

**MARINE MAMMAL DISTRIBUTION AND ABUNDANCE
IN THE NORTHEASTERN CHUKCHI SEA,
JULY-OCTOBER 2008-2010**



L.A.M. AERTS, A. KIRK, C. SCHUDEL, K. LOMAC-MACNAIR,
A. MCFARLAND, P. SEISER, AND B. WATTS

- Page Intentionally Left Blank -

MARINE MAMMAL DISTRIBUTION AND ABUNDANCE IN THE NORTHEASTERN CHUKCHI SEA, JULY-OCTOBER 2008-2010

FINAL REPORT
27 October 2011

Prepared for

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

Shell Exploration & Production Company
3601 C St., Suite 1334
Anchorage, AK 99503

and

Statoil USA E & P, Inc.
3800 Centerpoint Dr.
Anchorage, AK 99503

Prepared by

L.A.M. Aerts, A. Kirk and C. Schudel

OASIS Environmental, Inc.
825 W. 8th Ave., Anchorage, AK 99501

and

P. Seiser (ABR Inc.), K. Lomac-MacNair, A. McFarland and B. Watts (Fairweather Science)

- Page Intentionally Left Blank -

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS	6
SUMMARY	7
1. INTRODUCTION.....	9
1.1. Purpose and Objectives	12
2. STUDY AREAS	12
3. METHODOLOGY.....	13
3.1. Sampling Design.....	14
3.2. Data Collection Protocol.....	15
3.3. Data Analyses.....	16
3.3.1. Species Composition and Number.....	17
3.3.2. Annual and Seasonal Abundance.....	17
3.3.3. Habitat Use and Importance	19
3.3.4. Data Integration and Ecological Relationships	20
4. RESULTS AND DISCUSSION.....	20
4.1. Species Composition and Number	21
4.2. Annual and Seasonal Abundance	27
4.3. Habitat Use and Importance.....	29
4.3.1. Seals (other than bearded seals).....	29
4.3.2. Bearded seals.....	31
4.3.3. Walrus	32
4.3.4. Behavior	32
4.4. Data Integration and Ecological Relationships	34
4.4.1. Visual observations versus Acoustic detections.....	34
4.4.2. Comparison with other marine mammal data.....	38
5. CONCLUSION	43
ACKNOWLEDGEMENTS.....	44
LITERATURE CITED.....	44
APPENDICES	
A: Marine Mammal Sightings Recorded During Acoustic Recorder Deployment and Retrievals	
B: Detection Function Curves of Best Model for Seals and Walrus	
C: Point Density Maps of Bearded Seals, All Other Seals and Walrus in the Klondike, Burger and Statoil Areas for Each Season and Year	
D: Whale and Walrus Sighting Maps Combining Chukchi Sea Aerial Survey (OCSEAP 1982-1991, COMIDA 2008-2010) and Vessel Survey Data (CSESP 2008-2010)	

ACRONYMS AND ABBREVIATIONS

ABWC	Alaska Beluga Whale Committee
ADFG	Alaska Department of Fish and Game
AIC	Akaike's Information Criterion
BOEMRE	Bureau of Ocean Energy Management, Regulation and Reinforcement
CDS	conventional distance sampling
COMIDA	Chukchi Offshore Monitoring in Development Area
COP	ConocoPhillips Company
CSESP	Chukchi Sea Environmental Studies Program
e.g.	exempli gratia (for example)
i.e.	id est (that is)
km	kilometer
km ²	square kilometer
MCDS	multiple covariate distance sampling
mi	mile
mi ²	square mile
MRDS	mark recapture distance sampling
NM	nautical mile
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
Nr	number
NSB	North Slope Borough
OCSEAP	Outer Continental Shelf Environmental Assessment Program
OLF	Olgoonik-Fairweather LLC
USFWS	U.S. Fish and Wildlife Service

SUMMARY

This report summarizes the results of the 2008-2010 marine mammal monitoring study that forms part of the multi-disciplinary Chukchi Sea Environmental Study Program (CSESP). ConocoPhillips Company (ConocoPhillips) initiated this program in 2008, with cofounding and participation of Shell Exploration and Production Company (Shell). Statoil USA Exploration and Production, Inc. (Statoil) joined ConocoPhillips and Shell in 2010 and OLF took over operatorship from ConocoPhillips. The CSESP is ecosystem based, containing various components that include physical and chemical oceanography, plankton, benthic, fish, sea bird, marine mammal and acoustic studies.

The purpose of the marine mammal survey is to develop a baseline that will be used to monitor for potential changes in marine mammal distribution and abundance as a result of natural environmental and anthropogenic influences. This baseline will be established by combining the knowledge about movements, distribution and abundance of marine mammals in the northeastern Chukchi Sea with results from the other CSESP study components. The marine mammal information obtained through the CSESP will also be used in developing mitigation measures for offshore oil and gas developments and for evaluating the effectiveness of these measures.

Biologists recorded all marine mammals sighted along transect lines that covered three study areas (Klondike, Burger, and Statoil) as well as transits between Wainwright and these three study areas from July through October 2008-2010. In 2010, a total of 405 sightings and 515 individuals of four cetacean and four pinniped species were recorded along 8027 line kilometers (4334 NM) or during 519 hours of effort. Pinnipeds were the most frequently observed species group in the northeastern Chukchi Sea in 2010, consistent with results from 2008 and 2009. Whale sightings were rare in the study areas during 2008 and 2009; however, in 2010 a total of 36 sightings of 54 bowheads were observed.

Average densities of seals and walrus on-transect data for each year and area ranged from 0 to 0.126 ind/km² (0 to 0.328 ind/mi²) for ringed seals, 0.006 to 0.036 ind/km² (0.016 to 0.094 ind/mi²) for spotted seals, 0.004 to 0.070 ind/km² (0.01 to 0.182 ind/mi²) for bearded seals, and 0.004 to 0.036 ind/km² (0.01 to 0.094 ind/mi²) for walrus. With the exception of the average ringed seal densities in the Klondike study area in 2008, ringed seal densities on the offshore pack ice of the Chukchi Sea from 1976, 1999, and 2000 data were higher (Burns and Eley 1978, Bengston et al. 2005). The range of average bearded seal densities recorded during this study was similar to those reported for the offshore pack ice in 1999 and 2000 (Bengston et al. 2005). Although comparisons with historical data provide some indications, care should be

taken when comparing densities, due to differences in densities calculations (e.g., with or without correction factors), survey periods (year, seasons), and survey methodologies and protocols.

The higher seal densities in 2008 compared to 2009 and 2010 were related to the presence of sea ice early in the season. However, this was not always apparent for the Burger study area and also not for walrus and therefore sea ice was likely not the only factor determining the distribution of seal species. Earlier studies indicated that seal densities were influenced by ice conditions and biological productivity (Burns and Eley 1978). A link to biological productivity seemed also apparent in this study. For example, the data suggest that benthic-feeding bearded seals and walrus generally were more common in the Burger and Statoil study areas, which are benthic-dominated ecosystems. Pelagic-feeding spotted seal species tended to be more common in the Klondike study area, which is a more pelagic-dominated system affected by waters from the Central Channel. Ringed seals did not show a clear preference. These results indicate that the different oceanographic conditions of the three study areas seem to affect the distribution of some pinnipeds more than others; however, more detailed analyses are required to confirm these relationships.

Initial comparisons between visual and acoustic data showed that the relationship was most apparent for animals that are calling frequently, like bowhead whales. For animals that are not very vocal during a certain time of the year, like bearded seals in August and September, the correlation between acoustic detections and visual sightings was poor. The interpretations of these initial comparisons were difficult to interpret, because biologist observers can only cover a relatively small part of the study area in one day and therefore miss animals that were present in the other part, whereas acoustic recorders detect calls day and night covering most of the study area. A closer look at the visual and acoustic datasets is needed to determine how well comparisons between the two sets can be made and if call behavior of marine mammals can be extracted from the results.

Overall, the data gathered from 2008 to 2010 has provided valuable information on marine mammal abundance and distribution on a relatively local scale. It is not surprising that the variability was high between seasons (July – October) and between years, as many factors play a role in marine mammal movements.

1. INTRODUCTION

Marine mammal research in the Chukchi Sea has a history spanning at least 30 years. In 1975, the Department of the Interior initiated the Outer Continental Shelf Environmental Assessment Program (OCSEAP) to establish an environmental baseline for the Beaufort and Chukchi Seas. The objective was to use this dataset for predicting and mitigating potential impacts from oil and gas exploration and development. Since 1975, several marine mammal studies were conducted under the OCSEAP program. The Alaska Department of Fish and Game (ADFG), National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), and U.S. Geological Survey (USGS) implemented extensive ice seal, walrus and whale studies to obtain information on distribution, feeding ecology and behavioral aspects (e.g., Burns and Eley 1978, Burns et al. 1981, Burns and Seaman 1986, Gilbert 1989, Gilbert et al. 1992, Lowry et al. 1978, 1980a, 1980b, 1981). The Minerals Management Service (MMS¹) started aerial surveys in the Bering, Chukchi and Beaufort seas in 1979 under the OCSEAP. The primary objective was to study bowhead whale migration, distribution and abundance, but other marine mammal sightings were also recorded (e.g., Clarke et al. 1989, Ljungblad et al. 1984, 1986, 1987). The bowhead whale aerial survey program in the Beaufort Sea (BWASP) has been flown annually since 1979 and comprises more than 30 years of data (Clarke and Ferguson 2010a). Aerial bowhead whale surveys in the Chukchi Sea were flown from 1989 to 1991 (Moore and Clarke 1993) and were re-initiated again from 2008 to 2010 under the Chukchi Offshore Monitoring in Development Area (COMIDA)² program after a 17-year lapse (Clarke and Ferguson 2010b). The North Slope Borough (NSB), in cooperation with the Alaska Beluga Whale Committee (ABWC) and National Marine Fisheries Service (NMFS), started beluga movement and satellite studies in 1996; these studies are ongoing (Suydam et al. 2001, 2005). Other marine mammal monitoring programs, including acoustic surveys, occurred in the Chukchi Sea from 1989 to 1991 in conjunction with industrial activities (e.g., Brueggeman et al. 1990, 1991, 1992a, 1992b). All these surveys have provided valuable information on marine mammal ecology and distribution in the Bering, Chukchi and Beaufort Seas.

The intensity of marine mammal research in the Chukchi Sea was reduced in the early 1990s to 2000, but has increased again in recent years. This is mainly due to a renewed interest in offshore oil and gas activities, but also because of possible threats on the Arctic marine ecosystem from climate change. The USGS implemented a walrus radio and satellite tagging

¹ In 2010 the Minerals Management Service (MMS) was renamed to the Bureau of Ocean Energy Management, Regulation and Reinforcement (BOEMRE).

² The COMIDA project includes other components besides marine mammal aerial surveys, such as chemical, benthic and fish surveys.

program in 2006 to track their movements and haul-out behavior (Jay et al. 2006, Udevitz et al. 2009). Hunters from various villages bordering the Chukchi Sea have been an integral part of these tagging efforts. Walrus tagging also took place under a US-Russian collaborative effort (Speckman et al. 2010). Satellite tagging studies of young bearded seals were initiated in 2004 by the Native Village of Kotzebue (with an USFWS Tribal Wildlife Grant), and expanded in 2007 and 2009 to include adult bearded seals and ringed seals. The project was designed as a cooperative effort between biologists and local Kotzebue-area hunters, combining local knowledge about the distribution and habits of bearded seals with the knowledge of biologists about how to catch and tag seals and to analyze data recorded by the tags (Cameron et al. 2010). Distribution and abundance of seals in the Chukchi Sea were also monitored using aerial surveys (e.g., Bengtson et al. 2005), as were polar bears (Evans et al. 2003). Various studies on bowhead whales were initiated recently, such as the satellite tagging project that started in 2006 (Quakenbush et al. 2010) and the bowhead feeding study, BOWFEST, that has been ongoing since 2007 and focuses on late summer oceanography and prey densities relative to whale distribution over continental shelf waters within 100 miles north and east of Point Barrow (e.g., Goetz et al. 2010, Rugh et al. 2009).

Monitoring seasonal abundance and distribution of marine mammals using passive acoustic detection methods has become increasingly popular. Bottom mounted acoustic recorders have been deployed throughout the northeastern Chukchi Sea during all seasons by various research parties and have provided useful insights in marine mammal movements and occurrence (e.g., Berchok et al. 2009, Hannay et al. 2011, Martin et al. 2009, Moore et al. 2006).

In addition to the studies mentioned above, ConocoPhillips initiated an interdisciplinary research program in 2008, with cofounding and participation of Shell, focusing on their respective offshore lease areas. The Chukchi Sea Environmental Studies Program (CSESP) is ecosystem based, containing various components that include physical and chemical oceanography, planktonic, benthic, fish, sea bird, marine mammal and acoustic studies. Statoil joined ConocoPhillips and Shell in this effort in 2010, and OLF took over operatorship from ConocoPhillips. Independent of this program, ConocoPhillips and Shell conducted nearshore marine mammal aerial surveys and vessel-based offshore marine mammal observations during 2006 through 2009 as part of their monitoring and mitigation program for seismic and shallow hazard surveys (e.g. Brueggeman et al. 2009a, Funk et al. 2008, 2009, Ireland et al. 2009). Statoil implemented a vessel-based marine mammal monitoring program in 2010 during its seismic survey (Blees et al. 2011).

The above-mentioned studies, combined with other research, have resulted in increased knowledge of marine mammal abundance and distribution in the northeastern Chukchi Sea and have shown the spatial and temporal variability in abundance and distribution is very large. This report summarizes results of CSESP marine mammal monitoring survey from 2010 in comparison with the 2008 and 2009 data in the three offshore lease areas of interest to ConocoPhillips, Shell and Statoil. The three study areas, Klondike, Burger and Statoil, discussed in this report are shown on Figure 1.

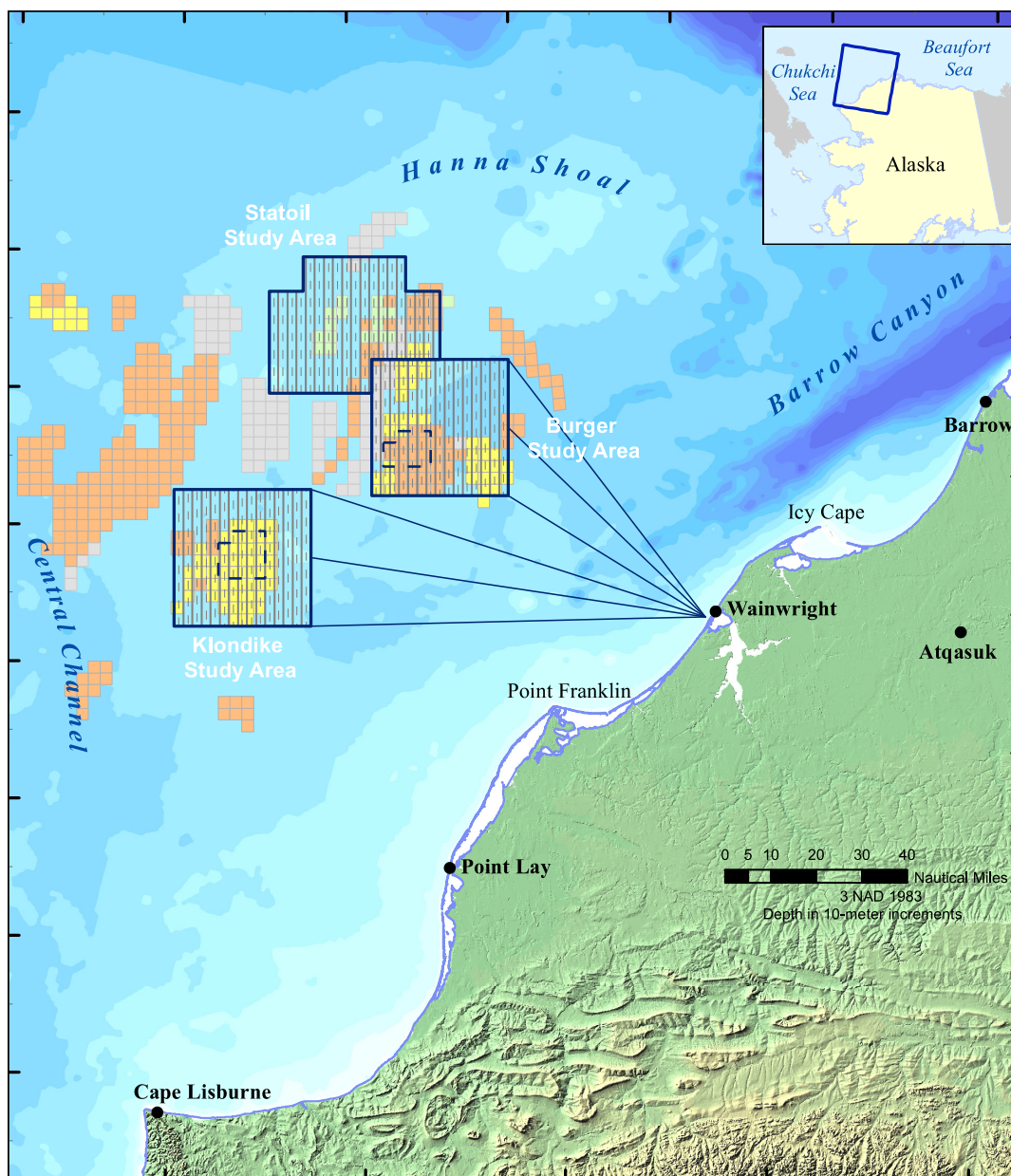


FIGURE 1: LOCATION OF THE THREE STUDY AREAS IN THE NORTHEASTERN CHUKCHI SEA, INCLUDING THE TRANSIT LINES TO WAINWRIGHT. MARINE MAMMAL SURVEYS IN THE STUDY AREAS WERE CONDUCTED ALONG TRANSECT LINES IN NORTH-SOUTH DIRECTION.

1.1. Purpose and Objectives

The purpose of this marine mammal study conducted during the summer/fall seasons (July – October) is to increase current knowledge about abundance and distribution of marine mammals in the Chukchi Sea lease areas of ConocoPhillips, Shell and Statoil. This information, combined with results from physical and chemical oceanography, plankton, benthos, fish, sea bird, and acoustic studies, will contribute to developing a baseline for determining potential changes in marine mammal distribution and abundance as a result of natural environmental and anthropogenic influences. The marine mammal information obtained through the CSESP will also be used in developing mitigation measures for offshore oil and gas exploration and development and for evaluating the effectiveness of these measures.

There are four general objectives identified to achieve this main goal.

1. Determine marine mammal species composition for each study area;
2. Determine the annual and seasonal abundance of marine mammal species within the study areas;
3. Identify habitat use and importance of the study areas for marine mammals, based on distribution and behavioral data (e.g. feeding areas, migration routes); and
4. Integrate results with the other components of the CSESP (i.e., chemical and physical oceanography, plankton, benthic, fish, sea birds and acoustic information) to increase our understanding of ecological relationships.

Objectives 1, 2, and 3 are discussed in this report. Objective 4 is only partially addressed, because specific analyses have not been conducted yet. It is anticipated to present more detailed analyses in future publications.

2. STUDY AREAS

The location, size and shape of the study areas were chosen based on the Chukchi Sea offshore lease areas of interest to ConocoPhillips, Shell and Statoil. There were three separate study areas identified (Figure 1).

1. *Klondike study area*, ConocoPhillips. A square study area of 30 × 30 nautical mile (NM) (900 square nautical miles [NM²]) in size that includes the historical well site Klondike as well as potential future drill sites. This study area is located approximately 120 NM (220 kilometer [km]) northwest of Wainwright.

2. *Burger study area*, Shell. A square study area of 30 × 30 NM (900 NM²) in size that includes historical as well as potential future drill sites. This study area is located approximately 55 NM (100 km) northwest of Wainwright.
3. *Statoil study area*, Statoil. An irregular shaped study area of 900 NM² in size that includes potential future drill sites. This study area is located approximately 130 NM (240 km) west of Barrow. The Statoil study area was added to the CSESP in 2010.

Within the Klondike and Burger study areas, core areas were identified as being of greatest interest for exploration (Figure 1). The core area in the Klondike study area is about 100 NM² (345 km²) in size, and the core area in the Burger study area is about 74 NM² (253 km²) in size. In addition to the three study areas, marine mammal observations were also conducted during transits to and from Wainwright for crew changes and/or supply delivery. Three lines extended from the Klondike study area to Wainwright, and three from the Burger study area to Wainwright (Figure 1). Transit from the Statoil study area to Wainwright occurred along the transit lines that were running from the Burger study area. Opportunistic observations were conducted when the vessel was transiting to or from Nome and during buoy deployments and retrievals.

Despite the relative close proximity of the three study areas to one another, 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 in 2008 and 2009 showed that the water masses in the Klondike study area were generally warmer and less saline than in the Burger study area (Weingartner & Danielson 2010). The extent of these temperature and salinity differences varied from year to year, depending on factors such as sea ice cover and prevailing wind speed and direction. These different physical characteristics are reflected by differences in planktonic, benthic, and seabird communities (Blanchard et al. 2010, Hopcroft et al. 2010, Gall and Day, 2010). Marine mammal distribution appeared to be highly variable, with pinniped abundance mostly correlated with the presence of sea ice, i.e., higher numbers of seals and walrus were observed in 2008 than in 2009 (Brueggeman et al. 2009b, 2010).

3. METHODOLOGY

This section briefly outlines the methods and observation protocols used during the 2010 marine mammal survey. Generally, the observation protocol is similar to that used in 2008 and 2009 and also to other vessel-based marine mammal programs conducted in the Chukchi Sea. In 2010, the observation platform consisted of two vessels, the *R/V Westward Wind*, and the



FIGURE 2: RESEARCH VESSELS *R/V NORSEMAN II* (LEFT) AND *R/V WESTWARD WIND* (RIGHT) WERE USED AS PLATFORM FOR MARINE MAMMAL OBSERVATIONS IN 2010.

R/V Norseman II (Figure 2). Only one vessel was used in 2009 and 2008, with the *R/V Westward Wind* in 2009 and the *M/V Bluefin* in 2008.

3.1. Sampling Design

Two biologists experienced in conducting Arctic marine mammal observations were aboard the vessel. At least one biologist observer watched for marine mammals during daylight hours from the bridge or flying bridge. Also present on the vessel was an Inupiat communicator, who assisted with marine mammal observations. The Inupiat communicator recorded all marine mammals sighted during buoy deployments and retrievals, as no biologist observers were available during these activities. The biologist observer recorded all marine mammals sighted along transect lines in each of the three study areas, and along transect lines from the study areas to Wainwright during crew changes and resupply trips. Two types of transect lines were distinguished in the study areas; primary and secondary lines, both oriented in a north-south direction (Figure 1). The spacing between the primary transect lines was 2 NM, with a total line length of 480 NM (Klondike and Burger study area), and 465 NM (Statoil study area). The Klondike and Burger study areas included 16 primary transect lines of 30 NM each, and the Statoil study area included 19 primary transect lines (8 lines of 30 NM, 8 lines of 22.5 NM and 3 lines of 15 NM in length). Secondary transect lines were placed at 1 NM distance from the primary transect lines and were only surveyed when primary transect lines were not accessible (e.g., due to presence of sea ice) or if time allowed extra transect lines to be surveyed.

