FINAL REPORT

MARINE MAMMAL DISTRIBUTION AND ABUNDANCE IN THE NORTHEASTERN CHUKCHI SEA FROM SHIPBOARD SURVEYS DURING SUMMER AND EARLY FALL, 2008−2013

L.A.M. AERTS, C.L. CHRISTMAN, C.A. SCHUDEL, W. HETRICK, AND D. SNYDER

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Cover page:
Upper photo—Walrus swimming in the Chukchi Sea during August.
Lower photo—Ringed seal hauled out on ice in the Chukchi Sea during August.
Background—Sea ice in the northeastern Chukchi Sea during September.
Photos taken by CSESP/Olgoonik-Fairweather, LLC.

Photographs in this report:

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FINAL REPORT
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Prepared for

ConocoPhillips Company
P.O. Box 100360
Anchorage, AK 99510-0360

Shell Exploration & Production Company
3601 C Street, Suite 1000
Anchorage, AK 99503

and

Statoil USA E & P, Inc.
3800 Centerpoint Drive, Suite 920
Anchorage, AK 99503

Prepared by

L.A.M. Aerts
lisanne@lamaecological.com
LAMA Ecological
4311 Edinburgh Drive, Anchorage, AK 99502

and

C.L. Christman (CLC Research, Soldotna, AK), C.A. Schudel (ERM Alaska, Inc., Anchorage, AK), W. Hetrick (Fairweather Science, Anchorage, AK), and D. Snyder (Resource Data, Inc., Anchorage, AK)

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ACRONYMS AND ABBREVIATIONS

ADCP .... Acoustic Doppler Current Profiler
AIC .... Akaike's Information Criterion
ARCWEST .... Arctic Whale Ecology Study
ASAMM .... Aerial Surveys of Arctic Marine Mammals
Aug .... August
BOWFEST .... Bowhead Whale Feeding Ecology Study
BWASP .... Bowhead Whale Aerial Survey Project
CHAOZ .... Chukchi Acoustic, Oceanographic, and Zooplankton study
CI .... Confidence Interval
COMIDA .... Chukchi Offshore Monitoring in Drilling Area
CSESP .... Chukchi Sea Environmental Studies Program
e.g. .... exempli gratia (for example)
fig. .... figure
GHS .... Greater Hanna Shoal
i.e. .... id est (that is)
ind .... individuals
ind km^{-2} .... individuals per square kilometer
Jul .... Jul
km .... kilometer
km^2 .... square kilometer
km^{-1} .... per kilometer
km h^{-1} .... kilometers per hour
m .... meter
MCDS .... Multiple Covariate Distance Sampling
mi .... mile
MRDS .... Mark–Recapture Distance Sampling
n .... number (sample size)
nmi .... nautical mile
NOAA .... National Oceanic and Atmospheric Administration
OCS .... Outer Continental Shelf
OCSEAP .... Outer Continental Shelf Environmental Assessment Program
Oct .... October
R/V .... Research Vessel
Sep .... September
sight .... sightings
SLR .... single-lens reflex camera
U.S. .... United States of America

EXECUTIVE SUMMARY

The Chukchi Sea Environmental Studies Program (CSESP) is an integrated, ecosystem-based survey involving physical and chemical oceanography, plankton, benthos, fish, seabird, marine mammal, and acoustic study components. The main purpose of this integrated approach has been to increase our understanding of how the continental shelf in the northeastern Chukchi Sea functions ecologically. This information will be used to predict potential changes to the marine ecosystem due to climate change at a time when the area is simultaneously undergoing exploration for oil and gas reserves. The integrated approach provides a more powerful tool for understanding, and therefore predicting, changes to the marine ecosystem than considering the study components separately.

ConocoPhillips initiated and managed CSESP in 2008 and 2009, with co-funding and participation from Shell. In 2010, Statoil joined this initiative, and Olgoonik-Fairweather assumed overall management of the project on behalf of the three sponsors. The CSESP surveys focused mainly on the companies' respective offshore lease areas. The 2013 survey season completes the sixth year of information collected on marine mammal distribution and abundance in the northeastern Chukchi Sea. This report summarizes and compares CSESP marine mammal data from 2013 with results from previous years (2008–2012).

In 2013, we conducted dedicated marine mammal line-transect surveys during two separate cruises (August 8–24 and September 18 – October 10). Besides collecting data during line-transect surveys, observers were also on board vessels during buoy deployment and retrieval cruises (mooring cruises) in the Chukchi Sea, to record marine mammal observations while the vessel was transiting to and from buoy locations. We conducted 6,934 km of on- and off-transect observation effort in the Chukchi and Bering seas when sea states were ≤5. Most of this effort (6,676 km; 96%) occurred in the northeastern Chukchi Sea. Observation effort in the Bering Sea (258 km; 4%) was conducted during transits to and from Nome. On- and off-transect effort in the three prospect-specific study areas accounted for approximately half (51%) of the total observation effort.

In 2013, during all effort modes (i.e., on-, off-, and non-transect), we recorded a total of 975 marine mammal sightings (6,153 animals) in the Chukchi Sea. The following species were observed: polar bear (*Ursus maritimus*), bowhead whale (*Balaena mysticetus*), gray whale (*Eschrichtius robustus*), fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), ringed seal (*Pusa hispida*), spotted seal (*Phoca largha*), bearded seal (*Erignathus barbatus*), Steller's sea lion (*Eumetopias jubatus*), and walrus (*Odobenus rosmarus*). We did not see any marine mammals in the Bering Sea in 2013, however, effort conducted there was minimal.

The main conclusions from 2013 are as follows:

- Bowhead whale density in 2013 was similar to densities recorded in 2010 and 2011 but was approximately four times lower than the density recorded in 2012. The seasonal density of bowhead whales, calculated from all six years of data combined, was two times higher in fall than in summer.
- In 2013, the bowhead whale sighting rate was highest in the Statoil study area. Although the number of bowhead whale sightings was variable from year to year, generally more bowhead whales were observed in Statoil and Burger than in Klondike. The number of bowhead whale sightings is largely dependent on the survey period and the timing of fall migration of these whales.

- In 2013, like previous years, most gray whales were sighted between Barrow and Wainwright, within 80 km from shore. One gray whale was observed farther from shore in the Statoil study area, but none were seen in Klondike or Burger. Few gray whales have been seen in the three prospect-specific study areas since 2008. Most gray whale sightings have occurred in August.
- Four beluga whales were observed in 2013, representing the first live beluga whales sighted during CSESP, since surveys began in 2008. Few beluga whale sightings are expected considering their seasonal distribution pattern relative to the timing and location of our survey.
- Fin whales, minke whales, and harbor porpoises were observed in 2013. Fin whales have been seen in only three years of CSESP surveys (2009, 2012, and 2013). Minke whales have been seen in all years except 2010, and harbor porpoises have been consistently seen each year since surveys began in 2008. Although minke whales and harbor porpoises occurred in low numbers, repeated encounters over the past six years suggest that these species are regular visitors to the Chukchi Sea.
- In 2013, observers recorded more ringed seals than spotted seals; this pattern was consistent with 2008, 2011, and 2012. Ringed seals were seen mainly in Burger, and spotted seals were seen mainly in Klondike.
- In 2013, the density of ringed and spotted seals combined was higher than previous years. Although ringed/spotted seal densities were highly variable among years and study areas, mean densities were highest in the Statoil study area since surveys were conducted there in 2010.
- The highest seasonal density of ringed/spotted seals in 2013 was recorded during fall. This pattern is different from other years with heavy ice cover (2008 and 2012), which were characterized by higher densities during summer than fall.
- By using densities of ringed and spotted seals that were identified to species from 2008 to 2013 (calculated with the detection function of the combined ringed/spotted seal category), we determined that the ratio of ringed and spotted seals was approximately 2:1.
- In 2013, the highest density of bearded seals occurred in the Statoil study area, consistent with results from previous years. Densities of bearded seals in Klondike and Burger in 2013 were similar to each other and were the highest densities recorded for those study areas since surveys began in 2008. In previous years, densities generally were higher in Burger than in Klondike.
- The highest seasonal density of bearded seals in 2013 occurred during summer. This was the highest summer density recorded since surveys began in 2008. Densities of bearded seals appeared to be variable seasonally, with no consistent pattern among years and no apparent relationship to sea ice conditions.
- In 2013, the highest density of walruses occurred in the Burger study area, consistent with patterns seen in previous years. Densities of walruses in Klondike and Statoil in 2013 were the highest recorded for those study areas since 2008. The highest density of walruses in Burger was recorded in 2012.
- The highest seasonal density of walruses in 2013 occurred during fall and was within the range of fall densities recorded in previous years. The density of walruses recorded during summer

in 2013 was the highest density recorded during summer since surveys began in 2008. In all years except 2009, densities of walruses have been higher in fall than in summer.

- Walruses were not seen continuously during the survey season, but instead occurred in pulses. In 2013, we recorded a summer peak in walrus sighting rates during late August and a fall peak during late September–early October. The summer peak in sighting rates in 2013 was the highest summer peak recorded since surveys began in 2008.
- Concentrations of walruses were observed in the Burger study area in 2013 and in previous years. This area also coincides with a high density and biomass of benthic infauna and a high biomass of bivalves, indicating the presence of a preferred foraging area.

CHAPTER 1

GENERAL SURVEY INFORMATION

INTRODUCTION

Marine mammal research in the Chukchi Sea has a history spanning over at least 30 years. In 1975, an extensive research program was developed under the Outer Continental Shelf Environmental Assessment Program (OCSEAP)[1] to establish a baseline of environmental data for the Alaska Outer Continental Shelf (OCS), including the Chukchi and Beaufort seas. The objective of OCSEAP was to collect sufficient data to predict potential impacts of oil and gas exploration and development activities and to identify mitigation measures to minimize those impacts. Various agencies were involved in conducting studies of whales, ice seals, and walruses to obtain information on their distribution, feeding ecology, and behavior (e.g., Burns and Eley 1978; Lowry et al. 1978, 1980a, 1980b; Burns et al. 1981; Lowry and Burns 1981; Burns and Seaman 1988; Gilbert 1989a, 1989b; Gilbert et al. 1992). Since 1979, aerial surveys have been conducted in the Alaskan Arctic to document the distribution and relative abundance of bowhead, gray, right, fin, and beluga whales, as well as other marine mammals, in areas of potential oil and natural gas exploration, development, and production activities (e.g., Ljungblad et al. 1984, 1986, 1987; Clarke et al. 1989). The Bowhead Whale Aerial Survey Project (BWASP), which conducts aerial surveys of marine mammals in the western Beaufort Sea, has been flown annually since 1979 and comprises over 30 years of data (Clarke and Ferguson 2010a). Aerial surveys in the northeastern Chukchi Sea were flown from 1989 to 1991 (Moore and Clarke 1993) and were re-initiated in 2008 under the Chukchi Offshore Monitoring in Drilling Area (COMIDA) program after a 17-year lapse (Clarke and Ferguson 2010b). The Aerial Surveys of Arctic Marine Mammals (ASAMM) project is a continuation of the BWASP and COMIDA aerial surveys and has been flown every year since 2011.

The increased focus on research in the Chukchi Sea is due mainly to a renewed interest in offshore oil and gas activities combined with potential threats to the arctic marine ecosystem from climate change. Marine mammal monitoring and acoustic programs were implemented as part of industrial activities in the Chukchi Sea from 1989 to 1991 and annually since 2006, primarily as mitigation but also to document potential impacts from anthropogenic activities (e.g., Brueggeman et al. 1990, 1991, 1992a, 1992b, 2009a; Funk et al. 2008, 2010; Ireland et al. 2009; Blees et al. 2010). Satellite-tagged bowhead and beluga whales have provided useful information on whale movements and migration patterns (Suydam et al. 2001, 2005; Quakenbush et al. 2010). Similarly, detailed information on seasonal movements, habitat use, and the foraging behavior of bearded seals, ringed seals, and walruses has been obtained through the use of satellite tags, radio transmitters, and dive recorders (Lowry et al. 1998; Jay and Hills 2005; Jay et al. 2006, 2010, 2012; Udevitz et al. 2009; Cameron et al. 2010; Speckman et al. 2010; Boveng et al. 2012; Herreman et al. 2012). Hunters from various villages bordering the Chukchi Sea have been an integral part of these tagging efforts, contributing greatly to their success. In addition, the detection of marine mammal vocalizations by bottom-mounted acoustic recorders has revealed interesting information on spatial and temporal patterns of migration (e.g., Moore et al. 2006; Martin et al. 2009; Berchok et al. 2010; Delarue et al. 2011b).

[1] OCSEAP was initiated by an inter-agency agreement between the Department of the Interior's Minerals Management Service (MMS) (now, Bureau of Ocean Energy Management [BOEM]) and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).

Although the Chukchi Sea research effort has been extensive, most studies were designed and implemented as stand-alone programs, making it difficult to integrate research findings. Exceptions include the Bowhead Whale Feeding Ecology Study (BOWFEST) conducted from 2007 to 2011 (e.g., Berchok et al. 2010; Goetz et al. 2010; Shelden and Mocklin 2012) and the multi-year Chukchi Acoustic, Oceanographic, and Zooplankton (CHAOZ) study that was initiated in 2010 (NOAA 2011a). The main goal of both studies was to determine how physical oceanography and prey densities influence the distribution and relative abundance of whales.

To address the need for an integrative research program in the Chukchi Sea, ConocoPhillips initiated and managed the Chukchi Sea Environmental Studies Program (CSESP) in 2008 and 2009, with co-funding and participation from Shell. In 2010, Statoil joined this initiative, and Olgoonik-Fairweather assumed overall management of the project on behalf of the three sponsors. The CSESP was designed to be a multiyear, interdisciplinary, research program that was ecosystem based, integrating survey components from physical and chemical oceanography, plankton, benthos, fish, seabird, marine mammal, and acoustic studies. The main purpose of this integrated approach was to increase the understanding of how the continental shelf in the northeastern Chukchi Sea functions ecologically. CSESP data collected during 2008–2010 have shown that the integrated approach is more powerful in understanding changes to the marine ecosystem than considering the study components separately (Day et al. 2013).

The CSESP study area focused on the three sponsors' respective offshore lease areas in all years from 2008 to 2013. Additionally, in 2011 and 2012, the study area was expanded to include Hanna Shoal and areas outside of the leased prospects, to provide a broader assessment of results. The 2013 survey season completes the sixth year of information collected on marine mammal distribution and abundance in the northeastern Chukchi Sea. This report summarizes and compares marine mammal data collected in 2013 with results from previous years (2008–2012).

Purpose and Objectives

The purpose of the CSESP marine mammal study is to expand current knowledge regarding the abundance and distribution of marine mammals in the Chukchi Sea during the open-water season (July–October) in the lease areas of ConocoPhillips, Shell, and Statoil. This information, combined with results from physical and chemical oceanography, plankton, benthos, fish, and acoustic studies, contributes to a baseline of data for determining potential changes in the distribution and abundance of marine mammals resulting from natural environmental and anthropogenic influences. The marine mammal information collected as part of CSESP will also be used to develop monitoring plans for future offshore oil and gas exploration and development.

Three objectives have been identified for the CSESP marine mammal study, as listed below. Objectives 1 and 2 are discussed in this report. Objective 3 requires more detailed analyses and will be addressed in separate publications.

1. Summarize general survey and marine mammal sighting information;
2. Determine interannual and (when possible) seasonal variations in the distribution and abundance of marine mammals within the study area; and
3. Integrate marine mammal results with other components of CSESP to increase our understanding of ecological relationships.

Structure of this Report

This report follows the structure of the 2011 and 2012 reports, presenting marine mammal information in separate chapters. Each chapter summarizes the results of either a group of species (e.g., whales and ice seals) or of one species (e.g., walrus), focusing on the first two objectives described above. The chapters in this report, and a brief description of their contents, are as follows:

CHAPTER 1 (current chapter) introduces the overall program and describes the study area, survey design, data collection protocol, and analytical approach. In addition, this chapter summarizes general survey results from 2013, including total sampling effort, environmental conditions, and the total number of marine mammal sightings. The limited sighting information on polar bears did not warrant a separate chapter; consequently, those data are summarized in the results section of this chapter. The analytical approach and general survey results are relevant to the marine mammal sighting information presented in Chapters 2–4 but are not repeated in those chapters.

CHAPTER 2 summarizes the 2013 CSESP results of cetacean abundance and distribution and compares them with previous CSESP surveys. We specifically focus on the interannual and seasonal abundance of bowhead and gray whales and their spatial distribution within the three prospect-specific study areas.

CHAPTER 3 summarizes the 2013 CSESP results of seal abundance and distribution and also compares them with previous years. We specifically focus on the annual and seasonal abundance of ringed, spotted, and bearded seals and their spatial distribution within the three prospect-specific study areas.

CHAPTER 4 summarizes the 2013 CSESP results of walrus abundance and distribution and compares them with previous years. We specifically focus on the interannual and seasonal abundance of walruses and their spatial distribution within the three prospect-specific study areas.

STUDY AREAS

The CSESP study area is located in the northeastern Chukchi Sea. The study area has evolved over the past six years. In 2008, two study areas were chosen based on offshore prospects of interest to ConocoPhillips and Shell; these locations are referred to as Klondike and Burger. In 2010, an additional prospect-specific site was added based on the lease interests of the new project partner, Statoil; this location is referred to as Statoil. Each of the three prospect-specific study areas is approximately 3,000 km^2. In 2011 and 2012, the CSESP study area was expanded to encompass the three prospect-specific study areas as well as Hanna Shoal. The expanded study area was referred to as Greater Hanna Shoal (GHS) and had an approximate area of 38,000 km^2. In 2013, survey effort again focused on the three prospect-specific study areas of Klondike, Burger, and Statoil (Fig. 1.1). While most survey effort was conducted in the Chukchi Sea, data were also recorded in the Bering and Beaufort seas during transits, crew changes, and mooring operations. In 2013, we also participated in the Distributed Biological Observatory (DBO) program that is sponsored by NOAA. The DBO uses a network of national and international platforms to sample locations in the Bering and Chukchi seas that have high productivity, biodiversity, and rates of biological change (NOAA 2011b).

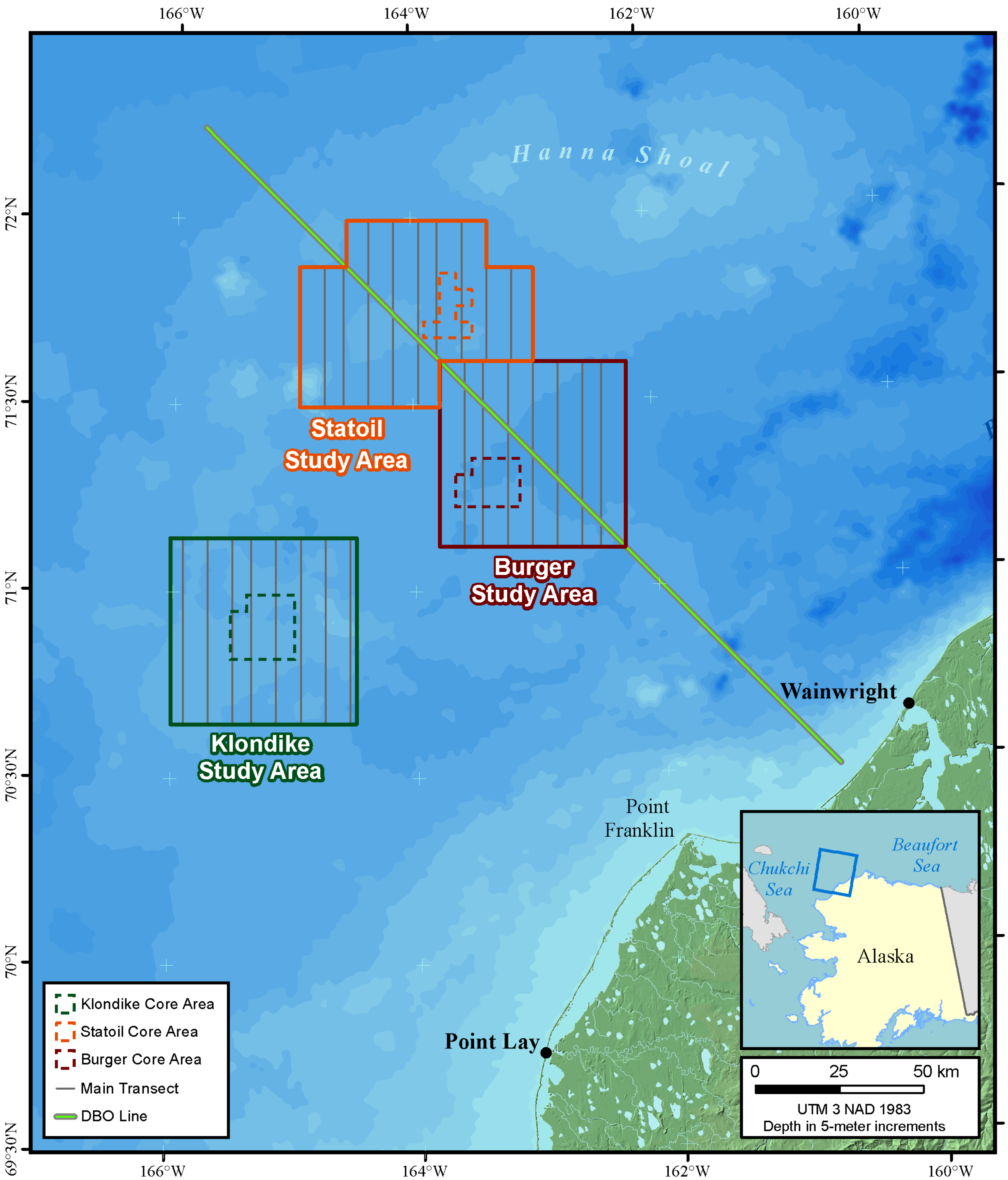


Figure 1.1. CSESP study area in the northeastern Chukchi Sea in 2013, including the three prospect-specific survey areas and transect lines. The core areas represent locations within the survey area that are of primary interest to the sponsoring companies.

The Chukchi Sea is bordered to the west by the East Siberian Sea, to the south by the Bering Sea, to the east by the mainland of Alaska and the Beaufort Sea, and to the north by the Arctic Ocean. The Chukchi Sea has an approximate area of 595,000 km^2, with water depths <50 m in 56% of the total area (http://en.wikipedia.org/wiki/Chukchi_Sea). The geomorphology of the Chukchi Sea shelf and the flow of summer water masses influence the local temperature and salinity ranges of surface and bottom waters. Oceanographic data recorded from 2008 to 2010 indicated that water masses in Klondike and Statoil were generally warmer and less saline than in Burger (Weingartner and Danielson 2010). During 2008–2010, water temperatures ranged from –1.7 to 8°C in the three prospect-specific study areas. Generally, water temperature was highest in Klondike, due to the influence of warm Bering Sea Water entering the Chukchi Sea through the Central Channel (Fig. 1.2). Temperature and salinity differences among the three study areas varied annually and were dependent on factors such as sea ice cover and prevailing wind speed and direction. These relationships were apparent in August 2011, when early ice retreat, combined with a greater heat flux through the Bering Strait, resulted in warmer water temperatures in the upper 15 m of water than in previous years (Weingartner et al. 2012). In contrast, in 2012, ice retreat and melting proceeded more slowly than in previous years, resulting in a strong salinity and temperature stratification that persisted well into the fall (Weingartner et al. 2013). The varying physical characteristics of the northeastern Chukchi Sea were also reflected by interannual differences in planktonic, benthic, and seabird communities (Gall et al. 2012; Questel et al. 2012; Blanchard et al. 2013a, 2013b).

