Geese. Auk 115: 642–652.

Ganter, B., F. Cooke, and P. Mineau. 1995. Long-term vegetation changes in a Snow Goose nesting habitat. Canadian Journal of Zoology 74: 965–969.

Hawkins, L.L. 1986. Nesting behaviour of male and female Whistling Swans and implications of male incubation. Wildfowl 37: 5–27.

Haefner, J. W. 1996. Modeling Biological Systems: Principles and Applications. Chapman and Hall, New York, NY. 473 pp.

Johnson, C. B. 1995. Abundance and distribution of eiders on the Colville River Delta, Alaska, 1994. Report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 12 pp.

Johnson, C. B., and A. A. Stickney. 2001. Avian surveys of exploration sites within the National Petroleum Reserve–Alaska, 2001. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 24 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2000a. Wildlife studies in the CD North study area, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 96 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. 2003a. Alpine Avian Monitoring Program, 2001. Fourth annual and synthesis report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 194 pp.

Johnson, C. B., R. M. Burgess, B. E. Lawhead, J. P. Parrett, J. R. Rose, A. A. Stickney, and A. M. Wildman. 2003b. 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. R. Rose, A. A. Stickney, and A. M. Wildman. 2002. Wildlife studies in the CD North study area, 2001. Second annual report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 114 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, by ABR, Inc., Fairbanks, AK. 129 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, by ABR, Inc., Fairbanks, AK. 155 pp.

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., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 154 pp.

Johnson, C. B., B. E. Lawhead, D. C. Payer, J. L. Petersen, J. R. Rose, A. A. Stickney, and A. M Wildman. 2001. Alpine Avian Monitoring Program, 2000. Third annual report for PHILLIPS Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 92 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, J. E. Roth, S. F. Schlentner, A. A. Stickney, and A. M. Wildman. 2000b. Alpine Avian Monitoring Program, 1999. Second annual report for PHILLIPS Alaska, Inc. and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 86 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1998. Wildlife studies on the Colville River Delta, Alaska, 1997. Sixth annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 144 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, M. D. Smith, A. A. Stickney, and A. M. Wildman. 1999a. Wildlife studies on the Colville River Delta, 1998. Seventh annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 102 pp.

Johnson, C. B., B. E. Lawhead, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1997. Wildlife studies on the Colville River Delta, Alaska, 1996. Fifth annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 139 pp.

Johnson, C. B., W. Lentz, J. R. Rose, A. A. Stickney, and A. M. Wildman. 1999b. Alpine Avian Monitoring Program, 1998. First annual report for ARCO Alaska, Inc., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 46 pp.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2006a. Spectacled Eider monitoring at the CD-3 development, 2005. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., J. P. Parrett, and P. E. Seiser. 2007a. Spectacled Eider monitoring at the CD-3 development, 2006. Annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK.

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, by ABR, Inc., Fairbanks, AK.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and J. E. Shook. 2006b. Avian studies for the Alpine Satellite Development Project, 2005. Third annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 30 pp.

Johnson, C. B., A. M. Wildman, J. P. Parrett, J. R. Rose, and T. Obritschkewitsch. 2007b. Avian studies for the Alpine Satellite Development Project, 2006. Fourth annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 31 pp.

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, 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, by ABR, Inc., Fairbanks, AK. 69 pp.

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

Jorgenson, M. T., J. E. Roth, M. Emers, S. Schlentner, D. K. Swanson, E.R. Pullman, J. Mitchell, and A. A. Stickney. 2003. An ecological land survey for the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2002. Report for ConocoPhillips Alaska, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 84 pp.

Jorgenson, M. T., J. E. Roth, M. Emers, W. Davis, E.R. Pullman, and G. J. Frost. 2004. An ecological land survey for the Northeast Planning Area of the National Petroleum Reserve–Alaska, 2003. Addendum to 2002 report for ConocoPhillips Alaska, Anchorage, AK and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 40 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., Anchorage, and Kuukpik Unit Owners by ABR, Inc., Fairbanks, AK. 160 pp.

Kerbes, R. H. 1983. Lesser Snow Goose colonies in the western Canadian Arctic. Journal of Wildlife Management 47: 523–526.

Kerbes, R. H., M. R. McLandress, G. E. J. Smith, G. W. Beyersbergen, and B. Godwin. 1983. Ross' Goose and Lesser Snow Goose colonies in the central Canadian Arctic. Canadian Journal of Zoology 61: 168–173.

Kerbes, R. H., P. M. Kotanen, and R. L. Jefferies. 1990. Destruction of wetland habitats by Lesser Snow Geese: a keystone species on the west coast of Hudson Bay. Journal of Applied Ecology 27: 242–258.

Larned, W., R. Stehn, and R. Platte. 2006. Eider breeding population survey, Arctic Coastal Plain, Alaska, 2006. U.S. Fish and Wildlife Service, Migratory Bird Management–Waterfowl Management Branch, Soldotna, AK. 53 pp.

Larned, W., R. Stehn, and R. Platte. 2010. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2008. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK.

Larned, W., R. Stehn, and R. Platte. 2011. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2010. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK.

Larned, W., R. Stehn, and R. Platte. 2012. Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2011. Unpublished report, U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Anchorage, AK.

Lawhead, B. E., and A. K. Prichard. 2012. Mammal surveys in the Greater Kuparuk Area, Northern Alaska, 2011. Report for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks.