In 2010, observations along all primary transect lines were completed twice (in August and September) in the Klondike and Statoil study areas, and three times in the Burger study area (August, September, and October). In 2008 and 2009, the Klondike and Burger study areas were both covered three times. It took a minimum of five days to complete a full marine mammal

survey in one study area, assuming an average cruising speed of 8-9 knots, ideal weather conditions, and at least 12 hours of daylight.

3.2. Data Collection Protocol

The biologist observers systematically scanned an area of 180° centered on the vessel's trackline with the naked eye and Fujinon 7×50 reticle binoculars, while the vessel moved along the tracklines with a constant speed of 8-9 knots (Figures 1 and 3). Fujinon 14×40 gyroscopically-stabilized binoculars were available to verify species identification and behavior when needed. A Canon SLR camera with a 120-400 mm zoom lens was also available for capturing photographs of marine mammals and provided an additional tool for marine mammal identification. Marine mammal observations were conducted for 12 to 14 hours/day, depending on weather conditions, day length, and the schedule of other scientific activities on the vessel. The biologist observers alternated watches every two hours to avoid fatigue. The biologist observers entered and stored all data on Panasonic Toughbook™ computers using TigerObserver™ data acquisition software that was specifically developed for this science program. Upon sighting a marine mammal (or group of animals) the biologist observer on watch recorded the following information:

- *Sighting info*: species, group size, number of juveniles, heading, bearing and distance of the animal relative to the vessel, behavior, movement, pace, sighting cue, identification reliability, and person who sighted the animal;
- *Environmental data*: sea state, ice cover (10% increments), visibility, and sun glare; and
- *Other*: the position(s) of any other vessel(s) in the vicinity of the research vessel.



FIGURE 3: MARINE MAMMAL OBSERVERS SCANNING THE AREA FROM THE *M/V BLEUFIN* IN 2008 (LEFT) AND THE *R/V NORSEMAN II N* IN 2010 (RIGHT).

Distances to marine mammals were estimated visually or with reticle binoculars for which distance conversion factors were known. A rangefinder and clinometer were also available and used when needed.

Environmental data (such as sea state, ice cover, visibility, and sun glare), can affect the probability of detecting marine mammals. The biologist observers recorded environmental data at the start of each transect line and whenever there was an obvious change in one or more of those variables. All environmental and marine mammal observations were directly entered in a computer using TigerObserver software system.

Observations were deemed unsuitable when (i) sea states exceed Beaufort scale 5, because the probability of detecting marine mammals in high seas was too low or (ii) visibility along the transect lines was less than 300 m. In these cases transect lines were rerun under better conditions.

As in 2009, navigation based software (TigerNav™) was used to record all vessel information on a real time basis. This information included date, time, vessel position, speed, water depth, sea surface temperature and salinity, and weather. Both TigerObserver and TigerNav were synchronized to a server system present on the vessel, which automatically linked all marine mammal sighting data to the relevant navigational and weather data.

3.3. Data Analyses

Environmental and marine mammal data recorded during the survey were divided into three categories and, depending on the objective, different subsets of the data were analyzed. The three categories are as follows:

- On-transect data: includes all observations made while the vessel was traveling on high- or low-priority transect lines within the study areas.
- Off-transect data: includes all other observations, such as data collected on the transect connectors, on transits to and from Wainwright, on other travel within the study areas, and on other travel outside the study areas.
- Non-effort data: includes all records of marine mammal sightings without associated effort data. The majority of the acoustic recorder deployment and retrieval data fall within this category.

The sections below describe in more detail the analytical approach used to address the objectives of this study.

3.3.1. Species Composition and Number

To obtain the first objective (i.e., to determine what marine mammal species occur in the area), data from all three categories were used. The entire dataset was used to analyze the survey conditions. Figures displaying number of sightings or number of marine mammals per unit of effort were developed using on- and off-transect data only. Correction for effort was needed to compare data between years, season and study areas.

3.3.2. Annual and Seasonal Abundance

The second objective (i.e., to determine the annual and seasonal abundance of marine mammal species within the study areas), was achieved using corrected species densities (or species groups) calculated for each year, season and study area using only on-transect data. Calculating abundance of marine mammals using sighting information from vessel-based line transect surveys can result in an underestimation due to two types of detection bias (Marsh and Sinclair 1989):

1. Availability bias: this represents undercounting animals because they were not available for detection, e.g., they were not at the sea surface and could therefore 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 location on the vessel and vessel survey speed) and on the behavior of the marine mammal species (such as surface time, dive cycle, activity).
2. Perception bias: this 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, distance to the observer, glare, fatigue, etc.

The number of animals missed because they were not available for detection was not taken into account in the density estimates presented in this study. The assumption was made that all animals available at distance zero from the observer, this is on the transect line, were detected [$g(0)=1$]. The amount of animals missed due to perception bias was calculated using distance sampling methodology (Buckland et al. 2001; Buckland et al. 2004). Program Distance 6.1 release 1 (Thomas et al. 2010) was used to analyze effects of distance and environmental factors (e.g., sea state, visibility) on the probability of detecting marine mammal species. The program was also used to model a detection function that provides an estimate of detection probability of animals at different perpendicular distances from the transect line. The analyses for calculating densities consisted of various steps.

The first step involved exploratory analyses of the 2010 dataset to find the most optimal model for estimating the detection function for each species (or species group). These exploratory analyses included a subset of the data, based on the following criteria:

- Only on-transect data were used. These are the observations made while traveling along primary and secondary transect lines (and transit lines), since observations made along these lines meet the assumptions of line transect theory.
- Only sightings with similar sighting cues, and thus equal detection probability were used. This resulted in:
 - Exclusion of sightings on ice (only applicable to 2008), because the detection probability of marine mammals on ice or in water varies greatly. For example, seals and walrus hauled-out on ice are easier to detect than those in water (they appear longer at the surface, often occur in larger groups, complete body is visible, etc.). The total number of sightings on-transect and on ice was too low for calculating a separate detection function for on ice sightings (seals $n=5$, walrus $n=7$).
 - Grouping of species of similar size, behavior, and color for datasets with low sample sizes. This means that for calculating the detection function $g(x)$ all seal species were grouped together and walrus data was treated separately.

The exploratory analyses with the 2010 dataset were conducted using the Conventional Distance Sampling (CDS) and Multiple Covariate Distance Sampling (MCDS) analyses engines from Program Distance 6.1. First the data were run using CDS, and because no acceptable fit could be found, MCDS models were run introducing covariates into the model. Various strategies for truncation of perpendicular distances and binning of other covariates were tested. The fit of all models was assessed with diagnostic plots, the Kolmogorov goodness-of-fit test, and the Akaike's Information Criterion or AIC (Buckland et al. 2001), provided by the distance software as part of each model output. The model type and covariates of the best fitting model for the 2010 dataset was then compared with those from 2008 and 2009. The best fitted model appeared to be the same for each year, hence the same model was run for the combined 2008-2010 datasets (using the same criteria mentioned above) to increase sample size. In case the best fitted model and covariates would have been different for each year, the different detection functions estimated for each year separately would have been applied to the data of that year.

The second step involved calculation of corrected densities for each seal species separately, using the detection function of the most optimal model. For this purpose the input parameters of the best fitted model were entered into the distance sampling model portion of the Mark Recapture Distance Sampling (MRDS) engine in Program Distance to fit a detection

function to the data. With the MRDS engine it is possible to apply the estimated detection function of the most optimal model to a subset of the data; in this case to specific seal species, study areas, and year. Due to low sample sizes, densities of each seal species could not be reliably estimated for each season within a year. Corrected density estimates and 95% confidence intervals for each species were then generated by running a separate analysis that applied the common detection to each specific species. The density equation for line transects from Buckland et al. (2001) was used for estimating densities.

$$\hat{D} = \frac{n \cdot \hat{E}(s)}{L \cdot \hat{P}_a}$$

where \hat{D} is the corrected density of a species or species group in number per km²; n is the number of sightings; $\hat{E}(s)$ is the mean cluster size of the sightings; L is the total length of the transect lines sampled (in kilometers), and \hat{P}_a is the probability of detection estimated by the model.

The large percentage of seal sightings classified as ringed/spotted seals (RSS – meaning it was either a spotted or a ringed seal) and unidentified seals (US – meaning it could be any of the four seal species observed) had to be taken into account to avoid an underestimation of densities for each separate seal species. The ratio of ringed versus spotted seal densities for each study area and year was used to estimate the proportional density of each of these two species from the combined ringed/spotted seal densities. This estimated proportional density was then added to the observed densities. The same method was used to proportionally divide the unidentified seal sightings over spotted, ringed, and bearded seal sightings. Applying the ratio of identified seal species to the unidentified individuals assumes that the disability of identification is similar for each species. Considering the conditions of these occurrences, this is very likely to be true. The adjustment increased densities for each species, but did not change observed trends in occurrence.

3.3.3. Habitat Use and Importance

The third objective identifies habitat use and the importance of the study areas for marine mammals, based on distribution and behavioral data (e.g., feeding areas, migration routes). Point density maps of on-transect sightings were developed to determine concentrations of bearded seals, all other seals, and walrus within the study areas for each season and year. These point density maps were created in ArcGIS10.0's Spatial Analyst extension, with a 5 km circular buffer around each sighting and weighted by the number of individuals observed. These point densities were not corrected for effort or availability and perception bias.

3.3.4. Data Integration and Ecological Relationships

The fourth objective is intended to integrate results of the marine mammal survey with other components of the CSESP to increase the understanding of ecological relationships. It includes detailed analyses integrating the benthic and fish data to determine to what extent the distribution of seals and walrus is related to possible food sources. These detailed analyses have not yet been conducted, but are planned for a later date and will be presented in separate publications.

Visual marine mammal data were compared to acoustic call detections. As an initial exploration, the number of individual bowheads, walrus and bearded seals observed per day in the study area were plotted against the total number of calls detected that same day in that specific study area. The call data were based on a manual analysis of 5% of the data from the recorder with the highest call detections. The 5% analysis protocol has been shown to provide an accurate representation of the acoustic occurrence of marine mammals that call frequently, such as walrus and bowhead whales. Reviewing 5% of the data usually underestimates occurrence of species with low calling rates.

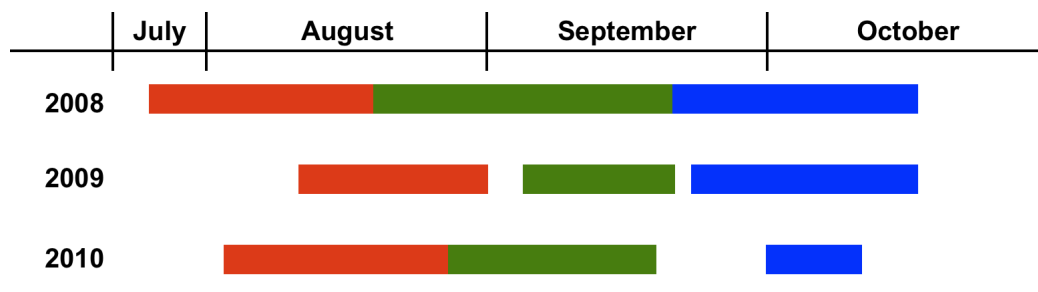
The 2008-2010 CSESP marine mammal data were compared to other marine mammal observations in the Chukchi Sea, where available. Walrus and whale sightings from the Chukchi Sea 1982-1991 OCSEAP and 2008-2010 COMIDA aerial surveys were obtained and plotted with the CSESP marine mammal data. Additional comparisons of other marine mammal observations were based on information available from literature and reports.

4. RESULTS AND DISCUSSION

Systematic marine mammal surveys were conducted during three separate cruise periods each year defined as Jul/Aug, Aug/Sep and Sep/Oct. Table 1 summarizes the periods of the three marine mammal cruises for 2008, 2009, and 2010. Both the Klondike and Burger study areas were sampled during all three cruise periods in 2008 and 2009. The Statoil study area was added to the study in 2010, during which the Klondike and Statoil study areas were covered during the first two cruise periods and the Burger study area during all three cruise periods. Inupiat Communicators, who were present on both vessels during the entire 2010 season, assisted with the observations and also recorded marine mammal data during acoustic recorder deployments and retrievals. This data was not collected according to predefined line transects, but provided additional information on marine mammal occurrence.

TABLE 1: SUMMARY OF CESP RESEARCH CONDUCTED IN THE NORTHEASTERN CHUKCHI SEA IN 2008-2010.

Description	Year	Start date	End date	Referred to as
Physical oceanography, plankton and benthic sampling. Seabird and marine mammal line transect surveys.	2008	23 Jul	18 Aug	Jul/Aug
	2009	12 Aug	30 Aug	
	2010	3 Aug	27 Aug	
Physical oceanography, plankton, benthic and fish sampling. Seabird and marine mammal line transect surveys	2008	19 Aug	22 Sep	Aug/Sep
	2009	4 Sep	22 Sep	
	2010	28 Aug	19 Sep	
Physical oceanography, ocean acidification and plankton sampling. Seabird and marine mammal line transect surveys.	2008	22 Sep	12 Oct	Sep/Oct
	2009	23 Sep	17 Oct	
	2010	1 Oct	8 Oct	



4.1. Species Composition and Number

Table 2 summarizes the number of sightings and number of individuals of all marine mammal species observed in the northeastern Chukchi Sea during the 2010 survey. Table 3 and Figure 4 summarize the observer effort for 2010 in comparison with 2008 and 2009.

TABLE 2: MARINE MAMMAL SPECIES AND NUMBER OF SIGHTINGS AND INDIVIDUALS OBSERVED IN 2010 WITHIN THE STUDY AREAS, BETWEEN STUDY AREAS AND WAINWRIGHT TRANSIT.

	Klondike		Burger		Statoil		Wainwright Transit		Other*		Total	
	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind	Sight	Ind
Pinnipeds												
Walrus	4	7	29	56	11	19	9	38	2	11	55	131
Spotted Seal	5	5	9	9	2	2	5	5	3	3	24	24
Ringed Seal	8	8	-	-	3	3	3	3	-	-	14	14
Ringed/Spotted Seal	20	20	14	14	14	15	18	18	1	1	67	68
Bearded Seal	8	8	41	41	52	54	9	9	2	2	112	114
Unid. Seal	15	15	24	24	10	10	14	15	-	-	63	64
Unid. Pinniped	3	3	4	4	4	4	3	3	-	-	14	14
Total Pinnipeds	63	66	121	148	96	107	61	91	9	18	349	429
Cetaceans												
Bowhead Whale	-	-	23	32	1	2	12	20	-	-	36	54
Gray Whale	-	-	1	2	-	-	12	16	1	1	14	19
Humpback Whale	-	-	-	-	-	-	-	-	2	7	2	7
Unid. Whale	1	1	2	2	-	-	-	-	-	-	3	3
Harbor Porpoise	1	3	-	-	-	-	-	-	-	-	1	3
Total Cetaceans	2	4	26	36	1	2	24	36	3	8	56	86
Total	65	70	147	184	97	109	85	127	11	25	405	515

*Numbers do not include observations during acoustic recorder deployment and retrieval and Nome transits.

TABLE 3: SURVEY EFFORT OF 2010 MARINE MAMMAL OBSERVATIONS WITHIN AND BETWEEN THE THREE STUDY AREAS AND DURING WAINWRIGHT TRANSITS. EFFORT FOR BUOY CRUISES AND NOME TRANSITS WAS NOT AVAILABLE. KM = KILOMETER, NM = NAUTICAL MILE, HR = HOUR.

	Effort (km)	Effort (NM)	Effort (hr)
Klondike	1979	1069	135
Burger	2977	1608	193
Statoil	1834	990	121
subtotal	6790	3667	449
Wainwright transit	825	445	39
Other	412	222	31
subtotal	1237	667	70
Total	8027	4334	519

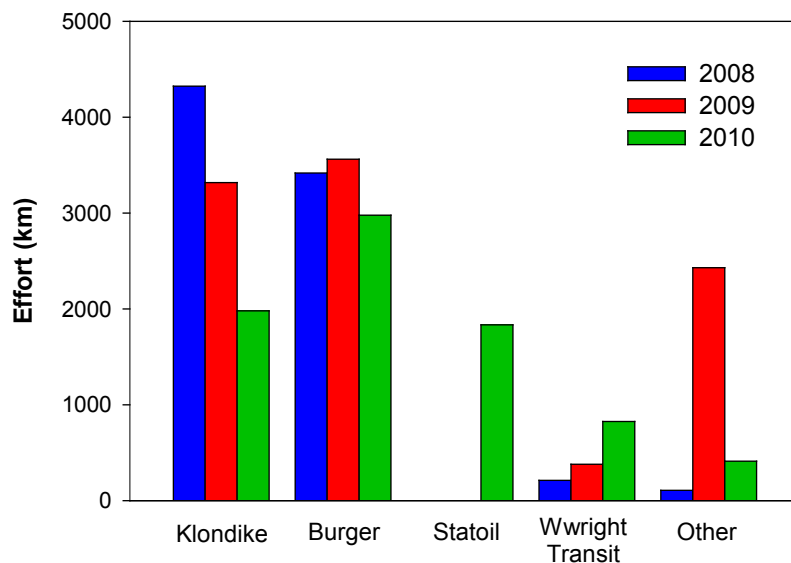


FIGURE 4: SURVEY EFFORT IN KILOMETERS OF 2010 MARINE MAMMAL SURVEY COMPARED TO 2008 AND 2009. NOTE THAT IN KLONDIKE AND STATOIL THERE WAS NO MARINE MAMMAL SURVEY IN OCTOBER 2010.

A total of 405 sightings and 515 individuals of four cetacean and four pinniped species were recorded along 8027 line kilometers (4334 NM) or during 519 hours of effort. An additional 93 sightings of 131 individuals were recorded during acoustic recorder deployment and retrieval (23-31 July and 9-16 October 2010) and during the Nome-Wainwright transit on 7 and 8 September. The observations during buoy deployment and retrieval included 24 walrus sightings of 55 individuals, 32 ringed and nine bearded seals. Polar bears were sighted three times at the end of July, with two sightings of one animal on sea ice and one sighting of an animal in the water. Six sightings of seven bowheads and nine spotted seals were observed in October (Appendix A). During the Nome transit one humpback whale, one minke whale and two killer whale sightings of eight animals were recorded.

Seals and walrus were the most frequently observed species in the northeastern Chukchi Sea in 2010, consistent with results from 2008 and 2009. Whale sightings were rare in the study areas, with the exception of bowhead whales. One sighting of two bowhead whales was

observed in the Statoil study area on 17 September 2010. The remaining 35 sightings of 52 bowhead whales were observed in the Burger study area and along the Burger-Wainwright transect line from 6 to 8 October, with 8 October being the last day of the survey. These sightings coincide with an increase in bowhead whale calls in the Burger study area starting 6 October with almost non-stop detections until the recorders were retrieved on 12 October (Julien Delarue, pers. comm.). Note that no marine mammal surveys were conducted in the Klondike and Statoil study areas during October 2010. Most gray whales were observed in nearshore waters close to Wainwright, similar to the previous two years.

In 2010, the survey effort was highest in the Burger study area, because of the October survey (Table 3 and Figure 4). The survey effort was fairly similar among the three years in the Burger study area (Figure 4). The 2010 effort in the Klondike survey area was reduced compared to 2008 and 2009, because there was no survey in October. The Statoil study area was only surveyed during two periods, and was similar in effort to the Klondike study area in 2010. The survey effort of the category “other” in 2009 is much higher than in 2008 and 2010 because it includes observations made during transits to and from Nome and most of the observations from acoustic recorder deployment. Records of effort during transits to and from Nome or during acoustic recorder deployment and retrieval in 2008 and 2010 were mostly absent, because marine mammal observations during these activities were of an opportunistic nature.

Figure 5 shows all on- and off-transect sightings (including on ice sightings) per 100 kilometer effort of bearded seals, ringed/spotted seals, walrus and all whale species for the Klondike and Burger study areas, split out for each year. Data of ringed and spotted seals were combined because no species distinction could be made for a large number of sightings. No sampling occurred in the Statoil study area in 2008 and 2009 and as such this area is not included in Figure 5. In the Klondike study area the number of ringed/spotted sightings was clearly highest in 2008. Because the average cluster size of ringed/spotted seals was also larger in 2008 (1.3 seal per sighting), this difference was even greater for number of individuals. The number of unidentified seal sightings resembled very much that of the ringed/spotted seals. In the Burger study area the number of ringed/spotted and unidentified seal sightings in 2008 was not much different compared to 2009 and 2010.

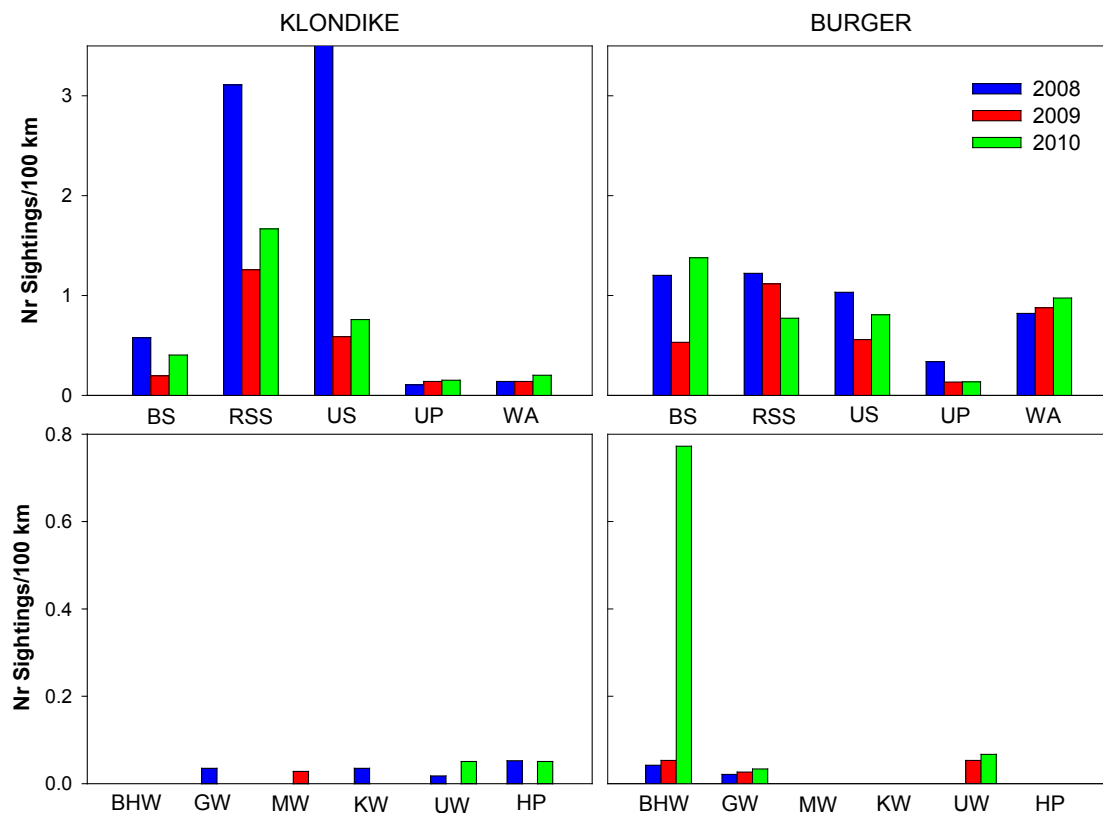


FIGURE 5: NUMBER OF PINNIPED (UPPER) AND CETACEAN (LOWER) SIGHTINGS PER 100 KM IN 2008, 2009 AND 2010 IN KLONDIKE (LEFT) AND BURGER (RIGHT). STATOIL STUDY AREA IS NOT INCLUDED, AS IT WAS NOT SURVEYED IN 2008 AND 2009. BS=BEARDED, RSS=RINGED/SPOTTED, AND US=UNID SEAL, UP=UNID PINNIPED, WA=WALRUS, BHW=BOWHEAD, GW=GRAY, MW=MINKE, KW=KILLER WHALE, AND UW=UNID WHALE, HP=HARBOR PORPOISE.