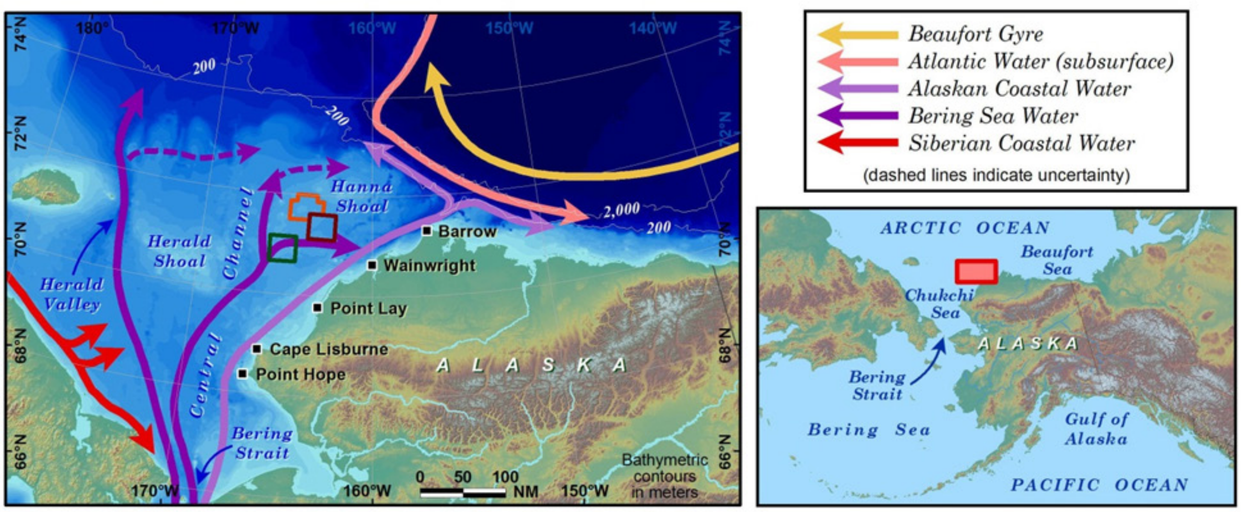


Figure 1.2. Main geographic features and prevailing currents in the Chukchi Sea. The orange, dark red, and green polygons represent the three prospect-specific study areas, as shown in Figure 1.1. Currents modified from Weingartner et al. (2008).

METHODS

The survey design, data collection protocol, and analytical approach used in 2013 were similar to those used in previous years (2008-2012). In 2013, the R/V *Westward Wind* was used to conduct marine mammal line-transect surveys; both the R/V *Westward Wind* and R/V *Norseman II* were used to conduct opportunistic surveys during transits and mooring operations (Fig. 1.3).

Survey Design

We recorded data along north–south oriented transect lines, spaced ~3.7 km apart, in each of the three prospect-specific study areas (Fig. 1.1). We also collected data on an opportunistic basis during mooring operations, sampling for other scientific disciplines, and transits between the Chukchi Sea and the Bering and Beaufort seas. Detailed information on 2013 survey dates is provided in Table 1.1.

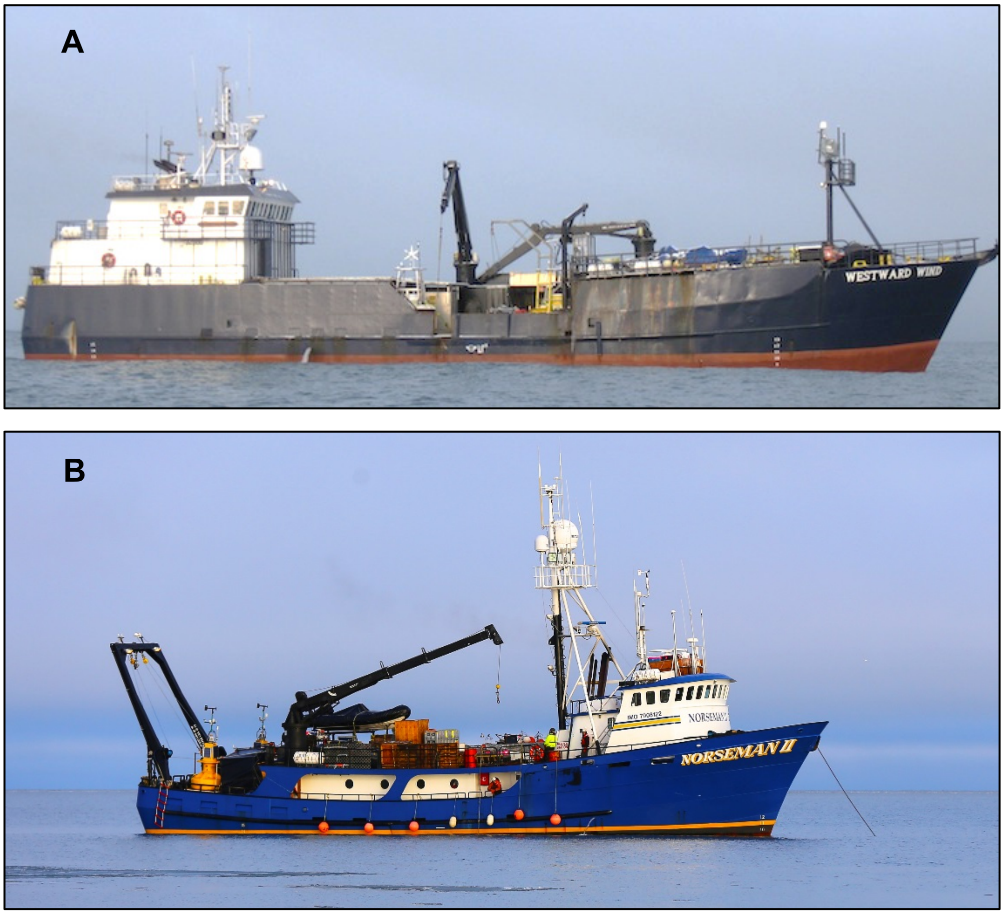


Figure 1.3. In 2013, the R/V *Westward Wind* (A) was used to conduct line-transect and opportunistic surveys. The R/V *Norseman II* (B) was used only for opportunistic surveys. Photo credit: CSESP/Olgoonik-Fairweather

Data Collection

One dedicated observer conducted visual surveys for marine mammals during daylight hours from either the bridge or flying bridge of the vessel. Surveys were conducted at an estimated eye height of ~5.2 m (*Norseman II*) or ~6.5 m (*Westward Wind*) above sea level. The observer systematically scanned a 180° area, centered on the vessel's trackline, with the naked eye and Fujinon 7x50 reticle binoculars while the vessel traveled at speeds ranging from 5–9 knots (9.3–17 km h^{-1}). Observers alternated watch every 2 hours during daylight. Line-transects were surveyed for ~10–14 hours per day depending on weather conditions, day length, and sampling for other scientific disciplines. An Iñupiat marine mammal observer, who was located on the bridge, assisted in the monitoring effort and reported sighting information to the dedicated observer. Leupold BX-3 Mojave 12x50 mm binoculars were available for observers to verify species identification or behavior when needed. A Canon SLR camera with a 120–400 mm zoom lens was available to take photographs of marine mammals, and photographs occasionally were used to assist in species identification.

Data were defined as "on-transect" when the vessel was within 600 m of a designated transect line and traveling at a speed of at least 5 knots. If the vessel deviated beyond this distance or traveled below the target speed, data were defined as "off-transect." Observers resumed "on-transect" effort once the vessel returned to transect course and speed. Data were defined as "non-transect" when effort was less than 1 km in length on a survey line or when observers were not on dedicated watch (e.g., when the vessel was stationary, when the vessel circled at one location during mooring operations, or when data were entered to record an opportunistic sighting). The assignment of on-, off-, or non-transect for each survey line was determined during post-season data quality control (see **Data Analysis** in Chapter 1).

The dedicated observer entered environmental and sighting information directly onto a Panasonic Toughbook™ computer that was equipped with TigerObserver™ data acquisition software specifically developed for this science program. Navigational software (TigerNav™) continuously logged vessel information, such as date, time, vessel position, vessel speed, and water depth. Both TigerNav™ and TigerObserver™ were synchronized to a server system on the vessel. Similarly, Acoustic Doppler Current Profiler (ADCP), thermosalinograph, and meteorological equipment recorded and stored data on the computer server. Those data included air and sea surface temperatures, salinity, wind speed and heading, and atmospheric pressure. The relevant navigational and oceanographic data were automatically linked to the marine mammal sighting data.

Environmental Data

Environmental conditions affect the probability of detecting marine mammals and were recorded during all visual surveys. Observers recorded environmental data at the beginning of each transect line, whenever there was an obvious change in one or more of the environmental variables, and whenever observers changed shifts. Recorded environmental data included sea state (in Beaufort wind force scale according to NOAA), visibility (in 1 km increments, with a maximum visibility of 10 km; <3.5 km or >3.5 km were also used to indicate variable visibility conditions), ice cover (in 10% increments, estimating a 360° area within a 2-km radius from the vessel), distance from pack ice (in km, when pack ice was visible), and sun glare (position and severity).

Sighting Data

When a marine mammal was sighted, the observer recorded a specific set of details. Those data included the species, group size, number of juveniles (determined based on size or presence of mother), position and heading relative to the vessel, behavior, movement, pace (the relative swimming or walking speed), habitat, distance of the animal from the vessel when first sighted, sighting cue[2], identification reliability, and initials of the observer who sighted the animal. The vessel did not approach animals to collect these data.

Ringed and spotted seals can be difficult to differentiate, especially when they have a short surface duration or are detected at a far distance. Consequently, the category "ringed/spotted seal" was used to record seal sightings that could not be confirmed as either a ringed seal or a spotted seal.

[2] A sighting cue is a stimulus that alerts the observer to the sighting.

We used reticle binoculars (when the horizon was visible) or made visual estimates to determine distances between the vessel and marine mammals. A rangefinder and clinometer also were available for distance estimation, although they generally were not used. Without a solid, contrasting target, rangefinders cannot acquire a reliable reading. Clinometers can be used to determine distances of animals close to the vessel, although doing so often proved challenging due to the combination of low observation height and a moving vessel. Visual estimates, therefore, were preferred for animals seen near (~500 m or less) the vessel. The rangefinder, clinometer, and ship's radar were occasionally used to calibrate eye-estimated distances when a suitable target (e.g., sea ice or another vessel) was present.

Data Analysis

This section describes the analytical approach used for the marine mammal survey data collected in 2013, starting with a summary of the data structure. Environmental and marine mammal sighting data recorded during the survey were divided into three categories based on the type of effort that was conducted. Depending on the objective, different subsets of data were analyzed. The three categories are as follows:

- On-transect: data recorded when the vessel traveled within 600 m of a designated transect line within the prospect-specific study areas (Fig. 1.1).
- Off-transect: data recorded when the vessel deviated more than 600 m from a designated transect line or when the vessel traveled along lines other than designated transect lines (e.g., transect connectors, transits to mooring locations, or transits between the Chukchi Sea and Bering or Beaufort seas).
- Non-transect: data recorded when effort was less than 1 km in length on a survey line or opportunistically when observers were not on dedicated watch, including when the vessel was stationary (e.g., in safe harbor due to storms, or on anchor ~1 mi off the coast of Wainwright), at mooring locations, or when data were entered to record an opportunistic sighting.

General Survey and Marine Mammal Sighting Information

We used on- and off-transect data to summarize general survey information such as effort and environmental conditions. All marine mammals sighted in the Chukchi Sea during all effort types (i.e., on-, off-, and non-transect) are reported in Table 1.3. Further analyses of sightings use subsets of data. For example, data were excluded from analyses when sea states exceeded Beaufort wind force scale 5, or when wave height was greater than 2 m, because the probability of detecting marine mammals in high seas was too low. In these cases, transect lines were resurveyed during better conditions when possible. Data parameters are described in the sections below and in table and figure captions.

The **Results** section in this chapter presents the overall effort, environmental conditions, and sightings from the 2013 survey and compares them with data collected in previous years (2008-2012). It also presents the results of polar bear and carcass sightings. Detailed results from the cetacean, ice seal, and walrus observation data are included in Chapters 2, 3, and 4, respectively.

Annual Variation in Marine Mammal Density and Distribution

This section summarizes the analytical approach used to determine the annual variation in the distribution and abundance of cetaceans, ice seals, and walruses. The results of these analyses are presented in Chapters 2–4.

Sighting rates

To account for variation in the amount of effort conducted during CSESP surveys, we calculated sighting rates for all marine mammals that were observed. Sighting rates are effort-corrected values that allow for comparisons among years and study areas. When the number of sightings for a particular species was low, we calculated sighting rates as the number of individuals per 100 km of transect line surveyed. When the number of sightings was higher, we calculated sighting rates as the number of individuals per 1 km of transect line surveyed. To determine the influence of environmental conditions on the sighting rate, we used the number of sightings per 100 km or 1 km of transect line surveyed.

We calculated annual sighting rates for polar bears, annual and seasonal sighting rates for bowhead and gray whales, and weekly sighting rates for walruses. We also calculated sighting rates by sea state and visibility category for cetaceans, seals, and walruses. In addition, we calculated sighting rates in 5x5 nmi grid cells for bowhead and gray whales; ringed, spotted, and bearded seals; and walruses (see ***Species distribution*** below).

Species densities

We analyzed distribution and abundance patterns for bowhead whales, ice seals, and walruses by estimating corrected densities (ind km^{-2}) for each study area and year using distance-sampling methodology (Buckland et al. 2001, 2004). This methodology builds on the fundamental concept that the probability of detecting an animal decreases with increasing distance from the transect line. One of the assumptions of distance sampling is that all animals available at perpendicular-distance zero from the observer (i.e., on the centerline of the transect) are detected [g(0)=1]. However, marine mammal sighting data from vessel-based line-transect surveys commonly violate this assumption due to availability and perception biases. As a result, density calculations can be underestimated by these types of detection biases as described below (Marsh and Sinclair 1989):

1. Availability bias: represents undercounting animals because they were not available for detection (i.e., they were not at the sea's surface and, therefore, could not be seen). The availability bias is dependent on the amount of time an area of water is observed during a survey (determined by the area visible from the observer's location on the vessel and the vessel's speed) and on the behavior of the animal (e.g., surface duration, dive cycle, activity).
2. Perception bias: represents undercounting animals that were available for detection but not observed. The perception bias is dependent on factors such as poor visibility, high sea states, glare, observer fatigue, and the distance of the animal from the observer.

Information on surface duration times for bowhead whales, ice seals, and walruses during the open-water (ice-free) season in the Chukchi Sea does not exist. Thus, availability bias could not be taken into account in this study. Likewise, no information was collected to confirm that all animals on the transect line were detected. Therefore, the assumption of g(0)=1 is presumably violated, indicating that our density calculations probably represent underestimates of true abundance.

We used software program Distance 6.1 Release 1 (Thomas et al. 2010a) to model a detection function for bowhead whales, ice seals, and walruses. The detection function allows for correction of density data due to perception bias. It estimates the proportion of animals missed at different perpendicular distances from the transect line, after taking into account environmental variables. As in previous years, only a subset of data was used based on the following criteria:

- Only on-transect data were used. These are the observations made while traveling along the north–south designated transect lines, because observations made along these lines meet the assumptions of line-transect theory.
- Only sightings with similar sighting cues, and thus equal probability of detection, were used, which resulted in:
  - Exclusion of animals on ice, because the detection probability of sighting marine mammals on ice is different from the detection probability of sighting marine mammals in the water. The number of sightings both on-transect and on ice was too low (e.g., $n = 11$ for seals and $n = 46$ for walruses) to calculate a separate detection function for on-ice sightings.
  - Combining (i.e., pooling) species of similar size, behavior, and color for datasets with low sample sizes. This method resulted in grouping all ringed and spotted seal sighting data (including sightings categorized as ringed/spotted seals).

To model each detection function, we used the Multiple Covariate Distance Sampling (MCDS) analysis tool to find the model that best fit the distribution of perpendicular distances. We assessed the fit of two different model types (hazard-rate and half-normal) with diagnostic plots, the Kolmogorov goodness-of-fit test, and the Akaike's Information Criterion (AIC; following Buckland et al. 2004), introducing covariates into the model that, besides distance, have the potential to affect the probability of detecting marine mammals (i.e., sea state, visibility, glare amount, observer, and vessel). The input parameters of the final model were entered into the distance-sampling model portion of the Mark–Recapture Distance Sampling (MRDS) engine that allowed us to apply the estimated detection function to a subset of data. We used the estimated f(0) from the MRDS detection function and the density equation for line transects from Buckland et al. (2001) to calculate corrected density estimates, and 95% confidence intervals (CI), for each species. We calculated annual and seasonal densities, with July and August representing summer and September and October representing fall.

With the exception of bowhead whale sightings, the number of other cetacean sightings on-transect was too low ($n < 60$) to model a detection function with confidence. However, the number of bowhead whale sightings on-transect from 2008–2013 was large enough ($n = 101$) to determine a reliable detection function. The best-fit model for the detection function of bowhead whales was the hazard-rate model with visibility as a covariate. The best results were obtained with no truncation of distance or binning of data, and visibility data grouped into three categories (poor = ≤1 km; fair = 2–7 km; good = 8–10 km). We calculated annual densities (pooling study areas and seasons) and seasonal densities (pooling study areas and years).

To model detection functions for ringed, spotted, and bearded seals, we used on-transect sightings of animals observed in the water. We also pooled all ringed and spotted seals into one category to increase our sample size and avoid underestimating their densities. The numbers of sightings for both ringed/spotted and bearded seals from 2008–2013 were high enough ($n = 719$ ringed/spotted seals, $n = 483$ bearded seals) to determine reliable detection functions. We used the best-fit models from 2012 and applied those to the 2008–2013 dataset. The best-fit model for the detection function of ringed/spotted seals was the hazard-rate model with sea state category (low = 0–2; high = 3–5), vessel, and observer as covariates and a truncation distance of 500 m. The best-fit model for bearded seals was the hazard-rate model with sea state and vessel as covariates and a truncation distance of 500 m. We calculated annual densities by study area (pooling seasons) and season (pooling study areas).

Because it was difficult to identify individual ringed and spotted seals to species, we pooled all ringed and spotted seal sightings into one category to estimate densities. To determine the proportion of ringed and spotted seals in this combined density, we calculated the density of confirmed ringed and spotted seal sightings using data from all six years (2008–2013) combined. We then calculated the ratio between identified ringed and spotted seal densities and applied that ratio to the combined ringed/spotted seal densities. We justify this approach by assuming that the difficultly in identifying ringed and spotted seals to species is similar. This assumption seems reasonable, considering the similarity in appearance and behavior of these species in offshore waters.

Estimated densities of ringed/spotted and bearded seals do not take into account the large number of seals that were not identifiable during the survey. These animals are recorded as unidentified seals but likely include ringed, spotted, and bearded seals. Consequently, densities calculated for ringed/spotted and bearded seals represent underestimates. To address this underestimation, we also estimated densities of unidentified seals (n = 501) by using the best-fit model from 2012 and applying it to data from 2008–2013. The best-fit model was the hazard-rate model with sea state as a covariate and a truncation distance of 500 m.

To model a detection function for walruses, we used on-transect sightings of animals observed in the water. The number of walrus sightings on-transect from 2008–2013 was high enough (n = 550) to obtain a reliable detection function. We used the best-fit model from 2012 and applied it to the 2008–2013 dataset. The best-fit model was the hazard-rate model with sea state category (low = 0–2; high = 3–5) and visibility as covariates and a truncation distance of 1.5 km. We calculated annual densities by study area (pooling seasons) and season (pooling study areas).

<u>Species distribution</u>

To visualize spatial distribution patterns of marine mammals sighted in 2013, we plotted sighting rates (ind km^{-1}) in 5×5 nmi grid cells within the three prospect-specific study areas. Plots were created for bowhead whales, ringed/spotted seals, bearded seals, and walruses. We calculated sighting rates for each 5×5 nmi grid cell by using on- and off-transect data collected when sea states were ≤5. A similar map was developed for 2008 to 2012 data combined to compare the distribution pattern observed in 2013 with the pattern observed in previous years.

Ecological Relationships

The third objective of the CSESP study, described under **Purpose and Objectives**, is to integrate results of the marine mammal survey with other components of CSESP to increase our understanding of ecological relationships. The collective CSESP reports and publications, and specifically the publication "The offshore northeastern Chukchi Sea, Alaska: a complex high-latitude ecosystem" (Day et al. 2013), address this relationship qualitatively. A quantitative approach, requiring a larger effort and multivariate analyses, has not yet been initiated.

In 2012, we conducted a preliminary quantitative analysis on the relationship between gray whale distribution and prey availability; results from that analysis are described in the 2012 Annual Report (Aerts et al. 2013a). We intend to integrate visual and acoustic marine mammal data with oceanographic and lower trophic data in a collaborative effort between CSESP study components and other non-CSESP science programs.

RESULTS

In 2013, we conducted dedicated marine mammal line-transect surveys in the three prospect-specific study areas from the *Westward Wind* during two separate cruises. The first cruise occurred August 8–24, and the second occurred September 18 – October 10 (Table 1.1). Besides collecting data during line-transect surveys, observers were aboard the *Westward Wind* and *Norseman II* during buoy deployment and retrieval cruises (mooring cruises) in the Chukchi Sea to record marine mammal observations while the vessel was transiting to and from buoy locations.

Table 1.1. Start and end dates of 2013 CSESP cruises from the research vessels R/V *Westward Wind* and R/V *Norseman II*.

R/V Westward Wind		R/V Norseman II	
Dates	**Description**	**Dates**	**Description**
Jul 27	Transit to Chukchi Sea	Jul 29	Transit to Chukchi Sea
Jul 28 – Aug 6	Chukchi Sea Mooring	Jul 30 – Aug 3	Chukchi Sea Mooring
Aug 7	Crew Change - Wainwright	Aug 4	Crew Change – Prudhoe Bay
Aug 8 – Aug 24	Science Cruise 1	Aug 5 – Aug 11	Beaufort Sea Mooring
Aug 26	Crew Change - Wainwright	Aug 12	Crew Change – Prudhoe Bay
Sep 18 – Oct 10	Science Cruise 2	Sep 28 – Oct 6	Beaufort Sea Mooring
Oct 10	Crew Change - Wainwright	Oct 7	Transit to Chukchi Sea
Oct 12 – Oct 18	Chukchi Sea Mooring	Oct 8 – Oct 13	Chukchi Sea Mooring
Oct 20	Transit to Nome	Oct 14 – Oct 15	Transit to Nome
Oct 23	Crew Change - Nome	Oct 16	Crew Change - Nome

Survey Effort

During the 2013 study, we conducted 6,934 km of on- and off-transect observation effort in the Chukchi and Bering seas when sea states were ≤5 (Fig. 1.4, Table 1.2). Most of this effort (6,676 km; 96%) occurred in the northeastern Chukchi Sea. On- and off-transect effort in the three prospect-specific study areas accounted for approximately half (3,555 km; 51%) of the total observation effort. Observation effort in the Bering Sea, which was conducted during transits to and from Nome, accounted for only 4% (258 km) of the total observation effort. Due to the presence of sea ice in the Statoil and Burger study areas in August, some locations were not accessible by the vessel; consequently, marine mammal observations were conducted along transects between the three study areas (the “transition area”). The presence of dedicated observers on board both vessels during mooring cruises in 2013 (as in 2012) increased the amount of off-transect effort compared to off-transect effort conducted from 2008-2011 (Fig. 1.4). The vessel tracks along which marine mammal survey effort occurred and the cumulative effort of these vessel tracks calculated for 5x5 nmi grid cells are shown in Figure 1.5.

Table 1.2. Summary of on- and off-transect effort (km of survey line sampled) in each study area during CSESP surveys from 2008 to 2013. The category "Other" includes effort in the Bering Sea during transits to and from Nome. Data include effort when sea states were ≤5.

	KLONDIKE		BURGER		STATOIL		OTHER		
YEAR	On	Off	On	Off	On	Off	On	Off	TOTAL
2008	3,653	650	2,500	707	-	-	255	465	8,231
2009	2,755	124	2,686	233	-	-	107	1,161	7,066
2010	1,749	207	2,714	182	1,660	174	826	425	7,937
2011	933	89	1,031	99	933	28	1,962	2,027	7,103
2012	798	135	1,144	347	836	320	1,430	4,679	9,690
2013	903	266	1,071	494	622	199	363	3,017	6,934
TOTAL	10,792	1,471	11,146	2,063	4,051	721	4,943	11,774	46,961

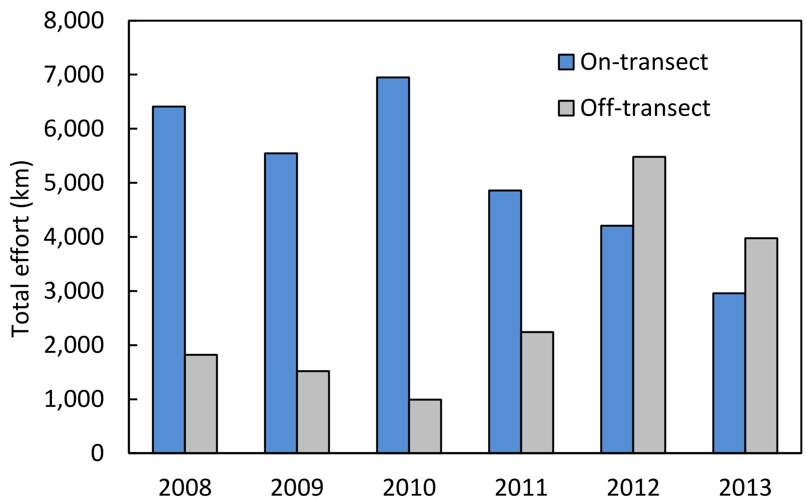


Figure 1.4. On- and off-transect sampling effort (km) in all study areas combined during CSESP surveys from 2008 to 2013. Data include effort in the Bering Sea during transits to and from Nome and effort when sea states were ≤5.