Lewis, T. L., P. L. Flint, J. A. Schmutz, and D. V. Derksen. 2009. Temporal distributions and patterns of habitat use by Black Brant molting in the Teshekpuk Lake Special Area, Alaska. Interagency Report by U. S. Geological Survey, Alaska Science Center, Anchorage, AK. 113 pp.

Mabee, T. J., A. M. Wildman, and C. B. Johnson. 2006. Using egg flotation and eggshell evidence to determine age and fate of arctic shorebird nests. Journal of Field Ornithology 77: 163–172.

Manly, B. F. J. 1997. Randomization, bootstrap, and Monte Carlo methods in biology. 2nd edition. Chapman and Hall, London. 399 pp.

McCormick, K. J., and B. Poston. 1988. Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories. Canadian Field-Naturalist 102: 530–532.

McIntyre, J. W., and J. F. Barr. 1997. Common Loon (*Gavia immer*). In The Birds of North America, No. 313 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.; The American Orthithologists' Union. 32 pp

Michael Baker Jr. Inc. 2012. 2012 Colville River Delta spring breakup monitoring and hydrological assessment. Report for ConocoPhillips Alaska, Inc., by Michael Baker, Jr., Inc. Anchorage, AK.

Monda, M. J., J. T. Ratti, and T. R. McCabe. 1994. Reproductive ecology of tundra swans on the Arctic National Wildlife Refuge, Alaska. Journal of Wildlife Management 58(4): 757-773.

Murphy, S. M., and B. A. Anderson. 1993. Lisburne Terrestrial Monitoring Program: The effects of the Lisburne Development Project on geese and swans, 1985–1989. Synthesis report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 202 pp.

Murphy, S. M., and A. A. Stickney. 2000. Baseline avian surveys within the National Petroleum Reserve–Alaska, 2000. Report for PHILLIPS Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 28 pp.

North, M. R. 1986. Breeding biology of Yellow-billed Loons on the Colville River Delta, arctic Alaska. M. S. thesis, North Dakota State University, Fargo. 109 pp.

North, M. R. 1994. Yellow-billed Loon (*Gavia adamsii*). In The Birds of North America, No. 121 (A. Poole and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.; The American Orthithologists' Union. 24 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, March 3–7, 2008, Fairbanks, Alaska. [abstract only]

Piper, W. H., K. B. Tischler, M. Klich. 2000. Territory acquisition in loons: the importance of take-over. Animal Behaviour 59: 385–394.

Person, B. T., C. A. Babcock, and R. W. Ruess. 1998. Forage variation in brood-rearing areas used by Pacific Black Brant geese on the Yukon-Kuskokwim Delta, Alaska. Journal of Ecology 86: 243–259.

Rothe, T. C., C. J. Markon, L. L. Hawkins, and P. S. Koehl. 1983. Waterbird populations and habitat analysis of the Colville River Delta, Alaska: 1981 summary report. U.S. Fish and Wildlife Service, Anchorage, AK. 131 pp.

Sedinger, J. S., and A. A. Stickney. 2000. Black Brant. Pages 221–232 in J. C. Truett and S. R. Johnson, eds. The Natural History of an Arctic Oil Field: Development and the Biota. Academic Press, 422 pp.

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, 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, 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, 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, by ABR, Inc., Fairbanks, AK. 14 pp.

Serie, J. R, and J. C. Bartonek. 1991. Population status and productivity of tundra swans Cyngus columbianus columbianus in North America. pp 172-177 in Proceedings of the Third International Swan Symposium, Oxford 1989 (J. Sears and P. J. Bacon, Eds.). Wildfowl, Supplement No. 1.

Serie, J. R., D. Luszcz and R. V. Raftovich. 2002. Population trends, productivity and harvest of eastern population tundra swans. pp 32-36 in Proceedings of the Fourth International Swan Symposium, 2001 (E. C. Rees, S. L. Earnst and J. Coulson, Eds.) Waterbirds 25, special publication 1.

Sjölander, S., and G. Ågren. 1976. Reproductive behavior of the Yellow-billed Loon, Gavia adamsii. Condor 78: 454–463.

Smith, L. N., L. C. Byrne, C. B. Johnson, and A. A. Stickney. 1994. Wildlife studies on the Colville River Delta, Alaska, 1993. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 95 pp.

Smith, L. N., L. C. Byrne, and R. J. Ritchie. 1993. Wildlife studies on the Colville River Delta, Alaska, 1992. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 69 pp.

Spindler. M. A. and K. F. Hall. 1991. Local movements and habitat use of Tundra or Whistilng Swans *Cygnus columbianus* in the Kobuk-Selawik Lowlands of northwest Alaska. Wildfowl 42: 17–32.

Srivastava, D. S., and R. L. Jefferies. 1996. A positive feedback: herbivory, plant growth, salinity and the desertification of an Arctic salt-marsh. Journal of Ecology 84: 31–42.

Stickney, A. A., and R. J. Ritchie. 1996. Distribution and abundance of Brant (Branta bernicla) on the Central Arctic Coastal Plain of Alaska. Arctic 49:44–52.

Stickney, A. A., R. J. Ritchie, B. A. Anderson, and D. A. Flint. 1993. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Sagavanirktok River, 1993. Report for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 83 pp.