The number of bearded seal sightings (and cluster size) in the Klondike study area did not show much difference between years. There was a difference in the number of bearded seal sightings between the study areas, however, with greater numbers in the Burger study area than in the Klondike study area. This was the opposite for ringed/spotted seals, i.e. greater number of sightings in the Klondike study area than in the Burger study area. In 2008, when sea ice was present in the Klondike study area until early September and in the Burger study area until mid-September, most seals were sighted during the Jul/Aug period. During the low ice years (2009, 2010) most seals were sighted in the Aug/Sep period.

The number of walrus sightings per kilometer was very similar between years for each study area, however, walruses were more abundant in the Burger study area than in the Klondike study area in all three years. Although the number of sightings is relatively constant in the Burger study area in all three years, the average cluster size varied greatly. In 2008, the average group size per sighting was 24 animals compared to two animals per sighting in 2009 and 2010. The high average group size of walrus in 2008 is due to large aggregations of walrus observed on the sea ice. In a total of eight on-ice sightings in the Burger study area, ~860 individuals were observed. This included one off-transect sighting of an estimated 700 walruses.

Large aggregations of walrus on sea ice were not observed in the Klondike study area, where they were sighted in groups averaging three animals in 2008, 1.5 in 2009 and two in 2010.

In conclusion, ringed/spotted seals were more abundant in the Klondike study area than in the Burger study area, especially in 2008, which was a year with high ice cover. Bearded seal abundance did not appear to be influenced by the presence of sea ice within or in close proximity to the Klondike and Burger study areas; the number of sightings between years was very similar for both study areas. However, bearded seals were more abundant in the Burger study area than in the Klondike study area. The same was true for walruses. Due to a few large aggregations of walruses observed on the sea ice that was present within the Burger study area until mid-September, the number of individual walruses was much higher in 2008 than in 2009 and 2010. Both 2009 and 2010 were low ice years for the northeastern Chukchi Sea during the period from August through mid-October.

Bowhead whales were primarily sighted in the Burger study area, but in 2010 they were also observed along the Burger-Wainwright transect line and in the Statoil study area (see Table 2A). In 2010, more bowhead whales were sighted than in the previous two years. All sightings in all three years were observed in early October, with the exception of the sighting of two animals in the Statoil study area on 17 September 2010. This higher number of bowhead sightings in 2010 coincides with an increase in number of call detections in the Burger study area during the same period. Calls were also detected in early October of 2008 and 2009, but not as frequent as in 2010 (Julien Delarue, pers. Communication). Section 4.4.1 provides additional information on whale calls and sightings.

Survey Effort

Environmental parameters can influence the effectiveness with which the biologist observers were able to detect animals. In 2010, the majority of observations (~70%) took place when visibility was 3.5 km or more, with about 50% of the observations recorded with visibility of 8 km or more. Beaufort windforce scale 3 was the most regular occurring sea state during 2010 (Figure 6). This corresponds to a wind speed of 7 to 10 knots and wave height of 2 to 3 feet. Sea state and visibility conditions in 2010 were very similar between study areas and seasons.

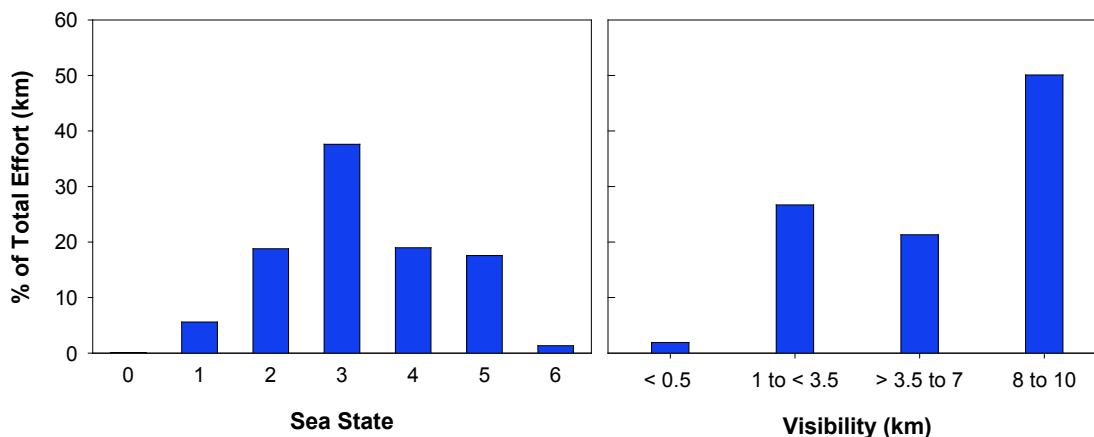


FIGURE 6: PERCENTAGE OF TOTAL OBSERVATION EFFORT FOR VARIOUS VISIBILITY AND SEA STATE CONDITIONS. VISIBILITY IS IN KILOMETERS, SEA STATE IN BEAUFORT WINDFORCE SCALE.

Figure 7 shows the number of sightings per kilometer effort for whales, walrus and seals for each sea state and visibility category in 2010. This figure shows that the number of seal sightings per kilometer increases with lower sea states, but not with higher visibilities. This was also true for walruses, though this relation was not apparent anymore for sea states lower than 2. So, the ability to detect seals and walruses was more determined by sea state than by visibility. The most common sighting cue for seals is their head, which is generally present at the sea surface for a limited amount of time. Higher sea states will hamper detection of seals, even when the visibility is high. The main reason that visibility conditions did not show a clear pattern with number of seal or walrus sightings is that the majority was sighted at distances of 1 km or less (Figure 8). Whales were generally sighted at distances of 1 km or more, during visibility conditions of 8 km or more and sea states of 4 or less. The blow was the most common sighting cue for whale observations.

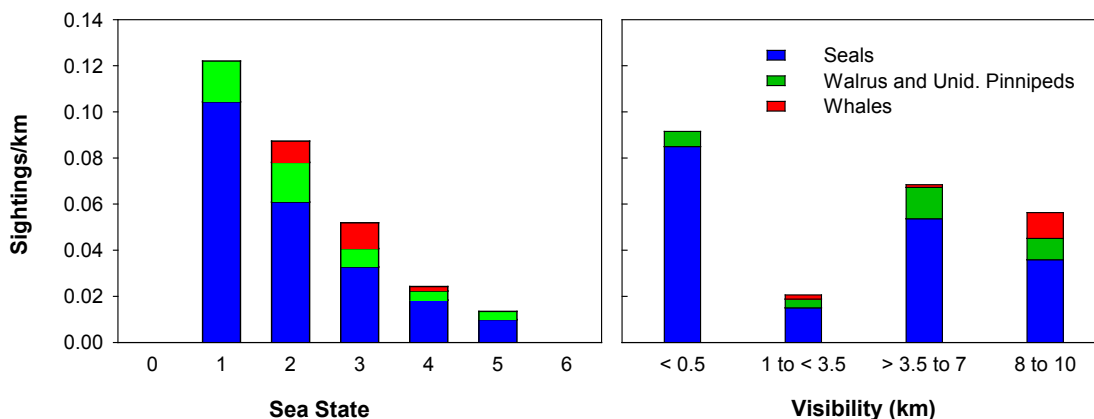


FIGURE 7: SUMMARY OF NUMBER OF SEAL, WALRUS (+UNIDENTIFIED PINNIPEDS) AND WHALE SIGHTINGS PER LINE KILOMETER FOR EACH SEA STATE AND VISIBILITY CATEGORY.

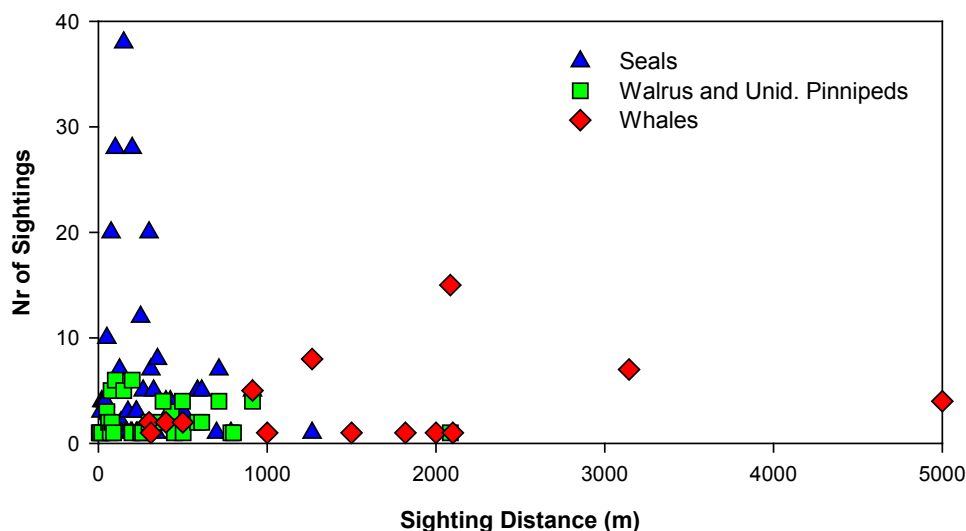


FIGURE 8: NUMBER OF SIGHTINGS PER (RADIAL) SIGHTING DISTANCE FOR PINNIPED (SEALS AND WALRUS) AND WHALE SPECIES. NOTE THAT DISTANCES TO EACH SIGHTING WERE RECORDED RELATIVE TO THE VESSEL.

4.2. Annual and Seasonal Abundance

The best fitting model for the 2010 dataset was the Hazard rate model, with Beaufort sea state and species as covariates. Other covariates tested, such as cluster size, visibility, and vessel, did not make it into the final model. The best results were obtained with a truncation distance of 1.5 km (note that this truncation distance refers to the perpendicular distance from the transect line), distance bins of 100 m intervals, and sea state data grouped into two categories (low = 0-2; high = 3-5). These results were consistent with the best fitting model, covariates, distance truncation and data binning obtained with the 2009 and 2008 datasets (Brueggeman et al. 2009b, 2010). To increase the sample size with which the detection function is calculated, the same model parameters were run for all three years together. This resulted in an even better model fit (see Appendix B). Under the assumption that the detection probability is similar for each of the observed seal species, the estimated seal detection function was used to calculate species specific densities. The detection function for walrus was calculated separately, because the sighting probability is different than for seals. Figure 9 shows the seal and walrus densities, with 95% confidence intervals, for each study area and season. Large confidence intervals were caused by occurrence of sightings in clusters, excess number of zeros, and relatively low sample sizes. Average densities of seals and walruses of on-transect data for each year and area ranged from 0 to 0.126 ind/km² (0 to 0.328 ind/mi²) for ringed seals, 0.006 to 0.036 ind/km² (0.016 to 0.094 ind/mi²) for spotted seals, 0.004 to 0.070 ind/km² (0.01 to 0.182 ind/mi²) for bearded seals, and 0.004 to 0.036 ind/km² (0.01 to 0.094 ind/mi²) for walruses.

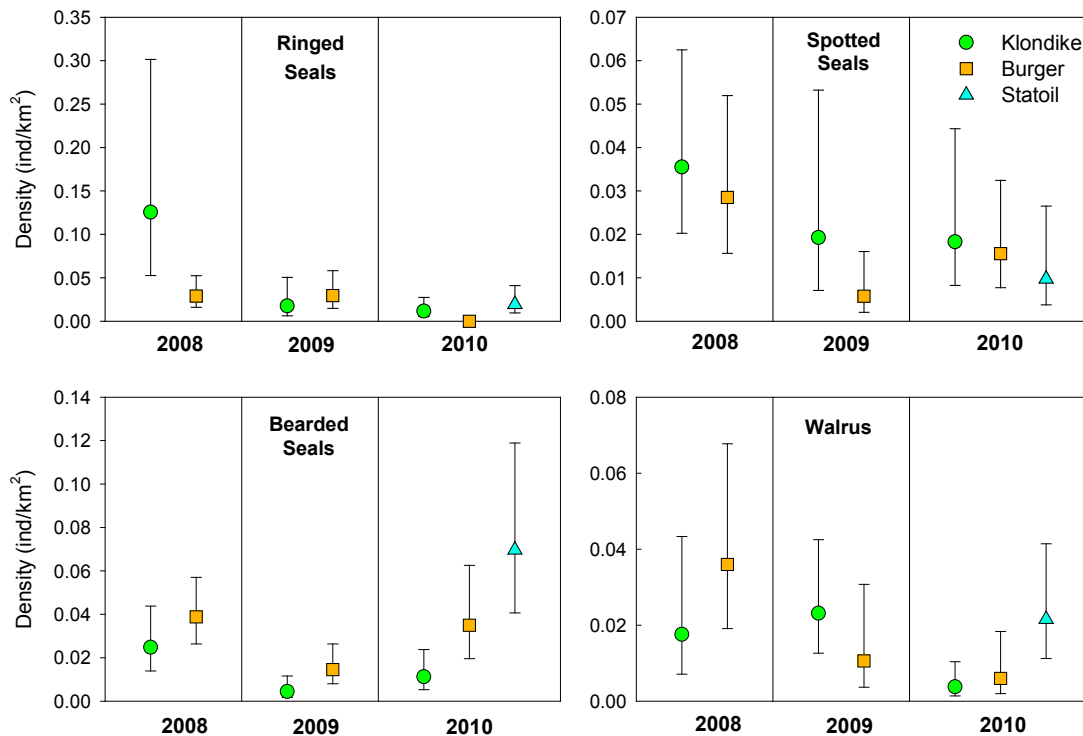


FIGURE 9: SEAL AND WALRUS DENSITY (WITH 95% CONFIDENCE INTERVALS) IN THE KLONDIKE, BURGER, AND STATOIL STUDY AREAS FOR EACH SEASON AND YEAR.

The seal densities in the Klondike study area in 2008, when sea ice was present until early September, were higher than those for 2009 and 2010. With the exception of ringed seals, this was also the case for seal densities in the Burger area in 2008, where sea ice was present until mid-September. A higher density in 2008 than in 2009 and 2010 was not apparent for walrus (of on-transect data, so not counting off-transect sightings consisting of large groups hauled out on the ice) (Figure 9). These higher seal densities in 2008 compared to 2009 and 2010 were related to the presence of sea ice early in the season. However, because this was not always apparent for the Burger study area and also not for walrus, sea ice was likely not the only factor determining the distribution of seal species.

Average ringed seal density on the pack ice in the Chukchi Sea as estimated from aerial surveys in June 1976 was 0.077 seals/km² (0.20 seals/mi²; Burns and Eley 1978). This densities, not corrected for availability and perception bias, is lower than the ringed seal density observed in 2008 in Klondike (0.126 seals/km²), but higher than the ringed seal density for the Burger study area in 2008 (and all ringed seal densities observed during the low ice years 2009 and 2010) (Figure 9). Corrected ringed seal densities in the offshore pack ice estimated by Bengston et al. (2005) from spring aerial surveys in the eastern Chukchi Sea in 1999 and 2000 were 0.81 and 0.23 seals/km² (2.10 and 0.60 seals/mi²) and higher than the CSESP densities. Both aerial surveys found higher ringed seal densities in nearshore than in offshore pack ice (Burns and Eley 1978, Bengston et al. 2005).

Bearded seal densities in the offshore pack ice of the Chukchi Sea, not corrected for availability bias, were 0.027 seals/km² (0.070 seals/mi²) in 1999 and 0.009 seals/km² (0.023 seals/mi²) in 2000 (Bengston et al. 2005). These densities are within the range of densities observed during the CSESP survey (Figure 9). Although comparisons with other survey results are useful, care should be taken, because of differences in densities calculations (e.g., with or without correction factors for availability and perception bias), survey periods (year, seasons), and survey methodologies and protocols.

Walrus densities were also variable, with highest densities observed in the Burger and Statoil study areas.

4.3. Habitat Use and Importance

The design of this study, with transect lines close together in defined spatial areas and two to three repetitions of the survey per study year (July-October) in each area, provided information on the abundance and distribution of marine mammals on a relatively fine spatial and temporal scale. Point density maps of on-transect sighting data were developed to display the spatial distribution of bearded seals, other seals (including ringed, spotted, ribbon, and unidentified seals) and walrus for each study area and year (Appendix C). These maps were also intended to identify hot spots within survey areas that could be correlated with other data, such as the presence of potential food sources. Bearded seals were displayed separately from other seal species, because they are primarily benthic feeders (Antonelis et al. 1994, Lowry et al. 1981), whereas spotted and ringed seals target mainly pelagic food (Holst et al. 2001, Lowry et al. 1981). The point densities were not corrected for availability and perception bias or for effort. Effort lines were included in the maps to show what part of the area was surveyed during a particular season and year. Findings based on these point density maps are summarized in the sections below for each species (or species group) separately. Note that these findings are preliminary. Detailed analyses correcting for effort and involving other data, such as benthic and fish biomass is planned for a later date. Observations of marine mammal behavior were also summarized in this section, because these observations could potentially provide information on use or importance of a specific area to marine mammals.

4.3.1. Seals (other than bearded seals)

The majority of seal species observed were spotted, ringed and unidentified seals. Spotted seals overwinter in the Bering Sea, while ringed seals are year-round residents in the northern Chukchi and Beaufort Seas. From July until September, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998). Spotted seals haul out on land part of the time, but also spend extended periods at sea.

Kasegaluk Lagoon is an important haul out area for spotted seals from mid-July until freeze-up in late October or November. Spotted seals are rarely seen on the pack ice, except when the ice is close to shore (Burns et al. 1981, Lowry et al. 1998). Ringed seals, however, are closely associated with sea ice and are often observed along the receding ice edges or farther north in the pack ice during the summer months (Burns 1970). Ringed seals tracked by satellite tags were observed to rest exclusively on shorefast or pack ice and were not recorded to haul out on land. In July, when basking is completed, ringed seals were observed to spend 70% of their time in the water. This increased to 90% or more during August through November (Kelly et al. 2010).

The presence of sea ice in July/Aug of 2008 in the northeastern part of the Klondike study area and throughout the Burger study area very likely resulted in higher number of seals than in the other two time periods of 2008 and compared to all periods of 2009 and 2010 (see point density maps in Appendix C). However, the presence of sea ice later in the season did not appear to influence the number of seals as much; the number of seals in Aug/Sep of 2008, when ice was still present in the Burger study area and in close proximity to the Klondike study area was lower than in Sep/Oct of that year when there was no sea ice in the study areas.

The number of seals was higher in the Klondike study area than in the Burger study area in all seasons of 2008 and in Sep/Oct of 2009, and lower in Aug/Sep of 2009. In Jul/Aug of 2009 and all seasons of 2010 the number of seals in each study area was fairly similar. So, overall there was no apparent preference in area use of the Klondike, Burger or Statoil study areas by seals. Similarly, there was no clear pattern in number of seals per season. For example, the number of seals in the Burger study area in the two years with low sea ice (2009 and 2010) were highest in Aug/Sep. In the Klondike study area, however, the highest numbers were observed in Sep/Oct (of 2009, no survey was conducted during this time period in 2010). It is possible that the lack of an apparent seasonal pattern is due to the fact that most sightings were unidentified seals or combined ringed/spotted seals. Spotted and ringed seals use sea ice differently and have different migration patterns, for example spotted seals migrate south at the end of the summer, but ringed seals reside year-round in the Chukchi Sea. So, at different times during the season different seal species might be present and a reduced number of sightings towards the end of the season is not necessarily expected.

An interesting observation was the high density of seals recorded in Sep/Oct of 2008 and 2009 in the southern part of the Klondike study area, just below the core area. There was no survey in 2010 during this season, but a similar concentration was apparent in Aug/Sep of 2010. Diet of adult ringed and spotted seals is known to consist mainly of Arctic cod, and also of sculpins and stout eelblenny (Lowry and Burns 1981, Holst et al 2001, Weslawski 1994). It is

possible that the observed seal concentrations later in the season is related to concentrations of Arctic and Saffran cod or other potential fish prey species that seem to occur in that same general area (Crawford and Raborn, 2011). More detailed analyses are required to confirm this relationship.

4.3.2. Bearded seals

Seasonal movements of bearded seals are directly associated with the advance and retreat of sea ice and water depth (Burns 1981, Kelly 1988). From mid-April to June as the ice recedes, bearded seals migrate northward from the Bering Sea to habitats along the margin of the pack ice in the central or northern Chukchi Sea. During the summer they are found near the widely fragmented margin of multi-year ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea. During the open water period, bearded seals occur mainly in relatively shallow areas, because they are predominantly benthic feeders (Burns 1981) that prefer areas of water no deeper than 656 feet or 200 m (e.g., Harwood et al. 2005). The northeastern Chukchi Sea is a very shallow continental shelf and the water depths in the study areas are generally around 132 feet or 40 m; a suitable habitat for benthic feeders. Bearded seal diet is variable and depends on age, but consists mainly of crabs, clams, sculpins, Arctic and Saffran cod, and eelpouts (Antonelis 1994, Lowry and Burns 1981).

Similarly to other seals, bearded seal numbers in the early Jul/Aug season were influenced by the presence of sea ice; highest numbers were observed in 2008, when sea ice was present in the northeastern part of the Klondike study area and throughout the Burger study area. The bearded seal density was low in both study areas in Jul/Aug of 2009 and 2010, when there was no or limited sea ice cover. The abundance of bearded seals reached its highest numbers in the study period Aug/Sep and decreased in Sep/Oct in all three years and study areas, which is consistent with the knowledge that they migrate south to the Bering Sea at the end of the season.

With the exception of the Aug/Sep 2008 period, the number of bearded seals was higher in the Burger study area compared to the Klondike study area. In Sep/Oct when overall numbers were decreasing this difference was less pronounced. The number of bearded seals in the Statoil study area was very similar to the Burger study area throughout 2010. The higher number of bearded seals in the Burger study area could be related to a higher abundance of potential prey species. Generally, the same benthic species were present in the three study areas and, generally, numerous within each area (Blanchard et al. 2011). However, number and biomass of bivalves, polychaetes, and crustacean groups of amphipods and ostracods were

greater in the Burger study area than in the Klondike study area with intermediate values in the Statoil study area. To what extent the higher observed number of bearded seals in the Burger study area was related to benthic biomass or abundance requires a more detailed analysis.

4.3.3. Walrus

The Pacific walrus population resides in the Bering Sea during the winter, where breeding and most of the calving occurs. In spring, females and calves follow the receding ice pack northward to summer in the Chukchi Sea. Most males remain near coastal areas of the Bering Sea where they use coastal haul-outs to rest between foraging trips. In autumn, females travel back to the Bering Sea where they join the males that remained in the area (Fay 1982, Jay and Hills 2005).