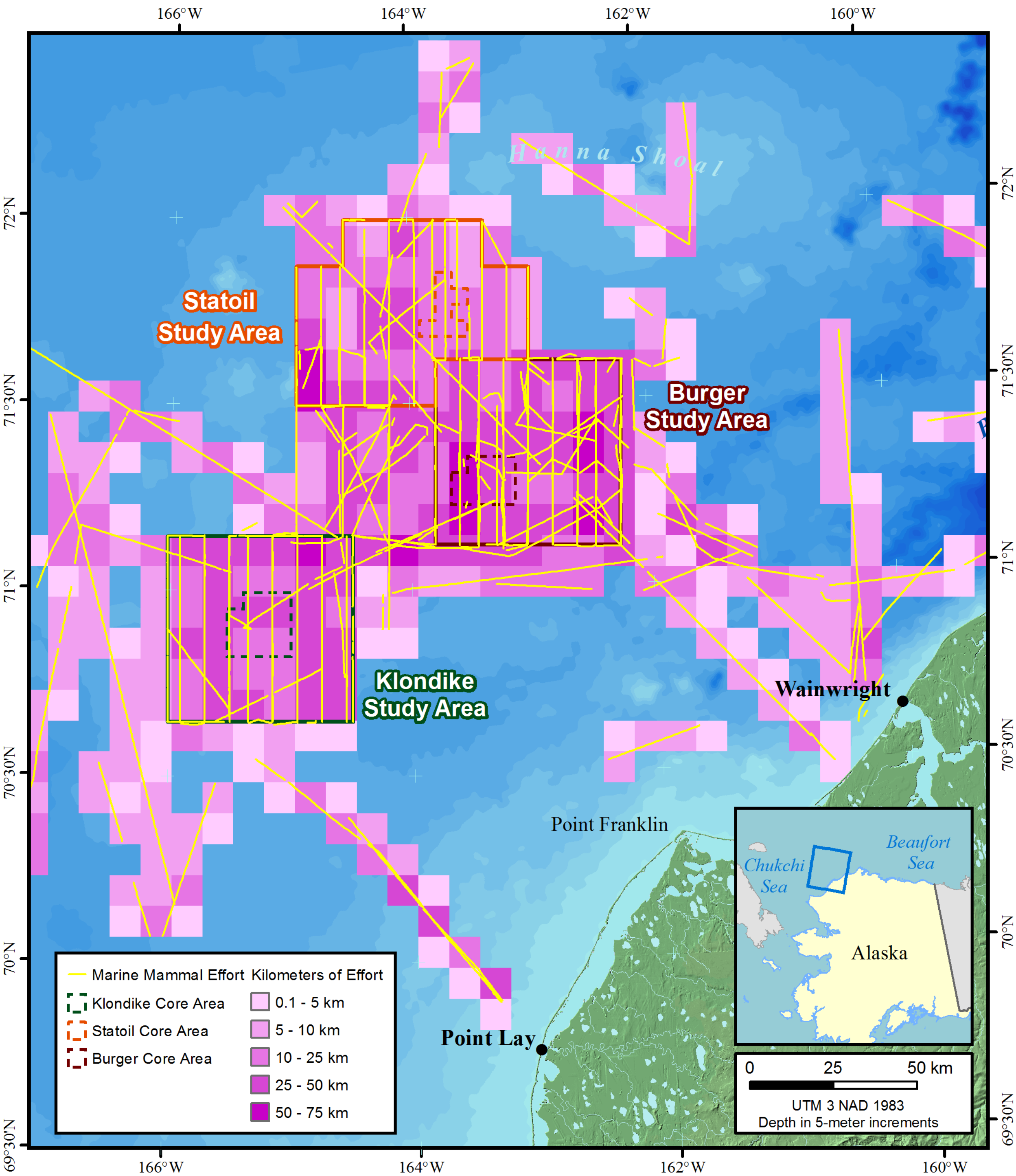


Figure 1.5. On- and off-transect sampling effort (km) in the northeastern Chukchi Sea during 2013 CSESP surveys. Yellow lines represent the actual vessel track at times when observers were sampling during sea states ≤5. Total effort (km) is shown in 5x5 nmi grid cells.

Environmental Conditions

In 2013, most effort occurred during sea states 2 and 3 (Fig. 1.6). Effort increased as visibility increased, with most effort occurring when visibility was ≥8 km (Fig. 1.6). Among the three prospect-specific study areas, there was large variation in the amount of effort conducted in 2013 during each sea state (Fig. 1.7); most effort occurred during sea states 2 and 5 in Klondike, during sea states 1 and 3–4 in Burger, and during sea state 3 in Statoil.

Overall sea state conditions during observations were more favorable in 2013 than in previous years, with more effort occurring during sea states 1 and 2 (Fig. 1.6). The pattern of visibility conditions was similar to that in previous years, with effort increasing as visibility increased (Fig. 1.6). In the three prospect-specific study areas, the large variation in the amount of effort conducted during each sea state in 2013 was similar to that in 2011 and 2012 (Fig. 1.7). In contrast, effort conducted in each study area during each sea state was much less variable in 2008-2010.

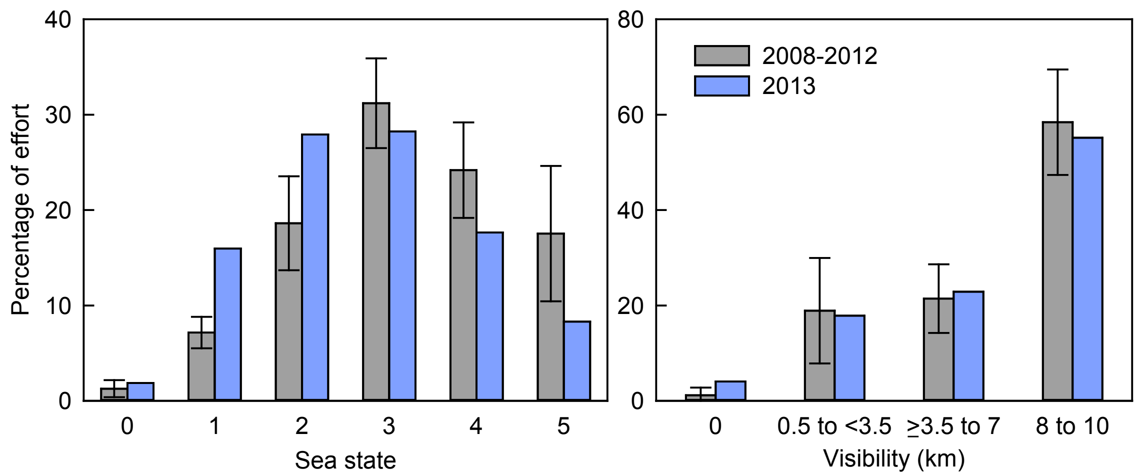
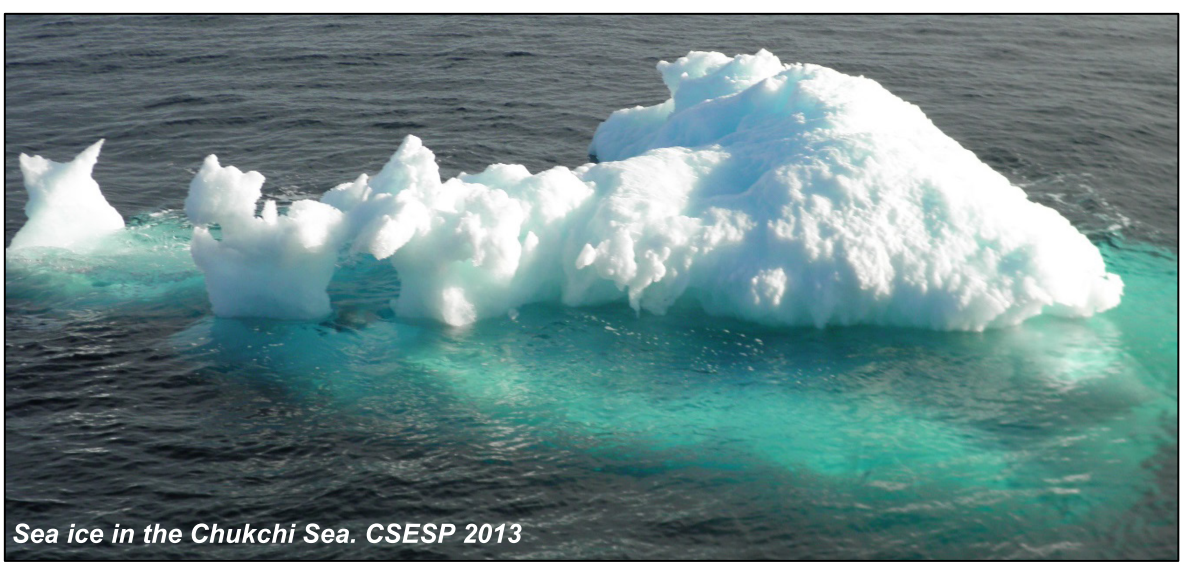


Figure 1.6. Sea state and visibility conditions during CSESP surveys in 2013 compared with 2008-2012. Sea state is expressed in Beaufort wind force scale (NOAA). Maximum visibility from the vessel is 10 km. Data include on- and off-transect effort when sea states were ≤5.



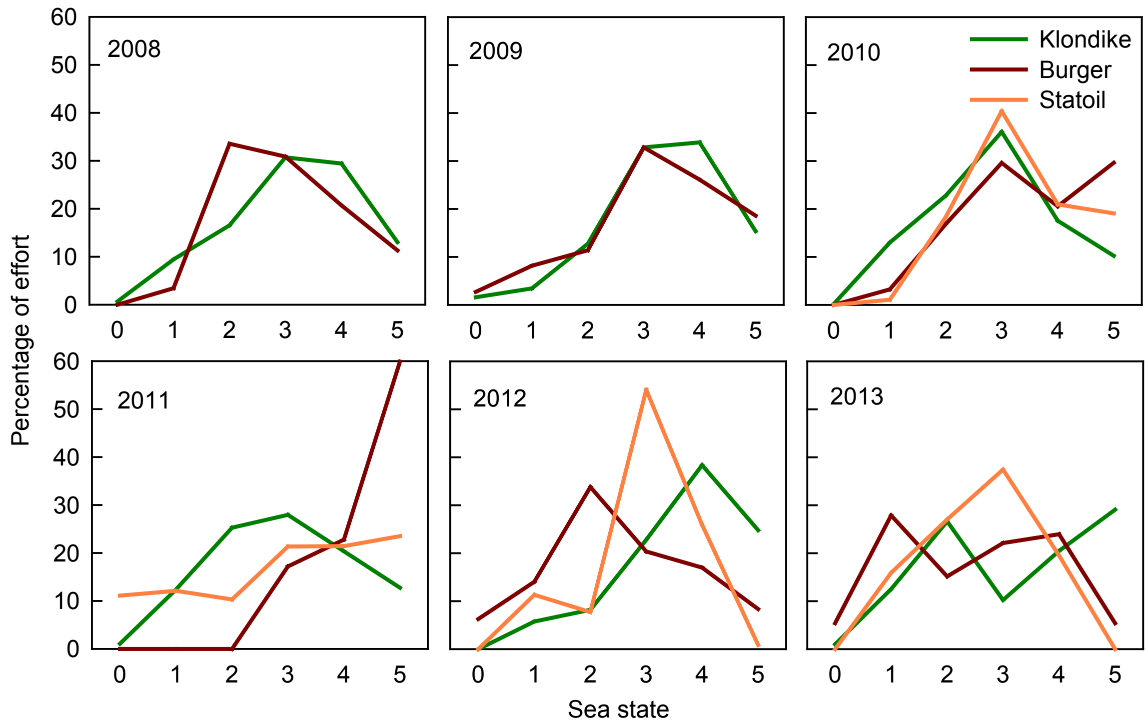


Figure 1.7. Percentage of total sampling effort by sea state and study area during CSESP surveys conducted from 2008 to 2013. Sea state is expressed in Beaufort wind force scale (NOAA). Data include on- and off-transect effort when sea states were ≤5.

During the 2013 survey, sea ice was present within the study areas in July, August, and September. In July 2013, ice retreated rapidly and the Klondike study area was mostly ice-free by July 19. At that time, sea ice cover in Burger was 10–30% in the southern part of the study area and 90–100% in the northern part, and Statoil was covered in 90–100% sea ice. By August 2, all three study areas were largely ice-free, with the exception of some ice cover in the northwestern parts of Burger and Statoil. From August 9–23, however, ice floes drifted back towards the study areas from the northeast and were present throughout Statoil and Burger and the northern side of Klondike. In early September 10–30% ice coverage remained in Statoil and in Burger, but Klondike was ice-free. By late September, sea ice retreated north and was absent from the study areas for the remainder of the survey period (Fig. 1.8).

The presence of sea ice in the northern study areas until mid-September in 2013 was similar to sea ice presence in 2008 and 2012. Ice cover in August prevented marine mammal surveys along sections of transect lines in the Burger study area and along nearly all transect lines in the Statoil study area. Consequently, line-transect surveys were conducted in the transition area between the three study areas while we waited for ice conditions to change (see Fig. 1.5).

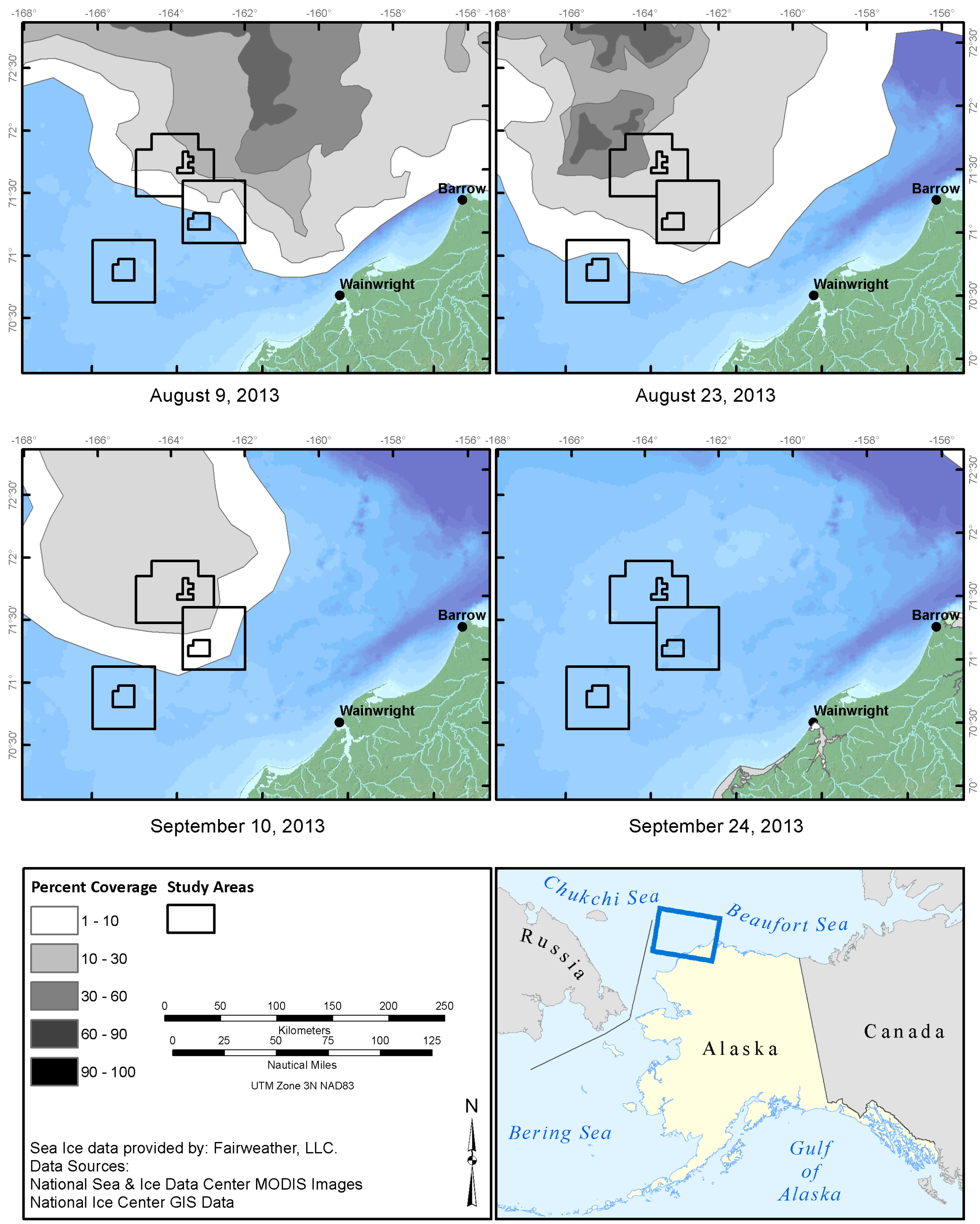


Figure 1.8. Changes in sea ice concentration in the CSESP study area in 2013. Marine mammal transect surveys were conducted from August 8–24 and from September 18 – October 10.

Marine Mammal Sightings

Sighting Summary

In 2013 during all effort modes (i.e., on-, off-, and non-transect), we recorded 975 marine mammal sightings, representing 6,153 animals, in the Chukchi Sea. Marine mammal sightings by effort type are provided in Table 1.3.

Although CSESP survey effort primarily targets the Chukchi Sea, we also recorded marine mammals observed during transits through the Beaufort Sea. In 2013, we recorded a total of 200 marine mammal sightings, representing 242 animals, in the Beaufort Sea. These observations include the following: one polar bear; bowhead whales (29 sightings/53 animals); unidentified whales (2 sightings/2 animals); ringed seals (32 sightings/37 animals); spotted seals (6 sightings/7 animals); ringed/spotted seals (60 sightings/68 animals); bearded seals (22 sightings/22 animals); and unidentified pinnipeds (48 sightings/52 animals). With the exception of the sighting totals described in this paragraph, results from the Beaufort Sea were not included in this report.

Species that were observed in 2013, but not in any other year since CSESP surveys began in 2008, included beluga whales and the single Steller's sea lion. Species that were observed in previous years, but not in 2013, included humpback whales (*Megaptera novaeangliae*), killer whales (*Orcinus orca*), Dall's porpoises (*Phocoenoides dalli*), and ribbon seals (*Histriophoca fasciata*). Further details about cetacean, seal, and walrus data collected in 2013 are provided in Chapters 2–4, respectively.

Table 1.3. Sighting summary of marine mammals observed in the Chukchi Sea by effort type (i.e., on-, off- and non-transect) during the 2013 CSESP survey.

SPECIES	ON-TRANSECT		OFF-TRANSECT		NON-TRANSECT		TOTAL	
	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind
Bowhead whale	17	18	11	17	0	0	28	35
Gray whale	9	15	10	19	0	0	19	34
Fin whale	0	0	2	2	0	0	2	2
Minke whale	0	0	1	1	0	0	1	1
Beluga whale	1	4	0	0	0	0	1	4
Harbor porpoise	4	4	1	1	0	0	5	5
Unid. whale	7	7	6	17	1	1	14	25
Ringed seal	42	43	25	26	1	1	68	70
Spotted seal	16	16	23	24	1	1	40	41
Ringed/spotted seal	110	111	52	53	1	1	163	165
Bearded seal	136	144	72	76	5	9	213	229
Unid. seal	102	105	72	74	0	0	174	179
Unid. pinniped	17	18	10	10	0	0	27	28
Steller's sea lion	0	0	1	1	0	0	1	1
Walrus	112	1,207	96	4,016	3	102	211	5,325
Polar bear	1	1	4	5	1	1	6	7
Unid. marine mammal	0	0	2	2	0	0	2	2
TOTAL	574	1,693	388	4,344	13	116	975	6,153

Polar Bear Sightings

In 2013, we observed a total of 6 polar bear sightings (7 animals) in the Chukchi Sea, including one mother–cub pair. The Burger study area was the only prospect-specific study area with polar bear observations (4 sightings of 5 animals; Fig. 1.9). In addition to the Burger study area, two polar bears were observed outside of the three prospect-specific study areas. One polar bear was seen ~20 km northwest of Wainwright and appeared to be swimming toward the shore. The other polar bear was offshore in the vicinity of Hanna Shoal, approximately 220 km northwest of Wainwright. We observed all polar bears during August, either on ice floes (5 animals, including the mother–cub pair) or in the water (2 animals).

In 2013, the sighting rate of polar bears observed in the Chukchi Sea was similar to the sighting rate recorded in 2008 (Fig. 1.10). Polar bears were primarily concentrated in the Burger study area in all years that they were observed (Fig. 1.9). Like previous years, no polar bears were observed in the Klondike study area in 2013. We acknowledge that sighting rates may be artificially high due to repeat sightings. In 2012, for example, a localized field of broken ice remained in the study area until late September and may have resulted in repeat sightings of the same polar bear(s) on different days. In general, we have seen few polar bears in the Chukchi Sea during the CSESP program. However, the low number of polar bear sightings is not unusual because the study occurs during the open-water (ice-free) season and polar bears are strongly associated with sea ice.

Polar bear on sea ice. CSESP 2013

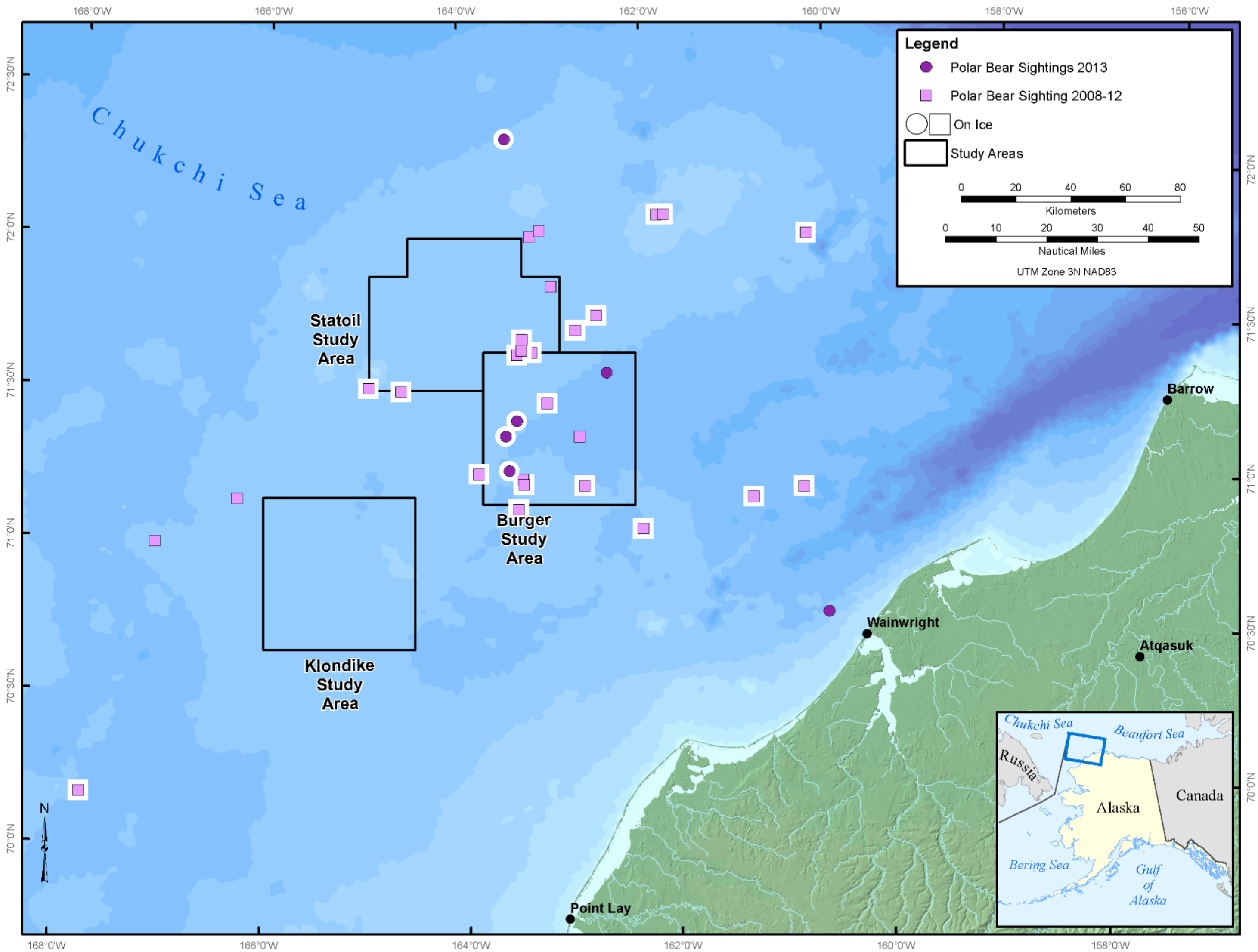


Figure 1.9. All polar bear sightings (i.e., including all effort types and sea states) recorded on sea ice and in the water in the Chukchi Sea during CSESP surveys in 2013 (purple circles) and 2008–2012 (pink squares).