Stickney, A. A., L. Attanas, and T. Obritschkewitsch. 2012. Avian studies in the Kuparuk Oilfield, 2011. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Stickney, A. A., L. Attanas, and T. Obritschkewitsch. 2013. Avian studies in the Kuparuk Oilfield, 2012. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 47 pp.

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

USFWS. 1987b. Trumpeter and Tundra swan survey protocol update. Unpublished memorandum, Office of Migratory Bird Management, Juneau, AK. 8 pp.

USFWS. 1991. Trumpeter and Tundra swan survey protocol. Unpublished memorandum, Office of Migratory Bird Management, Juneau, AK. 4 pp.

Walker, H. J. 1978. Lake tapping in the Colville River Delta, Alaska. Pages 233–238 in Proceedings of the 3rd International Conference on Permafrost, Vol. 1. Natural Research Council of Canada, Edmonton, AB.

Walker, H. J. 1983. Guidebook to permafrost and related features of the Colville River Delta, Alaska. Guidebook 2. Alaska Divisionof Geological and Geophysical Surveys, Anchorage, AK. 34 pp.

Williams, T. D., E. G. Cooch, R. L. Jefferies, and F. Cooke. 1993. Environmental degradation, food limitation and reproductive output: juvenile survival in Lesser Snow Geese. Journal of Animal Ecology 62: 766–777.

Wilson, H. M. 2011. Aerial photographic surveys of Brant colonies on the Yukon-Kuskokwim Delta, Alaska, 2011. Unpubl. report, U.S. Fish and Wildlife Service, Migratory Bird management, Anchorage, AK. 10 pp. <http://alaska.fws.gov/mbsp/mbm/waterfowl/surveys/ pdf/brant_ykd.pdf>

PERSONAL COMMUNICATIONS

Alice Stickney, Wildlife Biologist, ABR, Inc.—Environmental Research and Services, Fairbanks, AK.

Appendix A. Common, Iñupiaq, and scientific names of birds and mammals referenced in this report.

COMMON NAME	IÑUPIAQ NAME	SCIENTIFIC NAME
BIRDS		
Snow Goose	Kaŋuq	*Chen caerulescens*
Brant	Niġliŋġaq	*Branta bernicla*
Tundra Swan	Qugruk	*Cygnus columbianus*
Steller's Eider	Igniqauqtuq	*Polysticta stelleri*
Spectacled Eider	Qavaasuk	*Somateria fischeri*
King Eider	Qiŋalik	*Somateria spectabilis*
Common Eider	Amauligruaq	*Somateria mollissima*
Red-throated Loon	Qaqsrauq	*Gavia stellata*
Pacific Loon	Malġi	*Gavia pacifica*
Yellow-billed Loon	Tuullik	*Gavia adamsii*
Glaucous Gull	Nauyavasrugruk	*Larus hyperboreus*
Sabine's Gull	Iqirgagiak	*Xema sabini*
Parasitic Jaeger	Migiaqsaayuk	*Stercorarius parasiticus*
Golden Eagle	Tiŋmiaqpak	*Aquila chrysaetos*
Common Raven	Tulugaq	*Corvus corax*
MAMMALS		
Arctic Fox	Tiġiganniaq	*Vulpes lagopus*
Red Fox	Kayuqtuq	*Vulpes vulpes*
Brown (Grizzly) Bear	Akłaq	*Ursus arctos*
Caribou	Tuttu	*Rangifer tarandus*

Appendix B. Classification and descriptions of wildlife habitat types found in the Colville Delta or NE NPRA study areas, Alaska, 2012. Species associations of some habitats vary between the Colville Delta and the NE NPRA study areas.

Habitat Class	Description
Open Nearshore Water (Estuarine Subtidal)	Shallow estuaries, lagoons, and embayments along the coast of the Beaufort Sea. Winds, tides, river discharge, and icing create dynamic changes in physical and chemical characteristics. Tidal range normally is small (< 0.2 m), but storm surges produced by winds may raise sea level as much as 2–3 m. Bottom sediments are mostly unconsolidated mud. Winter freezing generally begins in late September and is completed by late November. An important habitat for some species of waterfowl for molting during spring and fall staging.
Brackish Water (Tidal Ponds)	Coastal ponds and lakes that are flooded periodically with saltwater during storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. Sediments may contain peat, reflecting a freshwater/terrestrial origin, but this peat is mixed with deposited silt and clay.
Tapped Lake with Low-water Connection	Waterbodies that have been partially drained by erosion of banks by adjacent river channels and are connected to rivers by distinct, permanently flooded channels. The water typically is brackish and the lakes are subject to flooding every year. Because water levels have dropped, the lakes generally have broad flat shorelines with silty clay sediments. Salt-marsh vegetation is common along the shorelines. Deeper lakes in this habitat do not freeze to the bottom during winter. Sediments are fine-grained silt and clay with some sand. These lakes form important over-wintering habitat for fish.
Tapped Lake with High-water Connection	Similar to Tapped Lake with Low-water Connection except that the connecting channels are dry during low water and the lakes are connected only during flooding events. Water tends to be fresh. Small deltaic fans are common near the connecting channel due to deposition during seasonal flooding. These lakes form important fish habitat.
Salt Marsh	On the Beaufort Sea coast, arctic Salt Marshes generally occur in small, widely dispersed patches, most frequently on fairly stable tidal flats associated with river deltas. The surface is flooded irregularly by brackish or marine water during high tides, storm surges, and river flooding events. Salt Marshes typically include a complex assemblage of small brackish ponds and Halophytic Sedge or Grass Wet Meadows. Moist Halophytic Dwarf Shrub and small barren areas also may occur in patches too small to map separately. Dominant plant species usually include *Carex subspathacea, C. ursina, C. ramenskii, Puccinellia phryganodes, Dupontia fisheri, P. andersonii, Salix ovalifolia, Cochlearia officinalis, Stellaria humifusa,* and *Sedum rosea*. Salt Marsh is important habitat for brood-rearing and molting waterfowl.
Moist Halophytic Dwarf Shrub	Tidal flats and regularly flooded riverbars of tidal rivers with vegetation dominated by dwarf willow and graminoids. Tide flat communities have brackish, loamy (with variable organic horizons), saturated soils, with ground water depths ~ 25 cm and active layer depths ~50 cm. Vegetation is dominated by *Salix ovalifolia, Carex subspathacea*, and *Calamagrostis deschampsioides*. On sandy sites *Elymus arenarius mollis* is a co-dominant. On active tidal river depostis, soils are loamy, less brackish, and vegetation is dominated by *Salix ovalifolia* with *Carex aquatilis* and *Dupontia fisheri*.