In July/Aug walrus were mainly observed in the Burger study area (2008, 2009 and 2010) and Statoil study area (2010). No walrus were observed along the transect lines in the Klondike study area early 2008 and 2010, and only a few in 2009. Also, no off-transect on-ice sightings were recorded during the July/Aug period of 2008, 2009, and 2010.

In the Burger study area, most sightings occurred in Jul/Aug (2009) or Aug/Sep (2008, 2010). The number of walrus sightings decreased towards the end of the season. The higher number of walrus observed on-transect in the years with low sea ice cover (2009 and 2010) compared to high sea ice cover (2008), shows that other factors than the presence of sea ice are important in walrus abundance and distribution. It should be noted that eight off-transect on-ice sightings in Aug/Sep 2008, consisting of large aggregations of walrus, were not included in the point density maps. However, even with these sightings the concentration of walrus in Aug/Sep 2010, when no ice was present, was similarly high (or higher) than in 2008. In the Klondike study area the highest number of walrus observed was also not correlated to the presence of ice. The data shows that other factors than sea ice cover are important in determining walrus density in this area.

4.3.4. Behavior

The biologist observers recorded the initial and second behavior of each marine mammal sighted. Swimming and diving was the most commonly observed behavior for walrus. The behavior most commonly observed for seals was swimming and looking (Figure 10). The behavior exhibited by all whales sighted was swimming, breathing (blow) or unknown. The number of polar bears sighted in the Chukchi Sea each year was nine in 2008, four in 2009, and three in 2010. Six of a total of sixteen animals were observed resting, five walking, two swimming, one feeding, and two displayed other behaviors.

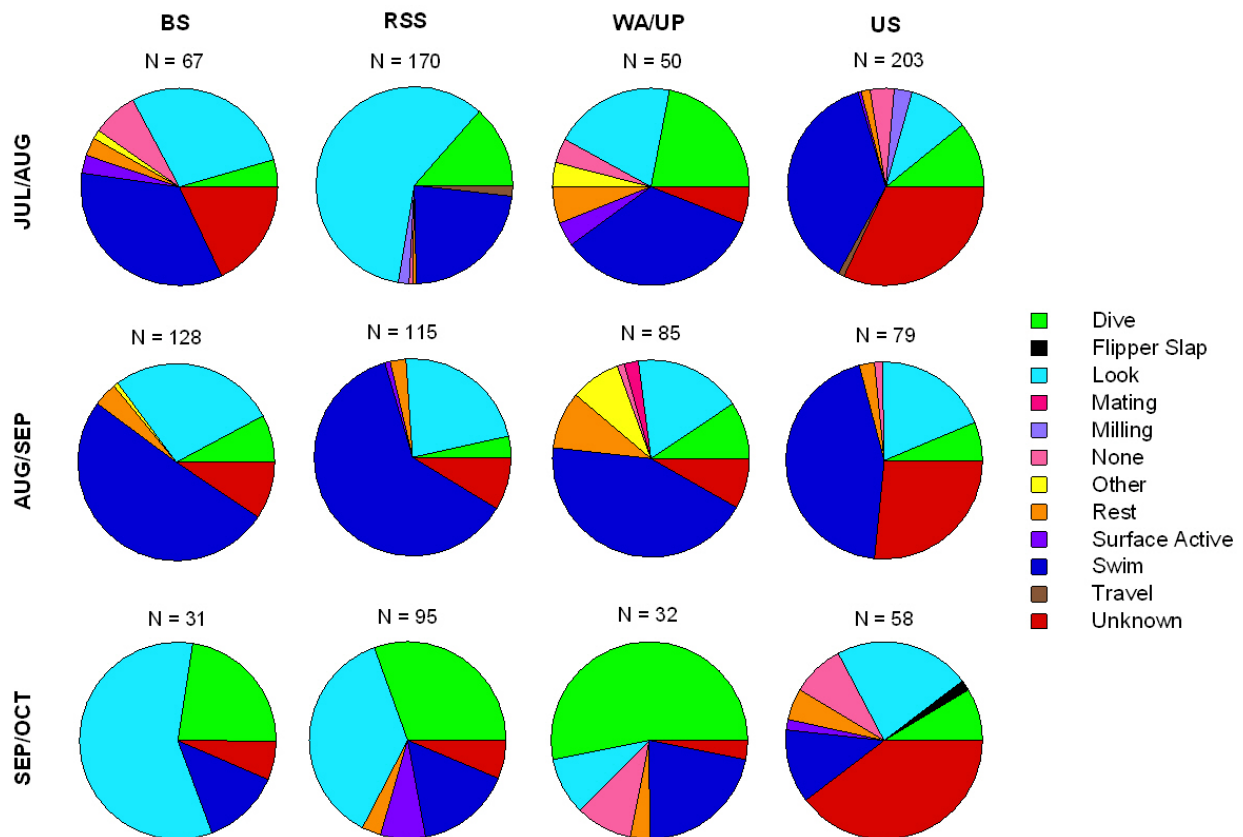


FIGURE 10: SEASONAL BEHAVIOR PATTERN OF BEARDED SEALS (BS), SPOTTED AND RINGED SEALS (RSS), WALRUS AND UNIDENTIFIED PINNIPEDS (WA/UP) AND UNIDENTIFIED SEALS (US) IN 2008-2010, BASED ON SIGHTINGS WITHIN THE STUDY AREAS. N= TOTAL NUMBER OF SIGHTINGS FOR EACH SPECIES GROUP AND SEASON.

The relative occurrence of bearded seal, ringed/spotted seal and walrus behavior was very similar between the three study areas. However, seals and walrus appeared to display a seasonal behavior pattern. Figure 10 shows frequency of behavioral activities for each season with data from all study areas and years combined. A similar pattern was also apparent for each year and study area separately, but sample sizes were low for some years and seasons. Seals were observed to swim more often during the Aug/Sep period. Later in the season swimming behavior decreased and activities such as diving and looking were observed more frequently.

The behavior of unidentified seal species is included for completeness, however, because these animals were either sighted from a large distance or just for a very short period of time (and hence unidentified) the majority of the displayed behavior was recorded as unknown.

Swimming behavior of walrus was also most dominant in Aug/Sep. Large aggregations of walrus hauled out onshore along the Alaskan coast from Peard Bay to Lisburne were first observed in 2007 (Funk et al. 2009) and again in 2009 and 2010 (Fishbach et al. 2009, Delarue et al. 2011). It is believed these haulouts occurred when the pack ice had dissipated far to the

north of continental shelf waters and the last of the marginal and sparse ice had disappeared. Walrus cannot remain at sea indefinitely without rest. Telemetry data from walrus in ice-bearing waters of the northern Bering Sea revealed walrus generally hauled out and rested every day or so, and that 98 percent of their in-water bouts lasted no longer than 7.5 days, and none exceeded 13 days (Udevitz et al. 2009). Traveling to and from their feeding grounds at Hanna Shoal and the coastal haul outs might therefore be related to the proportionally high swimming behavior. In Sep/Oct the most frequently observed behavior was diving.

4.4. Data Integration and Ecological Relationships

As mentioned earlier in this report, detailed analyses integrating benthic and fish data to determine to what extent the distribution of seals and walrus is related to presence of possible food sources are planned for a later date. This section briefly summarizes results from combined visual and acoustic marine mammal data. It also summarizes whale and walrus observations of the combined CSESP and COMIDA aerial survey dataset.

4.4.1. Visual observations versus Acoustic detections

Acoustic recorders deployed in the northeastern Chukchi Sea (since 2008 as part of the CSESP) have documented calls of bowheads and other marine mammals on a spatial and seasonal scale and provided valuable information on marine mammal presence and movements (Delarue et al. 2011, Martin et al. 2009). Because visual observations are not always possible due to environmental conditions (e.g., fog, darkness), and acoustic detections are only possible when animals are vocal or when background noise allows detection of calls, acoustic methods and visual observations complement each other very well. To date, comparisons of acoustic versus visual observations have been rather limited. The CSESP study provided a good basis for more detailed analyses between acoustic and visual marine mammal data, because recorders and observations were located in the same areas and data were collected during the same periods. Figures 11, 12 and 13 show the number of individual bearded seals, walrus and bowhead whales as observed by biologist observers in relation to the number of calls detected by acoustic recorders. Daily call numbers were extracted for the same day and area as where vessel-based visual observations were taking place.

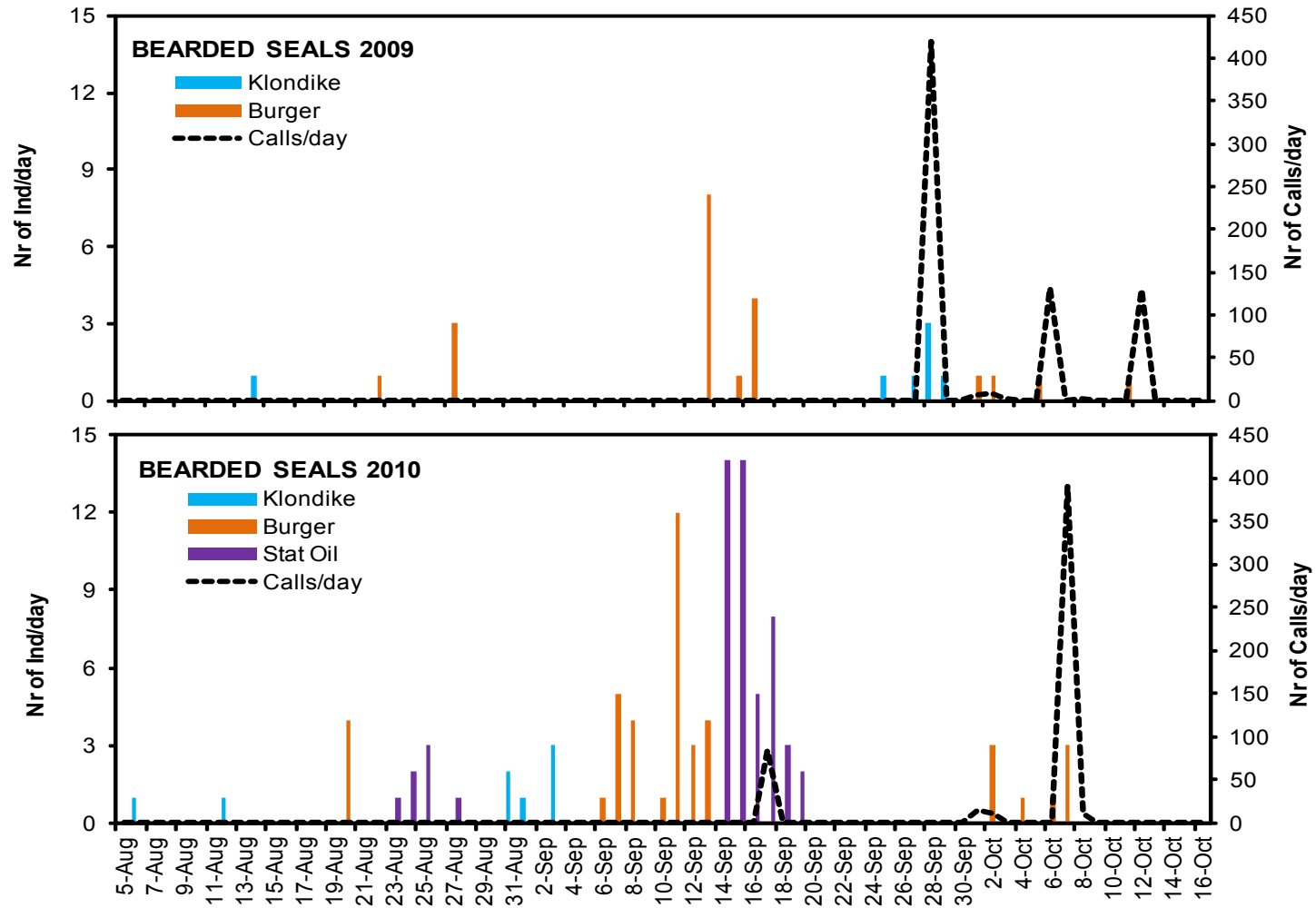


FIGURE 11. NUMBER OF BEARDED SEAL INDIVIDUALS PER DAY OBSERVED BY BIOLOGIST OBSERVERS AND BEARDED SEAL CALLS PER DAY DETECTED ON ACOUSTIC RECORDERS IN THE KLONDIKE, BURGER AND STATOIL STUDY AREAS.

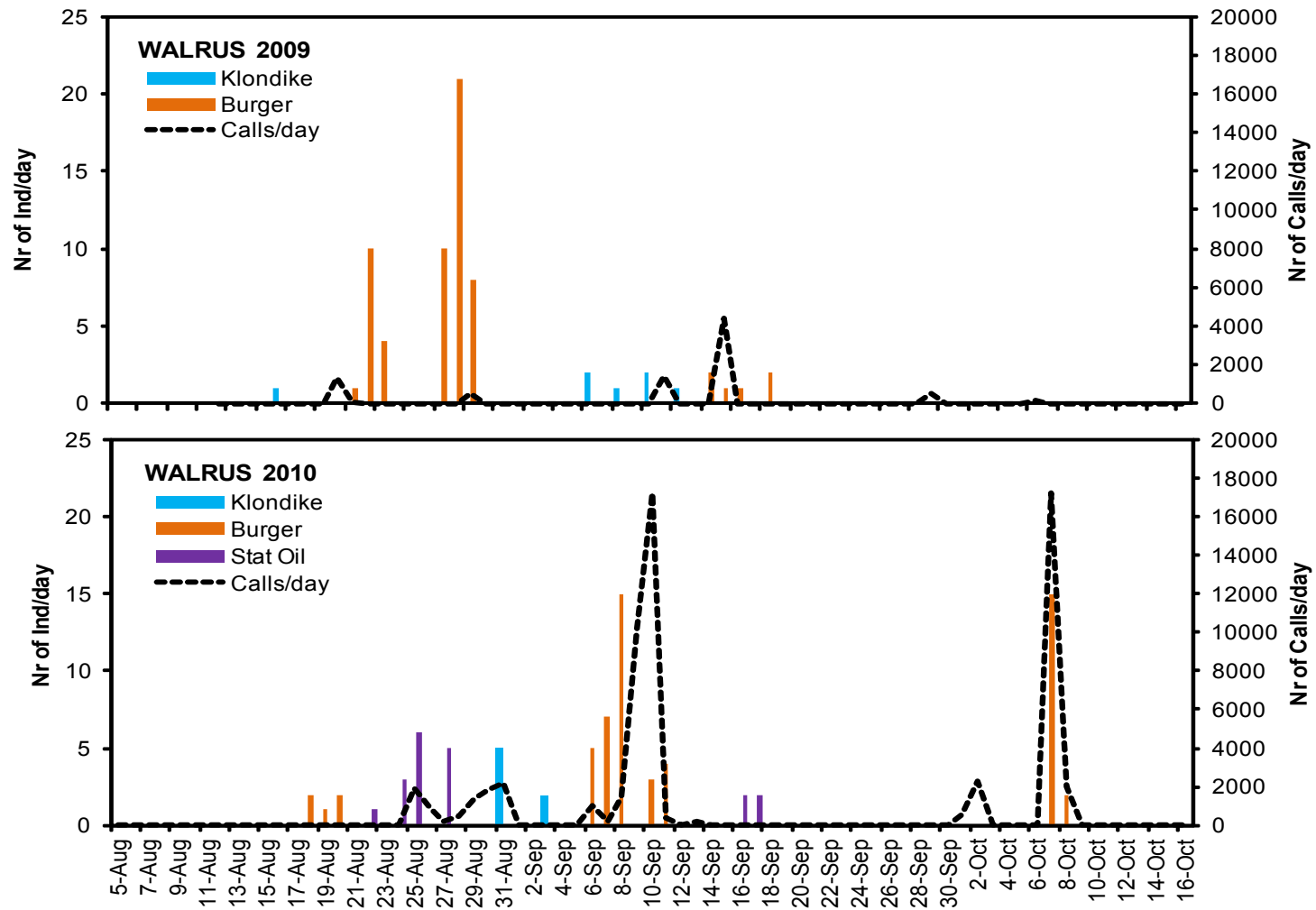


FIGURE 12. NUMBER OF WALRUS INDIVIDUALS PER DAY OBSERVED BY BIOLOGIST OBSERVERS AND WALRUS CALLS PER DAY DETECTED ON ACOUSTIC RECORDERS IN THE KLONDIKE, BURGER AND STATOIL STUDY AREAS.

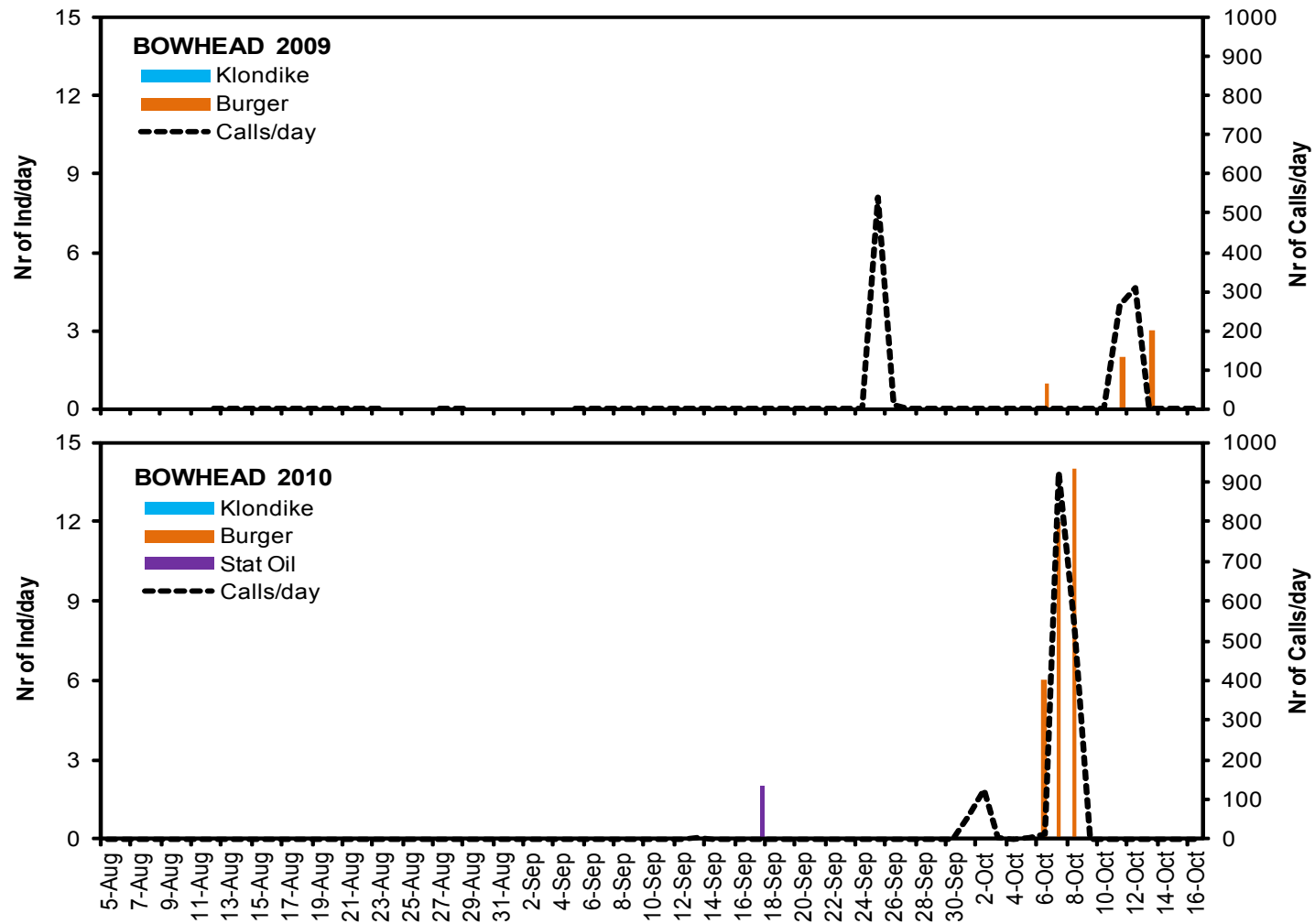


FIGURE 13. NUMBER OF BOWHEAD INDIVIDUALS PER DAY OBSERVED BY BIOLOGIST OBSERVERS AND BOWHEAD CALLS PER DAY DETECTED ON ACOUSTIC RECORDERS IN THE KLONDIKE, BURGER AND STATOIL STUDY AREAS.

Bearded seal vocalizations were detected regularly by the acoustic recorders during April and May and were absent during August and September. The absence of vocalizations in Aug/Sep did not indicate an absence of bearded seals, as they were sighted regularly by the biologist observers during that period, especially in 2010. Call activity of bearded seals increased at the end of September and through October, but this increase was not reflected by the visual observations. In contrast, the frequency of bearded seal observations and number of bearded seals decreased towards the end of September. Walrus seem vocally active during the entire season, but again there was no apparent relation between number of animals and calls. A high call detection rate and low number of observations as occurred on 9-10 September 2010, could be explained by the fact that biologist observers can only cover a relatively small part of the study area in one day and therefore miss animals that were present in the other part, whereas acoustic recorders detect calls day and night covering most of the study area. Bowhead numbers and calls seem to coincide relatively well. On 25 September 2009 when there were 540 calls per day, the observers covered only the most western part of the Klondike study area from 4 pm to 8 pm, so might have missed a group of whales in the eastern part of the study area. The peak of calls starting 6 October 2010 coincides with the high number of whales observed that day in the northeastern part of the Burger study area and the Wainwright transit line.

4.4.2. Comparison with other marine mammal data

The National Marine Mammal Laboratory (NMML) provided data from aerial surveys flown in the Chukchi Sea, consisting of 1982-1991 OCSEAP survey data and 2008-2010 COMIDA data. Walrus and whale sightings of the 2008-2010 CSESP, plotted together with the aerial survey data were compared through plots of species sightings. To focus on the area of interest to the CSESP study, aerial survey data were requested for the expanded 2011 CSESP study area that encompasses the Klondike, Burger and Statoil study areas. Figure 15 depicts the location of the proposed 2011 CSESP study area in relation to the 2008-2010 COMIDA survey blocks. Note that the 2008-2010 COMIDA aerial survey blocks do not cover the entire Hanna Shoal area. This northeastern part of the 2011 CSESP area was, however, covered by the OCSEAP aerial surveys of 1982-1991. Two sets of maps were created showing both the aerial survey and the CSESP marine mammal observations; one for walrus and one for whales (Appendix D). There were 24 bearded seals and two ringed seals sighted during the 13 years of aerial surveys in the proposed 2011 study area. In addition, there were 113 small unidentified pinnipeds and 110 unidentified pinnipeds recorded. The seal and unidentified pinniped data of the COMIDA survey were not used for comparisons.