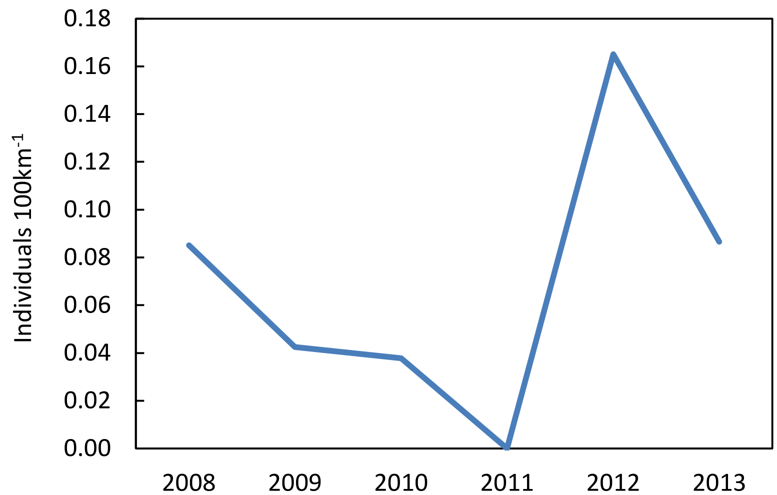


Figure 1.10. Sighting rates (individuals 100 km^{-1}) of polar bears during CSESP surveys from 2008 to 2013. Data include on- and off-transect effort when sea states were ≤5.

Carcass Sightings

Marine mammal carcasses occasionally are encountered during surveys. We collect information on each carcass and take photographs when possible. In 2013, three marine mammal carcasses were encountered, including two unidentified pinnipeds and one bowhead whale. The two unidentified pinniped carcasses were observed in the Burger study area during transect surveys aboard the Westward Wind; one was seen on August 15 and the other on September 27. The bowhead whale carcass was observed on September 11 during opportunistic surveys aboard the Norseman II, and was approximately 225 km northwest of Point Hope. A bowhead whale carcass recorded on the same day by observers from the ASAMM survey (Clarke et al. 2014) was probably the same carcass.

CHAPTER 2

DISTRIBUTION AND ABUNDANCE OF CETACEANS

This chapter summarizes the results of surveys for the presence, relative abundance, and distribution of cetaceans in the Chukchi Sea from CSESP vessel-based marine mammal surveys in 2013 and compares those results with results of previous years' surveys. We focus in more detail on the annual and seasonal variation in sighting rates of bowhead and gray whales, two species with the highest sighting numbers. Maps showing the sighting locations of fin, minke, beluga, and unidentified whales and harbor porpoises are included in Attachment A of this chapter.

RESULTS

Sighting Summary

Six cetacean species were seen during CSESP surveys in 2013. They included the bowhead whale (*Balaena mysticetus*), gray whale (*Eschrichtius robustus*), fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), beluga whale (*Delphinapterus leucas*), and harbor porpoise (*Phocoena phocoena*) (Table 2.1).

Table 2.1. Sighting summary of cetacean species observed in the Chukchi Sea by study area during all effort types (i.e., on-, off-, and non-transect) during the 2013 CSESP survey.

SPECIES	KLONDIKE		BURGER		STATOIL		OTHER		TOTAL	
	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind
Bowhead whale	5	7	7	8	9	10	7	10	28	35
Gray whale	0	0	0	0	1	1	18	33	19	34
Fin whale	0	0	0	0	0	0	2	2	2	2
Minke whale	0	0	0	0	0	0	1	1	1	1
Beluga whale	0	0	0	0	0	0	1	4	1	4
Harbor porpoise	3	3	0	0	0	0	2	2	5	5
Unid. whale	2	4	4	4	4	4	4	13	14	25
TOTAL	10	14	11	12	14	15	35	65	70	106

More detailed information on bowhead and gray whale distribution and abundance in 2013, compared with previous years, is provided in subsequent sections (see **Annual Variation in Distribution and Abundance of Bowhead and Gray Whales**). Sighting information for the other cetacean species is summarized as follows:

- Fin whales: The two fin whales observed in 2013 were located south of the three prospect-specific study areas; one was ~80 km northwest of Cape Lisburne and the other was ~80 km southwest of Point Hope (Figs. A-1, A-2). Few fin whales have been seen during CSESP surveys,

- and they have not been seen annually (we recorded fin whales only in 2009, 2012, and 2013). With the exception of the one fin whale sighted northwest of Cape Lisburne in 2013, all fin whales have been sighted south of Point Hope.
- Minke whales: The single minke whale recorded in the Chukchi Sea in 2013 was seen on August 1, ~50 km north-northeast of Wainwright (Fig. A-1). Few minke whales have been seen in any year during CSESP surveys. Although the overall number of minke whales sighted in any year has been low (range = 1–5), we have seen minke whales in the Chukchi Sea in every year except 2010.
- Beluga whales: The group of four beluga whales observed in 2013 was seen on October 3, ~160 km northwest of Wainwright (Fig. A-1). These beluga whales were the first live beluga whales observed during CSESP surveys. Prior to this sighting, observers sighted one beluga whale carcass in August 2012.
- Harbor porpoises: Five harbor porpoises were observed in 2013, three ~140 km northwest of Point Lay, one ~30 km southwest of Wainwright, and one in the southern Chukchi Sea ~85 km north of the Bering Strait (Figs. A-1, A-2). Few harbor porpoises have been seen during CSESP surveys, with a total of 27 animals recorded in six years. Although the number of harbor porpoises observed has been low, we have consistently seen harbor porpoises every year since surveys began in 2008 (range = 3–13 animals per year).

During the 2013 survey, several categories of primary and secondary behaviors were assigned to each sighting. The most common primary behaviors of cetaceans were swimming and exhaling (90%). The most common secondary behaviors were diving and swimming (59%). Feeding was recorded for 9 cetaceans (9%).

Effects of Environmental Conditions on Detectability

Cetacean sighting rates (sight 100 km^{-1}) for each sea state and visibility category are shown in Figure 2.1. In 2013, most cetaceans were sighted during sea state 4; lower sea states did not result in higher sighting rates (Fig. 2.1A). The sighting rate decreased at sea state 5, both in 2013 and previous years (Fig. 2.1C).

In 2013, most cetaceans were sighted when visibility ranged from 3.5 to 7 km (Fig. 2.1B). At visibilities <3.5 km, the sighting rate was much lower than at higher visibilities. In previous years, the sighting rate also showed an increasing trend with increasing visibilities (Fig. 2.1D). The high sighting rate at visibilities <500 m (visibility category 0) is due to the limited amount of effort conducted during that visibility (270 km total over five years); there was only one sighting at visibility category 0 in 2008–2012.

Most whales (~60%) were observed at a distance of 1 km or more from the vessel. The most common sighting cues were the whale's blow and body. All porpoise sightings were seen at distances <1 km from the vessel, with the exception of two sightings (one at 1.2 km and one at 1.5 km). The most common sighting cues for porpoises were the body and dorsal fin.

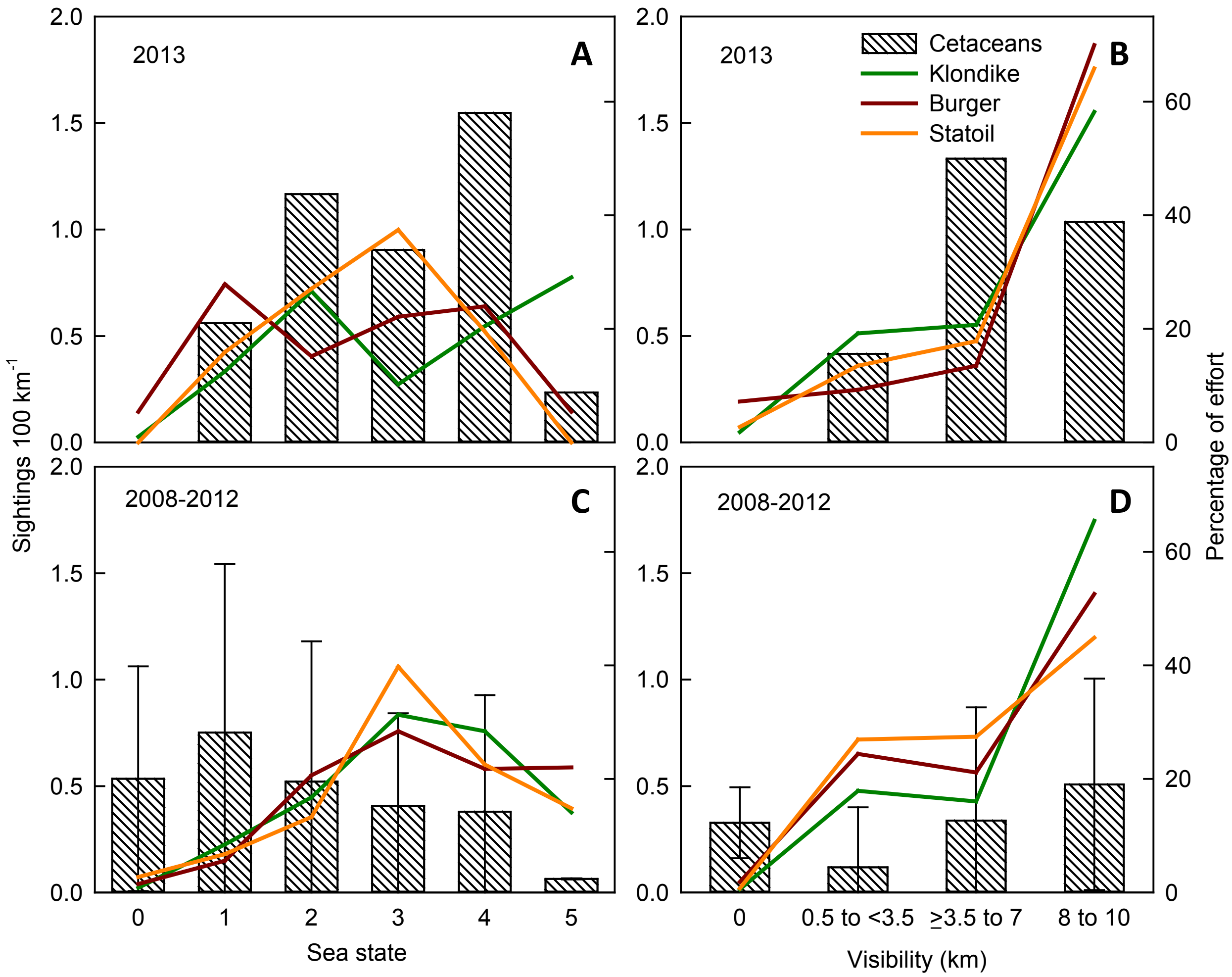


Figure 2.1. Sighting rates (sightings 100 km^{-1}) of cetaceans for each sea state (A, C) and visibility category (B, D) during CSESP surveys in 2013 and in 2008-2012. Sea state is expressed in Beaufort wind force scale; error bars represent standard deviations. Lines show the amount of effort in each prospect-specific study area, expressed as a percentage of total effort. Data include on- and off-transect sightings and effort in the three prospect-specific study areas when sea states were ≤5.

Annual Variation in Distribution and Abundance of Bowhead and Gray Whales

Bowhead Whales

In 2013, the density of bowhead whales was 0.001 ind km^{-2} (Table 2.1). This density was similar to bowhead whale densities recorded in 2010 and 2011, but was approximately four times lower than the bowhead whale density recorded in 2012. The high upper confidence limit of the bowhead whale density in 2008 was likely caused by a low sample size (n = 2) in combination with a clustered occurrence of these sightings. Seasonal densities of bowhead whales were approximately two times higher in fall than in summer (Table 2.1). Density data for bowhead whales are underestimated because not all whales are identifiable to species. In 2013, for example, observers recorded 25 unidentified whales. Most of those sightings (n = 12) occurred in the fall (Figs. A-1, A-2), when most bowhead whales are known to migrate through the Chukchi Sea. Based on the locations and dates, it is very likely that all of the unidentified whale sightings were of bowhead whales.

The highest sighting rate of bowhead whales in the three prospect-specific study areas in 2013 occurred in Statoil (1.22 ind 100 km^{-1}), followed by Klondike (0.60 ind 100 km^{-1}) and Burger (0.51 ind 100 km^{-1}; Fig. 2.2A). Prior to 2013, the highest annual sighting rates of bowhead whales occurred in Burger. Of the three prospect-specific study areas, Burger had the highest bowhead whale sighting rate in all years from 2008 to 2012.

In 2013, the highest monthly sighting rate of bowhead whales occurred in October (1.24 ind 100 km^{-1}), followed by September (0.60 ind 100 km^{-1}) and August (0.08 ind 100 km^{-1}; Fig. 2.2B). This pattern was similar to the pattern seen during previous years, with the exception of 2011, when the highest bowhead whale sighting rate occurred in August. In 2013, we recorded our first bowhead whale sighting on August 16; the earliest bowhead sighting since CSESP surveys began in 2008 occurred on August 6, 2011.

Maps displaying effort-corrected sighting rates (ind km^{-1}) of bowhead whales observed in the northeastern Chukchi Sea are shown in Figure 2.3. In 2013, the majority of bowhead whales were observed in the northern part of the study area at latitudes of 71°N or higher. With the exception of the one bowhead whale sighting in August, all observations were made in the fall beginning on September 23. In previous years, we observed a similar pattern.

Table 2.1. Summary of estimated mean annual and seasonal bowhead whale densities (ind km^{-2}). Summer = July and August, fall = September and October. UCL = upper 95% confidence limit, LCL = lower 95% confidence limit.

Year/Season	MEAN DENSITY	UCL	LCL
2013	**0.001**	**0.003**	**0.001**
2012	0.004	0.006	0.002
2011	0.001	0.002	0.000
2010	0.001	0.003	0.000
2009	0.000	0.001	0.000
2008	0.000	0.281	0.000
Summer	0.001	0.001	0.000
Fall	0.002	0.003	0.001

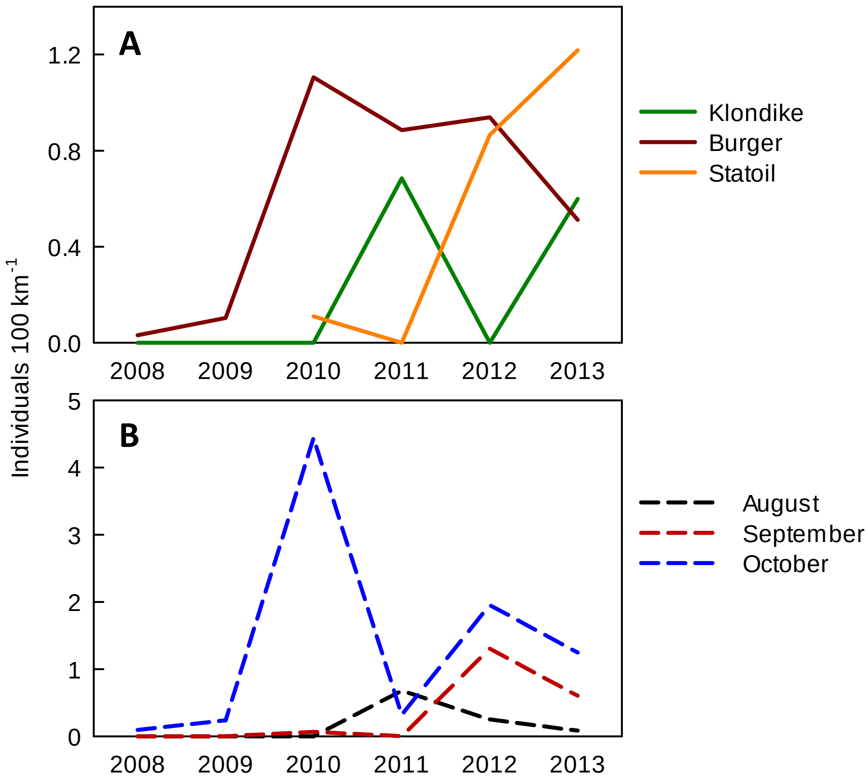


Figure 2.2. Annual variation of bowhead whale sighting rates (individuals 100 km^{-1}) within the three prospect-specific study areas (A) and within months (B) during CSESP surveys from 2008 to 2013. Data include on- and off-transect sightings and effort when sea states were ≤5.

Bowhead whale swimming in the Chukchi Sea. CSESP 2010

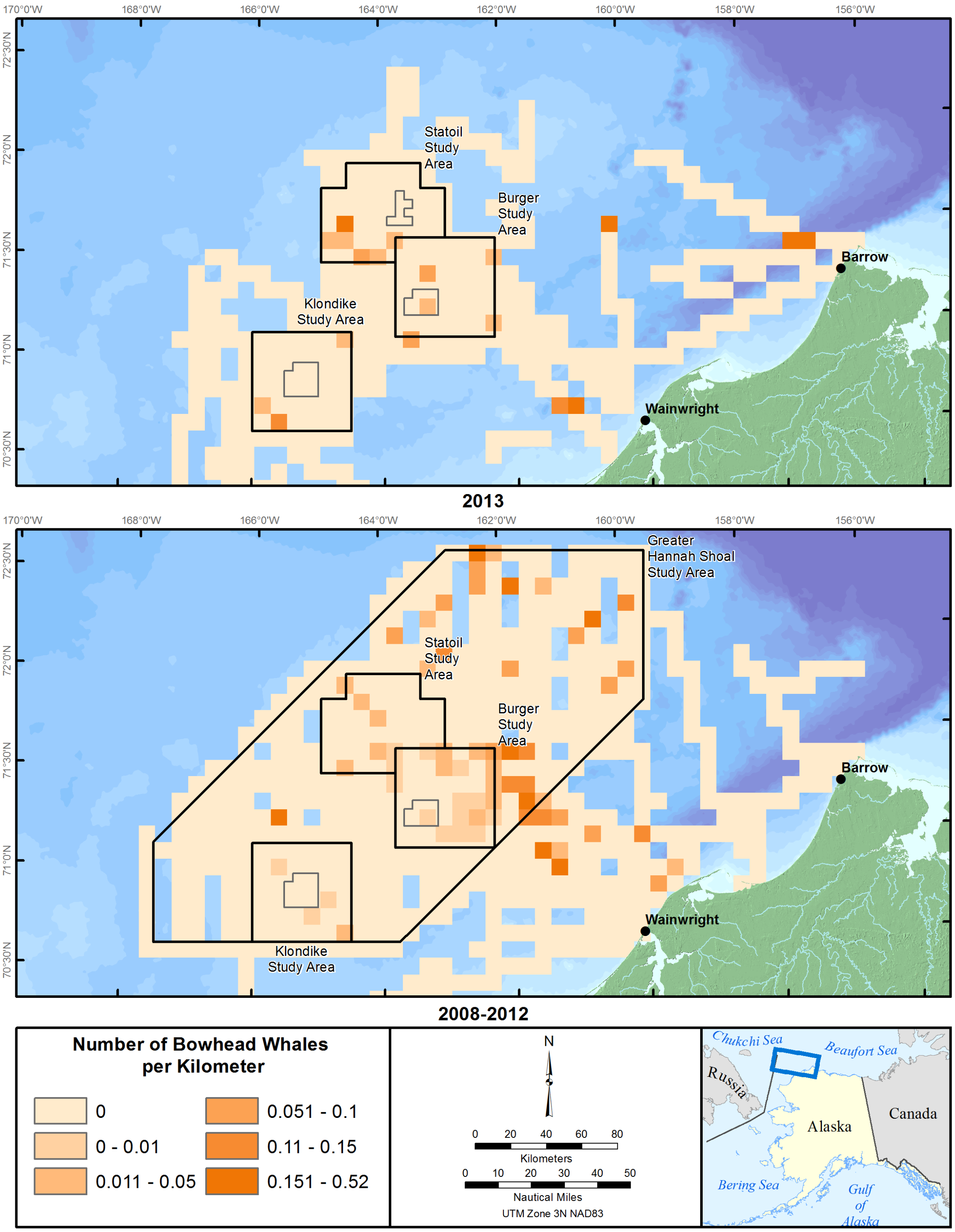


Figure 2.3. Distribution of bowhead whales in the northeastern Chukchi Sea from August to mid-October in 2013 (upper) and 2008–2012 (lower) based on sighting rates (ind km^{-1}) calculated for 5×5 nmi grid cells. Data include on- and off-transect sightings and effort when sea states were ≤5.

Gray Whales

In 2013, gray whale sightings in the three prospect-specific study areas were rare similar to the pattern seen in previous years. One gray whale was observed in the Statoil study area, resulting in a sighting rate of 0.12 ind 100 km^{-1} (Fig. 2.4A). This was the highest sighting rate recorded within any of the three prospect-specific study areas during the past six years. The second highest annual gray whale sighting rate was also recorded in Statoil, in 2012. No gray whales were sighted in Klondike or Burger in 2013. Prior to 2013, the highest annual gray whale sighting rate was 0.07 ind 100 km^{-1} which was recorded in Klondike in 2008 and Burger in 2010 and 2012 (Fig 2.4A). In general, few gray whales have been seen in the Klondike, Burger, and Statoil study areas, and when they have been observed, the number of animals sighted has been low (range = 1–3 animals). The majority (95%) of gray whales sighted were near the coast, within 80 km of land, with the highest concentrations of gray whales recorded between Barrow and due west of Wainwright (Fig. 2.5).

In 2013, the highest monthly sighting rate of gray whales occurred in August (1.17 ind 100 km^{-1}), followed by October (0.26 ind 100 km^{-1}; Fig. 2.4B). No gray whales were recorded in September. The highest sighting rates in four of the six years of CSESP surveys were recorded in August. In the other two years, the highest monthly sighting rates of gray whales occurred in October (2008) and September (2010).

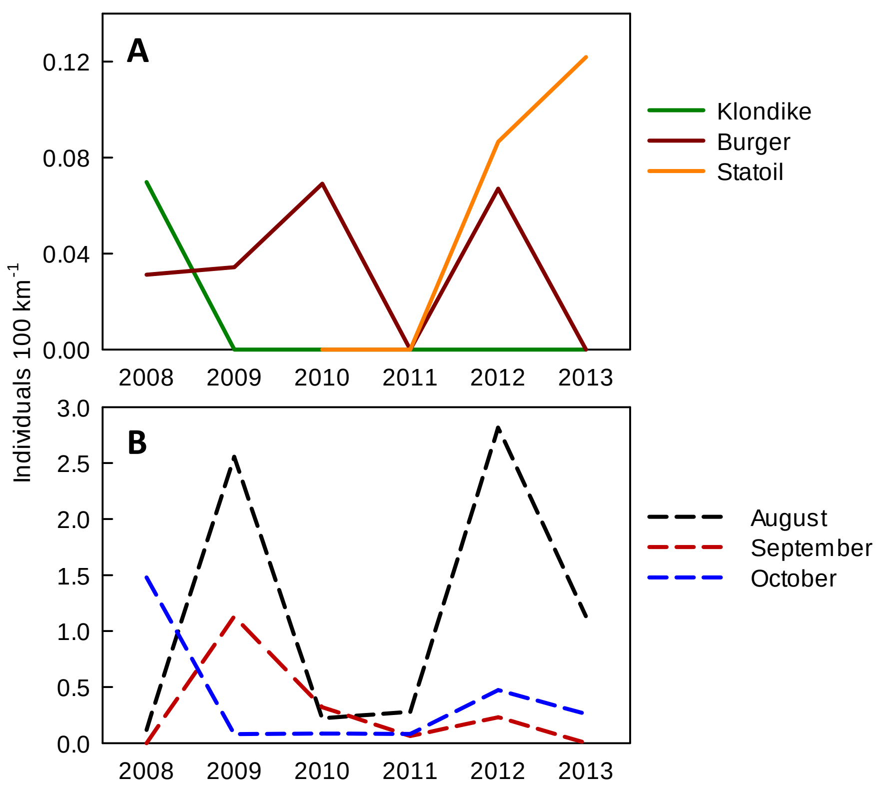


Figure 2.4. Annual variation of gray whale sighting rates (individuals 100 km^{-1}) within the three prospect-specific study areas (A) and within months (B) during CSESP surveys from 2008 to 2013. Data include on- and off-transect sightings and effort when sea states were ≤5.