Appendix B. Continued.

Habitat Class	Description
Dry Halophytic Meadow	Somewhat poorly vegetated, well-drained meadows on regularly inundated tidal flats and riverbars of tidal rivers, characterized by the presence of *Elymus arenarius mollis*. Soils are brackish sands with little organic material and deep active layers. Commonly associated species include *Salix ovalifolia, Sedum rosea, Stellaria humifusa*, (on tide flats) and *Deschampsia caespitosa* (on tidal river deposits).
Tidal Flat Barrens	Areas of nearly flat, barren mud or sand that are periodically inundated by tidal waters. Tidal Flat Barrens occur on the seaward margins of deltaic estuaries, leeward portions of bays and inlets, and at mouths of rivers. Tidal Flat Barrens frequently are associated with lagoons and estuaries and may vary widely in actual salinity levels. Tidal Flat Barrens are considered separately from other barren habitats because of their importance to estuarine and marine invertebrates and shorebirds.
Salt-killed Tundra	Coastal areas where saltwater intrusions from storm surges have killed much of the original terrestrial vegetation and are being colonized by salt-tolerant plants. Colonizing plants include *Puccinellia andersonii, Dupontia fisheri, Braya purpurascens, B. pilosa, Cochlearia officinalis, Stellaria humifusa, Cerastium beeringianum,* and *Salix ovalifolia*. This habitat typically occurs either on low-lying areas that originally supported Patterned Wet Meadows and Basin Wetland Complexes or, less commonly, along drier coastal bluffs that originally supported Moist Sedge–Shrub Meadow and Dry Dwarf Shrub. Salt-killed Tundra differs from Salt Marshes in having abundant litter from dead tundra vegetation, a surface horizon of organic soil, and salt-tolerant colonizers.
Deep Open Water without Islands	Deep (≥1.5 m) waterbodies range in size from small ponds in ice-wedge polygons to large open lakes. Most have resulted from thawing of ice-rich sediments, although some are associated with old river channels. They do not freeze to the bottom during winter and usually are not connected to rivers. Sediments are fine-grained silt in centers with sandy margins. Deep Open Waters without Islands are differentiated from those with islands because of the lack of nest sites for waterbirds that prefer islands.
Deep Open Water with Islands or Polygonized Margins	Similar to above except that they have islands or complex shorelines formed by thermal erosion of low-center polygons. The complex shorelines and islands are important features of nesting habitat for many species of waterbirds.
Shallow Open Water without Islands	Ponds and small lakes <1.5 m deep with emergent vegetation covering <5% of the waterbody’s surface. Due to the shallow depth, water freezes to the bottom during winter and thaws by early to mid-June. Maximal summer temperatures are higher than those in deep water. Sediments are loamy to sandy.
Shallow Open Water with Islands or Polygonized Margins	Shallow lakes and ponds with islands or complex low-center polygon shorelines, otherwise similar to Shallow Open Water without Islands. Distinguished from Shallow Open Water without Islands because shoreline complexity appears to be an important feature of nesting habitat for many species of waterbirds.
River or Stream	All permanently flooded channels large enough to be mapped as separate units. Rivers generally experience peak flooding during spring breakup and lowest water levels during mid-summer. The distributaries of Fish Creek are slightly saline, whereas other streams are non-saline.

Appendix B. Continued.