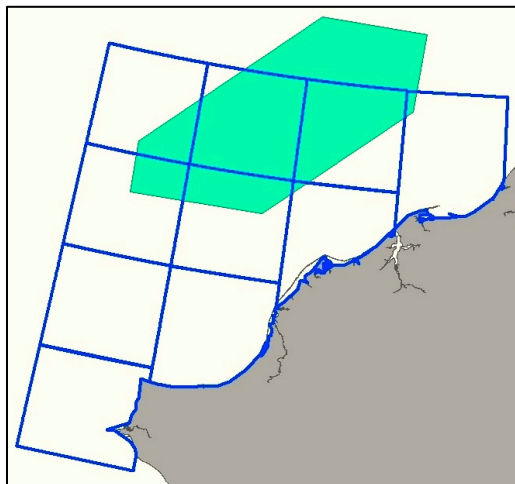


FIGURE 15: EXPANDED 2011 CSESP AREA (GREEN AREA EXTENT) IN RELATION TO THE 2008-2010 COMIDA AERIAL SURVEY GRID (BLUE BLOCKS). THE GREEN AREA OUTSIDE THE COMIDA GRID CELLS WAS ONLY COVERED DURING THE 1982-1991 AERIAL SURVEYS. DATA OF 1982-1991 AND 2008-2010 AERIAL SURVEYS WITHIN THE 2011 CSESP AREA WERE USED TO COMPARE TO THE 2008-2010 CSESP SIGHTINGS (SEE TEXT).

Walrus

Walrus were observed in very high numbers during the OCSEAP and COMIDA aerial surveys, mainly in close proximity to Hanna Shoal. The 2008-2010 CSESP walrus distribution was very similar to the aerial survey data, i.e., with high concentrations recorded in the northern part of the Burger study area. In the period from 20 August to 30 September 2010, a marine seismic survey was conducted in the Statoil study area. Marine mammal observers present on the source vessel and two support vessels observed 346 Pacific walrus groups of 1042 individuals. The majority (72%) of these sightings were observed between 28 and 31 August 2010 (250 sightings of 823 individuals) as a large number of Pacific walrus moved from the receding ice edge around Hanna Shoal towards land (Blees et al. 2011). Such large numbers of walrus were not observed during the CSESP marine mammal survey in the Statoil study area. On 28, 30 and 31 August the vessel was conducting surveys in the Klondike study area. On 29 August, when the vessel was traveling from the Klondike study area to Wainwright in the afternoon and early evening (and back during the night), no walrus were observed either.



FIGURE 16: WALRUS MOM AND PUP OBSERVED SWIMMING IN THE STATOIL STUDY AREA ON 24 AUGUST 2010.

Bowhead whale

Bowhead whale migration and seasonal and annual distribution have been studied quite extensively since the late 1970s. Vessel-based surveys took place in 1979, 1980 and 1982, primarily to determine whether there was a substock of bowhead whales summering in the western Chukchi Sea instead of migrating to the Beaufort Sea (Miller et al. 1986). Aerial surveys were conducted from 1982 to 1991 and again since 2008 (e.g., Ljungblad et al. 1984, 1986, 1987, Moore and Clarke 1993, Clarke and Ferguson 2010a, b) to document abundance and distribution of bowhead whales, and also of other large whales. Bowhead whales are an important subsistence resource for residents of Barrow, and other villages along the Chukchi and Beaufort Seas. On average, a total of 40 bowhead whales were landed by Alaskan natives in the period 1999-2008 (Suydam et al. 2010). Shore-based whale counts at Point Barrow were initiated in 1976 in response to concerns from the International Whaling Commission (IWC) that not enough information was available to endorse continuation of the hunt or to establish hunting quota. These counts were intended to derive at population estimates and have been continued regularly with the latest count effort in spring of 2011. Although not directly related to the IWC, information on the presence and distribution of bowhead whales throughout the year has come from passive acoustic monitoring systems deployed near Barrow in 1984-1986, 1992-1993, 2000-2001, 2003-2004 and also in the Chukchi Sea from 2006 onwards (e.g., Berchok et al. 2010, Clark and Ellison 2000, Clark 2010, Hannay et al. 2011, Martin et al. 2009, Stafford et al. 2006) and provided Although these studies increased the knowledge about bowhead whale migration, detailed local movements and behavior during the migration period remained largely unknown. Since 2007, satellite transmitters were placed on small number of whales to obtain information on individual movements and movements on a more local scale (Quakenbush et al. 2010). In addition, traditional knowledge from native hunters about whale movements was

collected to complement the satellite tagging information (Huntington and Quakenbush 2009, Quakenbush and Huntington 2010).

Information from satellite tagged bowhead whales, aerial surveys and acoustic detections all confirmed that bowhead whales pass through the Klondike, Burger, and Statoil study areas during fall migration. Based on the available information, whales were expected to be more abundant in the Burger and Statoil study areas than in the Klondike study area during the fall migration season. Sightings of bowhead whales were relatively scarce during the OCSEAP and COMIDA aerial surveys in the proposed 2011 CSESP study area (~22 sightings). Except for one sighting on 22 August 2008, all bowheads were observed in late September and October. Bowhead whale sightings were also limited during the CSESP survey, especially in 2008 and 2009. More bowheads were sighted during 2010. Two animals were sighted mid-September in the Statoil study area, and all other sightings were recorded in October, which is consistent with current knowledge about fall movements of bowhead whales. The low number of bowhead sightings in 2008 and 2009 do not indicate that whales were not present or that they were migrating at a later date. During both years whale calls were detected in the Klondike and Burger study areas during September and October, though the vessel-based observers might not always have been present at the exact location where most whales were passing through. This was different in 2010. Large numbers of whales were observed in the northeastern corner of the Burger study area, on days when there was also a peak in acoustic detections in that area. It is further interesting to note that in 2010, during the first week of October, the Wainwright community landed their first fall bowhead whale ever. Relatively large numbers of whales must have been migrating southward closer to shore than normal.

Gray whale

Gray whales routinely feed in the Chukchi Sea during the summer, with the northeastern-most feeding areas southwest of Barrow (Clarke et al. 1989). Amphipods are a preferred prey of gray whales in the northern Bering and Chukchi Seas (Highsmith and Coyle, 1992; Highsmith et al., 2006; Bluhm and Gradinger, 2008). During the summer, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal habitat. In autumn, gray whales were clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters northwest of Point Barrow at Hanna Shoal and southwest of Point Hope (Moore et al. 2000, Clarke and Ferguson 2010). Bluhm et al. (2007) noted high gray whale densities along ocean fronts and suggested that ocean fronts may play an important role in influencing prey densities in eastern North Pacific gray whale foraging areas. The large number of gray whale sightings offshore in proximity of Hanna Shoal is interesting. In the Klondike, Burger and Statoil study areas gray

whale sightings were relatively sparse for both the aerial survey data and the CSESP data. Abundance of amphipods was also relatively low in the Burger and Klondike study areas in 2008, 2009, and 2010 (Blanchard et al. 2011). Consistent with current knowledge, gray whales were predominantly observed in nearshore waters close to Wainwright during the CSESP study. Although not displayed on the map in Appendix D, the COMIDA data also recorded more gray whales nearshore (Clarke and Ferguson 2010b) than offshore. In 2009, benthic samples were collected at locations where gray whales were observed feeding nearshore to Wainwright where amphipod concentrations were much higher than in the three study areas further offshore (Blanchard et al. 2010). A similar link between gray whale and prey distribution was also apparent in the western gray whale population (Fadeev, 2011).

Beluga whale

Beluga whales of the Beaufort Sea and eastern Chukchi Sea stock overwinter in the Bering Sea and migrate north during spring to summer feeding grounds in the Beaufort Sea. Animals from the Chukchi Sea population are known to congregate in Kasegaluk Lagoon during summer where they are an important subsistence resource for residents of the village of Point Lay, and other villages in northwest Alaska. In 2007, approximately 70 belugas were harvested at Kivalina located southeast of Point Hope. The belugas have been predictably sighted near the lagoon from late June through mid- to late July (Suydam et al. 2001). However, evidence from a small number of satellite-tagged animals suggests that the range of these whales extends into the Arctic Ocean north of the Beaufort Sea (Suydam et al. 2005). Five of twenty-three tagged beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002 moved far into the Arctic Ocean and into the pack ice to 79–80°N. These and other whales moved to areas as far as 685 mile (1,100 km) offshore between Barrow and the Mackenzie River delta spending time in areas with 90% ice coverage. A relatively larger number of beluga whales (55) was observed during the OCSEAP aerial surveys in 1982-1991, with 95% of the whales sighted from mid-September to early November. Some of these belugas were sighted in the Klondike, Burger and Statoil study areas. No belugas were observed during the 2008-2010 COMIDA and CSESP studies, but beluga sounds were acoustically detected in 2008 in the Klondike study area (on seven days in September and one day in October) and in the Burger study area (on three days in September) (Clark 2010). These detections were missed by the biologist observers because they were surveying transect lines in the Burger study area on the days that beluga sounds were detected in the Klondike study area, and vice versa (with the exception of 18 September when the biologist observers were working in the Burger study area when also beluga calls were recorded). In 2009, no beluga calls were detected in the Klondike study area and only one to two beluga calls in the Burger study area on 7 October (Hannay et

al. 2011). On that day the biologist observers were surveying transect lines in the eastern part of the Burger study area, with a sea state of Beaufort 6, which precludes reliable detection of small, white whales like belugas.

5. CONCLUSION

Biologist observers and Inupiat communicators recorded all marine mammals sighted along transect lines that covered three study areas and transits between Wainwright and the study areas. Pinnipeds were the most frequently observed species in the northeastern Chukchi Sea in 2010, consistent with results from 2008 and 2009. Whale sightings were rare in the study areas during 2008 and 2009; however, in 2010 a total of 36 sightings of 54 bowheads were observed (mainly in northeastern corner of the Burger Study area).

Average densities of seals and walruses of on-transect data for each year and area ranged from 0 to 0.126 ind/km² (0 to 0.328 ind/mi²) for ringed seals, 0.006 to 0.036 ind/km² (0.016 to 0.094 ind/mi²) for spotted seals, 0.004 to 0.070 ind/km² (0.01 to 0.182 ind/mi²) for bearded seals, and 0.004 to 0.036 ind/km² (0.01 to 0.094 ind/mi²) for walruses. With the exception of the average ringed seal densities in the Klondike study area in 2008, ringed seal densities on the offshore pack ice of the Chukchi Sea from historical data were higher (Burns and Eley 1978, Bengston et al. 2005). The range of average bearded seal densities recorded during this study was similar to those reported for the offshore pack ice (Bengston et al. 2005). Although comparisons with historical data provide some indications, care should be taken when comparing densities from different studies, due to differences in densities calculations (e.g., with or without correction factors for availability and perception bias), in survey periods (year, seasons), and survey methodologies and protocols.

The higher seal densities in 2008 compared to 2009 and 2010 were related to the presence of sea ice early in the season. However, because this was not always apparent for the Burger study area and also not for walruses, sea ice was likely not the only factor determining the distribution of seal species. Earlier studies indicated that seal densities were influenced by ice conditions and biological productivity (Burns and Eley 1978). A link to biological productivity seemed also apparent in this study. For example, the data suggest that benthic-feeding bearded seals and walruses generally were more common in the Burger and Statoil study areas, which are benthic-dominated ecosystems (Blanchard et al. 2011). Pelagic-feeding spotted seal species tended to be more common in the Klondike study area, which is a more pelagic-dominated system affected by waters from the Central Channel. Ringed seals did not show a clear preference. These results indicate that the different oceanographic conditions of the three

study areas seem to affect the distribution of some pinnipeds more than others, however, more detailed analyses are required to confirm these relationships.

Initial comparisons between visual and acoustic data showed that the relationship was most apparent for animals that are calling frequently, like bowhead whales. For animals that are not very vocal during a certain time of the year, like bearded seals in August and September, the correlation between acoustic detections and visual sightings was poor. The interpretations of these initial comparisons were difficult to interpret, because biologist observers can only cover a limited area during an observation day whereas acoustic recorders can detect calls over larger ranges. A closer look at the visual and acoustic datasets is needed to determine how well comparisons between the two sets can be made and if call behavior of marine mammals can be extracted from the results.

Overall, the data gathered from 2008 to 2010 has provided valuable information on marine mammal abundance and distribution on a relatively local scale. It is not surprising that the variability was high between seasons and years, as many factors play a role in marine mammal movements.

ACKNOWLEDGEMENTS

This study was not possible without the support and dedication of many people. First of all we want to thank the Inupiat communicators and marine mammal observers Max Akpik, Herbert Tagarook, Blair Pakotak, and Patrick Brower for assisting with the observations. Sheyna Wisdom, the science manager for Olgoonik-Fairweather, was instrumental in keeping this program and all scientists on track, as were the scientific leads Bob Day and John Burns. We thank ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P for funding this study through Olgoonik-Fairweather LLC. We are also grateful to the crews of the R/V Westward Wind and the R/V Norseman II who were always ready to help and were making sure everybody was safe and comfortable on the vessels.

LITERATURE CITED

- Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. *Polar Biol.* 28: 833-845.
- Berchok, C., K. Stafford, D.K. Mellinger, S. Nieukirk, S. Moore, J.C. George, and F. Brower. 2010. Passive acoustic monitoring in the western Beaufort Sea. Section II in Bowhead Whale Feeding Study (BOWFEST) in the Western Beaufort Sea, 2010 Annual Report. P22-30.

- Blanchard, A., C. Parris, and H. Nichols. 2010. 2009 Environmental Studies Program in the Chukchi Sea: Benthic Ecology of the Burger and Klondike Survey Areas – Annual report. Institute of Marine Science, University of Alaska Fairbanks. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company.
- Blanchard, A., C. Parris and A.L. Knowlton. 2011. 2010 Environmental Studies Program in the northeastern Chukchi Sea: Benthic ecology of the Klondike, Burger and Statoil survey areas. Report prepared by Institute of Marine Science, UAF for ConocoPhillips Alaska, Inc., Shell Exploration and Production Company and Statoil USA E&P, Inc.
- Blees, M.K., K.G. Hartin, D.S. Ireland, and D. Hannay. (eds.) 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2010: 90-day report. LGL Rep. P1119. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for by Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 102 pp, plus appendices.
- Bluhm, B.A., K.O. Coyle, B. Konar and R.Highsmith. 2007. High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea. *Deep Sea Research II*, 54: 2919–2933.
- Bluhm, B.A. and R. Gradinger. 2008. Regional variability in food availability for Arctic marine mammals. *Ecological Applications*, 18 Supplement: S77–S96.
- Brueggeman, J.J., C.I. Malme, R.A. Grotefendt, D.P. Volsen, J.J. Burns, D.G. Chapman, D.K. Ljungblad, and G.A. Green. 1990. 1989 Walrus Monitoring Program, Klondike, Burger, and Popcorn Prospects in the Chukchi Sea. Shell Western E&P Inc. 121 pp plus appendices.
- Brueggeman, J.J., D.P. Volsen, R.A. Grotefendt, G.A. Green, J.J. Burns, and D.K. Ljungblad. 1991. 1990 Walrus Monitoring Program, Popcorn, Burger, and Crackerjack Prospects in the Chukchi Sea. Shell Western E&P Inc. 53 pp plus appendices.
- Brueggeman, J. J., R.A. Grotefendt, M.A. Smultea, G.A. Green, R.A. Rowlett, C.C. Swanson, D.P. Volsen, C.E. Bowlby, C.I. Malme, R. Mlawski, and J.J. Burns. 1992a. 1991 Marine Mammal Monitoring Program, Walruses and Polar Bears, Crackerjack and Diamond Prospects, Chukchi Sea. Shell Western E&P Inc. and Chevron USA, Inc. 109 pp plus appendices.
- Brueggeman, J. J., R.A. Grotefendt, M.A. Smultea, G.A. Green, R.A. Rowlett, C.C. Swanson, D.P. Volsen, C.E. Bowlby, C.I. Malme, R. Mlawski, and J.J. Burns. 1992b. 1991 Marine Mammal Monitoring Program, Whales and Seals, Crackerjack and Diamond Prospects, Chukchi Sea. Shell Western E&P Inc and Chevron USA, Inc. 62 pp plus appendices.
- Brueggeman, J.J., A. Cyr, A. McFarland, I.M. Laursen, and K. Lomac-MacNair. 2009a. 90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Alaska Shallow Hazards Survey Operations during the 2008 Open Water Season in the Chukchi Sea. Prepared by Canyon Creek Consulting LLC for ConocoPhillips Alaska, Inc., NMFS and USFWS.

- Brueggeman, J.J., B. Watts, M. Wahl, P. Seiser and A. Cyr. 2009b. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2008 open water season. Prepared by Canyon Creek Consulting LLC for ConocoPhillips Alaska, Inc. and Shell Exploration and Production.
- Brueggeman, J.J., B. Watts, K. Lomac-MacNair, A. McFarland, P. Seiser and A. Cyr. 2010. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2009 open water season. Prepared by Canyon Creek Consulting LLC for ConocoPhillips Alaska, Inc. and Shell Exploration and Production.
- Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas. 2001. Introduction to Distance Sampling. Oxford University Press, Oxford.
- Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas (eds). 2004. Advanced Distance Sampling. Oxford University Press, Oxford.
- Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. *Journal of Mammalogy* 51:445-454.
- Burns, J.J. and T.J. Eley. 1978. The Natural History and Ecology of the Bearded Seal (*Erignathus barbatus*) and the Ringed Seal (*Phoca hispida*). Environmental Assessment of the Alaskan Continental Shelf, Annual Reports 1:99-162.
- Burns JJ, Shapiro LH, Fay FH. 1981. Ice as marine mammal habitat in the Bering Sea. In: Hood DW, Calder JA (eds). The eastern Bering Sea shelf: oceanography and resources. University Washington Press, Seattle, p 781-797.
- Burns, J.J. and G.A. Seaman. 1986. Investigations of belukha whales in coastal waters of western and northern Alaska. II. Biology and Ecology. U.S. Dept. Commerce., NOAA, OCSEAP Final Rep. 56(1988): 221-357.
- Cameron, M., J. Goodwin, A. Whiting and P.L. Boveng. 2010. Seasonal movements, habitat selection, foraging and haul-out behavior of adult and sub-adult bearded seals in the Chukchi and Bering Seas. Abstract Alaska Marine Science Symposium 18-22 January 2010, Anchorage, AK.
- Clark 2010. Passive acoustic monitoring of marine mammals in the Chukchi Sea. 9 September – 14 October 2008. Technical Report 10-04, prepared by Bioacoustics Research Program, Cornell University for ConocoPhillips Alaska, Inc.
- Clark, C.W. and W.T. Ellison. 2000. Calibration and comparison of the acoustic location methods used during the spring migration of the bowhead whale, *Balaena mysticetus*, off Pt. Barrow, Alaska, 1984-1993. *J. Acoust. Soc. Am.* 107:3509-3517.
- Clarke, J.T., S.E. Moore and D.K. Ljungblad. 1989. Observations on gray whale (*Eschrichtius robustus*) utilization patterns in the northeastern Chukchi Sea, July-October 1982-1987. *Can. J. Zool.* 67(11): 2646-2654.

- Clarke J.T. and M.C. Ferguson. 2010a. Aerial surveys for bowhead whales in the Alaskan Beaufort Sea: BWASP update 2000-2009 with comparison to historical data. Int. Whaling Commission SC/62/BRG14.
- Clarke J.T. and M.C. Ferguson. 2010b. Aerial surveys of large whales in the northeastern Chukchi Sea, 2008-2009, with review of 1982-1991 data. Int. Whaling Commission SC/62/BRG13.
- Crawford S.C. and S.W. Raborn. 2011. Distribution and Abundance of key fish species in the northeastern Chukchi Sea, Alaska. Chapter 4 In: Gallaway, B.J., B. Norcross and B. Holladay [eds]. 2011. A synthesis of diversity, distribution, abundance, age, size and diet of fishes in the lease sale area 193 of the northeastern Chukchi Sea. Draft Report prepared by prepared by Institute of Marine Science, UAF and LGL Alaska Research Associates for ConocoPhillips Alaska, Inc., Shell Exploration and Production Company and Statoil USA E&P, Inc.
- Evans, T.J., A. Fishbach, S. Schliebe, B. Manly, S. Kalxdorff and G. York. 2003. Polar Bear Aerial Survey in the Eastern Chukchi Sea: A Pilot Study. Arctic 56(4): 359-366.
- Delarue, J., B. Martin, X. Mouy, J. MacDonnell, D. Hannay, and N.E. Chorney. 2011. Chukchi Sea Joint Acoustic Monitoring Program 2009–2010. Draft Report Version 1.0. Technical report for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by JASCO Applied Sciences.
- Fadeev, V.I. 2011. Benthos studies in the feeding grounds of western gray whales off the northeast coast of Sakhalin Island (Russia), 2002-2010. Report to the 63rd Int. Whaling Committee, Tromso, Norway.
- Fay, F.H. 1982. Ecology and biology of the Pacific walrus *Odobenus rosmarus divergens*. Illiger, Vol 74. U.S. Dept. of Interior, Fish and Wildlife Service, Washington, DC. 279 pp.
- Fischbach, A.S., D.H. Monson and C.V. 2009. Enumeration of Pacific walrus carcasses on beaches of the Chukchi Sea in Alaska following a mortality event, September 2009: U.S. Geological Survey Open-File Report 2009- 1291, 10 p.
- Funk, D., D Hannay, D. Ireland, R. Rodrigues and W. Koski. (eds.). 2008. Marine mammal monitoring and mitigation during open water seismic in the Chukchi and Beaufort Seas, July–November 2007: 90-day report. LGL Rep. P969-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore, Inc., NMFS, and USFWS. 218 pp plus appendices.
- Funk, D.W, D.S. Ireland, R. Rodrigues and W.R. Koski (eds). 2009. Joint Monitoring Program in the Chukchi and Beaufort Seas, Open Water Seasons, 2006-2008. Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research Ltd., for Shell Offshore Inc. and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 506 p. plus Appendices.
- Gall, A.E. and R.H. Day. 2010. Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 and 2009. Prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company.

- Gilbert, J.R. 1989. Aerial census of Pacific walruses in the Chukchi Sea, 1985. *Marine Mammal Science* 5(1): 17-28.
- Gilbert, J., G. Fedoseev, D. Seagars, E. Razlivalov, and A. Lachugin. 1992. Aerial census of Pacific walrus, 1990. U.S. Fish and Wildlife Service, Marine Mammal Management. Anchorage, Alaska.
- Goetz, K.T., D.J. Rugh, L.V. Brattström, and J.A. Mocklin. 2010. Aerial surveys of bowhead whales near Barrow in late summer. Section 1 In: Bowhead whale feeding ecology study. 2010 Annual Report. BOEMRE and NMML.
- Highsmith, R.C. and K.O. Coyle. 1992. Productivity of arctic amphipods relative to gray whale energy requirements. *Marine Ecology Progress Series*, 83: 141-150.
- Highsmith, R.C., K.O. Coyle, B.A. Bluhm, and B. Konar. 2006. Gray Whales in the Bering and Chukchi Seas. In Estes, J., DeMaster, D. P., Doak, D. F., Williams, T. M., Brownell, R. L. (eds) *Whales, Whaling and Ocean Ecosystems*. UC Press, pp 303-313.
- Holst, M., Stirling, I and K.A. Hobson. 2001. Diet of ringed seals (*Phoca hispida*) on the east and west sides of the north water polynya, northern Baffin Bay. *Marine Mammal Science*, 17 (4): 888–908.
- Hopcroft, R.R., J. Questel, and C. Clarke-Hopcroft. 2010. Oceanographic assessment of the planktonic communities in the Klondike and Burger survey areas of the Chukchi Sea – Report for survey year 2009. Report prepared by the University of Alaska Fairbanks for ConocoPhillips and Shell Exploration & Production, Anchorage, Alaska.
- Ireland, D.S., R. Rodrigues, D. Funk, W. Koski and D. Hannay. (eds.). 2009. Marine mammal monitoring and mitigation during open water seismic exploration in the Chukchi and Beaufort Seas, July–October 2008: 90-day report. LGL Rep. P1049-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc, NMFS, and USFWS. 277 pp, plus appendices.
- Jay C.V. and S. Hills. 2005. Movements of walruses radio-tagged in Bristol Bay, Alaska. *Arctic* 58:192–202.
- Jay, C.V., M.P. Heide-Jørgensen, A.S. Fishbach, M.V. Jensen, D.F. Tessler, and A.V. Jensen. 2006. Comparison of remotely deployed satellite radio transmitters on walruses. *Marine Mammal Science* 22(1): 226-236.
- Jay C.V., M.S. Udevitz, R. Kwok, A.S. Fischbach, and D.C. Douglas. 2010. Divergent movements of walrus and sea ice in the northern Bering Sea. *Mar. Ecol. Prog. Ser.* 407: 293-302.
- Kelly, B.P. 1988. Ringed seal, *Phoca hispida*. In: Lentfer JW (ed) *Selected marine mammals of Alaska: species accounts with research and management recommendations*. Marine Mammal Commission, Washington, DC, pp 59–75.
- Kelly, B.P., O.H. Badajos, M. Kunnsaranta, J.R. Moran, M. Martinez-Bakker, D. Wartzok, P. Boveng. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. *Polar Biology* 33:1095-1109.