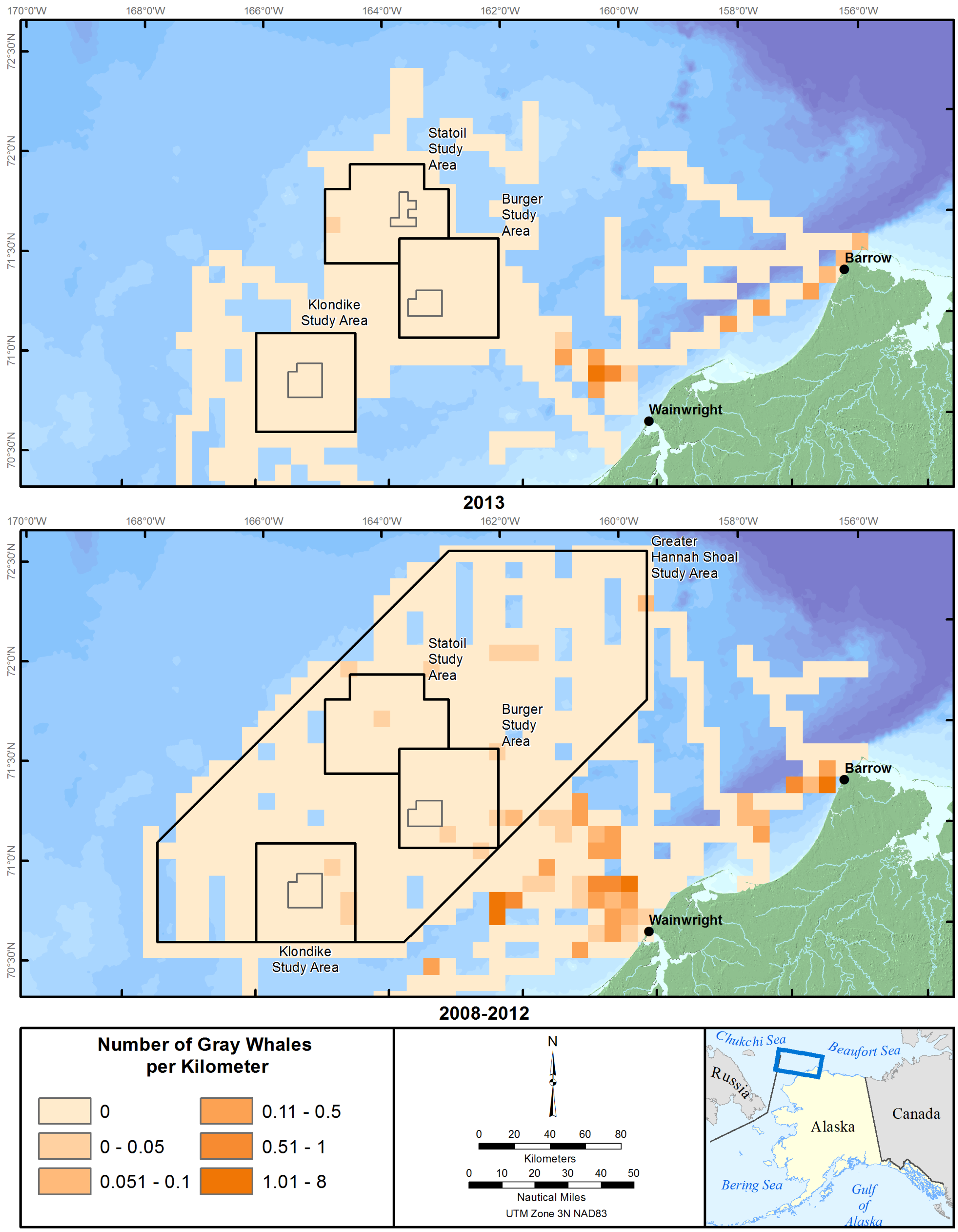


Figure 2.5. Distribution of gray whales in the northeastern Chukchi Sea from August to mid-October in 2013 (upper) and 2008-2012 (lower) based on sighting rates (ind km^{-1}) calculated for 5×5 nmi grid cells. Data include on- and off-transect sightings and effort when sea states were ≤5.

DISCUSSION

During CSESP surveys in 2013, we observed more bowhead whales in the Statoil study area than the Klondike or Burger study areas. Similar observations were made during CSESP surveys in previous years. During the fall migration, bowhead whales are believed to migrate across the northeastern Chukchi Sea farther offshore and at higher latitudes than they do during the spring, when migration occurs mainly through open leads in the ice near the coast. In this study, both during 2013 and in previous years, the highest sighting rates of bowhead whales occurred in the fall, offshore, and at latitudes of 71°N and higher. Few bowhead whales were seen in the southernmost part of the study area (i.e., Klondike). This pattern coincides with an offshore fall migration across the Chukchi Sea. Acoustic and telemetry studies have found similar results, showing more bowhead whale call detections north of 71°N (Delarue et al. 2013b, 2014) and more satellite-tagged bowhead whales traveling north of 71°N during fall (Quakenbush et al. 2010).

In 2013, we saw bowhead whales in the Chukchi Sea every month, with an increasing number of bowhead whales recorded as the year progressed. We expect to see more bowhead whales in the Chukchi Sea in late September and October, which is when they begin their fall migration across the Chukchi Sea. Bowhead whale sightings in the northeastern Chukchi Sea during August and early September are less common but have been recorded by other studies as well (Clarke et al. 2011, 2012, 2013a, 2014). Bowhead whales that occupy the Chukchi Sea in August and early September may reside in the Chukchi Sea during summer or may be early fall migrants from the Beaufort Sea. Due to the migratory nature of bowhead whales, their observed abundance during CSESP is largely dependent on the survey period and timing of the bowhead whale fall migration. It is unclear what factors trigger the timing of fall migration for bowhead whales, although the formation of sea ice presumably is a major factor. The influence of the presence of prey species on the timing and duration of fall migration, and therefore the abundance of bowhead whales in the Chukchi Sea during the fall, is largely unknown. The low sighting rate of bowhead whales in the fall of 2011, observed during both CSESP and ASAMM surveys (Aerts et al. 2012; Clarke et al. 2012), was indicative of a late fall migration. The late fall migration may have been influenced by an extended period of open water, as sea ice formed later than normal during that year. The sighting rate of bowhead whales in the fall of 2012 was the highest of all six years of our study; the ASAMM surveys also recorded large numbers of bowheads in 2012 (Clarke et al. 2013a). The abundance and biomass of copepods (predominantly *Calanus glacialis*) in 2012 was also the highest recorded since 2008 and outnumbered the biomass of all other zooplankton species (Hopcroft et al. 2013). Although not as prominent as in 2012, the copepod abundance and biomass in 2013 again dominated zooplankton communities, especially in September (Hopcroft et al. 2014). The influence of prey biomass in the Chukchi Sea on the timing and duration of the fall migration of bowhead whales currently is speculative, although it would be interesting to investigate this in more detail.

Gray whales observed during the CSESP survey in 2013 occurred primarily near the coast (within 80 km of land), with few sightings seen in offshore waters. Similar observations were made during CSESP surveys in previous years. Gray whales migrate north from Baja California, Mexico, in the spring to spend summers feeding in the Bering and Chukchi seas (Allen and Angliss 2010). Benthic sampling in previous and recent years has revealed a high biomass of amphipods (Feder et al. 1994; Blanchard and Knowlton 2013) that are the preferred prey for gray whales in nearshore areas of the Chukchi Sea, especially offshore of Wainwright. The near-coast distribution of gray whales in this study overlaps with the location of these high amphipod concentrations (Aerts et al. 2013a). The near-coast distribution of gray whales was evident from acoustic data as well, in that their vocalizations detected on bottom-mounted acoustic recorders in 2011, 2012, and 2013 were more common close to shore with few gray whale calls detected offshore (Delarue et al. 2012, 2013b, 2014).

The four beluga whales seen south of the Statoil study area in 2013 were the first live beluga whales sighted during CSESP since surveys began in 2008. The area and timing of the CSESP survey likely limits the probability of encountering beluga whales of either the Beaufort Sea stock or the Eastern Chukchi Sea stock. Beluga whale call detections from acoustic data and visual observations from aerial surveys in the northeastern Chukchi Sea have occurred mainly in spring and early summer, between early April and mid-July (Delarue et al. 2011a, 2013b; Clarke et al. 2012, 2013a). Aerial survey observers recorded substantially lower sighting rates in the fall (Clarke et al. 2014). Data on beluga vocalizations from overwintering acoustic recorders showed that most beluga whales migrate past Barrow into the Chukchi Sea starting mid-October (Delarue et al. 2013b). Satellite-telemetry data confirm that most beluga whales move north in July, mainly residing at high latitudes along the continental shelf-break between Point Barrow and the Canada border (Richard et al. 2001; Suydam et al. 2001, 2005) and return to their wintering grounds in the Bering Sea in late fall.

Few fin whales have been seen during CSESP since surveys began in 2008; they were recorded in three of the six years of surveys (2009, 2012, 2013). All fin whales except one in 2013 were recorded south of 68°N. Fin whales are common in the Bering Sea (Moore et al. 2002) and have been recorded in the southern Chukchi Sea in all years since 2010 (Clarke et al. 2013b). Fin whale sightings in the northeastern Chukchi Sea, however, have occurred less frequently and consist of few animals. During aerial surveys conducted in the northeastern Chukchi Sea in 2008–2013, only two fin whales were recorded north of 69°N (Clarke et al. 2014). Acoustic detections of fin whales were first recorded in the Chukchi Sea in 2007, primarily around 69°N offshore of Cape Lisburne and only a few at 70.4°N offshore off Point Lay (Delarue et al. 2013a). The number of detections decreased between 2007 and 2009 and remained rare thereafter. During the Arctic Whale Ecology Study (ARCWEST) in 2013, fin whale calls were detected in the northeastern Chukchi Sea offshore of Point Hope, south of 69°N (Friday et al. 2013).

During the six years of CSESP surveys, few minke whales have been seen. Although the number of minke whales sighted has been low, ranging from 1 to 5 animals per year, we have seen minke whales in the northeastern Chukchi Sea in all years except 2010, suggesting that they are regular visitors in this region. Aerial survey results from flights conducted in 1982–1991 (Moore and Clarke 1992) and 2008–2010 (Clarke et al. 2011) did not report any minke whales in the northeastern Chukchi Sea. However, in the past three years of aerial surveys (2011–2013), minke whales have been seen in the northeastern Chukchi Sea each year (Clarke et al. 2014). Minke whale vocalizations during the open-water season were recorded for the first time in 2011 and again were detected in 2012 and 2013 in similar numbers (Delarue et al. 2012, 2014), confirming their regular occurrence in this region, especially in recent years.

Harbor porpoises have been seen each year in the northeastern Chukchi Sea, specifically north of Cape Lisburne, since CSESP surveys began in 2008. Although numbers of animals recorded have been low, the harbor porpoise seems to be a regular visitor to the northeastern Chukchi Sea. Suydam and George (1992) reported nine records of harbor porpoises near Point Barrow during the period 1985–1991. During the summers and falls of 2006–2008, marine mammal observers recorded 16–25 harbor porpoises in the Chukchi Sea during seismic surveys (Haley et al. 2010). More recently, harbor porpoises were observed near Cape Lisburne and Ledyard Bay during the vessel-based ARCWEST survey in August and September 2013 (Friday et al. 2013).

CONCLUSIONS

- Bowhead whale density in 2013 was similar to densities recorded in 2010 and 2011 but was approximately four times lower than the density recorded in 2012. The seasonal density of bowhead whales, calculated from all six years of data combined, was two times higher in fall than in summer.
- In 2013, the bowhead whale sighting rate was highest in the Statoil study area. Although the number of bowhead whale sightings was variable from year to year, generally more bowhead whales were observed in Statoil and Burger than in Klondike. The number of bowhead whale sightings is largely dependent on the survey period and the timing of fall migration of these whales.
- In 2013, like previous years, most gray whales were sighted between Barrow and Wainwright, within 80 km from shore. One gray whale was observed farther from shore in the Statoil study area, but none were seen in Klondike or Burger. Few gray whales have been seen in the three prospect-specific study areas since 2008. Most gray whale sightings have occurred in August.
- Four beluga whales were observed in 2013, representing the first live beluga whales sighted during CSESP, since surveys began in 2008. Few beluga whale sightings are expected considering their seasonal distribution pattern relative to the timing and location of our survey.
- Fin whales, minke whales, and harbor porpoises were observed in 2013. Fin whales have been seen in only three years of CSESP surveys (2009, 2012, and 2013). Minke whales have been seen in all years except 2010, and harbor porpoises have been consistently seen each year since surveys began in 2008. Although minke whales and harbor porpoises occurred in low numbers, repeated encounters over the past six years suggest that these species are regular visitors to the Chukchi Sea.

ATTACHMENT A

Other Cetacean Sightings During CSESP Surveys in 2013

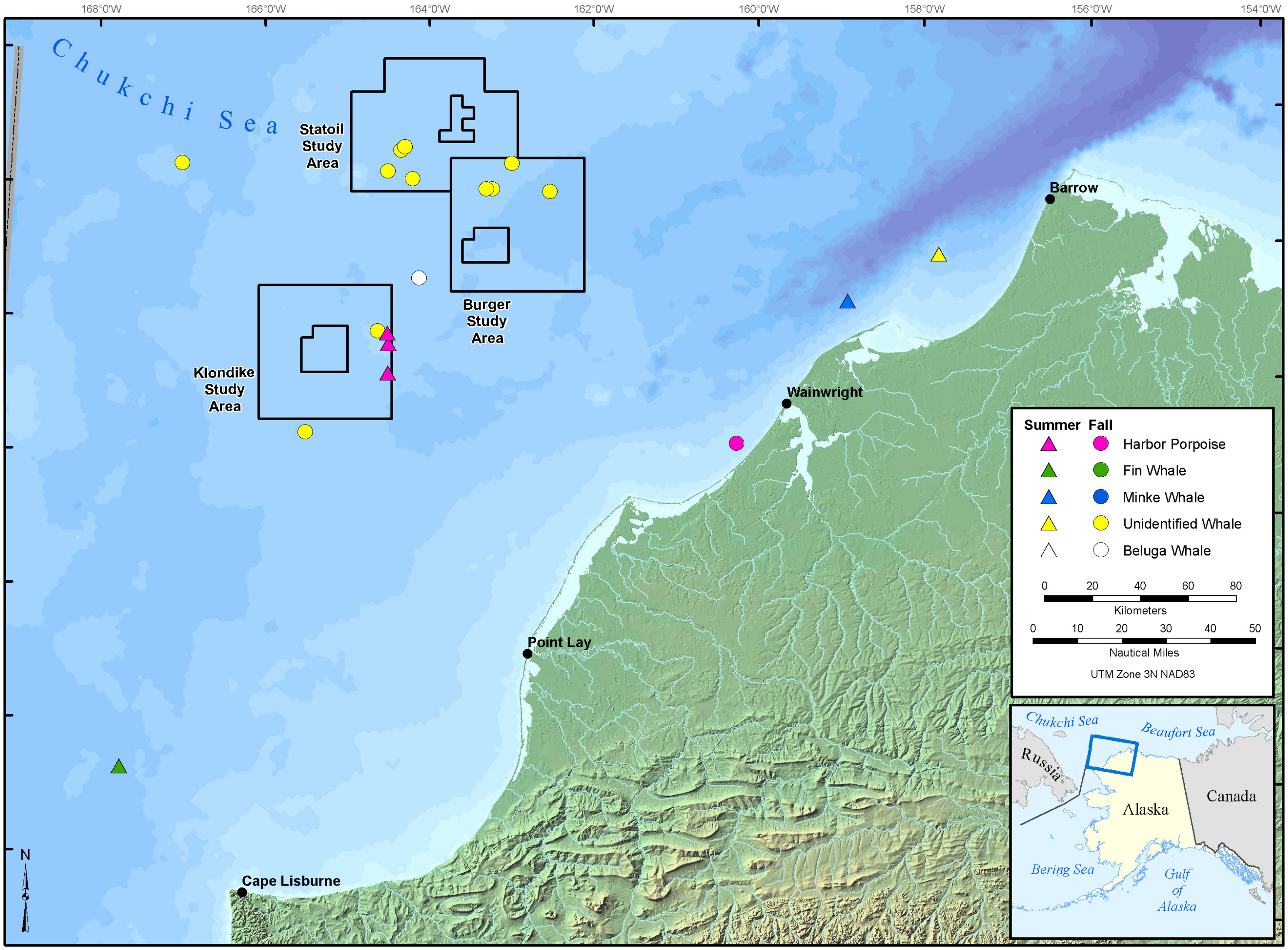


Figure A-1. Cetacean sightings, excluding bowhead and gray whales, recorded in the northeastern Chukchi Sea during CSESP surveys in summer and fall 2013.

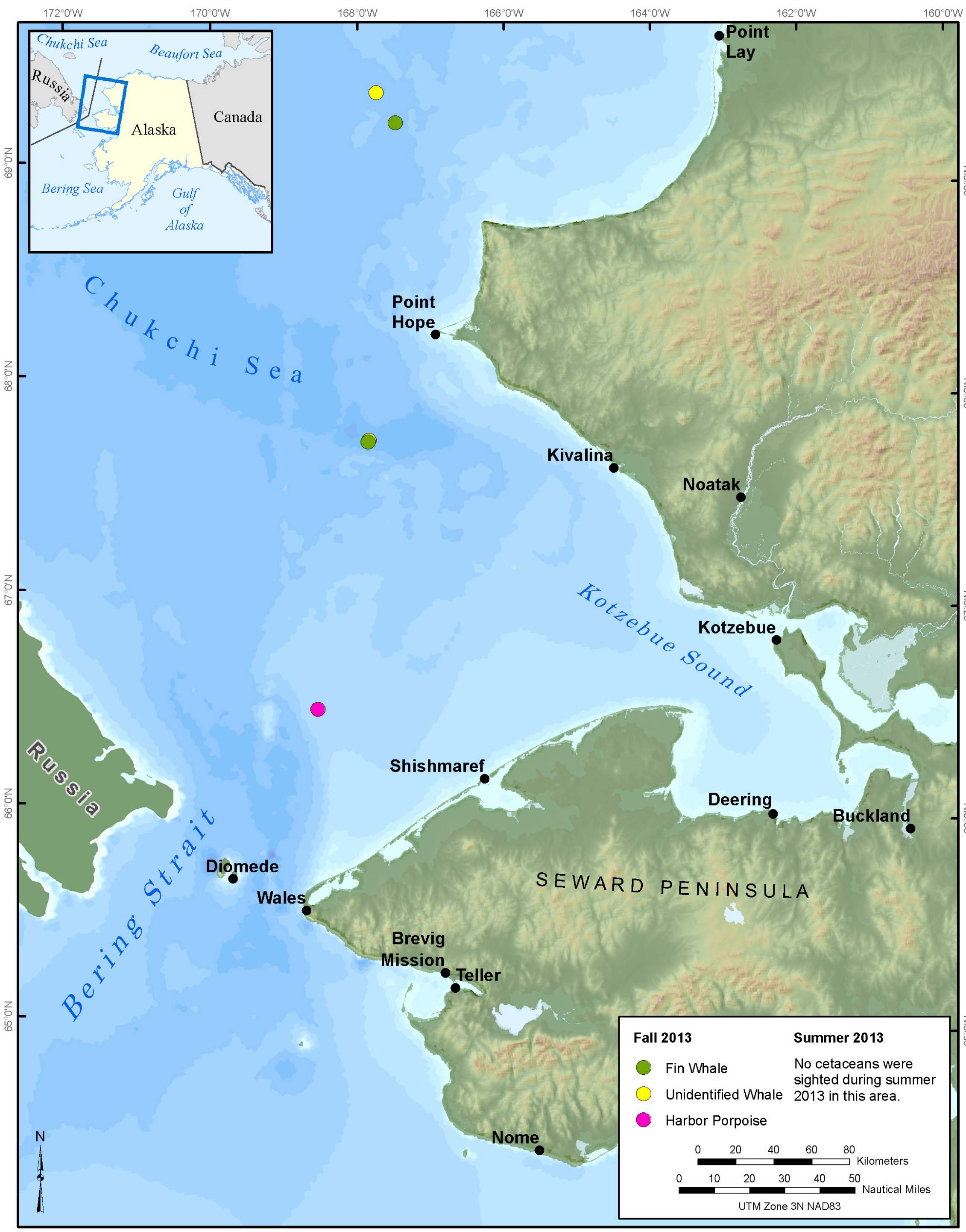


Figure A-2. Cetacean sightings recorded in the southern Chukchi Sea during vessel transits between the CSESP study areas and Nome in 2013.

CHAPTER 3

DISTRIBUTION AND ABUNDANCE OF SEALS

This chapter summarizes the results of surveys for the presence, relative abundance, and distribution of seals in the Chukchi Sea from the CSESP vessel-based marine mammal surveys in 2013 and compares those results with results of previous years' surveys.

RESULTS

Sighting Summary

Three of the four ice seal species that are known to occur in the Chukchi Sea were seen during CSESP surveys in 2013. They included the ringed seal (*Pusa hispida*), spotted seal (*Phoca largha*), and bearded seal (*Erignathus barbatus*) (Table 3.1).

In 2013, we observed 684 seals in 658 sightings. Ringed and spotted seals were the most commonly observed ice seal species (40% of all seal sightings). Bearded seals contributed 33% to the total number of seal sightings. Because bearded seals are easier to identify than ringed/spotted seals, most of the 26% unidentified seal sightings probably are of ringed or spotted seals, suggesting that their relative occurrence is underestimated. In all previous years with the exception of 2010, ringed and spotted seal sightings were more abundant than bearded seal sightings.

We did not see any ribbon seals (*Histriophoca fasciata*) in 2013. Of the six years of CSESP surveys, ribbon seals were recorded only in 2008 (6 animals: 4 in Klondike and 2 in Burger) and 2011 (2 animals: 1 in Klondike and 1 in Statoil).

During the 2013 surveys, we recorded 21 seals hauled out on sea ice, of which 2 were ringed seals, 2 were ringed/spotted seals, 16 were bearded seals, and 1 was an unidentified seal. Several categories of primary and secondary behaviors were assigned to each sighting. The most common primary behaviors of seals were swimming, looking, and resting (83%). The most common secondary behavior was diving (38%), followed by unknown, sinking, and no change in behavior (42%).

Table 3.1. Sighting summary of seal species observed in the Chukchi Sea by study area during all effort types (i.e., on-, off-, and non-transect) during the 2013 CSESP survey.

SPECIES	KLONDIKE		BURGER		STATOIL		OTHER		TOTAL	
	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind
Ringed seal	15	15	27	28	7	7	19	20	68	70
Spotted seal	10	10	4	4	4	4	22	23	40	41
Ringed/spotted seal	44	44	37	37	31	32	51	52	163	165
Bearded seal	35	35	59	68	25	25	94	101	213	229
Unidentified seal	39	39	36	37	28	28	71	75	174	179
TOTAL	143	143	163	174	95	96	257	271	658	684

In 2013, the distances relative to the vessel at which we sighted seals ranged from 10 to 3,144 m, with most sightings occurring between 251 and 500 m (Fig. 3.1). Like previous years, we recorded most seals when they were at distances between 101 and 500 m from the vessel, with fewer sightings both close to the vessel (≤100 m) and at distances farther away (≥501 m). The distances from the vessel at which ringed/spotted seals were sighted were similar to the sighting distances of bearded seals.