Habitat Class	Description
Sedge Marsh	Permanently flooded waterbodies dominated by *Carex aquatilis*. Typically, emergent sedges occur in water ≤0.5 m deep. Water and bottom sediments of this shallow habitat freeze completely during winter, but the ice melts in early June. The sediments generally consist of a peat layer (0.2–0.5 m deep) overlying loam or sand.
Deep Polygon Complex	A habitat associated with inactive and abandoned floodplains and deltas in which thermokarst of ice-rich soil has produced deep (>0.5 m), permanently flooded polygon centers. Emergent vegetation, mostly *Carex aquatilis,* usually is found around the margins of the polygon centers. Occasionally, centers will have the emergent grass *Arctophila fulva*. Polygon rims are moderately well drained and dominated by sedges and dwarf shrubs, including *Carex aquatilis, Eriophorum angustifolium, C. bigelowii, Dryas integrifolia, Salix reticulata,* and *S. ovalifolia*.
Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva*. Due to shallow water depths (<1 m), the water freezes to the bottom in the winter, and thaws by early June. *Arctophila fulva* stem densities and annual productivity can vary widely among sites. Sediments generally lack peat. This type usually occurs as an early successional stage in recently drained lake basins and is more productive than Sedge Marsh. This habitat tends to have abundant invertebrates and is important to many waterbirds.
Young Basin Wetland Complex (Ice-poor)	Complex habitat found in recently drained lake basins and characterized by a mosaic of open water, Sedge and Grass Marshes, Nonpatterned Wet Meadows, and Moist Sedge–Shrub Meadows in patches too small (<0.5 ha) to map individually. During spring breakup, basins may be entirely inundated, though water levels recede by early summer. Basins often have distinct banks marking the location of old shorelines, but these boundaries may be indistinct due to the coalescence of thaw basins and the presence of several thaw lake stages. Soils generally are loamy to sandy, moderately to richly organic, and ice-poor. Because there is little segregated ground ice the surface form is nonpatterned ground or disjunct polygons and the margins of waterbodies are indistinct and often interconnected. Ecological communities within young basins appear to be much more productive than are those in older basins: this was the primary rationale for differentiating these two types.
Old Basin Wetland Complex (Ice-rich)	Similar to above but characterized by well-developed low- and high-centered polygons resulting from ice-wedge development and aggradation of segregated ice. Complexes in basin margins generally include Sedge Marsh, Patterned Wet Meadow, Moist Sedge–Shrub Meadows, and small ponds (<0.25 ha). The waterbodies in old basins tend to have smoother, more rectangular shorelines and are not as interconnected as those in more recently drained basins. The vegetation types in basin centers generally include Moist Sedge–Shrub Meadow and Moist Tussock Tundra on high-centered polygons, and Patterned Wet Meadows. Grass Marsh generally is absent. Soils have a moderately thick (0.2–0.5 m) organic layer overlying loam or sand.

Appendix B. Continued.

Habitat Class	Description
Riverine Complex	Permanently flooded streams and floodplains characterized by a complex mosaic of water, Barrens, Dry Dwarf Shrub, Moist Tall Shrub and Moist Low Shrub, Sedge and Grass Marsh, Nonpatterned and Patterned Wet Meadow, and Moist Sedge–Shrub Meadow in patches too small (<0.5 ha) to map individually. Surface form varies from nonpatterned point bars and meadows to mixed high- and low-centered polygons and small, stabilized dunes. Small ponds tend to have smooth, rectangular shorelines resulting from the coalescing of low centered polygons. During spring flooding these areas may be entirely inundated, following breakup water levels gradually recede.
Dune Complex	Complex formed from the action of irregular flooding on inactive sand dunes, most commonly on river point bars. A series of narrow swale and ridge features develop in parallel with river flow that are too small to map separately. Swales are moist or saturated while ridges are moist to dry. Habitat classes in swales typically are Moist Low Shrub, Nonpatterned Wet Meadow, or Sedge Marsh, while ridges commonly are Dry Dwarf Shrub or Moist Low Shrub.
Nonpatterned Wet Meadow	Sedge-dominated meadows that occur within recently drained lake basins, as narrow margins of receding waterbodies, or along edges of small stream channels in areas that have not yet undergone extensive ice-wedge polygonization. Disjunct polygon rims and strang cover <5% of the ground surface. The surface generally is flooded during early summer (depth <0.3 m) and drains later, but water remains close to the surface throughout the growing season. The uninterrupted movement of water (and dissolved nutrients) in nonpatterned ground results in more robust growth of sedges than occurs in polygonized habitats. Usually dominated by *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present. Near the coast, the grass *Dupontia fisheri* may be present. Low and dwarf willows (*Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) occasionally are present. Soils generally have a moderately thick (10–30 cm) organic horizon overlying loam or sand.
Patterned Wet Meadow	Lowland areas with low-centered polygons or strang within drained lake basins, level floodplains, and flats and water tracks on terraces. Polygon centers are flooded in spring and water remains close to the surface throughout the growing season. Polygon rims or strang interrupt surface and groundwater flow, so only interconnected polygon troughs receive downslope flow and dissolved nutrients; in contrast, the input of water to polygon centers is limited to precipitation. As a result, vegetation growth typically is more robust in polygon troughs than in centers. Vegetation is dominated by sedges, usually *Carex aquatilis* and *Eriophorum angustifolium*, although other sedges may be present including *C. rotundata, C. saxatilis, C. membranacea, C. chordorrhiza,* and *E. russeolum*. On polygon rims, willows (e.g., *Salix lanata richardsonii, S. reticulata, S. planifolia pulchra*) and the dwarf shrubs *Dryas integrifolia* and *Cassiope tetragona* may be abundant along with other species typical of moist tundra.
Moist Sedge–Shrub Meadow	High-centered, low-relief polygons and mixed high- and low-centered polygons on gentle slopes of lowland, riverine, drained basin, and solifluction deposits. Soils are saturated at intermediate depths (>0.15 m) but generally are free of surface water during summer. Vegetation is dominated by *Dryas integrifolia*, and *Carex bigelowii*. Other common species include *C. aquatilis*, *Eriophorum angustifolium*, *Salix reticulata, S. lanata richardsonii,* and the moss *Tomentypnum nitens*. The active layer is relatively shallow and the organic horizon is moderate (0.1–0.2 m).