- Lowry, L.F., K.J. Frost, J.J. Burns, 1978. Food of ringed seals and bowhead whales near Point Barrow, Alaska. *Canadian Field Naturalist* 92:67-70.
- Lowry, L.F., K.J. Frost, J.J. Burns, 1980a. Feeding of bearded seals in the Bering and Chukchi Seas and trophic interaction with Pacific walruses. *Arctic* 33(2):330-342.
- Lowry, L.F., K.J. Frost, J.J. Burns, 1980b. Variability in the diet of ringed seals (*Phoca hispida*) in Alaska. *Canadian J. Fisheries and Aquatic Sciences* 37(12): 2254-2261.
- Lowry, L.F. and J.J. Burns. 1981. Trophic relationships among ice-inhabiting phocid seals and functionally related marine mammals in the Chukchi Sea. In: *Environmental Assessment of the Alaskan Continental Shelf, Final Reports, Biological Studies* 11:97-173.
- Lowry, L.F., K.J. Frost, R. Davis, D.P. DeMaster and R.S. Suydam. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. *Polar Biol.* 19(4):221-230.
- Ljungblad, D.K., S.E. Moore and D.R. van Schoik. 1984. Aerial surveys of endangered whales in the Beaufort, eastern Chukchi, and northern Bering Seas, 1983: with a five year review, 1979-1983. NOSC Tech Rep. 955. Rep. from Naval Ocean Systems Center, San Diego, CA for MMS, Anchorage, AK. 356 pp. NTIS AD-A146 373/6.
- Ljungblad, D.K., S.E. Moore, and D.R. van Schoik. 1986. Seasonal patterns of distribution, abundance, migration and behavior of the Western Arctic stock of bowhead whales, *Balaena mysticetus* in Alaskan seas. Rep. Int. Whaling Comm., Special Issue 8:177:205.
- Ljungblad, D.K., S.E. Moore, J.T. Clarke, and J.C. Bennett. 1987. Distribution, abundance, behavior and bioacoustics of endangered whales in the Alaskan Beaufort and eastern Chukchi Seas, 1979-86. NOSC Tech. Rep. 1177. OCS Study MMS 87-0039. Rep. from Naval Ocean Systems Center, San Diego, CA, for MMS, Anchorage, AK 391 p. NTIS PB88-116470.
- Marsh, H., and D.F. Sinclair. 1989. Correcting for visibility bias in strip transect aerial surveys of marine fauna. *Journal of Wildlife Management* 53(4): 1017-1024.
- Martin, B., D. Hannay, C. Whitt, X. Mouy and R. Bohan. Chukchi Sea acoustic monitoring program. 2009. Chapter 5 In: Funk, D.W, D.S. Ireland, R. Rodrigues and W.R. Koski (eds), *Joint Monitoring Program in the Chukchi and Beaufort Seas, Open Water Seasons, 2006-2008*. Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research Ltd., for Shell Offshore Inc. and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 506 p. plus Appendices.
- Miller, R.V., D.J. Rugh, and J.H. Johnson. 1986. The distribution of bowhead whales, *Balaena mysticetus*, in the Chukchi Sea. *Mar. Mammal Sci.* 2: 214-22.
- Moore, S.E. and Clarke, J.T. 1993. Bowhead whale autumn distribution and relative abundance in relation to oil and gas lease areas in the northeastern Chukchi Sea. *Polar Record* 29(17): 209-214.
- Moore, S.E., D.P. DeMaster and P.K. Dayton. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. *Arctic* 53(4): 432-447.

- Moore, S.E., K.M. Stafford, D.K. Mellinger, and J.A. Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. *BioScience* 56(1): 49-55.
- Norcross, B., B. Holladay, and L. Edenfield. 2010. 2009 Environmental Studies Program in the Chukchi Sea: Fisheries Ecology of the Burger and Klondike Survey Areas, Report prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company by the Institute of Marine Science, University of Alaska Fairbanks.
- Quakenbush, L.T. and H.P. Huntington. 2010. Traditional knowledge regarding bowhead whales in the Chukchi Sea near Wainwright, Alaska. Coastal Marine Institute, University of Alaska. Final Report, OCS Study MMS 2009-63.
- Quakenbush, L.T., J.J. Citta, J.C. George, R.J. Small and M.P. Heide-Jorgensen. 2010. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. *Arctic* 63(3): 289-307.
- Rugh, D., W. Koski, J. George, and J. Zeh. 2009. Interyear re-identification of bowhead whales during their spring migration past Barrow, Alaska, 1984-1994. *Journal of Cetacean Research and Management*. 10(3):195–200.
- Rugh, D.J., K.E.W. Shelden and D.E. Withrow. 1997. Spotted seals, *Phoca largha*, in Alaska. *Mar. Fish. Rev.* 59(1):1-18.
- Speckman, S.G., V.I. Chernook, D.M. Burn, M.S. Udevitz, A.A. Kochnev, A.Vasilev, C.V. Jay, A. Lisovsky, A.S. Fischbach, and R.B. Benter. 2010. Results and evaluation of a survey to estimate Pacific walrus population size, 2006. *Marine Mammal Science* DOI: 10.1111/j.1748-7692.2010.00419.x (published online 30 Sep 2010).
- Stafford, K.M., S.E. Moore, L. Munger. 2006. Bowhead whale calls recorded on an autonomous instrument in the Beaufort Sea, 2003-2004. Report to Int.Whaling Committee SC58/BRG8.
- Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O’Corry-Crowe and D. Pikkok, Jr. 2001. Satellite Tracking of Eastern Chukchi Sea Beluga Whales into the Arctic Ocean. *Arctic* 54 (3): 237-243.
- Suydam, R.S., L.F. Lowry, and K.J. Frost. 2005. Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn. Final Report, OCS Study MMS 2005-035. 48 pp.
- Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2010. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2009. Int. Whaling Commission, SC/62/BRG18.
- Thomas, L., S.T. Buckland, E.A. Rexstad, J.L. Laake, S. Strindberg, S.L. Hedley, J.R.B. Bishop, T.A. Marques and K.P. Burnham. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.
- Udevitz, M.S., C.V. Jay, A.S. Fishbach and J.L. Garlich-Miller. 2009. Modeling haul-out behavior of walrus in Bering Sea ice. *Canadian Journal of Zoology* 87: 1111-1128.

Weingartner, T. and S. Danielson. 2010. Physical Oceanographic Measurements in the Klondike and Burger Prospects of the Chukchi Sea: 2008 and 2009. Institute of Marine Science, University of Alaska Fairbanks. Report prepared for ConocoPhillips Alaska, Inc. and Shell Exploration & Production Company.

Weslawski, J.M., M. Ryg, T.G. Smith and N.A. Oritsland. 1994. Diet of Ringed Seals (*Phoca hispida*) in a Fjord of West Svalbard. *Arctic* 47(2): 109-114.

- Page Intentionally Left Blank -

APPENDIX A

Marine Mammal Sightings Recorded During Acoustic Recorder Deployment and Retrievals

- Page Intentionally Left Blank -

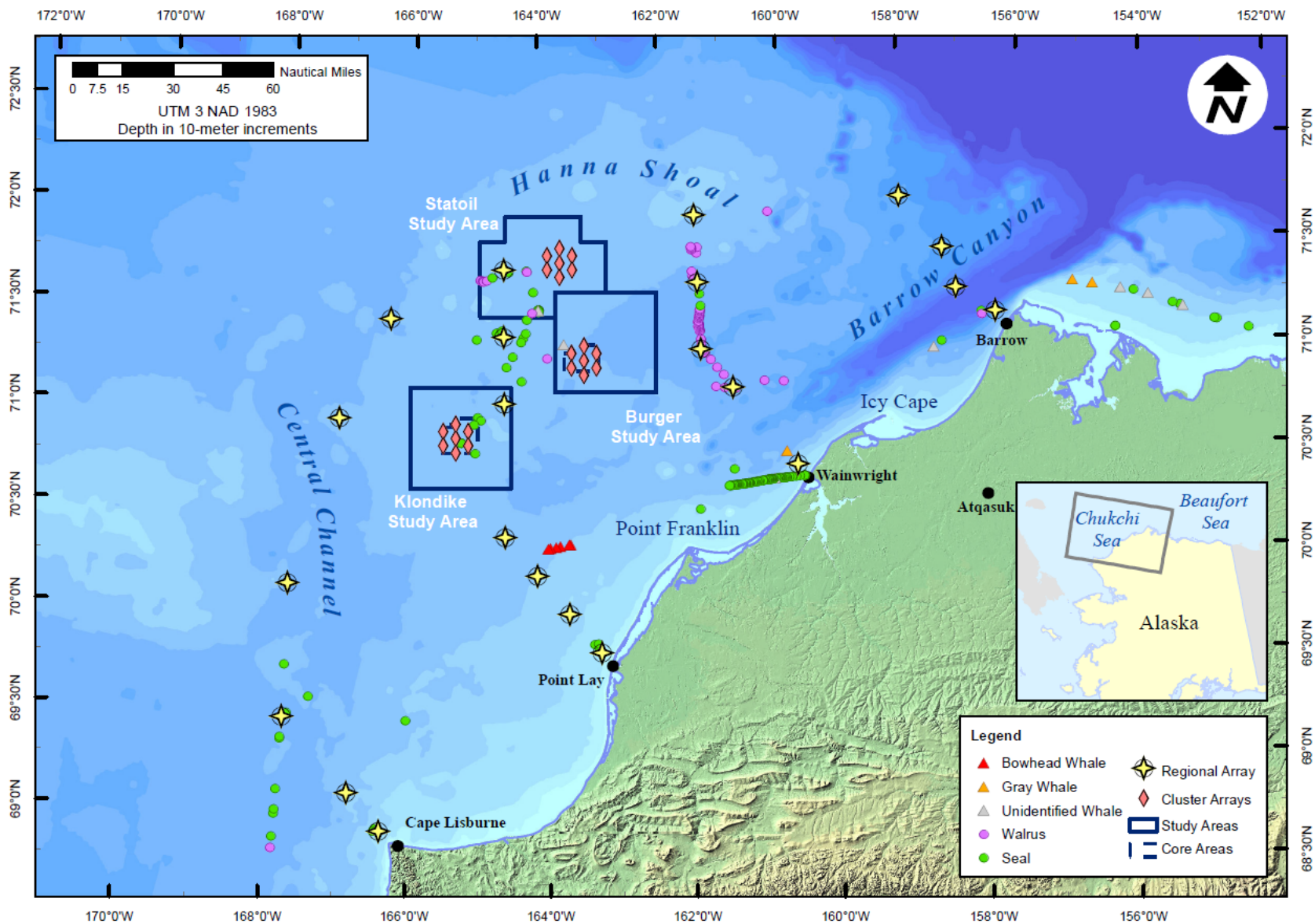


FIGURE A-1: MARINE MAMMAL SIGHTINGS RECORDED IN THE NE CHUKCHI SEA DURING ACOUSTIC RECORDER DEPLOYMENTS (5-10 AUGUST 2009 AND 23-31 JULY 2010), AND RETRIEVALS (15-23 OCTOBER 2008 AND 9-17 OCTOBER 2009).

- Page Intentionally Left Blank -

APPENDIX B

Detection Function Curves of Best Model for Seals and Walrus

- Page Intentionally Left Blank -

Detection function plot

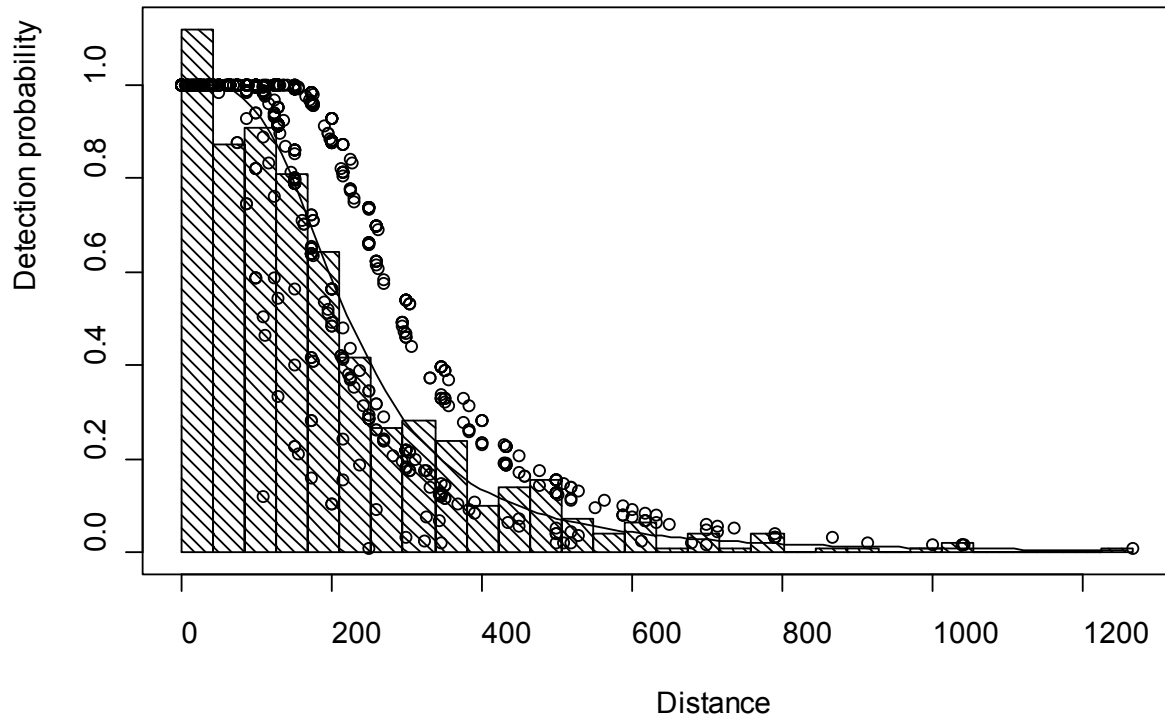


FIGURE B-1. DETECTION FUNCTION FOR SEALS BASED ON 2008-2010 DATA USING MRDS HAZARD RATE MODEL WITH BEAUFORT SEAS STATE AND SPECIES AS COVARIATES. DETECTION PROBABILITY IS SHOWN ON THE Y-AXIS AND PERPENDICULAR DISTANCE ON THE X-AXIS. THE DOTS REPRESENT SIGHTING INFORMATION (N=891), SHOWING A CLEAR DIFFERENCE IN DETECTION PROBABILITY BETWEEN HIGH AND LOW SEA STATE CONDITIONS.

Detection function plot

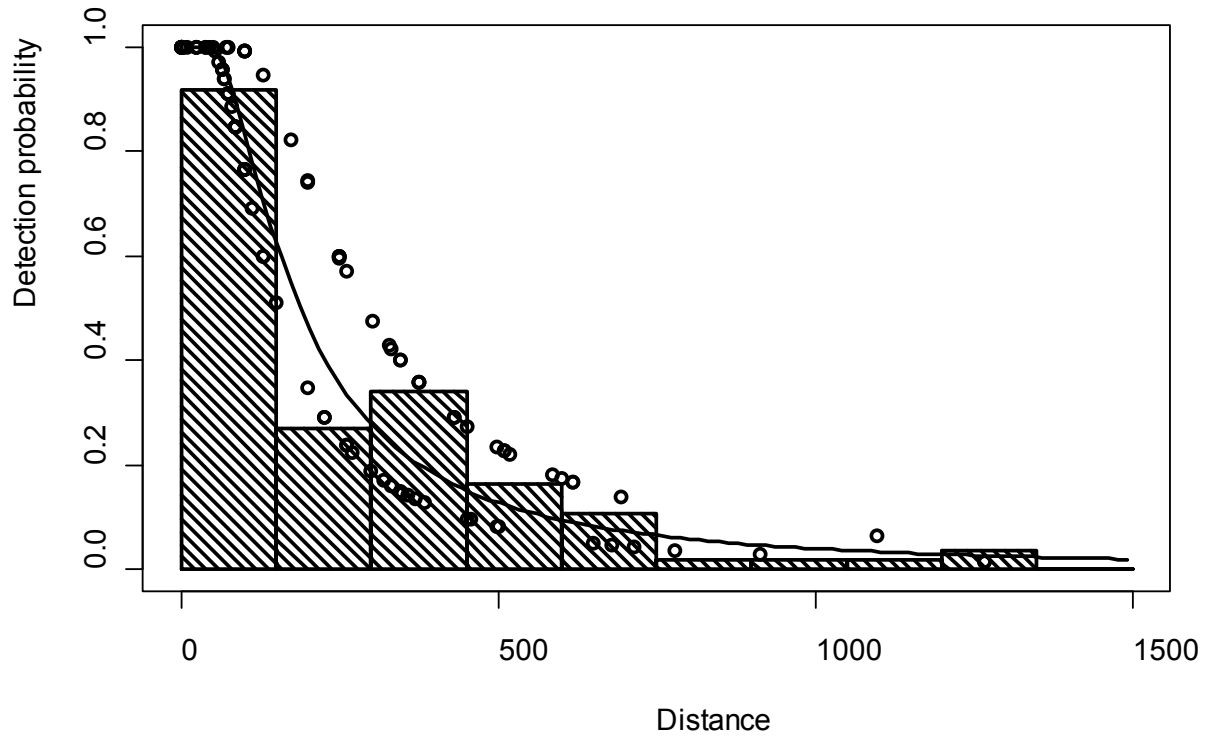


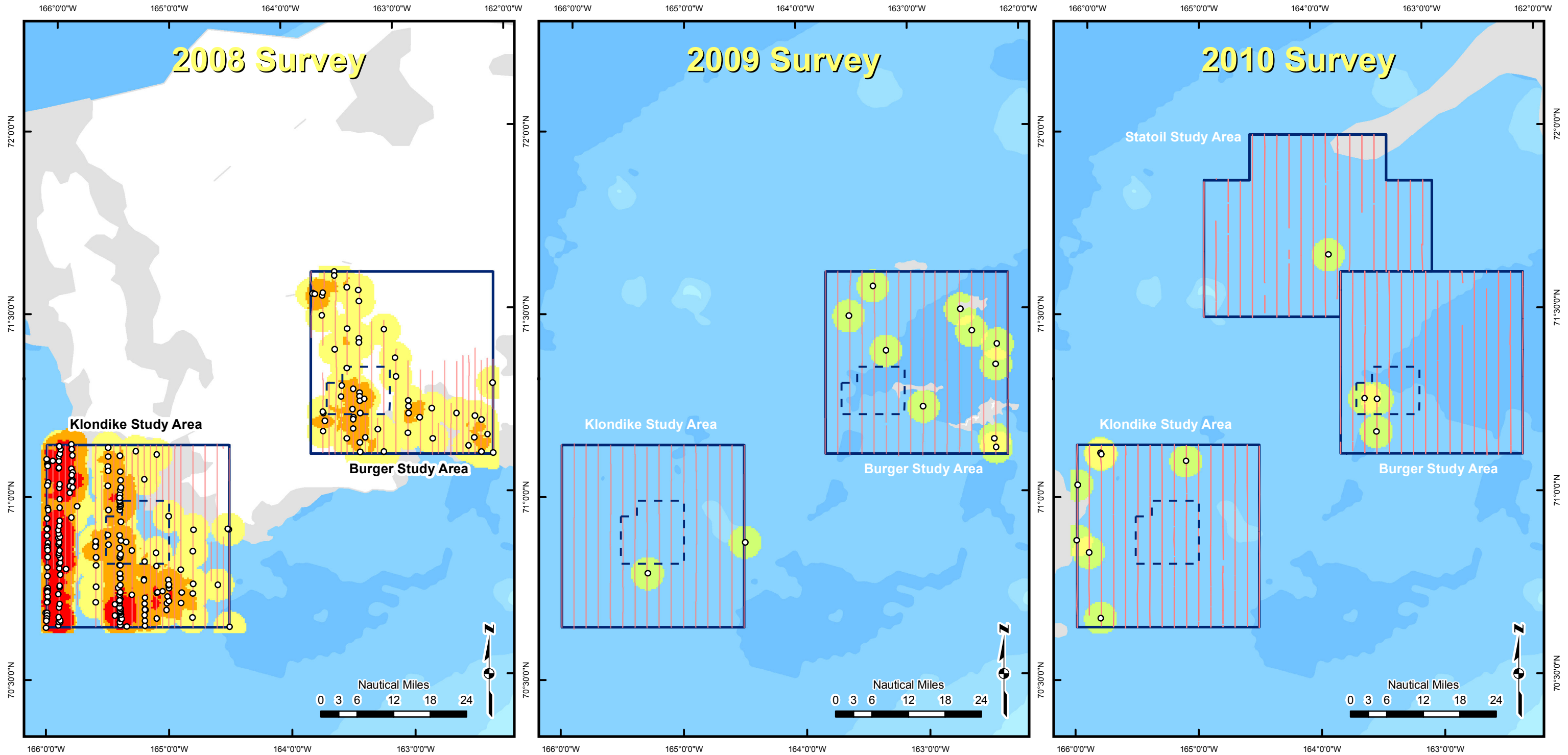
FIGURE B-2. DETECTION FUNCTION FOR WALRUS BASED ON 2008-2010 DATA USING MRDS HAZARD RATE MODEL WITH BEAUFORT SEAS STATE AS COVARIATE. DETECTION PROBABILITY IS SHOWN ON THE Y-AXIS AND PERPENDICULAR DISTANCE ON THE X-AXIS. THE DOTS REPRESENT SIGHTING INFORMATION (N=105), SHOWING A CLEAR DIFFERENCE IN DETECTION PROBABILITY BETWEEN HIGH AND LOW SEA STATE CONDITIONS

APPENDIX C

**Point Density Maps of bearded seals, all other seals and walrus in the Klondike,
Burger and Statoil Areas for each Season and Year**