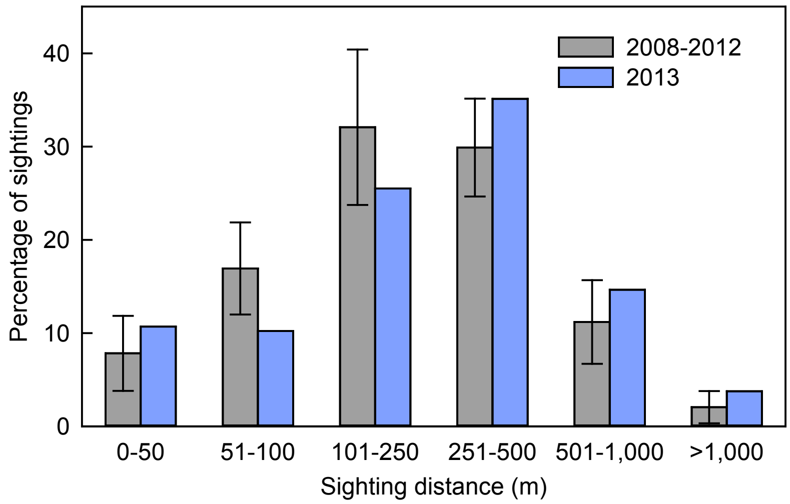


Figure 3.1. Radial sighting distance (in m) at which seals were sighted from the vessel, shown as a percentage of total number of sightings for 2013 and 2008-2012. Data include on- and off-transect sightings when sea states were ≤5; seals on ice were excluded. Error bars represent standard deviations.

Young ringed seal on ice in Burger. CSESP 2013

Effects of Environmental Conditions on Detectability

Seal sighting rates (sight km^{-1}) for each sea state and visibility category are shown in Figure 3.2. In 2013, sighting rates were highest during sea state 0, followed by sea state 1 (Fig. 3.2A). Sighting rates decreased for sea state 2 and higher. This pattern of decreasing sighting rates with increasing sea states is consistent with data from 2008–2012.

In 2013, seal sighting rates were highest for visibilities ≤500 m (category 0), followed by visibilities <3.5 km (Fig. 3.2B). In contrast to 2013, sighting rates in 2008–2012 were highest during visibilities between 3.5 and 7 km (Fig. 3.2D). Based on 2013 and previous years' data, no apparent relationship was observed between seal sightings and visibility category. Because most (82%) seals were sighted at distances ≤500 m from the vessel, the absence of a relationship between seal sighting rate and visibility is to be expected.

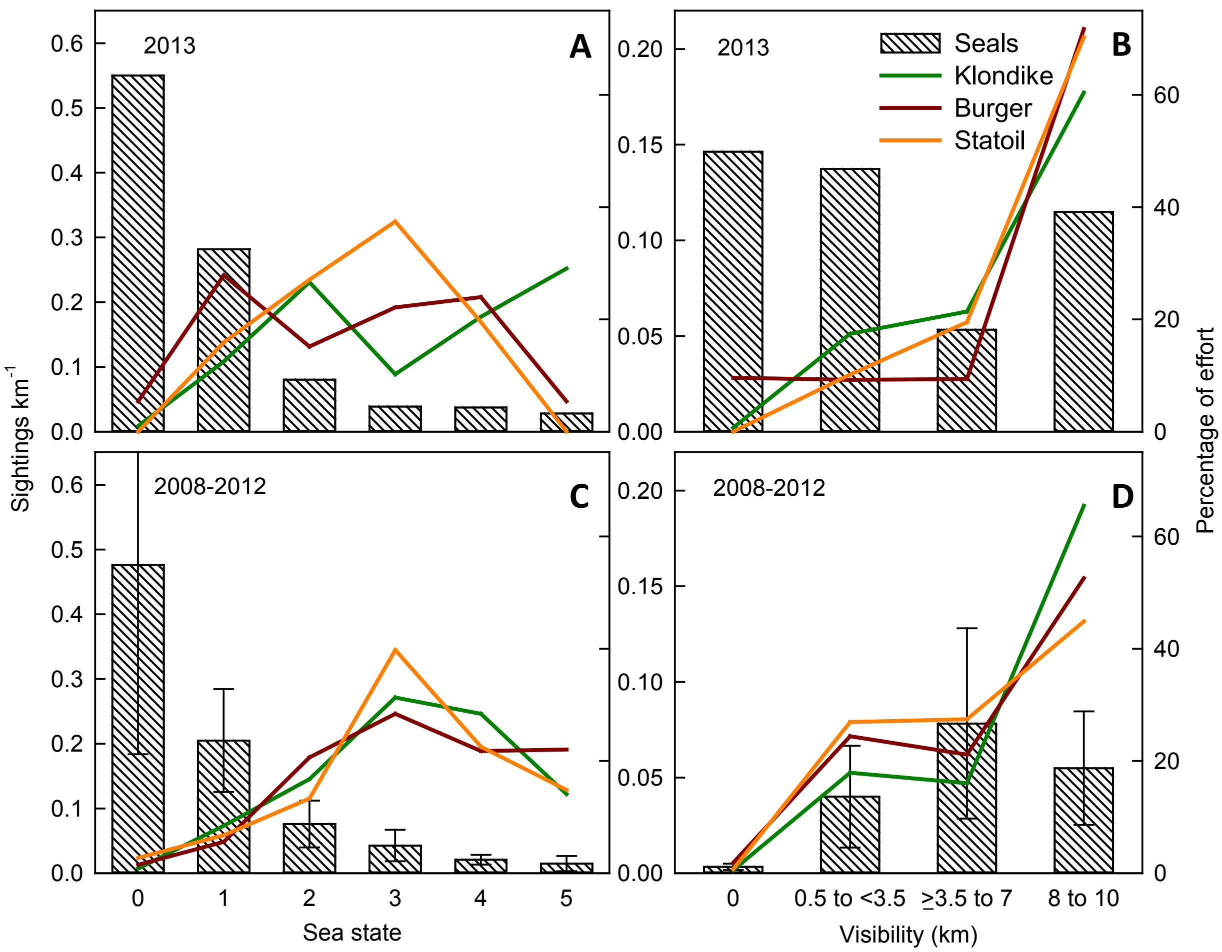


Figure 3.2. Sighting rates (sightings km^{-1}) of seals for each sea state (A, C) and visibility category (B, D) during CSESP surveys in 2013 and in 2008–2012. Sea state is expressed in Beaufort wind force scale; error bars represent standard deviations. Lines show the amount of effort in each prospect-specific study area, expressed as a percentage of total effort. Data include on- and off-transect sightings and effort in the three prospect-specific study areas when sea states were ≤5. Seals on ice were excluded.

Annual Variation in Distribution and Abundance

Seal Densities

In 2013, densities of unidentified seals within the three prospect-specific study areas ranged from 0.045 to 0.058 ind km^{-2}, with the highest density recorded in the Klondike study area (Table 3.2). Seasonal densities of unidentified seals ranged from 0.039 to 0.057 ind km^{-2}, with the highest density occurring in summer. In previous years, annual densities of unidentified seals ranged from 0.012 to 0.152 ind km^{-2}, and seasonal densities ranged from 0.004 to 0.171 ind km^{-2}. The proportional contributions of ringed/spotted seals and bearded seals to these densities of unidentified seals are unknown. The ratio between ringed/spotted and bearded seal densities for each study area and season, as summarized in Tables 3.3 and 3.4, could provide an indication. However, we recognize that this approach might overestimate the densities of bearded seals, which are easier to identify, and hence, might underestimate the densities of ringed/spotted seals.

Table 3.2. Summary of estimated densities of unidentified seals (ind km^{-2}), by year, study area, and season. Summer = July and August, fall = September and October. UCL = upper 95% confidence limit, LCL = lower 95% confidence limit.

YEAR	PARAMETER	STUDY AREA			SEASON	
		KLONDIKE	BURGER	STATOIL	SUMMER	FALL
2013	**ind km^{-2}**	**0.058**	**0.045**	**0.045**	**0.057**	**0.039**
	UCL	**0.118**	**0.150**	**0.096**	**0.146**	**0.072**
	LCL	**0.028**	**0.014**	**0.021**	**0.022**	**0.021**
2012	ind km^{-2}	0.019	0.062	0.038	0.042	0.032
	UCL	0.050	0.103	0.077	0.070	0.053
	LCL	0.007	0.037	0.018	0.025	0.019
2011	ind km^{-2}	0.015	0.033	0.041	0.015	0.066
	UCL	0.038	0.075	0.089	0.031	0.100
	LCL	0.006	0.015	0.019	0.007	0.044
2010	ind km^{-2}	0.017	0.023	0.014	0.004	0.032
	UCL	0.035	0.045	0.030	4.711	0.051
	LCL	0.009	0.012	0.007	0.000	0.020
2009	ind km^{-2}	0.012	0.014	not surveyed	0.010	0.014
	UCL	0.023	0.026		0.028	0.023
	LCL	0.006	0.007		0.004	0.008
2008	ind km^{-2}	0.152	0.049	not surveyed	0.171	0.035
	UCL	0.289	0.084		0.312	0.063
	LCL	0.080	0.029		0.093	0.020

Ringed/Spotted Seals

In 2013, densities of ringed/spotted seal within the three prospect-specific study areas ranged from 0.064 to 0.086 ind km^{-2}, with the highest density occurring in Statoil (Table 3.3). Seasonal densities ranged from 0.056 to 0.076 ind km^{-2}, with the highest density occurring in fall.

Densities of ringed/spotted seals from on-transect data appear to be highly variable among years and study areas. Densities recorded during the period 2008−2012 ranged from 0.011 to 0.112 ind km^{-2} (Fig. 3.3, Table 3.3). The density of ringed/spotted seals recorded in the Burger study area in 2013 was the highest density recorded for that study area since surveys began in 2008. The density of ringed/spotted seals in the Klondike and Statoil study areas in 2013 were the second highest densities recorded for those study areas. Every year since 2010, the highest densities of ringed/spotted seals have been recorded in the Statoil study area; however, there was no consistent pattern of abundance in the Klondike or Burger study areas.

Seasonal densities of ringed/spotted seals varied among years during 2008–2012, ranging from 0.004 to 0.127 ind km^{-2} (Fig. 3.4, Table 3.3). The density recorded during summer in 2013 was similar to the density recorded during summer in 2012; however, the highest summer density was recorded in 2008. The density of ringed/spotted seals recorded during fall in 2013 was the highest density recorded during the fall since surveys began in 2008. With the exception of 2008 and 2012, densities of ringed/spotted seal were higher during fall than during summer. The two years with high summer densities (2008, 2012) were characterized by the presence of sea ice in the study areas until mid-September. During light-ice years (i.e., 2009–2011), densities of ringed/spotted seals generally were lower in summer than in fall. The seasonal abundance in 2013 did not follow this pattern.

By using densities of confirmed ringed and spotted seals calculated from 2008–2013 data and the combined detection function for ringed/spotted seals, we determined that the ratio between ringed and spotted seals was approximately 2:1. This ratio could be applied to the annual combined densities for each study area and season, as summarized in Table 3.3, to determine how much, or little, these two species contributed to the combined ringed/spotted seal densities.

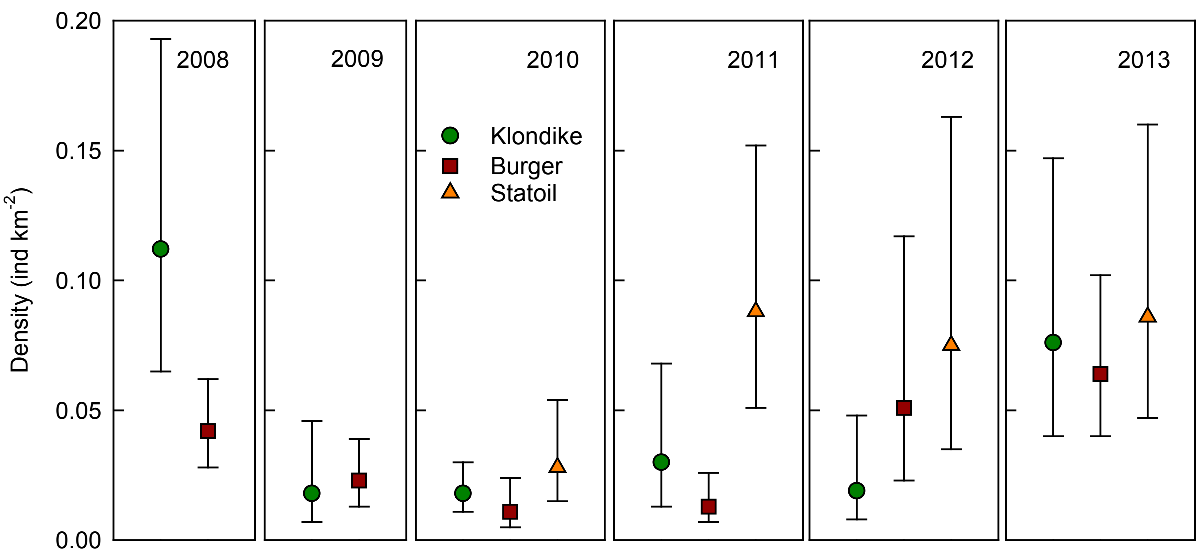


Figure 3.3. Densities of ringed/spotted seals, with 95% confidence intervals, during CSESP surveys from 2008 to 2013, by year and study area.

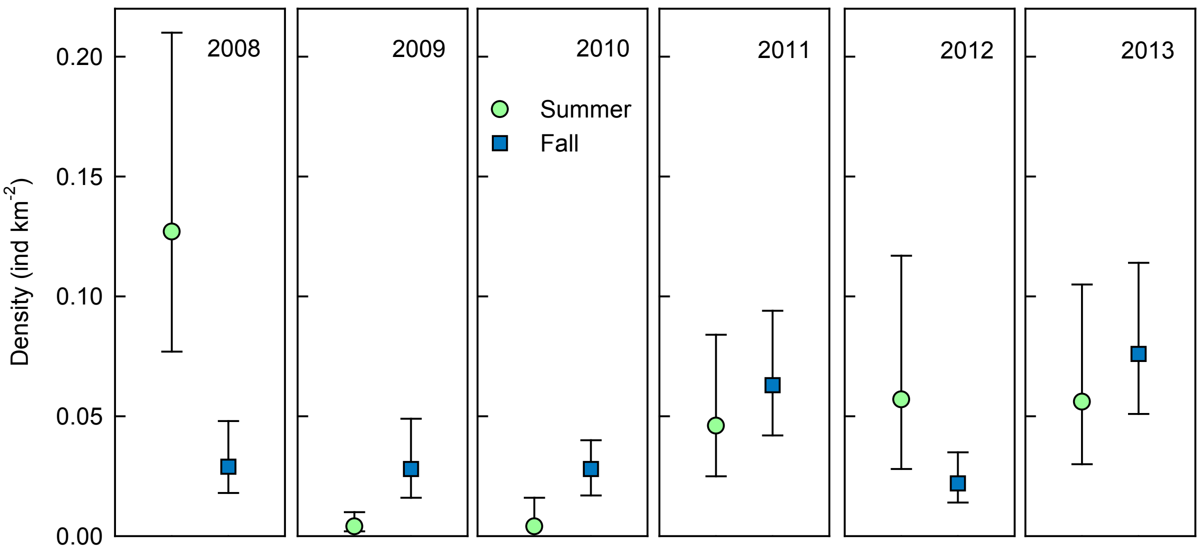


Figure 3.4. Densities of ringed/spotted seals, with 95% confidence intervals, during CSESP surveys from 2008 to 2013, by year and season. Summer = July and August; fall = September and October.

Table 3.3. Summary of estimated densities (ind km^{-2}) of ringed/spotted seals, by year, study area, and season. Summer = July and August, fall = September and October. UCL = upper 95% confidence limit, LCL = lower 95% confidence limit.

YEAR	PARAMETER	STUDY AREA			SEASON	
		KLONDIKE	BURGER	STATOIL	SUMMER	FALL
2013	**ind km^{-2}**	**0.076**	**0.064**	**0.086**	**0.056**	**0.076**
	UCL	**0.147**	**0.102**	**0.047**	**0.105**	**0.114**
	LCL	**0.040**	**0.040**	**0.160**	**0.030**	**0.051**
2012	ind km^{-2}	0.019	0.051	0.075	0.057	0.022
	UCL	0.048	0.117	0.163	0.117	0.035
	LCL	0.008	0.023	0.035	0.028	0.014
2011	ind km^{-2}	0.030	0.013	0.088	0.046	0.063
	UCL	0.068	0.026	0.152	0.084	0.094
	LCL	0.013	0.007	0.051	0.025	0.042
2010	ind km^{-2}	0.018	0.011	0.028	0.008	0.026
	UCL	0.030	0.024	0.054	0.016	0.040
	LCL	0.011	0.005	0.015	0.004	0.017
2009	ind km^{-2}	0.018	0.023	not surveyed	0.004	0.028
	UCL	0.046	0.039		0.010	0.049
	LCL	0.007	0.013		0.002	0.016
2008	ind km^{-2}	0.112	0.042	not surveyed	0.127	0.029
	UCL	0.193	0.062		0.210	0.048
	LCL	0.065	0.028		0.077	0.018

Bearded Seals

In 2013, densities of bearded seals within the three prospect-specific study areas ranged from 0.043 to 0.058 ind km^{-2}, with the highest density occurring in the Statoil study area (Table 3.4). Densities of bearded seals recorded in both the Klondike and Burger study areas were similar but lower than densities in Statoil. Seasonal densities of bearded seals ranged from 0.030 to 0.063 ind km^{-2}, with the highest density occurring in summer.

Densities recorded during the period 2008–2012 ranged from 0.004 to 0.074 ind km^{-2} (Fig. 3.5, Table 3.4). Every year since 2010, the highest densities of bearded seals have been recorded in the Statoil study area. The densities of bearded seals recorded in the Burger study area were higher than in the Klondike study area in all years except 2011 and 2013. Densities of bearded seals recorded in 2013 in the Klondike and Burger study areas were the highest densities recorded for those study areas since surveys began in 2008.

Seasonal densities of bearded seals varied among years during 2008–2012, ranging from 0.004 to 0.049 ind km^{-2} (Fig. 3.6, Table 3.4). The density of bearded seals recorded during summer in 2013 was the highest recorded during summer since surveys began in 2008. The density of bearded seals recorded during fall in 2013, however, was within the range of fall densities recorded in previous years. There was no apparent pattern between season and densities of bearded seals among years.

Table 3.4. Summary of estimated bearded seal densities (ind km^{-2}) by year, study area, and season. Summer = July and August, fall = September and October. UCL = upper 95% confidence limit, LCL = lower 95% confidence limit.

YEAR	PARAMETER	STUDY AREA			SEASON	
		KLONDIKE	BURGER	STATOIL	SUMMER	FALL
2013	**ind km^{-2}**	**0.043**	**0.043**	**0.058**	**0.063**	**0.030**
	UCL	**0.137**	**0.089**	**0.081**	**0.137**	**0.046**
	LCL	**0.014**	**0.021**	**0.042**	**0.028**	**0.020**
2012	ind km^{-2}	0.018	0.042	0.074	0.032	0.039
	UCL	0.037	0.079	0.124	0.058	0.056
	LCL	0.009	0.022	0.044	0.017	0.027
2011	ind km^{-2}	0.030	0.013	0.072	0.049	0.020
	UCL	0.065	0.021	0.138	0.086	0.031
	LCL	0.013	0.008	0.037	0.028	0.013
2010	ind km^{-2}	0.007	0.022	0.058	0.007	0.044
	UCL	0.016	0.039	0.100	0.013	0.068
	LCL	0.003	0.012	0.033	0.004	0.028
2009	ind km^{-2}	0.004	0.010	not surveyed	0.004	0.009
	UCL	0.010	0.020		0.012	0.017
	LCL	0.001	0.005		0.001	0.005
2008	ind km^{-2}	0.016	0.026	not surveyed	0.032	0.013
	UCL	0.029	0.040		0.051	0.022
	LCL	0.009	0.016		0.019	0.008

Because bearded seals are more easily identifiable than ringed and spotted seals, the number of bearded seals classified as unidentified is assumed to be less than for ringed/spotted seals. Therefore, actual densities of bearded seals from 2008 to 2013 are close to the average density, whereas actual densities for ringed/spotted seals probably are close to the upper confidence limit.

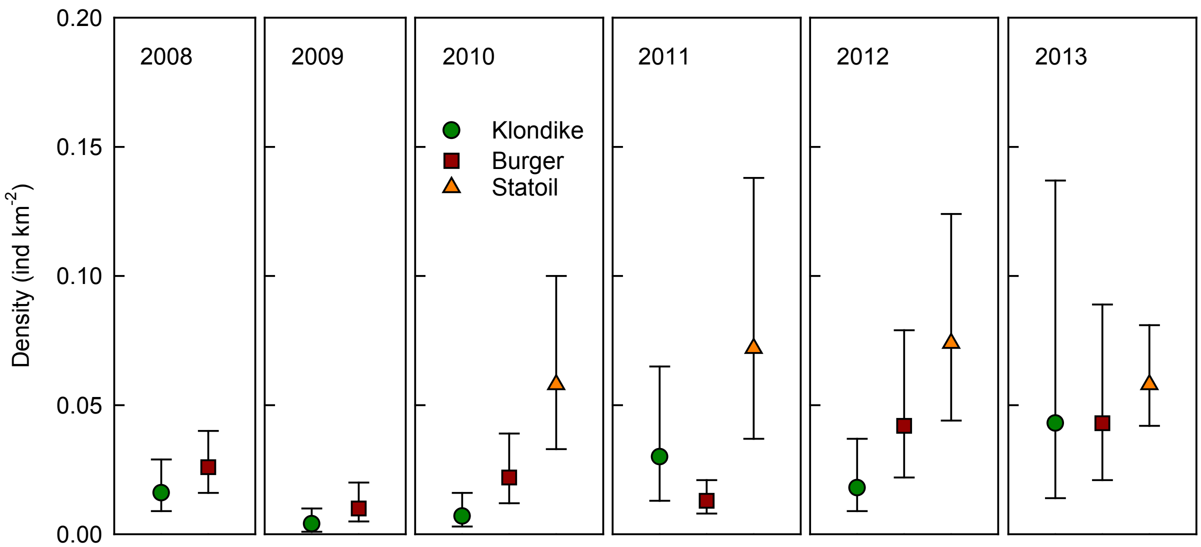


Figure 3.5. Densities of bearded seals, with 95% confidence intervals, during CSESP surveys conducted from 2008 to 2013, by year and study area.

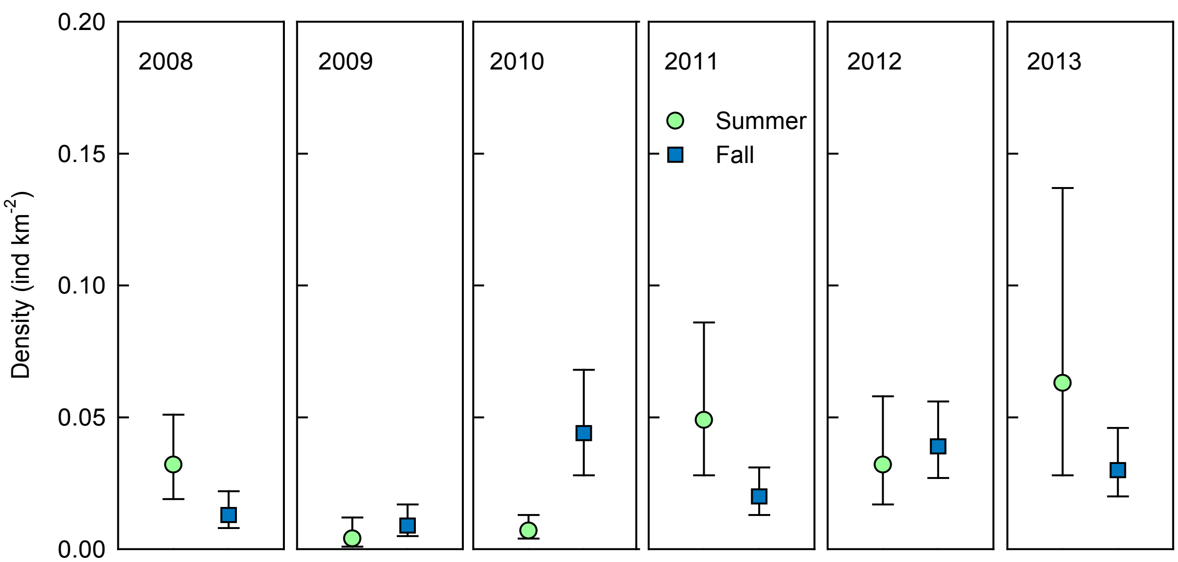


Figure 3.6. Densities of bearded seals, with 95% confidence intervals, during CSESP surveys conducted from 2008 to 2013, by year and season. Summer = July and August; fall =September and October.