Appendix B. Continued.

Habitat Class	Description
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins. Vegetation is dominated by tussock-forming plants, most commonly *Eriophorum vaginatum*. High-centered polygons of low or high relief are associated with this habitat. Soils are loamy to sandy, somewhat well-drained, acidic to circumneutral, with moderately thick (0.1–0.3 m) organic horizons and shallow (<0.4 m) active layer depths. On acidic sites, associated species include *Ledum decumbens, Betula nana, Salix planifolia pulchra, Cassiope tetragona* and *Vaccinium vitis-idaea*. On circumneutral sites common species include *Dryas integrifolia, S. reticulata, Carex bigelowii,* and lichens. Mosses are common at most sites.
Moist Tall Shrub	Most commonly found on actively flooded banks and bars of meander and tidal rivers dominated by tall (> 1.5 m) shrubs. Sites are nonpatterned and subject to variable flooding frequency, soils are well-drained, alkaline to circumneutral, and lack organic material. Vegetation is defined by an open canopy of *Salix alaxensis*. Understory species include *Equisetum arvense, Gentiana propinqua, Chrysanthemum bipinnatum, Festuca rubra* and *Aster sibiricus*. Moist Tall Shrub occasionally occurs on protected lowland sites where the dominant species may be *Salix* spp.or *Alnus crispa*.
Moist Low Shrub	Any community on moist soils dominated by willows < 1.5m tall. Upland sites are well-drained sands and loams characterized by *Salix glauca* (or infrequently, *Betula nana*), *Dryas integrifolia*, and *Arctostaphylos rubra*. Recently drained basins are somewhat poorly drained loams with moderate organic horizons dominated by either *S. lanata richardsonii* or *S. planifolia pulchra* with *Eriophorum angustifolium* and *Carex aquatilis*. Riverbank deposits also are dominated by either *S. lanata richardsonii* or *S. planifolia pulchra*, but with *Equisetum arvense*, *Arctagrostis latifolia*, or *Petasites frigidus*. Somewhat poorly-drained lowland flats and lower slopes have the greatest organic horizon development and are dominated by *S. planifolia pulchra*. Associated species are similar to those in drained basin communities. Thaw depths are deepest in riverine and upland communities and shallowest in lowland areas.
Moist Dwarf Shrub	Well-drained upland slopes and banks, and the margins of drained lake basins dominated by *Cassiope tetragona*. Soils are well-drained, loamy to sandy and circumneutral to acidic. Vegetation is species rich, associated species include *Dryas integrifolia, Salix phlebophylla, Vaccinium vitis-idaea, Carex bigelowii, Arctagrostis latifolia, Hierochloe alpina, Pyrola grandiflora,* and *Saussurea angustifolia*. Lichens and mosses also are common.
Dry Tall Shrub	Crests of active sand dunes with vegetation dominated by the tall willow *Salix alaxensis*. Soils are sandy, excessively drained, alkaline to circumneutral, with deep active layers (>1 m) and no surface organic horizons. The shrub canopy usually is open with dominant shrubs >1m tall. Other common species include *Chrysanthemum bipinnatum, Festuca rubra*, and *Equisetum arvense*.

Appendix B. Continued.

Habitat Class	Description
Dry Dwarf Shrub	Well-drained riverbank deposits and windswept, upper slopes and ridges dominated by the dwarf shrub *Dryas integrifolia*. Soils are sandy to loamy, alkaline to circumneutral, with deep active layers. Upland sites are lacking in organics, and in riverine sites organic accumulation is shallow. Riverbank communities have *Salix reticulata, Carex bigelowii, Arctagrostis latifolia, Equisetum variegatum, Oxytropis deflexa, Arctostaphylos rubra,* and lichens as common associates, while upland sites have *S. reticulata, S. glauca, S. arctica, C. bigelowii, Arctostaphylos alpina, Arctagrostis latifolia*, and lichens.
Barrens (Riverine, Eolian, or Lacustrine)	Includes barren and partially vegetated (<30% plant cover) areas related to riverine, eolian, or thaw basin processes. Riverine Barrens on river flats and bars are underlain by moist sands and are flooded seasonally. Early colonizers are *Deschampsia caespitosa, Poa hartzii, Festuca rubra, Salix alaxensis*, and *Equisetum arvense.* Eolian Barrens are active sand dunes that are too unstable to support more than a few pioneering plants (<5% cover). Typical species include *Salix alaxensis, Festuca rubra,* and *Chrysanthemum bipinnatum*. Lacustrine Barrens occur within recently drained lakes and ponds. These areas may be flooded seasonally or can be well drained. Typical colonizers are forbs, graminoids, and mosses including *Carex aquatilis, Dupontia fisheri, Scorpidium scorpioides*, and *Calliergon* sp. on wet sites and *Poa* spp., *Festuca rubra, Deschampsia caespitosa, Stellaria humifusa, Senecio congestus,* and *Salix ovalifolia* on drier sites. Barrens may receive intense use seasonally by caribou as mosquito-relief habitat.
Human Modified (Water, Fill, Peat Road)	A variety of small disturbed areas, including impoundments, gravel fill, and a sewage lagoon at Nuiqsut. Gravel fill is present at Nuiqsut, the Alpine facilities, and at the Helmericks' residence near the mouth of the Colville River.