- Page Intentionally Left Blank -

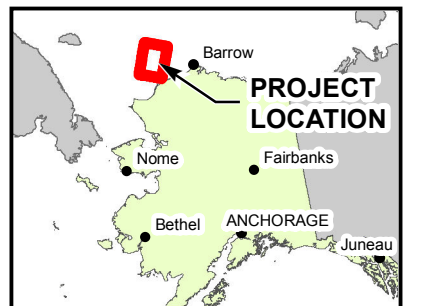
Other Seal Species Distribution in July - August



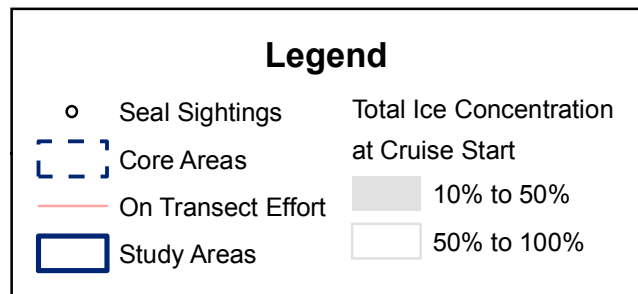
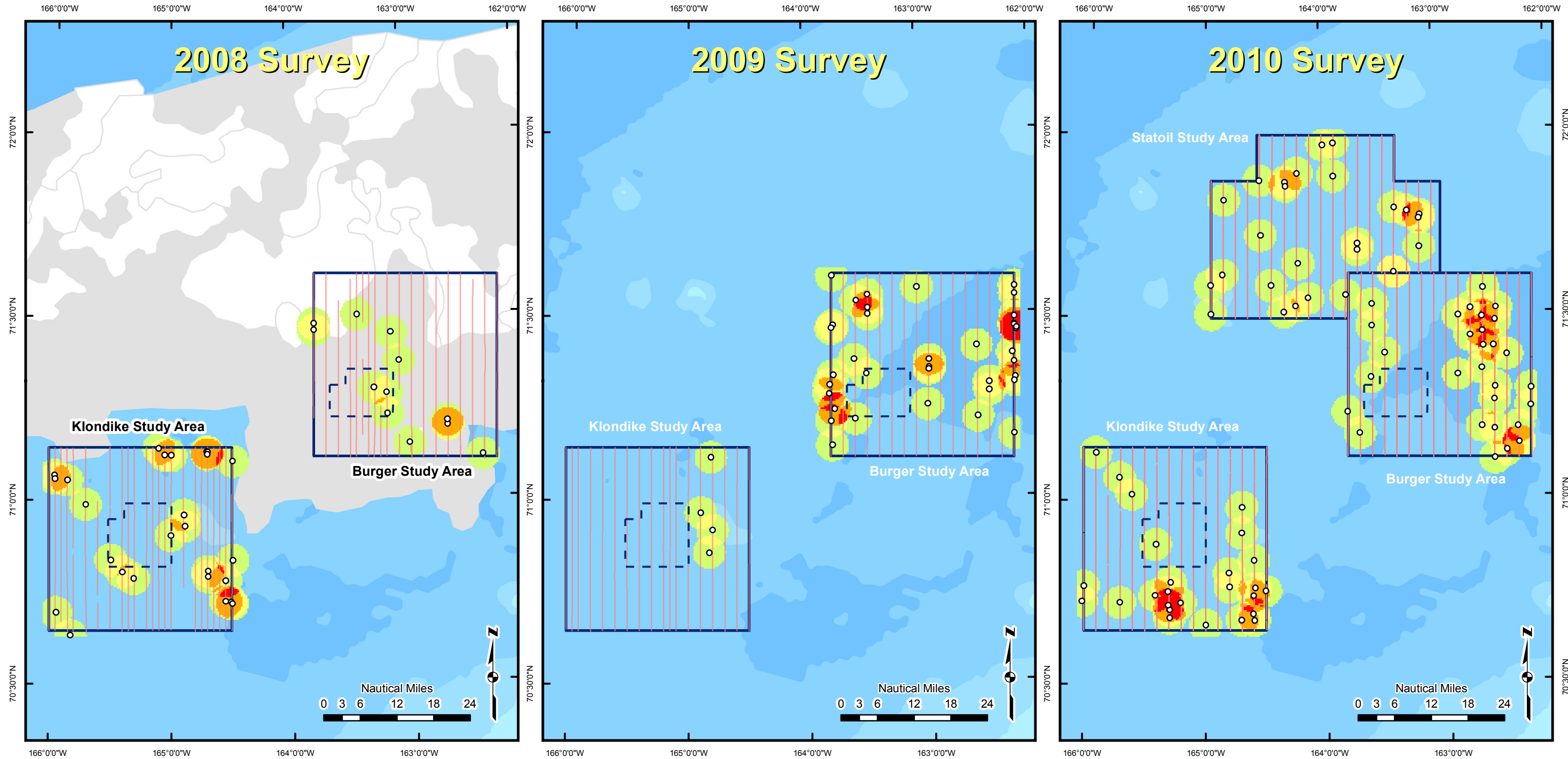
Legend

- Seal Sightings
- On Transect Effort
- ⌊ Core Areas
- ▭ Study Areas
- Total Ice Concentration at Cruise Start
- 10% to 50%
- 50% to 100%

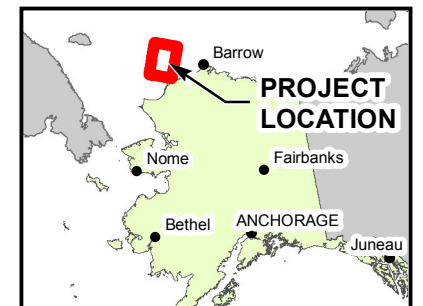
Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 22 July 2008, 14 August 2009, and 3 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



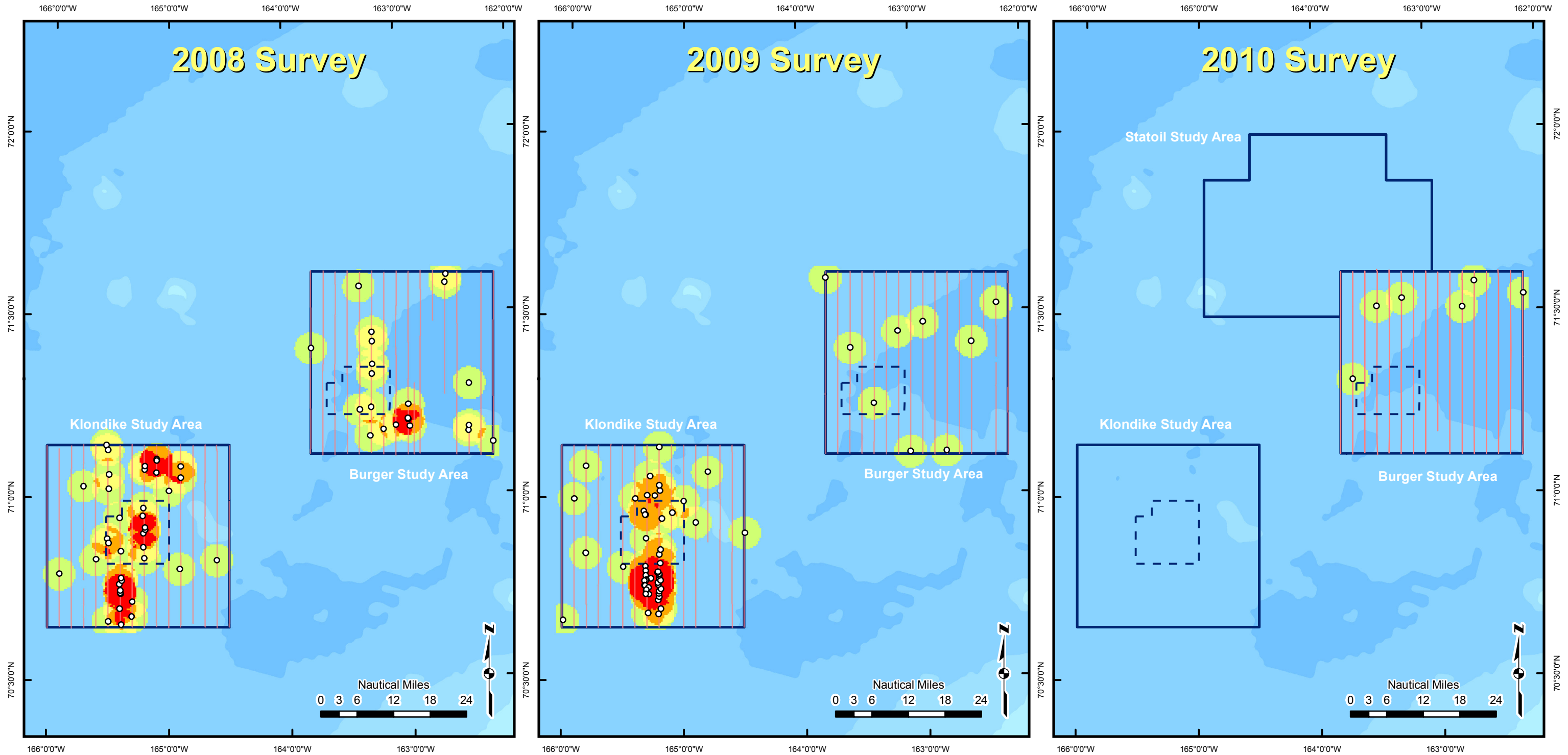
Other Seal Species Distribution in August - September



Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 19 August 2008, no ice in 2009, and 29 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



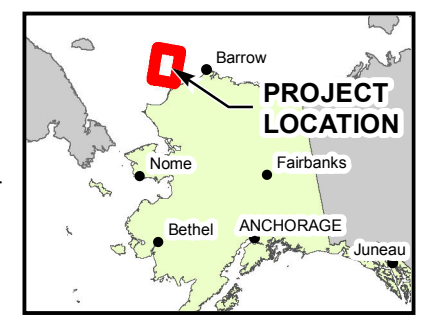
Other Seal Species Distribution in September - October



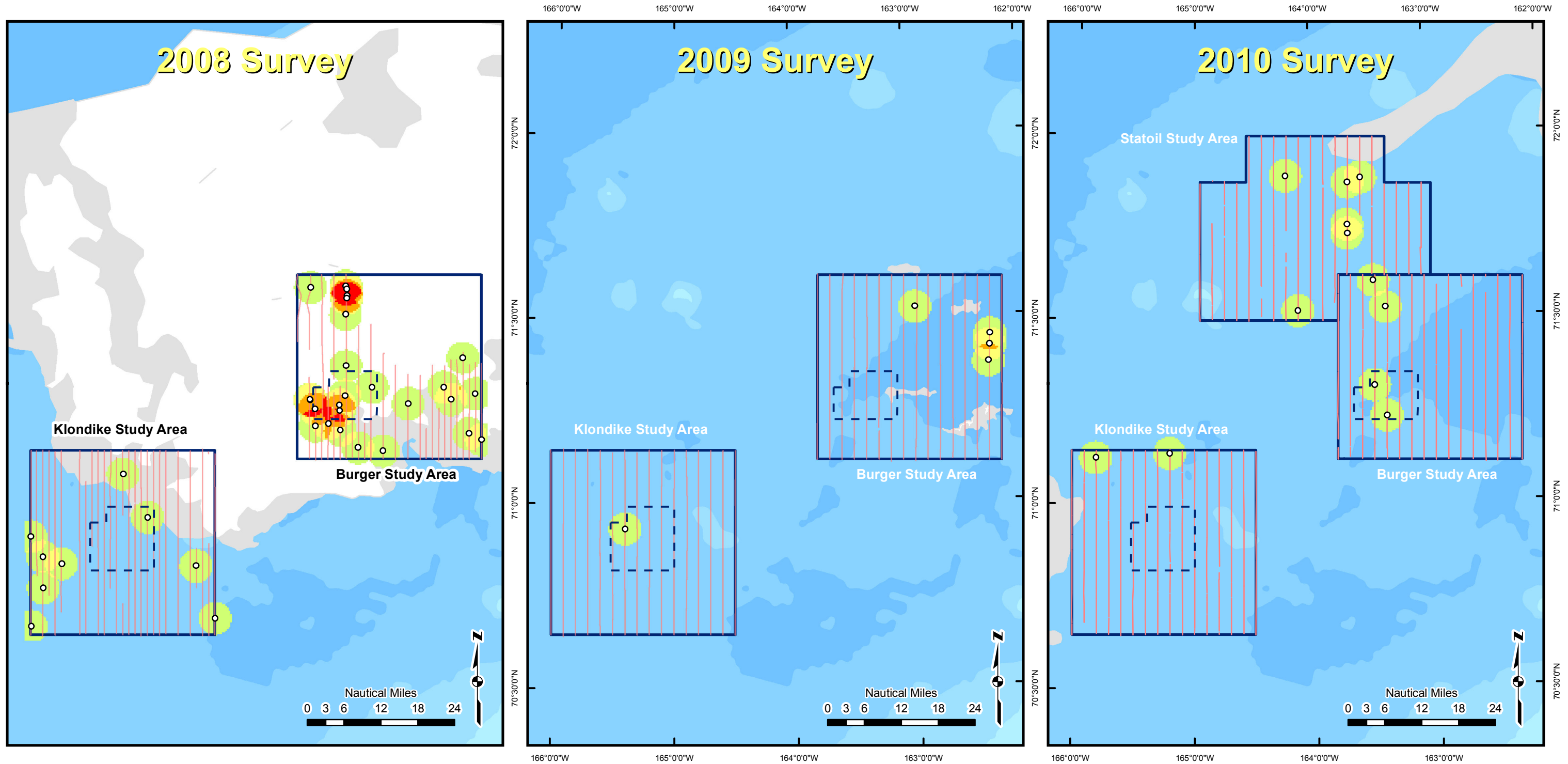
Legend

○ Seal Sightings	Total Ice Concentration at Cruise Start
⋮ Core Areas	10% to 50%
— On Transect Effort	50% to 100%
▭ Study Areas	

Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, but no sea ice was present in the study area at the beginning of these cruises. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



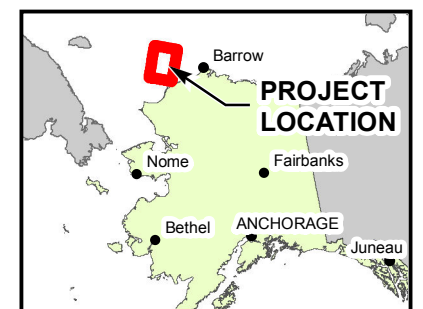
Bearded Seal Distribution in July - August



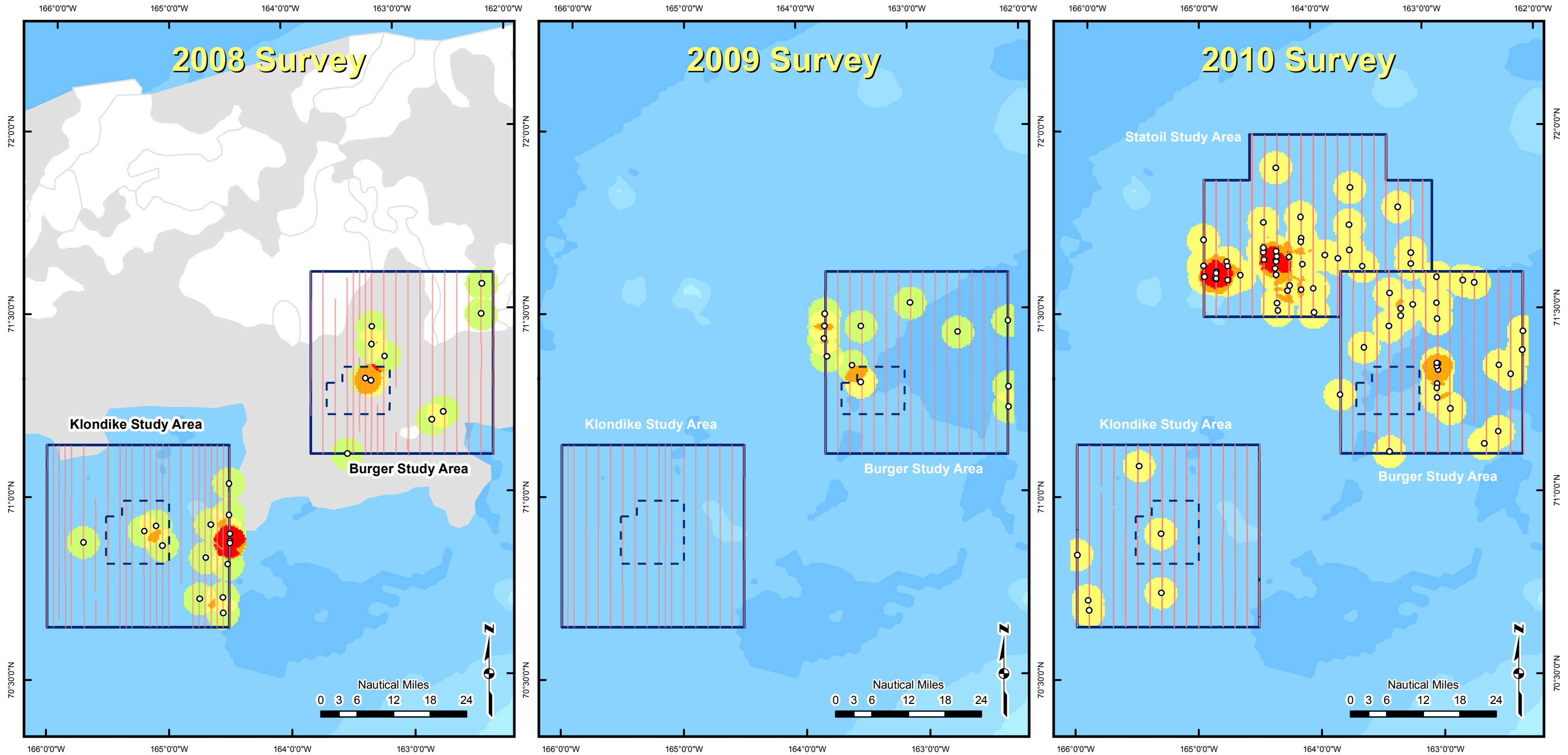
Legend

○ Bearded Seal Sightings	Total Ice Concentration at Cruise Start
— On Transect Effort	10% to 50%
⋮ Core Areas	50% to 100%
▭ Study Areas	

Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 22 July 2008, 14 August 2009, and 3 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



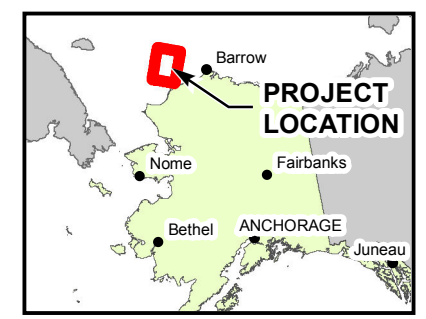
Bearded Seal Distribution in August - September



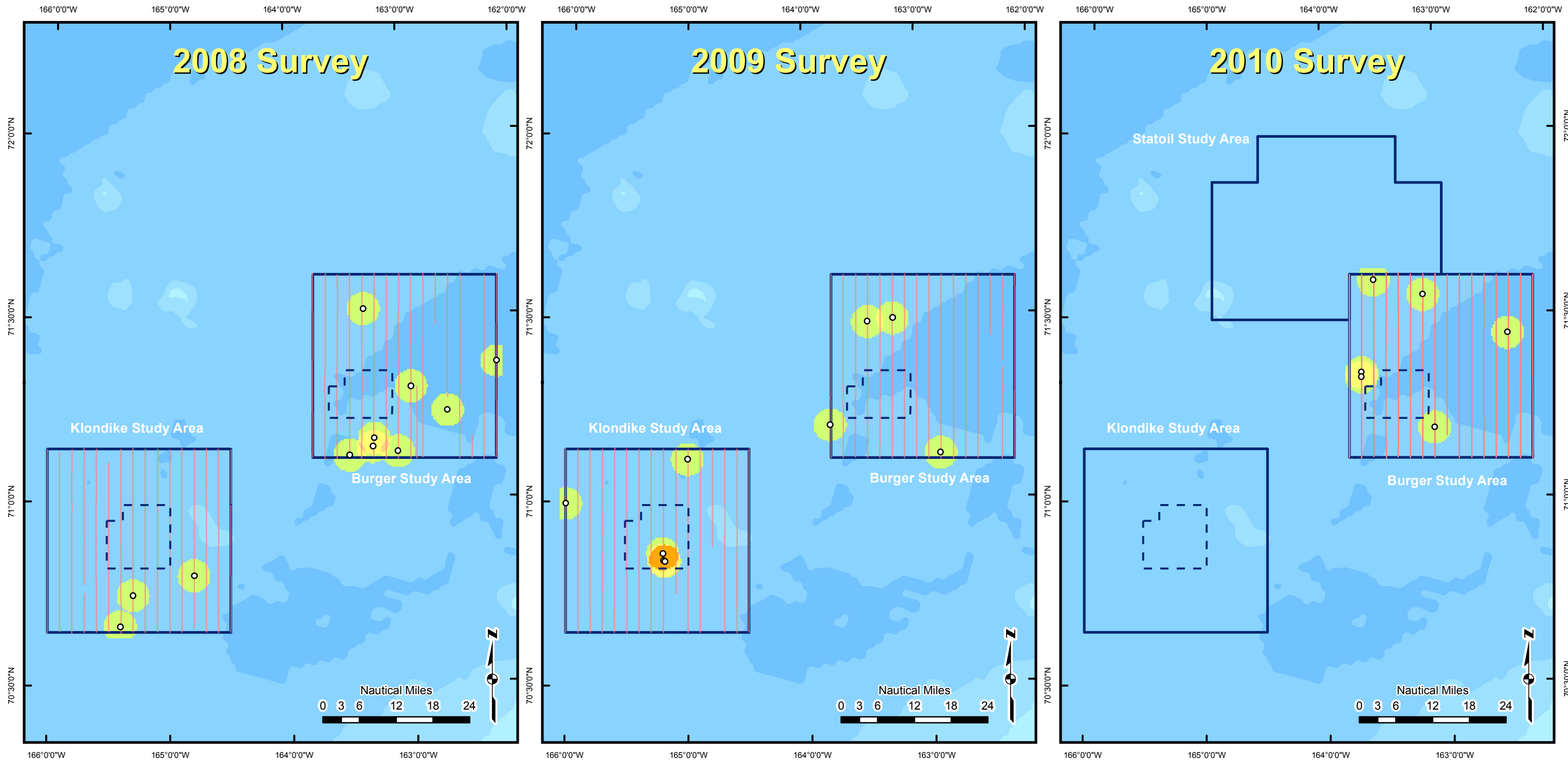
Legend

○ Bearded Seal Sightings	Total Ice Concentration at Cruise Start
⋮ Core Areas	10% to 50%
— On Transect Effort	50% to 100%
▭ Study Areas	

Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 19 August 2008, no ice in 2009, and 29 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