Seal Distribution

We created maps displaying the distribution of ringed/spotted seals and bearded seals based on effort-corrected sighting rates (ind km^{-1}) using on- and off-transect data (Figs. 3.7, 3.8). With the exception of the westernmost and south-central portions of the Klondike study area, ringed/spotted seals were distributed fairly evenly throughout the three prospect-specific study areas in 2013. Although most sightings were of solitary animals, sightings generally occurred in clusters (i.e., generally more than one animal was observed within a specific area). This clustered occurrence is apparent from the higher concentrations of ringed/spotted seals in the northeastern corner of the Statoil study area, the eastern side of the Klondike study area, and the northwestern corner of the Burger study area (Fig. 3.7). In 2013, we sampled the transitional area between the three prospect-specific study areas because sea ice prevented us from sampling portions of Statoil and Burger. In this transitional area, we observed the highest concentrations of ringed/spotted seals south of Statoil and east of Klondike. The distribution of ringed/spotted seals from 2008–2012 combined indicates that the highest concentrations occurred in the northwestern corner of the Statoil study area and the south-central portion of the Klondike study area. In all six years of this study, we frequently saw ringed/spotted seals near the coast (<80 km from shore) between Barrow and Wainwright.

In 2013, the distribution of bearded seals within the three prospect-specific study areas was more concentrated than that for ringed/spotted seals. The highest concentrations of bearded seals were located in the northern portion of the Statoil study area, the north-central portion of the Burger study area, and the eastern side of the Klondike study area (Fig. 3.8). In addition, densities were particularly high in the transitional area. Sighting rates of bearded seals in 2008–2012 combined indicate that the highest concentrations of bearded seals occurred in the central portion of the Statoil study area (Fig. 3.8). In general, higher densities of bearded seals were recorded in Statoil, followed by Burger, and the lowest densities were recorded in Klondike. In 2013, as in previous years, we frequently saw bearded seals near the coast (<80 km from shore) between Barrow and Wainwright.

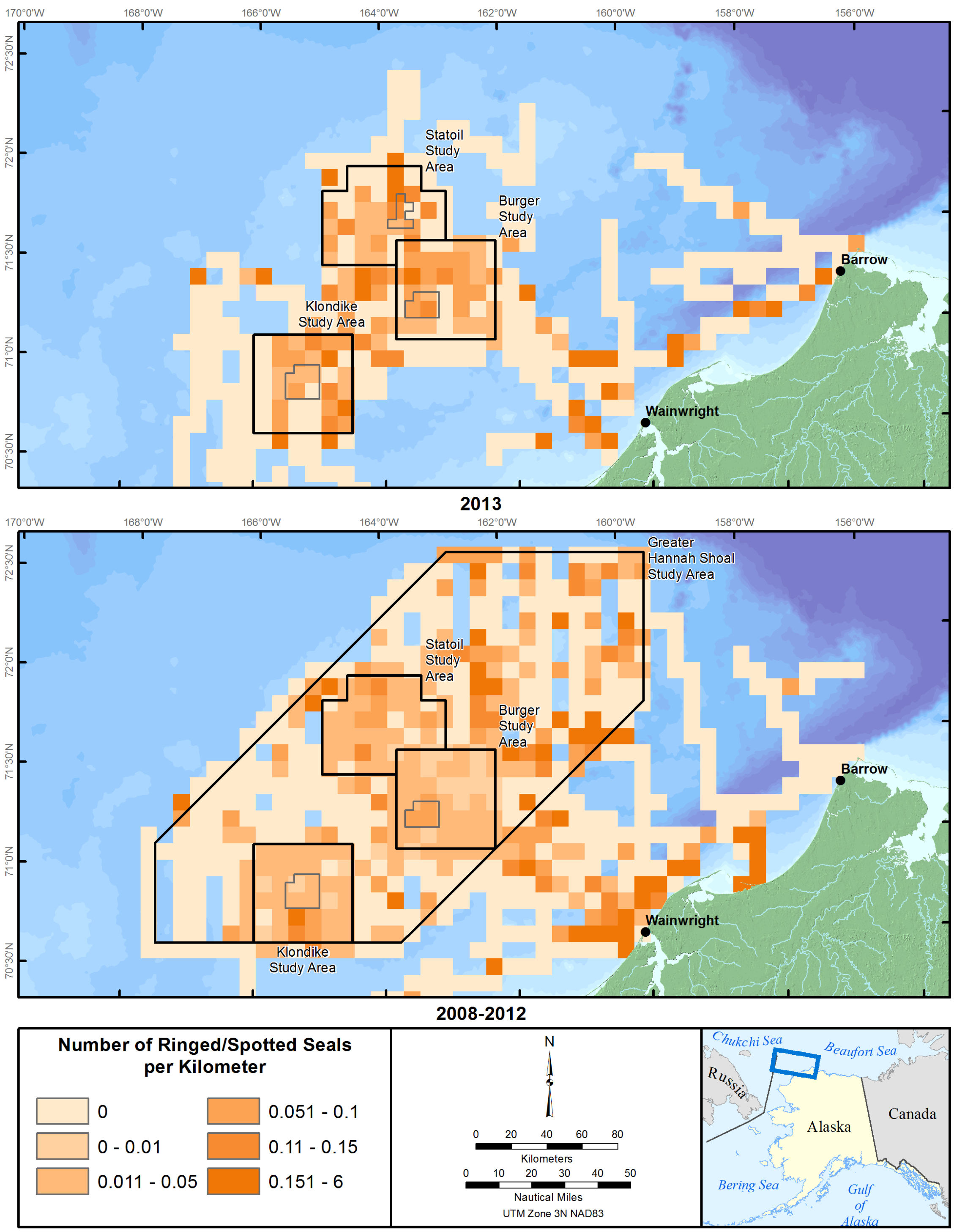


Figure 3.7 Distribution of ringed/spotted seals in the northeastern Chukchi Sea from August to mid-October in 2013 (upper) and 2008–2012 (lower) based on sighting rates (ind km^{-1}) calculated for 5×5 nmi grid cells. Data include on- and off-transect sightings and effort when sea states were ≤5.

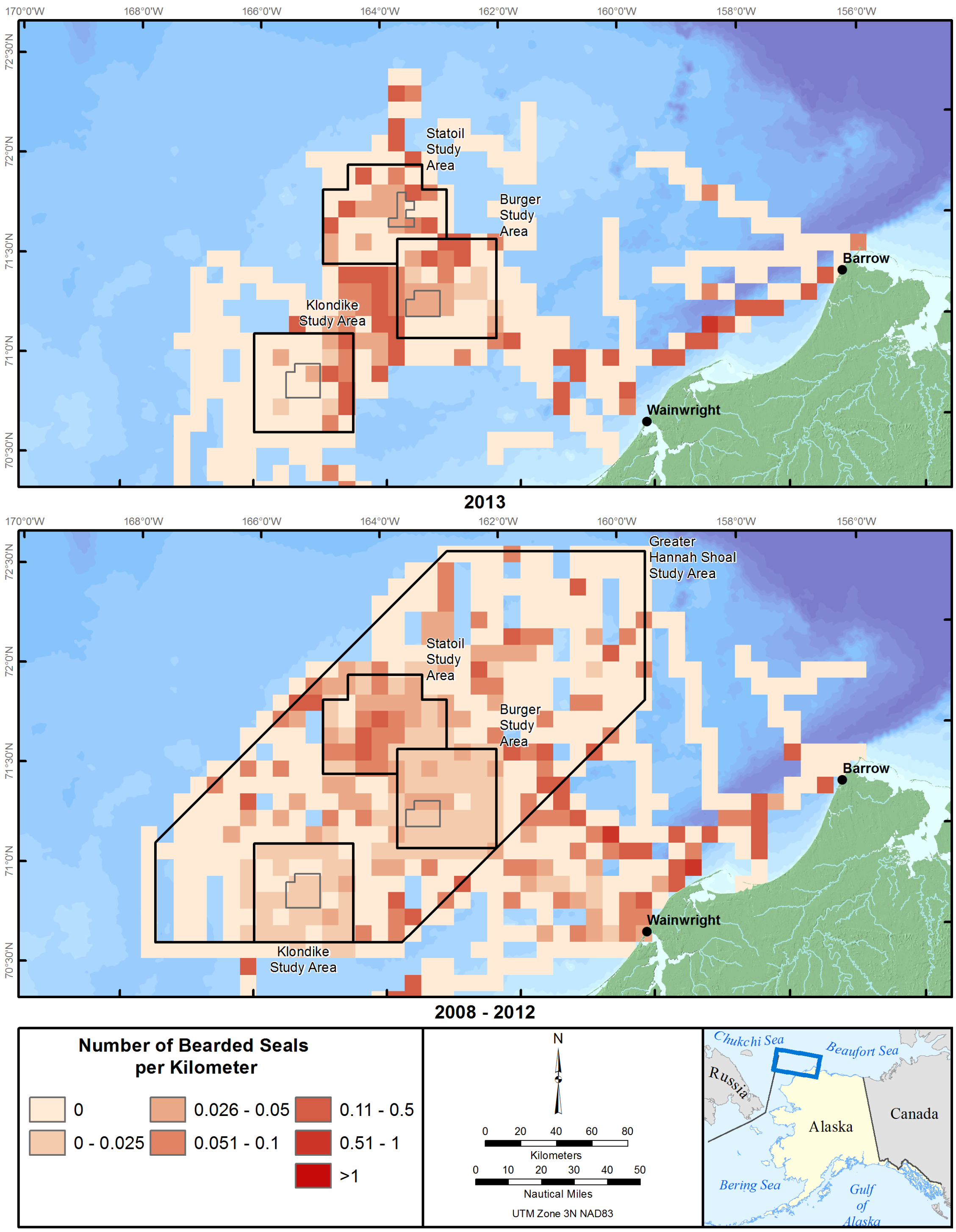


Figure 3.8. Distribution of bearded seals in the northeastern Chukchi Sea from August to mid-October in 2013 (upper) and 2008–2012 (lower) based on sighting rates (ind km^{-1}) calculated for 5×5 nmi grid cells. Data include on- and off-transect sightings and effort when sea states were ≤5.

DISCUSSION

Four species of phocid seals (i.e., true or earless seals) regularly inhabit the northeastern Chukchi Sea, either seasonally or year-round: the ringed seal, spotted seal, bearded seal, and ribbon seal. During the six years of CSESP marine mammal surveys, the most commonly observed species were ringed, spotted, and bearded seals. Since CSESP surveys began in 2008, we have recorded only eight solitary ribbon seals (six in 2008 and two in 2011), indicating that the occurrence of this species in the northeastern Chukchi Sea during the open-water season is rare.

Because ringed and spotted seals can be difficult to differentiate, we created a combined ringed/spotted seal category. During CSESP surveys in 2013, we observed the highest density of ringed/spotted seals in the Statoil study area. However, ringed/spotted seal densities appear to be highly variable among study areas and years, as might be expected for seal species that feed on mobile prey such as fishes, plankton, and shrimp. The seasonal abundance in 2013, with slightly higher densities during fall than summer, did not follow the pattern that was observed in previous years. Prior to 2013, ringed/spotted seal densities during light ice years (2009–2011) were generally higher in fall than in summer, whereas heavy ice years (2008, 2012) showed higher densities during the summer.

Although arctic seals are closely associated with sea ice during the breeding and molting seasons, ringed seals exhibit a pelagic lifestyle during the open-water period and use the Chukchi Sea primarily for foraging (Kelly et al. 2010a, 2010b). In contrast, spotted seals make foraging trips from coastal haulouts (Lowry et al. 1998, 2000) during the summer and do not use sea ice as a foraging platform. Based on data from 2008 to 2010, we suggested that interannual variability in the abundance of ringed/spotted seals was related mainly to food availability, which is influenced by oceanographic conditions (Aerts et al. 2013b). The diet of ringed seals is flexible and seasonally variable; crustaceans (primarily shrimp, amphipods, and mysids) are the main prey in the spring and summer (Burns and Eley 1978; Lowry et al. 1980b). Spotted seals also have a flexible diet and can feed on any prey that is available and abundant (Kato 1982; Bukhtiyarov et al. 1984). However, spotted seals mainly target schooling fishes (specifically Arctic cod) and shrimp.

The Klondike and western Statoil study areas are affected by Bering Sea Water from the Central Channel and, thus, have a stronger pelagic species component than does the Burger study area (Day et al. 2013). As a result, the biomass of zooplankton species, such as copepods and euphausiids, is generally higher in the Klondike study area than in the Burger study area. However, this pattern has not been apparent every year (Questel et al. 2012; Hopcroft et al. 2013). In comparison, the Burger study area is considered a benthic-dominated system (Day et al. 2013). We continue to believe that these differences in ecological conditions, together with other factors, influence the density and distribution of seals in the CSESP study areas. Because the Klondike and Statoil study areas have a stronger pelagic component than the Burger study area, we anticipated higher ringed/spotted seal densities in those locations. During this study in 2013, as in previous years, ringed/spotted seal densities were highest in the Statoil study area, followed by the Klondike and Burger study areas. Thus, our results were consistent with our hypothesis.

During the CSESP surveys in 2013, we observed the highest density of bearded seals in the Statoil study area. Similar observations were made during CSESP surveys in previous years, with the highest densities in the Statoil study area, followed by the Burger study area. The highest seasonal density of bearded seals occurred during the summer in 2013. However, no consistent pattern between season and abundance of bearded seals was apparent among the six years of CSESP surveys.

Vocalizations of bearded seals during CSESP surveys, as detected by acoustic recorders in the northeastern Chukchi Sea, also were highly concentrated near the Statoil study area (Delarue et al. 2013b, 2014). The variation among the three prospect-specific study areas in densities of bearded seals is also consistent with patterns seen in the benthic studies. The density and biomass of potential prey organisms for bearded seals were higher in the Statoil and Burger study areas than in the Klondike study area (Blanchard et al. 2013a). However, the density of bearded seals in Burger was lower than expected based on the abundance and biomass of potential prey organisms. These lower densities could be related to the presence of large numbers of walruses in the Burger study area (see Chapter 4) that might have decreased food availability for bearded seals through interspecific competition. Trophic interactions between walruses and bearded seals in the Chukchi Sea have been reported previously (Lowry et al. 1980a). An additional factor that may influence local bearded seal distribution is predation by walruses. Seal-eating walruses are fairly common, especially during restrictive sea ice conditions that can lead to a greater overlap in walrus and seal distributions (Lowry and Fay 1984), although sea ice sea ice extent alone does not appear to drive consumption of high trophic level prey (Seymour et al. 2014a). Stomach contents of walruses sampled in the summer during the 1960s and 1983 in the Chukchi Sea, where geographic ranges of walruses and seals overlap broadly, have indicated that approximately 9–11% of the walruses sampled were seal eaters (Lowry and Fay 1984). More recent studies of walrus diet, using stable isotope (C and N) analyses of various tissues from walruses, estimated a higher contribution of high trophic level prey such as seals to walrus diet (22% ±10%) (Seymour et al. 2014b).

The density and occurrence of bearded seals did not appear to differ between the summer and fall. During CSESP surveys in 2008–2013, the seasonal occurrence of bearded seals was highly variable. In addition, unlike ringed/spotted seal densities, which appeared to be more influenced by sea ice, there was no apparent relationship between bearded seal densities and heavy ice years (2008, 2012, 2013) or light-ice years (2009−2011). Therefore, we conclude that sea ice did not determine the seasonal distribution of bearded seals. However, seasonal variation in bearded seal abundance does exist on a larger spatial and temporal scale. Vocalizations of bearded seals in the Chukchi Sea were most numerous in spring (April–June) and almost absent during the summer, fall, and early winter; call detections increased again starting in January (Delarue et al. 2013b). We acknowledge, however, that abundance patterns based on vocalizations are partly influenced by seasonal differences in calling behavior (Aerts et al. 2011).

CONCLUSIONS

- In 2013, observers recorded more ringed seals than spotted seals; this pattern was consistent with 2008, 2011, and 2012. Ringed seals were seen mainly in Burger, and spotted seals were seen mainly in Klondike.
- In 2013, the density of ringed and spotted seals combined was higher than previous years. Although ringed/spotted seal densities were highly variable among years and study areas, mean densities were highest in the Statoil study area since surveys were conducted there in 2010.
- The highest seasonal density of ringed/spotted seals in 2013 was recorded during the fall. This pattern is different from the other years with heavy ice cover (2008 and 2012), which were characterized by higher densities during summer than fall.

- By using densities of ringed and spotted seals that were identified to species (calculated with the detection function of the combined ringed/spotted seal category), we estimated that the ratio between ringed and spotted seals was approximately 2:1.
- In 2013, the highest density of bearded seals occurred in the Statoil study area, consistent with results from previous years. Densities of bearded seals in Klondike and Burger in 2013 were similar to each other and were the highest densities recorded for those study areas since surveys began in 2008. In previous years, densities generally were higher in Burger than in Klondike.
- The highest seasonal density of bearded seals in 2013 occurred during summer. This was the highest summer density recorded since surveys began in 2008. Densities of bearded seals appeared to be variable seasonally, with no consistent pattern among years and no apparent relationship to sea ice conditions.
- The highest seasonal density of bearded seals in 2013 occurred during the summer. This was the highest summer density recorded since surveys began in 2008. Densities of bearded seals appeared to be variable seasonally, with no consistent pattern among years and no apparent relationship to sea ice conditions.

CHAPTER 4

DISTRIBUTION AND ABUNDANCE OF WALRUSES

This chapter summarizes the results of surveys for the presence, relative abundance, and distribution of walruses in the Chukchi Sea from the CSESP vessel-based marine mammal surveys in 2013 and compares those results with results of previous years' surveys.

RESULTS

Sighting Summary

In 2013, we recorded 211 walrus sightings, representing 5,325 animals, in the Chukchi Sea during all effort types (i.e., on-, off-, and non-transect). Our observations included walruses in the water (139 sightings/563 animals) and hauled out on sea ice (72 sightings/4,762 animals). The number of sightings of walruses on ice was less common than that of walruses in water (34%); however, the majority of individuals that we encountered were seen on sea ice (89%). The contribution of on-ice sightings and individuals to the total number for the other two heavy ice years was 18% and 90% (2008) and 10% and 50% (2012). In 2009, when sea ice was absent most of the survey season, on-ice sightings and individuals accounted only for 6% and 14% of the total number of sightings and individuals.

The distance of walruses sighted in the water from the vessel ranged from ~12 m to 3,144 m, with most sightings occurring between 501 and 1,000 m (Fig. 4.1). The distance of walruses sighted on sea ice from the vessel ranged from 34 m to 5,000 m. Approximately 90% of all on-ice sightings were at distances >1,000 m. Walruses are easier to detect on ice and, consequently, can be seen at greater distances than can walruses in the water. Also, due to safety reasons and mitigation measures vessels attempted to keep distance from ice floes.

As part of the standard observation protocol, observers recorded the primary and secondary behaviors of walruses. For a sighting consisting of >1 animal, the most common behavior of the group was recorded. Observed behaviors of walruses in water and on ice are shown in Figure 4.2. We also made a distinction between behaviors recorded at sighting distances <800 m and ≥800 m from the vessel, because the U.S. Fish and Wildlife Service uses this distance as a disturbance guideline. During the 2013 survey, the most common primary behaviors of walruses observed in the water were resting, looking, and swimming (83%). Ratios among these three behaviors varied slightly for animals observed at distances <800 m and ≥800 m (Fig. 4.2). Diving and no change in behavior (recorded as "none") were the most common secondary behaviors for walruses observed in water (60%), regardless of the distance at which they were observed. If observers were not able to determine the secondary behavior, it was recorded as "unknown." For walruses in water at distances ≥800 m, it was more difficult for observers to determine the secondary behavior (24%) than at distances <800 m (8%). Walruses observed on sea ice were predominantly resting, regardless of the distance at which they were observed. The most common secondary behavior was also predominantly resting for animals at distances of both <800 m and ≥800 m.

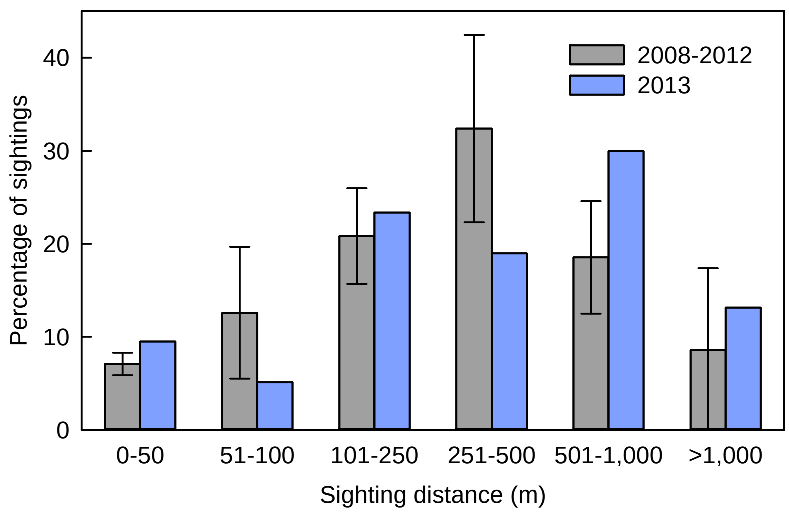


Figure 4.1. Radial sighting distance (in m) at which walruses were sighted from the vessel, shown as a percentage of total number of sightings for 2013 and 2008-2012. Data include on- and off-transect sightings when sea states were ≤5; walrus sightings on sea ice were excluded. Error bars represent standard deviations.

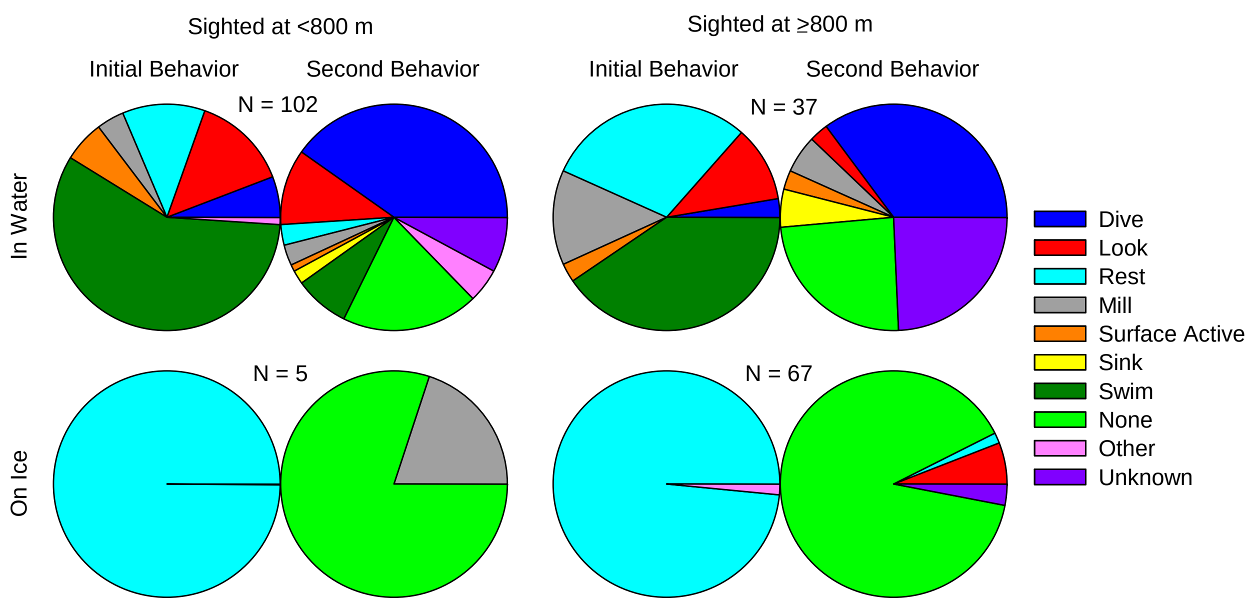


Figure 4.2. Primary and secondary behaviors of walruses observed in the water and hauled out on sea ice, based on different sighting distances from the vessel during the 2013 CSESP survey.

Effects of Environmental Conditions on Detectability

Sighting rates (sight 100 km^{-1}) of walruses that were seen in the water for each sea state and visibility category are shown in Figure 4.3. In 2013, most walruses were sighted during sea state 1, with sightings decreasing as sea state increased (Fig. 4.3A). In contrast, sighting rates in 2008–2012 indicated no apparent pattern between sea state and walrus sighting rates. We attribute the lack of a relationship between sea state and walrus sighting rates to the size and behavior of these animals; walruses have large bodies, often occur in groups, and generally remain at the surface for longer periods of time than seals do.

In 2013, walrus sighting rates were highest when visibility was ≥8 km (Fig. 4.3B) Sighting rates, however, did not follow a decreasing or increasing pattern with improved visibility. Because most walruses were seen at distances ≤1 km, a strong relationship between sighting rate and visibility is not expected.