Appendix C. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, Colville Delta study area, Alaska, 2012.

SPECIES Subarea Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
CD North							
On ground	25	19	44	19	50	0.21	0.24
In flight	2	3	5	2	–	0.02	–
All birds	27	22	49	21	–	0.24	–
Northeast Delta							
On ground	4	1	5	1	8	0.03	0.05
In flight	0	0	0	0	–	0.00	–
All birds	4	1	5	1	–	0.03	–
CD South							
On ground	1	1	2	1	2	0.01	0.01
In flight	2	1	3	1	–	0.02	–
All birds	3	2	5	2	–	0.04	–
Total (subareas combined)							
On ground	30	21	51	21	60	0.10	0.12
In flight	4	4	8	3	–	0.02	–
All birds	34	25	59	24	–	0.12	–
KING EIDER							
CD North							
On ground	7	6	13	6	14	0.06	0.07
In flight	4	2	6	2	–	0.03	–
All birds	11	8	19	8	–	0.09	–
Northeast Delta							
On ground	2	1	3	1	4	0.02	0.03
In flight	0	0	0	0	–	0.00	–
All birds	2	1	3	1	–	0.02	–
CD South							
On ground	1	1	2	1	2	0.01	0.01
In flight	1	0	1	0	–	0.01	–
All birds	2	1	3	1	–	0.02	–
Total (subareas combined)							
On ground	10	8	18	8	20	0.04	0.04
In flight	5	2	7	2	–	0.01	–
All birds	15	10	25	10	–	0.05	–

[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 D. Number and density (birds/km²) of eiders during pre-nesting aerial surveys, NE NPRA study area, Alaska, 2012.

SPECIES Subarea Location	Observed Males	Observed Females	Observed Total	Observed Pairs	Indicated Total[a]	Observed Density[b]	Indicated Density[a, b]
SPECTACLED EIDER							
Development							
On ground	0	0	0	0	0	0	0
In flight	0	0	0	0	–	0	–
All birds	0	0	0	0	–	0	–
Alpine West							
On ground	0	0	0	0	0	0	0
In flight	0	0	0	0	–	0	–
All birds	0	0	0	0	–	0	–
Fish Creek Delta							
On ground	1	1	2	1	2	0.03	0.03
In flight	1	1	2	1	–	0.03	–
All birds	2	2	4	2	–	0.07	–
Total (subareas combined)							
On ground	1	1	2	1	2	0.01	0.01
In flight	1	1	2	1	–	0.01	–
All birds	2	2	4	2	–	0.02	–
KING EIDER							
Development							
On ground	16	6	22	6	32	0.30	0.44
In flight	4	1	5	1	–	0.07	–
All birds	20	7	27	7	–	0.37	–
Alpine West							
On ground	7	4	11	4	14	0.26	0.33
In flight	1	1	2	1	–	0.05	–
All birds	8	5	13	5	–	0.31	–
Fish Creek Delta							
On ground	22	14	36	13	44	0.63	0.77
In flight	4	1	5	1	–	0.09	–
All birds	26	15	41	14	–	0.72	–
Total (subareas combined)							
On ground	45	24	69	23	90	0.40	0.52
In flight	9	3	12	3	–	0.07	–
All birds	54	27	81	26	–	0.47	–

[a] Total indicated birds was calculated according to standard USFWS protocol (USFWS 1987a)

[b] Numbers not corrected for sightability. Surveys conducted at 50% coverage. Density based on area surveyed: Development subarea = 72.9 km², Alpine West = 41.8 km², Fish Creek Delta = 57.3 km², all subareas combined = 172.0 km². Fish Creek West, Exploration, and the western portion of the Development subareas were not surveyed in 2011 (see Figure 1)

Appendix E. Number and density of loons and their nests, broods, and young during aerial surveys, Colville Delta and NE NPRA study areas, Alaska, 2012.

STUDY AREA / Subarea[b] / Survey Type	Yellow-billed Loon: Number			Yellow-billed Loon: Density (number/km²)		Pacific Loon[a]: Number			Red-throated Loon[a]: Number		
	Adults	Nests/ Brood	Young	Adults	Nests/ Broods	Adults	Nests/ Broods	Young	Adults	Nests/ Broods	Young
COLVILLE DELTA											
CD North											
Nesting	33	19[c]	–	0.16	0.09	94	2	–	2	0	–
Brood-rearing	24	11[d]	13	0.12	0.05	23	11	13	0	0	0
CD South											
Nesting	23	11[c]	–	0.15	0.07	49	9	–	3	0	–
Brood-rearing	25	4[d]	3	0.16	0.03	29	5	6	0	0	0
Northeast Delta[e]											
Nesting	3	2	–	–	–	13	2	–	0	0	–
Brood-rearing	3	2	3	–	–	6	4	4	0	0	0
Total (subareas combined)[f]											
Nesting	59	32[c]	–	0.15	0.08	156	13	–	5	0	–
Brood-rearing	52	17[d]	19	0.14	0.04	58	20	23	0	0	0
NE NPRA											
Alpine West											
Nesting	2	1	–	0.03	0.01	70	3	–	0	0	–
Brood-rearing	2	1	2	0.03	0.01	43	10	12	0	0	0
Fish Creek Delta											
Nesting	19	8[c]	–	0.15	0.06	88	2	–	2	0	–
Brood-rearing	13	4	5	0.10	0.03	38	4	4	0	0	0
Fish and Judy Creek Corridor											
Nesting	15	9[c]	–	0.37	0.22	22	0	–	0	0	–
Brood-rearing	27	7	7	0.66	0.17	11	2	3	0	0	0
Total (subareas combined)[f]											
Nesting	36	18[c]	–	0.14	0.07	180	5	–	2	0	–
Brood-rearing	42	12	14	0.17	0.05	92	16	19	0	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, Alpine West = 79.7 km², Fish Creek Delta = 130.5 km²; eastern portion of Fish and Judy Creek Corridor = 41.0 km²; see Figure 5