Bearded Seal Distribution in September - October



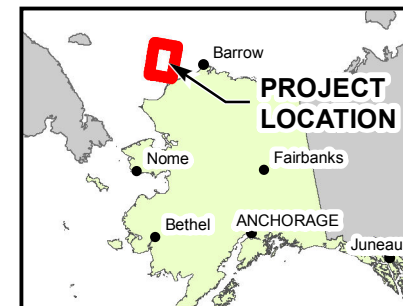
Legend

- Bearded Seal Sightings
- Core Areas
- On Transect Effort
- Study Areas

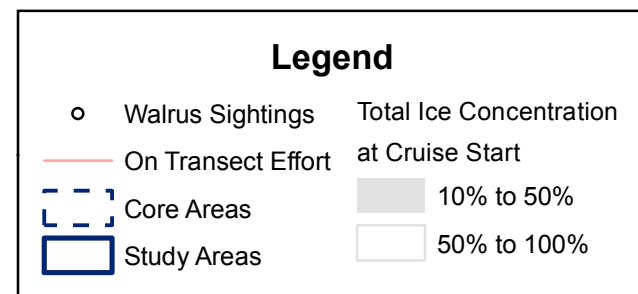
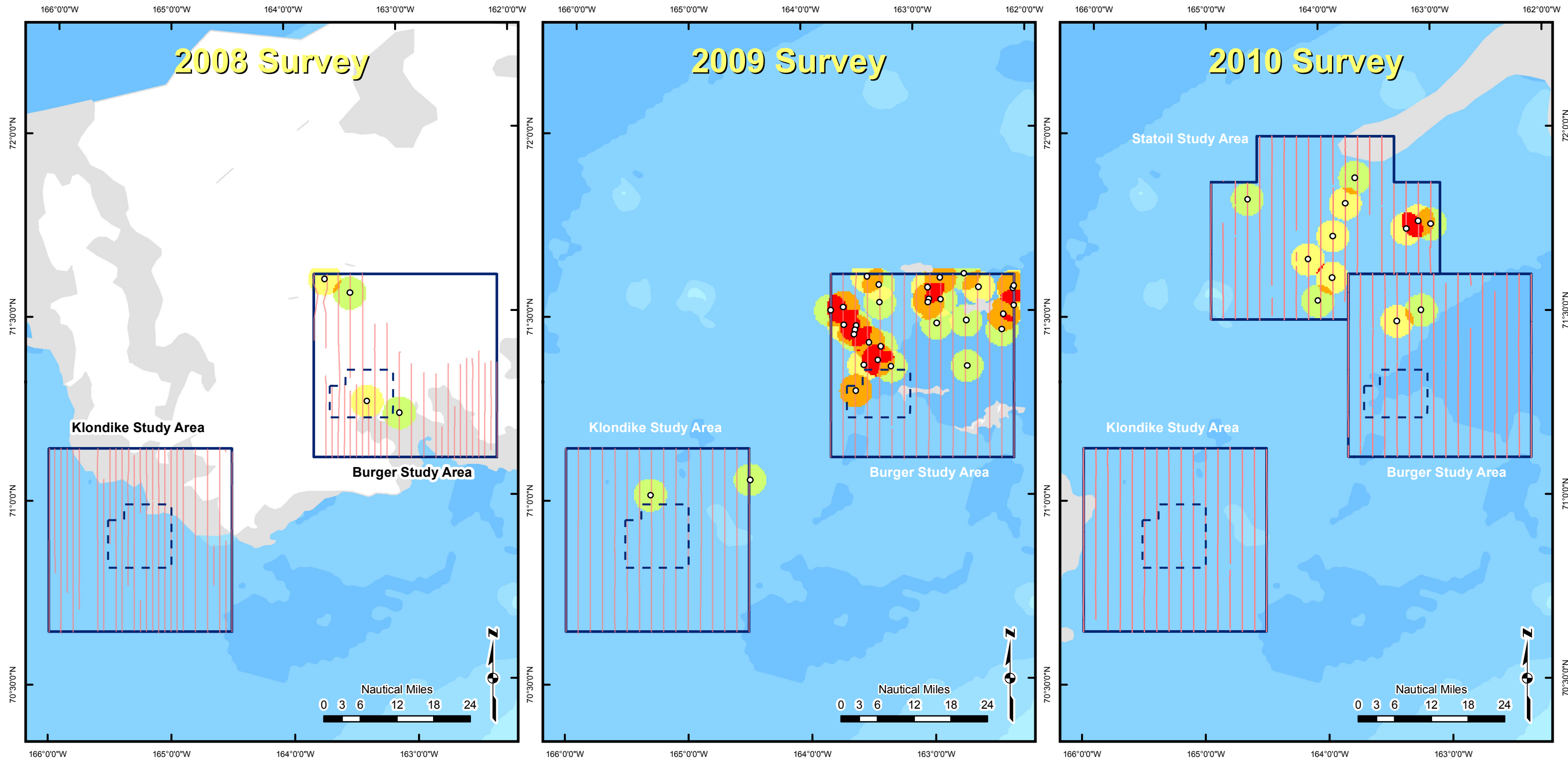
Total Ice Concentration at Cruise Start

- 10% to 50%
- 50% to 100%

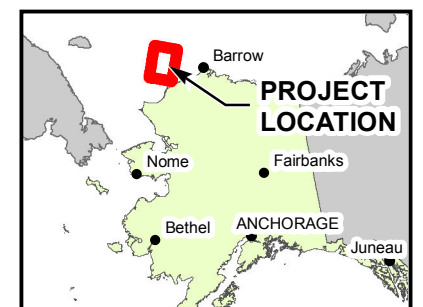
Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, but no sea ice was present in the study area at the beginning of these cruises. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



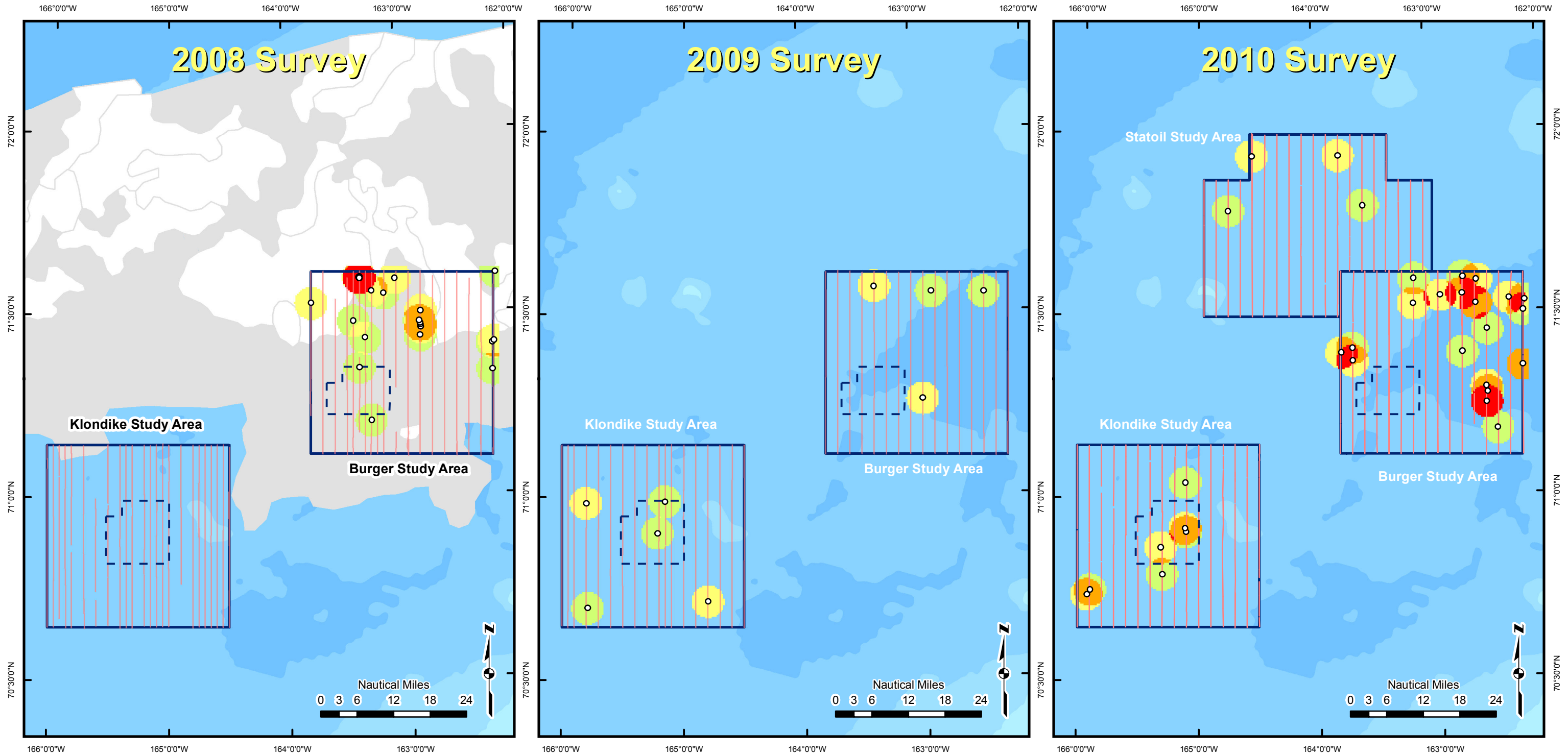
Walrus Distribution in July - August



Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 22 July 2008, 14 August 2009, and 3 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



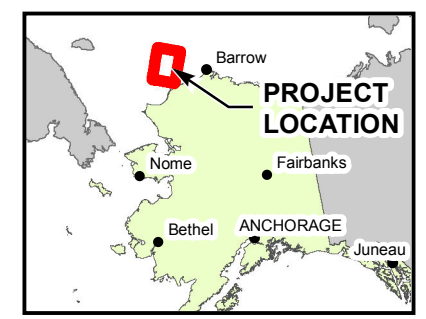
Walrus Distribution in August - September



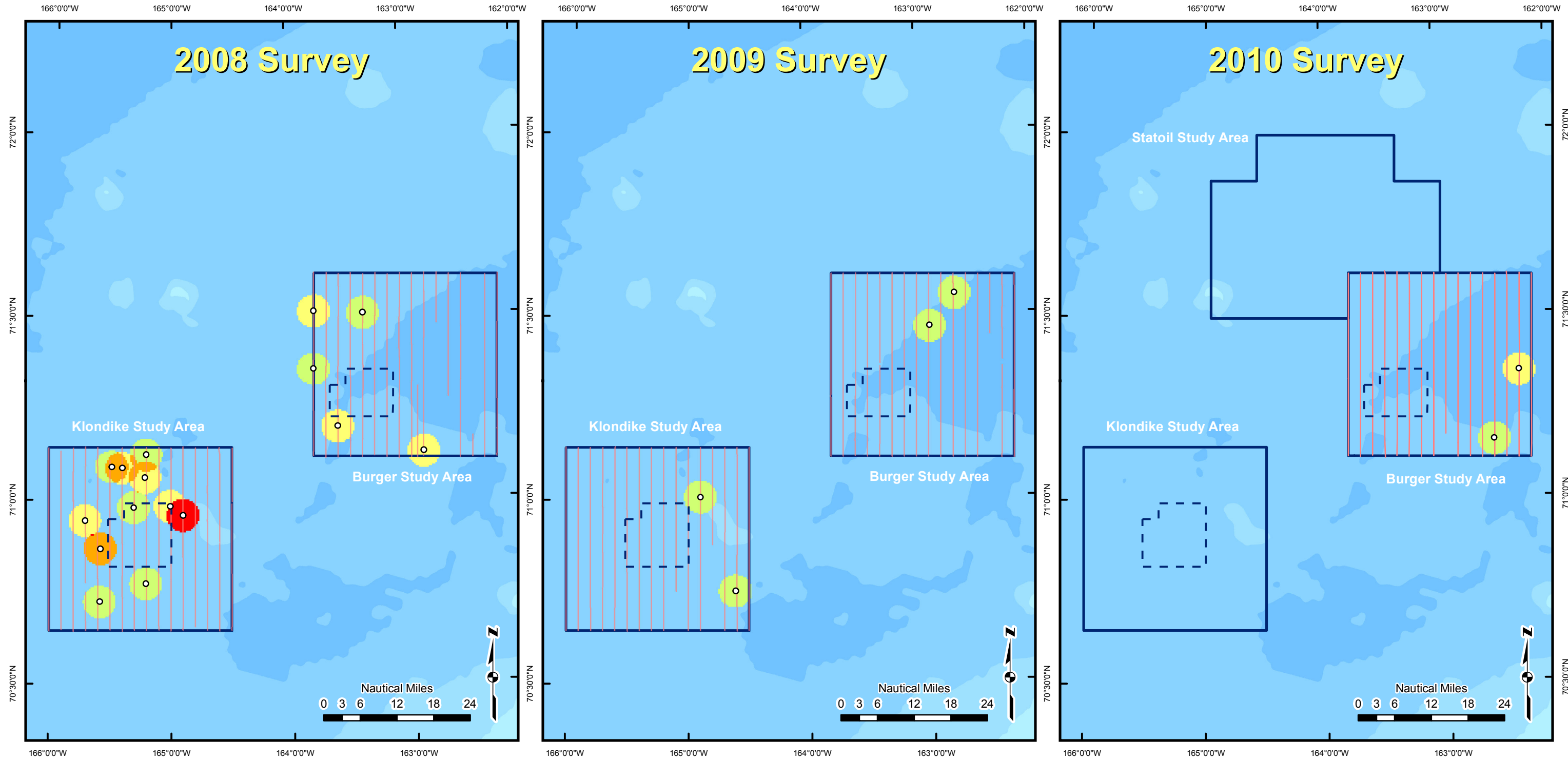
Legend

○ Walrus Sightings	Total Ice Concentration at Cruise Start
⋮ Core Areas	10% to 50%
— On Transect Effort	50% to 100%
▭ Study Areas	

Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, using the dates 19 August 2008, no ice in 2009, and 29 August 2010. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.



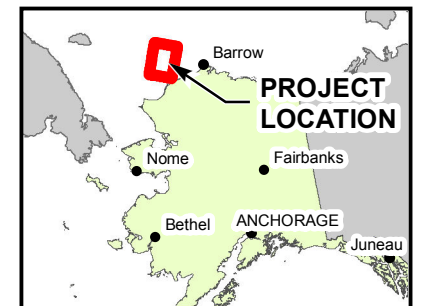
Walrus Distribution in September - October



Legend

○ Walrus Sightings	Total Ice Concentration at Cruise Start
⋮ Core Areas	10% to 50%
— On Transect Effort	50% to 100%
▭ Study Areas	

Sightings shown on transect, not on ice, and from one cruise and year per map. The effort lines shown here were generated from effort start and end points, using only high and low priority lines documented as on watch and on transect. Point density maps created using a 5 km buffer around sightings and weighted by the number of individuals seen, with green as lowest and red as highest uncorrected density. Ice data is in total ice concentration and is courtesy of Shell Ice and Weather Advisory Center, but no sea ice was present in the study area at the beginning of these cruises. Bathymetry is displayed in 10 m increments from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.

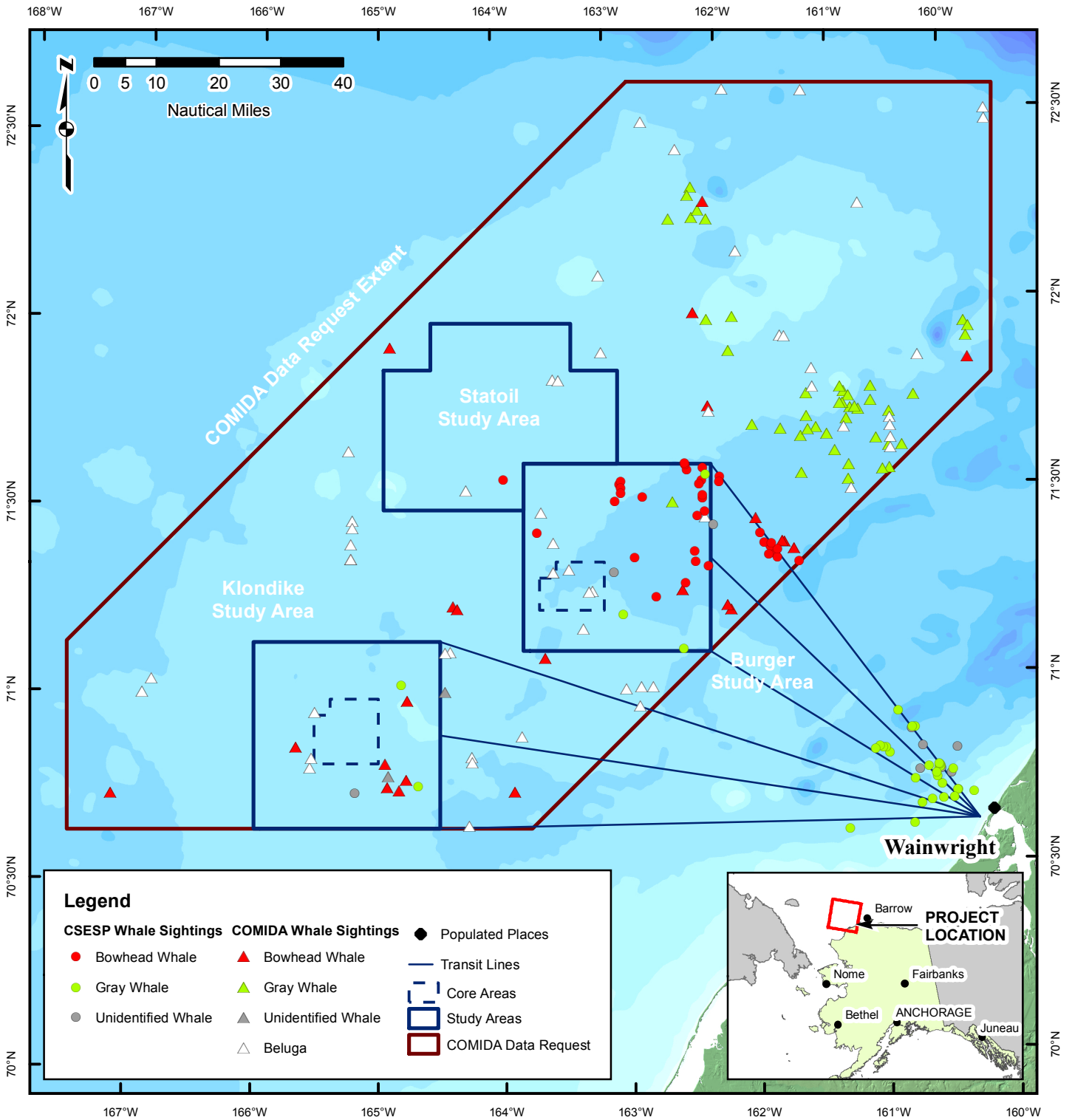


APPENDIX D

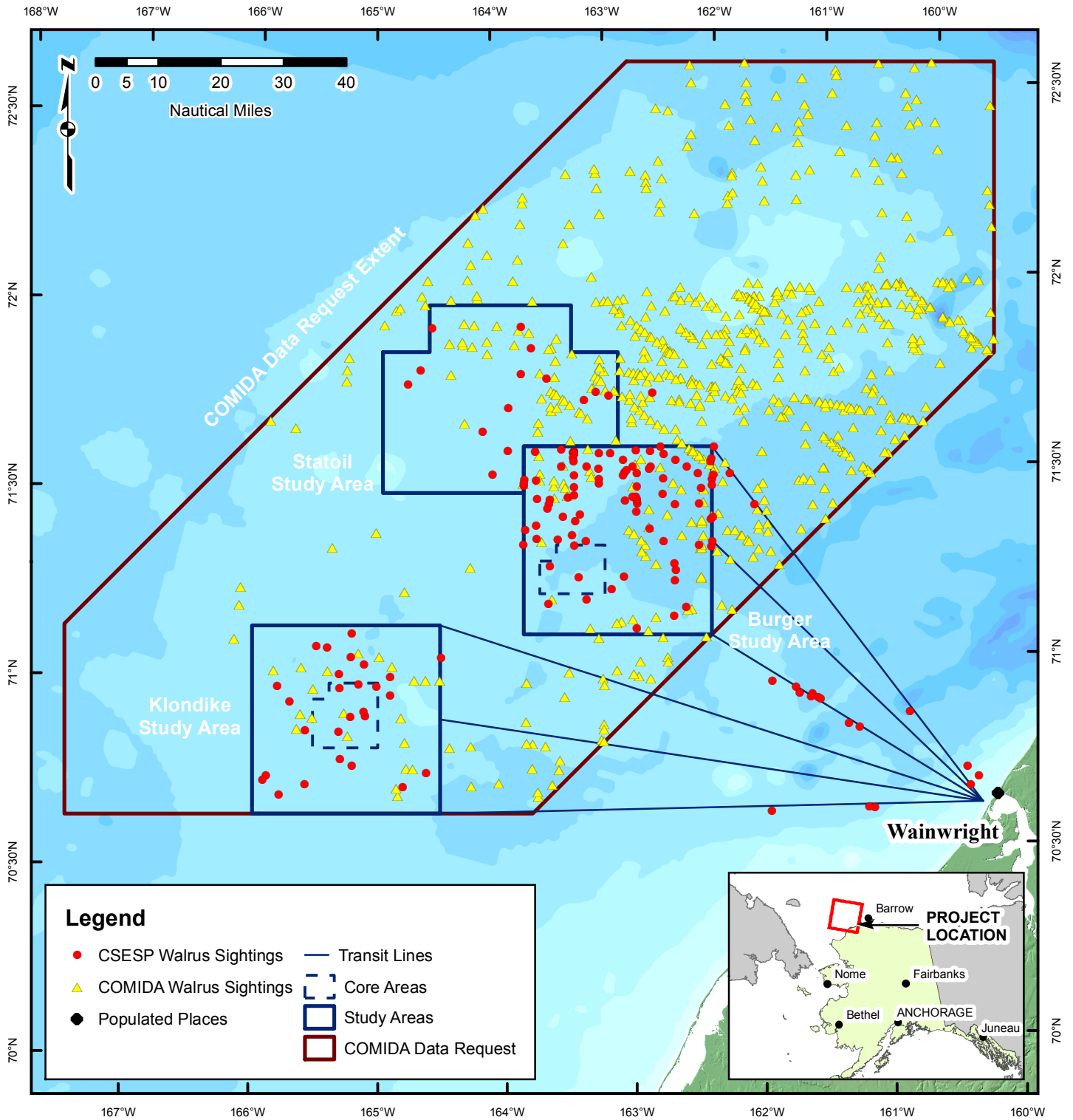
**Whale and Walrus Sighting Maps Combining Chukchi Sea Aerial Survey
(OCSEAP 1982-1991, COMIDA 2008-2010) and Vessel Survey Data (CSESP 2008-
2010)**

- Page Intentionally Left Blank -

Whales Distribution



Walrus Distribution



Chukchi Offshore Monitoring in Drilling Area (COMIDA) Aerial Survey Data provided by National Oceanic and Atmospheric Administration's (NOAA) National Marine Mammal Laboratory. More information can be found at <http://www.afsc.noaa.gov/nmml/cetacean/bwasp/index.php>. Data was collected from July to October 1982 -1991 and 2008-2010. Please note that no survey since 1991 has included the areas north of 72 deg. N latitude. CSESP (Chukchi Sea Environmental Studies Program) refers to data collected by this project, and these sightings are limited to on transect or transit and not on ice. Bathymetry is displayed in 10 m increments and is from the National Ocean Service Hydrographic Database (NOSHDB) maintained by the National Geophysical Data Center (NGDC) in conjunction with the NOS. Maps projected in Universal Transverse Mercator Zone 3, North American Datum of 1983, in meters.