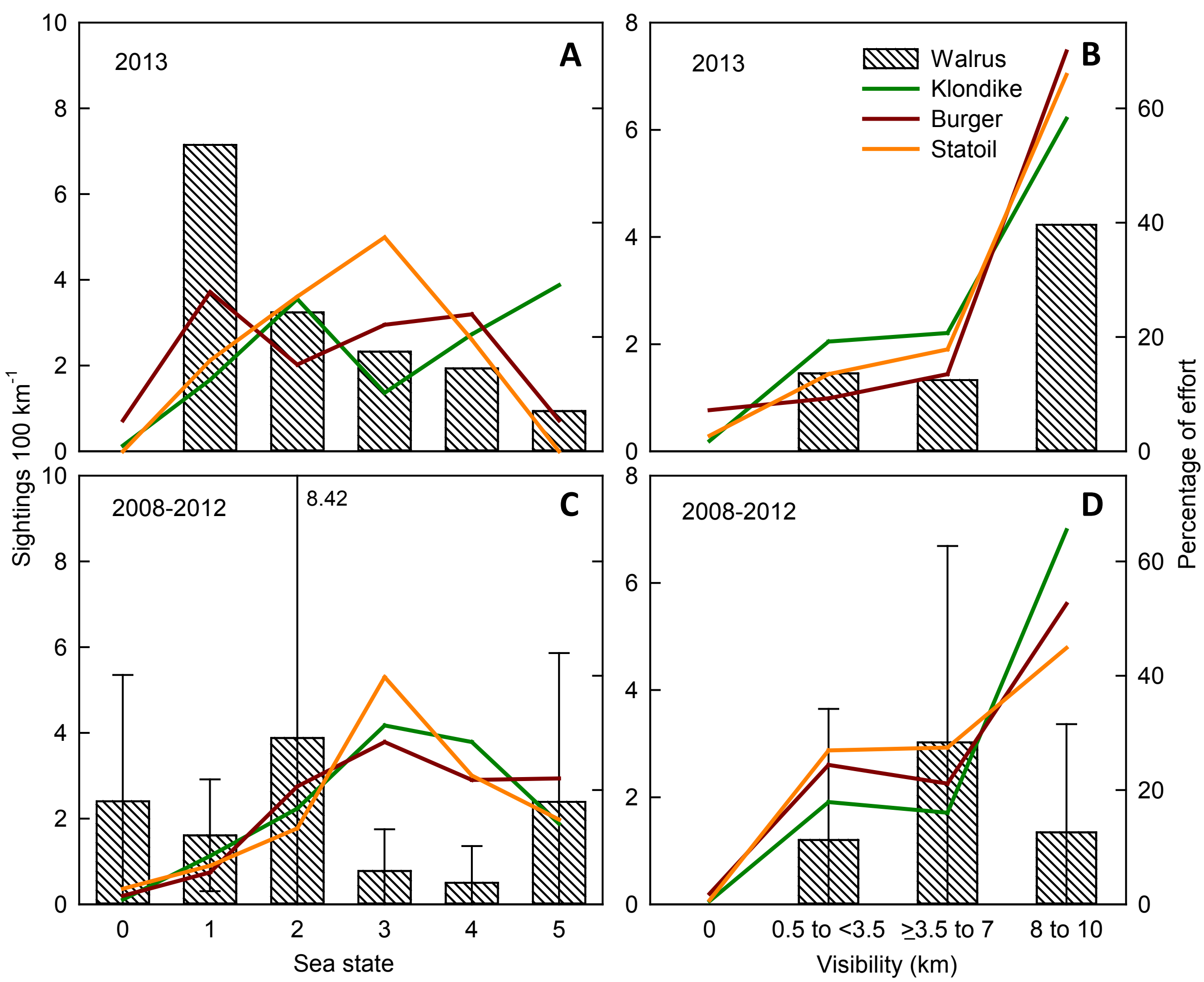


Figure 4.3. Sighting rates (sightings 100 km^{-1}) of walruses for each sea state (A, C) and visibility category (B, D) during CSESP surveys in 2013 and in 2008–2012. Sea state is expressed in Beaufort wind force scale; error bars represent standard deviations. Lines show the amount of effort in each prospect-specific study area, expressed as a percentage of total effort. Data include on- and off-transect sightings and effort in the three prospect-specific study areas when sea states were ≤5. Walruses on ice were excluded.

Annual Variation in Distribution and Abundance

Walrus Densities

In 2013, estimated densities of walruses within the three prospect-specific study areas ranged from 0.021 to 0.090 ind km^{-2}, with the highest density occurring in the Burger study area (Table 4.1). Seasonal densities ranged from 0.041 to 0.061 ind km^{-2}, with the highest density occurring in fall.

Densities of walruses during 2008–2012 ranged from 0.000 to 0.272 ind km^{-2} (Fig. 4.4, Table 4.1). Densities of walruses in the Klondike and Statoil study areas in 2013 were the highest densities recorded for those study areas since surveys began in 2008, whereas the density of walruses in the Burger study area was within the range of densities recorded for that study area in previous years. The highest density of walruses in the Burger study area occurred in 2012. In all years except 2010, densities of walruses have been higher in the Burger study area than the Klondike or Statoil study areas; in 2010, the density in Burger was similar to that in Statoil.

Seasonal densities of walruses varied during 2008–2012, ranging from 0.001 to 0.292 ind km^{-2} (Fig. 4.5, Table 4.1). The density of walruses during summer in 2013 was the highest density recorded during summer since surveys began in 2008. The density of walruses recorded during fall, however, was within the range of densities recorded during fall in previous years. The highest density of walruses during the fall was recorded in 2012. In all years except 2009, densities of walruses have been higher during fall than during summer.

Table 4.1. Summary of estimated walrus densities (ind km^{-2}) by year, study area, and season. Summer = July and August, fall = September and October. UCL = upper 95% confidence limit, LCL = lower 95% confidence limit.

YEAR	PARAMETER	STUDY AREA			SEASON	
		KLONDIKE	BURGER	STATOIL	SUMMER	FALL
2013	**ind km^{-2}**	**0.021**	**0.090**	**0.060**	**0.041**	**0.061**
	UCL	**0.068**	**0.162**	**0.110**	**0.106**	**0.099**
	LCL	**0.007**	**0.05**	**0.033**	**0.016**	**0.038**
2012	ind km^{-2}	0	0.272	0.016	0.006	0.292
	UCL	0	0.799	0.059	0.020	0.608
	LCL	0	0.092	0.004	0.002	0.140
2011	ind km^{-2}	0	0.250	0.025	0.021	0.103
	UCL	0	0.593	0.056	0.037	0.225
	LCL	0	0.105	0.011	0.012	0.047
2010	ind km^{-2}	0.004	0.018	0.020	0.011	0.016
	UCL	0.013	0.030	0.040	0.019	0.025
	LCL	0.001	0.011	0.010	0.007	0.010
2009	ind km^{-2}	0.004	0.029	not surveyed	0.040	0.004
	UCL	0.008	0.053		0.078	0.009
	LCL	0.001	0.016		0.021	0.002
2008	ind km^{-2}	0.008	0.013	not surveyed	0.001	0.021
	UCL	0.022	0.035		0.005	0.044
	LCL	0.003	0.005		0.000	0.010

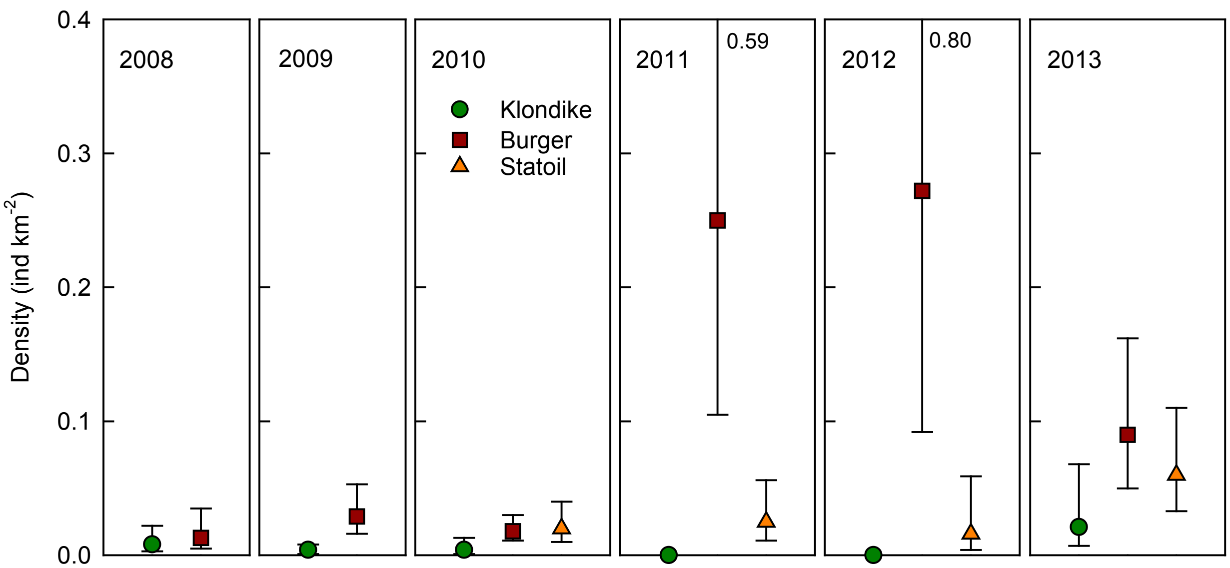


Figure 4.4. Densities of walruses, with 95% confidence intervals, during CSESP surveys from 2008 to 2013, by year and study area.

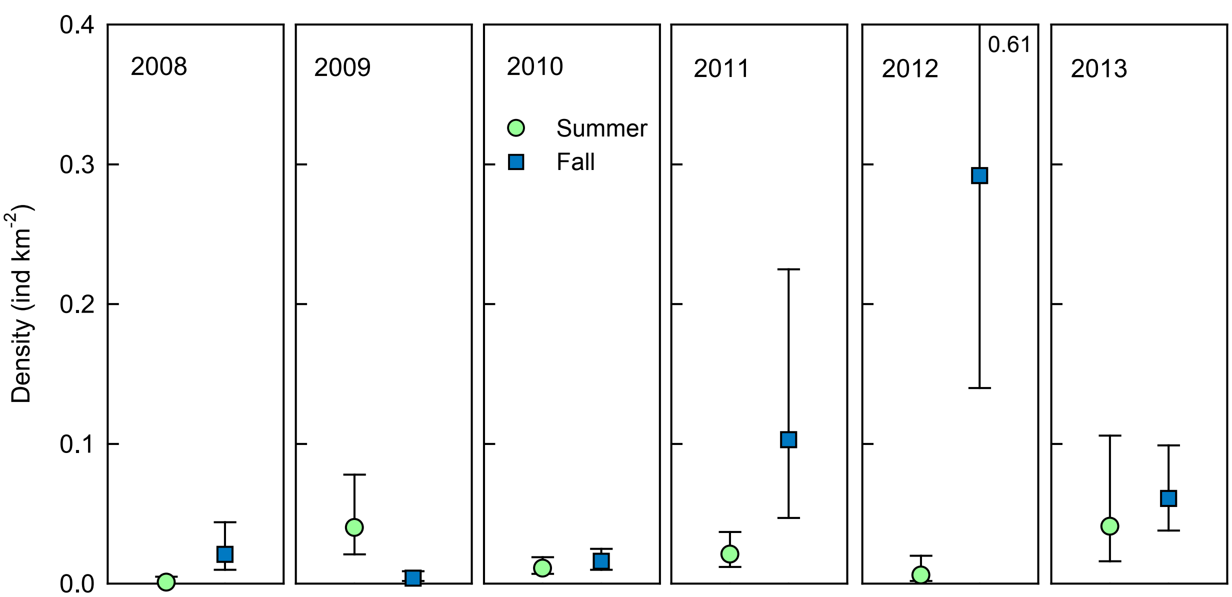


Figure 4.5. Densities of walruses, with 95% confidence intervals, during CSESP surveys from 2008 to 2013, by year and season. Summer = July and August; fall = September and October.

During on- and off-transect effort in the Chukchi Sea in 2013, the mean group size of walruses observed in the water was 4 animals (±15 animals), with a maximum estimate of 150 animals in one group. Most (95%) sightings of walruses in the water were of solitary walruses or walruses in groups of 2–5 animals. In 2013, the mean group size of walruses observed hauled out on sea ice was 67 animals (±143 animals), with a maximum estimate of 1,000 animals in one group. For walruses observed on ice, less than half (37%) of the sightings consisted of solitary walruses or walruses in groups of 2–5 animals.

In previous years (2008–2012), during on- and off-transect effort in the Chukchi Sea, the mean group size of walruses observed in the water was 3 animals (±10 animals), with a maximum estimate of 150 animals in one group. In 2008–2012, the mean group size of walruses observed hauled out on sea ice was 44 animals (±101 animals), with a maximum estimate of 700 animals in one group.

Walruses were not seen regularly during the survey season, but instead occurred in pulses. In 2013, we recorded pulses in walrus sightings in the water during both the summer and the fall. The summer pulse occurred during late August, with a peak in sightings during August 21–27 (Fig. 4.6). The fall pulse occurred during late September and early October, with a peak in sightings during September 25 – October 1. We recorded most walruses during the summer pulse.

The summer pulse in walrus sightings in 2013 was the highest summer pulse recorded since surveys began in 2008. In contrast, the fall pulse in walrus sightings in 2013 occurred later in the season than fall pulses recorded in previous years (2008, 2011, 2012) and consisted of fewer animals than in 2011 and 2012.

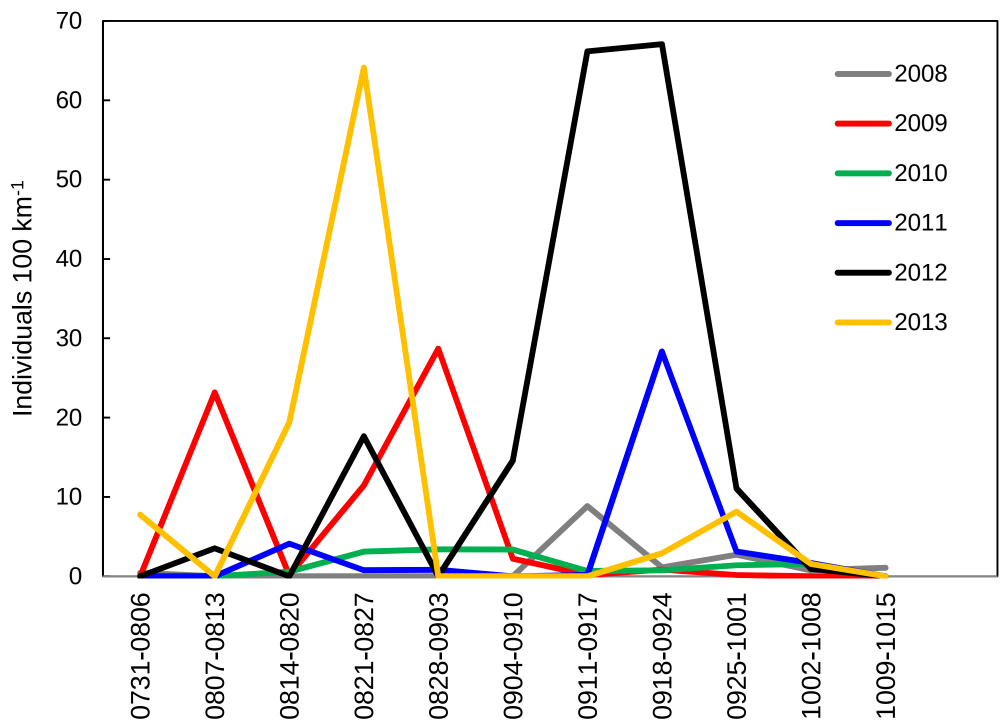


Figure 4.6. Weekly sighting rates of walruses (individuals 100 km^{-1}) in the Chukchi Sea during CSESP surveys from 2008 to 2013. Data include on- and off-transect sightings and effort when sea states were ≤5; walruses on ice were excluded.

Walrus Distribution

We plotted effort-corrected sighting rates (ind km^{-1}) using on- and off-transect data to display the distribution of walruses in 2013 and in 2008–2012 (Fig. 4.7).

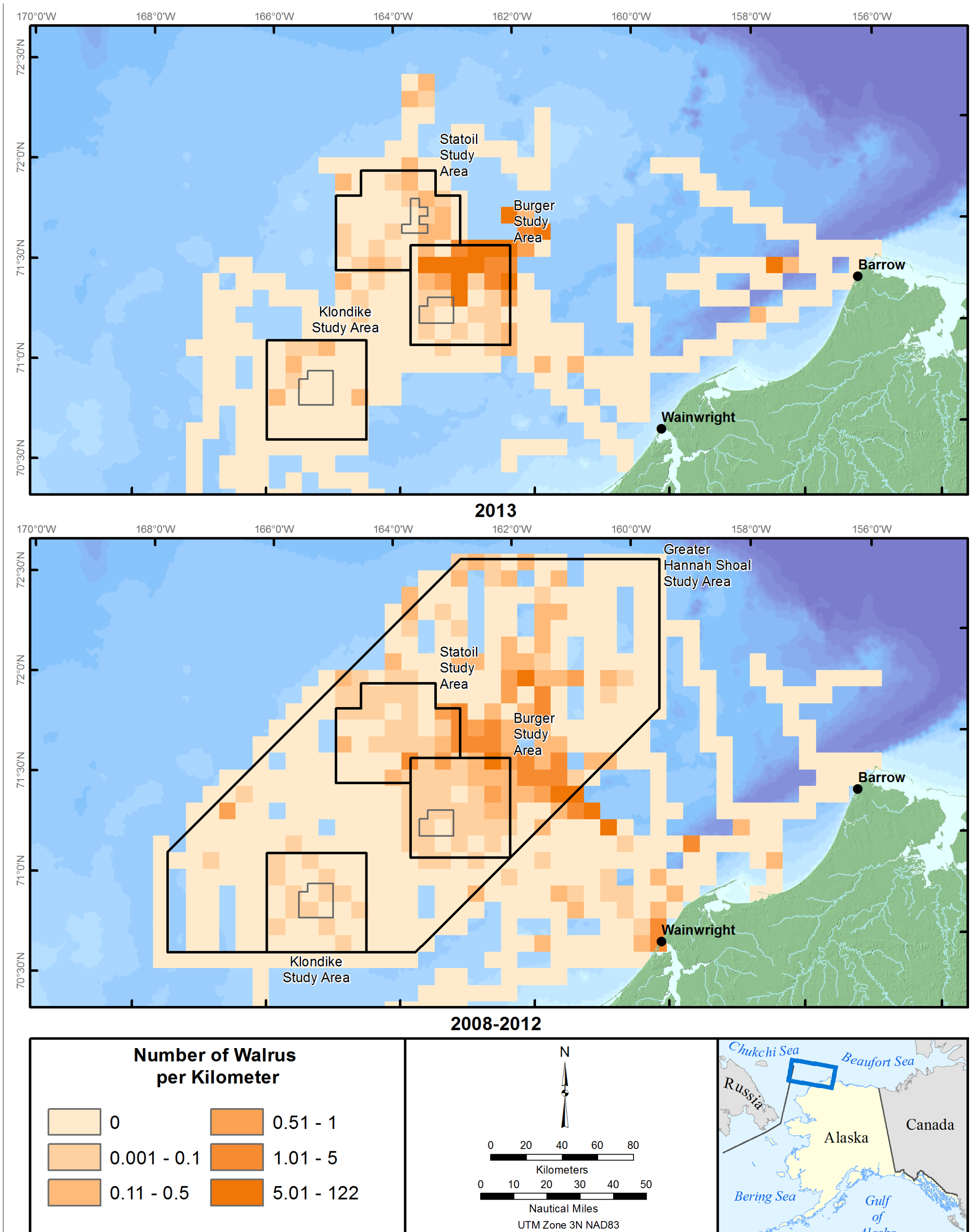


Figure 4.7. Distribution of walruses in the northeastern Chukchi Sea from August to mid-October in 2013 (upper) and 2008–2012 (lower) based on sighting rates (ind km^{-1}) calculated for 5×5 nmi grid cells. Data include on- and off-transect sightings and effort when sea states were ≤5.

In 2013, walruses were concentrated in the northeastern corner of the Burger study area (Fig. 4.7). Few walruses were recorded in the remainder of Burger and in the other two prospect-specific study areas. Densities in the northern part of the Klondike study area coincided with sea ice cover there during the last week of August. The presence of walruses in Statoil during the first cruise is unknown, because we were unable to survey most of this area due to heavy ice coverage. Sightings of walruses were also rare nearshore. The higher sighting rates in northeast Burger seen in 2013 were consistent with the distribution pattern observed in 2008–2012.

DISCUSSION

The distribution of walruses in the Chukchi Sea during summer is closely associated with the distribution and extent of sea ice (Fay et al. 1984; Garlich-Miller 2011). When broken ice is abundant during the summer, walruses typically occur in patchy aggregations on the ice, which is used as a resting platform between foraging bouts. In years when sea ice in the Chukchi retreats far north, beyond the edge of the continental shelf, walruses move closer to shore to use land as a resting platform and often congregate in large numbers. Since 2007, terrestrial haulouts of walruses have been observed along the northwestern coast of Alaska near Icy Cape, Point Lay, and Cape Lisburne during years with light sea ice coverage (Fishbach et al. 2009; Thomas et al. 2010b; Clarke et al. 2011, 2012). Acoustic data support these observations, as indicated by high concentrations of vocalizations close to shore (Delarue et al. 2012, 2013b, 2014).

During the six years of CSESP data collection, the 2013 survey season was considered a heavy ice year, with sea ice present within the study areas through mid-September. During August, sea ice was present throughout most of the Burger and Statoil study areas and portions of the Klondike study area. By mid-September, sea ice started to retreat northwestward out of the two northernmost study areas, leaving all three study areas ice-free by late September. In 2013, the presence and absence of sea ice in the study areas coincided with the seasonal peaks in walrus abundance that we observed. The highest peak in walrus sighting rates was recorded during late August, when sea ice was still present and extensive. A much reduced peak was observed during late September and early October, when the study areas were ice-free. The fall peak in sighting rates coincided with the timing of formation of a terrestrial walrus haulout. Aerial surveys conducted in the Chukchi Sea in 2013 recorded the first terrestrial walrus haulout near Point Lay on September 12 (Clarke et al. 2014). Acoustic data also recorded concentrations of walrus vocalizations near Point Lay. There was a peak in the detection of walrus vocalizations during September 7–13, followed by four days with few detections, and then a consistently high number of detections starting on September 18 (Delarue et al. 2014).

In five of the six years of CSESP surveys, the highest walrus densities occurred in the Burger study area (particularly in 2011 and 2012), followed by the Statoil study area. Only in 2010 were the densities in Statoil similar to those in Burger. We assume that the concentrations of walruses consistently observed in the Burger study area and extending eastward and northward indicate the presence of a preferred foraging area. The higher overall density and biomass of benthic infauna in the Burger study area than the Klondike and Statoil study areas (Blanchard et al. 2013a, 2013b) and the high biomass of bivalves in the area where we observed the most walruses support this assumption. Telemetry data collected in 2008–2011 also indicated that areas of heavy foraging by walruses in the Chukchi Sea corresponded with areas of reported high benthic biomass (Jay et al. 2012), further supporting our assumption that the availability of food influences the distribution of walruses. We plan to conduct more detailed analyses investigating the relationship between prey availability and the distribution of walruses.

Walruses hauled out on sea ice. CSESP 2013

CONCLUSIONS

- In 2013, the highest density of walruses occurred in the Burger study area, consistent with patterns seen in previous years. Densities of walruses in Klondike and Statoil in 2013 were the highest recorded for those study areas since 2008. The highest density of walruses in Burger was recorded in 2012.
- The highest seasonal density of walruses in 2013 occurred during fall and was within the range of fall densities recorded in previous years. The density of walruses recorded during summer in 2013 was the highest density recorded during summer since surveys began in 2008. In all years except 2009, densities of walruses have been higher in fall than in summer.
- Walruses were not seen continuously during the survey season, but instead occurred in pulses. In 2013, we recorded a summer peak in walrus sighting rates during late August and a fall peak during late September–early October. The summer peak in sighting rates in 2013 was the highest summer peak recorded since surveys began in 2008.
- Concentrations of walruses were observed in the Burger study area in 2013 and in previous years. This area also coincides with a high density and biomass of benthic infauna and a high biomass of bivalves, indicating the presence of a preferred foraging area.

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