[c] Number includes nests found during weekly monitoring surveys: 4 nests in the CD North subarea and 3 nests in the CD South subarea of the Colville Delta study area, and 1 nest in the Fish Creek Delta subarea and 2 nests in the Fish and Judy Creek Corridor subarea of the NE NPRA study area

[d] Number includes 1 brood in the CD North subarea and 2 broods in the CD South subarea of the Colville Delta study area determined by eggshell evidence

[e] Densities were not calculated for the Northeast Delta subarea because only a portion of the subarea was surveyed

[f] Total is the sum of all subareas but density calculations included only CD North and CD South for Colville Delta (362.6 km² total), and Alpine West, Fish Creek Delta, and eastern part of Fish and Judy Creek Corridor for NE NPRA (251.2 km² total)

Appendix F. Annual density (number/km²) of Yellow-billed Loons, nests, and broods, Colville Delta (1993–2012) and NE NPRA (2001–2012) study areas, Alaska.

STUDY AREA Year	Nesting Survey Adults	Nests[a]	Brood-rearing Survey Adults	Broods[b]
COLVILLE DELTA[c]				
1993	0.14	0.03	0.08	0.02
1995	0.10	0.03	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 (0.05)	0.18	0.02
2003	0.14	0.07	0.13	0.04
2004	0.11	0.07	0.14	0.03
2005	0.15	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)
Mean	0.15	0.05 (0.08)[d]	0.13	0.03 (0.05)
SE	<0.01	<0.01 (<0.01)[d]	0.01	<0.01 (<0.01)
NE NPRA[e, f]				
2001	0.07	0.03	0.08	0.01
2002	0.07	0.03	0.05	0.01
2003	0.06	0.03	0.06	0.02
2004	0.07	0.03	0.08	0.01
2005	0.11	0.04	0.06	0.01
2006	0.11	0.04	0.07	0.01
2008	0.17	0.05 (0.06)	0.14	0.02 (0.04)
2009	0.13	0.05 (0.06)	0.16	0.03 (0.03)
2010	0.15	0.06 (0.06)	0.14	0.03 (0.03)
2011	0.12	0.03 (0.05)	0.12	0.02 (0.02)
2012	0.14	0.06 (0.07)	0.17	0.05 (0.05)

[a] Density of nests found on the nesting survey and, in parentheses, cumulative density including additional nests found dur revisit (1996–2002) and monitoring (2006–2012) surveys

[b] Density of broods found on the brood-rearing survey and, in parentheses, cumulative density including additional broods during monitoring surveys (2005–2012) that did not survive to the time of the brood-rearing survey

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

[d] Mean density and SE includes only years when monitoring surveys were conducted: 2006–2012

[e] Survey area included 5 subareas: Development (617.8 km²) surveyed in 2001–2004, Exploration (260.4 km²) in 2002–20 Alpine West (79.7 km²) in 2002–2006 and 2008–2012, Fish Creek Delta (130.5 km²) in 2005–2006 and 2008–2012, and Fish and Judy Creek Corridor (255.9 km²) in 2008–2010. In 2011 and 2012, the eastern one-quarter of the Fish and Judy Corridor subarea (41.0 km²) was surveyed.

[f] Mean densities not calculated for NE NPRA because the study area differed among years

Appendix G. Annual number of Tundra Swan nests and broods during aerial surveys, NE NPRA study area, Alaska, 2001–2012.

SEASON Year	Alpine West	Development	Exploration	Fish Creek Delta	Fish Creek West
NESTING					
2001	1	20	11	–	–
2002	2	24	17	–	–
2003	3	27	13	–	–
2004	2	33	15	13	–
2005	3	25	9	4	7
2006	5	36	11	4	16
2008	5	32	18	4	10
2009	5	27	13	12	16
2011	4	1	–	7	–
2012	4	9	–	6	–
BROOD-REARING					
2001	2	16	5	–	–
2002	1	15	10	–	–
2003	3	12	5	–	–
2004	2	16	13	–	–
2005	2	18	6	3	8
2006	1	17	11	6	14
2008	2	16	4	4	9
2009	0	28	8	6	8
2011	0	5	–	5	–
2012	3	5	–	4	–

[a] Alpine West = 79.7 km², Development = 615.8 km², Exploration = 404.7 km², Fish Creek Delta = 130.5 km², Fish Creek West = 340.4 km². In 2011 and 2012, only a small portion (130.9 km²) of the Development Subarea was surveyed